Updated

Crooked River Wetland Mitigation Bank

Long-Term Management Plan

Crook County, Oregon

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Prepared for:

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1. INTRODUCTION
1.1 Summary

Ownership	City of Prineville, Oregon
Type of Bank	Single client (primarily)
Purpose of Bank	Mitigation of impacts associated with highway projects
Location	S ½ Section 26, Township 14 South, Range 15 East NE ¼ NE ¼ Section 25, Township 14 South, Range 15 East Latitude: 44º 19' 23" N; Longitude: 120º 53' 50" W Approximate river mile 45.5, Crooked River
Driving Directions	The property is approximately 2 miles northwest of Prineville, north of the O'Neil Highway and south of the Crooked River. To get there from the west, drive approximately 19 miles east of Redmond, Oregon on State Highway 126. At the bottom of a long descent (staying west of the Crooked River Bridge), take a left onto O'Neil Highway. Drive approximately one and a half miles to NW Rimrock Acres Loop and take a right. Drive to where the road makes a 90-degree left turn. Instead of turning, drive straight ahead through the gated area onto a dirt road. This road leads to the Crooked River and provides access to the mitigation areas.
Land Use	Past uses include grazing and gravel extraction. Since 2003, the land bordering the river has been set aside for environmental restoration. It is immediately adjacent to the City of Prineville's wastewater treatment facility.
Zoning	Exclusive Farm Use (EFU2)
Size of parcel	The City of Prineville owns approximately 400 acres. Of this, approximately 30 acres (along two miles of riverfront) have been set aside for wetland and riparian restoration.
Pre-existing wetlands on site (prior to mitigation)	Phase I: PEM/Riverine Impounding: 2.49 acres Phase II: PEM/Riverine Impounding: 0.81 acre
Mitigation wetlands on site	Phase I: 3.18 acres Phase II: XX acres (based on delineation of Phase II)
Site Description	The Crooked River comprises the north/northeastern boundary of the mitigation area, and a gravel access road forms the south/southwestern boundary. The surrounding 400-plus acre parcel is typical of high desert-land that has been irrigated and seeded to promote agricultural use. Until it was purchased by the City of Prineville, this parcel was used primarily as pasture for cattle.
Mitigation bank objectives	Create and/or enhance emergent wetlands. Establish diverse native wetland plant communities. Decrease downstream flooding. Improve water quality. Provide improved habitat conditions for wildlife.
Wetland Classifications	Cowardin: palustrine emergent HGM: riverine impounding
Service Area	Deschutes basin (below 4900 feet)

(Source: Cowie, 2007).

1.2 Bank Location

The Crooked River Wetland Mitigation Bank (Bank) lies approximately 2 miles northwest of Prineville, Oregon at the following location (ODOT, 2007, Exhibit F):

S ½ Section 26, Township 14 South, Range 15 East
NE ¼ NE ¼ Section 25, Township 14 South, Range 15 East
Latitude: 44º 19' 23" N; Longitude: 120º 53' 50" W

The Bank is approximately 14 acres of the 262.57 – acre Tax Lot #505. The Bank address is NW Rimrock Acres Loop, Prineville, OR. The City of Prineville (City) owns the Bank site. As shown in Figure 1, the property is located between the O'Neil Highway (to the south) and the Crooked River (to the north). The wetland mitigation site is in the vicinity of the confluence of Ochoco Creek and the Crooked River, near river mile 46 (Cowie, 2007).

1.3 Bank Description and History

The Bank was established by the Oregon Department of Transportation (ODOT) to improve the success of its wetland mitigation projects and to provide mitigation for highway projects located within a service area consisting of the Deschutes Basin below 4900 feet elevation. ODOT partnered with the City to create and enhance wetlands along a degraded reach of the Crooked River. The mitigation wetlands lie between the City's wastewater treatment facility to the south and the river to the north / northeast. The Bank site is located in an agricultural landscape that is surrounded by hills supporting native vegetation (Cowie, 2007). The site was chosen for its suitability to create and enhance wetlands, its contribution to watershed priority habitats and functions, its relatively secluded location that limits access and use, and because the City was willing to support the development of a wetland mitigation bank on the property. According to *Volume 1* of *Using an ODOT Mitigation /Conservation Bank* (March 2005), herbaceous wetlands are a priority habitat for the Deschutes Ecoprovince.

Prior to the establishment of the Bank, the site had historically been altered in several ways. The hydrology of the site has been dramatically altered by the presence of upstream dams on the Crooked River and Ochoco Creek and related irrigation practices. Management of flow releases from the dams can result in sudden and dramatic changes to the site's hydrology. During the irrigation season (April – September), irrigation of surrounding pastures and fields can raise groundwater levels significantly on the Bank site.

Following the 1964 flood, the Crooked River through this reach was straightened, channelized, and the riparian vegetation removed. Following relocation of the river, the site was used for gravel extraction, resulting in mounds of soil and gravel throughout the site. Wetlands formed in the depressions left following gravel extraction in the northwest end of the site. Cattle grazed the site since at least the early 1900's, leaving behind compacted soil, reduced water quality, and an altered plant community. In 2003, the approximately 400 acre parcel was purchased by the City for expansion of its wastewater treatment facility, and the land where the Bank is located was set aside for habitat restoration. In the summer of 2004, the City started expanding their wastewater treatment facility and the land bordering the river was fenced off to prevent cattle grazing and initiate passive restoration of the site (Cowie, 2007).

The ecological goal of the Bank is the creation and enhancement of up to 10 acres of primarily emergent wetlands along a portion of the Crooked River (Cowie, 2007). The objectives of the Bank include:

- Create and/or enhance emergent wetlands.

- Establish diverse wetland plant communities dominated by native species.
- Decrease downstream flooding by expanding the existing floodplain and reconnecting isolated floodplain areas to the Crooked River.
- Provide improved habitat conditions for wildlife.

The Memorandum of Agreement (MOA) and Instrument, an agreement entered into by the Mitigation/Conservation Banking Review Team (MCBRT) and ODOT, established guidelines and responsibilities for the establishment, use, operation, and maintenance of the Bank (ODOT, 2007). During the establishment phase of the Bank, ODOT is managing the Bank according to the performance standards identified in the Instrument (Cowie, 2007). The Crooked River Wetland Mitigation Bank Long-Term Management Plan (Plan) identifies long-term monitoring and management actions that will occur to ensure the long-term ecological functioning of the site once the bank is closed. The Plan is intended to meet requirements identified in the MOA (ODOT, 2007).

2. LONG-TERM PROTECTION AND MANAGEMENT

The Plan will guide long-term management of the Bank. The Plan takes effect when the Bank closes, once all performance standards have been met and credits have been used. ODOT established an endowment to fund long-term management of Bank lands by the Long-Term Steward (Steward). Following transfer of management responsibilities upon Bank closure to the Steward, authority and responsibility for implementing the long-term management plan will reside with the Steward, consistent with a Stewardship Agreement. The Stewardship Agreement will discuss the endowment and how it will be used for management. The Stewardship Agreement will reference this plan for long-term management activities. Projected long-term management costs are included in Appendix F. In June of 2013, the City of Prineville has agreed to be the steward of the Crooked River Wetland Mitigation Bank (Agreement No. 28322).

2.1 Permanent Protection Instrument

During Bank establishment, the site has been protected with a Deed Restriction signed and authorized by the City of Prineville (ODOT 2007, Exhibit F). The Deed Restriction protects the site from any uses that would adversely affect the functions and values of the wetlands.

2.2 Long-Term Management

The Plan describes long-term monitoring and management needs, roles and responsibilities of the Steward, and includes projected long-term management costs. The Steward will retain qualified staff and/or contractors with adequate ecological and biological qualifications to manage the Bank. Prior to taking over management of the Bank, the Steward will have ample time to work with ODOT while the Bank remains under ODOT's management responsibility in order for the Steward to become comfortable with the tasks associated with long term Bank management. Permits necessary to implement monitoring and management actions on the Bank site will be obtained and held by the Steward as necessary. The endowment will provide financial support of long-term monitoring; however, the Steward, at their discretion, may provide a higher level of monitoring than is described in this plan. The Plan is intended to stand indefinitely and will be revisited every 5 years and amended as necessary.

3. LONG-TERM MANAGEMENT GOALS AND OBJECTIVES

The Bank possesses habitat and wildlife values important to ODOT, the Steward, the people of the State of Oregon, and the people of the United States. The Bank provides high quality created and enhanced wetlands and contains jurisdictional waters of the United States and the State of Oregon. Individually and collectively, these habitat and wildlife values comprise the "Conservation Values" of the Bank.

The goal of long-term management is to ensure that the Conservation Values of the Bank are monitored, managed, and maintained over the long term by transferring management responsibilities to a qualified long-term Steward upon Bank closure. Long-term management shall support the Conservation Values of the Bank. Long-term management is intended to be adaptive, as defined in the federal mitigation rule (U.S. Army Corps of Engineers 2008) cited below:

> ***Adaptive management*** *means the development of a management strategy that anticipates likely challenges associated with compensatory mitigation projects and provides for the implementation of actions to address those challenges, as well as unforeseen changes to those projects. It requires consideration of the risk, uncertainty, and dynamic nature of compensatory mitigation projects and guides modification of those projects to optimize performance. It includes the selection of appropriate measures that will ensure that the aquatic resource functions are provided and involves analysis of monitoring results to identify potential problems of a compensatory mitigation project and the identification and implementation of measures to rectify those problems.*

Long-term management will be done on all lands within the Bank boundary including the Phase I and II wetlands and slopes surrounding the wetlands (Figure 2). The wetlands at the Bank will not be altered without obtaining all appropriate permits and clearances from regulatory agencies.

Long-term management is intended to promote the long-term functioning of the wetlands. As such, long-term management objectives support the ecological goals and objectives identified for Bank establishment (Cowie, 2007). Long-term management objectives for the Bank are as follows:

- Maintain emergent wetlands
- Maintain connection of Phase II wetlands to the Crooked River (that was reconnected during mitigation construction)
- Maintain diverse wetland plant communities dominated by native species.
- Maintain improved habitat conditions for wildlife

3.1 Limits of Responsibility

The Steward will not be responsible for Bank failure attributed to natural catastrophes such as flood, drought, disease, regional pest infestation, and others that are beyond their reasonable control. Active management is not expected for ecological change that comes about as a result of processes such as climate change, fluctuating river levels, and sedimentation due to overbank flood deposits that may affect the wetlands. Over time, natural successional processes will occur that may reduce wetland functioning or reduce wetland area. For example, during high flows, sediment will deposit in parts of the wetland resulting in a natural filling of some wetland area. The wetland may respond well to annual deposition of flood deposits, with wetland plants growing above newly deposited sediment, but over time, parts of the wetland will

naturally fill in. Regular, frequent management activities to prevent this natural filling are unnecessary.

4. MONITORING

4.1 General Monitoring Protocol

Long-term management objectives, performance standards, monitoring and management actions are summarized in Table 1. Long-term monitoring will inform adaptive management of the Bank. Since the wetlands are intended to be self-sustaining, performance standards are purposefully less rigorous than those identified in the Instrument, used during Bank establishment (Cowie, 2007). Unless otherwise noted, monitoring will occur annually during the growing season in order to trigger necessary management activities that will protect wetland functions and to maintain a consistent annual record of wetland conditions. More frequent monitoring visits, such as a spring, mid-summer, and fall visit, are recommended in order to manage weed infestations. Reports do not need to be submitted to the regulatory agencies following closure of the Bank. The Steward will have access to the monitoring reports prepared by ODOT during the 5-year performance monitoring period. The monitoring section of this Plan is followed by a section describing management actions to be taken, based on the findings during monitoring.

Table 1. Long-Term Management Objectives, Performance standards, Monitoring, and Management Actions

OBJECTIVES	PERFORMANCE STANDARDS	MONITORING	MANAGEMENT ACTIONS
1. Maintain emergent wetlands	Presence of wetland hydrology	1a. Monitor and document wetland hydrology at 8 test sites. If a given test site is not inundated or saturated to the surface, evaluate a 16-inch deep test hole to determine depth of saturation. 1b. Monitor 2 staff gauges	If wetland hydrology present, no action. If wetland hydrology absent, determine extent to which lack of hydrology is related to Phase II connection (see 2 below).
2. Maintain stable, open connection between Phase II wetland and the Crooked River that provides floodplain connectivity and avoids fish entrapment.	The Phase II wetland shall have a stable, open connection to the Crooked River with no severe bank erosion or downcutting.	Observe and photograph connection between river and Phase II wetland annually in late spring.	If stable, open connection, no actions. If connection closes, excavate. If significant fish stranding, contact ODFW & NOAA. If bank erosion and down-cutting, contact City to maintain upland strips between river and wetland (to protect treatment facility).
3. Maintain diverse wetland plant communities dominated by native species.	3a. All emergent wetland areas will have a richness greater than one species.	3a. Qualitative observation of species richness, looking for areas dominated by one species, such as cattails.	3a.Manage for declining diversity (see Section 5.2.1).
	3b. The created emergent wetland shall support less than 15% cover of invasive non-native plant species in any year.	3b. Visual estimate of invasive cover throughout Bank area.	3b. Control weed establishment (see Section 5.2.2). Abide by ODA and Crook County weed control laws.
	3c. At least 5 shrubs per 100 linear feet will be present along the edge of the emergent wetlands	3c. Stem count along wetland edges	3c. Replant if count drops below 5 shrubs per linear feet.
4. Provide improved habitat conditions for wildlife.	Five nest boxes, two mallard nest baskets, and one nesting platform will be maintained.	Count and evaluate condition of nest boxes, baskets, and platforms.	Maintain nest boxes, baskets, and platforms. If necessary, repair or replace structures used within last 5 years.
5. Documentation	Photographs taken at permanent photopoints Annual monitoring documentation	annual photographs and documentation	Label and store photographs for long-term record.

4.2 Hydrology Monitoring

The primary source of hydrology for the Phase I wetlands is groundwater. A secondary source of hydrology is surface water from the Crooked River during moderate to high flow events. Phase II is supported roughly equally by surface water from the Crooked River and by high groundwater. Yearly flooding caused by releases from the Prineville Reservoir was accounted for in the project design. The Phase I wetland is indirectly connected to the Crooked River at its downstream end through pre-existing wetlands. The Phase II wetland is directly connected to the river at its downstream end by an opening that was excavated during mitigation construction (Figure 3). The connections between the river and the wetlands were designed to allow flood water to passively back up into the wetlands, minimizing the erosive forces associated with dam releases and decreasing downstream flooding (Cowie, 2007). The opening of the Phase II wetland was specifically constructed to be at least as wide as the river to minimize potential erosive forces. The width of the Phase II connection following construction was 100 feet.

Continued monitoring of wetland hydrology in the 8 test sites throughout the Phase I and II wetlands will ensure that wetland hydrology continues to be present on the site, a requirement for the persistence of the wetlands (Figure 3). The test sites are identified on the ground by flagged and painted rebar stakes. In addition, two staff gauges will continue to be monitored to allow rapid assessment of inundation depths.

To determine whether a stable, open connection between the Phase II wetland and the Crooked River is maintained, the Steward will observe and photograph the connection annually in late spring or early summer, looking for deposition that is closing the connection, bank erosion, or downcutting. Management actions based on findings are discussed in Section 5.1.

4.3 Vegetation Monitoring

The cover of native herbaceous wetland plants is expected to be self-sustaining by Bank Closure and the end of the performance standard monitoring and will not be monitored over the long-term. However, species richness, the cover of invasive non-native plants, and stem counts of native woody plants along the edges of the wetlands will be monitored over the long-term.

4.3.1 Species Richness

By the end of performance standard monitoring, at least five native wetland plant species with a frequency greater than or equal to 10% will be established in the emergent wetlands. Although species richness will likely remain greater than five native wetland species, some wetland areas may experience declining species richness over time. Deep emergent wetlands can exhibit relatively low diversity over time (Cowie, 2007). In the wettest areas where cattails are established, their density may increase over time, creating monocultures. Monotypic stands of cattails have a reduced overall habitat value, although they do provide good habitat for deer, pheasants, and breeding birds such as marsh wrens, least bittern, and red-winged blackbirds (USFWS, 1993). Annual monitoring for species richness will entail qualitative observations of species richness throughout the Phase I and II wetland areas, looking for areas dominated by 1 species. If cattails or another single species occupy greater than 80% cover in any area larger than 1 acre, management actions to increase species diversity will be explored.

4.3.2 Non-native Invasive Species

The establishment and spread of invasive non-native species is one of the greatest long-term threats to the functioning of the Bank. The Steward will monitor the Bank as necessary to meet the intent of the Oregon Department of Agriculture's Noxious Weed Policy (ORS 570.510 and

570.540). Any non-regulated weed control activities, such as non-chemical weed removal, will commence without regulatory input. During Bank establishment, invasive weed control was conducted according to the Integrated Weed Management Plan for the Crooked River Wetland Mitigation Bank (Allen, 2007) whenever invasive species cover in the Phase I and II wetlands exceeded 15 percent cover. This same performance standard will remain in place for long-term management of Phase I and II wetlands. Additionally, the Phase I and II wetlands, along with the other land within the boundary of the Bank, will be monitored to insure compliance with Oregon's Noxious Weed Policy. This may entail identifying and monitoring weed infestations exhibiting less than 15% cover. New infestations of noxious weed species that were not identified in the Integrated Weed Management Plan or found on the site during Bank establishment may be added to the list of species to be controlled. In this case, the best control strategies known at the time for the new weed species will be determined and control efforts will be pursued.

4.3.2.1 Species Found at the Bank

Invasive plant species found on the Bank were inventoried and mapped in September, 2006 (Allen, 2007). ODOT will re-map weed infestations at Bank closure. Weeds present on the site are shown in Table 2, along with their state weed class. The Oregon Department of Agriculture (ODA) designates weeds according to the ODA Noxious Weed Rating System (ODA, 2009). Crook County follows the ODA's system. The rating system is as follows:

"A" designated weed: a weed of known economic importance which occurs in the state in small enough infestations to make eradication or containment possible; or is not known to occur, but its presence in neighboring states make future occurrence in Oregon seem imminent.

Recommended action: Infestations are subject to intensive control when and where found.

