U.S. Army Corps of Engineers
Walla Walla District

Lower Snake River Programmatic Sediment Management Plan, Final Environmental Impact Statement

Appendix I - Water Quality and Sediment Quality Reports

August 2014







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Lower Snake River Programmatic Sediment Management Plan Environmental Impact Statement

Appendix I

Water Quality and Sediment Quality Reports

August 2014

Section 1. Lower Snake and Clearwater Rivers Sediment Evaluation Report for Proposed 2013/2014 Channel Maintenance Dredging

U.S. Army Corps of Engineers, Walla Walla District

March 2013



U.S. Army Corps of Engineers
Walla Walla District

Lower Snake and Clearwater Rivers Sediment Evaluation Report for Proposed 2013/2014 Channel Maintenance Dredging

Prepared by:

U.S. Army Corps of Engineers
Walla Walla District

March 2013

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1.0 INTRODUCTION

1.1 Report Objective

The objective of this report is to evaluate material the Walla Walla District Corps of Engineers (Corps) proposes to dredge to determine if the material is suitable for unconfined open-water disposal in the Lower Snake River.

1.2 Project Description

The Corps proposes to perform maintenance dredging to meet the immediate need to provide a 14-foot depth as measured at minimum operating pool (MOP) at four locations in the lower Snake River and lower Clearwater River in Washington and Idaho (Figure 1). One site is the downstream navigation lock approach for Ice Harbor Dam (Snake River Mile or RM 9.5), while the other three sites are located at the confluence of the Snake and Clearwater rivers in Lower Granite reservoir. The three sites in Lower Granite are the Federal channel (Snake RM 138 to Clearwater RM 2) and the berthing areas for the Port of Lewiston (Idaho) (Clearwater RM 1-1.5) and Port of Clarkston (Washington) (Snake RM 137.9 - 139). The Corps identified a location in the Lower Granite reservoir, Snake RM 116 just upstream of Knoxway Canyon, as the preferred in-water discharge site of the dredged materials. The Corps proposes to use the dredged material to create additional shallow water habitat for juvenile salmonids, subject to funding.

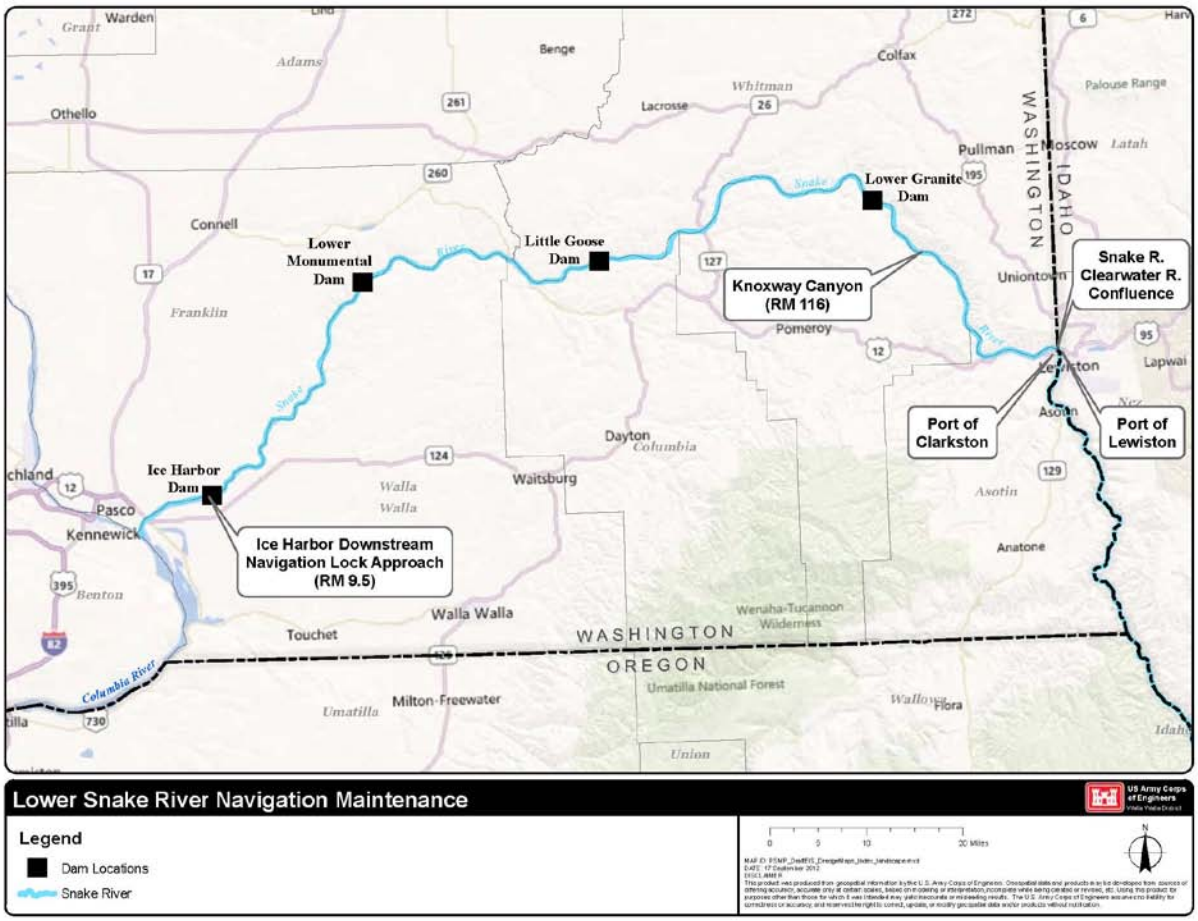


Figure 1. Project area map

Because navigation channel maintenance has not occurred since 2005-2006, shoaling in the channel and port berthing areas has become critical in these four locations. Sediment has been depositing in these areas in the Snake/Clearwater confluence primarily during spring runoff periods. Survey results from August 2011 show water depths in the Federal navigation channel at the confluence are now as shallow as about 7 feet while the berthing areas at the Port of Clarkston and Port of Lewiston are now as shallow as 7.3 feet and 9.3 feet, respectively, based on a MOP water surface elevation. Navigation channel depths less than 14 feet substantially impact access to port facilities.

Shoaling in the Ice Harbor navigation lock approach is interfering with the ability of barge traffic to safely maneuver when entering or exiting the navigation lock. Spill flows at the dam have scoured rock from the base of the four rock-filled coffer cells bordering the lock approach and have pushed material from the edge of the lock approach into the channel, narrowing the room available for barges to maneuver between the coffer cells and the north shore. At least one of the coffer cells has been losing rockfill through the exposed base and this may be contributing to the material encroaching in the lock approach. This material has created a shoal that encroaches across the south half of the lock approach for about 480 feet, reducing the depth to about 9 feet at MOP in McNary pool (the lock approach is within McNary reservoir, not Ice Harbor reservoir). There are also several small mounds of rock/cobble encroaching into the channel near the lock.

Under the proposed action all dredging and disposal action would occur during the in-water work window from December 15 to March 1. This in-water work window was established through coordination with state and Federal resource agencies as the time period in which in-water work could be performed with the least impact to ESA-listed salmonid stocks.

Dredging would be aimed at restoring the navigation channel to the authorized depth by dredging to a depth of no more than 16 feet as measured at MOP. The overdepth dredging (i.e., to 16 feet) is standard procedure as outlined in Engineer Regulation 1130-2-520, *Project Operations – Navigation and Dredging Operations and Maintenance Policies* (USACE 1996). Overdepth allowance helps minimize the need for more frequent and intermittent dredging of high spots. A 16-foot depth is used as the maximum dredging depth in the Federal navigation channel in order to maintain a consistent 14-foot depth. Of the additional 2 feet, 1 foot is considered advance maintenance, which is the additional depth and/or width specified to be dredged beyond the project channel dimensions for the purpose of reducing overall maintenance costs and impacts by decreasing the frequency of dredging. The other foot is considered allowable overdepth, which is the additional depth below the required section specified in a dredging contract, and is permitted because of inaccuracies in the dredging process.

Table 1 lists the sites proposed for immediate dredging and the estimated quantities of material to be removed from each site. Sediment is expected to continue to accumulate at these locations while this action is being planned, therefore the amount of material to be removed at the time of the dredging will likely be greater than what is shown in the table. The Corps anticipates the quantity of material needing to be dredged will range from 422,000 cubic yards (cy) to a maximum of 500,000 cy.

Table 1. Sites Proposed for Immediate Need Maintenance Dredging

Site to be Dredged	Quantity to be Dredged (cy)[1]
Federal navigation channel at confluence of Snake and Clearwater Rivers (Snake RM 138 to Clearwater RM 2)	469,212
Port of Clarkston (Snake RM 137 - 139)	14,143
Port of Lewiston (Clearwater RM 1-1.5)	4,485
Ice Harbor Navigation Lock Approach (Snake RM 9.5)	3,203
Total	**491,043**

Note: 1. Based on removal to 16 feet below MOP using survey data from November 2012.

1.2.1 Maintenance Dredging Sites

Confluence of Snake and Clearwater Rivers (Federal navigation channel). About 469,212 cy of material would be removed from the Federal navigation channel (Figure 2) at the confluence of the Snake and Clearwater Rivers. Only the areas less than 14 feet deep at MOP within the navigation channel limits would be dredged (Figure 3). The Congressionally-authorized dimensions of the navigation are 14 feet deep and 250 feet wide as measured at MOP. However, at locations in front of port berthing areas, the Federal navigation channel is expanded up to a maximum total width of 950 feet. This widening is provided to allow for maneuvering of barge tows in accordance with navigation practice described in 33 U.S.C. § 562, "Channel dimensions specified shall be understood to admit of such increase at the entrances, bends, sidings, and turning places as may be necessary to allow for the free movement of boats." This area was last dredged in the winter of 2005/2006.

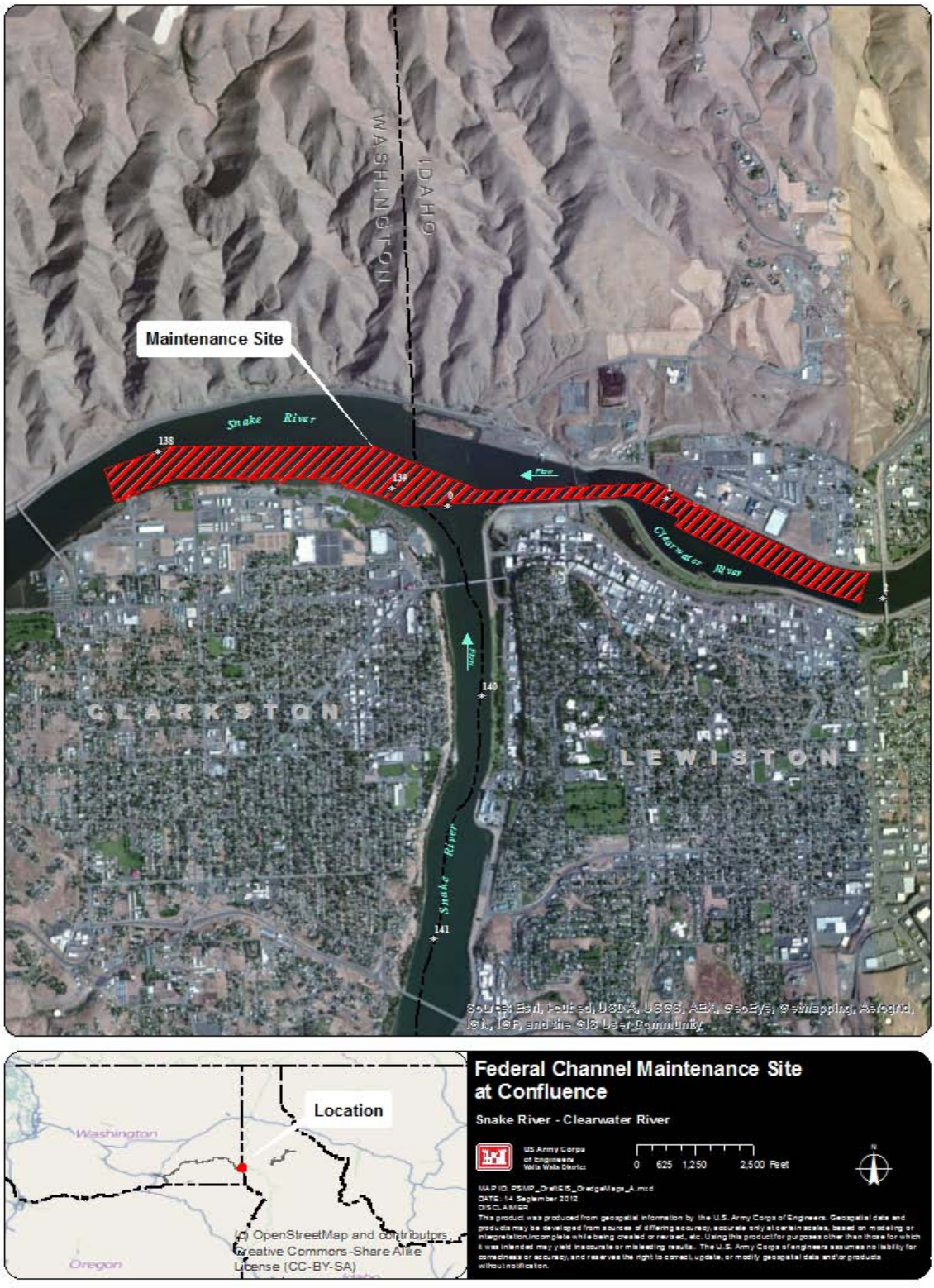


Figure 2. Dredging limits of the Federal Channel at the confluence of the Snake and Clearwater Rivers

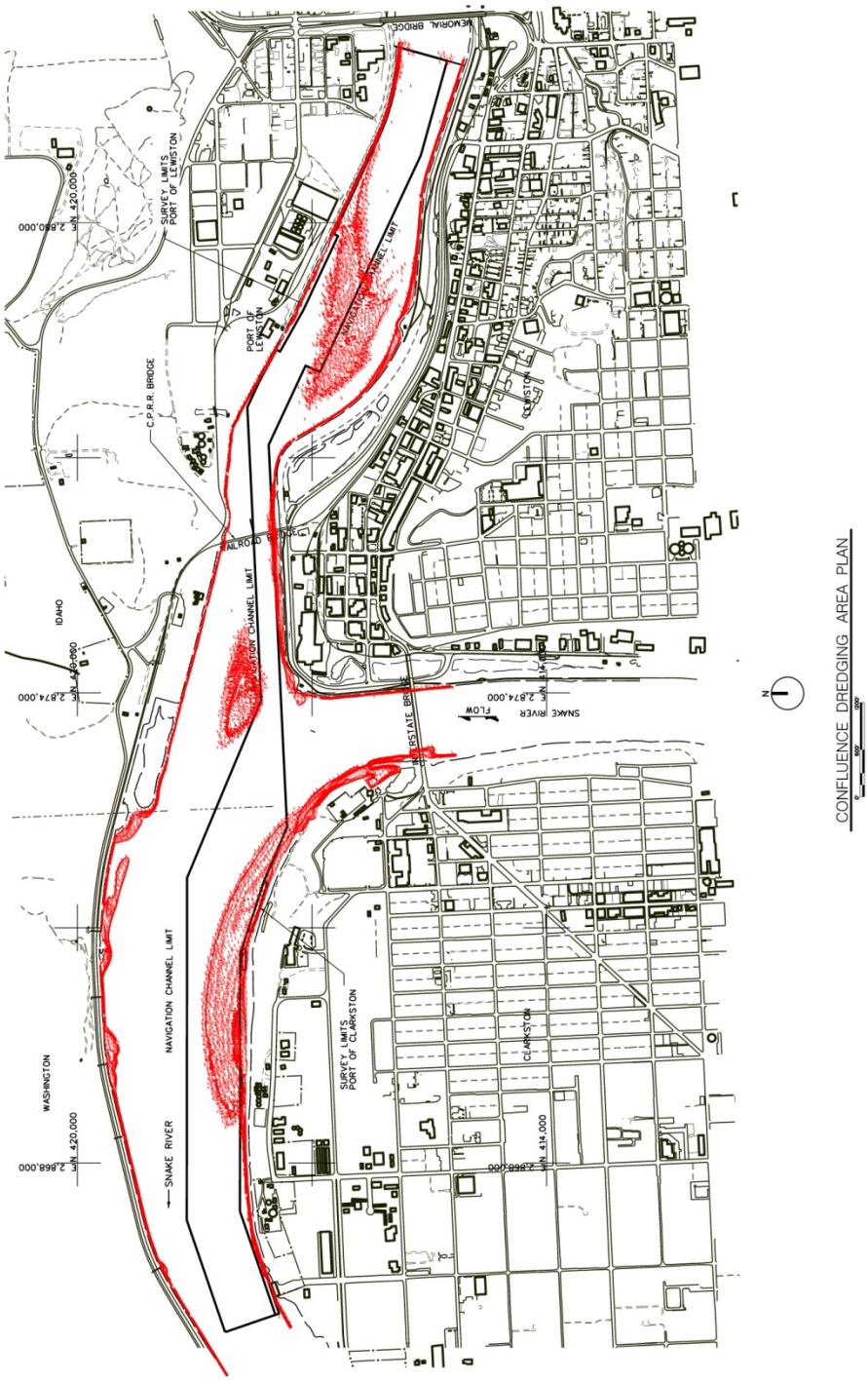


Figure 3. Shoaling locations at the Snake/Clearwater Rivers confluence (Areas to be dredged are the red areas within the black navigation channel limit lines).

Port of Clarkston. About 14,143 cy of material would be removed from four berthing areas at the Port of Clarkston: the crane dock at the downstream end of the Port property (RM 137.9), the Lewis-Clark Grain Terminal (RM 138.2), the recreation dock at RM 138.3, and the tour boat dock at the upstream end (RM 139) (Figure 4). The berthing area is defined as a zone extending 50 feet out into the river from the port facilities and running the length of the port facilities. Maintenance in this area is the port's responsibility,

and the Port of Clarkston would provide funding to the Corps for this portion of the work. Most of the area was last dredged in the winter of 2005/2006.

Port of Lewiston. About 4,485 cy of material would be removed from the berthing area at the Port of Lewiston (Figure 5). The berthing area is defined as a zone extending 50 feet out into the river from the port facilities and running the length of the port facilities. Maintenance in this area is the port's responsibility, and the Port of Lewiston would provide funding to the Corps for this portion of the work. The area was last dredged in the winter of 2005/2006.

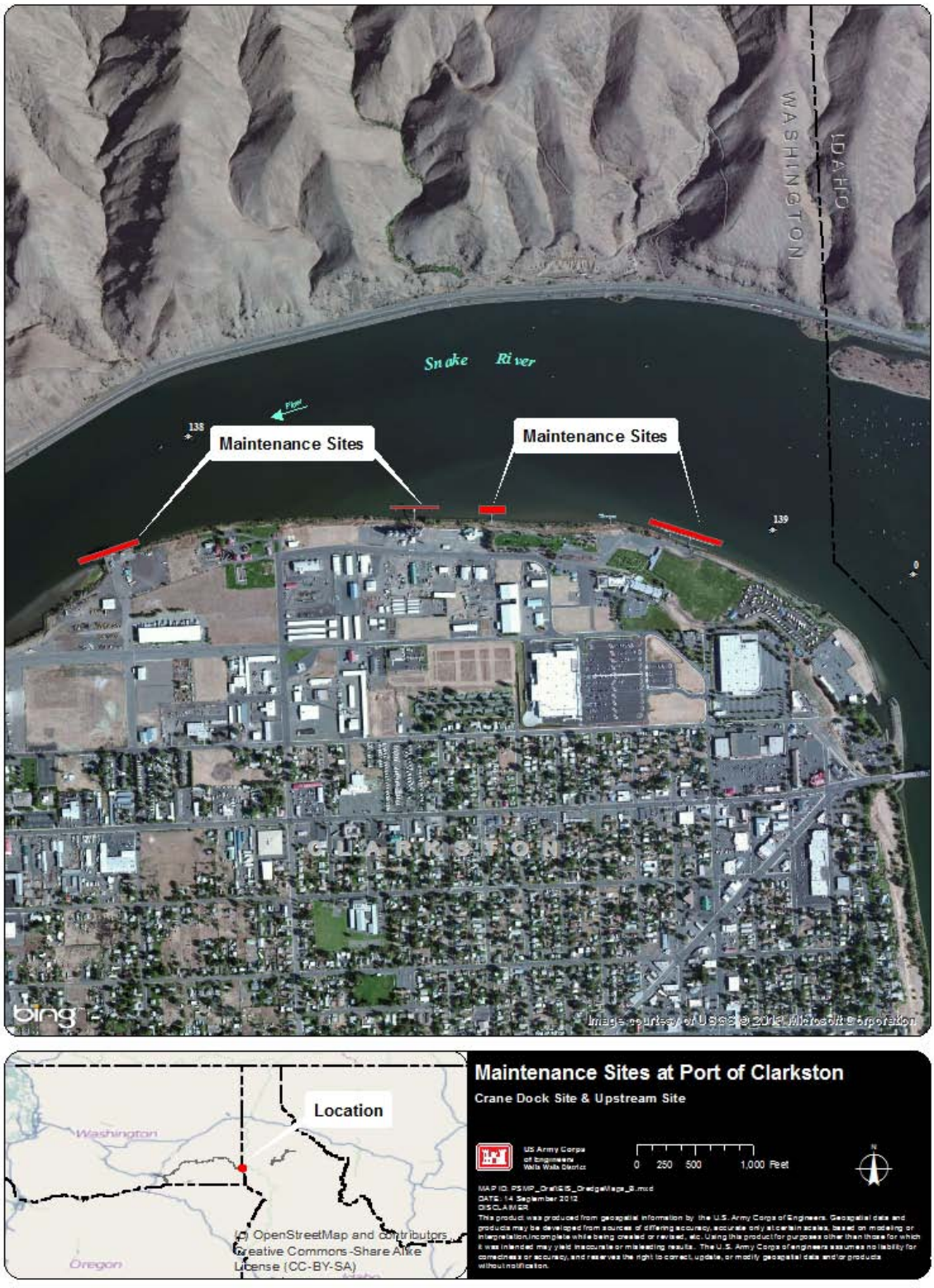


Figure 4. Dredging sites at the Port of Clarkston.



Figure 5. Dredging location at Port of Lewiston.

Ice Harbor Lock Approach. About 3,203 cy of material would be removed from the Ice Harbor lock approach (Figures 6 and 7). This area has not been dredged since the 1970's or 1980's except for a small spot 200 feet downstream of the navigation lock from which about 400 cy was removed in fall 2012.



Figure 6. Dredging limits at Ice Harbor Dam navigation lock approach.

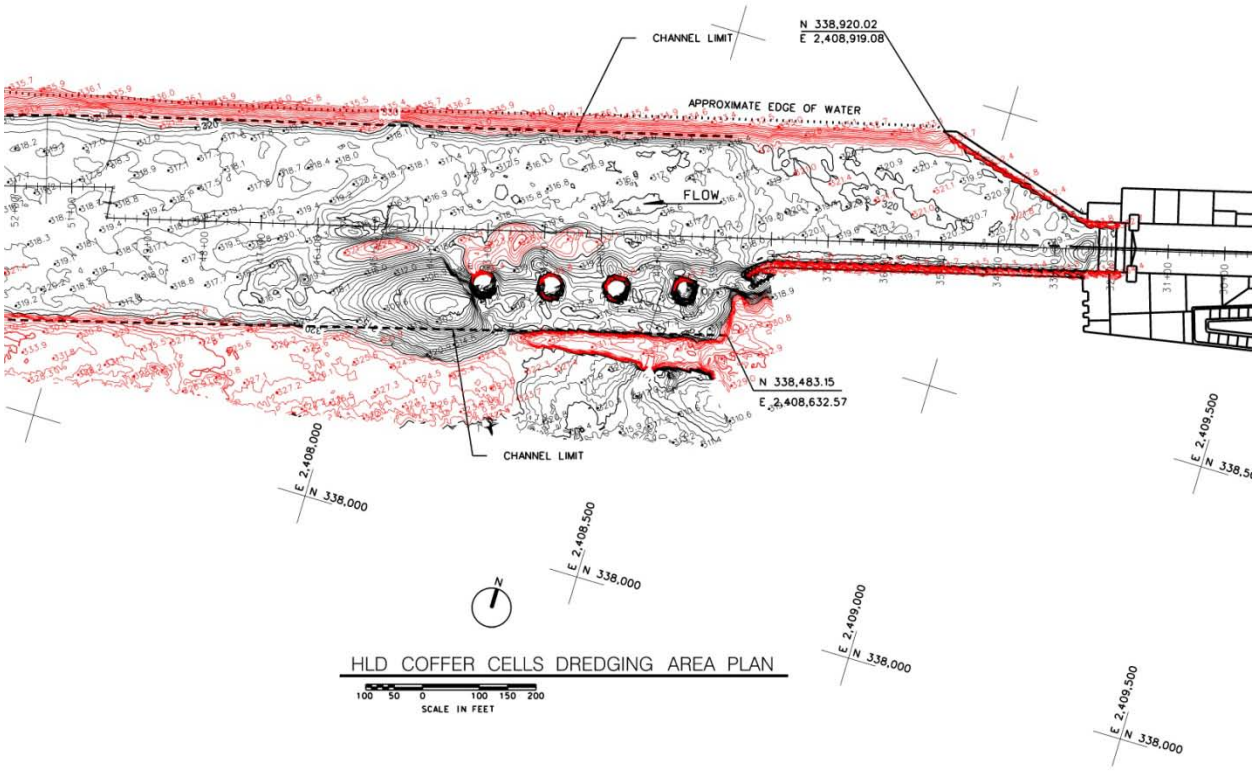


Figure 7. Shoaling at Ice Harbor navigation lock approach (areas in red within the channel limit would be dredged).

1.2.2 In-Water Disposal Site

The Corps proposes to use unconfined in-water disposal of the dredged material to create shallow-water habitat for resting and rearing by juvenile salmonids, primarily fall Chinook salmon. The proposed site is located in the Lower Granite reservoir at Snake River mile (RM) 116 and was selected for its proximity to dredging locations while meeting engineering and biological criteria. This site is an approximately 120-acre mid-depth bench on the left bank of the Snake River about 0.5 river miles upriver of Knoxway Canyon. The Knoxway site was historically an old homestead orchard and pasture located several hundred feet upland of the historic river shoreline. This beneficial use site is located in a low velocity area that has been accumulating sediment at an estimated rate of 2 inches per year since the filling of Lower Granite reservoir. The substrate at this site was visually inspected in 1992 during the reservoir drawdown test and was observed to be primarily silt. The upstream end of the site was used as the in-water disposal site for navigation maintenance dredging performed by the Corps in 2005/2006. Approximately 420,000 cubic yards of sand and silt was deposited on the upriver end of the Knoxway bench as part of that maintenance action. A shallow water habitat shelf estimated to be about 3.7-acres in size was created for summer rearing juvenile fall Chinook salmon (Figure 8). The upper surface of this material is sand that was reshaped to gently slope towards the river.

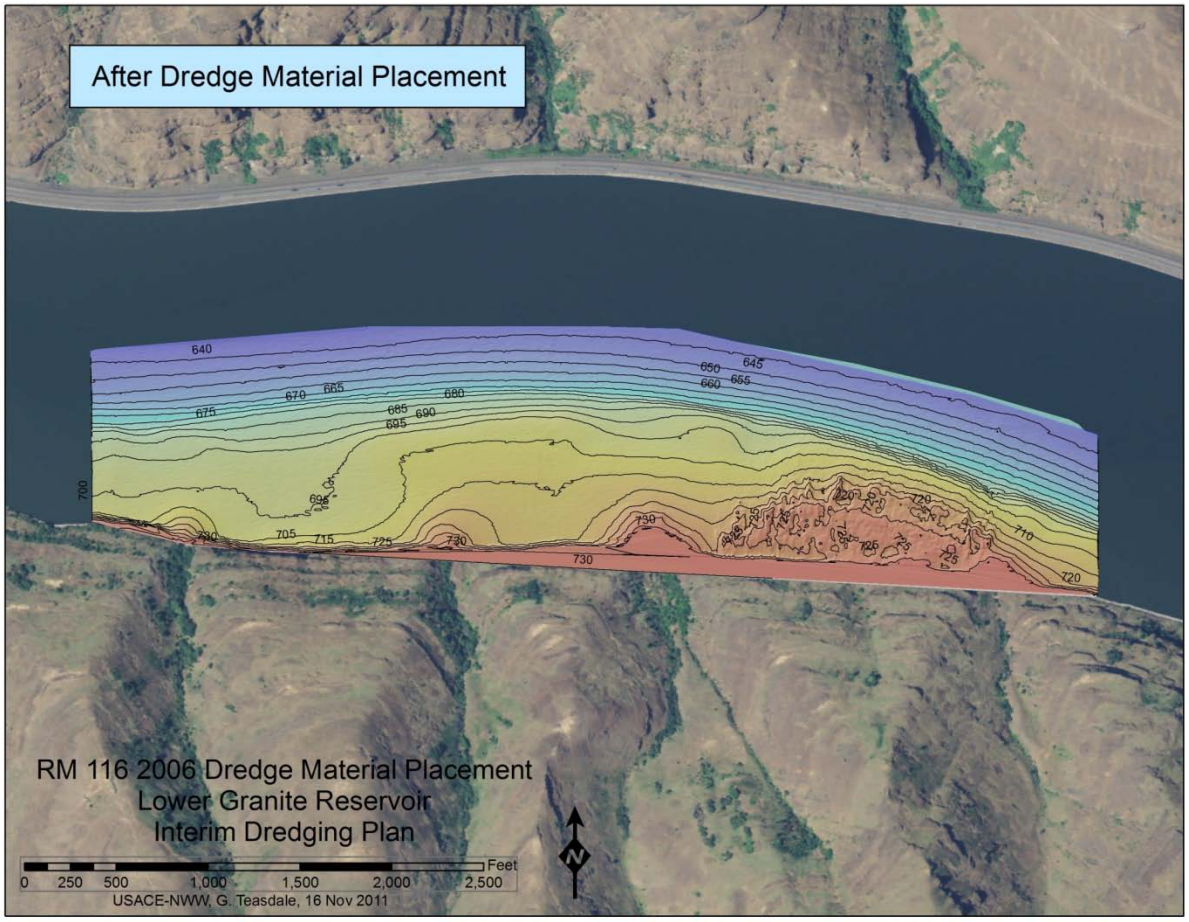


Figure 8. Contour map of RM 116 disposal site (shallow area to the right was created by dredged material disposal in 2005/2006).

The material from the proposed dredging would be deposited adjacent to and downstream of the material deposited in 2005-2006 (Figure 9). The new material would occupy an estimated 26-acre footprint and would form a somewhat uniform, gently sloping shallow-water bench along about 3,500 linear feet of shoreline. The top of the bench would have about a 2% slope and would provide an estimated 7.36 acres of additional aquatic habitat 6 feet deep at minimum operating pool (MOP) with features optimized for resting/rearing of out-migrating juvenile salmonids, particularly for fall Chinook salmon (Figures 10 and 11). All of these dimensions are target dimensions. The finished grade may be slightly different because of the limitations of the equipment that would be likely be used to create the habitat and because all work would be done underwater. The Corps anticipates there would be about 18 acres of lesser-quality shallow water habitat at depths of 6 to 20 feet on the slope of the bench.

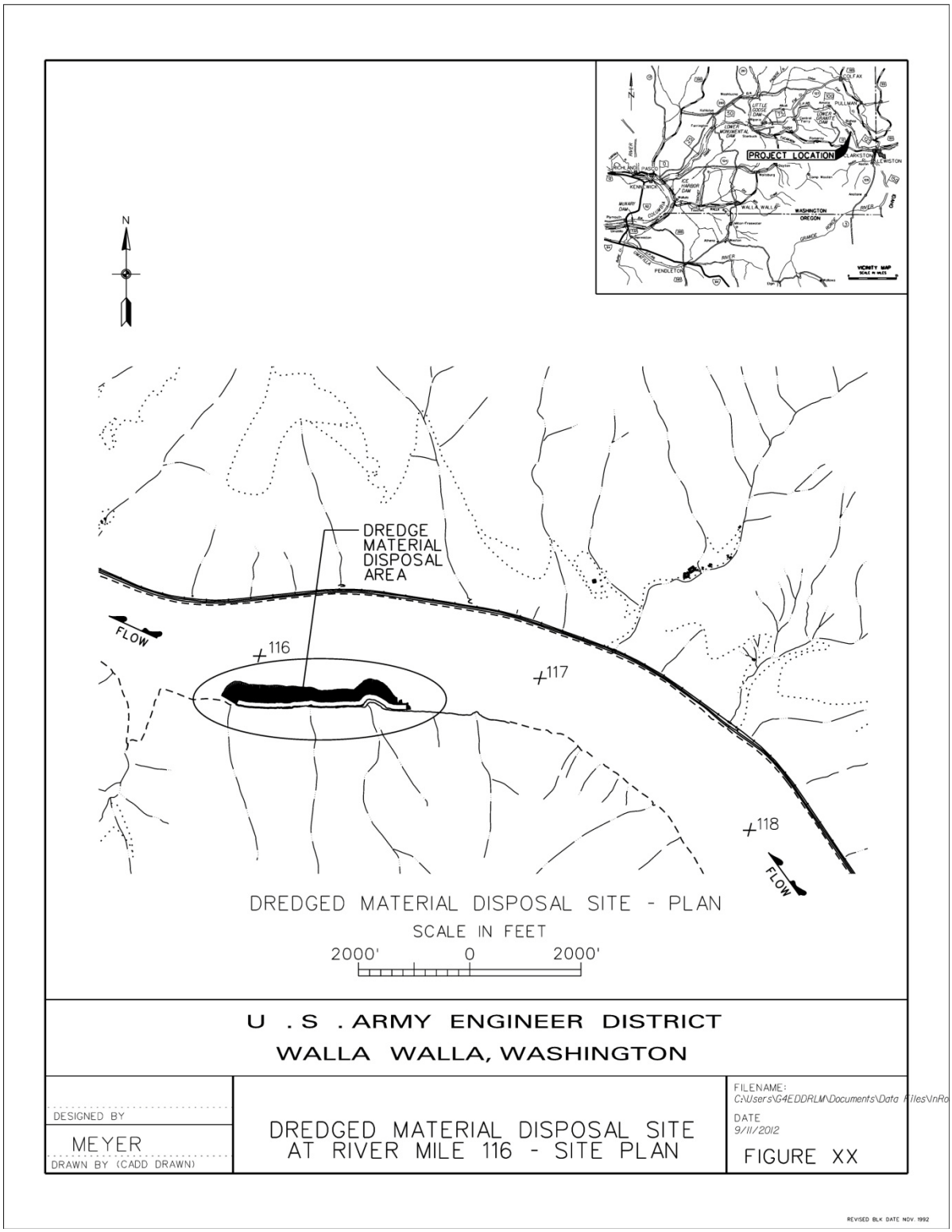


Figure 9. Location of proposed disposal site at RM 116 (Knoxway Canyon is the embayment just downstream of the disposal area).

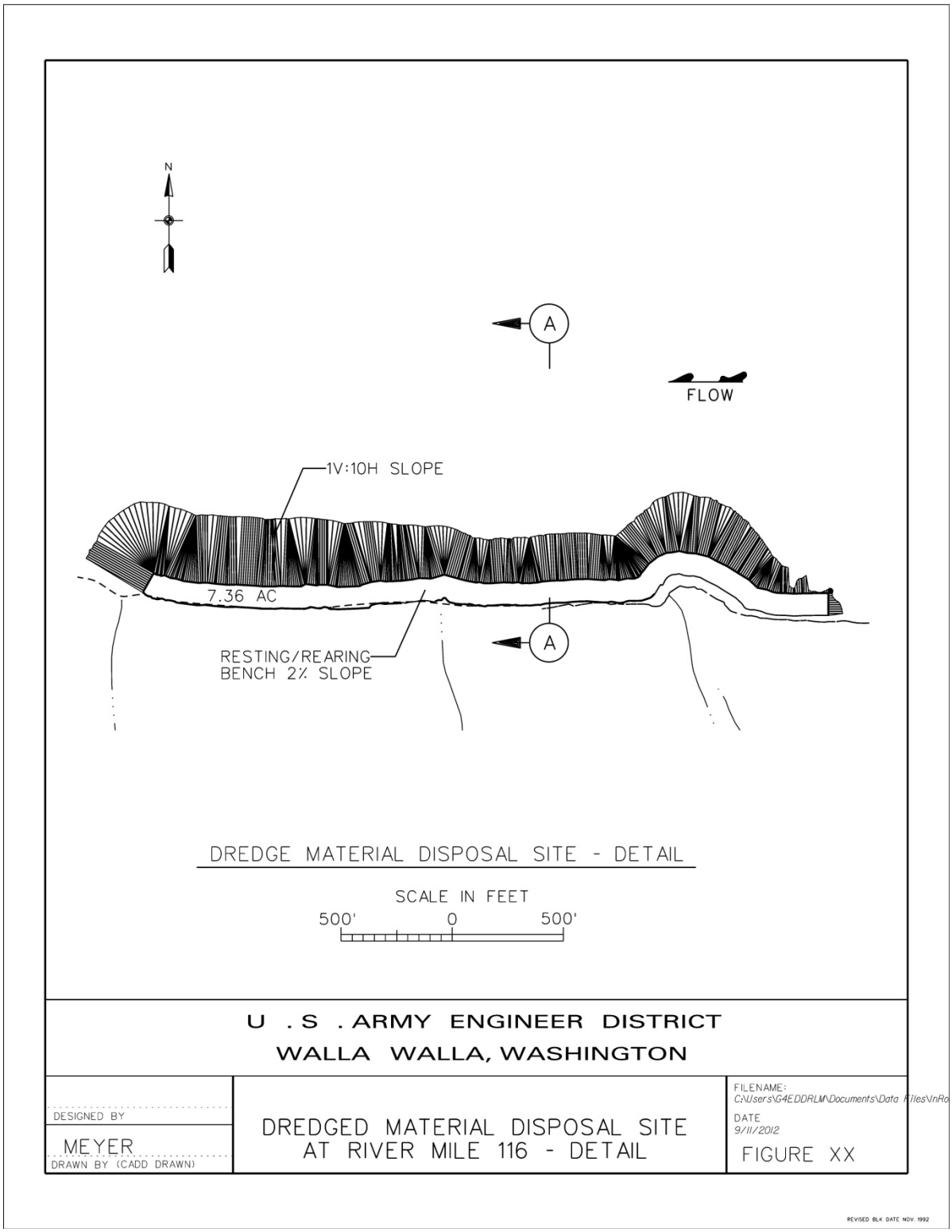


Figure 10. Site plan for disposal at RM 116.

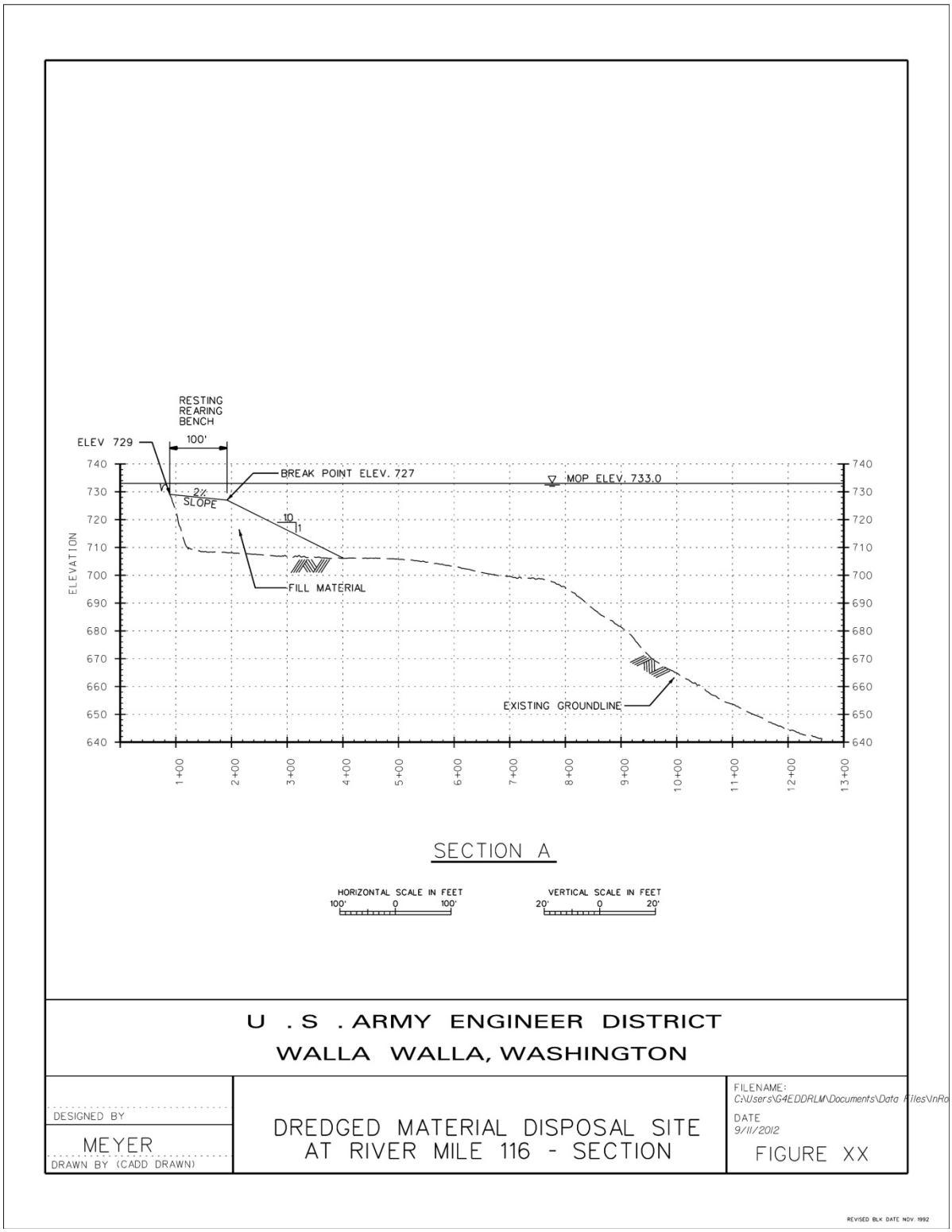


Figure 11. Cross-section of disposal at RM 116.

1.3 Site History

1.3.1 Snake/Clearwater Rivers Confluence

Sediment inputs to the Snake/Clearwater Rivers confluence area originate from a geographically large and diverse set of subbasins (Table 1). Previous characterizations of bed sediment (USACE 1988; CH2M Hill 1997; Battelle 2004) show that sand is the overall dominant material that deposits in this area. Below Snake RM 130, the dominant material is silts and fines (CH2M Hill 1997; USACE 2012b). Most of the sediment comes from the Salmon River subbasin (53.5 percent) (Figure 1). The Grande Ronde and Clearwater subbasins contribute 5.8 and 12.5 percent, respectively. The latest U.S. Geological Survey **(**USGS) Sediment Core Survey indicated that sand dominates the bed in the upper reach of Lower Granite Reservoir and that deposits below about RM 130 are mostly silt (Braun et al. 2012).

Table 2. Size of Sediment-Contributing Watersheds

Geographic Area	Area (acres)	Area (square miles)	Percent of Study Area
Salmon subbasin	8,956,160	13,994	43
Clearwater subbasin (excluding North Fork)	4,420,480	6,907	21
Grande Ronde subbasin	2,624,640	4,101	13
Lower Snake River basin- Hells Canyon to Clearwater River	1,346,560	2,104	6
Lower Snake River basin- Clearwater River to Columbia River	1,346,560	5,471	17
TOTAL	**20,849,280**	**32,576**	**100**

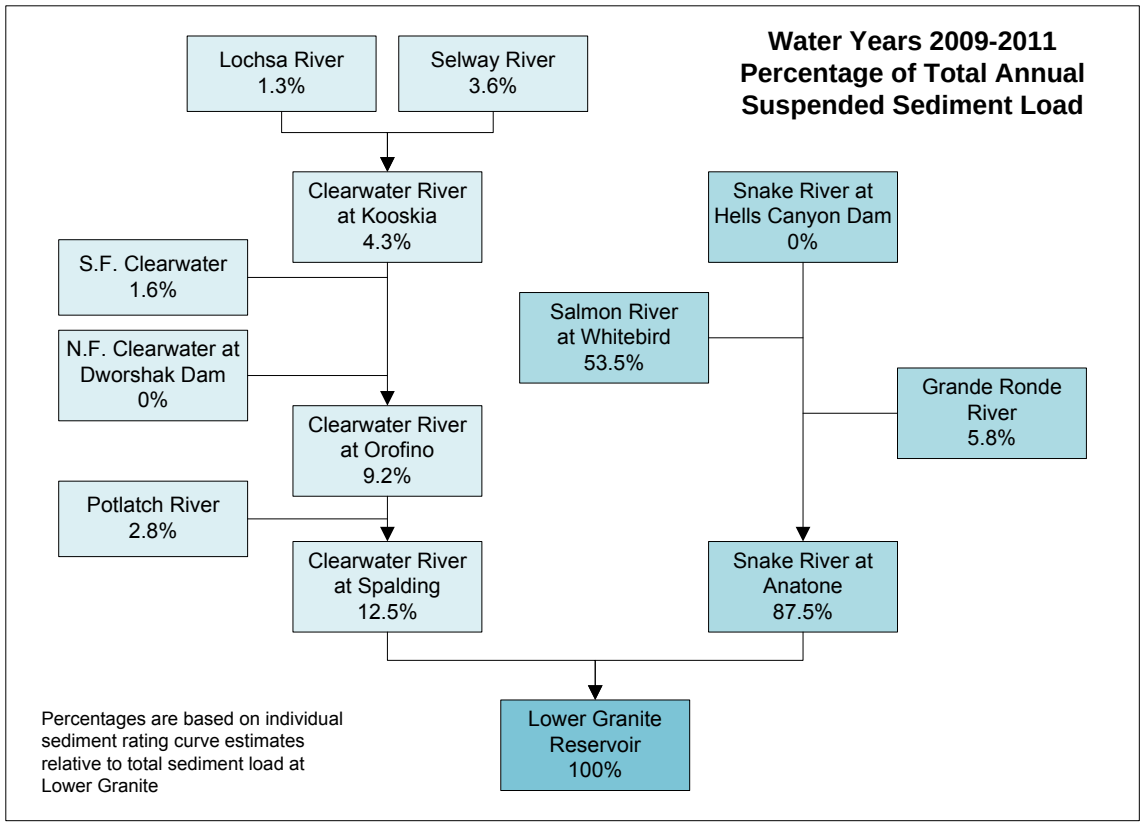


Figure 12. Relative Sediment Load Contributions to the Lower Granite Pool by Tributaries
Source: USACE (2012b).

1.3.1.1 Historical Dredging

Sediment deposition at the confluence of the Snake and Clearwater rivers has been an ongoing maintenance issue for the Corps since completion of Lower Granite Dam in 1975. The confluence is at the upstream end of Lower Granite reservoir where river velocities slow and sediment drops out of the water column. The Corps has dredged the federal navigation channel and the berthing areas of the Port of Lewiston and Port of Clarkston multiple times since 1982, most recently in the winter of 2005/2006 (Table 3). Quantities of material removed each time ranged from about 250,000 cubic yards to about 400,000 cubic yards. The Corps has also dredged a larger template in the confluence area several times to provide adequate passage for high flows to prevent overtopping the levees at Lewiston, Idaho. Quantities for this flow conveyance dredging ranged from about 500,000 cubic yards to almost 1 million cubic yards per dredging action.

Table 3. Historical Dredge Volumes from the Confluence of the Snake and Clearwater Rivers

Year	Location	Volume (cubic yards)
1982	Port of Lewiston – Lower Granite Reservoir	256,200
1982	Port of Clarkston – Lower Granite Reservoir	5,000
1985	Confluence of Clearwater and Snake Rivers	771,000
1986	Port of Lewiston – Lower Granite Reservoir	378,000
1988	Confluence of Clearwater and Snake Rivers	916,000
1989	Confluence of Clearwater and Snake Rivers	993,500
1992	Confluence of Clearwater and Snake Rivers	520,700
1996/97	Confluence of Clearwater and Snake Rivers	68,700
1997/98	Confluence of Clearwater and Snake Rivers	215,200
1997/98	Port of Lewiston	3,700
1997/98	Port of Clarkston	12,150
2005/06	Confluence of Clearwater and Snake Rivers, Ports of Lewiston and Clarkston	335,900

The Corps has performed sampling and analysis of sediment proposed to be dredged since 1985. Grain-size analysis has shown the material dredged from the confluence usually consists of more than 80 percent sand. Results of the contaminant analysis have shown the dredged materials do not contain contaminants in excess of biologically protective criteria (USACE 1999, 2000, 2002c, 2003a, 2003b, 2005, 2012b). In the Lower Granite reservoir, lower concentrations of major and trace elements were associated with coarser sediments (larger than 0.0625 mm in diameter) and higher concentrations of major and trace elements were associated with finer sediments (smaller than 0.0625 mm in diameter) (USACE 1999; Braun et al. 2012).

1.3.1.2 Potential Sources of Chemicals of Concern

The main potential sources of chemicals of concern for the Snake/Clearwater Rivers Confluence include industrial pollutants, storm water runoff, sewage treatment plant effluent, mining, and non-point pollutants.

Industrial Pollutants

The main potential source of industrial pollutants to the confluence area is the Clearwater Paper Corporation facility (formerly Potlatch Corporation) on the left bank of the lower Clearwater River at Lewiston, approximately 3 miles upstream of the confluence of the Snake and Clearwater Rivers. The mill has operated at this location since 1927. It manufactures wood products and bleached grades of paperboard, tissue, and market pulp by the bleach kraft mill (sulfate) process (NOAA 2004). This plant has a National Pollutant Discharge Elimination System (NPDES) Permit, Number ID0001163, from the Environmental Protection Agency. The design flow for the mill is 39.0 MGD (WDOE 2009a). The plant is authorized to discharge effluent through an outfall into the Snake River (at RM 140) and via seepage from the secondary treatment pond into the Clearwater River.

Storm Water Runoff

The majority of the storm water runoff that may be a source of pollutants for the confluence comes from the three urbanized areas in the vicinity, Lewiston, Clarkston, and Asotin. Lewiston (population 32,119) is located on the right bank of the Snake River (river miles 139 – 143) and both banks of the lower Clearwater River (river miles 0-2) at the confluence of the Snake and Clearwater rivers. Storm water from Lewiston is discharged into both rivers. Some of the storm water runoff from the city of Lewiston

flows into levee ponds operated by the Corps. The Corps periodically pumps water from these ponds into the Clearwater River as part of routine levee operation and maintenance. The results of a study completed in 2005 determined the Lewiston levee ponds did not pose a significant potential risk to salmonids in the Clearwater River (Steevens, et al., 2005). This conclusion was based on the relatively low chemical concentrations, often below conservative screening values, that were detected in the majority of the samples from the ponds.

Clarkston, Washington (population 7,331) is located on the left bank of the Snake River (river miles 136.5 to 143) opposite the mouth of the Clearwater River. Storm water from Clarkston is discharged into the Snake River.

Asotin, Washington, (population 1,270) is located on the left bank of the Snake River (river miles 145 to 146.5), about 6 miles upriver of the Snake/Clearwater rivers confluence. Storm water from Asotin is discharged into the Snake River.

Sewage Treatment Plant Effluent

Sewage treatment effluent originates from the three urbanized areas of Lewiston, Clarkston, and Asotin. Descriptions of their respective sewage treatment facilities are provided below:

a. Lewiston

Lewiston discharges from its municipal wastewater treatment plant to the Clearwater River about 1/2 mile upstream from the Snake-Clearwater River confluence (WDOE 2009a) (Figure 13). The treatment plant has a design flow of 0.55 MGD (EPA 2006a). It operates under permit number ID-0026531 and is classified as a conventional filtration plant (EPA 2006).

b. Clarkston

Clarkston operates a publicly owned wastewater treatment facility that uses an activated sludge process with ultraviolet light disinfection. The outfall was replaced in the fall of 1996 to provide additional diffusers and greater hydraulic capacity (WDOE 2009a). The city added a new secondary clarifier in 1999 (WDOE 2009a). The design flow is 2.20 million gallons per day (MGD) (WDOE 2009a). The treatment plant and its outfall are located at the downstream end of the proposed dredging area (Figure 14).

c. Asotin

Asotin currently operates an oxidation ditch wastewater treatment plant that was upgraded in 2005 (Figure 15) (WDOE 2009b). The 2005 upgrade project included rehabilitation work to the head works, modifications to the oxidation ditch, installation of ultraviolet light disinfection to replace the chlorine disinfection system, installation of new secondary clarifiers, sludge processing upgrades, and the conversion of the old secondary clarifiers into aerobic holding tanks (WDOE 2009b). Secondary treated and disinfected effluent discharges from the facility via a 12-inch single port diffuser into the Snake River. The design criteria included an average flow of 0.14 MGD (WDOE 2009b). WDOE placed the 0.5 mg/liter chlorine discharge limitation in the permit to protect the Snake River when the city uses chlorine as a back-up disinfectant because the ultraviolet disinfection system is not working or is overloaded with turbid effluents (WDOE 2009b).



Figure 13. Location of City of Lewiston wastewater treatment facility



Figure 14. Location of the City of Clarkston Wastewater Treatment Facility



Figure 15. Location of the City of Asotin Wastewater Treatment Facility

Mining

Diverse and extensive mining has occurred in the Clearwater drainage and the Snake River basin. The discovery of gold has played a major role in the history of Idaho dating back to the 1800s and several mines have been reopened on some parts of the Salmon River as the value of gold has increased (IMNH 2013). Rare earth elements and uranium were also mined historically in central Idaho before and during the 1950s (Gillerman and Bennett 2010, Herron and Freeman 2008). Currently, the Thompson Creek Mining company operates a large, open pit molybdenum mine near Challis in Custer County, Idaho (Gillerman et al. 2007). Six mines within the Salmon subbasin have records of toxic substance releases involving the following contaminants and conditions: arsenic, chromium, nitrate compounds, nickel, iron, silver, zinc, cadmium, lead, copper, manganese, mercury, cobalt, 2-mercaptomenzothiazole, chlorine, coliform, solids, and altered basic water chemistry (NPCC 2004).

Non-point Sources

Non-point sources include agriculture, forest fires, and pesticide applications on either agricultural or forest lands. The majority of these originate further up in the watershed and not near the confluence of the Snake and Clearwater rivers.

1.3.1.3 Categories of Chemical Constituents

Organic Compounds

Legacy chlorinated compounds are the most common, and potentially detrimental, organic chemicals identified in lower Snake River sediments. DDT, DDE, and DDD are the most frequently encountered compounds (Normandeau 1999b; USACE 2002a). The largest applications of DDT to U.S. Forests (approximately 80 percent) were to control infestations of the western budworm (*Choristonneura* sp.) and the gypsy moth (*Lymantria dispar*) from 1945 to 1965, (Wickman and Scharpf 1972; EPA 1975). DDT was also used as an occasional defoliator for pest infestations in the 1960s to early 1970s in federally managed forests (EPA 1975; Campbell and Sloan 1977) The last DDT application over a large area of Idaho occurred in in 1974 to halt an infestation of tussock moth (USFS 1975). Other chlorinated compounds such as aldrin, chlordane, dieldrin. endrin, endosulfan, and lindane have only been detected at very low concentrations, or not at all, during previous sediment evaluations.

Sediment samples taken for previous dredged material evaluations during the Potlatch ambient sediment monitoring period (CH2M Hill 1998, 1999, 2000, 2001, 2002) showed trace amounts of a few PAH species. However, sediment concentrations in the confluence area have never been high enough to suggest that the material could not be used for in-water disposal (USACE 1999, 2000, 2002c, 2003a, 2003b, 2005, 2012b). One source of PAHs within the watershed is from forest fires. Several studies have found that airborne pollution deposition is the main source of soil PAHs in remote areas (Edwards 1983; Vergnoux et al. 2011; Wick et al. 2011) and that a large proportion of the PAH content in water is probably adsorbed onto suspended solids (Harrison et al. 1975).

Dioxins and furans are an important chemical of concern due to their toxicity at low concentrations. One potential source of dioxins is from pulp and paper mills, and items specific to the facility along the Clearwater River were discussed in section 1.3.1.2 above. However, small amounts of dioxin and furans have also been found in smoke from wheat fires and agricultural burning practices (Gullett and Touati 2003; Goncalves et al. 2011) and stream concentrations have reportedly increases after wildfires (Tashiro et al. 1990; Gabos et al. 2001; Kim et al. 2003). These atmospheric routes can account for about 75 percent of the total loading in rural areas (Shabad 1980; Edwards 1983).

Metals

Mining for gold, molybdenum, phosphorus, uranium, and other rare earth elements has historically occurred, and continues in some locations today, in both the Clearwater and Snake River drainages. This activity has the potential to influence metals concentrations in the lower Snake River, although values greater than the screening limits have not occurred in dredged areas to date. Selenium is one element that has been identified at concentrations above the February 2013 Dredged Material Management Program (DMMP) (USACE, 2013) screening limits in some areas that are usually not dredged. Sediment concentrations as high as 4.2 mg/kg have been determined for the Yankee Fork Tributary of the Upper Salmon subbasin as a consequence of gold mining (U.S. Department of Interior, 2012). Even higher selenium concentrations have been determined in southeastern Idaho stream sediments where phosphate mining is occurring (USGS, 2002). Both of these cases illustrate that elevated background selenium concentrations occur in some parts of Idaho within the Snake River drainage area.

1.3.2 Ice Harbor Navigation Lock Approach

The area within the Ice Harbor downstream navigation lock approach is does not experience much sediment deposition as downstream movement of the majority of the sediment is blocked by the dam. The materials interfering with navigation in this area are riverbed cobbles pushed into the lock approach by river flows passing over the dam spillway or by operation of the navigation lock gate.

1.3.2.1 Historical Dredging

Material has been removed several times from the navigation channel downstream of Ice Harbor Dam since 1961 either by dredging, blasting, or knocking off rock spikes (Table 4). The channel extends from the dam downstream to the confluence of the Snake and Columbia Rivers, a distance of about 9 miles, so not all of the dredging actions listed in the table may have included the same area the Corps proposes to dredge in 2013/2014.

Table 4. Historical dredging from Ice Harbor Downstream Approach Channel

Year	Location	Volume (cubic yards)
1961	Navigation channel, part I and II, Channel construction	3,309,500
1962	Navigation channel, part III, Channel construction	120,000
1972	Downstream navigation channel	80,000
1973	Navigation channel downstream of Ice Harbor	185,000
1978	Downstream approach channel construction, Ice Harbor lock	110,000
1978, 1981/82	Downstream approach channel construction, Ice Harbor lock	816,814
1985	Downstream approach channel construction, Ice Harbor lock	98,826
1997/98	Navigation channel downstream of Ice Harbor	Not available[1]
2012	Downstream navigation lock approach	400

Note 1. Dredging was removal of individual rock spikes – no volumes provided

1.3.2.2 Potential Sources of Chemicals of Concern

Since Ice Harbor Dam blocks the downstream movement of most sediment, there is little opportunity for chemicals of concern to be deposited in the substrate downstream of the dam. Any potential sources would most likely be from the commercial navigation vessels and recreational watercraft that move through the lock. However, the substrate in the area proposed to be dredged is predominantly rock and cobble with very little fines, which limits the potential for chemicals of concern to be embedded in the substrate.

1.4 Existing Sediment Data

1.4.1 Background

Sediment samples have been collected from various locations within the lower Snake River project since at least 1985 (Crecelius and Gurtisen, 1985; Crecelius and Cotter, 1986; Pinza *et al*., 1992a, 1992b; Anatek, 1997; HDR, 1998; CH2M Hill (2000, 1999, 1997), USACE, 2002a, 2002b, 1998, 1987; Heaton and Juul, 2003). Most of these studies are linked directly to the Corps dredging authorities and projects, and predominantly focus on the Snake and Clearwater confluence area. The 1997, 2000, and 2003 studies were the most inclusive and the results from these investigations will be emphasized here.

The purpose of the 1997 sediment study completed for the Lower Snake River Juvenile Salmon Migration Feasibility Study was to determine the concentration and distribution of potential sediment contaminants in the four lower Snake River reservoirs. This study consisted of two phases. The first phase involved collecting particle-size distribution information along selected transects to target specific areas where finer-particle-size materials were predominant. Representative cores were retrieved using an 8-cm diameter by 2-m long (3-in diameter by 7-ft long) Balchek gravity core sampler. Most of the cores were

composited over the entire depth of sediment but some were cut into 0.6-m (2-ft) sections for layer analysis (CH2M HILL, 1997; Anatek Labs, 1997). During Phase 2 of the Feasibility Study sampling program, 94 sediment samples were submitted for laboratory analysis of selected inorganic and organic constituents.

The June 2000 sediment survey included 58 sites in the lower Snake River and Clearwater Rivers. The majority of the sites were in Lower Granite reservoir and the Clearwater River near the confluence with the Snake River. Off-channel areas evaluated in the study included Hollebeke HMU in Ice Harbor reservoir; Willow Landing and Illia Landing in Little Goose reservoir; and Greenbelt Boat Basin, Swallows Swim Beach, and Hells Canyon Resort Marina in Lower Granite reservoir. Ten sites in the four navigation lock approaches were evaluated and found to consist of rock and cobble. A Shipek grab sampler or Balchek core sampler were used to obtain the samples, the choice depending on sediment depth. Samples from 48 sites were analyzed for particle size distribution while fewer were processed for chemical analyses.

The 2003 study included ten proposed dredging areas from the mouth of the Snake River to the Swallows Boat Basin and from within the first 1.5 miles of the Clearwater River that were evaluated in 2000. In addition, the sediments at one in-reservoir disposal site in Lower Granite Reservoir were also evaluated. Samples were collected with a 3-in Balchek or Shipek sampler depending on the depth of the material. Of the 68 possible samples, 30 were selected to undergo Tier IIB analysis based on grain size and total volatile solids content. This suite of analyses included trace metals, mercury, oil and grease, total petroleum hydrocarbons, chlorinated herbicides, organophosphorus pesticides, semi-volatile herbicides and pesticides, polycyclic aromatic hydrocarbons, poly chlorinated biphenyls, total organic carbon and total volatile solids. A smaller subset of 20 samples was collected in Lower Granite pool and screened for dioxin-like compounds using P-450. Eleven of these sediment samples received a full high resolution dioxin analysis (EPA Method 8290).

1.4.2 Particle Size

A total of 487 grab sediment samples were collected as part of the Phase 1 task of the special Lower Snake River Juvenile Salmon Migration Feasibility Study sediment study (CH2M HILL, 1997). Of the 487 grab samples, 356 were sieved to develop particle-size distributions. The remaining 131 samples (or 26.9 percent) were not sieved either because there was no sample recovery or because the sample consisted only of gravel and/or cobble. The average grain size distributions for the sediment samples collected from above Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Locks and Dams are summarized in Table 5.

Table 5. Summary of Particle Size Analysis for the Sediment Samples collected from the Lower Snake River in 1997 during Phase I.

	Average Grain Size (%)				Cumulative Percent			
Sediment Size	**IHR**	**LM**	**LGO**	**LGR**	**IHR**	**LM**	**LGO**	**LGR**
Gravel	2.4	2.8	1.9	0.4	2.4	2.8	1.9	0.4
Very Fine Gravel	0.1	0.6	0.7	0.3	2.5	3.4	2.6	0.7
Very Coarse Sand	0.1	1.0	0.7	0.5	2.6	4.4	3.3	1.2
Coarse Sand	1.1	1.1	2.8	1.7	3.7	5.5	6.1	2.9
Medium Sand	18.3	2.8	10.2	6.9	22.0	8.3	16.3	9.8
Fine Sand	18.3	6.7	13.1	17.1	40.3	15.0	29.4	26.9
Very Fine Sand	23.3	13.2	16.8	20.1	63.6	28.2	46.2	47.0
Silt/Clay	35.8	71.8	53.8	52.4	99.4	100.0	100.0	99.4

Notes: IHR - Ice Harbor Reservoir (Lake Sacajawea), 41 samples

LM - Lower Monumental Reservoir (Lake West), 77 samples

LGO - Little Goose Reservoir (Lake Bryan), 127 samples

LGR - Lower Granite Reservoir (Lower Granite Lake), 104 samples

Source: Developed by Normandeau, 1999a

The 2000 sediment study of the lower Snake and Clearwater Rivers confluence (USACE, 2000) evaluated 53 samples for particle size with an emphasis on depositional areas. Some mid-channel and lock approach areas from Lower Granite and Little Goose locks and dams were also included in the sampling. Particle size was very dependent on locations of the sampling sites, but the average particle-size distribution for all sites were fines (silt and clay) 17.14 percent, sand 74.20 percent, and gravel 7.76 percent. The lock approach sites consisted of 2.5- to 15-centimeter (1- to 6-inch) cobbles exclusively. Generally, a sample location near the confluence that was more than 75 meters from the shoreline contained less than 1 percent fines.

The 2003 sediment study found that the proposed dredging areas differed with respect to percent of sand and fines in recovered samples. The samples from the Clearwater River, Port of Clarkston, and in the Snake River below the confluence with the Clearwater River all had median sand composition >90%. The areas at the Willow Landing and RM 116 (before it was used as an in-water disposal site in 2005/2006) had the highest median percent fines of 76% and 60%, respectively. The Greenbelt Boat Basin and Swallows Boat Basin areas were similar at 70% and 69% sand, respectively. Only one of three locations within each of the Port of Lewiston and Illia Landing areas provided recoverable samples and these were 57% and 83% sand, respectively.

1.4.3 Organics

Sediment analyses have included several organic compound groups, including: chlorinated herbicides, dioxins, glyphosate herbicide, organochlorine pesticides, organophosphorus pesticides, semi-volatile compounds, and total petroleum hydrocarbons. A few chlorinated herbicides, organophosphorus pesticides, or semi-volatile organic compounds have been detected in composite top layer sediment samples. In other studies, organic contaminants were detected sporadically. The following sections present the results of the polychlorinated dibenzo dioxin/furans, glyphosate herbicide, organochlorine pesticides, polynuclear aromatic hydrocarbons (PAHs), and total petroleum hydrocarbon analyses and other historical organic chemistry data sets.

1.4.3.1 Dioxins and Furans

There have been concerns about dioxin/furan contamination in the Snake and Columbia Rivers since the 1980s. In response, the Corps initiated a sediment quality study in 1991 to determine potential effects prior to the execution of the 1992 drawdown test of the Lower Granite reservoir. Five of the 19 composite sediment samples analyzed for dioxin/furan compounds yielded an average of 0.43 ppt 2,3,7,8-TCDD and 2.72 ppt 2,3,7,8-TCDF on the Clearwater River at approximately RM 3 (Pinza *et al.*, 1992a, 1992b).

Dioxin and furan tests were also completed for the 1997 Lower Snake River Juvenile Salmon Migration Feasibility Study downstream from previous sampling locations. Only two of the four samples yielded detectable levels of total dioxins of 0.69 and 1 ppt (no 2,3,7,8-TCDD was identified) (CH2M Hill, 1997).

Multiple sediment studies were completed in 1998 that included analyses for dioxins and furans. The first study documented nine samples that were taken in the Lewiston/Clarkston confluence area near Snake River RM 139. Only two of the nine samples yielded results with 1.3 and 1.7 ppt 2,3,7,8-TCDF and no detects for 2,3,7,8-TCDD (HDR, 1998). In a second study, CH2M Hill collected samples for dioxin analyses for Potlatch Corporation (now Clearwater Paper Corporation) in the Lower Granite pool and Clearwater arm of the pool (CH2M Hill 1997, 1998). Seven sites were selected and individual subsets were combined into a composite sample for analysis. A Ponar sampler was used to sample the top 7.5 inches of the sediments. The results from the in-river sites sampled consisted of no detects and below detection limits for 2,3,7,8-TCDD and 2,3,7,8-TCDF.

Sediment samples collected in 2000 included use of new technology to aid the detection of dioxin/furan in sediments. Ten samples were screened for the presence of dioxin/furan compounds using a cell-based assay (P-450). The samples were subsequently analyzed by a gas chromatograph mass spectrometer confirmatory test to quantify the congeners. The test results showed than some of the congeners were present, but 2,3,7,8-TCDD or 2,3,7,8-TCDF were not among them.

Dioxin and furan congeners were again analyzed in samples collected from three separate areas in Lower Granite reservoir (RM-116, Port of Clarkston, and the Snake River below the confluence) in 2003. The results showed that 2,3,7,8-TCDD and several other congeners were not detected in the samples. The two congeners that occurred in the highest concentrations were 1,2,3,4,6,7,8-HpCDD (2.03 to 4.95 ppt) and 1,2,3,4,6,7,8,9-OCDD (10.99 to 38.38 ppt). The toxic equivalents (TEQ) were calculated using maximum concentrations of all the congeners identified from RM 116, Port of Clarkston, and the Snake River below the confluence the results were 0.17, 0.04, and 0.23 ppt, respectively. In all cases, the calculated values were less than the bioaccumulation screening criteria by more than an order of magnitude.

1.4.3.2 Glyphosate and Aminomethylphosphoric Acid

Glyphosate is a post-emergence terrestrial and aquatic herbicide that has found widespread agricultural use in eastern Washington and Oregon, as well as domestic applications. A major metabolite is aminomethylphosphonic acid (AMPA). AMPA is much more persistent than glyphosate, and the half-life is dependent on the environment with reported ranges of 199 to 958 days (WHO, 1994), and 10 to 12 weeks in the pond environment (USFS, 1984).

The presence of glyphosate and AMPA were first evaluated during the 1997 feasibility study. During that evaluation, all top layer sediment samples (94 total samples) were tested and glyphosate and AMPA were detected in 36 percent and 16 percent of the samples, respectively. Individual concentrations of glyphosate ranged from non-detected to a maximum of 68.9 ppb (parts per billion) with an arithmetic mean of 12.52 ppb. The concentration of AMPA ranged from non-detected to a maximum of 29.3 ppb with an arithmetic mean of 7.48 ppb (Normandeau, 1999b). No screening criteria have been established for either glyphosate or AMPA in sediments within the Columbia River Basin.

There appeared to be slight downstream increases in the mean concentrations of both glyphosate and AMPA in sediment samples collected from each of the impoundments. Although the highest individual concentrations of glyphosate and AMPA were detected in samples collected from Lake Bryan (Little Goose reservoir) (Normandeau 1999b) the highest average reach concentration of glyphosate was found in the samples collected from Lake Sacajawea (Ice Harbor reservoir, see Table 6).

Table 6. Summary of Average Glyphosate and AMPA Concentrations (µg/L, Elutriate, and ppb, Sediment) for Sediment Samples Collected during 1997 in the Lower Snake River

	Ice Harbor	Lower Monumental	Little Goose	Lower Granite	Average
Elutriate					
AMPA	ND	ND	ND	ND	ND
Glyphosate	0.58	ND	0.69	ND	0.57
Sediment					
AMPA	8.08	8.28	7.58	6.07	7.48
Glyphosate	16.80	14.85	10.42	10.60	12.52

1/ ND = Not detected; ½ the detection level is used when concentrations < detection level.

Analyses for glyhopsate were included in the 2000 sampling program. One site in the Greenbelt Boat Basin had a concentration of 23 ppb, and was the only location with a reported value higher than the laboratory detection limits. Two other sample analyses from the same boat basin came back at less than the MDL.

1.4.3.3 Organochlorine Pesticides

Synthetic organic chemicals containing chlorine, including carbon tetrachloride and trichloroethylene, were available commercially by 1925. DDT was released into civilian markets in 1945 and used extensively over the next two decades to control agricultural and forest insects, as well as disease vectors. The last DDT application over a large area of Idaho occurred in 1974 to halt an infestation of tussock moth (USFS 1975). Other organochlorine pesticides, such as methoxychlor, aldrin, dieldrin, chlordane, endosulfan, endrin, and toxaphene were developed after World War II, and at least some of these have been used in the watershed.

Organochlorine pesticides are relatively insoluble in water, adhere strongly to soil particles, and are resistant to physical, chemical, and biological degradation. Because of these features, the original pesticides and their daughter products tend to remain in the environment for extended periods of time and many bioaccumulate. Several have been detected in sediment samples collected from the lower Snake River, including: 4,4-DDD; 4,4-DDE; 4,4-DDT; aldrin; dieldrin; endrin; heptachlor; and lindane.

The Corps has monitored sediments prior to dredging operations for a host of organic compounds since the mid 1980s. In the sediment analysis studies for 1984 and 1985 for interim dredging (USACE, 1987; 1988), the Corps sampled sediments between the Port of Lewiston and the confluence of the Snake and Clearwater River. At seven sample sites that were sampled in the Clearwater River in 1985, 4,4-DDD concentrations ranged from less than 0.3 to 3 ppb while 4,4-DDE ranged from less than 0.3 to 4.8 ppb. In 1988, during dredging in the upper end of the reservoir behind Lower Granite Lock and Dam, the Walla Walla District found 4,4-DDT at 6 ppb at a site in the Clearwater Snake River Confluence (USACE, 1987).

Sediment testing in the 1990s added to the database. Pinza *et al*. (1992b) tested 19 sites for chlorinated pesticides at port areas on the lower Snake and Columbia rivers. At the eight sample locations in the vicinity of the Snake and Clearwater River confluence, 4,4-DDT concentrations ranged from 1.2 to 2.0 ppb, which was below laboratory detection limits. The DDT metabolite 4,4-DDD concentrations ranged from 0.7 to 2.0 ppb while 4,4-DDE concentrations ranged from 0.6 to 3.3 ppb. Other organochlorine pesticides were reported as less than the laboratory detection limit of 2.0 ppb.

The sediment sampling completed for the1997 Lower Snake River Juvenile Salmon Migration Feasibility Study was spatially more extensive than previous investigations. Average DDE concentrations ranged from 2.68 ppb in Ice Harbor to 6.48 ppb in the Lower Granite reach, with an arithmetic mean concentration of 4.89 ppb. DDD was detected in 11 sediment samples, with an average maximum concentration of 6.48 ppb in the Lower Granite reach and an arithmetic mean of 2.07 ppb. DDT was detected in only five samples, with a mean arithmetic concentration of 1.62 ppb. Total DDT (DDD, DDE, and DDT) concentrations averaged 8.23 ppb. The highest mean reach concentration for total DDT was 11.3 ppb for Lower Granite Lake. The average reach concentration of total DDT decreased steadily downstream from Lower Granite Lake, reaching a mean concentration of 5.7 ppb in Lake Sacajawea.

The pesticides aldrin, dieldrin, endrin, heptachlor and lindane were also evaluated in the 94 sediment samples collected for the feasibility study. The concentrations of these compounds in Lower Granite reservoir were reported as non-detects.

The analysis for organochlorine compounds using EPA Method 8151A in 2000 did not include all of the compounds considered in 1997. As such, there is no data for aldrin, dieldrin, endrin, 4,4-DDD, 4,4-DDE, 4,4-DDT or other chlorinated pesticides identified above. The results for the sixteen chlorinated herbicides, including 2,4-D, 2,4-DB, 2,4,5-T, and 2,4,5-TP, that were evaluated were all less than the detection limits.

The evaluations organochlorine compounds such as 4,4-DDD, 4,4-DDE, 4,4-DDT, aldrin, chlordane, dieldrin, endrin, lindane, and mirex from the 2003 study were all reported as less than the MDL

1.4.3.4 Total Petroleum Hydrocarbons, Oil, and Grease

The lower Snake River area is not heavily industrialized, and significant pollution problems from oil spills and heavy industrial pollution are not expected to be as common as in the major northwest port areas such as Puget Sound and Portland. However, at certain portions of the river there are ports, grain

terminals, and boat launch areas that experience heavy use seasonally. These areas could be expected to have concentrations of residues from fueling operations and bilge wash.

Total petroleum hydrocarbon, fats, oils, greases, and traditional oil and grease analyses were completed in the 1980s and early 1990s, albeit with little continuity. Crecelius and Gurtisen (1985) reported oil and grease concentrations from sediment sites near Clarkston, Washington, on the Snake River ranging from 62 to 222 ppm. The Corps reported oil and grease in the sediments ranging from 38 to 1,096 ppm. Only two of these samples were greater than 500 ppm and these were both detected at an in-water disposal site in Lower Granite pool at RM 120. Pinza *et al*. (1992b) reported oil and grease concentrations ranging from 12.62 to 208.70 ppm for mid Columbia and Snake River sites. Total petroleum hydrocarbons ranged from 12.20 to 96.27 ppm.

Total petroleum hydrocarbons (TPHs) were again analyzed in all four lower Snake River reservoirs during the 1997 feasibility study. However, the method used (a modified version of EPA 418.1) only provides an indication of the amount of petroleum material in the sediments and does not quantify the specific type of petroleum material present. The results did show that the concentration of TPH ranged from non-detect to 256 ppm (Lower Monumental reservoir) with an arithmetic mean of 55.41 ppm (Anatek, 1997). Along the lower Snake River, the average concentration of TPH generally increased in the downstream direction with the highest average reach concentration (62.13 ppm) in Lake Sacajawea (Ice Harbor reservoir).

During the 2000 sediment survey in the area of the confluence of the Snake and Clearwater Rivers, the Corps sampled 38 sites for oil and grease. Concentrations ranged from 134 to 770 ppm, and only three of the sites had oil and grease concentrations greater than 400 ppm (USACE, 2000).

Samples for oil, grease, and TPH diesel/motor oil analyses were collected from seven potential dredge areas during the 2003 investigation. The oil and grease content of individual samples ranged from 70 mg/kg at Illia Landing to 817 mg/kg at the Greenbelt Boat Basin. The median values for areas where multiple samples were collected were not as disparate, ranging from 239 mg/kg and 274 mg/kg at the Willow Landing and Swallows Swim Beach, respectively, to 327 mg/kg and 463 mg/kg the at the Greenbelt Boat Basin and Port of Clarkston, respectively.

Since the natural organic breakdown products from plant and animal matter contribute to the oil and grease content of the sediments, TPH for diesel and motor oil analyses were completed to identify those components during the 2003 study. The values reported for TPH diesel at the Port of Lewiston, Illia Landing, and Willow Landing were all less than detection limits. Of the samples actually tested for TPH diesel that yielded positive results (six from the Port of Clarkston, five from the Greenbelt Boat Basin, and three from the Snake River below the confluence), the concentrations ranged from 22 mg/kg to 82 mg/kg. Calculated median values for the same three areas ranged from 34 mg/kg at the Greenbelt Boat Basin to 81 mg/kg below the confluence. The TPH motor oil results paralleled the TPH diesel data, but were four to five times higher.

1.4.3.5 Polynuclear Aromatic Hydrocarbons (PAH)

PAHs represent a class of suspected carcinogens and can pose a threat to aquatic life. The PAHs typically found in dredged material can originate from petroleum-fueled internal combustion engines since that are found in the engine's emission as a byproduct of incomplete combustion. Another source of PAHs within the watershed is from forest fires as previously mentioned.

The first recorded sample and analysis effort for PAHs was conducted in the Port of Lewiston area in 1985. Crecelius and Gurtisen (1985) did the first serious study of PAHs in the Snake River system prior to a proposed confluence dredging action. In their analysis of sediment core samples from the Port of Clarkston area, the total PAH concentration ranged from 77 ppb to 865 ppb. This suggested that there

was low probability of risk associated with suction dredging at that time. Crecelius and Cotter (1986) revisited the Lewiston area locations and found only trace amounts of low-molecular-weight PAH compounds. High-molecular-weight PAH compounds ranged from 54 ppb to 818 ppb, and fluoranthene was the predominant component.

The Clearwater and Snake River confluence sediments were again sampled prior to the 1987 dredging action. During this investigation, no low-molecular-weight PAH compounds were detected (USACE, 1987). The PAH compounds present were predominantly pyrene and perylene. Perylene is commonly found in sediments containing substantial amounts of decaying material and was not an EPA priority pollutant in 1987. In this study, flouranthene was present but in small amounts relative to pyrene, which was the most commonly found PAH. The highest concentration of low-molecular PAH was 1,544 ppb at the in-water disposal area.

Pinza *et al*. (1992b) conducted the next significant dredge material study in the Snake and Clearwater confluence area. This study analyzed the ten most common PAH compounds expected to be found in this area based on industrial and regional land use practices. Composite samples were taken from the proposed disposal site, Port of Wilma (in Lower Granite reservoir), Port of Clarkston sampling stations SRP 24 and 25, Port of Clarkston sampling stations SRP 26 and 27, Port of Lewiston sampling stations SRP 28 and 29, Port of Lewiston sampling stations SRP 30, 31, and 32, Port of Lewiston sampling stations SRP 33 and 34; and the Port of Almota (in Little Goose reservoir). The calculated results for low-molecular-weight PAHs derived from the reported individual species were: 12.4 ppb, less than detection limit, 13.7 ppb, 10.9 ppb, less than detection limit, 15.3 ppb, less than detection limit, and less than detection limit, respectively. The calculated results for the high-molecular-weight PAHs were: 34.4 ppb, less than detection limit, 46 ppb, 15.8 ppb, less than detection limit, 25.7 ppb, 211 ppb, and less than detection limit, respectively. This study suggested that PAHs were relatively low in environmental concentration and substantially less than found in the previous studies.

During the interim between the 1992 study and the most recent dredged material studies, there were no additional investigations of PAH compounds available from publicly accessible sources. The best data available in 1998 and 1999 are the Potlatch Corporation reports (CH2M HILL, 1998a: and 1999). CH2M HILL (1998) reported that the Lower Granite pool and Clearwater arm samples generally showed low-molecular-weight PAHs to be less than 10 ppb and high-molecular-weight PAHs to be less than 50 ppb.

Results from the 2000 investigation found phenanthrene, flouranthene, and benzo (a) pyrene in a single sample from the Clearwater at about RM 3. The calculated concentration of high-molecular-weight PAHs was 161.4 ppb.

A suite of PAHs was evaluated using EPA Method 8270C during the 2003 sediment survey. The areas at RM 116 and Illia Landing typically had the highest individual and mean sample results (four samples from RM 116 were analyzed and only one sample from Illia was processed for Tier IIB analysis) followed by Greenbelt Boat Basin (six samples). The sum of the average LPAH compounds was 325 ppb, 257 ppb, 93 ppb, and 80 ppb at Illia, RM 116, Clearwater River, and Greenbelt Boat Basin, respectively. The sum of the mean HPAH compounds followed a similar pattern with 1,028 ppb, 829 ppb, 364 ppb, and 182 ppb at Illia, RM 116, Greenbelt Boat Basin, and the Clearwater River, respectively. The highest individual concentrations of phenanthrene and pyrene were determined for RM 116 at 283 ppb and 369 ppb, respectively. However, due to the difference in the number of samples analyzed, the mean values determined for the Illia Landing area were actually higher than the ones determined for RM 116. The highest fluoranthene concentration was also determined at Illia at 354 ppb, followed by 330 ppb at RM 116 and 236 ppb at Greenbelt Boat Basin. The areas sampled at Swallows Swim Beach, Port of Lewiston, the Snake River below the confluence with the Clearwater River, Port of Clarkston, and Willow Landing did not have any positive results for the low-molecular weight PAHs. The two high-

molecular weight PAHs that were detected in these areas were fluoranthene and pyrene, and even these concentrations were very low. Individual fluoranthene concentrations in these five areas reached 31 ppb at Swallows Swim Beach, while the highest pyrene concentrations were at Swallows Swim Beach and the Port of Lewiston at 20 ppb and 22 ppb, respectively.

1.4.4 Metals

Crecelius and Gertisen (1985) conducted a comprehensive evaluation of material from proposed dredging locations prior to the confluence dredging of 1986. Metals concentrations of copper, lead, zinc, and cadmium were very similar to levels found during the sediment examination for the Lower Snake River Juvenile Salmon Migration Feasibility Study when compared to the geometric mean. The outliers were mercury and chromium. Mercury levels were lower and ranged from 0.015 to 0.049 mg/kg. Chromium was somewhat higher and ranged from 26 to 43 ppm.

Sediment sampling performed in 1987 to support the Corps' 1988 Interim Flood Control Dredging (USACE, 1987) reported concentrations of sediment metals as follows: arsenic 2.6 to 12.6 ppm, copper 17 to 48 ppm, lead 13 to 27 ppm, mercury 0.018 to 0.186 ppm, and zinc 77 to 110 ppm. Cadmium ranged from 0.075 to 1.02 ppm.

The 1992 sediment sampling of the dredging sites on the Snake and Clearwater Rivers (Pinza *et al*., 1992b) reported concentrations as follows: arsenic from 1.11 to 9.46 ppm; cadmium from 0.2 to 0.4 ppm; chromium from 6.6 to 23.4 ppm; copper from 6.9 to 38.8 ppm; lead from 2.5 to 18.4 ppm and mercury from 0.06 to 0.20 ppm. Concentrations of zinc ranged from 26 to 78.7 ppm.

Sediments were sampled and tested for the 1996/1997 Confluence Dredging in the lower Snake and Clearwater rivers (USACE, 2002a). In this study the sediment concentrations ranged as follows: aluminum 12,200 to 20,300 ppm; arsenic 1.25 to 4.36 ppm; barium 135 to 234 ppm; beryllium 0.5 to 0.71 ppm; chromium 12.2 to 18.2 ppm; cobalt 9.97 to 13.4 ppm; copper 17.3 to 34.9 ppm; lead 6.79 to 10.9 ppm; manganese 259 to 580 ppm; molybdenum 0.29 to 1.35 ppm; nickel 10.3 to 13.5 ppm; selenium 1.29 to 2.17 ppm; thallium 0.15 to 0.19 ppm; vanadium 52.1 to 68.7 ppm; and zinc 38.4 to 69.8 ppm.

In 1997, each of the 94 sediment samples were analyzed for a suite of 18 metals, including arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, vanadium, and zinc. Of the 18 metals analyzed, only cadmium, mercury, silver, and strontium were not detected in all 94 samples. Cadmium was detected in only two samples, mercury in 37 samples, silver was not detected in any of the samples, and strontium was detected in only four samples (CH2M HILL, 1998; Anatek, 1997).

The Corps' June 2000 sediment study in the lower Snake and Clearwater rivers tested for metals in 32 sample sites. Results for this study were as follows: antimony all below detection limits; aluminum 232 to 7,885 ppm; barium 2.2 to 108 ppm; beryllium all non-detects; calcium 12.77 to 37.87 ppm; cadmium 0.122 to 1.058 ppm; chromium 1.20 to 9.13 ppm; cobalt 1.099 to 9.573 ppm; copper 2.22 to 44.33 ppm; iron 1.242 to 15,529 ppm; magnesium 9.123 to 405 ppm; manganese 10.97 to 4,009 ppm; molybdenum all non-detects; nickel 1.921 to 9.478 ppm; potassium 6.529 to 2,023 ppm; sodium 5.623 to 253 ppm; vanadium 1.292 to 65.22 ppm; zinc 1.090 to 41.56 ppm; mercury all non-detects; and lead 1.109 to 8.353 ppm. In these samples, chromium and aluminum were detected in significantly lower quantities than in previous studies. These parameters were also well below the expected average background levels.

Thirty-one sediment samples were tested for the twenty-three metals on the target analyte list (TAL) in 2003 (Appendix A). A clear distinction between the potential dredging sites with respect to the

magnitude of the metals concentrations was not apparent. The highest and lowest median concentrations differed by an average factor of 1.8, but ranged from 1.4 for chromium and cobalt to 2.4 to 2.6 for manganese and selenium. The areas sampled in the Clearwater River and Port of Lewiston had the highest median concentrations of aluminum, antimony, barium, chromium, iron, manganese, selenium, thallium, and vanadium. In contrast, the Port of Clarkston, Illia Landing, and Snake River below the Confluence tended to have the lowest concentrations of the same elements, in addition to cobalt, copper, lead, magnesium, nickel, and zinc.

1.4.5 Elutriate Fraction

Elutriate tests were completed in 1997 to evaluate potential impacts on surface water quality from the re-suspension of channel sediment. The purpose of the elutriate tests were to evaluate potential impacts on surface water quality from the resuspension of channel sediment. An ambient pH elutriate was prepared for each sediment sample and analyzed for organophosphorus pesticides, organochlorine pesticides, metals, and nutrients, glyphosate, and AMPA. TPH and dioxin were not tested in the ambient pH elutriates.

1.4.5.1 Organophosphorus Pesticides

The ambient pH elutriates were tested for the presence of twenty-five different organophosphorus compounds. The only organophosphorus pesticide detected was ethyl parathion, in one sample from Little Goose at a concentration of 1.0 ppb (µg/L). Although identified in the one elutriate sample, ethyl parathion was not detected in any of the sediment samples.

1.4.5.2 Organochlorine Pesticides

No organochlorine pesticides were detected in any of the ambient pH elutriate samples. The organochlorine pesticides DDT (and its metabolites), aldrin, dieldrin, endrin, heptachlor and lindane had been detected in some of the sediment samples tested. The results of the elutriate tests suggest that although these compounds are present in the sediments they do not readily partition into water.

1.4.5.3 Glyphosate

Glyphosate was detected in only two of the 94 ambient pH elutriate samples, while AMPA was not detected in any of the samples. Glyphosate was detected at a concentration of 0.69 µg/L in a sample collected from Lake Bryan (Little Goose reservoir)and at a concentration of 0.58 µg/L in a sample collected from Lake Sacajawea (Ice Harbor reservoir).

1.4.5.4 Metals

Each of the 94 ambient pH elutriates were tested for the same suite of metals that were analyzed on their corresponding sediments. Of the 18 metals considered, only beryllium, silver, and thallium were not detected in the elutriate samples. Of these three metals, only silver was not detected in the original 1997 sediment samples.

The mean metal concentrations for the ambient pH elutriates are summarized by river reach in Table 7. The predominant metals detected included barium and manganese. The average concentration of barium, by river reach, in the ambient pH elutriates increased from 83.3 ppb for the samples collected from Lower Granite reservoir to 243.6 ppb for the sediment samples collected from Lake Sacajawea (Ice Harbor reservoir). Although a corresponding trend in the concentration of barium in the sediment samples was not observed, it was one of the predominant metals detected. Its relatively high concentration in the

ambient pH elutriates is most likely the result of its concentration in the sediments and its relatively high solubility in water (Hem, 1989).

The predominant metal identified in the ambient pH elutriates was manganese (Table 7). The average concentration of manganese, by river reach, in the ambient pH elutriates ranged from 504 ppb for the samples collected from Lower Granite reservoir to 1,432 ppb for the samples collected from Lake West (Lower Monumental reservoir). In general, the trend in manganese concentrations in the ambient pH elutriate samples increases with distance downstream. As observed with barium, there did not appear to be a clear relationship between the concentration of manganese in the sediment samples and in the ambient pH elutriates.

Table 7. Summary of Mean Metal Concentrations for Ambient pH Elutriate Samples Collected during the 1997 Lower Snake River Project

Metal (µg/L)	Ice Harbor	Lower Monumental	Little Goose	Lower Granite
Arsenic	3.9	2.6	2.2	1.8
Barium	243.6	197.5	140.9	83.3
Beryllium	ND	ND	ND	ND
Cadmium	ND	ND	0.1	ND
Chromium	0.6	0.8	0.4	0.6
Cobalt	0.5	1.2	0.4	0.5
Copper	2.9	3.2	3.2	4
Lead	ND	0.1	0.1	0.1
Manganese	861.5	1,432.1	799.9	504.4
Mercury	ND	0.1	0.1	0.1
Molybdenum	3	3.5	3.8	2.2
Nickel	2.8	4.1	0.7	0.9
Selenium	2.3	1.2	0.3	0.3
Silver	ND	ND	ND	ND
Strontium	0.4	0.3	0.3	0.2
Thallium	ND	ND	ND	ND
Vanadium	2.1	1.2	1.8	1.5
Zinc	37.7	17.8	16.9	12.9

Notes: ND=not detected
Ice Harbor Lock and Dam-Lake Sacajawea
Lower Monumental Lock and Dam-Lake West
Little Goose Lock and Dam-Lake Bryan
Lower Granite Lock and Dam-Lower Granite Lake

Source: USACE 2000

2.0 PROJECT TEAM AND RESPONSIBITILIES

Table 8. Project team tasks, responsibilities, and names of involved individuals or contractors.

Task	Responsibility	Names
Project management	Project manager	Richard Turner
Sample design		Russ Heaton and Steve Juul
Sediment sampling/ core processing		Gravity Environmental, Inc.
Chemical analyses	Primary analyses of metals and organics	AM-Test
	Dioxin and furan	Analytical Resources, Inc.
	Multi-residue pesticides and glyphosate	Pacific Agricultural Laboratories
	QA for metals and organics	Anatek Labs
	QA for dioxins/furans and glyphosate	Summit Environmental Technology, Inc.
Quality assurance/ Quality control	Field Chemical	Gravity Environmental, Inc. Kismet Scientific Services
Final report		Walla Walla District

3.0 CONFIGURATION OF DMMUs AND SAMPLE INFORMATION

This section provides information on Dredged Material Management Unit (DMMU) locations sampled in 2011.

3.1 Sample Location Naming Convention

The Corps began using a naming convention in 2009 to simplify migration from a local SEDQUAL 3.5 database to an ArcGIS graphical database using Washington Department of Ecology **(**WDOE) Environmental Information Management standard Microsoft Excel spreadsheets. The convention is as follows.

- The first three letters constitute the standard operating project three-letter code or a three-letter hydrologic unit identification code based on the river basin name.
- The next two to three digits are the river mile integer.
- The decimal and following digit signifies the 1/10th of a mile.
- The letter designator is a point designated transect on the 1/10th of a river mile usually from right to left bank in descending order.
- The number identifier to the right of the letter is used for one of the following
  - Subsections of the core sample.
  - Additional samples from the adjacent location.
  - A duplicate sample.

3.2 Description of the DMMUs Proposed for 2013/2014 Dredging

Five areas within the lower Snake River are considered as project specific DMMUs for the proposed channel maintenance considered in this report. The primary focus is Lower Granite Reservoir in the vicinity of the confluence of the Snake and Clearwater Rivers since this is an area where sediment historically accumulates. The Snake River reaches include the FNC (Federal Navigation Channel) Clarkston East and West, the Port of Clarkston, and the Clarkston Grain Elevator. The first 1.5 miles of

the Clearwater River contains two areas of interest, FNC Lewiston and the Port of Lewiston. The last area of interest is the downstream navigation approach to Ice Harbor Lock and Dam near Snake RM 9.6. Table 9 presents the estimated volumes of sediment that would be removed in the DMMUs proposed for dredging 2013/2014 based on 2011 survey data.

Figures 16 through 22 show the DMMUs and sample locations considered for winter 2013/2014 channel maintenance. Tables 10 through 16 provide the global positioning system (GPS) coordinates for each sample location, as well as the type of sample collected.

Table 9. Dredging Quantities and Substrate Materials in DMMUs Included in the Proposed Channel Maintenance Project.

Site to be Dredged			Quantity at 16 ft[1]	Type of Material
Ice Harbor Navigation Lock Approach (Snake RM 9.5)			2,155	Cobble/Rocks
FNC Clarkston West DMMU			133,482	Sand
FNC Clarkston East DMMU			168,910	Sand
Port of Clarkston DMMU			9,041	Sand/Silt
Clarkston Grain Elevator DMMU			3,218	Sand/Silt
Clarkston Crane Dock DMMU			848	Sand/Gravel
FNC Lewiston			140,210	Sand
Port of Lewiston DMMU			3,275	Sand/Silt
Total			**461,139**	

Note. 1. Quantities based on 2011 survey data.

3.2.1 Ice Harbor Navigation Lock Approach DMMU

The Ice Harbor Navigation Lock Approach DMMU covers 7.4 acres of the lower Snake River at approximately RM 9.6 (Figure 16, Table 10). This area has been sampled and dredged in the past and has consistently yielded cobbles ranging in size from 1 to 10 inches, or more, in diameter with some sands but no silts. The grab samples retrieved during the 2011 field event again only yielded large material and no samples were forwarded to the laboratory for further analyses. However, photos of the substrate material retrieved were taken for documentation.

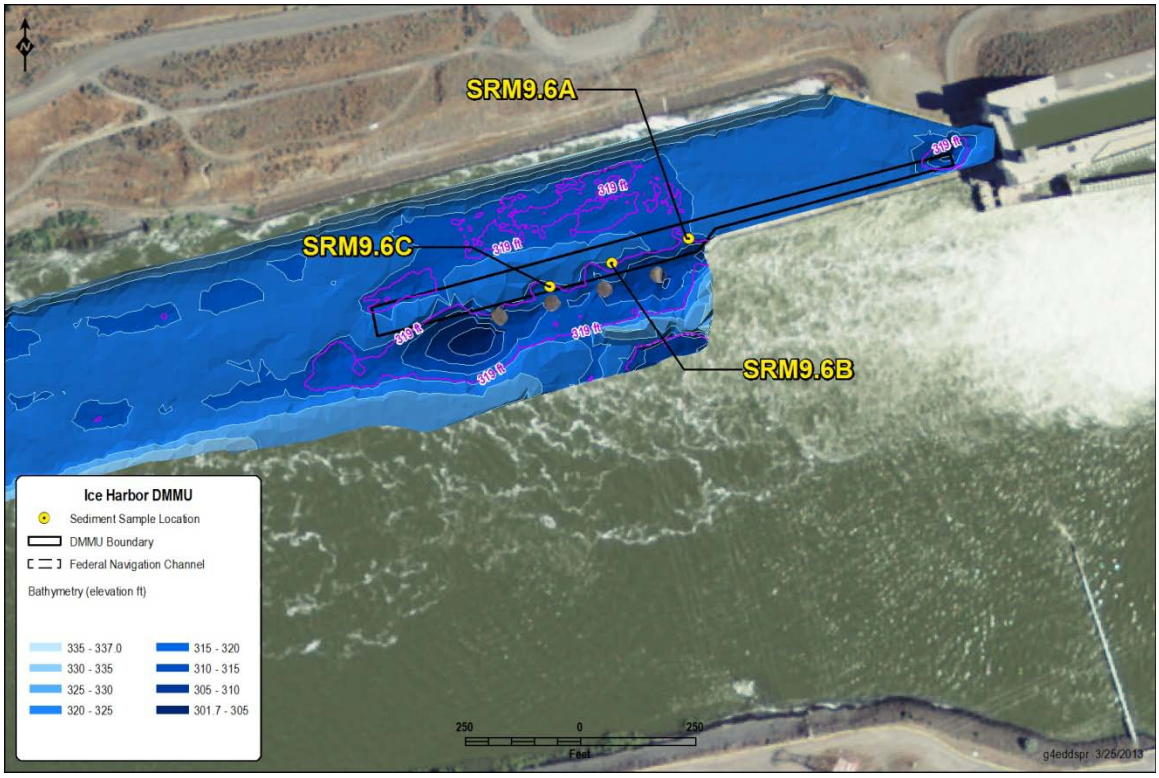


Figure 16. Ice Harbor Navigation Lock approach with 2011 sample locations.

Table 10. Sample Locations in the Ice Harbor Navigation Lock DMMU

Sample Location	Date	Latitude	Longitude	Water Depth	Sample Type	Notes
SRM9.6A	8/21/2011	46 15.018 N	118 53.152 W	ND	Grab	No Lab Analyses
SRM9.6B	8/21/2011	46 15.010 N	118 53.192 W	ND	Grab	No Lab Analyses
SRM9.6C	8/21/2011	46 15.002 N	118 53.224 W	ND	Grab	No Lab Analyses

3.2.2 FNC Clarkston West DMMU

The FNC West DMMU covers 2,100,741 square ft (48.2 acres) of the Snake River between RM 138 and RM 139 (Figure 17). Accelerated sedimentation within this DMMU began after the completion of Lower Granite Dam. The area with an elevation greater than 719 ft msl (less than 14 feet deep at MOP) is the portion of the DMMU that would be dredged. Four sediment samples were retrieved and processed from this DMMU (Table 11).

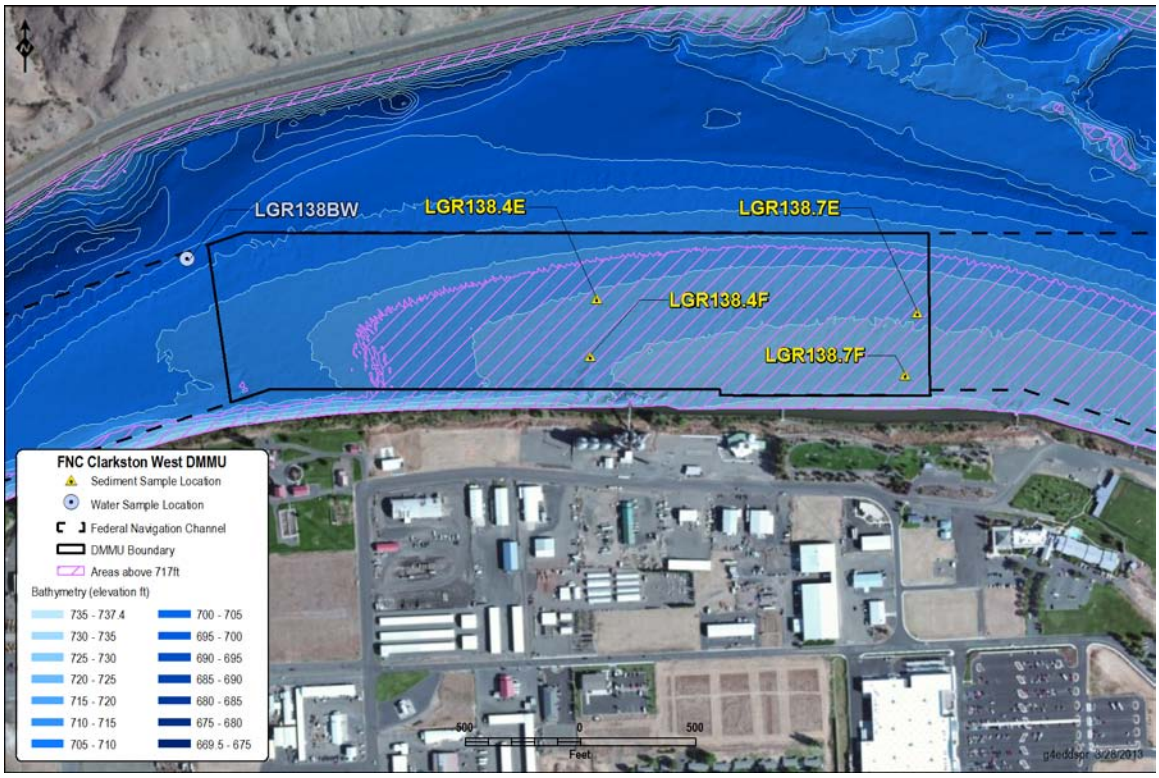


Figure 17. FNC Clarkston West DMMU with 2011 sample locations.

Table 11. Samples Used to Characterize the FNC Clarkston West DMMU

Sample Location	Date	Latitude	Longitude	Water Depth	Sample Type	Notes	Drive Length	Core Length
LGR138BW	8/16/2011	46 20.458 N	117 02.002 W	---	Water			
LGR138.4E	8/18/2011	46 25.698 N	117 03.269 W	17	Sediment	Core	43 cm	34 cm
LGR138.4F	8/18/2011	46 25.657 N	117 03.278 W	14	Sediment	Core	91 cm	76 cm,
LGR138.7E	8/20/2011	46 25.678 N	117 02.939 W	14	Sediment	Grab		
LGR138.7F	8/20/2011	46 25.634 N	117 02.954 W	11	Sediment	Grab		

3.2.3 Port of Clarkston Grain Elevator DMMU

The Port of Clarkston Grain Elevator DMMU covers 10,347 square ft (0.24 acres) of the Snake River at approximately RM 137 (Figure 18, Table 12). The dock at the grain elevator is used only for the off-loading of grain by transient shallow water barges and tugs and does not provide permanent moorage. Two sediment grab samples (one of them a duplicate) and one core were retrieved from this DMMU. The entire DMMU would be dredged as the water depth throughout the DMMU is less than 14 feet at MOP.

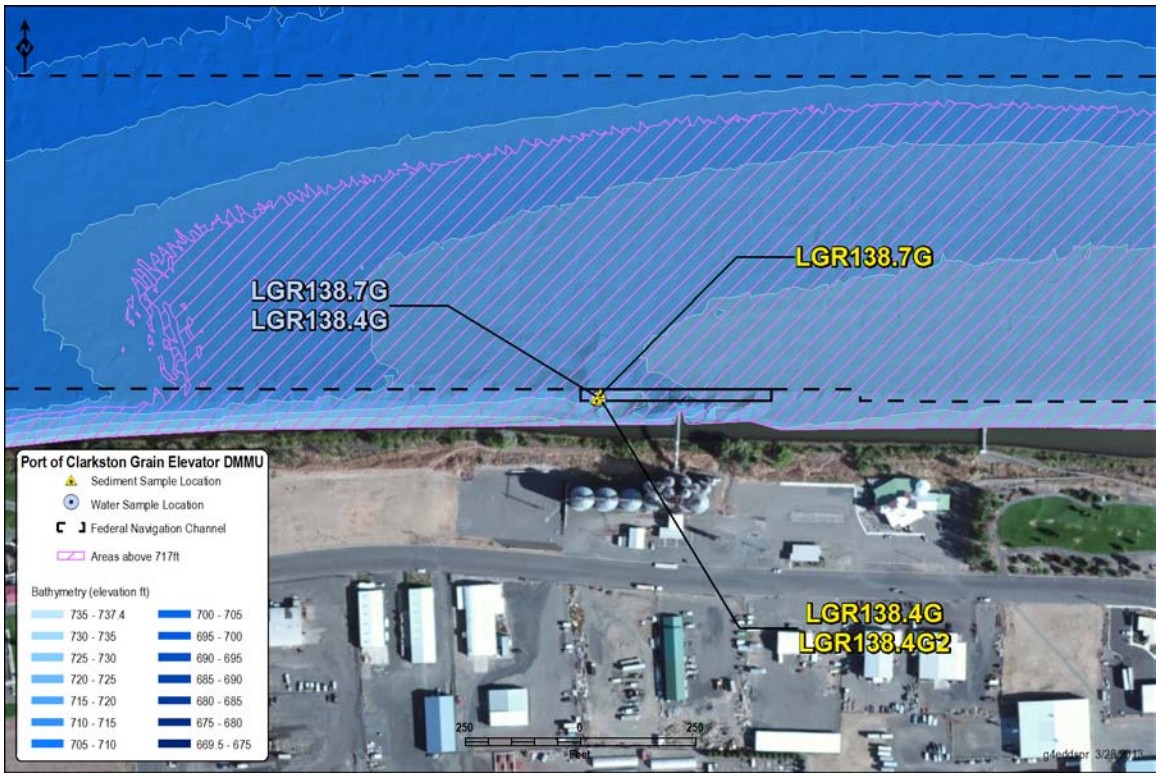


Figure 18. Port of Clarkston Grain Elevator DMMU with 2011 sample locations.

Table 12. Samples Used to Characterize the Port of Clarkston Grain Elevator DMMU

Sample Location	Date	Latitude	Longitude	Water Depth	Sample Type	Notes	Drive Length	Core Length
LGR138.4G	8/16/2011	46 25.630 N	117 03.281 W	15	Water			
LGR138.4G	8/20/2011	46 25.630 N	117 03.281 W	17	Sediment	Grab		
LGR138.4G2	8/20/2011	46 25.632 N	117 03.280 W	18	Sediment	Dupl. Grab		
LGR138.7G	8/16/2011	46 25.630 N	117 03.282 W	15	Water			
LGR138.7G	8/18/2011	46 25.630 N	117 03.279 W	13	Sediment	Core	213 cm	170 cm

3.2.4 FNC Clarkston East DMMU

The FNC Clarkston East DMMU covers 1,515,146 square ft (34.8 acres) of the Snake River at approximately RM 139 (Figure 19). Accelerated sedimentation within this DMMU began after the completion of Lower Granite Dam. One sediment grab sample and one core were collected from this DMMU (Table 13). The entire DMMU would be dredged as the water depth throughout the DMMU is less than 14 feet at MOP.

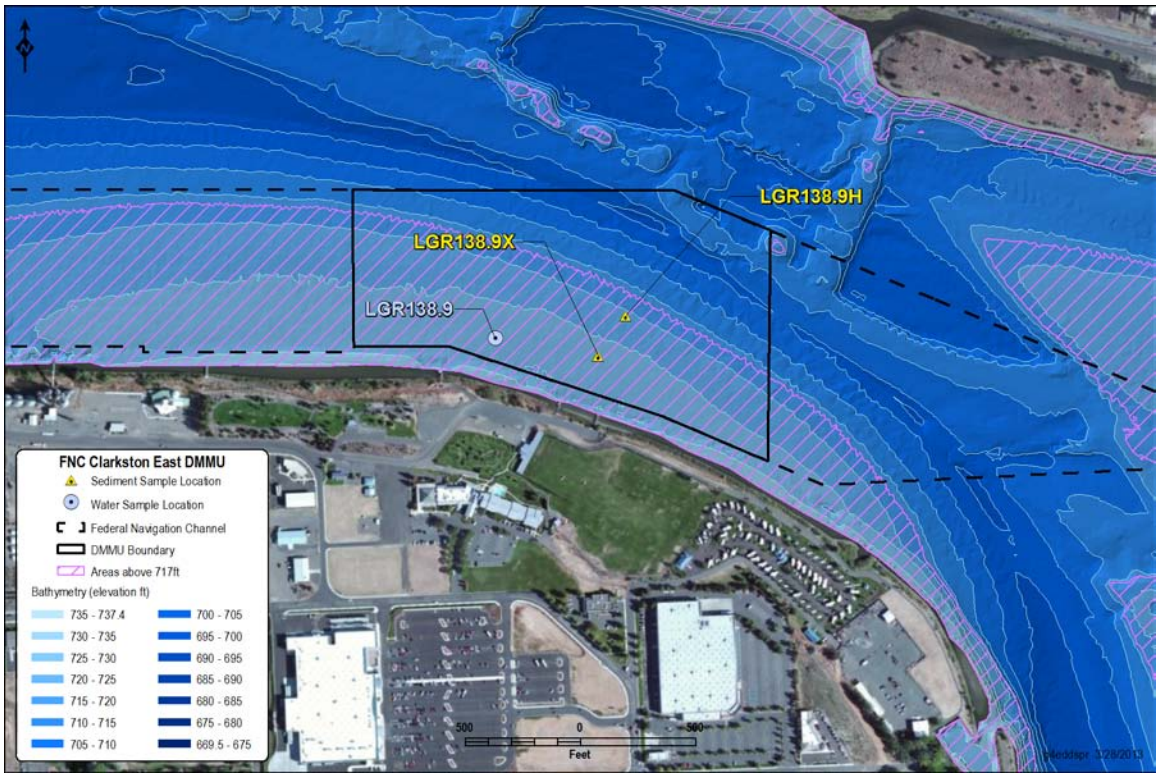


Figure 19. FNC Clarkston East DMMU with 2011 Sample Locations

Table 13. Samples Used to Characterize the FNC Clarkston East DMMU

Sample Location	Date	Latitude	Longitude	Water Depth	Sample Type	Notes	Drive Length	Core Length
LGR138.9	8/16/2011	46 25.624 N	117 02.783 W	13	Water			
LGR138.9H	8/20/2011	46 25.636 N	117 02.648 W	16	Sediment	Grab		
LGR138.9X	8/18/2011	46 25.608 N	117 02.678 W	11	Sediment	Core	183 cm	147 cm

3.2.5 Port of Clarkston DMMU

The Port of Clarkston DMMU covers 32,828 square ft (0.75 acres) of the Snake River at RM 137.8 (Figure 20, Table 14). One core sample that was sub-divided based on the expert opinion of a registered geologist on-site was collected from this DMMU. The entire DMMU would be dredged.

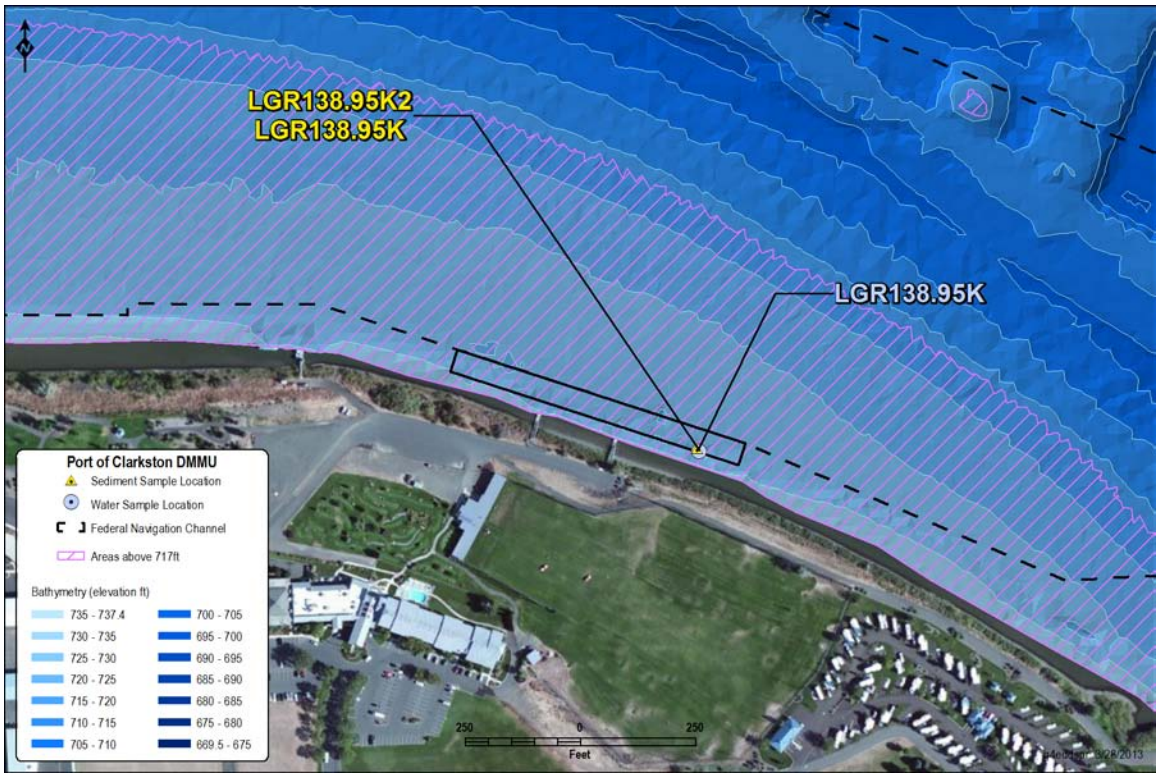


Figure 20. Port of Clarkston DMMU with 2011 Sample Locations

Table 14. Samples Used to Characterize the Port of Clarkston DMMU

Sample Location	Date	Latitude	Longitude	Water Depth	Sample Type	Notes	Drive Length
LGR138.95K	8/16/2011	46 25.562 N	117 02.639 W	12	Water		
LGR138.95K	8/18/2011	46 25.561 N	117 02.638 W	12	Sediment	Core (1-110 cm)	
LGR138.95K2	8/18/2011	46 25.561 N	117 02.638 W	12	Sediment	Core (111-212 cm)	244 cm

3.2.6 FNC Lewiston DMMU

The FNC Lewiston DMMU covers 2,598,416 square ft (59.6 acres) on the Clearwater River at approximately RM 3 (Figure 21, Table 15). Accelerated sedimentation within this DMMU began after the completion of Lower Granite Dam. One sediment grab sample and seven core samples were collected from this DMMU. Only the band of shallower water running diagonally across the center of this DMMU would be dredged.

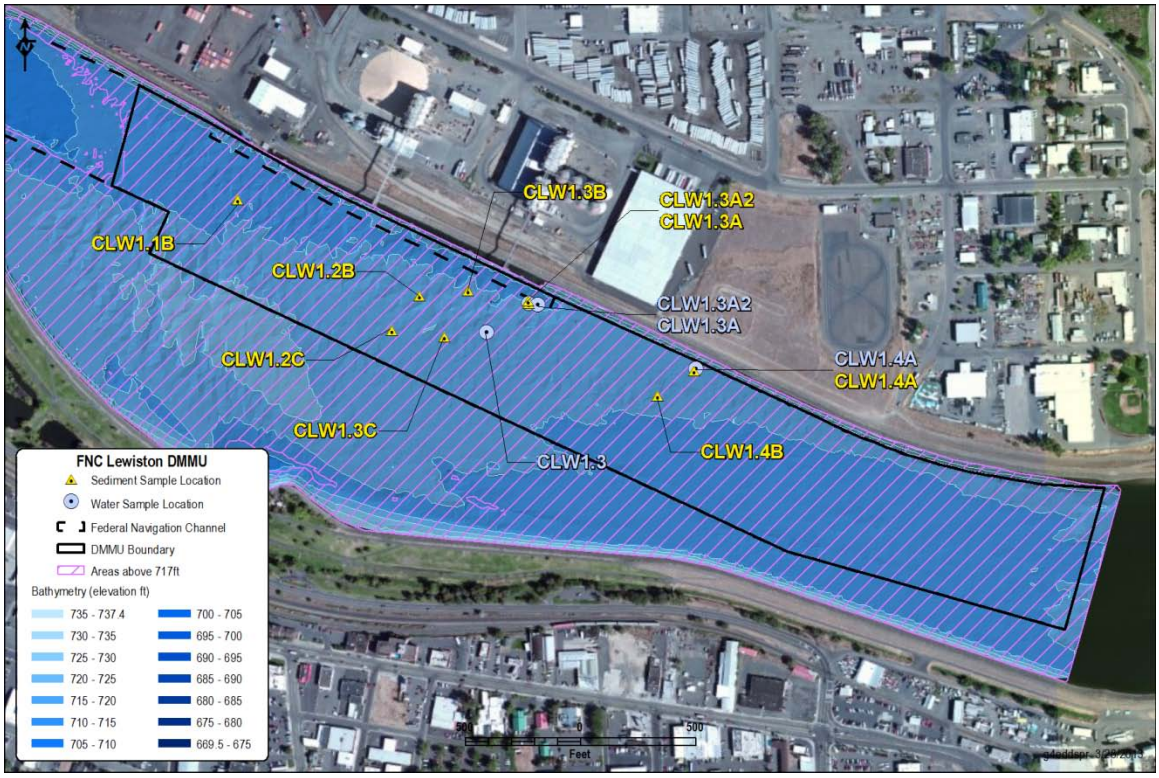


Figure 21. FNC Lewiston DMMU with 2011 Sample Locations

Table 15. Samples Used to Characterize the FNC Lewiston DMMU

Sample Location	Date	Latitude	Longitude	Water Depth	Sample Type	Notes	Drive Length	Core Length
CLW1.1B	8/20/2011	46 25.434 N	117 00.982 W	20	Sediment	Grab		
CLW1.2B	8/19/2011	46 25.360 N	117 00.799 W	13	Sediment	Core	145 cm	145 cm
CLW1.2C	8/19/2011	46 25.336 N	117 00.829 W	13	Sediment	Core	93 cm	86 cm
CLW1.3	8/16/2011	46 25.332 N	117 00.731 W	12	Water			
CLW1.3A	8/16/2011	46 25.350 N	117 00.677 W	15	Water			
CLW1.3A	8/16/2011	46 25.350 N	117 00.677 W	15	Sediment	Core	81 cm	67 cm
CLW1.3A2	8/16/2011	46 25.350 N	117 00.677 W	15	Water	Duplicate		
CLW1.3A2	8/16/2011	46 25.350 N	117 00.677 W	15	Sediment	Core (sand)	43 cm	
CLW1.3B	8/19/2011	46 25.362 N	117 00.748 W	13	Sediment	Core	76 cm	57 cm
CLW1.3C	8/19/2011	46 25.330 N	117 00.775 W	13	Sediment	Core	203 cm	180 cm
CLW1.4A	8/16/2011	46 25.299 N	117 00.517 W	12	Water			
CLW1.4A	8/19/2011	46 25.298 N	117 00.519 W	15	Sediment	Core	125 cm	124 cm
CLW1.4B	8/19/2011	46 25.281 N	117 00.558 W	19	Sediment	Core	228 cm	206 cm

3.2.7 Port of Lewiston DMMU

The Port of Lewiston DMMU covers 82,564 square ft (1.9 acres) on the Clearwater River at approximately RM 3 (Figure 22, Table 16). Two sediment samples, one grab and one core, were collected from this DMMU. The entire DMMU would be dredged.

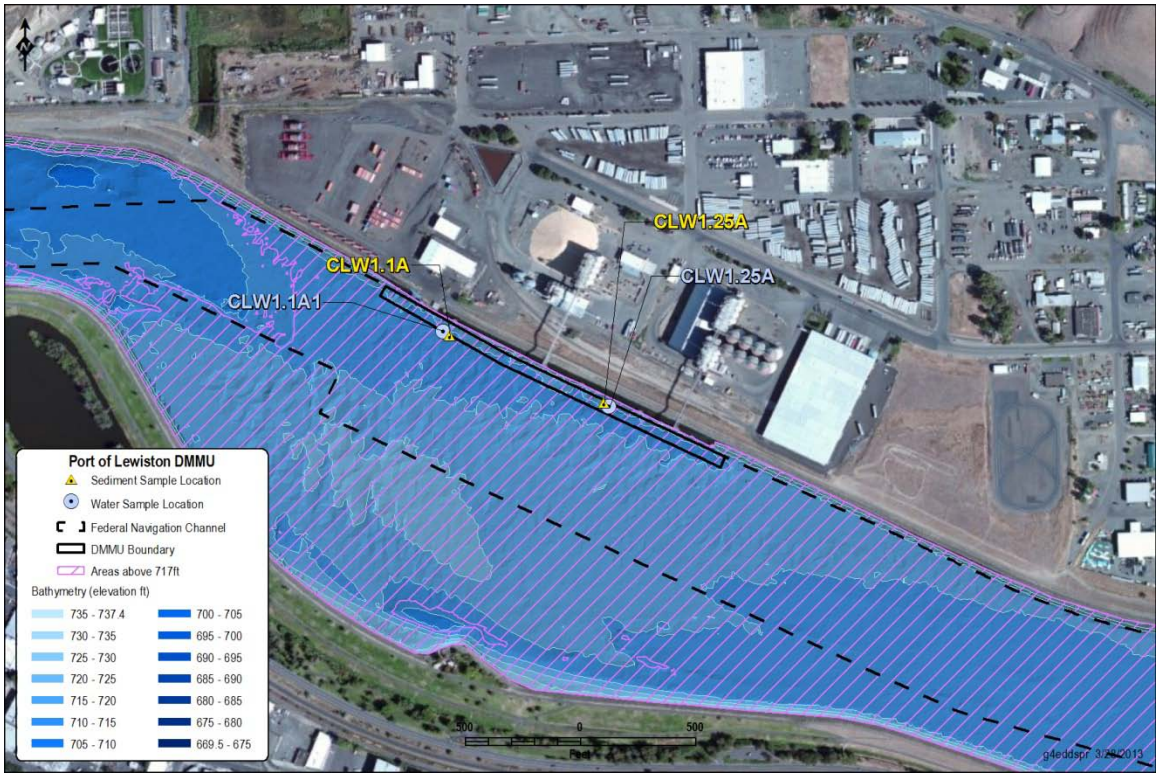


Figure 22. Port of Lewiston DMMU with 2011 Sample Locations

Table 16. Samples Used to Characterize the Port of Lewiston DMMU

Sample Location	Date	Latitude	Longitude	Water Depth	Sample Type	Notes	Drive Length	Core Length
CLW1.1A	8/16/2011	46 25.450 N	117 00.938 W	16	Water			
CLW1.1A	8/20/2011	46 25.453 N	117 00.944 W	18	Sediment	Grab		
CLW1.25A	8/16/2011	46 25.394 N	117 00.777 W	14	Water			
CLW1.25A	8/19/2011	46 25.397 N	117 00.782 W	19	Sediment	Core	61 cm	43 cm

3.3 Areas Sampled in 2011 but Not Included in Proposed 2013/2014 Dredging

Because the 2011 sampling program was designed to provide broad information for preparation of the Corps' *Draft Lower Snake River Programmatic Sediment Management Plan and Environmental Impact Statement* (PSMP/EIS) and was not focused on a specific dredging event, six additional areas were sampled (Table 17). The sample locations and types of samples collected are presented in Appendix B.

