ELLEN F. ROSENBLUM
Attorney General

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DEPARTMENT OF JUSTICE
GENERAL COUNSEL DIVISION

December 1, 2017

Ms. Kimberly D. Bose, Secretary
888 First Street, N.E., Room 1A
Washington, DC 20426

Re: *Jordan Cove LP Pacific Connector Gas Pipeline LP*
Docket Nos. PF17-4-000, CP17-494-000, and CP17-495-000

Dear Ms. Bose:

Please find the attached comments, submitted by the Oregon Department of Energy on behalf of the Oregon Department of Geology and Mineral Industries, in the above-referenced matters.

Sincerely,

/s/ Jesse D. Ratcliffe

Jesse D. Ratcliffe
Assistant Attorney General
Natural Resources Section

JDR:pjn/8643729

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November 6, 2017

Sean Mole
Jordan Cove Analyst
Oregon Department of Energy
550 Capitol St NE, 1st floor
Salem, OR 97301

Re: DOGAMI Comments Related to Geologic Hazards and the Proposed Jordan Cove LNG Terminal and Pacific Gas Connection Pipeline

Dear Mr. Mole:

The Oregon Department of Geology and Mineral Industries (DOGAMI) reviewed the materials relating to geologic hazards in:

- Resource Report 6 – Geological Resources Jordan Cove Energy Project, dated April 2017
- Resource Report 6 – Pacific Connector Gas Pipeline Project, dated May 2017
- Draft Resource Report 13 – Engineering and Design Material, Chapter 13.3 Natural Hazards and Conditions, Jordan Cove Energy Project, dated May 2017, which includes:
  - Appendix I.13 Natural Hazard Design Investigations and Forces, and
  - Appendix J.13 Site Investigation and Conditions, and Foundation Design

DOGAMI finds the information in the Resource Reports submitted by the Applicant to be incomplete, has comments about possible deficiencies in the scientific and engineering analyses related to geologic hazards; and at this point is not satisfied that geologic hazards will be adequately addressed to ensure public safety. Please see attached: 1) General Review comments, and 2) comments on the Resource Reports.

While DOGAMI has regulatory and statutory authority on mining operations and building in the tsunami regulatory zone, this letter is not intended to address those specific requirements. The Applicant must meet Oregon building code requirements and Oregon laws, including Section 1803.2.1 Tsunami Inundation Zone of the Oregon Structural Specialty Code (Oregon Revised Statutes [ORS] 455.446 and 455.447).

Thank you for the opportunity to assist with this project. If you have any questions, please contact me at 971-673-1555 (brad.avy@oregon.gov) or Yumei Wang at 971-673-1551 (yumei.wang@oregon.gov).

Sincerely,

Brad J. Avy
Director and State Geologist

cc: Jon Allan, Tsunami Lead
Bill Burns, Natural Hazards Section Supervisor
Laura Gabel, Geologist
Ian Madin, Deputy Director and Chief Scientist
Jed Roberts, Geological Survey and Services Program Manager
Yumei Wang, Engineer

General Review Comments

This proposed project is in a high seismic hazard area due to the Cascadia Subduction Zone, which can produce a magnitude 9 earthquake, and the proposed Liquefied Natural Gas (LNG) Terminal facility is located in the Cascadia tsunami inundation zone. Some specific concerns related to the performance of the proposed facilities and public safety include:

1. The long duration of shaking expected with a magnitude 9 earthquake and how it might impact the proposed facilities and safety of people;
2. Ground failure of the softer and looser soils in the nearby area and how it may impact the proposed facilities and safety of people;
3. How the proposed facilities may negatively impact the tsunami hazards in the surrounding areas and safety of people;
4. Tsunami scour in the nearby area and how the Maximum Considered Tsunami (MCT), that is, the design tsunami, may impact the local landforms, including the dunes, and proposed facilities and safety of people;
5. Dynamic erosion of the North Spit dunes in response to the design tsunami and how it may impact tsunami runup at the proposed facilities and safety of people;
6. Tsunami debris impacting the nearby area and how it may impact the local landforms, including the dunes, proposed facilities and safety of people;
7. Dependencies on existing infrastructure that may fail, such as roads and levees; and
8. Lack of discussion of instrument monitoring safety programs related to potential ground failures, including ground settlement of soft soils and movement of landslides.