"B" designated weed: a weed of economic importance which is regionally abundant, but which may have limited distribution in some counties.

Recommended action: Limited to intensive control at the state, county or regional level as determined on a case-by-case basis. Where implementation of a fully integrated statewide management plan is not feasible, biological control (when available) shall be the main control approach. ("B" weeds targeted for biological control are identified with an asterisk).

Table 2. Invasive weeds found on the Crooked River Wetland Mitigation Bank
(* Indicates weeds targeted for biological control)

Scientific Name	Common Name	ODA Weed Class
Acroptilon repens	Russian knapweed	B*
Cardaria draba	whitetop	B
Chenopodium album	lambsquarters	None
Cirsium arvense	Canada thistle	B*
Cirsium vulgare	bull thistle	B*
Conium maculatum	poison hemlock	B
Dipsacus fullonum	teasel	none; *D. laciniatus*: B
Erodium cicutarium	storksbill	None
Euphorbia esula	leafy spurge	B*
Kochia scoparia	kochia	B
Lactuca serriola	prickly lettuce	None
Lepidium perfoliatum	clasping pepperweed	none (L. latifolium: B)
Malva neglecta	common mallow	None
Melilotus alba	white sweetclover	None
Onopordum acanthium	scotch thistle	B
Phalaris arundinacea	reed canarygrass	None
Salsola kali	Russian thistle	None
Sisymbrium loeselii	loesel tumblemustard	None
Sonchus asper	spiny sowthistle	None
Verbascum thapsis	common mullein	None

4.3.2.2 Weed Monitoring

Monitoring for the presence and distribution of invasive non-native species ought to occur at least three times per year throughout the entire Bank including the Phase I and II wetland, pre-existing wetlands, and slopes surrounding the wetlands. The cover of invasives throughout these areas will be visually estimated and mapped, ideally in the spring so that spring treatment of existing weeds can occur. Established infestations will be re-mapped and new infestations will be mapped prior to control in order to effectively monitor their spread. The map will be used to determine the efficacy of the previous year's control efforts and to direct current management actions to control weeds found during monitoring. Careful documentation of control efforts used will help guide future decisions on the most effective control strategies. As infestations decrease in size, it may be useful to GPS isolated patches. Control priorities and weed control plans for each species are included in Section 5.2.2 below.

4.3.3 Native Woody Plants

Seasonally-flooded scrub-shrub wetlands will comprise up to 0.5 acre of the Phase I and II wetland areas. Shrubs and trees are establishing along the periphery of the emergent wetlands, where they were planted, and in drier areas within the wetland core, where they colonize. Species planted and colonizing include Pacific willow (*Salix lasiandra*), sandbar willow (*Salix exigua*), Lemmon's willow (*Salix lemmonii*), red-osier dogwood (*Cornus sericea*), Geyer's willow (*Salix geyeriana*), and thinleaf alder (*Alnus incana-tenuifolia*). Scrub-shrub wetlands provide critical nesting, cover, and perching habitat (Cowie, 2007).

The abundance of native woody plants will be at least five plants per 100 linear feet in the areas planted by the end of performance monitoring. By this time, the plants ought to be well-

established and self-sustaining. The same long-term performance standard of at least 5 shrubs per 100 linear feet in the areas planted along the edge of the emergent wetlands will ensure that this shrub and tree component and its associated functions are maintained.

4.4 Wildlife

At the time of Bank closure, the Bank will have five nest boxes, two mallard nest baskets, and one nesting platform to enhance wildlife habitat conditions. The Steward will evaluate the condition of these wildlife structures and maintain them as described in Section 5.3.

4.5 Photographic Monitoring

Permanent photopoints were established throughout the Bank to graphically illustrate the development of the wetlands. Photopoints document representative plant communities and provide expansive views of the wetlands. The locations of permanent photopoints are shown in Figure 3. Annual photographing from these photopoints will continue as part of long-term management.

5. MANAGEMENT ACTIONS

Management actions will be based on results of annual monitoring. Management activities may include restoring hydrology, replanting or reseeding if diversity is too low, treating non-native invasive plant species, replanting shrubs, and/or repairing wildlife structures, as described below.

5.1 Hydrology

No management actions are necessary if the presence of wetland hydrology is found in the Phase I and II wetlands. If wetland hydrology diminishes in the Phase I wetlands, the steward will attempt to determine a cause and potential solution to restore hydrology. However, no excavation is expected by the Steward to re-establish hydrology in this area.

If the connection between the Phase II wetlands and the Crooked River is stable and open, no action is necessary. If the connection closes, the main concerns are fish stranding and the inability of flood water to passively back up into the wetlands, minimizing the erosive forces associated with dam releases and decreasing downstream flooding. The wetlands were designed to provide off-channel habitat while minimizing the chances of fish stranding. However, as sediment from the river moves into and out of the Phase II wetland, fish stranding is possible. NOAA Fisheries and the Oregon Department of Fish and Wildlife (ODFW) recognize that fish stranding often occurs in natural wetlands and that site management should not interfere with natural processes and functions (Cowie, 2007). If fish stranding becomes an ongoing and significant issue, the Steward should consult with NOAA Fisheries and ODFW to determine what actions, if any, should be taken. If the connection closes, the reasons for sedimentation should be evaluated and it should be excavated to restore the connection. This is estimated to be potentially necessary every 50 to 100 years (Castro, personal communication 2009). The steward and/or others may evaluate the potential to lower a portion of the upland strip between the river and the wetland to create more of a flow through system during high water events. This could increase floodplain function and help maintain the connection with the river. No action is necessary if the width of the connection decreases but floodplain connectivity is maintained, fish passage is maintained, and the Phase II wetlands continue to have wetland hydrology.

If bank erosion is observed, the reason for the erosion ought to be determined. The city may want to evaluate the potential of providing erosion protection between the ODOT wetland and

the treatment facility instead of at the rivers edge to allow the rivers edge to function more naturally.

5.2 Vegetation

5.2.1 Species Richness

If cattails or another single species occupy greater than 80% cover in any area larger than 1 acre, the Steward may consider management actions to increase species diversity. Cattails are the most likely native species in the wetlands to develop into a monoculture. In general, cattails can be controlled in localized areas to set back succession by cutting, mowing, or burning in combination with high water levels; hand-pulling; or chemical herbicides. Removal should be followed by replanting and/or seeding with multiple obligate wetland species in order to attempt to quickly fill the newly created niche. At the time management actions are necessary, research into the current state of knowledge and best management practices will be pursued. Since cattails are the most likely species to develop into a monoculture, a brief description of currently acceptable cattail control methods is described in Section 7.

5.2.2 Non-Native Species

If a non-native plant species that is not included on the Oregon Department of Agriculture Noxious Weed List begins to function as an invasive weed, management actions may be warranted. A non-native plant species will be considered invasive if it comprises more than 15% cover in 10% or more of the wetland (by visual estimate) and increases in cover from the previous monitoring period. In this case, the steward may consider management actions to control that species to reduce its influence.

5.2.3 Non-Native Invasive Species

Priorities have been set for the control or elimination of weeds that are established on the site according to their actual and potential impacts on native communities. During the process of long-term weed management, an adaptive management approach will be used. This entails identifying weeds on the site, mapping the distribution of these weeds, researching current accepted methods for control, implementing weed control plans for each species, and monitoring the results of control efforts.

Specific objectives to be achieved through integrated weed management include:

1. Protect and maintain healthy plant communities by minimizing unnatural ground disturbance that promotes the invasion of weedy species.
2. Prevent the establishment of new infestations.
3. Reduce the vigor of existing populations and limit their spread.
4. Eliminate populations or portions of populations.
5. Exhaust the seed bank: prevent seed production and eradicate established plants.
6. Conduct regular surveillance for new infestations.
7. Monitor effectiveness of control treatments.
8. As infestations decrease in size, GPS isolated patches if beneficial.
9. Re-evaluate species and control priorities.
10. Seed newly disturbed sites in an effort to maintain healthy plant communities.

Three types of areas will be managed during long-term management. The first type is newly excavated areas where preventing weed establishment is a high priority. These areas will be seeded following disturbance. New infestations that occur in newly excavated areas will receive a high treatment priority. The second type is areas where no excavation will occur but where

new infestations become established. These will also receive a high treatment priority since small infestations will be easier to control than large ones. The third type of area is upland areas that are currently infested where no excavation will occur. These areas require a long-term integrated approach to eliminate weeds.

5.2.3.1 Control Priorities

Following annual inventorying and mapping of non-native invasive species infestations, weed control plans for the individual species will be implemented (Appendix C). Careful documentation of control efforts used will help guide future decisions on the most effective control strategies.

Weeds have been prioritized based on the threat they pose to the integrity of natural communities. Those infestations that are most likely to be controlled with available resources and those species which pose a greater threat to the integrity of the ecosystem are given a higher priority. Weed Control Plans from the Integrated Weed Management Plan (Allen, 2007) are provided below for each Priority 1, 2, and 3 species that has been found on the site. See Allen, 2007 for citations. A weed treatment schedule summarizes control recommendations by species and season (Appendix D).

Priority 1 (High): These species require immediate action. These are plants that have the greatest potential to disrupt the structure, function and composition of the ecosystem.

Acroptilon repens	Russian knapweed
Cardaria draba	whitetop
Cirsium arvense	Canada thistle
Cirsium vulgare	Bull thistle
Conium maculatum	poison hemlock
Euphorbia esula	leafy spurge
Kochia scoparia	kochia
Onopordum acanthium	Scotch thistle
Phalaris arundinacea	Reed canarygrass
Salsola kali	Russian thistle

Priority 2 (Medium): These species may be easier to eradicate, less competitive, or both. They may be moved to Priority 1 at any time.

Dipsacus fullonum	teasel
Lactuca serriola	prickly lettuce
Melilotus alba	white sweetclover
Sisymbrium loeselii	Loesel tumblemustard
Verbascum thapsus	Mullein

Priority 3 (Low): These species are well established and are a lower priority for control than priority 1 and 2. They will be treated as resources become available.

Chenopodium album	Lambsquarters
Lepidium perfoliatum	clasping pepperweed

Priority 4: Infestations occur on the site but no proposed action. No control plans were developed.

Malva neglecta	common mallow

Erodium cicutarium	storksbill
Sonchus asper	spiny sowthistle

5.2.3.2 Competitive Exclusion and Seeding

The best management strategy for dealing successfully with invasive species is prevention. An established, healthy, diverse native plant community is more resilient to non-native species invasions and can competitively exclude invasive weeds. Some invasive annual and biennial species are easily outcompeted in areas of dense vegetation. Invasive perennial species can be harder to eliminate once established. Infestations can be prevented by establishing a good cover of native wetland species in newly disturbed wetland areas. During project establishment, tufted hairgrass (*Deschampsia caesptosa)* and slender hairgrass (*Deschampsia elongata*) were seeded and successfully germinated in the wetland following construction.

Most non-native invasive infestations occur along the access road edge on drier soils. During Bank establishment, ODOT seeded a range of perennial grasses that compete with invasives to help reduce the success of weeds in these drier areas. If future disturbance necessitates seeding to help outcompete weeds, the following recommendations should be considered. Native species that are appropriate to seed in these drier parts of the site include Great Basin wildrye, Sandberg's bluegrass, bluebunch wheatgrass and bottlebrush squirreltail. Non-invasive non-native perennial grasses can augment a native seed mix and help establish a good vegetative cover that competes well with weeds and that prevents erosion. Species to consider include several drought-tolerant cultivars included in Round Butte Seed Grower's (RBSG) Dryland 715 Premium Mix which includes Russian wildrye, Siberian wheatgrass, intermediate wheatgrass, Sherman big bluegrass, and covar sheep fescue. Another appropriate mix from RBSG is their Native Grass Mix, which includes bluebunch wheatgrass, Idaho fescue, Indian ricegrass, Canby or Sandberg bluegrass, bottlebrush squirreltail, and blue flax. Drill seeding in November or December (dormant seeding) is favorable over broadcast seeding, which can be conducted from November through January. If the area can be irrigated, germination success will tend to be better. If no irrigation is applied to newly seeded areas, it may take several years for some species to germinate. Germination success is affected by the species seeded, dormancy requirements, moisture availability, and temperatures.

5.2.3.3 Herbicide Use

Weed control plans for individual species include integrated management strategies that combine the use of mechanical, chemical, and biological methods of controlling the target species. Biological control methods are mentioned, but not emphasized. Mechanical methods such as cutting, mowing, digging, and burning may be sufficient to eliminate some species. Other species, especially perennials with extensive root systems that give rise to many shoots may require herbicides to eliminate. The weed control plans that follow include herbicides recommended for control although some may not be approved for use near water. Additionally, a "take" permit from the National Marine Fisheries Service (NMFS) and/or USFWS may be required. Herbicides will be applied according to the Best Management Practices (BMPs) described in Appendix E.

One of the primary goals of the site is to establish a diverse, native wetland plant community. As such, it is very important to use chemicals selectively on the target species in order to avoid contact and harm to native plants. In general, herbicides will be applied by spot spraying or wicking rather than broadcast spraying in order to avoid native plants. Reference to herbicides in the weed control plans reflect chemicals recommended in 2007, often from the Pacific Northwest 2007 Weed Management Handbook (OSU, 2007). Annual research into the best chemical to use is recommended since new formulations are developed regularly, often

becoming more environmentally safe and requiring less chemical to kill target plants. A surfactant used with the herbicide often gives better results (Alexanian, personal comm.). Anyone who applies herbicides must be certified and licensed by the Oregon Department of Agriculture. Before applying any herbicide, *read the label.*

5.2.4 Native Woody Plants

No management actions are necessary if stem counts of native woody plants exceed 5 shrubs per 100 linear feet. If counts drop below this, replanting with cuttings and/or nursery stock will occur. The Steward will evaluate the likely cause of mortality and plant shrubs and trees in areas most likely to support them. Although the most appropriate species to plant will be identified based on current environmental conditions, the species planted and colonizing the area are listed in Section 4.3.3 and can serve as a reference.

5.3 Wildlife

All wildlife structures will be maintained to continue to enhance wildlife habitat conditions on the site. The Steward will repair or replace any of the five nest boxes, two mallard nest baskets, or one nesting platform that have fallen down or require maintenance. No replacement is necessary if a structure has not been used for 5 years.

5.4 Documentation

Annual photographs will be labeled and stored to maintain a long-term record. The cause of any dramatic changes that photographs reveal will be investigated and appropriate management actions taken.

6. MAINTENANCE

The City will be responsible for maintaining the existing fences and gates surrounding the Bank site. Any signs that are erected in the future will also be maintained by the City. As steward of the bank site, the City will remove any trash found during monitoring site visits and work to correct any damage resulting from trespassing.

7. POSSIBLE FUTURE RESTORATION ACTIVITIES

There may be situations that arise in the future whereby certain management actions are determined to have a superior value to the wetlands in the Bank. Potential future activities include prevention of a potential monoculture in the wetlands and stream habitat restoration activities aimed at improving stream function and habitat conditions for steelhead and other native fish.

7.1 Restoration of Species Richness

If a monoculture develops in an area greater than an acre, as described above in Section 5.2.1, the Steward may consider managing for declining species diversity. Since cattails are the most likely species to develop into a monoculture, a brief description of currently acceptable cattail control methods follows. An understanding of cattail ecology will help the Steward determine the best control methods and timing to use.

Cattails spread vigorously both asexually through rhizomes (thick, white spreading roots) and sexually through prolific seed production. A single cattail head can contain as many as 250,000 seeds, and almost 1,000 seeds / m2 may exist in the upper few inches of soil. Viability can approach 100% in the year following production, and seeds can remain viable in the seed bank for up to 100 years (USFWS, 1993). Cattail seeds, like those of almost all other emergent

plants, do not germinate under water that is more than 0.5 inch deep. Once established, cattails prefer shallow, flooded conditions and can grow in water depths of up to 1.5 feet. Cattails need to have “wet feet” during most of the growing season (Cornell Cooperative Extension, 2003).

Cutting or mowing cattails weakens the plant by depriving the roots of carbohydrates. Cutting is most effective in mid-summer when starch reserves in the rhizomes are the lowest. Cutting cattails below the water line two or three times in a season, at the appropriate time, has been shown to result in fewer plants growing back the following year. The most effective time to cut is during the 3-4 days when the pistillate spike is lime green and the staminate spike is dark green, and during a 3-week window from 1 week before to 1 week after this 3-4 day window (USFWS, 1993). Cutting cattails in May stimulates growth while winter cutting seems to have little effect on carbohydrate stores in the rhizomes (Cornell Cooperative Extension, 2003).

Cutting or burning used in conjunction with water level control can effectively kill cattails. However, because the water levels cannot be controlled at the Bank, these methods are not feasible at the site. Prescribed burns do not usually kill the plants because they are rarely hot enough to impede rhizome function or shoot viability.

Hand-pulling cattails when they are young is a good preventative control measure. The plant and rhizome can be slowly removed and discarded in a drier area where they will decompose and will not re-establish. Dredging older plants and roots may be considered as long as the dredging can be done with minimal disturbance to the wetland (Cornell Cooperative Extension, 2003).

Herbicides such as glyphosate that are translocated to the rhizomes and interrupt metabolic pathways have been used successfully to kill cattails. A mid- to late summer application when carbohydrates are being stored enhances the effectiveness of translocated herbicides. Any herbicide used to control cattail should readily degrade in water and soil (USFWS, 2003). All required permits must be obtained prior to chemical treatment and directions for application listed on the label should be carefully followed.

7.2 Habitat Improvement

Following the 1964 flood, the Crooked River was straightened, channelized, and the riparian vegetation removed. Photographs from 1905 showing the Crooked River downstream from Prineville prior to intensive agriculture and manipulation show a more sinuous channel and a continuous riparian vegetation community along its length (Cowie, 2007).

The Crooked River Watershed Council is currently involved in a stream restoration project immediately downstream from the Bank that entails levee lowering, floodplain lowering, and excavation of a historic backwater feature to increase floodplain connectivity. The project also includes adding large woody debris and planting riparian vegetation to enhance the existing wetland and riparian vegetation community (Inter-Fluve, Inc., 2007). Possible future stream restoration activities include improving in-stream habitat, increasing floodplain connectivity, and restoring the riparian shrub and tree community that provides shade, bank stability, habitat and food to higher trophic levels. In the future, the uplands between the Phase I and II wetlands and the river could be lowered to increase floodplain connectivity. If this is pursued, any design must include considerations to prevent draining of the wetlands and to protect the City’s treatment facility. Any net loss in wetlands at the Bank as a result of future restoration activities must be mitigated.

