INCREMETAL THIN LAYER CAPPING DESIGN ELEMENTS FOR THE LOWER BASIN COEUR D'ALENE RIVER

Phase 1 Pilot Project Implementation and Monitoring Report, Year 1 (2016)

PREPARED FOR

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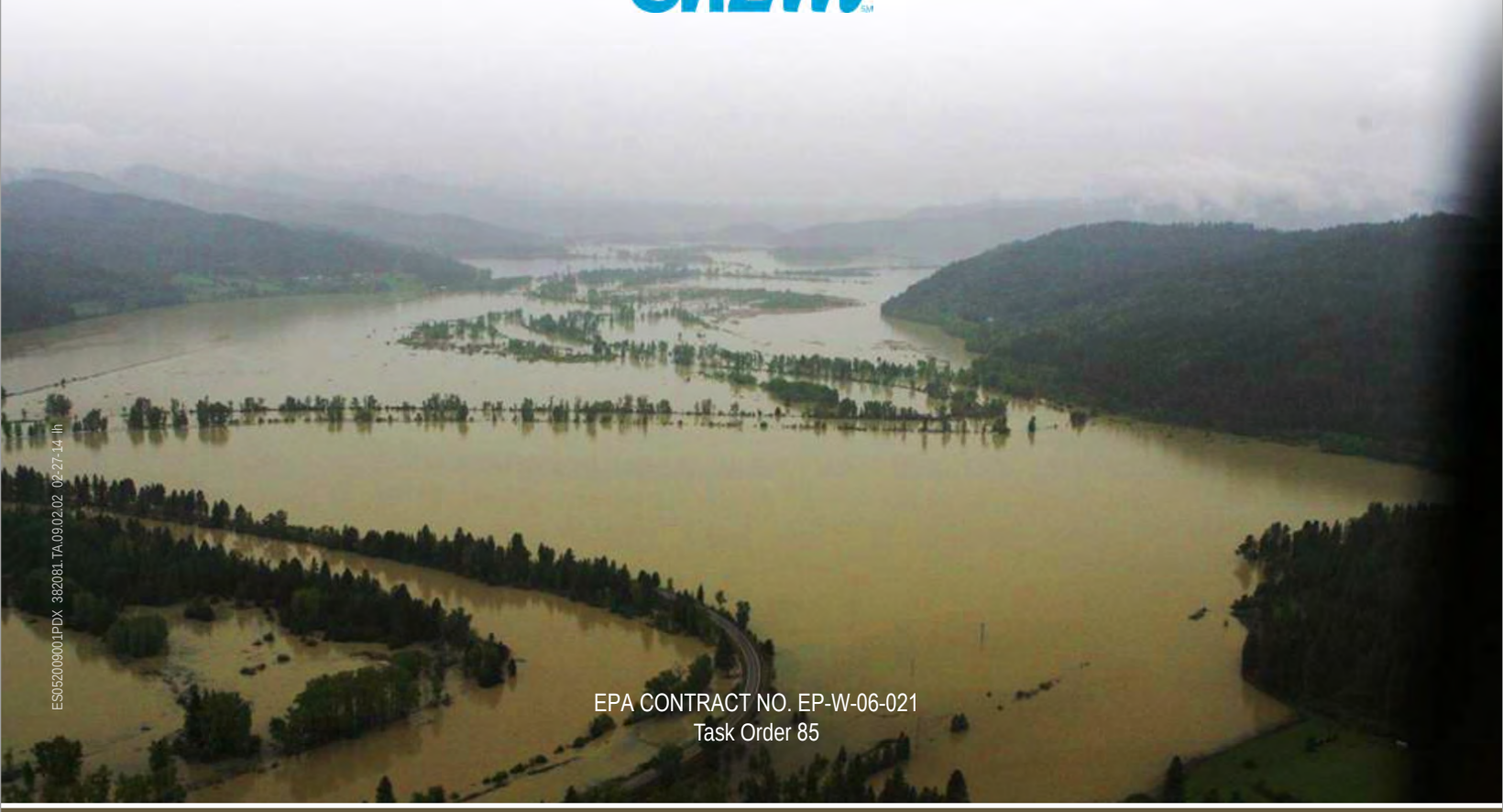

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Incremental Thin-layer Capping Design Elements

Phase 1 Pilot Project Implementation and Monitoring Report, Year 1 (2016)

Lower Basin of the Coeur d'Alene River

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Prepared for

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Region 10

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CH2M HILL, Inc.

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Acronyms and Abbreviations

1D	one-dimensional
Avista	Avista Corporation
CH2M	CH2M HILL, Inc.
cm	centimeters
EPA	U.S. Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, and Trichoptera
HBI	Hilsenhoff Biotic Index
ITLC	Incremental thin-layer capping
LMA	Lane Marsh Arrowhead Community
LMB	Lane Marsh Bur-reed Community
Lower Basin	Lower Basin of the Coeur d'Alene River
mg/kg	milligram per kilogram
MTI	Metals Tolerance Index
NRCS	Natural Resources Conservation Service
ORD	Office of Research and Development
OU3 ROD	*Record of Decision, Bunker Hill Mining and Metallurgical Complex Operable Unit 3 (Coeur d'Alene Basin), Shoshone County, Idaho*
PEM	palustrine emergent
QAPP	Quality Assurance Project Plan
SPAF	Sample Plan Alteration Form
USACE	U.S. Army Corps of Engineers
XRF	X-ray fluorescence

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CHAPTER 1

Summary

The U.S. Environmental Protection Agency (EPA), their contractor CH2M HILL, Inc. (CH2M), and the Coeur d'Alene Trust installed and monitored several capping test plots in Lane Marsh in the Lower Basin of the Coeur d'Alene River (Lower Basin), Idaho, in 2016. The focus of this pilot project was to evaluate possible actions that are cost-effective and feasible for application at a large scale in the Lower Basin to reduce impacts on waterfowl from lead-contaminated soil within floodplain and marshes in the Lower Basin.

This report describes results of the initial pilot project testing of incremental thin-layer capping (ITLC) of contaminated sediment at Lane Marsh. The Pilot Project Work Plan (CH2M, 2015a) described the design basis for the initial plot testing. Phase 1 (installation and baseline data collection) of the pilot project was implemented at Lane Marsh in February 2016. The following are key elements of the pilot project:

- Establishing test plots at Lane Marsh (six treatment plots and two control plots)
- Collecting baseline soil samples (for lead concentration, agronomic, and grain size data)
- Placing a capping material in three thicknesses, and in two types of aquatic vegetation (bur-reed and arrowhead) preferred by dabbling waterfowl
- Monitoring to evaluate the effect of the thin-layer cap treatments on vegetation regrowth, cap settlement, and migration of contaminated sediment or metals vertically through the cap material
- Conducting baseline sampling of benthic invertebrates in water and sediment

Monitoring of the first growing season (Year 1) showed that the response of marsh vegetation varied by plant community type and by the thickness of cap material placed in each test plot. The plots with a 2-inch cap exhibited robust vegetation regrowth that was similar to the control plots where no cap material was applied. The plots with a 4-inch and a 6-inch cap exhibited a substantive reduction in vegetation density and species composition compared to the control plots. Bur-reed and arrowhead are robust species (e.g., charismatic megaflora) that were generally able to emerge through the cap material. Smaller or finer species such as rush (*Juncus*), spikerush (*Eleocharis*), and sedge (*Carex*) exhibited reduced regrowth with increasing cap thickness. Re-colonization of spikerush on the cap surface was already observed during the first growing season. Average lead concentrations throughout the applied sand caps showed little to no vertical migration through the caps from below.

This report includes the following chapters:

- **Chapter 1, Summary,** includes an overview summary of the pilot project, including year 1 monitoring.
- **Chapter 2, Introduction,** summarizes the project purpose and scope, and describes the project area, goals and objectives, and general approach of the pilot project Phase 1.
- **Chapter 3, Phase 1 Test Plot Installation and Monitoring,** summarizes the Phase 1 test plot design for thin-layer capping and summarizes the plan to monitor the results and performance of the thin-layer capping implemented during the pilot project Phase 1.
- **Chapter 4, Phase 1 Key Outcomes,** summarizes the Year 1 conclusions for Phase 1 of the pilot project.
- **Chapter 5, References,** summarizes the references cited.

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CHAPTER 2

Introduction

This chapter summarizes the project purpose and scope, goal and objectives, and the general approach of the pilot project.

2.1 Purpose and Scope

This report describes the initial testing of incremental thin-layer capping of contaminated sediment in a wetland setting of the Lower Basin of the Coeur d'Alene River in Kootenai County, Idaho.

The Pilot Project Work Plan (CH2M, 2015a) described the existing site conditions and design basis for the activities conducted in 2016 for initial plot tests. Associated sampling was described in the Quality Assurance Project Plan (QAPP) Sample Plan Alteration Form (SPAF) (CH2M, 2016) approved by EPA. The objective of the pilot project was to evaluate an option for reducing impacts to waterfowl from lead-contaminated soil in a manner that may be cost effective and feasible for application at a large scale in the Lower Basin, and is resilient to recontamination that may result from large floods.

The pilot project is planned to be conducted in phases. The purpose of Phase 1 was to implement the initial test plots and to evaluate the responses of the native marsh vegetation to various thicknesses of capping material, evaluate the effectiveness of the caps, and better understand effects of the caps on site conditions.

Potential future phases of the pilot project would involve incorporating information learned from Phase 1 and conducting sequential future testing, such as a second application of capping material on Phase 1 plots, establishment of additional test plots (e.g., different materials/mixtures), or testing of a larger application area.

Under a separate but related effort, the EPA Office of Research and Development is planning to (1) conduct tests to better understand soil geochemistry and speciation of lead at Lane Marsh and to (2) conduct bench scale testing to evaluate possible amendments to reduce the bioavailability of lead.

2.2 Pilot Project Problem Definition, Goal, and Objectives

2.2.1 Problem Definition

Historical and ongoing transport and deposition of contaminated sediment in the marshes and floodplains of the Lower Basin have resulted in ecological exposure and risk, particularly to migratory and resident waterfowl that feed in the wetlands.

The Lower Basin contains more than 19,000 acres of waterfowl habitat. Some species of waterfowl feed by dabbling in shallow water, and in doing so ingest sediment contaminated with heavy metals, including lead. As a result of legacy mining in the Upper Basin, more than 95 percent of the Lower Basin wetland areas contain sediment that is toxic to wildlife (with lead concentrations greater than 530 milligrams per kilogram [mg/kg]), and more than 80 percent of the wetland areas contain sediment with lead concentrations that exceed the mortality threshold for waterfowl (1,800 mg/kg) (EPA, 2007).

The *Record of Decision, Bunker Hill Mining and Metallurgical Complex Operable Unit 3 (Coeur d'Alene Basin), Shoshone County, Idaho* (OU3 ROD) (EPA, 2002a) identified a range of actions for remediation of contaminated sediment, including removal, capping, and amendments. The selected actions and the identified need for pilot testing underscores recognition by EPA of the uncertainties and challenges of clean up actions in the Lower Basin. This complexity was further recognized in a review of the site by the National Research Council (2005), which recommended that adaptive management be used to adjust strategies based on managed trials of candidate remedies.

Conducting remedial actions in off-channel areas of the Lower Basin include the following:

- **Large areas to be treated**. The OU3 ROD identifies about 1,200 acres of wetland for initial treatment in pilot tests, but this area is less than 10 percent of the total wetland habitat in the Lower Basin. Because of the

mobility of waterfowl within the basin, a significant but unknown portion of the Lower Basin may require remediation. Remedies must therefore be feasible for application at a large scale.

- **In-water work**. Remediation in much of the wetland habitat areas will require in-water work or dewatering of the area.
- **Cost**. The unit cost for traditional in-water remediation (e.g., excavation or dredging) is high, potentially limiting the areas for which such remedies may be applied. For example, assuming a generic pilot testing cost of $25,000/acre, treatment for 1,200 acres would require $30 million.
- **Remote locations**. Many wetland areas in the Lower Basin are not accessible by road, requiring access by boat and barge (or road construction), further complicating and increasing the cost of remedial actions.
- **Revegetation needs**. Excavation or dredging, soil inversion, and traditional capping typically destroy existing vegetation, which reduces the quality of the habitat for several years and may require additional cost for revegetation measures.
- **Changes to hydrology**. Excavation or capping in shallow wetlands and marshes have the potential to change filling and draining dynamics, and habitat and ecosystem function; therefore, less excavation or filling is expected to reduce potential impacts.
- **Flooding and risk of recontamination**. Recent evaluations indicate that the potential for recontamination is less than previously thought (CH2M, 2015b). However, large floods have the potential to redeposit contaminated sediment on treated wetlands. Therefore, remedies that are more resilient to recontamination are desirable, as they may be considered for implementation in advance of basin-wide and river channel remediation.

The OU3 ROD identified seven priority marsh and lake sites for pilot testing of remedial technologies:

1. Lane Marsh
2. Cave Lake
3. Medicine Lake
4. Bare Marsh
5. Thompson Marsh
6. Thompson Lake
7. Anderson Lake

2.2.2 Goal

The goal of this pilot project is to test, on a small scale, whether clean sand can be placed incrementally in thin layers to cap and isolate contaminated sediment to reduce exposure via ingestion by waterfowl without adversely affecting marsh vegetation and water quality.

2.2.3 Objectives

The following are specific objectives of Phase 1 of this pilot project:

- Assess initial methods for plot sizing, location, layout, and surveying.
- Assess initial techniques to apply imported clean material in varying thicknesses, for plot-scale application but with consideration of future, larger-scale applications.
- Develop and implement a strategy to monitor performance of thin-layer capping test plots to evaluate rates of vegetation recovery and bioperturbation and the stability, migration, and recontamination of the placed material.
- Evaluate and report initial results of the pilot project.

2.3 Study Area

The Lower Basin study area includes the Coeur d'Alene River and associated marshes and lakes within the floodplain area (Figure 2-1; figures are located at the end of this report). The pilot project focused on Lane Marsh, which has elevated concentrations of lead and relatively high rates of waterfowl use (Figure 2-2).

2.3.1 Chemical of Potential Concern

Historical investigations of the Lower Basin are discussed in the following documents:

- *Coeur d'Alene Basin Remedial Investigation/Feasibility Study (RI/FS) for OU3* (EPA, 2001)
- OU3 ROD (EPA, 2002a)
- *Enhanced Conceptual Site Model for the Lower Basin of the Coeur d'Alene River* (CH2M, 2010).

Contaminants identified as posing risks to ecological receptors include metals, consisting primarily of lead, cadmium, and zinc, in upland and palustrine and lacustrine areas.

2.4 Pilot Project Site Selection

As described in the Pilot Project Work Plan (CH2M, 2015a), Lane Marsh was identified as one of several high-priority areas for initial cleanup in the OU3 ROD (EPA, 2002a), based on factors that included high levels of contamination, high usage rates by waterfowl, feasibility of site access, and relatively low potential for recontamination during flood events. In addition to meeting the criteria above, the southern portion of Lane Marsh was selected for Phase 1 plot testing because (1) it is owned by a public agency, (2) site sediment has been characterized (CH2M, 2008), and (3) site plants have been characterized (CH2M, 2013).

Characterization of sediment contamination was conducted in 2008. The characterization report (CH2M, 2008) included a topographic survey, a survey and analysis of vegetation and habitat, and collection and analysis of soil samples in Lane Marsh.

A one-dimensional (1D) sedimentation model was developed for the Lower Basin to help support decisions regarding data collection and pilot project planning (CH2M, 2015b). Sedimentation model results indicate that Lane Marsh is in the lowest category for recontamination risk among the priority wetlands identified in the OU3 ROD.

2.4.1 General Lower Basin Hydrologic Setting

Coeur d'Alene Lake surface water elevations are controlled by the Avista Corporation (Avista) dam in Post Falls, Idaho. Typically, surface water elevations in the lake are controlled at higher elevations than would be expected if no dam were present during drier times of the year. Generally, the lake is maintained at an elevation of 2,128 feet NAVD88 from Memorial Day through Labor Day. After Labor Day, the lake elevation is reduced to accommodate the increased volume of flow during the winter and spring months. The high lake elevation during the Memorial Day through Labor Day period results in a backwater effect in the Coeur d'Alene River that extends upstream from Lane Marsh as far as to Cataldo.

2.4.2 Physical Conditions of Lane Marsh

Lane Marsh is approximately 30 miles southeast of Coeur d'Alene. Lane Marsh is approximately 200 acres and is bounded on the north and west by the Trail of the Coeur d'Alenes and on the south and east by State Highway 3 (Figures 2-1 and 2-2).

2.4.2.1 Lane Marsh Property Ownership

Lane Marsh property owners include the Idaho Department of Fish and Game and a private property owner. Property ownership in the vicinity of Lane Marsh is shown on Figure 2-2.

2.4.2.2 Lane Marsh Topography

A topographic map of the Lane Marsh site with 1-foot contour intervals was prepared in June 2008 (CH2M, 2008). Overall, the ground surface of Lane Marsh is relatively flat; the majority of the land is below elevation 2,129 feet

NAVD88. The minimum surveyed elevation in Lane Marsh is 2,125.3 feet NAVD88. Ditches and borrow areas are along the perimeter of Lane Marsh where it is bounded by the Trail of the Coeur d'Alenes and State Highway 3. The bottom elevation of the channel that crosses under the bridge on the Trail of the Coeur d'Alenes is 2,119.8 feet NAVD88. There is an area of relatively higher elevation on the privately owned parcel in the southwestern portion of the site. Other areas with higher elevations are located in the southern portion of the site where fill is associated with Avista's electric transmission line poles; one of these access points was used during this pilot project for accessing the test plots in Lane Marsh.

The Trail of the Coeur d'Alenes bounds the site to the north and west. Elevations of the crown of the Trail of the Coeur d'Alenes range between 2,137.7 and 2,140.4 feet NAVD88. State Highway 3 bounds the site on the south and east. Elevations of the crown of State Highway 3 range between 2,140.2 and 2,170.0 feet NAVD88. The highest elevations on State Highway 3 occur at the northern end of the site.

2.4.2.3 Lane Marsh Soils

The Natural Resources Conservation Service (NRCS) has mapped soil types for Lane Marsh (Appendix A). The maps show that Lane Marsh is underlain by hydric soil, predominately Pywell muck (map unit 159), with a small portion of the southwestern end being underlain by Slickens (map unit 179). Both of these soil types are found on the floodplain of the Coeur d'Alene River. The Soil Survey for Kootenai County Area, Idaho (NRCS, 1981) describes these soils as follows:

- **Pywell muck** – consists of very deep, very poorly drained soils in level depressions of floodplains and bottom lands. These soils formed in organic material.
- **Slickens** – consists of poorly drained accumulations of medium textured materials, separated in ore mill operations, over stratified moderately fine and fine textured soils and organic material. It is on the floodplain along the Coeur d'Alene River and mainly consists of mine tailings from the Coeur d'Alene Mining District and alluvium from yearly overflow.

2.4.2.4 Lane Marsh Hydrologic Features

Available clean water sources for Lane Marsh include surface water from hillside drainage basins, groundwater discharges, and precipitation. The drainage area for Lane Marsh is approximately 847 acres and consists of six drainage subbasins located southeast of the marsh (CH2M, 2008). Water from the drainages represents the major source of clean water inflow to Lane Marsh and is conveyed under State Highway 3 through four culverts. Precipitation would be expected to be a small secondary source of clean water to Lane Marsh.

As previously mentioned, a bridge on the Trail of the Coeur d'Alenes allows the exchange of water between Lane Marsh and the river. Water from the river flows into Lane Marsh when the river stage rises above the invert elevation of the connection; the flow reverses when river stage declines below the invert elevation of the connection.

A 1D hydrology model developed by CH2M (2010) for the Lower Basin was used to predict mean daily water elevations in the Coeur d'Alene River near Lane Marsh (Figure 2-3). These data show that on average, water surface elevation in the river is lower than in Lane Marsh from October through March. The model was used to calculate the water surface elevation for water year 2016 (September 2015 through August 2016) during a portion of the pilot project Phase 1, as shown on Figure 2-3.