DOGAMI encourages designing and building for disaster resilience and future climate using science, data and community wisdom to protect against and adapt to risks. This will allow people, communities and systems to be better prepared to withstand catastrophic events and future climate—both natural and human-caused—and be able to bounce back more quickly and emerge stronger from shocks and stresses.

Applicant should follow existing regulations (e.g., State of Oregon's Oregon Revised Statutes, Oregon Administrative Rules, Oregon building codes, federal laws, and local regulations):

- Use best practices supporting public safety;
- Use a long-term view to protect citizens, property, environment, and standard of living;
- Integrate resilience, where possible, by avoiding high risk areas or embracing higher performance standards than may be required by building codes and regulations. This will lessen damage and speed recovery after disasters, and improve continuity of operations.

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- Integrate resilience, where possible, by avoiding high risk areas or embracing higher performance standards than may be required by building codes and regulations. This will lessen damage and speed recovery after disasters, and improve continuity of operations.

DOGAMI Comments on Resource Reports

DOGAMI's comments pertain to the specific resource reports as presented by the Applicant. It is possible that some of the comments on Resource Report 6 are addressed in Resource Report 13; however, the Applicant has not explained nor organized the information in a manner that can be readily reviewed.

Resource Report 6 – Jordan Cove Energy Project

9. The Resource Report 6 Jordan Cove Energy Project is incomplete. For example, none of the Appendices for have been provided in Resource Report 6, including:
    - Appendix A.6 – Geotechnical Data Report, Jordan Cove LNG Project
    - Appendix B.6 – Seismic Ground Motion Hazard Study, Jordan Cove LNG Project
    - Appendix C.6 – Geotechnical Report, Jordan Cove LNG Project
    - Appendix D.6 – Estuary Flood Risk and Hazard Study, Jordan Cove LNG Project
    - Appendix E.6 – Tsunami Hydrodynamic Modelling, Jordan Cove LNG Project
    - Appendix F.6 – Tsunami Maximum Run-up Modelling, Jordan Cove LNG Project
    - Appendix G.6 – Tsunami Wave Amplitude Analysis, Jordan Cove LNG Project
    - Appendix H.6 – Design Wind Speed Assessment, Jordan Cove LNG Project

10. Section 6.4.1.1 Earthquakes of the Resource Report 6 – Jordan Cove Energy Project provides seismic ground motions that are both incomplete and unclear. For example, the Applicant states that there is a "comparison in Table 6.4.1 includes values for soft rock site conditions as well as the anticipated site soil conditions after construction." Please provide this information in a clear manner that includes informative labels for the reviewer.

11. Section 6.4.1.1 Earthquakes of the Resource Report 6 – Jordan Cove Energy Project provides seismic ground motions that have not used new building code reference documents, namely American Society of Civil Engineers (ASCE) 7-16. Please discuss why ASCE 7-16 has not been used, or provide and discuss design values using ASCE 7-16.

12. Section 6.4.1.3 Soil Liquefaction of the Resource Report 6 – Jordan Cove Energy Project refers to Appendix C.6, however, this appendix was not provided. As requested earlier, please provide information that is referenced.

13. Section 6.4.1.3 Soil Liquefaction of the Resource Report 6 – Jordan Cove Energy Project does not include information on the method used for the liquefaction triggering analyses. DOGAMI recommends that the Applicant conduct analyses consistent with the National

Academies Liquefaction Study Report (2016), available at https://www.nap.edu/catalog/23474/state-of-the-art-and-practice-in-the-assessment-of-earthquake-induced-soil-liquefaction-and-its-consequences.

For all of the liquefaction analyses, the assumptions, methods used, and uncertainties associated with them should be explicitly stated and presented for each step of the analysis. This includes the uncertainties associated with field investigations, lab testing, triggering analyses, settlement analyses, lateral spreading analyses, and proposed mitigation. This should also be a part of any future analyses including soil-structure interaction and other modeling of the structural responses to the hazards and for proposed mitigation. Results should be summarized so that it is clear which resulting values are being used for design purposes.