8. PUBLIC USE AND ACCESS

To protect the site from vandalism, weeds, and disturbances to wildlife, access to the Bank site is currently restricted by fencing and a locked gate. In the future, the site will continue to be protected with fencing and a gate maintained by the City. Until an agreement is reached with a public agency such as the Crook County Park and Recreation District, the site will be protected from trespassing and vandalism, and access will be allowed for monitoring, management, or restoration activities. A long term goal of allowing public access has been discussed with the City and the Crook County Park and Recreation District. Future public access may include amenities such as interpretive signs, educational opportunities, and a boardwalk. Funding of these amenities is not a part of this Plan.

During the establishment phase of the Bank, public access is limited to arranged visits coordinated by ODOT. While educational uses by the agencies and possibly other groups may occur occasionally, no parking or other facilities are currently proposed for the site. Recreational use such as bird-watching and plant identification determined to not conflict with the goals of the Bank may be allowed by the Steward during long-term management. These allowances will be agreed to by ODOT and will not conflict with the terms of the deed restriction.

9. AMENDMENTS

This Plan is intended to be flexible and adaptive, and is recommended to be updated every 5 years or as needed. Upon Bank closure, in the event the conservation values of the Bank are determined by the Steward to be fundamentally compromised, the Steward will use available funding to develop and implement a Corrective Response Plan. If necessary, the Steward will collaborate with other agencies and organizations to seek additional funding to implement the Corrective Response Plan. This Plan is not intended to create an unfunded financial burden on the Steward.

10. ENDOWMENT FOR LONG-TERM MANAGEMENT

To finance the perpetual monitoring, management, and maintenance of the site after bank closure, ODOT established an endowment based on projected long-term management costs (Appendix F). The Steward will be provided with this endowment for long-term management to cover anticipated annual costs. The endowment will be of sufficient size to facilitate maintenance and the long-term ecological viability of the site. Once the endowment is provided to the Steward, ODOT will have satisfied long-term financial assurance obligations of the MOA (ODOT, 2007). The Stewardship Agreement describes the expectations for use of the endowment pertaining to the management of the Bank.

Projected long-term management costs are provided in Appendix F. The average annual cost of long-term stewardship was determined for each task. The total average annual stewardship cost was used to determine an appropriate amount for the endowment for long-term management. The endowment should be able to produce this amount annually while the principle grows. The total average annual stewardship cost is converted to an endowment using a capitalization rate (Center for Natural Lands Management, 2004).

The capitalization rate is used to determine the size of the endowment principal likely to be needed to fund annualized costs of long-term management while maintaining the principal with sufficient earning power after accounting for inflation and potential cost escalation. Based on discussions with the Oregon Community Foundation a conservative net distribution rate of 4.5% of the endowment is recommended. . Cost escalation is not anticipated to be substantial for long-term management tasks (ODOT, 2009). The total average annual stewardship costs have

been calculated to be $6,520. Using a capitalization rate of 4.5%, the endowment principle required to provide these annual costs is $144,889, calculated as:

$$\frac{\text{average annual stewardship costs}}{\text{capitalization rate}} = \frac{\$6520}{0.045} = \$144{,}889$$

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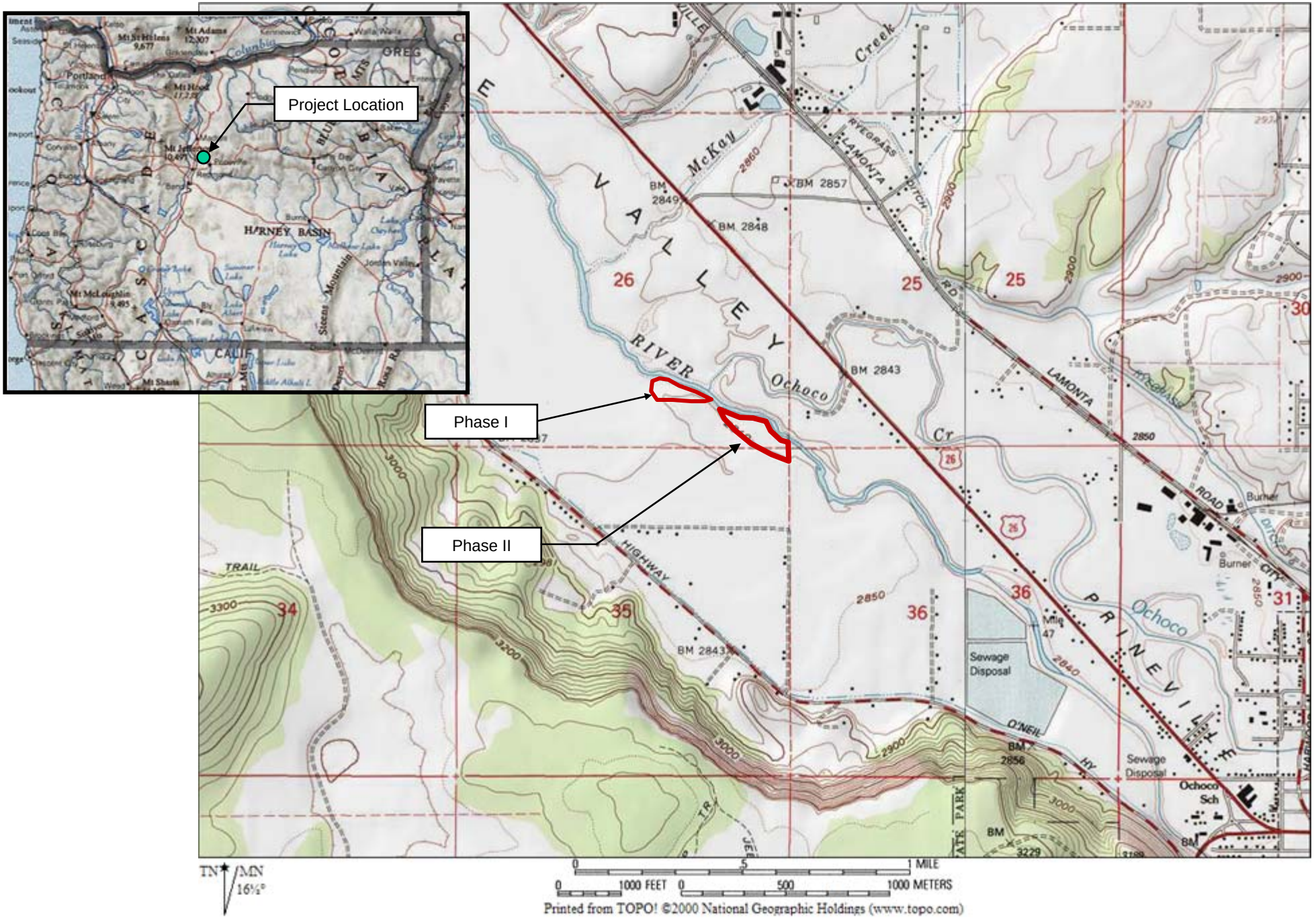
APPENDIX A.
FIGURES



Oregon Department of Transportation
63034 O.B. Riley Road
Bend, Oregon 97701
Phone: (541) 388-6032 Fax: (541) 385-0476

Figure 1
Crooked River Wetland Mitigation Bank
Site Vicinity Map

↑N

Date: 2000
Source: National Geographic TOPO!
Key #: 15395

Oregon Department of Transportation
63034 O.B. Riley Road
Bend, Oregon 97701
Phone: (541) 388-6032 Fax: (541) 385-0476

Figure 2
Crooked River Wetland Mitigation Bank
Site Map

Date: 2005
Source: ODOT_DATA/Projects/crooked river mit site/crooked riv dgn files/aerial photo.dgn [site plan model]

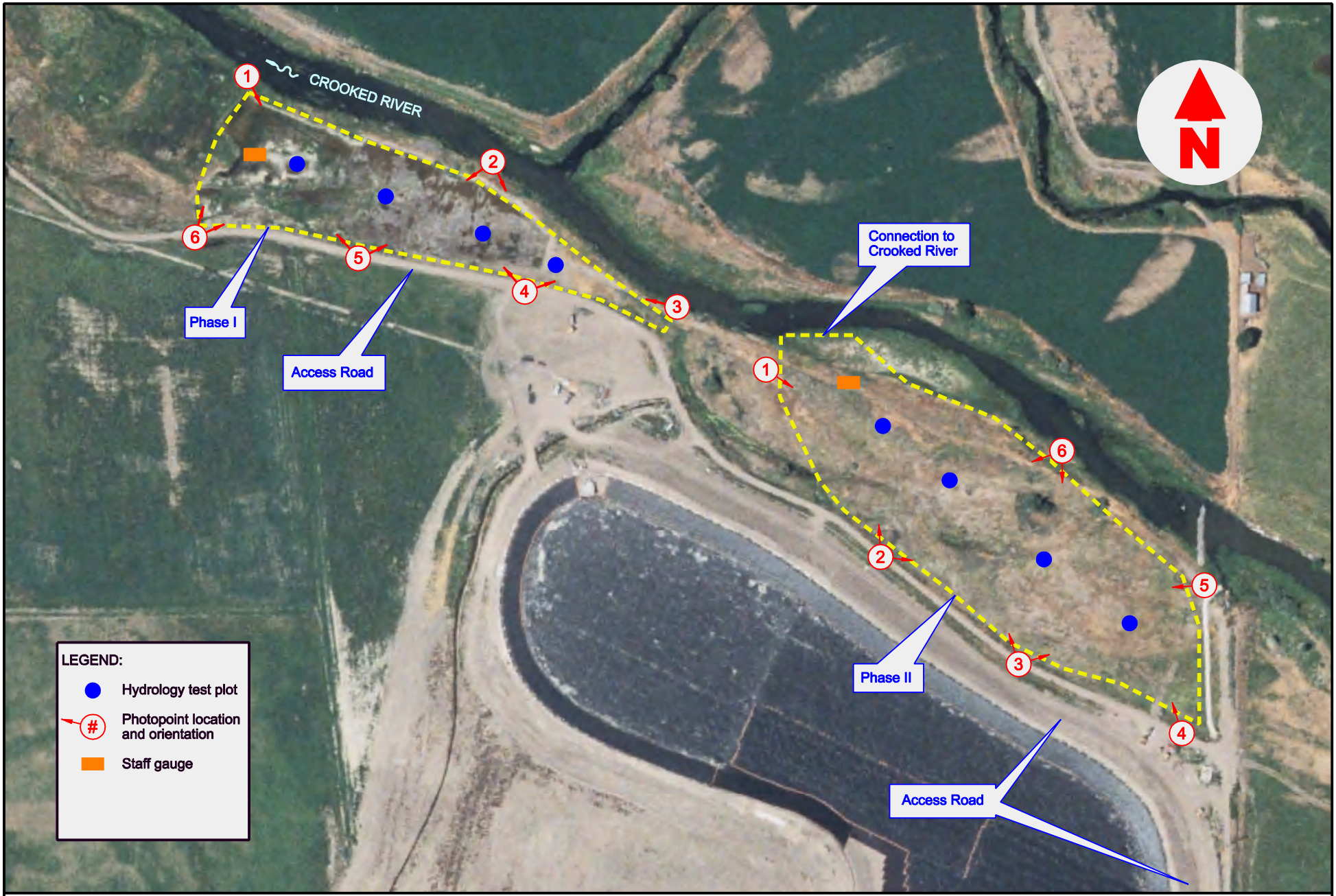


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Figure 3
Crooked River Wetland Mitigation Bank
Phase I and II Wetlands

Date: 2005
Source: ODOT
Base Files: WetlandPhaseFigure.dgn
WetlandPhaseShape.dgn
WetlandPhaseAerial.dgn
CrookedRiver.tif

APPENDIX B.
MONITORING DATA SHEETS

Crooked River Wetland Mitigation Bank Site
Monitoring Data Sheet

Date of Monitoring:
Name of monitor(s):
Weather conditions of day of monitoring:

Hydrology

Monitor and document wetland hydrology at 8 test sites & 2 staff gauges

Test Sites

Test Site #1 **Field Observations:** Surface Water Present? Yes _____ No ___ Depth (inches): _____ Saturation Present? (includes capillary fringe) Yes _____ No ___ Depth (inches): _____	**Wetland Hydrology Present?** **Yes ____ No _____**
Remarks:	
Test Site #2 **Field Observations:** Surface Water Present? Yes _____ No ___ Depth (inches): _____ Saturation Present? (includes capillary fringe) Yes _____ No ___ Depth (inches): _____	**Wetland Hydrology Present?** **Yes ____ No _____**
Remarks:	
Test Site #3 **Field Observations:** Surface Water Present? Yes _____ No ___ Depth (inches): _____ Saturation Present? (includes capillary fringe) Yes _____ No ___ Depth (inches): _____	**Wetland Hydrology Present?** **Yes ____ No _____**
Remarks:	
Test Site #4 **Field Observations:** Surface Water Present? Yes _____ No ___ Depth (inches): _____ Saturation Present? (includes capillary fringe) Yes _____ No ___ Depth (inches): _____	**Wetland Hydrology Present?** **Yes ____ No _____**
Remarks:	
Test Site #5 **Field Observations:** Surface Water Present? Yes _____ No ___ Depth (inches): _____ Saturation Present? (includes capillary fringe) Yes _____ No ___ Depth (inches): _____	**Wetland Hydrology Present?** **Yes ____ No _____**
Remarks:	
Test Site #6 **Field Observations:** Surface Water Present? Yes _____ No ___ Depth (inches): _____ Saturation Present? (includes capillary fringe) Yes _____ No ___ Depth (inches): _____	**Wetland Hydrology Present?** **Yes ____ No _____**
Remarks:	

Test Site #7 **Field Observations:** Surface Water Present? Yes _____ No ___ Depth (inches): _____ Saturation Present? (includes capillary fringe) Yes _____ No ___ Depth (inches): _____	**Wetland Hydrology Present?** **Yes ____ No _____**
Remarks:	
Test Site #8 **Field Observations:** Surface Water Present? Yes _____ No ___ Depth (inches): _____ Saturation Present? (includes capillary fringe) Yes _____ No ___ Depth (inches): _____	**Wetland Hydrology Present?** **Yes ____ No _____**
Remarks:	

Staff Gauges

Staff Gauge #1 **Field Observations:** Surface Water Present? Yes _____ No ___ Depth (inches): _____
Remarks:
Staff Gauge #2 **Field Observations:** Surface Water Present? Yes _____ No ___ Depth (inches): _____
Remarks:

Observations of Connection between Phase II and Crooked River: *(note deposition, downcutting and bank erosion)*
Recommended Management Actions:

_____

_____

Vegetation

Qualitative observation of species richness, looking for areas dominated by 1 species.

Number and locations of areas found to contain only a single species occupying >80% cover in an area >1 acre:

_____

_____

Recommended Management Actions:

_____

_____

Visual estimate of cover of invasives throughout the Bank, including Phase I and II, pre-existing wetlands, and road slopes. Map infestations on separate base map, updating map from last year.

Note presence of weed species found during monitoring:

Scientific	Common Name	Found	Not Found	Notes

Name		(x)	(x)	
Acroptilon repens	Russian knapweed			
Cardaria draba	whitetop			
Chenopodium album	lambsquarters			
Cirsium arvense	Canada thistle			
Cirsium vulgare	bull thistle			
Conium maculatum	poison hemlock			
Dipsacus fullonum	teasel			
Erodium cicutarium	storksbill			
Euphorbia esula	leafy spurge			
Kochia scoparia	kochia			
Lactuca serriola	prickly lettuce			
Lepidium perfoliatum	clasping pepperweed			
Malva neglecta	common mallow			
Melilotus alba	white sweetclover			
Onopordum acanthium	scotch thistle			
Phalaris arundinacea	reed canarygrass			
Salsola kali	Russian thistle			
Sisymbrium loeselii	loesel tumblemustard			
Sonchus asper	spiny sowthistle			
Verbascum thapsis	common mullein			

Notes (effectiveness of last previous control efforts, changes in abundance or distribution over last year)

_____

_____

_____

_____

Recommended Management Actions

_____

_____

_____

_____

Stem count of woody plants along wetland edges. Map any locations where count drops below 5 shrubs per 100 linear feet.

Stem Count: at least 5 shrubs per 100 linear feet? ____ yes ____no
Number of areas with < 5 shrubs per 100 linear feet? _____
Location of these areas _____
Probable cause of mortality and Recommended Management Actions (species and locations to replant)

_____

Wildlife

Count and evaluate condition of nest boxes, baskets, and platforms.

Condition of 5 nest boxes:

Condition of 2 mallard nest baskets:

Condition of 1 nesting platform:

Recommended Management Actions:

Photographs

All permanent photopoints re-photographed? Yes_____ No _____

Recommended Management Actions based on photographs

General Notes

Additional Notes on Site Conditions found during monitoring

Additional Management Actions Recommended

APPENDIX C.
WEED CONTROL PLANS

Acroptilon repens Russian knapweed

Priority: High
Russian knapweed is an aggressive perennial species that poses a threat to native plant diversity in wet habitats. It invades disturbed areas, forming dense single-species stands. It does not readily establish in healthy, natural habitats (Carpenter and Murray 1998).
The plant occurs in isolated patches at the west ends of both Phases I and II of the Crooked River Wetland Mitigation Bank.

Description, Biology and Ecology
Acroptilon repens, formerly known as *Centaurea repens*, is a perennial plant in the Aster family (Asteraceae). Stems are 18-36 inches tall, covered with short gray hairs. Young plants produce a basal rosette of toothed leaves covered with fine hairs (often appearing blue-green) in the early spring and bolt in late May to mid-June. Pink to lavender flowers occur at the tip of the branches, generally between June and October. The flower heads are composed entirely of disc flowers (Carpenter and Murray 1998). Involucral bracts of Russian knapweed have light thin hairs, papery margins and are green at the base (Duncan et al. 2001). Russian knapweed does not reproduce extensively by seed, although one plant may produce 1,200 seeds per year (Carpenter and Murray 1998). Achenes are 2-3 mm long and are wind dispersed. Russian knapweed is a native of Eurasia that was introduced to North America around 1898 (Whitson 2004).