Water level logger data recorded continuously in Lane Marsh from December 19, 2013 to February 5, 2016 shows that on average the water level is perched at or above 2,128 feet NAVD88 without draining out or evaporating, despite the decreases in river elevation (Figure 2-4). Water levels showed a substantial decreased from August through December 2015 in response to the unusually hot, dry summer in 2015.

2.4.2.5 Lane Marsh Soil Sampling Results

Concentrations of lead in soil in Lane Marsh showed that the majority of lead concentrations greater than 530 mg/kg are located in the upper 6 inches of the soil column (CH2M, 2008) (Figure 2-5). Contamination at depths greater than 12 inches is generally limited to the southwestern portion of the site near the hydraulic connection under the Trail of the Coeur d'Alenes.

2.4.3 Vegetation

2.4.3.1 Wetland Vegetation and Habitat

Lane Marsh was reported to be one of the highest use areas for waterfowl feeding within the Lower Basin (Audet et al., 1999). A wetland habitat characterization survey (CH2M, 2008) conducted at Lane Marsh to evaluate wetland habitat and vegetation reported most of Lane Marsh to be a palustrine emergent (PEM) wetland interspersed with areas of open water (aquatic). Thirteen species of wetland plants (including nine native species) were identified within these PEM wetlands and deeper aquatic habitat areas (Table 2-1). Common reed (*Phragmites australis*) was the only species identified in 2008 that is currently on the Idaho Noxious Weed Watch List (Idaho State Department of Agriculture, 2015). Reed canarygrass is considered invasive under some wetland conditions. Additional species were observed during a later survey (CH2M, 2013) for water howellia (*Howellia aquatilis*), which is listed as a threatened species by the U.S. Fish and Wildlife Service. Lane Marsh was identified as potential habitat for water howellia because it is located within a historic floodplain similar to other known habitat occurrences of howellia elsewhere in Idaho. CH2M (2013) reported that no water howellia plants were found. Continuous soil saturation and dense herbaceous cover make it unlikely that water howellia exists or will become established in Lane Marsh.

TABLE 2-1
Palustrine Emergent Marsh and Aquatic Species Observed at Lane Marsh (adapted from CH2M, 2008)
Lane Marsh Pilot Project Testing – Phase 1, Year 1 (2016)

Common Name	Scientific Name	Wetland Status	Native	Habitat
Nodding bur marigold	*Bidens cemua*	FACW+	Yes	Swamps, bogs, seeps, marshes, river and pond floodplains, wet meadows, and ditches along roads and railroads.
Water horsetail	*Equisetum fluviatile*	OBL	Yes	Shallow water areas of marshes, bogs, and streams.
Dwarf scouring rush	*Equisetum scirpoides*	FACW	Yes	Wet areas in woods, moist shaded slopes, and bogs.
Water lily	*Nymphaea* sp.	OBL	Unknown	Aquatic habitats.
Reed canarygrass	*Phalaris arundinacea*	FACW	No	Wide amplitude including streambanks, ponds, lakes, irrigation canals, ditches, wet meadows, brackish tidelands, and marshes. Tolerant of frequent and prolonged flooding, even submergence. Prefers fine-textured substrates.
Common reed	*Phragmites australis*	FACW+	No; noxious	Typically inhabits margins of creeks, drains, and wetlands, where flooding is prolonged. Prefers water depths of 1 inch or less.
Spotted ladys-thumb	*Polygonum persicaria*	FACW	No	Disturbed edges of ponds, shallow lakes, marshes, and streams. Typically found in moist to wet sites but will tolerate drying periodically.
Floating pondweed	*Potamogeton natans*	OBL	Yes	Ponds, lakes, slow-moving water up to 9 feet deep.
Arumleaf arrowhead (duck potato or wapato)	*Sagittaria cuneata*	OBL	Yes	Muddy marshes and shallow water wetlands. Swans prefer this rhizome as a food source.
Hardstem bulrush	*Schoenoplectus acutus*	OBL	Yes	Marshes, shorelines, and other wetlands with shallow water.
Panicled bulrush	*Scirpus microcarpus*	OBL	Yes	Marshes, swamps, and wet meadows.
Broadfruit bur-reed	*Sparganium eurycarpum*	OBL	Yes	Wet soils and up to 1.5 feet of standing water along lakes, ponds, or low velocity streams.
Common cattail	*Typha latifolia*	OBL	Yes	Deep marshes to open bogs on wet soils, often in 1 to 2 feet of standing water. Soils must remain wet, saturated

TABLE 2-1
Palustrine Emergent Marsh and Aquatic Species Observed at Lane Marsh (adapted from CH2M, 2008)
Lane Marsh Pilot Project Testing – Phase 1, Year 1 (2016)

Common Name	Scientific Name	Wetland Status	Native	Habitat
				or flooded during most of the growing season and preferably contain high amounts of organic matter.
Yellow pond lily	*Nuphar polysepalum*	OBL	Yes	Ponds, shallow lakes, and slow-moving streams.
Woolgrass	*Scirpus cyperinus*	OBL	Yes	Irregularly flooded tidal fresh marshes, inland marshes, wet meadows, and swamps. Grows best in areas with wet soil moisture content and is seldom found in more than a few inches of water (Voss, 1972). Prefers peat or sandy soil types in full to partially sunny locations.
Watershield	*Brasenia schreberi*	OBL	Yes	Ponds, lakes, and slow-moving streams.
Common spikerush	*Eleocharis palustris*	OBL	Yes	Areas that are flooded in the spring and saturated in the fall. Can grow in flooded conditions where the water is up to 3 feet deep for most of the growing season. Grows on fine-texture soils in neutral to alkaline or saline conditions.

Notes:
FACW = facultative wet
FACW+ = facultative wet plus
OBL = obligate

2.4.4 Historical Lane Marsh Site Conditions

Prior to the construction of the railroad causeway (now the Trail of the Coeur d'Alenes) across Lane Marsh in the late 1800s, the marsh was a relatively large floodplain wetland in direct hydraulic connection with the Coeur d'Alene River. The construction of the causeway bisected the marsh and isolated the southern portion of Lane Marsh from the river. This isolation resulted in the southern portion of Lane Marsh becoming drier during certain times of the year and facilitated the use of this area for animal grazing. The causeway was breached at an unknown time and repaired by the construction of a bridge (CH2M, 2008) near the western end of the marsh (Figure 2-5). Agricultural activity in Lane Marsh is currently limited to private property in the southwestern corner of marsh.

2.5 Pilot Project Phase 1 General Approach

The general approach of Phase 1 of the pilot project was to (1) initially apply different thicknesses of capping material to test plots in a representative marsh and (2) monitor regrowth of the marsh vegetation, bio-perturbation, and the stability of the cap material.

Monitoring was conducted during the first growing season (2016).

2.5.1 Overview of Thin-layer Capping for Lower Basin

Typical environmental capping of contaminated sediment is intended to isolate and immobilize sediment in place, eliminating mobility and pathways of exposure. Remediation capping is commonly conducted by placing a layer of sand or gravel (or alternatively, geotextile fabric) sufficient to prevent vertical migration of contaminants through the cap, and armoring the isolating layer with riprap or similar material to resist erosion by currents, wave action, propeller wash, bioperturbation, and similar disturbances.

This approach presents several potential problems in the context of the Lower Basin:

- Vegetation and ecosystem damage, requiring replanting and/or long recovery times

- Changes to shoreline shape, contour, and habitat caused by the addition of capping material, and corresponding changes to land surface elevations, plant communities and fluvial hydrogeomorphic processes
- Hydraulic changes (wetland filling and drainage patterns and frequency)
- Recontamination potential (from inundation of the capped area by floodwaters)
- Capping material in quantities sufficient to treat affected wetlands
- Bio-perturbation (mixing of contaminated sediment with capping material from biological activity, reducing the effectiveness of the barrier)

Thin-layer capping is an approach that was originally developed for disposal of clean dredged material from navigational projects, in which the dredged material is distributed over existing vegetation in layers thin enough to allow regrowth of existing vegetation through the fresh deposits (U.S. Army Corps of Engineers [USACE], 2007). This process mimics sedimentation that might occur during large storms or floods. In the context of remedial technologies, it may be considered enhanced natural recovery.

When used for environmental capping such as in the Lower Basin, thin-layer capping can offer several distinct advantages over conventional capping, including the following:

- **Cost-effective placement**. Distribution from a work barge by using a slinger truck or high-pressure hydraulic jet can rapidly spread material within a large radius at relatively low cost.
- **Variable thickness of application**. Application can be made in relatively thin layers, to mimic deposition of sediment from flooding and allowing regrowth of existing vegetation through the cap. Several applications may be necessary to achieve the cumulative desired cap thickness while maintaining healthy vegetation. In many off-channel areas of the Lower Basin, typical river velocities are sufficiently low enough that armoring of capping material (especially with the presence of vegetation) may not be necessary, particularly in areas behind the Trail of the Coeur d'Alenes.
- **Availability of materials**. Sourcing sufficient quantities of capping material may create logistical or cost issues. Native sediment may be recruited from within the Lower Basin (after removing contaminated overburden) from other drainages to Coeur d'Alene Lake, or clean material may be commercially sourced. Local sourcing from the floodplain may help maintain hydraulic balance in the Lower Basin. Hybrid caps incorporating amendment materials to reduce the bioavailability of lead and other heavy metals may be feasible, perhaps allowing the use of thinner caps (this option may be evaluated in Phase 2 or through other studies).
- **Utility.** Thin-layer capping may be used in conjunction with sediment amendments, if desired to help hold amendment material in place and increase overall remedy effectiveness by using both approaches to reducing bioavailability.

Thin-layer capping, though relatively new for environmental remediation work, has been selected for use in at least one other Superfund site, an existing marsh at the LCP Chemical Superfund Site in Brunswick, Georgia. The EPA (2013) proposed the use of a thin-cover restoration layer of 6 inches as a protective remedy alternative. Regeneration of the salt marsh is expected to occur within approximately 1 to 2 years after application of the target thicknesses. At this site, the thin cover is not intended as a chemical barrier, but as a layer to substantively reduce surface sediment chemical concentrations. The ITLC envisioned for the Lower Basin adds the element of multiple application cycles and layers over time. This incremental layering approach is intended to provide the following additional benefits:

- **Ensuring vegetation survival.** Thinner applications of capping material are expected to allow more natural rates of vegetation recovery and regrowth, reducing the need for replanting, while allowing, over a period of several years, accumulation of enough clean material to meet design objectives of limiting exposure of waterfowl to elevated levels of lead.
- **Resiliency to recontamination.** If contaminated material is deposited by flooding on top of a thin-layer cap, supplemental applications of a relatively small amount of additional clean material can reduce the impact of

the new contamination. Modern (present-day) deposition rates in many areas of the Lower Basin are now understood to be low relative to historical rates. Adding new capping material to the surface of previously placed capping material following a large flood can help reduce the average lead concentration in the cap profile (i.e., within the vertical waterfowl feeding range).

- **Flexibility in design.** Incremental addition of layers of capping material allows spatial adjustments based on elevation or water depth, or to the design depth, if pilot testing indicates such changes are appropriate.

Previous research on this capping technique is limited. The USACE (2007) reported the effects of thin-layer placement of dredge material primarily on coastal wetlands, noting that Koning (2004) observed in the laboratory that less than 2 cm of sediment had no effect on arrowhead (*Sagittaria latifolia*) growth in freshwater, and the addition of 2 cm of sediment resulted in increased aboveground biomass; and there was no detectable effect in field plots, presumably because of the low level of sediment application. Wang et al., (1994) reported that adult cattail plants were unaffected by addition of up to 4 cm of sediment.

Pilot-scale testing of thin-layer capping was selected for Lane Marsh based on the following factors:

- Lane Marsh was identified in the OU3 ROD (EPA, 2002a) as one of several waterbodies prioritized for early action because of high waterfowl use, high lead concentrations, low risk for recontamination, and road access.
- Most of Lane Marsh is owned by a collaborative partner.
- There is more site characterization information available for Lane Marsh than other sites (CH2M, 2008).

CHAPTER 3

Phase 1 Test Plot Installation and Monitoring

This chapter summarizes the design elements and first year monitoring results for the thin-layer capping test plots at Lane Marsh.

3.1 Study Strategy, Plot Layout, and Installation

3.1.1 Study Strategy

The ITLC approach is intended to reduce the amount of capping material, reduce adverse impacts on native vegetation caused by capping, and provide incremental benefits to larger areas than is possible using traditional methods. Application of relatively thin layers of capping material is intended to mimic natural sediment deposition processes during winter and spring flood cycles. Because native vegetation is dormant during these seasons, the test plots were planned for installation during that time.

3.1.2 Plot Layout

Phase 1 testing of ITLC was conducted by applying clean sand in test plots placed at three thicknesses within two plant communities, plus control plots for each type of vegetation. Eight test plots were laid out on December 15, 2015, in two plant communities used for feeding by dabbling waterfowl such as tundra swans:

1. Four test plots were placed in a plant community dominated by arrowhead (*Sagittaria cuneata,* also known as duck weed).
2. Four test plots were placed in a plant community dominated by bur-reed (*Sparganium eurycarpum*).

Test plots in each plant community included plots for cap thicknesses of 2, 4, and 6 inches. Steel T-posts were installed to mark the plot corners. The plot locations are shown on Figure 3-1, and the general plant communities are shown in Photographs 3-1 and 3-2.

3.1.3 Installation of Plot Design

On February 10, 2016, the Coeur d'Alene Trust and their contractor, McGillvray Environmental, installed the test plots and placed capping material in the test plots. Pioneer Technical Services surveyed the locations and elevations in the plots. Staff from CH2M observed the installation for conformity to the study design. Prefabricated, untreated, wooden plot frames with an inside dimension of 6 feet by 6 feet were used for the test plots. The frames were constructed with heights of 2, 4, and 6 inches and were placed on the marsh surface and fastened to steel posts with screws. Fine sand (approximately 300 minus, sourced from Interstate Concrete & Asphalt in Rathdrum, Idaho) was applied in the test plots as capping material to achieve the target depths per the Pilot Project Work Plan (CH2M, 2015a). Fine sand was used for Phase 1 test plots because it was a finest-grained uniformly graded, clean, commercially available material. However, the sand was coarser (Figure 3-2) and without the organic matter of the existing loam soil in Lane Marsh. See Appendix A for gradation of the fine sand used as cap material.

This study design resulted in eight test plots, which are listed in Table 3-1. Two undisturbed control plots provide a reference for conditions where no treatment material was applied. Imported clean fine sand was applied at three material thicknesses:

- 2 inches
- 4 inches
- 6 inches

TABLE 3-1
Thin-layer Capping Treatment Plots
Lane Marsh Pilot Project Testing – Phase 1, Year 1 (2016)

Cap Thickness (inches)	Plot Treatment Types[a]	
	Control (no treatment)	**Clean Fine Sand (cap treatment)**
Lane Marsh Arrowhead (LMA) Community		
0 inch	LM A1	-
2 inches	-	LM A2
4 inches	-	LM A3
6 inches	-	LM A4
Lane Marsh Bur-reed (LMB) Community		
0 inch	LM B4	-
2 inches	-	LM B3
4 inches	-	LM B2
6 inches	-	LM B1

[a] Plot size is approximately 6 feet by 6 feet square.

Photograph 3-1. Lane Marsh from south side near Highway 3, showing test plot location with arrowhead (LMA) plant community test plot area (September 22, 2016).

Photograph 3-2. Lane Marsh from south side near Highway 3, showing test plot location with bur-reed (LMB) plant community test plot area (September 22, 2016).

The test plot cap thicknesses were selected based on ecological and operational considerations, and on previous studies by others (e.g., USACE, 2007; Koning, 2004; Wang et al., 1994; EPA, 2013). A key objective of the study was to identify the thickest layer of material that could be placed without adversely affecting plant regrowth rates. The selected plant communities were relatively robust, and were assumed to be able to emerge through a sand layer 2 inches thick, which was selected as the cap minimum thickness.

The selected plant species have differing morphologies that may affect their ability to tolerate sediment deposition. When dormant, the tuber-producing rhizomes of arrowhead (duck potato or wapato) protrude approximately several inches from the ground surface (Photograph 3-3A). However, arrowhead leaves once emerged in spring would be potentially vulnerable to heavy sediment deposition (Photograph 3-3B). When dormant, bur-reed is approximately 18 to 24 inches tall with a relatively rigid, persistent, upright morphology (Photograph 3-4A). These plants are expected to grow through thin layers of applied capping

material, particularly when the material is applied during the dormant season before vegetative shoots emerge in spring (Photograph 3-4B).

Photograph 3-3A. Arrowhead rhizome while dormant (October 28, 2015).

Photograph 3-3B. Arrowhead plants during growing season (June 8, 2016).

Photograph 3-4A. Upright leaves of bur-reed generally persist during winter dormancy (October 28, 2015).

Photograph 3-4B. Bur-reed plant community during growing season. Also includes some arrowhead. (June 8, 2016).

Method for Access and Plot Installation

The Phase 1 test plots were manually installed; no heavy equipment was used in the marsh. Materials were delivered to a pullout along the highway, and capping material was carried by hand to the test plots using 5-gallon buckets.

Wooden frames were used to control the depth of the cap material in the test plots. Temporary plywood mats were placed to form walkways to and around the test plots to provide safe access for workers, to protect existing marsh vegetation, and to minimize disturbance of contaminated marsh sediment.

Plot corners were identified with steel posts that were surveyed.

Plot Installation

Plots were installed in February 2016, when the marsh was free from snow and ice, before the river level increased and migratory waterfowl arrived.

Approval was received from relevant landowners prior to installation of plots. The approvals included use of a pullout along Highway 3 (Idaho Transportation Department), an access ramp (Avista), and Lane Marsh (Idaho Department of Fish and Game) (Figure 3-1). Landowners were contacted in advance to obtain approval.

The following construction equipment was used on the project:

- Hand tools and equipment
- Plywood mats with 2-inch by 4-inch wood frame supports placed for safe walking access in marsh and to protect the marsh
- 5-gallon buckets were used to transport the material from the pullout on Highway 3 to the plots

Water depth in the plots during installation varied from approximately 0 to 6 inches. Water level logger data recorded continuously in Lane Marsh from 12/19/2013 to 2/5/2016 shows that on average water level is typically perched at or above 2,128 feet NAVD88 (North American Vertical Datum 1988), despite seasonal decreases in river elevation (Figure 2-4). However, the unusually dry conditions during summer 2015 resulted in a substantial decrease in water levels in Lane Marsh from late July 2015 through early December 2015.

3.1.4 Test Plot Surveying

After installation of the cap material, each test plot was surveyed to measure the elevation of the wood frame and the cap surface within the wood frame. The elevations of cap surfaces were measured on February 10 and on October 6, 2016 to determine possible subsidence or settlement in test plots during the first growing season.

3.2 Year 1 Monitoring Results

In mid-February 2016, after the test plots were installed, water levels in Lane Marsh increased in response to increased river levels (Figures 2-3 and 2-4 in Section 2), although water levels remained below flood stage for the remainder of the year.

3.2.1 Agronomic Characteristics

Soil samples were obtained from the two plant community areas (arrowhead and bur-reed) to characterize existing agronomic characteristics. Samples were collected on December 15, 2015. A duplicate soil sample was also included for quality control. Samples were analyzed by A&L Western Agricultural Laboratories in Portland, Oregon.

Capping material was also sampled on February 10, 2016, to characterize the fine sand used in the test plots. A duplicate sample was also included for quality control. Samples were analyzed by A&L Western Agricultural Laboratories in Portland, Oregon.

The results of the agronomic analyses are summarized in Table 3-2, with additional detail provided in Appendix B. In general, the marsh soil samples exhibited high levels of and iron, organic matter, sulfur, and zinc, and low or very low levels of macronutrients (nitrogen, phosphorus, and potassium), most micronutrients (boron, calcium, copper, and magnesium), and pH (4.1 to 4.5).

The agronomic analysis of the fine sand showed (as expected) very low organic matter, nitrogen, sodium, sulfur, and zinc, relative to native marsh soil, while levels of phosphorus, magnesium, calcium and boron were somewhat similar.

