**Attachment 5: Referenced Reviewing Agency Comment Letters and Documents**

***Note to Reader* Some documents are long. If Attachment is downloaded there are searchable headings for each comment letter and documents on the left side of a PDF viewer.**

# Table of Contents

# Idaho Power's Response to ODOE's Request for Additional Information 4
## Exhibit N – Need
## Boardman to Hemingway Transmission Line Project
## January 2018

| Reviewing Agency | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| ApASC RAI N-1 | Section 3.2.1, Page N-5 | OAR 345-023-0020(2) | Note: It is stated in Section 3.2.1 that the development of B2H has been included in the short-term plan of action in IPC's Integrated Resource Plans in 2009, 2011, 2013, and 2015, and that the Oregon Public Utilities Commission has acknowledged each plan. As such, IPC states that EFSC must find that the need standard has been met.<br><br>However, as described in the PUC's orders regarding the IPC 2013 and 2015 IRPs, the PUC only acknowledged the ongoing permitting, planning, and regulatory filings related to B2H. ODOE would consider the "development" of a project to include both the permitting and planning as well as the actual construction. The PUC orders state that the construction of B2H is beyond the typical IRP planning horizon.<br><br>OAR 345-023-0020(1) states that the "Council shall find that the applicant has demonstrated need for the facility if the capacity of the proposed facility …is identified for acquisition in the short-term plan of action…approved or acknowledged by a…governmental body that makes or implements energy policy…". OAR 345-023-0020(2) states that the Council shall find that a least-cost plan meets the criteria of an energy resource plan described in section (1) if the PUC of Oregon has acknowledged the least cost plan."<br><br>ODOE does not agree with IPC that the PUC acknowledgement of the 2013 and 2015 IRPs, which include only ongoing permitting, planning, and regulatory filings related to B2H (and not "development" as understood to include both planning/permitting and construction), constitute PUC acknowledgment of B2H "acquisition" under OAR 345-023-0020(1). As such, based on current information in the record, ODOE would not recommend compliance with the Council's Need Standard under OAR 345-023-0020 Least-Cost Plan Rule.<br><br>However, ODOE understands that in its 2017 IRP, IPC has specifically requested the PUC acknowledge the planning/permitting and construction of B2H. If PUC acknowledges the 2017 IRP including the permitting and construction of B2H, under OAR 345-023-0020, ODOE would recommend that Council shall find compliance with the Need Standard. | Currently, Idaho Power expects the OPUC to issue its acknowledgement order before the DPO is issued. Even so, Idaho Power would like to note that Idaho Power is seeking to meet the Need Standard alternatively under the Least Cost Plan Rule and the System Reliability Rule. Accordingly, the timing and outcome of the OPUC proceedings may not be determinative of whether the Need Standard is met, provided Idaho Power satisfies the System Reliability Rule. |

| Reviewing Agency | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| | | | ODOE understands that the PUC may not take action on the 2017 IRP until sometime later in 2018. ODOE will not require IPC to include the PUC's acknowledgment of the 2017 IRP in a complete application for site certificate. However, if IPC wishes to rely upon a PUC acknowledgment (if issued for both permitting and construction of B2H) to meet the Need Standard under OAR 345-023-0020 Least Cost Plan Rule, the PUC's acknowledgement must be part of the ODOE record prior to issuance of a DPO. | |
| ApASC RAI N-2 | Exhibit N - throughout | OAR 345-021-0010(1)(n) | Please update Exhibit N as appropriate to reference IPC's 2017 IRP. For example, Exhibit N Section 3.3.2.2 references IPC's 2015 IRP load-resource balance tables, including specific page references in the 2015 IRP. Please update these references to the 2017 IRP. As another example, Exhibit N Section 3.3.5 references that the "preferred resource portfolio in the 2015 IRP contemplates ceasing coal-fired operations for Valmy Units 1 and 2 in 2025," however, in the 2017 IRP, it is stated that IPC will cease coal-fired operations at Valmy Unit 1 by 2019 and Unit 2 by 2025. Table N-1 includes expected-case portfolio costs, from the 2015 IRP.<br><br>Please also include the 2017 IRP as an attachment to the exhibit. Please note that if IPC is not relying upon previous year's IRPs, these documents do not need to be included in the complete application. OAR 345-021-0010(1)(n)(B)(i) only requires the inclusion of the "energy resource plan or combination of plans which the applicant relies to demonstrate need," meaning, if IPC only relies upon the 2017 IRP, that is the only document that needs to be included in the application. | Idaho Power has updated the information in Exhibit N to incorporate the latest information from the 2017 IRP, including updating Section 3.2.2.2, Section 3.3.5, the North Valmy closure references, Table N-1, and other relevant information.<br><br>The 2017 IRP is attached as Attachment N-5. Additionally, while Idaho Power appreciates ODOE's suggestion that the company remove the pre-2017 IRPs from the application, Idaho Power believes those IRPs support the need for the Project, even if only as background and context for the Need Standard determination. Therefore, Idaho Power has left those IRPs in the application. |
| ApASC RAI N-3 | Section 3.3.6, Page N-15 | OAR 345-021-0010(1)(n)(F)(vi) | This section states that the NERC TPL and WECC rating processes were both used to demonstrate reliability compliance and regional performance criteria. Please provide reference to a document or report from IPC, NERC, WECC, or some other entity that documents the results of these planning studies. | The WECC process discussed in Exhibit N is a process whereby a utility proposes an increase to a certain transmission path, showing that the proposed increase would be achieved without violations of applicable NERC/WECC standards and local reliability criteria. With respect to B2H, WECC approved Idaho Power's proposal for B2H in 2012. Idaho Power added Footnote 27 to Exhibit N referencing that approval: |

| Reviewing Agency | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| | | | | See WECC Memorandum re: Hemingway-Boardman 500 kV Transmission Project Achieves Phase 3 Status (Nov. 27, 2012). |
| | | | While this section states that with the B2H project, IPC demonstrates compliance with NERC and WECC criteria, it does not state that without B2H, IPC does not meet compliance with the same standards. Could IPC meet the NERC and WECC standards without B2H? | B2H is not the only possible solution to meeting Idaho Power's growing demand for electricity in compliance with NERC and WECC reliability standards. However, Idaho Power would have to meet load growth demands through some alternative. Idaho Power has determined, over the course of many successive IRPs, that the B2H project is the least-cost, least-risk resource—as compared to many other alternatives—to meet the company's growing demands. |
| ApASC RAI N-4 | Section 3.2.8, Page N-18-19 | OAR 345-021-0010(1)(n)(F)(vii)(IV) | It is stated that the 2011 IRP included an analysis for the cost-effectiveness of the 500 kV single circuit design. Has this analysis been reviewed and reassessed in the 2017 IRP? | Yes, the 2017 IRP evaluated the B2H project against other feasible resource options and determined B2H was the least cost, lowest risk resource to meet the future needs of Idaho Power's customers. Chapter 9 of the 2017 IRP, beginning on page 109, presents an explanation of the analysis and a summary of the results. Further, Appendix D of the 2017 IRP provides a comprehensive review of the Project as a resource, including addressing the need for the Project, discussing (qualitatively and quantitatively) the benefits of the Project, and considering the risks and benefits of the Project in contrast to a traditional generation source. Of particular relevance, Table 2 in Appendix D provides a high-level explanation of the differences between the Project and other resource options, and Appendix D-1 provides comparisons among different transmission line construction and upgrade scenarios (e.g., replacing Oxbow-Lolo 230-kV line with a 500-kV line). |

**Idaho Power's Response to ODOE's Request for Additional Information 4**
**Exhibit X – Noise**
**Boardman to Hemingway Transmission Line Project**
**December 2017**

| Request for Information | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| RAI-4-X[1] | General Comment | | IPC has requested Council approval of both an exception and a variance for the proposed facility in its entirety, not only at the 30 identified NSRs with expected noise exceedances. ODOE will assess and make recommendations to Council regarding the requested exception and variance on each NSR or groupings of NSRs, and will not recommend to Council an exception and/or variance for the proposed facility in its entirety. This is based on two factors: 1) IPC does not need an exception/variance for the proposed facility in its entirety, only at the identified NSRs that are expected to exceed the noise standard, and 2) ODOE believes that the assessment of an exception/variance should be site-specific and based on local factors and conditions. For example, based on the weather data provided in Exhibit X, the foul weather conditions vary considerably between the weather stations and regions, and as such, the assessment of an exception request which relies upon infrequent circumstances of the event, will also vary. Additionally, the request for variance should be based on site-specific conditions at any particular NSR or NSR grouping with similar, site-specific circumstances. For example, IPC states that "…the only cure for an exceedance at a particular NSR is to reroute the line away from the NSR. Unfortunately, IPC's analysis reveals that such rerouting is not possible." (ApASC, Exh X, Page X-38). This blanket statement is not validated by the information currently included in Exhibit X. The analysis should instead be site-specific to demonstrate that avoiding the NSR exceedance is in fact not possible. For example, it may be the case that the exceedance at NSR-113 is impossible to avoid because the proposed route must stay within the designated energy corridor. On the contrary, at NSR-115, no other constraints appear on figure X-10 that seem to be obvious constraints on the routing in this area. It is also not obvious why the Willow Creek area, which contains multiple NSRs, could not be avoided. IPC explains on page X-29 that the BLM would not allow an alternative segment in this area to cross its land due to sage grouse considerations. ODOE does not question that trade-off | See attached correspondence from Mark Stokes, Idaho Power, to Kellen Tardaewether, ODOE, discussing certain issues raised by this comment.<br><br>Additionally, as requested by ODOE, Idaho Power has expanded in the text of Exhibit X the discussion of the siting constraints surrounding NSR-115, the Willow Creek area, and NSR-8 through NSR-11. |

[1] ODOE provided its Exhibit X Requests for Information 4 (RAI-4) to Idaho Power on or about October 19, 2017.

| Request for Information | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| | | | and understands that BLM has control over use of its land, but the decision to cross the Willow Creek valley as shown on figure X-7 is not on BLM land, and it is not clearly demonstrated why the line could not be moved to elsewhere on non-BLM land in this area to avoid the noise exceedance at multiple NSRs. Finally, IPC relies upon a general list of legal constraints (page X-37), including federal land management authority, WECC requirements, Category 1 habitat avoidance, and Protected Areas avoidance, but it is not evident that any of these constraints are at issue around NSRs 8-11 (figure X-5).<br><br>As such, please provide an assessment of the request for exception and/or variance for each NSR or NSR grouping, as appropriate (groupings as identified on figures X-5 to X-10). | |
| RAI-4-X[2] | Section 3.4.5.2, Page X-22, table X-6 | OAR 340-035-0010 | Table X-6, and the corresponding assessment of foul weather conditions, defines "foul weather" as periods when rainfall is between .8 mm/hr and 5 mm/hr. Please explain why this range was selected. Are there periods when rainfall would be greater than 5 mm/hr? Is that not considered foul weather? | As reviewed and approved by ODOE, Idaho Power used the Bonneville Power Administration's Corona and Field Effects (CAFE) program to analyze audible noise generated from the transmission lines. That method calculates the foul weather L50 noise level during rainy conditions of 1 millimeter per hour (mm/hr) (0.039 inch/hr). Long-term measurements show that L50 audible noise levels occur at this rain rate (EPRI 2005). The CAFE program assumes this standard rain rate, and does not allow for adjustments or modifications. However, as the analysis progressed, Idaho Power recognized that audible noise may be present from the conductors when there are water droplets on the conductors, such as just after rain (conductor not yet dried off) or a light mist or heavy fog although these latter conditions are highly variable. The rain rate of 1 mm/hour used in the CAFE model does not necessarily cover light rains or fog when corona noise will also be generated. Therefore, the Project assumed foul weather to be a rain rate of ranging from 0.8 to 5 mm/hour for the following reasons:<br>• It is a slightly more conservative definition of the weather conditions likely to result in maximum corona noise than the 1 mm/hour used by the CAFE program, but is consistent with EPRI |

[2] Idaho Power retained in this document the numbering used by ODOE in its RAI worksheet, which included two RAI "X"s and no RAI "1."

| Request for Information | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| | | | | guidance and further confirmed during Idaho Power's field verification measurements.<br>• It also correctly excludes precipitation heavy enough that it could be reasonably expected that the noise from the weather would increase ambient sound levels to the extent that the corona noise would be masked.<br>It is assumed that precipitation at a higher rate than 5 mm/hour would result in masking of corona noise. |
| RAI-4-X | Section 3.3.2.1 | | Reiteration of RAI 3-X-12: please provide the two referenced BPA documents related to the noise policy compliance or a link where the referenced documents can be accessed (footnotes 8 and 9 of Exhibit X). | See attached. |
| RAI-4-X-2 | Section 3.4.2, Page X-15 | OAR 340-035-0035(5) | Please provide any regulations, approval criteria or conditions of operation related to noise that will apply, or are expected to be applied, to the helicopter operations during construction as imposed by the FAA. | Idaho Power has added the relevant Code of Federal Regulations citation to Exhibit X, Section 3.4.2—i.e., 14 C.F.R. § 36.11, which provides for noise certification standards and noise level limits applicable to helicopters. To ensure compliance with such standards, Idaho Power has added the following requirement to Public Services Condition 2: "all helicopters must be compliant with the noise certification and noise level limits set forth in 14 C.F.R. § 36.11." Further, Public Services Condition 2 already includes the following requirements to avoid or minimize the noise impacts on the public by limiting the location of the helicopter flights to areas away from dwellings and by limiting the timing of the flights to daylight hours: "d. Multi-use areas and light-duty fly yards containing helipads shall be located: . . . (iii) at least 500 feet from existing dwellings on adjacent properties; and e. Flights shall occur only between sunrise and sunset." In its entirety, Public Services Condition 2, as revised, reads:<br><br>Public Services Condition 2: Prior to construction, the site certificate holder shall submit to the department for its approval a Helicopter Use Plan, which identifies or provides:<br>a. The type of helicopters to be used (all helicopters must be compliant with the noise |

| Request for Information | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| | | | | certification and noise level limits set forth in 14 C.F.R. § 36.11);<br>b. The duration of helicopter use;<br>c. Roads or residences over which external loads will be carried;<br>d. Multi-use areas and light-duty fly yards containing helipads shall be located: (i) in areas free from tall agricultural crops and livestock; (ii) at least 500 feet from organic agricultural operations; and (iii) at least 500 feet from existing dwellings on adjacent properties; and<br>e. Flights shall occur only between sunrise and sunset. |
| RAI-4-X-3 | Section 3.4.3, Page X-15 | OAR 340-035-0035(5) | Please discuss the expected frequency of use and any proposed conditions of use of helicopters during facility operation. | Response pending. |
| RAI-4-X-4 | Attachment X-4 | OAR 340-035-0035 | In Attachment X-4, is the predicted sound level shown in L1, L10 or L50 dBA? Please discuss how the facility complies with the entirety of the standard for new noise sources at night: L50, 50 dBA; L10, 55 dBA; and L1, 60 dBA. | The noise modelling methods developed by BPA provides predicted foul weather L50 and L5 sound levels. The model predicts that the L5 sound level is always 3.5 dBA greater than the L50 sound level. Thus, if the predicted L50 sound level is 50 dBA, the predicted L5 will be 53.5 dBA. The L5 represents the loudest 5-percent of an hour (3 minutes of an hour) while the L10 represents the loudest 10% of an hour (6 minutes of an hour). The L10 is therefore always less than or equal to the L5 and if the L5 complies with 55 dBA, the L10 will also comply with 55 dBA. The BPA model does not provide a method to calculate the L1 sound level, but it is not expected that the L1 will exceed the L5 by more than 6 dBA nor the L50 by more than 10 dBA; thus compliance with the L50 of 50 dBA criteria is anticipated to also yield compliance with the L10 criteria of 55 dBA and the L1 criteria of 60 dBA. |
| RAI-4-5 | Section 3.4.5.2, Page X-18 | OAR 340-035-0035(1)(b)(B)(i) | The discussion of Table X-5 and the anticipated 30 NSR noise exceedances references a late-night time period of midnight to 5 AM when exceedances may occur, during foul weather conditions. However, the L50 dBA nighttime noise standard applies between 10 PM and 7 AM. Please explain if the difference in time between the standard and what IPC appears to have | The midnight-5am timeframe appears to have come at the request of ODOE or ODOE's consultant over objections by Idaho Power. If we use the 10pm-7am timeframe instead, Idaho Power would expect that the existing baseline noise levels would be higher because the additional hours would capture more activity such as car noise and other actions that generate noise. |

| Request for Information | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| | | | analyzed result in a different outcome than what is reported in Exh. X. | |
| RAI-4-6 | Section 3.4.5.2, Page X-19 | OAR 340-035-0035(1)(b)(B)(i) | Table X-5 is reported in L50 dBA. However, the noise standard also considers standards for L1 and L10 dBA. Please explain if there is a difference in results from the analysis using L50 and an analysis using L1 or L10. | See response to RAI-4-X-4 above. |
| RAI-4-7 | Figure X-5-X-10 | OAR 345-021-0010(1)(x) | A number of NSRs from Table X-5 do not appear on Figures X-5 to X-10. Specifically these are NSRs: 71, 93, 95, 101, 102, and 104. Please add these to the maps or explain why they are not shown on the maps. | Idaho Power has added NSR-71, -93, -95, -102, -102, and -104 where missing. |

# November 2, 2017 Memorandum from Idaho Power to ODOE Regarding Noise Control Regulation Exception and Variance Requests

**Mark Stokes**
**Idaho Power Company**
**1221 W. Idaho Street**
**Boise, Idaho 83702**
**(208) 388-2483**
**MStokes@idahopower.com**

November 2, 2017

*Via Electronic Mail*

Kellen Tardaewether
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol Street NE, 1st Floor
Salem, Oregon 97301
Kellen.Tardaewether@oregon.gov

Re: Noise Control Regulations and Exhibit X
Boardman to Hemingway Transmission Line Project

Dear Ms. Tardaewether:

In ODOE's October 19, 2017 Requests for Information #4 related to Exhibit X, ODOE included a cover page with general comments discussing the exception and variance processes under the Oregon Department of Environmental Quality's Noise Control Regulations as they relate to the Boardman to Hemingway Transmission Line Project. I am writing in response to that discussion, providing additional information and context for Idaho Power's exception and variance request.

## I. The Requested Exception and Variance Should Apply to the Project as a Whole.

ODOE stated that it "will assess and make recommendations to Council regarding the requested exception and variance on each NSR [noise sensitive receptor] or groupings of NSRs, and will not recommend to Council an exception and/or variance for the proposed facility in its entirety." Idaho Power disagrees with ODOE's statement that Idaho Power must obtain separate exceptions or variances for each NSR expected to exceed the regulatory limits and not for the Project as a whole. The Noise Control Regulations regulate "noise sources" and not NSRs as the basis for compliance or for exceptions and variances. ODOE, on the other hand, appears to be treating each NSR as if it is being affected by separate noise sources. That, however, is not how the

Noise Control Regulations are applied. There is a single noise source here and an exceedance along that single noise source, at any point and regardless of where along that noise source the exceedance appears, prompts the need for either an exception or a variance. And in turn, an exception or variance will apply to the Project as a whole and not just to certain NSR locations. For example, OAR 340-035-0100(1) states that a variance may be granted to "such specific noise source" as necessary, meaning the variance isn't intended to apply at just certain locations or for certain NSR exceedances; it's intended to apply to the entire project. That being so, here, an exception or variance for the Project should be granted to the Project in its entirety and not just for specific NSR locations. This distinction is important, not only for explaining the scope of the exception or variance, but also for framing the context for the exception and variance evaluation, as explained below.

## II. ODOE Should Evaluate the Exception and Variance Requests Separately.

ODOE's comments addressed site-specific conditions surrounding certain NSR exceedances, but the comments did not identify whether that discussion applied to the exception analysis, the variance analysis, or both analyses. Idaho Power requests that ODOE provide a more-detailed response that addresses the exception and variance requests separately and that frames those comments in the context of the specific factors set forth in the exception and variance regulations.

## III. The Foul Weather Events Potentially Causing Exceedances of the Ambient Antidegradation Standard Will Be Infrequent, Justifying an Exception.

OAR 340-035-0035(6) provides that an owner of an industrial noise source—such as B2H—may receive an exception to the regulatory noise levels for "unusual and/or infrequent events." In this instance, Idaho Power shows that, while corona noise from the transmission line may exceed the ambient antidegradation standard at certain NSRs during certain foul weather events, the relevant foul weather events are predicted to occur only 1.3 percent of the time each year. The Noise Control Regulations do not define the term "infrequent" for purposes of the exception. However, the common meaning of that term is "seldom happening or occurring," or "placed or occurring at wide intervals in space or time."[1] Because the potential exceedances are anticipated to occur only 1.3 percent of the time, they certainly should be considered as "seldom happening" and therefore should be considered infrequent events for purposes of the exception. ODOE's comments do not appear to challenge that the exceedances will be "infrequent," and therefore, an exception is warranted.

ODOE states that it "believes that the assessment of an exception/variance should be site-specific and based on local factors and conditions," and "the foul weather conditions vary considerably between the weather stations and regions, and as such, the assessment of an exception request which relies upon infrequent circumstances of the event, will also vary." Here, Idaho Power believes that Exhibit X sufficiently discusses the local weather conditions affecting the NSR exceedance locations. And ODOE's comments do not mention any specific site-specific weather information that is missing from Exhibit X. That being so, again, Exhibit X provides sufficient information justifying an exception.

[1] Merriam-Webster Online Dictionary at https://www.merriam-webster.com/dictionary/infrequent.

To the extent ODOE suggests that in order to receive an exception Idaho Power must show that avoiding the exceedance NSRs is impossible, OAR 340-035-0035(6) does not require such a showing. Rather, that provision only requires a showing that the exceedance is due to an unusual or infrequent event. And in this case, Exhibit X clearly makes that showing, where the foul weather events that potentially will cause an exceedance are predicted to occur only 1.3 percent of the time. While ODOE's basis for its alternative routing analysis requirement is unclear from its October 19 comments, to the extent ODOE is relying on OAR 340-035-0035(6), ODOE should provide a more-detailed explanation of how it interpreted that rule as requiring an alternatives analysis.

If ODOE is relying on OAR 340-035-0010(2) and not OAR 340-035-0035(6), it must be clarified that the factors set forth in that subsection do not expressly include any alternative siting analysis. If ODOE is relying on OAR 340-035-0010(2), ODOE should explain in more detail how it determined that that provision contemplates an alternative siting analysis.

Additionally, and perhaps more importantly, OAR 340-035-0010(2) provides that the listed factors only need be "considered." OAR 340-035-0010(2) does not state that the factors are "requirements." ODOE should explain how an alternative siting analysis is a requirement and not just a consideration under OAR 340-035-0010(2). Also, to the extent ODOE is relying on OAR 340-035-0010(2), ODOE must consider each of the factors listed in that subsection and not just its alternative siting analysis. When all the factors are considered, the totality of the circumstances (even if ODOE's alternative siting analysis is taken into consideration) weighs heavily in favor of an exception, given that there are relatively few affected NSRs given the size of the Project (nearly 300-miles long), that the few affected NSRs are expected to experience exceedances only 1.3 percent of the time and then only during foul weather events when the occupants are likely to be inside buildings where the sound will be buffered, that Idaho Power is offering to fund window treatments to further buffer the sound inside the affected NSR buildings, that there were numerous competing siting constraints that drove the location of the Project, and that the quantity of noise generated is still expected in all instances to be below the 50 dBA maximum permissible limit. Finally, ODOE's analysis under OAR 340-035-0010(2) should consider the fact that the State of Oregon has defunded the noise program and the Oregon Department of Environmental Quality—the agency charged with administering and enforcing the Noise Control Regulations—has by rule suspended administration of the noise program:

> In 1991, the Legislative Assembly withdrew all funding for implementing and administering ORS Chapter 467 and the Department's noise program. Accordingly, the Commission and the Department have suspended administration of the noise program, including but not limited to processing requests for exceptions and variances, reviewing plans, issuing certifications, forming advisory committees, and responding to complaints. Similarly, the public's obligations to submit plans or certifications to the Department are suspended.

OAR 340-035-0110. While Idaho Power understands ODOE believes it must still consider the Noise Control Regulations because of EFSC's rules, ODOE's analysis under OAR 340-035-0010(2) should recognize that the Legislative Assembly and ODEQ no long fund or implement the noise program, suggesting that they do not view the Noise Control Regulations—let alone strict compliance with the ambient antidegradation standard—as being critical to "health, safety, and welfare of Oregon citizens" under OAR 340-035-0010(2). For all of the above reasons, Exhibit X provides sufficient information justifying an exception.

## IV. A Variance Requires a Showing of Special Considerations Making Compliance Unreasonable or Special Physical Conditions Making Compliance Impractical; There Is No Impossibility Test.

ODOE states that, in order to get a variance, Idaho Power must show that "avoiding the NSR exceedance is in fact not possible." Idaho Power disagrees with ODOE's interpretation of the rule. First, the relevant thresholds under OAR 340-035-0100(1) are whether strict compliance is "unreasonable" or "impractical," both of which thresholds are lower than ODOE's "impossible" threshold. Second, there is no siting-avoidance test under OAR 340-035-0100(1). Instead, that provision requires only that the person seeking a variance show it is unreasonable or impractical for the noise source to strictly comply with the noise rules, given special considerations or special physical conditions. OAR 340-035-0100(1) states that a variance is warranted if strict compliance is inappropriate "because of special circumstances which render strict compliance unreasonable, or impractical due to special physical conditions or cause . . . ." OAR 340-035-0100(1). Here, the foul weather events are the "special circumstances" or "special physical conditions" affecting strict compliance. The foul weather events are special because they will occur only infrequently and they uniquely cause corona noise on transmission lines (and not on most, if any, other facilities). The foul weather events render strict compliance unreasonable or impractical because Idaho Power cannot control those foul weather events, the cause of the non-compliance. The focus of the variance analysis is on the reasonableness or practicality of Project's ability to comply with the noise rules, given the special weather events. In this case, it's not reasonable or practical to expect the Project to meet the antidegradation standard, given that the certain foul weather events are expected to occur (if only infrequently) and Idaho Power cannot control the weather.

## V. Conclusion

Idaho Power appreciates ODOE's comments on Exhibit X of the June 2017 Amended Preliminary Application for Site Certificate. Idaho Power believes the additional information and explanation provided in this correspondence confirms that the Project warrants an exception, variance, or both to account for the projected exceedances of the ambient antidegradation standard caused by certain infrequent foul weather events. If you have any additional comments or questions regarding these issues, please do not hesitate to call or write.

Sincerely,

Mark Stokes
Engineering Project Leader

cc: Max Woods, Maxwell.Woods@oregon.gov

# May 26, 1982 Bonneville Power Administration Memorandum on Sound Level Limits for BPA Facilities

UNITED STATES GOVERNMENT
# Memorandum

Date : MAY 26 1982

Reply refer to : EOH

TO : Marvin Klinger, Assistant Administrator
for Engineering and Construction - E

FROM : Dean Perry, Director
Division of System Engineering - EO

Dean E. Perry

SUBJECT Sound Level Limits for BPA Facilities

The Noise Control Act of 1972 gave the States the responsibility for noise control. Executive Order No. 12088 requires that all Federal agencies comply with these State and local noise control regulations.

Noise control regulations differ greatly from state to state. Even cities and counties can enact noise control regulations. This means that a single transmission line may be under several different regulations along its length.

Noise regulations are also subject to change. These changes rarely include provisions for "grandfathering" existing facilities. Existing facilities can be forced into violation by the regulation change or the development of noise-sensitive property adjacent to the facility.

Therefore, in 1978, BPA established the Interim Sound Level Limits for Transmission Lines (Schaufelberger to Gens, 3/30/78) to provide guidelines until interpretations of State regulations, as they apply to BPA facilities, could be made.

Based on the results of our review and the interpretations reached with the Oregon State Department of Environmental Quality and the Washington State Department of Ecology, we recommend the following, in lieu of the Interim Sound Level Limits established in 1978:

<u>Lands Controlled by State or Local Noise Regulations</u>

BPA will meet State and local noise control regulations.

It is BPA's interpretation that a frequency of occurrence of less than 1 percent will qualify as an exception to the regulations. For a-c transmission lines located in areas where a rain rate from 0.8 to 5mm/hr will occur less than 1 percent of the time during the year, audible noise from the line will be an infrequent event and thus be considered as an exception from noise regulations. Based on a meteorological analysis of the frequency of these rain rates (0.8 - 5mm/hr), a-c transmission lines east of the Cascades will meet this criteria.

In all other areas of the system, new, rebuilt or uprated transmission lines shall be designed to meet an $L_{50}$ level of 50 dB(A) at the edge of the right-of-way. This level shall be determined within a ± 2 dB(A) tolerance at 98 percent of maximum system voltage and a rain rate of 1mm/hr.

Other new BPA facilities, and the additions to existing facilities, shall be designed to comply with state and local noise control regulations in force at the location. Transformer noise shall be evaluated at 100 percent rated voltage, with all cooling in service.

* With regard to existing facilities, BPA will continue to follow the procedures for handling noise-related complaints associated with BPA facilities as approved by the Administrator on July 7, 1978 (Memorandum from R. S. Gens and J. N. O'Neal to Sterling Munro, dated July 3, 1978). No program level effort is required until after receiving a validated complaint or notice of violation.

<u>Lands Not Controlled by State or Local Noise Regulations and Lands without Noise Sensitive Property</u>

In locations not controlled by State or local noise regulations, or where noise-sensitive property cannot be developed, the design noise levels will consider EPA guidelines, latest psychoacoustic research, probability of exposure and sound engineering economic practice.

When compliance with the above is not reasonable for design of a new facility, alternatives may be investigated with the approval of the Assistant Administrator for Engineering and Construction.

2 Attachments:
Memo dated July 3, 1978
Additional Interpretations of State Regulations

APPROVED: McClinzen

DATE: 6/1/82

* The procedures discussed in the July 7, 1978 memorandum have been incorporated into the Noise Control procedures, section 954.8.

# North Steens Transmission Line Project, Final EIS, Appendix C (October 2011)

APPENDIX C

# North Steens EMF Report

# ***NORTH STEENS TRANSMISSION LINE PROJECT***

# *APPENDIX C*

# *ELECTRICAL EFFECTS*

FEBRUARY 2010

DRAFT

**Prepared by**

**T. Dan Bracken, Inc.**

**For the**

**Bonneville Power Administration**

**And**

**ENTRIX**

# Table of Contents

# List of Tables



# List of Figures

# ELECTRICAL EFFECTS FROM THE NORTH STEENS TRANSMISSION LINE PROJECT

## 1.0 Introduction

The Echanis Wind Energy Project is proposing to build an approximately 12-mile (mi.) (19.3-kilometer [km]) 230-kilovolt (kV) double-circuit transmission line in Harney County, Oregon from the proposed Echanis Wind Energy Project substation to an interconnection station adjacent to an existing Harney Electric Cooperative 115-kV transmission line. The proposed line is designated the North Steens transmission line. It would be built on new right-of-way entirely within the state of Oregon. Initially the line would be operated at 115-kV. Successive phases of the project would see one side of the line energized at 230 kV and then the other.

The purpose of this report is to describe and quantify the electrical effects of all potential phases of the proposed North Steens transmission line project. These effects include the following:

- the levels of 60-hertz (Hz; cycles per second) electric and magnetic fields (EMF) at 3.28 feet (ft.) or 1 meter (m) above the ground,
- the effects associated with those fields,
- the levels of audible noise produced by the line, and
- electromagnetic interference associated with the line.

Electrical effects occur near all transmission lines, including existing 115- and 230-kV lines in Oregon. Levels of these quantities for the proposed line are computed and compared with those from existing lines in Oregon.

The line would be constructed on double-circuit steel-pole towers. Initially, a single circuit (three conductors) will be installed on one side of the tower (Phase I). Future plans call for a second line operating at 230 kV to placed on the other side of the tower (Phase II). Finally, the Phase I 115-kV line could be upgraded to 230-kV operation (Phase III). Implementation of Phases II and III would be contingent on the upgrade of existing transmission lines in the area to 230-kV operation.

Two alternative routes are being considered for the proposed line – the West Route and the North Route. Both of these routes would entail construction on new right-of-way with no existing parallel high-voltage transmission lines. For the purposes of assessing electrical effects, both routing alternatives are equivalent, since the line design and operating characteristics would be the same for both. Thus, the three configurations of interest for this report are the proposed line design with the operational characteristics of Phases I, II and III. There are no electrical effects associated with the no-action (no-build) alternative that can be compared with the action of constructing the proposed transmission line.

The voltage on the conductors of transmission lines generates an *electric field* in the space between the conductors and the ground. The electric field is calculated or measured in units of volts-per-meter (V/m) or kilovolts-per-meter (kV/m) at a height of 3.28 ft. (1 m) above the ground. The electric current flowing in the conductors of the transmission line generates a *magnetic field* in the air and earth near the transmission line; current is expressed in units of amperes (A). The magnetic field is expressed in milligauss (mG), and is also usually measured or calculated at a height of 3.28 ft. (1 m) above the ground. The relatively high electric field at the surface of the conductors causes the phenomenon of *corona*.

Corona is the electrical breakdown or ionization of air in very strong electric fields, and is the source of audible noise, electromagnetic radiation, and sometimes visible light.

To quantify EMF levels along the route, the electric and magnetic fields from the proposed transmission line were calculated using the BPA Corona and Field Effects Program (USDOE, undated). In this program, the calculation of 60-Hz fields uses standard superposition techniques for vector fields from several line sources: in this case, the line sources are transmission-line conductors. (Vector fields have both magnitude and direction: these must be taken into account when combining fields from different sources.) Important input parameters to the computer program are voltage, current, and geometric configuration of the line. The transmission-line conductors are assumed to be straight, parallel to each other, and located above and parallel to an infinite flat ground plane. Although such conditions do not occur under real lines because of conductor sag and variable terrain, the validity and limitations of calculations using these assumptions have been well verified by comparisons with measurements. This approach was used to estimate fields for the proposed North Steens line, where minimum clearances were assumed to provide worst-case (highest) estimates for the fields.

Electric fields are calculated using an imaging method. Fields from the conductors and their images in the ground plane are superimposed with the proper magnitude and phase to produce the total field at a selected location.

The total magnetic field is calculated from the vector summation of the fields from currents in all the transmission-line conductors. Balanced (equal) currents are assumed for each three-phase circuit; the contribution of induced image currents in the conductive earth is not included. Estimates of peak and average currents were estimated by the Echanis Wind Energy Project engineering team for years when the various phases of the project would be operational.

Electric and magnetic fields for the proposed line were calculated at the standard height (3.28 ft. or 1 m) above the ground (IEEE, 1994). Calculations were performed out to 300 ft. (91 m) from the centerline of the existing corridor. The validity and limitations of such calculations have been well verified by measurements. Because maximum voltage, maximum current, and minimum conductor height above-ground are used, **the calculated maximum or peak values given here represent worst-case conditions:** i.e., the calculated fields are higher than they would be in practice. Such worst-case conditions would seldom occur. Fields were also calculated for more typical or average conditions of average clearance along a span, average voltage and average current to characterized the fields expected along the entire line over a year.

The corona performance of the proposed line was also predicted using the BPA Corona and Field Effects Program (USDOE, undated). Corona performance is calculated using empirical equations that have been developed over several years from the results of measurements on numerous high-voltage lines (Chartier and Stearns, 1981; Chartier, 1983). The validity of this approach for corona-generated audible noise has been demonstrated through comparisons with measurements on other lines all over the United States (IEEE Committee Report, 1982). The accuracy of this method for predicting corona-generated radio and television interference from transmission lines has also been established (Olsen et al., 1992). Important input parameters to the computer program are voltage, current, conductor size, and geometric configuration of the line.

Corona is a highly variable phenomenon that depends on conditions along a length of line. Predictions of the levels of corona effects are reported in statistical terms to account for this variability. Calculations of audible noise and electromagnetic interference levels were made under conditions of an estimated average operating voltages of 121.7 and 241.5 kV and with the average line height along a span of 38.4 ft. (11.7 m).

Levels of audible noise, radio interference, and television interference are predicted for both fair and foul weather; however, corona is basically a foul-weather phenomenon. Wet conductors can occur during periods of rain, fog, snow, or icing. In the Harney County area of the proposed route, such conditions are expected to occur about 7% of the time during a year based on hourly precipitation records from Burns, Oregon during 2006 – 2008 (NOAA, 2010). Corona activity also increases with altitude. For purposes of evaluating corona effects from the proposed line, an altitude of 4500 ft. (1370 m) was assumed based on discussions with members of the project engineering team.

Both of the proposed alternative routes will traverse arid pasture and range land that is sparsely populated. With the exception of five residences along the North Route, all residences will be greater than 550 feet (170 m) from the line. The closest residences along the North Route are 75, 200, and 400 feet (23, 60, and 122 m) from the line, with three houses at the 200-foot distance.

# 2.0 Physical Description

## 2.1 Proposed Line

Initially, the proposed transmission line would be a three-phase, single-circuit line placed on mostly tubular steel double-circuit structures (Figure 1). At some locations where the line(s) change direction, the conductors for each line would be placed on separate single poles (Figure 2). The field and corona effects at these points would be very similar to those near the double circuit towers. Only the effects from the double circuit tower configurations are presented here.

The double-circuit towers would have two sets of three phases arranged vertically on either side of the structure. Each set of phase wires comprises a circuit. Voltage and current waves are displaced by 120° in time (one-third of a cycle) on each electrical phase. The maximum phase-to-phase voltage would be 121.7 kV for the 115-kV circuit and 241.5 for the 230-kV circuits. These maximum values were also assumed to be the average voltages, since estimates of the average voltage were not available.

Initially the single 115-kV line would carry the electrical output load from Phase I of the project. The peak load for this condition would be 104 megawatts (MW), corresponding to 500 A for 115-kV operation. The Phase II 230-kV line would carry a projected peak load of 416 MW from future expansion of the Echanis Wind Energy Project. This load would correspond to a peak current of 1000 A for 230-kV operation. Upgrading the initial 115-kV circuit to 230-kV (Phase III) would decrease the peak current on that circuit to 261 A.

The projected load factor for the North Steens Transmission Line Project is 0.35 (average load = peak load x load factor). Thus, the average currents on each circuit would be 35 percent of the maximum values. The Echanis engineering team provided the physical and operating characteristics of the proposed line.

The physical dimensions for the proposed double circuit line configuration are shown in Figure 2, and summarized in Table 2. The electrical characteristics of the 115-kV and 230-kV lines in Phases I, II and III are shown in Table 3. Each phase of the proposed lines would have one 1.545-inch (in.) (3.9-centimeter [cm]) diameter conductor.

The horizontal spacing between conductors of the two circuits would be 24.0 ft. (7.3 m). The vertical spacing between the conductor positions would be 16.0 ft. (4.9 m). The spacing between conductor locations would vary slightly where special towers are used, such as at angle points along the line. Short sections of the proposed line where conductor locations would change, such as upon entry to a interconnection station or substation, were not analyzed.

Minimum conductor-to-ground clearance would be 32.25 ft. (9.8 m) at a conductor temperature of 50°C; clearances above ground could be greater under normal operating temperatures. The average clearance above ground along a span would be approximately 38.5 ft. (11.7 m); this value was used for average field and corona calculations. At road crossings, the ground clearance would be at least 32.25 ft. (9.8 m). The final design of the proposed line could entail larger clearances. The right-of-way width for the proposed line would be 150 ft. (45.7 m).

The results reported here for fields and corona effects assume that the electrical phasing of the two circuits would be such as to place different electrical phases on the lower conductors of the two circuits as well as on the upper conductors of each circuit. This phasing configuration tends to minimize the electric and magnetic fields at ground level.

### 2.2 Existing Lines

The proposed 230-kV line would be built on new right-of-way. There are no existing transmission lines parallel to the proposed routes. Consequently, no existing transmission lines are included in the analysis of electrical effects.

## 3.0 Electric Field

### 3.1 Basic Concepts

An electric field is said to exist in a region of space if an electrical charge, at rest in that space, experiences a force of electrical origin (i.e., electric fields cause free charges to move). Electric field is a vector quantity: that is, it has both magnitude and direction. The direction corresponds to the direction that a positive charge would move in the field. Sources of electric fields are unbalanced electrical charges (positive or negative) and time-varying magnetic fields. Transmission lines, distribution lines, house wiring, and appliances generate electric fields in their vicinity because of unbalanced electrical charge on energized conductors. The unbalanced charge is associated with the voltage on the energized system. On the power system in North America, the voltage and charge on the energized conductors are cyclic (plus to minus to plus) at a rate of 60 times per second. This changing voltage results in electric fields near sources that are also time-varying at a frequency of 60 hertz (Hz; a frequency unit equivalent to cycles per second).

As noted earlier, electric fields are expressed in units of volts per meter (V/m) or kilovolts (thousands of volts) per meter (kV/m). Electric- and magnetic-field magnitudes in this report are expressed in root-mean-square (rms) units. For sinusoidal waves, the rms amplitude is given as the peak amplitude divided by the square root of two.

The spatial uniformity of an electric field depends on the source of the field and the distance from that source. On the ground, under a transmission line, the electric field is nearly constant in magnitude and direction over distances of several feet (1 meter). However, close to transmission- or distribution-line conductors, the field decreases rapidly with distance from the conductors. Similarly, near small sources such as appliances, the field is not uniform and falls off even more rapidly with distance from the device. If an energized conductor (source) is inside a grounded conducting enclosure, then the electric field outside the enclosure is zero, and the source is said to be shielded.

Electric fields interact with the charges in all matter, including living systems. When a conducting object, such as a vehicle or person, is located in a time-varying electric field near a transmission line, the external electric field exerts forces on the charges in the object, and electric fields and currents are induced in the object. If the object is grounded, then the total current induced in the body (the "short-circuit current") flows to earth. The distribution of the currents within, say, the human body, depends on the electrical conductivities of various parts of the body: for example, muscle and blood have higher conductivity than bone and would therefore experience higher currents.

At the boundary surface between air and the conducting object, the field both in the air and perpendicular to the conductor surface is much, much larger than the field in the conductor itself. For example, the average surface field on a human standing in a 10 kV/m field is 27 kV/m; the internal fields in the body are much smaller: approximately 0.008 V/m in the torso and 0.45 V/m in the ankles.

## 3.2 Transmission-line Electric Fields

The electric field created by a high-voltage transmission line extends from the energized conductors to other conducting objects such as the ground, towers, vegetation, buildings, vehicles, and people. The calculated strength of the electric field at a height of 3.28 ft. (1 m) above an unvegetated, flat earth is frequently used to describe the electric field under straight, parallel transmission lines. The most important transmission-line parameters that determine the electric field at a 1-m height are conductor height above ground and line voltage.

Calculations of electric fields from transmission lines are performed with computer programs based on well-known physical principles (cf., Deno and Zaffanella, 1982). The calculated values under these conditions represent an ideal situation. When practical conditions approach this ideal model, measurements and calculations agree. Often, however, conditions are far from ideal because of variable terrain and vegetation. In these cases, fields are calculated for ideal conditions, with the lowest conductor clearances to provide upper bounds on the electric field under the transmission lines. With the use of more complex models or empirical results, it is also possible to account accurately for variations in conductor height, topography, and changes in line direction. Because the fields from different sources add vectorially, it is possible to compute the fields from several different lines if the electrical and geometrical properties of the lines are known. However, in general, electric fields near transmission lines with vegetation below are highly complex and cannot be calculated. Measured fields in such situations are highly variable.

For evaluation of EMF from transmission lines, the fields must be calculated for a specific line condition. The NESC states the condition for evaluating electric-field-induced short-circuit current for lines with voltage above 98 kV, line-to-ground, as follows: conductors are at a minimum clearance from ground corresponding to a conductor temperature of 122°F (50°C), and at a maximum voltage (IEEE, 2002). Echanis has supplied the information for calculating electric and magnetic fields from the proposed transmission line: the maximum operating voltage, the estimated peak currents, and the minimum conductor clearances.

There are standard techniques for measuring transmission-line electric fields (IEEE, 1994). Provided that the conditions at a measurement site closely approximate those of the ideal situation assumed for calculations, measurements of electric fields agree well with the calculated values. If the ideal conditions are not approximated, the measured field can differ substantially from calculated values. Usually the actual electric field at ground level is reduced from the calculated values by various common objects that act as shields.

Maximum or peak field values occur over a small area at midspan, where conductors are closest to the ground. As the location of an electric-field profile approaches a tower, the conductor clearance increases, and the peak field decreases. A grounded tower will reduce the electric field considerably, by shielding.

For traditional transmission lines, such as the proposed line, where the right-of-way extends laterally well beyond the conductors, electric fields at the edge of the right-of-way are not as sensitive as the peak field to conductor height. Computed values at the edge of the right-of-way for any line height are fairly representative of what can be expected all along the transmission-line corridor. However, the presence of vegetation on and at the edge of the right-of-way will reduce actual electric-field levels below calculated values.

## 3.3 Calculated Values of Electric Fields

Table 2 shows the calculated maximum and average values of electric field at 3.28 ft. (1 m) above ground for the proposed North Steens transmission lines operated at maximum voltages. The peak value on the right-of-way and the value at the edge of the right-of-way are given for the proposed lines at minimum conductor clearance and at the estimated average clearance over a span. Figure 2 shows lateral profiles for the electric field from the proposed line at the minimum (32.25 ft.) and average (38.4 ft.) line heights.

The calculated peak electric field expected on the right-of-way of the proposed Phase I line is 1.3 kV/m. During Phases II and III, the peak electric fields on the right-of-way will increase to 2.1 and 1.8 kV/m, respectively. For average clearance, the peak field for Phase I would be 1.0 kV/m and for Phases II and III it would be 1.5 kV/m or less. As shown in Figure 2, the peak values would be present only at locations directly under the line, near mid-span, where the conductors are at the minimum clearance. The conditions of minimum conductor clearance at maximum current and maximum voltage occur very infrequently. The calculated peak levels are rarely reached under real-life conditions, because the actual line height is generally above the minimum value used in the computer model, because the actual voltage is below the maximum value used in the model, and because vegetation within and near the edge of the right-of-way tends to shield the field at ground level. Maximum electric fields on existing 230-kV corridors are typically 2.5 to 3 kV/m. On 500-kV transmission line corridors, the maximum electric fields range from 7 to 9 kV/m.

The largest value expected at the edge of the right-of-way with 230-kV operation would be about 0.1 kV/m, occurring for average conductor heights. Fields with the edge of the right-of-way adjacent to a 115-kV line (Phases I and II) are less than this as shown in Table 2 and Figure 2.

## 3.4 Environmental Electric Fields

The electric fields associated with the North Steens transmission line can be compared with those found in other environments. Sources of 60-Hz electric (and magnetic) fields exist everywhere electricity is used; levels of these fields in the modern environment vary over a wide range. Electric-field levels associated with the use of electrical energy are orders of magnitude greater than naturally occurring 60-Hz fields of about 0.0001 V/m, which stem from atmospheric and extraterrestrial sources.

Electric fields in outdoor, publicly accessible places range from less than 1 V/m to 12 kV/m; the large fields exist close to high-voltage transmission lines of 230 kV or higher. In remote areas without electrical service, 60-Hz field levels can be much lower than 1 V/m. Electric fields in home and work environments generally are not spatially uniform like those of transmission lines; therefore, care must be taken when making comparisons between fields from different sources such as appliances and electric lines. In addition, fields from all sources can be strongly modified by the presence of conducting objects. However, it is helpful to know the levels of electric fields generated in domestic and office environments in order to compare commonly experienced field levels with those near transmission lines.

Numerous measurements of residential electric fields have been reported for various parts of the United States, Canada, and Europe. Although there have been no large studies of residential electric fields, sufficient data are available to indicate field levels and characteristics. Measurements of domestic 60-Hz electric fields indicate that levels are highly variable and source-dependent. Electric-field levels are not easily predicted because walls and other objects act as shields, because conducting objects perturb the field, and because homes contain numerous localized sources. Internal sources (wiring, fixtures, and appliances) seem to predominate in producing electric fields inside houses. Average measured electric fields in residences are generally in the range of 5 to 20 V/m. In a large occupational exposure monitoring project that included electric-field measurements at homes, average exposures for all groups away from work were generally less than 10 V/m (Bracken, 1990).

Electric fields from household appliances are localized and decrease rapidly with distance from the source. Local electric fields measured at 1 ft. (0.3 m) from small household appliances are typically in the range of 30 to 60 V/m. In a survey, reported by Deno and Zaffanella (1982), field measurements at a 1-ft. (0.3-m) distance from common domestic and workshop sources were found to range from 3 to 70 V/m. The localized fields from appliances are not uniform, and care should be taken in comparing them with transmission-line fields.

Electric blankets can generate higher localized electric fields. Sheppard and Eisenbud (1977) reported fields of 250 V/m at a distance of approximately 1 ft. (0.3 m). Florig et al. (1987) carried out extensive empirical and theoretical analysis of electric-field exposure from electric blankets and presented results in terms of uniform equivalent fields such as those near transmission lines. Depending on what parameter was chosen to represent intensity of exposure and the grounding status of the subject, the equivalent vertical 60-Hz electric-field exposure ranged from 20 to over 3500 V/m. The largest equivalent field corresponds to the measured field on the chest with the blanket-user grounded. The average field on the chest of an ungrounded blanket-user yields an equivalent vertical field of 960 V/m. As manufacturers have become aware of the controversy surrounding EMF exposures, electric blankets have been redesigned to reduce *magnetic* fields. However, electric fields from these “low field” blankets are still comparable with those from older designs (Bassen et al., 1991).

Generally, people in occupations not directly related to high-voltage equipment are exposed to electric fields comparable with those of residential exposures. For example, the average electric field measured in 14 commercial and retail locations in rural Wisconsin and Michigan was 4.8 V/m (ITT Research Institute, 1984). Median electric field was about 3.4 V/m. These values are about one-third the values in residences reported in the same study. Electric-field levels in public buildings such as shops, offices, and malls appear to be comparable with levels in residences.

In a survey of 1,882 volunteers from utilities, electric-field exposures were measured for 2,082 work days and 657 non-work days (Bracken, 1990). Electric-field exposures for occupations other than those directly related to high-voltage equipment were equivalent to those for non-work exposure.

Thus, except for the relatively few occupations where high-voltage sources are prevalent, electric fields encountered in the workplace are probably similar to those of residential exposures. Even in electric-utility occupations where high field sources are present, exposures to high fields are limited on average to minutes per day.

Electric fields found in publicly accessible areas near high-voltage transmission lines can typically range up to 3 kV/m for 230-kV lines, to 10 kV/m for 500-kV lines, and to 12 kV/m for 765-kV lines. Although these peak levels are considerably higher than the levels found in other public areas, they are present only in limited areas on rights-of-way.

The calculated electric fields for the proposed North Steens transmission line are consistent with the levels reported for other 230-kV transmission lines in Oregon, Washington, and elsewhere. The calculated electric fields on the right-of-way of the proposed transmission line are generally much higher than levels normally encountered in residences and offices.

# 4.0 Magnetic Field

## 4.1 Basic Concepts

Magnetic fields can be characterized by the force they exert on a moving charge or on an electrical current. As with the electric field, the magnetic field is a vector quantity characterized by both magnitude and direction. Electrical currents generate magnetic fields. In the case of transmission lines, distribution lines, house wiring, and appliances, the 60-Hz electric current flowing in the conductors generates a time-varying, 60-Hz magnetic field in the vicinity of these sources. The strength of a magnetic field is measured in terms of magnetic lines of force per unit area, or magnetic flux density. The term “magnetic field,” as used here, is synonymous with magnetic flux density and is expressed in units of Gauss (G) or milligauss (mG).

The uniformity of a magnetic field depends on the nature and proximity of the source, just as the uniformity of an electric field does. Transmission-line-generated magnetic fields are quite uniform over horizontal and vertical distances of several feet near the ground. However, for small sources such as appliances, the magnetic field decreases rapidly over distances comparable with the size of the device.

The interaction of a time-varying magnetic field with conducting objects results in induced electric field and currents in the object. A changing magnetic field through an area generates a voltage around any conducting loop enclosing the area (Faraday's law). This is the physical basis for the operation of an electrical transformer. For a time-varying sinusoidal magnetic field, the magnitude of the induced voltage around the loop is proportional to the area of the loop, the frequency of the field, and the magnitude of the field. The induced voltage around the loop results in an induced electric field and current flow in the loop material. The induced current that flows in the loop depends on the conductivity of the loop.

## 4.2 Transmission-line Magnetic Fields

The magnetic field generated by currents on transmission-line conductors extends from the conductors through the air and into the ground. The magnitude of the field at a height of 3.28 ft. (1 m) is frequently used to describe the magnetic field under transmission lines. Because the magnetic field is not affected by non-ferrous materials, the field is not influenced by normal objects on the ground under the line. The direction of the maximum field varies with location. (The electric field, by contrast, is essentially vertical near the ground.) The most important transmission-line parameters that determine the magnetic field at

3.28 ft. (1 m) height are conductor height above ground and magnitude of the currents flowing in the conductors. As distance from the transmission-line conductors increases, the magnetic field decreases.

Calculations of magnetic fields from transmission lines are performed using well-known physical principles (cf., Deno and Zaffanella, 1982). The calculated values usually represent the ideal straight parallel-conductor configuration. For simplicity, a flat earth is usually assumed. Balanced currents (currents of the same magnitude for each phase) are also assumed. This is usually valid for transmission lines, where loads on all three phases are maintained in balance during operation. Induced image currents in the earth are usually ignored for calculations of magnetic field under or near the right-of-way. The resulting error is negligible. Only at distances greater than 300 ft. (91 m) from a line do such contributions become significant (Deno and Zaffanella, 1982). The clearance for magnetic-field calculations for the proposed line was the same as that used for electric-field evaluations.

Standard techniques for measuring magnetic fields near transmission lines are described in ANSI IEEE Standard No. 644-1994 (IEEE, 1994). Measured magnetic fields agree well with calculated values, provided the currents and line heights that go into the calculation correspond to the actual values for the line. To realize such agreement, it is necessary to get accurate current readings during field measurements (because currents on transmission lines can vary considerably over short periods of time) and also to account for all field sources in the vicinity of the measurements.

As with electric fields, the maximum or peak magnetic fields occur in areas near the centerline and at midspan where the conductors are the lowest. The magnetic field at the edge of the right-of-way is not very dependent on line height. For a double-circuit line or if more than one line is present, the peak field will depend on the relative electrical phasing of the conductors and the direction of power flow.

## 4.3 Calculated Values for Magnetic Fields

Table 3 gives the calculated values of the magnetic field at 3.28 ft. (1 m) height for the proposed North Steens transmission line. Field values on the right-of-way and at the edge of the right-of-way are given for projected maximum currents, for minimum and average conductor clearances. The maximum and average currents for the three phases of the North Steens line are given in Table 1, along with the phasing of the two circuits.

The actual magnetic-field levels would vary, as currents on the lines change daily and seasonally and as ambient temperature changes. Average currents over the year would be about 35% of the maximum values. The maximum levels shown in the figures represent the highest magnetic fields expected for the proposed North Steens line. Average fields over a year would be considerably reduced from the peak values, as a result of reduced average currents and increased clearances above the minimum value.

Figure 3 shows lateral profiles of the magnetic field under maximum current and minimum clearance conditions for the three phases of the proposed transmission line. A field profile for average height under average current conditions is also included in Figure 3.

For the proposed line during Phase I, the maximum calculated magnetic field on the right-of-way is 52 mG for the maximum current of 500 A and a minimum conductor height of 32.25 ft. (9.8 m). The maximum field would decrease for increased conductor clearance. For the average conductor height of 38.4 ft. (11.7 m), the maximum field would be 14 mG. During Phases II the maximum field would be 93 mG and during Phase III, 97 mG.

For maximum current and minimum clearance conditions during Phase I, the calculated magnetic fields at the edges of the 150-foot (45.7-m) right-of-way are 15 and 9 mG for the west and east sides of the right-of-way, respectively. For average current and conductor height during Phase I the fields at the edge of the right-of-way are 5 mG on the west side of the line and 3 mG on the east side. Under average conditions, the edge-of-right-of-way values during Phase II would be 2 and 7 mG, while during Phase III the values would be 4 and 8 mG.

### 4.4 Environmental Magnetic Fields

Transmission lines are not the only source of magnetic fields; as with 60-Hz electric fields, 60-Hz magnetic fields are present throughout the environment of a society that relies on electricity as a principal energy source. The magnetic fields associated with the proposed North Steens line can be compared with fields from other sources. The range of 60-Hz magnetic-field exposures in publicly accessible locations such as open spaces, transmission-line rights-of-way, streets, pedestrian walkways, parks, shopping malls, parking lots, shops, hotels, public transportation, and so on range from less than 0.1 mG to about 1 G, with the highest values occurring near small appliances with electric motors. In occupational settings in electric utilities, where high currents are present, magnetic-field exposures for workers can be above 1 G. At 60 Hz, the magnitude of the natural magnetic field is approximately 0.0005 mG.

Several investigations of residential fields have been conducted. In a large study to identify and quantify significant sources of 60-Hz magnetic fields in residences, measurements were made in 996 houses, randomly selected throughout the country (Zaffanella, 1993). The most common sources of residential fields were power lines, the grounding system of residences, and appliances. Field levels were characterized by both point-in-time (spot) measurements and 24-hour measurements. Spot measurements averaged over all rooms in a house exceeded 0.6 mG in 50 percent of the houses and 2.9 mG in 5 percent of houses. Power lines generally produced the largest average fields in a house over a 24-hour period. On the other hand, grounding system currents proved to be a more significant source of the highest fields in a house. Appliances were found to produce the highest local fields; however, fields fell off rapidly with increased distance. For example, the median field near microwave ovens was 36.9 mG at a distance of 10.5 in. (0.27 m) and 2.1 mG at 46 in. (1.17 m). Across the entire sample of 996 houses, higher magnetic fields were found in, among others, urban areas (vs. rural); multi-unit dwellings (vs. single-family); old houses (vs. new); and houses with grounding to a municipal water system.

In an extensive measurement project to characterize the magnetic-field exposure of the general population, over 1000 randomly selected persons in the United States wore a personal exposure meter for 24 hours and recorded their location in a simple diary (Zaffanella and Kalton, 1998). Based on the measurements of 853 persons, the estimated 24-hour average exposure for the general population is 1.24 mG and the estimated median exposure is 0.88 mG. The average field “at home, not in bed” is 1.27 mG and “at home, in bed” is 1.11 mG. Average personal exposures were found to be highest “at work” (mean of 1.79 mG and median of 1.01 mG) and lowest “at home, in bed” (mean of 1.11 mG and median of 0.49 mG). Average fields in school were also low (mean of 0.88 mG and median of 0.69 mG). Factors associated with higher exposures at home were smaller residences, duplexes and apartments, metallic rather than plastic water pipes, and nearby overhead distribution lines.

As noted above, magnetic fields from appliances are localized and decrease rapidly with distance from the source. Localized 60-Hz magnetic fields have been measured near about 100 household appliances such as ranges, refrigerators, electric drills, food mixers, and shavers (Gauger, 1985). At a distance of 1 ft. (0.3 m), the maximum magnetic field ranged from 0.3 to 270 mG, with 95% of the measurements below 100 mG. Ninety-five percent of the levels at a distance of 4.9 ft. (1.5 m) were less than 1 mG. Devices that use light-weight, high-torque motors with little magnetic shielding exhibited the largest fields. These included vacuum cleaners and small hand-held appliances and tools. Microwave ovens with large power transformers also exhibited relatively large fields. Electric blankets have been a much-studied source of magnetic-field exposure because of the length of time they are used and because of the close proximity to the body. Florig and Hoburg (1988) estimated that the average magnetic field in a person using an electric blanket was 15 mG, and that the maximum field could be 100 mG. "Low-field" blankets introduced in the 1990s have magnetic fields at least 10 times lower than those from conventional blankets (Bassen et al., 1991).

In a domestic magnetic-field survey, Silva et al. (1989) measured fields near different appliances at locations typifying normal use (e.g., sitting at an electric typewriter or standing at a stove). Specific appliances with relatively large fields included can openers (n = 9), with typical fields ranging from 30 to 225 mG and a maximum value up to 2.7 G; shavers (n = 4), with typical fields from 50 to 300 mG and maximum fields up to 6.9 G; and electric drills (n = 2), with typical fields from 56 to 190 mG and maximum fields up to 1.5 G. The fields from such appliances fall off very rapidly with distance and are only present for short periods. Thus, although instantaneous magnetic-field levels close to small hand-held appliances can be quite large, they do not contribute to average area levels in residences.

In a study with 162 subjects, Mezei et al. (2001) employed magnetic-field exposure measurements, simultaneous record-keeping of appliance proximity, and an appliance-use questionnaire to investigate the contributions of appliances to overall exposure. They found that individual appliance use did not contribute significantly to time-weighted-average exposure, unless the use was prolonged during the day of measurements. Use of small appliances did not contribute significantly to accumulated exposure but did contribute to the relatively short periods when high-field exposures were observed.

Although studies of residential magnetic fields have not all considered the same independent parameters, the following consistent characterization of residential magnetic fields emerges from the data:

(1) External sources play a large role in determining residential magnetic-field levels. Transmission lines, when nearby, are an important external source. Unbalanced ground currents on neutral conductors and other conductors, such as water pipes in and near a house, can represent a significant source of magnetic field. Distribution lines per se, unless they are quite close to a residence, do not appear to be a traditional distance-dependent source.

(2) Homes with overhead electrical service appear to have higher average fields than those with underground service.

(3) Appliances represent a localized source of magnetic fields that can be much higher than average or area fields. However, fields from appliances approach area levels at distances greater than 3.28 ft. (1 m) from the device.

Although important variables in determining residential magnetic fields have been identified, quantification and modeling of their influence on fields at specific locations is not yet possible. However, a general characterization of residential magnetic-field level is possible: average levels in the United States are in the range of 0.5 to 1.0 mG, with the average field in a small number of homes exceeding this range by as much as a factor of 10 or more. Average personal exposure levels are slightly higher, possibly due to use of appliances and varying distances to other sources. Maximum fields can be much higher.

Magnetic fields in commercial and retail locations are comparable with those in residences. As with appliances, certain equipment or machines can be a local source of higher magnetic fields. Utility workers who work close to transformers, generators, cables, transmission lines, and distribution systems clearly experience high-level fields. Other sources of fields in the workplace include motors, welding machines, and computers. In publicly accessible indoor areas, such as offices and stores, field levels are generally comparable with residential levels, unless a high-current source is nearby.

Because high-current sources of magnetic field are more prevalent than high-voltage sources, occupational environments with relatively high magnetic fields encompass a more diverse set of occupations than do those with high electric fields. For example, in occupational magnetic-field measurements reported by Bowman et al. (1988), the geometric mean field from 105 measurements of magnetic field in "electrical worker" job locations was 5.0 mG. "Electrical worker" environments showed the following elevated magnetic-field levels (geometric mean greater than 20 mG): industrial power supplies, alternating current (ac) welding machines, and sputtering systems for electronic assembly. For secretaries in the same study, the geometric mean field was 3.1 mG for those using old style VDTs (n = 6) and 1.1 mG for those not using VDTs (n = 3).

Measurements of personal exposure to magnetic fields were made for 1,882 volunteer utility workers for a total of 4,411 workdays (Bracken, 1990). Median workday mean exposures ranged from 0.5 mG for clerical workers without computers to 7.2 mG for substation operators. Occupations not specifically associated with transmission and distribution facilities had median workday exposures less than 1.5 mG, while those associated with such facilities had median exposures above 2.3 mG. Magnetic-field exposures measured in homes during this study were comparable with those recorded in offices.

Magnetic fields in publicly accessible outdoor areas seem to be, as expected, directly related to proximity to electric-power transmission and distribution facilities. Near such facilities, magnetic fields are generally higher than indoors (residential). Higher-voltage facilities tend to have higher fields. Typical maximum magnetic fields in publicly accessible areas near transmission facilities can range from less than a few milligauss up to 300 mG or more, near heavily loaded lines operated at 230 to 765 kV. The levels depend on the line load, conductor height, and location on the right-of-way. Because magnetic fields near high-voltage transmission lines depend on the current in the line, they can vary daily and seasonally.

Fields near distribution lines and equipment are generally lower than those near transmission lines. Measurements in Montreal indicated that typical fields directly above underground distribution systems were 5 to 19 mG (Heroux, 1987). Beneath overhead distribution lines, typical fields were 1.5 to 5 mG on the primary side of the transformer, and 4 to 10 mG on the secondary side. Near ground-based transformers used in residential areas, fields were 80 to 1000 mG at the surface and 10 to 100 mG at a distance of 1 ft. (0.3 m).

The magnetic fields from the proposed line would be comparable to or less than those from existing 230-kV lines in Oregon, Washington, and elsewhere. On and near the right-of-way of the proposed line, magnetic fields would be above average residential levels. However, the fields from the line would decrease rapidly and approach common ambient levels (2 mG) at a distance of about 165 feet or less from the edge of the right-of-way under maximum current conditions and at about 70 feet or less from the edge under average current conditions. Furthermore, the fields at the edge of the right-of-way would not be above those encountered during normal activities near common sources such as hand-held appliances.

## 5.0 Electric and Magnetic Field (EMF) Effects

Possible effects associated with the interaction of EMF from transmission lines with people on and near a right-of-way fall into two categories: short-term effects that can be perceived and may represent a nuisance, and possible long-term health effects. Only short-term effects are discussed here. The issue of whether there are long-term health effects associated with transmission-line fields is controversial. In recent years, considerable research on possible biological effects of EMF has been conducted. A review of these studies and their implications for health-related effects is provided in a separate technical report for the environmental assessment of the proposed North Steens transmission line (Exponent, 2009).

## 5.1 Electric Fields: Short-term Effects

Short-term effects from transmission-line electric fields are associated with perception of induced currents and voltages or perception of the field. Induced current or spark discharge shocks can be experienced under certain conditions when a person contacts objects in an electric field. Such effects occur in the fields associated with transmission lines that have voltages of 230-kV or higher. These effects could occur infrequently under the proposed North Steens transmission line.

Steady-state currents are those that flow continuously after a person contacts an object and provides a path to ground for the induced current. The amplitude of the steady-state current depends on the induced current to the object in question and on the grounding path. The magnitude of the induced current to vehicles and objects under the proposed line will depend on the electric-field strength and the size and shape of the object. When an object is electrically grounded, the voltage on the object is reduced to zero, and it is not a source of current or voltage shocks. If the object is poorly grounded or not grounded at all, then it acquires some voltage relative to earth and is a possible source of current or voltage shocks.

The responses of persons to steady-state current shocks have been extensively studied, and levels of response documented (Keesey and Letcher, 1969; IEEE, 1978). Primary shocks are those that can result in direct physiological harm. Such shocks will not be possible from induced currents under the existing or proposed lines, because clearances above ground required by the NESC preclude such shocks from large vehicles and grounding practices eliminate large stationary objects as sources of such shocks.

Secondary shocks are defined as those that could cause an involuntary and potentially harmful movement, but no direct physiological harm. Secondary shocks could occur under the proposed line when making contact with ungrounded conducting objects such as large vehicles or equipment. However, such occurrences are anticipated to be very infrequent, especially during Phase I with the lower fields under the 115-kV line. Even the infrequent shocks under the 230-kV line during Phases II and III are most likely to be below the nuisance level. Induced currents would not be perceived off the right-of-way.

Induced currents are always present in electric fields under transmission lines and will be present near the proposed line. A booklet is available from BPA describing how to live and work safely near transmission lines (USDOE, 2007). It describes safe practices for installation and maintenance of irrigation systems, underground pipes and cables, and fences on or near the right-of-way. For example, during initial construction, metal objects, such as fences, that are located on the right-of-way can be grounded to eliminate them as sources of induced current and voltage shocks. Multiple grounding points are used to provide redundant paths for induced current flow. After construction, prompt response to complaints and installation or repair of appropriate grounding can also mitigate nuisance shocks.

Unlike fences or buildings, mobile objects such as vehicles and farm machinery cannot be grounded permanently. Limiting the possibility of induced currents from such objects to persons is accomplished in several ways. First, required clearances for above-ground conductors tend to limit field strengths to levels that do not represent a hazard or nuisance. The NESC (IEEE, 2002) requires that, for lines with voltage exceeding 98 kV line-to-ground (170 kV line-to-line), sufficient conductor clearance be maintained to limit the induced short-circuit current in the largest anticipated vehicle under the line to 5 milliamperes (mA) or less. The proposed line will be designed and operated to be in compliance with the NESC.

For the proposed line, conductor clearances (50°C) would be at least 32.25 ft. (9.8 m) over road crossings along the route, resulting in a maximum field of 2.1 kV/m or less at the 3.28 ft. (1 m) height for all phases. The largest truck allowed on roads in Oregon without a special permit is 14 ft. high by 8.5 ft. wide by 75 ft. long (4.3 x 2.6 x 22.9 m). The induced currents to such a vehicle oriented perpendicular to the line in a maximum field of 2.1 kV/m (at 3.28-ft. height) would be less than 2.1 mA (Reilly, 1979).

For smaller trucks, the maximum induced currents for perpendicular orientation to the proposed line would be less than this value. (Larger special-permitted trucks, such as triple trailers, can be up to 105 feet in length. However, because they average the field over such a long distance, the maximum induced current to a 105-ft. vehicle oriented perpendicular to the line at a road crossing would be less than that for the 75-foot truck.) These large vehicles are not anticipated to be off highways on the right-of-way or oriented parallel and directly under the proposed line. Thus, the NESC 5-mA criterion would be met for road crossings of the proposed line during all phases of operation. Line clearances would also be in accordance with the NESC over other areas, such as railroads, orchards and water suitable for sailboating, where additional clearance might be required.

The computed induced currents at road crossings are for worst-case conditions that occur rarely. Several factors tend to reduce the levels of induced current shocks from vehicles at road crossings and elsewhere:

(1) Activities are distributed over the whole right-of-way, and only a small percentage of time is spent in areas where the field is at or close to the maximum value.

(2) At road crossings, vehicles are aligned perpendicular to the conductors, resulting in a substantial reduction in induced current.

(3) The conductor clearance at road crossings may not be at minimum values because of lower conductor temperatures and/or location of the road crossing away from midspan.

(4) The largest vehicles are permitted only on certain highways.

(5) Off-road vehicles are in contact with soil or vegetation, which reduces shock currents substantially.

Induced voltages occur on objects, such as vehicles, in an electric field where there is an inadequate electrical ground. If the voltage is sufficiently high, then a spark discharge shock can occur as contact is made with the object. Such shocks are similar to "carpet" shocks that occur, for example, when a person touches a doorknob after walking across a carpet on a dry day. The number and severity of spark discharge shocks depend on electric-field strength and generally of concern under lines with voltages of 345-kV or higher. Nuisance shocks, which are primarily spark discharges, are not anticipated to be a present under the proposed line.

In electric fields higher than those that would occur under the proposed line, it is theoretically possible for a spark discharge from the induced voltage on a large vehicle to ignite gasoline vapor during refueling. The probability for exactly the right conditions for ignition to occur is extremely remote. Even so, some utilities, including BPA, recommend that vehicles should not be refueled under the transmission lines unless specific precautions are taken to ground the vehicle and the fueling source (USDOE, 2007).

Under certain conditions, the electric field can be perceived through hair movement on an upraised hand or arm of a person standing on the ground under high-voltage transmission lines. The median field for perception in this manner was 7 kV/m for 136 persons; only about 12% could perceive fields of 2 kV/m or less (Deno and Zaffanella, 1982). In limited areas under the conductors at midspan during Phase II operation, the fields at ground level would exceed the levels where field perception can occur. However it is very unlikely that field perception would be common under the proposed line because fields would generally be below the perception level. Where vegetation provides shielding, the field would not be perceived.

Conductive shielding reduces both the electric field and induced effects such as shocks. Persons inside a vehicle cab or canopy are shielded from the electric field. Similarly, a row of trees or a lower-voltage distribution line reduces the field on the ground in the vicinity. Metal pipes, wiring, and other conductors in a residence or building shield the interior from the transmission-line electric field.

The electric fields from the proposed line would be comparable to or less than those from existing 230-kV lines in the project area and elsewhere. Potential impacts of electric fields can be mitigated through grounding policies and adherence to the NESC. Worst-case levels are used for safety analyses but, in practice, induced currents and voltages are reduced considerably by unintentional grounding. Shielding by conducting objects, such as vehicles and vegetation, also reduces the potential for electric-field effects.

## 5.2 Magnetic Field: Short-term Effects

Magnetic fields associated with transmission and distribution systems can induce voltage and current in long conducting objects that are parallel to the transmission line. As with electric-field induction, these induced voltages and currents are a potential source of shocks. A fence, irrigation pipe, pipeline, electrical distribution line, or telephone line forms a conducting loop when it is grounded at both ends. The earth forms the other portion of the loop. The magnetic field from a transmission line can induce a current to flow in such a loop if it is oriented parallel to the line. If only one end of the fence is grounded, then an induced voltage appears across the open end of the loop. The possibility for a shock exists if a person closes the loop at the open end by contacting both the ground and the conductor. The magnitude of this potential shock depends on the following factors: the magnitude of the field; the length of the object (the longer the object, the larger the induced voltage); the orientation of the object with respect to the transmission line (parallel as opposed to perpendicular, where no induction would occur); and the amount of electrical resistance in the loop (high resistance limits the current flow).

Magnetically induced currents from power lines have been investigated for many years; calculation methods and mitigating measures are available. A comprehensive study of gas pipelines near transmission lines developed prediction methods and mitigation techniques specifically for induced voltages on pipelines (Dabkowski and Taflove, 1979; Taflove and Dabkowski, 1979). Similar techniques and procedures are available for irrigation pipes and fences. Grounding policies employed by utilities for long fences reduce the potential magnitude of induced voltage.

The magnitude of the coupling with both pipes and fences is very dependent on the electrical unbalance (unequal currents) among the three phases of the line. Thus, a distribution line where a phase outage may go unnoticed for long periods of time can represent a larger source of induced currents than a transmission line where the loads are well-balanced (Jaffa and Stewart, 1981).

Knowledge of the phenomenon, grounding practices, and the availability of mitigation measures mean that magnetic-induction effects from the proposed transmission line would be minimal.

Magnetic fields from transmission and distribution facilities can interfere with certain electronic equipment. Magnetic fields can cause distortion of the image on older style VDTs and computer monitors that employ cathode-ray tubes. This can occur in fields as low as 10 mG, depending on the type and size of the monitor (Baishiki et al., 1990; Banfai et al., 2000). Generally, the problem arose when computer monitors were in use near electrical distribution facilities in large office buildings. Display devices using flat-panel technologies, such as liquid-crystal or plasma displays are not affected.

Interference from magnetic fields can be eliminated by shielding the affected device or moving it to an area with lower fields. Interference from 60-Hz fields with computers and control circuits in vehicles and other equipment is not anticipated at the field levels found under and near the proposed 230-kV transmission line.

The magnetic fields from the proposed line will be comparable to those from existing 230-kV lines in the area of the proposed line and elsewhere in Oregon.

## 6.0 Regulations

Regulations that apply to transmission-line electric and magnetic fields fall into two categories. Safety standards or codes are intended to limit or eliminate electric shocks that could seriously injure or kill persons. Field limits or guidelines are intended to limit electric- and magnetic-field exposures that can cause nuisance shocks or that might cause health effects. In no case has a limit or standard been established because of a known or demonstrated health effect.

The proposed line would be designed to meet the NESC (IEEE, 2002), which specifies how far transmission-line conductors must be from the ground and other objects. The clearances specified in the code provide safe distances that prevent harmful shocks to workers and the public. In addition, people who live and work near transmission lines must be aware of safety precautions to avoid electrical (which is not necessarily physical) contact with the conductors. For example, farmers should not up-end irrigation pipes under a transmission or other electrical line or direct the water stream from an irrigation system into or near the conductors. In addition, as a matter of safety, the NESC specifies that electric-field-induced currents from transmission lines must be below the 5 mA (“let go”) threshold deemed a lower limit for primary shock. Safety practices to protect against shock hazards near power lines are described in a brochure available from the Bonneville Power Administration (USDOE, 2001).

Field limits or guidelines have been adopted in several states and countries and by national and international organizations (Maddock, 1992). Electric-field limits have generally been based on minimizing nuisance shocks or field perception. The intent of magnetic-field limits has been to limit exposures to existing levels, given the uncertainty of their potential for health effects.

General guidelines for EMF exposure have been established for occupational and public exposure by national and international organizations. Three sets of such guidelines are described in Table 4.

The American Conference of Governmental Industrial Hygienists (ACGIH) sets guidelines (Threshold Limit Values or TLV) for occupational exposures to environmental agents (ACGIH, 2008). In general, a TLV represents the level below which it is believed that nearly all workers may be exposed repeatedly without adverse health effects. For EMF, the TLVs represent ceiling levels. For 60-Hz electric fields, occupational exposures should not exceed the TLV of 25 kV/m. However, the ACGIH also recognizes the potential for startle reactions from spark discharges and short-circuit currents in fields greater than 5-7 kV/m, and recommends implementing grounding practices. They recommend the use of conductive clothing for work in fields exceeding 15 kV/m. The TLV for occupational exposure to 60-Hz magnetic fields is a ceiling level of 10 G (10,000 mG) (ACGIH, 2008). These ACGIH occupational levels are all above the electric fields that would be present on the right-of-way.

The International Committee on Non-ionizing Radiation Protection (ICNIRP), working in cooperation with the World Health Organization (WHO) has developed guidelines for occupational and public exposures to EMF (ICNIRP, 1998). For occupational exposures at 60 Hz, the recommended limits to exposure are 8.3 kV/m for electric fields and 4.2 G (4,200 mG) for magnetic fields. The electric-field level can be exceeded, provided precautions are taken to prevent spark discharge and induced current shocks. For the general public, the ICNIRP guidelines recommend exposure limits of 4.2 kV/m for electric fields and 0.83 G (830 mG) for magnetic fields (ICNIRP, 1998).

More recently the International Committee on Electromagnetic Safety (ICES) under the auspices of the IEEE has established exposure guidelines for 60-Hz electric and magnetic fields (ICES, 2002). The ICES recommended limits for occupational exposures are 20 kV/m for electric fields and 27,100 mG for magnetic fields. The recommended limits for the general public are lower: 5 kV/m for the general public to electric fields, except on power line rights-of-way where the limit is 10 kV/m; and 9,040 mG for magnetic fields.

Electric and magnetic fields from various sources (including automobile ignitions, appliances and, possibly, transmission lines) can interfere with implanted cardiac pacemakers. In light of this potential problem, manufacturers design devices to be immune from such interference. However, research has shown that these efforts have not been completely successful and that a few models of older pacemakers still in use could be affected by 60-Hz fields from transmission lines. There were also numerous models of pacemakers that were not affected by fields larger than those found under transmission lines. Because of the known potential for interference with pacemakers by 60-Hz fields, field limits for pacemaker wearers have been established by the ACGIH. They recommend that, lacking additional information about their pacemaker, wearers of pacemakers and similar medical-assist devices limit their exposure to electric fields of 1 kV/m or less and to magnetic fields to 1 G (1,000 mG) or less (ACGIH, 2008). Additional discussion of interference with implanted devices is given in the accompanying technical report on health effects (Exponent 2009).

There are currently no national standards in the United States for 60-Hz electric and magnetic fields. Oregon's formal rule in its transmission-line-siting procedures specifically addresses field limits. The Oregon limit of 9 kV/m for electric fields is applied to areas accessible to the public (Oregon, State of, 1980). The Oregon rule also addresses grounding practices, audible noise, and radio interference. Oregon does not have a limit for magnetic fields from transmission lines.

Besides Oregon, several states have been active in establishing mandatory or suggested limits on 60-Hz electric and (in two cases) magnetic fields. Five other states have specific electric-field limits that apply to transmission lines: Florida, Minnesota, Montana, New Jersey, and New York. Florida and New York have established regulations for magnetic fields. These regulations are summarized in Table 5.

Government agencies and utilities operating transmission systems have established design criteria that include EMF levels. BPA has maximum allowable electric fields of 9 and 5 kV/m on and at the edge of the right-of-way, respectively (USDOE, 1996). BPA also has maximum-allowable electric-field strengths of 5 kV/m, 3.5 kV/m, and 2.5 kV/m for road crossings, shopping center parking lots, and commercial/ industrial parking lots, respectively. These levels are based on limiting the maximum short-circuit currents from anticipated vehicles to less than 1 mA in shopping center lots and to less than 2 mA in commercial parking lots.

The electric fields from the proposed transmission line would meet the ACGIH, ICNIRP, and IEEE standards, provided wearers of pacemakers and similar medical-assist devices are discouraged from unshielded right-of-way use. (A passenger in an automobile under the line would be shielded from the electric field.) The magnetic fields from the proposed line would be below the ACGIH occupational limits, and well as below those of ICNIRP and IEEE for occupational and public exposures. The electric fields present on the right-of-way could induce currents in ungrounded vehicles that exceeded the ICNIRP and IEEE levels of 0.5 mA.

The estimated peak electric fields on the right-of-way of the proposed transmission line would meet the limits of all states and the BPA electric field criteria (see Table 5). The edge-of-right-of-way electric fields from the proposed line would be below the edge-of-right-of-way limits set by all states. The magnetic field at the edge of the right-of-way from the proposed line would be below the regulatory levels of states where such regulations exist.

# 7.0 Audible Noise

## 7.1 Basic Concepts

Audible noise (AN), as defined here, represents an unwanted sound, as from a transmission line, transformer, airport, or vehicle traffic. Sound is a pressure wave caused by a sound source vibrating or displacing air. The ear converts the pressure fluctuations into auditory sensations. AN from a source is superimposed on the background or ambient noise that is present before the source is introduced.

The amplitude of a sound wave is the incremental pressure resulting from sound above atmospheric pressure. The sound-pressure level is the fundamental measure of AN; it is generally measured on a logarithmic scale with respect to a reference pressure. The sound-pressure level (SPL) in decibels (dB) is given by:

$$SPL = 20 \log (P/P_o) dB$$

where P is the effective rms (root-mean-square) sound pressure, $P_o$ is the reference pressure, and the logarithm (log) is to the base 10. The reference pressure for measurements concerned with hearing is usually taken as 20 micropascals (Pa), which is the approximate threshold of hearing for the human ear. A logarithmic scale is used to encompass the wide range of sound levels present in the environment. The range of human hearing is from 0 dB up to about 140 dB, a ratio of 10 million in pressure (EPA, 1978).

Logarithmic scales, such as the decibel scale, are not directly additive: to combine decibel levels, the dB values must be converted back to their respective equivalent pressure values, the total rms pressure level found, and the dB value of the total recalculated. For example, adding two sounds of equal level on the dB scale results in a 3 dB increase in sound level. Such an increase in sound pressure level of 3 dB, which corresponds to a doubling of the energy in the sound wave, is barely discernible by the human ear. It requires an increase of about 10 dB in SPL to produce a subjective doubling of sound level for humans. The upper range of hearing for humans (140 dB) corresponds to a sharply painful response (EPA, 1978).

Humans respond to sounds in the frequency range of 16 to 20,000 Hz. The human response depends on frequency, with the most sensitive range roughly between 2000 and 4000 Hz. The frequency-dependent sensitivity is reflected in various weighting scales for measuring audible noise. The A-weighted scale weights the various frequency components of a noise in approximately the same way that the human ear responds. This scale is generally used to measure and describe levels of environmental sounds such as those from vehicles or occupational sources. The A-weighted scale is also used to characterize transmission-line noise. Sound levels measured on the A-scale are expressed in units of dB(A) or dBA.

AN levels and, in particular, corona-generated audible noise (see below) vary in time. In order to account for fluctuating sound levels, statistical descriptors have been developed for environmental noise. Exceedance levels (L levels) refer to the A-weighted sound level that is exceeded for a specified percentage of the time. Thus, the $L_5$ level refers to the noise level that is exceeded only 5% of the time. $L_{50}$ refers to the sound level exceeded 50% of the time. Sound-level measurements and predictions for transmission lines are often expressed in terms of exceedance levels, with the $L_5$ level representing the maximum level and the $L_{50}$ level representing a median level.

Table 6 shows AN levels from various common sources. Clearly, there is wide variation. Noise exposure depends on how much time an individual spends in different locations. Outdoor noise generally does not contribute to indoor levels (EPA, 1974). Activities in a building or residence generally dominate interior AN levels.

BPA has established a transmission-line design criterion for corona-generated audible noise ($L_{50}$, foul weather) of 50 dBA at the edge of the right-of-way (USDOE, 2006). This criterion applies to new line construction and is under typical conditions of foul weather, altitude, and system voltage for the line. It is generally only of concern for 500-kV lines.

The EPA has established a guideline of 55 dBA for the annual average day-night level ($L_{dn}$) in outdoor areas (EPA, 1978). In computing this value, a 10 dB correction (penalty) is added to night-time noise between the hours of 10 p.m. and 7 a.m.

## 7.2 Transmission-line Audible Noise

Corona is the partial electrical breakdown of the insulating properties of air around the conductors of a transmission line. In a small volume near the surface of the conductors, energy and heat are dissipated. Part of this energy is in the form of small local pressure changes that result in audible noise. Corona-generated audible noise can be characterized as a hissing, crackling sound that, under certain conditions, is accompanied by a 120-Hz hum. Corona-generated audible noise is of concern primarily for contemporary lines operating at voltages of 345 kV and higher during foul weather. However, the proposed line will produce some noise under foul weather conditions.

The conductors of high-voltage transmission lines are designed to be corona-free under ideal conditions. However, protrusions on the conductor surface—particularly water droplets on or dripping off the conductors—cause electric fields near the conductor surface to exceed corona onset levels, and corona occurs. Therefore, audible noise from transmission lines is generally a foul-weather (wet-conductor) phenomenon. Wet conductors can occur during periods of rain, fog, snow, or icing. Based on hourly precipitation records near the route of the proposed transmission line, such conditions are expected to occur about 7% of the time during the year in the North Steens area.

For a few months after line construction, residual grease or oil on the conductors can cause water to bead up on the surface. This results in more corona sources and slightly higher levels of audible noise and electromagnetic interference if the line is energized. However, the new conductors "age" in a few months, and the level of corona activity decreases to the predicted equilibrium value. During fair weather, insects and dust on the conductor can also serve as sources of corona.

## 7.3 Predicted Audible Noise Levels

Corona-generated audible-noise levels are calculated for average voltage and average conductor heights for fair- and foul-weather conditions. The predicted levels of audible noise for the proposed line operated at a voltage of 241.5 kV are given in Table 7 and plotted in Figure 4 for Phases II and III, which have the only noise levels that will be noticeable.

The calculated median level ($L_{50}$) during foul weather at the edge of the proposed North Steens line right-of-way (75 ft. from centerline) is 47 dBA for Phase III operation and 44 dBA for Phase II. The calculated maximum level ($L_5$) during foul weather at the edge of the right-of-way for Phase III is 50 dBA. During fair-weather conditions, which occur about 93% of the time in the North Steens area, audible noise levels at the edge of the right-of-way would be about 20 dBA (if corona were present). The predicted foul and fair weather levels from Phase I (115-kV) are below 20 dBA. These lower levels could be masked by ambient noise on and off the right-of-way and would only be perceptible on rare occasions very near the line. .

## 7.4 Discussion

The calculated foul-weather corona noise levels for the proposed line would be comparable to, or less than, those from existing 230-kV lines in Oregon. During fair weather, noise from the 230-kV conductors might be perceivable on the right-of-way; however, beyond the right-of-way it would very likely be masked or so low as not to be perceived. During foul weather, when ambient noise is higher, it is also likely that corona-generated noise off the right-of-way would be masked to some extent.

On and off the right-of-way, the levels of audible noise from the proposed line during foul weather would be well below the 55-dBA level that can produce interference with speech outdoors. Also the predicted $L_{50}$ foul weather value is below 50 dBA and occurs very infrequently. Therefore the estimated $L_{dn}$ at the edge of the right-of-way of the proposed line would be well below the EPA annual guideline for $L_{dn}$ of 55 dBA.

If the North Route is selected only five residence would be within 1300 feet of the line, with the nearest residence at 75 feet. The other four houses would be 200 feet or greater from the line. At the 75-foot distance, audible noise would be as reported above for the edge of the right-of-way, with a median level, $L_{50}$, during foul weather of 47 dBA. A possible alternative to the North Route would increase the distance to the nearest residences to about 200 feet (61 m), where the median foul weather audible noise would be about 43 dBA.

If the West Route is selected, only two residences would be closer than 1300 feet (395 m) with the nearest at 550 feet (165 m), where the $L_{50}$ foul weather value would be about 38 dBA.

Thus, only a few residences would be impacted and at all residences the audible noise from the transmission line would be within guidelines established by the EPA, the State of Oregon, and BPA. At all locations ambient noise would be increased during foul weather due to wind and rain hitting foliage or buildings. At the larger distances this increase could be sufficient to mask the noise from the transmission line.

There would be no transformers or reactors at the interconnection stations adjacent to the existing 115-or 230-kV lines. Therefore the audible noise at these locations will be due to noise from the transmission line conductors. As noted above this noise will be barely perceptible, if at all, during fair weather, and would be below established noise limits during fair weather.

### 7.5 Conclusion

Along the proposed line route there could be increases in the perceived noise above ambient levels during foul weather at the edges of the proposed right-of-way. The corona-generated noise during foul weather would be masked to some extent by naturally occurring sounds such as wind and rain on foliage. During fair weather, the noise off the right-of-way from the proposed line would probably not be detectable above ambient levels. The noise levels from the proposed line would be below levels identified as causing interference with speech or sleep. The audible noise from the transmission line would be below EPA guideline levels and would meet the BPA design criterion that complies with state noise regulations. The new connection station are not anticipated to increase noise levels above those due to the nearby transmission lines.

## 8.0 Electromagnetic Interference

### 8.1 Basic Concepts

Corona on transmission-line conductors can also generate electromagnetic noise in the frequency bands used for radio and television broadcast signals. The noise can cause radio and television interference (RI and TVI). In certain circumstances, corona-generated electromagnetic interference (EMI) can also affect communications systems and other sensitive receivers. Interference with electromagnetic signals by corona-generated noise is generally associated with lines operating at voltages of 345 kV or higher. This is especially true of interference with television signals. The single 1.545-in diameter conductor used in the design of the proposed line would mitigate corona generation and keep radio and television interference levels at acceptable levels and below those of many existing 230-kV lines with smaller conductors.

Spark gaps on distribution lines and on low-voltage wood-pole transmission lines are a more common source of RI/TVI than is corona from high-voltage electrical systems. This gap-type interference is primarily a fair-weather phenomenon caused by loose hardware and wires. The proposed transmission line would be constructed with modern hardware that eliminates such problems and therefore minimizes gap noise. Consequently, this source of EMI is not anticipated for the proposed line.

No state has limits for either RI or TVI. In the United States, electromagnetic interference from power transmission systems is governed by the Federal Communications Commission (FCC) Rules and Regulations presently in existence (FCC, 1988). A power transmission system falls into the FCC category of "incidental radiation device," which is defined as "a device that radiates radio frequency energy during the course of its operation although the device is not intentionally designed to generate radio frequency energy." Such a device "shall be operated so that the radio frequency energy that is emitted does not cause harmful interference. In the event that harmful interference is caused, the operator of the device shall promptly take steps to eliminate the harmful interference." For purposes of these regulations, harmful interference is defined as: "any emission, radiation or induction which endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radio communication service operating in accordance with this chapter" (FCC, 1988: Vol II, part 15. 47CFR, Ch. 1).

Electric power companies have been able to work quite well under the present FCC rule because harmful interference can generally be eliminated. It has been estimated that more than 95 percent of power-line sources that cause interference are due to gap-type discharges. These can be found and completely eliminated, when required to prevent interference (USDOE, 1980). Complaints related to corona-generated interference occur infrequently. This is especially true with the advent of cable television and satellite television, which are not subject to corona-generated interference. Mitigation of corona-generated interference with conventional broadcast radio and television receivers can be accomplished in several ways, such as use of a directional antenna or relocation of an existing antenna (USDOE, 1977; USDOE, 1980; Loftness et al., 1981).

## 8.2 Radio Interference (RI)

Radio reception in the AM broadcast band (535 to 1605 kilohertz (kHz)) is most often affected by corona-generated EMI. FM radio reception is rarely affected. Generally, only residences very near to transmission lines can be affected by RI. The IEEE Radio Noise Design Guide identifies an acceptable limit of fair-weather RI as expressed in decibels above 1 microvolt per meter (dBμV/m) of about 40 dBμV/m at 100 ft. (30 m) from the outside conductor (IEEE Committee Report, 1971). As a general rule, average levels during foul weather (when the conductors are wet) are 16 to 22 dBμV/m higher than average fair-weather levels.

## 8.3 Predicted RI Levels

The predicted median ($L_{50}$) fair-weather RI levels at 100 ft. (30 m) from the outside conductor for the proposed Phase III line operating at 241.5 kV is 34 dBμV/m. This level is well below the IEEE 40 dBμV/m criterion for fair weather levels at distances greater than about 100 ft. (30 m) from the outside conductor. Predicted fair-weather $L_{50}$ levels are comparable to, or lower than, those for existing 230-kV lines in Oregon. The RI levels from the Phase I and II lines would be lower than those from Phase III.

## 8.4 Television Interference (TVI)

Corona-caused TVI occurs during foul weather and is generally of concern for transmission lines with voltages of 345 kV or above, and only for conventional receivers within about 600 ft. (183 m) of such a line. As is the case for RI, gap sources on distribution and low-voltage transmission lines are the principal observed sources of TVI. The use of modern hardware and construction practices for the proposed line would minimize such sources. TVI levels are expressed in dBμV/m at 75 MHz.

## 8.5 Predicted TVI Levels

The foul weather TVI level predicted at 100 ft. (30 m) from the outside conductor of the proposed line Phase III 230-kV line is 18 dBμV/m with the line operating at 241.5 kV. This is considerably below foul-weather TVI levels from existing 500-kV lines (24-27 dBμV/m), where TVI can be a problem.

Other forms of TVI from transmission lines are signal reflection (ghosting) and signal blocking caused by the relative locations of the transmission structure and the receiving antenna with respect to the incoming television signal. The steel pole towers proposed for use in the design of the proposed line are less effective in causing this type of interference than are lattice steel towers.

The distances between the proposed line route and all houses, except the single nearby residence adjacent to the edge of the North Route right-of-way, make any type of broadcast television interference very unlikely. Since other residences are 200 feet (60 m) or more from the line, corona-generated TVI, signal reflection or signal blocking are not anticipated to occur due to the proposed line. If interference with broadcast signals should occur at the nearest residence, there are mitigation techniques available to eliminate it, as described previously.

Television systems that operate at higher frequencies, such as satellite receivers, are not affected by corona-generated TVI. Cable television systems are similarly unaffected.

### 8.6 Interference with Other Devices

Corona-generated interference can conceivably cause disruption on other communications bands such as the citizen's (CB) and mobile bands. However, mobile-radio communications are not susceptible to transmission-line interference because they are generally frequency modulated (FM). Similarly, cellular telephones operate at a frequency of 900 MHz or higher, which is above the frequency where corona-generated interference is prevalent. In the unlikely event that interference occurs with these or other communications, mitigation can be achieved with the same techniques used for television and AM radio interference. As digital signal processing has been integrated into communications the potential impact of corona-generated EMI has decreased substantially.

### 8.7 Conclusion

Predicted EMI levels for the proposed transmission line are comparable to, or lower, than those that already exist near 230-kV lines and no impacts of corona-generated interference on radio, television, or other receptors are anticipated. Furthermore, if interference should occur, there are various methods for correcting it.

## 9.0 Other Corona Effects

Intense corona is visible as a bluish glow or as bluish plumes on higher voltage lines. On the proposed 230-kV line, corona levels would be relatively low, so it is very unlikely that it could be observed. Any corona on the conductors would be observable only under the darkest conditions and only with the aid of binoculars, if at all. Without a period of adaptation for the eyes and without intentional looking for the corona, it would not be noticeable.

When corona is present, the air surrounding the conductors is ionized and many chemical reactions take place, producing small amounts of ozone and other oxidants. Ozone is approximately 90% of the oxidants, while the remaining 10% is composed principally of nitrogen oxides. The corona level predicted for the proposed line is much lower than that from 500-kV lines. The levels from 500-kV lines are significantly below natural levels and fluctuations in natural levels. Consequently, any production of ozone from the proposed 230-kV line would be essentially undetectable at ground level.

## 10.0 Summary

Electric and magnetic fields from the proposed transmission line have been characterized using well-known techniques accepted within the scientific and engineering community. The expected electric-field levels from the proposed line at minimum design clearance would be comparable to those from existing 115-kV and 230-kV lines in Oregon, and elsewhere. The expected magnetic-field levels from the proposed line would be comparable to those from other 115-kV and 230-kV lines in Oregon, and elsewhere.

When the proposed line is operated at 115-kV, the peak electric field expected on the right-of-way would be 1.3 kV/m and the maximum value at the edge of the right-of-way would be about 0.3 kV/m. When operated at 230-kV, the maximum field values would be 2.1 kV/m on the right-of-way and 0.1 kV/m at the edge. The same maximum field values apply to road crossings for the two operating voltages.

For the single circuit Phase I 115-kV operation the peak magnetic field on the right-of-way would be a maximum of 52 mG and an average value of 14 mG. At the edge of the right-of-way during Phase I, the largest fields would occur at the west edge with a maximum of 15 mG and an average value of 5 mG. For double circuit operation with maximum current the peak fields on the right-of-way would be 93 mG for Phase II and 97 mG for Phase III. On average the peak magnetic field would be about one fourth the maximum value. During double circuit operation the largest fields would occur at the east edge of the right-of-way, where the maximum would be 21 mG during Phase II and 25 mG during Phase III. Average values at the edge of the right-of-way during double-circuit operation would be about one third of the maximum values.

The electric fields from the proposed line would meet regulatory limits for public exposure in Oregon and all other states that have limits and would meet the regulatory limits or guidelines for peak fields established by national and international guideline setting organizations. The magnetic fields from the proposed line would be within the regulatory limits of the two states that have established them and within guidelines for public exposure established by ICNIRP and IEEE. The state of Oregon does not have limits for magnetic fields from transmission lines.

Short-term effects from transmission-line fields are well understood and can be mitigated. Nuisance shocks arising from electric-field induced currents and voltages could be perceivable on the right-of-way of the proposed line. Such occurrences are anticipated to be rare. It is common practice to ground permanent conducting objects during and after construction to mitigate against such occurrences.

Corona-generated audible noise from the proposed line could be perceivable during foul weather at the edge of the right-of-way. The levels would be comparable with, or less than, those near existing 230-kV transmission lines in Oregon, would be in compliance with noise regulations in Oregon, and would be below levels specified in EPA guidelines.

Corona-generated electromagnetic interference from the proposed line would be comparable to or less than that from existing 230-kV lines in Oregon. Radio interference levels would be below limits identified as acceptable. Television interference, a foul-weather phenomenon usually associated with higher voltage lines, is not anticipated to occur from the proposed line.

## List of References Cited

ACGIH (American Conference of Governmental Industrial Hygienists). 2008. 2008 TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. American Conference of Governmental Industrial Hygienists, Cincinnati. 251 pages.

Baishiki, R.S.; Johnson, G.B.; Zaffanella, L.E.; Bracken, T.D.; Sussman, S.S.; Rauch, G.B.; and Silva, J.M. 1990. Studies of Power System Magnetic Fields: Characterization of Sources in Residential Environments, Measurement of Exposure, Influence On Computer Screens. (36-104) CIGRE, Paris, France. 10 pages.

Banfai, B.; Karady, G.G.; Kim, C.J.; and Maracas, K.B. 2000. Magnetic field effects on CRT computer monitors. IEEE Trans. on Power Delivery 15, 307-312.

Bassen, H.; Casamento, J.; and Crowl, B. 1991. Reduction of electric and magnetic field emissions from electric blankets (Meeting abstract). *In*: Bioelectromagnetics Society, 13th Annual Meeting, 23-27 June, Salt Lake City. Bioelectromagnetics Society, New York, 20.

Bowman, J.D.; Garabrant, D.H.; Sobel, E.; and Peters, J.M. June 1988. Exposures to Extremely Low Frequency (ELF) Electromagnetic Fields in Occupations with Elevated Leukemia Rates. Applied Industrial Hygienics, 3(6, June):189-194.

Bracken, T.D. 1990. The EMDEX Project: Technology Transfer and Occupational Measurements, Volumes 1-3 Interim Report. EPRI Report EN-7048. (EPRI EN-7048) Electric Power Research Institute, Palo Alto, CA.

Chartier, V.L. April 1983. Empirical Expressions for Calculating High Voltage Transmission Corona Phenomena, First Annual Seminar Technical Career Program for Professional Engineers. Bonneville Power Administration, Portland, Oregon. April 1983, 75-82.

Chartier, V.L.; and Stearns, R.D. January 1981. Formulas for Predicting Audible Noise from Overhead High Voltage AC and DC Lines. IEEE Transactions on Power Apparatus and Systems, PAS-100(No. 1, January 1981):121-129.

Dabkowski, J.; and Taflove, A. May/June 1979. Prediction Method for Buried Pipeline Voltages Due to 60 Hz AC Inductive Coupling. Part II: Field Test Verification. IEEE Transactions on Power Apparatus and Systems, PAS-98(3, May/June):788-794.

Deno, D.W.; and Zaffanella, L. 1982. Field effects of overhead transmission lines and stations. Chap. 8. *In*: Transmission Line Reference Book: 345 KV and Above. Second ed. (Ed: LaForest, J.J.). Electric Power Research Institute, Palo Alto, CA, 329-419.

EPA. 1974. Information On Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety. (No. PB-239 429.) U.S. Environmental Protection Agency, Washington, D.C.

EPA. 1978. Protective Noise Levels. Condensed Version of EPA Levels Document. (No. PB82-138827) U.S Environmental Protection Agency, Washington, DC.

Exponent. 2009. Update of EMF Research – 2009. Technical report prepared for Bonneville Power Administration by Exponent, New York, NY (April 2009).

FCC (Federal Communications Commission). 1988. Federal Communications Commission Rules and Regulations. 10-1-88 ed. Vol. II part 15, 47 CFR, Ch. 1.

Florig, H.K.; and Hoburg, J.F. 1988. Electric and Magnetic Field Exposure Associated With Electric Blankets. Project Resume. Contractor's Review. U.S. Department of Energy/Electric Power Research Institute.

Florig, H.K.; Hoburg, J.F.; and Morgan, M.G. April 1987. Electric Field Exposure from Electric Blankets. IEEE Transactions on Power Delivery, PWRD-2(2, April):527-536.

Gauger, J. September 1985. Household Appliance Magnetic Field Survey. IEEE Transactions on Power Apparatus and Systems, 104(9, September):2436-2445.

Heroux, P. 1987. 60-Hz Electric and Magnetic Fields Generated By a Distribution Network. Bioelectromagnetics, 8(2):135-148.

ICES (International Committee on Electromagnetic Safety): 2002. IEEE PC95.6-2002 Standard for Safety Levels With Respect to Human Exposure to Electromagnetic Fields, 0 to 3 kHz. Institute of Electrical and Electronics Engineers, Piscataway, NJ.

ICNIRP (International Committee on Non-ionizing Radiation Protection). April 1998. Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (Up to 300 GHz). Health Physics, 74(4, April):1-32.

IEEE (Institute of Electrical and Electronics Engineers, Inc.). 1978. Electric and Magnetic Field Coupling from High Voltage AC Power Transmission Lines—Classification of Short-Term Effects On People. IEEE Transactions on Power Apparatus and Systems, PAS-97:2243-2252.

IEEE. 1994. IEEE Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields from AC Power Lines. ANSI/IEEE Std. 644-1994, New York, NY.

IEEE. 2002. National Electrical Safety Code. 2002 ed. Institute of Electrical and Electronics Engineers, Inc., New York, NY. 287 pages.

IEEE Committee Report. March/April 1971. Radio Noise Design Guide for High Voltage Transmission Lines. IEEE Transactions on Power Apparatus and Systems, PAS-90(No. 2, March/April):833-842.

IEEE Committee Report. October 1982. A Comparison of Methods for Calculating Audible Noise of High Voltage Transmission Lines. IEEE Transactions on Power Apparatus and Systems, 101(10, October):4090-4099.

ITT Research Institute. 1984. Representative Electromagnetic Field Intensities Near the Clam Lake (WI) and Republic (MI) ELF Facilities. Report Prepared for Naval Electronics Systems Command, PME 110 E Washington, D.C. 20360. (Under contract N00039-84-C0070.) ITT Research Institute, Chicago, IL. 60 pages.

Jaffa, K.C.; and Stewart, J.B. March 1981. Magnetic Field Induction from Overhead Transmission and Distribution Power Lines On Buried Irrigation Pipelines. IEEE Transactions on Power Apparatus and Systems, PAS-100(3, March):990-1000.

Keesey, J.C.; and Letcher, F.S. 1969. Minimum Thresholds for Physiological Responses to Flow of Alternating Electric Current Through the Human Body At Power-Transmission Frequencies. (Report No. 1) Naval Medical Research Institute, Project MR 005.08-0030B, Bethesda, MD. 25 pages.

Loftness, M.O.; Chartier, V.L.; and Reiner, G.L. 1981. EMI Correction Techniques for Transmission Line Corona. (August 18-20, 1981, pp. 351-361.) Proceedings of the 1981 IEEE International Symposium on Electromagnetic Compatibility, Boulder, CO.

Maddock, B.J. September 1992. Guidelines and Standards for Exposure to Electric and Magnetic Fields At Power Frequencies. (Panel 2-05, CIGRE meeting August 30-September 5, 1992) CIGRE, Paris.

Mezei, G.; Kheifets, L.I.; Nelson, L.M.; Mills, K.M. ; Iriye, R. ;and Kelsey, J.L. 2001. Household Appliance Use and Residential Exposure to 60-Hz Magnetic Fields. Journal of Exposure Analysis and Environmental Epidemiology, Vol. 11, No. 1: 41-49.

NOAA, National Oceanic & Atmospheric Administration. 2010., National Climatic Data Center (NCDC). http://www.ncdc.noaa.gov/oa/ncdc.html

Olsen, R.G.; Schennum, S.D.; and Chartier, V.L. April 1992. Comparison of Several Methods for Calculating Power Line Electromagnetic Interference Levels and Calibration With Long Term Data. IEEE Transactions on Power Delivery, 7 (April, 1992):903-913.

Oregon, State of. 1980. *Oregon Administrative Rules Chapter 345, Division 80.* Energy Facility Siting Council standards relating to public health and safety, 934-80-055.

Reilly, J.P. 1979. Electric Field Induction on Long Objects—A Methodology for Transmission Line Impact Studies. IEEE Transactions on Power Apparatus and Systems, PAS-98(6, Nov/Dec):1841-1852.

Sheppard, A.R.; and Eisenbud, M. 1977. Biological Effects of Electric and Magnetic Fields of Extremely Low Frequency. New York University Press, New York.

Silva, M.; Hummon, N.; Rutter, D.; and Hooper, C. 1989. Power Frequency Magnetic Fields in the Home. IEEE Transactions on Power Delivery, 4:465-478.

Taflove, A. and Dabkowski, J. May/June 1979. Prediction Method for Buried Pipeline Voltages Due to 60 Hz AC Inductive Coupling. Part I: Analysis. IEEE Transactions on Power Apparatus and Systems, PAS-98(3, May/June):780-787.

USDOE (U.S. Department of Energy), Bonneville Power Administration. March 1977. A Practical Handbook for the Location, Prevention and Correction of Television Interference from Overhead Power Lines. Portland, OR.

USDOE, Bonneville Power Administration. May 1980. A Practical Handbook for the Correction of Radio Interference from Overhead Powerlines and Facilities. Portland, OR.

USDOE, Bonneville Power Administration. 1996. Electrical and Biological Effects of Transmission Lines: A Review. (DOE/BP 2938 December 1996 1M) Portland, OR.

USDOE, Bonneville Power Administration. 2007. Living and Working Safely Around High-Voltage Power Lines. (DOE/BP-3804). Portland, OR. 12 pages.

USDOE, Bonneville Power Administration. undated. "Corona and Field Effects" Computer Program (Public Domain Software). Bonneville Power Administration, P.O. Box 491-ELE, Vancouver, WA 98666.

USDOE, Bonneville Power Administration. 2006. Audible Noise Policy. TBL Policy T2006-1. Bonneville Power Administration, Portland, OR.

Zaffanella, L.E. 1993. Survey of Residential Magnetic Field Sources. Vol. 1: Goals, results, and conclusions. (EPRI TR-102759-V1, Project 3335-02) Electric Power Research Institute, Palo Alto, CA.

Zaffanella, L.E.; and Kalton, G.W. 1998. Survey of personal magnetic field exposure, Phase II: 1000-person survey. Interim Report. EMF RAPID Program Engineering Project #6. Enertech Consultants, Lee, MA.

## List of Preparers

T. Dan Bracken was the principal author of this report. He received a B.S. degree in physics from Dartmouth College and M.S. and Ph.D. degrees in physics from Stanford University. Dr. Bracken has been involved with research on and characterization of electric- and magnetic-field effects from transmission lines for over 35 years, first as a physicist with the Bonneville Power Administration (BPA) (1973 - 1980) and since then as a consultant. His firm, T. Dan Bracken, Inc., offers technical expertise in areas of electric- and magnetic-field measurements, instrumentation, environmental effects of transmission lines, exposure assessment and project management. Joseph Dudman provided data entry, graphics, and clerical support in the preparation of the report.

**Table 1: Physical and electrical characteristics of the proposed North Steens double-circuit transmission-line.** See Figure 1 for drawing of tower.

| Phase | I | | II | | III | |
|---|---|---|---|---|---|---|
| **Circuit** | **West** | **East** | **West** | **East** | **West** | **East** |
| **Voltage[1], kV** | 121.7 | – | 121.7 | 241.5 | 241.5 | 241.5 |
| **Current, A Maximum/average** | 500/175 | – | 500/175 | 1000/350 | 261/91 | 1000/350 |
| **Electric phasing** | A<br>B<br>C | – | A<br>B<br>C | C<br>B<br>A | A<br>B<br>C | C<br>B<br>A |
| **Clearance, ft. Minimum/Average[2]** | 32.25/38.4 | | 32.25/38.4 | | 32.25/38.4 | |
| **Tower configuration** | Vertical Single Circuit | | Vertical Double Circuit | | Vertical Double Circuit | |
| **Phase spacing, ft.[3]** | 16V | | 24H, 16 V | | 24H, 16 V | |
| **Conductor diameter, in** | 1.545 | | 1.545 | | 1.545 | |

1 Maximum and average voltage assumed to be the same.
2 Average voltage and average clearance used for corona calculations.
3 H = horizontal spacing, feet; V = vertical spacing, feet

**Table 2: Calculated peak and edge of right-of-way (ROW) electric fields for the proposed North Steens transmission line operated at maximum voltage.**

| | Electric Field, kV/m | | | | | |
|---|---|---|---|---|---|---|
| Phase | I | | II | | III | |
| Field[1] | **Maximum** | **Average** | **Maximum** | **Average** | **Maximum** | **Average** |
| **Peak on ROW** | 1.3 | 1.0 | 2.1 | 1.5 | 1.8 | 1.2 |
| **At Edge of ROW[2]** | 0.02, 0.04 | 0.3, 0.02 | 0.05, 0.04 | 0.05, 0.08 | 0.05 | 0.09 |

1 Maximum = Maximum voltage and minimum clearance; Average = Maximum voltage and average clearance.
2 Fields at west edge of right-of-way adjacent to the Phase I circuit are given first.

**Table 3: Calculated peak and edge of right-of-way (ROW) magnetic fields for the proposed North Steens transmission line.**

| | Magnetic Field, mG | | | | | |
|---|---|---|---|---|---|---|
| **Phase** | I | | II | | III | |
| **Field[1]** | **Maximum** | **Average** | **Maximum** | **Average** | **Maximum** | **Average** |
| **Peak on ROW** | 52 | 14 | 93 | 23 | 97 | 25 |
| **At Edge of ROW[2]** | 15, 9 | 5, 3 | 7, 21 | 2, 7 | 12, 25 | 4, 8 |

1 Maximum = Maximum current and minimum clearance; Average = Average current and average clearance.
2 Fields at west edge of right-of-way adjacent to the Phase I circuit are given first.

**Table 4: Electric- and magnetic-field exposure guidelines.**

| ORGANIZATION | TYPE OF EXPOSURE | ELECTRIC FIELD, kV/m | MAGNETIC FIELD, mG |
|---|---|---|---|
| **ACGIH** | Occupational | 25[1] | 10,000 |
| **ICNIRP** | Occupational | 8.3[2] | 4,200 |
| | General Public | 4.2 | 833 |
| **IEEE** | Occupational | 20 | 27,100 |
| | General Public | 5[3] | 9,040 |

[1] Grounding is recommended above 5 –7 kV/m and conductive clothing is recommended above 15 kV/m.
[2] Increased to 16.7 kV/m if nuisance shocks are eliminated.
[3] Within power line rights-of-way, the guideline is 10 kV/m.

Sources: ACGIH, 2008; ICNIRP, 1998; ICES, 2002

**Table 5: States with transmission-line field limits.**

| STATE AGENCY | WITHIN RIGHT-OF-WAY | AT EDGE OF RIGHT-OF-WAY | COMMENTS |
|---|---|---|---|
| **a. 60-Hz ELECTRIC-FIELD LIMIT, kV/m** | | | |
| Florida Department of Environmental Regulation | 8 ( 230 kV)<br>10 (500 kV) | 2 | Codified regulation, adopted after a public rulemaking hearing in 1989. |
| Minnesota Environmental Quality Board | 8 | – | 12-kV/m limit on the high voltage direct current (HVDC) nominal electric field. |
| Montana Board of Natural Resources and Conservation | 7[1] | 1[2] | Codified regulation, adopted after a public rulemaking hearing in 1984. |
| New Jersey Department of Environmental Protection | – | 3 | Used only as a guideline for evaluating complaints. |
| New York State Public Service Commission | 11.8<br>(7,11)[3] | 1.6 | Explicitly implemented in terms of a specified right-of-way width. |
| Oregon Facility Siting Council | 9 | – | Codified regulation, adopted after a public rulemaking hearing in 1980. |
| **b. 60-Hz MAGNETIC-FIELD LIMIT, mG** | | | |
| Florida Department of Environmental Regulation | – | 150 ( 230 kV)<br>200 (500 kV) | Codified regulations, adopted after a public rulemaking hearing in 1989. |
| New York State Public Service Commission | – | 200 | Adopted August 29, 1990. |

[1] At road crossings
[2] Landowner may waive limit
[3] At highway and private road crossings, respectively

Source: USDOE, 1996

**Table 6: Common noise levels.**

| Sound Level, dBA | Noise Source or Effect |
|---|---|
| 128 | Threshold of pain |
| 110 | Rock-and-roll band |
| 80 | Truck at 50 ft. |
| 70 | Gas lawnmower at 100 ft. |
| 60 | Normal conversation indoors |
| 50 | Moderate rainfall on foliage |
| 47 | $L_{50}$ at edge of right-of-way during rain for Phase III |
| 40 | Refrigerator |
| 25 | Bedroom at night |
| 0 | Hearing threshold |

Adapted from: USDOE, 1996.

**Table 7: Predicted foul-weather and fair-weather audible noise (AN) levels at edge of right-of-way (ROW) for the proposed North Steens transmission line.** AN levels expressed in decibels on the A-weighted scale (dBA).

| | Audible Noise at Edge of ROW, dBA | | | | | |
|---|---|---|---|---|---|---|
| Phase | I | | II | | III | |
| Descriptor[1] | $L_{50}$, dBA | $L_5$, dBA | $L_{50}$, dBA | $L_5$, dBA | $L_{50}$, dBA | $L_5$, dBA |
| **Foul Weather**[2] | 8, 6 | 11, 10 | 43, 44 | 46, 47 | 47 | 50 |
| **Fair Weather**[2] | – | – | 18, 19 | 21, 22 | 22 | 25 |

1 $L_{50}$ and $L_5$ denote the levels exceeded 50 and 5 percent of the time, respectively.
2 Fields at west edge of right-of-way adjacent to the Phase I circuit are given first.

**Figure 1: Double circuit tower for the proposed North Steens transmission line.** Line configurations for Phases I, II and III are described in Table 1.

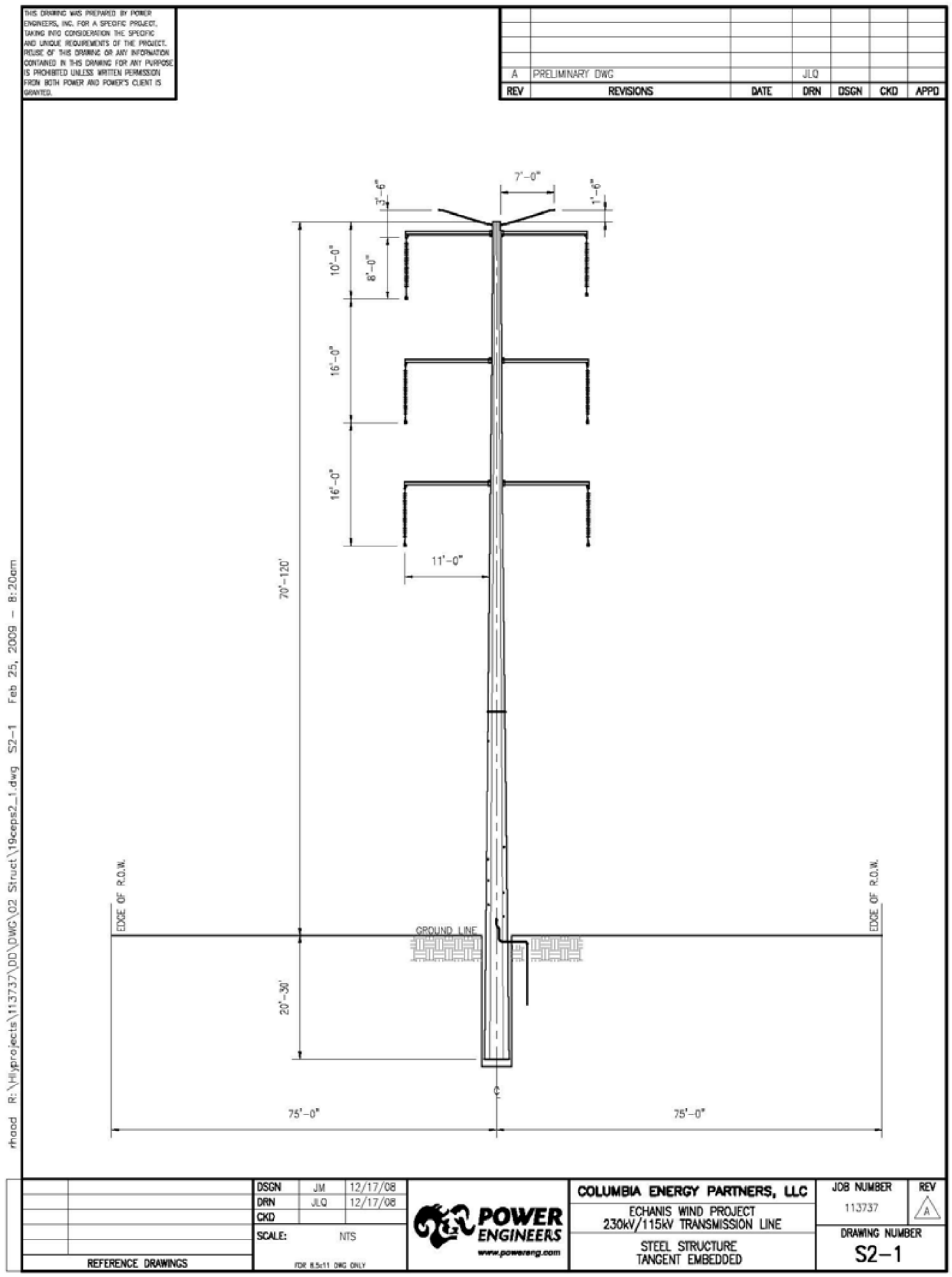
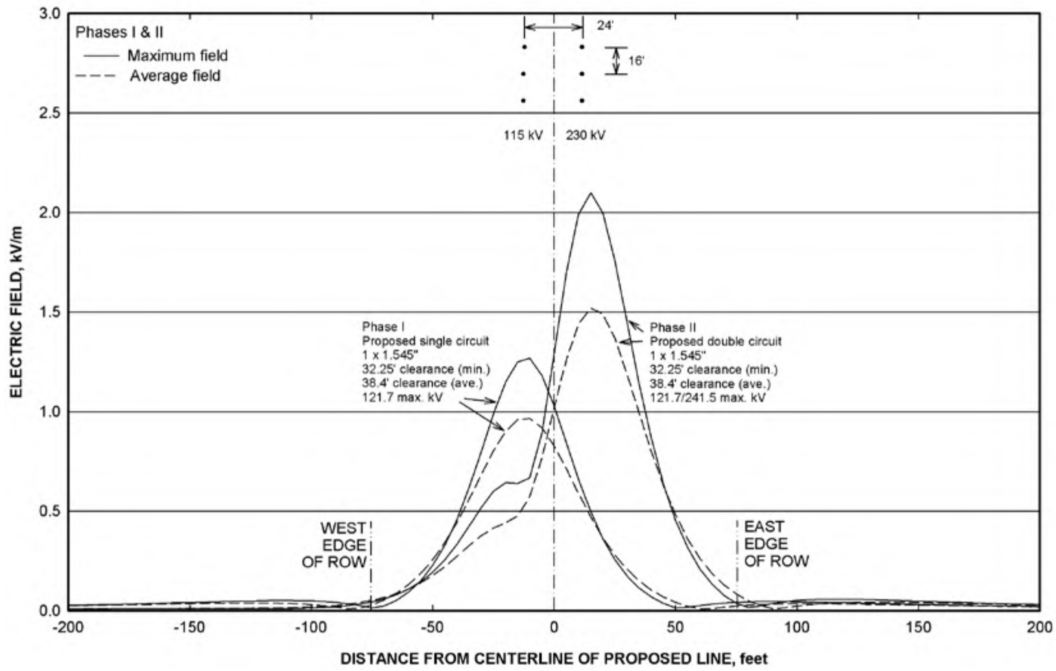


**Figure 2: Calculated maximum and average electric-field profiles for the proposed North Steens transmission line: a) Phases I and II; b) Phase III.** Line configurations are described in Table 1.

**a) Phases I and II**




**b) Phase III**

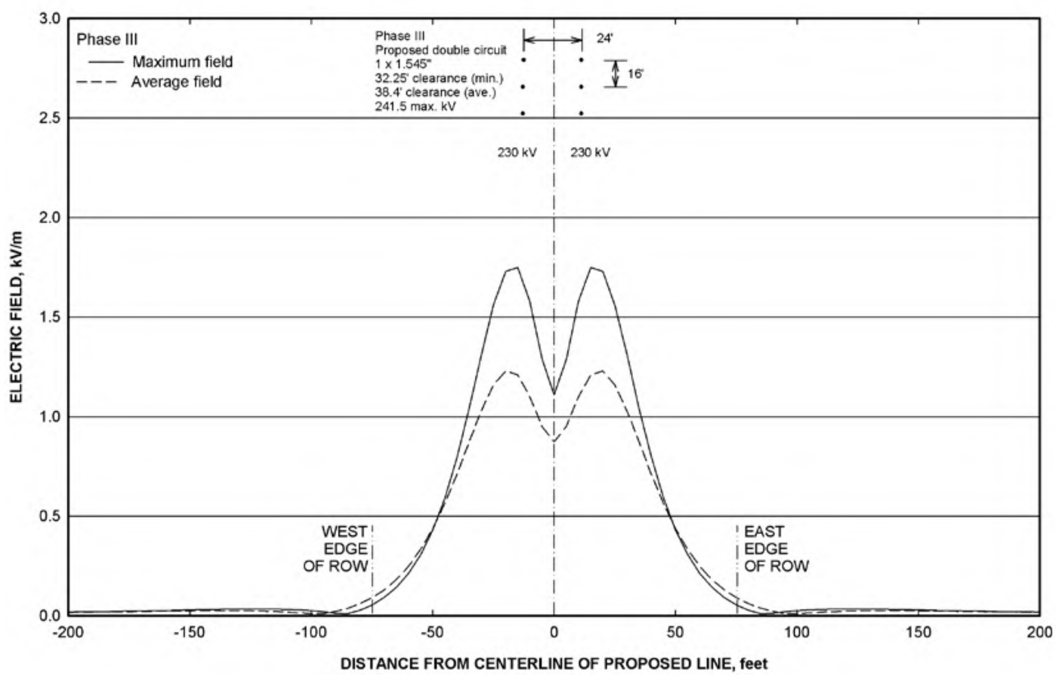
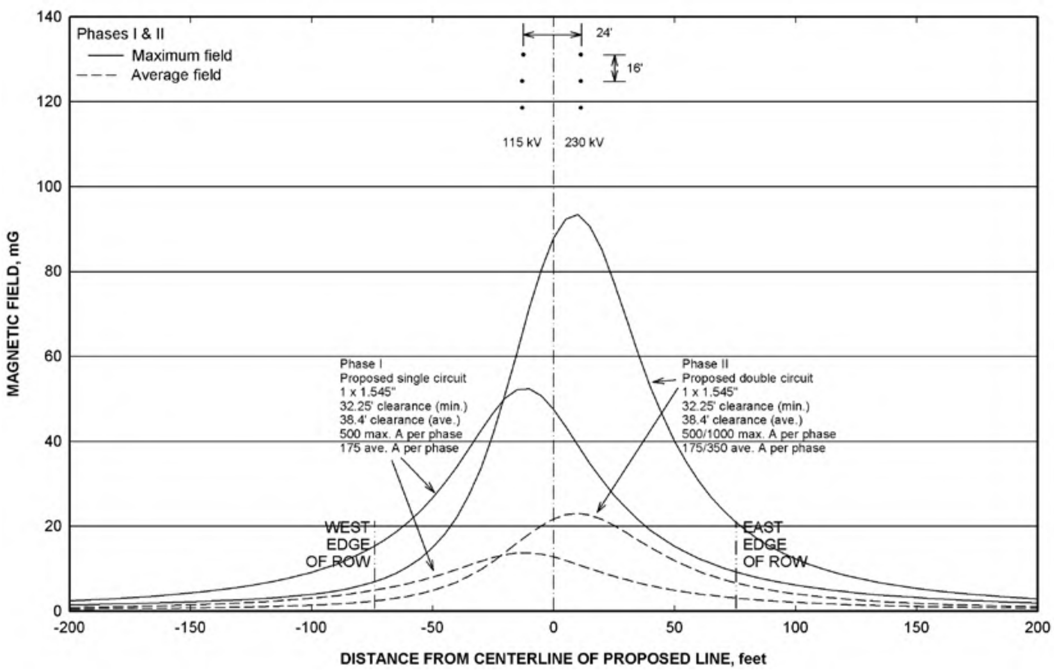


**Figure 3: Calculated maximum and average magnetic-field profiles for the proposed North Steens transmission line: a) Phases I and II; b) Phase III.** Line configurations are described in Table 1.

**a) Phases I and II**




**b) Phase III**

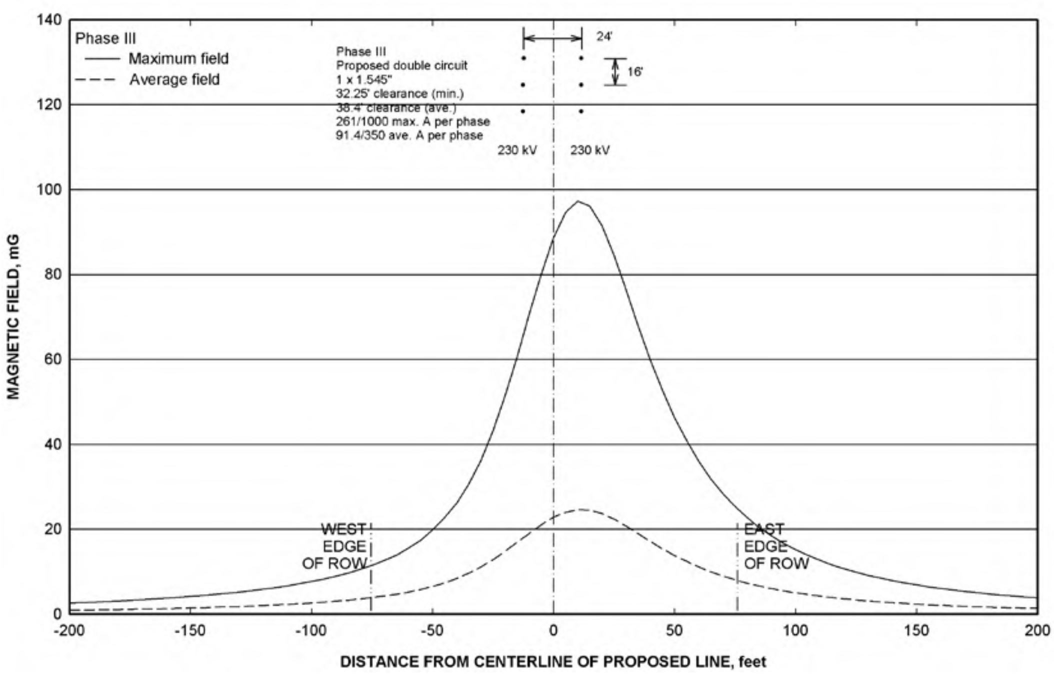
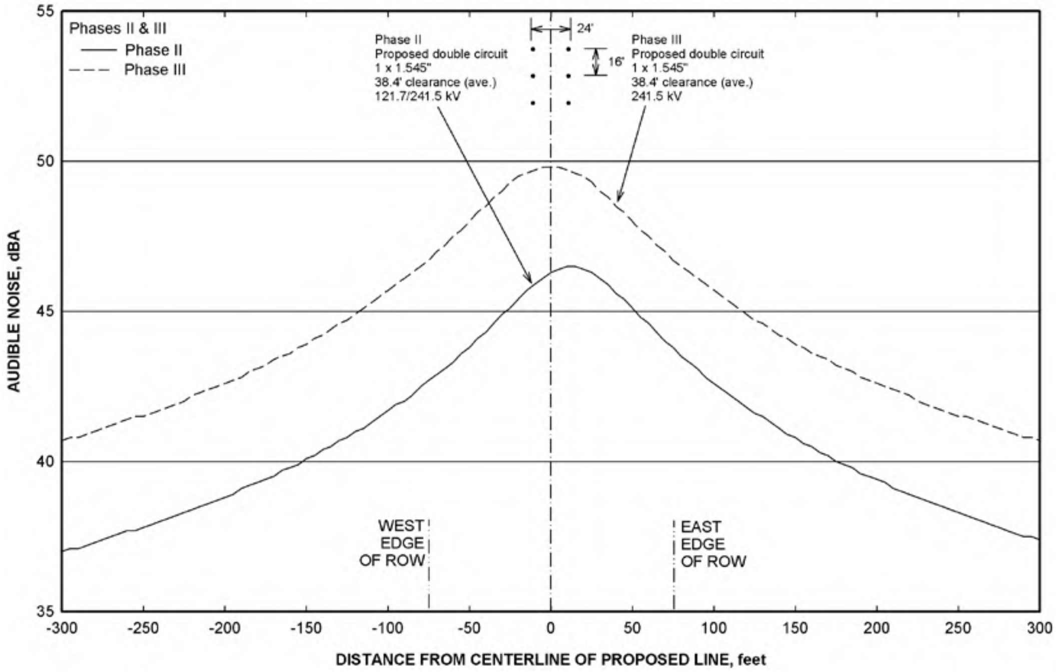


**Figure 4: Predicted foul-weather $L_{50}$ audible noise levels for Phases II and III of the proposed North Steens transmission line.** Line configurations are described in Table 1.



*This page intentionally left blank.*

Big Eddy-Knight 500-kV Project, Final EIS, Appendix E (July 2011)

# Appendix E

# Electric Fields, Magnetic Fields, Noise, and Radio Interference

# ***BIG EDDY – KNIGHT***
# ***500-kV TRANSMISSION PROJECT***

## *APPENDIX E*

## *ELECTRICAL EFFECTS*

March 2010

**Prepared by**

**T. Dan Bracken, Inc.**

**for**

**Bonneville Power Administration**

# Table of Contents

# List of Tables

# List of Figures

**This page intentionally left blank.**

# ELECTRICAL EFFECTS FROM THE PROPOSED BIG EDDY – KNIGHT 500-kV TRANSMISSION LINE PROJECT

## 1.0 Introduction

The Bonneville Power Administration (BPA) is proposing to build an approximately 28-mile 500-kilovolt (kV) transmission line from the existing BPA Big Eddy Substation in Wasco County, Oregon to the proposed BPA Knight Substation near Goldendale in Klickitat, County, Washington. The proposed line is designated the Big Eddy – Knight transmission line. The proposed transmission line will traverse mostly arid pasture and agricultural land that is sparsely populated. However, there are scattered structures throughout the project area. Three alternative routes – West, Middle and East - are under consideration for the proposed transmission line as shown in Figure 1.

The purpose of this report is to describe and quantify the electrical effects of the proposed Big Eddy – Knight 500-kV transmission line along the alternative routes. These effects include the following:

- the levels of 60-hertz (Hz; cycles per second) electric and magnetic fields (EMF) at 3.28 feet (ft.) or 1 meter (m) above the ground,
- the effects associated with those fields,
- the levels of audible noise produced by the line, and
- electromagnetic interference associated with the line.

Electrical effects occur near all transmission lines, including those 500-kV lines already present in the area of the proposed route for the Big Eddy – Knight line. Therefore, the levels of these quantities for the proposed line are computed and compared with those from the existing lines in Oregon, Washington and elsewhere.

The proposed line would be built on new and existing right-of-way, paralleling existing lower voltage lines along portions of the route. The length of the sections with parallel line depends on the alternative route. Electrical effects were analyzed for all segments with or without parallel lines that had constant physical and electrical characteristics for over more than one mile. Shorter segments (< 1 mile) could occur where the line changes direction, crosses a roadway or enters a substation. The electrical effects associated with these short line segments would be very similar to those for the analyzed segments. The proposed project has 13 different line configurations (physical and electrical changes that could affect the field levels) with line segments greater than one mile in length. The 13 line configurations are described in Table 1.

The voltage on the conductors of transmission lines generates an electric field in the space between the conductors and the ground. The electric field is calculated or measured in units of volts-per-meter (V/m) or kilovolts-per-meter (kV/m) at a height of 3.28 feet (ft.) (1 meter [m]) above the ground. The current flowing in the conductors of the transmission line generates a magnetic field in the air and earth near the transmission line; current is expressed in units of amperes (A). The magnetic field is expressed in milligauss (mG), and is usually measured or calculated at a height of 3.28 ft. (1 m) above the ground. The electric field at the surface of the conductors causes the phenomenon of corona. Corona is the electrical breakdown or ionization of air in very strong electric fields, and is the source of audible noise, electromagnetic radiation, and visible light.

To quantify EMF levels along the route, the electric and magnetic fields from the proposed and existing lines were calculated using the BPA Corona and Field Effects Program (USDOE, undated). In this program, the calculation of 60-Hz fields uses standard superposition techniques for vector fields from several line sources: in this case, the line sources are transmission-line conductors. (Vector fields have both magnitude and direction: these must be taken into account when combining fields from different sources.) Important input parameters to the computer program are voltage, current, and geometric configuration of the line. The transmission-line conductors are assumed to be straight, parallel to each other, and located above and parallel to an infinite flat ground plane. Although such conditions do not occur under real lines because of conductor sag and variable terrain, the validity and limitations of calculations using these assumptions have been well verified by comparisons with measurements. This approach was used to estimate fields for the proposed Big Eddy -Knight line, where minimum clearances were assumed to provide worst-case (highest) estimates for the fields.

Electric fields are calculated using an imaging method. Fields from the conductors and their images in the ground plane are superimposed with the proper magnitude and phase to produce the total field at a selected location.

The total magnetic field is calculated from the vector summation of the fields from currents in all the transmission-line conductors. Balanced currents are assumed for each three-phase circuit and the contribution of induced image currents in the conductive earth is not included. Peak current and power flow direction for the proposed line were provided by BPA and are based on the projected system normal annual peak power loads in 2013.

Electric and magnetic fields for the proposed line were calculated at the standard height (3.28 ft. or 1 m) above the ground (IEEE, 1987). Calculations were performed out to 300 ft. (91 m) from the centerline of the existing corridor. The validity and limitations of such calculations have been well verified by measurements. Because maximum voltage, maximum current, and minimum conductor height above-ground are used, ***the calculated values given here represent worst-case conditions:*** i.e., the calculated fields are higher than they would be in practice. Such worst-case conditions would seldom occur.

The corona performance of the proposed line was also predicted using the BPA Corona and Field Effects Program (USDOE, undated). Corona performance is calculated using empirical equations that have been developed over several years from the results of measurements on numerous high-voltage lines (Chartier and Stearns, 1981; Chartier, 1983). The validity of this approach for corona-generated audible noise has been demonstrated through comparisons with measurements on other lines all over the United States (IEEE Committee Report, 1982). The accuracy of this method for predicting corona-generated radio and television interference from transmission lines has also been established (Olsen et al., 1992). Important input parameters to the computer program are voltage, current, conductor size, and geometric configuration of the line.

Corona is a highly variable phenomenon that depends on conditions along a length of line. Predictions of the levels of corona effects are reported in statistical terms to account for this variability. Calculations of audible noise and electromagnetic interference levels were made under conditions of an estimated average operating voltage (536 kV for the proposed line) and with the average line height over a span of 47 ft. (14.3 m).

Levels of audible noise, radio interference, and television interference are predicted for both fair and foul weather; however, corona is basically a foul-weather phenomenon. Wet conductors can occur during periods of rain, fog, snow, or icing. Along the route of the proposed Big Eddy -Knight transmission line, such conditions are expected to occur about 1 percent of the time during a year, based on hourly precipitation records during years with complete records for Moro, Oregon (2000-2003) and Kennewick, WA (2006-2008).(NOAA, 2010) Corona activity also increases with altitude. For purposes of evaluating corona effects from the proposed line, an altitude that corresponded to the average where each line configuration would be constructed was assumed for that configuration. Assumed altitudes ranged from 350 to 1650 ft. (100 to 500 m).

# 2.0 Physical Description

## 2.1 Proposed Line

The proposed 500-kV transmission line would be a three-phase, single-circuit line. Each phase is carried on a separate set of conductors (wires). For the 500-kV line, each phase actually is carried on a bundle of three conductors (wires) and there are three bundles per circuit as shown in Figure 2.

The voltage and current waves on each phase are displaced by 120° in time (one-third of a cycle) from the waves on the other phases. The proposed line would be placed either on single-circuit towers with the phases arranged in a delta (triangular) configuration (Figure 2) or on double-circuit towers with three of six phase conductors or bundles arranged vertically on either side of the tower (Figure 8). The double-circuit towers would support both the proposed line and an existing parallel lower voltage line or just the proposed line with the proposed line located on the west side of the double-circuit tower. For some configurations, the proposed line would be operated as a split-phase line. In this case, each phase is split between two bundles, one on either side of the double-circuit tower. A total of 13 configurations were identified for the project based on parallel lines, tower type and conductors.

BPA provided the physical and operating characteristics of the proposed and existing lines. The electrical characteristics and physical dimensions for the configurations of the proposed line are shown in Table 2 and the configurations are shown in Figures 2 to 12.

The maximum phase-to-phase voltage for the proposed line would be 550 kV and the average voltage would be 536 kV. The maximum electrical current on the line would be 970 amperes (A) per phase, based on the BPA projected system annual peak load in 2013 as the base year. The load factor for this line will be about 0.50 (average load = peak load x load factor), resulting in an average current of 485 A.

For most of the configurations each bundle of the proposed 500-kV line will have three 1.300-inch diameter conductors arranged in an inverted triangle bundle configuration with approximately 17-in. (43.3 cm) spacing between conductors. Some portions of the line could have slightly larger conductors to meet a BPA design criterion for audible noise performance. In this case, the conductor bundles would be comprised of three 1.600-inch diameter conductors arranged in an inverted triangle with approximately 19-in. (48.9 cm) spacing.

For the double-circuit tower configurations the east circuit on the tower would be strung with a 1x1.300-in conductor for configurations with an existing 115-kV circuit on that side. For the two configurations where an existing 230- or 345-kV line would be placed on the double-circuit tower, then a 3x1.300-in bundle would be used. The three-conductor bundle would also be used if the proposed 500-kV line was split between the two sides of the tower.

For the single-circuit tower with the phases arranged in a triangle or delta configuration, the horizontal spacing between phases in the lower conductor positions would be 46 ft. (14 m). The vertical spacing between the conductor positions would be 31.5 ft. (9.6 m).

For the double-circuit tower the horizontal spacing between the top and bottom pairs of conductor bundles would be 36.5 ft. (11.1 m) and the spacing between the middle pair of conductor bundles would be 56.5 ft. (17.2 m). The vertical spacing between the bundles would be 36 ft. (11.0 m).

Minimum conductor-to-ground clearance would be 35 or 36 ft. (10.7 or 11.0 m) at a conductor temperature of 122°F (50°C). This temperature represents heavy operating conditions and high ambient air temperatures; clearances above ground would be greater under normal operating temperatures. The larger 36-foot clearance would be employed to ensure that the BPA criterion for maximum electric field at ground level (9 kV/m) is met along the entire route. The 35-foot clearance would be used for the single circuit towers except for Configuration 3 where it could be raised to 36 feet, depending on the relative phases of the proposed and adjacent 345-kV line. The 36-foot clearance would also be used for the double-circuit tower configurations (Configurations 7-12). The average clearance above ground along a span will be approximately 47 ft. (14.3 m); this value was used for corona calculations and to estimate average electric and magnetic fields along the line.

The minimum clearance of 35 ft (10.7-m) or greater provided by BPA exceeds the minimum distance of the conductors above ground required to meet the National Electric Safety Code (NESC) (IEEE, 2002). At road crossings, the ground clearance would be at least 50 ft. (15.2 m).

New right-of-way for the proposed line will be 150 ft. (46 m) wide. When placed on existing right-of-way the centerline of the proposed line will be at least 75 ft. (23 m) from the edge.

### 2.2 Existing Lines

The proposed Big Eddy – Knight 500-kV line would parallel existing transmission lines along parts of all three alternative routes. In all, there are five existing lines that could be paralleled: the Harvalum - Big Eddy 230-kV line, the McNary – Ross 345-kV line, the Chenowick – Goldendale 115-kV line, the Spearfish Tap 115-kV line and the Big Eddy – Spring Creek 230-kV line. The lines to be paralleled and lengths of their parallel segments are dependent on the route. Descriptions of the three routes and five existing lines and their associated routes are given in Tables 1 and 2.

## 3.0 Electric Field

### 3.1 Basic Concepts

An electric field is said to exist in a region of space if an electrical charge, at rest in that space, experiences a force of electrical origin (i.e., electric fields cause free charges to move). Electric field is a vector quantity: that is, it has both magnitude and direction. The direction corresponds to the direction that a positive charge would move in the field. Sources of electric fields are unbalanced electrical charges (positive or negative) and time-varying magnetic fields. Transmission lines, distribution lines, house wiring, and appliances generate electric fields in their vicinity because of the unbalanced electrical charges associated with voltage on the conductors. On the power system in North America, the voltage and charge on the energized conductors are cyclic (plus to minus to plus) at a rate of 60 times per second. This changing voltage results in electric fields near sources that are also time-varying at a frequency of 60 hertz (Hz; a frequency unit equivalent to cycles per second).

As noted earlier, electric fields are expressed in units of volts per meter (V/m) or kilovolts (thousands of volts) per meter (kV/m). Electric- and magnetic-field magnitudes in this report are expressed in root-mean-square (rms) units. For sinusoidal waves, the rms amplitude is given as the peak amplitude divided by the square root of two.

The spatial uniformity of an electric field depends on the source of the field and the distance from that source. On the ground, under a transmission line, the electric field is nearly constant in magnitude and direction over distances of several feet (1 meter). However, close to transmission- or distribution-line conductors, the field decreases rapidly with distance from the conductors. Similarly, near small sources such as appliances, the field is not uniform and falls off even more rapidly with distance from the device. If an energized conductor (source) is inside a grounded conducting enclosure, then the electric field outside the enclosure is zero, and the source is said to be shielded.

Electric fields interact with the charges in all matter, including living systems. When a conducting object, such as a vehicle or person, is located in a time-varying electric field near a transmission line, the external electric field exerts forces on the charges in the object, and electric fields and currents are induced in the object. If the object is grounded, then the total current induced in the body (the "short-circuit current") flows to earth. The distribution of the currents within, say, the human body, depends on the electrical conductivities of various parts of the body: for example, muscle and blood have higher conductivity than bone and would therefore experience higher currents.

At the boundary surface between air and the conducting object, the field in the air is perpendicular to the conductor surface and is much, much larger than the field in the conductor itself. For example, the average surface field on a human standing in a 10 kV/m field is 27 kV/m; the internal fields in the body are much smaller: approximately 0.008 V/m in the torso and 0.45 V/m in the ankles.

## 3.2 Transmission-line Electric Fields

The electric field created by a high-voltage transmission line extends from the energized conductors to other conducting objects such as the ground, towers, vegetation, buildings, vehicles, and people. The calculated strength of the electric field at a height of 3.28 ft. (1 m) above an unvegetated, flat earth is frequently used to describe the electric field under straight parallel transmission lines. The most important transmission-line parameters that determine the electric field at a 1-m height are conductor height above ground and line voltage.

Calculations of electric fields from transmission lines are performed with computer programs based on well-known physical principles (cf., Deno and Zaffanella, 1982). The calculated values under these conditions represent an ideal situation. When practical conditions approach this ideal model, measurements and calculations agree. Often, however, conditions are far from ideal because of variable terrain and vegetation. In these cases, fields are calculated for ideal conditions, with the lowest conductor clearances to provide upper bounds on the electric field under the transmission lines. With the use of more complex models or empirical results, it is also possible to account accurately for variations in conductor height, topography, and changes in line direction. Because the fields from different sources add vectorially, it is possible to compute the fields from several different lines if the electrical and geometrical properties of the lines are known. However, in general, electric fields near transmission lines with vegetation below are highly complex and cannot be calculated. Measured fields in such situations are highly variable.

For evaluation of EMF from transmission lines, the fields must be calculated for a specific line condition. The NESC states the condition for evaluating electric-field-induced short-circuit current for lines with voltage above 98 kV, line-to-ground, as follows: conductors are at a minimum clearance from ground corresponding to a conductor temperature of 120°F (50°C), and at a maximum voltage (IEEE, 2002). BPA has supplied the needed information for calculating electric and magnetic fields from the proposed transmission lines: the maximum operating voltage, the estimated peak current in 2013, and the minimum conductor clearances.

There are standard techniques for measuring transmission-line electric fields (IEEE, 1987). Provided that the conditions at a measurement site closely approximate those of the ideal situation assumed for calculations, measurements of electric fields agree well with the calculated values. If the ideal conditions are not approximated, the measured field can differ substantially from calculated values. Usually the actual electric field at ground level is reduced from the calculated values by various common objects that act as shields.

Maximum or peak field values occur over a small area at midspan, where conductors are closest to the ground (minimum clearance). As the location of an electric-field profile approaches a tower, the conductor clearance increases, and the peak field decreases. A grounded tower will reduce the electric field considerably by shielding.

For traditional transmission lines, such as the proposed line, where the right-of-way extends laterally well beyond the conductors, electric fields at the edge of the right-of-way are not as sensitive as the peak field to conductor height. Computed values at the edge of the right-of-way for any line height are fairly representative of what can be expected all along the transmission-line corridor. However, the presence of vegetation on and at the edge of the right-of-way will reduce actual electric-field levels below calculated values.

## 3.3 Calculated Values of Electric Fields

Table 3 shows the calculated values of electric field at 3.28 ft. (1 m) above ground for the proposed Big Eddy - Knight 500-kV transmission-line configurations. The maximum value on the right-of-way and the value at the edge of the right-of-way are given for the proposed configurations at minimum conductor clearance and at the estimated average clearance along a span. Both the maximum and average fields were computed with the line operating at the maximum voltage of 550 kV. Lateral profiles of the electric fields for the 13 configurations are shown in Figures 13 – 24.

The calculated maximum electric fields expected on the right-of-way of the proposed line range from 7.4 to 8.8 kV/m, depending on the configuration. For average clearance, the peak field ranges from 4.2 to 5.8 kV/m. As shown in Figures 13 to 24, the peak values would be present only at locations directly under the line, near mid-span, where the conductors are at the minimum clearance. The conditions of minimum conductor clearance at maximum current and maximum voltage occur very infrequently. The calculated peak levels are rarely reached under real-life conditions, because the actual line height is generally above the minimum value used in the computer model, because the actual voltage is below the maximum value used in the model, and because vegetation within and near the edge of the right-of-way tends to shield the field at ground level.

The average values expected at the edge of the right-of-way of the proposed line range from 2.4 to less than 0.1 kV/m. The largest field values at the edge of the right-of-way occur for configurations where the centerline of the proposed single-circuit delta tower is located 75 ft from the edge.

For comparison the electric fields along the existing corridors for the No-action alternative are also shown in Table 3. For the existing lines the maximum fields range from 0 to 4.5 kV/m and the average peak field ranges from 0 to 2.6 kV/m. Average fields at the edge of the right-of-way vary from 0 to 1.3 kV/m for the No-action alternative. The principal reason for the lower fields in the No-action alternative is the absence of a 500-kV line among the existing lines.

## 3.4 Environmental Electric Fields

The electric fields associated with the proposed Big Eddy - Knight transmission line can be compared with those found in other environments. Sources of 60-Hz electric (and magnetic) fields exist everywhere electricity is used; levels of these fields in the modern environment vary over a wide range. Electric-field levels associated with the use of electrical energy are orders of magnitude greater than the naturally occurring 60-Hz fields of about 0.0001 V/m, which stem from atmospheric and extraterrestrial sources.

Electric fields in outdoor, publicly accessible places range from less than 1 V/m to 12 kV/m; the large fields exist close to high-voltage transmission lines of 500 kV or higher. In remote areas without electrical service, 60-Hz field levels can be much lower than 1 V/m. Electric fields in home and work environments generally are not spatially uniform like those of transmission lines; therefore, care must be taken when making comparisons between fields from different sources such as appliances and electric lines. In addition, fields from all sources can be strongly modified by the presence of conducting objects. However, it is helpful to know the levels of electric fields generated in domestic and office environments in order to compare commonly experienced field levels with those near transmission lines.

Numerous measurements of residential electric fields have been reported for various parts of the United States, Canada, and Europe. Although there have been no large studies of residential electric fields, sufficient data are available to indicate field levels and characteristics. Measurements of domestic 60-Hz electric fields indicate that levels are highly variable and source-dependent. Electric-field levels are not easily predicted because walls and other objects act as shields, because conducting objects perturb the field, and because homes contain numerous localized sources. Internal sources (wiring, fixtures, and appliances) seem to predominate in producing electric fields inside houses. Average measured electric fields in residences are generally in the range of 5 to 20 V/m. In a large occupational exposure monitoring project that included electric-field measurements at homes, average exposures for all groups away from work were generally less than 10 V/m (Bracken, 1990).

Electric fields from household appliances are localized and decrease rapidly with distance from the source. Local electric fields measured at 1 ft. (0.3 m) from small household appliances are typically in the range of 30 to 60 V/m. In a survey, reported by Deno and Zaffanella (1982), field measurements at a 1-ft. (0.3-m) distance from common domestic and workshop sources were found to range from 3 to 70 V/m. The localized fields from appliances are not uniform, and care should be taken in comparing them with transmission-line fields.

Electric blankets can generate higher localized electric fields. Sheppard and Eisenbud (1977) reported fields of 250 V/m at a distance of approximately 1 ft. (0.3 m). Florig et al. (1987) carried out extensive empirical and theoretical analysis of electric-field exposure from electric blankets and presented results in terms of uniform equivalent fields such as those near transmission lines. Depending on what parameter was chosen to represent intensity of exposure and the grounding status of the subject, the equivalent vertical 60-Hz electric-field exposure ranged from 20 to over 3500 V/m. The largest equivalent field corresponds to the measured field on the chest with the blanket-user grounded. The average field on the chest of an ungrounded blanket-user yields an equivalent vertical field of 960 V/m. As manufacturers have become aware of the controversy surrounding EMF exposures, electric blankets have been redesigned to reduce magnetic fields. However, electric fields from these “low field” blankets are still comparable with those from older designs (Bassen et al., 1991).

Generally, people in occupations not directly related to high-voltage equipment are exposed to electric fields comparable with those of residential exposures. For example, the average electric field measured in 14 commercial and retail locations in rural Wisconsin and Michigan was 4.8 V/m (IIT Research Institute, 1984). Median electric field was about 3.4 V/m. These values are about one-third the values in residences reported in the same study. Electric-field levels in public buildings such as shops, offices, and malls appear to be comparable with levels in residences.

In a survey of 1,882 volunteers from utilities, electric-field exposures were measured for 2,082 work days and 657 non-work days (Bracken, 1990). Electric-field exposures for occupations other than those directly related to high-voltage equipment were equivalent to those for non-work exposure.

Thus, except for the relatively few occupations where high-voltage sources are prevalent, electric fields encountered in the workplace are probably similar to those of residential exposures. Even in electric utility occupations where high field sources are present, exposures to high fields are limited on average to minutes per day.

Electric fields found in publicly accessible areas near high-voltage transmission lines can typically range up to 3 kV/m for 230-kV lines, to 10 kV/m for 500-kV lines, and to 12 kV/m for 765-kV lines. Although these peak levels are considerably higher than the levels found in other public areas, they are present only in limited areas on rights-of-way.

The calculated electric fields for the proposed Big Eddy – Knight 500-kV transmission line are consistent with the levels reported for other 500-kV transmission lines in Washington, Oregon and elsewhere. The calculated electric fields on the right-of-way of the proposed transmission line would be much higher than levels normally encountered in residences and offices.

# 4.0 Magnetic Field

## 4.1 Basic Concepts

Magnetic fields can be characterized by the force they exert on a moving charge or on an electrical current. As with the electric field, the magnetic field is a vector quantity characterized by both magnitude and direction. Electrical currents generate magnetic fields. In the case of transmission lines, distribution lines, house wiring, and appliances, the 60-Hz electric current flowing in the conductors generates a time-varying, 60-Hz magnetic field in the vicinity of these sources. The strength of a magnetic field is measured in terms of magnetic lines of force per unit area, or magnetic flux density. The term “magnetic field,” as used here, is synonymous with magnetic flux density and is expressed in units of gauss (G) or milligauss (mG). (The tesla (T) is the unit of magnetic flux density preferred in scientific publications, where 1.0 gauss equals one ten-thousandth of a tesla (0.1 mT) and 1.0 mG equals 0.1 microtesla [µT]).

The uniformity of a magnetic field depends on the nature and proximity of the source, just as the uniformity of an electric field does. Transmission-line-generated magnetic fields are quite uniform over horizontal and vertical distances of several feet near the ground. However, for small sources such as appliances, the magnetic field decreases rapidly over distances comparable with the size of the device.

The interaction of a time-varying magnetic field with conducting objects results in induced electric fields and currents in the object. A changing magnetic field through an area generates a voltage around any conducting loop enclosing the area (Faraday's law). This is the physical basis for the operation of an electrical transformer. For a time-varying sinusoidal magnetic field, the magnitude of the induced voltage around the loop is proportional to the area of the loop, the frequency of the field, and the magnitude of the field. The induced voltage around the loop results in an induced electric field and current flow in the loop material. The induced current that flows in the loop depends on the conductivity of the loop as well as its area.

## 4.2 Transmission-line Magnetic Fields

The magnetic field generated by currents on transmission-line conductors extends from the conductors through the air and into the ground. The magnitude of the field at a height of 3.28 ft. (1 m) is frequently used to describe the magnetic field under transmission lines. Because the magnetic field is not affected by non-ferrous materials, the field is not influenced by normal objects on the ground under the line. The direction of the maximum field varies with location. (The electric field, by contrast, is essentially vertical near the ground.) The most important transmission-line parameters that determine the magnetic field at 3.28 ft. (1 m) height are conductor height above ground and magnitude of the currents flowing in the conductors. As distance from the transmission-line conductors increases, the magnetic field decreases.

Calculations of magnetic fields from transmission lines are performed using well-known physical principles (cf., Deno and Zaffanella, 1982). The calculated values usually represent the ideal straight parallel-conductor configuration. For simplicity, a flat earth is usually assumed. Balanced currents (currents of the same magnitude for each phase) are also assumed. This is usually valid for transmission lines, where loads on all three phases are maintained in balance during operation. Induced image currents in the earth are usually ignored for calculations of magnetic field under or near the right-of-way. The resulting error is negligible. Only at distances greater than 300 ft. (91 m) from a line do such contributions become significant (Deno and Zaffanella, 1982). The clearance for magnetic-field calculations for the proposed line was the same as that used for electric-field evaluations.

Standard techniques for measuring magnetic fields near transmission lines are described in ANSI IEEE Standard No. 644-1994 (1994). Measured magnetic fields agree well with calculated values, provided the currents and line heights that go into the calculation correspond to the actual values for the line. To realize such agreement, it is necessary to get accurate current readings during field measurements (because currents on transmission lines can vary considerably over short periods of time) and also to account for all field sources in the vicinity of the measurements.

As with electric fields, the maximum or peak magnetic fields occur in areas near the centerline and at midspan where the conductors are the lowest. The magnetic field at the edge of the right-of-way is not very dependent on line height. If more than one line is present, the peak field will depend on the relative electrical phasing of the conductors and the relative direction of power flow in the lines.

## 4.3 Calculated Values for Magnetic Fields

Table 4 gives the calculated values of the magnetic field at 3.28 ft. (1 m) height for the proposed 500-kV transmission-line configurations. Field values on the right-of-way and at the edge of the right-of-way are given for projected maximum currents and minimum clearance during system annual peak load in 2013. Field levels at the same locations for average current and average conductor clearance are also given. The projected maximum currents are 970 A on each of the three phases of the proposed line. For double-circuit configurations where the phases are split between two sets of conductors, the maximum current on each set of conductors would be 485 A. Average currents over the year would be about 50 percent of the maximum values.

Figures 25 to 38 show lateral profiles of magnetic fields under these same current and clearance conditions for the proposed 500-kV transmission line and the existing adjacent lines. The levels for maximum current and minimum clearance shown in the figures represent the highest magnetic fields under the proposed Big Eddy – Knight 500-kV line except under extreme temperature conditions. The actual day-to-day magnetic-field levels would be lower. They would vary as currents change daily and seasonally and as clearances change with ambient temperature. As shown in the figures, the average fields along the line over a year would be considerably reduced from the maximum values, as a result of increased clearances and reduced current.

The maximum calculated 60-Hz magnetic fields expected at 3.28 ft. (1 m) above ground for the proposed line range from 219mG to 60 mG for the 13 configurations of the proposed line. The highest fields would occur for single and double circuit towers that are adjacent to the existing Harvalum - Big Eddy 230-kV line (Configurations 2, 3 and 9). The lowest maximum fields would occur for the double-circuit tower configurations with split-phasing (Configurations 7 and 12). Maximum fields on the existing rights-of-way would range from 176 to 0 mG should the proposed line not be built – the No-action alternative. The maximum fields in this case would occur under the existing Big Eddy – Spring Creek and Harvalum - Big Eddy 230-kV lines.

The estimated average peak fields on the right-of-way for the proposed line would range from 65 to 17 mG. The average peak field on the existing rights-of-way would range from 48 to 0 mG for the No-action alternative.

At the edge of the right-of-way of the proposed line (on new right-of-way with no adjacent lines), estimated maximum fields would be 42 mG for the single-circuit tower (Configuration 1), 14 mG for the double-circuit tower with split phasing (Configurations 7) and 52 mG for the double-circuit tower with a single circuit on one side (Configurations 7A and 10). The peak average fields at the edge of the right-of-way for these configurations would be 18, 6, and 21 mG, respectively.

On existing rights-of-way with parallel adjacent lines, the calculated levels at the edge of the right-of-way obviously depend on the width of the right-of-way and the current on the existing line. Consequently, on existing rights-of-way, the maximum magnetic field at the edge of the right-of-way for maximum current conditions would range from 67 to less than 1 mG, while the average field at the edge would range from 23 to less than 1 mG. The maximum edge of right-of-way values for the No-action alternative would range from 67 to 0 mG, while the average values range from 23 to 0 mG. The highest edge of right-of-way levels for the No-action alternative occur adjacent to the Harvalum - Big Eddy and Big Eddy - Spring Creek 230-kV lines.

The magnetic field falls off rapidly as distance from the line increases. At a distance of 200 ft. (61 m) from the centerline of the proposed single-circuit tower line with maximum current, the field would be 6.4 mG and the average field would be about 3 mG. At the same current and distance from the double-circuit tower with the split phase configuration, the maximum and average fields would be less than 2 mG. For the double-circuit tower with only a single-circuit on one side, the maximum and average fields at 200 feet would be about 10 and 3 mG, respectively. The largest maximum and average fields at 200 feet from the existing lines for the No-action alternative would be 6-7 mG and 2-4 mG, respectively. These largest values for existing lines would occur adjacent to the Harvalum - Big Eddy 230-kV line, the Big Eddy – Spring Creek 230-kV line, and the McNary – Ross 345-kV line.

There would 2 to 5 houses within 300 feet of the proposed centerline and 10 to 12 houses within 500 ft, depending on which route and line designs are selected (Table 5). The average magnetic fields at these houses would range from 0.5 to 22.3 mG for the single-circuit configuration routes and from 0.1 to 3.5 mG for the double circuit routes. The range of maximum fields would be from 1.1 to 45 mG for the single-circuit routes and from 0.2 to 7 mG for the double circuit routes. (Note: A single house at 71 ft from the centerline of the proposed single-circuit configuration contributes the high upper ranges of average and maximum fields for the East and Middle alternatives shown in Table 5.)

In general, magnetic fields at houses would be higher for the East and Middle alternatives than for the West alternative when single circuit configurations are used. The opposite would be true if double-circuit configurations were used: in this case, magnetic fields would be higher at houses along the West alternative than along the other two routes.

### 4.4 Environmental Magnetic Fields

Transmission lines are not the only source of magnetic fields; as with 60-Hz electric fields, 60-Hz magnetic fields are present throughout the environment of a society that relies on electricity as a principal energy source. The magnetic fields associated with the proposed Big Eddy - Knight 500 kV line can be compared with fields from other sources. The range of 60-Hz magnetic-field exposures in publicly accessible locations such as open spaces, transmission-line rights-of-way, streets, pedestrian walkways, parks, shopping malls, parking lots, shops, hotels, public transportation, and so on range from less than 0.1 mG to about 1 G, with the highest values occurring near small appliances with electric motors. In occupational settings in electric utilities, where high currents are present, magnetic-field exposures for workers can be above 1 G. At 60 Hz, the magnitude of the natural magnetic field is approximately 0.0005 mG.

Several investigations of residential fields have been conducted. In a large study to identify and quantify significant sources of 60-Hz magnetic fields in residences, measurements were made in 996 houses, randomly selected throughout the country (Zaffanella, 1993). The most common sources of residential fields were power lines, the grounding system of residences, and appliances. Field levels were characterized by both point-in-time (spot) measurements and 24-hour measurements. Spot measurements averaged over all rooms in a house exceeded 0.6 mG in 50 percent of the houses and 2.9 mG in 5 percent of houses. Power lines generally produced the largest average fields in a house over a 24-hour period. On the other hand, grounding system currents proved to be a more significant source of the highest fields in a house. Appliances were found to produce the highest local fields; however, fields fell off rapidly with increased distance. For example, the median field near microwave ovens was 36.9 mG at a distance of 10.5 in (0.27 m) and 2.1 mG at 46 in (1.17 m). Across the entire sample of 996 houses, higher magnetic fields were found in, among others, urban areas (vs. rural); multi-unit dwellings (vs. single-family); old houses (vs. new); and houses with grounding to a municipal water system.

In an extensive measurement project to characterize the magnetic-field exposure of the general population, over 1000 randomly selected persons in the United States wore a personal exposure meter for 24 hours and recorded their location in a simple diary (Zaffanella and Kalton, 1998). Based on the measurements of 853 persons, the estimated 24-hour average exposure for the general population is 1.24 mG and the estimated median exposure is 0.88 mG. The average field “at home, not in bed” is 1.27 mG and “at home, in bed” is 1.11 mG. Average personal exposures were found to be largest “at work” (mean of 1.79 mG and median of 1.01 mG) and lowest “at home, in bed” (mean of 1.11 mG and median of 0.49 mG). Average fields in school were also low (mean of 0.88 mG and median of 0.69 mG). Factors associated with higher exposures at home were smaller residences, duplexes and apartments, metallic rather than plastic water pipes, and nearby overhead distribution lines.

As noted above, magnetic fields from appliances are localized and decrease rapidly with distance from the source. Localized 60-Hz magnetic fields have been measured near about 100 household appliances such as ranges, refrigerators, electric drills, food mixers, and shavers (Gauger, 1985). At a distance of 1 ft. (0.3 m), the maximum magnetic field ranged from 0.3 to 270 mG, with 95 percent of the measurements below 100 mG. Ninety-five percent of the levels at a distance of 4.9 ft. (1.5 m) were less than 1 mG. Devices that use light-weight, high-torque motors with little magnetic shielding exhibited the largest fields. These included vacuum cleaners and small hand-held appliances and tools. Microwave ovens with large power transformers also exhibited relatively large fields. Electric blankets have been a much-studied source of magnetic-field exposure because of the length of time they are used and because of the close proximity to the body. Florig and Hoburg (1988) estimated that the average magnetic field in a person using an electric blanket was 15 mG, and that the maximum field could be 100 mG. New "low-field" blankets have magnetic fields at least 10 times lower than those from conventional blankets (Bassen et al., 1991).

In a domestic magnetic-field survey, Silva et al. (1989) measured fields near different appliances at locations typifying normal use (e.g., sitting at a typewriter or standing at a stove). Specific appliances with relatively large fields included can openers (n = 9), with typical fields ranging from 30 to 225 mG and a maximum value up to 2.7 G; shavers (n = 4), with typical fields from 50 to 300 mG and maximum fields up to 6.9 G; and electric drills (n = 2), with typical fields from 56 to 190 mG and maximum fields up to 1.5 G. The fields from such appliances fall off very rapidly with distance and are only present for short periods. Thus, although instantaneous magnetic-field levels close to small hand-held appliances can be quite large, they do not contribute to average area levels in residences. The technology of newer energy-efficient appliances is likely to reduce fields from appliances further.

Although studies of residential magnetic fields have not all considered the same independent parameters, the following consistent characterization of residential magnetic fields emerges from the data:

(1) External sources play a large role in determining residential magnetic-field levels. Transmission lines, when nearby, are an important external source. Unbalanced ground currents on neutral conductors and other conductors, such as water pipes in and near a house, can represent a significant source of magnetic field. Distribution lines per se, unless they are quite close to a residence, do not appear to be a traditional distance-dependent source.

(2) Homes with overhead electrical service appear to have higher average fields than those with underground service.

(3) Appliances represent a localized source of magnetic fields that can be much higher than average or area fields. However, fields from appliances approach area levels at distances greater than 3 ft. (1 m) from the device.

Although important variables in determining residential magnetic fields have been identified, quantification and modeling of their influence on fields at specific locations is not yet possible. However, a general characterization of residential magnetic-field level is possible: average levels in the United States are in the range of 0.5 to 1.0 mG, with the average field in a small number of homes exceeding this range by as much as a factor of 10 or more. Average personal exposure levels are slightly higher, possibly due to use of appliances and varying distances to other sources. Maximum fields can be much higher.

Magnetic fields in commercial and retail locations are comparable with those in residences. As with appliances, certain equipment or machines can be a local source of higher magnetic fields. Utility workers who work close to transformers, generators, cables, transmission lines, and distribution systems clearly experience high-level fields. Other sources of fields in the workplace include motors, welding machines, computers, and office equipment. In publicly accessible indoor areas, such as offices and stores, field levels are generally comparable with residential levels, unless a high-current source is nearby.

Because high-current sources of magnetic field are more prevalent than high-voltage sources, occupational environments with relatively high magnetic fields encompass a more diverse set of occupations than do those with high electric fields. For example, in occupational magnetic-field measurements reported by Bowman et al. (1988), the geometric mean field from 105 measurements of magnetic field in "electrical worker" job locations was 5.0 mG. "Electrical worker" environments showed the following elevated magnetic-field levels (geometric mean greater than 20 mG): industrial power supplies, alternating current (ac) welding machines, and sputtering systems for electronic assembly.

Measurements of personal exposure to magnetic fields were made for 1,882 volunteer utility workers for a total of 4,411 workdays (Bracken, 1990). Median workday mean exposures ranged from 0.5 mG for clerical workers without computers to 7.2 mG for substation operators. Occupations not specifically associated with transmission and distribution facilities had median workday exposures less than 1.5 mG, while those associated with such facilities had median exposures above 2.3 mG. Magnetic-field exposures measured in homes during this study were comparable with those recorded in offices.

Magnetic fields in publicly accessible outdoor areas seem to be, as expected, directly related to proximity to electric-power transmission and distribution facilities. Near such facilities, magnetic fields are generally higher than indoors (residential). Higher-voltage facilities tend to have higher fields. Typical maximum magnetic fields in publicly accessible areas near transmission facilities can range from less than a few milligauss up to 300 mG or more, near heavily loaded lines operated at 230 to 765 kV. The levels depend on the line load, conductor height, and location on the right-of-way. Because magnetic fields near high-voltage transmission lines depend on the current in the line, they can vary daily and seasonally.

Fields near distribution lines and equipment are generally lower than those near transmission lines. Measurements in Montreal indicated that typical fields directly above underground distribution systems were 5 to 19 mG (Heroux, 1987). Beneath overhead distribution lines, typical fields were 1.5 to 5 mG on the primary side of the transformer, and 4 to 10 mG on the secondary side. Near ground-based transformers used in residential areas, fields were 80 to 1000 mG at the surface and 10 to 100 mG at a distance of 1 ft. (0.3 m).

The magnetic fields from the proposed line would be comparable to or less than those from existing 500-kV lines in Washington and elsewhere. On and near the right-of-way of the proposed line, magnetic fields would be well above average residential levels. However, the fields from the line would decrease rapidly and approach common ambient levels at distances greater than a few hundred feet from the line. Furthermore, the fields at the edge of the right-of-way would not be above those encountered during normal activities near common sources such as hand-held appliances.

# 5.0 Electric and Magnetic Field (EMF) Effects

Possible effects associated with the interaction of EMF from transmission lines with people on and near a right-of-way fall into two categories: short-term effects that can be perceived and may represent a nuisance, and possible long-term health effects. Only short-term effects are discussed here. The issue of whether there are long-term health effects associated with transmission-line fields is controversial. In recent years, considerable research on possible biological effects of EMF has been conducted. A review of these studies and their implications for health-related effects is provided in a separate technical report for the environmental assessment for the proposed Big Eddy – Knight 500-kV transmission line (Exponent, 2009).

## 5.1 Electric Fields: Short-term Effects

Short-term effects from transmission-line electric fields are associated with perception of induced currents and voltages or perception of the field. Induced current or spark discharge shocks can be experienced under certain conditions when a person contacts objects in an electric field. Such effects occur in the fields associated with transmission lines that have voltages of 230-kV or higher. These effects could occur infrequently under the proposed Big Eddy - Knight 500-kV line.

Steady-state currents are those that flow continuously after a person contacts an object and provides a path to ground for the induced current. The amplitude of the steady-state current depends on the induced current to the object in question and on the grounding path. The magnitude of the induced current to vehicles and objects under the proposed line will depend on the electric-field strength and the size and shape of the object. When an object is electrically grounded, the voltage on the object is reduced to zero, and it is not a source of current or voltage shocks. If the object is poorly grounded or not grounded at all, then it acquires some voltage relative to earth and is a possible source of current or voltage shocks.

The responses of persons to steady-state current shocks have been extensively studied, and levels of response documented (Keesey and Letcher, 1969; IEEE, 1978). Primary shocks are those that can result in direct physiological harm. Such shocks will not be possible from induced currents under the existing or proposed lines, because clearances above ground required by the NESC preclude such shocks from large vehicles and grounding practices eliminate large stationary objects as sources of such shocks.

Secondary shocks are defined as those that could cause an involuntary and potentially harmful movement, but no direct physiological harm. Secondary shocks could occur under the proposed 500-kV line when making contact with ungrounded conducting objects such as vehicles or equipment. However, such occurrences are anticipated to be very infrequent. Shocks, when they occur under the 500-kV line, are most likely to be below the nuisance level. Induced currents are extremely unlikely to be perceived off the right-of-way of the proposed line.

Induced currents are always present in electric fields under transmission lines and will be present near the proposed line. However, during initial construction, BPA routinely grounds metal objects that are located on or near the right-of-way. The grounding eliminates these objects as sources of induced current and voltage shocks. Multiple grounding points are used to provide redundant paths for induced current flow. After construction, BPA would respond to any complaints and install or repair grounding to mitigate nuisance shocks.