14. Section 6.4.1.4 Tsunamis of the Resource Report 6 – Jordan Cove Energy Project states: "The modeled rupture scenario XL1 has an estimated period longer than the 10,000-year event discussed in Volume 2, Section 13.I.2.4 of FERC's Guidance Manual for Environmental Report Preparation (February 2017)." DOGAMI's XL1 is a deterministic scenario. The DOGAMI XL1 scenario is not associated with a period longer than the 10,000-year event.

    Since 2016, there has been a national standard for tsunami resilient design in the American Society of Civil Engineers (ASCE) 7-16 Chapter 6 Tsunami Loads and Effects. This is the consensus-based engineering standard that is a referenced requirement in the latest (2018) International Building Code (IBC). The IBC is a model code that is widely adopted throughout the country including by the State of Oregon. ASCE 7-16 was extensively vetted by the American Society of Civil Engineers using an accredited and audited consensus process.

    DOGAMI recommends the Applicant comply with ASCE 7-16. DOGAMI recommends that the Applicant meet or exceed the inundation limit and other design parameters in the ASCE 7 Tsunami Design Geodatabase and select design procedures and parameters, such as design inundation depths and flow velocities, which would result in a proposed facility that will protect human safety. Any modeling procedure for determining site-specific tsunami design inundation and velocities should follow Section 6.7 of ASCE 7-16 and demonstrate that the tsunami input meets the Probabilistic Tsunami Hazard Analysis Offshore Tsunami Amplitude of the ASCE Tsunami Design Geodatabase. Maps and criteria in the ASCE 7-16 design standard are based on engineering risk analysis and reliability targets. The ASCE 7-16 Maximum Considered Tsunami (MCT) has a 2% probability of being exceeded in a 50-year period, or a 2,475 year average return period. The ASCE 7-16 MCT is a design basis event, characterized by the inundation depths and flow velocities at the stages of inflow and outflow most critical to the structure(s).

The Applicant should clearly present each step of the multiple tsunami analyses in a manner suitable for peer review by qualified professionals. All analyses, methods, assumptions and final values used for the structural design procedures for tsunami effects should be clearly documented so that results are reproducible. This includes, but is not limited to, identifying debris impact loads, foundation design factors, uplift forces, scour forces, and loads for all Tsunami Risk Category III and IV Nonbuilding Structures and designated nonstructural components.

15. Section 6.4.1.4 Tsunamis of the Resource Report 6 – Jordan Cove Energy Project refers to the existing Trans Pacific Parkway/US- 101 Intersection as being in the tsunami inundation zone. The Applicant states "To maintain grades, improvements to the intersection will not remove the intersection from the tsunami inundation zone." There appears to be only one access road for the proposed Jordan Cove LNG facility. This access road is in the tsunami inundation zone. In order for the access road to be reliably useable for safety purposes after a future tsunami disaster, it would need to incorporate both earthquake and tsunami resistant designs. These designs would need to factor in potential cyclic strain, liquefaction and lateral spreading from ground shaking. In addition, the designs would need to account for tsunami forces, including flooding, velocities, scour, buoyancy and debris impact. Has this roadway and access to the proposed facilities been evaluated for possible damage due to tsunami forces, such as tsunami scour and tsunami debris impact? Please provide analyses, results and, if needed, proposed mitigation that addresses both post-earthquake and post-tsunami safety for proposed berms, roadways and elevated ground. Related documents should be complete, clearly organized and presented to allow for peer review by qualified specialists.

<u>Resource Report 6 – Pacific Connector Gas Pipeline Project</u>

16. The Resource Report 6 – Pacific Connector Gas Pipeline Project is incomplete. For example, some of the Appendices for have not been provided, including:
    - APPENDIX C – Site-Specific Landslide Evaluation
    - APPENDIX H – Geotechnical Boring Logs
    - APPENDIX I – Laboratory Testing
    - APPENDIX J – Seismic Reflection Survey – Stukel Mt. Fault

17. The Applicant states (on page 7): "With the exception of those in the Klamath Falls area, these mapped surface faults are not considered active and are not believed to be capable of renewed movement or earthquake generation (USGS, 2002 interactive fault website)". DOGAMI considers Quaternary active faults as capable of generating potentially damaging earthquakes. DOGAMI has mapped late Quaternary faults in Coos Bay, which could impact the proposed project. Please refer to this publication: www.oregongeology.org/pubs/gms/GMS-094.pdf. DOGAMI recommends that a thorough literature review be conducted for known Quaternary active faults, as well as a site specific investigation that covers the proposed project area to evaluate if unknown Quaternary faults exist that may negatively impact the proposed facilities. Analysis of recently acquired lidar data throughout Oregon has identified numerous previously unidentified late Quaternary or Holocene fault scarps including in the Klamath Falls area. The entire pipeline right-of-way (ROW) should be evaluated thoroughly with lidar coverage of a broad area around the ROW to identify potentially hazardous faults.