Table 17. Areas Sampled in 2011 and Not Included in the Proposed 2013/2014 Channel Maintenance

Name of Area	River	River Mile	Pool	County	State
Clearwater	Clearwater, ID	RM 0.5	Lower Granite	Nez Perce	ID
Outside FNC Clarkston	Snake River, WA	RM 138.9	Lower Granite	Asotin	WA
Clarkston Bend	Snake River, WA	RM 139	Lower Granite	Asotin	WA
Greenbelt Boat Basin	Snake River, WA	RM 139.2	Lower Granite	Asotin	WA
Swallows Boat Basin	Snake River, WA	RM 142	Lower Granite	Asotin	WA
Asotin Boat Basin	Snake River, WA	RM 145.5	Lower Granite	Asotin	WA

4.0 FIELD PROCEDURES

The original purpose of the 2011 sediment-sampling program was to update the sediment quality database of the Clearwater and lower Snake Rivers for the PSMP/EIS. It did not focus on a specific dredging event. However, it did include areas where sediments have historically accumulated and have been dredged. Several guidance documents were considered during the development of the 2011 sampling plan. These included EPA (1995) and the Sediment Evaluation Framework (USACE 2009b). One of the objectives used to develop the list of sample sites was to revisit locations that were sampled in 2003 where possible (See Heaton and Juul, 2003, in Appendix A for those sites). This approach was intended to facilitate construction of a database specific to sediment quality that can be used to establish DMMU ranking, as well as complete long-term trend analyses of sediment chemistry in the reservoirs regardless of whether they may be dredged or not. Some of the previous sampling stations that were located at water depths greater than 14 ft were not included in the sampling plan. However, there were also instances where additional locations were added within previously established navigation dredging templates to ensure a thorough characterization. Sediment quantities per DMMU were not available at the time of sampling, but estimates were made based on historical data and the assumption that the DMMUs near the confluence of the Snake and Clearwater Rivers would be low or low-moderate in ranking. The Ice Harbor Navigation Lock approach was assumed to have a very low ranking, since previous samplings consisted of cobbles and rock.

4.1 Sampling Locations

Sampling locations within the DMMUs to be dredged, including GPS coordinates of each sample location, are shown in Tables 10 through 16 in Section 3.2 above.

4.2 Navigation and Positioning

Horizontal and vertical positioning was determined by using a Sonarmite acoustic survey package, Hypack Navigation software, Xsens heave pitch and roll sensor, and a Trimble R-8 GNSS RTK receiver. The stations were located and positions recorded during the fieldwork using the Differential Global Positioning System to within 1 ft of accuracy. Vertical control was established using water surface elevations and selected monuments installed along the shoreline during the construction of the Lewiston levee system. The datum used throughout the project was WGS84 decimal degrees as the reference to a minimum of six decimal places.

4.3 Sample Collection Techniques

The Corps contracted with Gravity Environmental to conduct the sampling program. For this project, Gravity Environmental used their 34-foot vessel, the RV Selkirk. This vessel is fully equipped with the necessary navigation equipment, mechanical equipment, hydraulic power packs, and electrical power generators to support all aspects of sample collection.

All core sampling tubes, core catchers, dredges, mixing bowls, spoons, and related tools that contacted the sediment were thoroughly cleaned prior to use. Pre-cleaning prior to initiating work at a sediment management unit consisted of washing with Liquinox or Alconox detergent, followed by sequential rinses with tap water, dilute (10 percent) reagent grade H_2SO_4 or HCl acid, de-ionized or distilled water, and finally with de-ionized water again. The equipment was then air-dried and wrapped in aluminum foil or protected in a sealed box, until used in the field. Cleaning between successive sampling stations within a designated area consisted of thoroughly washing with on-site water. Back-up sampling equipment and containers was available at all times.

Coring was performed using an electrically driven vibracorer that used polycarbonate liners inside a rigid external tube approximately 4 inches in diameter. A new liner was used for each of the individual stations. The vibracorer was lowered below the water surface and energized once in contact with the bottom.

The acceptance criteria for a sediment core samples were as follows:

- The core penetrated and retained material to target depth or refusal.
- Recovery was at least 75 percent of the length of core penetration.
- Cored material did not extend out of the sampling apparatus at the top of the core tube.
- There were no obstructions in the cored material that might have blocked the subsequent entry of sediment into the core tube to result in incomplete core collection.

If the above criteria were met, the liners were capped or placed in sealed buckets for later processing on shore.

At least three attempts to obtain cores were made at each location. Cores that yielded less than 1 ft of penetration to refusal were sampled with a hydraulically powered 0.3 m^3 clamshell sampler. Areas that consisted primarily of rock or gravel were also sampled with the grab sampler. For the latter samples, the material was photographed for documentation but not forwarded for laboratory analyses. If the sample was considered suitable for further analyses, sufficient volume was collected and placed in pre-cleaned buckets. If the bottom was impenetrable with the available equipment, the position was shifted 25 ft for subsequent attempts.

The depth of the cores retrieved from the DMMUs included in the proposed 2013/2014 dredging action was compared to the 16 ft maximum dredge cut line. In some cases the depth of refusal was less than the anticipated maximum dredging depth and the z-layer was not sampled (Figure 23).

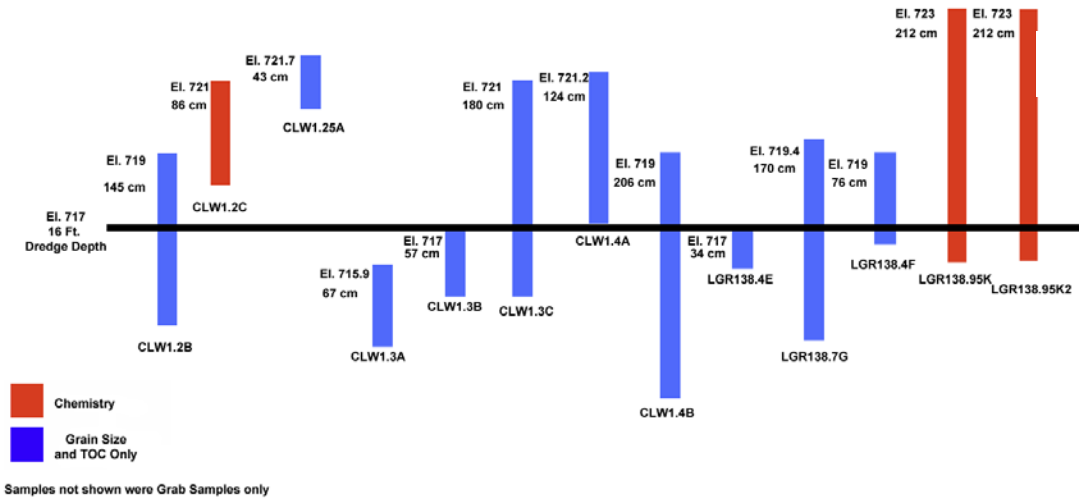


Figure 23. Depths of cores retrieved from the DMMUs relative to the proposed 16-ft dredging depth

4.4 Field Log

Once the samples were brought back to shore, the contents of the sediment cores and grab samples were visually examined and photographed by a registered geologist. Sediment cores were split and physical characteristics were logged. If the sample contained primarily cobble and gravel material, it was photographed along with a ruler and identification number for documentation but not processed for laboratory analyses. The data collected from the contractor's sampling task was provided to the Walla Walla District Geotechnical Branch for entry onto the standard district core log forms (Appendix C). The sediment samples that did not consist primarily of cobble or gravel were sectioned and further homogenized. This task consisted of placing the material in a large stainless steel bowl and mixing the contents with a stainless steel spoon until the mixture was completely homogeneous. The individual samples were removed and placed in appropriately sized and labeled sample containers (Table 18).

Multiple cores were not composited, and a percentage of the samples were sent for chemical analyses even if grain size would have precluded the need. The 2009 SEF requires some chemical analysis regardless of grain size because of mining influence (USACE et al. 2009b). Some of the cores were divided into sub-sections for separate analyses if the registered geologist on-site determined that there was sufficient heterogeneity within the length of the core to warrant this action.

If the sample contained primarily cobble and gravel material it was not forwarded to the laboratory. However, a digital photo with identification number was taken for documentation. If the core material was primarily sand and fines and the

4.5 Sample Containers

A listing of the sample containers and field preservation techniques used is shown in Table 18 below.

Table 18. Containers and Field Preservation Techniques Used for the Sediment Samples

Parameter	Water	Sediment
Archive sediment sample	NA	250-mililiter (mL) glass wide mouth jar
Carbamate Pesticides	With pesticides	With pesticides
Chlorinated Herbicides	1-liter (L) glass Boston round container	250-mL glass wide mouth jar
Chlorinated Pesticides	With pesticides	With pesticides
Diesel and oil	1-L glass Boston round container	With PAH
Dioxin, high resolution	1-L glass Boston round container	250-mL glass wide mouth jar
Elutriate water	2 x 4-L glass container	NA
Glyphosate	1-L glass Boston round container	With pesticides
Grain Size	NA	2 x 500-mL high density polyethylene (HDPE) wide mouth jar
Metals (including mercury)	250-mL HDPE Boston round container	250-mL glass wide mouth jar
Organophosphorus Pesticides	With pesticides	With pesticides
PAH	1-L glass Boston round container	250-mL glass wide mouth jar
PCBs	1-L glass Boston round container	With PAH
Phenylurea Herbicides	1-L glass Boston round container	2 x 500-mL glass wide mouth jar
Picloram	With herbicides	With pesticides
Total Organic Carbon (%)	40-mL VOC	250-mL HDPE wide mouth jar
Total Solids (%)	NA	
Triazine Herbicides	With herbicides	With herbicides

4.6 Chain of Custody

Chain of custody was maintained throughout the project and was in accordance with EPA guidelines and USACE Engineer Regulation 1110-1-263 (USACE 1998). Additionally, the sample identification number was written on the container lid in waterproof ink as a secondary label in case the primary label was damaged. The samples were initially placed in a refrigerator in a mobile laboratory trailer and custody sealed each night. Samples were packed with ice in coolers for shipping. Samples were packaged for shipment to the analytical laboratory as follows:

- Attached sample label to each container.
- Secured caps and wrote identification information on lid.
- Wrapped glass sample containers in bubble wrap or other packaging material.
- Placed containers in plastic zip-lock bags and removed as much air as possible before sealing.
- Packed ice around the samples in the ice chest.
- Completed chain of custody form for the samples in a given ice chest.
- Wrapped, sealed, and taped the form to the inside lid of the ice chest.
- Taped the ice chest drain and lid to prevent accidental opening during shipping and handling.

The majority of the samples were kept at a temperature as close as possible to 4 degrees centigrade (ºC) from the time of collection to the time of delivery at the laboratory. All samples received by AM-Test in Kirkland, Washington, on 17 August 2011 were at cooler temperatures of 4 ±2 °C. The sample coolers

delivered to AM-Test on 22 August 2011 were within the control temperatures according to laboratory staff, but this was not documented on the hard copy and cannot be certified externally. Sample coolers transported from AM-Test to Analytical Resources, Inc. (ARI) in Tukwila, Washington to Pacific Agricultural Laboratories in Portland, Oregon on 25 August 2011 and 30 August 2011 arrived in compliance with EPA guidelines, but temperatures were not documented on the chain of custody forms or on separate cooler receipt forms. Pacific Agricultural Laboratories did not report any sample or chain of custody abnormalities on their case narrative. Pesticide sample temperatures cannot be certified by external means.

5.0 LABORATORY ANALYSES

The sediment and equipment blank water samples were analyzed using the methods identified in Table 19. The analytes included in each method are presented in Appendix D.

Numerous organic and inorganic chemicals that are not identified as chemicals of concern (COC) for Walla Walla District (USACE et al, 2009b) were included in the list of analytes. The reason for completing the extra analyses was to be able to consistently evaluate a complete set of data from three sampling events and then decide if they need to be included as a COC or could be excluded from further consideration. The 2011 sampling event was the third one in the series.

Table 19. Laboratory methods used to analyze the sediment and water samples.

Parameter	Sediment	Water
Sieve analysis	ASTM D422	NA
Total solids	APHA 2540G	NA
Total organic carbon (TOC)	EPA 9060	Standard Methods 5310B
Metals	EPA 6020A, 6010B	EPA 200.8
Mercury	EPA 7471B	EPA 245.1
Aroclors (PCBs)	EPA 8081	EPA 608
Herbicides	EPA 8151	EPA 615
Diesel and heavy oils	WDOE	NWTRH-Dx
Semi-volatile organics	EPA 8270-SIM	EPA 625-SIM
Polycyclic aromatic hydrocarbons	EPA 8270-SIM	EPA 625-SIM
Pesticides	EPA 8321B, 8181B, 8141B, 8270D, Monsanto,	EPA 8321B, 8181B, 8141B, 8270D, 547

6.0 QUALITY CONTROL AND QUALITY ASSURANCE

6.1 Field Quality Control and Quality Assurance

Additional QA/QC samples were collected in the field in association with the execution of this sampling and analysis plan. Sample types include duplicates, split samples, and equipment blanks:

- Duplicate samples were collected at a rate of at least 10 percent of the sample locations and submitted to the laboratory as a new sample location.
- Split samples were also collected and sent to a separate laboratory for the appropriate analyses.

- Washing the samplers with de-ionized water and submitting the water to the laboratory for the same chemical analyses prescribed for the sediments constituted an equipment blank.

6.2 Laboratory Quality Control

Laboratory quality control consisted of internal QA/QC and submission of scheduled performance evaluation samples as prescribed by the Washington Department of Ecology's Accreditation Program. Prior to contract award, each laboratory's accreditation was verified for each parameter and each test method. Laboratories submitted the following types of data:

- Percent Recoveries.
- Matrix spikes.
- Blanks.
- Calibration standard recoveries.
- Surrogate recoveries.
- Batch QA metrics.

6.3 Third Party QA Audit

Data validation was conducted using the techniques described by PTI (1989a, b). The data validation was to QA-1 level and many of the procedures were evaluated to the QA-2 level, but the third party QA audit was at the QA-1 level (Appendix E).

7.0 RESULTS

The 2011 sediment sampling results (Appendix F and G) were compared against:

- The 2006 SEF freshwater and marine guidelines for the COC's where screening levels exist (SEF, 2009).
- DMMP marine guidelines for all other COC's (USACE et al, 2009a; 2009b).

7.1 Ice Harbor Navigation Lock Approach DMMU

Three grab samples were retrieved from the Ice Harbor Navigation Lock Approach DMMU. All three samples yielded cobble and large rock and were not forwarded for physicochemical analyses.

7.2 FNC Clarkston West DMMU

The sediment samples from the FNC Clarkston West DMMU were only analyzed for grain size, total organic carbon (TOC) and total solids.

- TOC ranged from 0.07 to 0.16 percent, and total solids were between 68.7 and 77.6 percent (Appendix G, Table G-1).
- 90.5 to 99.9 percent of the particles were retained by the number 230 sieve (Appendix G, Table G-2).

7.3 FNC Clarkston East DMMU

The sediment samples from the FNC Clarkston East DMMU were only analyzed for grain size, TOC and total solids.

- TOC ranged from 0.07 to 0.08 percent, and total solids were between 75.5 and 79.1 percent (Appendix G, Table G-3).

- 90.0 to 99.4 percent of the particles were retained by the number 230 sieve (Appendix G, Table G-4).

7.4 Port of Clarkston DMMU

One core sample was analyzed for the Port of Clarkston DMMU and some of the highlights include:

- TOC ranged from 1.5 to 5.3 percent, total solids were between 61.8 and 63.6 percent (Appendix G, Table G-5) and 12.9 to 26.3 percent of the material passed through a number 230 sieve (Appendix G, Table G-6).
- All of the metals concentrations analyzed for were less than the SEF or DMMP screening guidelines.
- The results for the majority of the carbamate pesticides, halogenated pesticides, organophosphorus pesticides, organonitrogen pesticides, and phenylurea herbicides (Appendix G, Tables G-14 through G-19) were less than the SEF/DMMP screening limits and/or the MDL. Two exceptions were the chlordane and dieldrin sediment results where the MDLs for the analytical method used for this investigation were higher than the DMMP screening limits (Appendix F; Appendix G, Tables G-6 through G-16). However, the results of elutriate tests where the dieldrin and chlordane reporting limits were 0.12 µg/L and 0.60 µg/L also resulted in non-detects.
- Four PAHs (i.e., benzo(a)anthracene, fluoranthene, phenanthrene, and pyrene) were detected in concentrations ranging from 8.4 to16.2 ppb – considerably less than the 2006 SEF freshwater guidelines (Appendix G, Table G-8).
- No diesel was detected in the sediment samples, but heavy oil residue was detected in core sample LGR138.95K2 at 86.0 ppm (Appendix G, Table G-9).
- Arochlor PCBs and semi-volatiles were not detected in the samples (Appendix G, Tables G-10 and G-11).
- Calculated U =0 and U = ½ toxicity equivalents (TEQs) were 0.363 ng/kg and 0.381 ng/kg, respectively (Appendix G, Tables G-12 and G-13).

7.5 Port of Clarkston Grain Elevator DMMU

Two grab samples (one duplicate) and one core sample were collected from the Port of Clarkston Grain Elevator DMMU. Some of the analytical highlights include:

- TOC ranged from 0.08 to 0.12 percent, and total solids were between 73.1 and 74.4 percent (Appendix G, Table G-21).
- 90.0 to 91.7 percent of the material was retained by a number 230 sieve (Appendix G, Table G-22).
- All of the metals concentrations were less than the SEF and DMMP criteria.
- The results for the majority of the carbamate pesticides, halogenated pesticides, organophosphorus pesticides, organonitrogen pesticides, phenylurea herbicides, and PAHs (Appendix G, Tables G-30 through G-35 were less than the SEF/DMMP screening limits and/or the MDL. As with the Port of Clarkston sample results, the MDLs for the chlordane and dieldrin sediment analyses were greater than the DMMP screening limits (Appendix F), but the analytical results for the elutriate samples were less than 0.60 µg/L and 0.12 µg/L, respectively.
- No diesel or heavy oil was detected in the sediment samples (Appendix G, Table G-25).
- Arochlor PCBs and semi-volatiles were not detected in the samples (Appendix G, Table G-26).
- Calculated U =0 and U = ½ toxicity equivalents (TEQs) averaged 0.356 ng/kg (Appendix G, Tables G-28 and G-29).

7.6 FNC Lewiston DMMU

One grab sample and eight core samples were collected for the FNC Lewiston DMMU. However, only one of the core samples was forwarded for chemical analyses even though the field determination was that it consisted primarily of sand. A summary of the results include:

- TOC ranged from 0.05 to 0.38 percent, and total solids were between 73.4 to 88.0 percent (Appendix G, Table G-37).
- The data show that most of the material that would be removed during channel maintenance from this DMMU would be sand. Ninety-eight to 100 percent of the sample material was retained by a number 230 sieve (Appendix G, Table G-38).
- Metals were detected at low levels, with aluminum 53 percent less than in the Port of Clarkston DMMU (Appendix G, Table G-39). None of the metals were greater than the 2006 SEF or DMMP screening limits.
- The results for the majority of the carbamate pesticides, halogenated pesticides, organophosphorus pesticides, organonitrogen pesticides, and phenylurea herbicides were less than the SEF/DMMP screening limits and/or the MDLs (Appendix F; Appendix G, Tables G-46 through G-51). The dieldrin and chlordane sediment results were again reported as less than the MDL which was greater than the DMMP screening limits, but the elutriate results were less than the laboratories reporting limits previously identified.
- Nine PAHs were detected in the CLW1.2C sample, but all were below the screening levels (Appendix G, Table G-40).
- Petroleum hydrocarbons, Arochlor PCBs, and semi-volatiles were not detected in the sediment samples (Appendix G, Table G-41).
- Calculated U =0 and U = ½ toxicity equivalents (TEQs) were 0.126 ng/kg and 0.128, respectively (Appendix G, Tables G-44 and G-45).

7.7 Port of Lewiston DMMU

The sediment samples from the Port of Lewiston DMMU were only analyzed for grain size, total organic carbon (TOC) and total solids. The results were:

- TOC ranged from 0.08 to 0.21 percent, and total solids were between 73.8 and 77.0 percent (Appendix G, Table G-53).
- 88.6 to 99.1 percent of the particles were retained by the number 230 sieve (Appendix G, Table G-54).

7.8 Areas Sampled But Not Included in Proposed 2013/2014 Channel Maintenance

The analytical results for additional areas that were sampled in 2011, but will not be disturbed during the proposed 2013/2014 channel maintenance activity, are presented in Appendix H Tables H-1 throughH-95.

8.0 SITE RANKING

Table 20 summaries the current rankings for the areas proposed for dredging in the 2013/2014 in-water work season. The ranking is based on the historical sediment sampling results, potential sources of contaminants, and the results of the 2011 sediment sampling.

Table 20. Site Rankings for the DMMUs Proposed for Dredging during 2013/2014

DMMU	Pool	Type of Material	Rank
FNC Ice Harbor Navigation Lock Approach	McNary	Cobble/ Rocks	Very Low
FNC Clarkston East	Lower Granite	Sand	Low
FNC Clarkston West	Lower Granite	Sand	Low
Port of Clarkston	Lower Granite	Sand/Silt	Low - Moderate
Clarkston Grain Elevator	Lower Granite	Sand/Silt	Low - Moderate
FNC Lewiston	Lower Granite	Sand	Low
Port of Lewiston	Lower Granite	Sand/Silt	Low - Moderate

8.1 FNC Ice Harbor Navigation Lock Approach DMMU

The hydrology and absence of new sediment loading directly downstream of Ice Harbor Dam has resulted in very limited amounts of sands and fines. The results from the most recent sampling of the FNC Ice Harbor Navigation Lock Approach DMMU, as well as previous investigations in the vicinity, have identified rock and cobbles of varying sizes as the primary substrate.

8.2 FNC Clarkston West DMMU

The FNC Clarkston West DMMU consists of the western half of the FNC adjacent to the Port of Clarkston. The results from the most recent sediment survey indicated that fines constituted less than 10 percent of the samples collected, and TOC was less than 0.2 percent. These results are similar to previous sediment evaluations that characterized the majority of the materials as homogeneous sands with less than 20 percent silts.

8.3 FNC Clarkston East DMMU

The FNC Clarkston East DMMU consists of the eastern half of the FNC adjacent to the Port of Clarkston. The present, as well as past, sediment characterizations have shown that the sediments have a similar composition to the ones located in the FNC Clarkston West DMMU.

8.4 Port of Clarkston DMMU

The sediment in the Port of Clarkston DMMU typically has a higher percentage of fines than those in the adjoining FNC DMMUs. The most recent sampling showed that 12.8 to 16.4 percent of the material passed through a number 230 sieve. These values are analogous to historical data that indicates fines normally do not exceed 20 percent. Metals concentrations determined for the 2011 and previous sediment characterizations were typically less than the 2006 SEF and DMMP screening limits. Organic chemicals of concern were either met the SEF/DMMP screening limits or were less than the MDLs.

8.5 Port of Clarkston Grain Elevator DMMU

There is a slightly higher percentage of fines in the Port of Clarkston Grain Elevator DMMU when compared to the FNC Clarkston East and West DMMUs, but the proportion of fines has historically been less than 20 percent. Metals and organics data from the 2011 sediment study were not significantly different than the results from previous studies and within the current SEF and DMMP criteria.

8.6 FNC Lewiston DMMU

The FNC Lewiston DMMU has historically contained moderately course sands with a higher percentage of small gravels in the higher energy portions of the river. Only one of the 2011 samples from this DMMU exceeded 10 percent fines. However, one sample was still forwarded for chemical analyses. The levels of metals, PAH, semi-volatile organic compounds, and PCBs in this sample were all less than the 2006 freshwater SEF and DMMP screening limits, or less than MDLs.

8.7 Port of Lewiston DMMU

Sediments in the Port of Lewiston DMMU have varied from year to year depending on the spring runoff. The percentage of fines in the 2011 sediment samples ranged from 0.9 to 11.4 percent, yet the 2003 sample had 43 percent fines. However, the metals and organics data from both characterizations did not exceed the current in-water disposal guidelines.

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Lower Snake River Programmatic Sediment Management Plan Environmental Impact Statement

Appendix I

Water Quality and Sediment Quality Reports

Section 1. Lower Snake and Clearwater Rivers Sediment Evaluation Report for Proposed 2013/2014 Channel Maintenance Dredging

U.S. Army Corps of Engineers, Walla Walla District

March 2013

Appendixes — *available upon request*

Lower Snake River Programmatic Sediment Management Plan Environmental Impact Statement

Appendix I

Water Quality and Sediment Quality Reports

August 2014

Section 2. 2013 Sediment Sampling

U.S. Army Corps of Engineers
Walla Walla District

Lower Snake River Programmatic Sediment Management Plan Environmental Impact Statement

Appendix I

Water Quality and Sediment Quality Reports

August 2014

Section 2A. Sampling and Analysis Plan for Lower Snake and Clearwater Rivers Proposed 2013/2014 Channel Maintenance Dredging

U.S. Army Corps of Engineers
Walla Walla District

July 2013



U.S. Army Corps of Engineers
Walla Walla District

Sampling and Analysis Plan for Lower Snake and Clearwater Rivers Proposed 2013/2014 Channel Maintenance Dredging

Prepared by:

U.S. Army Corps of Engineers
Walla Walla District

July 2013

Signature Page for Subcontractors

Sampling and Analysis Plan for Lower Snake and Clearwater Rivers Proposed 2013/2014 Channel Maintenance Dredging

July 2013

Approval signatures indicate that subcontractors have reviewed this Sampling and Analysis Plan and agree to follow the methods and QA procedures contained herein.

_____ _____

Nancy Case O'Bourke, Project Manager **Date**
Dalton, Olmsted and Fuglevand, Inc.

_____ _____

Tim Thompson, Technical Lead **Date**
Science and Engineering for the Environment

_____ _____

Mingta Lin, Laboratory Manager **Date**
Pyron Environmental

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1.0 INTRODUCTION

1.1 Project Description

The Walla Walla District Corps of Engineers (Corps) proposes to perform maintenance dredging to meet the immediate need to provide a 14-foot deep navigation channel as measured at minimum operating pool (MOP). Four areas are being considered in the lower Snake River and lower Clearwater River in Washington and Idaho (Figure 1). One site is the downstream navigation lock approach for Ice Harbor Dam (Snake River Mile or RM 9.5) while the other three areas are located at the confluence of the Snake and Clearwater rivers in Lower Granite reservoir. The three areas in Lower Granite are the Federal channel (Snake RM 138 to Clearwater RM 2) and the berthing areas for the Port of Lewiston (Idaho) (Clearwater RM 1-1.5) and Port of Clarkston (Washington) (Snake RM 137.9 - 139). The Corps identified a location in the Lower Granite reservoir, Snake RM 116 just upstream of Knoxway Canyon, as the preferred in-water discharge site of the dredged materials. The Corps proposes to use the dredged material to create additional shallow water habitat for juvenile salmonids, subject to funding.

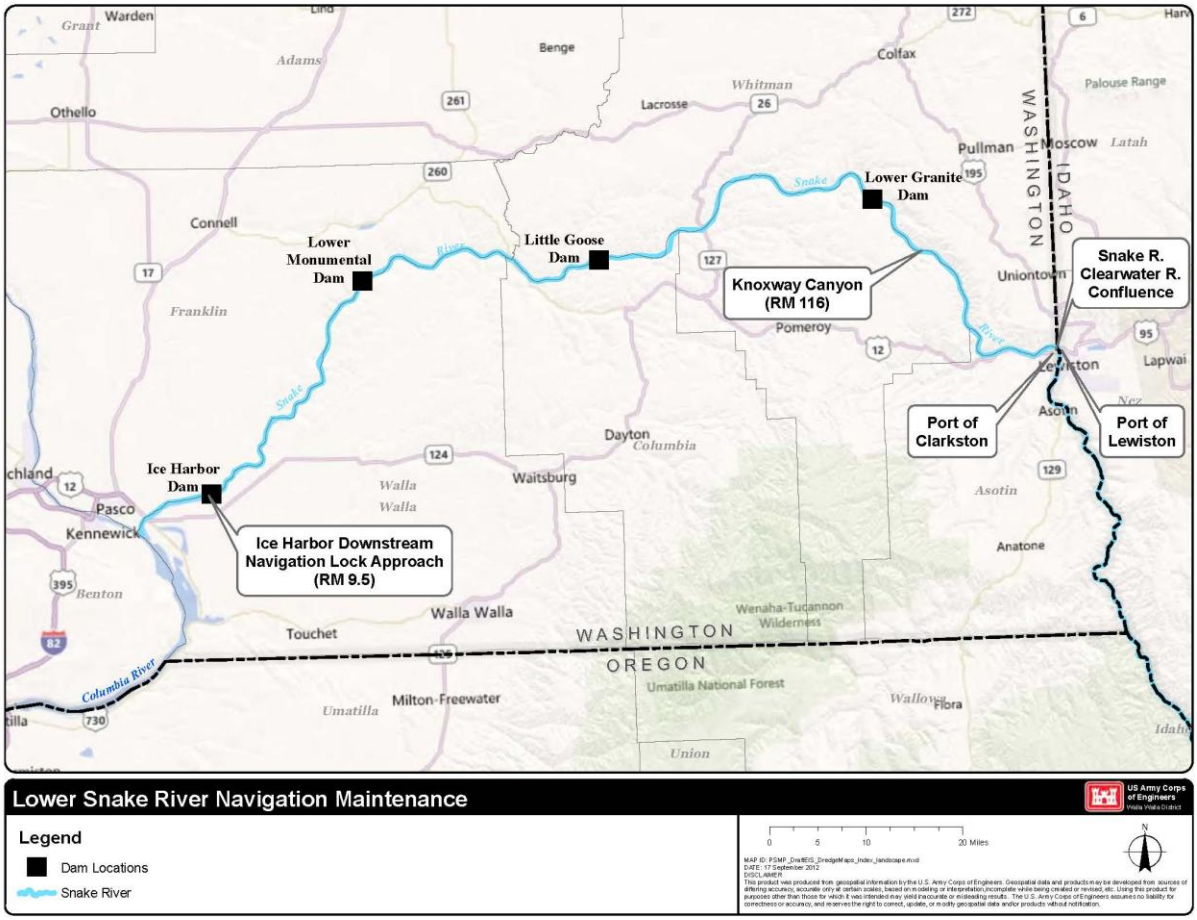


Figure 1. Project area map

Because navigation channel maintenance has not occurred since 2005-2006, shoaling in the channel and port berthing areas has become critical in these four locations. Sediment has been depositing in these areas in the Snake/Clearwater confluence primarily during spring runoff periods. Survey results from November 2012 show water depths in the Federal navigation channel at the confluence are now as shallow as about 7 feet while the berthing areas at the Port of Clarkston and Port of Lewiston are now as

shallow as 7.3 feet and 9.3 feet, respectively, based on a MOP water surface elevation. Navigation channel depths less than 14 feet substantially impact access to port facilities.

Shoaling in the Ice Harbor navigation lock approach is interfering with the ability of barge traffic to safely maneuver when entering or exiting the navigation lock. Spill flows at the dam have scoured rock from the base of the four rock-filled coffer cells bordering the lock approach and have pushed material from the edge of the lock approach into the channel, narrowing the room available for barges to maneuver between the coffer cells and the north shore. At least one of the coffer cells has been losing rockfill through the exposed base and this may be contributing to the material encroaching in the lock approach. This material has created a shoal that encroaches across the southern half of the lock approach for about 480 feet, reducing the depth to about 9 feet at MOP in McNary pool (the lock approach is within McNary reservoir, not Ice Harbor reservoir). There are also several small mounds of rock/cobble encroaching into the channel near the lock.

Under the proposed action all dredging and disposal action would occur during the in-water work window from December 15 to March 1. This in-water work window was established through coordination with state and Federal resource agencies as the time period in which in-water work could be performed with the least impact to ESA-listed salmonid stocks.

Dredging would be aimed at restoring the navigation channel to the authorized depth by dredging to a depth of no more than 16 feet as measured at MOP. The overdepth dredging (i.e., to 16 feet) is standard procedure as outlined in Engineer Regulation 1130-2-520, *Project Operations – Navigation and Dredging Operations and Maintenance Policies* (USACE 1996). Overdepth allowance helps minimize the need for more frequent and intermittent dredging of high spots. A 16-foot depth is used as the maximum dredging depth in the Federal navigation channel in order to maintain a consistent 14-foot depth. The additional two feet is considered allowable overdepth and is permitted because of inaccuracies in the dredging process.

Table 1 lists all sites proposed for immediate dredging and the estimated quantities of material to be removed from each site. Sediment is expected to continue to accumulate at these locations while this action is being planned, therefore the amount of material to be removed at the time of the dredging will likely be greater than what is shown in the table. The Corps anticipates the quantity of material needing to be dredged will range from 422,000 cubic yards (cy) to a maximum of 500,000 cy.

Table 1. All areas proposed for immediate need maintenance dredging.

Interest	Reach	Quantity to be Dredged (cy)[1]
Federal	FNC Ice Harbor Navigation Lock Approach	3,203
	FNC Clarkston West	173,608,
	FNC Clarkston East	137,416
	FNC Clearwater	17,934
	FNC Lewiston	140,242
Ports	Port of Clarkston Crane Dock	849
	Port of Clarkston Grain Elevator	3,218
	Port of Clarkston Recreation Dock	1,036
	Port of Clarkston Cruise Dock	9,041
	Port of Lewiston	4,485
	TOTAL	**491,031**

Note: [1] Based on removal to 16 feet below MOP using November 2012 survey data.

1.1.1 Maintenance Dredging Areas

Confluence of Snake and Clearwater Rivers (Federal navigation channel). About 469,199 cy of material would be removed from the Federal navigation channel (Figure 2) at the confluence of the Snake and Clearwater Rivers. Only the areas less than 14 feet deep at MOP within the navigation channel limits would be dredged (Figure 3). The Congressionally-authorized dimensions of the navigation are 14 feet deep and 250 feet wide as measured at MOP. However, at locations in front of port berthing areas, the Federal navigation channel is expanded up to a maximum total width of 950 feet. This widening is provided to allow for maneuvering of barge tows in accordance with navigation practice described in 33 U.S.C. § 562, "Channel dimensions specified shall be understood to admit of such increase at the entrances, bends, sidings, and turning places as may be necessary to allow for the free movement of boats." This area was last dredged in the winter of 2005/2006.

Port of Clarkston. About 14,144 cy of material would be removed from four berthing areas at the Port of Clarkston: the crane dock at the downstream end of the Port property (RM 137.9), the Lewis-Clark Grain Terminal (aka Port of Clarkston Grain Elevator) (RM 138.2), the recreation dock at RM 138.3, and the tour boat dock at the upstream end (RM 139) (Figure 4). The berthing area is defined as a zone extending 50 feet out into the river from the port facilities and running the length of the port facilities. Maintenance in this area is the port's responsibility, and the Port of Clarkston would provide funding to the Corps for this portion of the work. Most of the area was last dredged in the winter of 2005/2006.

Port of Lewiston. About 4,485 cy of material would be removed from the berthing area at the Port of Lewiston (Figure 5). The berthing area is defined as a zone extending 50 feet out into the river from the port facilities and running the length of the port facilities. Maintenance in this area is the port's responsibility, and the Port of Lewiston would provide funding to the Corps for this portion of the work. The area was last dredged in the winter of 2005/2006.

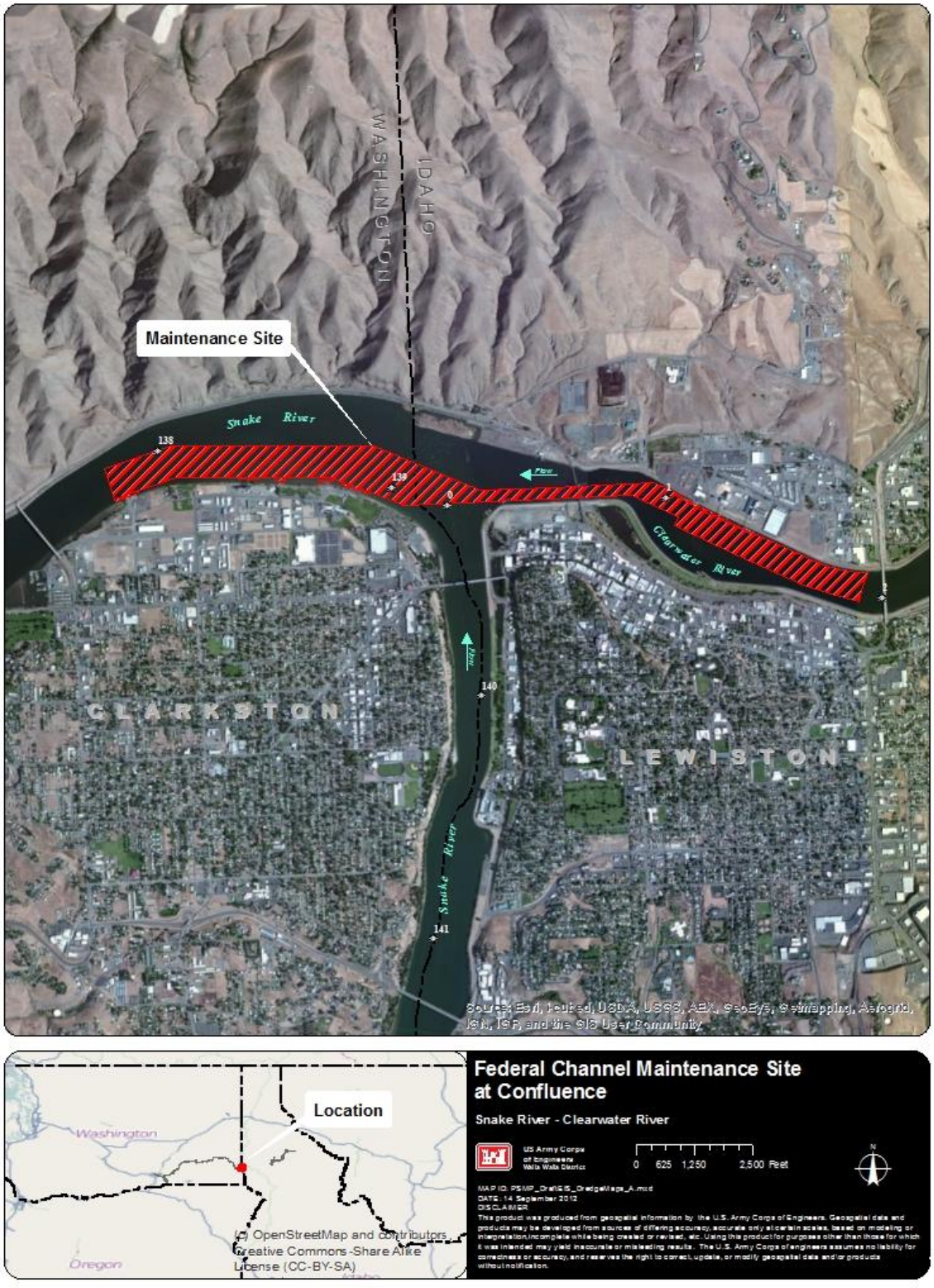


Figure 2. Dredging limits of the Federal Channel at the confluence of the Snake and Clearwater Rivers

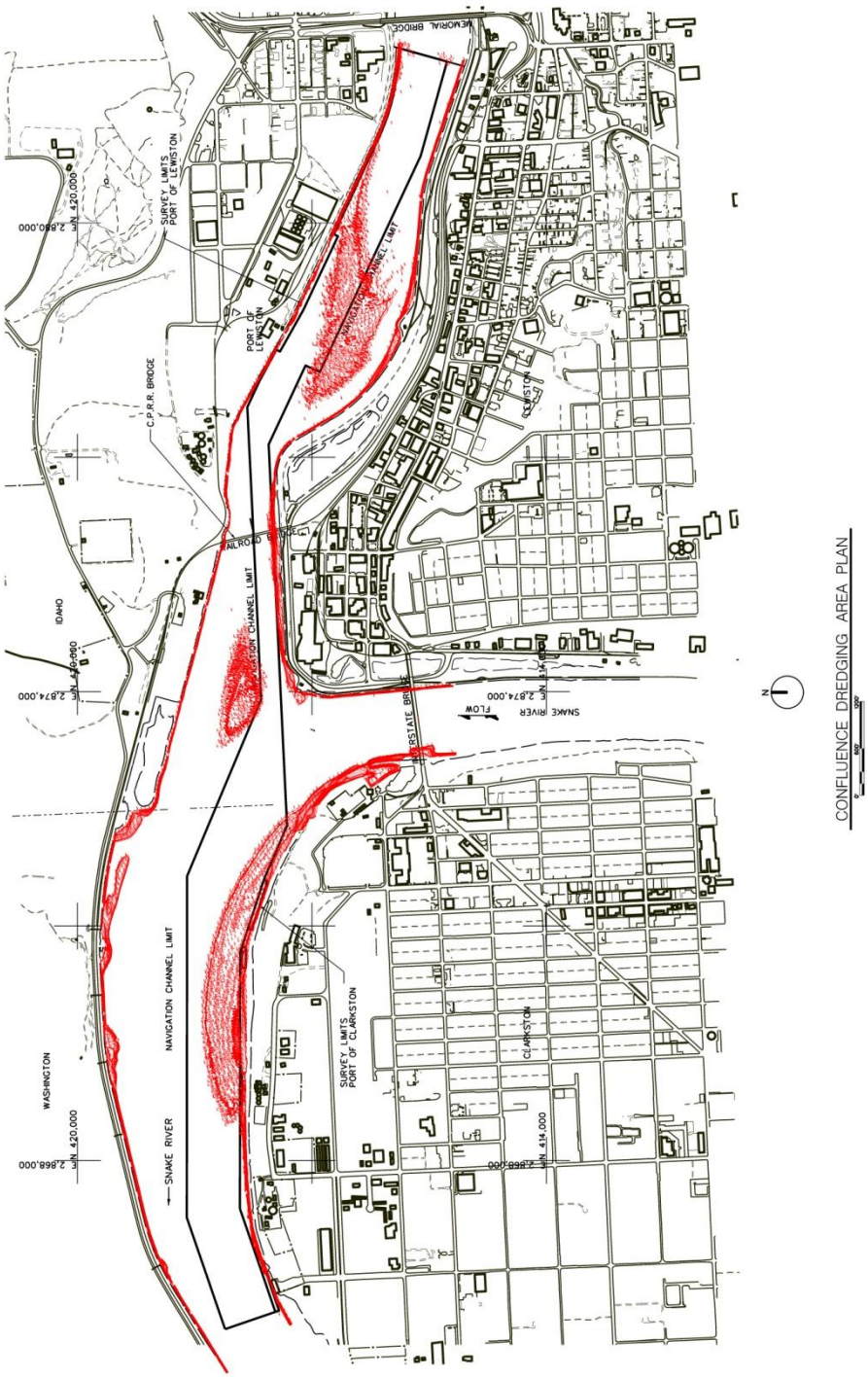


Figure 3. Shoaling locations at the Snake/Clearwater Rivers confluence (Areas to be dredged are the red areas within the black navigation channel limit lines).

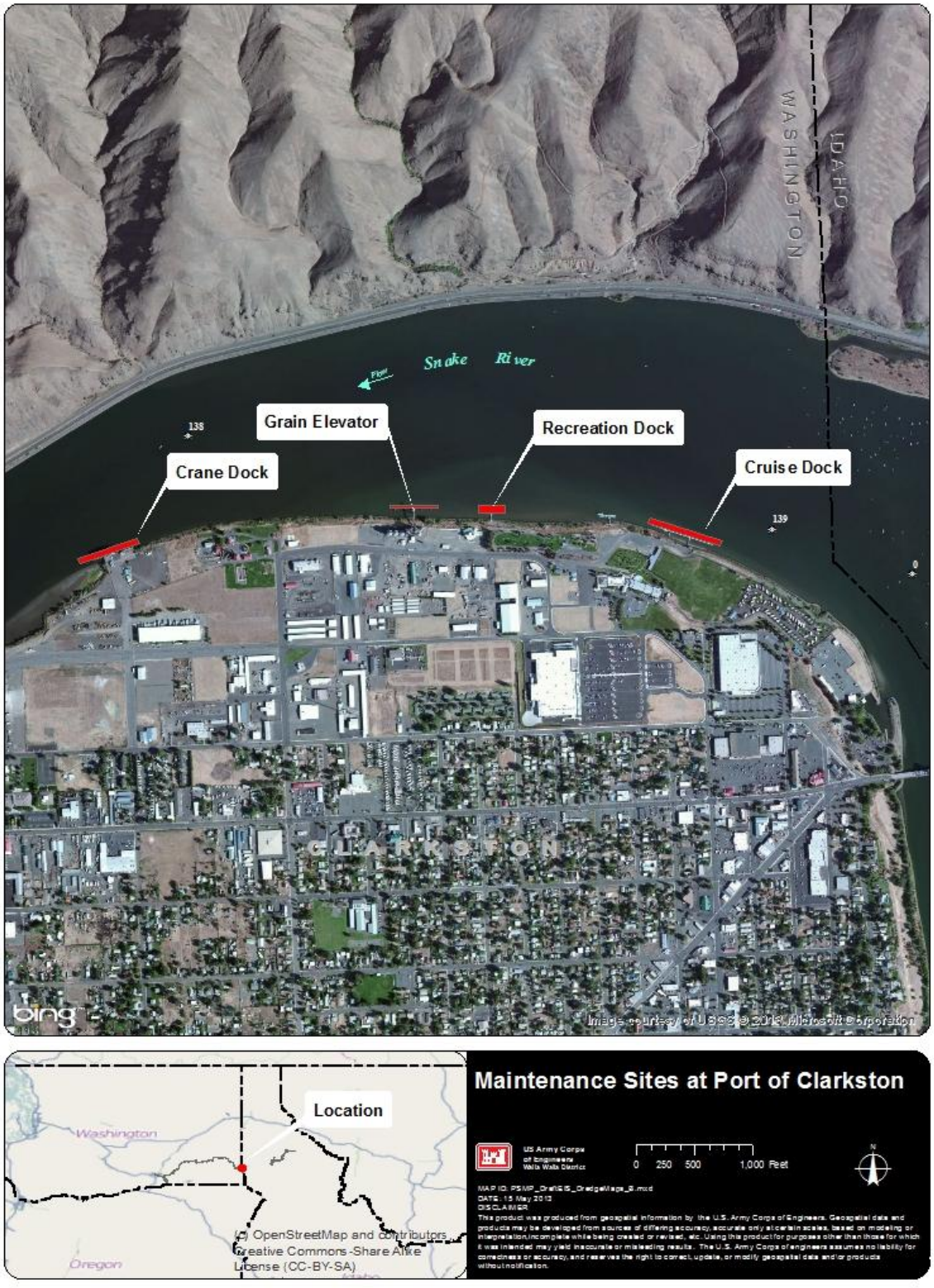


Figure 4. Dredging sites at the Port of Clarkston.

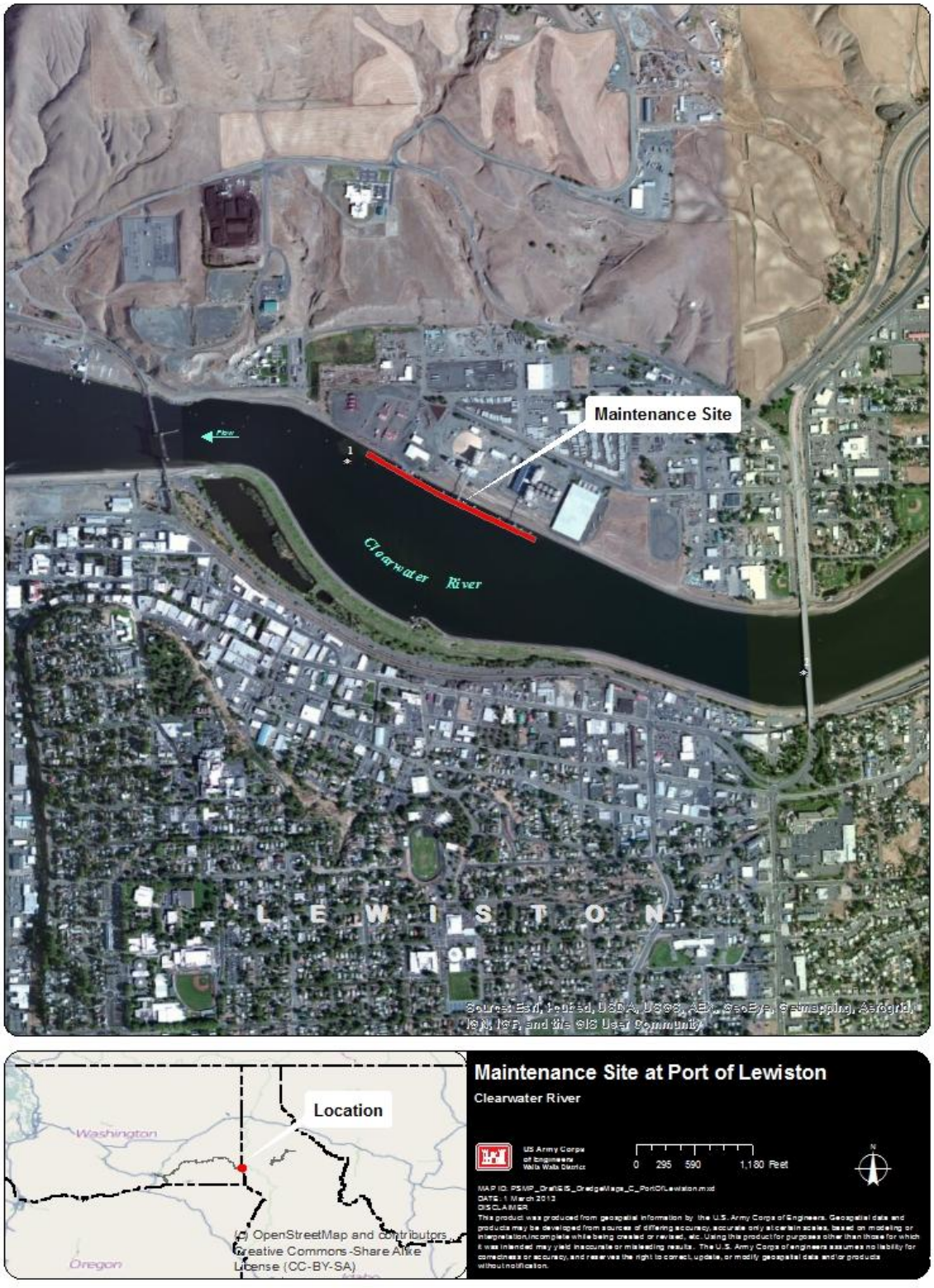


Figure 5. Dredging location at Port of Lewiston.

1.1.2 In-Water Disposal Site

The Corps proposes to use unconfined in-water disposal of the dredged material to create shallow-water habitat for resting and rearing by juvenile salmonids, primarily fall Chinook salmon. The proposed site is located in the Lower Granite reservoir at Snake River mile (RM) 116 and was selected for its proximity to dredging locations while meeting engineering and biological criteria. This site is an approximately 120-acre mid-depth bench on the left bank of the Snake River about 0.5 river miles upriver of Knoxway Canyon. The Knoxway site was historically an old homestead orchard and pasture located several hundred feet upland of the historic river shoreline. This beneficial use site is located in a low velocity area that has been accumulating sediment at an estimated rate of 2 inches per year since the filling of Lower Granite reservoir. The substrate at this site was visually inspected in 1992 during the reservoir drawdown test and was observed to be primarily silt. The upstream end of the site was used as the in-water disposal site for navigation maintenance dredging performed by the Corps in 2005/2006. Approximately 420,000 cubic yards of sand and silt was deposited on the upriver end of the Knoxway bench as part of that maintenance action. A shallow water habitat shelf estimated to be about 3.7-acres in size was created for summer rearing juvenile fall Chinook salmon (Figure 6). The upper surface of this material is sand that was reshaped to gently slope towards the river.

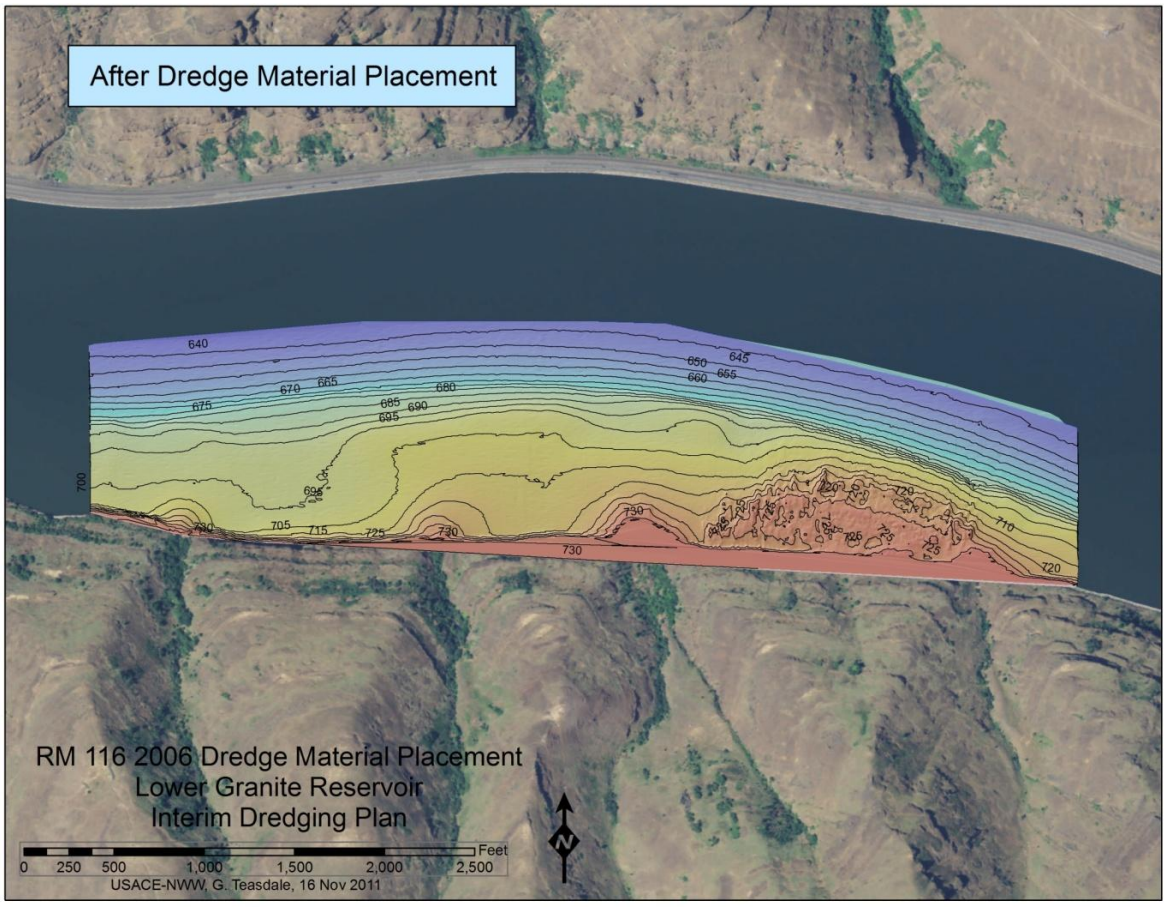


Figure 6. Contour map of RM 116 disposal site (shallow area to the right was created by dredged material disposal in 2005/2006).

The material from the proposed dredging would be deposited adjacent to and downstream of the material deposited in 2005-2006 (Figure 7). The new material would occupy an estimated 26-acre footprint and would form a somewhat uniform, gently sloping shallow-water bench along about 3,500 linear feet of

shoreline. The top of the bench would have about a 2% slope and would provide an estimated 7.36 acres of additional aquatic habitat 6 feet deep at minimum operating pool (MOP) with features optimized for resting/rearing of out-migrating juvenile salmonids, particularly for fall Chinook salmon (Figures 8 and 9). All of these dimensions are target dimensions. The finished grade may be slightly different because of the limitations of the equipment that would likely be used to create the habitat and because all work would be done underwater. The Corps anticipates there would be about 18 acres of lesser-quality shallow water habitat at depths of 6 to 20 feet on the slope of the bench.

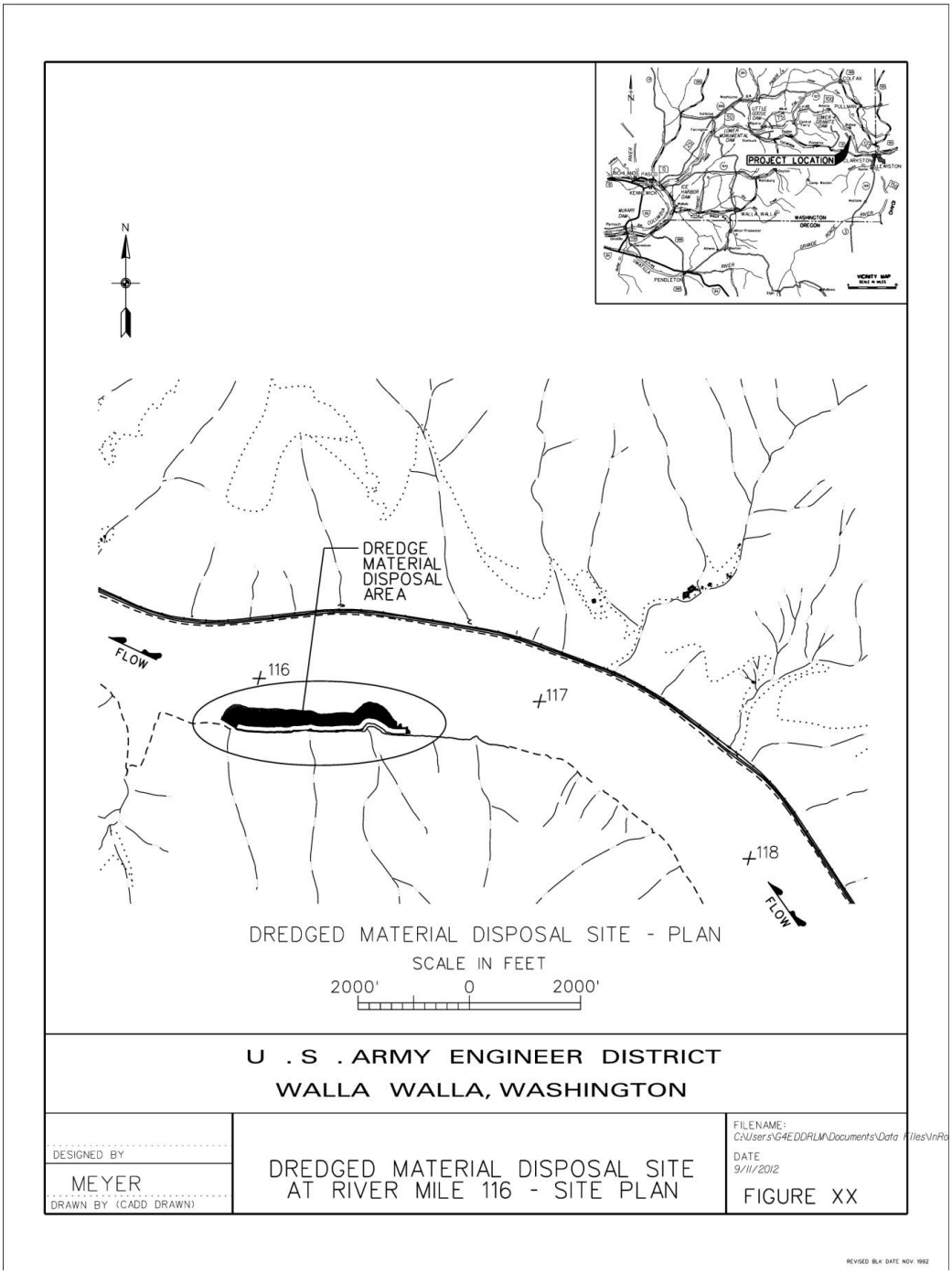


Figure 7. Location of proposed disposal site at RM 116 (Knoxway Canyon is the embayment just downstream of the disposal area).

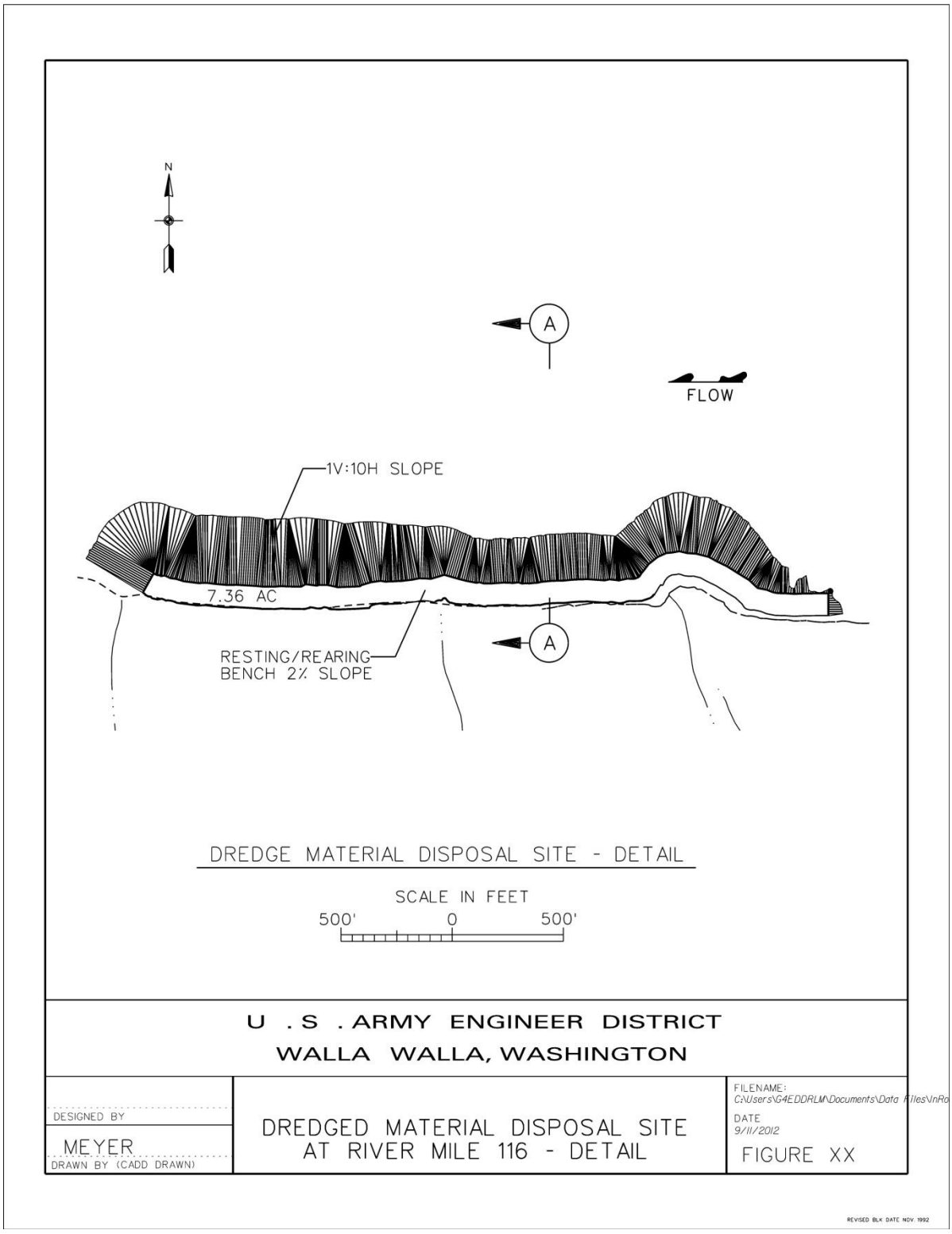


Figure 8. Site plan for disposal at RM 116.

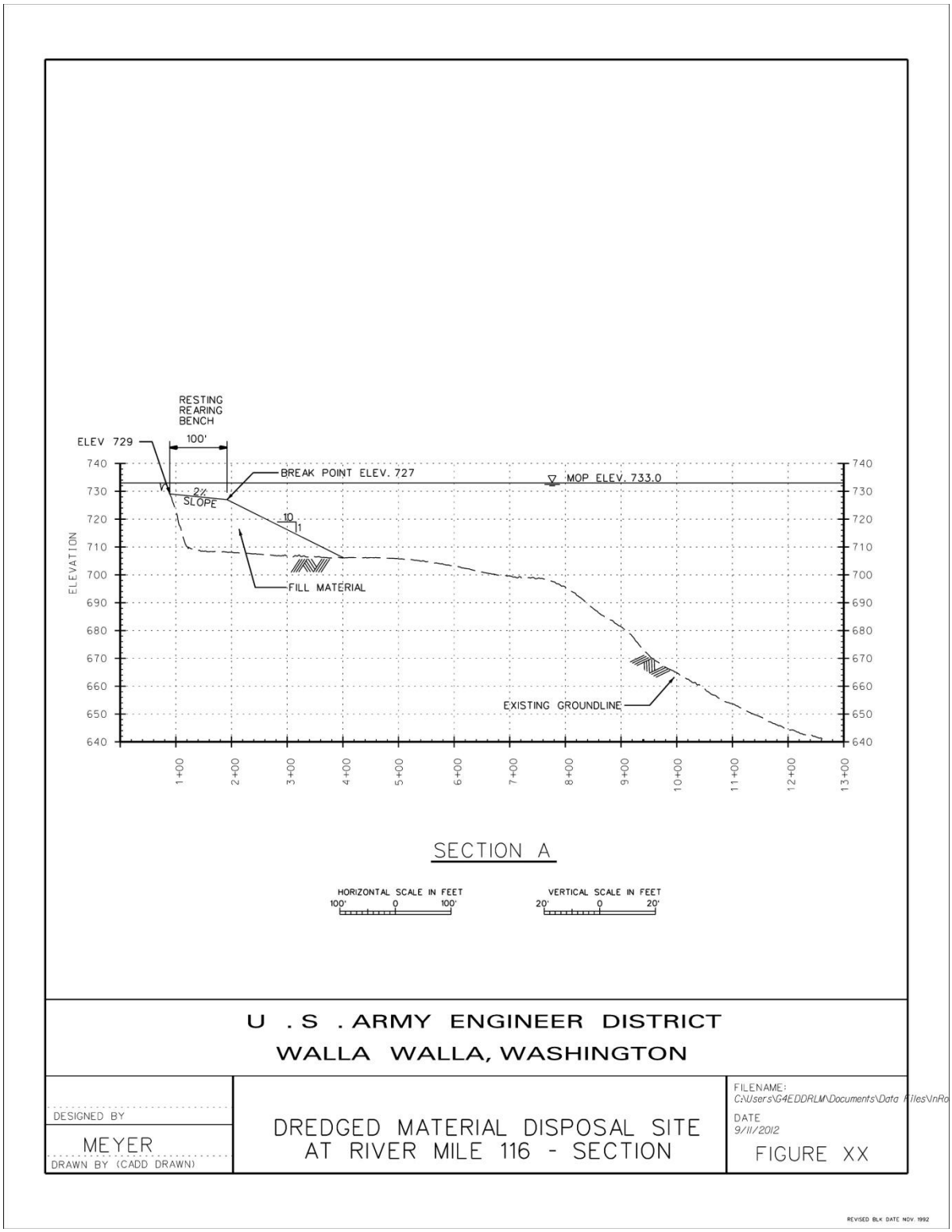


Figure 9. Cross-section of disposal at RM 116.

1.2 Site History

1.2.1 Snake/Clearwater Rivers Confluence

Sediment inputs to the Snake/Clearwater Rivers confluence area originate from a geographically large and diverse set of subbasins (Table 2). Previous characterizations of bed sediment (USACE 1988; CH2M Hill 1997; USACE 2003b; Battelle 2004) show that sand is the overall dominant material that deposits in this area. Downstream from Snake RM 130, the dominant material is silts and fines (CH2M Hill 1997; USACE 2012b). Most of the sediment (53.5%) comes from the Salmon River subbasin (Figure 10). The Grande Ronde and Clearwater subbasins contribute 5.8 and 12.5%, respectively. The latest U.S. Geological Survey **(**USGS) Sediment Core Survey also indicated that sand dominates the bed in the upper reach of Lower Granite Reservoir and that deposits below about RM 130 are mostly silt (Braun et al. 2012).

Table 2. Sizes of sediment-contributing watersheds

Geographic Area	Area (acres)	Area (square miles)	Percent of Study Area
Salmon subbasin	8,956,160	13,994	43
Clearwater subbasin (excluding North Fork)	4,420,480	6,907	21
Grande Ronde subbasin	2,624,640	4,101	13
Lower Snake River basin (Hells Canyon to Clearwater River)	1,346,560	2,104	6
Lower Snake River basin (Clearwater River to Columbia River)	1,346,560	5,471	17
TOTAL	**20,849,280**	**32,576**	**100**

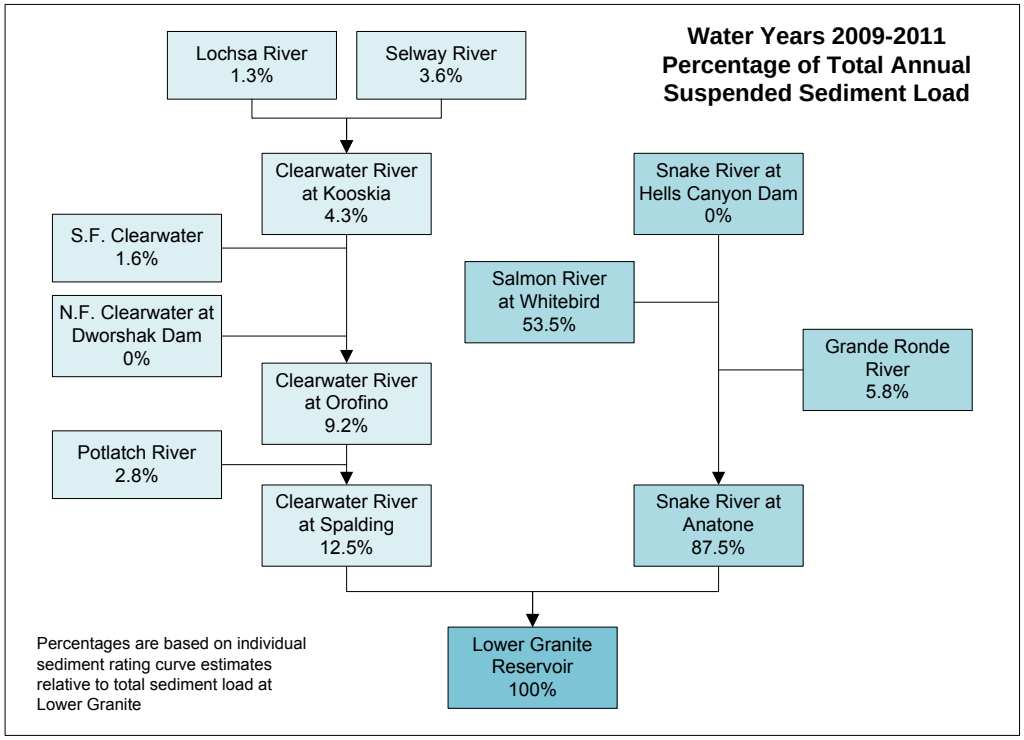


Figure 10. Relative sediment load contributions to the Lower Granite Reservoir by tributaries
Source: USACE (2012b).

1.2.1.1 Historical Dredging

Sediment deposition at the confluence of the Snake and Clearwater rivers has been an ongoing maintenance issue for the Corps since completion of Lower Granite Dam in 1975. The confluence is at the upstream end of Lower Granite reservoir where river velocities slow and sediment drops out of the water column. The Corps has dredged the Federal navigation channel and the berthing areas of the Port of Lewiston and Port of Clarkston multiple times since 1982, most recently in the winter of 2005/2006 (Table 3). Quantities of material removed each time ranged from about 250,000 cubic yards to about 400,000 cubic yards. The Corps has also dredged a larger template in the confluence area several times to provide adequate passage for high flows to prevent overtopping the levees at Lewiston, Idaho. Quantities for this flow conveyance dredging ranged from about 500,000 cubic yards to almost 1 million cubic yards per dredging action.

Table 3. Historical dredge volumes from the confluence of the Snake and Clearwater Rivers

Year	Location	Volume (cubic yards)
1982	Port of Lewiston – Lower Granite Reservoir	256,200
1982	Port of Clarkston – Lower Granite Reservoir	5,000
1985	Confluence of Clearwater and Snake Rivers	771,000
1986	Port of Lewiston – Lower Granite Reservoir	378,000
1988	Confluence of Clearwater and Snake Rivers	916,000
1989	Confluence of Clearwater and Snake Rivers	993,500
1992	Confluence of Clearwater and Snake Rivers	520,700
1996/97	Confluence of Clearwater and Snake Rivers	68,700
1997/98	Confluence of Clearwater and Snake Rivers	215,200
1997/98	Port of Lewiston	3,700
1997/98	Port of Clarkston	12,150
2005/06	Confluence of Clearwater and Snake Rivers, Ports of Lewiston and Clarkston	335,900

The Corps has performed sampling and analysis of sediment proposed to be dredged since 1985. Grain-size analysis has shown the material dredged from the confluence usually consists of more than 80% sand. Results of the chemical analyses have shown that the dredged materials did not contain chemical constituents in excess of biologically protective guidance available at that time (USACE 1999, 2000, 2002c, 2003a, 2003b, 2005, 2012b). In the Lower Granite reservoir, lower concentrations of major and trace elements were associated with coarser sediments (larger than 0.0625 mm in diameter) and higher concentrations of major and trace elements were associated with finer sediments (smaller than 0.0625 mm in diameter) (USACE 1999; Braun et al. 2012).

1.2.1.2 Potential Sources of Chemicals of Concern

The main potential sources of chemicals of concern for the Snake/Clearwater Rivers Confluence include industrial pollutants, storm water runoff, sewage treatment plant effluent, mining, and non-point pollutants.

Industrial Pollutants

The main potential source of industrial pollutants to the confluence area is the Clearwater Paper Corporation facility (formerly Potlatch Corporation) on the left bank of the lower Clearwater River at Lewiston, approximately 3 miles upstream of the confluence of the Snake and Clearwater Rivers. The mill has operated at this location since 1927. It manufactures wood products and bleached grades of

paperboard, tissue, and market pulp by the bleach kraft mill (sulfate) process (NOAA 2004). This plant has a National Pollutant Discharge Elimination System (NPDES) Permit, Number ID0001163, from the Environmental Protection Agency. The design flow for the mill is 39.0 million gallons per day (MGD) (WDOE 2009a). The plant is authorized to discharge effluent through an outfall into the Snake River (at RM 140) and via seepage from the secondary treatment pond into the Clearwater River.

Storm Water Runoff

The majority of the storm water runoff that may be a source of pollutants for the confluence comes from the three urbanized areas in the vicinity, Lewiston, Clarkston, and Asotin. Lewiston (population 32,119) is located on the right bank of the Snake River (river miles 139 – 143) and both banks of the lower Clearwater River (river miles 0-2) at the confluence of the Snake and Clearwater rivers. Storm water from Lewiston is discharged into both rivers. Some of the storm water runoff from the city of Lewiston flows into levee ponds operated by the Corps. The Corps periodically pumps water from these ponds into the Clearwater River as part of routine levee operation and maintenance. The results of a study completed in 2005 determined the Lewiston levee ponds did not pose a significant potential risk to salmonids in the Clearwater River (Steevens, et al., 2005). This conclusion was based on the relatively low chemical concentrations, often below conservative screening values, that were detected in the majority of the samples from the ponds.

Clarkston, Washington (population 7,331) is located on the left bank of the Snake River (river miles 136.5 to 143) opposite the mouth of the Clearwater River. Storm water from Clarkston is discharged into the Snake River.

Asotin, Washington, (population 1,270) is located on the left bank of the Snake River (river miles 145 to 146.5), about 6 miles upriver of the Snake/Clearwater rivers confluence. Storm water from Asotin is discharged into the Snake River.

Sewage Treatment Plant Effluent

Sewage treatment effluent originates from the three urbanized areas of Lewiston, Clarkston, and Asotin. Descriptions of their respective sewage treatment facilities are provided below:

a. Lewiston

Lewiston discharges from its municipal wastewater treatment plant to the Clearwater River about 1/2 mile upstream from the Snake-Clearwater River confluence (WDOE 2009a) (Figure 11). The treatment plant has a design flow of 0.55 MGD (EPA 2006a). It operates under permit number ID-0026531 and is classified as a conventional filtration plant (EPA 2006).

b. Clarkston

Clarkston operates a publicly owned wastewater treatment facility that uses an activated sludge process with ultraviolet light disinfection. The outfall was replaced in the fall of 1996 to provide additional diffusers and greater hydraulic capacity (WDOE 2009a). The city added a new secondary clarifier in 1999 (WDOE 2009a). The design flow is 2.20 million gallons per day (MGD) (WDOE 2009a). The treatment plant and its outfall are located at the downstream end of the proposed dredging area (Figure 12).

c. Asotin

Asotin currently operates an oxidation ditch wastewater treatment plant that was upgraded in 2005 (Figure 13) (WDOE 2009b). The 2005 upgrade project included rehabilitation work to the head works, modifications to the oxidation ditch, installation of ultraviolet light disinfection to replace the chlorine disinfection system, installation of new secondary clarifiers, sludge processing upgrades, and the conversion of the old secondary clarifiers into aerobic holding tanks (WDOE 2009b). Secondary treated

and disinfected effluent discharges from the facility via a 12-inch single port diffuser into the Snake River. The design criteria included an average flow of 0.14 MGD (WDOE 2009b). WDOE placed the 0.5 mg/liter chlorine discharge limitation in the permit to protect the Snake River when the city uses chlorine as a back-up disinfectant if the ultraviolet disinfection system is not working or is overloaded with turbid effluents (WDOE 2009b).



Figure 11. Location of City of Lewiston wastewater treatment facility



Figure 12. Location of the City of Clarkston Wastewater Treatment Facility

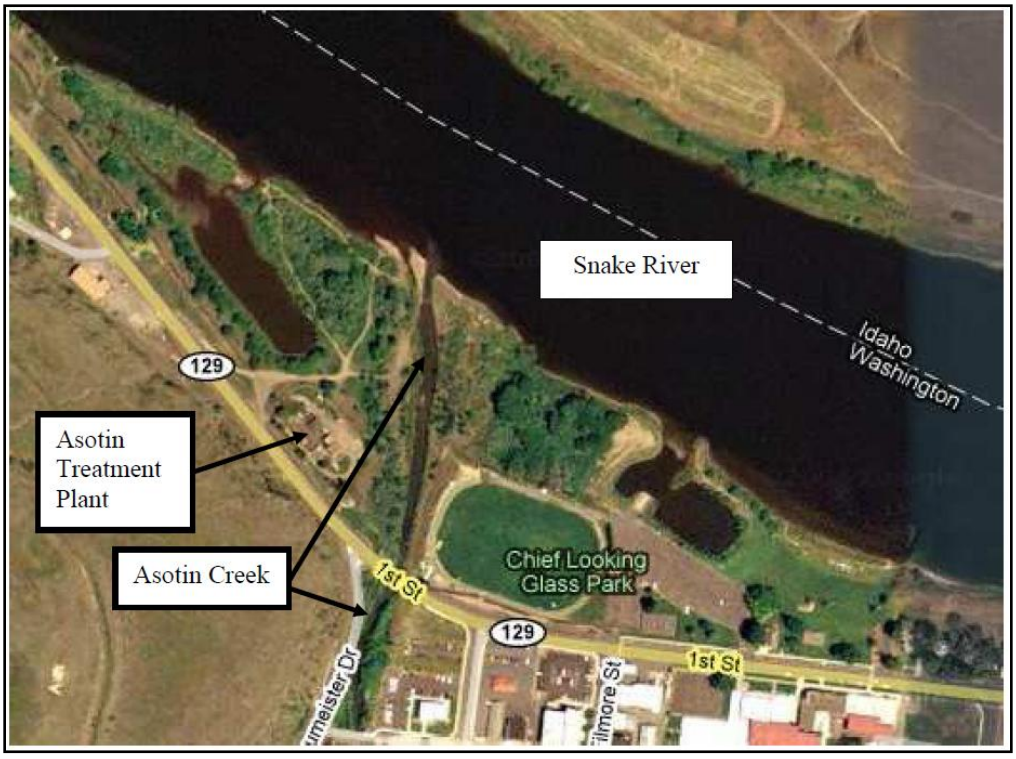


Figure 13. Location of the City of Asotin Wastewater Treatment Facility

Mining
Diverse and extensive mining has occurred in the Clearwater drainage and the Snake River basin. The discovery of gold has played a major role in the history of Idaho dating back to the 1800s and several mines have been reopened on some parts of the Salmon River as the value of gold has increased (IMNH 2013). Rare earth elements and uranium were also mined historically in central Idaho before and during the 1950s (Gillerman and Bennett 2010, Herron and Freeman 2008). Currently, the Thompson Creek Mining company operates a large, open pit molybdenum mine near Challis in Custer County, Idaho (Gillerman et al. 2007). Six mines within the Salmon subbasin have records of toxic substance releases involving the following contaminants and conditions: arsenic, chromium, nitrate compounds, nickel, iron, silver, zinc, cadmium, lead, copper, manganese, mercury, cobalt, 2-mercaptomenzothiazole, chlorine, coliform, solids, and altered basic water chemistry (NPCC 2004).

Non-point Sources
Non-point sources include agriculture, forest fires, and pesticide applications on either agricultural or forest lands. The majority of these originate further up in the watershed and not near the confluence of the Snake and Clearwater rivers.

1.2.1.3 Categories of Chemical Constituents

Organic Compounds
Legacy chlorinated compounds are the most common, and potentially detrimental, organic chemicals identified in lower Snake River sediments. DDT, DDE, and DDD are the most frequently encountered compounds (Normandeau 1999b; USACE 2002a). The largest applications of DDT to U.S. Forests (approximately 80%) were to control infestations of the western budworm (*Choristonneura* sp.) and the gypsy moth (*Lymantria dispar*) from 1945 to 1965 (Wickman and Scharpf 1972; EPA 1975). DDT was also used as an occasional defoliator for pest infestations in the 1960s to early 1970s in federally managed forests (EPA 1975; Campbell and Sloan 1977) The last DDT application over a large area of Idaho occurred in 1974 to halt an infestation of tussock moth (USFS 1975). Other chlorinated compounds such as aldrin, chlordane, dieldrin. endrin, endosulfan, and lindane have only been detected at very low concentrations, or not at all, during previous sediment evaluations.

Sediment samples taken for previous dredged material evaluations and during the Potlatch ambient sediment monitoring period (CH2M Hill 1998, 1999, 2000, 2001, 2002) showed trace amounts of a few polynuclear aromatic hydrocarbon (PAH) species. However, sediment concentrations in the confluence area have never been high enough to suggest that the material could not be used for in-water disposal (USACE 1999, 2000, 2002c, 2003a, 2003b, 2005, 2012b). One source of PAHs within the watershed is from forest fires. Several studies have found that airborne pollution deposition is the main source of soil PAHs in remote areas (Edwards 1983; Vergnoux et al. 2011; Wick et al. 2011) and that a large proportion of the PAH content in water is probably adsorbed onto suspended solids (Harrison et al. 1975).

Dioxins and furans are an important chemical of concern due to their toxicity at low concentrations. One potential source of dioxins is from pulp and paper mills, and items specific to the facility along the Clearwater River were discussed in section 1.3.1.2 above. However, small amounts of dioxin and furans have also been found in smoke from wheat fires and agricultural burning practices (Gullett and Touati 2003; Goncalves et al. 2011) and stream concentrations have reportedly increased after wildfires (Tashiro et al. 1990; Gabos et al. 2001; Kim et al. 2003). These atmospheric routes can account for about 75% of the total loading in rural areas (Shabad 1980; Edwards 1983).

Metals
Mining for gold, molybdenum, phosphorus, uranium, and other rare earth elements has historically occurred, and continues in some locations today, in both the Clearwater and Snake River drainages. This activity has the potential to influence metals concentrations in the lower Snake River, although values

greater than the screening limits have not occurred in dredged areas to date. Selenium is one element that has been identified at concentrations above the February 2013 Dredged Material Management Program (DMMP) (USACE, 2013a) screening limits in some areas that are usually not dredged. Sediment concentrations as high as 4.2 mg/kg have been determined for the Yankee Fork Tributary of the Upper Salmon subbasin as a consequence of gold mining (U.S. Department of Interior, 2012). Even higher selenium concentrations have been determined in southeastern Idaho stream sediments where phosphate mining is occurring (USGS, 2002). Both of these cases illustrate that elevated background selenium concentrations occur in some parts of Idaho within the Snake River drainage area.

1.3 Existing Sediment Data

1.3.1 Background

Sediment samples have been collected from various locations within the lower Snake River project since at least 1985 (Crecelius and Gurtisen, 1985; Crecelius and Cotter, 1986; Pinza *et al*., 1992a, 1992b; Anatek, 1997; HDR, 1998; CH2M Hill (2000, 1999, 1997), USACE, 2002a, 2002b, 1998, 1987; Heaton and Juul, 2003). Most of these studies are linked directly to the Corps dredging authorities and projects, and predominantly focus on the Snake and Clearwater confluence area. The 1997, 2000, and 2003 studies were the most inclusive and the results from these investigations will be emphasized here.

The purpose of the 1997 sediment study completed for the Lower Snake River Juvenile Salmon Migration Feasibility Study was to determine the concentration and distribution of potential sediment contaminants in the four lower Snake River reservoirs. This study consisted of two phases. The first phase involved collecting particle-size distribution information along selected transects to target specific areas where finer-particle-size materials were predominant. Representative cores were retrieved using an 8-cm diameter by 2-m long (3-in diameter by 7-ft long) Balchek gravity core sampler. Most of the cores were composited over the entire depth of sediment but some were cut into 0.6-m (2-ft) sections for layer analysis (CH2M HILL, 1997; Anatek Labs, 1997). During Phase 2 of the Feasibility Study sampling program, 94 sediment samples were submitted for laboratory analysis of selected inorganic and organic constituents.

The June 2000 sediment survey included 58 sites in the lower Snake River and Clearwater Rivers. The majority of the sites were in Lower Granite reservoir and the Clearwater River near the confluence with the Snake River. Off-channel areas evaluated in the study included Hollebeke HMU in Ice Harbor reservoir; Willow Landing and Illia Landing in Little Goose reservoir; and Greenbelt Boat Basin, Swallows Swim Beach, and Hells Canyon Resort Marina in Lower Granite reservoir. Ten sites in the four navigation lock approaches were evaluated and found to consist of rock and cobble. A Shipek grab sampler or Balchek core sampler were used to obtain the samples, the choice depending on sediment depth. Samples from 48 sites were analyzed for particle size distribution while fewer were processed for chemical analyses.

The 2003 study included ten proposed dredging areas from the mouth of the Snake River to the Swallows Boat Basin and from within the first 1.5 miles of the Clearwater River that were evaluated in 2000. In addition, the sediments at one in-reservoir disposal site in Lower Granite Reservoir were also evaluated. Samples were collected with a 3-in Balchek or Shipek sampler depending on the depth of the material. Of the 68 possible samples, 30 were selected to undergo Tier IIB analysis based on grain size and total volatile solids content. This suite of analyses included trace metals, mercury, oil and grease, total petroleum hydrocarbons, chlorinated herbicides, organophosphorus pesticides, semi-volatile herbicides and pesticides, polycyclic aromatic hydrocarbons, poly chlorinated biphenyls, total organic carbon and total volatile solids. A smaller subset of 20 samples was collected in Lower Granite pool and screened for dioxin-like compounds using P-450. Eleven of these sediment samples received a full high resolution dioxin analysis (EPA Method 8290).

Sediment sampling was also completed in 2011 as part of the PSMP/EIS. This program focused on areas of the Lower Snake and Clearwater Rivers where sediments have historically accumulated and have been dredged. The purpose of this project was to provide a synoptic overview of sediment quality in the selected areas and provide new information to update the sediment quality database to facilitate determination of long-term trends.

1.3.2 Particle Size

A total of 487 grab sediment samples were collected as part of the Phase 1 task of the special Lower Snake River Juvenile Salmon Migration Feasibility Study sediment study (CH2M HILL, 1997). Of the 487 grab samples, 356 were sieved to develop particle-size distributions. The remaining 131 samples (or 26%) were not sieved either because there was no sample recovery or because the sample consisted only of gravel and/or cobble. The average grain size distributions for the sediment samples collected from above Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Locks and Dams are summarized in Table 4.

Table 4. Summary of particle size results for the sediment samples collected from the Lower Snake River in 1997 during Phase I.

	Average Grain Size (%)				Cumulative Percent			
Sediment Size	**IHR**	**LM**	**LGO**	**LGR**	**IHR**	**LM**	**LGO**	**LGR**
Gravel	2.4	2.8	1.9	0.4	2.4	2.8	1.9	0.4
Very Fine Gravel	0.1	0.6	0.7	0.3	2.5	3.4	2.6	0.7
Very Coarse Sand	0.1	1.0	0.7	0.5	2.6	4.4	3.3	1.2
Coarse Sand	1.1	1.1	2.8	1.7	3.7	5.5	6.1	2.9
Medium Sand	18.3	2.8	10.2	6.9	22.0	8.3	16.3	9.8
Fine Sand	18.3	6.7	13.1	17.1	40.3	15.0	29.4	26.9
Very Fine Sand	23.3	13.2	16.8	20.1	63.6	28.2	46.2	47.0
Silt/Clay	35.8	71.8	53.8	52.4	99.4	100.0	100.0	99.4

Notes:
IHR - Ice Harbor Reservoir (Lake Sacajawea), 41 samples
LM - Lower Monumental Reservoir (Lake West), 77 samples
LGO - Little Goose Reservoir (Lake Bryan), 127 samples
LGR - Lower Granite Reservoir (Lower Granite Lake), 104 samples
Source: Developed by Normandeau, 1999a

The 2000 sediment study of the lower Snake and Clearwater Rivers confluence (USACE, 2000) evaluated 53 samples for particle size with an emphasis on depositional areas. Some mid-channel and lock approach areas from Lower Granite and Little Goose locks and dams were also included in the sampling. Particle size was very dependent on locations of the sampling sites, but the average particle-size distribution for all sites were fines (silt and clay) 17.1%, sand 74.2%, and gravel 7.8%. The lock approach sites consisted of 2.5- to 15-centimeter (1- to 6-inch) cobbles exclusively. Generally, a sample location near the confluence that was more than 75 meters from the shoreline contained less than 1% fines.

The 2003 sediment study found that the proposed dredging areas differed with respect to percent of sand and fines in recovered samples. The samples from the Clearwater River, Port of Clarkston, and in the Snake River below the confluence with the Clearwater River all had median sand composition greater than 90%. The areas at the Willow Landing and RM 116 (before it was used as an in-water disposal site

in 2005/2006) had the highest median percent fines of 76% and 60%, respectively. The Greenbelt Boat Basin and Swallows Boat Basin areas were similar at 70% and 69% sand, respectively. Only one of three locations within each of the Port of Lewiston and Illia Landing areas provided recoverable samples and these were 57% and 83% sand, respectively.

The results of the conventional analyses from the 2011 sampling event were similar to previous findings. The grain size (method ASTM D422) and total solids (method APHA 2540G) analyses from the Federal Navigation Channel, Port of Lewiston, and Port of Clarkston Grain Elevator locations showed that the sand component ranged from 89% to 100% while total solids ranged from 69% to 88%. The substrate at the second Port of Clarkston location had a higher percentage of fines resulting in a sand component that ranged from 74% to 87% while total solids ranged from 62% to 64%.

1.3.3 Organics

Sediment analyses have included several organic compound groups, including: chlorinated herbicides, dioxins, glyphosate herbicide, organochlorine pesticides, organophosphorus pesticides, semi-volatile compounds, and total petroleum hydrocarbons. A few chlorinated herbicides, organophosphorus pesticides, or semi-volatile organic compounds have been detected in composite top layer sediment samples. In other studies, organic contaminants were detected sporadically. The following sections present the results of the polychlorinated dibenzo dioxin/furans, glyphosate herbicide, organochlorine pesticides, PAHs, and total petroleum hydrocarbon analyses and other historical organic chemistry data sets.

1.3.3.1 Dioxins and Furans

There have been concerns about dioxin/furan contamination in the Snake and Columbia Rivers since the 1980s. In response, the Corps initiated a sediment quality study in 1991 to determine potential effects prior to the execution of the 1992 drawdown test of the Lower Granite reservoir. Five of the 19 composite sediment samples analyzed for dioxin/furan compounds yielded an average of 0.43 ppt 2,3,7,8-TCDD and 2.72 ppt 2,3,7,8-TCDF on the Clearwater River at approximately RM 3 (Pinza *et al.*, 1992a, 1992b).

Dioxin and furan tests were also completed for the 1997 Lower Snake River Juvenile Salmon Migration Feasibility Study downstream from previous sampling locations. Only two of the four samples yielded detectable levels of total dioxins of 0.69 and 1 ppt (no 2,3,7,8-TCDD was identified) (CH2M Hill, 1997).

Multiple sediment studies were completed in 1998 that included analyses for dioxins and furans. The first study documented nine samples that were taken in the Lewiston/Clarkston confluence area near Snake River RM 139. Only two of the nine samples yielded results with 1.3 and 1.7 ppt 2,3,7,8-TCDF and no detects for 2,3,7,8-TCDD (HDR, 1998). In a second study, CH2M Hill collected samples for dioxin analyses for Potlatch Corporation (now Clearwater Paper Corporation) in the Lower Granite pool and Clearwater arm of the pool (CH2M Hill 1997, 1998). Seven sites were selected and individual subsets were combined into a composite sample for analysis. A Ponar sampler was used to sample the top 7.5 inches of the sediments. The results from the in-river sites sampled consisted of no detects and below detection limits for 2,3,7,8-TCDD and 2,3,7,8-TCDF.

Sediment samples collected in 2000 included use of new technology to aid the detection of dioxin/furan in sediments. Ten samples were screened for the presence of dioxin/furan compounds using a cell-based assay (P-450). The samples were subsequently analyzed by a gas chromatograph mass spectrometer confirmatory test to quantify the congeners. The test results showed than some of the congeners were present, but 2,3,7,8-TCDD or 2,3,7,8-TCDF were not among them.

Dioxin and furan congeners were again analyzed in samples collected from three separate areas in Lower Granite reservoir (RM-116, Port of Clarkston, and the Snake River below the confluence) in 2003. The results showed that 2,3,7,8-TCDD and several other congeners were not detected in the samples. The two congeners that occurred in the highest concentrations were 1,2,3,4,6,7,8-HpCDD (2.03 to 4.95 ppt) and 1,2,3,4,6,7,8,9-OCDD (10.99 to 38.38 ppt). The toxic equivalents (TEQ) were calculated using maximum concentrations of all the congeners identified from RM 116, Port of Clarkston, and the Snake River below the confluence the results were 0.17, 0.04, and 0.23 ppt, respectively. In all cases, the calculated values were less than the bioaccumulation screening guidance by more than an order of magnitude.

Sediment dioxin and furan analyses were competed at the Port of Clarkston, Port of Clarkston Grain Elevator, and FNC Lewiston in 2011 using EPA method 8290. The concentrations of 2,3,7,8-TCDD at Port of Clarkston facilities ranged from 0.320 ng/kg to 0.540 ng/kg and were less than the detection limit at FNC Lewiston. 2,3,7,8-TCDF concentrations were similarly low, ranging from 0.100 ng/kg to 0.420 ng/kg at the Port of Clarkston locations and again undetected at the Port of Lewiston. Calculated U=0 TEQs at all three locations ranged from 0.126 ng/kg at FNC Lewiston to 0.509 ng/kg at the Port of Clarkston Grain Elevator.

1.3.3.2 Glyphosate and Aminomethylphosphoric Acid

Glyphosate is a post-emergence terrestrial and aquatic herbicide that has found widespread agricultural use in eastern Washington and Oregon, as well as domestic applications. A major metabolite is aminomethylphosphonic acid (AMPA). AMPA is much more persistent than glyphosate, and the half-life is dependent on the environment with reported ranges of 199 to 958 days (WHO, 1994), and 10 to 12 weeks in the pond environment (USFS, 1984).

The presence of glyphosate and AMPA were first evaluated during the 1997 feasibility study. During that evaluation, all top layer sediment samples (94 total samples) were tested and glyphosate and AMPA were detected in 36% and 16% of the samples, respectively. Individual concentrations of glyphosate ranged from non-detected to a maximum of 68.9 ppb (parts per billion) with an arithmetic mean of 12.52 ppb. The concentration of AMPA ranged from non-detected to a maximum of 29.3 ppb with an arithmetic mean of 7.48 ppb (Normandeau, 1999b). No screening guidance has been established for either glyphosate or AMPA in sediments within the Columbia River Basin.

There appeared to be slight downstream increases in the mean concentrations of both glyphosate and AMPA in sediment samples collected from each of the impoundments. Although the highest individual concentrations of glyphosate and AMPA were detected in samples collected from Lake Bryan (Little Goose reservoir) (Normandeau 1999b) the highest average reach concentration of glyphosate was found in the samples collected from Lake Sacajawea (Ice Harbor reservoir, see Table 5).

Table 5. Summary of average glyphosate and AMPA concentrations for sediment samples collected during 1997 in the Lower Snake River

	Ice Harbor	Lower Monumental	Little Goose	Lower Granite	Average
Elutriate (µg/L)					
AMPA	ND	ND	ND	ND	ND
Glyphosate	0.58	ND	0.69	ND	0.57
Sediment (ppb)					
AMPA	8.08	8.28	7.58	6.07	7.48
Glyphosate	16.80	14.85	10.42	10.60	12.52

1/ ND = Not detected; ½ the detection level is used when concentrations < detection level.

Analyses for glyhopsate were included in the 2000 sampling program. One site in the Greenbelt Boat Basin had a concentration of 23 ppb, and was the only location with a reported value higher than the laboratory detection limits. Two other sample analyses from the same boat basin came back at less than the method detection limit (MDL).

The concentrations of glyphosate and AMPA were reported as less than the detection limit for the sediments collected at the two Port of Clarkston facilities and FNC Lewiston during 2011.

1.3.3.3 Organochlorine Pesticides

Synthetic organic chemicals containing chlorine, including carbon tetrachloride and trichloroethylene, were available commercially by 1925. DDT was released into civilian markets in 1945 and used extensively over the next two decades to control agricultural and forest insects, as well as disease vectors. The last DDT application over a large area of Idaho occurred in 1974 to halt an infestation of tussock moth (USFS 1975). Other organochlorine pesticides, such as methoxychlor, aldrin, dieldrin, chlordane, endosulfan, endrin, and toxaphene were developed after World War II, and at least some of these have been used in the watershed.

Organochlorine pesticides are relatively insoluble in water, adhere strongly to soil particles, and are resistant to physical, chemical, and biological degradation. Because of these features, the original pesticides and their daughter products tend to remain in the environment for extended periods of time and many bioaccumulate. Several have been detected in sediment samples collected from the lower Snake River, including: 4,4-DDD; 4,4-DDE; 4,4-DDT; aldrin; dieldrin; endrin; heptachlor; and lindane.

The Corps has monitored sediments prior to dredging operations for a host of organic compounds since the mid 1980s. In the sediment analysis studies for 1984 and 1985 for interim dredging (USACE, 1987; 1988), the Corps sampled sediments between the Port of Lewiston and the confluence of the Snake and Clearwater River. At seven sample sites that were sampled in the Clearwater River in 1985, 4,4-DDD concentrations ranged from less than 0.3 to 3 ppb while 4,4-DDE ranged from less than 0.3 to 4.8 ppb. In 1988, during dredging in the upper end of the reservoir behind Lower Granite Lock and Dam, the Walla Walla District found 4,4-DDT at 6 ppb at a site in the Clearwater Snake River Confluence (USACE, 1987).

Sediment testing in the 1990s added to the database. Pinza *et al*. (1992b) tested 19 sites for chlorinated pesticides at port areas on the lower Snake and Columbia rivers. At the eight sample locations in the vicinity of the Snake and Clearwater River confluence, 4,4-DDT concentrations ranged from 1.2 to 2.0 ppb, which was below laboratory detection limits. The DDT metabolite 4,4-DDD concentrations ranged from 0.7 to 2.0 ppb while 4,4-DDE concentrations ranged from 0.6 to 3.3 ppb. Other organochlorine pesticides were reported as less than the laboratory detection limit of 2.0 ppb.

The sediment sampling completed for the1997 Lower Snake River Juvenile Salmon Migration Feasibility Study was spatially more extensive than previous investigations. Average DDE concentrations ranged from 2.68 ppb in Ice Harbor to 6.48 ppb in the Lower Granite reach, with an arithmetic mean concentration of 4.89 ppb. DDD was detected in 11 sediment samples, with an average maximum concentration of 6.48 ppb in the Lower Granite reach and an arithmetic mean of 2.07 ppb. DDT was detected in only five samples, with a mean arithmetic concentration of 1.62 ppb. Total DDT (DDD, DDE, and DDT) concentrations averaged 8.23 ppb. The highest mean reach concentration for total DDT was 11.3 ppb for Lower Granite Lake. The average reach concentration of total DDT decreased steadily downstream from Lower Granite Lake, reaching a mean concentration of 5.7 ppb in Lake Sacajawea.

The pesticides aldrin, dieldrin, endrin, heptachlor and lindane were also evaluated in the 94 sediment samples collected for the feasibility study. The concentrations of these compounds in Lower Granite reservoir were reported as non-detects.

The analysis for organochlorine compounds using EPA Method 8151A in 2000 did not include all of the compounds considered in 1997. As such, there is no data for aldrin, dieldrin, endrin, 4,4-DDD, 4,4-DDE, 4,4-DDT or other chlorinated pesticides identified above. The results for the sixteen chlorinated herbicides, including 2,4-D, 2,4-DB, 2,4,5-T, and 2,4,5-TP, that were evaluated were all less than the detection limits.

The evaluations organochlorine compounds such as 4,4-DDD, 4,4-DDE, 4,4-DDT, aldrin, chlordane, dieldrin, endrin, lindane, and mirex from the 2003 study were all reported as less than the MDL

The 2011 sediment characterization used EPA Method 8151A to analyze for chlorinated herbicides. All of the results from the two Port of Clarkston locations and FNC Lewiston were reported as less than the MDL.

1.3.3.4 Total Petroleum Hydrocarbons, Oil, and Grease

The lower Snake River area is not heavily industrialized, and significant pollution problems from oil spills and heavy industrial pollution are not expected to be as common as in the major northwest port areas such as Puget Sound and Portland. However, at certain portions of the river there are ports, grain terminals, and boat launch areas that experience heavy use seasonally. These areas could be expected to have concentrations of residues from fueling operations and bilge wash.

Total petroleum hydrocarbon, fats, oils, greases, and traditional oil and grease analyses were completed in the 1980s and early 1990s, albeit with little continuity. Crecelius and Gurtisen (1985) reported oil and grease concentrations from sediment sites near Clarkston, Washington, on the Snake River ranging from 62 to 222 ppm. The Corps reported oil and grease in the sediments ranging from 38 to 1,096 ppm. Only two of these samples were greater than 500 ppm and these were both detected at an in-water disposal site in Lower Granite pool at RM 120. Pinza *et al*. (1992b) reported oil and grease concentrations ranging from 12.62 to 208.70 ppm for mid Columbia and Snake River sites. Total petroleum hydrocarbons ranged from 12.20 to 96.27 ppm.

Total petroleum hydrocarbons (TPHs) were again analyzed in all four lower Snake River reservoirs during the 1997 feasibility study. However, the method used (a modified version of EPA 418.1) only provides an indication of the amount of petroleum material in the sediments and does not quantify the specific type of petroleum material present. The results did show that the concentration of TPH ranged from non-detect to 256 ppm (Lower Monumental reservoir) with an arithmetic mean of 55.41 ppm (Anatek, 1997). Along the lower Snake River, the average concentration of TPH generally increased in the downstream direction with the highest average reach concentration (62.13 ppm) in Lake Sacajawea (Ice Harbor reservoir).

During the 2000 sediment survey in the area of the confluence of the Snake and Clearwater Rivers, the Corps sampled 38 sites for oil and grease. Concentrations ranged from 134 to 770 ppm, and only three of the sites had oil and grease concentrations greater than 400 ppm (USACE, 2000).

Samples for oil, grease, and TPH diesel/motor oil analyses were collected from seven potential dredge areas during the 2003 investigation. The oil and grease content of individual samples ranged from 70 mg/kg at Illia Landing to 817 mg/kg at the Greenbelt Boat Basin. The median values for areas where multiple samples were collected were not as disparate, ranging from 239 mg/kg and 274 mg/kg at the Willow Landing and Swallows Swim Beach, respectively, to 327 mg/kg and 463 mg/kg the at the Greenbelt Boat Basin and Port of Clarkston, respectively.

Since the natural organic breakdown products from plant and animal matter contribute to the oil and grease content of the sediments, TPH for diesel and motor oil analyses were completed to identify those components during the 2003 study. The values reported for TPH diesel at the Port of Lewiston, Illia Landing, and Willow Landing were all less than detection limits. Of the samples actually tested for TPH diesel that yielded positive results (six from the Port of Clarkston, five from the Greenbelt Boat Basin, and three from the Snake River below the confluence), the concentrations ranged from 22 mg/kg to 82 mg/kg. Calculated median values for the same three areas ranged from 34 mg/kg at the Greenbelt Boat Basin to 81 mg/kg below the confluence. The TPH motor oil results paralleled the TPH diesel data, but were four to five times higher.

The 2011 sediment samples from the Ports of Clarkston and FNC Lewiston were analyzed for the presence of diesel and heavy oil using the NWTPH-DX method. All results were reported as less than the detection limit.

1.3.3.5 Polynuclear Aromatic Hydrocarbons (PAH)

PAHs represent a class of suspected carcinogens and can pose a threat to aquatic life. The PAHs typically found in dredged material can originate from petroleum-fueled internal combustion engines since that are found in the engine's emission as a byproduct of incomplete combustion. Another source of PAHs within the watershed is from forest fires as previously mentioned.

The first recorded sample and analysis effort for PAHs was conducted in the Port of Lewiston area in 1985. Crecelius and Gurtisen (1985) did the first serious study of PAHs in the Snake River system prior to a proposed confluence dredging action. In their analysis of sediment core samples from the Port of Clarkston area, the total PAH concentration ranged from 77 ppb to 865 ppb. This suggested that there was low probability of risk associated with suction dredging at that time. Crecelius and Cotter (1986) revisited the Lewiston area locations and found only trace amounts of low-molecular-weight PAH compounds. High-molecular-weight PAH compounds ranged from 54 ppb to 818 ppb, and fluoranthene was the predominant component.

The Clearwater and Snake River confluence sediments were again sampled prior to the 1987 dredging action. During this investigation, no low-molecular-weight PAH compounds were detected (USACE, 1987). The PAH compounds present were predominantly pyrene and perylene. Perylene is commonly found in sediments containing substantial amounts of decaying material and was not an EPA priority pollutant in 1987. In this study, flouranthene was present but in small amounts relative to pyrene, which was the most commonly found PAH. The highest concentration of low-molecular PAH was 1,544 ppb at the in-water disposal area.

Pinza *et al*. (1992b) conducted the next significant dredge material study in the Snake and Clearwater confluence area. This study analyzed the ten most common PAH compounds expected to be found in this area based on industrial and regional land use practices. Composite samples were taken from the proposed disposal site, Port of Wilma (in Lower Granite reservoir), Port of Clarkston sampling stations SRP 24 and 25, Port of Clarkston sampling stations SRP 26 and 27, Port of Lewiston sampling stations SRP 28 and 29, Port of Lewiston sampling stations SRP 30, 31, and 32, Port of Lewiston sampling stations SRP 33 and 34; and the Port of Almota (in Little Goose reservoir). The calculated results for low-molecular-weight PAHs derived from the reported individual species were: 12.4 ppb, less than detection limit, 13.7 ppb, 10.9 ppb, less than detection limit, 15.3 ppb, less than detection limit, and less than detection limit, respectively. The calculated results for the high-molecular-weight PAHs were: 34.4 ppb, less than detection limit, 46 ppb, 15.8 ppb, less than detection limit, 25.7 ppb, 211 ppb, and less than detection limit, respectively. This study suggested that PAHs were relatively low in environmental concentration and substantially less than found in the previous studies.

During the interim between the 1992 study and the most recent dredged material studies, there were no additional investigations of PAH compounds available from publicly accessible sources. The best data available in 1998 and 1999 are the Potlatch Corporation reports (CH2M HILL, 1998a: and 1999). CH2M HILL (1998) reported that the Lower Granite pool and Clearwater arm samples generally showed low-molecular-weight PAHs to be less than 10 ppb and high-molecular-weight PAHs to be less than 50 ppb.

Results from the 2000 investigation found phenanthrene, flouranthene, and benzo (a) pyrene in a single sample from the Clearwater at about RM 3. The calculated concentration of high-molecular-weight PAHs was 161.4 ppb.

A suite of PAHs was evaluated using EPA Method 8270C during the 2003 sediment survey. The areas at RM 116 and Illia Landing typically had the highest individual and mean sample results (four samples from RM 116 were analyzed and only one sample from Illia was processed for Tier IIB analysis) followed by Greenbelt Boat Basin (six samples). The sum of the average LPAH compounds was 325 ppb, 257 ppb, 93 ppb, and 80 ppb at Illia, RM 116, Clearwater River, and Greenbelt Boat Basin, respectively. The sum of the mean HPAH compounds followed a similar pattern with 1,028 ppb, 829 ppb, 364 ppb, and 182 ppb at Illia, RM 116, Greenbelt Boat Basin, and the Clearwater River, respectively. The highest individual concentrations of phenanthrene and pyrene were determined for RM 116 at 283 ppb and 369 ppb, respectively. However, due to the difference in the number of samples analyzed, the mean values determined for the Illia Landing area were actually higher than the ones determined for RM 116. The highest fluoranthene concentration was also determined at Illia at 354 ppb, followed by 330 ppb at RM 116 and 236 ppb at Greenbelt Boat Basin. The areas sampled at Swallows Swim Beach, Port of Lewiston, the Snake River below the confluence with the Clearwater River, Port of Clarkston, and Willow Landing did not have any positive results for the low-molecular weight PAHs. The two high-molecular weight PAHs that were detected in these areas were fluoranthene and pyrene, and even these concentrations were very low. Individual fluoranthene concentrations in these five areas reached 31 ppb at Swallows Swim Beach, while the highest pyrene concentrations were at Swallows Swim Beach and the Port of Lewiston at 20 ppb and 22 ppb, respectively.

The 2011 sediment samples were analyzed for PAHs using EPA method 8270. The results for the Port of Clarkston Grain Elevator were all reported as less than the MDL. Four quantitative results were reported for the Port of Clarkston samples: benzo(a)anthracene (8.9 µg/kg), phenanthrene (8.4 µg/kg), fluoranthrene (14.1 µg/kg), and pyrene (16.2 µg/kg). The FNC Lewiston sample presented ten PAH results, ranging from dibenzo(a,h)anthracene and phenanthrene at 4.1 and 5.3 µg/kg, respectively, to benzo(a)anthracene and benzo(a)pyrene that were both reported as 13.4 µg/kg. The calculated LPAH and HPAH for the Lewiston location were 5.3 µg/kg and 92.3 µg/kg, respectively.

1.3.4 Metals

Crecelius and Gertisen (1985) conducted a comprehensive evaluation of material from proposed dredging locations prior to the confluence dredging of 1986. Metals concentrations of copper, lead, zinc, and cadmium were very similar to levels found during the sediment examination for the Lower Snake River Juvenile Salmon Migration Feasibility Study when compared to the geometric mean. The outliers were mercury and chromium. Mercury levels were lower and ranged from 0.015 to 0.049 mg/kg. Chromium was somewhat higher and ranged from 26 to 43 mg/kg.

Sediment sampling performed in 1987 to support the Corps' 1988 Interim Flood Control Dredging (USACE, 1987) reported concentrations (mg/kg) of sediment metals as follows: arsenic 2.6 to 12.6; cadmium 0.075 to 1.02; copper 17 to 48; lead 13 to 27; mercury 0.018 to 0.186; zinc 77 to 110.

The 1992 sediment sampling of the dredging sites on the Snake and Clearwater Rivers (Pinza *et al*., 1992b) reported concentrations (mg/kg) as follows: arsenic from 1.11 to 9.46; cadmium from 0.2 to 0.4;

chromium from 6.6 to 23.4; copper from 6.9 to 38.8; lead from 2.5 to 18.4; mercury from 0.06 to 0.20; zinc ranged from 26 to 78.7.

Sediments were sampled and tested for the 1996/1997 Confluence Dredging in the lower Snake and Clearwater rivers (USACE, 2002a). In this study the sediment concentrations (mg/kg) ranged as follows: aluminum 12,200 to 20,300; arsenic 1.25 to 4.36; barium 135 to 234; beryllium 0.5 to 0.71; chromium 12.2 to 18.2; cobalt 9.97 to 13.4; copper 17.3 to 34.9; lead 6.79 to 10.9; manganese 259 to 580; molybdenum 0.29 to 1.35; nickel 10.3 to 13.5; selenium 1.29 to 2.17; thallium 0.15 to 0.19; vanadium 52.1 to 68.7; and zinc 38.4 to 69.8.

In 1997, each of the 94 sediment samples were analyzed for a suite of 18 metals, including arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, vanadium, and zinc. Of the 18 metals analyzed, only cadmium, mercury, silver, and strontium were not detected in all 94 samples. Cadmium was detected in only two samples, mercury in 37 samples, silver was not detected in any of the samples, and strontium was detected in only four samples (CH2M HILL, 1998; Anatek, 1997).

The Corps' June 2000 sediment study in the lower Snake and Clearwater rivers tested for metals in 32 sample sites. Results (as mg/kg) for this study were as follows: antimony all below detection limits; aluminum 232 to 7,885; barium 2.2 to 108; beryllium all non-detects; calcium 12.77 to 37.87; cadmium 0.122 to 1.058; chromium 1.20 to 9.13; cobalt 1.099 to 9.573; copper 2.22 to 44.33; iron 1.242 to 15,52; magnesium 9.123 to 405; manganese 10.97 to 4,009; molybdenum all non-detects; nickel 1.921 to 9.478; potassium 6.529 to 2,023; sodium 5.623 to 253; vanadium 1.292 to 65.22; zinc 1.090 to 41.56; mercury all non-detects; and lead 1.109 to 8.353. In these samples, chromium and aluminum were detected in significantly lower quantities than in previous studies. These parameters were also well below the expected average background levels.

Thirty-one sediment samples were tested for the twenty-three metals on the target analyte list (TAL) in 2003 (Appendix A). A clear distinction between the potential dredging sites with respect to the magnitude of the metals concentrations was not apparent. The highest and lowest median concentrations differed by an average factor of 1.8, but ranged from 1.4 for chromium and cobalt to 2.4 to 2.6 for manganese and selenium. The areas sampled in the Clearwater River and Port of Lewiston had the highest median concentrations of aluminum, antimony, barium, chromium, iron, manganese, selenium, thallium, and vanadium. In contrast, the Port of Clarkston, Illia Landing, and Snake River below the Confluence tended to have the lowest concentrations of the same elements, in addition to cobalt, copper, lead, magnesium, nickel, and zinc.

The 2011 sediment samples were analyzed for 16 metals using EPA methods 6010, 6020, and 7471 (mercury). The range of results (all in mg/kg) for each element were: antimony 0.03 to 0.08; aluminum 5,860 to 12,600; arsenic 0.8 to 3.5; barium 55.9 to 128; beryllium 0.2 to 0.5; cadmium <0.02 to 0.4; chromium 6.3 to 16.2; copper 5.6 to 17.3; nickel 4.4 to 12.8; lead 2.5 to 8.1; mercury 0.01 to 0.05; selenium <0.8 to 2.6; silver 0.02 to 0.09; thallium 0.05 to 0.16; vanadium 18.0 to 32.1; and zinc 22.7 to 49.4. All of these results were less than the 2006 SEF and DMMP guidance.

1.3.5 Elutriate Fraction

Elutriate tests were completed in 1997 to evaluate potential impacts on surface water quality from the re-suspension of channel sediment. The purpose of the elutriate tests were to evaluate potential impacts on surface water quality from the resuspension of channel sediment. An ambient pH elutriate was prepared for each sediment sample and analyzed for organophosphorus pesticides, organochlorine pesticides, metals, and nutrients, glyphosate, and AMPA. TPH and dioxin were not tested in the ambient pH elutriates.

Elutriate tests were also completed for the 2011 sampling program and followed the procedures described in the SEF. The same parameters that were considered for the sediment samples were applied to the elutriate samples.

1.3.5.1 Organophosphorus Pesticides

The 1997 ambient pH elutriates were tested for the presence of twenty-five different organophosphorus compounds. The only organophosphorus pesticide detected was ethyl parathion, in one sample from Little Goose at a concentration of 1.0 µg/L. Although identified in the one elutriate sample, ethyl parathion was not detected in any of the sediment samples.

Organophosphorus compounds were not included in the 2011 analysis package.

1.3.5.2 Organochlorine Pesticides

No organochlorine pesticides were detected in any of the 1997 ambient pH elutriate samples. The organochlorine pesticides DDT (and its metabolites), aldrin, dieldrin, endrin, heptachlor and lindane had been detected in some of the sediment samples tested. The results of the elutriate tests suggest that although these compounds are present in the sediments they do not readily partition into water.

The only chlorinated pesticide that was detected in the two Port of Clarkston locations and FNC Lewiston was dichlorprop. This compound was determined at a concentration of 10 µg/L at the Port of Clarkston Grain Elevator.

1.3.5.3 Glyphosate

Glyphosate was detected in only two of the 94 ambient pH elutriate samples from 1997, while AMPA was not detected in any of the samples. Glyphosate was detected at a concentration of 0.69 µg/L in a sample collected from Lake Bryan (Little Goose reservoir) and at a concentration of 0.58 µg/L in a sample collected from Lake Sacajawea (Ice Harbor reservoir).

Glyphosate and AMPA were not detected in any of the 2011 elutriate samples.

1.3.5.4 Metals

Each of the 94 ambient pH elutriates were tested for the same suite of metals that were analyzed on their corresponding sediments. Of the 18 metals considered, only beryllium, silver, and thallium were not detected in the elutriate samples. Of these three metals, only silver was not detected in the original 1997 sediment samples.

The mean metal concentrations for the ambient pH elutriates are summarized by river reach in Table 6. The predominant metals detected included barium and manganese. The average concentration of barium, by river reach, in the ambient pH elutriates increased from 83.3 µg/L for the samples collected from Lower Granite reservoir to 243.6 µg/L for the sediment samples collected from Lake Sacajawea (Ice Harbor reservoir). Although a corresponding trend in the concentration of barium in the sediment samples was not observed, it was one of the predominant metals detected. Its relatively high concentration in the ambient pH elutriates is most likely the result of its concentration in the sediments and its relatively high solubility in water (Hem, 1989).

The predominant metal identified in the ambient pH elutriates was manganese (Table 6). The average concentration of manganese, by river reach, in the ambient pH elutriates ranged from 504 µg/L for the Lower Granite reservoir samples to 1,432 µg/L for the Lower Monumental reservoir samples. In general, the trend in manganese concentrations in the ambient pH elutriate samples increases with distance

downstream. As observed with barium, there did not appear to be a clear relationship between the concentration of manganese in the sediment samples and in the ambient pH elutriates.

The results of the 2011 elutriate metals analyses are summarized in Table 7. The data for some of the elements such as lead, vanadium, and zinc appear to be similar, whereas the concentrations of arsenic, barium, chromium, copper, and nickel appear to be less in the 2011 data set. However, because the sample sizes and their spatial distributions are significantly different, specific trends cannot be determined.

Table 6. Summary of mean metal concentrations (µg/L) for ambient pH elutriate samples collected during the 1997 Lower Snake River project

Metal	Ice Harbor	Lower Monumental	Little Goose	Lower Granite
Arsenic	3.9	2.6	2.2	1.8
Barium	243.6	197.5	140.9	83.3
Beryllium	---	---	---	---
Cadmium	---	---	0.1	---
Chromium	0.6	0.8	0.4	0.6
Cobalt	0.5	1.2	0.4	0.5
Copper	2.9	3.2	3.2	4
Lead	---	0.1	0.1	0.1
Manganese	861.5	1,432.1	799.9	504.4
Mercury	---	0.1	0.1	0.1
Molybdenum	3	3.5	3.8	2.2
Nickel	2.8	4.1	0.7	0.9
Selenium	2.3	1.2	0.3	0.3
Silver	---	---	---	---
Strontium	0.4	0.3	0.3	0.2
Thallium	---	---	---	---
Vanadium	2.1	1.2	1.8	1.5
Zinc	37.7	17.8	16.9	12.9

Source: USACE 2000

Table 7. Metal concentrations (µg/L) determined for the 2011 elutriate samples.

Metal	Port of Clarkston Grain Elevator	Port of Clarkston	FNC Lewiston
Antimony	0.67	1.22	1.42
Aluminum	33.22	4.5	3.86
Arsenic	1.63	0.86	0.39
Barium	19.90	21.4	21.9
Beryllium	---	---	0.21
Cadmium	---	---	---
Chromium	0.21	0.07	0.18
Copper	1.00	1.08	1.29
Nickel	0.50	0.47	0.69
Lead	0.10	0.05	0.15
Mercury	---	---	---
Selenium	---	0.61	---
Silver	---	---	---
Thallium	---	---	---
Vanadium	2.21	0.70	2.61
Zinc	17.17	1.84	45.4

1.4 Site Ranking

Table 8 summaries the current rankings for eight areas proposed for dredging in the 2013/2014 in-water work season. Details for two other areas, the Ice Harbor Navigation Lock Approach (USACE, 2013b) and the Port of Clarkston Crane Dock (Gravity, 2012), were documented previously. The rankings for the eight areas are based on historical sediment sampling results, potential sources of contaminants, and a review by the Corp's Dredged Material Management Office (DMMO).

Table 8. Rank and type of material for the areas included in the proposed 2013/2014 dredging.

Interest	Reach	Type of Material	Rank
Federal	FNC Clarkston West	Sand	Low
	FNC Clarkston East	Sand	Low
	FNC Clearwater	Sand	Low
	FNC Lewiston	Sand	Low
Ports	Port of Clarkston Grain Elevator	Sand/silt	Low
	Port of Clarkston Recreation Dock	Sand/silt	Low/ moderate
	Port of Clarkston Cruise Dock	Sand/silt	Low/ moderate
	Port of Lewiston	Sand/silt	Low

1.4.1 FNC Clarkston West

The FNC Clarkston West reach consists of the western half of the FNC adjacent to the Port of Clarkston. The results from the most recent sediment survey indicated that fines constituted less than 10 percent of the samples collected, and total organic carbon (TOC) was less than 0.2%. These results are similar to previous sediment evaluations that characterized the majority of the materials as homogeneous sands with less than 20% silts.

1.4.2 FNC Clarkston East

The FNC Clarkston East reach consists of the eastern half of the FNC adjacent to the Port of Clarkston. The present, as well as past, sediment characterizations have shown that the sediments have a similar composition to the ones located in the FNC Clarkston West reach.

1.4.3 FNC Clearwater

The FNC Clearwater reach is the segment of the Federal navigation channel that connects FNC Clarkston East with FNC Lewiston. Previous sediment sampling results ranged from no recovery due to the hard substrate, to a sand component ranging from 51.8% to 99.7%.

1.4.4 FNC Lewiston

The FNC Lewiston area has historically contained moderately course sands with a higher percentage of small gravels in the higher energy portions of the river. Only one of the 2011 samples from this area exceeded 10% fines. However, one sample was still forwarded for chemical analyses. The levels of metals, PAH, semi-volatile organic compounds, and polychlorinated biphenyls (PCBs) in this sample were all less than the 2006 freshwater SEF and DMMP screening limits, or less than MDLs.

1.4.5 Port of Clarkston Grain Elevator

There is a slightly higher percentage of fines in the Port of Clarkston Grain Elevator DMMU when compared to the FNC Clarkston East and West reaches, but the proportion of fines has historically been less than 20%. Metals and organics data from the 2011 sediment study were not significantly different than the results from previous studies and within the current SEF and DMMP guidance.

1.4.6 Port of Clarkston Recreation Dock

The area adjacent to the port of Port of Clarkston Recreation Dock has not been considered during past sediment sampling events. However, given its proximity to the Port of Clarkston Grain Elevator and Cruise Dock locations the ranking is anticipated to be similar.

1.4.7 Port of Clarkston Cruise Dock

The sediment in the Port of Clarkston Cruise Dock typically has a higher percentage of fines than those in the adjoining federal navigation channel. The most recent sampling showed that 12.8 to 16.4% of the material passed through a number 230 sieve. These values are analogous to historical data that indicates fines normally do not exceed 20%. Metals concentrations determined for the 2011 and previous sediment characterizations were typically less than the 2006 SEF and DMMP screening limits. Organic chemicals of concern were either met the SEF/DMMP screening limits or were less than the MDLs.

1.4.8 Port of Lewiston

Sediments in the Port of Lewiston DMMU have varied from year to year depending on the spring runoff. The percentage of fines in the 2011 sediment samples ranged from 0.9 to 11.4%, yet the 2003 sample had 43% fines. However, the metals and organics data from both characterizations did not exceed the current in-water disposal guidelines.