Unlike fences or buildings, mobile objects such as vehicles and farm machinery cannot be grounded permanently. Limiting the possibility of induced currents from such objects to persons is accomplished in several ways. First, required clearances for above-ground conductors tend to limit field strengths to levels that do not represent a hazard or nuisance. The NESC (2002) requires that, for lines with voltage exceeding 98 kV line-to-ground (170 kV line-to-line), sufficient conductor clearance be maintained to limit the induced short-circuit current in the largest anticipated vehicle under the line to 5 milliamperes (mA) or less. This can be accomplished by limiting access or by increasing conductor clearances in areas where large vehicles could be present. BPA and other utilities design and operate lines to be in compliance with the NESC.

For the proposed line, conductor clearances at 50°C conductor temperature would be increased to at least 50 ft. (15.2 m) over road crossings along the route to meet the BPA requirement that electric fields be less than 5.0 kV/m at road crossings. The actual clearance to meet the criterion would depend on the configuration and parallel lines. For example, in order for Configuration 3 to meet the 5.0 kV/m criterion at a clearance of 50 feet, adjacent phases of the proposed Big Eddy – Knight 500-kV line and the existing McNary – Ross 345-kV line could not be the same; for Configurations 7A and 10 clearance would have to be increased to 54 feet to meet the 5.0 kV/m criterion. In any case, the conductor clearance at each road crossing would be checked during the line design stage to ensure that the BPA 5-kV/m and NESC 5-mA criteria are met. Line clearances would also be increased in accordance with the NESC, such as over railroads and water areas suitable for sailboating.

The largest truck allowed on roads in Oregon and Washington without a special permit is 14 feet high by 8.5 feet wide by 75 feet long (4.3 x 2.6 x 22.9 m). The induced currents to such a vehicle oriented perpendicular to the line in a maximum field of 5 kV/m (at 3.28-foot height) would be 4.5 mA (Reilly, 1979). For smaller trucks, the maximum induced currents for perpendicular orientation to the proposed line would be less than this value. (Larger special-permitted trucks, such as triple trailers, can be up to 105 feet in length, but are not expected on the roads crossed by the proposed line. However, because they average the field over such a long distance, the maximum induced current to a 105-foot vehicle oriented perpendicular to the 500-kV line at a road crossing would be less than 4.5 mA.) Thus, the NESC 5-mA criterion would be met for perpendicular road crossings of the proposed line. These large vehicles are not anticipated to be off highways or oriented parallel and on the right –of-way of the proposed line. As discussed below, these are worst-case estimates of induced currents at road crossings; conditions for their occurrence are rare.

Several factors tend to reduce the levels of induced current shocks from vehicles:

(1) Activities are distributed over the whole right-of-way, and only a small percentage of time is spent in areas where the field is at or close to the maximum value.

(2) At road crossings, vehicles are aligned perpendicular to the conductors, resulting in a substantial reduction in induced current.

(3) The conductor clearance at road crossings may not be at minimum values because of lower conductor temperatures and/or location of the road crossing away from midspan.

(4) The largest vehicles are permitted only on certain highways.

(5) Off-road vehicles are in contact with soil or vegetation, which reduces shock currents substantially.

Induced voltages occur on objects, such as vehicles, in an electric field where there is an inadequate electrical ground. If the voltage is sufficiently high, then a spark discharge shock can occur as contact is made with the object. Such shocks are similar to "carpet" shocks that occur, for example, when a person touches a doorknob after walking across a carpet on a dry day. The number and severity of spark discharge shocks depend on electric-field strength. Based on the low frequency of complaints reported by Glasgow and Carstensen (1981) for 500-kV ac transmission lines (one complaint per year for each 1,500 mi. or 2400 km of 500-kV line), nuisance shocks, which are primarily spark discharges, do not appear to be a serious impediment to allowed activities under 500-kV lines. Recommended safety practices and restricted activities on BPA transmission line rights-of-way are described in the BPA booklet “Living and Working Safely Around High-Voltage Transmission Lines” (USDOE, 2007).

In electric fields higher than will occur under the proposed line, it is theoretically possible for a spark discharge from the induced voltage on a large vehicle to ignite gasoline vapor during refueling. The probability for exactly the right conditions to occur for ignition is extremely remote. The additional clearance of conductors provided at road crossings reduces the electric field in areas where vehicles are prevalent and reduces the chances for such events. Even so, BPA recommends that vehicles should not be refueled under the proposed line unless specific precautions are taken to ground the vehicle and the fueling source (USDOE, 2007).

Under certain conditions, the electric field can be perceived through hair movement on an upraised hand or arm of a person standing on the ground under high-voltage transmission lines. The median field for perception in this manner was 7 kV/m for 136 persons; only about 12 percent could perceive fields of 2 kV/m or less (Deno and Zaffanella, 1982). In areas under the conductors at midspan, the fields at ground level would exceed the levels where field perception normally occurs. In these instances, field perception could occur on the right-of-way of the proposed line. It is unlikely that the field would be perceived beyond the edge of the right-of-way. Where vegetation provides shielding, the field would not be perceived.

Conductive shielding reduces both the electric field and induced effects such as shocks. Persons inside a vehicle cab or canopy are shielded from the electric field. Similarly, a row of trees or a lower-voltage distribution line reduces the field on the ground in the vicinity. Metal pipes, wiring, and other conductors in a residence or building shield the interior from the transmission-line electric field.

The electric fields from the proposed 500-kV line would be comparable to those from existing 500-kV lines in the project area and elsewhere. Potential impacts of electric fields can be mitigated through grounding policies, adherence to the NESC, and increased clearances above the minimums specified by the NESC. Worst-case levels are used for safety analyses but, in practice, induced currents and voltages are reduced considerably by unintentional grounding. Shielding by conducting objects, such as vehicles and vegetation, also reduces the potential for electric-field effects.

## 5.2 Magnetic Field: Short-term Effects

Magnetic fields associated with transmission and distribution systems can induce voltage and current in long conducting objects that are parallel to the transmission line. As with electric-field induction, these induced voltages and currents are a potential source of shocks. A fence, irrigation pipe, pipeline, electrical distribution line, or telephone line forms a conducting loop when it is grounded at both ends. The earth forms the other portion of the loop. The magnetic field from a transmission line can induce a current to flow in such a loop if it is oriented parallel to the line. If only one end of the fence is grounded, then an induced voltage appears across the open end of the loop. The possibility for a shock exists if a person closes the loop at the open end by contacting both the ground and the conductor. The magnitude of this potential shock depends on the following factors: the magnitude of the field; the length of the object (the longer the object, the larger the induced voltage); the orientation of the object with respect to the transmission line (parallel as opposed to perpendicular, where no induction would occur); and the amount of electrical resistance in the loop (high resistance limits the current flow).

Magnetically induced currents from power lines have been investigated for many years; calculation methods and mitigating measures are available. A comprehensive study of gas pipelines near transmission lines developed prediction methods and mitigation techniques specifically for induced voltages on pipelines (Dabkowski and Taflove, 1979; Taflove and Dabkowski, 1979). Similar techniques and procedures are available for irrigation pipes and fences. Grounding policies employed by utilities for long fences reduce the potential magnitude of induced voltage.

The magnitude of the coupling with both pipes and fences is very dependent on the electrical unbalance (unequal currents) among the three phases of the line. Thus, a distribution line where a phase outage may go unnoticed for long periods of time can represent a larger source of induced currents than a transmission line where the loads are well-balanced (Jaffa and Stewart, 1981).

Knowledge of the phenomenon, grounding practices, and the availability of mitigation measures mean that magnetic-induction effects from the proposed 500-kV transmission line will be minimal.

Magnetic fields from transmission and distribution facilities can interfere with certain electronic equipment. Magnetic fields have been observed to cause distortion of the image on older VDTs and computer monitors that employ cathode ray tubes. This can occur in fields as low as 10 mG, depending on the type and size of the monitor (Baishiki et al., 1990; Banfai et al., 2000). Generally, the problem arose when computer monitors were in use near electrical distribution facilities in large office buildings. Contemporary display devices using flat-panel technologies, such as liquid-crystal or plasma displays are not affected.

Interference from magnetic fields can be eliminated by shielding the affected device or moving it to an area with lower fields. Interference from 60-Hz fields with computers and control circuits in vehicles and other equipment is not anticipated at the field levels found under and near the proposed 500-kV transmission line.

The magnetic fields from the proposed line will be comparable to those from existing 500-kV lines in the area of the proposed line.

## 6.0 Regulations

Regulations that apply to transmission-line electric and magnetic fields fall into two categories. Safety standards or codes are intended to limit or eliminate electric shocks that could seriously injure or kill persons. Field limits or guidelines are intended to limit electric- and magnetic-field exposures that can cause nuisance shocks or might cause health effects. In no case has a limit or standard been established because of a known or demonstrated health effect.

The proposed line would be designed to meet the NESC (IEEE, 2002), which specifies how far transmission-line conductors must be from the ground and other objects. The clearances specified in the code provide safe distances that prevent harmful shocks to workers and the public. In addition, people who live and work near transmission lines must be aware of safety precautions to avoid electrical (which is not necessarily physical) contact with the conductors. For example, farmers should not up-end irrigation pipes under a transmission or other electrical line. In addition, as a matter of safety, the NESC specifies that electric-field-induced currents from transmission lines to vehicles must be below the 5 mA ("let go") threshold deemed a lower limit for primary shock. BPA publishes and distributes a booklet that describes safe practices to protect against shock hazards around power lines (USDOE, 2007).

Field limits or guidelines have been adopted in several states and countries and by national and international organizations (Maddock, 1992). Electric-field limits have generally been based on minimizing nuisance shocks or field perception. The intent of magnetic-field limits has been to limit exposures to existing levels, given the uncertainty of their potential for health effects.

General guidelines for EMF exposure have been established for occupational and public exposure by national and international organizations. The limits established by three such guidelines are described in Table 5.

The American Conference of Governmental Industrial Hygienists (ACGIH) sets guidelines (Threshold Limit Values or TLVs) for occupational exposures to environmental agents (ACGIH, 2008). In general, a TLV represents the level below which it is believed that nearly all workers may be exposed repeatedly without adverse health effects. For EMF, the TLVs represent ceiling levels. For 60-Hz electric fields, occupational exposures should not exceed the TLV of 25 kV/m. However, the ACGIH also recognizes the potential for startle reactions from spark discharges and short-circuit currents in fields greater than 5-7 kV/m, and recommends implementing grounding practices. They recommend the use of conductive clothing for work in fields exceeding 15 kV/m. The TLV for occupational exposure to 60-Hz magnetic fields is a ceiling level of 10 G (10,000 mG) (ACGIH, 2008).

The International Committee on Non-ionizing Radiation Protection (ICNIRP), working in cooperation with the World Health Organization (WHO) has developed guidelines for occupational and public exposures to EMF (ICNIRP, 1998). For occupational exposures at 60 Hz, the recommended limits to exposure are 8.3 kV/m for electric fields and 4.2 G (4,200 mG) for magnetic fields. The electric-field level can be exceeded, provided precautions are taken to prevent spark discharge and induced current shocks. For the general public, the ICNIRP guidelines recommend exposure limits of 4.2 kV/m for electric fields and 0.83 G (830 mG) for magnetic fields (ICNIRP, 1998).

More recently the International Committee on Electromagnetic Safety (ICES) under the auspices of the IEEE has established exposure guidelines for 60-Hz electric and magnetic fields (ICES, 2002). The ICES recommended limits for occupational exposures are 20 kV/m for electric fields and 27,100 mG for magnetic fields. The recommended limits for the general public are lower: 5 kV/m for the general public, except on power line rights-of-way where the limit is 10 kV/m; and 9,040 mG for magnetic fields.

Electric and magnetic fields from various sources (including automobile ignitions, appliances and, possibly, transmission lines) can interfere with implanted cardiac pacemakers. In light of this potential problem, manufacturers design devices to be immune from such interference. However, research has shown that these efforts have not been completely successful and that a few models of older pacemakers still in use could be affected by 60-Hz fields from transmission lines. There were also numerous models of pacemakers that were not affected by fields larger than those found under transmission lines. Because of the known potential for interference with pacemakers by 60-Hz fields, field limits for pacemaker wearers have been established by the ACGIH. They recommend that, lacking additional information about their pacemaker, wearers of pacemakers and similar medical-assist devices limit their exposure to electric fields of 1 kV/m or less and to magnetic fields to 1 G (1,000 mG) or less (ACGIH, 2008). Additional discussion of interference with implanted devices is given in the accompanying technical report on health effects (Exponent, 2009).

There are currently no national standards in the United States for 60-Hz electric and magnetic fields. The state of Washington does not have guidelines for electric or magnetic fields from transmission lines. However, several states have been active in establishing mandatory or suggested limits on 60-Hz electric and (in two cases) magnetic fields. Six states have specific electric-field limits that apply to transmission lines: Florida, Minnesota, Montana, New Jersey, New York, and Oregon. Florida and New York have established regulations for magnetic fields. These regulations are summarized in Table 6.

Government agencies and utilities operating transmission systems have established design criteria that include EMF levels. BPA has maximum allowable electric fields of 9 and 5 kV/m on and at the edge of the right-of-way, respectively (USDOE, 1996). BPA also has maximum-allowable electric field strengths of 5 kV/m, 3.5 kV/m, and 2.5 kV/m for road crossings, shopping center parking lots, and commercial/ industrial parking lots, respectively. The latter levels are based on limiting the maximum short-circuit currents from anticipated vehicles to less than 1 mA in shopping center lots and to less than 2 mA in commercial parking lots.

The electric fields from the proposed 500-kV line would meet the ACGIH standards, provided wearers of pacemakers and similar medical-assist devices are discouraged from unshielded right-of-way use. (A passenger in an automobile under the line would be shielded from the electric field.) The electric fields in limited areas on the right-of-way would exceed the ICNIRP guideline for public exposure, but would be below IEEE guideline limits. The magnetic fields from the proposed line would be below the ACGIH, ICNIRP, and IEEE limits.

The estimated peak electric fields on the right-of-way of the proposed transmission line would meet limits set in Florida, New York and Oregon, but not those of Minnesota and Montana (see Table 6). The BPA maximum allowable electric field limit would be met for all configurations of the proposed line. The edge of right-of-way electric fields from the proposed line would be below limits set in Florida and New Jersey, but above those in Montana and New York.

The magnetic field at the edge of the right-of-way from the proposed line would be below the regulatory levels of states where such regulations exist.

# 7.0 Audible Noise

## 7.1 Basic Concepts

Audible noise (AN), as defined here, represents an unwanted sound, as from a transmission line, transformer, airport, or vehicle traffic. Sound is a pressure wave caused by a sound source vibrating or displacing air. The ear converts the pressure fluctuations into auditory sensations. AN from a source is superimposed on the background or ambient noise that is present before the source is introduced.

The amplitude of a sound wave is the incremental pressure resulting from sound above atmospheric pressure. The sound-pressure level is the fundamental measure of AN; it is generally measured on a logarithmic scale with respect to a reference pressure. The sound-pressure level (SPL) in decibels (dB) is given by:

$$SPL = 20 \log (P/P_o)\text{dB}$$

where P is the effective rms (root-mean-square) sound pressure, $P_o$ is the reference pressure, and the logarithm (log) is to the base 10. The reference pressure for measurements concerned with hearing is usually taken as 20 micropascals (Pa), which is the approximate threshold of hearing for the human ear. A logarithmic scale is used to encompass the wide range of sound levels present in the environment. The range of human hearing is from 0 dB up to about 140 dB, a ratio of 10 million in pressure (EPA, 1978).

Logarithmic scales, such as the decibel scale, are not directly additive: to combine decibel levels, the dB values must be converted back to their respective equivalent pressure values, the total rms pressure level found, and the dB value of the total recalculated. For example, adding two sounds of equal level on the dB scale results in a 3 dB increase in sound level. Such an increase in sound pressure level of 3 dB, which corresponds to a doubling of the energy in the sound wave, is barely discernible by the human ear. It requires an increase of about 10 dB in SPL to produce a subjective doubling of sound level for humans. The upper range of hearing for humans (140 dB) corresponds to a sharply painful response (EPA, 1978).

Humans respond to sounds in the frequency range of 16 to 20,000 Hz. The human response depends on frequency, with the most sensitive range roughly between 2000 and 4000 Hz. The frequency-dependent sensitivity is reflected in various weighting scales for measuring audible noise. The A-weighted scale weights the various frequency components of a noise in approximately the same way that the human ear responds. This scale is generally used to measure and describe levels of environmental sounds such as those from vehicles or occupational sources. The A-weighted scale is also used to characterize transmission-line noise. Sound levels measured on the A-scale are expressed in units of dB(A) or dBA.

AN levels and, in particular, corona-generated audible noise (see below) vary in time. In order to account for fluctuating sound levels, statistical descriptors have been developed for environmental noise. Exceedence levels (L levels) refer to the A-weighted sound level that is exceeded for a specified percentage of the time. Thus, the $L_5$ level refers to the noise level that is exceeded only 5 percent of the time. $L_{50}$ refers to the sound level exceeded 50 percent of the time. Sound-level measurements and predictions for transmission lines are often expressed in terms of exceedence levels, with the $L_5$ level representing the maximum level and the $L_{50}$ level representing a median level.

Table 7 shows AN levels from various common sources. Clearly, there is wide variation. Noise exposure depends on how much time an individual spends in different locations. Outdoor noise generally does not contribute to indoor levels (EPA, 1974). Activities in a building or residence generally dominate interior AN levels.

BPA has established a transmission-line design criterion for corona-generated audible noise ($L_{50}$, foul weather) of 50 dBA at the edge of the right-of-way (USDOE, 2006). This criterion applies to new line construction and is under typical conditions of foul weather, altitude, and system voltage for the line. It is generally only of concern for 500-kV lines. This criterion has been interpreted by the state and BPA to meet Oregon Noise Control Regulations (Perry, 1982).

The Washington Administrative Code provides noise limitations by class of property, residential, commercial or industrial (Washington State, 1975). Transmission lines are classified as industrial and may cause a maximum permissible noise level of 60 dBA to intrude into residential property. During nighttime hours (10:00 pm to 7:00 am), the maximum permissible limit for noise from industrial to residential areas is reduced to 50 dBA. This latter level applies to transmission lines that operate continuously. The state of Washington Department of Ecology accepts the 50 dBA level at the edge of the right-of-way for transmission lines, but encouraged BPA to design lines with lower audible noise levels (WDOE, 1981).

Audible noise from substations is generated predominantly by equipment such as transformers, reactors and other wire-wound equipment. It is characterized by a 120 Hz hum that is associated with magnetic-field caused vibrations in the equipment. Noise from such equipment varies by voltage and other operating conditions. The BPA design level for substation noise is 50 dBA at the substation property line for new construction (USDOE, 2006). The design level is met by obtaining equipment that meets specified noise limits and, for new substations, by securing a no-built buffer beyond the substation perimeter fence.

In industrial, business, commercial, or mixed use zones the AN level from substations may exceed 50 dBA but must still meet any state or local AN requirements. The design criteria also allows the 50 dBA design level to be exceeded in remote areas where development of noise sensitive properties is highly unlikely.

The EPA has established a guideline of 55 dBA for the annual average day-night level ($L_{dn}$) in outdoor areas [EPA, 1978]. In computing this value, a 10 dB correction (penalty) is added to night-time noise between the hours of 10 p.m. and 7 a.m.

## 7.2 Transmission-line Audible Noise

Corona is the partial electrical breakdown of the insulating properties of air around the conductors of a transmission line. In a small volume near the surface of the conductors, energy and heat are dissipated. Part of this energy is in the form of small local pressure changes that result in audible noise. Corona-generated audible noise can be characterized as a hissing, crackling sound that, under certain conditions, is accompanied by a 120-Hz hum. Corona-generated audible noise is of concern primarily for contemporary lines operating at voltages of 345 kV and higher during foul weather. The proposed 500-kV line will produce some noise under foul weather conditions.

The conductors of high-voltage transmission lines are designed to be corona-free under ideal conditions. However, protrusions on the conductor surface—particularly water droplets on or dripping off the conductors—cause electric fields near the conductor surface to exceed corona onset levels, and corona occurs. Therefore, audible noise from transmission lines is generally a foul-weather (wet-conductor) phenomenon. Wet conductors can occur during periods of rain, fog, snow, or icing. Based on hourly meteorologic records over several years from Kennewick, WA and Moro, OR , such conditions are expected to occur about 1 percent of the time during the year in the vicinity of the proposed line.

For a few months after line construction, residual grease or oil on the conductors can cause water to bead up on the surface. This results in more corona sources and slightly higher levels of audible noise and electromagnetic interference if the line is energized. However, the new conductors "age" in a few months, and the level of corona activity decreases to the predicted equilibrium value. During fair weather, insects and dust on the conductor can also serve as sources of corona.

All except Configuration 7 would use three 1.30-inch diameter conductors per phase to yield acceptable corona levels. However, Configuration 7 with split-phase 500-kV circuits on either side of the double circuit tower would employ three 1.60-inch diameter conductors per phase to achieve the required 50 dBA or less at the edge of the right-of-way.

## 7.3 Predicted Audible Noise Levels

Audible noise levels are calculated for average voltage of 536 kV and average conductor heights for fair- and foul-weather conditions. The predicted levels of corona-generated audible noise at the edge of the right-of-way for the proposed line configurations are given in Table 8. The $L_{50}$ foul-weather levels for the proposed configurations range from 40 to 49 dBA. The highest levels would generally occur when the new 500-kV circuit is at the minimum distance of 75 feet from the edge of the right-of-way. This occurs for Configurations 1, 4, 6, 7, and 10. Predicted profiles of the $L_{50}$ foul-weather levels for Configurations 1 and 7 are shown in Figure 37.

The audible noise levels for the No-action alternative are generally lower than the levels at the same locations with the proposed configurations. For the No-action alternative, the levels at the edges of existing rights-of-way range from ambient to 48 dBA. In this case, the existing McNary – Ross 345-kV and parallel Harvalum - Big Eddy 230-kV lines produce the highest noise levels.

During fair-weather conditions, which occur about 99 percent of the time, audible noise levels at the edge of the right-of-way would be about 20 dBA lower (if corona were present). These lower levels could be masked by ambient noise on and off the right-of-way.

## 7.4 Discussion

Along much of the proposed routes there would be increases in the perceived noise above ambient levels during foul weather at the edges of the right-of-way. This would be especially true in areas where the centerline of the proposed 500-kV line is at 75 feet from the edge of the right-of-way. However, even there, the corona-generated noise during foul weather would be masked to some extent by naturally occurring sounds such as wind and rain on foliage. The calculated foul-weather corona noise levels for the proposed line would be comparable to, or less, than those from existing 500-kV lines in Oregon and Washington. Relatively lower levels would be especially prevalent in line segments with existing wide rights-of-way where the proposed 500-kV line would be placed well away from the edge of the right-of-way.

Off the right-of-way corona-generated noise during fair weather will likely be masked or so low as to not be perceived even in fair weather. During foul-weather ambient noise levels can be high due to rain hitting foliage or buildings and wind. These sounds can mask corona noise both on and off the right-of-way. Furthermore people tend to be inside with windows closed, providing additional attenuation when corona noise is present.

Off the right-of-way, the foul-weather levels of audible noise from the proposed line would be well below the 55 dBA level that can produce interference with speech outdoors. Residential buildings provide significant sound attenuation (-12 dBA with windows open; -24 dBA with windows closed). Therefore indoor noise levels off the right-of-way would be well below the 45 dBA level where interference with speech indoors can occur and below the 35 dBA level where sleep interference can occur (EPA, 1973; EPA, 1978).

The highest noise level of 49-dBA for the configurations would meet the BPA design criterion and, hence, the statutory limits established in both Oregon and Washington. The computed annual $L_{dn}$ level for transmission lines operating in areas with 1 to 2 percent foul weather is about $L_{dn} = L_{50} - 6$ dB (Bracken, 1987). Therefore, assuming such conditions in the Big Eddy Transmission Line Project area, the estimated worst case $L_{dn}$ at the edge of the right-of-way would be approximately 43 dBA, which is below the EPA $L_{dn}$ guideline of 55 dBA.

No transformers will be installed at the new Knight Substation so that the audible noise at the edge of the substation will be due to the transmission lines entering the substation. Since the proposed transmission line will meet the 50 dBA criterion at the edge of the right-of-way, this criterion as it applies to substations will also be met (USDOE, 2006).

At the existing Big Eddy substation audible noise levels will also be predominantly due to foul weather corona noise from incoming and outgoing transmission lines. Noise levels produced from the new transformers will be lower than that from the existing equipment and unnoticeable when added to the existing noise levels at the edge of the substation property.

Thus all applicable federal, state, and local regulations will be met by the proposed transmission line and substation addition and modification.

# 8.0 Electromagnetic Interference

## 8.1 Basic Concepts

Corona on transmission-line conductors can also generate electromagnetic noise in the frequency bands used for radio and television signals. The noise can cause radio and television interference (RI and TVI). In certain circumstances, corona-generated electromagnetic interference (EMI) can also affect communications systems and other sensitive receivers. Interference with electromagnetic signals by corona-generated noise is generally associated with lines operating at voltages of 345 kV or higher. This is especially true of interference with television signals. The bundle of three 1.3-inch (or 1.6-inch) diameter conductors used in the design of the proposed 500-kV line will mitigate corona generation and thus keep radio and television interference levels at acceptable levels.

Spark gaps on distribution lines and on low-voltage wood-pole transmission lines are a more common source of RI/TVI than is corona from high-voltage electrical systems. This gap-type interference is primarily a fair-weather phenomenon caused by loose hardware and wires. The proposed transmission line would be constructed with modern hardware that eliminates such problems and therefore minimizes gap noise. Consequently, this source of EMI is not anticipated for the proposed line.

No state has limits for either RI or TVI. In the United States, electromagnetic interference from power transmission systems is governed by the Federal Communications Commission (FCC) Rules and Regulations presently in existence (Federal Communications Commission, 1988). A power transmission system falls into the FCC category of "incidental radiation device," which is defined as "a device that radiates radio frequency energy during the course of its operation although the device is not intentionally designed to generate radio frequency energy." Such a device "shall be operated so that the radio frequency energy that is emitted does not cause harmful interference. In the event that harmful interference is caused, the operator of the device shall promptly take steps to eliminate the harmful interference." For purposes of these regulations, harmful interference is defined as: "any emission, radiation or induction which endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radio communication service operating in accordance with this chapter" (Federal Communications Commission, 1988: Vol II, part 15. 47CFR, Ch. 1).

Electric power companies have been able to work quite well under the present FCC rule because harmful interference can generally be eliminated. It has been estimated that more than 95 percent of power-line sources that caused interference were due to gap-type discharges. These can be found and completely eliminated, when required to prevent interference (USDOE, 1980). Complaints related to corona-generated interference occur infrequently. This is especially true due to increased use of FM radio, cable television and satellite television, which are not subject to corona-generated interference. Mitigation of corona-generated interference with conventional broadcast radio and television receivers can be accomplished in several ways, such as use of a directional antenna or relocation of an existing antenna (USDOE, 1977; USDOE, 1980; Loftness et al., 1981).

## 8.2 Radio Interference (RI)

Radio reception in the AM broadcast band (535 to 1605 kilohertz (kHz)) is most often affected by corona-generated EMI. FM radio reception is rarely affected. Generally, only residences very near to transmission lines can be affected by RI. The IEEE Radio Noise Design Guide identifies an acceptable limit of fair-weather RI as expressed in decibels above 1 microvolt per meter (dBμV/m) of about 40 dB(μV/m) at 1 megahertz (MHz) (IEEE Committee Report, 1971). This limit applies at 100 ft. (30 m) from the outside conductor. As a general rule, average levels during foul weather (when the conductors are wet) are 16 to 22 dBμV/m higher than average fair-weather levels.

## 8.3 Predicted RI Levels

The $L_{50}$ fair-weather RI levels were predicted for all configurations at the furthest of 100 ft. (30 m) from the outside conductor or the edge of the right-of-way. The results are shown in Table 9. The $L_{50}$ levels for all configurations are at or below the acceptable limit of about 40 dBμV/m and are therefore compliant with the IEEE guideline level. The RI levels for the proposed 500-kV configurations would exceed those from the existing lower voltage lines.

## 8.4 Television Interference (TVI)

Corona-caused TVI occurs during foul weather and is generally of concern for transmission lines with voltages of 345 kV or above, and only for conventional receivers within about 600 ft. (183 m) of a line. As is the case for RI, gap sources on distribution and low-voltage transmission lines are the principal observed sources of TVI. The use of modern hardware and construction practices for the proposed line would minimize such sources.

## 8.5 Predicted TVI Levels

The predicted foul-weather TVI levels at 75MHz from the proposed configurations operating at 536 kV are shown in Table 9. These levels are given for the further of 100 ft. (30 m) from the outside conductor or the edge of the right-of-way. The levels at these points range from 2 to 24 dBμV/m depending primarily on the distance from of the proposed 500-kV line. These levels are comparable to or lower than than those from existing 500-kV lines in Oregon and Washington. As with RI the largest values occur when the proposed 500-kV line is directly adjacent to the edge of the right-of-way.

At the highest predicted levels, there is a potential for interference with television signals at locations very near the proposed line in fringe reception areas. However, several factors reduce the likelihood of occurrence. Corona-generated TVI occurs only in foul weather; consequently, signals will not be interfered with most of the time, which is characterized by fair weather. Because television antennas are directional, the impact of TVI is related to the location and orientation of the antenna relative to the transmission line. If the antenna were pointed away from the line, then TVI from the line would affect reception much less than if the antenna were pointed towards the line. Since the level of TVI falls off with distance, the potential for interference becomes minimal at distances greater than several hundred feet from the centerline.

Other forms of TVI from transmission lines are signal reflection (ghosting) and signal blocking caused by the relative locations of the transmission structure and the receiving antenna with respect to the incoming television signal. Again only houses within several hundred feet of the proposed line would possibly be affected.

Television systems that operate at higher frequencies, such as satellite receivers, are not affected by corona-generated TVI. Cable television systems are also not affected.

Interference with television reception can be corrected by any of several approaches: improving the receiving antenna system; installing a remote antenna; installing an antenna for TV stations less vulnerable to interference; connecting to an existing cable system; or installing a translator (cf. USDOE, 1977). BPA has an active program to identify, investigate, and mitigate legitimate RI and TVI complaints. It is anticipated that any instances of TVI caused by the proposed line could be effectively mitigated.

## 8.6 Interference with Other Devices

Corona-generated interference can conceivably cause disruption on other communications bands such as the citizen's (CB) and mobile bands. However, mobile-radio communications are not susceptible to transmission-line interference because they are generally frequency modulated (FM). Similarly, cellular telephones operate at a frequency of about 900 MHz or higher, which is above the frequency where corona-generated interference is prevalent. In the unlikely event that interference occurs with these or other communications, mitigation can be achieved with the same techniques used for television and AM radio interference.

## 8.7 Conclusion

Predicted EMI levels for the proposed 500-kV transmission line are comparable to, or lower, than those that already exist near 500-kV lines and no impacts of corona-generated interference on radio, television, or other reception are anticipated. Based on land use surveys approximately 10 to 12 houses could be within 500 feet of the proposed line (Table 5) and possibly affected by interference. Whether interference occurs will depend on which 28-mile route alternative and line designs are selected as well as the type of television or radio receiver. Furthermore, if interference should occur, there are various methods for correcting it; BPA has a program to respond to legitimate complaints.

## 9.0 Other Corona Effects

Corona is visible as a bluish glow or as bluish plumes. On the proposed 500-kV line, corona levels would be very low, so that corona on the conductors would be observable only under the darkest conditions and only with the aid of binoculars, if at all. Without a period of adaptation for the eyes and without intentional looking for the corona, it would probably not be noticeable.

When corona is present, the air surrounding the conductors is ionized and many chemical reactions take place, producing small amounts of ozone and other oxidants. Ozone is approximately 90 percent of the oxidants, while the remaining 10 percent is composed principally of nitrogen oxides. The national primary ambient air quality standard for photochemical oxidants, of which ozone is the principal component, is 235 micrograms/cubic meter) or 120 parts per billion. The maximum incremental ozone levels at ground level produced by corona activity on the proposed transmission line during foul weather would be much less than 1 part per billion. This level is insignificant when compared with natural levels and fluctuations in natural levels.

## 10.0 Summary

The number of nearby houses/businesses that could be impacted by field or corona effects is small and fairly consistent among the three line route alternatives: ranging from 2 to 5 within 300 feet of centerline and from 10 to 12 within 500 feet.

Electric and magnetic fields from the proposed transmission line have been characterized using well-known techniques accepted within the scientific and engineering community. The expected electric-field levels from the proposed line at minimum design clearance would be comparable to those from existing 500-kV lines in Washington and elsewhere. The expected magnetic-field levels from the proposed line would be comparable to, or less than, those from other 500-kV lines in Washington, Oregon and elsewhere.

The peak electric field expected under the proposed line would be 8.8 kV/m; the maximum value at the edge of the right-of-way would be about 2.4 kV/m. Clearances at road crossings would be increased to reduce the peak electric-field value to 5 kV/m or less.

Under maximum current conditions, the maximum magnetic fields on and at the edge of the right-of-way vary considerably among configurations: ranging from 219 to 60 mG on the right-of-way and from 82 to less than 1 mG at the edge of the right-of-way. Average values of the fields are much reduced and also vary widely between configurations. The average field value at the edge of the right-of way adjacent to the proposed line ranges from 21 to less than 1 mG depending on right-of-way width and the presence of other lines.

For the No-action alternative, maximum magnetic fields would range from 163 to 0 mG on the right-of-way and from 67 to 0 mG at the edge. For this alternative average fields would be reduced to a maximum of 48 on the right-of-way and 23 at the edge.

The electric fields from the proposed line would meet regulatory limits for public exposure in some states and guidelines set established by IEEE. However, the electric fields from the line could exceed the regulatory limits or guidelines for peak fields established in some states and by ICNIRP. The magnetic fields from the proposed line would be within the regulatory limits of the two states that have established such limits and below the guidelines for public exposure established by ICNIRP and IEEE. Washington does not have any electric- or magnetic-field regulatory limits or guidelines.

Short-term effects from transmission-line fields are well understood and can be mitigated. Nuisance shocks arising from electric-field induced currents and voltages could be perceivable on the right-of-way of the proposed line. It is common practice to ground permanent conducting objects during and after construction to mitigate against such occurrences.

Corona-generated audible noise from the line would be perceivable during foul weather. The levels would be comparable to or less those near existing 500-kV transmission lines in Oregon and Washington, would be in compliance with noise regulations in Oregon and Washington, and would be below levels specified in EPA guidelines.

Corona-generated electromagnetic interference from the proposed line would be comparable to or less than that from existing 500-kV lines in Washington. Radio interference levels would be at or below limits identified as acceptable. Television interference, a foul-weather phenomenon, is anticipated to be comparable to or less than that from existing 500-kV lines in Washington. The presence of only 10 to 12 residences/businesses closer than 500 feet (183 m) to the line and the rarity of precipitation conditions when TVI occurs (about 1% of time) make it unlikely that television reception will be affected. However, if legitimate complaints arise, BPA has a mitigation program.

## List of References Cited

ACGIH (American Conference of Governmental Industrial Hygienists). 2008. 2008 TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. American Conference of Governmental Industrial Hygienists, Cincinnati. 251 pages.

Baishiki, R.S.; Johnson, G.B.; Zaffanella, L.E.; Bracken, T.D.; Sussman, S.S.; Rauch, G.B.; and Silva, J.M. 1990. Studies of Power System Magnetic Fields: Characterization of Sources in Residential Environments, Measurement of Exposure, Influence On Computer Screens. (36-104) CIGRE, Paris, France. 10 pages.

Banfai, B.; Karady, G.G.; Kim, C.J.; and Maracas, K.B. 2000. Magnetic field effects on CRT computer monitors. IEEE Trans. on Power Delivery 15, 307-312.

Bassen, H.; Casamento, J.; and Crowl, B. 1991. Reduction of electric and magnetic field emissions from electric blankets (Meeting abstract). *In*: Bioelectromagnetics Society, 13th Annual Meeting, 23-27 June, Salt Lake City. Bioelectromagnetics Society, New York, 20.

Bowman, J.D.; Garabrant, D.H.; Sobel, E.; and Peters, J.M. June 1988. Exposures to Extremely Low Frequency (ELF) Electromagnetic Fields in Occupations With Elevated Leukemia Rates. Applied Industrial Hygienics, 3(6, June):189-194.

Bracken, T.D. 1987. Audible Noise from High Voltage Transmission Facilities. A Briefing Paper Prepared for State of Florida Department of Environmental Regulation. (DER Contract No. SP122) State of Florida Department of Environmental Regulation.

Bracken, T.D. 1990. The EMDEX Project: Technology Transfer and Occupational Measurements, Volumes 1-3 Interim Report. EPRI Report EN-7048. (EPRI EN-7048) Electric Power Research Institute, Palo Alto, CA.

Chartier, V.L. April 1983. Empirical Expressions for Calculating High Voltage Transmission Corona Phenomena, First Annual Seminar Technical Career Program for Professional Engineers. Bonneville Power Administration, Portland, Oregon. April 1983, 75-82.

Chartier, V.L. and Stearns, R.D. January 1981. Formulas for Predicting Audible Noise from Overhead High Voltage AC and DC Lines. IEEE Transactions on Power Apparatus and Systems, PAS-100(No. 1, January 1981):121-129.

Dabkowski, J. and Taflove, A. May/June 1979. Prediction Method for Buried Pipeline Voltages Due to 60 Hz AC Inductive Coupling. Part II: Field Test Verification. IEEE Transactions on Power Apparatus and Systems, PAS-98(3, May/June):788-794.

Deno, D.W. and Zaffanella, L. 1982. Field effects of overhead transmission lines and stations. Chap. 8. *In*: Transmission Line Reference Book: 345 KV and Above. Second ed. (Ed: LaForest, J.J.). Electric Power Research Institute, Palo Alto, CA, 329-419.

EPA (Environmental Protection Agency). July 1973. Public Health and Welfare Criteria for Noise. (No. 500/9-73-002, July 27, 1973.) U.S. Environmental Protection Agency, Washington, D.C.

EPA. 1974. Information On Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety. (No. PB-239 429.) U.S. Environmental Protection Agency, Washington, D.C.

EPA. 1978. Protective Noise Levels. Condensed Version of EPA Levels Document. (No. PB82-138827) U.S Environmental Protection Agency, Washington, DC.

Exponent. 2009. Update of EMF Research – 2009. Technical report prepared for Bonneville Power Administration by Exponent, New York, NY (April 2009).

Federal Communications Commission. 1988. Federal Communications Commission Rules and Regulations. 10-1-88 ed. Vol. II part 15, 47 CFR, Ch. 1.

Florig, H.K. and Hoburg, J.F. 1988. Electric and Magnetic Field Exposure Associated With Electric Blankets. Project Resume. Contractor's Review. U.S. Department of Energy/Electric Power Research Institute.

Florig, H.K.; Hoburg, J.F.; and Morgan, M.G. April 1987. Electric Field Exposure from Electric Blankets. IEEE Transactions on Power Delivery, PWRD-2(2, April):527-536.

Gauger, J. September 1985. Household Appliance Magnetic Field Survey. IEEE Transactions on Power Apparatus and Systems, 104(9, September):2436-2445.

Glasgow, A.R. and Carstensen, E.L. February 1981. The Shock Record for 500 and 750 KV Transmission Lines in North America. IEEE Transactions on Power Apparatus and Systems, 100(2, February):559-562.

Heroux, P. 1987. 60-Hz Electric and Magnetic Fields Generated By a Distribution Network. Bioelectromagnetics, 8(2):135-148.

ICES (International Committee on Electromagnetic Safety): 2002. IEEE PC95.6-2002 Standard for Safety Levels With Respect to Human Exposure to Electromagnetic Fields, 0 to 3 kHz. Institute of Electrical and Electronics Engineers, Piscataway, NJ.

ICNIRP (International Committee on Non-ionizing Radiation Protection). April 1998. Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (Up to 300 GHz). Health Physics, 74(4, April):1-32.

IEEE (Institute of Electrical and Electronics Engineers, Inc.). 1978. Electric and Magnetic Field Coupling from High Voltage AC Power Transmission Lines -- Classification of Short-Term Effects On People. IEEE Transactions on Power Apparatus and Systems, PAS-97:2243-2252.

IEEE. 1994. IEEE Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields from AC Power Lines. ANSI/IEEE Std. 644-1994, New York, NY.

IEEE. 2002. National Electrical Safety Code. 2002 ed. Institute of Electrical and Electronics Engineers, Inc., New York, NY. 287 pages.

IEEE Committee Report. March/April 1971. Radio Noise Design Guide for High Voltage Transmission Lines. IEEE Transactions on Power Apparatus and Systems, PAS-90(No. 2, March/April):833-842.

IEEE Committee Report. October 1982. A Comparison of Methods for Calculating Audible Noise of High Voltage Transmission Lines. IEEE Transactions on Power Apparatus and Systems, 101(10, October):4090-4099.

IIT Research Institute. 1984. Representative Electromagnetic Field Intensities Near the Clam Lake (WI) and Republic (MI) ELF Facilities. Report Prepared for Naval Electronics Systems Command, PME 110 E Washington, D.C. 20360. (Under contract N00039-84-C0070.) IIT Research Institute, Chicago, IL. 60 pages.

Jaffa, K.C. and Stewart, J.B. March 1981. Magnetic Field Induction from Overhead Transmission and Distribution Power Lines On Buried Irrigation Pipelines. IEEE Transactions on Power Apparatus and Systems, PAS-100(3, March):990-1000.

Keesey, J.C. and Letcher, F.S. 1969. Minimum Thresholds for Physiological Responses to Flow of Alternating Electric Current Through the Human Body At Power-Transmission Frequencies. (Report No. 1) Naval Medical Research Institute, Project MR 005.08-0030B, Bethesda, MD. 25 pages.

Loftness, M.O.; Chartier, V.L.; and Reiner, G.L. 1981. EMI Correction Techniques for Transmission Line Corona. (August 18-20, 1981, pp. 351-361.) Proceedings of the 1981 IEEE International Symposium on Electromagnetic Compatibility, Boulder, CO.

Maddock, B.J. September 1992. Guidelines and Standards for Exposure to Electric and Magnetic Fields At Power Frequencies. (Panel 2-05, CIGRE meeting August 30-September 5, 1992) CIGRE, Paris.

NOAA, National Oceanic & Atmospheric Administration. 2010. National Climatic Data Center (NCDC). http://www.ncdc.noaa.gov/oa/ncdc.html

Olsen, R.G.; Schennum, S.D.; and Chartier, V.L. April 1992. Comparison of Several Methods for Calculating Power Line Electromagnetic Interference Levels and Calibration With Long Term Data. IEEE Transactions on Power Delivery, 7(April, 1992):903-913.

Perry, D. 1982. Sound Level Limits from BPA Facilities. BPA memorandum, May 26, 1982; Department of Environmental Quality, Noise Control Regulations, Chapter 340, Oregon Administrative Rules, Division 35, March 1, 1978.

Reilly, J.P. 1979. Electric Field Induction on Long Objects -- A Methodology for Transmission Line Impact Studies. IEEE Transactions on Power Apparatus and Systems, PAS-98(6, Nov/Dec):1841-1852.

Sheppard, A.R. and Eisenbud, M. 1977. Biological Effects of Electric and Magnetic Fields of Extremely Low Frequency. New York University Press, New York.

Silva, M.; Hummon, N.; Rutter, D.; and Hooper, C. 1989. Power Frequency Magnetic Fields in the Home. IEEE Transactions on Power Delivery, 4:465-478.

Taflove, A. and Dabkowski, J. May/June 1979. Prediction Method for Buried Pipeline Voltages Due to 60 Hz AC Inductive Coupling. Part I: Analysis. IEEE Transactions on Power Apparatus and Systems, PAS-98(3, May/June):780-787.

USDOE (U.S. Department of Energy), Bonneville Power Administration. March 1977. A Practical Handbook for the Location, Prevention and Correction of Television Interference from Overhead Power Lines. Portland, OR.

USDOE, Bonneville Power Administration. May 1980. A Practical Handbook for the Correction of Radio Interference from Overhead Powerlines and Facilities. (May 1980.) Portland, OR.

USDOE, Bonneville Power Administration. 1986. Electrical and Biological Effects of Transmission Lines: A Review. (DOE/BP 524 January 1986) Portland, OR.

USDOE, Bonneville Power Administration. 1996. Electrical and Biological Effects of Transmission Lines: A Review. (DOE/BP 2938 December 1996 1M) Portland, OR.

USDOE, Bonneville Power Administration. 2006. Audible Noise Policy. TBL Policy T2006-1. Bonneville Power Administration, Portland, OR.

USDOE, Bonneville Power Administration. 2007. Living and Working Safely Around High-Voltage Power Lines. (DOE/BP-3804). Portland, OR. 12 pages.

USDOE, Bonneville Power Administration. undated. "Corona and Field Effects" Computer Program (Public Domain Software). Bonneville Power Administration, P.O. Box 491-ELE, Vancouver, WA 98666.

Washington, State of. 1975. Washington Administrative Code, Chapter 173-60 WAC Maximum Environmental Noise Levels. Department of Ecology, Olympia, WA.

WDOE (Washington Department of Ecology). 1981. Letter from D.E. Saunders to J.H. Brunke, BPA, dated 9/3/81 regarding EDNA classification for substations and transmission line. State of Washington Department of Ecology, Olympia, WA.

Zaffanella, L.E. 1993. Survey of Residential Magnetic Field Sources. Vol. 1: Goals, results, and conclusions. (EPRI TR-102759-V1, Project 3335-02) Electric Power Research Institute, Palo Alto, CA.

Zaffanella, L.E. and Kalton, G.W. 1998. Survey of personal magnetic field exposure, Phase II: 1000-perosn survey. Interim Report. EMF RAPID Program Engineering Project #6. Enertech Consultants, Lee, MA.

## List of Preparers

T. Dan Bracken was the principal author of this report. He received a B.S. degree in physics from Dartmouth College and M.S. and Ph.D. degrees in physics from Stanford University. Dr. Bracken has been involved with research on and characterization of electric- and magnetic-field effects from transmission lines for over 35 years, first as a physicist with the Bonneville Power Administration (BPA) (1973 - 1980) and since then as a consultant. His firm, T. Dan Bracken, Inc., offers technical expertise in areas of electric- and magnetic-field measurements, instrumentation, environmental effects of transmission lines, exposure assessment and project management. Joseph Dudman of T. Dan Bracken, Inc., provided data entry, graphics, and clerical support in the preparation of the report.

**Table 1: Description of line configurations and associated segments along the proposed Big-Eddy– Knight 500-kV transmission line alternative routes.**

| Configuration | | Line segments[2] | Segment length, miles | Total configuration length by alternative, miles | | |
|---|---|---|---|---|---|---|
| No. | Description[1] | | | West | Middle | East |
| **1** | BE-KN SglCkt | W-1 thru W-3<br>W-5<br>W-8<br>M-3<br>M-5<br>M-7<br>E-4 | 3.9<br>0.8<br>4.9<br>1.9<br>7.6<br>4.9<br>14.0 | 9.6 | 14.0 | 14.4 |
| **2** | BE-KN SglCkt & \|\| HARV-BE | M-1 and M-2<br>E-1 and E-2 | 9.2<br>9.2 | - | 9.2 | 9.2 |
| **3** | BE-KN SglCkt & \|\| McN-RO & \|\| HARV-BE | E-3 | 4.8 | - | - | 4.8 |
| **4** | BE-KN SglCkt & \|\| CHE-GOL | W-6 and W-7<br>M-6 | 16.4<br>2.1 | 16.4 | 2.1 | - |
| **5** | BE-KN SglCkt & \|\| Spearfish Tap | W-4 | 1.1 | 1.1 | - | - |
| **6** | BE-KN SglCkt & \|\|BE-SPR | M-4 | 1.3 | - | 1.3 | - |
| **7** | BE-KN DblCkt split-phase w/ 3x1.6” bundles | W-1 thru W-3 | 3.9 | 3.9 | - | - |
| **7A** | BE-KN DblCkt tower with SglCkt w/ 3x1.3” bundles on one side | W-1 thru W-3 | 3.9 | 3.9 | - | - |
| **8** | BE-KN DblCkt w/ HARV-BE | M-1 and M-2<br>E-1 and E-2 | 9.2<br>9.2 | - | 9.2 | 9.2 |
| **9** | BE-KN DblCkt w/ McN-RO & \|\|HARV-BE | E-3 | 4.8 | - | - | 4.8 |
| **10** | BE-KN DblCkt w/ CHE-GOL | W-6 and W-7<br>M-6 | 16.4<br>2.1 | 16.4 | 2.1 | - |
| **11** | BE-KN DblCkt w/ Spearfish Tap | W-4 | 1.1 | 1.1 | - | - |
| **12** | BE-KN DblCkt split phase & \|\| Spearfish Tap | W-4 | 1.1 | 1.1 | - | - |

Notes for Table 1:

1 BE-KN = Big Eddy-Knight; HARV-BE = Harvalum-Big Eddy; McN-RO = McNary-Ross; CHE-GOL = Chenoweth-Goldendale; BE-SPR = Big Eddy Spring Creek; SglCkt = Single circuit; DblCkt = Double circuit; || = parallel to.

2 Physical locations of alternative routes and segments are shown in Figure 1. Segments are numbered from Big Eddy to Knight by route: W = West alternative, M = Middle alternative; E = East alternative

**Table 2: Physical and electrical characteristics of transmission lines in the Big Eddy – Knight 500-kV Transmission Line Project corridor.**

| Line Characteristics | Proposed Line | | Existing Lines | | | | |
|---|---|---|---|---|---|---|---|
| | Big Eddy – Knight 500-kV[2] | | Harvalum-Big Eddy 230-kV | McNary-Ross 345-kV | Chenoweth-Goldendale 115-kV[5] | Spearfish Tap 115-kV | Big Eddy-Spring Creek 230 kV |
| **Voltage, kV Maximum/Average[1]** | 550/536 | | 241.5/232 | 362/350 | 0/0 | 121/118 | 241.5/237 |
| **Circuit Configuration[2]** | Single | Double | Single | Single | Single | Single | Single |
| **Proposed Current, A Peak/Average** | 970/485 | 485/243 | 1075/505 | 630/380 | 0/0 | 35/9 | 872/244 |
| **No-action Current, A Peak/Average** | - | - | 820/410 | 520/244 | 0/0 | 35/9 | 950/266 |
| **Electric Phasing** (looking towards Knight) | B<br>A C | A C<br>B B<br>C A | C B A | C A B | B C A | C B A | B A C |
| **Clearance, ft. Minimum/Average[1, 3]** | 35/47 | 36/47 | 32.5/45.4 | 33.8/47.6 | 25.9/34.4 | 25.9/29.5 | 33.8/46.7 |
| **Tower configuration** | Delta | DC-Vert | Flat | Flat | Flat | Flat | Flat |
| **Phase spacing, ft.** | 46H, 31.5V | 36.5, 56.5H<br>36V | 27 | 32 | 12 | 12 | 27 |
| **Conductor: #/Diameter, in.** | 3/1.3 | 3/1.3 or 3x1.6[2] | 1/1.382 | 1/1.602 | 1/0.563 | 1/0.642 | 1/1.382 |
| **Centerline distance to edge of ROW, ft.[4]** | 75 | 75 | 187.5/62.5 | 312.5/187.5 | 50 | 425/50 | 62.5 |
| **Centerline distance to proposed line, ft.** | - | - | 125 | 125 | 125 | 125 | 125 |
| **Average altitude, ft.** | 1500 | 1500 | 600 | 600 | 1600 | 350 | 1650 |

Notes for Table 2:

1 Average voltage and average clearance used for corona calculations.

2 When the proposed Big Eddy – Knight 500-kV line is energized on all six 3x1.6" phase bundles on a double circuit tower (Configuration 7), the three phases of the line will be split between six conductor bundles with each carrying one half of the single-circuit current. When the proposed Big Eddy – Knight 500-kV line is energized with only three 3x1.3" phase bundles on the double circuit tower (Configuration 7A), the non-energized phases will be left ungrounded. In Configuration 7A the energized circuit of the proposed line could be on either the west or east side of the tower. When the proposed Big-Eddy – Knight 500-kV line is on a double circuit tower with one of the existing parallel lines, the respective circuits will have the same voltages and currents as the individual single-circuit lines. When the existing Harvalum - Big Eddy or McNary – Ross line is the parallel line, they will have a 3x1.3" bundle (Configurations 8 and 9). The Chenoweth – Goldendale and Spearfish Tap lines would have a single 1.3" conductor when placed on the double circuit tower (Configurations 10 and 11).

3 To meet the BPA 9 kV/m limit for peak electric field and use consistent design clearances, the minimum clearance for all proposed double-circuit tower configurations was increased to 36 feet.

4 The distance to the west and east) edges of the right-of-way depends on the configuration as shown in Figures 2 – 10.

5 The Chenoweth – Goldendale 115-kV line is normally open at both ends with no current.

**Table 3: Calculated maximum and average electric fields for the proposed Big Eddy – Knight 500-kV line operated at maximum voltage by configuration.** Configurations are described in Tables 1 and 2. [Note: all 1.3" bundles except Config. 7]

| **Configuration** | | **Electric Field, kV/m Proposed Alternative** | | | | **Electric Field, kV/m No-action Alternative** | | | |
|---|---|---|---|---|---|---|---|---|---|
| **No.** | **Location** | **Peak on ROW** | | **At Edge of ROW[2]** | | **Peak on ROW** | | **At Edge of ROW[2]** | |
| | **Field Description** | **Maximum** | **Average** | **Maximum** | **Average** | **Maximum** | **Average** | **Maximum** | **Average** |
| **1** | BE-KN SglCkt | 8.6 | 5.4 | 2.4, 2.4 | 2.3, 2.3 | - | - | - | - |
| **2** | BE-KN SglCkt & HARV-BE | 8.6 | 5.4 | 2.4, 1.5 | 2.4, 1.2 | 2.9 | 1.7 | 0.1, 1.3 | 0.1, 1.1 |
| **3** | BE-KN SglCkt & McN-RO & HARV-BE[3] Use CAB phasing | 8.8 | 5.8 | 0.2, 1.3 | 0.2, 1.1 | 4.5 | 2.6 | <0.1, 1.3 | <0.1, 1.1 |
| **4** | BE-KN SglCkt & CHE-GOL | 8.6 | 5.4 | 2.4, 0.3 | 2.3, 0.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| **5** | BE-KN SglCkt & Spearfish Tap | 8.6 | 5.4 | 0.1, 0.2 | 0.1, 0.2 | 1.2 | 1.0 | 0.1, 0.4 | 0.2, 0.4 |
| **6** | BE-KN SglCkt & BE-SPR | 8.6 | 5.4 | 2.4, 1.4 | 2.3, 1.2 | 2.7 | 1.6 | 1.3, 1.3 | 1.1, 1.1 |
| **7** | BE-KN DblCkt w/ 3x1.6" bundles[3] | 7.3 | 4.3 | 1.3, 1.3 | 1.3, 1.3 | - | - | - | - |
| **7A** | BE-KN DblCkt w/ only 1 circuit[3] | 8.8 | 5.8 | 1.3, 0.1 | 1.4, 0.3 | - | - | - | - |
| **8** | BE-KN DblCkt w/ HARV-BE[3] | 7.9 | 4.9 | 0.3, 0.5 | 0.2, 0.4 | 2.9 | 1.7 | 1.3, 0.1 | 1.1, 0.1 |
| **9** | BE-KN DblCkt w/ McN-RO & HARV-BE[3] | 7.6 | 4.6 | 0.1, 1.3 | 0.1, 1.1 | 4.5 | 2.6 | <0.1, 1.3 | <0.1, 1.1 |
| **10** | BE-KN DblCkt w/ CHE-GOL[3] | 8.7 | 5.7 | 1.3, 0.1 | 1.4, 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| **11** | BE-KN DblCkt w/ Spearfish Tap[3] | 8.5 | 5.6 | 0.1, 0.2 | 0.1, <0.1 | 1.2 | 1.0 | 0.0, 0.4 | 0.2, 0.4 |
| **12** | BE-KN DblCkt & Spearfish Tap[3] | 7.0 | 4.2 | 0.1, 0.3 | 0.1, 0.3 | 1.2 | 1.0 | 0.0, 0.4 | 0.2, 0.4 |

Notes for Table 3:

1 BE-KN = Big Eddy-Knight; HARV-BE = Harvalum- Big Eddy; McN-RO = McNary-Ross; CHE-GOL = Chenoweth-Goldendale; BE-SPR = Big Eddy Spring Creek; SngCkt = Single circuit; DblCkt = Double circuit

2 Field at west (north) edge of ROW shown first.

3 To meet the BPA 9 kV/m limit for peak electric field and use consistent design clearances, the minimum clearance for all proposed double-circuit tower configurations was increased to 36 feet.

**Table 4: Calculated maximum and average magnetic fields for the proposed Big Eddy – Knight 500-kV line operated at maximum current/minimum clearance and average current/average clearance.** Configurations are described in Tables 1 and 2.

| Configuration[1] | | Magnetic Field, mG Proposed Alternative | | | | Magnetic Field, mG No-action Alternative | | | |
|---|---|---|---|---|---|---|---|---|---|
| No. | Location<br>Field Description | Peak on ROW | | At Edge of ROW[2] | | Peak on ROW | | At Edge of ROW[2] | |
| | | Maximum | Average | Maximum | Average | Maximum | Average | Maximum | Average |
| **1** | BE-KN SglCkt | 159 | 50 | 42, 42 | 18, 18 | - | - | - | - |
| **2** | BE-KN SglCkt & HARV-BE | 219 | 65 | 49, 82 | 21, 31 | 163 | 48 | 7, 60 | 3, 22 |
| **3** | BE-KN SglCkt & McN-RO & HARV-BE | 214 | 62 | 7, 78 | 3, 29 | 161 | 46 | 3, 61 | 2, 23 |
| **4** | BE-KN SglCkt & CHE-GOL | 159 | 50 | 42, 8 | 18, 4 | 0 | 0 | 0 | 0 |
| **5** | BE-KN SglCkt & Spearfish Tap | 160 | 50 | 3, 8 | 1, 4 | 7 | 2 | 0, 2 | 0, <1 |
| **6** | BE-KN SglCkt & BE-SPR | 155 | 49 | 43, 64 | 18, 14 | 176 | 31 | 67, 67 | 15, 15 |
| **7** | BE-KN DblCkt w/ 3x1.6" bundles | 60 | 17 | 14, 14 | 6, 6 | - | - | - | - |
| **7A** | BE-KN DblCkt w/ only 3 bundles | 118 | 38 | 52, 29 | 21, 13 | - | - | - | - |
| **8** | BE-KN DblCkt w/ HARV-BE | 128 | 35 | 3, 33 | 2, 12 | 163 | 48 | 7, 60 | 3, 22 |
| **9** | BE-KN DblCkt w/ McN-RO & HARV-BE | 212 | 61 | 3, 79 | 1, 29 | 161 | 46 | 3, 61 | 2, 23 |
| **10** | BE-KN DblCkt w/ CHE-GOL 36' | 117 | 38 | 52, 29 | 21, 13 | 0 | 0 | 0 | 0 |
| **11** | BE-KN DblCkt w/ Spearfish Tap 36' | 116 | 38 | 3, 27 | 1, 13 | 7 | 2 | 0, 2 | 0, <1 |
| **12** | BE-KN DblCkt & Spearfish Tap | 60 | 17 | <1, 3 | <1, 1 | 7 | 2 | 0, 2 | 0, <1 |

Notes for Table 4:

1 BE-KN = Big Eddy-Knight; HARV-BE = Harvalum- Big Eddy; McN-RO = McNary-Ross; CHE-GOL = Chenoweth-Goldendale; BE-SPR = Big Eddy Spring Creek; SngCkt = Single circuit; DblCkt = Double circuit

2 Field at west (north) edge of ROW shown first.

3 To meet the BPA 9 kV/m limit for peak electric field and use consistent design clearances, the minimum clearance for all proposed double-circuit tower configurations was increased to 36 feet.

**Table 5: Locations and ranges of average and maximum magnetic fields at residences and businesses near proposed line by primary circuit configuration and line route.**

| Primary Configuration | Single Circuit | | | Double Circuit+ | | |
|---|---|---|---|---|---|---|
| **Route Alternative** | **East*** | **Middle*** | **West** | **East** | **Middle** | **West** |
| **Houses < 300 ft** | 3 | 2 | 4 | 5 | 4 | 4 |
| **Houses < 500 ft** | 12 | 11 | 10 | 10 | 10 | 10 |
| **Range of Distances from Centerline, ft** | 71 - 484 | 71 - 425 | 203 - 486 | 191 - 484 | 191 - 495 | 203 - 486 |
| **Range of Average Magnetic Field, mG** | 0.5 - 22.3 | 0.7 - 22.3 | 0.5 - 3.1 | 0.3 - 1.8 | 0.1 - 1.8 | 0.1 - 3.5 |
| **Range of Maximum Magnetic Field, mG** | 1.1 - 45 | 1.4 - 45 | 1.1 - 6.2 | 0.7 - 4.6 | 0.2 - 4.5 | 0.2 - 7 |

* A single house at 71 feet from the proposed centerline contributes the high field levels along the East and Middle alternatives.

+ Double circuit configuration counts include houses from single circuit sections E-4 and M-5, where no double circuit is planned.

**Table 6: Electric- and magnetic-field exposure guidelines.**

| ORGANIZATION | TYPE OF EXPOSURE | ELECTRIC FIELD, kV/m | MAGNETIC FIELD, mG |
|---|---|---|---|
| **ACGIH** | Occupational | 25[1] | 10,000 |
| **ICNIRP** | Occupational | 8.3[2] | 4,200 |
| | General Public | 4.2 | 833 |
| **IEEE** | Occupational | 20 | 27,100 |
| | General Public | 5[3] | 9,040 |

1 Grounding is recommended above 5 –7 kV/m and conductive clothing is recommended above 15 kV/m.
2 Increased to 16.7 kV/m if nuisance shocks are eliminated.
3 Within power line rights-of-way, the guideline is 10 kV/m.

Sources: ACGIH, 2008; ICNIRP, 1998; ICES, 2002

**Table 7: States with transmission-line field limits.**

| STATE AGENCY | WITHIN RIGHT-OF-WAY | AT EDGE OF RIGHT-OF-WAY | COMMENTS |
|---|---|---|---|
| **a. 60-Hz ELECTRIC-FIELD LIMIT, kV/m** | | | |
| Florida Department of Environmental Regulation | 8 ( 230 kV)<br>10 (500 kV) | 2 | Codified regulation, adopted after a public rulemaking hearing in 1989. |
| Minnesota Environmental Quality Board | 8 | – | 12-kV/m limit on the high voltage direct current (HVDC) nominal electric field. |
| Montana Board of Natural Resources and Conservation | 7[1] | 1[2] | Codified regulation, adopted after a public rulemaking hearing in 1984. |
| New Jersey Department of Environmental Protection | – | 3 | Used only as a guideline for evaluating complaints. |
| New York State Public Service Commission | 11.8<br>(7,11)[3] | 1.6 | Explicitly implemented in terms of a specified right-of-way width. |
| Oregon Facility Siting Council | 9 | – | Codified regulation, adopted after a public rulemaking hearing in 1980. |
| **b. 60-Hz MAGNETIC-FIELD LIMIT, mG** | | | |
| Florida Department of Environmental Regulation | – | 150 ( 230 kV)<br>200 (500 kV) | Codified regulations, adopted after a public rulemaking hearing in 1989. |
| New York State Public Service Commission | – | 200 | Adopted August 29, 1990. |

Notes for Table 6:
1 At road crossings
2 Landowner may waive limit
3 At highway and private road crossings, respectively

Source: USDOE, 1996

**Table 8: Common noise levels.**

| Sound Level, dBA | Noise Source or Effect |
|---|---|
| 130 | Threshold of pain |
| 110 | Rock-and-roll band |
| 80 | Truck at 50 ft. (15.2 m) |
| 70 | Gas lawnmower at 100 ft. (30 m) |
| 60 | Normal conversation indoors |
| 50 | Moderate rainfall on foliage |
| 49 | Highest foul-weather $L_{50}$ at edge of proposed 500-kV right-of-way |
| 40 | Refrigerator |
| 25 | Bedroom at night |
| 0 | Hearing threshold |

Adapted from: USDOE, 1985; USDOE, 1996.

**Table 9: Calculated median ($L_{50}$) foul-weather audible noise levels at the edge of the right-of-way for the proposed Big Eddy – Knight 500-kV line operated at average voltage.** Configurations are described in Table 1.

| Configuration | | Foul weather L50 Audible Noise, dBA | |
|---|---|---|---|
| **No.** | **Description[1]** | **Proposed Alternative[2]** | **No-action Alternative[2]** |
| **1** | BE-KN SglCkt | 49, 49 | - |
| **2** | BE-KN SglCkt & HARV-BE | 48, 45 | 30, 35 |
| **3** | BE-KN SglCkt & McN-RO & HARV-BE | 48, 49 | 45, 48 |
| **4** | BE-KN SglCkt & CHE-GOL | 49, 46 | - |
| **5** | BE-KN SglCkt & Spearfish Tap | 42, 45 | 13, 23 |
| **6** | BE-KN SglCkt & BE-SPR | 49, 46 | 37, 37 |
| **7** | BE-KN DblCkt w/ 3x1.6” bundles | 49, 49 | - |
| **7A** | BE-KN DblCkt w/ only SglCkt on west side | 48, 46 | - |
| **8** | BE-KN DblCkt w/ HARV-BE | 45, 47 | 30, 35 |
| **9** | BE-KN DblCkt w/ McN-RO & HARV-BE | 43, 44 | 45, 48 |
| **10** | BE-KN DblCkt w/ CHE-GOL | 49, 47 | - |
| **11** | BE-KN DblCkt w/ Spearfish Tap | 40, 46 | 13, 23 |
| **12** | BE-KN DblCkt & Spearfish Tap | 46, 48 | 13, 23 |

Notes for Table 8:
1 BE-KN = Big Eddy-Knight; HARV-BE = Harvalum-Big Eddy; McN-RO = McNary-Ross; CHE-GOL = Chenoweth-Goldendale; BE-SPR = Big Eddy Spring Creek; SglCkt = Single circuit; DblCkt = Double circuit
2 Field at west (north) edge of ROW shown first.

**Table 10 Calculated median ($L_{50}$) fair-weather radio interference level and foul weather television level for the proposed Big Eddy – Knight 500-kV line operated at average voltage.** Configurations are described in Table 1.

| Configuration | | L50 Fair-Weather RI Level at 1 MHz, dB(μV/m)[2] | Foul-Weather TVI at 75 MHz, dB(μV/m) [2] |
|---|---|---|---|
| **No.** | **Description[1]** | | |
| **1** | BE-KN SglCkt | 39, 39 | 24, 24 |
| **2** | BE-KN SglCkt & HARV-BE | 39, 31 | 23, 10 |
| **3** | BE-KN SglCkt & McN-RO & HARV-BE | 34, 31 | 16, 13 |
| **4** | BE-KN SglCkt & CHE-GOL | 39, 36 | 24, 17 |
| **5** | BE-KN SglCkt & Spearfish Tap | 29, 35 | 6, 16 |
| **6** | BE-KN SglCkt & BE-SPR | 39, 32 | 24, 11 |
| **7** | BE-KN DblCkt w/ 3x1.6” bundles | 38, 38 | 21, 21 |
| **7A** | BE-KN DblCkt w/ only 3 bundles | 41, 37 | 23, 18 |
| **8** | BE-KN DblCkt w/ HARV-BE | 37, 38 | 17, 18 |
| **9** | BE-KN DblCkt w/ McN-RO & HARV-BE | 33, 33 | 7, 8 |
| **10** | BE-KN DblCkt w/ CHE-GOL | 41, 37 | 23, 18 |
| **11** | BE-KN DblCkt w/ Spearfish Tap | 25, 36 | 2, 17 |
| **12** | BE-KN DblCkt & Spearfish Tap | 34, 36 | 8, 13 |

Notes for Table 9:

1 BE-KN = Big Eddy-Knight; HARV-BE = Harvalum- Big Eddy; McN-RO = McNary-Ross; CHE-GOL = Chenoweth-Goldendale; BE-SPR = Big Eddy Spring Creek; SglCkt = Single circuit; DblCkt = Double circuit

2 Field at west (north) side of ROW shown first. Calculated levels shown at 100 feet (30 m) from the outside conductor or at the edge of the right-of-way, whichever is further from the conductor.

**Figure 1: Alternative Routes and Segments for the Proposed Big Eddy – Knight 500-kV Transmission Line.**

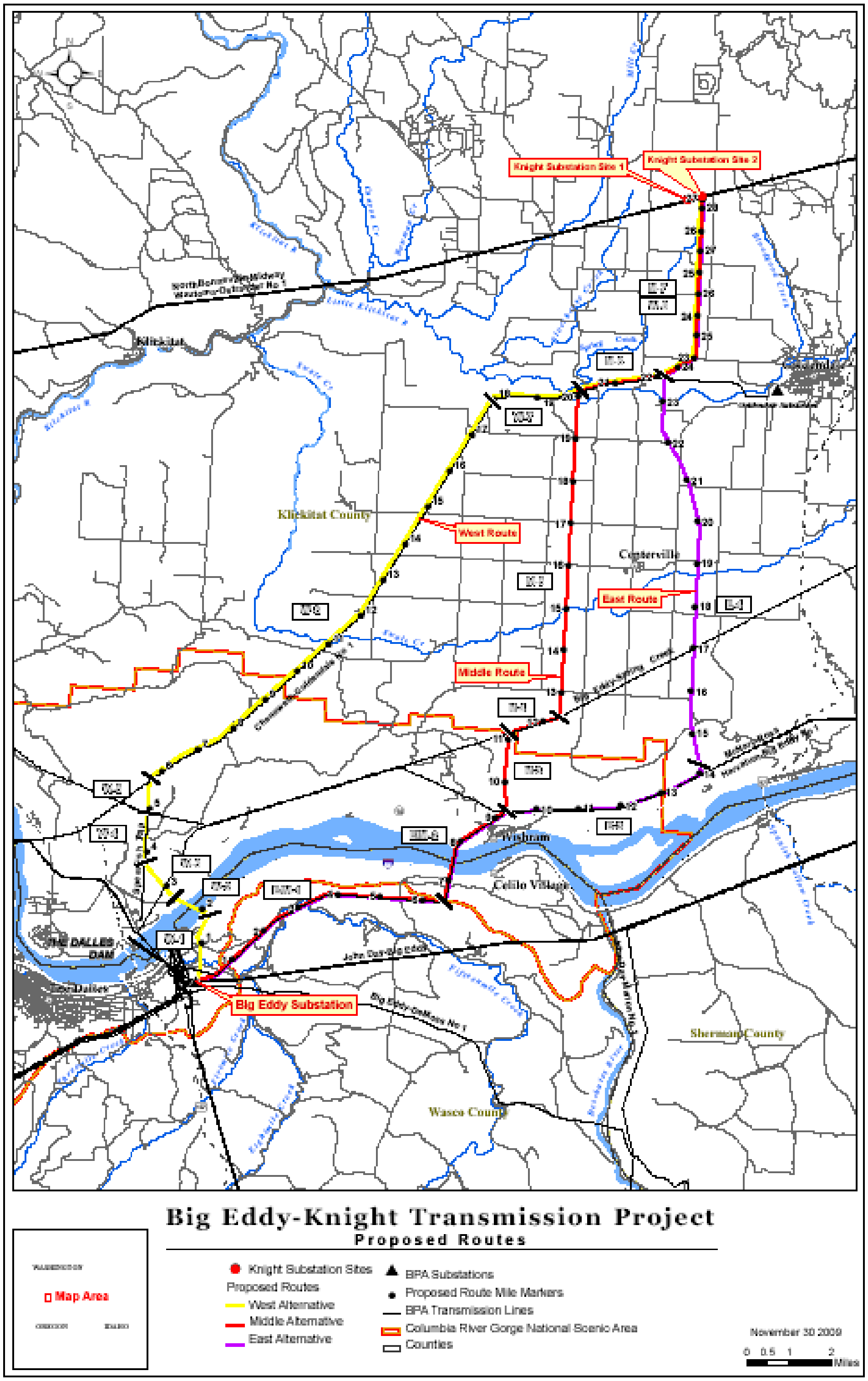


**Figure 2: Single-circuit Configuration 1 for the proposed Big Eddy – Knight 500-kV line.** Configurations are described in Tables 1 and 2.

Configuration 1

Big Eddy-Knight Proposed Single Circuit
Voltage: 536 kV (ave.), 550 kV (max.)
Current: 485 A (ave.), 970 A (max.)
Conductors: 3 x 1.3 in., 17 in. bundle spacing

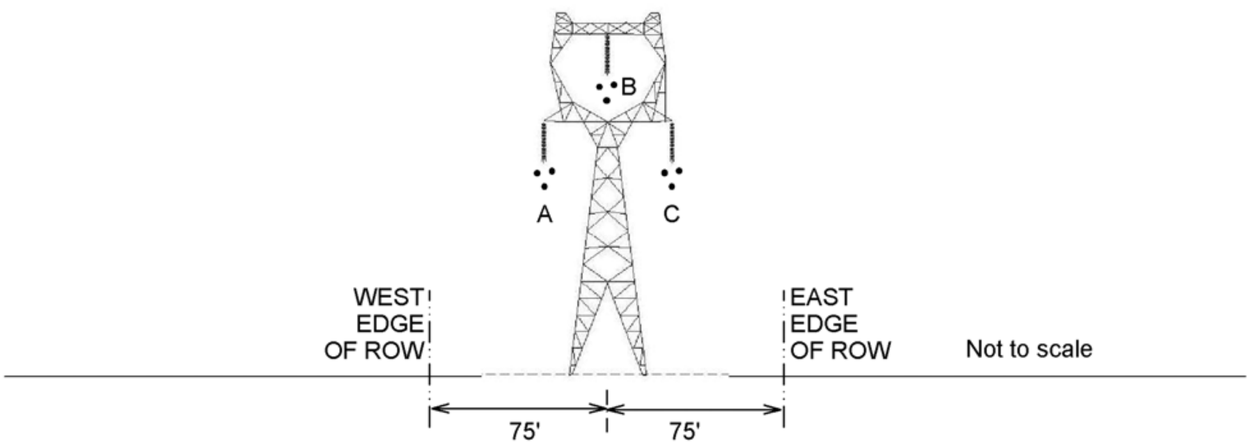


**Figure 3: Single-circuit Configuration 2 for the proposed Big Eddy – Knight 500-kV line.** Configurations are described in Tables 1 and 2.

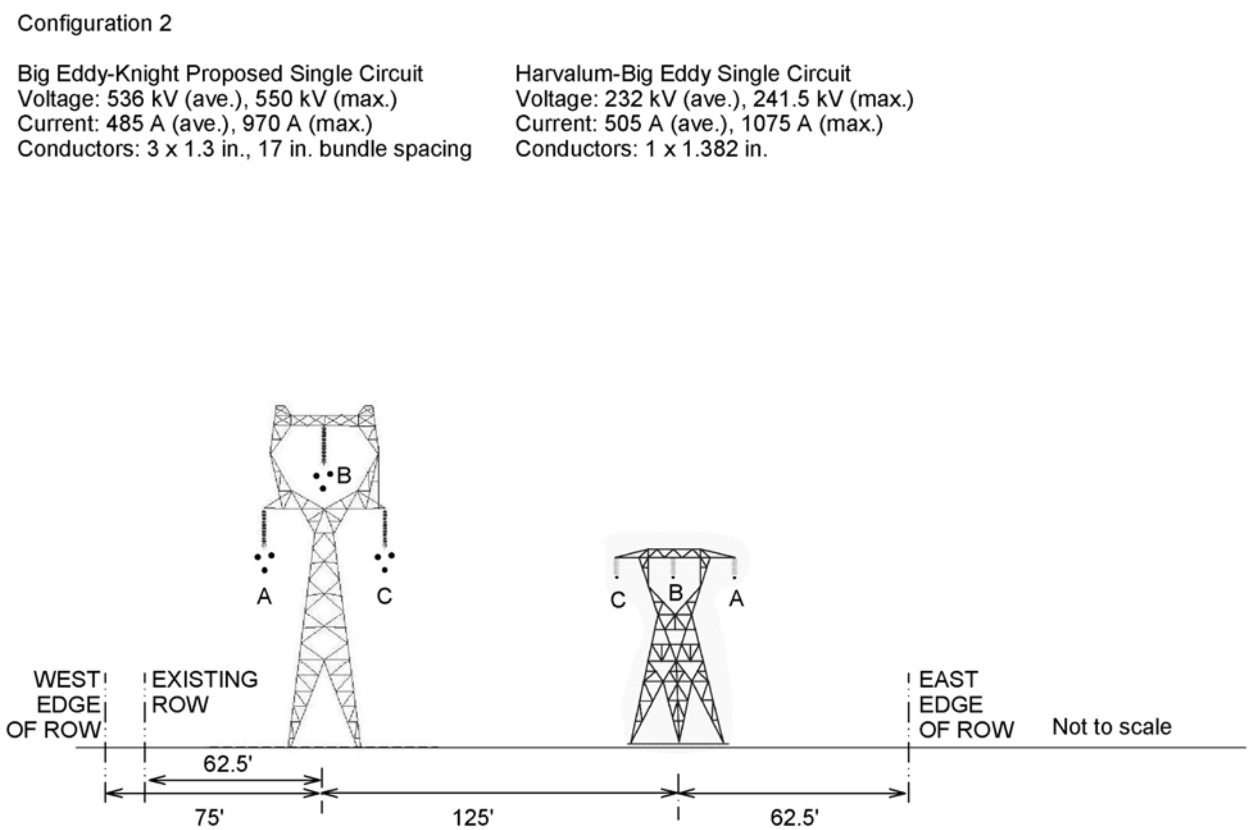


**Figure 4: Single-circuit Configuration 3 for the proposed Big Eddy – Knight 500-kV line.** Configurations are described in Tables 1 and 2.

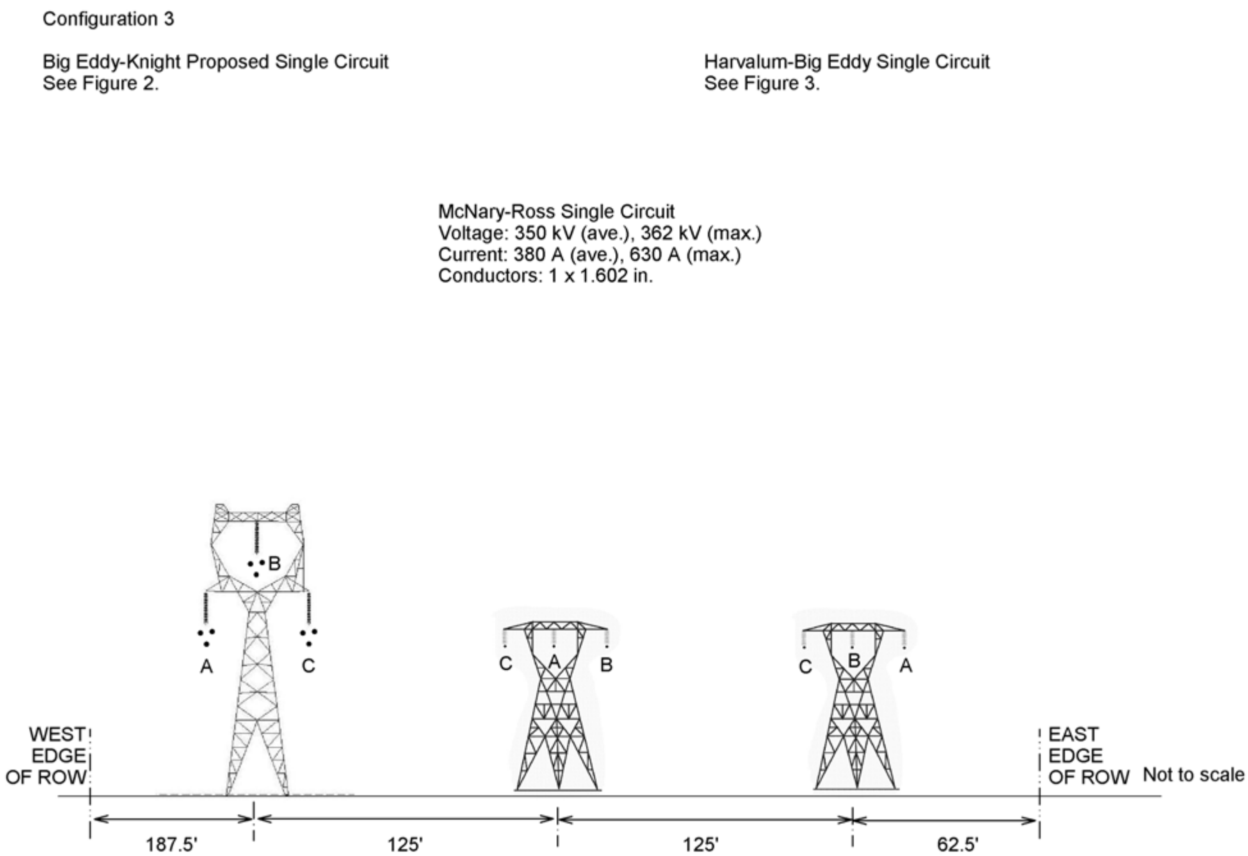


**Figure 5: Single-circuit Configuration 4 for the proposed Big Eddy – Knight 500-kV line.** Configurations are described in Tables 1 and 2.

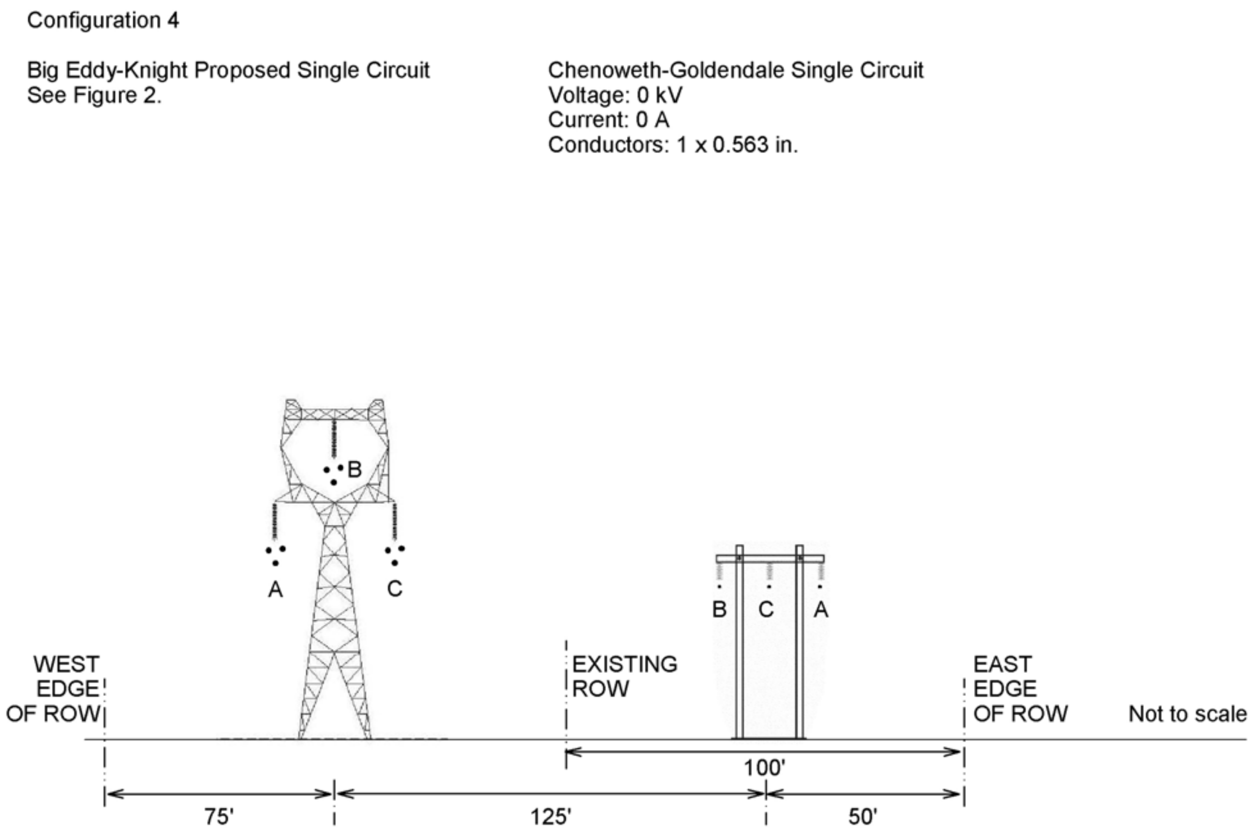


**Figure 6: Single-circuit Configuration 5 for the proposed Big Eddy – Knight 500-kV line.** Configurations are described in Tables 1 and 2.

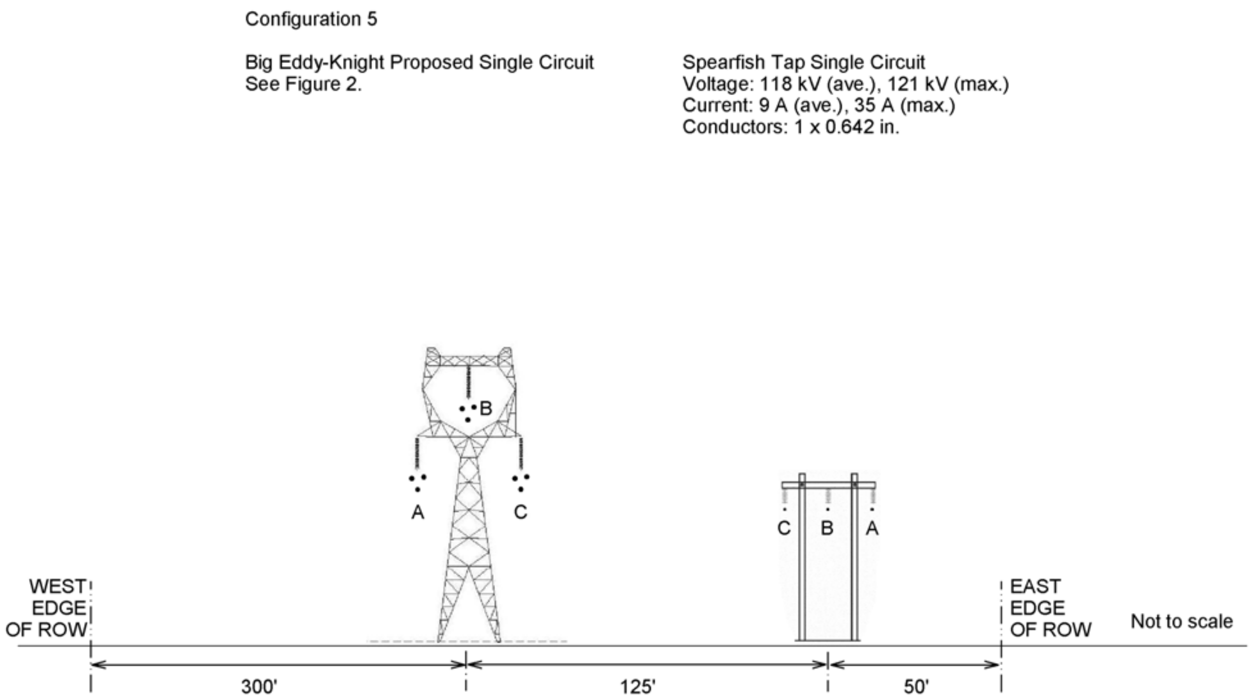


**Figure 7: Single-circuit Configuration 6 for the proposed Big Eddy – Knight 500-kV line.** Configurations are described in Tables 1 and 2.

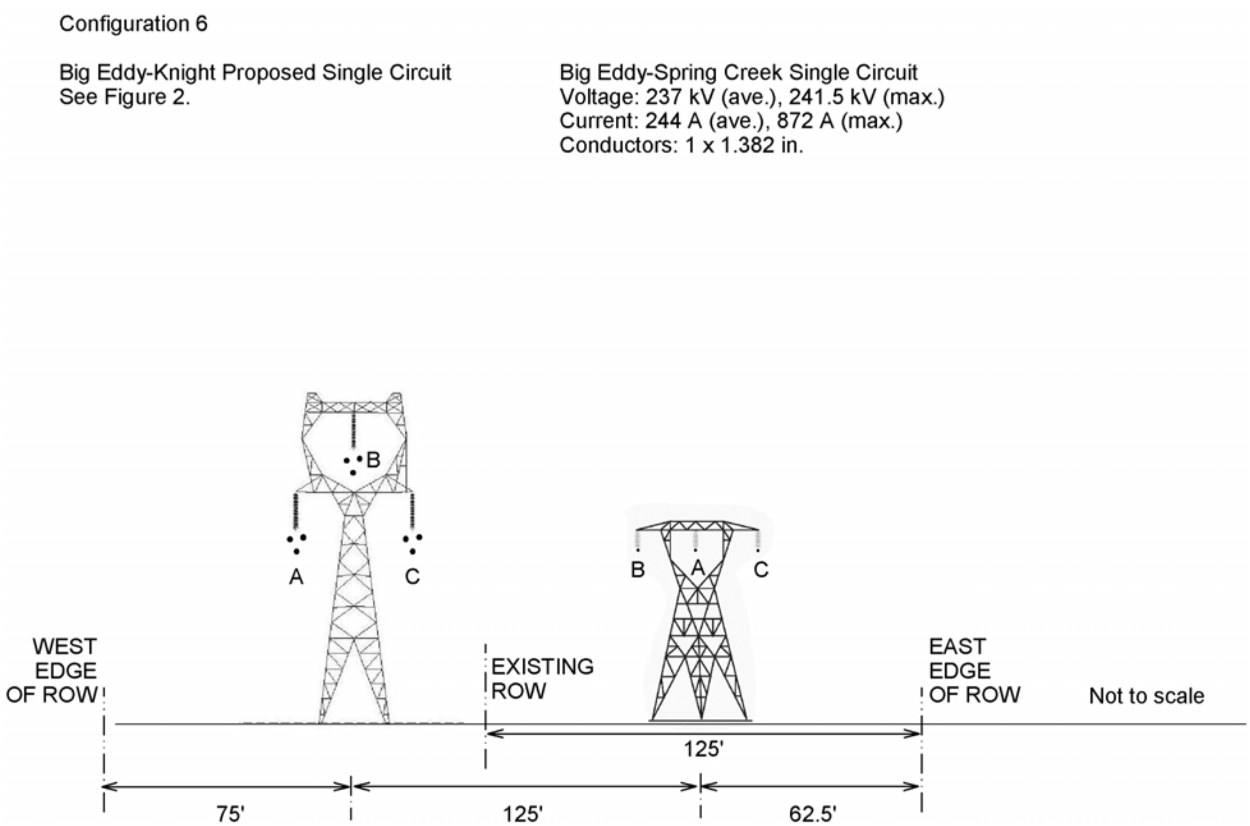


**Figure 8: Double-circuit Configurations 7 and 7A for the proposed Big Eddy – Knight 500-kV line.** The current is split between the two circuits in Configuration 7. The current is only on the west circuit in Configuration 7A and the east circuit conductors carry zero current and are not grounded. Configurations are described in Tables 1 and 2.

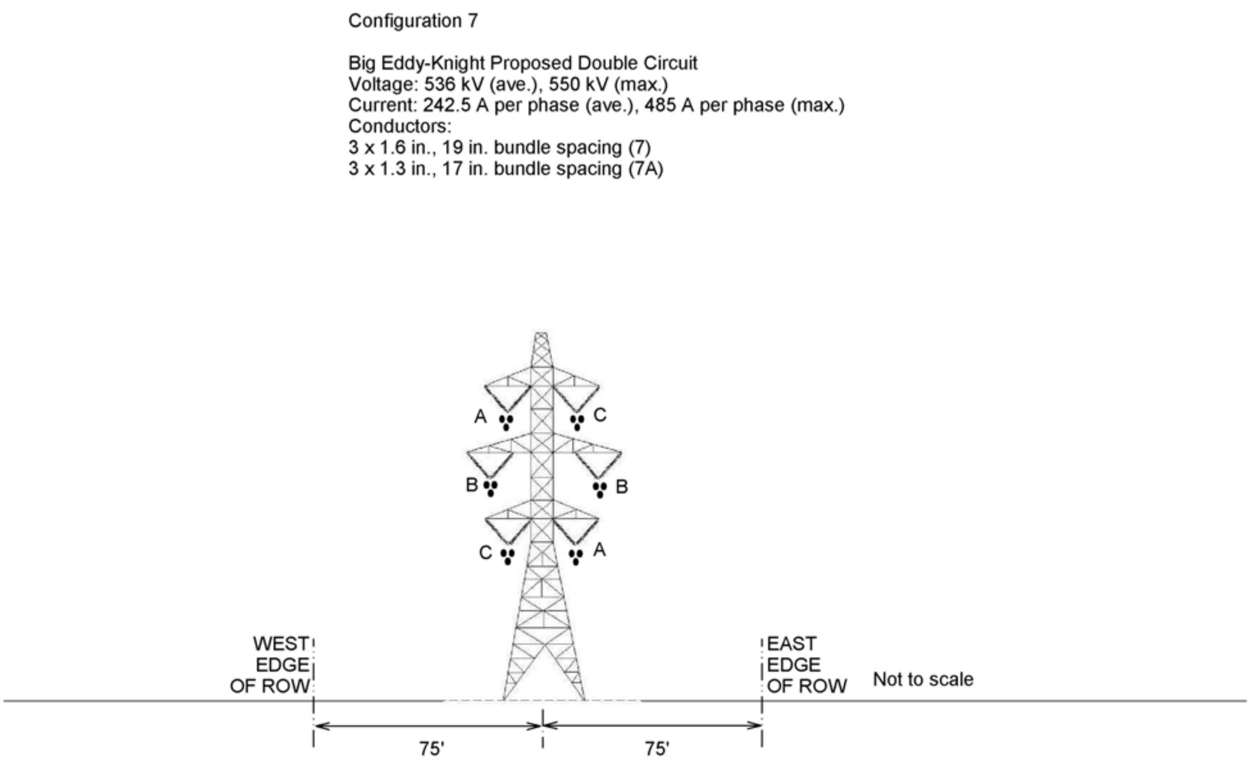


**Figure 9: Double-circuit Configuration 8 for the proposed Big Eddy – Knight 500-kV line.** Configurations are described in Tables 1 and 2.

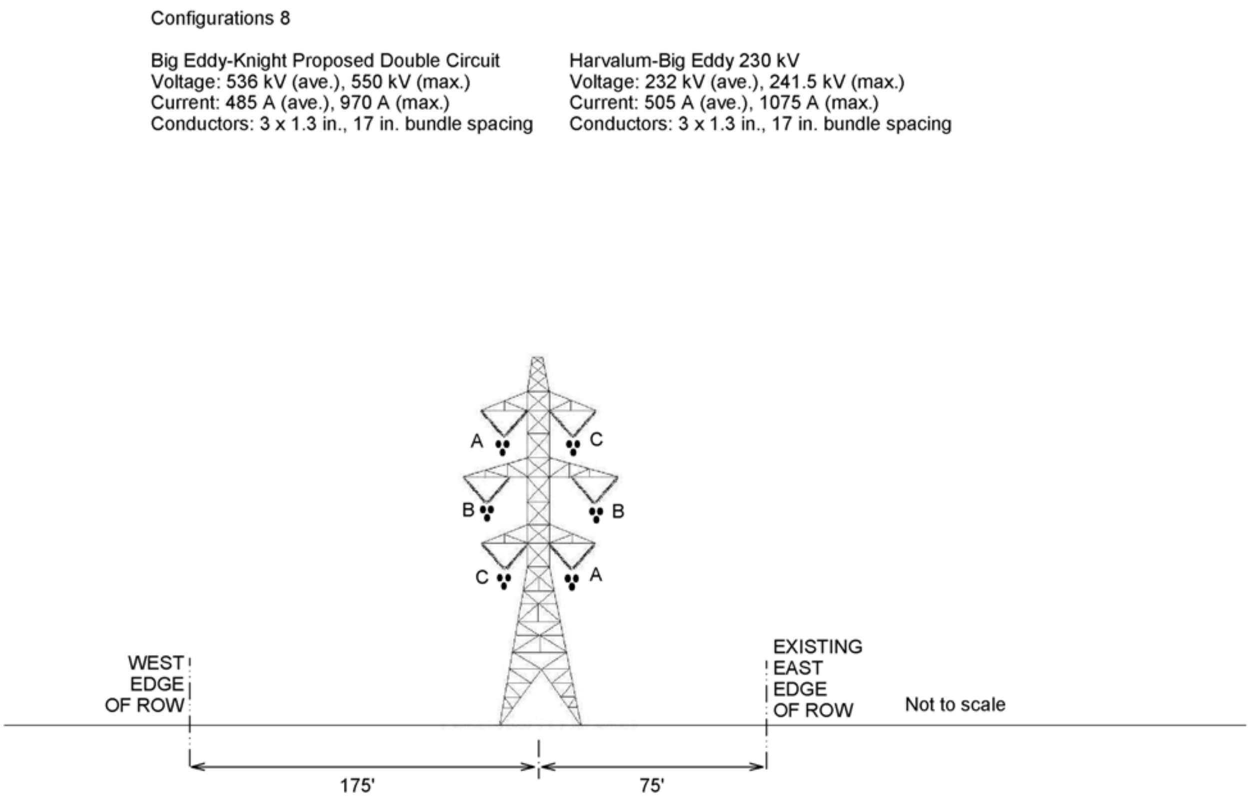


**Figure 10: Double-circuit Configuration 9 for the proposed Big Eddy – Knight 500-kV line.** Configurations are described in Tables 1 and 2.

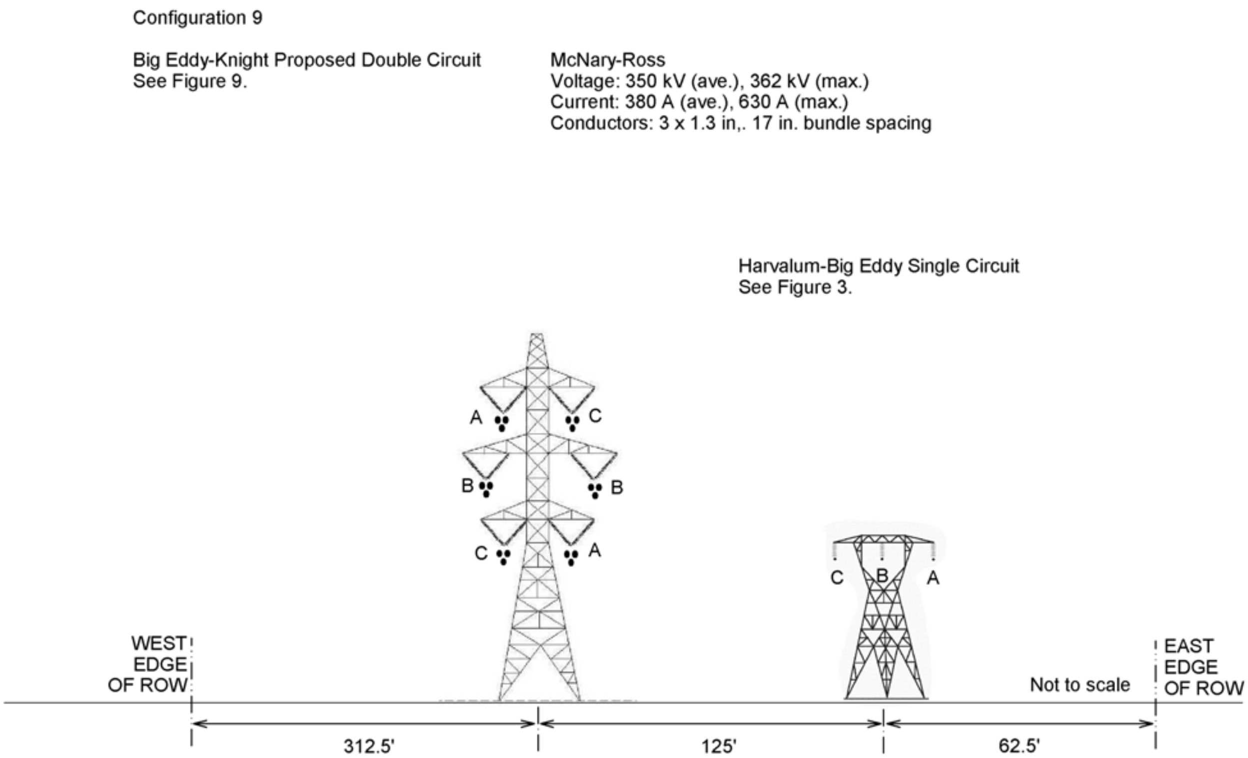


**Figure 11: Double-circuit Configurations 10 and 11 for the proposed Big Eddy – Knight 500-kV line.** The west circuit will be the proposed Big Eddy – Knight line and the east circuit will be the existing Chenoweth – Goldendale line (Configuration 10) or the existing Spearfish Tap line (Configuration 11). Configurations are described in Tables 1 and 2.

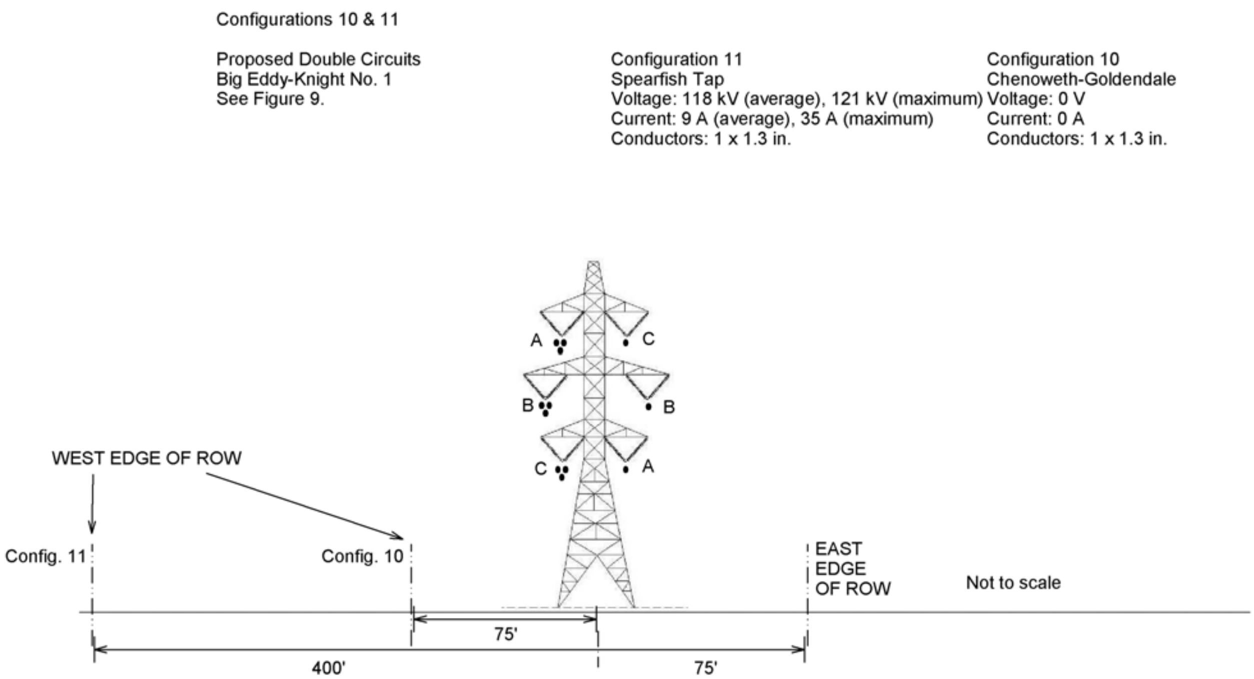


**Figure 12: Double-circuit Configuration 12 for the proposed Big Eddy – Knight 500-kV line.** Configurations are described in Tables 1 and 2.

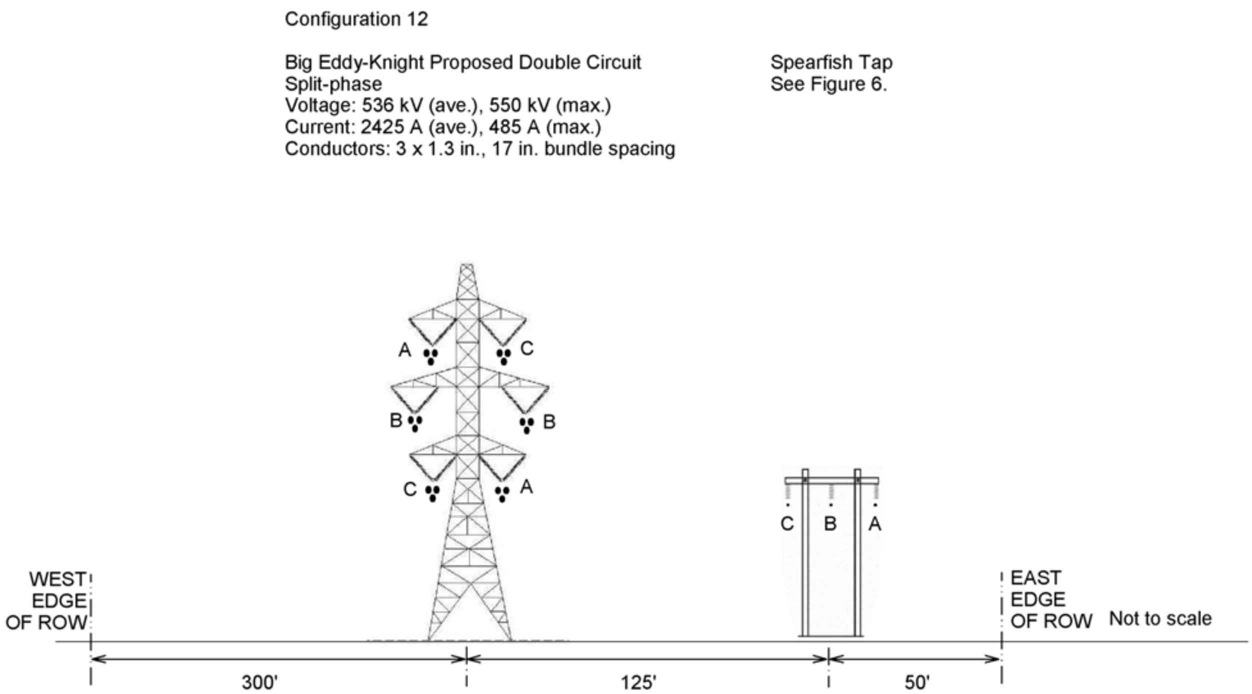


**Figure 13: Electric-field profiles for single-circuit Configuration 1 of the proposed Big Eddy – Knight 500-kV line.** Fields for maximum voltage with minimum and average clearances are shown. Configurations are described in Tables 1 and 2.

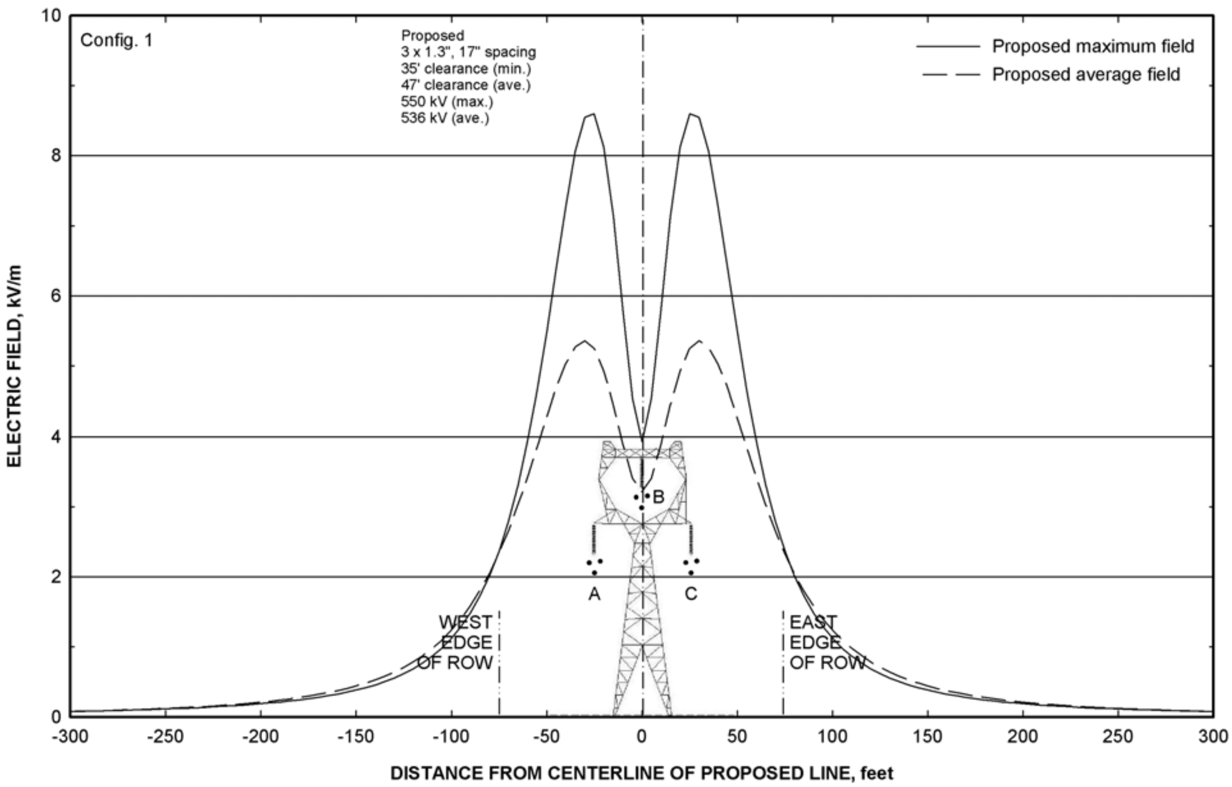


**Figure 14: Electric-field profiles for single-circuit Configuration 2 of the proposed Big Eddy – Knight 500-kV line.** Fields for maximum voltage with minimum and average clearances are shown. Configurations are described in Tables 1 and 2.

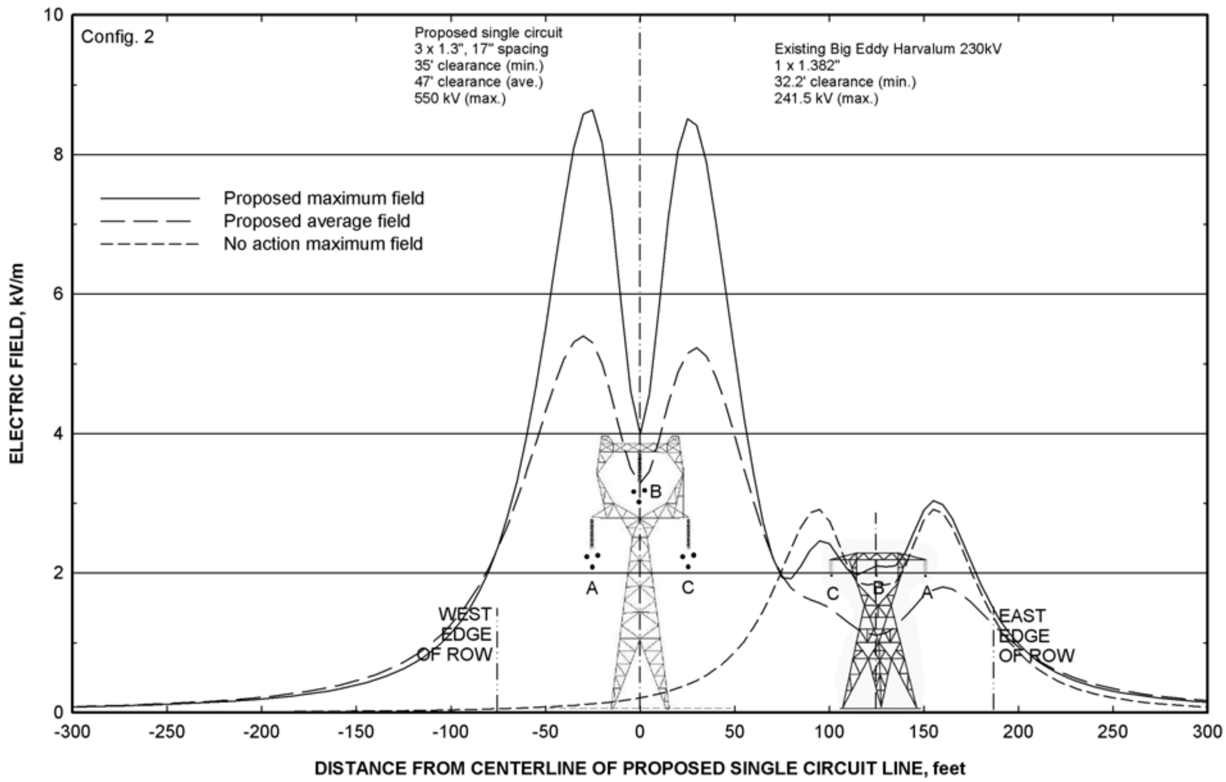


**Figure 15: Electric-field profiles for single-circuit Configuration 3 of the proposed Big Eddy – Knight 500-kV line.** Fields for maximum voltage with minimum and average clearances are shown. Configurations are described in Tables 1 and 2.

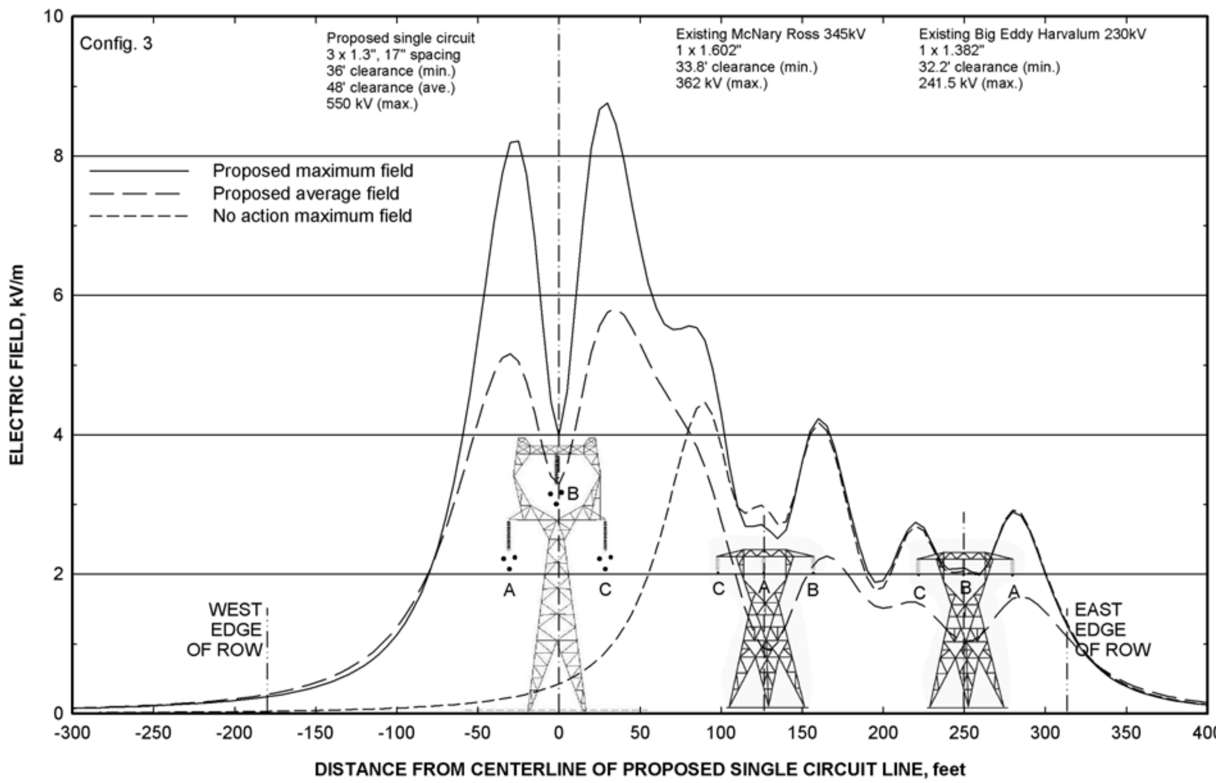


**Figure 16: Electric-field profiles for single-circuit Configuration 4 of the proposed Big Eddy – Knight 500-kV line:** Fields for maximum voltage with minimum and average clearances are shown. Configurations are described in Tables 1 and 2.

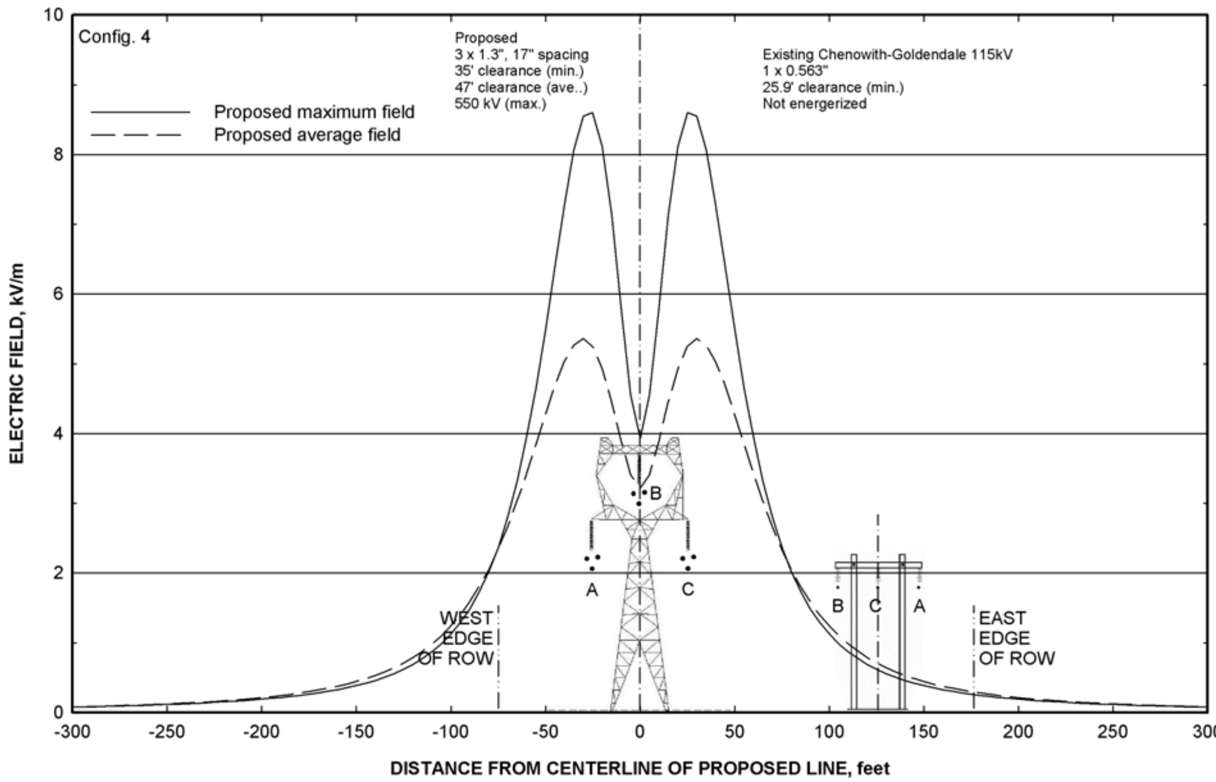


**Figure 17: Electric-field profiles for single-circuit Configuration 5 of the proposed Big Eddy – Knight 500-kV line:** Fields for maximum voltage with minimum and average clearances are shown. Configurations are described in Tables 1 and 2.

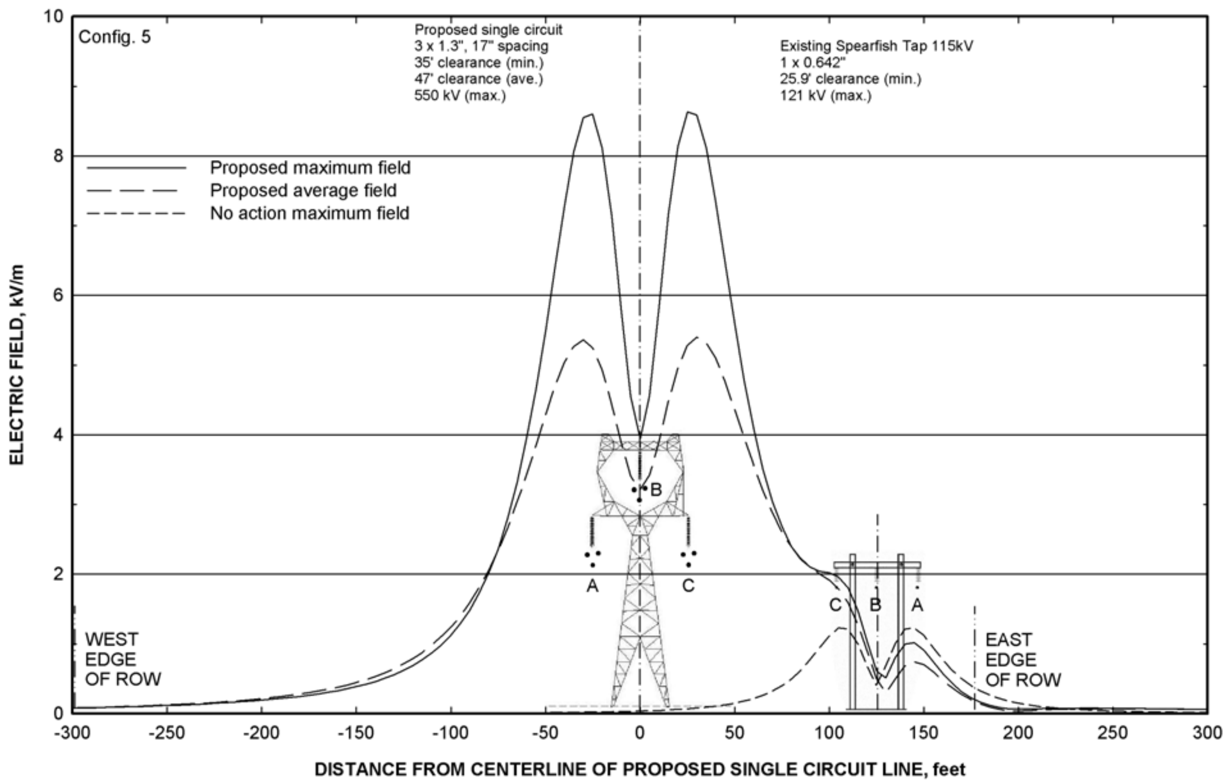


**Figure 18: Electric-field profiles for single-circuit Configuration 6 of the proposed Big Eddy – Knight 500-kV line:** Fields for maximum voltage with minimum and average clearances are shown. Configurations are described in Tables 1 and 2.

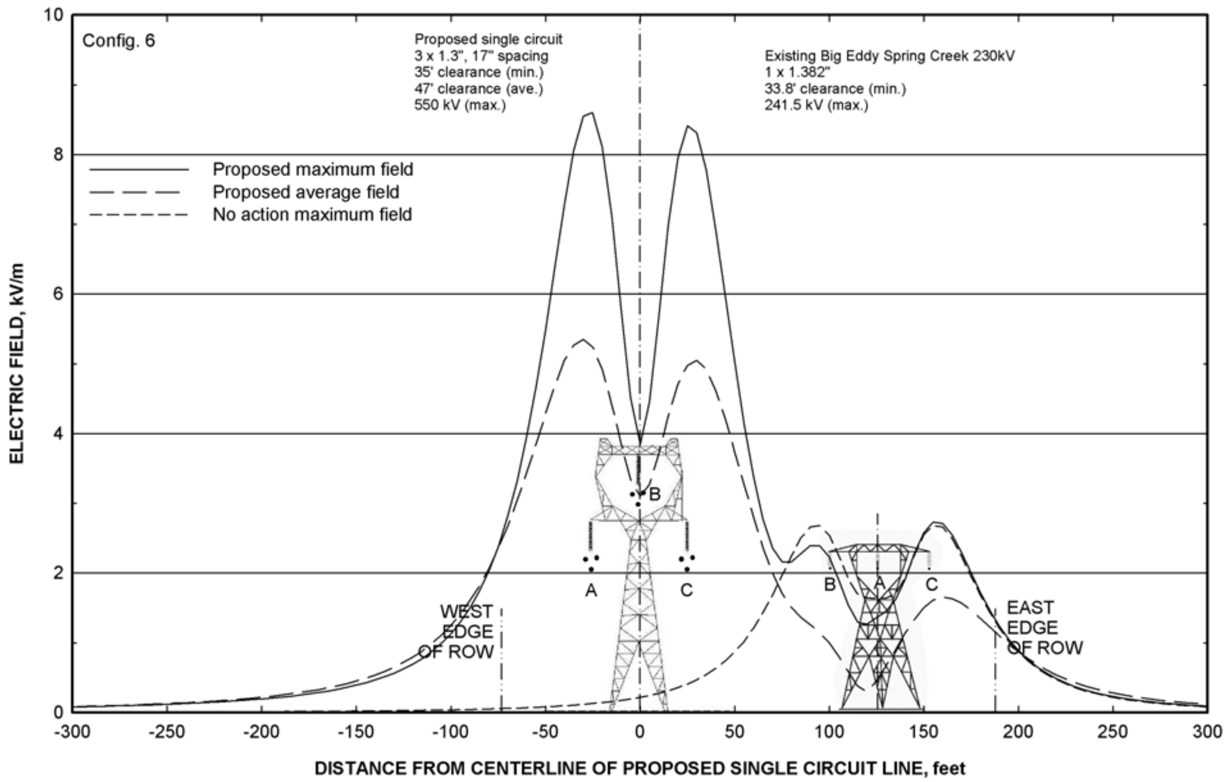


**Figure 19: Electric-field profiles for double-circuit Configurations 7 and 7A of the proposed Big Eddy – Knight 500-kV line:** Fields for maximum voltage with minimum and average clearances are shown. Configurations are described in Tables 1 and 2.

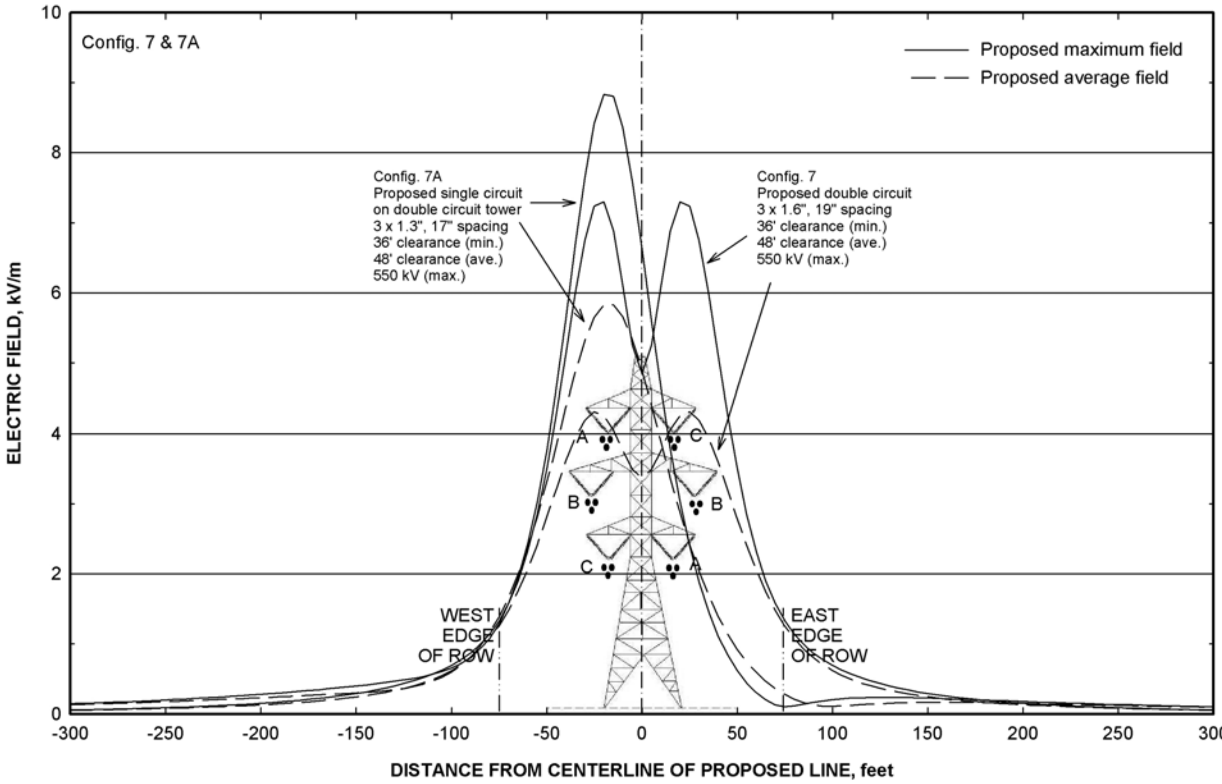


**Figure 20**: **Electric-field profiles for double-circuit Configuration 8 of the proposed Big Eddy – Knight 500-kV line.** Fields for maximum voltage with minimum and average clearances are shown. Configurations are described in Tables 1 and 2.

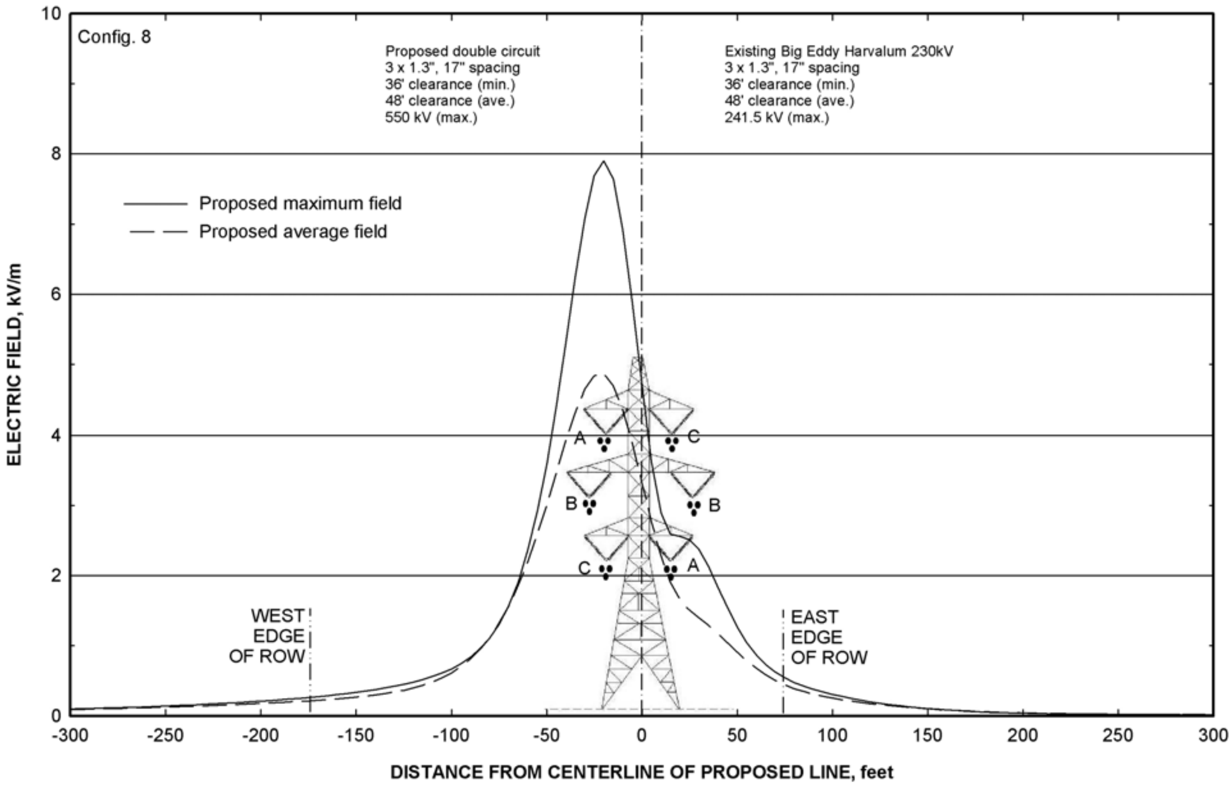


**Figure 21: Electric-field profiles for double-circuit Configuration 9 of the proposed Big Eddy – Knight 500-kV line:** Fields for maximum voltage with minimum and average clearances are shown. Configurations are described in Tables 1 and 2.

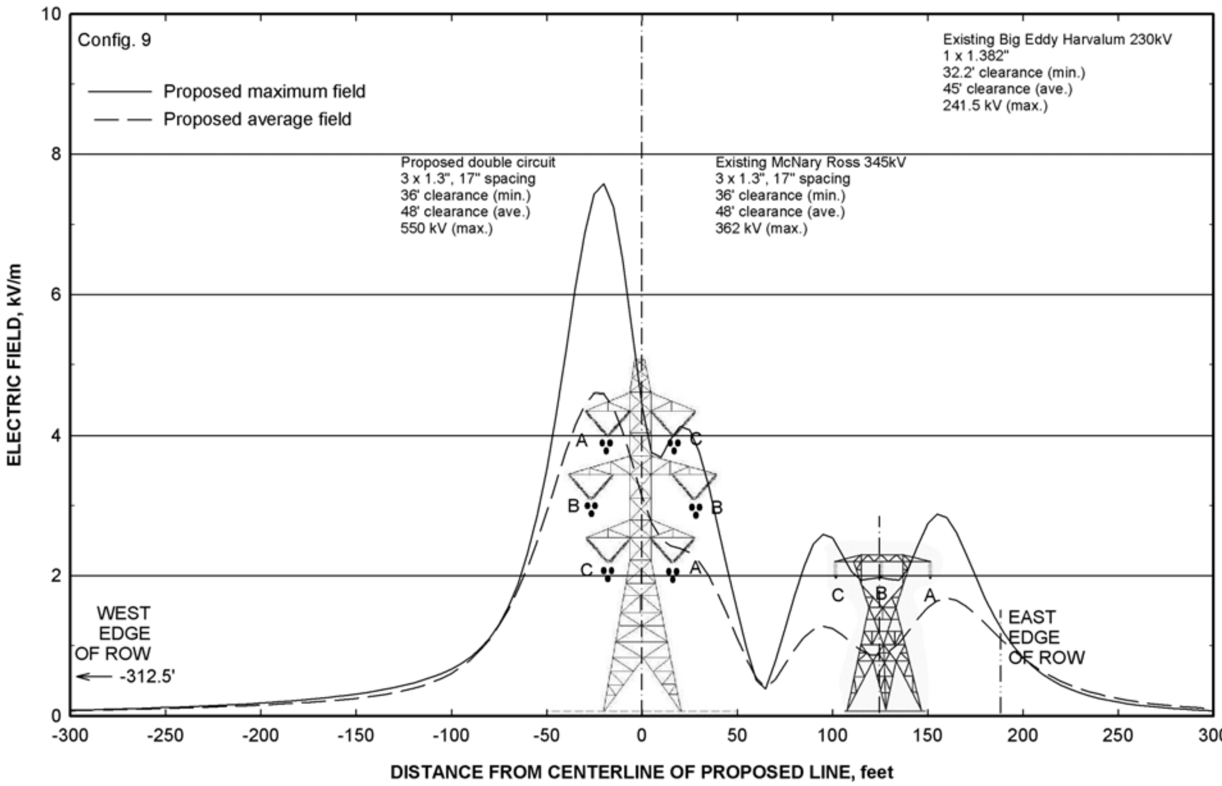


Figure 22: **Electric-field profiles for double-circuit Configuration 10 of the proposed Big Eddy – Knight 500-kV line:** Fields for maximum voltage with minimum and average clearances are shown. Configurations are described in Tables 1 and 2.

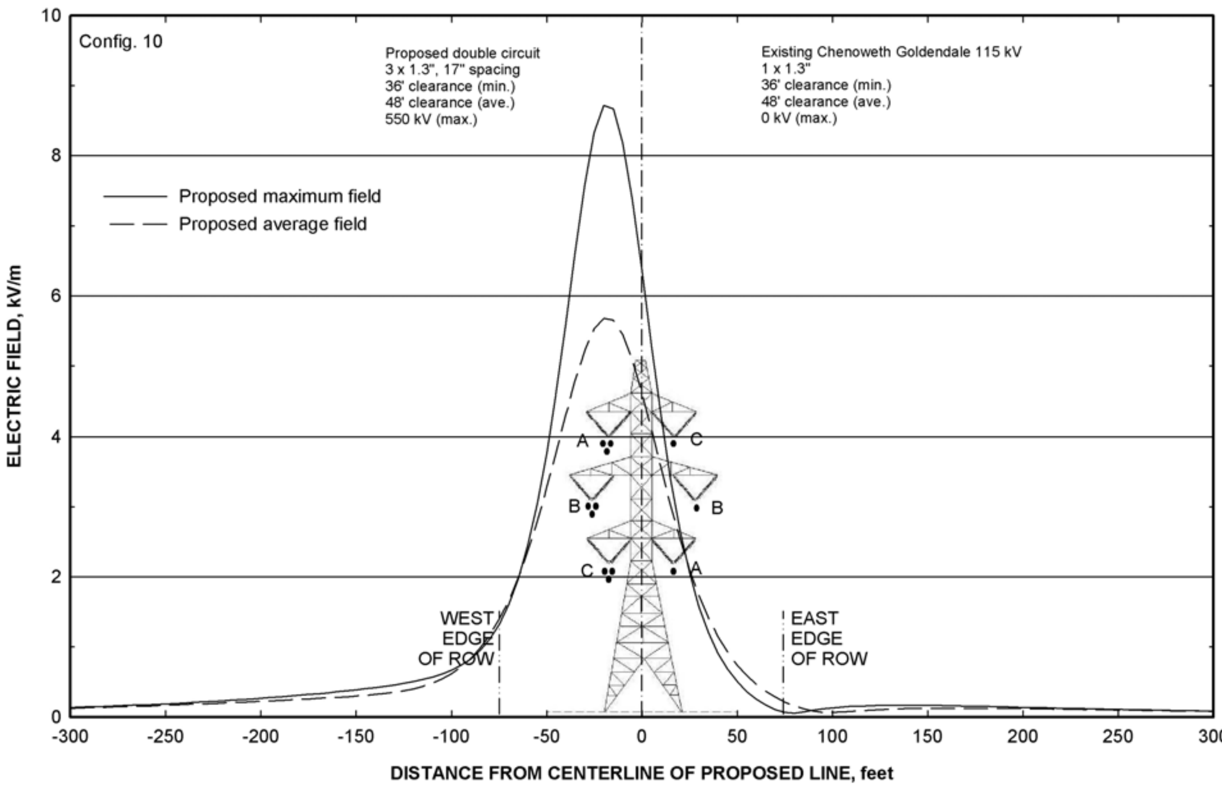


**Figure 23:** **Electric-field profiles for double-circuit Configuration 11 of the proposed Big Eddy – Knight 500-kV line**: Fields for maximum voltage with minimum and average clearances are shown. Configurations are described in Tables 1 and 2.

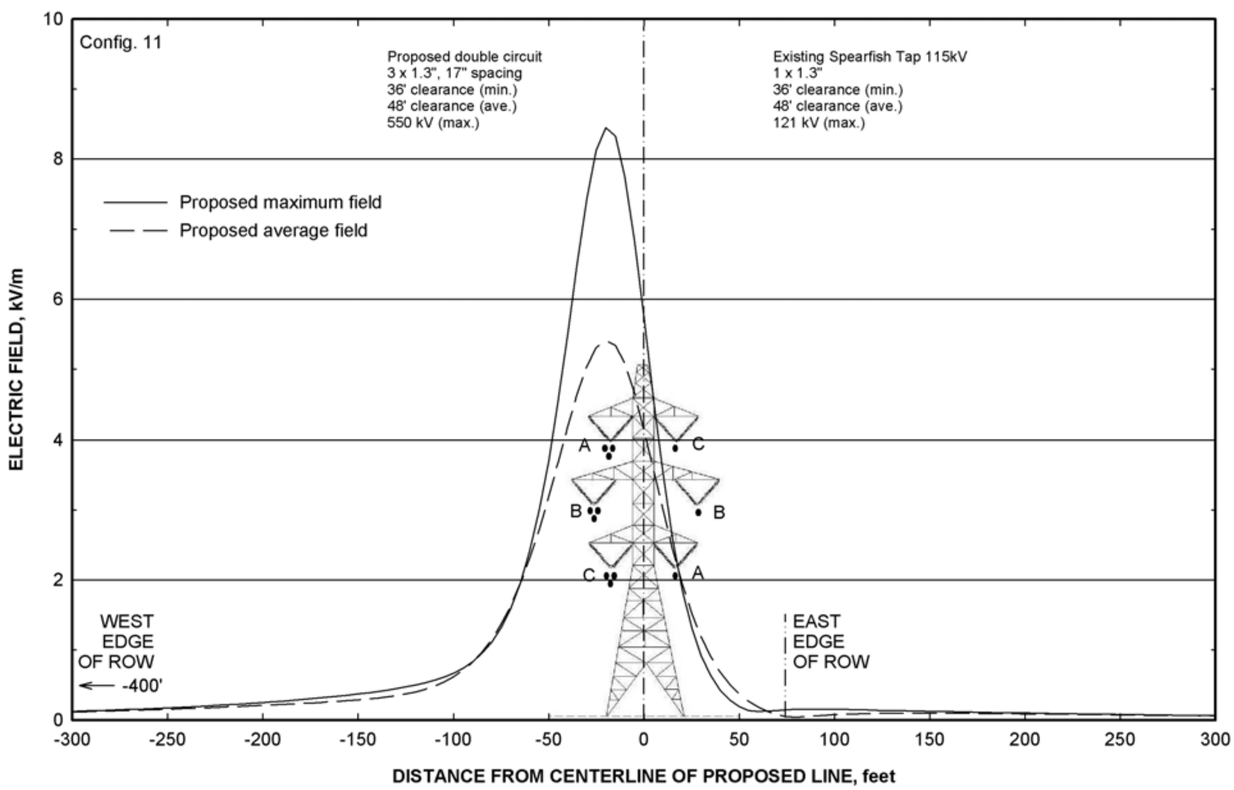


**Figure 24: Electric-field profiles for double-circuit Configuration 12 of the proposed Big Eddy – Knight 500-kV line:** Fields for maximum voltage with minimum and average clearances are shown. Configurations are described in Tables 1 and 2.

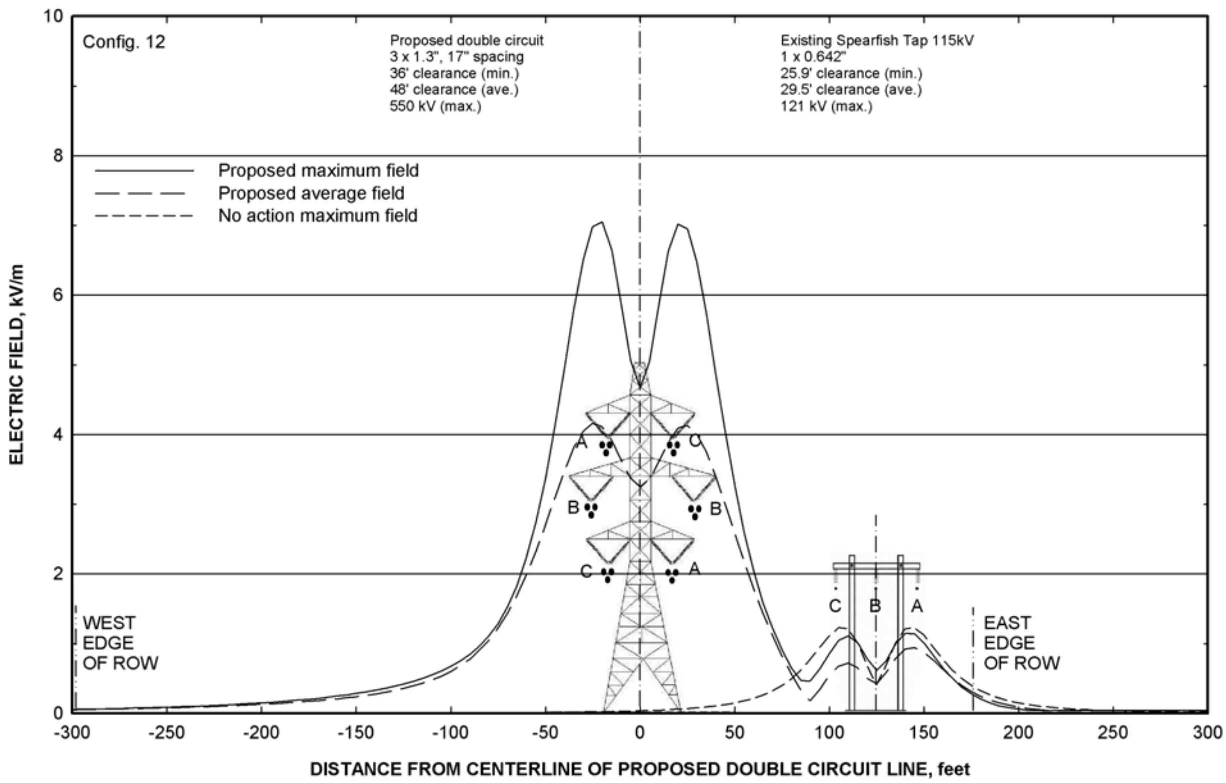


**Figure 25: Magnetic-field profiles for single-circuit Configuration 1 of the proposed Big Eddy – Knight 500-kV line.** Fields computed for maximum current with minimum clearance and for average current with average clearance are shown. Configurations are described in Tables 1 and 2.

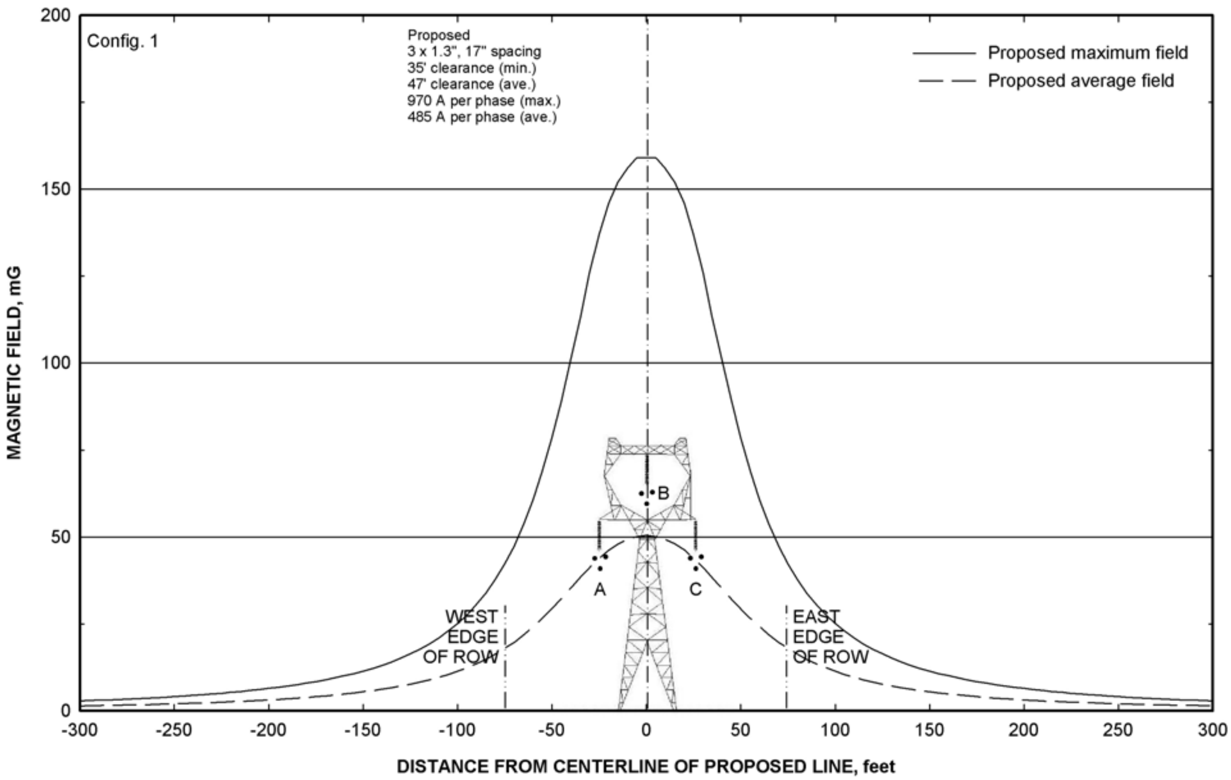


**Figure 26: Magnetic-field profiles for single-circuit Configuration 2 of the proposed Big Eddy – Knight 500-kV line.** Fields computed for maximum current with minimum clearance and for average current with average clearance are shown. Configurations are described in Tables 1 and 2.

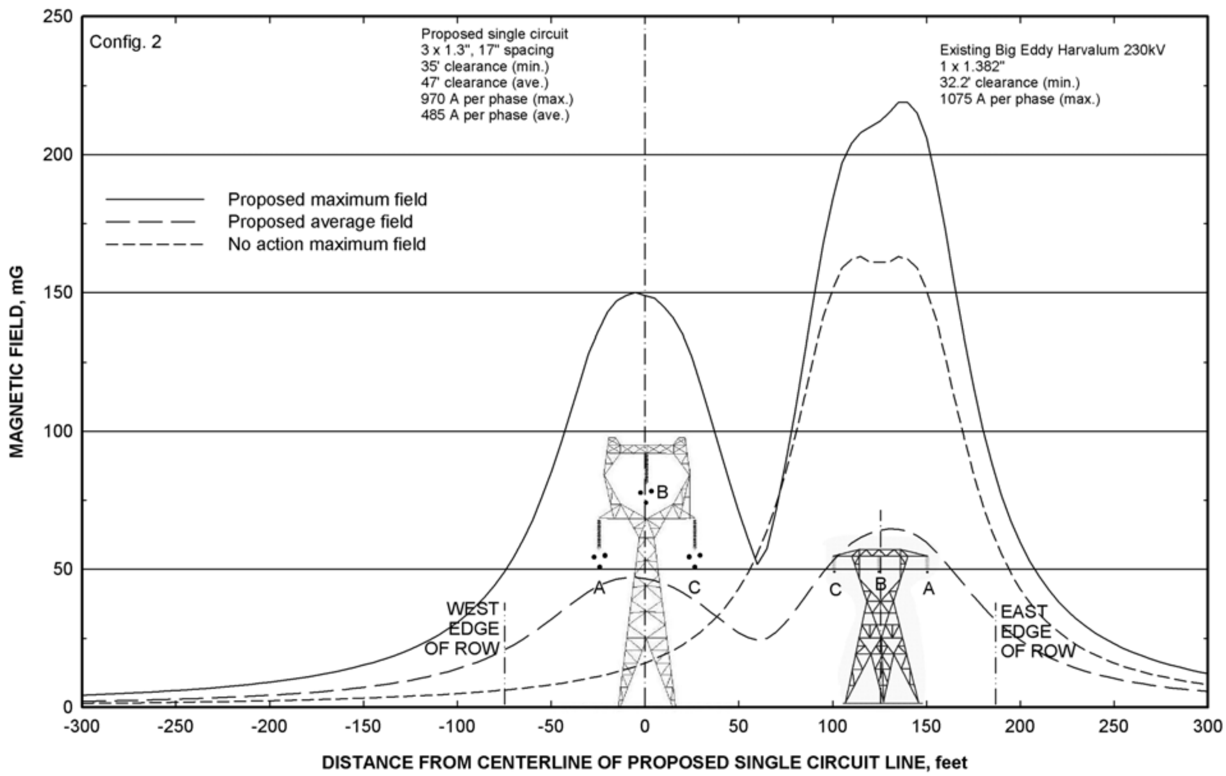


**Figure 27: Magnetic-field profiles for single-circuit Configuration 3 of the proposed Big Eddy – Knight 500-kV line.** Fields computed for maximum current with minimum clearance and for average current with average clearance are shown. Configurations are described in Tables 1 and 2.

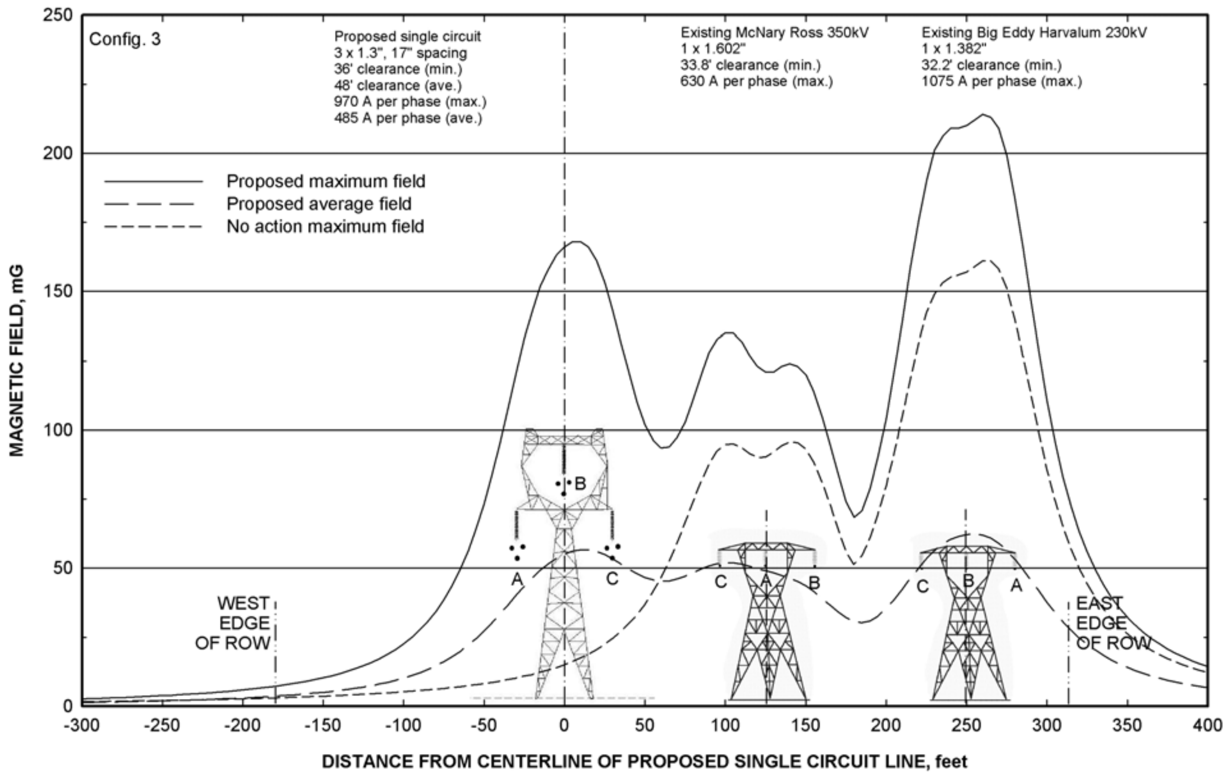


**Figure 28: Magnetic-field profiles for single-circuit Configuration 4 of the proposed Big Eddy – Knight 500-kV line.** Fields computed for maximum current with minimum clearance and for average current with average clearance are shown. Configurations are described in Tables 1 and 2.

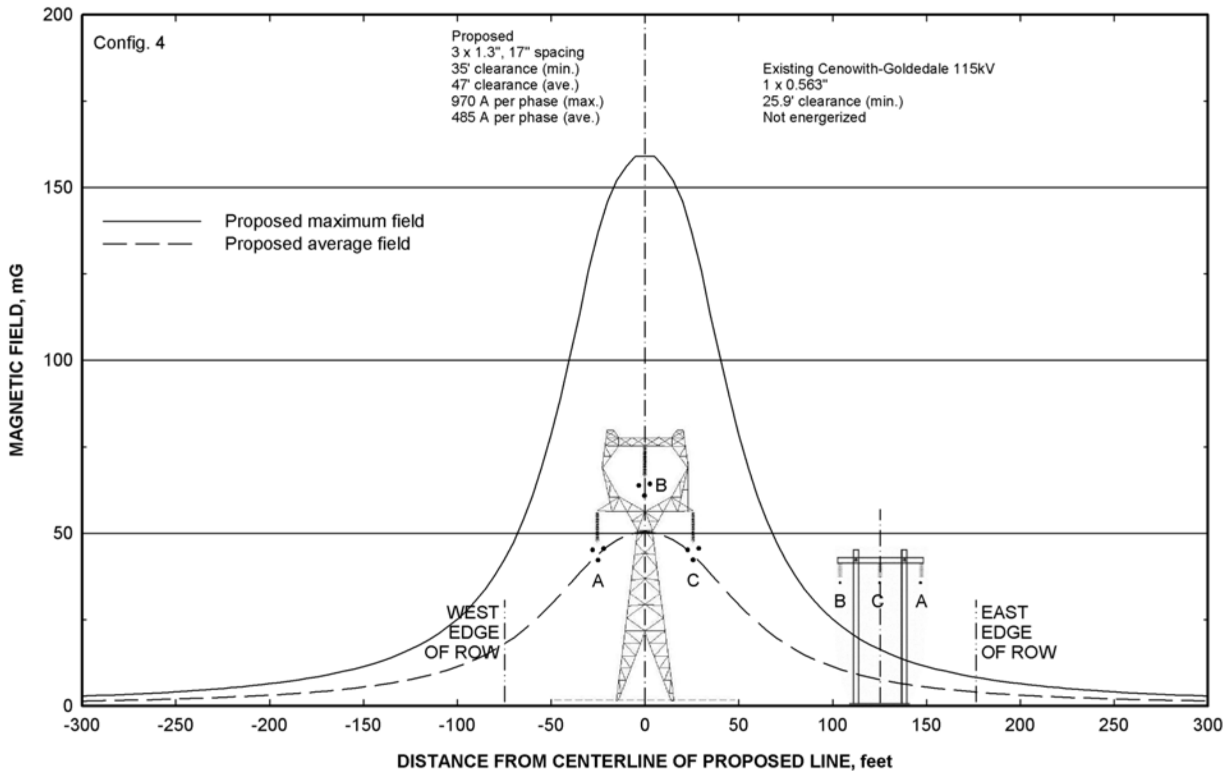


**Figure 29: Magnetic-field profiles for single-circuit Configuration 5 of the proposed Big Eddy – Knight 500-kV line.** Fields computed for maximum current with minimum clearance and for average current with average clearance are shown. Configurations are described in Tables 1 and 2.

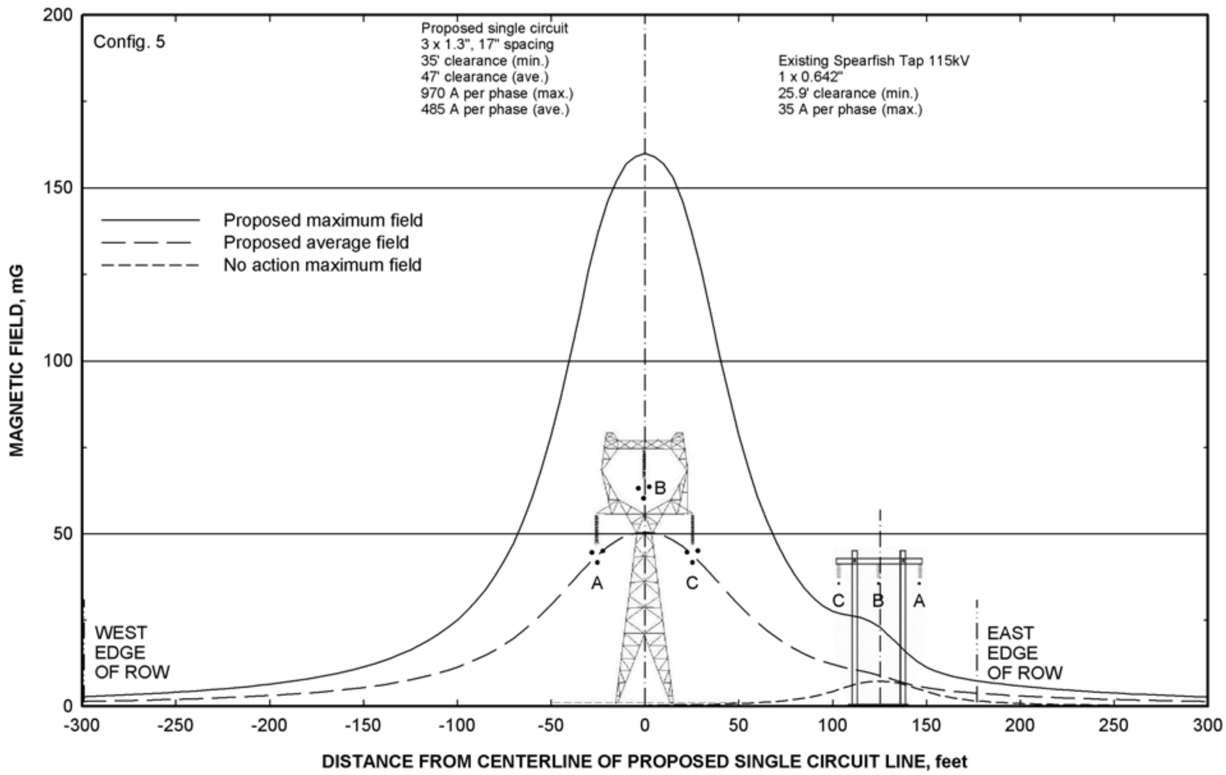


**Figure 30: Magnetic-field profiles for single-circuit Configuration 6 of the proposed Big Eddy – Knight 500-kV line.** Fields computed for maximum current with minimum clearance and for average current with average clearance are shown. Configurations are described in Tables 1 and 2.

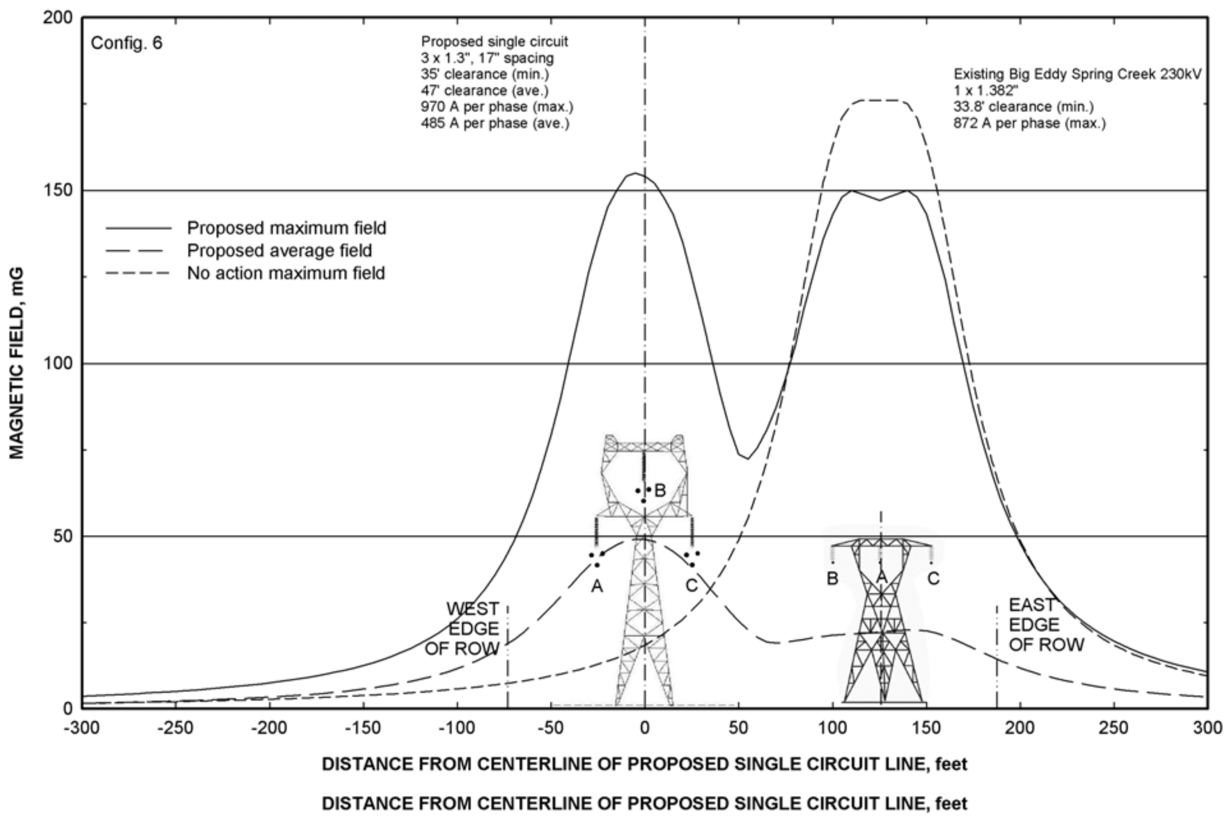


**Figure 31: Magnetic-field profiles for double-circuit Configurations 7 and 7A of the proposed Big Eddy – Knight 500-kV line.** Fields computed for maximum current with minimum clearance and for average current with average clearance are shown. Configurations are described in Tables 1 and 2.

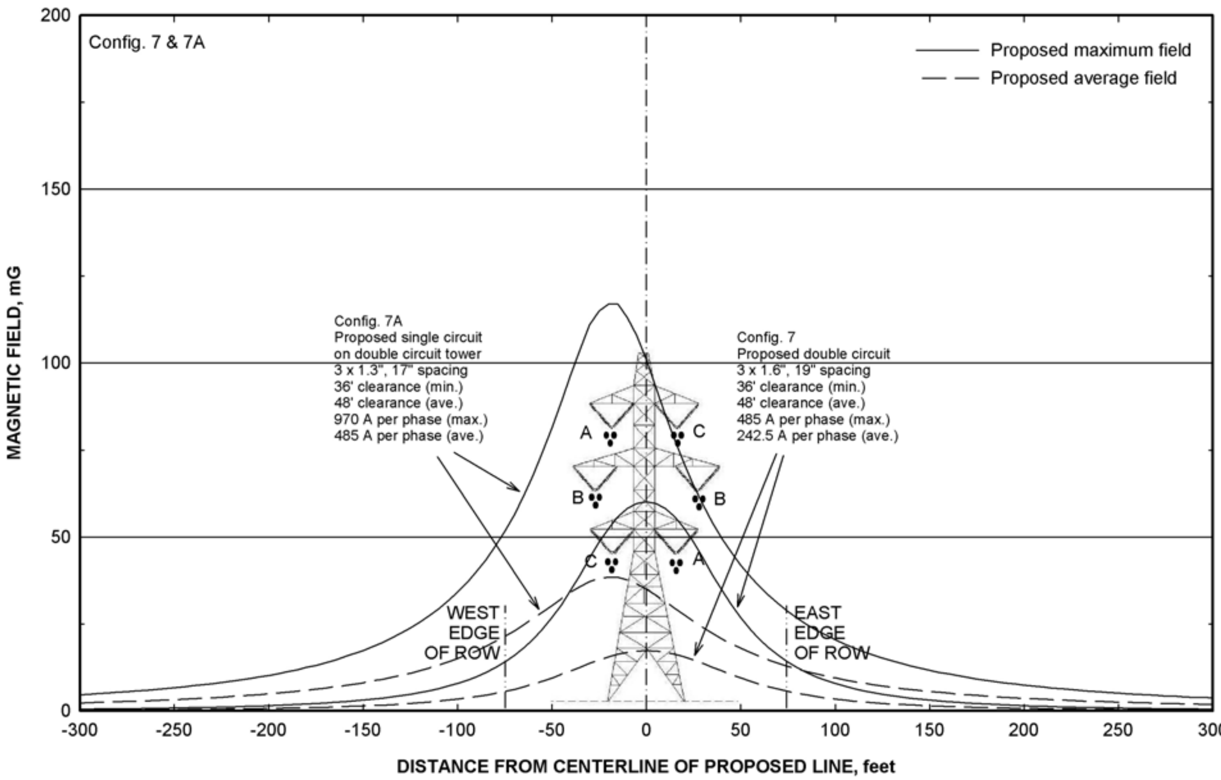


**Figure 32: Magnetic-field profiles for double-circuit Configuration 8 of the proposed Big Eddy – Knight 500-kV line.** Fields computed for maximum current with minimum clearance and for average current with average clearance are shown. Configurations are described in Tables 1 and 2.

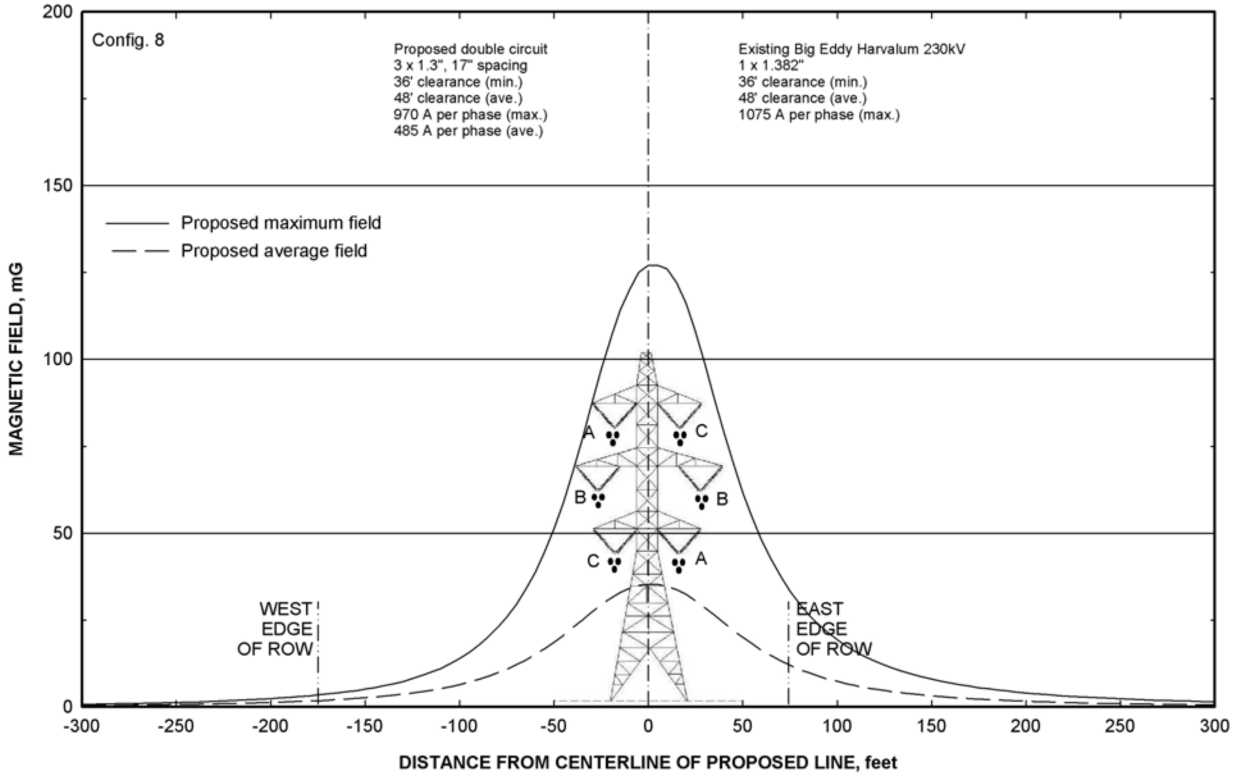


**Figure 33: Magnetic-field profiles for double-circuit Configuration 9 of the proposed Big Eddy – Knight 500-kV line.** Fields computed for maximum current with minimum clearance and for average current with average clearance are shown. Configurations are described in Tables 1 and 2.