18. The Applicant states (on page 8): "The PCGP Project is located in relatively sheltered areas of Coos Bay, where the effects of a tsunami on the pipeline are expected to be relatively minor". DOGAMI requests the tsunami analyses that supports this statement. What tsunami modeling was conducted for the proposed pipeline alignment? What are the tsunami flow depths used to estimate scour potential? Were tsunami scouring forces evaluated for both the incoming (inflow) and outgoing (outflow) tsunami waves?

19. The Applicant states (on page 9): "The recurrence interval between Cascadia events has been irregular and ranges from about 100 to 1,000 years (Atwater and Hemphill-Haley, 1997). Typical recurrence intervals are thought to be on the order of 400 to 600 years (Clague et al., 2000)." DOGAMI requests that the Applicant consider the most recent scientifically peer reviewed data on recurrence intervals for the Cascadia Subduction Zone (e.g., Goldfinger, et al, 2016). DOGAMI recommends that the Applicant consider the continually evolving scientific information on the Cascadia Subduction Zone and related seismic hazards.

20. The Applicant states (on page 10): " PGAs for the PCGP Project are listed in Table 2, based on USGS (2008) data compilation." DOGAMI requests that the Applicant consider the most recent USGS data, including the 2014 USGS seismic hazard maps.

21. The Applicant states (on page 10) "Higher PGAs are possible where soft soil overlies bedrock, such as in the vicinity of North Slough and Haynes Inlet MP 1.47H to 5.3H. We estimate Site Class D conditions are appropriate for the MP 1.47H to 5.3H areas." It is

common in estuaries to have soils that are softer than Site Class D conditions due to the presence of estuarine muds and river sediments, and these soils may amplify earthquake shaking. Rather than the Applicant estimating the Site Class type as D, DOGAMI recommends that both a literature review and site specific analyses are conducted to determine actual Site Class types and use those to determine PGAs and other relevant seismic ground motions and response. Downhole shear wave velocity measurements of Coos Bay estuarine sediments are available in the DOGAMI O-13-06 database.

22. The Applicant states (on page 11): " ...there is a low risk of pipeline damage from ground shaking in the absence of other deformation adversely affecting the pipeline. Based on these studies, the potential damage to buried pipelines from ground shaking intensity at the site is considered to be low." DOGAMI requests the Applicant to provide information on the vulnerability of buried pipelines in sloped areas without ground deformation during seismic shaking, such as along portions of the proposed corridor that crosses the Coast, Klamath and Cascade Ranges.

23. The Applicant states (on page 11): "ancient, inactive faults have no potential for rupture." DOGAMI finds this statement to be misleading. Weak planes or zones, such as ancient faults and bedding planes, can be displaced from earthquake shaking. DOGAMI recommends that the Applicant evaluate weak planes and zones for potential displacement that could impact the proposed pipeline.

24. The Applicant reviews faults that cross the proposed pipeline on pages 11 - 13 and includes "TABLE 3. MAPPED QUATERNARY AND HOLOCENE FAULTS CROSSING THE PCGP PROJECT". DOGAMI recommends that Applicant evaluate all faults that can impact the pipeline, including nearby active faults in Coos Bay. As stated in an earlier comment, DOGAMI has mapped late Quaternary faults in Coos Bay, which could impact the proposed project. Please refer to this publication: www.oregongeology.org/pubs/gms/GMS-094.pdf. DOGAMI recommends that a thorough literature review be conducted for known Quaternary active faults, as well as a site specific investigation that covers the proposed project area to evaluate if unknown Quaternary faults exist that may negatively impact the proposed facilities.