2.0 PROJECT OBJECTIVES

The objective of this sample analysis plan (SAP) is to present a strategy for further evaluation of sediments that the Corps proposes to dredge at the Snake/Clearwater rivers confluence area in 2013/2014. A review by the DMMP (2013) of historic sediment data indicated that there was insufficient information available to establish whether the material in the confluence is suitable for unconfined open-water disposal in the Lower Snake River. That same review indicated no further information was needed for the material proposed for removal from the Ice Harbor Dam navigation lock approach.

3.0 PROJECT TEAM AND RESPONSIBITILIES

The Corps Project manager is Richard Turner at Walla Walla District. The SAP was prepared by Steve Juul and Sandra Shelin in the water/sediment quality and environmental compliance sections, respectively.

The prime, field sampling, and laboratory contractors are Dalton, Olmsted and Fuglevand, Inc. (DOF), Science and Engineering for the Environment (SEE), and Pyron Environmental, respectively. The project manager with the prime contractor will provide project oversight and will be responsible for administrative coordination to ensure timely and successful completion of the sediment characterization. He/she will provide a copy of the SAP to all sampling and testing subcontractors for their signature approval. Additionally, DOF will perform QA oversight for both the field sampling and laboratory programs and will record and correct any activities that vary from this SAP. Upon completion of the sampling and analytical program, he/she will review laboratory QA/QC results and incorporate the findings into the final sampling and analysis report. Any QA/QC problems will be brought to the attention of the Corps and the DMMO as soon as possible to discuss issues related to the problem and to evaluate potential solutions. The technical lead with SEE will provide overall guidance for personnel assignments, logistics, and field operations. This individual will also supervise field collection of the sediment grab/core samples and will be responsible for ensuring accurate positioning and recording of sample locations, depths, and identification; ensuring conformity to sampling and handling requirements, including field decontamination procedures; conducting physical evaluation and logging the samples; and chain-of-custody. Finally, the technical lead, or a designee, will be responsible for documenting sample

preparation, observations, and chain-of-custody up until the time the samples are released to a commercial shipper or delivered to the analytical laboratory for chemical analysis.

The contract laboratory will assign a project chemist who will be responsible for the physical and chemical analyses. Analyses will be completed in accordance with DMMP analytical testing protocols, quality assurance/quality control (QA/QC) requirements, and requirements as specified in this or any subsequent revised SAP. The laboratory contractor will prepare a written report of analytical results and QA/QC procedures, which will be included as an appendix in the final data report.

Additional information regarding the project team and responsibilities will be forwarded to the DMMO by the Corps after the contract has been awarded. This information will include the signature page indicating that the subcontractors have reviewed, and agreed to follow, the SAP.

4.0 SAMPLING PROGRAM

4.1 Conceptual Dredging Plan

This sampling and analysis program was developed with consideration of site and environmental factors. A key requirement of the program is ensuring that the individual dredged material management units (DMMUs) do not have contaminants of concern (COCs) associated with them that exceed prescribed screening levels. Assessment of COC's within the DMMUs will be determined by chemical analysis of composites of all sediments sampled within the dredge prism, regardless of TOC levels and grain size.

Several guidance documents were considered during the development of this plan. These included the Regional Sediment Evaluation Framework (USACE 2009), the Dredged Material Evaluation and Disposal Procedures (Users Manual) (USACE 2013), and Dredged Material Management Program (DMMP) comments on the "Lower Snake and Clearwater Rivers, Sediment Evaluation Report for Proposed 2013/2014 Channel Maintenance Dredging" (USACE 2013b).

The primary objective of this investigation is a baseline Level 2A investigation to determine whether the sediments are suitable for in-water disposal. If the material from a given DMMU does not meet the Level 2A guidance, then it will not be dredged during the proposed 2013/2014 work window. However, sediment samples that could be used for level 2B analyses will be collected as part of the field sample collection program. Retrieving these samples will provide us with the option of pursuing the biological analyses if sediments from a specific DMMU are determined unsuitable for in-water disposal and funding is available. This information could then be useful if a suitability determination is needed for a later dredging cycle.

4.2 Configuration of DMMUs, Placement of Samples, and the Compositing Scheme

4.2.1 Sample Location Naming Convention

The Corps began using a naming convention in 2009 to simplify migration from a local SEDQUAL 3.5 database to an ArcGIS graphical database using Washington Department of Ecology **(**WDOE) Environmental Information Management (EIM) standard Microsoft Excel spreadsheets. The convention is as follows.

- The first three letters constitute the standard operating project three-letter code.
- The next two to three digits are the river mile integer.
- The decimal and following digit signifies the 1/10th of a mile.
- The letter designator is a point designated transect on the 1/10th of a river mile often, but not always, from right to left bank in descending order.

- The number identifier to the right of the letter is used for one of the following
  - Subsections of the core sample.
  - Additional samples from the adjacent location.
  - A duplicate sample.

4.2.2 Reaches Proposed for 2013/2014 Dredging

Eight areas within the lower Snake and Clearwater rivers are considered for the proposed channel maintenance considered in this report (information regarding the Ice Harbor Navigation Lock Approach and the Port of Clarkston Crane Dock were presented in previous reports). Five of these areas are within the lower Snake River. The primary focus is Lower Granite Reservoir in the vicinity of the confluence of the Snake and Clearwater Rivers since this is an area where sediment historically accumulates. The Snake River reaches include the FNC (Federal Navigation Channel) Clarkston East and West, as well as the Port of Clarkston Grain Elevator, Recreation Dock, and Cruise Dock. The first 1.5 miles of the Clearwater River contains three areas of interest, FNC Clearwater, FNC Lewiston, and the Port of Lewiston. Table 9 presents the estimated volumes of sediment that would be removed from the DMMUs proposed for dredging in 2013/2014 based on 2012 survey data. Figures 14 through 21 show the DMMUs and sample locations considered for the winter channel maintenance. Tables 10 through 17 provide the global positioning system (GPS) coordinates for each sample location, estimated depths to the mud line and top of z-layer, as well as the type of sample that will be collected.

Table 9. Dredging quantities and number of samples for each DMMU included in the proposed channel maintenance project, as well as number of laboratory analyses.

Area to be Dredged	DMMU	Quantity at 16 ft[(1,3)]	Dredged Material Area (acres)	Number of Grab Samples	Number of Core Samples	Number of Lab Samples
FNC Clarkston West	1	57,079	11.1	7		3
	2	58,365	6.2	7		
	3	58,165	6.2	7		
FNC Clarkston East	4	59,635	7.3	8		4[(4)]
	5	55,749	7.5	7		
	6	22,032	3.7	3		
FNC Clearwater	7	6,674	3.1	2		2
	8	11,261	2.4	2		
FNC Lewiston	9	55,591	11.0	7		3
	10	58,284	12.0	7		
	11	26,367	8.0	3		
Port of Clarkston Grain Elevator	Same as Area[(2)]	3,218	0.2	2		1
Port of Clarkston Rec. Dock	Same as Area[(2)]	1,036	0.3		2	1
Port of Clarkston Cruise Dock	Same as Area[(2)]	9,041	0.8		2	1
Port of Lewiston	Same as Area[(2)]	4,485	2.2	2		1
	TOTAL	**486,979**	**81.9**	**64**	**4**	**16**

Notes:

(1) Based on removal to 16 feet below MOP using survey data from November 2012.
(2) Because each Port area constitutes a DMMU, the names of the DMMU and the Port facility are the same.
(3) Port of Clarkston Recreation Dock volume based on dredge depth of 7.5 ft
(4) Includes duplicate sample

4.2.2.1 FNC Clarkston West

The FNC West area is located on the Snake River between RM 138 and RM 138.8 (Figure 14). The entire area consists of three DMMUs and covers 35.9 acres. Only the areas within each DMMU where a 14-ft channel depth is not available at MOP would be dredged and amounts to 23.4 acres.

These three DMMUs have an average volume of 57,869 cy each (Table 9). Seven grab samples will be collected from each DMMU and composited for a total of three laboratory analyses.

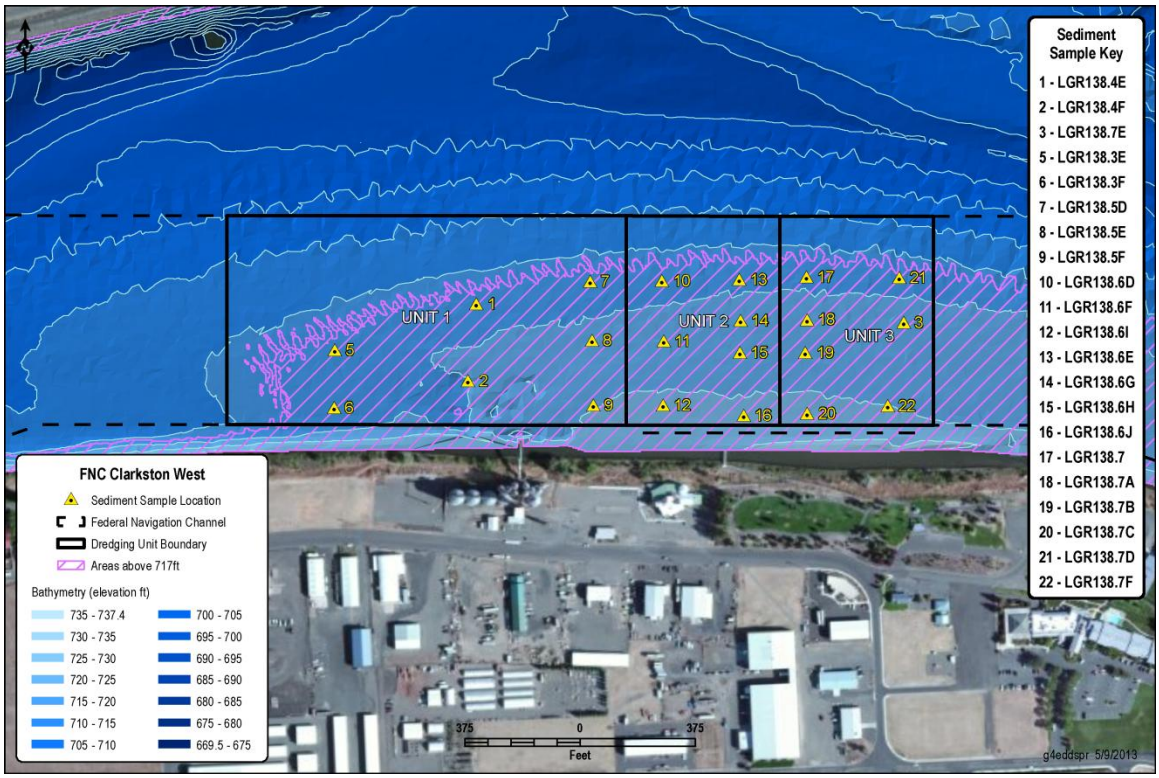


Figure 14. FNC Clarkston West and associated DMMUs with proposed 2013 sample locations.

Table 10. Samples that will be used to characterize the FNC Clarkston West area

DMMU	Sample Key	Sample ID	Latitude	Longitude	Distance to Mudline From MOP (ft)	Sediment Depth to Top of z-Layer (ft)	Sample Type
1	1	LGR138.4E	-117 3.268	46 25.705	-15.6	-0.4	Grab
	2	LGR138.4F	-117 3.277	46 25.664	-13.1	-2.9	Grab
	5	LGR-138.3E	-117 3.380	46 25.683	-14.2	-1.8	Grab
	6	LGR-138.3F	-117 3.382	46 25.652	-14.1	-1.9	Grab
	7	LGR-138.5D	-117 3.180	46 25.714	-14.4	-1.6	Grab
	8	LGR-138.5E	-117 3.180	46 25.682	-11.6	-4.4	Grab
	9	LGR-138.5F	-117 3.181	46 25.648	-7.8	-8.2	Grab
2	10	LGR138.6D	-117 3.124	46 25.713	-14.9	-1.1	Grab
	11	LGR138.6F	-117 3.125	46 25.680	-10.0	-6.0	Grab
	12	LGR138.6I	-117 3.127	46 25.646	-7.4	-8.6	Grab
	13	LGR138.6E	-117 3.064	46 25.712	-14.1	-1.9	Grab
	14	LGR138.6G	-117 3.064	46 25.690	-11.0	-5.0	Grab
	15	LGR138.6H	-117 3.066	46 25.672	-10.0	-6.0	Grab
	16	LGR138.6J	-117 3.065	46 25.639	-6.9	-9.1	Grab

Table 10. Samples that will be used to characterize the FNC Clarkston West area (continued)

DMMU	Sample Key	Sample ID	Latitude	Longitude	Distance to Mudline From MOP (ft)	Sediment Depth to Top of z-Layer (ft)	Sample Type
3	17	LGR138.7	-117 3.012	46 25.711	-14.0	-2.0	Grab
	18	LGR138.7A	-117 3.013	46 25.688	-11.2	-4.8	Grab
	19	LGR138.7B	-117 3.015	46 25.671	-9.7	-6.3	Grab
	20	LGR138.7C	-117 3.016	46 25.638	-6.9	-9.1	Grab
	21	LGR138.7D	-117 2.940	46 25.709	-13.9	-2.1	Grab
	22	LGR138.7F	-117 2.953	46 25.641	-7.5	-8.5	Grab
	3	LGR138.7E	-117 2.938	46 25.685	-11.1	-4.9	Grab

4.2.2.2 FNC Clarkston East

The FNC Clarkston East area is located along the left bank of the Snake River at approximately RM 139 (Figure 15). The navigation channel has been divided into three DMMUs that cover a total of 56.4 acres. However, since only the areas within each DMMU where a 14-ft channel depth is not available at MOP would be dredged, the dredged material area is much less at 18.4 acres (Table 9).

The sediment volumes in the three DMMUs that would be dredged range from 22,032 to 59,635 cy (Table 9). A total of 18 grab samples will be collected from the three DMMUs. The samples from each DMMU will be composited for a total of 3 laboratory analyses, plus one duplicate from DMMU 4.

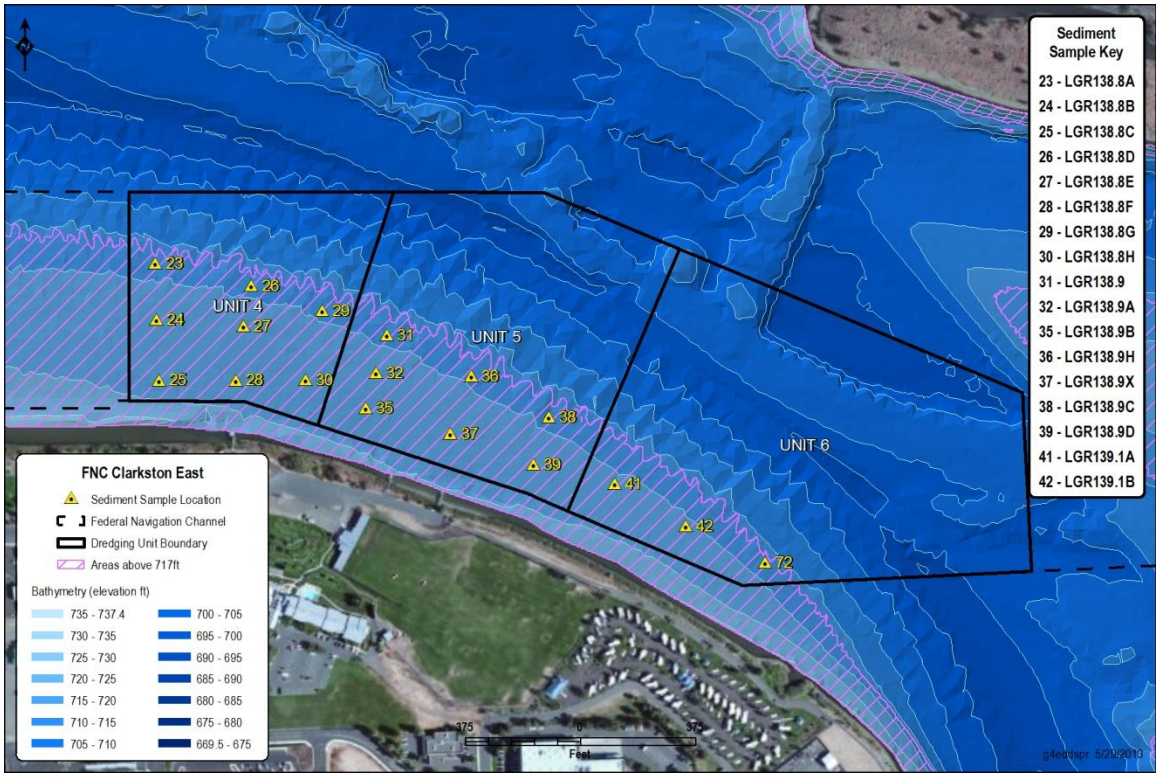


Figure 15. FNC Clarkston East and associated DMMUs with proposed 2013 sample locations.

Table 11. Samples that will be used to characterize the FNC Clarkston East area

DMMU	Sample Key	Sample ID	Latitude	Longitude	Distance to Mudline From MOP (ft)	Sediment Depth to Top of z-Layer (ft)	Sample Type
4	23	LGR138.8A	-117 2.894	46 25.702	-14.5	-1.5	Grab
	24	LGR138.8B	-117 2.895	46 25.672	-10.7	-5.3	Grab
	25	LGR138.8C	-117 2.895	46 25.639	-8.2	-7.8	Grab
	26	LGR138.8D	-117 2.820	46 25.688	-13.5	-2.5	Grab
	27	LGR138.8E	-117 2.828	46 25.666	-10.5	-5.5	Grab
	28	LGR138.8F	-117 2.836	46 25.638	-9.6	-6.4	Grab
	29	LGR138.8G	-117 2.766	46 25.673	-13.4	-2.6	Grab
	30	LGR138.8H	-117 2.782	46 25.636	-9.6	-6.4	Grab
5	31	LGR138.9	-117 2.717	46 25.658	-12.2	-3.8	Grab
	32	LGR138.9A	-117 2.727	46 25.638	-9.7	-6.3	Grab
	35	LGR138.9B	-117 2.736	46 25.620	-9.7	-6.3	Grab
	36	LGR138.9H	-117 2.654	46 25.627	-12.7	-3.3	Grab
	37	LGR138.9X	-117 2.672	46 25.597	-10.2	-5.8	Grab
	38	LGR138.9C	-117 2.595	46 25.610	-14.5	-1.5	Grab
	39	LGR138.9D	-117 2.609	46 25.585	-10.1	-5.9	Grab
6	41	LGR139.1A	-117 2.546	46 25.573	-11.8	-4.2	Grab
	42	LGR139.1B	-117 2.493	46 25.549	-11.8	-4.2	Grab
	72	LGR139.1I	-117 2.433	46 25.528	-14.7	-1.3	Grab

4.2.2.3. FNC Clearwater

The FNC Clearwater area is relatively narrow, and sediments have built-up at two locations - one along the northern side and one along the southern edge near the railroad bridge (Figure 16). DMMU number 7 includes the northern deposit with 6,674 cy of sediment that covers 3.1 acres that would be dredged. The estimated volume to be dredged in DMMU number 8 is 11,261 cy over an area of 2.4 acres. Two grab samples will be collected and composited from each DMMU (Table 12). A total of two samples will be forwarded for laboratory analyses.

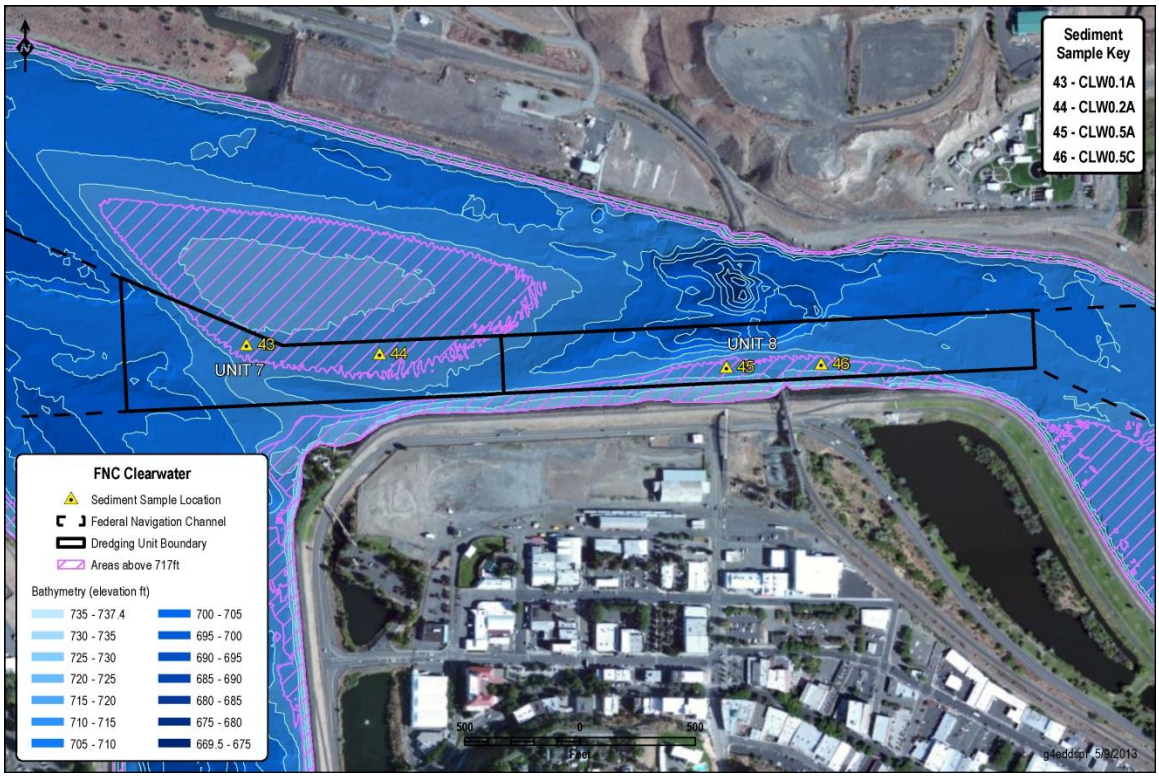


Figure 16. FNC Clearwater and associated DMMUs with proposed 2013 sample locations

Table 12. Samples that will be used to characterize the FNC Clearwater area

DMMU	Sample Key	Sample ID	Latitude	Longitude	Distance to Mudline From MOP (ft)	Sediment Depth to Top of z-Layer (ft)	Sample Type
7	43	CLW0.1A	-117 2.101	46 25.561	-13.5	-2.5	Grab
	44	CLW0.2A	-117 1.964	46 25.550	-14.4	-1.6	Grab
8	45	CLW0.5A	-117 1.607	46 25.523	-14.7	-1.3	Grab
	46	CLW0.5C	-117 1.509	46 25.522	-13.4	-2.6	Grab

4.2.2.4 FNC Lewiston

The FNC Lewiston area is located at approximately RM 1.3 of the Clearwater River (Figure 17). The area has been divided into three DMMUs (Table 9) that have a total area of 65.9 acres. Of this, 31.0 acres would be subject to dredging. DMMU 9 and 10 have sediment volumes of 55,591 cy and 58,284 cy, respectively. Seven grab samples will be collected from each of these DMMUs and composited to one sample analysis per DMMU. DMMU 11 is smaller at 26,367 cy, and sampling will consist of three grab samples that will be composited.

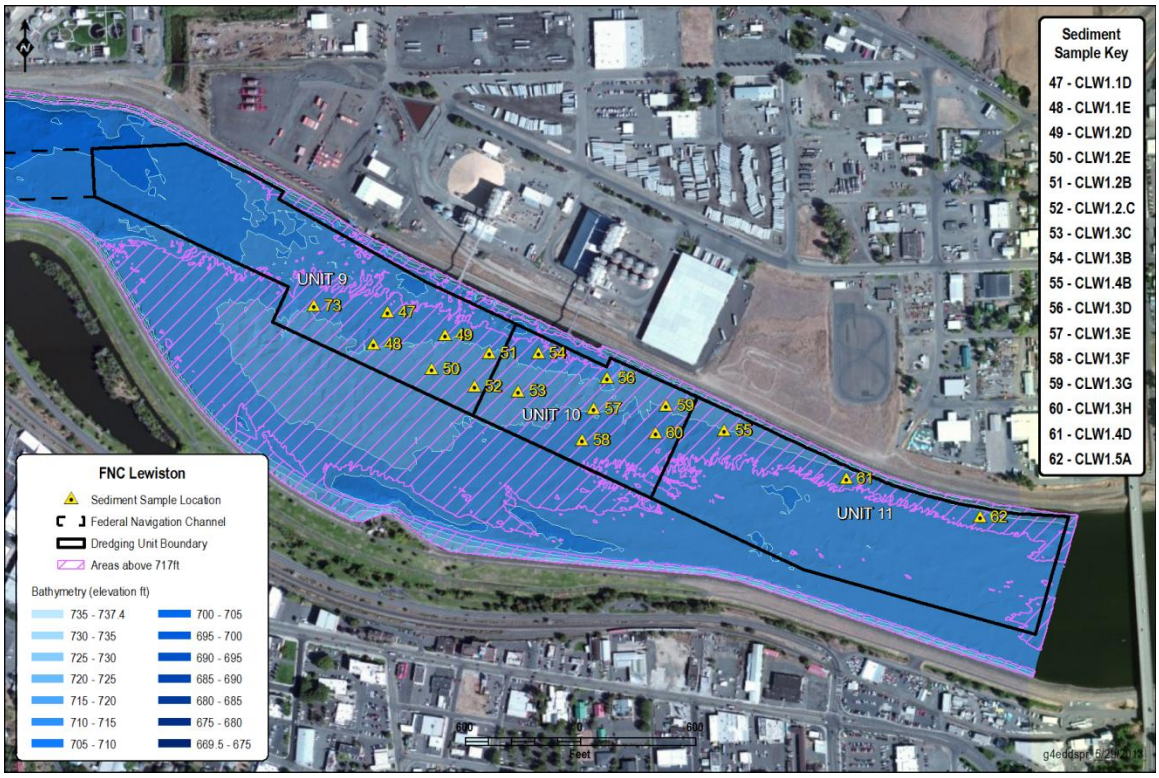


Figure 17. FNC Lewiston and associated DMMUs with proposed 2013 sample locations.

Table 13. Samples that will be used to characterize FNC Lewiston area.

DMMU	Sample Key	Sample ID	Latitude	Longitude	Distance to Mudline From MOP (ft)	Sediment Depth to Top of z-Layer (ft)	Sample Type
9	73	CLW1.1C	-117 1.023	46 25.411	-13.6	-2.4	Grab
	47	CLW1.1D	-117 0.931	46 25.409	-15.4	-0.6	Grab
	48	CLW1.1E	-117 0.951	46 25.382	-12.1	-3.9	Grab
	49	CLW1.2D	-117 0.862	46 25.387	-12.3	-3.7	Grab
	50	CLW1.2E	-117 0.880	46 25.359	-10.8	-5.2	Grab
	51	CLW1.2B	-117 0.808	46 25.363	-11.3	-4.7	Grab
	52	CLW1.2.C	-117 0.828	46 25.343	-11.5	-4.5	Grab
10	53	CLW1.3C	-117 0.774	46 25.337	-11.9	-4.1	Grab
	54	CLW1.3B	-117 0.747	46 25.369	-14.0	-2.0	Grab
	56	CLW1.3D	-117 0.664	46 25.344	-12.5	-3.5	Grab
	57	CLW1.3E	-117 0.681	46 25.319	-12.4	-3.6	Grab
	58	CLW1.3F	-117 0.698	46 25.292	-13.7	-2.3	Grab
	59	CLW1.3G	-117 0.592	46 25.319	-11.8	-4.2	Grab
	60	CLW1.3H	-117 0.606	46 25.296	-13.0	-3.0	Grab
11	55	CLW1.4B	-117 0.521	46 25.288	-12.8	-3.2	Grab
	61	CLW1.4D	-117 0.373	46 25.243	-14.7	-3.0	Grab
	62	CLW1.5A	-117 0.210	46 25.204	-13.5	-2.5	Grab

4.2.2.5 Port of Clarkston Grain Elevator

The Port of Clarkston Grain Elevator DMMU encompasses an area of 0.2 acres of the Snake River at approximately RM 138.4 (Figure 18). The dock at the grain elevator is used only for the off-loading of grain by transient shallow water barges and tugs and does not provide permanent moorage. The entire DMMU would be dredged as the water depth throughout is less than 14 feet at MOP

Two sediment grab samples will be retrieved from this DMMU and composited for one laboratory analysis (Table 9) to further characterize the 3,218 cy of material.

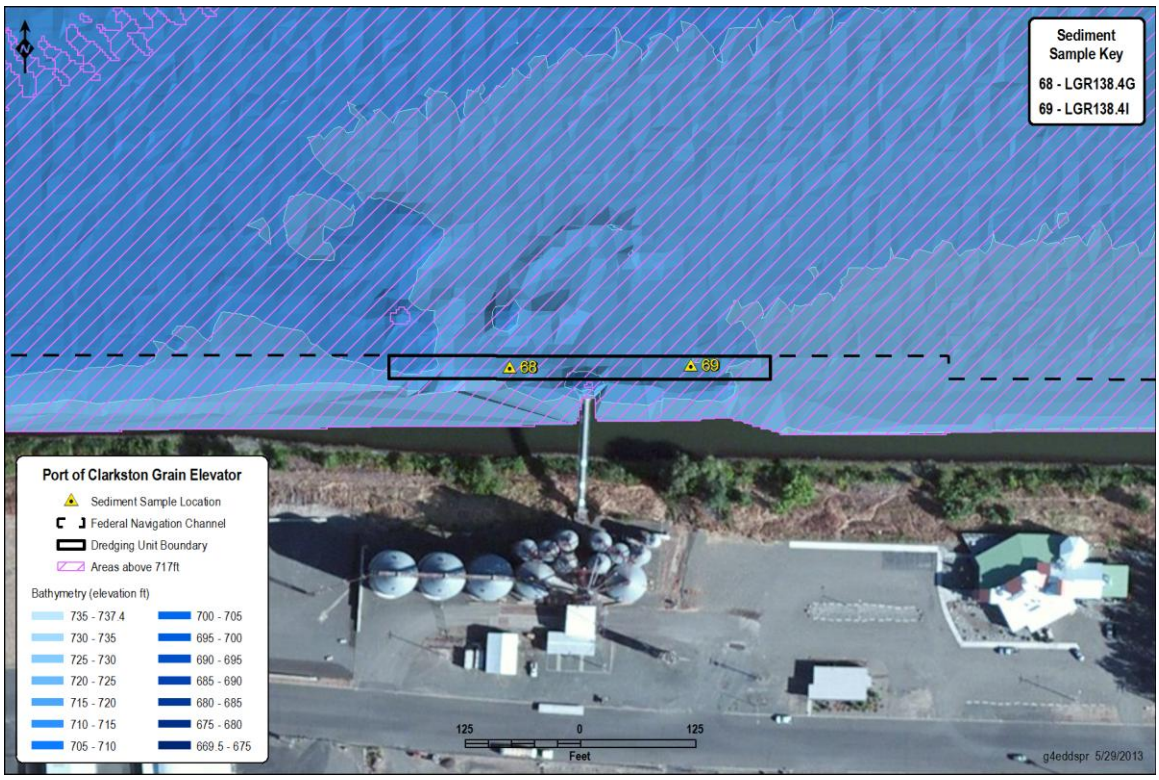


Figure 18. Port of Clarkston Grain Elevator DMMU with proposed 2013 sample locations.

Table 14. Samples that will be used to characterize the Port of Clarkston Grain Elevator DMMU.

Sample Key	Sample ID	Latitude	Longitude	Distance to Mudline From MOP (ft)	Sediment Depth to Top of z-Layer (ft)	Sample Type
68	LGR138.4G	-117 3.279	46 25.630	-9.6	-6.4	Grab
69	LGR138.4I	-117 3.212	46 25.636	-8.1	-7.9	Grab

4.2.2.6 Port of Clarkston Recreation Dock

The Port of Clarkston Recreation Dock DMMU covers an area of 0.3 acres upstream from the Grain Elevator (Figure 19). This is a new facility in an area that has not been sampled previously. This DMMU differs from the others in that dredging would be less extensive and only provide a water depth of approximately 7.5 ft at MOP. Consequently, only 1,036 cy would be removed.

Because this area has not been sampled before, two core samples will be collected from this DMMU and composited for one laboratory analysis (Table 9). Because it is a new sample area, the list of laboratory analyses prescribed for the sediment core is more extensive than it is for the other samples.

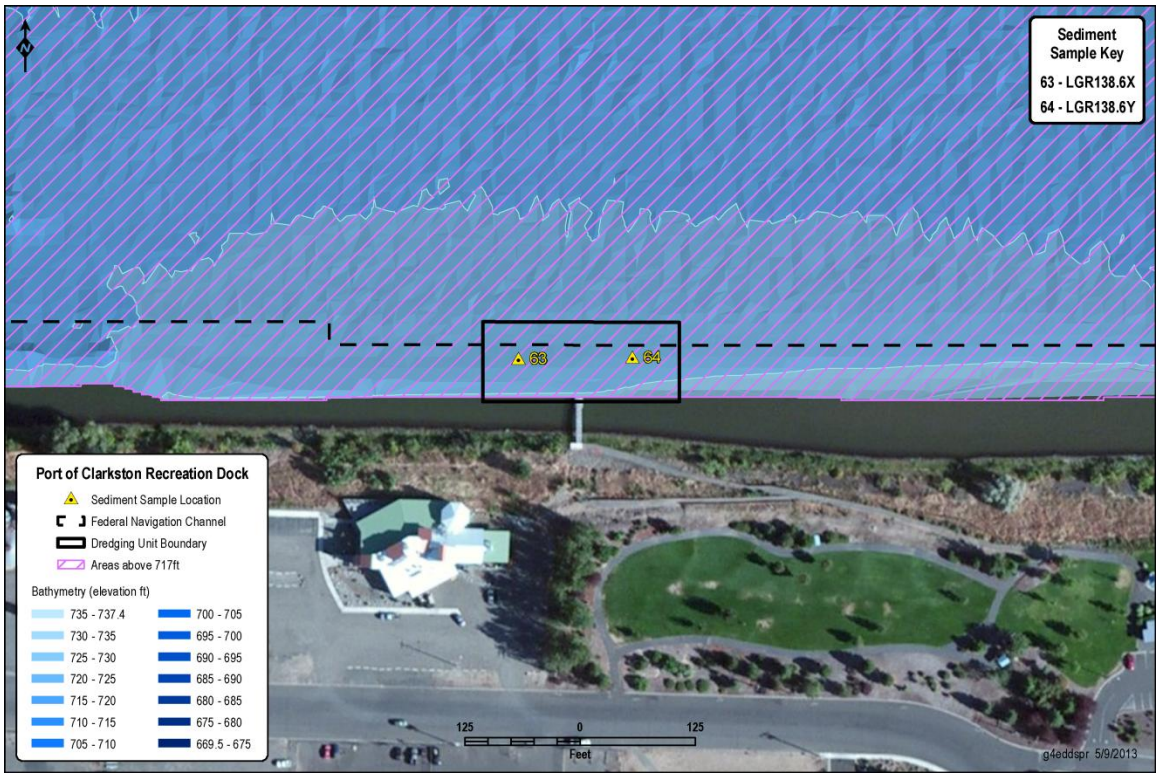


Figure 19. Port of Clarkston Recreation Dock DMMU with proposed 2013 sample locations.

Table 15. Samples that will be used to characterize the Port of Clarkston Recreation Dock DMMU.

Sample Key	Sample ID	Latitude	Longitude	Distance to Mudline From MOP (ft)	Sediment Depth to Top of z-Layer (ft)	Sample Type
63	LGR138.6X	-117 3.097	46 25.628	-5.7	-1.8	Core
64	LGR138.6Y	-117 3.067	46 25.627	-5.2	-2.3	Core

4.2.2.7 Port of Clarkston Cruise Dock

The Port of Clarkston Cruise Dock DMMU covers 0.8 acres of the Snake River at RM 137.8 (Figure 20). The entire DMMU would be dredged as the water depth throughout is less than 14 feet at MOP. Two core samples will be collected from this DMMU to characterize the 9,041 cy of sediment and composited for one laboratory analysis.

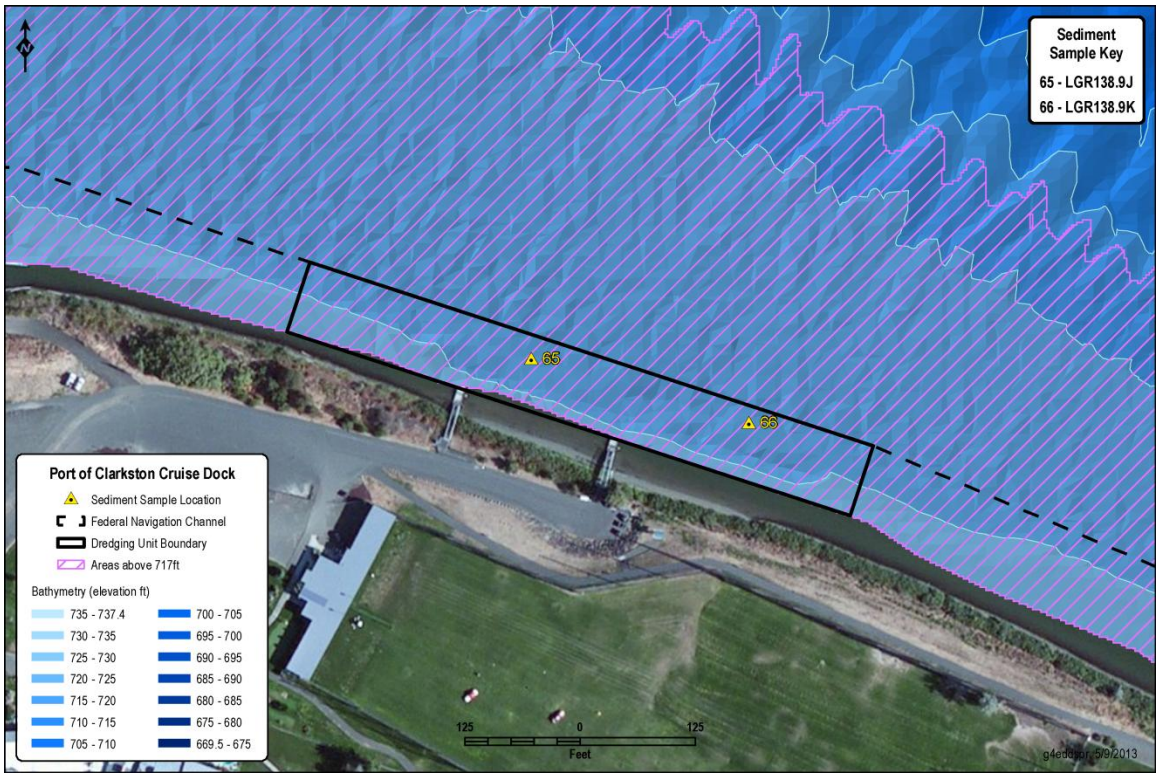


Figure 20. Port of Clarkston Cruise Dock DMMU with proposed 2013 sample locations

Table 16. Samples that will be used to characterize the Port of Clarkston Cruise Dock DMMU.

Sample Key	Sample ID	Latitude	Longitude	Distance to Mudline From MOP (ft)	Sediment Depth to Top of z-Layer (ft)	Sample Type
65	LGR138.9J	-117 2.700	46 25.588	-10.2	-5.8	Core
66	LGR138.9K	-117 2.645	46 25.575	-9.4	-6.6	Core

4.2.2.8 Port of Lewiston

The Port of Lewiston DMMU is located along the right bank of the Clearwater River adjacent to FNC Lewiston (Figure 21). The DMMU encompasses an area of 2.2 acres and the entire area would be dredged as the water depth throughout is less than 14 feet at MOP. Two grab samples will be collected from this DMMU to represent the 4,485 cy of dredge material and composited for one laboratory analysis.

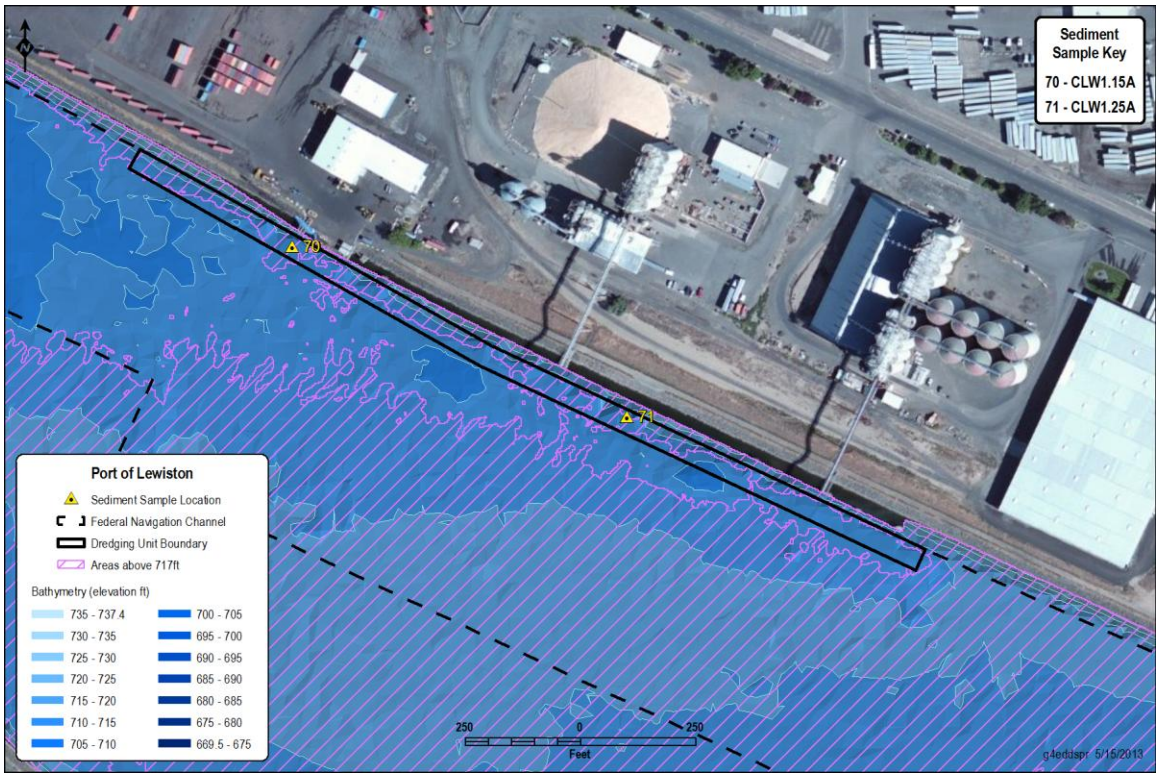


Figure 21. Port of Lewiston DMMU with proposed 2013 sample locations

Table 17. Samples that will be used to characterize the Port of Lewiston DMMU

Sample Key	Sample ID	Latitude	Longitude	Distance to Mudline From MOP (ft)	Sediment Depth to Top of z-Layer (ft)	Sample Type
70	CLW1.15A	-117 0.978	46 25.472	-13.4	-2.6	Grab
71	CLW1.25A	-117 0.809	46 25.406	-11.2	-4.8	Grab

4.3 Sample Collection and Handling Procedures

4.3.1 Field Sampling Schedule and Sampling Vessel

Sampling will occur after approval of this SAP by the DMMO, and is anticipated to begin within two weeks after that occurs. Collection of sediment cores and grab samples will be completed from a vessel similar to the one operated by Gravity Environmental LLC during the previous sampling event – specifics will be available after the contract is awarded. It is anticipated that field sampling and sample processing will require approximately six days.

4.3.2 Sampling Locations

Sample names and locations within the DMMUs (including GPS coordinates) are shown in Tables 10 through 17 in Section 4.2.2 above.

4.3.3 Site Health and Safety

The contractor will conform to all safety standards of the U.S. Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 dated 3 November 2003, and all-subsequent additions and amendments.

4.3.4 Navigation and Positioning

All samples will be obtained as close as possible to the target locations provided in Tables 10 through 17. Horizontal positioning will be determined by the onboard differential global positioning system (DGPS) based on target coordinates. Measured station positions will be converted to latitude and longitude (North American Datum [NAD] 83) to the nearest 0.1 second. The accuracy of measured and recorded horizontal coordinates will be within 6.6 ft (2 m). A survey reference marker in NAVD 88 at the Hells Canyon Marina will be used to calibrate the onboard GPS for measurement of pool elevation. The elevation of the sample location will be subtracted from the design depth elevation to arrive at an approximate sample depth.

The sample locations identified in Figures 14 through 21 and Tables 10 through 17 are estimated based on 2012 bathymetry. Since the sediment distribution is a dynamic environment, actual locations may need to be relocated based on sediment accumulation observed in the field. The goal is to have the individual samples capture as much of the dredge prism as possible to obtain a representative composite sample. If the targeted coordinates are at or below -14 ft from MOP, then the field crew will move the station to the nearest area that is above -14 ft. These changes will be documented in the field notes.

4.3.5 Sample Equipment Cleaning

Sample containers, instruments, working surfaces, technician protective gear, and other items that may come into contact with sediment sample material must meet high standards of cleanliness. All equipment and instruments used that are in direct contact with the sediment collected for analysis must be made of glass, stainless steel, high-density polyethylene (HDPE), or polytetrafluoroethylene (PTFE), and will be cleaned prior to each day's use and between sampling or compositing events. The cleaning procedure is:

- Pre-wash rinse with tap water
- Wash with solution of warm tap water and Alconox soap
- Rinse with warm tap water
- First rinse with distilled water
- Rinse three additional times with distilled water
- Cover (no contact) all cleaned items with aluminum foil
- Store in clean, closed container for next use

4.3.6 Sample Collection Techniques and Volumes

Approximately 3-L of grab or core sample material will be required for the conventional and chemical analyses, and an additional 5-L is needed for possible future bioassay testing.

4.3.6.1 Grab Samples

Areas that consist primarily of sand will be sampled with a grab sampler. A Van Veen-type sampler modified with pneumatic cylinders, or an equivalent, designed to sample the sediment to a depth of at least 10 cm will be used. A grab sample will be considered suitable if:

- The sampler is not over-filled
- The sampler jaws are properly shut with no sample loss from the sampler during retrieval
- The sediment surface is relatively flat (indicates minimal disturbance or winnowing)
- After water is siphoned off the top of the grab, surface should not be disturbed.

If these criteria are met, sufficient volume will be removed for the sulfide analysis and the remainder placed in pre-cleaned buckets for compositing as described in Section 4.3.8.1. Photographs and physical descriptions of the material will be completed following the guidelines prescribed in the Section 4.3.6.2 for core samples.

4.3.6.2 Core Samples

Sediment cores will be collected from the Port of Clarkston Cruise Dock and Recreation Dock using a vibracorer. Core samples will be driven through the target dredge prism and 2 feet below the new dredge surface to collect the z-layer sample.

The vibracorer will use polycarbonate liners inside a rigid external tube at least 4 inches in diameter. The vibracorer will be lowered to the substrate where the unit will be energized and allowed to penetrate. Acceptance criteria for a sediment core sample are as follows:

- The core penetrated to, and retained material to, project depth or refusal
- Recovery was at least 75 percent of the length of core penetration
- Cored material did not extend out the top of the core tube or contact any part of the sampling apparatus at the top of the core tube
- There are no obstructions in the cored material that might have blocked the subsequent entry of sediment into the core tube and resulted in incomplete core collection

Once the sampler is brought back onboard the survey vessel, the contents of the sampler will be visually examined. If the sample contains primarily cobble and gravel material then it will not be forwarded to the laboratory. However, a digital photo of the sample, along with a ruler and identification number will be taken for documentation. If the core material is predominantly smaller than gravel (i.e., sands and silts less than 2 mm in diameter) then it will be considered acceptable if the above criteria were met.

If core rejections require the core station to be relocated, three additional attempts will be made within a radius of 25 feet of the target. If relocation takes place, the field coordinator will ensure that the revised location remains within the respective DMMU. If relocation attempts are not successful, the proposed station relocation will be coordinated with Walla Walla District and the DMMO.

The core tube caps will be removed immediately prior to placement into the coring device. Care will be taken during sampling to avoid contact of the sample tube with potentially contaminated surfaces. Extra sample tubes will be available during sampling operations for uninterrupted sampling in the event of a potential core tube breakage or contamination. Core tubes suspected to have been accidentally contaminated will not be used.

4.3.7 Core Splitting and Extrusion

Sediment processing will be conducted aboard the sampling vessel or on-shore. All working surfaces and instruments will be thoroughly cleaned, decontaminated, and covered with aluminum foil to minimize outside contamination between sampling events. Disposable gloves will be discarded after processing each station and replaced prior to handling decontaminated instruments or work surfaces.

Sample containers will be kept in packaging as received from the analytical lab until use. A sample container will be withdrawn only when a sample is to be collected and will be returned to an ice chest containing completed samples.

The steps for processing the core samples are provided below.

1. Extrude sample material from sample core tube onto a stainless steel tray using a vibrating core-extruder. Alternatively, the core may be cut longitudinally using a circular saw, taking care not to penetrate the sediment while cutting.
2. Separate z-layer sample, relative to design depth, from dredge surface
3. Photograph the core, paying special attemtion to interesting horizons. Record the description of the core sample on the core log form for the following parameters as appropriate and present:
    - Sample recovery (depth in feet of penetration and sample compaction)

- Physical soil description in accordance with the Unified Soil Classification System (includes soil type, density/consistency of soil, and color)
- Odor (e.g., hydrogen sulfide, petroleum, etc.)
- Vegetation
- Debris
- Biological activity (e.g., detritus, shells, tubes, bioturbation, and live or dead organisms)
- Presence of oil sheen
- Any other distinguishing characteristics or features

4. Using a clean spoon, place sample material from the core into a cleaned stainless steel bowl or HDPE bucket, homogenize using a stainless steel paddle and variable speed drill, cover with foil, and set aside for composite sample preparation.
5. Repeat Steps 1, 2, 3, and 4 for the remaining core tubes associated with the composite that is being prepared.
6. To prepare the sample composite for a DMMU, place a representative volume of homogenized sediment taken from the full length of each individual core section into a compositing container (stainless steel bowl or HPDE bucket), and mix thoroughly to a uniform color and consistency using a variable speed drill fitted with a stainless steel paddle.
7. Using a clean, stainless steel spoon, completely fill pre-labeled sample containers, as indicated in Table 18, for the analyses.
8. Immediately after filling the sample container with sediment, place the screw cap on the sample container and tighten.
9. Repeat steps 3, 4, 7 and 8 for z-layer samples, but keep cores separate and do not composite.
10. Thoroughly check all sample containers for proper identification, analysis type, and lid tightness.
11. Pack each container carefully to prevent breakage and place upright inside a cooler with ice for storage at the proper temperature (4°± 2°C for all samples).

4.3.8 Sample Compositing and Sub-sampling

4.3.8.1 Grab Samples

Grab samples will be processed on the sampling vessel or on-shore after collection. The entire penetration depth of the sample (except for areas touching the sides of the sampler) should be represented in the portion taken for compositing and analyses. The subsample for sulfide analysis will be taken from a randomly selected, suitable grab sample from each DMMU before it is homogenized and mixed. The remainder of that sample, along with the other individual DMMU grab samples that will constitute a composite should be approximately the same volume and will be homogenized to a uniform color and consistency in a large stainless steel bowl. Mixing will occur while individual samples are removed to ensure that settling of course-grained sediments does not occur. Three liters of material is needed for the physicochemical analyses (includes the archived sediment sample) and 5-L are needed for the bioassay archive sample.

4.3.8.2 Core Samples

The sediment collected from each individual cores sample will be homogenized. Z-layer samples will be maintained separately. Because the two cores from the Port of Clarkston Cruise Dock and Recreation Dock represent single DMMUs, each set will be homogenized above the z-layer. A proportionate volume of each individual sample, which does not consist primarily of cobble and or gravel, will be placed into a decontaminated stainless steel bowl or HDPE bucket for compositing as described in Section 4.3.7. The material added to the composite container will be representative of the entire depth interval targeted for

each individual sample. As an individual contribution becomes available, its proportionate sediment volume will be added to the composite sample container. When all of the desired material is placed into the compositing container, the material will be homogenized with a stainless steel paddle attached to a variable speed drill or stainless steel spoon until uniform in color and texture, then placed into the appropriate sample jars, as identified in Table 18, and stored/preserved. In order to satisfy the volume requirements for analyses, the composite must consist of approximately eight liters of sediment. The homogenate will be mixed throughout the process of filling sample jars to ensure that each sample jar is representative of the homogenate mixture.

4.3.9 Sample Containers

A listing of the sample containers and field preservation techniques used is shown in Table 18 below. The contract laboratory will provide certified, pre-cleaned, U.S. Environmental Protection Agency (EPA) approved containers for all samples.

Table 18. Containers, sample size, and preservation for the sediment samples.

Parameter	Sample Size (wet weight)	Container	Preservation	Holding Times
Archive for contingencies	N/A	500-mL glass	Frozen	6 months
Particle Size	100-200 g	1-L glass (combined)	4º C	6 months
Total Organic Carbon	125 g			14 days
Total Solids	125 g			14 days
Ammonia	25 g			7 days
Total sulfides	50 g	125-mL glass or polyethylene	4º C(1)	7 days
Mercury (total)	50 g	125-mL Teflon or polyethylene	4º C	28 days
Metals (except mercury)	50 g	125-mL glass	4º C	6 months
Semivolatiles, Pesticides, PCBs, TPH Diesel, and PAHs	200 g	500 mL	4º C	14 days until extraction 40 days after extraction
Dioxins/ Furans	100 g	250-mL amber glass	4º C	14 days until extraction
Bioassay archive	5-L	5-L glass or polyethylene	4º C	8 weeks

Notes:

(1) The sulfides sample will be preserved with 5 mL of normal zinc acetate for every 30 gm of sediment

4.3.10 Field Log

Field notes will be taken for all samples and correlated to the sampling location map. The following information will be included in the log:

- Date and time of sample collection.
- Elevation of each station sampled as measured in NAVD 88
- Location of each station as determined by DGPS
- Names of the field crew
- Weather conditions
- Sample station identification code assigned to the grab sample and/or core section
- Qualitative notation of the sediment column resistance to coring
- The water depth of each sampling station
- Length, depth interval (referenced to the sediment/water interface), and percent recovery of the core sections

- Physical sediment description by a registered geologist, including type, density, color, consistency, odor, stratification, vegetation, debris, biological activity, presence of an oil sheen or any other distinguishing characteristics or features
- Notation of field QC samples
- Any deviation from the approved SAP

4.3.11 Chain of Custody

The chain of custody process will begin in the field from the time the samples are composited and continue until they reach the analytical laboratory. Important steps in the process include:

- Sample labels will be attached to each container using waterproof paper and ink.
- The container caps will be secured and sample identification information will be written on the lid with waterproof ink as a backup label.
- Glass sample containers will be wrapped in bubble wrap or other packaging material.
- Containers will be placed in plastic Zip-lock® bags and excess air will be expelled to the extent possible before sealing.
- The wrapped/sealed containers will be place in an ice chest and packed with ice that has been placed in separate/sealed plastic bags or blue ice.
- The signed and dated chain of custody form for the samples in a given ice chest will be enclosed in a sealed plastic bag and taped to the inside lid of the cooler.
- The ice chest drain and lid will be taped to prevent accidental opening during shipping and handling.
- Each ice chest should be delivered to the laboratory within 24 hours of being sealed.

5.0 LABORATORY ANALYSES

The sediment samples will be analyzed using the methods identified in Table 19. Because the sediment at the Port of Clarkston Recreation dock has not been sampled before, that sample will be analyzed for the full suite of analyses indicated in Table 19. The remaining fourteen samples, as well as the duplicate, will receive an abbreviated set of analyses since they are from areas that have been sampled multiple times.

The laboratory that will complete the sediment analyses is Pyron Environmental. After a contract has been awarded, any remaining laboratory related information and a copy of the signed SAP will be forwarded to the DMMO as previously mentioned.

Total PCB aroclors includes the sum of the following Aroclors: Aroclor-1016, 1221, 1232, 1242, 1248, 1254, and 1260. If present, Aroclor-1262 and Aroclor-1268 will be reported, but not included in the total PCB summation.

Total chlordane is the sum of two major compounds (cis-chlordane and trans-chlordane, also known as alpha-chlordane and gamma-chlordane, respectively) and three minor compounds (cis-nonachlor, trans-nonachlor, and oxychlordane) derived from technical chlordane and its metabolites.

All possible steps should be taken to ensure that the reporting limits (RL) are at, or below the DMMP SLs presented in Table 19, and meet the SQLs where possible. If it is not possible to bring RLs below the SLs, the raw data should be carefully reviewed to determine if non-detects can be reported at the MDL. Detected analytes at concentrations between the MDL and RL should be J-flagged as estimated values. Method detection limits and RLs will be reported for all non-detects. If the analytical laboratory encounters difficulty reaching the required screening limits the technical project managers at Walla Walla District and the DMMO should be notified immediately.

Table 19. Laboratory methods, SQLs, and screening limits (SL) for the sediment analyses.

POC Rec. Dock	All Other Locations	Parameter	CAS	Prep Method	Method	SQL[1]	SL1
		CONVENTIONALS					
X	X	Grain analysis (%)[5]	NA	---	ASTM D422 mod	1	---
X	X	Total solids (%)	NA	---	APHA 2540-G	0.1	---
X	X	Total Sulfides (mg/kg)	NA	---	PSEP 1986/ Plumb 1981	1.0	---
X	X	Ammonia (mg/kg)	NA	---	Plumb 1981	0.1	---
X	X	Total organic carbon (%)	NA	PSEP 1997	EPA 5310B mod or EPA 9060	0.1	---
		METALS (MG/KG DRY WEIGHT)					
X	X	Antimony	7440-36-0	EPA 6010/6020[2]	EPA 6010/6020	0.5	150
X	X	Arsenic	7440-38-2	"	"	5	14
X	X	Cadmium	7440-43-9	"	"	2.1	2.1
X	X	Chromium	7440-47-3	"	"	5	72
X	X	Copper	7440-50-8	"	"	5	400
X	X	Lead	7439-92-1	"	"	5	360
X	X	Mercury	7439-97-6	EPA 7471	EPA 7471	0.1	0.66
X	X	Nickel	7440-02-0	EPA 6010/6020[2]	EPA 6010/6020	5	26
X	X	Selenium	7782-49-2	"	EPA 6020/7440	---	3
X	X	Silver	7440-22-4	"	EPA 6010/6020	0.5	0.57
X	X	Zinc	7440-66-6	"	"	5	3,200
		POLYNUCLEAR AROMATIC HYDROCARBONS (PAHS; µG/KG)					
		LOW-MOLECULAR WEIGHT PAHS					
X		Naphthalene	91-20-3	EPA 3550-mod[3]	EPA 8270D	20	500
X		Acenaphthylene	208-96-8	"	"	20	470
X		Acenaphthene	83-32-9	"	"	20	1,100
X		Fluorene	86-73-7	"	"	20	1,000
X		Phenanthrene	85-01-8	"	"	20	6,100
X		Anthracene	120-12-7	"	"	20	1,200
X		2-Methylnaphthalene	91-57-6	"	"	20	470
		HIGH-MOLECULAR WEIGHT PAHS					
X		Fluoranthene	206-44-0	EPA 3550-mod[3]	EPA 8270D	20	11,000
X		Pyrene	129-00-0	"	"	20	8,800
X		Benz(a)anthracene	56-55-3	"	"	20	4,300
X		Chrysene	218-01-9	"	"	20	5,900
X		Benzofluoranthenes (b, j ,k)	205-99-2	"	"	20	600
X			205-82-3	"	"	20	
X			207-08-9	"	"	20	

Table 19. Laboratory methods, SQLs, and screening limits (SL) for the sediment analyses (continued).

POC Rec. Dock	All Other Locations	Parameter	CAS	Prep Method	Method	SQL	SL1
X		Benzo(a)pyrene	50-32-8	"	"	20	3,300
X		Indeno(1,2,3-c,d)pyrene	193-39-5	"	"	20	4,100
X		Dibenz(a,h)anthracene	53-70-3	"	"	20	800
X		Benzo(g,h,i)perylene	191-24-2	"	"	20	4,000
		CHLORINATED HYDROCARBONS (µG/KG)					
X		1,4-Dichlorobenzene	106-46-7	EPA 3550-mod(3)	EPA 8270D	20	110
X		1,2-Dichlorobenzene	95-50-1	"	"	20	35
X		1,2,4-Trichlorobenzene	120-82-1	"	"	20	31
X		Hexachlorobenzene (HCB)	118-74-1	EPA 3550(3)/3540	EPA 8270D/8081	10	22
		PHTHALATES (µG/KG DRY WEIGHT)					
X	X	Dimethyl phthalate	131-11-3	EPA 3550-mod(3)	EPA 8270D	20	46
X		Diethyl phthalate	84-66-2	"	"	20	200
X	X	Di-n-butyl phthalate	84-74-2	"	"	20	380
X	X	Butyl benzyl phthalate	85-68-7	"	"	20	260
X	X	Bis(2-ethylhexyl) phthalate	117-81-7	"	"	100	500
X	X	Di-n-octyl phthalate	117-84-0	"	"	20	39
		PHENOLS (µG/KG DRY WEIGHT)					
X	X	Phenol	108-95-2	EPA 3550-mod(3)	EPA 8270D	20	120
X	X	2-Methylphenol	95-48-7	"	"	20	63
X	X	4-Methylphenol	106-44-5	"	"	20	260
X	X	2,4-Dimethylphenol	105-67-9	"	"	20	29
X	X	Pentachlorophenol	87-86-5	"	"	100	1,200
		MISCELLANEOUS EXTRACTABLES (µG/KG DRY WEIGHT)					
X		Benzyl alcohol	100-51-6	EPA 3550-mod(3)	EPA 8270D	50	57
X	X	Benzoic acid	65-85-0	"	"	100	2,900
X	X	Dibenzofuran	132-64-9	"	"	20	200
X		Hexachlorobutadiene	87-68-3	EPA 3550(3)/3540	EPA 8270D/8081	10	11
X		N-Nitrosodiphenylamine	86-30-6	EPA 3550-mod(3)	EPA 8270D	20	28
X	X	beta-Hexachlorocyclohexane	319-85-7	"	"	---	7.2

Table 19. Laboratory methods, SQLs, and screening limits (SL) for the sediment analyses (continued).

POC Rec. Dock	All Other Locations	Parameter	CAS	Prep Method	Method	SQL	SL1
		PESTICIDES (µG/KG DRY WEIGHT)					
X	X	4,4'-DDD	72-54-8	EPA 3540	EPA 8081B	2	310
X	X	4,4'-DDE	72-55-9	"	"	2	21
X	X	4,4'-DDT	50-29-3	"	"	2	100
X	X	Aldrin	309-00-2	"	"	2	9.5
X	X	Carbazole	86-74-8	"	"	900	900
X	X	Chlordane compounds(4)	5103-71-9	"	"	2	2.8
X	X	Dieldrin	60-57-1	"	"	2	4.9
X	X	Endrin ketone	53494-70-5	"	"	8.5	8.5
X	X	Heptachlor	76-44-8	"	"	1.5	1.5
X		Lindane	58-89-9	"	"	2	---
X	X	Toxaphene(6)	8001-35-2	---	EPA 8081LL	4.98	25
X	X	TOTAL PCBS (AROCHLORS)	---	EPA 3540	EPA 8082	10	110
		TOTAL PETROLEUM (MG/KG)					
X		TPH-diesel	68476-34-6	EPA 3630/ 3665	NWTPH-Dx	25	---
X		TPH-residual	---	EPA 3630/ 3665	NWTPH-Dx	50	---

Notes:

(1) All sample quantitation limits are expressed on a wet-weight basis.
(2) SQLs are highly dependent on sample size. Details should be confirmed with the laboratory.
(3) Chlordane compounds include cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, and oxychlordane; in samples with interference from PCBs, the SQLs for cis- and trans-nonachlor and oxychlordane may be elevated.
(4) Selection of PCB analytical method will be determined on a project-specific basis.
(5) ASTM sieve numbers 4, 10, 20, 40, 60, 140, 200, and 230.
(6) The MDL, identified as the SQL, for toxaphene using EPA Method 8081LL is 4.98 µg/kg and the reporting limit, identified as the SL1, is 25µg/kg.

mg/kg = milligrams per kilogram; µg/kg = micrograms per kilogram; ng/kg = nanograms per kilogram.

6.0 QUALITY CONTROL AND QUALITY ASSURANCE

6.1 Field Quality Control and Quality Assurance

Additional QA/QC samples will be collected in the field in association with the execution of this sampling and analysis plan. Sample types include duplicates and equipment blanks:

- One field duplicate will be collected from a selected homogenized sample and submitted to the laboratory as a new sample location.
- One equipment wipe, trip blank and one filter blank will also be collected. The equipment wipe will consist of wiping down the sampling equipment after sample collection and decontamination with a clean, ashless, Whatman Grade No. 541 filter paper and placing it into a sample jar. The filter blank will be prepared by placing a clean piece of ashless Whatman Grade No. 541 filter paper directly into a sampling container. The blanks will be archived and analyzed only in the event of questionable data.

6.2 Laboratory Quality Control

The frequency of analysis for laboratory QA/QC samples is summarized in Table 20. When analyzing semi-volatile organic compounds (SVOCs), pesticides (PCBs), metals, and conventional parameters, the DMMP requires that initial calibrations must be completed before any samples are analyzed, after each major disruption of equipment, and when ongoing calibration fails to meet acceptance guidance. Ongoing calibration is required before and after every 10 to 12 samples or every 12 hours (whichever is more frequent).

Surrogates are required (organics only) for every sample, including matrix spike samples, blanks, laboratory control samples (LCS), and standard reference materials. Matrix spike and matrix spike duplicates are required for SVOCs and pesticides/PCBs at a rate of 5% or one per sample batch. Matrix spikes and laboratory duplicates will be analyzed for samples requiring metals analyses. Matrix triplicates will be analyzed for conventional parameters.

All samples will be diluted and re-analyzed if target compounds are detected at levels that exceed their respective established calibration ranges. Any cleanups will be conducted prior to the dilutions. Re-analyses will be performed if surrogate, internal standard, or spike recoveries are outside of the data quality objective parameters. QC samples may be re-analyzed if results are not within control limits and it cannot be determined that the sample matrix is the cause.

Table 21 provides the warning and action limits that have been adopted by the DMMP agencies. These QA limits are as consistent as possible with the Puget Sound Estuary Program (PSEP) and the EPA Contract Lab Program (CLP).

Table 20. Laboratory QA/QC requirements.

Analysis Type	Method Blanks[1]	Replicates[1]	Triplicates[1]	CRM/RM	MS/MSD[1]	Surrogates[2]
Semivolatiles [3,4]	X[5]	X[6]		X	X	X
Pesticides/PCBs [3,4]	X[5]	X[6]		X	X	X
Metals	X	X		X	X	
Ammonia	X		X			
Total sulfides	X		X			
Total Organic Carbon	X		X	X		
Total Solids			X			
Particle size			X			

Notes:

CRM = Certified Reference Material; RM = Reference Material; MS/MSD = matrix spike/matrix spike duplicate

1 Frequency of Analysis (FOA) = 5 percent or one per batch, whichever is more frequent

2 Surrogate spikes required for every sample, including matrix spiked samples, and reference materials

3 Initial calibrations required before any samples are analyzed, after each major disruption of equipment, and when ongoing calibration fails to meet criteria.

4 Ongoing calibration required at the beginning of each work shift, every 10-12 samples, or every 12 hours (whichever is more frequent) and at the end of each shift.

5 FOA = one per extraction batch

6 Matrix spike duplicates may be used

Table 21. DMMP warning and action limits.

QA Element	Warning Limits	Action Limits
Precision		
Conventionals:	None	20% COV
Metals:	none	20% RPD or COV
Organics:	35% RPD or COV	50% COV or a factor of 2 for duplicates
Matrix Spikes		
Metals:	none	75-125% recovery
Organics:		none (zero percent recovery may be cause for data rejection however)[1]
Semivolatiles and Pesticides:	50-150%	
Reference Materials		
Metals:	none	95% CI if specified for a particular CRM; 80-120% recovery if not.
Organics:	none	95% CI for CRMs. No action limit for uncertified RMs.
Surrogate Spikes		
Organics:		EPA CLP chemical-specific recovery limits
Pesticides:	60% minimum recovery	
Semi-volatiles:	50% minimum recovery	

Notes:

(1) Rigorous control limits are not recommended due to possible matrix effects and interferences.

7.0 REPORTING

7.1 Laboratory Report

The contract laboratory will prepare a detailed report that will be excerpted in an appendix in the final Sampling and Analysis Report documenting all activities associated with the sample analyses. Included in this report will be:

- Project Narrative: A detailed report that describes the samples received, analyses performed, any issues with analyses and corrective actions undertaken.
- Chain-of-Custody Documentation: Laboratory policy requires that chain-of-custody documentation be available for all samples received. The chain-of-custody will document basic sample demographics such as client and project names, sample identification, analyses requested, and special instructions.
- Data Summary Form: A tabular listing of concentrations and/or detection limits for all target analytes. The data report will also list other pertinent information such as the amount of sample analyzed, dilution factors, sample processing dates, extract cleanups, and surrogate recoveries.
- QA Summary: Includes results of all quality control analyses, specifically recovery information. Laboratory control samples are reported with each batch. Additional QC analysis may include laboratory replicates, matrix spikes, and standard reference materials.
- Instrument Calibration Forms and Raw Data: Includes initial and continuing calibration summaries and instrument tuning data, laboratory bench sheets, and log book pages.

The laboratory will also provide deliverables in the Washington Department of Ecology's EIM format.

7.2. Sampling and Analysis Results Report

A final Sampling and Analysis Results Report will be prepared by the selected environmental consulting contractor, documenting all activities associated with collecting, compositing, transporting, and chemically analyzing sediment samples. Portions of the laboratory reports will be included as appendices. At a minimum, the following will be included in the final report:

- Summary of all field activities including a description of any deviations from the approved SAP.
- Locations of sediment sampling stations in state plane coordinates (NAD 83) to the nearest foot, and in latitude and longitude in degrees and minutes to three decimal places. All vertical elevations of mudline and water surface will be reported to the nearest 0.1 foot relative to MOP NAVD88.
- A project map with target and actual sampling locations.
- A QA/QC narrative for chemical testing.
- Summary data results tables, including explanation of all data qualifiers, method reporting limits (MRLs), and MDLs.
- Tabular comparison and summary within the report text of chemical analytical results with DMMP guidance.
- As appendices, electronic copies of field data, core logs, laboratory analysis results, associated QA/QC, and approved SAP will be included.

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Lower Snake River Programmatic Sediment Management Plan Environmental Impact Statement

Appendix I

Water Quality and Sediment Quality Reports

August 2014

Section 2B. Supplemental 2013 Sediment Collection and Laboratory Analyses of the Lower Snake and Clearwater Rivers

U.S. Army Corps of Engineers
Walla Walla District

October 2013



U.S. Army Corps of Engineers
Walla Walla District

Supplemental 2013 Sediment Collection and Laboratory Analyses of the Lower Snake and Clearwater Rivers

Addendum to the Approved July 2013 Sample Analysis Plan

Prepared by:

U.S. Army Corps of Engineers
Walla Walla District

October 2013

Signature Page for Subcontractors

Supplemental 2013 Sediment Collection and Laboratory Analyses of the Lower Snake and Clearwater Rivers

October 2013

Approval signatures indicate that subcontractors have reviewed this Sampling and Analysis Plan and agree to follow the methods and QA procedures contained herein.

_____	_____
Tim Thompson, Project Manager/Technical Lead **Science and Engineering for the Environment**	**Date**
_____	_____
Mingta Lin, Data Validator **Pyron Environmental**	**Date**
_____	_____
Cheronne Oreiro, Senior Chemist **Analytical Resources, Inc.**	**Date**
_____	_____
Gerald Irissarri, Manager **Northwestern Aquatic Sciences**	**Date**

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1.0 INTRODUCTION

Sediment samples were collected for chemical analyses between 2 August and 6 August 2013 from the Snake and Clearwater Rivers in the vicinity of Lewiston, Idaho, and Clarkston, Washington. The purpose of this endeavor was to obtain information that could be used by the Dredged Material Management Office (DMMO) to determine if the sediments are suitable for unconfined in-water disposal. The field and laboratory protocols that were followed are described in the approved *Sampling and Analysis Plan for Lower Snake and Clearwater Rivers Proposed 2013/2014 Channel Maintenance Dredging* (USACE, 2013a).

The results of the August 2013 sampling are, in several ways, similar to those reported for the 2011 sampling (USACE 2013b, DOF/SEE 2013). Sediment samples from the Clearwater River DMMUs had higher percent sand and total solids than those collected from the Lower Snake River DMMUs, and most chemicals of concern were either non-detected, or below the Washington Ecology draft freshwater standards.

The unexpected result from the August sampling event was the detection of 4-methylphenol, phenol, and benzoic acid. The concentrations of 4-methylphenol in six of the eight Snake River DMMUs (1,2,3,5,6, and the Port of Clarkston Grain Elevator) exceeded the Screening Level 1 (SL1) guidelines, with values ranging from 340 ppb to 4,900 ppb. Phenol also exceeded SL1 guidelines in DMMU 6 where a concentration of 170 ppb was determined. Benzoic acid, though not detected at concentrations greater than the SL1 guideline, was identified at an unusually high 890 ppb in DMMU 6. Additionally, the highest concentrations of these three constituents all occurred in DMMU 6, the one farthest upstream in the Snake River (DOF/SEE 2013).

2.0 ADDENDUM PURPOSE

This addendum will provide details regarding the proposed supplemental sampling program, including summaries of field and laboratory analyses. References will be made to the original Sampling and Analysis Plan (SAP), and to the August 2013 Data Report (DOF/SEE 2013) which contains more details. Additionally, information regarding the site history, historical sediment data, and site ranking will not be repeated here.

3.0 PROJECT OBJECTIVES

The objective is to re-sample the previously visited sample locations in DMMUs 1,2,3,5,6 and the Port of Clarkston Grain Elevator (Figures 1-3 and Tables 1-3). The sediment samples will be collected using a 0.1 m^2 Power Grab sampler. The samples collected within a DMMU will be composited following the protocols used during the previous investigation (USACE 2013a). These composite samples will be analyzed for the conventional parameters as well as the phenols and miscellaneous extractables (Table 4). Additionally, the samples will be submitted for bioassay tests using the 20-day *Chironomus dilutus* survival and growth test, and the 10-day *Hyalella azteca* survival test.

A reference sediment sample will also be collected from an upstream location in the Snake River. The exact location has not been identified and will be determined in the field to match the grain size of the samples collected in the downstream DMMUs. This sample will be analyzed for the suite of chemicals of concern that were completed for the August 2013 samples (Table 4). The reference sample will also be submitted for the bioassays identified above.

4.0 PROJECT TEAM AND RESPONSIBILITIES

The U.S. Army Corps of Engineers, Walla Walla District, is the lead federal agency for the overall characterization, dredging, and disposal of the sediments. The Corps selected Resource Management Group (RMG) to conduct the sediment sampling. The team organization and responsibilities is described below.

4.1 USACE Project Lead

The Corps Project manager is Richard Turner at the Walla Walla District. The SAP addendum was prepared by Steve Juul in the water/sediment quality section who is also the main technical lead that will interface with the contractor.

4.2 Contractor Technical Lead

Mr. Tim Thompson of Science and Engineering for the Environment (SEE) is the Contract Team Technical Lead (CTL). SEE is a small business enterprise located in Seattle, Washington. The CTL provides the overall technical direction in consultation with the USACE. The CTL is responsible for executing the work plans, coordinating with and assisting the field collection team, ensuring that the data from the analytical laboratory meets the program requirements, and leading the data interpretation and report writing. The CTL also functions as the Site Safety Officer and is responsible for the safe operation of the field team.

4.3 Project Chemist/Quality Assurance Manager

Mr. Mingta Lin of Pyron Environmental (Pyron) was the Project Quality Assurance Manager. Pyron is a small business enterprise located in Olympia, WA. Mr. Lin is responsible for analytical laboratory coordination, oversight, and will conduct the quality review (QA1) of analytical data.

4.4 Analytical Laboratory Analyses

Chemical analyses of the samples will be completed by Analytical Resources, Inc. (ARI) of Tukwila, Washington. Ms. Cheronne Oreiro of ARI is the Project Chemist responsible for metals, organics, and sediment conventional analyses. ARI will handle and analyze the submitted samples in accordance with SEFPNW, DMMP and Puget Sound Estuary Program (PSEP) protocols. Laboratory reports of analytical results and QA/QC procedures will be included as appendices in the final data report.

4.5 Bioassay Laboratory

The bioassays will be completed by Northwestern Aquatic Sciences (NAS) located in Newport, Oregon. NAS is accredited by the Washington State Department of Ecology for aquatic toxicology testing. Mr. Gerald Irissarri **of** NAS will serve as the biological laboratory project manager. The biological laboratory will conduct bioassays in accordance with the Regional Sediment Evaluation Framework for the Pacific Northwest (RSET 2009) and the Dredged Material Management Program (DMMP) biological testing and QA/QC requirements (DMMP 2012). The biological laboratory report, including bioassay tests, references, negative control, positive control, and water quality results, will be included as an appendix in the final data report.

5.0 SAMPLING PROGRAM

5.1 DMMUs and Sample Locations

The DMMU sampling locations that will be re-visited during the November field event are identified in Figures 1 through 3 and Tables 1 through 3. Tables 1 through 3 are the actual sampling coordinates and

elevations reported in the August 2013 Data Report (DOF/SEE 2013). The North American Datum of 1983 (NAD83) datum is used for the latitude and longitude coordinates while the National Geodetic Vertical Datum of 1929 (NGVD29) is used for the vertical elevations.

FNC Clarkston West

The FNC West area is located on the Snake River between RM 138 and RM 138.8 (Figure 1). The entire area consists of three DMMUs and covers 35.9 acres. Only the areas within each DMMU where a 14-ft channel depth is not available at MOP would be dredged and amounts to 23.4 acres.

These three DMMUs have an average volume of 57,869 cubic yards (cy) each. Seven grab samples will be collected from each DMMU and composited for a total of three laboratory analyses and bioassays.

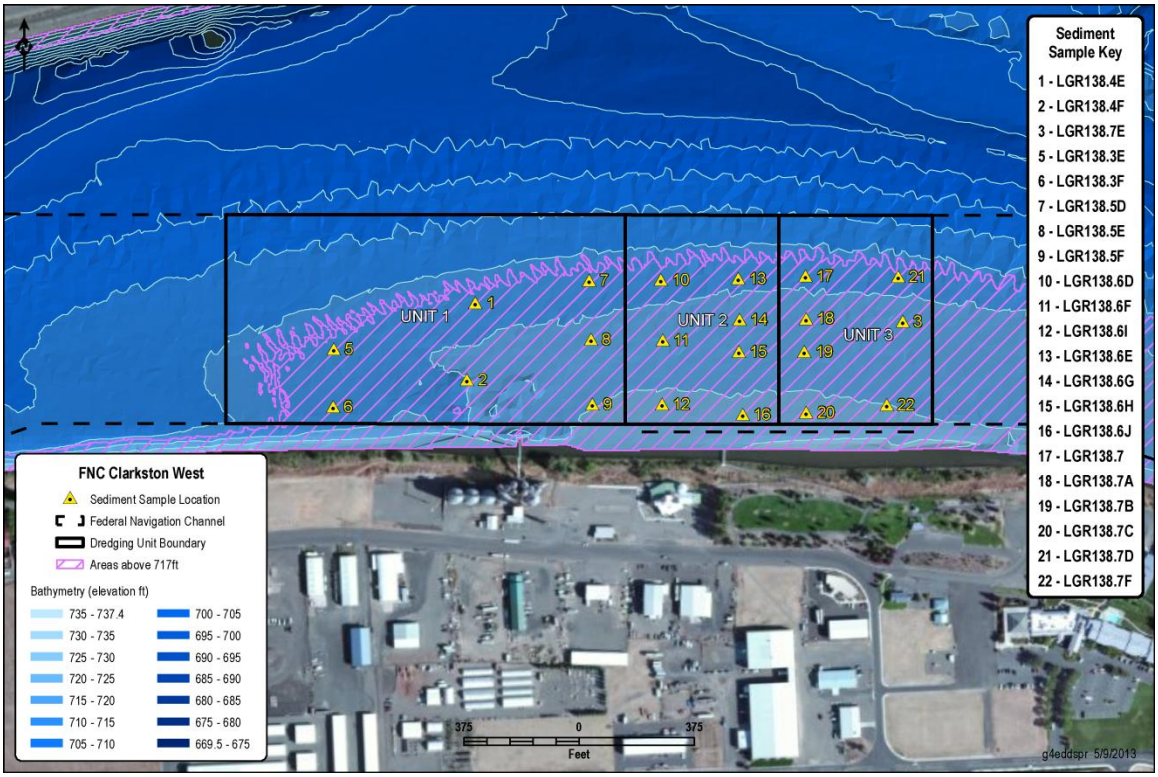


Figure 1. FNC Clarkston West and associated DMMUs with proposed 2013 re-sample locations.

Table 1. Samples that will be used to re-characterize the FNC Clarkston West DMMU.

DMMU	Sample Key	Sample ID	Latitude	Longitude	Mudline Elevation (ft)	Sediment Depth to Top of z-Layer (ft)
1	1	LGR138.4E	46 25.69455	-117 03.27004	714.8	-0.6
	2	LGR138.4F	46 25.66394	-117 03.27024	718.0	-3.8
	5	LGR-138.3E	46 25.67310	-117 03.38158	715.0	-0.8
	6	LGR-138.3F	46 25.65193	-117 03.38262	715.3	-1.1
	7	LGR-138.5D	46 25.70497	-117 03.17991	714.9	-0.7
	8	LGR-138.5E	46 25.68226	-117 03.17977	717.7	-3.5
	9	LGR-138.5F	46 25.64825	-117 03.18119	721.8	-7.6

Table 1. Samples that will be used to re-characterize the FNC Clarkston West DMMU (continued)

DMMU	Sample Key	Sample ID	Latitude	Longitude	Mudline Elevation (ft)	Sediment Depth to Top of z-Layer (ft)
2	10	LGR138.6D	46 25.70337	-117 03.12526	714.8	-0.6
	11	LGR138.6F	46 25.6804	-117 03.1251	719.5	-5.4
	12	LGR138.6I	46 25.64583	-117 03.12679	722.6	-8.5
	13	LGR138.6E	46 25.70047	-117 03.06436	716.2	-2.1
	14	LGR138.6G	46 25.69015	-117 03.06382	718.2	-4.1
	15	LGR138.6H	46 25.67219	-117 03.06631	719.7	-5.6
	16	LGR138.6J	46 25.63869	-117 03.06520	722.7	-8.6
3	17	LGR138.7	46 25.71100	-117 03.01280	714.9	-0.7
	18	LGR138.7A	46 25.68802	-117 03.01252	717.8	-3.6
	19	LGR138.7B	46 25.67138	-117 03.01453	719.5	-5.3
	20	LGR138.7C	46 25.63815	-117 03.01543	722.3	-8.1
	21	LGR138.7D	46 25.69680	-117 02.93750	716.2	-2.0
	22	LGR138.7F	46 25.64123	-117 02.95315	719.6	-5.4
	3	LGR138.7E	46 25.68523	-117 02.93810	718.3	-4.1

FNC Clarkston East

The FNC Clarkston East area is located along the left bank of the Snake River at approximately RM 139 (Figure 2). The navigation channel was previously divided into three DMMUs that cover a total of 56.4 acres. However, the 4-methylphenol concentrations only exceeded the SL1 guidelines in DMMU 5 and 6, while phenol surpassed the guideline in DMMU 6. Only those two DMMUs will be re-sampled.

The sediment volumes in the DMMUs range from 22,032 to 59,635 cy. A total of 11 grab samples will be collected from the two DMMUs. The samples from each DMMU will be composited for a total of two laboratory analyses and bioassays.

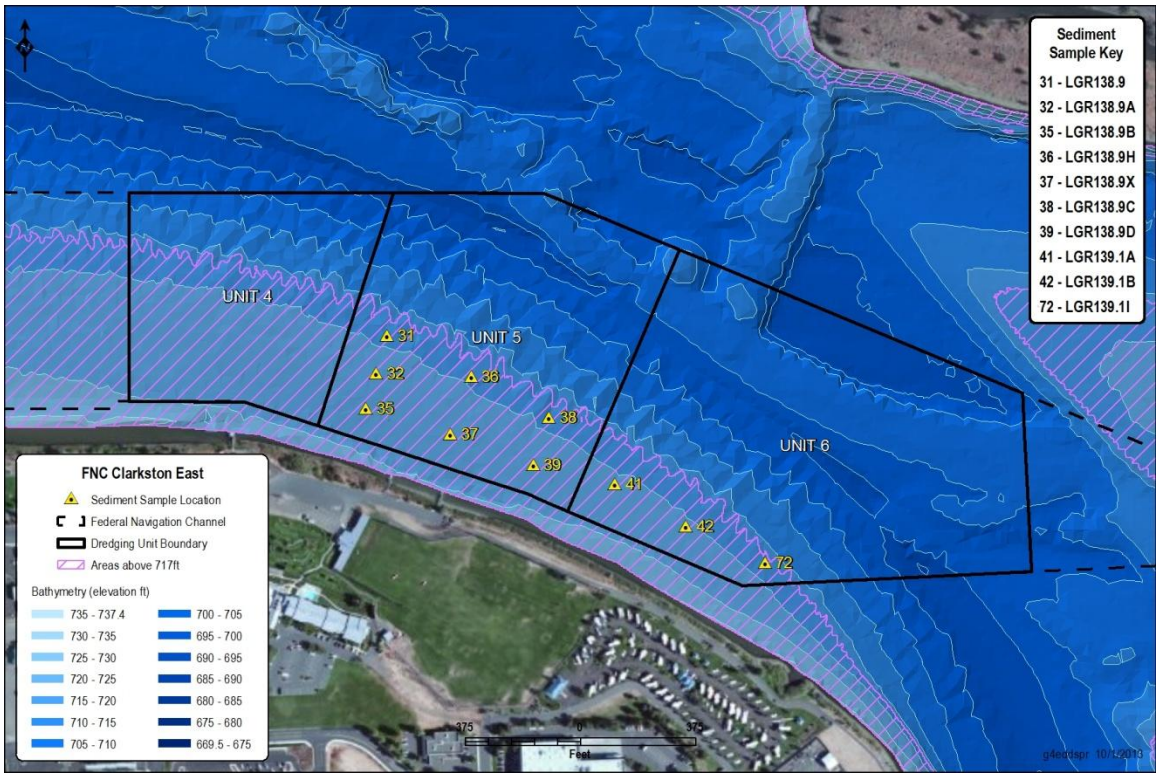


Figure 2. FNC Clarkston East and associated DMMUs with proposed 2013 re-sample locations.

Table 2. Samples that will be used to re-characterize the FNC Clarkston East DMMU.

DMMU	Sample Key	Sample ID	Latitude	Longitude	Mudline Elevation (ft)	Sediment Depth to Top of z-Layer (ft)
5	31	LGR138.9	46 25.64979	-117 02.72121	716.7	-2.5
	32	LGR138.9A	46 25.63780	-117 02.72684	718.8	-4.6
	35	LGR138.9B	46 25.62026	-117 02.73595	719.6	-5.4
	36	LGR138.9H	46 25.62729	-117 02.65398	716.4	-2.2
	37	LGR138.9X	46 25.59718	-117 02.67107	720.1	-5.9
	38	LGR138.9C	46 25.60119	-117 02.59998	716.8	-2.6
	39	LGR138.9D	46 25.58528	-117 02.60914	719.1	-4.9
6	41	LGR139.1A	46 25.57305	-117 02.54624	717.4	-3.2
	42	LGR139.1B	46 25.54852	-117 02.49284	716.7	-2.5
	72	LGR139.1I	46 25.52202	-117 02.44118	715.7	-1.5

Port of Clarkston Grain Elevator

The Port of Clarkston Grain Elevator DMMU encompasses an area of 0.2 acres of the Snake River at approximately RM 138.4 (Figure 3). The dock at the grain elevator is used only for the off-loading of grain by transient shallow water barges and tugs and does not provide permanent moorage. The entire DMMU would be dredged as the water depth throughout is less than 14 feet at MOP

Two sediment samples will be retrieved from this DMMU and composited for one laboratory analysis and bioassay to further characterize the 3,218 cy of material.

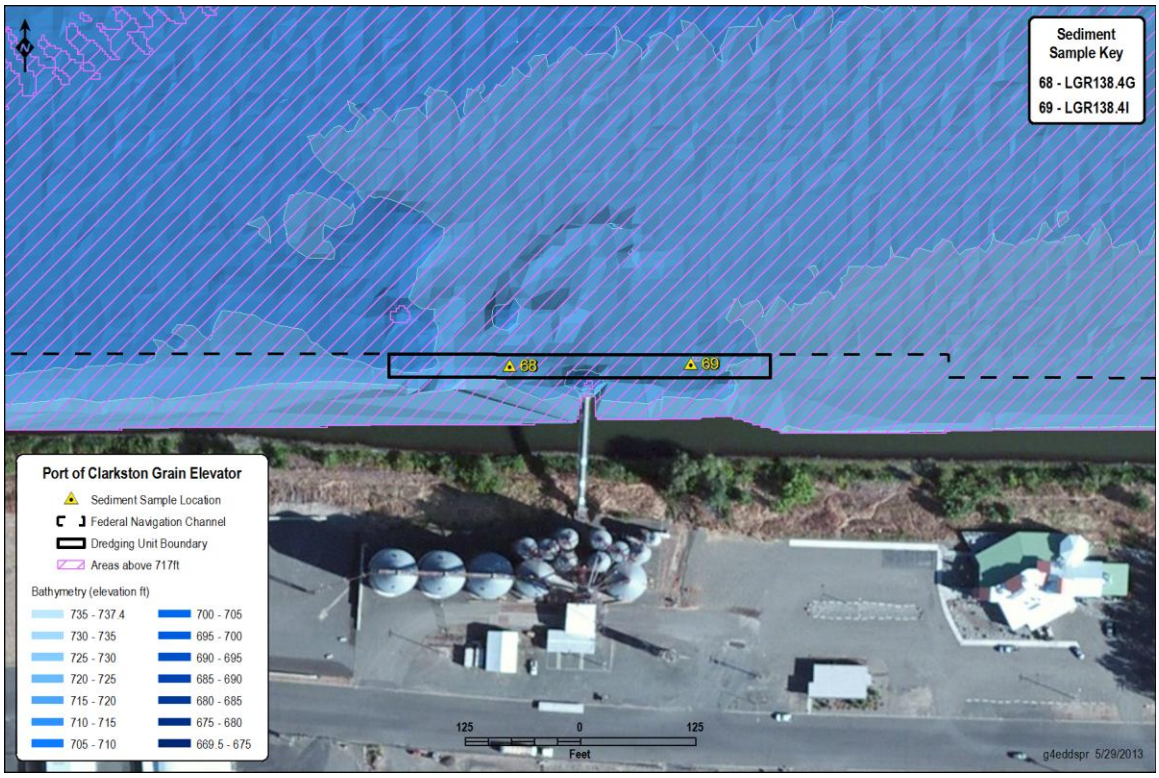


Figure 3. Port of Clarkston Grain Elevator DMMU with proposed 2013 re-sample locations.

Table 3. Samples that will be used to re-characterize the Port of Clarkston Grain Elevator DMMU.

Sample Key	Sample ID	Latitude	Longitude	Mudline Elevation (ft)	Sediment Depth to Top of z-Layer (ft)
68	LGR138.4G	46 25.63010	-117 03.2784	717.6	-3.2
69	LGR138.4I	46 25.63600	-117 03.2118	721.9	-7.5

Reference Site

A reference sediment sample will be collected from another location within the Clearwater/Snake River Basin for the bioassays. The approximate location (upstream on the Clearwater or Snake River) has not been identified, but will be done so in counsultation with the DMMO. The final reference sediment site will be determined in the field, and will follow the procedures identified in the 2008 DMMP white paper Reference Areas for Freshwater Bioassay (Stirling and RSET 2008).. To the degree practicable, the objective is to find an area where there is less than 25 percent difference in percent fines between the reference sediments and those retrieved from the DMMUs. Physical characteristics of the five DMMUs are given in Table 4. The preferred alternative is to identify an upstream Snake River location to minimize anthropogenic influences. However, if a suitable site cannot be located during that effort alternatives may include an upstream Clearwater River location or downstream in the Snake River near Silcot Island (RM 130). The field determination of grain size for the bioassay reference samples will be accomplished by wet sieving of sediments, following the methods described in the DMMP Users' Manual.

Table 4. Physical parameters measured at the six re-test DMMUs.

Parameter	DMMU 1	DMMU 2	DMMU 3	DMMU 5	DMMU 6	POC-GE
Total solids (%)	56.58	67.55	68.03	68.41	43.72	48.26
Total organic carbon (%)	1.53	1.47	0.84	1.03	6.84	4.14
Sand (%)	85.2	87	88.7	86.9	69.4	76.6
Silt (%)	8.3	6.7	4.5	8.4	16.5	15.6
Clay (%)	6.6	6.4	6.7	4.7	14.2	7.9

5.2 Site Health and Safety Plan

The site-specific Health and Safety Plan previously developed by DOF/SEE will be utilized for the re-sampling effort. That plan was developed in accordance with federal safety regulations [Occupational Safety and Health Administration (OSHA), 29 CFR 1910 and 29 CFR 1926] and U.S. Army Corps of Engineers (USACE) safety and health requirements (EM 385-1-1 (2008) and ER 385-1-92 (2007)).

5.3 Field Sampling Schedule and Sampling Vessel

Sampling will occur after approval of this addendum to the SAP by the DMMO, and is anticipated to begin the second week of November and last approximately three to four days. Collection of the grab samples will be completed by Sampling and Engineering for the Environment, LLC (SEE) using the *R/V Peter R* that was employed during the previous field event.

5.4 Navigation and Positioning

A differential global positioning system (DGPS) will be used to navigate to, occupy, and document all stations during each sampling event. A Trimble AG 132 DGPS, utilizing a differential signal from Spokane, Washington will be interfaced to an on-board computer running software enabling real-time plan view navigation to the required sampling stations. All station coordinates will be recorded in latitude and longitude as decimal minutes with a minimum precision of four decimal places and will be based on the North American Datum of 1983 (NAD 83).

The precision and reproducibility of the navigation system will be based on the same horizontal control points used in the August 2013 sampling (DOF/SEE 2013). These two fixed points will be checked daily, and include a fixed steel pile at the end of the boat launch ramp at Hells Canyon Marina and a light post located within the USACE Lower Granite Natural Resources Office boat bay at Greenbelt Park. The fixed coordinates for these two points will be post-checked using the coordinates established during the August 2013 sampling. The navigation checks will be within ±0.5 (range 0.2 – 0.5) meters of the control points.

Vertical control will also be consistent with that used in the August 2013 sampling. One check consists of a Corps-maintained water level gage at the confluence of the Lower Snake and Clearwater Rivers (LWSI) that provides hourly updates on the water level. This gage reports Lower Granite Lake elevations in feet above mean sea level (amsl) in NGVD29. These water elevations will be obtained by phone routinely throughout the day and recorded in the field notebook. The second check will consist of a transmitting tide gage (Hazen Gage) installed at the Lower Granite Natural Resources Office boat bay that is calibrated to the Corps river stage gage. This gage will be connected to a radio transponder that sends a signal to a receiver on-board the *Peter R*. The corresponding water depths (depth to mudline) will confirmed at each station with a direct lead-line reading and corrected to Minimum Operating Pool (MOP) elevation (NGVD29) using the readings from LWSI and/or the Hazen gauge. Elevation and MOP-corrected elevations will be recorded in the field notebook and on the sediment drive logs.

As the stations targeted for resampling have been previously occupied, it is anticipated that the elevation at those locations will be the same. However, if the MOP-corrected depth at a target station is found to be at, or deeper than 717 ft amsl, the sample location will be moved to a proximal shallower location. As a general rule-of-thumb applied in the field; when locating a station the elevation will be at least 717.5 ft amsl or greater before a sample is collected, thus ensuring that the sample is collected above the targeted channel depth. Sample depths will also be taken using a lead line immediately prior to, and then again at the point the sample is collected, and recorded in the field log book and sediment drive log.

5.5 Sample Equipment Cleaning

Prior to sampling within a DMMU, the power grab will be washed with a cleaning detergent (e.g., Alconox®) and rinsed with site water. Furthermore, the grab will be rinsed with site water between individual stations of the same DMMU.

The composite bowl and spoons used will be subjected to a thorough decontamination procedure. For all sub-sampling equipment (e.g., stainless steel bowls and utensils), the equipment will first be cleaned with site water and detergent, using a brush to remove particulate matter, and then rinsed with de-ionized water (DI). The equipment will then be rinsed with isopropyl alcohol, followed by DI, then a 1% nitric acid rinse, rinsed again with DI, and wrapped or covered with aluminum foil until use.

The isopropyl alcohol and nitric acid rinsates will be properly handled and disposed of as investigative-derived wastes (IDW), using the same procedures described in the August 2013 data report (DOF/SEE 2013). All other IDW will also be appropriately disposed of as described in the data report.

5.6 Sample Collection Techniques and Volumes

A minimum of 8 liters (L) of composited material will be required for all chemical and biological analyses. Approximately 3-L of grab sample material will be required for the conventional and chemical analyses, and an additional 5-L is needed for possible future bioassay testing. As a rule, an additional 8-liters of material is collected and held in archive in case any re-testing is required. Sampling and compositing procedures are described, below.

5.7 Grab Sample Compositing and Sub-sampling

Grab samples will be processed on the sampling vessel or on-shore after collection. The entire penetration depth of the sample (except for areas touching the sides of the sampler) should be represented in the portion taken for compositing and analyses. The subsample for sulfide analysis will be taken from a randomly selected, suitable grab sample from each DMMU before it is homogenized and mixed. The remainder of that sample, along with the other individual DMMU grab samples that will constitute a composite should be approximately the same volume and will be homogenized to a uniform color and consistency in a large stainless steel bowl. Mixing will occur while individual samples are removed to ensure that settling of course-grained sediments does not occur.

5.8 Field Grain Size Characterization

The selection of the appropriate reference sediment will be based upon field grain size determinations conducted on site sediments from the composite material. Field grain size is determined by passing 100 mL of site sediments through a 63 micron (#230) sieve. The volume of sand retained on the sieve is re-measured, indicating the percent sand versus silt/clay. For example, if 37 mL of sand are retained on the sieve, the fraction of sand is then 37% and the fine fraction (silt/clay) is 63%. A second confirmation method will be employed using mass instead of volume. One hundred grams of material will be weighed out, washed through the #230 screen, and the retained material re-weighed. Field grain size characterization will be conducted on all composited DMMU samples prior to collecting the reference sediment, and recorded in the field notebook and/or the core logs

5.9 Sample Containers

A listing of the sample containers, required volumes, and field preservation techniques are shown in Table 5. The contract laboratory will provide certified, pre-cleaned, U.S. Environmental Protection Agency (EPA) approved containers for all samples. The laboratory sample identifications for each DMMU are presented in Table 6.

Table 5. Containers, sample size, and preservation for the sediment samples.

Parameter	Sample Size (wet weight)	Container	Preservation	Holding Times
Chemistry				
Particle Size	100 g	16-oz glass or HDPE	4°C ± 2°C	6 months
Total Organic Carbon	25 g	16-oz glass or HDPE	4°C ±2°C	14 days
Total Solids	50 g		-20°C ±2°C	6 months
Ammonia	25 g		4°C ± 2°C	7 days
Total sulfides[1]	50 g	2-oz glass jar	4°C ± 2°C	7 days
Mercury (total)	10 g	4-oz glass jar	4° C	28 days
Metals (except mercury)	50 g	125-mL glass	4°C ±2°C -20°C ±2°C	6 months 2 years
Semivolatiles, Pesticides, PCBs, and PAHs	200 g	16-oz glass or HDPE	4°C ±2°C -20°C ±2°C	14 days 1 year
Bioassays				
Hyalella mortality	1.25 L	Four (4) 16 oz glass or one (1) 68 oz. HDPE	4°C ± 2°C	8 weeks
Chironomus survival and growth	1.25 L			
Archive				
Chemistry Archive	500 mL	16 oz glass	4°C ± 2°C -20°C ±2°C	14 days 6 months
Bioassay Archive	8 L	2 – 1 gallon HDPE	4°C ± 2°C	8 weeks

Notes:

(1) The sulfides sample will be preserved with 5 mL of normal zinc acetate for every 30 gm of sediment

Table 6. Laboratory sample identifications, sample types, and number of composites.

Area to be Dredged	DMMU	Laboratory Sample ID	Sample Type	Number of Composites	Number of Samples
FNC Clarkston West	1	DMMU-1-G-C1B	Grab composite	3	4
		DMMU-1-G-C1BSP	Split		
	2	DMMU-2-G-C1B	Grab composite		
	3	DMMU-3-G-C1B	Grab composite		
FNC Clarkston East	5	DMMU-5-G-C1B	Grab composite	1	1
	6	DMMU-6-G-C1B	Grab composite	1	3
		DMMU-6-G-C1BD	Duplicate		
		DMMU-6-G-C1BSP	Split		
Port of Clarkston Grain Elevator	POC Grain Elevator	POC-GE-G-C1B	Grab composite	1	1
Snake River Reference Sample	Upstream SNR	SNR-REF-C1	Grab composite	1	1
TOTAL				7	**10**

5.10 Sample Shipping and Chain of Custody

The chain of custody process will begin in the field from the time the samples are composited and continue until they reach the analytical laboratory. Important steps in the process include:

- Sample labels will be attached to each container using waterproof paper and ink.
- The container caps will be secured and sample identification information will be written on the lid with waterproof ink as a backup label.
- Glass sample containers will be wrapped in bubble wrap or other packaging material.
- Containers will be placed in plastic Zip-lock® bags and excess air will be expelled to the extent possible before sealing.
- The wrapped/sealed containers will be place in an ice chest and packed with ice that has been placed in separate/sealed plastic bags or blue ice.
- The signed and dated chain of custody form for the samples in a given ice chest will enclosed in a sealed plastic bag and taped to the inside lid of the cooler.
- The ice chest drain and lid will be taped to prevent accidental opening during shipping and handling.
- Each ice chest should be delivered to the laboratory within 24 hours of being sealed.
- A single temperature blank will be included with each shipment.

5.11 Field Log

Field notes will be taken for all samples and correlated to the sampling location map. The following information will be included in the log:

- Date and time of sample collection.
- Elevation of each station sampled as measured in NAVD 29
- Location of each station as determined by DGPS
- Names of the field crew
- Weather conditions
- Sample station identification code assigned to the grab sample
- Qualitative notation of the sediment column resistance to coring
- The water depth of each sampling station
- Physical sediment description by a registered geologist, including type, density, color, consistency, odor, vegetation, debris, biological activity, presence of an oil sheen or any other distinguishing characteristics or features
- Notation of field QC samples
- Any deviation from the approved SAP

6.0 LABORATORY ANALYSES

6.1 Chemical Analyses

The sediment samples will be analyzed by Analytical Resources, Inc. using the methods identified in Table 7. The DMMU samples will only be analyzed for the conventional parameters as well as the phenols and miscellaneous extractables since the COCs that exceeded the SL during the past sampling

event were in those two categories. The sediment sample from the reference site will be analyzed for the full suite of analyses indicated in Table 7.

Total PCB Aroclors includes the sum of the following Aroclors: Aroclor-1016, 1221, 1232, 1242, 1248, 1254, and 1260. If present, Aroclor-1262 and Aroclor-1268 will be reported, but not included in the total PCB summation.

Total chlordane is the sum of two major compounds (cis-chlordane and trans-chlordane, also known as alpha-chlordane and gamma-chlordane, respectively) and three minor compounds (cis-nonachlor, trans-nonachlor, and oxychlordane) derived from technical chlordane and its metabolites.

All possible steps should be taken to ensure that the reporting limits (RL) are at, or below the DMMP SLs presented in Table 7, and meet the SQLs where possible. If it is not possible to bring RLs below the SLs, the raw data should be carefully reviewed to determine if non-detects can be reported at the MDL. Detected analytes at concentrations between the MDL and RL should be J-flagged as estimated values. Method detection limits and RLs will be reported for all non-detects. If the analytical laboratory encounters difficulty reaching the required screening limits the technical project managers at Walla Walla District and the DMMO should be notified immediately.

Table 7. Laboratory methods, SQLs, and screening limits (SL) for the sediment analyses.

Reference Sample	All Other DMMUs	Parameter	CAS	Prep Method	Method	SQL[1]	SL1
		CONVENTIONALS					
X	X	Grain analysis (%)[2]	NA	---	ASTM D422 mod	1	---
X	X	Total solids (%)	NA	---	APHA 2540-G	0.1	---
X	X	Total Sulfides (mg/kg)	NA	---	PSEP 1986/ Plumb 1981	1.0	---
X	X	Ammonia (mg/kg)	NA	---	Plumb 1981	0.1	---
X	X	Total organic carbon (%)	NA	PSEP 1997	EPA 5310B mod or EPA 9060	0.1	---
		METALS (MG/KG DRY WEIGHT)					
X		Antimony	7440-36-0	EPA 6010/6020	EPA 6010/6020	0.5	150
X		Arsenic	7440-38-2	"	"	5	14
X		Cadmium	7440-43-9	"	"	2.1	2.1
X		Chromium	7440-47-3	"	"	5	72
X		Copper	7440-50-8	"	"	5	400
X		Lead	7439-92-1	"	"	5	360
X		Mercury	7439-97-6	EPA 7471	EPA 7471	0.1	0.66
X		Nickel	7440-02-0	EPA 6010/6020	EPA 6010/6020	5	26
X		Selenium	7782-49-2	"	EPA 6020/7440	---	3
X		Silver	7440-22-4	"	EPA 6010/6020	0.5	0.57
X		Zinc	7440-66-6	"	"	5	3,200
		POLYNUCLEAR AROMATIC HYDROCARBONS (PAHS; µG/KG)					
		LOW-MOLECULAR WEIGHT PAHS					
X		Naphthalene	91-20-3	EPA 3550-mod	EPA 8270D	20	500
X		Acenaphthylene	208-96-8	"	"	20	470
X		Acenaphthene	83-32-9	"	"	20	1,100
X		Fluorene	86-73-7	"	"	20	1,000
X		Phenanthrene	85-01-8	"	"	20	6,100
X		Anthracene	120-12-7	"	"	20	1,200
X		2-Methylnaphthalene	91-57-6	"	"	20	470
		HIGH-MOLECULAR WEIGHT PAHS					
X		Fluoranthene	206-44-0	EPA 3550-mod	EPA 8270D	20	11,000
X		Pyrene	129-00-0	"	"	20	8,800
X		Benz(a)anthracene	56-55-3	"	"	20	4,300
X		Chrysene	218-01-9	"	"	20	5,900
X		Benzofluoranthenes (b, j ,k)	205-99-2	"	"	20	600
X			205-82-3	"	"	20	
X			207-08-9	"	"	20	

Table 7. Laboratory methods, SQLs, and screening limits (SL) for the sediment analyses (continued).

Reference Sample	All Other DMMUs	Parameter	CAS	Prep Method	Method	SQL	SL1
X		Benzo(a)pyrene	50-32-8	"	"	20	3,300
X		Indeno(1,2,3-c,d)pyrene	193-39-5	"	"	20	4,100
X		Dibenz(a,h)anthracene	53-70-3	"	"	20	800
X		Benzo(g,h,i)perylene	191-24-2	"	"	20	4,000
		CHLORINATED HYDROCARBONS (µG/KG)					
X		1,4-Dichlorobenzene	106-46-7	EPA 3550-mod	EPA 8270D	20	110
X		1,2-Dichlorobenzene	95-50-1	"	"	20	35
X		1,2,4-Trichlorobenzene	120-82-1	"	"	20	31
X		Hexachlorobenzene (HCB)	118-74-1	EPA 3550/3540	EPA 8270D/8081	10	22
		PHTHALATES (µG/KG DRY WEIGHT)					
X		Dimethyl phthalate	131-11-3	EPA 3550-mod	EPA 8270D	20	46
X		Diethyl phthalate	84-66-2	"	"	20	200
X		Di-n-butyl phthalate	84-74-2	"	"	20	380
X		Butyl benzyl phthalate	85-68-7	"	"	20	260
X		Bis(2-ethylhexyl) phthalate	117-81-7	"	"	100	500
X		Di-n-octyl phthalate	117-84-0	"	"	20	39
		PHENOLS (µG/KG DRY WEIGHT)					
X	X	Phenol	108-95-2	EPA 3550-mod	EPA 8270D	20	120
X	X	2-Methylphenol	95-48-7	"	"	20	63
X	X	4-Methylphenol	106-44-5	"	"	20	260
X	X	2,4-Dimethylphenol	105-67-9	"	"	20	29
X	X	Pentachlorophenol	87-86-5	"	"	100	1,200
		MISCELLANEOUS EXTRACTABLES (µG/KG DRY WEIGHT)					
X		Benzyl alcohol	100-51-6	EPA 3550-mod	EPA 8270D	50	57
X	X	Benzoic acid	65-85-0	"	"	100	2,900
X		Dibenzofuran	132-64-9	"	"	20	200
X		Hexachlorobutadiene	87-68-3	EPA 3550/3540	EPA 8270D/8081	10	11
X		N-Nitrosodiphenylamine	86-30-6	EPA 3550-mod	EPA 8270D	20	28
X		beta-Hexachlorocyclohexane	319-85-7	"	"	---	7.2

Table 7. Laboratory methods, SQLs, and screening limits (SL) for the sediment analyses (continued).

Reference Sample	All Other DMMUs	Parameter	CAS	Prep Method	Method	SQL	SL1
		PESTICIDES (µG/KG DRY WEIGHT)					
X		4,4'-DDD	72-54-8	EPA 3540	EPA 8081B	2	310
X		4,4'-DDE	72-55-9	"	"	2	21
X		4,4'-DDT	50-29-3	"	"	2	100
X		Aldrin	309-00-2	"	"	2	9.5
X		Carbazole	86-74-8	"	"	900	900
X		Chlordane compounds(3)	5103-71-9	"	"	2	2.8
X		Dieldrin	60-57-1	"	"	2	4.9
X		Endrin ketone	53494-70-5	"	"	8.5	8.5
X		Heptachlor	76-44-8	"	"	1.5	1.5
X		Lindane	58-89-9	"	"	2	---
X		Toxaphene(4)	8001-35-2	---	EPA 8081LL	4.98	25
X		TOTAL PCBS (AROCHLORS)	---	EPA 3540	EPA 8082	10	110

Notes:

(1) All sample quantitation limits are expressed on a dry-weight basis.

(2) ASTM sieve numbers 4, 10, 20, 40, 60, 140, 200, and 230.

(3) Chlordane compounds include cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, and oxychlordane; in samples with interference from PCBs, the SQLs for cis- and trans-nonachlor and oxychlordane may be elevated.

(4) The MDL, identified as the SQL, for toxaphene using EPA Method 8081LL is 4.98 µg/kg and the reporting limit, identified as the SL1, is 25µg/kg.

mg/kg = milligrams per kilogram; µg/kg = micrograms per kilogram; ng/kg = nanograms per kilogram

6.2 Bioassays

The project requires biological testing of the six (6) DMMU composite samples and one (1) reference sediment sample. Bioassays will be conducted by NAS at its Newport, OR facility, and will be the following tests:

- 20-day *Chironomus dilutes* survival and growth test
- 10-day *Hyalella azteca* survival test

Bioassay testing will be initiated as soon as possible after receipt of the samples at the laboratory; anticipated to be within three days of sample collection. This includes obtaining test organisms and control and reference sediments in a timely manner. Prior to testing all bioassay sediment samples will be stored at 4°C with no head space, (i.e., anaerobic environment). All bioassays, including retests, will commence within 56 days from the collection/processing of the first sediment core sample in the sediment composite to be tested. The laboratory will maintain CoC procedures throughout biological testing.

Testing protocols as required by the Regional Sediment Evaluation Framework are either the ASTM (ASTM 2001 or EPA (USEPA 2000) standards. NAS uses a combination of those methods; the NAS test protocol is attached to this addendum.

Interpretive criteria for the bioassays are presented in Table 8. Statistical differences will be evaluated using the DMMO-developed program Bio-Stat.

7.0 QUALITY CONTROL AND QUALITY ASSURANCE

7.1 Field Quality Control and Quality Assurance

Additional QA/QC samples will be collected in the field in association with the execution of this sampling and analysis plan. Sample types include duplicates and equipment blanks:

- One field duplicate will be collected from a selected homogenized sample and submitted to the laboratory as a new sample location (see Table 6 for sample ID). A field duplicate of DMMU-6 is planned as it was found to have levels of 4-methylphenol and phenol above the Screening Level.
- Split samples from DMMUs 1 and 6 will be collected and sent to a second certified laboratory for analyses.
- One equipment wipe blank will also be collected. The equipment wipe will consist of wiping down the sampling equipment after sample collection and decontamination with a clean, ashless, Whatman Grade No. 541 filter paper and placing it into a sample jar. The filter blank will be prepared by placing a clean piece of ashless Whatman Grade No. 541 filter paper directly into a sampling container. The blanks will be archived and analyzed only in the event of questionable data.

7.2 Analytical Laboratory Quality Control

The frequency of analysis for laboratory QA/QC samples is summarized in Table 9. When analyzing semi-volatile organic compounds (SVOCs), pesticides (PCBs), metals, and conventional parameters, the DMMP requires that initial calibrations must be completed before any samples are analyzed, after each major disruption of equipment, and when ongoing calibration fails to meet acceptance guidelines. Ongoing calibration is required before and after every 10 to 12 samples or every 12 hours (whichever is more frequent).

Surrogates are required (organics only) for every sample, including matrix spike samples, blanks, laboratory control samples (LCS), and standard reference materials. Matrix spike and matrix spike duplicates are required for SVOCs and pesticides/PCBs at a rate of 5% or one per sample batch. Matrix spikes and laboratory duplicates will be analyzed for samples requiring metals analyses. Matrix triplicates will be analyzed for conventional parameters.

All samples will be diluted and re-analyzed if target compounds are detected at levels that exceed their respective established calibration ranges. Any cleanups will be conducted prior to the dilutions. Re-analyses will be performed if surrogate, internal standard, or spike recoveries are outside of the data quality objective parameters. QC samples may be re-analyzed if results are not within control limits and it cannot be determined that the sample matrix is the cause.

Table 10 provides the warning and action limits that have been adopted by the DMMP agencies. These QA limits are as consistent as possible with the Puget Sound Estuary Program (PSEP) and the EPA Contract Lab Program (CLP).

7.3 Bioassay Laboratory Quality Control

Appropriate QA/QC controls will include negative controls, positive controls, and the reference sediment. QA/QC limits, along with bioassay interpretive guidelines, are shown in Table 8. NAS uses sediment as the clean negative control that it collects from Beaver Creek, approximately 8 miles south of Newport, OR. The positive control, or reference toxicant, LC50 or EC50 will be within the 95 percent confidence interval of previous responses observed by NWAS.

QA/QC review of bioassays will follow the methods in the USACE Quality Assurance/Quality Control (QA/QC) Guidance for Laboratory Dredged Material Bioassays (USACE 1994).

Table 8. Bioassay performance standards and interpretive criteria.

Toxicity Test	Negative Control Performance Standard	Reference Sediment Performance Standard	1-Hit Criteria	2-Hit Criteria
Hyalella azteca 10-day mortality	Mortality ≤ 20%	Mortality ≤ 25%	Mortality > 25% over reference Statistically different from reference sediment (p = 0.05)	Mortality > 10% over reference Statistically different from reference sediment (p = 0.05)
Chironomus dilutus 20-day mortality	Mortality ≤ 32%	Mortality ≤ 35%	Mortality > 25% over reference Statistically different from reference sediment (p = 0.05)	Mortality > 15% over reference Statistically different from reference sediment (p = 0.05)
Chironomus dilutus 20-day growth	Mean individual growth/day ≥ 0.48 mg/day	Mean individual growth rate ≥ 80 percent of the control sediment	Mean growth rate < 60% reference Statistically different from reference sediment (p = 0.05)	Mean growth rate < 75% reference Statistically different from reference sediment (p = 0.05)

NOTE TO THE DMMO REVIEWERS: THIS TABLE IS A PLACE HOLDER. WE AWAIT CLARIFICATION BASED ON THE EMAIL WE SENT TO THE DMMO ON 10/24/2013.

Table 9. Analytical laboratory QA/QC requirements.

Analysis Type	Method Blanks[1]	Replicates[1]	Triplicates[1]	CRM/RM	MS/MSD[1]	Surrogates[2]	Split Sample
Semivolatiles [3,4]	X[5]	X[6]		X	X	X	X
Pesticides/PCBs [3,4]	X[5]	X[6]		X	X	X	
Metals	X	X		X	X		
Ammonia	X		X				
Total sulfides	X		X				
Total Organic Carbon	X		X	X			
Total Solids			X				
Particle size			X				

Notes:

CRM = Certified Reference Material; RM = Reference Material; MS/MSD = matrix spike/matrix spike duplicate

1 Frequency of Analysis (FOA) = 5 percent or one per batch, whichever is more frequent
2 Surrogate spikes required for every sample, including matrix spiked samples, and reference materials
3 Initial calibrations required before any samples are analyzed, after each major disruption of equipment, and when ongoing calibration fails to meet criteria.
4 Ongoing calibration required at the beginning of each work shift, every 10-12 samples, or every 12 hours (whichever is more frequent) and at the end of each shift.
5 FOA = one per extraction batch
6 Matrix spike duplicates may be used

Table 10. DMMP warning and action limits.

QA Element	Warning Limits	Action Limits
Precision		
Conventionals:	None	20% COV
Metals:	none	20% RPD or COV
Organics:	35% RPD or COV	50% COV or a factor of 2 for duplicates
Matrix Spikes		
Metals:	none	75-125% recovery
Organics:		none (zero percent recovery may be cause for data rejection however)[1]
Semivolatiles and Pesticides:	50-150%	
Reference Materials		
Metals:	none	95% CI if specified for a particular CRM; 80-120% recovery if not.
Organics:	none	95% CI for CRMs. No action limit for uncertified RMs.
Surrogate Spikes		
Organics:		EPA CLP chemical-specific recovery limits
Pesticides:	60% minimum recovery	
Semi-volatiles:	50% minimum recovery	

Notes:

(1) Rigorous control limits are not recommended due to possible matrix effects and interferences.

8.0 DATA ANALYSIS AND REPORTING

8.1 Intermediate Data Deliverables

Daily field activity reports will be sent electronically to the point of contact at Walla Walla District.

As preliminary laboratory data become available, the tabulated results will be made available to the DMMO. For the analytical laboratory results, a table showing the station results relative to the SL1 guidelines shown in Table 7 will be prepared and e-mailed to the DMMO for review and distribution to the agencies. The accompanying laboratory QA/QC data reports will also be provided; the external validation report will be provided with the final report. The purpose of providing these data is to allow the DMMP agencies to determine if there are any additional stations with SL1 exceedances.

Upon completion of the bioassay data compilation, those data will also be tabulated and provided to the DMMO. This intermediate deliverable will consist of a draft table showing the results for each of the bioassays, including control, reference, and test stations relative to the guidelines shown in Table 8. Should any problems arise that are communicated from NAS to the Contractor Team (e.g., control or reference failures), these will be reported immediately to the DMMO.

8.2 Laboratory Reports

Both the contract analytical and bioassay laboratories will prepare a detailed report that will be excerpted as appendices in the final Sampling and Analysis Report documenting all activities associated with the sample analyses. Included in this report will be:

- Project Narrative: A detailed report that describes the samples received, analyses performed, any issues with analyses and corrective actions undertaken.
- Chain-of-Custody Documentation: Laboratory policy requires that chain-of-custody documentation be available for all samples received. The chain-of-custody will document basic sample demographics such as client and project names, sample identification, analyses requested, and special instructions.
- Data Summary Form: A tabular listing of concentrations and/or detection limits for all target analytes. The data report will also list other pertinent information such as the amount of sample analyzed, dilution factors, sample processing dates, extract cleanups, and surrogate recoveries.
- QA Summary: Includes results of all quality control analyses, specifically recovery information. Laboratory control samples are reported with each batch. Additional QC analysis may include laboratory replicates, matrix spikes, and standard reference materials.
- Instrument Calibration Forms and Raw Data: Includes initial and continuing calibration summaries and instrument tuning data, laboratory bench sheets, and log book pages.

The laboratories will also provide deliverables in the Department of Ecology's EIM format.

8.3 Sampling and Analysis Results Report

Submittal of sampling and analysis data report will follow the requirements that listed in the DMMP User's Manual (Section 6.7) which will include:

- Sediment Characterization Report (electronic copies)
- Data in Ecology's EIM format

The final report will document all activities associated with collecting, compositing, transporting, and chemically analyzing sediment samples. The chemical, biological, and QA/QC reports, as well as the field logs will be included as appendices.

At a minimum, the following will be included in the final report:

- Summary of all field activities including a description of any deviations from the approved SAP.
- Locations of sediment sampling stations in state plane coordinates (NAD 83) to the nearest foot, and in latitude and longitude in degrees and minutes to three decimal places. All vertical elevations of mud line and water surface will be reported to the nearest 0.1 foot relative to MOP NAVD29.
- A project map with target and actual sampling locations.
- A QA/QC narrative for chemical testing.
- Summary data results tables, including explanation of all data qualifiers, MRLs, and MDLs.
- Tabular comparison and summary within the report text of chemical analytical results with DMMP guidance.
- As appendices, electronic copies of field data, laboratory analysis results, associated QA/QC, and approved SAP will be included.

9.0 REFERENCES

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Lower Snake River Programmatic Sediment Management Plan Environmental Impact Statement

Appendix I

Water Quality and Sediment Quality Reports

Section 2C. Data Report, 2013 Lower Snake/Clearwater River Sediment Sampling and Analyses

Appendixes — *available upon request*

Lower Snake River Programmatic Sediment Management Plan Environmental Impact Statement

Appendix I

Water Quality and Sediment Quality Reports

August 2014

Section 2C. Data Report, 2013 Lower Snake/Clearwater River Sediment Sampling and Analyses

Prepared for U.S. Army Corps of Engineers
Walla Walla District

By Science and Engineering for the Environment

January 2014

Data Report

2013 Lower Snake/Clearwater River Sediment Sampling and Analysis

Contract W9112DW-12-D-1002
Contract W912EF-13-D-0006

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January 30, 2014

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1.0 INTRODUCTION

This data report presents the results of sediment sampling, along with chemical, geophysical and bioassay testing, conducted by Science and Engineering for the Environment LLC (SEE), with Dalton, Olmsted and Fuglevand (DOF) Inc. and Resource Management Group (RMG). This work was initiated under USACE Contract W9112-DW-12-D-1002 to DOF, and completed under Contract W912EF-13-D-006 to RMG.

The objective of the work was to characterize sediments in the federally authorized navigation channel within the Lower Snake and Clearwater Rivers located at Clarkston, WA and Lewiston, Idaho. The purpose of these task orders was to provide supplemental information to data obtained from most of the same areas in 2011. The complimentary data will be used by the U.S. Army Corps of Engineers Walla Walla District (Corps) and the Dredged Material Management Office (DMMO) to establish whether the material is suitable for unconfined open-water disposal in the Lower Snake River. As such, the field sampling and laboratory analyses must adhere to the protocols set forth in the sample analysis plan, *the Dredged Material Evaluation and Disposal Procedures* (USACE et al. 2009a), and the *Sediment Evaluation Framework for the Pacific Northwest (SEF)* (USACE et al 2009b).

Two separate sampling and analysis events occurred: August, and then again in November 2013. The first event collected sediments and analyzed only for chemicals of concern. The second event focused on a subset of the stations sampled in August where phenolic compounds exceeded the allowable in-water disposal guidelines. These additional collections were subjected to additional chemical and biological analyses.

The following sections provide a brief description of the project, the sample collection methods, changes and additions to the sampling plan, a summary of the actual sampling locations, and the results of the sediment conventional and chemical analyses with the results compared to draft freshwater sediment quality standards that were provided by the DMMO.

1.1 PROJECT DESCRIPTION

The focus of this characterization study is three areas located at the confluence of the Snake and Clearwater rivers in Lower Granite reservoir; the Federal channel (Snake River mile (RM) 138 to Clearwater RM 2), and the berthing areas for the Port of Lewiston (Idaho) (Clearwater RM 1-1.5) and the Port of Clarkston (Washington) (Snake RM 137.9 - 139) (Figure 1-1). The Corps identified a location in the Lower Granite reservoir, Snake RM 116 just upstream of Knoxway Canyon, as the preferred in-water discharge site of the dredged materials. The Corps proposes to use the dredged material to create additional shallow water habitat for juvenile salmonids, subject to funding.