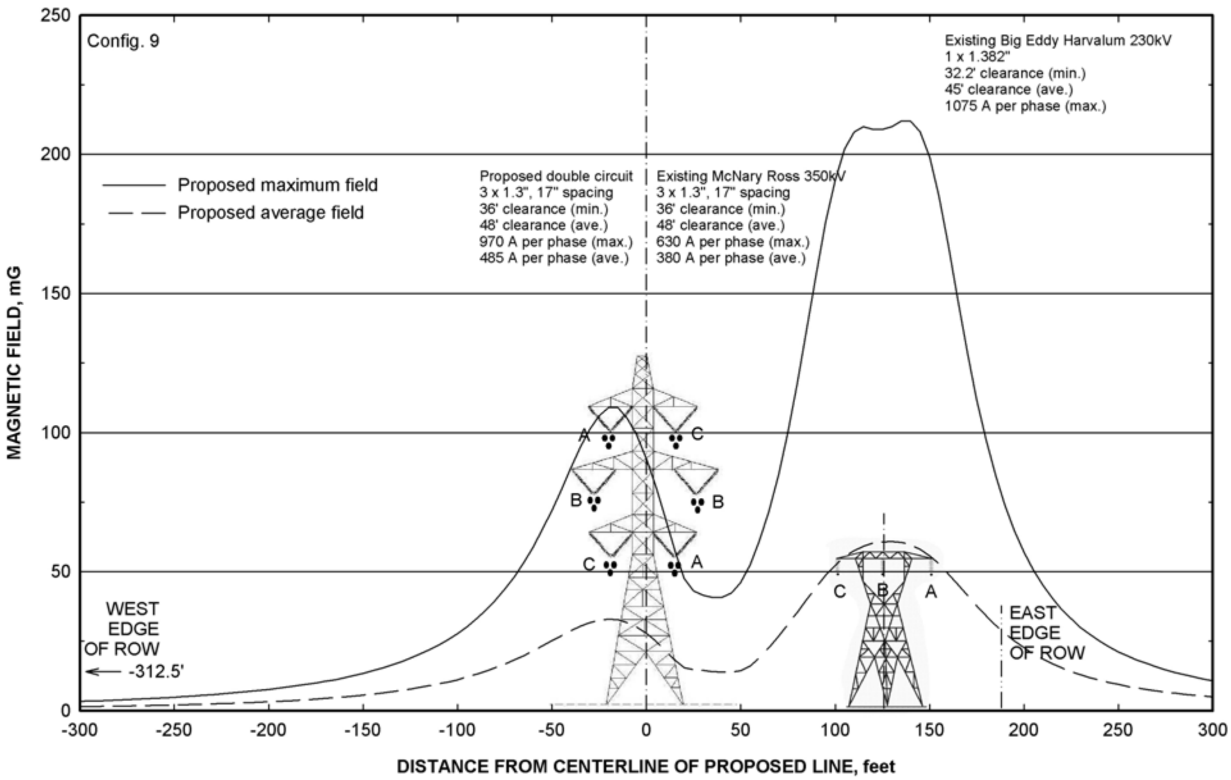


**Figure 34: Magnetic-field profiles for double-circuit Configuration 10 of the proposed Big Eddy – Knight 500-kV line.** Fields computed for maximum current with minimum clearance and for average current with average clearance are shown. Configurations are described in Tables 1 and 2.

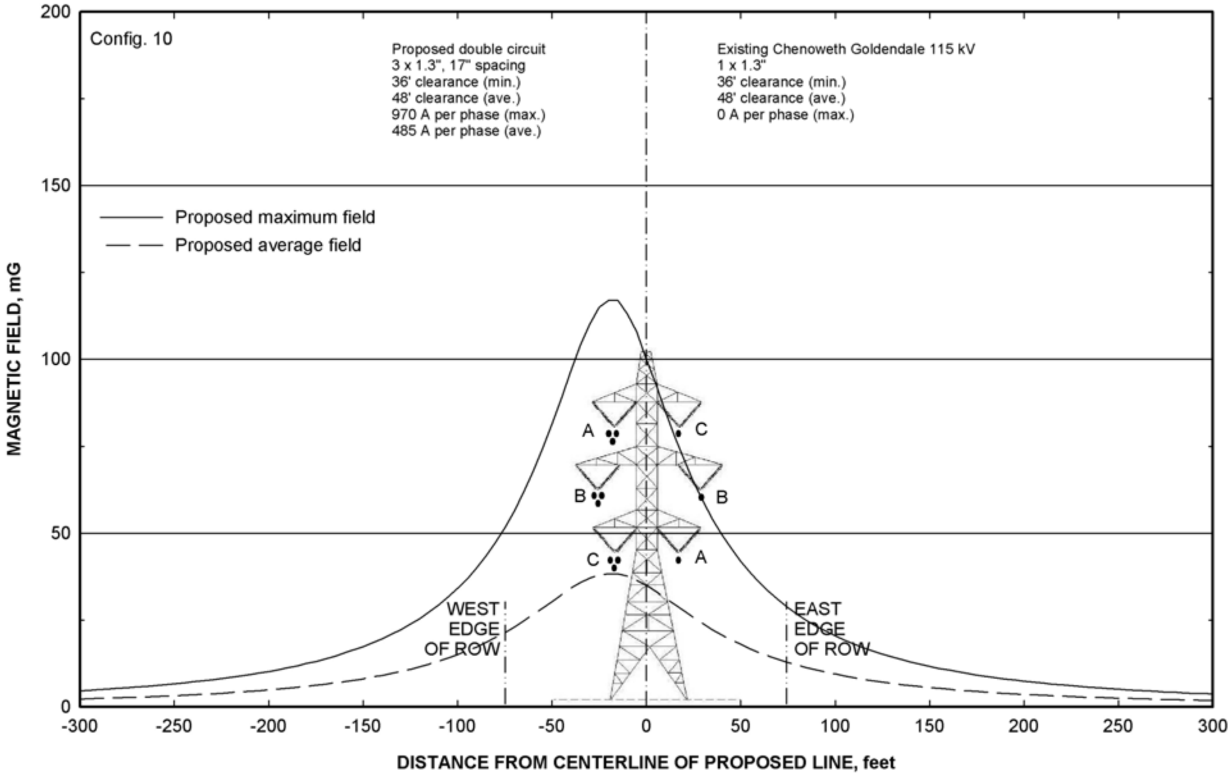


**Figure 35: Magnetic-field profiles for double-circuit Configuration 11 of the proposed Big Eddy – Knight 500-kV line.** Fields computed for maximum current with minimum clearance and for average current with average clearance are shown. Configurations are described in Tables 1 and 2.

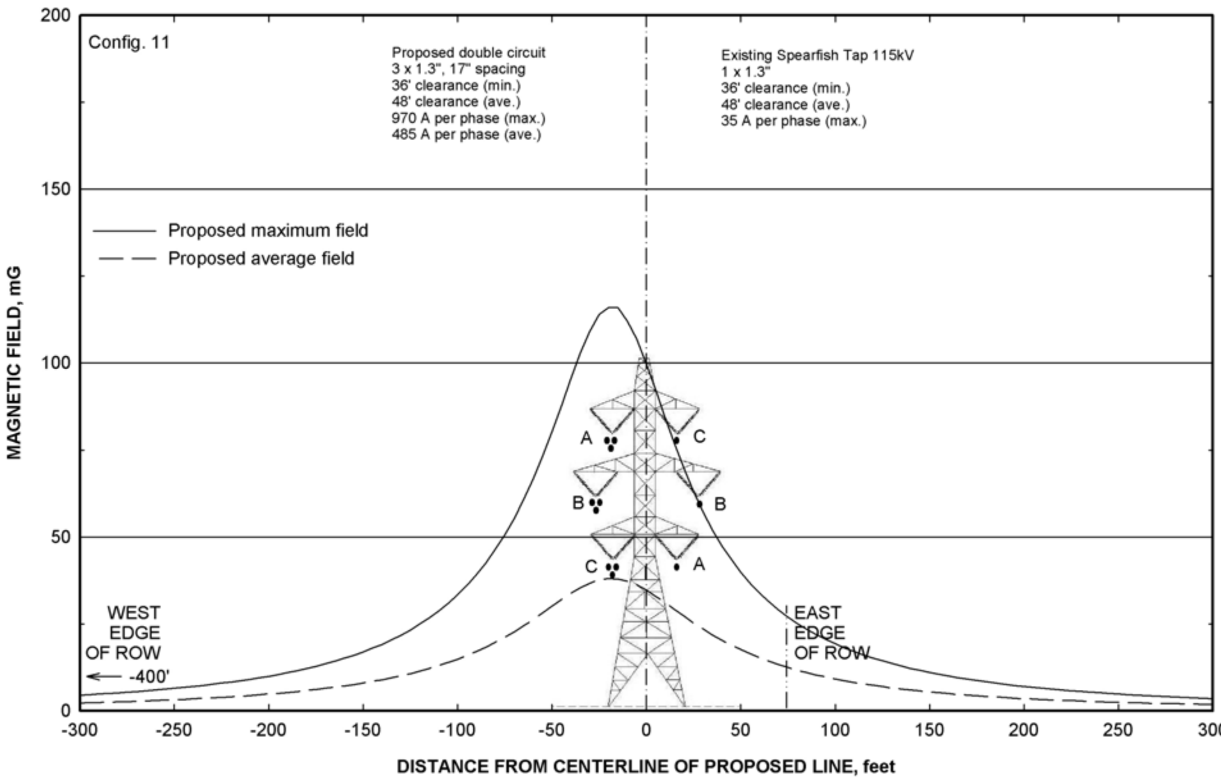


**Figure 36: Magnetic-field profiles for double-circuit Configuration 12 of the proposed Big Eddy – Knight 500-kV line.** Fields computed for maximum current with minimum clearance and for average current with average clearance are shown. Configurations are described in Tables 1 and 2.

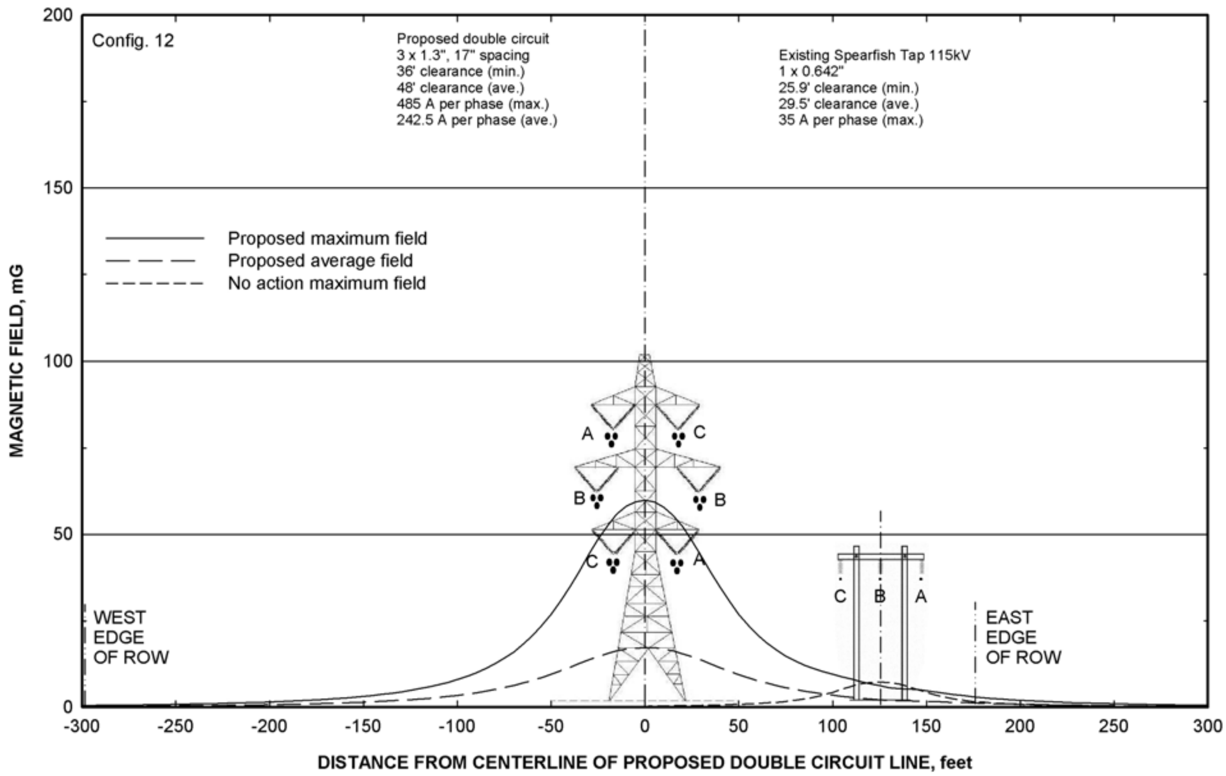
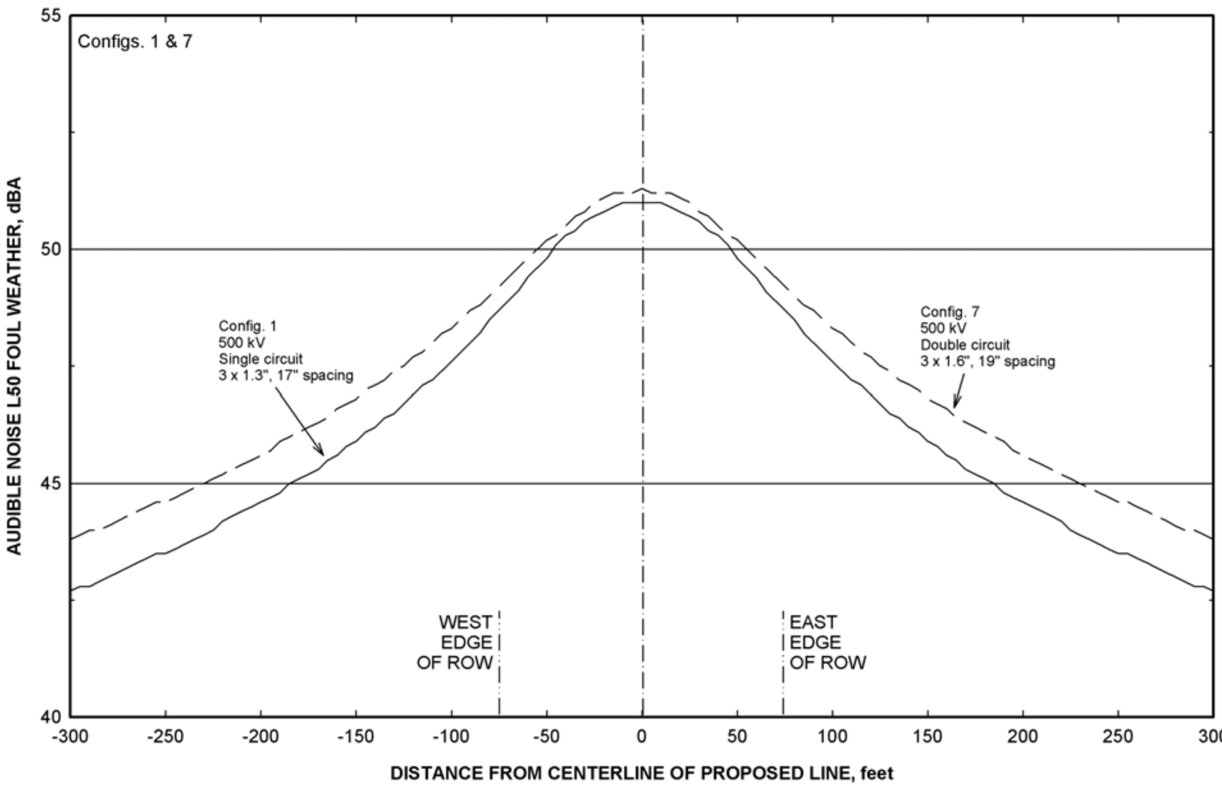


**Figure 37: Audible Noise Profile for Proposed Big Eddy – Knight 500-kV Transmission Line Configurations 1 and 7 with No Adjacent Transmission Lines.** Calculations performed for average voltage and average height. Configurations are described in Tables 1 and 2.



*This page intentionally left blank.*

# Klondike III/Biglow Canyon Wind Integration Project, Final EIS, Appendix C (September 2006)

***<u>KLONDIKE III/BIGLOW CANYON WIND INTEGRATION PROJECT</u>***

# *APPENDIX C*

# *ELECTRICAL EFFECTS*

JULY 2006

**Prepared by**

**T. Dan Bracken, Inc.**

**for**

**Bonneville Power Administration**

# Table of Contents

# List of Tables



# List of Figures

# ELECTRICAL EFFECTS FROM BPA'S PORTION OF THE KLONDIKE III/BIGLOW CANYON WIND INTEGRATION PROJECT

## 1.0 Introduction

The Bonneville Power Administration (BPA) is proposing to build an approximately 12-mile (mi.) (19.3-kilometer [km]) 230-kilovolt (kV) double-circuit transmission line from the existing Klondike Schoolhouse Substation east of Wasco, Oregon, to a proposed BPA John Day 230-kV Substation adjacent to BPA's existing John Day 500-kV Substation near Rufus, Oregon. The proposed line is designated the Klondike - John Day 230-kV transmission line. The proposed line would be built on new right-of-way entirely within the state of Oregon. Two alternative routes are being considered for the proposed line – the North Alternative and the Middle Alternative (Table 1). There are no existing high-voltage transmission lines that parallel the proposed line routes.

The purpose of this report is to describe and quantify the electrical effects of the proposed Klondike - John Day 230-kV transmission line and the proposed substations. These effects include the following:

- the levels of 60-hertz (Hz; cycles per second) electric and magnetic fields (EMF) at 3.28 feet (ft.) or 1 meter (m) above the ground,
- the effects associated with those fields,
- the levels of audible noise produced by the line, and
- electromagnetic interference associated with the line.

Electrical effects occur near all transmission lines, including existing 230-kV lines in Oregon and the 500-kV lines that connect into the existing BPA John Day 500-kV Substation. Therefore, the levels of these quantities for the proposed line are computed and compared with those from the existing lines in Oregon.

The voltage on the conductors of transmission lines generates an *electric field* in the space between the conductors and the ground. The electric field is calculated or measured in units of volts-per-meter (V/m) or kilovolts-per-meter (kV/m) at a height of 3.28 ft. (1 m) above the ground. The current flowing in the conductors of the transmission line generates a *magnetic field* in the air and earth near the transmission line; current is expressed in units of amperes (A). The magnetic field is expressed in milligauss (mG), and is also usually measured or calculated at a height of 3.28 ft. (1 m) above the ground. The electric field at the surface of the conductors causes the phenomenon of *corona*. Corona is the electrical breakdown or ionization of air in very strong electric fields, and is the source of audible noise, electromagnetic radiation, and visible light.

To quantify EMF levels along the route, the electric and magnetic fields from the proposed transmission line were calculated using the BPA Corona and Field Effects Program (USDOE, undated). In this program, the calculation of 60-Hz fields uses standard superposition techniques for vector fields from several line sources: in this case, the line sources are transmission-line conductors. (Vector fields have both magnitude and direction: these must be taken into account when combining fields from different sources.) Important input parameters to the computer program are voltage, current, and geometric configuration of the line. The transmission-line conductors are assumed to be straight, parallel to each other, and located above and parallel to an infinite flat ground plane. Although such conditions do not occur under real lines because of conductor sag and variable terrain, the validity and limitations of calculations using these assumptions have been well verified by comparisons with measurements. This approach was used to estimate fields for the proposed Klondike – John Day line, where minimum clearances were assumed to provide worst-case (highest) estimates for the fields.

Electric fields are calculated using an imaging method. Fields from the conductors and their images in the ground plane are superimposed with the proper magnitude and phase to produce the total field at a selected location.

The total magnetic field is calculated from the vector summation of the fields from currents in all the transmission-line conductors. Balanced (equal) currents are assumed for each three-phase circuit; the contribution of induced image currents in the conductive earth is not included.

Electric and magnetic fields for the proposed line were calculated at the standard height (3.28 ft. or 1 m) above the ground (IEEE, 1994). Calculations were performed out to 300 ft. (91 m) from the centerline of the existing corridor. The validity and limitations of such calculations have been well verified by measurements. Because maximum voltage, maximum current, and minimum conductor height above-ground are used, **the calculated values given here represent worst-case conditions:** i.e., the calculated fields are higher than they would be in practice. Such worst-case conditions would seldom occur.

The corona performance of the proposed line was also predicted using the BPA Corona and Field Effects Program (USDOE, undated). Corona performance is calculated using empirical equations that have been developed over several years from the results of measurements on numerous high-voltage lines (Chartier and Stearns, 1981; Chartier, 1983). The validity of this approach for corona-generated audible noise has been demonstrated through comparisons with measurements on other lines all over the United States (IEEE Committee Report, 1982). The accuracy of this method for predicting corona-generated radio and television interference from transmission lines has also been established (Olsen et al., 1992). Important input parameters to the computer program are voltage, current, conductor size, and geometric configuration of the line.

Corona is a highly variable phenomenon that depends on conditions along a length of line. Predictions of the levels of corona effects are reported in statistical terms to account for this variability. Calculations of audible noise and electromagnetic interference levels were made under conditions of an estimated average operating voltage of 237 kV and with the average line height along a span of 38.5 ft. (11.7 m). Levels of audible noise, radio interference, and television interference are predicted for both fair and foul weather; however, corona is basically a foul-weather phenomenon. Wet conductors can occur during periods of rain, fog, snow, or icing. In the Rufus-Wasco area of the proposed route, such conditions are expected to occur about 6% of the time during a year based on hourly precipitation records from Moro, Oregon (near Wasco) during 2000 – 2004 (NOAA, 2005). Corona activity also increases with altitude. For purposes of evaluating corona effects from the proposed line, an altitude of 1500 ft. (460 m) was assumed.

# 2.0 Physical Description

## 2.1 Proposed Line

The proposed 230-kV transmission line would be a three-phase, double-circuit line placed on mostly tubular steel structures. (Some towers would be lattice steel construction, for example where the line changed direction. The double-circuit towers would have two sets of three phases arranged vertically on either side of the structure. Each set of phase wires comprises a circuit. Voltage and current waves are displaced by 120° in time (one-third of a cycle) on each electrical phase. The maximum phase-to-phase voltage would be 242 kV; the average voltage would be 237 kV.

The line would be operated with the load from the Biglow Canyon project on one of the circuits and the load from the Klondike III project on the other. Initially the projected peak loads for the two circuits of the proposed line are: 400 megawatts (MW) for the Biglow Canyon circuit and 300 MW for the Klondike circuit. When the Orion project is completed the peak load on the Biglow Canyon circuit would increase to 600 MW. These loads correspond to an initial maximum current per phase of 974 A on the Biglow Canyon circuit, increasing to 1462 A with the addition of the Orion load, and 731 A on the Klondike circuit. The Orion project load could be added in the future and is only considered as a cumulative impact with the proposed project.

The load factor for wind power is 0.30 (average load = peak load x load factor). Thus, the average currents on each circuit would be 30 percent of the maximum values. BPA provided the physical and operating characteristics of the proposed line.

The electrical characteristics and physical dimensions for the proposed line configuration are shown in Figure 1, and summarized in Table 2. Each phase of the proposed 230-kV line would have one 1.6-inch (in.) (4.06-centimeter [cm]) diameter conductors (AAC: all aluminum conductors).

The horizontal phase spacing between the lower and upper conductor positions would be 20.0 ft. (6.1 m). Between the middle conductors, the horizontal spacing would be 32.0 ft. (9.76 m). The vertical spacing between the conductor positions would be 18.0 ft. (5.49 m). The spacing between conductor locations would vary slightly where special towers are used, such as at angle points along the line. Short sections of the proposed line where conductor locations would change, such as upon entry to a substation, were not analyzed.

Minimum conductor-to-ground clearance would be 26.5 ft. (8.08 m) at a conductor temperature of 212°F (100°C); clearances above ground would be greater under normal operating temperatures. The average clearance above ground along a span would be approximately 38.5 ft. (11.7 m); this value was used for corona calculations. At road crossings, the ground clearance would be at least 37.5 ft. (11.4 m). The final design of the proposed line could entail larger clearances. The right-of-way width for the proposed line would be 125 ft. (38.11 m).

The electrical phasing of the proposed line would be selected to ensure that BPA criteria for electric-field and audible-noise levels are met and to minimize magnetic field to the extent practical. The results reported here for fields and corona effects assume that the electrical phasing of the two circuits would be such as to place different electrical phases on the lower conductors of each circuit and on the upper conductors of each circuit. This phasing configuration tends to minimize the fields at ground level. During the design process, BPA will verify that any changes from the phasing described here continue to meet design criteria.

## 2.2 Existing Lines

There are no existing transmission lines parallel to the proposed routes.

# 3.0 Electric Field

## 3.1 Basic Concepts

An electric field is said to exist in a region of space if an electrical charge, at rest in that space, experiences a force of electrical origin (i.e., electric fields cause free charges to move). Electric field is a vector quantity: that is, it has both magnitude and direction. The direction corresponds to the direction that a positive charge would move in the field. Sources of electric fields are unbalanced electrical charges (positive or negative) and time-varying magnetic fields. Transmission lines, distribution lines, house wiring, and appliances generate electric fields in their vicinity because of unbalanced electrical charge on energized conductors. The unbalanced charge is associated with the voltage on the energized system. On the power system in North America, the voltage and charge on the energized conductors are cyclic (plus to minus to plus) at a rate of 60 times per second. This changing voltage results in electric fields near sources that are also time-varying at a frequency of 60 hertz (Hz; a frequency unit equivalent to cycles per second).

As noted earlier, electric fields are expressed in units of volts per meter (V/m) or kilovolts (thousands of volts) per meter (kV/m). Electric- and magnetic-field magnitudes in this report are expressed in root-mean-square (rms) units. For sinusoidal waves, the rms amplitude is given as the peak amplitude divided by the square root of two.

The spatial uniformity of an electric field depends on the source of the field and the distance from that source. On the ground, under a transmission line, the electric field is nearly constant in magnitude and direction over distances of several feet (1 meter). However, close to transmission- or distribution-line conductors, the field decreases rapidly with distance from the conductors. Similarly, near small sources such as appliances, the field is not uniform and falls off even more rapidly with distance from the device. If an energized conductor (source) is inside a grounded conducting enclosure, then the electric field outside the enclosure is zero, and the source is said to be shielded.

Electric fields interact with the charges in all matter, including living systems. When a conducting object, such as a vehicle or person, is located in a time-varying electric field near a transmission line, the external electric field exerts forces on the charges in the object, and electric fields and currents are induced in the object. If the object is grounded, then the total current induced in the body (the "short-circuit current") flows to earth. The distribution of the currents within, say, the human body, depends on the electrical conductivities of various parts of the body: for example, muscle and blood have higher conductivity than bone and would therefore experience higher currents.

At the boundary surface between air and the conducting object, the field both in the air and perpendicular to the conductor surface is much, much larger than the field in the conductor itself. For example, the average surface field on a human standing in a 10 kV/m field is 27 kV/m; the internal fields in the body are much smaller: approximately 0.008 V/m in the torso and 0.45 V/m in the ankles.

## 3.2 Transmission-line Electric Fields

The electric field created by a high-voltage transmission line extends from the energized conductors to other conducting objects such as the ground, towers, vegetation, buildings, vehicles, and people. The calculated strength of the electric field at a height of 3.28 ft. (1 m) above an unvegetated, flat earth is frequently used to describe the electric field under straight, parallel transmission lines. The most important transmission-line parameters that determine the electric field at a 1-m height are conductor height above ground and line voltage.

Calculations of electric fields from transmission lines are performed with computer programs based on well-known physical principles (cf., Deno and Zaffanella, 1982). The calculated values under these conditions represent an ideal situation. When practical conditions approach this ideal model, measurements and calculations agree. Often, however, conditions are far from ideal because of variable terrain and vegetation. In these cases, fields are calculated for ideal conditions, with the lowest conductor clearances to provide upper bounds on the electric field under the transmission lines. With the use of more complex models or empirical results, it is also possible to account accurately for variations in conductor height, topography, and changes in line direction. Because the fields from different sources add vectorially, it is possible to compute the fields from several different lines if the electrical and geometrical properties of the lines are known. However, in general, electric fields near transmission lines with vegetation below are highly complex and cannot be calculated. Measured fields in such situations are highly variable.

For evaluation of EMF from transmission lines, the fields must be calculated for a specific line condition. The NESC states the condition for evaluating electric-field-induced short-circuit current for lines with voltage above 98 kV, line-to-ground, as follows: conductors are at a minimum clearance from ground corresponding to a conductor temperature of 122°F (50°C), and at a maximum voltage (IEEE, 2002). BPA has supplied the information for calculating electric and magnetic fields from the proposed transmission line: the maximum operating voltage, the estimated peak currents, and the minimum conductor clearances. The minimum clearances (100°C) provided by BPA are lower than those specified in the NESC (50°C). If the fields under the lower BPA conductor clearances meet the NESC criterion, they will also meet the criterion at the NESC specified clearance.

There are standard techniques for measuring transmission-line electric fields (IEEE, 1994). Provided that the conditions at a measurement site closely approximate those of the ideal situation assumed for calculations, measurements of electric fields agree well with the calculated values. If the ideal conditions are not approximated, the measured field can differ substantially from calculated values. Usually the actual electric field at ground level is reduced from the calculated values by various common objects that act as shields.

Maximum or peak field values occur over a small area at midspan, where conductors are closest to the ground. As the location of an electric-field profile approaches a tower, the conductor clearance increases, and the peak field decreases. A grounded tower will reduce the electric field considerably, by shielding. **Thus the assumption of minimum clearance results in peak (worst-case) fields that may be larger than what occur in practice.**

For traditional transmission lines, such as the proposed line, where the right-of-way extends laterally well beyond the conductors, electric fields at the edge of the right-of-way are not as sensitive as the peak field to conductor height. Computed values at the edge of the right-of-way for any line height are fairly representative of what can be expected all along the transmission-line corridor. However, the presence of vegetation on and at the edge of the right-of-way will reduce actual electric-field levels below calculated values.

## 3.3 Calculated Values of Electric Fields

Table 3 shows the calculated values of electric field at 3.28 ft. (1 m) above ground for the proposed Klondike - John Day 230-kV transmission-line operated at maximum voltage. The peak value on the right-of-way and the value at the edge of the right-of-way are given for the proposed line at minimum conductor clearance and at the estimated average clearance over a span. Figure 2 shows lateral profiles for the electric field from the proposed line at the minimum and average line heights.

The calculated peak electric field expected on the right-of-way of the proposed line is 2.5 kV/m. For average clearance, the peak field would be 1.2 kV/m or less. As shown in Figure 2, the peak values would be present only at locations directly under the 230-kV line, near mid-span, where the conductors are at the minimum clearance. The conditions of minimum conductor clearance at maximum current and maximum voltage occur very infrequently. The calculated peak levels are rarely reached under real-life conditions, because the actual line height is generally above the minimum value used in the computer model, because the actual voltage is below the maximum value used in the model, and because vegetation within and near the edge of the right-of-way tends to shield the field at ground level. Maximum electric fields on existing 230-kV corridors are typically 2.5 to 3 kV/m. On 500-kV transmission line corridors, the maximum electric fields range from 7 to 9 kV/m.

The largest value expected at the edge of the right-of-way of the proposed line is 0.3 kV/m decreasing to about 0.2 kV/m opposite conductors at average clearance.

## 3.4 Environmental Electric Fields

The electric fields associated with the Klondike - John Day 230-kV line can be compared with those found in other environments. Sources of 60-Hz electric (and magnetic) fields exist everywhere electricity is used; levels of these fields in the modern environment vary over a wide range. Electric-field levels associated with the use of electrical energy are orders of magnitude greater than naturally occurring 60-Hz fields of about 0.0001 V/m, which stem from atmospheric and extraterrestrial sources.

Electric fields in outdoor, publicly accessible places range from less than 1 V/m to 12 kV/m; the large fields exist close to high-voltage transmission lines of 230 kV or higher. In remote areas without electrical service, 60-Hz field levels can be much lower than 1 V/m. Electric fields in home and work environments generally are not spatially uniform like those of transmission lines; therefore, care must be taken when making comparisons between fields from different sources such as appliances and electric lines. In addition, fields from all sources can be strongly modified by the presence of conducting objects. However, it is helpful to know the levels of electric fields generated in domestic and office environments in order to compare commonly experienced field levels with those near transmission lines.

Numerous measurements of residential electric fields have been reported for various parts of the United States, Canada, and Europe. Although there have been no large studies of residential electric fields, sufficient data are available to indicate field levels and characteristics. Measurements of domestic 60-Hz electric fields indicate that levels are highly variable and source-dependent. Electric-field levels are not easily predicted because walls and other objects act as shields, because conducting objects perturb the field, and because homes contain numerous localized sources. Internal sources (wiring, fixtures, and appliances) seem to predominate in producing electric fields inside houses. Average measured electric fields in residences are generally in the range of 5 to 20 V/m. In a large occupational exposure monitoring project that included electric-field measurements at homes, average exposures for all groups away from work were generally less than 10 V/m (Bracken, 1990).

Electric fields from household appliances are localized and decrease rapidly with distance from the source. Local electric fields measured at 1 ft. (0.3 m) from small household appliances are typically in the range of 30 to 60 V/m. Stopps and Janischewskyj (1979) reported electric-field measurements near 20 different appliances; at a 1-ft. (0.3-m) distance, fields ranged from 1 to 150 V/m, with a mean of 33 V/m. In another survey, reported by Deno and Zaffanella (1982), field measurements at a 1-ft. (0.3-m) distance from common domestic and workshop sources were found to range from 3 to 70 V/m. The localized fields from appliances are not uniform, and care should be taken in comparing them with transmission-line fields.

Electric blankets can generate higher localized electric fields. Sheppard and Eisenbud (1977) reported fields of 250 V/m at a distance of approximately 1 ft. (0.3 m). Florig et al. (1987) carried out extensive empirical and theoretical analysis of electric-field exposure from electric blankets and presented results in terms of uniform equivalent fields such as those near transmission lines. Depending on what parameter was chosen to represent intensity of exposure and the grounding status of the subject, the equivalent vertical 60-Hz electric-field exposure ranged from 20 to over 3500 V/m. The largest equivalent field corresponds to the measured field on the chest with the blanket-user grounded. The average field on the chest of an ungrounded blanket-user yields an equivalent vertical field of 960 V/m. As manufacturers have become aware of the controversy surrounding EMF exposures, electric blankets have been redesigned to reduce *magnetic* fields. However, electric fields from these “low field” blankets are still comparable with those from older designs (Bassen et al., 1991).

Generally, people in occupations not directly related to high-voltage equipment are exposed to electric fields comparable with those of residential exposures. For example, the average electric field measured in 14 commercial and retail locations in rural Wisconsin and Michigan was 4.8 V/m (ITT Research Institute, 1984). Median electric field was about 3.4 V/m. These values are about one-third the values in residences reported in the same study. Power-frequency electric fields near video display terminals (VTDs) are about 10 V/m, similar to those of other appliances (Harvey, 1983). Electric-field levels in public buildings such as shops, offices, and malls appear to be comparable with levels in residences.

In a survey of 1,882 volunteers from utilities, electric-field exposures were measured for 2,082 work days and 657 non-work days (Bracken, 1990). Electric-field exposures for occupations other than those directly related to high-voltage equipment were equivalent to those for non-work exposure.

Thus, except for the relatively few occupations where high-voltage sources are prevalent, electric fields encountered in the workplace are probably similar to those of residential exposures. Even in electric-utility occupations where high field sources are present, exposures to high fields are limited on average to minutes per day.

Electric fields found in publicly accessible areas near high-voltage transmission lines can typically range up to 3 kV/m for 230-kV lines, to 10 kV/m for 500-kV lines, and to 12 kV/m for 765-kV lines. Although these peak levels are considerably higher than the levels found in other public areas, they are present only in limited areas on rights-of-way.

The calculated electric fields for the proposed Klondike - John Day 230-kV transmission line are consistent with the levels reported for other 230-kV transmission lines in Oregon, Washington, and elsewhere. The electric fields on the right-of-way of the proposed transmission line, as calculated, would be much higher than levels normally encountered in residences and offices.

# 4.0 Magnetic Field

## 4.1 Basic Concepts

Magnetic fields can be characterized by the force they exert on a moving charge or on an electrical current. As with the electric field, the magnetic field is a vector quantity characterized by both magnitude and direction. Electrical currents generate magnetic fields. In the case of transmission lines, distribution lines, house wiring, and appliances, the 60-Hz electric current flowing in the conductors generates a time-varying, 60-Hz magnetic field in the vicinity of these sources. The strength of a magnetic field is measured in terms of magnetic lines of force per unit area, or magnetic flux density. The term “magnetic field," as used here, is synonymous with magnetic flux density and is expressed in units of Gauss (G) or milligauss (mG).

The uniformity of a magnetic field depends on the nature and proximity of the source, just as the uniformity of an electric field does. Transmission-line-generated magnetic fields are quite uniform over horizontal and vertical distances of several feet near the ground. However, for small sources such as appliances, the magnetic field decreases rapidly over distances comparable with the size of the device.

The interaction of a time-varying magnetic field with conducting objects results in induced electric field and currents in the object. A changing magnetic field through an area generates a voltage around any conducting loop enclosing the area (Faraday's law). This is the physical basis for the operation of an electrical transformer. For a time-varying sinusoidal magnetic field, the magnitude of the induced voltage around the loop is proportional to the area of the loop, the frequency of the field, and the magnitude of the field. The induced voltage around the loop results in an induced electric field and current flow in the loop material. The induced current that flows in the loop depends on the conductivity of the loop.

## 4.2 Transmission-line Magnetic Fields

The magnetic field generated by currents on transmission-line conductors extends from the conductors through the air and into the ground. The magnitude of the field at a height of 3.28 ft. (1 m) is frequently used to describe the magnetic field under transmission lines. Because the magnetic field is not affected by non-ferrous materials, the field is not influenced by normal objects on the ground under the line. The direction of the maximum field varies with location. (The electric field, by contrast, is essentially vertical near the ground.) The most important transmission-line parameters that determine the magnetic field at 3.28 ft. (1 m) height are conductor height above ground and magnitude of the currents flowing in the conductors. As distance from the transmission-line conductors increases, the magnetic field decreases.

Calculations of magnetic fields from transmission lines are performed using well-known physical principles (cf., Deno and Zaffanella, 1982). The calculated values usually represent the ideal straight parallel-conductor configuration. For simplicity, a flat earth is usually assumed. Balanced currents (currents of the same magnitude for each phase) are also assumed. This is usually valid for transmission lines, where loads on all three phases are maintained in balance during operation. Induced image currents in the earth are usually ignored for calculations of magnetic field under or near the right-of-way. The resulting error is negligible. Only at distances greater than 300 ft. (91 m) from a line do such contributions become significant (Deno and Zaffanella, 1982). The clearance for magnetic-field calculations for the proposed line was the same as that used for electric-field evaluations.

Standard techniques for measuring magnetic fields near transmission lines are described in ANSI IEEE Standard No. 644-1994 (IEEE, 1994). Measured magnetic fields agree well with calculated values, provided the currents and line heights that go into the calculation correspond to the actual values for the line. To realize such agreement, it is necessary to get accurate current readings during field measurements (because currents on transmission lines can vary considerably over short periods of time) and also to account for all field sources in the vicinity of the measurements.

As with electric fields, the maximum or peak magnetic fields occur in areas near the centerline and at midspan where the conductors are the lowest. The magnetic field at the edge of the right-of-way is not very dependent on line height. For a double-circuit line or if more than one line is present, the peak field will depend on the relative electrical phasing of the conductors and the direction of power flow.

## 4.3 Calculated Values for Magnetic Fields

Table 4 gives the calculated values of the magnetic field at 3.28 ft. (1 m) height for the proposed Klondike – John Day 230-kV double-circuit transmission line. Field values on the right-of-way and at the edge of the right-of-way are given for projected maximum currents, for minimum and average conductor clearances. The maximum currents for the Biglow Canyon circuit and Klondike circuit are given in Table 2. The maximum current on the Biglow Canyon circuit is 974 A initially and 1462 A after the Orion load is added. The maximum current on the Klondike circuit is 731 A. Power on both circuits is assumed to flow from Klondike to John Day and the phasing of the conductors is selected to be different on the lower phases to produce minimum electric and magnetic fields.

The actual magnetic-field levels would vary, as currents on the lines change daily and seasonally and as ambient temperature changes. Average currents over the year would be about 30% of the maximum values. The levels shown in the figures represent the highest magnetic fields expected for the proposed Klondike - John Day 230-kV line. Average fields over a year would be considerably reduced from the peak values, as a result of reduced average currents and increased clearances above the minimum value due to conductor temperatures less than the design value of 100 C°.

Figure 3 shows lateral profiles of the magnetic field under maximum current and minimum clearance conditions for the proposed 230-kV transmission line. A field profile for average height under maximum current conditions is also included in Figure 3.

For the proposed 230-kV line, the maximum calculated 60-Hz magnetic field expected at 3.28 ft. (1 m) above ground is 132 mG for a minimum conductor height of 26.5 ft. (8.1 m). This field is calculated for maximum currents of 974 and 731 A on the Biglow Canyon and Klondike circuits, respectively. The maximum field would decrease for increased conductor clearance. For the average conductor height over a span of 38.5 ft. (11.7 m), the maximum field would be 59 mG.

For maximum currents in both circuits and minimum clearance conditions, the calculated magnetic fields at the edges of the 125-foot (38.1-m) right-of-way are 25 mG on the edge adjacent to the Biglow Canyon circuit and 12 mG adjacent to the Klondike circuit. For average conductor height the fields at the edge of the right-of-way are 19 and 10 mG for the Biglow Canyon and Klondike sides of the line, respectively.

With the Klondike circuit out of service (0 A), the fields from the two circuits would no longer cancel. In this case the maximum field due to the Biglow Canyon circuit alone would be 150 mG at the peak location on the right-of-way and 44 mG at the edge of the right-of-way.

All of these magnetic field levels averaged over a year would be about 30-percent of the above values. Thus, averaged over the year the maximum levels at the respective edges of the right-of-way would be about 7 and 4 mG.

## 4.4 Environmental Magnetic Fields

Transmission lines are not the only source of magnetic fields; as with 60-Hz electric fields, 60-Hz magnetic fields are present throughout the environment of a society that relies on electricity as a principal energy source. The magnetic fields associated with the proposed Klondike - John Day 230-kV line can be compared with fields from other sources. The range of 60-Hz magnetic-field exposures in publicly accessible locations such as open spaces, transmission-line rights-of-way, streets, pedestrian walkways, parks, shopping malls, parking lots, shops, hotels, public transportation, and so on range from less than 0.1 mG to about 1 G, with the highest values occurring near small appliances with electric motors. In occupational settings in electric utilities, where high currents are present, magnetic-field exposures for workers can be above 1 G. At 60 Hz, the magnitude of the natural magnetic field is approximately 0.0005 mG.

Several investigations of residential fields have been conducted. In a large study to identify and quantify significant sources of 60-Hz magnetic fields in residences, measurements were made in 996 houses, randomly selected throughout the country (Zaffanella, 1993). The most common sources of residential fields were power lines, the grounding system of residences, and appliances. Field levels were characterized by both point-in-time (spot) measurements and 24-hour measurements. Spot measurements averaged over all rooms in a house exceeded 0.6 mG in 50% of the houses and 2.9 mG in 5% of houses. Power lines generally produced the largest average fields in a house over a 24-hour period. On the other hand, grounding system currents proved to be a more significant source of the highest fields in a house. Appliances were found to produce the highest local fields; however, fields fell off rapidly with increased distance. For example, the median field near microwave ovens was 36.9 mG at a distance of 10.5 in. (0.27 m) and 2.1 mG at 46 in. (1.17 m). Across the entire sample of 996 houses, higher magnetic fields were found in, among others, urban areas (vs. rural); multi-unit dwellings (vs. single-family); old houses (vs. new); and houses with grounding to a municipal water system.

In an extensive measurement project to characterize the magnetic-field exposure of the general population, over 1000 randomly selected persons in the United States wore a personal exposure meter for 24 hours and recorded their location in a simple diary (Zaffanella and Kalton, 1998). Based on the measurements of 853 persons, the estimated 24-hour average exposure for the general population is 1.24 mG and the estimated median exposure is 0.88 mG. The average field “at home, not in bed” is 1.27 mG and “at home, in bed” is 1.11 mG. Average personal exposures were found to be highest “at work” (mean of 1.79 mG and median of 1.01 mG) and lowest “at home, in bed” (mean of 1.11 mG and median of 0.49 mG). Average fields in school were also low (mean of 0.88 mG and median of 0.69 mG). Factors associated with higher exposures at home were smaller residences, duplexes and apartments, metallic rather than plastic water pipes, and nearby overhead distribution lines.

As noted above, magnetic fields from appliances are localized and decrease rapidly with distance from the source. Localized 60-Hz magnetic fields have been measured near about 100 household appliances such as ranges, refrigerators, electric drills, food mixers, and shavers (Gauger, 1985). At a distance of 1 ft. (0.3 m), the maximum magnetic field ranged from 0.3 to 270 mG, with 95% of the measurements below 100 mG. Ninety-five percent of the levels at a distance of 4.9 ft. (1.5 m) were less than 1 mG. Devices that use light-weight, high-torque motors with little magnetic shielding exhibited the largest fields. These included vacuum cleaners and small hand-held appliances and tools. Microwave ovens with large power transformers also exhibited relatively large fields. Electric blankets have been a much-studied source of magnetic-field exposure because of the length of time they are used and because of the close proximity to the body. Florig and Hoburg (1988) estimated that the average magnetic field in a person using an electric blanket was 15 mG, and that the maximum field could be 100 mG. New "low-field" blankets have magnetic fields at least 10 times lower than those from conventional blankets (Bassen et al., 1991).

In a domestic magnetic-field survey, Silva et al. (1989) measured fields near different appliances at locations typifying normal use (e.g., sitting at an electric typewriter or standing at a stove). Specific appliances with relatively large fields included can openers (n = 9), with typical fields ranging from 30 to 225 mG and a maximum value up to 2.7 G; shavers (n = 4), with typical fields from 50 to 300 mG and maximum fields up to 6.9 G; and electric drills (n = 2), with typical fields from 56 to 190 mG and maximum fields up to 1.5 G. The fields from such appliances fall off very rapidly with distance and are only present for short periods. Thus, although instantaneous magnetic-field levels close to small hand-held appliances can be quite large, they do not contribute to average area levels in residences.

In a study with 162 subjects, Mezei et al. (2001) employed magnetic-field exposure measurements, simultaneous record-keeping of appliance proximity, and an appliance-use questionnaire to investigate the contributions of appliances to overall exposure. They found that individual appliance use did not contribute significantly to time-weighted-average exposure, unless the use was prolonged during the day of measurements. For example, approximately 16% of exposure accumulated during periods when a subject was using a computer. For all subjects exposure during computer use accounted for on-average 9% of total exposure. Cell phones were identified as another source of relatively low fields and long use times that could contribute to overall exposure. Use of other small appliances did not contribute significantly to accumulated exposure but did contribute to the relatively short periods when high-field exposures were observed.

Although studies of residential magnetic fields have not all considered the same independent parameters, the following consistent characterization of residential magnetic fields emerges from the data:

(1) External sources play a large role in determining residential magnetic-field levels. Transmission lines, when nearby, are an important external source. Unbalanced ground currents on neutral conductors and other conductors, such as water pipes in and near a house, can represent a significant source of magnetic field. Distribution lines per se, unless they are quite close to a residence, do not appear to be a traditional distance-dependent source.

(2) Homes with overhead electrical service appear to have higher average fields than those with underground service.

(3) Appliances represent a localized source of magnetic fields that can be much higher than average or area fields. However, fields from appliances approach area levels at distances greater than 3.28 ft. (1 m) from the device.

Although important variables in determining residential magnetic fields have been identified, quantification and modeling of their influence on fields at specific locations is not yet possible. However, a general characterization of residential magnetic-field level is possible: average levels in the United States are in the range of 0.5 to 1.0 mG, with the average field in a small number of homes exceeding this range by as much as a factor of 10 or more. Average personal exposure levels are slightly higher, possibly due to use of appliances and varying distances to other sources. Maximum fields can be much higher.

Magnetic fields in commercial and retail locations are comparable with those in residences. As with appliances, certain equipment or machines can be a local source of higher magnetic fields. Utility workers who work close to transformers, generators, cables, transmission lines, and distribution systems clearly experience high-level fields. Other sources of fields in the workplace include motors, welding machines, computers, and video display terminals (VDTs). In publicly accessible indoor areas, such as offices and stores, field levels are generally comparable with residential levels, unless a high-current source is nearby.

Because high-current sources of magnetic field are more prevalent than high-voltage sources, occupational environments with relatively high magnetic fields encompass a more diverse set of occupations than do those with high electric fields. For example, in occupational magnetic-field measurements reported by Bowman et al. (1988), the geometric mean field from 105 measurements of magnetic field in "electrical worker" job locations was 5.0 mG. "Electrical worker" environments showed the following elevated magnetic-field levels (geometric mean greater than 20 mG): industrial power supplies, alternating current (ac) welding machines, and sputtering systems for electronic assembly. For secretaries in the same study, the geometric mean field was 3.1 mG for those using VDTs (n = 6) and 1.1 mG for those not using VDTs (n = 3).

Measurements of personal exposure to magnetic fields were made for 1,882 volunteer utility workers for a total of 4,411 workdays (Bracken, 1990). Median workday mean exposures ranged from 0.5 mG for clerical workers without computers to 7.2 mG for substation operators. Occupations not specifically associated with transmission and distribution facilities had median workday exposures less than 1.5 mG, while those associated with such facilities had median exposures above 2.3 mG. Magnetic-field exposures measured in homes during this study were comparable with those recorded in offices.

Magnetic fields in publicly accessible outdoor areas seem to be, as expected, directly related to proximity to electric-power transmission and distribution facilities. Near such facilities, magnetic fields are generally higher than indoors (residential). Higher-voltage facilities tend to have higher fields. Typical maximum magnetic fields in publicly accessible areas near transmission facilities can range from less than a few milligauss up to 300 mG or more, near heavily loaded lines operated at 230 to 765 kV. The levels depend on the line load, conductor height, and location on the right-of-way. Because magnetic fields near high-voltage transmission lines depend on the current in the line, they can vary daily and seasonally. To characterize fields from the distribution system, Heroux (1987) measured 60-Hz magnetic fields with a mobile platform along 140 mi. (223 km) of roads in Montreal. The median field level averaged over nine different routes was 1.6 mG, with 90% of the measurements less than about 5.1 mG. Spot measurements indicated that typical fields directly above underground distribution systems were 5 to 19 mG. Beneath overhead distribution lines, typical fields were 1.5 to 5 mG on the primary side of the transformer, and 4 to 10 mG on the secondary side. Near ground-based transformers used in residential areas, fields were 80 to 1000 mG at the surface and 10 to 100 mG at a distance of 1 ft. (0.3 m).

The magnetic fields from the proposed line would be comparable to or less than those from existing 230-kV lines in Oregon, Washington, and elsewhere. On and near the right-of-way of the proposed line, magnetic fields would be above average residential levels. However, the fields from the line would decrease rapidly and approach common ambient levels (1 mG) at a distance of about 200 feet from the edge of the right-of-way under maximum current conditions and at about 100 feet from the edge under average current conditions. Furthermore, the fields at the edge of the right-of-way would not be above those encountered during normal activities near common sources such as hand-held appliances.

# 5.0 Electric and Magnetic Field (EMF) Effects

Possible effects associated with the interaction of EMF from transmission lines with people on and near a right-of-way fall into two categories: short-term effects that can be perceived and may represent a nuisance, and possible long-term health effects. Only short-term effects are discussed here. The issue of whether there are long-term health effects associated with transmission-line fields is controversial. In recent years, considerable research on possible biological effects of EMF has been conducted. A review of these studies and their implications for health-related effects is provided in a separate technical report for the environmental assessment for the proposed Klondike - John Day 230-kV transmission line.

## 5.1 Electric Fields: Short-term Effects

Short-term effects from transmission-line electric fields are associated with perception of induced currents and voltages or perception of the field. Induced current or spark discharge shocks can be experienced under certain conditions when a person contacts objects in an electric field. Such effects occur in the fields associated with transmission lines that have voltages of 230-kV or higher. These effects could occur infrequently under the proposed Klondike - John Day 230-kV line.

Steady-state currents are those that flow continuously after a person contacts an object and provides a path to ground for the induced current. The amplitude of the steady-state current depends on the induced current to the object in question and on the grounding path. The magnitude of the induced current to vehicles and objects under the proposed line will depend on the electric-field strength and the size and shape of the object. When an object is electrically grounded, the voltage on the object is reduced to zero, and it is not a source of current or voltage shocks. If the object is poorly grounded or not grounded at all, then it acquires some voltage relative to earth and is a possible source of current or voltage shocks.

The responses of persons to steady-state current shocks have been extensively studied, and levels of response documented (Keesey and Letcher, 1969; IEEE, 1978). Primary shocks are those that can result in direct physiological harm. Such shocks will not be possible from induced currents under the existing or proposed lines, because clearances above ground required by the NESC preclude such shocks from large vehicles and grounding practices eliminate large stationary objects as sources of such shocks.

Secondary shocks are defined as those that could cause an involuntary and potentially harmful movement, but no direct physiological harm. Secondary shocks could occur under the proposed 230-kV line when making contact with ungrounded conducting objects such as large vehicles or equipment. However, such occurrences are anticipated to be very infrequent. Shocks, when they occur under the 230-kV line, are most likely to be below the nuisance level. Induced currents would not be perceived off the right-of-way.

Induced currents are always present in electric fields under transmission lines and will be present near the proposed line. However, during initial construction, it is BPA policy to ground metal objects, such as fences, that are located on the right-of-way. The grounding eliminates these objects as sources of induced current and voltage shocks. Multiple grounding points are used to provide redundant paths for induced current flow. After construction, BPA would respond to any complaints and install or repair grounding to mitigate nuisance shocks.

Unlike fences or buildings, mobile objects such as vehicles and farm machinery cannot be grounded permanently. Limiting the possibility of induced currents from such objects to persons is accomplished in several ways. First, required clearances for above-ground conductors tend to limit field strengths to levels that do not represent a hazard or nuisance. The NESC (IEEE, 2002) requires that, for lines with voltage exceeding 98 kV line-to-ground (170 kV line-to-line), sufficient conductor clearance be maintained to limit the induced short-circuit current in the largest anticipated vehicle under the line to 5 milliamperes (mA) or less. This can be accomplished by limiting access or by increasing conductor clearances in areas where large vehicles could be present. BPA and other utilities design and operate lines to be in compliance with the NESC.

For the proposed line, conductor clearances (100°C) would be increased to at least 37.5 ft. (11.4 m) over major road crossings along the route, resulting in a maximum field of 1.2 kV/m or less at the 3.28 ft. (1 m) height. The largest truck allowed on roads in Oregon without a special permit is 14 ft. high by 8.5 ft. wide by 75 ft. long (4.3 x 2.6 x 22.9 m). The induced currents to such a vehicle oriented perpendicular to the line in a maximum field of 1.2 kV/m (at 3.28-ft. height) would be less than 1.2 mA (Reilly, 1979). For smaller trucks, the maximum induced currents for perpendicular orientation to the proposed line would be less than this value. (Larger special-permitted trucks, such as triple trailers, can be up to 105 feet in length. However, because they average the field over such a long distance, the maximum induced current to a 105-ft. vehicle oriented perpendicular to the 230-kV line at a road crossing would be less than that for the 75-foot truck.) These large vehicles are not anticipated to be off highways on the right-of-way or oriented parallel and directly under the proposed line. Thus, the NESC 5-mA criterion would be met for road crossings of the proposed line. In accordance with the NESC, line clearances would also be increased over other areas, such as over railroads, orchards and water areas suitable for sailboating.

The computed induced currents at road crossings are for worst-case conditions that occur rarely. Several factors tend to reduce the levels of induced current shocks from vehicles at road crossings and elsewhere:

(1) Activities are distributed over the whole right-of-way, and only a small percentage of time is spent in areas where the field is at or close to the maximum value.

(2) At road crossings, vehicles are aligned perpendicular to the conductors, resulting in a substantial reduction in induced current.

(3) The conductor clearance at road crossings may not be at minimum values because of lower conductor temperatures and/or location of the road crossing away from midspan.

(4) The largest vehicles are permitted only on certain highways.

(5) Off-road vehicles are in contact with soil or vegetation, which reduces shock currents substantially.

Induced voltages occur on objects, such as vehicles, in an electric field where there is an inadequate electrical ground. If the voltage is sufficiently high, then a spark discharge shock can occur as contact is made with the object. Such shocks are similar to "carpet" shocks that occur, for example, when a person touches a doorknob after walking across a carpet on a dry day. The number and severity of spark discharge shocks depend on electric-field strength and generally of concern under lines with voltages of 345-kV or higher. Nuisance shocks, which are primarily spark discharges, are not anticipated to be a problem under the proposed line.

In electric fields higher than those that would occur under the proposed line, it is theoretically possible for a spark discharge from the induced voltage on a large vehicle to ignite gasoline vapor during refueling. The probability for exactly the right conditions for ignition to occur is extremely remote. The additional clearance of conductors provided at road crossings reduces the electric field in areas where vehicles are prevalent and reduces the chances for such events. Even so, BPA recommends that vehicles should not be refueled under the proposed line unless specific precautions are taken to ground the vehicle and the fueling source (USDOE, 1995).

Under certain conditions, the electric field can be perceived through hair movement on an upraised hand or arm of a person standing on the ground under high-voltage transmission lines. The median field for perception in this manner was 7 kV/m for 136 persons; only about 12% could perceive fields of 2 kV/m or less (Deno and Zaffanella, 1982). In limited areas under the conductors at midspan, the fields at ground level would exceed the levels where field perception can occur. However it is unlikely that field perception would be common under the proposed 230-kV line because fields would generally be below the perception level. Where vegetation provides shielding, the field would not be perceived.

Conductive shielding reduces both the electric field and induced effects such as shocks. Persons inside a vehicle cab or canopy are shielded from the electric field. Similarly, a row of trees or a lower-voltage distribution line reduces the field on the ground in the vicinity. Metal pipes, wiring, and other conductors in a residence or building shield the interior from the transmission-line electric field.

The electric fields from the proposed 230-kV line would be comparable to or less than those from existing 230-kV lines in the project area and elsewhere. Potential impacts of electric fields can be mitigated through grounding policies and adherence to the NESC. Worst-case levels are used for safety analyses but, in practice, induced currents and voltages are reduced considerably by unintentional grounding. Shielding by conducting objects, such as vehicles and vegetation, also reduces the potential for electric-field effects.

## 5.2 Magnetic Field: Short-term Effects

Magnetic fields associated with transmission and distribution systems can induce voltage and current in long conducting objects that are parallel to the transmission line. As with electric-field induction, these induced voltages and currents are a potential source of shocks. A fence, irrigation pipe, pipeline, electrical distribution line, or telephone line forms a conducting loop when it is grounded at both ends. The earth forms the other portion of the loop. The magnetic field from a transmission line can induce a current to flow in such a loop if it is oriented parallel to the line. If only one end of the fence is grounded, then an induced voltage appears across the open end of the loop. The possibility for a shock exists if a person closes the loop at the open end by contacting both the ground and the conductor. The magnitude of this potential shock depends on the following factors: the magnitude of the field; the length of the object (the longer the object, the larger the induced voltage); the orientation of the object with respect to the transmission line (parallel as opposed to perpendicular, where no induction would occur); and the amount of electrical resistance in the loop (high resistance limits the current flow).

Magnetically induced currents from power lines have been investigated for many years; calculation methods and mitigating measures are available. A comprehensive study of gas pipelines near transmission lines developed prediction methods and mitigation techniques specifically for induced voltages on pipelines (Dabkowski and Taflove, 1979; Taflove and Dabkowski, 1979). Similar techniques and procedures are available for irrigation pipes and fences. Grounding policies employed by utilities for long fences reduce the potential magnitude of induced voltage.

The magnitude of the coupling with both pipes and fences is very dependent on the electrical unbalance (unequal currents) among the three phases of the line. Thus, a distribution line where a phase outage may go unnoticed for long periods of time can represent a larger source of induced currents than a transmission line where the loads are well-balanced (Jaffa and Stewart, 1981).

Knowledge of the phenomenon, grounding practices, and the availability of mitigation measures mean that magnetic-induction effects from the proposed 230-kV transmission line would be minimal.

Magnetic fields from transmission and distribution facilities can interfere with certain electronic equipment. Magnetic fields can cause distortion of the image on older style VDTs and computer monitors (cathode-ray tubes). The threshold field for interference depends on the type and size of monitor and the frequency of the field. Interference has been observed for certain monitors at fields at or below 10 mG (Baishiki et al., 1990; Banfai et al., 2000). The problem typically arises when computer monitors are in use near electrical distribution or transmission facilities or near the distribution system in large office buildings. Under peak current conditions fields from the proposed line would fall below this level from the edge of the right of way to about 30 ft. (9 m) beyond the right of way depending on line height. For average current conditions the field at the edge of the right-of-way and beyond would be below the 10 mG level where interference can occur.

Interference from magnetic fields does not occur for flat-screen monitors, such as used in laptop computers. If interference does occur for an older monitor, it can be eliminated by shielding the affected monitor or moving it to an area with lower fields. Similar mitigation methods could be applied to other sensitive electronics, if necessary. Interference from 60-Hz fields with computers and control circuits in vehicles and other equipment is not anticipated at the field levels found under and near the proposed 230-kV transmission line.

# 6.0 Regulations

Regulations that apply to transmission-line electric and magnetic fields fall into two categories. Safety standards or codes are intended to limit or eliminate electric shocks that could seriously injure or kill persons. Field limits or guidelines are intended to limit electric- and magnetic-field exposures that can cause nuisance shocks or that might cause health effects. In no case has a limit or standard been established because of a known or demonstrated health effect.

The proposed line would be designed to meet the NESC (IEEE, 2002a), which specifies how far transmission-line conductors must be from the ground and other objects. The clearances specified in the code provide safe distances that prevent harmful shocks to workers and the public. In addition, people who live and work near transmission lines must be aware of safety precautions to avoid electrical (which is not necessarily physical) contact with the conductors. For example, farmers should not up-end irrigation pipes under a transmission or other electrical line or direct the water stream from an irrigation system into or near the conductors. In addition, as a matter of safety, the NESC specifies that electric-field-induced currents from transmission lines must be below the 5 mA (“let go”) threshold deemed a lower limit for primary shock. BPA publishes and distributes a brochure that describes safe practices to protect against shock hazards around power lines (USDOE, 1995).

Field limits or guidelines have been adopted in several states and countries and by national and international organizations. Electric-field limits have generally been based on minimizing nuisance shocks or field perception. In some cases, such as the state limits in Table 5, the intent of magnetic-field limits has been to limit exposures to existing levels, given the uncertainty of their potential for health effects. In the case of international standard or guideline setting organizations, magnetic field limits have been based on thresholds for possible effects from induced internal currents or electric fields (ICNIRP, 1998; IEEE, 2002b).

There are currently no national standards in the United States for 60-Hz electric and magnetic fields. Oregon's formal rule in its transmission-line-siting procedures specifically addresses field limits. The Oregon limit of 9 kV/m for electric fields is applied to areas accessible to the public (Oregon, State of, 1980). The Oregon rule also addresses grounding practices, audible noise, and radio interference. Oregon does not have a limit for magnetic fields from transmission lines.

Besides Oregon, several states have been active in establishing mandatory or suggested limits on 60-Hz electric and (in two cases) magnetic fields. Five other states have specific electric-field limits that apply to transmission lines: Florida, Minnesota, Montana, New Jersey, and New York. Florida and New York have established regulations for magnetic fields. These regulations are summarized in Table 5, adapted from TDHS Report (1989).

Government agencies and utilities operating transmission systems have established design criteria that include EMF levels. BPA has maximum allowable electric fields of 9 and 5 kV/m on and at the edge of the right-of-way, respectively (USDOE, 1996). BPA also has maximum-allowable electric-field strengths of 5 kV/m, 3.5 kV/m, and 2.5 kV/m for road crossings, shopping center parking lots, and commercial/ industrial parking lots, respectively. These levels are based on limiting the maximum short-circuit currents from anticipated vehicles to less than 1 mA in shopping center lots and to less than 2 mA in commercial parking lots.

Electric-field limits for overhead power lines have also been established in other countries (Maddock, 1992). Limits for magnetic fields from overhead power lines have not been explicitly established anywhere except in Florida and New York (see Table 5). However, general guidelines and limits on EMF have been established for occupational and public exposure in several countries and by national and international organizations.

The American Conference of Governmental Industrial Hygienists (ACGIH) sets guidelines (Threshold Limit Values® or TLV®) for occupational exposures to environmental agents (ACGIH, 2000). In general, a TLV represents the level below which it is believed that nearly all workers may be exposed repeatedly without adverse health effects. For EMF, the TLVs represent ceiling levels. For 60-Hz electric fields, occupational exposures should not exceed the TLV of 25 kV/m. However, the ACGIH also recognizes the potential for startle reactions from spark discharges and short-circuit currents in fields greater than 5-7 kV/m, and recommends implementing grounding practices. They recommend the use of conductive clothing for work in fields exceeding 15 kV/m. The TLV for occupational exposure to 60-Hz magnetic fields is a ceiling level of 10 G (10,000 mG) (ACGIH, 2000).

Electric and magnetic fields from various sources (including automobile ignitions, appliances and, possibly, transmission lines) can interfere with implanted cardiac pacemakers. In light of this potential problem, manufacturers design devices to be immune from such interference. However, research has shown that these efforts have not been completely successful and that a few older models of pacemakers could be affected by 60-Hz fields from transmission lines. There were also numerous models of pacemakers that were not affected by fields even larger than those found under transmission lines. Because of the known potential for interference with pacemakers by 60-Hz fields, field limits for pacemaker wearers have been established by the ACGIH. They recommend that wearers of pacemakers and similar medical-assist devices limit their exposure to electric fields of 1 kV/m or less and to magnetic fields to 1 G (1,000 mG) or less (ACGIH, 2000).

The International Committee on Non-ionizing Radiation Protection (ICNIRP), working in cooperation with the World Health Organization (WHO), has developed guidelines for occupational and public exposures to EMF (ICNIRP, 1998). For occupational exposures at 60 Hz, the recommended limits to exposure are 8.3 kV/m for electric fields and 4.2 G (4,200 mG) for magnetic fields. The electric-field level can be exceeded, provided precautions are taken to prevent spark discharge and induced current shocks. For the general public, the ICNIRP guidelines recommend exposure limits of 4.2 kV/m for electric fields and 0.83 G (830 mG) for magnetic fields (ICNIRP, 1998).

ICNIRP has also established guidelines for contact currents, which could occur when a grounded person contacts an ungrounded object in an electric field. The guideline levels are 1.0 mA for occupational exposure and 0.5 mA for public exposure.

The Institute of Electrical and Electronic Engineers (IEEE, 2002b) has also set limits for occupational and public exposure to electric and magnetic fields and to contact currents. The magnetic-field limits are based on an extensive assessment of possible neurological responses to magnetic field exposures. The limit for public exposure to 60-Hz magnetic fields are 9,040 mG.

The IEEE electric-field limits are based on thresholds for possible reactions to perceivable spark discharges that occur in electric fields. The limits for public exposure to electric fields are 5 kV/m except on power line rights-of-way, where the limit is 10 kV/m. The current limit for the general public is 0.5 mA for a touch contact.

The electric fields from the proposed 230-kV transmission line would meet the ACGIH, ICNIRP, and IEEE standards, provided wearers of pacemakers and similar medical-assist devices are discouraged from unshielded right-of-way use. (A passenger in an automobile under the line would be shielded from the electric field.) The magnetic fields from the proposed line would be below the ACGIH occupational limits, and well as below those of ICNIRP and IEEE for occupational and public exposures. The electric fields present on the right-of-way could induce currents in ungrounded vehicles that exceeded the ICNIRP and IEEE levels of 0.5 mA.

The estimated peak electric fields on the right-of-way of the proposed transmission line would meet the limits of all states. (see Table 5). The BPA electric field criteria would be met by the proposed line. for all configurations of the proposed line. The edge-of-right-of-way electric fields from the proposed line would be below the edge-of-right-of-way limits set by all states. The magnetic field at the edge of the right-of-way from the proposed line would be below the regulatory levels of states where such regulations exist.

# 7.0 Audible Noise

## 7.1 Basic Concepts

Audible noise (AN), as defined here, represents an unwanted sound, as from a transmission line, transformer, airport, or vehicle traffic. Sound is a pressure wave caused by a sound source vibrating or displacing air. The ear converts the pressure fluctuations into auditory sensations. AN from a source is superimposed on the background or ambient noise that is present before the source is introduced.

The amplitude of a sound wave is the incremental pressure resulting from sound above atmospheric pressure. The sound-pressure level is the fundamental measure of AN; it is generally measured on a logarithmic scale with respect to a reference pressure. The sound-pressure level (SPL) in decibels (dB) is given by:

$$SPL = 20 \log (P/P_o)\text{dB}$$

where P is the effective rms (root-mean-square) sound pressure, $P_o$ is the reference pressure, and the logarithm (log) is to the base 10. The reference pressure for measurements concerned with hearing is usually taken as 20 micropascals (Pa), which is the approximate threshold of hearing for the human ear. A logarithmic scale is used to encompass the wide range of sound levels present in the environment. The range of human hearing is from 0 dB up to about 140 dB, a ratio of 10 million in pressure (EPA, 1978).

Logarithmic scales, such as the decibel scale, are not directly additive: to combine decibel levels, the dB values must be converted back to their respective equivalent pressure values, the total rms pressure level found, and the dB value of the total recalculated. For example, adding two sounds of equal level on the dB scale results in a 3 dB increase in sound level. Such an increase in sound pressure level of 3 dB, which corresponds to a doubling of the energy in the sound wave, is barely discernible by the human ear. It requires an increase of about 10 dB in SPL to produce a subjective doubling of sound level for humans. The upper range of hearing for humans (140 dB) corresponds to a sharply painful response (EPA, 1978).

Humans respond to sounds in the frequency range of 16 to 20,000 Hz. The human response depends on frequency, with the most sensitive range roughly between 2000 and 4000 Hz. The frequency-dependent sensitivity is reflected in various weighting scales for measuring audible noise. The A-weighted scale weights the various frequency components of a noise in approximately the same way that the human ear responds. This scale is generally used to measure and describe levels of environmental sounds such as those from vehicles or occupational sources. The A-weighted scale is also used to characterize transmission-line noise. Sound levels measured on the A-scale are expressed in units of dB(A) or dBA.

AN levels and, in particular, corona-generated audible noise (see below) vary in time. In order to account for fluctuating sound levels, statistical descriptors have been developed for environmental noise. Exceedence levels (L levels) refer to the A-weighted sound level that is exceeded for a specified percentage of the time. Thus, the $L_5$ level refers to the noise level that is exceeded only 5% of the time. $L_{50}$ refers to the sound level exceeded 50% of the time. Sound-level measurements and predictions for transmission lines are often expressed in terms of exceedence levels, with the $L_5$ level representing the maximum level and the $L_{50}$ level representing a median level.

Table 6 shows AN levels from various common sources. Clearly, there is wide variation. Noise exposure depends on how much time an individual spends in different locations. Outdoor noise generally does not contribute to indoor levels (EPA, 1974). Activities in a building or residence generally dominate interior AN levels.

The BPA transmission-line design criterion for corona-generated audible noise ($L_{50}$, foul weather) is 50 dBA at the edge of the ROW (USDOE, 2006). This criterion applies to new line construction and is under typical conditions of foul weather, altitude, and system voltage.

Audible noise from substations is generated predominantly by equipment such as transformers, reactors and other wire-wound equipment. It is characterized by a 120 Hz hum that is associated with magnetic-field caused vibrations in the equipment. Noise from such equipment varies by voltage and other operating conditions. The BPA design level for substation noise is 50 dBA at the substation property line for new construction (USDOE, 2006). The design level is met by obtaining equipment that meets specified noise limits and, for new substations, by securing a no-built buffer beyond the substation perimeter fence.

In industrial, business, commercial, or mixed use zones the AN level from substations may exceed 50 dBA but must still meet any state or local AN requirements. The design criteria also allows the 50 dBA design level to be exceeded in remote areas where development of noise sensitive properties is highly unlikely.

The EPA has established a guideline of 55 dBA for the annual average day-night level ($L_{dn}$) in outdoor areas (EPA, 1978). In computing this value, a 10 dB correction (penalty) is added to night-time noise between the hours of 10 p.m. and 7 a.m.

## 7.2 Transmission-line Audible Noise

Corona is the partial electrical breakdown of the insulating properties of air around the conductors of a transmission line. In a small volume near the surface of the conductors, energy and heat are dissipated. Part of this energy is in the form of small local pressure changes that result in audible noise. Corona-generated audible noise can be characterized as a hissing, crackling sound that, under certain conditions, is accompanied by a 120-Hz hum. Corona-generated audible noise is of concern primarily for contemporary lines operating at voltages of 345 kV and higher during foul weather. However, the proposed 230-kV line will produce some noise under foul weather conditions.

The conductors of high-voltage transmission lines are designed to be corona-free under ideal conditions. However, protrusions on the conductor surface—particularly water droplets on or dripping off the conductors—cause electric fields near the conductor surface to exceed corona onset levels, and corona occurs. Therefore, audible noise from transmission lines is generally a foul-weather (wet-conductor) phenomenon. Wet conductors can occur during periods of rain, fog, snow, or icing. Based on meteorologic records near the route of the proposed transmission line, such conditions are expected to occur about 6% of the time during the year in the Wasco area.

For a few months after line construction, residual grease or oil on the conductors can cause water to bead up on the surface. This results in more corona sources and slightly higher levels of audible noise and electromagnetic interference if the line is energized. However, the new conductors "age" in a few months, and the level of corona activity decreases to the predicted equilibrium value. During fair weather, insects and dust on the conductor can also serve as sources of corona.

## 7.3 Predicted Audible Noise Levels

Corona-generated audible-noise levels are calculated for average voltage and average conductor heights for fair- and foul-weather conditions. The predicted levels of audible noise for the proposed line operated at a voltage of 237 kV are given in Table 7 and plotted in Figure 4.

The calculated median level ($L_{50}$) during foul weather at the edge of the proposed Klondike - John Day 230-kV line right-of-way (62.5 ft. from centerline) is 42 dBA; the calculated maximum level ($L_5$) during foul weather at the edge of the right-of-way is 45 dBA. During fair-weather conditions, which occur about 94% of the time in the Wasco area, audible noise levels at the edge of the right-of-way would be about 20 dBA (if corona were present). These lower levels could be masked by ambient noise on and off the right-of-way.

## 7.4 Discussion

The calculated foul-weather corona noise levels for the proposed line would be comparable to, or less than, those from existing 230-kV lines in Oregon. During fair weather, noise from the conductors might be perceivable on the right-of-way; however, beyond the right-of-way it would very likely be masked or so low as not to be perceived. During foul weather, when ambient noise is higher, it is also likely that corona-generated noise off the right-of-way would be masked to some extent.

On and off the right-of-way, the levels of audible noise from the proposed line during foul weather would be well below the 55-dBA level that can produce interference with speech outdoors. The distance to the nearest residence to the proposed line is about 0.25 miles (0.4 km). At this distance the AN from the line would be about 30 dBA during foul weather and probably not be perceived above background noise. During such periods ambient noise levels can be increased due to wind and rain hitting foliage or buildings.

The computed annual $L_{dn}$ level for transmission lines operating in areas with about 6% foul weather is about $L_{dn} = L_{50}$ - 3 dBA (Bracken, 1987). Therefore, assuming such conditions in the area of the proposed Klondike - John Day 230-kV line, the estimated $L_{dn}$ at the edge of the right-of-way would be approximately 39 dBA, which is well below the EPA $L_{dn}$ guideline of 55 dBA.

The transformers and other equipment installed at the new Klondike substation will be specified so that the BPA noise level criterion of 50 dBA for new substations will be met at the edge of the property (USDOE, 2006). This will ensure that all applicable federal, state, and local regulations are met.

For the expansion to the John Day Substation, the new equipment would be required to meet the same specifications as for new substations (USDOE, 2006). However, the new equipment would be placed in an environment with noise from existing transmission lines and existing equipment in the John Day Substation. The combined noise level from the existing and new facilities could exceed the 50 dBA design level at points on the perimeter of the expanded substation. However, the levels would be controlled to meet all applicable regulations at the edge of the property.

### 7.5 Conclusion

Along the proposed line route there could be increases in the perceived noise above ambient levels during foul weather at the edges of the proposed 230-kV right-of-way. The corona-generated noise during foul weather would be masked to some extent by naturally occurring sounds such as wind and rain on foliage. During fair weather, the noise off the right-of-way from the proposed line would probably not be detectable above ambient levels. The noise levels from the proposed line would be below levels identified as causing interference with speech or sleep. The audible noise from the transmission line would be below EPA guideline levels and would meet the BPA design criterion that complies with state noise regulations. Similarly the new substations would be designed and constructed to meet BPA design criteria that all federal, state and local regulations be met.

## 8.0 Electromagnetic Interference

### 8.1 Basic Concepts

Corona on transmission-line conductors can also generate electromagnetic noise in the frequency bands used for radio and television signals. The noise can cause radio and television interference (RI and TVI). In certain circumstances, corona-generated electromagnetic interference (EMI) can also affect communications systems and other sensitive receivers. Interference with electromagnetic signals by corona-generated noise is generally associated with lines operating at voltages of 345 kV or higher. This is especially true of interference with television signals. The single 1.6-in diameter conductor used in the design of the proposed 230-kV line would mitigate corona generation and keep radio and television interference levels at acceptable levels below those of many existing 230-kV lines with smaller conductors.

Spark gaps on distribution lines and on low-voltage wood-pole transmission lines are a more common source of RI/TVI than is corona from high-voltage electrical systems. This gap-type interference is primarily a fair-weather phenomenon caused by loose hardware and wires. The proposed transmission line would be constructed with modern hardware that eliminates such problems and therefore minimizes gap noise. Consequently, this source of EMI is not anticipated for the proposed line.

No state has limits for either RI or TVI. In the United States, electromagnetic interference from power transmission systems is governed by the Federal Communications Commission (FCC) Rules and Regulations presently in existence (FCC, 1988). A power transmission system falls into the FCC category of "incidental radiation device," which is defined as "a device that radiates radio frequency energy during the course of its operation although the device is not intentionally designed to generate radio frequency energy." Such a device "shall be operated so that the radio frequency energy that is emitted does not cause harmful interference. In the event that harmful interference is caused, the operator of the device shall promptly take steps to eliminate the harmful interference." For purposes of these regulations, harmful interference is defined as: "any emission, radiation or induction which endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radio communication service operating in accordance with this chapter" (FCC, 1988: Vol II, part 15. 47CFR, Ch. 1).

Electric power companies have been able to work quite well under the present FCC rule because harmful interference can generally be eliminated. It has been estimated that more than 95% of power-line sources that cause interference are due to gap-type discharges. These can be found and completely eliminated, when required to prevent interference (USDOE, 1980). Complaints related to corona-generated interference occur infrequently. This is especially true with the advent of cable television and satellite television, which are not subject to corona-generated interference. Mitigation of corona-generated interference with conventional radio and television receivers can be accomplished in several ways, such as use of a directional antenna or relocation of an existing antenna (USDOE, 1977; USDOE, 1980; Loftness et al., 1981).

## 8.2 Radio Interference (RI)

Radio reception in the AM broadcast band (535 to 1605 kilohertz (kHz)) is most often affected by corona-generated EMI. FM radio reception is rarely affected. Generally, only residences very near to transmission lines can be affected by RI. The IEEE Radio Noise Design Guide identifies an acceptable limit of fair-weather RI as expressed in decibels above 1 microvolt per meter (dBμV/m) of about 40 dBμV/m at 100 ft. (30 m) from the outside conductor (IEEE Committee Report, 1971). As a general rule, average levels during foul weather (when the conductors are wet) are 16 to 22 dBμV/m higher than average fair-weather levels.

## 8.3 Predicted RI Levels

The predicted median ($L_{50}$) fair- and foul-weather RI levels at 100 ft. (30 m) from the outside conductor for the proposed line operating at 237 kV are 28 and 45 dBμV/m, respectively. This level will meet the IEEE 40 dBμV/m criterion for fair weather levels at distances greater than about 100 ft. (30 m) from the outside conductor. Predicted fair-weather $L_{50}$ levels are comparable to, or lower than, those for existing 230-kV lines in Oregon..

## 8.4 Television Interference (TVI)

Corona-caused TVI occurs during foul weather and is generally of concern for transmission lines with voltages of 345 kV or above, and only for conventional receivers within about 600 ft. (183 m) of such a line. As is the case for RI, gap sources on distribution and low-voltage transmission lines are the principal observed sources of TVI. The use of modern hardware and construction practices for the proposed line would minimize such sources. TVI levels are expressed in dBμV/m at 75 MHz.

## 8.5 Predicted TVI Levels

The foul weather TVI level predicted at 100 ft. (30 m) from the outside conductor of the proposed line is 13 dBμV/m with the line operating at 237 kV. This is considerably below foul-weather TVI levels from existing 500-kV lines (24-27 dBμV/m), where TVI can be a problem.

Other forms of TVI from transmission lines are signal reflection (ghosting) and signal blocking caused by the relative locations of the transmission structure and the receiving antenna with respect to the incoming television signal. The steel pole towers proposed for use in the design of the proposed line are less effective in causing this type of interference than are lattice steel towers. Television systems that operate at higher frequencies, such as satellite receivers, are not affected by corona-generated TVI. Cable television systems are similarly unaffected. The distance between the proposed line route and nearby residences makes this type of interference very unlikely for the proposed line.

Since residences are 0.25 miles or more distant, corona-generated TVI, signal reflection or signal blocking are not anticipated to occur due to the proposed 230-kV line. In the unlikely event that RI or TVI is caused by the proposed line, BPA has a program to identify, investigate, and mitigate legitimate RI and TVI complaints.

### 8.6 Interference with Other Devices

Corona-generated interference can conceivably cause disruption on other communications bands such as the citizen's (CB) and mobile bands. However, mobile-radio communications are not susceptible to transmission-line interference because they are generally frequency modulated (FM). Similarly, cellular telephones operate at a frequency of 900 MHz or higher, which is above the frequency where corona-generated interference is prevalent. In the unlikely event that interference occurs with these or other communications, mitigation can be achieved with the same techniques used for television and AM radio interference. As digital signal processing has been integrated into communications the potential impact of corona-generated EMI has decreased substantially.

### 8.7 Conclusion

Predicted EMI levels for the proposed 230-kV transmission line are comparable to, or lower, than those that already exist near 230-kV lines and no impacts of corona-generated interference on radio, television, or other receptors are anticipated. Furthermore, if interference should occur, there are various methods for correcting it: BPA has a program to respond to legitimate complaints.

## 9.0 Other Corona Effects

Corona is sometimes visible as a bluish glow or as bluish plumes on higher voltage lines. On the proposed 230-kV line, corona levels would be very low, so it is very unlikely that it could be observed. Any corona on the conductors would be observable only under the darkest conditions and only with the aid of binoculars, if at all. Without a period of adaptation for the eyes and without intentional looking for the corona, it would probably not be noticeable.

When corona is present, the air surrounding the conductors is ionized and many chemical reactions take place, producing small amounts of ozone and other oxidants. Ozone is approximately 90% of the oxidants, while the remaining 10% is composed principally of nitrogen oxides. The corona level predicted for the proposed line is much lower than that from 500-kV lines. The levels from 500-kV lines are significantly below natural levels and fluctuations in natural levels. Consequently, any production of ozone from the proposed line would be essentially undetectable at ground level.

## 10.0 Summary

Electric and magnetic fields from the proposed transmission line have been characterized using well-known techniques accepted within the scientific and engineering community. The expected electric-field levels from the proposed line at minimum design clearance would be comparable to those from existing 230-kV lines in Oregon, and elsewhere. The expected magnetic-field levels from the proposed line would be comparable to those from other 230-kV lines in Oregon, and elsewhere.

The peak electric field expected under the proposed line would be 2.5 kV/m; the maximum value at the edge of the right-of-way would be about 0.3 kV/m. Clearances at road crossings would be increased to reduce the peak electric-field value to 1.2 kV/m or less.

Under maximum current conditions on both circuits, the maximum magnetic fields under the proposed line would be 132 mG; at the edge of the right-of-way of the proposed line the maximum magnetic field would be 25 mG. With only the Biglow Canyon circuit loaded to maximum current the magnetic fields would increase to a maximum of 150 mG on the right-of-way and 44 mG at the edge. Over a year, the magnetic field levels would average to be about 30% of the above levels.

The electric fields from the proposed line would meet regulatory limits for public exposure in Oregon and all other states that have limits and would meet the regulatory limits or guidelines for peak fields established by national and international guideline setting organizations. The magnetic fields from the proposed line would be within the regulatory limits of the two states that have established them and within guidelines for public exposure established by ICNIRP and IEEE. The state of Oregon does not have limits for magnetic fields from transmission lines.

Short-term effects from transmission-line fields are well understood and can be mitigated. Nuisance shocks arising from electric-field induced currents and voltages could be perceivable on the right-of-way of the proposed line. It is common practice to ground permanent conducting objects during and after construction to mitigate against such occurrences.

Corona-generated audible noise from the proposed line could be perceivable during foul weather at the edge of the right-of-way. The levels would be comparable with, or less than, those near existing 230-kV transmission lines in Oregon, and would be in compliance with noise regulations in Oregon, and would be below levels specified in EPA guidelines.

Corona-generated electromagnetic interference from the proposed line would be comparable to or less than that from existing 230-kV lines in Oregon. Radio interference levels would be below limits identified as acceptable. Television interference, a foul-weather phenomenon usually associated with higher voltage lines, is not anticipated to occur from the proposed 230-kV line. If legitimate TVI complaints arise, BPA has a mitigation program.

## List of References Cited

ACGIH (American Conference of Governmental Industrial Hygienists). 2000. 2000 TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. American Conference of Governmental Industrial Hygienists, Cincinnati. 192 pages.

Baishiki, R.S.; Johnson, G.B.; Zaffanella, L.E.; Bracken, T.D.; Sussman, S.S.; Rauch, G.B.; and Silva, J.M. 1990. Studies of Power System Magnetic Fields: Characterization of Sources in Residential Environments, Measurement of Exposure, Influence On Computer Screens. (36-104) CIGRE, Paris, France. 10 pages.

Banfai, B.; Karady, G.G.; Kim, C.J.; and Maracas, K.B. 2000. Magnetic field effects on CRT computer monitors. IEEE Trans. on Power Delivery 15, 307-312.

Bassen, H.; Casamento, J.; and Crowl, B. 1991. Reduction of electric and magnetic field emissions from electric blankets (Meeting abstract). *In*: Bioelectromagnetics Society, 13th Annual Meeting, 23-27 June, Salt Lake City. Bioelectromagnetics Society, New York, 20.

Bowman, J.D.; Garabrant, D.H.; Sobel, E.; and Peters, J.M. June 1988. Exposures to Extremely Low Frequency (ELF) Electromagnetic Fields in Occupations with Elevated Leukemia Rates. Applied Industrial Hygienics, 3(6, June):189-194.

Bracken, T.D. 1987. Audible Noise from High Voltage Transmission Facilities. A Briefing Paper Prepared for State of Florida Department of Environmental Regulation. (DER Contract No. SP122) State of Florida Department of Environmental Regulation.

Bracken, T.D. 1990. The EMDEX Project: Technology Transfer and Occupational Measurements, Volumes 1-3 Interim Report. EPRI Report EN-7048. (EPRI EN-7048) Electric Power Research Institute, Palo Alto, CA.

Chartier, V.L. April 1983. Empirical Expressions for Calculating High Voltage Transmission Corona Phenomena, First Annual Seminar Technical Career Program for Professional Engineers. Bonneville Power Administration, Portland, Oregon. April 1983, 75-82.

Chartier, V.L.; and Stearns, R.D. January 1981. Formulas for Predicting Audible Noise from Overhead High Voltage AC and DC Lines. IEEE Transactions on Power Apparatus and Systems, PAS-100(No. 1, January 1981):121-129.

Dabkowski, J.; and Taflove, A. May/June 1979. Prediction Method for Buried Pipeline Voltages Due to 60 Hz AC Inductive Coupling. Part II: Field Test Verification. IEEE Transactions on Power Apparatus and Systems, PAS-98(3, May/June):788-794.

Deno, D.W.; and Zaffanella, L. 1982. Field effects of overhead transmission lines and stations. Chap. 8. *In*: Transmission Line Reference Book: 345 KV and Above. Second ed. (Ed: LaForest, J.J.). Electric Power Research Institute, Palo Alto, CA, 329-419.

EPA (Environmental Protection Agency). July 1973. Public Health and Welfare Criteria for Noise. (No. 500/9-73-002, July 27, 1973.) U.S. Environmental Protection Agency, Washington, D.C.

EPA. 1974. Information On Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety. (No. PB-239 429.) U.S. Environmental Protection Agency, Washington, D.C.

EPA. 1978. Protective Noise Levels. Condensed Version of EPA Levels Document. (No. PB82-138827) U.S Environmental Protection Agency, Washington, DC.

FCC (Federal Communications Commission). 1988. Federal Communications Commission Rules and Regulations. 10-1-88 ed. Vol. II part 15, 47 CFR, Ch. 1.

Florig, H.K.; and Hoburg, J.F. 1988. Electric and Magnetic Field Exposure Associated With Electric Blankets. Project Resume. Contractor's Review. U.S. Department of Energy/Electric Power Research Institute.

Florig, H.K.; Hoburg, J.F.; and Morgan, M.G. April 1987. Electric Field Exposure from Electric Blankets. IEEE Transactions on Power Delivery, PWRD-2(2, April):527-536.

Gauger, J. September 1985. Household Appliance Magnetic Field Survey. IEEE Transactions on Power Apparatus and Systems, 104(9, September):2436-2445.

Harvey, S.M. 1983. Analysis of operator exposure to electric fields from video display units. Chap. 2. *In:* Video Display Units—Characterization of Electric and Magnetic Fields. (Ontario Hydro Research Division Report # 83-503-K) (Ed: Walsh, M.L.). Ontario Hydro, Toronto, 31-56.

Heroux, P. 1987. 60-Hz Electric and Magnetic Fields Generated By a Distribution Network. Bioelectromagnetics, 8(2):135-148.

ICNIRP (International Committee on Non-ionizing Radiation Protection). April 1998. Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (Up to 300 GHz). Health Physics, 74(4, April):1-32.

IEEE (Institute of Electrical and Electronics Engineers, Inc.). 1978. Electric and Magnetic Field Coupling from High Voltage AC Power Transmission Lines—Classification of Short-Term Effects On People. IEEE Transactions on Power Apparatus and Systems, PAS-97:2243-2252.

IEEE. 1994. IEEE Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields from AC Power Lines. ANSI/IEEE Std. 644-1994, New York, NY.

IEEE. 2002a. National Electrical Safety Code. 2002 ed. Institute of Electrical and Electronics Engineers, Inc., New York, NY. 287 pages.

IEEE (Institute of Electrical and Electronics Engineers, Inc.). 2002b. IEEE PC95.6-2002 Standard for Safety Levels With Respect to Human Exposure to Electromagnetic Fields, 0 to 3 kHz. Piscataway, NJ: prepared by Subcommittee 3 of Standards Coordinating Committee 28, IEEE Standards Department, 2002.

IEEE Committee Report. March/April 1971. Radio Noise Design Guide for High Voltage Transmission Lines. IEEE Transactions on Power Apparatus and Systems, PAS-90(No. 2, March/April):833-842.

IEEE Committee Report. October 1982. A Comparison of Methods for Calculating Audible Noise of High Voltage Transmission Lines. IEEE Transactions on Power Apparatus and Systems, 101(10, October):4090-4099.

ITT Research Institute. 1984. Representative Electromagnetic Field Intensities Near the Clam Lake (WI) and Republic (MI) ELF Facilities. Report Prepared for Naval Electronics Systems Command, PME 110 E Washington, D.C. 20360. (Under contract N00039-84-C0070.) ITT Research Institute, Chicago, IL. 60 pages.

Jaffa, K.C.; and Stewart, J.B. March 1981. Magnetic Field Induction from Overhead Transmission and Distribution Power Lines On Buried Irrigation Pipelines. IEEE Transactions on Power Apparatus and Systems, PAS-100(3, March):990-1000.

Keesey, J.C.; and Letcher, F.S. 1969. Minimum Thresholds for Physiological Responses to Flow of Alternating Electric Current Through the Human Body At Power-Transmission Frequencies. (Report No. 1) Naval Medical Research Institute, Project MR 005.08-0030B, Bethesda, MD. 25 pages.

Loftness, M.O.; Chartier, V.L.; and Reiner, G.L. 1981. EMI Correction Techniques for Transmission Line Corona. (August 18-20, 1981, pp. 351-361.) Proceedings of the 1981 IEEE International Symposium on Electromagnetic Compatibility, Boulder, CO.

Maddock, B.J. September 1992. Guidelines and Standards for Exposure to Electric and Magnetic Fields At Power Frequencies. (Panel 2-05, CIGRE meeting August 30-September 5, 1992) CIGRE, Paris.

Mezei, G.; Kheifets, L.I.; Nelson, L.M.; Mills, K.M. ; Iriye, R. ;and Kelsey, J.L. 2001. Household Appliance Use and Residential Exposure to 60-Hz Magnetic Fields. Journal of Exposure Analysis and Environmental Epidemiology, Vol. 11, No. 1: 41-49.

NOAA, National Oceanic & Atmospheric Administration. 2005. National Environmental Satellite, Data, and Information Service (NESDIS), National Climatic Data Center (NCDC). http://www.ncdc.noaa.gov/oa/ncdc.html

Olsen, R.G.; Schennum, S.D.; and Chartier, V.L. April 1992. Comparison of Several Methods for Calculating Power Line Electromagnetic Interference Levels and Calibration With Long Term Data. IEEE Transactions on Power Delivery, 7 (April, 1992):903-913.

Oregon, State of. 1980. *Oregon Administrative Rules Chapter 345, Division 80.* Energy Facility Siting Council standards relating to public health and safety, 934-80-055.

Reilly, J.P. 1979. Electric Field Induction on Long Objects—A Methodology for Transmission Line Impact Studies. IEEE Transactions on Power Apparatus and Systems, PAS-98(6, Nov/Dec):1841-1852.

Sheppard, A.R.; and Eisenbud, M. 1977. Biological Effects of Electric and Magnetic Fields of Extremely Low Frequency. New York University Press, New York.

Silva, M.; Hummon, N.; Rutter, D.; and Hooper, C. 1989. Power Frequency Magnetic Fields in the Home. IEEE Transactions on Power Delivery, 4:465-478.

Stopps, G.J.; and Janischewskyj, W. 1979. Epidemiological Study of Workers Maintaining HV Equipment and Transmission Lines in Ontario. (Canadian Electrical Association Research Report) Canadian Electrical Association, Montreal. 82 pages.

Taflove, A. and Dabkowski, J. May/June 1979. Prediction Method for Buried Pipeline Voltages Due to 60 Hz AC Inductive Coupling. Part I: Analysis. IEEE Transactions on Power Apparatus and Systems, PAS-98(3, May/June):780-787.

TDHS Report. March 1989. EMF Rule Becomes Law; Hillsborough County Commission Challenges. Transmission/Distribution Health & Safety Report, 7(9, 31 March):1-3.

TDHS Report. August 1990. Updates: New York. Transmission/Distribution Health & Safety Report, 8(7, 31 August):4.

USDOE (U.S. Department of Energy), Bonneville Power Administration. March 1977. A Practical Handbook for the Location, Prevention and Correction of Television Interference from Overhead Power Lines. Portland, OR.

USDOE, Bonneville Power Administration. May 1980. A Practical Handbook for the Correction of Radio Interference from Overhead Powerlines and Facilities. Portland, OR.

USDOE, Bonneville Power Administration. 1995. Living and Working Around High-Voltage Power Lines. (DOE/BP-799). Portland, OR. 9 pages.

USDOE, Bonneville Power Administration. 1996. Electrical and Biological Effects of Transmission Lines: A Review. (DOE/BP 2938 December 1996 1M) Portland, OR.

USDOE, Bonneville Power Administration. undated. "Corona and Field Effects" Computer Program (Public Domain Software). Bonneville Power Administration, P.O. Box 491-ELE, Vancouver, WA 98666.

USDOE, Bonneville Power Administration. 2006. Audible Noise Policy. TBL Policy T2006-1. Bonneville Power Administration, Portland, OR.

Zaffanella, L.E. 1993. Survey of Residential Magnetic Field Sources. Vol. 1: Goals, results, and conclusions. (EPRI TR-102759-V1, Project 3335-02) Electric Power Research Institute, Palo Alto, CA.

Zaffanella, L.E.; and Kalton, G.W. 1998. Survey of personal magnetic field exposure, Phase II: 1000-person survey. Interim Report. EMF RAPID Program Engineering Project #6. Enertech Consultants, Lee, MA.

## List of Preparers

T. Dan Bracken was the principal author of this report. He received a B.S. degree in physics from Dartmouth College and M.S. and Ph.D. degrees in physics from Stanford University. Dr. Bracken has been involved with research on and characterization of electric- and magnetic-field effects from transmission lines for over 30 years, first as a physicist with the Bonneville Power Administration (BPA) (1973 - 1980) and since then as a consultant. His firm, T. Dan Bracken, Inc., offers technical expertise in areas of electric- and magnetic-field measurements, instrumentation, environmental effects of transmission lines, exposure assessment and project management. Joseph Dudman of T. Dan Bracken, Inc., provided data entry, graphics, and clerical support in the preparation of the report.

*This page intentionally left blank.*

**Table 1: Alternative routes for proposed Klondike - John Day 500-kV transmission line.**

| Route | Description | Miles (length) |
|---|---|---|
| **North Alternative** | Runs northwest from Klondike Substation; due north from the intersection with Old Wasco-Happner Highway; then northwest along Herrin Road to the John Day Substation. | 12.0 |
| **Middle Alternative** | Runs northwest from the Klondike Substation; due north to Medler Road; west along Medler Road; then north and westa nd north again along property lines to the John Day Substation. | 12.5 |

**Table 2: Physical and electrical characteristics of the proposed Klondike - John Day double-circuit 230-kV transmission-line. See Table 1 for descriptions of alternative routes and Figure 1 for physical layout of line.**

| **Klondike - John Day 230-kV Double-circuit** | |
|---|---|
| **Voltage, kV Maximum/Average**[1] | 242/237 |
| **Peak current, A** | |
| **Biglow Canyon circuit**[2] | 974 (1462) |
| **Klondike circuit** | 731 |
| **Electric phasing (north –- south)** | C A<br>B B<br>A C |
| **Clearance, ft. Minimum/Average**[1] | 26.5/38.5 |
| **Tower configuration** | Vertical DC |
| **Phase spacing, ft.**[3] | 20/32 H, 18 V |
| **Conductor: #/diameter, in** | 1/1.6 |

1 Average voltage and average clearance used for corona calculations.
2 Maximum current will increase to 1462 A with addition of Orion project load.
3 H = horizontal feet; V = vertical feet

**Table 3: Calculated peak and edge-of-right-of-way electric fields for the proposed Klondike - John Day 230-kV line operated at maximum voltage.**

| **Location** | **Electric Field, kV/m** | |
|---|---|---|
| **Line Clearance** | Minimum | Average |
| **Peak** | 2.5 | 1.2 |
| **Edge-of-ROW** | 0.3 | 0.2 |

**Table 4: Calculated peak and edge-of-right-of-way magnetic fields for the proposed Klondike - John Day 230-kV line operated at maximum current. Average fields would be 30% of table values.**

| **Location** | **Magnetic Field, mG** | |
|---|---|---|
| **Line Clearance** | Minimum | Average |
| **Peak** | 132 | 59 |
| **Edge-of-ROW**[1] | 25/12 | 19/10 |

[1] Higher value is at edge of right-of-way adjacent to circuit with Biglow Canyon load.

**Table 5: States with transmission-line field limits**

| STATE AGENCY | WITHIN RIGHT-OF-WAY | AT EDGE OF RIGHT-OF-WAY | COMMENTS |
|---|---|---|---|
| **a. 60-Hz ELECTRIC-FIELD LIMIT, kV/m** | | | |
| Florida Department of Environmental Regulation | 8 ( 230 kV)<br>10 (500 kV) | 2 | Codified regulation, adopted after a public rulemaking hearing in 1989. |
| Minnesota Environmental Quality Board | 8 | — | 12-kV/m limit on the high-voltage direct-current (HVDC) nominal electric field. |
| Montana Board of Natural Resources and Conservation | 7[1] | 1[2] | Codified regulation, adopted after a public rulemaking hearing in 1984. |
| New Jersey Department of Environmental Protection | — | 3 | Used only as a guideline for evaluating complaints. |
| New York State Public Service Commission | 11.8<br>(7,11)[1] | 1.6 | Explicitly implemented in terms of a specified right-of-way width. |
| Oregon Facility Siting Council | 9 | — | Codified regulation, adopted after a public rulemaking hearing in 1980. |
| **b. 60-Hz MAGNETIC-FIELD LIMIT, mG** | | | |
| Florida Department of Environmental Regulation | — | 150 ( 230 kV)<br>200 (500 kV) | Codified regulations, adopted after a public rulemaking hearing in 1989. |
| New York State Public Service Commission | — | 200 | Adopted August 29, 1990. |

[1] At road crossings
[2] Landowner may waive limit

Sources: TDHS Report, 1989; TDHS Report, 1990

**Table 6: Common noise levels**

| Sound Level, dBA | Noise Source or Effect |
|---|---|
| 128 | Threshold of pain |
| 108 | Rock-and-roll band |
| 80 | Truck at 50 ft. |
| 70 | Gas lawnmower at 100 ft. |
| 60 | Normal conversation indoors |
| 50 | Moderate rainfall on foliage |
| 49 | Edge of proposed 500-kV right-of-way during rain (no parallel lines) |
| 40 | Refrigerator |
| 25 | Bedroom at night |
| 0 | Hearing threshold |

Adapted from: USDOE, 1996.

**Table 7: Predicted foul-weather and fair-weather audible noise (AN) levels at edge of right-of-way (ROW) for the proposed Klondike - John Day 230-kV line.** AN levels expressed in decibels on the A-weighted scale (dBA). $L_{50}$ and $L_5$ denote the levels exceeded 50 and 5 percent of the time, respectively.

| Edge of Right-of-Way Audible Noise | | |
|---|---|---|
| **Descriptor** | **$L_{50}$, dBA** | **$L_5$, dBA** |
| **Foul weather** | 42 | 45 |
| **Fair weather** | 17 | 20 |

**Figure 1: Configuration for the proposed Klondike – John Day 230-kV transmission line.** Routes and configuration are described in Tables 1 and 2.

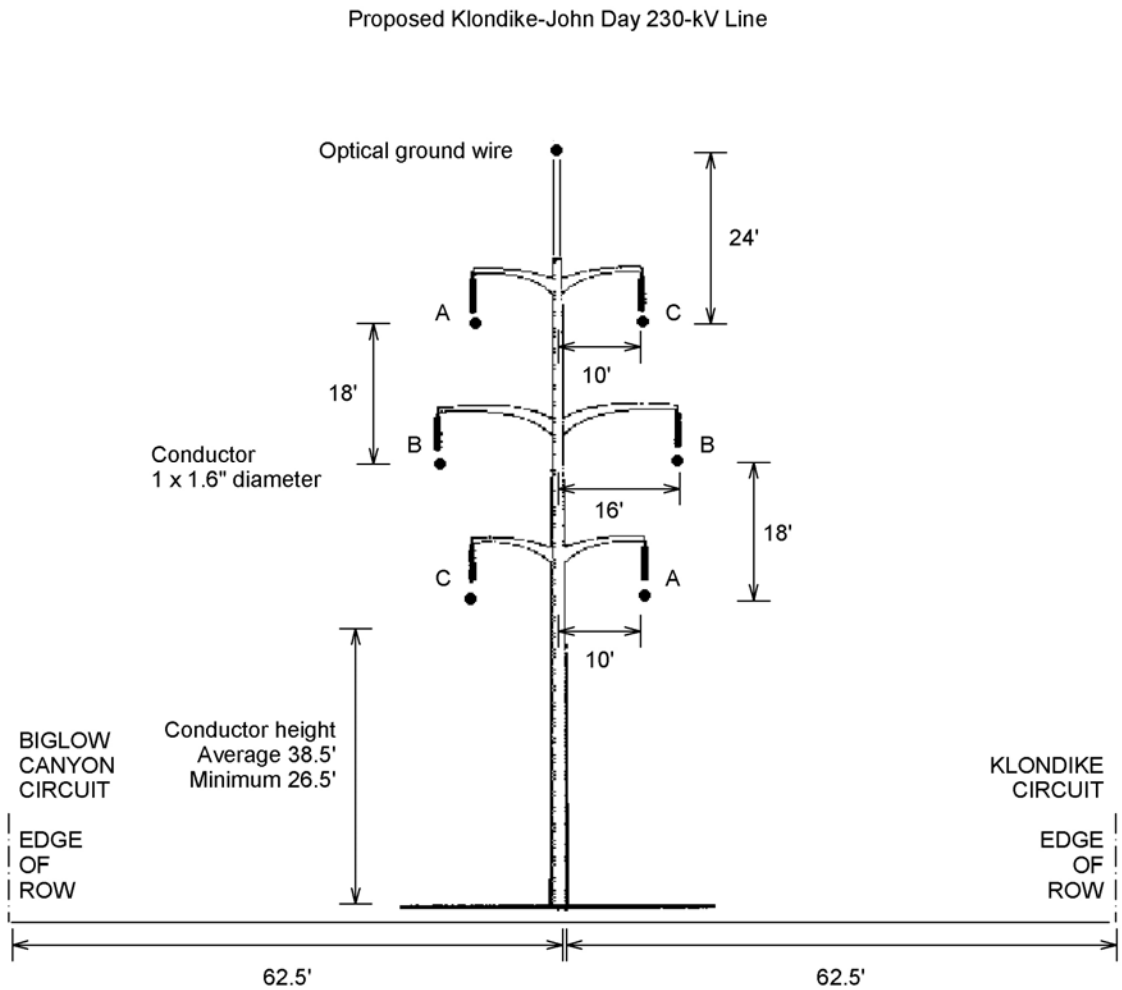


**Figure 2: Electric-field profiles for the proposed Klondike – John Day 230-kV transmission line under maximum voltage conditions.** Configuration is described in Table 2.

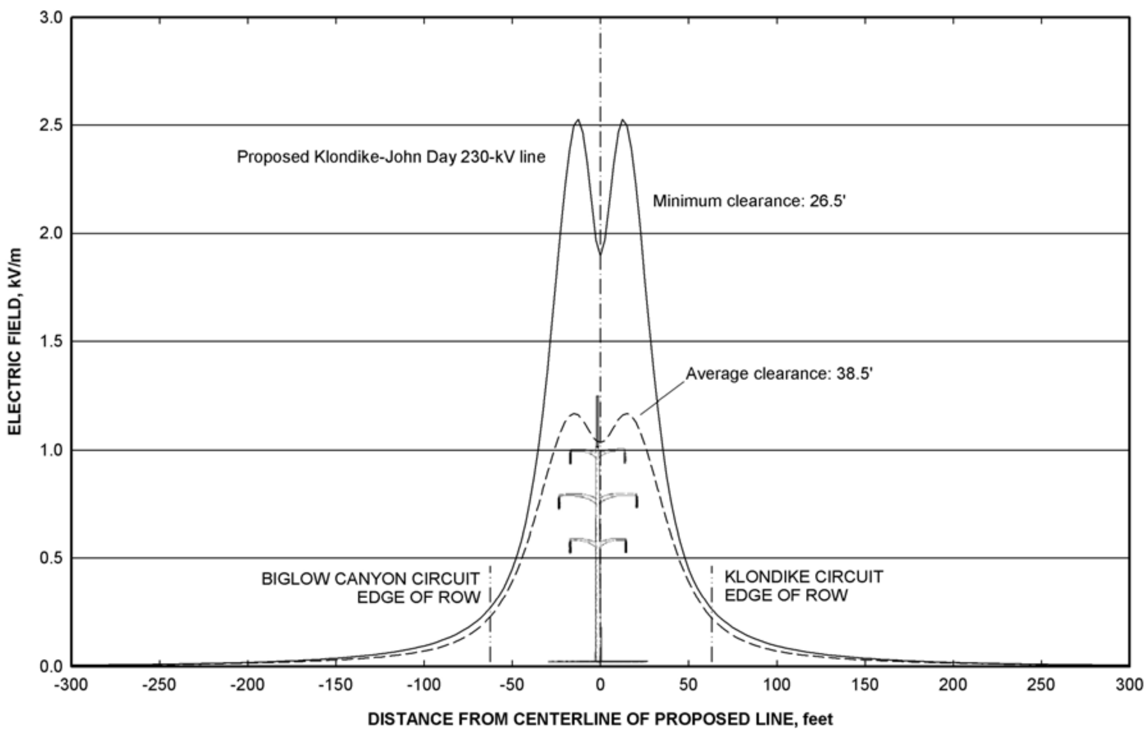


**Figure 3: Magnetic-field profiles for the proposed Klondike – John Day 230-kV transmission line under maximum current conditions.** Configuration is described in Table 2.

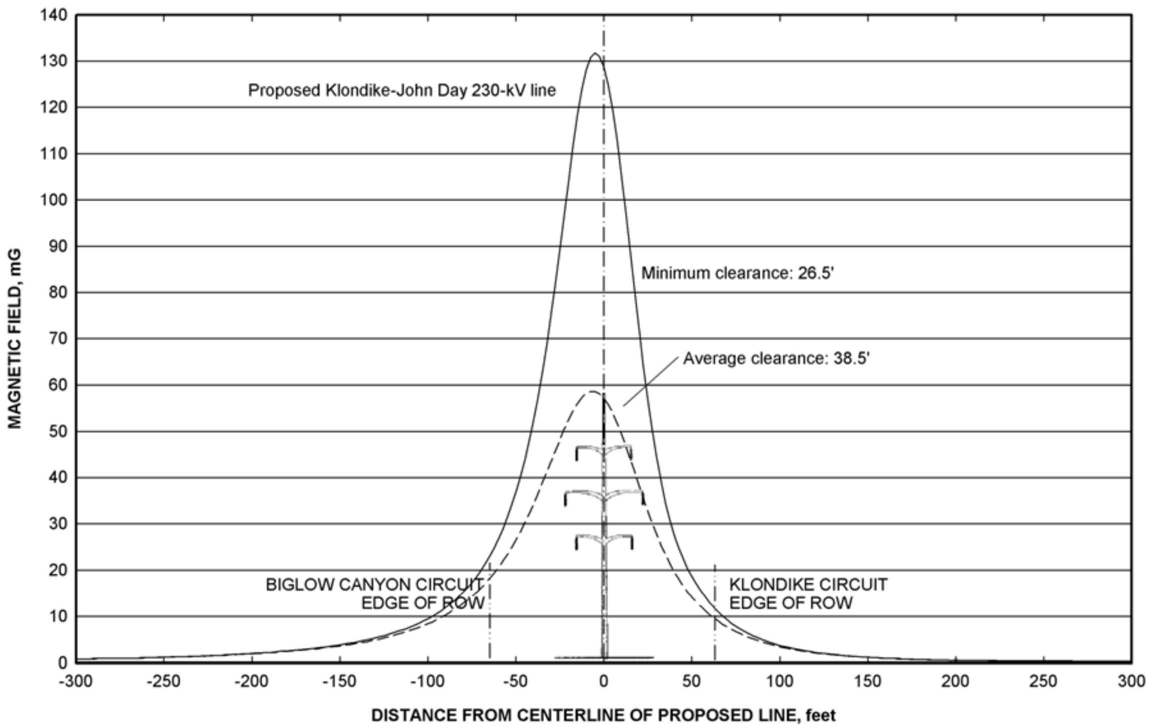
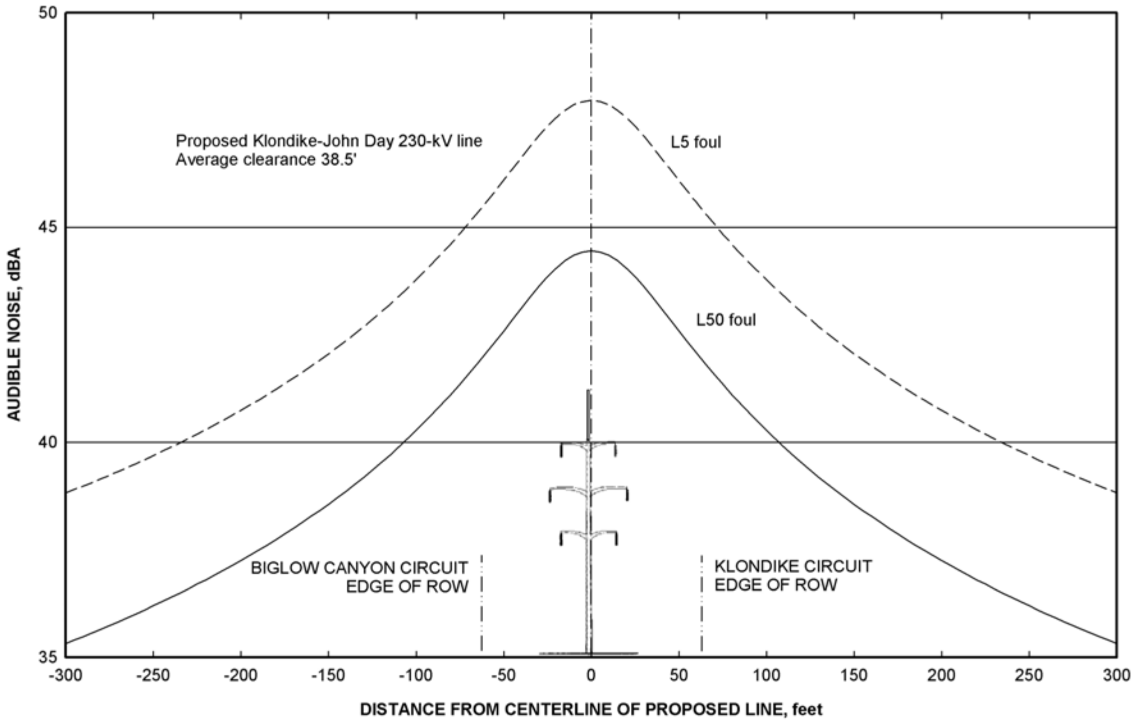


**Figure 4: Predicted foul-weather $L_{50}$ audible noise levels for the proposed Klondike - John Day 230-kV transmission line.** Configuration is described in Table 2.



*This page intentionally left blank.*

# McNary-John Day Transmission Project, Draft EIS, Appendix G (February 2002)

# Appendix G
# Electric and Magnetic Fields

- Assessment of Research Regarding EMF and Health and Environmental Effects
- Electrical Effects

***<u>McNARY – JOHN DAY TRANSMISSION-LINE PROJECT</u>***

# *ASSESSMENT OF RESEARCH REGARDING EMF AND HEALTH AND ENVIRONMENTAL EFFECTS*

January, 2002

**Prepared by**

Exponent™

**and**

**T. Dan Bracken, Inc.**

**for**

**Bonneville Power Administration**

# Table of Contents

# ASSESSMENT OF RESEARCH REGARDING EMF AND HEALTH AND ENVIRONMENTAL EFFECTS

## 1.0 Introduction

Over the last 20 years, research has been conducted in the United States and around the world to examine whether exposures to electric and magnetic fields (EMF) at 50/60 Hertz (Hz) from electric power lines are a cause of cancer or adversely affect human health. The research included epidemiology studies that suggested a link with childhood leukemia for some types of exposures, as well as other epidemiology studies that did not; it also included lifetime animal studies, which showed no evidence of adverse health effects. Comprehensive reviews of the research conducted by governmental and scientific agencies in the U.S. and in the United Kingdom (UK) had examined the research, and did not find a basis for imposing additional restrictions (NIEHS, 1999; IEE, 2000).

The Bonneville Power Administration (BPA) requested that Exponent update the BPA on research on EMF and health in relation to exposures that might occur near the McNary – John Day Transmission Line Project. This update concentrates on recent major research studies to explain how they contribute to the assessment of effects of EMF on health (Section 2). The focus is on both epidemiologic and laboratory research, because these research approaches provide different and complementary information for determining whether an environmental exposure can affect human health. Section 3, Ecological Research, reviews studies of potential effects of EMF on plants and animals in the natural environment. This update includes studies of residential or environmental exposures to EMF and health effects that became available in 2001 (through November).

## 2.0 Health

### 2.1 The NIEHS Report and Research Program

In 1998, the NIEHS completed a comprehensive review of the scientific research on health effects of EMF. The NIEHS had been managing a research program that Congress funded in 1992 in response to questions regarding exposure to EMF from power sources. The program was known as the RAPID Program (Research and Public Information Dissemination Program). The NIEHS convened a panel of scientists (the "Working Group") to review and evaluate the RAPID Program research and other research. Their report, *Assessment of Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields,* was completed in July 1998 (NIEHS, 1998).

The director of the NIEHS prepared a health risk assessment of EMF and submitted his report to Congress in June 1999 (NIEHS, 1999). Experts at NIEHS, who had considered the previous Working Group report, reports from four technical workshops, and research that became available after June 1998, concluded as follows:

> The scientific evidence suggesting that ELF-EMF [extremely low frequency-electric and magnetic field] exposures pose any health risk is weak. The strongest evidence for health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and chronic lymphocytic leukemia in occupationally exposed

> adults. . . . In contrast, the mechanistic studies and animal toxicology literature fail to demonstrate any consistent pattern. . . . No indication of increased leukemias in experimental animals has been observed. . . . The lack of consistent, positive findings in animal or mechanistic studies weakens the belief that this association is actually due to ELF-EMF, but it cannot completely discount the epidemiology findings. . . . The NIEHS does not believe that other cancers or other non-cancer health outcomes provide sufficient evidence of a risk to currently warrant concern (NIEHS, 1999: 9-10).

Although the results of the RAPID research are described in some detail in the 1998 report, many of the studies had not been published in the peer-reviewed literature. Recognizing the need to have these results reviewed and considered for publication, the NIEHS arranged for a special edition of the journal *Radiation Research* (Radiation Research, 153[5], 2000) to be devoted to this topic.[1]

## 2.2 Update of Research Related to Cancer

This update includes studies of residential or occupational exposures to EMF and leukemia that became available through November 2001, including several epidemiology studies of childhood cancer and meta-analyses. The California Department of Health Services (CDHS) conducted a workshop in 1999 to discuss epidemiologic research on EMF and health. The reports presented at this workshop were published in January 2001 as a supplement to the journal, *Bioelectromagnetics*. Many of the papers were technical discussions of methodology issues in epidemiologic studies of EMF, including discussions of how to better understand the conflicting results reported in previous studies (Neutra and Del Pizzo, 2001). For example, one study evaluates the extent to which systematic errors (known in epidemiology as selection bias or information bias) occurred in EMF studies, and if those errors occurred, whether the effect on results could be evaluated (Wartenberg, 2001a). Other researchers discuss epidemiologic approaches to study how possible confounding factors, such as the age and type of home and traffic density, might affect the interpretation of studies of EMF and childhood cancer (Langholz, 2001; Reynolds et al., 2001).

For this update, we reviewed epidemiology and laboratory studies of cancer and reproduction. Several of the studies are "meta-analyses," an approach that incorporates statistical methods to analyze differences among studies and aggregate the results of smaller studies. The sections below include a review of meta-analyses of the studies of childhood leukemia, and a meta-analysis of studies of breast cancer in adults (Erren, 2001).

### 2.2.1 Epidemiology Studies of Children

The question of power lines and childhood cancer has been based on the assumption that the relevant exposure associated with power lines is the magnetic field, rather than the electric field. This assumption rests on the fact that electric fields are shielded from the interior of homes (where people spend the vast majority of their time) by walls and vegetation, while magnetic fields are not. The magnetic field in the vicinity of a power line results from the flow of current; higher currents result in higher levels of magnetic fields.

Epidemiologic studies report results in the form of statistical associations. The term "statistical association" is used to describe the tendency of two things to be linked or to vary in the same way, such

---

[1] See, for instance, the articles cited in the **List of References** under Balcer-Kubiczek, Boorman, Loberg, and Ryan.

as level of exposure and occurrence of disease. However, statistical associations are not automatically an indication of cause and effect, because the interpretation of numerical information depends on the context, including (for example) the nature of what is being studied, the source of the data, how the data were collected, and the size of the study. The larger studies and more powerful studies of EMF have not reported convincing statistical associations between power lines and childhood leukemia (e.g., Linet et al., 1997; McBride et al., 1999; UKCCS, 1999). Despite the larger sample size, these studies usually had a limited number of cases exposed over 2 or 3 milligauss (mG).

*Epidemiology Studies*

The following discussion briefly describes major studies.

- A study from Germany included 514 children with leukemia and 1,301 control children (Schuz et al., 2001). Measurements of magnetic-field intensity (50 Hz) were taken for 24 hours in each child's bedroom. The results were calculated separately for daytime or nighttime levels in the bedroom, rather than for a child's overall 24-hour exposure. The authors report an association with leukemia for mean daytime magnetic-field exposures that might have been due to chance. They reported an association between mean nighttime magnetic-field levels and leukemia for the highest exposed group (4 mG or higher; 9 cases). The assessment of exposure by mean field levels in the bedroom did not link magnetic-field levels to any specific source. The authors note in their conclusions that " . . . fewer than one-third of all stronger magnetic fields were caused by high-voltage powerlines . . . . " (Schuz et al., 2001:734).

  Several aspects of the study detract from the validity of the results: the estimate included a broad margin of error because only a small number of cases was exposed at the higher levels, and many eligible cases and controls did not participate, which means that the responders may not represent the population and results could be biased. Another concern is that these magnetic-field measurements were taken in 1997, long after the relevant exposure period for cases diagnosed in 1990-1994. Magnetic-field levels may have changed over time, as electricity usage changed.

- A study from British Columbia, Canada, included 462 children who had been diagnosed with leukemia and an equal number of children without leukemia for comparison (McBride et al., 1999). Magnetic-field exposure was assessed for each of the children in several ways: personal monitors were worn in a backpack for 48 hours, a monitor took measurements in the bedroom for 24 hours, the wiring outside the house was rated by potential exposure level (wire codes), and measurements were taken around the outside perimeter of the homes. (Wire codes are a method of estimating relative exposure intensity based on the configuration of the power lines.) Regardless of the method used to estimate magnetic-field exposure, the magnetic-field exposure of children who had leukemia was not greater than that of the children in the comparison group.

- A study conducted in Ontario, Canada reported on the magnetic-field exposure of a smaller group of children than in other recent studies (Green et al., 1999a). No increased risk estimates were found with the average magnetic fields in the bedroom or the interior, or with any of the three methods of estimating exposure from wire-configuration codes. A still smaller group of 88 children with leukemia and their controls wore personal monitors to measure magnetic fields (Green et al., 1999b). Associations with magnetic fields were reported in some of the analyses, but most of the risk estimates had a broad margin of error, and major methodological problems in the study preclude any clear interpretation of the findings.

- The United Kingdom Childhood Cancer Study, the largest study to date, included a total of 1073 childhood leukemia cases (UKCCS, 1999). Exposure was assessed by spot measurements in the home (bedroom and family room) and school, and summarized by averaging these over time. No evidence was found to support the idea of an increased risk of leukemia from exposures to magnetic fields inside or outside of the home.

- The UKCCS investigators had obtained magnetic-field measurements on only a portion of the childhood cancer cases in their study (UKCCS, 1999). To obtain additional information, they used a method to assess exposure to magnetic fields without entering homes; they were thus able to analyze 1331 child leukemia cases (UKCCS, 2000). For these children, they measured distances to power lines and substations. This information was used to calculate the magnetic field from these external field sources, based on power-line characteristics related to production of magnetic fields. The results of the second UKCCS study showed no evidence for an association with leukemia for magnetic fields calculated to be between 1 mG and 2 mG, 2 mG and 4 mG, or 4 mG or greater at the residence, in contrast to the weak association reported for measured fields of 4 mG or greater in the first report (UKCCS, 1999).

Researchers have proposed that the associations that are sometimes reported between childhood leukemia and power lines might be due to other factors that can confound (other risk factors for disease that may distort the analysis) the analysis. One example is heavy traffic, which may occur near power lines and which can increase the levels of potentially carcinogenic chemicals in the area. Earlier studies had reported associations between traffic density and childhood cancer (Savitz et al., 1988). If power lines were more common in areas that had higher traffic density, then the increased air pollution might explain an association between power lines and childhood cancer. However, more recent studies seem to eliminate this possibility. In a study of 90 cases of childhood leukemia, Reynolds et al. (2001) found no evidence of an association with traffic density. In a larger study that included 986 cases of childhood leukemia, no association was found with high traffic-density exposure during pregnancy or childhood (Raaschou-Nielsen et al., 2001).

*Meta-analyses of Studies of Leukemia*

Recently, researchers re-analyzed the data from previous epidemiology studies of magnetic fields and childhood leukemia (Ahlbom et al., 2000; Greenland et al., 2000). The researchers pooled the data on individuals from each of the studies, creating a study with a larger number of subjects and therefore greater statistical power than any single study. A pooled analysis is preferable to other types of meta-analyses in which the results from several studies are combined from grouped data obtained from the published studies. These analyses focused on studies that assessed exposure to magnetic fields using 24-hour measurements or calculations based on the characteristics of the power lines and current load. Both Ahlbom et al. and Greenland et al. used exposure categories of <1 mG (<0.1 microtesla [μT]) as a reference category. The statistical results of these analyses can be summarized as follows:

- The pooled analyses provided no indication that wire codes are more strongly associated with leukemia than measured fields.

- Pooling these data corroborates an absence of an association between childhood leukemia and magnetic fields for exposures below 3 mG (0.3 μT).

- Pooling these data results in a statistical association with leukemia for exposures greater than 3-4 mG (0.3 or 0.4 μT).

The authors are appropriately cautious in the interpretation of their analyses, and they clearly identify the limitations in their evaluation of the original studies. Magnetic fields above 3 mG (0.3 μT) in residences are estimated to be rather rare, about 3% in the U.S. (Zaffanella, 1993). Limitations include sparse data (few cases) to adequately characterize a relationship between magnetic fields and leukemia, uncertainties related to pooling different magnetic-field measures without evidence that all of the measures are comparable, and the incomplete and limited data on important confounders such as housing type and traffic density.

A meta-analysis of the data from epidemiologic studies of childhood leukemia studies was presented at the California Workshop and recently published (Wartenberg, 2001b). This meta-analysis did not have the advantage of obtaining and pooling the data on all of the individuals in the studies, unlike those published before it (Ahlbom et al., 2000; Greenland et al., 2000). Instead of using individual data, Wartenberg (2001b) used an approach that extracted the published results, reported as grouped data from several published studies. He used 19 studies overall, after excluding 7 studies that had insufficient data on individuals or deficiencies in the exposure assessment data. He reported a weak association for a) "proximity to electrical facilities" based on wire codes or distance, and b) magnetic-field level over 2 mG, based on either calculations from wiring and loading characteristics (if available) or on spot magnetic-field measurements. The results show more cases than controls exposed to measured or calculated fields above 2 mG. The author concludes that the analysis supports an association, although the size of the effect is small to moderate, but also notes "limitations due to design, confounding, and other biases may suggest alternative interpretations" (Wartenberg, 2001b:S-100).

The results of this meta-analysis are not directly comparable to previous ones regarding fields of 3 or 4 mG because the analysis was not based on individual data. The comparison of grouped data used different exposure cut points for the analysis and different criteria for the comparison group. None of these three analyses (Ahlbom et al., 2000; Greenland et al., 2000; Wartenberg, 2001b) included the results of the latest UK analysis of 1331 child leukemia cases based on calculated fields, which found no association between EMF and childhood leukemia or other cancers, regardless of the exposure level.

### 2.2.2 Epidemiology Studies of Adults

Studies of adults with certain types of cancer, such as brain cancer, breast cancer, or leukemia, have reported associations with exposure to magnetic fields at residences, but results have not been consistent across studies. Contradictory results among studies argue against a conclusion that the association reflects a cause-and-effect relationship. In their assessments of risk, scientists give most weight to studies that include more people, obtain more detailed and individual exposure assessments, and/or include people who have higher exposures.

A study of 492 adult cases of brain cancer in California included measurements of magnetic fields taken in the home and at the front door, and considered the types of power-line wiring (Wrensch et al., 1999). The authors report no evidence of increased risk with higher exposures, no association with type of power line, and no link with levels measured at the front door.

A number of recent studies of breast cancer focused on electric blankets as a source of high exposure. Electric blankets are assumed to be one of the strongest sources of EMF exposure in the home. Three studies of electric-blanket use found no evidence that long-term use increased the risk of breast cancer. Women who developed breast cancer reported no difference in total use of electric blankets, use in recent years, or use many years in the past:

- Gammon et al. (1998) reported that, even for those who kept the blanket on most of the time, no increase in risk was found for those who had longer duration of use (measured in months).

- A study of 608 breast cancer cases found no evidence of increased use of electric blankets or other home appliances in cases compared to controls, and no indication of increasing risk with a longer time of use (Zheng et al., 2000).

- In a cohort of over 120,000 female nurses, data were obtained on known risk factors for breast cancer as well as electric-blanket use (Laden et al., 2000). For a large subset of this group, the questions about exposure were asked before the disease occurred, a step taken to eliminate bias in recalling exposure. No associations with electric blanket use were found.

Erren (2001) reported the results of a meta-analysis of the studies of breast cancer, in which the results of 24 different studies in women were statistically aggregated. When the results of all 24 studies, including studies of workplace exposures, were pooled, the estimate indicated an association between EMF and a small excess breast cancer risk. The pooled results for exposure to EMF in the vicinity of electrical facilities did not show an association with breast cancer, nor did the results for exposure to EMF from appliance use. However, the meta-analysis also showed a lack of consistency among the results of the individual studies, a broad variation in the designs, and a wide range of methods used to assess exposure. No adjustments were made to the data to give increased weight to studies based on more comprehensive exposure assessments. The author also noted that the weak statistical association might be an artifact (a result of chance or unforeseen error) rather than an indication of a cause-and-effect relationship (Erren, 2001).

### 2.2.3 Laboratory Studies of EMF

Laboratory studies complement epidemiologic studies of people because the effects of heredity, diet, and other health-related exposures of animals can be better controlled or eliminated. The assessment of EMF and health, as for any other exposure, includes chronic, long-term studies in animals (*in vivo* studies) and studies of changes in genes or other cellular processes observed in isolated cells and tissues in the laboratory (*in vitro*).

Although the results of the RAPID Program were described in some detail in the NIEHS reports (NIEHS, 1998), many of the studies had not been published in the peer-reviewed literature. The RAPID research program included studies of four biological effects, each of which had previously been observed in only one laboratory. These effects are as follows: effects on gene expression, increased intracellular calcium in a human cell line, proliferation of cell colonies on agar, and increased activity of the enzyme ornithine decarboylase (ODC). Some scientists have suggested that these biological responses are signs of possible adverse health effects of EMF. It is standard scientific procedure to attempt to replicate results in other laboratories, because artifacts and investigator error can occur in scientific investigations. Replications, often using more experiments or more rigorous protocols, help to ensure objectivity and validity. Attempts at replication can substantiate and strengthen an observation, or they may discover the underlying reason for the observed response.

Studies in the RAPID program reported no consistent biological effects of EMF exposure on gene expression, intracellular calcium concentration, growth of cell colonies on agar, or ODC activity (Boorman et al., 2000b). For example, Balcer-Kubiczek et al. (2000) and Loberg et al. (2000) studied the expression of hundreds of cancer-related genes in human mammary or leukemia cell lines. They found no increase in gene expression with increased intensity of magnetic fields. To test the experimental procedure, they used X-rays and treatments known to affect the genes. These are known as positive controls and, as expected, caused gene expression in exposed cells.

Scientists have concluded that the combined animal bioassay results provide no evidence that magnetic fields cause, enhance, or promote the development of leukemia and lymphoma, or mammary cancer (e.g., Boorman et al., 1999; McCormick et al., 1999; Boorman et al., 2000 a, b; Anderson et al., 2001).

#### 2.2.4 Summary Regarding Cancer

Epidemiology studies do not support the idea that EMF from power lines increase the risk of cancers in adults. The latest epidemiologic studies of childhood cancer, considered in the context of the other data, provide no persuasive evidence that leukemia in children is causally associated with magnetic fields measured at the home, calculated magnetic fields based on distance and current loading, or wire codes. Recent meta-analyses reported no association between childhood cancer and magnetic fields below 2 or 3 mG. Although some association was reported for fields above this level, fields at most residences are likely to be below 3 or 4 mG. The authors of each of these analyses list several biases and problems that render the data inconclusive and prevent resolution of the inconsistencies in the epidemiologic data. For this reason, laboratory studies can provide important complementary information. Large, well-conducted animal studies and studies of initiation and promotion, provide no basis to conclude that EMF increases leukemia, lymphoma, breast, brain, or any other type of cancer.

### 2.3 Research Related to Reproduction

Previous epidemiologic studies reported no association with birth weight or fetal growth retardation after exposure to sources of relatively strong magnetic fields, such as electric blankets, or sources of typically weaker magnetic fields such as power lines (Bracken et al., 1995; Belanger et al., 1998).

A recent epidemiology study examined miscarriages[2] in relation to exposures to magnetic fields from electric bed-heating (electric blankets, heated waterbeds and mattress pads), which result in higher exposures than residential fields in general (Lee et al., 2000). The researchers assessed exposure prior to the birth (a prospective study) and included information to control for potential confounding factors (other exposures and conditions that affect the risk of miscarriage). This study had a large number of cases and high participation rates. Miscarriage rates were lower among users of electric bed-heating.

Studies of laboratory animals exposed to pure 60-Hz fields have shown no increase in birth defects, no multigenerational effects, and no changes that would indicate an increase in miscarriage or loss of fertility (e.g., Ryan et al., 1999; Ryan et al., 2000). Exposed and unexposed litters were no different in the amount of fetal loss and the number and type of birth defects, indicating no reproductive effect of EMF.

In summary, the recent evidence from epidemiology and laboratory studies provides no indication that exposure to power-frequency EMF has an adverse effect on reproduction, pregnancy, or growth and development of the embryo. The results of these recent studies are consistent with the conclusions of the NIEHS.

### 2.4 Power-line Electric Fields and Airborne Particles and Ions

Researchers from a university in England have suggested that the alternating-current (ac) electric fields from power lines might affect health indirectly, by interacting with the electrical charges on certain airborne particles in the air. They hypothesize that more particles would be deposited on the skin by a strong electric field, or in the lung by charges on particles (Henshaw et al., 1996; Fews et al., 1999a, b).

---

[2] The medical term for miscarriage is spontaneous abortion.

If this hypothesis were correct, and interaction did occur (i.e., the airborne particles were charged to increase deposition on skin and in lungs to a sufficient degree), then the researchers further hypothesize that human exposure to various airborne particles and disease might increase. These hypotheses remain highly speculative; scientists have found their assumptions unconvincing, and recognize data gaps in the steps of the hypotheses. Nevertheless, questions about effects of these charged particles have been raised in the media.

In their laboratory, Henshaw and colleagues have developed models to test the physical assumptions that are the first step of their hypotheses: that electric fields can change the behavior of particulates in the air. For example, they measured the deposition of radon daughter[3] particles on metal plates, in the presence of electric fields at intensities found under or near power lines. They also reported increased deposition at similar electric field strengths outdoors near high voltage transmission lines. Under these conditions, deposition of products on surfaces was slightly increased, an occurrence that implies that the deposition might also occur on other surfaces, such as the skin. However, Henshaw and colleagues have not tested the most speculative parts of their hypothesis: that such changes in the deposition rate of particles would lead to an important increase in human exposure, and also that the increased skin exposure would be sufficient to affect human health, in this case to cause an increase in skin cancer. Given (a) the small change anticipated, (b) the ability of wind to disperse particles, and (c) the limited amount of time that people spend outdoors directly under high-voltage power lines, the assumption of health effects is unsupported (Swanson and Jeffers, 2000).

Henshaw et al. also hypothesize that ac electric fields at the surface of power line conductors lead to increased charges on particles, and thereby increase the likelihood that inhaled particles, including radon daughters, would be deposited on surfaces inside the lung or airways, even at considerable distances from the line. Air contains particles of various sizes, including aerosols[4] from emissions from cars and trucks and manufacturing, as well as natural sources such as radon from soil, rock, and building materials. If, as hypothesized, charges on the aerosol particles were increased, and if this change were to increase deposition in the lungs when inhaled over long periods of time, in theory these events could lead to increases in respiratory disease, and possibly other diseases.

The physical basis for aspects of these hypotheses is reasonable. However, the other steps of the hypothesis are highly speculative, and the idea that power lines could substantially affect human exposure to airborne particles or lead to adverse health effects is unwarranted (Swanson and Jeffers, 2000).

The National Radiological Protection Board (NRPB) of Great Britain considered the hypotheses and data published by Fews et al. regarding aerosol deposition increased by electric fields (1999a) and exposure to corona ions from power lines (1999b). The NRPB report (2001) concluded:

> The physical principles for enhanced aerosol deposition in large electric fields are well understood. However, it has not been demonstrated that any such enhanced deposition will increase human exposure in a way that will result in adverse health effects to the general public (NRPB, 2001: 23).

## 2.5 Recent Reviews by Scientific Advisory Groups

Reviews of the scientific research regarding EMF and health by the Health Council of the Netherlands (HCN) were published in 2000 and updated in May 2001. The Institute of Electrical Engineers of Great

---

[3] Radon daughters refers to the radioactive decay products of radon ($^{222}Rn$).
[4] An aerosol is a relatively stable suspension of solid particles or liquid droplets in a gaseous medium.

Britain (IEE) published a review in 2000. The NRPB Advisory Group on Non-Ionising Radiation (AGNIR) published the most recent review in 2001. That review includes research published in 2000, and includes the most comprehensive discussion of the individual research studies. The International Agency for Research on Cancer (IARC) evaluated health effects of EMF and released a statement regarding their findings in June 2001.

### 2.5.1 National Radiological Protection Board of Great Britain (NRPB) Advisory Group on Non-Ionising Radiation

The conclusions from the report prepared by the NRPB's Advisory Group on Non-Ionising Radiation (AGNIR) on ELF-EMF and the risk of cancer are consistent with previous reviews. Members from universities, medical schools, and cancer research institutes reviewed the reports of experimental and epidemiological studies, including reports in the literature in 2000. Their general conclusions are as follows:

> Laboratory experiments have provided no good evidence that extremely low frequency electromagnetic fields are capable of producing cancer, nor do human epidemiological studies suggest that they cause cancer in general. There is, however, some epidemiological evidence that prolonged exposure to higher levels of power frequency magnetic fields is associated with a small risk of leukaemia in children. In practice, such levels of exposure are seldom encountered by the general public in the UK [or in the U.S.] (NRPB, 2001: 164).

The group further recognizes that the scientific evidence suggesting that exposure to power-frequency electromagnetic fields poses an increased risk of cancer is very weak. Virtually all of the cellular, animal and human laboratory evidence provides no support for an increased risk of cancer incidence following such exposure to power frequencies, although sporadic positive findings have been reported. In addition, the epidemiological evidence is, at best, weak.

These conclusions of the Advisory Group are consistent with previous reviews by the NIEHS (1999) and the Health Council of the Netherlands (HCN, 2000). The NRPB response to the Advisory Group report states that "the review of experimental studies by [the Advisory Group] AGNIR gives no clear support for a causal relationship between exposure to ELF-EMFs and cancer" (NRPB, 2001: 1).

### 2.5.2 Health Council of the Netherlands (HCN)

The Health Council of the Netherlands has prepared updates of its 1992 Advisory Report on exposure to electromagnetic fields (0 Hz to 10 MHz) (HCN, 2000; 2001). Members of the Expert Committee who prepared the report include specialists in physics, biology, and epidemiology. The Expert Committee based its analysis on the review and summaries of the studies provided in the NIEHS (1998) and concurred with the views of the director of the NIEHS (1999). For the update, the Committee evaluated a number of publications that appeared after these reports, e.g., McBride et al., (1999) and Green et al. (1999a), and wrote:

> The committee thinks that the quality of the relevant epidemiological research has improved considerably since the publication of the advisory report in 1992. Even so, this research has not resulted in unequivocal, scientifically reliable conclusions (HCN, 2000: 15).

The Council emphasizes that the associations with EMF reported in epidemiologic studies are strictly statistical and do not demonstrate a cause-and-effect relationship. In their view, experimental research does not demonstrate a causal link or a mechanism to explain EMF as a cause of disease in humans. They concluded that there is no reason to recommend measures to limit residence near overhead power lines (HCN, 2000).

The 2001 update (HCN, 2001) includes three major studies (described above) published in 2000 and 2001 (Ahlbom et al., 2000; Greenland et al., 2000; Wartenberg 2001b). The Council concludes:

> Because the association is only weak and without a reasonable biological explanation, it is not unlikely that [an association between ELF exposure and childhood leukemia] could also be explained by chance . . . . The committee therefore sees no reason to modify its earlier conclusion that the association is not likely to be indicative of a causal relationship (HCN, 2001: 40).

### 2.5.3 Institution of Electrical Engineers (IEE) of Great Britain

One of the recent reviews was that of the Institution of Electrical Engineers (IEE) of Great Britain (IEE, 2000). In 1992, the IEE set up a Working Party whose eight members, with broad expertise in the health sciences, review the relevant scientific literature and prepare reports of their views. Their conclusion is based on recent major epidemiologic studies and the scientific literature built up over the past 20 years. In May 2000, the Working Party concluded " . . . that there is still not convincing scientific evidence showing harmful effects of low level electromagnetic fields on humans" (IEE, 2000:1).

### 2.5.4 International Agency for Research on Cancer (IARC)

The International Agency for Research on Cancer sponsored a review of EMF research by a Working Group of scientific experts from 10 countries. This multidisciplinary group reviewed health effects of ELF-EMF. Although their monograph is still in preparation, IARC has released a summary of the Group's conclusions. The Working Group concluded that the epidemiologic studies do not provide support for an association between childhood leukemia and residential magnetic fields at intensities less than 4 mG. IARC reviewers also evaluated the animal data and concluded that it was "inadequate" to support a risk for cancer. Their summary states that the EMF data does not merit the category "carcinogenic to humans" or the category "probably carcinogenic to humans," nor did they find that "the agent is probably not carcinogenic to humans" (IARC, 2001).

## 2.6 Summary

The results of the latest epidemiologic studies of childhood cancer do not provide convincing evidence to support the hypothesis that exposure to magnetic fields or power lines near the home are a cause of leukemia in children. The larger, more reliable, residential studies do not support the idea that fields in the residence contribute to the risk of cancer in adults. Although epidemiology studies provide evidence most relevant to humans, the results may include uncertainties because they are observational rather than experimental. For this reason, laboratory studies can provide important complementary information. The larger and more thorough animal studies that exposed animals for EMF for their entire lifespan show no increases in cancer or other adverse health effects, including reproduction outcomes, in exposed animals.

# 3.0 Ecological Research

Scientists have studied the effects of high-voltage transmission lines on many plant and animal species in the natural environment. In this section, the research on the effects of EMF on ecological systems to assess the likelihood of adverse impacts was briefly reviewed. In addition to the comprehensive review of research on this topic by wildlife biologists at BPA (Lee et al., 1996), a search of the published scientific literature for more recent studies published between 1995 and June 2001 was conducted.

## 3.1 Fauna

The habitat on the transmission-line right-of-way and surrounding area shields most wildlife from electric fields. Vegetation in the form of grasses, shrubs, and small trees largely shields small ground-dwelling species such as mice, rabbits, foxes, and snakes from electric fields. Species that live underground, such as moles, woodchucks, and worms, are further shielded from electric fields by the soil. Hence, large species such as deer and domestic livestock (e.g., sheep and cattle) have greater potential exposures to electric fields since they can stand taller than surrounding vegetation. However, the duration of exposure for deer and other large animals is likely to be limited to foraging bouts or the time it takes them to cross under the line. Furthermore, all species would be exposed to higher magnetic fields under a transmission line than elsewhere, as the vegetation and soil do not provide shielding from this aspect of the transmission-line electrical environment.

Field studies have been performed in which the behavior of large mammals in the vicinity of high-voltage transmission lines was monitored. No effects of electric or magnetic fields were evident in two studies from the northern United States on big game species, such as deer and elk, exposed to a 500-kilovolt (kV) transmission line (Goodwin 1975; Picton et al., 1985). In such studies, a possible confounding factor is audible noise. Audible noise associated with high-voltage power transmission lines (with voltages greater than 110-kV) is due to corona. Audible noise generated by transmission lines reaches its highest levels in inclement weather (rain or snow).

Much larger populations of animals that might spend time near a transmission line are livestock that graze under or near transmission lines. To provide a more sensitive and reliable test for adverse effects than informal observation, scientists have studied animals continuously exposed to fields from the lines in relatively controlled conditions. For example, grazing animals such as cows and sheep have been exposed to high-voltage transmission lines and their reproductive performance examined (Lee et al., 1996). No adverse effects were found among cattle exposed over one or more successive breedings to a 500-kV direct-current overhead transmission line (Angell et al., 1990). Compared to unexposed animals in a similar environment, the exposure to 50-Hz fields did not affect reproductive functions or pregnancy of cows (Algers and Hennichs, 1985; Algers and Hultgren, 1987).

A group of investigators from Oregon State University, Portland State University, and other academic centers evaluated the effects of long-term exposure to EMF from a 500-kV transmission line operated by BPA on various cellular aspects of immune response, including the production of proteins by leukocytes (IL-1 and IL-2) of sheep. In previous unpublished reports, the researchers found differences in IL-1 activity between exposed and control groups. However, in their most recent replication, the authors found no evidence of differences in these measures of immune function. The sheep were exposed to 27 months of continuous exposure to EMF, a period of exposure much greater than the short, intermittent exposures that sheep would incur grazing under transmission lines. Mean exposures of EMF were 3.5-3.8 µT (35-38 mG) and 5.2-5.8 kV/m, respectively (Hefeneider et al., 2001).

Scientists from the Illinois Institute of Technology (IIT) monitored the possible effects of electric and magnetic fields on fauna and flora in Michigan and Wisconsin from 1969 – 1997 to evaluate the effects of an above-ground, military-communications antenna operating at 76 Hz. The antenna produces EMF similar in physical characteristics to those produced by high-voltage transmission lines, but of much lower intensity. This study, which included embryonic development, fertility, postnatal growth, maturation, aerobic metabolism, and homing behavior, showed no adverse impacts of ELF electric and magnetic fields on the animals (NRC, 1997).

The hormone melatonin, secreted at night by the pineal gland, plays a role in animals that are seasonal breeders. Studies in laboratory mice and rats have suggested that exposure to electric and/or magnetic fields might affect levels of the hormone melatonin, but results have not been consistent (Wilson et al., 1981; Holmberg, 1995; Kroeker et al., 1996; Vollrath et al., 1997; Huuskonen et al., 2001). However, when researchers examined sheep and cattle exposed to EMF from transmission lines exceeding 500-kV, they found no effect on the levels of the hormone melatonin in blood, weight gain, onset of puberty, or behavior in sheep and cattle (Stormshak et al., 1992; Lee et al., 1993; Lee et al., 1995; Thompson et al., 1995; Burchard et al., 1998).

Another part of the IIT study examined the effect of the antenna system fields on the growth, development, and homing behavior of birds. Studies of embryonic development (Beaver et al., 1993), fertility, postnatal growth, maturation, aerobic metabolism, and homing behavior showed no adverse impacts of ELF electric and magnetic fields on the animals (NRC, 1997). Fernie and colleagues studied the effects of continuous EMF exposure of raptors to an electric field of 10 kV/m in a controlled, laboratory setting. The exposure was designed to mimic exposure to a 765-kV transmission line. Continuous EMF exposure was found to reduce hatching success and increase egg size, fledging success, and embryonic development (Fernie et al., 2000). In a study of the effects on body mass and food intake of reproducing falcons, the authors found that EMF lengthened the photoperiod as a result of altered melatonin levels in the male species, yet concluded that "EMF effects on adult birds may only occur after continuous, extended exposure," which is not likely to occur from resting on power lines (Fernie and Bird, 1999:620).

Several avian species are reported to use the earth's magnetic field as one of the cues for navigation. It has been proposed that deposits of magnetite in specialized cells in the head are the mechanism by which the birds can detect variations in the inclination and intensity of a direct-current (dc) magnetic field (Kirschvink and Gould, 1981; Walcott et al., 1988). In early studies of transmission lines, it was reported that the migratory patterns of birds appeared to be altered near transmission lines (Southern, 1975; Larkin and Sutherland, 1977). However, these studies were of crude design, and Lee et al. (1996) concluded that, "During migration, birds must routinely fly over probably hundreds (or thousands) of electrical transmission and distribution lines. We are not aware of any evidence to suggest that such lines are disrupting migratory flights" (Lee et al., 1996:4-59). No further studies on this topic were identified in the literature.

Bees, like birds, are able to detect the earth's dc magnetic fields. They are known to use magnetite particles, which are contained in an abdominal organ, as a compass (Kirschvink and Gould, 1981). In the laboratory, they are able to discriminate between a localized magnetic anomaly and a uniform background dc magnetic field (Walker et al., 1982; Kirschvink et al., 1992).

Greenberg et al. (1981) studied honeybee colonies placed near 765-kV transmission lines. They found that hives exposed to electric fields of 7 kV/m had decreased hive weight, abnormal amounts of propolis (a resinous material) at hive entrances, increased mortality and irritability, loss of the queen in some hives, and a decrease in the hive's overall survival compared to hives that were not exposed. Exposure to electric fields of 7-12 kV/m may induce a current or heat the interior of the hive; however, placing the hive farther from the line, shielding the hive, or using hives without metallic parts eliminates this problem. ITT studied the effects of EMF on bees exposed to the 76-Hz antenna system at lower intensities and concluded that these behavioral effects of "ELF-EMF impacts are absent or at most minimal" (NRC, 1997:102).

Reptiles and amphibians contribute to the overall functioning of the forest ecosystems. However, little research has been performed on the effects of EMF on reptiles and amphibians in their natural habitat.

## 3.2 Flora

Numerous studies have been carried out to assess the effect of exposure of plants to transmission-line electric and magnetic fields. These studies have involved both forest species and agriculture crops. Researchers have found no adverse effects on plant responses, including seed germination, seedling emergence, seedling growth, leaf area per plant, flowering, seed production, germination of the seeds, longevity, and biomass production (Lee et al., 1996).

The only confirmed adverse effect of transmission lines on plants was reported for transmission lines with voltages above 1200 kV. For example, Douglas Fir trees planted within 15 m of the conductors were shorter than trees planted away from the line. Shorter trees are believed to result from corona-induced damage to the branch tips. Trees between 15 and 30 m away from the line suffered needle burns, but those 30 m and beyond were not affected (Rogers et al., 1984). These effects would not occur at the lower field intensities expected beyond the right-of-way of the proposed 500-kV transmission line.

## 3.3 Summary

The habitat on the transmission-line rights-of-way and surrounding areas shields smaller animals from electric fields produced by high-voltage transmission lines; thus, vegetation easily shields small animals from electric fields. The greatest potential for larger animals to be exposed to EMF occurs when they are passing beneath the lines. Studies of animal reproductive performance, behavior, melatonin production, immune function, and navigation have found minimal or no effects of EMF. Past studies have found little effect of EMF on plants; no recent studies of plants growing near transmission lines have been performed. In summary, the literature published to date has shown little evidence of adverse effects of EMF from high-voltage transmission lines on wildlife and plants. At the field intensities associated with the proposed 500-kV transmission line, no adverse effects on wildlife or plants are expected.

## List of References

Ahlbom, A.; Day, N.; Feychting, M.; Roman, E.; Skinner, J.; Dockerty, J.; Linet, M.; Michealis, J.; Olsen, J.H.; Tynes, T.; Verasalo, P.K. 2000. A pooled analysis of magnetic fields and childhood leukaemia. British Journal of Cancer, 83(5):692-698.

Algers, B.; and Hennichs, K. 1985. The effect of exposure to 400-kV transmission lines on the fertility of cows: a retrospective cohort study. Preventive Veterinary Medicine, 3:351-361.

Algers, B.; and Hultgren, J. 1987. Effects of long-term exposure to a 400-kV, 50-Hz transmission line on estrous and fertility in cows. Preventive Veterinary Medicine, 5:21-36.

Anderson, L.E.; Morris, J.E.; Miller, D.L.; Rafferty, C.N.; Ebi, K.L.; Sasser, L.B. 2001. Large granular lymphocytic (LGL) leukemia in rats exposed to intermittent 60 Hz magnetic fields. Bioelectromagnetics, 22:185-193.

Angell, R.F.; Schott, M.R.; Raleigh, R.J.; Bracken, T.D. 1990. Effects of a high-voltage direct-current transmission line on beef cattle production. Bioelectromagnetics, 11(4):273-82.

Balcer-Kubiczek, E.K.; Harrison, G.H.; Davis, C.C.; Haas, M.L.; Koffman, B.H. 2000. Expression analysis of human HL60 exposed to 60 Hz square or sine-wave magnetic fields. Radiation Research, 153(5):670-678.

Beaver, D.L.; Hill, R.W.; Lederle, P.E. 1993. Assessment of the effects of extremely low frequency electromagnetic radiation on growth and maturation in nestling tree swallows and deer mice. Electricity and Magnetism in Biology and Medicine. M. Blank, ed., San Francisco Press, Inc., pp. 925-926.

Belanger, K.; Leaderer, B.; Hellenbrand, K.; Holford, T.R.; McSharry, J.; Power, M.E.; Bracken, M.B. 1998. Spontaneous abortion and exposure to electric blankets and heated water beds. Epidemiology, 9:36-42.

Boorman, G.A.; Anderson, L.E.; Morris, J.E.; Sasser, L.B.; Mann, P.C.; Grumbein, S.L.; Hailey, J.R.; McNally, A.; Sills, R.C.; Haseman, J.K. 1999. Effects of 26-week magnetic field exposure in a DMBA initiation-promotion mammary glands model in Sprague-Dawley rats. Carcinogenesis, 20:899-904.

Boorman, G.A.; McCormick, D.J.; Ward, J.M.; Haseman, J.K.; Sills, R.C. 2000a. Magnetic fields and mammary cancer in rodents: A critical review and evaluation of published literature. Radiation Research, 153(5), Part 2:617.

Boorman, G.A.; Rafferty, C.N.; Ward, J.M.; Sills, R.C. 2000b. Leukemia and lymphoma incidence in rodents exposed to low-frequency magnetic fields. Radiation Research, 153(5), Part 2:627.

Bracken, M.B.; Belanger, K.; Hellenbrand, K.; Dlugosz, L.; Holford, T.R.; McSharry, J.E.; Addesso, K.; Leaderer, B. 1995. Exposure to electromagnetic fields during pregnancy with emphasis on electrically heated beds: association with birth weight and intrauterine growth retardation. Epidemiology, 6(3):263-270.

Burchard, J.F.; Nguyen, D.H.; Block, E. 1998. Effects of electric and magnetic fields on nocturnal melatonin concentrations in dairy cows. Journal of Dairy Science, 81(3):722-7.

Erren, T.C. 2001. A meta-analysis of epidemiological studies of electric and magnetic fields and breast cancer in women and men. Bioelectromagnetics Supplement, 5:S105-S119.

Fernie, K.J.; and Bird, D.M. 1999. Effects of electromagnetic fields on body mass and food-intake of American kestrels. The Condor, 101:616-621.

Fernie, K.J.; Bird, D.M.; Dawson, R.D.; Lague, P.C. 2000. Effects of electromagnetic fields on the reproductive success of American kestrels. Physiological Biochemistry and Zoology, 73(1):60-5.

Fews, A.P.; Henshaw, D.L.; Wilding, R.L.; Keitch, P.A. 1999a. Increased exposure to pollutant aerosols under high voltage power lines. International Journal of Radiation Biology, 75: 1505-1521.

Fews, A.P.; Henshaw, D.L.; Wilding, R.L.; Keitch, P.A. 1999b. Corona ions from power lines and increased exposure to pollutant aerosols. International Journal of Radiation Biology, 75:1523-31.

Gammon, M.D.; Schoenberg, J.B.; Britton, J.A.; Kelsey, J.L.; Stanford, J.L.; Malone, K.E.; Coates, R.J.; Brogan, D.J.; Potischman, N.; Swanson, C.A.; Brinton, L.A. 1998. Electric blanket use and breast cancer risk among younger women. American Journal of Epidemiology, 148:556-63.

Goodwin Jr., J.G. 1975. Big game movement near a 500-kV transmission line in northern Idaho. Bonneville Power Administration, Engineering and Construction Division, Portland, OR. June 27.

Green, L.M.; Miller, A.B.; Villeneuve, P.J.; Agnew, D.A.; Greenberg, M.L.; Li, J.H.; Donnelly, K.E. 1999a. A case control study of childhood leukemia in southern Ontario, Canada, and exposure to magnetic fields in residences. International Journal of Cancer, 82:161-170.

Green, L.M.; Miller, A.B.; Agnew, D.A.; Greenberg, M.L.; Li, J.H.; Villeneuve, P.J.; Tibshirani, R. 1999b. Childhood leukemia and personal monitoring of residential exposures to electric and magnetic fields in Ontario, Canada. Cancer Causes and Control, 10:233-243.

Greenberg, B.; Bindokas, V.P.; Frazier, M.J.; Gauger, J.R. 1981. Response of honey bees, *apis mellifera L.*, to high-voltage transmission lines. Environmental Entomology, 10:600-610.

Greenland, S.; Sheppard, A.; Kelsh, M.; Kuane, W.; Poole, C.; Kelsh, M.A. 2000. Childhood leukemia and power frequency magnetic fields: analysis from pooled data of thirteen epidemiologic studies. Epidemiology, 11:624-634.

HCN (Health Council of the Netherlands). 2000. Report on Exposure to Electromagnetic Fields (0 Hz – 10 MHz). No. 2000/06E.

HCN (Health Council of the Netherlands). 2001. ELF Electromagnetic Fields Committee. Electromagnetic fields: Annual Update 2001. No. 2001/14.

Hefeneider, S.H.; McCoy, S.L.; Hausman, F.A.; Christensen, H.L.; Takahashi, D.; Perrin, N.; Bracken, T.D.; Shin, K.Y.; Hall, A.S. 2001. Long-term effects of 60-Hz electric vs. magnetic fields on IL-1 and IL-2 activity in sheep. Bioelectromagnetics, 22(3):170-177.

Henshaw, D.L.; Ross, A.N.; Fews, A.P.; Preece, A.W. 1996. Enhanced deposition of radon daughter nuclei in the vicinity of power frequency electromagnetic fields. International Journal of Radiation Biology, 69: 25-38.

Holmberg, B. 1995. Magnetic fields and cancer: animal and cellular evidence—an overview. Environmental Health Perspectives, 103 Suppl. 2:63-7.

Huuskonen, H.; Saastamoinen, V.; Komulainen, H.; Laitinen, J.; Juutilainen, J. 2001. Effects of low-frequency magnetic fields on implantation in rats. Reproductive Toxicology, 15(1):49-59.

IARC (International Agency for Research on Cancer). 2001. Press Release: IARC finds limited evidence that residential magnetic fields increase risk of childhood leukaemia. June. Website: http://www.iarc.fr/pageroot/PRELEASES/pr136a.html.

IEE (Institution of Electrical Engineers), Biological Effects Working Party. May 2000. The possible harmful biological effects of low level electromagnetic fields of frequencies up to 300 GHz. IEE Position Statement.

Kirschvink, J.L.; and Gould, J.L. 1981. Biogenic magnetite as a basis for magnetic field detection in animals. Biosystems, 13(3):181-201.

Kirschvink, J.L.; Diaz Ricci, J.; Nesson, M.H.; Kirschvink, S.J. 1992. Magnetite-based magnetoreceptors in animals: structural, behavioral, and biophysical studies. Electric Power Research Institute (EPRI), Report No. TR-102008, Palo Alto, CA. September.

Kroeker, G.; Parkinson, D.; Vriend, J.; Peeling, J. 1996. Neurochemical effects of static magnetic field exposure. Surgical Neurology, 45(1):62-6.

Laden, F.; Neas, L.M.; Tolbert, P.E.; Holmes, M.D.; Hankinson, S.E.; Spiegelman, D.; Speizer, F.E.; Hunter, D.J. 2000. Electric blanket use and breast cancer in the nurses' health study. American Journal of Epidemiology, 152(1):41-49.

Langholz, B. 2001. Factors that explain the power line configuration wiring code - childhood leukemia association: what would they look like? Bioelectromagnetics Supplements, 5:S19-S31.

Larkin, R.P.; and Sutherland, P.J. 1977. Migrating birds respond to Project Seafarer's electromagnetic field. Science, 195(4280):777-9. February 25.

Lee, G.M.; Neutra, R.R.; Hristova, L.; Yost, M.; Hiatt, R.A. 2000. The use of electric bed heaters and the risk of clinically recognized spontaneous abortion. Epidemiology, 11:406-415.

Lee, J.M.; Pierce, K.S.; Spiering, C.A.; Stearns, R.D.; VanGinhoven, G. 1996. Electrical and biological effects of transmission lines: a review. Bonneville Power Administration, Portland, Oregon. December.

Lee, J.M., Stormshak, F., Thompson, J., Hess, D.L., Foster, D.L. 1995. Melatonin and puberty in female lambs exposed to EMF: a replicate study. Bioelectromagnetics, 16(2):119-23

Lee, J., Stormshak, F., Thompson, J., Thinesen, P., Painter, L., Olenchek, B., Hess, D., Forbes, R. 1993. Melatonin secretion and puberty in female lambs exposed to environmental electric and magnetic fields. Biology of Reproduction, 49(4):857-64

Linet, M.S.; Hatch E.H.; Kleinerman, R.A.; Robinson, L.L.; Kaune, W.T.; Friedman, D.R.; Seversch, R.K.; Haines, C.M.; Hartsock, C.T.; Niwa, S.; Wacholder, S.; Tarone, R.E. 1997. Residential exposure to magnetic fields and acute lymphoblastic leukemia in children. New England Journal of Medicine, 337:1-7.

Loberg, L.I.; Engdahl, W.R.; Gauger, J.R.; McCormick, D.L. 2000. Expression of cancer-related genes in human cells exposed to 60 Hz magnetic fields. Radiation Research, 153(5):679-684.

McBride, M.L.; Gallagher, R.P.; Thériault, G.; Armstrong, B.G.; Tamaro, S.; Spinelli, J.J.; Deadman, J.E.; Fincham, S.; Robinson, D.; Choi, W. 1999. Power-frequency electric and magnetic fields and risk of childhood leukemia in Canada. American Journal of Epidemiology, 149:831-842.

McCormick, D.L.; Boorman, G.A.; Findlay, J.C.; Hailey, J.R.; Johnson, T.R.; Gauger, J.R.; Pletcher, J.M.; Sill, R.C.; Haseman, J.K. 1999. Chronic toxicity/oncogenicity evaluation of 60 Hz (power frequency) magnetic fields in B6C3F mice. Toxicologic Pathology, 27:279-285.

Neutra, R.R.; and Del Pizzo, V. 2001. A richer conceptualization of "exposure" for epidemiological studies of the "EMF mixture." Bioelectromagnetics Supplements, 5:S48-S57.

NIEHS (National Institute of Environmental Health Sciences). 1998. Assessment of health effects from exposure to power-line frequency electric and magnetic fields: Working Group Report. NIH Publication No. 98-3981. Research Triangle Park, NC: National Institute of Environmental Health Sciences of the U.S. National Institutes of Health.

NIEHS (National Institute of Environmental Health). 1999. Health effects from exposure to power line frequency electric and magnetic fields. NIH; National Institute of Health; NIH No. 99-4493; Research Triangle Park, NC.

NRC (National Research Council). 1997. An evaluation of the U.S. Navy's extremely low frequency communications system ecological monitoring program. National Academy Press, Washington, D.C.

NRPB (National Radiological Protection Board). 2001. Response statement of the NRPB: ELF electromagnetic fields and the risk of cancer. National Radiological Protection Board, Chilton, Dicot, Oxon, Volume 12, No.1, ISNB 0-859951-456-0.

Picton, H.D., Canfield, J.E., Nelson, G.P. 1985. The impact of a 500-kV transmission line upon the North Boulder Winter Elk Range. U.S. Forest Service Contract 53-0398-30E-3.

Raaschou-Nielsen, O.; Hertel, O.; Thomsen, B.L.; Olsen, J.H. 2001. Air pollution from traffic at the residence of children with cancer. American Journal of Epidemiology, 153(5):433-43.

*Radiation Research*. 2000. (Special Edition Updating RAPID results.) 153(5):637-641. *See entries under Balcer-Kubiczek, Boorman, Loberg, and Ryan.*

Reynolds, P.; Elkin, E.; Scalf, R.; Von Behren, J.; Neutra, R.R. 2001. A case-control pilot study of traffic exposures and early childhood leukemia using a geographic information system. Bioelectromagnetics Supplements, 5:S58-S6.

Rogers, L.E., Beedlow, P.A., Carlile, D.W., Ganok, K.A., Lee, J.M. 1984. Environmental studies of a 1100-kV prototype transmission line: an annual report for the 1984 study period. Prepared by Battelle Pacific Northwest Laboratories for Bonneville Power Administration, Portland, Oregon.

Ryan, B.M.; Polen, M.; Gauger, J.R.; Mallett, E.; Kerns, M.B.; Bryan, T.L.; McCormick, D.L. 2000. Evaluation of the developmental toxicity in Sprague-Dawley rats. Radiation Research, 153(5):637-641.

Ryan, B.M.; Symanski, R.R.; Pomeranz, L.E.; Johnson, T.R.; Gauger, J.R.; McCormick, D.L. 1999. Multi-generation reproduction toxicity assessment of 60-Hz magnetic fields using a continuous breeding protocol in rats. Teratology, 59(3):156-62.

Savitz, D.A., Wachtel, H., Barnes, F.A., John, E.M., and Tvrdik, J.G. 1988. Case-control study of childhood cancer and exposure to 60 Hz magnetic fields. American Journal of Epidemiology, 128**,** 21-38.

Schuz, J.; Grigat, J.P.; Brinkmann, K.; Michaelis, J. 2001. Residential magnetic fields as a risk factor for childhood acute leukaemia: results from a German population-based case-control study. International Journal of Cancer, 91(5): 728-735.

Southern, W.E. 1975. Orientation of gull chicks exposed to project Sanguine's electromagnetic field. Science, 189:143-144.

Stormshak, F.; Bracken, T.D.; Carey, M.; Chartier, V.; Dickson, L.; Forbes, R.; Hall, A.; Havens, P.; Hess, D.; Krippaehne, S.; Lee, J.; Ogden, B.; Olenchek, B.; Painter, L.; Rowe, K.; Stearns, R.; Thinesen, P.; Thompson, J. 1992. Joint HVAC transmission EMF environmental study: final report on experiment 1. Bonneville Power Administration, Contract # DE-B179-90BPO4293, Portland, OR, May.

Swanson, J.; and Jeffers, D.E. 2000. Comments on the paper "Increased exposure to pollutant aerosols under high voltage power lines". International Journal of Radiation Biology, 76(12): 1685-91.

Thompson, J.M.; Stormshak, F.; Lee, J.M.; Hess, D.; Painter, L. 1995. Cortisol secretion and growth in ewe lambs chronically exposed to electric and magnetic fields of a 60-Hertz 500-kilovolt AC transmission line. Journal of Animal Science, 73(11):3274-80

UKCCS (United Kingdom Childhood Cancer Study Investigators). 1999. Exposure to power frequency magnetic fields and the risk of childhood cancer. The Lancet, 353(9194):1925-31.

UKCCS (United Kingdom Childhood Cancer Study Investigators). 2000. Childhood cancer and residential proximity to power lines. British Journal of Cancer, 83:1573-80.

Vollrath, L.; Spessert, R.; Kratzsch, T.; Keiner, M.; Hollmann, H. 1997. No short-term effects of high-frequency electromagnetic fields on the mammalian pineal gland. Bioelectromagnetics, 18(5):376-87.

Walcott, C.; Gould, J.L.; Lednor, A.J. 1988. Homing of magnetized and demagnetized pigeons. Journal of Experimental Biology, 134:27-41.

Walker, C.E.; Seitelman, D.L.; McElhaney, J.H.; Mullen, S.P.; Hagadorn, B.; Seto, Y.J. 1982. Effects of high-intensity 60-Hz fields on bone growth. Journal of Bioelectricity, 1(3):339-349.

Wartenberg, D. 2001a. The potential impact of bias in studies of residential exposure to magnetic fields and childhood leukemia. Bioelectromagnetics Supplements, 5:S32-S47.

Wartenberg, D. 2001b. Residential EMF exposure and childhood leukemia: Meta-analysis and population attributable risk. Bioelectromagnetics Supplements, 5:S86-S104.

Wilson, B.W.; Anderson, L.E.; Hilton, D.I.; Phillips, R.D. 1981. Chronic exposure to 60-Hz electric fields: effects on pineal function in the rat. Bioelectromagnetics, 2(4):371-80.

Wrensch, M.; Yost, M.; Miike, R.; Lee, G.; Touchstone, J. 1999. Adult glioma in relation to residential power frequency electromagnetic field exposures in the San Francisco Bay Area. Epidemiology, 10:523-527.

Zaffanella, L.E. 1993. Survey of residential magnetic field sources. Vol. 1: Goals, results, and conclusions. (EPRI TR-102759-V1, Project 3335-02). Electric Power Research Institute, Palo Alto, CA.

Zheng, T.Z.; Holford, T.R.; Mayne, S.T.; Owens, P.H.; Zhang, B.; Boyle, P.; Carter, D.; Ward, Y.W.; Zahm, S.H. 2000. Exposure to electromagnetic fields from use of electric blankets and other in-home electrical appliances and breast cancer risk. American Journal of Epidemiology, 151(11):1103-11.

## List of Preparers

**Linda S. Erdreich, Ph.D.**, is a Managing Scientist in the Health Group at Exponent. She received her Ph.D. in Epidemiology and an M.S. in Biostatistics and Epidemiology from The University of Oklahoma Health Sciences Center. Dr. Erdreich is an epidemiologist with specific expertise in biological and health research related to non-ionizing radiation, both radiofrequency and power-frequency fields. Formerly, she was Acting Section Chief and Group Leader of the Methods Evaluation and Development Staff at the U.S. Environmental Protection Agency (EPA) and Senior Epidemiologist of the Environmental Criteria and Assessment Office at the EPA. While at the EPA, she developed methods in quantitative health risk assessment, coordinated the drafting of federal guidelines, and participated in science policy decisions. Both in government and private industry, she has provided rigorous evaluations of the impact on public health or occupational health of a variety of chemicals, therapeutic drugs, and physical agents, including electric and magnetic fields. As a member of the Institute of Electrical and Electronics Engineers (IEEE) Standards Coordinating Committees on Non-Ionizing Radiation, Dr. Erdreich is chairman of a working group to evaluate epidemiologic data on radiofrequency exposures (3 kHz–300 Ghz). She has been appointed as a member of the Committee on Man and Radiation (COMAR) of the IEEE's *Engineering in Biology and Medicine Society*. Dr. Erdreich serves as Adjunct Associate Professor at the University of Medicine & Dentistry of New Jersey.

**William H. Bailey, Ph.D.,** is a Principal Scientist and manages the Health Group scientists in Exponent's New York office. Before joining Exponent, Dr. Bailey was President of Bailey Research Associates, Inc., the oldest research and consulting firm with specialized expertise in electro-magnetic fields and health. Dr. Bailey specializes in applying state-of-the-art assessment methods to environmental health and impact issues. His 30 years of training and experience include laboratory and epidemiologic research, health risk assessment, and comprehensive exposure analysis. Dr. Bailey is particularly well known for his research on potential health effects of electromagnetic fields and is active in setting IEEE standards for human exposure to electromagnetic fields. He uses advanced analytical and statistical methods in the design and analysis of both experimental studies and epidemiology and survey research studies. In addition, Dr. Bailey's postgraduate training in the social, economic, and behavioral sciences is helpful in assessing the important effects of social, economic, and community factors on health risks and vulnerability to environmental impacts in health and environmental justice research. He is a member of a working group that advises a committee of the World Health Organization on risk assessment, perception, and communication. Dr. Bailey is also a visiting scientist at the Cornell University Medical College. He was formerly Head of the Laboratory of Neuropharmacology and Environmental Toxicology at the New York State Institute for Basic Research, Staten Island, New York, and an Assistant Professor and NIH postdoctoral fellow in Neurochemistry at The Rockefeller University in New York.

**Maria DeJoseph, M.S.,** is an Epidemiologist in Exponent's Health Group and is based in New York, New York. Ms. DeJoseph has a background in epidemiology and biological sciences. She served as the primary investigator for a case-control epidemiologic study of her design to investigate a mediastinitis outbreak in cardiothoracic surgery patients. Ms. De Joseph also has recruited and interviewed subjects, and analyzed hormone levels for an epidemiologic breast cancer study. She has conducted phytochemical analyses of medicinal plants, including the isolation and fractionation of tropical plants used medicinally by indigenous peoples and primates of Central and South America. Ms. DeJoseph has served as an ethnobotanical and zoopharmacological field researcher in Mexico, Costa Rica, and Venezuela. She has used a variety of methods to identify chemical and prospective pharmaceutical compounds, including HPLC, column chromatography, anti-microbial assays, gas chromatography mass spectrometry (GC-MS), and nuclear magnetic resonance spectroscopy (NMR). Before joining Exponent, Ms. DeJoseph was a Research Assistant in the Medical School, Division of Epidemiology at Stanford University.