3.2.2 Soil Texture

Soil texture analyses conducted on the native soils and sand samples are summarized in Table 3-3. The samples of existing soil at Lane Marsh are classified as loam with similar percentages of sand and silt and lesser amounts of clay. The sample of sand capping material contained 92 percent sand-size particles. Additional detail regarding the agronomic soil sampling results is presented in Appendix B.

TABLE 3-2

Agronomic Results for Samples Collected from ITLC Test Plots at Lane Marsh

Lane Marsh Pilot Project Testing – Phase 1, Year 1 (2016)

Lab ID	Soil Layer	A&L Laboratory Number	Organic Matter (%)	Nitrogen NO_3-N (ppm)	Phosphorus Weak Bray (ppm)	Potassium K (ppm)	Magnesium Mg (ppm)	Calcium Ca (ppm)	Sodium Na (ppm)	Sulfur SO_4-S (ppm)	Zinc Zn (ppm)	Manganese Mn (ppm)	Iron Fe (ppm)	Copper Cu (ppm)	Boron B (ppm)	pH
Soil from Arrowhead Community																
LM-A	0 to 6-inch depth	59387	17.9 VH	7 L	5 VL	58 L	108 L	517 VL	83 M	130 VH	20.4 VH	9 M	133 VH	0.8 L	0.2 VL	4.5
Soil from Bur-Reed Community																
LM-B	0 to 6-inch depth	59388	21.6 VH	5 L	3 VL	53 L	103 L	365 VL	103 M	107 VH	18.8 VH	9 M	145 VH	0.7 L	0.2 VL	4.1
LM-FD	0 to 6-inch depth	59389	18.2 VH	5 L	6 VL	44 L	112 L	462 VL	94 M	140 VH	20.8 VH	9 M	140 VH	0.6 L	0.2 VL	4.2
Fine Sand Used in Test Plots[a]																
CAP	Grab sample	58429	0.3 VL	1 VL	7 VL	36 L	114 L	473 VL	9 VL	1 VL	0.3 VL	2 L	21 H	0.2 VL	0.1 VL	7.7

[a] Sourced from Interstate Concrete & Asphalt in Rathdrum, Idaho

Notes:

The depth of sampling was 0 to 0.5 feet.

Analysis performed by A&L Western Laboratories. Qualitative descriptions of constituent concentrations (e.g., low or high) assigned by A&L Western Laboratories. FD = field duplicate

H = high

ID = identification

L = low

M = medium

ppm = parts per million

VH = very high

VL = very low

TABLE 3-3
Soil Texture for Samples Collected from ITLC Test Plots at Lane Marsh
Lane Marsh Pilot Project Testing – Phase 1, Year 1 (2016)

Sample Identifier	Laboratory Number	Sand (percent)	Silt (percent)	Clay (percent)	Soil Texture
Soil from Test Plot in Arrowhead Community					
LM-A	59387	38	48	13	Loam
Soil from Test Plot in Bur-reed Community					
LM-B	59388	44	39	17	Loam
LM-FD	59389	38	47	15	Loam
Fine Sand Used in Test Plots[a]					
Cap Material	58429	92	2	6	Sand

[a] Sourced from Interstate Concrete & Asphalt in Rathdrum, Idaho.

Note:
Analysis performed by A&L Western Laboratories.

3.2.3 Grain Size

Soil samples (0 to 6 inches) near the test plots in both plant communities (plus one duplicate) and a grab sample of the sand capping material were collected and sent to Analytical Resources Inc. for grain size analysis. The marsh soil samples (LM-A and LM-B) exhibited considerably finer grain sizes than the sand cap material, which had considerably coarser grain sizes (Figure 3-2). Additional detail is provided in Appendix A.

3.2.4 Lead Concentration

3.2.4.1 Baseline Soil Sampling

Representative soil samples (0- to 6-inch depth) were collected near the test plots from the arrowhead and bur-reed plant communities in December 2015 and analyzed for lead (Table 3-4). Lead concentrations from the marsh soil samples ranged from approximately 1,100 to 1,300 mg/kg, with values that exceed the toxicity threshold for avian receptors (530 mg/kg) but below the mortality threshold for waterfowl of (1,800 mg/kg) (EPA, 2007).

Previous baseline sampling in Lane Marsh was conducted in 2008. A sampling point from that effort was located about 50 feet north of the test plots and had a lead concentration of 2,510 in the 0 to 6-inch interval (CH2M, 2008). The previous sampling was conducted on a 250-foot grid spacing (Figure 2-5, located at end of this report).

TABLE 3-4
Baseline Lead Concentration for Samples Collected from ITLC Test Plots at Lane Marsh
Lane Marsh Pilot Project Testing – Phase 1, Year 1 (2016)

Sample ID	Lead (mg/kg) EPA Manchester Laboratory	Lead (mg/kg) A&L Western Agricultural Laboratory	Sampling Depth (inches)
Soil from Test Plot in Arrowhead Community			
LM-A	1,130	1,083.6	0 to 6
Soil from Test Plot in Bur-reed Community			
LM-B	1,300	1,218.2	0 to 6
LM-B	1,270	-	0 to 6

TABLE 3-4
Baseline Lead Concentration for Samples Collected from ITLC Test Plots at Lane Marsh
Lane Marsh Pilot Project Testing – Phase 1, Year 1 (2016)

Sample ID	Lead (mg/kg) EPA Manchester Laboratory	Lead (mg/kg) A&L Western Agricultural Laboratory	Sampling Depth (inches)
LM-FD (LM-B)	1,330	-	0 to 6
Fine Sand Used in Test Plots[a]			
LM-A	0.41 to 13.5	-	Grab sample

[a] Sourced from Interstate Concrete & Asphalt in Rathdrum, Idaho.

3.2.4.2 1-Year Monitoring Core Samples

After the first growing season, core samples of the cap material were collected to assess potential bioturbation from causes such as plant shoots, benthic activity, and waterfowl and wildlife feeding and use. Sampling was also intended to measure the extent to which recontamination from flooding may have affected cap integrity. Sampling was conducted on October 14, 2016, at the end of the growing season from each of the six test plots where cap material had been applied.

The core sampling was conducted to allow measurement of lead concentrations at discrete depths in the thin cap layer, using the following procedure (Photograph 3-5):

1. Near each corner and approximately 1 foot in from the edge of each wooden frame, an approximately 12-inch-long section of 1.5-inch-diameter rigid plastic tubing was inserted through the cap material and a short distance into the underlying native soil.
2. A stainless steel T-sampler was inserted into the plastic core tube.
3. Both the exterior plastic tube and the T-sampler were removed as a single unit to retain the core sample (this was the only method tested was able to consistently retrieve complete core samples of the thin sand layers).
4. The T-sampler was carefully removed from the tube and sampler. The core was split into 1-inch vertical increments that were placed in separate plastic baggies and placed in a cooler for later analysis in the laboratory.
5. In the laboratory, a portable X-ray fluorescence (XRF) analyzer (InnovX 600 Alpha Series XRF Analyzer) was used to analyze the concentration of lead and other metals in each sample.
6. Samples were then composited from the top of cap layer (0 to 1 inch below cap surface) and bottom of cap layer (0 to 1 inch above the native marsh soil) from each plot, and analyzed for lead by XRF and then shipped to an EPA Contract Laboratory Program laboratory for lead analysis.

Figures 3-3 and 3-4 show the analysis results of lead concentrations from the core samples collected in the test plots. The following general observations were made:

- Most of the lead concentrations measured using the XRF instrument were below the detection limit of the instrument (approximately 11 to 14 mg/kg).
- Some of the overall sand cap layers were measured as slightly thicker than planned likely due to variations in the marsh surface and sampling technique (assuming the core samples are an accurate measure of the actual cap thickness) (Photograph 3-6). The core samples for most of the plots measured approximately 1 inch thicker than nominal depth.
- The bottom sand layer interface with the native soil remained fairly discrete and did not indicate obvious mixing or intrusion into the underlying marsh soil (Photograph 3-6). The lower 1-inch increments of the sand

cap exhibited only marginally elevated concentrations of lead relative to baseline samples of the capping material.

- The top layer of the sand cap showed slightly higher concentrations of lead than the capping material for several plots. A thin depositional layer was observed on the surface of the capping material of the 2-inch and the 4-inch arrowhead plots (Photograph 3-7) and is assumed to be the result suspended sediment deposition from minor flooding or wind-generated wave action. It is speculated that with low water levels, the 6-inch arrowhead plot may have had little or no water coverage relative to the thinner plot. In any case, the surface increment of all caps showed lead concentrations more than an order of magnitude below the waterfowl toxicity level.

Photograph 3-5. Custom technique using T-sampler inserted into a core tube to collect samples of the sand cap material from each test plot (October 14, 2016).

Photograph 3-6. Example of a core sample of the cap material from test plot A3 (4-inch cap) showing sand from 0 to 5 inches (below the cap surface) and native marsh soil at 5 inches and below (October 14, 2016).

Photograph 3-7. Sand cap covered with a thin layer (approximately 1 to 2 millimeters) of fine marsh sediment in the 2-inch bur-reed plot (September 22, 2016).

3.2.5 Surveying for Subsidence/Settlement

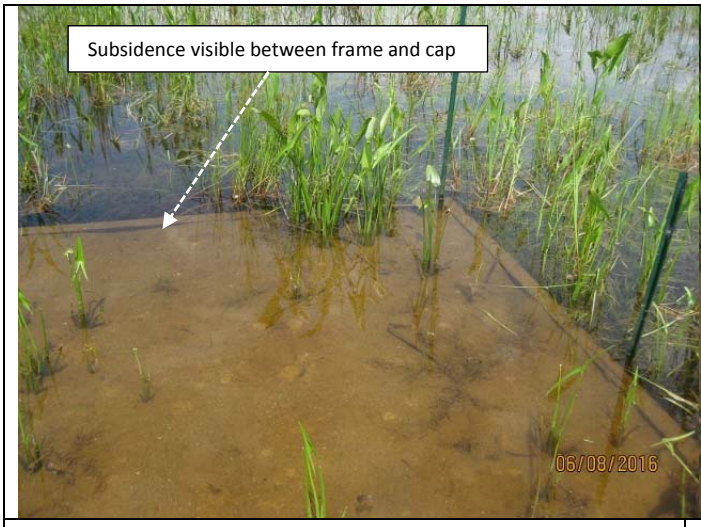
Surveying measurements were taken to document potential subsidence or changes in the surface elevation of the test plot. Each plot was sight leveled on February 10, 2016, and again on October 6, 2016. All four corners of the plot frame were surveyed, as well as the ground surface at eight locations within each plot (near the corners and halfway between each corner). Results are summarized in Table 3-5.

The following subtle but detectable changes in surface elevations were observed:

- The amount of settlement generally increased with increasing cap thickness.
- Most settlement occurred in plots with 6-inch caps (-0.05 to -0.07 foot, or approximately 5/8 to 3/4 inch of settlement) (Photographs 3-8 to 3-10).
- Minimal to no detectable change in elevation was noted for the 2-inch plots and control plots.

TABLE 3-5
Thin-layer Capping Treatment Plots Sight Level/Subsidence Data
Lane Marsh Pilot Project Testing – Phase 1, Year 1 (2016)

Cap Thickness	Change in Ground Elevation		
	Foot	**Inch**	**cm**
Arrowhead (A) Community			
0 inch (plot A1)	-0.002	-0.02	-0.06
2 inches (plot A2)	-0.006	-0.07	-0.2
4 inches (plot A3)	-0.04	-0.5	-1.2
6 inches (plot A4)	-0.05	-0.6	-1.5
Bur-reed (B) Community			
6 inches (plot B1)	-0.07	-0.8	-2.1
4 inches (plot B2)	-0.04	-0.5	-1.2
2 inches (plot B3)	0.035	0.4	1.1
0 inch (plot B4)	0.06	0.7	1.8



Photograph 3-8. Plot settlement indicated by difference between wood frame and cap surface in 6-inch cap plot LM A4 (June 8, 2016).

Photograph 3-9. Plot settlement indicated by difference between wood frame and cap surface in 6-inch cap plot LM B1 (June 8, 2016).

Photograph 3-10. Plot settlement indicated by difference between wood frame and cap surface in 6-inch cap plot LM B1 (September 22, 2016).

3.2.6 Cap Stability

The cap surface was visually assessed and appeared to be stable. During the June 8, 2016, inspection a slight unevenness was noted in Plots LM A2, LM A3, LM A4, LM B1, and LM B2. This may have been caused by differential settlement of the cap material, waterfowl feeding activity, and/or possible wave action. There appeared to be evidence of possible waterfowl dabbling and minor cap disturbance in test plots LM A3 and LM B1 (Photograph 3-13). Noticeable herbivory of the arrowhead leaves was observed in arrowhead test plots LM A2, LM A3, and LM A4 and are also assumed to have been caused by waterfowl.

3.2.7 Vegetation

The ability of existing vegetation to emerge through the thin-layer cap material was a key objective of the study. The Phase 1 test plots provided initial estimates of survival and re-establishment for several wetland plant species with varying material thickness.

Vegetation percent areal cover was documented and photographed in June and September 2016 during the first growing season after application of the cap material (Appendix C). Vegetation was documented beneath shallow water in June 2016; by September, little standing water remained in the test area, and the thicker (4- and 6-inch plots) were perched above the water level. Water levels in Lane Marsh during the pilot project are summarized in Section 2 (Figure 2-4).

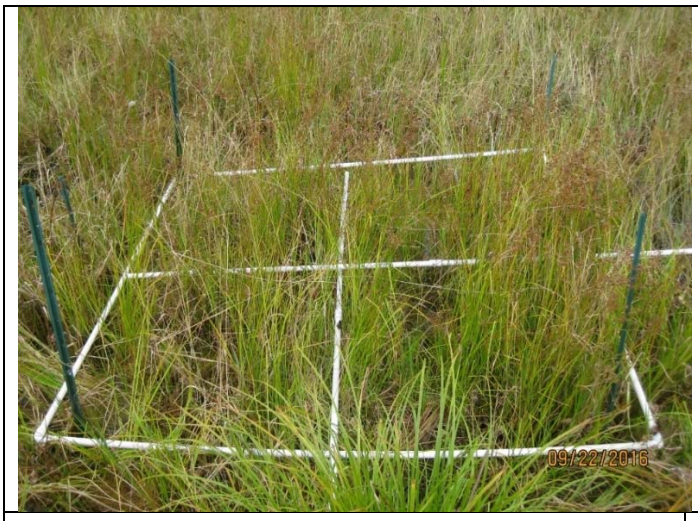
The relative percent cover of vegetation was estimated to compare the relative performance of each test plot. Care was taken during the initial layout of the plots so that the vegetation composition within each vegetation community (arrowhead and bur-reed) was uniform to achieve a similar starting baseline condition before the cap material was applied. The control plots that did not receive cap material served as references for comparing the relative performance of the other plots that received cap material.

Performance measures for regrowth were defined in the QAPP SPAF (CH2M, 2016), including maintaining the integrity of local vegetation (e.g., no substantive reduction in vegetation density and species composition compared to control plots). For purposes of this study, a substantive reduction was defined as the *percent cover* having more than a 20 percent reduction of the primary dominant plant species at the end of the second growing season, as compared to baseline vegetation monitoring and/or control test plots. A substantive reduction of species composition is defined as a reduction in the number of secondary dominant plant species at the end of the second growing season.

The relative vegetative cover at the end of the growing season (September 2016) for each test plot is shown in Photographs 3-11 through 3-18. The estimated relative percent vegetative cover in the test plots is shown on Figure 3-5. The following is a summary of the preliminary results from vegetation monitoring:

1. The percent vegetative cover in the test plots at the end of the first growing season varied by the thickness of cap material and by plant community, with the percent cover generally decreasing with increasing cap thickness:
   - The 2-inch bur-reed plot (LM B3) and the 2-inch arrowhead plot (LM A2) had percent vegetative covers nearly equal to their respective control plots, showing nearly full recovery.
   - The 4-inch and 6-inch plots had substantially lower percent vegetative cover compared to the control plots. Vegetation in these plots appeared to be relatively shorter and less robust than the 2-inch and control plots.
2. The primary dominant vegetative species composition was generally similar across plots within each plant community regardless of the thickness of cap material applied; it appeared to reflect the surrounding vegetation type.
3. Less robust species such as rush (*Juncus*), spikerush (*Eleocharis*), and sedge (*Carex*) (Photographs 3-11 and 3-12) were sensitive to cap material placement and exhibited substantially reduced regrowth.
4. Re-colonization of spikerush on the cap surface was already observed during the first growing season (Photograph 3-19).
5. The 4-inch and 6-inch plots appeared to be potentially dehydrated, perhaps due to the combination of being perched above the water level of the marsh during an unusually dry summer and having a well-drained sand cap without silt, clay, or organic matter to help maintain soil moisture.
6. Herbivory was a factor that may have also reduced the percent vegetative cover in the test plots, especially in the arrowhead plots (Photograph 3-20).
7. A reed canarygrass plant was observed in three of the eight plots in September 2016 (LM A1-control, LM B1-6”, and LM B4-control). Remedies that do not promote establishment of reed canarygrass or other noxious weeds need to be incorporated into the design.

Photographs of each test plot are included in Appendix C. The plant species observed in the test plots are listed with the vegetation monitoring data in Appendix D.



Photograph 3-11. Arrowhead control plot LM A1 without application of cap material (September 22, 2016).

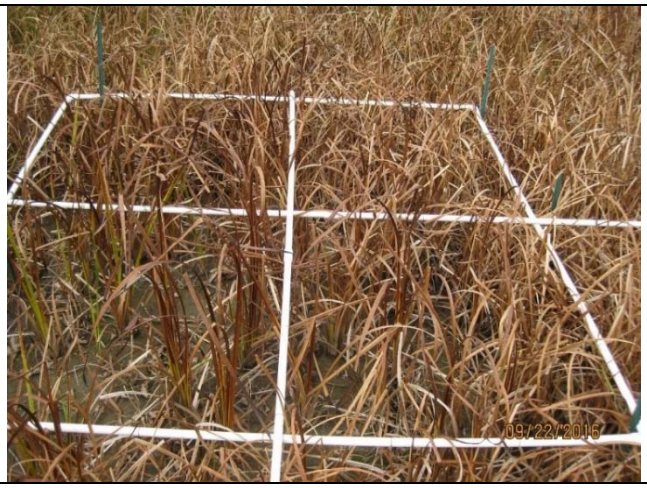
Photograph 3-12. Arrowhead 2-inch plot LM A2 showing similar but less robust cover than the control plot (September 22, 2016).

Photograph 3-13. Arrowhead 4-inch plot LM A3 showing reduced cover compared to the control plot (September 22, 2016).

Photograph 3-14. Arrowhead 6-inch plot LM A4 showing reduced cover compared to the control plot (September 22, 2016).

Photograph 3-15. Bur-reed control plot LM B4 without application of cap material (September 22, 2016).

Photograph 3-16. Bur-reed 2-inch plot LM B3 showing similar cover as the control plot (September 22, 2016).



Photograph 3-17. Bur-reed 4-inch plot LM B2 showing reduced cover compared to the control plot (September 22, 2016).

Photograph 3-18. Bur-reed 6-inch plot LM B1 showing reduced cover compared to the control plot (September 22, 2016).

Photograph 3-19. Spikerush colonized the cap surface during the first growing season, such as in the 6-inch bur-reed plot LM B1 (September 22, 2016).

Photograph 3-20. Evidence of herbivory of the arrowhead, presumably by waterfowl (June 8, 2016).

3.2.8 Benthic Sampling

Benthic sampling was conducted twice after cap placement. On June 8, 2016, one composite water column sample and one composite soil sample from each plant community near the test plots were collected and sent to a laboratory for identification of benthic invertebrates. On September 22, 2016, one sample from each control plot in each plant community was collected and sent to the laboratory. On September 22, 2016, samples from the cap material were collected and examined, but no benthic invertebrates were observed to be living in the sand cap material; therefore, the cap samples were not sent to the laboratory. The relatively coarse capping material (sand) may have been inhospitable for invertebrate habitat relative to the marsh loam soil.