Russian knapweed primarily reproduces vegetatively from well-developed rhizomes.
The plant spreads by deep, scaly, creeping rhizomes (underground stems) that can grow to depths of 8 feet the first year and to 23 feet during the second growing season (Duncan et al. 2001). Rhizomes can be recognized by their dark brown or black color and the presence of alternately arranged scale leaves with buds in the leaf axils. The buds develop into adventitious shoots, allowing the plant to rapidly form dense colonies. A dense patch might have up to 100-300 shoots per square meter! The plant also produces allelopathic chemicals that inhibit the growth of other species and allow it to spread (Carpenter and Murray, 1998).

Overview of Control Options
An integrated control strategy using mechanical and chemical control along with restoring a competitive vegetation community have shown to be most effective for controlling Russian knapweed. Because of its extensive root system, the key to successful control of Russian knapweed lies in stressing the plant and causing it to deplete its carbohydrate reserves in the root system, preventing seed production, and controlling its vegetative spread. Infestations of Russian knapweed have been contained by pulling, cutting, and mowing, while including chemical control seems to be necessary to eliminate infestations. Two biological control agents (a gall-forming nematode and a seed gall mite) have been released in the United States (Carpenter and Murray 1998). No information on burning Russian knapweed was found.

Mechanical
Pulling/Cutting/Mowing
Cutting or otherwise removing the above-ground shoots reduces the current year's growth and may eliminate seed set but will not kill Russian knapweed. Cutting or mowing three times per year stresses the plants, forcing them to use nutrient reserves stored in the root system. The new shoots that emerge from the roots are often smaller and less vigorous. Since mowing could damage nearby plants that may be competitive, care should be taken if mowing is a selected control strategy. Pulling Russian knapweed two to three times per year contained but did not eliminate an infestation in Washington. Russian knapweed may contain a compound that can

cause a rash if it comes in contact with skin (Carpenter and Murray 1998). Consequently, when pulling the plant, workers should wear gloves and later wash their hands and exposed skin.

Burning

Although no specific information on the response of Russian knapweed to burning was found, burning would probably not control the plant and may promote its spread. Burning would likely eliminate shoots for a short time before they re-emerged and it would not kill the roots system. Burning may increase the size of infestations since the plant is such a strong competitor in disturbed soil (Carpenter and Murray 1998).

Chemical

The extensive root system of Russian knapweed makes it more difficult to control than other knapweeds. Herbicides can effectively eliminate Russian knapweed and are often the most cost-effective treatment for small infestations (Duncan et al. 2001). A number of herbicides have been effective in controlling Russian knapweed including glyphosate; picloram (Tordon); 2,4-D; clopyralid + 2,4-D amine (Curtail); clopyralid (Stinger or Transline); triclopyr + clopyralid (Redeem R&P), aminopyralid (Milestone), imazapic (Plateau), and diflufenzopyr + dicamba (Overdrive). Aquatic-approved versions of these chemical should be used near water. See the Pacific Northwest Weed Management Handbook for application rates for the chemical selected (OSU 2007).

The timing of application of herbicides is important and varies with the chemical. Glyphosate can be applied to actively growing plants in the bud stage. Abundant regrowth from the root system will occur the following year requiring additional applications. Careful spot spraying or wick application will help prevent it from getting on other plants.

Picloram (Tordon 22K) at 0.5 to 0.75 lbs a.i. acre (1 to 1.5 quarts), clopyralid + 2,4-D amine (Curtail) at 1.8 lbs a.i. per acre (3 quarts) or clopyralid (Transline) at 0.375 to 0.5 lbs a.i. acre (1 to 1.3 pints) should be applied to Russian knapweed at the late bud to early bloom growth stages or in the fall following a light frost (the lower recommended herbicide rate can be applied in the fall) (Duncan et al. 2001). If applied later when plants are in the bud stage, picloram may not prevent seed production. Picloram does not bind to soil and may leach into groundwater, so should not be used near water. Clopyralid applied during bud-growth and in the fall at 1.3 pints per acre controlled Russian knapweed by 96% and 100% respectively (Carpenter and Murray 1998). It will kill other composites, legumes, and smartweeds but has little or no impact on other forbs. Clopyralid can leach into the groundwater, so should not be used near streams.

2,4-D can be applied in late spring before and during stem elongation. The "amine" formulation of 2,4-D can be applied along rivers and riparian areas but provides the most inconsistent control of these herbicides (Duncan et al. 2001). Overdrive should be applied after most rosettes emerge but before stem elongation.

Redeem R&P should be mixed with a nonionic surfactant and applied from rosette to early bolt stage. Milestone should be applied in spring and summer to plants in the bud-to-flowering stage and to dormant plants in the fall. Plateau should be applied in fall or early winter after plants have withered (OSU 2007). Kev Alexanian, Crook County Weed Master, recommends applying Milestone, Transline, or Tordon in November or December before the ground has frozen as a pre-emergent. This allows the herbicide to get in the soil and to kill the tender young shoots when they emerge in the spring (Alexanian personal comm.).

Banvel at 2 lbs a.i. per acre (2 quarts) alone and in combination with 2,4-D provided inconsistent control of Russian knapweed at all growth stages (Duncan et al. 2001).

Control Recommendations

The treatment options chosen depend on the ability to use herbicides and on available resources. Each method requires follow-up monitoring and treatment to ensure long-term success.

1. Kill plants by spot spraying at the appropriate time of year, depending on the herbicide chosen.
2. Cut or pull shoots three times per year to stress the plants, forcing them to use nutrient reserves stored in the root system.

Cardaria draba **whitetop**

Priority: High
Whitetop is a perennial species that is highly competitive once established, posing a threat to native plant diversity. It is a challenge to control due to prolific shoot production from creeping horizontal roots (Lyons 1998a). Whitetop occurs along the road on the south side of the wetland mitigation site and along the berm between the wetland and the Crooked River.

Description, Biology and Ecology
Cardaria draba is a hardy, deep-rooted perennial that can grow up to 2 feet tall. It is a member of the mustard family (Brassicaceae). It was originally placed in the genus *Draba*, then in the genus *Lepidium*, and most recently in *Cardaria*. The plant has a number of common names including heart-podded hoary cress, whitetop, perennial peppergrass, and Cranson dravier (Lyons 1998a, CDFA 2007). Plants of *Cardaria draba*, *C. chalepensis*, and *C. pubescens* are easily confused and are distinguished by their differences in fruit. *Cardaria chalepensis* and *C. draba* are known to hybridize (Lyons 1998a). Whitetop leaves are bluish-green and lance-shaped. The lower leaves have petioles while the upper leaves clasp the stem. Plants produce many white 4-petaled flowers. Inverted heart-shaped capsules contain two seeds. Whitetop is common on disturbed and alkaline soils (Whitson 2004). The plant often grows on moderately moist, alkaline to saline soils but tolerates a wide range of soil types and moisture conditions (CDFA 2007). It is native to southwest Asia and probably arrived in the U.S. in ship ballast or contaminated alfalfa (Lyons 1998a).

Whitetop reproduces from roots, root fragments and seeds. Whitetop is very cold-tolerant and begins growth early in the spring (Whitson, 2004). The plant flowers in late May or June and fruits from mid-July into August. Whitetop can produce up to 850 fruits per flowering stem, each with two seeds. Germination rates are high (93%) but seed viability is low (2 years) (Lyons 1998a). Whitetop produces an extensive root system that can account for 75% of the total plant biomass and can store large amounts of carbohydrates. Both roots and root fragments can generate new plants, allowing the plant to spread rapidly. Vertical roots have been found to 2 m depth. Carbohydrate reserves are minimal in early to mid-spring and typically reach maximum levels by mid-summer. Roots survive cold winter climates and periods of drought (CDFA 2007).

Overview of Control Options
Because plants can regenerate from extensive root systems, control efforts often require 2-3 years to be effective (Lyons 1998a). Infestations of whitetop have been contained by combinations of mowing, cutting, pulling, ceasing irrigation, restoring the native plant community, decreasing grazing, and chemical control. Of these, pulling, cutting, mowing, and herbicide treatment are most practical for the site. Burning is mentioned below, but is not a recommended control strategy. There appear to be no biological agents currently used to control whitetop. Plant competition is an effective way to prevent new infestations of whitetop.

Mechanical
Pulling/Cutting/Mowing
Cutting or otherwise removing the above-ground shoots may reduce growth and eliminate seed production but will not kill whitetop. The most effective timing for mowing is when plants are in the late bud to early flowering stage. Cutting alone has not been shown to be an effective control strategy since shoots quickly emerge from the roots (Lyons 1998a). Repeated cutting or mowing stresses the plants, but does not kill the roots. Mowing may also decrease competitive vegetation. Any mechanical control therefore must be aggressively maintained for several years (CDFA 2007). Although mowing alone is not generally effective, research on a similar species

(*Lepidium latifolium*, perennial pepperweed) showed that mowing followed by treatment with glyphosate dramatically improved control over mowing alone (CDFA 2007).
Some research suggests that repeated tilling can eliminate whitetop, although the intensity necessary is not practical for the Crooked River site. Repeated tilling every 10 days for 2-5 years eliminated a whitetop infestation (Lyons 1998a).

Burning
Prescribed fire is not recommended to control whitetop due to the emergence of new shoots from root buds following disturbance. Some observations suggest that *Cardaria spp.* populations expand following fire. *Cardaria draba* seedlings have been reported to rapidly appear after grassland fires in Australia (CDFA 2007).

Chemical
A number of herbicides have been effectively used to control whitetop including 2,4-D LV ester, 2,4-D amine, amitrole (Amitrol), imazapic (Plateau), chlorsulfuron (Telar), and metsulfuron (Escort or Cimarron) (OSU 2007). Spot treatment of glyphosate used in the early bud stage has also been shown to be effective (CDFA 2007). Control efforts may require more than 1 year. The first two, 2,4-D LV ester and 2,4-D amine can be applied by spot spraying or wicking at 1 lb ae/A in pre-bud stage and can be reapplied in fall if new growth appears. Amitrole (3 lb ai/50 gal water for spot treatment) should be applied before first blooms open. Foliage needs to be thoroughly wet. Imazapic (0.125 to 0.188 lb/A) should be applied when blossoms are in full bloom until plants desiccate, and can be applied to rosettes in fall. Chlorsulfuron and metsulfuron should be applied at prebloom to bloom growth stages or to rosettes in the fall (OSU 2007). Lyons (1998a) reports that 2-4D and amitrol are the most effective herbicides for whitetop and that they are most effective when used in combination with plantings of competitive species.

Research on the efficacy of various herbicide treatments shows varying results. A study in England found that using 2,4-D provided 90% control when applied for 2 years. In Canada, 2,4-D provided 90-99% control and amitrole provided 97-100% control (Lyons 1998a).

Control Recommendations
The treatment options chosen depend on the ability to use herbicides and on available resources. Each method requires follow-up monitoring and treatment to ensure long-term success.

1. Kill plants by spot spraying at the appropriate time of year, depending on the herbicide chosen.
2. Cut or mow repeatedly throughout the growing season, as described above, followed by application of herbicides. As described above, mowing or cutting alone may contain but will likely not eliminate whitetop.

Cirsium arvense Canada thistle

Priority: High
Canada thistle is an aggressive perennial species that poses a serious threat to native plant diversity in wet habitats. It occurs in isolated patches along the road edge and along the berm between the mitigation wetlands and the Crooked River on the Crooked River Wetland Mitigation Bank.

Description, Biology and Ecology
Canada thistle is an introduced perennial rhizomatous plant that thrives in moist soil, but can also be found on dry, disturbed sites. Plants have a basal rosette of wavy, spine-tipped leaves and sessile alternate leaves along the stem. Canada thistle is dioecious, with male and female flowers produced on different plants. Flower heads are white to purplish pink and smaller than other thistles, approximately ½ inch (1.3 cm) wide. The involucral bracts under the flowers are spineless. Flowering generally begins in late June and continues through August and September in Central Oregon. Flowers are insect-pollinated and seed set depends on the presence of both male and female plants in the area. A member of the Asteraceae family, it is a prolific seed producer. A single plant can produce up to 5000 seeds. These wind dispersed seeds can be viable for many years when buried (UC 2007; Whitson 2004). Germination and dormancy requirements vary with ecotype (Nuzzo 1997). Canada thistle is native to southeastern Eurasia. By the late 18th century it had been introduced to Canada as a crop seed contaminant (Whitson 2004).

Canada thistle forms dense clusters of clones and spreads primarily by vegetative horizontal growth of rhizomes. The extensive root system can reach 20 feet (6 m) deep (UC 2007). Individual clones have been measured as large as 35 m in diameter (Nuzzo 1997). Since Canada thistle spreads readily from stem and root fragments, cutting the roots or disturbing the soil can increase thistle density. New shoots have emerged from root fragments as small as 0.5 cm. A flush of growth from roots occurs in both the spring and fall, although a flush can occur anytime during the growing season when adequate soil moisture is available (Beck 2003).

Overview of Control Options
Since Canada thistle spreads primarily by expansion of the root system, control efforts should aim to kill established clones. Once established, Canada thistle is difficult to control. The plant's well-developed root system helps it survive most control methods, including herbicides. There are many different treatment and timing strategies for controlling Canada thistle and it may respond differently to various treatments depending on ecotype, environment, soils and weather conditions. For example, drought stress reduces the efficacy of herbicides but increases the effectiveness of mechanical methods. Research has shown that a single control method is rarely effective, and often two or more methods are necessary at a given site (Nuzzo 1997). Nuzzo (1997) recommends two strategies when resources are limited: 1) treat entire clones to prevent resprouting from undamaged roots; and 2) target female clones to reduce seed production. Possible control efforts include cutting or mowing, burning, and herbicide treatment. Pulling or digging should be avoided since this can stimulate new shoot production (Nuzzo 1997). Solarization (covering with plastic to "bake" the plant) is not practical since the roots extend far and fast from the parent plant. Actively seeding with desirable native plants once an infestation is controlled or in newly disturbed areas is an important part of eliminating reed canarygrass from the site. *Ceutorhyncus litura* is a weevil currently used as a biocontrol agent in Colorado although it must be combined with other methods to be successful (Beck 2003). Because of its extensive root system, the key to successful control lies in depleting the plant's carbohydrate reserves. In general, the root carbohydrate reserves are lowest in the spring and

summer when the plant is fully leafed out and its energy is up in its photosynthesizing leaves, buds or flowers. In the fall after flowering and seed set, the plant begins to pull its carbohydrate reserves back down into its roots. This has implications for the best time to cut or apply herbicides to Canada thistle.

Mechanical

Cutting/Mowing

Although mowing may temporarily reduce the above-ground biomass and remove buds prior to flowering and seed set, research shows a high mowing intensity necessary to kill Canada thistle. Mowing has been shown to kill Canada thistle only when repeated at 7-28 day intervals for up to 4 years (Nuzzo 1997). Another study showed that mowing alone is not effective unless conducted at 1-month intervals over several growing seasons (Beck 2003). Mowing two to three times per year can prevent seed set. To prevent production of viable seeds, mowing must occur before the flowers have opened (ideally) or within a day or 2 of opening. The goal is to remove the flower prior to pollination. Flowers that have been open for 8-10 days can develop viable seeds (Nuzzo 1997). Hunter et al. (1985) found that when the main stem is removed, rootbuds are stimulated to produce new shoots. They recommend leaving >20 cm of bare stem tissue or >9 leaves per stem when mowing since mature Canada thistle leaves and stems inhibit the development of shoots from rootbuds. While cutting flowering stems may deplete a plant's energy reserves, care should be taken in order to not disturb the root system (as pulling may do), since this may trigger the growth of additional stems. Mowing can also be an effective tool if combined with herbicide treatments.

Burning

The success of fire as a tool to control Canada thistle depends on the season, soil moisture, and location. Dormant season burning can reduce the abundance of Canada thistle by stimulating the growth of native herbaceous vegetation. Fires during the growing season may reduce thistle density but may also harm native species. In one study on a mesic site in Oregon, dormant season fire reduced flowerhead and seed production but stimulated the production of shoots (Nuzzo 1997). No research was found that supported the use of fire as a primary control method for Canada thistle.

Chemical

Herbicides alone may effectively control Canada thistle. The effectiveness of an herbicide is dependent upon the plant's growth stage, ecotype and genotype. Since an herbicide that is effective on one clone may not be effective on another, it is important to vary herbicides to prevent clones tolerant of one herbicide from becoming dominant. The entire clone must be treated. Two or more applications give better control than a single application (Nuzzo 1997).

Fall is the best time to treat with herbicides. Since the plant begins to pull its carbohydrate reserves back down into its roots in the fall after flowering and seed set, most experts agree that herbicide treatment is most effective in getting down to its roots when applied in the fall. If applied during the growing season, herbicide will kill the green above-ground part of the plant, but the chemical will not be translocated down to its root system. One study found control was improved by cutting the stems in late July followed by treating the new, young, resprouted stems with glyphosate approximately 4 weeks later in late August.

The second best time to treat Canada thistle is in the flower-bud stage when root reserves are the lowest. Tworkoski (1992) discusses the reasoning behind spring and fall herbicide applications. In the spring, young plants are more susceptible to herbicides but the roots systems are larger and more difficult to kill in the spring before the flower stalk emerges. In the

fall, older plants have a thicker cuticle and are less susceptible to chemicals but the root system is depleted and smaller and assimilates are naturally moving from the leaf tissue down to the root system. Short days and low temperatures enhance herbicide and other assimilate movement to the roots.

Herbicide effect is enhanced when the roots are weakened during the growing season by either mowing or herbicide treatment and when new shoots are stimulated to grow. Suitable herbicides should be applied to new green leaves (September or October) rather than to old leaves that have a thick cuticle that limits absorption (Nuzzo 1997).