*This page intentionally left blank.*

# ***McNARY – JOHN DAY TRANSMISSION-LINE PROJECT***

# *ASSESSMENT OF RESEARCH REGARDING EMF AND HEALTH AND ENVIRONMENTAL EFFECTS*

January, 2002


**Prepared by**

Exponent™

**and**

**T. Dan Bracken, Inc.**

**for**

**Bonneville Power Administration**

# Table of Contents

# ASSESSMENT OF RESEARCH REGARDING EMF AND HEALTH AND ENVIRONMENTAL EFFECTS

## 1.0 Introduction

Over the last 20 years, research has been conducted in the United States and around the world to examine whether exposures to electric and magnetic fields (EMF) at 50/60 Hertz (Hz) from electric power lines are a cause of cancer or adversely affect human health. The research included epidemiology studies that suggested a link with childhood leukemia for some types of exposures, as well as other epidemiology studies that did not; it also included lifetime animal studies, which showed no evidence of adverse health effects. Comprehensive reviews of the research conducted by governmental and scientific agencies in the U.S. and in the United Kingdom (UK) had examined the research, and did not find a basis for imposing additional restrictions (NIEHS, 1999; IEE, 2000).

The Bonneville Power Administration (BPA) requested that Exponent update the BPA on research on EMF and health in relation to exposures that might occur near the McNary – John Day Transmission Line Project. This update concentrates on recent major research studies to explain how they contribute to the assessment of effects of EMF on health (Section 2). The focus is on both epidemiologic and laboratory research, because these research approaches provide different and complementary information for determining whether an environmental exposure can affect human health. Section 3, Ecological Research, reviews studies of potential effects of EMF on plants and animals in the natural environment. This update includes studies of residential or environmental exposures to EMF and health effects that became available in 2001 (through November).

## 2.0 Health

### 2.1 The NIEHS Report and Research Program

In 1998, the NIEHS completed a comprehensive review of the scientific research on health effects of EMF. The NIEHS had been managing a research program that Congress funded in 1992 in response to questions regarding exposure to EMF from power sources. The program was known as the RAPID Program (Research and Public Information Dissemination Program). The NIEHS convened a panel of scientists (the "Working Group") to review and evaluate the RAPID Program research and other research. Their report, *Assessment of Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields,* was completed in July 1998 (NIEHS, 1998).

The director of the NIEHS prepared a health risk assessment of EMF and submitted his report to Congress in June 1999 (NIEHS, 1999). Experts at NIEHS, who had considered the previous Working Group report, reports from four technical workshops, and research that became available after June 1998, concluded as follows:

> The scientific evidence suggesting that ELF-EMF [extremely low frequency-electric and magnetic field] exposures pose any health risk is weak. The strongest evidence for health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and chronic lymphocytic leukemia in occupationally exposed

> adults. . . . In contrast, the mechanistic studies and animal toxicology literature fail to demonstrate any consistent pattern. . . . No indication of increased leukemias in experimental animals has been observed. . . . The lack of consistent, positive findings in animal or mechanistic studies weakens the belief that this association is actually due to ELF-EMF, but it cannot completely discount the epidemiology findings. . . . The NIEHS does not believe that other cancers or other non-cancer health outcomes provide sufficient evidence of a risk to currently warrant concern (NIEHS, 1999: 9-10).

Although the results of the RAPID research are described in some detail in the 1998 report, many of the studies had not been published in the peer-reviewed literature. Recognizing the need to have these results reviewed and considered for publication, the NIEHS arranged for a special edition of the journal *Radiation Research* (Radiation Research, 153[5], 2000) to be devoted to this topic.[1]

## 2.2 Update of Research Related to Cancer

This update includes studies of residential or occupational exposures to EMF and leukemia that became available through November 2001, including several epidemiology studies of childhood cancer and meta-analyses. The California Department of Health Services (CDHS) conducted a workshop in 1999 to discuss epidemiologic research on EMF and health. The reports presented at this workshop were published in January 2001 as a supplement to the journal, *Bioelectromagnetics*. Many of the papers were technical discussions of methodology issues in epidemiologic studies of EMF, including discussions of how to better understand the conflicting results reported in previous studies (Neutra and Del Pizzo, 2001). For example, one study evaluates the extent to which systematic errors (known in epidemiology as selection bias or information bias) occurred in EMF studies, and if those errors occurred, whether the effect on results could be evaluated (Wartenberg, 2001a). Other researchers discuss epidemiologic approaches to study how possible confounding factors, such as the age and type of home and traffic density, might affect the interpretation of studies of EMF and childhood cancer (Langholz, 2001; Reynolds et al., 2001).

For this update, we reviewed epidemiology and laboratory studies of cancer and reproduction. Several of the studies are "meta-analyses," an approach that incorporates statistical methods to analyze differences among studies and aggregate the results of smaller studies. The sections below include a review of meta-analyses of the studies of childhood leukemia, and a meta-analysis of studies of breast cancer in adults (Erren, 2001).

### 2.2.1 Epidemiology Studies of Children

The question of power lines and childhood cancer has been based on the assumption that the relevant exposure associated with power lines is the magnetic field, rather than the electric field. This assumption rests on the fact that electric fields are shielded from the interior of homes (where people spend the vast majority of their time) by walls and vegetation, while magnetic fields are not. The magnetic field in the vicinity of a power line results from the flow of current; higher currents result in higher levels of magnetic fields.

Epidemiologic studies report results in the form of statistical associations. The term "statistical association" is used to describe the tendency of two things to be linked or to vary in the same way, such

[1] See, for instance, the articles cited in the **List of References** under Balcer-Kubiczek, Boorman, Loberg, and Ryan.

as level of exposure and occurrence of disease. However, statistical associations are not automatically an indication of cause and effect, because the interpretation of numerical information depends on the context, including (for example) the nature of what is being studied, the source of the data, how the data were collected, and the size of the study. The larger studies and more powerful studies of EMF have not reported convincing statistical associations between power lines and childhood leukemia (e.g., Linet et al., 1997; McBride et al., 1999; UKCCS, 1999). Despite the larger sample size, these studies usually had a limited number of cases exposed over 2 or 3 milligauss (mG).

*Epidemiology Studies*

The following discussion briefly describes major studies.

- A study from Germany included 514 children with leukemia and 1,301 control children (Schuz et al., 2001). Measurements of magnetic-field intensity (50 Hz) were taken for 24 hours in each child's bedroom. The results were calculated separately for daytime or nighttime levels in the bedroom, rather than for a child's overall 24-hour exposure. The authors report an association with leukemia for mean daytime magnetic-field exposures that might have been due to chance. They reported an association between mean nighttime magnetic-field levels and leukemia for the highest exposed group (4 mG or higher; 9 cases). The assessment of exposure by mean field levels in the bedroom did not link magnetic-field levels to any specific source. The authors note in their conclusions that " . . . fewer than one-third of all stronger magnetic fields were caused by high-voltage powerlines . . . . " (Schuz et al., 2001:734).

  Several aspects of the study detract from the validity of the results: the estimate included a broad margin of error because only a small number of cases was exposed at the higher levels, and many eligible cases and controls did not participate, which means that the responders may not represent the population and results could be biased. Another concern is that these magnetic-field measurements were taken in 1997, long after the relevant exposure period for cases diagnosed in 1990-1994. Magnetic-field levels may have changed over time, as electricity usage changed.

- A study from British Columbia, Canada, included 462 children who had been diagnosed with leukemia and an equal number of children without leukemia for comparison (McBride et al., 1999). Magnetic-field exposure was assessed for each of the children in several ways: personal monitors were worn in a backpack for 48 hours, a monitor took measurements in the bedroom for 24 hours, the wiring outside the house was rated by potential exposure level (wire codes), and measurements were taken around the outside perimeter of the homes. (Wire codes are a method of estimating relative exposure intensity based on the configuration of the power lines.) Regardless of the method used to estimate magnetic-field exposure, the magnetic-field exposure of children who had leukemia was not greater than that of the children in the comparison group.

- A study conducted in Ontario, Canada reported on the magnetic-field exposure of a smaller group of children than in other recent studies (Green et al., 1999a). No increased risk estimates were found with the average magnetic fields in the bedroom or the interior, or with any of the three methods of estimating exposure from wire-configuration codes. A still smaller group of 88 children with leukemia and their controls wore personal monitors to measure magnetic fields (Green et al., 1999b). Associations with magnetic fields were reported in some of the analyses, but most of the risk estimates had a broad margin of error, and major methodological problems in the study preclude any clear interpretation of the findings.

- The United Kingdom Childhood Cancer Study, the largest study to date, included a total of 1073 childhood leukemia cases (UKCCS, 1999). Exposure was assessed by spot measurements in the home (bedroom and family room) and school, and summarized by averaging these over time. No evidence was found to support the idea of an increased risk of leukemia from exposures to magnetic fields inside or outside of the home.

- The UKCCS investigators had obtained magnetic-field measurements on only a portion of the childhood cancer cases in their study (UKCCS, 1999). To obtain additional information, they used a method to assess exposure to magnetic fields without entering homes; they were thus able to analyze 1331 child leukemia cases (UKCCS, 2000). For these children, they measured distances to power lines and substations. This information was used to calculate the magnetic field from these external field sources, based on power-line characteristics related to production of magnetic fields. The results of the second UKCCS study showed no evidence for an association with leukemia for magnetic fields calculated to be between 1 mG and 2 mG, 2 mG and 4 mG, or 4 mG or greater at the residence, in contrast to the weak association reported for measured fields of 4 mG or greater in the first report (UKCCS, 1999).

Researchers have proposed that the associations that are sometimes reported between childhood leukemia and power lines might be due to other factors that can confound (other risk factors for disease that may distort the analysis) the analysis. One example is heavy traffic, which may occur near power lines and which can increase the levels of potentially carcinogenic chemicals in the area. Earlier studies had reported associations between traffic density and childhood cancer (Savitz et al., 1988). If power lines were more common in areas that had higher traffic density, then the increased air pollution might explain an association between power lines and childhood cancer. However, more recent studies seem to eliminate this possibility. In a study of 90 cases of childhood leukemia, Reynolds et al. (2001) found no evidence of an association with traffic density. In a larger study that included 986 cases of childhood leukemia, no association was found with high traffic-density exposure during pregnancy or childhood (Raaschou-Nielsen et al., 2001).

*Meta-analyses of Studies of Leukemia*

Recently, researchers re-analyzed the data from previous epidemiology studies of magnetic fields and childhood leukemia (Ahlbom et al., 2000; Greenland et al., 2000). The researchers pooled the data on individuals from each of the studies, creating a study with a larger number of subjects and therefore greater statistical power than any single study. A pooled analysis is preferable to other types of meta-analyses in which the results from several studies are combined from grouped data obtained from the published studies. These analyses focused on studies that assessed exposure to magnetic fields using 24-hour measurements or calculations based on the characteristics of the power lines and current load. Both Ahlbom et al. and Greenland et al. used exposure categories of <1 mG (<0.1 microtesla [μT]) as a reference category. The statistical results of these analyses can be summarized as follows:

- The pooled analyses provided no indication that wire codes are more strongly associated with leukemia than measured fields.

- Pooling these data corroborates an absence of an association between childhood leukemia and magnetic fields for exposures below 3 mG (0.3 μT).

- Pooling these data results in a statistical association with leukemia for exposures greater than 3-4 mG (0.3 or 0.4 μT).

The authors are appropriately cautious in the interpretation of their analyses, and they clearly identify the limitations in their evaluation of the original studies. Magnetic fields above 3 mG (0.3 μT) in residences are estimated to be rather rare, about 3% in the U.S. (Zaffanella, 1993). Limitations include sparse data (few cases) to adequately characterize a relationship between magnetic fields and leukemia, uncertainties related to pooling different magnetic-field measures without evidence that all of the measures are comparable, and the incomplete and limited data on important confounders such as housing type and traffic density.

A meta-analysis of the data from epidemiologic studies of childhood leukemia studies was presented at the California Workshop and recently published (Wartenberg, 2001b). This meta-analysis did not have the advantage of obtaining and pooling the data on all of the individuals in the studies, unlike those published before it (Ahlbom et al., 2000; Greenland et al., 2000). Instead of using individual data, Wartenberg (2001b) used an approach that extracted the published results, reported as grouped data from several published studies. He used 19 studies overall, after excluding 7 studies that had insufficient data on individuals or deficiencies in the exposure assessment data. He reported a weak association for a) "proximity to electrical facilities" based on wire codes or distance, and b) magnetic-field level over 2 mG, based on either calculations from wiring and loading characteristics (if available) or on spot magnetic-field measurements. The results show more cases than controls exposed to measured or calculated fields above 2 mG. The author concludes that the analysis supports an association, although the size of the effect is small to moderate, but also notes "limitations due to design, confounding, and other biases may suggest alternative interpretations" (Wartenberg, 2001b:S-100).

The results of this meta-analysis are not directly comparable to previous ones regarding fields of 3 or 4 mG because the analysis was not based on individual data. The comparison of grouped data used different exposure cut points for the analysis and different criteria for the comparison group. None of these three analyses (Ahlbom et al., 2000; Greenland et al., 2000; Wartenberg, 2001b) included the results of the latest UK analysis of 1331 child leukemia cases based on calculated fields, which found no association between EMF and childhood leukemia or other cancers, regardless of the exposure level.

### 2.2.2 Epidemiology Studies of Adults

Studies of adults with certain types of cancer, such as brain cancer, breast cancer, or leukemia, have reported associations with exposure to magnetic fields at residences, but results have not been consistent across studies. Contradictory results among studies argue against a conclusion that the association reflects a cause-and-effect relationship. In their assessments of risk, scientists give most weight to studies that include more people, obtain more detailed and individual exposure assessments, and/or include people who have higher exposures.

A study of 492 adult cases of brain cancer in California included measurements of magnetic fields taken in the home and at the front door, and considered the types of power-line wiring (Wrensch et al., 1999). The authors report no evidence of increased risk with higher exposures, no association with type of power line, and no link with levels measured at the front door.

A number of recent studies of breast cancer focused on electric blankets as a source of high exposure. Electric blankets are assumed to be one of the strongest sources of EMF exposure in the home. Three studies of electric-blanket use found no evidence that long-term use increased the risk of breast cancer. Women who developed breast cancer reported no difference in total use of electric blankets, use in recent years, or use many years in the past:

- Gammon et al. (1998) reported that, even for those who kept the blanket on most of the time, no increase in risk was found for those who had longer duration of use (measured in months).

- A study of 608 breast cancer cases found no evidence of increased use of electric blankets or other home appliances in cases compared to controls, and no indication of increasing risk with a longer time of use (Zheng et al., 2000).

- In a cohort of over 120,000 female nurses, data were obtained on known risk factors for breast cancer as well as electric-blanket use (Laden et al., 2000). For a large subset of this group, the questions about exposure were asked before the disease occurred, a step taken to eliminate bias in recalling exposure. No associations with electric blanket use were found.

Erren (2001) reported the results of a meta-analysis of the studies of breast cancer, in which the results of 24 different studies in women were statistically aggregated. When the results of all 24 studies, including studies of workplace exposures, were pooled, the estimate indicated an association between EMF and a small excess breast cancer risk. The pooled results for exposure to EMF in the vicinity of electrical facilities did not show an association with breast cancer, nor did the results for exposure to EMF from appliance use. However, the meta-analysis also showed a lack of consistency among the results of the individual studies, a broad variation in the designs, and a wide range of methods used to assess exposure. No adjustments were made to the data to give increased weight to studies based on more comprehensive exposure assessments. The author also noted that the weak statistical association might be an artifact (a result of chance or unforeseen error) rather than an indication of a cause-and-effect relationship (Erren, 2001).

### 2.2.3 Laboratory Studies of EMF

Laboratory studies complement epidemiologic studies of people because the effects of heredity, diet, and other health-related exposures of animals can be better controlled or eliminated. The assessment of EMF and health, as for any other exposure, includes chronic, long-term studies in animals (*in vivo* studies) and studies of changes in genes or other cellular processes observed in isolated cells and tissues in the laboratory (*in vitro*).

Although the results of the RAPID Program were described in some detail in the NIEHS reports (NIEHS, 1998), many of the studies had not been published in the peer-reviewed literature. The RAPID research program included studies of four biological effects, each of which had previously been observed in only one laboratory. These effects are as follows: effects on gene expression, increased intracellular calcium in a human cell line, proliferation of cell colonies on agar, and increased activity of the enzyme ornithine decarboylase (ODC). Some scientists have suggested that these biological responses are signs of possible adverse health effects of EMF. It is standard scientific procedure to attempt to replicate results in other laboratories, because artifacts and investigator error can occur in scientific investigations. Replications, often using more experiments or more rigorous protocols, help to ensure objectivity and validity. Attempts at replication can substantiate and strengthen an observation, or they may discover the underlying reason for the observed response.

Studies in the RAPID program reported no consistent biological effects of EMF exposure on gene expression, intracellular calcium concentration, growth of cell colonies on agar, or ODC activity (Boorman et al., 2000b). For example, Balcer-Kubiczek et al. (2000) and Loberg et al. (2000) studied the expression of hundreds of cancer-related genes in human mammary or leukemia cell lines. They found no increase in gene expression with increased intensity of magnetic fields. To test the experimental procedure, they used X-rays and treatments known to affect the genes. These are known as positive controls and, as expected, caused gene expression in exposed cells.

Scientists have concluded that the combined animal bioassay results provide no evidence that magnetic fields cause, enhance, or promote the development of leukemia and lymphoma, or mammary cancer (e.g., Boorman et al., 1999; McCormick et al., 1999; Boorman et al., 2000 a, b; Anderson et al., 2001).

#### 2.2.4 Summary Regarding Cancer

Epidemiology studies do not support the idea that EMF from power lines increase the risk of cancers in adults. The latest epidemiologic studies of childhood cancer, considered in the context of the other data, provide no persuasive evidence that leukemia in children is causally associated with magnetic fields measured at the home, calculated magnetic fields based on distance and current loading, or wire codes. Recent meta-analyses reported no association between childhood cancer and magnetic fields below 2 or 3 mG. Although some association was reported for fields above this level, fields at most residences are likely to be below 3 or 4 mG. The authors of each of these analyses list several biases and problems that render the data inconclusive and prevent resolution of the inconsistencies in the epidemiologic data. For this reason, laboratory studies can provide important complementary information. Large, well-conducted animal studies and studies of initiation and promotion, provide no basis to conclude that EMF increases leukemia, lymphoma, breast, brain, or any other type of cancer.

### 2.3 Research Related to Reproduction

Previous epidemiologic studies reported no association with birth weight or fetal growth retardation after exposure to sources of relatively strong magnetic fields, such as electric blankets, or sources of typically weaker magnetic fields such as power lines (Bracken et al., 1995; Belanger et al., 1998).

A recent epidemiology study examined miscarriages[2] in relation to exposures to magnetic fields from electric bed-heating (electric blankets, heated waterbeds and mattress pads), which result in higher exposures than residential fields in general (Lee et al., 2000). The researchers assessed exposure prior to the birth (a prospective study) and included information to control for potential confounding factors (other exposures and conditions that affect the risk of miscarriage). This study had a large number of cases and high participation rates. Miscarriage rates were lower among users of electric bed-heating.

Studies of laboratory animals exposed to pure 60-Hz fields have shown no increase in birth defects, no multigenerational effects, and no changes that would indicate an increase in miscarriage or loss of fertility (e.g., Ryan et al., 1999; Ryan et al., 2000). Exposed and unexposed litters were no different in the amount of fetal loss and the number and type of birth defects, indicating no reproductive effect of EMF.

In summary, the recent evidence from epidemiology and laboratory studies provides no indication that exposure to power-frequency EMF has an adverse effect on reproduction, pregnancy, or growth and development of the embryo. The results of these recent studies are consistent with the conclusions of the NIEHS.

### 2.4 Power-line Electric Fields and Airborne Particles and Ions

Researchers from a university in England have suggested that the alternating-current (ac) electric fields from power lines might affect health indirectly, by interacting with the electrical charges on certain airborne particles in the air. They hypothesize that more particles would be deposited on the skin by a strong electric field, or in the lung by charges on particles (Henshaw et al., 1996; Fews et al., 1999a, b).

[2] The medical term for miscarriage is spontaneous abortion.

If this hypothesis were correct, and interaction did occur (i.e., the airborne particles were charged to increase deposition on skin and in lungs to a sufficient degree), then the researchers further hypothesize that human exposure to various airborne particles and disease might increase. These hypotheses remain highly speculative; scientists have found their assumptions unconvincing, and recognize data gaps in the steps of the hypotheses. Nevertheless, questions about effects of these charged particles have been raised in the media.

In their laboratory, Henshaw and colleagues have developed models to test the physical assumptions that are the first step of their hypotheses: that electric fields can change the behavior of particulates in the air. For example, they measured the deposition of radon daughter[3] particles on metal plates, in the presence of electric fields at intensities found under or near power lines. They also reported increased deposition at similar electric field strengths outdoors near high voltage transmission lines. Under these conditions, deposition of products on surfaces was slightly increased, an occurrence that implies that the deposition might also occur on other surfaces, such as the skin. However, Henshaw and colleagues have not tested the most speculative parts of their hypothesis: that such changes in the deposition rate of particles would lead to an important increase in human exposure, and also that the increased skin exposure would be sufficient to affect human health, in this case to cause an increase in skin cancer. Given (a) the small change anticipated, (b) the ability of wind to disperse particles, and (c) the limited amount of time that people spend outdoors directly under high-voltage power lines, the assumption of health effects is unsupported (Swanson and Jeffers, 2000).

Henshaw et al. also hypothesize that ac electric fields at the surface of power line conductors lead to increased charges on particles, and thereby increase the likelihood that inhaled particles, including radon daughters, would be deposited on surfaces inside the lung or airways, even at considerable distances from the line. Air contains particles of various sizes, including aerosols[4] from emissions from cars and trucks and manufacturing, as well as natural sources such as radon from soil, rock, and building materials. If, as hypothesized, charges on the aerosol particles were increased, and if this change were to increase deposition in the lungs when inhaled over long periods of time, in theory these events could lead to increases in respiratory disease, and possibly other diseases.

The physical basis for aspects of these hypotheses is reasonable. However, the other steps of the hypothesis are highly speculative, and the idea that power lines could substantially affect human exposure to airborne particles or lead to adverse health effects is unwarranted (Swanson and Jeffers, 2000).

The National Radiological Protection Board (NRPB) of Great Britain considered the hypotheses and data published by Fews et al. regarding aerosol deposition increased by electric fields (1999a) and exposure to corona ions from power lines (1999b). The NRPB report (2001) concluded:

> The physical principles for enhanced aerosol deposition in large electric fields are well understood. However, it has not been demonstrated that any such enhanced deposition will increase human exposure in a way that will result in adverse health effects to the general public (NRPB, 2001: 23).

## 2.5 Recent Reviews by Scientific Advisory Groups

Reviews of the scientific research regarding EMF and health by the Health Council of the Netherlands (HCN) were published in 2000 and updated in May 2001. The Institute of Electrical Engineers of Great

---

[3] Radon daughters refers to the radioactive decay products of radon ($^{222}Rn$).
[4] An aerosol is a relatively stable suspension of solid particles or liquid droplets in a gaseous medium.

Britain (IEE) published a review in 2000. The NRPB Advisory Group on Non-Ionising Radiation (AGNIR) published the most recent review in 2001. That review includes research published in 2000, and includes the most comprehensive discussion of the individual research studies. The International Agency for Research on Cancer (IARC) evaluated health effects of EMF and released a statement regarding their findings in June 2001.

### 2.5.1 National Radiological Protection Board of Great Britain (NRPB) Advisory Group on Non-Ionising Radiation

The conclusions from the report prepared by the NRPB's Advisory Group on Non-Ionising Radiation (AGNIR) on ELF-EMF and the risk of cancer are consistent with previous reviews. Members from universities, medical schools, and cancer research institutes reviewed the reports of experimental and epidemiological studies, including reports in the literature in 2000. Their general conclusions are as follows:

> Laboratory experiments have provided no good evidence that extremely low frequency electromagnetic fields are capable of producing cancer, nor do human epidemiological studies suggest that they cause cancer in general. There is, however, some epidemiological evidence that prolonged exposure to higher levels of power frequency magnetic fields is associated with a small risk of leukaemia in children. In practice, such levels of exposure are seldom encountered by the general public in the UK [or in the U.S.] (NRPB, 2001: 164).

The group further recognizes that the scientific evidence suggesting that exposure to power-frequency electromagnetic fields poses an increased risk of cancer is very weak. Virtually all of the cellular, animal and human laboratory evidence provides no support for an increased risk of cancer incidence following such exposure to power frequencies, although sporadic positive findings have been reported. In addition, the epidemiological evidence is, at best, weak.

These conclusions of the Advisory Group are consistent with previous reviews by the NIEHS (1999) and the Health Council of the Netherlands (HCN, 2000). The NRPB response to the Advisory Group report states that "the review of experimental studies by [the Advisory Group] AGNIR gives no clear support for a causal relationship between exposure to ELF-EMFs and cancer" (NRPB, 2001: 1).

### 2.5.2 Health Council of the Netherlands (HCN)

The Health Council of the Netherlands has prepared updates of its 1992 Advisory Report on exposure to electromagnetic fields (0 Hz to 10 MHz) (HCN, 2000; 2001). Members of the Expert Committee who prepared the report include specialists in physics, biology, and epidemiology. The Expert Committee based its analysis on the review and summaries of the studies provided in the NIEHS (1998) and concurred with the views of the director of the NIEHS (1999). For the update, the Committee evaluated a number of publications that appeared after these reports, e.g., McBride et al., (1999) and Green et al. (1999a), and wrote:

> The committee thinks that the quality of the relevant epidemiological research has improved considerably since the publication of the advisory report in 1992. Even so, this research has not resulted in unequivocal, scientifically reliable conclusions (HCN, 2000: 15).

The Council emphasizes that the associations with EMF reported in epidemiologic studies are strictly statistical and do not demonstrate a cause-and-effect relationship. In their view, experimental research does not demonstrate a causal link or a mechanism to explain EMF as a cause of disease in humans. They concluded that there is no reason to recommend measures to limit residence near overhead power lines (HCN, 2000).

The 2001 update (HCN, 2001) includes three major studies (described above) published in 2000 and 2001 (Ahlbom et al., 2000; Greenland et al., 2000; Wartenberg 2001b). The Council concludes:

> Because the association is only weak and without a reasonable biological explanation, it is not unlikely that [an association between ELF exposure and childhood leukemia] could also be explained by chance . . . . The committee therefore sees no reason to modify its earlier conclusion that the association is not likely to be indicative of a causal relationship (HCN, 2001: 40).

### 2.5.3 Institution of Electrical Engineers (IEE) of Great Britain

One of the recent reviews was that of the Institution of Electrical Engineers (IEE) of Great Britain (IEE, 2000). In 1992, the IEE set up a Working Party whose eight members, with broad expertise in the health sciences, review the relevant scientific literature and prepare reports of their views. Their conclusion is based on recent major epidemiologic studies and the scientific literature built up over the past 20 years. In May 2000, the Working Party concluded " . . . that there is still not convincing scientific evidence showing harmful effects of low level electromagnetic fields on humans" (IEE, 2000:1).

### 2.5.4 International Agency for Research on Cancer (IARC)

The International Agency for Research on Cancer sponsored a review of EMF research by a Working Group of scientific experts from 10 countries. This multidisciplinary group reviewed health effects of ELF-EMF. Although their monograph is still in preparation, IARC has released a summary of the Group's conclusions. The Working Group concluded that the epidemiologic studies do not provide support for an association between childhood leukemia and residential magnetic fields at intensities less than 4 mG. IARC reviewers also evaluated the animal data and concluded that it was "inadequate" to support a risk for cancer. Their summary states that the EMF data does not merit the category "carcinogenic to humans" or the category "probably carcinogenic to humans," nor did they find that "the agent is probably not carcinogenic to humans" (IARC, 2001).

## 2.6 Summary

The results of the latest epidemiologic studies of childhood cancer do not provide convincing evidence to support the hypothesis that exposure to magnetic fields or power lines near the home are a cause of leukemia in children. The larger, more reliable, residential studies do not support the idea that fields in the residence contribute to the risk of cancer in adults. Although epidemiology studies provide evidence most relevant to humans, the results may include uncertainties because they are observational rather than experimental. For this reason, laboratory studies can provide important complementary information. The larger and more thorough animal studies that exposed animals for EMF for their entire lifespan show no increases in cancer or other adverse health effects, including reproduction outcomes, in exposed animals.

# 3.0 Ecological Research

Scientists have studied the effects of high-voltage transmission lines on many plant and animal species in the natural environment. In this section, the research on the effects of EMF on ecological systems to assess the likelihood of adverse impacts was briefly reviewed. In addition to the comprehensive review of research on this topic by wildlife biologists at BPA (Lee et al., 1996), a search of the published scientific literature for more recent studies published between 1995 and June 2001 was conducted.

## 3.1 Fauna

The habitat on the transmission-line right-of-way and surrounding area shields most wildlife from electric fields. Vegetation in the form of grasses, shrubs, and small trees largely shields small ground-dwelling species such as mice, rabbits, foxes, and snakes from electric fields. Species that live underground, such as moles, woodchucks, and worms, are further shielded from electric fields by the soil. Hence, large species such as deer and domestic livestock (e.g., sheep and cattle) have greater potential exposures to electric fields since they can stand taller than surrounding vegetation. However, the duration of exposure for deer and other large animals is likely to be limited to foraging bouts or the time it takes them to cross under the line. Furthermore, all species would be exposed to higher magnetic fields under a transmission line than elsewhere, as the vegetation and soil do not provide shielding from this aspect of the transmission-line electrical environment.

Field studies have been performed in which the behavior of large mammals in the vicinity of high-voltage transmission lines was monitored. No effects of electric or magnetic fields were evident in two studies from the northern United States on big game species, such as deer and elk, exposed to a 500-kilovolt (kV) transmission line (Goodwin 1975; Picton et al., 1985). In such studies, a possible confounding factor is audible noise. Audible noise associated with high-voltage power transmission lines (with voltages greater than 110-kV) is due to corona. Audible noise generated by transmission lines reaches its highest levels in inclement weather (rain or snow).

Much larger populations of animals that might spend time near a transmission line are livestock that graze under or near transmission lines. To provide a more sensitive and reliable test for adverse effects than informal observation, scientists have studied animals continuously exposed to fields from the lines in relatively controlled conditions. For example, grazing animals such as cows and sheep have been exposed to high-voltage transmission lines and their reproductive performance examined (Lee et al., 1996). No adverse effects were found among cattle exposed over one or more successive breedings to a 500-kV direct-current overhead transmission line (Angell et al., 1990). Compared to unexposed animals in a similar environment, the exposure to 50-Hz fields did not affect reproductive functions or pregnancy of cows (Algers and Hennichs, 1985; Algers and Hultgren, 1987).

A group of investigators from Oregon State University, Portland State University, and other academic centers evaluated the effects of long-term exposure to EMF from a 500-kV transmission line operated by BPA on various cellular aspects of immune response, including the production of proteins by leukocytes (IL-1 and IL-2) of sheep. In previous unpublished reports, the researchers found differences in IL-1 activity between exposed and control groups. However, in their most recent replication, the authors found no evidence of differences in these measures of immune function. The sheep were exposed to 27 months of continuous exposure to EMF, a period of exposure much greater than the short, intermittent exposures that sheep would incur grazing under transmission lines. Mean exposures of EMF were 3.5-3.8 µT (35-38 mG) and 5.2-5.8 kV/m, respectively (Hefeneider et al., 2001).

Scientists from the Illinois Institute of Technology (IIT) monitored the possible effects of electric and magnetic fields on fauna and flora in Michigan and Wisconsin from 1969 – 1997 to evaluate the effects of an above-ground, military-communications antenna operating at 76 Hz. The antenna produces EMF similar in physical characteristics to those produced by high-voltage transmission lines, but of much lower intensity. This study, which included embryonic development, fertility, postnatal growth, maturation, aerobic metabolism, and homing behavior, showed no adverse impacts of ELF electric and magnetic fields on the animals (NRC, 1997).

The hormone melatonin, secreted at night by the pineal gland, plays a role in animals that are seasonal breeders. Studies in laboratory mice and rats have suggested that exposure to electric and/or magnetic fields might affect levels of the hormone melatonin, but results have not been consistent (Wilson et al., 1981; Holmberg, 1995; Kroeker et al., 1996; Vollrath et al., 1997; Huuskonen et al., 2001). However, when researchers examined sheep and cattle exposed to EMF from transmission lines exceeding 500-kV, they found no effect on the levels of the hormone melatonin in blood, weight gain, onset of puberty, or behavior in sheep and cattle (Stormshak et al., 1992; Lee et al., 1993; Lee et al., 1995; Thompson et al., 1995; Burchard et al., 1998).

Another part of the IIT study examined the effect of the antenna system fields on the growth, development, and homing behavior of birds. Studies of embryonic development (Beaver et al., 1993), fertility, postnatal growth, maturation, aerobic metabolism, and homing behavior showed no adverse impacts of ELF electric and magnetic fields on the animals (NRC, 1997). Fernie and colleagues studied the effects of continuous EMF exposure of raptors to an electric field of 10 kV/m in a controlled, laboratory setting. The exposure was designed to mimic exposure to a 765-kV transmission line. Continuous EMF exposure was found to reduce hatching success and increase egg size, fledging success, and embryonic development (Fernie et al., 2000). In a study of the effects on body mass and food intake of reproducing falcons, the authors found that EMF lengthened the photoperiod as a result of altered melatonin levels in the male species, yet concluded that "EMF effects on adult birds may only occur after continuous, extended exposure," which is not likely to occur from resting on power lines (Fernie and Bird, 1999:620).

Several avian species are reported to use the earth's magnetic field as one of the cues for navigation. It has been proposed that deposits of magnetite in specialized cells in the head are the mechanism by which the birds can detect variations in the inclination and intensity of a direct-current (dc) magnetic field (Kirschvink and Gould, 1981; Walcott et al., 1988). In early studies of transmission lines, it was reported that the migratory patterns of birds appeared to be altered near transmission lines (Southern, 1975; Larkin and Sutherland, 1977). However, these studies were of crude design, and Lee et al. (1996) concluded that, "During migration, birds must routinely fly over probably hundreds (or thousands) of electrical transmission and distribution lines. We are not aware of any evidence to suggest that such lines are disrupting migratory flights" (Lee et al., 1996:4-59). No further studies on this topic were identified in the literature.

Bees, like birds, are able to detect the earth's dc magnetic fields. They are known to use magnetite particles, which are contained in an abdominal organ, as a compass (Kirschvink and Gould, 1981). In the laboratory, they are able to discriminate between a localized magnetic anomaly and a uniform background dc magnetic field (Walker et al., 1982; Kirschvink et al., 1992).

Greenberg et al. (1981) studied honeybee colonies placed near 765-kV transmission lines. They found that hives exposed to electric fields of 7 kV/m had decreased hive weight, abnormal amounts of propolis (a resinous material) at hive entrances, increased mortality and irritability, loss of the queen in some hives, and a decrease in the hive's overall survival compared to hives that were not exposed. Exposure to electric fields of 7-12 kV/m may induce a current or heat the interior of the hive; however, placing the hive farther from the line, shielding the hive, or using hives without metallic parts eliminates this problem. ITT studied the effects of EMF on bees exposed to the 76-Hz antenna system at lower intensities and concluded that these behavioral effects of "ELF-EMF impacts are absent or at most minimal" (NRC, 1997:102).

Reptiles and amphibians contribute to the overall functioning of the forest ecosystems. However, little research has been performed on the effects of EMF on reptiles and amphibians in their natural habitat.

## 3.2 Flora

Numerous studies have been carried out to assess the effect of exposure of plants to transmission-line electric and magnetic fields. These studies have involved both forest species and agriculture crops. Researchers have found no adverse effects on plant responses, including seed germination, seedling emergence, seedling growth, leaf area per plant, flowering, seed production, germination of the seeds, longevity, and biomass production (Lee et al., 1996).

The only confirmed adverse effect of transmission lines on plants was reported for transmission lines with voltages above 1200 kV. For example, Douglas Fir trees planted within 15 m of the conductors were shorter than trees planted away from the line. Shorter trees are believed to result from corona-induced damage to the branch tips. Trees between 15 and 30 m away from the line suffered needle burns, but those 30 m and beyond were not affected (Rogers et al., 1984). These effects would not occur at the lower field intensities expected beyond the right-of-way of the proposed 500-kV transmission line.

## 3.3 Summary

The habitat on the transmission-line rights-of-way and surrounding areas shields smaller animals from electric fields produced by high-voltage transmission lines; thus, vegetation easily shields small animals from electric fields. The greatest potential for larger animals to be exposed to EMF occurs when they are passing beneath the lines. Studies of animal reproductive performance, behavior, melatonin production, immune function, and navigation have found minimal or no effects of EMF. Past studies have found little effect of EMF on plants; no recent studies of plants growing near transmission lines have been performed. In summary, the literature published to date has shown little evidence of adverse effects of EMF from high-voltage transmission lines on wildlife and plants. At the field intensities associated with the proposed 500-kV transmission line, no adverse effects on wildlife or plants are expected.

## List of References

Ahlbom, A.; Day, N.; Feychting, M.; Roman, E.; Skinner, J.; Dockerty, J.; Linet, M.; Michealis, J.; Olsen, J.H.; Tynes, T.; Verasalo, P.K. 2000. A pooled analysis of magnetic fields and childhood leukaemia. British Journal of Cancer, 83(5):692-698.

Algers, B.; and Hennichs, K. 1985. The effect of exposure to 400-kV transmission lines on the fertility of cows: a retrospective cohort study. Preventive Veterinary Medicine, 3:351-361.

Algers, B.; and Hultgren, J. 1987. Effects of long-term exposure to a 400-kV, 50-Hz transmission line on estrous and fertility in cows. Preventive Veterinary Medicine, 5:21-36.

Anderson, L.E.; Morris, J.E.; Miller, D.L.; Rafferty, C.N.; Ebi, K.L.; Sasser, L.B. 2001. Large granular lymphocytic (LGL) leukemia in rats exposed to intermittent 60 Hz magnetic fields. Bioelectromagnetics, 22:185-193.

Angell, R.F.; Schott, M.R.; Raleigh, R.J.; Bracken, T.D. 1990. Effects of a high-voltage direct-current transmission line on beef cattle production. Bioelectromagnetics, 11(4):273-82.

Balcer-Kubiczek, E.K.; Harrison, G.H.; Davis, C.C.; Haas, M.L.; Koffman, B.H. 2000. Expression analysis of human HL60 exposed to 60 Hz square or sine-wave magnetic fields. Radiation Research, 153(5):670-678.

Beaver, D.L.; Hill, R.W.; Lederle, P.E. 1993. Assessment of the effects of extremely low frequency electromagnetic radiation on growth and maturation in nestling tree swallows and deer mice. Electricity and Magnetism in Biology and Medicine. M. Blank, ed., San Francisco Press, Inc., pp. 925-926.

Belanger, K.; Leaderer, B.; Hellenbrand, K.; Holford, T.R.; McSharry, J.; Power, M.E.; Bracken, M.B. 1998. Spontaneous abortion and exposure to electric blankets and heated water beds. Epidemiology, 9:36-42.

Boorman, G.A.; Anderson, L.E.; Morris, J.E.; Sasser, L.B.; Mann, P.C.; Grumbein, S.L.; Hailey, J.R.; McNally, A.; Sills, R.C.; Haseman, J.K. 1999. Effects of 26-week magnetic field exposure in a DMBA initiation-promotion mammary glands model in Sprague-Dawley rats. Carcinogenesis, 20:899-904.

Boorman, G.A.; McCormick, D.J.; Ward, J.M.; Haseman, J.K.; Sills, R.C. 2000a. Magnetic fields and mammary cancer in rodents: A critical review and evaluation of published literature. Radiation Research, 153(5), Part 2:617.

Boorman, G.A.; Rafferty, C.N.; Ward, J.M.; Sills, R.C. 2000b. Leukemia and lymphoma incidence in rodents exposed to low-frequency magnetic fields. Radiation Research, 153(5), Part 2:627.

Bracken, M.B.; Belanger, K.; Hellenbrand, K.; Dlugosz, L.; Holford, T.R.; McSharry, J.E.; Addesso, K.; Leaderer, B. 1995. Exposure to electromagnetic fields during pregnancy with emphasis on electrically heated beds: association with birth weight and intrauterine growth retardation. Epidemiology, 6(3):263-270.

Burchard, J.F.; Nguyen, D.H.; Block, E. 1998. Effects of electric and magnetic fields on nocturnal melatonin concentrations in dairy cows. Journal of Dairy Science, 81(3):722-7.

Erren, T.C. 2001. A meta-analysis of epidemiological studies of electric and magnetic fields and breast cancer in women and men. Bioelectromagnetics Supplement, 5:S105-S119.

Fernie, K.J.; and Bird, D.M. 1999. Effects of electromagnetic fields on body mass and food-intake of American kestrels. The Condor, 101:616-621.

Fernie, K.J.; Bird, D.M.; Dawson, R.D.; Lague, P.C. 2000. Effects of electromagnetic fields on the reproductive success of American kestrels. Physiological Biochemistry and Zoology, 73(1):60-5.

Fews, A.P.; Henshaw, D.L.; Wilding, R.L.; Keitch, P.A. 1999a. Increased exposure to pollutant aerosols under high voltage power lines. International Journal of Radiation Biology, 75: 1505-1521.

Fews, A.P.; Henshaw, D.L.; Wilding, R.L.; Keitch, P.A. 1999b. Corona ions from power lines and increased exposure to pollutant aerosols. International Journal of Radiation Biology, 75:1523-31.

Gammon, M.D.; Schoenberg, J.B.; Britton, J.A.; Kelsey, J.L.; Stanford, J.L.; Malone, K.E.; Coates, R.J.; Brogan, D.J.; Potischman, N.; Swanson, C.A.; Brinton, L.A. 1998. Electric blanket use and breast cancer risk among younger women. American Journal of Epidemiology, 148:556-63.

Goodwin Jr., J.G. 1975. Big game movement near a 500-kV transmission line in northern Idaho. Bonneville Power Administration, Engineering and Construction Division, Portland, OR. June 27.

Green, L.M.; Miller, A.B.; Villeneuve, P.J.; Agnew, D.A.; Greenberg, M.L.; Li, J.H.; Donnelly, K.E. 1999a. A case control study of childhood leukemia in southern Ontario, Canada, and exposure to magnetic fields in residences. International Journal of Cancer, 82:161-170.

Green, L.M.; Miller, A.B.; Agnew, D.A.; Greenberg, M.L.; Li, J.H.; Villeneuve, P.J.; Tibshirani, R. 1999b. Childhood leukemia and personal monitoring of residential exposures to electric and magnetic fields in Ontario, Canada. Cancer Causes and Control, 10:233-243.

Greenberg, B.; Bindokas, V.P.; Frazier, M.J.; Gauger, J.R. 1981. Response of honey bees, *apis mellifera L*., to high-voltage transmission lines. Environmental Entomology, 10:600-610.

Greenland, S.; Sheppard, A.; Kelsh, M.; Kuane, W.; Poole, C.; Kelsh, M.A. 2000. Childhood leukemia and power frequency magnetic fields: analysis from pooled data of thirteen epidemiologic studies. Epidemiology, 11:624-634.

HCN (Health Council of the Netherlands). 2000. Report on Exposure to Electromagnetic Fields (0 Hz – 10 MHz). No. 2000/06E.

HCN (Health Council of the Netherlands). 2001. ELF Electromagnetic Fields Committee. Electromagnetic fields: Annual Update 2001. No. 2001/14.

Hefeneider, S.H.; McCoy, S.L.; Hausman, F.A.; Christensen, H.L.; Takahashi, D.; Perrin, N.; Bracken, T.D.; Shin, K.Y.; Hall, A.S. 2001. Long-term effects of 60-Hz electric vs. magnetic fields on IL-1 and IL-2 activity in sheep. Bioelectromagnetics, 22(3):170-177.

Henshaw, D.L.; Ross, A.N.; Fews, A.P.; Preece, A.W. 1996. Enhanced deposition of radon daughter nuclei in the vicinity of power frequency electromagnetic fields. International Journal of Radiation Biology, 69: 25-38.

Holmberg, B. 1995. Magnetic fields and cancer: animal and cellular evidence—an overview. Environmental Health Perspectives, 103 Suppl. 2:63-7.

Huuskonen, H.; Saastamoinen, V.; Komulainen, H.; Laitinen, J.; Juutilainen, J. 2001. Effects of low-frequency magnetic fields on implantation in rats. Reproductive Toxicology, 15(1):49-59.

IARC (International Agency for Research on Cancer). 2001. Press Release: IARC finds limited evidence that residential magnetic fields increase risk of childhood leukaemia. June. Website: http://www.iarc.fr/pageroot/PRELEASES/pr136a.html.

IEE (Institution of Electrical Engineers), Biological Effects Working Party. May 2000. The possible harmful biological effects of low level electromagnetic fields of frequencies up to 300 GHz. IEE Position Statement.

Kirschvink, J.L.; and Gould, J.L. 1981. Biogenic magnetite as a basis for magnetic field detection in animals. Biosystems, 13(3):181-201.

Kirschvink, J.L.; Diaz Ricci, J.; Nesson, M.H.; Kirschvink, S.J. 1992. Magnetite-based magnetoreceptors in animals: structural, behavioral, and biophysical studies. Electric Power Research Institute (EPRI), Report No. TR-102008, Palo Alto, CA. September.

Kroeker, G.; Parkinson, D.; Vriend, J.; Peeling, J. 1996. Neurochemical effects of static magnetic field exposure. Surgical Neurology, 45(1):62-6.

Laden, F.; Neas, L.M.; Tolbert, P.E.; Holmes, M.D.; Hankinson, S.E.; Spiegelman, D.; Speizer, F.E.; Hunter, D.J. 2000. Electric blanket use and breast cancer in the nurses' health study. American Journal of Epidemiology, 152(1):41-49.

Langholz, B. 2001. Factors that explain the power line configuration wiring code - childhood leukemia association: what would they look like? Bioelectromagnetics Supplements, 5:S19-S31.

Larkin, R.P.; and Sutherland, P.J. 1977. Migrating birds respond to Project Seafarer's electromagnetic field. Science, 195(4280):777-9. February 25.

Lee, G.M.; Neutra, R.R.; Hristova, L.; Yost, M.; Hiatt, R.A. 2000. The use of electric bed heaters and the risk of clinically recognized spontaneous abortion. Epidemiology, 11:406-415.

Lee, J.M.; Pierce, K.S.; Spiering, C.A.; Stearns, R.D.; VanGinhoven, G. 1996. Electrical and biological effects of transmission lines: a review. Bonneville Power Administration, Portland, Oregon. December.

Lee, J.M., Stormshak, F., Thompson, J., Hess, D.L., Foster, D.L. 1995. Melatonin and puberty in female lambs exposed to EMF: a replicate study. Bioelectromagnetics, 16(2):119-23

Lee, J., Stormshak, F., Thompson, J., Thinesen, P., Painter, L., Olenchek, B., Hess, D., Forbes, R. 1993. Melatonin secretion and puberty in female lambs exposed to environmental electric and magnetic fields. Biology of Reproduction, 49(4):857-64

Linet, M.S.; Hatch E.H.; Kleinerman, R.A.; Robinson, L.L.; Kaune, W.T.; Friedman, D.R.; Seversch, R.K.; Haines, C.M.; Hartsock, C.T.; Niwa, S.; Wacholder, S.; Tarone, R.E. 1997. Residential exposure to magnetic fields and acute lymphoblastic leukemia in children. New England Journal of Medicine, 337:1-7.

Loberg, L.I.; Engdahl, W.R.; Gauger, J.R.; McCormick, D.L. 2000. Expression of cancer-related genes in human cells exposed to 60 Hz magnetic fields. Radiation Research, 153(5):679-684.

McBride, M.L.; Gallagher, R.P.; Thériault, G.; Armstrong, B.G.; Tamaro, S.; Spinelli, J.J.; Deadman, J.E.; Fincham, S.; Robinson, D.; Choi, W. 1999. Power-frequency electric and magnetic fields and risk of childhood leukemia in Canada. American Journal of Epidemiology, 149:831-842.

McCormick, D.L.; Boorman, G.A.; Findlay, J.C.; Hailey, J.R.; Johnson, T.R.; Gauger, J.R.; Pletcher, J.M.; Sill, R.C.; Haseman, J.K. 1999. Chronic toxicity/oncogenicity evaluation of 60 Hz (power frequency) magnetic fields in B6C3F mice. Toxicologic Pathology, 27:279-285.

Neutra, R.R.; and Del Pizzo, V. 2001. A richer conceptualization of "exposure" for epidemiological studies of the "EMF mixture." Bioelectromagnetics Supplements, 5:S48-S57.

NIEHS (National Institute of Environmental Health Sciences). 1998. Assessment of health effects from exposure to power-line frequency electric and magnetic fields: Working Group Report. NIH Publication No. 98-3981. Research Triangle Park, NC: National Institute of Environmental Health Sciences of the U.S. National Institutes of Health.

NIEHS (National Institute of Environmental Health). 1999. Health effects from exposure to power line frequency electric and magnetic fields. NIH; National Institute of Health; NIH No. 99-4493; Research Triangle Park, NC.

NRC (National Research Council). 1997. An evaluation of the U.S. Navy's extremely low frequency communications system ecological monitoring program. National Academy Press, Washington, D.C.

NRPB (National Radiological Protection Board). 2001. Response statement of the NRPB: ELF electromagnetic fields and the risk of cancer. National Radiological Protection Board, Chilton, Dicot, Oxon, Volume 12, No.1, ISNB 0-859951-456-0.

Picton, H.D., Canfield, J.E., Nelson, G.P. 1985. The impact of a 500-kV transmission line upon the North Boulder Winter Elk Range. U.S. Forest Service Contract 53-0398-30E-3.

Raaschou-Nielsen, O.; Hertel, O.; Thomsen, B.L.; Olsen, J.H. 2001. Air pollution from traffic at the residence of children with cancer. American Journal of Epidemiology, 153(5):433-43.

*Radiation Research*. 2000. (Special Edition Updating RAPID results.) 153(5):637-641. *See entries under Balcer-Kubiczek, Boorman, Loberg, and Ryan.*

Reynolds, P.; Elkin, E.; Scalf, R.; Von Behren, J.; Neutra, R.R. 2001. A case-control pilot study of traffic exposures and early childhood leukemia using a geographic information system. Bioelectromagnetics Supplements, 5:S58-S6.

Rogers, L.E., Beedlow, P.A., Carlile, D.W., Ganok, K.A., Lee, J.M. 1984. Environmental studies of a 1100-kV prototype transmission line: an annual report for the 1984 study period. Prepared by Battelle Pacific Northwest Laboratories for Bonneville Power Administration, Portland, Oregon.

Ryan, B.M.; Polen, M.; Gauger, J.R.; Mallett, E.; Kerns, M.B.; Bryan, T.L.; McCormick, D.L. 2000. Evaluation of the developmental toxicity in Sprague-Dawley rats. Radiation Research, 153(5):637-641.

Ryan, B.M.; Symanski, R.R.; Pomeranz, L.E.; Johnson, T.R.; Gauger, J.R.; McCormick, D.L. 1999. Multi-generation reproduction toxicity assessment of 60-Hz magnetic fields using a continuous breeding protocol in rats. Teratology, 59(3):156-62.

Savitz, D.A., Wachtel, H., Barnes, F.A., John, E.M., and Tvrdik, J.G. 1988. Case-control study of childhood cancer and exposure to 60 Hz magnetic fields. American Journal of Epidemiology, 128**,** 21-38.

Schuz, J.; Grigat, J.P.; Brinkmann, K.; Michaelis, J. 2001. Residential magnetic fields as a risk factor for childhood acute leukaemia: results from a German population-based case-control study. International Journal of Cancer, 91(5): 728-735.

Southern, W.E. 1975. Orientation of gull chicks exposed to project Sanguine's electromagnetic field. Science, 189:143-144.

Stormshak, F.; Bracken, T.D.; Carey, M.; Chartier, V.; Dickson, L.; Forbes, R.; Hall, A.; Havens, P.; Hess, D.; Krippaehne, S.; Lee, J.; Ogden, B.; Olenchek, B.; Painter, L.; Rowe, K.; Stearns, R.; Thinesen, P.; Thompson, J. 1992. Joint HVAC transmission EMF environmental study: final report on experiment 1. Bonneville Power Administration, Contract # DE-B179-90BPO4293, Portland, OR, May.

Swanson, J.; and Jeffers, D.E. 2000. Comments on the paper "Increased exposure to pollutant aerosols under high voltage power lines". International Journal of Radiation Biology, 76(12): 1685-91.

Thompson, J.M.; Stormshak, F.; Lee, J.M.; Hess, D.; Painter, L. 1995. Cortisol secretion and growth in ewe lambs chronically exposed to electric and magnetic fields of a 60-Hertz 500-kilovolt AC transmission line. Journal of Animal Science, 73(11):3274-80

UKCCS (United Kingdom Childhood Cancer Study Investigators). 1999. Exposure to power frequency magnetic fields and the risk of childhood cancer. The Lancet, 353(9194):1925-31.

UKCCS (United Kingdom Childhood Cancer Study Investigators). 2000. Childhood cancer and residential proximity to power lines. British Journal of Cancer, 83:1573-80.

Vollrath, L.; Spessert, R.; Kratzsch, T.; Keiner, M.; Hollmann, H. 1997. No short-term effects of high-frequency electromagnetic fields on the mammalian pineal gland. Bioelectromagnetics, 18(5):376-87.

Walcott, C.; Gould, J.L.; Lednor, A.J. 1988. Homing of magnetized and demagnetized pigeons. Journal of Experimental Biology, 134:27-41.

Walker, C.E.; Seitelman, D.L.; McElhaney, J.H.; Mullen, S.P.; Hagadorn, B.; Seto, Y.J. 1982. Effects of high-intensity 60-Hz fields on bone growth. Journal of Bioelectricity, 1(3):339-349.

Wartenberg, D. 2001a. The potential impact of bias in studies of residential exposure to magnetic fields and childhood leukemia. Bioelectromagnetics Supplements, 5:S32-S47.

Wartenberg, D. 2001b. Residential EMF exposure and childhood leukemia: Meta-analysis and population attributable risk. Bioelectromagnetics Supplements, 5:S86-S104.

Wilson, B.W.; Anderson, L.E.; Hilton, D.I.; Phillips, R.D. 1981. Chronic exposure to 60-Hz electric fields: effects on pineal function in the rat. Bioelectromagnetics, 2(4):371-80.

Wrensch, M.; Yost, M.; Miike, R.; Lee, G.; Touchstone, J. 1999. Adult glioma in relation to residential power frequency electromagnetic field exposures in the San Francisco Bay Area. Epidemiology, 10:523-527.

Zaffanella, L.E. 1993. Survey of residential magnetic field sources. Vol. 1: Goals, results, and conclusions. (EPRI TR-102759-V1, Project 3335-02). Electric Power Research Institute, Palo Alto, CA.

Zheng, T.Z.; Holford, T.R.; Mayne, S.T.; Owens, P.H.; Zhang, B.; Boyle, P.; Carter, D.; Ward, Y.W.; Zahm, S.H. 2000. Exposure to electromagnetic fields from use of electric blankets and other in-home electrical appliances and breast cancer risk. American Journal of Epidemiology, 151(11):1103-11.

# List of Preparers

**Linda S. Erdreich, Ph.D.**, is a Managing Scientist in the Health Group at Exponent. She received her Ph.D. in Epidemiology and an M.S. in Biostatistics and Epidemiology from The University of Oklahoma Health Sciences Center. Dr. Erdreich is an epidemiologist with specific expertise in biological and health research related to non-ionizing radiation, both radiofrequency and power-frequency fields. Formerly, she was Acting Section Chief and Group Leader of the Methods Evaluation and Development Staff at the U.S. Environmental Protection Agency (EPA) and Senior Epidemiologist of the Environmental Criteria and Assessment Office at the EPA. While at the EPA, she developed methods in quantitative health risk assessment, coordinated the drafting of federal guidelines, and participated in science policy decisions. Both in government and private industry, she has provided rigorous evaluations of the impact on public health or occupational health of a variety of chemicals, therapeutic drugs, and physical agents, including electric and magnetic fields. As a member of the Institute of Electrical and Electronics Engineers (IEEE) Standards Coordinating Committees on Non-Ionizing Radiation, Dr. Erdreich is chairman of a working group to evaluate epidemiologic data on radiofrequency exposures (3 kHz–300 Ghz). She has been appointed as a member of the Committee on Man and Radiation (COMAR) of the IEEE's *Engineering in Biology and Medicine Society*. Dr. Erdreich serves as Adjunct Associate Professor at the University of Medicine & Dentistry of New Jersey.

**William H. Bailey, Ph.D.,** is a Principal Scientist and manages the Health Group scientists in Exponent's New York office. Before joining Exponent, Dr. Bailey was President of Bailey Research Associates, Inc., the oldest research and consulting firm with specialized expertise in electro-magnetic fields and health. Dr. Bailey specializes in applying state-of-the-art assessment methods to environmental health and impact issues. His 30 years of training and experience include laboratory and epidemiologic research, health risk assessment, and comprehensive exposure analysis. Dr. Bailey is particularly well known for his research on potential health effects of electromagnetic fields and is active in setting IEEE standards for human exposure to electromagnetic fields. He uses advanced analytical and statistical methods in the design and analysis of both experimental studies and epidemiology and survey research studies. In addition, Dr. Bailey's postgraduate training in the social, economic, and behavioral sciences is helpful in assessing the important effects of social, economic, and community factors on health risks and vulnerability to environmental impacts in health and environmental justice research. He is a member of a working group that advises a committee of the World Health Organization on risk assessment, perception, and communication. Dr. Bailey is also a visiting scientist at the Cornell University Medical College. He was formerly Head of the Laboratory of Neuropharmacology and Environmental Toxicology at the New York State Institute for Basic Research, Staten Island, New York, and an Assistant Professor and NIH postdoctoral fellow in Neurochemistry at The Rockefeller University in New York.

**Maria DeJoseph, M.S.,** is an Epidemiologist in Exponent's Health Group and is based in New York, New York. Ms. DeJoseph has a background in epidemiology and biological sciences. She served as the primary investigator for a case-control epidemiologic study of her design to investigate a mediastinitis outbreak in cardiothoracic surgery patients. Ms. De Joseph also has recruited and interviewed subjects, and analyzed hormone levels for an epidemiologic breast cancer study. She has conducted phytochemical analyses of medicinal plants, including the isolation and fractionation of tropical plants used medicinally by indigenous peoples and primates of Central and South America. Ms. DeJoseph has served as an ethnobotanical and zoopharmacological field researcher in Mexico, Costa Rica, and Venezuela. She has used a variety of methods to identify chemical and prospective pharmaceutical compounds, including HPLC, column chromatography, anti-microbial assays, gas chromatography mass spectrometry (GC-MS), and nuclear magnetic resonance spectroscopy (NMR). Before joining Exponent, Ms. DeJoseph was a Research Assistant in the Medical School, Division of Epidemiology at Stanford University.

*This page intentionally left blank.*

# ***MCNARY – JOHN DAY 500-kV TRANSMISSION-LINE PROJECT***

# ***ELECTRICAL EFFECTS***

January 2002

**Prepared by**

**T. Dan Bracken, Inc.**

**for**

**Bonneville Power Administration**

# Table of Contents

# List of Tables



# List of Figures

# ELECTRICAL EFFECTS FROM THE PROPOSED MCNARY — JOHN DAY TRANSMISSION-LINE PROJECT

## 1.0 Introduction

The Bonneville Power Administration (BPA) is proposing to build a 87-mile (mi.) (140- kilometer [km]) 500-kilovolt (kV) transmission line from the existing BPA McNary Substation near the McNary Dam on the Columbia River, to the existing BPA John Day Substation near the John Day Dam on the Columbia River. The proposed line is designated the McNary – John Day 500-kV line. The proposed line would be built on new and existing right-of-way. Although both substations are located on the south (Oregon) side of the river, most of the proposed line route is on the north (Washington) side of the river. For most of its length the proposed line would parallel existing 230- and 345-kV lines. For some portions of the route, the proposed line would also parallel existing 500-kV lines and in one section there would be no parallel lines within about 600 feet of the line. The parallel line configurations and their lengths are given in Table 1. The purpose of this report is to describe and quantify the electrical effects of the proposed McNary – John Day 500-kV transmission line. These effects include the following:

- the levels of 60-hertz (Hz; cycles per second) electric and magnetic fields (EMF) at 3.28 feet (ft.) or 1 meter (m) above the ground,
- the effects associated with those fields,
- the levels of audible noise produced by the line, and
- electromagnetic interference associated with the line.

Electrical effects occur near all transmission lines, including those 500-kV lines already present in the area of the proposed route for the McNary – John Day line. Therefore, the levels of these quantities for the proposed line are computed and compared with those from the existing lines in Oregon, Washington, and elsewhere.

The voltage on the conductors of transmission lines generates an *electric field* in the space between the conductors and the ground. The electric field is calculated or measured in units of volts-per-meter (V/m) or kilovolts-per-meter (kV/m) at a height of 3.28 ft. (1 m) above the ground. The current flowing in the conductors of the transmission line generates a *magnetic field* in the air and earth near the transmission line; current is expressed in units of amperes (A). The magnetic field is expressed in milligauss (mG), and is also usually measured or calculated at a height of 3.28 ft. (1 m) above the ground. The electric field at the surface of the conductors causes the phenomenon of *corona*. Corona is the electrical breakdown or ionization of air in very strong electric fields, and is the source of audible noise, electromagnetic radiation, and visible light.

To quantify EMF levels along the route, the electric and magnetic fields from the proposed and existing lines were calculated using the BPA Corona and Field Effects Program (USDOE, undated). In this program, the calculation of 60-Hz fields uses standard superposition techniques for vector fields from several line sources: in this case, the line sources are transmission-line conductors. (Vector fields have both magnitude and direction: these must be taken into account when combining fields from different sources.) Important input parameters to the computer program are voltage, current, and geometric configuration of the line. The transmission-line conductors are assumed to be straight, parallel to each other, and located above and parallel to an infinite flat ground plane. Although such conditions do not occur under real lines because of conductor sag and variable terrain, the validity and limitations of calculations using these assumptions have been well verified by comparisons with measurements. This approach was used to estimate fields for the proposed McNary – John Day line, where minimum clearances were assumed to provide worst-case (highest) estimates for the fields.

Electric fields are calculated using an imaging method. Fields from the conductors and their images in the ground plane are superimposed with the proper magnitude and phase to produce the total field at a selected location.

The total magnetic field is calculated from the vector summation of the fields from currents in all the transmission-line conductors. Balanced currents are assumed for each three-phase circuit; the contribution of induced image currents in the conductive earth is not included.

Electric and magnetic fields for the proposed line were calculated at the standard height (3.28 ft. or 1 m) above the ground (IEEE, 1987). Calculations were performed out to 300 ft. (91 m) from the centerline of the existing corridor. The validity and limitations of such calculations have been well verified by measurements. Because maximum voltage, maximum current, and minimum conductor height above-ground are used, ***the calculated values given here represent worst-case conditions:*** i.e., the calculated fields are higher than they would be in practice. Such worst-case conditions would seldom occur.

The corona performance of the proposed line was also predicted using the BPA Corona and Field Effects Program (USDOE, undated). Corona performance is calculated using empirical equations that have been developed over several years from the results of measurements on numerous high-voltage lines (Chartier and Stearns, 1981; Chartier, 1983). The validity of this approach for corona-generated audible noise has been demonstrated through comparisons with measurements on other lines all over the United States (IEEE Committee Report, 1982). The accuracy of this method for predicting corona-generated radio and television interference from transmission lines has also been established (Olsen et al., 1992). Important input parameters to the computer program are voltage, current, conductor size, and geometric configuration of the line.

Corona is a highly variable phenomenon that depends on conditions along a length of line. Predictions of the levels of corona effects are reported in statistical terms to account for this variability. Calculations of audible noise and electromagnetic interference levels were made under conditions of an estimated average operating voltage (98 percent of maximum voltage) and with the average line height over a span: 540 kV and about 45 ft. (13.7 m) clearance for the proposed 500-kV line. Levels of audible noise, radio interference, and television interference are predicted for both fair and foul weather; however, corona is basically a foul-weather phenomenon. Wet conductors can occur during periods of rain, fog, snow, or icing. Along the route of the proposed McNary – John Day transmission line, such conditions are expected to occur about 1% of the time during a year, based on hourly precipitation records recorded at Arlington, Oregon during 1997 – 2000. Corona activity also increases with altitude. For purposes of evaluating corona effects from the proposed line, an altitude of 600 ft. (183 m) was assumed.

# 2.0 Physical Description

## 2.1 Proposed Line

The proposed 500-kV transmission line would be a three-phase, single-circuit line with the phases arranged in a delta (triangular) configuration. The maximum phase-to-phase voltage would be 550 kV; the average voltage would be 540 kV. The maximum electrical current on the line would be 1758 A per phase, based on the BPA projected normal system annual peak load with 2004 as the base year. The load factor for this load would be about 0.50 (average load = peak load x load factor). BPA provided the physical and operating characteristics of the proposed and existing lines.

The electrical characteristics and physical dimensions for the configuration of the proposed line are shown in Figure 1, and summarized in Table 2. Each phase of the proposed 500-kV line would have three 1.3-inch (in.) (3.30-centimeter [cm]) diameter conductors (ACSR: steel-reinforced aluminum conductor) arranged in an inverted triangle bundle configuration, with 17-in. (43.3-cm) spacing between conductors. Voltage and current waves are displaced by 120° in time (one-third of a cycle) on each electrical phase. The horizontal phase spacing between the lower conductor positions would be 48 ft. (14.6 m). The vertical spacing between the conductor positions would be 34.5 ft. (10.5 m). (The spacing between conductor locations would vary slightly where special towers are used, such as at angle points along the line.)

Minimum conductor-to-ground clearance would be 35 ft. (10.7 m) at a conductor temperature of 122°F (50°C), which represents maximum operating conditions and high ambient air temperatures; clearances above ground would be greater under normal operating temperatures. The average clearance above ground along a span would be approximately 45 ft. (13.7 m); this value was used for corona calculations. At road crossings, the ground clearance would be at least 54 ft. (16.5 m). The 35-ft. (10.7-m) minimum clearance provided by BPA is greater than the minimum distance of the conductors above ground required to meet the National Electrical Safety Code (NESC) (IEEE, 2002). The final design of the proposed line could entail larger clearances. The right-of-way width for the proposed line would vary depending on location and the presence of parallel lines. The distance from the centerline of the proposed line to the edge of the right-way would vary from 72.5 ft. (22 m) to 187.5 ft. (57 m).

## 2.2 Existing Lines

Six possible corridor configurations were identified for analyzing electrical effects along the route from McNary Substation to John Day Substation (Table 1). These configurations are:

1) the proposed line parallel to and north of the existing McNary – Horse Heaven – Harvalum 230-kV and McNary – Ross No. 1 345-kV lines;

2) the proposed line parallel to and north of the existing 230-kV and 345-kV lines and the existing Ashe – Marion No. 1/Ashe – Slatt No. 1 double circuit 500-kV line;

3) the proposed line with no parallel lines within 600 feet;

4) the proposed line parallel to and 125 feet south of the existing 230-kV and 345-kV lines and the existing Hanford – John Day 500-kV line;

4A) the proposed line located on the existing Hanford – John Day 500-kV towers and parallel to and north of the existing McNary – Horse Heaven – Harvalum 230-kV and McNary – Ross No. 1 345-kV lines (The existing Hanford – John Day 500-kV line would be relocated on new towers north of the proposed line.); and

4B) the proposed line parallel to and 275 feet south of the existing 230-kV and 345-kV lines and the existing Hanford – John Day 500-kV line.

Configurations 4, 4A, and 4B are possible alternatives in the short section of the route where the proposed line parallels the existing Hanford – John Day 500-kV line; their presence and respective lengths would depend on the final engineering design for the line.

The physical and electrical characteristics of the corridor configurations that were analyzed are given in Table 2; cross-sections of the corridors are shown in Figure 1. Short sections of the proposed line entering the substations were not analyzed.

Changes in the electrical phasing of the existing lines in Configuration 1 occur and would affect field levels slightly. The four phasing schemes produce similar electric and magnetic fields and only the maximum results for field calculations are included here. In portions of Configuration 1, it may be necessary to increase the ground clearance to 37 feet (11.3 m) to ensure that the BPA criterion of 9 kV/m for peak electric field is met. BPA would select the means of achieving the 9-kV/m field criterion during the engineering design of the line. Corona effects from all phasing schemes of Configuration 1 were essentially the same. The maximum levels for fields and corona effects computed for the different phasing schemes are reported here.

# 3.0 Electric Field

## 3.1 Basic Concepts

An electric field is said to exist in a region of space if an electrical charge, at rest in that space, experiences a force of electrical origin (i.e., electric fields cause free charges to move). Electric field is a vector quantity: that is, it has both magnitude and direction. The direction corresponds to the direction that a positive charge would move in the field. Sources of electric fields are unbalanced electrical charges (positive or negative) and time-varying magnetic fields. Transmission lines, distribution lines, house wiring, and appliances generate electric fields in their vicinity because of unbalanced electrical charge on energized conductors. The unbalanced charge is associated with the voltage on the energized system. On the power system in North America, the voltage and charge on the energized conductors are cyclic (plus to minus to plus) at a rate of 60 times per second. This changing voltage results in electric fields near sources that are also time-varying at a frequency of 60 hertz (Hz; a frequency unit equivalent to cycles per second).

As noted earlier, electric fields are expressed in units of volts per meter (V/m) or kilovolts (thousands of volts) per meter (kV/m). Electric- and magnetic-field magnitudes in this report are expressed in root-mean-square (rms) units. For sinusoidal waves, the rms amplitude is given as the peak amplitude divided by the square root of two.

The spatial uniformity of an electric field depends on the source of the field and the distance from that source. On the ground, under a transmission line, the electric field is nearly constant in magnitude and direction over distances of several feet (1 meter). However, close to transmission- or distribution-line conductors, the field decreases rapidly with distance from the conductors. Similarly, near small sources such as appliances, the field is not uniform and falls off even more rapidly with distance from the device. If an energized conductor (source) is inside a grounded conducting enclosure, then the electric field outside the enclosure is zero, and the source is said to be shielded.

Electric fields interact with the charges in all matter, including living systems. When a conducting object, such as a vehicle or person, is located in a time-varying electric field near a transmission line, the external electric field exerts forces on the charges in the object, and electric fields and currents are induced in the object. If the object is grounded, then the total current induced in the body (the "short-circuit current") flows to earth. The distribution of the currents within, say, the human body, depends on the electrical conductivities of various parts of the body: for example, muscle and blood have higher conductivity than bone and would therefore experience higher currents.

At the boundary surface between air and the conducting object, the field both in the air and perpendicular to the conductor surface is much, much larger than the field in the conductor itself. For example, the average surface field on a human standing in a 10 kV/m field is 27 kV/m; the internal fields in the body are much smaller: approximately 0.008 V/m in the torso and 0.45 V/m in the ankles.

## 3.2 Transmission-line Electric Fields

The electric field created by a high-voltage transmission line extends from the energized conductors to other conducting objects such as the ground, towers, vegetation, buildings, vehicles, and people. The calculated strength of the electric field at a height of 3.28 ft. (1 m) above an unvegetated, flat earth is frequently used to describe the electric field under straight parallel transmission lines. The most important transmission-line parameters that determine the electric field at a 1-m height are conductor height above ground and line voltage.

Calculations of electric fields from transmission lines are performed with computer programs based on well-known physical principles (cf., Deno and Zaffanella, 1982). The calculated values under these conditions represent an ideal situation. When practical conditions approach this ideal model, measurements and calculations agree. Often, however, conditions are far from ideal because of variable terrain and vegetation. In these cases, fields are calculated for ideal conditions, with the lowest conductor clearances to provide upper bounds on the electric field under the transmission lines. With the use of more complex models or empirical results, it is also possible to account accurately for variations in conductor height, topography, and changes in line direction. Because the fields from different sources add vectorially, it is possible to compute the fields from several different lines if the electrical and geometrical properties of the lines are known. However, in general, electric fields near transmission lines with vegetation below are highly complex and cannot be calculated. Measured fields in such situations are highly variable.

For evaluation of EMF from transmission lines, the fields must be calculated for a specific line condition. The NESC states the condition for evaluating electric-field-induced short-circuit current for lines with voltage above 98 kV, line-to-ground, as follows: conductors are at a minimum clearance from ground corresponding to a conductor temperature of 120°F (49°C), and at a maximum voltage (IEEE, 2002). BPA has supplied the needed information for calculating electric and magnetic fields from the proposed transmission lines: the maximum operating voltage, the estimated peak current in 2004, and the minimum conductor clearances.

There are standard techniques for measuring transmission-line electric fields (IEEE, 1987). Provided that the conditions at a measurement site closely approximate those of the ideal situation assumed for calculations, measurements of electric fields agree well with the calculated values. If the ideal conditions are not approximated, the measured field can differ substantially from calculated values. Usually the actual electric field at ground level is reduced from the calculated values by various common objects that act as shields.

Maximum or peak field values occur over a small area at midspan, where conductors are closest to the ground. As the location of an electric-field profile approaches a tower, the conductor clearance increases, and the peak field decreases. A grounded tower will reduce the electric field considerably by shielding. For the parallel-line configurations considered here, minimum conductor clearances were assumed to occur along the same lateral profile for both lines. This condition will not necessarily occur in practice, because the towers for the parallel lines may be offset or located at different elevations. **The assumption of simultaneous minimum clearance results in peak (worst-case) fields that may be larger than what occurs in practice.**

For traditional transmission lines, such as the proposed line, where the right-of-way extends laterally well beyond the conductors, electric fields at the edge of the right-of-way are not as sensitive as the peak field to conductor height. Computed values at the edge of the right-of-way for any line height are fairly representative of what can be expected all along the transmission-line corridor. However, the presence of vegetation on and at the edge of the right-of-way will reduce actual electric-field levels below calculated values. The triangular arrangement of the conductor bundles for the proposed line reduces the electric and magnetic field levels below what they would be for a flat conductor arrangement.

## 3.3 Calculated Values of Electric Fields

Table 3 shows the calculated values of electric field at 3.28 ft. (1 m) above ground for the proposed McNary – John Day 500-kV transmission-line configurations. The peak value on the right-of-way and the value at the edge of the right-of-way are given for the six proposed configurations at minimum conductor clearances and at the estimated average clearance over a span. Figure 2 shows lateral profiles for the electric field for both existing and proposed configurations. Electric fields for the minimum and average line heights for the proposed line with no immediately adjacent parallel lines are shown in Figure 2c.

The calculated peak electric field expected on the right-of-way of the proposed line is 8.97 kV/m or less, depending on the configuration. For average clearance, the peak field would be 6.0 kV/m or less. As shown in Figure 2, the peak values would be present only at locations directly under the line, near mid-span, where the conductors are at the minimum clearance. The conditions of minimum conductor clearance at maximum current and maximum voltage occur very infrequently. The calculated peak levels are rarely reached under real-life conditions, because the actual line height is generally above the minimum value used in the computer model, because the actual voltage is below the maximum value used in the model, and because vegetation within and near the edge of the right-of-way tends to shield the field at ground level. The largest value expected at the edge of the right-of-way of the proposed line would be 2.8 kV/m. Maximum electric fields under the existing parallel 500-kV, 345-kV, and 230-kV lines are 8.9, 4.7 and 4.5 kV/m, respectively.

## 3.4 Environmental Electric Fields

The electric fields associated with the McNary – John Day 500-kV line can be compared with those found in other environments. Sources of 60-Hz electric (and magnetic) fields exist everywhere electricity is used; levels of these fields in the modern environment vary over a wide range. Electric-field levels associated with the use of electrical energy are orders of magnitude greater than naturally occurring 60-Hz fields of about 0.0001 V/m, which stem from atmospheric and extraterrestrial sources.

Electric fields in outdoor, publicly accessible places range from less than 1 V/m to 12 kV/m; the large fields exist close to high-voltage transmission lines of 500 kV or higher. In remote areas without electrical service, 60-Hz field levels can be much lower than 1 V/m. Electric fields in home and work environments generally are not spatially uniform like those of transmission lines; therefore, care must be taken when making comparisons between fields from different sources such as appliances and electric lines. In addition, fields from all sources can be strongly modified by the presence of conducting objects. However, it is helpful to know the levels of electric fields generated in domestic and office environments in order to compare commonly experienced field levels with those near transmission lines.

Numerous measurements of residential electric fields have been reported for various parts of the United States, Canada, and Europe. Although there have been no large studies of residential electric fields, sufficient data are available to indicate field levels and characteristics. Measurements of domestic 60-Hz electric fields indicate that levels are highly variable and source-dependent. Electric-field levels are not easily predicted because walls and other objects act as shields, because conducting objects perturb the field, and because homes contain numerous localized sources. Internal sources (wiring, fixtures, and appliances) seem to predominate in producing electric fields inside houses. Average measured electric fields in residences are generally in the range of 5 to 20 V/m. In a large occupational exposure monitoring project that included electric-field measurements at homes, average exposures for all groups away from work were generally less than 10 V/m (Bracken, 1990).

Electric fields from household appliances are localized and decrease rapidly with distance from the source. Local electric fields measured at 1 ft. (0.3 m) from small household appliances are typically in the range of 30 to 60 V/m. Stopps and Janischewskyj (1979) reported electric-field measurements near 20 different appliances; at a 1-ft. (0.3-m) distance, fields ranged from 1 to 150 V/m, with a mean of 33 V/m. In another survey, reported by Deno and Zaffanella (1982), field measurements at a 1-ft. (0.3-m) distance from common domestic and workshop sources were found to range from 3 to 70 V/m. The localized fields from appliances are not uniform, and care should be taken in comparing them with transmission-line fields.

Electric blankets can generate higher localized electric fields. Sheppard and Eisenbud (1977) reported fields of 250 V/m at a distance of approximately 1 ft. (0.3 m). Florig et al. (1987) carried out extensive empirical and theoretical analysis of electric-field exposure from electric blankets and presented results in terms of uniform equivalent fields such as those near transmission lines. Depending on what parameter was chosen to represent intensity of exposure and the grounding status of the subject, the equivalent vertical 60-Hz electric-field exposure ranged from 20 to over 3500 V/m. The largest equivalent field corresponds to the measured field on the chest with the blanket-user grounded. The average field on the chest of an ungrounded blanket-user yields an equivalent vertical field of 960 V/m. As manufacturers have become aware of the controversy surrounding EMF exposures, electric blankets have been redesigned to reduce *magnetic* fields. However, electric fields from these “low field” blankets are still comparable with those from older designs (Bassen et al., 1991).

Generally, people in occupations not directly related to high-voltage equipment are exposed to electric fields comparable with those of residential exposures. For example, the average electric field measured in 14 commercial and retail locations in rural Wisconsin and Michigan was 4.8 V/m (ITT Research Institute, 1984). Median electric field was about 3.4 V/m. These values are about one-third the values in residences reported in the same study. Power-frequency electric fields near video display terminals

(VTDs) are about 10 V/m, similar to those of other appliances (Harvey, 1983). Electric-field levels in public buildings such as shops, offices, and malls appear to be comparable with levels in residences.

In a survey of 1,882 volunteers from utilities, electric-field exposures were measured for 2,082 work days and 657 non-work days (Bracken, 1990). Electric-field exposures for occupations other than those directly related to high-voltage equipment were equivalent to those for non-work exposure.

Thus, except for the relatively few occupations where high-voltage sources are prevalent, electric fields encountered in the workplace are probably similar to those of residential exposures. Even in electric-utility occupations where high field sources are present, exposures to high fields are limited on average to minutes per day.

Electric fields found in publicly accessible areas near high-voltage transmission lines can typically range up to 3 kV/m for 230-kV lines, to 10 kV/m for 500-kV lines, and to 12 kV/m for 765-kV lines. Although these peak levels are considerably higher than the levels found in other public areas, they are present only in limited areas on rights-of-way.

The calculated electric fields for the proposed McNary – John Day 500-kV transmission line are consistent with the levels reported for other 500-kV transmission lines in Oregon, Washington, and elsewhere. The calculated electric fields on the right-of-way of the proposed transmission line would be much higher than levels normally encountered in residences and offices.

# 4.0 Magnetic Field

## 4.1 Basic Concepts

Magnetic fields can be characterized by the force they exert on a moving charge or on an electrical current. As with the electric field, the magnetic field is a vector quantity characterized by both magnitude and direction. Electrical currents generate magnetic fields. In the case of transmission lines, distribution lines, house wiring, and appliances, the 60-Hz electric current flowing in the conductors generates a time-varying, 60-Hz magnetic field in the vicinity of these sources. The strength of a magnetic field is measured in terms of magnetic lines of force per unit area, or magnetic flux density. The term “magnetic field,” as used here, is synonymous with magnetic flux density and is expressed in units of Gauss (G) or milligauss (mG).

The uniformity of a magnetic field depends on the nature and proximity of the source, just as the uniformity of an electric field does. Transmission-line-generated magnetic fields are quite uniform over horizontal and vertical distances of several feet near the ground. However, for small sources such as appliances, the magnetic field decreases rapidly over distances comparable with the size of the device.

The interaction of a time-varying magnetic field with conducting objects results in induced electric field and currents in the object. A changing magnetic field through an area generates a voltage around any conducting loop enclosing the area (Faraday's law). This is the physical basis for the operation of an electrical transformer. For a time-varying sinusoidal magnetic field, the magnitude of the induced voltage around the loop is proportional to the area of the loop, the frequency of the field, and the magnitude of the field. The induced voltage around the loop results in an induced electric field and current flow in the loop material. The induced current that flows in the loop depends on the conductivity of the loop.

## 4.2 Transmission-line Magnetic Fields

The magnetic field generated by currents on transmission-line conductors extends from the conductors through the air and into the ground. The magnitude of the field at a height of 3.28 ft. (1 m) is frequently used to describe the magnetic field under transmission lines. Because the magnetic field is not affected by non-ferrous materials, the field is not influenced by normal objects on the ground under the line. The direction of the maximum field varies with location. (The electric field, by contrast, is essentially vertical near the ground.) The most important transmission-line parameters that determine the magnetic field at 3.28 ft. (1 m) height are conductor height above ground and magnitude of the currents flowing in the conductors. As distance from the transmission-line conductors increases, the magnetic field decreases.

Calculations of magnetic fields from transmission lines are performed using well-known physical principles (cf., Deno and Zaffanella, 1982). The calculated values usually represent the ideal straight parallel-conductor configuration. For simplicity, a flat earth is usually assumed. Balanced currents (currents of the same magnitude for each phase) are also assumed. This is usually valid for transmission lines, where loads on all three phases are maintained in balance during operation. Induced image currents in the earth are usually ignored for calculations of magnetic field under or near the right-of-way. The resulting error is negligible. Only at distances greater than 300 ft. (91 m) from a line do such contributions become significant (Deno and Zaffanella, 1982). The clearance for magnetic-field calculations for the proposed line was the same as that used for electric-field evaluations.

Standard techniques for measuring magnetic fields near transmission lines are described in ANSI IEEE Standard No. 644-1987 (IEEE, 1987). Measured magnetic fields agree well with calculated values, provided the currents and line heights that go into the calculation correspond to the actual values for the line. To realize such agreement, it is necessary to get accurate current readings during field measurements (because currents on transmission lines can vary considerably over short periods of time) and also to account for all field sources in the vicinity of the measurements.

As with electric fields, the maximum or peak magnetic fields occur in areas near the centerline and at midspan where the conductors are the lowest. The magnetic field at the edge of the right-of-way is not very dependent on line height. If more than one line is present, the peak field will depend on the relative electrical phasing of the conductors and the direction of power flow.

## 4.3 Calculated Values for Magnetic Fields

Table 4 gives the calculated values of the magnetic field at 3.28 ft. (1 m) height for the proposed 500-kV transmission line configurations. Field values on the right-of-way and at the edge of the right-of-way are given for projected maximum currents during system annual peak load in 2004, for minimum and average conductor clearances. The maximum currents are 1758 A on each of the three phases of the proposed line. The actual magnetic-field levels would vary, as currents on the lines change daily and seasonally and as ambient temperature changes. Average currents over the year would be about 50% of the maximum values. The levels shown in the figures represent the highest magnetic fields expected for the proposed McNary – John Day 500-kV line. Average fields over a year would be considerably reduced from the peak values, as a result of increased clearances above the minimum value and reduced currents from the maximum value.

Figure 3 shows lateral profiles of the magnetic field under maximum current and minimum clearance conditions for configurations of the proposed 500-kV transmission line. A field profile for average height under Configuration 3 is also included in Figure 3c. Maximum field levels for the existing configurations are also shown in Figure 3.

For the proposed 500-kV line, the maximum calculated 60-Hz magnetic field expected at 3.28 ft. (1 m) above ground is 311 mG. This field is calculated for the maximum current of 1758 A, with the conductors at a height of 35 ft. (10.7 m). The maximum field would decrease for increased conductor clearance. For an average conductor height over a span of 45 ft. (13.7 m), the maximum field would be 216 mG. Maximum fields under the proposed line in the configuration with no immediately adjacent parallel lines would be slightly less than these values.

The magnetic field at the edge of the right-of-way depends on the width of the right-of-way which varies considerably for the proposed line. For maximum current conditions the calculated magnetic field at the edge of the right-of-way varies from 89 mG to 16 mG as the center line to edge of right-of-way distance varies from 72.5 ft. to 175 ft. The field at the edge of the right-of-way adjacent to a parallel line would depend on that line.

The magnetic field falls off rapidly as distance from the line increases. At a distance of 225 ft. (69 m) from the centerline of the proposed line with no parallel lines, the field would be less than 10 mG for maximum current conditions.

For the existing lines, the peak magnetic fields on the rights-of-way are 327 mG and 298 mG, for the 500-kV and 230-kV lines, respectively. The peak value of 327 mG occurs under the existing Hanford – John Day 500-kV line. Fields at the edges of the existing rights-of-way range from 84 mG for the McNary – Horse Heaven 230-kV line to 9 mG for the Hanford – John Day 500-kV line which is 220 ft. from the edge of the right-of-way.

## 4.4 Environmental Magnetic Fields

Transmission lines are not the only source of magnetic fields; as with 60-Hz electric fields, 60-Hz magnetic fields are present throughout the environment of a society that relies on electricity as a principal energy source. The magnetic fields associated with the proposed McNary – John Day 500-kV line can be compared with fields from other sources. The range of 60-Hz magnetic-field exposures in publicly accessible locations such as open spaces, transmission-line rights-of-way, streets, pedestrian walkways, parks, shopping malls, parking lots, shops, hotels, public transportation, and so on range from less than 0.1 mG to about 1 G, with the highest values occurring near small appliances with electric motors. In occupational settings in electric utilities, where high currents are present, magnetic-field exposures for workers can be above 1 G. At 60 Hz, the magnitude of the natural magnetic field is approximately 0.0005 mG.

Several investigations of residential fields have been conducted. In a large study to identify and quantify significant sources of 60-Hz magnetic fields in residences, measurements were made in 996 houses, randomly selected throughout the country (Zaffanella, 1993). The most common sources of residential fields were power lines, the grounding system of residences, and appliances. Field levels were characterized by both point-in-time (spot) measurements and 24-hour measurements. Spot measurements averaged over all rooms in a house exceeded 0.6 mG in 50% of the houses and 2.9 mG in 5% of houses. Power lines generally produced the largest average fields in a house over a 24-hour period. On the other hand, grounding system currents proved to be a more significant source of the highest fields in a house. Appliances were found to produce the highest local fields; however, fields fell off rapidly with increased distance. For example, the median field near microwave ovens was 36.9 mG at a distance of 10.5 in (0.27 m) and 2.1 mG at 46 in (1.17 m). Across the entire sample of 996 houses, higher magnetic fields were found in, among others, urban areas (vs. rural); multi-unit dwellings (vs. single-family); old houses (vs. new); and houses with grounding to a municipal water system.

In an extensive measurement project to characterize the magnetic-field exposure of the general population, over 1000 randomly selected persons in the United States wore a personal exposure meter for 24 hours and recorded their location in a simple diary (Zaffanella and Kalton, 1998). Based on the measurements of 853 persons, the estimated 24-hour average exposure for the general population is 1.24 mG and the estimated median exposure is 0.88 mG. The average field "at home, not in bed" is 1.27 mG and "at home, in bed" is 1.11 mG. Average personal exposures were found to be largest "at work" (mean of 1.79 mG and median of 1.01 mG) and lowest "at home, in bed" (mean of 1.11 mG and median of 0.49 mG). Average fields in school were also low (mean of 0.88 mG and median of 0.69 mG). Factors associated with higher exposures at home were smaller residences, duplexes and apartments, metallic rather than plastic water pipes, and nearby overhead distribution lines.

As noted above, magnetic fields from appliances are localized and decrease rapidly with distance from the source. Localized 60-Hz magnetic fields have been measured near about 100 household appliances such as ranges, refrigerators, electric drills, food mixers, and shavers (Gauger, 1985). At a distance of 1 ft. (0.3 m), the maximum magnetic field ranged from 0.3 to 270 mG, with 95% of the measurements below 100 mG. Ninety-five percent of the levels at a distance of 4.9 ft. (1.5 m) were less than 1 mG. Devices that use light-weight, high-torque motors with little magnetic shielding exhibited the largest fields. These included vacuum cleaners and small hand-held appliances and tools. Microwave ovens with large power transformers also exhibited relatively large fields. Electric blankets have been a much-studied source of magnetic-field exposure because of the length of time they are used and because of the close proximity to the body. Florig and Hoburg (1988) estimated that the average magnetic field in a person using an electric blanket was 15 mG, and that the maximum field could be 100 mG. New "low-field" blankets have magnetic fields at least 10 times lower than those from conventional blankets (Bassen et al., 1991).

In a domestic magnetic-field survey, Silva et al. (1989) measured fields near different appliances at locations typifying normal use (e.g., sitting at an electric typewriter or standing at a stove). Specific appliances with relatively large fields included can openers ($n = 9$), with typical fields ranging from 30 to 225 mG and a maximum value up to 2.7 G; shavers ($n = 4$), with typical fields from 50 to 300 mG and maximum fields up to 6.9 G; and electric drills ($n = 2$), with typical fields from 56 to 190 mG and maximum fields up to 1.5 G. The fields from such appliances fall off very rapidly with distance and are only present for short periods. Thus, although instantaneous magnetic-field levels close to small hand-held appliances can be quite large, they do not contribute to average area levels in residences.

Although studies of residential magnetic fields have not all considered the same independent parameters, the following consistent characterization of residential magnetic fields emerges from the data:

(1) External sources play a large role in determining residential magnetic-field levels. Transmission lines, when nearby, are an important external source. Unbalanced ground currents on neutral conductors and other conductors, such as water pipes in and near a house, can represent a significant source of magnetic field. Distribution lines per se, unless they are quite close to a residence, do not appear to be a traditional distance-dependent source.

(2) Homes with overhead electrical service appear to have higher average fields than those with underground service.

(3) Appliances represent a localized source of magnetic fields that can be much higher than average or area fields. However, fields from appliances approach area levels at distances greater than 3.28 ft. (1 m) from the device.

Although important variables in determining residential magnetic fields have been identified, quantification and modeling of their influence on fields at specific locations is not yet possible. However, a general characterization of residential magnetic-field level is possible: average levels in the United States are in the range of 0.5 to 1.0 mG, with the average field in a small number of homes exceeding this range by as much as a factor of 10 or more. Average personal exposure levels are slightly higher, possibly due to use of appliances and varying distances to other sources. Maximum fields can be much higher.

Magnetic fields in commercial and retail locations are comparable with those in residences. As with appliances, certain equipment or machines can be a local source of higher magnetic fields. Utility workers who work close to transformers, generators, cables, transmission lines, and distribution systems clearly experience high-level fields. Other sources of fields in the workplace include motors, welding machines, computers, and video display terminals (VDTs). In publicly accessible indoor areas, such as offices and stores, field levels are generally comparable with residential levels, unless a high-current source is nearby.

Because high-current sources of magnetic field are more prevalent than high-voltage sources, occupational environments with relatively high magnetic fields encompass a more diverse set of occupations than do those with high electric fields. For example, in occupational magnetic-field measurements reported by Bowman et al. (1988), the geometric mean field from 105 measurements of magnetic field in "electrical worker" job locations was 5.0 mG. "Electrical worker" environments showed the following elevated magnetic-field levels (geometric mean greater than 20 mG): industrial power supplies, alternating current (ac) welding machines, and sputtering systems for electronic assembly. For secretaries in the same study, the geometric mean field was 3.1 mG for those using VDTs (n = 6) and 1.1 mG for those not using VDTs (n = 3).

Measurements of personal exposure to magnetic fields were made for 1,882 volunteer utility workers for a total of 4,411 workdays (Bracken, 1990). Median workday mean exposures ranged from 0.5 mG for clerical workers without computers to 7.2 mG for substation operators. Occupations not specifically associated with transmission and distribution facilities had median workday exposures less than 1.5 mG, while those associated with such facilities had median exposures above 2.3 mG. Magnetic-field exposures measured in homes during this study were comparable with those recorded in offices.

Magnetic fields in publicly accessible outdoor areas seem to be, as expected, directly related to proximity to electric-power transmission and distribution facilities. Near such facilities, magnetic fields are generally higher than indoors (residential). Higher-voltage facilities tend to have higher fields. Typical maximum magnetic fields in publicly accessible areas near transmission facilities can range from less than a few milligauss up to 300 mG or more, near heavily loaded lines operated at 230 to 765 kV. The levels depend on the line load, conductor height, and location on the right-of-way. Because magnetic fields near high-voltage transmission lines depend on the current in the line, they can vary daily and seasonally. To characterize fields from the distribution system, Heroux (1987) measured 60-Hz magnetic fields with a mobile platform along 140 mi. (223 km) of roads in Montreal. The median field level averaged over nine different routes was 1.6 mG, with 90% of the measurements less than about 5.1 mG. Spot measurements indicated that typical fields directly above underground distribution systems were 5 to 19 mG. Beneath overhead distribution lines, typical fields were 1.5 to 5 mG on the primary side of the transformer, and 4 to 10 mG on the secondary side. Near ground-based transformers used in residential areas, fields were 80 to 1000 mG at the surface and 10 to 100 mG at a distance of 1 ft. (0.3 m).

The magnetic fields from the proposed line would be comparable to or less than those from existing 500-kV lines in Oregon, Washington, and elsewhere. On and near the right-of-way of the proposed line, magnetic fields would be well above average residential levels. However, the fields from the line would decrease rapidly and approach common ambient levels at distances greater than a few hundred feet from the line. Furthermore, the fields at the edge of the right-of-way would not be above those encountered during normal activities near common sources such as hand-held appliances.

# 5.0 Electric and Magnetic Field (EMF) Effects

Possible effects associated with the interaction of EMF from transmission lines with people on and near a right-of-way fall into two categories: short-term effects that can be perceived and may represent a nuisance, and possible long-term health effects. Only short-term effects are discussed here. The issue of whether there are long-term health effects associated with transmission-line fields is controversial. In recent years, considerable research on possible biological effects of EMF has been conducted. A review of these studies and their implications for health-related effects is provided in a separate technical report for the environmental assessment for the proposed McNary – John Day 500-kV transmission line.

## 5.1 Electric Fields: Short-term Effects

Short-term effects from transmission-line electric fields are associated with perception of induced currents and voltages or perception of the field. Induced current or spark discharge shocks can be experienced under certain conditions when a person contacts objects in an electric field. Such effects occur in the fields associated with transmission lines that have voltages of 230-kV or higher. These effects could occur infrequently under the proposed McNary – John Day 500-kV line.

Steady-state currents are those that flow continuously after a person contacts an object and provides a path to ground for the induced current. The amplitude of the steady-state current depends on the induced current to the object in question and on the grounding path. The magnitude of the induced current to vehicles and objects under the proposed line will depend on the electric-field strength and the size and shape of the object. When an object is electrically grounded, the voltage on the object is reduced to zero, and it is not a source of current or voltage shocks. If the object is poorly grounded or not grounded at all, then it acquires some voltage relative to earth and is a possible source of current or voltage shocks.

The responses of persons to steady-state current shocks have been extensively studied, and levels of response documented (Keesey and Letcher, 1969; IEEE, 1978). Primary shocks are those that can result in direct physiological harm. Such shocks will not be possible from induced currents under the existing or proposed lines, because clearances above ground required by the NESC preclude such shocks from large vehicles and grounding practices eliminate large stationary objects as sources of such shocks.

Secondary shocks are defined as those that could cause an involuntary and potentially harmful movement, but no direct physiological harm. Secondary shocks could occur under the proposed 500-kV line when making contact with ungrounded conducting objects such as vehicles or equipment. However, such occurrences are anticipated to be very infrequent. Shocks, when they occur under the 500-kV line, are most likely to be below the nuisance level. Induced currents are extremely unlikely to be perceived off the right-of-way of the proposed line.

Induced currents are always present in electric fields under transmission lines and will be present near the proposed line. However, during initial construction, BPA routinely grounds metal objects that are located on or near the right-of-way. The grounding eliminates these objects as sources of induced current and voltage shocks. Multiple grounding points are used to provide redundant paths for induced current flow. After construction, BPA would respond to any complaints and install or repair grounding to mitigate nuisance shocks.

Unlike fences or buildings, mobile objects such as vehicles and farm machinery cannot be grounded permanently. Limiting the possibility of induced currents from such objects to persons is accomplished in several ways. First, required clearances for above-ground conductors tend to limit field strengths to levels that do not represent a hazard or nuisance. The NESC (IEEE, 2002) requires that, for lines with voltage exceeding 98 kV line-to-ground (170 kV line-to-line), sufficient conductor clearance be maintained to limit the induced short-circuit current in the largest anticipated vehicle under the line to 5 milliamperes (mA) or less. This can be accomplished by limiting access or by increasing conductor clearances in areas where large vehicles could be present. BPA and other utilities design and operate lines to be in compliance with the NESC.

For the proposed line, conductor clearances (50°C conductor temperature) would be increased to at least 54 ft. (16.5 m) over major road crossings along the route, resulting in a maximum field of 4.4 kV/m or less at the 3.28 ft. (1 m) height. The largest truck allowed on roads in Oregon and Washington without a special permit is 14 ft. high by 8.5 ft. wide by 75 ft. long (4.3 x 2.6 x 22.9 m). The induced currents to such a vehicle oriented perpendicular to the line in a maximum field of 4.2 kV/m (at 3.28-ft. height) would be less than 4.0 mA (Reilly, 1979). For smaller trucks, the maximum induced currents for perpendicular orientation to the proposed line would be less than this value. (Larger special-permitted trucks, such as triple trailers, can be up to 105 feet in length. However, because they average the field over such a long distance, the maximum induced current to a 105-ft. vehicle oriented perpendicular to the 500-kV line at a road crossing would be less than 3.8 mA.) Thus, the NESC 5-mA criterion would be met for perpendicular road crossings of the proposed line. These large vehicles are not anticipated to be off highways or oriented parallel to the proposed line. As discussed below, these are worst-case estimates of induced currents at road crossings; conditions for their occurrence are rare. The conductor clearance at each road crossing would be checked during the design stage of the line to ensure that the NESC 5-mA criterion is met. Furthermore, it is BPA policy to limit the maximum induced current from vehicles to 2 mA in commercial parking lots. Line clearances would also be increased in accordance with the NESC, such as over railroads and water areas suitable for sailboating.

Several factors tend to reduce the levels of induced current shocks from vehicles:

(1) Activities are distributed over the whole right-of-way, and only a small percentage of time is spent in areas where the field is at or close to the maximum value.

(2) At road crossings, vehicles are aligned perpendicular to the conductors, resulting in a substantial reduction in induced current.

(3) The conductor clearance at road crossings may not be at minimum values because of lower conductor temperatures and/or location of the road crossing away from midspan.

(4) The largest vehicles are permitted only on certain highways.

(5) Off-road vehicles are in contact with soil or vegetation, which reduces shock currents substantially.

Induced voltages occur on objects, such as vehicles, in an electric field where there is an inadequate electrical ground. If the voltage is sufficiently high, then a spark discharge shock can occur as contact is made with the object. Such shocks are similar to "carpet" shocks that occur, for example, when a person touches a doorknob after walking across a carpet on a dry day. The number and severity of spark discharge shocks depend on electric-field strength. Based on the low frequency of complaints reported by Glasgow and Carstensen (1981) for 500-kV alternating current transmission lines (one complaint per year for each 1,500 mi. or 2400 km of 500-kV line), nuisance shocks, which are primarily spark discharges, do not appear to be a serious impediment to normal activities under 500-kV lines.

In electric fields higher than will occur under the proposed line, it is theoretically possible for a spark discharge from the induced voltage on a large vehicle to ignite gasoline vapor during refueling. The probability for exactly the right conditions for ignition to occur is extremely remote. The additional clearance of conductors provided at road crossings reduces the electric field in areas where vehicles are prevalent and reduces the chances for such events. Even so, BPA recommends that vehicles should not be refueled under the proposed line unless specific precautions are taken to ground the vehicle and the fueling source (USDOE, 1995).

Under certain conditions, the electric field can be perceived through hair movement on an upraised hand or arm of a person standing on the ground under high-voltage transmission lines. The median field for perception in this manner was 7 kV/m for 136 persons; only about 12% could perceive fields of 2 kV/m or less (Deno and Zaffanella, 1982). In areas under the conductors at midspan, the fields at ground level would exceed the levels where field perception normally occurs. In these instances, field perception could occur on the right-of-way of the proposed line. It is unlikely that the field would be perceived beyond the edge of the right-of-way. Where vegetation provides shielding, the field would not be perceived.

Conductive shielding reduces both the electric field and induced effects such as shocks. Persons inside a vehicle cab or canopy are shielded from the electric field. Similarly, a row of trees or a lower-voltage distribution line reduces the field on the ground in the vicinity. Metal pipes, wiring, and other conductors in a residence or building shield the interior from the transmission-line electric field.

The electric fields from the proposed 500-kV line would be comparable to those from existing 500-kV lines in the project area and elsewhere. Potential impacts of electric fields can be mitigated through grounding policies, adherence to the NESC, and increased clearances above the minimums specified by the NESC. Worst-case levels are used for safety analyses but, in practice, induced currents and voltages are reduced considerably by unintentional grounding. Shielding by conducting objects, such as vehicles and vegetation, also reduces the potential for electric-field effects.

## 5.2 Magnetic Field: Short-term Effects

Magnetic fields associated with transmission and distribution systems can induce voltage and current in long conducting objects that are parallel to the transmission line. As with electric-field induction, these induced voltages and currents are a potential source of shocks. A fence, irrigation pipe, pipeline, electrical distribution line, or telephone line forms a conducting loop when it is grounded at both ends. The earth forms the other portion of the loop. The magnetic field from a transmission line can induce a current to flow in such a loop if it is oriented parallel to the line. If only one end of the fence is grounded, then an induced voltage appears across the open end of the loop. The possibility for a shock exists if a person closes the loop at the open end by contacting both the ground and the conductor. The magnitude of this potential shock depends on the following factors: the magnitude of the field; the length of the object (the longer the object, the larger the induced voltage); the orientation of the object with respect to the transmission line (parallel as opposed to perpendicular, where no induction would occur); and the amount of electrical resistance in the loop (high resistance limits the current flow).

Magnetically induced currents from power lines have been investigated for many years; calculation methods and mitigating measures are available. A comprehensive study of gas pipelines near transmission lines developed prediction methods and mitigation techniques specifically for induced voltages on pipelines (Dabkowski and Taflove, 1979; Taflove and Dabkowski, 1979). Similar techniques and procedures are available for irrigation pipes and fences. Grounding policies employed by utilities for long fences reduce the potential magnitude of induced voltage.

The magnitude of the coupling with both pipes and fences is very dependent on the electrical unbalance (unequal currents) among the three phases of the line. Thus, a distribution line where a phase outage may go unnoticed for long periods of time can represent a larger source of induced currents than a transmission line where the loads are well-balanced (Jaffa and Stewart, 1981).

Knowledge of the phenomenon, grounding practices, and the availability of mitigation measures mean that magnetic-induction effects from the proposed 500-kV transmission line will be minimal. In addition, the proposed line would be located in an existing corridor where mitigation measures will have already been implemented for the existing lines.

Magnetic fields from transmission and distribution facilities can interfere with certain electronic equipment. Magnetic fields can cause distortion of the image on VDTs and computer monitors. The threshold field for interference depends on the type and size of monitor and the frequency of the field. Interference has been observed for certain monitors at fields at or below 10 mG (Baishiki et al., 1990; Banfai et al., 2000). Generally, the problem arises when computer monitors are in use near electrical distribution facilities in large office buildings. Fields from the proposed line would fall below this level at approximately 225 ft. (69 m) from the centerline.

Interference from magnetic fields can be eliminated by shielding the affected monitor or moving it to an area with lower fields. Similar mitigation methods could be applied to other sensitive electronics, if necessary. Interference from 60-Hz fields with computers and control circuits in vehicles and other equipment is not anticipated at the field levels found under and near the proposed 500-kV transmission line.

The magnetic fields from the proposed line would be comparable to those from existing 500-kV lines in the area of the proposed line.

## 6.0 Regulations

Regulations that apply to transmission-line electric and magnetic fields fall into two categories. Safety standards or codes are intended to limit or eliminate electric shocks that could seriously injure or kill persons. Field limits or guidelines are intended to limit electric- and magnetic-field exposures that can cause nuisance shocks or might cause health effects. In no case has a limit or standard been established because of a known or demonstrated health effect.

The proposed line would be designed to meet the NESC (IEEE, 2002), which specifies how far transmission-line conductors must be from the ground and other objects. The clearances specified in the code provide safe distances that prevent harmful shocks to workers and the public. In addition, people who live and work near transmission lines must be aware of safety precautions to avoid electrical (which is not necessarily physical) contact with the conductors. For example, farmers should not up-end irrigation pipes under a transmission or other electrical line or direct the water stream from an irrigation system into or near the conductors. In addition, as a matter of safety, the NESC specifies that electric-field-induced currents from transmission lines must be below the 5 mA ("let go") threshold deemed a lower limit for primary shock. BPA publishes and distributes a brochure that describes safe practices to protect against shock hazards around power lines (USDOE, 1995).

Field limits or guidelines have been adopted in several states and countries and by national and international organizations. Electric-field limits have generally been based on minimizing nuisance shocks or field perception. The intent of magnetic-field limits has been to limit exposures to existing levels, given the uncertainty of their potential for health effects.

There are currently no national standards in the United States for 60-Hz electric and magnetic fields. Oregon's formal rule in its transmission-line-siting procedures specifically addresses field limits. The Oregon limit of 9 kV/m for electric fields is applied to areas accessible to the public (Oregon, State of, 1980). The Oregon rule also addresses grounding practices, audible noise, and radio interference. Oregon does not have a limit for magnetic fields from transmission lines. The state of Washington does not have guidelines for electric or magnetic fields from transmission lines.

Besides Oregon, several states have been active in establishing mandatory or suggested limits on 60-Hz electric and (in two cases) magnetic fields. Five other states have specific electric-field limits that apply to transmission lines: Florida, Minnesota, Montana, New Jersey, and New York. Florida and New York have established regulations for magnetic fields. These regulations are summarized in Table 5, adapted from TDHS Report (1989).

Government agencies and utilities operating transmission systems have established design criteria that include EMF levels. BPA has maximum allowable electric fields of 9 and 5 kV/m on and at the edge of the right-of-way, respectively (USDOE, 1996). BPA also has maximum-allowable electric field strengths of 5 kV/m, 3.5 kV/m, and 2.5 kV/m for road crossings, shopping center parking lots, and commercial/ industrial parking lots, respectively. These levels are based on limiting the maximum short-circuit currents from anticipated vehicles to less than 1 mA in shopping center lots and to less than 2 mA in commercial parking lots.

Electric-field limits for overhead power lines have also been established in other countries (Maddock, 1992). Limits for magnetic fields from overhead power lines have not been explicitly established anywhere except in Florida and New York (see Table 5). However, general guidelines and limits on EMF have been established for occupational and public exposure in several countries and by national and international organizations.

The American Conference of Governmental Industrial Hygienists (ACGIH) sets guidelines (Threshold Limit Values or TLV) for occupational exposures to environmental agents (ACGIH, 2000). In general, a TLV represents the level below which it is believed that nearly all workers may be exposed repeatedly without adverse health effects. For EMF, the TLVs represent ceiling levels. For 60-Hz electric fields, occupational exposures should not exceed the TLV of 25 kV/m. However, the ACGIH also recognizes the potential for startle reactions from spark discharges and short-circuit currents in fields greater than 5-7 kV/m, and recommends implementing grounding practices. They recommend the use of conductive clothing for work in fields exceeding 15 kV/m. The TLV for occupational exposure to 60-Hz magnetic fields is a ceiling level of 10 G (10,000 mG) (ACGIH, 2000).

Electric and magnetic fields from various sources (including automobile ignitions, appliances and, possibly, transmission lines) can interfere with implanted cardiac pacemakers. In light of this potential problem, manufacturers design devices to be immune from such interference. However, research has shown that these efforts have not been completely successful and that a few models of pacemakers could be affected by 60-Hz fields from transmission lines. There were also numerous models of pacemakers that were not affected by fields even larger than those found under transmission lines. Because of the known potential for interference with pacemakers by 60-Hz fields, field limits for pacemaker wearers have been established by the ACGIH. They recommend that wearers of pacemakers and similar medical-assist devices limit their exposure to electric fields of 1 kV/m or less and to magnetic fields to 1 G (1,000 mG) or less (ACGIH, 2000).

The International Committee on Non-ionizing Radiation Protection (ICNIRP), working in cooperation with the World Health Organization (WHO), has developed guidelines for occupational and public exposures to EMF (ICNIRP, 1998). For occupational exposures at 60 Hz, the recommended limits to exposure are 8.3 kV/m for electric fields and 4.2 G (4,200 mG) for magnetic fields. The electric-field level can be exceeded, provided precautions are taken to prevent spark discharge and induced current shocks. For the general public, the ICNIRP guidelines recommend exposure limits of 4.2 kV/m for electric fields and 0.83 G (830 mG) for magnetic fields (ICNIRP, 1998).

ICNIRP has also established guidelines for contact currents, which could occur when a grounded person contacts an ungrounded object in an electric field. The guideline levels are 1.0 mA for occupational exposure and 0.5 mA for public exposure.

The electric fields from the proposed 500-kV line would meet the ACGIH standards, provided wearers of pacemakers and similar medical-assist devices are discouraged from unshielded right-of-way use. (A passenger in an automobile under the line would be shielded from the electric field.) The electric fields in limited areas on the right-of-way would exceed the ICNIRP guideline for public exposure. The magnetic fields from the proposed line would be below the ACGIH limits, as well as below those of ICNIRP. The electric fields present on the right-of-way could induce currents in ungrounded vehicles that exceeded the ICNIRP level of 0.5 mA.

The estimated peak electric fields on the right-of-way of the proposed transmission line would meet the Oregon limit as well as those set in Florida and New York, but not those of Minnesota and Montana (see Table 5). The BPA maximum allowable electric field-limit would be met for all configurations of the proposed line. The edge-of-right-of-way electric fields from the proposed line would be below limits set in New Jersey, but above those in Florida, Montana, and New York.

The magnetic field at the edge of the right-of-way from the proposed line would be below the regulatory levels of states where such regulations exist.

# 7.0 Audible Noise

## 7.1 Basic Concepts

Audible noise (AN), as defined here, represents an unwanted sound, as from a transmission line, transformer, airport, or vehicle traffic. Sound is a pressure wave caused by a sound source vibrating or displacing air. The ear converts the pressure fluctuations into auditory sensations. AN from a source is superimposed on the background or ambient noise that is present before the source is introduced.

The amplitude of a sound wave is the incremental pressure resulting from sound above atmospheric pressure. The sound-pressure level is the fundamental measure of AN; it is generally measured on a logarithmic scale with respect to a reference pressure. The sound-pressure level (SPL) in decibels (dB) is given by:

$$SPL = 20 \log (P/P_o) dB$$

where P is the effective rms (root-mean-square) sound pressure, $P_O$ is the reference pressure, and the logarithm (log) is to the base 10. The reference pressure for measurements concerned with hearing is usually taken as 20 micropascals (Pa), which is the approximate threshold of hearing for the human ear. A logarithmic scale is used to encompass the wide range of sound levels present in the environment. The range of human hearing is from 0 dB up to about 140 dB, a ratio of 10 million in pressure (EPA, 1978).

Logarithmic scales, such as the decibel scale, are not directly additive: to combine decibel levels, the dB values must be converted back to their respective equivalent pressure values, the total rms pressure level found, and the dB value of the total recalculated. For example, adding two sounds of equal level on the dB scale results in a 3 dB increase in sound level. Such an increase in sound pressure level of 3 dB, which corresponds to a doubling of the energy in the sound wave, is barely discernible by the human ear. It requires an increase of about 10 dB in SPL to produce a subjective doubling of sound level for humans. The upper range of hearing for humans (140 dB) corresponds to a sharply painful response (EPA, 1978).

Humans respond to sounds in the frequency range of 16 to 20,000 Hz. The human response depends on frequency, with the most sensitive range roughly between 2000 and 4000 Hz. The frequency-dependent sensitivity is reflected in various weighting scales for measuring audible noise. The A-weighted scale weights the various frequency components of a noise in approximately the same way that the human ear responds. This scale is generally used to measure and describe levels of environmental sounds such as those from vehicles or occupational sources. The A-weighted scale is also used to characterize transmission-line noise. Sound levels measured on the A-scale are expressed in units of dB(A) or dBA.

AN levels and, in particular, corona-generated audible noise (see below) vary in time. In order to account for fluctuating sound levels, statistical descriptors have been developed for environmental noise. Exceedence levels (L levels) refer to the A-weighted sound level that is exceeded for a specified percentage of the time. Thus, the $L_5$ level refers to the noise level that is exceeded only 5% of the time. $L_{50}$ refers to the sound level exceeded 50% of the time. Sound-level measurements and predictions for transmission lines are often expressed in terms of exceedence levels, with the $L_5$ level representing the maximum level and the $L_{50}$ level representing a median level.

Table 6 shows AN levels from various common sources. Clearly, there is wide variation. Noise exposure depends on how much time an individual spends in different locations. Outdoor noise generally does not contribute to indoor levels (EPA, 1974). Activities in a building or residence generally dominate interior AN levels. The amount of sound attenuation (reduction) provided by buildings is given in Table 7. Assuming that residences along the line route fall in the "warm climate, windows open" category, the typical sound attenuation provided by a house is about 12 dBA.

The BPA design criterion for corona-generated audible noise ($L_{50}$, foul weather) is 50 ±2 dBA at the edge of the ROW (Perry, 1982). This criterion has been interpreted by the state and BPA to meet Oregon Noise Control Regulations (Perry, 1982). The Washington Administrative Code provides noise limitations by class of property, residential, commercial or industrial (Washington, State of, 1975). Transmission lines are classified as industrial and may cause a maximum permissible noise level of 60 dBA to intrude into residential property. During nighttime hours (10:00 p.m. to 7:00 a.m.), the maximum permissible limit for noise from industrial to residential areas is reduced to 50 dBA. This latter level applies to transmission lines that operate continuously. The state of Washington Department of Ecology accepts the 50 dBA level at the edge of the right-of-way for transmission lines, but encouraged BPA to design lines with lower audible noise levels (WDOE, 1981).

The EPA has established a guideline of 55 dBA for the annual average day-night level ($L_{dn}$) in outdoor areas (EPA, 1978). In computing this value, a 10 dB correction (penalty) is added to night-time noise between the hours of 10 p.m. and 7 a.m.

## 7.2 Transmission-line Audible Noise

Corona is the partial electrical breakdown of the insulating properties of air around the conductors of a transmission line. In a small volume near the surface of the conductors, energy and heat are dissipated. Part of this energy is in the form of small local pressure changes that result in audible noise. Corona-generated audible noise can be characterized as a hissing, crackling sound that, under certain conditions, is accompanied by a 120-Hz hum. Corona-generated audible noise is of concern primarily for contemporary lines operating at voltages of 345 kV and higher during foul weather. The proposed 500-kV line will produce some noise under foul weather conditions.

The conductors of high-voltage transmission lines are designed to be corona-free under ideal conditions. However, protrusions on the conductor surface—particularly water droplets on or dripping off the conductors—cause electric fields near the conductor surface to exceed corona onset levels, and corona occurs. Therefore, audible noise from transmission lines is generally a foul-weather (wet-conductor) phenomenon. Wet conductors can occur during periods of rain, fog, snow, or icing. Based on meteorologic records near the route of the proposed transmission line, such conditions are expected to occur only about 1% of the time during the year.

For a few months after line construction, residual grease or oil on the conductors can cause water to bead up on the surface. This results in more corona sources and slightly higher levels of audible noise and electromagnetic interference if the line is energized. However, the new conductors "age" in a few months, and the level of corona activity decreases to the predicted equilibrium value. During fair weather, insects and dust on the conductor can also serve as sources of corona. The proposed line has been designed with three 1.3-inch (3.30-cm) diameter conductors per phase, which will yield acceptable corona levels.

## 7.3 Predicted Audible Noise Levels

Audible noise levels are calculated for average voltage and average conductor heights for fair- and foul-weather conditions. The predicted levels of corona-generated audible noise for the proposed line operated at a voltage of 540 kV are given in Table 8 and plotted in Figure 4 for the proposed configurations. For comparison, Table 8 also gives the calculated levels for the existing parallel lines.

The calculated median level ($L_{50}$) during foul weather 75 feet from the centerline of the proposed McNary – John Day right-of-way with no parallel lines is 47 dBA; the calculated maximum level ($L_5$) during foul weather at this location is 51 dBA. These levels are comparable with levels at the edges of some existing 500-kV lines in Oregon and Washington and lower than the levels from the existing Hanford – John Day 500-kV line in the corridor. However, for all the proposed configurations the resulting AN levels are higher than these because of contributions from existing lines.

For the configurations with immediately adjacent parallel lines (Configurations 1, 2 and 4), the foul weather $L_{50}$ AN level at the edge of the right-of-way adjacent to the proposed line would be 49 to 54 dBA. In these cases, AN from the existing parallel 345-kV and/or 500-kV lines is comparable to or greater than that from the proposed line; and the proposed line would add 4 dBA or less to existing noise levels at the proposed edge of the right-of-way. Such an increase would be barely discernible. Even for Configuration 3 where the proposed line would be more than 600 feet from the existing 345-kV line, the proposed line would add only about 6 dBA to existing levels. At the edge of the right-of-way adjacent to the existing lines in the corridor, the foul weather $L_{50}$ AN level would change 1 dBA or less with the addition of the proposed line.

During fair-weather conditions, which occur about 99% of the time, audible noise levels at the edge of the right-of-way would be about 20 dBA lower than the foul weather levels (if corona were present). These lower levels could be masked by ambient noise on and off the right-of-way.

## 7.4 Discussion

The calculated foul-weather corona noise levels for the proposed line with no parallel lines would be comparable to, or less, than those from existing 500-kV lines in Oregon and Washington. During fair weather, noise from the conductors might be perceivable on the right-of-way, but beyond the right-of-way it would likely be masked or so low as not to be perceived, even during foul weather when ambient noise is higher.

Where the proposed line parallels the existing lines, the increase of less than 4 dBA due to the addition of the proposed line would barely be discernible at the edge of the right of-way and beyond. The level at the edge of the right-of-way of the existing lines would be the same, whether the proposed line were present or not.

No transformers are being added to the existing McNary and John Day Substations. Noise from the existing substation equipment and transmission lines would remain the primary source of environmental noise at these locations. The large-diameter tubular conductors in the station do not generate corona noise during fair weather and any noise generated during foul weather would be masked by noise from the transmission lines entering and leaving the station. During foul weather the noise from the proposed and existing lines would mask the substation noise at the outer edges of the rights-of-way.

Off the right-of-way, the levels of audible noise from the proposed line during foul weather would be below the 55 dBA level that can produce interference with speech outdoors. Since residential buildings provide significant sound attenuation (-12 dBA with windows open; -24 dBA with windows closed), the noise levels off the right-of-way would be well below the 45 dBA level required for interference with speech indoors and below the 35 dBA level where sleep interference can occur (EPA, 1973; EPA, 1978). Since corona is a foul-weather phenomenon, people tend to be inside with windows possibly closed, providing additional attenuation when corona noise is present. In addition, ambient noise levels can be high during such periods (due to rain hitting foliage or buildings), and can mask corona noise.

The 47-dBA level for the proposed line would meet the BPA design criterion and, hence, the Oregon regulations and the Washington Administrative Code limits for transmission lines. Noise levels at the edges of the rights-of-way of the existing McNary – Ross 345-kV and Hanford – John Day 500-kV lines (not shown in Table 8) exceed the limits of both Oregon and Washington and presumably are allowed because of the ages of the lines.

The computed annual $L_{dn}$ level for transmission lines operating in areas with about 1% foul weather is about $L_{dn} = L_{50} - 6$ dB (Bracken, 1987). Therefore, assuming such conditions in the area of the proposed McNary – John Day 500-kV line, the estimated $L_{dn}$ at the edge of the right-of-way would be approximately 48 dBA or less, which is well below the EPA $L_{dn}$ guideline of 55 dBA.

### 7.5 Conclusion

Along the proposed line route where no parallel lines are within 600 feet, there would be increases in the perceived noise above ambient levels during foul weather at the edges of the right-of-way. Where the proposed line parallels the existing 345-kV or 500-kV lines, the incremental noise contributed by the proposed line would be less than 4 dBA at the edge of the proposed new right-of-way and beyond, and would probably not be discernible from existing noise levels.

The corona-generated noise during foul weather would be masked to some extent by naturally occurring sounds such as wind and rain on foliage. During fair weather, the noise off the right-of-way from the proposed line would probably not be detectable above ambient levels. The noise levels from the proposed line would be below levels identified as causing interference with speech or sleep. The audible noise from the transmission line would be below EPA guideline levels and would meet the BPA design criterion that complies with the Oregon and Washington state noise regulations.

## 8.0 Electromagnetic Interference

### 8.1 Basic Concepts

Corona on transmission-line conductors can also generate electromagnetic noise in the frequency bands used for radio and television signals. The noise can cause radio and television interference (RI and TVI). In certain circumstances, corona-generated electromagnetic interference (EMI) can also affect communications systems and other sensitive receivers. Interference with electromagnetic signals by corona-generated noise is generally associated with lines operating at voltages of 345 kV or higher. This is especially true of interference with television signals. The bundle of three 1.3-in. diameter conductors used in the design of the proposed 500-kV line would mitigate corona generation and thus keep radio and television interference levels at acceptable levels.

Spark gaps on distribution lines and on low-voltage wood-pole transmission lines are a more common source of RI/TVI than is corona from high-voltage electrical systems. This gap-type interference is primarily a fair-weather phenomenon caused by loose hardware and wires. The proposed transmission line would be constructed with modern hardware that eliminates such problems and therefore minimizes gap noise. Consequently, this source of EMI is not anticipated for the proposed line.

No state has limits for either RI or TVI. In the United States, electromagnetic interference from power transmission systems is governed by the Federal Communications Commission (FCC) Rules and Regulations presently in existence (FCC, 1988). A power transmission system falls into the FCC category of "incidental radiation device," which is defined as "a device that radiates radio frequency energy during the course of its operation although the device is not intentionally designed to generate radio frequency energy." Such a device "shall be operated so that the radio frequency energy that is emitted does not cause harmful interference. In the event that harmful interference is caused, the operator of the device shall promptly take steps to eliminate the harmful interference." For purposes of these regulations, harmful interference is defined as: "any emission, radiation or induction which endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radio communication service operating in accordance with this chapter" (FCC, 1988: Vol II, part 15. 47CFR, Ch. 1).

Electric power companies have been able to work quite well under the present FCC rule because harmful interference can generally be eliminated. It has been estimated that more than 95% of power-line sources that cause interference are due to gap-type discharges. These can be found and completely eliminated, when required to prevent interference (USDOE, 1980). Complaints related to corona-generated interference occur infrequently. This is especially true with the advent of cable television and satellite television, which are not subject to corona-generated interference. Mitigation of corona-generated interference with conventional radio and television receivers can be accomplished in several ways, such as use of a directional antenna or relocation of an existing antenna (USDOE, 1977; USDOE, 1980; Loftness et al., 1981).

## 8.2 Radio Interference (RI)

Radio reception in the AM broadcast band (535 to 1605 kilohertz (kHz)) is most often affected by corona-generated EMI. FM radio reception is rarely affected. Generally, only residences very near to transmission lines can be affected by RI. The IEEE Radio Noise Design Guide identifies an acceptable limit of fair-weather RI as expressed in decibels above 1 microvolt per meter (dBµV/m) of about 40 dBµV/m at 100 ft. (30 m) from the outside conductor (IEEE Committee Report, 1971). As a general rule, average levels during foul weather (when the conductors are wet) are 16 to 22 dBµV/m higher than average fair-weather levels.

## 8.3 Predicted RI Levels

Table 9 gives the predicted fair- and foul-weather RI levels (1000 kHz) at 100 ft. (30 m) from the outside conductor for the proposed 500-kV line in the four configurations. Median foul-weather levels would be about 17 dB higher than the fair-weather levels. The predicted $L_{50}$ fair-weather level at the edge of the proposed right-of-way with no parallel lines is 45 dBµV/m for 540-kV line operation; at 100 ft. (30 m) from the outside conductor, the level is 36 dBµV/m. Predictions indicate that fair-weather RI will meet the IEEE 40 dBµV/m criterion at distances greater than about 100 ft. (30 m) from the outside conductor of the proposed line in all configurations. Predicted fair-weather $L_{50}$ levels are comparable with those for the existing 345-kV line and lower than that from the existing 500-kV Hanford – John Day 500-kV line (45 dBµV/m at 100 ft. [30 m]).

## 8.4 Television Interference (TVI)

Corona-caused TVI occurs during foul weather and is generally of concern for transmission lines with voltages of 345 kV or above, and only for conventional receivers within about 600 ft. (183 m) of a line. As is the case for RI, gap sources on distribution and low-voltage transmission lines are the principal observed sources of TVI. The use of modern hardware and construction practices for the proposed line would minimize such sources.

## 8.5 Predicted TVI Levels

Table 10 shows TVI levels predicted at 100 ft. (30 m) from the outside conductor of the proposed line operating at 540 kV and from existing lines. At this distance, the foul-weather TVI level (75 megahertz (MHz)) predicted for the proposed line is 23 to 24 dBµV/m for all configurations. This is comparable with TVI levels from the existing 345-kV line and some other existing BPA 500-kV lines, and lower than that from the existing Hanford – John Day 500-kV line (33 dBμV/m at 100 ft. [30 m] from the outside conductor).

There is a potential for interference with television signals at locations very near the proposed line in fringe reception areas. However, several factors reduce the likelihood of occurrence. Corona-generated TVI occurs only in foul weather; consequently, signals would not be interfered with most of the time, which is characterized by fair weather. Because television antennas are directional, the impact of TVI is related to the location and orientation of the antenna relative to the transmission line. If the antenna were pointed away from the line, then TVI from the line would affect reception much less than if the antenna were pointed towards the line. Since the level of TVI falls off with distance, the potential for interference becomes minimal at distances greater than several hundred feet from the centerline. Where the proposed line parallels the existing 500-kV line with higher TVI levels, interference issues may have already been addressed and the potential for impacts would be less than where a new line with no parallel lines is built.

Other forms of TVI from transmission lines are signal reflection (ghosting) and signal blocking caused by the relative locations of the transmission structure and the receiving antenna with respect to the incoming television signal. Television systems that operate at higher frequencies, such as satellite receivers, are not affected by corona-generated TVI. Cable television systems are similarly unaffected.

Interference with television reception can be corrected by any of several approaches: improving the receiving antenna system; installing a remote antenna; installing an antenna for TV stations less vulnerable to interference; connecting to an existing cable system; or installing a translator (cf. USDOE, 1977). BPA has an active program to identify, investigate, and mitigate legitimate RI and TVI complaints. It is anticipated that any instances of TVI caused by the proposed line could be effectively mitigated.

### 8.6 Interference with Other Devices

Corona-generated interference can conceivably cause disruption on other communications bands such as the citizen's (CB) and mobile bands. However, mobile-radio communications are not susceptible to transmission-line interference because they are generally frequency modulated (FM). Similarly, cellular telephones operate at a frequency of about 900 MHz, which is above the frequency where corona-generated interference is prevalent. In the unlikely event that interference occurs with these or other communications, mitigation can be achieved with the same techniques used for television and AM radio interference.

### 8.7 Conclusion

Predicted EMI levels for the proposed 500-kV transmission line are comparable to, or lower, than those that already exist near 500-kV lines; no impacts of corona-generated interference on radio, television, or other reception are anticipated. Furthermore, if interference should occur, there are various methods for correcting it: BPA has a program to respond to legitimate complaints.

## 9.0 Other Corona Effects

Corona is visible as a bluish glow or as bluish plumes. On the proposed 500-kV line, corona levels would be very low, so that corona on the conductors would be observable only under the darkest conditions and only with the aid of binoculars, if at all. Without a period of adaptation for the eyes and without intentional looking for the corona, it would probably not be noticeable.

When corona is present, the air surrounding the conductors is ionized and many chemical reactions take place, producing small amounts of ozone and other oxidants. Ozone is approximately 90% of the oxidants, while the remaining 10% is composed principally of nitrogen oxides. The national primary ambient air quality standard for photochemical oxidants, of which ozone is the principal component, is a one-hour average not to exceed 235 micrograms/cubic meter) or 120 parts per billion. The maximum incremental ozone levels at ground level produced by corona activity on the proposed transmission line during foul weather would be much less than 1 part per billion. This level is insignificant when compared with natural levels and fluctuations in natural levels.

## 10.0 Summary

Electric and magnetic fields from the proposed transmission line have been characterized using well-known techniques accepted within the scientific and engineering community. The expected electric-field levels from the proposed line at minimum design clearance would be comparable to those from existing 500-kV lines in Oregon, Washington, and elsewhere. The expected magnetic-field levels from the proposed line would be comparable to, or less than, those from other 500-kV lines in Oregon, Washington, and elsewhere.

The peak electric field expected under the proposed line would be less than 9.0 kV/m; the maximum value at the edge of the right-of-way would be about 2.8 kV/m. Clearances at road crossings would be increased to reduce the peak electric-field value to 4.4 kV/m.

Under maximum current conditions, the maximum magnetic fields under the proposed line would be 311 mG; at the edge of the right-of-way of the proposed line the maximum magnetic field would be 89 mG.

The electric fields from the proposed line would meet regulatory limits for public exposure in Oregon, but could exceed the regulatory limits or guidelines for peak fields established in some other states and by ICNIRP. Washington does not have a limit for electric fields from transmission lines. The magnetic fields from the proposed line would be within the regulatory limits of the two states that have established them and within guidelines for public exposure established by ICNIRP. Oregon and Washington do not have any magnetic-field regulatory limits or guidelines.

Short-term effects from transmission-line fields are well understood and can be mitigated. Nuisance shocks arising from electric-field induced currents and voltages could be perceivable on the right-of-way of the proposed line. It is common practice to ground permanent conducting objects during and after construction to mitigate against such occurrences.

Corona-generated audible noise from the line would be perceivable during foul weather in areas where there are no immediately adjacent parallel lines. In sections with parallel lines the increase in audible noise during foul weather caused by the proposed line would be barely perceptible. The levels would be comparable to those near existing 500-kV transmission lines in Oregon and Washington, would be in compliance with noise regulations in Oregon and Washington, and would be below levels specified in EPA guidelines.

Corona-generated electromagnetic interference from the proposed line would be comparable to or less than that from existing 500-kV lines in Washington and Oregon. Radio interference levels would be below limits identified as acceptable. Television interference, a foul-weather phenomenon, is anticipated to be comparable to or less than that from existing 500-kV lines in Oregon and Washington; if legitimate complaints arise, BPA has a mitigation program.

## List of References Cited

ACGIH (American Conference of Governmental Industrial Hygienists). 2000. 2000 TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. American Conference of Governmental Industrial Hygienists, Cincinnati. 192 pages.

Baishiki, R.S.; Johnson, G.B.; Zaffanella, L.E.; Bracken, T.D.; Sussman, S.S.; Rauch, G.B.; and Silva, J.M. 1990. Studies of Power System Magnetic Fields: Characterization of Sources in Residential Environments, Measurement of Exposure, Influence On Computer Screens. (36-104) CIGRE, Paris, France. 10 pages.

Banfai, B.; Karady, G.G.; Kim, C.J.; and Maracas, K.B. 2000. Magnetic field effects on CRT computer monitors. IEEE Trans. on Power Delivery 15, 307-312.

Bassen, H.; Casamento, J.; and Crowl, B. 1991. Reduction of electric and magnetic field emissions from electric blankets (Meeting abstract). *In*: Bioelectromagnetics Society, 13th Annual Meeting, 23-27 June, Salt Lake City. Bioelectromagnetics Society, New York, 20.

Bowman, J.D.; Garabrant, D.H.; Sobel, E.; and Peters, J.M. June 1988. Exposures to Extremely Low Frequency (ELF) Electromagnetic Fields in Occupations with Elevated Leukemia Rates. Applied Industrial Hygienics, 3(6, June):189-194.

Bracken, T.D. 1987. Audible Noise from High Voltage Transmission Facilities. A Briefing Paper Prepared for State of Florida Department of Environmental Regulation. (DER Contract No. SP122) State of Florida Department of Environmental Regulation.

Bracken, T.D. 1990. The EMDEX Project: Technology Transfer and Occupational Measurements, Volumes 1-3 Interim Report. EPRI Report EN-7048. (EPRI EN-7048) Electric Power Research Institute, Palo Alto, CA.

Chartier, V.L. April 1983. Empirical Expressions for Calculating High Voltage Transmission Corona Phenomena, First Annual Seminar Technical Career Program for Professional Engineers. Bonneville Power Administration, Portland, Oregon. April 1983, 75-82.

Chartier, V.L.; and Stearns, R.D. January 1981. Formulas for Predicting Audible Noise from Overhead High Voltage AC and DC Lines. IEEE Transactions on Power Apparatus and Systems, PAS-100(No. 1, January 1981):121-129.

Dabkowski, J.; and Taflove, A. May/June 1979. Prediction Method for Buried Pipeline Voltages Due to 60 Hz AC Inductive Coupling. Part II: Field Test Verification. IEEE Transactions on Power Apparatus and Systems, PAS-98(3, May/June):788-794.

Deno, D.W.; and Zaffanella, L. 1982. Field effects of overhead transmission lines and stations. Chap. 8. *In*: Transmission Line Reference Book: 345 KV and Above. Second ed. (Ed: LaForest, J.J.). Electric Power Research Institute, Palo Alto, CA, 329-419.

EPA (Environmental Protection Agency). July 1973. Public Health and Welfare Criteria for Noise. (No. 500/9-73-002, July 27, 1973.) U.S. Environmental Protection Agency, Washington, D.C.

EPA. 1974. Information On Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety. (No. PB-239 429.) U.S. Environmental Protection Agency, Washington, D.C.

EPA. 1978. Protective Noise Levels. Condensed Version of EPA Levels Document. (No. PB82-138827) U.S Environmental Protection Agency, Washington, DC.

FCC (Federal Communications Commission). 1988. Federal Communications Commission Rules and Regulations. 10-1-88 ed. Vol. II part 15, 47 CFR, Ch. 1.

Florig, H.K.; and Hoburg, J.F. 1988. Electric and Magnetic Field Exposure Associated With Electric Blankets. Project Resume. Contractor's Review. U.S. Department of Energy/Electric Power Research Institute.

Florig, H.K.; Hoburg, J.F.; and Morgan, M.G. April 1987. Electric Field Exposure from Electric Blankets. IEEE Transactions on Power Delivery, PWRD-2(2, April):527-536.

Gauger, J. September 1985. Household Appliance Magnetic Field Survey. IEEE Transactions on Power Apparatus and Systems, 104(9, September):2436-2445.

Glasgow, A.R.; and Carstensen, E.L. February 1981. The Shock Record for 500 and 750 KV Transmission Lines in North America. IEEE Transactions on Power Apparatus and Systems, 100(2, February):559-562.

Harvey, S.M. 1983. Analysis of operator exposure to electric fields from video display units. Chap. 2. In Video Display Units--Characterization of Electric and Magnetic Fields. (Ontario Hydro Research Division Report # 83-503-K) (Ed: Walsh, M.L.). Ontario Hydro, Toronto, 31-56.

Heroux, P. 1987. 60-Hz Electric and Magnetic Fields Generated By a Distribution Network. Bioelectromagnetics, 8(2):135-148.

ICNIRP (International Committee on Non-ionizing Radiation Protection). April 1998. Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (Up to 300 GHz). Health Physics, 74(4, April):1-32.

IEEE (Institute of Electrical and Electronics Engineers, Inc.). 1978. Electric and Magnetic Field Coupling from High Voltage AC Power Transmission Lines -- Classification of Short-Term Effects On People. IEEE Transactions on Power Apparatus and Systems, PAS-97:2243-2252.

IEEE. 1987. IEEE Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields from AC Power Lines. ANSI/IEEE Std. 644-1987, New York, NY.

IEEE. 2002. National Electrical Safety Code. 2002 ed. Institute of Electrical and Electronics Engineers, Inc., New York, NY. 287 pages.

IEEE Committee Report. March/April 1971. Radio Noise Design Guide for High Voltage Transmission Lines. IEEE Transactions on Power Apparatus and Systems, PAS-90(No. 2, March/April):833-842.

IEEE Committee Report. October 1982. A Comparison of Methods for Calculating Audible Noise of High Voltage Transmission Lines. IEEE Transactions on Power Apparatus and Systems, 101(10, October):4090-4099.

ITT Research Institute. 1984. Representative Electromagnetic Field Intensities Near the Clam Lake (WI) and Republic (MI) ELF Facilities. Report Prepared for Naval Electronics Systems Command, PME 110 E Washington, D.C. 20360. (Under contract N00039-84-C0070.) ITT Research Institute, Chicago, IL. 60 pages.

Jaffa, K.C.; and Stewart, J.B. March 1981. Magnetic Field Induction from Overhead Transmission and Distribution Power Lines On Buried Irrigation Pipelines. IEEE Transactions on Power Apparatus and Systems, PAS-100(3, March):990-1000.

Keesey, J.C.; and Letcher, F.S. 1969. Minimum Thresholds for Physiological Responses to Flow of Alternating Electric Current Through the Human Body At Power-Transmission Frequencies. (Report No. 1) Naval Medical Research Institute, Project MR 005.08-0030B, Bethesda, MD. 25 pages.

Loftness, M.O.; Chartier, V.L.; and Reiner, G.L. 1981. EMI Correction Techniques for Transmission Line Corona. (August 18-20, 1981, pp. 351-361.) Proceedings of the 1981 IEEE International Symposium on Electromagnetic Compatibility, Boulder, CO.

Maddock, B.J. September 1992. Guidelines and Standards for Exposure to Electric and Magnetic Fields At Power Frequencies. (Panel 2-05, CIGRE meeting August 30-September 5, 1992) CIGRE, Paris.

Olsen, R.G.; Schennum, S.D.; and Chartier, V.L. April 1992. Comparison of Several Methods for Calculating Power Line Electromagnetic Interference Levels and Calibration With Long Term Data. IEEE Transactions on Power Delivery, 7 (April, 1992):903-913.

Oregon, State of. 1980. *Oregon Administrative Rules Chapter 345, Division 80.* Energy Facility Siting Council standards relating to public health and safety, 934-80-055.

Perry, D. 1982. Sound Level Limits from BPA Facilities. BPA memorandum, May 26, 1982; Department of Environmental Quality, Noise Control Regulations, Chapter 340, Oregon Administrative Rules, Division 35, March 1, 1978.

Reilly, J.P. 1979. Electric Field Induction on Long Objects -- A Methodology for Transmission Line Impact Studies. IEEE Transactions on Power Apparatus and Systems, PAS-98(6, Nov/Dec):1841-1852.

Sheppard, A.R.; and Eisenbud, M. 1977. Biological Effects of Electric and Magnetic Fields of Extremely Low Frequency. New York University Press, New York.

Silva, M.; Hummon, N.; Rutter, D.; and Hooper, C. 1989. Power Frequency Magnetic Fields in the Home. IEEE Transactions on Power Delivery, 4:465-478.

Stopps, G.J.; and Janischewskyj, W. 1979. Epidemiological Study of Workers Maintaining HV Equipment and Transmission Lines in Ontario. (Canadian Electrical Association Research Report) Canadian Electrical Association, Montreal. 82 pages.

Taflove, A. and Dabkowski, J. May/June 1979. Prediction Method for Buried Pipeline Voltages Due to 60 Hz AC Inductive Coupling. Part I: Analysis. IEEE Transactions on Power Apparatus and Systems, PAS-98(3, May/June):780-787.

TDHS Report. March 1989. EMF Rule Becomes Law; Hillsborough County Commission Challenges. Transmission/Distribution Health & Safety Report, 7(9, 31 March):1-3.

TDHS Report. August 1990. Updates: New York. Transmission/Distribution Health & Safety Report, 8(7, 31 August):4.

USDOE (U.S. Department of Energy), Bonneville Power Administration. March 1977. A Practical Handbook for the Location, Prevention and Correction of Television Interference from Overhead Power Lines. Portland, OR.

USDOE, Bonneville Power Administration. May 1980. A Practical Handbook for the Correction of Radio Interference from Overhead Powerlines and Facilities. (May 1980.) Portland, OR.

USDOE, Bonneville Power Administration. 1995. Living and Working Around High-Voltage Power Lines. (DOE/BP-799). Portland, OR. 9 pages.

USDOE, Bonneville Power Administration. 1996. Electrical and Biological Effects of Transmission Lines: A Review. (DOE/BP 2938 December 1996 1M) Portland, OR.

USDOE, Bonneville Power Administration. undated. "Corona and Field Effects" Computer Program (Public Domain Software). Bonneville Power Administration, P.O. Box 491-ELE, Vancouver, WA 98666.

Washington, State of. 1975. Washington Administrative Code, Chapter 173-60 WAC Maximum Environmental Noise Levels. Department of Ecology, Olympia, WA.

WDOE (Washington Department of Ecology). 1981. Letter from D.E. Saunders to J.H. Brunke, BPA, dated 9/3/81 regarding EDNA classification for substations and transmission line. State of Washington Department of Ecology, Olympia, WA.

Zaffanella, L.E. 1993. Survey of Residential Magnetic Field Sources. Vol. 1: Goals, results, and conclusions. (EPRI TR-102759-V1, Project 3335-02) Electric Power Research Institute, Palo Alto, CA.

Zaffanella, L.E.; and Kalton, G.W. 1998. Survey of personal magnetic field exposure, Phase II: 1000-perosn survey. Interim Report. EMF RAPID Program Engineering Project #6. Enertech Consultants, Lee, MA.

## List of Preparers

T. Dan Bracken was the principal author of this report. He received a B.S. degree in physics from Dartmouth College and M.S. and Ph.D. degrees in physics from Stanford University. Dr. Bracken has been involved with research on and characterization of electric- and magnetic-field effects from transmission lines for over 27 years, first as a physicist with the Bonneville Power Administration (BPA) (1973 - 1980) and since then as a consultant. His firm, T. Dan Bracken, Inc., offers technical expertise in areas of electric- and magnetic-field measurements, instrumentation, environmental effects of transmission lines, exposure assessment and project management. Joseph Dudman of T. Dan Bracken, Inc., provided data entry, graphics, and clerical support in the preparation of the report.

Judith H. Montgomery of Judith H. Montgomery/Communications served as technical editor for the report. She holds an A.B. degree in English literature from Brown University, 1966; and a Ph.D. degree in American literature from Syracuse University, 1971. Dr. Montgomery has provided writing, editing, and communications services to government and industry for 20 years. Her experience includes preparation of National Environmental Policy Act documents and technical papers dealing with transmission-line environmental impact assessment and other utility-related activities.

*This page intentionally left blank.*

**Table 1: Possible configurations for McNary – John Day 500-kV corridor.**

| Configuration | Description of other lines in corridor with McNary – John Day 500-kV line | Miles |
|---|---|---|
| **1** | McNary – Horse Heaven – Harvalum 230-kV and McNary – Ross 345-kV lines[1] | 73.0 |
| **2** | Horse Heaven – Harvalum 230-kV, McNary – Ross 345-kV, and Ashe – Marion No. 1/ Ashe – Slat No. 1 double-circuit 500-kV | 4.1 |
| **3** | Proposed McNary – John Day 500-kV line only | 3.0 |
| **4** | Horse Heaven – Harvalum 230-kV, McNary – Ross 345-kV, and Hanford – John Day 500-kV lines (125-ft. spacing) | —[2] |
| **4A** | Horse Heaven – Harvalum 230-kV, McNary – Ross 345-kV, and re-located Hanford – John Day 500-kV lines (proposed line located on existing Hanford – John Day towers) | —[2] |
| **4B** | Horse Heaven – Harvalum 230-kV, McNary – Ross 345-kV, and Hanford – John Day 500-kV lines (275-ft. spacing) | —[2] |

1 Four different electrical phasing options are present. Only maximum field results are presented.
2 Length of individual configurations depends on engineering design. Total length of section parallel to Hanford –John Day 500-kV line is 6.7 miles.

**Table 2: Physical and electrical characteristics of configurations in the McNary – John Day 500-kV transmission-line corridor.** (4 pages)

| | **Proposed** | **Existing Lines in Corridor** | |
|---|---|---|---|
| **Configuration** | **3** | **1** | |
| **Line Description** | **McNary – John Day 500-kV Only** | **McNary – Horse Heaven – Harvalum 230-kV** | **McNary – Ross 345-kV** |
| **Voltage, kV Maximum/Average[1]** | 550/540 | 242/237 | 362/355 |
| **Peak current, A Existing/Proposed** | 1758 | 1107/985 | 516/604 |
| **Electric phasing (south-north)** | CBA | CBA[2] | ACB[2] |
| **Clearance, ft. Minimum/Average[1]** | 35/45 | 26.5/36.5 | 34/44 |
| **Centerline distance-direction from McNary – John Day 500-kV Line, ft.** | —[3] | 250 South | 125 South |
| **Centerline distance to edge of ROW, ft.** | 72.5 – 187.5 | 62.5 | 62.5 |
| **Tower configuration** | Delta | Flat | Flat |
| **Phase spacing, ft.** | 48H, 34.5V | 26.3H | 32H |
| **Conductor: #/diameter, in.; spacing, in.** | 3/1.300; 17.04 | 1/1.382 | 1/1.602 |

[1] Average voltage and average clearance used for corona calculations.
[2] Most prevalent phasing scheme; three other phasing schemes also present in corridor.
[3] Existing lines are 625 feet south of proposed line and affect audible noise but not electric or magnetic fields near proposed line.

**Table 2, continued**

| | Existing Lines in Corridor | | | |
|---|---|---|---|---|
| **Configuration** | **2** | | | |
| **Line Description** | **Horse Heaven – Harvalum 230-kV** | **McNary – Ross 345-kV** | **Ashe – Marion No. 1/ Ashe – Slatt No. 1 500-kV Double Circuit** | |
| **Voltage, kV Maximum/Average**[1] | 242/237 | 362/355 | 550/540 | |
| **Peak current, A Existing/Proposed** | 817/805 | 516/604 | 1239/1332 | 1760/1802 |
| **Electric phasing (south-north)** | CBA | ACB | A A<br>B C<br>C B | |
| **Clearance, ft. Minimum/Average**[1] | 26.5/36.5 | 34/44 | 35/45 | |
| **Centerline distance-direction from McNary – John Day 500-kV Line, ft.** | 435 South | 310 South | 200 South | |
| **Centerline distance to edge of ROW, ft.** | 62.5 | — | 100 | |
| **Tower configuration** | Flat | Flat | Vertical, Double-circuit | |
| **Phase spacing, ft.** | 26.3H | 32H | 30H, 50H, 30H, 31V | |
| **Conductor: #/diameter, in.; spacing, in.** | 1/1.382 | 1/1.602 | 3/1.602; 17.04 | |

[1] Average voltage and average clearance used for corona calculations.

**Table 2, continued**

| Configuration | Existing Lines in Corridor 4, 4B | | |
|---|---|---|---|
| **Line Description** | **Horse Heaven – Harvalum 230-kV** | **McNary – Ross 345-kV** | **Hanford – John Day 500-kV** |
| **Voltage, kV Maximum/Average[1]** | 242/237 | 362/355 | 550/540 |
| **Peak current, A Existing/Proposed** | 817/805 | 516/604 | 1797/1842 |
| **Electric phasing (south-north)** | BAC | BAC | CBA |
| **Clearance, ft. Minimum/Average[1]** | 26.5/36.5 | 34/44 | 33/43 |
| **Centerline distance-direction from McNary – John Day 500-kV Line, ft.** | 125 North (4)<br>275 North (4B) | 250 North (4)<br>400 North (4B) | 375 North (4)<br>525 North (4B) |
| **Centerline distance to edge of ROW, ft.** | 62.5 | — | 220 |
| **Tower configuration** | Flat | Flat | Delta |
| **Phase spacing, ft.** | 26.3H | 32H | 40H, 27.5V |
| **Conductor: #/diameter, in.; spacing, in.** | 1/1.382 | 1/1.602 | 2/1.602; 18.0 |

[1] Average voltage and average clearance used for corona calculations.

**Table 2, continued**

| | Existing Lines in Corridor | | |
|---|---|---|---|
| **Configuration** | **4A** | | |
| **Line Description** | **Horse Heaven – Harvalum 230-kV** | **McNary – Ross 345-kV** | **Hanford – John Day 500-kV[4]** |
| **Voltage, kV Maximum/Average[1]** | 242/237 | 362/355 | 550/540 |
| **Peak current, A Existing/Proposed** | 817/805 | 516/604 | 1797/1842 |
| **Electric phasing (south-north)** | BAC | BAC | CBA |
| **Clearance, ft. Minimum/Average[1]** | 26.5/36.5 | 34/44 | 33/43 |
| **Centerline distance-direction from McNary – John Day 500-kV Line, ft.** | 250 South | 125 South | 0 North[4] |
| **Centerline distance to edge of ROW, ft.** | 62.5 | — | 220 (existing)<br>75 (proposed) |
| **Tower configuration** | Flat | Flat | Delta |
| **Phase spacing, ft.** | 26.3H | 32H | 40H, 27.5V |
| **Conductor: #/diameter, in.; spacing, in.** | 1/1.382 | 1/1.602 | 2/1.602; 18.0 |

1 Average voltage and average clearance used for corona calculations.

4 Data is for existing configuration. Proposed line would be located on the existing towers and the Hanford – John Day 500-kV line would be re-located 200 feet north of its existing location on new towers with 3/1.300-in. conductors (Figure 1e).

**Table 3: Calculated peak and edge-of-right-of-way electric fields for the proposed McNary – John Day 500-kV line operated at maximum voltage by configuration.** Configurations are described in Tables 1 and 2 and shown in Figure 1.

**a) Peak electric field on right-of-way, kV/m**

| Location | Under Proposed Line | | In Remainder of Proposed Corridor | | In Existing Corridor | |
|---|---|---|---|---|---|---|
| **Line Clearance** | Minimum | Average | Minimum | Average | Minimum | Average |
| **Configuration 1** | 8.9 | 6.0 | 4.8 | 3.4 | 4.7 | 3.3 |
| **Configuration 2** | 8.9 | 6.0 | 8.8 | 6.4 | 8.8 | 6.3 |
| **Configuration 3** | 9.0 | 6.0 | — | — | — | — |
| **Configuration 4** | 8.8 | 5.9 | 8.9 | 6.0 | 8.9 | 6.0 |
| **Configuration 4A** | 8.9 | 6.0 | 8.8 | 5.9 | 8.9 | 6.0 |
| **Configuration 4B** | 8.8 | 5.9 | 8.9 | 6.0 | 8.9 | 6.0 |

**b) Electric field at edge of proposed right-of-way, kV/m**

| Location | Adjacent to Proposed Line[1] | | Adjacent to Existing Line in Proposed Corridor | | In Existing Corridor[1] | |
|---|---|---|---|---|---|---|
| **Line Clearance** | Minimum | Average | Minimum | Average | Minimum | Average |
| **Configuration 1** | 0.3 | 0.3 | 1.4 | 1.3 | 0.03, 1.4 | 0.04, 1.3 |
| **Configuration 2** | 2.8 | 2.8 | 1.2 | 1.1 | 0.3, 1.2 | 0.3, 1.1 |
| **Configuration 3** | 2.5, 0.4 | 2.4, 0.4 | — | — | — | — |
| **Configuration 4** | 2.5 | 2.5 | 0.2 | 0.2 | 0.1, 0.2 | 0.1, 0.2 |
| **Configuration 4A** | 2.5 | 2.5 | 1.5 | 1.4 | 0.1, 1.5 | 0.1,1.4 |
| **Configuration 4B** | 2.5 | 2.5 | 0.2 | 0.2 | 0.1, 0.2 | 0.1, 0.2 |

[1] Electric field at edge of right-of-way adjacent to proposed line is given first, except for Configuration 3, where levels at 75 and 175 ft. from centerline are given.

**Table 4: Calculated peak and edge-of-right-of-way magnetic fields for the proposed McNary – John Day 500-kV line operated at maximum current by configuration.** Configurations are described in Tables 1 and 2 and shown in Figure 1.

**a) Peak magnetic field on right-of-way, mG**

| **Location** | **Under Proposed Line** | | **In Remainder of Proposed Corridor** | | **In Existing Corridor** | |
|---|---|---|---|---|---|---|
| **Line Clearance** | Minimum | Average | Minimum | Average | Minimum | Average |
| **Configuration 1** | 296 | 203 | 261 | 166 | 298 | 192 |
| **Configuration 2** | 309 | 216 | 241 | 178 | 225 | 162 |
| **Configuration 3** | 303 | 207 | — | — | — | — |
| **Configuration 4** | 301 | 207 | 333 | 218 | 327 | 215 |
| **Configuration 4A** | 311 | 202 | 302 | 205 | 327 | 215 |
| **Configuration 4B** | 296 | 203 | 335 | 219 | 327 | 215 |

**b) Magnetic field at edge of proposed right-of-way, mG**

| **Location** | **Adjacent to Proposed Line[1]** | | **Adjacent to Existing Line in Proposed Corridor** | | **In Existing Corridor[1]** | |
|---|---|---|---|---|---|---|
| **Line Clearance** | Minimum | Average | Minimum | Average | Minimum | Average |
| **Configuration 1** | 17 | 17 | 78 | 65 | 3, 84 | 3, 71 |
| **Configuration 2** | 89 | 79 | 58 | 47 | 12, 58 | 12, 48 |
| **Configuration 3** | 82, 16 | 71, 16 | — | — | — | — |
| **Configuration 4** | 77 | 67 | 10 | 10 | 8, 9 | 7, 9 |
| **Configuration 4A** | 89 | 77 | 69 | 60 | 69, 6 | 59, 6 |
| **Configuration 4B** | 80 | 70 | 10 | 10 | 3, 9 | 3, 9 |

[1] Magnetic field at edge of right-of-way adjacent to proposed line is given first, except for Configuration 3,where levels at 75 and 175 ft. from centerline are given.

**Table 5: States with transmission-line field limits.**

| STATE AGENCY | WITHIN RIGHT-OF-WAY | AT EDGE OF RIGHT-OF-WAY | COMMENTS |
|---|---|---|---|
| **a. 60-Hz ELECTRIC-FIELD LIMIT, kV/m** | | | |
| Florida Department of Environmental Regulation | 8 ( 230 kV)<br>10 (500 kV) | 2 | Codified regulation, adopted after a public rulemaking hearing in 1989. |
| Minnesota Environmental Quality Board | 8 | — | 12-kV/m limit on the high-voltage direct-current (HVDC) nominal electric field. |
| Montana Board of Natural Resources and Conservation | 7[1] | 1[2] | Codified regulation, adopted after a public rulemaking hearing in 1984. |
| New Jersey Department of Environmental Protection | — | 3 | Used only as a guideline for evaluating complaints. |
| New York State Public Service Commission | 11.8<br>(7,11)[1] | 1.6 | Explicitly implemented in terms of a specified right-of-way width. |
| Oregon Facility Siting Council | 9 | — | Codified regulation, adopted after a public rulemaking hearing in 1980. |
| **b. 60-Hz MAGNETIC-FIELD LIMIT, mG** | | | |
| Florida Department of Environmental Regulation | — | 150 ( 230 kV)<br>200 (500 kV) | Codified regulations, adopted after a public rulemaking hearing in 1989. |
| New York State Public Service Commission | — | 200 | Adopted August 29, 1990. |

[1] At road crossings
[2] Landowner may waive limit

Sources: TDHS Report, 1989; TDHS Report, 1990

**Table 6: Common noise levels.**

| Sound Level, dBA | Noise Source or Effect |
|---|---|
| 128 | Threshold of pain |
| 108 | Rock-and-roll band |
| 80 | Truck at 50 ft. |
| 70 | Gas lawnmower at 100 ft. |
| 60 | Normal conversation indoors |
| 50 | Moderate rainfall on foliage |
| 47 | Edge of proposed 500-kV right-of-way during rain |
| 40 | Refrigerator |
| 25 | Bedroom at night |
| 0 | Hearing threshold |

Adapted from: USDOE, 1996.

**Table 7: Typical sound attenuation (in decibels) provided by buildings.**

| | Windows opened | Windows closed |
|---|---|---|
| **Warm climate** | 12 | 24 |
| **Cold climate** | 17 | 24 |

Source: EPA, 1978.

**Table 8: Predicted foul-weather audible noise (AN) levels at edge of proposed right-of-way (ROW) for the McNary – John Day 500-kV line by configuration.** AN levels expressed in decibels on the A-weighted scale (dBA). $L_{50}$ and $L_5$ denote the levels exceeded 50 and 5 percent of the time, respectively. Configurations are described in Tables 1 and 2 and shown in Figure 1.

| | Foul-weather AN | | | |
|---|---|---|---|---|
| | Proposed Corridor[1] | | Existing Corridor[1] | |
| Configuration[1] | $L_{50}$, dBA | $L_5$, dBA | $L_{50}$, dBA | $L_5$, dBA |
| **1** | 49, 50 | 52, 54 | 46, 49 | 50, 53 |
| **2** | 51, 50 | 54, 54 | 47, 50 | 51, 53 |
| **3** | 49, 46 | 52, 49 | 43, 41 | 46, 45 |
| **4** | 53, 54 | 56, 57 | 51, 54 | 55, 57 |
| **4A** | 54, 53 | 57, 57 | 53,53 | 56, 57 |
| **4B** | 52, 54 | 55, 57 | 50, 54 | 53, 57 |

[1] AN level at edge of right-of-way adjacent to proposed line is given first, except for Configuration 3, where levels at 75 and 175 ft. from centerline are given.

**Table 9: Predicted fair-weather radio interference (RI) levels at 100 feet (30.5 m) from the outside conductor of the proposed McNary – John Day 500-kV line by configuration.** RI levels given in decibels above 1 microvolt/meter (dBμV/m) at 1.0 MHz. $L_{50}$ denotes level exceeded 50 percent of the time. Configurations are described in Tables 1 and 2 and shown in Figure 1.

| | Fair-weather RI | |
|---|---|---|
| | Proposed Corridor [1] | Existing Corridor[1] |
| Configuration | $L_{50}$, dBμV/m | $L_{50}$, dBμV/m |
| **1** | 38, 31 | 39, 30 |
| **2** | 38, 31 | 38, 31 |
| **3** | 37 | — |
| **4** | 37, 45 | 33, 45 |
| **4A** | 37, 33 | 45, 33 |
| **4B** | 37, 45 | 33, 45 |

[1] RI level at 100 ft. from outside conductor of proposed line given first.

**Table 10: Predicted maximum foul-weather television interference (TVI) levels at 100 feet (30.5 m) from the outside conductor of the proposed McNary – John Day 500-kV line by configuration**. TVI levels given in decibels above 1 microvolt/meter (dBµV/m) at 75 MHz. Configurations are described in detail in Tables 1 and 2 and shown in Figure 1.

| Configuration | Foul-weather TVI | |
|---|---|---|
| | Proposed Corridor[1] | Existing Corridor[1] |
| | Maximum (foul), dBµV/m | Maximum (foul), dBµV/m |
| **1** | 23, 14 | 26, 14 |
| **2** | 23, 14 | 21, 14 |
| **3** | 23 | — |
| **4** | 23, 33 | 14, 33 |
| **4A** | 23, 14 | 33, 14 |
| **4B** | 23, 33 | 14, 33 |

[1] TVI level at 100 ft. from outside conductor of proposed line is given first.