Maintenance dredging is proposed to meet the immediate need to provide a 14-foot deep navigation channel, plus two foot over-dredge, as measured at minimum operating pool (MOP). MOP at the confluence of the Snake and Clearwater Rivers is identified as an elevation of 733 ft National Geodetic Vertical Datum of 1929 (NGVD29). The maximum dredge-to elevation is 717 ft NGVD29. The August SAP notes that shoaling in the channel and port berthing areas of

the Snake/Clearwater River is impacting the commercial facilities at the Port of Clarkston (on the Snake River) and the Port of Lewiston (on the Clearwater River) (Figure 1-2).

A complete description of the proposed dredging and creation of the shallow water habitat using dredged materials may be found in the *Sampling and Analysis Plan for Lower Snake and Clearwater Rivers Proposed 2013/2014 Channel Maintenance Dredging* (August SAP) (Appendix A1). The need for additional sampling, and procedures followed, is found in the *Supplemental 2013 Sediment Collection and Laboratory Analyses of the Lower Snake and Clearwater Rivers* (November SAP) (Appendix A3). The Dredged Material Management Units (DMMUs), and the volumes of dredged materials represented by each unit, are provided in Table 1-1. The number and types of samples (grab vs. core samples) may be found in Table 9 of the August SAP. The physical sampling locations are discussed further in Section 3 of this report.

1.2 REPORT ORGANIZATION

This report is organized by section as described below. The entire report is provided in electronic format on a DVD to the Corps. Sections 1 – 8 are provided as a single report in pdf format. Appendices A – L are only provided as electronic data on the DVD.

- Section 1.0 – Introduction
- Section 2.0 – Project Team
- Section 3.0 – Field and Laboratory Methods
- Section 4.0 – August 2013 Sampling Results
- Section 5.0 – November 2013 Sampling and Analytical Results
- Section 6.0 – November 2013 Bioassay Results
- Section 7.0 - Summary
- Section 8.0 – References

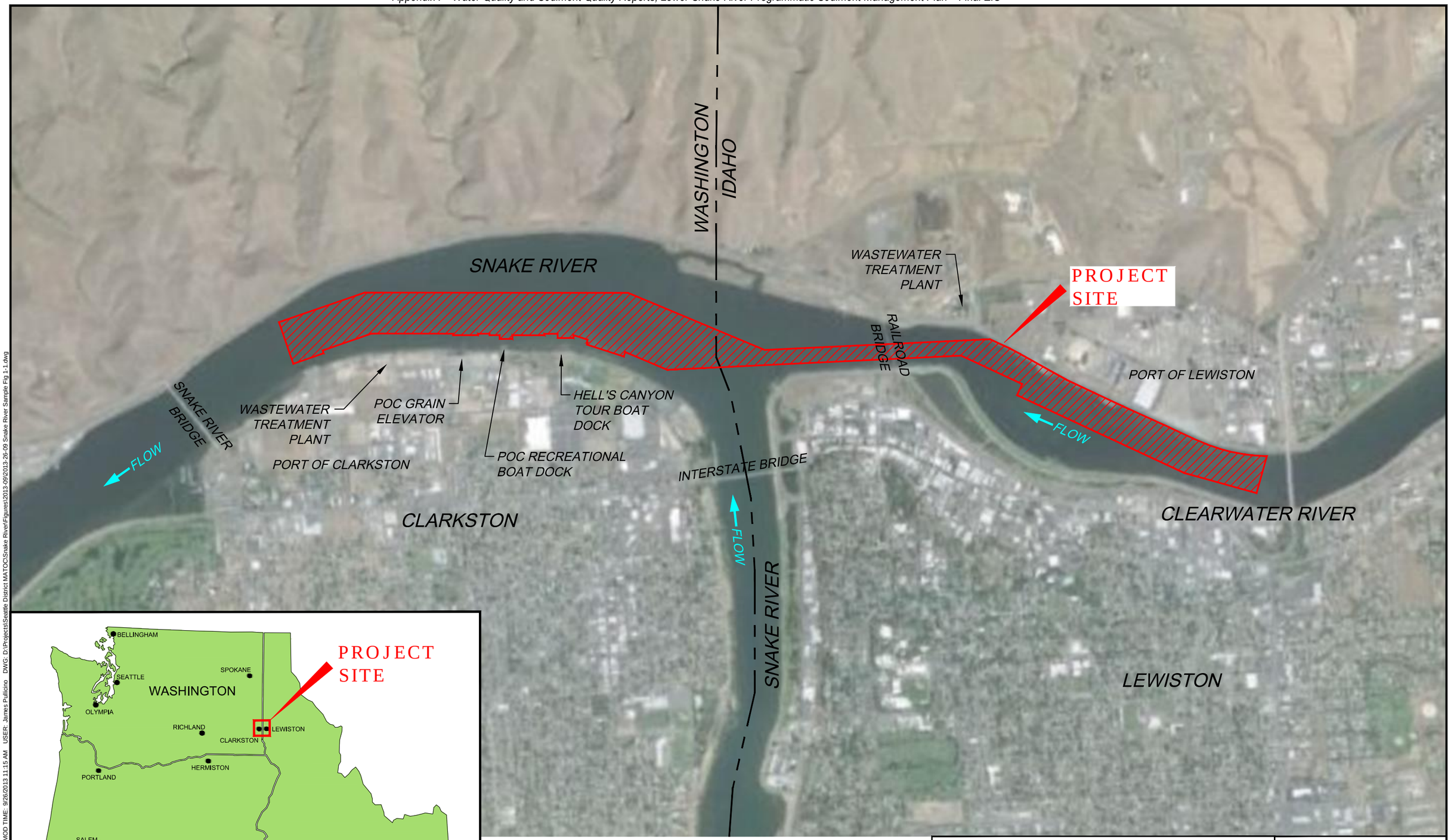
- Appendices
  - Appendix A – Sampling Plans
    - A1 – DMMO April 23, 2013 Memorandum
    - A2 - USACE Sampling and Analysis Plan
    - A3 - USACE Scope of Work 2013 Lower Snake/Clearwater River Sediment Sampling and Analyses For Proposed Dredging
    - A4 - Supplemental 2013 Sediment Collection and Laboratory Analyses of the Lower Snake and Clearwater Rivers
  - Appendix B – Field Daily Reports
    - Appendix B1 – August Sampling Reports
    - Appendix B2 – November Sampling Reports
  - Appendix C – Site Health and Safety Plan
  - Appendix D – Field Notebook
    - Appendix D1 – August Field Notebook
    - Appendix D2 – November Field Notebook
  - Appendix E – Sediment Collection Logs
    - Appendix E1 – August Sediment Collection Logs
    - Appendix E2 – November Sediment Collection Logs
  - Appendix F – August Sediment Core Logs
  - Appendix G
    - Appendix G1 – August Sediment Grab Sample Photographs
    - Appendix G2 – August Sediment Core Photographs
    - Appendix G3 – November Sediment Grab Sample Photographs
  - Appendix H – Chain-of-Custody Forms
  - Appendix I – ARI Data Reports
  - Appendix J – ALS Data Report
  - Appendix K – Data Validation Reports
  - Appendix L – Bioassay Data Reports
    - Appendix L1 – NWAS Data and Report
    - Appendix L2 – Bioassay Data Validation Report
  - Appendix M – Electronic Data Deliverable

Table 1-1 Dredging quantities for each DMMU in the proposed channel maintenance project.

Area to be Dredged	DMMU	Quantity at 16 ft[1,2] (yd^3)
FNC Clarkston West	1	57,818
	2	60,167
	3	55,453
FNC Clarkston East	4	57,849
	5	52,221
	6	20,948
FNC Clearwater	7	6,187
	8	11,261
FNC Lewiston	9	55,591
	10	58,284
	11	26,367
Port of Clarkston Grain Elevator	Same as Area[2]	3,218
Port of Clarkston Rec. Dock	Same as Area[2]	1,036
Port of Clarkston Cruise Dock	Same as Area[2]	9,041
Port of Lewiston	Same as Area[2]	4,485
TOTAL		**479,926**

Notes:

1. DMMU 1-7 volumes based on removal to 16 ft below MOP using August 2013 survey data
2. DMMU 8-11, Port of Clarkston, and Port of Lewiston volumes based on removal to 16 ft below MOP using November 2012 survey data



SNAKE RIVER VICINITY MAP

DALTON OLMSTED FUGLEVAND

FIGURE
1-1

SEPTEMBER 27, 2013

PLOT TIME: 9/27/2013 10:17 AM MOD TIME: 9/26/2013 11:15 AM USER: James Pullicino DWG: D:\Projects\Seattle District MATOC\Snake River\Figures\2013-09\2013-26-09 Snake River Sample Fig 1-1.dwg

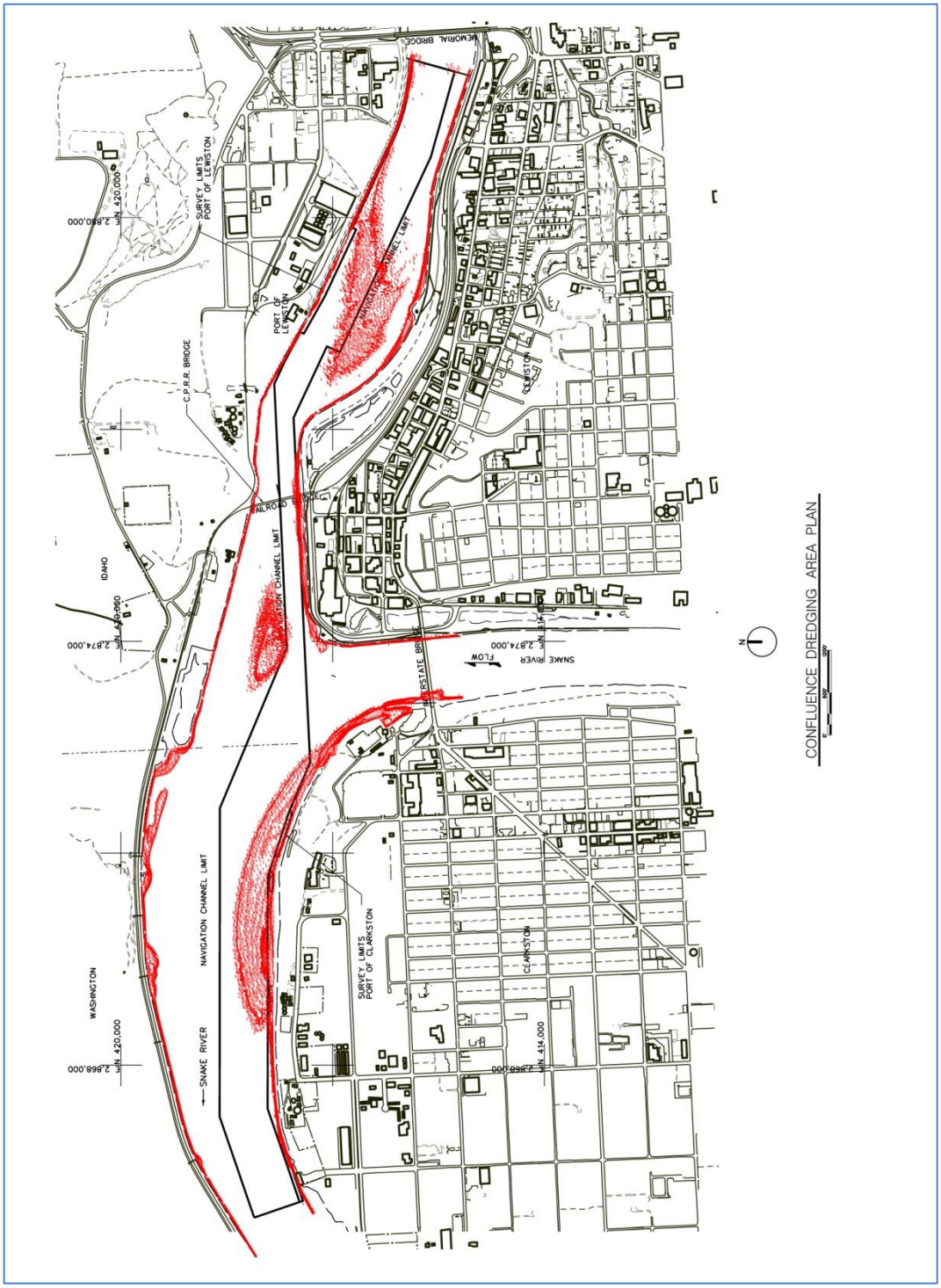


Figure 1-2 Shoaling locations at the Snake/Clearwater Rivers confluence (Areas to be dredged are the red areas within the black navigation channel limit lines).

2.0 PROJECT TEAM

The U.S. Army Corps of Engineers, Walla Walla District, is the lead federal agency for the overall characterization, dredging, and disposal of the sediments. The Corps contracted with DOF to conduct the August sediment sampling. The Corps subsequently contracted with RMG to conduct the November sampling and analyses. The team organization and responsibilities, as articulated in the respective SAPs, is described below.

2.1 USACE PROJECT LEAD

The Corps Project manager is Richard Turner at the Walla Walla District. The SAP was prepared by Steve Juul and Sandra Shelin in the water/sediment quality and environmental compliance sections, respectively. Steve Juul was the main technical lead that interacted with DOF personnel in the field.

2.2 CONTRACTOR LEAD

Ms. Nancy Case O'Bourke was the Contractor Project Manager (PM) for DOF. As the PM her responsibilities included implementing the project activities, monitoring the project progress, and interacting with the Corps. The PM was also responsible for planning, scheduling, cost control, and completion of project tasks. The PM also had overall responsibility for monitoring the quality of the technical and managerial aspects of the project, and ensuring the timeliness of all project deliverables.

Mr. Doug Thompson was the Contractor Project Manager for RMG. The PM responsibilities were assigned to Tim Thompson of SEE for the November sampling and analyses.

2.3 SUBCONTRACTORS

2.3.1 Technical Lead

Mr. Tim Thompson of Science and Engineering for the Environment (SEE) served as the Contract Team Technical Lead (CTL) for DOF, and as the CTL and PM for RMG. SEE is a small business enterprise located in Seattle, Washington. The CTL served as a secondary point of contact for the prime contractor and the Corps, and provided the overall technical direction in consultation with the Corps. The CTL was responsible for executing the work plans, coordinating with and assisting the field collection team, ensuring that the data from the analytical laboratory meets the program requirements, and leading the data interpretation and report writing. The CTL also functioned as the Site Safety Officer and was responsible for the safe operation of the field team.

2.3.2 Professional Geologist

Mr. David Browning of Browning Environmental Services (BES) was the professional geologist assigned to ensure the correct logging of sediment grab samples and cores. BES is a small business enterprise located in Olympia, Washington. Mr. Browning assisted in the

performance of field operations, including adherence to the SAP, scheduling, sample collection, logging, and custody.

2.3.3 Field Support Services

Marine Sampling Systems (MSS) supplied the sampling vessel *R/V Peter R*, the power grab sampler, the vibracore system, the ship captain and field assistance. MSS is a small business enterprise, owned by Mr. Bill Jaworski, and located in Burley, Washington. Mr. Dale Dickinson of MSS was the vessel captain for this effort.

2.3.4 Project Chemist/Quality Assurance Manager

Mr. Mingta Lin of Pyron Environmental (Pyron) was the Project Quality Assurance Manager. Pyron is a small business enterprise located in Olympia, Washington. Mr. Lin was responsible for laboratory coordination, oversight and conducted the quality review (QA1) of analytical data. Pyron wrote the data validation report.

2.3.5 Analytical Laboratory Analyses

Chemical analyses of samples collected in the field were conducted by Analytical Resources, Inc. (ARI) of Tukwila, Washington. Ms. Cheronne Oreiro of ARI was the Project Chemist responsible for metals, organics, and sediment conventional analyses. ARI handled and analyzed the submitted samples in accordance with SEF, DMMP and Puget Sound Estuary Program (PSEP) protocols. Laboratory reports of analytical results and QA/QC procedures are included as appendices in the final data report.

A subset of the sediment samples collected in the August event was sent for comparative analysis to ALS Environmental of Kelso, Washington. Mr. Howard Holmes of ALS was the project chemist responsible for these analyses.

3.0 METHODS

Except as noted in this section, the sampling and analysis activities were conducted according to the procedures defined in documents provided by the Corps (Appendix A); the August SAP, the *Scope of Work (SOW) 2013 Lower Snake/Clearwater River Sediment Sampling and Analyses for Proposed Dredging* that was provided with the *Request for Proposal* (RFP) to DOF, and the November 2013 SAP. These SAPs, which are provided in Appendix A to this report, provide the background, sampling strategy, targeted sample locations, procedures for collecting and compositing the sediments to be characterized, procedures for analyzing the sediments, and data reporting requirements.

The SAPs were written to ensure that the collection, handling, and analysis of representative sediments fully characterize the sediments in accordance with the *Sediment Evaluation Framework for the Pacific Northwest* (SEF) (USACE et al 2009b), the *Dredged Material Management Program User Manual (USACE* 2009a), and reviewed for consistency with the 2013 update to the DMMP *User Manual* and the DMMP quality assurance/quality control (QA/QC) requirements (USACE 1994). The SAP also reflects modifications made through the DMMP annual review process (Sediment Management Annual Review Meetings [SMARM] updates). The November SAP reflects the additional sampling, chemical analyses, and the bioassays methods, organisms, and interpretation standards.

Draft sediment quality standards, called Screening Level 1 (SL1) were first provided by the DMMO in a memorandum dated April 23, 2013. During the SAP review, and during development by the District of the scope of work for sampling, further information received from the DMMP agencies and chemistry laboratories resulted in some modifications of the requirements outlined in the 23 April memo and the approved SAP. A summary of these modifications for the SAP is given in a second memorandum from the DMMO dated January 30, 2014. These memoranda are included with this report in Appendix A1.

The SOW is also cited herein as information pertinent to the collection and analyses of the sediment samples listed in that document was not included in the SAP. This included, for example, specifications for the depth of the z-layer for bioassay sediment collection, SOW Table 3 that specifies specific analyte groups for different DMMUs, and the laboratory sample identifications.

Sediment sampling occurred August 2 – 6, 2013, and then again from November 10 – 13, 2013. Where changes to the sampling and sub-compositing scheme from the SAP occurred, these were pre-coordinated with the Corps prior to sampling, and are documented below. Daily field activity reports were provided to the Corps during both operations; these may be found in Appendix B.

The text below focuses on the August sampling. The November sampling and chemical analyses are discussed in Section 5; the bioassay testing and results are discussed in Section 6.

3.1 HEALTH AND SAFETY

Prior to sediment sampling, DOF developed a site-specific Health and Safety Plan in accordance with federal safety regulations [Occupational Safety and Health Administration (OSHA), 29 CFR 1910 and 29 CFR 1926] and U.S. Army Corps of Engineers (USACE) safety and health requirements (EM 385-1-1 (2008) and ER 385-1-92 (2007)). A copy of the HSP is provided in Appendix C.

There were no injuries or near-miss incidents during this project.

3.2 SAMPLING VESSEL, NAVIGATION AND POSITIONING

A differential global positioning system (DGPS) was used to navigate to, occupy, and document all stations aboard the *R/V Peter R* during each sampling event. A Trimble AG 132 DGPS, utilizing a differential signal from Spokane, Washington was interfaced to an on-board computer running software enabling real-time plan view navigation to the required sampling stations. All station coordinates were recorded in latitude and longitude as decimal minutes with a minimum precision of four decimal places and were based on the North American Datum of 1983 (NAD 83).

To confirm the precision and reproducibility of the navigation system, the SAP required that a horizontal control point be checked daily, and described a survey reference mark at the Hells Canyon Marina. However, according to the marina owners, no such survey reference mark was known to exist. The field crew consulted further with the Port of Clarkston and the Corps; the only known points were geodetic survey control points along the Lower Snake River that were too far upland to be measured by the on-board navigation system. Two fixed points were determined in the field as a daily horizontal measure: a fixed steel pile at the end of the boat launch ramp at Hells Canyon Marina[1], and a light post located within the USACE Lower Granite Natural Resources Office[2] boat bay at Greenbelt Park (Figure 3-1). The fixed coordinates for these two points were post-checked using coordinates from Google Earth and CAD files of the area obtained from the Corps. The results of the daily navigation checks and the offset from the target navigation point for the August sampling are shown on Figure 3-1. The navigation checks were within ±0.5 (range 0.2 – 0.5) meters of the control points, which was within the ±2 meters specification required in the SAP.

Vertical control was established in two ways. First, the Corps maintains a water level gage at the confluence of the Lower Snake and Clearwater Rivers that provides hourly updates on the water level. Lower Granite Lake elevations are reported in ft above mean sea level (amsl) in NGVD29 (called the LWSI gage elevation). Water elevations were obtained by phone[3] regularly throughout the day, and recorded in the field notebook. The second check established a transmitting river elevation gage fixed and calibrated to the river stage gage at the Lower Granite Natural Resources Office boat bay. The specific instrument used was a Hazen gage,

[1] Hells Canyon Resort, 1560 Port Drive, Clarkston, Washington 99403
[2] USACE Management Office, 100 Fair Street, Clarkston, Washington 99403
[3] http://www.nwd-wc.usace.army.mil/nww/rreports.htm Confluence phone line number 208-743-3319

which is a pressure sensor that was fixed to the river stage gage and calibrated with the reported river height at LWSI. The gage was connected to a radio transponder which sent a signal to a receiver on-board the *Peter R*. At each station the corresponding water depths (depth to mudline) were confirmed with a direct lead-line reading, and corrected to MOP elevation (NGVD29) using the readings from LWSI and/or the Hazen gage. Elevation and MOP-corrected elevations are found in the Field Notebook and on the Sediment Drive Logs (Appendices D and E, respectively).

In the field, where the MOP-corrected depth at a target station was found to be at, or deeper than 717 ft amsl, the sample location was moved to a proximal shallower location. As a general rule-of-thumb applied in the field; when locating a station the elevation had to be at least 717.5 ft amsl or greater before a sample was collected, thus ensuring that the sample was collected above the targeted channel depth.

Sample depths were also taken using a lead line immediately prior to sampling, and then again at the final location where the sample was collected, and recorded in the field log book and sediment drive log. Target and actual elevations for the August sampling are listed in Table 3-2.

3.3 SEDIMENT COLLECTION

3.3.1 Sampling Locations

The August 2013 target and actual sampling locations are shown on Figures 3-2 through 3-6. Target and actual station grab-sample coordinates are given in Table 3-1; core locations are given in Table 3-2. A total of 64 sediment grab locations were composited to characterize thirteen Dredged Material Management Units (DMMUs). The DMMUs on the Snake River were labeled DMMUs 1 – 6, and the Port of Clarkston (POC) Grain Elevator (POC Grain Elevator). The DMMUs on the Clearwater River were labeled DMMUs 7 – 11, and the Port of Lewiston (POL). The individual surface samples that were composited for each DMMU are given in Table 3-2. Two additional DMMUs were characterized by composites of two sediment cores per DMMU; POC Recreation Dock and POC Cruise Dock. Collection and compositing of grab samples and cores are discussed further, below.

While every effort was made to sample at the SAP-target coordinates, it was necessary in the field to relocate stations when either there was an obstruction preventing sampling at a coordinate, or when the elevation (depth) at the target coordinate was deeper than the authorized channel depth of 717 ft NAGVD29. Most often, a station was moved to adjust for the target depth. Specific obstructions are discussed further in Section 4.

3.3.2 Decontamination and IDW Procedures

For sediment grab sample collection, prior to sampling within a DMMU the power grab was washed with a cleaning detergent (e.g., Alconox®), and rinsed with site water. Between individual stations of the same DMMU, the grab was simply rinsed with site water. For coring, all core tubes were pre-cleaned with detergent, thoroughly rinsed, and then capped until just prior to sampling.

The composite bowl and spoons were subject to a more thorough decontamination procedure than what was described in the SAP. For all subsampling equipment (e.g., stainless steel bowls and utensils), the equipment was first cleaned with site water and detergent, using a brush to remove particulate matter, and then rinsed with deionized water (DI). The equipment was then rinsed with isopropyl alcohol, followed by DI, then a 1% nitric acid rinse, rinsed again with DI, and wrapped or covered with aluminum foil until use.

Investigation-Derived Wastes (IDW) were handled appropriately. All residual collected grab or core sediments were disposed of back into the river. Alconox® is non-toxic and can be rinsed overboard, or discarded down a sink. All isopropyl alcohol and nitric acid, and rinse water for those chemicals was collected in a marked, lidded bucket. On the last day of sampling, the lid was left off the bucket in a safe, dry place, and allowed to evaporate. For the little liquid remaining, the nitric acid was neutralized with baking soda, and the isopropyl alcohol and rinse water were diluted and disposed of in the city treatment system. All gloves, towels, and other equipment were collected and appropriately disposed of as trash. The processed aluminum core tubes were cleaned, and recycled.

3.3.3 Sediment Grab Samples

Surface sediment was defined as the top 10 cm of material in the sediment column. For the surface sediment grab samples a 0.1 m^2 hydraulic Power Grab was used. Field notebooks and sediment drive logs were maintained for each sample collected during the project, including those stations where the sample was rejected. The field notebook is reproduced in Appendix D; the sediment drive logs are found in Appendix E. Surface sediment collection was conducted according to the SAP for grab samples collected at the 64 individual locations and composited according to the DMMUs as listed in Table 3-2.

For each grab, the time, location, nominal water depth, and MOP-corrected elevation were noted on the sediment drive log (Appendix E) and in the field notebook (Appendix D). Samples were evaluated for acceptability according to the criteria in the SAP, and if acceptable, a photograph (Appendix G1) was taken and observations about the sediments (physical conditions, odors, color, biota, etc.) were recorded on the drive log (Appendix E). Samples for total sulfides analysis were collected from discrete grabs. Based upon the number of grab samples making up the DMMU, approximately equal volumes of sediment were taken from each grab, and the bowl held on ice until all samples were collected. At that point, the collected sediment was homogenized until uniform in physical consistency and color and then placed in appropriately labeled sample containers. All samples were kept on ice through transport to ARI.

3.3.4 Vibracore Sediment Collection

Cores were collected using MSS' vibracore system that uses 4-inch inner-diameter decontaminated aluminum core tubes. Cores were collected for DMMUs for the Port of Clarkston Cruise Dock and the Recreation Dock. A continuous core sample was collected by driving the core tube the length required to achieve the target elevations in the SAP. The length of the core drive was recorded, and once retrieved acquisition was determined by measuring the amount of sediment within the core tube. Percent recovery was recorded as recovery length

divided by drive length multiplied by 100. Once measured, the cores were either left intact, or cut into intact 4- to 6-ft lengths for transport to the processing laboratory. Each section was covered with aluminum foil, capped to prevent leakage of porewater, and the ends duct-taped to secure the caps. Each segment was labeled with station name, replicate, time, date, interval below mudline, and a direction arrow indicating the direction to the top of the tube. Cores were stored upright until processing.

Field notebooks and sediment drive logs were maintained for each core collected during the project. The field notebook is reproduced in Appendix D; the sediment drive logs are found in Appendix E. A high standard for percent recovery was set in the SAP: 80% recovery was the target for each core. The average percent recovery across all accepted cores was 84%, with a range of 52.1% to 100% recovery. Samples that were accepted with less than 80% recovery were collected after three or more unsuccessful attempts.

Additional observations on core collection are discussed in Section 4.

3.3.5 Core Processing

Sectioning, logging, subsampling, and compositing of the core samples was done at the Corps' secure facility in Clarkston. The cores were collected on August 5 – 6, and stored upright, and packed in ice at the facility until processed.

Core segments were cut longitudinally by scoring each segment lengthwise and then splitting the tube to expose the sediment. All processing occurred on a foil-covered processing table. The time, date, personnel present, sediment type, stratigraphic features, and the presence or absence of any visible contamination was recorded in the core log for each core. Core logs are discussed further in Section 4, and are found in Appendix F. Photographs of each core segment were taken (Appendix G). Each core photograph included a label denoting station, replicate, time and date, and a scale (tape measure) showing depth below mud surface. Each core was logged for lithology by the project geologist, and those observations recorded in the sediment coring log (see Appendix F).

3.3.6 Field Quality Control Samples

Field replicate samples and sufficient volume for matrix spike/matrix spike duplicate (MS/MSD) samples were collected from selected stations and submitted to the laboratory to provide a means of assessing the quality of data resulting from the field sampling program. QC sample requirements are presented in Table 20 of the SAP, and are discussed further below.

Blind Split Samples

Blind split samples (field duplicates) were collected to evaluate laboratory analytical reproducibility. For this program, two separate samples from the homogenate for location DMMU 9 were sent to ARI labeled as DMMU 9, and DMMU12. QC criteria and calculations for reporting the relative percent difference (RPD) of field replicate samples are described in the Data Validation Report (Appendix K).

While not listed as a QC sample in the SAP, in consultation with the Corps and the DMMO, field replicates for ammonia, total sulfides, TOC, total solids and particle size were added to the list of analytes.

Matrix Spike/Matrix Spike Duplicates (MS/MSD)

MS/MSD samples are used to assess sample matrix interferences and to measure the accuracy and precision of the analyses. Known concentrations of analytes are added to environmental samples. The spiked samples are then processed through the entire analytical procedure and the recovery of the analytes is calculated. Results are expressed as percent recovery of the known spiked amount (and RPD for MS/MSD pairs). The field-designated MS/MSD sample was the Port of Lewiston grab sample. While it was not recorded on the chain-of-custody form, it was clearly noted on the sample bottles and subsequently identified by both ARI and SEE.

Equipment Wipe

As required by the SAP, an equipment wipe was collected after a decontamination sequence. Whatman Grade No. 541 filter paper was wiped over the sample compositing equipment, and placed in a clean chemical analyses jar and sent under Chain-of-Custody and archived at ARI. The equipment wipe sample was not analyzed for this report.

3.3.7 Sample Shipping and Chain-of-Custody

After compositing the samples were placed in plastic Zip-lock® bags and then into ice coolers and held on ice in a secure location until shipment/transport to the laboratory. A single temperature blank was included with each shipment. Sample shipping and handling followed procedures described in the SAP. Chain-of-Custody records are found in Appendix H.

Two batches of samples were sent to ARI under chain-of-custody and custody seals. One batch was sent via Federal Express and arrived safely at ARI within 24 hours of shipping. The second batch was transported directly by the field crew to ARI after demobilization.

3.4 PHYSICAL AND CHEMICAL ANALYSES

Conventional and sediment chemical analyses proceeded as described in the SAP. There were no significant variances to the procedures. The results of the chemical analyses were compared to the *Screening Level 1* (SL1) values provided by the DMMO in the April 23, 2013 memorandum (Appendix A1). The rationale for the numbers of samples, the list of chemicals of concern, and the SL1 values for this program are presented in the DMMO April 23, 2013 memorandum, and are reflected in the SAPs. Specific findings are described in Section 4.

Table 3-1 Proposed and Actual August 2013 Sampling Locations and Elevations

DMMU	Sample Key	Sample ID	SAP-Listed Sampling Stations and Elevations						Actual Sampling Stations and Elevations								Sample Type
			Longitude (NAD83)	Latitude (NAD83)	Mudline From MOP (ft)	MOP Elevation (NGVD 29)	Mudline Elevation (NGVD 29)	Depth to Top of z-Layer (ft) (717 ft NGVD29)	Sample Date	Sample Time	Latitude (NAD83)	Longitude (NAD83)	Measured Mudline (ft)	LWSI Elevation (NGVD 29)	Mudline Elevation (NGVD 29)	Depth to Top of z-Layer (ft) (717 ft NGVD29)	
FNC Clarkston West																	
1	1	LGR138.4E	-117 3.268	46 25.705	15.6	733.0	717.4	-0.4	8/2/2013	9:42	46 25.69455	-117 03.27004	-18.2	735.8	717.6	-0.6	Grab
	2	LGR138.4F	-117 3.277	46 25.664	13.1	733.0	719.9	-2.9	8/2/2013	9:57	46 25.66394	-117 03.27024	-15.0	735.8	720.8	-3.8	Grab
	5	LGR-138.3E	-117 3.380	46 25.683	14.2	733.0	718.8	-1.8	8/2/2013	10:15	46 25.67310	-117 03.38158	-18.0	735.8	717.8	-0.8	Grab
	6	LGR-138.3F	-117 3.382	46 25.652	14.1	733.0	718.9	-1.9	8/2/2013	10:27	46 25.65193	-117 03.38262	-17.7	735.8	718.1	-1.1	Grab
	7	LGR-138.5D	-117 3.180	46 25.714	14.4	733.0	718.6	-1.6	8/2/2013	10:55	46 25.70497	-117 03.17991	-18.1	735.8	717.7	-0.7	Grab
	8	LGR-138.5E	-117 3.180	46 25.682	11.6	733.0	721.4	-4.4	8/2/2013	11:04	46 25.68226	-117 03.17977	-15.3	735.8	720.5	-3.5	Grab
	9	LGR-138.5F	-117 3.181	46 25.648	7.8	733.0	725.2	-8.2	8/2/2013	11:15	46 25.64825	-117 03.18119	-11.2	735.8	724.6	-7.6	Grab
2	10	LGR138.6D	-117 3.124	46 25.713	14.9	733.0	718.1	-1.1	8/2/2013	12:35	46 25.70337	-117 03.12526	-18.2	735.9	717.7	-0.6	Grab
	11	LGR138.6F	-117 3.125	46 25.680	10.0	733.0	723.0	-6.0	8/2/2013	12:58	46 25.6804	-117 03.1251	-13.5	735.9	722.4	-5.4	Grab
	12	LGR138.6I	-117 3.127	46 25.646	7.4	733.0	725.6	-8.6	8/2/2013	13:02	46 25.64583	-117 03.12679	-10.4	735.9	725.5	-8.5	Grab
	13	LGR138.6E	-117 3.064	46 25.712	14.1	733.0	718.9	-1.9	8/2/2013	13:19	46 25.70047	-117 03.06436	-16.8	735.9	719.1	-2.1	Grab
	14	LGR138.6G	-117 3.064	46 25.690	11.0	733.0	722.0	-5.0	8/2/2013	13:41	46 25.69015	-117 03.06382	-14.8	735.9	721.1	-4.1	Grab
	15	LGR138.6H	-117 3.066	46 25.672	10.0	733.0	723.0	-6.0	8/2/2013	13:50	46 25.67219	-117 03.06631	-13.3	735.9	722.6	-5.6	Grab
	16	LGR138.6J	-117 3.065	46 25.639	6.9	733.0	726.1	-9.1	8/2/2013	14:05	46 25.63869	-117 03.06520	-10.3	735.9	725.6	-8.6	Grab
3	17	LGR138.7	-117 3.012	46 25.711	14.0	733.0	719.0	-2.0	8/2/2013	14:47	46 25.71100	-117 03.01280	-18.1	735.8	717.7	-0.7	Grab
	18	LGR138.7A	-117 3.013	46 25.688	11.2	733.0	721.8	-4.8	8/2/2013	14:58	46 25.68802	-117 03.01252	-15.2	735.8	720.6	-3.6	Grab
	19	LGR138.7B	-117 3.015	46 25.671	9.7	733.0	723.3	-6.3	8/2/2013	15:10	46 25.67138	-117 03.01453	-13.5	735.8	722.3	-5.3	Grab
	20	LGR138.7C	-117 3.016	46 25.638	6.9	733.0	726.1	-9.1	8/2/2013	15:21	46 25.63815	-117 03.01543	-10.7	735.8	725.1	-8.1	Grab
	21	LGR138.7D	-117 2.940	46 25.709	13.9	733.0	719.1	-2.1	8/2/2013	15:41	46 25.69680	-117 02.93750	-16.8	735.8	719.0	-2.0	Grab
	22	LGR138.7F	-117 2.953	46 25.641	7.5	733.0	725.5	-8.5	8/2/2013	15:54	46 25.64123	-117 02.95315	-13.4	735.8	722.4	-5.4	Grab
	3	LGR138.7E	-117 2.938	46 25.685	11.1	733.0	721.9	-4.9	8/2/2013	16:07	46 25.68523	-117 02.93810	-14.7	735.8	721.1	-4.1	Grab
FNC Clarkston East																	
4	23	LGR138.8A	-117 2.894	46 25.702	14.5	733.0	718.5	-1.5	8/3/2013	7:31	46 25.70190	-117 02.89425	-18.3	735.7	717.4	-0.4	Grab
	24	LGR138.8B	-117 2.895	46 25.672	10.7	733.0	722.3	-5.3	8/3/2013	7:43	46 25.67186	-117 02.89512	-13.8	735.7	721.9	-4.9	Grab
	25	LGR138.8C	-117 2.895	46 25.639	8.2	733.0	724.8	-7.8	8/3/2013	7:58	46 25.63918	-117 02.89506	-11.9	735.7	723.8	-6.8	Grab
	26	LGR138.8D	-117 2.820	46 25.688	13.5	733.0	719.5	-2.5	8/3/2013	8:17	46 25.68083	-117 02.82305	-16.5	735.7	719.2	-2.2	Grab
	27	LGR138.8E	-117 2.828	46 25.666	10.5	733.0	722.5	-5.5	8/3/2013	8:31	46 25.66595	-117 02.82836	-13.7	735.7	722.0	-5.0	Grab
	28	LGR138.8F	-117 2.836	46 25.638	9.6	733.0	723.4	-6.4	8/3/2013	8:43	46 25.63801	-117 02.83616	-13.3	735.7	722.4	-5.4	Grab
	29	LGR138.8G	-117 2.766	46 25.673	13.4	733.0	719.6	-2.6	8/3/2013	9:01	46 25.66574	-117 02.76873	-16.3	735.7	719.4	-2.4	Grab
	30	LGR138.8H	-117 2.782	46 25.636	9.6	733.0	723.4	-6.4	8/3/2013	9:12	46 25.63579	-117 02.78207	-13.5	735.7	722.2	-5.2	Grab
5	31	LGR138.9	-117 2.717	46 25.658	12.2	733.0	720.8	-3.8	8/3/2013	9:49	46 25.64979	-117 02.72121	-16.3	735.8	719.5	-2.5	Grab

Table 3-1 Proposed and Actual August 2013 Sampling Locations and Elevations

DMMU	Sample Key	Sample ID	SAP-Listed Sampling Stations and Elevations						Actual Sampling Stations and Elevations								Sample Type
			Longitude (NAD83)	Latitude (NAD83)	Mudline From MOP (ft)	MOP Elevation (NGVD 29)	Mudline Elevation (NGVD 29)	Depth to Top of z-Layer (ft) (717 ft NGVD29)	Sample Date	Sample Time	Latitude (NAD83)	Longitude (NAD83)	Measured Mudline (ft)	LWSI Elevation (NGVD 29)	Mudline Elevation (NGVD 29)	Depth to Top of z-Layer (ft) (717 ft NGVD29)	
	32	LGR138.9A	-117 2.727	46 25.638	9.7	733.0	723.3	-6.3	8/3/2013	10:00	46 25.63780	-117 02.72684	-14.2	735.8	721.6	-4.6	Grab
	35	LGR138.9B	-117 2.736	46 25.620	9.7	733.0	723.3	-6.3	8/3/2013	10:10	46 25.62026	-117 02.73595	-13.4	735.8	722.4	-5.4	Grab
	36	LGR138.9H	-117 2.654	46 25.627	12.7	733.0	720.3	-3.3	8/3/2013	10:24	46 25.62729	-117 02.65398	-16.6	735.8	719.2	-2.2	Grab
	37	LGR138.9X	-117 2.672	46 25.597	10.2	733.0	722.8	-5.8	8/3/2013	10:39	46 25.59718	-117 02.67107	-12.9	735.8	722.9	-5.9	Grab
	38	LGR138.9C	-117 2.595	46 25.610	14.5	733.0	718.5	-1.5	8/3/2013	10:55	46 25.60119	-117 02.59998	-16.2	735.8	719.6	-2.6	Grab
	39	LGR138.9D	-117 2.609	46 25.585	10.1	733.0	722.9	-5.9	8/3/2013	11:08	46 25.58528	-117 02.60914	-13.9	735.8	721.9	-4.9	Grab
6	41	LGR139.1A	-117 2.546	46 25.573	11.8	733.0	721.2	-4.2	8/3/2013	11:51	46 25.57305	-117 02.54624	-15.6	735.8	720.2	-3.2	Grab
	42	LGR139.1B	-117 2.493	46 25.549	11.8	733.0	721.2	-4.2	8/3/2013	12:07	46 25.54852	-117 02.49284	-16.3	735.8	719.5	-2.5	Grab
	72	LGR139.1I	-117 2.433	46 25.528	14.7	733.0	718.3	-1.3	8/3/2013	12:28	46 25.52202	-117 02.44118	-17.3	735.8	718.5	-1.5	Grab
FNC Clearwater																	
7	43	CLW0.1A	-117 2.101	46 25.561	13.5	733.0	719.5	-2.5	8/3/2013	14:04	46 25.56085	-117 02.10144	-17.6	735.7	718.1	-1.1	Grab
	44	CLW0.2A	-117 1.964	46 25.550	14.4	733.0	718.6	-1.6	8/3/2013	14:21	46 25.54994	-117 01.96369	-17.0	735.7	718.7	-1.7	Grab
8	45	CLW0.5A	-117 1.607	46 25.523	14.7	733.0	718.3	-1.3	8/3/2013	15:04	46 25.52161	-117 01.59620	-17.8	735.7	717.9	-0.9	Grab
	46	CLW0.5C	-117 1.509	46 25.522	13.4	733.0	719.6	-2.6	8/3/2013	15:29	46 25.51716	-117 01.50833	-15.9	735.7	719.8	-2.8	Grab
FNC Lewiston																	
9	73	CLW1.1C	-117 1.023	46 25.411	13.6	733.0	719.4	-2.4	8/4/2013	10:03	46 25.41100	-117 01.02259	-16.2	735.5	719.3	-2.3	Grab
	47	CLW1.1D	-117 0.931	46 25.409	15.4	733.0	717.6	-0.6	8/4/2013	10:16	46 25.40938	-117 00.93063	-18.0	735.5	717.5	-0.5	Grab
	48	CLW1.1E	-117 0.951	46 25.382	12.1	733.0	720.9	-3.9	8/4/2013	10:26	46 25.38205	-117 00.95121	-16.4	735.5	719.1	-2.1	Grab
	49	CLW1.2D	-117 0.862	46 25.387	12.3	733.0	720.7	-3.7	8/4/2013	10:40	46 25.38732	-117 00.86200	-16.3	735.5	719.2	-2.2	Grab
	50	CLW1.2E	-117 0.880	46 25.359	10.8	733.0	722.2	-5.2	8/4/2013	10:55	46 25.35906	-117 00.88025	-14.2	735.5	721.3	-4.3	Grab
	51	CLW1.2B	-117 0.808	46 25.363	11.3	733.0	721.7	-4.7	8/4/2013	11:18	46 25.36294	-117 00.80782	-15.0	735.5	720.5	-3.5	Grab
	52	CLW1.2.C	-117 0.828	46 25.343	11.5	733.0	721.5	-4.5	8/4/2013	11:32	46 25.34316	-117 00.82860	-14.2	735.5	721.3	-4.3	Grab
10	53	CLW1.3C	-117 0.774	46 25.337	11.9	733.0	721.1	-4.1	8/4/2013	12:50	46 25.33680	-117 00.77380	-14.5	735.5	721.0	-4.0	Grab
	54	CLW1.3B	-117 0.747	46 25.369	14.0	733.0	719.0	-2.0	8/4/2013	13:05	46 25.36910	-117 00.74646	-17.8	735.5	717.7	-0.7	Grab
	56	CLW1.3D	-117 0.664	46 25.344	12.5	733.0	720.5	-3.5	8/4/2013	13:37	46 25.34296	-117 00.66073	-17.6	735.5	717.9	-0.9	Grab
	57	CLW1.3E	-117 0.681	46 25.319	12.4	733.0	720.6	-3.6	8/4/2013	13:51	46 25.31921	-117 00.68108	-14.1	735.5	721.4	-4.4	Grab
	58	CLW1.3F	-117 0.698	46 25.292	13.7	733.0	719.3	-2.3	8/4/2013	14:04	46 25.29224	-117 00.69795	-16.1	735.5	719.4	-2.4	Grab
	59	CLW1.3G	-117 0.592	46 25.319	11.8	733.0	721.2	-4.2	8/4/2013	14:15	46 25.31923	-117 00.59241	-14.6	735.6	721.0	-4.0	Grab
	60	CLW1.3H	-117 0.606	46 25.296	13.0	733.0	720.0	-3.0	8/4/2013	14:32	46 25.29570	-117 00.60594	-15.5	735.6	720.1	-3.1	Grab
11	55	CLW1.4B	-117 0.521	46 25.288	12.8	733.0	720.2	-3.2	8/4/2013	14:59	46 25.28813	-117 00.52123	-16.0	735.6	719.6	-2.6	Grab
	61	CLW1.4D	-117 0.373	46 25.243	14.7	733.0	718.3	-1.3	8/4/2013	15:18	46 25.24317	-117 00.37379	-17.4	735.6	718.2	-1.2	Grab

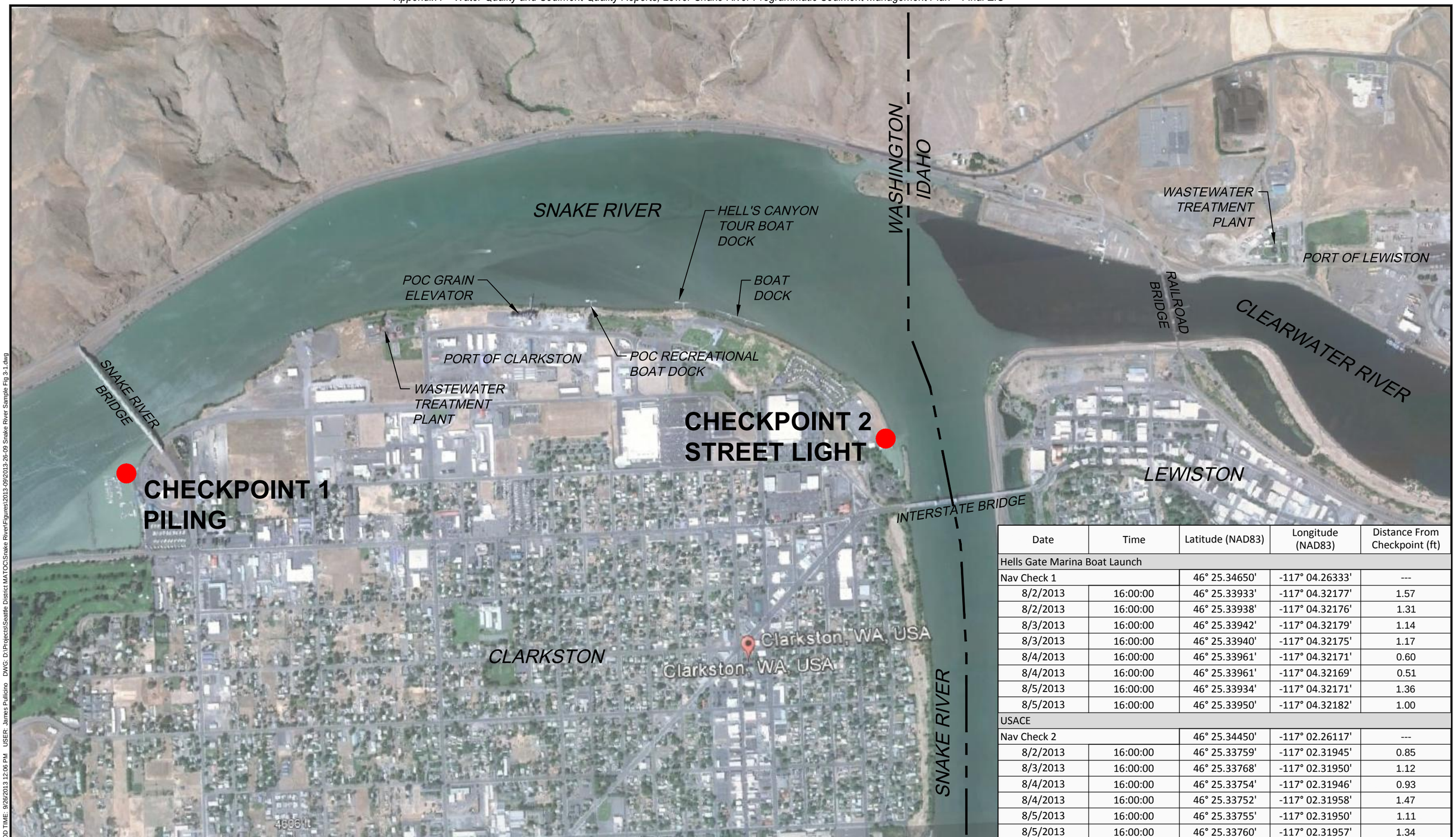
Table 3-1 Proposed and Actual August 2013 Sampling Locations and Elevations

DMMU	Sample Key	Sample ID	SAP-Listed Sampling Stations and Elevations						Actual Sampling Stations and Elevations								Sample Type
			Longitude (NAD83)	Latitude (NAD83)	Mudline From MOP (ft)	MOP Elevation (NGVD 29)	Mudline Elevation (NGVD 29)	Depth to Top of z-Layer (ft) (717 ft NGVD29)	Sample Date	Sample Time	Latitude (NAD83)	Longitude (NAD83)	Measured Mudline (ft)	LWSI Elevation (NGVD 29)	Mudline Elevation (NGVD 29)	Depth to Top of z-Layer (ft) (717 ft NGVD29)	
	62	CLW1.5A	-117 0.210	46 25.204	13.5	733.0	719.5	-2.5	8/4/2013	15:34	46 25.20398	-117 00.21044	-17.7	735.6	717.9	-0.9	Grab
Port of Clarkston Grain Elevator																	
POC GE	68	LGR138.4G	-117 3.279	46 25.630	9.6	733.0	723.4	-6.4	8/3/2013	16:33	46 25.63010	-117 03.2784	-15.4	735.6	720.2	-3.2	Grab
	69	LGR138.4I	-117 3.212	46 25.636	8.1	733.0	724.9	-7.9	8/3/2013	16:12	46 25.63600	-117 03.2118	-11.1	735.6	724.5	-7.5	Grab
Port of Clarkston Recreation Dock																	
POC Rec Dock	63	LGR138.6X	-117 3.097	46 25.628	5.7	733.0	727.3	-1.8	8/5/2013	11:43	46 25.61961	-117 03.10163	-7.4	735.5	728.1	-2.6	Core
	63	LGR138.6X Recollection							8/6/2013	12:42	46 25.61990	-117 03.10000	-5.6	735.5	729.9	-4.4	Core
	64	LGR138.6Y	-117 3.067	46 25.627	5.2	733.0	727.8	-2.3	8/5/2013	12:21	46 25.61896	-117 03.06731	-6.7	735.5	728.8	-3.3	Core
Port of Clarkston Cruise Dock																	
POC Cruise Dock	65	LGR138.9J	-117 2.700	46 25.588	10.2	733.0	722.8	-5.8	8/5/2013	14:21	46 25.5895	-117 02.6988	-12.5	735.5	723.0	-6.0	Core
	66	LGR138.9K	-117 2.645	46 25.575	9.4	733.0	723.6	-6.6	8/5/2013	17:56	46 25.5758	-117 02.6435	-11.9	735.5	723.6	-6.6	Core
	66	LGR138.9K Recollection							8/6/2013	13:29	46 25.5753	-117 02.6440	-12.6	735.5	722.9	-5.9	Core
Port of Lewiston																	
POL	70	CLW1.15A	-117 0.978	46 25.472	13.4	733.0	719.6	-2.6	8/4/2013	9:05	46 25.45081	-117 00.92356	-15.8	735.5	719.7	-2.7	Grab
	71	CLW1.25A	-117 0.809	46 25.406	11.2	733.0	721.8	-4.8	8/4/2013	9:29	46 25.40506	-117 00.79649	-10.8	735.5	724.7	-7.7	Grab

Note: Red font indicates a corrected error from the SAP.

Table 3-2 Sediment Core Penetration and Acquisition Data for the August 2013 Sampling Event

DMMU/ Station	Sample ID	Sample Date	Sample Time	Latitude (NAD83)	Longitude (NAD83)	Measured Mudline (ft)	LWSI Elevation (NGVD 29)	Mudline Elevation (NGVD 29)	Depth to Top of z-Layer (ft) (717 ft NGVD29)	Core Penetration (ft)	Acquisition (ft)	Recovery (%)	Comment
Port of Clarkston Recreation Dock													
63	LGR138.6X	8/5/2013	11:43	46 25.61961	-117 03.10163	-7.4	735.5	728.1	-2.6	7	6.1	87%	---
63	LGR138.6X Recollection	8/6/2013	12:42	46 25.61990	-117 03.10000	-5.6	735.5	729.9	-4.4	7	5.0	71%	Only collected overburden (above 717 ft) material
64	LGR138.6Y	8/5/2013	12:21	46 25.61896	-117 03.06731	-6.7	735.5	728.8	-3.3	7	6.1	87%	
Port of Clarkston Cruise Dock													
65	LGR138.9J	8/5/2013	14:21	46 25.5895	-117 02.6988	-12.5	735.5	723.0	-6.0	9	7.3	81%	---
66	LGR138.9K	8/5/2013	17:56	46 25.5758	-117 02.6435	-11.9	735.5	723.6	-6.6	9	8.6	96%	---
66	LGR138.9K Recollection	8/6/2013	13:29	46 25.5753	-117 02.6440	-12.6	735.5	722.9	-5.9	4	4	100%	Only collected overburden (above 717 ft) material



Date	Time	Latitude (NAD83)	Longitude (NAD83)	Distance From Checkpoint (ft)
Hells Gate Marina Boat Launch				
Nav Check 1		46° 25.34650'	-117° 04.26333'	---
8/2/2013	16:00:00	46° 25.33933'	-117° 04.32177'	1.57
8/2/2013	16:00:00	46° 25.33938'	-117° 04.32176'	1.31
8/3/2013	16:00:00	46° 25.33942'	-117° 04.32179'	1.14
8/3/2013	16:00:00	46° 25.33940'	-117° 04.32175'	1.17
8/4/2013	16:00:00	46° 25.33961'	-117° 04.32171'	0.60
8/4/2013	16:00:00	46° 25.33961'	-117° 04.32169'	0.51
8/5/2013	16:00:00	46° 25.33934'	-117° 04.32171'	1.36
8/5/2013	16:00:00	46° 25.33950'	-117° 04.32182'	1.00
USACE				
Nav Check 2		46° 25.34450'	-117° 02.26117'	---
8/2/2013	16:00:00	46° 25.33759'	-117° 02.31945'	0.85
8/3/2013	16:00:00	46° 25.33768'	-117° 02.31950'	1.12
8/4/2013	16:00:00	46° 25.33754'	-117° 02.31946'	0.93
8/4/2013	16:00:00	46° 25.33752'	-117° 02.31958'	1.47
8/5/2013	16:00:00	46° 25.33755'	-117° 02.31950'	1.11
8/5/2013	16:00:00	46° 25.33760'	-117° 02.31957'	1.34

LEGEND

CHECKPOINT 1 ● CHECKPOINT

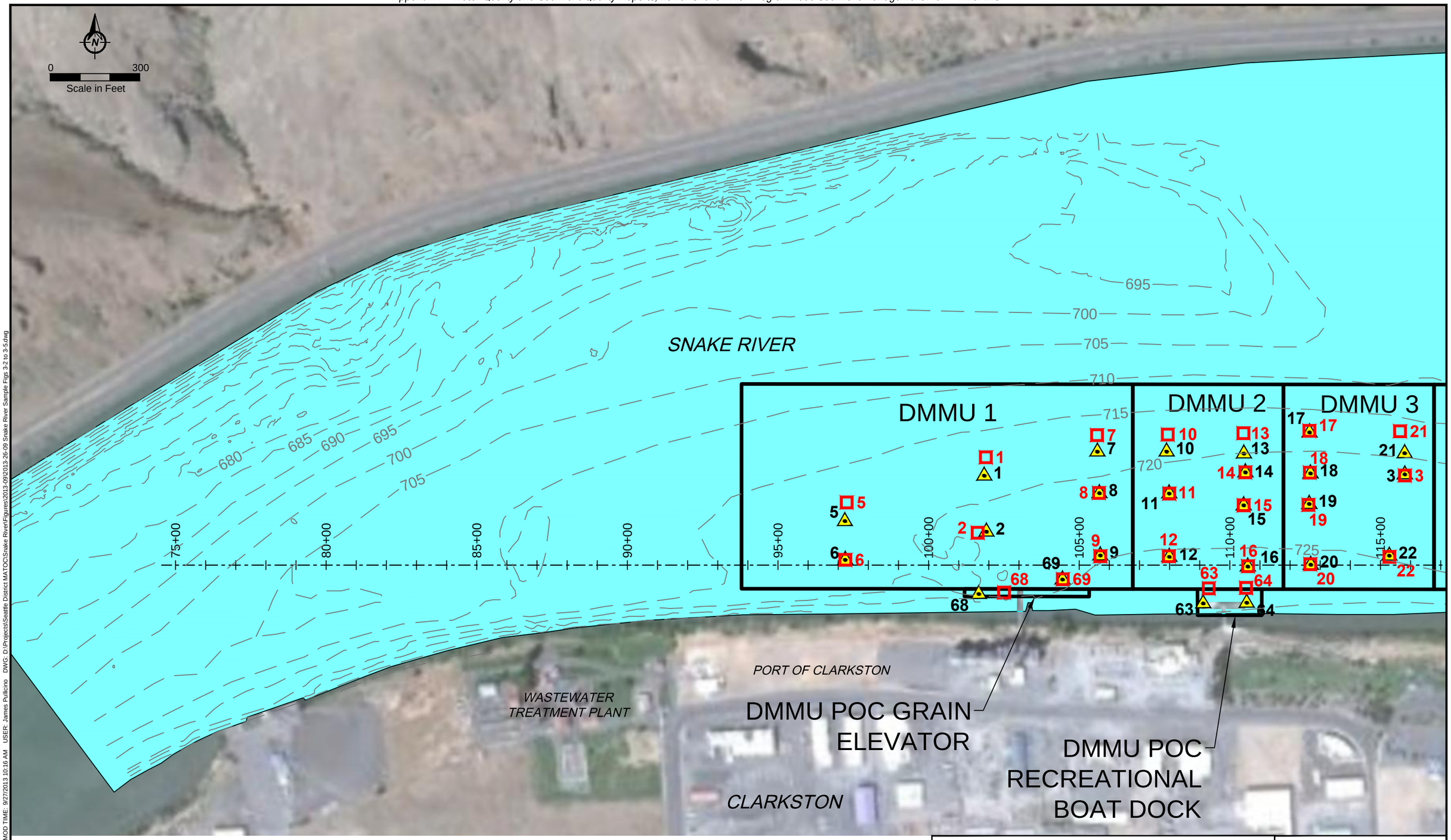
0 1000
Scale in Feet

SNAKE RIVER CHECKPOINT LOCATIONS

DALTON OLMSTED FUGLEVAND

FIGURE
3-1
SEPTEMBER 27, 2013

PLOT TIME: 9/27/2013 10:17 AM MOD TIME: 9/26/2013 12:06 PM USER: James Pullicino DWG: D:\Projects\Seattle District MATOC\Snake River\Figures\2013-09\2013-26-09 Snake River Sample Fig 3-1.dwg



LEGEND

- 2 — ACTUAL SEDIMENT SAMPLE LOCATION
- 2 — PROPOSED SEDIMENT SAMPLE LOCATION
- DREDGING DMMU BOUNDARY
- EXISTING CONTOUR

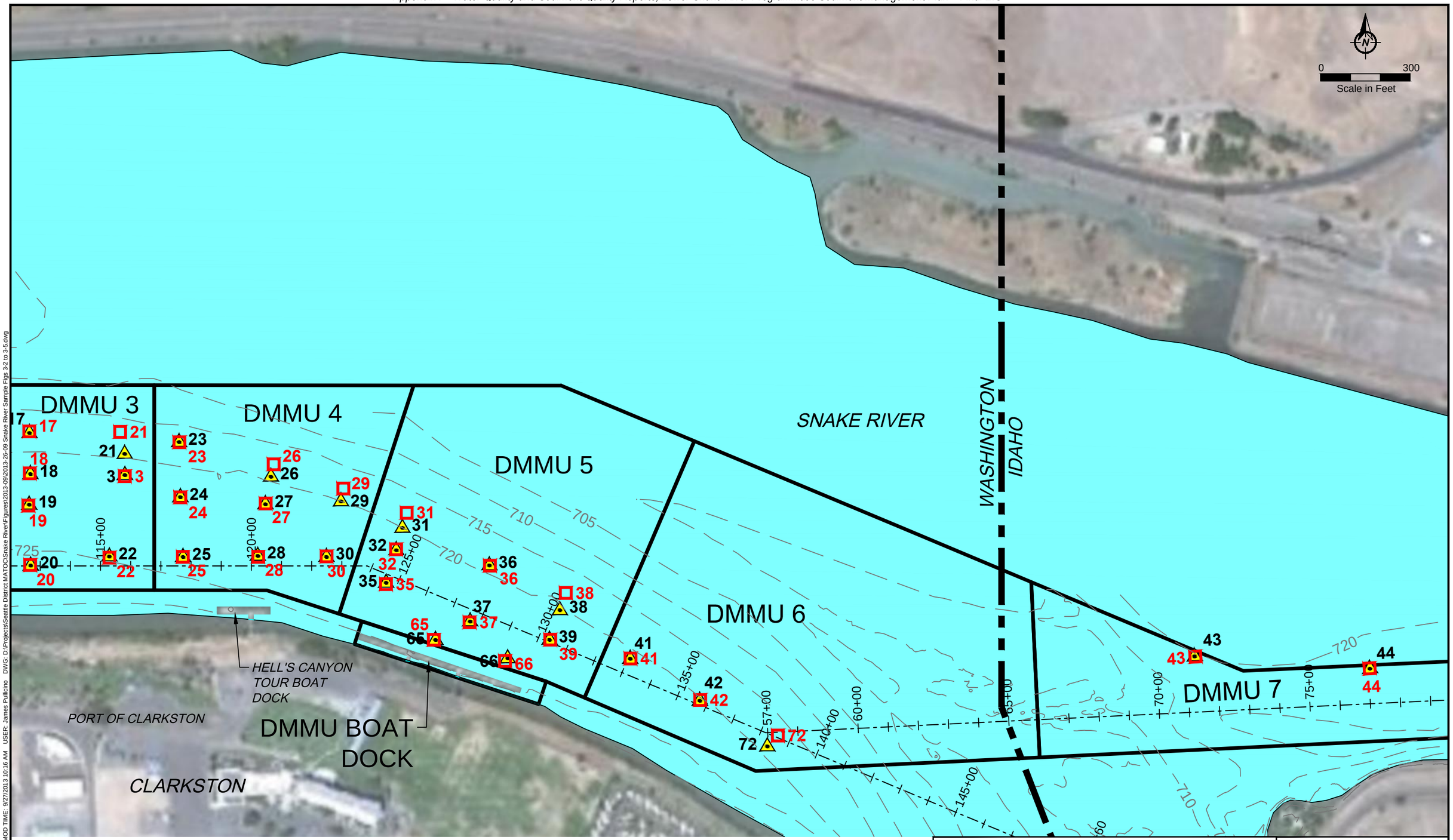
SNAKE RIVER SAMPLING

DALTON OLMSTED FUGLEVAND

FIGURE 3-2

SEPTEMBER 27, 2013

PLOT TIME: 9/27/2013 10:18 AM MOD TIME: 9/27/2013 10:16 AM USER: James Pulkino DWG: D:\Projects\Seattle District MATOC\Snake River\Figures\2013-09\2013-26-09 Snake River Sample Figs 3-2 to 3-5.dwg



LEGEND

- 2 ACTUAL SEDIMENT SAMPLE LOCATION
- 2 PROPOSED SEDIMENT SAMPLE LOCATION
- DREDGING DMMU BOUNDARY
- EXISTING CONTOUR

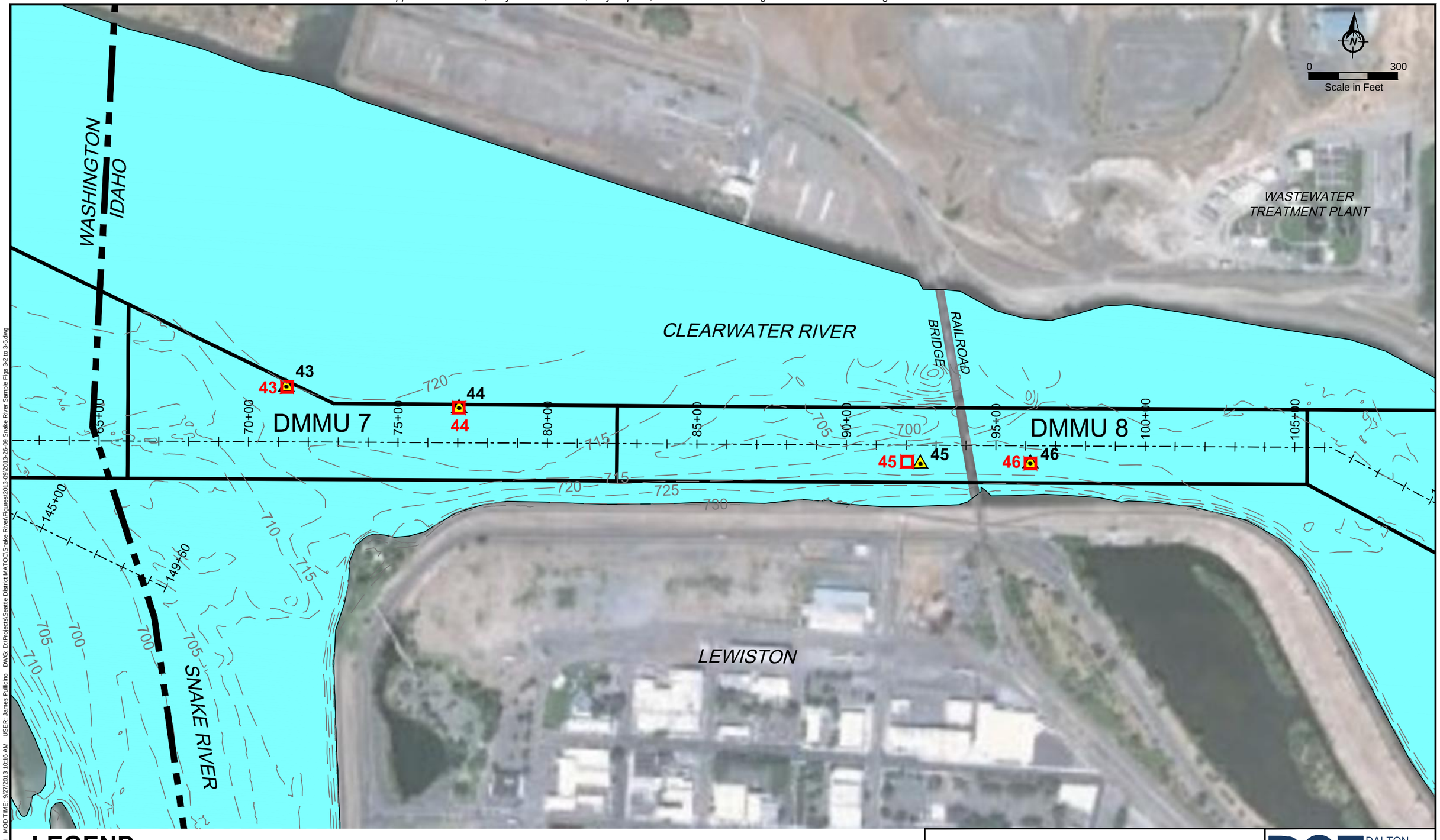
SNAKE RIVER SAMPLING

DALTON OLMSTED FUGLEVAND

FIGURE 3-3

SEPTEMBER 27, 2013

PLOT TIME: 9/27/2013 10:18 AM MOD TIME: 9/27/2013 10:16 AM USER: James Pulicino DWG: D:\Projects\Seattle District MATOCS\Snake River\Figures\2013-09\2013-26-09 Snake River Sample Figs 3-2 to 3-5.dwg



PLOT TIME: 9/27/2013 10:18 AM MOD TIME: 9/27/2013 10:16 AM USER: James Pullerino DWG: D:\Projects\Seattle District MATOC\Snake River\Figures\2013-09\2013-26-09 Snake River Sample Figs 3-2 to 3-5.dwg

LEGEND

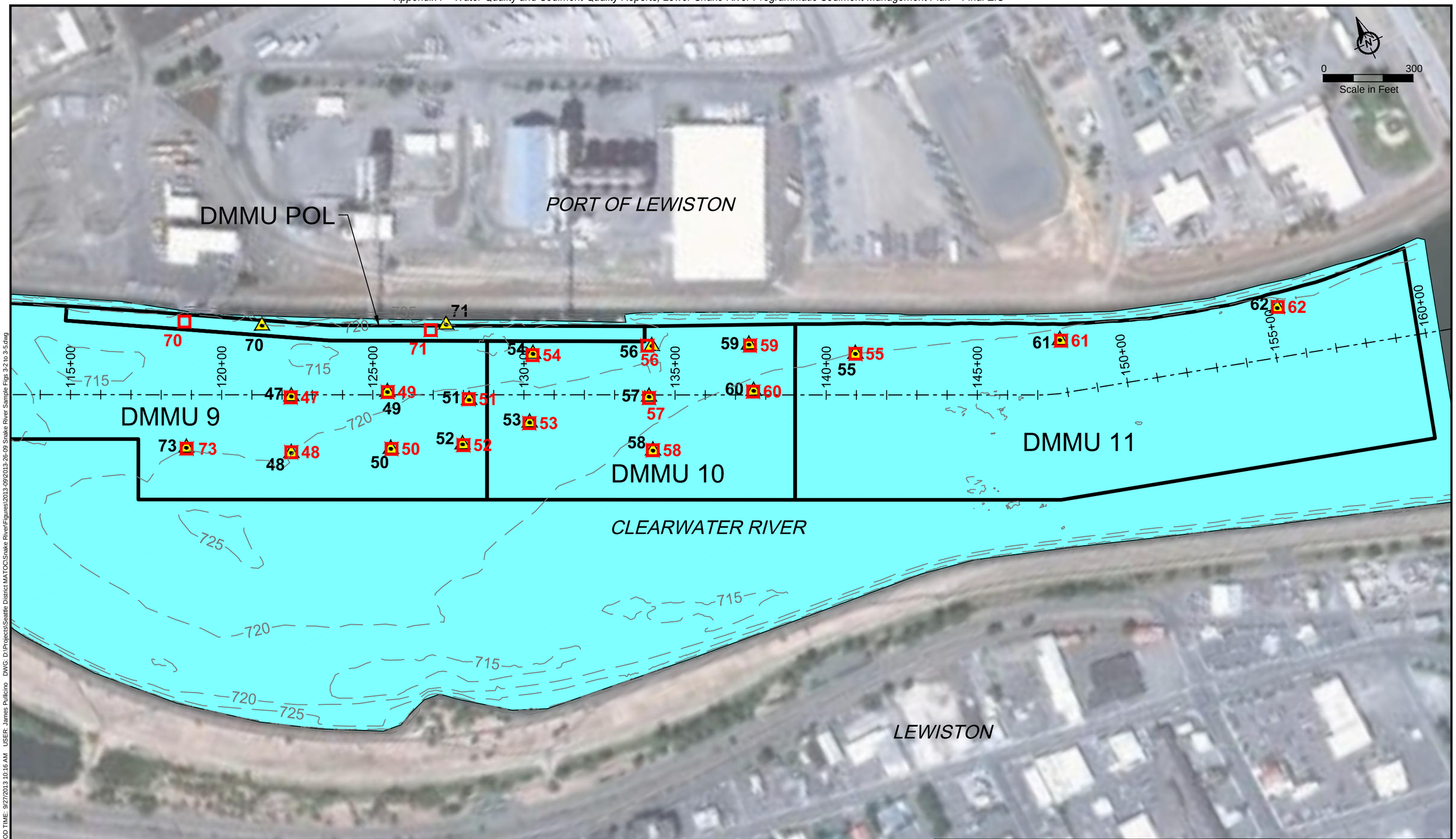
- 2 — ACTUAL SEDIMENT SAMPLE LOCATION
- 2 — PROPOSED SEDIMENT SAMPLE LOCATION
- DREDGING DMMU BOUNDARY
- EXISTING CONTOUR

CLEARWATER RIVER SAMPLING

DALTON OLMSTED FUGLEVAND

FIGURE
3-4

SEPTEMBER 27, 2013



LEGEND

- 2 ACTUAL SEDIMENT SAMPLE LOCATION
- 2 PROPOSED SEDIMENT SAMPLE LOCATION
- DREDGING DMMU BOUNDARY
- EXISTING CONTOUR

CLEARWATER RIVER SAMPLING

DALTON OLMSTED FUGLEVAND

FIGURE 3-5

SEPTEMBER 27, 2013

PLOT TIME: 9/27/2013 10:18 AM MOD TIME: 9/27/2013 10:16 AM USER: James Pulficino DWG: D:\Projects\Seattle District MATOC\Snake River\Figures\2013-09\2013-26-09 Snake River Sample Figs 3-2 to 3-5.dwg

4.0 RESULTS OF AUGUST 2013 SAMPLING AND ANALYSES

4.1 FIELD OBSERVATIONS

Photos of the grab samples and cores may be found in Appendix G1. Unique conditions encountered at DMMU Port of Lewiston and POC Cruise Dock are described below.

Station obstructions were encountered at DMMU POL at stations 70 and 71. A grain barge was berthed over target station 70 (Figure 4-1). An attempt was made to sample at the downstream end of the grain barge, but there was heavy construction rock that had been placed there, covering the underlying sediment. The station was relocated upstream of the barge. At Station 71 a cable strung between two dolphins prevented access; the station was located as close as practicable to the target location.

Core collection at POC Cruise Dock presented challenges in getting the core drives to penetrate into the z-layer. Seven drives at different locations were required to successfully collect a core at Stations 65 and 66. The difficulty was that refusal occurred in all drives between 717-718 ft NGVD29, and the core was not able to get adequate penetration into the z-layer. A layer of fine woody debris at that elevation was encountered across all sampling locations that was not penetrable with the equipment on the *Peter R* (Figure 4-2). Another observation on these cores was that there was no overlying soft, wet, silty-clays as observed at all of the other Lower Snake River stations, and that all of the material above the woody debris was sand (Figure 4-2).

An error occurred during core processing that required a re-collection of core samples at POC Recreation Dock Station 63 and POC Cruise Dock Station 65. During processing for POC Recreation Dock, cores from Station 63 and 65 were opened, logged, and the surface sediment composited. Belatedly recognizing that the two cores were from different DMMUs, the field crew determined to (1) discard the incorrectly composited sample, (2) correct the core log sheets to accurately reflect the lithology associated with each core, (3) retain, but correctly re-label the retained z-layer samples[4], and (4) re-collect the overburden sediments (mud-line to 717 amsl) as cores at Stations 63 and 65. The resultant corrective action assured the integrity of the final samples submitted for chemical analysis.

4.2 ANALYTICAL RESULTS

The results of the physical and chemical analyses for the Lower Snake River DMMUs that were characterized based on surface sediment samples are given in Table 4-1. The results for the Clearwater River DMMUs are in Table 4-2, while the two DMMUs characterized by sediment core profiles from mudline to 717 ft amsl are presented in Table 4-3.

[4] For core samples, the z-layers for each core were individually retained. In this case, the Station 63 z-sample was correctly retained, but the Station 65 z-layer sample was retained and mistakenly labeled as Station 64. Those z-samples were then re-labeled as Station 65.

Chemical analyses were conducted by ARI of Tukwila, Washington, The data were validated by Pyron Environmental (Pyron) of Olympia, Washington.

All data supporting the chemical analyses are included in Appendices I through K. Appendix I provides the ARI analytical laboratory reports; Appendix J is the ALS analytical report, while Appendix K are the Data Validation Reports. Validated data in the Environmental Information Management System (EIMS) format are included in Appendix M.

4.2.1 Data Validation

A data validation report for QA1 was not listed as part of the SAP, but was included in this deliverable as at least that level of quality assurance review is required for dredged material characterization projects. The analytical data review and validation procedures were consistent with that defined in the *DMMP User Manual*. Data qualifiers assigned during validation by the validator were incorporated into the analytical tables in Tables 4-1 through 4-3, and in the Electronic Data Deliverable in Appendix M. Definitions for the analytical qualifiers used in this report are included in the DVR (Appendix K), and are listed at the bottom of each table presenting analytical results in this section.

All data are considered to be of known quality and acceptable for use as qualified, with the exception of heptachlor. Heptachlor results were rejected in all samples because it was not recovered in the Standard Reference Material.

After receipt of the initial analytical data package, SEE initiated a request to the lab to review the toxaphene results relative to the un-detected value reported in the EDD. ARI evaluated, and then revised the Pesticide Forms (Appendix I); the UJ-flagged toxaphene results were set to 1/2 the LOQ for diluted samples. For example, a 48ppb U-flagged toxaphene result was reset at 24ppb UJ. (ARI email 09/05/2013)

4-Methylphenol hits were confirmed by re-processing data with the SIM channel on the GC/MS. While ARI did not run CCALs for SIM, they were able to re-process based on the 5th standard of the original calibration, and use those results to compare to the reported values. Based upon this review, it was confirmed that the reported results were comparable with the SIM data (ARI email 09/04/2013).

4.2.2 Results of Conventional Analyses

Conventional analyses for the surface (grab) samples are presented in Table 4-1. In general, the grain size and total solids were higher in the Clearwater River DMMUs relative to those DMMUs below the confluence in the Snake River. For Clearwater DMMUs (7 – 11 and POL Grain Dock), the grain size averaged 95.8% sand, with a relatively narrow range between the DMMUs of 92.4 – 98.4% sand. Total solids are also high in the Clearwater DMMUs (range 67.6 – 77.7%), and total organic carbon (TOC) is the lowest measured in the main channel DMMUs (0.23 – 0.72%).

The DMMUs below the confluence were still relatively course, but had lower total sand and total solids content. Total percent sand for DMMUs 1 – 6 and the POC Grain Dock averaged 83.8%, with a range of 69.4 – 92.5%. Total solids were lower; averaging 60.43% (43.7 –

70.46%). TOC was elevated relative to the Clearwater DMMUs with a range of 0.67 – 6.8%. Of specific note are DMMUs 6 and POC Grain Elevator which had very elevated TOCs (4.1 and 6.8%, respectively), suggestive of organic enrichment at these sites.

Results for the cores composited for the POC Cruise Dock and POC Recreation Dock are given in Table 4-2. For the Cruise Dock composite, the grain size is consistent with the observation made on the two collected cores; the percentage sand in the composite is 94% with high total solids (73.6%), but relatively high TOC (3.6%). The POC Recreation Dock composite had the lowest percent sand observed at any site (44.8%), low total solids (53.78%) and relatively elevated TOC (2.02%).

4.2.3 Results for Chemical Analyses

Analytical results for all DMMUs are presented in Tables 4-1 and 4-2. Briefly summarized,

- For all DMMUs, the concentrations of metals were below the relevant SL1 levels. This included selenium, which had been a chemical of concern in past characterization events.

- For all DMMUs, the reported levels of phthalates, pesticides, and PCBs were all reported principally as non-detected compounds, or where detected were below the SL1. This included toxaphene, which was a special chemical of concern requested by the Washington Department of Ecology and the Department of Fish and Wildlife.

- DMMUs 4, 7-11, and the Port of Lewiston had levels of chemicals of concern that were all below the screening levels (SL1). Based on the criteria in the SAP, these DMMUs may be eligible for open water disposal, pending the decision by the DMMO.

- DMMUs 1 – 3, 5, and POC-Grain Elevator have detected levels of 4-methylphenol that exceed the SL1. All other COCs at these stations were below SL1. Based upon the decision criteria in the SAP, these DMMUs would require bioassays to determine whether the sediments may be considered eligible for open water disposal.

- DMMU 6 had detected levels of both 4-methylphenol, and phenol that exceeded SL1. All other COCs at these stations were below the SL1. Based upon the decision criteria in the SAP, this DMMU would require bioassays to determine whether the sediment may be considered eligible for open water disposal.

- DMMU POC Cruise Dock had levels of chemicals of concern that were all below SL1. Based on the criteria in the SAP, this DMMU may be eligible for open water disposal, pending the decision by the DMMO.

- DMMU POC Recreation Dock had levels of chemicals of concern that were all below SL1. While both phenol and 4-methylphenol were detected in this composite sample, the reported levels were below SL1. Based on the criteria in the SAP, this DMMU may be eligible for open water disposal, pending the decision by the DMMO.

For the DMMUs represented by composite surface sediment (grab) samples, the levels of metals were all well below SL1. Of the measured organic compounds for those DMMUs, the levels of phthalates, pesticides, and PCBs were generally non-detected, or in the single case where bis(2-ethylhexylphthalate) was reported as an estimate (J-flagged), the level was below the corresponding SL1. Other phenols and miscellaneous extractables that were not detected include 2-methylphenol, 2,4-dimethylphenol, pentachlorophenol, and beta-hexachlorocyclohexane. Dibenzofuran was reported as an estimated (J-flagged) value at DMMU 5, at a very low level well below the corresponding SL1.

For those same DMMUs, the detected compounds included phenol, 4-methylphenol, and benzoic acid. Phenol and 4-methylphenol were both detected and elevated at all the Lower Snake River DMMUs, but not at those DMMUs above the confluence and in the Clearwater River. Benzoic acid was also detected and elevated at the Snake River DMMUs, but was undetected in the DMMUs above the confluence.

For the two DMMUs represented by core-composites, the same general pattern of detections seen in the surface sediments occurred. Metals were either non-detected, or at levels well below SL1. Of the organics, phthalates, pesticides, and PCBs all were non-detected. The analytical suite for POC-Recreation Dock also included polycyclic aromatic hydrocarbons (PAHs), chlorinated hydrocarbons, hexachlorobutadiene, N-nitrosodiphylamine, and total petroleum hydrocarbons. Of those, all but total petroleum hydrocarbon (TPH) were reported as non-detected below SL1.

4-methylphenol and benzoic acid were detected in both the Cruise Dock and Recreation Dock composite samples. Phenol was detected in the Recreation Dock sample, but not the Cruise Dock sample. The reported levels for all three compounds were higher in the Recreation Dock samples, but at levels below SL1.

Table 4-1 Results for August 2013 Lower Snake River DMMU Composite Samples

Parameter	MDLs	MRLs	SQL(1)	SL1	DMMU 1		DMMU 2		DMMU 3		DMMU 4		DMMU 5		DMMU 6		POC-GE	
					Value	Qual	Value	Qual	Value	Qual	Value	Qual	Value	Qual	Value	Qual	Value	Qual
CONVENTIONALS																		
Total solids (%)	—	0.10%	0.1	—	56.58		67.55		68.03		70.46		68.41		43.72		48.26	
Total organic carbon (%)	0.02%	0.05%	0.1	—	1.53		1.47		0.84		0.67		1.03		6.84		4.14	
Total Sulfides (mg/kg)	0.01	1.0	1.0	—	89.3		74.2		125		7.98		1.7		30		66	
Ammonia (mg/kg)	0.02	0.1	0.1	—	41.2		29		25		17		25.8		69.5		69.8	
Sand (%)	—	—	—	—	85.2		87		88.7		92.5		86.9		69.4		76.6	
Silt (%)	—	—	—	—	8.3		6.7		4.5		2.7		8.4		16.5		15.6	
Clay (%)	—	—	—	—	6.6		6.4		6.7		4.8		4.7		14.2		7.9	
Metals (mg/kg dry weight)																		
Antimony	0.63	5	0.5	150	8.00	UJ	8.00	UJ	7.00	UJ	7.00	UJ	8.00	UJ	10.00	UJ	10.00	UJ
Arsenic	0.33	5	5	14	8.00	U	8.00	U	7.00	U	7.00	U	8.00	U	10.00	U	10.00	U
Cadmium	0.18	0.2	2.1	2.1	0.40		0.30		0.30		0.30		0.30		0.50		0.50	
Chromium	0.12	0.5	5	72	14.60		13.00		10.80		11.30		12.00		21.00		18.00	
Copper	0.1	0.2	5	400	12.50		10.90		10.40		10.20		10.50		17.10		16.90	
Lead	0.16	2	5	360	6.00	J	5.00	J	4.00	J	3.00	J	4.00	J	8.00	J	7.00	J
Mercury	0.0021	0.025	0.1	0.66	0.03	U	0.04	U	0.03	U	0.03	U	0.03	U	0.05	U	0.04	U
Nickel	0.08	0.5	5	26	11.00		9.00		8.00		8.00		9.00		13.00		11.00	
Selenium	0.13	0.5	—	3	0.80	U	0.80	U	0.70	U	0.70	U	0.70	U	1.00	U	1.00	U
Silver	0.04	0.3	0.5	0.57	0.50	U	0.50	U	0.40	U	0.40	U	0.50	U	0.70	U	0.60	U
Zinc	0.15	1	5	3,200	47.00		40.00		38.00		33.00		35.00		55.00		59.00	
Phthalates (µg/kg dry weight)																		
Dimethyl phthalate	2.9	20	20	46	19.00	U	20.00	U	19.00	U	19.00	U	19.00	U	19.00	U	19.00	U
Diethyl phthalate	36.6	50	20	200	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Di-n-butyl phthalate	8.16	20	20	380	19.00	U	20.00	U	19.00	U	19.00	U	19.00	U	19.00	U	19.00	U
Butyl benzyl phthalate	6.14	20	20	260	19.00	U	20.00	U	19.00	U	19.00	U	19.00	U	19.00	U	19.00	U
Bis(2-ethylhexyl) phthalate	14.6	25	100	500	48.00	U	49.00	U	47.00	U	48.00	U	48.00	U	48.00	U	48.00	U
Di-n-octyl phthalate	5.84	20	20	39	19.00	U	20.00	U	19.00	U	48.00	U	19.00	U	19.00	U	19.00	U
Phenols (µg/kg dry weight)																		
Phenol	8.64	20	20	120	28.00		23.00		19.00	U	12.00	J	46.00		170.00		67.00	
2-Methylphenol	5.25	20	20	63	19.00	U	20.00	U	19.00	U	19.00	U	19.00	U	19.00	U	19.00	U
4-Methylphenol	8.64	20	20	260	1700.00		650.00		340.00		190.00		1300.00		4900.00		1400.00	
2,4-Dimethylphenol	5.25	40	20	29	26.00	UJ	26.00	UJ	25.00	UJ	26.00	UJ	26.00	UJ	26.00	UJ	26.00	UJ
Pentachlorophenol	6.63	200	100	1,200	95.00	UJ	98.00	UJ	94.00	UJ	96.00	UJ	96.00	UJ	96.00	UJ	97.00	U
Miscellaneous Extractables (µg/kg dry weight)																		
Benzoic acid	48.5	200	100	2,900	280.00		140.00	J	120.00	J	61.00	J	130.00	J	890.00		570.00	
Dibenzofuran	4.1	20	20	200	19.00	U	20.00	U	19.00	U	19.00	U	19.00	U	14.00	J	19.00	U
beta-Hexachlorocyclohexane	0.139	0.5	—	7.2	0.97	U	0.97	U	0.49	U	0.47	U	0.47	U	0.98	U	0.47	U

Table 4-1 Results for August 2013 Lower Snake River DMMU Composite Samples

Parameter	MDLs	MRLs	SQL(1)	SL1	DMMU 1		DMMU 2		DMMU 3		DMMU 4		DMMU 5		DMMU 6		POC-GE	
					Value	Qual	Value	Qual	Value	Qual	Value	Qual	Value	Qual	Value	Qual	Value	Qual
Pesticides (µg/kg dry weight)																		
4,4'-DDD	0.124	1	2	310	1.90	U	1.90	U	0.98	U	0.94	U	0.95	U	2.00	U	1.90	U
4,4'-DDE	0.135	1	2	21	1.90	U	1.90	U	0.98	U	0.94	U	0.95	U	1.50	U	1.90	U
4,4'-DDT	0.192	1	2	100	1.90	UJ	1.90	UJ	0.98	U	0.94	U	0.95	UJ	2.00	UJ	1.90	UJ
Aldrin	0.055	0.5	2	9.5	0.97	U	0.97	U	0.49	U	0.47	U	0.47	U	0.98	U	0.96	U
Carbazole	2.69	20	900	900	19.00	U	20.00	U	19.00	U	19.00	U	19.00	U	19.00	U	19.00	UJ
cis –chlordane	0.051	0.5	—	—	0.97	U	0.97	U	0.49	U	0.47	U	0.47	U	0.98	U	0.96	U
trans-chlordane	0.077	0.5	—	—	1.90	U	1.90	U	0.98	U	0.94	U	0.95	U	2.00	U	1.90	U
cis – nonachlor	0.541	1	—	—	0.97	U	0.97	U	0.49	U	0.47	U	0.47	U	0.98	U	0.96	U
trans – nonachlor	0.529	1	—	—	1.90	U	1.90	U	0.98	U	0.94	U	0.95	U	2.00	U	1.90	U
oxychlordane	0.825	1	—	—	1.90	U	1.90	U	0.98	U	0.94	U	0.95	U	2.00	U	1.90	U
Total Chlordane Compounds			2	2.8	***1.90***	***U***	***1.90***	***U***	***0.98***	***U***	***0.94***	***U***	***0.95***	***U***	***2.00***	***U***	***1.90***	***U***
Dieldrin	0.1	1	2	4.9	1.90	U	1.90	U	0.98	U	0.94	U	0.95	U	2.00	U	1.90	U
Endrin ketone	0.119	1	8.5	8.5	1.90	UJ	1.90	UJ	0.98	U	0.94	U	0.95	UJ	2.00	UJ	1.90	UJ
Heptachlor	0.132	0.5	1.5	1.5	0.97	R	0.97	R	0.49	R	0.47	R	0.47	R	0.98	R	0.96	R
Lindane	0.048	0.5	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Toxaphene	35	100	0.2	0.2	48.00	UJ	48.00	UJ	25.00	U	24.00	U	24.00	UJ	49.00	UJ	48.00	UJ
TOTAL PCBS (AROCHLORS)	10	20	10	110	***39.00***	***U***	***40.00***	***U***	***38.00***	***U***	***18.00***	***U***	***39.00***	***U***	***46.00***	***U***	***39.00***	***U***
Aroclor 1016			—	—	19.00	U	20.00	U	19.00	U	18.00	U	19.00	U	18.00	U	20.00	U
Aroclor 1242			—	—	19.00	U	20.00	U	19.00	U	18.00	U	19.00	U	18.00	U	20.00	U
Aroclor 1248			—	—	19.00	U	20.00	U	19.00	U	18.00	U	19.00	U	18.00	U	20.00	U
Aroclor 1254			—	—	19.00	U	20.00	U	19.00	U	18.00	U	19.00	U	18.00	U	20.00	U
Aroclor 1260			—	—	19.00	U	20.00	U	19.00	U	18.00	U	19.00	U	18.00	U	20.00	U
Aroclor 1221			—	—	19.00	U	20.00	U	19.00	U	18.00	U	19.00	U	18.00	U	20.00	U
Aroclor 1232			—	—	39.00	U	40.00	U	38.00	U	18.00	U	39.00	U	46.00	U	39.00	U
Aroclor 1262			—	—	19.00	U	20.00	U	19.00	U	18.00	U	19.00	U	18.00	U	20.00	U
Aroclor 1268			—	—	19.00	U	20.00	U	19.00	U	18.00	U	19.00	U	18.00	U	20.00	U

Notes:
Red values indicate exceeds the SL1
MDL = Method Detection Limit
MRL = Method Reporting Limit
SQL = Sediment Quantitation Limit
SL1 = Freshwater Screening Level 1 (DMMO Memorandum Appendix A.1)
mg/kg = milligrams per kilogram; **µg/kg** = micrograms per kilogram

Data Qualifiers
U Indicates that the target analyte was not detected at the reported concentration
UJ - The analyte was analyzed for, and the associated quantitation limit was an estimated value.
J Estimated concentration when the value is less than ARI's established reporting limits
R - The reported result was rejected.

Table 4-2 Results for the August 2013 Clearwater River DMMU Composite Samples

Lower Snake/Clearwater Sediment Sampling
W9112DW-12-D-1002
W912EF-13-D-0006

Parameter	MDLs	MRLs	SQL(1)	SL1	DMMU 7		DMMU 8		DMMU 9		DMMU 10		DMMU 11		DMMU 12		POL	
					Value	Qual	Value	Qual	Value	Qual	Value	Qual	Value	Qual	Field Rep DMMU 9		Value	Qual
CONVENTIONALS																		
Total solids (%)	—	0.10%	0.1	—	74.53		67.59		74.2		77.71		75.69		76.11		68.15	
Total organic carbon (%)	0.02%	0.05%	0.1	—	0.419		0.721		0.231		0.672		0.265		0.26		0.235	
Total Sulfides (mg/kg)	0.01	1.0	1.0	—	1.53		1.7		1.34	U	1.52		2.77		—		3.36	
Ammonia (mg/kg)	0.02	0.1	0.1	—	2.86		6.18		0.32		13.6		0.5		0.25		6.56	
Sand (%)	—	—	—	—	94.3		96.3		98.2		92.4		98.4		98.8		95.1	
Silt (%)	—	—	—	—	3.9		1.5		0.8		4.3		1.2		0.3		2	
Clay (%)	—	—	—	—	1.6		2.2		0.8		3.1		0.4		0.9		2.5	
Metals (mg/kg dry weight)																		
Antimony	0.63	5	0.5	150	6.00	UJ	7.00	UJ	6.00	UJ	6.00	UJ	6.00	UJ	6.00	UJ	7.00	UJ
Arsenic	0.33	5	5	14	6.00	U	7.00	U	6.00	U	6.00	U	6.00	U	6.00	U	7.00	U
Cadmium	0.18	0.2	2.1	2.1	0.30		0.30		0.30		0.30		0.30		0.30		0.30	
Chromium	0.12	0.5	5	72	6.30		7.00		5.90		7.40		5.70		5.60		6.40	
Copper	0.1	0.2	5	400	4.40		5.60		4.50	UJ	6.80		4.30		4.40		5.70	
Lead	0.16	2	5	360	3.00	UJ	3.00	UJ	3.00	U	3.00	J	2.00	UJ	2.00	UJ	12.00	J
Mercury	0.0021	0.025	0.1	0.66	0.03	U	0.03	U	0.03	U	0.03	U	0.02	U	0.02	U	0.03	U
Nickel	0.08	0.5	5	26	4.00		5.00		4.00		5.00		4.00		4.00		5.00	
Selenium	0.13	0.5	—	3	0.60	U	0.70	U	0.60	U	0.70	U	0.60	U	0.60	U	0.70	U
Silver	0.04	0.3	0.5	0.57	0.40	U	0.40	U	0.40	U	0.40	U	0.40	U	0.40	U	0.40	U
Zinc	0.15	1	5	3,200	25.00		36.00		24.00		28.00		22.00		21.00		26.00	
Phthalates (µg/kg dry weight)																		
Dimethyl phthalate	2.9	20	20	46	20.00	U	18.00	U	19.00	U	19.00	U	19.00	U	19.00	U	19.00	U
Diethyl phthalate	36.6	50	20	200	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Di-n-butyl phthalate	8.16	20	20	380	20.00	U	18.00	U	19.00	U	19.00	U	19.00	U	19.00	U	19.00	U
Butyl benzyl phthalate	6.14	20	20	260	20.00	U	18.00	U	19.00	U	19.00	U	19.00	U	19.00	U	19.00	U
Bis(2-ethylhexyl) phthalate	14.6	25	100	500	49.00	U	46.00	U	130.00	J	48.00	U	48.00	U	48.00	UJ	48.00	U
Di-n-octyl phthalate	5.84	20	20	39	20.00	U	18.00	U	19.00	U	19.00	U	19.00	U	19.00	U	19.00	U
Phenols (µg/kg dry weight)																		
Phenol	8.64	20	20	120	20.00	U	18.00	U	19.00	U	19.00	U	13.00	J	12.00	J	19.00	U
2-Methylphenol	5.25	20	20	63	20.00	U	18.00	U	19.00	U	19.00	U	19.00	U	19.00	U	19.00	U
4-Methylphenol	8.64	20	20	260	15.00	J	18.00	U	19.00	U	19.00	U	19.00	U	19.00	U	19.00	U
2,4-Dimethylphenol	5.25	40	20	29	26.00	UJ	25.00	UJ	26.00	UJ	26.00	UJ	26.00	UJ	26.00	UJ	26.00	UJ
Pentachlorophenol	6.63	200	100	1,200	98.00	UJ	93.00	UJ	95.00	U	95.00	U	97.00	U	96.00	U	97.00	U
Miscellaneous Extractables (µg/kg dry weight)																		
Benzoic acid	48.5	200	100	2,900	200.00	U	180.00	U	190.00	U	190.00	U	190.00	U	190.00	U	190.00	U
Dibenzofuran	4.1	20	20	200	20.00	U	18.00	U	19.00	U	19.00	U	19.00	U	19.00	U	19.00	U
beta-Hexachlorocyclohexane	0.139	0.5	—	7.2	0.47	U	0.48	U	0.49	U	0.49	U	0.48	U	0.96	U	0.50	U
Pesticides (µg/kg dry weight)																		
4,4'-DDD	0.124	1	2	310	0.94	U	0.96	U	0.98	U	0.98	U	0.95	U	1.00	U	0.95	U

Table 4-2 Results for the August 2013 Clearwater River DMMU Composite Samples

Parameter	MDLs	MRLs	SQL(1)	SL1	DMMU 7		DMMU 8		DMMU 9		DMMU 10		DMMU 11		DMMU 12		POL	
					Value	Qual	Value	Qual	Value	Qual	Value	Qual	Value	Qual	Field Rep DMMU 9		Value	Qual
4,4'-DDE	0.135	1	2	21	0.94	U	0.96	U	0.98	U	1.60	U	0.95	U	1.00	U	0.95	U
4,4'-DDT	0.192	1	2	100	0.94	U	0.96	U	0.98	U	0.98	U	0.95	U	1.00	U	0.95	U
Aldrin	0.055	0.5	2	9.5	0.47	U	0.48	U	0.49	U	0.49	U	0.48	U	0.50	U	0.47	U
Carbazole	2.69	20	900	900	20.00	U	18.00	U	19.00	UJ	19.00	UJ	19.00	UJ	19.00	U	13.00	J
cis -chlordane	0.051	0.5	—	—	0.47	U	0.48	U	0.49	U	0.49	U	0.48	U	0.50	U	0.47	U
trans-chlordane	0.077	0.5	—	—	0.94	U	0.96	U	0.98	U	0.98	U	0.95	U	1.00	U	0.95	U
cis - nonachlor	0.541	1	—	—	0.47	U	0.48	U	0.49	U	0.49	U	0.48	U	0.50	U	0.47	U
trans - nonachlor	0.529	1	—	—	0.94	U	0.96	U	0.98	U	0.98	U	0.95	U	1.00	U	0.95	U
oxychlordane	0.825	1	—	—	0.94	U	0.96	U	0.98	U	0.98	U	0.95	U	1.00	U	0.95	U
***Total Chlordane Compounds*(1)**			2	2.8	***0.94***	***U***	***0.96***	***U***	***0.98***	***U***	***0.98***	***U***	***0.95***	***U***	***1.00***	***U***	***0.95***	***U***
Dieldrin	0.1	1	2	4.9	0.94	U	0.96	U	0.98	U	0.98	U	0.95	U	1.00	U	0.95	U
Endrin ketone	0.119	1	8.5	8.5	0.94	U	0.96	U	0.98	U	0.98	U	0.95	U	1.00	U	0.95	U
Heptachlor	0.132	0.5	1.5	1.5	0.47	R	0.48	R	0.49	R	0.49	R	0.48	R	0.50	R	0.47	R
Lindane	0.048	0.5	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Toxaphene	35	100	0.2	0.2	24.00	U	24.00	U	24.00	U	24.00	U	24.00	U	25.00	U	24.00	U
TOTAL PCBS (AROCHLORS)	10	20	10	110	***27.00***	***U***	***19.00***	***U***	***27.00***	***U***	***22.00***	***U***	***18.00***	***U***	***27.00***	***U***	***28.00***	***U***
Aroclor 1016			—	—	18.00	U	19.00	U	18.00	U	18.00	U	18.00	U	18.00	U	18.00	U
Aroclor 1242			—	—	18.00	U	19.00	U	18.00	U	18.00	U	18.00	U	18.00	U	18.00	U
Aroclor 1248			—	—	18.00	U	19.00	U	18.00	U	18.00	U	18.00	U	18.00	U	18.00	U
Aroclor 1254			—	—	18.00	U	19.00	U	18.00	U	18.00	U	18.00	U	18.00	U	18.00	U
Aroclor 1260			—	—	18.00	U	19.00	U	18.00	U	18.00	U	18.00	U	18.00	U	18.00	U
Aroclor 1221			—	—	18.00	U	19.00	U	18.00	U	18.00	U	18.00	U	18.00	U	18.00	U
Aroclor 1232			—	—	27.00	U	19.00	U	27.00	U	22.00	U	18.00	U	27.00	U	28.00	U
Aroclor 1262			—	—	18.00	U	19.00	U	18.00	U	18.00	U	18.00	U	18.00	U	18.00	U
Aroclor 1268			—	—	18.00	U	19.00	U	18.00	U	18.00	U	18.00	U	18.00	U	18.00	U

Notes:
Red values indicate exceeds the SL1
MDL = Method Detection Limit
MRL = Method Reporting Limit
SQL = Sediment Quantitation Limit
SL1 = Freshwater Screening Level 1 (DMMO Memorandum Appendix A.1.)
mg/kg = milligrams per kilogram; **µg/kg** = micrograms per kilogram

Data Qualifiers
U Indicates that the target analyte was not detected at the reported concentration
UJ - The analyte was analyzed for, and the associated quantitation limit was an estimated value.
J Estimated concentration when the value is less than ARI's established reporting limits
R - The reported result was rejected.

Table 4-3. Results for the August 2013 POC Cruise Dock and Recreation Dock Composite Samples

Parameter	MDLs	MRLs	SQL	SL1	POC Cruise Dock		POC Rec Dock	
					Value	Qual	Value	Qual
CONVENTIONALS								
Total solids (%)	—	0.10%	0.1	—	73.58		53.78	
Total organic carbon (%)	0.02%	0.05%	0.1	—	3.63		2.02	
Total Sulfides (mg/kg)	0.01	1.0	1.0	—	21.5		5640	
Ammonia (mg/kg)	0.02	0.1	0.1	—	38.5		330	
Sand (%)	—	—	—	—	94		44.8	
Silt (%)	—	—	—	—	3.1		40.8	
Clay (%)	—	—	—	—	2.9		14.5	
Metals (mg/kg)								
Antimony	0.63	5	0.5	150	6.00	UJ	9.00	UJ
Arsenic	0.33	5	5	14	6.00	U	9.00	U
Cadmium	0.18	0.2	2.1	2.1	0.30		0.70	
Chromium	0.12	0.5	5	72	13.40		20.00	
Copper	0.1	0.2	5	400	11.20		24.50	
Lead	0.16	2	5	360	4.00	J	8.00	J
Mercury	0.0021	0.025	0.1	0.66	0.03	U	0.06	
Nickel	0.08	0.5	5	26	10.00		15.00	
Selenium	0.13	0.5	—	3	0.70	U	0.90	U
Silver	0.04	0.3	0.5	0.57	0.40	U	0.50	U
Zinc	0.15	1	5	3,200	40.00		70.00	
Polynuclear Aromatic Hydrocarbons (PAHs; µg/kg)								
Low-Molecular Weight PAHs								
Naphthalene	2.63	5	20	500	—	—	19.00	U
Acenaphthylene	1.26	5	20	470	—	—	19.00	U
Acenaphthene	1.32	5	20	1,100	—	—	19.00	U
Fluorene	1.29	5	20	1,000	—	—	19.00	U
Phenanthrene	1.98	5	20	6,100	—	—	19.00	U
Anthracene	1.46	5	20	1,200	—	—	19.00	U
2-Methylnaphthalene	1.52	5	20	470	—	—	19.00	U
High-Molecular Weight PAHs								
Fluoranthene	1.77	5	20	11,000	—	—	19.00	U
Pyrene	2.22	5	20	8,800	—	—	19.00	U
Benz(a)anthracene	1.6	5	20	4,300	—	—	19.00	U
Chrysene	1.88	5	20	5,900	—	—	19.00	U
Benzo(b)fluoranthene	1.9	5	20	—	—	—	19.00	U
Benzo(j)fluoranthene	1.98	5	20	—	—	—	—	—
Benzo(k)fluoranthene	2.05	5	20	—	—	—	19.00	U
Total Benzofluoranthene	—	—	—	600	—	—	19.00	U
Benzo(a)pyrene	1.75	5	20	3,300	—	—	19.00	U
Indeno(1,2,3-c,d)pyrene	3.47	5	20	4,100	—	—	19.00	U

Table 4-3. Results for the August 2013 POC Cruise Dock and Recreation Dock Composite Samples

Parameter	MDLs	MRLs	SQL	SL1	POC Cruise Dock		POC Rec Dock	
					Value	Qual	Value	Qual
Dibenz(a,h)anthracene	2.38	5	20	800	—	—	19.00	U
Benzo(g,h,i)perylene	3.05	5	20	4,000	—	—	19.00	U
Chlorinated Hydrocarbons (µg/kg)								
1,4-Dichlorobenzene	2.86	20	20	110	—	—	19.00	U
1,2-Dichlorobenzene	2.5	20	20	35	—	—	19.00	U
1,2,4-Trichlorobenzene	3.48	20	20	31	—	—	19.00	U
Hexachlorobenzene (HCB)	0.094	0.5	10	22	—	—	1.90	U
Phthalates (µg/kg)								
Dimethyl phthalate	2.9	20	20	46	19.00	U	19.00	U
Diethyl phthalate	36.6	50	20	200	—	—	19.00	U
Di-n-butyl phthalate	8.16	20	20	380	19.00	U	19.00	U
Butyl benzyl phthalate	6.14	20	20	260	19.00	U	19.00	U
Bis(2-ethylhexyl) phthalate	14.6	25	100	500	47.00	U	48.00	U
Di-n-octyl phthalate	5.84	20	20	39	19.00	U	19.00	U
Phenols (µg/kg)								
Phenol	8.64	20	20	120	19.00	U	36.00	
2-Methylphenol	5.25	20	20	63	19.00	U	19.00	U
4-Methylphenol	8.64	20	20	260	28.00		130.00	
2,4-Dimethylphenol	5.25	40	20	29	26.00	UJ	26.00	UJ
Pentachlorophenol	6.63	200	100	1,200	95.00	U	97.00	U
Miscellaneous Extractables (µg/kg)								
Benzyl alcohol	2.1	20	50	57	—	—	19.00	U
Benzoic acid	48.5	200	100	2,900	110.00	J	430.00	
Dibenzofuran	4.1	20	20	200	19.00	U	19.00	U
Hexachlorobutadiene	0.138	0.5	10	11	—	—	1.90	U
N-Nitrosodiphenylamine	5.39	20	20	28	—	—	19.00	U
beta-Hexachlorocyclohexane	0.139	0.5	—	7.2	0.49	U	3.90	U
Pesticides (µg/kg)								
4,4'-DDD	0.124	1	2	310	0.98	U	1.80	J
4,4'-DDE	0.135	1	2	21	0.98	U	1.90	U
4,4'-DDT	0.192	1	2	100	0.98	U	1.90	UJ
Aldrin	0.055	0.5	2	9.5	0.49	U	0.95	U
Carbazole	2.69	20	900	900	19.00	UJ	13.00	J
cis -chlordane	0.051	0.5	—	—	0.49	U	0.95	U
trans-chlordane	0.077	0.5	—	—	0.49	U	0.95	U
cis - nonachlor	0.541	1	—	—	0.98	U	1.90	U
trans - nonachlor	0.529	1	—	—	0.98	U	1.90	U
oxychlordane	0.825	1	—	—	0.98	U	1.90	U
Total Chlordane Compounds	—	—	2	2.8	***0.98***	***U***	***1.90***	***U***

Table 4-3. Results for the August 2013 POC Cruise Dock and Recreation Dock Composite Samples

Parameter	MDLs	MRLs	SQL	SL1	POC Cruise Dock		POC Rec Dock	
					Value	Qual	Value	Qual
Dieldrin	0.1	1	2	4.9	0.98	U	1.90	U
Endrin ketone	0.119	1	8.5	8.5	0.98	U	1.90	UJ
Heptachlor	0.132	0.5	1.5	1.5	0.49	R	0.95	R
Lindane	0.048	0.5	2	—	—	—	0.95	U
Toxaphene	35	100	0.2	0.2	25.00	U	48.00	UJ
Total PCBS (AROCHLORS)	10	20	10	110	***19.00***	***U***	***20.00***	***U***
Aroclor 1016			—	—	19.00	U	20.00	U
Aroclor 1242			—	—	19.00	U	20.00	U
Aroclor 1248			—	—	19.00	U	20.00	U
Aroclor 1254			—	—	19.00	U	20.00	U
Aroclor 1260			—	—	19.00	U	20.00	U
Aroclor 1221			—	—	19.00	U	20.00	U
Aroclor 1232			—	—	19.00	U	39.00	U
Aroclor 1262			—	—	19.00	U	20.00	U
Aroclor 1268			—	—	19.00	U	20.00	U
Total Petroleum Hydrocarbons (mg/kg)								
TPH-diesel	1.35	5	25	—	—	—	41	
TPH-residual	2.48	10	50	—	—	—	120	

Notes:
Red values indicate exceeds the SL1
MDL = Method Detection Limit
MRL = Method Reporting Limit
SQL = Sediment Quantitation Limit
SL1 = Freshwater Screening Level 1 (DMMO Memorandum Appendix A.1)
mg/kg = milligrams per kilogram; **µg/kg** = micrograms per kilogram

Data Qualifiers
U Indicates that the target analyte was not detected at the reported concentration
UJ - The analyte was analyzed for, and the associated quantitation limit was an estimated value.
J Estimated concentration when the value is less than ARI's established reporting limits
R - The reported result was rejected.

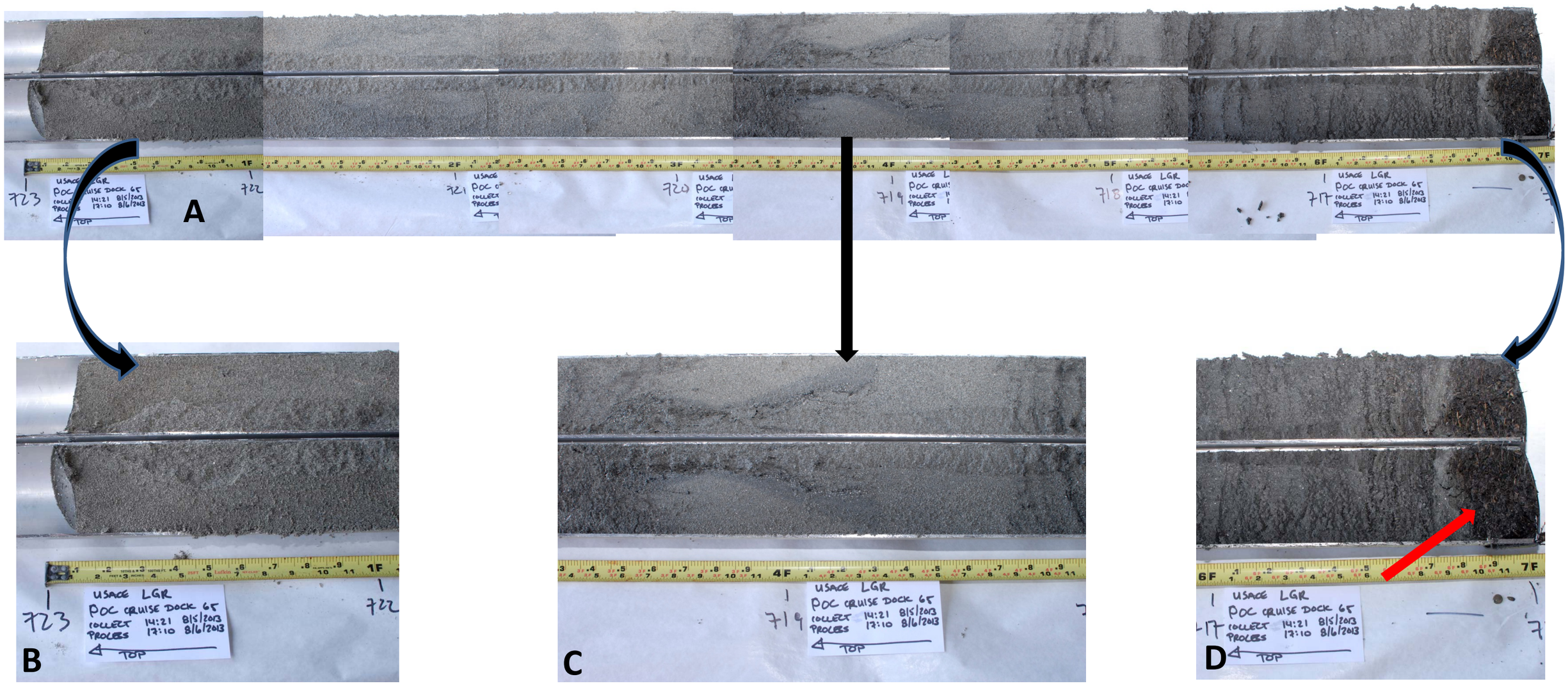


Figure 4-2. Port of Clarkston Cruise Ship Dock Station 65 Core Photos

A – Composite of core photos showing full length of the core from 723 ft to 716 ft amsl. Core could not penetrate below 715 ft amsl

B – Enlargement of the section from 723 – 722 ft amsl showing that from the surface this core did not have an overlying soft sediment deposition.

C – Enlargement of mid-core showing well-sorted fine sand through most of the core length.

D – Enlargement of the last segment at 716.8 ft amsl and the fine wood-debris layer (red arrow) that was consistently seen at all cores attempted at this DMMU.



Figure 4-1 Port of Lewiston DMMU: Stations 70 and 71
A – Showing the grain barge in dock and over Station 70
B – Down-river on Station 70, showing the steel pile wall and on-going construction
C – 1" well-sorted trap rock in the grab sampler. Same as the material being placed behind the sheet-pile wall.
D – Station 71 showing the cable that prevented the boat from reaching the target location.

5.0 NOVEMBER 2013 ANALYSES

Additional sampling and analyses were required by the DMMP agencies based upon the detection of 4-methylphenol, phenol, and benzoic acid. The concentrations of 4-methylphenol in six of the eight Snake River DMMUs (1, 2, 3, 5, 6, and the Port of Clarkston Grain Elevator) exceeded the SL1 guidelines, with values ranging from 340 ppb to 4,900 ppb. Phenol also exceeded SL1 guidelines in DMMU 6 where a concentration of 170 ppb was determined. Benzoic acid, though not detected at concentrations greater than the SL1 guideline, was identified at an unusually high 890 ppb in DMMU 6. Additionally, the highest concentrations of these three constituents all occurred in DMMU 6, the one farthest upstream in the Snake River (Table 4-3). The DMMP agencies informed the Corps that for those stations recollection of sediment for those DMMUs would be required, with chemical analyses for phenolic compounds and benzoic acid, as well as bioassay testing, to further evaluate the suitability of the sediment from those DMMUs for open water disposal.

5.1 PROJECT OBJECTIVES

The objective of the re-sampling effort was to collect sufficient sediment at the previously visited sample locations in DMMUs 1, 2, 3, 5, 6 and the Port of Clarkston Grain Elevator (POC GE) (Figures Tables 3-1 and Figures 3-2 and 3-3) to conduct additional chemical and biological testing. A supplemental SAP (November SAP) (Appendix A3) was written and submitted to the DMMO that substantively reflected the same procedures followed for the August sampling event, with the following changes/additions:

- Composite sediment samples would be collected for each of the DMMUs following the same collection and compositing procedures
- These composite samples would be analyzed for the conventional parameters as well as the phenols, benzoic acid, and pentachlorophenol (Table 5-1)
- Bioassay testing was required for each DMMU using the 20-day *Chironomus dilutus* survival and growth test, and the 10-day *Hyalella azteca* survival test. The interpretive criteria were included in the November SAP
- A reference sediment sample would be collected from an upstream location in the Snake River or Clearwater River. The exact location was not specified in the SAP, but would be determined in the field to match the grain size of the samples collected in the test DMMUs
- The reference sediment was also to be analyzed for the complete suite of chemicals of concern that were completed for the August 2013 samples (Table 4-1).
- The reference sample would also be submitted for the bioassays identified above.

One additional test conducted with this additional effort was to send the August-collected archived sediment samples for DMMUs 1, 2, 3, 5, 6 and POC GE where the SL1 was exceeded to ALS Environmental as an independent check of the phenolic and benzoic acid levels reported by ARI.

5.2 FIELD OBSERVATIONS

Actual field sampling occurred from November 11 – 13, 2013. Details of the sampling event may be found in the Daily Monitoring Reports (Appendix B2), the November 2013 Field Notebook (Appendix D2), the November Sediment Collection Logs (Appendix E2). Photographs of the collected grab samples are found in Appendix G3.

Navigation checks were performed at the same checkpoints used for the August sampling. The checks were within the ± 2.0 m specification required in the SAP (Table 5-1). Table 5-2 shows the target (August) sampling locations, and the actual sampling locations and sample depths in NGVD 29. The target and actual locations by DMMU are shown in Figures 5-1 and 5-2. In general, the actual locations and sampling depths were very close to the August sampled locations.

Differences from the August sampling and compositing procedures are as follows:

1. The Hazen gage was not set up because access to the Corps boat shed/dock was unavailable due to the federal holiday (Veteran's Day). As the LWSI river elevation levels were available by phone, the Hazen was not required for the sampling.
2. Station DMMU 3-3 was not included in Table 1 of the November SAP, but was in the SAP figure and was previously sampled in August. This was noted by the field crew, collected and included in the sample composite
3. The lab did not include sufficient 2 oz glass jars to be able to collect both a composite sulfide, and another sample from an individual grab sample. In addition, there was only sufficient zinc acetate on site to do one sulfide per station. As the last communication from the DMMO was to analyze the composite sample, only the station composite was sub-sampled for sulfides.

Field grain size measures for the DMMUs are presented in Table 5-2. All the field grain size analyses were done by mass; 100 gms of sediment washed through the 62 µm screen, and then retained fines were re-weighed and the final result present as percent retained.

Two reference sediments were collected in an effort to match the grain size of the DMMUs for the bioassays. Initially, the field team travelled upriver on the Snake River and visited the reference station locations listed in a previous report by Anchor Environmental (2006). While the team was able to locate the general areas described by Anchor, the latitude and longitude in the report did not match actual area. Although sediment could have been collected at these sites that likely would match the grain sizes of the test station, it was determined that these were still within areas of industrial influence (e.g., outfalls and marinas) and it could not be assured that the collected sediments, when tested would be below the SL1 criteria.

Field reconnaissance onboard the *Peter R* of potential locations was then conducted beginning upriver at Asotin Creek, working downstream. Several grab sample attempts were made along both shores in relatively quiescent areas in an effort to locate depositional areas. Near the Hells Gate Park on the Idaho bank at a somewhat sheltered cove, a silty-sand (Table 5-1, Figure 5-3) was collected that was compositionally similar to what was collected at DMMUs 1 – 3 and POC GE (Table 5-2).

On November 13, 2013, an on-land reconnaissance was conducted with Steve Juul of the Walla Walla District. Several locations were attempted up the Clearwater River as far as the Potlatch

River confluence with the Clearwater just above Arrow Bridge on Highway 12. There were no areas identified with potentially fine-grained sediments. Even in the quiescent areas, the only deposited materials were fine sands.

Steve Juul knew of a feeder creek, that while downstream of Clarkston Washington, was off-channel and had a pond just prior to the confluence with the Snake River. The pond is located at the intersection of Highway 193 (Wawawai Road) and Steptoe Canyon Road at approximately River Mile 125.5 (Figure 5-4). Above the pond the creek braids through reed canary grass, and the braided creek channel was muddy at the bottom. While there is agriculture above the creek, and there was also evidence of cattle in the area, there was suitably fine grained sediment. Sediments were collected here for compositing and analyses. The coordinates provided in Table 5-2 were estimated from Google Maps.

All samples (DMMU and reference sediments) were sent to Northwest Aquatic Sciences under seal and chain-of-custody by Federal Express overnight delivery (Appendix H). Sediments for chemical analyses were transported under seal and chain-of-custody by SEE directly to ARI. The August-collected sediments to be re-analyzed for phenolics and benzoic acid were sent to ALS from the archive at ARI by SEE under seal and chain-of-custody.

5.3 ANALYTICAL RESULTS

The results of the conventional analyses for the DMMUs are presented in Table 5-3. In general the measured conventionals were similar to those observed in the August-collected samples, with some notable differences. Total Organic Carbon (TOC) measured in the November DMMUs 2, 3, and 6 samples were between 2 – 4.7% higher than the same samples collected in August. Sulfide levels were also elevated in the November samples at DMMUs 1, 2, 5, 6, and POC-GE. Grain size was generally similar, except at DMMUs 5 and 6 which had higher percent fines (plus 25.6 and 17.8%, respectively) than the August samples.

Results for the phenolics and benzoic analyses for the two sampling events, and the ALS re-analysis, are presented in Table 5-4. The samples submitted from the November collection confirmed the presence of 4-methylphenol at levels above the SL1 for DMMUs 1, 3, 5 and 6, but for DMMUs 2 and POC-GE the reported levels were below the SL1. For DMMU 6, the phenol level in the August sample was reported above the SL1; for the November sample phenol was below the SL1.

The results of the August samples submitted to ALS confirmed the findings of ARI for 4-methylphenol; all reported values exceeded the SL1. However, the reported phenol level for DMMU 6 by ALS was approximately ½ of that reported by ARI and was below SL1. While all of the ALS-reported values for 2,4-dimethylphenol were reported non-detected at levels above the SL1, it is worth noting the difference in reporting between the two labs. ARI reports non-detects for 2,4-dimethyphenol to the limits of detection ([LODs]; rather than the limits of quantitation [LOQs]) as the reporting limits, and flags the results (UJ), as listed in the table. The ALS' reporting limits are method reporting limits ([MRLs]; equivalent to the LOQs in this case). In comparing these results, ½ the LOQ as the reporting limits and (flag the results "UJ") as ARI has been done in other USACE projects (e.g., Grays Harbor, Lower Duwamish), the ALS' RLs would be comparable to those of ARI.