The term “benthic” (meaning bottom dwelling) refers to the organisms that live in, crawl and attach themselves to the bottom or the substrate in waterbodies. The term “macroinvertebrate” refers to those invertebrates that can be seen with the eye. The benthic macroinvertebrate community is often a major component of the aquatic ecosystem. Benthic macroinvertebrate data from Lane Marsh (or in any marsh in the Lower Basin) has either not been collected previously or has not been previously reported. Therefore, the objectives of Lane Marsh sampling were to document benthic macroinvertebrates existing in the water and or/soil and how they differ between media (water versus soil) and between plant communities.

Monitoring of macroinvertebrate communities is often used as an indicator of water and sediment quality in aquatic environments because these organisms generally have limited mobility and are sensitive to chemical, physical, and biological stressors. Macroinvertebrates are small spineless organisms that are important food sources for higher trophic level organisms. Examples of macroinvertebrates include insect larvae (stonefly or dragonfly), worms, amphipods (scuds), midges (chironomids), and snails.

The following published methods were used as a guide for benthic sampling:

- **Water column** – *Protocols for Sampling Aquatic Macroinvertebrates in Freshwater Wetlands* (Maine Department of Environmental Protection, 2006).
- **Soil** – *Standard Operating Procedure for Benthic Invertebrate Field Sampling* (EPA, 2002b).

Benthic sampling of the water column involved using a 500-micrometer dip net to conduct a measured sweep of 1 meter. Three separate kick-net samples were collected in the vicinity of each set of test plots (at the gaps between test plot frames), placed in a 500-micrometer sieve and rinsed with water to remove fine sediment. The sample was then composited in a 1-liter poly bottle and preserved with 100 percent isopropyl alcohol (Photographs 3-21 and 3-22).

Benthic sampling of the soil in June and September involved using a plastic tube inserted a minimum of 6 inches into the marsh soil. Three separate soil samples were collected in the vicinity of each set of test plots (at the gaps between test plot frames), placed in a 500-micrometer sieve, and rinsed with water to remove fine sediment. The sample was then composited in a 1-liter poly bottle and preserved with 100 percent isopropyl alcohol.

Laboratory results from EcoAnalysts, Inc. are included in Appendix E.

Although not comprehensive, the information gathered in 2016 was intended to provide a baseline assessment of the macroinvertebrate community and was expected to be used for comparison with future monitoring following remedial pilot testing. Four macroinvertebrate samples were collected from the Lane Marsh substrate and water column in June 2016. Two additional substrate samples were collected in late September. The samples included organisms collected from both the water column and surface sediment (Photographs 3-20 and 3-21), while only sediment samples were collected in September 2016. Benthic macroinvertebrates were observed to be relatively abundant and active in and on the water. Abundant dragonfly activity and black flies were also observed on June 8, 2016.

Photograph 3-21. D-frame kick net used for benthic sampling (June 8, 2016).	**Photograph 3-22**. Bucket with 500-micrometer sieve used for rinsing benthic samples (June 8, 2016).

Benthic samples were coded as follows:

- Lane Marsh Arrowhead Water Column: LMA-W
- Lane March Arrowhead Sediment: LMA-S
- Lane Marsh Bur-reed Water Column: LMB-W
- Lane March Bur-reed Sediment: LMB-S

Results from the macroinvertebrate sampling at Lane Marsh in June 2016 are summarized in Table 3-6, with complete results presented in Appendix E. Results from the macroinvertebrate sampling in September 2016 are summarized in Table 3-7, with complete results presented in Appendix E. Interpretation of macroinvertebrate survey results can be challenging due to confounding factors and the absence of information from (uncontaminated) reference areas. Furthermore, although protocols for using macroinvertebrates to assess water and sediment quality in streams are common, they are less common for marsh or wetland areas. For example, the abundance and richness of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), collectively referred to as Ephemeroptera, Plecoptera, and Trichoptera (EPT) species, are recognized metrics for measurement of stream conditions because they are known to be sensitive to pollutants. These organisms are naturally much less prevalent in marsh or wetland environments because EPT species prefer well oxygenated environments. Therefore, the absense of EPT species in a marsh or wetland area may not be related to pollutant stresses. Nevertheless, observations from the semi-quantitative evaluation using the metrics provided in the laboratory report may be useful for understanding future changes to the macroinvertebrate community following remedial activities. The benthic evaluation included a focus on the total abundance, total taxa richness, EPT

species abundance and richness, comparisons of dominant taxa, the Hilsenhoff Biotic Index, and the Metals Tolerance Index.

Key findings form the June 2016 survey include the following:

- Midges (Psectrocladius sp., Ablabesmyia sp., and Chironomus sp.) represent the dominant taxa within all four samples, representing both the water column and soil. Worms and stoneflies were also considered part of the dominant taxa in the arrowhead plots (LMA-S and LMA-W).
- EPT species are notably absent from three of four samples and rare in the other (LMA-W). This may be indicative of contamination; however, limited flow and oxygen content within the marsh likely play a significant role.
- Diffferences in functional group and community composition between the plant communities appear to be marginal.
- Metals Tolerance Index (MTI) scores indicate the presence of metals-tolerant organisms and were consistent between samples (ranging from 3.4 to 3.6). The MTI uses a scale from 0 to 10, with higher values indicating more tolerant organisms and more polluted conditions.
- The Hilsenhoff Biotic Index (HBI) scores, which similarly indicate the presence of pollution tolerant organisms, was consistent between samples (ranging from 7.8 ot 8.7). The HBI uses a scale from 0 to 10, with higher values indicating more tolerant organisms and more polluted conditions.

TABLE 3-6
Summary of Macroinvertebrate Metrics from June 2016 by Medium and Vegetation Community at Lane Marsh
Lane Marsh ITLC Monitoring Report, Phase 1, Year 1 (2016)

Laboratory Identifier	Vegetation Community	Medium	Dominant Taxa by Genus (percent)	Metals Tolerance Index	Hilsenhoff Biotic Index	EPT Abundance/ Richness/%	Functional Group Composition (percent)
LMA-S	Arrowhead	Sediment	Tubificade sp. – 29.8 Psectrocladius sp. – 19.5 Ablabesmyia sp. – 12.5	3.4	8.7	0/0/0	Filterers – 1.1 Gatherers – 77.6 Predators – 15.8 Scrapers – 0.0 Shredders – 4.8 Piercers – 0.2 Unclassified – 0.4
LMB-S	Bur-reed	Sediment	Psectrocladius sp. – 17.4 Ablabesmyia sp. – 16.8 Chironomus sp. – 10.5	3.5	7.8	2/1/0.2	Filterers – 0.8 Gatherers – 62.9 Predators – 24.4 Scrapers – 0.2 Shredders – 11 Piercers – 0.0 Unclassified – 0.6
LMA-W	Arrowhead	Water	Psectrocladius sp. – 13.8 Ablabesmyia sp. – 9.4 Lestes sp. – 5.9	3.6	8.2	0/0/0	Filterers – 1.0 Gatherers – 51.1 Predators – 29.1 Scrapers – 0.0 Shredders – 4.9 Piercers – 3.4 Unclassified – 10.5
LMB-W	Bur-reed	Water	Ablabesmyia sp. – 4.6 Chironomus sp. – 4.3 Psectrocladius sp. – 3.3	3.6	8.0	0/0/0	Filterers – 1.0 Gatherers – 56.2 Predators – 30.4 Scrapers – 0.0 Shredders – 9.7 Piercers – 0.0 Unclassified – 2.4

The following are the key findings from the September 2016 survey:

- Total abundance of macroinvertebrates in sediment was significantly lower than in June. Qualitative field observations also noted that flying insects were mostly absent during this period.
- Midges represent the dominant taxa within both samples.
- EPT species are notably absent from both samples.
- The functional group composition at LMB-S comprises a larger percentage of shredders than were identified in June and also a larger percentage when compared with LMA-S.
- MTI scores indicate the presence of metals tolerant organisms and were consistent between samples (ranging from 4.0 to 4.25). As previously stated, the MTI uses a scale from 0 to 10, with higher values indicating more tolerant organisms and more polluted conditions.
- HBI scores, which similarly indicate the presence of pollution tolerant organisms, was consistent between samples (ranging from 6.8 to 7.3). As previously stated, the HBI uses a scale from 0 to 10 with higher values indicating more tolerant organisms, and more polluted conditions.

TABLE 3-7
Summary of Macroinvertebrate Metrics in Sediment from September 2016 by Vegetation Community at Lane Marsh
Lane Marsh ITLC Monitoring Report, Phase 1, Year 1 (2016)

Laboratory Identifier	Vegetation Community	Medium	Dominant Taxa by Genus (percent)	Metals Tolerance Index	Hilsenhoff Biotic Index	EPT Abundance/ Richness/%	Functional Group Composition (percent)
LMA-S	Arrowhead	Sediment	Bezzia/Palpomyai sp. – 12.5 Dasyhelea sp. – 12.5 Ablabesmyia sp. – 12.5 Corynoneura sp. – 12.5 Dicrotendipes sp. – 12.5 Procladius sp. – 12.5 Psectrocladius sp. – 12.5 Crangonyx sp. – 12.5	4.25	7.3	0/0/0	Filterers – 0.0 Gatherers – 62.5 Predators – 37.5 Scrapers – 0.0 Shredders – 0.0 Piercers – 0.0 Unclassified – 0.0
LMB-S	Bur-Reed	Sediment	Polypedilum sp. – 73 Chironomus sp. – 13 Sphaeriidae sp. – 3 Natarsia sp. – 3 Parachironomus sp. – 3 Procladius sp. – 3	4.0	6.8	0/0/0	Filterers – 3.3 Gatherers – 16.7 Predators – 6.7 Scrapers – 0.0 Shredders – 73.3 Piercers – 0.0 Unclassified – 0.6

Although it is good that the MTI and HBI have been relatively uniform between areas and seasons, the data set is small making reliable inferences challenging. The low MTI may be attributable to low metals concentrations in the cap material; the higher HBI may not be related to toxicity but rather to the currently overall poor substrate conditions for benthos (e.g., sand with limited flow and food). Another factor often used as an indicator of metals toxicity is the abundance and diversity of EPT species as they are known to be sensitive to heavy metals. These are largely absent here; however, this is more likely attributable to the wetland (rather than stream) habitat conditions present in Lane Marsh, rather than metals toxicity.

3.2.9 Bioturbation

Bioturbation is defined as disturbance of sedimentary deposits by living organisms. Evidence of waterfowl activity was observed in several plots:

- **Herbivory**. Herbivory of the vegetation was observed, particularly in the arrowhead plots, which were less densely vegetated. Arrowhead leaves were observed to have been eaten, presumably by dabbling waterfowl (Photograph 3-19).

- **Sand cap disturbance**. Minor disturbance of the sand cap from burrowing or dabbling waterfowl was observed in Test Plots LM A2 and LM B1 (Photograph 3-8).

3.2.10 Photographic Monitoring

During implementation of Phase 1, fixed photographic points were established to document and monitor the condition and vegetation re-establishment in the test plots. Reference points for repeat photographs will be established for individual plots and for the vicinity of the test plots. This allowed for consistent comparisons and monitoring. See site photographs in Appendix C.

3.2.11 Reporting and Adaptive Management

Additional monitoring will be conducted for a second growing season in summer 2017. An updated report will be prepared to document the results and data from the Year 2 monitoring and possible future Phase 2 work.

3.2.12 Data Quality Analysis Report

A data quality analysis report is included in Appendix F.

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CHAPTER 4

Phase 1 Key Outcomes – Year 1 (2016)

This chapter summarizes the preliminary Year 1 key outcomes for Phase 1 of the pilot project. Conclusions for Phase 1 of the ITLC pilot testing are summarized in Table 4-1. Continued monitoring of the test plots in 2017 (Year 2) will provide further completeness to the study.

TABLE 4-1
Preliminary Conclusions for ITLC Pilot Project Phase 1
Lane Marsh Pilot Project Testing—Phase 1, Year 1 (2016)

Parameter	Preliminary Conclusions
Vegetation	• Arrowhead and bur-reed grew through the 2-, 4-, and 6-inch thicknesses of sand that were tested. • Arrowhead and bur-reed grew through the thin layer (2-inch) of fine sand placed during the dormant season without a substantial reduction of marsh vegetation density. • Compared to similar vegetation in control plots, there was a substantial reduction of marsh vegetation density in the plots with 4 inches and 6 inches of cap material. • Small or finer vegetation species such as rush, spikerush, and sedge exhibited reduced regrowth in the 4-inch and 6-inch arrowhead plots. • Re-colonization of spikerush on the cap surface was already observed during the first growing season indicating favorable rapid natural regeneration by this small but prolific marsh plant.
Lead Concentration	• Average lead concentrations throughout the applied sand caps showed little to no vertical migration through the caps from below. • Wind-induced wave action was observed as a potential source of minor recontamination of the cap surface.
Subsidence/Settlement	• Some minor settlement of capping material was observed, especially in the thicker test plots. This is presumably due to the greater weight on underlying soil and/or the greater volume of material that was placed and settled.
Benthos	• Benthic macroinvertebrates are relatively abundant and diverse in water and soil at Lane Marsh during the active growing season in early summer (June 2016). • Midges represented the dominant taxa within the soil and water column in both the arrowhead and bur-reed vegetation communities. • Benthic scores indicated the relatively greater presence of metals or pollution tolerant organisms. The small data set and limited sampling makes reliable inferences challenging. • Benthic macroinvertebrates were not observed in cap material in September 2016. The cap material may be too coarse and lacking organic matter to be suitable habitat for these organisms.
Cap Material and Grain Size	• Fine sand was desirable as a trial cap material because it is clean, uniform, commercially available, and it had a minimal effect on water quality. • Fine sand is much coarser and is low in organic matter and soil nutrients compared to the native floodplain soil and may have affected saturation capacity in the thicker caps.
Bioturbation	• Indications of bioturbation from waterfowl were observed; possible burrowing or dabbling, and herbivory within the test plots appears to have occurred in test plots. The elevated test plots (shallower water) may have attracted waterfowl.

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CHAPTER 5

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Figures

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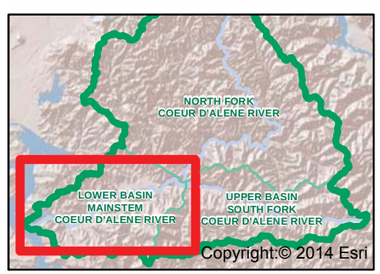

LEGEND

- USGS Gage Station (selected)
- City
- River Mile Marker
- Roads
- Waterbody
- Marsh or Slough

N

0 1 2 4 6 Kilometers

FIGURE 2-1

Lower Basin of the Coeur d'Alene River

Pilot Project Testing Design Elements of Incremental Thin-Layer Capping, Phase 1 (2016)
Lower Basin of the Coeur d'Alene River (OU3)

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ch2m

Trail of the
Coeur d' Alenes

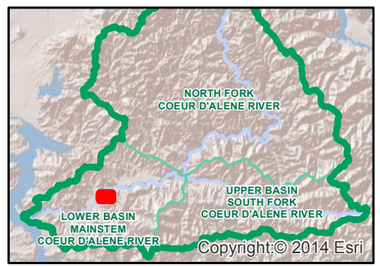
Test Plot Location at
Lane Marsh
(see Figure 3-1)

Coeur D'Alene River

Section 10
Section 11
Section 12
Section 13
Section 7
Section 18

R2W
R1W

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community



LEGEND

Tax Lot Parcels

Public Land Survey System (Township, Section, Range)

Sources:
Tax Lot Parcels - Kootenai County, 2015,
http://www.kcgov.us/departments/mapping/
Public Land Survey System data: BLM, 2015,
http://www.geocommunicator.gov/GeoComm/lsis_home/home/

N

0 400 800 1,600 Feet

FIGURE 2-2
Lane Marsh Site Map
Pilot Project Testing Design Elements of Incremental Thin-Layer Capping, Phase 1 (2016)
Lower Basin of the Coeur d'Alene River (OU3)

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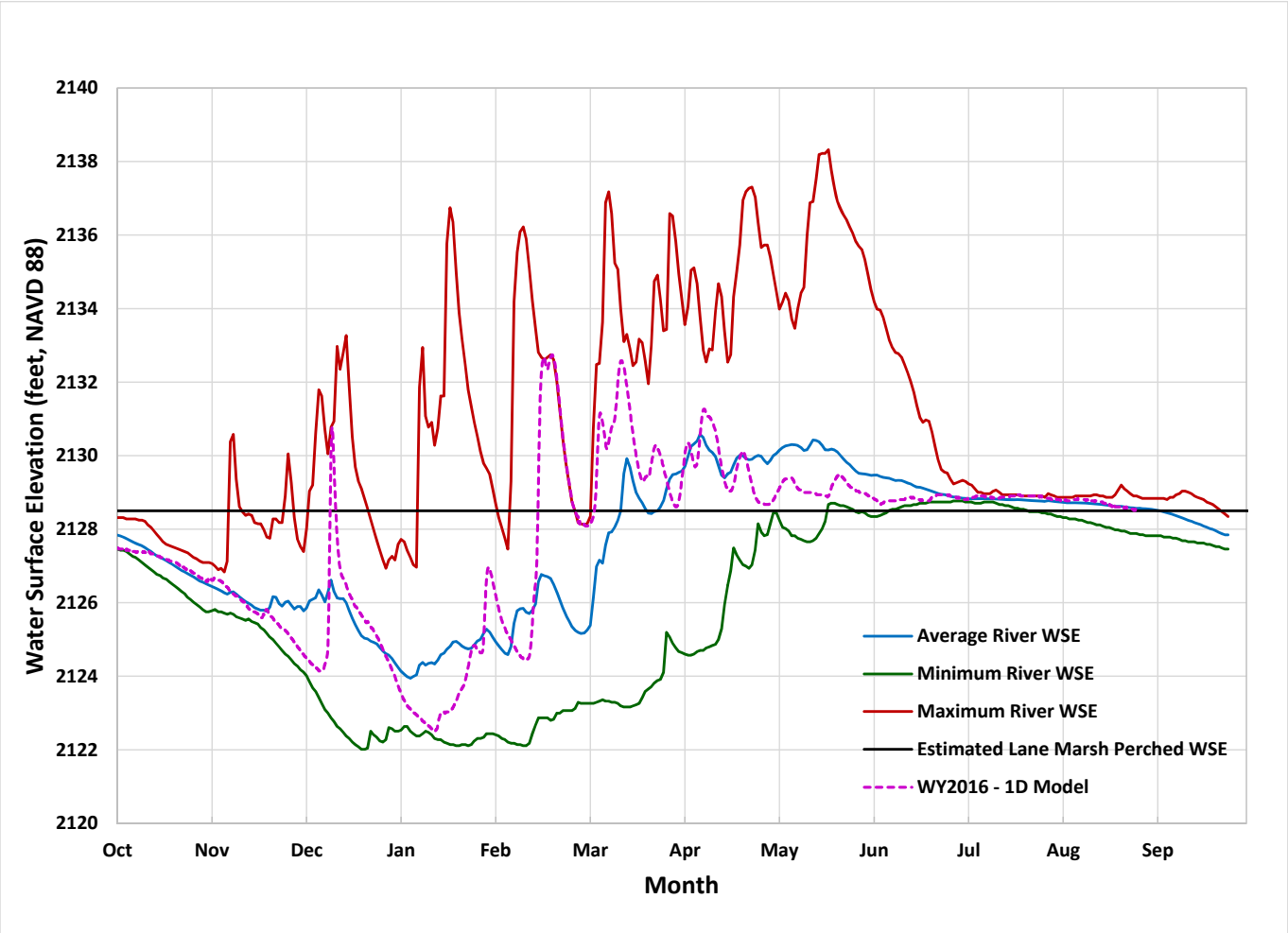


Figure 2-3. Average Modeled Water Surface Elevation of the Coeur d'Alene River near Lane Marsh South (2004 to 2016) and Modeled Water Surface Elevation for Water Year 2016 (October 2015 to August 2016).