**Figure 1: Configurations for the proposed McNary – John Day 500-kV line: a) Proposed line with parallel 230-kV and 345-kV lines (Configuration 1); b) Proposed line with parallel 230-kV, 345-kV, and double-circuit 500-kV lines (Configuration 2); c) Proposed line with no parallel lines (Configuration 3); d) Proposed line with parallel 230-kV, 345-kV, and 500-kV lines (Configurations 4 and 4B); and e) Proposed line on existing Hanford – John Day 500-kV line towers with parallel 230-kV, 345-kV, and 500-kV lines (Configuration 4A).** (5 pages)

a) Proposed line with parallel 230-kV and 345-kV lines (Configuration 1) (not to scale)

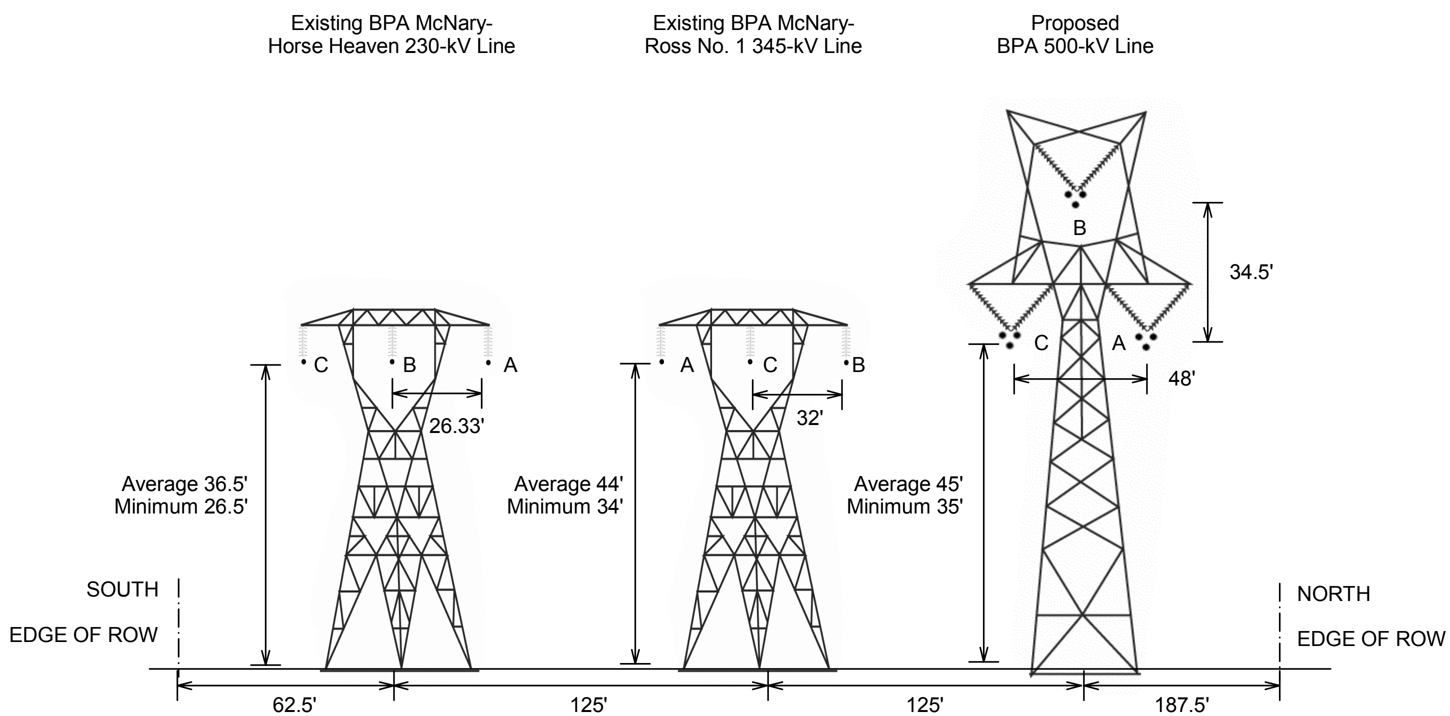


**Figure 1, continued**

b) Proposed line with parallel 230-kV, 345-kV, and double-circuit 500-kV lines (Configuration 2) (not to scale)

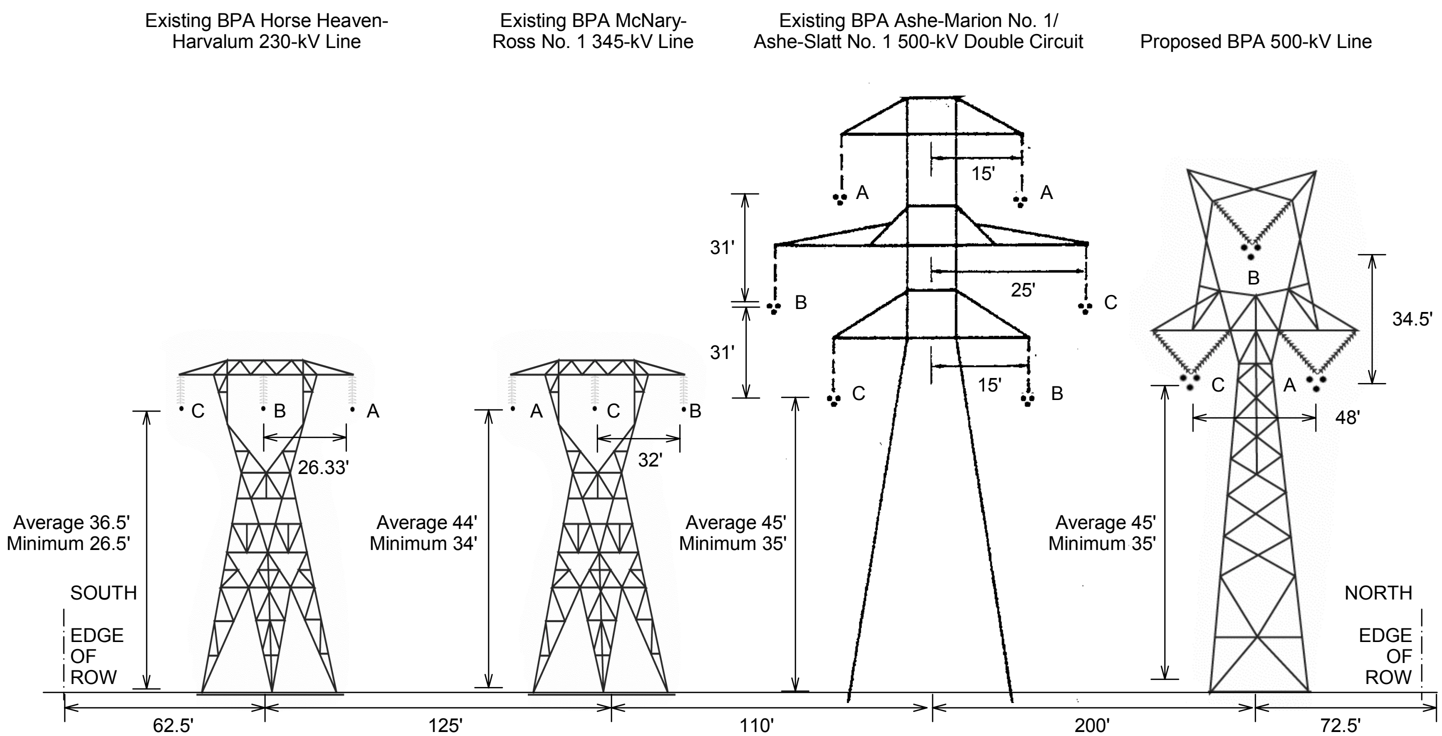
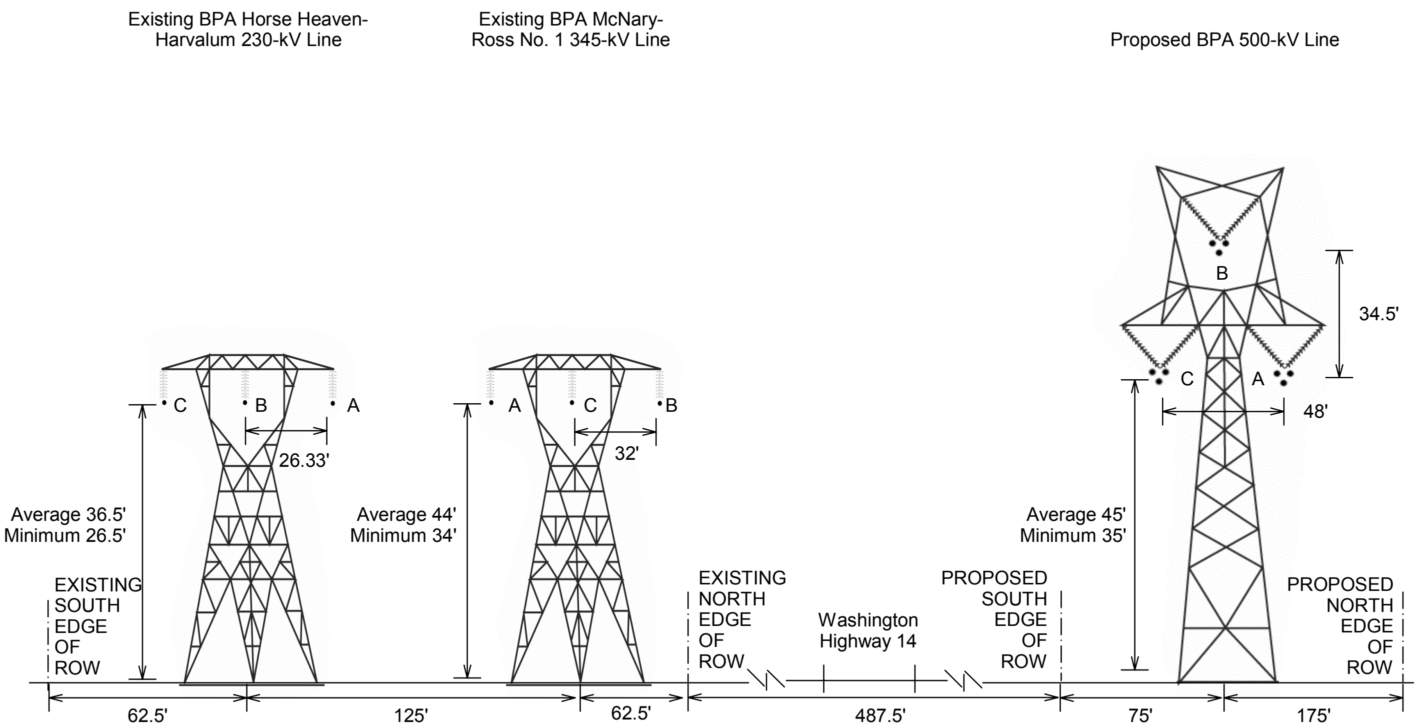


**Figure 1, continued**

c) Proposed line with no parallel lines within 600 feet (Configuration 3) (not to scale)



## Figure 1, continued

d) Proposed line with parallel 230-kV, 345-kV, and 500-kV lines (Configurations 4 and 4B) (not to scale)

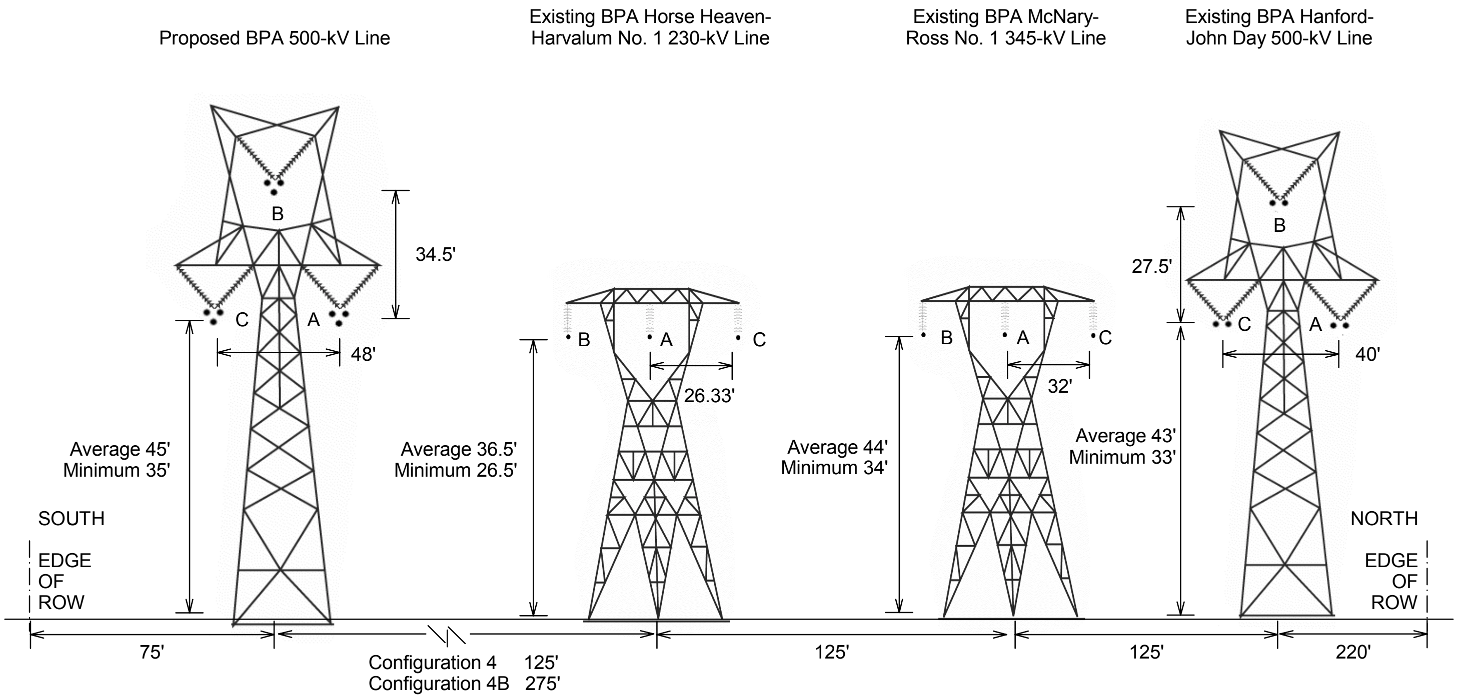


**Figure 1, continued**

e) Proposed line on existing Hanford – John Day 500-kV towers with parallel 230-kV, 345-kV, and 500-kV lines (Configuration 4A) (not to scale)

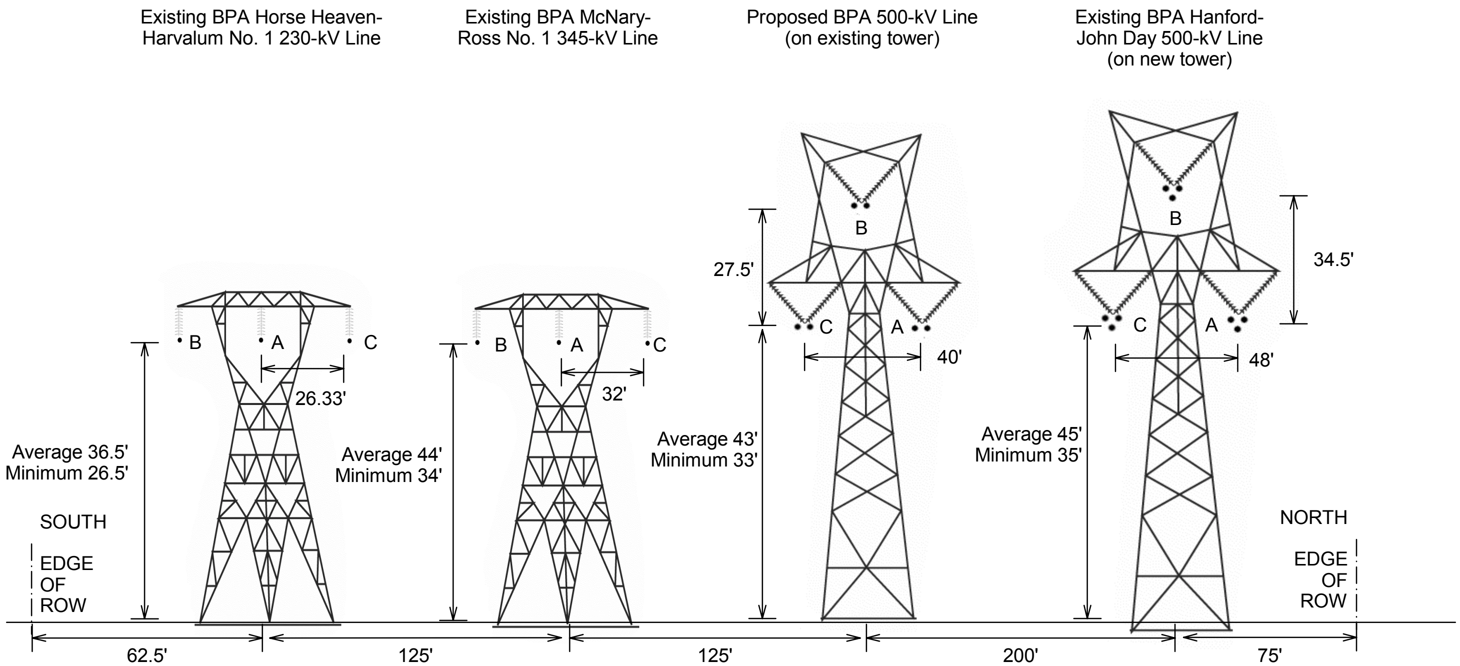


**Figure 2: Electric-field profiles for configurations of the proposed McNary – John Day 500-kV line under maximum voltage conditions: a) Proposed line with parallel 230-kV and 345-kV lines (Configuration 1); b) Proposed line with parallel 230-kV, 345-kV, and double-circuit 500-kV lines (Configuration 2); c) Proposed line with no parallel lines within 600 feet (Configuration 3); d) Proposed line with parallel 230-kV, 345-kV, and 500-kV lines (Configurations 4); e) Proposed line on existing towers with parallel 230-kV, 345-kV, and 500-kV lines (Configurations 4A); and f) Proposed line with parallel 230-kV, 345-kV, and 500-kV lines (Configuration 4B).** (4 pages) Configurations are described in Tables 1 and 2 and shown in Figure 1.

a) Proposed line with parallel 230-kV and 345-kV lines (Configuration 1)

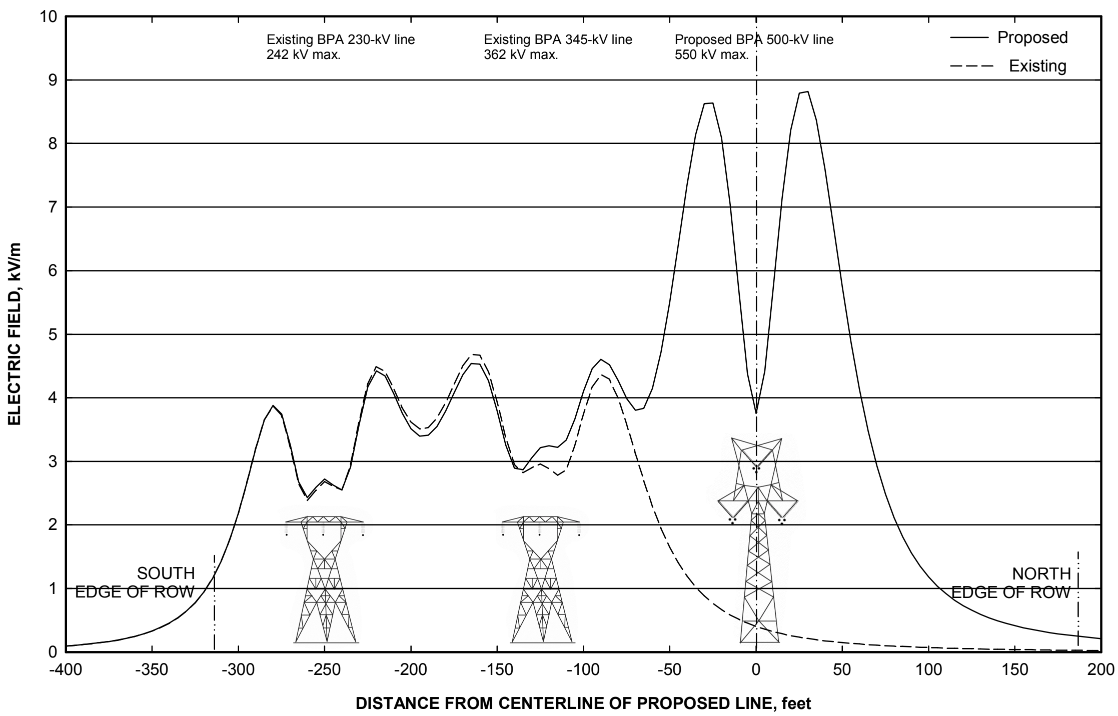
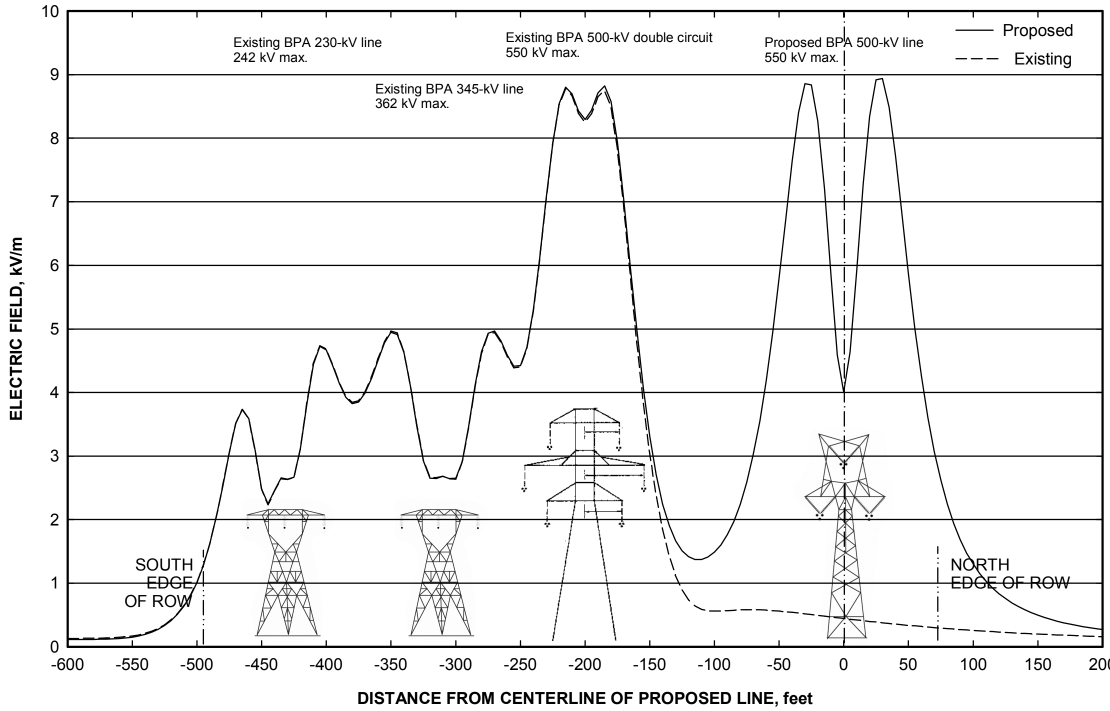


**Figure 2, continued**

b) Proposed line with parallel 230-kV, 345-kV, and double-circuit 500-kV lines (Configuration 2)




c) Proposed line with no parallel lines within 600 feet (Configuration 3)

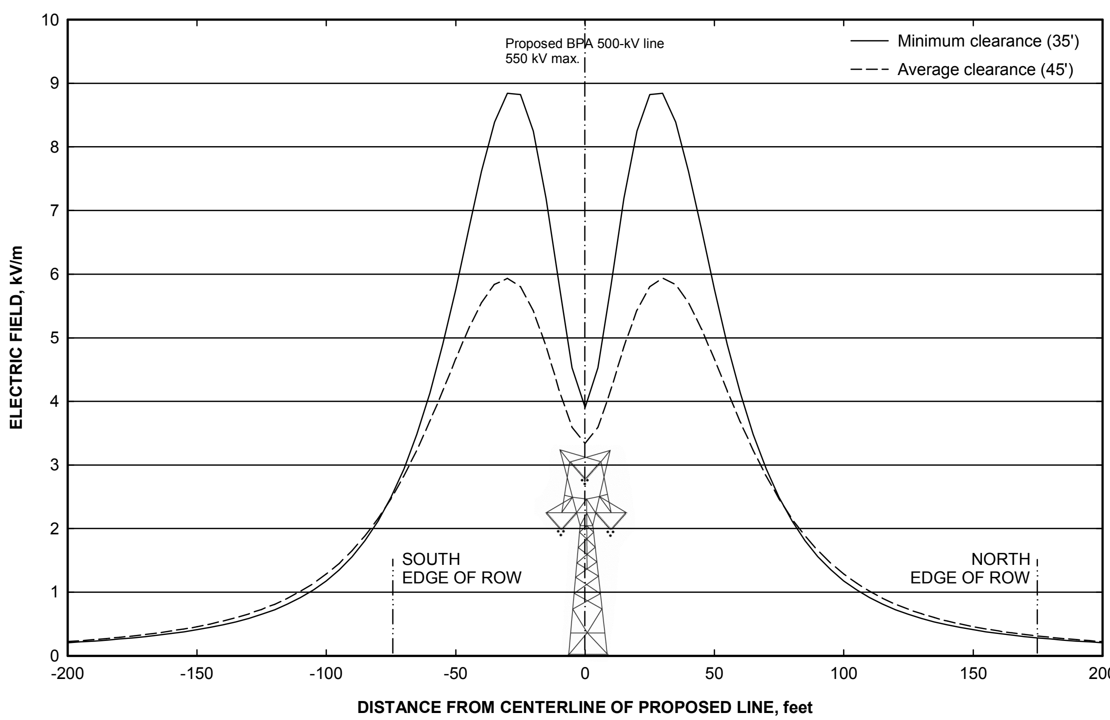
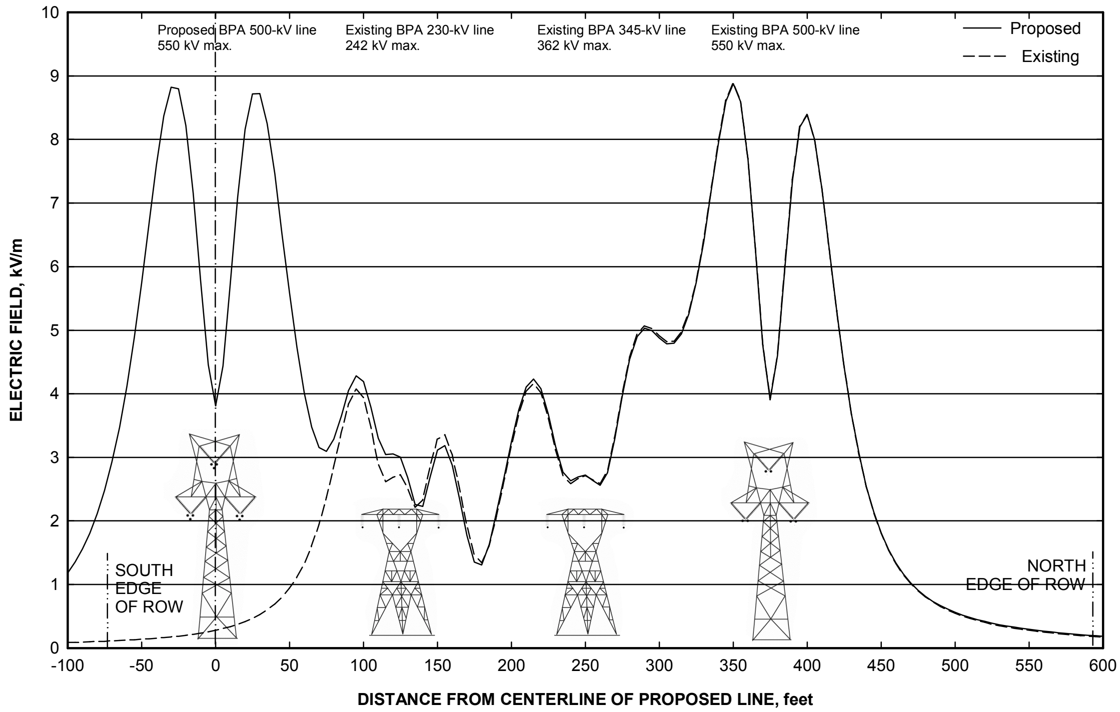
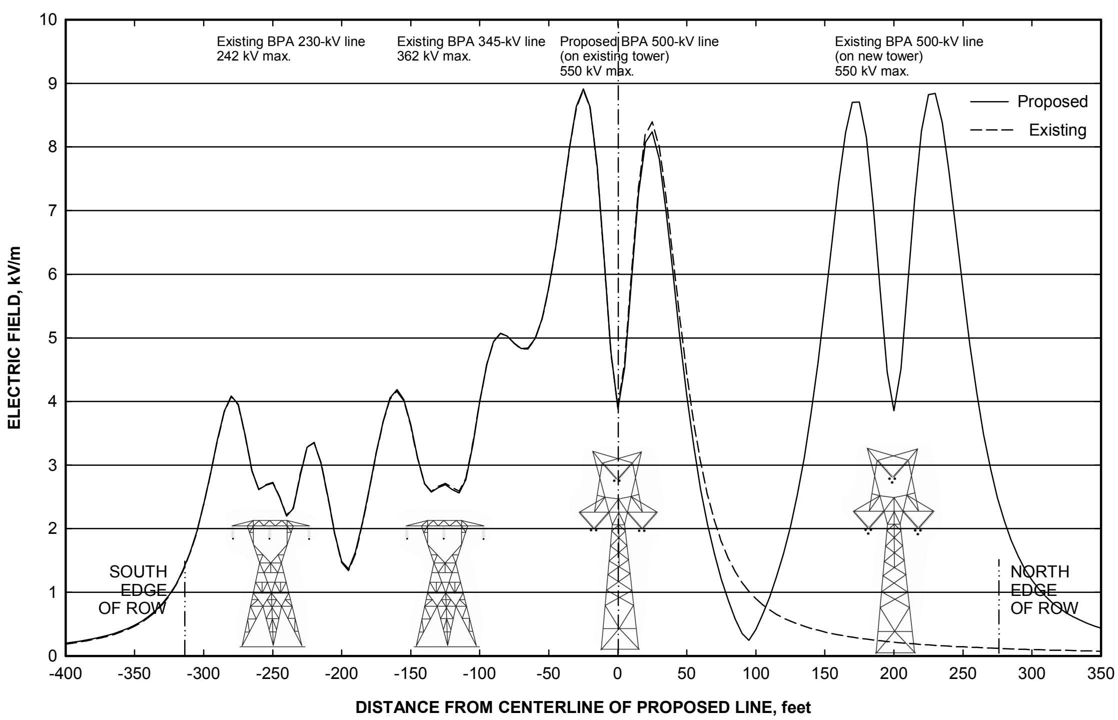


**Figure 2, continued**

d) Proposed line with parallel 230-kV, 345-kV, and 500-kV lines (Configuration 4, 125-ft. spacing)




e) Proposed line on existing towers with parallel 230-kV, 345-kV, and 500-kV lines (Configuration 4A)



## Figure 2, continued

f) Proposed line with parallel 230-kV, 345-kV, and 500-kV lines (Configuration 4B, 275-ft. spacing)

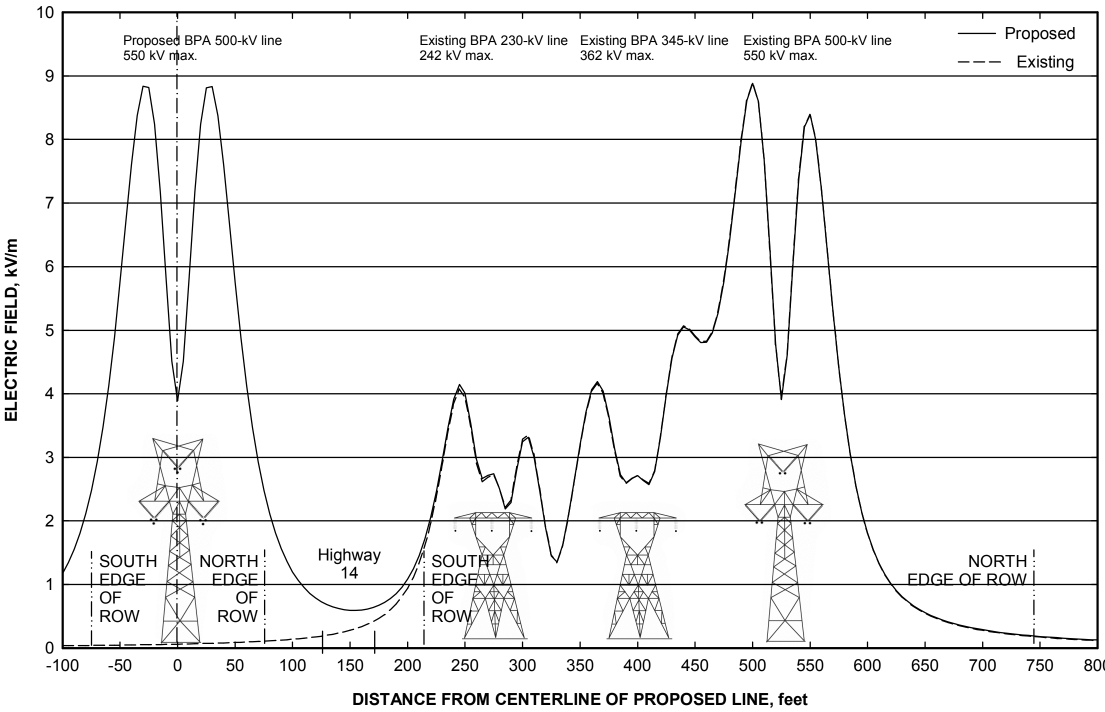


**Figure 3: Magnetic-field profiles for configurations of the proposed McNary – John Day 500-kV line under maximum current conditions: a) Proposed line with parallel 230-kV and 345-kV lines (Configuration 1); b) Proposed line with parallel 230-kV, 345-kV, and double-circuit 500-kV lines (Configuration 2); c) Proposed line with no parallel lines (Configuration 3); and d) Proposed line with parallel 230-kV, 345-kV, and 500-kV lines (Configuration 4); e) Proposed line on existing towers with parallel 230-kV, 345-kV, and 500-kV lines (Configurations 4A); and f) Proposed line with parallel 230-kV, 345-kV, and 500-kV lines (Configuration 4B).** (4 pages) Configurations are described in Tables 1 and 2 and shown in Figure 1.

a) Proposed line with parallel 230-kV and 345-kV lines (Configuration 1)

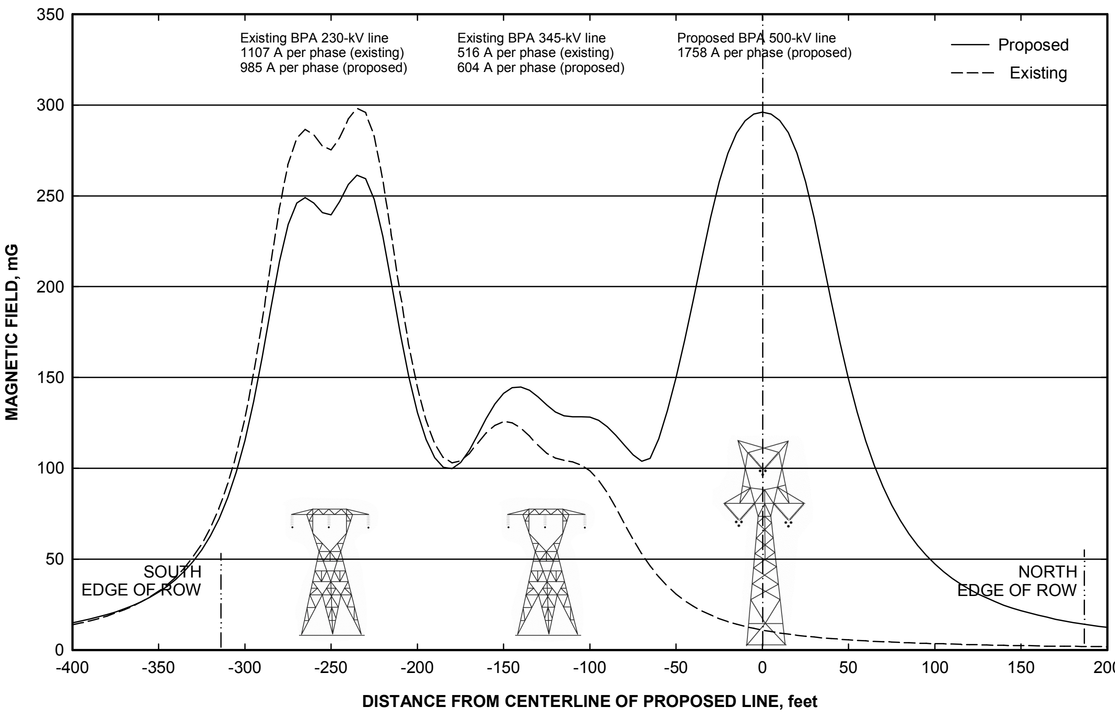
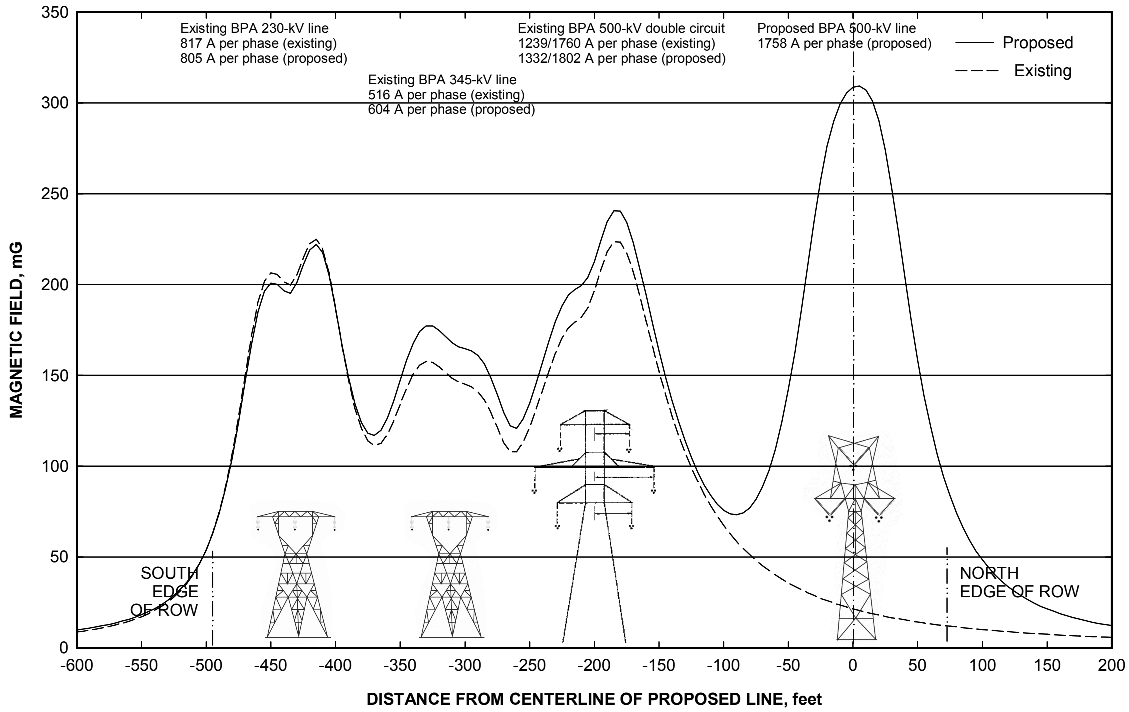


**Figure 3, continued**

b) Proposed line with parallel 230-kV, 345-kV, and double-circuit 500-kV lines (Configuration 2)




c) Proposed line with no parallel lines within 600 feet (Configuration 3)

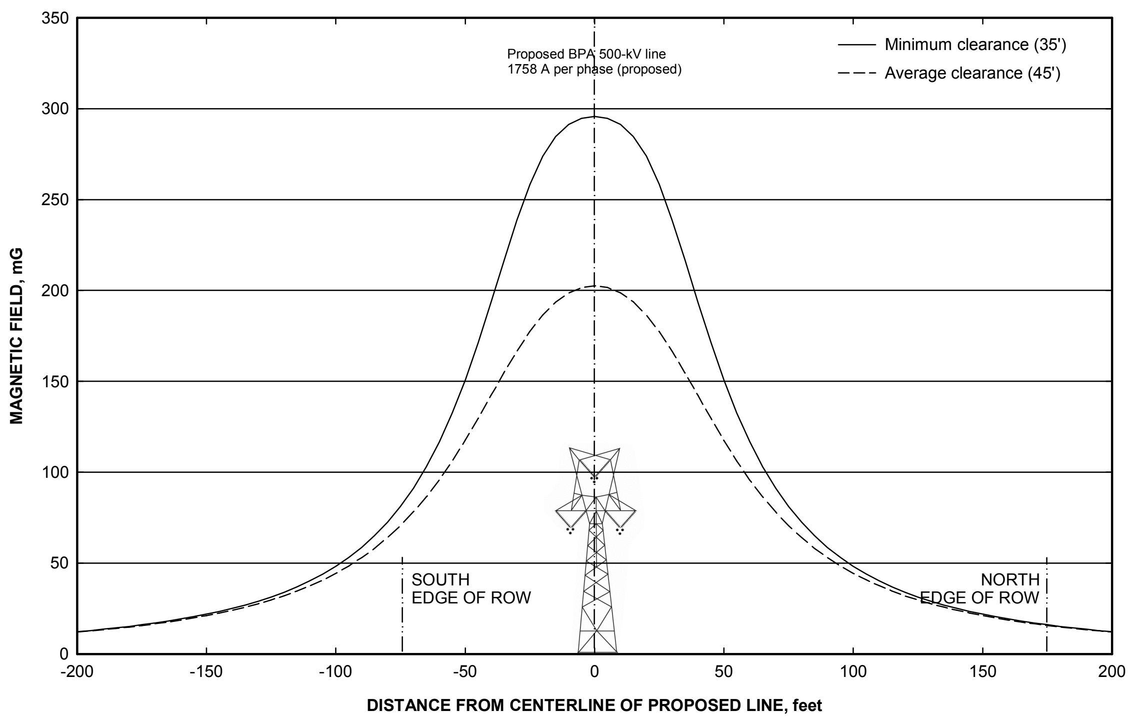
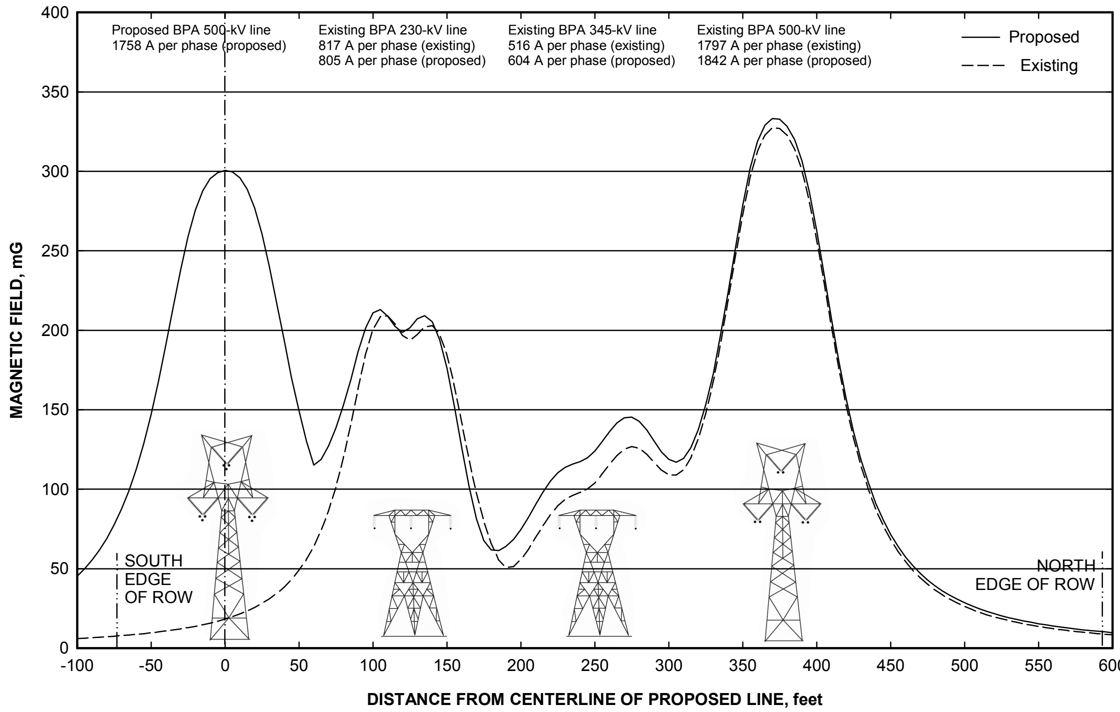


**Figure 3, continued**

d) Proposed line with parallel 230-kV, 345-kV, and 500-kV lines (Configuration 4, 125-ft. spacing)




e) Proposed line on existing towers with parallel 230-kV, 345-kV, and 500-kV lines (Configuration 4A)

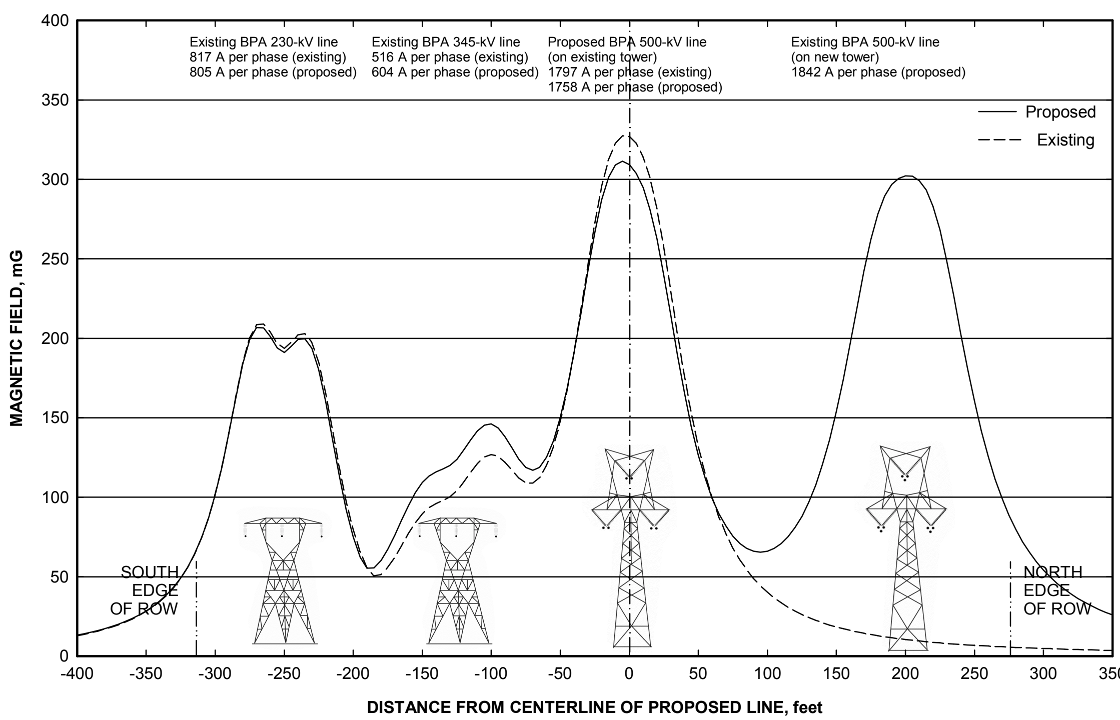


**Figure 3, continued**

f) Proposed line with parallel 230-kV, 345-kV, and 500-kV lines (Configuration 4B, 275-ft. spacing)

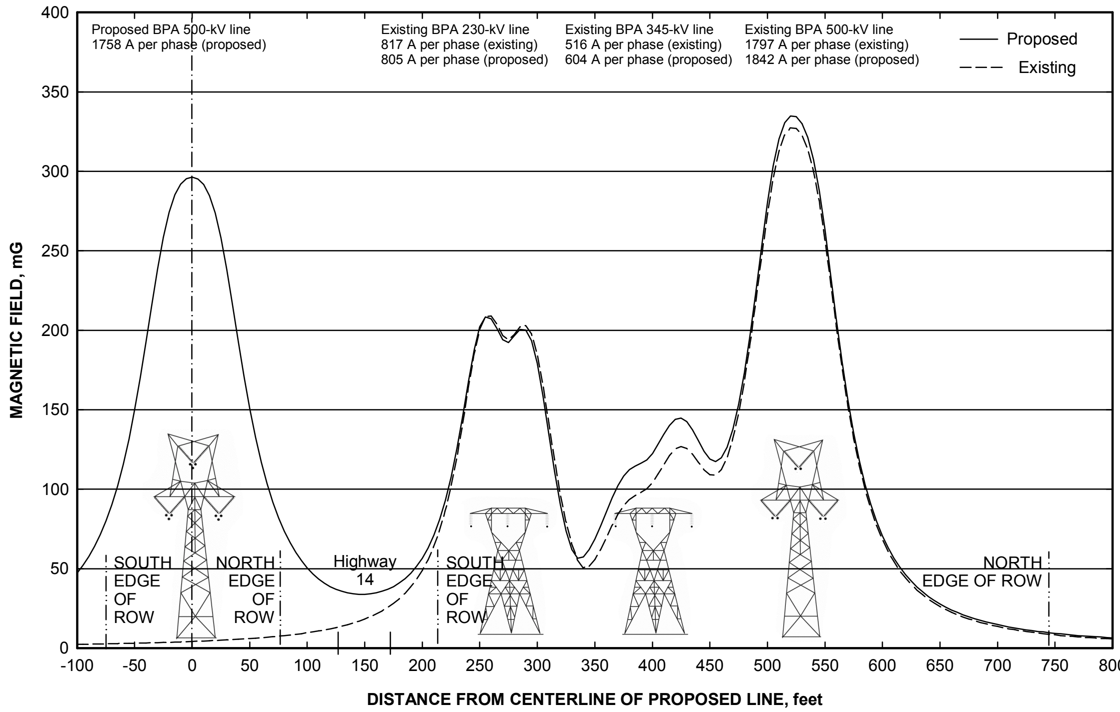


**Figure 4: Predicted foul-weather $L_{50}$ audible noise levels from configurations of proposed McNary – John Day 500-kV line: a) Proposed line with parallel 230-kV and 345-kV lines (Configuration 1); b) Proposed line with parallel 230-kV, 345-kV, and double-circuit 500-kV lines (Configuration 2); c) Proposed line with no parallel lines (Configuration 3); and d) Proposed line with parallel 230-kV, 345-kV, and 500-kV lines (Configuration 4); e) Proposed line on existing towers with parallel 230-kV, 345-kV, and 500-kV lines (Configurations 4A); and f) Proposed line with parallel 230-kV, 345-kV, and 500-kV lines (Configuration 4B).** (4 pages) Configurations are described in Tables 1 and 2 and shown in Figure 1.

a) Proposed line with parallel 230-kV and 345-kV lines (Configuration 1)

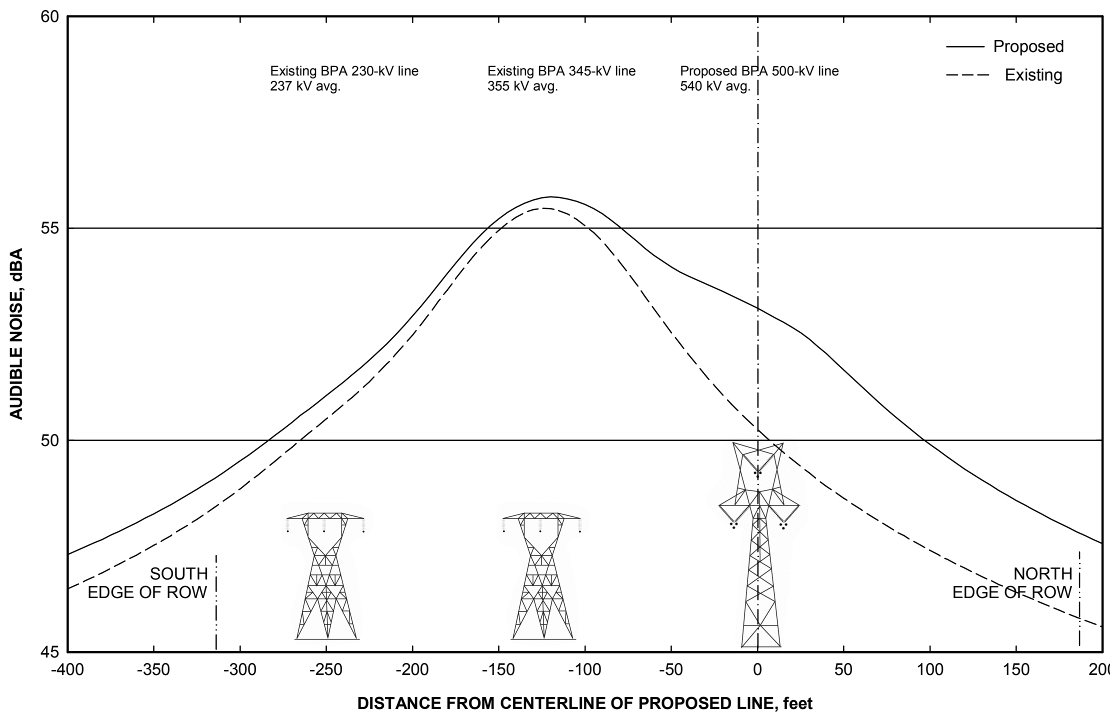
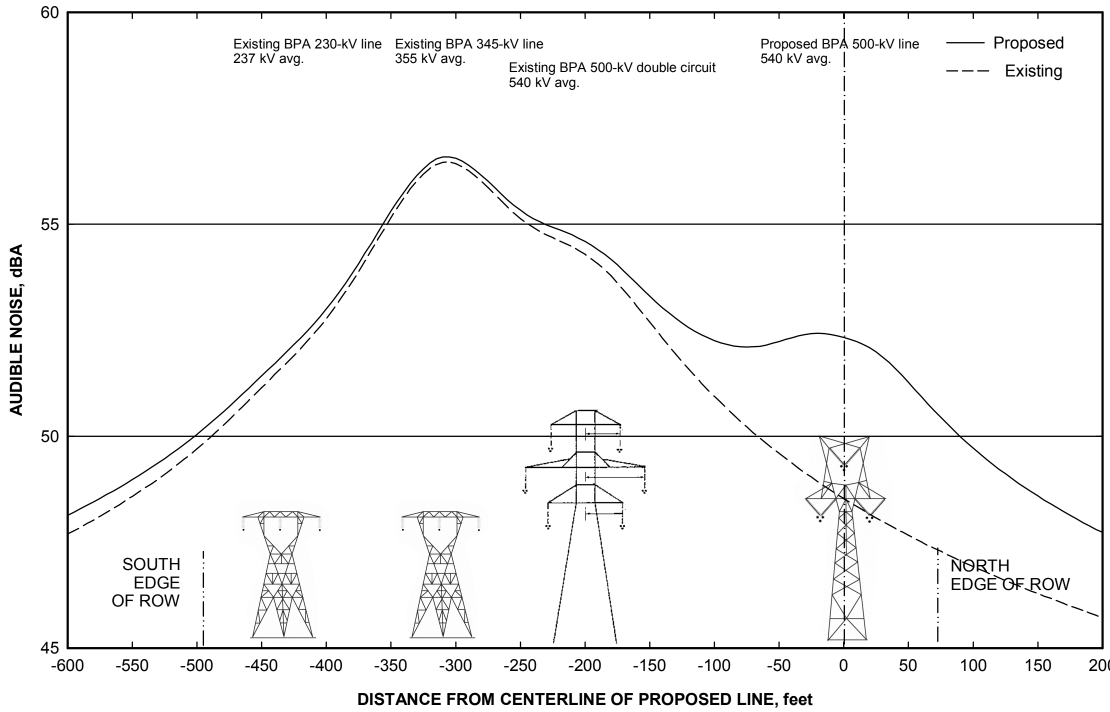


**Figure 4, continued**

b) Proposed line with parallel 230-kV, 345-kV, and double-circuit 500-kV lines (Configuration 2)




c) Proposed line with no parallel lines within 600 feet (Configuration 3)

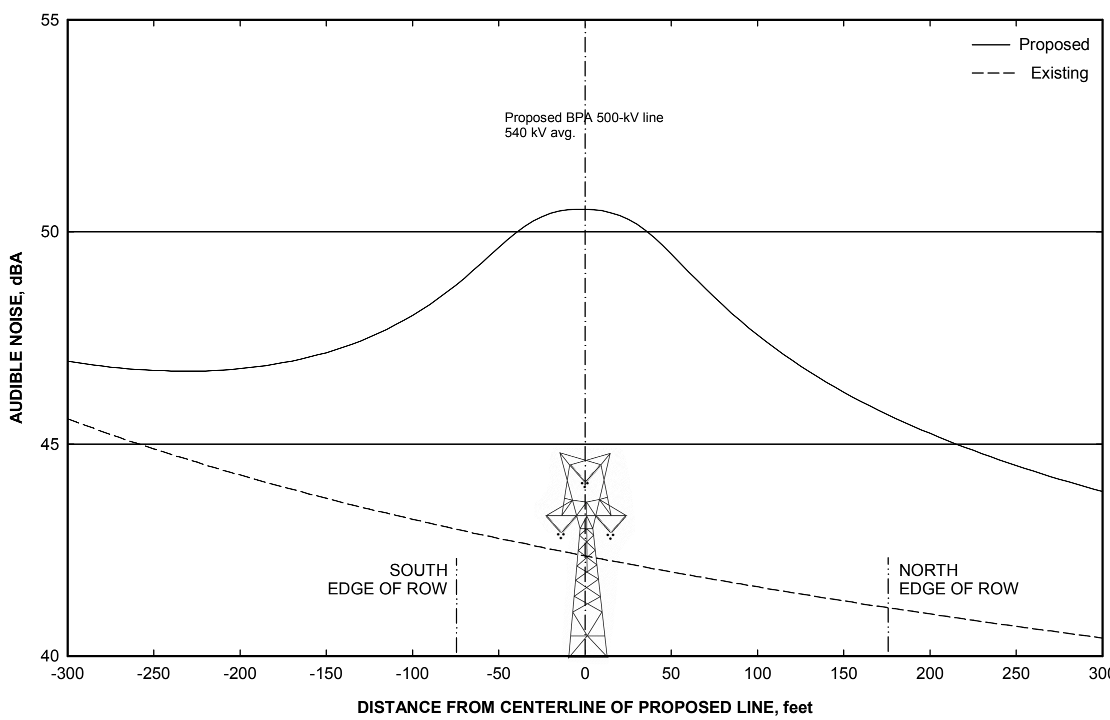
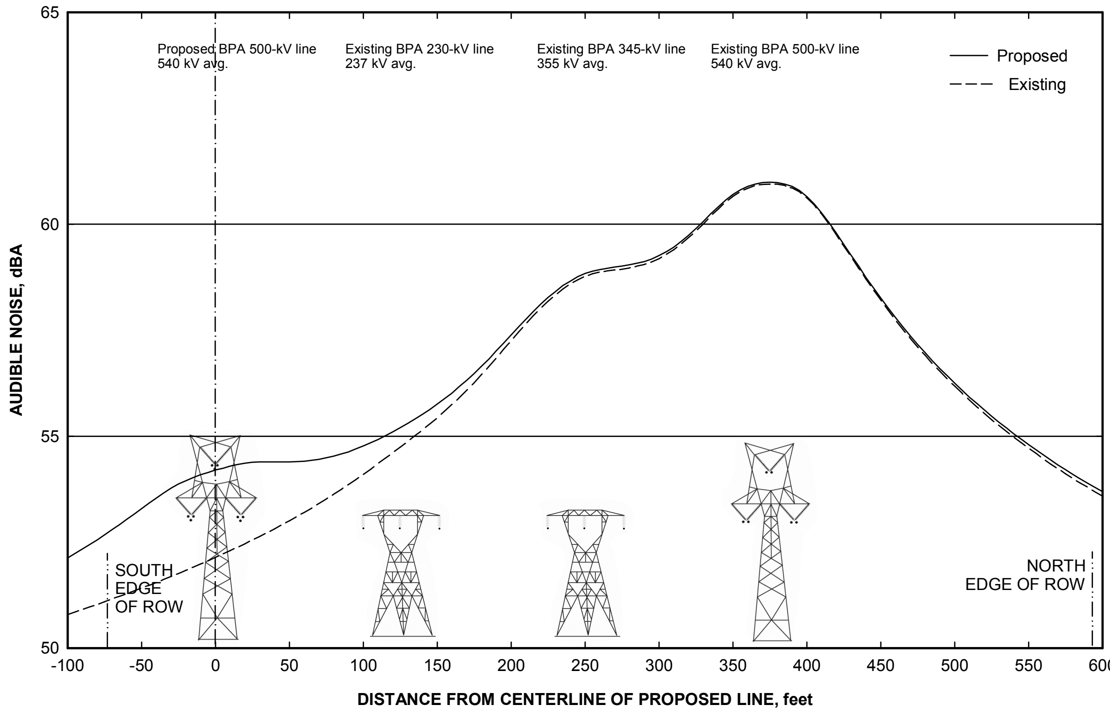


**Figure 4, continued**

d) Proposed line with parallel 230-kV, 345-kV, and 500-kV lines (Configuration 4, 125-ft. spacing)




e) Proposed line on existing towers with parallel 230-kV, 345-kV, and 500-kV lines (Configuration 4A)

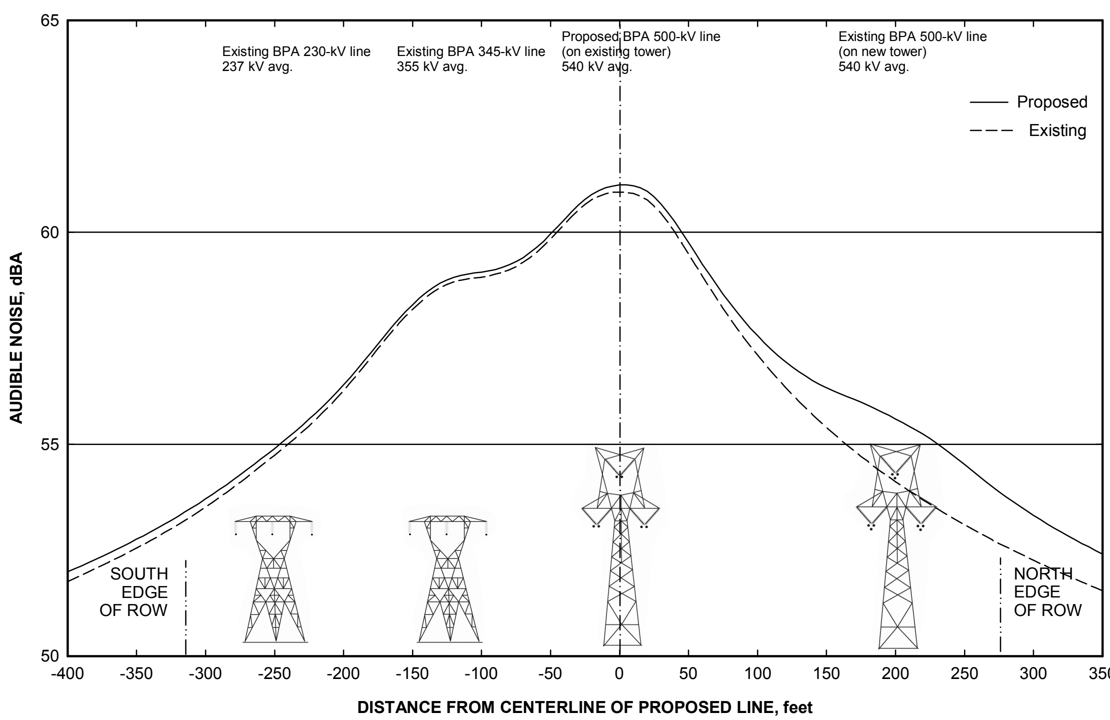
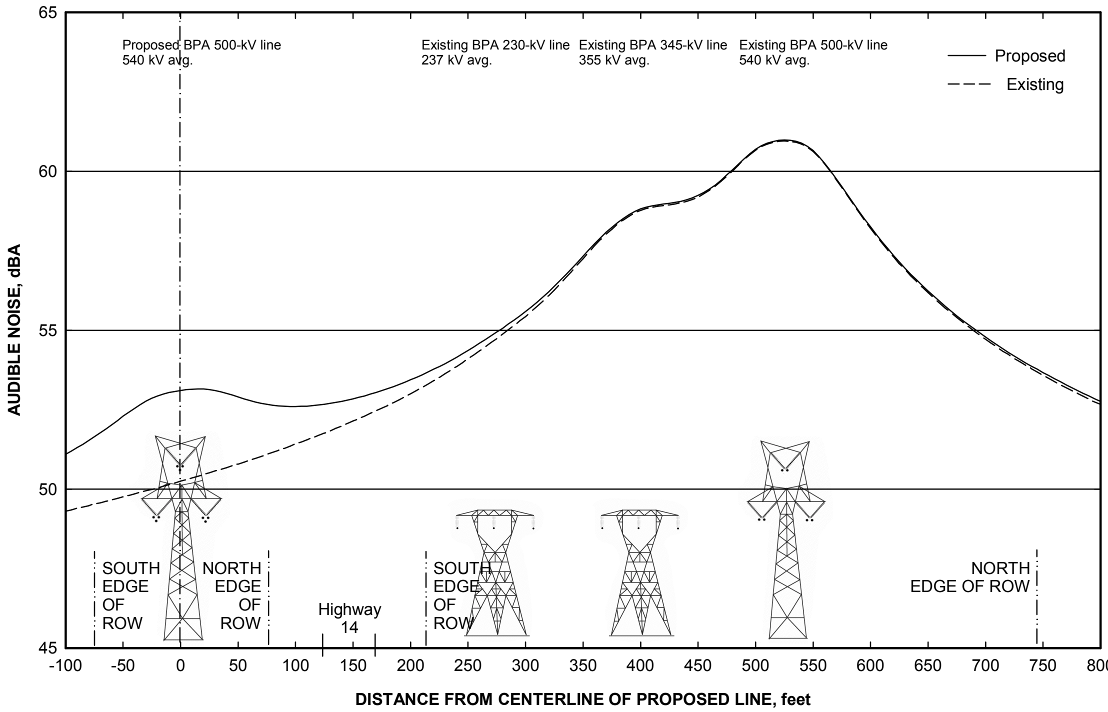


**Figure 4, continued**

f) Proposed line with parallel 230-kV, 345-kV, and 500-kV lines (Configuration 4B, 275-ft. spacing)



# TECHNICAL MEMORANDUM

| | | | |
|---|---|---|---|
| **Date:** | December 19, 2017 | **Project No.:** | 17-88390 |
| **To:** | Kellen Tardaewether, Senior Siting Analyst | **Company:** | Oregon Department of Energy |
| **From:** | Gage Miller, Kara Warner, and Kennard F. Kosky, P.E. | **Email:** | Kellen.Tardaewether@oregon.gov |

**RE: REVIEW OF EXHIBIT X, NOISE FOR BOARDMAN TO HEMINGWAY TRANSMISSION LINE PROJECT**

## 1.0 INTRODUCTION

Golder Associates Inc. (Golder) was contracted by Oregon Department of Energy (CDOE) to review Exhibit X which provides analysis of potential noise impacts from the proposed Idaho Power Boardman to Hemmingway Transmission Line (Project). Golder reviewed the Exhibit X redlined version dated December 2017 and the responses to ODOE's Request for Additional Information also dated December 2017. In general Golder found the assessment to be adequately conservative and thorough.

## 2.0 GOLDER'S COMMENTS

### 2.1 Baseline

Golder's review of the Sound Survey Analysis and Results (Exhibit X, Section 3.4.5.2), Noise Control Regulation OAR 340-035-0035(3) sound measurement procedures, and Attachment X-6 found the baseline noise analysist to be properly performed from a technical standpoint and the use of the "late night" noise level to be conservative in nature for use as the baseline noise level for comparison to the Ambient Antidegradation Standard [OAR 340-035-0035(1)(b)(B)(i)].

### 2.2 Impact Assessment

Based on comments and concerns brought up in the request for additional information, Golder focused on the operational noise impacts caused by the Corona Effect. Based on research and side by side comparison of similar impact studies Golder has performed, we found the expected audible noise levels resulting from corona during foul weather conditions of 52 dBA at the edge of the right or way and 58 dBA under the transmission line (Exhibit X, Section 3.3.2.1) to be consistent with our sources and conservative in nature.

Additionally Golder reviewed the impact assessment at the identified receptors of the foul weather corona noise conditions added to the baseline noise levels (Exhibit X, Section 3.4.5) and found them to be calculated properly and to be conservative as the calculated impacts were based only on geometric



**Golder Associates Inc.**
6026 NW 1st Place
Gainesville, FL 32607 USA
Tel: (352) 336-5600 Fax: (352) 336-6603 www.golder.com

spreading of noise (distance attenuation) and did not include any other attenuation factors such as ground attenuation, foliage, terrain, or other barriers that may be between the noise source and sensitive receptors.

The conclusion that the Project would comply with the maximum permissible sound levels outlined in Table 8 of regulation OAR 340-035-0035(1)(b)(B)(i), but would exceed the ambient antidegradation standard outlined in that same standard at the identified receptors seems reasonable and conservative.

## 2.3 Frequency of Foul Weather

The determination of frequency of foul weather (Exhibit X, pages X-22 to X-27) was reviewed by Golder's staff meteorologist and were found to be adequate. The stations chosen for analysis were also reviewed by our meteorologist and are deemed to be complete and accurate. The region is arid in nature, and the use of 0.8 to 5.0 mm/hr based on a conservative application of the Corona and Field Effects (CAFÉ) program is adequate for this study's purposes.

Historical weather data is the preferred standard to use when it comes to this type of analysis. The analysis demonstrates the "infrequent" nature of the meteorological conditions of concern (foul weather events) presented in the data from the identified weather stations and summarized in Table X-8 and Table X-9. Additionally there does appear to be some precedent, based on the footnotes (8 and 9) found and summarized on page X-27, that similar levels of precipitation in a similar area ("east of the Cascades") have been considered to be "infrequent", though Golder is not sure if exemptions were given for these projects. Using the thresholds summarized on page X-27 to determine infrequency is reasonable, but Golder considers the foul weather events to be infrequent as the Project resides in an arid climate with low levels of precipitation. This determination is based on the meteorological data alone.

## 2.4 Request for Exemption

Based review of the Request for Exception to Ambient Antidegratdation Standard (Exhibit X, Page X-22 to X-52) and OAR 340-.35-0035(6), Golder in general found the request to be reasonable as exceedances would be infrequent based on the following reasons:

1. Baseline noise levels are conservatively estimated and are based on a late night period of time when outdoor human activities are limited. Based on the typical attenuation of open windows or doors of -10 dBA, the noise levels impacting humans indoors would be close to that of the original outdoor baseline noise levels.
2. Impact noise levels were conservatively estimated based only on distance attenuation, therefore this noise level is not expected to be consistently this elevated during every foul weather event.
3. The infrequency of foul weather events given the meteorological data provided and the arid nature of the area of the Project.

## 2.5 Exception Conditions

Golder reviewed the Exception Conditions sections (Exhibit X, page X-52). The requested conditions include the following language “IPC requests that authorization for exemption not be limited to a specific time of day or in any other temporal or weather-dependent manner.” In section 3.3.2.1 Predicted Operational Noise Level stated that “irregularities” such as nicks and scrapes on the conductor surface, contaminants such as dust or insects, and foul weather conditions can all cause an increased corona noise level.

The condition outlined above would include an exception for all irregularities that would be difficult to identify. Some of the above irregularities, such as nicks and scrapes, could result in longer term noise impacts (not infrequent) and may be within IPC’s ability to fix and control. Such irregularities would not qualify as infrequent.

Additionally when applied to the OAR 340-0035-0100 provisions for variance, this would also not qualify as being “conditions beyond the control of the persons granted such variance”.

## 2.6 Conclusion

The applicant’s Noise Exhibit X impact assessment study is reasonable, technically sound, and appropriately conservative in nature. The Project has a very low risk of having a negative impact on human health and a low risk of outdoor or indoor interference with human activities. Based on the ODEQ’s Noise Control Regulations, the Project would not qualify for an exceedance/variance for non-weather related irregularities as those irregularities could be long term in nature and potentially within IPC’s control. Golder recommends that ODOE confirm that the exemption would not include non-weather related irregularities that are not caused by foul weather events or a variance for irregularities that are under the operator’s control.

Based on the meteorological data, foul weather events that would increase the corona noise levels to that of exceeding the Antidegradation Standard would be infrequent as a stand-alone factor, and additionally infrequent since any foul weather event would have to occur simultaneously with a low baseline noise level (typically occurring late at night). While the exhibit primarily focuses on the foul weather conditions as the only factor that it considers for determining infrequency, the exhibit does not go into much detail that foul weather conditions would also have to occur during a limited time when lower baseline noise levels are also occurring.



Golder Associates

**TARDAEWETHER Kellen * ODOE**

| | |
|---|---|
| **From:** | Robert Strope <RStrope@cityoflagrande.org> |
| **Sent:** | Monday, April 30, 2018 1:21 PM |
| **To:** | TARDAEWETHER Kellen * ODOE |
| **Subject:** | RE: B2H ApASC Completeness Review Update and City Comments |

Kellen,

I appreciate your following up on this. Have a great week.

*Robert*

Robert A. Strope, MPA
City Manager
City of La Grande
rstrope@cityoflagrande.org
(541) 962-1309
(541) 963-3333 fax



---

**From:** TARDAEWETHER Kellen * ODOE [mailto:Kellen.Tardaewether@oregon.gov]
**Sent:** Monday, April 30, 2018 9:49 AM
**To:** Robert Strope <RStrope@cityoflagrande.org>
**Subject:** RE: B2H ApASC Completeness Review Update and City Comments

Hi Robert,

Sorry I'm just getting back to you now, I was at the Council meeting at the end of last week. I see that you included these comments in your letter and I will send them to IPC and review the letter. If, at a later date, IPC proposes to add the MUA-1 back into the proposed project, they would have to do so via an amendment and the City's applicable substantive criteria and comments would be reviewed at that time. Let me know if you have any questions and talk to you soon,

Kellen

**Kellen Tardaewether**
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor

Salem, OR 97301
P:(503) 373-0214
C: (503) 586-6551
Oregon.gov/energy

*Leading Oregon to a safe, clean, and sustainable energy future.*

---

**From:** Robert Strope [mailto:RStrope@cityoflagrande.org]
**Sent:** Friday, April 27, 2018 9:43 AM
**To:** TARDAEWETHER Kellen * ODOE <Kellen.Tardaewether@oregon.gov>
**Subject:** RE: B2H ApASC Completeness Review Update and City Comments

Kellen,

The City of La Grande would like to provide additional comments regarding IPC response, specifically, we want to identify route and road improvements that will be required to provide access to the proposed or Morgan Lake alternative routes and to request the use of H Frame towers in any view sheds that can be observed from Morgan Lake or the City of La Grande. We also want to ask that a condition be added to require IPC to go through the City's permitting process if they later decide to add the MUA back into our jurisdiction. The statement that they have been removed and therefore the issue us mute is fine provided they can't later amend the application to put them back in without adhering to our standards. I was unsure of the format for our response.

*Robert*

Robert A. Strope, MPA
City Manager
City of La Grande
rstrope@cityoflagrande.org
(541) 962-1309
(541) 963-3333 fax



---

**From:** TARDAEWETHER Kellen * ODOE [mailto:Kellen.Tardaewether@oregon.gov]
**Sent:** Friday, April 13, 2018 9:33 AM
**To:** Robert Strope <RStrope@cityoflagrande.org>
**Subject:** B2H ApASC Completeness Review Update and City Comments

Good Morning Robert,

I hope you have been well. There is a lot of information in this email, thank you in advance for your patience getting though it!

The Boardman to Hemingway Transmission Line (B2H) proposed facility is undergoing the completeness review by the Oregon Department of Energy (ODOE) for its Amended Preliminary Application for Site Certificate (ApASC). The completeness review conducted by ODOE, reviewing agencies, Special Advisory Groups, and Tribal Governments, is the review to verify that the information required, outlined in OAR 345-021-0010 (Contents of an Application), is present in the application materials.

The City of La Grande, on behalf of the La Grande City Council, submitted comments and Requests for Additional Information (RAI's) on the ApASC. Attached is an ODOE compiled document with the City of La Grande comments and RAI's with Idaho Power (IPC) responses. It is understood by IPC that the edits provided in these tables shall be reflected in the complete application. Please review this document and notify me by April 27, 2018 if there is any missing or incomplete information *specific to OAR 345-021-0010*.
Here is a link to the rule language that outlines the necessary information required for each exhibit, as it pertains to completeness (OAR 345-021-0010):
https://secure.sos.state.or.us/oard/displayDivisionRules.action;JSESSIONID_OARD=cEvl4-_1cwJkYFPai2eKxcwHAUj20YEiO_RiPf4ZhVo_kY-DY712!1243901809?selectedDivision=1578

Please keep in mind that per OAR 345-015-00190(5), *an application is complete when the Department finds that the applicant has submitted information adequate for the Council to make findings or impose conditions on all applicable Council standards*. The application completeness review is a separate step from the compliance review phase, as discussed below.

**Please note that the City of La Grande will have an additional opportunity to comment on the application during the "compliance review".** If the ApASC is deemed complete by ODOE, the complete Application for Site Certificate (ASC) will be distributed to all reviewing agencies. ODOE will send notice to reviewing agencies, Special Advisory Groups, and Tribal Governments that the application is complete and requests the reviewing agencies submit an agency report. OAR 345-015-0200(4), outlines the items that ODOE requests to be included in the report.
These items are:
OAR 345-015-0200 (Notice to Agencies that the Application is Complete)
(4) Request an agency report containing the following information:
(a) The agency's recommendations regarding any applications for permits administered by the agency that are applicable to construction or operation of the proposed facility.
(b) Issues significant to the agency.
(c) The agency's conclusions concerning the proposed facility's compliance with state statutes, administrative rules or ordinances administered by the agency.
(d) A list of site certificate conditions recommended by the agency.
(e) Any other information that the reviewing agency believes will be useful to the Council in reviewing the site certificate application.

ODOE generally refers to this as the "compliance review." The comments submitted during this review are on-the-record and ODOE uses this information, information within the ASC, and agency comments to draft the findings in the Draft Proposed Order (DPO). Please also keep in mind that the comments submitted during the compliance review may include recommended conditions of approval, as well as any necessary conditions of approval recommended by ODOE itself, and they could vary with what IPC has proposed in the ASC. We will fairly present to EFSC IPC's represented conditions, and any differences in condition language if recommended by ODOE or reviewing agencies.

If the ApASC is deemed complete, ODOE will send the abovementioned notice which will also have information about public informational meetings. ODOE will hold public informational meetings on the complete application and EFSC review process in each of the five counties proposed to be crossed by B2H. ODOE will coordinate with the Counties for the meetings.

Finally, I will be providing EFSC an update on the B2H proposed facility as an informational item at the April EFSC meeting. The EFSC meeting is on April 27, in The Dalles. Specific meeting details will be posted to the website in the coming days. http://www.oregon.gov/energy/facilities-safety/facilities/Pages/Council-Meetings.aspx

Let me know if you have any questions. Thank you,

Kellen

**Kellen Tardaewether**
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301
P:(503) 373-0214
C: (503) 586-6551
Oregon.gov/energy

OREGON DEPARTMENT OF ENERGY
*Leading Oregon to a safe, clean, and sustainable energy future.*

## TARDAEWETHER Kellen * ODOE

**From:** Robert Strope <RStrope@cityoflagrande.org>
**Sent:** Friday, April 27, 2018 12:02 PM
**To:** TARDAEWETHER Kellen * ODOE
**Subject:** April 27 2018 Letter to DOE B2H City of La Grande reply to IPC Responses for additional information Preliminary Application for submission
**Attachments:** April 27 2018 Letter to DOE B2H City of La Grande reply to IPC Responses for additional information Preliminary Application for submission.pdf

Kellen,

Attached is the City of La Grande's reply to Idaho Power's response. Please call me if you have any questions.

*Robert*

Robert A. Strope, MPA
City Manager
City of La Grande
rstrope@cityoflagrande.org
(541) 962-1309
(541) 963-3333 fax

CITY OF LA GRANDE

THE HUB OF NORTHEASTERN OREGON

**MEMORANDUM**

**TO:** Kellen Tardaewether
Oregon Department of Energy
550 Capitol St. N.E., 1st Floor
Salem, OR 97301

**FROM:** Robert A. Strope, City Manager
City of La Grande, Oregon
P.O. Box 670
1000 Adams Avenue
La Grande, OR 97850
(541) 962-1309
rstrope@cityoflagrande.org

**DATE:** April 27, 2018

**RE**: Idaho Power Responses to City of La Grande Comments on the Amended Preliminary Application for Site Certification for the Boardman to Hemingway Transmission Line

**General Comments:** The La Grande City Council renews our objection to the Proposed Route in the preliminary application and again strongly requests that Idaho Power remove the Proposed Route from their application and instead use the Morgan Lake Alternative or ideally reconsider the BLM preferred route. As we stated previously, of the two routes identified in the application, the applicant selected the one <u>most impactful</u> to the City of La Grande as their Proposed Route. In their response Idaho Power states they intend to construct on the route that has the most <u>support</u> from the local community. The local community does not support the B2H project as evidenced by the overwhelming adverse public response each time the topic is on an agenda. Therefore Idaho Power is unlikely to get community support for any route as it will be perceived as support for the project. Perhaps another way to put it, the La Grande City Council, which represents over the more than 13,000 residents who are in closest proximity to B2H, has stated they object more to the Proposed Route than the Morgan Lake Alternative. This should be more than sufficient for Idaho Power to remove the Proposed Route from their application.

The City of La Grande is disappointed that the Idaho Power response to our comments repeatedly reference a lack of specific deficiencies given one of the main points we and other jurisdictions have made is the preliminary application itself does not provide sufficient information in many areas to adequately review what they are proposing to construct as we would with a normal land use application that had detailed site plans.

Given the lack of detail contained in the preliminary application, we would ask that conditions of approval be included to protect the City's interests and avoid any disputes in the future should the project be approved. Some specific conditions we are requesting are shown in bold in the following paragraphs. Idaho Power could also revise their application to include these to streamline the process.

Below are additional comments regarding the Idaho Power response:

**Exhibit T – Recreation.**

**View Shed Concerns of Morgan Lake Park with respect to possible impacts of B2H power line construction in close proximity to the park:**
Despite the detailed information provided by Dr. Karen Antell, PhD, Professor of Biology, Eastern Oregon University in our previous submission, Idaho Power's states that we have not provided evidence of impacts the line may have on Morgan Lake. It is difficult to be more precise on impacts given the lack of detail in the Idaho Power preliminary application that we pointed out. Their submission lacks details regarding how they plan to access the line during construction, the types and quantities of equipment that will travel up Morgan Lake Road during construction. Idaho Power's staff acknowledged during public meetings that the towers would be an impact on the view shed but that people would get used to it over time. We would ask that Idaho Power be required to provide evidence that such a project does not adversely impact an amenity such as Morgan Lake. Another option would be for Idaho Power to consider physical improvements at Morgan Lake to enhance the recreational experience and help offset the view shed impacts.

**At a minimum, the City would ask that if the project is approved, a condition of approval would include that for the approximately 1.5 miles of the line that would be in view from Morgan Lake that H Frame towers be used to help mitigate the adverse impact to the view shed. If the Proposed Route is selected instead of the Morgan Lake Alternative, a condition of approval should be added to require H Frame towers in the view shed visible from the City of La Grande.** Again, the City of La Grande adamantly opposes the Proposed Route and would ask Idaho Power to remove it from their application.

**Exhibit U – Public Services include utilities such as road systems, water, sanitation services, power, and other amenities necessary for the construction.**

**If Morgan Lake Road will be used for construction access, for the safety of the public and Idaho Power's construction crews, the City of La Grande requests that a condition of approval be included to require Idaho Power to widen Morgan Lake Road to a standard 22 foot width from the end of the asphalt in the vicinity of 91 Walnut to the end of the road with guardrails from Skyline Drive to Marvin Road.** Given the grade and winter conditions, asphalt would not be the preferred surface, but rather a minimum 6 inch thick rock and gravel surface using base rock from Harney Rock & Paving Company, Haines, Oregon, which has proven to be ideally suited to the existing conditions on this road. **If Glass Hill will be used for construction access, it would also need to be improved to these same standards with the addition of improving the intersection of Glass Hill and Morgan Lake Road to allow for left turns from Glass Hill onto Morgan Lake Road.** Glass Hill would not require guard rails. Soil stabilization, slide areas, and improved drainage will be required to be addressed as part of needed improvements to accommodate construction traffic, as well as the use of Mag Chloride for dust control and to aid in the stabilization. Union County Public Works can provide more detailed information regarding the standards.

Route for construction traffic, both proposed and Morgan Lake Alternative: **If the project is approved, in addition to the actions Idaho Power stated they would be taking regarding traffic, the City would ask that as a condition of approval Idaho Power will use the following route: From Highway 30 to Gekeler Lane to C Avenue to Walnut Street to Morgan Lake Road to Glass Hill Road. Further, that prior to the start of construction, the section of C Avenue from the intersection of C Avenue and Sunset and the section of Walnut from Morgan Lake Road to C Avenue be improved to City of La Grande Class I standards to accommodate the construction traffic and restored if needed upon completion of the project. Also, that Idaho Power be required as a condition of approval to repair any damage resulting from their vehicles and equipment that occur during construction and that upon completion of construction all infrastructure be restore to as good or better than it was prior to construction.**

**TARDAEWETHER Kellen * ODOE**

| | |
|---|---|
| **From:** | TARDAEWETHER Kellen * ODOE |
| **Sent:** | Friday, February 16, 2018 1:57 PM |
| **To:** | 'Stokes, Mark'; Stanish, David |
| **Cc:** | English, Aaron; WOODS Maxwell * ODOE (Maxwell.Woods@oregon.gov) |
| **Subject:** | FW: B2H - Exhibit H - Idaho Power's responses to reviewing agency comments |

Please see DOGAMI's response to IPC's Responses to Exhibit H and DOGAMI RAI's. Thanks,

Kellen

**Kellen Tardaewether**
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301
P:(503) 373-0214
C: (503) 586-6551
Oregon.gov/energy

OREGON DEPARTMENT OF ENERGY
*Leading Oregon to a safe, clean, and sustainable energy future.*

---

**From:** WANG Yumei * DGMI
**Sent:** Friday, February 16, 2018 1:54 PM
**To:** TARDAEWETHER Kellen * ODOE <Kellen.Tardaewether@oregon.gov>
**Cc:** WANG Yumei * DGMI <Yumei.WANG@oregon.gov>
**Subject:** Re: B2H - Exhibit H - Idaho Power's responses to reviewing agency comments

Kellen,

Thanks for this gentle reminder.

DOGAMI is satisfied with Idaho Power's responses and has no further comments.

Yumei

On Feb 16, 2018, at 1:32 PM, TARDAEWETHER Kellen * ODOE <Kellen.Tardaewether@oregon.gov> wrote:

Hi Yumei,

I know we have bombarded you with comment requests for some EFSC facilities. But I'm re-forwarding Idaho Power's responses to DOGAMI's comments on the B2H ApASC. Will you have time to provide feedback on these? I really appreciate it and hope you have a nice weekend!

Kellen

**Kellen Tardaewether**
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301
P:(503) 373-0214
C: (503) 586-6551
Oregon.gov/energy

<image002.jpg> <image003.jpg><image004.png><image005.png><image006.png><image007.png><image008.png>
*Leading Oregon to a safe, clean, and sustainable energy future.*

---

**From:** TARDAEWETHER Kellen * ODOE
**Sent:** Friday, February 2, 2018 3:20 PM
**To:** WANG Yumei * DGMI <Yumei.WANG@oregon.gov>
**Cc:** BURNS Bill * DGMI <Bill.BURNS@oregon.gov>; WOODS Maxwell * ODOE (Maxwell.Woods@oregon.gov) <Maxwell.Woods@oregon.gov>
**Subject:** FW: B2H - Exhibit H - Idaho Power's responses to reviewing agency comments

Good afternoon Yumei,

It's been a little while since we spoke last. I know Idaho Power (IPC) has been in contact with you regarding the B2H facility and the EFSC completeness review. Attached are the IPC responses to reviewing agency and DOGAMI comments and RAI's. For the completeness review, IPC sends ODOE and agencies responses to comments and RAI's in this table format. We do not request redlines and, once sufficient, the responses shall reflect what will be in the complete application. In this context IPC's responses are targeted toward what information is necessary for this completeness review phase. That said, could you review their responses and let us know your thoughts? I'll touch bases with you next week to discuss as well. Thanks and have a good weekend.

Kellen

**Kellen Tardaewether**
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301
P:(503) 373-0214
C: (503) 586-6551
Oregon.gov/energy

<image010.jpg> <image003.jpg><image004.png><image005.png><image006.png><image007.png><image008.png>
*Leading Oregon to a safe, clean, and sustainable energy future.*

<2018-02-01 - B2H - Exhibit H - IPC Responses to Reviewing Agencies.pdf>

# Idaho Power's Response to Reviewing Agency Comments
# Exhibit H – Geology
# Boardman to Hemingway Transmission Line Project
# February 2018

| Reviewing Agency | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| City of La Grande[1] | General Comment | | The south and west hills of La Grande have been classified by the adopted engineering report titled "Engineering Geology of the La Grande Area, Union County, Oregon", dated 1971, as a geological hazard area. The study addresses numerous fault lines from Sheep Creek to and through the La Grande area, which covers the area submitted for site selection. That document is attached and supports concerns for all work proposed within the submitted study area. This plan is addressed in the City of La Grande Comprehensive Plan in addressing Goal 7. | As requested, Idaho Power revised Exhibit H, Attachment H-1 to include a new section, Section 4.4, which addresses the report "Engineering Geology of the La Grande Area, Union County, Oregon", dated 1971. Section 4.4 states:<br><br>As part of our study, we reviewed DOGAMI's open file report: Engineering Geology of the La Grande Area, Union County, Oregon, by Schlicker and Deacon (1971). The study identified several northwest-trending faults in the area west and south of La Grande. Faults shown on the Geologic Map sheets in Appendix A are based on more recent studies compiled in Ferns and others (2010). The fault locations shown in Ferns and others (2010) are similar to, although not exactly the same as, those mapped by Schlicker and Deacon (1971). The differences between the fault maps are due to improvements in the understanding of local stratigraphy over time. The only faults within the area mapped by Schlicker and Deacon (1971) that are recognized by the USGS as having been active within the Quaternary period are those of the West Grande Ronde Fault Zone, which is discussed in Section 4.2.3. Current mapping of the West Grande Ronde Fault Zone, consistent with Ferns and others (2010), is shown and labeled on the Geologic Map sheets in Appendix A. |
| DOGAMI[2] | General Comment | | The Amended Preliminary ASC does not adequately address or propose to adequately address the local seismic sources, seismic ground motions, fault surface rupture hazard, and co-seismic effects including landslides, liquefaction, lateral spreading, and settlement along the numerous faults in the proximity of the proposed route. The Applicant's use of a national dataset is not adequate for site specific evaluation. The ASC needs to address or propose to adequately address the earthquake hazard that can impact the proposed facilities. | This particular comment does not include any specific information request and therefore no specific text or information revisions are necessary based on this comment alone.<br><br>That said, the seismic design of the transmission towers will not control the transmission tower design. The American Society of Civil Engineers (ASCE) Guidelines for Electrical Transmission Line Structural Loading |

[1] The City of La Grande submitted comments on the Amended Preliminary Application for Site Certificate to ODOE on or about August 31, 2017.
[2] The Oregon Department of Geology and Mineral Industries (DOGAMI) submitted comments on the Amended Preliminary Application for Site Certificate to ODOE on or about September 15, 2017.

| Reviewing Agency | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| | | | | (manual 74, 2010) states:<br><br>Transmission structures need not be designed for ground-induced vibrations caused by earthquake motion; historically, transmission structures have performed well under earthquake events, and transmission structure loadings caused by wind/ice combinations and broken wire forces exceed earthquake loads. This may not be the case if the transmission structure is partially erected or if the foundations fail due to earth fracture or liquefaction.<br><br>Transmission structures are designed to resist large, horizontal loads of wind blowing on the wires and structures. These loads and the resulting strengths provide ample resistance to the largely transvers motions of a majority of earthquakes. Decades of experience with lines of all sizes have shown that very infrequent line damages have resulted from soil liquefaction or when earth failures affect the structural capacity of the foundation.<br><br>Exhibit H provides that Idaho Power will review site specific geo-seismic hazards at each tower site as necessary and consistent with ASCE manual 74 (2010) guidelines, which is the standard of practice used by structural engineers for power line design. The individual tower assessments for geo-seismic hazards will be performed during final design phases. Idaho Power will rely on the published available resources on known faults that may cause a direct displacement on the towers' foundations. The geo-seismic hazards, including landslide, lateral spreading, liquefaction, and surface rupture or settlement will be further evaluated using the subsurface conditions identified through a planned geotechnical exploration program. For those soil failures, Idaho power will use the latest available USGS probabilistic seismic hazard analysis, 2014, to obtain 500-, 2,500-, and 5,000-year return period ground acceleration motions for the evaluation. This approach is consistent with the EFSC rules and standards. |

| Reviewing Agency | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| | | | | While Idaho Power appreciates DOGAMI's quest to gather fine-scale site-specific geological data, DOGAMI has failed to show how that scale of data is necessary to meet EFSC standards or requirements, and perhaps more importantly, DOGAMI has failed to provide any evidence that such fine-scale data is necessary from an engineering perspective to ensure protection of the facility. For example, DOGAMI's suggestion that Idaho Power use seismic sources not included in the national seismic hazard maps is unsupported by industry practice and is an unnecessary, overly-cautionary step for defining the structural design load. DOGAMI has provided no evidence that such data is necessary to ensure the facility will not be impacted by geological hazards or to ensure the facility will not impact the public or the environment. Without that showing, DOGAMI's requests are not relevant to the letter or intent of the EFSC standards and rules, and rather appear to be data requests intended simply for the sake of gathering data. |
| | General Comment | | The Amended Preliminary ASC Methods does not refer to current standards, references and information. As two examples, the current versions of NESC and ASCE-7 should be considered.<br><br>Also, as already mentioned in DOGAMI's March 31, 2016 letter to ODOE, the most recent information on regional seismic studies at the U.S. Department of Energy's Hanford Site and Columbia and Snake River dams should be considered. | As requested, Idaho Power revised Exhibit H to addresses current codes and how they apply to the geotechnical, geologic, and geo-seismic components of the project. Those changes occur throughout the exhibit.<br><br>Attachment H-1 has been revised to include a discussion which addresses the regional seismic studies at U.S. Department of Energy's Hanford Site and Columbia and Snake River dams. Section 4.8 of Attachment H-1 states:<br><br>As part of our study, we reviewed two regional seismic studies: the Hanford Sitewide Probabilistic Hazard Analysis (PNNL, 2014), and the Probabilistic Seismic Hazard Analysis for the Mid-Columbia Dams (URS and others, 2012). The Hanford Sitewide Probabilistic Hazard Analysis was prepared for the U.S. Department of Energy by the Pacific Northwest National Laboratory |

| Reviewing Agency | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| | | | | (PNNL). It updated a previous seismic hazard analysis for the Hanford Site and included collection of new field data, which PNNL used for seismic source characterization.<br>The Probabilistic Seismic Hazard Analysis for the Mid-Columbia Dams was prepared for the Public Utility Districts of Chelan, Douglas, and Grant Counties, Washington, by numerous consultants. The scope of the latter study did not include acquisition of new field data.<br>Both studies will be considered in the seismic hazard analysis for final design of the Boardman to Hemingway 500kV Transmission Line Project. |
| | General Comment | | The Amended Preliminary ASC Site-specific Geotechnical Work (section 3.4 on Page H-6 and 7) and Locations of Geotechnical Work (section 3.6 on Page H-9) specify boring locations along the alignment but does not specifically include Quaternary faults and fault zones. Additional subsurface exploration should be considered at fault and fault zones and locations where ground shaking can influence the site response, such as river crossings and near drainages with softer soil conditions. | In Exhibit H, Attachment H-1, Section 4.2.1, Idaho Power already discusses in detail quarternary faults. No edits are necessary.<br><br>With respect to DOGAMI's subsurface exploration comments, during the planned geotechnical exploration program, Idaho Power will complete borings at river crossings and review the proposed boring locations regarding areas of soil deposits where geo-seismic hazards such as liquefaction and lateral spreading may occur and at tower locations nearest to mapped quarternary faults. Borings will be added as necessary. No edits are necessary. |
| | General Comment | | The Amended Preliminary ASC does not adequately address or propose to adequately address landslide hazard along the proposed right of way. We recommend the collection of high resolution lidar data along the route. The lidar should be collected with enough buffer distance from the route so that the lidar data can be used to evaluate the geologic hazards properly. For example, for landslide hazards the lidar data is needed from the valley bottom to the top of the ridge. | Idaho Power will conduct LiDAR or ground survey analysis of the entire site boundary. This will include detailed survey analysis 250 feet on either side of the transmission line centerline; this approach is consistent with industry standards and sufficient to identify potential geotechnical hazards based on the industry's decades-long experience building and maintaining transmission lines (see Exhibit H, Section 3.8.5). The Project is intending to gather LiDAR data 0.5 miles either side of the project centerline. To the extent DOGAMI is suggesting that LiDAR is necessary beyond these parameters, DOGAMI has provided no evidence to show that the same is necessary to meet EFSC standards or rules or is consistent with industry standards (see Exhibit H, Attachment H-1, Section 4.1 (considering the IBC 2015, OSSC 2014)). |

| Reviewing Agency | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| | | | | Again, without that showing, DOGAMI's requests are not relevant to the letter or intent of the EFSC standards and rules, and rather appear to be data requests intended simply for the sake of gathering data. |
| | General Comment | | The Amended Preliminary ASC proposes to adequately address the current International Building Code, Oregon Structural Specialty Code, and Guidelines for Geologic Hazard Evaluations in Oregon. We recognize that the EFSC Structural Standards for siting facilities have not been updated with the current State of Oregon Building codes, therefore we recommend that the Applicant address both the EFSC Structural Standards and the current codes, such as those listed below:<br>• International Building Code 2015<br>• Oregon Structural Specialty Code 2014<br>• Guidelines for Preparing Engineering Geology Reports<br>• American Society of Civil Engineers (ASCE) 7-16 | As requested, Idaho Power revised Exhibit H to addresses current codes including, EFSC Structural Standards, IBC 2015, OSSC 2014, and ASCE 7-16 and how they apply to the geotechnical, geologic, and geo-seismic components of the project. Those changes occur throughout the exhibit. Additionally, Attachment H-1, Section 3.2, has been revised to include a discussion which addresses Guidelines for Preparing Engineering Geology Report. |
| | General Comment | | In the Amended Preliminary ASC on page H-8 line 3 8-3 9, it says "You were aware that in transmission line construction, design for wind and ice forces is more than sufficient to account for typical seismic forces We are generally aware that sometimes other forces can be significant. However, it is the applicant's responsibility to properly evaluate the possible forces and effects, including seismically induced liquefaction and landslides, and design and construct accordingly. | Idaho Power disagrees with DOGAMI's assertion that the exhibit does not sufficiently address the hazards listed in this comment. Exhibit H and its attachments are full of specific, thorough information related to the hazards. Further, DOGAMI has not identified any specific information that it believes is necessary for completeness—that is, DOGAMI has not identified any specific omissions, deficiencies, or additional information that DOGAMI believes is necessary for completeness. Rather, DOGAMI simply makes broad, general statements that the exhibit is deficient. Because DOGAMI has not requested any specific information and has not shown how that information would be necessary to address any specific EFSC standard, this comment does not raise any issues related to application completeness and no changes to the application are necessary. |
| | General Comment | | In Attachment H-1 (Shannon and Wilson report, dated December 7, 2016), Table 1 provides 5,000-year return period peak ground accelerations at seven locations to represent the entire proposed facilities. Additional locations at key geologic features, such as | Idaho Power revised Attachment H-1 to address this by removing Table 1 and instead presenting contour maps for 5,000-year return period peak ground accelerations (see e.g., Attachment H-1, App'x D, Figure D10). The data to produce these |

| Reviewing Agency | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| | | | near faults, and at facilities, such as substations, communication sites, and multiuse areas, are needed. | maps were recently made available by the USGS. By presenting these contour maps, the 5,000-year PGA variation is provided for a broader area than that 7 site locations in former Table 1. |
| | Multiple Locations, including 2016 ApASC page H-9 and June 2017 ApASC Section 3.4 page H-7 and Section 3.6 page H-9 | | The reference to faults was removed from the ApASC dated January 2016, Exhibit H, page H-9 line 25, and "Areas near Quaternary faults" was not included in the updated June 2017 ApASC on page H-7. Quaternary faults need to be evaluated for seismic hazards and risk. Seismic hazards include ground shaking and secondary hazards, including permanent ground displacement. Please include Quaternary faults with a relevant discussion in the ApASC and relevant supporting documentation. | Exhibit H, Attachment H-1, Section 4.2.1 already addresses quaternary faults. No edits are necessary. |
| | Multiple locations, including ApASC, in the Table C1: Summary of Proposed Borings, Section 3.4 page H-7 and Section 3.6 page H-9, and other relevant supporting documentation e.g., Appendix B: Soils Data Table and Maps and Appendix D: Seismic Evaluation | | Boring locations should be selected with consideration of fault locations and hazards, including rupture, liquefaction, lateral spreading, co-seismic landslides, and settlement, and the proposed facilities, including towers, substations, communication sites, roads, multi-use areas, fly yards and other sites. Please include fault locations and hazards in a discussion in the ApASC and in the Table C1: Summary of Proposed Borings, and other relevant supporting documentation. Please refer to the faults in a manner that makes it clear to the reader the location of the faults, e.g., refer to the faults by name and location such as shown on Figure D9. Provide additional maps where needed. | Idaho Power has revised Attachment H-1, Section 3.1, to include new criteria such as geo-seismic hazard and proximity to faults as follows:<br><br>In general, criteria for boring placement included borings at the following:<br>. . .<br>➢ Locations for potential geo-seismic hazards such as liquefaction, lateral spreading, and seismic slope instability.<br><br>Additionally, Idaho Power has revised Attachment H-1 to add proposed boring locations in areas of soil deposits where geo-seismic hazards such as liquefaction and lateral spreading may occur and at tower locations nearest to mapped Quaternary faults.<br><br>In Table C1 of Attachment H-1, headings for geo-seismic hazards and towers adjacent to faults were added. |
| | Multiple locations, including ApASC Section 3.8, page H-10 lines 8 and 40 and Appendix D: Seismic Evaluation | | The peak ground accelerations (PGA) for a 5000 year recurrence interval are to be provided. The Applicant states that "5,000-year return period have been included in this evaluation and are shown in Attachment H-1." Table 1 in Attachment H-1 includes PGA values for only 7 locations, and does not provide a map of the locations. A map of the locations with respect to the Quaternary faults | Idaho Power revised Attachment H-1 to address this by removing Table 1 and instead presenting contour maps for 5,000-year return period peak ground accelerations (see e.g., Attachment H-1, App'x D, Figure D10). The data to produce these maps were recently made available by the USGS. By presenting these contour maps, the 5,000-year |

| Reviewing Agency | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| | | | should be provided. The Applicant presents ground motions in Figures D-2, D3, D4, D6, D7 and D8 are for a 2,500 year return period. Additional locations for PGA, including at proposed substations and other key facilities, at a closer spacing and at key geologic features, such as near faults, are needed. In areas with softer soils, such in flood plains and certain river crossings, ground motions and their effects from site soils need to be characterized. | PGA variation is provided for a broader area than that 7 site locations in former Table 1. |
| | Section 3.8 Page H-10 Lines38 and 39 | | The Applicant states: "the seismic sources are not mapped sufficiently to perform a deterministic evaluation of ground motions along a several hundred-mile-long powerline alignment." The Applicant will need to map and characterize the hazards from any seismic sources that are not sufficiently mapped to ensure that the proposed facilities can be designed and constructed to ensure reasonable public safety. | Idaho Power disagrees with DOGAMI's assertion that the exhibit does not sufficiently address or map the hazards listed in this comment. There's no reason to map those areas where the hazards are not significant. And, as discussed above, DOGAMI has provided no evidence that such data is necessary to ensure the facility will not be impacted by geological hazards or to ensure the facility will not impact the public or the environment. Without that showing, DOGAMI's requests are not relevant to the letter or intent of the EFSC standards and rules, and rather appear to be data requests intended simply for the sake of gathering data. |
| | Attachment H-1, Section 4.2.1 Quaternary Faults. On page 69 of 237 pf Part1 pdf and Table D1 on page 88 of 157 of Part 2 pdf | | The Applicant states: "These Quaternary faults within an approximate 5-mile radius of the proposed alignments are also summarized in Appendix D, Table D1." A 5 miles radius is insufficient to characterize the seismic hazards. Please expand to include all Quaternary fault sources that could impact the proposed facilities. Also, please provide a description of the faults that could impact the proposed facilities. For example, please include the large east-west trending fault zones in Washington state. | The 5-mile radius is used to evaluate faults which may contribute to fault rupture hazard only. The ground shaking contribution for faults outside of the 5-mile radius is already included in the current USGS hazard maps. DOGAMI has provided no evidence to support its assertion that this approach is insufficient or inconsistent with the EFSC standards or rules, or with industry standards.<br><br>Exhibit H, Attachment H-1, Section 4.2 already sufficiently addresses faults, with quaternary faults being addressed specifically in Section 4.2.1. If DOGAMI would like Idaho Power to consider additional faults not already discussed in the exhibit or its attachments, DOGMAMI must identify those faults specifically and provide evidence demonstrating how they're relevant to the project including from an engineering and design perspective. Data requests intended simply for the sake of gathering data are insufficient. |

| Reviewing Agency | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| | | | | |
| | Section 3.8 Page H-10 | | The Applicant states: "Generally NESC-mandated combined ice and loading cases have been determined by the industry to be sufficient to address seismic hazards from earthquakes." This statement is misleading, and the Applicant must characterize and evaluate seismic hazards from earthquakes including shaking and seismically-induced ground failures. This includes co-seismic slope stability, liquefaction, cyclic strain, and lateral spreading. Electrical equipment at substations have been damaged by earthquake ground shaking. In Addition to earthquake forces, the loading conditions in the January 2017 winter storm were anecdotally reported to be higher than in the current IBC design maps; thus historic loading conditions should be considered in addition to building code requirements. | Exhibit H, Attachment H-1 addresses each of the seismic events listed in OAR 345-021-0010(1)(h). This comment fails to allege otherwise or to request any specific information required by the EFSC rules. That being so, no edits are necessary.<br><br>That said, slope stability is addressed throughout Attachment H-1, liquefaction and lateral spreading are addressed in Section 4.5.3, and cyclic shearing is also addressed in Section 4.5.3.<br><br>Additionally, DOGAMI's reliance on anecdotal reports of loading in January 2017 is insufficient to show that building standards above the IBC are required. DOGAMI provides no scientific data to supports its anecdotes or to show that the IBC standards were insufficient to address the loading of those anecdotal conditions (if true). Again, DOGAMI cannot demand information based on unsubstantiated, conclusory hunches or wants. The requests must be relevant to the EFSC standards and rules, and must have a rationale connection to the intent of the same.<br><br>No edits are necessary. |
| | Attachment H-1 Page 47-53. | | Please update the Section 9 References. For example, burns et al and SLIDO 2 is included in the reference list. However, Appendix E refers to a SLIDO 3.2, which is later reference. | As requested, Idaho Power revised the references to reflect the use of SLIDO version 3.4 as well as SLIDO version 2:<br><br>Data sources for the inventory included the Statewide Landslide Information Database for Oregon (SLIDO), version 2 (Burns and others, 2011) and version 3.4 (Burns and Watzig, 2017), published geologic mapping, review of LiDAR data, review of aerial photographs, and limited site reconnaissance. |
| | Section 3.8.5 Page H-16, Appendix E: Landslide Inventory. Page E-1 | | The Applicant is not clear about how they evaluated potential landslide hazards. They state that they "reviewed the majority of the transmission line route". They list data sources, including "Review of GIS files compiled by Oregon Department of | As requested, Idaho Power has revised the discussion of landslide evaluation methodology in Attachment H-1 to clarify the approach taken. |

| Reviewing Agency | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| | | | Geology and Mineral Industries (DOGAMI) in the 2014 Statewide Landslide Information Database for Oregon (SLIDO), version 3.2". Please evaluate the entire route for landslide hazards, and describe the method of evaluation. For example, the Applicant has proposed to review landslide data compiled by DOGAMI using the SLIDO database, however, SLIDO is incomplete. Therefore, the Applicant must also do original landslide hazard evaluations where necessary. The Applicant must not solely rely on published data. The original landslide hazard evaluations can include mapping, borings, trenching and more to characterize landslide features and help with design for landslide mitigation. | |
| | Section 3.8.5 Page H-16 and Appendix E: Landslide Inventory. Page E-1 | | The Applicant states: "the review included landslides within a 1-mile wide route corridor". Please evaluate potential large landslides that may exceed the 1 mile wide route corridor. Landslides may extend from the tops of ridges and may move downslope to block rivers. | Idaho Power has not identified any areas relevant to this Project that indicate an analysis area greater than 1-mile is necessary. If DOGAMI has knowledge of specific areas along the Project where landslide risk extends beyond 1-mile, Idaho Power would welcome that information. In any event, DOGAMI has provided no evidence demonstrating that an analysis area greater than 1-mile is necessary for the entire Project or supported by industry practices. Therefore, the current level of landslide evaluation is adequate for completeness and to meet the EFSC standards, and no edits are necessary. |
| | Appendix E: Landslide Inventory. Page E-1 | | The Applicant states: "DOGAMI LiDAR Data Viewer (relevant LiDAR data was only available for portions of the Meacham Lake, Huron, Kamela SE, Hilgard, LaGrande SE, Glass Hill, Craig Mountain, North Powder, Telocaset, Baker, Virtue Flat, and Owyhee Dam quadrangles); no LiDAR data was available in Idaho." DOGAMI recommends the collection of high resolution lidar along the proposed route. Lidar coverage should be collected with enough buffer distance to characterize potential seismic and landslide hazards. For example, for landslide hazards, the lidar should include from the valley bottom to the top of the ridge. In addition, lidar can be used to evaluate seismic sources. | Idaho Power will conduct LiDAR or ground survey analysis of a corridor along the transmission line. That will nominally be 1 mile. The boundaries of this corridor will be extended for areas where warranted to analyze the hazard of landslides. Where it is unlikely that landslides are a hazard additional LIDAR data will not be obtained beyond the nominal 1 mile corridor (half mile either side of the centerline). This approach is consistent with industry standards and sufficient to identify potential geotechnical hazards based on Idaho Power's decades-long experience building and maintaining transmission lines (see Exhibit H, Section 3.8.5). To the extent DOGAMI is suggesting that LiDAR is necessary beyond these parameters, DOGAMI has provided no evidence to show that the same is necessary or consistent with industry |

**Idaho Power's Response to Reviewing Agency Comments**
**Exhibit H – Geology**
**Boardman to Hemingway Transmission Line Project**
**February 2018**

| Reviewing Agency | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| | | | | standards (see Exhibit H, Attachment H-1, Section 4.1 (considering the IBC 2015, OSSC 2014)). |
| | Section 3.8 Page H-10, H32 and H33 | | All design should use current, up-to-date, codes, standards, references, guidelines and best practices. However, as examples, the Applicant refers to ASCE 7-13 and IEEE's NESC Code C2-2007. The current version of these documents are ASCE7-16 and NESC 2017. Please use current industry standards for design, and provide references for them. | As stated above, Idaho Power revised Exhibit H to include a new section which addresses current codes. |
| | Section 3.8.5 Page H-15 and H33 | | The Applicant uses the 1996 OPS data to review the earthquake hazard zones to conduct a preliminary seismic risk assessment. The 1996 reference is outdated, and the method to develop earthquake hazard rankings is insufficient. The Applicant states; "To identify existing earthquake conditions the mileage crossed for each earthquake hazard risk (low, medium, or high) was mapped and expressed as a percent for each county." Please evaluate the hazard at the proposed sites and alignments. | Idaho Power removed reference to 1996 OPS data from Exhibit H.<br><br>Attachment H-1 has been revised to include borings at locations where there is a potential for geo-seismic hazards such as at fault crossings. Site specific geo-seismic hazard evaluation will be conducted as part of final design once site specific data has been collected. |
| | Section 3.8.5 Page H-16 | | The Applicant states that "Prior to the development of final engineering design, liquefaction studies will be conducted for susceptible areas, including areas that cross or approach rivers and areas where thick unconsolidated sediments are encountered in the field". For liquefaction evaluations, recommendations in this reference, as well as other geotechnical references should be used: National Academies Liquefaction Study Report (2016) https://www.nap.edu/catalog/23474/state-of-the-art-and-practice-in-the-assessment-of-earthquake-induced-soil-liquefaction-and-its-consequences | Idaho Power did not use this reference because it is currently only a draft document and in no case binding on this Project. |
| | Section 3.8.5 Page H-17 | | The Applicant states that "For locations where liquefaction poses a risk, an assessment will be made to determine if lateral spreading would be an additional hazard." If the Applicant determines that lateral spreading is an additional hazard, the Applicant should design and describe mitigation measures. | Exhibit H, Attachment H-1, Section 6.2 presents typical mitigation techniques that would be appropriate if liquefaction and lateral spreading is found to be a geo-seismic risk, stating:<br><br>For structures or towers which are located in areas that have a risk of liquefaction, there are a number of methods available to either adequately reduce the risk of liquefaction or to improve the performance of the structure (or improve |

| Reviewing Agency | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| | | | | resiliency), if liquefaction were to occur. Specific methods to reduce the liquefaction potential are ground densification to increase the soil's natural resistance to liquefaction, installation of drains to prevent excess ground water pore pressure build-up during a seismic event, and installation of soil-cement shear cells which reduce the seismic shearing demands on the soil.<br><br>Alternative to the methods which improve the soils resistance to liquefaction described above, the foundations for structures may be designed to account for a layer of soil which may liquefy. Deep foundations can be designed to bypass the liquefiable layer, being founded on deeper layers.<br><br>No edits are necessary. |
| | Page H-17 Section 3.9.2 Flooding | | The Applicant states that "Project roads would be permanent features and have permanent impacts in the flood zones." The Applicant will need to comply with requirements by local jurisdictions, including requirements by the County Flood Plain Managers and building departments. Building in the flood zone can alter the flood hazards and affect others. Road design and construction should be in accordance to best practices, and should consider impacts from flood hazards. | Local jurisdictional requirements related to flood zone construction and building are addressed in Exhibit K, and are outside of DOGAMI's jurisdiction. No edits are necessary. |
| | Page H-17 Section 3.9.2 Flooding and H-32 | | The Applicant states: "To evaluate flood hazards, DOGAMI Statewide Flood Hazard Database for Oregon – FEMA Flood Insurance Study inundation zones (2015) were compared to the temporary and permanent disturbance areas associated with the preliminary design." The Applicant should refer to FEMA websites for official flood data, including at https://msc.fema.gov/portal and not rely solely on DOGAMI's flood database. | FEMA's official flood data was reviewed for Umatilla and Morrow counties, because FEMA data was not available for remaining project counties including Union, Baker, Malheur or Owyhee counties. A reference to FEMA data has been added to the main text of Exhibit H. No additional edits are necessary since the data from FEMA was consistent with the data from DOGAMI. |
| Union County[3] | UN-09<br><br>Project Order<br>And | | On September 22, 2017 the Council adopted new rules modifying OAR 345-021-0010, 345-022-0020, and 345-027-0020 that are applicable to the Boardman to Hemingway project. The staff report for the | Idaho Power revised Exhibit H and its attachments to address, and to be consistent with, the 2017 revisions to OAR 345-021-0010, 345-022-0020, and 345-050-0060. |

[3] Union County submitted comments on the Amended Preliminary Application for Site Certificate to ODOE on or about October 12, 2017.

| Reviewing Agency | Amended pASC Reference | Statute/Rule/Ordinance Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| | Exhibit H | | rulemaking action clearly stated that "Absent any specific language stating otherwise, any and all changes that are approved in an EFSC rulemaking project (other than rules relating to the Council's land use standard) become applicable to all in process applications for site certificates and all in process requests for amendment upon their effective date. The Council's land use standard is the only EFSC rule that becomes fixed upon the date an application is submitted, or the date a request for amendment is submitted."14 [emphasis added]<br><br>Both the Project Order and Exhibit H (and elsewhere in the application, as applicable) should be modified to reflect these newly adopted rules. | |

**TARDAEWETHER Kellen * ODOE**

| | |
|---|---|
| **From:** | WANG Yumei * DGMI |
| **Sent:** | Friday, September 15, 2017 11:04 AM |
| **To:** | TARDAEWETHER Kellen * ODOE |
| **Cc:** | WANG Yumei * DGMI |
| **Subject:** | Dogami RAI on B2H |
| **Attachments:** | B2H-dogami-RAI-9-15-17.pdf |

Hi Kellen,

Please see the attached. If you require a hard copy, please let me know. Thanks!

Yumei

Yumei Wang, P.E. | Geotechnical Engineer
Oregon Department of Geology and Mineral Industries (DOGAMI)
800 NE Oregon Street, Suite 965, Portland, Oregon 97232
Office: (971) 673-1551 | Mobile: (503) 913-5749
yumei.wang@oregon.gov | www.oregongeology.org

Follow us! Facebook Twitter

Oregon
Kate Brown, Governor

Department of Geology and Mineral Industries
Administrative Offices
800 NE Oregon St., Suite 965
Portland, OR 97232-2162
(971) 673-1555
Fax: (971) 673-1562
www.oregongeology.org

September 15, 2017

Kellen Tardaewether
Energy Facility Siting Analyst
Oregon Department of Energy
550 Capitol St NE, 1st floor
Salem, OR 97301

Re: DOGAMI request for additional information on the Amended Preliminary Application for Site Certificate, Boardman to Hemingway Transmission Line Project, dated June 2017

Dear Ms. Tardaewether,

The Oregon Department of Geology and Mineral Industries (DOGAMI) performed a review of the Boardman to Hemingway Amended Preliminary Application for Site Certificate (ASC) dated June 2017.

DOGAMI's review included Exhibit H: Geologic Hazards and Soil Stability and the appendices. The bases for the completeness review were a) professional standard-of-practice for characterization of geologic and natural hazards and b) relevant State of Oregon requirements. Specific Energy Facility Siting Council's (EFSC) rules and standards referenced in the completeness of the Amended Preliminary ASC include:

1. Oregon Administration Rule (OAR) 345-021-0010 on the Contents of the Application
2. OAR 345-022-0020 on the EFSC Structural Standard

Overall, DOGAMI finds the Amended Preliminary ASC to currently lack adequate geologic hazards and geotechnical information and/or the acknowledgment of future studies to be performed prior to permitting. Please refer to DOGAMI's request for additional information (RAI) table (attachment).

In addition, we note the following:

1) The Amended Preliminary ASC does not adequately address or propose to adequately address the local seismic sources, seismic ground motions, fault surface rupture hazard, and co-seismic effects including landslides, liquefaction, lateral spreading, and settlement along the numerous faults in the proximity of the proposed route. The Applicant's use of a national dataset is not adequate for site specific evaluation. The ASC needs to address or propose to adequately address the earthquake hazard that can impact the proposed facilities.

2) The Amended Preliminary ASC Methods does not refer to current standards, references and information. As two examples, the current versions of NESC and ASCE-7 should be considered. Also, as already mentioned in DOGAMI's March 31, 2016 letter to ODOE, the most recent information on regional seismic studies at the U.S. Department of Energy's Hanford Site and Columbia and Snake River dams should be considered.

3) The Amended Preliminary ASC Site-specific Geotechnical Work (section 3.4 on Page H-6 and 7) and Locations of Geotechnical Work (section 3.6 on Page H-9) specify boring locations along the alignment but does not specifically include Quaternary faults and fault zones. Additional subsurface exploration should be considered at fault and fault zones and locations where ground shaking can influence the site response, such as river crossings and near drainages with softer soil conditions.

4) The Amended Preliminary ASC does not adequately address or propose to adequately address landslide hazard along the proposed right of way. We recommend the collection of high resolution lidar data along the route. The lidar should be collected with enough buffer distance from the route so that the lidar data can be used to evaluate the geologic hazards properly. For example, for landslide hazards the lidar data is needed from the valley bottom to the top of the ridge.

5) The Amended Preliminary ASC proposes to adequately address the current International Building Code, Oregon Structural Specialty Code, and Guidelines for Geologic Hazard Evaluations in Oregon. We recognize that the EFSC Structural Standards for siting facilities have not been updated with the current State of Oregon Building codes, therefore we recommend that the Applicant address both the EFSC Structural Standards and the current codes, such as those listed below:

- International Building Code 2015
- Oregon Structural Specialty Code 2014
- Guidelines for Preparing Engineering Geology Reports
  http://www.oregon.gov/osbge/pdfs/Publications/EngineeringGeologicReports_5.2014.pdf
- American Society of Civil Engineers (ASCE) 7-16

We recommend that the Applicant provide a discussion and recommendations where the results differ.

6) In the Amended Preliminary ASC on page H-8 line 38-39, it says "You were aware that in transmission line construction, design for wind and ice forces is more than sufficient to account for typical seismic forces We are generally aware that sometimes other forces can be significant. However, it is the applicant's responsibility to properly evaluate the possible forces and effects, including seismically induced liquefaction and landslides, and design and construct accordingly.

7) In Attachment H-1 (Shannon and Wilson report, dated December 7, 2016), Table 1 provides 5,000-year return period peak ground accelerations at seven locations to represent the entire proposed facilities. Additional locations at key geologic features, such as near faults, and at facilities, such as substations, communication sites, and multiuse areas, are needed.

Thank you for the opportunity to review the documents. If you have any questions, please contact me at 971-673-1551 (or yumei.wang@oregon.gov).

Sincerely,

Yumei Wang
Geotechnical Engineer

CC: Brad Avy, DOGAMI Director
Bill Burns, Geohazards Section Leader

Attachment: *DOGAMI RAI Table*

**Boardman to Hemingway Transmission Line Project –Amended Preliminary Application for Site Certificate (ApASC)**
**DOGAMI**
**Request for Additional Information for the ApASC (ApASC RAI) Exhibit H – EXHIBIT Geological Hazards and Soil Stability**
**September 15, 2017**

| Request No. | ApASC Section Ref. | ApASC Page Ref. | Applicable Rule (OAR 345-021-, 345-022-0020 or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| 1 for ApASC RAI | Exhibit H | Multiple locations, including 2016 ApASC page H-9 and June 2017 ApASC Section 3.4 page H-7 and Section 3.6 page H-9 | | The reference to faults was removed from the ApASC dated January 2016, Exhibit H, page H-9 line 25, and "Areas near Quaternary faults" was not included in the updated June 2017 ApASC on page H-7. Quaternary faults need to be evaluated for seismic hazards and risk. Seismic hazards include ground shaking and secondary hazards, including permanent ground displacement. Please include Quaternary faults with a relevant discussion in the ApASC and relevant supporting documentation. | |
| 2 for ApASC RAI | Exhibit H | Multiple locations, including ApASC, in the Table C1: Summary of Proposed Borings, Section 3.4 page H-7 and Section 3.6 page H-9, and other relevant supporting documentation e.g., Appendix B: Soils Data Table and Maps and Appendix D: Seismic Evaluation | | Boring locations should be selected with consideration of fault locations and hazards, including rupture, liquefaction, lateral spreading, co-seismic landslides, and settlement, and the proposed facilities, including towers, substations, communication sites, roads, multi-use areas, fly yards and other sites. Please include fault locations and hazards in a discussion in the ApASC and in the Table C1: Summary of Proposed Borings, and other relevant supporting documentation. Please refer to the faults in a manner that makes it clear to the reader the location of the faults, e.g., refer to the faults by name and location such as shown on Figure D9. Provide additional maps where needed. | |
| 3 for ApASC RAI | Exhibit H | Multiple locations, including ApASC Section 3.8, page H-10 lines 8 and 40 and Appendix D: Seismic Evaluation | OAR 345-021-0010(1)(h)(F) | The peak ground accelerations (PGA) for a 5000 year recurrence interval are to be provided. The Applicant states that "5,000-year return period have been included in this evaluation and are shown in Attachment H-1." Table 1 in Attachment H-1 includes PGA values for only 7 locations, and does not provide a map of the locations. A map of the locations with respect to the Quaternary faults should be provided. The Applicant presents ground motions in Figures D-2, D3, D4, D6, D7 and D8 are for a 2,500 year return period. Additional | |

| Request No. | ApASC Section Ref. | ApASC Page Ref. | Applicable Rule (OAR 345-021-, 345-022-0020 or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| | | | | locations for PGA, including at proposed substations and other key facilities, at a closer spacing and at key geologic features, such as near faults, are needed. In areas with softer soils, such in flood plains and certain river crossings, ground motions and their effects from site soils need to be characterized. | |
| 4 for ApASC RAI | | Section 3.8 Page H-10 Lines 38 and 39 | | The Applicant states "the seismic sources are not mapped sufficiently to perform a deterministic evaluation of ground motions along a several hundred-mile-long powerline alignment." The Applicant will need to map and characterize the hazards from any seismic sources that are not sufficiently mapped to ensure that the proposed facilities can be designed and constructed to ensure reasonable public safety. | |
| 5 for ApASC RAI | Exhibit H | Attachment H-1, Section 4.2.1 Quaternary Faults. On page 69 of 237 of Part 1 pdf and Table D1 on page 88 of 157 of Part 2 pdf | | The Applicant states "These Quaternary faults within an approximate 5-mile radius of the proposed alignments are also summarized in Appendix D, Table D1."A 5 miles radius is insufficient to characterize the seismic hazards. Please expand to include all Quaternary fault sources that could impact the proposed facilities. Also, please provide a description of the faults that could impact the proposed facilities. For example, please include the large east-west trending fault zones in Washington state. | |
| 6 for ApASC RAI | | Section 3.8 Page H-10 | | The Applicant states: "Generally, NESC-mandated combined ice and loading cases have been determined by the industry to be sufficient to address seismic hazards from earthquakes." This statement is misleading, and the Applicant must characterize and evaluate seismic hazards from earthquakes, including shaking and seismically-induced ground failures. This includes co-seismic slope stability, liquefaction, cyclic strain, and lateral spreading. Electrical equipment at substations have been damaged by earthquake ground shaking. In addition to earthquake forces, the loading conditions in the January 2017 winter | |

| Request No. | ApASC Section Ref. | ApASC Page Ref. | Applicable Rule (OAR 345-021-, 345-022-0020 or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| | | | | storm were anecdotally reported to be higher than in the current IBC design maps; thus historic loading conditions should be considered in addition to building code requirements. | |
| 7 for ApASC RAI | | Attachment H-1 Page 47-53. | | Please update the Section 9 References. For example, Burns et al and SLIDO 2 is included in the reference list. However, Appendix E refers to a SLIDO 3.2, which is later reference. | |
| 8 for ApASC RAI | | Section 3.8.5 Page H-16, Appendix E: Landslide Inventory. Page E-1 | | The Applicant is not clear about how they evaluated potential landslide hazards. They state that they "reviewed the majority of the transmission line route". They list data sources, including "Review of GIS files compiled by Oregon Department of Geology and Mineral Industries (DOGAMI) in the 2014 Statewide Landslide Information Database for Oregon (SLIDO), version 3.2" Please evaluate the entire route for landslide hazards, and describe the method of evaluation. For example, the Applicant has proposed to review landslide data compiled by DOGAMI using the SLIDO database, however, SLIDO is incomplete. Therefore, the Applicant must also do original landslide hazard evaluations where necessary. The Applicant must not solely rely on published data. The original landslide hazard evaluations can include mapping, borings, trenching and more to characterize landslide features and help with design for landslide mitigation. | |
| 9 for ApASC RAI | | Section 3.8.5 Page H-16 and Appendix E: Landslide Inventory. Page E-1 | | The Applicant states "the review included landslides within a 1-mile wide route corridor". Please evaluate potential large landslides that may exceed the 1 mile wide route corridor. Landslides may extend from the tops of ridges and may move downslope to block rivers. | |
| 10 for ApASC RAI | | Appendix E: Landslide Inventory. Page E-1 | | The Applicant states "DOGAMI LiDAR Data Viewer (relevant LiDAR data was only available for portions of the Meacham Lake, Huron, Kamela SE, Hilgard, LaGrande SE, Glass Hill, Craig Mountain, North Powder, Telocaset, Baker, Virtue Flat, and Owyhee Dam quadrangles); No LiDAR | |

| Request No. | ApASC Section Ref. | ApASC Page Ref. | Applicable Rule (OAR 345-021-, 345-022-0020 or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| | | | | data was available in Idaho." DOGAMI recommends the collection of high resolution lidar along the proposed route. Lidar coverage should be collected with enough buffer distance to characterize potential seismic and landslide hazards. For example, for landslide hazards, the lidar should include from the valley bottom to the top of the ridge. In addition, lidar can be used to evaluate seismic sources. | |
| 11 for ApASC RAI | | Section 3.8 Page H-10, H32 and H33 | | All design should use current, up-to-date, codes, standards, references, guidelines and best practices. However, as examples, the Applicant refers to ASCE 7-13 and IEEE's NESC Code C2-2007. The current version of these documents are ASCE 7-16 and NESC 2017. Please use current industry standards for design, and provide references for them. | |
| 12 for ApASC RAI | | Section 3.8.5 Page H-15 and H33 | | The Applicant uses the 1996 OPS data to review the earthquake hazard zones to conduct a preliminary seismic risk assessment. The 1996 reference is outdated, and the method to develop earthquake hazard rankings is insufficient. The Applicant states "To identify existing earthquake conditions the mileage crossed for each earthquake hazard risk (low, medium, or high) was mapped and expressed as a percent for each county." Please evaluate the hazard at the proposed sites and alignments. | |
| 13 for ApASC RAI | | Section 3.8.5 Page H-16 | | The Applicant states that "Prior to the development of final engineering design, liquefaction studies will be conducted for susceptible areas, including areas that cross or approach rivers and areas where thick unconsolidated sediments are encountered in the field". For liquefaction evaluations, recommendations in this reference, as well as other geotechnical references, should be used: National Academies Liquefaction Study Report (2016) | |

| Request No. | ApASC Section Ref. | ApASC Page Ref. | Applicable Rule (OAR 345-021-, 345-022-0020 or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| | | | | https://www.nap.edu/catalog/23474/state-of-the-art-and-practice-in-the-assessment-of-earthquake-induced-soil-liquefaction-and-its-consequences | |
| 14 for ApASC RAI | | Section 3.8.5 Page H-17 | | The Applicant states that "For locations where liquefaction poses a risk, an assessment will be made to determine if lateral spreading would be an additional hazard." If the Applicant determines that lateral spreading is an additional hazard, the Applicant should design and describe mitigation measures. | |
| 15 for ApASC RAI | | Page H-17 Section 3.9.2 Flooding | | The Applicant states that "Project roads would be permanent features and have permanent impacts in the flood zones." The Applicant will need to comply with requirements by local jurisdictions, including requirements by the County Flood Plain Managers and building departments. Building in the flood zone can alter the flood hazards and affect others. Road design and construction should be in accordance to best practices, and should consider impacts from flood hazards. | |
| 16 for ApASC RAI | | Page H-17 Section 3.9.2 Flooding and H-32 | | The Applicant states "To evaluate flood hazards, DOGAMI Statewide Flood Hazard Database for Oregon – FEMA Flood Insurance Study inundation zones (2015) were compared to the temporary and permanent disturbance areas associated with the preliminary design." The Applicant should refer to FEMA websites for official flood data, including at https://msc.fema.gov/portal and not rely solely on DOGAMI's flood database. | |

## TARDAEWETHER Kellen * ODOE

| | |
|---|---|
| **From:** | Teara Farrow Ferman <TearaFarrowFerman@ctuir.org> |
| **Sent:** | Friday, September 1, 2017 3:49 PM |
| **To:** | TARDAEWETHER Kellen * ODOE |
| **Subject:** | CTUIR Comments on B2H Amended Preliminary Application |
| **Attachments:** | CTUIR Comments_B2H Amended Preliminary Application 9-1-17.pdf; Specific Comment - B2H.xlsx |

Kellen,
Attached are the CTUIR comments.
Thank you,

**TEARA FARROW FERMAN**



---

**From:** TARDAEWETHER Kellen * ODOE [mailto:Kellen.Tardaewether@oregon.gov]
**Sent:** Thursday, June 29, 2017 3:21 PM
**To:** dlteeman.burns.paiute@gmail.com; robert.brunoe@ctwsbnr.org; roberta.kirk@ctwsbnr.org; Kathleen.sloan@ctwsbnr.org; Teara Farrow Ferman
**Cc:** WOODS Maxwell * ODOE
**Subject:** B2H Amended pASC Tribal Reviewing Agency Memo

Good afternoon,

The Oregon Department of Energy (ODOE) has received an electronic version of the Amended Preliminary Application for Site Certificate (Amended pASC) for the Boardman to Hemingway Transmission Line (B2H) project. The Applicant, Idaho Power (IPC), will begin sending reviewing agencies electronic copies today. In the next two weeks they will print and send the hard copies to agencies that have specified that they would like certain application exhibits or the entire application in a hard copy. If ODOE or IPC has not received written confirmation of a preference to receive application materials in electronic form, by default, reviewing agencies will receive materials in hard copy.

Attached is the Tribal Government Reviewing Agency Memo issued by ODOE. The memo provides the project background, outlines the EFSC process, as well as the request for Tribal review of the project. The comment deadline is September 1, 2017. This deadline is 45 days from July 19, 2017, which is when ODOE expects that all agencies will have received an electronic and/or hard copy of the application materials.

I will coordinate with all reviewing agencies for an interdisciplinary team meeting to provide an opportunity to discuss the project and the EFSC process. Let me know if you have any questions and I look forward to working with everyone.

Kellen

**Kellen Tardaewether**
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor

Salem, OR 97301
P:(503) 373-0214
C: (503) 586-6551
Oregon.gov/energy

OREGON
DEPARTMENT OF
ENERGY

*Leading Oregon to a safe, clean, and sustainable energy future.*

Confederated Tribes *of the* Umatilla Indian Reservation
Department of Natural Resources
46411 Timíne Way, Pendleton, Oregon 97801

# MEMORANDUM

To: Kellen Tardaewether, Senior Siting Analyst
Oregon Department of Energy
Sent via email to: kellen.tardaewether@oregon.gov

From: Eric Quaempts, Department of Natural Resources Director
Confederated Tribes of the Umatilla Indian Reservation
46411 Timine Way, Pendleton, OR 97801
EricQuaempts@ctuir.org
541-276-3447

Date: September 1, 2017

RE: Confederated Tribes of the Umatilla Indian Reservation's Comments on the Amended Preliminary Application (APA) for Site Certificate for the proposed Boardman to Hemingway Transmission Line

General Comments:
Thank you for contacting the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) regarding the Boardman to Hemingway Transmission Line amended preliminary application for site certificate. The CTUIR offers the following comments with the project.

The CTUIR has been working on this project with Idaho Power Corporation (IPC) and the BLM for almost ten years. Although we have dedicated hundreds of hours to improving the project, we do not feel that our input has been incorporated nor have explanations been forthcoming when our comments have been ignored.

Treaty Rights:
At no point does the APA mention the CTUIR Treaty of 1855 except summarizing comments without addressing them. In Exhibit BB the APA states that the project does not occur on reservation lands and concludes our concerns are addressed. Our concerns have not been addressed. Specifically, our Tribal Treaty Rights and resources concerns have been dismissed in the exhibits concerning habitat fragmentation, introduction of noxious weeds, effects on historic properties, noise, visual effects and cultural resource impacts. Our 2010 scoping comments to EFSC and BLM are attached to document the concerns of the CTUIR raised regarding impacts to treaty reserved rights and resources. Without discussing Treaty Rights the document fails to identify how these rights and resources are addressed. The Exhibits ignore that treaty rights are the supreme law of the lands under Article VI of the US Constitution and represent property

rights, protected under the due process clause of the Fifth and Fourteenth Amendments to the US Constitution.

In Exhibit BB, Page BB-8, Line 16-18 of the APA concludes that First Foods are "fully addressed under the Section 106 of the National Historic Preservation Act compliance process that will be memorialized in a Programmatic Agreement for the Project". The Exhibit fails to acknowledge that the Programmatic Agreement has been executed and is contained in Exhibit S, Attachment S-5 and does not mention First Foods. Further, Section 3.3 states that CTUIR First Foods are not relevant to the EFSC siting standard. CTUIR First Foods are resources the tribe has legally protected interests in that can and will be materially affected by the construction of this line. This Exhibit clearly delineates the fact that the APA failed to address First Foods and that this continued failure to acknowledge and address First Foods is a critical flaw in the APA.

Cultural Resources:
Through the site certificate process, ODOE is asking about the sufficiency of the information provided for achieving the EFSC Historic, Cultural, and Archaeological Resources standard (OAR 345-022-0090). From our perspective, it is not. A detailed list of specific comments on Exhibit S is attached. Generally, the insufficiency can be summarized as two main points. First, even discounting the poor consultation that has taken place through the BLM, IPC has failed to include us in the review of many documents that are attached to Exhibit S but which have never come out through the 106 process to consulting parties. Thus, we are unable to determine whether the numbers of sites and eligibility are correct. That means that we cannot "find that that construction and operation of the facility, taking into account mitigation, are not likely to result in significant adverse impacts to" historic, cultural, or archaeological resources eligible for inclusion in the National Register of Historic Places. We don't think the information in Exhibit S puts EFSC into a position to make such a finding either.

The second general insufficiency is how the Exhibit addresses historic properties of religious and cultural significance to Indian tribes. These are "historic, cultural or archaeological resources." The document discusses two or three (depending on the section of the report) such properties that are in the SHPO database. They assert that they requested additional data and were denied such data when we in fact provided them detailed information. They do not mention that the CTUIR and likely other tribes have worked with the BLM on other areas of religious and cultural significance. IPC should have worked with tribes to write a section on HPRCSITs. This would have shown that they take this site type seriously and reflected that the Section 106 process for those site types is still in its infancy.

The project order, Section III(s) states, "The application shall include evidence of consultation with affected tribes regarding archaeological and cultural sites and materials that may be found on the proposed facility site." From our perspective, the application provides no such evidence. The CTUIR also feels that IPC has made little to no effort to meet this requirement. The fact that we have not received several documents developed for this application is further evidence of the insufficiency of their consultation.

**Below is taken from our objection to the FEIS.**
The CTUIR recommended avoidance of Glass Hill in the DEIS due to a combination of natural and cultural resource concerns the CTUIR raised over the years in our discussions regarding the B2H line. Glass Hill is currently undeveloped and crosses multiple fisheries habitat restoration

efforts planned and implemented between the CTUIR and the owner of the Elk Song Ranch as well as the former 516 Ranch along Rock Creek and Graves Creek. To place an entirely new energy corridor across an area lacking any corridors fragments critical winter and summer elk range. The CTUIR recommended selection of the proposed alternative in the DEIS relative to Glass Hill because it was adjacent to an existing impact, the 230kV power line, which would introduce fewer new impacts to the landscape. An enormous National Register of Historic Places eligible archaeological site and site significant to the CTUIR dating to the Pleistocene/Holocene transition will also be adversely affected by the Glass Hill alternative. Additionally, rather than avoiding impacts to elk, the EIS acknowledges that the Glass Hill alternative would impact elk winter range.

Idaho Power's efforts to address this project's impacts on cultural resources have been problematic since the outset. They proposed to conduct a 15% random sample of all alternatives. The sample conducted was not random and did not include the myriad alternatives added after the DEIS, including elements of the route eventually selected as the preferred route. Portions of the Visual Assessment of Historic Properties were not completed as proposed. Consideration of effects to historic properties has been poorly explained and incomplete. Due to a failure to provide the background information it has been impossible for the CTUIR to determine whether sites have been omitted from consideration or considered as not significant when in fact they are eligible for inclusion in the National Register of Historic Places (National Register). Many of the various contracting companies working on cultural resources for this project lack familiarity with the history and prehistory of the region, as has been clear from their discussion of sites and context provided. Based on these failures and limitations, it is clear that the Council does not have adequate or equal levels of information regarding the alternatives. It is not possible for them to understand how the different alternatives will impact cultural resources. Any decision made does not taken into account those impacts.

The model employed to analyze the impacts of route options does not take into account existing impacts relative to previous development/disturbance. Without such consideration, it is impossible to understand how this project impacts sites listed in and eligible for inclusion in the National Register. Several route options were chosen in absence of consideration of pre-existing developments, such as Glass Hill discussed above. The failure to include preexisting impacts resulted in equating the impacts of a new line on Glass Hill to co-locating the line with the existing 230kV line in the analysis of the EIS, see page 3-1533.

The project proponent has a predisposition to elevate historic resources, especially the Oregon Trail, over prehistoric resources. This bias has been present throughout the cultural resource process for this project.

Specific Comments:
See attached specific comments spreadsheet.

| Boardman to Hemingway Transmission Line<br>Comments on the Amended Preliminary Application for Site Certificate<br>From the Confederated Tribes of the Umatilla Indian Reservation | | | |
|---|---|---|---|
| **Exhibit** | **Section No.** | **Pg./Para./Sentence Reference (as needed)** | **Comment** |
| B | Attachment B-2, Appendix A, Page A-2 | No line numbers | This summary inadequately documents the concerns of the CTUIR. The summary focuses exclusively on prioritizaiton of line siting without addressing any other issues or concerns raised by the CTUIR in our letter to BLM scoping for the B2H project. For the record, we have attached our scoping comments provided to BLM and those comments provided to Oregon EFSC. |
| BB | 3.3 | BB-7, Lines 31-35. | The Amended Perliminary Application repeatedly states that the line does not cross the reservation and concludes therefore that no tribal resources need to be addressed beyond existing exhibits. This fails to mention that the visual, noise and cultural impacts occur on reservation as well as fails to understand that tribal rights to resources off reservation can and will be impacted by the project. Treaty reserved rights and resources do not exclusively occur on reservation lands. |
| BB | 3.3 | BB-8, Lines 16-18. | The Amended Perliminary Application states "Project impacts on the First Foods are, however, fully addressed under the Section 106 of the National Historic Preservation Act compliance process that will be memorialized in a Programmatic Agreement for the Project." This is patently false, nowhere in the Programmatic Agreement does it address first foods. The PA is only about complying with Section 106 of the NHPA. The PA is contained in Exhibit S, Attachment S-5. Even a cursory review would confirm First Foods are not addressed. |
| S | S1 | Footnote 1 | "The SHPO is yet to concur with findings of field surveyes." Without SHPO concurrence, we really have no idea what sites are and are not eligible. Nor have other consulting parties been involved. |
| | S3 | 34-36 | "The application shall include evidence of consultation with affected tribes regarding archaeological and cultural sites and materials that may be found on the proposed facility site." As you'll note in comments below, especially the lack of providing us with the confidential attachments to Exhibit S, from our perspective this requirement has not been met. |
| | S9 | 32-34 | "Although compliance with Section 106 of the NHPA does not equate to compliance with EFSC standards, studies conducted in support of Section 106 compliance are utilized to support compliance with EFSC standards." We just want to make sure that EFSC understands that some documents submitted as part of Exhibit S have been developed through the 106 mandated consultation process (even though we remain highly disappointed at the ability of the BLM to address our comments; at least we have seen the documents), but some have not. They are required as part of the 106 process but have not been submitted to consulting parties to review. |
| | S11 | 20, 21, 25, and 27 | The existence of these documents (High Probability Areas Assessment, Enhanced Archaeological Survey, ILS, HPMP), or revised documents, is news to us. |
| | S12 | 17 | Based on other uses of the word "aboveground" in this document, this does not include properties of religious and cultural significance to the CTUIR. Visual impacts can affect the integrity of setting, feeling, and association for these types of properties. The treatment of this type of property is spotty and confusing throughout the document. We prefer the term "historic properties of religious and cultural significance to Indian trbes" (HPRCSIT), as recommended by the ACHP. They eventually use the term TCP, which is not necessary since no such non-tribal properties were located. It is unclear to what degree such properties were inventoried. |

| | | | |
|---|---|---|---|
| | S12 | 30-31 | "Resources that are addressed by these studies can be categorized as archaeological or aboveground resources."  This is not consistent with ODOE's language regarding cultural resources.  Other types of resources may be eligible for the National Register.  This is overly simplistic and does not adequately address the types of impacts to archaeological sites that may have values other than just archaeology.  It is unclear which of these two categories HPRCSITs would fall into. |
| | S14-15 | 42-1 | The CTUIR never saw an updated literature review for the alternatives suddenly added to the FEIS, after the DEIS. |
| | S15 | 6 through 9 | We objected to several aspects of this plan, especially the validity of the non-random 15% sample.  No evidence of its adequacy was provided.  IPC and the federal agencies simply said "that's what's been done on other projects."  A true random sample is critical, as is an understanding of what percentage sample is needed to provide an adequate sample to answer the research questions (which here are likely presence/absence of archaeological sites).  Also, an adequate sample of each alternative is critical if one is trying to determine whether one alternative is better or worse for archaeological resources.  From the CTUIR's perspective, this was simply an exercise, and seemingly was never intended to gather data sufficient to actually influence a decision on which route to use.  This may not pertain to the EFSC process, but it let's you know that the process for choosing a route did not seriously consider culturla resources. |
| | S15 | 11 through 12 | Based on the definition of Site Boundary, we have not been provided the information referred to. |
| | S15 | 37-38 | If existing roads need to be improved in any way, they should be surveyed. |
| | S15 | 47 | We do not agree that lawns have been "extensively disturbed."  It should be noted that archaeological sites and cemeteries have been found under paved roads, highways, and parking lots.  If any such will be disturbed, there must be an assessment of subsurface materials. |
| | S16 | 1 | Please note that in the Columbia Plateau, talus slopes were often used for burials.  How is IPC taking this into account?  Were bedrock exposures examined for rock images and features? |
| | S16 | 4 through 37 | There needs to be some indication that IPC understands that archaeological sites exist within a larger context and may in fact be properties of religious and cultural significance to tribes.  How does that fit in here? |
| | S16 | 29 | There has been no discussion of the definition of a high probability area with the CTUIR.  Seems like the kind of thing we would be consulted about. |
| | S16 | 26 | Please define this "acceptable" visibility.  Is the assumption that there has been no natural deposition that could obscure a 10,000 year old site? |
| | S16 | 33-34 | Given the number of isolated finds just east of Bombing Range Road, as well as the recorded HPRCSITs, we're surprised no high probability areas were found along the West of Bombing Range Road alternatives. |
| | S17 | 22 | "Unlikely" is not a category of evaluation.  For the purposes of the NHPA, a site is either eligible or not eligible.  Only the consulting parties can determine whether or not it is actually eligible.  The CTUIR's comments on the VAHP and RLS were not adequately addressed.  The RLS did not adhere to the VAHP.  We did not receive a 2017 version of the ILS. |
| | S17 | 22 | From our perspective, and based on the documents we were provided, only Criterion C was adequately considered.  Research was not carried out to determine if important people were associated with the properties.  Assessment of association with important events or patterns of our history was also lacking. |
| | S18 | 16 | How many invited signatories/concurring parties signed? As written, the implication is the CTUIR might sign.  The CTUIR has not signed and has no intention of doing so because our comments have not been adequately addressed. |

| | | | |
|---|---|---|---|
| | S18 | 23 | I don’t believe that is why it’s a phased approach. The phased approach was more because of alternative considerations required under the NEPA process and the lack of desire to do the work for all of the alternatives. That's how we got to the poorly considered 15% sample. |
| | S18 | 31 | The existence of an ODOE specific HPMP is news to the CTUIR. We are unaware of approaches to effect determinations. |
| | S19 | 6 | How are HPRCSITs addressed in this document? Where do I look to understand impacts and mitigation of those impacts to those sites? |
| | S35 | 9 through 11 | In order to be true to the intent of the law, we think this section needs to include what comes between “Archaeological Object” and “Archaeological Site.” That’s “Site of Archaeological Significance, ORS 358.905(1)(b). This term shows the importance of consultation with tribes to the state of Oregon. Since we’ve never seen forms or information about the new sites identified during this survey, we have not had an opportunity to give our opinion about their significance in writing. |
| | S35 | 30 | Please note that this is the only HPRCSITs that have been identified to the SHPO. Additional properties and areas of concern were provided to the lead federal agency for this undertaking. This document does not seem to address them at all. |
| | S36 | 8 | "No information pertaining to the two TCPs could be obtained from CTUIR or BLM and therefore could not be fully addressed by the field survey." This is false. We provided information on September 27, 2016 to Kirk Ranzetta of AECOM on which criteria they were eligible under, the physical characteristics that make them eligible, character defining features, viewshed information, the criteria of adverse effect, and information regarding micrositing. On September 27 Mr. Ranzetta answered, "Thank you Catherine for the thorough responses. They were very helpful. I may have some follow up questions to clarify a few points.." No follow up questions were forthcoming. It is our understanding that Mr. Ranzetta was working on the ILS. |
| | S36 | 9 through 10 | As noted above, if the existing roads will need to be modified, additional work should take place. |
| | S36 | 13 | Will the areas of these "potential resources" be subsurface tested? |
| | S37 | Table S5, last two rows | How is it that the “TCPs” identified in Table S-2 aren’t included in this table? None of the other HPRCSITs are either, but I’d expect at least those two to be in the Bombing Range Road alternatives. |
| | S38 | Table S6, last two rows | This table is also missing the "TCPs". |
| | S39 | 7 through 8 | As noted above, statements that no information was provided regarding the HPRCSITs, how the project will impact them, and why they are eligible are simply untrue. |
| | S39 | 21 | "NRHP-eligibility determinations of resources and acceptance of archaeological resources identified thus far are pending review and concurrence by SHPO." For the 106 process, tribes are to be consulted regarding properties’ eligibility. Such a review is not pending with the CTUIR as we have not been provided that information. |
| | S39 | 23 | "Final impact analyses will follow completion of the enhanced archaeological survey, NRHP-eligibility and archaeological site boundary testing, and SHPO concurrence with findings." What about other consulting parties? This document overly focuses on SHPO's roll, ignoring other parties. |
| | S39 | 33 | What did the NPS recommended for this project? |
| | S39 | 40-43 | "For those unevaluated sites that cannot be avoided by Project activities, a resource-specific evaluation or testing plan consistent with the HPMP will be developed after completion of the archaeological survey (including inaccessible areas and subsurface testing) to determine the NRHP eligibility of the sites." This can't happen until after completion of the HPMP. |

| | | | |
|---|---|---|---|
| | S47 | 1 through 4 | This is a great recommendation. However, given the proposed route and alternatives, and the size of the properties, I do not believe it's possible. Even if by some engineering feat a tower was not built in the footprint of the site, the wires between the towers would be within the site and the towers would in all likelihood also be visible. This statement seems to suggest to EFSC that these sites won't be impacted. The CTUIR does not agree. |
| | S49 | 5 through 6 | "86 sites have been recommended as not eligible for listing in the NRHP…" The CTUIR needs more information to determine whether or not we agree with these recommendations. |
| | S49 | 16-17 | "All NRHP eligibility recommendations are considered preliminary and require the concurrence of the SHPO." Any role for tribes? It's hard to tell if tribes think a property is significant if no one asks them. |
| | S49 | 25 | It's important to remember that avoiding the footprint does not necessarily avoid impacts to the characteristics of the site that make it significant. |
| | S49 | 26-27 | "If avoidance is infeasible, it is recommended that data recovery, additional research, and/or consultation with local Native American tribes be conducted." A better way to descibe this process is to say a mitigation plan will be developed with consulting parties. Presumably the yet to be written HPMP would describe such a process. This sentence unreasonably limits mitigation measures. |
| | S49 | 33 | Usually treatment is a term associated with the resolution of adverse effects, not with evaluation. |
| | S49 | 33-34 | As noted, the ODOE-specific HPMP was not developed in consultation with tribes. |
| | S50 | Table S10 | The CTUIR received this report late and have not had a through chance to review the sites that make up this table, we are unable to determine if we agree with these numbers. |
| | S50 | | The RLS of the indirect APE consists of 5 miles or to the visual horizon on either side of the centerline of the Proposed Route and alternatives. The section lists the number of resources identified within the indirect APE. Some tribal data has been included but that data are solely based on the file and literature review. The VAHP states that "A RLS is designed to be a 'first look' at a broad group of historic resources and records basic information. Fieldwork for the RLS will be conducted by teams of two field crew members, who will drive publicly accessible rights-of-way and record resources in a systematic manner." The RLS and ILS fieldwork has not occurred for the indirect APE on tribal lands and this document does not state this. The RLS and ILS data need to gathered and taken into account. It should be acknowledged that the numbers of sites in this document may not be final as the fieldwork as not been conducted. |
| | S50 | 5 | It would be better to define the term "aboveground" earlier, when it is used the first time. |
| | S50 | 5 through 7 | The definition of aboveground leads me to believe it doesn't include HPRCSITs. |
| | S54 | 9 | Archaeological sites may require integrity of feeling, setting, and association even if they don't have aboveground features. How did IPC take that into account? |
| | S54 | 18-19 | "because the Project is so distant that any change to the setting will be extremely minor." At maximum, it will be 5 miles away. Transmission line towers are quite visible at that distance. |
| | S54 | 33 | "22 resources retain no aboveground features." That doesn't mean there can't be an impact to the site, depending on what characteristics make it significant. |
| | S54 | 36-40 | We haven't seen the document this is based on, so can't tell if we agree. We had many comments on a draft of the RLS that were not addressed. |

| | | | |
|---|---|---|---|
| | S55 | 5 | We're not sure of the value of separating direct and indirect effects. They are both adverse effects. It seems possible that people can infer that an indirect effect is less important than a direct effect when that is neither true nor the intent of the NHPA. |
| | S62 | 26 | We do not understand how having and IDP mitigates an adverse effect. It's a protocol for what to do when a site or burial is found during construction. The last draft of this document we received was in 2015. |
| | S63 | Table S17 | One column is Type of Impact. Another is Duration of Impact. Some permanent impacts are permanent, some permanent impacts' duration is the life of the project. We do not understand. |
| | S63 | Table S17 | The bottom two rows are about unidentified sites that will be identified after the issuance of the site certificate, but before construction begins. They are unidentified now, but they won't be when ground disturbance happens. Therefore, we don't understand why they are being treated differently than sites that are known now. |
| | S64 | Table S17 | The top row on this page has the same problem as the previous two rows. |
| | S64 | 28 | Refers to "three identified TCPs"; EFSC should know that the CRPP has identified many more. |
| | S65 | Table S18 | "IPC, in coordination with BLM, will continue to consult with the Oregon SHPO regarding the TCPs within the Site Boundary and indirect analysis area to determine the nature of the resources and appropriate mitigation." It is inconceivable that there is no role for tribes in this process. |
| | S65 | 14 | "Impacts on the two TCPs identified by the Class I literature MAY be direct and/or indirect." Please change that to "will be direct and/or indirect." Also, it is unclear why sometimes two HPRCSITs are discussed and sometimes three sites are discussed. The effects will also apply to all the other HPRCSITs that IPC is not discussing at all, but that tribes have identified during this process. |
| | S66 | 2 | "If avoidance is not possible…" Rather than trying to design the project around such impacts, a route was selected that goes right through several and affects others as well. Avoidance was rejected before this project reached EFSC. |
| | S66 | 5 through 7 | In all likelihood, offsite mitigation will be required for these and other properties, as we have told IPC repeatedly. Public education for non-tribal members is not a high priority in the face of destruction of elements of our culture. When something is taken from the culture, something else needs to be given back. |
| | S66 | 17-19 | Regarding "measures for avoidance", as noted above, the time for preventing destruction of resources was during the identification of the route. Input on how to route the line to minimize and avoid impacts was disregarded. Now big picture avoidance is off the table, except for eliminating a few terrible alternatives, such as the Morgan Lake alternative, that will have more significant impacts on resources. |
| | S66 | 22 | One does not mitigate sites. One mitigates effects to sites. |
| | S66 | 25-26 | NHPA says to avoid, minimize, or mitigate effects. Thus, avoidance is not mitigation. |
| | S66 | 35 | Please insure the training includes state regulations that protect archaeological resources and burials. |
| | S66 | 45 | As noted, the CTUIR does not have an up to date IDP. The BLM told us they were putting it on "hold" in November 2015. The contents of this document are very important to us and we expect to develop it in consultation with the various parties. |
| | S67 | 12 | Sturdy fencing may be required to protect areas. We have seen many instances of flagging or loose plastic fencing being insufficient to keep a large piece of equipment out of a site area. |
| | S67 | 14 | Monitors are likely to be appropriate for all or some of this project, not just in areas with known sites. |

| | | | |
|---|---|---|---|
| | S68 | Table S19 | First row indicates surveys were completed between 2011 and 2014. Some portions of this route were not under consideration at that time. Pleaes explain. |
| | S68 | Table S19 | Third row, middle column states, "Evaluation may include site testing and Native American consultations." Please clarify that evaluation WILL include Native American consultations. |
| | S69 | Table S19 | First row, please note that no analysis of impacts to properties of religious and historic places has started. |
| | S70 | 10 through 25 | Please ensure the HPMP is developed in meaningful consultation with affected tribes. Thus far, there have been many meetings about this project, but not much meaningful consultation. |
| | S70 | 31 | Please add the following to the sentence: "consistent with the HPMP, which was developed in consultation with consulting parties." |
| | S70 | 42 | This may be the appropriate place to require the presence of a culutral resource monitor during construction. |
| | S71 | 4 | Please add something to the effect, "Within one year after construction is completed, the site certificate holder shall provide evidence of the completion of all mitigation as detailed in site-specific HPMPs or the HPMP as a whole." |
| | S71 | 32-38 | This section asserts that this project, taking into account mitigation, will not result in significant adverse impacts to cultural resources. What if significant adverse effects cannot be mitigated? What if no agreement on such mitigation can be reached between parties? What does that mean for the site certificate? It would mean that the conclusion of this Exhibit is false. Are there certificate conditions that could address such a concern? |
| | 81 | Attachment S-1 | If ODOE would like details of the comments the CTUIR made on this plan and the lack of addressing of those comments, please let us know. |
| | 131 | Attachment S-4 | The CTUIR did not initially receive this document and asked for it on August 25 which was not enough time to review prior to these comments being submitted; CTUIR would like an extension to review this document. |
| | 132 | Attachment S-5 | If ODOE would like details of the comments the CTUIR made on the PA and the lack of addressing of those comments, please let us know. |
| | 225 | Attachment S-6 | The CTUIR did not initially receive this document and asked for it on August 25 which was not enough time to review prior to these comments being submitted; CTUIR would like an extension to review this document. |
| | 226 | Attachment S-7 | The CTUIR did not initially receive this document and asked for it on August 25 which was not enough time to review prior to these comments being submitted; CTUIR would like an extension to review this document. |
| | 504 | Attachment S-8 | IPC did not provide the CTUIR this document in 2016. This is the first we’ve seen of it. The PA requires development of the HPMP with consulting parties. |
| | 564 | Attachment S-10 | The CTUIR did not initially receive this document and asked for it on August 25 which was not enough time to review prior to these comments being submitted; CTUIR would like an extension to review this document. |

**Confederated Tribes** *of the*
**Umatilla Indian Reservation**
Department of Natural Resources
Administration

46411 Timíne Way
Pendleton, OR 97801

www.ctuir.org ericquaempts@ctuir.org
Phone 541-276-3165 Fax: 541-276-3095

September 27, 2010

Bureau of Land Management
B2H Project
Post Office Box 655
Vale, Oregon 97918

Submitted electronically to: comment@boardmantohemingway.com

Dear Bureau of Land Management:

The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) Department of Natural Resources (DNR) has reviewed the July 27, 2010 *Federal Register* article "Revised Notice of Intent to Prepare an Environmental Impact Statement for the Proposed Boardman to Hemingway 500kV Transmission Line (B2H) Project in Idaho and Oregon and Possible Land Use Plan Amendments." Because the proposed Boardman to Hemingway line has the potential to significantly and adversely impact treaty reserved resources, the CTUIR DNR offers the following suggestions for consideration during the National Environmental Policy Act (NEPA) process. The comments contained in this letter are not an exclusive list of the CTUIR's concerns regarding this project and we anticipate consulting with the BLM and Forest Service (FS) over the duration of this project to fully evaluate the impacts of this project.

The proposed B2H route has already been identified. The CTUIR DNR obtained information regarding this route from Idaho Power's *Notice of Intent to Apply for a Site Certificate for the Boardman to Hemingway Transmission Line*, which describes the process followed to determine a route. Included in this process is the identification of Selected Key Constraints and their Permitting Importance (see Table D-2). The CTUIR DNR does not know whether the federal agencies were included in the identification of the constraints or in their permitting importance, but we are confident that the CTUIR was not consulted on their determination. We recommend that alternative routes be considered in the NEPA process so that government to government consultation includes a meaningful discussion of the location of the proposed transmission line rather than simply consultation on whether or not it should be permitted. For example, in developing the proposed route, Idaho Power determined that avoiding crossing federal land was a low priority. The availability of federally owned and managed land is essential to the exercise of treaty rights reserved by the CTUIR, and if the proposed line prevents the use of a substantial amount of federal land for traditional, treaty-protected activities, the impact to the CTUIR will be significant. Avoiding the Oregon National Historic Trail Interpretive Center was a high priority, but constructing within 500 feet of a cemetery had an avoidance level of moderate. Similarly, avoiding big game winter range was considered a moderate priority. The avoidance of impacts to such areas is a high priority to the CTUIR. There must be an opportunity for the CTUIR and the federal government to work together on our priorities involving the meaningful opportunity to relocate the line when priorities conflict.

The BLM and Forest Service have identified ten preliminary issues, with which we agree.  The CTUIR DNR requests that impacts to both treaty-reserved resources and cultural resources be added to that list.  The CTUIR DNR is concerned about impacts this proposed project will have on First Food resources.  The First Foods (water, salmon, deer, cous, and huckleberry) are ritualistically served at the Longhouse, the center of the CTUIR community culture.  The serving ritual represents a closely-held, ecologically and culturally informed view of the landscape upon which the CTUIR depends.  Each First Food represents a grouping of similar species, with salmon representing a variety of aquatic life forms (e.g. steelhead, lamprey, freshwater mussels, and various resident fish), deer (big game), cous (plant bulbs), and the huckleberry representing fruiting plants.  DNR's mission is to ensure that the First Foods are protected, restored, and enhanced for the perpetual cultural and economic benefit of the CTUIR.  Essentially, the DNR seeks to ensure that, at a minimum, the First Foods will be present at every community meal, with a long-term goal of restoring species within each food grouping to provide a serving table rich in native species.

In entering into the Treaty of 1855, the CTUIR ceded to the United States 6.3 million acres, but reserved the perpetual right to hunt, gather and graze livestock on all unclaimed lands within its aboriginal territory.  Each of the First Foods, and the right to harvest them, are explicitly protected in the Treaty of 1855.  As portions of the CTUIR's aboriginal homeland passed into private ownership, the CTUIR's access to these resources diminished.  Therefore, it is crucial for the Tribes to cooperatively manage the remaining federal land to maximize the health of the First Foods.  A healthy culture is not possible without a healthy ecosystem providing the First Foods.  As tribal members can hunt, gather and graze livestock on unclaimed lands, it is important that there be sufficient habitat on federal lands and that habitat be protected from development.  The impacts to the treaty-reserved resources from power line construction, operation and maintenance must be analyzed, such as the impact of high-voltage lines on the wintering habitats of big game and whether construction access will open previously closed areas to resource damage by the public.

There should be an analysis of the viewshed impacts of the line, particularly through the Blue Mountains immediately south of the Umatilla Indian Reservation.  There are currently no power lines through this area, and the CTUIR believes that placement of a 500kV line through this area will have a significant negative effect on the viewshed.  Further, the proposed route would cross the original Umatilla Indian Reservation as established by the Treaty of 1855.  The CTUIR has established a policy to purchase back lands which were part of the original reservation to bring these lands back into trust for the tribe and therefore has a significant interest in analysis of  the long term impacts of the proposed route.

The cernterline of the proposed route crosses a portion of the Umatilla Indian Reservation, as it passes through parcel 6300 in Township1 South, Range 35 East, WM at approximately milepost 93.  This land is owned by and under the jurisdiction of the CTUIR, but is not indicated as tribally-owned land on the maps Idaho Power has provided.  None of the agreements regarding cultural resource work have included the CTUIR's Tribal Historic Preservation Officer (THPO).

Please initiate consultation with the THPO regarding the undertaking's area of potential effects as soon as possible.

The CTUIR DNR expects to remain informed and involved throughout the NEPA process with the BLM and the FS. Please feel free to contact me or Audie Huber, DNR Intergovernmental Affairs Manager at 541-276-3165 with any questions regarding these comments. We can be reached at 541-276-3165.

Respectfully,

Teara Farrow Ferman for

Eric J. Quaempts, Director
Department of Natural Resources

cc: Ted Davis, BLM
Donald N. Gonzalez, BLM
Steve Ellis, USFS
Kevin Martin, USFS
CTUIR: CRC, Bruce Zimmerman, Audie Huber

Confederated Tribes *of the*
Umatilla Indian Reservation
Department of Natural Resources
Administration

46411 Timíne Way
Pendleton, OR 97801

www.ctuir.org ericquaempts@ctuir.org
Phone 541-276-3165 Fax: 541-276-3095

September 27, 2010

Sue Oliver
Energy Facility Siting Officer
Oregon Department of Energy
395 East Highland Avenue
Hermiston, Oregon 97838

Submitted electronically to: Sue.Oliver@state.or.us

Dear Ms. Oliver:

The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) Department of Natural Resources (DNR) has reviewed Idaho Power's *Notice of Intent to Apply for a Site Certificate for the Boardman to Hemingway Transmission Line* (Notice of Intent). The Oregon Department of Energy has asked the CTUIR to provide comments on specific issues as a reviewing agency. This letter addresses those issues, but also outlines several additional concerns of the CTUIR. These comments are offered based on our government to government relationship with the State of Oregon and we hope to work with the Oregon Energy Facility Siting Council (EFSC) in consultation throughout the facility siting process.

**Responses to Comments Requested by the Oregon Department of Energy:**

**a. Contact person assigned to coordinate DNR's comments on the NOI:**

Eric Quaempts, Director
Department of Natural Resources
46411 Timíne Way
Pendleton, Oregon 97801
(541) 276-3447

**b. Comments on aspects of the facility that are within DNR's particular responsibility or area of expertise.**

The CTUIR DNR is concerned about the impacts this proposed project will have on First Food resources. The First Foods (water, salmon, deer, cous, and huckleberry) are ritualistically served at the Longhouse, the center of the CTUIR community culture. The serving ritual represents an intimate, ecologically and culturally informed view of the landscape upon which the CTUIR depends. Each First Food represents a grouping of similar species, with salmon representing a variety of aquatic life forms (e.g. steelhead, lamprey, freshwater mussels, and various resident fish), deer (big game), cous (plant bulbs), and the huckleberry representing fruiting plants. The CTUIR DNR's mission is to ensure that the First Foods are protected, restored, and enhanced for the perpetual cultural and economic benefit of the CTUIR. Essentially, the CTUIR DNR seeks to ensure that, at a minimum, the First Foods will be present at every community meal, with a long-term goal of restoring species within each food grouping to provide a serving table rich in native species.

In entering into the Treaty of 1855, the CTUIR ceded to the United States 6.3 million acres, but reserved the perpetual right to hunt, gather and graze livestock on all unclaimed lands within its aboriginal territory. Each of the First Foods, and the right to harvest them, are explicitly protected in the Treaty of 1855. As portions of the CTUIR's aboriginal homeland passed into private ownership, the CTUIR's access to these resources diminished. Therefore, it is crucial for the Tribes to cooperatively manage the remaining federal land to maximize the health of the First Foods. A healthy culture is not possible without a healthy ecosystem providing the First Foods. As tribal members can hunt, gather and graze livestock on unclaimed lands, it is important that there be sufficient habitat on federal lands and that habitat be protected from development. The impacts to the treaty-reserved resources from power line construction, operation and maintenance must be analyzed, such as the impact of high-voltage lines on the wintering habitats of big game and whether construction access will open previously closed areas to resource damage by the public.

The CTUIR DNR is concerned about this project's potential to cause habitat fragmentation, disruption of wildlife migration habits, and connectivity. In addition, we are concerned about the introduction of weed species from habitat disturbance and the construction of many miles of new roads. We would like information on the long-term plan to manage weed impacts. We would also like to know what will be planted in forested areas from which all trees will be removed, how such areas will be managed and whether herbicides will be used.

Permitting this project is an undertaking within the meaning of the National Historic Preservation Act and the CTUIR DNR believes this undertaking is likely to adversely affect historic properties, including those of religious and cultural significance to the CTUIR. Known resources likely to be impacted include the Oregon Trail, tribal trails, named places, villages, camps, traditional hunting, fishing, medicine, gathering, and digging areas, as well as archaeological sites.

**c. Recommendations regarding the size and location of analysis areas**

As noted in the cover letter to the NOI, it is a preliminary document so it is premature to define analysis areas for various resources. The CTUIR DNR, however, looks forward to working with Idaho Power and BLM/FS on the study design for resources protected by treaty and statute. See our comments below on the phased approach for additional comments regarding analysis areas for viewshed impacts.

**d. List of necessary studies**

A traditional use study should be conducted in consultation with affected tribes to identify historic properties of religious and cultural significance. Additionally, studies analyzing the proposed project's impacts on big game and other wildlife species will be necessary. Unless existing data document how wildlife respond to transmission lines, such studies need to be conducted before the potential wildlife impacts of this line can be understood. Wildlife impact studies should identify the corridors through which wildlife travel in the area of the transmission line and analyze the implications of the line on habitat fragmentation and connectivity. Page B-7 of the Notice of Intent indicates, "In accordance with Idaho Power's Avian Protection Plan, avian-safe design will be implemented as practical and feasible to reduce risk of bird collision and electrocution in high avian risk areas." Are there plans to identify high avian risk areas? Also, we would like to ensure that studies of migratory bat corridors be undertaken. Bats have historically been under analyzed and as such many impacts permitted without the necessary information.

**e. Relative merits of the preferred and alternate transmission line corridors**

Idaho Power identifies constraints to constructing the line and provides avoidance priorities for each. However, there is no explanation of how these avoidance priorities for specific categories, such as public lands and cemeteries were determined. Without that information, it is difficult to determine whether or not we agree with Idaho Power's findings.

The CTUIR DNR strongly questions the alternative in Malheur County designed to avoid irrigated farmland near the Snake River. That alternative lengthens the transmission line by diverting onto BLM land, which will disproportionately impact treaty-reserved resources.

The centerline of the proposed route crosses the Umatilla Indian Reservation, across parcel 6300 in Township 1 South, Range 35 East, WM, at approximately milepost 93. This land is owned and under the jurisdiction of the CTUIR, held in trust by the Bureau of Indian Affairs for the CTUIR. If the state issues a site certificate, the CTUIR DNR expects that these lands will be specifically excluded from the certificate.

**f. List of statutes, administrative rules and local government ordinances administered by the CTUIR that might apply to construction or operation of the proposed facility and a description of any information needed for determining compliance.**

First and foremost, the Treaty of 1855 between the CTUIR and the United States must be considered in establishing the line. The CTUIR secured perpetual rights under the Treaty that are linked to much of the lands affected by this project. Among other rights secured by the Treaty, the CTUIR retains the rights to hunt, fish, gather, and graze livestock on lands that will be affected by the proposed line. The reservation of these rights includes a corresponding right to the resources associated with those rights (i.e. fish, big game, traditional plants, etc.). In analyzing the impacts of the line EFSC must consider the potential impacts to these treaty-reserved rights and resources.

Additionally, there are a number of federal and state laws addressing cultural resources which must be considered as part of this process, including but not limited to:

- The Native American Graves Protection and Repatriation Act, 25 USC 3000 et seq, for portions of the line on federal and Indian lands.

- The Archaeological Resources Protection Act, 16 USC 470aa et seq, for portions on federal and Indian lands.
- The National Historic Preservation Act, 16 USC 470 et seq, for the area of potential effect.
- Oregon Indian Graves and Protected Objects law, ORS 97.740 et seq, for the portions not on federal or Indian lands.
- Oregon Archaeological Objects and Sites, ORS 358.905 et seq, for portions not on federal or Indian lands.

**g. List of Permits:**

In the event the line crosses the Umatilla Indian Reservation, Idaho Power will need permission from the CTUIR Board of Trustees, the Bureau of Indian Affairs and the Tribal Planning Office which administers our Land Development Code. There may be more permits depending upon the resources impacted, but that will need to be addressed with the appropriate zoning/regulatory authority.

**h. Road building standards applicable within jurisdiction.**

Similar to above, section (g), road standard construction on reservation would be determined by the Tribal Planning Office.

**i. Comments on the phased study approach.**

The CTUIR DNR does not understand how the phased approach will work with the NEPA process. The draft environmental impact statement (DEIS) will be prepared based on input from Phase 1. But the purpose of the DEIS is to identify the alternatives' impacts so that a decision can be made determining which is the best alternative. For many resources, the only activities during Phase 1 are reviewing existing data. For some categories of potential impacts, there may be no existing data regarding the specific proposed area or its alternatives. Similarly, it seems that the Oregon Department of Energy will not have enough information to determine whether the proposed project meets your requirements.

Appendix J-1 of the Notice of Intent provides more detail on the phased approach. The Noise Analysis Area is insufficient. Rather than identifying noise sensitive areas about which it knows, Idaho Power should create a map of the entire proposed line and alternative routes indicating where different levels of noise will be audible, from the loudest to no audible sound. The studies of historic properties of religious and cultural significance to Indian tribes will likely identify noise sensitive areas. A noise level map would streamline the process whereby affected tribes determine the level of auditory impact to these sites.

Similarly, maps showing the areas from which the project will be visible should be developed. Rather than using arbitrary distances, the map should extend to where the project will no longer be visible, whether because of topography or distance. It is also not appropriate to judge when an object on the horizon is and is not intrusive; different people and different cultures will have differing ideas about intrusiveness. The visual analysis needs to be sure to include consideration not just of the towers, but of any lights that will be associated with the structures. In addition, within forested areas, large swaths of trees will be removed. These areas will likely be visible from longer distances than the towers themselves. Of particular note, there should be an analysis of the viewshed impacts of the line through the Blue Mountains immediately south of the Umatilla Indian Reservation. This area is relatively pristine, with no existing power lines. The CTUIR DNR believes placement of a 500kV line through this area will have a significant, negative effect on the viewshed. Further, this area is part of the original Umatilla Indian Reservation established by the Treaty of 1855. The CTUIR has established a policy to purchase back lands which were on the original reservation to bring these lands back into trust for the tribe. The CTUIR therefore has a significant interest in analysis of the long term impacts of the location of the line here.

Idaho Power limits its cumulative impacts analysis to "projects that have applied for a permit from local, state, or federal authorities and which are publicly known." The DNR does not believe this is an adequate interpretation of the phrase "reasonably foreseeable." Wind projects have historically developed in close proximity to existing transmission lines. The two things that wind proponents look for are wind and an ability to transmit the power it could generate. Idaho Power must look at wind resources along the proposed route and address developments that this proposed line, simply by its presence, will allow to be developed. The BLM has several wind evaluation projects which are pre-permit but post analysis at the conceptual level. The fact that these projects will become viable once transmission becomes available should be considered in whether they are "reasonably foreseeable." In addition, EFSC will need to consider cumulative impacts to the Oregon Trail and other historic properties which have been crossed by previous transmission lines, roads, and pipelines.

The phased approach to cultural resource analysis does not include an analysis area. Clarification of what area will be analyzed for cultural resource impacts needs to be developed. The phased approach also refers to established key observation points. What are these points and how will they be used? A survey of only 15% of the proposed transmission line is not acceptable. Under Phase 2 of the Phased Study Plan, it says "Listed Sites or Sites Eligible for Listing on the National Register of Historic Places," But no information is included about what analysis will be undertaken regarding such places. The CTUIR DNR suggests that in Phase 1, all cultural resources are identified through literature review, on the ground study, and traditional use studies. In Phase 2, these cultural resources should be evaluated to determine whether they are eligible for inclusion in the National Register of Historic Places. A plan to avoid, minimize, or mitigate effects to historic properties will be developed, to inform the agencies in their decision on which alternative to select in the NEPA process and on whether issuing a site certificate is consistent with their regulations. In Phase 3, the avoidance, minimization, and mitigation measures will be implemented.

The analysis of Social and Economic Resources focuses on counties. Please ensure that the Umatilla Indian Reservation, as a sovereign governmental unit, is included in consideration of the proposed project's impacts. It will be necessary to look at data beyond the census to determine how tribal members utilize the area to be impacted; without that information, it will not be clear whether there are trust resource issues and environmental justice issues.

**j. List of tribal codes that the tribe recommends to the Council for review:**

In the event the line crosses the Umatilla Indian Reservation, applicable tribal laws would be the Land Development Code, Tribal Employment Rights Office Code, Taxation Code, Water Code, Environmental Health Code as well as other regulatory rulemakings depending upon the activity. Copies of these codes are available on-line.[1] Other regulatory requirements may be in place depending upon the exact nature of the activity associated with siting, construction as well as operations and maintenance.

**k. Errors in the Document**

Exhibit E addresses the permits necessary for the proposed project. Both the BLM and the Forest Service issue permits for cultural resource work on the lands they manage. The exhibit indicates that those permits are issued pursuant to the National Historic Preservation Act. In the case of both agencies, the permits are issued under the Archaeological Resources Protection Act.

Table J-1 indicates the gray wolf was removed from the list of Endangered Species in Eastern Oregon and Idaho. That information is out of date; the gray wolf has been returned to the Endangered Species list throughout the Northern Rocky Mountain Region.

**Conclusion**

The CTUIR appreciates EFSC's invitation to provide comments on Idaho Power's Notice of Intent as a reviewing agency. The CTUIR fully expects to remain informed and involved throughout the siting process. Please feel free to contact me or Audie Huber, DNR Intergovernmental Affairs Manager at 541-276-3165 with any questions regarding these comments.