25. The Applicant states (on page 13): "As mentioned in the previous section, published maps are adequate for identifying the presence or absence of active faults, but are generally not detailed enough for pipeline design." DOGAMI disagrees with this statement—many areas have not been carefully mapped by geologists and it is highly likely that many active faults have not yet been identified. Furthermore, newer technologies that allow for identification

of active faults are now readily available whereas in the past they were not. As stated in an earlier comment, DOGAMI recommends that a thorough literature review be conducted for known Quaternary active faults, as well as a site specific investigation that covers the proposed project area to evaluate if unknown Quaternary faults exist that may negatively impact the proposed facilities.

26. The Applicant discusses a three phase liquefaction analysis approach and states (on page 15): "This second phase liquefaction analysis was completed using simplified methods (Seed et al., 2003; Idriss and Boulanger, 2008; and Boulanger and Idriss 2014)". DOGAMI recommends that the Applicant conduct analyses consistent with the National Academies Liquefaction Study Report (2016), available at https://www.nap.edu/catalog/23474/state-of-the-art-and-practice-in-the-assessment-of-earthquake-induced-soil-liquefaction-and-its-consequences. For the Applicant's second phase, conducting analyses using additional methods to estimate liquefaction triggering would be considered as standard-of-practice. As DOGAMI stated in earlier comments, for all of the liquefaction analyses, the assumptions, methods used, and uncertainties associated with them need to be explicitly stated and presented for each step in the analysis. This includes the uncertainties associated with field investigations, lab testing, triggering analyses, settlement analyses, lateral spreading analyses, and proposed mitigation. This should also be a part of any future analyses including soil-structure interaction and other modeling of the structural responses to the hazards and for proposed mitigation. Results should be summarized so that it is clear which results are being used for design purposes.

27. The Applicant states (on page 15): "If liquefaction will be triggered at previously identified susceptible pipeline segments under the maximum considered earthquake (MCE) per ASCE 7-10 code". As DOGAMI stated in an earlier comment, the Applicant has developed seismic ground motions that have not used newer building code reference documents, namely ASCE 7-16, which was published in 2016 as opposed to 2010. Ground motion values using ASCE 7-16 should be presented and used in the liquefaction analyses.

28. The Applicant states (on page 16): "the liquefaction and lateral spreading potential at Indian Creek (MP 128.58 – 128.62) remains unknown and access to the site remains restricted". DOGAMI requests that the Applicant keep DOGAMI informed on the status of this situation and data gap, and explain their next steps. For example, will the Applicant select another proposed route?

29. The Applicant states (on page 16): "The third phase analysis for the rerouted pipeline segment extending from MP 1.5H to 5.5H is in process and the results will be available for

the final submittal of this report." DOGAMI requests that the Applicant keep DOGAMI informed on the status of these analyses.

30. The Applicant states (on page 17): "Higher PGAs are possible where soft soil overlies bedrock, such as in the vicinity of North Slough at MP 1.47 to 3.2H and Haynes Inlet MP 4.7H to 5.5. We estimate Site Class D conditions are appropriate for the North Slough and Haynes Inlet areas." As DOGAMI stated earlier, it is common in estuaries to have soils that are softer than Site Class D conditions due to the presence of estuarine muds and river sediments, and these soils may amplify earthquake shaking. Rather than the Applicant estimating the Site Class type as D, DOGAMI recommends that site specific analyses are conducted to determine actual Site Class types and use those to determine PGAs and other relevant seismic ground motions and response.

31. The Applicant states (on page 20): "At the Coos River site, stresses exceed 100 percent SMYS but are estimated to be below the combined stress limit as shown in Figure 4.3.1 above. However, the analyses were based on elastic modulus and when the yield stress is exceeded, as in the case of the Coos River site, a fully plastic analysis is required to accurately assess the pipe stresses and strains. A fully plastic analysis requires modeling the stress-strain behavior of the pipeline under cyclic conditions in such a way as to capture strain-hardening effects, which requires a full-scale cyclic pipe load test to develop accurate model parameters. It also requires that the operational hoop, thermal, and internal pressures are accounted for during cyclic conditions. This type of analysis is beyond the scope and expertise of GeoEngineers." DOGAMI recommends that appropriate pipeline analyses are conducted by qualified specialists for the Coos Bay site, and potential impacts associated with liquefaction, lateral spreading, cyclic strain, and buoyancy forces be addressed to ensure public safety.