A number of herbicides can effectively control Canada thistle including glyphosate and clopyralid (OSU 2007). A non-selective glyphosate approved for aquatic use such as Rodeo can be broadcast sprayed with a backpack sprayer or applied with a dripless wick applicator for more selective application if desirable broadleaved plants are nearby. Research at Colorado State University shows that Transline (clopyralid), among others, is effective against Canada thistle, especially when combined with mechanical control and successful establishment of grasses that can compete well with it. Transline is effective when applied in spring after all Canada thistle plants have emerged. Apply Transline (2/3 to 1 pt/A) when Canada thistle is in the rosette to bud growth stages. Transline at 1 pt/A also is effective when applied in fall (Beck 2003). Other chemicals the Pacific Northwest Weed Management Handbook identifies as effective on Canada thistle include amitrole (Amitrol), chlorsulfuron (Telar), sodium chlorate, sodium borate, dicamba (Banvel or Clarity), Picloram (Tordon), clopyralid + 2, 4-D amine (Curtail), triclopyr +clopyralid (Redeem R&P), aminopyralid (Milestone) and diflufensopyr + dicamba (Overdrive) (OSU 2007).

Herbicides in combination with cutting or mowing may be an effective strategy for controlling the plant. The most effective control strategy in Canada is referred to as the “August rosette method”, tilling until mid- to late-July, applying herbicide in mid-August, and tilling again in 3 weeks (Nuzzo 1997). Researchers at Colorado State University found that repeat mowings at about 1 month intervals, beginning when the plants are 12 to 15 inches tall, followed by application of Curtail in October or 1 month after the third mowing, repeated for 2 consecutive years, controlled the plant (Beck 2003). Another study found that mowing one, two or three times before autumn applications of the herbicides picloram (Tordon), chlorsulfuron (Telar), clopyralid+2,4-D (Curtail) or dicamba (Banvel) provided inconsistent results and the authors conclude that such a combination should not be commonly recommended (Beck and Sebastian 2000).

Control Recommendations

The treatment options chosen depend on the ability to use herbicides and on available resources. Persistence is the key to controlling Canada thistle so that the plant is continually stressed, forcing it to exhaust root nutrient stores and eventually die (Beck 2003). Each method requires follow-up monitoring and treatment to ensure long-term success.

1. In the spring and early summer, kill bolting plants when they are in late bud stage by spot spraying with herbicide. Spot treat with herbicide in the fall, when herbicide absorption is enhanced.
2. In the spring and early summer, kill bolting plants when they are in late bud stage by cutting. Although cutting bolting plants may initiate new root buds and shoots, root reserves are lowest at this time. Repeat cuttings at least every month throughout the growing season. If possible, follow up in fall with herbicide.

Cirsium vulgare **Bull thistle**

Priority: High
Bull thistle occurs in relatively small infestations along the road edge at the west end of the Phase 1 area and along the berm between the wetland and river.

Description, Biology and Ecology
Bull thistle is a biennial plant that reproduces only by seed. It is a true biennial in that it produces a spiny basal rosette of leaves in the first year and a many-branched flowering stem in the second year and then dies. Its leaves are hairy above, cottony below, and sharply winged (Whitson 2004). Flowering occurs between July and October. Flowers are purple, 1 ½ to 2 inches in diameter, and clustered at the ends of the branches (OSU Extension Service 2006). Plants may produce up to 5000 wind-dispersed seeds of which less than 1% may remain viable for up to 5 years. Although bull thistle is a highly competitive weed that is favored by disturbance, its life history lends itself to being fairly self-limiting, especially if seed production is controlled.

Overview of Control Options
Since bull thistle is a biennial, a control strategy that emphasizes removing flowering stems before they flower can be an effective means of eliminating the plant and exhausting the seed bank. Possible control options to eliminate established plants include cutting and digging, burning, and herbicide treatment. No information specifically on mowing bull thistle was found, although mowing serves the same function as cutting, described below.

Mechanical
Cutting and Digging
Bull thistle can be easily killed by digging up or breaking the taproot. In the first year rosette stage, the roots can be dug up. In the second year of growth, flowering stems can be cut prior to seed production. If the flowers on the bolted stem have not opened, they can be left on the ground without risk of seed maturation. If the flowers have opened, they should be removed from the site. Opened flowers may have been pollinated and seed maturation can occur after cutting.

Burning
Burning has been shown to kill bull thistle provided the fire is hot enough to kill the stem and flowering buds. Fall burns may kill rosettes, although the heat may promote seed dispersal of mature plants.

Chemical
Bull thistle is also easily killed with chemicals while in the rosette stage in the spring.
The Pacific Northwest 2007 Weed Management Handbook (OSU 2007) suggests eleven different herbicides that have been effectively used on bull thistle, including 2,4-D, dicamba (Banvel or Clarity), picloram (Tordon), chlorsulfuron (Telar), metsulfuron (Escort or Cimarron), 2,4-D amine (Curtail), clopyralid (Stinger or Transline), triclopyr + clopyralid (Redeem R&P), aminopyralid (Milestone), glyphosate + 2,4-D (Campaign), and diflyfensopyr + dicamba (Overdrive). Most should be applied to actively growing plants up to the bud stage and some are appropriate to apply in the fall to control rosettes as well. Recommended timing and application rates vary with the chemical (OSU 2007).

Control Recommendations

Treatment recommendations are listed in order of preference below. The treatment options chosen depend on the ability to use herbicides and on available resources. Each method requires follow-up monitoring and treatment to ensure long-term success.

1. Cut or dig plants prior to seed production;
2. Treat plants with herbicide in the spring and fall.

Conium maculatum poison hemlock

Priority: High
Poison hemlock can quickly colonize newly disturbed sites, especially in moist habitats and along streams, displacing native species and degrading habitat quality (Pitcher 1989). Poison hemlock occurs in relatively small infestations along the road at the west end of the Crooked River site.

Description, Biology and Ecology
Poison hemlock is a biennial or sometimes a perennial plant in the parsley family (Apiaceae) that is native to Europe, western Asia, and North Africa. During the first year, the plant forms a large rosette and usually remains in the vegetative stage of growth. The plant produces tall stems then flowers during the second year (Pokorny and Sheley 2000). It was brought to the United States as a garden plant (Pitcher 1989). It tends to grow 6-8 feet tall. Stems are branched, spotted with purple and have distinct ridges. Leaves are shiny green and fern-like (pinnately divided 3 or 4 times). The white flowers are borne in clusters at the tips of the branches. Poison hemlock tolerates poorly-drained soils and is often found along streams, ditches and wetlands. All parts of the plant are poisonous, containing at least five distinct alkaloids (Pitcher 1989, Whitson 2004).

As a biennial, poison hemlock reproduces by seed. Flowering stems persist through the winter after seed set, dispersing seeds throughout the winter months. Up to 85% of dispersed seeds germinate once environmental conditions are suitable. Seeds remain viable for just 3 years. Seeds germinate whenever temperature and moisture conditions are suitable, generally from late summer to early spring (Pokorny and Sheley 2000). Although poison hemlock is a highly competitive weed that is favored by disturbance, its life history lends itself to being fairly self-limiting, especially if seed production is controlled.

Overview of Control Options
Since poison hemlock is a biennial, a control strategy that emphasizes removing flowering stems before they flower can be an effective means of eliminating the plant and exhausting the seed bank. Mechanical or chemical control can be relatively easy (Pitcher 1989). Possible control options to eliminate established plants include hand pulling and digging, mowing, and herbicide treatment. Small and new infestations of poison hemlock can be eradicated by digging or spot spraying (Pokorny and Sheley 2000). No information on burning was found. No biological control agent has been approved to control poison hemlock (ODA 2007).

Mechanical
Hand Pulling and Digging
Poison hemlock can be easily killed by digging up or breaking the taproot. In the first year rosette stage, the roots can be dug up. In the second year of growth, flowering stems can be cut prior to seed production. Hand pulling is an effective control strategy for small infestations and is easiest in wet soils. The plants remain toxic for several years after being pulled (Pitcher 1989).

Mowing
Poison hemlock can eventually be killed by mowing multiple times close to the ground. Repeated mowings will serve the function of removing bolting plant material, reducing its competitive ability by depleting its carbohydrate reserves, and preventing seed production (Pokorny and Sheley 2000). New growth will often be produced from the base of the plant, requiring subsequent mowings (Pitcher 1989). For this reason, pulling, digging, or herbicide treatment are more effective control strategies.

Chemical
Chemical treatment of poison hemlock is simpler and less labor intensive than hand-pulling, digging, or mowing. Pitcher (1989) reports that poison hemlock can be easily controlled with 2,4-D, and less effectively with Dicamba (Banvel). A more recent recommendation from the Pacific Northwest Weed Management Handbook (OSU 2007) suggests three herbicides: 2,4-D, glyphosate, and metsulfuron (Escort or Cimarron). The first, 2, 4-D, is most effective on newly emerging plants in seedling to rosette stage of growth, applied with a wetting agent at 1.5 lb ae/A (OSU 2007; Pokorny and Sheley 2000). Glyphosate is also most effective on actively growing plants before they bolt (0.75 lb ae/A). Aquatic-approved glyphosate (Rodeo) should be used near water. Metsulfuron should be applied to actively growing plants with a nonionic surfactant or silicone surfactant at 0.6 oz ai/A (1 oz product/A). Pokorny and Sheley (2000) report good results with Escort when sprayed in the early spring or late fall but warn that it should not be sprayed within 20 feet of water. Glyphosate and 2,4-D usually require yearly applications while Escort should be applied only every 2-4 years.

Excellent pre-emergent control has been found with tebuthiuron, sulfonylurea, chlorsulfuron (Glean FC), and a combination of chlorsulfuron and metsulfuron (Escort). If used to control the emergence of poison hemlock sprouts from seed, herbicide should be sprayed when other plants are dormant (Pokorny and Sheley 2000).

Control Recommendations
Treatment recommendations are listed in order of preference below. The treatment options chosen depend on the ability to use herbicides and on available resources. Each method requires follow-up monitoring and treatment to ensure long-term success.

1. Pull or dig plants prior to seed production;
2. Spot spray young plants with herbicide.

Euphorbia esula leafy spurge

Priority: High
Leafy spurge is a long-lived, aggressive perennial weed that tends to displace native vegetation. It is extremely invasive because it produces a large number of seeds and has the capacity to produce large numbers of underground shoot buds that can each produce a new shoot. Its extensive roots have vast nutrient stores that help the plant recover from control attempts (Beck 2007). Once established, leafy spurge spreads rapidly, crowding out desirable native species. If left unchecked, leafy spurge can completely displace native forbs and grasses in a few years (Eckardt, 1996). Leafy spurge occurs along the berm between the Phase 1 wetland and the Crooked River, in the northeast part of Phase 2, and along the road edge at the east end of the site.

Description, Biology and Ecology
Leafy spurge is an aggressive perennial forb, up to 3 feet tall, in the Euphorbiaceae family. Plants contain a milky juice. It reproduces both by seed and vegetatively from an extensive root system, making control difficult (Whitson 2004). Leaves are bluish-green with smooth margins, 0.25 inch to 0.5 inch wide, and 1 inch to 4 inches long (Beck 2007). Flowers are small, yellowish-green, and subtended by a pair of heart-shaped yellowish bracts. Roots have many pink buds that can produce new roots or shoots (Whitson 2004). Leafy spurge grows in a wide range of habitats, from rich damp soils to very dry and nutrient poor soils. Leafy spurge is native to central and eastern Europe and was likely introduced to North America with shiploads of oats, as a seed impurity, to Minnesota in about 1827.

Seed germination usually occurs in late May to early June and seedlings appear reddish due to the presence of anthocyanins. Seeds have a high germination rate of 60-80% and are viable for 5-8 years, although 99% of germination occurs within the first 2 years. Seedlings generally die, while their underground parts persist and produce adventitious buds. An adventitious shoot that will mature and produce flowers and seeds is produced from the bud. Stems usually do not flower the first year. Flowers form between June and the end of July, with seeds maturing over a 4-6 week period from mid- to late July and into August. Seed yield can be very high. In Saskatchewan, leafy spurge patches were found to produce between 24 and 3400 pounds of seed per acre. As the seed capsule dries, seeds explode sometime over 4 meters from the parent plant (Eckardt 1996).

Besides prolific seed production, leafy spurge's ability to spread rapidly by vegetative reproduction makes it difficult to control. A crown develops just below the soil surface that produces many buds that then produce stems. The crown also produces roots. Vegetative reproduction occurs from both crown buds and root buds that overwinter and produce new seedlings in the spring. The root system can give rise to shoots anywhere along its length. Roots have been documented over 15 feet. While the upper portion of the plant may be killed with herbicides, deep roots or detached roots will continue to produce new shoots. Leafy spurge is apparently particularly aggressive on drier sites (Eckardt 1996).

Overview of Control Options
Control of leafy spurge is very difficult. Any control program, including herbicides, must be long term. If infestations are limited and caught early, 100% eradication may be possible. The key to control leafy spurge or any creeping perennial is to exhaust the root nutrient stores (Beck 2007). Rapid re-establishment of dense stands will sometimes occur after seemingly successful control efforts due to the extensive root system that persists for many years. Chemical control is the best method for eliminating leafy spurge. Repeated cutting or mowing and fire have been

effective when used with herbicides. Fifteen different insects (including six different *Aphthona* flea beetles) have been tested, approved and released for biological control of leafy spurge. Significant success at controlling leafy spurge, however, has been achieved by only two flea beetles: *A. nigriscutis* and *A. lacertosa* (USDA APHIS 2007). Documentation of control efforts used will help guide future decisions on the most effective strategies.

Mechanical

Digging

Digging leafy spurge is not recommended. Because the roots can grow quite deep, shallow removal of the plant has been found to cause a net increase in the number of stems (Eckardt 1996).

Cutting/Mowing

Mowing leafy spurge as the sole control strategy is not effective and usually not practical (OSU 2007). Repeated mowing or hand cutting can be used in conjunction with herbicide applications, although no information was found that suggests this is the best strategy to control leafy spurge. Since the plant resprouts quickly, mowing would likely reduce the competitive ability of other species in the area. Since mowing stimulates growth, repeated mowing during a single season would be required for this to be an effective strategy. Without herbicides, mowing alone will not reduce leafy spurge abundance in a patch (Eckardt 1996).

Burning

Fire used alone can eliminate the tops and seeds of leafy spurge but established plants would quickly resprout (Eckardt 1996). Fire used in conjunction with herbicides has been shown to be effective and some believe gives better control than herbicides alone. There seems to be reasoning behind and different opinions on burning first or spraying first. Burning in May followed by herbicide application in June before seed set is one strategy. Burning first helps produce a uniform dense stand for easier herbicide application. Bjugstad (1987, reported in Eckardt 1996) conducted burning and herbicide tests on leafy spurge in South Dakota with good results. He found that leafy spurge burns well due to its high oil content, but even better *after* herbicide treatment. Plots were sprayed with a mix of 2,4-D and Picloram in September 1984, burned the following April, sprayed again in June, and burned again in October 1985. Results showed reduced seed viability by 10% and reduced seedling development. Two years later, the burned and sprayed plots were free of leafy spurge within a larger landscape dominated by the plant. Burning helps stimulate vegetative production and a uniform stand of leafy spurge ideal for herbicide application (Eckardt 1996). Another study suggests that the timing of burning is not critical, although burning 3-4 weeks before herbicide application worked best.

Chemical

Chemical control is the best method for eliminating leafy spurge. A number of chemicals have been used to control leafy spurge including Picloram, glyphosate, Imazapic (Plateau), 2,4-D, dicamba, amitrole, 2,4-D LV ester, fosamine, and glyphosate + 2,4-D (Eckardt 1996; OSU 2007). Herbicides should be applied around the perimeter of an infestation to prevent spread (USDA APHIS 2007). Picloram or 2-3 applications of glyphosate are recommended for starters, followed by establishing a competitive grass community and using 2,4-D to prevent seed production (OSU 2007). Kev Alexanian, Crook County Weed Master, recommends using aquatic glyphosate if near water and waiting until June to spray when the showy bracts are visible (Alexanian personal comm.).

Picloram is considered the most effective herbicide to treat leafy spurge. However, Picloram is expensive and most formulations are restricted use herbicides (pose known health risks) and

can contaminate water. Picloram can be applied any time during the growing season and usually requires additional treatments for several years to control seedlings. A series of applications at a rate of 0.5 lb ae/A are recommended where applied near water (OSU, 2007). Two applications in one season of Picloram has proven to be the most effective (one in mid- to late June during seed development and one in late September during fall regrowth) (Eckardt 1996).

Glyphosate is better to use near water or when reseeding of grasses is planned. Glyphosate applications prevent vegetative growth the year of application and will prevent seed production the second year. Glyphosate is most effective when applied sequentially at 1 month intervals. Recommendations for glyphosate are to apply it every 30 days at 0.38 lb ae/A (1 pint) rate, applying 1 pint near June 1, July 1, and August 1, or to apply it at 0.75 lb ae/A (2 pints) rate, applying 2 pints of glyphosate near June 1 and July 2 (OSU, 2007). Leafy spurge may recover from these treatments. A fall application of 2,4-D (2.0 quart/A) in September can control regrowth. A dormant planting of perennial grasses can then be seeded in late fall (Beck 2007).

Imazapic, 2,4-D, and dicamba have all effectively controlled leafy spurge. Imazapic (Plateau) can be applied in late summer or fall (mid-August through October) before the plant loses its milky sap from drought or a killing frost (rate: 0.125 to 0.188 lb ai/A; Add 1 qt/A methylated seed oil) (Beck 2007). Team Leafy Spurge reports that Plateau should be applied in mid-September for best results (USDA APHIS 2007).

Biannual applications of 2,4-D have been shown to prevent seed production and spread, but not reduce the original infestation area. In one study, low rates of Picloram with 2,4-D in repeated treatments gave the best long-term control of leafy spurge. Picloram + 2,4-D is a less expensive and very effective treatment (0.25 lb/acre Picloram mixed with 1 lb/acre 2,4-D) when applied once a year in the spring.

Dicamba has shown some success but is expensive. It has a short soil residual and a corresponding low threat to returning desirable forbs. Dicamba and 2,4-D are best applied in mid- to late June during seed development and in late September during fall regrowth (Eckardt 1996).

For additional information on rates and timing of the other herbicides mentioned, refer to OSU and Eckardt (OSU 2007, Eckardt 1996).