Table 5-1 November 2013 Navigation Checks

Date	Time	Latitude (NAD83)	Longitude (NAD83)	Distance From Checkpoint (ft)
Hells Gate Marina Boat Launch				
Nav Check 1		46^0 25.33955'	-117^0 04.32159'	---
11/11/2013	8:24	46^0 25.33963'	-117^0 04.32217'	2.47
11/11/2013	16:43	46^0 25.33964'	-117^0 04.32200'	1.82
11/12/2013	8:01	46^0 25.33970'	-117^0 04.32192'	1.66
11/12/2013	16:41	46^0 25.33976'	-117^0 04.32199'	2.11
USACE				
Nav Check 2		46^0 25.33760’	-117^0 02.31925'	---
11/11/2013	16:14	46^0 25.33780'	-117^0 02.31969'	2.2
11/12/2013	8:27	46^0 25.33765'	-117^0 02.31958'	1.41
11/12/2013	13:17	46^0 25.33767'	-117^0 02.31976'	2.18

HGM = Hells Gate Marina
USACE = Corps Lower Granite Natural Resources Office boat bay

Table 5-2 November 2013 Target and Actual Sampling Locations

DMMU	Sample Key	Sample ID	November 2013 SAP-Listed Sampling Stations and Elevations						November 2013 Actual Sampling Stations and Elevations								Sample Type
			Latitude (NAD83)	Longitude (NAD83)	Measured Mudline (ft)	LWSI Elevation (NGVD 29)	Mudline Elevation (NGVD 29)	Depth to Top of z-Layer (ft) (717 ft NGVD29)	Sample Date	Sample Time	Latitude (NAD83)	Longitude (NAD83)	Measured Mudline (ft)	LWSI Elevation (NGVD 29)	Mudline Elevation (NGVD 29)	Depth to Top of z-Layer (ft) (717 ft NGVD29)	
FNC Clarkston West																	
1	5	LGR-138.3E	46 25.67310	-117 03.38158	-18.0	735.8	717.8	-0.8	11/11/2013	8:44	46 25.66653 N	-117 03.38313	-19.3	737.3	718.0	-1.0	Grab
	6	LGR-138.3F	46 25.65193	-117 03.38262	-17.7	735.8	718.1	-1.1	11/11/2013	9:02	46 25.65040 N	-117 03.38274	-18.9	737.3	718.4	-1.4	Grab
	1	LGR138.4E	46 25.69455	-117 03.27004	-18.2	735.8	717.6	-0.6	11/11/2013	9:20	46 25.69435 N	-117 03.27038	-18.7	737.3	718.6	-1.6	Grab
	2	LGR138.4F	46 25.66394	-117 03.27024	-15.0	735.8	720.8	-3.8	11/11/2013	9:33	46 25.66344 N	-117 03.27030	-15.8	737.1	721.3	-4.3	Grab
	7	LGR-138.5D	46 25.70497	-117 03.179910	-18.1	735.8	717.7	-0.7	11/11/2013	9:52	46 25.70464 N	-117 03.18045	-19.0	737.1	718.1	-1.1	Grab
	8	LGR-138.5E	46 25.68226	-117 03.17977	-15.3	735.8	720.5	-3.5	11/11/2013	10:07	46 25.68205 N	-117 03.17995	-15.7	737.0	721.3	-4.3	Grab
	9	LGR-138.5F	46 25.64825	-117 03.18119	-11.2	735.8	724.6	-7.6	11/11/2013	10:20	46 25.64841 N	-117 03.18110	-11.9	737.0	725.1	-8.1	Grab
2	10	LGR138.6D	46 25.70337	-117 03.12526	-18.2	735.9	717.7	-0.6	11/11/2013	11:28	46 25.70346 N	-117 03.12553	-17.9	737.0	719.1	-2.1	Grab
	13	LGR138.6E	46 25.70047	-117 03.06436	-16.8	735.9	719.1	-2.1	11/11/2013	12:31	46 25.70081 N	-117 03.06462	-16.5	736.8	720.3	-3.3	Grab
	11	LGR138.6F	46 25.6804	-117 03.1251	-13.5	735.9	722.4	-5.4	11/11/2013	11:57	46 25.68085 N	-117 03.12505	-15.2	736.9	721.7	-4.7	Grab
	14	LGR138.6G	46 25.69015	-117 03.06382	-14.8	735.9	721.1	-4.1	11/11/2013	12:46	46 25.69010 N	-117 03.06405	-15.5	736.8	721.3	-4.3	Grab
	15	LGR138.6H	46 25.67219	-117 03.06631	-13.3	735.9	722.6	-5.6	11/11/2013	13:00	46 25.67219 N	-117 03.06644	-14.0	736.8	722.8	-5.8	Grab
	12	LGR138.6I	46 25.64583	-117 03.12679	-10.4	735.9	725.5	-8.5	11/11/2013	12:15	46 25.64600 N	-117 03.12727	-11.4	736.9	725.5	-8.5	Grab
	16	LGR138.6J	46 25.63869	-117 03.06520	-10.3	735.9	725.6	-8.6	11/11/2013	13:14	46 25.63855 N	-117 03.06530	-11.1	736.8	725.7	-8.7	Grab
3	17	LGR138.7	46 25.71100	-117 03.01280	-18.1	735.8	717.7	-0.7	11/11/2013	14:24	46 25.71151 N	-117 03.01295	-18.9	736.7	717.8	-0.8	Grab
	18	LGR138.7A	46 25.68802	-117 03.01252	-15.2	735.8	720.6	-3.6	11/11/2013	14:38	46 25.68810 N	-117 03.01258	-15.9	736.7	720.8	-3.8	Grab
	19	LGR138.7B	46 25.67138	-117 03.01453	-13.5	735.8	722.3	-5.3	11/11/2013	14:52	46 25.67174 N	-117 03.01455	-14.8	736.7	721.9	-4.9	Grab
	20	LGR138.7C	46 25.63815	-117 03.01543	-10.7	735.8	725.1	-8.1	11/11/2013	15:07	46 25.63811 N	-117 03.01509	-10.8	736.7	725.9	-8.9	Grab
	21	LGR138.7D	46 25.69680	-117 02.93750	-16.8	735.8	719.0	-2.0	11/11/2013	15:24	46 25.69651 N	-117 02.93810	-17.1	736.6	719.5	-2.5	Grab
	3	LGR138.7E	46 25.68523	-117 02.93810	-14.7	735.8	721.1	-4.1	11/11/2013	15:56	46 25.68545 N	-117 02.93833	-15.7	736.6	720.9	-3.9	Grab
	22	LGR138.7F	46 25.64123	-117 02.95315	-13.4	735.8	722.4	-5.4	11/11/2013	15:41	46 25.64147 N	-117 02.95305	-14.3	736.6	722.3	-5.3	Grab
FNC Clarkston East																	
5	31	LGR138.9	46 25.64979	-117 02.72121	-16.3	735.8	719.5	-2.5	11/12/13 1	1:18	46 25.65019 N	-117 02.72151	-16.9	736.9	720.0	-3.0	Grab
	32	LGR138.9A	46 25.63780	-117 02.72684	-14.2	735.8	721.6	-4.6	11/12/2013	11:30	46 25.63814 N	-117 02.72725	-15.3	736.9	721.6	-4.6	Grab
	35	LGR138.9B	46 25.62026	-117 02.73595	-13.4	735.8	722.4	-5.4	11/12/2013	11:46	46 25.62056 N	-117 02.73644	-14.3	736.9	722.6	-5.6	Grab
	38	LGR138.9C	46 25.60119	-117 02.59998	-16.2	735.8	719.6	-2.6	11/12/2013	12:23	46 25.60119 N	-117 02.60027	-16.9	736.9	720.0	-3.0	Grab
	39	LGR138.9D	46 25.58528	-117 02.60914	-13.9	735.8	721.9	-4.9	11/12/2013	12:35	46 25.58514 N	-117 02.60975	-14.7	736.8	722.1	-5.1	Grab
	36	LGR138.9H	46 25.62729	-117 02.65398	-16.6	735.8	719.2	-2.2	11/12/2013	11:58	46 25.62744 N	-117 02.65408	-17.5	736.9	719.4	-2.4	Grab
	37	LGR138.9X	46 25.59718	-117 02.67107	-12.9	735.8	722.9	-5.9	11/12/2013	12:11	46 25.59747 N	-117 02.67121	-13.9	736.9	723.0	-6.0	Grab
6	41	LGR139.1A	46 25.57305	-117 02.54624	-15.6	735.8	720.2	-3.2	11/12/2013	9:06	46 25.57321 N	-117 02.54631	-16.7	736.8	720.1	-3.1	Grab

Table 5-2 November 2013 Target and Actual Sampling Locations

DMMU	Sample Key	Sample ID	November 2013 SAP-Listed Sampling Stations and Elevations						November 2013 Actual Sampling Stations and Elevations								Sample Type
			Latitude (NAD83)	Longitude (NAD83)	Measured Mudline (ft)	LWSI Elevation (NGVD 29)	Mudline Elevation (NGVD 29)	Depth to Top of z-Layer (ft) (717 ft NGVD29)	Sample Date	Sample Time	Latitude (NAD83)	Longitude (NAD83)	Measured Mudline (ft)	LWSI Elevation (NGVD 29)	Mudline Elevation (NGVD 29)	Depth to Top of z-Layer (ft) (717 ft NGVD29)	
	42	LGR139.1B	46 25.54852	-117 02.49284	-16.3	735.8	719.5	-2.5	11/12/2013	8:54	46 25.54882 N	-117 02.49284	-17.3	736.9	719.6	-2.6	Grab
	72	LGR139.1I	46 25.52202	-117 02.44118	-17.3	735.8	718.5	-1.5	11/12/2013	8:37	46 25.52215 N	-117 02.44100	-18.3	736.9	718.6	-1.6	Grab
Port of Clarkston Grain Elevator																	
POC-GE	68	LGR138.4G	46 25.63010	-117 03.2784	-15.4	735.6	720.2	-3.2	11/12/2013	10:21	46 25.63025 N	-117 03.27859	-17.5	736.8	719.3	-2.3	Grab
	69	LGR138.4I	46 25.63600	-117 03.2118	-11.1	735.6	724.5	-7.5	11/12/2013	10:38	46 25.63606 N	-117 03.2 -1174	-12.9	736.8	723.9	-6.9	Grab
Reference Sediments																	
Hells Canyon Natural Resource Area, ID (RM 144)									11/12/2013	15:04	46 21.24158 N	-117 03.6430	---	---	---	---	Grab
Steptoe Creek Confluence, WA (RM 128.5)									11/13/2013	12:30	46 27.16417	-117 12.26467	---	---	---	---	Hand

Table 5-3 Field Grain Size Estimate and Laboratory Report Results for the November 2013 Samples

Parameter	DMMU 1	DMMU 2	DMMU 3	DMMU 5	DMMU 6	POC-GE	R144.R-G	R128.5.R-G	NWAS Control
November Field Estimate									
Sand (%)	77.0	81	64.0	53.0	41.0	92.0	80.0	40.0	---
Total Fines (%)	23.0	19.0	36.0	47.0	59.0	8.0	20.0	60.0	---
November Lab Results									
Sand (%)	80.7	85.8	78.9	61.3	51.6	85.8	70.3	35.2	---
Total Fines (%)	19.3	14.2	21.1	38.7	48.4	14.2	29.7	64.8	---
August Lab Results									
Sand (%)	85.2	87	88.7	86.9	69.4	76.6	70.3	35.2	51.6
Total Fines (%)	14.9	13.1	11.2	13.1	30.7	23.5	29.7	64.8	48.8

Table 5-4 Results of Conventional Analyses for the November 2013 Sampling Locations

Parameter	Units	DMMU-1		DMMU-2		DMMU-3		DMMU-5		DMMU-6		POC-GE	
		Value	Qual	Value	Qual	Value	Qual	Value	Qual	Value	Qual	Value	Qual
November 2013 Samples													
Total Solids	percent	56.4		61.2		58.1		41.4		37.0		60.9	
Total Organic Carbon	percent	2.0	J	4.2	J	5.5	J	5.6	J	8.7	J	3.8	J
Sulfide	mg/kg	179.0	J	106.0	J	130.0	J	243.0	J	185.0	J	142.0	J
Ammonia (NH3) as Nitrogen (N)	mg/kg	29.6		23.6		37.6		60.2		101.0		52.1	
Particle/Grain Size, Sand	percent	80.7		85.8		78.9		61.3		51.6		85.8	
Particle/Grain Size, Silt	percent	11.8		8.4		12.0		22.5		29.5		8.6	
Particle/Grain Size, Clay	percent	7.5		5.8		8.9		16.2		18.9		5.5	
August 2013 Samples													
Total Solids	percent	56.6		67.6		68.0		68.4		43.7		48.3	
Total Organic Carbon	percent	1.5		1.5		0.8		1.0		6.8		4.1	
Sulfide	mg/kg	89.3		74.2		125.0		1.7		30.0		66.0	
Ammonia (NH3) as Nitrogen (N)	mg/kg	41.2		29.0		25.0		25.8		69.5		69.8	
Particle/Grain Size, Sand	percent	85.2		87.0		88.7		86.9		69.4		76.6	
Particle/Grain Size, Silt	percent	8.3		6.7		4.5		8.4		16.5		15.6	
Particle/Grain Size, Clay	percent	6.6		6.4		6.7		4.7		14.2		7.9	

Table 5-5 Analytical Results for the November 2013 Sampling Locations for Phenols, Benzoic Acid, and Pentachlorophenol

Parameter	MDLs	MRLs	SQL(1)	SL1	DMMU-1-G-C1-B		DMMU-2-G-C1-B		DMMU-3-G-C1-B		DMMU-5-G-C1-B		DMMU-6-G-C1-B		POC-GE-G-C1-B	
					Value	Qual	Value	Qual	Value	Qual	Value	Qual	Value	Qual	Value	Qual
ARI November 2013 Sample Results																
Total Solids (%)					56.4		61.2		58.1		41.4		37.0		60.9	
Phenol	8.64	20	20	120	39.0		27.0		33.0		100.0		110.0		25.0	
2-Methylphenol	5.25	20	20	63	19.0	U	20.0	U	19.0	U	18.0	J	20.0	U	20.0	U
4-Methylphenol	8.64	20	20	260	**340.0**		160.0		**340.0**		**660.0**		**1200.0**		81.0	
2,4-Dimethylphenol	5.25	40	20	29	26.0	UJ	27.0	UJ	26.0	UJ	26.0	UJ	27.0	UJ	26.0	UJ
Benzoic acid	48.5	200	100	2900	260.0		220.0		200.0		850.0		960.0		170.0	J
Pentachlorophenol	6.63	200	100	1,200	97.0	U	99.0	U	95.0	U	96.0	U	100.0	U	32.0	J
ARI August 2013 Sample Results																
Total Solids (%)					56.6		67.6		68.0		68.4		43.7		48.3	
Phenol	8.64	20	20	120	28.0		23.0		19.0	U	46.0		170.0		67.0	
2-Methylphenol	5.25	20	20	63	19.0	U	20.0	U	19.0	U	19.0	U	19.0	U	19.0	U
4-Methylphenol	8.64	20	20	260	**1700.0**		**650.0**		**340.0**		**1300.0**		**4900.0**		**1400.0**	
2,4-Dimethylphenol	5.25	40	20	29	26.0	UJ	26.0	UJ	25.0	UJ	26.0	UJ	26.0	UJ	26.0	UJ
Benzoic acid	48.5	200	100	2900	280.0		140.0	J	120.0	J	130.0	J	890.0		570.0	
Pentachlorophenol	6.63	200	100	1,200	95.0	UJ	98.0	UJ	94.0	UJ	96.0	UJ	96.0	UJ	97.0	U
ALS-August 2013 Sample Results																
Total Solids (%)					58.7		66.3		68.0		66.8		60.1		48.3	
Phenol	8.64	20	20	120	8.9	J	13.0	J	9.9	J	22.0	J	83.0	J	31.0	J
2-Methylphenol	5.25	20	20	63	8.5	U	7.6	U	7.5	U	7.5	U	42.0	U	7.7	J
4-Methylphenol	8.64	20	20	260	**1100.0**		**690.0**		**550.0**		**870.0**		**4000.0**		**940.0**	
2,4-Dimethylphenol	5.25	40	20	29	**43.0**	U	**38.0**	U	**37.0**	U	**38.0**	U	**210.0**	U	**52.0**	U
Benzoic Acid	6.63	200	100	1,200	150.0	J	120.0	J	110.0	J	100.0	J	**2000.0**	R	220.0	J
Pentachlorophenol	48.5	200	100	2900	85.0	U	76.0	U	74.0	U	75.0	U	420.0	U	110.0	U

Notes:
Red values indicate exceeds the SL1
MDL = Method Detection Limit
MRL = Method Reporting Limit
SQL = Sediment Quantitation Limit
SL1 = Freshwater Screening Level 1 (DMMO Memorandum Appendix A.1)
mg/kg = milligrams per kilogram; **µg/kg** = micrograms per kilogram
U Indicates that the target analyte was not detected at the reported concentration
UJ - The analyte was analyzed for, and the associated quantitation limit was an estimated value.
J Estimated concentration when the value is less than ARI's established reporting limits
R - The reported result was rejected.

Table 5-6 Analytical Results for the November 2013 Reference Sediments

Parameter	MDLs	MRLs	SQL(1)	SL1	SR128.5-R-G1		SR144-R-G	
					Value	Qual	Value	Qual
CONVENTIONALS								
Total solids (%)	—	0.10%	0.1	—	53.54		56.19	
Total organic carbon (%)	0.02%	0.05%	0.1	—	2.18	J	2.24	J
Total Sulfides (mg/kg)	0.01	1.0	1.0	—	44.7	J	332	J
Ammonia (mg/kg)	0.02	0.1	0.1	—	2.88		30.1	
Gravel (%)					0.3		0.1	U
Sand (%)	—	—	—	—	35.2		70.3	
Silt (%)	—	—	—	—	50.6		22.2	
Clay (%)	—	—	—	—	13.9		7.5	
Metals (mg/kg dry weight)								
Antimony	0.63	5	0.5	150	9	UJ	9	UJ
Arsenic	0.33	5	5	14	9	U	9	U
Cadmium	0.18	0.2	2.1	2.1	0.4		0.4	U
Chromium	0.12	0.5	5	72	15.9		16.5	
Copper	0.1	0.2	5	400	17		14.9	
Lead	0.16	2	5	360	6		7	
Mercury	0.0021	0.025	0.1	0.66	0.03	U	0.04	U
Nickel	0.08	0.5	5	26	13		11	
Selenium	0.13	0.5	—	3	0.9	UJ	0.9	UJ
Silver	0.04	0.3	0.5	0.57	0.5	U	0.5	U
Zinc	0.15	1	5	3,200	63		54	
POLYNUCLEAR AROMATIC HYDROCARBONS (PAHS; µg/kg)								
LOW-MOLECULAR WEIGHT PAHS								
Naphthalene	2.63	5	20	500	19	U	15	J
Acenaphthylene	1.26	5	20	470	19	U	19	U
Acenaphthene	1.32	5	20	1,100	19	U	19	U
Fluorene	1.29	5	20	1,000	19	U	19	U
Phenanthrene	1.98	5	20	6,100	19	U	19	U
Anthracene	1.46	5	20	1,200	19	U	19	U
2-Methylnaphthalene	1.52	5	20	470	19	U	19	U
HIGH-MOLECULAR WEIGHT PAHS								
Fluoranthene	1.77	5	20	11,000	19	U	19	U
Pyrene	2.22	5	20	8,800	19	U	19	U
Benz(a)anthracene	1.6	5	20	4,300	19	U	19	U
Chrysene	1.88	5	20	5,900	19	U	19	U
Benzofluoranthenes (b, j ,k)	—	—	—	600	38	U	38	U
Benzo(a)pyrene	1.75	5	20	3,300	19	U	19	U
Indeno(1,2,3-c,d)pyrene	3.47	5	20	4,100	19	U	19	U
Dibenz(a,h)anthracene	2.38	5	20	800	19	U	19	U
Benzo(g,h,i)perylene	3.05	5	20	4,000	19	U	19	U

Table 5-6 Analytical Results for the November 2013 Reference Sediments

Parameter	MDLs	MRLs	SQL(1)	SL1	SR128.5-R-G1		SR144-R-G	
					Value	Qual	Value	Qual
CHLORINATED HYDROCARBONS (µg/kg)								
1,4-Dichlorobenzene	2.86	20	20	110	19	U	19	U
1,2-Dichlorobenzene	2.5	20	20	35	19	U	19	U
1,2,4-Trichlorobenzene	3.48	20	20	31	19	U	19	U
Hexachlorobenzene (HCB)	0.094	0.5	10	22	1.9		0.97	U
Phthalates (µg/kg dry weight)								
Dimethyl phthalate	2.9	20	20	46	19	U	19	U
Diethyl phthalate	36.6	50	20	200	26	U	58	U
Di-n-butyl phthalate	8.16	20	20	380	19	U	19	U
Butyl benzyl phthalate	6.14	20	20	260	19	U	19	U
Bis(2-ethylhexyl) phthalate	14.6	25	100	500	48	U	34	J
Di-n-octyl phthalate	5.84	20	20	39	19	U	19	U
Phenols (µg/kg dry weight)								
Phenol	8.64	20	20	120	20		19	U
2-Methylphenol	5.25	20	20	63	19	U	19	U
4-Methylphenol	8.64	20	20	260	19	U	120	
2,4-Dimethylphenol	5.25	40	20	29	26	UJ	26	UJ
Pentachlorophenol	6.63	200	100	1,200	96	U	96	U
Miscellaneous Extractables (µg/kg dry weight)								
Benzyl alcohol	2.1	20	50	57	19	U	16	J
Benzoic acid	48.5	200	100	2,900	70	J	90	J
Dibenzofuran	4.1	20	20	200	19	U	19	U
Hexachlorobutadiene	0.138	0.5	10	11	0.98	U	0.97	U
N-Nitrosodiphenylamine	5.39	20	20	28	19	U	19	U
beta-Hexachlorocyclohexane	0.139	0.5	—	7.2	0.49	U	1.3	U
Pesticides (µg/kg dry weight)								
4,4'-DDD	0.124	1	2	310	8.3	J	0.97	U
4,4'-DDE	0.135	1	2	21	0.98	U	0.97	U
4,4'-DDT	0.192	1	2	100	0.98	U	0.97	U
Aldrin	0.055	0.5	2	9.5	0.49	U	0.48	U
Carbazole	2.69	20	900	900	19	U	19	U
cis -chlordane	0.051	0.5	—	—	0.49	U	0.48	U
trans-chlordane	0.077	0.5	—	—	0.49	U	0.48	U
cis - nonachlor	0.541	1	—	—	0.98	U	0.97	U
trans - nonachlor	0.529	1	—	—	0.98	U	0.97	U
oxychlordane	0.825	1	—	—	0.98	U	0.97	U
Total Chlordane Compounds(1)			2	2.8	0.98	U	0.97	U
Dieldrin	0.1	1	2	4.9	0.98	U	0.97	U
Endrin ketone	0.119	1	8.5	8.5	0.98	U	0.97	U
Heptachlor	0.132	0.5	1.5	1.5	0.49	UJ	0.48	UJ

Table 5-6 Analytical Results for the November 2013 Reference Sediments

Parameter	MDLs	MRLs	SQL(1)	SL1	SR128.5-R-G1		SR144-R-G	
					Value	Qual	Value	Qual
Lindane	0.048	0.5	2	—	0.49	U	0.48	U
Toxaphene	35	100	0.2	0.2	24	U	24	U
TOTAL PCBS (AROCHLORS)	10	20	10	110				
Aroclor 1016			—	—	19	U	18	U
Aroclor 1242			—	—	19	U	18	U
Aroclor 1248			—	—	19	U	18	U
Aroclor 1254			—	—	19	U	18	U
Aroclor 1260			—	—	19	U	18	U
Aroclor 1221			—	—	19	U	18	U
Aroclor 1232			—	—	48	U	54	U
Aroclor 1262			—	—	19	U	18	U
Aroclor 1268			—	—	19	U	18	U

Notes:

Red values indicate exceeds the SL1

MDL = Method Detection Limit

MRL = Method Reporting Limit

SQL = Sediment Quantitation Limit

SL1 = Freshwater Screening Level 1 (DMMO Memorandum Appendix A.1)

mg/kg = milligrams per kilogram; **µg/kg** = micrograms per kilogram

U Indicates that the target analyte was not detected at the reported concentration

UJ - The analyte was analyzed for, and the associated quantitation limit was an estimated value.

J Estimated concentration when the value is less than ARI's established reporting limits

R - The reported result was rejected.

(1) Chlordane compounds include cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, and in samples with interference from PCBs, the SQLs for cis- and trans-nonachlor and oxychlordane may be elevated

0 300
Scale in Feet

SNAKE RIVER

680 685 690 695 700 705 710 715 720 725

DMMU 1

DMMU 2

DMMU 3

PORT OF CLARKSTON

WASTEWATER TREATMENT PLANT

DMMU POC GRAIN ELEVATOR

DMMU POC RECREATIONAL BOAT DOCK

CLARKSTON

LEGEND

- 2 AUGUST 2013 SAP LOCATION
- 2 AUGUST 2013 ACTUAL SEDIMENT SAMPLE LOCATION
- 5 NOVEMBER 2013 ACTUAL SAMPLE LOCATION
- EXISTING CONTOUR
- DREDGING DMMU BOUNDARY

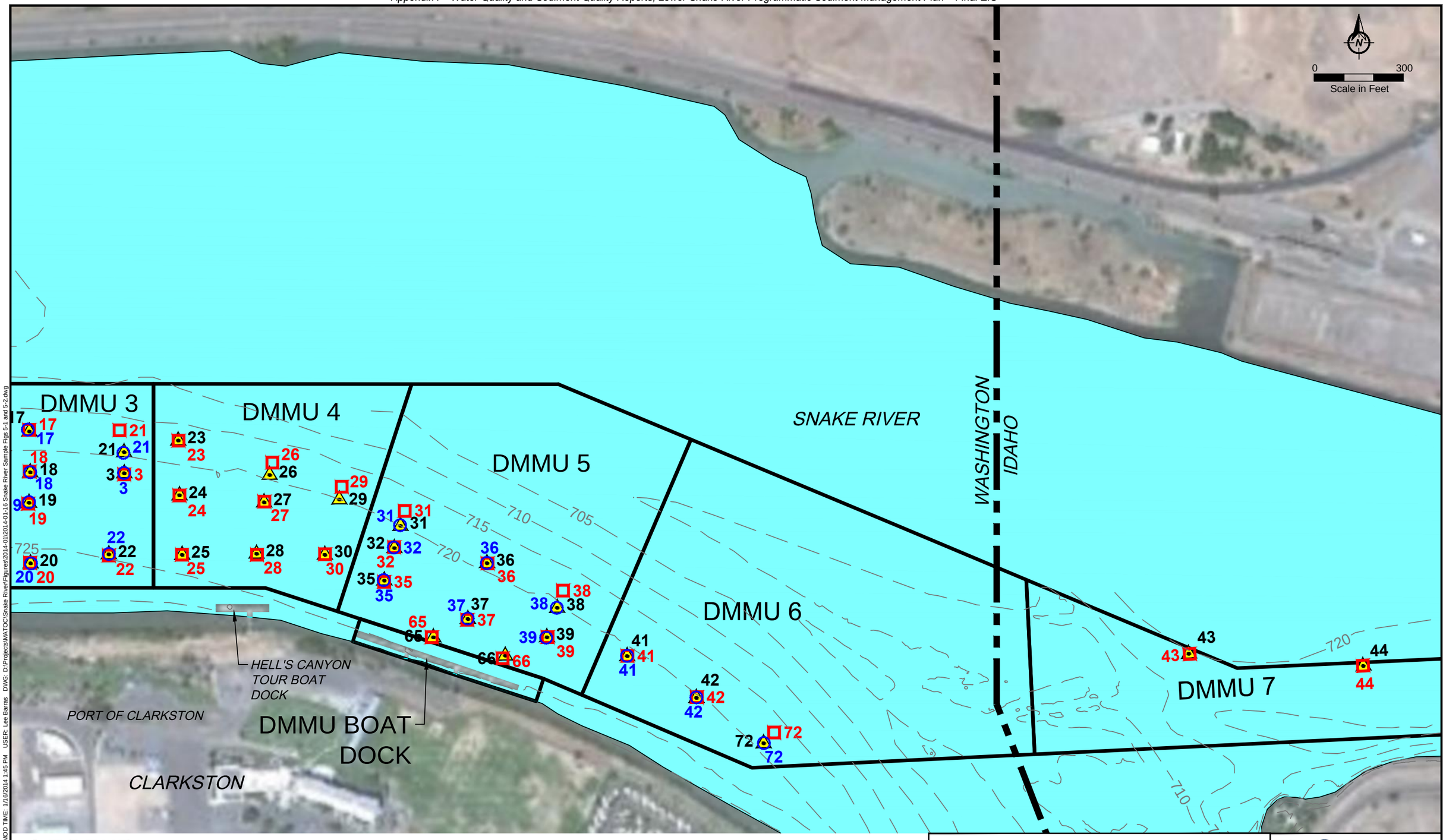
SNAKE RIVER SAMPLING

DALTON OLMSTED FUGLEVAND

FIGURE 5-1

JANUARY 2014

PLOT TIME: 1/16/2014 2:15 PM MOD TIME: 1/16/2014 1:45 PM USER: Lee Barras DWG: D:\Projects\MATOC\Snake River\Figures\2014-01\2014-01-16 Snake River Sample Figs 5-1 and 5-2.dwg



LEGEND

- 2 AUGUST 2013 SAP LOCATION
- 2 AUGUST 2013 ACTUAL SEDIMENT SAMPLE LOCATION
- 5 NOVEMBER 2013 ACTUAL SAMPLE LOCATION
- EXISTING CONTOUR
- DREDGING DMMU BOUNDARY

SNAKE RIVER SAMPLING

DALTON OLMSTED FUGLEVAND

FIGURE 5-2

JANUARY 2014

PLOT TIME: 1/16/2014 2:15 PM MOD TIME: 1/16/2014 1:45 PM USER: Lee Barras DWG: D:\Projects\MATOC\Snake River\Figures\2014-01\2014-01-16 Snake River Sample Figs 5-1 and 5-2.dwg

Figure 5-3 Reference Sediment Sampling at Hells Gate State Recreation Area, ID (RM 144).







Figure 5-4 Reference Sediment Sampling at Steptoe Creek Confluence, Washington (RM 128.5).



6.0 BIOASSAY RESULTS

Bioassays were conducted on the six (6) DMMU composite samples and on both reference sediment samples. The following bioassays were conducted:

- 10-day *Hyalella azteca* survival test
- 20-day *Chironomus dilutus* survival and growth test

For this program the DMMO instructed the Corps to evaluate the results of the bioassays using the Department of Ecology's draft sediment management standard biological criteria (WAC 173-204-563 Table VII). Consistent with Table VII, the DMMO further instructed the Corps to compare the DMMU test results to the reference stations approved by Ecology.

The DMMP uses these bioassay criteria to determine single-hit (major) and two-hit (minor) failures. A single hit failure occurs when any one biological test exhibits a test sediment response that exceeds the bioassay-specific guidelines relative to the negative control and/or reference, and which is statistically significant in comparison to the reference. A two-hit failure occurs when any two biological tests exhibit test sediment responses that exceed the bioassay-specific guidelines relative to the negative control and are statistically significant compared to the reference sediment, but are less than the bioassay-specific reference-comparison guidelines noted above for a single-hit failure. In the event of one hit under the single-hit rule or two hits under the two-hit rule, the DMMU is judged to be unsuitable for unconfined open-water disposal. Per communication from the DMMO, the Ecology Sediment Cleanup Objective criteria were used for the two-hit guideline, while the Cleanup Screening Level would be used for the single-hit guideline.

The relevant interpretive criteria were included in the approved November SAP, but when evaluating the results it was determined that the SAP-criteria for the criterion for the 10-day *Hyalella azteca* mortality test were not consistent with the draft Ecology criteria; the corrected criteria are provided in Table 6-1.

All analyses were conducted by Northwestern Aquatic Sciences (NWAS) of Newport, Oregon, and the data were validated by SEE, LLC. All bioassay results, including the summary results tables, statistical evaluations, bioassay validation reports, and the NWAS data reports are in Appendix L. All bioassay data were judged to be of known quality and acceptable for use.

6.1 REFERENCE SEDIMENT PAIRINGS

Bioassay testing for dredged material characterization requires comparing the results of the test sediment to suitable reference sediments. As discussed in Section 5.2, two reference sediments were collected: SR144 upriver next to the Hells Gate State Recreation Area, and at SR 128.5 which was off the main stem of the Snake River in Steptoe Creek. Test sediments were paired with reference sediment based upon the relative grain size of each (Table 6-2). In consultation with the DMMO, and including approval by Ecology, test sediments from DMMUs 1, 2, 3, and POC GE were paired with reference sediment SR 144 for evaluation. All of these stations had relatively course (high sand, low fines) sediments. The material collected at SR 128.5 was considered to be too fine for comparative use to the test dredge sediments, so as an alternative for DMMUs 5 and 6, these were paired with NWAS' control sediment from Beaver Creek. Beaver Creek sediments were collected by NWAS on November 18, 2013 from an area

approximately one mile east of the Highway 101 Bridge at Beaver Creek; approximately 8 miles south of Newport, Oregon.

6.2 *HYALELLA AZTECA* 10-DAY MORTALITY TESTING

The results of the 10-day freshwater amphipod mortality test may be seen in Table 6-2. The percent mortality control and reference sediment met the relevant performance criteria; the test may be considered a valid test. The laboratory report and data validation report may be found in Appendix L1.

All tested sediments (control, reference, and DMMUs) had mortality that was less than 5%. All test sediments were well below the one and two-hit criteria, and are considered to have passed relative to these guidelines.

6.3 *CHIRONOMUS DILUTUS* 20-DAY MORTALITY TESTING

The results of the 20-day freshwater midge mortality test may be seen in Table 6-3. The percent mortality control and reference sediment met the relevant performance criteria; the test may be considered a valid test. The laboratory report and data validation report may be found in Appendix L1

All tested DMMU-composite sediments had mortality that was less than that observed in the control sediment (18.8%); i.e., greater survival of the midge was observed in the test sediments relevant to the controls. Relative to the respective reference sediment, all tested DMMU-sediments were within the range of ±3.8%. All test sediments were well below the one and two-hit criteria, and are considered to have passed relative to these guidelines.

6.4 *CHIRONOMUS DILUTUS 20-DAY GROWTH TEST*

The results of the 20-day freshwater midge growth test may be seen in Table 6-4. The mean individual growth rate (MIG), expressed as the ash free dry weight (AFDW) exceeded the relevant performance criteria for the control and reference sediments. The test may be considered a valid test. The laboratory report and data validation report may be found in Appendix L2

All tested DMMU-composite sediments had MIG that was at least 80% of that observed in the Beaver Creek control sediment, and at least 91% of that observed in the relevant reference sediment. In several cases the MIG exceeded that observed in the control and reference sediments. All test sediments were well below the one and two-hit criteria, and are considered to have passed relative to these guidelines.

Table 6-1 Bioassay Interpretive Guidelines for Freshwater Testing

Toxicity Test	Negative Control Performance Standard	Reference Sediment Performance Standard	1-Hit Criteria	2-Hit Criteria
Hyalella azteca 10-day mortality	Mortality ≤ 20%	Mortality ≤ 25%	Mortality > 25% over reference Statistically different from reference sediment (p = 0.05)	Mortality > 15% over reference Statistically different from reference sediment (p = 0.05)
Chironomus dilutus 20-day mortality	Mortality ≤ 32%	Mortality ≤ 35%	Mortality > 25% over reference Statistically different from reference sediment (p = 0.05)	Mortality > 15% over reference Statistically different from reference sediment (p = 0.05)
Chironomus dilutus 20-day growth	Mean individual growth/day ≥ 0.6 mg/day	Mean individual growth rate ≥ 80 percent of the control sediment	Mean growth rate < 60% reference Statistically different from reference sediment (p = 0.05)	Mean growth rate < 75% reference Statistically different from reference sediment (p = 0.05)

Note: These criteria are corrected over those submitted with the November 2013 SAP.

Table 6-2 *Hyalella azteca* 10-day mortality results.

Sample	% fines	Mean mortality (%)	$M_T - M_C$ [1,2]	$M_T - M_C$ > 25%?	$M_T - M_R$ [3]	Statistically greater than reference?	Trans-formation	1-Hit Criteria: M_T-M_R >25% and M_T vs. M_R SS (p = 0.05)	2-Hit Criteria: M_T-M_R >15% and M_T vs. M_R SS (p = 0.05)	Interpretation
DMMU 1	19.3	1.3	0.0	no	0.0	no	---	no	no	no hit
DMMU 2	14.2	0.0	-1.3	no	-1.3	no	---	no	no	no hit
DMMU 3	20.9	0.0	-1.3	no	-1.3	no	---	no	no	no hit
DMMU 5	38.7	0.0	-1.3	no	-1.3	no	---	no	no	no hit
DMMU 6	48.4	1.3	0.0	no	0.0	no	---	no	no	no hit
DMMU GE	14.1	0.0	-1.3	no	-1.3	no	---	no	no	no hit
Control (Beaver Creek) (C)	39.4	1.3	---	control acceptable	---	---	---	---	---	---
Reference SR 144	29.7	1.3	0.0	no	---	reference acceptable	---	---	---	---
Reference SR 128.5	64.5	3.8	2.5	no	---	reference acceptable	---	---	---	---

Notes:
1. M_C = Mean Control Mortality
2. M_T = Mean Test Station Mortality
3. M_R = Mean Reference Mortality

Test Sediments DMMU 1, 2, 3 and POC GE paired with reference sediment 1 (SR 144)
Test Sediments DMMU 5 and 6 paired with the Beaver Creek Control Sediment as a reference

Table 6-3 *Chironomus dilutus* 20-day mortality results.

Sample	% fines	Mean mortality (%)	$M_T - M_C$ [1,2]	$M_T - M_C$ > 25%?	$M_T - M_R$ [3]	Statistically greater than reference?	Trans-formation	1-Hit Criteria: M_T-M_R >25% and M_T vs. M_R SS (p = 0.05)	2-Hit Criteria: M_T-M_R >10% and M_T vs. M_R SS (p = 0.05)	Interpretation
DMMU 1	19.3	13.8	-5.1	no	0.0	no	---	no	no	no hit
DMMU 2	14.2	15.0	-3.8	no	1.3	no	---	no	no	no hit
DMMU 3	20.9	13.8	-5.1	no	0.0	no	---	no	no	no hit
DMMU 5	38.7	12.5	-6.3	no	-1.3	no	---	no	no	no hit
DMMU 6	48.4	12.5	-6.3	no	-1.3	no	---	no	no	no hit
DMMU GE	14.1	17.5	-1.3	no	3.8	no	---	no	no	no hit
Control (Beaver Creek)	39.4	18.8	---	control acceptable	---	---	---	---	---	---
Reference SR 144	29.7	13.8	-5.1	no	---	reference acceptable	---	---	---	---
Reference SR 128.5	64.5	26.3	7.5	no	---	reference acceptable	---	---	---	---

Notes:
1. M_C = Mean Control Mortality
2. M_T = Mean Test Station Mortality
3. M_R = Mean Reference Mortality

Test Sediments DMMU 1, 2, 3 and POC GE paired with reference sediment 1 (SR 144)
Test Sediments DMMU 5 and 6 paired with the Beaver Creek Control Sediment as a reference

Table 6-4 *Chironomus dilutus* 20-day growth results.

Sample	% fines	Growth - mean Individual AFDW (mg) [1]	Control Performance MIG_C > 0.60 mg/individual [2]	Reference Performance MIG_R / MIG_C ≥ 0.8 [3]	MIG_T/MIG_C	MIG_T/MIG_R [4]	MIG_T SS < MIG_R (p = 0.05)	Trans-formation	1-Hit Criteria: MIG_T/MIG_R < 0.6 and MIG_T SS < MIG_R (p = 0.05)	2-Hit Criteria: MIG_T/MIG_R < 0.75 and MIG_T SS < MIG_R (p = 0.05)	Interpretation
DMMU 1	19.3	1.42	---	---	0.82	0.91	no	---	no	no	no hit
DMMU 2	14.2	1.67	---	---	0.97	1.07	no	---	no	no	no hit
DMMU 3	20.9	1.62	---	---	0.94	1.04	no	---	no	no	no hit
DMMU 5	38.7	1.52	---	---	0.88	0.88	no	---	no	no	no hit
DMMU 6	48.4	1.65	---	---	0.95	0.95	no	---	no	no	no hit
DMMU GE	14.1	1.95	---	---	1.13	1.25	no	---	no	no	no hit
Control (Beaver Creek)	39.4	1.73	1.73	---	---	---	---	---	---	---	---
Reference SR 144	29.7	1.56	---	0.90	---	---	---	---	---	---	---
Reference SR 128.5	64.5	1.70	---	0.99	---	---	---	---	---	---	---

Notes:
1. AFDW = Ash Free Dry Weight at the conclusion of the test
2. MIG_C = Mean Individual Growth Control
3. MIG_R = Mean Individual Growth Reference
4. MIG_T = Mean Individual Growth Test Mortality

Test Sediments DMMU 1, 2, 3 and POC GE paired with reference sediment 1 (SR 144)
Test Sediments DMMU 5 and 6 paired with the Beaver Creek Control Sediment as a reference

7.0 DISCUSSION

Overall, the findings in the 2013 sampling events are similar to those reported for the 2011 sampling (USACE 2012). Sediment samples from the Clearwater River DMMUs had higher percent sand and total solids than those collected from the Lower Snake River DMMUs, and for most chemicals of concern were either non-detected, or below the screening levels (SL1) agreed to with the DMMO in the SAP.

The clear contrast in these sampling events is the detection of 4-methylphenol, phenol, and benzoic acid, and the exceedance of 4-methylphenol of SL1 for all but DMMU 4 in the Lower Snake River samples. Phenol also exceeded SL1 at DMMU 6; benzoic acid while elevated did not exceed SL1. The November 2013 sampling confirmed the presence and exceedance of 4-methylphenol, but at lower levels than were observed in the August 2013 sampling. In addition, a confirmation analyses performed by ALS on the August 2013 samples further confirmed the presence of 4-methylphenol above the SL1.

While these same three compounds were detected in the composite samples from cores collected within DMMUs for the POC Recreation Dock and Cruise Dock, as noted previously they were at lower levels than the DMMUs represented by grab samples, and below SL1.

Table 7-1 compares the results of the 2011 and 2013 sampling events for 4-methylphenol. The data comparison lists the 2011 DMMU, station location, type of sample (grab vs. core), and the analytical results, and then contrasts those with the August 2013 results in the corresponding DMMU. Table 5-5 previously compared the analytical results for the November 2013 sampling with the August 2013 results by both ARI and ALS.

The presence of 4-methlyphenol was confirmed where detected in 2013, but as noted previously in lower concentrations in the November 2013 sampling. In 2011, Table 7-1 shows that 4-methylphenol was undetected at all sampling locations, and that with the exception of the POC Grain Elevator all of those samples were composites represented by up to a meter of the sediment column. While there are only four comparable samples from the August 2013 event there are some contrasts worth noting. In both sampling events, 4-methylphenol was not detected in the Clearwater River samples. This may be a function of high sand content (i.e., low silts and clays), low total organic carbon, above a possible source, or a combination of all of the above. For the single comparable surface grab between the two events, the samples collected at the Port of Clarkston Grain Elevator were undetected in 2011, but had one of the highest levels found in 2013. The samples collected at the POC Cruise Dock were both core samples, and had either non-detected or low levels below SL1 (Table 7-2). Finally, the contrast between the 2011 core samples within DMMU 6 and the August 2013 surface grab is undetected (11 U ppb) vs. the highest level measured in all samples (4,900 ppb).

Given the confirmation of 4-methylphenol at levels above the SL1 at these locations, the bioassays under the DMMP are required and decisive for the suitability determination. For the two organisms and three end-points tested, the proposed dredge sediments passed the DMMP biological guidelines. In consideration then of all test data, from 2011 and 2013, the sediments should be suitable for in-water disposal. The final suitability determination rests with the DMMP agencies.

Table 7-1. Comparison of Results for POC Cruise Dock and Recreation Dock Samples collected in 2011 and 2013.

2011 Locations and Results					August 2013 Locations and Results				
2011 DMMU Location	**2011 Station ID**	**Type of Sample**	**Value**	**Qual**	**2013 DMMU**	**2013 ID**	**Type of Sample**	**Value**	**Qual**
FNC Lewiston DMMU	CLW1.2C	Core (86 cm)	4.1	U	POL Lewiston	POL-G-C1	Surface Grab	19.0	U
POC Grain Elevator	LGR138.4G	Grab	8.8	U	POC Grain Elevator	POC-GE-G-C1	Surface Grab	1,400	
POC Grain Elevator	LGR138.4G2	Duplicate Grab	9.0	U					
POC DMMU	LGR138.95K2	Core (111-212 cm)	10.0	U	POC Cruise Dock [1]	POC-CD-C-C1	Core	28.0	
FNC Clarkston East	LGR138.9Y1	Core (1 - 123 cm)	11.0	U	DMMU 6	DMMU-6-G-C1	Surface Grab	4,900	
FNC Clarkston East	LGR138.9Y2	Core (124 - 215) cm)	11.0	U					
Greenbelt Boat Basin	LGR139.4E2	Core (no depth reported)	13.0	U	Not sampled in 2013				
Greenbelt Boat Basin	LGR139.5E21	Core (0-99 cm)	12.0	U	Not sampled in 2013				
Greenbelt Boat Basin	LGR139.5E22	Core (99-110 cm)	10.0	U	Not sampled in 2013				
Greenbelt Boat Basin	LGR139.5E23	Duplicate of LGR139.5E21	14.0	U	Not sampled in 2013				

Notes:
1. The core lengths for the POC Cruise Dock samples were 0-1.2 and 01.8 meters.
Values in red exceed SL1

Table 7-2. Summary Results for all August 2013 Samples

Parameter	**SL1**	**POC-GE**	**DMMU 1**	**DMMU 2**	**DMMU 3**	**DMMU 4**	**DMMU 5**	**DMMU 6**	**POC Cruise Dock**	**POC Rec Dock**	**DMMU 7**	**DMMU 8**	**DMMU 9**	**POL**	**DMMU 10**	**DMMU 11**
		Lower Snake River DMMUs									**Clearwater River DMMUs**					
% Total solids	—	48.26	56.58	67.55	68.03	70.46	68.41	43.72	73.58	53.78	74.53	67.59	74.2	68.15	77.71	75.69
% TOC	—	4.14	1.53	1.47	0.84	0.67	1.03	6.84	3.63	2.02	0.419	0.721	0.231	0.235	0.672	0.265
% Sand	—	76.6	85.2	87	88.7	92.5	86.9	69.4	94	44.8	94.3	96.3	98.2	95.1	92.4	98.4
Phenol	120	67.0	28.0	23.0	19.0	12.0	46.0	170.0	19.0	36.0	20.0	18.0	19.0	19.0	19.0	13.0
4-Methylphenol	260	1400.0	1700.0	650.0	340.0	190.0	1300.0	4900.0	28.0	130.0	15.0	18.0	19.0	19.0	19.0	19.0
Benzoic acid	2,900	570.0	280.0	140.0	120.0	61.0	130.0	890.0	110.0	430.0	200.0	180.0	190.0	190.0	190.0	190.0

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Lower Snake River Programmatic Sediment Management Plan Environmental Impact Statement

Appendix I

Water Quality and Sediment Quality Reports

August 2014

Section 2D. Memorandum for Record
Subject: Determination on the Suitability of Proposed Dredged Material from Lower Snake River Maintenance Dredging for Open Water Disposal in the Snake River or at an Approved Beneficial Use or Upland Site

U.S. Army Corps of Engineers
Seattle District
CENWS-OD-TS-NR-DM

February 18, 2013

CENWS-OD-TS-NR-DM

MEMORANDUM FOR: RECORD February 18, 2014

SUBJECT: DETERMINATION ON THE SUITABILITY OF PROPOSED DREDGED MATERIAL FROM LOWER SNAKE/CLEARWATER RIVER MAINTENANCE DREDGING FOR OPEN WATER DISPOSAL IN THE SNAKE RIVER OR AT AN APPROVED BENEFICIAL USE OR UPLAND SITE.

1. Introduction. This memorandum reflects the consensus determination of the Dredged Material Management Program (DMMP) agencies (U.S. Army Corps of Engineers, Washington Departments of Ecology and Natural Resources, and the Environmental Protection Agency) regarding the suitability of approximately 489,212 cubic yards (cy) (Table 1) of dredged material from the lower Snake/Clearwater federal navigation channel and from locations at the Ports of Clarkston, Washington and Lewiston, Idaho, for open water disposal. The Corps of Engineers currently proposes unconfined open water disposal for all material in the Snake River near Knoxway Canyon at river mile (RM) 116, Garfield County, Washington. The proposal is to build a shallow water habitat bench for juvenile salmonids.

2. Project. The area proposed for dredging includes the federal navigation channel and associated port facilities at the confluence of two rivers in two states. Permitting procedures for Corps and Port dredging projects are different, so project notification occurred under two separate notices. For federal dredging see CENWW-PM-PD-EC 13-01; for port dredging see joint notice: NWS-2013-519 and NWS-2013-916. Though permitting procedures are different for these entities, the projects will be dredged as a whole and were thus—for the most part—characterized together. This Suitability Determination covers the entire project area except for the Port of Clarkston Crane Dock, which was characterized under a separate effort but will be dredged under the referenced Port of Clarkston permit. The project actions, as described in the referenced Public Notices and as shown in Figure 1, are:

   a. The Corps of Engineers, Walla Walla district, proposes dredging the federal navigation channel in four locations in the Lower Granite and McNary Reservoirs on the lower Snake and Clearwater Rivers in Washington and Idaho for a total of approximately 469,212 cy. This maintenance dredging is proposed to provide a 14-foot deep navigation channel, plus two foot over-depth, as measured at minimum operating pool (MOP). MOP at the confluence of the Snake and Clearwater Rivers is identified as an elevation of 733 ft National Geodetic Vertical Datum of 1929 (NGVD29).

   b. The Port of Clarkston proposes to dredge approximately 14,000 cy in four berthing areas: Crane Dock, Grain Elevator, Recreation Dock and Cruise Dock. The Crane Dock, Grain Elevator and Cruise Dock will be dredged to 16 ft MOP (14 ft plus two foot over-depth). The Recreation Dock will be dredged to a depth of 7.5 ft MOP (including over-depth).

   c. The Port of Lewiston proposes to dredge approximately 6,000 cy in one berthing area, to a depth of 16 ft MOP (14 ft plus two foot over-depth).

   Proposed disposal of all material suitable for open water disposal is a location in the Lower Granite reservoir, Snake RM 116 just upstream of Knoxway Canyon. The proponents propose to use the dredged material to create a shallow water habitat bench for juvenile salmonids.

   Dredging at the confluence of the Snake and Clearwater Rivers last took place in the winter of 2005 - 2006.

Table 1. Snake/Clearwater project summary

Project ranking		Low/Low-moderate
Proposed dredging volumes (from Public Notices)		Port of Lewiston: ~ 6,000 cy Port of Clarkston: ~ 14,000 cy Federal Navigation Channel: 469,212 cy
Proposed dredging depth		16 ft MOP/7.5 MOP (min. operating pool)
Tier 2 (chemistry)	SAP received	May 20, 2013
	SAP approved	May 23, 2013
	Sampling dates	August 2-6, 2013
Tier 3 (bioassays)	SAP received	October 28, 2013
	SAP approved	November 5, 2013
	Sampling dates	November 11-13, 2013
Final Report received		January 17, 2014
EIM Study ID		SNCLW13
Public Notices: • Port of Lewiston • Port of Clarkston • Federal Navigation Channel		• NWS-2013-519 • NWS-2013-916 • CENWW-PM-PD-EC 13-01
Recency Determination (Low ranked areas = 7 years; LM ranked areas 6 years)		September 2018/2019

Table 2. Volume comparisons for Snake/Clearwater proposed dredging. Volumes used for Suitability Determination are shaded in blue.

Area to be Dredged	DMMU	Approximate volumes (cy)			
		SAP	Final report	Corps PN	Ports PN
FNC Clarkston West	1	57,079	57,818		
	2	58,365	60,167		
	3	58,165	55,453		
FNC Clarkston East	4	59,635	57,849		
	5	55,749	52,221		
	6	22,032	20,948		
FNC Clearwater	7	6,674	6,187		
	8	11,261	11,261		
FNC Lewiston	9	55,591	55,591		
	10	58,284	58,284		
	11	26,367	26,367		
All Federal Dredging	--	469,199	462,146	469,212	--
Port of Clarkston Grain Elevator	POC-GE	3,218	3,218		
Port of Clarkston Rec. Dock	POC-RD	1,036	1,036		
Port of Clarkston Cruise Dock	POC-CD	9,041	9,041		
All Port of Clarkston	--	13,295	13,295	14,143	~14,000
Port of Lewiston	POL	3,276	4,485	4,485	~ 6,000
All Port of Lewiston	--	3,276	4,485	4,485	~ 6,000
TOTALS	--	485,770	479,926	487,840	--

3. Background. The project area drains over 32,000 square miles of watershed (USACE 2012). As a part of its Congressional authorization, the Corps operates and maintains the navigation system on the lower Snake River. Sediment accumulation in the lower Snake River can interfere with authorized project purposes and the Corps has historically dredged accumulated sediment that impeded navigation. Dredged sediments were placed in areas where they would no longer interfere with the authorized purposes, either in-water within the reservoirs or on upland sites. Several previous characterizations have been performed in the dredging area since 1985, though none under the auspices of the DMMP. Previous chemical analyses have shown that the proposed dredged material did not contain compounds over regulatory criteria consulted at the time.

   Sampling and testing of sediments in the region was accomplished in 2011 in support of the draft Programmatic Sediment Management Plan EIS (USACE 2013). This report was reviewed as part of a Tier 1 analysis of the proposed dredging. A Tier 1 review is done on every project to determine whether further testing is necessary for the DMMP to make a decision on the suitability of project material for in-water disposal. Though the 2011 testing wasn't sufficient to support a suitability determination without further characterization, it provided enough information to focus this DMMP characterization on project specific questions.

4. Tier 1 - Project Ranking and Sampling Requirements. The Tier 1 evaluation provided the DMMP with enough information to determine rank and homogeneity/heterogeneity of the sediments, the two factors that influence sampling and testing frequency and sample type. Previous descriptions and data were used to distinguish five general reaches of the proposed dredging prism that could be considered separately for Tier 2 (chemical analysis) sampling and characterization purposes. These areas were identified based on apparent shoaling patterns and sediment characteristics. These five areas were:

   1. Ice Harbor Lock (sufficient data available for Tier 1 evaluation, no further testing needed)
   2. Clarkston West (including both the Federal Navigation Channel (FNC) and the Port of Clarkston Grain Elevator)
   3. Clarkston East (including the Federal Navigation Channel)
   4. Port of Clarkston (Recreation Dock and Cruise Dock)
   5. Clearwater River (including the Federal Navigation Channel and the Port of Lewiston)

   Clarkston West, Clarkston East and Lewiston reaches were all considered homogenous and ranked of low concern. Core logs from Clarkston West showed some indications of heterogeneity, but the DMMP agencies determined that grab samples would represent the mixture of fines and sand that were observed in previous core samples. Area 4 (Port of Clarkston) showed the greatest amount of core variability and fines content. This area was considered heterogeneous and was sampled with core samples. It was given a low-moderate rank. The Clearwater River portion of the project (Area 5) was considered homogenous and given a low rank.

   Table 2 shows how volume estimates have changed slightly over the course of this project. Since volume calculations are estimates that can vary with changing river conditions and method of measurement, these differences are noted here but are not considered by the DMMP to affect suitability as described in this memorandum. Given the ranks and character of the proposed dredging areas, the DMMP guidelines for sampling density (Table 3) were applied to estimated project volumes available at the time of SAP preparation (Table 4).

Table 3. Maximum sediment volume requirements for DMMP sampling

Project Rank	Homogeneous Material		Heterogeneous Material			
	# of samples required	# of analyses (DMMUs) required	# of samples required		# of analyses (DMMUs) required	
			Surface	Subsurface	Surface	Subsurface
L	8,000 cy	60,000 cy	8,000 cy	48,000 cy	72,000 cy	60,000 cy
LM	8,000 cy	40,000 cy	8,000 cy	32,000 cy	48,000 cy	40,000 cy
M	4,000 cy	20,000 cy	4,000 cy	16,000 cy	24,000 cy	20,000 cy
H	4,000 cy	8,000 cy	4,000 cy	4,000 cy	12,000 cy	8,000 cy

Table 4. Volume and DMMUs in the Snake/Clearwater characterization

Area to be Dredged	Rank	# grab samples	# core samples	# analyses	DMMU name	SAP Volume (cy)
FNC Clarkston West	L	7	--	1	1	57,818
		7	--	1	2	60,167
		7	--	1	3	55,453
FNC Clarkston East	L	8	--	1	4	57,849
		7	--	1	5	52,221
		3	--	1	6	20,948
FNC Clearwater	L	2	--	1	7	6,187
		2	--	1	8	11,261
FNC Lewiston	L	7	--	1	9	55,591
		7	--	1	10	58,284
		3	--	1	11	26,367
All Federal Dredging		60	0	11	11 DMMUs	462,146
POC Grain Elevator	L	2	--	1	POC-GE	3,218
POC Rec. Dock	LM	--	2	1	POC-RD	1,036
POC Cruise Dock	LM	--	2	1	POC-CD	9,041
All Port of Clarkston		2	4	3	3 DMMUs	13,295
Port of Lewiston	LM	2	--	1	POL	4,485
All Port of Lewiston		2	0	1	1 DMMU	4,485
TOTALS		64	4	15	15 DMMUs	479,926

Notes:

- All sampling and analysis requirements are based on estimated volumes. At least two samples are required for one DMMU, regardless of volume.
- All volumes based on removal to 16 feet below MOP, except for Port of Clarkston Recreation Dock, which has volume based on removal to 7.5 ft below MOP.
- Because each Port area constitutes one DMMU, the names of the DMMU and the Port facility are the same.

5. Chemicals of Concern. The timing of this project characterization straddled implementation of the Department of Ecology changes to Chapter 173-204 WAC Sediment Management

Standards, which became effective on September 1, 2013 (Ecology 2013). As part of the SMS rule changes, Ecology promulgated new numeric chemical and biological cleanup objectives for freshwater sediment to protect the benthic community—essentially an update to the 2006 interim guidelines used by the DMMP from the Sediment Evaluation Framework for the Pacific Northwest (USACE *et al* 2009). Though the DMMP in general uses only guidelines which have been adopted through a public notification and comment process, it also strives to use the most current relevant technical and project-specific information for sediment evaluation. This is also consistent with Ecology's implementation of WAC 173-204-340, which allows use of the best available methods and guidelines.

In making these project-specific decisions, the DMMP strove to do two things: allow comparison to past data collection efforts and existing guideline values, while creating a bridge to future characterization for this project that will likely include the most up-to-date COCs and values for comparison (i.e. the 2013 SMS FW guidelines.) All decisions about analytes and regulatory guidelines were made prior to sampling and testing. The DMMP used the new SMS guidelines—then in draft form—as the basic list of COCs and regulatory guidelines to use in this project. The new SMS rule was considered to have the most current and supportable list of potential COCs and regulatory guidelines, at least for protection of benthic resources. This list was amended as appropriate on a site-specific basis based on previous testing and requests from other agencies. A summary of decisions and rationale behind the project-specific COCs are as follows (DMMP 2013a; DMMP 2014):

a. No dioxin/furan analysis required. Very low TEQs were found in most samples analyzed in 2011, and in all the samples in areas proposed for dredging. They indicated a low "reason-to-believe" that dioxins are of concern in the proposed dredge prism. Due to the presence of an upstream paper plant and associated outfall, however, this decision should be revisited for future characterizations.

b. No analysis for PAHs required. Levels of PAHs, when occasionally detected, have been found at orders of magnitude below levels of concern in either marine or freshwater guidelines. There are few sources in the area for this class of chemicals.

c. No analysis for other organics required (chlorinated hydrocarbons and some miscellaneous extractables). Again, lack of sources and previous data show low reason-to-believe for presence of omitted chemicals at levels of concern.

d. Analysis for the full suite of DMMP COCs for the Port of Clarkston Recreation Dock DMMU and for reference sediments is required. Since no samples from previous characterizations had been taken at the recreation dock, the DMMP requested that chemical analysis be performed for all DMMP COCs, rather than the abbreviated list required for all other DMMUs. Reference sediments used during the bioassay round were also tested for the full list of COCs.

e. Add toxaphene to the list of COCs for all DMMUs. This request was made by fish biologists at the Washington Department of Ecology (Ecology), due to previous detections of toxaphene in some parts of Eastern Washington. However, there are no regulatory sediment guidelines set for toxaphene in Washington State, including the existing DMMP marine guidelines, the Regional Sediment Evaluation Team (RSET) Sediment Evaluation Framework (SEF) guidelines and Ecology's 2013 Sediment Management Standards freshwater guidelines. A rough estimate was calculated based on the water quality

standard for toxaphene in water (EPA 1986) and using a K_{oc} value of 5 (ASTDR Toxaphene Fact Sheet) per the SEF (2009, p. 10-4). The result of this calculation was a theoretical screening level of 0.2 ppb in sediments. The analytical method requested by Ecology, however, cannot reach a detection limit that low. Typical toxaphene sediment quantitation limits (SQL) using Method 8081 are generally around 100 ppb. The chosen laboratory was requested and able to reduce the toxaphene SQL to the lowest possible value. Ecology accepted this approach.

f. Use the DMMP marine BT for selenium as the regulatory guideline, rather than the higher guideline found in the 2013 SMS freshwater guidelines. Selenium was the only element for which a marine guideline was used when a more current freshwater guideline was available. Selenium has been identified at concentrations above the DMMP screening limits in some areas of the watershed, most likely due to mining activities in the watershed. The DMMP marine screening level guideline for selenium is 3 mg/kg dry wt.; the 2013 SMS guidelines use 11 mg/kg as the screening level. It should be noted that the freshwater guidelines use data from freshwater to calculate effects levels, so there is no technical reason to apply the marine rather than the freshwater guidance. The marine value was simply used as a conservative option in a watershed that has some history of selenium detections.

6. Sampling. Two separate sampling and analysis events occurred: the first from August 2 - 6, 2013, and the second from November 10 - 13, 2013. Sediments collected during August were analyzed only for project-specific chemicals of concern (Tier 2). When results from the August sampling became available, it was clear that, for DMMUs 1, 2, 3, 5, 6 and POC-GE, additional information in the form of a Tier 3 biological evaluation would be necessary to make a determination of suitability for open water disposal (Figure 4). Sediments collected during the second sampling event were from those DMMUs with screening level exceedances of project COCs. These sediments underwent additional chemical and biological analyses, as described below.

   a. Tier 2 (August sampling). During the Tier 2 sampling event, 64 grab samples were taken using a 0.1 m^2 hydraulic power grab that were then composited for 13 DMMUs. Four core samples were taken with a vibracore system using 4-inch inner-diameter decontaminated aluminum core tubes that were then composited into two DMMUs (Table 3).

      Some Tier 2 sampling locations were modified based on field situations which included obstructions such as vessels, or when the depth at the target coordinate was deeper than the authorized channel depth.

      Of the fifteen DMMUs characterized in Tier 2, six DMMUs (DMMUs 1, 2, 3, 5, 6 and POC-GE) had screening level exceedances that necessitated further characterization, i.e. Tier 3.

   b. Tier 3 (November sampling). Sediment volumes remaining from the Tier 2 sampling event were insufficient to run bioassays, so additional sampling was required. Tier 3 grab sample locations targeted the sampling locations occupied during Tier 2, and were composited into the six needed DMMUs. During the November sampling event, in addition to the test sediments, two potential reference sediments were collected from the Snake River: one at RM 144 (upstream of Clarkston, WA) and one from a ponded area at RM 128.5, downstream of the Snake/Clearwater confluence. Control sediment for Tier 3 bioassays was collected by Northwestern Aquatic Sciences on November 18, 2013 from

an area approximately one mile east of the Highway 101 Bridge at Beaver Creek, near Newport, Oregon. Table 5 shows all sampling locations for the Tier 3 sampling event.

7. Tier 2 Conventional & Chemical Analyses. The approved sampling and analysis plans (USACE 2013a and 2013b) were followed, with the exceptions noted below. Chemical analyses were conducted by Analytical Resources, Inc. (ARI) of Tukwila, Washington. The resulting analytical data were validated by Mr. Mingta Lin of Pyron Environmental (Pyron). All data were considered to be of known quality and acceptable for use as qualified, with the exception of heptachlor. Heptachlor results were rejected in all samples because none was recovered in the Standard Reference Material.

   The sediment conventional results for Tier 2 are in Table 8. In general, the grain size was slightly coarser and total solids were higher in the Clearwater River DMMUs than in those DMMUs below the Clearwater confluence with the Snake River. Total organic carbon also was higher in the Snake River DMMUs as opposed to the Clearwater DMMUs, especially in DMMU 6 and POC-GE. Total sulfides were elevated over the SMS screening levels in some DMMUs in Tier 2. Sulfide exceedances by themselves are not considered problematic, due to aeration of the sediments during open water disposal. However, most DMMUs with sulfide exceedances underwent bioassays during Tier 3 due to other exceedances.

   Chemical results are compared to the project-specific COC list and regulatory guidelines in Table 11 and Table 12. All chemicals were either detected or undetected at levels below the regulatory guidelines except for 4-methylphenol SL exceedances in DMMUs 1, 2, 3, 5, 6 & POC-GE. DMMU 6 also had an ML exceedance for 4-Methylphenol and an SL exceedance of phenol. 4-Methylphenol results were confirmed by re-processing data with the SIM channel on the GC/MS. These analytes have never been detected above screening levels in previous characterizations of the area. Toxaphene was undetected in all DMMU at levels between 24 and 48 ppb.

8. Tier 3 Conventional and Chemical Analyses. All Tier 3 test sediments underwent both conventional and chemical analyses of the phenols, benzoic acid, and pentachlorophenol. The sediment conventional results for Tier 3 are in Table 9. Total sulfides were elevated over the SMS screening level in all six re-tested DMMUs, as well as both the reference sediments. Reference sediments were analyzed for the same suite of COCs used for the Port of Clarkston Recreation dock during Tier 2 (Table 11). Tier 3 chemistry results are in Table 14. Sample analysis still showed presence of 4-methylphenol at levels above the SL for DMMUs 1, 3, 5 and 6, but for DMMUs 2 and POC-GE the reported levels were below the SL. For DMMU 6, the phenol level in the August sample was reported above the SL; for the November sample phenol was below the SL.

9. Tier 3 - Bioassay Analyses. Due to the regulatory guideline exceedances described above, six DMMUs were required to undergo appropriate biological tests to determine whether these DMMUs are suitable for open water disposal. Consistent with Tier 2 chemical analyses, for Tier 3 the DMMP looked to Ecology's 2013 SMS FW guidelines for required tests and interpretive criteria. As approved in the addendum SAP, three bioassay tests--using two species and including one chronic test--were performed:

   - 10-day *Hyalella azteca* (amphipod) survival test
   - 20-day *Chironomus dilutus* (midge) survival test
   - 20-day *Chironomus dilutus* (midge) growth test

Six test sediments—one composite sample each from DMMUs 1, 2, 3, 5, 6 and POC-GE-- as well as two reference sediments and one control sediment were subjected to the bioassay tests listed above. Tests were run at Northwestern Aquatic Sciences (NWAS) of Newport, Oregon. The control sediment was from Beaver Creek, near Newport, Oregon. Reference and control sediments for all tests met acceptability criteria as defined by the Sediment Management Standards, Chapter 173-204 WAC (Ecology 2013) (Table 15). For test interpretation, test sediments were compared to the control or reference with the closest match to total fines content. As shown in Table 16, Table 17, and Table 18, DMMUs 1, 2, 3 and POC-GE were paired with SR 144 for test interpretation. Reference sediment collected at SR 128.5 proved too fine-grained to use for comparison to any of the test sediments. Because relative grain size of the Beaver Creek sediments was closest to grain sizes for DMMUs 5 and 6, those DMMUs were compared to the control sediment.

All data were considered valid and suitable for decision-making. Survival and growth in test sediments were statistically indistinguishable from control and reference sediments. All test sediments passed the relative interpretive guidelines and are thus suitable for open water disposal.

10. Suitability Determination. This memorandum documents the evaluation of the suitability of sediment proposed for dredging from the Lower Snake and Clearwater Rivers for open water disposal in the Snake River or at an approved beneficial use or upland site. The approved sampling and analysis plan was adequately followed and the data gathered were deemed sufficient and acceptable for regulatory decision-making under the DMMP program.

    Based on the results of the previously described testing, the DMMP agencies concluded that:

    - all 6,000 of proposed dredged material from the Port of Lewiston are suitable for open water disposal in the Snake River as described in NWS-2013-519.
    - all 14,000 of proposed dredged material from the Port of Clarkston are suitable for open water disposal as described in NWS-2013-916.
    - all 469,212 of proposed dredged material from the Federal Navigation Channel are suitable for open water disposal as described in CENWW-PM-PD-EC 13-01.

    This suitability determination does *not* constitute final agency approval of the project. A final decision will be made after full consideration of agency input, and after an alternatives analysis is done under section 404(b)(1) of the Clean Water Act.

Table 5. Summary of proposed dredging locations, with basis for suitability

Location	DMMUs	Determination	Reference
FNC - Ice Harbor Lock	NA	suitable	Tier 1
FNC - Clarkston West	1, 2, 3	suitable	Tier 3
FNC - Clarkston East	4, 5, 6	suitable	Tiers 2 & 3
POC - Grain Elevator	POC - GE	suitable	Tier 3
POC - Recreation Dock	POC - RD	suitable	Tier 2
POC - Cruise Dock	POC - CD	suitable	Tier 2
POC - Crane Dock	NA	suitable	Port of Clarkston Crane Dock, Snake River
FNC - Clearwater	7, 8	suitable	Tier 2
FNC - Lewiston	9, 10, 11	suitable	Tier 2
Port of Lewiston	POL	suitable	Tier 2

Tier 1 - sufficient information available
Tier 2 - chemical evaluation
Tier 3 - biological evaluation

11. References.

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USACE 2012. Lower Snake River Draft Programmatic Sediment Management Plan Environmental Impact Statement, Lower Snake and Clearwater Rivers, Washington and Idaho. Walla Walla: USACE, Walla Walla District. December 2012.

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12. Agency Signatures

SUBJECT: DETERMINATION ON THE SUITABILITY OF PROPOSED DREDGED MATERIAL FROM LOWER SNAKE/CLEARWATER RIVER MAINTENANCE DREDGING FOR OPEN-WATER DISPOSAL IN THE SNAKE RIVER OR AT AN APPROVED BENEFICIAL USE OR UPLAND SITE.

Concur:

2/19/14 _____
Date — Lauran Cole Warner - Seattle District Corps of Engineers

2/18/14 _____
Date — Justine Barton - Environmental Protection Agency

02/18/2014 _____
Date — Laura Inouye, Ph.D. - Washington Department of Ecology

2/18/2014 _____
Date — Celia Barton - Washington Department of Natural Resources

Copies furnished:

DMMP signatories
Steve Juul, NWW
Bob Ries, NOAA

Table 6. Snake/Clearwater sampling locations for Tier 2 (August) sampling

DMMU	Sample Key	Sample Date	Latitude (NAD83)	Longitude (NAD83)	Measured Mudline (ft)	LWSI Elevation (NGVD 29)	Mudline Elevation (NGVD 29)	Depth to Top of z-Layer (ft) (717 ft NGVD29)	Sample Type
FNC Clarkston West									
1	1	08/02/13	46 25.69455	-117 03.27004	-18.2	735.8	717.6	-0.6	Grab
	2	08/02/13	46 25.66394	-117 03.27024	-15	735.8	720.8	-3.8	Grab
	5	08/02/13	46 25.67310	-117 03.38158	-18	735.8	717.8	-0.8	Grab
	6	08/02/13	46 25.65193	-117 03.38262	-17.7	735.8	718.1	-1.1	Grab
	7	08/02/13	46 25.70497	-117 03.17991	-18.1	735.8	717.7	-0.7	Grab
	8	08/02/13	46 25.68226	-117 03.17977	-15.3	735.8	720.5	-3.5	Grab
	9	08/02/13	46 25.64825	-117 03.18119	-11.2	735.8	724.6	-7.6	Grab
2	10	08/02/13	46 25.70337	-117 03.12526	-18.2	735.9	717.7	-0.6	Grab
	11	08/02/13	46 25.6804	-117 03.1251	-13.5	735.9	722.4	-5.4	Grab
	12	08/02/13	46 25.64583	-117 03.12679	-10.4	735.9	725.5	-8.5	Grab
	13	08/02/13	46 25.70047	-117 03.06436	-16.8	735.9	719.1	-2.1	Grab
	14	08/02/13	46 25.69015	-117 03.06382	-14.8	735.9	721.1	-4.1	Grab
	15	08/02/13	46 25.67219	-117 03.06631	-13.3	735.9	722.6	-5.6	Grab
	16	08/02/13	46 25.63869	-117 03.06520	-10.3	735.9	725.6	-8.6	Grab
3	17	08/02/13	46 25.71100	-117 03.01280	-18.1	735.8	717.7	-0.7	Grab
	18	08/02/13	46 25.68802	-117 03.01252	-15.2	735.8	720.6	-3.6	Grab
	19	08/02/13	46 25.67138	-117 03.01453	-13.5	735.8	722.3	-5.3	Grab
	20	08/02/13	46 25.63815	-117 03.01543	-10.7	735.8	725.1	-8.1	Grab
	21	08/02/13	46 25.69680	-117 02.93750	-16.8	735.8	719	-2	Grab
	22	08/02/13	46 25.64123	-117 02.95315	-13.4	735.8	722.4	-5.4	Grab
	3	08/02/13	46 25.68523	-117 02.93810	-14.7	735.8	721.1	-4.1	Grab
FNC Clarkston East									
4	23	08/03/13	46 25.70190	-117 02.89425	-18.3	735.7	717.4	-0.4	Grab
	24	08/03/13	46 25.67186	-117 02.89512	-13.8	735.7	721.9	-4.9	Grab
	25	08/03/13	46 25.63918	-117 02.89506	-11.9	735.7	723.8	-6.8	Grab
	26	08/03/13	46 25.68083	-117 02.82305	-16.5	735.7	719.2	-2.2	Grab
	27	08/03/13	46 25.66595	-117 02.82836	-13.7	735.7	722	-5	Grab
	28	08/03/13	46 25.63801	-117 02.83616	-13.3	735.7	722.4	-5.4	Grab
	29	08/03/13	46 25.66574	-117 02.76873	-16.3	735.7	719.4	-2.4	Grab
	30	08/03/13	46 25.63579	-117 02.78207	-13.5	735.7	722.2	-5.2	Grab

Table 6. Snake/Clearwater sampling locations for Tier 2 (August) sampling

DMMU	Sample Key	Sample Date	Latitude (NAD83)	Longitude (NAD83)	Measured Mudline (ft)	LWSI Elevation (NGVD 29)	Mudline Elevation (NGVD 29)	Depth to Top of z-Layer (ft) (717 ft NGVD29)	Sample Type
5	31	08/03/13	46 25.64979	-117 02.72121	-16.3	735.8	719.5	-2.5	Grab
	32	08/03/13	46 25.63780	-117 02.72684	-14.2	735.8	721.6	-4.6	Grab
	35	08/03/13	46 25.62026	-117 02.73595	-13.4	735.8	722.4	-5.4	Grab
	36	08/03/13	46 25.62729	-117 02.65398	-16.6	735.8	719.2	-2.2	Grab
	37	08/03/13	46 25.59718	-117 02.67107	-12.9	735.8	722.9	-5.9	Grab
	38	08/03/13	46 25.60119	-117 02.59998	-16.2	735.8	719.6	-2.6	Grab
	39	08/03/13	46 25.58528	-117 02.60914	-13.9	735.8	721.9	-4.9	Grab
6	41	08/03/13	46 25.57305	-117 02.54624	-15.6	735.8	720.2	-3.2	Grab
	42	08/03/13	46 25.54852	-117 02.49284	-16.3	735.8	719.5	-2.5	Grab
	72	08/03/13	46 25.52202	-117 02.44118	-17.3	735.8	718.5	-1.5	Grab
FNC Clearwater									
7	43	08/03/13	46 25.56085	-117 02.10144	-17.6	735.7	718.1	-1.1	Grab
	44	08/03/13	46 25.54994	-117 01.96369	-17	735.7	718.7	-1.7	Grab
8	45	08/03/13	46 25.52161	-117 01.59620	-17.8	735.7	717.9	-0.9	Grab
	46	08/03/13	46 25.51716	-117 01.50833	-15.9	735.7	719.8	-2.8	Grab
FNC Lewiston									
9	73	08/04/13	46 25.41100	-117 01.02259	-16.2	735.5	719.3	-2.3	Grab
	47	08/04/13	46 25.40938	-117 00.93063	-18	735.5	717.5	-0.5	Grab
	48	08/04/13	46 25.38205	-117 00.95121	-16.4	735.5	719.1	-2.1	Grab
	49	08/04/13	46 25.38732	-117 00.86200	-16.3	735.5	719.2	-2.2	Grab
	50	08/04/13	46 25.35906	-117 00.88025	-14.2	735.5	721.3	-4.3	Grab
	51	08/04/13	46 25.36294	-117 00.80782	-15	735.5	720.5	-3.5	Grab
	52	08/04/13	46 25.34316	-117 00.82860	-14.2	735.5	721.3	-4.3	Grab
10	53	08/04/13	46 25.33680	-117 00.77380	-14.5	735.5	721	-4	Grab
	54	08/04/13	46 25.36910	-117 00.74646	-17.8	735.5	717.7	-0.7	Grab
	56	08/04/13	46 25.34296	-117 00.66073	-17.6	735.5	717.9	-0.9	Grab
	57	08/04/13	46 25.31921	-117 00.68108	-14.1	735.5	721.4	-4.4	Grab
	58	08/04/13	46 25.29224	-117 00.69795	-16.1	735.5	719.4	-2.4	Grab
	59	08/04/13	46 25.31923	-117 00.59241	-14.6	735.6	721	-4	Grab
	60	08/04/13	46 25.29570	-117 00.60594	-15.5	735.6	720.1	-3.1	Grab

Table 6. Snake/Clearwater sampling locations for Tier 2 (August) sampling

DMMU	Sample Key	Sample Date	Latitude (NAD83)	Longitude (NAD83)	Measured Mudline (ft)	LWSI Elevation (NGVD 29)	Mudline Elevation (NGVD 29)	Depth to Top of z-Layer (ft) (717 ft NGVD29)	Sample Type
11	55	08/04/13	46 25.28813	-117 00.52123	-16	735.6	719.6	-2.6	Grab
	61	08/04/13	46 25.24317	-117 00.37379	-17.4	735.6	718.2	-1.2	Grab
	62	08/04/13	46 25.20398	-117 00.21044	-17.7	735.6	717.9	-0.9	Grab
Port of Clarkston Grain Elevator									
POC GE	68	08/03/13	46 25.63010	-117 03.2784	-15.4	735.6	720.2	-3.2	Grab
	69	08/03/13	46 25.63600	-117 03.2118	-11.1	735.6	724.5	-7.5	Grab
Port of Clarkston Recreation Dock									
POC Rec Dock	63	08/05/13	46 25.61961	-117 03.10163	-7.4	735.5	728.1	-2.6	Core
	63	08/06/13	46 25.61990	-117 03.10000	-5.6	735.5	729.9	-4.4	Core
	64	08/05/13	46 25.61896	-117 03.06731	-6.7	735.5	728.8	-3.3	Core
Port of Clarkston Cruise Dock									
POC Cruise Dock	65	08/05/13	46 25.5895	-117 02.6988	-12.5	735.5	723	-6	Core
	66	08/05/13	46 25.5758	-117 02.6435	-11.9	735.5	723.6	-6.6	Core
	66	08/06/13	46 25.5753	-117 02.6440	-12.6	735.5	722.9	-5.9	Core
Port of Lewiston									
POL	70	08/04/13	46 25.45081	-117 00.92356	-15.8	735.5	719.7	-2.7	Grab
	71	08/04/13	46 25.40506	-117 00.79649	-10.8	735.5	724.7	-7.7	Grab

Table 7. Snake/Clearwater sampling locations for Tier 3 (November) sampling

DMMU	Sample Key	Sample Date	Sample Time	Latitude (NAD83)	Longitude (NAD83)	Measured Mudline (ft)	LWSI Elevation (NGVD 29)	Mudline Elevation (NGVD 29)	Depth to Top of z-Layer (ft) (717 ft NGVD29)	Sample Type
FNC Clarkston West										
1	5	11/11/13	8:44	46 25.66653 N	-117 03.38313	-19.3	737.3	718	-1	Grab
	6	11/11/13	9:02	46 25.65040 N	-117 03.38274	-18.9	737.3	718.4	-1.4	Grab
	1	11/11/13	9:20	46 25.69435 N	-117 03.27038	-18.7	737.3	718.6	-1.6	Grab
	2	11/11/13	9:33	46 25.66344 N	-117 03.27030	-15.8	737.1	721.3	-4.3	Grab
	7	11/11/13	9:52	46 25.70464 N	-117 03.18045	-19	737.1	718.1	-1.1	Grab
	8	11/11/13	10:07	46 25.68205 N	-117 03.17995	-15.7	737	721.3	-4.3	Grab
	9	11/11/13	10:20	46 25.64841 N	-117 03.18110	-11.9	737	725.1	-8.1	Grab
2	10	11/11/13	11:28	46 25.70346 N	-117 03.12553	-17.9	737	719.1	-2.1	Grab
	13	11/11/13	12:31	46 25.70081 N	-117 03.06462	-16.5	736.8	720.3	-3.3	Grab
	11	11/11/13	11:57	46 25.68085 N	-117 03.12505	-15.2	736.9	721.7	-4.7	Grab
	14	11/11/13	12:46	46 25.69010 N	-117 03.06405	-15.5	736.8	721.3	-4.3	Grab
	15	11/11/13	13:00	46 25.67219 N	-117 03.06644	-14	736.8	722.8	-5.8	Grab
	12	11/11/13	12:15	46 25.64600 N	-117 03.12727	-11.4	736.9	725.5	-8.5	Grab
	16	11/11/13	13:14	46 25.63855 N	-117 03.06530	-11.1	736.8	725.7	-8.7	Grab
3	17	11/11/13	14:24	46 25.71151 N	-117 03.01295	-18.9	736.7	717.8	-0.8	Grab
	18	11/11/13	14:38	46 25.68810 N	-117 03.01258	-15.9	736.7	720.8	-3.8	Grab
	19	11/11/13	14:52	46 25.67174 N	-117 03.01455	-14.8	736.7	721.9	-4.9	Grab
	20	11/11/13	15:07	46 25.63811 N	-117 03.01509	-10.8	736.7	725.9	-8.9	Grab
	21	11/11/13	15:24	46 25.69651 N	-117 02.93810	-17.1	736.6	719.5	-2.5	Grab
	3	11/11/13	15:56	46 25.68545 N	-117 02.93833	-15.7	736.6	720.9	-3.9	Grab
	22	11/11/13	15:41	46 25.64147 N	-117 02.95305	-14.3	736.6	722.3	-5.3	Grab
FNC Clarkston East										
5	31	11/12/13	11:18	46 25.65019 N	-117 02.72151	-16.9	736.9	720	-3	Grab
	32	11/12/13	11:30	46 25.63814 N	-117 02.72725	-15.3	736.9	721.6	-4.6	Grab
	35	11/12/13	11:46	46 25.62056 N	-117 02.73644	-14.3	736.9	722.6	-5.6	Grab
	38	11/12/13	12:23	46 25.60119 N	-117 02.60027	-16.9	736.9	720	-3	Grab
	39	11/12/13	12:35	46 25.58514 N	-117 02.60975	-14.7	736.8	722.1	-5.1	Grab
	36	11/12/13	11:58	46 25.62744 N	-117 02.65408	-17.5	736.9	719.4	-2.4	Grab
	37	11/12/13	12:11	46 25.59747 N	-117 02.67121	-13.9	736.9	723	-6	Grab

Table 7. Snake/Clearwater sampling locations for Tier 3 (November) sampling

DMMU	Sample Key	Sample Date	Sample Time	Latitude (NAD83)	Longitude (NAD83)	Measured Mudline (ft)	LWSI Elevation (NGVD 29)	Mudline Elevation (NGVD 29)	Depth to Top of z-Layer (ft) (717 ft NGVD29)	Sample Type
6	41	11/12/13	9:06	46 25.57321 N	-117 02.54631	-16.7	736.8	720.1	-3.1	Grab
	42	11/12/13	8:54	46 25.54882 N	-117 02.49284	-17.3	736.9	719.6	-2.6	Grab
	72	11/12/13	8:37	46 25.52215 N	-117 02.44100	-18.3	736.9	718.6	-1.6	Grab
Port of Clarkston Grain Elevator										
POC-GE	68	11/12/13	10:21	46 25.63025 N	-117 03.27859	-17.5	736.8	719.3	-2.3	Grab
	69	11/12/13	10:38	46 25.63606 N	-117 03.2 -1174	-12.9	736.8	723.9	-6.9	Grab
Bioassay Reference Sediments										
River Mile 144		11/12/13	15:04	46 21.24158 N	-117 03.6430	---	---	---	---	Grab
River Mile 128		11/13/13	12:30	46 27.16417	-117 12.26467	---	---	---	---	Hand

Table 8. Conventional results from Tier 2 - Chemistry Round

	GRAB SAMPLES													CORE SAMPLES	
	DMMU 1	DMMU 2	DMMU 3	DMMU 4	DMMU 5	DMMU 6	POC-GE	DMMU 7	DMMU 8	DMMU 9	DMMU 10	DMMU 11	POL	POC-CD	POC-RD
Total solids (%)	56.58	67.55	68.03	70.46	68.41	43.72	48.26	74.53	67.59	74.2	77.71	75.69	68.15	73.58	53.78
Total organic carbon (%)	1.53	1.47	0.84	0.67	1.03	6.84	4.14	0.419	0.721	0.231	0.672	0.265	0.235	3.63	2.02
Total Sulfides (mg/kg)	89.3	74.2	125	7.98	1.7	*30*	66	1.53	1.7	1.34 U	1.52	2.77	3.36	21.5	5,640
Ammonia (mg/kg)	41.2	29	25	17	25.8	69.5	69.8	2.86	6.18	0.32	13.6	0.5	6.56	38.5	330
Sand (%)	85.2	87	88.7	92.5	86.9	69.4	76.6	94.3	96.3	98.2	92.4	98.4	95.1	94	44.8
Silt (%)	8.3	6.7	4.5	2.7	8.4	16.5	15.6	3.9	1.5	0.8	4.3	1.2	2	3.1	40.8
Clay (%)	6.6	6.4	6.7	4.8	4.7	14.2	7.9	1.6	2.2	0.8	3.1	0.4	2.5	2.9	14.5
Total Fines % (silt + clay)	14.9	13.1	11.2	7.5	13.1	30.7	23.5	5.5	3.7	1.6	7.4	1.6	1.2	4.5	55.3

Table 9. Conventional results from Tier 3 – Bioassay Round

	DMMUs undergoing bioassays												References				Control	
	DMMU-1		DMMU-2		DMMU-3		DMMU-5		DMMU-6		POC-GE		SR128.5		SR144		Beaver Creek	
Total Solids (%)	56.4		61.2		58.1		41.4		37.0		60.9		53.54		56.19		---	
Total Organic Carbon (%)	2.0	J	4.2	J	5.5	J	5.6	J	8.7	J	3.8	J	2.18	J	2.24	J	---	
Sulfide (mg/kg)	179.0	J	106.0	J	130.0	J	243.0	J	185.0	J	142.0	J	*44.7*	J	332	J	---	
Ammonia (mg/kg)	29.6		23.6		37.6		60.2		101.0		52.1		2.88		30.1		---	
Gravel (%)	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.3		0.1	U	0	
Sand (%)	80.7		85.8		78.9		61.3		51.6		85.8		35.2		70.3		51.6	
Silt (%)	11.8		8.4		12.0		22.5		29.5		8.6		50.6		22.2		34.4	
Clay (%)	7.5		5.8		8.9		16.2		18.9		5.5		13.9		7.5		5.0	
Total Fines % (silt + clay)	19.3		14.2		20.9		38.7		48.4		14.1		64.5		29.7		39.4	

Note for Tables 8 & 9: *Bold, italicized, yellow-shaded* values indicate exceeds the SL; Bold, orange-shaded values exceed the CL.
For Total Sulfides, SL = 39; CL = 61. For Ammonia, SL = 230 and CL = 300.

Table 10. Final Chemicals of Concern and Regulatory Guidelines used for the Snake/Clearwater River characterization.

CHEMICAL	CAS[1] NUMBER	DMMP Marine 2013			Interim FW 2006 (SEF)		SMS FW 2013		Used for Snake/Clearwater River Source is shaded	
		SL	BT	ML	SL1	SL2	SL1 (SCO)	SL2 (CSL)	Screening Level	Cleanup Level
CONVENTIONALS (mg/kg dry weight)										
Ammonia							230	300	230	300
Total sulfides							39	61	39	61
METALS (mg/kg dry weight)										
Antimony	7440-36-0	150	---	200	---	---	---	---	150	200
Arsenic	7440-38-2	57	507.1	700	20	51	14	120	14	120
Cadmium	7440-43-9	5.1	11.3	14	1.1	1.5	2.1	5.4	2.1	5.4
Chromium	7440-47-3	260	260	---	95	100	72	88	72	88
Copper	7440-50-8	390	1,027	1,300	80	830	400	1,200	400	1,200
Lead	7439-92-1	450	975	1,200	340	430	360	> 1,300	360	> 1,300
Mercury	7439-97-6	0.41	1.5	2.3	0.28	0.75	0.66	0.8	0.66	0.8
Nickel	7440-02-0	---	---	---	60	70	26	110	26	110
Selenium	7782-49-2	---	3	---	---	---	11	>20	3	---
Silver	7440-22-4	6.1	6.1	8.4	2	2.5	0.57	1.7	0.57	1.7
Zinc	7440-66-6	410	2,783	3,800	130	400	3,200	> 4,200	3,200	> 4,200
PHTHALATES (µg/kg dry weight)										
Dimethyl phthalate	131-11-3	71	---	1,400	46	440	---	---	46	440
Diethyl phthalate	84-66-2	200	---	1,200	---	---	---	---	200	1,200
Di-n-butyl phthalate	84-74-2	1,400	---	5,100	---	---	380	1,000	380	1,000
Butyl benzyl phthalate	85-68-7	63	---	970	260	370	---	---	260	370
Bis(2-ethylhexyl) phthalate	117-81-7	1,300	---	8,300	220	320	500	22,000	500	22,000
Di-n-octyl phthalate	117-84-0	6,200	---	6,200	26	45	39	> 1,100	39	> 1,100
PHENOLS (µg/kg dry weight)										
Phenol	108-95-2	420	---	1,200	---	---	120	210	120	210
2-Methylphenol	95-48-7	63	---	77	---	---	---	---	63	77
4-Methylphenol	106-44-5	670	---	3,600	---	---	260	2,000	260	2,000
2,4-Dimethylphenol	105-67-9	29	---	210	---	---	---	---	29	210
Pentachlorophenol	87-86-5	400	504	690	---	---	1,200	> 1,200	1,200	> 1,200

Table 10. Final Chemicals of Concern and Regulatory Guidelines used for the Snake/Clearwater River characterization.

CHEMICAL	CAS[1] NUMBER	DMMP Marine 2013			Interim FW 2006 (SEF)		SMS FW 2013		Used for Snake/Clearwater River Source is shaded	
		SL	BT	ML	SL1	SL2	SL1 (SCO)	SL2 (CSL)	Screening Level	Cleanup Level
MISCELLANEOUS EXTRACTABLES (µg/kg dry weight)										
Benzoic acid	65-85-0	650	---	760	---	---	2,900	3,800	2,900	3,800
Dibenzofuran	132-64-9	540	---	1,700	400	440	200	680	200	680
beta-Hexachlorocyclohexane	319-85-7	---	---	---	---	---	7.2	11	7.2	11
PESTICIDES & PCBs (µg/kg dry weight)										
4,4'-DDD	72-54-8	16	---	---			310	860	310	860
4,4'-DDE	72-55-9	9	---	---			21	33	21	33
4,4'-DDT	50-29-3	12	---	---	---	---	100	8100	100	8100
sum of 4,4'-DDD, 4,4'-DDE and 4,4'-DDT		---	50	69			---	---	---	---
Total Chlordane	5103-71-9	2.8	37	---	---	---	---	---	2.8	37
Dieldrin	60-57-1	1.9	---	1,700	---	---	4.9	9.3	4.9	9.3
Heptachlor	76-44-8	1.5	---	270	---	---	---	---	1.5	270
Endrin ketone	53494-70-5						8.5	> 8.5	8.5	> 8.5
Carbazole	86-74-8						900	1100	900	1100
Total PCBs (Aroclors)	---	130	38 [2]	3,100	60	120	110	2500	110	2500
SPECIAL CHEMICALS OF CONCERN[4]										
Toxaphene	8001-35-2	---	---	---	---	---	---	---	0.2[4]	---

[1] Chemical Abstract Service Registry Number

[2] This value is normalized to total organic carbon, and is expressed in mg/kg carbon.

[3] Analyses required only when there is sufficient reason-to-believe for presence in given project or location.

[4] This is not a required or reviewed screening level; simply a target detection limit for laboratory analyses

Table 11. Additional Chemicals of Concern and Regulatory Guidelines required for POC Recreational Dock & Bioassay Samples

CHEMICAL	CAS[1] NUMBER	DMMP Marine 2013			Interim FW 2006 (SEF)		SMS FW 2013		Used for Snake River Source is shaded	
		SL	BT	ML	SL1	SL2	SL1 (SCO)	SL2 (CSL)	Screening Level	Cleanup Level
PAHs (µg/kg dry weight)										
Naphthalene	91-20-3	2,100	---	2,400	500	1,300	---	---	500	1,300
Acenaphthylene	208-96-8	560	---	1,300	470	640	---	---	470	640
Acenaphthene	83-32-9	500	---	2,000	1,100	1,300	---	---	1,100	1,300
Fluorene	86-73-7	540	---	3,600	1,000	3,000	---	---	1,000	3,000
Phenanthrene	85-01-8	1,500	---	21,000	6,100	7,600	---	---	6,100	7,600
Anthracene	120-12-7	960	---	13,000	1,200	1,200	---	---	1,200	1,200
2-Methylnaphthalene	91-57-6	670	---	1,900	470	560	---	---	470	560
Total LPAH	---	5,200	---	29,000	6,600	9,200	---	---	6,600	9,200
Fluoranthene	206-44-0	1,700	4,600	30,000	11,000	15,000	---	---	11,000	15,000
Pyrene	129-00-0	2,600	11,980	16,000	8,800	16,000	---	---	8,800	16,000
Benz(a)anthracene	56-55-3	1,300	---	5,100	4,300	5,800	---	---	4,300	5,800
Chrysene	218-01-9	1,400	---	21,000	5,900	6,400	---	---	5,900	6,400
Benzofluoranthenes (b, j ,k)	205-99-2	3,200	---	9,900	600	4000	---	---	600	4,000
	205-82-3						---	---		
	207-08-9						---	---		
Benzo(a)pyrene	50-32-8	1,600	---	3,600	3,300	4,800	---	---	3,300	4,800
Indeno(1,2,3-c,d)pyrene	193-39-5	600	---	4,400	4,100	5,300	---	---	4,100	5,300
Dibenz(a,h)anthracene	53-70-3	230	---	1,900	800	840	---	---	800	840
Benzo(g,h,i)perylene	191-24-2	670	---	3,200	4,000	5,200	---	---	4,000	5,200
Total HPAH	---	12,000	---	69,000	31,000	55,000	---	---	31,000	55,000
CHLORINATED HYDROCARBONS (µg/kg dry weight)										
1,4-Dichlorobenzene	106-46-7	110	---	120	---	---	---	---	110	120
1,2-Dichlorobenzene	95-50-1	35	---	110	---	---	---	---	35	110
1,2,4-Trichlorobenzene	120-82-1	31	---	64	---	---	---	---	31	64
Hexachlorobenzene (HCB)	118-74-1	22	168	230	---	---	---	---	22	230

Table 11. Additional Chemicals of Concern and Regulatory Guidelines required for POC Recreational Dock & Bioassay Samples

CHEMICAL	CAS[1] NUMBER	DMMP Marine 2013			Interim FW 2006 (SEF)		SMS FW 2013		Used for Snake River Source is shaded	
		SL	BT	ML	SL1	SL2	SL1 (SCO)	SL2 (CSL)	Screening Level	Cleanup Level
Benzyl alcohol	100-51-6	57	---	870	---	---	---	---	57	870
Hexachlorobutadiene	87-68-3	11	---	270	---	---	---	---	11	270
N-Nitrosodiphenylamine	86-30-6	28	---	130	---	---	---	---	28	130
BULK PETROLEUM HYDROCARBONS										
Total Petroleum Hydrocarbon (TPH) - Diesel		---	---	---	---	---	340	510	340	510
Total Petroleum Hydrocarbon (TPH) - Residual		---	---	---	---	---	3600	4400	3600	4400

[1] Chemical Abstract Service Registry Number

Table 12. Results of Chemical Analysis for Grab-sampled DMMUs, Tier 2 (August 2013)

CHEMICAL	Used for Snake River		DMMU 1		DMMU 2		DMMU 3		DMMU 4		DMMU 5		DMMU 6		POC-GE		DMMU 7		DMMU 8		DMMU 9		DMMU 10		DMMU 11		POL	
	SL	CL	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
CONVENTIONALS (mg/kg dry weight)																												
Ammonia	230	300	41.2		29		25		17		25.8		69.5		69.8		2.86		6.18		0.32		13.6		0.5		6.56	
Total sulfides	39	61	89.3		74.2		125		7.98		1.7		30		66		1.53		1.7		1.34	U	1.52		2.77		3.36	
METALS (mg/kg dry weight)																												
Antimony	150	200	8	UJ	8	UJ	7	UJ	7	UJ	8	UJ	10	UJ	10	UJ	6	UJ	7	UJ	6	UJ	6	UJ	6	UJ	7	UJ
Arsenic	14	120	8	U	8	U	7	U	7	U	8	U	10	U	10	U	6	U	7	U	6	U	6	U	6	U	7	U
Cadmium	2.1	5.4	0.4		0.3		0.3		0.3		0.3		0.5		0.5		0.3		0.3		0.3		0.3		0.3		0.3	
Chromium	72	88	14.6		13		10.8		11.3		12		21		18		6.3		7		5.9		7.4		5.7		6.4	
Copper	400	1,200	12.5		10.9		10.4		10.2		10.5		17.1		16.9		4.4		5.6		4.5	UJ	6.8		4.3		5.7	
Lead	360	> 1,300	6	J	5	J	4	J	3	J	4	J	8	J	7	J	3	UJ	3	UJ	3	U	3	J	2	UJ	12	J
Mercury	0.66	0.8	0.03	U	0.04	U	0.03	U	0.03	U	0.03	U	0.05	U	0.04	U	0.03	U	0.03	U	0.03	U	0.03	U	0.02	U	0.03	U
Nickel	26	110	11		9		8		8		9		13		11		4		5		4		5		4		5	
Selenium	3	---	0.8	U	0.8	U	0.7	U	0.7	U	0.7	U	1	U	1	U	0.6	U	0.7	U	0.6	U	0.7	U	0.6	U	0.7	U
Silver	0.57	1.7	0.5	U	0.5	U	0.4	U	0.4	U	0.5	U	0.7	U	0.6	U	0.4	U	0.4	U	0.4	U	0.4	U	0.4	U	0.4	U
Zinc	3,200	> 4,200	47		40		38		33		35		55		59		25		36		24		28		22		26	
PHTHALATES (µg/kg dry weight)																												
Dimethyl phthalate	46	440	19	U	20	U	19	U	19	U	19	U	19	U	19	U	20	U	18	U	19	U	19	U	19	U	19	U
Diethyl phthalate	200	1,200	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Di-n-butyl phthalate	380	1,000	19	U	20	U	19	U	19	U	19	U	19	U	19	U	20	U	18	U	19	U	19	U	19	U	19	U
Butyl benzyl phthalate	260	370	19	U	20	U	19	U	19	U	19	U	19	U	19	U	20	U	18	U	19	U	19	U	19	U	19	U
Bis(2-ethylhexyl) phthalate	500	22,000	48	U	49	U	47	U	48	U	48	U	48	U	48	U	49	U	46	U	130	J	48	U	48	U	48	U
Di-n-octyl phthalate	39	> 1,100	19	U	20	U	19	U	48	U	19	U	19	U	19	U	20	U	18	U	19	U	19	U	19	U	19	U
PHENOLS (µg/kg dry weight)																												
Phenol	120	210	28		23		19	U	12	J	46		*170*		67		20	U	18	U	19	U	19	U	13	J	19	U
2-Methylphenol	63	77	19	U	20	U	19	U	19	U	19	U	19	U	19	U	20	U	18	U	19	U	19	U	19	U	19	U
4-Methylphenol	260	2,000	*1,700*		*650*		*340*		190		*1,300*		4,900		*1,400*		15	J	18	U	19	U	19	U	19	U	19	U
2,4-Dimethylphenol	29	210	26	UJ	26	UJ	25	UJ	26	UJ	26	UJ	26	UJ	26	UJ	26	UJ	25	UJ	26	UJ	26	UJ	26	UJ	26	UJ
Pentachlorophenol	1,200	> 1,200	95	UJ	98	UJ	94	UJ	96	UJ	96	UJ	96	UJ	97	U	98	UJ	93	UJ	95	U	95	U	97	U	97	U
MISCELLANEOUS EXTRACTABLES (µg/kg dry weight)																												
Benzoic acid	2,900	3,800	280		140	J	120	J	61	J	130	J	890		570		200	U	180	U	190	U	190	U	190	U	190	U
Dibenzofuran	200	680	19	U	20	U	19	U	19	U	19	U	14	J	19	U	20	U	18	U	19	U	19	U	19	U	19	U

Table 12. Results of Chemical Analysis for Grab-sampled DMMUs, Tier 2 (August 2013)

CHEMICAL	Used for Snake River		DMMU 1		DMMU 2		DMMU 3		DMMU 4		DMMU 5		DMMU 6		POC-GE		DMMU 7		DMMU 8		DMMU 9		DMMU 10		DMMU 11		POL	
	SL	CL	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
beta-Hexachlorocyclohexane	7.2	11	0.97	U	0.97	U	0.49	U	0.47	U	0.47	U	0.98	U	0.47	U	0.47	U	0.48	U	0.49	U	0.49	U	0.48	U	0.5	U
PESTICIDES & PCBs (µg/kg dry weight)																												
4,4'-DDD	310	860	1.9	U	1.9	U	0.98	U	0.94	U	0.95	U	2	U	1.9	U	0.94	U	0.96	U	0.98	U	0.98	U	0.95	U	0.95	U
4,4'-DDE	21	33	1.9	U	1.9	U	0.98	U	0.94	U	0.95	U	1.5	U	1.9	U	0.94	U	0.96	U	0.98	U	1.6	U	0.95	U	0.95	U
4,4'-DDT	100	8,100	1.9	UJ	1.9	UJ	0.98	U	0.94	U	0.95	UJ	2	UJ	1.9	UJ	0.94	U	0.96	U	0.98	U	0.98	U	0.95	U	0.95	U
Total Chlordane	2.8	37	1.9	U	1.9	U	0.98	U	0.94	U	0.95	U	2	U	1.9	U	0.94	U	0.96	U	0.98	U	0.98	U	0.95	U	0.95	U
Dieldrin	4.9	9.3	1.9	U	1.9	U	0.98	U	0.94	U	0.95	U	2	U	1.9	U	0.94	U	0.96	U	0.98	U	0.98	U	0.95	U	0.95	U
Heptachlor	1.5	270	0.97	R	0.97	R	0.49	R	0.47	R	0.47	R	0.98	R	0.96	R	0.47	R	0.48	R	0.49	R	0.49	R	0.48	R	0.47	R
Endrin ketone	8.5	> 8.5	1.9	UJ	1.9	UJ	0.98	U	0.94	U	0.95	UJ	2	UJ	1.9	UJ	0.94	U	0.96	U	0.98	U	0.98	U	0.95	U	0.95	U
Carbazole	900	1,100	19	U	20	U	19	U	19	U	19	U	19	U	19	UJ	20	U	18	U	19	UJ	19	UJ	19	UJ	13	J
Total PCBs (Aroclors)	110	2,500	39	U	40	U	38	U	18	U	39	U	46	U	39	U	27	U	19	U	27	U	22	U	18	U	28	U
SPECIAL CHEMICALS OF CONCERN																												
Toxaphene	0.2*	---	48	UJ	48	UJ	25	U	24	U	24	UJ	49	UJ	48	UJ	24	U	24	U	24	U	24	U	24	U	24	U

* Toxaphene SL is not a required or reviewed screening level; simply a target detection limit for laboratory analyses

Bold, italicized, yellow-shaded values indicate exceeds the SL; **Bold, orange-shaded** values exceed the CL

S/C SL1 and S/C CL = Project-specific screening levels from source indicated

mg/kg = milligrams per kilogram; **µg/kg** = micrograms per kilogram

Data Qualifiers

U Indicates that the target analyte was not detected at the reported concentration

UJ - The analyte was analyzed for, and the associated quantitation limit was an estimated value.

J Estimated concentration when the value is less than ARI's established reporting limits

R - The reported result was rejected.

Table 13. Results of Chemical Analysis for Core-sampled DMMUs, Tier 2 (August 2013)

CHEMICAL	Used for Snake River		Project Data			
			POC Cruise Dock		POC Rec Dock	
	Screening Level	Cleanup Level	Value	Q	Value	Q
CONVENTIONALS (mg/kg dry weight)						
Ammonia	230	300	38.5		330	
Total sulfides	39	61	21.5		5,640	
METALS (mg/kg dry weight)						
Antimony	150	200	6	UJ	9	UJ
Arsenic	14	120	6	U	9	U
Cadmium	2.1	5.4	0.3		0.7	
Chromium	72	88	13.4		20	
Copper	400	1,200	11.2		24.5	
Lead	360	> 1,300	4	J	8	J
Mercury	0.66	0.8	0.03	U	0.06	
Nickel	26	110	10		15	
Selenium	3	---	0.7	U	0.9	U
Silver	0.57	1.7	0.4	U	0.5	U
Zinc	3,200	> 4,200	40		70	
PHTHALATES (µg/kg dry weight)						
Dimethyl phthalate	46	440	19	U	19	U
Diethyl phthalate	200	1,200	—	—	19	U
Di-n-butyl phthalate	380	1,000	19	U	19	U
Butyl benzyl phthalate	260	370	19	U	19	U
Bis(2-ethylhexyl) phthalate	500	22,000	47	U	48	U
Di-n-octyl phthalate	39	> 1,100	19	U	19	U
PHENOLS (µg/kg dry weight)						
Phenol	120	210	19	U	36	
2-Methylphenol	63	77	19	U	19	U
4-Methylphenol	260	2,000	28		130	
2,4-Dimethylphenol	29	210	26	UJ	26	UJ
Pentachlorophenol	1,200	> 1,200	95	U	97	U
MISCELLANEOUS EXTRACTABLES (µg/kg dry weight)						
Benzyl alcohol	57	870	—	—	19	U
Benzoic acid	2,900	3,800	110	J	430	
Dibenzofuran	200	680	19	U	19	U
Hexachlorobutadiene	11	270	—	—	1.9	U
N-Nitrosodiphenylamine	28	130	—	—	19	U
beta-Hexachlorocyclohexane	7.2	11	0.49	U	3.9	U
PESTICIDES & PCBs (µg/kg dry weight)						
4,4'-DDD	310	860	0.98	U	1.8	J
4,4'-DDE	21	33	0.98	U	1.9	U
4,4'-DDT	100	8,100	0.98	U	1.9	UJ
Total Chlordane	2.8	37	0.98	U	1.9	U
Dieldrin	4.9	9.3	0.98	U	1.9	U
Heptachlor	1.5	270	0.49	R	0.95	R
Endrin ketone	8.5	> 8.5	0.98	U	1.9	UJ
Carbazole	900	1,100	19	UJ	13	J
Total PCBs (Aroclors)	110	2,500	19	U	20	U

Table 13. Results of Chemical Analysis for Core-sampled DMMUs, Tier 2 (August 2013)

CHEMICAL	Used for Snake River		Project Data			
			POC Cruise Dock		POC Rec Dock	
	Screening Level	Cleanup Level	Value	Q	Value	Q
SPECIAL CHEMICALS OF CONCERN[4]						
Toxaphene	0.2*	---	25	U	48	UJ
PAHs (µg/kg dry weight)						
Naphthalene	500	1,300	—	—	19	U
Acenaphthylene	470	640	—	—	19	U
Acenaphthene	1,100	1,300	—	—	19	U
Fluorene	1,000	3,000	—	—	19	U
Phenanthrene	6,100	7,600	—	—	19	U
Anthracene	1,200	1,200	—	—	19	U
2-Methylnaphthalene[2]	470	560	—	—	19	U
Total LPAH	6,600	9,200	—	—	19	U
Fluoranthene	11,000	15,000	—	—	19	U
Pyrene	8,800	16,000	—	—	19	U
Benz(a)anthracene	4,300	5,800	—	—	19	U
Chrysene	5,900	6,400	—	—	19	U
Benzofluoranthenes (b, j ,k)	600	4,000	—	—	19	U
Benzo(a)pyrene	3,300	4,800	—	—	19	U
Indeno(1,2,3-c,d)pyrene	4,100	5,300	—	—	19	U
Dibenz(a,h)anthracene	800	840	—	—	19	U
Benzo(g,h,i)perylene	4,000	5,200	—	—	19	U
Total HPAH	31,000	55,000	—	—	19	U
CHLORINATED HYDROCARBONS (µg/kg dry weight)						
1,4-Dichlorobenzene	110	120	—	—	19	U
1,2-Dichlorobenzene	35	110	—	—	19	U
1,2,4-Trichlorobenzene	31	64	—	—	19	U
Hexachlorobenzene (HCB)	22	230	—	—	1.9	U
BULK PETROLEUM HYDROCARBONS						
Total Petroleum Hydrocarbon (TPH) - Diesel	340	510	—	—	41	
Total Petroleum Hydrocarbon (TPH) - Residual	3,600	4,400	—	—	120	

Table 14. Results of Chemical Analysis for DMMUs undergoing bioassays, Tier 3 (November 2013)

CHEMICAL	SL	CL	DMMU-1-G-C1-B		DMMU-2-G-C1-B		DMMU-3-G-C1-B		DMMU-5-G-C1-B		DMMU-6-G-C1-B		POC-GE-G-C1-B		SR144-R-G1		SR128.5-R-G1	
PHENOLS & MISC. EXTRACTABLES (µg/kg dry weight)																		
Phenol	120	210	39		27		33		100		110		25		19	U	20	
2-Methylphenol	---	---	19	U	20	U	19	U	18	J	20	U	20	U	19	U	19	U
4-Methylphenol	260	2,000	*340*		160		*340*		*660*		*1,200*		81		120		19	U
2,4-Dimethylphenol	---	---	26	UJ	27	UJ	26	UJ	26	UJ	27	UJ	26	UJ	26	UJ	26	UJ
Benzoic acid	2,900	3,800	260		220		200		850		960		170	J	90	J	70	J
Pentachlorophenol	1,200	> 1,200	97	U	99	U	95	U	96	U	100	U	32	J	96	U	96	U

Bold, italicized, yellow-shaded values indicate exceeds the SL

Table 15. SMS 2013 Freshwater Bioassay Interpretive Criteria for Tests Used In Snake/Clearwater Characterization

Biological Test/ Endpoint	Performance Standard		Sediment Cleanup Objective for each biological test	Cleanup Screening Level for each biological test
	Control	Reference		
Hyalella azteca				
10-day mortality	$M_C \leq 20\%$	$M_R \leq 25\%$	$M_T - M_C > 15\%$ and M_T vs M_C SD ($p \leq 0.05$)	$M_T - M_C > 25\%$ and M_T vs M_C SD ($p \leq 0.05$)
Chironomus dilutus				
20-day mortality	$M_C \leq 32\%$	$M_R \leq 35\%$	$M_T - M_C > 15\%$ and M_T vs M_C SD ($p \leq 0.05$)	$M_T - M_C > 25\%$ and M_T vs M_C SD ($p \leq 0.05$)
20-day growth	$MIG_C \geq 0.60$ mg/individual	$MIG_R/MIG_C \geq 0.8$	$(MIG_C - MIG_T)/MIG_C > 0.25$ and MIG_T vs MIG_C SD ($p \leq 0.05$)	$(MIG_C - MIG_T)/MIG_C > 0.40$ and MIG_T vs MIG_C SD ($p \leq 0.05$)

M_C = mean control sediment
M_R = mean reference sediment
M_T = mean test sediment
MIG_R = mean individual growth - reference sediment
MIG_T = mean individual growth - test sediment
MIG_C = mean individual growth - control sediment
SD = significant difference
Growth measured via dry wt

Table 16. *Hyallela azteca* 10-day mortality results

Sample	% fines	Mean mortality (%)	Control Performance Standard **C ≤ 20%**	Reference Performance Standard **R ≤ 25%**	Compared with	1-Hit Criteria: T-R >25% and T vs. R SS	2-Hit Criteria: T-R >15% and T vs. R SS	Pass/Fail
Control (Beaver Creek) (C)	39.4	1.3	1.3 < 20;		--			
Reference 1 (SR mile 144) - coarse (R_C)	29.7	1.3		1.3 < 25, accept	--			
Reference 2 (SR mile 128.5) - fine (R_F)	64.5	3.8		3.8 < 25, accept	--			
DMMU 1	19.3	1.3			R_C	T- R_C = 0.0	T-R_C = 0.0	Pass
DMMU 2	14.2	0.0			R_C	T- R_C = -1.3	T- R_C = -1.3	Pass
DMMU 3	20.9	0.0			R_C	T- R_C = -1.3	T- R_C = -1.3	Pass
DMMU 5	38.7	0.0			C	T-C = -1.3	T-C = -1.3	Pass
DMMU 6	48.4	1.3			C	T-C = 0.0	T-C = 0.0	Pass
DMMU GE	14.1	0.0			R_C	T- R_C = -1.3	T- R_C = -1.3	Pass

Table 17. *Chironomus dilutus* 20-day mortality results

Sample	% fines	Mean mortality (%)	Control Performance Standard **C ≤ 32%**	Reference Performance Standard **R ≤ 35%**	Compared with	1-Hit Criteria: T-R >25% and T vs. R SS	2-Hit Criteria: T-R >15% and T vs. R SS	Pass/Fail
Control (Beaver Creek) (C)	39.4	18.8	18.8 < 32; accept		--			
Reference 1 (SR mile 144) - coarse (R_C)	29.7	13.8		13.8 < 35; accept	--			
Reference 2 (SR mile 128.5) - fine (R_F)	64.5	26.3		26.3 < 35; accept	--			
DMMU 1	19.3	13.8			R_C	T-R_C=0.0	T-R_C=0.0	Pass
DMMU 2	14.2	15.0			R_C	T-R_C=1.3	T-R_C=1.3	Pass
DMMU 3	20.9	13.8			R_C	T-R_C=0.0	T-R_C=0.0	Pass
DMMU 5	38.7	12.5			C	T-C=-6.3	T-C=-6.3	Pass
DMMU 6	48.4	12.5			C	T-C=-6.3	T-C=-6.3	Pass
DMMU GE	14.1	17.5			R_C	T-R_C=3.8	T-R_C=3.8	Pass

Table 18. *Chironomus dilutus* 20-day growth results

Sample	% fines	Growth - mean AFDW (mg/ind.)	Control Performance Standard **C ≥ 0.**60 mg/ind.	Reference Performance Standard **R/C ≥ 0.8**	Compared with	1-Hit: $(MIG_R - MIG_T)/MIG_R > 0.25$ and MIG_T vs. MIG_R SS	2-Hit: $(MIG_R - MIG_T)/MIG_R > 0.40$ and MIG_T vs. MIG_R SS	Pass/Fail
Control (Beaver Creek) (C)	39.4	1.73	1.73 > 0.6; accept		--			
Reference 1 (SR mile 144) - coarse (R_C)	29.7	1.56		R/C = 0.9; accept	--			
Reference 2 (SR mile 128.5) - fine (R_F)	64.5	1.70		R/C = 0.99; accept	--			
DMMU 1	19.3	1.42			R_C	0.09	0.09	Pass
DMMU 2	14.2	1.67			R_C	-0.07	-0.07	Pass
DMMU 3	20.9	1.62			R_C	-0.04	-0.04	Pass
DMMU 5	38.7	1.52			C	0.12	0.12	Pass
DMMU 6	48.4	1.65			C	0.05	0.05	Pass
DMMU GE	14.1	1.95			R_C	-0.25	-0.25	Pass

Figure 1. Vicinity Map showing dredging limits of the Federal Channel at the confluence of the Snake and Clearwater Rivers

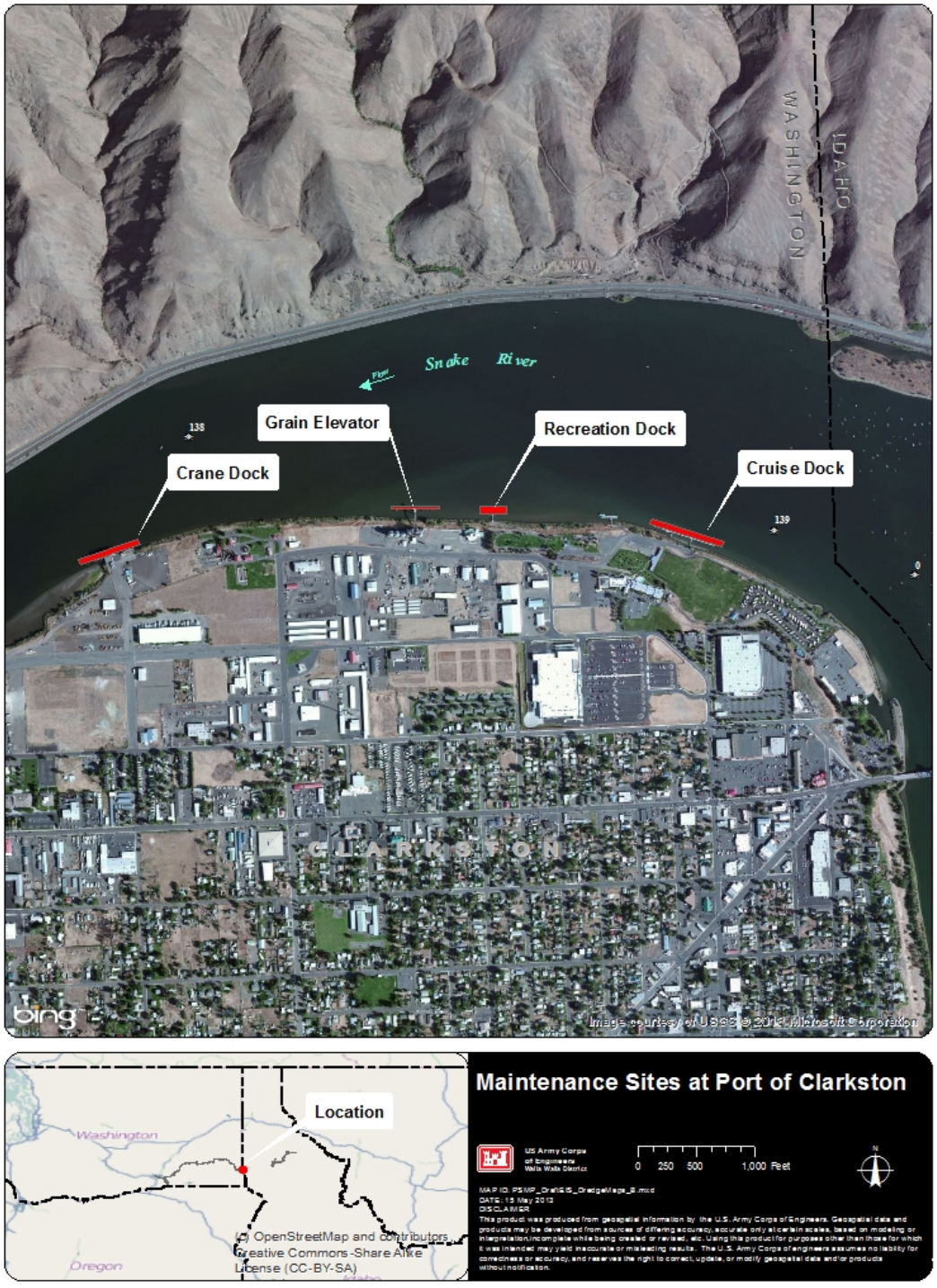


Figure 2. Snake River Vicinity Map showing Port of Clarkston proposed dredge areas. Grain Elevator, Recreation Dock and Cruise Dock are evaluated in this SD; Crane Dock is evaluated separately in Port of Clarkston Crane Dock, Snake River.

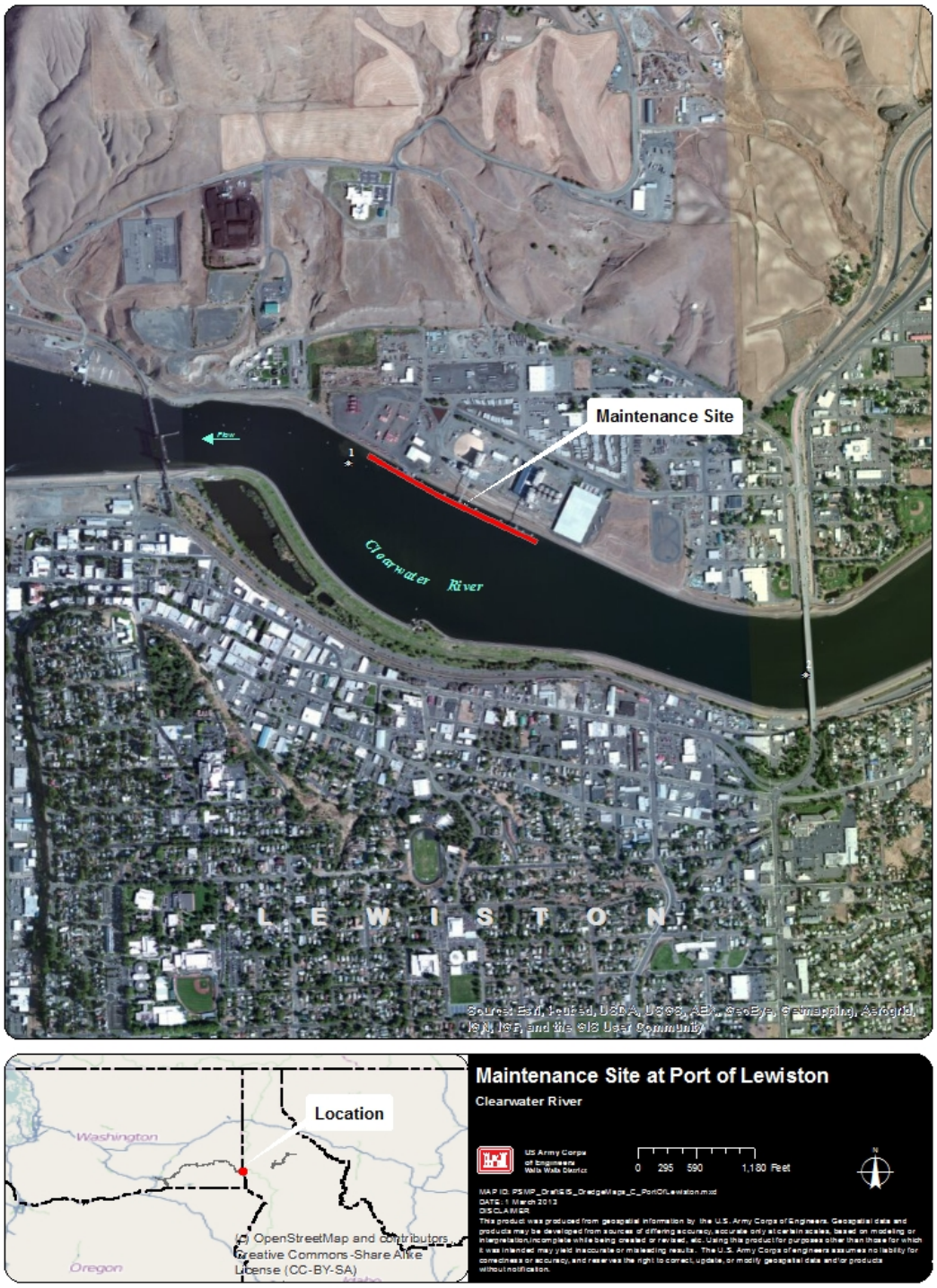


Figure 3. Proposed dredging in Clearwater River at Port of Lewiston.



Figure 4. Approximate DMMU locations with 4-methylphenol exceedances in red. Yellow pins indicate elevated 4-methlyphenol without SL exceedance; green pins indicate low 4-methylphenol detections.

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Section 3. U.S. Army Corps of Engineers Engineer Research and Development Center Reports

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Appendix I

Water Quality and Sediment Quality Reports

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Section 3A. Technical Summary of 4-Methyl Phenol Occurrence and Fate in Aquatic and Terrestrial Environments and Review of NOAA Comments on the Snake River Sediment Evaluation

U.S. Army Corps of Engineers
Engineer Research and Development Center

May 2014

Technical summary of 4-methyl phenol occurrence and fate in aquatic and terrestrial environments and review of NOAA comments on Snake River sediment evaluation [from Lyndal Johnson, March 26]

by

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16 May 2014

Objective

The Walla Walla District is evaluating the suitability of lower Snake/Clearwater River dredged material to be beneficially used for creation of shallow water habitat on the Snake River. The evaluation is being conducted in accordance with the USEPA/USACE Clean Water Act 404(b)(1) guidance. Elevated concentrations of phenol and 4-methylphenol (p-cresol) were detected in the navigation channel sediments scheduled for maintenance dredging. The following provides a brief review on the occurrence and fate of phenol and 4-methylphenol in aquatic environments and response to NOAA comments on Snake River sediment evaluation provided by Lyndal Johnson, NOAA, NWFSC, on March 26, 2014. The following review provides context to the detection of these chemicals in sediment samples collected as part of the 2014 dredged material evaluation for lower Snake/Clearwater river sediment samples.