Respectfully,

Teara Farrow Ferman
for
Eric J. Quaempts, Director
Department of Natural Resources

cc: Ted Davis, BLM
Donald N. Gonzalez, BLM
Steve Ellis, USFS
Kevin Martin, USFS
CTUIR: CRC, Bruce Zimmerman, Audie Huber

[1] http://www.umatilla.nsn.us/laws.html

| Boardman to Hemingway Transmission Line<br>Comments on the Amended Preliminary Application for Site Certificate<br>From the Confederated Tribes of the Umatilla Indian Reservation | | | |
|---|---|---|---|
| **Exhibit** | **Section No.** | **Pg./Para./Sentence Reference (as needed)** | **Comment** |
| B | Attachment B-2, Appendix A, Page A-2 | No line numbers | This summary inadequately documents the concerns of the CTUIR. The summary focuses exclusively on prioritizaiton of line siting without addressing any other issues or concerns raised by the CTUIR in our letter to BLM scoping for the B2H project. For the record, we have attached our scoping comments provided to BLM and those comments provided to Oregon EFSC. |
| BB | 3.3 | BB-7, Lines 31-35. | The Amended Perliminary Application repeatedly states that the line does not cross the reservation and concludes therefore that no tribal resources need to be addressed beyond existing exhibits. This fails to mention that the visual, noise and cultural impacts occur on reservation as well as fails to understand that tribal rights to resources off reservation can and will be impacted by the project. Treaty reserved rights and resources do not exclusively occur on reservation lands. |
| BB | 3.3 | BB-8, Lines 16-18. | The Amended Perliminary Application states "Project impacts on the First Foods are, however, fully addressed under the Section 106 of the National Historic Preservation Act compliance process that will be memorialized in a Programmatic Agreement for the Project." This is patently false, nowhere in the Programmatic Agreement does it address first foods. The PA is only about complying with Section 106 of the NHPA. The PA is contained in Exhibit S, Attachment S-5. Even a cursory review would confirm First Foods are not addressed. |
| S | S1 | Footnote 1 | "The SHPO is yet to concur with findings of field surveyes." Without SHPO concurrence, we really have no idea what sites are and are not eligible. Nor have other consulting parties been involved. |
| | S3 | 34-36 | "The application shall include evidence of consultation with affected tribes regarding archaeological and cultural sites and materials that may be found on the proposed facility site." As you'll note in comments below, especially the lack of providing us with the confidential attachments to Exhibit S, from our perspective this requirement has not been met. |
| | S9 | 32-34 | "Although compliance with Section 106 of the NHPA does not equate to compliance with EFSC standards, studies conducted in support of Section 106 compliance are utilized to support compliance with EFSC standards." We just want to make sure that EFSC understands that some documents submitted as part of Exhibit S have been developed through the 106 mandated consultation process (even though we remain highly disappointed at the ability of the BLM to address our comments; at least we have seen the documents), but some have not. They are required as part of the 106 process but have not been submitted to consulting parties to review. |
| | S11 | 20, 21, 25, and 27 | The existence of these documents (High Probability Areas Assessment, Enhanced Archaeological Survey, ILS, HPMP), or revised documents, is news to us. |
| | S12 | 17 | Based on other uses of the word "aboveground" in this document, this does not include properties of religious and cultural significance to the CTUIR. Visual impacts can affect the integrity of setting, feeling, and association for these types of properties. The treatment of this type of property is spotty and confusing throughout the document. We prefer the term "historic properties of religious and cultural significance to Indian trbes" (HPRCSIT), as recommended by the ACHP. They eventually use the term TCP, which is not necessary since no such non-tribal properties were located. It is unclear to what degree such properties were inventoried. |

| | | | |
|---|---|---|---|
| | S12 | 30-31 | "Resources that are addressed by these studies can be categorized as archaeological or aboveground resources." This is not consistent with ODOE's language regarding cultural resources. Other types of resources may be eligible for the National Register. This is overly simplistic and does not adequately address the types of impacts to archaeological sites that may have values other than just archaeology. It is unclear which of these two categories HPRCSITs would fall into. |
| | S14-15 | 42-1 | The CTUIR never saw an updated literature review for the alternatives suddenly added to the FEIS, after the DEIS. |
| | S15 | 6 through 9 | We objected to several aspects of this plan, especially the validity of the non-random 15% sample. No evidence of its adequacy was provided. IPC and the federal agencies simply said "that's what's been done on other projects." A true random sample is critical, as is an understanding of what percentage sample is needed to provide an adequate sample to answer the research questions (which here are likely presence/absence of archaeological sites). Also, an adequate sample of each alternative is critical if one is trying to determine whether one alternative is better or worse for archaeological resources. From the CTUIR's perspective, this was simply an exercise, and seemingly was never intended to gather data sufficient to actually influence a decision on which route to use. This may not pertain to the EFSC process, but it let's you know that the process for choosing a route did not seriously consider culturla resources. |
| | S15 | 11 through 12 | Based on the definition of Site Boundary, we have not been provided the information referred to. |
| | S15 | 37-38 | If existing roads need to be improved in any way, they should be surveyed. |
| | S15 | 47 | We do not agree that lawns have been "extensively disturbed." It should be noted that archaeological sites and cemeteries have been found under paved roads, highways, and parking lots. If any such will be disturbed, there must be an assessment of subsurface materials. |
| | S16 | 1 | Please note that in the Columbia Plateau, talus slopes were often used for burials. How is IPC taking this into account? Were bedrock exposures examined for rock images and features? |
| | S16 | 4 through 37 | There needs to be some indication that IPC understands that archaeological sites exist within a larger context and may in fact be properties of religious and cultural significance to tribes. How does that fit in here? |
| | S16 | 29 | There has been no discussion of the definition of a high probability area with the CTUIR. Seems like the kind of thing we would be consulted about. |
| | S16 | 26 | Please define this "acceptable" visibility. Is the assumption that there has been no natural deposition that could obscure a 10,000 year old site? |
| | S16 | 33-34 | Given the number of isolated finds just east of Bombing Range Road, as well as the recorded HPRCSITs, we're surprised no high probability areas were found along the West of Bombing Range Road alternatives. |
| | S17 | 22 | "Unlikely" is not a category of evaluation. For the purposes of the NHPA, a site is either eligible or not eligible. Only the consulting parties can determine whether or not it is actually eligible. The CTUIR's comments on the VAHP and RLS were not adequately addressed. The RLS did not adhere to the VAHP. We did not receive a 2017 version of the ILS. |
| | S17 | 22 | From our perspective, and based on the documents we were provided, only Criterion C was adequately considered. Research was not carried out to determine if important people were associated with the properties. Assessment of association with important events or patterns of our history was also lacking. |
| | S18 | 16 | How many invited signatories/concurring parties signed? As written, the implication is the CTUIR might sign. The CTUIR has not signed and has no intention of doing so because our comments have not been adequately addressed. |

| | | | |
|---|---|---|---|
| | S18 | 23 | I don’t believe that is why it’s a phased approach.  The phased approach was more because of alternative considerations required under the NEPA process and the lack of desire to do the work for all of the alternatives.  That's how we got to the poorly considered 15% sample. |
| | S18 | 31 | The existence of an ODOE specific HPMP is news to the CTUIR.  We are unaware of approaches to effect determinations. |
| | S19 | 6 | How are HPRCSITs addressed in this document?  Where do I look to understand impacts and mitigation of those impacts to those sites? |
| | S35 | 9 through 11 | In order to be true to the intent of the law, we think this section needs to include what comes between “Archaeological Object” and “Archaeological Site.”  That’s “Site of Archaeological Significance, ORS 358.905(1)(b).  This term shows the importance of consultation with tribes to the state of Oregon.  Since we’ve never seen forms or information about the new sites identified during this survey, we have not had an opportunity to give our opinion about their significance in writing. |
| | S35 | 30 | Please note that this is the only HPRCSITs that have been identified to the SHPO.  Additional properties and areas of concern were provided to the lead federal agency for this undertaking.  This document does not seem to address them at all. |
| | S36 | 8 | "No information pertaining to the two TCPs could be obtained from CTUIR or BLM and therefore could not be fully addressed by the field survey."  This is false.  We provided information on September 27, 2016 to Kirk Ranzetta of AECOM on which criteria they were eligible under, the physical characteristics that make them eligible, character defining features, viewshed information, the criteria of adverse effect, and information regarding micrositing.  On September 27 Mr. Ranzetta answered, "Thank you Catherine for the thorough responses.  They were very helpful.  I may have some follow up questions to clarify a few points.."  No follow up questions were forthcoming.  It is our understanding that Mr. Ranzetta was working on the ILS. |
| | S36 | 9 through 10 | As noted above, if the existing roads will need to be modified, additional work should take place. |
| | S36 | 13 | Will the areas of these "potential resources" be subsurface tested? |
| | S37 | Table S5, last two rows | How is it that the “TCPs” identified in Table S-2 aren’t included in this table?  None of the other HPRCSITs are either, but I’d expect at least those two to be in the Bombing Range Road alternatives. |
| | S38 | Table S6, last two rows | This table is also missing the "TCPs". |
| | S39 | 7 through 8 | As noted above, statements that no information was provided regarding the HPRCSITs, how the project will impact them, and why they are eligible are simply untrue. |
| | S39 | 21 | "NRHP-eligibility determinations of resources and acceptance of archaeological resources identified thus far are pending review and concurrence by SHPO."  For the 106 process, tribes are to be consulted regarding properties’ eligibility.  Such a review is not pending with the CTUIR as we have not been provided that information. |
| | S39 | 23 | "Final impact analyses will follow completion of the enhanced archaeological survey, NRHP-eligibility and archaeological site boundary testing, and SHPO concurrence with findings."  What about other consulting parties?  This document overly focuses on SHPO's roll, ignoring other parties. |
| | S39 | 33 | What did the NPS recommended for this project? |
| | S39 | 40-43 | "For those unevaluated sites that cannot be avoided by Project activities, a resource-specific evaluation or testing plan consistent with the HPMP will be developed after completion of the archaeological survey (including inaccessible areas and subsurface testing) to determine the NRHP eligibility of the sites."  This can't happen until after completion of the HPMP. |

| | | | |
|---|---|---|---|
| | S47 | 1 through 4 | This is a great recommendation. However, given the proposed route and alternatives, and the size of the properties, I do not believe it's possible. Even if by some engineering feat a tower was not built in the footprint of the site, the wires between the towers would be within the site and the towers would in all likelihood also be visible. This statement seems to suggest to EFSC that these sites won't be impacted. The CTUIR does not agree. |
| | S49 | 5 through 6 | "86 sites have been recommended as not eligible for listing in the NRHP…" The CTUIR needs more information to determine whether or not we agree with these recommendations. |
| | S49 | 16-17 | "All NRHP eligibility recommendations are considered preliminary and require the concurrence of the SHPO." Any role for tribes? It's hard to tell if tribes think a property is significant if no one asks them. |
| | S49 | 25 | It's important to remember that avoiding the footprint does not necessarily avoid impacts to the characteristics of the site that make it significant. |
| | S49 | 26-27 | "If avoidance is infeasible, it is recommended that data recovery, additional research, and/or consultation with local Native American tribes be conducted." A better way to descibe this process is to say a mitigation plan will be developed with consulting parties. Presumably the yet to be written HPMP would describe such a process. This sentence unreasonably limits mitigation measures. |
| | S49 | 33 | Usually treatment is a term associated with the resolution of adverse effects, not with evaluation. |
| | S49 | 33-34 | As noted, the ODOE-specific HPMP was not developed in consultation with tribes. |
| | S50 | Table S10 | The CTUIR received this report late and have not had a through chance to review the sites that make up this table, we are unable to determine if we agree with these numbers. |
| | S50 | | The RLS of the indirect APE consists of 5 miles or to the visual horizon on either side of the centerline of the Proposed Route and alternatives. The section lists the number of resources identified within the indirect APE. Some tribal data has been included but that data are solely based on the file and literature review. The VAHP states that "A RLS is designed to be a 'first look' at a broad group of historic resources and records basic information. Fieldwork for the RLS will be conducted by teams of two field crew members, who will drive publicly accessible rights-of-way and record resources in a systematic manner." The RLS and ILS fieldwork has not occurred for the indirect APE on tribal lands and this document does not state this. The RLS and ILS data need to gathered and taken into account. It should be acknowledged that the numbers of sites in this document may not be final as the fieldwork as not been conducted. |
| | S50 | 5 | It would be better to define the term "aboveground" earlier, when it is used the first time. |
| | S50 | 5 through 7 | The definition of aboveground leads me to believe it doesn't include HPRCSITs. |
| | S54 | 9 | Archaeological sites may require integrity of feeling, setting, and association even if they don't have aboveground features. How did IPC take that into account? |
| | S54 | 18-19 | "because the Project is so distant that any change to the setting will be extremely minor." At maximum, it will be 5 miles away. Transmission line towers are quite visible at that distance. |
| | S54 | 33 | "22 resources retain no aboveground features." That doesn't mean there can't be an impact to the site, depending on what characteristics make it significant. |
| | S54 | 36-40 | We haven't seen the document this is based on, so can't tell if we agree. We had many comments on a draft of the RLS that were not addressed. |

| | | | |
|---|---|---|---|
| | S55 | 5 | We're not sure of the value of separating direct and indirect effects. They are both adverse effects. It seems possible that people can infer that an indirect effect is less important than a direct effect when that is neither true nor the intent of the NHPA. |
| | S62 | 26 | We do not understand how having and IDP mitigates an adverse effect. It's a protocol for what to do when a site or burial is found during construction. The last draft of this document we received was in 2015. |
| | S63 | Table S17 | One column is Type of Impact. Another is Duration of Impact. Some permanent impacts are permanent, some permanent impacts' duration is the life of the project. We do not understand. |
| | S63 | Table S17 | The bottom two rows are about unidentified sites that will be identified after the issuance of the site certificate, but before construction begins. They are unidentified now, but they won't be when ground disturbance happens. Therefore, we don't understand why they are being treated differently than sites that are known now. |
| | S64 | Table S17 | The top row on this page has the same problem as the previous two rows. |
| | S64 | 28 | Refers to "three identified TCPs"; EFSC should know that the CRPP has identified many more. |
| | S65 | Table S18 | "IPC, in coordination with BLM, will continue to consult with the Oregon SHPO regarding the TCPs within the Site Boundary and indirect analysis area to determine the nature of the resources and appropriate mitigation." It is inconceivable that there is no role for tribes in this process. |
| | S65 | 14 | "Impacts on the two TCPs identified by the Class I literature MAY be direct and/or indirect." Please change that to "will be direct and/or indirect." Also, it is unclear why sometimes two HPRCSITs are discussed and sometimes three sites are discussed. The effects will also apply to all the other HPRCSITs that IPC is not discussing at all, but that tribes have identified during this process. |
| | S66 | 2 | "If avoidance is not possible…" Rather than trying to design the project around such impacts, a route was selected that goes right through several and affects others as well. Avoidance was rejected before this project reached EFSC. |
| | S66 | 5 through 7 | In all likelihood, offsite mitigation will be required for these and other properties, as we have told IPC repeatedly. Public education for non-tribal members is not a high priority in the face of destruction of elements of our culture. When something is taken from the culture, something else needs to be given back. |
| | S66 | 17-19 | Regarding "measures for avoidance", as noted above, the time for preventing destruction of resources was during the identification of the route. Input on how to route the line to minimize and avoid impacts was disregarded. Now big picture avoidance is off the table, except for eliminating a few terrible alternatives, such as the Morgan Lake alternative, that will have more significant impacts on resources. |
| | S66 | 22 | One does not mitigate sites. One mitigates effects to sites. |
| | S66 | 25-26 | NHPA says to avoid, minimize, or mitigate effects. Thus, avoidance is not mitigation. |
| | S66 | 35 | Please insure the training includes state regulations that protect archaeological resources and burials. |
| | S66 | 45 | As noted, the CTUIR does not have an up to date IDP. The BLM told us they were putting it on "hold" in November 2015. The contents of this document are very important to us and we expect to develop it in consultation with the various parties. |
| | S67 | 12 | Sturdy fencing may be required to protect areas. We have seen many instances of flagging or loose plastic fencing being insufficient to keep a large piece of equipment out of a site area. |
| | S67 | 14 | Monitors are likely to be appropriate for all or some of this project, not just in areas with known sites. |

| | | | |
|---|---|---|---|
| | S68 | Table S19 | First row indicates surveys were completed between 2011 and 2014. Some portions of this route were not under consideration at that time. Pleaes explain. |
| | S68 | Table S19 | Third row, middle column states, "Evaluation may include site testing and Native American consultations." Please clarify that evaluation WILL include Native American consultations. |
| | S69 | Table S19 | First row, please note that no analysis of impacts to properties of religious and historic places has started. |
| | S70 | 10 through 25 | this project, but not much meaningful consultation.<br>Also, perhpas a site certificate condition is the place to address the incomplete consideration of HPRCSITs. |
| | S70 | 31 | Please add the following to the sentence: "consistent with the HPMP, which was developed in consultation with consulting parties." |
| | S70 | 42 | This may be the appropriate place to require the presence of a culutral resource monitor during construction. |
| | S71 | 4 | Please add something to the effect, "Within one year after construction is completed, the site certificate holder shall provide evidence of the completion of all mitigation as detailed in site-specific HPMPs or the HPMP as a whole." |
| | S71 | 32-38 | This section asserts that this project, taking into account mitigation, will not result in significant adverse impacts to cultural resources. What if significant adverse effects cannot be mitigated? What if no agreement on such mitigation can be reached between parties? What does that mean for the site certificate? It would mean that the conclusion of this Exhibit is false. Are there certificate conditions that could address such a concern? |
| | 81 | Attachment S-1 | If ODOE would like details of the comments the CTUIR made on this plan and the lack of addressing of those comments, please let us know. |
| | 131 | Attachment S-4 | The CTUIR did not initially receive this document and asked for it on August 25 which was not enough time to review prior to these comments being submitted; CTUIR would like an extension to review this document. |
| | 132 | Attachment S-5 | If ODOE would like details of the comments the CTUIR made on the PA and the lack of addressing of those comments, please let us know. |
| | 225 | Attachment S-6 | The CTUIR did not initially receive this document and asked for it on August 25 which was not enough time to review prior to these comments being submitted; CTUIR would like an extension to review this document. |
| | 226 | Attachment S-7 | The CTUIR did not initially receive this document and asked for it on August 25 which was not enough time to review prior to these comments being submitted; CTUIR would like an extension to review this document. |
| | 504 | Attachment S-8 | IPC did not provide the CTUIR this document in 2016. This is the first we've seen of it. The PA requires development of the HPMP with consulting parties. |
| | 564 | Attachment S-10 | The CTUIR did not initially receive this document and asked for it on August 25 which was not enough time to review prior to these comments being submitted; CTUIR would like an extension to review this document. |

Oregon

Kate Brown, Governor

**Department of State Lands**
775 Summer Street NE, Suite 100
Salem, OR 97301-1279
(503) 986-5200
FAX (503) 378-4844
www.oregon.gov/dsl



September 13, 2018

Idaho Power Company
Attn: Zach Funkhouser
1221 W. Idaho St.
Boise, ID 83702

Re: WD # 2017-0229 Wetland Delineation Report for Boardman to Hemingway Transmission Line Project (B2H); Morrow, Umatilla, Union, Baker and Malheur Counties

Dear Mr. Funkhouser:

The Department of State Lands has reviewed the wetland delineation report prepared by Tetra Tech Inc. for the site referenced above. Please note that the numerous study areas include only a portion of the tax lots (see the attached maps Appendix A-2). Based upon the information presented in the report, and additional information submitted upon request, we concur with the wetland and waterway boundaries as mapped in Figures Appendix A-5 of the report. Please replace all copies of the preliminary wetland map with these final Department-approved maps. The final maps can be accessed from the agency's Dropbox site under the WD # 2017-0229 folder for the next 30 days.

Within the study areas, 45 wetlands, 54 waterways, 51 ephemeral waterways and 5 ponds were identified (Appendix B-1 through B-14). The wetlands, waterways and ponds are subject to the permit requirements of the state Removal-Fill Law. Under current regulations, a state permit is required for cumulative fill or annual excavation of 50 cubic yards or more in the wetlands or below the ordinary high-water line (OHWL) of the waterway (or the 2 year recurrence interval flood elevation if OHWL cannot be determined). However, East and West Birch Creek and Rock Creek are essential salmonid streams; therefore, fill or removal of any amount of material within the OHWL and hydrologically-connected wetlands may require a state permit. The 51 ephemeral waterways are not regulated per OAR 141-085-0515(3); therefore, are not subject to current state Removal-Fill requirements.

This concurrence is for purposes of the state Removal-Fill Law only. Federal or local permit requirements may apply as well. The Army Corps of Engineers will determine jurisdiction for purposes of the Clean Water Act.

This concurrence is based on information provided to the agency. The jurisdictional determination is valid for five years from the date of this letter unless new information necessitates a revision. Circumstances under which the Department may change a determination are found in OAR 141-090-0045 (available on our web site or upon request). In addition, laws enacted by the legislature and/or rules adopted by the Department may result in a change in jurisdiction; individuals and applicants are subject to the regulations that are in effect at the time of the removal-fill activity or complete permit application. The applicant, landowner, or agent may submit a request for reconsideration of this determination in writing within six months of the date of this letter.

Thank you for having the site evaluated. Please phone me at 503-986-5218 if you have any questions.

Sincerely,

Lauren Brown
Jurisdiction Coordinator

Approved by

Peter Ryan, PWS
Aquatic Resource Specialist

Enclosures

ec: Ed Strohmaier, Tetra Tech Inc.
Kellen Tardaewether, ODOE
Morrow, Umatilla, Union, Baker and Malheur Planning Departments
Melanie O'Meara, Corps of Engineers
Joy Vaughan, ODFW
Dan Cary, DSL

## WETLAND DELINEATION / DETERMINATION REPORT COVER FORM

This form must be included with any wetland delineation report submitted to the Department of State Lands for review and approval. A wetland delineation report submittal is not "complete" unless the fully completed and signed report cover form and the required fee are submitted. Attach this form to the front of an unbound report or include a hard copy of the completed form with a CD/DVD that includes a single PDF file of the report cover form and report (minimum 300 dpi resolution) and submit to: **Oregon Department of State Lands, 775 Summer Street NE, Suite 100, Salem, OR 97301-1279.** A single PDF attachment of the completed cover from and report may be e-mailed to **Wetland_Delineation@dsl.state.or.us**. For submittal of PDF files larger than 10 MB, e-mail instructions on how to access the file from your ftp or other file sharing website. Fees can be paid by check or credit card. Make the check payable to the Oregon Department of State Lands. To pay the fee by credit card, call 503-986-5200.

| | |
|---|---|
| ☒ Applicant ☐ Owner Name, Firm and Address:<br>**Zach Funkhouser, Permitting**<br>**Idaho Power Company**<br>**1221 W. Idaho Street**<br>**Boise, ID 83702** | Business phone # **(208) 388-5375**<br>Mobile phone # (optional)<br>E-mail: **zfunkhouser@idahopower.com** |
| ☒ Authorized Legal Agent, Name and Address:<br>**Zach Funkhouser, Permitting**<br>**Idaho Power Company**<br>**1221 W. Idaho Street**<br>**Boise, ID 83702** | Business phone # **(208) 388-5375**<br>Mobile phone #<br>E-mail: **zfunkhouser@idahopower.com** |

I either own the property described below or I have legal authority to allow access to the property. I authorize the Department to access the property for the purpose of confirming the information in the report, after prior notification to the primary contact.

Typed/Printed Name: **Zach Funkhouser** Signature: [signature]

Date: Special instructions regarding site access:

**Project and Site Information** (using decimal degree format for lat/long.,enter centroid of site or start & end points of linear project)

| | | |
|---|---|---|
| Project Name: **Boardman to Hemingway Transmission Line Project** | Latitude: **Start, 45.846764**<br>**End, 43.549194** | Longitude: **Start, -119.616633**<br>**End, -117.026997** |
| Proposed Use: **New 500-kilovolt transmission line and associated facilities.** | Tax Map # **See Appendix A-2** | |
| Project Street Address (or other descriptive location):<br>**The project crosses five counties from Boardman to near Nyssa.** | Township Range Section QQ<br>Tax Lot(s) **See Table 2-1** | |
| City: **NA** County: **Morrow, Umatilla, Union, Baker, Malheur** | Waterway: **Multiple, See Appendix A-5**<br>NWI Quad(s): **See Appendix A-3** | River Mile: **NA** |

**Wetland Delineation Information**

| | |
|---|---|
| Wetland Consultant Name, Firm and Address:<br>**Tetra Tech, Inc., Attn. Ed Strohmaier**<br>**1750 SW Harbor Way, Ste. 400**<br>**Portland, OR 97201** | Phone # **503-721-7234**<br>Mobile phone # **503-320-6917**<br>E-mail: **ed.strohmaier@tetratech.com** |

The information and conclusions on this form and in the attached report are true and correct to the best of my knowledge.

Consultant Signature: Ed Strohmaier | Date: **05/02/2017**

**Primary Contact** for report review and site access is ☒ Consultant ☒ Applicant/Owner ☒ Authorized Agent

Wetland/Waters Present? ☒ Yes ☐ No | Study Area size: **404 acres** | Total Wetland Acreage: **25.04**

| **Check Box Below if Applicable:** | **Fees:** |
|---|---|
| ☐ R-F permit application submitted | ☐ Fee payment submitted |
| ☐ Mitigation bank site | ☐ Fee ($100) for resubmittal of rejected report |
| ☐ Wetland restoration/enhancement project (not mitigation) | ☐ No fee for request for reissuance of an expired report |
| ☐ Industrial Land Certification Program Site | |
| ☐ Reissuance of a recently expired delineation<br>Previous DSL # Expiration date ____ | |

| **Other Information:** | Y | N | |
|---|---|---|---|
| Has previous delineation/application been made on parcel? | ☐ | ☒ | If known, previous DSL # |
| Does LWI, if any, show wetland or waters on parcel? | ☐ | ☒ | |

**For Office Use Only**

| | | |
|---|---|---|
| DSL Reviewer: ________________ | Fee Paid Date: _____ / _____ / _____ | DSL WD # ________________ |
| Date Delineation Received: ____ / ____ / ____ | DSL Project # ______________ | DSL Site # ________________ |
| Scanned: ☐ Final Scan: ☐ | DSL WN # ________________ | DSL App. # ________________ |

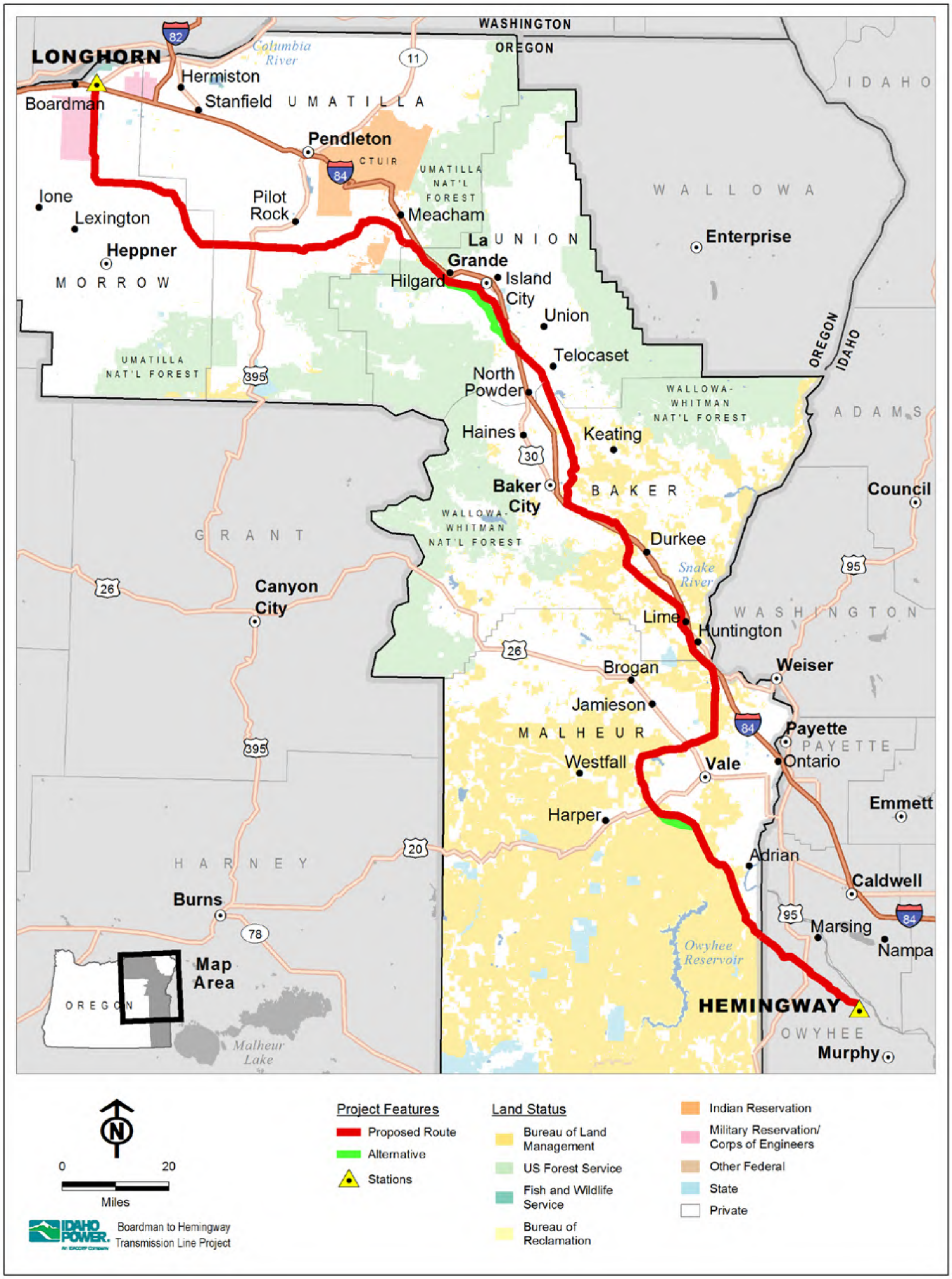



**Figure 1. Project Overview Map**

**TARDAEWETHER Kellen * ODOE**

**From:** CARY Dan <dan.cary@state.or.us>
**Sent:** Friday, November 2, 2018 4:34 PM
**To:** TARDAEWETHER Kellen * ODOE
**Subject:** B2H Application Review
**Attachments:** ApASC_RAI_Exhibit XX_2018 Draft.docx

Kellen,

I have attached DSL's request for additional information (RAI). Idaho Power provided all the items we asked for during the preliminary application review and Idaho Power received a concurred wetland delineation. The new wetland/non-wetland compensatory mitigation plan is well done and meets our requirements. We are only missing the JPA form (included in the preliminary application!)

Dan

Dan Cary, PWS
Aquatic Resource Coordinator Columbia and Clatsop Counties
Aquatic Resource Management Program
Oregon Department of State Lands
775 Summer Street NE, Suite 100
Salem OR 97301-1279
Phone: (503) 986-5302
DSL websites: www.oregon.gov/dsl; https://lands.dsl.state.or.us/

**Oregon Department of Energy**
**Request for Additional Information for the ApASC (ApASC RAI) Exhibit XXX – EXHIBIT DSL Comments**
**November 2, 2018**

| Request No. | ApASC Section Ref. | ApASC Page Ref. | Applicable Rule (OAR 345-021- or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| Exhibit J Parts 1, 2, 3 | | | OAR 141-085-0550 (5) | The applicant is required to provide the Joint Permit Application form. It doesn't have to include all the information on the form. It can reference attachments. (Just like what was provided in the Preliminary Application.) | |
| Exhibit J Parts 1, 2, 3 | JPA–Block 12 | | OAR 141-085-0550(5)(t) | The applicant is required to sign the application | |

## TARDAEWETHER Kellen * ODOE

**From:** Stokes, Mark <MStokes@idahopower.com>
**Sent:** Tuesday, November 13, 2018 8:55 AM
**To:** CARY Dan
**Cc:** TARDAEWETHER Kellen * ODOE; English, Aaron
**Subject:** Boardman to Hemingway Joint Permit Application
**Attachments:** 2018-11-12 USACOE and ODSL Joint Permit Application.pdf

Dear Mr. Cary,

Please see the attached Joint Permit Application for the Boardman to Hemingway Transmission Line Project. Please contact me if you have any questions concerning the application.

Thank you.


**Mark Stokes**
ENGINEERING PROJECT LEADER
Idaho Power Company
Work (208) 388-2483 | Cell (208) 863-0043
mstokes@idahopower.com


--------------------------------------------------------------------



--------------------------------------------------------------------

# Joint Permit Application

This is a joint application, and must be sent to both agencies, who administer separate permit programs. Alternative forms of permit applications may be acceptable; contact the Corps and DSL for more information.

Date Stamp

| U.S. Army Corps of Engineers Portland District | Oregon Department of State Lands |
|---|---|
| Corps Action ID Number | DSL Number |

## (1) APPLICANT AND LANDOWNER CONTACT INFORMATION

| | Applicant | Property Owner (if different) | Authorized Agent (if applicable) ☐ Consultant ☐ Contractor |
|---|---|---|---|
| Contact Name<br>Business Name<br>Mailing Address 1<br>Mailing Address 2<br>City, State, Zip | **Dave Wymond**<br>**Idaho Power Company**<br>**1221 W Idaho Street**<br><br>**Boise, ID 83702** | **See Appendix A** | |
| Business Phone<br>Cell Phone<br>Fax<br>Email | **(208) 388-2742** | | |

## (2) PROJECT INFORMATION

**A. Provide the project location.**

| Project Name<br>**Boardman to Hemingway Transmission Line Project** | Tax Lot #<br>**See Appendix C** | Latitude & Longitude*<br>**Start: 45.846764, -119.616633**<br>**End: 43.549194, -117.026997**<br>**See Appendix C** |
|---|---|---|
| Project Address / Location<br>**See Appendix B** | City (nearest)<br>N/A | County<br>Mo, Um, Un, Ba, Ma |

| Township<br>**See Appendix C** | Range<br>**See Appendix C** | Section<br>**See Appendix C** | Quarter/Quarter<br>**See Appendix C** |
|---|---|---|---|

Brief Directions to the Site
**See Appendix D for Directions to the Sites.**

**B. What types of waterbodies or wetlands are present in your project area? (Check all that apply.)**

☑ River / Stream ☐ Non-Tidal Wetland ☐ Lake / Reservoir / Pond
☐ Estuary or Tidal Wetland ☐ Other ☐ Pacific Ocean

| Waterbody or Wetland Name**<br>**See Appendix E** | River Mile | 6th Field HUC Name | 6th Field HUC (12 digits) |
|---|---|---|---|

**C. Indicate the project category. (Check all that apply.)**

☐ Commercial Development ☐ Industrial Development ☐ Residential Development
☐ Institutional Development ☐ Agricultural ☐ Recreational
☐ Transportation ☐ Restoration ☐ Bank Stabilization
☐ Dredging ☑ Utility lines ☐ Survey or Sampling

| (2) PROJECT INFORMATION | | |
|---|---|---|
| ☐ In- or Over-Water Structure | ☐ Maintenance | ☐ Other: |

* In decimal format (e.g., 44.9399, -123.0283)
** If there is no official name for the wetland or waterway, create a unique name (such as "Wetland 1" or "Tributary A").

## (3) PROJECT PURPOSE AND NEED

**Provide a statement of the purpose and need for the overall project.**

**See Appendix F for Project Purpose and Need.**

## (4) DESCRIPTION OF RESOURCES IN PROJECT AREA

**A. Describe the existing physical and biological characteristics of each wetland or waterway. Reference the wetland and waters delineation report if one is available. Include the list of items provided in the instructions.**

**See Appendix G, Description of Resources: Wetlands and Waters Characteristics.**

**Table G-1A. Characteristics of Delineated Wetland Resources Proposed for Removal Fill Impacts**

**Table G-2A. Characteristics of Delineated Other Waters Proposed for Removal Fill Impacts**

**Table G-3. Characteristics of Delineated Other Waters (Ephemeral Streams) Proposed for Removal Fill Impacts**

**See Appendix H, State and Federally Listed Species.**

**Table H-1 Federal or State Threatened and Endangered Species Potentially Present within the Project Site Boundary**

**B. Describe the existing navigation, fishing and recreational use of the waterway or wetland.**

OAR § 141-085-0565(3)(c) states that the Department of State Lands will issue a permit if it determines the project "would not unreasonably interfere with the paramount policy of this state to preserve the use of its waters for navigation, fishing and public recreation, when the project is on state-owned land."

**No impacts to wetlands or other waters are currently proposed on state-owned land within the Site Boundary.**

## (5) PROJECT SPECIFIC CRITERIA AND ALTERNATIVES ANALYSIS

**Describe project-specific criteria necessary to achieve the project purpose. Describe alternative sites and project designs that were considered to avoid or minimize impacts to the waterway or wetland.**

## (5) PROJECT SPECIFIC CRITERIA AND ALTERNATIVES ANALYSIS

**See Appendix I, Alternatives Analysis.**
**Table I-1 Avoidance and Minimization Actions**

## (6) PROJECT DESCRIPTION

**A. Briefly summarize the overall project including work in areas both in and outside of waters or wetlands.**

**See Appendix J, Summary of Overall Project Work.**

**B. Describe work within waters and wetlands.**

**See Appendix K, Work in Waters and Wetlands.**

**C. Construction Methods. Describe how the removal and/or fill activities will be accomplished to minimize Impacts to waters and wetlands.**

## (6) PROJECT DESCRIPTION

**See Appendix L, Measures to Minimize Impacts.**
**Table L-1**

**See Appendix M, Erosion and Sediment Control Plan.**

**D. Describe source of fill material and disposal locations if known.**

**See Appendix N, Fill Material and Disposal Locations.**

## (6) PROJECT DESCRIPTION

**E. Construction timeline.**

| | |
|---|---|
| **What is the estimated project start date?** | **2023** |
| **What is the estimated project completion date?** | **2025** |
| **Is any of the work underway or already complete? If yes, describe.** | ☐ Yes ☐ No |

**F. Fill Volumes and Dimensions** (if more than 4 impact sites, include a summary table as an appendix)

| Wetland / Waterbody Name * | Fill Dimensions | | | | | Duration of Impact** | Material*** |
|---|---|---|---|---|---|---|---|
| | Length (ft.) | Width (ft.) | Depth (ft.) | Area (sq.ft. or ac.) | Volume (c.y.) | | |
| **See Appendix O** | **See Appendix K Figures K-239 through K-241** | | | **ACRES** | | | **See Appendix N** |
| **Wetlands** | **varies** | **varies** | **varies** | **0.211 ac** | **576** | **Permanent** | " |
| **Wetlands** | **varies** | **varies** | **varies** | **0.386 ac** | **TBD** | **Temporary** | " |
| **Other Waters** | **varies** | **varies** | **varies** | **0.071 ac (0.072 ac for ephemerals)** | **88 (96 c.y. for ephemerals)** | **Permanent** | " |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Other Waters** | **varies** | **varies** | **varies** | **0.125 ac (0.339 ac for ephemerals)** | **TBD** | **Temporary** | " |

**G. Total Fill Volumes and Dimensions**

| Fill Impacts to Waters | Length (ft.) | Area (sq. ft or ac.) | Volume (c.y.) |
|---|---|---|---|
| Total Fill to Wetlands | **varies** | **0.597 ac.** | **576** |
| Total Fill Below Ordinary High Water | **526' Permanent**<br>**+887' Temporary**<br>**1413' Total**<br><br>**(1083' Permanent for ephemerals)** | **0.071ac Perm.**<br>**0.125ac Temp.**<br>**0.196ac Total**<br><br>**(0.09 ac Permanent for ephemerals)** | **88 Permanent;**<br><br>**(119 c.y. Permanent for ephemerals)** |
| Total Fill Below Highest Measured Tide | **N/A** | **N/A** | **N/A** |
| Total Fill Below High Tide Line | **N/A** | **N/A** | **N/A** |
| Total Fill Below Mean High Water Tidal Elevation | **N/A** | **N/A** | **N/A** |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**H. Removal Volumes and Dimensions** (if more than 4 impact sites, include a summary table as an appendix)

| Wetland / Waterbody Name* | Removal Dimensions | | | | | Duration of Impact** | Material*** |
|---|---|---|---|---|---|---|---|
| | Length (ft.) | Width (ft.) | Depth (ft.) | Area (sq. ft. or ac.) | Volume (c.y.) | | |
| **See Appendix O** | **See Appendix K Figures K-239 through K-241** | | | **ACRES** | | | **See Appendix N** |
| **Wetlands** | **varies** | **varies** | **varies** | **0.211 ac** | **545** | **Permanent** | " |
| **Wetlands** | **varies** | **varies** | **varies** | **0.386 ac** | **TBD** | **Temporary** | " |
| **Other Waters** | **varies** | **varies** | **varies** | **0.071 ac (0.072 ac for ephemerals)** | **129 (139 c.y. for ephemerals)** | **Permanent** | " |
| **Other Waters** | **varies** | **varies** | **varies** | **0.125 ac (0.339 ac for ephemerals)** | **TBD** | **Temporary** | " |

**I. Total Removal Volumes and Dimensions**

| Removal Impacts to Waters | Length (ft.) | Area (sq. ft or ac.) | Volume (c.y.) |
|---|---|---|---|
| Total Removal to Wetlands | **varies** | **0.597 ac.** | **545** |
| Total Removal Below Ordinary High Water | **526' Permanent**<br>**+887' Temporary**<br>**1413' Total**<br><br>**(1083' Permanent for ephemerals)** | **0.071ac Perm.**<br>**0.125ac Temp.**<br>**0.196ac Total**<br><br>**(0.09 ac Permanent for ephemerals)** | **129 c.y. permanent;**<br><br>**(139 c.y. Permanent for ephemerals)** |
| Total Removal Below Highest Measured Tide | **N/A** | **N/A** | **N/A** |
| Total Removal Below High Tide Line | **N/A** | **N/A** | **N/A** |
| Total Removal Below Mean High Water Tidal Elevation | **N/A** | **N/A** | **N/A** |

* If there is no official name for the wetland or waterway, create a unique name (such as "Wetland 1" or "Tributary A").
** Indicate the days, months or years the fill or removal will remain. Enter "permanent" if applicable. For DSL, permanent removal or fill is defined as being in place for 24 months or longer.
*** Example: soil, gravel, wood, concrete, pilings, rock etc.

## (7) ADDITIONAL INFORMATION

| | | | |
|---|---|---|---|
| Are there any state or federally listed species on the project site? | ☑ Yes | ☐ No | ☐ Unknown |
| Is the project site within designated or proposed critical habitat? | ☑ Yes | ☐ No | ☐ Unknown |
| Is the project site within a national Wild and Scenic River? | ☐ Yes | ☑ No | ☐ Unknown |
| Is the project site within the 100-year floodplain? | ☐ Yes | ☐ No | ☑ Unknown |

*** If yes to any of the above, explain in Block 4 and describe measures to minimize adverse effects to these resources in Block 5. See Appendix H regarding critical habitat noted in Block 4, and Appendix P regarding fish passage.**

| | | | |
|---|---|---|---|
| Is the project site within the Territorial Sea Plan (TSP) Area? | ☐ Yes | ☑ No | ☐ Unknown |

*** If yes, attach TSP review as a separate document for DSL.**

| | | | |
|---|---|---|---|
| Is the project site within a designated Marine Reserve? | ☐ Yes | ☑ No | ☐ Unknown |

*** If yes, certain additional DSL restrictions will apply.**

| | | | |
|---|---|---|---|
| Will the overall project involve construction dewatering or ground disturbance of one acre or more? | ☑ Yes | ☐ No | ☐ Unknown |

*** If yes, you may need a 1200-C permit from the Oregon Department of Environmental Quality (DEQ).**

| | | | |
|---|---|---|---|
| Is the fill or dredged material a carrier of contaminants from on-site or off- site spills? | ☐ Yes | ☑ No | ☐ Unknown |
| Has the fill or dredged material been physically and/or chemically tested? | ☐ Yes | ☑ No | ☐ Unknown |

***If yes, explain in Block 4 and provide references to any physical/chemical testing report(s).**

| | | | |
|---|---|---|---|
| Has a cultural resource (archaeological) survey been performed on the project area? | ☑ Yes | ☐ No | ☐ Unknown |

*** If yes, provide a copy of the survey with this application. Do not describe any resources in this document.**
**See Appendix Q, Cultural and Historic Resources.**

Identify any other federal agency that is funding, authorizing or implementing the project.

| Agency Name | Contact Name | Phone Number | Most Recent Date of Contact |
|---|---|---|---|
| **US Army Corps of Engineers** | **Brad Johnson** | **(503) 808-4383** | **10-05-2018** |

List other certificates or approvals/denials required or received from other federal, state or local agencies for work described in this application. For example, certain activities that require a Corps permit also require 401 Water Quality Certification from Oregon DEQ.

| Approving Agency | Certificate/ approval / denial description | Date Applied |
|---|---|---|
| **USACE** | **CWA Section 404** | **Application will be made 60 days prior to issuance of the site certificate.** |

Other DSL and/or Corps Actions Associated with this Site (Check all that apply.)

☐ Work proposed on or over lands owned by or leased from the Corps

| | | |
|---|---|---|
| ☐ State owned waterway | DSL Waterway Lease # | |
| ☐ Other Corps or DSL Permits | Corps # | DSL # |
| ☐ Violation for Unauthorized Activity | Corps # | DSL # |

☑ Wetland and Waters Delineation | Corps # | DSL # **WD2012-0050, 0091, -0092, -0197, -0141. WD2017-0229**

☑ A wetland / waters delineation has been completed (if so, provide a copy with the application)

☑ The Corps has approved the wetland / waters delineation within the last 5 years

☑ DSL has approved the wetland / waters delineation within the last 5 years

## (8) IMPACTS, RESTORATION/REHABILITATION, COMPENSATORY MITIGATION

**A. Describe unavoidable environmental impacts that are likely to result from the proposed project. Include permanent, temporary, direct, and indirect impacts.**

**See Appendix R, Unavoidable Project Impacts**

**B. For temporary removal or fill or disturbance of vegetation in waterways, wetlands or riparian (i.e., streamside) areas, discuss how the site will be restored after construction.**

**See Appendix S, Restoration and Rehabilitation of Temporary Impacts.**

**Compensatory Mitigation**

**C. Proposed mitigation approach. Check all that apply:**

☐ Permittee-responsible Onsite Mitigation

☑ Permittee-responsible Offsite mitigation

☐ Mitigation Bank or in-lieu fee program

☐ Payment to Provide (not approved for use with Corps permits)

**D. Provide a brief description of mitigation approach and the rationale for choosing that approach. If you believe mitigation should not be required, explain why.**

**See Appendix T, Compensatory Wetland and Non-Wetland Mitigation Plan.**

**Mitigation Bank / In-Lieu Fee Information:**

Name of mitigation bank or in-lieu fee project: N/A

Type of credits to be purchased: N/A

If you are proposing permittee-responsible mitigation, have you prepared a compensatory mitigation plan?

☑ Yes. Submit the plan with this application and complete the remainder of this section.

☐ No. A mitigation plan will need to be submitted (for DSL, this plan is required for a complete application).

**Mitigation Location Information (Fill out only if permittee-responsible mitigation is proposed)**

| | | |
|---|---|---|
| Mitigation Site Name/Legal Description<br>**See Appendix U, Mitigation Location Information** | Mitigation Site Address | Tax Lot # |
| County | City | Latitude & Longitude (in DD.DDDD format) |

| (8) IMPACTS, RESTORATION/REHABILITATION, COMPENSATORY MITIGATION | | | |
|---|---|---|---|
| Township | Range | Section | Quarter/Quarter |

| (9) ADJACENT PROPERTY OWNERS FOR PROJECT AND MITIGATION SITE | | |
|---|---|---|
| ☐ Pre-printed mailing labels of adjacent property owners attached | **Project Site Adjacent Property Owners** | **Mitigation Site Adjacent Property Owners** |

**See Appendix V, Names and Addresses of Property Owners**

## (10) CITY/COUNTY PLANNING DEPARTMENT LAND USE AFFIDAVIT (TO BE COMPLETED BY LOCAL PLANNING OFFICIAL)

I have reviewed the project described in this application and have determined that:

- ☐ This project is not regulated by the comprehensive plan and land use regulations.
- ☐ This project is consistent with the comprehensive plan and land use regulations.
- ☐ This project will be consistent with the comprehensive plan and land use regulations when the following local approval(s) are obtained:
  - ☐ Conditional Use Approval
  - ☐ Development Permit
  - ☐ Other Permit (see comment section)
- ☐ This project is not consistent with the comprehensive plan. Consistency requires:
  - ☐ Plan Amendment
  - ☐ Zone Change
  - ☐ Other Approval or Review (see comment section)

An application ☐ has ☐ has not been filed for local approvals checked above.

| Local planning official name (print) | Title | City / County (circle one) |
|---|---|---|
| | | |

| Signature | Date |
|---|---|
| | |

Comments:

**This Block of the JPA is not applicable to this project.**

## (11) COASTAL ZONE CERTIFICATION

If the proposed activity described in your permit application is within the Oregon coastal zone, the following certification is required before your application can be processed. A public notice will be issued with the certification statement, which will be forwarded to the Oregon Department of Land Conservation and Development (DLCD) for its concurrence or objection. For additional information on the Oregon Coastal Zone Management Program, contact DLCD at 635 Capitol Street NE, Suite 150, Salem, Oregon 97301 or call 503-373-0050.

CERTIFICATION STATEMENT

I certify that, to the best of my knowledge and belief, the proposed activity described in this application complies with the approved Oregon Coastal Zone Management Program and will be completed in a manner consistent with the program.

| Print /Type Name | Title |
|---|---|
| **This Block of the JPA is not applicable to this project.** | |
| **Signature** | **Date** |
| | |

## (12) SIGNATURES

*Application is hereby made for the activities described herein. I certify that I am familiar with the information contained in the application, and, to the best of my knowledge and belief, this information is true, complete and accurate. I further certify that I possess the authority to undertake the proposed activities. By signing this application I consent to allow Corps or DSL staff to enter into the above-described property to inspect the project location and to determine compliance with an authorization, if granted. I hereby authorize the person identified in the authorized agent block below to act in my behalf as my agent in the processing of this application and to furnish supplemental information in support of this permit application. I understand that the granting of other permits by local, county, state or federal agencies does not release me from the requirement of obtaining the permits requested before commencing the project. I understand that payment of the required state processing fee does not guarantee permit issuance.*

**To be considered complete, the fee must accompany the application to DSL. The fee is not required for submittal of an application to the Corps.**

| | |
|---|---|
| **Fee Amount Enclosed** | $ |

**Applicant Signature**

| | |
|---|---|
| Print Name<br>VERN PORTER | Title<br>VP TRANSMISSION & DISTRIBUTION ENGINEERING & CONSTRUCTION |
| Signature<br>Vern Porter | Date<br>11/13/2018 |

**Authorized Agent Signature**

| | |
|---|---|
| Print Name | Title |
| Signature | Date |

**Landowner Signature(s)**

**Landowner of the Project Site (if different from applicant)**

| | |
|---|---|
| Print Name<br>**See Appendix W, Signatures.** | Title |
| Signature | Date |

**Landowner of the Mitigation Site (if different from applicant)**

| | |
|---|---|
| Print Name<br>**See Appendix W, Signatures.** | Title |
| Signature | Date |

**Department of State Lands, Property Manager (to be completed by DSL)**

*If the project is located on state-owned submerged and submersible lands, DSL staff will obtain a signature from the Land Management Division of DSL. A signature by DSL for activities proposed on state-owned submerged/submersible lands only grants the applicant consent to apply for a removal-fill permit. A signature for activities on state-owned submerged and submersible lands grants no other authority, express or implied and a separate proprietary authorization may be required.*

| | |
|---|---|
| Print Name | Title |
| Signature | Date |

## (13) ATTACHMENTS

☑ **Drawings (items in bold are required)**

- ☑ **Location map with roads identified**
- ☑ **U.S.G.S topographic map**
- ☑ **Tax lot map**
- ☑ **Site plan(s)**
- ☑ **Cross section drawing(s)**
- ☑ **Recent aerial photo**
- ☐ Project photos
- ☑ Erosion and Pollution Control Plan(s), if applicable
- ☐ DSL/Corps Wetland Concurrence letter and map, if approved and applicable

☑ Pre-printed labels for adjacent property owners (Required if more than 5)

☑ Restoration plan or rehabilitation plan for temporary impacts

☑ Mitigation plan

☑ Wetland functional assessment and/or stream functional assessment

☑ Alternatives analysis

☐ Biological assessment (if requested by Corps project manager during pre-application coordination.)

☐ Stormwater management plan (may be required by the Corps or DEQ)

☐ Other:

- ☐
- ☐

**Send Completed form to:**

**U.S. Army Corps of Engineers**
**ATTN: CENWP-OD-GP**
**PO Box 2946**
**Portland, OR 97208-2946**
**Phone: 503-808-4373**

**Counties:**
**Baker, Clackamas, Clatsop, Columbia, Gilliam, Grant, Hood River, Jefferson, Lincoln, Malheur, Marion, Morrow, Multnomah, Polk, Sherman, Tillamook, Umatilla, Union, Wallowa, Wasco, Washington, Wheeler, Yamhill**

**OR**

**U.S. Army Corps of Engineers**
**ATTN: CENWP-OD-GE**
**211 E. 7th AVE, Suite 105**
**Eugene, OR 97401-2722**
**Phone: 541-465-6868**

**Counties:**
**Benton, Coos, Crook, Curry, Deschutes, Douglas Jackson, Josephine, Harney, Klamath, Lake, Lane, Linn**

**Send Completed form to:**

**DSL - West of the Cascades:**

**Department of State Lands**
**775 Summer Street NE, Suite 100**
**Salem, OR 97301-1279**
**Phone: 503-986-5200**

**OR**

**DSL - East of the Cascades:**

**Department of State Lands**
**1645 NE Forbes Road, Suite 112**
**Bend, Oregon 97701**
**Phone: 541-388-6112**

**Send all Fees to:**
**Department of State Lands**
**775 Summer Street NE, Suite 100**
**Salem, OR 97301-1279**
**Pay by Credit Card by Calling 503-986-5253**

## INSTRUCTIONS FOR PREPARING THE JOINT APPLICATION

This is a joint application, and must be sent to both agencies, who administer separate permit processes. For more complete instructions, contact the Corps and/or DSL or refer to online resources:

- DSL's Removal-Fill Guide; or,
- The Corps' "Permitting 101" video: http://www.nwp.usace.army.mil/Missions/Regulatory.aspx

General Instructions and Tips

- Provide the information in the appropriate blocks of the application form. If you need more space, provide a summary in the space provided and attach additional detail as an appendix to the application.
- Not all items on the application form will apply to all projects.
- For most applications, binding and section dividers are not necessary and require additional handling.

The information requested on the form is necessary for the agencies to begin their review. For complex projects or for those that may have more than minimal impacts, additional information may be necessary to complete the evaluation and make a permit decision. Alternative forms of permit applications may be acceptable; contact the Corps and DSL for more information.

**Section 1. Applicant and Landowner Contact information**
Applicant: The applicant is the responsible party. If the applicant is an agency, business entity or other organization, indicate the name of the organization and a person that has the authority to sign the application.
Authorized Agent: An authorized agent is someone who has permission from the applicant to represent their interests and supply information to the agencies. An agent can be a consultant, an attorney, builder, contractor, or any other person or organization. An authorized agent is optional.
Landowner: Provide landowner information if different from the applicant. The landowner must also sign the application.

**Section 2. Project Information**
Provide location information. Latitude and longitude can be found by zooming in to your respective project location and reading off the coordinates displayed on the bottom of the map.
Provide information on wetlands and waterways within the project area. Indicate the category of activities that make up your project.

**Section 3. Project Purpose and Need**
Explain the purpose and need for the project. Also include a brief description of any related activities needed to accomplish the project objectives.

The following items are required by DSL, as applicable:

- If the removal-fill would satisfy a public need and the applicant is a public body, include any pertinent findings regarding public need and benefit.
- If the project involves fill in the estuary for a non-water dependent use, explain how the project is for public use and/or satisfies a public need.
- If the project is located within a marine reserve or marine protected area, explain how the project is needed to study, monitor, evaluate, enforce or protect the designated area.

**Section 4. Description of Resources in Project Area**
Territorial Sea: For activities in the Territorial Sea (mean lower low water seaward 3 nautical miles), provide a separate evaluation of the resources and effects determination.

For each wetland, include:

- Whether the wetland is freshwater or tidal, and the Cowardin class and Hydrogeomorphic (HGM) class.
- Source of hydrology and direction of flow (if any).
- Dominant plant species by layer (herb, shrub, tree).
- A functional assessment of the wetland to be impacted (for impacts greater than 0.2 acre, DSL requires use of ORWAP or HGM), should be attached as a separate document.
- Identify any vernal pools, bogs, fens, mature forested wetland, seasonal mudflats, or native wet prairies in or near the project area.
- Refer to wetland delineation report if available, and provide copies to agencies (if not previously provided).
- Describe existing uses, including fish and wildlife use (type, abundance, period of use, significance of site).

For rivers, streams, other waterways, lakes and ponds, include a description of, as applicable:

- Streamflow regime (e.g., perennial year-round flow, intermittent seasonal flow, ephemeral event-driven flow). If flow is ephemeral, provide streamflow assessment data sheet or other information that supports your determination.
- Field indicators used to identify the Ordinary High Water Mark (OHWM).
- Channel and bank conditions.
- Type and condition of riparian (streamside) vegetation.
- Channel morphology (structure and shape).
- Stream substrate.
- Assessment of the functional attributes including hydrologic, geomorphic, biological and chemical and nutrient related functions.
- Fish and wildlife (type, abundance, period of use, significance of site).

**Section 5. Alternatives to Avoid and Minimize Impacts to Waters**

Provide a brief explanation describing how impacts to waters and wetlands are being avoided and minimized on the project site. For DSL, the alternatives analysis must include:

- Project-specific criteria that are needed to accomplish the stated project purpose.
- A range of alternative sites and designs that were considered with less impact.
- An evaluation of each alternative site and design against the project criteria and a reason for why the alternative was not chosen.
- If the project involves fill in an estuary for a non-water dependent use, a description of Alternative non- estuarine sites must be included.

**Section 6. Project Description**

Overall Description. Provide a brief description of the overall project, including:

- All associated work with the project both outside and within waters or wetlands.
- Total ground disturbance for all associated work (i.e, area and volume of ground disturbance).
- Total area of impervious surfaces created or modified by the project, if applicable.

Work within Waters and Wetlands. Provide a description of the proposed work within waters and wetlands, including:

- Each removal or fill activity proposed in waters or wetlands, as well as any construction or maintenance of in-water or over-water structures.
- The number and dimensions of in-water or over-water structures (i.e., pilings, floating docks) proposed within waters or wetlands.

Fill Material and Disposal. Provide a description of fill material and procedure for disposal of removed material, including:

- The source(s) of fill materials (if known).
- Locations for disposal area(s) for dredged material, if applicable. If dredged material is to be discharged on an upland site, identify the site and the steps to be taken (if necessary) to prevent runoff from the dredged material back into a waterbody. If using an upland disposal area that is not a DEQ-regulated landfill, a Solid Waste Letter of Authorization or a Beneficial Use Determination from DEQ may be required.

Construction Methods. Describe how the removal and/or fill activities will be accomplished including the following:

- Construction methods, equipment to be used, access and staging areas, etc.
- Measures you will use during construction to minimize impacts to the waterway or wetland. Examples may include isolating work areas, controlling construction access and using specialized equipment or materials. Attach work area isolation and/or erosion and pollution control plans, if applicable.

Construction Timing. Provide the proposed start and completion date for the project. Describe project work that is already complete, if applicable.

Summary of removal and fill activities. Summarize the dimensions, volume and type/composition of material being placed or removed in each waterbody or wetland. Describe each impact on a separate row. For instance, if two culverts are being removed from Clear Creek, use two rows. Add extra rows if needed, or include an appendix.

The DSL and the Corps use different elevations for determining whether an activity in tidal waters is regulated by the State's Removal-Fill law, the Clean Water Act, and/or the Rivers and Harbors Act. DSL regulates activities below the highest measured tide. The Clean Water Act applies below the high tide line. The Rivers and Harbors Act applies below the mean high water.

**Section 7. Additional Information**
Any additional information you provide helps the reviewer(s) understand your project and the other approvals or reviews that may be required.

**Section 8. Site Restoration/Rehabilitation and Compensatory Mitigation**
Site Restoration/Rehabilitation. For temporary disturbance of soils and/or vegetation in waterways, wetlands or riparian (streamside) areas, discuss how you will restore the site after construction. This may include the following:

- Grading plans to restore pre-existing elevations.
- Planting plans and species list (native species only) to replace vegetation in riparian or wetland areas.
- Maintenance and monitoring plans to document restoration to wetland condition and/or vegetation establishment.
- Associated erosion control for site stabilization.

Compensatory Mitigation. Describe your proposed compensatory mitigation approach, or explain why you believe compensatory mitigation is not required. If proposing permittee-responsible mitigation for permanent impact to wetlands, see OAR 141-085-0705 and 33 CFR 332.4(c) for plan requirements. For permanent impact to waters other than wetlands, see OAR 141-085-0765 and 33 CFR 332.4(c) for plan requirements.

**Section 9. Adjacent Property Owners for Impact and Mitigation Site(s)**
Names and addresses for properties that are adjacent to the project site and permittee responsible mitigation site (if applicable), are required. "Adjacent" means those properties that share or touch upon a common property line or are across the street or stream. If more than 5, attach pre-printed labels. A list of property owners may be obtained by contacting the county tax assessor's office.

**Section 10. City/County Planning Department Land Use Affidavit**
This section is required to demonstrate land use compatibility for removal fill permits and water quality certifications. Provide this form to your local planning official for them to complete and sign.

**Section 11. Coastal Zone Certification**
Your signature for this statement is required for projects within the coastal zone (generally, west of the summit of the Coast Range).

**Section 12. Signatures**
The application must be signed by the responsible party, landowner and agent, as identified in section 1.

**Section 13: Appendixs**
Project Drawings. A complete application must include a location map, site plan, cross-section drawings and recent aerial photo. All drawings should be clear, legible and formatted for 8.5 by 11 printing. Use the fewest number of sheets necessary for your drawings or illustrations. While illustrations need not be professionally prepared, they should be clear, accurate, and contain all necessary information, as follows:

Location maps (with subject property identified):

- Location map with roads identified
- U.S.G.S. Topographic map
- Tax lot map (with subject tax lot(s) identified)

Site plan(s), including:

- Entire project site and activity areas
- Existing and proposed contours

- Location of ordinary high water, wetland boundaries or other jurisdictional boundaries (include wetland delineation report if not previously provided)
- Identification of temporary and permanent impact areas within waterways or wetlands
- Map scale or dimensions and north arrow
- Location of staging areas and construction access
- Location of cross section(s), as applicable
- Location of mitigation area, if applicable

Cross section drawing(s), including:
- Existing and proposed elevations
- Identification of temporary and permanent impact areas within waterways or wetlands
- Ordinary high water and/or wetland boundary or other jurisdictional boundaries
- Map scale or dimensions

Recent Aerial photo
- 1:200, or if not available for your site, highest resolution possible

DSL Wetland Concurrence (map and letter)

OCEO Transmission Overview Outline 30 min
+ 15 min QA

2030 RPS and Resource Needs Picture

- West Coast
- Desert Southwest
- Intermountain West

For each of the areas discuss:

- Seasonal & Daily Load/Resource Balance
- Deficiencies
- IRP Plans

Transmission Shift:

- Existing Transmission and Usage
- Transmission included in Regional Transmission Plans (NTTG, West Connect, etc)
- Other Proposed Transmission (TransWest, SWIP North, SunZia, TransCanyon)

Transmission's ability to meet the needs of the areas,

B2H and Gateway – Fit in the future

B2HAPPDoc13-6 ASC Reviewing Agency Comment CTWS_Nauer 2018-11-16

## TARDAEWETHER Kellen * ODOE

| | |
|---|---|
| **From:** | Christian Nauer <christian.nauer@ctwsbnr.org> |
| **Sent:** | Friday, November 16, 2018 12:31 PM |
| **To:** | TARDAEWETHER Kellen * ODOE |
| **Cc:** | Robert Brunoe |
| **Subject:** | Re: Update on B2H EFSC Complete Application for Site Certificate |
| **Attachments:** | PastedGraphic-1.pdf |

Dear Kellen,

Thank you for the opportunity to comment on the B2H EFSC Complete Application for Site Certificate.

General Comment:

As the technical reviewer for NHPA Section 106 and other cultural resource issues for the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO), the CTWSRO Tribal Historic Preservation Office (THPO) has concerns with the potential effects to historic properties or cultural resources within the Project Area of Potential Effects (APE). The Project APE is within the areas of concern for the CTWSRO.

Project-specific Comment(s):

This office is aware of the ongoing discussions and consultations related to historic properties and cultural resources that have been conducted with the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) and their Cultural Resources Protection Program (CRPP). We have great faith in our neighbors at CTUIR, and defer to them with regard to cultural resource issues associated with B2H.

Please continue to consult with this office and the CTWSRO Tribal Council on future ODOE and EFSC endeavors that will occur within areas of concern for the CTWSRO.

Thank you again for your consideration,

Christian Nauer, MS

Archaeologist
Confederated Tribes of the Warm Springs Reservation of Oregon
Branch of Natural Resources

christian.nauer@ctwsbnr.org
Office 541.553.2026
Cell 541.460.8448

Standard Disclaimers:

*The Confederated Tribes of the Warm Springs Reservation of Oregon have reserved treaty rights in Ceded Lands, as well as Usual and Accustomed and Aboriginal Areas, as set forth through the Treaty with the Middle Tribes of Oregon, June 25, 1855.

*Please know that review by the Tribal Historic Preservation Office does not constitute Government-to-Government consultation. Please ensure that appropriate Government-to-Government consultation is made with the Confederated Tribes of the Warm Springs Tribal Council.

On Oct 22, 2018, at 9:21 AM, Christian Nauer <christian.nauer@ctwsbnr.org> wrote:

Dear Kellen,

Thank you for the Update on B2H EFSC Complete Application for Site Certificate.

As the technical reviewer for NHPA Section 106 and other cultural resource issues for the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO), the CTWSRO Tribal Historic Preservation Office (THPO) has concerns with the potential effects to historic properties or cultural resources within the Project Area of Potential Effects (APE). The Project APE is within the territories and areas of concern for the CTWSRO.

This office would like to request additional information about efforts to identify, evaluate, and protect potential historic properties within the Project APE. If any such efforts have been undertaken, would you please share them with this office?

Thank you again for your consideration

Christian Nauer, MS

Archaeologist
Confederated Tribes of the Warm Springs Reservation of Oregon
Branch of Natural Resources

christian.nauer@ctwsbnr.org
Office 541.553.2026
Cell 541.460.8448

<PastedGraphic-1.pdf>

*The Confederated Tribes of the Warm Springs Reservation of Oregon have reserved treaty rights in Ceded Lands, as well as Usual and Accustomed and Aboriginal Areas, as set forth through the Treaty with the Middle Tribes of Oregon, June 25, 1855.

*Please know that review by the Tribal Historic Preservation Office does not constitute Government-to-Government consultation. Please ensure that appropriate Government-to-Government consultation is made with the Confederated Tribes of the Warm Springs Tribal Council.

On Sep 28, 2018, at 11:57 AM, TARDAEWETHER Kellen * ODOE <Kellen.Tardaewether@oregon.gov> wrote:

Good morning Christian,

I’m writing to provide an update on the Boardman to Hemingway Transmission Line application for site certificate submitted to the Oregon Department of Energy (ODOE), staff to the Energy Facility Siting Council (EFSC). Under Oregon law, the applicant, Idaho Power Company, must obtain a site certificate from EFSC before constructing and operating the proposed facility. I’ve bulleted essential dates below for brevity.

- July 19, 2017 - Idaho Power submits amended preliminary application for site certificate
- September 21, 2018 - ODOE determines application for site certificate (ASC) complete
- September 28, 2018 - Idaho Power files ASC with ODOE
- October 3, 2018 – ODOE issues formal public notice of the informational meetings on the ASC
- October 10, 2018 – Begin 47-day reviewing agency/Tribal Government compliance comment period
- October 15-18, 2018 – Public informational meetings on the ASC in each county (see below for more details)
- November 26, 2018 – Deadline for reviewing agency/Tribal Government compliance comment period

**If you are not the appropriate contact at the Confederated Tribes of Warm Springs to comment on this EFSC facility, please respond and indicate who the appropriate point of contact should be to comment on behalf of the Tribes.** Please let me know what questions you have and I look forward to working with you.

Kellen

**Public Informational Meetings:**
ODOE will hold a series of public informational meetings with the applicant to provide the public and agencies with more information about the proposed facility and the EFSC review process. The informational meetings will include a presentation starting at 5:30 p.m. ODOE and applicant representatives will be available after the presentation to answer specific questions. The informational meetings are *not* public hearings and will not include public testimony or on-the-record public comments. Dual meetings will be held on Thursday the 18th in Umatilla and Morrow counties and will have the same format, presentation and content. We encourage representatives and members of the Confederated Tribes of Warm Springs to attend the meetings☺

**County: Malheur**
Date: Monday, October 15, 2018
Time: 5:00 pm – 8:00 pm
Location: Four Rivers Cultural Center, 676 SW 5th Ave, Ontario, OR

**County: Baker**
Date: Tuesday, October 16, 2018
Time: 5:00 pm – 8:00 pm
Location: Community Connections - Baker County Senior Center, 2810 Cedar St, Baker City, OR

**County: Union**
Date: Wednesday, October 17, 2018
Time: 5:00 pm – 8:00 pm

Location: Blue Mountain Conference Center, 404 12th St, La Grande, OR

**County: Umatilla**
Date: Thursday, October 18, 2018
Time: 5:00 pm – 8:00 pm
Location: Pendleton Convention Center, 1601 Westgate, Pendleton, OR

**County: Morrow**
Date: Thursday, October 18, 2018
Time: 5:00 pm – 8:00 pm
Location: Sage Center, 101 Olson Road, Boardman, OR

**Kellen Tardaewether**
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301
P:(503) 373-0214
C: (503) 586-6551
[Oregon.gov/energy](Oregon.gov/energy)

<image002.jpg> <image003.jpg><image004.png><image005.png><image006.png><image007.png><image008.png>
*Leading Oregon to a safe, clean, and sustainable energy future.*

## TARDAEWETHER Kellen * ODOE

| | |
|---|---|
| **From:** | TARDAEWETHER Kellen * ODOE |
| **Sent:** | Monday, October 22, 2018 3:02 PM |
| **To:** | Stokes, Mark; Stanish, David |
| **Cc:** | English, Aaron |
| **Subject:** | FW: Update on B2H EFSC Complete Application for Site Certificate |
| **Attachments:** | PastedGraphic-1.pdf |

Hi Mark and David,

Please see the below email from the CTWS. I spoke with Christian at the Tribe and pointed out the locations in Exhibit S and the attachments where he can find information to help answer his questions of "..efforts to identify, evaluate, and protect potential historic properties.." Thanks,

Kellen


**Kellen Tardaewether**
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301
P:(503) 373-0214
C: (503) 586-6551
Oregon.gov/energy

OREGON DEPARTMENT OF ENERGY
*Leading Oregon to a safe, clean, and sustainable energy future.*


---

**From:** Christian Nauer [mailto:christian.nauer@ctwsbnr.org]
**Sent:** Monday, October 22, 2018 9:21 AM
**To:** TARDAEWETHER Kellen * ODOE <Kellen.Tardaewether@oregon.gov>
**Cc:** Robert Brunoe <robert.brunoe@ctwsbnr.org>
**Subject:** Re: Update on B2H EFSC Complete Application for Site Certificate

Dear Kellen,

Thank you for the Update on B2H EFSC Complete Application for Site Certificate.

As the technical reviewer for NHPA Section 106 and other cultural resource issues for the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO), the CTWSRO Tribal Historic Preservation Office (THPO) has concerns with the potential effects to historic properties or cultural resources within the Project Area of Potential Effects (APE). The Project APE is within the territories and areas of concern for the CTWSRO.

This office would like to request additional information about efforts to identify, evaluate, and protect potential historic properties within the Project APE. If any such efforts have been undertaken, would you please share them with this office?

Thank you again for your consideration

Christian Nauer, MS

Archaeologist
Confederated Tribes of the Warm Springs Reservation of Oregon
Branch of Natural Resources

christian.nauer@ctwsbnr.org
Office 541.553.2026
Cell 541.460.8448

*The Confederated Tribes of the Warm Springs Reservation of Oregon have reserved treaty rights in Ceded Lands, as well as Usual and Accustomed and Aboriginal Areas, as set forth through the Treaty with the Middle Tribes of Oregon, June 25, 1855.

*Please know that review by the Tribal Historic Preservation Office does not constitute Government-to-Government consultation. Please ensure that appropriate Government-to-Government consultation is made with the Confederated Tribes of the Warm Springs Tribal Council.

> On Sep 28, 2018, at 11:57 AM, TARDAEWETHER Kellen * ODOE <Kellen.Tardaewether@oregon.gov> wrote:
>
> Good morning Christian,
>
> I'm writing to provide an update on the Boardman to Hemingway Transmission Line application for site certificate submitted to the Oregon Department of Energy (ODOE), staff to the Energy Facility Siting Council (EFSC). Under Oregon law, the applicant, Idaho Power Company, must obtain a site certificate from EFSC before constructing and operating the proposed facility. I've bulleted essential dates below for brevity.
>
> - July 19, 2017 - Idaho Power submits amended preliminary application for site certificate
> - September 21, 2018 - ODOE determines application for site certificate (ASC) complete
> - September 28, 2018 - Idaho Power files ASC with ODOE
> - October 3, 2018 – ODOE issues formal public notice of the informational meetings on the ASC
> - October 10, 2018 – Begin 47-day reviewing agency/Tribal Government compliance comment period
> - October 15-18, 2018 – Public informational meetings on the ASC in each county (see below for more details)
> - November 26, 2018 – Deadline for reviewing agency/Tribal Government compliance comment period
>
> **If you are not the appropriate contact at the Confederated Tribes of Warm Springs to comment on this EFSC facility, please respond and indicate who the appropriate point of contact should be to comment**

**on behalf of the Tribes.** Please let me know what questions you have and I look forward to working with you.

Kellen

**Public Informational Meetings:**
ODOE will hold a series of public informational meetings with the applicant to provide the public and agencies with more information about the proposed facility and the EFSC review process. The informational meetings will include a presentation starting at 5:30 p.m. ODOE and applicant representatives will be available after the presentation to answer specific questions. The informational meetings are *not* public hearings and will not include public testimony or on-the-record public comments. Dual meetings will be held on Thursday the 18th in Umatilla and Morrow counties and will have the same format, presentation and content. We encourage representatives and members of the Confederated Tribes of Warm Springs to attend the meetings☺

**County: Malheur**
Date: Monday, October 15, 2018
Time: 5:00 pm – 8:00 pm
Location: Four Rivers Cultural Center, 676 SW 5th Ave, Ontario, OR

**County: Baker**
Date: Tuesday, October 16, 2018
Time: 5:00 pm – 8:00 pm
Location: Community Connections - Baker County Senior Center, 2810 Cedar St, Baker City, OR

**County: Union**
Date: Wednesday, October 17, 2018
Time: 5:00 pm – 8:00 pm
Location: Blue Mountain Conference Center, 404 12th St, La Grande, OR

**County: Umatilla**
Date: Thursday, October 18, 2018
Time: 5:00 pm – 8:00 pm
Location: Pendleton Convention Center, 1601 Westgate, Pendleton, OR

**County: Morrow**
Date: Thursday, October 18, 2018
Time: 5:00 pm – 8:00 pm
Location: Sage Center, 101 Olson Road, Boardman, OR

**Kellen Tardaewether**
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301
P:(503) 373-0214
C: (503) 586-6551
Oregon.gov/energy

<image002.jpg> <image003.jpg><image004.png><image005.png><image006.png><image007.png><image008.png>
*Leading Oregon to a safe, clean, and sustainable energy future.*

**TARDAEWETHER Kellen * ODOE**

| | |
|---|---|
| **From:** | Robert Strope <RStrope@cityoflagrande.org> |
| **Sent:** | Monday, November 26, 2018 4:52 PM |
| **To:** | TARDAEWETHER Kellen * ODOE |
| **Cc:** | Michael Boquist; Stu Spence; Kyle Carpenter |
| **Subject:** | November 26 2018 Letter to DOE B2H City of La Grande |
| **Attachments:** | November 26 2018 Letter to DOE B2H City of La Grande.docx |

Hi Kellen,

Hope you had a wonderful Thanksgiving! Here is our response to the latest version. We opted not to restate everything from past correspondence and focus mostly on a new element. Let me know if you have any questions.

Best Regards,

Robert

Robert A. Strope, MPA
City Manager
City of La Grande
rstrope@cityoflagrande.org
(541) 962-1309
(541) 963-3333 fax

CITY OF LA GRANDE

THE HUB OF NORTHEASTERN OREGON

**MEMORANDUM**

---

**TO:** Kellen Tardaewether
Oregon Department of Energy
550 Capitol St. N.E., 1st Floor
Salem, OR 97301

**FROM:** Robert A. Strope, City Manager
City of La Grande, Oregon
P.O. Box 670
1000 Adams Avenue
La Grande, OR 97850
(541) 962-1309
rstrope@cityoflagrande.org

**DATE:** November 26, 2018

**RE**: City of La Grande Comments on the Application for Site Certification for the Boardman to Hemingway Transmission Line

---

**General Comments:** Thank you for this opportunity to provide comments on the Boardman to Hemingway Transmission Line project submitted by Idaho Power. None of the proposed facilities are located within the City of La Grande's jurisdiction and the most recent version of the proposal is unchanged from the prior submittal. As a result, our comments on this version is limited.

From the original application, Map #52 has been removed from the report, which included the staging area at the Union County Airport. This was the only element that was located within the City of La Grande's jurisdiction. With the removal of this facility, none of the remaining facilities are subject to City of La Grande land use regulations.

Within the proposed application, the most significant element that concerns the City of La Grande is on map #51 (Exhibit C) which shows a proposed access road for the Proposed Route (see orange line in illustration below). This access road is labeled as a "substantial modification 21%-70% improvements." This access road is an extension of Hawthorn Drive, which is a steep gravel road that currently serves only a couple single-family dwellings and does not conform to City development standards. The road is located within an area subject to geological hazard issues, which could make the proposed improvements challenging and may result in adverse impacts to City of La Grande residential properties in the vicinity. Also, Hawthorn Drive is accessed via Sunset Drive which is near capacity and may not support the additional traffic impacts caused during this development. The applicant's report is not clear about the traffic volumes or impacts that may occur on these roads. Based on this, the City of La Grande would ask that Idaho Power be required to provide detailed information regarding this proposed access.


The La Grande City Council renews our objection to the Proposed Route in the preliminary application and again strongly requests that Idaho Power remove the Proposed Route from their application and instead use the Morgan Lake Alternative or ideally reconsider the BLM preferred route. As we stated previously, of the two routes identified in the application, the applicant selected the one most impactful to the City of La Grande as their Proposed Route. In their response Idaho Power states they intend to construct on the route that has the most support from the local community. The local community does not support the B2H project as evidenced by the overwhelming adverse public response each time the topic is on an agenda. Therefore Idaho Power is unlikely to get community support for any route as it will be perceived as support for the project. Perhaps another way to put it, the La Grande City Council, which represents over the more than 13,000 residents who are in closest proximity to B2H, has stated they object more to the Proposed Route than the Morgan Lake Alternative. This should be more than sufficient for Idaho Power to remove the Proposed Route from their application.

The City of La Grande has met with Idaho Power to discuss mitigation and is optimistic that Idaho Power will address view shed and other concerns raised in our previous correspondence. It would be beneficial for our previously requested mitigation to be included as conditions of approval.

## TARDAEWETHER Kellen * ODOE

| | |
|---|---|
| **From:** | hkerns@bakercounty.org |
| **Sent:** | Friday, December 14, 2018 3:53 PM |
| **To:** | TARDAEWETHER Kellen * ODOE; Cornett, Todd |
| **Cc:** | mbennett@bakercounty.org; bharvey@bakercounty.org; bnichols@bakercounty.org; hmartin@bakercounty.org; david.petersen@tonkon.com |
| **Subject:** | Baker County Agency Report for B2H Application for Site Certificate |
| **Attachments:** | Agency Report on ASC.pdf |

Kellen,

Attached, please find Baker County's agency report on the ASC. Thank you for all of your help with this, I appreciate it so much. Please let me know if you have any questions.

Holly Kerns
Director, Baker City & County Planning Department
Office: 541.523.8219
Fax: 541.523.5925
1995 Third Street, Suite 131
Baker City, OR 97814

1995 Third Street
Baker City, Oregon 97814

December 14, 2018

Kellen Tardaewether, Senior Siting Analyst
Oregon Department of Energy
550 Capitol St. N.E., Salem
*Sent via e-mail to Kellen.Tardaewether@oregon.gov*

RE: Baker County Comments on the Complete ASC

Ms. Tardaewether and the Energy Facility Siting Council,

Baker County is providing comments on the ASC submitted by Idaho Power Company ("IPC") filed September 28, 2018. The comments are specific to Exhibits K, L, R and U. This letter provides a review of the proposed facility's "compliance with applicable statutes, rules and ordinances, issues significant to [the County], and recommended site conditions." Baker County extends our thanks again to the Energy Facility Siting Council for approving Baker County to use a subcontractor, David Petersen with Tonkon Torp, for this set of comments. The timing of this comment period was inopportune for the County, and the subcontractor's assistance and expertise were invaluable to us. These comments are more complete and focused than would have been possible without Mr. Petersen's assistance, which will ultimately benefit Idaho Power, ODOE staff and the Council. We appreciate the Council allowing this opportunity.

Before getting into the specifics of our agency review comments, its important to acknowledge that Baker County continues to believe the project would not be appropriate in Baker County. The totality of the impact to our landowners, agricultural lands, resources, and viewsheds has not been appropriately mitigated through the measures proposed in this document. Baker County will not receive a direct benefit from the project; the closest analogy would be allowing a developer to build an interstate highway through Baker County without installing any on or off ramps. The totality of the impacts to land and tourism values are not taken into consideration by IPC. However, the agency report requested by the Oregon Department of Energy is focused on obtaining information about the ASC, and accordingly Baker County will focus our comments on the ASC document rather than the larger picture of project suitability.

**Exhibit K**

<u>Section 4.0</u>

On page K-28, IPC describes measures that will be taken after construction to restore agricultural land, as nearly as possible, to former productivity. Specific measures will be outlined in the final Agricultural Assessment. Land Use Conditions 1 and 15, in turn, require IPC to obtain ODOE approval of the final Agricultural Assessment and to implement the mitigation measures described therein "during construction." Presumably those measures will include measures to restore agricultural land.

In its May 25, 2018 memorandum responding to IPC's responses to comments and requests for additional information, Baker County advocated for amendment of Land Use Condition 1 to require that the final Agricultural Assessment be provided to Baker County, so that the final mitigation measures could be reviewed for sufficiency. The County notes that EFSC promises in its memorandum of October 1, 2018 to share final plans with the SAGs for review and comment, which presumably includes the final Agricultural Assessment. Given this, there should be no objection to making the obligation to provide the final Agricultural Assessment to Baker County an express requirement of Land Use Condition 1, and Baker County reiterates this request.

The same rationale applies to the Helicopter Use Plan under Public Services Condition 2 and the County-specific transportation and traffic plan under Land Use Condition 12. These conditions should require copies of the final plans be given to Baker County (and in the case of the Helicopter Use Plan, the other SAGs). Also, Land Use Condition 12 should specifically require IPC to post a bond for the benefit of the County to secure the cost of any repairs to County roads that are necessary following IPC's construction activities.

Since some of the agricultural land restoration measures to be described in the final Agricultural Assessment expressly will take place after construction is complete, Land Use Condition 15 should be amended accordingly to require compliance with the Agricultural Assessment both during and after construction.

Section 6.8

Baker County agrees that the ASC identifies all applicable Baker County substantive land use criteria.

BCZSO 401(B)(1) does not establish a setback. It is a frontage requirement. All affected properties with buildings (i.e., multi-use areas and communications stations) in Baker County must be located on a property at least 220 feet wide at the property line in front of the buildings. IPC's analysis does not evaluate the frontages of the properties hosting the multi-use areas and communication stations in Baker County, so the County cannot evaluate whether this criterion is met.

The County setbacks set forth in BCZSO 401(B) apply to all "structures" as defined in BCZSO 108a(B). Land Use Condition 25 attempts to require compliance with these setbacks, but does not use the term "structures." Instead, IPC's proposed language applies the setbacks only to "buildings" and "the fixed bases of transmission towers," on the theory that these are the only kinds of "structures" that will be built in Baker County as part of the project. That may be, but the condition should nonetheless impose the setbacks on all "structures" as defined in the BCZSO, so as to capture any other structures that may not be anticipated as part of the project at this time. Each of clauses a. through d. of Land Use Condition 25 should be changed to apply the setbacks to all "structures" as that term is defined in BCZSO 108a(B).

In response to BCZSO 412 on pages K-295 to K-298, IPC identifies the Virtue Flat Mining Area as a County historical resource (see Figure K-50) but provides no analysis of the impact of the project on this resource. Accordingly, the County cannot fully evaluate the project's compliance with BCZSO 412.

With respect to the Virtue Flat Oregon Trail historic resource designated by Baker County, the ASC defers a full evaluation of impacts to the final Visual Assessment of Historic Properties Study Plan (VAHP). The rationale set forth above for the proposed change to Land Use Condition 1 regarding the final Agricultural Assessment, applies equally to Historic, Cultural, and Archaeological Resources Condition 2 (Exhibit S) and the final Historic Property Management Plan. To permit the County to meaningfully evaluate the proposed mitigation for impacts on County-designated historic resources, Historic, Cultural, and Archaeological Resources Condition 2 should be modified to require a copy of the final Historic Property Management Plan be provided to the County (and other SAGs).

With respect to the Flagstaff Hill Monument historic resource designated by Baker County, the ASC merely concludes on page K-297 that "the Project will not affect the characteristics that make the monument important," but does not explain what those important characteristics are or how the Project will not affect them. This conclusory statement is insufficient for the County to evaluate whether IPC is justified in deciding to not conduct further analysis of this resource.

On page K-307, IPC commits to managing noxious weeds consistent with ORS 569.350 through 569.450 and the Baker County Noxious Weed Management Plan. Fish and Wildlife Condition 6, in turn (Exhibit P), obligates IPC to obtain final ODOE approval of its Noxious Weed Plan. Again, the rationale for providing final plans to the County (and other SAGs) applies here – Baker County should have the opportunity to review the final plan to ensure in complies with the Baker County Noxious Weed Management Plan. Fish and Wildlife Condition 6 should be revised accordingly.

Also with respect to weed control, Baker County reiterates its recommendation that a condition of approval be adopted obligating IPC to provide a bond specifically to secure its weed management obligations. This bond should remain in place until 10 years after construction of the project is complete. While Exhibit W requires a general retirement and restoration bond, weed management is an ongoing obligation during project construction and operation, not just an obligation associated with retirement and decommissioning.

Land Use Condition 11c. only requires IPC to consult with the County when a County ROW permit is required. Baker County requests that Land Use Condition 11c. be modified to require that any work in a Baker County ROW (whether requiring a County ROW permit or not) be coordinated with the County to minimize impacts to other users of those ROWs. This change would be consistent with Public Services Conditions 1 and 8.

**Exhibit L**

Baker County finds IPC's analysis of visual impacts at the National Historic Oregon Trail Interpretive Center (NHOTIC) to be unpersuasive and insufficient. The County does not believe the mitigation required by Scenic Resources Condition 2 would reduce the visual impacts of the project on NHOTIC below significance.

Baker County reiterates its previous recommendation that IPC evaluate the feasibility of undergrounding the transmission line in the vicinity of NHOTIC. Scenic Resources Condition 2 requires above-ground visual mitigation for 1.6 miles of transmission line (from MP 145.1 to MP 146.7). This is a short distance, particularly compared to the 300-mile length of the entire project. Exhibit BB Section 3.4 dismisses undergrounding the entire project as cost-prohibitive, but no feasibility study has ever been conducted to quantify that additional cost for just the 1.6 miles at issue near NHOTIC. Without a location-specific analysis of the cost and feasibility of undergrounding the line in the vicinity of NHOTIC and an evaluation of the superior mitigation that would result, ODOE cannot conclude that the proffered above-ground mitigation is the best option to mitigate impacts. This is particularly true given the prominent stature of NHOTIC, the critical importance of this visual resource and the close proximity of the project to NHOTIC (less than 125 feet to the centerline of the transmission line route, according to Table L-2).

**Exhibit R**

Baker County reiterates its concerns regarding the significant impact of the proposed project on NHOTIC, as discussed above regarding Exhibit L.

Baker County also reiterates its concern, originally expressed in its comment letter dated October 2, 2017, regarding the proposed route near the community of Durkee and the Burnt River Canyon area owned by BLM (identified in Exhibit R as scenic resource VRM B3). Baker County believes that route selection near Durkee overemphasized resource values on the BLM property and improperly minimized impacts to nearby private agricultural lands, thereby avoiding BLM property to the maximum extent possible. The proposed route also unnecessarily bisects agricultural parcels to the detriment of the landowners despite the fact that alternative routes across those parcels with less adverse impacts are available. Baker County and IPC have reached an agreement in principle to amend the proposed route in the general vicinity of Durkee so that the route, while still on private agricultural lands, has less adverse impacts to Goal 3 values; however, as currently described in the ASC, the proposed route does not implement that agreement. Consequently, Baker County finds that the analysis in Exhibits K and R, and elsewhere in the ASC, with respect to the proposed route near Durkee is insufficient to comply with Oregon's protections afforded agricultural land under Goal 3.

**Exhibit U**

Baker County reiterates its concerns expressed in prior comments that the ASC provides insufficient mitigation for fire risk and medical emergencies. With respect to fire, much of the land in Baker County has minimal fire protection available. The scale of the map in Figure U-4 is too large to be able to specifically determine jurisdictional boundaries; however, in review of the map, Baker County finds it likely that there are two fire response jurisdictions that were not identified. Baker County requests that IPC investigate the impact the project may have on the Huntington Fire Department and the Lookout-Glasgow Rangeland Fire Protection Association. Also, the narrative describing fire response on page U-16 states, "For private lands within the analysis area, fire protection and response falls to one of the 9 organizations listed in Table U-10." Baker County disagrees with this statement; while the large scale of the map makes it impossible to be certain, it is likely that at least portions of the project fall inside the response area of the two jurisdictions listed above, as well as outside the service area of any fire district or association. Page U-16 includes the statement: *"Not all lands fall within a designated fire district. In those cases, the closest or best situated fire district responds to fires."* While that may be true under ideal circumstances, in areas outside of a fire district or association, there is no guarantee of fire response. Mutual aid agreements as used in this context are between two fire response organizations who have like resources to 'trade', they are not made to cover lands that don't fall within any jurisdiction's response territory.

Furthermore, Table U-10 states that ODF can achieve response times of 15-30 minutes to the project site, but this statement is not supported by any evidence. The two notes of conversations with ODF in Attachment U-1 say nothing about response times. Fire response to portions of the project area in Baker County could extend to 1-2 hours if there is any response at all. The potential for fire spread in hot, dry and/or windy conditions is enormous, making a 1-2 hour response time unacceptable for high fire-risk activities such as project construction. Baker County believes Table U-10 is inaccurate and unreasonably optimistic regarding fire response potential in more remote areas of the County.

Page U-17, footnote 1, states the Burnt River Rangeland Fire Protection District could not be reached because no contact information was available on the Oregon Fire Agency List maintained by the Oregon State Fire Marshal's office. The most likely reason Burnt River RFPA is not included on this list is they are a Rangeland Fire Protection Association rather than a Rural Fire District, and they are formed under the Oregon Department of Forestry rather than the Oregon State Fire Marshal's office. If IPC contacts the Oregon Department of Forestry or Baker County, either can help establish contact with the RFPA, but IPC failing to make contact and establish impact with the impacted service providers cannot provide the Council enough information to evaluate the standard identified in OAR 345-021-0010 (1).

Baker County disagrees with the statement on page U-24 that the project will not have significant impacts on fire protection services. The first paragraph under Section 3.5.6.2, after making that statement, describes precisely why the fire protection impact is significant – most construction will occur during hot and dry weather, when fire risk is highest, in grassland and shrub-dominated landscapes particularly vulnerable to fire. Project construction involves many potential fire-inducing activities including use of motorized vehicles and equipment, welding, refueling and smoking. As we know from the last few summers, fire risk is already elevated in eastern Oregon even without introducing increased fire hazards into remote areas.

Given the high fire risk and the minimal available public services, IPC needs a more robust Fire Prevention and Suppression Plan. Giving construction workers a few hours of training plus a shovel, ax, fire extinguisher and some water is not sufficient. Additionally, page U-25 says, *"Construction workers are maintenance personnel are not trained firefighters and not expected to fight fires."* Instead, IPC should be required to provide meaningful mitigation for the impact, such as a full complement of fire protection equipment and trained firefighting personnel on site during construction, as well as an emergency plan coordinated with the County Emergency Management staff.

With respect to medical emergencies, Exhibit U lacks critical information that is needed to evaluate the standard identified in OAR 345-021-0010. IPC fails to identify relevant health care providers, including Saint Alphonsus Medical Center in Baker City, and does acknowledge first responders as health care providers. Ambulance service, or Life Flight air service, are the critical link between medical emergency and hospital. Response times to some portions of the project route can exceed one hour, which could then be followed by long travel to a hospital in Baker City, La Grande, Ontario or even Boise depending on the event. To improve response time, IPC should be required to develop a specific Medical Response Plan and have all onsite project managers carry a copy of the plan at all times. The plan should specifically require advance notice to ambulance and life-flight services of active construction locations, and should pre-identify life-flight landing locations near the work zone. If predicted response times are likely to adversely impact an ambulance service provider's ability to provide services, and it's reasonable to believe having an ambulance committed to a call for multiple hours will, IPC is required to mitigate the impact.

Lastly, conditions of approval should be imposed requiring that both the final Fire Prevention and Suppression Plan and Medical Response Plan be provided to Baker County (and other SAGs) for review and comment, as discussed above regarding other plans still in draft format.

If you have any questions or would like further information on Baker County's comments, please contact me by calling 541-523-8219 or by e-mail at hkerns@bakercounty.org.

Sincerely,

Holly Kerns
Planning Director

# Oregon

Kate Brown, Governor

**Department of Transportation**
District 14
1390 SE 1st Avenue
Ontario, OR, 97914-2945
Phone: (541) 823-4017
Fax: (541) 889-6600
Email: thomas.j.davis@odot.state.or.us

**TO:** Kellen Tardaewether
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301

**FROM:** Tom Davis, District 14 Operations Coordinator
Oregon Department of Transportation
1390 SE 1st Avenue
Ontario, OR 97914
(541) 823-4017
Thomas.j.davis@odot.state.or.us

**DATE:** December 21, 2018

**RE:** Oregon Department of Transportation Follow-up to our November 23, 2018 Comments for the Site Certificate for the Boardman to Hemingway Transmission Line

---

Kellen: this is a follow-up to our phone conversation and email on December 7, 2018. We have been working with Idaho Power on the Rock Quarries and the I-84 Right of Way/Access. We did provide Idaho Power with GIS data on the Rock Quarries and Scenic Byways. We also used the Idaho Power data to map their facilities to show conflicts with our Rock Quarries. I have included maps of those that are still in conflict.

**Aggregate Sites:** Based upon data provided by Idaho Power, and incorporated into the exhibits, the transmission line alignment and micro-siting corridor do not cross through, and are not directly adjacent to, the boundaries of the following material sources:

- South Nye Junction Quarry
- Spring Creek Quarry
- Clover Creek Quarry
- Jimmy Creek Quarry
- Pleasant Valley Quarry
- Love Reservoir Quarry
- Tub Mountain Quarry
- Vines Hill Quarry

One quarry, Baldock Slough East, is traversed by the micro siting corridor at two locations. As per discussions with Idaho Power, the proposed transmission line alignment should be adjusted within the micro siting corridor to avoid traversing the quarry boundary directly, Furthermore, we must once again reiterate that if engineering based buffers are required around tower and transmission lines to protect these facilities from impacts attributable to quarry operations, the proposed alignment must be placed outside of these buffers.

Three material sources, Palmer & Denham Quarry, Durbin Quarry and Pine Creek Ridge Quarry are in direct conflict with the proposed transmission line alignment. Palmer & Denham Quarry is privately owned and occupied by ODOT via a 99 year lease. I have attached current information, forwarded by the ODOT Region 5 ROW office, for this site. Durbin and Pine Tree Ridge Creek Quarry are both BLM owned and ODOT Controlled, by deed of right of way. The BLM granted ODOT the control of 70 acres for Durbin Creek Quarry in 1966. In 1955, the BLM granted ODOT control of 120 acres for Pine Tree Ridge Creek Quarry. In December 1955, ODOT purchased an additional 4.77 acres of quarry land and 4.92 acres for use as a haul road. Another thing that needs to be clearly understood is that, for the sites shown as BLM owned and, ODOT controlled, ODOT has an existing right of way (R/W) for use of that site through Federal Highway. BLM cannot issue another RW over top of our use that will impact our use as a material source unless agreed upon by ODOT. So, unless the proposed powerline alignment is within an existing easement or right of way previously approved and predating our rights to these sites, BLM will have to request ODOT concurrence before issuing a conflicting RW. ODOT has clearly and repeatedly stated that having towers in or close to these sites, or having lines above these sites is an impact to future operations, and as such ODOT would not agree to any impact to these sites. This is a regulatory protection of the existing use of both sites and has been noted as a "yes" in the included table.

| Source Number: | OR-01-039-5 | OR-01-037-5 | OR-01-064-5 | OR-23-003-5 |
|---|---|---|---|---|
| Quarry Name: | Baldock Slough East | Palmer & Denham | Durbin Quarry | Pine Creek Ridge |
| Ownership: | ODOT | Palmer & Denham | BLM | BLM & ODOT |
| County: | Baker | Baker | Baker | Malheur |
| DOGAMI #: | - | - | - | - |
| Conditional Use Permit: | Not Applicable | Not Applicable | Not Applicable | Not Applicable |
| Land Use Approval: | Not Applicable | Not Applicable | Not Applicable | Not Applicable |
| Existing legal or regulatory protections: | Not Applicable | Not Applicable | Yes - Deed of ROW | Yes - Deed of ROW |
| Location: | NE1/4 NE1/4 Sec 24, T8S, R40E,Willamette | SW 1/4 NW 1/4 Sec 1, T10S, R40E,Willamette | NE 1/4 NE1/4 Sec 23, T14S, R44E,Willamette | NE 1/4 SW 1/4 NW 1/4 Sec 34, T15S, R45E,Willamette |
| EFSC Comment: | Public Services | Public Services | Public Service | Public Services |

Regarding Goal 5 - not all counties have addressed sites the same way. Since 1996 counties have been required to maintain countywide assessments of significant aggregate sites. Aggregate sites are added to a local inventory of significant sites in response to an application. It is therefore not sufficient to rely on county inventories to identify aggregate sites that are important to the long term maintenance of Oregon's highways. So again the comment regarding the sites listed in the ODOT letter as not being shown on County Goal 5 Inventories is misleading. Granted some of these sites are small, maybe have limited reserves, but that does not decrease the value or the need for ODOT to be able to utilize these sites as needed when needed. Not being shown on a county Goal 5 inventory doesn't mean the site is not there and that it has value, or that a transmission line will not impact the potential use of the site.

**I-84 Right of Way:** In our conversation with Idaho Power, they have no intentions of working within the Interstate right of way. They understand that they cannot encroach, work within, construct features or have access within the Interstate right of way. They also understand that they will need to apply for and be approved for permits as outlined in previous letters.

**Scenic Byways:** The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) established the National Scenic Byways Program, implemented by FHWA. Under the National Scenic Byways Program, (23 U.S.C. 162) a roadway can be designated as a State Scenic Byway, a National Scenic Byway, or an All-American Road based upon intrinsic scenic, historic, recreational, cultural, archeological, or natural qualities. A road must exemplify the criteria for at least one of these six intrinsic qualities to be designated a National Scenic Byway. For the All-American Roads designation, criteria must be met for a minimum of two intrinsic qualities. The jurisdiction of the municipal, county, State, tribal, or Federal Governments that govern the designated highway and the lands adjacent to it remains unchanged. The byway's intrinsic qualities are typically protected by those jurisdictions.

To be designated a scenic byway, a strong local commitment must be "provided by communities along the scenic byway that they will undertake actions, such as zoning and other protective measures, to preserve the scenic, historic, recreational, cultural, archeological, and natural integrity of the scenic byway and the adjacent area as identified in the corridor management plan." Understanding how a byway's resources contribute to the visual quality of the project corridor is an important factor in conducting a Visual Impact Analysis for a project that affects a designated scenic byway. You can find more information on the National Scenic Byways Program and federally designated scenic routes at FHWA's America's Byways website:
**http://www.fhwa.dot.gov/byways/**

As described in Section 2.3.1, National Scenic Byways Program, local city, county, or State DOTs provide protective measures for federally designated scenic routes. Cities, counties, and States may have other officially designated scenic routes. These scenic routes are often listed and described under each State DOT's website or within city and county general and specific plans. There may also be local ordinances pertaining to scenic routes or other designated scenic areas, such as historic roads and streets. Authors should become familiar with the regulations and customs that dictate how the visual quality of these routes and areas are managed.

Hells Canyon (All American Roads) Scenic Byway Corridor Management, Journey Through Time Tour Route Management Plan, The Grande Tour Route Management Plan and the Elkhorn Drive National Forest Scenic Byway Management Plan were not analyzed for impacts in the Application for Site Certification.

In Exhibit R, Table R-1 page R-16 incorrectly states that in the ODOT Plans, Scenic Resources are not identified, when in fact each plan clearly describes the scenic resources available. Additionally, the Corridor Management Plans do show one or more of the following intrinsic qualities: scenic, historic, recreational, cultural, archeological, or natural.

*Boardman to Hemingway Transmission Line Project* *Exhibit R*

| Jurisdiction | Plan | Scenic Resources Identified? (Y/N) | Name of Scenic Resource | Location in Plan | Location of Scenic Resource | GIS ID No. | Analyzed in Exhibit R? (Y/N) |
|---|---|---|---|---|---|---|---|
| Oregon Department of Transportation | Hells Canyon Scenic Byway Corridor Management Plan (Eastern Oregon Visitors Association/ Hells Canyon Scenic Byway Committee,2004) | N | N/A | III. Intrinsic Qualities and Context Statement | N/A | N/A | N |
| Oregon Department of Transportation | Journey Through Time Tour Route Management Plan (Michael Wetter and Associates 1996) | N | N/A | Background; Vision, Goals, Objectives | N/A | N/A | N |
| | No corridor management plan | N | N/A | II. Resource Inventory | N/A | N/A | N |
| | Elkhorn Drive National Forest Scenic Byway Management Plan (1996) | N | N/A | Resource Inventory | N/A | N/A | N |
| **TRIBAL** | | | | | | | |
| Confederated Tribes of the Umatilla Indian Reservation (CTUIR) | Comprehensive Plan for the Confederated Tribes of the Umatilla Indian Reservation (2010) | N | None identified | 5. Plan Elements: Goals & Objectives | N/A | N/A | N |

*APPLICATION FOR SITE CERTIFICATE* *Page R-16*

On page R-37 of the Application, Idaho Power reviewed the plans a mistakenly did not identify scenic resources as significant or important.

1. **Hells Canyon Scenic Byway Corridor Management Plan**
   - Intrinsic Qualities and Context Statement' includes a description of the scenic quality that is of national significance.
   - Visual Resource Management, includes visual quality goals, objectives, character types, distance zones (foreground 3000'-½ mile, middle-ground ½ to 4 miles, background 4 miles to horizon), variety classes and sensitivity levels.
   - Existing Recreational Facilities describes scenic views and landmarks
2. **Journey Through Time Management Plan**
   - A Few Highlights includes scenic locations
   - Points of Interest and Enhancement/Protection Projects – includes scenic resources
3. **Elkhorn Drive Scenic Byway Management Plan**
   - Resource Inventory identifies scenic resources.
4. **The Grande Tour Route Management Plan**
   - Scenic Qualities;
   - Vision, Goals and Objectives;
   - Protection strategy;
   - Enhancement strategy - all identify scenic resources

Idaho Power should include an analysis on these scenic byways to insure that they will not be impacted by the project.

In Exhibit L an example was found for the protected area of the Oregon Trail ACEC - National Historic Oregon Trail Interpretive Center which is adjacent to the Hells Canyon Scenic Byway Corridor. The Analysis Area in Table L-2 page L-28 has a Visual Impact Intensity Level Medium. Idaho Power under mitigation 3.6 page L-43-L-45 has addressed mitigation to satisfy the requirements of OAR 345-022-0080. The mitigation was making adjustments in the transmission line route along with the type of structure. Without performing an analysis on the impacts to the Scenic Byways, however, we are not able to determine the full impacts. Idaho Power should perform an analysis to determine if the project will result in significant adverse impact to the scenic resources and values of the Scenic Byways.

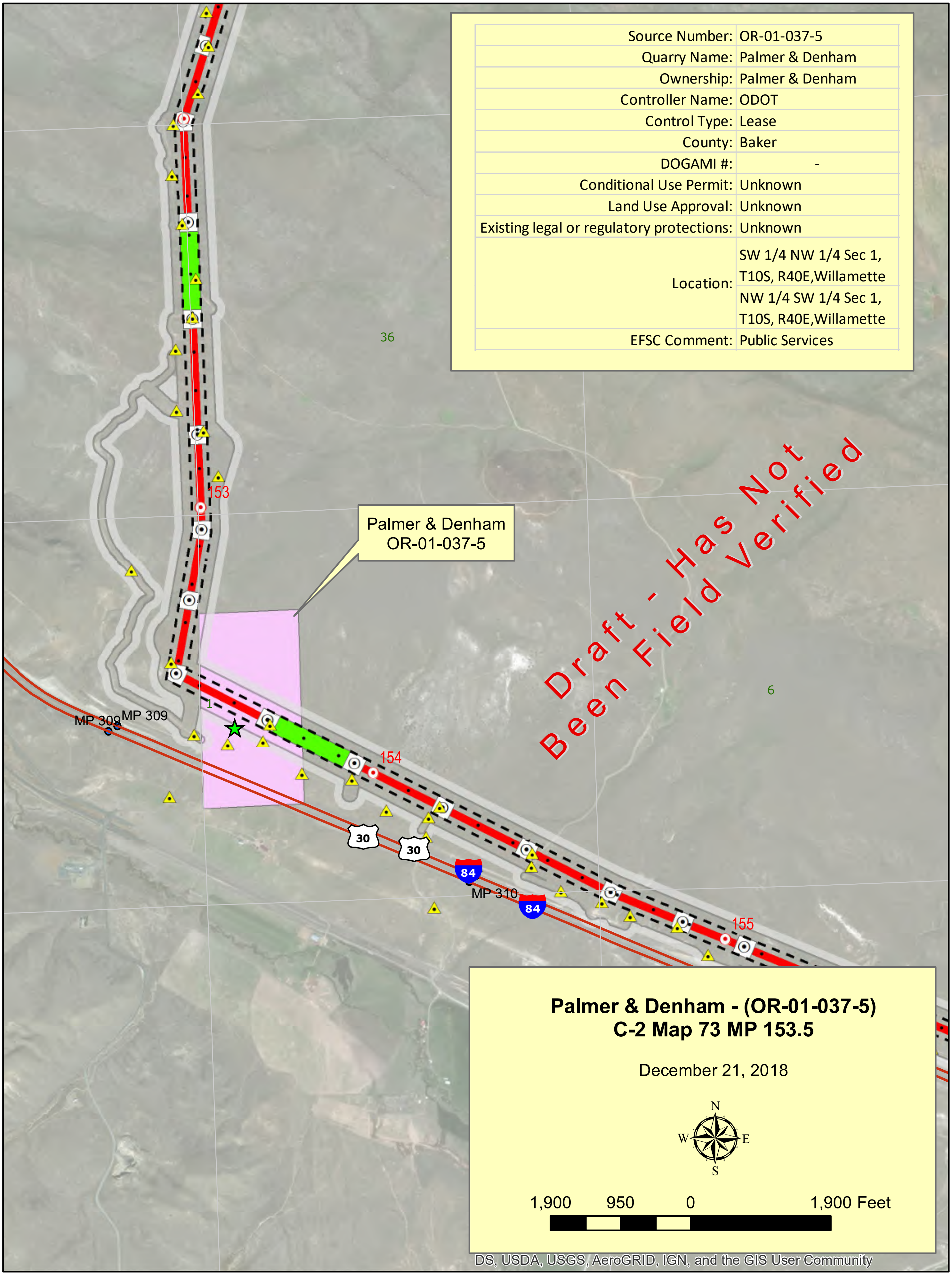
Kellen; we have been in touch with the Counties to request information on their Goal 5 on Aggregate and Scenic Resources. Due to the holidays, I have been told that it would be after the first of the year before we get the needed information from the Counties.

We are continuing to put together the needed information. We have a conference call with Idaho Power on January 7th to further discuss the rock quarries.

We will also need to continue working with you on trying to have an analysis performed on the scenic byways.

Sincerely;

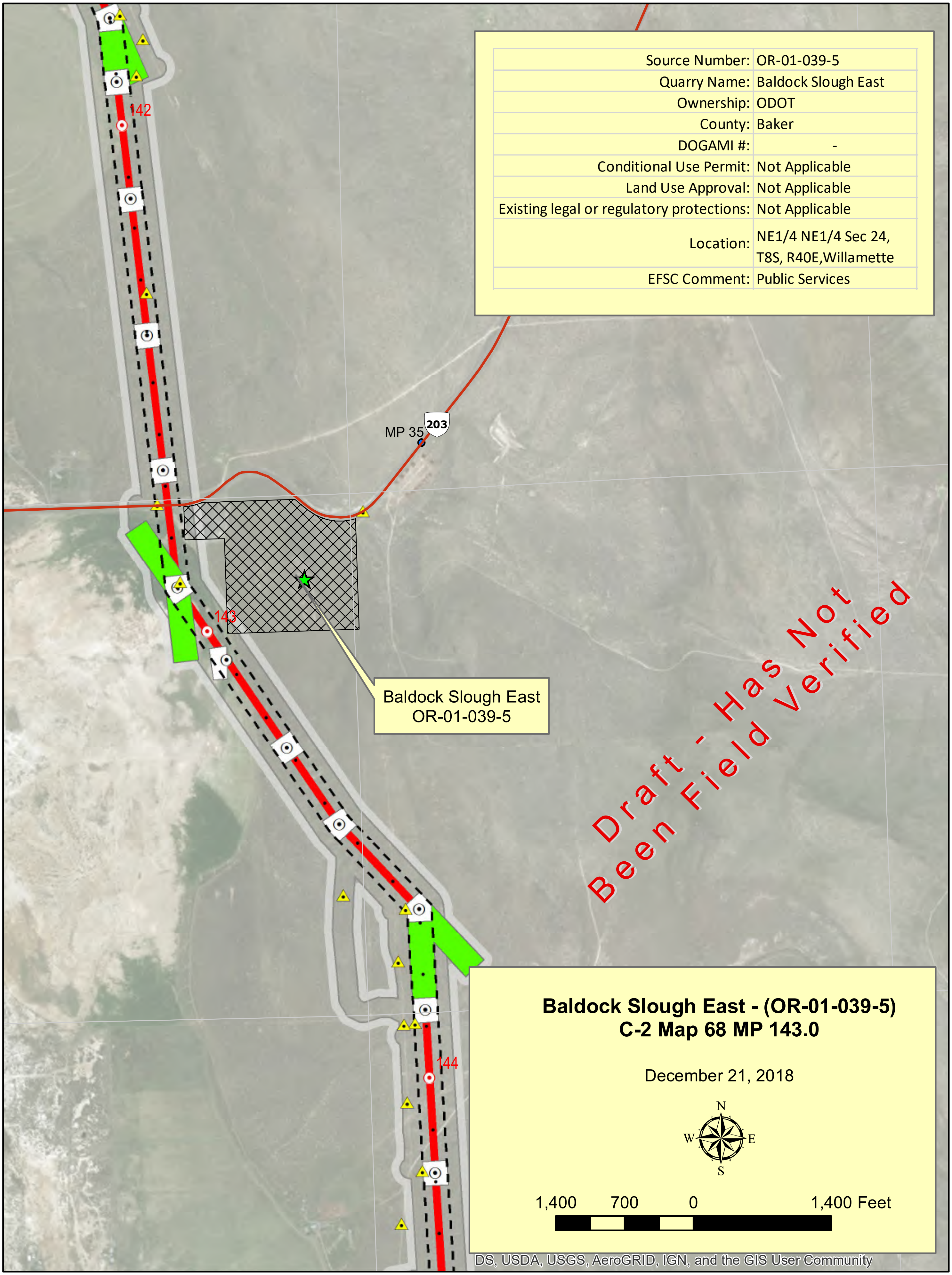
Tom Davis;
District 14 Operation Coordinator




| | |
|---|---|
| Source Number: | OR-01-037-5 |
| Quarry Name: | Palmer & Denham |
| Ownership: | Palmer & Denham |
| Controller Name: | ODOT |
| Control Type: | Lease |
| County: | Baker |
| DOGAMI #: | - |
| Conditional Use Permit: | Unknown |
| Land Use Approval: | Unknown |
| Existing legal or regulatory protections: | Unknown |
| Location: | SW 1/4 NW 1/4 Sec 1, T10S, R40E,Willamette<br>NW 1/4 SW 1/4 Sec 1, T10S, R40E,Willamette |
| EFSC Comment: | Public Services |

**Palmer & Denham - (OR-01-037-5)**
**C-2 Map 73 MP 153.5**

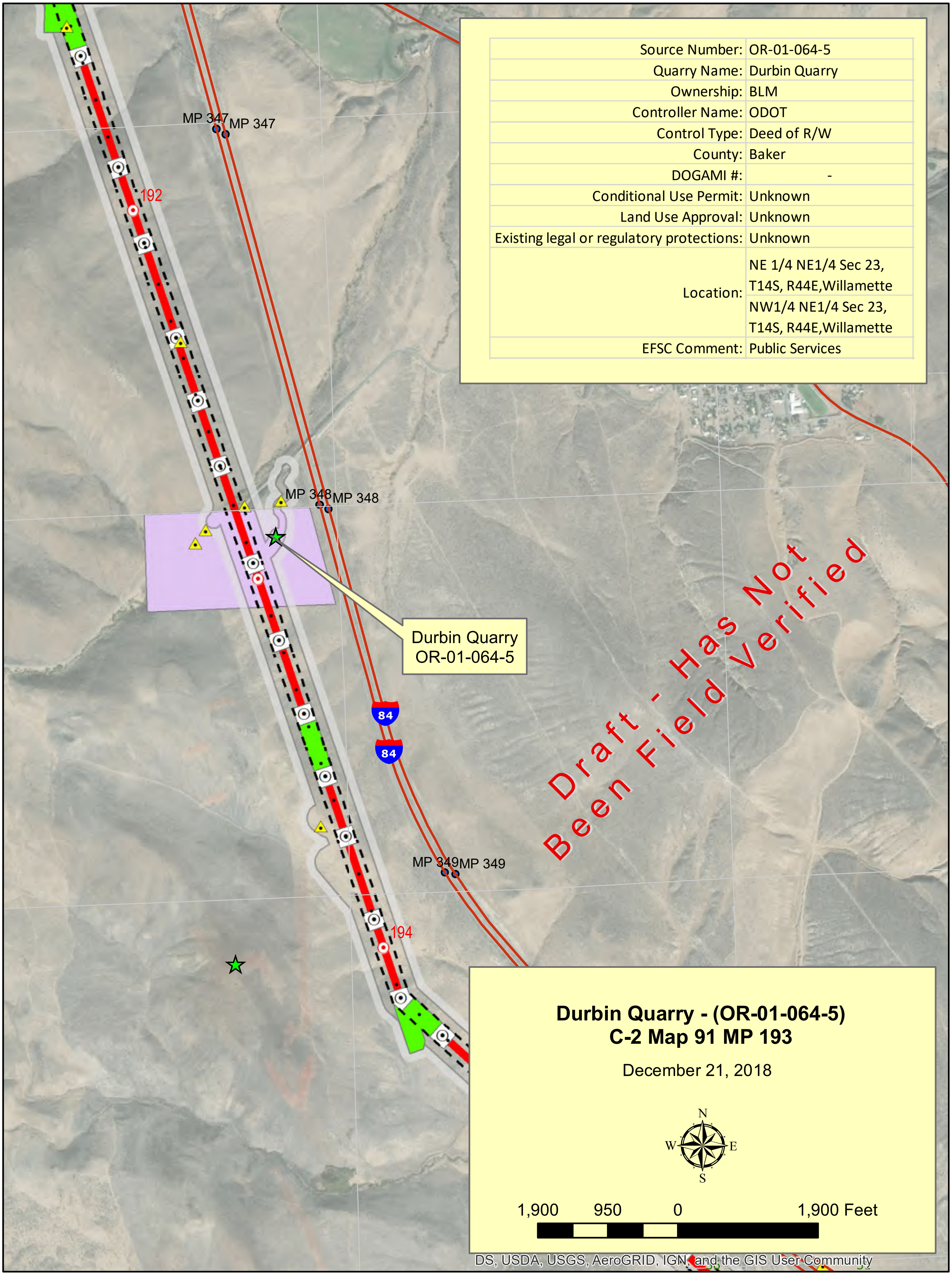
December 21, 2018




| | |
|---|---|
| Source Number: | OR-01-039-5 |
| Quarry Name: | Baldock Slough East |
| Ownership: | ODOT |
| County: | Baker |
| DOGAMI #: | - |
| Conditional Use Permit: | Not Applicable |
| Land Use Approval: | Not Applicable |
| Existing legal or regulatory protections: | Not Applicable |
| Location: | NE1/4 NE1/4 Sec 24, T8S, R40E,Willamette |
| EFSC Comment: | Public Services |

**Baldock Slough East - (OR-01-039-5)**
**C-2 Map 68 MP 143.0**

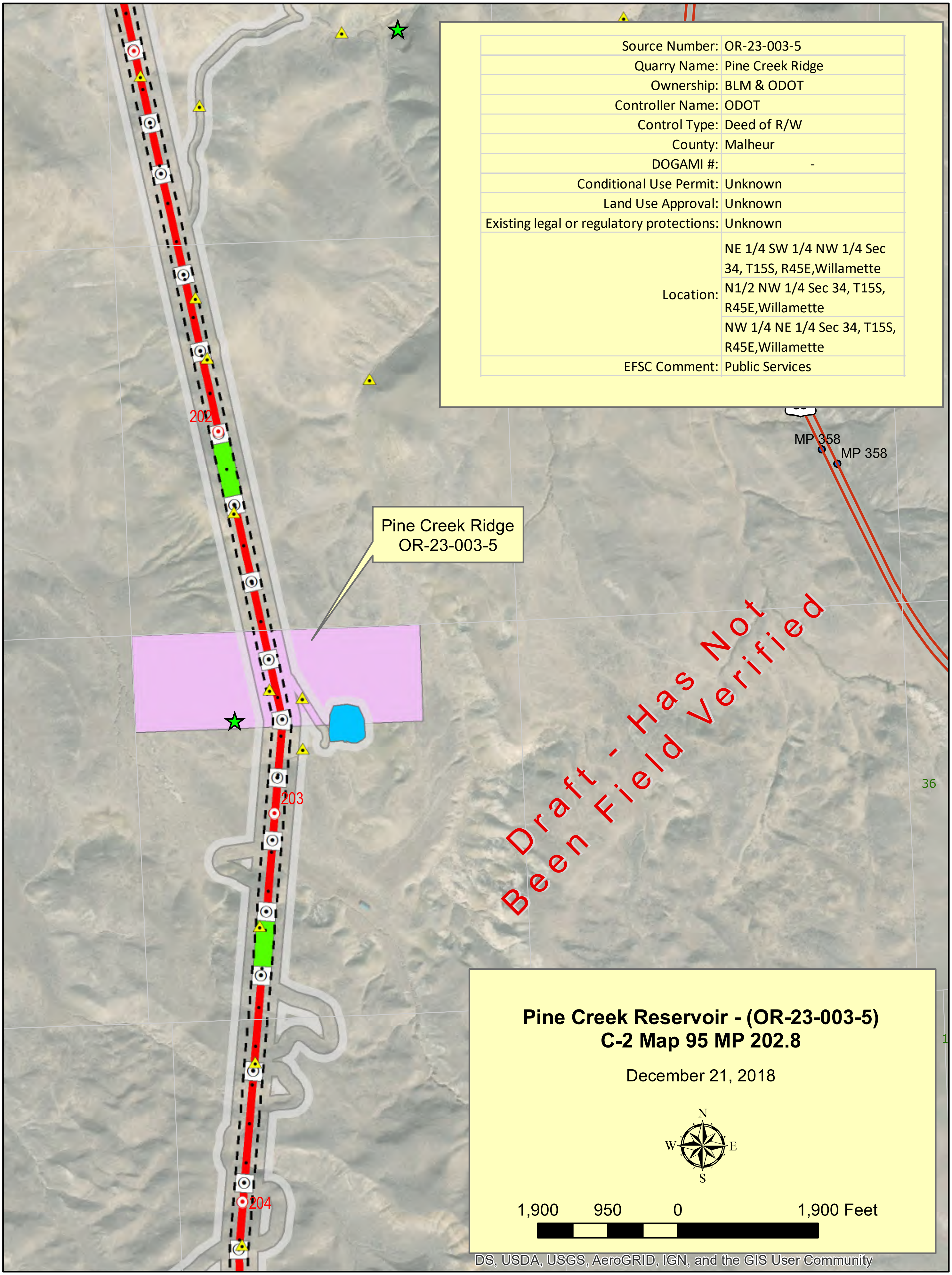
December 21, 2018




| | |
|---|---|
| Source Number: | OR-01-064-5 |
| Quarry Name: | Durbin Quarry |
| Ownership: | BLM |
| Controller Name: | ODOT |
| Control Type: | Deed of R/W |
| County: | Baker |
| DOGAMI #: | - |
| Conditional Use Permit: | Unknown |
| Land Use Approval: | Unknown |
| Existing legal or regulatory protections: | Unknown |
| Location: | NE 1/4 NE1/4 Sec 23, T14S, R44E,Willamette NW1/4 NE1/4 Sec 23, T14S, R44E,Willamette |
| EFSC Comment: | Public Services |

**Durbin Quarry - (OR-01-064-5)**
**C-2 Map 91 MP 193**

December 21, 2018




| | |
|---|---|
| Source Number: | OR-23-003-5 |
| Quarry Name: | Pine Creek Ridge |
| Ownership: | BLM & ODOT |
| Controller Name: | ODOT |
| Control Type: | Deed of R/W |
| County: | Malheur |
| DOGAMI #: | - |
| Conditional Use Permit: | Unknown |
| Land Use Approval: | Unknown |
| Existing legal or regulatory protections: | Unknown |
| Location: | NE 1/4 SW 1/4 NW 1/4 Sec 34, T15S, R45E,Willamette<br>N1/2 NW 1/4 Sec 34, T15S, R45E,Willamette<br>NW 1/4 NE 1/4 Sec 34, T15S, R45E,Willamette |
| EFSC Comment: | Public Services |

**TARDAEWETHER Kellen * ODOE**

| | |
|---|---|
| **From:** | Sarah J Reif <Sarah.J.Reif@state.or.us> |
| **Sent:** | Friday, January 25, 2019 8:14 AM |
| **To:** | TARDAEWETHER Kellen * ODOE; WOODS Maxwell * ODOE |
| **Subject:** | RE: Boardman to Hemingway EFSC Request on Complete Application |
| **Attachments:** | B2HAPP ASC Reviewing Agency_ODFW Comments 01.25.19.pdf |

Kellen and Max,

Attached you will find ODFW's review and comment on the B2H application for site certificate. We greatly appreciate your patience, and that of the applicant. As always, I'm available to discuss any questions you may have regarding these comments. Thanks, and have a great weekend!

Sarah Reif
Office: 503-947-6082
Cell: 503-991-3587

---

**From:** TARDAEWETHER Kellen * ODOE <Kellen.Tardaewether@oregon.gov>
**Sent:** Wednesday, October 10, 2018 4:48 PM
**To:** BLEAKNEY Leann <lbleakney@nwcouncil.org>; CANE Jason <jason.cane@state.or.us>; MILLS David <david.mills@state.or.us>; JOHNSON Jim * ODA <jjohnson@oda.state.or.us>; jeff.caines@aviation.state.or.us; svelund.greg@deq.state.or.us; nigg.eric@deq.state.or.us; SEIDEL Nigel E <Nigel.E.Seidel@state.or.us>; MYATT Nick A <Nick.A.Myatt@state.or.us>; REIF Sarah J <Sarah.J.Reif@state.or.us>; WANG Yumei * DGMI <Yumei.WANG@oregon.gov>; EDELMAN Scott <scott.edelman@state.or.us>; JININGS Jon <jon.jinings@state.or.us>; MURPHY Tim <timothy.murphy@state.or.us>; BROWN Lauren <Lauren.BROWN@state.or.us>; CARY Dan <dan.cary@state.or.us>; Thomas.J.Davis@odot.state.or.us; BEALS Alice * OPRD <Alice.Beals@oregon.gov>; MULDOON Matt <Matt.MULDOON@state.or.us>; HANHAN Nadine <nadine.hanhan@state.or.us>; LGKOHO@puc.state.or.us; POULEY John * OPRD <John.Pouley@oregon.gov>; ALLEN Jason * OPRD <Jason.Allen@oregon.gov>; SAUTER Jerry K <Jerry.K.SAUTER@state.or.us>; Natalie Perrin <nperrin@hrassoc.com>; Kara_Warner@golder.com; Brad Bowden <bbowden@hrassoc.com>; cityofadrian@hotmail.com; kpettigrew@cityofboardman.com; ecpl@centurytel.net; karen@islandcityhall.com; rstrope@cityoflagrande.org. <rstrope@cityoflagrande.org>; cityadmin@cityofcove.org; tamra@umatilla-city.org; bob@umatilla.org; town055@centurytel.net; teri.bacus@cityofpilotrock.org; citymanager@cityofstanfield.com; admin@cityofunion.com; rnudd@bakercity.com; bsmith@hermiston.or.us; ddrotzmann@hermiston.or.us; manager@ci.irrigon.or.us; mayor@cityofvale.com; klamb@cityofvale.com; haines@cascadeaccess.com; TOKARCZYK John A * ODF <John.A.TOKARCZYK@oregon.gov>
**Subject:** Boardman to Hemingway EFSC Request on Complete Application

Good afternoon,

On September 21, 2018, the Oregon Department of Energy (ODOE), as staff to the Energy Facility Siting Council (EFSC), determined that Idaho Power Company's (applicant) amended preliminary application for a site certificate for the Boardman to Hemingway Transmission Line is complete. You have been identified as a reviewing agency for the Boardman to Hemingway Transmission Line and have been sent a copy of the complete application for site certificate (ASC) by the applicant along with a copy of an ODOE Request for Agency Report Memo. I have attached that memo to this email for your convenience. The Request for an Agency Report on the ASC is associated with compliance and recommended site certificate conditions for the proposed facility.

The deadline for agency comments on the ASC associated with compliance is <u>Monday, November 26, 2018.</u>

If you have not received a copy of the application in electronic and/or print format in the mail, please notify me. The ASC is also available on the ODOE project webpage. ODOE will host a series of informational meetings next week along the proposed route, you are encourage to attend, if you like.

I have spoken with many of you already to coordinate a time to discuss this review request. If you have questions, I am more than happy to have an in-person meeting or a call to go over the process, review request or the application. Thank all of you!

Kellen


**Kellen Tardaewether**
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301
P:(503) 373-0214
C: (503) 586-6551
Oregon.gov/energy


OREGON DEPARTMENT OF ENERGY

*Leading Oregon to a safe, clean, and sustainable energy future.*

Oregon
Kate Brown, Governor

OREGON DEPARTMENT OF ENERGY
550 Capitol St. N.E., 1st Floor
Salem, OR 97301-3737
Phone: (503) 378-4040
Toll Free: 1-800-221-8035
FAX: (503) 373-7806
www.Oregon.gov/ENERGY

**TO:** Kellen Tardaewether
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301

**FROM:** Sarah Reif, Energy Coordinator
Oregon Department of Fish and Wildlife
4034 Fairview Industrial Drive SE
Salem, Oregon 97302
503-947-6082
sarah.j.reif@state.or.us

**DATE:** January 25, 2019

**RE:** Oregon Department of Fish and Wildlife Agency Report on the Application for Site Certificate for the Boardman to Hemingway Transmission Line

---

**General Comments:**

Thank you for the opportunity to review the Boardman to Hemingway (B2H) Transmission Line Application for Site Certificate (ASC). The Oregon Department of Fish and Wildlife (ODFW) has appreciated the high level of coordination with Idaho Power Company (IPC) and Oregon Department of Energy (ODOE) on this project since its inception; coordination that was facilitated by the B2H Coordinator position formerly housed in the ODFW field office in La Grande. In general, ODFW found this ASC to be thorough and well-constructed, and IPC has addressed many of ODFW's prior concerns and recommendations provided during the Notice of Intent. Remaining comments and recommendations are provided below.

Many of the fish and wildlife conditions in the ASC are provisional at this time, subject to ODOE and ODFW review prior to construction (see Fish and Wildlife Conditions 1-9 and Other Information Condition 1). ODFW understands the need for provisional plans on a project of this scale, and that final surveys, impact assessments, avoidance and minimization measures, and mitigation plans cannot be finalized until the Right-of-Way (ROW) location can be finalized and access obtained. Given the provisional nature of the current ASC, comments and recommendations made by ODFW herein are subject to change based on the results of final surveys and final plans. Furthermore, ODFW anticipates significant workload for the agency in the pre-construction phase to review finalized plans. ODFW would appreciate a coordinated and sequenced schedule that offers adequate time for review prior to IPC's desired construction start date.

**Specific Comments:** Please see ODFW comments in the table provided below.

| Boardman to Hemingway Transmission Line<br>Comments on the Application for Site Certificate (ASC)<br>From Oregon Department of Fish and Wildlife | | | |
|---|---|---|---|
| **Exhibit** | **Rule/ Ordinance/Law Reference** | **Pg. / Para. / Sentence Reference (as needed)** | **Compliance Comment or Condition Language** |
| L | OAR 635-008-0120 | Protected Areas | The project proposes to cross upland habitat on Ladd Marsh Wildlife Area (LMWA), which is land owned and managed by ODFW. There is an existing transmission line and natural gas pipeline also located on Ladd Marsh Wildlife Area, in close proximity to the proposed ROW. The location of the proposed crossing functions as winter habitat for big game, and therefore ODFW expects that the best management practices and mitigation plans for Big Game Winter Range (as described in Exhibit P1) will apply to lands within the LMWA as well. When the time comes for planning roads, gated access, and timing of construction activity, ODFW recommends those plans be coordinated with the Wildlife Area Manager. |
| L | ORS 97.740, ORS 358.905-358.962, ORS 390.235, and OAR 736-051-0080 | Protected Areas | ODFW is aware of cultural resources in the vicinity of the proposed crossing of Ladd Marsh Wildlife Area. Under Oregon State Law (ORS 97.740, ORS 358.905-358.962, ORS 390.235, and OAR 736-051-0080) archaeological sites are protected on all non-federal public lands. To ensure compliance with applicable state cultural resource laws, ODFW requires Idaho Power contact the Oregon State Historic Preservation Office (SHPO) and provide documentation of concurrence from SHPO for the portion of the project that crosses Ladd Marsh Wildlife Area. If the overall project is determined by Idaho Power to have a federal nexus then documentation of compliance with relevant federal law, including Section 106 of the National Historic Preservation Act, may be provided instead. |
| P1 | (standard ODFW comment) | Page 21; Condition 2 and 13 | If construction activities encounter federally listed species covered by the Endangered Species Act, or those raptors and eagles covered the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act, ODFW |

| Boardman to Hemingway Transmission Line<br>Comments on the Application for Site Certificate (ASC)<br>From Oregon Department of Fish and Wildlife | | | |
|---|---|---|---|
| **Exhibit** | **Rule/ Ordinance/Law Reference** | **Pg. / Para. / Sentence Reference (as needed)** | **Compliance Comment or Condition Language** |
| | | | recommends IPC contact the U.S. Fish and Wildlife Service given their federal jurisdiction. |
| P1 | OAR 635-022-0060; OAR 635-415-0025 | Page 26; Section 3.3.2 Category 2 habitat | In the time that has passed since the original design of biological surveys for the B2H project, ODFW has identified pygmy rabbits as State Sensitive Species and has recommended mitigation for pygmy rabbits on other energy facility projects proposed in the sagebrush habitats of eastern Oregon. Pygmy rabbits are dependent on mature sagebrush and deeper soils, and given the conservation concern regarding their populations, ODFW has determined active pygmy rabbit colonies meet the definition of Category 2 habitat. ODFW understands that pygmy rabbits were not detected in the initial B2H surveys, where access was granted. However, ODFW recommends that pygmy rabbits be a part of pre-construction surveys, and if active pygmy rabbit colonies are found within areas proposed for temporary or permanent disturbance, ODFW recommends they be contacted. At that time, ODFW would work with IPC to explore avoidance options including spanning colonies, locating tensioning/pulling/fly yards outside of colonies, and assure that unavoidable impacts are mitigated according to policy. |
| P1, see also Exhibit BB Fish Passage | OAR 635-022-0060; OAR 635-415-0025; OAR 635-412 | Page 73; Section 3.5.5.6 | ODFW Fish Division and local District Fish Programs have reviewed this section, and based on the current application (subject to finalization prior to construction), ODFW finds fish impacts to be adequately considered and addressed. It is ODFW's understanding that fish passage plans and approvals have yet to be finalized prior to construction. |
| P1-3 Reclamation and | OAR 635-022-0060; OAR 635-415-0025 | Page 20; Section 6.0 Reclamation success standards, | Revegetation and reclamation serve an important function in minimizing impacts to wildlife habitat. Some habitats that will be impacted by this project, namely sagebrush shrubland and forests, take upwards of 10 to 50 |

| Boardman to Hemingway Transmission Line<br>Comments on the Application for Site Certificate (ASC)<br>From Oregon Department of Fish and Wildlife | | | |
|---|---|---|---|
| **Exhibit** | **Rule/ Ordinance/Law Reference** | **Pg. / Para. / Sentence Reference (as needed)** | **Compliance Comment or Condition Language** |
| Revegetation Plan | | monitoring, and maintenance | years to recover their pre-disturbance form and function. IPC has offered a robust revegetation plan, however ODFW stands by its previous recommendation that reclamation/revegetation monitoring be performed for longer than 5 years post-construction. ODFW recommends IPC utilize an adaptive monitoring schedule and management plan that can address Project impacts as long as necessary to achieve success criteria.<br><br>ODFW also finds IPC's proposed reclamation standards (Table 6) to be low relative to what ODFW has recommended and supported for other projects in similar habitats. Below are the recommendations ODFW made to ODOE for the B2H Notice of Intent, which we believe are still appropriate:<br><br>[ODFW recommends the following criteria for reclamation success]:<br>1. Maintain percent foliar cover of weed species within reclamation sites at a level equal to or less-than the paired control site. This will reduce the risk of invasive weeds outcompeting favorable vegetation and creating a source population for dispersing weed species.<br>2. Reclamation actions should prioritize establishment of native perennial bunchgrasses. Native, perennial bunchgrasses are our best defense against fire-prone annual grasses that threaten the arid habitats crossed by this project. Maintain >=70% percent foliar cover of native perennial bunchgrasses of the paired control site. The remaining percentage of vegetation can be other desirable vegetation species not present at the control site or functional bare ground. |

| Boardman to Hemingway Transmission Line<br>Comments on the Application for Site Certificate (ASC)<br>From Oregon Department of Fish and Wildlife | | | |
|---|---|---|---|
| **Exhibit** | **Rule/ Ordinance/Law Reference** | **Pg. / Para. / Sentence Reference (as needed)** | **Compliance Comment or Condition Language** |
| | | | 3. Reclamation actions in forested and shrub habitats should have appropriate woody species in the plant mix. Woody species should be plugged using appropriate aged plants to ensure the greatest possible revegetation success. Successful revegetation of sagebrush habitats should have at least 15 percent sagebrush foliar cover.<br>4. Maturity of vegetation within paired control sites should be used to determine the reclamation monitoring timeframe. Monitoring should be conducted on a regular 1-2 year interval until vegetation is established in a similar species composition as the paired control site. Monitoring efforts should then be extended to every 5-10 years (depending on habitat vegetation) until the vegetation reaches the same maturity as the paired control site when the Project impact occurred. |
| P1-3 Reclamation and Revegetation Plan | OAR 635-022-0060; OAR 635-415-0025 | Page 29; Section 6.5 Adaptive Management and Site Release | ODFW does not support the concept of waivers in the event of revegetation failure because that equates to permanent impact without offset, and the mitigation policy calls for no net loss. In the event of reclamation failure, despite remedial efforts, temporary impacts to wildlife habitat become permanent impacts. In these cases, the difference in compensatory mitigation offsets should be addressed (for example, if temporary impacts were mitigated at a 0.5:1 rate, the now permanent impacts would need to be mitigated at a 1:1 (or higher) rate). To account for such cases, ODFW recommends compensatory mitigation also be listed as a potential adaptive management option in the reclamation plan. |

| Boardman to Hemingway Transmission Line<br>Comments on the Application for Site Certificate (ASC)<br>From Oregon Department of Fish and Wildlife | | | |
|---|---|---|---|
| **Exhibit** | **Rule/ Ordinance/Law Reference** | **Pg. / Para. / Sentence Reference (as needed)** | **Compliance Comment or Condition Language** |
| P1-5 Noxious Weed Plan | OAR 635-022-0060; OAR 635-415-0025 | Page 26; Section 6.1 Monitoring | Linear projects such as transmission lines and pipelines, often inadvertently spread noxious weeds across the landscape. This is perhaps the greatest risk of this project to Oregon's wildlife habitats. For this reason, ODFW believes noxious weed monitoring and control is an extremely important minimization measure (per OAR 635-415). IPC is proposing noxious weed monitoring only for the first 5 years of the project, post-construction. If control efforts are not successful, IPC will consult with ODOE on next steps and may request a 'waiver'. ODFW contends that noxious weed monitoring and control ought to be the obligation of the applicant for the life of the project impact, for if this project led to noxious weed expansion, that could be interpreted as an expansion of project footprint. If the project's footprint were to expand over time, the areal extent of the project impact would need to be recalculated and could impact the compensatory mitigation quantities.<br><br>Long-term monitoring and successful treatment of weeds are important to the success of habitat restoration efforts and for habitat health. ODFW recommends that IPC monitor and control invasive weeds beyond the initial 5-year treatment period on a regular schedule of every 7 –10 years for the life of the Project. Treatment should occur when IPC has identified established weeds at a rate higher than pre-Project conditions. The Department recommends IPC work collaboratively with ODOE and the Department to define an appropriate monitoring schedule. |

| Boardman to Hemingway Transmission Line<br>Comments on the Application for Site Certificate (ASC)<br>From Oregon Department of Fish and Wildlife | | | |
|---|---|---|---|
| **Exhibit** | **Rule/ Ordinance/Law Reference** | **Pg. / Para. / Sentence Reference (as needed)** | **Compliance Comment or Condition Language** |
| P1-6 Fish and Wildlife Habitat Mitigation Plan | OAR 635-022-0060; OAR 635-415-0025 | Page 15; Section 3.3.2; Table 9. Accounting for Mitigation Debit for Permanent Direct Impacts, Category 2 | IPC proposes to mitigate for permanent direct impacts in Category 2 habitat at the rate of >1 acre offset per 1 acre of impact (>1:1). The ODFW Fish and Wildlife Habitat Mitigation Policy sets forth a goal for Category 2 habitats of no net loss of either habitat quantity or quality and to provide a net benefit of habitat quantity or quality. While the proposed rate of >1:1 technically meets the 'no net loss' of quantity, if the rate tends closer to 1 (for example 1.1:1, as opposed to 2:1) it does not leave much of a 'buffer' to achieve no net loss of quality, and even more difficult to achieve net gain in quality. A larger ratio creates a buffer to safeguard against failure of the habitat restoration/enhancement activities that IPC would be performing as part of their 'net benefit' activity. The narrower the ratio, the more in-depth monitoring ODFW would recommend to ensure that the goals of no net loss in quantity and quality were achieved. This is the reason most project applicants opt for a larger mitigation ratio (such as 2:1) in category 2 habitats, so they can have some portion of the mitigation area that is struggling to provide uplift while still meeting the net benefit goal. |
| P1-6 Fish and Wildlife Habitat Mitigation Plan | OAR 635-022-0060; OAR 635-415-0025 | Page 15; Section 3.3.2; Table 10. Accounting for Mitigation Debit for Temporary Direct Impacts, Category 3 and 4 | Similar to the comment provided above, the ratio of <1:1 could meet the policy but if the rate of mitigation is 0.1:1 it will be unlikely that IPC can meet the goals of the policy with regard to temporal loss. If the rate of mitigation is closer to 0.5:1 or 0.9:1 it becomes more obvious that temporal habitat loss will be adequately addressed. |
| P2 | OAR 635-140-0000 - 0025 | P2-12 / Section 3.6 Baseline Surveys | Due to changes in sage-grouse abundance and habitat use over time, sage-grouse lek survey data has a 10-year shelf-life. Before construction and calculation of |

| Boardman to Hemingway Transmission Line<br>Comments on the Application for Site Certificate (ASC)<br>From Oregon Department of Fish and Wildlife | | | |
|---|---|---|---|
| **Exhibit** | **Rule/ Ordinance/Law Reference** | **Pg. / Para. / Sentence Reference (as needed)** | **Compliance Comment or Condition Language** |
| | | | mitigation responsibility, the project proponent should resurvey areas for sage-grouse leks where previous surveys were conducted 10 or more years prior to construction. This resurvey effort should be minimal because ODFW and BLM have significantly increased survey efforts for sage-grouse leks and the project proponent will only be requested to survey areas that have been surveyed within 10 years prior to project construction. The project proponent must coordinate with ODFW to determine where resurveys should be conducted. |
| P2 | OAR 635-140-0000 - 0025 | P2-17 / Fish and Wildlife Condition 25: | Condition 25 indicates that mitigation for project impacts to sage-grouse and their habitats will not be calculated or provided until the 3rd year of operation in order to incorporate final analysis of indirect impacts from project roads. Postponing mitigation from initial project construction impacts through year 3 of project operation will result in a detrimental temporal loss of sage-grouse habitat. This several-year loss of sage-grouse habitat does not meet OAR 635-140-0010 and 635-140-0025. To comply with these policies, ODFW proposes that the project proponent reduce prolonged loss of sage-grouse habitat by calculating and providing mitigation for sage-grouse in a 2 stage process. First, the project proponent should fully mitigate, as outlined in OAR 635-140-0025(3), for areas of known, direct (towers, roads, pulling & tensioning area, etc.) and indirect project impacts (excluding roads) prior to construction. Second, upon completion of the traffic study in year 3 of operation, the project proponent should provide mitigation for any remaining indirect impacts to sage-grouse habitat identified from the project road analysis. Mitigation for indirect road impacts should be established immediately after finalizing the road analysis. Mitigation will be calculated using the ODFW Habitat Quantification Tool (HQT), and can be completed through permittee-responsible offsite mitigation or payment into ODFW's In-Lieu Fee program. |
| P2 | OAR 635-140-0000 - 0025 | P2-22 / Table P2-6 | ODFW recommends Table P2-6 identify the need for compensatory mitigation for permanent indirect impacts from project access roads. Roads can have long lasting indirect impacts on sage-grouse habitat as vehicle traffic results in auditory impacts |

| Boardman to Hemingway Transmission Line<br>Comments on the Application for Site Certificate (ASC)<br>From Oregon Department of Fish and Wildlife | | | |
|---|---|---|---|
| **Exhibit** | **Rule/ Ordinance/Law Reference** | **Pg. / Para. / Sentence Reference (as needed)** | **Compliance Comment or Condition Language** |
| | | | and human presence can interfere with sage-grouse use of habitat adjacent to roads. ODFW will request compensatory mitigation for new project roads or existing roads with increased traffic rates if access control cannot be implemented. ODFW will use the HQT to calculate a mitigation responsibility and assimilate any minimization measure proposed by the project proponent. Use this information to update relevant sections such as on page P2-23. |
| P2 | OAR 635-140-0000 - 0025 | P2-24 / Table P2-7 | Table P2-7 describes temporary indirect impacts to sage-grouse habitat from access roads and invasive plant species. ODFW requests that the project proponent also address temporary indirect impacts that will be generated from the construction of the transmission line, associated ancillary features, and use of any multi-use or fly yards within sage-grouse habitat. |
| P2 | OAR 635-140-0000 - 0025 | P2-27 / Third paragraph | ODFW requests the project proponent coordinate design and execution of the project road traffic analysis to ensure state considerations are met. |
| P3 | OAR 635-022-0060; OAR 635-415-0025 | Fish and Wildlife Condition 27 | ODFW recommends that IPC provide confirmation of access control on relevant facility access roads, and that the access control be included in monitoring/reporting so as to ensure that disturbance to elk populations are minimized. |
| P3 | OAR 635-022-0060; OAR 635-415-0025 | Monitoring | ODFW recommends IPC develop a plan for deploying counters in collaboration with ODFW to ensure the goals of the monitoring are met. It would be helpful for this plan to identify which category roads will be monitored, where, how many, etc. |
| Q | OAR 345-022-0070; ORS 496.171-192; OAR 635-100-0105; OAR 635-415 | Section 3.2 Methods, Washington ground squirrel | It is ODFW’s understanding that the majority of the proposed project has not yet been surveyed for Washington grounds squirrels (WAGS) due to limitations of access. Given the last date of survey (2014), ODFW notes that all WAGS areas will need to be re-surveyed because we are beyond the standard three-year shelf life for those survey data.<br>Upon further review of the survey methods for WAGS, ODFW realized that previous survey was not in line with our recommended standard survey methodology. ODFW |

| Boardman to Hemingway Transmission Line<br>Comments on the Application for Site Certificate (ASC)<br>From Oregon Department of Fish and Wildlife | | | |
|---|---|---|---|
| **Exhibit** | **Rule/ Ordinance/Law Reference** | **Pg. / Para. / Sentence Reference (as needed)** | **Compliance Comment or Condition Language** |
| | | | apologizes for not recognizing this sooner. IPC's analysis area consists of the Right-of-Way plus a ½ mile buffer to provide flexibility in potential ground disturbance for roads, laydown sites, or other ground-disturbance purposes. The WAGS survey extended out an additional 785 feet beyond the ½ mile buffer. ODFW did not correct this distance in its previous reviews, however, the standard methodology recommends survey out an additional 1000 feet beyond areas of potential ground disturbance. ODFW recommends that future WAGS surveys include this additional 215 feet. |
| Q | OAR 345-022-0070; ORS 496.171-192; OAR 635-100-0105; OAR 635-415 | Page Q-21; Impacts to Washington Ground Squirrel habitat | In the first paragraph on page Q-21, IPC discusses potential impacts to habitats occupied by WAGS. Mid-paragraph IPC states "temporary impacts to category 2 WAGS habitat in agricultural areas will likely be short-term…". It is not clear if IPC then included active agricultural areas in its calculation of impacts, however, ODFW does not consider active agricultural areas to be WAGS habitat because the ground disturbance precludes occupancy. |
| Q | OAR 345-022-0070; ORS 496.171-192; OAR 635-100-0105; OAR 635-415 | Page Q-75; Washington Ground Squirrel Monitoring | To be consistent with ODFW recommendations on other EFSC projects with potential impacts to WAGS, ODFW recommends long-term monitoring of active colonies. The purpose of this long-term monitoring is to assess adequacy of the 785-foot buffer and to monitor for any potential drift in colony extent that may require some additional avoidance measures in the O&M phase of the project to avoid potential take of WAGS. ODFW recommends surveys of existing, active colonies plus an additional 500 feet. Frequency would be years 1, 3, 5, and then at 5-year intervals for the life of the project with reporting to ODFW and ODOE. |

## TARDAEWETHER Kellen * ODOE

| | |
|---|---|
| **From:** | FIELDS Tom * ODF |
| **Sent:** | Monday, February 4, 2019 4:34 PM |
| **To:** | TARDAEWETHER Kellen * ODOE |
| **Cc:** | BONEBRAKE Jeff C * ODF; TOKARCZYK John A * ODF; FIELDS Tom * ODF |
| **Subject:** | RE: Follow up Call with ODF-ODOE per B2H |

Hi Kellen.

Rather than taking up time during tomorrow's call, I thought that I would provide you with a few items that need to be updated within the proposal. I still plan on being on the phone.

**Exhibit K, Attachment K-2**

**4.1.5 Fire Protection during Logging Operations**

Forest fire control rules are included in OAR 629. All logging operations shall be required to comply with these regulations, ~~with recognition of the limitations of the specific wildfire hazard zone (OAR 629-044-0020).~~

***This OAR does not relate to industrial operations. I believe they are referring to "Regulated Use Zones", which are not identified in OAR or ORS.***

**Fire Prevention and Suppression Plan**

**1.3 Responsibilities and Coordination**

In paragraph 3, remove **"Fire risk is anticipated to be low during Project operations"**

***There is no way of predicting what the fire risk will be. The rest of the statement referring to fire prevention and suppression measures is accurate.***

**2.1 Preconstruction and Construction**

Update "ODF's Fire Prevention Rules, OAR Chapter 629, Division 43 (ODF 2015) to (ODF 2017)….when rule changes occurred.

**2.1.5 Equipment**

***Typo - 8-pound capacity should be 8-ounce capacity.***

Update pump requirement to 2017 language.

***The pump will discharge not less than 20 gallons per minute at a pressure of at least 115 pounds per square inch at pump level;***

***Hose and nozzle: A nozzle, and enough serviceable hose of not less than 3/4 inch inside diameter, to reach from the water supply to any location in the operation area affected by power driven machinery, or 500 feet, whichever is greater.***

***Typo – Each power saw must have an 8-ounce fire extinguisher and a round pointed shovel…***

Update "Watchman" in accordance with 2017 OAR's. (Now Firewatch with new language).

***The firewatch must constantly observe the operation area during any breaks (up to three hours) in operation activity and for three hours after the power driven machinery used by the operator has been shut down for the day; visually observe all portions of the operation area on which operation activity occurred during the preceding period of activity; and be qualified in the use and operation of assigned firefighting equipment and tools; be physically capable of performing assigned fire suppression activities; and be advised of single employee assignment responsibilities (OAR 437-007-1315), when working alone. Each person providing fire watch service on an operation area must have adequate facilities for transportation and communication to be able to summon firefighting assistance in a timely***

***manner. Upon discovery of a fire, fire watch personnel must first report the fire, summon any necessary firefighting assistance, describe intended fire suppression activities and agree on a checking system; then after determining a safety zone and an escape route that will not be cut off if the fire increases or changes direction, immediately proceed to control and extinguish the fire, consistent with firefighting training and safety.***

### 2.2 Restricted Operations

***2nd Paragraph.*** Change "During periods of high fire danger" to ***"During fire season…"***

Thanks,

Tom

*Tom Fields*
Fire Prevention Coordinator
Oregon Department of Forestry
2600 State Street
Salem, Oregon 97310
(503) 945-7440 (desk)
(503) 983-8897 (cell)
Prevention on the Web

-----Original Appointment-----
**From:** FIELDS Tom * ODF
**Sent:** Tuesday, January 22, 2019 2:44 PM
**To:** TARDAEWETHER Kellen * ODOE
**Subject:** Accepted: Follow up Call with ODF-ODOE per B2H
**When:** Tuesday, February 05, 2019 10:00 AM-11:00 AM (UTC-08:00) Pacific Time (US & Canada).
**Where:** ODOE Room Hermiston * ODOE

# Oregon

Kate Brown, Governor

**Department of Forestry**
State Forester's Office
2600 State Street
Salem, OR 97310-1336
503-945-7200
FAX 503-945-7212
www.oregon.gov/ODF

"STEWARDSHIP IN FORESTRY"

February 19, 2019

From: Tom Fields
Fire Prevention Coordinator
Oregon Department of Forestry

To: Oregon Department of Energy
Re: Boardman to Hemmingway Powerline Construction Project

The Oregon Department of Forestry (ODF) has reviewed the application for site certificate from Idaho Power Company to the Oregon Department of Energy to construct, operate and maintain a high-voltage electric transmission line between Boardman, Oregon and the Hemingway Substation in southwest Idaho as an extension of IPC's electric transmission system.

The proposal includes provisions for meeting requirements under the Oregon Forest Practices Act and other laws and rules pertaining to fire prevention and suppression measures regarding industrial operations on private and public lands within ODF's protection boundaries. Additionally, the proposal details further expectations relating to ongoing and future maintenance upon establishment of the transmission line.

Upon review, ODF finds that fire prevention measures and vegetation management objectives are consistent with current policies, laws and rules under Oregon Revised Statute Chapters 477 (Fire Protection of Forests and Vegetation) and 527 (Forest Practices) and Oregon Administrative Rules Chapter 629 (Department of Forestry) as they relate to proposed operations with the following stipulations.

1) Update language in the Fire Prevention and Suppression Plan to be consistent with current administrative rules for fire prevention. This includes requirements for water supply and equipment for fire suppression under OAR 629-043-0020 and requirements for Firewatch under OAR 629-043-0030.
2) Remove language in the Fire Prevention and Suppression Plan section 1.3 inferencing that "fire danger is anticipated to be low during Project operations…" as the level of fire danger is difficult to predict prior to the Project.
3) Replace "During periods of high fire danger…" language in the Fire Prevention and Suppression Plan section 2.2 with "During fire season…"
4) In Attachment K-2, Right-of-Way Clearing Assessment, replace "wildfire hazard zones (OAR 629-044-0200)" with "regulated use zones," as wildfire hazard zones do not correlate with industrial fire prevention rules.

This letter of review in no way removes potential liability in the event of a wildfire. Should the project operation be out of compliance with any fire prevention and suppression requirements, the responsible party is subject to full liability and all fire suppression costs. Liability is limited to $300,000 in fire suppression costs if the operation was in full compliance.

Sincerely,

Tom Fields

Oregon

Kate Brown, Governor

OREGON DEPARTMENT OF AVIATION

3040 25th Street, SE
Salem, OR 97302-1125
Phone: (503) 378-4880
Toll Free: (800) 874-0102
FAX: (503) 373-1688

March 7, 2019

Kellen Tardaewether
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301

Re: Boardman to Hemingway – ODA Comments

Dear Ms. Tardaewether:

The Oregon Department of Aviation (ODA) appreciates the opportunity to review and comment on the Boardman to Hemingway Transmission Line. According to the preliminary site plan the transmission line will be within 5 miles of two public use airports (i.e., La Grande/Union County and Backer City Municipal). In accordance with ORS 836.535(2)(b) – Hazards to Air Navigation; OAR 738-070-0010(2)(a-c) and (6) (General Information); OAR 738-070-0110(1)(b) – Standards for Determining Obstructions; the ODA would like to submit the following comments and proposed conditions of approval.

ODA would request to the following Conditions of Approval apply to all new structures or power lines within 5 nautical miles of the La Grande / Union County Airport and Baker City Airport.

- The applicant must file and receive a determination from the Oregon Department of Aviation as required by OAR 738-070-0060 on **FAA Form 7460-1** Notice of Proposed Construction or Alteration to determine if any structures or power lines will pose a hazard to aviation safety to the **La Grande / Union County Airport** and **Baker City Airport**. A subsequent submittal may be required by the FAA due to its location to the La Grande / Union County Airport and Baker City Airport, to ensure Federal Grant Assurances.
- The height of the new structures or power lines should not penetrate FAA Part 77 Imaginary Surfaces, as determined by ODA and the FAA.
- Marking Lights, per FAA AC 70/7460-1L, may be needed to identify to structures or power lines.
- Coordination with the La Grande / Union County Airport may be needed to issue a NOTAM during any construction near the airport.
- All proposed helipads / personal use / private use airport will need to comply with ORS 836.630.

ODA appreciates the opportunity to comment on this application. The Department requests to be identified as a party of record for any future land use application.

If you have any questions or need further information or clarification on the comments, please feel free to contact me at 503-378-2529 or Jeff.Caines@aviation.state.or.us.

Sincerely

Jeff Caines, AICP
Aviation Planner
Oregon Department of Aviation

Dep
775 Summer Street, Suite 100
Salem, OR 97301-1279
☎ 503-986-5200

| | |
|---|---|
| Permit Type: | **Removal/Fill** |
| Waterway: | **Many various wetlands/waters** |
| County: | **Morrow, Umatilla, Union, Baker, Malheur** |
| Expiration Date: | ***(To be determined when the permit is issued.)*** |

***Idaho Power Company***

**IS AUTHORIZED IN ACCORDANCE WITH ORS 196.800 TO 196.990 TO PERFORM THE OPERATIONS DESCRIBED IN THE REFERENCED APPLICATION, SUBJECT TO THE SPECIAL CONDITIONS LISTED ON ATTACHMENT A AND TO THE FOLLOWING GENERAL CONDITIONS:**

1. This permit does not authorize trespass on the lands of others. The permit holder must obtain all necessary access permits or rights-of-way before entering lands owned by another.
2. This permit does not authorize any work that is not in compliance with local zoning or other local, state, or federal regulation pertaining to the operations authorized by this permit. The permit holder is responsible for obtaining the necessary approvals and permits before proceeding under this permit.
3. All work done under this permit must comply with Oregon Administrative Rules, Chapter 340; Standards of Quality for Public Waters of Oregon. Specific water quality provisions for this project are set forth on Attachment A.
4. Violations of the terms and conditions of this permit are subject to administrative and/or legal action, which may result in revocation of the permit or damages. The permit holder is responsible for the activities of all contractors or other operators involved in work done at the site or under this permit.
5. Employees of the Department of State Lands (DSL) and all duly authorized representatives of the Director must be permitted access to the project area at all reasonable times for the purpose of inspecting work performed under this permit.
6. In issuing this permit, DSL makes no representation regarding the quality or adequacy of the permitted project design, materials, construction, or maintenance, except to approve the project's design and materials, as set forth in the permit application, as satisfying the resource protection, scenic, safety, recreation, and public access requirements of ORS Chapters 196, 390, and related administrative rules.
7. Permittee must defend and hold harmless the State of Oregon, and its officers, agents and employees from any claim, suit, or action for property damage or personal injury or death arising out of the design, material, construction, or maintenance of the permitted improvements.
8. Authorization from the U.S. Army Corps of Engineers may also be required.

NOTICE: If removal is from state-owned submerged and submersible land, the permittee must comply with leasing and royalty provisions of ORS 274.530. If the project involves creation of new lands by filling on state-owned submerged or submersible lands, you must comply with ORS 274.905 to 274.940 if you want a transfer of title; public rights to such filled lands are not extinguished by issuance of this permit. This permit does not relieve the permittee of an obligation to secure appropriate leases from DSL, to conduct activities on state-owned submerged or submersible lands. Failure to comply with these requirements may result in civil or criminal liability. For more information about these requirements, please contact Department of State Lands, 503-986-5200.

Kirk Jarvie, Southern Operations Manager
Aquatic Resource Management
Oregon Department of State Lands

**Authorized Signature**

**ATTACHMENT A**

**Permit Holder: Idaho Power Company**

**Project Name: Boardman to Hemmingway Transmission Line Project (B2H)**

**Special Conditions for Removal/Fill Permit No. 61621-RF**

**READ AND BECOME FAMILIAR WITH CONDITIONS OF YOUR PERMIT.**

**The project site may be inspected by the Department of State Lands (DSL) as part of our monitoring program. A copy of this permit must be available at the work site whenever authorized operations are being conducted.**

1. **Responsible Party:** By signature on the application, Dave Wymond is acting as the representative of Idaho Power Company (IPC). By proceeding under this permit, Idaho Power Company agrees to comply with and fulfill all terms and conditions of this permit, unless the permit is officially transferred to another party as approved by the Energy Facility Siting Council (EFSC) in consultation with DSL.

2. **Authorization to Conduct Removal and/or Fill:** This permit authorizes removal and fill of material in various locations in Morrow, Umatilla, Union, Baker and Malheur counties as referenced in the Application for Site Certificate (ASC), Exhibit J, Tables C1A and C2A, maps (Appendices C1-C165), with a final date of September 2018 and summarized as follows:

**Summary of Authorized Wetland Impacts**

| Wetland # | Permanent | | | Temporary | | |
|---|---|---|---|---|---|---|
| | Acres | Removal (cy) | Fill (cy) | Acres | Removal (cy) | Fill (cy) |
| See ASC, Exhibit J, Table O-1A | 0.211 | 545 | 576 | 0.386 | 622 | 622 |
| **Total:** | **0.211** | **545** | **576** | **0.386** | **622** | **622** |

**Summary of Authorized Waterway Impacts**

| Waterway Name | Permanent | | | Temporary | | |
|---|---|---|---|---|---|---|
| | Linear Ft. /Acres | Removal (cy) | Fill (cy) | Linear Ft. /Acres | Removal (cy) | Fill (cy) |
| See ASC, Exhibit J, Table O-2A | 526/0.071 | 129 | 88 | 887/0.125 | 206 | 206 |
| **Total:** | **526/0.071** | **129** | **88** | **887/0.125** | **206** | **206** |

This permit also authorizes removal and fill activities necessary to complete the required compensatory mitigation. In the event information in the application conflicts with these permit conditions, the permit conditions prevail. See ASC, Exhibit J, JPA, Compensatory Mitigation Plan Figure 1 for project location.

3. **Impacts to Areas Where Access has not been Granted (Data-Gap):** This permit allows for removal and fill impacts only within wetlands and other waters of the state that the applicant has had access to, had a delineation and received a concurrence from the Department. When permission to enter the Data-Gap areas is received, an updated wetland delineation will be

provided to the Department for review. After receipt of a concurrence from the Department, and after review of a revised removal-fill permit application with updated impacts, EFSC, in consultation with DSL, will make a permit decision regarding the additional impacts.

4. **Work Period in Jurisdictional Areas:** Fill or removal activities below the ordinary high water elevation of waterways listed in ASC, Exhibit J, Table O-2A must be conducted during the Oregon Department of Fish and Wildlife (ODFW) recommended in-water -work periods, unless otherwise coordinated with ODFW and approved in writing by ODOE and DSL. If fish eggs are observed within the project area, work must cease, and DSL contacted immediately.

5. **Changes to the Project or Inconsistent Requirements from Other Permits:** It is the permittee's responsibility to ensure that all state, federal and local permits are consistent and compatible with the final approved project plans and the project as executed. Any changes made in project design, implementation or operating conditions to comply with conditions imposed by other permits resulting in removal-fill activity must be approved by EFSC in consultation with DSL prior to implementation.

6. **DSL May Halt or Modify:** DSL retains the authority to temporarily halt or modify the project or require rectification in case of unforeseen adverse effects to aquatic resources or permit non-compliance.

7. **DSL May Modify Conditions Upon Permit Renewal:** EFSC, in consultation with DSL retains the authority to modify conditions upon renewal, as appropriate, pursuant to the applicable rules in effect at the time of the request for renewal or to protect waters of this state.

## Pre-Construction

8. **Stormwater Management Approval Required Before Beginning Work:** Prior to the start of construction, the permittee must obtain a National Pollution Discharge Elimination System (NPDES) permit from the Oregon Department of Environmental Quality (DEQ), if one is required by DEQ.

9. **Authorization to Use Property for Linear Projects**: For linear facility projects, the removal-fill activity cannot occur until the person obtains:

   a. The landowner's consent;
   b. A right, title or interest with respect to the property, that is sufficient to undertake the removal or fill activity; or
   c. A court order or judgment authorizing the use of the property

10. **Pre-construction Resource Area Fencing or Flagging:** Prior to any site grading, the boundaries of the avoided wetlands, waterways, and riparian areas adjacent to the project site must be surrounded by noticeable construction fencing or flagging. The marked areas must be maintained during construction of the project and be removed immediately upon project completion.

## General Construction Conditions

11. **Water Quality Certification:** The Department of Environmental Quality (DEQ) may evaluate this project for a Clean Water Act Section 401 Water Quality Certification (WQC). If the evaluation

results in issuance of a Section 401 WQC, that turbidity condition will govern any allowable turbidity exceedance and monitoring requirements.

12. **Erosion Control Methods:** The following erosion control measures (and others as appropriate) must be installed prior to construction and maintained during and after construction as appropriate, to prevent erosion and minimize movement of soil into waters of this state.

    a. All exposed soils must be stabilized during and after construction to prevent erosion and sedimentation.
    b. Filter bags, sediment fences, sediment traps or catch basins, leave strips or berms, or other measures must be used to prevent movement of soil into waterways and wetlands.
    c. To prevent erosion, use of compost berms, impervious materials or other equally effective methods, must be used to protect soil stockpiled during rain events or when the stockpile site is not moved or reshaped for more than 48 hours.
    d. Unless part of the authorized permanent fill, all construction access points through, and staging areas in, riparian and wetland areas must use removable pads or mats to prevent soil compaction. However, in some wetland areas under dry summer conditions, this requirement may be waived upon approval by DSL. At project completion, disturbed areas with soil exposed by construction activities must be stabilized by mulching and native vegetative plantings/seeding. Sterile grass may be used instead of native vegetation for temporary sediment control. If soils are to remain exposed more than seven days after completion of the work, they must be covered with erosion control pads, mats or similar erosion control devices until vegetative stabilization is installed.
    e. Where vegetation is used for erosion control on slopes steeper than 2:1, a tackified seed mulch must be used so the seed does not wash away before germination and rooting.
    f. Dredged or other excavated material must be placed on upland areas having stable slopes and must be prevented from eroding back into waterways and wetlands.
    g. Erosion control measures must be inspected and maintained as necessary to ensure their continued effectiveness until soils become stabilized.
    h. All erosion control structures must be removed when the project is complete, and soils are stabilized and vegetated.

13. **Hazardous, Toxic, and Waste Material Handling:** Petroleum products, chemicals, fresh cement, sandblasted material and chipped paint, wood treated with leachable preservatives or other deleterious waste materials must not be allowed to enter waters of this state. Machinery refueling is to occur at least 150 feet from waters of this state and confined in a designated area to prevent spillage into waters of this state. Barges must have containment system to effectively prevent petroleum products or other deleterious material from entering waters of this state. Project-related spills into waters of this state or onto land with a potential to enter waters of this state must be reported to the Oregon Emergency Response System (OERS) at 1-800-452-0311.

14. **Archaeological Resources:** If any archaeological resources, artifacts or human remains are encountered during construction, all construction activity must immediately cease. The State Historic Preservation Office must be contacted at 503-986-0674. You may be contacted by a Tribal representative if it is determined by an affected Tribe that the project could affect Tribal cultural or archeological resources.

15. **Construction Corridor:** There must be no removal of vegetation or heavy equipment operating or traversing outside the designated construction corridor or footprint (Appendices C1-C165).

16. **Hazards to Recreation, Navigation or Fishing:** The activity must be timed so as not to unreasonably interfere with or create a hazard to recreational or commercial navigation or fishing.

17. **Operation of Equipment in the Water:** Heavy equipment may be positioned on or traverse the area below ordinary high water only when the area is free of flowing or standing water or if the area is isolated from the waterway and aquatic organism salvage is completed, as described in the application. All machinery operated below ordinary high water (OHW) elevation must use vegetable-based hydraulic fluids, be steam cleaned and inspected for leaks prior to each use, and be diapered to prevent leakage of fuels, oils, or other fluids below OHW elevation. Any equipment found to be leaking fluids must be immediately removed from and kept out of OHW until repaired. Equipment staging, cleaning, maintenance, refueling, and fuel storage must be at least 150 feet from OHW and wetlands to prevent contaminates from entering waters of the state.

18. **Work Area Isolation:** Within perennial streams or when water is present in intermittent streams, the work area must be isolated from the water during construction by using a coffer dam or similar structure in accordance with the work area isolation plan in the application. All structures and materials used to isolate the work area must be removed immediately following construction and water flow returned to pre-construction conditions.

19. **Fish Salvage Required:** Fish must be salvaged from the isolation area. Permits from NOAA Fisheries and Oregon Department of Fish and Wildlife, Fish Research are required to salvage fish. Fish salvage permit information may be obtained by contacting ODFW Fish Research at 503-947-6254 or Fish.Research@state.or.us.

20. **Fish Passage Required:** The project must meet Oregon Department of Fish and Wildlife requirements for fish passage.

21. **Raising or Redirecting Water:** The project must not cause water to rise or be redirected and result in damage to structures or property on the project site as well as adjacent, nearby, upstream, and downstream of the project site.

22. **Temporary Ground Disturbances:** All temporarily disturbed areas must be returned to original ground contours at project completion.

## Riprap Placement

23. **Riprap Placement Methods:** Riprap/rock must be placed under the following conditions:

    a. Only clean, erosion resistant rock from an upland source must be used as riprap. No broken concrete or asphalt must be used.
    b. Riprap rock must be placed in a manner that does not increase the upland surface area.
    c. Riprap must be placed in a way as to minimize impacts to the active stream channel.
    d. Gravel or filter fabric should be placed behind the riprap rock, including the toe trench rock, as a filter blanket.
    e. All riprap rock must be placed, not dumped, from above the bank line.

24. **Riprap Must Be Covered:** Riprap above ordinary high water elevation must be covered and the voids filled with soil, gravel, and / or mulch sufficient to allow the performance standards to be achieved and wildlife to move across it naturally.

**Rectification of Temporary Impacts**

25. **Site Rectification Required for Temporary Wetland Impacts:** Site rectification for temporary impacts to 0.386 acre of wetland and 887 linear feet of other waters must be conducted according to the Site Rehabilitation Plan in the application. Failure to rectify the site may result in additional compensatory mitigation.

26. **Pre-construction Elevations Must Be Restored Within the Same Construction Season:** Construction activities within areas identified as temporary impact must not exceed two construction seasons and rectification of temporary impacts must be completed within 24 months of the initiation of impacts. However, if the temporary impact only requires one construction season, re-establishment of pre-construction contours must be completed within that same construction season, before the onset of fall rains.

27. **Woody Vegetation Planting Required:** Planting of native woody vegetation must be completed before the next growing season after re-establishment of the pre-construction contours.

28. **Rectification Monitoring Report(s) Required:** A post-construction rectification report demonstrating as-built conditions and discussing any variation from the approved plan must be provided to DSL and ODOE within 90 days of revegetation. The post-construction rectification report must include:

    a. Photos from fixed photo points. This should clearly show the site conditions.
    b. A narrative that describes any deviation from the approved rectification plan.

**<u>Compensatory Mitigation</u>**

**The following conditions apply to the actions proposed in the final compensatory mitigation plan, dated September, 2018.**

29. **Acreage and Type:** Mitigation must be conducted according to the minimum acreages and methods described in the table below.

**Summary of Wetland Mitigation**

| Acres | Credits | Cowardin, HGM Class | Method |
|---|---|---|---|
| 2.5 | 1.67 | riverine flow-through, Palustrine Emergent (PEM) | creation |
| 1.69 | 1.13 | riverine flow-through, Palustrine Scrub-shrub (PSS) | creation |
| 0.57 | 0.38 | riverine flow-through, Palustrine Forested (PFO) | creation |
| 1.45 | 0.48 | riverine flow-through, Palustrine Emergent (PEM) | enhancement |
| **6.21** | **3.66** | **Wetland Mitigation Totals** | |

**Summary of Waterway Mitigation**

| Linear Feet | | Action | Method |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 432 | | In water structure placement | enhancement |
| 1080 | | Riparian planting | enhancement |
| 810 | | New channel construction | creation |
| **1322** | | **Waterway Total** | |

30. **Mitigation Site Location:** The mitigation must be conducted off-site. The center-point of the mitigation site is 45.3775 degrees Latitude, -117.8878 degrees Longitude. The current legal description is Township 2 South, Range 40 East, Section 19CB, in Tax Lot 3200. as shown on ASC, Exhibit J, JPA, Compensatory Wetland Mitigation Plan, Figure 1.

31. **Timing of Mitigation Site Grading:** Mitigation site grading must be completed prior to or within the same construction season as the commencement of the wetland impacts.

32. **Signs Required:** Signs must be posted along the mitigation site perimeter stating that the area behind the sign is a protected site.

33. **Long-term Protection of the Mitigation Site - Deed Restriction:** The mitigation site must be protected in perpetuity by recording the approved Declaration of Covenants and Restrictions and Access Easement (Protection Instrument) on the deed of the property. The protection instrument must be approved and signed by DSL prior to recording with Union County. A copy of the recorded instrument must be sent to DSL and ODOE with the post-construction report.

34. **Long-term Protection of the Mitigation Site - Conservation Easement:** The mitigation site must be protected in perpetuity by conveying an approved Conservation Easement to Grande Ronde Model Watershed or another non-profit or non-governmental organization. The protection instrument must be approved and signed by DSL prior to recording with Union County. A copy of the recorded easement must be sent to DSL and ODOE with the post-construction report.

35. **GIS Data:** A georeferenced shapefile (.shp) must be submitted to DSL prior to mitigation site release that documents the spatial extent of the mitigation site(s), including buffers. The shapefile must conform to the Oregon Lambert (Intl. Feet) projection.

36. **Long-term Maintenance Required:** Long-term site maintenance is required as described in the Compensatory Mitigation Plan in the application.

**Monitoring and Reporting Requirements**

37. **Post-Construction Report Required:** A post-construction report demonstrating as-built conditions and discussing any variation from the approved plan must be provided to DSL and ODOE within 90 days of revegetation. The post-construction report must include:

    c. A scaled drawing, accurate to 1-foot elevation, clearly showing the following:
        1. Finished contours of the site.
        2. Current tax lot and right-of-way boundaries.
        3. Photo point locations.
    d. Photos from fixed photo points. This should clearly show the site conditions, and any signage, and fencing required.
    e. A narrative that describes any deviation from the approved mitigation plan.
    f. A copy of the recorded deed restriction or conservation easement.

38. **Annual Monitoring Reports Required:** Monitoring is required until DSL has officially released the site from further monitoring when the site has met all success criteria as determined by DSL. The permittee must monitor the site to determine whether the site is meeting performance standards for a minimum period of 5 growing seasons after completion of all the initial plantings. Annual monitoring reports are required and are due by December 31, with a copy sent to ODOE. Failure to submit the required monitoring report by the due date may result in an extension of the monitoring period, forfeiture of the financial security and/or enforcement action.

39. **Extension of the Monitoring Period:** The monitoring period may be extended, at the discretion of DSL, for failure of the site to meet performance standards for the final two consecutive years without corrective or remedial actions (such as irrigation, significant weed/invasive plants treatment or replanting) or when needed to evaluate corrective or remedial actions.

40. **Contents of the Annual Monitoring Report:** The annual monitoring report must include the following information:

    a. Completed Monitoring Report Cover Sheet, which includes permit number, permit holder name, monitoring date, report year, performance standards, and a determination of whether the site is meeting performance standards.
    b. Site location map(s) that clearly shows the impact site and mitigation site boundaries.
    c. Site Plan that clearly shows at least the following.
        1. The area seeded, with the square foot area listed.
        2. The area planted with trees and shrubs, with the square foot area listed.
        3. Current tax lot and right-of-way boundaries.
        4. Permanent monitoring plot locations that correspond to the data collected and fixed photo-points. These points should be overlaid on the as-built map.
        5. PEM, PSS, PFO, riparian areas, and buffer clearly identified separately and the area (square foot or acreage) of each noted.
        6. Creation, restoration, enhancement, and preservations areas identified separately, with the area of each listed.
    d. A brief narrative that describes maintenance activities and recommendations to meet success criteria. This includes when irrigation occurred and when the above ground portion of the irrigation system was or will be removed from the site.
    e. Data collected to support the conclusions related to the status of the site relative to the performance standards listed in this permit (include summary/analysis in the report and raw data in the appendix). Data should be submitted using the DSL Mitigation Monitoring Vegetation Spreadsheet or presented in a similar format as described in DSL's Routine Monitoring Guidance for Vegetation.
    f. Photos from fixed photo points (include in the appendix).
    g. Other information necessary or required to document compliance with the performance standards listed in this permit.
    h. A post-construction functional assessment by the end of the monitoring period.

41. **Corrective Action May Be Required:** DSL retains the authority require corrective action in the event the performance standards are not accomplished at any time within the monitoring period.

**Performance Standards**

**To be deemed successful, the mitigation areas including buffers must meet the following performance standards, as determined by DSL:**

42. **Establishment of Permanent Monitoring Locations Required:** Permanent plot locations must be established during the first annual monitoring in sufficient number and locations to be representative of the site. The permanent plot locations must be clearly marked on the ground.

43. **Wetland Acreage Required:** The site will have a minimum acreage as shown in the Acreage and Type table above, as determined by a Wetland Delineation Light with data collected during spring of a year when precipitation has been near normal, vegetation has been established, and irrigation has been removed for at least two years. Acreage must be documented on a printed map and in a GIS shapefile (.shp) including attribute information for each unique wetland polygon identifying the size as well as HGM and Cowardin classes.

### *Herbaceous Wetlands*

44. **Native Species Cover:** The cover of native species, as defined in the USDA Plants Database, in the herbaceous stratum is at least 60%.

45. **Invasive Species Cover:** The cover of invasive species is no more than 10%. A plant species should automatically be labeled as invasive if it appears on the current Oregon Department of Agriculture noxious weed list, plus known problem species including *Phalaris arundinacea, Mentha pulegium, Holcus lanatus, Anthoxanthum odoratum,* and the last crop plant if it is non-native. Non-native plants should be labeled as such if they are listed as non-native on the USDA Plants Database. Beginning in Year 2 of monitoring, DSL will consider a non-native plant species invasive if it comprises more than 15% cover in 10% or more of the sample plots in any habitat class and increases in cover or frequency from the previous monitoring period. Plants that meet this definition will be considered invasive for all successive years of monitoring.

46. **Bare Substrate Cover:** Bare substrate represents no more than 20% cover.

47. **Species Diversity:** By Year 3 and thereafter, there are at least 6 different native species. To qualify, a species must have at least 5% average cover in the habitat class and occur in at least 10% of the plots sampled.

48. **Moisture Prevalence Index:** Prevalence Index is <3.0.

### *Shrub-dominated and Forested Wetlands*

49. **Native Species Cover:** The cover of native species, as defined in the USDA Plants Database, in the herbaceous stratum is at least 60%.

50. **Invasive Species Cover:** The cover of invasive species is no more than 10%. A plant species should automatically be labeled as invasive if it appears on the current Oregon Department of Agriculture noxious weed list, plus known problem species including *Phalaris arundinacea, Mentha pulegium, Holcus lanatus, Anthoxanthum odoratum,* and the last crop plant if it is non-native. Non-native plants should be labeled as such if they are listed as non-native on the USDA Plants Database. Beginning in Year 2 of monitoring, DSL will consider a non-native plant species invasive if it comprises more than 15% cover in 10% or more of the sample plots in any

habitat class and increases in cover or frequency from the previous monitoring period. Plants that meet this definition will be considered invasive for all successive years of monitoring. After the site has matured to the stage when desirable canopy species reach 50% cover, the cover of invasive understory species may increase but may not exceed 30%.

51. **Bare Substrate Cover:** Bare substrate represents no more than 20% cover.

52. **Woody Vegetation:** The density of woody vegetation is at least 1,600 live native plants (shrubs) and/or stems (trees) per acre OR the cover of native woody vegetation on the site is at least 50%. Native species volunteering on the site may be included, dead plants do not count, and the standard must be achieved for 2 years without irrigation.

53. **Species Diversity:** By Year 3 and thereafter, there are at least 6 different native species. To qualify, a species must have at least 5% average cover in the habitat class and occur in at least 10% of the plots sampled.

54. **Moisture Prevalence Index:** Prevalence Index total for all strata is <3.0.

### ***Riparian Areas***

55. **Native Species Cover:** The cover of native species, as defined in the USDA Plants Database, in the herbaceous stratum is at least 60%.