Notes:

1. One-dimensional model run without tributary inflows. Inflow at Cataldo was increased by 5 percent to compensate for missing tributary inflows.
2. Flow from the Coeur d'Alene River to Lane Marsh is controlled by a culvert with apparent invert elevation of 2,128.3 feet NAVD88. This elevation has not been surveyed but is assumed, based on Lane Marsh logger data.
3. Lane Marsh logger data were last downloaded on February 5, 2016.
4. Available precipitation data is through August 2016.
5. WSE = water surface elevation

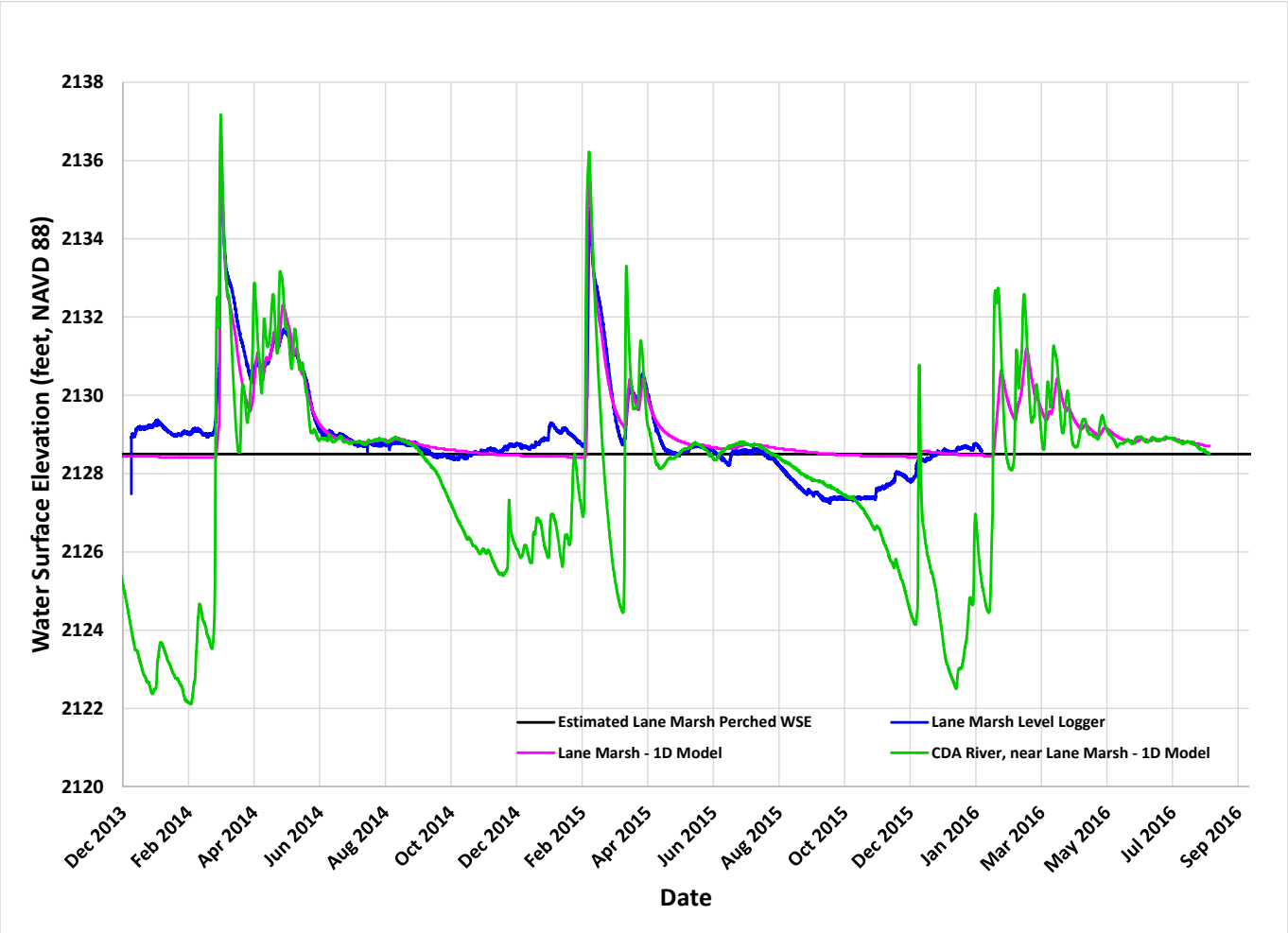
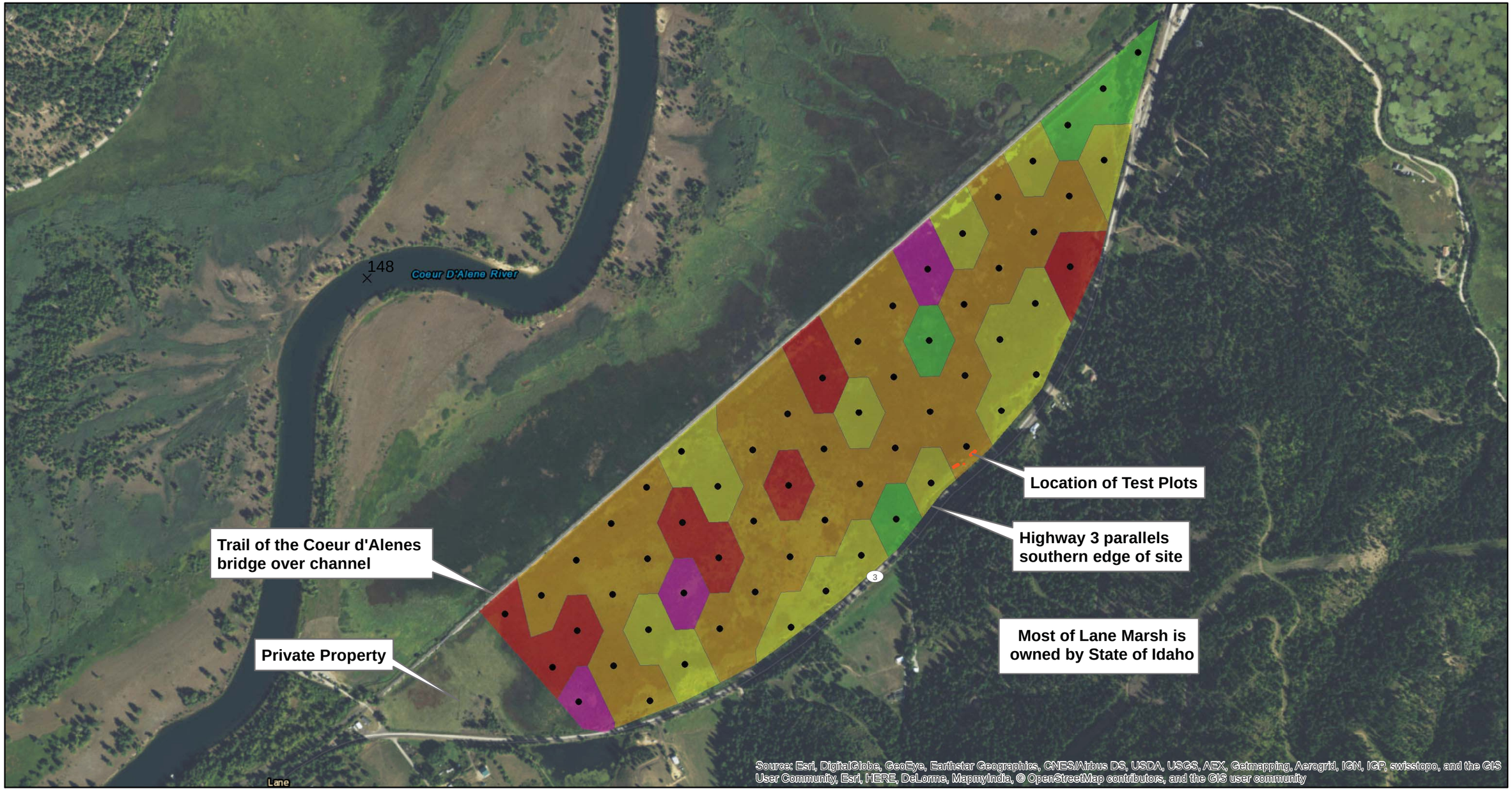
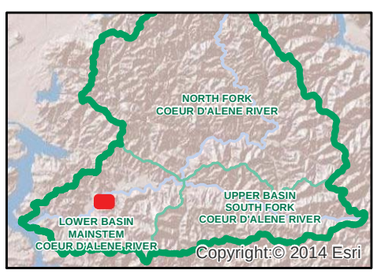


Figure 2-4. Measured Water Surface Elevation of Lane Marsh (level logger) and Modeled Water Surface Elevation for Lane Marsh and the Coeur d'Alene River near Lane Marsh**.**

Notes:

1. 1D model run without tributary inflows. Inflow at Cataldo was increased by 5 percent to compensate for missing tributary inflows.
2. Flow from the Coeur d'Alene River to Lane Marsh is controlled by a culvert with an apparent invert elevation of 2,128.3 feet NAVD88. This elevation has not been surveyed but is assumed, based on Lane Marsh logger data.
3. Lane Marsh logger data were last downloaded on February 5, 2016.
4. Available precipitation data are through August 2016.
5. WSE = water surface elevation





LEGEND

Test Plot

Lane Marsh - 2008 sampling (0 - 6 inches shown)

92% of samples >530 mg/kg Pb

- 8%: <530 mg/kg
- 26%: 530 - 1,800 mg/kg
- 48%: 1,800 - 4,000 mg/kg
- 13%: 4,000 - 6,000 mg/kg
- 5%: >6,000 mg/kg

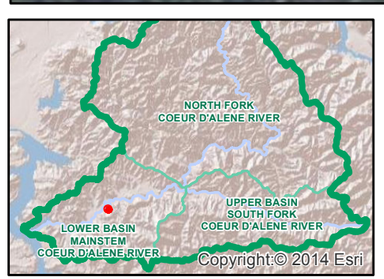
N

0 400 800 1,600 Feet

FIGURE 2-5
Lane Marsh South - Soil Lead Concentrations 0 to 6 inches, August 2008 Sampling
Pilot Project Testing Design Elements of Incremental Thin-Layer Capping, Phase 1 (2016)
Lower Basin of the Coeur d'Alene River (OU3)

ch2m

\\PDXFPP01\PROJ\USEPA\382081BUNKERHILL\LOWERBASIN\GIS\MAPFILES\2016\LANEMARSH\FIGURE3-4_LANEMARSHWTESTPLOTS.MXD GGEE 4/27/2016 1:08:30 PM



LEGEND

Test Plot

N

0 20 40 80 Feet

FIGURE 3-1
Lane Marsh Test Plot Locations
Pilot Project Testing Design Elements of Incremental Thin-Layer Capping, Phase 1 (2016)
Lower Basin of the Coeur d'Alene River (OU3)

ch2m

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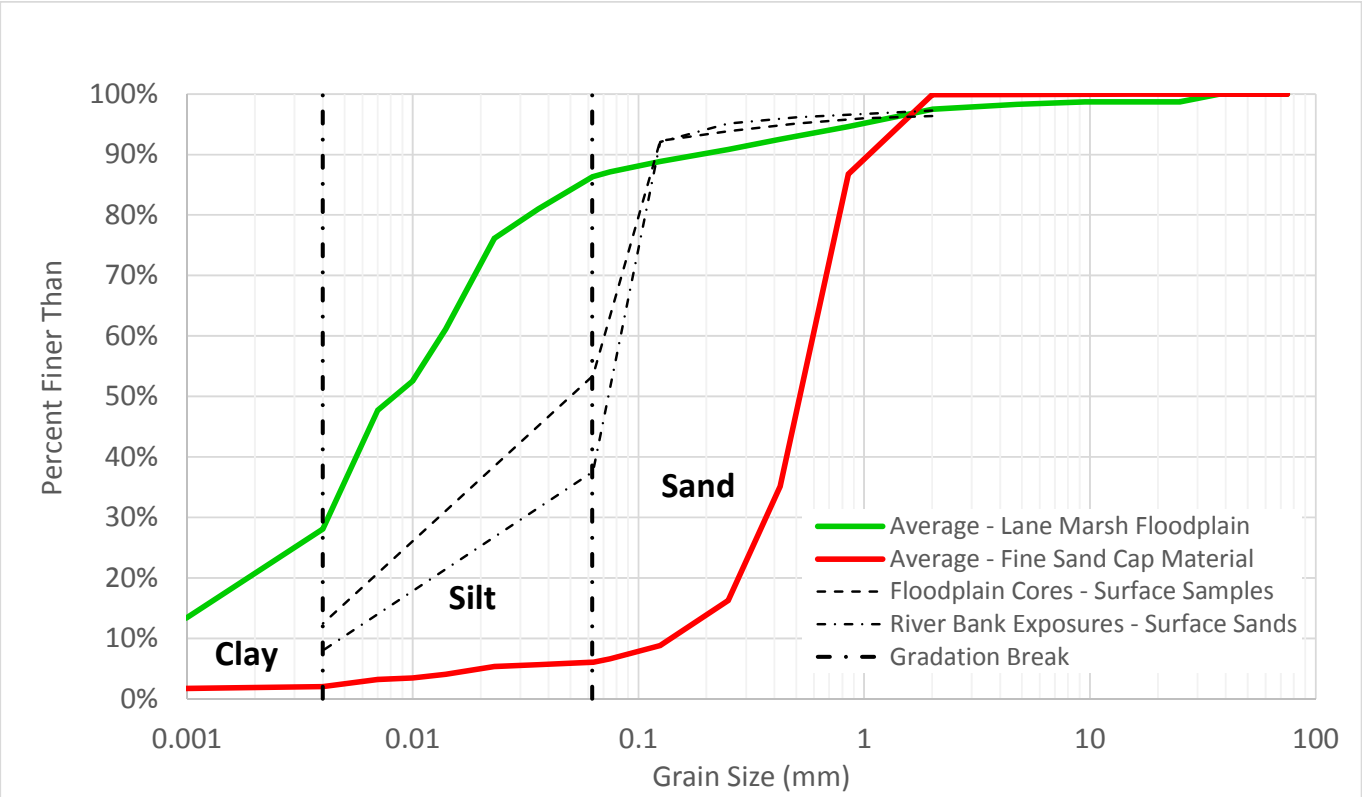

Figure 3-2. Grain Size Distribution for Lane Marsh Floodplain Soil (green curve) and the Fine Sand Cap Material Applied to Test Plots (red curve).

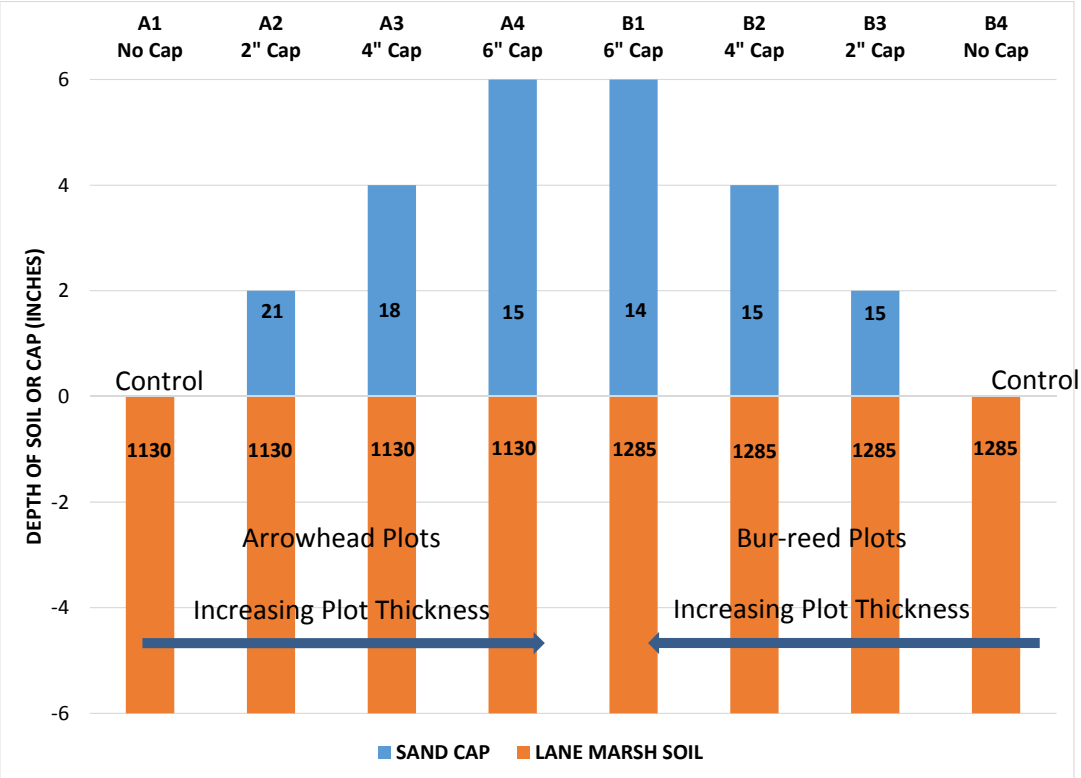

Figure 3-3. Average Lead Concentration for Sand Cap and Lane Marsh Soil in Arrowhead and Bur-reed Plots

Notes:
"A" plots are arrowhead; "B" plots are bur-reed.
Lead concentrations shown for Lane Marsh soil represent average values for 0 to 6 inches below ground surface.

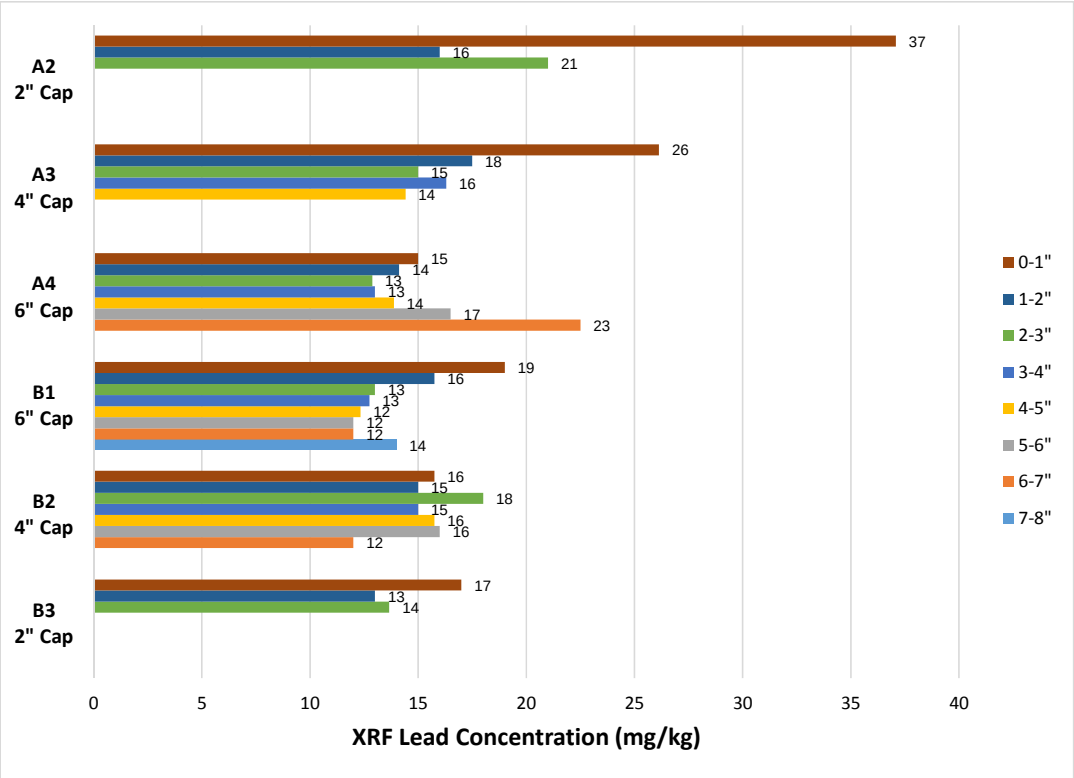

Figure 3-4. Lead Concentration for Each 1-inch Vertical Layer of Sand Cap for Arrowhead and Bur-reed Plots

Notes: "A" plots are arrowhead; "B" plots are bur-reed.

For plot A2 (2" Cap), potential uncertainty regarding the sampling method resulted in a discrepancy between the core length and cap thickness.

Surface layer is at top. Control plots not shown.