Lower Snake/Clearwater River Concentrations and Potential for Toxicity

The compound 4-methylphenol was detected in six of the eight Snake River DMMUs (1, 2, 3, 5, 6, and the Port of Clarkston Grain Elevator) at concentrations exceeding the SL1 guideline of 260 µg/kg, with values ranging from 340 to 4,900 µg/kg, resulting in a mass-weighted average concentration of 554 µg/kg. Phenol also exceeded SL1 guidelines in DMMU 6 where a concentration of 170 µg/kg was detected (the SL1 is 120 µg/kg); however, the mass-weighted average concentration is estimated to be ~25 µg/kg. Although the DMMU samples exceeded SL1 sediment quality screening values, none of these sediments were determined to be toxic to benthic macroinvertebrates in Tier 3 laboratory bioassays.

To evaluate potential toxicity to fish and other aquatic life in the water column, Lyndal Johnson developed sediment quality benchmarks. The sediment quality benchmarks were derived using ecotoxicity data from the literature and estimates of sediment pore water concentrations based on simple contaminant aqueous partitioning relationships. However, these sediment quality benchmarks do not take into account the specific physical characteristics of the sediment nor the processes that occur as the contaminant is transported to the water column where potentially there would be exposure to fish.

To develop estimates of actual fish exposure, estimates of the maximum water concentrations for 4-methylphenol and phenol were conservatively developed for areas adjacent to dredged material placement during habitat construction (>150 feet distance), dredging locations (>150 feet distance), and directly above the constructed shoal following placement (< 2 cm above the sediment surface). The maximum water constructions for these locations were determined to be 50, 0.97 and <0.3 µg/L for 4-methylphenol and 2.0, 0.034 and <0.25 µg/L for phenol, respectively. The predicted maximum water concentrations are all less than the water quality screening values identified by Lyndal Johnson for 4-methylphenol (1,350 µg/L for early life stage mortality of fathead minnow) and phenol (70 µg/L for survival of rainbow trout eggs and larvae in hard water).

As described by Lyndal Johnson, there are no national aquatic life water quality criterion for phenol nor 4-methylphenol at this time in the U.S. Criteria were developed and subsequently

withdrawn by the USEPA (USEPA 1980). However, a Canadian Water Quality Guideline for protection of aquatic life has been established for the combined concentrations of mono- and dihydric phenols (i.e. sum of phenol, methyl-phenols and dimethyl-phenols) based on toxicity observed to the Northern Leopard Frog (*Rana pipiens*; 9-day LC50 40 µg/L; Birge et al. 1980). The Canadian Guideline for mono- and dihydric phenols, 4 µg/L, was developed by applying a by a safety factor of 0.1 to the sum of mono- and dihydric phenols (CCME 1991). Although the maximum modeled concentration of 4-methylphenol plus phenol (52 µg/L) in the water column may exceed the 9-day LC50 value for Northern Leopard Frog, the time frame for this hypothetical exposure would be several minutes compared to the 9-day time frame used for the toxicity tests with frogs. In addition, these maximum predicted values are for the center line of the 4-methylphenol plume following discharge of 3000 cy of dredged material from the DMMU with the highest pore water concentration when the river water velocity is 0.4 ft/sec. Concentrations along the shoreline (associated with frog habitat) at slower river water velocity (i.e., 0.2 ft sec) and smaller loads of dredged material discharged (i.e., 2000 cy) would result in a maximum 4-methylphenol concentrations of less than 32 µg/L for a short duration. It is important to note that mono- and dihydric phenols have been shown to exhibit different degrees of toxicity to fish with phenol considered to be the most toxic and the methyl phenols having less toxicity in the following order; phenol > p-cresol > o-cresol > m-cresol > catechol (Devi, 1987). Based on this conservative water criterion for *Rana pipiens,* no toxicity for the combined impacts of 4-methylphenol and phenol are anticipated to aquatic life. The New York State water quality standard for total unchlorinated phenols is 5 µg/L. This state standard is based on aesthetic considerations for food sources (NYSDEC 1998). The taste and odor threshold for phenol and 4-methyl phenol is a subjective measure dependent on the specific chemical compound, water temperature and individual sensitivity to odors. Lyndal Johnson identified 120 µg/L specific for 4-methylphenol as a threshold for tainting of rainbow trout (Shumway and Parkening, 1973). However, much higher fish tainting threshold specific for phenol (trout) and 4-methylphenol (unspecified fish) have been reported to be 25,000 and 10,000 µg/L, respectively, by the Ontario Ministry of the Environment (de Barros 1984). Based on the predicted water concentrations in the immediate area of dredged material placement, dredging operations, and directly above the constructed shoal, toxicity to fish and tainting of fish tissue are not expected.

Chemical/Physical Characteristics

The chemical 4-methylphenol is one of three types (or isomers) of phenol that have a methyl group on the aromatic ring structure of the parent organic chemical, phenol. The common names for these compounds, cresols, are ortho-cresol, meta-cresol, and para-cresol; abbreviated as o-cresol, m-cresol, and p-cresol. The compound 4-methylphenol is referred to as p-cresol, where the methyl group is located opposite to the hydroxyl group (-OH) on the aromatic ring structure. Pure cresols are solid, while mixtures tend to be liquid. They are highly soluble in water (21,520–25,950 mg/L) and have a relatively high vapor pressure (0.11±0.03 mmHg at 25.5 °C). The octanol-water partitioning coefficient (K_{OW}) is low for both 4-methyl phenol and phenol (85.1 and 28.8 vol/vol, respectively). These chemical/physical properties control the behavior of 4-methylphenol and phenol in the environment. These compounds sorb only modestly to organic particulates in water, sediment and air preferring to remain in the dissolved in water or the volatile state in air. When present in sediments, typically 20 to 80 percent of these compounds

would be dissolved in the pore water. Consequently, phenol and 4-methylphenol do not bioconcentrate into the lipids of fish such as salmonids or other aquatic life. They are naturally present at low concentrations in vertebrates and are readily metabolized endogenously by aquatic life or by their gut microbes (ASTDR, 2008). The low bioconcentration from water into lipids and endogenous metabolism within aquatic organisms prevents these compounds from bioaccumulating through food webs to higher trophic level fish such as steelhead and salmon.

Although ubiquitous, the concentration of cresols in environmental media is typically low due to their rapid removal rate. Microbial biodegradation is the dominant mechanism responsible for their rapid breakdown in sediments. However, these compounds may persist under anaerobic conditions where microbial activity is lower, such as in subsurface sediments. In aerobic water, the biodegradation half-life of cresols is on the order of a day to a week. In soils and sediments under aerobic conditions, the biodegradation half-life is on the order of a week or less. Under anaerobic conditions, biodegradation also occurs, but half-lives are much longer ranging from weeks to months.

Environmental Sources and Occurrence

The source of 4-methylphenol in lower Snake/Clearwater River sediments is uncertain and will be difficult to determine. Forensic analysis for source attribution is complex for phenol and 4-methylphenol due to the vast number of potential sources. Cresols, including 4-methylphenol, are commonly detected in stream water and sediments as the result of both natural and man-made sources. In a study of streambed sediment in 20 major river basins of the United States from 1992 to1995, 4-methylphenol was identified in 37.8% of the sites with a maximum value of 4,800 µg/kg dry weight (Lopes 2001). The mass-weighted average concentration of 4-methylphenol (554 µg/kg) for the lower Snake/Clearwater River DMMU's falls within the range considered typical in the sediment of major U.S. river basins (90th percentile 430 µg/kg dry weight). In a national study of organic contaminants present in a network of 139 streams across 30 states, 4-methylphenol was detected in 24.7% of the samples with a maximum concentration of 0.54 µg/L and a median concentration of 0.05 µg/L (Kolpin 2002). The concentrations of 4-methylphenol and phenol detected in sediments and estimated for water directly above the reestablished shallow water habitat (6 month time frame) would be typical for other U.S rivers having low level impacts from urban and agricultural watersheds.

Phenol and cresols are created naturally by microbes and higher organisms as well as through chemical manufacturing and the degradation of industrial products. They are formed during the burning of wood, coal, and fossil fuels, including tobacco smoke, and are a primary constituent of coal tar derived creosote wood preservatives. Low levels of cresols are naturally found in foods such as tomatoes, tomato ketchup, asparagus, cheeses, butter, bacon, and contribute to the desired flavor of smoked foods. Some drinks also contain cresols (coffee, black tea, wine, Scotch whisky, brandy and rum). They are an excretory product of mammals, a component of human sweat and considered a normal constituent of human urine. Humans normally excrete approximately 50 – 80 mg of 4-methylphenol in the urine daily, which is produced endogenously from amino acids by anaerobic bacteria in the gastrointestinal tract (Sullivan 2001).

Phenols are created naturally in aquatic environments at low concentrations by algae and from the decomposition of aquatic vegetation (Dobbins 1987; Knuutinen , 1991). They are created by microbes and then become the building blocks of humic materials in both soil and sediment. Consequently, naturally produced phenol and cresols are constantly being released to soils and sediment via excrement, exocellular secretions, and necromass of living and former living organisms. Under anaerobic conditions higher concentrations of phenol and 4-methylphenol may accumulate due to slower biodegradation rates and limits to organic matter mineralization.

In agricultural landscapes, grazing animals on pasture lands and feed lots may contribute relatively large amounts of 4-methylphenol to soil and adjacent waterways. Poultry manure has been reported to contain an average concentration of 11,700 μg/kg 4-methylphenol (Yasuhara 1987). Various pesticides degrade in the environment, forming phenolic compounds. For example, tolclofos-methyl, an organophosphate fungicide that is used as a seed treatment for small grains and potatoes, has relatively strong sorption to soil and sediment organic matter (K_{OW} 4.6) and then slowly degrades under anaerobic conditions to 4-methylphenol. Approximately 3% of the fungicide degrades to 4-methylphenol under anaerobic conditions (FAO/WHO 1994).

Forest products and creosote preserved wood products are associated with phenol and cresols. Lignin is composed of polymerized phenol-based building blocks and the aromatic content of lignin, expressed as monomeric phenol, is approximately 51%. During the pulping process for paper manufacture, phenolic compounds are released and treated as part of the industrial waste water treatment process. There is a significant difference in the quality of the wastewaters from pulping and papermaking operations due to the diversity of the industrial pulping processes and wastewater treatment systems in use. In a survey of Ontario pulp and paper industry waste water effluents, phenol was determined to range in concentration up to 17,000 μg/L while 4-methylphenol was not detected (de Barros1984).

Conclusions

The compounds phenol and 4-methylphenol are ubiquitous in the environment and commonly found in sediment and surface water at low concentrations as the result of both natural and anthropogenic sources. These compounds rapidly and completely degraded to simpler molecules or become incorporated into natural organic matter under aerobic conditions in fresh water, sediment and upland soil; however, much slower degradation occurs under anaerobic conditions such as found in subsurface sediments and wetland soils.

Given the high water solubility and low organic carbon partitioning coefficient for phenol and 4-methylphenol, it is highly unlikely that the maximum concentrations of phenol (170 μg/kg) and 4-methylphenol (4,900 μg/kg) observed originated from the presence of dissolved chemicals in the water column and subsequent sorption into sediment. The observed phenol and 4-methylphenol occurred through the deposition of suitable natural or anthropogenic particulates, solids or sludge with the subsequent formation of phenol and 4-methylphenol through microbial processes in anaerobic sediments.

Although the dredged material evaluation showed that sediments exceeded SL1 screening values, none of these sediments were determined to be toxic to benthic macroinvertebrates in Tier 3 laboratory bioassays. Based on the predicted water concentrations within the immediate area of dredging operations, dredged material placement, and above or within the bioactive zone of the constructed shoal following site construction, toxicity to fish and tainting of fish tissue is not expected.

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Section 3B. Prediction of Turbidity Plumes from Dredging Operations on the Snake River

U.S. Army Corps of Engineers
Engineer Research and Development Center

July 2014

Prediction of Turbidity Plumes from Dredging Operations on the Snake River

by

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25 July 2014

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Prediction of Turbidity Plumes from Dredging Operations on the Snake River

Background

The Walla Walla District is planning to dredge shoaling sediment in the Lower Snake River (DMMUs 1 through 6) and Clearwater River (DMMUs 7 through 11) and then place the dredged material at Lower Snake River Mile 116 to build a 13-ft high habitat bench (shown in Figure 1). Previous modeling of this operation (Gidley and Schroeder, 13 May 2014) focused on the release of 4-methylphenol (4MP) (mass-weighted average of 554 µg/kg) and phenol (~25 µg/kg). This modeling effort seeks to predict the footprint of the plume bounded by the proposed turbidity criterion of 5 NTU above background (for background turbidities of less than 50 NTUs, which is the case during dredging operations on the Snake River) at both the dredging and placement site using the DREDGE and STFATE models calibrated to site conditions. Predictions are made for the time and distance required to reliably meet the turbidity criteria in addition to the turbidity at 300 ft downstream, a distance commonly used for compliance monitoring.

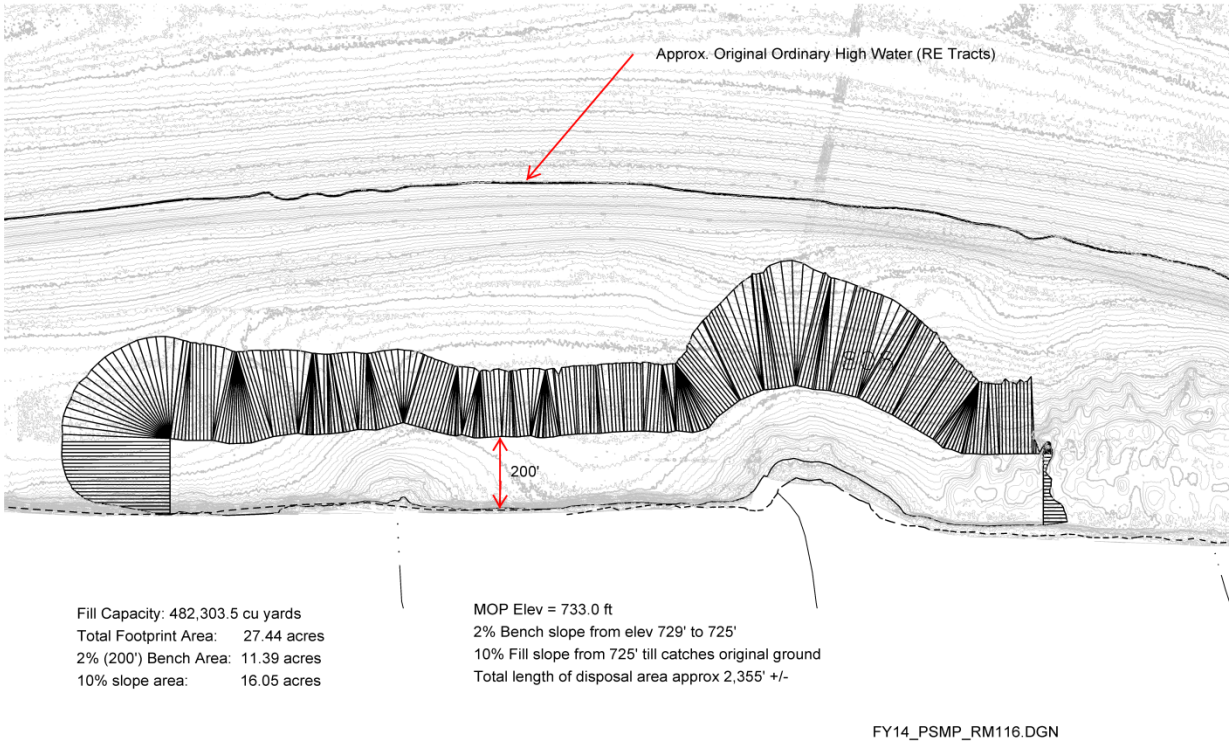


Figure 1. Plan view of the proposed shallow water placement habitat at river mile 116.

STFATE Modeling

Input. The STFATE model was used to evaluate the short-term fate of dredged material during open water placement using theoretical Gaussian functions. The processes modeled included descent, collapse and diffusion of the dredged material. The water depth used for the simulation was 27 ft (range 24-30 ft) (Lower Snake/Clearwater Sampling Report). The average water temperature of the river was assumed to be 10°C. The depth averaged water velocity in the river ranges from 0.2-0.4 ft/s from a HEC-RAS model run provided by the District. The roughness height for the river bottom was selected as the "Nikuradse roughness" (Soulsby, 1997), which in this case was taken to be that of medium sand (0.005 ft diameter). Bottom dump barges with a holding capacity of 2000-4000 cy will most likely be used for this operation. The dimensions of these dump scows have lengths ranging from 150-200 ft, widths ranging from 40-50 ft, loaded drafts ranging from 11.5-15 ft, and unloaded drafts ranging from 4-7 ft. STFATE model parameters are provided in Table A1 of the Appendix.

The dredged material to be released from split hull barges is comprised of a non-cohesive mixture of sand, clay and silt. As a conservative assumption, the particle size distributions found in the most fine-grained sediment were used in the simulation for TSS: 69% sand, 14% clay, and 17% silt. The fine-grained materials are not present in the sediment bed as distinct separate particles. Measurements of resuspended sediment particles characteristics by Smith et al. (2012) shows that over 90% of these particles are aggregates of particles that have sizes and settling velocities of fine sand and medium to coarse silt. Therefore, the solids were divided into sand, coarse aggregates (silt aggregates), fine aggregates (dispersed silt and clay aggregates), and clay (dispersed clay), assuming 10% of the fines are dispersed. Representative default settling velocities were used in the model: 0.002 fps for clay, 0.007 fps for fine aggregates, 0.02 fps for coarse aggregates, and 0.03 fps for sand. The clay, fine aggregates and coarse aggregates are modeled as available to be stripped during descent and collapse of the discharge.

Calibration. Upon establishing all of the input describing the site conditions and material properties, the model was calibrated using past monitoring data. Monitoring data from 1988 provided some data to correlate turbidity with total suspended solids concentration (TSS). The background data showed a ratio of 1.4 mg/L TSS to 1 NTU while the dredging plume data showed a ratio of 2.4 mg/L TSS to 1 NTU. This finding is typical because the dredging plume would be composed largely of aggregates, which would produce less turbidity per particle mass than fine particles.

The monitoring results from 2006 were rather variable, characteristic of dredging operations due to its transient disjointed processes in the water column such as dropping the bucket, hitting the bottom, closing the bucket, raising the bucket, slewing the bucket, and emptying the

bucket. Therefore, the monitoring data was screened to include values which yielded a positive difference between the monitoring station and the background station, which occurred 74% of the time at the dredging site and 58% of the time at the placement site. The filtered data was then sorted to compute the 50th, 80th, 90th, 95th and 99th percentile to examine the magnitude of the turbidity increase and its variability at the monitoring stations (300 ft from the operation). See Table 1 for monitoring results for TSS and turbidity increases above background.

Table 1. 2006 Monitoring Results above Background by Percentile

	Dredging	74%	Placement	58%
Percentile	NTU	TSS* (mg/L)	NTU	TSS* (mg/L)
50	1.9	4.4	2.0	4.7
80	5.6	13.4	4.5	10.7
90	9.5	22.5	7.3	17.5
95	14.4	34.5	11.9	28.5
99	28.9	69.4	29. 2	70.0

* Estimated to be 2.4 times the turbidity in NTU

The 2006 monitoring data was used for calibrating the STFATE model for placing dredged material from 2000-cy dump scows in 27 feet of water having a velocity of 0.2 fps, representative of the 2006 dredging operation. During calibration the default model coefficients are adjusted within a narrow range of values reported in the literature until the model predictions match the monitoring (or calibration) data. STFATE has numerous coefficients but only a couple would impact the turbidity source strength (collapse entrainment coefficient [ALPHAC] and descent entrainment coefficient [ALPHA0]) and its dissipation during passive transport (horizontal diffusion dissipation factor [ALAMDA] and the vertical diffusion coefficient [AKY0]) after already accounting for the material characteristics and settling properties. Due to the shallow nature of the site and large barge sizes, the predictions are less sensitive to entrainment coefficients than diffusion coefficients. Due to the higher density of sediment ladened water, horizontal spreading is much more dominant than vertical spreading due to gravity forces. Therefore, the 4/3 law horizontal diffusion dissipation factor, ALAMDA, was selected for calibration. The ALAMDA coefficient was increased from a default of 0.001 to 0.004 for worst case predictions and to 0.006 for typical case predictions, within the range of values for small grid cells which could be as high as 0.01. The worst-case calibrated model produces results between the 95th percentile and 99th percentile, representing a reasonable worst case whereby the actual results should not exceed the model results more than 2 or 3% of the time, while the typical-case calibrated model produces results representative of the 80th percentile.

Predictions. Upon completion of the calibration, the model was run for four operating scenarios, 2000-cy and 4000-cy dump scows at 0.2 fps and 0.4 fps. The predicted TSS concentrations at 300, 600 and 900 ft from the downstream edge of the plume during the placement (about 150 ft from the center of the dump barge) are presented in Table 2, representing worst case TSS concentrations; typical concentrations would only be 10 to 20 percent of these values based on the 2006 monitoring data. Table 3 lists the time and distance that it would take for a worst case plume to attain a maximum TSS concentration of 12 mg/L, corresponding to a turbidity of 5 NTUs based on a TSS to NTU ratio of 2.4 as obtained from the 1988 monitoring data. The plume will consist primarily of dispersed clay, silt and organic particles and clay aggregates. Most of the sand and silt aggregates settle out in the first 300 feet and 600 feet, respectively.

Table 2. Predicted Worst-Case TSS Concentrations in Placement Plumes

Velocity ft/sec	Barge Volume cy	Solids Fraction	Predicted TSS Concentrations, mg/L Distance from Initial Edge, feet 300	600	900
0.2	2000	Clay	25.9	7.6	3.1
		Clay Flocs & Silt	30.4	5.9	1.6
		Silt Flocs	2.6	0.2	0
		Sum	58.9	13.7	4.7
	4000	Clay	44.1	13.7	5.9
		Clay Flocs & Silt	49.6	10	2.9
		Silt Flocs	4.7	0.5	0.1
		Sum	98.4	24.2	8.9
0.4	2000	Clay	123	48.6	23.5
		Clay Flocs & Silt	236	68.4	25.9
		Silt Flocs	104	21.1	5.6
		Sum	463	138.1	55
	4000	Clay	191	80.4	40.4
		Clay Flocs & Silt	347	105	41.4
		Silt Flocs	165	35.4	9.7
		Sum	703	220.8	91.5

Table 3. Predicted Worst-Case TSS Concentrations in Placement Plumes

Velocity ft/sec	Barge Volume cy	Time to Compliance sec	Distance to Compliance ft
0.2	2000	3950	650
0.2	4000	4750	800
0.4	2000	4400	1600
0.4	4000	5200	1950

Since the results in Tables 2 and 3 represents worst case conditions, compliance would typically be expected to be achieved about 300 ft closer to the discharge location or 1500 seconds sooner at 0.2 fps and about 500 ft closer or 1200 seconds sooner at 0.4 fps.

DREDGE Modeling

The DREDGE model was used to simulate sediment resuspension and the resulting TSS concentrations/turbidity at the dredging site (Figure 2.). The DREDGE model results from the previous modeling effort (Gidley and Schroeder, 13 May 2014) were compared with the monitoring results presented in Table 1 to determine the need for additional calibration of the DREDGE model. The worst case modeling results from May 2014, representing a high solids loss rate of 0.31 kg/sec (0.67% of the fines) with a stream velocity of 0.8 fps, matched very closely to the 95th percentile of the 2006 monitoring data assuming 2.4 for the ratio of the TSS concentration (in mg/L) to turbidity in NTU as determined from the 1988 monitoring data. Similarly, the typical case modeling results from May 2014, representing a more typical solids loss rate of 0.12 kg/sec (0.25% of the fines) also at a stream velocity of 0.8 fps, matched very closely to the 80th percentile of the 2006 monitoring data using 2.4 for the ratio of the TSS to NTU. These loss rates are typical of loss rates from clamshell buckets; Hayes and Wu (2001) reported loss rates of 0.2 to 0.9%, Pennekamp et al. (1996) reported loss rates of 0.3 to 1%, and Nakai (1978) reported loss rates of 0.2 to 0.6%. The DREDGE model predictions for TSS concentrations and turbidity are shown in Figures 3 and 4, respectively. Typically, the resuspension meets the turbidity criteria at less than 600 ft from the dredge location (a travel time of about 10 minutes), but under worst case the resuspension may not meet the criteria closer than 3000 ft from the dredge (a travel time of about 60 minutes). DREDGE model input parameters are provided in Table A2 of the Appendix.

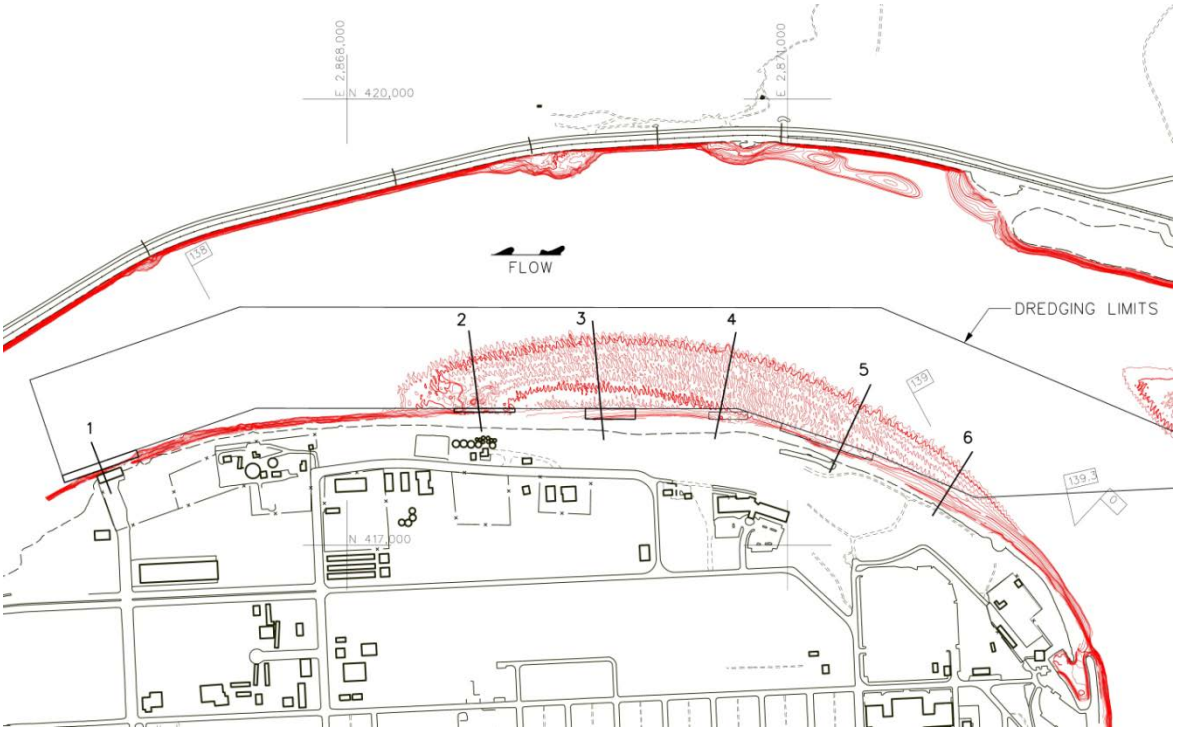


Figure 2. Illustration of proposed dredge footprint in the Snake River. Transect numbers correspond to water velocity transects.

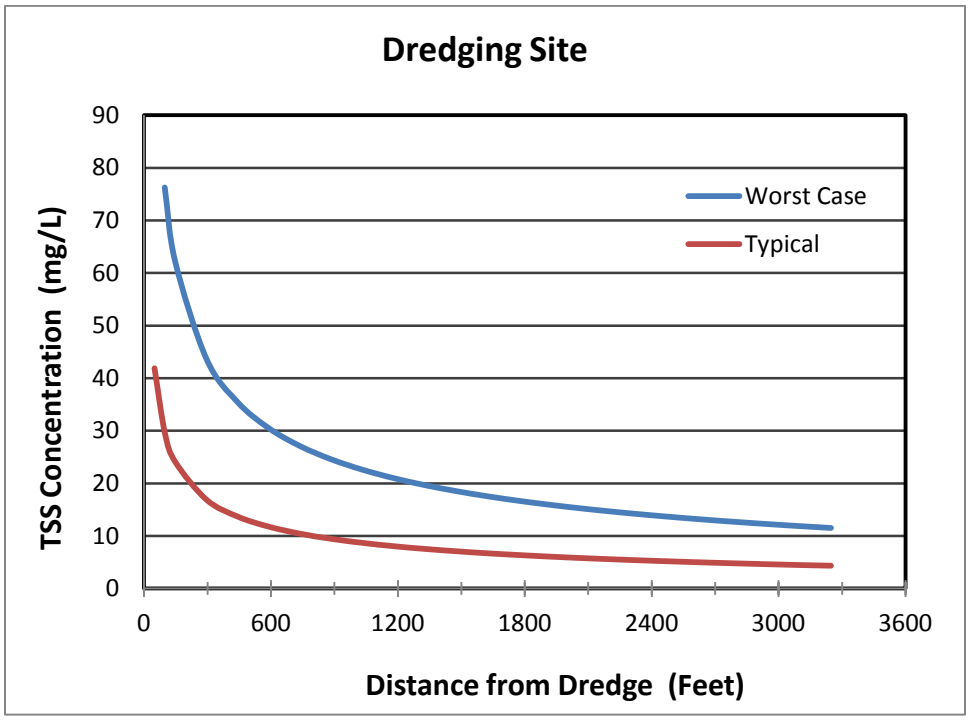


Figure 3. DREDGE model predictions for TSS concentrations.

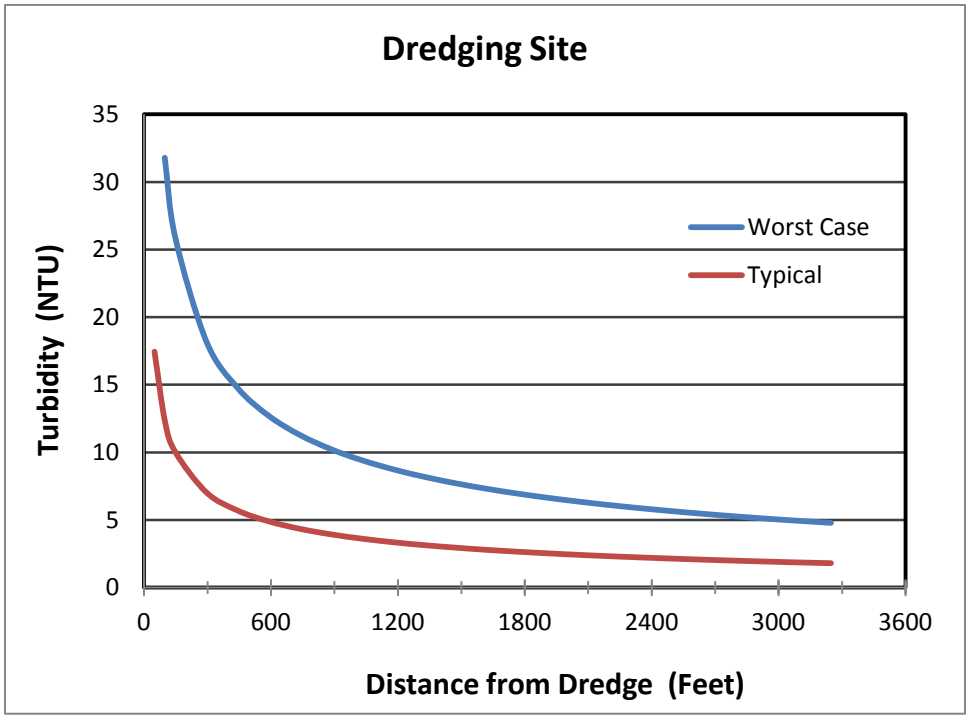


Figure 4. DREDGE model predictions for turbidity (assuming 2.4 for the ratio of TSS to NTU).

Conclusions

Monitoring data from 1988 and 2006 shows that the turbidity plumes from dredging and placement operations are quite unsteady and vary greatly over the course of an hour. The majority of the turbidity measurements are less than 15% of the values in the top 5% of the measurements. No increase in background turbidity was observed about a third of the time at the compliance monitoring locations (300 ft downstream of operations). Under typical conditions at the dredging and placement sites, the turbidity criterion is predicted to be commonly met within 600 feet of the resuspension source. Under high flow and worst case conditions, the required mixing zone lengths to achieve compliance with the turbidity criterion are much longer, up to about 2000 feet at the placement site and 3000 feet at the dredging site.

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Appendix A: Model Inputs

Table A1. STFATE Model Inputs

STFATE Model Parameter (if not specified, leave on default or allow auto adjustment)	Value
Program Options	
Section 404(b)(1)	selected
Disposal from a split hull barge	selected
Descent, Collapse, and Diffusion	selected
Tier II, Compare Water Quality	selected
Evaluation Type-Water Quality Analysis	
Water Quality Standard (µg/L)	1,350 (4MP); 70 (phenol)
Contaminant of Concern	4MP
Predicted Initial Concentration in Fluid (µg/L)	600
Background Concentration (mg/L)	0
Transport Diffusion Output	
Number of Transport-Diffusion Outputs	3
Output Depths (ft)	10, 18, 26
Output Options-Time Steps and Print Options	
Duration of Simulation (seconds)	1800 to18000
Long-Term Time Step for Diffusion (seconds)	60 to 750
Number of Print Times	3-7
Print Times (seconds)	600, 1200, 1800
Site Description	
Number of Grid Points in Z direction	40
Number of Grid Points in X direction	60
Spacing between grid points (Z direction)	20 to 50
Spacing between grid points (X direction)	30 to 75
Roughness Height (ft)	0.005
Slope of Bottom	0
Constant Water Depth (ft)	27
Number of Points to Describe Water Density	2
Density Point Depths (ft)	0, 27
Material Description	
Number of Layers	1
Volume (cy)	2000 to 4000
Material Properties Select:	
Fraction Sand (Fraction of Total Volume)	.157
Fraction Clay	0.003
Fraction Clay Aggregates and Silt	0.032
Fraction Silt Aggregates	0.034
Water temperature °C	10
Single Depth Averaged Velocity	selected
Velocity (ft/s)	0.2-0.4
Depth at Location (ft)	27 ft
Disposal Operation Data	
Location of Disposal Point from Top of Grid (ft)	390 to 600
Location of Disposal Point from left edge (ft)	380 to 1000
Length of Disposal Vessel Bin (ft)	175
Width of Disposal (ft)	45
Pre-Disposal Draft (ft)	13
Post-Disposal Draft (ft)	5
Time Needed to Empty (sec.)	50

Table A2. DREDGE Model Inputs

DREDGE Model Parameter (if not specified, leave on default or allow auto adjustment)	Value
Dredge Characteristics	
Select Dredge	Mechanical Dredge/Open Clamshell
Bucket Size (m^3)	9
Cycle Time (sec)	115
Settling Velocity (m/s)	0.0001
In-Situ Dry Density (kg/m^3)	600
Near Field Model	
User Estimate	selected
Estimated Source Strength (kg/s)	0.123 (probable); 0.31 (worst case)
% Loss	0.26; 0.66
Far Field Model	Kuo's Model
Lateral Diffusion Coefficient (cm^2/s)	390
Vertical Diffusion Coefficient (cm^2/s)	52
Settling Velocity (m/s)	0.0001
Downstream Locations (m)	990; 15 (step)
Lateral Locations (m)	30; 3 (step)
Desired Water Depth (m)	1
Contaminant Modeling	
TSS	yes
4MP (mg/L)	4.9
Phenol (mg/L)	0.17
Site Characteristics	
Water Depth (m)	2.134
Ambient Water Velocity (m/s)	0.2439
Mean Particle Size (microns)	10
Fraction of Particles Smaller than 74 µm	0.307
Fraction of Particles Smaller than Particles with Critical Settling Velocity	0.142
Dredged Material Transport Method	NA

Lower Snake River Programmatic Sediment Management Plan Environmental Impact Statement

Appendix I

Water Quality and Sediment Quality Reports

August 2014

Section 3C. STFATE, DREDGE, and RECOVERY Modeling of Snake River Sediment

U.S. Army Corps of Engineers
Engineer Research and Development Center

May 2014

STFATE, DREDGE, and RECOVERY Modeling of Snake River Sediment

by

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13 May 2014

Prepared for the USACE Walla Walla District
Walla Walla, WA

STFATE, DREDGE, and RECOVERY Modeling of Snake River Sediment

Background

The Walla Walla District is planning to dredge shoaling sediment in the Lower Snake River (DMMUs 1 through 6) and Clearwater River (DMMUs 7 through 11) and then place the dredged material at Lower Snake River Mile 116 to build a 13-ft high habitat bench (shown in Figure 1). The sediment in DMMUs 1 through 6 have elevated levels of 4-methylphenol (4MP) (mass-weighted average of 554 µg/kg) and phenol (~25 µg/kg) and will therefore be used to form the bottom 9 feet of the proposed bench. The sediment in DMMUs 7 through 11 will form a 4-ft isolation layer above the more contaminated dredged material. Due to elevated contaminant concentrations in DMMUs 1 through 6, this worst-case modeling study was performed to predict the water column exposures from dredging, placement and use of Lower Snake River sediment. The resulting water column concentrations of 4MP and phenol at both the dredging site and the placement site were then compared with water quality criteria developed by NOAA (a value of 1.35 mg/L for 4MP and 0.07 mg/L for phenol was selected for initial comparisons). In addition, the water concentrations of total suspended solids (TSS) were assessed. To perform the exposure analysis, STFATE, DREDGE, and RECOVERY models are used.

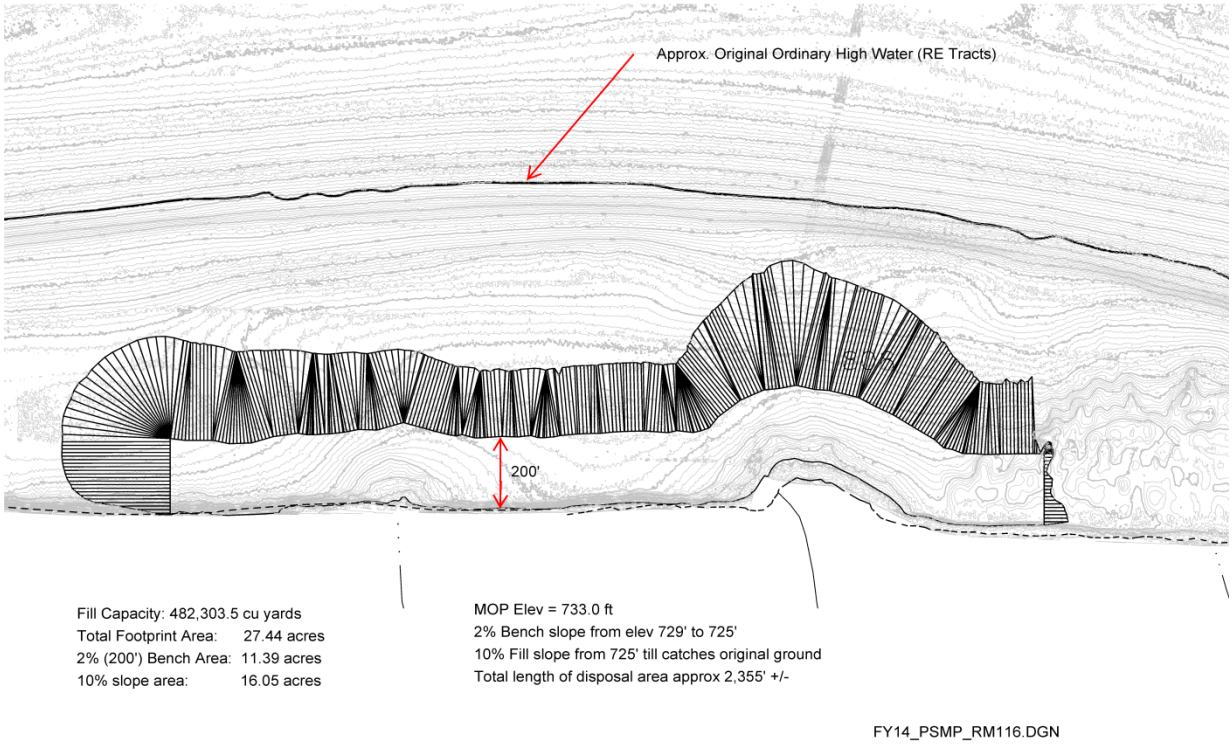


Figure 1. Plan view of the proposed shallow water placement habitat at river mile 116.

STFATE Modeling

The STFATE model was used to evaluate the short-term fate of dredged material during open water placement using theoretical Gaussian functions. The processes modeled included descent, collapse and diffusion of the dredged material. The water depth used for the simulation was 27 ft (range 24-30 ft) (Lower Snake/Clearwater Sampling Report). The average water temperature of the river was assumed to be 10°C. The depth averaged water velocity in the river ranges from 0.2-0.4 ft/s from a HEC-RAS model run provided by the District. The roughness height for the river bottom was selected as the "Nikuradse roughness" (Soulsby, 1997), which in this case was taken to be that of medium sand (0.005 ft). Bottom dump barges with a holding capacity of 2000-3000 cy will most likely be used for this operation. The dimensions of these dump scows have lengths ranging from 150-200 ft, widths ranging from 40-50 ft, loaded drafts ranging from 11.5-15 ft, and unloaded drafts ranging from 4-7 ft. STFATE model parameters are provided in Table A1 of the Appendix.

The dredged material to be released from split hull barges is comprised of a non-cohesive mixture of sand, clay and silt. As a conservative assumption, the particle size distributions found in the most contaminated sediment were used in the simulation for TSS: 69% sand, 14% clay, and 17% silt, which is also the sediment with the greatest fraction of fine-grained particles and TOC. Partitioning of contaminants to sediment TOC was assumed to behave similar to that described by Karickhoff (1979). TOC limits the dissolved contaminant concentration in the pore water. A greater dry bulk density decreases the depletion of contaminants on the particulates when in equilibrium with the pore water, increasing the dissolved contaminant concentration for a given bulk sediment concentration. The maximum bulk sediment concentration occurred at DMMU 6 with 4900 µg/kg 4MP and 170 µg/kg phenol as determined from an August 2013 sampling event. However, the maximum sediment pore water (associated only with water, not solids or other phases including dissolved organic carbon) at in situ density were calculated in sediment to be 1297 µg/L for 4MP and 71 µg/L for phenol at DMMU 5, while the pore water concentration at DMMU 6 were calculated to be 1004 µg/L for 4MP and 68 µg/L for phenol. This effect is due to low TOC content and high dry bulk density at DMMU 5, while DMMU 6 has high TOC content and low dry bulk density. The maximum phenol pore water calculation is just higher than a representative NOAA criterion of 70 µg/L phenol, while the maximum 4MP pore water calculation is somewhat lower than a representative NOAA criterion of 1350 µg/L 4MP, indicating the potential for toxicity to aquatic organisms is highly unlikely.

The STFATE model predicts that the descent and collapse of 3000 cy of dredged material at the placement site is predicted to entrain 2 parts of water per part of dredged material released. Using this ratio to predict an elutriate concentration by equilibrium partitioning, as opposed to a less conservative standard elutriate mixture of 4 parts of

water to one part of sediment, the elutriate specified in the mixing modeling for this lower dry bulk density had concentrations of just 597 µg/L 4MP and 29.2 µg/L phenol for DMMU 6 and just 485 µg/L 4MP and 19.8 µg/L phenol for DMMU 5. DMMU 5 and 6 are the first two DMMUs to be dredged on the Snake River and will be part of the initially placed material. Therefore, the worst-case dissolved concentrations of both 4MP and phenol at the time of initial transport from the placement locale prior to any additional mixing and dilution in a mixing zone are predicted to be less than half of the representative NOAA criteria based solely on the elutriate calculations.

The “mixing zone” used in this study is small relative to typical models for evaluating dredged material placement, extending just 150 to 300 ft downstream of the edge of disposal or dredging. Common lengths of a “mixing zone” would be about half the width of the water body, which in this case would be about 900 ft. Common widths of a “mixing zone” would be up to one quarter of the width of the water body, which in this case would be up to about 450 ft. The simulation duration was one half hour (1800 seconds) based on the travel time of the plume to pass through the mixing zone (mixing zone length divided by the minimum velocity of the river near the bottom). Longer simulation durations were also run to examine the fall of TSS concentrations.

The results of the STFATE modeling for a 2000-cy discharge are given in Table 1 for the maximum plume centerline concentrations for 4MP, phenol and TSS at 150 ft, 300 ft, 1200 ft, 2400 ft and 3600 ft from the discharge site under low and high velocity conditions (0.2 ft/s and 0.4 ft/s). The results for a 3000-cy discharge are given in Table 2.

Table 1. STFATE maximum results for a 2000-cy discharge at placement site

Velocity	Distance (ft)	Dissolved Concentration (mg/L)		TSS (mg/L)
		4MP	Phenol	
0.2 ft/sec	150	0.03	0.002	5290
	300	0.02	0.001	1802
	1200	0.004	0.0002	25.4
	2400	0.0008	0.00004	4.8
	3600	0.0003	0.00002	1.6
0.4 ft/sec	150	0.04	0.002	-
	300	0.03	0.002	3370
	1200	0.01	0.0005	134
	2400	0.003	0.0002	33.8
	3600	0.002	0.00008	13.2
Criteria		1.35	0.07	7*

* Median background TSS concentration

Table 2. STFATE maximum results for a 3000-cy discharge at placement site

Velocity	Distance (ft)	Dissolved Concentration (mg/L)		TSS (mg/L)
		4MP	Phenol	
0.2 ft/sec	150	0.04	0.002	5190
	300	0.03	0.001	1543
	1200	0.005	0.0002	36.3
	2400	0.001	0.00006	7.0
	3600	0.0005	0.00002	2.4
0.4 ft/sec	150	0.05	0.002	-
	300	0.04	0.002	2460
	1200	0.013	0.0006	168
	2400	0.005	0.0002	43.5
	3600	0.002	0.0001	17.2
Criteria		1.35	0.07	7*

* Median background TSS concentration

The results of the STFATE runs for 2000-cy and 3000-cy discharges are comparable. Predicted concentrations are a little lower initially for the 3000-cy discharge than for the 2000-cy discharge due to greater entrainment/dilution and spreading laterally and vertically resulting from greater momentum initiating the collapse. Since the initial plume dimensions are greater for the 3000-cy discharge than for the 2000-cy discharge, dilution of the larger plume is slower and the predicted concentrations are a little higher in the long run for the 3000-cy discharge than for the 2000-cy discharge. The predicted concentrations as a function of distance from the discharge point for the 0.4 ft/sec velocity condition are higher than the predicted concentrations for the 0.2 ft/sec velocity condition because the plume had less time to be diluted. The dissolved contaminant concentrations at the placement site as predicted by the STFATE model are less than five percent of the NOAA criteria for worst-case conditions (including all discharge and velocity conditions) at the proposed mixing zone boundaries. The TSS concentrations are expected to return to background levels within a half mile of the placement site for most conditions.

The results of the modeling show that the water quality criteria for 4MP and phenol can be met without a mixing zone extending beyond the initial plume dimensions immediately following the plume collapse.

DREDGE Modeling

The DREDGE model was used to simulate sediment resuspension and contaminant release at the dredging site (Figure 2.). The DREDGE model was not used at the placement site to model "smoothing" of the habitat shelf because the surface material of the shelf will be clean material from the Clearwater River. The input for the DREDGE model assumes a production rate of 250-375 cy/hour for a clamshell bucket size of 15 cy. Sediment characteristics for DMMU 6 were used in the analysis because; this DMMU has the highest density of fine-grained material, the highest total concentrations for 4MP and phenol, and would produce the greatest release of contaminants. The dredge will lower the elevation of the shoal shown in Figure 2 from 7 ft to 15 ft. The water velocity at the dredging site is predicted to be about 0.8 ft/sec. The DREDGE modeling parameters are given in Table A2 in the Appendix. The results of the DREDGE model are provided in Table 3.

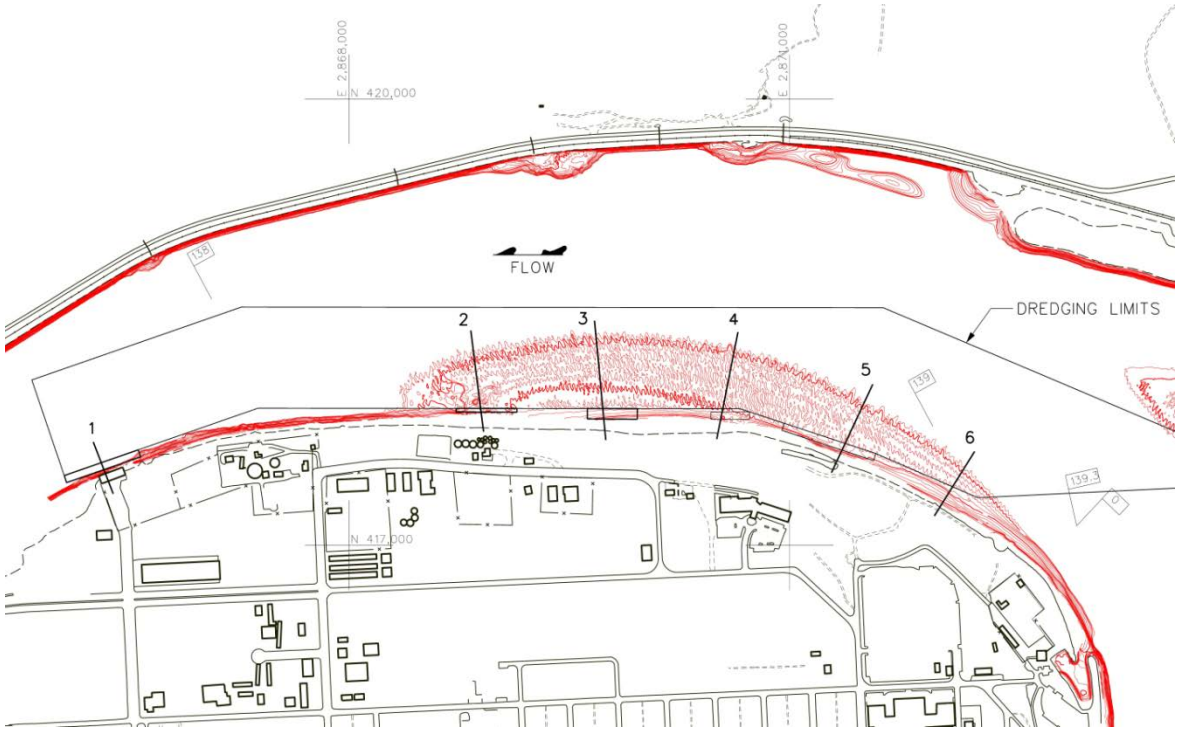


Figure 2. Illustration of proposed dredge footprint in the Snake River. Transect numbers correspond to water velocity transects.

Table 3. DREDGE model results

Velocity	Distance (ft)	Total Concentration (µg/L)		TSS (mg/L)
		4MP	Phenol	
0.8 ft/sec	150	0.97	0.034	62
	300	0.68	0.024	44
	1200	0.35	0.012	23
	2400	0.24	0.0082	15
	3600	0.18	0.0064	12
Criteria		1350	70	7*

* Median background TSS concentration

The total contaminant concentrations at the dredging site as predicted by the DREDGE model are less than 0.1 percent of the NOAA criteria for worst-case conditions at the proposed mixing zone boundaries. The TSS concentrations are expected to return to background levels within a half mile of the placement site for most conditions.

RECOVERY Modeling

The USACE RECOVERY screening model (Boyer et al. 1994, Ruiz et al. 2001) can be used to assess the impact of contaminated bottom sediments and surface waters (Figure 3.) The model assumes linear, reversible, equilibrium sorption. The model simulation period focused on sediment and surface water concentrations after 6 month durations, but longer simulations are also explored. RECOVERY was designed to model organic contaminant fate and transport, and has the major advantage of accounting for particulates. The model has several layers. The placed material in the Lower Snake River is all defined as variably contaminated material (Figure 3). The mixed layer will be part of the top layer of the placement area constructed of Clearwater River sediment. The silt foundation of the placement area was not entered into the model, because only the concentration in the mixed layer and surface water were of interest (not diffusion of contaminant into the foundation).

The Walla Walla District provided a variety of mean and median TSS measurements. Average values are more representative of the annual mass available for deposition than median values. One of the higher mean values of approximately 12 mg/L was chosen as best because measurements were biased low by debris, and flow weighted averages of TSS would be even higher. The fraction organic carbon (f_{oc}) in the suspended material was a mass weighted average of the sediment f_{oc} normalized to fines (f_{oc} of particulates = 0.1). The normalization to fines was done because there was a strong correlation between organic content and particle size. Higher levels of organic content were observed in fines, which tend to be the predominant suspended material.

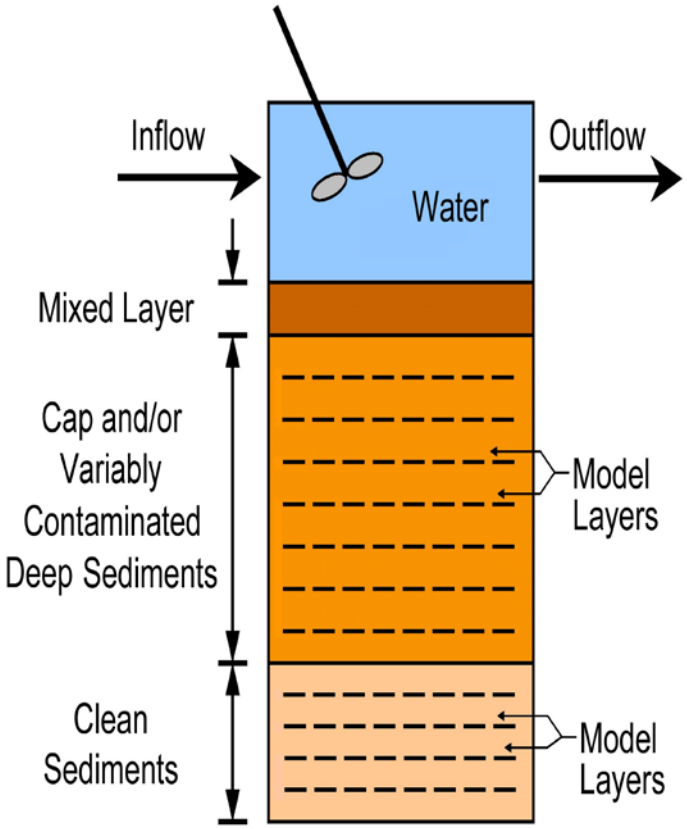


Figure 3. Recovery model diagram.

The Walla Walla District provided a variety of mean and median TSS measurements. Average values are more representative of the annual mass available for deposition than median values. One of the higher mean values of approximately 12 mg/L was chosen as best because measurements were biased low by debris, and flow weighted averages of TSS would be even higher. The fraction organic carbon (f_{oc}) in the suspended material was a mass weighted average of the sediment f_{oc} normalized to fines (f_{oc} of particulates = 0.1). The normalization to fines was done because there was a strong correlation between organic content and particle size. Higher levels of organic content were observed in fines, which tend to be the predominant suspended material.

The modeled placement area (109,264 m^2) was provided by the District and confirmed from maps of the placement area found in the Sampling and Analysis Plan (SAP) for the Lower Snake and Clearwater Rivers (2013/2014). To develop a conservative prediction of the maximum potential exposure to juvenile fish, the concentrations of 4MP and phenol were estimated just above the sediment surface to reflect the highest concentration along the gradient from the sediment surface to the water surface. To do this, the modeled water depth was artificially set to 0.02 meters to prevent dilution with the water column. The residence time for water above the placement area was

calculated with the aid of a HEC-RAS model run using a low velocity estimate of 0.2 ft/s. The residence time along the length of the placement area (2355 ft) was then calculated as 3.27 hrs.

The average depth of sediments having elevated 4MP and phenol was estimated to be 2.7 meters based on cross-sectional diagrams of the fill material (SAP 2013/2014). The contaminated sediment will be covered by 1.2 meters of clean Clearwater River sediment. The bulk contaminant concentrations found in the Clearwater River sediment had a weighted average of 26 µg/kg 4MP and 18 µg/kg phenol. The maximum calculated sediment pore water concentrations in the Clearwater River were 57 µg/L and 49 µg/L for 4MP and phenol, respectively (both DMMU 9).

The depth of the mixed layer was assumed to be 0.02 m (2-5 cm is common for freshwater sediments). The porosity of the mixed layer could range from that of the Clearwater River sediment to that of the settled material over time. Since the material is mostly fine silt that has settled as a foundation, a value of 0.7 is more appropriate. The specific gravity of the material was assumed to be 2.65. The fraction of organic carbon (f_{oc}) in the sediments was a mass weighted average of 0.005 for the Clearwater River (top layer) and 0.068 for the most contaminated Snake River (DMMU6, bottom layer) all obtained directly from the Lower Snake/Clearwater Sampling Report.

The average wind speed was estimated to be 3.3 meters/second based on data recorded at the Walla Walla Regional Airport (NOAA); however, this parameter does not significantly influence the model. The enhanced diffusion was set an order of magnitude greater than the diffusivity (Dr. Carlos E. Ruiz, personal communication), being 5E-6 cm^2/sec. The enhanced mixing depth was set to 3 cm, providing a conservative additional depth of enhanced contaminant flux to account for uncertainties such as movement of contaminated sediment pore water or deeper bioturbation. As indicated by the District, groundwater discharge is unlikely at the placement site. A burial velocity of 0.051 m/year was obtained directly from the SAP. Settling velocities were set to 3400 meters/year for a silty sediment.

The initial surface water concentration of both 4MP and phenol were both assumed to be zero. Both chemicals degrade rapidly under aerobic conditions that can be found in surface water. Concentrations of 4MP and phenol in the sediments were previously described for this model based on a mass weighted average of the measured dredged material (Lower Snake/Clearwater Sampling Report). The chemical properties of these chemicals, such as: Henry's Law, molecular weight, and octanol-water partitioning coefficient are all built into the RECOVERY model (see Table A3). Model simulations were run for 6 months, 5 years, and 50 years. Longer durations fall short of simulating seasonal variations and should be interpreted with caution.

The half-life of 4-methylphenol is 55 hrs in aerobic water and 170 hrs in aerobic sediment as reported in the Estimation Programs Interface (EPI) Suite (USEPA). These values correspond to decay coefficients of 8.3E-4 $years^{-1}$ and 2.7E-4 $years^{-1}$. It would seem likely that unfiltered water degradation is the same rate that occurs in filtered water, which is relevant when the mass transfer of chemical from solid to liquid phases is fastest (i.e. the surface layer and mixed sediments layer). No degradation should then be applied to deep sediments below the mixed layer because anaerobic conditions exist in the sediment pore water. Phenol degradation is similar to 4-methylphenol (EPI Suite, USEPA). Table A3 in the Appendix provides model parameters for RECOVERY.

RECOVERY model results showed no obvious differences between assuming degradation or no degradation. The model examined results of solid phase and dissolved concentrations in the mixed layer and water concentrations in the overlying water near the sediment surface. In all model runs (6 months, 5 years, 50 years) the concentrations steadily decrease over time. Exposure concentrations in the surficial pore water were initially less than one percent of the NOAA criteria and then decrease rapidly to less than 0.1 percent of the NOAA criteria. Contaminant concentrations in the interfacial water above the sediment surface are predicted to be about one percent of the dissolved pore water concentrations. Results of six-month model runs are shown below.

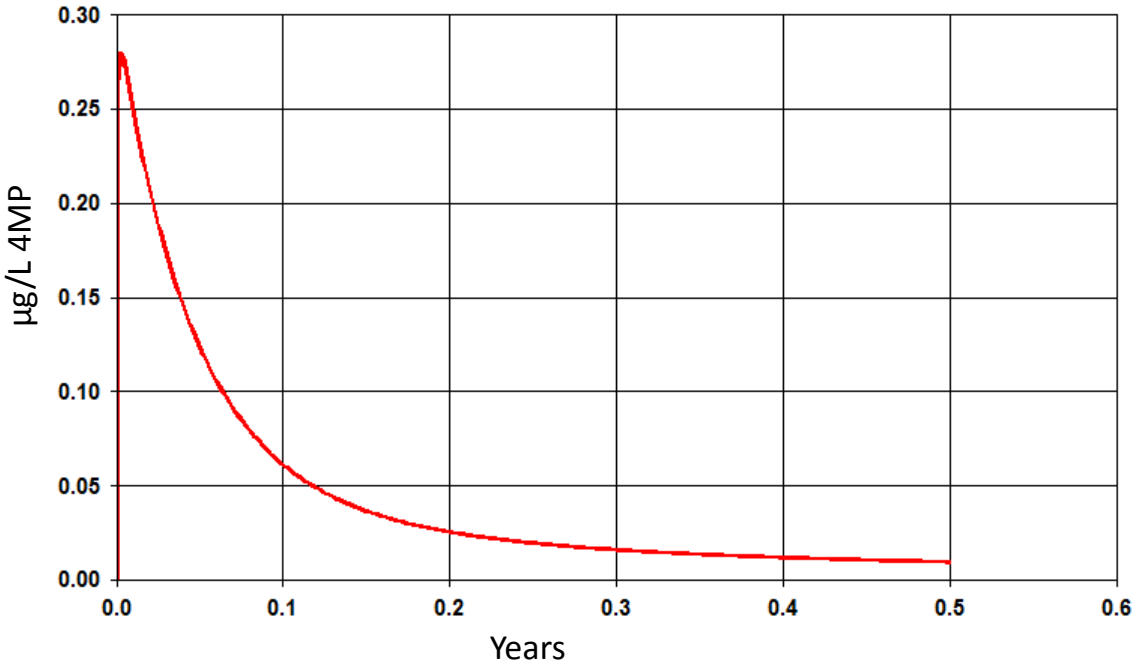


Figure 4. 4MP surface water concentrations just above the mixed sediment layer over time after placement (assuming degradation).

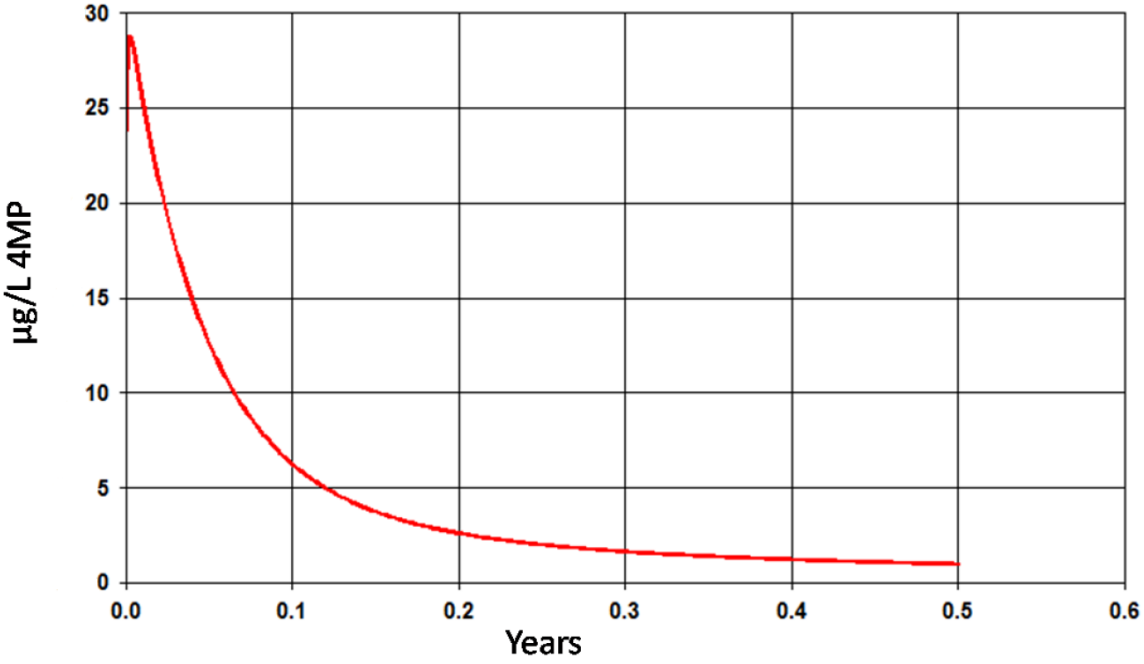


Figure 5. 4MP dissolved mixed layer concentrations over time after placement (assuming degradation).

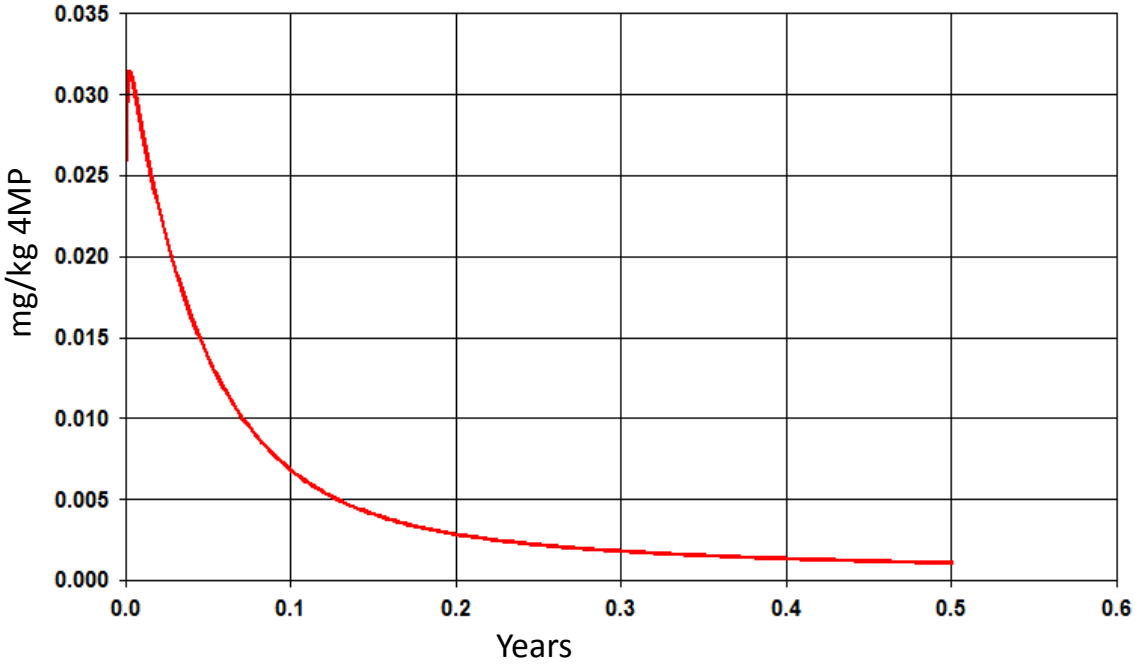


Figure 6. 4MP mixed layer sediment concentrations over time after placement (assuming degradation).

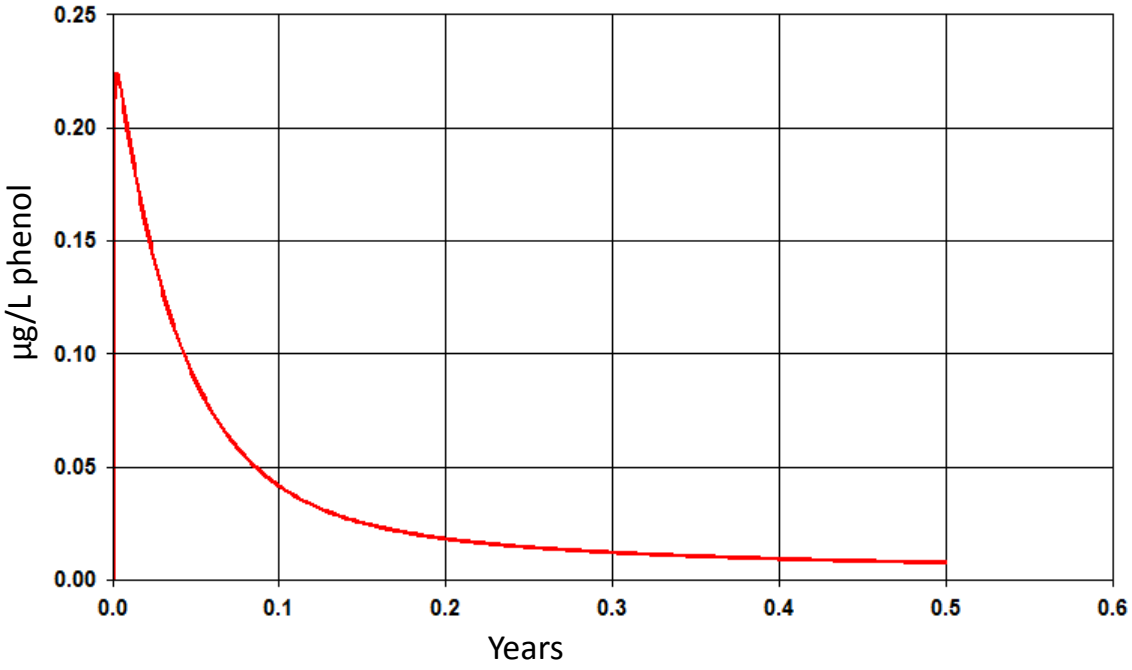


Figure 7. Phenol surface water concentrations just above the mixed sediment layer over time after placement (assuming degradation).

Conclusions

The results show that there should be no concerns about 4MP or phenol toxicity. Virtually all exposure concentrations at the boundaries of the mixing zone are less than five percent of the NOAA criteria at the placement site and less than 0.1 percent of the NOAA criteria at the dredging site. Similarly, nearly all sustained exposure concentrations at the placement site after construction is completed are less than 0.1 percent of the NOAA criteria.

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Appendix A: Model Inputs

Table A1. STFATE Model Inputs

STFATE Model Parameter (if not specified, leave on default or allow auto adjustment)	Value
Program Options	
Section 404(b)	selected
Disposal from a split hull barge	selected
Descent, Collapse, and Diffusion	selected
Tier II, Compare Water Quality	selected
Evaluation Type-Water Quality Analysis	
Water Quality Standard (µg/L)	1,350 (4MP); 70 (phenol)
Contaminant of Concern	4MP
Predicted Initial Concentration in Fluid (µg/L)	600
Background Concentration (mg/L)	0
Transport Diffusion Output	
Number of Transport-Diffusion Outputs	3
Depths (ft)	10, 18, 26
Output Options-Time Steps and Print Options	
Duration of Simulation (seconds)	1800 to18000
Long-Term Time Step for Diffusion (seconds)	60 to 750
Number of Print Times	3-7
Print Times (seconds)	600, 1200, 1800
Site Description	
Number of Grid Points in Z direction	40
Number of Grid Points in X direction	60
Spacing between grid points (Z direction)	20 to 50
Spacing between grid points (X direction)	30 to 75
Roughness Height (ft)	0.005
Slope of Bottom	0
Constant Water Depth (ft)	27
Number of Points to Describe Water Density	2
Point Depths (ft)	0, 27
Material Description	
Number of Layers	1
Volume (cy)	2000 to 3000
Material Properties Select:	
Fraction Sand (Fraction of Total Volume)	.157
Fraction Clay	.032
Fraction Silt	.037
Water temperature °C	10
Single Depth Averaged Velocity	selected
Velocity (ft/s)	0.2-0.4
Depth at Location (ft)	27ft
Disposal Operation Data	
Location of Disposal Point from Top of Grid (ft)	390 to 600
Location of Disposal Point from left edge (ft)	380 to 1000
Length of Disposal Vessel Bin (ft)	175
Width of Disposal (ft)	45
Pre-Disposal Draft (ft)	13
Post-Disposal Draft (ft)	5
Time Needed to Empty (sec.)	50

Table A2. DREDGE Model Inputs

DREDGE Model Parameter (if not specified, leave on default or allow auto adjustment)	Value
Dredge Characteristics	
Select Dredge	Mechanical Dredge/Open Clamshell
Bucket Size (m^3)	9
Cycle Time (sec)	115
Settling Velocity (m/s)	0.0001
In-Situ Dry Density (kg/m^3)	600
Near Field Model	
user estimate	selected
Estimated Source Strength (kg/s)	0.123 (probable); 0.31 (worst case)
% Loss	0.26; 0.66
Far Field Model	Kuo's Model
Lateral diffusion coefficient (cm^2/s)	390
Vertical diffusion coefficient (cm^2/s)	52
Settling Velocity (m/s)	0.0001
Downstream locations (m)	150; 15 (step)
Lateral Locations (m)	30; 3 (step)
Desired Water Depth (m)	1
Contaminant Modeling	
TSS	yes
4MP (mg/L)	4.9
Phenol (mg/L)	0.17
Site Characteristics	
Water Depth (m)	2.134
Ambient Water Velocity (m/s)	0.2439
Mean Particle Size (microns)	10
Fraction of Particles Smaller than 74 µm	0.307
Fraction of Particles Smaller than particles with critical settling velocity	0.142
Dredged Material Transport Method	NA

Table A3. Recovery Model Inputs

Recovery Model Parameter	Value
Water Column	
Suspended Solids Concentration (mg/L)	12
Weight Fraction Carbon in Solid	0.1
Water Surface Area (m^2)	109,264
Water Depth (m)	0.02*
Residence Time (years)	0.000373
Mixed Layer	
Contaminated Sediments Depth (m)	3.9 total (1.2 top; 2.7 lower)
Depth of Mixed Sediments Layer (m)	0.02
Surface Area (m^2)	109,264
Porosity	0.7
Particle Specific Gravity	2.65
Weight Fraction Carbon in Solid	0.004
Sediment Layer	
Porosity	0.5 top; 0.77 lower
Particle Specific Gravity	2.65
Weight Fraction Carbon in Solid	0.004 top; 0.0684 lower
System Properties	
Wind Speed (m/s)	3.3
Enhanced Diffusion (cm^2/s)	5E-5
Enhanced Mixing Depth (cm)	3
Resuspension Velocity (m/year)	-
Burial Velocity (m/year)	0.051
Settling Velocity (m/year)	3400
4MP, Phenol Properties	
Initial concentration in water (µg/L)	0
Inflow concentration (µg/L)	0
Initial conc. in mixed sediment (mg/kg)	0.026; 0.019
Initial conc. in deep sediment (mg/kg)	
Clearwater River Layer (mg/kg)	0.026; 0.019
Snake River Layer (mg/kg)	4.9; 0.17
Molecular Diffusivity (cm^2/sec)	5E-6
Henry's Constant (atm-m^3/gmole)	2.38E-7; 1.3E-6
Molecular Weight	108; 94.1
Octanol-Water Partitioning Coefficient (mg/m^3 Octanol/mg/m^3 Water)	85.1; 28.8
Water Decay Coefficient ($years^{-1}$)	8.3E-4
Particulate Decay Coefficient ($years^{-1}$)	2.7E-4
Model Parameters	
Total Period of Simulation (years)	0.5; 5; 50
Number of Time Steps Between Print Intervals for Output File	10; 100; 100
Number of Time Steps Between Print Intervals for Sediment Layers	50; 400; 400
Number of Layers to Print	50; 400; 400

Lower Snake River Programmatic Sediment Management Plan Environmental Impact Statement

Appendix I

Water Quality and Sediment Quality Reports

August 2014

Section 4. NMFS Memorandum Comments on Snake River Sediment Evaluation

March 2014

Comments on Snake River sediment evaluation
[from Lyndal Johnson, NOAA, NWFSC. March 26, 2014]

As described in the 2013 PSMP Sediment Sampling Summary, unexpectedly high concentrations of phenol and 4-methylphenol (*p*-cresol) were detected in sediments collected in August 2013 from the Snake and Clearwater Rivers in the vicinity of Lewiston, Idaho, and Clarkston, Washington. These sediments were collected and analyzed so the Dredged Material Management Office (DMMO) could determine if they were suitable for unconfined in-water disposal.

The concentrations of 4-methylphenol in six of the eight Snake River DMMUs (1,2,3,5,6, and the Port of Clarkston Grain Elevator) exceeded the SL1 guideline of 260 ppb, with values ranging from 340 ppb to 4,900 ppb. Phenol also exceeded SL1 guidelines in DMMU 6 where a concentration of 170 ppb was determined (the SL1 is 120 ppb). Because of the elevated concentrations of phenols in the samples, additional sediment samples were collected from the DMMUs where guidelines were exceeded, as well as from two reference areas upstream of the area, for toxicity testing in the 10-day *Hyalella azteca* survival test and the 20-day *Chironomus dilutus* survival and growth tests. The sediments tested as non-toxic in these assays, so were considered suitable for in-water disposal.

This testing provides adequate evidence that the sediments are non-toxic to the benthic community at the sites, and would not injure fish through indirect effects on their prey base. However, it does not address the direct toxicity of the phenols in these sediments to fish. It is important to remember that the freshwater sediment guidelines are based on toxicity to freshwater invertebrates, and so are designed for the protection of benthos only. This means they are not necessarily protective of fish.

Information on the toxicity of phenols in sediments to fish is limited, but a number of studies have been conducted on toxicity of phenols in water to fish. Table 1 lists a subset of these studies conducted with salmonid species. For adult and juvenile fish, lethal concentrations (LC_{50}s) are in the 5-10 mg/L range (Lazorchak and Smith 2007; Swift 1975; Miller and Ogilvie 1975). However, sublethal effects and effects on early life stages are reported at much lower concentrations. Monfared and Salati (2013) reported reductions in liver weight, and condition factor, and declines in total protein and albumen in plasma in rainbow trout exposed to phenol at concentrations as low as 0.6 mg/L. Reduced growth of larval and juvenile trout was observed at concentrations in the 0.2 - 0.3 mg/L range (DeGraeve et al. 1980; Hodson et al. 1984), with 23-27 day LC_{50}s for this life stage in the 0.1-0.2 mg/L range (Milleman et al. 1984; Black et al. 1984). Water hardness appears to have an influence on the toxicity of phenol to early life stages of trout and salmon. Birge et al. (1979) observed reduced hatching of rainbow trout eggs at a phenol concentration of 0.1 mg/L in soft water (50 mg/L $CaCO_3$) but at concentrations as low as 0.01 mg/L in hard water (200 mg/L $CaCO_3$). They also determined 27-day LC_{50}s of 0.3 mg/L for rainbow trout larvae at 50 mg/L $CaCO_3$ and 0.07 mg/L at 200 mg/L $CaCO_3$ (Birge et al. 1979). Changes in behavior of fingerling rainbow trout were reported at concentrations above 0.05 mg/L (Kaiser et al. 1995).

Less information is available on the toxicity of 4-methylphenol to salmonids (Table 2). Several studies report 2-4 day LC_{50} values in the 3 to 8 mg/L range (Korn et al. 1985; DeGraeve et al. 1980 Bergman and Anderson 1977; Shumway and Palensky 1973; Hodson et al. 1985), with a no-mortality concentration for rainbow trout of 2.8 mg/L in 3-4 day exposures (Bergman and Anderson 1977). However, only a few studies document the

sublethal effects of this compound on fish. McKim et al. (1985) and Dixon et al. (1987) reported physiological changes such as alterations in liver enzymes following 6-48 hour exposures in the 3-4 mg/L range. Shumway and Palensky (1973) report tainting of flesh in rainbow trout exposed to 4-methylphenol at concentrations as low as 0.12 mg/L. No growth data are available for salmonids, but in fathead minnow, Barron and Adelman (1984) report effects on growth at a concentration of 2.57 mg/L after 32 days, with biochemical effects such as changes in nucleic acid and protein content at concentrations as low as 0.4 mg/L for 4 days. These authors also cite an early life stage toxicity threshold fir this species of 1.35 mg/L. However, rainbow trout and other salmon species are typically more sensitive than fathead minnow to chemical contaminant exposure. Reported LC_{50}s for fathead minnow for 4-methyphenol range from 17 to 30 mg/L (Mattson et al. 1976; Geiger et al. 1986; Bergman and Anderson 1977; DeGraeve et al. 1989), several times higher than values for rainbow trout. Dwyer et al. (2005) estimated LC_{50} ratios ranging from 1.4 to 5.9 for fathead minnow relative to rainbow trout for a range of chemicals including carbaryl, copper, 4-nonylphenol, pentachlorophenol, and permethrin, and Besser et al. (2005) observed that rainbow trout were about twice as sensitive as fathead minnow in chronic exposures to pentachlorophenol. Thus we might expect effects on rainbow trout comparable to those seen in fathead minnow at somewhat lower concentrations of 4-methylphenol, possibly in the 0.5-1.5 mg/L range.

Based on the studies mentioned above and other data, some aquatic life water quality criteria have been established for phenol or for total non-chlorinated phenols. These values include the New York State water quality criterion of 5 ug/L (NYDEC 1999); the British Columbia water quality guideline of 50 ug/L for non-halogenated phenols (BCMLWAP 2002); and the recommended Canadian freshwater guideline for aquatic life of 4 ug/L (CCME 1991). Some of these guidelines are quite conservative; for example, the Canadian guideline is derived from multiplying the most sensitive endpoint observed (the 9-day LC_{50} for the frog, *Rana pipiens* of 40 µg/L (Birge et al. 1980) by a safety factor of 0.1 (CCME 1991). In the United States, there are no national aquatic life water quality criterion for phenol or 4-methylphenol at this time; in 1980, EPA suggest a value of 0.6 mg/L (EPA 1980) but this has since been withdrawn. There are few sediment quality criteria for non-chlorinated phenols; however New York State has adopted a criterion of 0.5 mg/kg OC for non-chlorinated phenols (NYDEC 1999).

We can estimate the sediment concentration associated with the water benchmarks in Tables 1 and 2, as well as existing aquatic life water quality criteria, using the sediment-water partition coefficients (Koc) for phenol and 4-methylphenol normalized to the total organic carbon content of the sediment, most important factor controlling the partitioning of these compounds from sediment to water.

The Koc values for these and other compounds have been modeled by several researchers as a function of the octanol-water partition coefficient (Kow) using the following equation (Di Toro et al. 1991):

$$Koc = 0.983*Kow + 0.00028$$

The Koc is then used to predict the sediment concentration (Sedoc) that would be produced from the benchmark water concentration using the formula:

Sed_{oc} = Water benchmark* K_{oc}

To convert to a bulk sediment concentration the Sedoc is multiplied by the fraction of organic carbon found in the sediment (e.g., 0.01 for a 1% TOC content). Resulting sediment benchmarks are for phenol and 4- methylphenol are shown in Tables 3 and 4.

As Tables 3a and 3b show, sediment phenol concentrations associated with water concentrations that could be lethal to salmon and trout (~9 mg/L in water, 255 mg/kg OC in sediment) are well above those found in the both Snake and Clearwater River sediment grab samples and bioassay samples. Similarly, concentrations associated with most sublethal effects such as changes in growth, liver weight, and delayed mortality (0.1-0.6 mg/L) are also associated with sediment concentrations (2.8-17 mg/kg OC) above those reported in the samples. However, there may some risk of increased mortality of eggs in areas where there is hard water, as well as behavioral changes. Sediment concentrations of phenol associated with water concentrations where these effects occur (0.28 to 1.98 mg/kg OC at water concentration of 0.01-0.05 mg/L) are in the range of those measured in several of the Snake and Clearwater River grab and bioassay samples.

As with phenol, the concentrations of 4-methylphenol (Tables 4a and 4b) measured in the grab and bioassay sediment samples sediments from at the Snake and Clearwater Rivers would not be acutely lethal to fish including listed salmon; the sediment benchmark associated with the lowest reported LC_{50} of 3.36 ug/L is 294 mg/kg OC, well, above concentrations measured in the samples. However, there may be some risk of sublethal effects, especially on early life stages. Water concentrations of 0.5-1 mg/L, which are associated with biochemical changes related to reduced growth and early life stage toxicity in fathead minnow (Barron and Adelman 1984), and may have other impacts as well on more sensitive salmon species, yield sediment benchmarks in the 44 to 88 mg/kg OC range, below levels measured in several of the grab samples. The 4-methylphenol concentration associated with fish flesh tainting (0.12 ug/L) is associated with a sediment benchmark of 10.5 mg/kg OC. Concentrations in nearly all of the grab samples and a few bioassay samples were above this level.

When existing water quality guidelines are used to generate sediment benchmarks for phenol (Table 5), concentrations range from 1.42 mg/kg OC for the British Columbia criterion to 0.11 to 0.12 mg/kg OC for the Canadian and New York State criteria. Even the reference samples from the Snake River, phenol concentrations are are above these levels. The same is true if the New York State sediment quality guideline for phenols of 0.5 mg/kg OC is applied to the Snake and Clearwater River sediment samples.

In summary, the concentrations of phenol and 4-methylphenol measured in some of the sediment samples from Snake and Clearwater Rivers from the proposed dredging sites are high enough to potentially cause injury in salmon and other fish, including reduced egg hatching success and survival and growth of early life stages, as well as tainting of fish flesh. However, the likelihood of injury would be influenced by a number of factors, including the volume of sediment released with concentrations above toxicity thresholds, the organic carbon content of those sediments, sediment dispersion patterns, and the hardness of the water into which the sediment was released.

Table 1. Studies documenting the toxicity of water-borne phenols to salmonids

Concentration (mg/L)	species	Endpoint	Source
11.7	Brown trout	24 hr LC50	Miller and Ogilvie 1975
11	Brown trout fingerlings	7 day LC 50	Lazorchak and Smith 2007
9	Rainbow trout	48 hr LC50	Swift 1975
6	Rainbow trout fingerlings	7 day LC 50	Lazorchak and Smith 2007
6	Brown trout fingerlings	7 d growth IC 25	Lazorchak and Smith 2007
4	Rainbow trout fingerlings	7 d growth IC 25	Lazorchak and Smith 2007
1.1	Laval rainbow trout	LC50	DeGraeve et al. 1980
0.6	Rainbow trout	Changes in liver weight, liver cell morphology, plasma protein and albumen	Monfared and Salati 2013
0.3	Larval rainbow trout	growth	Hodson et al. 1984
0.2	Larval rainbow trout	growth	DeGraeve et al. 1980
0.12	Larval Rainbow trout	27 d LC 50	Milleman et al. 1984
0.19	Larval Rainbow trout	23 d LC50	Black et al. 1983
0.1	Rainbow trout eggs	Reduced hatching success in soft water	Birge 1979
0.1	Rainbow trout eggs and larvae	27 d LC 50 in soft water	Birge 1979
0.07	Rainbow trout eggs and larvae	27 d LC 50 in hard water	Birge 1979
0.05	Rainbow trout fingerlings	Changes in activity, ventilation rate, other behaviors	Kaiser et al. 1995
0.01	Rainbow trout eggs	Reduced hatching success in hard water	Birge 1979

Table 2. Studies documenting the toxicity of 4-methylphenol (p-cresol) to salmonids and other fish

Concentration (mg/L)	Species	Endpoint	Source
11.3	Raimbow trout	4-day LC100	Bergman and Anderson 1977
8.6	Rainbow Trout	4-day LC50	Bergman and Anderson 1977
7.9	Rainbow Trout	4-day LC50	Degraeve et al. 1980
7.4	Rainbow trout	4-day LC50	Hodson et al. 1984
5	Rainbow trout	2-day LC50	Shumway and Palensky 1973
3.82	Rainbow trout	6 hrs Physiological changes	McKim et al. 1985
3.36	Pink salmon	4-day LC50	Korn et al. 1985
3.0	Rainbow trout	2- days Liver enzyme changes	Dixon et al. 1987
2.8	Rainbow Trout	4-day NOEC concentration for mortality	Bergman and Anderson 1977
2.8	Rainbow Trout	4-day NOEC concentration for mortality	Bergman and Anderson 1977
0.12	Rainbow trout	Tainting of fish	Shumway and Parkening 1973
2.57	Fathead minnow	Growth 32 days	Barron and Adelman 1984
0.4	Fathead minnow	Biochemical changes (nucleic acid & protein) 4 days	Barron and Adelman 1984

Table 3a. Sediment phenol benchmarks derived from selected water benchmarks for salmonid species (see Table 1) as compared to phenol concentrations in Snake and Clearwater River sediments from grab samples.

Water benchmark (mg/L)	Endpoint	Sediment Benchmark (mg/kg OC)	Sample	% TOC	Sediment Concentration (ug/kg dry wt)	Sediment Concentration (mg/kg OC)
9	LC50	255	DMMU1	0.0153	28	1.83
			DMMU2	0.0147	23	1.56
			DMMU3	0.084	12	0.14
			DMMU5	0.0103	46	4.47
			DMMU6	0.0684	170	2.49
			POC-GE	0.0414	67	1.62
0.2	Growth	5.67	DMMU1	0.0153	28	1.83
			DMMU2	0.0147	23	1.56
			DMMU3	0.084	12	0.14
			DMMU5	0.0103	46	4.47
			DMMU6	0.0684	170	2.49
			POC-GE	0.0414	67	1.62
0.07	Embryo LC50	1.98	DMMU1	0.0153	28	1.83
	(hard water)		DMMU2	0.0147	23	1.56
			DMMU3	0.084	12	0.14
			DMMU5	0.0103	46	**4.47**
			DMMU6	0.0684	170	**2.49**
			POC-GE	0.0414	67	1.62
0.05	Behavior	1.41	DMMU1	0.0153	28	**1.83**
			DMMU2	0.0147	23	**1.56**
			DMMU3	0.084	12	0.14
			DMMU5	0.0103	46	**4.47**
			DMMU6	0.0684	**170**	**2.49**
			POC-GE	0.0414	67	**1.62**
0.01	Reduced hatching success in hard water	0.28	DMMU1	0.0153	28	**1.83**
			DMMU2	0.0147	23	**1.56**

			DMMU3	0.084	12	0.14
			DMMU5	0.0103	46	**4.47**
			DMMU6	0.0684	**170**	**2.49**
			POC-GE	0.0414	67	**1.62**

Table 3b. Sediment phenol benchmarks derived from selected water benchmarks for salmonid species (Table 1) as compared to phenol concentrations in Snake and Clearwater River sediment samples from sediment bioassays

Water benchmark (mg/L)	Endpoint	Sediment Benchmark (mg/kg OC)	Sample	% TOC	Sediment Concentration (ug/kg dry wt)	Sediment Concentration (mg/kg OC)
9	LC50	255	DMMU1	0.02	28	1.40
			DMMU2	0.042	23	0.55
			DMMU3	0.055	12	0.22
			DMMU5	0.056	46	0.82
			DMMU6	0.087	170	1.95
			POC-GE	.038	25	0.66
			SR128.5-B	.022	19	0.87
			SR144-B	.022	20	0.89
0.2	Growth	5.67	DMMU1	0.02	28	1.40
			DMMU2	0.042	23	0.55
			DMMU3	0.055	12	0.22
			DMMU5	0.056	46	0.82
			DMMU6	0.087	170	1.95
			POC-GE	.038	25	0.66
			SR128.5-B	.022	19	0.87
			SR144-B	.022	20	0.89
0.07	Embryo LC50	1.98	DMMU1	0.02	28	1.40
			DMMU2	0.042	23	0.55
			DMMU3	0.055	12	0.22
			DMMU5	0.056	46	0.82
			DMMU6	0.087	170	1.95
			POC-GE	.038	25	0.66
			SR128.5-B	.022	19	0.87
			SR144-B	.022	20	0.89
0.05	Behavior	1.41	DMMU1	0.02	28	1.40
			DMMU2	0.042	23	0.55
			DMMU3	0.055	12	0.22
			DMMU5	0.056	46	0.82

			DMMU6	0.087	170	**1.95**
			POC-GE	.038	25	0.66
			SR128.5-B	.022	19	0.87
			SR144-B	.022	20	0.89

Table 4a. Sediment 4-methylphenol benchmarks derived from selected water benchmarks for fish (see Table 2) as compared to 4-methylphenol concentrations in Snake and Clearwater River sediment grab samples.

Water benchmark (mg/L)	Endpoint	Sediment Benchmark (mg/kg OC)	Sample	% TOC	Sediment Concentration (ug/kg dry wt)	Sediment Concentration (mg/kg OC)
3.36	LC50	255	DMMU1	0.0153	1700	111
	Pink salmon		DMMU2	0.0147	650	44
			DMMU3	0.084	340	4.1
			DMMU5	0.0103	1300	126
			DMMU6	0.0684	4900	72
			POC-GE	0.0414	1400	34
2.8	LC0	245	DMMU1	0.0153	1700	111
	Rainbow trout		DMMU2	0.0147	650	44
			DMMU3	0.084	340	4.1
			DMMU5	0.0103	1300	126
			DMMU6	0.0684	4900	72
			POC-GE	0.0414	1400	34
1.35	Early life stage mortality	118	DMMU1	0.0153	1700	111
	Fathead minnow		DMMU2	0.0147	650	44
			DMMU3	0.084	340	4.1
			DMMU5	0.0103	1300	**126**
			DMMU6	0.0684	4900	72
			POC-GE	0.0414	1400	34
0.4	Biochemical changes	35	DMMU1	0.0153	1700	**111**
	Fathead minnow		DMMU2	0.0147	650	**44**
			DMMU3	0.084	340	4.1
			DMMU5	0.0103	1300	**126**
			DMMU6	0.0684	4900	**72**
			POC-GE	0.0414	1400	34
0.12	Fish tainting		DMMU1	0.0153	1700	**111**

	Rainbow trout	10.5	DMMU2	0.0147	650	**44**
			DMMU3	0.084	340	4.1
			DMMU5	0.0103	1300	**126**
			DMMU6	0.0684	4900	**72**
			POC-GE	0.0414	1400	**34**

Table 4b. 4-methylphenol benchmarks derived from selected water benchmarks for salmonid species (Table 2) as compared to 4-methylphenol concentrations in Snake and Clearwater River sediment samples from sediment bioassays

Water benchmark (mg/L)	Endpoint	Sediment Benchmark (mg/kg OC)	Sample	% TOC	Sediment Concentration (ug/kg dry wt)	Sediment Concentration (mg/kg OC)
3.36	LC50	255	DMMU1	0.02	340	17.00
	Pink salmon		DMMU2	0.042	160	3.81
			DMMU3	0.055	340	6.18
			DMMU5	0.056	660	11.79
			DMMU6	0.087	1200	13.79
			POC-GE	.038	81	2.13
			SR128.5-B	.022	120	5.50
			SR144-B	.022	19	0.85
2.8	LC0	245	DMMU1	0.02	340	17.00
	Rainbow trout		DMMU2	0.042	160	3.81
			DMMU3	0.055	340	6.18
			DMMU5	0.056	660	11.79
			DMMU6	0.087	1200	13.79
			POC-GE	.038	81	2.13
			SR128.5-B	.022	120	5.50
			SR144-B	.022	19	0.85
1.35	Early life stage mortality	118	DMMU1	0.02	340	17.00
	Fathead minnow		DMMU2	0.042	160	3.81
			DMMU3	0.055	340	6.18
			DMMU5	0.056	660	11.79
			DMMU6	0.087	1200	13.79
			POC-GE	.038	81	2.13
			SR128.5-B	.022	120	5.50
			SR144-B	.022	19	0.85
0.4	Biochemical changes	35	DMMU1	0.02	340	17.00

	Fathead minnow		DMMU2	0.042	160	3.81
			DMMU3	0.055	340	6.18
			DMMU5	0.056	660	11.79
			DMMU6	0.087	1200	13.79
			POC-GE	.038	81	2.13
			SR128.5-B	.022	120	5.50
			SR144-B	.022	19	0.85
0.12	Fish tainting	10.5	DMMU1	0.02	340	**17.00**
	Rainbow trout		DMMU2	0.042	160	3.81
			DMMU3	0.055	340	6.18
			DMMU5	0.056	660	**11.79**
			DMMU6	0.087	1200	**13.79**
			POC-GE	.038	81	2.13
			SR128.5-B	.022	120	5.50
			SR144-B	.022	19	0.85

Table 5. Sediment benchmarks for phenols derived from water and sediment quality criteria as compared to phenol concentrations in Snake and Clearwater River sediment samples.

Water quality criterion (mg/L)	Source	Sediment Benchmark (mg/kg OC)	Sample Location	Grab sample phenol concentration (mg/kg OC)	Bioassay sample phenol concentration (mg/kg OC)
0.004	Canadian Aquatic life Criterion	0.11	DMMU1	**1.83**	**1.40**
			DMMU2	**1.56**	**0.55**
			DMMU3	**0.14**	**0.22**
			DMMU5	**4.47**	**0.82**
			DMMU6	**2.49**	**1.95**
			POC-GE	**1.62**	**0.66**
			SR128.5-B	NS	**0.87**
			SR144-B	NS	**0.89**
0.005	NY WQG	0.14	DMMU1	**1.83**	**1.40**
			DMMU2	**1.56**	**0.55**
			DMMU3	0.14	**0.22**
			DMMU5	**4.47**	**0.82**
			DMMU6	**2.49**	**1.95**
			POC-GE	**1.62**	**0.66**
			SR128.5-B	NS	**0.87**
			SR144-B	NS	**0.89**
0.050	British Columbia aquatic life criterion	1.42	DMMU1	**1.83**	1.40
			DMMU2	**1.56**	0.55
			DMMU3	0.14	0.22
			DMMU5	**4.47**	0.82
			DMMU6	**2.49**	**1.95**
			POC-GE	**1.62**	0.66
			SR128.5-B	NS	0.87
			SR144-B	NS	1.40
NA	NY SQG	0.50	DMMU1	**1.83**	**0.55**
			DMMU2	**1.56**	0.22

			DMMU3	0.14	**0.82**
			POC-GE	**4.47**	**1.95**
			SR128.5-B	NS	**0.66**
			SR144-B	NS	**0.87**

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Lower Snake River Programmatic Sediment Management Plan Environmental Impact Statement

Appendix I

Water Quality and Sediment Quality Reports

August 2014

Section 5. Port of Clarkston Crane Dock

Lower Snake River Programmatic Sediment Management Plan Environmental Impact Statement

Appendix I

Water Quality and Sediment Quality Reports

August 2014

Section 5A. Sampling and Analysis Plan
Sediment Quality Study
Port of Clarkston Crane Dock
Clarkston, Washington

Prepared for the Port of Clarkston

By Gravity Consulting

November 2012

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SAMPLING AND ANALYSIS PLAN

SEDIMENT QUALITY STUDY
PORT OF CLARKSTON CRANE DOCK

CLARKSTON, WASHINGTON

Prepared for

Port of Clarkston

Prepared by

Gravity Consulting, L.L.C.
32617 SE 44th ST
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November 21, 2012

Sampling and Quality Assurance Project Plan

Sediment Quality Study
Port of Clarkston Crane Dock
Clarkston, WA

November 21, 2012

Approvals

Shawn Hinz, Gravity Project Manager — Date: 11-23-12

Wanda Keefer, Port of Clarkston — Date: 11/22/12

Steve Saugen, Gravity Field Coordinator — Date: 11-23-12

Greg Salata, ALS Laboratories — Date: 11/21/12

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1 INTRODUCTION

The Port of Clarkston proposes to dredge sediments within the vicinity of the Crane Dock. Sedimentation at the Crane Dock has rendered this facility unusable for commercial purposes due to unsafe navigable conditions for vessels and barges.

The crane dock is located at Snake River mile marker 138 (see figure 1). The Crane Dock consists of an overwater pier for vessel unloading. Because of its location, the Crane Dock receives a significant sedimentation load from the Snake River. Over the years the area has conducted maintenance dredging to remove sedimentation, although it has been more than 10 years since the last such event.

1.1 Project Description

The proposed area to be dredged is shown in Figure 1 and ranges from about river 137.9 to 138 on the lower Snake River. The dredge is planned for December 2013. Dredge material is planned to be disposed of at the Knoxway Canyon disposal site, at Snake River mile 116. This disposal site accepts material determined to be open and unconfined.

Table 1. Proposed dredging area, estimated quantity to be dredged

DESIGNATION	AREA	QUANTITY TO BE DREDGED (YD^3)	REACH (APPROX. RIVER MILE)
Dredge Site	Clarkston Crane Dock	2,050	LGR 137.9

1.2 Site History

The Port of Clarkston's 250 foot crane dock, located on the northern most end of 14th Street is complemented by a series of three dolphins for additional barge anchoring; together they extend over 400 feet. The dock was last extended in 1996, and at that time received reinforcements and overlay in the immediate dock area and also to the east. The primary parcel of land, on which the original portion of the dock was constructed, was purchased from the U.S. Army Corps of Engineers on September 15, 1975, and consisted of 1.33 acres.

An additional 3.9 acres was purchased from the Corps June 5, 1978, for a storage yard to complement freight movement on the river. The Clarkston Crane Dock has not been in operation since 2007 due to a build-up of sediment that inhibits safe navigation. Significant economic loss over the past 5 years was the result.

1.3 Previous Data

Sediment

Based on analysis by the U.S. Army Corps of Engineers, samples evaluated during 2003 showed very little contamination of semi-volatile organics about 1-4 miles upstream of this study area (Heaton and Juul 2004). That survey using EPA test methods included semi-volatile compounds (8270C), dioxins and furans (8290), herbicides (8141), organophosphate pesticides (8151A), oil and grease (9071), and glyphosate (547). Some dioxin and furan congeners were detected but at 100 times below the Puget Sound Disposal bioaccumulation trigger (Crecelius and Gurtisen 1985; Crecelius and Cotter 1986; Pinza et al. 1992). PAH compounds were also identified but none of them were found to exceed the SEF 2009 freshwater screening limits.

Twenty-one elemental metals were also examined using EPA method 6020 in 2003 (Heaton and Juul 2004). For the metals that had screening and bioaccumulation limits, all results were below the recommended screening values (SEF 2009). Laboratory detection limits for mercury were very close to the bioaccumulation trigger but none of the samples evaluated for the previously planned 2002/2003 dredging program had detectable concentrations. The arsenic results from the 2000 study were not usable, but Tier I data indicated that the average concentrations were ten times below the screening limit (USACE 2002a; 2002b.).

Elutriate Analysis

Elutriate tests were also completed in 1997 at simulated ambient pH conditions and did not yield cautionary results (Anatek 1997; HDR 1998). No organochlorine pesticides were identified in any of the elutriate samples. Some linuron was detected in 2003 in the sieve net samples but it was near detection limits (Heaton and Juul 2004). Glyphosate was detected in

only two of the 94 samples at concentrations of 0.69 µg/L and 0.58 µg/L in samples collected from Lake Bryan and Lake Sacajawea, respectively (HDR 1998). Barium and manganese were the predominant metals detected (HDR 1998). The average concentration of barium increased from 83.3 ppb for the Lower Granite Lake samples to 243.6 ppb for the Lake Sacajawea samples (HDR 1998). Of the eighteen metals evaluated, only beryllium, silver, and thallium were not detected in the elutriate samples (HDR 1998). Average elutriate ammonia concentrations ranged from 2.5 mg/L in Lake Herbert G. West to 3.6 mg/L in Lake Sacajawea and Lower Granite Pool (HDR 1998). All elutriate samples were below drinking water standards.

1.4 Sediment Characterization Overview

The overall dredge footprint is designed to allow the crane dock to be accessible during minimum operating pool (MOP) elevation. MOP for the Lower Granite pool is 732 feet in NAVD 88 coordinate reference frame. The dredge prism is designed to allow 15 feet of clearance during MOP plus an extra foot of depth for allowable over dredge. Therefore the final design depth is 16 feet below MOP, which is 716 ft. The total volume of material estimated for removal is approximately 2,050 cubic yards. The sediments will be tested and evaluated in accordance with the Dredged Material Management Program (DMMP) guidelines and the Interim Final Regional Sediment Evaluation and Testing guidance (RSET 2006).

A separate z-layer sample will also be collected for archive and possible characterization for each core. The z-layer is defined as the material comprises the new sediment surface (2 ft bgs) after dredging is completed. This sample will be collected from the appropriate elevation of the core and archived. If dredge prism results are above screening levels the z-layer sample will be analyzed for chemistry.

2 PROJECT TEAM AND RESPONSIBILITIES

This section discusses the proposed project team and their responsibilities for conducting the basin and channel sediment characterization and supporting the suitability determination.

ROLE	NAME	PHONE	E-MAIL
Project Manager	Wanda Keefer	509-758-5272	wanda@portofclarkston.com
Principle Investigator	Shawn Hinz	425-281-1471	shawn@gravityenv.com
Field Coordinator	Steve Saugen	206-999-2427	steve@gravityenv.com
QA/QC Officer	Sue Snyder	206-999-2427	sue@gravityenv.com
Project Chemist (ALS)	Jeff Christian	360-636-1068	jchristian@caslab.com
Project Chemist (PAL)	Steve Thun	503-626-7943	sthun@pacaglab.com

2.1 Project Planning and Coordination

Shawn Hinz (Gravity) is the overall project manager responsible for developing and completing this SAP. Following approval of the SAP by DMMP agencies, Mr. Hinz will be responsible for administrative coordination to ensure timely and successful completion of the sediment characterization. He will provide a copy of the approved SAP, as well as the DMMP agencies' approval letter, to all sampling and testing subcontractors. Any significant deviation from the approved SAP will be coordinated with the Corps' Dredged Material Management Office (DMMO).

2.2 Field Sample Collection

Gravity Field Coordinator (FC) Steve Saugen will provide overall direction for personnel assignments, logistics, and field operations. The FC will supervise field collection of the sediment core samples and will be responsible for ensuring accurate positioning and recording of sample locations, depths, and identification; ensuring conformity to sampling and handling requirements, including field decontamination procedures; conducting physical evaluation and logging the samples; and chain-of-custody of the core samples.

The FC, or a designee, will be responsible for documenting sample preparation, observations, and chain-of-custody up until the time the samples are released to a commercial shipper or delivered to the analytical laboratory for chemical analysis or the bioassay laboratory for toxicity testing. Gravity will ensure that archived sediments are stored under proper conditions until delivery.

2.3 Laboratory Preparation and Analyses

Jeff Christian of ALS Laboratories (ALS), in Kelso, WA will be responsible for physical and chemical analyses. Pesticide analysis will be the responsibility of Steve Thun with PAL. They will handle and analyze the submitted samples in accordance with DMMP analytical testing protocols, quality assurance/quality control (QA/QC) requirements, and requirements as specified in this or any subsequent revised SAP. They will prepare a written report of analytical results and QA/QC procedures, which will be included as an appendix in the final data report.

2.4 QA/QC Management

Ms. Susan Snyder of Gravity, or her designee, will serve as QA Representative for this project. She will perform QA oversight for both the field sampling and laboratory programs. She will be kept fully informed of field program procedures and progress during sample collection and laboratory activities during sample preparation. She will record and correct any activities that vary from this SAP. Upon completion of the sampling and analytical program, she will review laboratory QA/QC results and incorporate findings into the final sampling and analysis report. Any QA/QC problems will be brought to the attention of the DMMO as soon as possible to discuss issues related to the problem and to evaluate potential solutions.

2.5 Final Sampling and Analysis Results Report

Mr. Hinz, or his designee, will be responsible for preparation of the final sampling and analysis results report to support the suitability determination. This report will summarize the sampling effort, analytical methods, QA/QC narrative, and analytical and biological testing results.

3 CONCEPTUAL DREDGING PLAN

The sampling and analysis program was developed with consideration of site-specific project and environmental factors. A key requirement of the program is ensuring that the individual dredged material management units (DMMUs) do not have contaminants of concern (COCs) associated with them. Assessment of COC's within the DMMUs will be determined by chemical analysis of all sediments sampled within the dredge prism, regardless of TOC levels and grain size.

Several guidance documents were considered during the development of this plan. These reports included those by Washington Department of Ecology EAP -040 (Blakely 2008); Guidance on the Development of Sediment Sampling and Analysis Plans Meeting the Requirements of the Sediment Management Standards (Chapter 173-204 WAC) and the Sediment Evaluation Framework (USACE 2009). Because of cost and mobilization enough sample material will be taken to perform grain size analysis, the conventional, chemistry and elutriate analysis so that a second round of sampling will not be needed. Water samples will also be taken to provide background analysis and elutriation if the sample material warrants the additional level of testing based on screening analysis (Table 5).

The primary objective of this investigation is baseline level 2A investigation to confirm a determination that a discharge will not contain contaminating sediments. The data collected will be used in determining whether the 2006 Interim Freshwater values are exceeded or that the sediment to be discharged will have no significant environmental impact as a result of potential discharge.

3.1 Characterization Frequencies and Dredging Plan Specifics

The sediment quality ranking determines the number of DMMUs and the number of samples required to represent each DMMU. Currently, there is no ranking specific to the Port of Clarkston Crane Dock Area. This proposed dredge site has never been evaluated under the Sediment Evaluation Framework procedures and this would be the first round of sampling. In reference to the 2009 SEF (USACE 2009) this DMMU would be initially ranked as low-moderate risk. The thickness of the proposed dredge prism, including over depth, is 2 to 10 feet over most of the dredge area. Because the volume of the proposed dredge is

only 2,050 cubic yards and because the area is considered low-moderate risk Gravity proposes the dredge area be considered 1 DMMU for evaluation and sampling.

4 SAMPLE COLLECTION, PROCESSING, AND HANDLING PROCEDURES

This section addresses the sample collection, processing, and handling procedures that will be used to ensure data quality.

4.1 Sampling Platform and Schedule

Sampling will occur after approval of this SAP by the DMMO, and is anticipated to begin within two weeks of approval of this SAP by the DMMP agencies. Collection of sediment cores will be conducted from the *R/V Tahoma* operated by Gravity Environmental LLC. It is anticipated that field sampling and sample processing will require approximately 2 days.

4.2 Station Positioning

Horizontal positioning will be determined by the onboard differential global positioning system (DGPS) based on target coordinates. Measured station positions will be converted to latitude and longitude (North American Datum [NAD] 83) to the nearest 0.1 second. The accuracy of measured and recorded horizontal coordinates will be within 2 meters.

Vertical elevation of each station will be measured using a fathometer and lead line. A survey reference marker in NAVD 88 at the Hells Canyon Marina will be used to calibrate the onboard GPS for measurement of pool elevation. The elevation of the sample location will be subtracted from the design depth elevation to arrive at an approximate sample depth (table 2). An additional 2 feet below the design depth of the dredge will be included to capture the appropriate amount of sediment for z-layer sample.

4.3 Station and Sample Identification

Table 2 lists all the core and composite sample IDs for the sediment characterization in the DMMU. A total of 3 cores will be collected within the DMMU. Cores will be composited into one individual sample to represent the full dredge prism. A duplicate sample will also

be collected from the homogenized core. Archive samples from each core will also be saved for further analysis as needed including an archive of the z-layer for each core.

Each sediment sample will be assigned a unique alphanumeric identifier using the format described below:

- The sample name starts with "CCD" denoting the project location (Clarkston Crane Dock).
- Individual core samples are identified by 1-3 (e.g., CCD-1).
- For filter wipe and filter blank samples, FW or FB, as appropriate, will be appended to the sample identification number.

Table 2
Proposed Sampling Coordinates, and Mudline Elevations

Sample Site Name	Pool Location	Location Name	Longitude WGS-84	Latitude WGS-84	Mud Line Elevation (NAVD 88)	Sample Depth ft	River Mile
CCD-1	L. Granite	POC Crane Dock-1	46° 25.597	117° 3.800	724	8-10	LGR 137.9
CCD-2	L. Granite	POC Crane Dock-2	46° 25.597	117° 3.852	715	2-4	LGR 137.9
CCD-3	L. Granite	POC Crane Dock-3	46° 25.578	117° 3.906	717	2-4	LGR 137.9

Note: mudline elevations and sample depths are estimates and will be re-calculated in the field prior to sampling and actual will be documented in the field log.

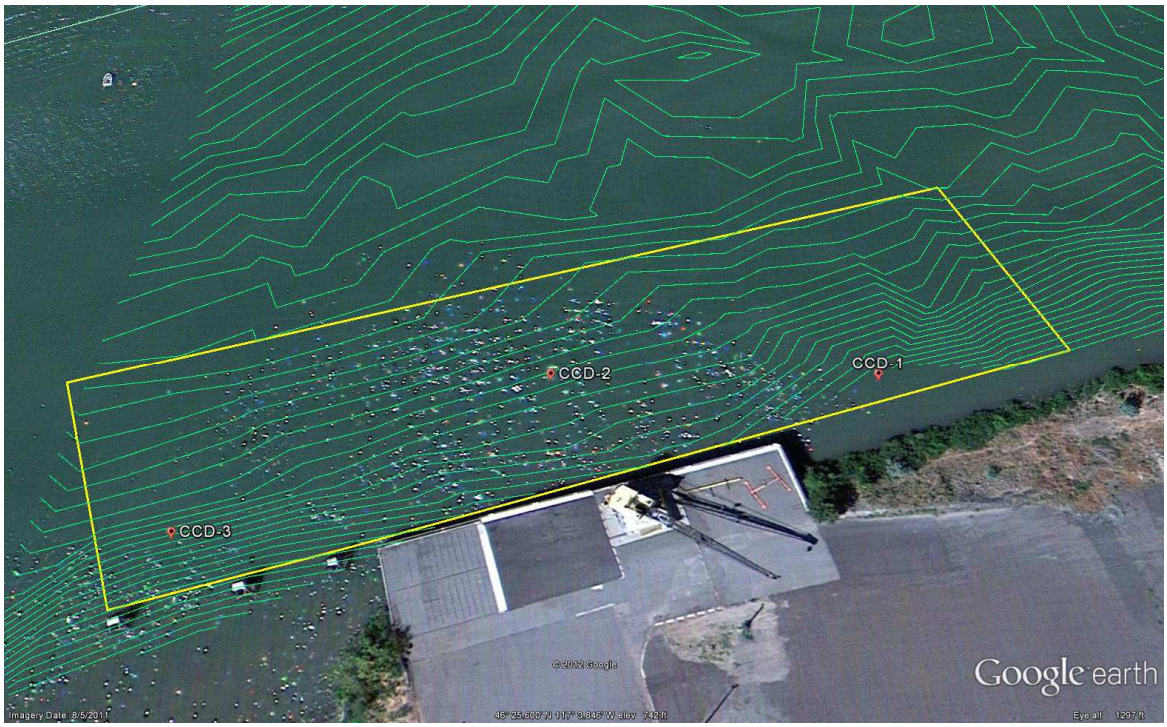


Figure 1 -Proposed sampling location for Port of Clarkston Crane Dock. Yellow box depicts proposed dredge prism. Green lines show bathymetry contours drawn from 2006 survey data in 1 ft intervals.

4.4 Station Locations

Figure 1 shows the location of the proposed core sampling locations within the DMMU. Table 1 presents the coordinates and water surface elevations for proposed sampling locations.

A Bathymetric survey conducted in 2006 was used to determine the DMMU size and layout and to assist in choosing core sampling locations. Station locations were chosen with the objective of representing, as accurately as possible, the physical and chemical characteristics of the sediments to be dredged. Stations were distributed to provide representative spatial coverage and were placed in locations where the proposed dredge prism would represent the bulk of material to be dredged.

4.5 Core Collection

Approximately 4 liters will be required for chemical analysis with an additional 0.5 liter sample container collected and archived from the DMMU for TCLP analysis and 6 liters collected for future Bioassay testing. Bioassay testing will require an addendum to this SAP

if the sediments fail DMMO screening (Table 5). Water will also be collected upstream of the site for potential elutriate testing.

Sediment cores will be collected at each location identified in Table 1 using a vibracorer. Core samples will be driven through the target dredge prism and 2 feet below the new dredge surface to collect the z-layer sample.

The vibracorer will use polycarbonate liners inside a rigid external tube approximately 4 inches in diameter. The vibracorer will be lowered to the bottom, where the unit will then be energized and allowed to penetrate. The core will be driven to its maximum length of 12 feet or to refusal. Acceptance criteria for a sediment core sample are as follows:

- The core penetrated to, and retained material to, project depth or refusal
- Recovery was at least 75 percent of the length of core penetration
- Cored material did not extend out the top of the core tube or contact any part of the sampling apparatus at the top of the core tube
- There are no obstructions in the cored material that might have blocked the subsequent entry of sediment into the core tube and resulted in incomplete core collection

Once the sampler is brought back onboard the survey vessel, the contents of the sampler will be visually examined. If the sample contains primarily cobble and gravel material then it will not be forwarded to the laboratory. However, a digital photo of the sample, along with a ruler and identification number will be taken for documentation. If the core material is predominantly smaller than gravel then it will be considered acceptable if (a) the sampler is not over-filled with sediment, (b) overlying water is present and not excessively turbid, and (c) the desired penetration has been achieved.

If core rejections require the core station to be relocated, three additional attempts will be made within a radius of 25 feet of the target. If relocation takes place, the FC will ensure that the revised location remains within the respective DMMU. If relocation attempts are not successful, the proposed station relocation will be coordinated with the DMMP through the DMMO.

The core tube caps will be removed immediately prior to placement into the coring device. Care will be taken during sampling to avoid contact of the sample tube with potentially contaminated surfaces. Extra sample tubes will be available during sampling operations for uninterrupted sampling in the event of a potential core tube breakage or contamination. Core tubes suspected to have been accidentally contaminated will not be used. Logs and field notes of all core samples will be maintained as samples are collected and correlated to the sampling location map. The following information will be included in this log:

- Elevation of each station sampled as measured in NAVD 88
- Location of each station as determined by DGPS
- Date and time of collection of each sediment core sample
- Names of field supervisor and person(s) collecting and handling the sample
- Observations made during sample collection including: weather conditions, complications, ship traffic, and other details associated with the sampling effort
- The sample station identification
- Length and depth intervals of each core and estimated recovery for each sediment sample
- Qualitative notation of apparent resistance of sediment column to coring
- Any deviation from the approved SAP

4.6 Core Processing and Handling Procedures

Sediments will be manually extruded from the core tubes onto a previously decontaminated and aluminum foil lined processing tray. If encountered substrate proves difficult for extrusion (i.e. stiff clays), polycarbonate core tubes will be cut lengthwise with an electric nipper or another suitable device. The cutter will be decontaminated between successive cores. After initial extrusion of the core tube, one of the 3 cores will be randomly selected for sub-sampling of sulfides. Prior to homogenization a qualified person will examine the core and log the geology and take photos.

4.6.1 Equipment Decontamination Procedures

This section describes the equipment decontamination procedures, sample containers, core processing, and sample compositing procedures.

Sample containers, instruments, working surfaces, technician protective gear, and other items that may come into contact with sediment sample material must meet high standards of cleanliness. All equipment and instruments used that are in direct contact with the sediment collected for analysis must be made of glass, stainless steel, high-density polyethylene (HDPE), or polytetrafluoroethylene (PTFE), and will be cleaned prior to each day's use and between sampling or compositing events. Decontamination of all items will follow PSEP protocols. The decontamination procedure is:

- Pre-wash rinse with tap water
- Wash with solution of warm tap water and Alconox soap (brush)
- Rinse with warm tap water
- First rinse with distilled water
- Rinse three times with distilled water
- Cover (no contact) all decontaminated items with aluminum foil
- Store in clean, closed container or for next use

4.6.2 Sample Containers for Analysis

The contract laboratory will provide certified, pre-cleaned, U.S. Environmental Protection Agency (EPA)-approved containers for all samples. Prior to shipping, the analytical laboratory will add preservative, where required, according to PSEP protocols. Sediment for archival and future bioassay tests will be placed in HDPE buckets with absolutely no headroom. These buckets will have undergone the decontamination procedures described in Section 4.6.1.

4.6.3 Core Processing Procedures

Sediment processing will be conducted aboard the sampling vessel. Filled sample containers will be stored in coolers containing ice to maintain the samples at 4°± 2°C until delivery or shipping to the analytical laboratories.

All working surfaces and instruments will be thoroughly cleaned, decontaminated, and covered with aluminum foil to minimize outside contamination between sampling events. Disposable gloves will be discarded after processing each station and replaced prior to handling decontaminated instruments or work surfaces.

Sample containers will be kept in packaging as received from the analytical lab until use; a sample container will be withdrawn only when a sample is to be collected and will be returned to a cooler containing completed samples.

The steps for processing the samples are provided below.

1. Extrude sample material from sample core tube onto a stainless steel tray using a vibrating core-extruder. Alternatively, the core may be cut longitudinally using a circular saw, taking care not to penetrate the sediment while cutting.
2. Separate z-layer sample, relative to design depth, from dredge surface
3. Randomly select one of the 3 cores and using a clean, stainless steel spoon, fill a pre-labeled 4-ounce glass total sulfides container (zinc acetate added previously, following the chemistry laboratory's instructions) leaving no headspace.
4. Place cap on sample container, tighten, and shake vigorously.
5. Take photograpsh of whole core, paying special attemtion to interesting horizons. Record the description of the core sample on the core log form for the following parameters as appropriate and present:
   - Sample recovery (depth in feet of penetration)
   - Physical soil description in accordance with the Unified Soil Classification System (includes soil type, density/consistency of soil, and color)
   - Odor (e.g., hydrogen sulfide, petroleum, etc.)
   - Vegetation
   - Debris
   - Biological activity (e.g., detritus, shells, tubes, bioturbation, and live or dead organisms)
   - Presence and depth (in feet) of the redox potential discontinuity layer
   - Presence of oil sheen
   - Any other distinguishing characteristics or features
6. Using a clean spoon, place sample material from the core into a cleaned stainless steel bowl or HDPE bucket, homogenize using a stainless steel paddle and variable speed drill, cover with foil, and set aside for composite sample preparation (discussed in Step 8 below).

7. Repeat Steps 1, 2, and 6 for the remaining core tubes associated with the composite that is being prepared.
8. To prepare the sample composite for a DMMU, place a representative (e.g. mudline to bottom of dredge prism at 716ft) volume of homogenized sediment from each of the individual core sections into a compositing container (stainless steel bowl or HPDE bucket), and mix thoroughly to a uniform color and consistency using a variable speed drill fitted with a stainless steel paddle.
9. Using a clean, stainless steel spoon, completely fill pre-labeled sample containers, as indicated in Table 3, for the remaining analyses.
10. Immediately after filling the sample container with sediment, place the screw cap on the sample container and tighten.
11. Repeat steps 9 and 10 for the remaining sample jars.
12. For z-layer samples repeat steps 3-10 but keep cores separate and do not composite.
13. Thoroughly check all sample containers for proper identification, analysis type, and lid tightness.
14. Pack each container carefully to prevent breakage and place upright inside a cooler with ice for storage at the proper temperature (4°± 2°C for all samples).

Table 3
Guidelines for Sample Handling and Storage

ANALYSIS	CONTAINER[1]	PRESERVATION	HOLDING TIMES
Grain Size	1.0-L Glass	4°C	6 months
Total volatile solids, total organic carbon, Sulfides, Total Solids, Ammonia,TOC	1.0-L Glass	4°C	14 days to extraction; 40 days to analysis after extraction TOC - 1 month
Pesticides, herbicides, PCBs, PAH	8-oz Glass	4°C	14 days to extraction; 40 days to analysis after extraction
Metals	4-oz Glass	4°C	6 months
Total mercury	125-mL PE or TEF	4°C	28 days
Water for Elutriate	4000-ml G TEF	4°C	30 days
Bioassay archive	6000-ml G TEF	4°C	6 months
[1]EPA certified containers will be provided by the contractor.			

4.6.4 Sample Compositing Procedures

The sediment collected from each individual core will be homogenized. Z-layer samples will be maintained separately and archived. Because the cores represent a single DMMU all 3 cores will be homogenized above the z-layer. A proportionate volume of each individual sample, which does not consist primarily of cobble and or gravel, will be placed into a decontaminated stainless steel bowl or HDPE bucket for compositing as described in Section 4.6.3, step 12. For example, if a composite is made up of two cores of equal length, the composite container will receive a 50 percent contribution from each individual sediment sample. If the composite is comprised of two cores of different lengths, then the sample will receive appropriate amounts from each core for composition. The material added to the composite container will be representative of the entire depth interval targeted for each individual sample. As an individual contribution becomes available, its proportionate sediment volume will be added to the composite sample container. When all of the desired material is placed into the compositing container, the material will be homogenized with a stainless steel paddle

attached to a variable speed drill or stainless steel spoon until uniform in color and texture, then placed into the appropriate sample jars, as identified in Table 2, and stored/preserved. In order to satisfy the volume requirements for analyses, the composite must consist of approximately 10 liters of sediment. The homogenate will be mixed throughout the process of filling sample jars to ensure that each sample jar is representative of the homogenate mixture.

Filled sample jars will be labeled with the name of the project, sample number, type of analysis, date, time, and initials of the person preparing the sample. This information will be recorded on the chain-of-custody forms. Following proper sealing and labeling, all sample containers will be placed on ice in a cooler or container and maintained at 4°± 2°C.

4.6.5 Elutriate samples

Elutriate water will be collected upstream of the dredge project area. A total of 10 gallons of water will be collected for elutriate analysis. 4000 ml of sediment will also be collected from the homogenized core samples. Analysis of elutriate samples will only be conducted if the chemical results from sediment samples prove the need for elutriate analysis. These samples will help identify any impact these samples may have on the water column during dredging.

4.7 Field Quality Assurance Samples

Field QA samples will be used to evaluate the efficiency of field decontamination procedures. All field QC samples will be documented in the field logs. One Field Duplicate sample will be collected from the homogenized sediments. One equipment wipe, trip blank and one filter blank will also be collected. The equipment wipe will consist of wiping down the sampling equipment after sample collection and decontamination with a clean, ashless, Whatman Grade No. 541 filter paper and placing it into a sample jar. The filter blank will be prepared by placing a clean piece of ashless Whatman Grade No. 541 filter paper directly into a sampling container. The blanks will be archived and will be analyzed only in the event of questionable data.