Biological Control

Biological control of leafy spurge can be combined with herbicide treatments for an effective long-term management strategy. Fifteen different insects (including six different Aphthona flea beetles) have been tested, approved and released for biological control of leafy spurge. However, significant success has been achieved by only two flea beetles: *A. nigriscutis* and *A. lacertosa*. Biocontrol agents usually take several years to successfully establish a population and begin making a significant contribution to leafy spurge management. A biocontrol agent that works well in one soil type may not work at all in another and more than one type of biocontrol agent may have to be used to achieve uniform control across a variety of different situations and land types (USDA APHIS, 2007). If pursuing the release of a biocontrol agent on the site is desirable, USDA APHIS should be consulted.

Control Recommendations

Treatment recommendations are listed in order of preference below. The treatment options chosen depend on the ability to use herbicides and on available resources. Each method requires follow-up monitoring and treatment to ensure long-term success.

1. Apply herbicides during the growing season (timing dependent on chemicals used);
2. Burn in spring or fall, followed by herbicide application.

Kochia scoparia **Kochia**

Priority: High
Kochia is an invasive annual species that successfully outcompetes native vegetation, especially along roadsides where it thrives. It displaces native vegetation, forms dense monocultures, and diminished biological and habitat diversity. The invasion of kochia is promoted by disturbance. Kochia occurs primarily along the road edge of the site.

Description, Biology and Ecology
Kochia scoparia, also known as Bassia scoparia, is an introduced annual species that can reach 6-8 feet in height. As an annual, Kochia reproduces only by seed, not vegetatively. Kochia is an escaped ornamental that is native to Asia and was introduced from Europe (Whitson 2004). Kochia has been promoted and used as forage for sheep and cattle even though cattle occasionally die from grazing solid kochia stands due to its toxic compounds (nitrates, saponins, oxalates, and alkaloids). These allelopathic compounds inhibit growth of soybeans and sorghum and possibly other plants (Pacific Northwest Extension 1993a). Its stems are branched, round, usually soft-hairy and often have light and green, or green and red lengthwise stripes (Whitson 2004). The whole plant often takes on a reddish tint in the autumn. Leaves are alternate, lance-shaped, ½ to 2 inches long and 1/8-1/2 inch wide with hairy margins and 3-5 prominent veins. The lower surface of the leaf is often covered in soft hairs.

Seedlings emerge in early spring and are frost tolerant. The plant can germinate in temperatures as low as 40 degrees F (Pacific Northwest Extension 1993a). Flowering and seed production occur between July and a killing frost. Flowers form short dense spikes in the leaf axils and one plant may produce 50,000 seeds. One study reported Kochia produced 230,000 seeds per square foot of soil (Pacific Northwest Extension 1993a). Kochia fruit have 5 papery bracts on the edges, distinguished from the 5 curved spines on the fruit edges of fivehook bassia (Bassia hyssopifolia). Kochia seeds are viable for only 1-2 years. The plant breaks off at the base at maturity, scattering seeds as the plant tumbles in the wind.

Kochia is a drought tolerant plant with an extensive root system and a high water use efficiency. Roots of a 5 ½ foot tall plant can extend 6 feet deep and 11 feet laterally from the plant. Kochia also flourishes in irrigated fields (Pacific Northwest Extension 1993a).

Overview of Control Options
Since Kochia is an annual, a control strategy that emphasizes removing flowering stems before they flower can be an effective means of eliminating the plant and exhausting the seed bank. Kochia can be controlled by pulling, mowing and herbicide treatment. No information on the use of fire as a control strategy was found.

Mechanical
Pulling and Mowing
The best time to pull or mow the plant is just prior to flowering. Since new branches and flowers can emerge from the remaining stem, Kochia may need to be mowed 3-4 times throughout a growing season. Mowing immediately prior to seeding desirable competitive grasses will help open up the area to light and help the seeded species become established.

Chemical

Young seedlings have been effectively killed with herbicides. The best time to spray is in early spring as the young plants are just emerging from the ground and before they bolt.
Little information was found regarding the best chemicals to use on kochia. The Pacific Northwest 2007 Weed Management Handbook refers to several herbicides to treat annuals including but not limited to glyphosate, imazapic (Plateau), sulfometron (Oust), dicamba, and 2, 4-D, and 2,4-D amine (OSU 2007).

An assessment of herbicide effectiveness east of the Cascades on annual weeds in wheat found ten herbicides or combinations of herbicides to produce excellent results controlling kochia, including metribuzin (Sencor, Lexone), thifensulfuron + tribenuron (Harmony Extra), tribenuron (Express), dicamba + 2,4-D, bromoxynil + dicamba, bromoxynil + MCPA, bromoxynil + MCPA + dicamba, metribuzin + bromoxynil, metribuzin + chlorsulfuron, and dicamba + chlorsulfuron (OSU 2007). Kochia has been found to be resistant to sulfonylurea herbicides (Glean, Amber, Ally, and other Group 2 inhibitors) (OSU 2007).

Control Recommendations
Treatment recommendations are listed in order of preference below. The treatment options chosen depend on the ability to use herbicides and on available resources. Each method requires follow-up monitoring and treatment to ensure long-term success.

1. Pull or mow infestations repeatedly to eliminate plants, prevent seed production, and exhaust the seed bank.
2. Treat seedlings with herbicide in spring.

Onopordum acanthium **Scotch thistle**

Priority: High
Scotch thistle is an aggressive biennial plant that can form dense stands that compete with native vegetation, limiting diversity (OSU Extension Service 2006). It is found along the road on the Crooked River site.

Description, Biology and Ecology
Scotch thistle is a biennial plant that reproduces only by seed. It forms a large rosette of leaves up to 2 feet in diameter in the first year. It can grow up to 12 feet tall and has broad spiny wings along the length of the stem. Leaves appear grayish due to a covering of fine dense hairs. The upper leaves are alternate and broadly lobed, whereas the basal leaves are very large, up to 2 feet long and 1 foot wide. Flower heads are purple to reddish, 1-2 inches in diameter, occur at the tips of branches, and have spine-tipped bracts. They are produced in the second year of growth (Whitson 2004). As a member of the Asteraceae family, scotch thistle produces many wind-dispersed seeds per flower head. Scotch thistle is native of Europe and eastern Asia.

Overview of Control Options
Since scotch thistle is a biennial, a control strategy that emphasizes removing flowering stems before they flower can be an effective means of eliminating the plant and exhausting the seed bank. Possible control options to eliminate established plants include cutting, digging and herbicide treatment. No information on mowing or burning scotch thistle was found, although mowing serves the same function as cutting, described below.

Mechanical
Cutting and Digging
Scotch thistle can be easily killed by digging up or breaking the taproot. In the first year rosette stage, the roots can be dug up. In the second year of growth, flowering stems can be cut prior to seed production. If the flowers on the bolted stem have not opened, they can be left on the ground without risk of seed maturation. If the flowers have opened, they should be removed from the site. Opened flowers may have been pollinated and seed maturation can occur after cutting.

Chemical
Scotch thistle is also easily killed with chemicals while in the rosette stage in the spring. The Pacific Northwest 2007 Weed Management Handbook (OSU 2007) suggests eleven different herbicides that have been effectively used on scotch thistle, including 2,4-D, dicamba (Banvel or Clarity), picloram (Tordon), chlorsulfuron (Telar), metsulfuron (Escort or Cimarron), 2,4-D amine (Curtail), clopyralid (Stinger or Transline), triclopyr + clopyralid (Redeem R&P), aminopyralid (Milestone), glyphosate + 2,4-D (Campaign), and diflyfensopyr + dicamba (Overdrive). Most should be applied to actively growing plants up to the bud stage and some are appropriate to apply in the fall to control rosettes as well. Recommended timing and application rates vary with the chemical (OSU 2007).

Control Recommendations
Treatment recommendations are listed in order of preference below. The treatment options chosen depend on the ability to use herbicides and on available resources. Each method requires follow-up monitoring and treatment to ensure long-term success.
1. Cut or dig plants prior to seed production;
2. Treat plants with herbicide in the spring and fall.

Phalaris arundinacea **Reed canarygrass**

Priority: High
Reed canarygrass is an aggressive perennial grass species that poses a serious threat in wet meadows, wetlands, floodplains, and other wet habitats (Lyons 1998b). As it invades wetland and riparian areas, it rapidly displaces native plant species, easily forms monocultures, and limits biological and habitat diversity. The invasion of reed canarygrass is promoted by disturbance. The plant also evapotranspirates large quantities of soil moisture, potentially affecting shallow groundwater levels (Antieau 1998). It is abundant along the banks of the Crooked River in the immediate vicinity and upstream of the Crooked River Wetland Mitigation Bank.

Description, Biology and Ecology
Reed canarygrass is a large sod-forming perennial grass, 0.6-2.0 m tall, that produces stems from stout creeping rhizomes (Lyons, 1998b). The wide green leaves of reed canarygrass have a bluish-gray hue and spread out at 45 degrees to the swollen stem nodes. The clasping auricles surround the stem at the top of the sheath. Flowers and seeds occur in densely-packed spike-like panicles. Reed canarygrass can be found in disturbed wet areas such as wetlands, roadside ditches, around ponds, lakes, and streams where water levels fluctuate (Guard 1995).

There is debate as to whether *Phalaris arundinacea* is native to North America. Several authors view it as native to North America (Lyons 1998b, USDA no date, Antieau 1998). Others consider it introduced from Eurasia (Hitchcock and Cronquist 1996, Guard 1995). Although reed canarygrass was collected in the inland Pacific Northwest in the mid-1800's, suggesting it is native to the region, it was also planted as a productive forage crop on wet sites (Antieau 1998, USDA 2002a). The invasive character of some populations may be the result of agronomic breeding for drought tolerance and vigor (Merigliano & Lesica 1998). The invasive populations of reed canarygrass are thought to be an aggressive, non-native cultivar introduced for erosion control and wetland forage (Guard, 1995) or the vigorous crosses between cultivated varieties and native strains (Lyons 1998b). Reed canarygrass was planted in Oregon as early as 1918 for pasture and erosion control (TNC 2004).

Understanding the growth and reproduction of reed canarygrass is important for determining the efficacy of control measures. The plant easily outcompetes other species due in part to its tolerance of freezing temperatures and its early spring growth. In the Pacific Northwest, it is one of the earliest grasses to begin growing in the early spring (Antieau 1998). Vegetative growth peaks in mid-June, with flowering from June to August. The plant has two periods of growth, one prior to seed maturation and one after (Lyons 1998b). Since nitrogen has been found to greatly benefit the growth of reed canarygrass, limiting nitrogen inputs may help reduce the vigor of some stands (Antieau 1998).

The primary means of reproduction for reed canarygrass is vegetative. Laboratory studies using mature roots have shown that 74% of new shoots originate from rhizomes and the remainder from axillary buds on basal nodes (Apfelbaum 1987). It forms dense, productive monocultures that spread radially from rhizomes. When its culms are cut, additional culms form from axillary buds in the rhizome, and broken rhizomes are capable of sprouting into additional culms, making mechanical control difficult.

Reed canary grass is an obligate out-crosser, requiring cross pollination to set seed. Each inflorescence can produce approximately 600 seeds (TNC 2004). While it does produce viable seed, germination is thought to be slow and irregular, with low germination rates in dense

shade. Seeds apparently have no known dormancy requirements and can therefore germinate immediately upon ripening. Seeds may be viable for 5-7 years. The plant grows vertically for 5-7 weeks after germination, and then spreads laterally via rhizomes (Antieau 1998). This delay in horizontal spread of the root system may limit its early competitive ability against other rhizomatous grass species and chemical treatment. Seedlings lack vigor and are very sensitive to competition (USDA 2002b).

Overview of Control Options

There appears to be no definitive strategy for controlling reed canarygrass. A combination of strategies employed over several years may be the most successful way to control the plant. Most methods are effective at controlling the spread or reducing the density of the plant, but it is very difficult to eradicate the grass. The literature contains a wide range of variability in success with different combinations of methods, and success appears to be somewhat site-specific. Careful documentation of control efforts used will help guide future decisions on the most effective control strategies. Possible control efforts include digging up the entire plant and root system, cutting or mowing, solarization (covering plants with clear or black plastic), shading (competitive exclusion), disking, grazing, burning, flooding, and herbicide treatment. On the Crooked River site, practical control efforts are limited to digging (where appropriate), mowing, solarization, burning, and herbicide treatment. Actively seeding with desirable native plants once an infestation is controlled or in newly disturbed areas is an important part of eliminating reed canarygrass from the site.

Mechanical

Digging

Removal by digging is recommended only if and where infestations are limited to individual plants or very small clumps. Digging is the most labor intensive of the proposed treatment methods. Rhizomes break off easily when dug and can inadvertently be left behind in the soil. Digging is easiest in moist soil. It is necessary to remove all rhizomes and the sites must be monitored regularly for new vegetative growth emerging from remaining rhizomes. Plants that are pulled must be removed from the site and killed before being disposed of or they may become established at the dump site. One possibility is to cover removed plants with plastic and solarize them (described below).

Cutting/Mowing

Cutting or mowing can be used to reduce the vigor and seed production of reed canarygrass but used by itself it will not kill the plant. Mowing stresses plants, especially when done repeatedly without allowing the plant to recover between cuttings. Stress is manifested as reduced vigor, reduced flowering and seed set, and stand thinning. If sufficiently stressed, stands may thin enough to allow the establishment of other native species (Antieau 1998). The best time to cut the plant is just prior to flowering since at this time carbohydrate reserves are the lowest in the rhizome system and this will prevent seed production. One study found that mowing 2 times per year for 4 years removed seedheads before maturation and opened up the area to light, increasing the density and cover of native species (Brown 1997). In another study, cutting was shown to effectively control reed canarygrass when done at least five times in one growing season (Lyons 1998b). TNC (2004) reports that if mowed only once or twice a year stem production may be stimulated but that continued mowing 5 or more times per year for 5-10 years has been shown to effectively control reed canarygrass infestations.

Reed canarygrass has been successfully controlled by mowing used in combination with herbicide application (TNC, 2004). One strategy is to mow reed canarygrass for multiple years to eliminate the seed bank, followed by herbicide application after a final mow.

Solarization

Solarization entails covering an infestation with thick clear or black plastic. Solarization is appropriate to use where reed canarygrass grows in patches as a monoculture. The plants are typically first cut to within a couple inches of the ground. To be successful the plastic ought to remain on the plants for over 1 year (two growing seasons) (TNC 2004). The heat generated under the "greenhouse" of the plastic is intended to be hot enough to bake and kill the plants and rhizomes. To be effective, plants must not grow beyond the edge of the plastic in order to limit the amount of carbohydrates provided to the root system. Following successful control with plastic, the area should be revegetated and seeded with local, native species.

Some researchers have found solarization to not be effective, even after 2 years under cover (Lyons 1998b). In an Illinois nature preserve, plants were clipped to ground level and covered with opaque black plastic for two growing seasons. Although the project reduced the size of the populations, the species persisted (Apfelbaum 1987). One drawback to using plastic is the labor involved in placing it and the regular follow up required to ensure no plants are growing beyond its edges. It is also an eyesore. The ground underneath the plastic gets so hot that the soil may get sterilized. Once the plastic is removed, the site needs to be reseeded immediately. Additions of mycorrhizal fungus may help revitalize the life in the soil.

Burning

Fire has been reported to be an effective treatment for reed canarygrass. It is particularly effective if there is a healthy native seed bank. Late spring and late autumn burns were found to be the most beneficial at controlling the plant. Early spring burns were found to accelerate its spread (Lyons 1998b). Burning is not effective in dense monocultures where native species are absent, as the plant tends to re-emerge. Repeated burnings can weaken established stands of reed canarygrass and prevent seed production, serving a similar purpose as cutting/mowing. Burning does not tend to kill mature reed canarygrass and can, like mowing, actually stimulate additional stem production unless the fire burns through the entire sod layer down to mineral soil (TNC 2004).

A 22-year study of burning reed canarygrass has been conducted by Rich Henderson in Wisconsin. By switching from early spring burns to late spring burns, he found a 99% reduction in seed production, a 75% decrease in vigor and stature, an increase in native species cover, and a reduction in reed canarygrass to 10-20% cover (Brown 1997).

Burning can be used in combination with herbicide treatment. Herbicide treatment prior to burning can help a prescribed fire burn hot. Burning can also be effectively used as a pre-treatment to solarization or herbicide application (TNC 2004).

Chemical

Control of reed canarygrass is difficult due to the plant's rhizomatous nature and may require herbicide treatment for several years (Lyons 1998b). Small infestations can be effectively killed with one application, while larger infestations may require several applications (TNC 2004). The use of a glyphosate product that is specifically designed for use near water is the most successful method for controlling reed canarygrass. One study of spring and fall application of glyphosate resulted in 99% effectiveness in control during the first year. In another study, glyphosate (1.1 kg/ha) controlled nearly 100% of 5 to 10 week old seedlings (Apfelbaum 1987).

A non-selective glyphosate approved for aquatic use such as Rodeo can be selectively applied to reed canarygrass. Glyphosate is a non-selective herbicide that kills or harms most species.

Generic, less expensive versions of Rodeo are also commercially available: Aquatic-approved Killz-All and Aquamaster. A 2% solution with a nonionic surfactant works well to kill reed canarygrass (TNC 2004). Label instructions should be followed with all herbicide application.

Glyphosate, sulfometuron, fluazifop, and imazapyr have all been used to treat reed canarygrass (OSU, 2007). Imazapyr should be applied when the plant is actively growing, up through the fall, at a rate of 0.5 to 1 pound ae/acre. Habitat is an aquatic-approved version of imazapyr.

The best time to spray is in the fall after the first frost when the plant will actively translocate the product to its root system and the rhizomes will be killed. Care should be taken to spray before a hard frost that causes the plant to go dormant for the year.
Spring is another ideal time to spray. A follow-up treatment in the spring targeting new young shoots and older plants that survived the fall treatment will ideally kill the plants. This spring application will also limit seed production. Herbicides may also effectively be applied in mid-summer just prior to summer dormancy (assuming one could accurately determine when this dormancy occurs) (TNC 2004).