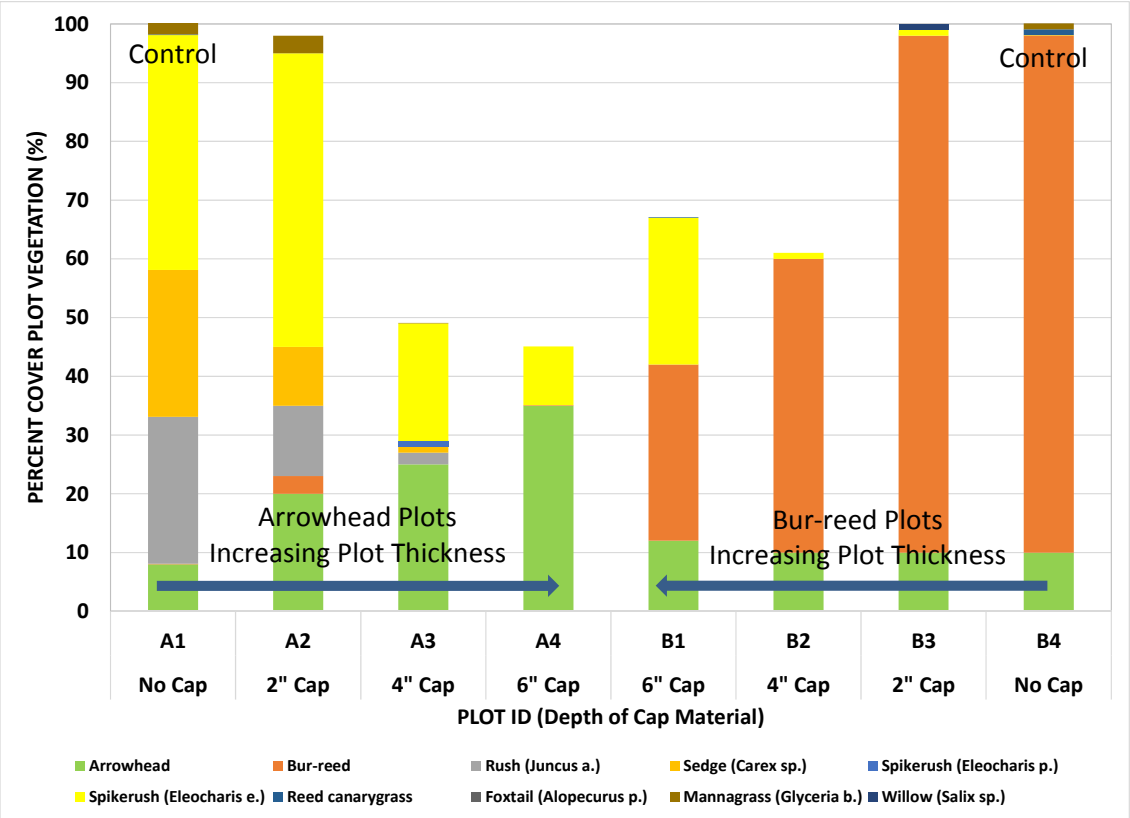

Figure 3-5. Vegetation Percent Cover in Test Plots at Lane Marsh after One Growing Season (2016).
Note:
"A" plots are arrowhead; "B" plots are bur-reed.

Appendix A
Gradation of Lane Marsh Soil at Test Plots and Fine Sand Cap Material

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Wyoming Road
8805 W Wyoming Road
Rathdrum, ID 83858
208-687-5213

Plant 120_01709-Wyoming Road

Product 2125-Fine Sand

Period: 01/01/2015 - 07/28/2015

Name/Title Ed Benson / QC Supervisor

Report Date 07/28/2015

Procedure	Sieve/Test	Result	Unit	Fine Sand
	3/8" (9.5mm)	100.0	%	
	1/4" (6.3mm)	100.0	%	
	#4 (4.75mm)	100.0	%	
	#8 (2.36mm)	100.0	%	98-100
	#16 (1.18mm)	98.5	%	95-100
	#30 (0.6mm)	60.6	%	80-95
	#50 (0.3mm)	20.3	%	30-50
	#100 (0.15mm)	7.6	%	6-13
	#200 (75um)	3.99	%	0-5
	Pan	0.00	%	

ALLWEST Testing & Engineering

LABORATORY SUMMARY

PROJECT NAME:	Source Investigation	SOURCE:	Wyoming Pit
CLIENT NAME:	Interstate Concrete & Asphalt	PROJECT NO:	112-077G
LOCATION:	Post Falls, Idaho	DATE:	4/4/2012

SAMPLE NUMBER:		1		2	3	
LAB SAMPLE NUMBER:		A312-048		A312-048	A312-048	
SAMPLED BY:		C. Meehan		C. Meehan	C. Meehan	
DATE SAMPLED:		3/5/2012		3/5/2012	3/5/2012	
MATERIAL:		Pit Run		Fine Sand	Washed Sand	
TEST DESCRIPTION	SPEC					
IDAHO DEGRADATION (IDAHO T15)						
Before Weight (%)		5.6				
After Weight (%)		10.6				
Degradation Loss (%)	5.0 MAX.	5.0				
Sieve Analysis (AASHTO T27/T248)		BEFORE	AFTER			
3/4"		100	100			
1/2"		83	84			
3/8"		67	67			
#4		50	50			
#8		33	35			
#16		20	24			
#30		13	18			
#50		9	16			
#100		7	13			
#200		5.6	10.6			
SAND EQUIVALENT (AASHTO T176)	30 MIN	73	54			
L.A. ABRASION (AASHTO T96)						
Percent Loss (%)	35 MAX	13				
DMSO						
Percent Loss (%)	12 MAX	0.1				
SULFATE SOUNDNESS (AASHTO T104)						
Fine Aggregate (%)	12 MAX	-		0.3	0.7	
Coarse Aggregate (%)	12 MAX	0.1				

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☒ 2127 2nd Avenue North • Lewiston, ID 83501 • (208) 743-5710 • Fax (208) 743-8270

Prepared: 01.28.11

ALLWEST Testing & Engineering

LABORATORY SUMMARY

PROJECT NAME:	Source Investigation	SOURCE:	Wyoming Pit
CLIENT NAME:	Interstate Concrete & Asphalt	PROJECT NO:	112-077G
LOCATION:	Post Falls, Idaho	DATE:	4/4/2012

SAMPLE NUMBER:		1	2	3	
LAB SAMPLE NUMBER:		A312-048	A312-048	A312-048	
SAMPLED BY:		C. Meehan	C. Meehan	C. Meehan	
DATE SAMPLED:		3/5/2012	3/5/2012	3/5/2012	
MATERIAL:		Pit Run	Fine Sand	Washed Sand	
TEST DESCRIPTION	SPEC				
CLAY LUMPS & FRIABLE PARTICLES					
(AASHTO T112)					
Fine Aggregate		-	-	0.1	
Coarse Aggregate		0.1			
LIGHT WEIGHT PIECES (ASTM C123-04)					
Fine Aggregate		-	0	0	
ORGANIC IMPURITIES					
(AASHTO T267 / ASTM D2974)	< 3	-	1-Non Organic	1-Non Organic	
FINE SPECIFIC GRAVITY (AASHTO T84)					
Bulk Specific Gravity		-	2.573	2.519	
Percent Absorption (%)		-	1.9	2.7	
COARSE SPECIFIC GRAVITY (AASHTO T85)					
Bulk Specific Gravity		2.622	-	-	
Percent Absorption (%)		1.2	-	-	

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Prepared: 01.28.11

Appendix B
Agronomic and Lead Analysis of Lane Marsh Soils at Test Plots

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A & L WESTERN AGRICULTURAL LABORATORIES

10220 SW NIMBUS AVE Bldg K-9 I PORTLAND OREGON 97223 I (503) 968-9225 I FAX (503) 598-7702

REPORT NUMBER: 16-048-109

CLIENT NO: 3971

SEND TO: CH2M HILL
2020 SW 4TH AVE 3RD FLOOR
PORTLAND, OR 97201

SUBMITTED BY: STEVE DEMUS

GROWER: 382081.FI.12.03.05

DATE OF REPORT: 02/26/16

SOIL ANALYSIS REPORT

SAMPLE ID	LAB NUMBER	Organic Matter		Phosphorus		Potassium	Magnesium	Calcium	Sodium	pH		Hydrogen	Cation Exchange Capacity	PERCENT CATION SATURATION (COMPUTED)				
		* % Rating	** ENR lbs/A	P1 (Weak Bray) **** * ppm	$NaHCO_3$-P (OlsenMethod) **** * ppm	K ***** * ppm	Mg *** * ppm	Ca *** * ppm	Na *** * ppm	Soil pH	Buffer Index	H meq/100g	C.E.C. meq/100g	K %	Mg %	Ca %	H %	Na %
CAP	58429	0.3VL	37	7 *	6L	36	114	473	9	7.7	7.8	0.0	3.4	2.7	27.2	68.9	0.0	1.2

* Weak Bray unreliable at M or H excess lime or pH > 7.5

SAMPLE NUMBER	Nitrogen NO_3-N ppm	Sulfur SO_4-S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Excess Lime Rating	Soluble Salts mmhos/cm	Chloride Cl ppm		PARTICLE SIZE ANALYSIS			
												SAND %	SILT %	CLAY %	SOIL TEXTURE
CAP	1VL	1VL	0.3VL	2L	21H	0.2VL	0.1VL	L	0.1VL			92	2	6	SAND

* CODE TO RATING: VERY LOW (VL), LOW (L), MEDIUM (M), HIGH (H), AND VERY HIGH (VH).
** ENR - ESTIMATED NITROGEN RELEASE
*** MULTIPLY THE RESULTS IN ppm BY 2 TO CONVERT TO LBS. PER ACRE OF THE ELEMENTAL FORM
**** MULTIPLY THE RESULTS IN ppm BY 4.6 TO CONVERT TO LBS. PER ACRE P_2O_5
***** MULTIPLY THE RESULTS IN ppm BY 2.4 TO CONVERT TO LBS. PER ACRE K_2O
MOST SOILS WEIGH TWO (2) MILLION POUNDS (DRY WEIGHT) FOR AN ACRE OF SOIL 6-2/3 INCHES DEEP

This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

Darcy L. Peebles

Darcy L. Peebles, CCA
A & L WESTERN LABORATORIES, INC.

A & L WESTERN AGRICULTURAL LABORATORIES

10220 SW NIMBUS AVE Bldg K-9 I PORTLAND OREGON 97223 I (503) 968-9225 I FAX (503) 598-7702

REPORT NUMBER: 16-048-109 **CLIENT:** 3971

SUBMITTED BY: STEVE DEMUS

SEND TO: CH2M HILL
2020 SW 4TH AVE 3RD FLOOR
PORTLAND, OR 97201

GROWER: 382081.FI.12.03.05

DATE OF REPORT: 02/26/16

SOIL FERTILITY GUIDELINES

RATE: lb/acre **PAGE:** 1

Sample ID	Lab Number	Crop	SOIL AMENDMENTS				Nitrogen N	Phosphate P_2O_5	Potash K_2O	Magnesium Mg	Sulfur SO_4-S	Zinc Zn	Manganese Mn	Iron Fe	Copper Cu	Boron B
			Dolomite	Lime	Gypsum	Elemental Sulfur										
CAP	58429	WETLAND				900	140	140	270			10	10		10	2.0

NOTES:

COMMENTS

NITROGEN: Use local conditions and experience with variety to determine rates and timing. Allow for nitrate levels in your water source also (ppm NO3 X 0.61 = lb N/ac-ft water). Monitor tissue-N.
BORON: Aim for soil levels above 0.5 ppm to avoid a deficiency. A tissue analysis at the appropriate time will determine more accurately, plant availability. ADD BORON WITH CAUTION.
ORGANIC MATTER: Low levels may restrict beneficial microbial activity and lead to soil compaction and erosion. Consider the inclusion of compost and/or cover crops if a concern.
INCORPORATE 3.0 to 6.0 cubic yards/1,000 sq ft (one to two-inch layer) of nitrified/composted organic amendment where organic matter levels are rated as LOW ("L") to VERY LOW ("VL").
* MICRONUTRIENTS: Where levels are low, maintaining correct soil pH and adequate organic matter levels may be sufficient to correct deficiencies.

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Darcy L. Peebles

Darcy L. Peebles, CCA
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10220 SW NIMBUS AVE Bldg K-9 I PORTLAND OREGON 97223 I (503) 968-9225 I FAX (503) 598-7702

REPORT NUMBER: 15-356-048

CLIENT NO: 3971

SEND TO: CH2M HILL
2020 SW 4TH AVE 3RD FLOOR
PORTLAND, OR 97201

SUBMITTED BY: STEVE DEMUS-SPOKANE

GROWER: 382081.FI.12.03.05

DATE OF REPORT: 12/29/15

SOIL ANALYSIS REPORT

SAMPLE ID	LAB NUMBER	Organic Matter		Phosphorus		Potassium	Magnesium	Calcium	Sodium	pH		Hydrogen	Cation Exchange Capacity	PERCENT CATION SATURATION (COMPUTED)				
		* % Rating	** ENR lbs/A	P1 (Weak Bray) **** * ppm	NaHCO$_3$-P (OlsenMethod) **** * ppm	K ***** * ppm	Mg *** * ppm	Ca *** * ppm	Na *** * ppm	Soil pH	Buffer Index	H meq/100g	C.E.C. meq/100g	K %	Mg %	Ca %	H %	Na %
LM-A	59387	17.9VH	388	5VL	11**	58L	108L	517VL	83M	4.5	5.7	5.5	9.5	1.6	9.4	27.2	58.0	3.8
LM-B	59388	21.6VH	462	3VL	12**	53L	103L	365VL	103M	4.1	5.6	9.3	12.5	1.1	6.8	14.5	74.0	3.6
LM-FD	59389	18.2VH	393	6VL	10**	44L	112L	462VL	94M	4.2	5.7	8.9	12.7	0.9	7.3	18.2	70.4	3.2

** NaHCO3-P unreliable at this soil pH

SAMPLE NUMBER	Nitrogen NO$_3$-N ppm	Sulfur SO$_4$-S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Excess Lime Rating	Soluble Salts mmhos/cm	Chloride Cl ppm		PARTICLE SIZE ANALYSIS			
												SAND %	SILT %	CLAY %	SOIL TEXTURE
LM-A	7L	130VH	20.4VH	9M	133VH	0.8L	0.2VL	L	0.8M			38	48	13	LOAM
LM-B	5L	107VH	18.8VH	9M	145VH	0.7L	0.2VL	L	0.8M			44	39	17	LOAM
LM-FD	5L	140VH	20.8VH	9M	140VH	0.6L	0.2VL	L	0.9M			38	47	15	LOAM

* CODE TO RATING: VERY LOW (VL), LOW (L), MEDIUM (M), HIGH (H), AND VERY HIGH (VH).
** ENR - ESTIMATED NITROGEN RELEASE
*** MULTIPLY THE RESULTS IN ppm BY 2 TO CONVERT TO LBS. PER ACRE OF THE ELEMENTAL FORM
**** MULTIPLY THE RESULTS IN ppm BY 4.6 TO CONVERT TO LBS. PER ACRE P_2O_5
***** MULTIPLY THE RESULTS IN ppm BY 2.4 TO CONVERT TO LBS. PER ACRE K_2O
MOST SOILS WEIGH TWO (2) MILLION POUNDS (DRY WEIGHT) FOR AN ACRE OF SOIL 6-2/3 INCHES DEEP

This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

Darcy L. Peebles

Darcy L. Peebles, CCA
A & L WESTERN LABORATORIES, INC.

A & L WESTERN AGRICULTURAL LABORATORIES

10220 SW NIMBUS AVE Bldg K-9 I PORTLAND OREGON 97223 I (503) 968-9225 I FAX (503) 598-7702

REPORT NUMBER: 15-356-048 **CLIENT:** 3971

SUBMITTED BY: STEVE DEMUS-SPOKANE

SEND TO: CH2M HILL
2020 SW 4TH AVE 3RD FLOOR
PORTLAND, OR 97201

GROWER: 382081.FI.12.03.05

DATE OF REPORT: 12/29/15

SOIL FERTILITY GUIDELINES

RATE: lb/acre **PAGE:** 1

Sample ID	Lab Number	Crop	SOIL AMENDMENTS				Nitrogen N	Phosphate P_2O_5	Potash K_2O	Magnesium Mg	Sulfur SO_4-S	Zinc Zn	Manganese Mn	Iron Fe	Copper Cu	Boron B
			Dolomite	Lime	Gypsum	Elemental Sulfur										
LM-A	59387	WETLAND SOIL	9999				40	200	210							2.0
LM-B	59388	WETLAND SOIL	9999				40	200	210							2.0
LM-FD	59389	WETLAND SOIL	9999				40	200	240							2.0

NOTES:

COMMENTS

You may want to split high lime requirements over more than one year if you are unable to adequately incorporate the material.
REVEGETATION should preferably be conducted on soils with a pH above 6.5 but below 7.5 and more than 2% organic matter. A minimum of 30 lb N/acre (15 ppm NO3-N) should be available at planting.
IDEALLY, fertilize just before the first germinating rain if irrigation is not available. For maximum economic return, one should probably not fertilize more than once every two years.
BORON: Aim for soil levels above 0.5 ppm to avoid a deficiency. A tissue analysis at the appropriate time will determine more accurately, plant availability. ADD BORON WITH CAUTION.
AMMONIUM AND UREA fertilizers applied directly after liming may lead to some volatilization of nitrogen. Keep this in mind when timing operations. Maintain calcium above 1000 ppm.

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1311 Woodland Avenue, Suite 1 • Modesto, California 95351 • (209) 529-4080

Report No: 15-356-048

Account No:3971

Send to: CH2M HILL
2020 SW 4TH AVE 3RD FLOOR
PORTLAND,OR 97201
Attention: STEVE DEMUS

Grower: 382081.FL.12.03.05

Submitted by: STEVE DEMUS

Date Received: 12/18/15
Date Reported: 01/12/16

SOIL ANALYSIS REPORT

Sample Preparation Method: EPA SW846-3050B

Analyte:	**Lead**
Detection Limit:	**0.5 mg/kg**
Method Code:	**EPA SW 846-6010**

Lab Number:	**Sample ID:**	**mg/kg (ppm)**
59387	LM-A	1083.6
59388	LM-B	1218.2

BDL - INDICATES THE LEVEL FOUND IS BELOW THE ESTABLISHED DETECTION LIMIT FOR THAT ANALYTE.

A & L Western Agricultural Laboratories, Inc.