4.8 Sample Transport and Chain-of-Custody Procedures

All containerized sediment samples will be transported to the analytical laboratory after preparation is completed. Specific sample shipping procedures will be as follows:

- Each cooler or container containing the sediment samples to be analyzed will be delivered to the laboratory within 24 hours of being sealed.
- The shipping containers will be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the container, and consultant's office name and address) to enable positive identification.
- Glass jars will be separated in the shipping container by shock absorbent material (e.g., bubble wrap) to prevent breakage.
- A sufficient amount of ice will be double-bagged in sealable plastic bags and placed within the cooler.
- A sealed envelope containing chain-of-custody forms will be enclosed in a plastic bag and taped to the inside lid of the cooler.
- Signed and dated chain-of-custody seals will be placed on all coolers prior to shipping.

The persons transferring custody of the sample containers and core tubes (for archives) will sign the chain-of-custody form upon transfer of sample possession to the analytical laboratory. The shipping container seal will be broken upon receipt of samples at the laboratory and the receiver will record the condition of the samples. Chain-of-custody forms will be used internally by the lab to track sample handling and final disposition.

4.9 Waste Management

All sediment remaining after sampling will be washed overboard at the collection site prior to moving to the next sampling station. Any sediment spilled on the deck of the sampling vessel will be washed into the surface waters at the collection site.

All disposable sampling materials and personnel protective equipment used in sample processing, such as disposable coveralls, gloves, and paper towels, will be placed in heavy duty garbage bags or other appropriate containers.

5 CHEMICAL/CONVENTIONAL ANALYSES

The DMMP process specifies sampling and testing protocols for the chemical and biological characterization of dredge material. Table 4 summarizes the analytical methods and sample quantitation limits that will be used for this assessment. The results of the testing will be used to assess the level of contamination of the sediments. Reporting limits must be below screening levels for all COCs in order to avoid need for bioassays. Table 5 provides the freshwater bulk sediment screening levels, as updated under the SEF 2009 guidance document.

5.1 Quality Assurance/Quality Control

Attachment 1 includes the CRMs/SRMs for the laboratories. The frequency of analysis for laboratory QA/QC samples is summarized in Table 6. When analyzing VOCs, semi-volatile organic compounds (SVOCs), pesticides (PCBs), metals, and conventional parameters, DMMP requires that initial calibrations must be completed before any samples are analyzed, after each major disruption of equipment, and when ongoing calibration fails to meet acceptance criteria. Ongoing calibration is required before and after every 10 to 12 samples or every 12 hours (whichever is more frequent).

Surrogates are required (organics only) for every sample, including matrix spike samples, blanks, laboratory control samples (LCS), and standard reference materials. Matrix spike and matrix spike duplicates are required for,SVOCs and pesticides/PCBs at a rate of 5% or one per sample batch. Matrix spikes and laboratory duplicates will be analyzed for samples requiring metals analyses. Matrix triplicates will be analyzed for conventional parameters.

All samples will be diluted and re-analyzed if target compounds are detected at levels that exceed their respective established calibration ranges. Any cleanups will be conducted prior to the dilutions. Re-analyses will be performed if surrogate, internal standard, or spike recoveries are outside of the data quality objective parameters. QC samples may be re-analyzed if results are not within control limits and it cannot be determined that the sample matrix is the cause.

Table 4 Recommended Sediment Analytical Methods and Sample Quantitation Limits

Parameter	Prep Method	Analysis Method	Sample Quantitation Limit (SQL) [1/]
STANDARD CHEMICALS OF CONCERN			
Conventionals:			
Total Solids (%)	---	EPA 2450-G	0.1
Total Organic Carbon (%)	PSEP 1997 and Bragdon-Cook 1993	EPA 5310B mod or EPA 9060	0.1
Total Sulfides (mg/kg)	---	PSEP 1997	1.0
Ammonia (mg/kg)	---	Plumb 1981	0.1
Grain Size (%)	---	PSEP 1986 or ASTM D-422 mod	1.0
Metals (mg/kg):			
Antimony	EPA 6010/6020 [2/]	EPA 6010/6020	0.5
Arsenic	EPA 6010/6020	EPA 6010/6020	5
Cadmium	EPA 6010/6020	EPA 6010/6020	0.5
Chromium	EPA 6010/6020	EPA 6010/6020	5
Copper	EPA 6010/6020	EPA 6010/6020	5
Lead	EPA 6010/6020	EPA 6010/6020	5
Mercury	EPA 7471	EPA 7471	0.05
Nickel	EPA 6010/6020	EPA 6010/6020	5
Silver	EPA 6010/6020	EPA 6010/6020	0.5
Zinc	EPA 6010/6020	EPA 6010/6020	5
Polynuclear Aromatic Hydrocarbons (PAHs; µg/kg):			
Low-molecular weight PAHs			
Naphthalene	EPA 3550-mod[3/]	EPA 8270	20
Acenaphthylene	EPA 3550-mod[3/]	EPA 8270	20
Acenaphthene	EPA 3550-mod[3/]	EPA 8270	20
Fluorene	EPA 3550-mod[3/]	EPA 8270	20
Phenanthrene	EPA 3550-mod[3/]	EPA 8270	20
Anthracene	EPA 3550-mod[3/]	EPA 8270	20
2-Methylnaphthalene	EPA 3550-mod[3/]	EPA 8270	20
High-molecular weight PAHs			
Fluoranthene	EPA 3550-mod[3/]	EPA 8270	20
Pyrene	EPA 3550-mod[3/]	EPA 8270	20
Benzo(a)anthracene	EPA 3550-mod[3/]	EPA 8270	20
Chrysene	EPA 3550-mod[3/]	EPA 8270	20
Benzofluoranthenes	EPA 3550-mod[3/]	EPA 8270	20
Benzo(a)pyrene	EPA 3550-mod[3/]	EPA 8270	20
Indeno(1,2,3-c,d)pyrene	EPA 3550-mod[3/]	EPA 8270	20
Dibenzo(a,h)anthracene	EPA 3550-mod[3/]	EPA 8270	20
Benzo(g,h,i)perylene	EPA 3550-mod[3/]	EPA 8270	20
Chlorinated Hydrocarbons (µg/kg):			
1,4-Dichlorobenzene	EPA 3550-mod[3/]	EPA 8270	20
1,2-Dichlorobenzene	EPA 3550-mod[3/]	EPA 8270	20
1,2,4-Trichlorobenzene	EPA 3550-mod[3/]	EPA 8270	20
Hexachlorobenzene	EPA 3550[3/]/3540	EPA 8270/8081	10

Table 4 - Cont.. Recommended Sediment Analytical Methods and Sample Quantitation Limits

Parameter	Prep Method	Analysis Method	Sample Quantitation Limit (SQL) [1/]
Phthalates (µg/kg):			
Dimethyl phthalate	EPA 3550-mod[3/]	EPA 8270	20
Diethyl phthalate	EPA 3550-mod[3/]	EPA 8270	20
Di-n-butyl phthalate	EPA 3550-mod[3/]	EPA 8270	20
Butyl benzyl phthalate	EPA 3550-mod[3/]	EPA 8270	20
Bis(2-ethylhexyl)phthalate	EPA 3550-mod[3/]	EPA 8270	100
Di-n-octyl phthalate	EPA 3550-mod[3/]	EPA 8270	20
Phenols (µg/kg):			
Phenol	EPA 3550-mod[3/]	EPA 8270	20
2 Methylphenol	EPA 3550-mod[3/]	EPA 8270	20
4 Methylphenol	EPA 3550-mod[3/]	EPA 8270	20
2,4-Dimethylphenol	EPA 3550-mod[3/]	EPA 8270	20
Pentachlorophenol	EPA 3550-mod[3/]	EPA 8270	100
Miscellaneous Extractables (µg/kg):			
Benzyl alcohol	EPA 3550-mod[3/]	EPA 8270	50
Benzoic acid	EPA 3550-mod[3/]	EPA 8270	100
Dibenzofuran	EPA 3550-mod[3/]	EPA 8270	20
Hexachloroethane	EPA 3550-mod[3/]	EPA 8270	20
Hexachlorobutadiene	EPA 3550[3/]/3540	EPA 8270/8081	10
N-Nitrosodiphenylamine	EPA 3550-mod[3/]	EPA 8270	20
Pesticides/PCBs (µg/kg):			
DDE (p,p'-, o,p'-)	EPA 3540	EPA 8081	2
DDD (p,p'-, c	Table 5 - Bulking Sediment Screening Levels		
DDT (p,p'-, c			
Aldrin	EPA 3540	EPA 8081	2
Chlordane compounds[4/]	EPA 3540	EPA 8081	2
Dieldrin	EPA 3540	EPA 8081	2
Heptachlor	EPA 3540	EPA 8081	2
Lindane	EPA 3540	EPA 8081	2
Total PCBs	EPA 3540	EPA 8082	10

[1/] SQLs are based on dry sample weight assuming no interferences; site-specific method modifications may be required to achieve these SQLs in some cases.
[2/] Includes hydrochloric acid digestion per EPA 3050-B.
[3/] EPA Method 3550 is modified to add matrix spikes before the dehydration step, not after.
[4/] Chlordane compounds include cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, and oxychlordane. In samples with interference from PCBs, the SQLs for cis- and trans-nonachlor and oxychlordane may be elevated.
mg/kg= milligrams per kilogram; ng/kg = nanograms per kilogram; µg/kg = micrograms per kilogram.

Table 5. Sediment Quality Guideline Screening Levels for Bulk Sediment

CHEMICAL	CAS[1] NUMBER	Marine			2006 Freshwater	
		SL	BT	ML	SL1	SL2
METALS (mg/kg)						
Antimony	7440-36-0	150	---	200	--	--
Arsenic	7440-38-2	57	507.1	700	20	51
Cadmium	7440-43-9	5.1	11.3	14	1.1	1.5
Chromium	7440-47-3	260	260	---	95	100
Copper	7440-50-8	390	1,027	1,300	80	830
Lead	7439-92-1	450	975	1,200	340	430
Mercury	7439-97-6	0.41	1.5	2.3	0.28	0.75
Nickel	7440-02-0	---	---	---	60	70
Selenium	7782-49-2	---	3	---	--	--
Silver	7440-22-4	6.1	6.1	8.4	2.0	2.5
Zinc	7440-66-6	410	2,783	3,800	130	400
ORGANOMETALLIC COMPOUNDS						
Tributyltin ion (interstitial water; ug/L)	56573-85-4	0.15	0.15	---	---	---
Tributyltin ion (bulk; ug/kg)[2]	56573-85-4	73	73	---	75	75
ORGANICS (µg/kg)						
PAHs						
Total LPAH	---	5,200	---	29,000	6,600	9,200
Naphthalene	91-20-3	2,100	---	2,400	500	1,300
Acenaphthylene	208-96-8	560	---	1,300	470	640
Acenaphthene	83-32-9	500	---	2,000	1,100	1,300
Fluorene	86-73-7	540	---	3,600	1,000	3,000
Phenanthrene	85-01-8	1,500	---	21,000	6,100	7,600
Anthracene	120-12-7	960	---	13,000	1,200	1,600
2-Methylnaphthalene[3]	91-57-6	670	---	1,900	470	560
Total HPAH	---	12,000	---	69,000	31,000	55,000
Fluoranthene	206-44-0	1,700	4,600	30,000	11,000	15,000
Pyrene	129-00-0	2,600	11,980	16,000	8,800	16,000
Benz(a)anthracene	56-55-3	1,300	---	5,100	4,300	5,800
Chrysene	218-01-9	1,400	---	21,000	5,900	6,400
Benzofluoranthenes (b, j ,k)	205-99-2 205-82-3 207-08-9	3,200	---	9,900	600	4,000
Benzo(a)pyrene	50-32-8	1,600	---	3,600	3,300	4,800
Indeno(1,2,3-c,d)pyrene	193-39-5	600	---	4,400	4,100	5,300
Dibenz(a,h)anthracene	53-70-3	230	---	1,900	800	840
Benzo(g,h,i)perylene	191-24-2	670	---	3,200	4,000	5,200
CHLORINATED HYDROCARBONS						
1,4-Dichlorobenzene	106-46-7	110	---	120	---	---
1,2-Dichlorobenzene	95-50-1	35	---	110	---	---
1,2,4-Trichlorobenzene	120-82-1	31	---	64	---	---
Hexachlorobenzene (HCB)	118-74-1	22	168	230	---	---
PHTHALATES						
Dimethyl phthalate	131-11-3	71	---	1,400	46	440
Diethyl phthalate	84-66-2	200	---	1,200	---	---
Di-n-butyl phthalate	84-74-2	1,400	---	5,100	---	---
Butyl benzyl phthalate	85-68-7	63	---	970	260	370
Bis(2-ethylhexyl) phthalate	117-81-7	1,300	---	8,300	220	320

Table 5. Cont.. Sediment Quality Guideline Screening Levels for Bulk Sediment

Di-n-octyl phthalate	117-84-0	6,200	---	6,200	26	45
PHENOLS						
Phenol	108-95-2	420	---	1,200	---	---
2-Methylphenol	95-48-7	63	---	77	---	---
4-Methylphenol	106-44-5	670	---	3,600	---	---
2,4-Dimethylphenol	105-67-9	29	---	210	---	---
Pentachlorophenol	87-86-5	400	504	690	---	---
MISCELLANEOUS EXTRACTABLES						
Benzyl alcohol	100-51-6	57	---	870	---	---
Benzoic acid	65-85-0	650	---	760	---	---
Dibenzofuran	132-64-9	540	---	1,700	400	440
Hexachlorobutadiene	87-68-3	11	---	270	---	---
N-Nitrosodiphenylamine	86-30-6	28	---	130	---	---
PESTICIDES & PCBs						
4,4'-DDD	72-54-8	16	---	---	---	---
4,4'-DDE	72-55-9	9	---	---	---	---
4,4'-DDT	50-29-3	12	---	---	---	---
sum of 4,4'-DDD, 4,4'-DDE and 4,4'-DDT)		---	50	69	---	---
Aldrin	309-00-2	9.5	---	---	---	---
Total Chlordane	5103-71-9	2.8	37	---	---	---
(sum of cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, oxychlordane)	5103-74-2					
	5103-73-1					
	39765-80-5					
	27304-13-8					
Dieldrin	60-57-1	1.9	---	---	---	---
Heptachlor	76-44-8	1.5	---	---	---	---
Total PCBs	---	130	38 [(4)]	3,100	60	120

1 - Chemical Abstract Service Registry Number
2 - bulk sediment measurement of TBT is only used when porewater extraction cannot be accomplished
3 - 2-Methylnaphthalene is not included in the summation for total LPAH
4 - This value is normalized to total organic carbon, and is expressed in mg/kg carbon

Table 6

Laboratory QA/QC Requirements

Analysis Type	Method Blanks[1]	Replicates[1]	Triplicates[1]	CRM/RM	MS/MSD[1]	Surrogates[2]
Volatile Organics[3,4]	X	X[6]			X	X
Semivolatiles[3,4]	X[5]	X[6]		X	X	X
Pesticides/PCBs[3,4]	X[5]	X[6]		X	X	X
Metals	X	X		X	X	
Ammonia	X		X			
Total Sulfides	X		X			
Total Organic Carbon	X		X	X		
Total Solids			X			
Total Volatile Solids			X			
Particle Size			X			

Notes:

CRM = Certified Reference Material; RM = Reference Material; MS/MSD = matrix spike/matrix spike duplicate

[1] Frequency of Analysis (FOA) = 5 percent or one per batch, whichever is more frequent.

[2] Surrogate spikes required for every sample, including matrix spiked samples, blanks, and reference materials.

[3] Initial calibrations required before any samples are analyzed, after each major disruption of equipment, and when ongoing calibration fails to meet criteria.

[4] Ongoing calibration required at the beginning of each work shift, every 10–12 samples or every 12 hours (whichever is more frequent), and at the end of each shift.

[5] FOA = one per extraction batch.

[6] Matrix spike duplicates may be used.

Table 6 – Laboratory QA/QC requirements from USACE Dredge Material Evaluation and Disposal Procedures Manual 2008.

5.2 Laboratory Report

ALS and PAL will prepare a detailed report that will be excerpted in an appendix in the final Sampling and Analysis Report documenting all activities associated with the sample analyses. Included in this report will be:

- Project Narrative: A detailed report that describes the samples received, analyses performed, any issues with analyses and corrective actions undertaken.
- Chain-of-Custody Documentation: Laboratory policy requires that chain-of-custody documentation be available for all samples received. The chain-of-custody will document basic sample demographics such as client and project names, sample identification, analyses requested, and special instructions.

- Data Summary Form: A tabular listing of concentrations and/or detection limits for all target analytes. The data report will also list other pertinent information such as the amount of sample analyzed, dilution factors, sample processing dates, extract cleanups, and surrogate recoveries.
- QA Summary: Includes results of all quality control analyses, specifically recovery information. Laboratory control samples are reported with each batch. Additional QC analysis may include laboratory replicates, matrix spikes, and standard reference materials.
- Instrument Calibration Forms and Raw Data: Includes initial and continuing calibration summaries and instrument tuning data, laboratory bench sheets, and log book pages.

ALS and PAL will also provide deliverables in the Department of Ecology's EIM format.

6 SAMPLING AND ANALYSIS RESULTS REPORT

A final Sampling and Analysis Results Report will be prepared by Gravity documenting all activities associated with collecting, compositing, transporting, and chemically and biologically analyzing sediment samples. Portions of the laboratory reports will be included as appendices. At a minimum, the following will be included in the final report:

- Summary of all field activities including a description of any deviations from the approved SAP.
- Locations of sediment sampling stations in state plane coordinates (NAD 83) to the nearest foot, and in latitude and longitude in degrees and minutes to three decimal places. All vertical elevations of mudline and water surface will be reported to the nearest 0.1 foot relative to MOP NAVD88.
- A project map with target and actual sampling locations.
- A QA/QC narrative for chemical testing.
- Summary data results tables, including explanation of all data qualifiers, MRLs, MDLs.
- Summary of comparison of chemical and toxicity test results with DMMP and SMS interpretive criteria.
- As appendices, electronic copies of field data, laboratory analysis results, associated QA/QC, and approved SAP will be included.

7 REFERENCES

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PSDDA. 2008. Dredged Material Evaluation and Disposal Procedures. A User's Manual for the Puget Sound Dredged Disposal Analysis (PSDDA) Program. Prepared by U.S. Army Corps of Engineers, Seattle District; U.S. Environmental Protection Agency, Region 10; Washington Department of Natural Resources; Washington Department of Ecology.

Puget Sound Estuary Program (PSEP). 1986 as updated in 1989, 1991, 1995, and 1997. Recommended guidelines for measuring conventional sediment variables in Puget Sound. Prepared for the Puget Sound Estuary Program, U.S. Environmental Protection Agency, Region 10, Office of Puget Sound, Seattle, Washington.

PSEP. 1995. Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments. Prepared for the Puget Sound Estuary Program and U.S. Environmental Protection Agency, Region 10, Seattle, Washington. July 1995.

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Multiresidue Screen Analyte List and Reporting Limits, Soil

This is a multiresidue profile that incorporates the following methods:

Halogenated Pesticides in Soil	**EPA 8081B (GC-ECD)**
Organophosphorous Pesticides in Soil	**EPA 8141B (GC-FPD)**
Organonitrogen Pesticides in Soil	**EPA 8270D (GC-MS, SIM mode)**
Miscellaneous Pesticides in Soil	**EPA 8321B (HPLC-MS)**

Organophosphorous and Organosulfur Pesticides

Analyte	Reporting limit	Analyte	Reporting limit
Aspon	0.017 mg/kg (ppm)	Fensulfothion	0.017 mg/kg (ppm)
Azinphos-methyl	0.017 mg/kg (ppm)	Fenthion	0.017 mg/kg (ppm)
Carbofenothion	0.017 mg/kg (ppm)	Malathion	0.017 mg/kg (ppm)
Chlorfenvinphos	0.017 mg/kg (ppm)	Methidathion	0.017 mg/kg (ppm)
Chlorpyrifos	0.017 mg/kg (ppm)	Merphos	0.017 mg/kg (ppm)
Chlorpyrifos-methyl	0.017 mg/kg (ppm)	Mevinphos	0.017 mg/kg (ppm)
Coumaphos	0.017 mg/kg (ppm)	Monocrotophos	0.017 mg/kg (ppm)
Demeton	0.017 mg/kg (ppm)	Parathion	0.017 mg/kg (ppm)
Diazinon	0.017 mg/kg (ppm)	Parathion-methyl	0.017 mg/kg (ppm)
Dichlorofenthion	0.017 mg/kg (ppm)	Phorate	0.017 mg/kg (ppm)
Dichlorvos	0.017 mg/kg (ppm)	Phosmet	0.017 mg/kg (ppm)
Dicrotophos	0.017 mg/kg (ppm)	Phosphamidon	0.017 mg/kg (ppm)
Dimethoate	0.017 mg/kg (ppm)	Pirimiphos-methyl	0.017 mg/kg (ppm)
Disulfoton	0.017 mg/kg (ppm)	Propargite	0.033 mg/kg (ppm)
EPN	0.017 mg/kg (ppm)	Ronnel	0.017 mg/kg (ppm)
Ethion	0.017 mg/kg (ppm)	Sulprofos	0.017 mg/kg (ppm)
Ethoprop	0.017 mg/kg (ppm)	Terbufos	0.017 mg/kg (ppm)
Famphur	0.017 mg/kg (ppm)	Tetrachlorvinphos	0.017 mg/kg (ppm)
Fenamiphos	0.017 mg/kg (ppm)	Tokuthion	0.017 mg/kg (ppm)
Fenitrothion	0.017 mg/kg (ppm)	Tricloronate	0.017 mg/kg (ppm)

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Halogenated Pesticides

Analyte	Reporting limit
Acetochlor	0.017 mg/kg (ppm)
Alachlor	0.017 mg/kg (ppm)
Aldrin	0.0067 mg/kg (ppm)
Benfluralin	0.0067 mg/kg (ppm)
Bifenthrin	0.0067 mg/kg (ppm)
α-BHC	0.0067 mg/kg (ppm)
β-BHC	0.0067 mg/kg (ppm)
δ-BHC	0.0067 mg/kg (ppm)
γ-BHC (Lindane)	0.0067 mg/kg (ppm)
Captafol	0.0067 mg/kg (ppm)
Captan	0.017 mg/kg (ppm)
Chlordane	0.033 mg/kg (ppm)
Chlorobenzilate	0.017 mg/kg (ppm)
Chloroneb	0.017 mg/kg (ppm)
Chlorothalonil	0.0067 mg/kg (ppm)
Cyfluthrin	0.033 mg/kg (ppm)
Cyhalothrin	0.033 mg/kg (ppm)
Cypermethrin	0.033 mg/kg (ppm)
p,p'-DDD	0.0067 mg/kg (ppm)
p,p'-DDE	0.0067 mg/kg (ppm)
p,p'-DDT	0.0067 mg/kg (ppm)
Dacthal	0.0067 mg/kg (ppm)
Deltamethrin	0.033 mg/kg (ppm)
Dichlobenil	0.0067 mg/kg (ppm)
Dicloran	0.0067 mg/kg (ppm)
Dicofol	0.017 mg/kg (ppm)
Dieldrin	0.0067 mg/kg (ppm)
Dithiopyr	0.0067 mg/kg (ppm)
Endosulfan I	0.0067 mg/kg (ppm)
Endosulfan II	0.0067 mg/kg (ppm)
Endosulfan sulfate	0.0067 mg/kg (ppm)
Endrin	0.0067 mg/kg (ppm)
Endrin aldehyde	0.0067 mg/kg (ppm)
Endrin ketone	0.0067 mg/kg (ppm)
Esfenvalerate	0.0067 mg/kg (ppm)
Ethalfluralin	0.0067 mg/kg (ppm)
Etridiazole	0.0067 mg/kg (ppm)
Fenarimol	0.0067 mg/kg (ppm)
Fenvalerate	0.0067 mg/kg (ppm)
Flutolanil	0.033 mg/kg (ppm)
Folpet	0.017 mg/kg (ppm)
Heptachlor	0.0067 mg/kg (ppm)
Heptachlor epoxide	0.0067 mg/kg (ppm)
Hexachlorobenzene	0.0067 mg/kg (ppm)
Iprodione	0.0067 mg/kg (ppm)
Methoxychlor	0.0067 mg/kg (ppm)
Metolachlor	0.017 mg/kg (ppm)
Mirex	0.0067 mg/kg (ppm)
Norflurazon	0.0067 mg/kg (ppm)
Ovex	0.0067 mg/kg (ppm)
Oxadiazon	0.0067 mg/kg (ppm)
Oxyfluorfen	0.0067 mg/kg (ppm)
PCNB	0.0067 mg/kg (ppm)
Permethrin	0.033 mg/kg (ppm)
Prodiamine	0.0067 mg/kg (ppm)
Pronamide	0.0067 mg/kg (ppm)
Propachlor	0.017 mg/kg (ppm)
Propanil	0.0067 mg/kg (ppm)
Propiconazole	0.017 mg/kg (ppm)
Terbacil	0.0067 mg/kg (ppm)
Trifloxystrobin	0.0067 mg/kg (ppm)
Triflumazole	0.0067 mg/kg (ppm)
Trifluralin	0.0067 mg/kg (ppm)
Vinclozalin	0.0067 mg/kg (ppm)

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Organonitrogen Pesticides

Analyte	Reporting limit	Analyte	Reporting limit
Amitraz	0.033 mg/kg (ppm)	Imidacloprid	0.017 mg/kg (ppm)
Ametryn	0.017 mg/kg (ppm)	Isoxaben	0.017 mg/kg (ppm)
Atrazine	0.017 mg/kg (ppm)	Mefenoxam	0.017 mg/kg (ppm)
Azoxystrobin	0.017 mg/kg (ppm)	Metalaxyl	0.017 mg/kg (ppm)
Bensulide	0.017 mg/kg (ppm)	Metribuzin	0.033 mg/kg (ppm)
Boscalid	0.017 mg/kg (ppm)	Myclobutanil	0.033 mg/kg (ppm)
Bromacil	0.017 mg/kg (ppm)	Oryzalin	0.017 mg/kg (ppm)
Bromopropylate	0.033 mg/kg (ppm)	Pendimethalin	0.0067 mg/kg (ppm)
Carfentrazone-ethyl	0.017 mg/kg (ppm)	Pirimicarb	0.017 mg/kg (ppm)
Clothianidin	0.017 mg/kg (ppm)	Prometon	0.033 mg/kg (ppm)
Cyanazine	0.033 mg/kg (ppm)	Prometryn	0.017 mg/kg (ppm)
Diclofop-methyl	0.033 mg/kg (ppm)	Propazine	0.017 mg/kg (ppm)
Dimethenamid	0.017 mg/kg (ppm)	Pyraclostrobin	0.017 mg/kg (ppm)
Diphenylamine	0.017 mg/kg (ppm)	Pyridaben	0.033 mg/kg (ppm)
Ethofumesate	0.017 mg/kg (ppm)	Pyrimethanil	0.017 mg/kg (ppm)
Fenbuconazole	0.033 mg/kg (ppm)	Sethoxydim	0.17 mg/kg (ppm)
Fenoxaprop-ethyl	0.033 mg/kg (ppm)	Simazine	0.033 mg/kg (ppm)
Fipronil	0.033 mg/kg (ppm)	Simetryn	0.017 mg/kg (ppm)
Fluazifop-P-butyl	0.033 mg/kg (ppm)	Sulfentrazone	0.017 mg/kg (ppm)
Fludioxonil	0.033 mg/kg (ppm)	Tebuconazole	0.033 mg/kg (ppm)
Flumioxazin	0.017 mg/kg (ppm)	Tebuthiuron	0.033 mg/kg (ppm)
Fluometuron	0.017 mg/kg (ppm)	Thiabendazole	0.017 mg/kg (ppm)
Fluoxypyr-meptyl	0.017 mg/kg (ppm)	Triadimefon	0.033 mg/kg (ppm)
Hexazinone	0.017 mg/kg (ppm)		

Phenylurea Herbicides

Diuron	0.017 mg/kg (ppm)	Monuron	0.017 mg/kg (ppm)
DCPMU	0.017 mg/kg (ppm)	Neburon	0.017 mg/kg (ppm)
Fenuron	0.017 mg/kg (ppm)	Siduron	0.017 mg/kg (ppm)
Linuron	0.017 mg/kg (ppm)		

Carbamate Pesticides

Aldicarb	0.017 mg/kg (ppm)	3-Hydroxycarbofuran	0.017 mg/kg (ppm)
Aldicarb sulfone	0.017 mg/kg (ppm)	Methiocarb	0.017 mg/kg (ppm)
Aldicarb sulfoxide	0.017 mg/kg (ppm)	Methomyl	0.017 mg/kg (ppm)
Bendiocarb	0.017 mg/kg (ppm)	Oxamyl	0.017 mg/kg (ppm)
Carbaryl	0.017 mg/kg (ppm)	Propoxur	0.017 mg/kg (ppm)
Carbofuran	0.017 mg/kg (ppm)	Thiobencarb	0.017 mg/kg (ppm)
Fenobucarb	0.017 mg/kg (ppm)		

National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 1944

New York/New Jersey Waterway Sediment

Standard Reference Material (SRM) 1944 is a mixture of marine sediment collected near urban areas in New York and New Jersey. SRM 1944 is intended for use in evaluating analytical methods for the determination of selected polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyl (PCB) congeners, chlorinated pesticides, and trace elements in marine sediment and similar matrices. Reference values are also provided for selected polybrominated diphenyl ether (PBDE) congeners, selected dibenzo-*p*-dioxin and dibenzofuran congeners, total organic carbon, total extractable material, and particle size characteristics. Information values are provided for selected polychlorinated naphthalenes (PCNs) and hexabromocyclododecanes (HBCDs). All of the constituents for which certified, reference, and information values are provided in SRM 1944 were naturally present in the sediment before processing. A unit of SRM 1944 consists of a bottle containing 50 g of radiation-sterilized, freeze-dried sediment.

Certified Mass Fraction Values: Certified values for mass fractions of PAHs, PCB congeners, chlorinated pesticides, and trace elements are provided in Tables 1 through 4. A NIST certified value is a value for which NIST has the highest confidence in its accuracy in that all known or suspected sources of bias have been investigated or taken into account [1]. The certified values for the PAHs, PCB congeners, and chlorinated pesticides are based on the agreement of results obtained at NIST using two or more chemically independent analytical techniques. The certified values for the trace elements are based on NIST measurements by one technique and additional results from several collaborating laboratories.

Reference Mass Fraction Values: Reference values are provided for mass fractions of additional PAHs (some in combination) in Tables 5 and 6, additional PCB congeners and chlorinated pesticides in Table 7, PBDE congeners in Table 8, and additional inorganic constituents in Tables 9 and 10. Reference values are provided in Table 11 for the 2,3,7,8-substituted polychlorinated dibenzo-*p*-dioxin and dibenzofuran congeners and total tetra-, penta-, hexa-, and hepta-congeners of polychlorinated dibenzo-*p*-dioxin and dibenzofuran. Reference values for particle size characteristics are provided in Table 12 and 13. Reference values for total organic carbon and percent extractable mass are provided in Table 14. Reference values are noncertified values that are the best estimate of the true value; however, the values do not meet the NIST criteria for certification and are provided with associated uncertainties that may reflect only measurement precision, may not include all sources of uncertainty, or may reflect a lack of sufficient statistical agreement among multiple analytical methods [1].

Information Mass Fraction Values: Information values are provided in Table 15 for mass fractions of additional trace elements, in Table 16 for PCN congeners (some in combination), and in Table 17 for HBCD isomers. An information value is considered to be a value that will be of interest and use to the SRM user, but insufficient information is available to assess the uncertainty associated with the value or only a limited number of analyses were performed [1].

Expiration of Certification: The certification of **SRM 1944** is valid, within the measurement uncertainties specified, until **31 March 2017**, provided the SRM is handled and stored in accordance with the instructions given in this certificate (see "Instructions for Handling, Storage, and Use"). The certification is nullified if the SRM is damaged, contaminated, or otherwise modified.

Stephen A. Wise, Chief
Analytical Chemistry Division

Gaithersburg, MD 20899
Certificate Issue Date: 27 September 2011
Certificate Revision History on Page 20

Robert L. Watters, Jr., Chief
Measurement Services Division

Maintenance of SRM Certification: NIST will monitor this SRM over the period of its certification. If substantive technical changes occur that affect the certification before the expiration of this certificate, NIST will notify the purchaser. Registration (see attached sheet) will facilitate notification.

The coordination of the technical measurements leading to the certification was performed by M.M. Schantz and S.A. Wise of the NIST Analytical Chemistry Division.

Consultation on the statistical design of the experimental work and evaluation of the data were provided by S.D. Leigh, M.G. Vangel, and M.S. Levenson of the NIST Statistical Engineering Division.

Support aspects involved in the issuance of this SRM were coordinated through the NIST Measurement Services Division.

The sediment was collected with the assistance of the New York District of the U.S. Army Corp of Engineers (ACENYD), who provided the expertise in the site selection, the ship, sampling equipment, and personnel. L. Rosman of ACENYD and R. Parris (NIST) coordinated the collection of this sediment. Collection and preparation of SRM 1944 were performed by R. Parris, M. Cronise, and C. Fales (NIST); L. Rosman and P. Higgins (ACENYD), and the crew of the *Gelberman* from the ACE Caven Point facility in Caven Point, NJ.

Analytical measurements for the certification of SRM 1944 were performed at NIST by E.S. Beary, D.A. Becker, R.R. Greenberg, J.M. Keller, J.R. Kucklick, M. Lopez de Alda, K.E. Murphy, R. Olfaz, B.J. Porter, D.L. Poster, L.C. Sander, P. Schubert, M.M. Schantz, S.S. Vander Pol, and L. Walton of the Analytical Chemistry Division. Measurements for percent total organic carbon measurements were provided by three commercial laboratories and T.L. Wade of the Geochemical and Environmental Research Group, Texas A&M University (College Station, TX, USA). The particle-size distribution data were provided by Honeywell, Inc. (Clearwater, FL, USA). Additional results for PBDE congeners were used from ten laboratories (see Appendix A) that participated in an interlaboratory study specifically for PBDEs in Marine Sediment coordinated by H.M. Stapleton of the NIST Analytical Chemistry Division. M. LaGuardia of Virginia Institute of Marine Science (Gloucester Point, VA, USA) provided one set of measurements for the HBCDs.

Values for the polychlorinated dibenzo-*p*-dioxins and dibenzofurans were the results of an interlaboratory comparison study among fourteen laboratories (see Appendix B) coordinated by S.A. Wise of the NIST Analytical Chemistry Division and R. Turle and C. Chiu of Environment Canada Environmental Technology Centre, Analysis and Air Quality Division (Ottawa, ON, Canada). Analytical measurements for selected trace elements were provided by the International Atomic Energy Agency (IAEA, Seibersdorf, Austria) by M. Makarewicz and R. Zeisler. Results were also used from seven laboratories (see Appendix C) that participated in an intercomparison exercise coordinated by S. Willie of the Institute for National Measurement Standards, National Research Council Canada (NRCC; Ottawa, ON, Canada).

INSTRUCTIONS FOR HANDLING, STORAGE, AND USE

Handling: This material is naturally occurring marine sediment from an urban area and may contain constituents of unknown toxicities; therefore, caution and care should be exercised during its handling and use.

Storage: SRM 1944 must be stored in its original bottle at temperatures less than 30 °C away from direct sunlight.

Use: Prior to removal of test portions for analysis, the contents of the bottle should be mixed. The concentrations of constituents in SRM 1944 are reported on a dry-mass basis. The SRM, as received, contains a mass fraction of approximately 1.3 % moisture. The sediment sample should be dried to a constant mass before weighing for analysis or, if the constituents of interest are volatile, a separate test portion of the sediment should be removed from the bottle at the time of analysis and dried to determine the mass fraction on a dry-mass basis.

PREPARATION AND ANALYSIS[(1)]

Sample Collection and Preparation: The sediment used to prepare this SRM was collected from six sites in the vicinity of New York Bay and Newark Bay in October 1994. Site selection was based on contaminant levels measured in previous samples from these sites and was intended to provide relatively high concentrations for a variety of chemical classes of contaminants. The sediment was collected using an epoxy-coated modified Van Veen-type grab sampler designed to sample the sediment to a depth of 10 cm. A total of approximately 2100 kg of wet sediment was collected from the six sites. The sediment was freeze-dried, sieved (nominally 250 μm to 61 μm), homogenized in a cone blender, radiation sterilized at an estimated minimum dose of 32 kilograys (^{60}Co), and then packaged in screw-capped amber glass bottles.

Conversion to Dry-Mass Basis: The results for the constituents in SRM 1944 are reported on a dry-mass basis; however, the material as received contains residual moisture. The amount of moisture in SRM 1944 was determined by measuring the mass loss after freeze drying test portions of 1.6 g to 2.5 g for five days at 1 Pa with a –10 °C shelf temperature and a –50 °C condenser temperature. The mass fraction of moisture in SRM 1944 at the time of the certification analyses was 1.25 % ± 0.03 % (95 % confidence level).

Polycyclic Aromatic Hydrocarbons: The general approach used for the value assignment of the PAHs in SRM 1944 consisted of combining results from analyses using various combinations of different extraction techniques and solvents, cleanup/isolation procedures, and chromatographic separation and detection techniques [2]. Techniques and solvents involved were Soxhlet extraction and pressurized fluid extraction (PFE) using dichloromethane (DCM) or a hexane/acetone mixture, clean up of the extracts using solid-phase extraction (SPE), or normal-phase liquid chromatography (LC), followed by analysis using the following techniques: (1) reversed-phase liquid chromatography with fluorescence detection (LC-FL) analysis of the total PAH fraction, (2) reversed-phase LC-FL analysis of isomeric PAH fractions isolated by normal-phase LC (i.e., multidimensional LC), (3) gas chromatography/mass spectrometry (GC/MS) analysis of the PAH fraction on four stationary phases of different selectivity, i.e., a 5 % (mole fraction) phenyl-substituted methylpolysiloxane phase, a 50 % phenyl-substituted methylpolysiloxane phase, a proprietary non-polar polysiloxane phase, and a smectic liquid crystalline stationary phase.

Seven sets of GC/MS results, designated as GC/MS (I), GC/MS (II), GC/MS (III), GC/MS (IV), GC/MS (V), GC/MS (VI), and GC/MS (Sm), were obtained using four columns with different selectivities for the separation of PAHs. For GC/MS (I) analyses, duplicate test portions of 1 g from eight bottles of SRM 1944 were Soxhlet extracted for 24 h with DCM. Copper powder was added to the extract to remove elemental sulfur. The concentrated extract was passed through a silica SPE cartridge and eluted with 2 % DCM in hexane. (All extraction and LC solvent compositions are expressed as volume fractions unless otherwise noted.) The processed extract was then analyzed by GC/MS using a 0.25 mm i.d. × 60 m fused silica capillary column with a 5 % phenyl-substituted methylpolysiloxane phase (0.25 μm film thickness) (DB-5 MS, J&W Scientific, Folsom, CA). The GC/MS (II) analyses were performed using 1 g to 2 g test portions from three bottles of SRM 1944 and 2 g to 3 g test portions from three bottles of SRM 1944 that had been mixed with a similar amount of water (i.e., a wetted sediment). These test portions were Soxhlet extracted with DCM and processed through the silica SPE as described above; however, the extract was further fractionated using normal-phase LC on a semi-preparative aminopropylsilane column to isolate the PAH fraction. The PAH fraction was then analyzed using the same column as described above for GC/MS (I); however, the test portions were extracted, processed, and analyzed as part of three different sample sets at different times using different calibrations for each set. For the GC/MS (III), 1 g to 2 g test portions from six bottles of SRM 1944 were Soxhlet extracted for 18 h with 250 mL of a mixture of 50 % hexane/50 % acetone. The extracts were then processed and analyzed as described for GC/MS (II). For GC/MS (IV) analyses, 1 g to 2 g test portions from six bottles of SRM 1944 were extracted using PFE with a mixture of 50 % hexane/50 % acetone, and the extracts were processed as described above for GC/MS (II). The GC/MS (V) results were obtained by analyzing three of the same PAH fractions that were analyzed in GC/MS (III) and three of the PAH fractions that were analyzed in GC/MS (IV) using a 50 % (mole fraction) phenyl-substituted methylpolysiloxane stationary phase (0.25 mm i.d. × 60 m, 0.25 μm film thickness) (DB-17MS, J&W Scientific, Folsom, CA). For GC/MS (VI) analyses, three test portions of 0.7 g from one bottle of SRM 1944 were Soxhlet extracted for 24 h with DCM. Copper powder was added to the extract to remove elemental sulfur. The concentrated extract was passed through an aminopropyl SPE cartridge and eluted with 20 % DCM in hexane. The processed extract was then analyzed by GC/MS using a 0.25 mm i.d. × 60 m fused silica capillary column with a proprietary non-polar polysiloxane phase (0.25 μm film thickness) (DB-XLB, J&W Scientific). For GC/MS (Sm) 1 g to 2 g test portions from six bottles of SRM 1944 were Soxhlet extracted for 24 h with 250 mL of DCM. The extracts were processed as described above for

[(1)]Certain commercial equipment, instruments, or materials are identified in this report to adequately specify the experimental procedure. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

GC/MS (I) using an aminopropylsilane SPE cartridge followed by GC/MS analysis using 0.2 mm i.d. × 25 m (0.15 μm film thickness) smectic liquid crystalline phase (SB-Smectic, Dionex, Lee Scientific Division, Salt Lake City, UT).

Two sets of LC-FL results, designated as LC-FL (Total) and LC-FL (Fraction), were used in the certification process. Test portions of approximately 1 g from six bottles of SRM 1944 were Soxhlet extracted for 20 h using 200 mL of 50 % hexane/50 % acetone. The extracts were concentrated and then processed through two aminopropylsilane SPE cartridges connected in series to obtain the total PAH fraction. A second 1 g test portion from the six bottles was Soxhlet extracted and processed as described above; the PAH fraction was then fractionated further on a semi-preparative aminopropylsilane column (μBondapak NH_2, 9 mm i.d. × 30 cm, Waters Associates, Milford, MA) to isolate isomeric PAH fractions. The total PAH fraction and the isomeric PAH fractions were analyzed using a 5-μm particle-size polymeric octadecylsilane (C_{18}) column (4.6 mm i.d. × 25 cm, Hypersil-PAH, Keystone Scientific, Inc., Bellefonte, PA) with wavelength-programmed fluorescence detection. For all of the GC/MS and LC-FL measurements described above, selected perdeuterated PAHs were added to the sediment prior to solvent extraction for use as internal standards for quantification purposes.

Homogeneity Assessment for PAHs: The homogeneity of SRM 1944 was assessed by analyzing duplicate test portions of 1 g from eight bottles selected by stratified random sampling. Test portions were extracted, processed, and analyzed as described above for GC/MS (I). No statistically significant differences among bottles were observed for the PAHs at the 1 g test portion size.

PAH Isomers of Molecular Mass 300 and 302: For the determination of the molecular mass 300 and 302 PAH isomers, three test portions of approximately 5 g each were extracted using PFE with DCM. The extracts were then concentrated with a solvent change to hexane and passed through an aminopropyl SPE cartridge and eluted with 10 % DCM in hexane. The processed extract was then analyzed by GC/MS using a 0.25 mm i.d. × 60 m fused silica capillary column with a 50 % phenyl-substitued methylpolysiloxane phase (0.25 μm film thickness; DB-17MS, J&W Scientific, Folsom, CA). Perdeuterated dibenzo[*a,i*]pyrene was added to the sediment prior to extraction for use as an internal standard.

PCBs and Chlorinated Pesticides: The general approach used for the determination of PCBs and chlorinated pesticides in SRM 1944 consisted of combining results from analyses using various combinations of different extraction techniques and solvents, cleanup/isolation procedures, and chromatographic separation and detection techniques [2]. This approach consisted of Soxhlet extraction and PFE using DCM or a hexane/acetone mixture, clean up/isolation using SPE or LC, followed by analysis using GC/MS and gas chromatography with electron capture detection (GC-ECD) on two columns with different selectivity.

Eight sets of results were obtained designated as GC-ECD (I) A and B, GC-ECD (II) A and B, GC/MS (I), GC/MS (II), GC/MS (III), and QA Exercise. For the GC-ECD (I) analyses, 1 g test portions from four bottles of SRM 1944 were Soxhlet extracted with DCM for 18 h. Copper powder was added to the extract to remove elemental sulfur. The concentrated extract was passed through a silica SPE cartridge and eluted with 10 % DCM in hexane. The concentrated eluant was then fractionated on a semi-preparative aminopropylsilane column to isolate two fractions containing: (1) the PCBs and lower polarity pesticides and, (2) the more polar pesticides. GC-ECD analyses of the two fractions were performed on two columns of different selectivities for PCB separations: 0.25 mm × 60 m fused silica capillary column with a 5 % phenyl-substituted methylpolysiloxane phase (0.25 μm film thickness) (DB-5, J&W Scientific, Folsom, CA) and a 0.32 mm × 100 m fused silica capillary column with a 50 % (mole fraction) octadecyl (C18) methylpolysiloxane phase (0.1 μm film thickness) (CPSil 5 C18 CB, Chrompack International, Middelburg, The Netherlands). The results from the 5 % phenyl phase are designated as GC-ECD (IA) and the results from the C18 phase are designated as GC-ECD (IB). A second set of samples was also analyzed by GC-ECD (i.e., GC-ECD IIA and IIB). Test portions of 1 g to 2 g from three bottles of SRM 1944 and 2 g to 3 g test portions from three bottles of SRM 1944 that had been mixed with a similar amount of water (i.e., a wetted sediment) were extracted, processed, and analyzed as described above for GC-ECD (I); however, the test portions were extracted, processed and analyzed as part of three different sample sets at different times using different calibrations for each set.

Three sets of results were obtained by GC/MS. For GC/MS (I), 1 g to 2 g test portions from six bottles were Soxhlet extracted with a mixture of 50 % hexane/50 % acetone. Copper powder was added to the extract to remove elemental sulfur. The concentrated extract was passed through a silica SPE cartridge and eluted with 10 % DCM in hexane. The extract was then analyzed by GC/MS using a 0.25 mm × 60 m fused silica capillary column with a 5 % phenyl-substituted methylpolysiloxane phase (0.25 μm film thickness). The GC/MS (II) results were obtained in the same manner as the GC/MS (I) analyses except that the six test portions were extracted using PFE. The GC/MS (III) analyses were performed on the same extract fractions analyzed in GC-ECD (II) using the 5 % phenyl-substituted methylpolysiloxane phase describe above for GC/MS (I). For both the GC-ECD and GC/MS analyses, two PCB congeners that are not significantly present in the sediment extract (PCB 103 and PCB 198 [3]), and 4,4'-DDT-d_8 were added to the sediment prior to extraction for use as internal standards for quantification purposes.

In addition to the analyses performed at NIST, SRM 1944 was used in an interlaboratory comparison exercise in 1995 as part of the NIST Intercomparison Exercise Program for Organic Contaminants in the Marine Environment [4]. Results from nineteen laboratories that participated in this exercise were used as the eighth data set in the determination of the certified values for PCB congeners and chlorinated pesticides in SRM 1944. The laboratories participating in this exercise used the analytical procedures routinely used in their laboratories to measure PCB congeners and chlorinated pesticides.

Polybrominated Diphenyl Ethers: Value assignment of the concentrations of eight PBDE congeners was based on the means of results from two interlaboratory studies [5,6] and two sets of data from NIST. The laboratories participating in the interlaboratory exercises (see Appendix A) employed the analytical procedures routinely used in their laboratories to measure PBDEs. For the two methods used at NIST, six test portions (between 1 g and 2 g) were extracted using PFE at 100 °C with DCM. The extracts were cleaned up using an alumina column (5 % deactivated) SPE column. Size exclusion chromatography (SEC) on a divinylbenzene-polystyrene column (10 μm particle size, 10 nm (100 angstrom) pore size, 7.5 mm i.d. × 300 mm, PL-Gel, Polymer Labs, Inc.) was then used to remove the sulfur. The PBDEs, as well as PCBs and pesticides, were quantified using GC/MS in the electron impact mode on a 0.18 mm i.d. × 30 m fused silica capillary column with a 5 % (mole fraction) phenyl methylpolysiloxane phase (0.18 μm film thickness; DB-5MS, Agilent Technologies). The PBDEs were also quantified using GC/MS in the negative chemical ionization mode on a 0.18 mm i.d. × 10 m fused silica capillary column with a 5 % (mole fraction) phenyl methylpolysiloxane phase (0.18 μm film thickness; DB-5MS, Agilent Technologies). Selected Carbon-13 labeled PBDE and PCB congeners were added to the sediment prior to extraction for use as internal standards for quantification purposes.

Polychlorinated Dibenzo-*p*-dioxins and Dibenzofurans: Value assignment of the concentrations of the polychlorinated dibenzo-*p*-dioxin and dibenzofuran congeners and the total tetra- through hepta- substituted polychlorinated dibenzo-*p*-dioxins and dibenzofurans was accomplished by combining results from the analysis of SRM 1944 by fourteen laboratories that participated in an interlaboratory comparison study (see Appendix B). Each laboratory analyzed three test portions (typically 1 g) of SRM 1944 using their routine analytical procedures and high resolution gas chromatography with high resolution mass spectrometry detection (GC-HRMS). The analytical procedures used by all of the laboratories included spiking with ^{13}C-labeled surrogates (internal standards); Soxhlet extraction with toluene; sample extract cleanup with acid/base silica, alumina, and carbon columns; and finally analysis of the cleaned up extract with GC-HRMS. Most of the laboratories used a 5 % phenyl-substituted methylpolysiloxane phase capillary column (DB-5), and about half of the laboratories confirmed 2,3,7,8-tetrachlorodibenzofuran using a 50 % cyanopropylphenyl-substituted methylpolysiloxane (DB-225, J&W Scientific, Folsom, CA) capillary column.

Analytical Approach for Inorganic Constituents: Value assignment for the concentrations of selected trace elements was accomplished by combining results of the analyses of SRM 1944 from NIST, NRCC, IAEA, and seven laboratories that participated in an interlaboratory comparison exercise coordinated by NRCC [7] (see Appendix C). The analytical methods used for the determination of each element are summarized in Table 18. For the certified concentration values listed in Table 4, results were combined from: (1) analyses at NIST using isotope dilution inductively coupled plasma mass spectrometry (ID-ICPMS) or instrumental neutron activation analysis (INAA), (2) analyses at NRCC using ID-ICPMS, graphite furnace atomic absorption spectrometry (GFAAS), and/or inductively coupled plasma optical emission spectroscopy (ICPOES), (3) analyses at IAEA using INAA, and (4) the mean of the results from seven laboratories that participated in the NRCC interlaboratory comparison exercise. The reference mass fraction values in Table 9 were determined by combining results from (1) analyses performed at NIST using INAA; (2) analyses at NRCC using ID-ICPMS, GFAAS, ICPOES, and/or cold vapor atomic absorption spectroscopy (CVAAS); (3) analyses at IAEA using INAA; and (4) the mean of the results from five to seven laboratories that participated in the NRCC interlaboratory comparison exercise. The information concentration values in Table 15 were determined by INAA at NIST and IAEA.

NIST Analyses using ID-ICPMS: Lead, cadmium, and nickel were determined by ID-ICPMS [8]. Test portions (0.4 g to 0.5 g) from six bottles of the SRM were spiked with ^{206}Pb, ^{111}Cd, and ^{62}Ni and wet ashed using a combination of nitric,

hydrochloric, hydrofluoric, and perchloric acids. Lead and cadmium were determined in the same test portions; nickel was determined in a second sample set. A small amount of crystalline material remained after the acid dissolution. Lithium metaborate fusion was performed on this residue to confirm that the residue contained insignificant amounts of the analytes. Cadmium and nickel were separated from the matrix material to eliminate the possibility of spectral interferences, and concentrations were determined from the measurement of the $^{112}Cd/^{111}Cd$ and $^{62}Ni/^{60}Ni$ ratios, respectively. The $^{208}Pb/^{206}Pb$ ratios were measured directly because interferences at these masses are negligible.

NIST Analyses using INAA: Analyses were performed in two steps [9]. Elements with short-lived irradiation products (Al, Ca, Cl, K, Mg, Mn, Na, Ti, and V) were determined by measuring duplicate 300 mg test portions from each of ten bottles of SRM 1944. The samples, standards, and controls were packaged in clean polyethylene bags and were individually irradiated for 15 s in the NIST Reactor Pneumatic Facility RT-4. Reactor power was 20 MW, which corresponds to a neutron fluence rate of about 8×10^{13} $cm^{-2} \cdot s^{-1}$. After irradiation, the samples, controls, and standards were repackaged in clean polyethylene bags and counted (gamma-ray spectrometry) three times at different decay intervals. A sample-to-detector distance (counting geometry) of 20 cm was used. Elements with long-lived irradiation products (Ag, As, Br, Co, Cr, Cs, Fe, Rb, Sb, Sc, Se, Th, and Zn) were determined by measuring one 300 mg test portion from each of nine bottles of SRM 1944. The samples, standards, controls, and blank polyethylene bags were irradiated together for a total of 1 h at a reactor power of 20 MW. Approximately four days after irradiation, the polyethylene bags were removed, and each sample, standard, control, and blank was counted at 20 cm from the detector. The samples were then recounted at 10 cm from another detector. After an additional decay time of about one month, the samples, standards, controls, and blanks were counted a third time (at 10 cm) from the second detector.

Homogeneity Assessment for Inorganic Constitutents: For some of the trace elements, most notably Cd, Fe, Pb, Rb, Sb, Sc, and Th, the variations among the test portions measured at NIST (between 0.3 g and 0.5 g) were larger than expected from the measurement process. Based on experience, it was concluded that there is some material inhomogeneity for trace elements in the test portions used. Sample variations among the NIST measurements are used as slightly conservative estimates of the sample inhomogeneities.

Particle Size Information: Dry particle-size distribution measurements for SRM 1944 were obtained as part of a collaborative effort with Honeywell's Particle and Components Measurements Laboratory (Clearwater, FL). A Microtrac particle analyzer, which makes use of light-scattering techniques, was used to measure the particle-size distribution of SRM 1944. Briefly, a reference beam is used to penetrate a field of particles and the light that scatters in the forward direction from the field is measured and the particle-size as a volume distribution is derived via a computer-assisted analysis. From these data, the total volume, average size, and a characteristic width of the particle size distribution are calculated. The system has a working range from 0.7 μm to 700 μm.

Total Organic Carbon and Percent Extractable Mass: Four laboratories provided results for total organic carbon (TOC) using similar procedures. Briefly, test portions of approximately 200 mg were reacted with 6 mol/L hydrochloric acid and rinsed with deionized water prior to combustion in a gas fusion furnace. The carbon monoxide and carbon dioxide produced were measured and compared to a blank for calculation of the percent TOC. Each laboratory analyzed test portions from six bottles of SRM 1944. For the determination of percent extractable mass, six test portions of approximately 1 g to 2 g of SRM 1944 were extracted using Soxhlet extraction for 18 h with DCM. The extraction thimbles were allowed to air dry. After reaching constant mass, the difference in the mass before and after extraction was determined.

Polychlorinated Naphthalenes: Value assignment of PCN congener concentrations was accomplished by combining results from the analysis of SRM 1944 by six laboratories that participated in an interlaboratory comparison study (see Appendix D). Each laboratory analyzed three test portions (typically 1 g to 2 g) of SRM 1944 using their routine analytical procedures that included high-resolution gas chromatography with either high-resolution mass spectrometry detection (GC-HRMS) or low-resolution MS in the negative chemical ionization mode. Calibration mixtures included either Halowax mixtures with known volume fractions of individual congeners or individual PCN congeners.

HBCDs: Value assignment of the concentrations of three HBCD isomers was accomplished by combining results from the analysis of SRM 1944 in two sets from NIST and one set from Virginia Institute of Marine Science. For the two sets analyzed at NIST, the second fraction from an acidified silica SPE clean-up was analyzed by LC/MS/MS for the HBCDs using both electrospray ionization (ESI) and atmospheric pressurized photoionization (APPI). A C18 column (3.0 mm × 150 mm × 3.5 µm column, Eclipse Plus, Agilent Technologies) and YMC Carotenoid S5 C30 column (4.6 mm × 250 mm × 5 µm column) were used with a solvent gradient using 2.5 mmol/L ammonium acetate in 12.5 % water in methanol and acetonitrile at a flow rate of 0.3 mL/min. Carbon-13 labeled HBCDs were added to the sediment prior to solvent extraction for use as internal standards for quantification purposes.

Table 1. Certified Mass Fraction Values for Selected PAHs in SRM 1944 (Dry-Mass Basis)

	Mass Fraction[a,b] (mg/kg)		
Phenanthrene[c,d,e,f,g]	5.27	±	0.22
Fluoranthene[c,d,e,f,g]	8.92	±	0.32
Pyrene[c,d,e,f,g]	9.70	±	0.42
Benzo[*c*]phenathrene[c,d,e,f,h]	0.76	±	0.10
Benz[*a*]anthracene[c,d,e,f,g,h]	4.72	±	0.11
Chrysene[,h,k]	4.86	±	0.10[i]
Triphenylene[h,k]	1.04	±	0.27
Benzo[*b*]fluoranthene[g,h,j]	3.87	±	0.42
Benzo[*j*]fluoranthene[h,j]	2.09	±	0.44
Benzo[*k*]fluoranthene[c,d,e,f,g,h,j]	2.30	±	0.20
Benzo[*a*]fluoranthene[c,d,e,f,h,,j]	0.78	±	0.12
Benzo[*e*]pyrene[c,d,e,f,h,j]	3.28	±	0.11
Benzo[*a*]pyrene[c,d,e,f,g,h,j]	4.30	±	0.13
Perylene[c,d,e,f,g,h,j]	1.17	±	0.24
Benzo[*ghi*]perylene[c,d,e,f,,j,k]	2.84	±	0.10
Indeno[1,2,3-*cd*]pyrene[c,d,e,f,j,k]	2.78	±	0.10
Dibenz[*a,j*]anthracene[c,d,e,f,,j,k]	0.500	±	0.044
Dibenz[*a,c*]anthracene[,j,k]	0.335	±	0.013
Dibenz[*a,h*]anthracene[j,k]	0.424	±	0.069
Pentaphene[c,d,e,f,,j,k]	0.288	±	0.026
Benzo[*b*]chrysene[c,d,e,f,j,k,h]	0.63	±	0.10
Picene[c,d,e,f,j,k]	0.518	±	0.093

[a] Mass fractions are reported on dry-mass basis; material as received contains approximately 1.3 % moisture.
[b] Each certified value is a mean of the means from two or more analytical methods, weighted as described in Paule and Mandel [10]. Each uncertainty, computed according to the Comité International des Poids et Mesures (CIPM) approach as described in the ISO Guide [11,12], is an expanded uncertainty at the 95 % level of confidence, which includes random sources of uncertainty within each analytical method as well as uncertainty due to the drying study. The expanded uncertainty defines a range of values within which the true value is believed to lie, at a level of confidence of approximately 95 %.
[c] Gas chromatography/mass spectrometry (GC/MS) (I) on 5 % phenyl-substituted methylpolysiloxane phase after Soxhlet extraction with DCM.
[d] GC/MS (II) on 5 % phenyl-substituted methylpolysiloxane phase after Soxhlet extraction with DCM.
[e] GC/MS (III) on 5 % phenyl-substituted methylpolysiloxane phase after Soxhlet extraction with 50 % hexane/50 % acetone mixture.
[f] GC/MS (IV) on 5 % phenyl-substituted methylpolysiloxane phase after PFE with 50 % hexane/50 % acetone mixture.
[g] LC-FL of total PAH fraction after Soxhlet extraction with 50 % hexane/50 % acetone mixture.
[h] GC/MS (Sm) using a smectic liquid crystalline phase after Soxhlet extraction with DCM.
[i] The uncertainty interval for chrysene was widened in accordance with expert consideration of the analytical procedures, along with the analysis of the data as a whole, which suggests that the half-widths of the expanded uncertainties should not be less than 2 %.
[j] GC/MS (V) on 50 % phenyl-substituted methylpolysiloxane phase of extracts from GC/MS (III) and GC/MS (IV).
[k] LC-FL of isomeric PAH fractions after Soxhlet extraction with 50 % hexane/50 % acetone mixture.

Table 2. Certified Mass Fraction Values for Selected PCB Congeners[a] in SRM 1944 (Dry-Mass Basis)

		Mass Fraction[b,c] (µg/kg)		
PCB 8	(2,4'-Dichlorobiphenyl)[d,e,f,g,h,i,j,k]	22.3	±	2.3
PCB 18	(2,2',5-Trichlorobiphenyl)[d,e,f,g,h,i,j,k]	51.0	±	2.6
PCB 28	(2,4,4'-Trichlorobiphenyl)[d,e,f,g,j,k]	80.8	±	2.7
PCB 31	(2,4',5-Trichlorobiphenyl)[d,e,f,g,j]	78.7	±	1.6[l]
PCB 44	(2,2'3,5'-Tetrachlorobiphenyl)[d,e,f,g,h,i,j,k]	60.2	±	2.0
PCB 49	(2,2'4,5'-Tetrachlorobiphenyl)[d,e,f,g,h,i,j,k]	53.0	±	1.7
PCB 52	(2,2',5,5'-Tetrachlorobiphenyl)[d,e,f,g,h,i,j,k]	79.4	±	2.0
PCB 66	(2,3',4,4'-Tetrachlorobiphenyl)[e,g,h,i,j]	71.9	±	4.3
PCB 95	(2,2',3,5',6-Pentachlorobiphenyl)[e,g,h,i,j]	65.0	±	8.9
PCB 87	(2,2',3,4,5'-Pentachlorobiphenyl)[d,e,f,g,h,i,j]	29.9	±	4.3
PCB 99	(2,2',4,4',5-Pentachlorobiphenyl)[d,e,f,g,h,i,j,k]	37.5	±	2.4
PCB 101	(2,2',4,5,5'-Pentachlorobiphenyl)[d,e,f,g,h,i,j,k]	73.4	±	2.5
PCB 105	(2,3,3',4,4'-Pentachlorobiphenyl)[e,f,g,h,i,j,k]	24.5	±	1.1
PCB 110	(2,3,3',4',6-Pentachlorobiphenyl)[g,h,i,j]	63.5	±	4.7
PCB 118	(2,3',4,4',5-Pentachlorobiphenyl)[d,e,f,g,h,i,j,k]	58.0	±	4.3
PCB 128	(2,2',3,3',4,4'-Hexachlorobiphenyl)[d,e,f,g,h,i,j,k]	8.47	±	0.28
PCB 138	(2,2',3,4,4',5'-Hexachlorobiphenyl)[d,e,f,g,h,i,j,k]	62.1	±	3.0
PCB 149	(2,2',3,4',5',6-Hexachlorobiphenyl)[d,e,f,g,h,i,j,k]	49.7	±	1.2
PCB 151	(2,2',3,5,5',6-Hexachlorobiphenyl)[d,e,f,g,h,i,j,k]	16.93	±	0.36
PCB 153	(2,2',4,4',5,5'-Hexachlorobiphenyl)[d,e,f,g,h,i,j,k]	74.0	±	2.9
PCB 156	(2,3,3',4,4',5-Hexachlorobiphenyl)[d,e,f,g,h,i,j]	6.52	±	0.66
PCB 170	(2,2',3,3',4,4',5-Heptachlorobiphenyl)[d,e,f,g,h,i,j,k]	22.6	±	1.4
PCB 180	(2,2',3,4,4',5,5'-Heptachlorobiphenyl)[d,e,f,g,h,i,j,k]	44.3	±	1.2
PCB 183	(2,2',3,4,4',5',6-Heptachlorobiphenyl)[d,e,f,g,h,i,j]	12.19	±	0.57
PCB 187	(2,2',3,4',5,5',6-Heptachlorobiphenyl)[d,e,f,g,h,i,j,k]	25.1	±	1.0
PCB 194	(2,2',3,3',4,4',5,5'-Octachlorobiphenyl)[d,e,f,g,h,i,j]	11.2	±	1.4
PCB 195	(2,2',3,3',4,4',5,6-Octachlorbiphenyl)[d,e,f,g,h,i,j,k]	3.75	±	0.39
PCB 206	(2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl)[d,e,f,g,h,i,j,k]	9.21	±	0.51
PCB 209	Decachlorobiphenyl[d,e,f,g,h,i,j,k]	6.81	±	0.33

[a] PCB congeners are numbered according to the scheme proposed by Ballschmiter and Zell [13] and later revised by Schulte and Malisch [3] to conform with IUPAC rules; for the specific congeners mentioned in this SRM, the Ballschmiter-Zell numbers correspond to those of Schulte and Malisch.

[b] Mass fractions are reported on dry-mass basis; material as received contains approximately 1.3 % moisture.

[c] Each certified value is a mean of the means from two or more analytical methods, weighted as described in Paule and Mandel [10]. Each uncertainty, computed according to the CIPM approach as described in the ISO Guide [11,12], is an expanded uncertainty at the 95 % level of confidence, which includes random sources of uncertainty within each analytical method as well as uncertainty due to the drying study. The expanded uncertainty defines a range of values within which the true value is believed to lie, at a level of confidence of approximately 95 %.

[d] GC-ECD (IA) on 5 % phenyl-substituted methylpolysiloxane phase after Soxhlet extraction with DCM.

[e] GC-ECD (IB) on the 50 % C-18 dimethylpolysiloxane phase; same extracts analyzed as in GC-ECD (IA).

[f] GC-ECD (IIA) on 5 % phenyl-substituted methylpolysiloxane phase after Soxhlet extraction with DCM.

[g] GC-ECD (IIB) on the 50 % octadecyl (C-18) methylpolysiloxane phase; same extracts analyzed as in GC-ECD (IIA).

[h] GC/MS (I) on 5 % phenyl-substituted methylpolysiloxane phase after Soxhlet extraction with 50 % hexane/50 % acetone mixture.

[i] GC/MS (II) on 5 % phenyl-substituted methylpolysiloxane phase after PFE extraction with 50 % hexane/50 % acetone mixture.

[j] GC/MS (III) on 5 % phenyl-substituted methylpolysiloxane phase; same extracts analyzed as in GC-ECD (IIA).

[k] Results from nineteen laboratories participating in an interlaboratory comparison exercise.

[l] The uncertainty interval for PCB 31 was widened in accordance with expert consideration of the analytical procedures, along with the analysis of the data as a whole, which suggests that the half-widths of the expanded uncertainties should not be less than 2 %.

Table 3. Certified Mass Fraction Values for Selected Chlorinated Pesticides in SRM 1944 (Dry-Mass Basis)

	Mass Fraction[a,b] (μg/kg)		
Hexachlorobenzene[e,f,g,h,i,j]	6.03	±	0.35
cis-Chlordane (α-Chlordane)[c,d,e,f,g,h,i,j]	16.51	±	0.83
trans-Nonachlor [c,d,e,f,g,h,i,j]	8.20	±	0.51

[a] Mass fractions are reported on dry-mass basis; material as received contains approximately 1.3 % moisture.
[b] Each certified value is a mean of the means from two or more analytical methods, weighted as described in Paule and Mandel [10]. Each uncertainty, computed according to the CIPM approach as described in the ISO Guide [11,12], is an expanded uncertainty at the 95 % level of confidence, which includes random sources of uncertainty within each analytical method as well as uncertainty due to the drying study. The expanded uncertainty defines a range of values within which the true value is believed to lie, at a level of confidence of approximately 95 %.
[c] GC-ECD (IA) on 5 % phenyl-substituted methylpolysiloxane phase after Soxhlet extraction with DCM.
[d] GC-ECD (IB) on the 50 % octadecyl (C-18) methylpolysiloxane phase; same extracts analyzed as in GC-ECD (IA).
[e] GC-ECD (IIA) on 5 % phenyl-substituted methylpolysiloxane phase after Soxhlet extraction with DCM.
[f] GC-ECD (IIB) on the 50 % octadecyl (C-18) methylpolysiloxane phase; same extracts analyzed as in GC-ECD (IIA).
[g] GC/MS (I) on 5 % phenyl-substituted methylpolysiloxane phase after Soxhlet extraction with 50 % hexane/50 % acetone mixture.
[h] GC/MS (II) on 5 % phenyl-substituted methylpolysiloxane phase after PFE extraction with 50 % hexane/50 % acetone mixture.
[i] GC/MS (III) on 5 % phenyl-substituted methylpolysiloxane phase; same extracts analyzed as in GC-ECD (IIA).
[j] Results from nineteen laboratories participating in an interlaboratory comparison exercise.

Table 4. Certified Mass Fraction Values for Selected Elements in SRM 1944 (Dry-Mass Basis)

	Degrees of Freedom	Mass Fractions[a,b] (%)		
Aluminum[c,d,e]	4	5.33	±	0.49
Iron[c,d,e]	6	3.53	±	0.16
		Mass Fractions[a,b] (mg/kg)		
Arsenic[c,d,e,f,g]	10	18.9	±	2.8
Cadmium[c,f,,h,i]	6	8.8	±	1.4
Chromium[c,d,f,g,i]	9	266	±	24
Lead[c,h,i]	5	330	±	48
Manganese[c,d,e]	8	505	±	25
Nickel[c,g,h,i]	6	76.1	±	5.6
Zinc[c,d,e,g,i]	9	656	±	75

[a] The certified value is the mean of four results: (1) the mean of NIST INAA or ID-ICPMS analyses, (2) the mean of two methods performed at NRCC, and (3) the mean of results from seven selected laboratories participating in the NRCC intercomparison exercise, and (4) the mean results from INAA analyses at IAEA. The expanded uncertainty in the certified value is equal to $U = ku_c$ where u_c is the combined standard uncertainty and k is the coverage factor, both calculated according to the ISO Guide [11,12]. The value of u_c is intended to represent at the level of one standard deviation the combined effect of all the uncertainties in the certified value. Here u_c accounts for both possible method biases, within-method variation, and material inhomogeneity. The coverage factor, k, is the Student's t-value for a 95 % confidence interval with the corresponding degrees of freedom. Because of the material inhomogeneity, the variability among the measurements of multiple samples can be expected to be greater than that due to measurement variability alone.
[b] Mass fractions are reported on dry-mass basis; material as received contains approximately 1.3 % moisture.
[c] Results from five to seven laboratories participating in the NRCC interlaboratory comparison exercise.
[d] Measured at NIST using INAA.
[e] Measured at NRCC using ICPOES.
[f] Measured at NRCC using GFAAS.
[g] Measured at IAEA using INAA.
[h] Measured at NIST using ID-ICPMS.
[i] Measured at NRCC using ID-ICPMS.

Table 5. Reference Mass Fraction Values for Selected PAHs in SRM 1944

	Mass Fractions[a] (mg/kg)		
Naphthalene[b]	1.28	±	0.04[c]
1-Methylnaphthalene[b]	0.47	±	0.02[c]
2-Methylnaphthalene[b]	0.74	±	0.06[c]
Biphenyl[b]	0.25	±	0.02[c]
Acenaphthene[b]	0.39	±	0.03[c]
Fluorene[b]	0.48	±	0.04[c]
Dibenzothiophene[b]	0.50	±	0.03[c]
Anthracene[b]	1.13	±	0.07[c]
1-Methylphenanthrene[d,e,f,g]	1.7	±	0.1[h]
2-Methylphenanthrene[d,e,f,g]	1.90	±	0.06[h]
3-Methylphenanthrene[d,e,f,g]	2.1	±	0.1[h]
4-Methylphenanthrene and 9-Methylphenanthrene[d,e,f,g]	1.6	±	0.2[h]
2-Methylanthracene[d,e,f,g]	0.58	±	0.04[h]
3,5-Dimethylphenanthrene[d]	1.31	±	0.04[h]
2,6-Dimethylphenanthrene[d]	0.79	±	0.02[h,i]
2,7-Dimethylphenanthrene[d]	0.67	±	0.02[h,i]
3,9-Dimethylphenanthrene[d]	2.42	±	0.05[h,i]
1,6-, 2,9-, and 2,5-Dimethylphenanthrene[d]	1.67	±	0.03[h,i]
1,7-Dimethylphenanthrene[d]	0.62	±	0.02[h,i]
1,9- and 4,9-Dimethylphenanthrene[d]	1.20	±	0.03[h,i]
1,8-Dimethylphenanthrene[d]	0.24	±	0.01[h,i]
1,2-Dimethylphenanthrene[d]	0.28	±	0.01[h,i]
8-Methylfluoranthene[d]	0.86	±	0.02[h,i]
7-Methylfluoranthene[d]	0.69	±	0.02[h]
1-Methylfluoranthene[b]	0.39	±	0.01[c]
3-Methylfluoranthene[b]	0.56	±	0.02[c]
2-Methylpyrene[d]	1.81	±	0.04[h,i]
4-Methylpyrene[d]	1.44	±	0.03[h,i]
1-Methylpyrene[d]	1.29	±	0.03[h]
Anthanthrene[j]	0.9	±	0.1[h]

[a] Mass fractions are reported on dry-mass basis; material as received contains approximately 1.3 % moisture.
[b] GC/MS (VI) on proprietary non-polar methylpolysiloxane phase after Soxhlet extraction with DCM.
[c] Reference values are the means of results obtained by NIST using one analytical technique. The expanded uncertainty, U, is calculated as $U = ku_c$, where u_c is one standard deviation of the analyte mean, and the coverage factor, k, is determined from the Student's t-distribution corresponding to the associated degrees of freedom (df = 2) and 95 % confidence level for each analyte.
[d] GC/MS (I) on 5 % phenyl-substituted methylpolysiloxane phase after Soxhlet extraction with DCM.
[e] GC/MS (II) on 5 % phenyl-substituted methylpolysiloxane phase after Soxhlet extraction with DCM.
[f] GC/MS (III) on 5 % phenyl-substituted methylpolysiloxane phase after Soxhlet extraction with 50 % hexane/50 % acetone mixture.
[g] GC/MS (IV) on 5 % phenyl-substituted methylpolysiloxane phase after PFE with 50 % hexane/50 % acetone mixture.
[h] The reference value for each analyte is the equally-weighted mean of the means from two or more analytical methods or the mean from one analytical technique. The uncertainty in the reference value defines a range of values that is intended to function as an interval that contains the true value at a level of confidence of 95 %. This uncertainty includes sources of uncertainty within each analytical method, among methods, and from the drying study.
(i) The uncertainty interval for this compound was widened in accordance with expert consideration of the analytical procedures, along with the analysis of the data as a whole, which suggests that the half-widths of the expanded uncertainties should not be less than 2 %.
[j] LC-FL of isomeric PAH fractions after Soxhlet extraction with 50 % hexane/50 % acetone mixture.

Table 6. Reference Mass Fractions for Selected PAHs of
Relative Molecular Mass 300 and 302 in SRM 1944 (Dry-Mass Basis)

	Mass Fraction[a,b,c] (mg/kg)		
Coronene	0.53	±	0.04
Dibenzo[*b,e*]fluoranthene	0.076	±	0.008
Naphtho[1,2-*b*]fluoranthene	0.70	±	0.06
Naphtho[1,2-*k*]fluoranthene and Naphtho[2,3-*j*]fluoranthene	0.66	±	0.05
Naphtho[2,3-*b*]fluoranthene	0.21	±	0.01
Dibenzo[*b,k*]fluoranthene	0.75	±	0.06
Dibenzo[*a,k*]fluoranthene	0.22	±	0.02
Dibenzo[*j,l*]fluoranthene	0.56	±	0.03
Dibenzo[*a,l*]pyrene	0.12	±	0.02
Naphtho[2,3-*k*]fluoranthene	0.11	±	0.01
Naphtho[2,3-*e*]pyrene	0.33	±	0.02
Dibenzo[*a,e*]pyrene	0.67	±	0.05
Naphtho[2,1-*a*]pyrene	0.76	±	0.05
Dibenzo[*e,l*]pyrene	0.28	±	0.02
Naphtho[2,3-*a*]pyrene	0.23	±	0.01
Benzo[*b*]perylene	0.43	±	0.04
Dibenzo[*a,i*]pyrene	0.30	±	0.03
Dibenzo[*a,h*]pyrene	0.11	±	0.01

[a] Mass fractions are reported on dry-mass basis; material as received contains approximately 1.3 % moisture.
[b] Reference values are the means of results obtained by NIST using one analytical technique. The expanded uncertainty, U, is calculated as $U = ku_c$, where u_c is one standard deviation of the analyte mean, and the coverage factor, k, is determined from the Student's t-distribution corresponding to the associated degrees of freedom (df = 2) and 95 % confidence level for each analyte.
[c] GC/MS on 50 % phenyl-substituted methylpolysiloxane phase after PFE with DCM.

Table 7. Reference Mass Fractions for Selected PCB Congeners[a] and Chlorinated Pesticides in SRM 1944 (Dry-Mass Basis)

	Mass Fraction[b] (µg/kg)
PCB 45 (2,2',3,6-Tetrachlorobiphenyl)[c]	10.8 ± 1.4[d]
PCB 146 (2,2',3,4',5,5'-Hexachlorobiphenyl)[c]	10.1 ± 1.9[d]
PCB 163 (2,3,3',4',5,6-Hexachlorobiphenyl)[c]	14.4 ± 2.0[d]
PCB 174 (2,2',3,3',4,5,6'-Heptachlorobiphenyl)[c]	16.0 ± 0.6[d]
α-HCH[f,g,h,i]	2.0 ± 0.3[e]
trans-Chlordane (γ-Chlordane)[c]	19.0 ± 1.7[d]
cis-Nonachlor[g,h,i,l,m]	3.7 ± 0.7[e]
2,4'-DDE[f,g,h,i,j,k,l,m]	19 ± 3[e]
2,4'-DDD[h,j,k,l,m]	38 ± 8[e]
4,4'-DDE[f,g,h,ihj,k,l,m]	86 ± 12[e]
4,4'-DDD [f,g,h,I,j,k,l,m]	108 ± 16[e]
4,4'-DDT[c]	170 ± 32[d]

[a] PCB congeners are numbered according to the scheme proposed by Ballschmiter and Zell [13] and later revised by Schulte and Malisch [3] to conform with IUPAC rules; for the specific congeners mentioned in this SRM, the Ballschmiter-Zell numbers correspond to those of Schulte and Malisch.

[b] Mass fractions are reported on dry-mass basis; material as received contains approximately 1.3 % moisture.

[c] NIST participation in the 2007 interlaboratory study using GC/MS.

[d] Reference values are the means of results obtained by NIST using one analytical technique. The expanded uncertainty, U, is calculated as $U = ku_c$, where u_c is one standard deviation of the analyte mean, and the coverage factor, k, is determined from the Student's t-distribution corresponding to the associated degrees of freedom (df = 2) and 95 % confidence level for each analyte.

[e] The reference value for each analyte is the equally-weighted mean of the means from two or more analytical methods or he mean from one analytical technique. The uncertainty in the reference value defines a range of values that is intended to function as an interval that contains the true value at a level of confidence of 95 %. This uncertainty includes sources of uncertainty within each analytical method, among methods, and from the drying study.

[f] GC-ECD (IA) on 5 % phenyl-substituted methylpolysiloxane phase after Soxhlet extraction with DCM.

[g] GC-ECD (IB) on the 50 % octadecyl (C-18) methylpolysiloxane phase; same extracts analyzed as in GC-ECD (IA).

[h] GC-ECD (IIA) on 5 % phenyl-substituted methylpolysiloxane phase after Soxhlet extraction with DCM.

[i] GC-ECD (IIB) on the 50 % octadecyl (C-18) methylpolysiloxane phase; same extracts analyzed as in GC-ECD (IIA).

[j] GC/MS (I) on 5 % phenyl-substituted methylpolysiloxane phase after Soxhlet extraction with 50 % hexane/50 % acetone mixture.

[k] GC/MS (II) on 5 % phenyl-substituted methylpolysiloxane phase after PFE extraction with 50 % hexane/50 % acetone mixture.

[l] GC/MS (III) on 5 % phenyl-substituted methylpolysiloxane phase; same extracts anlayzed as in GC-ECD (IIA).

[m] Results from nineteen laboratories participating in an interlaboratory comparison exercise.

Table 8. Reference Mass Fraction Values for Selected PBDEs in SRM 1944 (Dry-Mass Basis)

	Mass Fractions[a] (µg/kg)
PBDE 47 (2,2',4,4'-Tetrabromodiphenyl ether)[c,d,e,f]	1.72 ± 0.28[b]
PBDE 99 (2,2',4,4',5-Pentabromodiphenyl ether)[c,d,f]	1.98 ± 0.26[b]
PBDE 100 (2,2',4,4',6-Pentabromodiphenyl ether)[c,d]	0.447 ± 0.027[b]
PBDE 153 (2,2',4,4',5,5'-Hexabromodiphenyl ether)[c,d,e,f]	6.44 ± 0.37[b]
PBDE 154 (2,2',4,4',5,6'-Hexabromodiphenyl ether)[c,d,f]	1.06 ± 0.08[b]
PBDE 183 (2,2',3,4,4',5',6-Heptabromodiphenyl ether)[c,d,e,f]	31.8 ± 0.1[b]
PBDE 206 (2,2',3,3',4,4',5,5',6-Nonabromodiphenyl ether)[d,e]	6.2 ± 1.0[b]
PBDE 209 (Decabromodiphenyl ether)[c,d,e,f]	93.5 ± 4.4[b]

[a] Mass fractions are reported on dry-mass basis; material as received contains approximately 1.3 % moisture.
[b] Reference values are weighted means of the results from two to four analytical methods [14]. The uncertainty listed with each value is an expanded uncertainty about the mean, with coverage factor 2 (approximately 95 % confidence), calculated by combining a between-method variance incorporating inter-method bias with a pooled within-source variance following the ISO/NIST Guide to the Expression of Uncertainty in Measurements [11,12].
[c] Results from ten laboratories participating in an interlaboratory study for PBDEs in sediment [12].
[d] Results from four laboratories participating in the 2007 interlaboratory study [13].
[e] NIST participation in the 2007 interlaboratory study using GC/MS.
[f] Data set from NIST for PBDEs using GC/MS following PFE with alumina SPE and SEC clean-up.

Table 9. Reference Mass Fraction Values for Selected Elements in SRM 1944 (Dry-Mass Basis)

	Degrees of Freedom	Mass Fraction[a,b] (%)
Silicon[c,d]	81	31 ± 3
		Mass Fraction[a,b] (mg/kg)
Antimony[c,e,f,g]	18	4.6 ± 0.9
Beryllium[c,h]	17	1.6 ± 0.3
Copper[c,d,f]	101	380 ± 40
Mercury[c,i]	18	3.4 ± 0.5
Selenium[c,e,f]	24	1.4 ± 0.2
Silver[c,d,e,g]	8	6.4 ± 1.7
Thallium[c,f]	12	0.59 ± 0.1
Tin[c,f]	22	42 ± 6

[a] The reference value is the equally weighted mean of available results from: (1) NIST INAA analyses, (2) two methods performed at NRCC, (3) results from seven selected laboratories participating in the NRCC intercomparison exercise, and (4) results from INAA analyses at IAEA. The expanded uncertainty in the reference value is equal to $U = ku_c$ where u_c is the combined standard uncertainty and k is the coverage factor, both calculated according to the ISO Guide [11,12]. The value of u_c is intended to represent at the level of one standard deviation the uncertainty in the value. Here u_c accounts for possible method differences, within-method variation, and material inhomogeneity. The coverage factor, k, is the Student's t-value for a 95 % confidence interval with the corresponding degrees of freedom. Because of material inhomogeneity, the variability among the measurements of multiple test portions can be expected to be greater than that due to measurement variability alone.
[b] Mass fractions are reported on dry-mass basis; material as received contains approximately 1.3 % moisture.
[c] Results from five to seven laboratories participating in the NRCC interlaboratory comparison exercise.
[d] Measured at NRCC using GFAAS.
[e] Measured at NIST using INAA.
[f] Measured at NRCC using ID-ICPMS.
[g] Measured at IAEA using INAA.
[h] Measured at NRCC using ICPOES.
[i] Measured at NRCC using cold vapor atomic absorption spectroscopy (CVAAS).

Table 10. Reference Mass Fraction Values for Elements in SRM 1944 as Determined by INAA (Dry-Mass Basis)

	Effective Degrees of Freedom	Mass Fraction[a,b] (%)		
Calcium	21	1.0	±	0.1
Chlorine	21	1.4	±	0.2
Potassium	21	1.6	±	0.2
Sodium	25	1.9	±	0.1
		Mass Fraction[a,b] (mg/kg)		
Bromine	10	86	±	10
Cesium	11	3.0	±	0.3
Cobalt	10	14	±	2
Rubidium	14	75	±	2
Scandium	37	10.2	±	0.2
Titanium	21	4300	±	300
Vanadium	21	100	±	9

[a] The reference value is based on the results from an INAA study. The associated uncertainty accounts for both random and systematic effects, but because only one method was used, the results should be used with caution. The expanded uncertainty in the reference value is equal to $U = ku_c$ where u_c is the combined standard uncertainty and k is the coverage factor, both calculated according to the ISO Guide [11,12]. The value of u_c is intended to represent at the level of one standard deviation the uncertainty in the value. Here u_c accounts for possible method differences, within-method variation, and material inhomogeneity. The coverage factor, k, is the Student's t-value for a 95 % confidence interval with the corresponding degrees of freedom. Because of material inhomogeneity, the variability among the measurements of multiple test portions can be expected to be greater than that due to measurement variability alone.

[b] Mass fractions are reported on dry-mass basis; material as received contains approximately 1.3 % moisture.

Table 11. Reference Mass Fraction Values for
Selected Dibenzo-*p*-Dioxin and Dibenzofuran Congeners in SRM 1944 (Dry-Mass Basis)

	Mass Fraction[a,b] (µg/kg)		
2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	0.133	±	0.009
1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin	0.019	±	0.002
1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin	0.026	±	0.003
1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin	0.056	±	0.006
1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin	0.053	±	0.007
1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin	0.80	±	0.07
Octachlorodibenzo-*p*-dioxin	5.8	±	0.7
2,3,7,8-Tetrachlorodibenzofuran[c]	0.039	±	0.015[d]
1,2,3,7,8-Pentachlorodibenzofuran	0.045	±	0.007
2,3,4,7,8-Pentachlorodibenzofuran	0.045	±	0.004
1,2,3,4,7,8-Hexachlorodibenzofuran	0.22	±	0.03
1,2,3,6,7,8-Hexachlorodibenzofuran	0.09	±	0.01
2,3,4,6,7,8-Hexachlorodibenzofuran	0.054	±	0.006[e]
1,2,3,4,6,7,8-Heptachlorodibenzofuran	1.0	±	0.1
1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.040	±	0.006[e]
Octachlorodibenzofuran	1.0	±	0.1
Total Toxic Equivalents (TEQ)[f]	0.25	±	0.01
Total Tetrachlorodibenzo-*p*-dioxins	0.25	±	0.05[e]
Total Pentachlorodibenzo-*p*-dioxins	0.19	±	0.06
Total Hexachlorodibenzo-*p*-dioxins	0.63	±	0.09
Total Heptachlorodibenzo-*p*-dioxins	1.8	±	0.2
Total Tetrachlorodibenzofurans	0.7	±	0.2
Total Pentachlorodibenzofurans	0.74	±	0.07
Total Hexachlorodibenzofurans	1.0	±	0.1
Total Heptachlorodibenzofurans	1.5	±	0.1
Total Dibenzo-*p*-dioxins[g]	8.7	±	0.9
Total Dibenzofurans[g]	5.0	±	0.5

[a] Each reference value is the mean of the results from up to fourteen laboratories participating in an interlaboratory exercise. The expanded uncertainty in the reference value is equal to $U = ku_c$ where u_c is the combined standard uncertainty calculated according to the ISO Guide [11,12] and k is the coverage factor. The value of u_c is intended to represent at the level of one standard deviation the combined effect of all the uncertainties in the reference value. Here u_c is the uncertainty in the mean arising from the variation among the laboratory results. The degrees of freedom is equal to the number of available results minus one (13 unless noted otherwise). The coverage factor, k, is the value from a Student's t-distribution for a 95 % confidence interval.

[b] Mass fractions are reported on dry-mass basis; material as received contains approximately 1.3 % moisture.

[c] Confirmation results using a 50 % cyanopropyl phenyl polysiloxane or 90 % *bis*-cyanopropyl 10 % cyanopropylphenyl polysiloxane phase columns.

[d] Degrees of freedom = 7 for this compound.

[e] Degrees of freedom = 12 for this compound.

[f] TEQ is the sum of the products of each of the 2,3,7,8-substituted congeners multiplied by their individual toxic equivalency factors (TEFs) recommended by the North Atlantic Treaty Organization (NATO) [15]. With regard to 2,3,7,8-tetrachlorodibenzofuran, the results of the confirmation column were used when available to calculate the TEQ.

[g] Total of tetra- through octachlorinated congeners.

Table 12. Reference Values for Particle Size Characteristics for SRM 1944

Particle Measurement	Value[a]
Mean diameter (volume distribution, MV, μm)[b]	151.2 ± 0.4
Mean diameter (area distribution, μm)[c]	120.4 ± 0.1
Mean diameter (number distribution, μm)[d]	75.7 ± 0.3
Surface Area (m^2/cm^3)[e]	0.050 ± 0.013

[a] The reference value is the mean value of measurements from the analysis of test portions from four bottles. Each uncertainty, computed according to the CIPM approach as described in the ISO Guide [11,12], is an expanded uncertainty at the 95 % level of confidence, which includes random sources of uncertainty. The expanded uncertainty defines a range of values for the reference value within which the true value is believed to lie, at a level of confidence of 95 %.

[b] The mean diameter of the volume distribution represents the center of gravity of the distribution and compensates for scattering efficiency and refractive index. This parameter is strongly influenced by coarse particles.

[c] The mean diameter of the area distribution, calculated from the volume distribution with less weighting by the presence of coarse particles than MV.

[d] The mean diameter of the number distribution, calculated using the volume distribution weighted to small particles.

[e] Calculated specific surface area assuming solid, spherical particles. This is a computation and should not be interchanged with an adsorption method of surface area determination as this value does not reflect porosity or topographical characteristics.

Table 13. Percentage of the Volume That is Smaller Than the Indicated Size

Percentile	Particle Diameter[a] (μm)
95	296 ± 5
90	247 ± 2
80	201 ± 1
70	174 ± 1
60	152 ± 1
50[b]	135 ± 1
40	120 ± 1
30	106 ± 1
20	91 ± 1
10	74 ± 1

[a] The reference value for particle diameter is the mean value of measurements from the analysis of test portions from four bottles. Each uncertainty, computed according to the CIPM approach as described in the ISO Guide [11,12], is an expanded uncertainty at the 95 % level of confidence, which includes random sources of uncertainty. The expanded uncertainty defines a range of values for the reference value within which the true value is believed to lie, at a level of confidence of 95 %.

[b] Median diameter (50 % of the volume is less than 135 μm).

Table 14. Reference Values for Total Organic Carbon and Percent Extractable Mass in SRM 1944

	Mass Fraction (%)		
Total Organic Carbon (TOC)[a,b]	4.4	±	0.3
Extractable Mass[c,d]	1.15	±	0.04

[a] Mass fraction is reported on a dry-mass basis; material as received contains approximately 1.3 % moisture.
[b] The reference value for total organic carbon is an equally weighted mean value from routine measurements made by three laboratories. Each uncertainty, computed according to the CIPM approach as described in the ISO Guide [11,12], is an expanded uncertainty at the 95 % level of confidence, which includes random sources of uncertainty. The expanded uncertainty defines a range of values for the reference value within which the true value is believed to lie, at a level of confidence of 95 %.
[c] Extractable mass as determined from Soxhlet extraction using DCM.
[d] The reference value for extractable mass is the mean value of six measurements. Each uncertainty, computed according to the CIPM approach as described in the ISO Guide [11,12], is an expanded uncertainty at the 95 % level of confidence, which includes random sources of uncertainty. The expanded uncertainty defines a range of values for the reference value within which the true value is believed to lie, at a level of confidence of 95 %.

Table 15. Information Mass Fraction Values for Selected Elements in SRM 1944 as Determined by INAA (Dry-Mass Basis)

	Mass Fraction[a] (%)
Magnesium[b]	1.0

	Mass Fraction[a] (mg/kg)
Cerium[b]	65
Europium[b]	1.3
Gold[b]	0.10
Lanthanum[b]	39
Thorium[b]	13
Uranium[b]	3.1

[a] Mass fraction is reported on a dry-mass basis; material as received contains approximately 1.3 % moisture.
[b] Measured at IAEA using INAA

Table 16. Information Mass Fraction Values for
Selected Polychlorinated Naphthalenes in SRM 1944 (Dry-Mass Basis)

			Mass Fraction[a] (µg/kg)
PCN	19	(1,3,5-Trichloronaphthalene)	1.4
PCN	23	(1,4,5-Trichloronaphthalene)	2.4
PCN	42	(1,3,5,7-Tetrachloronaphthalene)	2.7
PCN	47	(1,4,6,7-Tetrachloronaphthalene)	3.5
PCN	52	(1,2,3,5,7-Pentachloronaphthalene)	2.5
	60	(1,2,4,6,7-Pentachloronaphthalene)	
PCN	50	(1,2,3,4,6-Pentachloronaphthalene)	1.0
PCN	66	(1,2,3,4,6,7-Hexachloronaphthalene)	0.63
	67	(1,2,3,5,6,7-Hexachloronaphthalene)	
PCN	69	(1,2,3,5,7,8-Hexachloronaphthalene)	1.6
PCN	73	(1,2,3,4,5,6,7-Heptachloronaphthalene)	0.51
PCN	75	(Octachloronaphthalene)	0.20

[a] Mass fractions reported on dry-mass basis; material as received contains approximately 1.3 % moisture. Information values are the median of the results from six laboratories participating in an interlaboratory comparison exercise (Appendix D).

Table 17. Information Mass Fraction Values for Three HBCD Isomers in SRM 1944 (Dry-Mass Basis)

	Mass Fraction[a,b] (µg/kg)
alpha-HBCD[b]	2.2
beta-HBCD[b]	1.0
gamma-HBCD[b]	18

[a] The information value is the median of the results from three analytical methods.
[b] Mass fractions are reported on dry-mass basis; material as received contains approximately 1.3 % moisture.

Table 18. Analytical Methods Used for the Measurement of Elements in SRM 1944

Elements	Analytical Methods
Aluminum	FAAS, ICPOES, INAA, XRF
Antimony	GFAAS, HGAAS, ICP-MS, ID-ICPMS, INAA
Arsenic	GFAAS, HGAAS, ICPMS, INAA, XRF
Beryllium	GFAAS, ICP-AES, ICPMS
Bromine	INAA
Cadmium	FAAS, GFAAS, ICPMS, ID-ICPMS
Calcium	INAA
Cerium	INAA
Cesium	INAA
Chlorine	INAA
Chromium	FAAS, GFAAS, ICPMS, ID-ICPMS, INAA, XRF
Cobalt	INAA
Copper	FAAS, GFAAS, ICPOES, ICPMS, ID-ICPMS, XRF
Europium	INAA
Gold	INAA
Iron	FAAS, ICPOES, ICPMS, ID-ICPMS, INAA, XRF
Lanthanum	INAA
Lead	FAAS, GFAAS, ICPMS, ID-ICPMS, XRF
Magnesium	INAA
Manganese	FAAS, ICPOES, ICPMS, INAA, XRF
Mercury	CVAAS, ICPMS
Nickel	GFAAS, ICPOES, ICPMS, ID-ICPMS, INAA, XRF
Potassium	INAA
Rubidium	INAA
Scandium	INAA
Selenium	GFAAS, HGAAS, ICPMS, INAA
Silicon	FAAS, ICPOES, XRF
Silver	FAAS, GFAAS, ICPMS, INAA
Sodium	INAA
Thallium	GFAAS, ICPOES, ICPMS, ID-ICPMS,
Thorium	INAA
Tin	GFAAS, ICPMS, ID-ICPMS
Titanium	INAA
Uranium	INAA
Vanadium	INAA
Zinc	FAAS, ICPOES, ICPMS, ID-ICPMS, XRF, INAA

Methods	
CVAAS	Cold vapor atomic absorption spectrometry
FAAS	Flame atomic absorption spectrometry
GFAAS	Graphite furnace atomic absorption spectrometry
HGAAS	Hydride generation atomic absorption spectrometry
ICPOES	Inductively coupled plasma optical emission spectrometry
ICPMS	Inductively coupled plasma mass spectrometry
ID-ICPMS	Isotope dilution inductively coupled plasma mass spectrometry
INAA	Instrumental neutron activation analysis
XRF	X-ray fluorescence spectrometry

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Certificate Revision History: 27 September 2011 (Addition of mass fraction values for PBDE and PCN congeners; change of mass fraction reference values; editorial changes); **22 December 2008** (Extension of certification period); **14 May 1999** (Original certificate date).

Users of this SRM should ensure that the Certificate of Analysis in their possession is current. This can be accomplished by contacting the SRM Program at: telephone (301) 975-2200; fax (301) 926-4751; e-mail srminfo@nist.gov; or via the Internet at http://www.nist.gov/srm.

APPENDIX A

The analysts and laboratories listed below participated in the interlaboratory comparison exercise for the determination of PBDEs in SRM 1944 [4].

D. Hoover and C. Hamilton, AXYS Analytical, Sidney, BC, Canada
S. Klosterhaus and J. Baker, Chesapeake Biological Laboratory, Solomons, MD, USA
S. Backus, Environment Canada, Ecosystem Health Division, Burlington, ON, Canada
E. Sverko, Environment Canada, Canada Centre for Inland Waters, Burlington, ON, Canada
P. Lepom, Federal Environmental Agency, Berlin, Germany
R. Hites and L. Zhu, Indiana University, Bloomington, IN, USA
G. Jiang, Research Center for Eco-Environmental Sciences, Beijing, China
H. Takada, Tokyo University of Agriculture and Technology, Tokyo, Japan
A. Covaci and S. Vorspoels, University of Antwerp, Antwerp, Belgium
A. Li, Universtiy of Illinois at Chicago, Chicago, IL, USA

APPENDIX B

The analysts and laboratories listed below participated in the interlaboratory comparison exercise for the determination of polychlorinated dibenzo-*p*-dioxins and dibenzofurans in SRM 1944.

W.J. Luksemburg, Alta Analytical Laboratory, Inc., El Dorado Hills, CA, USA
L. Phillips, AXYS Analytical Services Ltd., Sidney, British Columbia, Canada
M.J. Armbruster, Battelle Columbus Laboratories, Columbus, OH, USA
G. Reuel, Canviro Analytical Laboratories Ltd., Waterloo, Ontario, Canada
C. Brochu, Environment Québec, Laval, Québec, Canada
G. Poole, Environment Canada Environmental Technology Centre, Ottawa, Ontario, Canada
B. Henkelmann, GSF National Research Center for Environment and Health, Neuherberg, Germany
R. Anderson, Institute of Environmental Chemistry, Umeå University, Umeå, Sweden
C. Lastoria, Maxxam Analytics Inc., Mississauga, Ontario, Canada
E. Reiner, Ontario Ministry of Environment and Energy, Etobicoke, Ontario, Canada
J. Macaulay, Research and Productivity Council, Fredericton, New Brunswick, Canada
T.L. Wade, Texas A&M University, College Station, TX, USA
C. Tashiro, Wellington Laboratories, Guelph, Ontario, Canada
T.O. Tiernan, Wright State University, Dayton, OH, USA

APPENDIX C

The analysts and laboratories listed below participated in the interlaboratory comparison exercise for the determination of trace elements in SRM 1944.

A. Abbgy, Applied Marine Research Laboratory, Old Dominion University, Norfolk, VA, USA
A. Scott, Australian Government Analytical Laboratories, Pymble, Australia
H. Mawhinney, Animal Research Institute, Queensland Department of Primary Industries, Queensland, Australia
E. Crecelius, Battelle Pacific Northwest, Sequim, WA, USA
M. Stephenson, California Department of Fish and Game, Moss Landing, CA, USA
B. Presley, Department of Oceanography, Texas A&M University, College Station, TX, USA
K. Elrick, U.S. Geological Survey, Atlanta, GA, USA

APPENDIX D

The analysts and laboratories listed below participated in the interlaboratory comparison exercise for the determination of polychlorinated naphthalenes in SRM 1944.

J. Kucklick, National Institute of Standards and Technology, Charleston, SC, USA
E. Sverko, Environment Canada, Canada Centre for Inland Waters, Burlington, ON, Canada
P. Helm, Ontario Ministry of the Environment, Etobicoke, ON, Canada
N. Yamashita, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan
T. Harner, Environment Canada, Meteorological Service of Canada, Toronto, ON, Canada
R. Lega, Ontario Ministry of the Environment, Etobicoke, ON, Canada

National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 1941b

Organics in Marine Sediment

This Standard Reference Material (SRM) is marine sediment collected at the mouth of the Baltimore (MD) Harbor. SRM 1941b is intended for use in evaluating analytical methods for the determination of selected polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyl (PCB) congeners, and chlorinated pesticides in marine sediment and similar matrices. Information values are also provided for total organic carbon (TOC), total carbon, hydrogen, and nitrogen. All of the constituents for which certified, reference, and information values are provided in SRM 1941b were naturally present in the sediment before processing. A unit of SRM 1941b consists of a bottle containing 50 g of radiation-sterilized, freeze-dried sediment.

Certified Mass Fraction Values: Certified mass fraction values for 24 PAHs, 29 PCB congeners, and 7 chlorinated pesticides are provided in Tables 1 through 3. The certified values for the PAHs, PCB congeners, and chlorinated pesticides are based on the agreement of results obtained at NIST from two or more chemically independent analytical techniques along with results from an interlaboratory comparison study [1]. A NIST certified value is a value for which NIST has the highest confidence in its accuracy in that all known or suspected sources of bias have been investigated or taken into account [1].

Reference Mass Fraction Values: Reference mass fraction values for 44 additional PAHs (some in combination), 13 additional PCB congeners, and 2 additional chlorinated pesticides are provided in Tables 4 to 7. Reference values for 27 alkylated PAH groups are provided in Table 8 and for selected hopanes and steranes in Table 9. A reference value for total organic carbon is provided in Table 10. Reference values are noncertified values that are the best estimate of the true value; however, the values do not meet the NIST criteria for certification and are provided with associated uncertainties that may reflect only measurement precision, may not include all sources of uncertainty, or may reflect a lack of sufficient statistical agreement among multiple analytical methods [1].

Information Mass Fraction Values: Information mass fraction values are provided in Table 11 for carbon, hydrogen, and nitrogen. An information value is considered to be a value that will be of use to the SRM user, but insufficient information is available to assess the uncertainty associated with the value [1].

Expiration of Certification: The certification of **SRM 1941b** is valid, within the measurement uncertainty specified, until **01 October 2020**, provided the SRM is handled and stored in accordance with the instructions given in this certificate (see "Instructions for Handling, Storage, and Use"). This certification is nullified if the SRM is damaged, contaminated, or otherwise modified.

Maintenance of SRM Certification: NIST will monitor this SRM over the period of its certification. If substantive technical changes occur that affect the certification before the expiration of this certificate, NIST will notify the purchaser. Registration (see attached sheet) will facilitate notification.

The coordination of the technical measurements leading to the certification of this material was under the leadership of M.M. Schantz and S.A. Wise of the NIST Analytical Chemistry Division.

Analytical measurements for the certification of SRM 1941b were performed at NIST by J.R. Kucklick, B.J. Porter, D.L. Poster, M.M. Schantz, P. Schubert, S. Tutschku, and L.L. Yu of the NIST Analytical Chemistry Division.

Stephen A. Wise, Chief
Analytical Chemistry Division

Gaithersburg, MD 20899
Certificate Issue Date: 10 April 2012

Robert L. Watters, Jr., Chief
Measurement Services Division

Certificate Revision History on Page 13

Measurements for TOC were provided by a commercial laboratory and T.L. Wade of the Geochemical and Environmental Research Group, Texas A&M University (College Station, TX). The carbon, hydrogen, and nitrogen data were provided by a commercial laboratory. Results for the PAHs, PCBs, and chlorinated pesticides from 38 laboratories (see Appendix A) that participated in an interlaboratory comparison exercise coordinated by NIST were used. Results for the alkylated PAH groups, hopanes, and steranes from 33 laboratories (see Appendix B) that participated in another interlaboratory comparison exercise coordinated by NIST were also used.

Collection and preparation of SRM 1941b were performed by M.P. Cronise and C.N. Fales of the NIST Measurement Services Division and B.J. Porter and M.M. Schantz of the NIST Analytical Chemistry Division. The sediment material was collected with the assistance of G.G. Lauenstein, J. Collier, and J. Lewis (National Oceanic and Atmospheric Administration, Silver Spring, MD).

Consultation on the statistical design of the experimental work and evaluation of the data were provided by S.D. Leigh and J.H. Yen of the NIST Statistical Engineering Division.

Support aspects involved in the issuance of this SRM were coordinated through the NIST Measurement Services Division.

INSTRUCTIONS FOR HANDLING, STORAGE, AND USE

Handling: This material is naturally occurring marine sediment from an urban area and may contain constituents of unknown toxicities; therefore, caution and care should be exercised during its handling and use.

Storage: SRM 1941b must be stored in its original bottle at temperatures less than 30 °C and away from direct sunlight.

Use: Prior to removal of subsamples for analysis, the contents of the bottle should be mixed. The mass fractions of constituents in SRM 1941b are reported on a dry-mass basis. The SRM, as received, contains a mass fraction of approximately 2.4 % moisture (see "Conversion to Dry-Mass Basis"). The sediment sample should be dried to a constant mass before weighing for analysis; or a separate subsample of the sediment should be removed from the bottle at the time of analysis and dried to determine the mass fraction on a dry-mass basis. If the constituents of interest are volatile, then the moisture must be determined with a separate subsample.

PREPARATION AND ANALYSIS[(1)]

Sample Collection and Preparation: The sediment used to prepare this SRM was collected from the Chesapeake Bay at the mouth of the Baltimore (MD) Harbor near the Francis Scott Key Bridge (39°12.3'N and 76°31.4'W). This location is very near the site where SRM 1941 and SRM 1941a were collected. The sediment was collected using a Kynar-coated modified Van Veen-type grab sampler. A total of approximately 3300 kg of wet sediment was collected from the site. The sediment was freeze-dried, sieved at 150 µm (100 % passing), homogenized in a cone blender, radiation sterilized (^{60}Co), and then packaged in screw-capped amber glass bottles each containing approximately 50 g.

Conversion to Dry-Mass Basis: The results for the constituents in SRM 1941b are reported on a dry-mass basis; however, the material "as received" contains residual moisture. The amount of moisture in SRM 1941b was determined by measuring the mass loss after freeze-drying subsamples of 1.1 g to 1.3 g for four days at 1 Pa with a –10 °C shelf temperature and a –50 °C condenser temperature. The moisture content in SRM 1941b at the time of the certification analyses was 2.39 % ± 0.08 % (95 % confidence level). Analytical results for the organic constituents were determined on an as-received basis and then converted to a dry-mass basis by dividing by the conversion factor of 0.9761 (gram dry mass per gram as-received mass).

Polycyclic Aromatic Hydrocarbons: The general approach used for the value assignment of the PAHs in SRM 1941b was similar to that reported in detail elsewhere [2]. The approach consisted of combining results from analyses using various combinations of different extraction techniques and solvents, clean-up/isolation procedures, and chromatographic separation and detection techniques: Soxhlet extraction and pressurized-fluid extraction (PFE) using dichloromethane (DCM) or a hexane/acetone mixture, cleanup of the extracts using solid-phase extraction (SPE) or normal-phase liquid chromatography (LC), followed by analysis using the following techniques: (1) reversed-phase liquid chromatography with fluorescence detection (LC-FL) analysis of the total PAH fraction, (2) reversed-phase LC-FL analysis of isomeric PAH fractions isolated by normal-phase LC (i.e., multidimensional LC), (3) gas chromatography/mass spectrometry (GC/MS) analysis of the PAH fraction on three stationary phases of different

[(1)] Certain commercial equipment, instruments or materials are identified in this certificate to adequately specify the experimental procedure. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

selectivity, i.e., a 5 % (all column compositions are given as mole fractions in %) phenyl-substituted methylpolysiloxane phase, a 50 % phenyl-substituted methylpolysiloxane phase, and a relatively non-polar proprietary phase.

Three sets of GC/MS results, designated as GC/MS (I), GC/MS (II), and GC/MS (III), were obtained using three columns with different selectivities for the separation of PAHs. For GC/MS (I) analyses, duplicate subsamples of approximately 1 g from ten bottles of SRM 1941b were extracted using PFE with DCM. Copper powder was added to the extract to remove elemental sulfur. The concentrated extract was passed through an aminopropyl SPE cartridge and eluted with 2 % DCM in hexane (all solvent concentrations are given as volume fractions in %). The processed extract was then analyzed by GC/MS using a 0.25 mm i.d. × 60 m fused silica capillary column with a 5 % phenyl-substituted methylpolysiloxane phase (0.25 μm film thickness; DB-5 MS, J&W Scientific, Folsom, CA). The GC/MS (II) analyses were performed using 5 g subsamples from six bottles of SRM 1941b. These samples were extracted using PFE with DCM. The high molecular mass compounds were removed from the extracts using size exclusion chromatography (SEC) with a preparative-scale divinylbenzene-polystyrene column (10 μm particle size with 10 nm diameter pores), and the sulfur was removed from the extracts by adding copper powder. The concentrated extract was passed through an aminopropyl SPE cartridge and eluted with 10 % DCM in hexane. The analysis was by GC/MS using a 0.25 mm i.d. × 60 m fused silica capillary column with a 50 % phenyl-substituted methylpolysiloxane phase (0.25 μm film thickness; DB-17 MS, J&W Scientific, Folsom, CA). For the GC/MS (III), 9 g subsamples from six bottles of SRM 1941b were Soxhlet-extracted for 18 h with 250 mL of a mixture of 50 % hexane/50 % acetone. Copper powder was added to the extract to remove elemental sulfur, and the concentrated extract was passed through a silica SPE cartridge and eluted with 10 % DCM in hexane. The processed extract was then analyzed by GC/MS using a 0.25 mm i.d. × 60 m fused silica capillary column with a relatively non-polar proprietary phase (0.25 μm film thickness; DB-XLB, J&W Scientific, Folsom, CA).

Two sets of LC-FL results, designated as LC-FL (total) and LC-FL (isomer), were used in the certification process. For the LC-FL (total), subsamples of approximately 1 g from six bottles of SRM 1941b were extracted using PFE with a mixture of 50 % hexane/50 % acetone. The extracts were concentrated and then processed through an aminopropylsilane SPE cartridge using 2 % DCM in hexane to obtain the total PAH fraction. For the LC-FL (isomer), a 5 g subsample from the six bottles was extracted using PFE with DCM and processed through an aminopropylsilane SPE cartridge using 10 % DCM in hexane; the PAH fraction was then fractionated further on a semi-preparative aminopropylsilane column (μBondapak NH_2, 9 mm i.d. × 30 cm, Waters Associates, Milford, MA) to isolate isomeric PAH fractions as described previously [3–6]. The total PAH fraction and the isomeric PAH fractions were analyzed using a 5 μm particle-size polymeric octadecylsilane (C_{18}) column (4.6 mm i.d. × 25 cm, Hypersil-PAH, Keystone Scientific, Inc., Bellefonte, PA) with wavelength-programmed fluorescence detection [4,5].

For the GC/MS and LC-FL measurements described above, selected perdeuterated PAHs were added to the sediment prior to solvent extraction for use as internal standards for quantification purposes.

In addition to the analyses performed at NIST, SRM 1941b was used in an interlaboratory comparison exercise in 1999 as part of the NIST Intercomparison Exercise Program for Organic Contaminants in the Marine Environment [7]. Results from 38 laboratories that participated in this exercise were used as the sixth data set in the determination of the certified values for PAHs in SRM 1941b. The laboratories participating in this exercise used the analytical procedures routinely used in their laboratories to measure the analytes of interest.

Homogeneity Assessment for PAHs: The homogeneity of SRM 1941b was assessed by analyzing duplicate samples of approximately 1 g from ten bottles selected by stratified random sampling. Samples were extracted, processed, and analyzed as described above for GC/MS (I). No statistically significant differences among bottles were observed for the PAHs at this sample size.

PAH Isomers of Molecular Mass 300 and 302: For the determination of the molecular mass 300 and 302 isomers, three subsamples of approximately 5 g each were extracted using PFE with DCM. The extracts were then concentrated with a solvent change to hexane and passed through an aminopropyl SPE cartridge and eluted with 10 % DCM in hexane. The processed extract was then analyzed by GC/MS using a 0.25 mm i.d. × 60 m fused silica capillary column with a 50 % phenyl-substituted methylpolysiloxane phase (0.25 μm film thickness; DB-17MS, J&W Scientific, Folsom, CA). Perdeuterated dibenzo[*a*,*i*]pyrene was added to the sediment prior to extraction for use as an internal standard [8].

PCBs and Chlorinated Pesticides: The general approach used for the determination of PCBs and chlorinated pesticides in SRM 1941b consisted of combining results from analyses using various combinations of different extraction techniques and solvents, cleanup/isolation procedures, and chromatographic separation and detection techniques. Techniques and solvents included Soxhlet extraction and PFE using DCM or a hexane/acetone mixture, clean-up/isolation using SPE or LC, followed by analysis using GC/MS and gas chromatography with electron capture detection (GC-ECD) on two columns with different selectivity for the separation of PCBs and chlorinated pesticides. The analytical methods are described in detail elsewhere [2].

Six sets of results were obtained and designated as GC-ECD (I) A and B, GC/MS (I) A and B, GC/MS (II), and Interlaboratory Comparison Exercise. For the GC-ECD (I) analyses, approximately 10 g subsamples from six bottles of SRM 1941b were extracted using PFE with DCM. Copper powder was added to the extract to remove elemental sulfur, and SEC, as described above, was used to remove the high molecular mass compounds. The concentrated extract was then fractionated on a semi-preparative aminopropylsilane column to isolate two fractions containing: (1) the PCBs and lower-polarity pesticides and (2) the more polar pesticides. GC-ECD analyses of the two fractions were performed on two columns of different selectivities for PCB separations: 0.25 mm × 60 m fused silica capillary column with a 5 % phenyl-substituted methylpolysiloxane phase (0.25 µm film thickness; DB-5, J&W Scientific, Folsom, CA), and a 0.25 mm × 60 m fused silica capillary column with a non-polar proprietary phase (0.25 µm film thickness; DB-XLB, J&W Scientific, Folsom, CA). The results from the 5 % phenyl phase are designated as GC-ECD (IA) and the results from the proprietary phase are designated as GC-ECD (IB). For the GC-ECD analyses, two PCB congeners that are not significantly present in the sediment extract (PCB 103 and PCB 198 [9,10]) and endosulfan I-d_4, 4,4'-DDE-d_8, 4,4'-DD-d_8, and 4,4'-DDT-d_8 were added to the sediment prior to extraction for use as internal standards for quantification purposes.

Two sets of results were obtained by GC/MS. For GC/MS (I), approximately 9 g subsamples from six bottles were Soxhlet- extracted with a mixture of 50 % hexane/50 % acetone for approximately 18 h. Copper powder was added to the extract to remove elemental sulfur, and the concentrated extract was passed through a silica SPE cartridge and eluted with 10 % DCM in hexane. The processed extract was then analyzed by GC/MS with two ionization modes, electron impact (EI) and negative ion chemical ionization (NICI). The GC/MS EI method, GC/MS (IA), used a 0.25 mm i.d. × 60 m fused silica capillary column with a relatively non-polar proprietary phase (0.25 µm film thickness; DB-XLB, J&W Scientific, Folsom, CA). The GC/MS NICI method, GC/MS (IB), used a 0.25 mm i.d. × 60 m fused silica capillary column with a 5 % phenyl-substituted methylpolysiloxane phase (0.25 µm film thickness; DB-5MS, J&W Scientific, Folsom, CA). The GC/MS (II) results were obtained in the same manner as the GC/MS (IA) analyses except that three subsamples were Soxhlet-extracted with DCM for approximately 18 h. For the GC/MS analyses, selected carbon-13 labeled PCB congeners and chlorinated pesticides were added to the sediment prior to extraction for use as internal standards for quantification purposes.

In addition to the analyses performed at NIST, SRM 1941b was used in an interlaboratory comparison exercise in 1999 as part of the NIST Intercomparison Exercise Program for Organic Contaminants in the Marine Environment [7]. Results from 38 laboratories that participated in this exercise were used as the sixth data set in the determination of the certified values for PCB congeners and chlorinated pesticides in SRM 1941b. The laboratories participating in this exercise used the analytical procedures routinely used in their laboratories to measure the analytes of interest.

The reference value for PCB 77 was determined from a separate fraction. The samples were extracted and processed as for GC-ECD (I) above. The first (PCB and lower-polarity pesticide) fraction from the semi-preparative aminopropylsilane column was further fractionated using a Cosmosil PYE (pyrenylethyl group bonded) column (5 µm particle size, 4.6 mm i.d. × 25 cm ; Phenomenex, Torrance, CA) [11]. Three fractions were collected: the first fraction contained the pesticides and multi-*ortho* PCBs, the second fraction contained the polychlorinated naphthalenes, non-*ortho* PCB congeners, and some mono-*ortho* PCB congeners, and the third fraction removed the residual planar compounds from the column. The second fraction was analyzed by GC/MS NICI using the same column as GC/MS (IB) above. Carbon-13 labeled PCB 77 was used as an internal standard for quantification purposes.

Alkylated PAH Groups, Hopanes, and Steranes: SRM 1941b was used in an interlaboratory comparison exercise in 2011 [12]. Results from 33 laboratories that participated in this exercise were used in the determination of the reference values for alkylated PAH groups, hopanes, and steranes in SRM 1941b. Note that not all laboratories returned data for each analyte. The laboratories participating in this exercise used the analytical procedures routinely used in their laboratories to measure the analytes of interest. For the alkylated PAHs, the majority of the laboratories (>90 %) used the parent PAH for determination of the response factor for the corresponding alkylated group.

Total Organic Carbon: Two laboratories provided results for TOC using similar procedures. Briefly, subsamples of approximately 200 mg were reacted with 6 mol/L hydrochloric acid and rinsed with deionized water prior to combustion in a gas fusion furnace. The carbon monoxide and carbon dioxide produced were measured and compared to a blank for calculation of the percent TOC. Each laboratory analyzed subsamples from three bottles of SRM 1941b. One of the laboratories also analyzed three subsamples from three bottles of SRM 1941b for carbon, hydrogen, and nitrogen.

Table 1. Certified Mass Fraction Values for Selected PAHs in SRM 1941b

PAHs	Mass Fractions[a] µg/kg		
Naphthalene[b,c,d,e,f,g]	848	±	95[h]
Fluorene[b,c,d,e,f,g]	85	±	15[h]
Phenanthrene[b,c,d,e,f,g]	406	±	44[h]
Anthracene[b,c,d,e,f,g]	184	±	18[h]
3-Methylphenanthrene[b,c,d]	105	±	13[h]
2-Methylphenathrene[b,c,d]	128	±	14[h]
1-Methylphenanthrene[b,c,d,g]	73.2	±	5.9[h]
Fluoranthene[b,c,d,e,f,g]	651	±	50[h]
Pyrene[b,c,d,e,f,g]	581	±	39[h]
Benz[*a*]anthracene[b,c,d,e,f,g]	335	±	25[h]
Chrysene[d,f]	291	±	31[h]
Triphenylene[d,f]	108	±	5[i]
Benzo[*b*]fluoranthene[c,e]	453	±	21[h]
Benzo[*k*]fluoranthene[b,c,d,e]	225	±	18[h]
Benzo[*e*]pyrene[b,c,d,g]	325	±	25[h]
Benzo[*a*]pyrene[b,c,d,f,g]	358	±	17[h]
Perylene[b,c,d,f,g]	397	±	45[h]
Benzo[*ghi*]perylene[b,c,d,f,g]	307	±	45[h]
Indeno[1,2,3-*cd*]pyrene[b,c,d,f,g]	341	±	57[h]
Dibenz[*a,j*]anthracene[b,c,d,f]	48.9	±	4.6[h]
Dibenz[*a,c*]anthracene[c,f]	36.7	±	5.2[h]
Dibenz[*a,h*]anthracene[c,f]	53	±	10[h]
Benzo[*b*]chrysene[b,c,d,f]	53	±	12[h]
Picene[b,c,d]	46.6	±	4.7[h]

[a] Mass fractions reported on dry-mass basis; material as received contains approximately 2.4 % moisture.
[b] GC/MS (I) on 5 % phenyl-substituted methylpolysiloxane phase after PFE with DCM.
[c] GC/MS (II) on 50 % phenyl-substituted methylpolysiloxane phase after PFE with DCM.
[d] GC/MS (III) on a relatively non-polar proprietary phase after Soxhlet extraction with 50 % hexane/50 % acetone mixture.
[e] LC-FL (total) of total PAH fraction after PFE with DCM.
[f] LC-FL (isomer) of isomeric PAH fractions after PFE with DCM.
[g] 1999 Interlaboratory Comparison Study [7] with 21 to 29 laboratories submitting data for each PAH.
[h] Certified values are weighted means of the results from two to six analytical methods [13]. The uncertainty listed with each value is an expanded uncertainty about the mean, with coverage factor 2 (approximately 95 % confidence), calculated by combining a between-method variance incorporating inter-method bias with a pooled within-method variance following the ISO Guide [14,15].
[i] The certified value is an unweighted mean of the results from two analytical methods. The uncertainty listed with the value is an expanded uncertainty about the mean, with coverage factor 2, calculated by combining a between-method variance [16] with a pooled, within-method variance following the ISO Guide [14,15].

Table 2. Certified Mass Fraction Values for Selected PCB Congeners[a] in SRM 1941b

PCB Congeners		Mass Fractions[b] µg/kg		
PCB 8	(2,4'-Dichlorobiphenyl)[c,d,e,f,g]	1.65	±	0.19[h]
PCB 18	(2,2',5-Trichlorobiphenyl)[c,d,e,f,g]	2.39	±	0.29[h]
PCB 28	(2,4,4'-Trichlorobiphenyl)[c,d,e,f,g]	4.52	±	0.57[h]
PCB 31	(2,4',5-Trichlorobiphenyl)[c,e,f]	3.18	±	0.41[h]
PCB 44	(2,2'3,5'-Tetrachlorobiphenyl)[c,d,e,f,g]	3.85	±	0.20[i]
PCB 49	(2,2'4,5'-Tetrachlorobiphenyl)[c,d,e,f]	4.34	±	0.28[i]
PCB 52	(2,2',5,5'-Tetrachlorobiphenyl)[c,d,e,f,g]	5.24	±	0.28[i]
PCB 66	(2,3',4,4'-Tetrachlorobiphenyl)[c,e,f,g,j]	4.96	±	0.53[i]
PCB 87	(2,2',3,4,5'-Pentachlorobiphenyl)[c,d,f,j]	1.14	±	0.16[h]
PCB 95	(2,2',3,5',6-Pentachlorobiphenyl)[c,e,f,g]	3.93	±	0.62[i]
PCB 99	(2,2',4,4',5-Pentachlorobiphenyl)[c,d,e,f,g]	2.90	±	0.36[i]
PCB 101	(2,2',4,5,5'-Pentachlorobiphenyl)[c,e,f,g,j]	5.11	±	0.34[i]
PCB 105	(2,3,3',4,4'-Pentachlorobiphenyl)[c,d,e,f,g,j]	1.43	±	0.10[i]
PCB 110	(2,3,3',4',6-Pentachlorobiphenyl)[c,e,f,j]	4.62	±	0.36[i]
PCB 118	(2,3',4,4',5-Pentachlorobiphenyl)[c,d,e,f,g,j]	4.23	±	0.19[i]
PCB 128	(2,2',3,3',4,4'-Hexachlorobiphenyl)[c,d,e,f,g,j]	0.696	±	0.044[i]
PCB 138	(2,2',3,4,4',5'-Hexachlorobiphenyl)[c,e,f,j]	3.60	±	0.28[i]
PCB 149	(2,2',3,4',5',6-Hexachlorobiphenyl)[c,d,e,j]	4.35	±	0.26[h]
PCB 153	(2,2',4,4',5,5'-Hexachlorobiphenyl)[c,d,e,f,g,j]	5.47	±	0.32[i]
PCB 156	(2,3,3',4,4',5-Hexachlorobiphenyl)[c,d,e,f,j]	0.507	±	0.090[h]
PCB 170	(2,2',3,3',4,4',5-Heptachlorobiphenyl)[c,d,e,f,g,j]	1.35	±	0.09[i]
PCB 180	(2,2',3,4,4',5,5'-Heptachlorobiphenyl)[c,d,e,f,g,j]	3.24	±	0.51[i]
PCB 183	(2,2',3,4,4',5',6-Heptachlorobiphenyl)[c,d,e,j]	0.979	±	0.087[h]
PCB 187	(2,2',3,4',5,5',6-Heptachlorobiphenyl)[c,d,e,f,g,j]	2.17	±	0.22[i]
PCB 194	(2,2',3,3',4,4',5,5'-Octachlorobiphenyl)[c,d,e,j]	1.04	±	0.06[h]
PCB 195	(2,2',3,3',4,4',5,6-Octachlorbiphenyl)[c,e,g,j]	0.645	±	0.060[i]
PCB 201	(2,2',3,3',4,5',6,6'-Octachlorobiphenyl)[c,e,j]	0.777	±	0.034[h]
PCB 206	(2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl)[c,e,f,g,j]	2.42	±	0.19[i]
PCB 209	Decachlorobiphenyl[c,d,e,f,g,j]	4.86	±	0.45[i]

[a] PCB congeners are numbered according to the scheme proposed by Ballschmiter and Zell [9] and later revised by Schulte and Malisch [10] to conform with IUPAC rules; for the specific congeners mentioned in this SRM, only PCB 201 and PCB 107 (see Table 5) are different in the numbering systems. Under the Ballschmiter and Zell numbering system, the IUPAC PCB 201 is listed as PCB 200 and the IUPAC PCB 107 is listed as PCB 108.