If plants are too large to effectively spray, they can be mowed or burned, then sprayed after the plants have regrown to approximately 12 inches. Eliminating some of the above-ground biomass reduces the amount of herbicide needed and helps one obtain better herbicides coverage of the plant (TNC 2004). Another strategy is to apply herbicides, then burn or mow the vegetative growth 2-3 weeks later. The following spring, new growth is easily seen. Apfelbaum (1993) reports that prescribed fire in late spring, summer or fall 2 to 3 weeks after treatment with herbicides was an effective treatment combination.

Reed canarygrass has also been shown to be sensitive to boron. Complete tissue necrosis occurred 3 weeks after reed canarygrass leaves and roots were exposed to 300 ppm of boron (Apfelbaum 1987).

Control Recommendations
Treatment recommendations are listed in order of preference below. The treatment options chosen depend on the ability to use herbicides and on available resources. The methods listed below have been used with some success in the Pacific Northwest (TNC 2004). Each method requires follow-up monitoring and treatment to ensure long-term success.

Scattered individual plants and small infestations

1. Dig out
2. Apply herbicide (spot spray or dripless wick)
3. Spot flame with propane torch (for young seedlings)

Distinct patches within native vegetation

1. Mow or spot-burn then herbicide (spot-spray regrowth)
2. Apply herbicide (can burn 2-3 weeks later in late fall if high biomass, in order to see regrowth in the spring).
3. Mow then solarize
4. Mow prior to flowering and multiple times throughout the year for multiple years.

Salsola iberica (S. kali) **Russian thistle, tumbleweed**

Priority: High
Russian thistle is an invasive annual species that successfully outcompetes native vegetation. It spreads easily on bare soil or during drought conditions and tends to be found in disturbed areas such as roadsides, along lakes and streams, and overgrazed pastures (Morisawa 1999). Russian thistle occurs in relatively small infestations along the road edge of Phase 1.

Description, Biology and Ecology
Salsola iberica, also known as *Salsola kali*, is an introduced summer annual that reproduces by seed. Native to Russia and Siberia, Russian thistle was brought to the U.S. in contaminated flax seed (Pacific Northwest Extension, 1993b). It can grow to 3 feet tall and has branched stems with reddish stripes. Leaves are alternate, cylindrical, and succulent, 2 ½ inches long. Later leaves are short, scale-like and tipped with a stiff spine. Small flowers are borne in the leaf axils and are accompanied by a pair of spiny bracts (Whitson 2004).

Russian thistle can germinate when night temperatures are below freezing if daytime temperatures are above freezing, but frost easily kills young seedlings. Seedlings emerge in early spring in temperatures ranging from 45 to 95 degrees F. Seeds also germinate with little moisture. One plant may produce over 150,000-200,000 seeds (Morisawa 1999; Manitoba Agriculture, Food and Rural Initiatives 2006b). After maturity, the plant breaks off at the base, scattering seeds as the plant tumbles in the wind. Russian thistle seeds are only viable for ~1 year (Pacific Northwest Extension, 1993b).

Russian thistle is very drought tolerant with an extensive root system and high water use efficiency. Roots of one plant may extend 6 feet deep and over 6 feet laterally (Pacific Northwest Extension, 1993b). Russian thistle is a high user of nitrogen and this can indirectly affect the growth of desirable plant species (Manitoba Agriculture, Food and Rural Initiatives 2006b).

Overview of Control Options
Since Russian thistle is an annual, a control strategy that emphasizes removing flowering stems before they flower can be an effective means of eliminating the plant and exhausting the seed bank. The plant can be controlled by pulling, mowing or herbicide treatment. Establishing desirable perennial grasses in newly disturbed areas will help prevent Russian thistle establishment.

Mechanical
Pulling and Mowing
Pulling young plants before seed set or cutting flowers before maturity will help exhaust the seedbank. Repeated mowing may also control the plant (Morisawa, 1999). Mowing will not kill the plant, as it tends to resprouts from the cut stem (Pacific Northwest Extension, 1993b).

Chemical
A non-selective broadleaf herbicide such as glyphosate, applied before seed set, can control Russian thistle (Morisawa 1999). Russian thistle has shown a resistance to sulfonylurea herbicides (Glean, Amber, Ally, and other Group 2 inhibitors) (OSU 2007). Resistance to tranzine herbicides has also been found (Morisawa 1999).

Control Recommendations

The treatment options chosen depend on the ability to use herbicides and on available resources. Each method requires follow-up monitoring and treatment to ensure long-term success.

1. Mow infestations repeatedly to eliminate plants, prevent seed production, and exhaust the seed bank.
2. Treat seedlings with herbicide in spring.

Dipsacus sylvestris Teasel

Priority: Medium
Teasel has been found at the far western end of the site in relatively small infestations.

Description, Biology and Ecology
Teasel is an aggressive species that if allowed to proliferate, can form dense monocultures, excluding native vegetation. Teasel is a taprooted biennial or short lived perennial that grows to 6 feet tall (Whitson 2004). First year plants form a rosette with a thick taproot that may be up to 2 feet long. Stems and leaves are lined with prickles. During the second year, teasel produces a spiny head full of purple flowers. Teasel has been reported to flower from June to October, although in Central Oregon the flowering season is likely shorter. A single plant can produce more than 2000 seeds which may be viable for at least 2 years. Immature flower heads, when cut, are capable of producing viable seed. Seeds drop close to the parent plant, which dies after flowering, leaving a large area of bare ground for new seedling establishment. Teasel is native to Europe.

Overview of Control Options
Since teasel tends to act as a biennial, a control strategy that emphasizes removing flowering stems before they flower can be an effective means of eliminating the plant and exhausting the seed bank. Digging, cutting, and herbicides can effectively eliminate teasel infestations.

Mechanical
Digging and cutting
For small infestations, first year rosettes can be dug up, but much of the root must be removed to prevent resprouting. This can be accomplished on smaller rosettes by using a dandelion digger. Flowering stems can be pulled up or cut before they go to seed. Since seeds can mature on the stem after cut, any flowering or seeding heads should be removed from the site. No information on burning or mowing was found.

Chemical
For larger infestation, herbicides will kill the plants. A number of herbicides have been used to treat teasel. The Pacific Northwest Weed Management Handbook recommends 2,4-D amine, 2,4-D amine + dicamba (Banvel or Clarity), chlorsulfuron (Telar), metsulfuron (Escort or Cimarron), triclopyr + clopyralid (Redeem R&P), imazapic (Plateau), and diflufenzopyr + dicamba (Overdrive) to treat teasel (OSU 2007). Most recommend applying the herbicide to the rosette stage in fall or spring. For application rates, read the label or refer to the Pacific Northwest Weed Management Handbook (OSU, 2007).

Control Recommendations
Each treatment method listed below requires follow-up monitoring and treatment to ensure long-term success.

1. Cut flower heads prior to seed production. Remove from site if plants are flowering;
2. Dig up rosettes, including most of the root to prevent resprouting;
3. For larger infestations, apply herbicide to rosettes in spring and fall, or as directed on the label.

Lactuca serriola **prickly lettuce**

Priority: Medium
Prickly lettuce is found along the road edges on the Crooked River Wetland Mitigation Bank site.

Description, Biology and Ecology
Prickly lettuce is a biennial or winter annual in the sunflower family (Asteraceae). It has a large taproot but reproduces only by seed. Seedling leaves are lobed. Leaves on the flowering stem are alternate, clasp the stem, and are prickly along the midrib of the bottom side of the leaf. Plants flower between July and September. Flower heads are yellow, 1/8 to 1/3 inch wide and composed only of ray flowers. Each inflorescence produces 6 to 30 fruit that are wind dispersed. Prickly lettuce is native to Europe (Whitson 2004).

Overview of Control Options
Since prickly lettuce is an annual or biennial, a control strategy that emphasizes removing flowering stems before they flower can be an effective means of eliminating the plant and exhausting the seed bank. No information on control strategies for prickly lettuce was found. Given this, a strategy similar to other annual and biennial species may prove effective. Potential strategies include digging or cutting prior to seed set and use of a general broadleaf herbicide. Prickly lettuce has shown a resistance to metsulfuron, chlorsulfuron, and imazethapyrimazethapyr (OSU 2007). Weedmaster and 2,4-D will both kill young seedlings and Weedmaster is effective once the plants bolt (Alexanian, personal comm.).

Control Recommendations
Treatment recommendations are listed in order of preference below. The treatment options chosen depend on the ability to use herbicides and on available resources. Each method requires follow-up monitoring and treatment to ensure long-term success.

1. Cut or dig plants prior to seed production;
2. Treat plants with herbicide in the spring.

Melilotus alba White Sweetclover

Priority: Medium
It grows along the road edge and on hummocks in the wetland on the site.

Description, Biology and Ecology
White sweetclover is an annual or biennial plant in the legume family (Fabaceae) that easily invades open areas (Eckardt 1987). It has alternate, pinnately three-foliate leaves that are serrated for more than half the edge, starting at the tip (Whitson 2004). It grows 1-3 meters high and has white flowers rather than the yellow flowers that distinguish it from yellow sweetclover (*Melilotus officinalis*). *Melilotus sp*. are native to the Mediterranean region from central Europe to Tibet and were brought to North America as early as 1664. Sweetclovers have been used for forage crops, soil builders (nitrogen fixers), and as a nectar source for honey bees. *Melilotus sp.* have long taproots, are drought tolerant, and are adapted to a wide range of climatic conditions. White sweetclover flowers in June and July. As a biennial, it produces a vegetative shoot that grows to 10-30 cm by October, and then dies back (the taproot and crown bud overwinter). The following spring, one or more flowering shoots emerge from the buds, elongate to a meter or more, flowers, produces seed, and dies (Eckardt, 1987).

Overview of Control Options
Since white sweetclover is a biennial, a control strategy that emphasizes removing flowering stems before they flower can be an effective means of eliminating the plant and exhausting the seed bank. Hand-pulling, cutting, burning and herbicides have been used to treat it. The seeds are resistant to solarization and soil fumigation (UC, 2007). No effective biological controls that are currently feasible in natural areas are known (Cole, 1990).

Mechanical
Hand-pulling and cutting
For small patches, white sweetclover can be hand-pulled. Hand-pulling is recommended in late fall after the first- year plant root-crown buds have developed, or anytime early in the spring, before second year plants develop flower buds. Hand-pulling is effective if done when the ground is moist and most of the root can be removed.

Alternatively, first and second year stems can be cut as low to the ground as possible up to the early stage of flowering, below the lowest branch axil to reduce the chances of resprouting. Sweet clover usually does not resprout when the stems are cut close to the ground during this time (Cole 1990). One study reported success by mowing first year plants in mid-to-late August, leaving the cut tops to dry for several weeks, then burning them in mid-to-late September. Removing the above-ground biomass before the plant starts to translocate energy back into its root system in September, followed by a burn helps kill the plants (Eckardt 1987).

Burning
The best burn strategy seems to be a dormant season burn in late fall or early spring to stimulate germination, followed by a later spring burn in May to eliminate the second year plants before they set seed (Eckardt 1987). Eckardt dedicates most of the discussion of control of this species to burning, but it appears most of it is in reference to areas such as prairies in the Midwest that are dominated by *Melilotus sp*. Use of a hand-torch on smaller patches may provide the same results although no reference to this strategy was found. *Melilotus* can be difficult to burn due to its low fuel content. Mowing the first fall, followed by a spring burn was also suggested.

Chemical
Herbicides can be useful in controlling large infestations in degraded areas. A fall burn will reduce the above-ground biomass, making individual seedlings visible in the spring to be treated. While plants are very small in the cotyledon or seedling stage, a uniform coverage of 2,4-D amine can be applied, wetting the entire leaf. (Eckardt 1987, Cole 1990). A 1% solution of Mecamine (2,4-D plus Dicamba) spot sprayed on the foliage is also very effective (Cole 1990).

Control Recommendations
The treatment recommendations suggested below will vary with the size of the particular infestation to be treated and available resources. Each treatment method listed below requires follow-up monitoring and treatment to ensure long-term success.

1. Pull or cut small patches prior to flowering;
2. Burn small patches in the fall and again in the spring;
3. For larger infestations, burn in fall and apply herbicide to seedlings in the spring.

Sisymbrium loeselii Loesel tumblemustard

Priority: Medium
Several infestations of Loesel tumblemustard occur along the road edge throughout the site and on the berm between the wetland and river in Phase 1.

Description, Biology and Ecology
Loesel tumblemustard, also known as small tumbleweed mustard, is a well-established Eurasian weed that is common in Oregon, Montana and Idaho (USDA, no date). It is closely related to *Sisymbrium altissimum*, Jim Hill or tumble mustard, another European weed widespread in disturbed habitats and for which there is more information on its control. They both have siliques over 15 mm in length, however Loesel tumblemustard has thinner and longer pedicels than Jim Hill mustard, with shorter ascending siliques (long, thin pod) relative to Jim Hill's longer and spreading siliques (Hitchcock and Cronquist 1996). The plant is an annual or biennial in the mustard family (Brassicaceae). The plant flowers between June and August. Yellow, 4-parted flowers, ½ inch wide, are borne in a loose raceme (cluster). The plants often break off at ground level when mature and scatter seeds as they tumble in the wind (Whitson 2004). Allen and Knight (1984) suggest tumble mustard's success as an invasive weed is due to its effective seed dispersal, morphological plasticity in response to density stress (tumble mustard plants are short with shallow roots when crowded, but still produce numerous seeds), and earlier germination and more rapid seedling growth compared to native herbs.

Overview of Control Options
No information on the control of Loesel tumblemustard was found. Instead, the following recommendations refer to the control of Jim Hill mustard. Jim Hill mustard does not usually persist in late-seral communities and may not require special control measures. Over time, canopy closure, litter accumulation and/or growth interference from later-successional species tend to exclude tumble mustard. Since the plant is an annual or biennial and an early seral species, minimizing soil disturbance and seed dispersal while maintaining a healthy plant community is the best way to prevent establishment of tumble mustard. Treatments include hand-pulling and herbicide treatment. No research on the use of fire to control tumble mustard was found. However, given its early seral nature and positive response to increased light and open ground, fire alone is unlikely to provide control of tumble mustard (Howard 2003).

Mechanical
Hand-pulling
Small infestations can be controlled by digging or hand pulling rosettes in the fall or early spring.

Chemical
Although herbicides can be used to gain initial control of an infestation, an integrated approach that includes establishing a diverse plant community will help outcompete the plants. Ninety to ninety-nine percent control has been found with 2,4-D and MCPA. Jim Hill mustard is also susceptible to other broadleaf herbicides including bromoxynil, atrazine, and chlorsulfon (Howard 2003). Weedmaster and 2,4-D will both kill young seedlings and Weedmaster is effective once the plants bolt (Alexanian, personal comm.).

Control Recommendations

Each treatment method listed below requires follow-up monitoring and treatment to ensure long-term success.

1. Dig or hand pull rosettes in the fall or early spring.
2. Apply herbicides to rosettes in the spring or fall.

Verbascum thapsis common mullein

Priority: Medium
Very little mullein occurs in small infestations at the west end of the Crooked River Wetland Mitigation Bank.

Description, Biology and Ecology
Mullein is a tap-rooted biennial plant, reproducing only from seed. In the first year, mullein forms a large basal rosette of thick fuzzy leaves. In year 2, it bolts and produces a single flowering stalk, 2-6 feet tall and sets seed (Whitson 2004). Mullein seedling establishment is most successful on bare or recently disturbed ground, and recolonization appears to be dependent on locally available patches of bare ground. The plant is easily out-competed in areas of dense vegetation. Flowering occurs from June to August of the second year, and usually the plant dies back after flowering. Flowers mature from the base to the tip of the stalk and continue producing seed into the fall. An individual plant can produce 100,000-180,000 seeds that may remain viable for over 100 years. The seeds are dispersed by movement of the stalk, with 93% of them falling within 5 meters of the parent plant (Hoshovsky 2003). Mullein is native to Europe and Asia.

Overview of Control Options
Since mullein is a biennial and produces so many seeds with such a high viability, a control strategy that emphasizes removing flowering stems before they flower can be an effective means of eliminating the plant and exhausting the seed bank.

Mechanical
Digging, cutting, and mowing
Manually removing plants prior to seed set, establishing a dense vegetative cover, and minimizing bare soil is the most cost-effective control strategies for mullein (Hoshovsky 2003). Rosettes can be dug up or flowering stems can be pulled up or cut before they go to seed. If pulled up after they go to seed, the seeding head should be removed from the site. Once flowers have emerged, it is difficult to determine whether or not the plant has been pollinated and seed production may follow, even if cut.

Flowering stems can also be removed by mowing prior to flowering. Repeated mowing may be required, as the plant can bolt and produce flowers from the large taproot. Several species are used as biological control on mullein. Spot burning with a weed burner can also effectively kill bolting stems (Hoshovsky 2003). Although spot burning is reported to be effective, since hand pulling tends to be successful, the use of fire as a primary control strategy is not recommended.

Chemical
Herbicides have been used to control mullein, although chemicals are not necessary or recommended, given the plant's life history. One study found that the thick leaf hairs prevented penetration of 2,4-D. Hoshovsky (2003) reported that high concentrations of herbicides in oil or other penetrating carriers are necessary, applied to the basal portion of the stems in fall. No specific information on herbicides was provided. The Pacific Northwest Weed Management Handbook does not provide any information on chemical treatment of mullein, implying that mechanical methods may be more effective (OSU 2007).

Control Recommendations

Each treatment method listed below requires follow-up monitoring and treatment to ensure long-term success.

1. Hand pull or cut flower heads prior to seed production;
2. Hand pull rosettes, given available resources.

Chenopodium album **Lambsquarters**

Priority: Low
Lambsquarters occurs along the road edge and along the berm between the river and wetland on the site.

Description, Biology and Ecology
Lambsquarters is a common annual weed, reproducing by seed, in the goosefoot family (Chenopodiaceae). Seed leaves are narrow with nearly parallel sides and mature leaves are ovate with toothed margins. Leaves are bluish green above, often purple below, and coated with tiny white scales. Depending on moisture and soil fertility, lambsquarters can reach a height of 6 feet (Hitchcock and Cronquist 1996, UC 2007). Stems are erect, branched, longitudinally grooved, and often red or light green striped. The plant contains oxalic acid that can be poisonous to livestock if ingested in large amounts (Manitoba Agriculture, Food and Rural Initiatives 2006a). Tiny flowers in dense clusters are found at the tips of the branches. Lambsquarters produces many long-living seeds, about 72,000 seeds per plant. The seeds germinate both early and late in the season, with the greatest flush of germination occurring in the spring. Lambsquarters is native to Europe and is widespread in the United States.