56. **Invasive Species Cover:** The cover of invasive species is no more than 10%. A plant species should automatically be labeled as invasive if it appears on the current Oregon Department of Agriculture noxious weed list, plus known problem species including *Phalaris arundinacea, Mentha pulegium, Holcus lanatus, Anthoxanthum odoratum,* and the last crop plant if it is non-native. Non-native plants should be labeled as such if they are listed as non-native on the USDA Plants Database. Beginning in Year 2 of monitoring, DSL will consider a non-native plant species invasive if it comprises more than 15% cover in 10% or more of the sample plots in any habitat class and increases in cover or frequency from the previous monitoring period. Plants that meet this definition should be considered invasive for all successive years of monitoring. After the site has matured to the stage when desirable canopy species reach 50% cover, the cover of invasive understory species may increase but may not exceed 30%.

57. **Woody Vegetation:** The density of woody vegetation is at least 1,600 live native plants (shrubs) and/or stems (trees) per acre OR the cover of native woody vegetation on the site is at least 50%. Native species volunteering on the site may be included, dead plants do not count, and the standard must be achieved for 2 years without irrigation.

### Financial Security

58. **Financial Security Required:** A performance bond (financial security) in the amount of $15,078 has been provided to DSL to ensure completion of compensatory mitigation in accordance with the conditions of this permit. Failure to keep the performance bond continuously in effect through the date of full performance of all the permit holder’s obligations hereunder will constitute a violation and default of this permit by permit holder. If at any time DSL is notified that the performance bond is to be canceled or not renewed, and a replacement financial security is not in place before the termination date, DSL may declare the permit holder to be in breach or

default of its performance obligation under this permit. DSL may claim the full unreleased portion of the penal sum of the financial security, which the holder must pay to DSL with 20 days after delivery of written notice to the holder of such financial security of such breach of default by permit holder.

59. **Incremental Release of the Financial Security:** The permit holder must file a written request with the agency for release of portions of this financial security. Portions of the financial security may be released at the discretion of DSL, based on the following schedule:

a. 25% release upon approval of the post-construction report, site protection instrument recorded, and first growing season monitoring report showing site constructed as approved by DSL.
b. 25% release upon demonstration that the required acreages of wetland have been confirmed by delineation of wetland hydrology and hydrophytic vegetation, and the site is meeting all applicable performance standards after two growing seasons.
c. 50% release upon approval of the final monitoring report and demonstrated success of the mitigation project based on the performance standards listed in this permit. All performance standards must be met for the final two consecutive years without irrigation, substantial weed or invasive species treatment, or replanting.

**Monitoring and Reporting Schedule**

| **Report** | **Requirements** | **Schedule** | **Financial Surety Release Schedule** |
|---|---|---|---|
| Post-Construction | Post-construction report<br><br>Recorded Protection Instrument | 90 days after completion of revegetation | |
| First Annual Report | Establishment of permanent monitoring locations<br><br>Vegetation performance standards<br><br>Demonstration that wetland hydrology has been accomplished<br><br>Evidence that water rights are secured, or are not required | After one growing season of all proposed plantings | 25% upon approval of the first annual monitoring report and post-construction report.<br><br>Site protection instrument recorded. |
| Second Annual Report | Vegetation performance standards | After two growing seasons | |
| Third and Fourth Annual Reports | Vegetation performance standards<br><br>Actual acreage achieved by HGM and Cowardin class[1]. | After three and four growing seasons, respectively. One “light delineation” should be completed during spring of a year when precipitation has been near normal and no irrigation has been in use during the previous two years | Up to 25% of original amount upon achieving wetland acreage confirmed by delineation of wetland hydrology and wetland vegetation, and meeting all applicable performance standards |

| Report | Requirements | Schedule | Financial Surety Release Schedule |
|---|---|---|---|
| Fifth Annual Report (or final report if the monitoring period has been extended) | Vegetation performance standards<br><br>Functional assessment[1,2] | After five growing seasons | Final 50% release upon meeting all performance standards. The performance standards must be met for the final two consecutive years without corrective or remedial actions (such as irrigation, significant weed/invasive plants treatment or replanting) |

[1]These requirements may be fulfilled any time during the monitoring period but must be received by DSL no later than the fifth annual monitoring.

[2]Functional assessments must meet the standards and requirements in OAR 141-085-0685. The same assessment method used for the pre-mitigation site functional assessment should be used for monitoring purposes, unless otherwise approved by DSL.

## TARDAEWETHER Kellen * ODOE

| | |
|---|---|
| **From:** | Teara Farrow Ferman <TearaFarrowFerman@ctuir.org> |
| **Sent:** | Friday, April 19, 2019 2:38 PM |
| **To:** | TARDAEWETHER Kellen * ODOE |
| **Cc:** | Stokes, Mark |
| **Subject:** | CTUIR's letter regarding B2H mitigation |
| **Attachments:** | CTUIR letter to ODOE regarding B2H mitigation 4-19-19.pdf |

Kellen,

Please find attached the Confederated Tribes of the Umatilla Indian Reservation's letter to ODOE regarding the resolution of our concerns with Idaho Power's proposed B2H project. The letter outlines agreed upon conditions for the site certificate by both the CTUIR and Idaho Power. If you have further questions please contact me.

I will be sending a copy of the letter to the individuals on the copied correspondence list as well via email.

Respectfully,

**TEARA FARROW FERMAN**
Manager | Cultural Resources Protection Program
Confederated Tribes of the Umatilla Indian Reservation
46411 Timíne Way | Pendleton | Oregon 97801
541.276.3447 Office | 541.429.7230 Fax
TearaFarrowFerman@ctuir.org

Assistant General Manager | Átaw Consulting, LLC
A Small Business Enterprise of the CTUIR
46411 Timíne Way | Pendleton | Oregon 97801
541.429.7230 Office|Fax
TearaFarrowFerman@ctuir.org

**Confederated Tribes** *of the*
**Umatilla Indian Reservation**

Board of Trustees & General Council

46411 Timíne Way • Pendleton, OR 97801
(541) 429-7030 • fax (541) 276-3095
info@ctuir.org • www.umatilla.nsn.us

April 19, 2019

Kellen Tardaewether
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol Street NE, 1st Floor
Salem, Oregon 97301

Dear Ms. Tardaewether,

The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) thanks the Oregon Department of Energy (ODOE) for helping engage the CTUIR and Idaho Power to consult pursuant to the National Historic Preservation Act (NHPA) Section 106, Oregon Revised Statue 469.350, Oregon Administrative Rule 345-015-0180, and Oregon Energy Facility Siting Council (EFSC) Historic, Cultural, and Archaeological Resources standards OAR 345-022-0090 for Idaho Power's proposed Boardman to Hemingway Transmission Line Project (the B2H project).

We understand that the Bureau of Land Management, U.S. Forest Service, the Department of the Navy and other federal agencies are at different phases in their respective permitting processes and thus not all have completed consultation with the CTUIR about the B2H Project. Section 101(d)(6)(B) of the NHPA requires federal agencies, in carrying out their Section 106 responsibilities, to consult with an Indian tribe that attaches religious and cultural significance to historic properties that may be affected by an undertaking. The B2H Project is a federal undertaking which requires consultation with the CTUIR. Additionally, the Bureau of Land Management, U.S. Forest Service, Bonneville Power Administration, U.S. Army Corps of Engineer, Bureau of Reclamation, Advisory Council on Historic Preservation, Oregon State Historic Preservation Officer, Idaho State Historic Preservation Officer, Washington Department of Archaeology and Historic Preservation, and the CTUIR Tribal Historic Preservation Officer entered into a Programmatic Agreement (PA) for phased compliance with Section 106 of the NHPA. The PA provides for a Historic Properties Management Plan to be developed to address identification and evaluation of historic properties, determinations of specific effects on historic properties, and consultation concerning measures to avoid, minimize, or mitigate any adverse effects prior to the issuance of any notices to proceed by the relevant federal agencies. The CTUIR elected not to sign the PA.

The CTUIR has been in discussions with Idaho Power regarding the B2H Project and we have come to a mutual agreement on the effects the B2H Project may have on historic, cultural, and archaeological resources, NHPA listed, eligible, or likely to be listed historic properties, and historic properties of religious and cultural significance to the CTUIR. The CTUIR is pleased to inform the ODOE and the federal agencies that the CTUIR's concerns have been addressed and will be mitigated by Idaho Power pursuant to a confidential mitigation agreement between the CTUIR and Idaho Power. Therefore, the construction and operation of the proposed B2H project, taking into account mitigation, are not likely to result in significant adverse impacts to eligible or likely eligible historic properties of religious and cultural significance or resources identified by the

CTUIR. Additionally, the CTUIR and Idaho Power have agreed to the following edits (in red) to Idaho Power's proposed condition and request that EFSC include the edited condition in the EFSC site certificate:

**Idaho Power's Proposed Historic, Cultural, and Archaeological Resources Condition 2:** Prior to construction, the certificate holder shall finalize, and submit to the department for its approval, a final Historic Properties Management Plan and High Probability Areas Assessment. The final Historic Properties Management Plan and High Probability Areas Assessment shall include, or provide for, the following, unless otherwise approved by the department:

a. The areas that were surveyed for historic, cultural, and archaeological resources;

b. The location of all facility components and related and supporting facilities;

c. The areas that will be permanently and temporarily disturbed during construction;

d. The protective measures described in the draft Historic Properties Management Plan in ASC Exhibit S, Attachment S-9;

e. The State Historic Preservation Officer's National-Register-of-Historic-Places-eligibility determinations and archaeological resources findings; ~~and~~

f. The results of the cultural and historical pedestrian surveys referenced in Historic, Cultural, and Archaeological Resources Condition 1~~.~~; and

g. Before the certificate holder submits the final Historic Properties Management Plan and High Probability Areas Assessment to the department, the certificate holder shall provide the Confederated Tribes of the Umatilla Reservation (CTUIR) the following opportunities to review and comment on the Historic Properties Management Plan and High Probability Areas Assessment:

i. When the certificate holder begins to finalize the Historic Properties Management Plan and High Probability Areas Assessment, the certificate holder shall notify the CTUIR that the certificate holder is beginning to finalize the Historic Properties Management Plan and High Probability Areas Assessment and shall request that the CTUIR provide written comments within 60 calendar days from said notice. If requested by the CTUIR, the certificate holder shall reasonably attempt to meet in-person with the CTUIR prior to the 60-day deadline to discuss the Historic Properties Management Plan and High Probability Areas Assessment; however, the timing of the in-person meeting will not affect the CTUIR's obligation to provide comments by the 60-day deadline.

ii. The certificate holder shall provide to the CTUIR a copy of the revised Historic Properties Management Plan and revised High Probability Areas Assessment along with written responses to any CTUIR comments received within the 60-day window set forth above in subsection (g)(i) of this condition. The certificate holder shall request that the CTUIR provide written comments on the revised Historic Properties Management Plan and revised High Probability Areas Assessment within 60 calendar days. If requested by the CTUIR, the certificate holder shall reasonably attempt to meet in-person with the CTUIR prior to the 60-day deadline to discuss the revised Historic Properties Management Plan and revised High Probability Areas Assessment; however, the timing of the in-person meeting will not affect the CTUIR's obligation to provide comments by the 60-day deadline.

iii. When the certificate holder submits the final Historic Properties Management Plan and High Probability Areas Assessment to the department, the certificate holder shall provide to the CTUIR written responses to any CTUIR comments received within the 60-day window set forth above in subsection (g)(ii) of this condition.

Nothing in this condition shall affect the CTUIR's roles and opportunities as a reviewing agency. The department shall request that the CTUIR, as a reviewing agency, review the final Historic Properties Management Plan and High Probability Areas Assessment submitted by the certificate holder. If the CTUIR has any concerns remaining with the final Historic Properties Management Plan and High Probability Areas Assessment, the CTUIR may raise those concerns with the department at that time.

The mitigation agreement and above condition language fully resolves all concerns and comments identified in previous CTUIR comment letters to ODOE/EFSC. The CTUIR has no further concerns with the proposed B2H Project (including the alternative routes identified in the EFSC application) unless the route of the Project changes, in which case consultation with the CTUIR will be required.

Should you have questions or concerns, please contact Mrs. Teara Farrow Ferman, Manager, Cultural Resources Protection Program, at (541) 276-3447 or tearafarrowferman@ctuir.org.

Respectfully,

Gary Burke

Gary Burke, Chairman
Board of Trustees

Cc: Donald Gonzalez, Bureau of Land Management
Tom Montoya, Wallowa Whitman National Forest Supervisor, U.S. Forest Service
F. Lorraine Bodi, Vice President, Environment, Fish and Wildlife, Bonneville Power Administration
Aaron Dorf, Colonel, District Commander, U.S. Army Corps of Engineers
Roland Springer, Area Manager, Bureau of Reclamation
Elizabeth Ellis, Cultural Resources Manager, Department of the Navy

**TARDAEWETHER Kellen * ODOE**

| | |
|---|---|
| **From:** | POULEY John * OPRD |
| **Sent:** | Monday, April 29, 2019 3:59 PM |
| **To:** | TARDAEWETHER Kellen * ODOE |
| **Cc:** | maxwell.woods@state.or.us; SCHWARTZ Tracy * OPRD |
| **Subject:** | SHPO Case Nbr SHPO Case No.: 08-2232, Boardman To Hemmingway Transmission Line Project (B2H) |
| **Attachments:** | SHPO Response Letter Case Nbr SHPO Case No._ 08-2232.pdf |

Hi Kellen,
Please find attached our letter for B2H. Tracy and I are available if you have any questions.
Thanks
-John

John Pouley
Assistant State Archaeologist
Oregon SHPO
503-986-0675

Oregon
Kate Brown, Governor

Parks and Recreation Department
State Historic Preservation Office
725 Summer St NE Ste C
Salem, OR 97301-1266
Phone (503) 986-0690
Fax (503) 986-0793
www.oregonheritage.org

April 29, 2019

Ms. Kellen Tardaewether
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301

RE: SHPO Case No. 08-2232
Boardman To Hemmingway Transmission Line Project (B2H)
Construct powerline from Boardman, OR to Hemmingway, ID
multiple sections, Boardman and Murphy, Morrow/ Umatilla/Union/Baker/Malheur County

Dear Ms. Tardaewether:

Oregon SHPO is providing comments to the project referenced above, related to our role in the Energy Facility Siting Council (EFSC) and National Historic Preservation Act (NHPA) processes. The comments include: a summary of the Section 106 (of the NHPA) process for determinations of eligible, not eligible, and unevaluated to the National Register of Historic Places (NRHP); a statement of support for proceeding with EFSC review that includes keeping archaeological sites recommended not eligible by the applicant as "unevaluated"; and those specific to above ground resources.

Section 106 of the National Historic Preservation Act (NHPA) is defined in the implementing regulations (36CFR800) drafted by the Advisory Council on Historic Preservation (ACHP). The process for eligibility determinations is included in 36 CFR 800.4(c). Note: Historic Properties consist of any prehistoric or historic district, site, building, structure, or object included in or eligible for inclusion in the NRHP, including historic properties of religious and cultural significance to an Indian Tribe (HPRCSIT) and Traditional Cultural Properties (TCP). Under 36CFR800.4(c) it states that the Federal agency official shall apply the National Register of Historic Places (NRHP) criteria to properties identified within the Area of Potential Effect (APE) for the undertaking.

Under 36CFR800.4(c)(2), the Federal agency determines whether a property is eligible, or not eligible to the NRHP. If SHPO agrees with the agency determination, the property is eligible or not eligible as applicable. If SHPO does not agree, the Federal agency shall obtain a determination of eligibility from a representative of the Secretary of the Interior. The representative is the Keeper of the NRHP. If a tribe attaches religious and cultural significance to a property that is determined not eligible by the Federal agency, it may ask the ACHP to request the Federal agency to obtain a determination of eligibility.

According to 36CFR800.4(d) the Federal agency must make a finding of effect (No properties affected, or historic properties affected). If there are no historic properties, or historic properties are present but the undertaking will have no effect on them, the Federal agency will provide documentation to SHPO for concurrence. The SHPO has 30 days to object. If the SHPO objects, the Federal agency may either engage in consultation, or forward their finding to the ACHP for review. Eligible properties are entered into SHPO records (GIS-based) as eligible. Not Eligible properties are entered into SHPO records as not eligible. The status remains not eligible until proven otherwise. Not eligible properties have no protections from projects or undertakings and can be damaged, altered, or destroyed without requiring mitigation.

The NRHP is a federal process and the NHPA is federal law. State Historic Preservation Offices (SHPOs) were first defined in the NHPA in 1966, and run the NRHP program at the state level. All SHPOs receive federal funding to enact these defined roles in both federal processes. To prevent potential confusion, conflicts, and duplication of review from the federally defined role of the SHPO in the NRHP and NHPA processes with its state defined role in the EFSC review, archaeological resources will be addressed as follows: Archaeological sites recommended “not eligible” to the NRHP under EFSC will remain “unevaluated” and treated as eligible in terms of status. Since the EFSC process needs approval prior to completion of the Section 106 process, keeping all recommended “not eligible” archaeological sites as “unevaluated” would meet the cultural standard for the former and allow completion of the latter without contradicting one another.

By treating them as unevaluated at this time, archaeological sites that may be eligible to the NRHP will not be adversely affected and if they are later determined not eligible with concurrence, will not need mitigation, which would satisfy the EFSC standard. Adhering to this process additionally prevents a situation where an archaeological site determined not eligible to the NRHP through the EFSC process, is later determined eligible by the federal agency. Even if SHPO disagrees with the federal agency in their determination, through the Section 106 process, the Advisory Council on Historic Preservation (ACHP) would be called in to review the disagreement at this point, which may result in a finding that the site is eligible, regardless of the view of SHPO. Treating sites as not eligible (unevaluated) at this time both meets the EFSC standard, and allows the federal Section 106 process to run its course without contradicting one another.

Regarding above ground resources, after reviewing the Intensive Level Surveys (ILS) provided to our office we concur with all determinations of eligibility for listing in the NRHP except the following. We cannot concur on the determinations of eligibility for any resources located on federal land until the federal land managing agency consults with our office. These resources should remain unevaluated, but should be treated as eligible. We concur that Huntington likely does not retain sufficient integrity to be eligible as a historic district. However, there may be resources individually eligible for listing in Huntington and that evaluation fell outside of the scope of this survey. That being said, we do not find that there will be any direct or indirect effects to these potentially eligible properties as a result of the proposed undertaking. The site form for 4B2H-EK-47 identifies the property as eligible/contributing under Criterion A for its association with agricultural and irrigation in the western United States. However, other sections of Exhibit S indicate the resource as not eligible/non-contributing. Until this discrepancy is clarified and resolved, the resource should be treated as eligible.

We do not concur with the following segments of Oregon Trail being non-contributing: B2H-UN-005 Whiskey Creek Segment: As noted on the site form, the previous survey on Bureau of Land Management (BLM) property identified possible swales. Without a definitive understanding on their origin, we recommend the segment be considered contributing. We also need additional information to determine if the marker could be contributing to the linear resource to the Oregon Trail or within another context. Survey methodology regarding how the segment was evaluated would also be helpful context to include. How was the four-mile segment surveyed and were available technological resources (like LiDAR) used to verify if ruts still exist? Further, we cannot concur with a determination of eligibility on federal land without consultation from the federal land managing agency; B2H-MA-003 Meek Cutoff: The provided documentation does not properly address the historic significance of the Meek Cutoff. The site form asserts that the Meek Cutoff is not eligible under Criterion A due to a lack of sufficient integrity. However, a property can be significant under any of the four criteria, but may not retain sufficient integrity to convey that significance, therefore rendering it not eligible or non-contributing. Survey methodology regarding how the segment was evaluated would also be helpful context to include, as the documented segment is quite long, though no exact length was provided. We are unsure if and how the entire length of the resource was surveyed for intact integrity, and if available technological resources (like LiDAR) was used to verify if the resource may still be present on the landscape. Until additional information is provided to our office and the National Park Service feasibility is made available to the public, we recommend the segment be treated as contributing to the overall linear resource.

A number of above-ground resources were left unevaluated. Until additional research and documentation is completed, these resources are considered eligible for listing in the NRHP. Any potential direct or indirect impacts should be avoided or mitigated. These resources include:B2H-SA-37 Irrigation Ditch; 4B2H-EK-43 Willow Creek Diversion Canal (Please also note that the property name was not universally corrected from Warm Spring Pump Canal throughout the report and site forms.); 6B2H-MC-07 Clover Creek Valley Homestead; and 4B2H-EK-26 OWR&N Roundhouse and OWR&N/OSL Joint Railyard. Until additional information is provided on these resources, we should assume these resources are eligible for listing in the National Register. Please remember and consider that it is the policy of the Oregon SHPO to re-survey above-ground historic resources every five (5) years. Also, if another agency, including the BLM, provides additional information to our office we may always reconsider eligibility for any resource.

With regard to direct effects, if all project impacts can be avoided then we concur that the undertaking will result in no significant adverse impact. However, if direct effects cannot be avoided mitigation must be pursued. It is difficult based on the information, maps, and plans provided to determine if direct effects will occur, especially to linear resources located within the Area of Potential Effect. For example, the Union Pacific Railroad (UPRR)-Morrow County (4B2H-EK-04) is located within the direct analysis area and adjacent to the construction footprint. However, it cannot be determined if construction activities will directly affect the historic property based on the information provided. Further, without additional information on the types of infrastructure being proposed (footprint, height, materials, etc.) assessing indirect effects also proves difficult. That being said, and based solely on the information provided at this time, we concur with the Visual Assessment of Historic Properties (VAHP) included in Exhibit S except the following: 6B2H-RP-09 Oregon Trail Segment: The VAHP indicates the Project will "cause partial obstruction," but also notes the Project will follow an existing transmission line. Until more information can be provided on the design, we cannot concur with no significant impact and recommend further consultation with our office to determine if mitigation is needed; B2H-BA-337 Oregon Trail ACEC – Powell Creek Segment: The VAHP notes that the Project will "partially obstruct views of distant hills" but "the towers would blend in with the hillside beyond the valley." Once the location and design of the poles are determined we recommend further consultation with our office to determine if mitigation is needed; There was no VAHP provided for 4B2H-EK-41 Oregon Trail Unnamed Segment. Since the segment was identified as eligible/contributing, we cannot concur without the necessary information; and 050305144SI Kiwanis Oregon Trail Monument: The site form notes that Project will follow an existing transmission line. Based on the photo it is assumed new lines will not be visible. Can this be confirmed with additional photos and information on the height of the new transmission line? Also, the VAHP form has inconsistent information about the distance from the project.

Broadly speaking, we agree with the framework for potential minimization and mitigation for direct and indirect impacts to above-ground historic properties. We appreciate that the HPMP considers resource-specific impacts for contributing segments and cumulative impacts. Since resource-specific mitigation plans should be developed in consultation with a number of parties including our office, Tribes, local historical societies/museums, and historic preservation groups, we hope that Idaho Power will be open to additional ideas that are proposed by parties during the development of these resource-specific mitigation plans.

Taking into account mitigation for impacts, and based solely on the information provided in Exhibit S, we believe that the construction and operation of the facility is not likely to result in significant adverse impacts to above-ground historic resources.

If you have any questions regarding above ground resources, please contact Tracy Schwartz, Historic Preservation Specialist at 503-986-0661 or Tracy.Schwartz@Oregon.gov. For archaeological resources, please contact John Pouley, Assistant State Archaeologist at 503-986-0675 or John.Pouley@Oregon.gov.

We look forward to continuing to review this undertaking under Section 106 of the National Historic Preservation Act (NHPA) as outlined in the *Programmatic Agreement Among the Bureau of Land Management, the U.S.D.A. Forest Service, the Bonneville Power Administration, the U.S. Army Corps of Engineers, Bureau of Reclamation, the Advisory Council on Historic Preservation, the Oregon SHPO, Idaho SHPO, the Washington DAHP, the Confederated Tribes of the Umatilla Indian Reservation THPO, National Park Service, Idaho Power Company Regarding Compliance with the NHPA for the Construction of the Boardman to Hemingway 500 kV Transmission Line Project*. The BLM and other federal agencies can use the information provided in these site forms to help guide future decisions for determinations of eligibility and evaluations of effects under Section 106 as appropriate.

Sincerely,

John Pouley, M.A., RPA
Assistant State Archaeologist
(503) 986-0675
john.pouley@oregon.gov

cc: Maxwell Woods, Oregon Department of Energy

**TARDAEWETHER Kellen * ODOE**

| | |
|---|---|
| **From:** | SCHWARTZ Tracy * OPRD |
| **Sent:** | Monday, May 13, 2019 9:14 AM |
| **To:** | TARDAEWETHER Kellen * ODOE |
| **Cc:** | maxwell.woods@state.or.us; 'Stokes, Mark'; POULEY John * OPRD |
| **Subject:** | SHPO Case Nbr SHPO Case No.: 08-2232, Boardman To Hemingway Transmission Line Project (B2H) |
| **Attachments:** | SHPO Response Letter Case Nbr SHPO Case No._ 08-2232.pdf |

Good Morning Kellen,

Attached is our response to Idaho Power's May 8, 2019 letter. I hope this clarifies some of the issues that they raised. Please let me or John know if additional information or clarification is needed.

Thanks and have a super great week!
-Tracy

Tracy Schwartz
Review & Compliance | Historic Preservation Specialist Oregon SHPO
725 Summer Street NE, Suite C
Salem, OR 97301
Phone: (503) 986-0677

Oregon

Kate Brown, Governor

**Parks and Recreation Department**
State Historic Preservation Office
725 Summer St NE Ste C
Salem, OR 97301-1266
Phone (503) 986-0690
Fax (503) 986-0793
www.oregonheritage.org

May 13, 2019

Ms. Kellen Tardaewether
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301

RE: SHPO Case No. 08-2232
Boardman To Hemingway Transmission Line Project (B2H)
Construct powerline from Boardman, OR to Hemingway, ID
multiple sections, Boardman and Murphy, Morrow/ Umatilla/Union/Baker/Malheur County

Dear Ms. Tardaewether:

We have received a response from Idaho Power Company (IPC), dated May 8, 2019, regarding our review of Exhibit S of Application for Site Certificate for the Boardman to Hemingway Transmission Line Project. We appreciate that IPC is committed to continued consultation under Section 106 of the National Historic Preservation Act to address some of the concerns regarding cultural resources within the project area. IPC did request clarification regarding two points in our April 29, 2019 letter.

1. IPC is correct and our statement should have read, "Taking into account mitigation for impacts and based solely on the information provided in Exhibit S, we believe that the construction and operation of the facility is not likely to result in significant adverse impacts to historic, cultural, and archaeological resources that have been listed [in], or would likely be listed [in] the National Register of Historic Places," pursuant to OAR 345-022-0090(1).
2. With regard to their second comment, if direct effects can be avoided entirely then there will be no significant impact as a result of those direct effects. However, we do agree with IPC, and within the framework of the Oregon Energy Facility Siting Council, that if those direct effects are also minimized and mitigated then they will also result in no significant impact.

If you have any questions regarding above ground resources, please contact Tracy Schwartz, Historic Preservation Specialist, at 503-986-0677 or Tracy.Schwartz@Oregon.gov. For archaeological resources, please contact John Pouley, Assistant State Archaeologist, at 503-986-0675 or John.Pouley@Oregon.gov.

Thank you again for the timely response and we look forward to continued consultation with IPC on this undertaking.

Sincerely,

Tracy Schwartz
Historic Preservation Specialist
(503) 986-0677
tracy.schwartz@oregon.gov

cc: Maxwell Woods, Oregon Department of Energy

## TARDAEWETHER Kellen * ODOE

| | |
|---|---|
| **From:** | Stokes, Mark <MStokes@idahopower.com> |
| **Sent:** | Wednesday, May 8, 2019 1:23 PM |
| **To:** | POULEY John * OPRD; SCHWARTZ Tracy * OPRD; JOHNSON Ian * OPRD |
| **Cc:** | Stanish, David; Baker, Shane; English, Aaron; TARDAEWETHER Kellen * ODOE; Wymond, Dave |
| **Subject:** | B2H IPC Follow-Up Letter |
| **Attachments:** | 2019-05-08 Oregon SHPO Letter from IPC.pdf |

John, Tracy, and Ian,

Attached is a letter from Idaho Power to Oregon SHPO following-up on your revised comment letter submitted to ODOE. Specifically, we are asking you to review the two clarification statements on page 3 of the letter and let ODOE and Idaho Power know if you concur or not. If you feel like a conference call to discuss this in more detail would be helpful, please let me know and I'll take care of setting it up.

Time is getting short on this, so your prompt attention would be appreciated.

Thank you.

**Mark Stokes**
ENGINEERING PROJECT LEADER
Idaho Power Company
Work (208) 388-2483 | Cell (208) 863-0043
mstokes@idahopower.com

## TARDAEWETHER Kellen * ODOE

| | |
|---|---|
| **From:** | TARDAEWETHER Kellen * ODOE |
| **Sent:** | Wednesday, May 8, 2019 1:42 PM |
| **To:** | POULEY John * OPRD; SCHWARTZ Tracy * OPRD; JOHNSON Ian * OPRD |
| **Subject:** | RE: B2H ASC IPC Follow-Up Letter Request |
| **Attachments:** | B2HAPP ASC Oregon SHPO Request Letter from IPC 2019-05-08.pdf |

Hi all,

Idaho Power compiled and sent the attached response letter to SHPO requesting SHPO's clarification. They point out a few topics of that I agree should be followed up on. Could you please review their letter and provide clarifications to their requests? I know you're busy but because I am trying to get the B2H DPO issued in the next 1.5 weeks, and having a clear record would be very helpful for us to reference in the DPO. Tracy and John, could you please review and provide responses by Monday or Tuesday next week? If it saves time to reply by email, that's fine and I'll save the email as an agency comment. Anyhow…let me know and I appreciate the help!

Kellen

**Kellen Tardaewether**
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301
P:(503) 373-0214
C: (503) 586-6551
[Oregon.gov/energy](Oregon.gov/energy)

OREGON DEPARTMENT OF ENERGY
*Leading Oregon to a safe, clean, and sustainable energy future.*

---

**From:** Stokes, Mark [mailto:MStokes@idahopower.com]
**Sent:** Wednesday, May 8, 2019 1:23 PM
**To:** POULEY John * OPRD <John.Pouley@oregon.gov>; SCHWARTZ Tracy * OPRD <Tracy.Schwartz@oregon.gov>; JOHNSON Ian * OPRD <Ian.Johnson@oregon.gov>
**Cc:** Stanish, David <DStanish@idahopower.com>; Baker, Shane <SBaker@idahopower.com>; English, Aaron <Aaron.English@tetratech.com>; TARDAEWETHER Kellen * ODOE <Kellen.Tardaewether@oregon.gov>; Wymond, Dave <DWymond@idahopower.com>
**Subject:** B2H IPC Follow-Up Letter

John, Tracy, and Ian,

Attached is a letter from Idaho Power to Oregon SHPO following-up on your revised comment letter submitted to ODOE.  Specifically, we are asking you to review the two clarification statements on page 3 of the letter and let ODOE and Idaho Power know if you concur or not.  If you feel like a conference call to discuss this in more detail would be helpful, please let me know and I'll take care of setting it up.

Time is getting short on this, so your prompt attention would be appreciated.

Thank you.

**Mark Stokes**
ENGINEERING PROJECT LEADER
Idaho Power Company
Work (208) 388-2483 | Cell (208) 863-0043
mstokes@idahopower.com

An IDACORP Company

May 8, 2019

John Pouley, M.A., RPA
Assistant State Archaeologist
Oregon State Historic Preservation Office
725 Summer Street, NE, Suite C
Salem, OR 97301-1266

RE: SHPO Case No. 08-2232
Boardman to Hemingway Transmission Line Project (B2H)

Dear Mr. Pouley,

Thank you for your letter dated April 29, 2019 and the associated comments and findings concerning Exhibit S of Idaho Power Company's (IPC's) Application for Site Certificate (ASC) for the Boardman to Hemingway Transmission Line Project (B2H) that was prepared consistent with Oregon's Energy Facility Siting Council (EFSC) statutes and rules (Oregon Revised Statute (ORS) Chapter 469 and Oregon Administrative Rules (OAR) Chapter 345, Division 1). This letter 1) discusses the completeness and compliance reviews performed for Exhibit S after IPC submitted an Amended Preliminary Site Certificate Application (pASC) on July 19, 2017 to the present; and 2) confirms and clarifies your comments concerning Exhibit S as they pertain to the applicable EFSC standards for Historic, Cultural and Archaeological Resources.

Background

Following IPC's submittal of the pASC on July 19, 2017, the Oregon Department of Energy (ODOE), HRA (a third-party contractor working under the supervision of ODOE), and the Oregon State Historic Preservation Office (SHPO) reviewed Exhibit S. HRA (through ODOE) provided a Request for Additional Information (RAI) #1 on November 3, 2017.[1] Another request (RAI #2) was delivered to IPC on March 2, 2018.[2] IPC addressed these comments and concerns and revised Exhibit S accordingly. ODOE subsequently issued its Second Amended Project Order on July 26, 2018. Following a review of the Order, IPC revised Exhibit S again and provided ODOE with those revisions.[3] Following a "Completeness Check" of the revised Exhibit S by HRA (August 31, 2018) and ODOE (September 12, 2018) and with the concurrence of the SHPO (September 20, 2018), the ASC was deemed complete by ODOE on September 28, 2018. After the completeness phase, HRA, ODOE, and SHPO undertook a compliance level review of Exhibit S and provided comments for Exhibit S on November 9, November 13, and December 6, 2018,

[1] The SHPO provided correspondence concurring with the HRA RAI #1 on November 13, 2017.

[2] The SHPO provided correspondence concurring with the HRA RAI #2 on March 21, 2018.

[3] See https://www.oregon.gov/energy/facilities-safety/facilities/Facilities%20library/2018-09-28-B2H-ASC-Exhibit-S.pdf.

1221 W. Idaho St. (83702)
P.O. Box 70
Boise, ID 83707

respectively. IPC addressed those comments and prepared an Errata for Exhibit S, as well as for Attachments S-6 (Cultural Resources Technical Report), S-9 (Historic Properties Management Plan), and S-10 (Intensive Level Survey – Visual Assessment of Historic Properties (VAHP) Report).[4] The Errata for Exhibit S and Attachment S-9 were published for public review by ODOE in February 2019. On April 29, 2019, the SHPO provided its final comments on the Errata and concluded, that after, "Taking into account mitigation for impacts and based solely on the information provided in Exhibit S, we believe that the construction and operation of the facility is not likely to result in significant adverse impacts to above ground historic resources," thus partially satisfying OAR 345-022-0090(1)(a). The letter, however, does not specifically mention an impact finding for cultural and archaeological resources covered under OAR 345-022-0090(1)(a), archaeological objects and sites on private land (OAR 345-022-0090(a)(1)) and archaeological sites on public land (OAR 345-022-0090(1)(c)).

Responses to SHPO Comments Concerning Exhibit S

IPC agrees in concept with SHPO's discussion concerning the treatment of certain above ground historic resources, archaeological resources and/or sites as unevaluated until their eligibility for the National Register of Historic Places (NRHP) can be verified through the Section 106 consultation process as codified in 36 C.F.R. Part 800. These resources will be avoided by any potential project activities in the interim period. IPC also agrees that the Section 106 Programmatic Agreement (Exhibit S, Attachment S-5) and the Historic Properties Management Plan (HPMP) (Exhibit S, Attachment S-9) shall serve as the consultation blueprint for further identification efforts, resolving NRHP eligibility, and avoiding, minimizing, and/or mitigating potential project impacts to resources covered under the EFSC standards contained in OAR 345-022-0090.[5]

*Resource Specific Responses and Resolution*

Resource 4B2H-EK-47 was recommended as not eligible in the text of the site form. The discrepancies in Exhibit S mapping and SHPO database will be rectified during the Section 106 process. The resource will be treated as likely eligible and avoided by project activities until a federal agency makes the final determination of eligibility, in concurrence with the SHPO.

---

[4] See https://www.oregon.gov/energy/facilities-safety/facilities/Facilities%20library/2019-03-28-B2H-ASC-Exhibit-S-Errata-Info-Redacted.pdf and https://www.oregon.gov/energy/facilities-safety/facilities/Facilities%20library/2019-03-28-B2H-ASC-Exhibit-S9-Errata-Info.pdf.

[5] The formal title of the Programmatic Agreement is *Programmatic Agreement Among the Bureau of Land Management, the U.S.D.A. Forest Service, the Bonneville Power Administration, the U.S. Army Corps of Engineers, Bureau of Reclamation, the Advisory Council on Historic Preservation, the Oregon SHPO, Idaho SHPO, the Washington DAHP, the Confederated Tribes of the Umatilla Indian Reservation THPO, National Park Service, Idaho Power Company Regarding Compliance with the NHPA for the Construction of the Boardman to Hemingway 500 kV Transmission Line Project.*

B2H-UN-005 (Whiskey Creek Segment) shall be treated as likely eligible for the NRHP and avoided by project activities until a federal agency makes the final determination of eligibility, in concurrence with the SHPO during the Section 106 process.

The inventory form in the revised Exhibit S (Attachment S-10), revised SHPO database, and the Exhibit S Errata Sheet (page S-70) that discusses B2H-MA-003 Meek Cutoff applies all of the NRHP Criteria for Evaluation and the fieldwork methods employed during its assessment are described in the Exhibit S, as well as Attachments S-2 (VAHP Plan), S-6, S-7 (Reconnaissance Level Survey), and S-10. Project crossings and the route, as identified by NPS GIS shapefiles within the Analysis Area, were assessed in the field and no evidence of the trail was identified. Furthermore, a Class I research review was utilized to identify potential routes in the area. Meek Cutoff shall be treated as likely eligible for the NRHP and avoided by potential project activities until a federal agency makes the final determination regarding eligibility, in concurrence with the SHPO, during the Section 106 process.

The following resources will remain unevaluated for the NRHP and avoided by project activities until a federal agency makes a final determination of eligibility, in concurrence with the SHPO during the Section 106 process: B2H-SA-37, 4B2H-EK-43, 6B2H-MC-07, and 4B2H-EK-26.

The following resources will be avoided by project activities until the SHPO's concerns regarding the potential for project impacts are resolved through the Section 106 process. These resources include 4B2H-EK-04, 6B2H-RP-09, B2H-BA-337, 4B2H-EK-41, and 050305144SI.

Request for Clarifications

Given the comments and findings of the April 29, 2019 letter from SHPO, IPC requests the following clarifications:

1) That when SHPO determined that, "Taking into account mitigation for impacts and based solely on the information provided in Exhibit S, we believe that the construction and operation of the facility is not likely to result in significant adverse impacts to above ground historic resources" the agency intended this statement to include not just "historical resources" covered under OAR 345-022-0090(1)(a) but also cultural and archaeological resources covered under OAR 345-022-0090(1)(a), archaeological objects and sites on private land (OAR 345-022-0090(1)(b)) and archaeological sites on public land (OAR 345-022-0090(1)(c)).
2) Given its previous statement in the letter, that when SHPO noted that, "With regard to direct effects, if all project impacts can be avoided then we concur that the undertaking will result in no significant adverse impact." the agency intended to say that if all project-related direct impacts to resources covered under OAR 345-022-0090 are avoided, minimized, or otherwise mitigated through measures included in

Exhibit S and Attachment S-9 (HPMP), then the construction and operation of the facility is not likely to result in significant adverse impacts to resources described in OAR 345-022-0090(1).

Thank you again for your assistance on this project. Please call Mark Stokes (208) 388-2483 or Aaron English (208) 489-2851 if you should have any questions or concerns.

Sincerely,

M. Mark Stokes, PE
Engineering Project Leader

cc: Ian Johnson, Oregon SHPO
Tracy Schwartz, Oregon SHPO
Kellen Tardaewether, ODOE
Aaron English, Tetra Tech

## TARDAEWETHER Kellen * ODOE

**From:** TARDAEWETHER Kellen * ODOE
**Sent:** Thursday, December 6, 2018 9:02 AM
**To:** 'Stokes, Mark'; 'Stanish, David'; English, Aaron
**Cc:** Baker, Shane; kirk.ranzetta@aecom.com; 'King, Erin'; WOODS Maxwell * ODOE (Maxwell.Woods@oregon.gov); Wymond, Dave
**Subject:** B2H ASC Follow up Exhibit S Direct Impacts and Mitigation Proposals

Good morning all,

Based on the discussion from the call on Monday, the below email is guidance and an additional information request regarding information within Exhibit S.

ODOE previously stated that resources on properties where IPC has gained site access shall be evaluated with proposed eligibility determinations and mitigation, if necessary, prior to issuance of the Draft Proposed Order (DPO). IPC has provided proposed mitigation measures based on the type of impact and on the type of resource. However, this information is dispersed throughout the ASC Exhibit S and Attachments (confidential and non-confidential). Additionally, the information for proposed mitigation for eligible resources that are directly impacted require more detail.

1.) ODOE is requesting that IPC provide a more robust discussion of mitigation proposals in Exhibit S (HPMP, and the body of Exhibit S, as appropriate). IPC should describe in more details each mitigation measure found in Table 6-2, 6-3 and 6-4 in Exhibit S. Attachments S-10, explains that "…Mitigation plans may include completion of NRHP nomination forms, conservation easements, purchase of land for log-term protection of historic properties, partnerships and funding for public archaeology projects, partnerships and funding for historic properties interpretation, and/or print or media publication…" Each of these items should be provided and discussed in the non-confidential portion of Exhibit S in more detail as to which proposals correspond to what type of resource.
2.) ODOE is requesting IPC expand on the mitigation proposals for direct impacts to resources. Table 6-2 lists mitigation measures for direct impacts to resources. However, the level of detail for indirect impacts to resources found in Tables 6-3 and 6-4 is more detailed than mitigation for direct impacts. The level of detail for mitigation measures for direct impacts to resources should be more detailed and site-specific. The level of details for mitigation for direct impacts should be commensurate to the impact. For each eligible resource found in Table S-2 that states that there is a proposed direct impact, IPC should provide a mitigation proposal in a level of detail that is commensurate for the impacts (for Oregon Trail resources and all other eligible resources with direct impacts). For example, if IPC is proposing to directly impact an eligible segment of the Oregon Trail by siting a tower foundation or building an access road across it, IPC should provide a mitigation proposal discussing how it will mitigate this impact by securing, preserving, funding, or conserving a similar currently un-protected Trail segment, or something of the like.
3.) Alternatively, IPC can re-visit Table S-2 and re-evaluate whether or not there will indeed be direct impacts to eligible resources. If, at this point, IPC knows that it can site the facility to avoid direct impacts IPC may:
    a. Represent that there will not be direct impacts to eligible resources and describe mitigation for indirect impacts, if applicable
    b. Represent in a condition that avoidance of direct impacts to eligible resources will occur as part of final design and construction
4.) Where in the materials does IPC describe what activities are proposed to occur in the sites that IPC states will be impacted directly or indirectly?

I hope this helps explain what ODOE is requesting. Please let me know if you would like to discuss further or have additional questions. Thanks!

Kellen

**Kellen Tardaewether**
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301
P:(503) 373-0214
C: (503) 586-6551
Oregon.gov/energy

OREGON DEPARTMENT OF ENERGY

*Leading Oregon to a safe, clean, and sustainable energy future.*

## TARDAEWETHER Kellen * ODOE

| | |
|---|---|
| **From:** | TARDAEWETHER Kellen * ODOE |
| **Sent:** | Wednesday, March 6, 2019 1:05 PM |
| **To:** | 'Stokes, Mark' |
| **Cc:** | English, Aaron; Stanish, David |
| **Subject:** | B2H ASC RAI's for Public Services and Siting Standards for T-Lines EMF |
| **Attachments:** | B2HAPP ASC_ODOE RAI_Exhibit U.DOCX; B2HAPP ASC_ODOE RAI_Exhibit AA.DOCX; B2HAPP ASC Tracking Doc Additional Info to ASC 2019-03-06.docx; B2HAPPDoc ApASC Reviewing Agency Comment ODA_Caines 2018-02-21.pdf |

Good afternoon,

Please see the attached Word documents that outline RAI's the Department is requesting responses to, and if necessary, revisions or additions to the ASC in an errata sheet be provided to the Department.

- The first attachment is for Public Services, primarily in response to the letter from ODA. Please respond to ODA's comments and, if necessary, indicate what responses will be provided in an errata sheet.
- The second attachment is a draft section/portion of section from the DPO for Division 24 – Siting Standards for Transmission Lines (Exhibit AA). Comments and RAI's are in the form of comment bubbles in the margin and not in a table. IPC responses maybe provided in a table and/or errata sheet, etc. Please review and have your engineering Dept provide feedback as necessary.
- The third attachment is an updated version of the additional info tracking sheet I've sent previously.

It would be the most helpful for ODOE to receive responses or draft errata sheets ASAP for the below items so that we may use this info to complete drafting sections in the DPO:
Exhibit W
Exhibit U
Exhibit AA

That said, final versions of all errata will be submitted as a package per Exhibit once IPC has prepared the documents in coordination with ODOE. Thanks!

Kellen

**Kellen Tardaewether**
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301
P:(503) 373-0214
C: (503) 586-6551
Oregon.gov/energy

OREGON DEPARTMENT OF ENERGY

*Leading Oregon to a safe, clean, and sustainable energy future.*

Comments and RAI's included in the comment bubbles.

**DRAFT Section Portions of IV.P. Division 24 Standards**

*Electric Fields*

The electric charge (measured as voltage) on an energized transmission line conductor produces electric fields. The greater the overall transmission line voltage, the greater the strength of the electric field. In contrast, the amount of current flowing on the conductor, which fluctuates daily and seasonally with changes in electricity usage, does not impact the strength of electric fields produced by the conductor. Electric fields diminish in strength proportional to distance from the transmission line conductors (the greater the distance from the conductors, the lower the electric fields), and are weakened or blocked by conductive objects (such as trees or buildings).[1]

**Commented [KT1]:** This doesn't take into account that the amount of current flowing on the conductor leads to greater line sag, therefore bringing the same amount of electric fields closer to the ground (meaning, the receptor thereby experiences higher electric fields, because the closer to the source, the higher the electric field experienced).

The applicant used a model developed by the Electric Power Research Institute[2] (which utilizes a methodology developed by the Bonneville Power Administration) to calculate the electric fields, measured in units of kilovolts per meter (kV/m), which would be produced by the proposed new 500 kV transmission line, rebuilt 230-kV transmission line, and rebuilt 138-kV transmission line. The model considered the following line geometries that the applicant expects to use in Oregon:

- 500-kV transmission line on a single-circuit lattice tower (delta configuration; ASC Exhibit B, Figure B-15) with a minimum ground clearance of 34.5 feet
- 230-kV transmission line on a single-circuit H-frame structure (horizontal configuration; ASC Exhibit B, Figure B-19) with a minimum ground clearance of 20 feet
- 138-kV transmission line on a single-circuit H-frame structure (horizontal configuration; ASC Exhibit B, Figure B-20) with a minimum ground clearance of 20 feet

In addition, the applicant modeled the electric fields from one alternative geometry that would be used when unique siting concerns require the use of special structures:

- 500-kV transmission line on a single-circuit H-frame or Y-frame structure (horizontal configuration; see ASC Exhibit B, Figures B-16 and B-17) with a minimum ground clearance of 34.5 feet

The model used the nominal voltage of the 230-kV and 138-kV transmission lines, but evaluated a more conservative (higher) voltage of 550-kv for the 500-kv transmission line to account for overvoltage situations. The model provided the predicted electric field levels out to distances of 200 feet on either side of each proposed transmission line structure type. Table X-X, reproduced from ASC Exhibit DD, Table DD-1, summarizes the electric field strengths at the

**Commented [KT2]:** See footnote below for circumstances/conditions where maximum line sag may occur.

[1] B2HAPPDoc3-44 ASC 27_Exhibit AA_EMF_ASC 2018-09-28, Section 3.2.1.
[2] The model is EMFWorkstation: ENVIRO (Version 3.52).

peak and edge of the ROW for each of these transmission line configurations. The 500-kV single-circuit lattice tower configuration would produce the highest electric fields. As shown in Table X-X, the maximum electric field modeled is 8.9 kV/m at one meter above the ground. This value is slightly below the limit for electric fields from transmission lines (set at OAR 345-024-0090(1)) of not more than 9 kV per meter at 1 meter above the ground surface in areas that are accessible to the public.

**Table X-X: Electric Field Strength for Each Considered Structural Configuration**

| Structure Type | ROW Width (feet) | South/West ROW Edge (kV/m) | Maximum within ROW (kV/m) | North/East ROW Edge (kV/m) |
|---|---|---|---|---|
| 500-kV lattice | 250 | 0.8 | 8.9 | 0.8 |
| 500-kV tubular steel H-frame and Y-frame monopole | 250 | 0.9 | 8.8 | 0.9 |
| 230-kV wood H-frame | 125 | 0.8 | 5.0 | 0.8 |
| 138-kV wood H-frame | 100 | 0.5 | 2.3 | 0.5 |
| Electric field strength calculated at standard height of one meter above ground surface.<br>kV/m = kilovolt per meter; ROW = right-of-way | | | | |

The applicant's position is that post-construction monitoring of electric fields is unnecessary because the modeling results assumed worst-case conditions of line overvoltage and minimum ground clearance, and those conservative calculations show that the electric fields would be slightly below the threshold established at OAR 345-024-0090(1).[3] As previously stated, the applicant's modeling exercise assumed a minimum conductor ground clearance of 34.5 feet. The applicant requests a site certificate condition establishing a minimum clearance for the 500-kV transmission line conductors of 34.5 feet from the ground "at normal operating conditions."[4] However, such a condition would allow a lesser minimum conductor clearance when the line is operating outside of normal operating conditions, such as at maximum line sag.[5] Because the model shows that maximum electric fields that would be produced by the 500-kV lattice single-circuit lattice tower configuration is 8.9 kV/meter at one meter above the ground when the line is modeled at 34.5 feet from the ground, a lesser minimum conductor clearance could result in electric fields that exceed 9 kV/m at 1 meter above the ground. Therefore, the Department recommends that the Council adopt the following condition requiring that the certificate holder design and construct the 500-kV transmission line with a minimum ground clearance of 34.5 feet under all conditions:

**Commented [KT3]:** The modeling assumed overloading and minimum clearance but did not take into account similar circumstances in addition to hot temperatures as well as when lines cross.

[3] B2HAPPDoc3-44 ASC 27_Exhibit AA_EMF_ASC 2018-09-28, Section 3.8.
[4] B2HAPPDoc3-44 ASC 27_Exhibit AA_EMF_ASC 2018-09-28, Section 3.7.
[5] On hot days and when a transmission line is heavily loaded (e.g., on summer days when demand for electricity to run air conditioners is high), the conductor heats and expands, causing the line to sag closer to the ground.

**Recommended Siting Standards for Transmission Lines Condition 1:** To reduce or manage human exposure to electromagnetic fields, the certificate holder shall design and construct:

a. All aboveground 500-kV transmission lines such that a minimum clearance of 34.5 feet from the ground is maintained under all conditions;
b. All aboveground 230-kV transmission lines with a minimum clearance of 20 feet from the ground at normal operating conditions; and
c. All aboveground 138-kV transmission lines with a minimum clearance of 20 feet from the ground at normal operating conditions.

In areas where an existing transmission line would parallel a proposed transmission line, the electric fields within the transmission line ROW may increase or decrease depending on the proximity, load, and phasing of the parallel line.[6] Therefore, in addition to modeling the electric fields that would be produced by each transmission line alone, the applicant also modeled the interactions between the electric fields that would be produced by the 500-kV lattice structures and the electric fields that would be produced by parallel transmission lines.[7] ASC Exhibit AA, Figure AA-9 shows that existing parallel lines located near the proposed 500-kV corridors will not result in exceedances of 9 kV/m at 1 meter above the ground surface, in compliance with OAR 345-024-0090(1). The proposed 500-kV transmission line has the potential to exceed this threshold, however, where the line would cross (rather than parallel) existing transmission lines.

[applicant representations and conditions]

*Induced Voltage and Current*

The Siting Standards for Transmission Lines requires the Council to find that the applicant "can design, construct and operate the proposed transmission line so that induced currents resulting from the transmission line and related or supporting facilities will be as low as reasonably achievable."

As explained in ASC Exhibit DD, the flow of electricity in a transmission line can induce a small electric charge, or voltage, in nearby conductive objects, such as metallic objects (e.g., vehicles, equipment, metal fences, signs, and metallic roofs). An induced electric charge can flow, or

[6] A single-circuit transmission line carries one phase in each of its three conductors. The voltage and current in each phase conductor is out of sync with the other two phases by 120 degrees, or one-third of the 360 degree cycle. The fields from these conductors tend to cancel out because of this phase difference. Therefore, depending on the geometry and arrangement of the conductors in the parallel transmission line, a parallel transmission line can either increase or decrease the electric fields within the transmission line ROW. B2HAPPDoc3-44 ASC 27_Exhibit AA_EMF_ASC 2018-09-28, Section 3.2.1.

[7] The 500-kV lattice configuration would produce the highest electric fields; therefore, the applicant modeled the interaction of electric fields from parallel transmission lines with the electric fields from this transmission line configuration. B2HAPPDoc3-44 ASC 27_Exhibit AA_EMF_ASC 2018-09-28, Section 3.5.3.

**Commented [KT4]:** The proposed 500-kV transmission line has the likely potential to exceed the 9 kV/m at 1 m above the ground threshold where the line would cross (rather than parallel) existing transmission lines. How does IPC plan to design, engineer, construct and operate the transmission line to avoid an exceedance (out of compliance with the standard) at crossings.

**Commented [KT5R4]:** In areas where crossings occur, the vertical
transmission line height and separation will be selected during detailed design in a manner to
maintain electric fields in the area of the crossing below the 9 kV/m standard. Table AA-3 shows the existing adjacent lines for the Proposed Route by county AA-9

**Commented [KC6]:** The applicant's current proposed condition is:

During construction, the certificate holder shall take the following steps to reduce or manage human exposure to electromagnetic fields:
***
In areas where aboveground transmission line will cross an existing transmission line, constructing the transmission line at a height and separation ensuring that alternating current electric fields do not exceed 9-kV per meter at one meter above the ground surface

become electric current, when a path to ground is presented. For example, a vehicle that is insulated from grounding by its tires and is parked under a transmission line long enough to build up a charge can cause humans that touch the vehicle to experience a momentary shock as the person becomes the conducting path for the current to flow to ground. A person can generally notice induced current if the available electrical charge is greater than 1 milliampere (mA), and at 5 mA most children (99.5 percent) are able to still let go of an electrified object.[8] The National Electric Safety Code (NESC) sets a performance standard at Rule 234G.3 limiting the steady-state current due to electrostatic effects to 5 mA.

The strength of the induced current in an object is positively related to the electric field strength of a nearby transmission line. The applicant therefore calculated the induced current expected to result for various objects located near the 500-kV lattice configuration, because this configuration would produce the strongest electric fields. Table X-X below, reproduced from Table DD-2 of ASC Exhibit DD, shows the maximum current that could be induced in several types of vehicles and agricultural equipment if those objects were located in the transmission line ROW. The maximum induced current is calculated by multiplying the factors in the middle column (derived from an Electric Power Research Institute publication) by the maximum expected electric field strength from the proposed facility (under normal operating conditions). As shown in Table X-X, cars, pickup trucks, and combines located within the ROW of the 500-kV lattice transmission line configuration would build up an inducible charge that would be less than the 5-mA threshold established by the NESC. If a large tractor-semitrailer were located parallel to and directly under the transmission line, it would have the potential to build up an inducible charge that would exceed the 5-mA threshold. However, the applicant explains that tractor-semitrailers are unlikely to drive directly under and parallel to the line; tractor-semitrailers may briefly cross under the line where the transmission line crosses a road, but in these circumstances the tractor-semitrailer would be under the transmission line for only a short duration and would not be parallel to the line. If the transmission line crossed a location where tractor-semitrailers may be parked long enough to build up an inducible charge (such as at a gas station or a parking lot), the resulting induced current may exceed the 5-mA threshold; therefore, the applicant represents that at these locations it would alter the transmission line design if necessary to ensure that the line complies with the 5-mA threshold established by the NESC.

**Table X-X: Induced Current Factors**

| Object | Isc/E (mA/kV/m) | Maximum Induced Current (mA)[1] |
|---|---|---|
| Car—L 4.6 m x W 1.78 m x 1.37 m | 0.088 | 0.78 |
| Pickup Truck—L 5.2 m x W 2.0 m x H 1.7m | 0.10 | 0.89 |
| Large Tractor-Trailer—Total Length 15.75 m Trailer: 12.2 m x W 2.4 m x H 3.7 m | 0.64 | 5.70 |
| Combine—L 9.15 m x W 2.3 m x H 3.5 m | 0.38 | 3.38 |
| Source: Table 7-8.2, EPRI AC Transmission Line Reference Book: 200 kV and Above (EPRI 2005) | | |

[8] B2HAPPDoc3-47 ASC 30_Exhibit DD_Specific Standards_ASC 2018-09-28, Section 3.4.1.

| |
|---|
| [1] Maximum induced current calculated for strongest predicted electric field of 8.9 kV/m, associated with the proposed lattice segment.<br>Isc = short-circuit current E = AC electric field<br>m = meter |

To reduce the risk of induced current and nuisance shocks, the applicant proposes to inform landowners of the risks of induced current, develop and implement a program to ground or bond conductive objects or structures that could become charged by the electric fields from the transmission line, and to follow NESC grounding requirements. The applicant therefore proposes, and the Department recommends, that the Council impose the following site certificate condition:

> **Recommended Siting Standards for Transmission Lines Condition 2:** Prior to placing the facility in service, the certificate holder shall takes the following steps to reduce the risk of induced current and nuisance shocks:
> a. Provide to landowners a map of overhead transmission lines on their property and advise landowners of possible health and safety risks from induced currents caused by electric and magnetic fields.
> b. Develop and implement a program that provides reasonable assurance that all fences, gates, cattle guards, trailers, irrigation systems, or other objects or structures of a permanent nature that could become inadvertently charged with electricity are grounded or bonded throughout the life of the line.
> c. Implement a safety protocol to ensure adherence to National Electric Safety Code grounding requirements.

In addition, the applicant states that IPC would design, construct, and operate the facility in accordance with the version of the NESC that is most current at the time final engineering of the facility is completed. The applicant proposes and the Department recommends that the Council adopt the following condition:

> **Recommended Siting Standards for Transmission Lines Condition 3:** The certificate holder shall design, construct, and operate the transmission line in accordance with the requirements of the version of the National Electrical Safety Code that is most current at the time that final engineering of the facility is completed.

Like the proposed transmission lines (the new 500 kV transmission line, rebuilt 230-kV transmission line, and rebuilt 138-kV transmission line), the Longhorn Station and communication stations have the potential to generate induced currents in nearby conductive objects. To reduce the risk of induced current and nuisance shocks from the Longhorn Station and communication stations, the applicant proposes to….[fill in once we receive more information from the IPC].

**Commented [KT7]:** EFSC Site Specific Conditions [OAR 345-025-0010] has an out-of date NESC reference. This is a draft condition ODOE is considering to replace or use in conjunction with the site-specific condition.

**Commented [KT8]:** The standard states:
*Can design, construct and operate the proposed transmission line so that induced currents resulting from the transmission line and related or supporting facilities will be as low as reasonably achievable.*

Exhibit DD says, "Longhorn Station and communication stations will be constructed in a manner to minimize induced currents in surrounding facilities" but doesn't provide any specifics.

Please explain how the Longhorn Station and communication stations would be constructed (e.g., with a grounding mat) to minimize induced currents in nearby conductive objects.

[consider recommending a condition related to grounding the substation and communication stations]

**Boardman to Hemingway Transmission Line Project –Application for Site Certificate (ASC)**
**Oregon Department of Energy**
**Request for Additional Information for the ASC (ASC RAI) Exhibit U – Public Services**
**March, 2019**

| Request No. | ASC Section Ref. | ASC Page Ref. | Applicable Rule (OAR 345-021- or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| ASC RAI U- 1 | Attachment U-1C | Attachment U-1C and page U-25 | | ASC Exhibit U, Attachment U-1C provides correspondence with fire prevention agencies. The Oregon Department of Forestry and the Union County Emergency Services-Fire Department both expressed concerns about waiting times and delayed response times due to waiting for the transmission line to be de-energized. Page U-25 of Exhibit U states the ODF "Rangeland Coordinator expressed concern regarding the risk of fighting fires near energized transmission lines, because electricity could arc through the smoke and strike firefighters" However, this does not appear to be the concern of ODF described in Attachment U-1C.<br>Please provide a description of the procedures that IPC would employ to de-energize the transmission lines in the event of an emergency? Please include how the operation/control center notify local emergency agencies, conversely how do local emergency agencies notify the control center of an emergency that necessitates shutting the transmission line down? What are the response times associated with de-energizing the line? | |

| | | | | | |
|---|---|---|---|---|---|
| ASC RAI U- 2 | | Page U-25 | | Page U-25 states, “Construction workers and maintenance personnel are not trained firefighters and are not expected to fight fires. However, qualified equipment operators, at the direction of Incident Command, may use construction equipment to assist local firefighting efforts when safe to do so.”<br><br>What, who and where is Incident Command?<br><br>Section 2.1.1 of the Fire Prevention and Suppression Plan states that “The Contractor and IPC will train all personnel on the measures to take in the event of a fire. The Contractor and IPC will immediately proceed to control and extinguish any fire started resulting from their activity.” Yet page U-25 states, “Construction and operations crews will implement the Fire Prevention and Suppression Plan, so that the Project will not increase the risk of fire. Construction workers and maintenance personnel are not trained firefighters and are not expected to fight fires…”<br><br>What construction personnel are expected to use the equipment listed in Section 2.1.5 of the Fire Prevention and Suppression Plan? How will they be trained? | |

| Request No. | ASC Section Ref. | ASC Page Ref. | Applicable Rule (OAR 345-021- or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| ASC RAI U- 3 | Section 2.1.5 | Attachment U-3 | OAR 437-007-1315 | To reflect the requirements of OAR 437-007-1315 and in response to the comments from ODF, the revised Fire Prevention and Suppression Plan states that, "The firewatch… be qualified in the use and operation of assigned firefighting equipment and tools; be physically capable of performing assigned fire suppression activities; and be advised of single employee assignment responsibilities…. Each person providing fire watch service on an operation area must have adequate facilities for transportation and communication to be able to summon firefighting assistance in a timely manner."<br><br>Please describe during construction who will operate as the Firewatch? How will they be trained? How many personnel will receive this training? Which personnel will trained and authorized to operate the equipment listed in Section 2.1.5. See also RAI above. | |

| Request No. | ASC Section Ref. | ASC Page Ref. | Applicable Rule (OAR 345-021- or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| ASC RAI U- 4 | Section 3.4.7 and 3.5.6.3 | U-18 and U-26 | | Page U-26 states "Workers suffering minor injuries will be treated at local medical facilities or emergency rooms. Workers suffering more serious injuries, were they to occur, will be taken to one of the major hospitals in the project vicinity."<br><br>Are the "local medical facilities" included in the 3 health care facilities listed in Exhibit U?<br><br>What are considered "minor injuries" that would require visitation to a medical facility?<br><br>Will there be any first aid materials or facilities provided on-site?<br><br>Will any personnel be required to hold active Fist Aid and CPR certifications?<br><br>How will workers suffering from a minor or serious injury be transported to a medical facility? | |

| Request No. | ASC Section Ref. | ASC Page Ref. | Applicable Rule (OAR 345-021- or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| ASC RAI U- 4 | Section 3.4.7 and 3.5.6.3 | | | In its letter on the ASC, Baker County expressed concerns about the response times and potential impacts to medical responders if they were committed to a project-related incident and would not be available to provide other services.<br><br>Please provide a discussion of the ambulance services that serve the analysis area and how many ambulances are available to serve multiple incidents? | |

**Boardman to Hemingway Transmission Line Project –Application for Site Certificate (ASC)**
**Oregon Department of Energy**
**Request for Additional Information for the ASC (ASC RAI) Exhibit W – Retirement**
**February, 2019**

| Request No. | ASC Section Ref. | ASC Page Ref. | Applicable Rule (OAR 345-021- or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| ASC RAI W- 1 | 3.2 | W-3 | | Exhibit W describes decommission the facilities associated with the switching station "For the station, these facilities include an interconnecting bus system, switches, breakers, and instrumentation for the control and protection of the equipment."<br><br>However, this doesn't match with the Cost Estimating Worksheet, which shows "N/A" for the switch yard on pages 25 and 26 of Exh W PDF) and $0 for the switch yard on page 19 of the PDF.<br><br>Please include costs associated with decommissioning the station. | |
| ASC RAI W- 2 | 3.2 | W-3 | | Exhibit W states: "This restoration will include restoring the site to a condition suitable for uses comparable with the surrounding land uses, intended land use, and then-current technologies."<br>What is meant by current technologies? | |
| ASC RAI W- 3 | | Attachment W-1 and Section 3.3 | | PDF Page 20 of the Exh W PDF states "3rd Quarter 2016 Dollars" at the top of the page, but then the GDP index is for 2nd quarter 2016, and the text of Exh W (Section 3.3) states that it's in 4th quarter 2016 dollars.<br><br>What quarter of 2016 was used to generate the cost estimate? | |
| ASC RAI W- 4 | | Attachment W-1 and Exhibit W | | The Cost Estimate states "Adjusted to Current Dollars" and "Total Site Restoration Cost (current dollars)"<br><br>What quarter and year were last used to update for inflation? | |

| Request No. | ASC Section Ref. | ASC Page Ref. | Applicable Rule (OAR 345-021- or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| ASC RAI W- 5 | | Attachment 1 | | The Site Restoration Cost Estimating Guide recommends that the contingency for administrative and management expenses total 10 percent (10%) of the cost estimate; however, the applicant's cost estimate applies a value of only 4 percent (4%) yes does not explain the justification for proposing the lesser percentage. Please provide such justification. | |

**TARDAEWETHER Kellen * ODOE**

| | |
|---|---|
| **From:** | Stanish, David <DStanish@idahopower.com> |
| **Sent:** | Monday, January 14, 2019 2:38 PM |
| **To:** | TARDAEWETHER Kellen * ODOE |
| **Cc:** | Stokes, Mark; English, Aaron |
| **Subject:** | RE: SHPO's Question RE: Call with ODOE-SHPO-IPC-HRA per B2H ASC SHPO Letter |
| **Attachments:** | 2019-01-14 - B2H - Exhibit S - Idaho Power's Response to Comment Letters.pdf |

Kellen –

Please find attached our questions. Thanks.

**David Stanish** | **Senior Counsel** | Idaho Power Company
1221 W. Idaho Street, Boise, Idaho 83702 | ☎:(208) 388-2631
🖷:(208) 433-2807 | ✉: DStanish@idahopower.com

---

**From:** TARDAEWETHER Kellen * ODOE <Kellen.Tardaewether@oregon.gov>
**Sent:** Monday, January 14, 2019 9:34 AM
**To:** Stokes, Mark <MStokes@idahopower.com>; English, Aaron <Aaron.English@tetratech.com>
**Cc:** Stanish, David <DStanish@idahopower.com>
**Subject:** [EXTERNAL] FW: SHPO's Question RE: Call with ODOE-SHPO-IPC-HRA per B2H ASC SHPO Letter



Good morning,

Do you guys have specific questions drafted for SHPO for the call tomorrow? If so, it may help them prepare if you send them over or give a rough idea of what your questions are. My response to them is below. Thanks,

Kellen

**Kellen Tardaewether**
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301
P:(503) 373-0214
C: (503) 586-6551
Oregon.gov/energy

OREGON DEPARTMENT OF ENERGY

*Leading Oregon to a safe, clean, and sustainable energy future.*

---

**From:** TARDAEWETHER Kellen * ODOE
**Sent:** Friday, January 11, 2019 4:15 PM
**To:** JOHNSON Ian * OPRD <Ian.Johnson@oregon.gov>
**Cc:** POULEY John * OPRD <John.Pouley@oregon.gov>; SCHWARTZ Tracy * OPRD <Tracy.Schwartz@oregon.gov>; WOODS Maxwell * ODOE (Maxwell.Woods@oregon.gov) <Maxwell.Woods@oregon.gov>
**Subject:** SHPO's Question RE: Call with ODOE-SHPO-IPC-HRA per B2H ASC SHPO Letter

There are a lot of emails going back and forth, sorry about that. To be clear, and if it's easier, the meeting I set up for Tuesday is a telephone call with IPC and HRA, so if it is easier for you to call in that would be fine.

I am unsure of the specific questions that IPC will have. ODOE wants to find out if the missing information or analysis for some resources in SHPO's letter is a comprehensive list, or just examples? I think IPC may have the same question. One of the goals for the call is to find out what information IPC needs to provide to SHPO for SHPO concurrence or other recommendations of their eligibility proposals.

Based on SHPO's eligibility recommendations (concurring or otherwise with IPC's proposals), ODOE would also like SHPO's feedback on IPC's impact assessment and mitigation proposals. That said, ODOE has requested that IPC provide a more robust discussion of mitigation proposals that will be provided as additional information to the ASC. Anyhow, I hope this helps and that you all can call-into or attend the meeting on Tuesday. Thank you!!!

Kellen

**Kellen Tardaewether**
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301
P:(503) 373-0214
C: (503) 586-6551
Oregon.gov/energy

OREGON DEPARTMENT OF ENERGY

*Leading Oregon to a safe, clean, and sustainable energy future.*

---

**From:** JOHNSON Ian * OPRD
**Sent:** Friday, January 11, 2019 4:03 PM

**To:** TARDAEWETHER Kellen * ODOE <Kellen.Tardaewether@oregon.gov>
**Cc:** POULEY John * OPRD <John.Pouley@oregon.gov>
**Subject:** RE: Call with ODOE-SHPO-IPC-HRA per B2H ASC SHPO Letter

Kellen,

Thanks. Do they have specific questions? Given the issues with arranging a meeting perhaps a teleconference or we can respond to written questions. I do not want to slow this project for lack of a meeting time.

Ian


***Ian P. Johnson*** | Associate Deputy State Historic Preservation Officer
Oregon Parks and Recreation Department, Heritage Division
State Historic Preservation Office
Desk: 503.986.0678 cell: 971.718.1137


Visit our website: www.oregonheritage.org
Like us on Facebook: https://www.facebook.com/OregonHeritage
Visit our Blog, The Oregon Heritage Exchange: http://oregonheritage.wordpress.com/

---

**From:** TARDAEWETHER Kellen * ODOE
**Sent:** Thursday, January 10, 2019 9:45 AM
**To:** JOHNSON Ian * OPRD
**Cc:** POULEY John * OPRD
**Subject:** Re: Call with ODOE-SHPO-IPC-HRA per B2H ASC SHPO Letter

Hi Ian and John,

Idaho Power had questions about how they should respond to SHPOs comments provided in its letter on the B2H ASC. So if SHPO could be prepared to elaborate on comments or provide examples of deficiencies I think that would be helpful. Does that help? Thanks!

Kellen


Kellen Tardaewether
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301
P:(503) 373-0214
C: (503) 586-6551
Oregon.gov/energy


Leading Oregon to a safe, clean, and sustainable energy future.

On Thu, Jan 10, 2019 at 9:39 AM -0800, "JOHNSON Ian * OPRD" <Ian.Johnson@oregon.gov> wrote:

Hello Kellen, John and I will complete the poll soon.

I am curious what the agenda would cover at this meeting. Are there specific issues or questions? We would like to be prepared.

Thanks.

Ian

--------------------------------------------------------------------



--------------------------------------------------------------------

**Idaho Power's Response to Reviewing Agency Comments**
**Exhibit S – Cultural Resources**
**Boardman to Hemingway Transmission Line Project**
**January 14, 2019**

**Oregon Department of Energy**
**Requests for Additional Information for the ASC Exhibit S - Historic, Cultural, and Archaeological Resources**
**Received November9 (HRA) November13 (ODOE), and December 6 (SHPO), 2018**

| Comment # | Reviewing Agency | ASC Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| 1 | ODOE | Exhibit S | Attached is the draft "compliance review" memo that HRA/Golder sent to SHPO for its review. Please note that this is preliminary and the recommendations and comments that are submitted to ODOE by SHPO at a later date may differ. I've also attached an ODOE comment letter on the Revised Exhibit S that we sent on September 9, 2018. In it ODOE states; "The Department reiterates that resources on properties where IPC has gained site access shall be evaluated with proposed eligibility determinations and mitigation, if necessary, prior to issuance of the Draft Proposed Order (DPO). Based on the Council's standard, it is not possible to defer the impact assessment and subsequent mitigation requirements (if any) to a pre-construction condition or otherwise defer to an ODOE staff determination." | Noted. NRHP-eligibility evaluations have been recommended for all identified resources and the impacts of the Project on those resources assessed based on the recommended NRHP-eligibility recommendations. As discussed in Exhibit S, Section 3.4.1, resources that could not yet be properly evaluated are recommended as unevaluated but are treated as NRHP-eligible for the purposes of analysis.<br><br>IPC understands this comment to have been resolved through communications with ODOE (12/3/18 conference call). |

**Oregon Department of Energy**
**Requests for Additional Information for the ASC Exhibit S - Historic, Cultural, and Archaeological Resources**
**Received November9 (HRA) November13 (ODOE), and December 6 (SHPO), 2018**

| Comment # | Reviewing Agency | ASC Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| 2 | ODOE | Exhibit S | Additionally, Page 25 of Attachment S-9 (HPMP) of Exhibit S states, "The appropriate mitigation measure(s) depends on a number of factors, including the applicable criteria for NRHP eligibility and significance to a tribe(s). Following the identification of impacts and the development of appropriate mitigation measures, resource specific mitigation plans will be prepared and included as Appendix B to this HPMP." Appendix B states that it is "To Be Determined". | Yes, resource-specific mitigation plans are to be determined. However, the generalized category of mitigation (data recovery, further research/testing, pubic interpretation, etc.) is identified for each resource is the respective survey reports and in the main body of Exhibit S. As noted in the HPMP, a resource-specific mitigation plan (such as specific locations for excavation units and research designs) for each resource impacted by the final design will be included in Appendix B of a revised draft HPMP, developed in consultation with reviewing agencies and affected tribes.<br><br>As agreed upon by IPC and ODOE on the 12/3/18 conference call, the draft HPMP will be updated via an errata to include additional detailing of actions typically included in the generalized mitigation categories, as well as a listing of which resources are proposed to be mitigated by those actions. |
| 3 | ODOE | Exhibit S | Does IPC have an estimated timeline for the resource-specific Mitigation Plans (Appendix B)? This information will also need to be reviewed by SHPO (and potentially HRA). | See above. |

| Comment # | Reviewing Agency | ASC Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| 4 | ODOE | Exhibit S | Based on IPC's estimated timeline for this, I think we should have a call to begin outlining the process to add information to the ASC, post completeness determination. I'd like to start planning for what information is expected to be included, how it should be submitted to ODOE and tracked with the existing ASC. OAR 345-015-0190 (9) states,<br><br>"After a determination that an application is complete, the applicant shall submit additional information to the Department if the Department identifies a need for that information during its review of the application. Submission of such information does not constitute an amendment of the application." | Noted. IPC understands this comment to have been resolved through communications with ODOE (12/3/18 conference call). |
| 4 | HRA | Exhibit S | Precontact Archaeological Sites. In general, nearly all of the site evaluations were updated based on concerns provided during the completeness review. Most precontact sites were recommended eligible or unevaluated; a few precontact sites were recommended not eligible due to the lack of potential for buried deposits as evidenced by the presence of bedrock and/or the lack of evidence for soil development. Two precontact sites did not follow this pattern: Sites 2B2H-SA-16 and 2B2H-SA-17 were recommended not eligible, but neither description fully addressed a lack of potential for soil development. For Site 2B2H-SA-16, an erosional area within the site boundary was mentioned, but there was no indication that it occupied a significant portion of the site and precluded the possibility of any buried materials being present. Site 2B2H-SA-17 was determined to be on a stable dune, but there was no discussion of whether soil development of any kind could have obscured artifact exposure. Clarification of the potential for buried deposits at these sites is needed to confirm that they are not eligible. | The NRHP-eligibility evaluations and the associated site descriptions for 2B2H-SA-16 and 2B2H-SA-17 will be reviewed and revised as necessary. |

| Comment # | Reviewing Agency | ASC Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| 6 | HRA | Exhibit S | Historic Archaeological Sites. Most historical archaeological site evaluations contained adequate reasoning for their NRHP evaluations; however, three historical sites (6B2H-SA-12, 6B2H-SA-16, and 35UN0326) were recommended not eligible, but the research did not support the archaeological data, leaving questions as to the specific origin of the archaeological remains. In these three instances, the evaluations do not specifically address these data gaps. The sites may not retain sufficient integrity or may be unlikely to contain additional archaeological information, but these issues are not explored, and the lack of subsurface archaeological examination creates doubt as to whether additional information could be present. When the historical research does not adequately explain the archaeological data, additional exploration of whether the data could meet the NRHP criteria independent of their specific context should be included to fully explore the resource's eligibility. | The NRHP-eligibility evaluations and the associated site descriptions for 6B2H-SA-12, 6B2H-SA-16, and 35UN0326 will be reviewed and revised as necessary. |

| Comment # | Reviewing Agency | ASC Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| 7 | HRA | Exhibit S | Aboveground (Architectural) Resources. Reconnaissance-level survey (RLS) inventories were not updated in the OHSD to include the requisite minimum information (i.e., two photos, maps). Certain intensive-level survey (ILS) resources were recorded as sites instead of buildings or structures, which is inconsistent with both NRHP and SHPO guidance on cultural resource reporting; such instances are likely typographical errors remaining from previous reporting but should be clarified. The Visual Assessment of Historic Properties (VAHP) forms are inconsistently used for evaluation of potential impacts. Contributing and noncontributing resource counts are still in error on certain forms. | The RLS was updated on several occasions between 2012 and 2016. Following a review of the RLS data on February 18, 2014, the Oregon SHPO commented that "all properties, regardless of evaluation status, must include at least one photo, which must display on the accompanying printouts." Also, in some instances, the RLS was not revised for resources located in the Baker City and LaGrande as the SHPO noted that "Based on the information provided to date [2014], the Oregon SHPO is satisfied that historic properties located in urban areas, such as within or surrounding large communities of Baker City, Ontario, and LaGrande, or that are physically separated from the B2H project by an interstate highway or other significant visual interruption are unlikely to be adversely affected by the B2H project. No further assessment is needed in these cases…" The RLS has previously addressed this request. The maps for the RLS were likewise submitted with the previous 2016 report and will be added to the database RLS grouping information.<br><br>The ILS resources recorded as sites will be recorded as structures, buildings, or districts as applicable. The VAHP forms will be reviewed for consistency. Forms will be reviewed to ensure contributing/non-contributing resources are properly accounted for. |

| Comment # | Reviewing Agency | ASC Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| 8 | HRA | Exhibit S Archaeological Resources: | Despite outstanding errors and omissions, HRA feels that IPC provided sufficient information for SHPO to move forward with determinations of eligibility of resources. HRA recommends SHPO make determinations of eligibility that concur with Tetra Tech's recommendations, with the following minimal exceptions:<br>**Site 2B2H-SA-16**: Table S-2 recommends the site not eligible, but it is unclear if the erosional area within the site boundary occupied a significant portion of the site and precludes the possibility of buried materials being present. HRA recommends the site Undetermined pending additional studies.<br>Note that this resource is located on federal lands, and the federal agency should be consulted regarding resource determinations | As stated above in response to Question #4, the NRHP-eligibility evaluation and the associated site description for 2B2H-SA-16 will be reviewed and revised as necessary. |
| 9 | HRA | Exhibit S | **Site 2B2H-SA-17**: Table S-2 recommends the site not eligible, but the site's location on a stable dune may yield additional information. HRA recommends the site Undetermined pending additional studies. Note that this resource is located on federal lands, and the federal agency should be consulted regarding resource determinations | As stated above in response to Question #4, the NRHP-eligibility evaluation and the associated site description for 2B2H-SA-17 will be reviewed and revised as necessary. |
| 10 | HRA | Exhibit S | **Site 6B2H-SA-12:** Table S-2 recommends the site not eligible, but data gaps remain. HRA recommends the site Undetermined pending additional studies. This site is located on private lands. | As stated above in response to Question #6, the NRHP-eligibility evaluation and the associated site description for 6B2H-SA-12 will be reviewed and revised as necessary. |
| 11 | HRA | Exhibit S | **Site 6B2H-SA-16:** Table S-2 recommends the site not eligible, but data gaps remain. HRA recommends the site Undetermined pending additional studies. This site is located on private lands. | As stated above in response to Question #6, the NRHP-eligibility evaluation and the associated site description for 6B2H-SA-16 will be reviewed and revised as necessary. |
| 12 | HRA | Exhibit S | **Site 35UN0326:** Table S-2 recommends the site not eligible, but data gaps remain. HRA recommends the site Undetermined pending additional studies. This site is located on private lands. | As stated above in response to Question #6, the NRHP-eligibility evaluation and the associated site description for 35UN0326 will be reviewed and revised as necessary. |

| Comment # | Reviewing Agency | ASC Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| 12 | HRA | Exhibit S Architectural (Above-ground) Resources: | **71863 Wilson Lane**: Table S-2 recommends the resource not eligible, but the resource is noted as eligible in the OHSD at a reconnaissance-level (specifically, a barn and silo. An associated house and mobile homes were assessed as not eligible). Exhibit S-7 (RLS), Appendix C notes the resource required an intensive-level survey and, though it is mentioned in Exhibit S-10 (ILS) as being not eligible, there is no associated site form in either Exhibit S-10 or OHSD. HRA recommends the resource Undetermined pending additional studies; however, according to Table S-2, the resource will not be impacted by the Project, so no additional work may be necessary at this time. | Idaho Power will prepare a form for the resource located at 71863 Wilson Lane. |
| 13 | HRA | Exhibit S HPMP | To that end, HPMP Section 3.1, Preconstruction tasks, should include bullet points for resolving the NRHP eligibility of unevaluated resources and assessing project effects to NRHP eligible resources, archaeological sites and archaeological objects, with specific reference to Sections 5.1 and 5.2 of the HPMP. This will clarify that these steps are needed prior to construction. Otherwise, HRA recommends the HPMP is adequate to address the EFSC statute. SHPO may wish to request that the HPMP be updated to include a comprehensive list of known historic properties and other cultural or archaeological resources in the Project Analysis Area, though this information may be better contained in a confidential Appendix that also includes current, anticipated, and completed project actions and/or needed cultural resource studies, as appropriate. | Section 3.1 of the draft HPMP will be updated as requested via an errata sheet, as agreed to by ODOE. |

| Comment # | Reviewing Agency | ASC Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| 14 | SHPO | Exhibit S | Many resources are misidentified in terms of resource type. Many are identified as "sites" that are actually structures, or built linear resources, but others are well. These should be properly identified according to the National Park Service standards. | The property types discussed in the exhibit will be reviewed to ensure consistency with the National Register bulletins. Please provide a list of specific resources where this is a concern. Terminology in Exhibit S is consistent with the terminology used in EFSC siting standards and ODOE regulations, which refer to archaeological sites, archaeological objects, and resources listed on or eligible for listing on the NRHP (historic properties). Thus, “sites” was used in this document. Project 106 documents (as well as the text in the survey reports attached to Exhibit S) use the NPS terminology in site descriptions and NRHP eligibility evaluations. Identification of sites and objects is also consistent with SHPO/HRA comments received during previous reviews of the application. |
| 15 | SHPO | Exhibit S | Lack of information regarding the history of a resource should never be used to recommend that a resource does not meet a significance criterion. For example, the resource "Road to Rye Valley" evaluation includes the following statements: "It is unclear who created the road. Therefore, the road does not appear to be associated with a person who played a significant role in our nation’s history (Criterion B). The road has been modernized and there is no indication of what the road looked like originally. Therefore, the road no longer embodies the distinctive characteristics of an architectural style or architect or exhibit high artistic value, if it ever did (Criterion C)." No bibliographic materials are identified on the form. These indicate that further research should be done, rather than assuming that no significance exists. | The sources listed in Att. S-6 (see Section 6.2.4 and resource-specific evaluations in Chapter 8) were consulted as appropriate for each evaluated resource. If no information could be found, then there is nothing else to cite. A resource’s lack of discussion/documentation in the historical record is indicative of a lack of significance. In addition to those sources that were cited in the text for this resource, Idaho Power will provide the additional sources consulted that didn’t contain relevant information.<br><br>Please provide a list of specific resources where this is a concern. |

| Comment # | Reviewing Agency | ASC Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| 16 | SHPO | Exhibit S Built Environment | As noted in the Oregon Linear Resources Guidance, irrigation delivery ditches such as that (apparently) identified as "Unnamed Water Conveyance System" (4B2H-EK-44) should be evaluated within the context of the agricultural unit to which it delivers water (usually fields associated with a ranch or farmstead), not in a vacuum. To that end, evaluations of such resources should include identification of the agricultural unit with which it is associated, and analysis of that farmstead or ranch should inform the evaluation of the irrigation system. If the ditch is actually a lateral or sublateral of a larger irrigation system (i.e., it delivers water to more than one farm), then the MPD that applies to those systems should guide evaluation (see comment regarding Vale Oregon Irrigation District below). | Irrigation ditches will be reviewed to confirm their context in any larger system and their place within the larger historical landscape.<br><br>Please provide a list of specific resources where this is a concern. |
| 17 | SHPO | Exhibit S Built Environment | Oregon SHPO does not concur with some of the recommendations of eligibility submitted. Several of the resources are identified as "unevaluated", or their eligibility is "undetermined". Our office does not leave historic, built resources that appear in project Areas of Potential Effect (APE) unevaluated, as this does not resolve the questions required by the project regulatory review process, namely, "Is the resource eligible for listing in the National Register of Historic Places (NRHP)", and "Will the project adversely affect any eligible resources?" Resources seeking consensus determinations should default to eligibility until such time as application of all four NRHP criteria for eligibility and the aspects of integrity are made. If no adverse effects are anticipated, regardless of eligibility, but eligibility is not fully explored, the resources should be left as "eligible" until non-eligibility is sufficiently supported by data and analyses. | Evaluations will be reviewed for consistency. As the evaluation of resources is a part of the Programmatic Agreement concurrence from the SHPO would not be required at this point, but rather when the BLM (or applicable federal agency) makes the eligibility determination and then requests the SHPO's concurrence. All four NRHP criteria were applied to a majority of resources where their significance (or lack thereof) was readily apparent. For other resources, such as cairns, the resources were typically classified as unevaluated because their significance is not known, but they were considered eligible by the project team in order to complete the effects analysis. See Exhibit S, Section 3.4.1. |

**Oregon Department of Energy**
**Requests for Additional Information for the ASC Exhibit S - Historic, Cultural, and Archaeological Resources**
**Received November9 (HRA) November13 (ODOE), and December 6 (SHPO), 2018**

| Comment # | Reviewing Agency | ASC Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| 18 | SHPO | Exhibit S Built Environment | As noted by HRA, Inc., 71863 Wilson Lane does not have a submitted evaluation form. This form must be completed and provided in order for our office to provide concurrence. In the meantime, the resource should be evaluated as "eligible". | IPC will prepare a form for the resource located at 71863 Wilson Lane. |
| 19 | SHPO | Exhibit S Built Environment | All segments of the Oregon Trail that occur within the APE, including the Meek Cutoff, should be evaluated through the Oregon Trail Multiple Property Document, currently in draft, but expected to be finalized in the coming months. | All segments of the Oregon Trail that occur within the APE, including the Meek Cutoff, were evaluated using the latest (2015) post-SACHP version of the Oregon Trail, Oregon, 1840-1880 MPDF (Beckham 2015). As noted on page 3 of the Meek Cutoff form, for instance, the text reads "The historical segment of the Meek Cutoff is within the study's analysis area but does not appear to be visible. As a trail segment, the portion of the Meet Cutoff within the project area does not appear to meet the registration requirements of the Intersecting Routes property type as contained in the Oregon Trail, Oregon, 1840-1880 MPDF." It should be noted that the MPDF has been in draft form for over 6 years and has not yet been accepted by the Keeper of the National Register. |
| 20 | SHPO | Exhibit S Built Environment | Linear resources (canals, laterals, roads, trails, railroads, etc.) should be evaluated with reference to the Oregon Linear Resources Guidance document, available on the SHPO website. All linear resource evaluation forms should reference this document explicitly. | Comment noted. Reference will be added as applicable.<br><br>Please clarify if this comment is regarding site forms only and, if so, should it be done on both built environment and archaeological forms? |

| Comment # | Reviewing Agency | ASC Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| 21 | SHPO | Exhibit S Built Environment | All Intensive Level survey documentation/evaluation forms must include a bibliography. Many do not. | IPC will revise the following forms to address the concern: OR&N Heppner Branch; OWR&N/UPRR Coyote Cut-off; 4B2H-EK-04; 6B2H-TH-03 USGS Survey Marker; B2H-BA-178 refers the reader to the National Register nomination.; Road to Rye Valley (6B2H-SA-08); 3B2H-SA-16 (more); 4B2H-EK-19; Banks Ditch; B2H-JF-14; Stone Survey Marker near Farewell Bend (4B2H-EK-35); Warm Springs Pump Canal (4B2H-EK-43); Take out page 453; South Canal (B2H-SA-10); Unnamed Water Conveyance System (4B2H-EK-44).<br><br>Please confirm forms of concern are limited to the above list. |

| Comment # | Reviewing Agency | ASC Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| 22 | SHPO | Exhibit S Built Environment | All elements of the Vale Oregon Irrigation District should be evaluated according to the Multiple Property Document "Carey and Reclamation Acts Irrigation Projects in Oregon, 1901-1978", available from our website or that of the National Park Service. This MPD has been registered with the Keeper of the National Register. | Those elements of the Vale Oregon Irrigation District identified in the APE were evaluated according to the Multiple Property Document “Carey and Reclamation Acts Irrigation Projects in Oregon, 1901-1978.” On the form for B2H-MA-001 Vale Irrigation Project Canal, for instance, page 2 reads<br>*“The Vale Irrigation Project Canal retains all aspects of integrity (location, design, materials, setting, feeling, association, and workmanship). It meets the registration requirements outlined in the Carey and Reclamation Acts Irrigation Projects in Oregon, 1901-1978 MPDF as the canal maintains sufficient integrity and is long enough to represent its original function and demonstrate its functional relationship and connectivity to other contributing elements.”*<br>Other resources evaluated under the Carey and Reclamation Acts MPDF include B2H-MA-043, B2H-MO-047, 126CSF-12, B2H-SA-01, B2H-MA-001, and B2H-MA-044. |

| Comment # | Reviewing Agency | ASC Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| 23 | SHPO | Exhibit S Built Environment | The resource "Building" (B2H-MA-008) includes in the evaluation the following statement, "The resource's physical characteristics are aboveground and visible, and existing documentary sources discuss little to no significant information about the property. It therefore holds little to no potential to yield information significant to the past and therefore is recommended as not eligible under NRHP Criterion D." This statement appears to suggest that a standing building cannot be eligible under Criterion D, which is not accurate, especially with reference to vernacular architecture, which this building may represent. The fact that little information about it exists in the documentary record does not address the possibility that it could, in fact, provide important information that does not occur in the documentary record, which is in large part the point of Criterion D. While the evaluation of the building as not eligible may be adequately supported by analysis of integrity, the use of the above phrasing is not suitable. Alternatively, if no adverse effect is likely, consensus determination of "eligible" could be made at this time, with no further work required for this project. | Built environment resources can be eligible under Criterion D; however, all we are saying here is that the resource B2H-MA-008 has all of its characteristics readily evident, therefore it does not have the potential to convey information significant to our past. |
| 24 | SHPO | Exhibit S Built Environment | If the abandoned irrigation ditch identified as "B2H-MA-043" has been abandoned for 75 years (under state law) or 50 years (under federal law), then the resource should be reported and recorded as an archaeological site. | As noted in the exhibit and survey report attachments, the approach utilized for the Project was limited to federal regulations, which require a resource to be 50 years old. For the purposes of consistency between the two processes, this approach was agreed to by consulting parties to the PA, including ODOE. |

| Comment # | Reviewing Agency | ASC Reference | Comment or Request for Additional Information | Response |
|---|---|---|---|---|
| 25 | SHPO | Exhibit S Archaeology | Statements such as "a few precontact sites were recommended not eligible due to the lack of potential for buried deposits…" suggests evaluations only considered Criterion D, and further, that important research questions can only be addressed if buried deposits exist. In the same paragraph, it states: "Clarification of the potential for buried deposits at these sites is needed to confirm that they are not eligible". Please note, evaluations must address all four criteria, whether they are archaeological sites, built structures, properties of religious and cultural significance to an Indian tribe, or traditional cultural properties. In addition, important research questions do not only address buried deposits, or intact deposits for that matter. Guidance on NRHP evaluations with examples for each criterion is in NR Bulletin 15. Regarding archaeological sites, according to NR Bulletin 16A, “the integrity of archaeological resources is generally based on the degree to which remaining evidence can provide important information. All seven qualities do not need to be present for eligibility as long as the overall sense of past time and place is evident”. To meet the EFSC standard of whether an archaeological site would likely be listed in the NRHP, all four criteria must be addressed, and applied accordingly. | In Att. S-6, all resources (archaeology and built environment) are evaluated under all four NRHP eligibility criteria, consistent with the described methodology and previous comments received from SHPO/HRA and CTUIR during earlier reviews. The quoted HRA comment from their 11/9/18 memo to SHPO and ODOE is specific to the archaeological sites listed in their comment. These two NRHP-eligibility evaluations and the associated site descriptions will be reviewed and revised as necessary. |

**TARDAEWETHER Kellen * ODOE**

| | |
|---|---|
| **From:** | English, Aaron <Aaron.English@tetratech.com> |
| **Sent:** | Friday, April 12, 2019 9:19 AM |
| **To:** | TARDAEWETHER Kellen * ODOE |
| **Cc:** | mstokes@idahopower.com |
| **Subject:** | IPC Response to Agency Comments |
| **Attachments:** | 2019-03-20 - B2HAPP ASC_ODOE RAI_Exhibit AA (002).pdf; B2HAPP ASC Reviewing Agency Comment DSL_Cary 2019-01-28.pdf; B2HAPP ASC Reviewing Agency_ODFW Comment_Response 01.25.19.pdf; B2HAPP ASC_ODOE RAI_Exhibit U.pdf; B2HAPP ASC_ODOE RAI_Exhibit U_V2.pdf; B2HAPP ASC_ODOE RAI_Exhibit W.pdf |

Kellen,
Attached are IPC's responses to ODOE and other agency comments on the ASC. All of these comments were addressed where applicable in the errata previously provided to you.

Let me know if you any questions.

**Aaron English** | **Project Manager/NEPA Specialist**
Direct: 208.489.2851 | Cell: 208.685.9806
aaron.english@tetratech.com

**Tetra Tech, Inc.** | **CES**
3380 Americana Terrace, Suite 201 | Boise, Idaho 83706 | www.tetratech.com

Comments and RAI's included in the comment bubbles.

**DRAFT Section Portions of IV.P. Division 24 Standards**

*Electric Fields*

The electric charge (measured as voltage) on an energized transmission line conductor produces electric fields. The greater the overall transmission line voltage, the greater the strength of the electric field. In contrast, the amount of current flowing on the conductor, which fluctuates daily and seasonally with changes in electricity usage, does not impact the strength of electric fields produced by the conductor. Electric fields diminish in strength proportional to distance from the transmission line conductors (the greater the distance from the conductors, the lower the electric fields), and are weakened or blocked by conductive objects (such as trees or buildings).[1]

**Commented [KT1]:** This doesn't take into account that the amount of current flowing on the conductor leads to greater line sag, therefore bringing the same amount of electric fields closer to the ground (meaning, the receptor thereby experiences higher electric fields, because the closer to the source, the higher the electric field experienced).

**Commented [IPC2R1]:** The highlighted sentence is accurate. However, we understand ODOE's concern to be that the reference to "normal operating conditions" in Condition 1 suggests there are non-normal operating conditions where the transmission line may sag below the minimum ground clearances set forth in that condition and thus it may not meet the 9 kV/m at 1 meter above ground surface standard during those non-normal operating conditions. To address that concern and to clarify Idaho Power's intent that it will design and construct the transmission line to comply with the ground clearances set forth in Condition 1 ***under all conditions***, therefore, ensuring compliance with the 9 kV/m standard, Idaho Power proposes the following edits to Condition 1:

***Siting Standard Condition 1:*** *During construction, the certificate holder shall take the following steps to reduce or manage human exposure to electromagnetic fields:*
*. . .*
*b. Constructing all aboveground 500 kV transmission lines with a minimum clearance of 34.5 feet from the ground ~~at normal~~ under all operating conditions;*
*c. Constructing all aboveground 230 kV transmission lines with a minimum clearance of 20 feet from the ground ~~at normal~~ under all operating conditions;*
*d. Constructing all aboveground 138 kV transmission lines with a minimum clearance of 20 feet from the ground ~~at normal~~ under all operating conditions;*
*. . . .*

The applicant used a model developed by the Electric Power Research Institute[2] (which utilizes a methodology developed by the Bonneville Power Administration) to calculate the electric fields, measured in units of kilovolts per meter (kV/m), which would be produced by the proposed new 500 kV transmission line, rebuilt 230-kV transmission line, and rebuilt 138-kV transmission line. The model considered the following line geometries that the applicant expects to use in Oregon:

- 500-kV transmission line on a single-circuit lattice tower (delta configuration; ASC Exhibit B, Figure B-15) with a minimum ground clearance of 34.5 feet
- 230-kV transmission line on a single-circuit H-frame structure (horizontal configuration; ASC Exhibit B, Figure B-19) with a minimum ground clearance of 20 feet
- 138-kV transmission line on a single-circuit H-frame structure (horizontal configuration; ASC Exhibit B, Figure B-20) with a minimum ground clearance of 20 feet

In addition, the applicant modeled the electric fields from one alternative geometry that would be used when unique siting concerns require the use of special structures:

- 500-kV transmission line on a single-circuit H-frame or Y-frame structure (horizontal configuration; see ASC Exhibit B, Figures B-16 and B-17) with a minimum ground clearance of 34.5 feet

The model used the nominal voltage of the 230-kV and 138-kV transmission lines, but evaluated a more conservative (higher) voltage of 550-kv for the 500-kv transmission line to account for overvoltage situations. The model provided the predicted electric field levels out to distances of 200 feet on either side of each proposed transmission line structure type. Table X-X, reproduced from ASC Exhibit DD, Table DD-1, summarizes the electric field strengths at the

**Commented [KT3]:** See footnote below for circumstances/conditions where maximum line sag may occur.

**Commented [IPC4R3]:** See response above clarifying that the transmission line will be designed and constructed to meet minimum ground clearances under all operating conditions and not just normal operating conditions.

[1] B2HAPPDoc3-44 ASC 27_Exhibit AA_EMF_ASC 2018-09-28, Section 3.2.1.
[2] The model is EMFWorkstation: ENVIRO (Version 3.52).

peak and edge of the ROW for each of these transmission line configurations. The 500-kV single-circuit lattice tower configuration would produce the highest electric fields. As shown in Table X-X, the maximum electric field modeled is 8.9 kV/m at one meter above the ground. This value is slightly below the limit for electric fields from transmission lines (set at OAR 345-024-0090(1)) of not more than 9 kV per meter at 1 meter above the ground surface in areas that are accessible to the public.

**Table X-X: Electric Field Strength for Each Considered Structural Configuration**

| Structure Type | ROW Width (feet) | South/West ROW Edge (kV/m) | Maximum within ROW (kV/m) | North/East ROW Edge (kV/m) |
|---|---|---|---|---|
| 500-kV lattice | 250 | 0.8 | 8.9 | 0.8 |
| 500-kV tubular steel H-frame and Y-frame monopole | 250 | 0.9 | 8.8 | 0.9 |
| 230-kV wood H-frame | 125 | 0.8 | 5.0 | 0.8 |
| 138-kV wood H-frame | 100 | 0.5 | 2.3 | 0.5 |
| Electric field strength calculated at standard height of one meter above ground surface. kV/m = kilovolt per meter; ROW = right-of-way | | | | |

The applicant's position is that post-construction monitoring of electric fields is unnecessary because the modeling results assumed worst-case conditions of line overvoltage and minimum ground clearance, and those conservative calculations show that the electric fields would be slightly below the threshold established at OAR 345-024-0090(1).[3] As previously stated, the applicant's modeling exercise assumed a minimum conductor ground clearance of 34.5 feet. The applicant requests a site certificate condition establishing a minimum clearance for the 500-kV transmission line conductors of 34.5 feet from the ground "at normal operating conditions."[4] However, such a condition would allow a lesser minimum conductor clearance when the line is operating outside of normal operating conditions, such as at maximum line sag.[5] Because the model shows that maximum electric fields that would be produced by the 500-kV lattice single-circuit lattice tower configuration is 8.9 kV/meter at one meter above the ground when the line is modeled at 34.5 feet from the ground, a lesser minimum conductor clearance could result in electric fields that exceed 9 kV/m at 1 meter above the ground. Therefore, the Department recommends that the Council adopt the following condition requiring that the certificate holder design and construct the 500-kV transmission line with a minimum ground clearance of 34.5 feet under all conditions:

**Commented [KT5]:** The modeling assumed overloading and minimum clearance but did not take into account similar circumstances in addition to hot temperatures as well as when lines cross.

**Commented [IPC6R5]:** See response above clarifying that the transmission line will be designed and constructed to meet minimum ground clearances under all operating conditions and not just normal operating conditions.

[3] B2HAPPDoc3-44 ASC 27_Exhibit AA_EMF_ASC 2018-09-28, Section 3.8.
[4] B2HAPPDoc3-44 ASC 27_Exhibit AA_EMF_ASC 2018-09-28, Section 3.7.
[5] On hot days and when a transmission line is heavily loaded (e.g., on summer days when demand for electricity to run air conditioners is high), the conductor heats and expands, causing the line to sag closer to the ground.

**Recommended Siting Standards for Transmission Lines Condition 1:** To reduce or manage human exposure to electromagnetic fields, the certificate holder shall design and construct:

a. All aboveground 500-kV transmission lines such that a minimum clearance of 34.5 feet from the ground is maintained under all conditions;
b. All aboveground 230-kV transmission lines with a minimum clearance of 20 feet from the ground at normal operating conditions; and
c. All aboveground 138-kV transmission lines with a minimum clearance of 20 feet from the ground at normal operating conditions.

In areas where an existing transmission line would parallel a proposed transmission line, the electric fields within the transmission line ROW may increase or decrease depending on the proximity, load, and phasing of the parallel line.[6] Therefore, in addition to modeling the electric fields that would be produced by each transmission line alone, the applicant also modeled the interactions between the electric fields that would be produced by the 500-kV lattice structures and the electric fields that would be produced by parallel transmission lines.[7] ASC Exhibit AA, Figure AA-9 shows that existing parallel lines located near the proposed 500-kV corridors will not result in exceedances of 9 kV/m at 1 meter above the ground surface, in compliance with OAR 345-024-0090(1). The proposed 500-kV transmission line has the potential to exceed this threshold, however, where the line would cross (rather than parallel) existing transmission lines.

[applicant representations and conditions]

*Induced Voltage and Current*

The Siting Standards for Transmission Lines requires the Council to find that the applicant "can design, construct and operate the proposed transmission line so that induced currents resulting from the transmission line and related or supporting facilities will be as low as reasonably achievable."

As explained in ASC Exhibit DD, the flow of electricity in a transmission line can induce a small electric charge, or voltage, in nearby conductive objects, such as metallic objects (e.g., vehicles, equipment, metal fences, signs, and metallic roofs). An induced electric charge can flow, or

[6] A single-circuit transmission line carries one phase in each of its three conductors. The voltage and current in each phase conductor is out of sync with the other two phases by 120 degrees, or one-third of the 360 degree cycle. The fields from these conductors tend to cancel out because of this phase difference. Therefore, depending on the geometry and arrangement of the conductors in the parallel transmission line, a parallel transmission line can either increase or decrease the electric fields within the transmission line ROW. B2HAPPDoc3-44 ASC 27_Exhibit AA_EMF_ASC 2018-09-28, Section 3.2.1.

[7] The 500-kV lattice configuration would produce the highest electric fields; therefore, the applicant modeled the interaction of electric fields from parallel transmission lines with the electric fields from this transmission line configuration. B2HAPPDoc3-44 ASC 27_Exhibit AA_EMF_ASC 2018-09-28, Section 3.5.3.



**Commented [KT7]:** The proposed 500-kV transmission line has the likely potential to exceed the 9 kV/m at 1 m above the ground threshold where the line would cross (rather than parallel) existing transmission lines. How does IPC plan to design, engineer, construct and operate the transmission line to avoid an exceedance (out of compliance with the standard) at crossings.

**Commented [IPC8R7]:** Idaho Power disagrees with the suggestion that the transmission line will exceed the 9 kV/m at 1 meter above ground surface standard at crossings. Exhibit AA, Section 3.5.3 makes it clear that Idaho Power will design the crossings so that the heights and separation clearances ensure the 9 kV/m at 1 meter above ground surface standard is met: "In areas where crossings occur, the vertical transmission line height and separation will be selected during detailed design in a manner to maintain electric fields in the area of the crossing below the 9 kV/m standard." Condition 1 also ensures that Idaho Power will design the crossing heights and separation clearances to meet that standard:

***Siting Standard Condition 1:** During construction, the certificate holder shall take the following steps to reduce or manage human exposure to electromagnetic fields:*
. . .
e. In areas where aboveground transmission line will cross an existing transmission line, constructing the transmission line at a height and separation ensuring that alternating current electric fields do not exceed 9-kV per meter at one meter above the ground surface; and
. . . .

**Commented [KC9]:** The applicant's current proposed condition is:

During construction, the certificate holder shall take the following steps to reduce or manage human exposure to electromagnetic fields:
***
In areas where aboveground transmission line will cross an existing transmission line, constructing the transmission line at a height and separation ensuring that alternating current electric fields do not exceed 9-kV per meter at one meter above the ground surface

**Commented [IPC10R9]:** The proposed transmission line will be designed so that the 9kV per meter electrical field strength at one meter above the ground will not be exceeded under any/all operating conditions. This includes maximum load conditions, maximum sag conditions, and locations where the line crosses or is adjacent to other transmission lines.

become electric current, when a path to ground is presented. For example, a vehicle that is insulated from grounding by its tires and is parked under a transmission line long enough to build up a charge can cause humans that touch the vehicle to experience a momentary shock as the person becomes the conducting path for the current to flow to ground. A person can generally notice induced current if the available electrical charge is greater than 1 milliampere (mA), and at 5 mA most children (99.5 percent) are able to still let go of an electrified object.[8] The National Electric Safety Code (NESC) sets a performance standard at Rule 234G.3 limiting the steady-state current due to electrostatic effects to 5 mA.

The strength of the induced current in an object is positively related to the electric field strength of a nearby transmission line. The applicant therefore calculated the induced current expected to result for various objects located near the 500-kV lattice configuration, because this configuration would produce the strongest electric fields. Table X-X below, reproduced from Table DD-2 of ASC Exhibit DD, shows the maximum current that could be induced in several types of vehicles and agricultural equipment if those objects were located in the transmission line ROW. The maximum induced current is calculated by multiplying the factors in the middle column (derived from an Electric Power Research Institute publication) by the maximum expected electric field strength from the proposed facility (under normal operating conditions). As shown in Table X-X, cars, pickup trucks, and combines located within the ROW of the 500-kV lattice transmission line configuration would build up an inducible charge that would be less than the 5-mA threshold established by the NESC. If a large tractor-semitrailer were located parallel to and directly under the transmission line, it would have the potential to build up an inducible charge that would exceed the 5-mA threshold. However, the applicant explains that tractor-semitrailers are unlikely to drive directly under and parallel to the line; tractor-semitrailers may briefly cross under the line where the transmission line crosses a road, but in these circumstances the tractor-semitrailer would be under the transmission line for only a short duration and would not be parallel to the line. If the transmission line crossed a location where tractor-semitrailers may be parked long enough to build up an inducible charge (such as at a gas station or a parking lot), the resulting induced current may exceed the 5-mA threshold; therefore, the applicant represents that at these locations it would alter the transmission line design if necessary to ensure that the line complies with the 5-mA threshold established by the NESC.

**Table X-X: Induced Current Factors**

| Object | Isc/E (mA/kV/m) | Maximum Induced Current (mA)[1] |
|---|---|---|
| Car—L 4.6 m x W 1.78 m x 1.37 m | 0.088 | 0.78 |
| Pickup Truck—L 5.2 m x W 2.0 m x H 1.7m | 0.10 | 0.89 |
| Large Tractor-Trailer—Total Length 15.75 m Trailer: 12.2 m x W 2.4 m x H 3.7 m | 0.64 | 5.70 |
| Combine—L 9.15 m x W 2.3 m x H 3.5 m | 0.38 | 3.38 |
| Source: Table 7-8.2, EPRI AC Transmission Line Reference Book: 200 kV and Above (EPRI 2005) | | |

[8] B2HAPPDoc3-47 ASC 30_Exhibit DD_Specific Standards_ASC 2018-09-28, Section 3.4.1.

| |
|---|
| [1] Maximum induced current calculated for strongest predicted electric field of 8.9 kV/m, associated with the proposed lattice segment.<br>Isc = short-circuit current E = AC electric field<br>m = meter |

To reduce the risk of induced current and nuisance shocks, the applicant proposes to inform landowners of the risks of induced current, develop and implement a program to ground or bond conductive objects or structures that could become charged by the electric fields from the transmission line, and to follow NESC grounding requirements. The applicant therefore proposes, and the Department recommends, that the Council impose the following site certificate condition:

> **Recommended Siting Standards for Transmission Lines Condition 2:** Prior to placing the facility in service, the certificate holder shall takes the following steps to reduce the risk of induced current and nuisance shocks:
> a. Provide to landowners a map of overhead transmission lines on their property and advise landowners of possible health and safety risks from induced currents caused by electric and magnetic fields.
> b. Develop and implement a program that provides reasonable assurance that all fences, gates, cattle guards, trailers, irrigation systems, or other objects or structures of a permanent nature that could become inadvertently charged with electricity are grounded or bonded throughout the life of the line.
> c. Implement a safety protocol to ensure adherence to National Electric Safety Code grounding requirements.

In addition, the applicant states that IPC would design, construct, and operate the facility in accordance with the version of the NESC that is most current at the time final engineering of the facility is completed. The applicant proposes and the Department recommends that the Council adopt the following condition:

> **Recommended Siting Standards for Transmission Lines Condition 3:** The certificate holder shall design, construct, and operate the transmission line in accordance with the requirements of the version of the National Electrical Safety Code that is most current at the time that final engineering of the facility is completed.

Like the proposed transmission lines (the new 500 kV transmission line, rebuilt 230-kV transmission line, and rebuilt 138-kV transmission line), the Longhorn Station and communication stations have the potential to generate induced currents in nearby conductive objects. To reduce the risk of induced current and nuisance shocks from the Longhorn Station and communication stations, the applicant proposes to….[fill in once we receive more information from the IPC].

**Commented [KT11]:** EFSC Site Specific Conditions [OAR 345-025-0010] has an out-of date NESC reference. This is a draft condition ODOE is considering to replace or use in conjunction with the site-specific condition.

**Commented [IPC12R11]:** Idaho Power agrees with this proposed language referencing the NESC that is operative at the time of final design.

**Commented [KT13]:** The standard states:
*Can design, construct and operate the proposed transmission line so that induced currents resulting from the transmission line and related or supporting facilities will be as low as reasonably achievable.*

Exhibit DD says, "Longhorn Station and communication stations will be constructed in a manner to minimize induced currents in surrounding facilities" but doesn't provide any specifics.

Please explain how the Longhorn Station and communication stations would be constructed (e.g., with a grounding mat) to minimize induced currents in nearby conductive objects.

**Commented [IPC14R13]:** To reduce the risk of induced current and nuisance shocks from the Longhorn Station and communication stations, Idaho Power will design those facilities to include such features as grounding, bonding, shielding, and physical barriers such as fencing around the stations. Idaho Power will also employ signage to deter trespass and employee training to eliminate or manage shock hazards that might be experienced inside the fence.

[consider recommending a condition related to grounding the substation and communication stations]

**Commented [IPC15]:** Requiring specific grounding features beyond what already might be required by NESC is unnecessary and unsupported by any evidence in the record, as NESC already requires that such facilities be sufficiently designed and constructed to protect against electrical shock hazards. The NESC requirements protect the public who might approach such facilities from the outside of stations or on the ROW of the transmission line. They also protect employees who would be inside the stations, or work on the transmission line. Therefore, no additional grounding requirements beyond the NESC condition are required.

| Request No. | ASC Section Ref. | ASC Page Ref. | Applicable Rule (OAR 345-021- or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| ASC RAI U- 1 | Attachment U-1C | Attachment U-1C and page U-25 | | ASC Exhibit U, Attachment U-1C provides correspondence with fire prevention agencies. The Oregon Department of Forestry and the Union County Emergency<br><br>Services-Fire Department both expressed concerns about waiting times and delayed response times due to waiting for the transmission line to be de-energized. Page U-25 of Exhibit U states the ODF "Rangeland Coordinator expressed concern regarding the risk of fighting fires near energized transmission lines, because electricity could arc through the smoke and strike firefighters" However, this does not appear to be the concern of ODF described in Attachment U-1C.<br><br>Please provide a description of the procedures that IPC would employ to de-energize the transmission lines in the event of an emergency? Please include how the operation/control center notify local emergency agencies, conversely how do local emergency agencies notify the control center of an emergency that necessitates shutting the transmission line down? What are the response times associated with de-energizing the line? | A contact number directly to Idaho Power's 24/7 dispatch center will be provided to all necessary agencies for notification purposes. Upon being notified of a fire, Idaho Power dispatch will gather as much information as possible and immediately dispatches appropriate personnel to monitor the fire and/or coordinate with onsite emergency agencies.<br><br>Once onsite, and if requested, Idaho Power personnel will confirm facilities to be removed from service for safety of fire personnel and communicates this back to Idaho Power dispatch. Idaho Power dispatch then removes the line from service, relaying that information to the Idaho Power onsite personnel, who in turn communicates the condition to onsite emergency agencies.<br><br>Response time will vary, based on initial notification times to Idaho Power dispatch. Once onsite, Idaho Power personnel requesting a line outage for safety concerns can expect a line outage within a few minutes. The line would then be considered unavailable to return to service until onsite Idaho Power personnel are able to verify with onsite emergency agencies that all personnel and equipment are no longer in danger of electrical contact. |

| Request No. | ASC Section Ref. | ASC Page Ref. | Applicable Rule (OAR 345-021- or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| ASC RAI U- 2 | | Page U-25 | | Page U-25 states, “Construction workers and maintenance personnel are not trained firefighters and are not expected to fight fires. However, qualified equipment operators, at the direction of Incident Command, may use construction equipment to assist local firefighting efforts when safe to do so.”<br><br>What, who and where is Incident Command? | Text on Page U-25 is revised in the Exhibit U Errata to include the following text: In the event of a fire, the Incident Management Team may request local assistance in fire fighting if personnel have required training including the use construction equipment on the Project site.<br><br>Incident management teams (IMT’s) respond to large wildfire incidents upon the request of the local jurisdiction in which the fire is burning. Teams are comprised of overhead personnel from single or multiple agencies to come in and relieve local resources on incidents that have exceeded their capacity. IMT’s order additional resources from local, regional and national systems based on the need of the incident. In many cases, IMT’s will order qualified local equipment operators and equipment to assist in the fire suppression effort. These operators must have basic fire suppression and safety training in order to join the fire suppression effort. |
| | | | | Section 2.1.1 of the Fire Prevention and Suppression Plan states that “The Contractor and IPC will train all personnel on the measures to take in the event of a fire. The Contractor and IPC will immediately proceed to control and extinguish any fire started resulting from their activity.” Yet page U-25 states, “Construction and operations crews will implement the Fire Prevention and Suppression Plan, so that the Project will not increase the risk of fire. Construction workers and maintenance personnel are not trained firefighters and are not expected to fight fires…” | Text on Page U-25 is revised in the Exhibit U Errata deleting the following sentence:<br><br>~~Construction workers and maintenance personnel are not trained firefighters and are not expected to fight fires~~ |
| | | | | What construction personnel are expected to use the equipment listed in Section 2.1.5 of the Fire Prevention and Suppression Plan? How will they be trained? | Construction personnel that have received firefighting training provided by one or more of the Interagency Firefighting Crew Agreement Region 6 Approved MOU Training Providers. |

| Request No. | ASC Section Ref. | ASC Page Ref. | Applicable Rule (OAR 345-021- or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| ASC RAI U- 3 | Section 2.1.5 | Attachment U-3 | OAR 437-007-1315 | To reflect the requirements of OAR 437-007-1315 and in response to the comments from ODF, the revised Fire Prevention and Suppression Plan states that, "The firewatch… be qualified in the use and operation of assigned firefighting equipment and tools; be physically capable of performing assigned fire suppression activities; and be advised of single employee assignment responsibilities…. Each person providing fire watch service on an operation area must have adequate facilities for transportation and communication to be able to summon firefighting assistance in a timely manner."<br><br>Please describe during construction who will operate as the Firewatch? How will they be trained? How many personnel will receive this training? Which personnel will trained and authorized to operate the equipment listed in Section 2.1.5. See also RAI above. | During construction the construction contractor will provide staff to the position of Firewatch. Staff in the position of Firewatch will be trained to meet and implement the requirements of OAR 437-007-1315 and OAR 629-043-0030<br>Training will be provided one or more of the Interagency Firefighting Crew Agreement Region 6 Approved MOU Training Providers. The construction contractor may also decide to hire a company that provides wildland fire fighting services including firewatch. Such company would meet the _____ |
| ASC RAI U- 4 | Section 3.4.7 and 3.5.6.3 | U-18 and U-26 | | Page U-26 states "Workers suffering minor injuries will be treated at local medical facilities or emergency rooms. Workers suffering more serious injuries, were they to occur, will be taken to one of the major hospitals in the project vicinity."<br><br>Are the "local medical facilities" included in the 3 health care facilities listed in Exhibit U? | No only the major facilities/hospitals that have true emergency/trauma services are included. |
| | | | | What are considered "minor injuries" that would require visitation to a medical facility? | Any injury requiring treatment by a licensed medical provider will require visitation to a medical facility. |
| | | | | Will there be any first aid materials or facilities provided on-site? | Yes, first aid materials will be provided on-site during construction. The type and distribution of first aid materials on site will be included in the Environmental and Safety Training Plan. See Public Services Condition 4. |
| | | | | Will any personnel be required to hold active Fist Aid and CPR certifications? | The need for personnel to hold active First Aid and CPR certifications will be included in the Environmental and Safety Training Plan. See Public Services Condition 4. |
| | | | | How will workers suffering from a minor or serious injury be transported to a medical facility? | The method of transportation of injured workers to a medical facility will be decided in the field at the time of injury. The chosen method will be the method the provides the best care for the injured worker. A summary of methods of transportation of injured workers to a medical facility will be included in the Environmental and Safety Training Plan. See Public Services Condition 4. |

| Request No. | ASC Section Ref. | ASC Page Ref. | Applicable Rule (OAR 345-021- or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| ASC RAI U- 4 | Section 3.4.7 and 3.5.6.3 | | | In its letter on the ASC, Baker County expressed concerns about the response times and potential impacts to medical responders if they were committed to a project-related incident and would not be available to provide other services.<br><br>Please provide a discussion of the ambulance services that serve the analysis area and how many ambulances are available to serve multiple incidents? | The B2H project is rural in nature and IPC would not rely on ambulance services to drive to a remote location emergency. As stated in Exhibit U (Section 3.4.7) each medical facility has access to Life Flight and/or Airlink. Life Flight has bases with helicopters in La Grande, Ontario, Pendleton, and Boise that could service the analysis area. Each medical provider in the analysis area as listed in Exhibit U, Section 3.4.7, have indicated that they have adequate capacity and the Project should not adversely impact these medical facilities. In addition, Saint Alphonsus Medical Center was contacted in March 2019 and has indicated that they could likely serve 3,500 more emergency room visits a year and would have capacity to still serve the community (see errata for Exhibit U). For non-emergency medical attention, personnel would be driven to the nearest medical facility for treatment. |

**Boardman to Hemingway Transmission Line Project –Application for Site Certificate (ASC)**
**Oregon Department of Energy**
**Request for Additional Information for the ASC (ASC RAI) Exhibit W – Retirement**
**February 2019**

| Request No. | ASC Section Ref. | ASC Page Ref. | Applicable Rule (OAR 345-021- or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| ASC RAI W- 1 | 3.2 | W-3 | | Exhibit W describes decommission the facilities associated with the switching station "For the station, these facilities include an interconnecting bus system, switches, breakers, and instrumentation for the control and protection of the equipment."<br><br>However, this doesn't match with the Cost Estimating Worksheet, which shows "N/A" for the switch yard on pages 25 and 26 of Exh W PDF) and $0 for the switch yard on page 19 of the PDF.<br><br>Please include costs associated with decommissioning the station. | If the transmission line was decommissioned, the switching station would remain in place and not be decommissioned because it would continue to be used by other transmission lines entering and existing the station. In other words, it would continue to have value beyond the B2H Project, and therefore, it would not be decommissioned, which is why the worksheet indicates "N/A" and the cost should not be included. |
| ASC RAI W- 2 | 3.2 | W-3 | | Exhibit W states: "This restoration will include restoring the site to a condition suitable for uses comparable with the surrounding land uses, intended land use, and then-current technologies."<br>What is meant by current technologies? | "Then-current technologies" refers to how land use might change between now and in the future. For example, if the future land use of some agriculture land utilized new farming techniques, the restoration would match or accommodate the future land use and technologies, and not be limited how the land is used today. |

**Boardman to Hemingway Transmission Line Project –Application for Site Certificate (ASC)**
**Oregon Department of Energy**
**Request for Additional Information for the ASC (ASC RAI) Exhibit W – Retirement**
**February 2019**

| Request No. | ASC Section Ref. | ASC Page Ref. | Applicable Rule (OAR 345-021- or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| ASC RAI W- 3 | | Attachment W-1 and Section 3.3 | | PDF Page 20 of the Exh W PDF states “3rd Quarter 2016 Dollars” at the top of the page, but then the GDP index is for 2nd quarter 2016, and the text of Exh W (Section 3.3) states that it’s in 4th quarter 2016 dollars.<br><br>What quarter of 2016 was used to generate the cost estimate? | 3rd quarter, August 15, 2016 |
| ASC RAI W- 4 | | Attachment W-1 and Exhibit W | | The Cost Estimate states “Adjusted to Current Dollars” and “Total Site Restoration Cost (current dollars)”<br><br>What quarter and year were last used to update for inflation? | 3rd quarter, August 15, 2016 |

| Request No. | ASC Section Ref. | ASC Page Ref. | Applicable Rule (OAR 345-021- or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| ASC RAI W- 5 | | Attachment 1 | | The Site Restoration Cost Estimating Guide recommends that the contingency for administrative and management expenses total 10 percent (10%) of the cost estimate; however, the applicant's cost estimate applies a value of only 4 percent (4%) yes does not explain the justification for proposing the lesser percentage. Please provide such justification. | A project the size of B2H, that covers such a large area is expected to realize an economy of scale that would justify a 4% contingency for Site Restoration. Also, the B2H project in operation will not result in any hazardous conditions that would be difficult or unusually expensive to restore (i.e. everything to be removed are inert materials) thus the lower restoration contingency is appropriate. The Project Owner Engineer (HDR) has extensive experience restoring transmission line projects that have demonstrated a 4% contingency is appropriate. |

| Boardman to Hemingway Transmission Line Comments on the Application for Site Certificate (ASC) From Oregon Department of Fish and Wildlife | | | | |
|---|---|---|---|---|
| **Exhibit** | **Rule/ Ordinance/Law Reference** | **Pg. / Para. / Sentence Reference (as needed)** | **Compliance Comment or Condition Language** | **IPC Response** |
| L | OAR 635-008-0120 | Protected Areas | The project proposes to cross upland habitat on Ladd Marsh Wildlife Area (LMWA), which is land owned and managed by ODFW. There is an existing transmission line and natural gas pipeline also located on Ladd Marsh Wildlife Area, in close proximity to the proposed ROW. The location of the proposed crossing functions as winter habitat for big game, and therefore ODFW expects that the best management practices and mitigation plans for Big Game Winter Range (as described in Exhibit P1) will apply to lands within the LMWA as well. When the time comes for planning roads, gated access, and timing of construction activity, ODFW recommends those plans be coordinated with the Wildlife Area Manager. | It's unclear what specific "best management practices and mitigation plans" ODFW is referring to in this comment. The following management plans, and the best management practices specified therein, would apply to the portion of the project location on the Land Marsh Wildlife Area parcels: Reclamation and Revegetation Plan (Attachment P1-3); Vegetation Management Plan (Attachment P1-5); and Noxious Weed Plan (Attachment P1-5). Idaho Power will submit final versions of those plans to ODOE for its approval. ODFW is free to review and comment on those plans through their role as a reviewing agency.<br><br>To the extent the parcels contain elk or mule deer winter range, ground disturbing activities would generally be restricted between December 1 to March 31 (see Fish and Wildlife Condition 10) and access control would be employed on project access roads with ODFW approval, as the landowner (see Fish and Wildlife Condition 27).<br><br>Regarding timing of construction, besides the temporal limitations discussed above, Idaho Power will work with ODFW as the landowner to avoid or minimize impacts from construction work. |
| L | ORS 97.740, ORS 358.905-358.962, ORS 390.235, and OAR 736-051-0080 | Protected Areas | ODFW is aware of cultural resources in the vicinity of the proposed crossing of Ladd Marsh Wildlife Area. Under Oregon State Law (ORS 97.740, ORS 358.905-358.962, ORS 390.235, and OAR 736-051-0080) archaeological sites are protected on all non-federal public lands. To ensure compliance with applicable state cultural resource laws, ODFW requires Idaho Power contact the Oregon State Historic Preservation Office (SHPO) and provide documentation of concurrence from SHPO for the portion of the project that crosses Ladd Marsh Wildlife Area. If the overall project is determined by Idaho Power to have a federal nexus then documentation of compliance with relevant federal law, including Section 106 of the National Historic Preservation Act, may be provided instead. | Idaho Power has submitted cultural resource survey information for the Project to SHPO, including that portion of the Project which crosses LMWA (see Exhibit S). |
| P1 | (standard ODFW comment) | Page 21; Condition 2 and 13 | If construction activities encounter federally listed species covered by the Endangered Species Act, or those raptors and eagles covered the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act, ODFW recommends IPC contact the U.S. Fish and Wildlife Service given their federal jurisdiction. | Recommendation noted. As part of the NEPA permitting, IPC will be required to adhere to the ESA, MBTA, and bald and golden eagle act. Please refer to the NEPA POD, Appendix B1 for survey, monitoring, and reporting requirements for federal agencies. This does not need to be included in EFSC condition language as the comment addresses federal, and not state, jurisdiction. |
| P1 | OAR 635-022-0060; OAR 635-415-0025 | Page 26; Section 3.3.2 Category 2 habitat | In the time that has passed since the original design of biological surveys for the B2H project, ODFW has identified pygmy rabbits as State Sensitive Species and has recommended mitigation for pygmy rabbits on other energy facility projects proposed in the sagebrush habitats of eastern Oregon. Pygmy rabbits are dependent on mature sagebrush and deeper soils, and given the conservation concern regarding their populations, ODFW has determined active pygmy rabbit colonies meet the definition of Category 2 habitat. | As requested, Idaho Power will add pygmy rabbit to the list of pre-construction surveys as follows:<br><br>***Fish and Wildlife Condition 2:*** *Prior to construction, the certificate holder shall conduct, as applicable, the following biological surveys on all portions of the site boundary, regardless of whether those portions have been surveyed at the time of issuance of the site certificate:* |

| Boardman to Hemingway Transmission Line Comments on the Application for Site Certificate (ASC) From Oregon Department of Fish and Wildlife | | | | |
|---|---|---|---|---|
| **Exhibit** | **Rule/ Ordinance/Law Reference** | **Pg. / Para. / Sentence Reference (as needed)** | **Compliance Comment or Condition Language** | **IPC Response** |
| | | | ODFW understands that pygmy rabbits were not detected in the initial B2H surveys, where access was granted. However, ODFW recommends that pygmy rabbits be a part of pre-construction surveys, and if active pygmy rabbit colonies are found within areas proposed for temporary or permanent disturbance, ODFW recommends they be contacted. At that time, ODFW would work with IPC to explore avoidance options including spanning colonies, locating tensioning/pulling/fly yards outside of colonies, and assure that unavoidable impacts are mitigated according to policy. | *a. Washington ground squirrels;* ~~*and*~~<br>*b. Raptor Nests*~~.~~*;*<br>*c. Pigmy rabbits; and*<br>*. . . .*<br><br>And as set forth in the forthcoming errata sheet for Exhibit P1, Idaho Power has addressed pygmy rabbit colonies as Category 2 habitat in Section 3.3.2 as follows:<br><br>Category 2 habitat:<br>• ODFW elk (*Cervus canadensis nelsoni*) winter range (ODFW 2013a);[1]<br>• ODFW mule deer (*Odocoileus hemionus*) winter range (ODFW 2013a);<br>• Bighorn sheep (*Ovis canadensis*) herd ranges (ODFW 2013b);<br>• Areas of potential ground squirrel use, defined as areas adjacent to and within 4,921 feet (1.5 kilometers [km]) of WAGS Category 1 habitat, but not occupied by any squirrels either for burrowing or foraging, which is of similar habitat type and quality to the adjacent WAGS Category 1 habitat;<br>• Fish-bearing streams;<br>• Bat roosts and hibernacula other than caves; and<br>• Pygmy rabbit (*Brachylagus idahoensis*) colonies.<br><br>In addition, Idaho Power has added pygmy rabbit to the language in Fish and Wildlife Condition 14:<br><br>***Fish and Wildlife Condition 14****: During construction, if active pygmy rabbit colonies or the roost of a State Sensitive bat species is observed during the biological surveys set forth in Fish and Wildlife Conditions 1, 2, or 3, the certificate holder shall submit to the department for its approval a notification addressing the following:*<br>*a. Identification of the State Sensitive bat species observed;*<br>*b. Location of the pygmy rabbit colony or bat roost; and*<br>*c. Any actions the certificate holder will take to avoid, minimize, or mitigate impacts to the pygmy rabbit colony or bat roost.* |
| P1, see also Exhibit BB Fish Passage | OAR 635-022-0060; OAR 635-415-0025; OAR 635-412 | Page 73; Section 3.5.5.6 | ODFW Fish Division and local District Fish Programs have reviewed this section, and based on the current application (subject to finalization prior to construction), ODFW finds fish impacts to be adequately considered and addressed. It is ODFW's understanding that fish passage plans and approvals have yet to be finalized prior to construction. | Comment noted. Fish passage plans and designs will need to be finalized based on final design and once access has been granted to survey all necessary waters. |

[1] See Exhibit P3 for a complete discussion of elk habitat categorization.

| Boardman to Hemingway Transmission Line Comments on the Application for Site Certificate (ASC) From Oregon Department of Fish and Wildlife | | | | |
|---|---|---|---|---|
| **Exhibit** | **Rule/ Ordinance/Law Reference** | **Pg. / Para. / Sentence Reference (as needed)** | **Compliance Comment or Condition Language** | **IPC Response** |
| P1-3 Reclamation and Revegetation Plan | OAR 635-022-0060; OAR 635-415-0025 | Page 20; Section 6.0 Reclamation success standards, monitoring, and maintenance | Revegetation and reclamation serve an important function in minimizing impacts to wildlife habitat. Some habitats that will be impacted by this project, namely sagebrush shrubland and forests, take upwards of 10 to 50 years to recover their pre-disturbance form and function. IPC has offered a robust revegetation plan, however ODFW stands by its previous recommendation that reclamation/revegetation monitoring be performed for longer than 5 years post-construction. ODFW recommends IPC utilize an adaptive monitoring schedule and management plan that can address Project impacts as long as necessary to achieve success criteria.<br><br>ODFW also finds IPC's proposed reclamation standards (Table 6) to be low relative to what ODFW has recommended and supported for other projects in similar habitats. Below are the recommendations ODFW made to ODOE for the B2H Notice of Intent, which we believe are still appropriate:<br><br>[ODFW recommends the following criteria for reclamation success]:<br>1. Maintain percent foliar cover of weed species within reclamation sites at a level equal to or less-than the paired control site. This will reduce the risk of invasive weeds outcompeting favorable vegetation and creating a source population for dispersing weed species.<br>2. Reclamation actions should prioritize establishment of native perennial bunchgrasses. Native, perennial bunchgrasses are our best defense against fire-prone annual grasses that threaten the arid habitats crossed by this project. Maintain >=70% percent foliar cover of native perennial bunchgrasses of the paired control site. The remaining percentage of vegetation can be other desirable vegetation species not present at the control site or functional bare ground.<br>3. Reclamation actions in forested and shrub habitats should have appropriate woody species in the plant mix. Woody species should be plugged using appropriate aged plants to ensure the greatest possible revegetation success. Successful revegetation of sagebrush habitats should have at least 15 percent sagebrush foliar cover.<br>4. Maturity of vegetation within paired control sites should be used to determine the reclamation monitoring timeframe. Monitoring should be conducted on a regular 1-2 year interval until vegetation is established in a similar species composition as the paired control site. Monitoring efforts should then be extended to every 5-10 years (depending on habitat vegetation) until the vegetation reaches the same maturity as the paired control site when the Project impact occurred. | The Reclamation and Revegetation Plan provides for the possibility for additional monitoring beyond 5 years, including additional reclamation efforts and compensatory mitigation, stating:<br><br>• If after 5 years of monitoring some sites have not attained the success criteria or if at any point during the annual monitoring it is clear that reclamation cannot be successful (including private landowner denial of reclamation activities), IPC will coordinate with ODOE regarding appropriate steps forward. At this point, IPC may suggest additional reclamation techniques or strategies or monitoring, or IPC may propose mitigation to compensate for any permanent habitat loss.<br><br>Idaho Power thanks ODFW for its recommendations on success criteria. However, the success criteria currently set forth in the Reclamation and Revegetation Plan are sufficient to meet the EFSC Fish and Wildlife Siting Standard and for compliance purposes—e.g., Idaho Power's success criteria are similar to those in the Revegetation Plan approved by EFSC for the Wheatridge Wind Energy Facility site certificate). Therefore, neither ODOE nor EFSC should adopt ODFW's proposed criteria. |

| Boardman to Hemingway Transmission Line Comments on the Application for Site Certificate (ASC) From Oregon Department of Fish and Wildlife | | | | |
|---|---|---|---|---|
| **Exhibit** | **Rule/ Ordinance/Law Reference** | **Pg. / Para. / Sentence Reference (as needed)** | **Compliance Comment or Condition Language** | **IPC Response** |
| P1-3 Reclamation and Revegetation Plan | OAR 635-022-0060; OAR 635-415-0025 | Page 29; Section 6.5 Adaptive Management and Site Release | ODFW does not support the concept of waivers in the event of revegetation failure because that equates to permanent impact without offset, and the mitigation policy calls for no net loss. In the event of reclamation failure, despite remedial efforts, temporary impacts to wildlife habitat become permanent impacts. In these cases, the difference in compensatory mitigation offsets should be addressed (for example, if temporary impacts were mitigated at a 0.5:1 rate, the now permanent impacts would need to be mitigated at a 1:1 (or higher) rate). To account for such cases, ODFW recommends compensatory mitigation also be listed as a potential adaptive management option in the reclamation plan. | Use of the term "waiver" was brought to attention during RAI 4. It was Idaho Power's intent to remove this term from the Reclamation and Revegetation Plan and replace it with the language recommended by ODOE in RAI 4. The term was removed in all but one location of the Reclamation and Revegetation Plan. It is in error that this term is still in the Reclamation and Revegetation Plan. See Exhibit P errata sheet for the changes to text in Section 6.5 of the Reclamation and Revegetation Plan to eliminate the "waiver" issue. |
| P1-5 Noxious Weed Plan | OAR 635-022-0060; OAR 635-415-0025 | Page 26; Section 6.1 Monitoring | Linear projects such as transmission lines and pipelines, often inadvertently spread noxious weeds across the landscape. This is perhaps the greatest risk of this project to Oregon's wildlife habitats. For this reason, ODFW believes noxious weed monitoring and control is an extremely important minimization measure (per OAR 635-415). IPC is proposing noxious weed monitoring only for the first 5 years of the project, post-construction. If control efforts are not successful, IPC will consult with ODOE on next steps and may request a 'waiver'. ODFW contends that noxious weed monitoring and control ought to be the obligation of the applicant for the life of the project impact, for if this project led to noxious weed expansion, that could be interpreted as an expansion of project footprint. If the project's footprint were to expand over time, the areal extent of the project impact would need to be recalculated and could impact the compensatory mitigation quantities.<br><br>Long-term monitoring and successful treatment of weeds are important to the success of habitat restoration efforts and for habitat health. ODFW recommends that IPC monitor and control invasive weeds beyond the initial 5-year treatment period on a regular schedule of every 7 –10 years for the life of the Project. Treatment should occur when IPC has identified established weeds at a rate higher than pre-Project conditions. The Department recommends IPC work collaboratively with ODOE and the Department to define an appropriate monitoring schedule. | Use of the term "waiver" was brought to attention during RAI 4. IPC made changes to the Reclamation and Revegetation Plan as recommended by ODOE. It is in error that those changes were not also made to the Noxious Weed Plan. See Exhibit P errata for the changes to text in Sections 5.3.4 and 6.1 of the Noxious Weed Plan.<br><br>Further, Section 5.3.4 of the Noxious Weed Plan provides for the possibility for weed control beyond 5 years (appropriate plan for long-term weed control) in areas of the Project where weed control has been <u>successful</u>, stating:<br><br>• Noxious weed control efforts will occur on an annual basis for the first 5 years post-construction. When it is determined that an area of the Project has successfully controlled noxious weeds at any point during the first 5 years of control and monitoring, IPC will request concurrence from ODOE. If ODOE concurs, IPC will consult with ODOE to design an appropriate plan for long-term weed control.<br><br>Because the Noxious Weed Plan provides for adaptive management that may include monitoring after the 5-year period, no further changes are necessary to identify specific monitoring periods at this time, as requested by ODFW. |
| P1-6 Fish and Wildlife Habitat Mitigation Plan | OAR 635-022-0060; OAR 635-415-0025 | Page 15; Section 3.3.2; Table 9. Accounting for Mitigation Debit for Permanent Direct Impacts, Category 2 | IPC proposes to mitigate for permanent direct impacts in Category 2 habitat at the rate of >1 acre offset per 1 acre of impact (>1:1). The ODFW Fish and Wildlife Habitat Mitigation Policy sets forth a goal for Category 2 habitats of no net loss of either habitat quantity or quality and to provide a net benefit of habitat quantity or quality. While the proposed rate of >1:1 technically meets the 'no net loss' of quantity, if the rate tends closer to 1 (for example 1.1:1, as opposed to 2:1) it does not leave much of a 'buffer' to achieve no net loss of quality, and even more difficult to achieve net gain in quality. A larger ratio creates a buffer to safeguard against failure of the habitat restoration/enhancement activities that IPC would be performing as part of their 'net benefit' activity. The narrower the ratio, the more in-depth | Idaho Power thanks ODFW for its recommendations on Category 2 mitigation. However, as ODFW acknowledges, the >1:1 mitigation offset meets the no-net-loss standard, and therefore, no further changes to the HMP are necessary. |

| Boardman to Hemingway Transmission Line Comments on the Application for Site Certificate (ASC) From Oregon Department of Fish and Wildlife | | | | |
|---|---|---|---|---|
| **Exhibit** | **Rule/ Ordinance/Law Reference** | **Pg. / Para. / Sentence Reference (as needed)** | **Compliance Comment or Condition Language** | **IPC Response** |
| | | | monitoring ODFW would recommend to ensure that the goals of no net loss in quantity and quality were achieved. This is the reason most project applicants opt for a larger mitigation ratio (such as 2:1) in category 2 habitats, so they can have some portion of the mitigation area that is struggling to provide uplift while still meeting the net benefit goal. | |
| P1-6 Fish and Wildlife Habitat Mitigation Plan | OAR 635-022-0060; OAR 635-415-0025 | Page 15; Section 3.3.2; Table 10. Accounting for Mitigation Debit for Temporary Direct Impacts, Category 3 and 4 | Similar to the comment provided above, the ratio of <1:1 could meet the policy but if the rate of mitigation is 0.1:1 it will be unlikely that IPC can meet the goals of the policy with regard to temporal loss. If the rate of mitigation is closer to 0.5:1 or 0.9:1 it becomes more obvious that temporal habitat loss will be adequately addressed. | Again, Idaho Power thanks ODFW for its recommendations, but as ODFW acknowledges, the <1:1 mitigation offset meets the mitigation standard, and therefore, no further changes to the HMP are necessary. |
| P2 | OAR 635-140-0000 - 0025 | P2-12 / Section 3.6 Baseline Surveys | Due to changes in sage-grouse abundance and habitat use over time, sage-grouse lek survey data has a 10-year shelf-life. Before construction and calculation of mitigation responsibility, the project proponent should resurvey areas for sage- grouse leks where previous surveys were conducted 10 or more years prior to construction. This resurvey effort should be minimal because ODFW and BLM have significantly increased survey efforts for sage-grouse leks and the project proponent will only be requested to survey areas that have been surveyed within 10 years prior to project construction. The project proponent must coordinate with ODFW to determine where resurveys should be conducted. | Idaho Power understands the dynamic nature of sage-grouse habitat use and the related concept that surveys may have a temporal shelf life. That said, Idaho Power's compensatory mitigation requirements will be dictated by the State's Sage-Grouse Habitat Quantification Tool, which has not been finalized so it's unclear what survey information, if any, will be required to run the Tool for the Project. Accordingly, while Idaho Power acknowledges that certain sage-grouse surveys may need to be updated prior to construction, Idaho Power suggests that any new condition language regarding surveys should defer to the forthcoming HQT protocols in general terms and not specify any specific survey protocol as suggested by ODFW here. That way, the condition language will be flexible enough to incorporate the as-yet-defined HQT protocols, which may differ from ODFW's current proposal. Idaho Power includes the following change to the pre-construction survey condition language in its Exhibit P errata:<br><br>***Fish and Wildlife Condition 2:*** *Prior to construction, the certificate holder shall conduct, as applicable, the following biological surveys on all portions of the site boundary, regardless of whether those portions have been surveyed at the time of issuance of the site certificate:*<br>*a. Washington ground squirrels;* ~~*and*~~<br>*b. Raptor Nests*~~*.*~~*;*<br>*c. Pigmy rabbits; and*<br>*d. Greater sage-grouse, as necessary for the State of Oregon to calculate the amount of sage-grouse habitat compensatory mitigation required for the facility using Oregon's Sage-Grouse Habitat Quantification Tool.* |

| Boardman to Hemingway Transmission Line Comments on the Application for Site Certificate (ASC) From Oregon Department of Fish and Wildlife | | | | |
|---|---|---|---|---|
| **Exhibit** | **Rule/ Ordinance/Law Reference** | **Pg. / Para. / Sentence Reference (as needed)** | **Compliance Comment or Condition Language** | **IPC Response** |
| P2 | OAR 635-140-0000 - 0025 | P2-17 / Fish and Wildlife Condition 25: | Condition 25 indicates that mitigation for project impacts to sage-grouse and their habitats will not be calculated or provided until the 3rd year of operation in order to incorporate final analysis of indirect impacts from project roads. Postponing mitigation from initial project construction impacts through year 3 of project operation will result in a detrimental temporal loss of sage-grouse habitat. This several-year loss of sage-grouse habitat does not meet OAR 635-140-0010 and 635- 140-0025. To comply with these policies, ODFW proposes that the project proponent reduce prolonged loss of sage-grouse habitat by calculating and providing mitigation for sage-grouse in a 2 stage process. First, the project proponent should fully mitigate, as outlined in OAR 635-140-0025(3), for areas of known, direct (towers, roads, pulling & tensioning area, etc.) and indirect project impacts (excluding roads) prior to construction. Second, upon completion of the traffic study in year 3 of operation, the project proponent should provide mitigation for any remaining indirect impacts to sage-grouse habitat identified from the project road analysis. Mitigation for indirect road impacts should be established immediately after finalizing the road analysis. Mitigation will be calculated using the ODFW Habitat Quantification Tool (HQT), and can be completed through permittee-responsible offsite mitigation or payment into ODFW's In-Lieu Fee program. | Idaho Power's approach to sage-grouse mitigation already appears to be aligned with ODFW's comment. Fish and Wildlife Conditions 8 and 21 provide that Idaho Power will implement sage-grouse conservation actions during construction. Then, under Fish and Wildlife Condition 25, Idaho Power will provide traffic data to the State so it can calculate access road mitigation using the Sage-Grouse Habitat Quantification Tool. After receiving the State's calculations, Idaho Power will provide a report to ODOE demonstrating that Idaho Power's conservation actions have already fully covered the State's final mitigation calculations, and if not, Idaho Power will include additional compensatory mitigation in the report. In either scenario, consistent with ODFW's proposal, Idaho Power will commence mitigation for impacts (direct and indirect) from all facility components other than the access roads during construction. The plan also may, at Idaho Power's discretion, include additional mitigation that may ultimately be shown to cover the access roads impacts; but at a minimum, it will cover impacts from all non-access-road facility components as proposed by ODFW. And after the State provides the final impact calculations after receiving the traffic study results, Idaho Power will demonstrate that all impacts (from roads or otherwise) will be mitigated either because the existing conservation actions were overly-conservative and already sufficient to cover the road impacts, or because Idaho Power proposes additional conservation actions to address any uncovered road impacts.<br><br>*Idaho Power includes the following changes to the conditions in its Exhibit P errata to make this clear:*<br><br>***Fish and Wildlife Condition 8:*** *Prior to construction, the certificate holder shall finalize, and submit to the department for its approval, a final Sage-Grouse Habitat Mitigation Plan.*<br>. . .<br>*b. The final Sage-Grouse Habitat Mitigation Plan shall address the potential sage-grouse habitat impacts through mitigation banking, an in-lieu fee program, development of mitigation projects by the certificate holder, or a combination of the same.*<br>. . .<br>*iii. The final Sage-Grouse Habitat Mitigation Plan shall include compensatory mitigation sufficient to address impacts from, at a minimum, all facility components except indirect impacts from access roads. As referenced in Fish and Wildlife Condition 25, the certificate holder shall demonstrate during or about the third year of operation that sage-grouse habitat mitigation shall be commensurate with the final compensatory mitigation calculations, which will be based on the as-constructed facility and will include indirect impacts from access roads, either by showing the already-implemented mitigation is sufficient to cover all facility component impacts, or by proposing additional mitigation to address any uncovered impacts.*<br>. . . . |

| Boardman to Hemingway Transmission Line Comments on the Application for Site Certificate (ASC) From Oregon Department of Fish and Wildlife | | | | |
|---|---|---|---|---|
| **Exhibit** | **Rule/ Ordinance/Law Reference** | **Pg. / Para. / Sentence Reference (as needed)** | **Compliance Comment or Condition Language** | **IPC Response** |
| P2 | OAR 635-140-0000 - 0025 | P2-22 / Table P2-6 | ODFW recommends Table P2-6 identify the need for compensatory mitigation for permanent indirect impacts from project access roads. Roads can have long lasting indirect impacts on sage-grouse habitat as vehicle traffic results in auditory impacts and human presence can interfere with sage-grouse use of habitat adjacent to roads. ODFW will request compensatory mitigation for new project roads or existing roads with increased traffic rates if access control cannot be implemented. ODFW will use the HQT to calculate a mitigation responsibility and assimilate any minimization measure proposed by the project proponent. Use this information to update relevant sections such as on page P2-23. | The requested information is already provided. Table P2-6 provides for compensatory mitigation for permanent indirect impacts to roads. Under the Mitigation Measures column, Table P2-6 reads, “Permanent indirect impacts from the access roads will be mitigated by . . . implementing the Sage-Grouse Habitat Mitigation Plan.” Fish and Wildlife Conditions 8, 21, and 25 set forth the framework for implementation of the Sage-Grouse Habitat Mitigation Plan. These include Idaho Power providing the State of Oregon the information necessary to calculate compensatory mitigation. The information necessary includes final design prior to construction and the as-built design post-construction including the results of traffic studies. It is Idaho Power’s understanding and intent that the HQT will calculate compensatory mitigation requirements for Project roads that are part of the final design and as-built facility. |
| P2 | OAR 635-140-0000 - 0025 | P2-24 / Table P2-7 | Table P2-7 describes temporary indirect impacts to sage-grouse habitat from access roads and invasive plant species. ODFW requests that the project proponent also address temporary indirect impacts that will be generated from the construction of the transmission line, associated ancillary features, and use of any multi-use or fly yards within sage-grouse habitat. | Idaho Power addresses the effects from the transmission line, associated ancillary features, and multi-use or fly yards in the discussions on permanent and temporary direct impacts from vegetation clearing in Section 3.7.3 of Exhibit P2. |
| P2 | OAR 635-140-0000 - 0025 | P2-27 / Third paragraph | ODFW requests the project proponent coordinate design and execution of the project road traffic analysis to ensure state considerations are met. | Per Fish and Wildlife Condition 3, Idaho Power will submit the traffic study to ODOE for its approval, and ODFW is free to review the plan as a reviewing agency. Before that time, Idaho Power anticipates working with ODFW in the development of the plan before submittal to ODOE to benefit from ODFW’s knowledge on the subject, but Idaho Power sees no need to specify that in a condition as such coordination is not necessarily required. |
| P3 | OAR 635-022-0060; OAR 635-415-0025 | Fish and Wildlife Condition 27 | ODFW recommends that IPC provide confirmation of access control on relevant facility access roads, and that the access control be included in monitoring/reporting so as to ensure that disturbance to elk populations are minimized. | Idaho Power is committed to pursuing access control on all facility access roads in sensitive elk and sage-grouse habitat, subject to landowner approval (see Fish and Wildlife Condition 27). However, it is the responsibility of the landowner/local law enforcement to enforce such access control. |
| P3 | OAR 635-022-0060; OAR 635-415-0025 | Monitoring | ODFW recommends IPC develop a plan for deploying counters in collaboration with ODFW to ensure the goals of the monitoring are met. It would be helpful for this plan to identify which category roads will be monitored, where, how many, etc. | As discussed above, Idaho Power anticipates working with ODFW to develop the traffic study and will address these types of specific suggestions at that time. |
| Q | OAR 345-022-0070; ORS 496.171-192; OAR 635-100-0105; OAR 635-415 | Section 3.2 Methods, Washington ground squirrel | It is ODFW’s understanding that the majority of the proposed project has not yet been surveyed for Washington grounds squirrels (WAGS) due to limitations of access. Given the last date of survey (2014), ODFW notes that all WAGS areas will need to be re-surveyed because we are beyond the standard three-year shelf life for those survey data.<br>Upon further review of the survey methods for WAGS, ODFW realized that previous survey was not in line with our recommended standard survey methodology. ODFW apologizes for not recognizing this sooner. IPC’s analysis area consists of the Right- of-Way plus a ½ mile buffer to provide flexibility in potential ground disturbance for roads, laydown sites, or other ground-disturbance purposes. | Idaho Power understands the shelf-life of WAGS surveys, and in Fish and Wildlife Condition 2, Idaho Power is proposing to survey all areas of the site boundary for WAGS whether those areas have been previously surveyed or not, consistent with ODFW’s comment here.<br><br>Idaho Power will conduct the pre-construction WAGS surveys referenced in Fish and Wildlife Condition 2 using the 1,000-foot buffer as recommended by ODFW. Idaho Power has included this information in the Exhibit P1 Errata for Fish and Wildlife Condition 2, as shown above. |

| Boardman to Hemingway Transmission Line Comments on the Application for Site Certificate (ASC) From Oregon Department of Fish and Wildlife | | | | |
|---|---|---|---|---|
| **Exhibit** | **Rule/ Ordinance/Law Reference** | **Pg. / Para. / Sentence Reference (as needed)** | **Compliance Comment or Condition Language** | **IPC Response** |
| | | | The WAGS survey extended out an additional 785 feet beyond the ½ mile buffer. ODFW did not correct this distance in its previous reviews, however, the standard methodology recommends survey out an additional 1000 feet beyond areas of potential ground disturbance. ODFW recommends that future WAGS surveys include this additional 215 feet. | |
| Q | OAR 345-022-0070; ORS 496.171-192; OAR 635-100-0105; OAR 635-415 | Page Q-21; Impacts to Washington Ground Squirrel habitat | In the first paragraph on page Q-21, IPC discusses potential impacts to habitats occupied by WAGS. Mid-paragraph IPC states "temporary impacts to category 2 WAGS habitat in agricultural areas will likely be short-term…". It is not clear if IPC then included active agricultural areas in its calculation of impacts, however, ODFW does not consider active agricultural areas to be WAGS habitat because the ground disturbance precludes occupancy. | The Exhibit Q errata addresses this comment as follows:<br><br>***Washington Ground Squirrel Surveys***<br><br>The objective of these surveys was to identify the presence of WAGS colonies in the vicinity of the Project so that impacts to WAGS may be avoided and/or minimized. The protocols used during the WAGS surveys were based on the survey methods described in Morgan and Nugent (1999). The details and justifications for these methods are provided in the Revised Final Biological Survey Work Plan (Exhibit P1, Attachment P1-2).<br><br>The survey area extends from Bombing Range Road in Morrow County east to East Birch Creek Road south of Pilot Rock, Oregon, in Umatilla County (milepost [MP] 0 to 64 of the Proposed Route). ODFW considers a 785-foot buffer in continuous suitable habitat around WAGS colonies as Category 1 habitat. As a result, the survey area consisted of the ~~analysis area~~ Site Boundary plus a 785-foot buffer in suitable habitat. Suitable habitat for WAGS includes native grasslands and shrub-steppe; however, the species is also known to use lesser quality habitat such as non-native annual grasslands. IPC has identified a total of 18,263 acres of survey area. |
| Q | OAR 345-022-0070; ORS 496.171-192; OAR 635-100-0105; OAR 635-415 | Page Q-75; Washington Ground Squirrel Monitoring | To be consistent with ODFW recommendations on other EFSC projects with potential impacts to WAGS, ODFW recommends long-term monitoring of active colonies. The purpose of this long-term monitoring is to assess adequacy of the 785- foot buffer and to monitor for any potential drift in colony extent that may require some additional avoidance measures in the O&M phase of the project to avoid potential take of WAGS. ODFW recommends surveys of existing, active colonies plus an additional 500 feet. Frequency would be years 1, 3, 5, and then at 5-year intervals for the life of the project with reporting to ODFW and ODOE. | Typical O&M would be limited to trucks driving the ROW once or twice a year. Because of the de minimis nature of the potential impact involved with these visits, no WAGS monitoring should be required post-construction. |

**Oregon Department of Energy**
**Request for Additional Information for the ApASC (ApASC RAI) Exhibit XXX – EXHIBIT DSL Comments**
**November 2, 2018**

| Request No. | ApASC Section Ref. | ApASC Page Ref. | Applicable Rule (OAR 345-021- or other as indicated) | Request for Additional Information | Response |
|---|---|---|---|---|---|
| Exhibit J Parts 1, 2, 3; JPA Form Block 6 | | | OAR 141-085-0550 (5) | Though the JPA form has the totals of permanent and temporary split between removal and fill, Exhibit J Impact tables : J-2-6, J-2-7, J-2-8A, J-2-8B, J-2-9A, J-2-9B, J-2-10 list the impacts in both temporary and permanent for each wetland and waters but do not indicate whether the impact proposed will be removal, fill or both. Please provide a table of all impacts showing removal and fill both permanent and temporary. The JPA Block 6 refers to Appendix O and K for the lists. It is not clear what /where those appendices are. | The 2018 JPA submittal included a separate appendices document to the JPA form. The JPA Appendices have detailed narrative, tables, and figures pertaining to the different sections of the JPA form.<br>JPA Appendices Table O-1A and Table O-2A were revised to include columns for temporary removal-fill volumes. Values for temporary removal and fill were added to the JPA form Block 6. The revised Tables O-1A and O-2A, and the revised JPA Form Block 6 have been submitted to ODOE, along with Appendix K figures K-239, K-240, and K-241. |

**TARDAEWETHER Kellen * ODOE**

| | |
|---|---|
| **From:** | TARDAEWETHER Kellen * ODOE |
| **Sent:** | Tuesday, February 12, 2019 3:36 PM |
| **To:** | 'Stokes, Mark'; Stanish, David |
| **Cc:** | English, Aaron |
| **Subject:** | ODOE Guidance Doc for HPRCSITs in the EFSC Process |
| **Attachments:** | HPRCSITs EFSC Pathway Guidance Doc 2019-02-11.pdf |

Good afternoon,

The question of how Historic Properties of Religious and Cultural Significance to Indian Tribes (“HPRCSITs”) are treated in the EFSC process has been raised for several facilities. ODOE has generated a guidance document to provide to Tribes and to applicants/certificate holder to help outline the various options for EFSC to review and make findings, based on the evidence on the record, with respect to HPRCSITs. There is a lot of information in this document and I'd recommend having a call to go over the nuances and details associated with each pathway. Pease also note that these are not strict pathways and that it is most likely that a combination of the pathways apply to some facilities in the EFSC review process. Let me know when you can chat or what questions there are. Thanks,

Kellen

**Kellen Tardaewether**
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301
P:(503) 373-0214
C: (503) 586-6551
[Oregon.gov/energy](Oregon.gov/energy)

OREGON DEPARTMENT OF ENERGY

*Leading Oregon to a safe, clean, and sustainable energy future.*

## TARDAEWETHER Kellen * ODOE

| | |
|---|---|
| **From:** | TARDAEWETHER Kellen * ODOE |
| **Sent:** | Tuesday, February 12, 2019 3:38 PM |
| **To:** | Teara Farrow Ferman |
| **Cc:** | 'Catherine Dickson'; Carey Miller |
| **Subject:** | ODOE Guidance Doc for HPRCSITs in the EFSC Process |
| **Attachments:** | HPRCSITs EFSC Pathway Guidance Doc 2019-02-11.pdf |

Good afternoon,

The question of how Historic Properties of Religious and Cultural Significance to Indian Tribes ("HPRCSITs") are treated in the EFSC process has been raised for several facilities. ODOE has generated a guidance document to provide to Tribes and to applicants/certificate holder to help outline the various options for EFSC to review and make findings, based on the evidence on the record, with respect to HPRCSITs. There is a lot of information in this document and I'd recommend having a call to go over the nuances and details associated with each pathway. Pease also note that these are not strict pathways and that it is most likely that a combination of the pathways apply to some facilities in the EFSC review process. Let me know when you can chat or what questions there are. Thanks,

Kellen

**Kellen Tardaewether**
Senior Siting Analyst
Energy Facility Siting Division
Oregon Department of Energy
550 Capitol St N.E., 1st Floor
Salem, OR 97301
P:(503) 373-0214
C: (503) 586-6551
Oregon.gov/energy

OREGON DEPARTMENT OF ENERGY
*Leading Oregon to a safe, clean, and sustainable energy future.*

# HPRCSITs* in the EFSC Process

## PATHWAY 1

° HPRCSITs** identified in EFSC process (application, SHPO, Tribal comments)
° Applicant and Tribe negotiate independently to come to an agreement about impacts to and mitigation for HPRCSITs
° ODOE/EFSC receive confirmation from Tribe that facility (w/ mitigation) not likely to result in significant adverse impacts

**Less info on the record**

° No additional information on HPRCSITs provided
° ODOE recommends EFSC finding under OAR 345-022-0090(1) relying on Tribal and applicant letters ***
° EFSC may adopt specific mitigation conditions only if proposed as applicant representations, if provided

## PATHWAY 2

° HPRCSITs** identified in EFSC process (application, SHPO, Tribal comments)
° Applicant and Tribe negotiate independently and agree to what info provided regarding:
  * Description of HPRCSITs
  * Impact Assessment
  * Mitigation
° ODOE/EFSC receive confirmation from Tribe that facility (w/ mitigation) not likely to result in significant adverse impacts

**Coordination for info on the record**

° Agreed upon information on HPRCSITs, impact assessment and mitigation measures provided
° ODOE recommends EFSC finding under OAR 345-022-0090(1)relying on Tribal and applicant letters and/or info provided
° EFSC may adopt specific mitigation conditions if proposed as applicant representations, if provided

## PATHWAY 3

° HPRCSITs** identified in EFSC process (application, SHPO, Tribal comments)
° based on available data, applicant provides:
  * Description of HPRCSITs
  * Impact Assessment
  * Mitigation
° Tribes and SHPO provide comments, applicant may revise application

**More info on the record**

° Available information on HPRCSITs, impact assessment and mitigation measures provided
° ODOE recommends EFSC makes finding
° EFSC may incorporate comments from SHPO and Tribes, including mitigation conditions
° EFSC imposes mitigation conditions, if necessary

* Information on Historic Properties of Religious and Cultural Significance to Indian Tribes ("HPRCSITs") will be kept confidential consistent with state statute and ODOE policy. Confidential information on HPRCSITs may be provided to Council in a closed, executive session at a Council meeting or information on HPRCSITs may be provided in Orders in a manner satisfactory to Tribes to maintain confidentiality.

** If HPRCSITs have not been determined eligible by SHPO, and there is not information available for the applicant to evaluate impacts, if the Tribe represents they are likely or recommended eligible, the Tribe must provide evidence to substantiate its representation for evaluation by Council under Pathway 2 and Pathway 3.

*** EFSC may disagree with ODOE recommendation and require more evidence to make finding.
OAR 345-022-0090(2) states: "The Council may issue a site certificate for a facility that would produce power from wind, solar or geothermal energy without making the findings described in section (1). However, the Council may apply the requirements of section (1) to impose conditions on a site certificate issued for such a facility."

This Guidance Document is Subject to Change

**Attachment 5: Documents and Agency Consultation in Referenced Proposed Order (added after DPO)**

# Memo

Daly • Standlee & Associates, Inc.
4900 S.W. Griffith Drive
Suite 205
Beaverton, Oregon 97005
(503) 646-4420
Fax (503) 646-3385

**Date:** **March 6, 2016**

**To:** **Max Woods**

**Oregon Department of Energy**

**From:** **Kerrie G. Standlee, P.E.**

**Re:** **B2H Application For Site Certificate - Identification of Ambient Noise Monitoring Sites Representative of New Noise Sensitive Receptors**

**DSA File #: 108161**

**CC:** **Kristine Robson, Cardno**
**Emily Merickel, Cardno**

---

**Max:**

In our February 22, 2016 meeting at McDowell, Rackner & Gibson, P.C., we discussed the idea that Idaho Power might be able to use ambient noise data measured in 2012 to represent the ambient noise levels that would be found at residential receivers located along newly identified segments of the B2H power line. I commented during the meeting that I could agree with the approach proposed by Mr. Bastasch of CH2M if he could provide information that would explain how the data measured at a specific monitoring site would be representative of that expected at a particular residence. It was my understanding that Mr. Bastasch would work to provide that information.

After I received the March 15, 2016 CH2M Technical Memorandum entitled, *Updated Monitoring Point Applicability for Boardman to Hemingway (B2H*, I reviewed it to see if the information provided was sufficient enough for me to conclude that the ambient noise at residences along the revised B2H line path could be found in the data already collected in 2012. While I still think it might be possible to find representative data within the 2012 data, I cannot agree at this time that the ambient noise levels at residences along the new segments of B2H are found at the monitoring locations proposed in the memorandum. To reach that conclusion I need to see more information concerning how the 2012 monitoring locations proposed in the March 15 memorandum would have noise levels like those that would be found at the new residences. Simply saying that the original monitoring locations are within the proximity of the new locations is not enough explanation for me.

At this time, it would be helpful if more detailed aerial photographs were provided like those presented in the original B2H application materials showing the residences located along the new segments of the power line route. In addition, it would be helpful to know if a field trip has been made to determine if the conditions affecting the acoustic environment at the new residential locations are actually similar to those affecting the environment at the proposed representative monitoring locations. It would be good to know if there is any plan to do a reconnaissance trip if one has not been conducted. Finally, it would be helpful if more information could be provided concerning why the proposed monitoring locations would provide data that would be representative of the environment found at the new residences.

## TARDAEWETHER Kellen * ODOE

**From:** Stu Spence <SSpence@cityoflagrande.org>
**Sent:** Tuesday, April 14, 2020 3:13 PM
**To:** TARDAEWETHER Kellen * ODOE
**Cc:** Robert Strope
**Subject:** Morgan Lake Question
**Attachments:** Morgan Lake Sign.pdf

Hello Kellen,

City Manager Robert Strope asked me to clarify this question for you. This attachment is a mock up of the sign that's at the lake and does illustrate the existing campsites along the Northwest section of the lake. They are essentially all clustered around the same area. We don't have a map other than this. The rest of the park is designated as Day Use only. Please let me know if you need further clarification or for me to label on a Google Earth illustration.


Stu Spence

Parks & Recreation Director
Direct Line: 541-962-1348
Cell: 541-656-7340

LA GRANDE PARKS & RECREATION




---

**From:** Robert Strope <RStrope@cityoflagrande.org>
**Sent:** Tuesday, April 14, 2020 10:24 AM
**To:** Stu Spence <SSpence@cityoflagrande.org>
**Subject:** FW: Morgan Lake Question

Stu,

Please see below and prepare a response.

Robert

Robert A. Strope, MPA

City Manager
City of La Grande
rstrope@cityoflagrande.org
(541) 962-1309
(541) 963-3333 fax



---

**From:** TARDAEWETHER Kellen * ODOE <Kellen.Tardaewether@oregon.gov>
**Sent:** Monday, April 13, 2020 2:26 PM
**To:** Robert Strope <RStrope@cityoflagrande.org>; Robert Strope <RStrope@cityoflagrande.org>
**Subject:** Morgan Lake Question

Hi Robert!

Long time no talk! (We are in another "dormant" period as we are working on the proposed order addressing the comments on the DPO, quite the effort so far but we are making progress).

How's the City holding together? Are you and staff working remotely during the COVID19 emergency? The vast majority of ODOE staff are working from home, it's taken a bit to get used to but we are chugging along as usual.

I'm working on addressing comments regarding Morgan Lake and am going though the comments and IPC responses about noise at Morgan Lake. Based on the DPO comments from the public, IPC provided an updated noise analysis that includes the campsites at Morgan Lake. However, as I recall from visiting and my understanding of Morgan Lake, it appears that IPC may have modeled the day use areas as campsites as well as the campsites. IPC sent me the attached doc for informational purposes, but because the record is closed to those except reviewing agencies, could you verify where the campsites/day use areas are at Morgan Lake? Or do you have and can send this map if it's from the City? Let me know if this makes sense or if you'd like to discuss, I'm available via email and my mobile. I really hope you and everyone else over there is doing well! Crazy times!

Kellen

OREGON DEPARTMENT OF ENERGY

**Kellen Tardaewether**
Senior Siting Analyst
550 Capitol St. NE Salem, OR 97301
P: 503-373-0214
C: 503-586-6551
P (In Oregon): 800-221-8035

Stay connected!

**From:** Stanish, David <DStanish@idahopower.com>
**Sent:** Monday, April 13, 2020 1:42 PM
**To:** TARDAEWETHER Kellen * ODOE <Kellen.Tardaewether@oregon.gov>
**Cc:** Stokes, Mark <MStokes@idahopower.com>; English, Aaron <Aaron.English@tetratech.com>
**Subject:** RE: Morgan Lake NSR Question

That’s correct. They’re not all campsites based on the information we have. Some are day-use-only areas. The attached City of La Grande sign shows the 11 actual campsites along the northwest portion of the lake.

**David Stanish** | **Senior Counsel** | Idaho Power Company
1221 W. Idaho Street, Boise, Idaho 83702 | ☎:(208) 388-2631
🖷:(208) 433-2807 | ✉: DStanish@idahopower.com

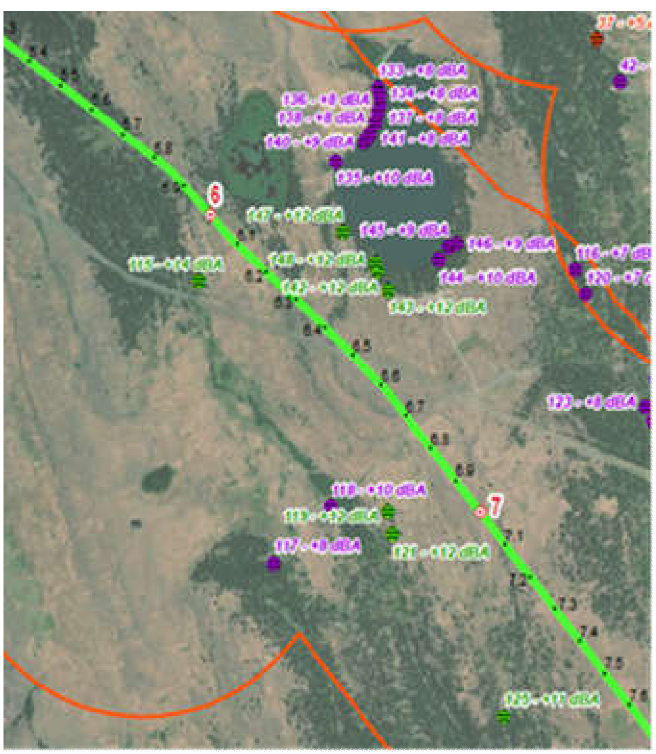
**From:** TARDAEWETHER Kellen * ODOE <Kellen.Tardaewether@oregon.gov>
**Sent:** Monday, April 13, 2020 9:37 AM
**To:** Stanish, David <DStanish@idahopower.com>
**Cc:** Stokes, Mark <MStokes@idahopower.com>; English, Aaron <Aaron.English@tetratech.com>
**Subject:** [EXTERNAL]Morgan Lake NSR Question



---

David,

Could you verify the NSR’s that are the campsites modeled for the revised noise analysis? It appears that some of these locations modeled aren’t campsites but I wanted to confirm.




OREGON DEPARTMENT OF ENERGY

**Kellen Tardaewether**
Senior Siting Analyst
550 Capitol St. NE Salem, OR 97301
P: 503-373-0214
C: 503-586-6551
P (In Oregon): 800-221-8035
Stay connected!

# STOP! CAMPERS MUST REGISTER

LA GRANDE PARKS & RECREATION

## CAMPER REGISTRATION INSTRUCTIONS

**THERE IS NO FEE - CHECK OUT TIME IS NOON**

**QUIET HOURS 10PM - 7AM**

- Please camp only in designated numbered sites. Set up your campsite, then return to complete form.
- Drop copy of registration form in box.
- Attach campsite copy to site marker post.
- Enjoy!

Camping Area
With numbered campsites

Day ONLY Use Area


## CAMPGROUND RULES

- Park open first day of ODFW fishing season thru October 31st.
- All vehicles must stay on approved roads and parking areas.
- Camping is only allowed in the camping area around the northwest side of the lake where numbered sign posts designate camp sites.
- Overnight camping is limited to three (3) days.
- Fires allowed only in metal fire rings until fire ban is in effect.
- Pick up after yourself.
- No fireworks or firearms.
- No smoking / vaping.

## ANNOUNCEMENTS

## ESTERSON Sarah * ODOE

**From:** ESTERSON Sarah * ODOE
**Sent:** Wednesday, October 30, 2019 2:59 PM
**To:** BRINKMANN Bob * DGMI
**Subject:** Information on Blasting

Hi Bob,

It was great to talk to you; please forward any information you think would be helpful in understanding requirements for blasting/blasting permits.

Thanks,
Sarah

OREGON DEPARTMENT OF ENERGY

**Sarah T. Esterson**
Senior Siting Analyst
550 Capitol St. NE | Salem, OR 97301
P: 503-373-7945
C: 503-385-6128
P (In Oregon): 800-221-8035
Stay connected!

## ESTERSON Sarah * ODOE

| | |
|---|---|
| **From:** | BRINKMANN Bob * DGMI |
| **Sent:** | Wednesday, October 30, 2019 3:11 PM |
| **To:** | ESTERSON Sarah * ODOE |
| **Subject:** | Blasting Guidelines |
| **Attachments:** | Blasting Guidelines.pdf |

Hi Sarah, Per our conversation regarding the above please see the attached for info on blasting.