Phoebe Gordon, PhD
Agronomist

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LANE MARSH ITLC TEST PLOT SEDIMENT CORE - XRF LEAD CONCENTRATIONS - OCT 2016
ARROWHEAD (LMA)

A4 LMA - 6" Lead concentration (ppm)

bgs	NE	NW	SE	SW	Average	
0					**1130**	
0-0.5	***17***	***22***	***17***	***12***	***17.0***	15.0 0-1"
0.5-1.0	***15***	***12***	***13***	***12***	***13.0***	
1.0-1.5	12	18	14	12	***14.0***	14.1 1-2"
1.5-2.0	13	20	12	12	***14.3***	
2.0-2.5	14	12	13	12	***12.8***	12.9 2-3"
2.5-3.0	12	13	12	15	***13.0***	
3.0-3.5	12	18	13	12	***13.8***	13.0 3-4"
3.5-4.0	13	12	12	12	***12.3***	
4.0-4.5	15	14	12	16	***14.3***	13.9 4-5"
4.5-5.0	12	16	14	12	***13.5***	
5.0-5.5	15	***21***	***25***	***12***	***18.3***	16.5 5-6"
5.5-6.0	12	***17***	***18***	***12***	***14.8***	
6.0-6.5	***15***				***15.0***	22.5 6-7"
6.5-7.0	***30***				***30.0***	
<7"					**15.4**	**Total Ave**

A3 LMA - 4" Lead concentration (ppm)

bgs	NE	NW	SE	SW	Average	
0					**1130**	
0-0.5	***26***	***28***	***20***	***27***	***25.3***	26.1 0-1"
0.5-1.0	***23***	***24***	***43***	***18***	***27.0***	
1.0-1.5	20	14	21	12	***16.8***	17.5 1-2"
1.5-2.0	18	19	19	17	***18.3***	
2.0-2.5	17	14	15	12	***14.5***	15.0 2-3"
2.5-3.0	15	12	***12***	23	***15.5***	
3.0-3.5	23	12	***26***	12	***18.3***	16.3 3-4"
3.5-4.0	19	***12***		12	***14.3***	
4.0-4.5	***12***	***22***		***12***	***15.3***	14.4 4-5"
4.5-5.0	***15***			***12***	***13.5***	
<5"					**17.9**	**Total Ave**

A2 LMA - 2" Lead concentration (ppm)

bgs	NE	NW	SE	SW	Average		For SW
0					**1130**		
0-0.5	***21***	***82***		***13***	***38.7***		37.1 0-1"
0.5-1.0	***15***	***56***			***35.5***		
1.0-1.5	22	19		19	***20.0***		21.0 1-2"
1.5-2.0	19	25			***22.0***		
2.0-2.5	25	12		12	***16.3***		14.7 2-3"
2.5-3.0	14	12			***13.0***		
3.0-3.5	14	***16***		14	***14.7***		15.3 3-4"
3.5-4.0	13	***19***			***16.0***		
4.0-5.0	11			12	***11.5***		11.5 4-5"
5.0-6.0	***29***			***13***	***21.0***		21.0 5-6"
<6"					**20.9**	**Total Ave**	

Could not Collect

Switched to 1" increments

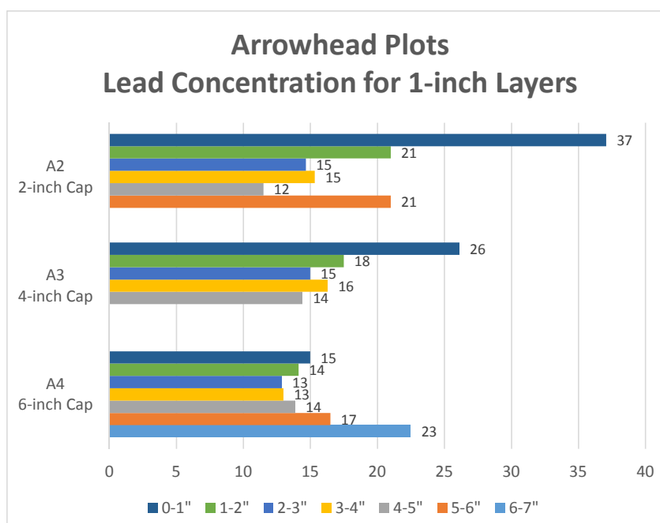
NOTE: For plot A2 (2" Cap), potential uncertainty in sampling method resulted in discrepancy between core length and cap thickness.

Top one inch and bottom one inch composited for laboratory samples. These sub-samples are bold and italicized.
Values in Red are reported as less than (<) - Detection Limit of XRF instrument.

Sample ID	XRF Lead (ppm)
LMA-6-0-1	16
LMA-6-5-6	16
LMA-4-0-1	14
LMA-4-3-4	14
LMA-2-0-1	27
LMA-2-1-2	26

LMA XRF Summary

Sample Depth	A4 6-inch Cap	A3 4-inch Cap	A2 2-inch Cap
7	23		
6	17		21
5	14	14	12
4	13	16	15
3	13	15	15
2	14	18	21
1	15	26	37



LANE MARSH ITLC TEST PLOT SEDIMENT CORE - XRF LEAD CONCENTRATIONS - OCT 2016

BUR-REED (LMB)

B1 LMB 6"	Lead concentration (ppm)				Average
Sample Depth	**NE**	**NW**	**SE**	**SW**	**LMB 6-inch**
1	***17***	***32***	***12***	***15***	***19.0***
2	13	12	12	26	***15.8***
3	12	13	13	14	***13.0***
4	12	***12***	12	15	***12.8***
5	12		13	12	***12.3***
6	***11***		***12***	*13*	***12.0***
7				12	***12.0***
8				***14***	***14.0***
<8"					**13.9 Total Ave**

B2 LMB 4"	Lead concentration (ppm)				Average
bgs	**NE**	**NW**	**SE**	**SW**	**LMB 4-inch**
0-1"	***12***	***19***	***12***	***20***	***15.8***
1-2"	16	13	15	16	***15.0***
2-3"	18	12	24	18	***18.0***
3-4"	12	21	14	13	***15.0***
4-5"	***20***	16	13	***14***	***15.8***
5-6"		***18***	14		***16.0***
6-7"			***12***		***12.0***
7-8"					
					15.4 Total Ave

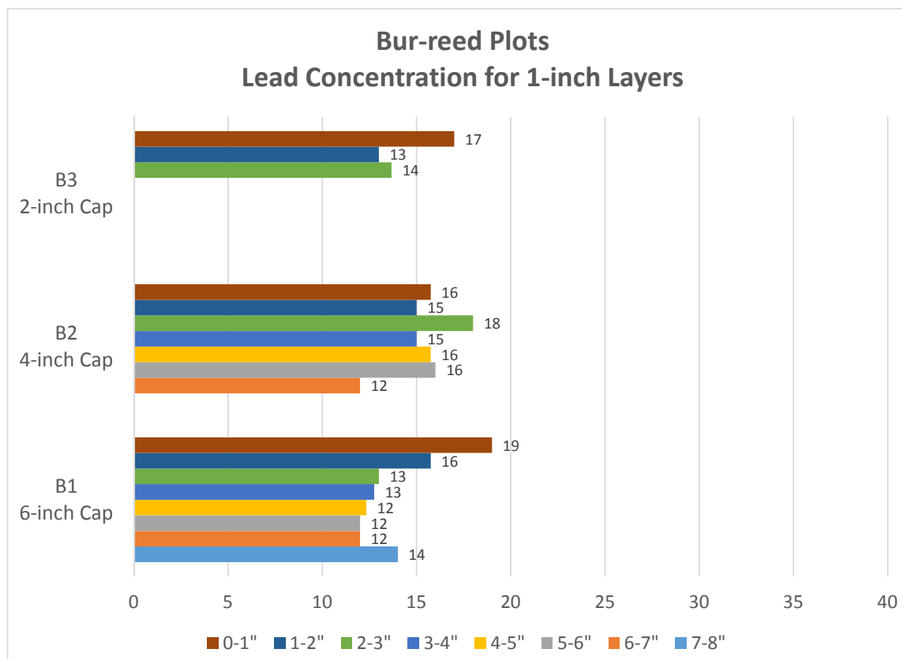
B3 LMB 2"	Lead concentration (ppm)				Average	LMB - 0 inch
bgs	**NE**	**NW**	**SE**	**SW**	**LMB 2-inch**	**LMB - 0 inch**
0-1"	***12***	***19***	***17***	***20***	***17.0***	
1-2"	12	12	16	***12***	***13.0***	
2-3"	***18***	***11***	***12***		***13.7***	
3-4"						
					14.6 Total Ave	

Top one inch and bottom one inch composited for laboratory samples. These sub-samples are bold and italicized.
Values in Red are reported as less than (<) - Detection Limit of XRF instrument.

Sample ID	XRF Lead (ppm)
LMB-6-0-1	<12
LMB-6-5-6	17
LMB-4-0-1	<11
LMB-4-3-4	27
LMB-2-0-1	18
LMB-2-1-2	26

LMB XRF Summary

Sample Depth	B1 6-inch Cap	B2 4-inch Cap	B3 2-inch Cap
8	14		
7	12	12	
6	12	16	
5	12	16	
4	13	15	
3	13	18	14
2	16	15	13
1	19	16	17



Appendix C
Photographic Monitoring of Test Plots – Year 1 (2016)

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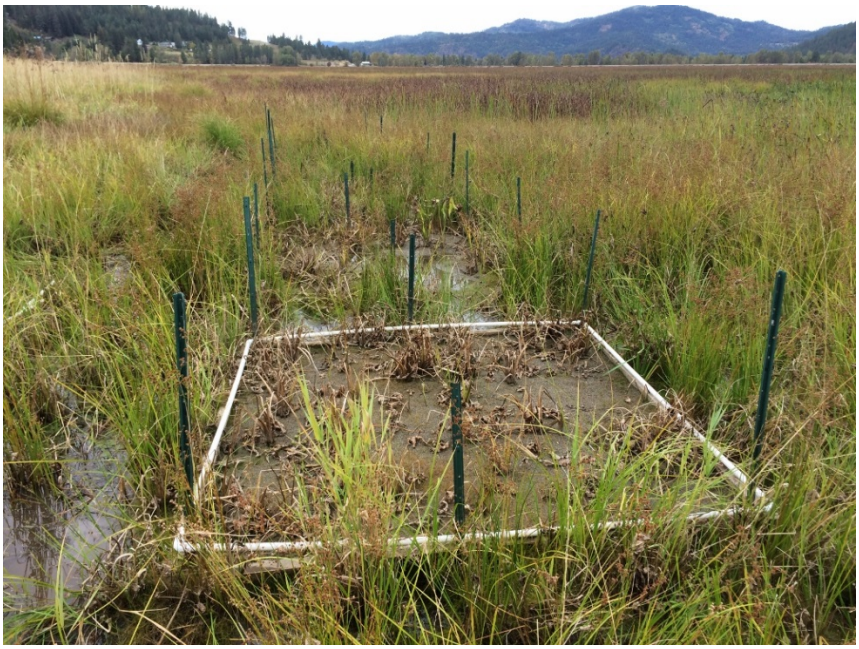
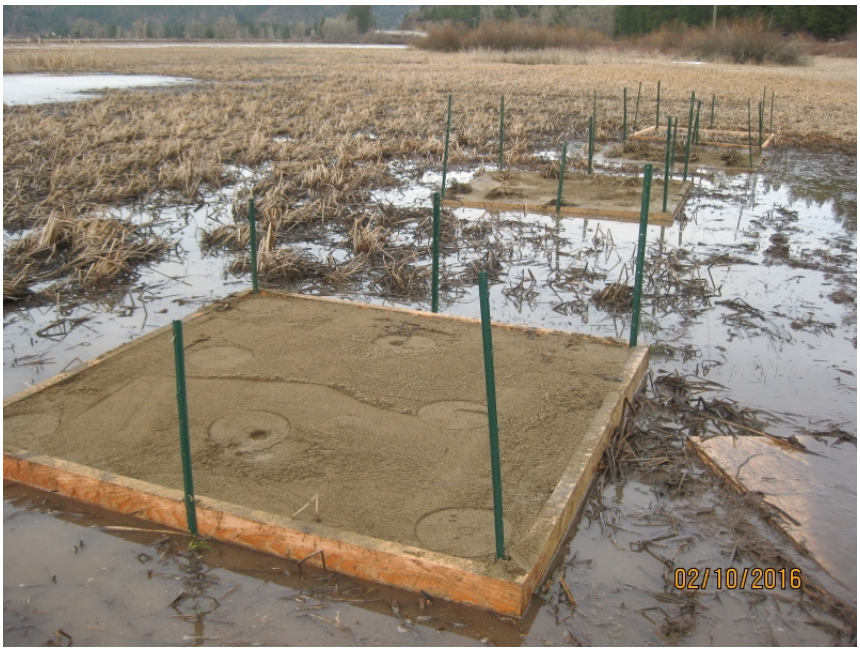
Photograph C-1. Overview of test plots in arrowhead plant community after installation on 2/10/2016.

Photograph C-2. Overview of test plots in arrowhead plant community during preliminary monitoring on 6/8/2016.



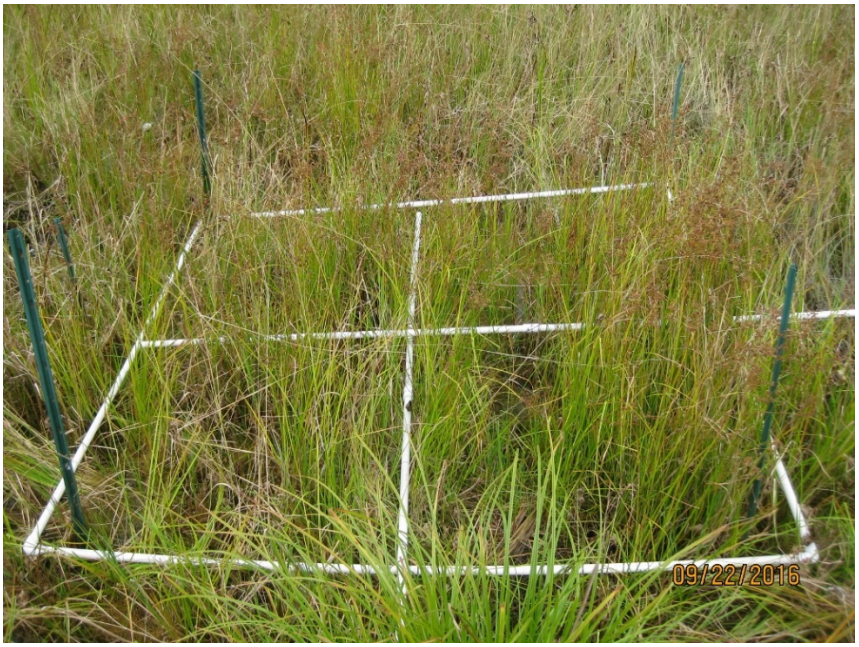
Photograph C-3. Overview of test plots in arrowhead plant community during fall monitoring on 9/22/2016.



Photograph C-4. Overview of test plots in bur-reed plant community after installation on 2/10/2016.

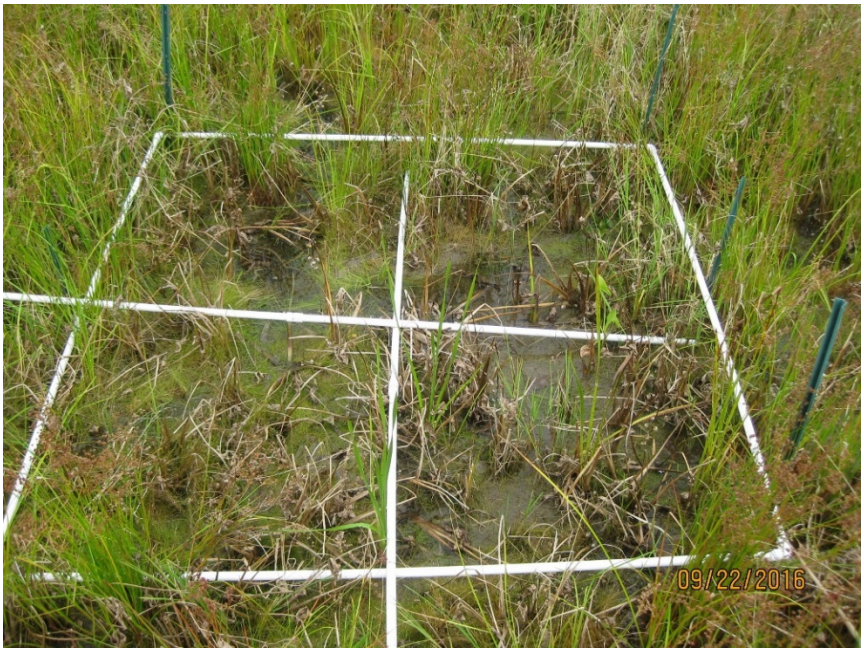
Photograph C-5. Overview of test plots in bur-reed plant community during preliminary monitoring on 6/8/2016.

Photograph C-6. Arrowhead test plot A1 (control, 0” cap) (6/8/2016).



Photograph C-7. Arrowhead test plot A1 (control, 0” cap) (9/22/2016).

Photograph C-8. Arrowhead test plot A2 (2” cap) (6/8/2016).



Photograph C-9. Arrowhead test plot A2 (2” cap) (9/22/2016).

Photograph C-10. Arrowhead test plot A3 (4” cap) (2/10/2016).

Photograph C-11. Arrowhead test plot A3 (4” cap) (6/8/2016).

Photograph C-12. Arrowhead test plot A3 (4” cap) (9/22/2016).

Photograph C-13. Arrowhead test plot A4 (6” cap) (2/10/2016).

Photograph C-14. Arrowhead test plot A4 (6” cap) (6/8/2016).

Photograph C-15. Arrowhead test plot A4 (6” cap) (9/22/2016).

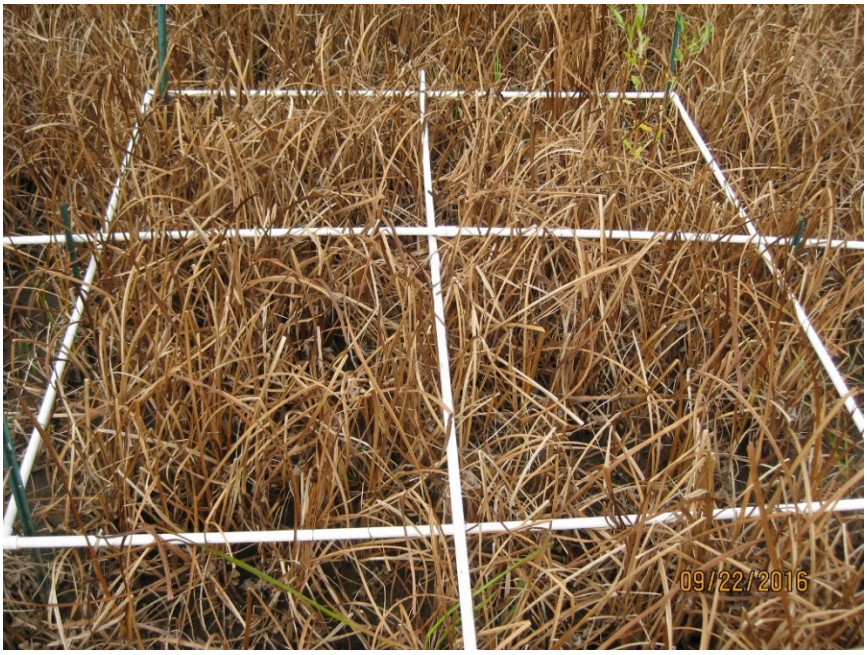
Photograph C-16. Bur-reed test plot B4 (control, 0” cap) (2/10/2016).
Also shows dormant vegetation condition at a less damaging time to apply a thin-layer cap.

Photograph C-17. Bur-reed test plot B4 (control, 0” cap) (6/8/2016).

Photograph C-18. Bur-reed test plot B4 (control, 0” cap) (9/22/2016).

Photograph C-19. Bur-reed test plot B3 (2” cap) (2/10/2016).

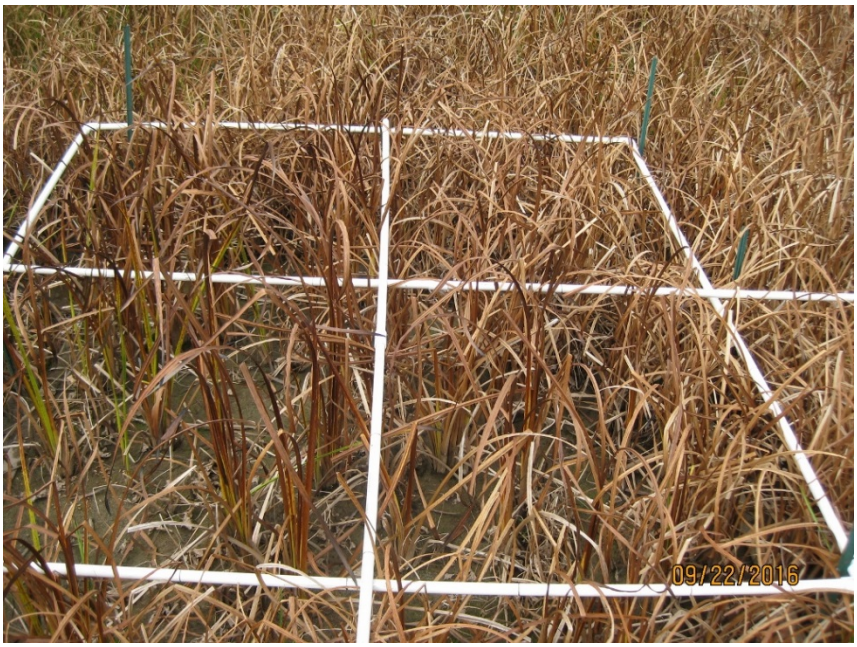
Photograph C-20. Bur-reed test plot B3 (2” cap) (6/8/2016).