32. The Applicant states (on page 20): "with the potential for very large, long recurrence interval, Cascadia events". DOGAMI finds this statement as misleading. Seismologists and earthquake geoscientists, as professionals, would not generally consider earthquake recurrence intervals on the order of a few hundred years to be "very large, long". DOGAMI requests the Applicant to clarify, substantiate or change their statement.

33. The Applicant states (on page 20): "a fully plastic analysis of pipe strain will be completed to verify that the liquefaction and lateral spreading induced plastic deformation of the pipe at the Coos River crossing is tolerable." As stated earlier, DOGAMI recommends that appropriate pipeline analyses are conducted by qualified specialists for the Coos Bay site,

and potential impacts associated with liquefaction, lateral spreading, cyclic strain, and buoyancy forces are addressed to ensure public safety.

34. The Applicant states in their Conclusion sector (on page 21): "One Holocene (active) fault crossing and three Quaternary fault crossings were identified along the proposed pipeline alignment as listed in Table 3." As DOGAMI stated earlier, DOGAMI recommends that a thorough literature review be conducted for known Quaternary active faults, as well as a site specific investigation that covers the proposed project area to evaluate if unknown Quaternary faults exist that may negatively impact the proposed facilities. The faults should not be limited to locations of the proposed pipeline crossings.

35. The Applicant states (on page 25): "some of the later reroute alignments are currently outside the area of LiDAR and aerial photograph coverage". DOGAMI recommends the Applicant obtain high resolution lidar for all areas that may impact the proposed facilities 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. Also, there is publicly available statewide aerial photography. Please evaluate the potential large landslides keeping in mind that landslides may extend from the tops of ridges and may move downslope to block rivers. In addition, lidar should be used to evaluate seismic sources.

36. The Applicant states (on page 27): "The DOGAMI study provides a broad-scale assessment and mapping of slopes potentially susceptible to RMLs along the portion of the pipeline within Coos, Douglas and Jackson counties (MPs 1.5H - 166). The potential for RMLs to occur east of MP 166 generally is considered to be relatively low based on geologic conditions, relatively little rainfall and statistically fewer past historical RML occurrences. However, the slopes east of MP 166 were reviewed for this hazards report to identify high-risk sites based on general guidelines provided in Forest Practices (FP) Technical Note 2 of the Oregon Department of Forestry (ODF, 2000). The ODF guidelines recommend screening for high-risk sites by identifying slopes that exceed 65 percent gradient on existing topographic maps, then performing surface reconnaissance to identify high risk site features." Both the DOGAMI RML and ODF RML methods are outdated. DOGAMI recommends that the Applicant use current state of practice methods that include lidar as a base map.

37. The Applicant states (on page 27): "Based on available topographic mapping, no slopes along the pipeline alignment east of MP 166 exceed 65 percent or appear to be at high

potential for RML occurrence." DOGAMI does not agree with the conclusion based on the fact that state-of-practice methods were not used to develop this conclusion. DOGAMI recommends that the Applicant use current state of practice methods that include lidar as a base map.

38. The Applicant states (on page 46): "As currently planned the portions of the pipeline that are crossing waterbodies that have the potential to be impacted by tsunami scour, will be installed using trenchless methods at depths well below the potential scour depths. Therefore, tsunami scour is not considered a hazard to the pipeline project." The Applicant further states "The modeling analysis showed that some temporary scour may occur in Coos Bay along the pipeline during inundation of the tsunami (approximately 1 to 2 hours)." The Applicant indicates that scour from tidal currents and river flows are approximately 3 feet at the pipeline crossing, and "it is recommended to use a 3-foot depth of scour resulting from tsunami impact". DOGAMI requests the Applicant provide information on maximum potential scour depth from a Cascadia tsunami. Also, DOGAMI requests information on the minimum factor of safety the Applicant applied to address the maximum potential scour depth from Cascadia tsunamis along the proposed alignment in greater Coos Bay area.