Regards,
Bob Brinkmann, R.G.
Hydrogeologist; Hydrocarbon/
Geothermal Resources Geologist
**Oregon Department of Geology and Mineral Industries**
**Mineral Land Regulation & Reclamation**
**541 967-2068**

*Unless otherwise indicated, all information in this correspondence is classified as Level 1, "Published" according to State of Oregon statute and administrative policy*

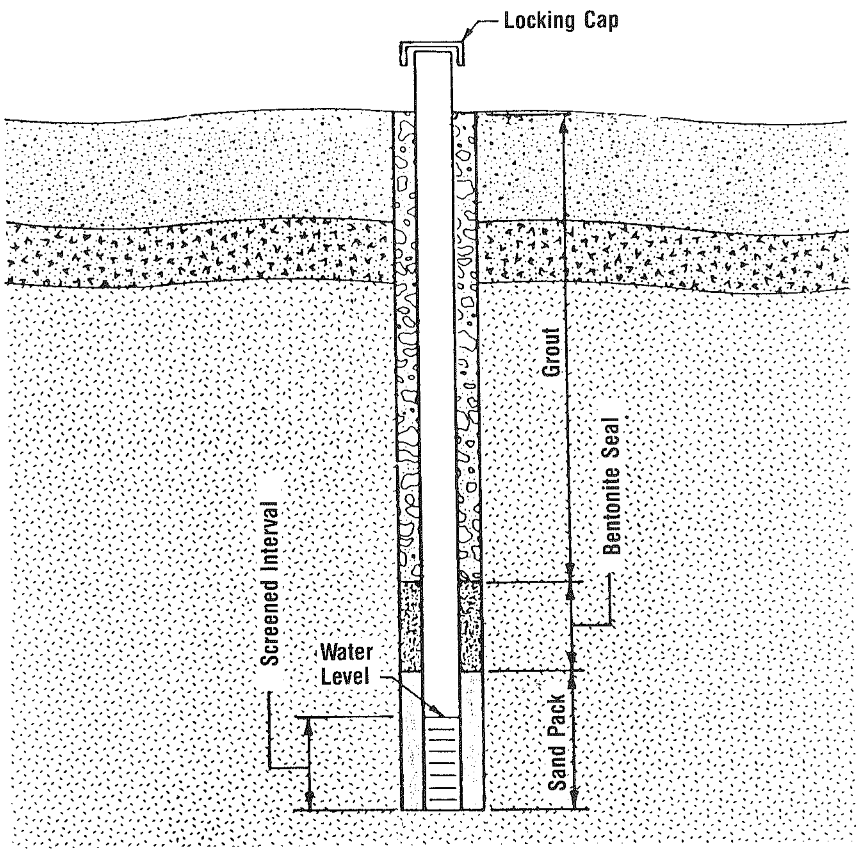



**Figure 5.9 Typical cross-section of groundwater monitor well.**

- Recycle process water through closed-loop settling pond systems;
- Routinely inspect water dust suppression systems to ensure that piping does not leak and that spray nozzles are operating efficiently;
- Operate customer truck washdown systems on a closed-loop basis utilizing a recirculation pond;
- Keep adequate vegetation on all areas possible to minimize erosion and reduce runoff water velocities to allow water to filter back into the ground.

## Blasting Concerns

Every hard rock quarrying operation extracts stone from its geologic formation by the controlled use of explosives and/or blasting agents. No aspect of quarrying causes more apprehension or is less understood than blasting. Lay perceptions of blasting are often based on movie or television scenes showing dust and debris flying in all



directions accompanied by thunderous noise. These spectacular productions reinforce the idea that the use of explosives is an ultra-hazardous activity. They do not represent what actually happens in a modern, well-controlled blasting operation.

**Blasting Statistics:** Obviously the use of explosives requires great care. However, the ultra-hazardous perception needs to be viewed in a statistical light. In the United States during 1987, 4.5 billion pounds of explosive materials were used in blasting activities, largely in coal mining. Charge weight per blast varied from less than one pound to several hundred thousand pounds, with an estimated average of 7,000 lb per blast.[5] This means that about 640,000 blasts were detonated during the year, an average of more than 2,400 blasts each and every work day. Quarry blasting in 1987 accounted for slightly more than 10% of the total quantity of explosive materials used, amounting to approximately 483 million pounds. During 1987 as well as 1988, not one fatality was attributed to quarry blasting,[6] which is a commendable safety record. *Terming quarry blasting as an ultra-hazardous activity is therefore quite unfounded and certainly misleading.*

**Regulation:** The manufacture and use of blasting materials is strictly controlled by a number of federal agencies: the Bureau of Alcohol, Tobacco and Firearms (BATF) of the Treasury Department; the Department of Transportation (DOT); the Occupational Safety and Health Administration (OSHA); and the Mine Safety and Health Administration (MSHA). In addition, many states and local jurisdictions regulate the effects of blasting in terms of ground and air vibration levels.

Blasting damage occurs in three ways: (1) direct impact by flying rock, usually referred to as *flyrock*; (2) cracks and failures in buildings from excessive ground motion; and (3) conditions produced by excessive air concussion, which is referred to as *overpressure* or *airblast*.

**Flyrock:** For safety and economic reasons, quarry blasts are usually designed to restrict the area over which loose rock fragments are distributed, thus minimizing the likelihood of flyrock. Personnel safety is paramount to the operator, who also has a vested interest in preventing damage to equipment. Further, the larger the area over which the rock is distributed by a blast, the more expensive is the cleanup and loading of this material for transport to the primary crushers.

**Ground Motion:** The purposes of blasting are to displace rock from the quarry face and to produce fragmentation that permits efficient crushing and screening (sizing) of the rock by the plant's equipment. Almost all of the energy in a properly designed blast is used for this purpose. A very small fraction of the total blast energy, however, is dissipated in the form of vibrations traveling outward from the blast location through both the ground and the air. These vibrations can be of concern to persons living in the vicinity of the quarry, and the vibrations can result in complaints or, in extreme cases, in claims of damage to structures.

Excessive ground vibration indicates an inefficient blasting operation due to wasted explosive energy. From a public relations point of view, the smaller the vibration levels the less the likelihood of complaints. From an operational standpoint, the quarry operator wants maximum utilization of explosive energy in breaking up the rock. Explosive materials are expensive commodities, and energy from their use, which is dissipated in the form of air or ground vibrations, represents an economic loss. In short, efficient blasting benefits both the operator and his neighbors.

**Blast Vibrations:** A blast produces vibrations which radiate outward through the ground in all directions, primarily along the ground surface. The radiation of vibrations outward is analogous to what happens when a rock is dropped into a body of water, resulting in ripples radiating outward from the point of impact. However, two important differences exist: (1) the water ripples can be seen, whereas the ground displacement is generally limited to a few thousandths of an inch at most and therefore is not visible; and (2) in the case of water ripples the distance between successive waves (wave length) is measured in inches or a few feet at most, depending upon the size of rock hitting the water; the wave length of the ground motion is measured in hundreds of feet.

*Particle Velocity:* A major concern is what happens when the ground vibrations reach and pass by a building or other structure. The vibrations cause the ground at a given point and as a result the structure at that point to oscillate briefly back and forth, up and down, and side to side. Research in blasting seismology dating back to the 1920s shows that structural damage does not correlate with the amount of movement (particle displacement) to which the structure is subjected.[7,8] Damage is related instead to the rate of ground movement, which is called *particle velocity.* Recent authoritative studies stress the point that, with regard to the possibility of damage, *"particle velocity is still the best ground motion descriptor."*[7] Particle velocity should not be confused with seismic velocity. Particle velocity is the rate of movement at a specific location produced by passing ground vibrations. Seismic velocity is the speed at which vibrations travel through the ground, usually measured in thousands of feet per second.

*Vibration Intensity:* Other similarities exist in the ground motion/water ripple analogy. The intensity of the vibration almost always decreases with increasing distance from a blast or from the point where the rock hits the water surface. In addition, blasts are usually detonated with one of a number of available delay systems. These produce very short time delays, commonly 8 to 50 milliseconds, between the detonation of individual blast holes or groups of holes. Seismological studies[7,9] have shown that such delay systems produce



a significant reduction in vibration intensity. Accordingly, peak particle velocity is correlated, not with the total amount of explosive materials in a blast, but instead with the number of holes detonated per delay (max. holes/delay) and the charge weight contained in those holes (max. lb/delay). This concept can perhaps be better understood by considering the water wave analogy. A much larger wave is generated by a single rock striking the water than is caused by dividing the rock into a number of pieces and rapidly dropping the pieces into the water over a short period of time.

*Low Frequency Sites:* The blast design factors discussed in the previous paragraph may not be as effective in controlling vibration intensity when the overburden at and in the vicinity of a quarry is relatively deep (20 ft. or more) and/or consists of loosely consolidated material. The same is true at comparatively long distances from a blast. These situations tend to produce low vibration frequencies. A recent Bureau of Mines study[10] suggests that, under these circumstances, *"the widely-used blast design criteria of 8 ms minimum delay separation may not be sufficiently long for sites with abnormally low frequencies."* Geologic structure becomes the primary factor in determining vibration characteristics including both frequency and amplitude. Specialized studies may be required to evaluate the effectiveness of vibration control measures such as establishing a vertical seismic profile, conducting a detailed refraction survey, and/or monitoring a test blast at a very large number of sites at various distances and in many directions.

**Allowable Vibration Limits:** The limits imposed by many states and local jurisdictions on ground motion and airblast produced at structures in the vicinity of blasting operations are usually based upon recommendations of the United States Bureau of Mines.[7] The recommended limits on particle velocity vary according to ground vibration frequency expressed in cycles per second, or *hertz* (Hz). This dependency is based on the fact that ground motion occurring at frequencies close to the natural frequencies of structures is more likely to cause damage than ground motion taking place at a frequency significantly different than the natural frequency of the structure. The *natural frequency* of a structure is the frequency at which the structure would vibrate if it is displaced a small amount and then allowed to freely vibrate; a structure has more than one natural frequency. Typical natural frequency ranges for residential structures as found by Medearis[11] are:

1 story: 8-18 Hz
1½ story: 7-14 Hz
2 story: 4-11 Hz

*Criteria:* The primary and most easily applied recommendations of the U.S. Bureau of Mines are given in Table 5.1. When the vibration pattern (frequency) is relatively constant, the above standards are easily applied. Occasionally, however, the peak particle velocity occurs

**Table 5.1 Safe Levels of Blasting Vibrations for Residential Type Structures**[7]

| Type of Structure | Ground vibration—peak particle velocity, in./sec At low frequency (<40 Hz) | At high frequency (>40 Hz) |
|---|---|---|
| Modern homes, drywall interiors | 0.75 | 2.0 |
| Older homes, plaster on wood lath construction for interior walls | 0.50 | 2.0 |

at a frequency of 40 Hz or higher followed by a wave train at lower frequencies. The peak at the lower frequency then must be compared with either the 0.50 or 0.75 in./sec limit depending upon which one is applicable.

Because of the discontinuity in recommended limits at 40 Hz, as shown in Table 5.1, the U.S. Bureau of Mines developed alternative criteria in which the recommended particle velocity maxima vary directly with frequency over the ranges of 1 to 2.7 Hz and 15 to 40 Hz. These criteria are illustrated in Figure 5.10. In the frequency ranges cited, the vibration limits are constant particle displacements of 0.030 in. and 0.008 in., respectively. The specific particle velocity (PV) limit in these frequency ranges can be calculated from the equation

$$PV = 2\pi fA \quad (5\text{-}1)$$

where A is the appropriate displacement limit and f is the measured frequency. Representative calculated particle velocity limits are 1.0 in./sec at a frequency of 20 Hz and 1.75 in./sec at 35 Hz.

The limits recommended by the U.S. Bureau of Mines, from 0.50 to 2.0 in./sec depending on the vibration frequency, provides protection in more than 95% of the cases. The damage probability refers to the percentage of homes that could sustain threshold damage at these vibration levels, which is less than 5%. The above limits are considered to be reasonable operating parameters. As vibration levels decrease from these limits, the data suggest that the *no damage* level is reached quickly, at approximately 0.4 in./sec for low frequency motion.

Also note that the 0.50 in./sec limit is lower than levels at which damage was observed. The lowest level at which a minor crack extension in drywall occurred was 0.79 in./sec. Further, there were many observations of no damage at particle velocities up to 3.0 in./sec.[7]

**Repeated Blasting:** The question as to the effect of repeated blasting frequently arises, i.e., will more damage occur at lower vibration levels with continuous blasting than with a single blast. The U.S. Bureau of Mines investigated this possibility by subjecting a



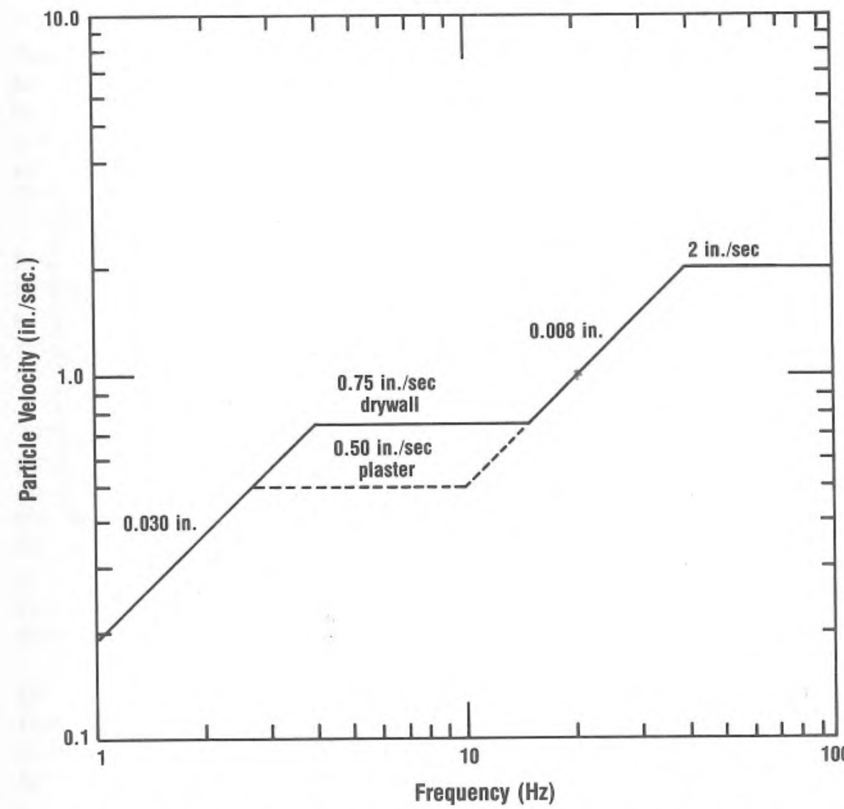



**Figure 5.10 Safe levels of blasting vibration using a combination of velocity and displacement.**

commercially built test home to particle velocities of 0.10 to 6.94 in./sec as blasting approached the home over a two-year period.[8] The fatigue factor was further studied by mechanically shaking the building. The conclusions of this study are:

1. When particle velocities were maintained below 1.0 in./sec the rate of cracking in the building was the same during periods of no blasting as during those times when blasting was taking place.
2. In the shaking tests, the first crack appeared after 56,000 cycles of motion, the equivalent of 28 years of shaking twice per day of blast-produced particle velocities of 0.50 in./sec.
3. Human activity and changes in temperature and humidity produced strains in the walls equivalent to those produced by particle velocities of up to 1.2 in./sec.

**Vibration Monitoring Instrumentation:** Blasting vibrations are monitored with instruments especially designed for this purpose. A


**Figure 5.11 A typical recording system used to monitor ground motion and air overpressure.**

typical recording system used to monitor ground motion as well as air overpressure is shown in Figure 5.11. A *seismic recording system* consists of two elements: the *seismometer* or *seismic pick-up unit* and the *recorder*, which is now usually computerized. The seismic pick-up unit, shown in the left foreground of Figure 5.11, contains three velocity-type transducers oriented at right angles to each other. To record a blast, the seismic pick-up unit is set up so that one transducer responds to the horizontal component of motion along the line between the blast and the seismograph; this is referred to as the longitudinal (L) or radial component. A second transducer responds to horizontal motion at right angles to the longitudinal (L) direction and is called the transverse (T) direction, while the third responds to vertical (V) motion. Thermal printers, pen and ink recorders, and disk or tape recorders are all used by various manufacturers to produce permanent seismic recordings.



A representative seismic record is shown in Figure 5.12. This record contains the three seismic traces and a fourth portraying airblast intensity. Seismic trace amplitudes are directly proportional to particle velocity. In addition to the waveform record, this instrument also provides computer analysis of vibration intensity and airblast with peak values of particle velocity (PPV), displacement (PD), acceleration (PPA), and airblast being printed out. The vibration frequencies (Frq) in Hz corresponding to the peak values and the peak resultant velocity (RPPV) are also given. Such recordings permit direct comparison with recommended or mandated limits on ground motion and air concussion. Observe that the peak particle velocity of 0.71 in./sec shown in Figure 5.12 exceeds the limit recommended for plaster-on-lath construction.

**Damage To Underground Facilities:** While blasting concerns usually focus on the possibility of damage to homes and other above-ground buildings and structures, concern about the effects of blasting on underground facilities such as pipelines, water wells, and sewers is also common. In general, underground facilities are far less susceptible to vibration damage than above-ground structures. Damage is usually associated with permanent displacement of the soil or rock enclosing the facility; this usually occurs only within about 20 to 30 ft. from a blast.[12,13,14]

**Air Concussion and Noise:** In addition to vibration traveling through the ground, blasting also produces airborne vibrations, represented by transient increases in atmospheric pressure, commonly termed *overpressure*, *concussion*, or *noise*. These airborne waves can be broken down into two types: (1) the noise that is heard—that part of the air wave being transmitted at frequencies in the audible range, which is above 20 to 25 Hz; and (2) the concussion transmitted at lower inaudible frequencies. Concussion can rattle windows and doors and occasionally produce perceptible movement inside buildings.

*Decibel Scale:* The range of overpressures to which the human ear is commonly subjected is extremely large. Rather than compare noise/concussion levels in these units, it is far more convenient to use the *logarithmic decibel scale*. With the latter, an increase of 20 decibels represents a 10-fold increase in overpressure. Comparing 140 decibels with 0 decibels, for example, the increase is from $2.9 \times 10^{-9}$ psi to $2.9 \times 10^{-2}$ psi, a ratio of 10 million to 1. The conversion of overpressure in psi to decibels (dB) is given by the equation

$$dB = 20 \log_{10} [P/(2.9 \times 10^{-9})] \quad (5\text{-}2)$$

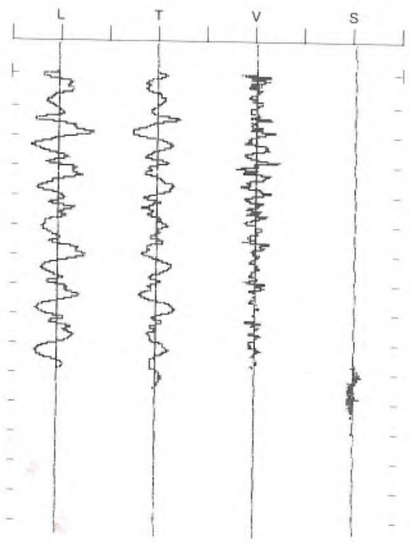
where P is the measured overpressure in psi.

Blast noise measurements are stated in dBL, where the L signifies that the response of the monitoring equipment is uniform or flat down through both the audible and inaudible range of frequencies. The most sensitive seismic research equipment possesses a flat response

** SAFEGUARD SEISMIC UNIT 1000D **
FEB 19/88 08:22:29
INSTRUMENT # SSU 1521
EVENT # 006
COPY # 1
CLIENT: ABC CONSTRUCTION CO.
OPERATION: ROUTE 48 PHASE 1
SSU LOCATION: L. SMITH'S BACK YARD
DISTANCE TO BLAST (ft): 850
OPERATOR: D. JOHNSON, BLASTER
SEIS TRIG LVL (ips): .05
SOUND TRIG LEVEL (dB): 100
RECORD TIME (sec): 5

GRAPHICAL RECORD
********************

TIME = .333 sec/in
SOUND = 0.028 psi/div
L,T,V = 1 ips/div




FEB 19/88 08:22:29

| | L | T | V |
|---|---|---|---|
| PPV(in/s) | 0.71 | 0.48 | 0.47 |
| PD(in) | 0.00943 | 0.00697 | 0.00214 |
| PPA(g) | 0.187 | 0.166 | 0.332 |
| Frq(hz) | 11.0 | 10.7 | 30.1 |
| RPPV(in/s) | 0.94 | | |
| PEAK SOUND | 125 dB | | 0.00500 psi |

** A/D CALIBRATED OK **

CALIBRATION GRAPH

TIME = .384 sec/in
SOUND = 0.028 psi/div
L,T,V = 1 ips/div

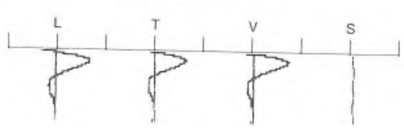



**Figure 5.12 A representative seismographic record.**



down to a frequency of 0.1 Hz, while commercially available instruments have a uniform response down to 2 or 6 Hz.

**Limits on Airblast:** A U.S. Bureau of Mines report[15] gives recommended limits on airblast which are widely recognized and often used in state and local regulations. Safe levels were found to be 134 dBL (for equipment with flat response to 0.1 Hz), 133 dBL (flat to 2 Hz), and 129 dBL (flat to 6 Hz). From a practical viewpoint, therefore, recommended upper limits are either 133 or 129 dBL, depending upon whether the instrument employed has a flat response down to 2 Hz or 6 Hz, respectively.

The Bureau's recommended limits are conservative. In the same report, the authors note *"there is a consensus (in the reports of other investigators) that damage is improbable below 0.030 psi (140 dBL)."* Damage refers to broken windows, the components of buildings which are most susceptible to excessive overpressures.

Damaging overpressures are rarely encountered with modern blasting procedures. Confinement of explosives within the rock minimizes the effect of overpressures. In days gone by a common method of breaking up large boulders was to place a piece of dynamite on the boulder, cover it with mud, and then detonate the charge. This procedure results in excessive overpressure. Boulders are now usually reduced in size using a *drop ball*, which is a large steel weight dropped on the rock. Infrequently boulders are broken using a small explosive charge placed in holes drilled in the rock.

In summary, it is not difficult to conduct blasting operations in a quarry so that homes in the surrounding area are protected from damage. Well documented and widely recognized limits on ground motion and air concussion can be used to achieve this necessary goal.

## Noise

A major environmental consideration associated with the operation of an aggregate plant is the noise generated by the operating equipment and the reaction to this noise by persons living or working in the vicinity. This discussion is concerned with steady-state noise, which is continuous or semi-continuous during the periods while the plant is in operation. Noise of transient or short duration character, such as that produced by blasting operations, was discussed in the previous section.

**Measurement Equipment:** Sound or noise consists of pressure waves traveling through the air producing temporary increases in atmospheric pressure to which the human ear responds. The human ear discriminates against certain sound frequencies. For example, sounds at frequencies less than 20 to 25 Hz are inaudible. Noise measurements to assess human reaction are made with equipment designed to duplicate as closely as possible the frequency response of

## ESTERSON Sarah * ODOE

| | |
|---|---|
| **From:** | WANG Yumei * DGMI |
| **Sent:** | Tuesday, April 16, 2019 12:05 PM |
| **To:** | ESTERSON Sarah * ODOE |
| **Cc:** | WANG Yumei * DGMI |
| **Subject:** | EFSC B2H, blasting and landslide hazards |

Hi Sarah,

Here's a single email:

For site-specific landslide hazard evaluations, DOGAMI considers the below references as important. The first reference, SLIDO, should be used as part of a literature review of existing mapped landslides. Keep in mind that many areas of Oregon have not been mapped. As such, the absence of mapped landslides on SLIDO does not mean that there are no landslides in that area.

DOGAMI considers the method outlined in special paper 42 as the state-of-practice method. This includes using lidar as the base map. If existing active landslides are identified, the further analyses would be warranted including field investigation. And, shallow and/or deep landslide susceptibility using methods outlined in special papers 45 and 48 may be warranted. I have included links to these for your convenience.

I. Statewide Landslide Information Database for Oregon (SLIDO)
   https://www.oregongeology.org/slido/index.htm

II. **Special Paper 42, Protocol for Inventory Mapping of Landslide Deposits from Light Detection and Ranging (Lidar) Imagery**, 2009, by William J. Burns and Ian P. Madin.
   https://www.oregongeology.org/pubs/sp/p-SP-42.htm

III. **Special Paper 45, Protocol for Shallow-Landslide Susceptibility Mapping**, 2012, by William J. Burns, Ian P. Madin, and Katherine A. Mickelson.
   https://www.oregongeology.org/pubs/sp/p-SP-45.htm

IV. **Special Paper 48, Protocol for deep landslide susceptibility mapping**, 2016, by William J. Burns and Katherine A. Mickelson
   https://www.oregongeology.org/pubs/sp/p-SP-48.htm

Here's what I found out about blasting:

The Oregon State Fire Marshal has jurisdiction over storage of explosives. But, they do not regulate the actual blasting activities.

The National Fire Protection Association has codes on blasting via NFPA 495
https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=495

Certain local jurisdictions may have requirements that would need to be satisfied.

Here's an example of what you might request. See #1, 2 and 3 from the below link:
https://www.tvfr.com/DocumentCenter/View/1704/Explosive-Blasting-Permit-Info?bidId=

If you have further questions on the blasting, I would likely refer you to my co-worker Bob Brinkman (and let me know if you want his contact info. I can e-introduce you).

Yumei

Yumei Wang, P.E. | Resilience Engineer
Oregon Department of Geology and Mineral Industries (DOGAMI)
800 NE Oregon Street, Suite 965, Portland, Oregon 97232
Mobile: (503) 913-5749
yumei.wang@oregon.gov | www.oregongeology.org

Follow us! Facebook Twitter

*Unless otherwise indicated, all information in this correspondence is classified as Level 1, "Published" according to State of Oregon statute and administrative policy.*

# Tualatin Valley Fire & Rescue
# Explosive Blasting Permits


**North Operating Center**
11945 SW 70th Avenue
Tigard, OR 97223
Phone: 503-649-8577
Fax: 503-642-4814

**South Operating Center**
8445 SW Elligsen Road
Wilsonville, OR 97070
Phone: 503-259-1500
Fax: 503-259-1520


Tualatin Valley Fire & Rescue requires a permit to be issued for any type of explosive blasting conducted within District boundaries. **In order to receive a permit, a complete packet must be submitted at least 14 days prior to blasting.**

The packet must include the following:

1. **Oregon State Fire Marshal (OSFM) Certificate to Possess Explosives** in the State of Oregon.
2. **Blasting Plan** prepared in accordance with 2018 NFPA 495 and industry standards. It must include:
   a. Explosives delivery information
   b. Explosives storage information (magazine, location and responsible person)
   c. Drilling information
   d. Explosives products and loading information
   e. Safety procedures
   f. Directions for pre-blast notification and proper posting in area of work (350' minimum).
   g. Verification of contact with city (if applicable), county, and local police or sheriff agency where work is being performed to determine if additional requirements apply.
   h. Pre-blast survey of any structures, within 300' of the blast site unless the Blaster-in-Charge determines a greater distance is necessary.
   i. A monitoring plan to identify how seismic monitoring will be conducted to ensure ground vibration does not exceed the maximum limit in 2018 NFPA 495 Figure 11.2.1 at the nearest structures or buildings.
   j. Where seismic monitoring is not provided, explosive use shall be limited to the "scaled distance factors" at the nearest structure as identified in 2018 NFPA 495 Table 11.2.2.
   k. Post blast monitoring and seismic report. Provide a copy to TVFR when requested.

   *Note: Blasting operations shall be overseen by a Blaster-in-Charge qualified to perform such work.*
3. **Bond or insurance certificate** for the project in an amount not less than $1,000,000. The Fire Marshal may determine that more coverage is necessary for certain projects.
4. **TVF&R Permit Application** obtained by:
   a. Visiting our website at www.tvfr.com (click on Online Resources)
   b. Contacting the nearest Operating Center

For more information, contact TVF&R Fire Marshal's Office at 503-259-1500.

## ESTERSON Sarah * ODOE

**Subject:** FW: B2H Reveg Success Criteria Review

**From:** Sarah J Reif <Sarah.J.Reif@state.or.us>
**Sent:** Monday, June 29, 2020 3:41 PM
**To:** ESTERSON Sarah * ODOE <Sarah.Esterson@oregon.gov>
**Subject:** RE: B2H Reveg Success Criteria Review

Hi Sarah –

I spoke with Nigel on Friday, and we have some clarifications that might be helpful as your wrap up your B2H proposed order.

- The 70% native bunchgrass criterion was indeed a relic of sage-grouse recommendations, and we both agreed it doesn't really make sense in more generalized habitats. Our apologies for the confusion in our earlier recommendations.
    - Instead, we recommend success criteria be made more similar to what we've recommended on other EFSC projects: Percent cover of grass, forb, shrub, tree be equal to – or greater than – percent cover of paired control sites.
- Paired control sites should be of similar ecological site conditions to the areas of temporary disturbance, and we recommend IPC seek concurrence from ODOE (ODFW) on the location of the paired control sites **prior to** disturbance (so that control site data can be compared with pre-disturbance data). Essentially we're trying to avoid a situation where poor-quality control sites are established, therefore setting a very low bar for success. I think the reveg plan's intent was to establish these control sites prior to disturbance, but it wasn't entirely clear.
- We find the percentage goals listed in the table below set a very low bar that will not equate to replacement of lost habitat. For example, a site with 40% grass and 60% bare ground would only need to be revegetated to 20% grass, 80% bare ground? This does not amount to replacement of lost habitat. Did you mention in our last call that IPC was offering additional mitigation to account for this lost habitat? If so, can you point me to where this is explained in their application?
- The 15% sagebrush recommendation is indeed specific to sage-grouse, but should apply anywhere you have sagebrush as it is a number indicative of a healthy sagebrush system. So this would be the one % cover recommendation that might be in addition to the percent cover recommendation above.
    - So, for example. If you have a paired control site with 60% native bunchgrass, 10% sagebrush, 20% litter, and 10% bare ground. In your reveg area, you should be shooting for at least 60% native bunchgrass and at least 15% sagebrush, the rest can be litter and bare ground. Let me know if that does not make sense.
- We recommend that desirable species be defined. It should be mostly native, but we can imagine situations where a non-native grass might be desirable in an effort to out-compete cheatgrass (e.g., crested wheatgrass is often used to preclude establishment of invasive annuals), but the species and situations should be developed in coordination with ODOE (ODFW).

Let me know if you have additional questions. Thanks for the coordination.

*Sarah Reif*
ODFW Energy Coordinator
o:503-947-6082; m: 503-991-3587

## ESTERSON Sarah * ODOE

**Subject:** FW: Sandhill Crane Travel Routes - B2H
**Attachments:** Sandhill Crane Travel Routes 1.jpg; Sandhill Crane Travel Routes 2.jpg; Sandhill Crane Travel Routes 3.jpg

---

**From:** Cathy Nowak
**Sent:** Monday, August 12, 2019 3:34 PM
**To:** Sarah J Reif <Sarah.J.Reif@coho2.dfw.state.or.us>; Kyle W Martin <Kyle.W.Martin@coho2.dfw.state.or.us>
**Cc:** Bruce Eddy <Bruce.R.Eddy@coho2.dfw.state.or.us>; Jeff Yanke <Jeff.Yanke@coho2.dfw.state.or.us>; Nick Myatt <Nick.A.Myatt@coho2.dfw.state.or.us>; 'Nigel E Seidel' <nigel.e.seidel@state.or.us>
**Subject:** RE: Sandhill Cranes

Sarah,

In response to your email, below, I have created a map of simplified representative sandhill crane travel routes to and from Ladd Marsh Wildlife Area and the Grande Ronde Valley using Satellite telemetry data from 5 different sandhill cranes. The maps use the following line colors:

- Red = a generalized representation of the proposed route of the B2H power line.
- Shades of green = spring travel routes of migrating sandhill cranes returning to the area from wintering sites.
- Shades of orange/yellow = fall travel routes of sandhill cranes leaving the area enroute to wintering sites.
- Shades of blue = exploratory travels of 2 newly independent sub-adult sandhill cranes and summer movements of one representative adult post-breeding sandhill crane.

The three maps show a successively higher elevation view beginning with one zoomed in to Ladd Marsh and working out to include much of Baker and Union Counties. The travel lines are abbreviated to show only the birds' movements relevant to the proposed line.

These telemetry data are a simple representation of the likely movement of hundreds of sandhill cranes that move through the valley and the Ladd Marsh Wildlife Area during spring and fall migrations as well as during the summer nesting season. The maps include a line of travel (in sort of mint green) that comes in from the southeast. This represents a sandhill crane that winters in the lower Colorado River Valley, travels to the Payette River Valley in Idaho, then north and west to Ladd Marsh. This route is reversed in fall. It is the one bird we know of, possibly representing others, that may not cross the powerline route.

The largest flock of migrating sandhill cranes I have seen on the wildlife area numbered about 700 birds. These were largely lesser sandhill cranes belonging to the Central Valley Population which winters in California's Central Valley. All of those birds would have had to cross the proposed route of the B2H line at some point. They almost certainly do so every year.

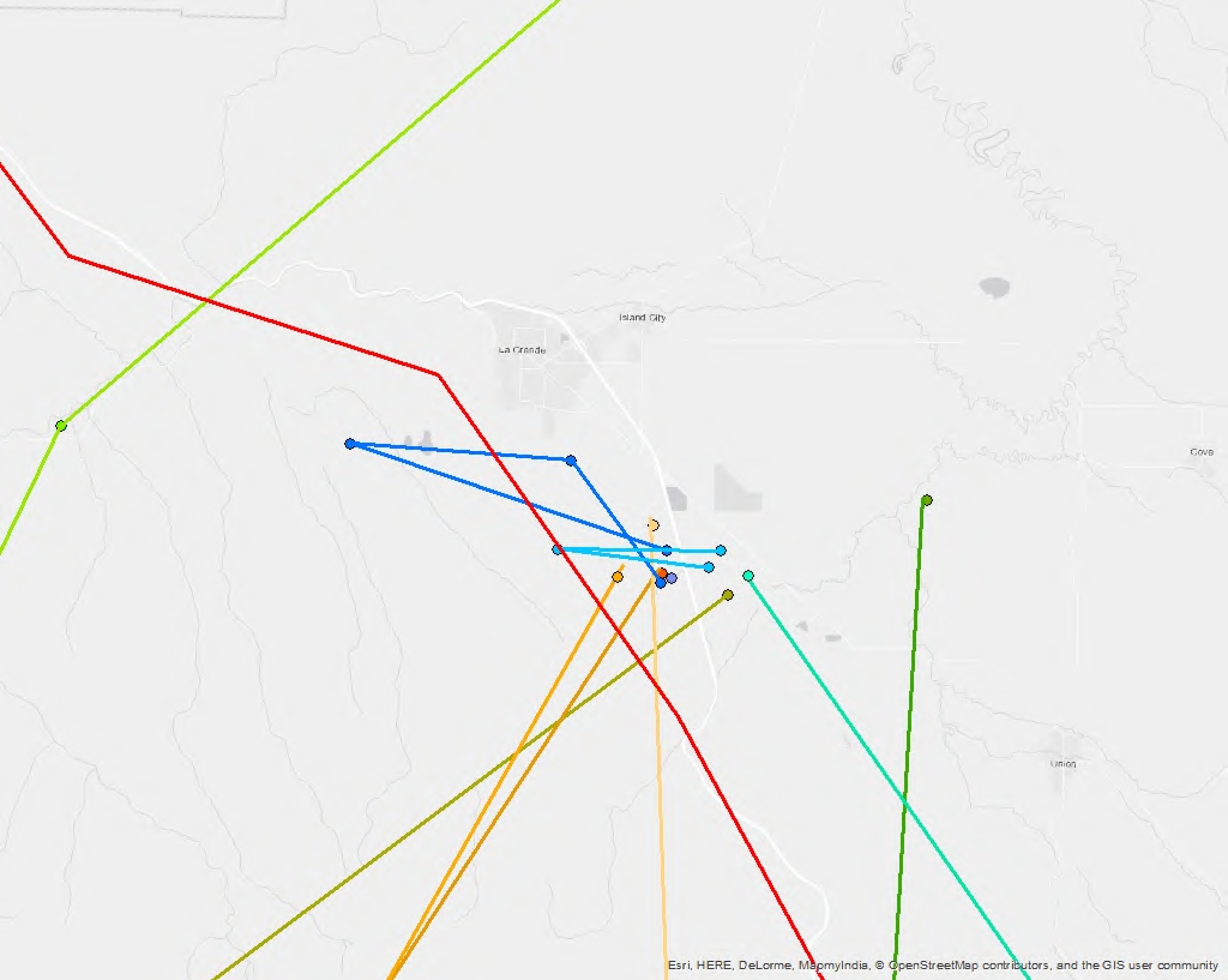
Given a high level of concern regarding sandhill crane mortality due to collisions with transmission power lines (Birds of North America Online), I believe these data support a request for mitigation measures, in the form of UV lights on the lines, along the B2H transmission line from central Baker County to the Umatilla County line.

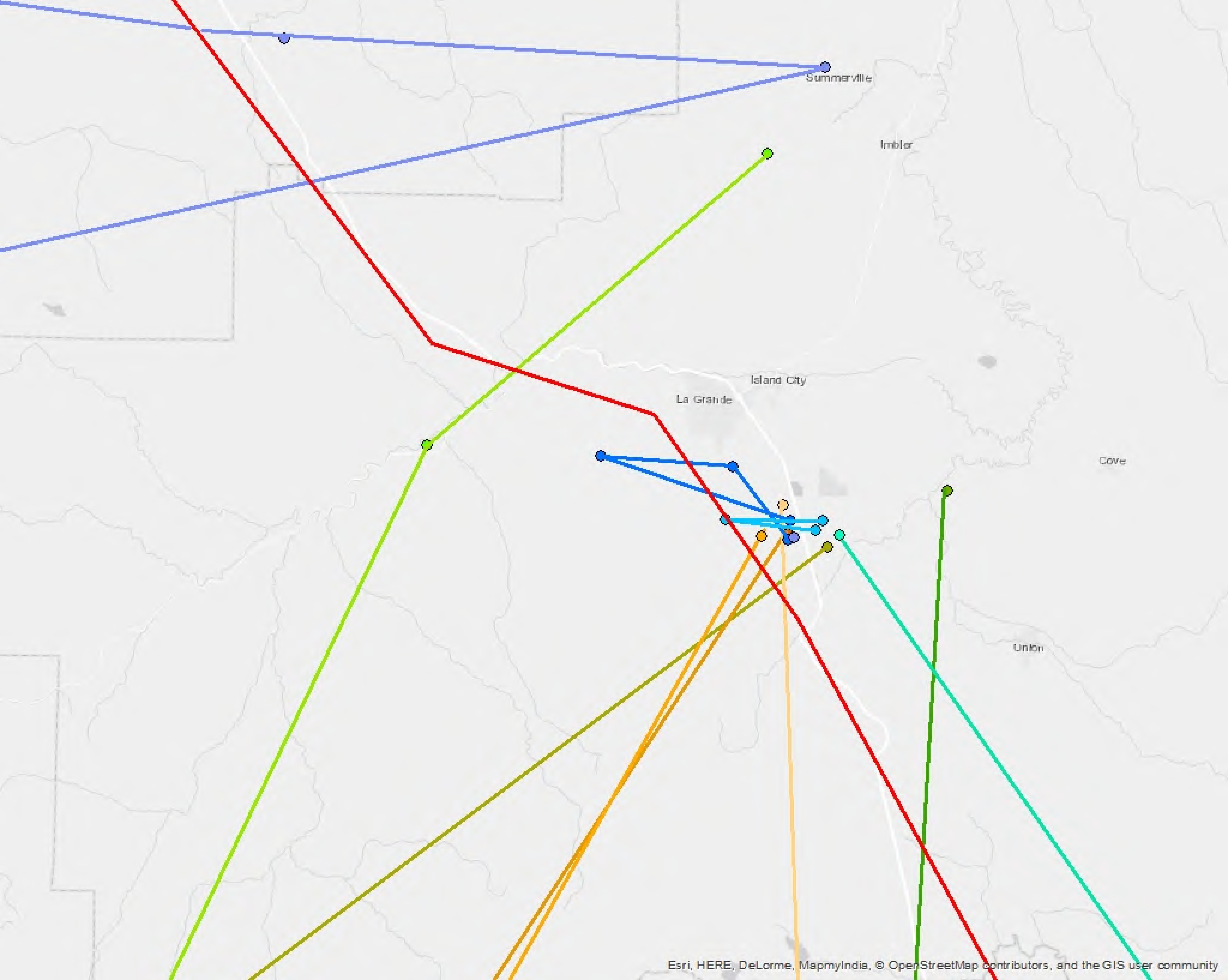
If more detailed data are useful, I do have the raw telemetry data for numerous migrations by several sandhill cranes.

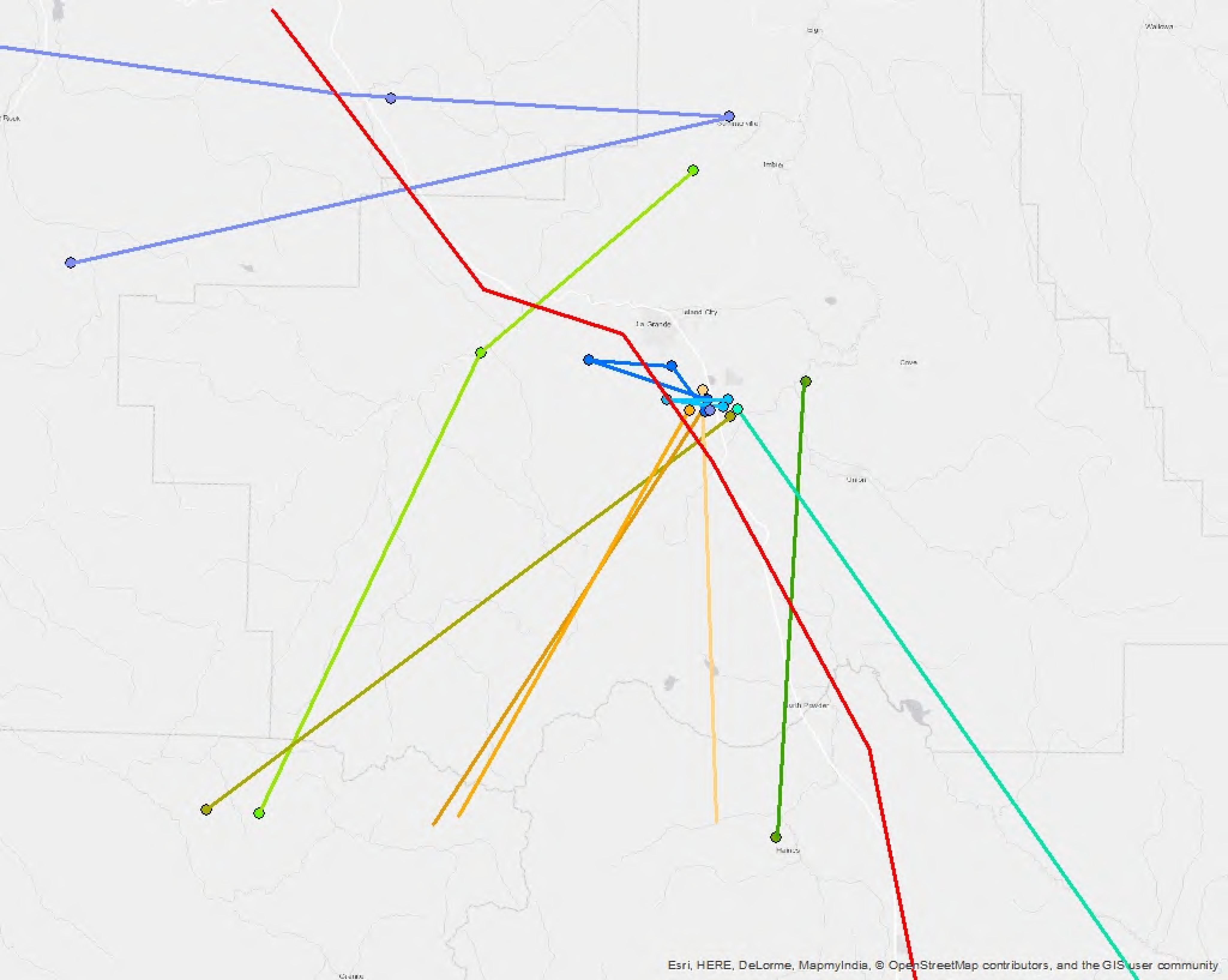
I hope this information is of use,

M. Cathy Nowak

Certified Wildlife Biologist
Ladd Marsh Wildlife Area
59116 Pierce Rd
La Grande, OR 97850
541-963-4954


Island City
La Grande
Cove
Union
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community


Summerville
Imbler
Island City
La Grande
Cove
Union
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community



Elgin
Wallowa
Imbler
Island City
La Grande
Cove
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

## ESTERSON Sarah * ODOE

**Subject:** FW: B2H DPO Comments on F&W Condition 17
**Attachments:** B2HAPP DPO FW Condition 17 (ODFW Edits).docx; Connelly et al. 2000 Habitat guidelines.pdf; Davies_etal_2019_postwildfire seeding to restore native vegetation and limite exotic annuals_an evaluation in juniper-dominated sagebrush steppe.pdf

**From:** Nigel E Seidel <Nigel.E.Seidel@state.or.us>
**Sent:** Monday, September 23, 2019 3:02 PM
**To:** ESTERSON Sarah * ODOE <Sarah.Esterson@oregon.gov>
**Subject:** RE: B2H DPO Comments on F&W Condition 17

Ok, I have made a few minor edits to Condition 17. I feel the condition edits require some additional description in DPO language which I included as a comment on the attached Condition 17 Word Doc. Let me know if you need some additional discussion/clarification.

I have attached 2 journal articles to supplement the revegetation/reclamation success criteria ODFW proposed for sage-grouse. The attached Davies paper implicitly supports 5 PG/$m^2$ from the standpoint of elimination of invasive weeds and not the biological need of sage-grouse. That being said, a plant density of 5 PG/$m^2$ is completely conducive to sage-grouse use. The Connelly et al. habitat guidelines show that 10 – 25% sagebrush canopy cover is optimal for sage-grouse. However we are making the assumption that replanting sagebrush to the 15% level is sufficient and will allow for natural regeneration to take place from the seeded plants.

I hope this helps and let me know if you have additional questions/comments.

Cheers
Nigel


**Nigel Seidel**
Sage-Grouse Mitigation Coordinator
Oregon Department of Fish & Wildlife
4034 Fairview Industrial Dr SE
Salem, OR 97302
Office: 503-947-6074
Cell: 971-719-6015

# Guidelines to manage sage grouse populations and their habitats

*John W. Connelly, Michael A. Schroeder, Alan R. Sands, and Clait E. Braun*

**Abstract** The status of sage grouse populations and habitats has been a concern to sportsmen and biologists for >80 years. Despite management and research efforts that date to the 1930s, breeding populations of this species have declined throughout much of its range. In May 1999, the western sage grouse (C. urophasianus phaios) in Washington was petitioned for listing under the Endangered Species Act because of population and habitat declines (C. Warren, United States Fish and Wildlife Service, personal communication). Sage grouse populations are allied closely with sagebrush (Artemisia spp.). Despite the well-known importance of this habitat to sage grouse and other sagebrush obligates, the quality and quantity of sagebrush habitats have declined for at least the last 50 years. Braun et al. (1977) provided guidelines for maintenance of sage grouse habitats. Since publication of those guidelines, much more information has been obtained on sage grouse. Because of continued concern about sage grouse and their habitats and a significant amount of new information, the Western States Sage and Columbian Sharp-tailed Grouse Technical Committee, under the direction of the Western Association of Fish and Wildlife Agencies, requested a revision and expansion of the guidelines originally published by Braun et al. (1977). This paper summarizes the current knowledge of the ecology of sage grouse and, based on this information, provides guidelines to manage sage grouse populations and their habitats.

**Key words** Artemisia, Centrocercus urophasianus, guidelines, habitat, management, populations, sage grouse, sagebrush

The status of sage grouse populations and habitats has been a concern to sportsmen and biologists for >80 years (Hornaday 1916, Patterson 1952, Autenrieth 1981). Despite management and research efforts that date to the 1930s (Girard 1937), breeding populations of this species have declined by at least 17–47% throughout much of its range (Connelly and Braun 1997). In May 1999, the western sage grouse (*C. urophasianus phaios*) in Washington was petitioned for listing under the Endangered Species Act because of population and habitat declines (C. Warren, United States Fish and Wildlife Service, personal communication).

Sage grouse populations are allied closely with sagebrush (*Artemisia* spp.) habitats (Patterson 1952, Braun et al. 1977, Braun 1987). The dependence of sage grouse on sagebrush for winter habitat has been well documented (Eng and Schladweiler 1972, Beck 1975, Beck 1977, Robertson 1991). Similarly, the relationship between sagebrush

Address for John W. Connelly: Idaho Department of Fish and Game, 1345 Barton Road, Pocatello, ID 83204, USA; e-mail: JCsagegrouse@gateway.net. Address for Michael A. Schroeder: Washington Department of Fish and Wildlife, P.O. Box 1077, Bridgeport, WA 98813, USA. Address for Alan R. Sands: Bureau of Land Management, 1387 S. Vinnell Way, Boise, ID 83709-1657, USA; present address: The Nature Conservancy, 2404 Bank Drive, Suite 314, Boise, ID 83705, USA. Address for Clait E. Braun: Colorado Division of Wildlife, Wildlife Research Center, 317 W. Prospect Road, Fort Collins, CO 80526, USA; present address: Grouse Inc., 5572 North Ventana Vista Road, Tucson, AZ 85750-7204,USA.

Sage grouse on a nest with good shrub and herbaceous cover. The nest was successful.

habitats and sage grouse nest success has been described thoroughly (Klebenow 1969, Wallestad and Pyrah 1974, Wakkinen 1990, Connelly et al. 1991, Gregg et al. 1994). Despite the well-known importance of this habitat to sage grouse and other sagebrush obligates (Braun et al. 1976, Saab and Rich 1997), the quality and quantity of sagebrush habitats have declined for at least the last 50 years (Braun et al. 1976, Braun 1987, Swenson et al. 1987, Connelly and Braun 1997).

Braun et al. (1977) provided guidelines for maintenance of sage grouse habitats. Since publication of those guidelines, much more information has been obtained on relative size of sagebrush habitats used by these grouse (Connelly 1982, Connelly et al. 1988, Wakkinen et al. 1992), seasonal use of sagebrush habitats (Benson et al. 1991, Connelly et al. 1991), effects of insecticides on sage grouse (Blus et al. 1989), importance of herbaceous cover in breeding habitat (Wakkinen 1990, Connelly et al. 1991, Gregg 1991, Barnett and Crawford 1994, Drut et al. 1994*a*, Gregg et al. 1994), and effects of fire on their habitat (Hulet 1983; Benson et al. 1991; Robertson 1991; Fischer 1994; Fischer et al. 1996*a*, 1997; Pyle and Crawford 1996; Connelly et al. 2000*b*). Because of continued concern about sage grouse and their habitats and a significant amount of new information, the Western States Sage and Columbian Sharp-tailed Grouse Technical Committee, under the direction of the Western Association of Fish and Wildlife Agencies, requested a revision and expansion of the guidelines originally published by Braun et al. (1977). This paper summarizes the current knowledge of the ecology of sage grouse and, based on this information, provides guidelines to manage sage grouse populations and their habitats.

## Population biology

### *Seasonal movements and home range*

Sage grouse display a variety of annual migratory patterns (Beck 1975, Wallestad 1975, Hulet 1983, Berry and Eng 1985, Connelly et al. 1988, Wakkinen 1990, Fischer 1994). Populations may have: 1) distinct winter, breeding, and summer areas; 2) distinct summer areas and integrated winter and breeding areas; 3) distinct winter areas and integrated breeding and summer areas; or 4) well-integrated seasonal habitats (nonmigratory populations). Seasonal movements between distinct seasonal ranges may exceed 75 km (Dalke et al. 1963, Connelly et al. 1988), which complicates attempts to define populations. Thus, Connelly et al. (1988) suggested that sage grouse populations be defined on a temporal and geographic basis. Because of differences in seasonal movements among populations (Dalke et al. 1963, Wallestad 1975, Connelly et al. 1988, Wakkinen 1990), 3 types of sage grouse populations can

Sage grouse on a nest with poor shrub and herbaceous cover. This nest was unsuccessful. Photo by Jena Hickey.


Sage grouse on winter range. Note the relatively sparse cover; without snow, the canopy cover of sagebrush in this area exceeds 20%.

be defined: 1) nonmigratory, grouse do not make long-distance movements (i.e., >10 km one way) between or among seasonal ranges; 2) one-stage migratory, grouse move between 2 distinct seasonal ranges; and 3) 2-stage migratory, grouse move among 3 distinct seasonal ranges. Within a given geographic area, especially summer range, there may be birds that belong to more than one of these types of populations.

On an annual basis, migratory sage grouse populations may occupy areas that exceed 2,700 km$^2$ (Hulet 1983, Leonard et al. 2000). During winter, Robertson (1991) reported that migratory sage grouse in southeastern Idaho made mean daily movements of 752 m and occupied an area $\geq$140 km$^2$. For a nonmigratory population in Montana, Wallestad (1975) reported that winter home range size ranged from 11 to 31 km$^2$. During summer, migratory sage grouse in Idaho occupied home ranges of 3 to 7 km$^2$ (Connelly and Markham 1983, Gates 1983).

Despite large annual movements, sage grouse have high fidelity to seasonal ranges (Keister and Willis 1986, Fischer et al. 1993). Females return to the same area to nest each year (Fischer et al. 1993) and may nest within 200 m of their previous year's nest (Gates 1983, Lyon 2000).

## *Survival*

Wallestad (1975) reported that annual survival rates for yearling and adult female sage grouse were 35 and 40%, respectively, for poncho-tagged birds. However, Zablan (1993) reported that survival rates for banded yearling and adult females in Colorado were similar and averaged 55%; survival rates for yearling and adult males differed, averaging 52 and 38%, respectively. In Idaho, annual survival of male sage grouse ranged from 46 to 54% and female survival from 68 to 85% (Connelly et al. 1994). Lower survival rates for males may be related to physiological demands because of sexual dimorphism and greater predation rates (Swenson 1986).

## *Reproduction*

Bergerud (1988) suggested that most female tetraonids nest as yearlings. Although essentially all female sage grouse nested in Washington (Schroeder 1997), Connelly et al. (1993) reported that in Idaho up to 45% of yearling and 22% of adult female sage grouse do not nest each year. Gregg (1991) indicated that, of 119 females monitored through the breeding season in eastern Oregon, 26 (22%) did not nest. However, Coggins (1998) reported a 99% nest initiation rate for 3 years for the same population in Oregon. The differences may be related to improved range condition that resulted in better nutritional status of pre-laying hens (Barnett and Crawford 1994).

Estimates of sage grouse nest success throughout the species' range vary from 12 to 86% (Trueblood 1954, Gregg 1991, Schroeder et al. 1999). Nest success also may vary on an annual basis (Schroeder 1997, Sveum et al. 1998*a*). Wallestad and Pyrah (1974) observed greater nest success by adults than yearlings. However, significant differences in nest success between age groups have not been reported in other studies (Connelly et al. 1993, Schroeder 1997).

Clutch size of sage grouse is extremely variable and relatively low compared to other species of gamebirds (Edminster 1954, Schroeder 1997). Average clutch size for first nests varies from 6.0 to


Sage grouse nest. Photo by Jena Hickey.

9.5 throughout the species' range (Sveum 1995, Schroeder 1997). Greatest and least average clutch sizes have been reported in Washington (Sveum 1995, Schroeder 1997).

Renesting by sage grouse varies regionally from <20% (Patterson 1952, Eng 1963, Hulet 1983, Connelly et al. 1993) to >80% (Schroeder 1997). Despite regional variation, differences in renesting rates due to age have not been documented (Connelly et al. 1993, Schroeder 1997). Because of variation in nest initiation, success, and renesting rates, the proportion of females successfully hatching a brood varies between 15 and 70% (Wallestad and Pyrah 1974, Gregg et al. 1994). Despite this variation, sage grouse generally have low reproductive rates and high annual survival compared to most gallinaceous species (Zablan 1993, Connelly et al. 1994, Connelly and Braun 1997, Schroeder 1997, Schroeder et al. 1999).

Little information has been published on mortality of juvenile sage grouse or the level of production necessary to maintain a stable population. Among western states, long-term ratios have varied from 1.40 to 2.96 juveniles/hen in the fall; since 1985 these ratios have ranged from 1.21 to 2.19 (Connelly and Braun 1997). Available data suggest that a ratio $\geq$2.25 juveniles/hen in the fall should result in stable to increasing sage grouse populations (Connelly and Braun 1997, Edelmann et al. 1998).

## Habitat requirements

### *Breeding habitats*

Leks, or breeding display sites, typically occur in open areas surrounded by sagebrush (Patterson 1952, Gill 1965); these sites include, but are not limited to, landing strips, old lakebeds, low sagebrush flats and ridge tops, roads, cropland, and burned areas (Connelly et al. 1981, Gates 1985). Sage grouse males appear to form leks opportunistically at sites within or adjacent to potential nesting habitat. Although the lek may be an approximate center of annual ranges for nonmigratory populations (Eng and Schladweiler 1972, Wallestad and Pyrah 1974, Wallestad and Schladweiler 1974), this may not be the case for migratory populations (Connelly et al. 1988, Wakkinen et al. 1992). Average distances between nests and nearest leks vary from 1.1 to 6.2 km, but distance from lek of female capture to nest may be >20 km (Autenrieth 1981, Wakkinen et al. 1992, Fischer 1994, Hanf et al. 1994, Lyon 2000). Nests are placed independent of lek location (Bradbury et al. 1989, Wakkinen et al. 1992).

Habitats used by pre-laying hens also are part of the breeding habitat. These areas should provide a diversity of forbs high in calcium, phosphorus, and protein; the condition of these areas may greatly affect nest initiation rate, clutch size, and subsequent reproductive success (Barnett and Crawford 1994, Coggins 1998).

Most sage grouse nests occur under sagebrush (Patterson 1952, Gill 1965, Gray 1967, Wallestad and Pyrah 1974), but sage grouse will nest under other plant species (Klebenow 1969, Connelly et al. 1991, Gregg 1991, Sveum et al. 1998*a*). However, grouse nesting under sagebrush experience greater nest success (53%) than those nesting under other plant species (22%, Connelly et al. 1991).

Table 1. Habitat characteristics associated with sage grouse nest sites.

| | Sagebrush | | Grass | | |
|---|---|---|---|---|---|
| State | Height[a](cm) | Coverage (%)[b] | Height(cm) | Coverage(%)[c] | Reference |
| Colo. | 52 | | | | Petersen 1980 |
| Id. | | 15 | | 4 | Klebenow 1969 |
| Id. | 58–79 | 23–38 | | | Autenrieth 1981 |
| Id. | 71 | 22 | 18 | 3–10 | Wakkinen 1990 |
| Id. | | | 19–23 | 7–9 | Connelly et al. 1991 |
| Id. | 61 | | 22 | 30 | Fischer 1994 |
| Id. | | 15–32 | 15–30 | | Klott et al. 1993 |
| Id. | 69 | 19 | 34 | 15 | Apa 1998 |
| Mont. | 40 | 27 | | | Wallestad 1975 |
| Oreg. | 80 | 20 | | | Keister and Willis 1986 |
| Oreg. | | 24 | 14 | 9–32 | Gregg 1991 |
| Wash. | | 20 | | 51 | Schroeder 1995 |
| Wash. | | 19 | | 32 | Sveum et al. 1998a |
| Wyo. | 36 | | | | Patterson 1952 |
| Wyo. | 29 | 24 | 15 | 9 | Heath et al. 1997 |
| Wyo. | 31 | 25 | 18 | 5 | Holloran 1999 |
| Wyo. | 33 | 26 | 21 | 11 | Lyon 2000 |

[a] Mean height of nest bush.
[b] Mean canopy coverage of the sagebrush surrounding the nest.
[c] Some coverage estimates may include both grasses and forbs.

Mean height of sagebrush most commonly used by nesting grouse ranges from 29 to 80 cm (Table 1), and nests tend to be under the tallest sagebrush within a stand (Keister and Willis 1986, Wakkinen 1990, Apa 1998). In general, sage grouse nests are placed under shrubs having larger canopies and more ground and lateral cover as well as in stands with more shrub canopy cover than at random sites (Wakkinen 1990, Fischer 1994, Heath et al. 1997, Sveum et al. 1998*a*, Holloran 1999). Sagebrush cover near the nest site was greater around successful nests than unsuccessful nests in Montana (Wallestad and Pyrah 1974) and Oregon (Gregg 1991). Wallestad and Pyrah (1974) also indicated that successful nests were in sagebrush stands with greater average canopy coverage (27%) than those of unsuccessful nests (20%). Gregg (1991) reported that sage grouse nest success varied by cover type. The greatest nest success occurred in a mountain big sagebrush (*A. t. tridentata vaseyana*) cover type where shrubs 40–80 cm in height had greater canopy cover at the site of successful nests than at unsuccessful nests (Gregg 1991). These observations were consistent with the results of an artificial nest study showing greater coverage of medium-height shrubs improved success of artificial nests (DeLong 1993, DeLong et al. 1995).

Grass height and cover also are important components of sage grouse nest sites (Table 1). Grass associated with nest sites and with the stand of vegetation containing the nest was taller and denser than grass at random sites (Wakkinen 1990, Gregg 1991, Sveum et al. 1998*a*). Grass height at nests under non-sagebrush plants was greater ($P<0.01$) than that associated with nests under sagebrush, further suggesting that grass height is an important habitat component for nesting sage grouse (Connelly et al. 1991). Moreover, in Oregon, grass cover was greater at successful nests than at unsuccessful nests (Gregg 1991). Grass >18 cm in height occurring in stands of sagebrush 40–80 cm tall resulted in lesser nest predation rates than in stands with lesser grass heights (Gregg et al. 1994). Herbaceous cover associated with nest sites may provide scent, visual, and physical barriers to potential predators (DeLong et al. 1995).

Early brood-rearing areas occur in upland sagebrush habitats relatively close to nest sites, but movements of individual broods may vary (Connelly 1982, Gates 1983). Within 2 days of hatching, one brood moved 3.1 km (Gates 1983). Early brood-rearing habitats may be relatively open

Radiotelemetry and a pointing dog are used to capture sage grouse chicks for a research project in southeastern Idaho.

(about 14% canopy cover) stands of sagebrush (Martin 1970, Wallestad 1971) with ≥15% canopy cover of grasses and forbs (Sveum et al. 1998*b,* Lyon 2000). Great plant species richness with abundant forbs and insects characterize brood areas (Dunn and Braun 1986, Klott and Lindzey 1990, Drut et al. 1994*a*, Apa 1998). In Oregon, diets of sage grouse chicks included 34 genera of forbs and 41 families of invertebrates (Drut et al. 1994*b*). Insects, especially ants (Hymenoptera) and beetles (Coleoptera), are an important component of early brood-rearing habitat (Drut et al. 1994*b*, Fischer et al. 1996*a*). Ants and beetles occurred more frequently ($P=0.02$) at brood-activity centers compared to nonbrood sites (Fischer et al. 1996*a*).

### *Summer–late brood-rearing habitats*

As sagebrush habitats desiccate, grouse usually move to more mesic sites during June and July (Gill 1965, Klebenow 1969, Savage 1969, Connelly and Markham 1983, Gates 1983, Connelly et al. 1988, Fischer et al. 1996*b*). Sage grouse broods occupy a variety of habitats during summer, including sagebrush (Martin 1970), relatively small burned areas within sagebrush (Pyle and Crawford 1996), wet meadows (Savage 1969), farmland, and other irrigated areas adjacent to sagebrush habitats (Connelly and Markham 1983, Gates 1983, Connelly et al. 1988). Apa (1998) reported that sites used by grouse broods had twice as much forb cover as independent sites.

### *Fall habitats*

Sage grouse use a variety of habitats during fall. Patterson (1952) reported that grouse move from summer to winter range in October, but during mild weather in late fall, some birds may still use summer range. Similarly, Connelly and Markham (1983) observed that most sage grouse had abandoned summering areas by the first week of October. Fall movements to winter range are slow and meandering and occur from late August to December (Connelly et al. 1988). Wallestad (1975) documented a shift in feeding habits from September, when grouse were consuming a large amount of forbs, to December, when birds were feeding only on sagebrush.

### *Winter habitats*

Characteristics of sage grouse winter habitats are relatively similar throughout most of the species' range (Table 2). Eng and Schladweiler (1972) and Wallestad (1975) indicated that most observations of radiomarked sage grouse during winter in Montana occurred in sagebrush habitats with >20% canopy cover. However, Robertson (1991) indicated that sage grouse used sagebrush habitats that had average canopy coverage of 15% and average height of 46 cm during 3 winters in southeastern Idaho. In Idaho, sage grouse selected areas with greater canopy cover of Wyoming big sagebrush (*A. t. wyomingensis*) in stands containing taller shrubs when compared to random sites (Robertson 1991).

Table 2. Characteristics of sagebrush at sage grouse winter-use sites.

| State | Canopy Coverage[a] (%) | Canopy Height[a] (cm) | Reference |
|---|---|---|---|
| Colo. | | 24–36[bd] | Beck 1977 |
| Colo. | | 20–30[cd] | Beck 1977 |
| Colo. | 43[b] | 34[b] | Schoenberg 1982 |
| Colo. | 37[c] | 26[c] | Schoenberg 1982 |
| Colo. | 30–38[de] | 41–54[de] | Hupp 1987 |
| Id. | 38[e] | 56[e] | Autenrieth 1981 |
| Id. | 26[b] | 29[b] | Connelly 1982 |
| Id. | 25[c] | 26[c] | Connelly 1982 |
| Id. | 15 | 46 | Robertson 1991 |
| Mont. | 27 | 25 | Eng and Schladweiler 1972 |
| Mont. | >20 | | Wallestad 1975 |
| Oreg. | 12–17[d] | | Hanf et al. 1994 |

[a] Mean canopy coverage or height of sagebrush above snow.

[b] Males

[c] Females

[d] Ranges are given when data were provided for more than one year or area.

[e] No snow present when measurements were made or total height of plant was measured.

In Colorado, sage grouse may be restricted to <10% of the sagebrush habitat because of variation in topography and snow depth (Beck 1977, Hupp and Braun 1989). Such restricted areas of use may not occur throughout the species' range because in southeastern Idaho, severe winter weather did not result in the grouse population greatly reducing its seasonal range (Robertson 1991).

During winter, sage grouse feed almost exclusively on leaves of sagebrush (Patterson 1952, Wallestad et al. 1975). Although big sagebrush dominates the diet in most portions of the range (Patterson 1952; Wallested et al. 1975; Remington and Braun 1985; Welch et al. 1988, 1991), low sagebrush (*A. arbuscula*), black sagebrush (*A. nova,* Dalke et al. 1963, Beck 1977), fringed sagebrush (*A. frigida*, Wallestad et al. 1975), and silver sagebrush (*A. cana*, Aldridge 1998) are consumed in many areas depending on availability. Sage grouse in some areas apparently prefer Wyoming big sagebrush (Remington and Braun 1985, Myers 1992) and in other areas mountain big sagebrush (Welch et al. 1988, 1991). Some of the differences in selection may be due to preferences for greater levels of protein and the amount of volatile oils (Remington and Braun 1985, Welch et al. 1988).

## Effects of habitat alteration

### *Range management treatments*

*Breeding habitat*. Until the early 1980s, herbicide treatment (primarily with 2,4-D) was the most common method to reduce sagebrush on large tracts of rangeland (Braun 1987). Klebenow (1970) reported cessation of nesting in newly sprayed areas with < 5% live sagebrush canopy cover. Nesting also was nearly nonexistent in older sprayed areas containing about 5% live sagebrush cover (Klebenow 1970). In virtually all documented cases, herbicide application to blocks of sagebrush rangeland resulted in major declines in sage grouse breeding populations (Enyeart 1956, Higby 1969, Peterson 1970, Wallestad 1975). Effects of this treatment on sage grouse populations seemed more severe if the treated area was subsequently seeded to crested wheatgrass (*Agropyron cristatum*, Enyeart 1956).

Using fire to reduce sagebrush has become more common since most uses of 2,4-D on public lands were prohibited (Braun 1987). Klebenow (1972) and Sime (1991) suggested that fire may benefit sage grouse populations. Neither Gates (1983), Martin (1990), nor Bensen et al. (1991) reported adverse effects of fire on breeding populations of sage grouse. In contrast, following a 9-year study, Connelly et al. (1994, 2000*b*) indicated that prescribed burning of Wyoming big sagebrush during a drought period resulted in a large decline (>80%) of a sage grouse breeding population in southeastern Idaho. Additionally, Hulet (1983) documented loss of leks from fire and Nelle et al. (2000) reported that burning mountain big sagebrush stands had long-term negative impacts on sage grouse nesting and brood-rearing habitats. Canopy cover in mountain big sagebrush did not provide appropriate nesting habitat 14 years after burning (Nelle et al. 2000). The impact of fire on sage grouse populations using habitats dominated by silver sagebrush (which may resprout following fire) is unknown.

Cheatgrass (*Bromus tectrorum*) will often occupy sites following disturbance, especially burning (Valentine 1989). Repeated burning or burning in late summer favors cheatgrass invasion and may be a major cause of the expansion of this species (Vallentine 1989). The ultimate result may be a loss of the sage grouse population because of long-term conversion of sagebrush habitat to rangeland dominated by an annual exotic grass. However, this situation largely appears confined to the western portion of the species' range and does not commonly occur in Wyoming (J. Lawson, Wyoming Department of Game and Fish, personal communication).

Mechanical methods of sagebrush control have often been applied to smaller areas than those treated by herbicides or fire, especially to convert rangeland to cropland. However, adverse effects of this type of treatment on sage grouse breeding populations also have been documented. In Montana, Swenson et al. (1987) indicated that the number of breeding males declined by 73% after 16% of their study area was plowed.

*Brood-rearing habitats*. Martin (1970) reported that sage grouse seldom used areas treated with herbicides to remove sagebrush in southwestern Montana. In Colorado, Rogers (1964) indicated that an entire population of sage grouse appeared to emigrate from an area that was subjected to several years of herbicide application to remove sagebrush. Similarly, Klebenow (1970) reported that herbicide spraying reduced the brood-carrying capacity of an area in southeastern Idaho. However, application of herbicides in early spring to reduce sagebrush cover may enhance some brood-rearing habitats by increasing the amount of herbaceous plants used for food (Autenrieth 1981).

Fire may improve sage grouse brood-rearing habitat (Klebenow 1972, Gates 1983, Sime 1991), but until recently, experimental evidence was not available to support or refute these contentions (Braun 1987). Pyle and Crawford (1996) suggested that fire may enhance brood-rearing habitat in montane settings but cautioned that its usefulness requires further investigation. A 9-year study of the effects of fire on sage grouse did not support that prescribed fire, conducted during late summer in a Wyoming big sagebrush habitat, improved brood-rearing habitat for sage grouse (Connelly et al. 1994, Fischer et al. 1996*a*). Prescribed burning of sage grouse habitat did not increase amount of forbs in burned areas compared to unburned areas (Fischer et al. 1996*a*, Nelle et al. 2000) and resulted in decreased insect populations in the treated area compared to the unburned area. Thus, fire may negatively affect sage grouse brood-rearing habitat rather than improve it in Wyoming big sagebrush habitats (Connelly and Braun 1997), but its effect on grouse habitats in mountain big sagebrush communities requires further investigation (Pyle and Crawford 1996, Nelle et al. 2000).

Sage grouse often use agricultural areas for brood-rearing habitat (Patterson 1952, Wallestad 1975, Gates 1983, Connelly et al. 1988, Blus et al. 1989). Grouse use of these areas may result in mortality because of exposure to insecticides. Blus et al. (1989) reported die-offs of sage grouse that were exposed to methamidiphos used in potato fields and dimethoate used in alfalfa fields. Dimethoate is used commonly for alfalfa, and 20 of 31 radio-marked grouse (65%) died following direct exposure to this insecticide (Blus et al. 1989).

*Winter habitat*. Reduction in sage grouse use of an area treated by herbicide was proportional to the severity (i.e., amount of damage to sagebrush) of the treatment (Pyrah 1972). In sage grouse winter range, strip partial kill, block partial kill, and total kill of sagebrush were increasingly detrimental to sage grouse in Montana (Pyrah 1972) and Wyoming (Higby 1969).

In Idaho, Robertson (1991) reported that a 2,000-ha prescribed burn that removed 57% of the sagebrush cover in sage grouse winter habitat minimally impacted the sage grouse population. Although sage grouse use of the burned area declined following the fire, grouse adapted to this disturbance by moving 1 to 10 km outside of the burn to areas with greater sagebrush cover (Robertson 1991) than was available in the burned area.

## Land use

*Mining–energy development*. Effects of mining, oil, and gas developments on sage grouse populations are not well known (Braun 1998). These activities negatively impact grouse habitat and populations over the short term (Braun 1998), but research suggests some recovery of populations following initial development and subsequent reclamation of the affected sites (Eng et al. 1979, Tate et al. 1979, Braun 1986). In Colorado, sage grouse were displaced by oil development and coal-mining activities, but numbers returned to pre-disturbance levels once the activities ceased (Braun 1987, Remington and Braun 1991). At least 6 leks in Alberta were disturbed by energy development and 4 were abandoned (Aldridge 1998). In Wyoming, female sage grouse captured on leks disturbed by natural gas development had lower nest-initiation rates, longer movements to nest sites, and different nesting habitats than hens captured on undisturbed leks (Lyon 2000). Sage grouse may repopulate an area following energy development but may not attain population levels that occurred prior to development (Braun 1998). Thus, short-term and long-term habitat loss appears to result from energy development and mining (Braun 1998).

*Grazing*. Domestic livestock have grazed over most areas used by sage grouse and this use is generally repetitive with annual or biennial grazing periods of varying timing and length (Braun 1998). Grazing patterns and use of habitats are often dependent on weather conditions (Valentine 1990). Historic and scientific evidence indicates that livestock grazing did not increase the distribution of sagebrush (Peterson 1995) but markedly reduced the herbaceous understory over relatively large areas and increased sagebrush density in some areas (Vale 1975, Tisdale and Hironaka 1981). Within the intermountain region, some vegetation changes from livestock grazing likely occurred because sagebrush steppe in this area did not evolve with intensive grazing by wild herbivores, as did the grassland prairies of central North America (Mack and Thompson 1982). Grazing by wild ungulates may reduce sagebrush cover (McArthur et al. 1988, Peterson 1995), and livestock grazing may result in high trampling mortality of sagebrush seedlings (Owens and Norton 1992). In Wyoming big sagebrush habitats, resting areas from livestock grazing may improve understory production as well as decrease sagebrush cover (Wambolt and Payne 1986).

There is little direct experimental evidence linking grazing practices to sage grouse population levels (Braun 1987, Connelly and Braun 1997). However, grass height and cover affect sage grouse nest site selection and success (Wakkinen 1990, Gregg 1991, Gregg et al. 1994, Delong et al. 1995, Sveum et al. 1998*a*). Thus, indirect evidence suggests grazing by livestock or wild herbivores that significantly reduces the herbaceous understory in breeding habitat may have negative impacts on sage grouse populations (Braun 1987, Dobkin 1995).

*Miscellaneous activities*. Construction of roads, powerlines, fences, reservoirs, ranches, farms, and housing developments has resulted in sage grouse habitat loss and fragmentation (Braun 1998). Between 1962 and 1997, >51,000 km of fence were constructed on land administered by the Bureau of Land Management in states supporting sage grouse populations (T. D. Rich, United States Bureau of Land Management, personal communication). Structures such as powerlines and fences pose hazards to sage grouse because they provide additional perch sites for raptors and because sage grouse may be injured or killed when they fly into these structures (Call and Maser 1985).

## Weather

Prolonged drought during the 1930s and mid-1980s to early 1990s coincided with declining sage grouse populations throughout much of the species' range (Patterson 1952, Fischer 1994, Hanf et al. 1994). Drought may affect sage grouse populations by reducing herbaceous cover at nests and the quantity and quality of food available for hens and chicks during spring (Hanf et al. 1994, Fischer et al. 1996*a*).

Spring weather may influence sage grouse production. Relatively wet springs may result in increased production (Wallestad 1975, Autenrieth 1981). However, heavy rainfall during egg-laying or unseasonably cold temperatures with precipitation during hatching may decrease production (Wallestad 1975).

There is no evidence that severe winter weather affects sage grouse populations unless sagebrush cover has been greatly reduced or eliminated (Wallestad 1975, Beck 1977, Robertson 1991).

### *Predation*

Over the last 25 years, numerous studies have used radiotelemetry to address sage grouse survival and nest success (Wallestad 1975; Hulet 1983; Gregg 1991; Robertson 1991; Connelly et al. 1993, 1994; Gregg et al. 1994; Schroeder 1997). Only Gregg (1991) and Gregg et al. (1994) indicated that predation was limiting sage grouse numbers, and their research suggested that low nest success from predation was related to poor nesting habitat. Most reported nest-success rates are >40%, suggesting that nest predation is not a widespread problem. Similarly, high survival rates of adult (Connelly et al. 1993, Zablan 1993) and older (>10 weeks of age) juvenile sage grouse indicate that population declines are not generally related to high levels of predation. Thus, except for an early study in Oregon (Batterson and Morse 1948), predation has not been identified as a major limiting factor for sage grouse (Connelly and Braun 1997).

Constructing ranches, farms, and housing developments has resulted in the addition of nonnative predators to sage grouse habitats, including dogs, cats, and red foxes (*Vulpes vulpes*; J. W. Connelly, Idaho Department of Fish and Game, unpublished data; B. L. Welch, United States Forest Service, personal communication) and may be responsible for increases in abundance of the common raven (*Corvus corax*, Sauer et al. 1997). Relatively high raven populations may decrease sage grouse nest success (Batterson and Morse 1948, Autenrieth 1981), but rigorous field studies using radiotelemetry do not support this hypothesis. Current work in Strawberry Valley, Utah, suggests that red foxes are taking a relatively high proportion of the population (Flinders 1999). This may become a greater problem if red foxes become well established throughout sage grouse breeding habitat.

## Recommended guidelines

Sage grouse populations occupy relatively large areas on a year-round basis (Berry and Eng 1985, Connelly et al. 1988, Wakkinen 1990, Leonard et al. 2000), invariably involving a mix of ownership and jurisdictions. Thus, state and federal natural resource agencies and private landowners must coordinate efforts over at least an entire seasonal range to successfully implement these guidelines. Based on current knowledge of sage grouse population and habitat trends, these guidelines have been developed to help agencies and landowners effectively assess and manage populations, protect and manage remaining habitats, and restore damaged habitat. Because of gaps in our knowledge and regional variation in habitat characteristics (Tisdale and Hironaka 1981), the judgment of local biologists and quantitative data from population and habitat monitoring are necessary to implement the guidelines correctly. Further, we urge agencies to use an adaptive management approach (Macnab 1983, Gratson et al. 1993), using monitoring and evaluation to assess the success of implementing these guidelines to manage sage grouse populations.

Activities responsible for the loss or degradation of sagebrush habitats also may be used to restore these habitats. These activities include prescribed fire, grazing, herbicides, and mechanical treatments. Decisions on land treatments using these tools should be based on quantitative knowledge of vegetative conditions over an entire population's seasonal range. Generally, the treatment selected should be that which is least disruptive to the vegetation community and has the most rapid recovery time. This selection should not be based solely on economic cost.

### *Definitions*

For the purpose of these guidelines, we define an occupied lek as a traditional display area in or adjacent to sagebrush-dominated habitats that has been attended by ≥2 male sage grouse in ≥2 of the previous 5 years. We define a breeding population as a group of birds associated with 1 or more occupied leks in the same geographic area separated from other leks by >20 km. This definition is somewhat arbitrary but generally based on maximum distances females move to nest.

### *Population management*

1) Before making management decisions, agencies should cooperate to first identify lek locations and determine whether a population is migratory or nonmigratory. In the case of migratory populations, migration routes and seasonal habitats must be identified to allow for meaningful and correct management decisions.

2) Breeding populations should be assessed by either lek counts (census number of males attending leks) or lek surveys (classify known leks as active or inactive) each year (Autenrieth et al. 1982). Depending on number of counts each spring (Jenni and Hartzler 1978, Emmons and Braun

1984) and weather conditions when the counts were made, lek counts may not provide an accurate assessment of sage grouse populations (Beck and Braun 1980) and the data should be viewed with caution. Despite these shortcomings, lek counts provide the best index to breeding population levels and many long-term data sets are available for trend analysis (Connelly and Braun 1997).

3) Production or recruitment should be monitored by brood counts or wing surveys (Autenrieth et al. 1982). Brood counts are labor-intensive and usually result in inadequate sample size. Where adequate samples of wings can be obtained, we recommend using wing surveys to obtain estimates of sage grouse nesting success and juvenile:adult hen (including yearlings) ratios.

4) Routine population monitoring should be used to assess trends and identify problems for all hunted and nonhunted populations. Check stations, wing collections, and questionnaires can be used to obtain harvest information. Breeding population and production data (above) can be used to monitor nonhunted populations.

5) The genetic variation of relatively small, isolated populations should be documented to better understand threats to these populations and implement appropriate management actions (Young 1994, Oyler-McCance et al. 1999).

6) Hunting seasons for sage grouse should be based on careful assessments of population size and trends. Harvest should not be based on the observations of Allen (1954:43), who stated, "Our populations of small animals operate under a 1-year plan of decimation and replacement; and Nature habitually maintains a wide margin of overproduction. She kills off a huge surplus of animals whether we take our harvest or not." To the contrary, sage grouse tend to have relatively long lives with low annual turnover (Zablan 1993, Connelly et al. 1994) and a low reproductive rate (Gregg 1991, Connelly et al. 1993). Consequently, hunting may be additive to other causes of mortality for sage grouse (Johnson and Braun 1999, Connelly et al. 2000*a*). However, most populations appear able to sustain hunting if managed carefully (Connelly et al. 2000*a*).

7) If populations occur over relatively large geographic areas and are stable to increasing, seasons and bag limits can be relatively liberal (2- to 4-bird daily bag limit and a 2- to 5-week season) for hunting seasons allowing firearms (Braun and Beck 1985).

8) If populations are declining (for 3 or more consecutive years) or trends are unknown, seasons and bag limits should be generally conservative (1- or 2-bird daily bag limit and a 1-to 4-week season) for hunting seasons allowing firearms, or suspended (for all types of hunting, including falconry and Native American subsistence hunting) because of this species' population characteristics (Braun 1998, Connelly et al. 2000*a*).

9) Where populations are hunted, harvest rates should be 10% or less of the estimated fall population to minimize negative effects on the subsequent year's breeding population (Connelly et al. 2000*a*).

10) Populations should not be hunted where $\leq$300 birds comprise the breeding population (i.e., $\leq$100 males are counted on leks [C. E. Braun, Colorado Division of Wildlife, unpublished report]).

11) Spring hunting of sage grouse on leks should be discouraged or, if unavoidable, confined to males only during the early portion of the breeding season. Spring hunting is considered an important tradition for some Native American tribes. However, in Idaho, 80% of the leks hunted during spring in the early 1990s ($n=5$) had become inactive by 1994 (Connelly et al. 1994).

12) Viewing sage grouse on leks (and censusing leks) should be conducted so that disturbance to birds is minimized or preferably eliminated (Call and Maser 1986). Agencies should generally not provide all lek locations to individuals simply interested in viewing birds. Instead, 1 to 3 lek locations should be identified as public viewing leks, and if demand is great enough, agencies should consider erecting 2–3 seasonal blinds at these leks for public use. Camping in the center of or on active leks should be vigorously discouraged.

13) Discourage establishment of red fox and other nonnative predator populations in sage grouse habitats.

14) For small, isolated populations and declining populations, assess the impact of predation on survival and production. Predator control programs are expensive and often ineffective. In some cases, these programs may provide temporary help while habitat is recovering. Predator management programs also could be considered in areas where seasonal habitats are in good condition but their extent has been reduced greatly. However, predator management should be implemented only if the available data (e.g., nest success <25%, annual survival of adult hens <45%) support the action.

## *General habitat management*

The following guidelines pertain to all seasonal habitats used by sage grouse:

1) Monitor habitat conditions and propose treatments only if warranted by range condition (i.e., the area no longer supports habitat conditions described in the following guidelines under habitat protection). Do not base land treatments on schedules, targets, or quotas.

2) Use appropriate vegetation treatment techniques (e.g., mechanical methods, fire) to remove junipers and other conifers that have invaded sage grouse habitat (Commons et al. 1999). Whenever possible, use vegetation control techniques that are least disruptive to the stand of sagebrush, if this stand meets the needs of sage grouse (Table 3).

3) Increase the visibility of fences and other structures occurring within 1 km of seasonal ranges by flagging or similar means if these structures appear hazardous to flying grouse (e.g., birds have been observed hitting or narrowly missing these structures or grouse remains have been found next to these structures).

4) Avoid building powerlines and other tall structures that provide perch sites for raptors within 3 km of seasonal habitats. If these structures must be built, or presently exist, the lines should be buried or poles modified to prevent their use as raptor perch sites.

Table 3. Characteristics of sagebrush rangeland needed for productive sage grouse habitat.

| | Breeding | | Brood-rearing | | Winter[e] | |
|---|---|---|---|---|---|---|
| | Height (cm) | Canopy (%) | Height (cm) | Canopy (%) | Height (cm) | Canopy (%) |
| Mesic sites[a] | | | | | | |
| Sagebrush | 40–80 | 15–25 | 40–80 | 10–25 | 25–35 | 10–30 |
| Grass–forb | >18[c] | ≥25[d] | variable | >15 | N/A | N/A |
| Arid sites[a] | | | | | | |
| Sagebrush | 30–80 | 15–25 | 40–80 | 10–25 | 25–35 | 10–30 |
| Grass/forb | >18[c] | ≥15 | variable | >15 | N/A | N/A |
| Area[b] | >80 | | >40 | | >80 | |

[a] Mesic and arid sites should be defined on a local basis; annual precipitation, herbaceous understory, and soils should be considered (Tisdale and Hironaka 1981, Hironaka et al. 1983).

[b] Percentage of seasonal habitat needed with indicated conditions.

[c] Measured as "droop height"; the highest naturally growing portion of the plant.

[d] Coverage should exceed 15% for perennial grasses and 10% for forbs; values should be substantially greater if most sagebrush has a growth form that provides little lateral cover (Schroeder 1995)

[e] Values for height and canopy coverage are for shrubs exposed above snow.1

## *Breeding habitat management*

For migratory and nonmigratory populations, lek attendance, nesting, and early brood rearing occur in breeding habitats. These habitats are sagebrush-dominated rangelands with a healthy herbaceous understory and are critical for survival of sage grouse populations. Mechanical disturbance, prescribed fire, and herbicides can be used to restore sage grouse habitats to those conditions identified as appropriate in the following sections on habitat protection. Local biologists and range ecologists should select the appropriate technique on a case-by-case basis. Generally, fire should not be used in breeding habitats dominated by Wyoming big sagebrush if these areas support sage grouse. Fire can be difficult to control and tends to burn the best remaining nesting and early brood-rearing habitats (i.e., those areas with the best remaining understory), while leaving areas with poor understory. Further, we recommend against using fire in habitats dominated by xeric mountain big sagebrush (*A. t. xericensis*) because annual grasses commonly invade these habitats and much of the original habitat has been altered by fire (Bunting et al. 1987).

Although mining and energy development are common activities throughout the range of sage grouse, quantitative data on the long-term effects of these activities on sage grouse are limited. However, some negative impacts have been documented (Braun 1998, Lyon 2000). Thus, these activities should be discouraged in breeding habitats, but when they are unavoidable, restoration efforts should follow procedures outlined in these guidelines.

### *Habitat protection*

1) Manage breeding habitats to support 15–25% canopy cover of sagebrush, perennial herbaceous cover averaging ≥18 cm in height with ≥15% canopy cover for grasses and ≥10% for forbs and a diversity of forbs (Barnett and Crawford 1994, Drut et al. 1994*a*, Apa 1998) during spring (Table 3). Habitats meeting these conditions should have a high priority for wildfire suppression and should

not be considered for sagebrush control programs. Sagebrush and herbaceous cover should provide overhead and lateral concealment from predators. If average sagebrush height is >75 cm, herbaceous cover may need to be substantially greater than 18 cm to provide this protection. There is much variability among sagebrush-dominated habitats (Tisdale and Hironaka 1981, Hironaka et al. 1983), and some Wyoming sagebrush and low sagebrush breeding habitats may not support 25% herbaceous cover. In these areas, total herbaceous cover should be ≥15 % (Table 3). Further, the herbaceous height requirement may not be possible in habitats dominated by grasses that are relatively short when mature. In all of these cases, local biologists and range ecologists should develop height and cover requirements that are reasonable and ecologically defensible. Leks tend to be relatively open, thus cover on leks should not meet these requirements.

2) For nonmigratory grouse occupying habitats that are distributed uniformly (i.e., habitats have the characteristics described in guideline 1 and are generally distributed around the leks), protect (i.e., do not manipulate) sagebrush and herbaceous understory within 3.2 km of all occupied leks. For nonmigratory populations, consider leks the center of year-round activity and use them as focal points for management efforts (Braun et al. 1977).

3) For nonmigratory populations where sagebrush is not distributed uniformly (i.e., habitats have the characteristics described in guideline 1 but distributed irregularly with respect to leks), protect suitable habitats for ≤5 km from all occupied leks. Use radiotelemetry, repeated surveys for grouse use, or habitat mapping to identify nesting and early brood-rearing habitats.

4) For migratory populations, identify and protect breeding habitats within 18 km of leks in a manner similar to that described for nonmigratory sage grouse. For migratory sage grouse, leks generally are associated with nesting habitats but migratory birds may move >18 km from leks to nest sites. Thus, protection of habitat within 3.2 km of leks may not protect most of the important nesting areas (Wakkinen et al. 1992, Lyon 2000).

5) In areas of large-scale habitat loss (≥40% of original breeding habitat), protect all remaining habitats from additional loss or degradation. If remaining habitats are degraded, follow guidelines for habitat restoration listed below.

6) During drought periods (≥2 consecutive years), reduce stocking rates or change management practices for livestock, wild horses, and wild ungulates if cover requirements during the nesting and brood-rearing periods are not met. Grazing pressure from domestic livestock and wild ungulates should be managed in a manner that at all times addresses the possibility of drought.

Sage grouse just leaving a nest in good-condition breeding habitat in southwestern Idaho. Note the height of grass and herbaceous cover.

7) Suppress wildfires in all breeding habitats. In the event of multiple fires, land management agencies should have all breeding habitats identified and prioritized for suppression, giving the greatest priority to those that have become fragmented or reduced by >40% in the last 30 years.

8) Adjust timing of energy exploration, development, and construction activity to minimize disturbance of sage grouse breeding activities. Energy-related facilities should be located >3.2 km from active leks whenever possible. Human activities within view of or <0.5 km from leks should be minimized during the early morning and late evening when birds are near or on leks.

*Habitat restoration*

1) Before initiating vegetation treatments, quantitatively evaluate the area proposed for treatment to ensure that it does not have sagebrush and herbaceous cover suitable for breeding habitat (Table 3). Treatments should not be undertaken within sage grouse habitats until the limiting vegetation factor(s) has been identified, the proposed treatment is known to provide the desired vegetation response, and land-use activities can be managed after treatment to ensure that vegetation objectives are met.

2) Restore degraded rangelands to a condition that again provides suitable breeding habitat for sage grouse by including sagebrush, native forbs

(especially legumes), and native grasses in reseeding efforts (Apa 1998). If native forbs and grasses are unavailable, use species that are functional equivalents and provide habitat characteristics similar to those of native species.

3) Where the sagebrush overstory is intact but the understory has been degraded severely and quality of nesting habitat has declined (Table 3), use appropriate techniques (e.g., brush beating in strips or patches and interseed with native grasses and forbs) that retain some sagebrush but open shrub canopy to encourage forb and grass growth.

4) Do not use fire in sage grouse habitats prone to invasion by cheatgrass and other invasive weed species unless adequate measures are included in restoration plans to replace the cheatgrass understory with perennial species using approved reseeding strategies. These strategies could include, but are not limited to, use of pre-emergent herbicides (e.g., Oust®, Plateau®) to retard cheatgrass germination until perennial herbaceous species become established.

5) When restoring habitats dominated by Wyoming big sagebrush, regardless of the techniques used (e.g., prescribed fire, herbicides), do not treat >20% of the breeding habitat (including areas burned by wildfire) within a 30-year period (Bunting et al. 1987). The 30-year period represents the approximate recovery time for a stand of Wyoming big sagebrush. Additional treatments should be deferred until the previously treated area again provides suitable breeding habitat (Table 3). In some cases, this may take <30 years and in other cases >30 years. If 2,4-D or similar herbicides are used, they should be applied in strips such that their effect on forbs is minimized. Because fire generally burns the best remaining sage grouse habitats

Nest habitat is measured in Owyhee County, southwestern Idaho.

This breeding habitat is in poor condition because of a lack of understory.

(i.e., those with the best understory) and leaves areas with sparse understory, use fire for habitat restoration only when it can be convincingly demonstrated to be in the best interest of sage grouse.

6) When restoring habitats dominated by mountain big sagebrush, regardless of the techniques used (e.g., fire, herbicides), treat ≤20% of the breeding habitat (including areas burned by wildfire) within a 20-year period (Bunting et al. 1987). The 20-year period represents the approximate recovery time for a stand of mountain big sagebrush. Additional treatments should be deferred until the previously treated area again provides suitable breeding habitat (Table 3). In some cases, this may take <20 years and in other cases >20 years. If 2,4-D or similar herbicides are used, they should be applied in strips such that their effect on forbs is minimized.

7) All wildfires and prescribed burns should be evaluated as soon as possible to determine whether reseeding is necessary to achieve habitat management objectives. If needed, reseed with sagebrush, native bunchgrasses, and forbs whenever possible.

8) Until research unequivocally demonstrates that using tebuthiuron and similar-acting herbicides to control sagebrush has no long-lasting negative impacts on sage grouse habitat, use these herbicides only on an experimental basis and over a sufficiently small area that any long-term negative impacts are negligible. Because these herbicides have the potential of reducing but not eliminating sagebrush cover within grouse breeding habitats, thus stimulating herbaceous development, their use as sage grouse habitat management tools should be examined closely.

John Crawford explains Oregon's sage grouse research program to field-trip attendees during a meeting of the Western States Sage and Columbian sharp-tailed Grouse Technical Committee.

## *Summer–late brood-rearing habitat management*

Sage grouse may use a variety of habitats, including meadows, farmland, dry lakebeds, sagebrush, and riparian zones from late June to early November (Patterson 1952, Wallestad 1975, Connelly 1982, Hanf et al. 1994). Generally, these habitats are characterized by relatively moist conditions and many succulent forbs in or adjacent to sagebrush cover.

*Habitat protection*

1) Avoid land-use practices that reduce soil moisture effectiveness, increase erosion, cause invasion of exotic plants, and reduce abundance and diversity of forbs.

2) Avoid removing sagebrush within 300 m of sage grouse foraging areas along riparian zones, meadows, lakebeds, and farmland, unless such removal is necessary to achieve habitat management objectives (e.g., meadow restoration, treatment of conifer encroachment).

3) Discourage use of very toxic organophosphorus and carbamate insecticides in sage grouse brood-rearing habitats. Sage grouse using agricultural areas may be adversely affected by pesticide applications (Blus et al. 1989). Less toxic agrichemicals or biological control may provide suitable alternatives in these areas.

4) Avoid developing springs for livestock water, but if water from a spring will be used in a pipeline or trough, design the project to maintain free water and wet meadows at the spring. Capturing water from springs using pipelines and troughs may adversely affect wet meadows used by grouse for foraging.

*Habitat restoration*

1) Use brush beating or other mechanical treatments in strips 4–8 m wide in areas with relatively high shrub-canopy cover ($\geq$35% total shrub cover) to improve late brood-rearing habitats. Brush beating can be used to effectively create different age classes of sagebrush in large areas with little age diversity.

2) If brush beating is impractical, use fire or herbicides to create a mosaic of openings in mountain big sagebrush and mixed-shrub communities used as late brood-rearing habitats where total shrub cover is $\geq$35%. Generally, 10–20% canopy cover of sagebrush and $\leq$25% total shrub cover will provide adequate habitat for sage grouse during summer.

3) Construct water developments for sage grouse only in or adjacent to known summer-use areas and provide escape ramps suitable for all avian species and other small animals. Water developments and "guzzlers" may improve sage grouse summer habitats (Autenrieth et al. 1982, Hanf et al. 1994). However, sage grouse used these developments infrequently in southeastern Idaho because most were constructed in sage grouse winter and breeding habitat rather than summer range (Connelly and Doughty 1989).

4) Whenever possible, modify developed springs and other water sources to restore natural free-flowing water and wet meadow habitats.

## *Winter habitat management*

Sagebrush is the essential component of winter habitat. Sage grouse select winter-use sites based on snow depth and topography, and snowfall can affect the amount and height of sagebrush available to grouse (Connelly 1982, Hupp and Braun 1989, Robertson 1991). Thus, on a landscape scale, sage grouse winter habitats should allow grouse access to sagebrush under all snow conditions (Table 3).

*Habitat protection*

1) Maintain sagebrush communities on a landscape scale, allowing sage grouse access to sagebrush stands with canopy cover of 10–30% and heights of at least 25–35 cm regardless of snow cover. These areas should be high priority for wildfire suppression and sagebrush control should be avoided.

2) Protect patches of sagebrush within burned areas from disturbance and manipulation. These areas may provide the only winter habitat for sage grouse and their loss could result in the extirpation of the grouse population. They also are important

seed sources for sagebrush re-establishment in the burned areas. During fire-suppression activities do not remove or burn any remaining patches of sagebrush within the fire perimeter.

3) In areas of large-scale habitat loss ($\geq$40% of original winter habitat), protect all remaining sagebrush habitats.

*Habitat restoration*

1) Reseed former winter range with the appropriate subspecies of sagebrush and herbaceous species unless the species are recolonizing the area in a density that would allow recovery (Table 3) within 15 years.

2) Discourage prescribed burns >50 ha, and do not burn >20% of an area used by sage grouse during winter within any 20–30-year interval (depending on estimated recovery time for the sagebrush habitat).

## Conservation strategies

We recommend that each state and province develop and implement conservation plans for sage grouse. These plans should use local working groups comprised of representatives of all interested agencies, organizations, and individuals to identify and solve regional issues (Anonymous 1997). Within the context of these plans, natural resource agencies should cooperate to document the amount and condition of sagebrush rangeland remaining in the state or province. Local and regional plans should summarize common problems to conserve sage grouse and general conditions (Table 3) needed to maintain healthy sage grouse populations. Local differences in conditions that affect sage grouse populations may occur and should be considered in conservation plans. Natural resource agencies should identify remaining breeding and winter ranges in Wyoming big sagebrush habitats and establish these areas as high priority for wildfire suppression. Prescribed burning in habitats that are in good ecological condition should be avoided. Protection and restoration of sage grouse habitats also will likely benefit many other sagebrush obligate species (Saab and Rich 1997) and enhance efforts to conserve and restore sagebrush steppe.

Although translocating sage grouse to historical range has been done on numerous occasions, few attempts have been successful (Musil et al. 1993, Reese and Connelly 1997). Thus, we agree with Reese and Connelly (1997) that translocation efforts should be viewed as only experimental at this time and not as a viable management strategy.

More information is needed on characteristics of healthy sagebrush ecosystems and the relationship of grazing to sage grouse production. Field experiments should be implemented to evaluate the relationship of grazing pressure (i.e., disturbance and removal of herbaceous cover) to sage grouse nest success and juvenile survival (Connelly and Braun 1997). The overall quality of existing sage grouse habitat will become increasingly important as quantity of these habitats decrease. Sage grouse populations appear relatively secure in some portions of their range and at risk in other portions. However, populations that have thus far survived extensive habitat loss may still face extinction because of a time lag between habitat loss and ultimate population collapse (Cowlishaw 1999).

*Acknowledgments.* This is a contribution from Colorado Federal Aid in Wildlife Restoration Project W-167-R, Idaho Federal Aid in Wildlife Restoration Project W-160-R, and Washington Federal Aid in Wildlife Restoration Project W-96-R. We thank state and federal representatives to the Western States Sage and Columbian Sharp-tailed Grouse Technical Committee for providing comments on earlier drafts. We are very grateful to A. D. Apa, J. A. Crawford, J. T. Flinders, T. P. Hemker, M. Pellant, and T. D. Rich for their contributions to the development of these guidelines. We also thank K. P. Reese and an anonymous reviewer for helpful comments on this manuscript. Finally, we greatly appreciate the thoughts and suggestions provided by many other individuals interested in conservation and management of sage grouse.

## Literature cited

Aldridge, C. L. 1998. Status of the sage grouse (*Centrocercus urophasianus urophasianus*) in Alberta. Alberta Environmental Protection, Wildlife Management Division, and Alberta Conservation Association, Wildlife Status Report 13, Edmonton, Canada.

Allen, D. L. 1954. Our wildlife legacy. Funk and Wagnalls, New York, New York, USA.

Anonymous. 1997. Gunnison sage grouse conservation plan, Gunnison Basin, Colorado. Colorado Division of Wildlife, Fort Collins, USA.

Apa, A. D. 1998. Habitat use and movements of sympatric sage and Columbian sharp-tailed grouse in southeastern Idaho. Dissertation, University of Idaho, Moscow, USA.

Autenrieth, R. E. 1981. Sage grouse management in Idaho. Idaho Department of Fish and Game, Wildlife Bulletin 9, Boise, Idaho, USA.

AUTENRIETH, R. E., W. MOLINI, AND C. E. BRAUN. 1982. Sage grouse management practices. Western States Sage Grouse Committee, Technical Bulletin 1, Twin Falls, Idaho, USA.

BARNETT, J. F., AND J. A. CRAWFORD. 1994. Pre-laying nutrition of sage grouse hens in Oregon. Journal of Range Management 47: 114–118.

BATTERSON, W. M., AND W. B. MORSE. 1948. Oregon sage grouse. Oregon Game Commission Fauna Series 1, Portland, USA.

BECK, T. D. I. 1975. Attributes of a wintering population of sage grouse, North Park, Colorado. Thesis, Colorado State University, Fort Collins, USA.

BECK, T. D. I. 1977. Sage grouse flock characteristics and habitat selection during winter. Journal of Wildlife Management 41: 18–26.

BECK, T. D. I., AND C. E. BRAUN. 1980. The strutting ground count: variation, traditionalism, management needs. Proceedings of the Western Association of Fish and Wildlife Agencies 60: 558–566.

BENSON, L. A., C. E. BRAUN, AND W. C. LEININGER. 1991. Sage grouse response to burning in the big sagebrush type. Proceedings, issues and technology in the management of impacted western wildlife. Thorne Ecological Institute 5: 97–104.

BERGERUD, A. T. 1988. Population ecology of North American grouse. Pages 578–648 *in* A. T. Bergerud and M. W. Gratson, editors. Adaptive strategies and population ecology of northern grouse. University of Minnesota, Minneapolis, USA.

BERRY, J. D., AND R. L. ENG. 1985. Interseasonal movements and fidelity to seasonal use areas by female sage grouse. Journal of Wildlife Management 49: 237–240.

Blus, L. J., C. S. Staley, C. J. Henny, G. W. Pendleton, T. H. Craig, E. H. Craig, and D. K. HALFORD. 1989. Effects of organophosphorus insecticides on sage grouse in southeastern Idaho. Journal of Wildlife Management 53: 1139–1146.

BRADBURY, J. W., R. M. GIBSON, C. E. MCCARTHY, AND S. L. VEHRENCAMP. 1989. Dispersion of displaying male sage grouse. II. The role of female dispersion. Behavioral Ecology and Sociobiology 24: 15–24.

BRAUN, C. E. 1986. Changes in sage grouse lek counts with advent of surface coal mining. Proceedings, issues and technology in the management of impacted western wildlife. Thorne Ecological Institute 2: 227–231.

BRAUN, C. E. 1987. Current issues in sage grouse management. Proceedings of the Western Association of Fish and Wildlife Agencies 67: 134–144.

BRAUN, C. E. 1998. Sage grouse declines in western North America: what are the problems? Proceedings of the Western Association of State Fish and Wildlife Agencies 78: 139–156.

BRAUN, C. E., AND T. D. I BECK. 1985. Effects of changes in hunting regulations on sage grouse harvest and populations. Pages 335–344 *in* S. L. Beasom and S. F. Roberson, editors. Game harvest management. Caesar Kleberg Wildlife Research Institute, Kingsville, Texas, USA.

BRAUN C. E., T. BRITT, AND R. O. WALLESTAD. 1977. Guidelines for maintenance of sage grouse habitats. Wildlife Society Bulletin 5: 99–106.

BRAUN C. E., M. F. BAKER, R. L. ENG, J. W. GASHWILER, AND M. H. SCHROEDER. 1976. Conservation committee report on effects of alteration of sagebrush communities on the associated avifauna. Wilson Bulletin 88: 165–171.

BUNTING, S. C., B. M. KILGORE, AND C. L. BUSHEY. 1987. Guidelines for prescribed burning sagebrush-grass rangelands in the northern great basin. United States Department of Agriculture, Forest Service, General Technical Report INT-231, Ogden, Utah, USA.

CALL, M. W., AND C. MASER. 1985. Wildlife habitats in managed rangelands—the great basin of southeastern Oregon. Sage grouse. United States Department of Agriculture, Forest Service, General Technical Report PNW-187, Portland, Oregon, USA.

COGGINS, K. A. 1998. Sage grouse habitat use during the breeding season on Hart Mountain National Antelope Refuge. Thesis, Oregon State University, Corvallis, USA.

COMMONS, M. L., R. K. BAYDACK, AND C. E. BRAUN. 1999. Sage grouse response to pinyon-juniper management. Pages 238–239 *in* S. B. Monson and R. Stevens, compilers. Proceedings: ecology and management of pinyon–juniper communities. United States Department of Agriculture, Forest Service, RMRS-P9, Fort Collins, Colorado, USA.

CONNELLY, J. W., JR. 1982. An ecological study of sage grouse in southeastern Idaho. Dissertation, Washington State University, Pullman, USA.

CONNELLY, J. W., W. J. ARTHUR, AND O. D. MARKHAM. 1981. Sage grouse leks on recently disturbed sites. Journal of Range Management 52: 153–154.

Connelly, J. W., A. D. Apa, R. B. Smith, and K. P. Reese. 2000*a*. Effects of predation and hunting on adult sage grouse *Centrocercus urophasianus* in Idaho. Wildlife Biology 6: in press.

CONNELLY, J. W., AND C. E. BRAUN. 1997. Long-term changes in sage grouse *Centrocercus urophasianus* populations in western North America. Wildlife Biology 3/4: 123–128.

CONNELLY, J. W., H. W. BROWERS, AND R. J. GATES. 1988. Seasonal movements of sage grouse in southeastern Idaho. Journal of Wildlife Management 52: 116–122.

CONNELLY, J. W., AND L. A. DOUGHTY. 1989. Sage grouse use of wildlife water developments in southeastern Idaho. Pages 167–173 *in* S. Stiver and G. Tsukomoto, editors. Symposium on wildlife water developments. Nevada Department of Fish and Game, Reno, USA.

CONNELLY, J. W., R. A. FISCHER, A. D. APA, K. P. REESE, AND W. L. WAKKINEN. 1993. Renesting of sage grouse in southeastern Idaho. Condor 95: 1041–1043.

CONNELLY, J. W., AND O. D. MARKHAM. 1983. Movements and radionuclide concentrations of sage grouse in southeastern Idaho. Journal of Wildlife Management 47: 169–177.

CONNELLY, J. W., K. P. REESE, R. A. FISCHER, AND W. L. WAKKINEN. 2000*b*. Response of sage grouse breeding population to fire in southeastern Idaho. Wildlife Society Bulletin 28: 90–96.

CONNELLY, J. W., K. P. REESE, W. L. WAKKINEN, M. D. ROBERTSON, AND R. A. FISCHER. 1994. Sage grouse ecology report. Idaho Department of Fish and Game, Job Completion Report W-160-R-19, Subproject 9, Boise, Idaho, USA.

CONNELLY, J. W., W. L. WAKKINEN, A. D. APA, AND K. P. REESE. 1991. Sage grouse use of nest sites in southeastern Idaho. Journal of Wildlife Management 55: 521–524.

COWLISHAW, G. 1999. Predicting the pattern of decline of African primate diversity: an extinction debt from historical deforestation. Conservation Biology 13: 1183–1193.

DALKE, P. D., D. B. PYRAH, D. C. STANTON, J. E. CRAWFORD, AND E. F. SCHLATTERER. 1963. Ecology, productivity, and management of sage grouse in Idaho. Journal of Wildlife Management 27: 810–841.

DELONG, A. K. 1993. Relationships between vegetative structure and predation rates of artificial sage grouse nests. Thesis, Oregon State University, Corvallis, USA.

DeLong, A. K., J. A. Crawford, and D. C. DeLong, Jr. 1995. Relationships between vegetational structure and predation of artificial sage grouse nests. Journal of Wildlife Management 59:88–92.

Dobkin, D. S. 1995. Management and conservation of sage grouse, denominative species for the ecological health of shrubsteppe ecosystems. United States Department of Interior, Bureau of Land Management, Portland, Oregon, USA.

Drut, M. S., J. A. Crawford, and M. A. Gregg. 1994*a*. Brood habitat use by sage grouse in Oregon. Great Basin Naturalist 54: 170–176.

Drut, M. S., W. H. Pyle, and J. A. Crawford. 1994*b*. Diets and food selection of sage grouse chicks in Oregon. Journal of Range Management 47:90–93.

Dunn, P. O., and C. E. Braun. 1986. Summer habitat use by adult female and juvenile sage grouse. Journal of Wildlife Management 50:228–235.

Edelmann, F. B., M. J. Ulliman, M. J. Wisdom, K. P. Reese, and J. W. Connelly. 1998. Assessing habitat quality using population fitness parameters: a remote sensing–GIS-based habitat-explicit population model for sage grouse (*Centrocercus urophasianus*). Idaho Forest, Wildlife and Range Experiment Station, Technical Report 25, Moscow, USA.

Edminster, F. C. 1954. American game birds of field and forest. Charles Scribner's Sons, New York, New York, USA.

Emmons, S. R., and C. E. Braun. 1984. Lek attendance of male sage grouse. Journal of Wildlife Management 48:1023–1028.

Eng, R. L. 1963. Observations on the breeding biology of male sage grouse. Journal of Wildlife Management 27:841–846.

Eng, R. L., and P. Schladweiler. 1972. Sage grouse winter movements and habitat use in central Montana. Journal of Wildlife Management 36:141–146.

Eng, R. L., E. J. Pitcher, S. J. Scott, and R. J. Greene. 1979. Minimizing the effect of surface coal mining on a sage grouse population by a directed shift of breeding activities. Pages 464–468 *in* G. A. Swanson, technical coordinator. The mitigation symposium: a national workshop on mitigating losses of fish and wildlife habitats. United States Department of Agriculture, Forest Service, General Technical Report RM-65, Fort Collins, Colorado, USA.

Enyeart, G. 1956. Responses of sage grouse to grass reseeding in the Pines area, Garfield County, Utah. Thesis, Utah State Agricultural College, Logan, USA.

Fischer, R. A. 1994. The effects of prescribed fire on the ecology of migratory sage grouse in southeastern Idaho. Dissertation, University of Idaho, Moscow, USA.

Fischer, R. A., A. D. Apa, W. L. Wakkinen, K. P. Reese, and J. W. Connelly. 1993. Nesting-area fidelity of sage grouse in southeastern Idaho. Condor 95:1038–1041.

Fischer, R. A., K. P. Reese, and J. W. Connelly. 1996*a*. An investigation on fire effects within xeric sage grouse brood habitat. Journal of Range Management 49:194–198.

Fischer, R. A., K. P. Reese, and J. W. Connelly. 1996*b*. Influence of vegetal moisture content and nest fate on timing of female sage grouse migration. Condor 98:868–872.

Fischer, R. A., K. P. Reese, and J. W. Connelly. 1997. Effects of prescribed fire on movements of female sage grouse from breeding to summer ranges. Wilson Bulletin 109:82–91.

Flinders, J. T. 1999. Restoration of sage grouse in Strawberry Valley, Utah, 1998–99 report. Utah Reclamation Mitigation and Conservation Commission, Progress Report. Brigham Young University, Provo, Utah, USA.

Gates, R. J. 1983. Sage grouse, lagomorph, and pronghorn use of a sagebrush grassland burn site on the Idaho National Engineering Laboratory. Thesis, Montana State University, Bozeman, USA.

Gates, R. J. 1985. Observations of the formation of a sage grouse lek. Wilson Bulletin 97:219–221.

Gill, R. B. 1965. Distribution and abundance of a population of sage grouse in North Park, Colorado. Thesis, Colorado State University, Fort Collins, USA.

Girard, G. L. 1937. Life history, habits, and food of the sage grouse, *Centrocercus urophasianus* Bonaparte. University of Wyoming, Publication 3, Laramie, USA.

Gratson, M. W., J. W. Unsworth, P. Zager, and L. Kuck. 1993. Initial experiences with adaptive resource management for determining appropriate antlerless elk harvest rates in Idaho. Transactions of the North American Wildlife and Natural Resources Conference 58:610–619.

Gray, G. M. 1967. An ecological study of sage grouse broods with reference to nesting, movements, food habits and sagebrush strip spraying in the Medicine Lodge drainage, Clark County, Idaho. Thesis, University of Idaho, Moscow, USA.

Gregg, M. A. 1991. Use and selection of nesting habitat by sage grouse in Oregon. Thesis, Oregon State University, Corvallis, USA.

Gregg, M. A., J. A. Crawford, M. S. Drut, and A. K. DeLong. 1994. Vegetational cover and predation of sage grouse nests in Oregon. Journal of Wildlife Management 58:162–166.

Hanf, J. M., P. A. Schmidt, and E. B. Groshens. 1994. Sage grouse in the high desert of central Oregon: results of a study, 1988–1993. United States Department of Interior, Bureau of Land Management, Series P-SG-01, Prineville, Oregon, USA.

Heath, B. J., R. Straw, S. H. Anderson, and J. Lawson. 1997. Sage grouse productivity, survival, and seasonal habitat use near Farson, Wyoming. Wyoming Game and Fish Department, Project Completion Report, Laramie, USA.

Higby, L. W. 1969. A summary of the Longs Creek sagebrush control project. Proceedings, Biennial Western States Sage Grouse Workshop 6:164–168.

Hironaka, M., M. A. Fosberg, and A. H. Winward. 1983. Sagebrush-grass habitat types of southern Idaho. Idaho Forest, Wildlife and Range Experiment Station, Bulletin 35, Moscow, Idaho, USA.

Holloran, M. J. 1999. Sage grouse (*Centrocercus urophasianus*) seasonal habitat use near Casper, Wyoming. Thesis, University of Wyoming, Laramie, USA.

Hornaday, W. T. 1916. Save the sage grouse from extinction, a demand from civilization to the western states. New York Zoological Park Bulletin 5:179–219.

Hulet, B. V. 1983. Selected responses of sage grouse to prescribed fire, predation, and grazing by domestic sheep in southeastern Idaho. Thesis, Brigham Young University, Provo, Utah, USA.

Hupp, J. W. 1987. Sage grouse resource exploitation and endogenous reserves in Colorado. Dissertation, Colorado State University, Fort Collins, USA.

Hupp, J. W., and C. E. Braun. 1989. Topographic distribution of sage grouse foraging in winter. Journal of Wildlife Management 53:823–829.

Jenni, D. A., and J. E. Hartzler. 1978. Attendance at a sage grouse lek: implications for spring censuses. Journal of Wildlife Management 42:46–52.

JOHNSON, K. H., AND C. E. BRAUN. 1999. Viability and conservation of an exploited sage grouse population. Conservation Biology 13:77–84.

KEISTER, G. P., AND M. J. WILLIS. 1986. Habitat selection and success of sage grouse hens while nesting and brooding. Oregon Department of Fish and Wildlife, Progress Report W-87-R-2, Subproject 285, Portland, Oregon, USA.

KLEBENOW, D. A. 1969. Sage grouse nesting and brood habitat in Idaho. Journal of Wildlife Management 33:649–661.

KLEBENOW, D. A. 1970. Sage grouse versus sagebrush control in Idaho. Journal of Range Management 23:396–400.

KLEBENOW, D. A. 1972. The habitat requirements of sage grouse and the role of fire in management. Tall Timbers Fire Ecology Conference 12:305–315.

KLOTT, J. H., AND F. G. LINDZEY. 1990. Brood habitats of sympatric sage grouse and Columbian sharp-tailed grouse in Wyoming. Journal of Wildlife Management 54:84–88.

KLOTT, J. H., R. B. SMITH, AND C. VULLO. 1993. Sage grouse habitat use in the Brown's Bench area of south-central Idaho. United States Department of Interior, Bureau of Land Management, Idaho State Office, Technical Bulletin 93–4, Boise, Idaho, USA.

LYON, A.G. 2000. The potential effects of natural gas development on sage grouse (*Centrocercus urophasianus*) near Pinedale, Wyoming. Thesis, University of Wyoming, Laramie, USA.

LEONARD, K. M., K. P. REESE, AND J. W. CONNELLY. 2000. Distribution, movements, and habitats of sage grouse *Centrocercus urophasianus* on the Upper Snake River Plain of Idaho: changes from the 1950's to the 1990's. Wildlife Biology 6: in press.

MACK, R. N., AND J. N. THOMPSON. 1982. Evolution in steppe with few large, hooved mammals. American Naturalist 119: 757–773.

MACNAB, J. 1983. Wildlife management as scientific experimentation. Wildlife Society Bulletin 11:397–401.

MARTIN, N. S. 1970. Sagebrush control related to habitat and sage grouse occurrence. Journal of Wildlife Management 34: 313–320.

MARTIN, R. C. 1990. Sage grouse responses to wildfire in spring and summer habitats. Thesis, University of Idaho, Moscow, USA.

MCARTHUR, E. D., A. C. BLAUER, AND S. C. SANDERSON. 1988. Mule deer-induced mortality of mountain big sagebrush. Journal of Range Management 41:114–117.

MUSIL, D. D., J. W. CONNELLY, AND K. P. REESE. 1993. Movements, survival, and reproduction of sage grouse translocated into central Idaho. Journal of Wildlife Management 57:85–91.

MYERS, O. B. 1992. Sage grouse habitat enhancement: effects of sagebrush fertilization. Dissertation, Colorado State University, Fort Collins, USA.

NELLE, P. J. , K. P. REESE, AND J. W. CONNELLY. 2000. The long-term effect of fire on sage grouse nesting and brood-rearing habitats on the Upper Snake River Plain. Journal of Range Management 53:586–591.

OWENS, M. K., AND B. E. NORTON. 1992. Interactions of grazing and plant protection on basin big sagebrush (*Artemisia tridentata* spp. *tridentata*) seedling survival. Journal of Range Management 45:257–262.

OYLER-MCCANCE, S. J., N. W. KAHN, K. P. BURNHAM, C. E. BRAUN, AND T. W. QUINN. 1999. A population genetic comparison of large and small-bodied sage grouse in Colorado using microsatellite and mitochondrial DNA markers. Molecular Ecology, 8: 1457–1465.

PATTERSON, R. L. 1952. The sage grouse in Wyoming. Sage Books, Denver, Colorado, USA.

PETERSEN, B. E. 1980. Breeding and nesting ecology of female sage grouse in North Park, Colorado. Thesis, Colorado State University, Fort Collins, USA.

PETERSON, J. G. 1970. The food habits and summer distribution of juvenile sage grouse in central Montana. Journal of Wildlife Management 34:147–155.

PETERSON, J. G. 1995. Ecological implications of sagebrush manipulation: a literature review. Montana Fish, Wildlife, and Parks, Helena, USA.

PYLE, W. H., AND J. A. CRAWFORD. 1996. Availability of foods of sage grouse chicks following prescribed fire in sagebrush–bitterbrush. Journal of Range Management 49:320–324.

PYRAH, D. B. 1972. Effects of chemical and mechanical sagebrush control on sage grouse. Montana Fish and Game Department, Job Completion Report W-105-R-6, Helena, USA.

REESE, K. P., AND J. W. CONNELLY. 1997. Translocations of sage grouse *Centrocercus urophasianus* in North America. Wildlife Biology 3/4:235–241.

REMINGTON, T. E., AND C. E. BRAUN. 1985. Sage grouse food selection in winter, North Park, Colorado. Journal of Wildlife Management 49:1055–1061.

REMINGTON, T. E., AND C. E. BRAUN. 1991. How surface coal mining affects sage grouse, North Park, Colorado. Proceedings, Issues and Technology in the Management of Impacted Western Wildlife. Thorne Ecological Institute 5:128–132.

ROBERTSON, M. D. 1991. Winter ecology of migratory sage grouse and associated effects of prescribed fire in southeastern Idaho. Thesis, University of Idaho, Moscow, USA.

ROGERS, G. E. 1964. Sage grouse investigations in Colorado. Colorado Game, Fish, and Parks Department, Technical Publication 16, Denver, Colorado, USA.

SAAB, V. A., AND T. D. RICH. 1997. Large-scale conservation assessment for neotropical migratory land birds in the interior Columbia River Basin. United States Department of Agriculture, Forest Service, General Technical Report PNW-GTR-399, Portland, Oregon, USA.

SAUER, J. R., J. E. HINES, J. FALLON AND G. GOUGH. 1997. The North American breeding bird survey, results and analysis 1996–98. Version 98.1. United States Geological Survey, Patuxent Wildlife Research Center, Laurel, Maryland, USA.

SAVAGE, D. E. 1969. Relation of sage grouse to upland meadows in Nevada. Nevada Fish and Game Commission, Job Completion Report, Project W-39-R-9, Job 12, Reno, Nevada, USA.

SCHOENBERG, T. J. 1982. Sage grouse movements and habitat selection in North Park, Colorado. Thesis, Colorado State University, Fort Collins, USA.

SCHROEDER, M. A. 1995. Productivity and habitat use of sage grouse in north-central Washington. Washington Department of Fish and Wildlife, Job Progress Report Project W-96-R, Olympia, USA.

SCHROEDER, M. A. 1997. Unusually high reproductive effort by sage grouse in a fragmented habitat in north-central Washington. Condor 99:933–941.

SCHROEDER, M. A., J. R. YOUNG, AND C. E. BRAUN. 1999. Sage grouse (*Centrocercus urophasianus*). Pages 1–28 *in* A. Poole and F. Gill, editors. The birds of North America, No. 425. The Birds of North America, Philadelphia, Pennsylvania, USA.

SIME, C. A. 1991. Sage grouse use of burned, non-burned, and seeded vegetation communities on the Idaho National

Engineering Laboratory, Idaho. Thesis, Montana State University, Bozeman, USA.

Sveum, C. M. 1995. Habitat selection by sage grouse hens during the breeding season in south-central Washington. Thesis, Oregon State University, Corvallis, USA.

Sveum, C. M., W. D. Edge, and J. A. Crawford. 1998*a*. Nesting habitat selection by sage grouse in south-central Washington. Journal of Range Management 51: 265–269.

Sveum, C. M., J. A. Crawford, and W. D. Edge. 1998*b*. Use and selection of brood-rearing habitat by sage grouse in south-central Washington. Great Basin Naturalist 58: 344–351.

Swenson, J. E. 1986. Differential survival by sex in juvenile sage grouse and gray partridge. Ornis Scandinavica 17: 14–17.

Swenson, J. E., C. A. Simmons, and C. D. Eustace. 1987. Decrease of sage grouse *Centrocercus urophasianus* after plowing of sagebrush steppe. Biological Conservation 41: 125–132.

Tate, J., Jr., M. S. Boyce, and T. R. Smith. 1979. Response of sage grouse to artificially created display ground. Pages 464–468 *in* G. A. Swanson, technical coordinator. The mitigation symposium: a national workshop on mitigating losses of fish and wildlife habitats. United States Department of Agriculture, Forest Service, General Technical Report RM-65, Fort Collins, Colorado, USA.

Tisdale, E. W., and M. Hironaka. 1981. The sagebrush-grass region: a review of the ecological literature. Idaho Forest, Wildlife, and Range Experiment Station, Bulletin 33, Moscow, USA.

Trueblood, R. W. 1954. The effect of grass reseeding in sagebrush lands on sage grouse populations. Thesis, Utah State Agricultural College, Logan, USA.

Vale, T. R. 1975. Presettlement vegetation in the sagebrush-grass area of the Intermountain West. Journal of Range Management 28: 32–36.

Vallentine, J. F. 1989. Range development and improvements. Third edition. Academic, San Diego, California, USA.

Vallentine, J. F. 1990. Grazing management. Academic, San Diego, California, USA.

Wakkinen, W. L. 1990. Nest site characteristics and spring–summer movements of migratory sage grouse in southeastern Idaho. Thesis, University of Idaho, Moscow, USA.

Wakkinen, W. L., K. P. Reese, and J. W. Connelly. 1992. Sage grouse nest locations in relation to leks. Journal of Wildlife Management 56:381–383.

Wallestad, R. O. 1971. Summer movements and habitat use by sage grouse broods in central Montana. Journal of Wildlife Management 35: 129–136.

Wallestad, R. O. 1975. Life history and habitat requirements of sage grouse in central Montana. Montana Fish and Game Department, Technical Bulletin, Helena, USA.

Wallestad, R. O., and D. B. Pyrah. 1974. Movement and nesting of sage grouse hens in central Montana. Journal of Wildlife Management 38: 630–633.

Wallestad, R. O., and P. Schladweiller. 1974. Breeding season movements and habitat selection of male sage grouse. Journal of Wildlife Management 38: 634–637.

Wallestad, R. O., J. G. Peterson, and R. L. Eng. 1975. Foods of adult sage grouse in central Montana. Journal of Wildlife Management 39: 628–630.

Wambolt, C. L., and G. F. Payne. 1986. An 18-year comparison of control methods for Wyoming big sagebrush in southwestern Montana. Journal of Range Management 39: 314–319.

Welch, B. L., J. C. Pederson, and R. L. Rodriquez. 1988. Selection of big sagebrush by sage grouse. Great Basin Naturalist 48: 274–279.

Welch, B. L., F. J. Wagstaff, and J. A. Roberson. 1991. Preference of wintering sage grouse for big sagebrush. Journal of Range Management 44: 462–465.

Young, J. R. 1994. The influence of sexual selection on phenotypic and genetic divergence among sage grouse populations. Dissertation, Purdue University, West Lafayette, Indiana, USA.

Zablan, M. A. 1993. Evaluation of sage grouse banding program in North Park, Colorado. Thesis, Colorado State University, Fort Collins, USA.

John W. (Jack) Connelly (left) is a wildlife research biologist with the Idaho Department of Fish and Game. He received his B.S. in fish and wildlife resources from the University of Idaho and M.S. in wildlife biology and Ph.D. in zoology from Washington State University. He has been a member of The Wildlife Society for 25 years and is past-president of the Idaho Chapter and current president of the Northwest Section. He has been involved with research on sage grouse since 1977. Michael A. (Mike) Schroeder (right) is the upland bird research biologist for the Washington Department of Fish and Wildlife. He received his B.S. in wildlife ecology from Texas A&M University, M.S. in zoology from the University of Alberta, and Ph.D. in wildlife biology from Colorado State University. He has been a member of The Wildlife Society for 21 years. He has been studying Washington populations of sage grouse, sharp-tailed grouse, and spruce grouse since 1992. Alan R. Sands retired after 21 years as a wildlife biologist for the Bureau of Land Management and is now employed by The Nature Conservancy as a field representative for southwestern Idaho. He received his B.A. in math and science from San Diego State University and M.S. in wildlife management from Humboldt State University. He has been a member of The Wildlife Society for 25 years and is past vice-president of the Idaho Chapter. Clait E. Braun (center) recently retired from the Colorado Division of Wildlife. He received his B.S. in soil science from Kansas State University, M.S. from the University of Montana in forest wildlife management, and Ph.D. from Colorado State University in wildlife biology. He has been a member of The Wildlife Society for 39 years and is past-editor of The Journal of Wildlife Management, past-president of the Central Mountain and Plains Section, past Council Member, and past-president of The Wildlife Society.

RESTORATION ECOLOGY
The Journal of the Society for Ecological Restoration

SER SOCIETY FOR ECOLOGICAL RESTORATION

RESEARCH ARTICLE

# Postwildfire seeding to restore native vegetation and limit exotic annuals: an evaluation in juniper-dominated sagebrush steppe

Kirk W. Davies[1,2], Jon D. Bates[1], Chad S. Boyd[1]

**Reestablishment of perennial vegetation is often needed after wildfires to limit exotic species and restore ecosystem services. However, there is a growing body of evidence that questions if seeding after wildfires increases perennial vegetation and reduces exotic plants. The concern that seeding may not meet restoration goals is even more prevalent when native perennial vegetation is seeded after fire. We evaluated vegetation cover and density responses to broadcast seeding native perennial grasses and mountain big sagebrush (*Artemisia tridentata* Nutt. spp. *vaseyana* [Rydb.] Beetle) after wildfires in the western United States in six juniper (*Juniperus occidentalis* ssp. *occidentalis* Hook)-dominated mountain big sagebrush communities for 3 years postfire. Seeding native perennial species compared to not seeding increased perennial grass and sagebrush cover and density. Perennial grass cover was 4.3 times greater in seeded compared to nonseeded areas. Sagebrush cover averaged 24 and less than 0.1% in seeded and nonseeded areas at the conclusion of the study, respectively. Seeding perennial species reduced exotic annual grass and annual forb cover and density. Exotic annual grass cover was 8.6 times greater in nonseeded compared to seeded areas 3 years postfire. Exotic annual grass cover increased over time in nonseeded areas but decreased in seeded areas by the third-year postfire. Seeded areas were perennial-dominated and nonseeded areas were annual-dominated at the end of the study. Establishing perennial vegetation may be critical after wildfires in juniper-dominated sagebrush steppe to prevent the development of annual-dominated communities. Postwildfire seeding increased perennial vegetation and reduced exotic plants and justifies its use.**

**Key words: annual grasses, broadcast , cheatgrass, seeding, shrubs, western juniper**

### Implications for Practice

- Postfire seeding can increase native vegetation and limit exotic plants.
- After wildfire in juniper-dominated sagebrush steppe, perennial vegetation should be seeded to restore ecosystem services and limit exotic annual grasses.
- Broadcast seeding native perennial grasses and sagebrush is a viable restoration method after fire in juniper-dominated sagebrush communities.
- Research is needed to increase restoration efficiency by determining optimal broadcast seeding rates and seeding mixtures.
- Preventing conifer-dominance of sagebrush communities should be a management priority to limit the need for postfire restoration.

## Introduction

Postfire restoration of native vegetation is often needed in imperiled ecosystems. Restoring native vegetation is critical because some native fauna require specific habitat components that only native vegetation can provide. As areas burned annually increase in some regions (Krawchuk et al. 2009; Adams 2013), restoration of native vegetation will only become a more pressing issue. This need will likely increase in many areas because larger and more frequent and severe wildfires are expected with climate change and increasing $CO_2$ levels (Fried et al. 2004; Fulé 2008; Yue et al. 2013).

Seeding after wildfires is a commonly used management tool applied with the goal of increasing vegetation cover and reducing the abundance of exotic species (Robichaud et al. 2000; Beyer 2004). Seeding vegetation after fire is assumed to increase seeded species that will utilize resources that would otherwise be available to exotic species. However, seeding after fire has generally not achieved the goal of increasing native vegetation cover and reducing exotic species (Peppin et al. 2010; Stella et al. 2010). Furthermore, seeding native species after wildfires has been limited and there is little published information on the effectiveness of postfire seeding of native species (Beschta et al. 2004). One notable exception is Thompson et al. (2006)

Author contributions: all authors conceived and designed the study; KWD carried out the experiment, analyzed the data, and wrote the manuscript; all authors edited the manuscript.

[1]USDA-Agricultural Research Service, Eastern Oregon Agricultural Research Center, 67826-A Hwy 205, Burns, OR 97720, U.S.A.
[2]Address correspondence to K. W. Davies, email kirk.davies@ars.usda.gov


doi: 10.1111/rec.12848

who reported seeding native and non-native species in sagebrush (*Artemisia* L.) steppe communities in Utah, United States, increased perennial vegetation and limited exotic plants.

The sagebrush steppe is an ecosystem that is imperiled from multiple threats (Knick et al. 2003; Davies et al. 2011) and, consequently, multiple sagebrush-associated species are of conservation concern (Crawford et al. 2004; Suring et al. 2005; Shipley et al. 2006). The sagebrush steppe developed with infrequent fire (Wright & Bailey 1982; Mensing et al. 2006); however, exotic annual grasses have altered its recovery after fire (Davies et al. 2009). Periodic fire is necessary for limiting conifer encroachment in higher elevation sagebrush communities (Miller & Tausch 2001; Miller et al. 2005). However, once a conifer woodland has developed, the potential for a more severe fire is elevated because of increased fuel loads (Tausch 1999; Miller et al. 2008; Stebleton & Bunting 2009). Higher severity fire in fully developed woodlands increases the probability of a substantial exotic annual grass invasion (Bates et al. 2014). Limiting exotic annual grasses is important because they compete with native vegetation (Melgoza et al. 1990; Humphrey & Schupp 2004) and promote frequent wildfires that are detrimental to native species (D'Antonio & Vitousek 1992). Increases in exotic annual grass abundance are also correlated with exponential declines in native plant species and biodiversity (Davies 2011).

Reestablishing native perennial-dominated plant communities after wildfire in western juniper (*Juniperus occidentalis* ssp. *occidentalis* Hook)-encroached mountain big sagebrush (*Artemisia tridentata* Nutt. spp. *vaseyana* [Rydb.] Beetle) is important because postfire exotic plant invasion can be substantial in some locations (e.g. Bates et al. 2014; Davies & Bates 2017). Furthermore, restoring native vegetation in mountain big sagebrush communities is important because these are some of the most productive sagebrush communities (Hironaka et al. 1983; Davies & Bates 2010*a*, 2010*b*). This is an issue on millions of hectares of mountain big sagebrush that have been or are at risk of juniper encroachment in the northern Great Basin and Columbia Plateau (Miller et al. 2000; Miller et al. 2005).

Information on postwildfire seeding of native vegetation in juniper-dominated sagebrush communities is lacking. What information is available focuses on seeding after prescribed fire (Sheley & Bates 2008; Davies et al. 2014, 2017; Davies & Bates 2017). These studies were also limited as they only seeded sagebrush (Davies et al. 2017; Davies & Bates 2017), included non-native species (Davies et al. 2014), or used small plot design (2 × 2 m) that did not include sagebrush (Sheley & Bates 2008). Seeding mountain big sagebrush is often successful (Davies et al. 2014, 2018; Davies & Bates 2017). Herbaceous vegetation, particularly non-native species, may limit shrub establishment (Rinella et al. 2015, 2016; Davies et al. 2017). The effects, however, of seeding sagebrush in combination with native herbaceous vegetation are unknown. Exotic annual species can be limited when native perennial species become established in high numbers in Wyoming big sagebrush (*Artemisia tridentata* Nutt. ssp. *wyomingensis* Beetle & Young) communities (Davies & Johnson 2017), but this has not been tested in mountain big sagebrush communities. Evaluating the ability of seeded native species to establish after wildfire in juniper-dominated mountain big sagebrush is critically needed to assist land managers developing postfire restoration plans, especially in plant communities at risk of exotic annual grass invasion after wildfire.

There is a prevailing assumption that mountain big sagebrush communities recover after fire without the need for active restoration efforts (e.g. seeding). This view likely developed because mountain big sagebrush plant communities are considered more resilient to wildfire and resistant to exotic annual grass invasion than lower elevation sagebrush communities (Davies et al. 2011; Chambers et al. 2014). Mountain big sagebrush also historically burned more frequently than less productive sagebrush communities (Miller et al. 2005) and intact (i.e. nonconifer encroached) mountain big sagebrush communities often recover after fire without seeding (Lesica et al. 2007; Nelson et al. 2014). Another common assumption is that if burned mountain big sagebrush communities need seeding, introduced species should be used to rapidly occupy the site and prevent exotic plant invasion. This likely evolved from experiences in hotter, drier Wyoming big sagebrush communities where seeding introduced species is much more successful at increasing perennial vegetation and limiting exotic annual species than seeding native species (Eiswerth et al. 2009; Boyd & Davies 2010; Davies et al. 2015). Therefore, it is important to determine if seeding is needed and if seeding native vegetation can increase perennial vegetation and limit exotic annual species after wildfire in juniper-dominated mountain big sagebrush communities.

The purpose of this study was to evaluate the effects of seeding native perennial vegetation after wildfire in western juniper-dominated mountain big sagebrush communities that may be at risk of postfire exotic annual grass invasion and dominance. We hypothesized that seeding native perennial grasses and sagebrush after wildfire in juniper-dominated mountain big sagebrush communities would increase sagebrush and perennial grass cover and density and limit exotic annual grass and annual forb cover and density compared to unseeded areas.

## Methods

### Study Area

The study was conducted in southeastern Oregon in areas burned in the Buzzard wildfire complex and the Glass Butte wildfire in 2014. Study sites were located between 52 km west and 90 km southeast of Burns, Oregon. At the time of the wildfires, study sites were fully developed western juniper woodlands (i.e. dominated by juniper) established on mountain big sagebrush-bunchgrass plant communities. Juniper cover ranged from 23 to 42% across the sites prior to burning. Sagebrush was largely displaced from the communities by juniper encroachment prior to the wildfires. Wildfires killed 100% of the junipers at the study sites. Historical fire return intervals for these communities would have been less than 50 years and may have been as common as every decade (Miller et al. 2005). Common perennial grasses postfire included bluebunch wheatgrass (*Pseudoroegneria spicata* [Pursh] A. Löve), Thurber's needlegrass (*Achnatherum thurberianum* [Piper] Barkworth), Idaho fescue (*Festuca idahoensis* Elmer), bottlebrush squirreltail (*Elymus elymoides* [Raf.] Swezey), and Sandberg bluegrass (*Poa secunda* J. Presl). Study sites ranged in elevation from 1,499 to 1,683 m above sea level. Slopes ranged from 0 to 45° with aspects facing north, south, east, and west. Soils ranged from silty clay to loamy among study sites. Regional climate consists of cool, wet winters and hot, dry summers. Long-term annual precipitation (1981–2010) ranged from 300 to 426 mm among the study sites (PRISM 2018). Crop year (1 October–30 September) precipitation averaged 91, 87, and 101% of the long-term average in 2014–2015, 2015–2016, and 2016–2017, respectively. Livestock were excluded for the duration of study. Wildlife was not excluded but we saw little evidence of wildlife use.

### Experimental Design and Measurements

We used a randomized complete block design with six blocks (sites) to evaluate the effects of seeding native perennial vegetation after wildfire in juniper-dominated mountain big sagebrush communities. Blocks were separated by up to 133 km. Treatments were: (1) broadcast seeded with sagebrush and native perennial grasses (seeded), and (2) not seeded (control). Treatments were randomly assigned to one of two 10 × 30 m plots at each block. Seeding treatments were applied on 18 and 19 November of 2014. The native seed mix contained mountain brome (*Bromus marginatus* Nees ex Steud.), thickspike wheatgrass (*Elymus lanceolatus* [Scribn. & J.G. Sm.] Gould), Sherman big bluegrass (*Poa secunda* J. Presl), prairie Junegrass (*Koeleria macrantha* [Ledeb.] Schult.), Idaho fescue, Snake River wheatgrass (*Elymus wawawaiensis* J. Carlson & Barkworth), bottlebrush squirreltail, bluebunch wheatgrass, Sandberg bluegrass, and mountain big sagebrush. We originally intended to seed each species at 1.45 kg/ha but a technical error in the application resulted in each species being seeded at 5.8 kg/ha.

Vegetation measurements were conducted in early July of 2015, 2016, and 2017 using four, parallel 30-m transects spaced 2 m apart in each treatment plot in each block. Herbaceous foliar cover by species was estimated in 0.2 $m^{-2}$ quadrats located every 3 m along each 30-m transect (starting at 3 m and ending at 27 m). Bare ground, litter, biological soil crust, and rock cover were also estimated in the 0.2 $m^{-2}$ quadrats. Herbaceous density by species was measured by counting all plants rooted in the 0.2 $m^{-2}$ quadrats. Rhizomatous species density was estimated by dividing quadrats into quarters and counting quarters that contained the species. Shrub cover by species was measured using the line-intercept method along each 30-m transect. Shrub density by species was measured by counting shrubs rooted inside a 2 × 30-m belt transect place over each 30-m transect. Sagebrush density was also recorded as juvenile or mature. Sagebrush was considered mature if it had reproductive stems.

### Statistical Analyses

Repeated measures analysis of variance (ANOVA) using the mixed models procedure (Proc Mixed) in SAS v. 9.4 (SAS Institute Inc., Cary, NC, U.S.A.) was used to compare between treatments and years. Block and block by treatment interactions were considered random effects and year of sampling was the repeated variable. Covariance structure was determined using Akaike's information criterion (Littell et al. 1996). Data that violated ANOVA assumptions were square root transformed prior to analyses to better meet the assumptions of ANOVAs. All data presented are in their original dimensions (i.e. nontransformed). For analyses, herbaceous cover and density were separated into five groups: Sandberg bluegrass, perennial grasses, exotic annual grasses, perennial forbs, and annual forbs. Sandberg bluegrass was treated as its own plant group because it is smaller in stature, develops phenologically earlier, and responses differently to disturbances than other perennial grasses of the sagebrush steppe. Sherman big bluegrass, though currently classified as a variety of Sandberg bluegrass, was grouped with the other perennial grasses in the analyses because it is larger and matures later than the more common Sandberg bluegrass in this ecosystem. The exotic annual grass group was predominately comprised of cheatgrass (*Bromus tectorum* L.) with some medusahead (*Taeniatherum caput-medusae* [L.] Nevski). Shrubs were separated into sagebrush and other shrubs for analyses. Significance level for all tests was set at $p \leq 0.05$ and response variable means were reported with standard errors.

## Results

Perennial grass cover differed between treatments and among years ($p = 0.026$ and 0.012, respectively; Fig. 1A). Perennial grass cover was 4.3 times greater in the seeded treatment compared to the controls 3 years postfire. Sandberg bluegrass cover did not differ between treatments ($p = 0.069$; Fig. 1B) but varied by year ($p < 0.001$) and generally declined over time. Perennial forb cover did not vary between treatments ($p = 0.848$) or among years ($p = 0.815$) and averaged $1.3 \pm 0.5\%$ and $1.5 \pm 0.5\%$ in the seeded treatment and controls at the end of the study, respectively. Exotic annual grass cover varied by the interaction between treatment and year ($p = 0.001$; Fig. 1C). In the controls, exotic annual grass cover increased over time but in the seeded treatment, annual grass cover peaked the second postfire year and then declined the third-year postfire. Nonseeded controls had 8.6 times greater exotic annual grass cover compared to the seeded treatment at the end of the study. Annual forb cover varied between treatments and among years ($p = 0.003$ and <0.001, respectively; Fig. 1D). Annual forb cover was 2.4 times greater in the controls compared to the seeded treatment 3 years postfire. Bare ground and rock cover did not differ between treatments ($p = 0.642$ and 0.274, respectively) but both varied among years ($p < 0.001$; Fig. 2A & 2B). Bare ground and rock generally declined over time in both treatments. Litter was similar between treatments ($p = 0.141$) but varied among years ($p < 0.001$; Fig. 2C). Litter increased over time in both treatments. Biological soil crust cover was similar between treatments and among years ($p = 0.810$ and 0.086, respectively). At the end of the study, biological soil crust cover was $0.005 \pm 0.005$ and $0.006 \pm 0.004\%$ in the seeded treatment and controls, respectively. Sagebrush cover varied by the

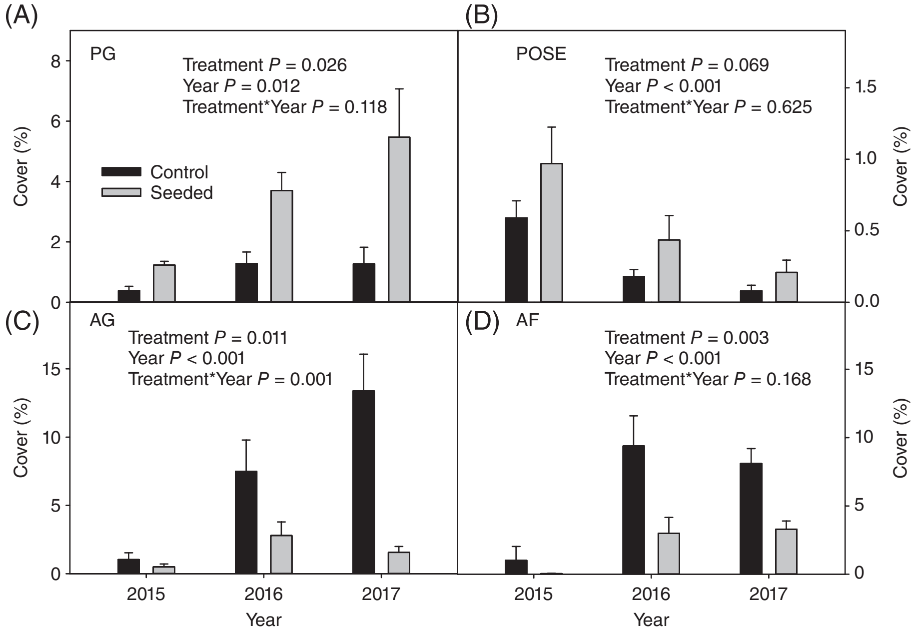



Figure 1. Herbaceous functional group cover (mean + SE) in the seeded and control treatments in 2015, 2016, and 2017. PG, perennial grass (A), POSE, Sandberg bluegrass (B), AG, exotic annual grass (C), and AF, annual forb (D).

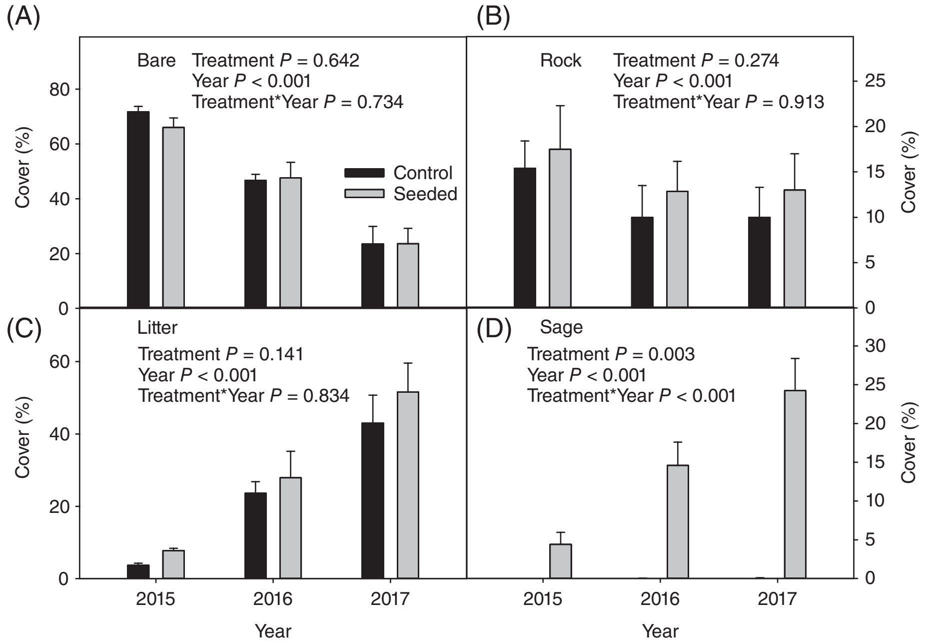



Figure 2. Cover groups cover (mean + SE) in the seeded and control treatments in 2015, 2016, and 2017. Bare, bare ground (A); rock, rock (B); litter, ground litter (C); and sage, sagebrush (D).

interaction between treatment and year ($p < 0.001$; Fig. 2D). Sagebrush cover increased over time in the seeded treatment but remained low and constant in the control treatment. By the end of the study, sagebrush cover average $24 \pm 4\%$ and $0.06 \pm 0.06\%$ in the seeded treatment and controls, respectively. Other shrub cover was similar between treatments and among years ($p = 0.206$ and $0.101$, respectively). Other shrub cover was $1.7 \pm 1.6\%$ and $1.7 \pm 1.2\%$ in the seeded treatment and controls at the conclusion of the study, respectively.

Perennial grass density was greater in the seeded treatment compared to the controls ($p = 0.007$, respectively; Fig. 3A) and varied among years ($p < 0.001$). In the final sampling year, perennial grass density was 3.3 times greater in the seeded treatment compared to the controls. Perennial grass density

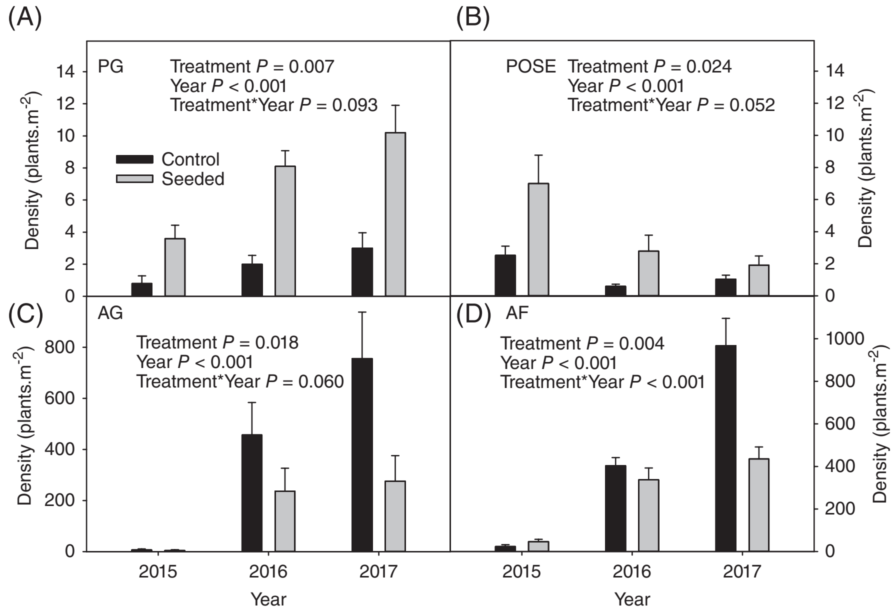



Figure 3. Herbaceous functional group density (mean + SE) in the seeded and control treatments in 2015, 2016, and 2017. PG, perennial grass (A); POSE, Sandberg bluegrass (B); AG, exotic annual grass (C); and AF, annual forb (D).

increased with time since seeding. Sandberg bluegrass density was greater in the seeded treatment compared to the controls and varied among years ($p = 0.024$ and <0.001, respectively; Fig. 3B). Sandberg bluegrass density generally decreased over time. Perennial forb density was similar between treatments and among years ($p = 0.948$ and 0.610, respectively). In the final sampling year, perennial forb density was $3.6 \pm 1.8$ and $4.2 \pm 1.2$ plants/m$^2$ in the seeded treatment and controls, respectively. Exotic annual grass density was greater in the controls compared to the seeded treatment ($p = 0.018$; Fig. 3C) and varied among years ($p < 0.001$). The controls had 270% greater exotic annual grass abundance than the seeded treatment 3 years after seeding. Exotic annual grass density increased with time in both treatments. Annual forb density was influenced by the interaction between treatment and year ($p < 0.001$; Fig. 3D). Annual forb density was more similar between the controls than the seeded treatment in the first year, slightly greater in the controls than the seeded treatment in the second year, and more than two times greater in the controls compared to the seeded treatment in the third year. In the third sampling year, annual forb density was 532 plants/m$^2$ greater in controls compared to the seeded treatment. Juvenile sagebrush density was greater in the seeded treatment compared to the controls ($p < 0.001$; Fig. 4A) but did not vary among years ($p = 0.075$). Mature sagebrush density varied by the interaction between treatment and year ($p = 0.004$; Fig. 4B). In the first year, neither treatment contained any mature sagebrush. However, in the second and third postfire year, mature sagebrush density was over 200 times greater in the seeded treatment compared to the controls (Fig. 4B). Sagebrush was only detected at two of the six unseeded controls. Density of other shrubs did not differ between treatments or among years ($p = 0.460$ and 0.082, respectively). In the final sampling year, other shrub density was $0.49 \pm 0.43$ and $0.38 \pm 0.32$ plants/m$^2$ in the controls and seeded treatment, respectively.

## Discussion

Our results support the rational for seeding after wildfires to increase perennial vegetation and limit exotic plants. The results of our study specifically support our hypotheses that seeding native perennial vegetation can increase perennial grass and sagebrush cover and density and reduce exotic annual grass and annual forb response after wildfire in western juniper-dominated sagebrush steppe in the western United States. These results suggest that seeding native perennial vegetation after wildfires may be needed to promote recovery and prevent exotic annual grass dominance in juniper-encroached sagebrush steppe. Importantly, our results suggest that seeding native vegetation after wildfire in juniper-encroached sagebrush communities is a viable restoration strategy. With the increase in area burned in wildfires in many regions (Krawchuk et al. 2009; Adams 2013), establishing that seeding native perennial species can increase perennial vegetation and limit exotic plants after wildfires provides critically needed guidance for postfire restoration. This is particularly important as other research (e.g. Stella et al. 2010) has suggested that postwildfire seeding is ineffective at reducing exotic plants.

Prior research demonstrated that exotic annual grasses could increase after prescribed fire in some juniper-encroached mountain big sagebrush communities with risk of annual grass dominance increasing with greater woodland development and with decreasing site resistance and resilience (Bates et al. 2014; Roundy et al. 2014; Davies & Bates 2017). The results from our unseeded plots further indicate that exotic annual grass invasion and dominance after fire in juniper-dominated mountain

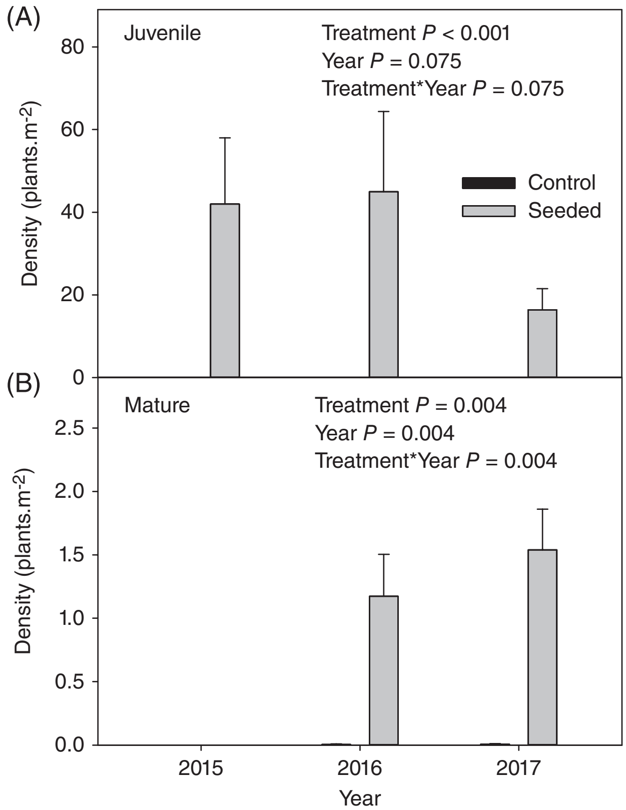



Figure 4. Sagebrush density (mean + SE) in the seeded and control treatments in 2015, 2016, and 2017. Juvenile, juvenile sagebrush (A) and mature, mature sagebrush (B).

big sagebrush steppe is of concern. This likely occurs because junipers decrease herbaceous vegetation as they dominate a site (Miller et al. 2000; Bates et al. 2005) and after fires the former juniper canopy locations are often devoid of vegetation and have high soil resource availability (Bates & Davies 2017; Davies et al. 2017). The abundance of soil resources and reduction in herbaceous vegetation, in particular perennial grasses, creates a perfect scenario for exotic annual grass invasion and dominance (Chambers et al. 2007).

Our results agree with prior research that establishing perennial vegetation is critical to limiting exotic annual species (Davies et al. 2015; Davies & Johnson 2017). This is particularly important after wildfires in areas susceptible to exotic annual grass invasion and dominance. Although exotic annual grass cover increased each year in areas not seeded, in areas seeded with native perennial vegetation, exotic annual grass cover peaked in the second-year postfire and declined almost 50% by the third-year postfire. This indicates that seeded vegetation may limited resources available to exotic annual grasses. Furthermore, this also suggests that the trajectory for the seeded areas is continued perennial vegetation dominance. At the end of the study, the areas not seeded were dominated by annual species (exotic annual grasses and annual forbs). The future trajectory of these communities is unknown but there is a high probability of continued exotic annual species dominance given the low abundance of perennial grasses in these areas. Exotic annual grass dominance increases the risk of an annual grass-fire cycle developing because annual grasses dry out earlier and increase fine fuel loads and continuity compared to native vegetation (D'Antonio & Vitousek 1992). Increased fire frequency is especially detrimental to native vegetation that evolved with less frequent fire (D'Antonio & Vitousek 1992).

Sagebrush recovered rapidly after seeding with cover averaging 24% by the third-year postfire. However, sagebrush was largely absent from areas not seeded with sagebrush cover averaging less than 0.1% at the end of the study. Seeding sagebrush after juniper control with fire has generally accelerated the recovery of sagebrush cover and density (Davies et al. 2014; Davies & Bates 2017), except when herbaceous vegetation was allowed to recover prior to seeding sagebrush (Davies et al. 2017). These findings and the current study suggest the loss of sagebrush with juniper encroachment followed by fire that imposes strong juniper mortality results in a scenario of slow sagebrush recovery. This is counter to the assumption that sagebrush will often naturally recover rapidly after conifer control (Barney & Frischknecht 1974; Tausch & Tueller 1977; Skousen et al. 1989; Miller et al. 2005). Rapid recovery of sagebrush is needed because sagebrush is a crucial habitat component for sagebrush-associated wildlife species that are of conservation concern (Crawford et al. 2004; Shipley et al. 2006; Aldridge et al. 2008).

One caveat of our study was the high seeding rate, which was three or more times the rate often applied by land management agencies, especially for sagebrush. This may be one of the reasons that our results differ from other studies suggesting that postwildfire seeding is not effective (Peppin et al. 2010; Stella et al. 2010). Broadcast seeding after wildfires in juniper-dominated sagebrush communities as well as many other communities has not been empirically tested to establish optimal seeding rates. The high establishment of sagebrush and subsequent high cover of sagebrush probably limited perennial grass cover. As sagebrush cover increases, perennial grass production decreases (Cook & Lewis 1963; Rittenhouse & Sneva 1976). Our results, however, suggest that sagebrush and native perennial grasses can be seeded together. Additional research evaluating different seeding rates and ratios of different plant groups and species in seed mixtures would be valuable in establishing optimal seeding rates and mixtures. This is important because habitat requirements for sagebrush-associated wildlife often require a mixture of sagebrush and herbaceous species (e.g. Crawford et al. 2004).

Though our seeding rate was high, our study demonstrated that seeding native perennial vegetation after wildfire can promote recovery of perennial grasses and sagebrush and limit exotic annual grasses. Importantly, this suggests that seeding introduced species is not necessary to achieve management objectives after fire in mountain big sagebrush communities. This is a stark contrast to Wyoming big sagebrush communities, where seeded native vegetation often fails to establish (Eiswerth et al. 2009; Boyd & Davies 2010; Davies et al. 2015); however, there are exceptions (see Davies et al. 2018). Mountain big sagebrush communities are cooler and wetter than Wyoming big sagebrush communities (West et al. 1978; Winward 1980; Hironaka et al. 1983) and this likely explains why seeded native vegetation often successfully establishes in these communities.

The high abundance and cover of exotic annual grasses in nonseeded areas at the end of the study suggests that seeding perennial vegetation is needed after wildfires in juniper-dominated sagebrush steppe to prevent exotic annual grass dominance and restore ecosystem services. This can be achieved by broadcast seeding native perennial grasses and sagebrush. Refinement of seeding mixtures and rates would be beneficial to improve restoration success and efficiency. We suggest that restoration practitioners consider seeding perennial vegetation after fires in juniper-dominated sagebrush communities, especially those at risk of exotic plant invasion.

Tree encroached-shrublands in Australia (Rundel et al. 2014), Africa (Holmes & Cowling 1997; Rundel et al. 2014), and South America (Sarasola et al. 2006; Langdon et al. 2010) may, similar to our current study, be at risk of postfire exotic plant invasion. Tree mortality from fire reduces competition and opens the plant community to exotic plant invasion. This may be even more problematic if tree encroachment or the fire that controls the trees reduces understory species that are keys for resistance to exotic plant invasion. Our results demonstrate that seeding native perennial vegetation after wildfire is a method that can counter this threat.

## Acknowledgments

We thank W. Strachan and numerous student technicians for assisting with data collection and entry. We are also grateful for thoughtful reviews of earlier versions of this manuscript by D. Johnson and E. Hamerlynck. Constructive reviews by the associate editor and anonymous reviewers were also greatly appreciated. Mention of a proprietary product does not constitute a guarantee or warranty of the product by USDA or the authors and does not imply its approval to the exclusion of other products. USDA is an equal opportunity provider and employer.

## LITERATURE CITED

Adams MA (2013) Mega-fires, tipping points and ecosystem services: managing forests and woodlands in an uncertain future. Forest Ecology and Management 294:250–261

Aldridge CL, Nielsen SE, Beyer HL, Boyce MS, Connelly JW, Knick ST, Schroeder MA (2008) Range-wide patterns of greater sage-grouse persistence. Diversity and Distributions 14:983–994

Barney M, Frischknecht N (1974) Vegetation changes following fire in the pinyon-juniper type of west-Central Utah. Journal of Range Management 27:91–96

Bates JD, Davies KW (2017) Effects of conifer treatments on soil nutrient availability and plant composition in sagebrush steppe. Forest Ecology & Management 400:631–644

Bates JD, Miller RF, Svejcar TJ (2005) Long-term successional trends following western juniper cutting. Rangeland Ecology & Management 58:533–541

Bates JD, Sharp RN, Davies KW (2014) Sagebrush steppe recovery after fire varies by development phase of *Juniperus occidentalis* woodland. International Journal of Wildland Fire 23:117–130

Beschta RL, Rhodes JJ, Kauffman JB, Gresswell RE, Minshall GW, Karr JR, Perry DA, Hauer FR, Frissell CA (2004) Post-fire management of forested public lands of the western United States. Conservation Biology 18:957–967

Beyer JL (2004) Post-fire seeding for erosion control: effectiveness and impacts on native plant communities. Conservation Biology 18:947–956

Boyd CS, Davies KW (2010) Shrub microsite influences post-fire perennial grass establishment. Rangeland Ecology & Management 63:248–252

Chambers JC, Roundy BA, Blank RR, Meyer SE, Whittaker A (2007) What makes Great Basin sagebrush ecosystems invasible by *Bromus tectorum*? Ecological Monographs 77:117–145

Chambers JC, Bradley BA, Brown CS, D'Antonio C, Germino MJ, Grace JB, Hardegree SP, Miller RF, Pyke DA (2014) Resilience to stress and disturbance and resistance to *Bromus tectorum* L. invasion in cold desert shrublands of western North America. Ecosystems 17:360–375

Cook CW, Lewis CE (1963) Competition between big sagebrush and seeded grasses on foothill ranges in Utah. Journal of Range Management 16:245–250

Crawford JA, Olson RA, West NE, Mosley JC, Schroeder MA, Whitson TD, Miller RF, Gregg MA, Boyd CS (2004) Ecology and management of sage-grouse and sage-grouse habitat. Journal of Range Management 57:2–19

D'Antonio CM, Vitousek PM (1992) Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annual Review of Ecology and Systematics 23:63–87

Davies KW (2011) Plant community diversity and native plant abundance decline with increasing abundance of an exotic annual grass. Oecologia 167:481–491

Davies KW, Bates JD (2010a) Native perennial forb variation between mountain big sagebrush and Wyoming big sagebrush plant communities. Environmental Management 46:452–458

Davies KW, Bates JD (2010b) Vegetation characteristics of mountain and Wyoming big sagebrush plant communities in the northern Great Basin. Rangeland Ecology & Management 63:461–466

Davies KW, Bates JD (2017) Restoring big sagebrush after controlling encroaching western juniper with fire: aspect and subspecies effects. Restoration Ecology 25:33–41

Davies KW, Johnson DD (2017) Established perennial vegetation provides high resistance to reinvasion by exotic annual grasses. Rangeland Ecology & Management 70:748–754

Davies KW, Svejcar TJ, Bates JD (2009) Interaction of historical and nonhistorical disturbances maintains native plant communities. Ecological Applications 19:1536–1545

Davies KW, Boyd CS, Beck JL, Bates JD, Svejcar TJ, Gregg MA (2011) Saving the sagebrush sea: an ecosystem conservation plan for big sagebrush plant communities. Biological Conservation 144:2573–2584

Davies KW, Bates JD, Madsen MD, Nafus AM (2014) Restoration of mountain big sagebrush steppe following prescribed burning to control western juniper. Environmental Management 53:1015–1022

Davies KW, Boyd CS, Johnson DD, Nafus AM, Madsen MD (2015) Success of seeding native compared to introduced perennial vegetation for revegetating medusahead-invaded sagebrush rangeland. Rangeland Ecology & Management 68:224–230

Davies KW, Bates JD, Hulet A (2017) Attempting to restoring mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) four years after fire. Restoration Ecology 25:717–722

Davies KW, Boyd CS, Madsen MD, Kerby J, Hulet A (2018) Evaluating a seed technology for sagebrush restoration efforts across an elevation gradient: support for bet hedging. Rangeland Ecology & Management 71:19–24

Eiswerth ME, Krauter K, Swanson SR, Zielinski M (2009) Post-fire seeding on Wyoming big sagebrush ecological sites: regression analyses of seeded nonnative and native species densities. Journal of Environmental Management 90:1320–1325

Fried JS, Torn MS, Mills E (2004) The impact of climate change on wildfire severity: a regional forecast for northern California. Climate Change 64:169–191

Fulé PZ (2008) Does it make sense to restore wildland fire in changing climate? Restoration Ecology 16:526–531

Hironaka MM, Fosberg M, Winward AH (1983) Sagebrush-grass habitat types of southern Idaho. University of Idaho, Moscow. Bulletin 35

Holmes PM, Cowling RM (1997) Diversity, composition, and guild structure relationships between soil stored seed banks and mature vegetation in alien plant-invaded South African fynbos shrublands. Plant Ecology 133:107–122

Humphrey LD, Schupp EW (2004) Competition as a barrier to establishment of a native perennial grass (*Elmus elymoides*) in alien annual grass (*Bromus tectorum*) communities. Journal of Arid Environments 58:405–422

Knick ST, Dobkin DS, Rotenberry JT, Schroeder MA, Vander Haegen WM, Riper CV (2003) Teetering on the edge or too late? Conservation and research issues for avifauna of sagebrush habitats. Condor 105:611–634

Krawchuk MA, Moritz MA, Parisien MA, Van Dorn J, Hayhoe K (2009) Global pryogeography: the current and future distribution of wildfire. PLoS One 4:1–12

Langdon B, Pauchard A, Aguayo M (2010) *Pinus contorta* invasion in Chilean Patagonia: local patterns in a global context. Biological Invasions 12:3961–3971

Lesica P, Cooper SV, Kunray G (2007) Recovery of big sagebrush following fire in Southwest Montana. Rangeland Ecology & Management 60:261–269

Littell RC, Milliken GA, Stroup WW, Wolfinger RD (1996) SAS system for mixed models. SAS Institute Inc., Cary, North Carolina

Melgoza G, Nowak RS, Tausch RJ (1990) Soil water exploitation after fire: competition between *Bromus tectorum* (cheatgrass) and two native species. Oecologia 83:7–13

Mensing S, Livingston S, Barker P (2006) Long-term fire history in Great Basin sagebrush reconstructed from macroscopic charcoal in spring sediments, Newark Valley, Nevada. Western North American Naturalist 66:64–77

Miller RF, Tausch RJ (2001) The role of fire in pinyon and juniper woodlands: a descriptive analysis. Tall Timbers Research Station Miscellaneous Publication 11:15–30

Miller RF, Svejcar TJ, Rose JR (2000) Impacts of western juniper on plant community composition and structure. Journal of Range Management 53:574–585

Miller RF, Bates JD, Svejcar TJ, Pierson FB, Eddleman LE (2005) Biology, ecology, and management of western juniper. Oregon State University Agricultural Experiment Station Technical Bulletin No. 152, Corvallis, OR

Miller RF, Tausch RJ, McArthur ED, Johnson DD, Sanderson SC (2008) Age structure and expansion of piñon–juniper woodlands: a regional perspective in the Intermountain West. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado. Research Paper RMRS-RP-69

Nelson ZJ, Weisberg PJ, Kitchen SG (2014) Influence of climate and environment on post-fire recovery of mountain big sagebrush. International Journal of Wildland Fire 23:131–142

Peppin D, Fulé PZ, Sieg CH, Beyers JL, Hunter ME (2010) Post-wildfire seeding in forests of the western United States: an evidence-based review. Forest Ecology & Management 260:573–586

PRISM (2018). PRISM climate group database. http://prism.nacse.org/explorer/ (accessed 28 Mar 2018)

Rinella MJ, Hammond DH, Bryant AM, Kozar BJ (2015) High precipitation and seeded species competition reduce seeded shrub establishment during dryland restoration. Ecological Applications 25:1044–1053

Rinella MJ, Espeland EK, Moffat BJ (2016) Studying long-term, large-scale grassland restoration outcome to improving seeding methods and reveal knowledge gaps. Journal of Applied Ecology 53:1565–1574

Rittenhouse LR, Sneva FA (1976) Expressing the competitive relationship between Wyoming big sagebrush and crested wheatgrass. Journal of Range Management 29:326–327

Robichaud PR, Beyers JL, Neary DG (2000) Evaluating the effectiveness of post-fire rehabilitation treatments. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado General Technical Report RMRS-GTR63

Roundy BA, Miller RF, Tausch RJ, Young K, Hulet A, Rau B, Jessop B, Chambers JC, Eggett D (2014) Understory cover responses to piñon-juniper treatments across tree dominance gradients in the Great Basin. Rangeland Ecology & Management 67:482–494

Rundel RW, Dickie IA, Richardson DM (2014) Tree invasions into treeless areas: mechanisms and ecosystem process. Biological Invasions 16:663–675

Sarasola M, Rusch V, Schlichter T, Ghersa C (2006) Invasión de coníferas forestales en áreas de estepa y bosques de ciprés de la cordillera en la región Andino Patagónica. Ecología Austral 16:143–156

Sheley RL, Bates JD (2008) Restoring western juniper (*Juniperus occidentalis*) infested rangeland after prescribed fire. Weed Science 56:469–476

Shipley LA, Davila TB, Thines NJ, Elias BA (2006) Nutritional requirements and diet choices of the pygmy rabbit (*Bachylagus idahoensis*): a sagebrush specialist. Journal of Chemical Ecology 32:2455–2474

Skousen JG, Davis JN, Brotherson JD (1989) Pinyon-juniper chaining and seeding for big game in Central Utah. Journal of Range Management 42:98–104

Stebleton A, Bunting S (2009) Guide for quantifying fuels in sagebrush steppe and juniper woodlands of the Great Basin. Bureau of Land Management, Denver, Colorado. Technical Note 430

Stella KA, Sieg CH, Fulé PZ (2010) Minimal effectiveness of native and non-native seeding following three high-severity wildfires. International Journal of Wildland Fire 19:746–758

Suring LH, Rowland MM, Wisdom MJ (2005) Identifying species of conservation concern. Pages 150–162. In: Wisdom MJ, Rowland MM, Suring LH (eds) Habitat threats in the sagebrush ecosystem – methods of regional assessment and applications in the Great Basin. Alliance Communications Group, Lawrence, Kansas

Tausch RJ (1999) Transitions and thresholds: influences and implications for management in pinyon and Utah juniper woodlands. Pages 61–65. In: Monsen SB, Stevens R, Tausch RJ, Miller R, Goodrich S (eds) Proceedings of the ecology and management of pinyon–juniper communities within the interior west', 15–18 September 1999, Provo, UT. USDA Forest Service, Rocky Mountain Research Station, Ogden, Utah. Proceedings RMRS-P-9

Tausch RJ, Tueller PT (1977) Plant succession following chaining of pinyon–juniper woodlands in eastern Nevada. Journal of Range Management 30:44–49

Thompson TW, Roundy BA, McArthur ED, Jessop BD, Waldron B, Davis JN (2006) Fire rehabilitation using native and introduced species: a landscape trial. Rangeland Ecology & Management 59:237–248

West NE, Tausch RJ, Rea KH, Tueller PT (1978) Taxonomic determination, distribution, and ecological indicator values of sagebrush within the pinyon-juniper woodlands of the Great Basin. Journal of Range Management 31:87–92

Winward AH (1980) Taxonomy and ecology of sagebrush in Oregon. Oregon State University, Corvallis, Oregon. Oregon Agricultural Experiment Station Bulletin 642

Wright HA, Bailey AW (1982) Fire ecology: United States and southern Canada. John Wiley & Sons, Inc, New York

Yue X, Mickley LJ, Logan JA, Kaplan JO (2013) Ensemble projections of wildfire activity and carbonaceous aerosol concentrations over the western United States in the mid-21st century. Atmospheric Environment 77:767–780

*Coordinating Editor: Lora Perkins*

*Received: 11 May, 2018; First decision: 5 June, 2018; Revised: 12 June, 2018; Accepted: 13 June, 2018; First published online: 12 July, 2018*