Photograph C-21. Bur-reed test plot B3 (2” cap) (9/22/2016).

Photograph C-22. Bur-reed test plot B2 (4” cap) (2/10/2016).

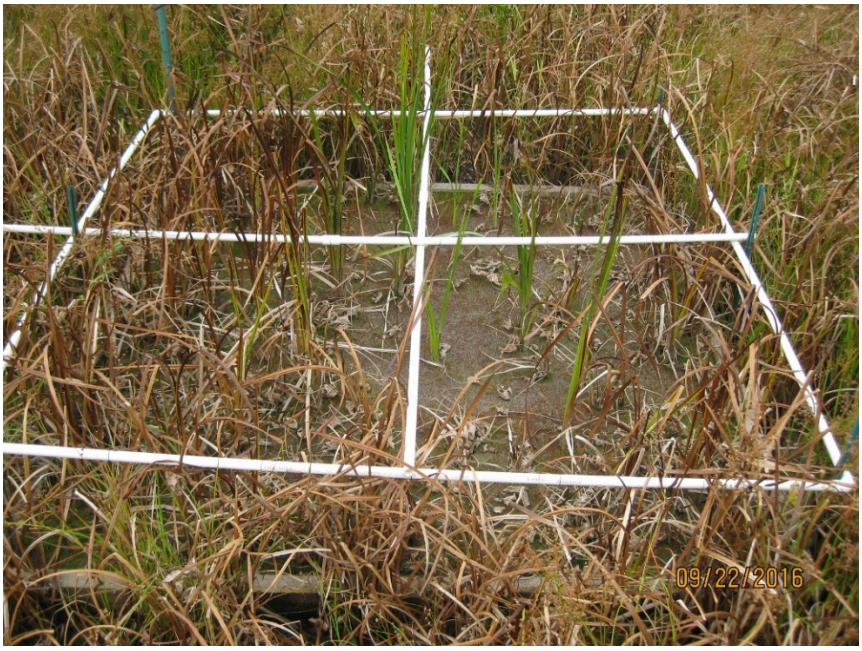
Photograph C-23. Bur-reed test plot B2 (4” cap) (6/8/2016).



Photograph C-24. Bur-reed test plot B2 (4” cap) (9/22/2016).

Photograph C-25. Bur-reed test plot B1 (6” cap) (2/10/2016).

Photograph C-26. Bur-reed test plot B1 (6” cap) (6/8/2016).



Photograph C-27. Bur-reed test plot B1 (6” cap) (9/22/2016).

Photograph C-28. Spikerush colonized the sand cap surface during the first growing season, such as in the 6-inch bur-reed plot LM B1 (September 22, 2016).

Photograph C-29. Temporary walkways used to allow safe access and minimize impact during test plot installation (2/10/2016).

Photograph C-30. Kick net with 500µm mesh used during benthic invertebrate sampling (6/8/2016).

Photograph C-31. Bucket with 500µm sieve used during benthic invertebrate sampling (6/8/2016).

Appendix D
Vegetation Monitoring Data

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LANE MARSH ITLC TEST PLOTS									
12/15/2016 BASELINE									
	ARROWHEAD (West to East)				**BUR-REED (West to East)**				
	(0")	**(2")**	**(4")**	**(6")**	**(6")**	**(4")**	**(2")**	**(0")**	
	A1	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**	**B4**	**Notes**
Arrowhead	60	75	80	80	30	30	30	30	Present but difficult to estimate
Bur-reed					90	90	95	95	
Rush (Juncus acuminatus)	5	3	6		10	T			
Sedge (Carex)	5	10	2	12	1	1	T	T	
Spikerush (Eleocharis p.)	1	1	T						
Spikerush (Eleocharis e.)	12	15	3	5					
Unidentified grass	5		6						
Reed canarygrass					1		T		
Unid#1 (Alopecurus)									
Unid#2 (Glyceria)									
Bare	12		3	3					
Total	**100**	**104**	**100**	**100**	**132**	**121**	**125**	**125**	
Water depth	3-4"	3-5"	3-5"	2-5"	1-3"	1-4"	0-1"	0-1"	
Photo #	1139-40	1134-35	1129-33	1126-27	1124-25	1122-23	1117-21	1102-03	
Numerous floating seeds									
6/8/2016 Initial Vegetation Percent Cover - Early Summer (Year 1)									
	ARROWHEAD (West to East)				BUR-REED (West to East)				
	(0")	**(2")**	**(4")**	**(6")**	**(6")**	**(4")**	**(2")**	**(0")**	
	A1	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**	**B4**	**Notes**
Arrowhead	25	15	6	10	20	20	40	45	
Bur-reed					20	20	40	45	
Rush (Juncus a.)	15	3							
Sedge (Carex sp.)									NONE OBSERVED
Spikerush (Eleocharis p.)									
Spikerush (Eleocharis e.)	35	25	3	3	0.1				
Reed canarygrass									NONE OBSERVED
Foxtail (Alopecurus p.)	1		0.1						
Mannagrass (Glyceria b.)	3	1	0.1						
Willow (Salix sp.)									
Total Veg Cover	**79**	**44**	**9.2**	**13**	**40.1**	**40**	**80**	**90**	
Bare	21	56	91	87	60	60	20	10	
Water depth	16-18"			16-20"	6-8"	8-9"	8-10"	6-8"	
Water depth in plot					2"	4-5"	6-8"	6-8"	
9/22/2016 Vegetation Percent Cover - Late Summer (Year 1)									
	ARROWHEAD (West to East)				BUR-REED (West to East)				
	(0")	**(2")**	**(4")**	**(6")**	**(6")**	**(4")**	**(2")**	**(0")**	
	A1	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**	**B4**	**Notes**
Arrowhead	8	20	25	35	12	10	10	10	
Bur-reed	0.1	3		0.1	30	50	88	88	
Rush (Juncus a.)	25	12	2						
Sedge (Carex sp.)	25	10	1					0.1	
Spikerush (Eleocharis p.)			1						
Spikerush (Eleocharis e.)	40	50	20	10	25	1	1		
Reed canarygrass	0.1				0.1			1	
Foxtail (Alopecurus p.)									
Mannagrass (Glyceria b.)	2	3	0.1					1	
Willow (Salix sp.)							1		
Total Veg Cover	**100.2**	**98**	**49.1**	**45.1**	**67.1**	**61**	**100**	**100.1**	
Bare	0	2	51	55	33	39	0	0	
Water depth									
Water depth in plot	1-2"	0-2"	0-2"	0"	0"	0"	0"	0"	

Appendix E
Benthic Analysis at Test Plots in Lane Marsh

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CH2M CDA Lake Benthos 2016				
Data are adjusted for subsampling				
Calculations use EcoAnalysts Inc. standard attributes				
Sample ID	**LMA-S**	**LMA-W**	**LMB-S**	**LMB-W**
Site	**Lane Marsh**	**Lane Marsh**	**Lane Marsh**	**Lane Marsh**
Time	**14:45**	**14:15**	**15:25**	**15:05**
Collection Date	**06-08-2016**	**06-08-2016**	**06-08-2016**	**06-08-2016**
Percent Subsampled	**100.00**	**56.25**	**75.00**	**20.83**
EcoAnalysts Sample ID	**7547.01-1**	**7547.01-2**	**7547.01-3**	**7547.01-4**
Abundance Measures				
Corrected Abundance	456.00	935.11	678.67	2419.20
EPT Abundance	0.00	1.78	0.00	0.00
Dominance Measures				
Dominant Taxon	Tubificidae w/o cap setae sp.	Psectrocladius sp.	Psectrocladius sp.	Ablabesmyia sp.
Dominant Abundance	136.00	129.00	118.00	112.00
2nd Dominant Taxa	Psectrocladius sp.	Ablabesmyia sp.	Ablabesmyia sp.	Chironomus sp.
2nd Dominant Abundance	89.00	88.00	114.00	103.00
3rd Dominant Taxa	Ablabesmyia sp.	Lestes sp.	Chironomus sp.	Psectrocladius sp.
3rd Dominant Abundance	57.00	55.00	71.00	79.00
% Dominant Taxon	29.82	24.52	23.18	22.22
% 2 Dominant Taxa	49.34	41.25	45.58	42.66
% 3 Dominant Taxa	61.84	51.71	59.53	58.33
Richness Measures				
Species Richness	28.00	39.00	24.00	39.00
EPT Richness	0.00	1.00	0.00	0.00
Ephemeroptera Richness	0.00	1.00	0.00	0.00
Plecoptera Richness	0.00	0.00	0.00	0.00
Trichoptera Richness	0.00	0.00	0.00	0.00
Chironomidae Richness	15.00	11.00	13.00	18.00
Oligochaeta Richness	5.00	4.00	3.00	3.00
Non-Chiro. Non-Olig. Richness	8.00	24.00	8.00	18.00
Rhyacophila Richness	0.00	0.00	0.00	0.00
Community Composition				
% Ephemeroptera	0.00	0.19	0.00	0.00
% Plecoptera	0.00	0.00	0.00	0.00
% Trichoptera	0.00	0.00	0.00	0.00
% EPT	0.00	0.19	0.00	0.00
% Coleoptera	0.44	6.08	0.00	1.19
% Diptera	59.43	70.72	94.70	88.29
% Oligochaeta	39.04	4.75	0.98	1.39
% Baetidae	0.00	0.19	0.00	0.00
% Brachycentridae	0.00	0.00	0.00	0.00
% Chironomidae	58.55	68.06	93.91	81.75
% Ephemerellidae	0.00	0.00	0.00	0.00
% Hydropsychidae	0.00	0.00	0.00	0.00
% Odonata	0.22	11.41	0.79	2.38
% Perlidae	0.00	0.00	0.00	0.00
% Pteronarcyidae	0.00	0.00	0.00	0.00
% Simuliidae	0.00	0.00	0.00	0.00
Functional Group Composition				
% Filterers	1.10	0.95	0.79	0.99
% Gatherers	77.63	51.14	62.87	56.15
% Predators	15.79	29.09	24.36	30.36
% Scrapers	0.00	0.00	0.20	0.00
% Shredders	4.82	4.94	11.00	9.72
% Piercer-Herbivores	0.22	3.42	0.00	0.00
% Unclassified	0.44	10.46	0.59	2.38
Filterer Richness	1.00	3.00	2.00	2.00
Gatherer Richness	14.00	14.00	12.00	15.00
Predator Richness	6.00	16.00	5.00	12.00
Scraper Richness	0.00	0.00	1.00	0.00
Shredder Richness	4.00	4.00	2.00	5.00
Piercer-Herbivore Richness	1.00	1.00	0.00	0.00
Unclassified	2.00	1.00	1.00	3.00
Diversity/Evenness Measures				
Shannon-Weaver H' (log 10)	1.00	1.18	0.95	1.11
Shannon-Weaver H' (log 2)	3.33	3.91	3.15	3.68
Shannon-Weaver H' (log e)	2.31	2.71	2.19	2.55
Margalef's Richness	4.41	5.56	3.53	4.88
Pielou's J'	0.69	0.74	0.69	0.70
Simpson's Heterogeneity	0.85	0.89	0.85	0.87
Biotic Indices				
% Indiv. w/ HBI Value	99.56	85.55	98.62	92.26
Hilsenhoff Biotic Index	8.68	8.15	7.78	8.02
% Indiv. w/ MTI Value	33.99	38.59	70.53	65.48
Metals Tolerance Index	3.36	3.56	3.47	3.58
% Indiv. w/ FSBI Value	0.00	0.00	0.00	0.00
Fine Sediment Biotic Index	N/A	N/A	N/A	N/A
FSBI - average	N/A	N/A	N/A	N/A
FSBI - weighted average	N/A	N/A	N/A	N/A
% Indiv. w/ TPM Value	5.48	6.27	11.39	9.13
Temp. Pref. Metric - average	0.18	0.26	0.17	0.54
TPM - weighted average	1.96	1.55	2.00	2.24
Karr BIBI Metrics				
Long-Lived Taxa Richness	1.00	3.00	2.00	3.00
Clinger Richness	4.00	5.00	3.00	5.00
% Clingers	5.70	6.84	12.38	9.33
Intolerant Taxa Richness	0.00	1.00	0.00	1.00
% Tolerant Individuals	82.60	45.75	51.25	15.14
% Tolerant Taxa	57.14	35.90	41.67	30.77
Coleoptera Richness	2.00	8.00	0.00	5.00
Montana DEQ Metrics				
MT Biotic Index	8.68	8.15	7.78	8.02
C-Gatherers + C-Filterers	78.73	52.09	63.65	57.14
% Scraper + % Shredder	4.82	4.94	11.20	9.72
% Univoltine	21.49	37.07	24.95	19.05
% Multivoltine	16.45	21.10	38.90	38.29
% Semivoltine	0.22	3.61	0.20	0.20
Community Tolerance Quotient	N/A	N/A	N/A	N/A
% Hydropsychinae	0.00	0.00	0.00	0.00
Lake Metrics				
% Orthocladiinae	24.56	27.00	29.08	18.45
Orthocladiinae Richness	3.00	2.00	2.00	5.00
% Chironomini	12.94	12.74	30.45	32.34
Chironomini Richness	6.00	4.00	5.00	6.00
% Tanytarsini	6.36	4.37	10.61	4.56
% Chironomus	3.07	1.90	13.95	20.44
% Tanytarsus	1.10	0.19	0.59	0.00
% Dicrotendipes	1.54	3.99	5.30	2.58
% Dicrotendipes + Chironomus	4.61	5.89	19.25	23.02
% Corbicula	0.00	0.00	0.00	0.00
% Manayunkia speciosa	0.00	0.00	0.00	0.00
% Intolerant	0.00	0.67	0.00	0.65
% Intolerant Indiv. (S.CA)	0.00	0.57	0.00	0.60
% Individuals w/ CAHBI value	11.62	17.49	19.65	19.44
% Intolerant Indiv. (CAHBI)	0.00	0.00	0.00	0.00
% Sensitive EPT (CAHBI)	0.00	0.00	0.00	0.00
% Non-Insect Individuals (S.CA)	39.69	7.60	4.52	7.54
% Non-Insect Taxa	28.57	23.08	25.00	17.95
% Crustacea + Mollusca	0.66	2.47	3.54	6.15
Average Abundance (per Taxon)	16.29	23.98	28.28	62.03
NYDEC PMA Metrics				
% Crustacea	0.66	2.28	3.34	5.16
% Mollusca	0.00	0.19	0.20	0.99
% Non-Chironomidae	1.75	24.33	1.57	10.71

CH2M CDA Lake Benthos 2016		
Calculations use EcoAnalysts Inc. standard attributes		
EcoAnalysts, Inc. LIFE IN WATER		
Sample ID	**LMA-S**	**LMB-S**
Site	**Lane Marsh**	**Lane Marsh**
Time	**12:00**	**12:20**
Collection Date	**09-22-2016**	**09-22-2016**
Percent Subsampled	**100.00**	**100.00**
EcoAnalysts Sample ID	**7547.02-1**	**7547.02-2**
Abundance Measures		
Abundance	8.00	30.00
EPT Abundance	0.00	0.00
Dominance Measures		
Dominant Taxon	Ablabesmyia sp.	Polypedilum sp.
Dominant Abundance	1.00	22.00
2nd Dominant Taxa	Bezzia/Palpomyia sp.	Chironomus sp.
2nd Dominant Abundance	1.00	4.00
3rd Dominant Taxa	Corynoneura sp.	Natarsia sp.
3rd Dominant Abundance	1.00	1.00
% Dominant Taxon	12.50	73.33
% 2 Dominant Taxa	25.00	86.67
% 3 Dominant Taxa	37.50	90.00
Richness Measures		
Species Richness	8.00	6.00
EPT Richness	0.00	0.00
Ephemeroptera Richness	0.00	0.00
Plecoptera Richness	0.00	0.00
Trichoptera Richness	0.00	0.00
Chironomidae Richness	5.00	5.00
Oligochaeta Richness	0.00	0.00
Non-Chiro. Non-Olig. Richness	3.00	1.00
Rhyacophila Richness	0.00	0.00
Community Composition		
% Ephemeroptera	0.00	0.00
% Plecoptera	0.00	0.00
% Trichoptera	0.00	0.00
% EPT	0.00	0.00
% Coleoptera	0.00	0.00
% Diptera	87.50	96.67
% Oligochaeta	0.00	0.00
% Baetidae	0.00	0.00
% Brachycentridae	0.00	0.00
% Chironomidae	62.50	96.67
% Ephemerellidae	0.00	0.00
% Hydropsychidae	0.00	0.00
% Odonata	0.00	0.00
% Perlidae	0.00	0.00
% Pteronarcyidae	0.00	0.00
% Simuliidae	0.00	0.00
Functional Group Composition		
% Filterers	0.00	3.33
% Gatherers	62.50	16.67
% Predators	37.50	6.67
% Scrapers	0.00	0.00
% Shredders	0.00	73.33
% Piercer-Herbivores	0.00	0.00
% Unclassified	0.00	0.00
Filterer Richness	0.00	1.00
Gatherer Richness	5.00	2.00
Predator Richness	3.00	2.00
Scraper Richness	0.00	0.00
Shredder Richness	0.00	1.00
Piercer-Herbivore Richness	0.00	0.00
Unclassified	0.00	0.00
Diversity/Evenness Measures		
Shannon-Weaver H' (log 10)	0.90	0.41
Shannon-Weaver H' (log 2)	3.00	1.37
Shannon-Weaver H' (log e)	2.08	0.95
Margalef's Richness	3.37	1.47
Pielou's J'	1.00	0.53
Simpson's Heterogeneity	1.00	0.46
Biotic Indices		
% Indiv. w/ HBI Value	75.00	100.00
Hilsenhoff Biotic Index	7.33	6.83
% Indiv. w/ MTI Value	50.00	96.67
Metals Tolerance Index	4.25	4.00
% Indiv. w/ FSBI Value	0.00	0.00
Fine Sediment Biotic Index	N/A	N/A
FSBI - average	N/A	N/A
FSBI - weighted average	N/A	N/A
% Indiv. w/ TPM Value	0.00	73.33
Temp. Pref. Metric - average	N/A	0.33
TPM - weighted average	N/A	2.00
Karr BIBI Metrics		
Long-Lived Taxa Richness	0.00	1.00
Clinger Richness	0.00	1.00
% Clingers	0.00	73.33
Intolerant Taxa Richness	0.00	0.00
% Tolerant Individuals	66.67	23.33
% Tolerant Taxa	50.00	66.67
Coleoptera Richness	0.00	0.00
Montana DEQ Metrics		
MT Biotic Index	7.33	6.83
C-Gatherers + C-Filterers	62.50	20.00
% Scraper + % Shredder	0.00	73.33
% Univoltine	25.00	0.00
% Multivoltine	37.50	13.33
% Semivoltine	0.00	0.00
Community Tolerance Quotient	N/A	N/A
% Hydropsychinae	0.00	0.00
Lake Metrics		
% Orthocladiinae	25.00	0.00
Orthocladiinae Richness	2.00	0.00
% Chironomini	12.50	90.00
Chironomini Richness	1.00	3.00
% Tanytarsini	0.00	0.00
% Chironomus	0.00	13.33
% Tanytarsus	0.00	0.00
% Dicrotendipes	12.50	0.00
% Dicrotendipes + Chironomus	12.50	13.33
% Corbicula	0.00	0.00
% Manayunkia speciosa	0.00	0.00
% Intolerant	0.00	0.00
% Intolerant Indiv. (S.CA)	0.00	0.00
% Individuals w/ CAHBI value	37.50	76.67
% Intolerant Indiv. (CAHBI)	0.00	0.00
% Sensitive EPT (CAHBI)	0.00	0.00
% Non-Insect Individuals (S.CA)	12.50	3.33
% Non-Insect Taxa	12.50	16.67
% Crustacea + Mollusca	12.50	3.33
Average Abundance (per Taxon)	1.00	5.00
NYDEC PMA Metrics		
% Crustacea	12.50	0.00
% Mollusca	0.00	3.33
% Non-Chironomidae	25.00	0.00