Draft Resource Report 13 Engineering and Design Material, Chapter 13.3 Natural Hazards and Conditions, Jordan Cove Energy Project, dated May 2017, which includes:

- Appendix I.13 Natural Hazard Design Investigations and Forces, and
- Appendix J.13 Site Investigation and Conditions, and Foundation Design

Based on the review of tsunami-related documents in Resource Report 13, DOGAMI requests additional supporting information that discusses and clarifies the following:

39. The Applicant, in general, found that their MIKE21 modeling matched the DOGAMI L1 first wave arrival (which reflects the largest wave), although wave amplitudes and phase differences were observed for later wave arrivals. No explanation is provided to account for the latter differences. DOGAMI requests further discussion of differences in the modeling results after the initial wave arrival to account for phase and amplitude differences observed in the modeling results.

40. DOGAMI requests that the Applicant provide peer reviewed documentation that describes the MIKE21 FM model and its ability to model tsunami inundation. Many issues are unclear, for example, does MIKE21 adequately account for the (vertical) wave runup on the wall and/or composite structure?

41. DOGAMI requests that the Applicant provide further explanation of the approach used to define the digital elevation model (DEM) that is recommended. In particular, how does the developed grid differ from the tsunami grids generated by NOAA's National Center for Environmental Information (NCEI). These data may be obtained here: https://www.ngdc.noaa.gov/mgg/inundation/tsunami/.

42. DOGAMI requests that the Applicant explain to what extent has the model been tuned to match the DOGAMI L1 scenario and inundation results.

43. DOGAMI requests that the Applicant provide a better depiction of the three cases used to define the design crests. It is unclear whether the design reflects a berm, wall, or a composite structure around the perimeter of the entire complex, or portions of the complex. Please provide figures that characterize the proposed design.

44. DOGAMI requests that the Applicant explain why mean high water (MHW) was used as opposed to MHHW (as used by DOGAMI).

45. Values of future sea level rise (SLR) presented by the Applicant are based on existing (historical) trends derived for the Charleston tide gauge. Based on its current rate, estimates were made out into the future (i.e. 30 years). This is an overly simplistic approach that assumes the past is the key to the future and hence discounts possible acceleration of SLR in the future. A more effective approach would be to base future estimates on the National Research Council (2012) SLR study that was completed for the US West Coast. National Research Council estimates account for expected local tectonic changes as well eustatic and steric responses and are a more reasonable (and current) estimates for the future. Please address SLR using current scientific data and methods.

46. Provide analysis of the potential role of sediment erosion of the North Spit dunes caused by the design tsunami. Research on the US East Coast suggests that sediment erosion during a tsunami may be significant and could impact inundation extents and runup (Tehranirad et al., 2015, 2016; Tehranirad, 2016). This notion is also supported by field studies following the March 11, 2011 Tohoku, Japan tsunami (Goto et al., 2012; Tanaka et al., 2012).

47. Provide analyses of the potential role of tsunami wave reflection/focusing/defocusing as the tsunami impacts the proposed LNG facilities and its possible public safety implications for the surrounding Coos Bay environment. Tsunami waves that impact against proposed protective structures (e.g., berm, wall or composite structure) and the subsequent transfer of that energy to other areas within the bay is a public safety concern. DOGAMI requests

additional modeling for the purposes of addressing public safety. All documents should be complete, clearly organized and presented to allow for peer review by qualified specialists.

48. DOGAMI requests that the Applicant provide analysis of maritime vessels and their potential to become ballistics within the bay. Maritime evacuation planning in response to the tsunami should be conducted and provided.

49. DOGAMI requests that the Applicant provide analysis on the potential for off-site debris impacting the facilities and the potential ramifications with respect to public safety.

50. DOGAMI requests that the Applicant provide information on each of the DEMs used for the tsunami model. For example, were three different DEMs used that reflect the three different case studies: berm, wall and composite structure? Please provide the DEMs.

51. Elevated structures, including elevated berms, used for assembly areas in the tsunami inundation zone are subject to ASCE 7-16 chapter 6 requirements. To ensure public safety, DOGAMI strongly recommends that the Applicant design all elevated structures to be used as assembly areas in the ASCE tsunami design zone in accordance with ASCE 7-16 chapter 6. Design documents should be complete, clearly organized and presented to allow for peer review by qualified specialists.