Overview of Control Options
Since lambsquarters is an annual, a control strategy that emphasizes removing flowering stems before they flower can be an effective means of eliminating the plant and exhausting the seed bank. Lambsquarters is easily outcompeted by other later-successional species (Alexanian, personal comm.). No information on the control of lambsquarters was found in the literature. Lambsquarters can be controlled by pulling, mowing and herbicide treatment.

Mechanical
Pulling and Mowing
The best time to pull or mow the plant is just prior to flowering. Mowing immediately prior to seeding desirable competitive grasses will help open up the area to light and help the seeded species become established.

Chemical
Young seedlings have been effectively killed with herbicides. The best time to spray is in early spring as the young plants are just emerging from the ground and before they bolt. Weedmaster and 2,4-D will both kill young seedlings and Weedmaster is effective once the plants bolt (Alexanian, personal comm.).

Control Recommendations
The treatment options chosen depend on the ability to use herbicides and on available resources.

1. Pull or mow infestations repeatedly to eliminate plants, prevent seed production, and exhaust the seed bank.
2. Treat seedlings with herbicide in spring.

Lepidium perfoliatum **clasping pepperweed**

Priority: Low
Clasping pepperweed occurs along the road edge on the Crooked River Wetland Mitigation Bank.

Description, Biology and Ecology
Clasping pepperweed is a winter annual or annual (sometimes a biennial) plant in the mustard family (Brassicaceae). It stands 6 to 18 inches tall and has two kinds of alternate leaves. The lower leaves are dissected while the upper leaves are heart-shaped and clasp the stem. Flowering and seed production occur between April and June. White to yellow flowers are arranged in elongated racemes at the stem tips. Fruits are a 2-valved capsule containing two seeds. The plant is native to Europe and is established throughout the United States (Whitson 2004). Perennial pepperweed, *Lepidium latifolium*, is a closely relate perennial weed that is much more difficult to eradicate.

Overview of Control Options
Since clasping pepperweed is an annual, a control strategy that emphasizes removing flowering stems before they flower can be an effective means of eliminating the plant and exhausting the seed bank. No information on the control of clasping pepperweed was found in the literature. Clasping pepperweed can be controlled by pulling, mowing and herbicide treatment.

Mechanical
Pulling and Mowing
The best time to pull or mow the plant is just prior to flowering. Mowing immediately prior to seeding desirable competitive grasses will help open up the area to light and help the seeded species become established.

Chemical
Young seedlings have been effectively killed with herbicides. The best time to spray is in early spring as the young plants are just emerging from the ground and before they bolt. Weedmaster and 2,4-D will both kill young seedlings. Weedmaster is also effective once they bolt (Alexanian, personal comm.).

Control Recommendations
The treatment options chosen depend on the ability to use herbicides and on available resources.

1. Pull or mow infestations repeatedly to eliminate plants, prevent seed production, and exhaust the seed bank.
2. Treat seedlings with herbicide in spring.

APPENDIX D.
WEED TREATMENT SCHEDULE

Weed Treatment Schedule

Crooked River Wetland Mitigation Bank

Species	April	May	June	July	August	September	October
Annuals							
Kochia	pull/cut young plants before seed set						
	Mow infestations repeatedly to eliminate plants, prevent seed production, and exhaust the seed bank						
	treat young seedlings with herbicide						
Russian thistle	pull/cut young plants before seed set						
	Mow infestations repeatedly to eliminate plants, prevent seed production, and exhaust the seed bank						
	Apply glyphosate						
Lambsquarters	pull or mow prior to flowering						
	treat young plants with herbicide						
Biennials							
Bull thistle		dig rosettes; cut flowering stems prior to seed production				cut and remove flowering stalks	
	treat young plants with herbicide					treat young plants with herbicide	
Scotch thistle		dig rosettes; cut flowering stems prior to seed production				cut and remove flowering stalks	
	treat young plants with herbicide					treat young plants with herbicide	
Teasel		dig rosettes; cut flowering stems prior to seed production				cut and remove flowering stalks	
	treat young plants with herbicide					treat young plants with herbicide	
Poison hemlock		dig rosettes; cut flowering stems prior to seed production				cut and remove flowering stalks	
	treat young plants with herbicide					treat young plants with herbicide	
Prickly lettuce		dig rosettes; cut flowering stems prior to seed production				cut and remove flowering stalks	
	treat young plants with herbicide					treat young plants with herbicide	
White Sweetclover	hand pull or cut prior to flowering						hand pull
		2nd burn (after fall burn)					first burn
	treat young plants with herbicide						
Loesel tumblemustard	dig/pull rosettes					dig/pull rosettes	
	treat young plants with herbicide					treat young plants with herbicide	
Mullein	dig rosettes; cut or pull flowering stem prior to seed production						
Perennials							
Reed Canarygrass	Apply glyphosate					apply glyphosate after first frost; (can burn patches 2-3 weeks after herbicide application)	
		Cut/mow patches prior to flowering (remove seedheads from site)			mow in anticipation of fall herbicide		
	Dig out individual plants						
Canada thistle	Apply herbicide					Apply herbicide	
	cut bolting stems prior to flowering			cut and remove flowering stems and seeds			
Leafy Spurge	apply herbicide at appropriate time, depending on chemical						
		Burn, then apply herbicide					Burn, then apply herbicide in
Russian knapweed		cut flowering stems 3x/yr. prior to seed production					
	apply herbicide at appropriate time, depending on chemical						
Whitetop	apply herbicide at appropriate time, depending on chemical						
	mow repeatedly throughout growing season, then apply herbicide						

APPENDIX E.
BEST MANAGEMENT PRACTICES
FOR HERBICIDE APPLICATION

BEST MANAGEMENT PRACTICES FOR HERBICIDE APPLICATION
If herbicide use is necessary to accomplish management goals, the Steward will implement the following Best Management Practices (BMPs).

***Minimize toxicity of chemicals used during each application*:**
1. Contractor will choose chemicals based on the combination of two criteria: chemicals that have minimal impacts to the surrounding natural resources, and chemicals that contain sufficient strength to control and/or eradicate non-native vegetation.
2. Contractor will use the lowest functional concentration of chemicals to ensure minimal impacts to the surrounding environment. Herbicide concentrations will not exceed those indicated on product labels.

Minimize incidental take of listed fish and exposure to fish and wildlife species from herbicide application activities:
1. Contractor will minimize chemical exposure to natural resources (e.g., listed species, fish and wildlife, riparian and upland vegetation, wetlands and waterways) by using proper application procedures.

A. Herbicides will be used only in conjunction with other methods of control (manual/mechanical, cultural, etc.).
B. In most cases, herbicide usage will be limited to one or two applications per management activity per growing season, with limited follow-up spot spraying occurring throughout the growing season.

i. Exceptions may be made when a single application, in combination with other control methods, is not adequate to control a target species in a given area. Possible exceptions include areas where there are extensive, monotypic stands of invasive species.
ii. Main herbicide application will occur during, just before, or just after summer months, when there is the least chance of major rain events.

C. Rodeo® or Aquamaster™ will not be used in rain or with rain forecast within 24 hours.
D. Spray application will not be used with winds exceeding 5 mph or when winds disrupt the normal spray pattern.

i. Dyes and/or spray drift cards may be used to facilitate monitoring of spray patterns by spray personnel during application. If weather conditions disrupt the normal spray patterns (visual signs of drift from the target area), spraying will cease and no-drift methods such as wicking, wiping, painting, injecting, or similar methods will be used).

E. Herbicides will not be sprayed during temperature inversions.
F. No spray boom or aerial applications of herbicide will occur within the project boundaries.
G. Proper maintenance and calibration of spray equipment will occur before each main application to ensure proper application rates.

2. Contractor will incorporate guidelines to protect streams and wetlands from chemical contamination during the application process.

A. Broadcast or spot application using backpack sprayers will not occur within 10 feet of any open water, areas of inundation, and/or surface saturated soils.
B. Application within 10 feet of any open water, areas of inundation, surface saturated soils, and/or dry areas below OHW that do not contain MCR steelhead will be done by no-drift methods including wicking, wiping, painting, injecting, or similar methods. In addition, applications within 10 feet of OHW and/or on steep slopes near OHW will be

made over the minimum area possible to avoid complete de-vegetation and subsequent soil erosion.

C. At no time will any herbicide be used within open water.

D. In stream reaches, outside the 100-foot MCR steelhead buffer, where foliar application of glyphosate is used to treat invasive species growing in dry portions of the stream channel below OHW, application is limited to the in-water work period.

E. No chemical herbicides will be applied to road or ditch surfaces where open water, areas on inundation, or surface saturated soils are present, that directly contribute to stream channel flow.

F. Erosion control measures (e.g. silt fence, native grass seeding) will be used where de-vegetation may result in the significant delivery of sediment to waterways or wetlands.

G.Minimum buffer strips will meet or exceed state-mandated standards for all applied herbicides. Note: At this time, there are no state-mandated buffer standards for glyphosate. However, site managers will abide by any new regulations regarding herbicide usage.

3. Contractor will use application methods conducive to the minimization of herbicide off-target movement, drip, and drift of chemicals during application.

A. When spraying near the edge of treatment unit perimeters, spraying will be done by directing the nozzle towards the center of the treatment unit, minimizing the chance for drift outside designated treatment areas.

B. Wide applicators, cut-stump wick applicators, low-pressure sprayers with a single or large droplet nozzle (i.e. backpack or hand sprayers), or other application methods that decrease or eliminate drift will be used to apply herbicides within the project area to minimize drift potential. Low-pressure sprayers increase droplet size, which virtually eliminates drift.

i. Low-pressure sprayers will be used with 0.5 gallons per minute nozzles.

C. Wind speed will be monitored onsite by trained professional before, and hourly during, spray applications. Additional weather monitoring will occur whenever a weather change may affect safe application of the herbicide on the target area.

I. Weather monitoring devices must be capable of measuring wind speeds of 1 mph or greater.

D Erosion control measures (e.g., silt fences, native grass seeding) will be used where de-vegetation may result in the significant delivery of sediment to sensitive areas.

E. Herbicide applications will treat the minimum area necessary for the control of noxious weeds.

4. Contractor will use appropriate herbicide application methods to assure control and/or eradication of non-native vegetation within the target areas.

A. Target plans will have adequate surface area for herbicide coverage.

i. Spray applications will be used only on plants at the optimum height (generally 12-32 inches) in order to allow for adequate leaf surface, ease of application, and minimization of drift and drip.

B. Herbicides will be applied during appropriate plant growth stages.

C. Partial or incomplete treatment will not be considered. Any control action initiated will be completed. If weather conditions prevent completion of an application, the application will be resumed once weather conditions return to an acceptable level (within the shortest amount of time possible dependent on weather conditions).

D. No applications will occur if snow or ice covers the target foliage.

E. Target weeds will not be sprayed during periods of drought or other stress. As indicated on product labels, herbicides may not be as effective when plants are otherwise subjected to stress conditions. Plant metabolic activity slows during periods of stress, thereby decreasing the translocation of the herbicide through the plant.
F. Intensive weed control measures, including herbicide applications over greater than 30 percent of mitigation activity areas, are planned to occur primarily during the first 2 years of project implementation (native plant establishment). This time period extends from approximately 2008 to 2010.

i.Aggressive invasive species control early in the project will reduce long-term need for herbicide use in riparian areas by helping to romote the growth of desirable plant species and reducing the potential for future infestations.

G. Routine maintenance, including herbicide application to target weeds, is expected to occur indefinitely due to the extent of weed infestation in the surrounding areas. However, these efforts are expected to be greatly reduced after the first 5 years of project activity.

5. Prior to operations, the contractor will prepare a spill prevention and contingency plan for review and approval by MCBRT and ODOT. This plan will satisfy all pertinent requirements set forth by federal, state, and local laws and regulations.

A. A spill kit will be onsite during all herbicide application (minimum FOSS Spill Tote-Universal or equivalent.

i.All vehicles used onsite will be equipped with a spill containment kit including a shovel, containment boom, absorptive material, leak proof containers (with labels), and other appropriate equipment.

B. A spill cleanup kit will be available wherever herbicides are transported or stored. A comprehensive spill kit, including component amounts needed to address the accidental spill of all stored chemicals will be present at an onsite location, during herbicide applications. A travel spill kit will be taken with any transported herbicides and will contain containment/clean-up supplies needed to address the accidental spill of the entire amount of transported herbicides.
C. A spill prevention and contingency plan will be developed by the contractor (approved by MCBRT and ODOT) prior to any herbicide applications. Individuals involved in herbicide handling or application will be instructed on the spill prevention and contingency plan, spill control, and spill cleanup procedures.
D. Directions and contact numbers of the nearest emergency medical treatment facility will be provided to all applicators.

Prior to herbicide applications, the contractor will take all necessary precautions to prevent a spill:
E. Areas used for mixing herbicides will be placed where an accidental spill will not run into surface waters or result in groundwater contamination.
F. Areas used for mixing herbicides will be located in an approved area chosen by the contractor. Runoff from this facility is directed such than an accidental spill will not run into surface waters or result in groundwater contamination.
G. Impervious covers such as a plastic tarp (not subject to reaction with chemical herbicides) will be placed beneath mixing areas to contain any spills associated with mixing/refilling.
H. Equipment cleaning and storage and disposal of rinsates and containers will follow all applicable state and federal laws.

I. The contracted applicator will be familiar with the spill prevention and contingency plan and use of the spill kit before commencing herbicide application operations.
J. Equipment used for herbicide transport, mixing, storage, and application will be properly maintained offsite in a leak-proof container.
K. Only daily quantities of herbicides will be transported to the project site. If refilling is required during the course of a day's application, it will occur at an offsite facility and not within the project area.
L. With the exception of excavation equipment, vehicles used onsite will not go into waterways or on steep slopes or other unstable terrain.

Ensure compliance with all performance standards developed for this program:

1. Contractor will have the experience and qualifications to fulfill the guidelines set forth by the performance standards developed for the CRWMB.
    A. Licensed professionals will apply all herbicides.
    B. All licensed spray technicians will be further trained to site-specific methods of herbicide application.
    C. The contracted applicator will be made aware of the provisions of the Biological Opinion before commencing herbicide application operations.
    D. The contracted applicator will be familiar with the use of all herbicide products.
        i. Herbicide products will only be used in a manner consistent with its label.
        ii. An herbicide may be used only in compliance with all federal, state, and local regulations, including those related to licensing and/or certification of applicators, use of protective gear, and posting requirements.
    E. Maintenance and calibration of spray equipment will occur at least annually to ensure proper application rates.

2. Contractor will utilize BMPs to maximize control efforts and minimize off-target effects.
    A. Only certified, noxious weed-free seeds, hay, straw, mulch, or other vegetation material will be used for site stability and re-vegetation projects.
    B. Disturbed areas will be re-vegetated as soon as practical in order to avoid soil erosion and weed infestation. Temporary fencing will be used when necessary to assure new seedling establishment and erosion control.
    C. Where possible, populations of invasive species located outside of mitigation activity areas but within the project site as well as populations near the project site may be controlled with landowner consent. When evaluating invasive populations for potential management, particular attention will be given to onsite and upstream populations in which seeds or plant parts may be transported downstream to the site by water. Additionally, special attention will be given to invasive species that have the potential to devastate native habitat. Only methods described in the BA/BO for the CRWMB project will be used by ODOT/Contractors for control of onsite and/or upstream weed sources.
    D. Herbicide application will be performed in order to avoid contact with desired or planted vegetation, particularly existing native vegetation communities.

3. Develop and carry out a monitoring and reporting program to confirm that (1) the performance standards are being properly followed, (2) the performance standards are achieving the goals of habitat improvement (invasive species control), and (3) performance standards are successfully avoiding and minimizing adverse ecosystem effects.

A long-term management plan that includes surveying and monitoring will be developed for the site. Application techniques, monitoring strategies, and impact/progress toward goals (including desired plant community restoration) and required reporting information shall be documented.

All herbicide applications will be documented reported at least yearly to ODOT. For each application mitigation activity, the herbicide application record shall contain, at a minimum:
Date(s) of application.
Target weed(s).
Name(s) of applicators.
A map showing the percentage of the area covered.
Treatment method (direct injection, wicking, folia application, etc.)
Name(s) and quantity of herbicide used, including concentration, the application rate, and total volume applied.
Weather conditions (e.g., wind, precipitation) during application periods and notation of any precipitation occurring within a 24-hour period following treatment.
Licensing requirements for all herbicides used.
Any injured, sick, or dead listed species will be reported immediately to the proper agency.
Non-target plant mortality will be reported. Probable causes of mortality will be identified and addressed.

APPENDIX F.
PROJECTED LONG-TERM MANAGEMENT COSTS

Crooked River Wetland Mitigation Bank						
Long-Term Management Estimated Costs						
Task	**Description**	**Units**	**Number of Units**	**Cost/unit ($)**	**Frequency (every number of years)**	**Average Annual Cost**
Monitoring						
	Prep for annual monitoring (review previous year report, maps; basemaps, data sheets, equt.); contact City	hours	6	50	1	300
	Annual Monitoring (3-4 site visits/yr)	hours	20	50	1	1000
Management						
Hydrology						
	(assume 2 ft x 2 acres = 174,240 ft3,	excavation	6453	$10	100	645.30
Vegetation						
Weed treatment						
	chemical	acre	2	30.15	0.5	120.60
	mechanical herbicide treatment	hours	5.5	90	0.5	990.00
	manual herbicide treatment (wicking)	hours	6	90	0.5	1080.00
Wildlife						
	maintain/replace wildlife structures	hours	1	50	1	50.00
Maintenance						
	trash removal, correct trespass damage	hours	1	15	0.0416666	360.00
Materials & Equipment						
	general materials & equipment		1	100	5	20
Documentation						
	Annual Monitoring Documentation	hours	5	50	1	250
	update management plan	hours	20	50	5	200
Subtotal						**5015.90**
Administration (10%)						501.59
Contingency (20%)						1003.18
Total Annualized Cost						**6520.67**