[b] Mass fractions reported on dry-mass basis; material as received contains approximately 2.4 % moisture.

[c] GC/MS (IA) on a relatively non-polar proprietary phase after Soxhlet extraction with 50 % hexane/50 % acetone mixture.

[d] GC-ECD (IA) on 5 % phenyl-substituted methylpolysiloxane phase after PFE extraction with DCM.

[e] GC-ECD (IB) on a relatively non-polar proprietary phase; same extracts analyzed as in GC-ECD (IA).

[f] GC/MS (II) on a relatively non-polar proprietary phase after Soxhlet extraction with DCM.

[g] 1999 Interlaboratory Comparison Study [7] with 13 to 31 laboratories submitting data for each PCB congener.

[h] Certified values are unweighted means of the results from three to five analytical methods. The uncertainty listed with each value is an expanded uncertainty about the mean, with coverage factor 2, calculated by combining a between-method variance [16] with a pooled, within method variance following the ISO Guide [14,15].

[i] Certified values are weighted means of the results from three to six analytical methods [13]. The uncertainty listed with each value is an expanded uncertainty about the mean, with coverage factor 2 (approximately 95 % confidence), calculated by combining a between-method variance incorporating inter-method bias with a pooled within-method variance following the ISO Guide [14,15].

[j] GC/MS (IB) on 5 % phenyl-substituted methylpolysiloxane phase; same extracts analyzed as in GC/MS (IA).

Table 3. Certified Mass Fraction Values for Selected Chlorinated Pesticides in SRM 1941b

Chlorinated Pesticides	Mass Fractions[a] µg/kg
Hexachlorobenzene[b,c,d,e]	5.83 ± 0.38[f]
cis-Chlordane[b,c,d,e,g]	0.85 ± 0.11[h]
trans-Chlordane[b,c,e]	0.566 ± 0.093[f]
cis-Nonachlor[b,e,g]	0.378 ± 0.053[h]
trans-Nonachlor[b,c,d,e,g]	0.438 ± 0.073[f]
4,4'-DDE[b,d,e,g]	3.22 ± 0.28[h]
4,4'-DDD[b,d,e,g]	4.66 ± 0.46[h]

[a] Mass fractions reported on dry-mass basis; material as received contains approximately 2.4 % moisture.
[b] GC/MS (IA) on a relatively non-polar proprietary phase after Soxhlet extraction with 50 % hexane/50 % acetone mixture.
[c] GC/MS (IB) on 5 % phenyl-substituted methylpolysiloxane phase; same extracts analyzed as in GC/MS (IA).
[d] GC/MS (II) on a relatively non-polar proprietary phase after Soxhlet extraction with DCM.
[e] 1999 Interlaboratory Comparison Study [7] with 13 to 31 laboratories submitting data for each pesticide.
[f] Certified values are unweighted means of the results from three to five analytical methods. The uncertainty listed with each value is an expanded uncertainty about the mean, with coverage factor 2, calculated by combining a between-method variance [16] with a pooled, within-method variance following the ISO Guide [14,15].
[g] GC-ECD (IA) on 5 % phenyl-substituted methylpolysiloxane phase after PFE extraction with DCM.
[h] Certified values are weighted means of the results from three to five analytical methods [13]. The uncertainty listed with each value is an expanded uncertainty about the mean, with coverage factor 2 (approximately 95 % confidence), calculated by combining a between-method variance incorporating inter-method bias with a pooled within-method variance following the ISO Guide [14,15].

Table 4. Reference Mass Fraction Values for Selected PAHs in SRM 1941b

PAHs	Mass Fractions[a] µg/kg		
1-Methylnaphthalene[b,c,d,e]	127	±	14[f]
2-Methylnaphthalene[b,c,d,e]	276	±	53[f]
2,6-Dimethylnaphthalene[b,c,d,e]	75.9	±	4.5[f]
2,3,5-Trimethylnaphthalene[b,c,d,e]	25.5	±	5.1[f]
Biphenyl[b,c,d,e]	74.0	±	8.0[f]
Acenaphthylene[b,c,d,e]	53.3	±	6.4[f]
Acenaphthene[b,c,d,e]	38.4	±	5.2[f]
9-Methylphenanthrene[c]	63.5	±	2.5[g]
4-Methylphenanthrene and 9-Methylphenanthrene[b,d]	80.1	±	4.8[f]
2-Methylanthracene[c,d]	36	±	15[f]
8-Methylfluoranthene[b]	49.5	±	2.7[g]
7-Methylfluoranthene[b]	45.4	±	1.5[g]
1-Methylfluoranthene[b]	42.4	±	2.1[g]
3-Methylfluoranthene[b]	28.8	±	1.3[g]
2-Methylpyrene[b]	78.7	±	4.0[g]
4-Methylpyrene[b]	66.4	±	2.6[g]
1-Methylpyrene[b]	52.5	±	2.3[g]
Acephenanthrene[d]	30.5	±	1.9[g]
Benzo[*c*]phenanthrene[b,c,d]	58	±	15[f]
Benzo[*a*]fluoranthene[b,c,d]	73	±	18[f]
Benzo[*j*]fluoranthene[c]	217	±	5[g]
Indeno[1,2,3-*cd*]fluoranthene[d]	9.63	±	0.34[g]
Pentaphene[d]	25.3	±	1.0[g]

[a] Mass fractions reported on dry-mass basis; material as received contains approximately 2.4 % moisture.
[b] GC/MS (I) on 5 % phenyl-substituted methylpolysiloxane phase after PFE with DCM.
[c] GC/MS (II) on 50 % phenyl-substituted methylpolysiloxane phase after PFE with DCM.
[d] GC/MS (III) on a relatively non-polar proprietary phase after Soxhlet extraction with 50 % hexane/50 % acetone mixture.
[e] 1999 Interlaboratory Comparison Study [7] with 14 to 26 laboratories submitting data for each PAH.
[f] Reference values are weighted means of the results from two to four analytical methods [13]. The uncertainty listed with each value is an expanded uncertainty about the mean, with coverage factor 2 (approximately 95 % confidence), calculated by combining a between-method variance incorporating inter-method bias with a pooled within-method variance following the ISO Guide [14,15].
[g] Reference values are the means of results obtained by NIST using one analytical technique. The expanded uncertainty, U, is calculated as $U = ku_c$, where u_c is one standard deviation of the analyte mean, and the coverage factor, k, is determined from the Student's t-distribution for the associated degrees of freedom (19 for footnote b and 5 for footnotes c and d) and 95 % confidence level for each analyte.

Table 5. Reference Mass Fraction Values for Selected PAHs of Molecular Mass 300 and 302 in SRM 1941b

PAHs	Mass Fractions[a,b,c] µg/kg
Coronene	72.6 ± 4.7
Dibenzo[*b,e*]fluoranthene	10.3 ± 0.3
Naphtho[1,2-*b*]fluoranthene	91.0 ± 3.1
Naphtho[1,2-*k*]fluoranthene and Naphtho[2,3-*j*]fluoranthene	79.8 ± 2.5
Naphtho[2,3-*b*]fluoranthene	23.5 ± 0.3
Dibenzo[*b,k*]fluoranthene	95.6 ± 3.1
Dibenzo[*a,k*]fluoranthene	26.6 ± 0.4
Dibenzo[*j,l*]fluoranthene	63.8 ± 1.8
Dibenzo[*a,l*]pyrene	11.1 ± 1.0
Naphtho[2,3-*k*]fluoranthene	10.7 ± 0.6
Naphtho[1,2-*a*]pyrene	16.7 ± 1.4
Naphtho[2,3-*e*]pyrene	33.2 ± 2.3
Dibenzo[*a,e*]pyrene	76.1 ± 3.6
Naphtho[2,1-*a*]pyrene	59.2 ± 1.8
Dibenzo[*e,i*]pyrene	35.0 ± 2.4
Naphtho[2,3-*a*]pyrene	16.5 ± 0.6
Benzo[*b*]perylene	38.2 ± 1.2
Dibenzo[*a,i*]pyrene	25.5 ± 1.0
Dibenzo[*a,h*]pyrene	6.94 ± 0.29

[a] Mass fractions reported on dry-mass basis; material as received contains approximately 2.4 % moisture.
[b] Reference values are the means of results obtained by NIST using one analytical technique. The expanded uncertainty, U, is calculated as $U = ku_c$, where u_c is one standard deviation of the analyte mean, and the coverage factor, k, is determined from the Student's t-distribution for two degrees of freedom and 95 % confidence level for each analyte.
[c] GC/MS on 50 % phenyl-substituted methylpolysiloxane phase after PFE with DCM [8].

Table 6. Reference Mass Fraction Values for Selected PCB Congeners[(a)] in SRM 1941b

PCB Congeners		Mass Fractions[(b,c)] µg/kg		
PCB 45	(2,2',3,6-Tetrachlorobiphenyl)[(d,e)]	0.73	±	0.12
PCB 56	(2,3,3',4-Tetrachlorobiphenyl)[(d,f,g)]	1.21	±	0.11
PCB 63	(2,3,4',5-Tetrachlorobiphenyl)[(e,f,g)]	0.213	±	0.040
PCB 70	(2,3',4',5-Tetrachlorobiphenyl)[(e,f,g)]	4.99	±	0.29
PCB 74	(2,4,4',5-Tetrachlorobiphenyl)[(e,f,g)]	2.04	±	0.15
PCB 77	(3,3',4,4'-Tetrachlorobiphenyl)[(h)]	0.31	±	0.03
PCB 107	(2,3,3',4,5'-Pentachlorobiphenyl)[(d,e,f,g)]	0.628	±	0.028
PCB 132	(2,2',3,3',4,6'-Hexachlorobiphenyl)[(d,f,g)]	1.28	±	0.27
PCB 146	(2,2',3,4',5,5'-Hexachlorobiphenyl)[(e,f,g)]	1.22	±	0.12
PCB 158	(2,3,3',4,4',6-Hexachlorobiphenyl)[(d,e,f,g)]	0.65	±	0.15
PCB 163	(2,3,3',4',5,6-Hexachlorobiphenyl)[(e,f,g)]	1.28	±	0.06
PCB 174	(2,2',3,3',4,5,6'-Heptachlorobiphenyl)[(d,e,f,g)]	1.51	±	0.39
PCB 193	(2,3,3',4',5,5',6-Heptachlorobiphenyl)[(d,e,f,g)]	0.292	±	0.075

[(a)] PCB congeners are numbered according to the scheme proposed by Ballschmiter and Zell [9] and later revised by Schulte and Malisch [10] to conform with IUPAC rules; for the specific congeners mentioned in this SRM, only PCB 201 (see Table 2) and PCB 107 are different in the numbering systems. Under the Ballschmiter and Zell numbering system, the IUPAC PCB 201 is listed as PCB 200 and the IUPAC PCB 107 is listed as PCB 108.

[(b)] Mass fractions reported on dry-mass basis; material as received contains approximately 2.4 % moisture.

[(c)] For these PCB congeners except PCB 77, the reference values are unweighted means of the results from two to four analytical methods. The uncertainty listed with each value is an expanded uncertainty about the mean, with coverage factor 2, calculated by combining a between-method variance [16] with a pooled within-method variance following the ISO Guide [14,15]. For PCB 77, the reference value is the mean of results obtained by NIST using one analytical technique. The expanded uncertainty, U, is calculated as $U = ku_c$, where u_c is one standard deviation of the analyte mean, and the coverage factor, k, is determined from the Student's t-distribution corresponding to two degrees of freedom and 95 % confidence level for PCB 77.

[(d)] GC-ECD (IA) on 5 % phenyl-substituted methylpolysiloxane phase after PFE extraction with DCM.

[(e)] GC-ECD (IB) on a relatively non-polar proprietary phase; same extracts analyzed as in GC-ECD (IA).

[(f)] GC/MS (IA) on a relatively non-polar proprietary phase after Soxhlet extraction with 50 % hexane/50 % acetone mixture.

[(g)] GC/MS (IB) on 5 % phenyl-substituted methylpolysiloxane phase; same extracts analyzed as in GC/MS (IA).

[(h)] GC/MS NICI on a 5 % phenyl-substituted methylpolysiloxane phase; same extracts analyzed as in GC-ECD (I) fractionated using a PYE column.

Table 7. Reference Mass Fraction Values for Selected Chlorinated Pesticides in SRM 1941b

Chlorinated Pesticides	Mass Fractions[a,b] µg/kg
2,4'-DDE[c,d]	0.38 ± 0.12
4,4'-DDT[e,f]	1.12 ± 0.42

[a] Mass Fractions reported on dry-mass basis; material as received contains approximately 2.4 % moisture.
[b] The reference values are unweighted means of the results from two analytical methods. The uncertainty listed with each value is an expanded uncertainty about the mean, with coverage factor 2, calculated by combining a between-method variance [16] with a pooled, within-method variance following the ISO Guide [14,15].
[c] GC/MS (IB) on 5 % phenyl-substituted methylpolysiloxane phase; same extracts analyzed as in GC/MS (IA).
[d] GC-ECD (IB) on a relatively non-polar proprietary phase; same extracts analyzed as in GC-ECD (IA).
[e] GC/MS (II) on a relatively non-polar proprietary phase after Soxhlet extraction with DCM.
[f] 1999 Interlaboratory Comparison Study [7] with 10 laboratories submitting data for 4,4'-DDT.

Table 8. Reference Mass Fraction Values for Selected Alkylated PAH Groups in SRM 1941b

Alkylated PAH Group	Mass Fraction[a,b] mg/kg
C2-decalins	18 ± 5
C4-decalins	41 ± 4
C2-naphthalenes	187 ± 53
C3-naphthalenes	158 ± 42
C1-benzothiophenes	25 ± 14
C2-benzothiophenes	20 ± 11
C3-benzothiophenes	22 ± 13
C4-benzothiophenes	18 ± 5
C1-fluorenes	57 ± 18
C2-fluorenes	122 ± 43
C3-fluorenes	128 ± 31
C1-phenanthrenes/anthracenes	313 ± 99
C2-phenanthrenes/anthracenes	247 ± 62
C3-phenanthrenes/anthracenes	165 ± 46
C4-phenanthrenes/anthracenes	87 ± 36
C1-dibenzothiophenes	54 ± 13
C2-dibenzothiophenes	91 ± 18
C3-dibenzothiophenes	84 ± 15
C4-dibenzothiophenes	57 ± 13
C1-fluoranthenes/pyrenes	252 ± 48
C2-fluoranthenes/pyrenes	205 ± 38
C3-fluoranthenes/pyrenes	102 ± 22
C4-fluoranthenes/pyrenes	121 ± 59
C1-benzanthraces/chrysenes/triphenylenes	208 ± 43
C2-benzanthraces/chrysenes/triphenylenes	120 ± 24
C3-benzanthraces/chrysenes/triphenylenes	73 ± 31
C4-benzanthraces/chrysenes/triphenylenes	41 ± 11

[a] The reference mass fraction value reported on a dry-mass basis is the median of results using one analytical technique. The expanded uncertainty, U, is calculated as $U = ku_c$, where u_c is one standard deviation of the median, and the coverage factor, $k = 2$.
[b] Data from the interlaboratory study [12].

Table 9. Reference Mass Fraction Values for Selected Hopanes and Steranes in SRM 1941b

Hopane or Sterane	Mass Fraction[a,b] mg/kg
17α(H)-22,29,30-Trisnorhopane	54 ± 18
17α(H)-21β(H)-30-Norhopane	137 ± 21
17α(H)-21β(H)-30-Hopane	215 ± 44
17α(H)-21β(H)-22R-Homohopane	44 ± 10
17α(H)-21β(H)-22S-Homohopane	48 ± 13
5α(H)-14α(H),17α(H)-Cholestane 20R	41 ± 11
5α(H)-14β(H),17β(H)-Cholestane 20R	27 ± 6
5α(H)-14β(H),17β(H)-24-Methylcholestane 20R	21 ± 8
5α(H)-14α(H),17α(H)-24-Ethylcholestane 20R	19 ± 5
5α(H)-14β(H),17β(H)-24-Ethylcholestane 20R	41 ± 9

[a] The reference mass fraction value reported on a dry-mass basis is the median of results using one analytical technique. The expanded uncertainty, U, is calculated as $U = ku_c$, where u_c is one standard deviation of the median, and the coverage factor, $k = 2$.
[b] Data from the interlaboratory study [12].

Table 10. Reference Mass Fraction Value for Total Organic Carbon in SRM 1941b

Total Organic Carbon (TOC)	2.99 % ± 0.24 %[a,b]

[a] Mass fraction is reported on a dry-mass basis; material as received contains approximately 2.4 % moisture.
[b] The reference value for total organic carbon is a weighted mean value from routine measurements made by two laboratories [21]. The uncertainty listed is an expanded uncertainty about the mean, with coverage factor 2 (approximately 95 % confidence), calculated by combining a between-method variance incorporating inter-method bias with a pooled within-method variance. The reporting follows the ISO Guides [2].

Table 11. Information Mass Fraction Values for Carbon, Hydrogen, and Nitrogen in SRM 1941b

Elements	Mass Fractions[a] %
Carbon	3.3
Hydrogen	1.2
Nitrogen	<0.5

[a] Mass fraction is reported on a dry-mass basis; material as received contains approximately 2.4 % moisture.

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Certificate Revision History: 10 April 2012 (This revision adds reference values for alkylated PAH groups, hopanes, and steranes; extension of certification period; editorial changes); 16 August 2004 (This revision removes the reference values for the butyl tins and makes editorial changes); 15 July 2002 (Original certificate date).

Users of this SRM should ensure that the Certificate of Analysis in their possession is current. This can be accomplished by contacting the SRM Program: telephone (301) 975-2200; fax (301) 948-3730; e-mail srminfo@nist.gov; or via the Internet at http://www.nist.gov/srm.

APPENDIX A

The laboratories listed below performed measurements that contributed to the certification of PAHs, PCBs, and chlorinated pesticides in SRM 1941b Organics in Marine Sediment.

Arthur D. Little, Inc; Cambridge, MA, USA
Axys Analytical Services; Sidney, BC, Canada
B & B Laboratories; College Station, TX, USA
Battelle Ocean Sciences; Duxbury, MA, USA
Bedford Institute of Oceanography; Dartmouth, NS, Canada
California Department of Fish and Game; Rancho Cordova, CA, USA
Central Contra Costa Sanitary District; Martinez, CA, USA
Chesapeake Biological Laboratory; Solomons, MD, USA
Centro de Investigacionies Energeticas Medioambientales y Tecnologicas; Madrid, Spain
City of Los Angeles Environmental Monitoring Division; Playa del Rey, CA, USA
City of San Jose Environmental Services Department; San Jose, CA, USA
Columbia Analytical Services; Kelso, WA, USA
East Bay Municipal Utility District; Oakland, CA, USA
Florida Department of Environmental Protection; Tallahassee, FL, USA
Manchester Environmental Laboratory; Port Orchard, WA, USA
Murray State University; Murray, KY, USA
Massachusetts Water Resources Authority Central Lab; Winthrop, MA, USA
National Research Council of Canada; Ottawa, Ontario, Canada
National Oceanic and Atmospheric Association (NOAA), National Marine Fisheries Service (NMFS), Auke Bay Laboratory; Juneau, AK, USA
NOAA, National Ocean Service/Center for Coastal Environmental Health and Biomolecular Research; Charleston, SC, USA
NOAA, NMFS, Sandy Hook Marine Laboratory; Highlands, NJ, USA
NOAA, NMFS, Northwest Fisheries Science Center; Seattle, WA, USA
Orange County Sanitation District; Fountain Valley, CA, USA
Philip Analytical Services; Burlington, Ontario, Canada
Serv de Hidrografia Naval; Buenos Aires, Argentina
Skidaway Institute of Technology; Savannah, GA, USA
Southwest Laboratory of Oklahoma; Broken Arrow, OK, USA
Severn Trent Knoxville Laboratory; Knoxville, TN, USA
Texas A&M University, Geochemical and Environmental Research Group; College Station, TX, USA
Texas Parks and Wildlife Department; San Marcos, TX, USA
University of California at Los Angeles, Institute of Geophysics and Planetary Physics; Los Angeles, CA, USA
University of Connecticut, Environmental Research Institute; Storrs, CT, USA
University of Rhode Island, Graduate School of Oceanography; Narragansett, RI, USA
US Department of Agriculture, Environmental Chemistry Laboratory; Beltsville, MD, USA
US Environmental Protection Agency, Atlantic Ecology Division; Narragansett, RI, USA
US Geological Survey, National Water Quality Laboratory; Denver, CO, USA
Woods Hole Group Environmental Lab; Raynham, MA, USA
Wright State University; Dayton, OH, USA

APPENDIX B

The laboratories listed below performed measurements that contributed to the certification of alkylated PAH groups, hopanes, and steranes in SRM 1941b Organics in Marine Sediment.

Alpha Analytical, Inc.; Mansfield, MA, USA
Analytical Resources, Inc.; Tukwila, WA, USA
Axys Analytical Services; Sydney, BC, Canada
Battelle Analytical & Environmental Chemistry Laboratory; Duxbury, MA, USA
Center for Laboratory Sciences; Pasco, WA, USA
Columbia Analytical Services; Jacksonville, FL, USA
Columbia Analytical Services; Rochester, NY, USA
Columbia Analytical Services, Kelso, WA, USA
Florida Department of Environmental Protection; Tallahassee, FL, USA
Florida International University; North Miami, FL, USA
Michigan Department of Natural Resources and Environment; Lansing, MI, USA
Mississippi State Chemical Laboratory; Mississippi State, MS, USA
NIST; Charleston, SC, USA
NIST; Gaithersburg, MD, USA
NOAA/NCCOS/NOS; Charleston, SC, USA
NOAA/NMFS/Alaska Fisheries Science Center; Juneau, AK, USA
NY State Department of Health; Albany, NY, USA
Pace Analytical Services, Inc. Minneapolis; Minneapolis, MN, USA
RJ Lee Group, Inc; Monroeville, PA, USA
TDI/B&B Laboratories, Inc.; College Station, TX
TestAmerica Laboratories; Mobile, AL, USA
TestAmerica Laboratories; West Sacramento, CA, USA
TestAmerica Laboratories; University Park, IL, USA
TestAmerica Laboratories; Schriever, LA, USA
TestAmerica Laboratories; Edison, NJ, USA
TestAmerica Laboratories; Knoxville, TN, USA
TestAmerica Laboratories; Pittsburgh, PA, USA
TestAmerica Laboratories; South Burlington, VT, USA
TestAmerica Laboratories; Tacoma, WA, USA
US Army Engineer Research and Development Center; Vicksburg, MS, USA
USGS Columbia Environmental Research Center; Columbia, MO, USA
University of Iowa, State Hygienic Laboratory; Iowa City, IO, USA
Washington State Public Health Laboratories; Shoreline, WA, USA

Lower Snake River Programmatic Sediment Management Plan Environmental Impact Statement

Appendix I

Water Quality and Sediment Quality Reports

August 2014

Section 5B. Sediment Analysis Data Report

Prepared for the Port of Clarkston

By Gravity Consulting

January 2013

Sediment Analysis

Data Report

PORT OF CLARKSTON CRANE DOCK SEDIMENT CHARACTERIZATION

CLARKSTON, WASHINGTON

Prepared for

The Port of Clarkston

Prepared by

Gravity Consulting, L.L.C.

32617 SE 44th St

Fall City, Washington 98024

January 2013

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Figure Description

Figure 1. Sampling locations

APPENDICES

Appendix	Description
Appendix I	Field Photo Log
Appendix II	Core Sample Logs
Appendix III	Chain-of-Custody Forms, Laboratory Data Reports and Data Validation Reports
Appendix IV	Signed Sampling and Analysis Plan

1. Introduction

This data report summarizes the results of samples collected at the Port of Clarkston Crane Dock. These samples were collected for a dredge materials management assessment.

1.1. Project Location

The crane dock is located at Snake River mile marker 138 (see figure 1). The Crane Dock consists of an overwater pier for vessel unloading. Because of its location, the Crane Dock receives a significant sedimentation load from the Snake River.

2. Field Sampling

Sediment core samples were successfully collected on November 28th 2012. During sediment sample collection the Snake Lower Granite Pool was at 736.9 ft (NAVD 88) as measured from a reference marker at Swallows Nest USACE facility to water height. Field measured water depths ranged from 12.5 to 23.1 feet below pool or mudline elevations from 729.3 to 718.7.

2.1. Positioning

A differential global positioning system (DGPS) was used aboard the sample vessel for station positioning. Once the vessel was anchored in place, the actual position was recorded. Table 1 shows the sample locations and mud line depths. Latitude and longitude of all sample locations are within 10^{-5} seconds of the proposed sample locations shown in the Sampling and Analysis Plan prepared for this project. Sample locations are shown in Figure 1 and listed along with water depth measurements in Table 1.

Table 1 – actual coordinates and measured water depth

Location	Date	Time	Actual X	Actual Y	Water Depth (ft)	Mudline (NAVD88)
CCD-1	11.26.2012	1301	46 25.593 N	117 03.808 W	12.5	724.4
CCD-2	11.26.2012	1425	46 25.594 N	117 03.852 W	23.1	713.8
CCD-3	11.26.2012	1447	46 25.578 N	117 03.905 W	19.4	717.5

Figure 1. Sample locations and dredge area.

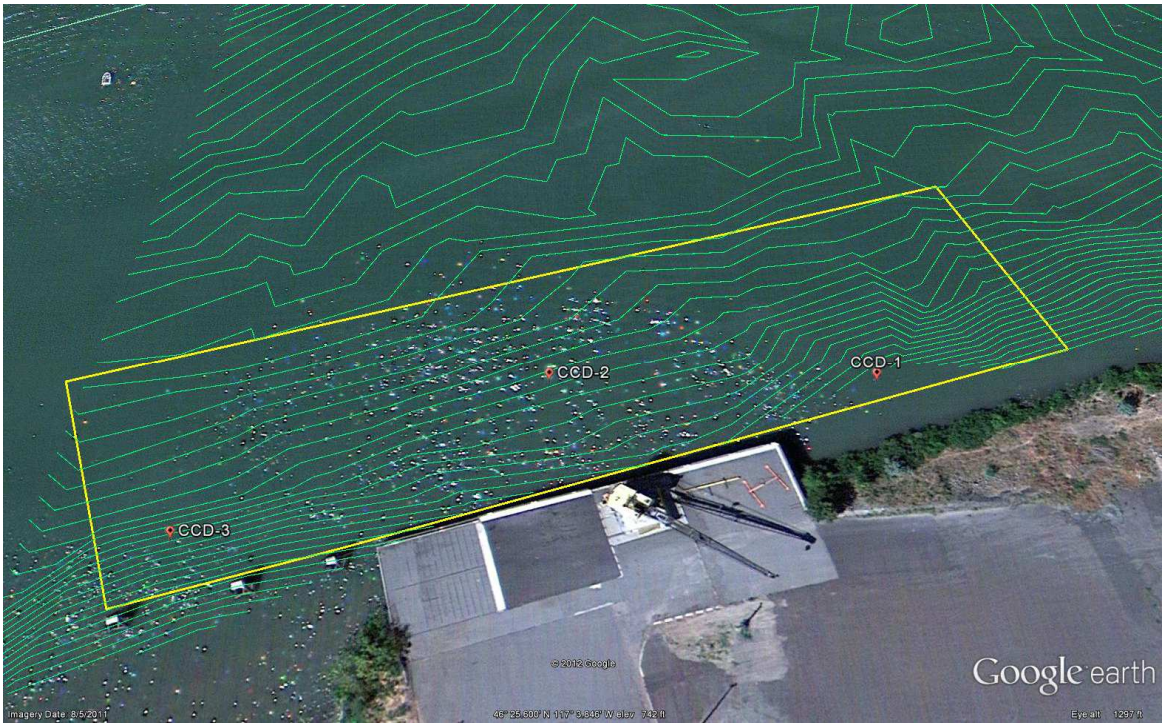


Table 2 – Summary Of Core Drives and Sampling

Location	Core Drive (ft)	Recovery (ft)	Composite range	Z - Sample
CCD-1	5’6”	5’	0’ to 5’	none
CCD-2	37”	34”	None	0’ to 1’
CCD-3	36”	32”	0’ to 1’6”	1’6” to 2’6”

2.2. Sediment Collection and Processing

Samples were collected from the research vessel R/V Selkirk, owned and operated by Gravity. The vessel is fully equipped with the necessary navigation equipment, mechanical equipment, hydraulic power

packs, and electrical power generators to support all aspects of sample collection and processing aboard the boat.

Coring was performed using an electrically-driven vibracorer equipped with 4-inch diameter polycarbonate tubes. A new tube was used for each of the individual stations. Tubes were advanced to the target penetration depth or to refusal, if the target depth could not be achieved. Cores were then extruded, sampled for volatiles and sulfides from discrete intervals, logged, and then sub-sampled. Core processing and compositing occurred on-shore after all samples were collected and were delivered to the laboratory.

2.3. Sample Collection Deviations from the SAP

Two deviations from the SAP were observed in the field activities. At CCD-1 location collection of sample from below the 5 foot layer was not feasible. Three attempts were made at CCD-1 and in all instances a refusal on large cobble 2-3" in size was encountered. Because cobble is not suitable for analytical sampling and because the vibracorer is not able to penetrate this substrate, a shorter core was accepted that did not include a z-layer sample. At station CCD-2 and in the surrounding area a location could not be found that needed dredging (e.g. water depth was over 18 feet at MOP). A core was taken at CCD-2 and archived but not included in the overall composite sample. The composite sample was therefore made up of only station CCD-1 and CCD-3 (see table 2). These deviations were documented and USACE was informed at the time of sampling for approval.

2.4. Sample Transport and Custody

After sample containers were filled, they were packed on ice in coolers. The coolers were transferred to ALS and PEL Laboratories at the end of the day. Chain-of-custody procedures were as follows:

- Samples were packaged and shipped in accordance with U.S. Department of Transportation regulations as specified in 49 CFR 173.6 and 49 CFR 173.24;
- Individual sample containers were packed to prevent breakage;
- The coolers were clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the cooler) to enable positive identification;
- Chain-of-custody forms were enclosed in a plastic bag and placed inside lid of the cooler; and
- Signed and dated chain-of-custody seals were placed on all coolers prior to shipping.

3. Sediment Chemical Testing

Sediment sampling analysis was conducted in accordance with Section 4 of the SAP. Guidance included specification of methods, method report limits, and applicable QA/QC measures. Complete details are included in the SAP Tables 8, 9 and 10. The samples were analyzed for all the parameters listed in Table 6 of SAP and compared to DMMP guidelines for potential open-water disposal.

4. Sediment Sample Analysis

Chemical/physical testing was conducted by ALS and PEL. See Table 4 of the SAP (Appendix IV) for a full list of samples analyzed. Both labs are accredited by the State of Washington.

4.1. Sample Analysis and Data Validation Summary

All chemical and physical testing followed the most recent QA/QC procedures and analysis protocols as specified in the SAP. Attached to this report in Appendix IV are electronic files for the chain-of-custody forms, laboratory data reports and data validation reports.

Prior to sample analysis the laboratory calculated method detection limits for each of the analytes of interest, where applicable. Method reporting limits were confirmed to be below the sediment quality criteria specified in Table 6 of the SAP.

Data validation was performed on all samples in the data set, using EPA guidelines. The data were validated in accordance with guidance provided in the following documents:

- Sampling and Analysis Plan
- EPA Functional Guidelines for Organic and Inorganic data, 1999; 2001; 2002, and 2004
- USEPA EPA Region 10 Standard Operating Procedure (SOP) for the Validation of Polychlorinated Dibenzodioxin (PCDD) and Polychlorinated Dibenzofuran (PCDF) Data, 1996
- USEPA Region 10 SOP for Validation of Inorganic Analyses
- USEPA guidelines as stated in SW 846, Third Edition, Test Methods for Evaluating Solid Waste, update 1, July 1992; update IIA, August 1993, update II, September 1994; update IIB, January 1995; update III, December 1996; update IIIA, April 1998; update IV, January 3, 2008

Each laboratory report was reviewed initially against the chain-of-custody forms to ensure that the requested analyses were performed. Requirements for each analytical parameter were reviewed to ensure the technical holding times were met. Results were reviewed to assess target compound identification, compound quantification and achievement of compound quantitation limits as identified in the SAP. All initial and continuing calibrations were reviewed for method compliance. All surrogates, method blanks, internal standards, instrument performance checks, matrix spikes, matrix duplicates, laboratory control samples, standard reference material samples, and system

performance checks were performed at the required frequency and within SAP specified criteria where applicable. A field duplicate was checked for consistency and compliance with relative percent difference (RPD) criteria.

Any omitted or discrepant data were resubmitted to respective laboratory for clarification and re-analysis, if needed. Any sample or standard data not meeting the guidelines in the documents listed above were flagged and qualified accordingly. See section 4.2 for deviations.

All data presented in this report were considered useable as qualified in the respective Laboratory Data Review Reports.

4.2. Analytical deviations from the SAP

All Analyses were performed consistent with the QA program documented in the SAP with the exception of the following two issues:

- Ammonia Nitrogen was received past holding time. Data was flagged but is considered acceptable.
- Relative percent difference was outside of control limits for total Sulfide due to heterogeneous nature of sediments. Sulfide data was considered acceptable.

5. Results

5.1. Analytical Results

Tables 2-4 provide a summary of the organic compounds, total metals, conventional analytical results and grain size results based on dry-weight. The SAP contained USACE freshwater screening levels (SL1 and SL2). For ease of comparison, the summary tables present these criteria for the sediment samples collected.

Three cores were collected in the Port of Clarkston Crane Dock area which were composited into one sample CCD-Comp-A. Z layer samples were archived for possible later analysis. The results consistently showed that very little organic chemistry was present in these samples. Samples also had a very low TOC (0.316%) which likely accounts for the low organic chemistry. Only metals were detected in the results and those were and very low levels that were nowhere near the screening levels. Pesticides by standard method (ALS laboratories) and by multi-residue analysis (PEL) were not present in the sediments.

Conventional parameters (grain size, TOC, total solids, and total volatile solids) were measured in the core chemistry results and are summarized in Table 4. Grain size analysis showed that sands were predominant in the cores.

5.2. Geological observations

Core samples were logged upon sub-sampling. Appendix II, III present the photos and core logs of the results respectively. Core samples were consistenly stratified with sands with some silt near the surface of the cores moving to courser materials and 2-3 inch cobble at approximately 4 feet. The cobbles caused refusal in all cores.

6. Summary

The goal of the sampling program was to evaluate the sediments for dredge at the crane dock area. It is obvious that this area is impacted by sediment transport with fines and organics not residing in localized sediments. The grain size results and core logs provide evidence of this high energy environment. Chemistry results are consistent with this conclusion and show that organics are not present in this sediment and that metals are not an issue based on screening review. The sediments in this area should be considered acceptable for open water disposal.

Table 2.Sediment Composite Core Analytical Data Summary & Criteria Screening

Analyte	Units	2006 Freshwater		2009 Marine			Comp-A Result	Qualifiers
		SL1	SL2	SL	BT	ML		
PAHS								
2-Methylnaphthalene	ug/Kg	470	560	670		1900	2.8	U
Acenaphthene	ug/Kg	1,100	1,300	500		2,000	3.3	U
Acenaphthylene	ug/Kg	470	640	560		1300	2.6	U
Anthracene	ug/Kg	1,200	1,600	960		13,000	3.2	U
Benz(a)anthracene	ug/Kg	4,300	5,800	1,300		5,100	3.6	U
Benzo(a)pyrene	ug/Kg	3,300	4,800			3,600	3.6	U
Benzo(b)fluoranthene	ug/Kg	600	4,000	3,200		9,900	3.4	U
Benzo(g,h,i)perylene	ug/Kg	4,000	5,200			3,200	3.7	U
Benzo(k)fluoranthene	ug/Kg			3,200		9,900	4	U
Chrysene	ug/Kg	5,900	6,400	1400		21000	4.1	U
Dibenz(a,h)anthracene	ug/Kg	800	840			1,900	3	U
Fluoranthene	ug/Kg	11,000	15,000	1700	4600	30000	3.7	U
Fluorene	ug/Kg	1,000	3,000	540		3,600	3.3	U
Indeno(1,2,3-cd)pyrene	ug/Kg	4,100	5,300			4,400	3.2	U
Naphthalene	ug/Kg	500	1,300	2,100		2,400	2.9	U
Phenanthrene	ug/Kg	6,100	7,600	1,500		21,000	3.6	U
Pyrene	ug/Kg	8,800	16,000	2,600	11,980	16,000	3.7	U
Total HPAH	31,000	31,000	55,000	12,000		69,000	12.9	U
Total LPAH	6,600	6,600	9,200	5,200		29,000	13.9	U
Phthalates								
Diethyl Phthalate	ug/Kg			200		1200	3.7	U
Dimethyl Phthalate	ug/Kg	46	440	71		1400	4	U
Di-n-butyl Phthalate	ug/Kg			1400		5100	4.8	U
Di-n-octyl Phthalate	ug/Kg	26	45	6200	26	45	12	J
Butyl Benzyl Phthalate	ug/Kg	260	370	63		970	3.7	U
Phthalate	ug/Kg	220	320	1300		8300	8.9	U
Hydrocarbons								
1,2,4-Trichlorobenzene	ug/Kg			31		64	2.6	U
1,2-Dichlorobenzene	ug/Kg			35		110	2.4	U
1,3-Dichlorobenzene	ug/Kg						2.3	U
1,4-Dichlorobenzene	ug/Kg			110		120	2.5	U
Hexachlorobenzene	ug/Kg			22	168	230	3.3	U
Phenols								
Phenol	ug/Kg			420		1200	13	J
2-Methylphenol	ug/Kg			63		77	4.1	U
4-Methylphenol	ug/Kg			670		3600	4.5	U
2,4-Dimethylphenol	ug/Kg			29		210	6.3	U
Pentachlorophenol	ug/Kg			400	504	690	5.3	U
Pesticides								
4,4'-DDD	ug/Kg			16			0.11	U

Analyte	Units	2006 Freshwater		2009 Marine			Comp-A Result	Qualifiers
		SL1	SL2	SL	BT	ML		
4,4'-DDE	ug/Kg			9			0.21	JP
4,4'-DDT	ug/Kg			12			0.17	U
Sum DDT's	ug/Kg				50	69		
Aldrin	ug/Kg	37		9.5			0.16	U
Dieldrin	ug/Kg			1.9			0.14	U
alpha-BHC	ug/Kg						0.11	U
gamma-BHC (Lindane)	ug/Kg						0.08	U
alpha-Chlordane	ug/Kg						0.1	U
gamma-Chlordane	ug/Kg						0.09	U
Total Cholrdane	ug/Kg			2.8	37		0.095	U
Heptachlor Epoxide	ug/Kg						0.084	U
Heptachlor	ug/Kg			1.5			0.12	U
cis-Nonachlor	ug/Kg						0.12	U
trans-Nonachlor	ug/Kg						0.087	U
PCBs								
Aroclor 1016	ug/Kg						2.1	U
Aroclor 1221	ug/Kg						2.1	U
Aroclor 1232	ug/Kg						2.1	U
Aroclor 1242	ug/Kg						2.1	U
Aroclor 1248	ug/Kg						2.1	U
Aroclor 1254	ug/Kg						2.1	U
Aroclor 1260	ug/Kg						2.1	U
Total PCBs	ug/Kg	60	120	130	38	3100	7.35	U
Organics - Miscellaneous								
2,4,5-Trichlorophenol	ug/Kg						3	U
2,4,6-Trichlorophenol	ug/Kg						3	U
2,4-Dichlorophenol	ug/Kg						2.6	U
2,4-Dinitrotoluene	ug/Kg						2.5	U
2,6-Dinitrotoluene	ug/Kg						2.9	U
2-Chloronaphthalene	ug/Kg						3.2	U
2-Chlorophenol	ug/Kg						3	U
dinitrophenol	ug/Kg						39	U
2-Methylphenol	ug/Kg						4.1	U
2-Nitroaniline	ug/Kg						3.3	U
2-Nitrophenol	ug/Kg						4	U
3,3'-Dichlorobenzidine	ug/Kg						4.1	U
Ether	ug/Kg						3.1	U
Ether	ug/Kg						3.2	U
4-Nitroaniline	ug/Kg						3.8	U
4-Nitrophenol	ug/Kg						7.7	U
Ammonia as Nitrogen	mg/Kg						25.6	
Benzoic Acid	ug/Kg			650	---	760	130	J
Benzyl Alcohol	ug/Kg			57	---	870	4.9	U

Analyte	Units	2006 Freshwater		2009 Marine			Comp-A Result	Qualifiers
		SL1	SL2	SL	BT	ML		
beta-BHC	ug/Kg						0.18	U
chloroethoxy)methane	ug/Kg						2.8	U
Bis(2-chloroethyl) Ether	ug/Kg						3.1	U
Ether	ug/Kg						2.8	U
Chlorpyrifos	ug/Kg						0.15	U
delta-BHC	ug/Kg						0.074	U
Dibenzofuran	ug/Kg	400	440	540	---	1700	3.4	U
Endosulfan I	ug/Kg						0.063	U
Endosulfan II	ug/Kg						0.14	U
Endosulfan Sulfate	ug/Kg						0.11	U
Endrin Aldehyde	ug/Kg						0.12	U
Endrin Ketone	ug/Kg						0.093	U
Endrin	ug/Kg						0.094	U
Hexachlorobutadiene	ug/Kg			11	---	270	0.21	U
ne	ug/Kg						4	U
Hexachloroethane	ug/Kg						2.5	U
Isodrin	ug/Kg						0.17	U
Isophorone	ug/Kg						2.8	U
Methoxychlor	ug/Kg						0.19	U
Mirex	ug/Kg						0.099	U
Nitrobenzene	ug/Kg						3.4	U
propylamine	ug/Kg						3.3	U
N-Nitrosodiphenylamine	ug/Kg			28	---	130	3.2	U
Oxychlordane	ug/Kg						0.085	U
Metals								
Antimony	mg/Kg			150		200	0.119	N
Arsenic	mg/Kg	20	51	57	507.1	700	1.87	
Cadmium	mg/Kg	1.1	1.5	5.1	11.3	14	0.096	
Chromium	mg/Kg	95	100	260	260		8.82	
Copper	mg/Kg	80	830	390	1027	1300	11.5	
Lead	mg/Kg	340	430	450	975	1200	4.44	
Mercury	mg/Kg	0.28	0.75	0.41	1.5	2.3	0.03	
Nickel	mg/Kg	60	70				8.5	
Selenium	mg/Kg		3		3		0.2	U
Silver	mg/Kg	2	2.5	6.1	6.1	8.4	0.05	
Zinc	mg/Kg	130	400	410	2783	3800	32.7	

Notes:

Qualifier J = estimated value

Qualifier P = pesticide and Aroclor target compound with a greater than 25% difference between colums

Qualifier N = Spiked sample recovery not within control limits.

Qualifier U = Non Detect

Analyte	Units	2006 Freshwater		2009 Marine			Comp-A Result	Qualifiers
		SL1	SL2	SL	BT	ML		

Bold numbers signify detected value above method detection limit (MDL)

(d) The LPAH criterion represents the sum of the following "low molecular weight polynuclear aromatic hydrocarbon"

(e) The HPAH criterion represents the sum of the following "high molecular weight polynuclear aromatic hydrocarbon"

OCN = Organic Carbon Normalized from sample TOC result

Table 3.Sediment Composite Core Analytical Data Summary & Criteria Screening

Analyte		Units	CCD-Comp-A **Result** (% Dry Weight)
Grain Size			
Clay		%	0.93%
Silt		%	3.46%
Sand	Sand, Very Fine	%	3.38%
	Sand, Fine	%	5.75%
	Sand, Medium	%	15.43%
	Sand, Coarse	%	16.78%
	Sand, Very Coarse	%	17.62%
Gravel	Gravel, Fine	%	18.32%
	Gravel, Medium	%	18.32%
Physical			
Carbon, Total Organic (TOC)		%	0.316
Solids, Total Volatile		%	1.67
Sulfide, Total		mg/Kg	4.04
Total Solids		%	79.1

Table 4.Sediment Composite Core Data - Multiresidue and Glyphosate Results

Analyte	Units	CCD-Comp-A	Qualifiers
3-Hydroxycarbofuran	mg/kg	0.017	U
a-BHC	mg/kg	0.0065	U
Alachlor	mg/kg	0.017	U
Aldicarb	mg/kg	0.032	U
Aldicarb Sulfone	mg/kg	0.0065	U
Aldicarb Sulfoxide	mg/kg	0.017	U
Aldrin	mg/kg	0.017	U
Ametryn	mg/kg	0.0065	U
Amitraz	mg/kg	0.032	U
AMPA	mg/kg	0.032	U
Aspon	mg/kg	0.032	U
Atrazine	mg/kg	0.0065	U
Azinphos-methyl	mg/kg	0.017	U
Azoxystrobin	mg/kg	0.0065	U
b-BHC	mg/kg	0.0065	U
Bendiocarb	mg/kg	0.0065	U
Benfluralin	mg/kg	0.032	U
Bensulide	mg/kg	0.0065	U
Bifenthrin	mg/kg	0.0065	U
Boscalid	mg/kg	0.017	U
Bromacil	mg/kg	0.0065	U
Bromopropylate	mg/kg	0.0065	U
Captafol	mg/kg	0.0065	U
Captan	mg/kg	0.0065	U
Carbaryl	mg/kg	0.0065	U
Carbofenothion	mg/kg	0.0065	U
Carbofuran	mg/kg	0.0065	U
Carfentrazone-ethyl	mg/kg	0.0065	U
Chlordane	mg/kg	0.0065	U
Chlorfenvinphos	mg/kg	0.0065	U
Chlorobenzilate	mg/kg	0.0065	U
Chloroneb	mg/kg	0.0065	U
Chlorothalonil	mg/kg	0.0065	U
Chlorpyrifos	mg/kg	0.0065	U
Chlorpyrifos-methyl	mg/kg	0.0065	U
Clothianidin	mg/kg	0.065	U
Coumaphos	mg/kg	0.017	U
Cyanazine	mg/kg	0.0065	U
Cyfluthrin	mg/kg	0.0065	U
Cyhalothrin	mg/kg	0.0065	U
Cypermethrin	mg/kg	0.0065	U
Dacthal	mg/kg	0.0065	U
d-BHC	mg/kg	0.017	U
DCBP	mg/kg	**0.0714**	
DCPMU	mg/kg	0.0065	U

Analyte	Units	CCD-Comp-A	Qualifiers
Deltamethrin	mg/kg	0.0065	U
Demeton	mg/kg	0.0065	U
Diazinon	mg/kg	0.0065	U
Dichlobenil	mg/kg	0.0065	U
Dichlorofenthion	mg/kg	0.0065	U
Dichlorvos	mg/kg	0.0065	U
Diclofop-methyl	mg/kg	0.032	U
Dicloran	mg/kg	0.0065	U
Dicofol	mg/kg	0.0065	U
Dicrotophos	mg/kg	0.017	U
Dieldrin	mg/kg	0.0065	U
Dimethenamid	mg/kg	0.0065	U
Dimethoate	mg/kg	0.017	U
Diphenylamine	mg/kg	0.0065	U
Disulfoton	mg/kg	0.0065	U
Dithiopyr	mg/kg	0.0065	U
Diuron	mg/kg	0.0065	U
Endosulfan I	mg/kg	0.0065	U
Endosulfan II	mg/kg	0.0065	U
Endosulfan sulfate	mg/kg	0.0065	U
Endrin	mg/kg	0.0065	U
Endrin aldehyde	mg/kg	0.017	U
Endrin ketone	mg/kg	0.017	U
EPN	mg/kg	0.017	U
Esfenvalerate	mg/kg	0.017	U
Ethalfluralin	mg/kg	0.017	U
Ethion	mg/kg	0.017	U
Ethofumesate	mg/kg	0.017	U
Ethoprop	mg/kg	0.017	U
Etridiazole	mg/kg	0.017	U
Famphur	mg/kg	0.017	U
Fenamiphos	mg/kg	0.017	U
Fenarimol	mg/kg	0.017	U
Fenbuconazole	mg/kg	0.017	U
Fenitrothion	mg/kg	0.017	U
Fenobucarb	mg/kg	0.017	U
Fenoxaprop-ethyl	mg/kg	0.017	U
Fensulfothion	mg/kg	0.017	U
Fenthion	mg/kg	0.017	U
Fenuron	mg/kg	0.017	U
Fenvalerate	mg/kg	0.017	U
Fipronil	mg/kg	0.017	U
Fluazifop-p-butyl	mg/kg	0.017	U
Fludioxonil	mg/kg	0.017	U
Flumioxazin	mg/kg	0.017	U
Fluometuron	mg/kg	0.017	U
Fluroxypyr-meptyl	mg/kg	0.017	U

Analyte	Units	CCD-Comp-A	Qualifiers
Flutolanil	mg/kg	0.017	U
Folpet	mg/kg	0.017	U
g-BHC	mg/kg	0.017	U
Glyphosate	mg/kg	0.017	U
Heptachlor	mg/kg	0.017	U
Heptachlor epoxide	mg/kg	0.017	U
Hexachlorobenzene	mg/kg	0.017	U
Hexazinone	mg/kg	0.017	U
Imidacloprid	mg/kg	0.017	U
Iprodione	mg/kg	0.017	U
Isoxaben	mg/kg	0.017	U
Linuron	mg/kg	0.017	U
Malathion	mg/kg	0.017	U
Mefenoxam	mg/kg	0.032	U
Merphos	mg/kg	0.032	U
Metalaxyl	mg/kg	0.032	U
Methidathion	mg/kg	0.032	U
Methiocarb	mg/kg	0.017	U
Methomyl	mg/kg	0.017	U
Methoxychlor	mg/kg	0.017	U
Metolachlor	mg/kg	0.017	U
Metribuzin	mg/kg	0.032	U
Mevinphos	mg/kg	0.032	U
Mirex	mg/kg	0.032	U
Monocrotophos	mg/kg	0.032	U
Monuron	mg/kg	0.017	U
Myclobutanil	mg/kg	0.032	U
Napropamide	mg/kg	0.017	U
Neburon	mg/kg	0.032	U
Norflurazon	mg/kg	0.017	U
Ovex	mg/kg	0.032	U
Oxadiazon	mg/kg	0.17	U
Oxamyl	mg/kg	0.032	U
Oxyfluorfen	mg/kg	0.017	U
p,p'-DDD	mg/kg	0.017	U
p,p'-DDE	mg/kg	0.032	U
p,p'-DDT	mg/kg	0.032	U
Parathion	mg/kg	0.032	U
Parathion methyl	mg/kg	0.032	U
PCNB	mg/kg	0.032	U
Pendimethalin	mg/kg	0.032	U
Permethrin	mg/kg	0.017	U
Phorate	mg/kg	0.017	U
Phosmet	mg/kg	0.032	U
Phosphamidon	mg/kg	0.017	U
Pirimicarb	mg/kg	0.017	U
Pirimiphos-methyl	mg/kg	0.017	U

Analyte	Units	CCD-Comp-A	Qualifiers
Prodiamine	mg/kg	0.017	U
Prometon	mg/kg	0.017	U
Prometryn	mg/kg	0.017	U
Pronamide	mg/kg	0.017	U
Propachlor	mg/kg	0.017	U
Propanil	mg/kg	0.017	U
Propargite	mg/kg	0.017	U
Propazine	mg/kg	0.017	U
Propiconazole	mg/kg	0.017	U
Propoxur	mg/kg	0.017	U
Pyraclostrobin	mg/kg	0.017	U
Pyridaben	mg/kg	0.017	U
Pyrimethanil	mg/kg	0.017	U
Ronnel	mg/kg	0.017	U
Sethoxydim	mg/kg	0.017	U
Siduron	mg/kg	0.017	U
Simazine	mg/kg	0.017	U
Simetryn	mg/kg	0.017	U
Sulfentrazone	mg/kg	0.017	U
Sulprofos	mg/kg	0.017	U
Tebuconazole	mg/kg	0.017	U
Tebuthiuron	mg/kg	0.017	U
Terbacil	mg/kg	0.017	U
Terbufos	mg/kg	0.017	U
Tetrachlorvinphos	mg/kg	0.017	U
Thiabendazole	mg/kg	0.017	U
Thiobencarb	mg/kg	0.017	U
Tokuthion	mg/kg	0.017	U
Triadimefon	mg/kg	0.017	U
Trichloronate	mg/kg	0.017	U
Trifloxystrobin	mg/kg	0.017	U
Triflumizole	mg/kg	0.017	U
Trifluralin	mg/kg	0.034	U
Vinclozalin	mg/kg	0.034	U

7. References

Barton, J. 2002. DMMP Clarification Paper U.S. Environmental Protection Agency, Region 10, Seattle, Washington. April 29, 2002.

Hoffman, E. 2003. DMMP Issue Paper concern (BCOC) list. Prepared by the U.S. Environmental Protection Agency, Region 10,Seattle, WA. April 29, 2002.

Kendall, D.R. 2001. DMMP Clarification Paper: Clarifications to the DMMP Z Guidance and/or Post Dredge Monitoring Policy. Prepared by the U.S. Army Corps of Engineers for the DMMP agencies, October 2001.

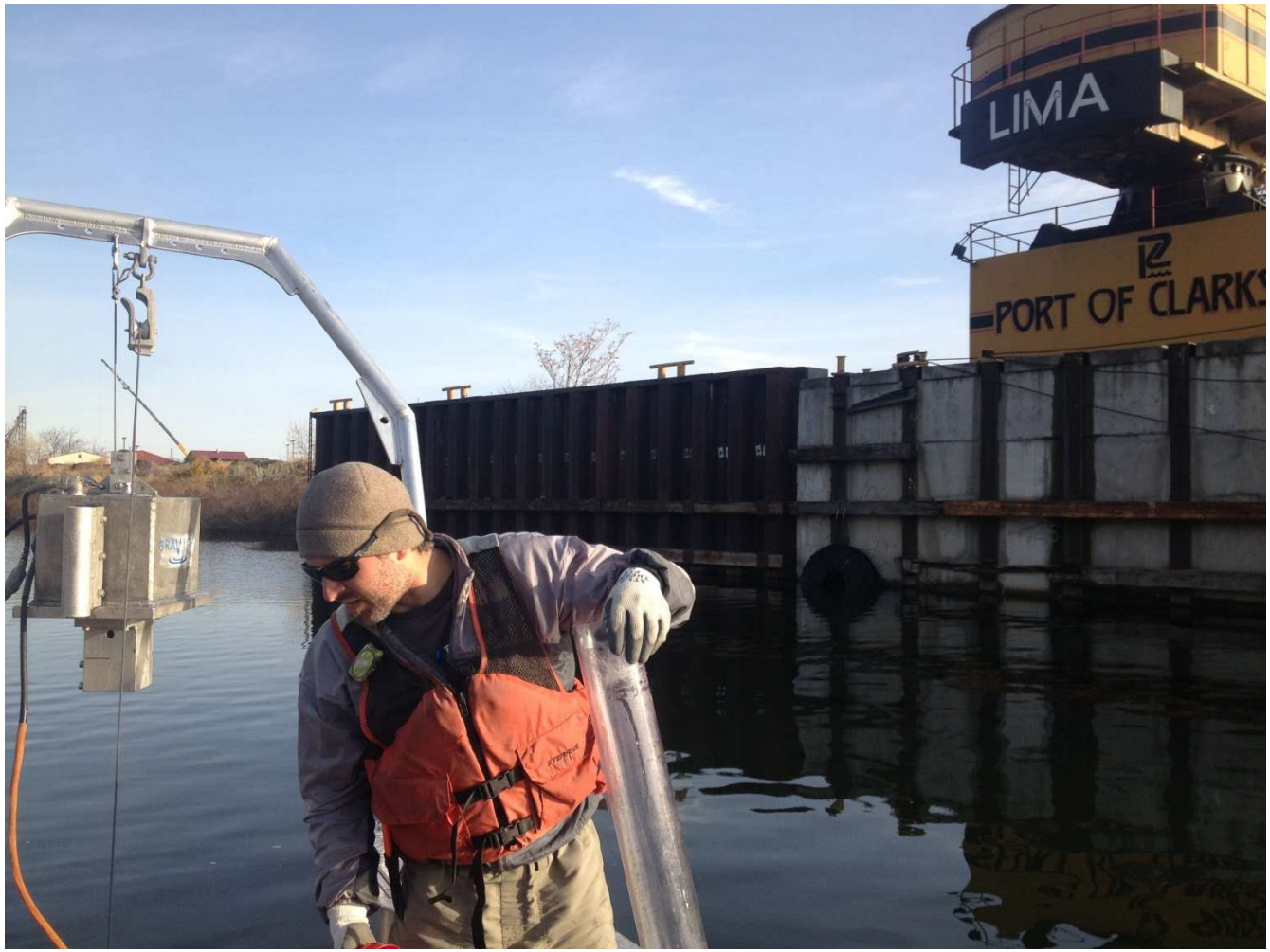
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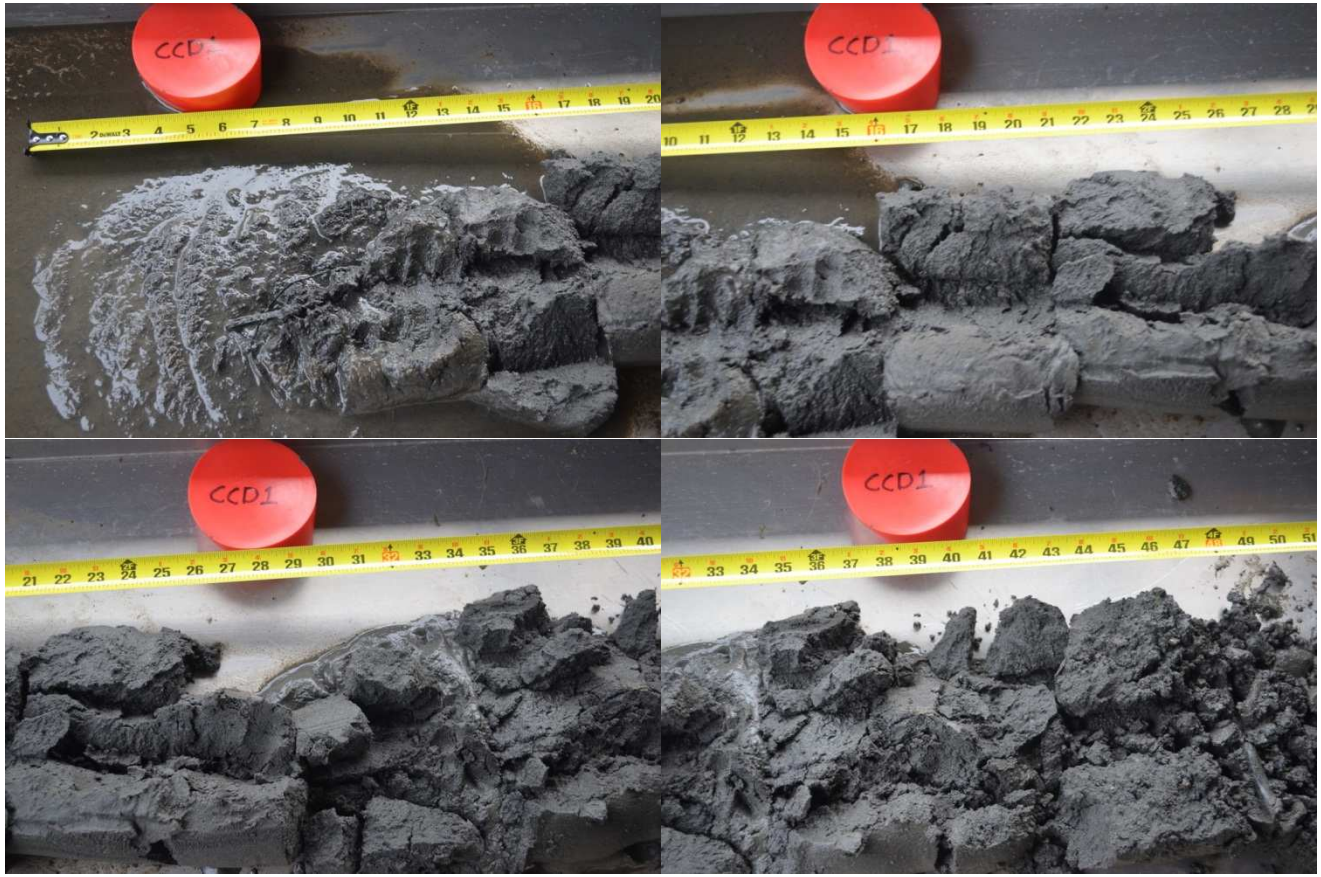
Puget Sound Estuary Program (PSEP). 1986 as updated in 1989, 1991, 1995, and 1997. Recommended guidelines for measuring conventional sediment variables in Puget Sound. Prepared for the Puget Sound Estuary Program, U.S. Environmental Protectio Agency, Region 10, Office of Puget Sound, Seattle, Washington.

PSEP. 1995. Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments. Prepared for the Puget Sound Estuary Program and U.S. Environmental Protection Agency, Region 10, Seattle, Washington. July 1995.

Appendix 1 – Field Photo Log

Photo Log – Port of Clarkston Crane Dock

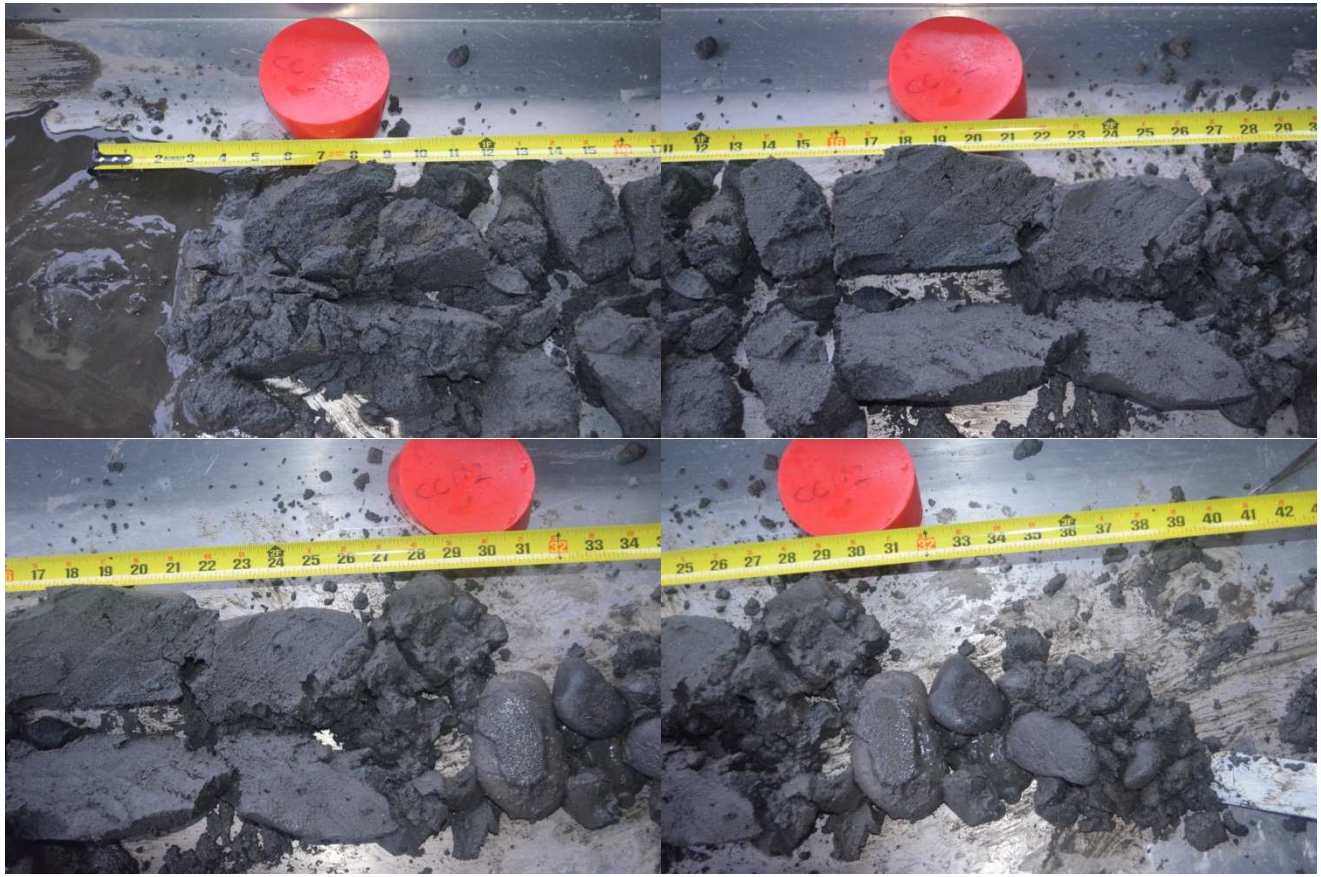




CCD-1 Core Photos



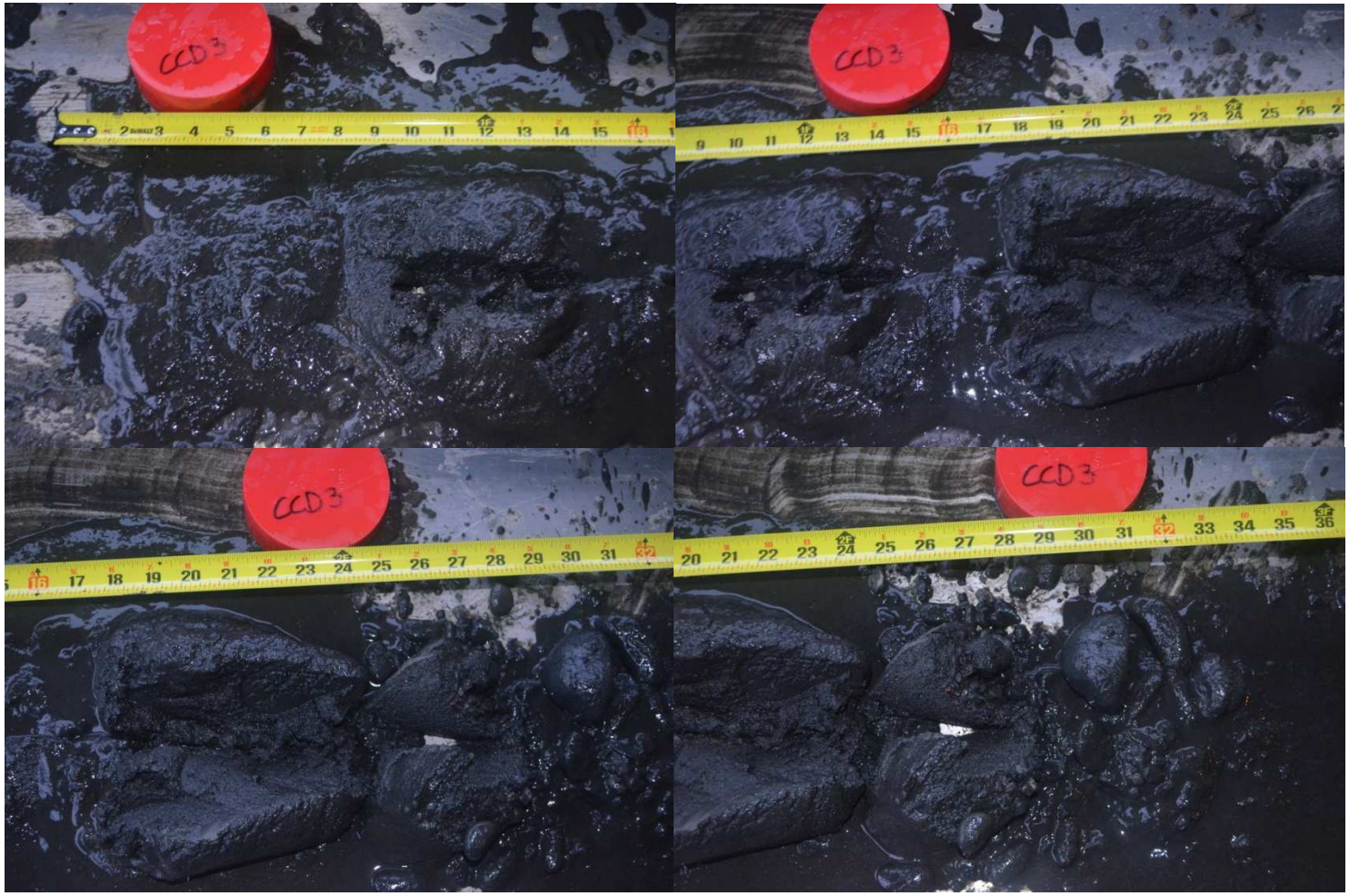
CCD-1 Core Photos



CCD-2 Core Photos



CCD-2 Core Photos



CCD-3 Core Photos



CCD-3 Core Photos

Appendix 2 – Core Logs

Sediment Core Collection Form

Sampler: Steve Saugen, Gravity Consulting LLC

Station ID:	CCD-1	**Date:**	11/28/12
Project Name:	Port of Clarkston Crane	**Project Number:**	1216 GS
Coordinates:	See Navigation Log		
Vertical Datum	MOP – NAVD88		
Measured Depth	Sounder/Lead Line		

	Attempt 1	Attempt 2	Attempt 3
Time:	13:01	13:10	13:20
Measured Water Depth	12.5	12.5	12.5
Elevation (NAVD 88)	736.9 (+4.9)	736.9 (+4.9)	736.9 (+4.9)
Mudline Elevation	724.4	724.4	724.4
Estimated Penetration	4’	39”	5’6”
Description of Core Drive	Smooth drive to hard bottom at 4’	Smooth drive to hard bottom at 4’	Smooth full drive to hard bottom starting at 4’ with refusal at bottom
Refusal Encountered?	yes	yes	yes
Total Core Length	34”	22”	5’
Recovery	71%	56%	88%

Core Characteristics

Interval	Type	Odor	Color
0-8”	Sand with silts and 3% wood debris w/roots	Slight organic	grey
8” – 47”	Fine & medium sands with low water content	None	grey
47” – 60”	Sands with cobbles to 2” in size	None	gray

Comments:
Accepted attempt 3 after 3 refusals
Collected composite sample and z-layer archive from core
Vertical reference was from Swallows Nest USACE marker

Sediment Core Collection Form

Sampler: Steve Saugen, Gravity Consulting LLC

Station ID:	CCD-2	**Date:**	11/28/12
Project Name:	Port of Clarkston Crane	**Project Number:**	1216 GS
Coordinates:	See Navigation Log		
Vertical Datum	MOP – NAVD88		
Measured Depth	Sounder/Lead Line		

	Attempt 1	Attempt 2	Attempt 3
Time:	14:25	14:30	
Measured Water Depth	23.1	23.1	
Elevation (NAVD 88)	736.9 (+4.9)	736.9 (+4.9)	
Mudline Elevation	713.8	713.8	
Estimated Penetration	22’	37”	
Description of Core Drive	Hard drive with refusal. Cobble in tube	Hard drive with refusal. Large cobble	
Refusal Encountered?	yes	yes	
Total Core Length	12”	34”	
Recovery	71%	94%	

Core Characteristics

Interval	Type	Odor	Color
0-6”	Sand with silts high water content	Slight organic	grey
6” – 28”	Fine & medium sands	None	grey
28” – 34”	Sands with cobbles to 3” in size	None	gray

Comments:
Accepted attempt 2 after 2 refusals – area is all hard rock and cobble
Collected composite sample and z-layer archive from core
Vertical reference was from Swallows Nest USACE marker

Sediment Core Collection Form

Sampler: Steve Saugen, Gravity Consulting LLC

Station ID:	CCD-3	**Date:**	11/28/12
Project Name:	Port of Clarkston Crane	**Project Number:**	1216 GS
Coordinates:	See Navigation Log		
Vertical Datum	MOP – NAVD88		
Measured Depth	Sounder/Lead Line		

	Attempt 1	Attempt 2	Attempt 3
Time:	14:47	14:58	15:10
Measured Water Depth	19.4	19.4	19.4
Water Elevation (NAVD 88)	736.9 (+4.9)	736.9 (+4.9)	736.9 (+4.9)
Mudline	717.5	717.5	717.5
Estimated Penetration	36”	32”	36”
Description of Core Drive	Hard drive with refusal.	Hard drive with refusal. Large cobble	Hard drive with refusal. Large cobble
Refusal Encountered?	yes	yes	yes
Total Core Length	28”	25”	32”
Recovery	71%	56%	

Core Characteristics

Interval	Type	Odor	Color
0-17”	Sand with silts high water content	none	grey
17” – 28”	Fine & medium sands	None	grey
28” – 32”	Sands with cobbles to 3” in size	None	gray

Comments:
Accepted attempt 3 after 3 refusals – area is all hard rock and cobble
Collected composite sample and z-layer archive from core
Vertical reference was from Swallows Nest USACE marker

Lower Snake River Programmatic Sediment Management Plan Environmental Impact Statement

Appendix I

Water Quality and Sediment Quality Reports

Section 5B. Sediment Analysis Data Report

Appendixes — *available upon request*

Lower Snake River Programmatic Sediment Management Plan Environmental Impact Statement

Appendix I

Water Quality and Sediment Quality Reports

August 2014

Section 5C. Memorandum for Record
Subject: Determination Regarding the Suitability of Proposed Dredging Material

U.S. Army Corps of Engineers
Seattle District
CENWS-OD-ME-DMMO

February 2012

CENWS-OD-ME-DMMO

MEMORANDUM FOR: RECORD February 22, 2013

SUBJECT: DETERMINATION REGARDING THE SUITABILITY OF PROPOSED DREDGED MATERIAL FROM THE PORT OF CLARKSTON CRANE DOCK, ASOTIN COUNTY, WA EVALUATED UNDER SECTION 404 OF THE CLEAN WATER ACT FOR OPEN-WATER PLACEMENT AT AN IDENTIFIED KNOXWAY CANYON LOCATION NEAR SNAKE RIVER MILE 116.

1. Introduction. This memorandum reflects the consensus determination of the Dredged Material Management Program (DMMP) agencies (U.S. Army Corps of Engineers, Washington State Department of Ecology, Washington State Department of Natural Resources, and the Environmental Protection Agency) regarding the suitability of up to 2,050 cubic yards (cy) of dredged material from the Port of Clarkson Crane Dock for open-water placement at an identified Knoxway Canyon location along the Snake River at mile 116.

2. Background. The Port of Clarkston's Crane Dock is located at Snake River mile 138 in Clarkston, Washington (Figure 1). The Crane Dock consists of a 250 foot overwater pier for vessel unloading which is complimented by three dolphins for additional barge anchoring. Since 2007, sedimentation at the site has rendered the facility too shallow for commercial purposes, causing unsafe navigation conditions for vessels and barges. Maintenance dredging is necessary to restore access to the Crane Dock.

3. Project Summary. Table 1 includes project summary and tracking information.

Table 1. Project Summary

Project ranking	Low-moderate
Proposed dredging volume	2,050 cubic yards
Proposed dredging depth	-16 ft minimum operating pool (MOP), including 1 ft overdredge depth
1st draft SAP received	August 13, 2012
Comments provided on 1st draft SAP	October 12, 2012
2nd draft SAP received	November 16, 2012
Comments provided on 2nd draft SAP	November 20, 2012
Final SAP received	November 23, 2012
SAP approved	November 23, 2012
Sampling dates	November 26, 2012
Draft data report received	January 16, 2013
Comments provided on draft report	January 29, 2013
Final data report received	February 5, 2013
DAIS Tracking number	POCCD-1-A-F-331
Recency Determination (low-moderate = 6 years)	November 2018

4. Project Ranking and Sampling Requirements. This project was ranked low-moderate according to the guidelines set out in the DMMP User's Manual, since available data indicate a low rank may be warranted, but data are not sufficient to validate a low ranking. In a low-moderate ranked area the number of samples and analyses are calculated using the following guidelines (DMMP, 2008a):
    - Maximum volume of sediment represented by each field sample = 8,000 cubic yards
    - Maximum volume of sediment represented by each analysis in the upper 4-feet of the dredging prism (surface sediment) = 32,000 cubic yards
    - Maximum volume of sediment represented by each analysis in the subsurface portion of the dredging prism = 48,000 cubic yards

    Due to the small volume of this project, a single DMMU was required, see Figure 2. Three cores were collected for a single analysis. Z-samples were collected from the cores and archived individually.

5. Sampling. Sampling took place November 26, 2012 using an electrically-driven 4-inch vibracore. The approved SAP was followed, with the following deviations. At sample location CCD-1 three attempts were made to collect a core long enough to include material from the z-layer, but it was not possible due to Vibracore refusal on 2-3" cobble (Figure 3). A shorter core that did not include a z-sample was accepted. At station CCD-2 and in the surrounding area mudline elevations were below the depth at which dredging would be necessary. Only material for a z-sample archive was collected from this location. Therefore, the composite sample sent for chemical analysis was made up of material from two stations – CCD-1 and CCD-3. Composite information is shown in Table 2.

6. Chemical Analysis. The approved sampling and analysis plan (Gravity, 2012) was followed, with the exceptions noted below, and the resulting analytical data were deemed adequate to characterize the proposed dredged material.

    The sediment conventional and chemistry results can be found in Table 3. Results are compared to the 2006 SEF freshwater guidelines for the COC's where screening levels exist and to DMMP marine guidelines for all other COCs (SEF, 2009; DMMP, 2011). The characterized sediment was primarily sand and gravel, with 58.96 and 36.64% respectively, and only 4.38% fines content.

    Initial chemistry results indicated that chemical concentrations were well below all screening levels, but the results did not include selenium. The DMMP agencies requested the lab re-analyze the sample for selenium, which was subsequently done. Selenium was undetected at levels well below the DMMP bioaccumulation trigger. Although there were minor QA issues identified in the report, the DMMP agencies deemed the data acceptable for decision making purposes.

    Chemical results were also compared to the elutriate testing trigger values in Table 10-1 of the SEF, using the relatively conservative assumptions of 1% TOC, 100 mg/L TSS and the default water hardness of 100 mg/L. No elutriate testing triggers were exceeded by this dataset.

7. Sediment Exposed by Dredging. The sediment to be exposed by dredging must either meet the State of Washington Sediment Quality Standards (SQS) (Ecology, 1995) or the State's antidegradation standard (DMMP, 2008b). All COC's in the dredged material analysis were below screening levels, so no additional analysis of z-samples was required by the DMMP agencies for decision-making.

As demonstrated by the results of the above analysis, the sediment to be exposed by dredging is not considered to be degraded relative to the current sediment surface. On this basis the DMMP agencies conclude that this project is in compliance with the State of Washington anti-degradation policy.

8. Suitability Determination. This memorandum documents the evaluation of the suitability of sediment proposed for dredging from the Port of Clarkston Crane Dock for placement at the Knoxway Canyon site at Snake River mile 116. The approved sampling and analysis plan was generally followed. The data gathered were deemed sufficient and acceptable for regulatory decision-making under the DMMP program.

   In summary, based on the results of the previously described testing, the DMMP agencies conclude that all 2,050 cubic yards are suitable for open-water placement at the Knoxway Canyon site.

   This suitability determination does ***not*** constitute final agency approval of the project. The Walla Walla District of the Army Corps of Engineers will release the public notice for this project. During the public comment period that follows a public notice, the resource agencies will provide input on the overall project. A final decision will be made after full consideration of agency input, and after an alternatives analysis is done under section 404(b)(1) of the Clean Water Act.

   A pre-dredge meeting with DNR, Ecology and the Corps of Engineers is required at least 7 days prior to dredging. A dredging quality control plan must be developed and submitted to the Seattle District Dredged Material Management Office and the Walla Walla District Corps of Engineers at least 7 days prior to the pre-dredge meeting.

9. References.

DMMP, 2011. *Marine Sediment Quality Screening Levels: Adopting RSET Marine SLs for Use in DMMP.* A Clarification Paper prepared by Laura Inouye (Ecology) and David Fox (USACE) for the Dredged Material Management Program, June 2011.

DMMP, 2008a. *Dredged Material Evaluation and Disposal Procedures (Users Manual).* Prepared by the Seattle District Dredged Material Management Office for the Dredged Material Management Program, July 2008.

DMMP, 2008b. *Quality of Post-Dredge Sediment Surfaces (Updated).* A Clarification Paper Prepared by David Fox (USACE), Erika Hoffman (EPA) and Tom Gries (Ecology) for the Dredged Material Management Program, June 2008.

Ecology, 1995. *Sediment Management Standards – Chapter 173-204 WAC*. Washington State Department of Ecology, December 1995.

Gravity, 2012. Sampling and Analysis Plan: Sediment Quality Study Port of Clarkston Crane Dock; Clarkston, WA. Gravity Consulting, LLC, November 2012.

SEF, 2009. Sediment Evaluation Framework for the Pacific Northwest. May 2009.

10. Agency Signatures.

Concur:

2/22/2013 — Date — Kelsey van der Elst - Seattle District Corps of Engineers

2/25/13 — Date — Justine Barton - Environmental Protection Agency

03/06/2013 — Date — Laura Inouye, Ph.D. - Washington Department of Ecology

3/6/13 — Date — Celia Barton - Washington Department of Natural Resources

Copies furnished:

DMMP signatories

Shawn Hinz, Gravity Environmental

Richard Turner, USACE Walla Walla District

Wanda Keefer, Port of Clarkston

Table 2. Sampling and Compositing.

		DMMU CCD-1	z-sample	Total
SAP volume (CY):		2,050		2,050
Station	CCD-1	-7.6 to -12.6	---	
	CCD-2	---	-18.2 to -19.2	
	CCD-3	-14.5 to -16	-16 to -17	

Notes:

1) The design depth for DMMU-1 is -16 feet MOP; including 1 foot of overdepth.

Table 3. Chemical results compared to DMMP regulatory guidelines.

	DMMP Marine Guidelines			Freshwater 2006		DMMU	
CHEMICAL	SL	BT	ML	SL1	SL2	CCD-1	
CONVENTIONALS						conc	LQ
Gravel, %						36.64	
Sand, %						58.96	
Silt, %						3.46	
Clay, %						0.93	
Fines (Silt + Clay), %						4.39	
Total Solids, %						79.1	
Volatile Soilids, %						1.67	
Total Organic Carbon, %						0.316	
Total Sulfides, mg/kg						4.04	
Total Ammonia, mg N/kg						25.6	
METALS (mg/kg dry)							
Antimony	150	---	200			0.119	J
Arsenic				20	51	1.87	
Cadmium				1.1	1.5	0.096	
Chromium				95	100	8.82	
Copper				80	830	11.5	
Lead				340	430	4.44	
Mercury				0.28	0.75	0.03	
Selenium		3				1.0	U
Silver				2	2.5	0.05	
Zinc				130	400	32.7	
PAHs (ug/kg dry)							
Total LPAH				6,600	9,200	9.9	U
Naphthalene				500	1,300	9.9	U
Acenaphthylene				470	640	9.9	U
Acenaphthene				1,100	1,300	9.9	U
Fluorene				1,000	3,000	9.9	U
Phenanthrene				6,100	7,600	9.9	U
Anthracene				1,200	1,600	9.9	U
2-Methylnaphthalene				470	560	9.9	U
Total HPAH				31,000	55,000	9.9	U
Fluoranthene				11,000	15,000	9.9	U
Pyrene				8,800	16,000	9.9	U
Benzo(a)anthracene				4,300	5,800	9.9	U
Chrysene				5,900	6,400	9.9	U
Total benzofluoranthenes	3,200	---	9,900			9.9	U
Benzo[a]pyrene				3,300	4,800	9.9	U
Indeno(1,2,3-c,d)pyrene				4,100	5,300	9.9	U
Dibenzo(a,h)anthracene				800	840	9.9	U
Benzo(g,h,i)perylene				4,000	5,200	9.9	U
CHLORINATED BENZENES (ug/kg dry)							
1,2-Dichlorobenzene	35	---	110			9.9	U
1,4-Dichlorobenzene	110	---	120			9.9	U
1,2,4-Trichlorobenzene	31	---	64			9.9	U
Hexachlorobenzene	22	168	230			9.9	U
PHTHALATE ESTERS (ug/kg dry)							
Dimethyl phthalate				46	440	9.9	U
Diethyl phthalate	200	---	1,200			9.9	U
Di-n-butyl phthalate	1,400	---	5,100			20	U
Butyl benzyl phthalate				260	370	9.9	U
Bis(2-ethylhexyl)phthalate				220	320	99	U
Di-n-octyl phthalate				26	45	12	J

CHEMICAL	SL	BT	ML	SL1	SL2	DMMU CCD-1	
PHENOLS (ug/kg dry)							
Phenol	420	---	1,200			13	J
2 Methylphenol	63	---	77			9.9	U
4 Methylphenol	670	---	3,600			9.9	U
2,4-Dimethylphenol	29	---	210			*6.3*	*U*
Pentachlorophenol	400	504	690			99	U
MISCELLANEOUS EXTRACTABLES (ug/kg dry)							
Benzoic acid	650	---	760			130	J
Benzyl alcohol	57	---	870			20	U
Dibenzofuran				400	440	9.9	U
Hexachlorobutadiene	11	---	270			0.68	U
Hexachloroethane	---	---	---			0.68	U
N-Nitrosodiphenylamine	28	---	130			9.9	U
PESTICIDES (ug/kg dry)							
Aldrin				37	---	0.63	U
Total Chlordane	2.8	37	---			0.63	U
Dieldrin	1.9	---	---			0.63	U
Heptachlor	1.5	---	---			0.63	U
p,p'-DDE	9	---	---			0.2	J
p,p'-DDD	16	---	---			0.63	J
p,p'-DDT	5	---	---			0.63	U
Total DDT		50	69			0.63	J
PCBs (ug/kg dry)							
Total PCBs				60	120	13	U
Total PCBs (mg/kg OC)	---	38	---				
DMMP SUMMARY							
DMMU volume						2,050	
Rank						Low-Moderate	
Mean sample depth						-12.7 ft MOP	
Maximum sampling depth						-16 ft MOP	
DMMU Determination						Pass	
	SL	BT	ML	SL1	SL2	DMMU CCD-1	

U = undetected at the MRL unless otherwise noted
LQ = laboratory qualifier
J = estimated concentration
OC = organic carbon
SL = screening level
BT = bioaccumulation trigger
ML = maximum level
reported at the MDL

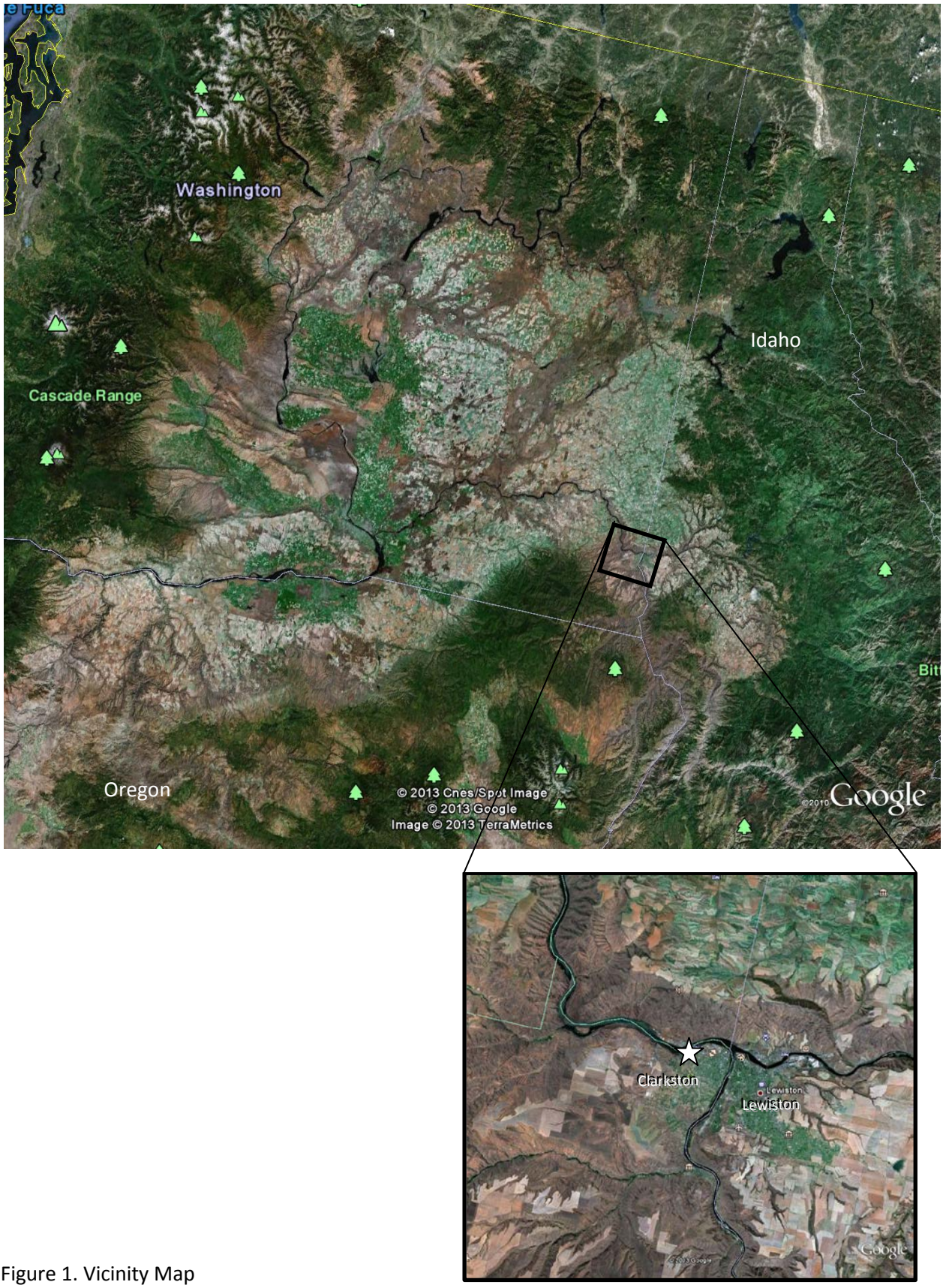
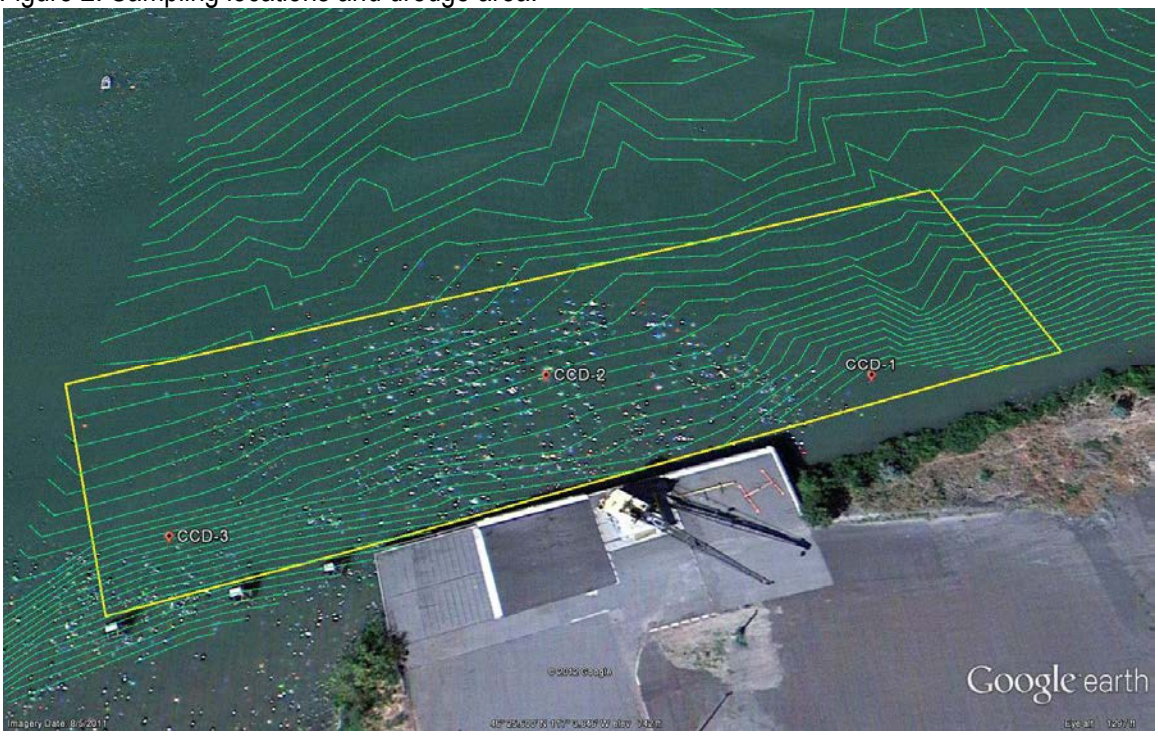


Figure 1. Vicinity Map

Figure 2. Sampling locations and dredge area.



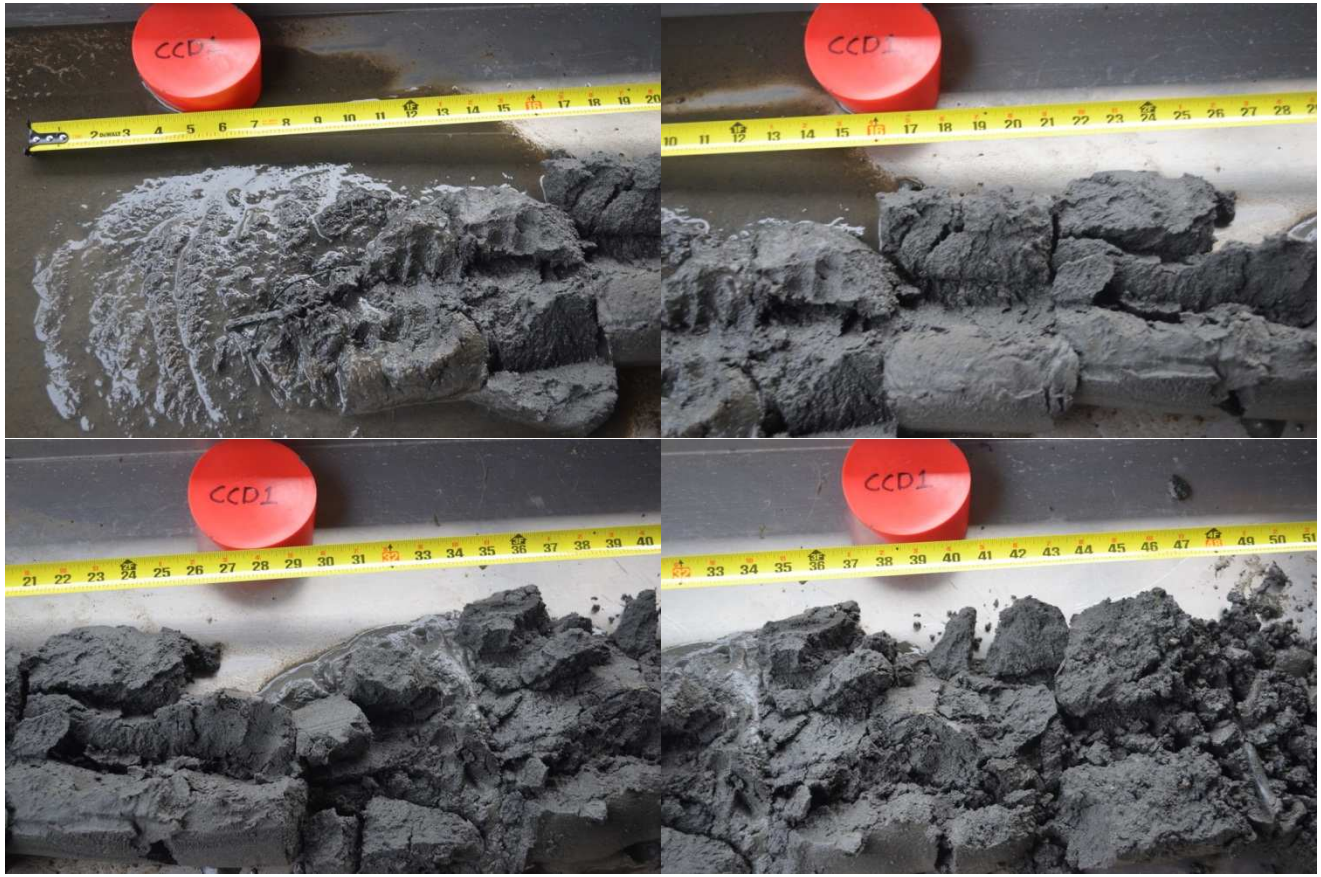


Figure 3. CCD-1 core photos.



Figure 3 continued. CCD-1 core photos.

Lower Snake River Programmatic Sediment Management Plan Environmental Impact Statement

Appendix I

Water Quality and Sediment Quality Reports

August 2014

Section 6. Lower Snake River Programmatic Sediment Management Plan, Environmental Impact Statement , Water Quality Review of the Lower Snake and Clearwater Rivers

U.S. Army Corps of Engineers
Walla Walla District

April 2011



US Army Corps
of Engineers®
Walla Walla District

Lower Snake River Programmatic Sediment Management Plan Environmental Impact Statement

Water Quality Review of the Lower Snake and Clearwater Rivers

April 2011

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Acronyms and Abbreviations

7Q10	7 day, consecutive flow with a 10-yr return frequency
ABA	Attached Benthic Algae
AMIP	Adaptive Management Implementation Plan
BiOP	Biological Opinion
BRZ	Boat Restricted Zone
CLW	Clearwater River
CWMS	Corps Water Management System
DO	Dissolved oxygen
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FCRPS	Federal Columbia River Power System
Feasibility Study	Lower Snake River Juvenile Salmon Migration Feasibility Study
Flip lips	Spillway flow deflectors
FMS	Fixed monitoring system
GOES	Geostationary Operational Environmental Satellite
g/m^2	Grams per square meter
IAC	Idaho Administrative Code
IDEQ	Idaho Department Environmental Quality
kcfs	thousand cubic feet per second
$mg^{12}C/m^3/hr$	Milligrams carbon 12 per cubic meter per hour
mg/L	Milligrams per liter
mg/m^2	Milligrams per square meter
NFC	North Fork Clearwater River
NH_3-N	Ammonia-nitrogen
NH_4-N	Ammonium-nitrogen
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NO_2-N	Nitrite-nitrogen
NO_3-N	Nitrate-nitrogen
NTU	Nephelometric turbidity units
NWD	Northwestern Division
POC	Port of Clarkston
POL	Port of Lewiston
ppm	Parts per million
PSMP	Programmatic Sediment Management Plan
RM	River Mile
RPA	Reasonable and Prudent Alternative

Acronyms and Abbreviations (continued)

SNR	Snake River
TDG	Total dissolved gas
TMDL	Total maximum daily load
TMT	Technical management team
TN	Total nitrogen
TP	Total phosphorus
TSI	Trophic State Index
TSS	Total suspended solids
µg/L	Microgram per liter
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WADOE	Washington State Department of Ecology

English to Metric Conversion Factors

To Convert From	To	Multiply By
Length Conversions		
Inches	Millimeters	25.4
Feet	Meters	0.3048
Miles	Kilometers	1.6093
Area Conversions		
Acres	Hectares	0.4047
Acres	Square meters	4,047
Square miles	Square kilometers	2.590
Volume Conversions		
Gallons	Cubic meters	0.003785
Cubic yards	Cubic meters	0.7646
Acre-feet	Hectare-meters	0.1234
Acre-feet	Cubic meters	1,234
Other Conversions		
Feet/mile	Meters/kilometer	0.1894
Cubic feet/second	Cubic meters/second	0.02832
Degrees Fahrenheit	Degrees Celsius	(Deg F-32) x (5/9)

Executive Summary

This Water Quality Appendix was prepared as part of the Programmatic Sediment Management Plan Environmental Impact Statement. This document describes existing water quality conditions within the study reach (a 225-km [140-mi] corridor through the four lower Snake River reservoirs to the mouth of the Snake River as it enters the Columbia River). Sampling stations above the study reach on the lower Snake River and Clearwater River were also included to establish baseline conditions.

The primary water quality considerations include temperature, total dissolved gas, dissolved oxygen, pH, turbidity, nutrients, inorganic ions, chlorophyll *a*, phytoplankton, and zooplankton. The main focus of this review is the water quality data that was collected from thirteen locations throughout the study area between spring 2008 and fall 2010. For some water quality parameters such as temperature, a continuous set of historic data is available and will be included in the evaluation. Water quality data recorded during the 2005-2006 dredging projects at the Port of Lewiston and Port of Clarkston were also utilized to evaluate the effects of that activity on local water quality conditions.

Hydrologic Considerations

Summer cold-water releases from Dworshak Dam began in 1992 to improve conditions for Endangered Species Act (ESA) listed anadromous fish in the lower Snake River. Approximately 44 percent of the July through August discharge in the Clearwater River between 1975 and 1991 was due to Dworshak Dam releases, but this increased to 70 percent between 1992 and 2010. At Lower Granite Dam, an average of 12 percent of the inflow originated from the Dworshak project during the first 16 year period, and this increased to almost 30 percent during the past 18 years.

Water Quality

General Water Quality Criteria:

- The Washington State Department of Ecology Aquatic Life Use designation for the Snake River from its mouth to the Washington-Idaho-Oregon border (SNR-176.1) is for salmonid spawning, rearing and migration.
- The Idaho Department of Environmental Quality has designated aquatic life uses for the segment of the Lower Granite pool located in Idaho, as well as the free-flowing reach of the Snake River above the reservoir, as Cold Water. The Clearwater River upstream from Lower Granite pool includes salmonid spawning in addition to the cold water criteria.

Water Temperature:

- Snake River water temperatures above the Lower Granite reservoir reached or exceeded 23 degrees Celsius (°C) (73 degrees Fahrenheit [°F]) during 31 of the last 33 years where there is sufficient data to make the determination. Temperatures normally exceed 20 °C (68 ^{o}F) 60 to 80 days each year.
- Clearwater River water temperatures above Lower Granite pool exceeded 20 °C (68 °F) each year, and sometimes reached 25 °C (77 °F) between 1975 and 1991. Water

temperatures have exceeded 20 °C (68 °F) during seven of the past 17 years, and did not exceed 17.5 °C (63.5 °F) during the past four years.

- Daily maximum Snake River water temperatures below Lower Granite Dam did exceed 20 °C (68 °F) during thirteen of the past sixteen recent years. However, the frequency of occurrence has decreased as the ability to model the thermal impacts of cold-water releases from Dworshak Dam using CE-QUAL-W2 have increased. Farther downstream below Ice Harbor Dam, the 20 °C criterion has been exceeded 45 to 80 days per year during the past sixteen years.

Total Dissolved Gas (TDG):

- Based on an eleven-year average, forebay TDG levels exceed the 115 percent criteria one day out of the year at Lower Granite Dam, increasing to 33 days at Ice Harbor Dam during voluntary spill. The 120 percent tailwater standard is exceeded approximately 12 days per year.

Dissolved Oxygen:

- Hourly dissolved oxygen concentrations ranged from approximately 9 to 15 mg/L in the Clearwater River between 2008 and 2010, and from 6 to 15 mg/L in the Snake River. Minimum concentrations typically occurred during late summer and early Fall and were attributed to senescing algae. Mean hourly concentrations in the Snake River ranged from 10 to 12 mg/L during the same period.

pH

- Hourly pH measurements ranged from approximately 6.5 units to 8.7 units in the Clearwater River and averaged 7.4 units for the study period. Snake River measurements ranged from 7.1 units to 9.2 units, and averaged approximately 8 units. Point measurements greater than 8.5 units have been documented in the Snake River since at least the late 1960's and early 1970's.

Specific Conductance and Ionic Concentrations

- Specific conductance in both rivers is inversely related to river discharge. The specific conductance of the Clearwater River is significantly less than in the Snake River. The mean for the Clearwater River during the study period was 33 µS/cm and hourly measurements did not exceed 68 µS/cm. The station farthest upstream at river mile 141 on the Snake River had the highest mean conductivity of 271 µS/cm. Conductivity decreased downstream, with calculated means of 220 µS/cm and 199 µS/cm at SNR-108 and SNR-2, respectively.
- The concentrations of ten major ions, along with alkalinity and hardness, were also considered. With the possible exceptions of aluminum and iron, ionic concentrations were markedly less in the Clearwater River.

Nitrogen and Phosphorus Concentrations

- The concentrations of nitrate-N and total-N were significantly lower in the Clearwater River than in the Snake River, while ammonia-N concentrations did not follow the same pattern. The median nitrate-N concentration in the Clearwater River was 0.03 mg/L. Median Snake River concentrations ranged from 0.56 mg/L at the inflowing reach and

ranged from 0.32 mg/L to 0.43 mg/L in the lower Snake River reservoirs and were not statistically different. The median total-N concentration in the Clearwater River was 0.14 mg/L, and of that approximately 33 percent was nitrate-N. Total-N concentrations were also highest in the inflowing reach of the Snake River where the median was 0.82 mg/L compared to a range of 0.51 mg/L to 0.63 mg/L in the lower Snake River where approximately 68 percent of the total-N was nitrate-N. Median ammonia-N concentrations were 0.03 mg/L, or less, at all sampling stations.

- Orthophosphorus and total phosphorus concentrations mirrored the pattern set by nitrate-N and total-N. Orthophosphorus and total phosphorus concentrations were significantly less in the Clearwater River where the median values were 0.001 mg/L and 0.011 mg/L, respectively. Both constituents were again found at higher concentrations at the upper Snake River sampling stations where the median orthophosphorus and total phosphorus concentrations were 0.026 mg/L and 0.049 mg/L, respectively. Analogous metrics in the lower Snake River ranged from 0.014 to 0.023 mg/L orthophosphorus and 0.037 to 0.043 mg/L total phosphorus.

Light Attenuation

- Light attenuation, as measured with a Secchi disc were not statistically different at any of the sampling stations with median values ranging from 2.1 m to 2.8 m.

Turbidity and Total Suspended Solids

- Median turbidity values were comparatively low. The Clearwater River has the least turbidity with a median of 2.4 NTU while the Snake River calculated medians ranged from 3.0 NTU at SNR-142 to 4.5 NTU near the mouth at SNR-2. Episodic measurements exceeded 600 NTU in the Clearwater River, and ranged from 81 NTU to 240 NTU in the Snake River.
- Total suspended solids concentrations showed some of the same characteristics as turbidity. The median concentration in the Clearwater River was 2.0 mg/L and the analogous values in the Snake River ranged from 4.7 to 5.0 mg/L. However, concentrations did reach 100 mg/L at CLW-3, 160 mg/L at SNR-147, and ranged from 32 to 114 mg/L at the reservoir sites.

Water Quality Effects of Dredging

- The water quality monitoring program implemented during the 2005-2006 navigation channel maintenance project in the Lower Snake River monitored seven parameters at 5-min intervals over the course of the project. The objective of the program was to ensure that the dredging program met the terms and conditions of the water quality certifications specified in the project permit. The analysis of the data set revealed that dredging activities in the project area did not affect most water quality parameters beyond the permit criteria established for the project. Dissolved oxygen, which is inversely related to temperature, was not impacted by the dredging activities and remained stable throughout the project. Ammonia, which is also inversely related to pH, did not display trends beyond the criteria set for this constituent, and dredging did not lead to in-water ammonia concentrations that are considered acutely toxic to salmonids. Turbidity was the only parameter influenced by the dredging program. When concentrations reached permit criteria, corrective actions were taken by the dredge crew to mitigate turbidity

levels. The frequency of turbidity concentrations that approached the criteria established for the State of Washington was directly related to the material being dredged rather than the dredging methodology or rate.

Chlorophyll a and Phytoplankton

- Chlorophyll *a* concentrations were significantly less in the Clearwater River than in the Snake River. The median concentration in the Clearwater River for the project period was 2.0 µg/L. The corresponding median concentrations determined for the inflowing Snake River was 3.6 µg/L, and ranged from 2.8 µg/L to 5.5 µg/L at the reservoir stations.
- Phytoplankton biovolume at all of the sampling stations consisted of more than 90 percent Bacillariophyta. The primary species were *Aulacoseira* sp., *Fragillaria* sp., *Melosira* sp., *Staphanodiscus* sp., and *Synedra* sp. Biovolume at the Clearwater River sampling station was significantly less than at any of the corresponding Snake River stations which displayed considerable variability but were not statistically different from each other when the entire project period is considered.

Zooplankton

- Median zooplankton biomass was least in the inflowing reaches of the Snake and Clearwater Rivers, was greatest at the reservoir stations, and reached a maximum at Lower Monumental Dam forebay. The copepods, primarily Cyclopoid copepodid, *Diacyclops thomasi*, and nauplii, were consistently present and constituted the largest median biomass for the study period at the Clearwater River sampling station and downstream from Snake River mile 82. However, the cladocera, primarily *Daphnia retrocurva*, was by far the dominant group when they reached seasonal maxima during August and September. Median rotifer biomass, primarily due to *Brachionus* sp., *Polyarthra* sp., *Synchaeta* sp., and *Keratella* sp., was usually less that of the copepods when the entire study period is considered and population pulses were typically observed during the first four months of the year. The one exception was a *Asplanchna girodi* bloom during August in Lower Granite reservoir.

Trophic State

- The Secchi disc, total phosphorus, and chlorophyll *a* data were used to calculate the Carlson Trophic State Indices, and indicate that the trophic state of the lower Snake River ranges from mesotrophic to lower eutrophic

1.0 INTRODUCTION

The primary objective of this appendix is to summarize the current water quality conditions throughout the lower Snake River. Section 2.0 provides background information on the study reach and available water quality data used for this evaluation. Section 3.0 document contains a detailed description of the existing water quality conditions in the lower Snake River system.

2.0 BACKGROUND

2.1 Study Area

The Snake River originates in western Wyoming at Yellowstone National Park, and flows approximately 1,609 km (1,000 mi) through the states of Idaho, Washington, and Oregon to its confluence with the Columbia River near Pasco and Burbank, Washington. It is the largest tributary to the Columbia River and drains an area of approximately 282,000 km^2 (109,000 mi^2), including most of Idaho and portions of Oregon, Washington, Wyoming, Nevada, and Utah. The topography within the basin ranges from steep mountainous areas, mainly in the upper headwater areas, to extensive volcanic plateaus and plains that have been deeply incised by the river over geologic time. The Snake River flows through several different physiographic provinces including the Columbia Plateau/Basalt Plain, which extends east from the foothills of the Cascade Range in Washington and Oregon to western Idaho; the Snake River Plain, which extends from southeastern Oregon, across southern Idaho and northern Nevada and Utah; the Blue Mountains province, which extends from southeastern Washington to central Oregon; and, the Northern Rocky Mountains province, which encompasses much of Idaho and Wyoming (BPA, 1995). Elevations range from approximately 152 m (500 ft) along the gorges of the lower Snake River in the Columbia Plateau physiographic province to more than 3,048 m (10,000 ft) in the mountains (BPA, 1995). The geology primarily consists of basaltic and granitic rocks and to a lesser extent consolidated sedimentary rocks and alluvium. Soils within the drainage area of the Snake River generally consist of young alluvial materials along the lower terraces of the river and a fine wind-deposited loess in large areas of the uplands in the Columbia Plateau. In addition, areas of glacial outwash and lake-bed silts caused by past glacial activity can be found in the Columbia Plateau. Soils within the Rocky Mountain province include a variety of parent materials, including metamorphic rock, as well as deposits of glacial drift, outwash, and alluvium (BPA, 1995).

The study area includes the lower Snake River drainage basin and associated tributaries (Figure 2-1). The lower Snake River consists of a 225-km (140-mi) reach extending from the point of confluence with the Columbia River, upstream to the Clearwater River near Lewiston, Idaho. Between 1961 and 1975, the Corps completed construction and began operating four run-of-river lock and dam projects on this reach of the Snake River: Lower Granite, Little Goose, Lower Monumental, and Ice Harbor. The reservoirs behind each of these dams are approximately 30-m (100-ft) deep at each forebay and approximately 5 m (16 ft) deep at the upper end of the pool. The length of each pool ranges from 45 to 65 km (28 to 45 mi). Lower Granite pool extends 63-km (39.3-mi) upstream on the Snake River and 4.6 mi on the Clearwater River. Project uses include navigation, power generation, recreation, irrigation, and fish and wildlife. Table 1-1 summarizes some key elements of the lower Snake River reservoir system projects.

Table 2-1. Selected characteristics of the Walla Walla District projects located on the Snake and Clearwater Rivers.

Project	River Mile	Year Completed	Hydraulic Head (ft)	Surface Area (acres)
Dworshak	NFC-1.9	1973	632	17,090
Lower Granite	SNR-107.5	1975	105	8,900
Little Goose	SNR-70.3	1970	103	10,025
Lower Monumental	SNR-41.6	1969	101	6,590
Ice Harbor	SNR-9.7	1961	105	8,375

Dworshak Dam is located on the North Fork of the Clearwater River near Orofino, Idaho, approximately 35 miles east of Lewiston, Idaho. It is one of the tallest straight axis dams in the world with a structural height of 717 ft (218.5 m). At the normal maximum operating elevation of 1,600 ft (487.7 m) above mean sea level (ft msl) the reservoir is nearly 53.6 mi (33.4 km) long, has a surface area of 17,090 acres (6,916 ha), and contains approximately 3,468,000 acre-feet of water.

2.2 Water Quality Data Utilized For This Analysis

Extensive temperature data is available for the lower Snake and Clearwater Rivers. The U.S. Geological Survey (USGS) operates a stream gaging station (site number 13334300) at Anatone, Washington, in cooperation with the U.S. Army Corps of Engineers (USACE) where water temperatures have been recorded since 1959 (http://waterdata.usgs.gov/ wa/nwis/). A similar USGS gaging station (site number 13342500) on the Clearwater River at Spalding, Idaho, also has data available since 1959 (http://waterdata.usgs.gov/id/nwis/). The Corps operates fixed-monitoring stations in the forebay and tailwater of each lower Snake River Dam, as well as downstream from Dworshak Dam. Water temperature and total dissolved gas are measured hourly at these locations for all or part of the year, and the data is transmitted real-time to USGS and USACE databases. Finally, the USACE installed twelve-sensor temperature strings in 2004 in the forebays of each lower Snake River dam, as well as a sixteen-sensor string in the forebay of Dworshak Reservoir, that transmit hourly to the Corps CWMS data base,

Existing water quality conditions of the lower Snake River were evaluated with a sampling program that began in April 2008. Seven sampling stations were located in the impounded reach of the lower Snake River at river mile 2 (SNR-2), 18 (SNR-18), 42 (SNR-42), 82 (SNR-82), 108 (SNR-108), 119 (SNR-119), and 129 (SNR-129) (Figure 2-1 and Table 2-1). Two additional sampling station were established at the upper end of Lower Granite pool at approximately Snake River mile 147 (SNR-147) and Clearwater River mile three (CLW-3). The stations were visited monthly beginning April 2008. Field measurements included water column profiles for temperature, dissolved oxygen, pH, conductivity and turbidity, as well as Secchi disc measurements. Water samples were collected at selected dephs for chemical analyses that included alkalinity, chloride, sulfate, ICP metals scan, nitrite plus nitrate nitrogen, ammonia

nitrogen, total nitrogen, orthophosphate, total phosphorus, and total suspended solids. Chlorophyll *a*, phytoplankton, and zooplankton samples were also retrieved from the photic zone.

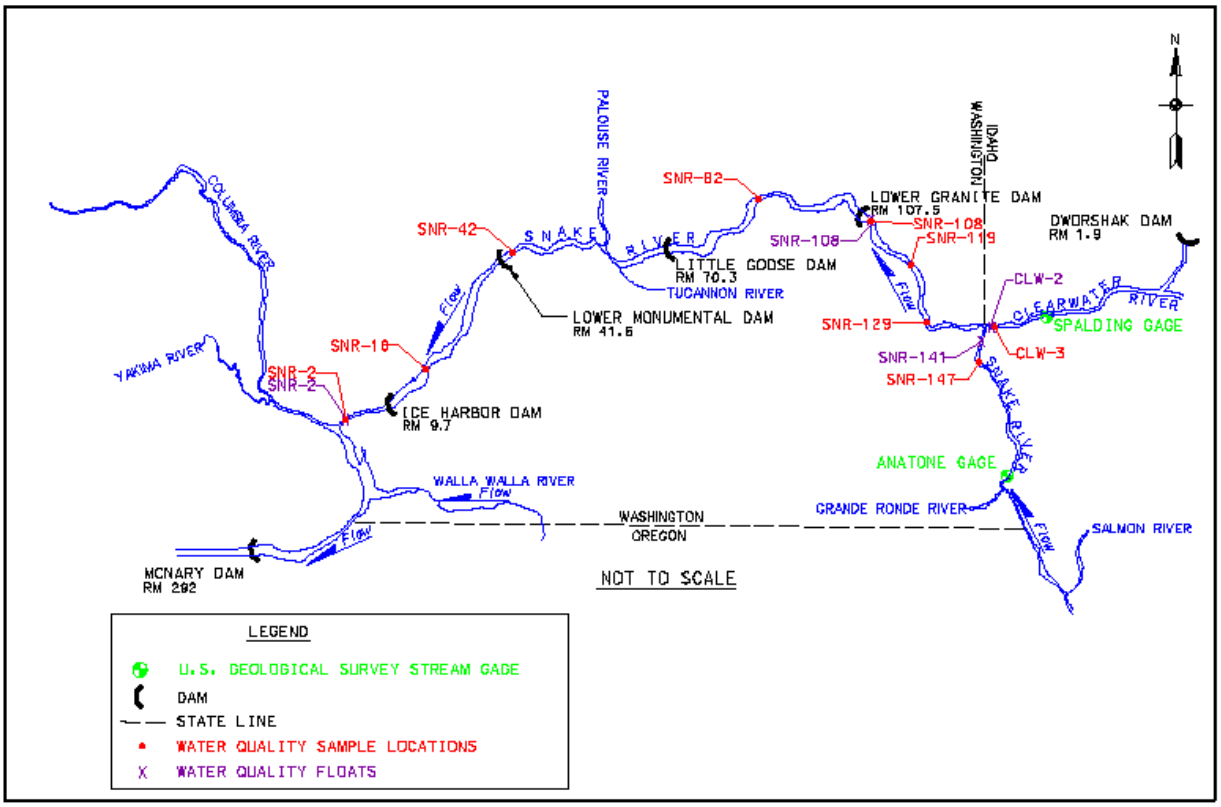


Figure 2-1. Locations of the 2008-2010 lower Snake River water quality sampling stations.

Four water-quality monitoring floats were deployed to measure temperature, dissolved oxygen, pH, conductivity, and turbidity in April 2008. The data was transmitted via satellite or cellular phone to a website on an hourly basis. The stations were located near the confluence of the Snake and Clearwater Rivers (*i.e.*, Memorial Bridge [CLW-2] and Southway Bridge [SNR-141]), Lower Granite Dam forebay (SNR-108) at the boat restricted zone (BRZ), and between Ice Harbor Dam (SNR-2) and the confluence with the Columbia River. All floats initially consisted of one multi-parameter sonde positioned at approximately mid-depth in the water column. An additional sonde that was equipped with a chlorophyll *a* sensor was added to the Lower Granite forebay station near the surface in 2010.

Table 2-1. Summary of water quality data utilized for this report.

River	Station Type	Location	River Mile	Agency	Sampling Period
Snake	Long-term Fixed Monitoring	Anatone	167.2	USGS/ USACE	1975 – October 2010
		Lower Granite Dam tailwater	106.7	USACE	1991 – October 2010
		Ice Harbor Dam tailwater	6.0	USACE	1991 – October 2010
	Temperature String	Lower Granite Dam forebay	107.6	USACE	2005 – October 2010
		Little Goose Dam forebay	70.4	USACE	2005 – October 2010
		Lower Monumental Dam forebay	41.8	USACE	2005 – October 2010
		Ice Harbor Dam forebay	10.0	USACE	2005 – October 2010
	Water Quality Profile	Free-flowing reach above Asotin	147	USACE	April 2008 – October 2010
		Downstream Silcott Island	129	USACE	April 2008 – October 2010
		Centennial Island	119	USACE	April 2008 – October 2010
		Lower Granite Dam forebay	108	USACE	April 2008 – October 2010
		Central Ferry Park	82	USACE	April 2008 – October 2010
		Lower Monumental Dam forebay	42	USACE	April 2008 – October 2010
		Fishhook Recreational Area	18	USACE	April 2008 – October 2010
		Highway 12 Bridge	2.3	USACE	April 2008 – October 2010
	Water-Quality Floats	Southway Bridge	141.2	USACE	April 2008 – October 2010
		Lower Granite Dam forebay	107.8	USACE	April 2008 – October 2010
		Highway 12 Bridge	2.3	USACE	April 2008 – October 2010
	Dredge WQ Monitoring	Port of Clarkston	138.5	USACE	January 2006 – February 2006
North Fork Clearwater	Long-term Fixed Monitoring	Dworshak Dam tailwater	0.5	USACE	1993 to October 2010
Clearwater	Long-term Fixed Monitoring	Spalding	11.6	USGS	January 1975 – October 2010
	Water Quality Profile	Free-flowing Reach at Lewiston	3.3	USACE	April 2008 – October 2010
	Water-Quality Floats	Memorial Bridge	2.0	USACE	April 2008 – October 2010
	Dredge WQ Monitoring	Port of Lewiston	1.2	USACE	December 2005 – February 2006

3.0 AFFECTED ENVIRONMENT

3.1 Water Resources

The Snake River is the largest tributary to the Columbia River, composing about 42 percent of the overall drainage area and about 18 percent of the water flow in the Columbia River system. From its origin in Yellowstone National Park to its confluence with the Columbia River near Pasco, Washington, the river flows slightly more than 1,609 km (1,000 mi). The Snake River watershed is about 282,000 km^2 (109,000 mi^2), comprising most of Idaho, the eastern part of Oregon, and lesser parts of Washington, Wyoming, Nevada, and Utah. The topography within the basin ranges from steep mountainous areas, mainly in the upper headwater areas, to extensive volcanic plateaus and plains that have been deeply incised by the river over geologic time. The geology primarily consists of basaltic and granitic rocks and to a lesser extent consolidated sedimentary rocks and alluvium. Annual precipitation ranges from 20 cm (8 in) or less in much of the lower plains to more than 203 cm (80 in) in the higher mountains (USACE, 2005).

Historically, the average annual flow for the lower Snake River segment is 49.8 kcfs. Peak monthly flows average around 115 kcfs in June compared to an average seasonal monthly low flow of around 20 kcfs in September. The highest historical flow was 409 kcfs recorded in 1894, and the lowest historical flows were 10 kcfs and 6.6 kcfs recorded in 1931 and 1958, respectively.

The 7Q10 is the average peak annual flow for seven consecutive days that has a recurrence interval of ten years. The Washingtron State Department of Ecology (WADOE) estimated this discharge for the Snake River at each of the four lower Snake River dams at 214 kcfs (WADOE, 2003). The period of record used in the total dissolved gas Total Maximum Daily Load (TMDL) analysis was from 1975-2000. The 7Q10 flow was updated by Schneider (2010) using the extended period of record from 1975-2009, the methodology described in Bulletin #17B (USGS, 1982), and the data identified in the Lower Snake River TMDL. The updated mean 7Q10 high flow in the lower Snake River was estimated to equal 203 kcfs with an 80 percent confidence limit ranging from 184.4 to 247.6 kcfs. This evaluation did not correct the skew coefficient of the station record. A review of the historic records show that the updated 7Q10 flow of 203 kcfs was exceeded in only two of the past 35 water years which infers a return period of once every 17.5 years (Schneider, 2010).

The Clearwater River, the largest tributary to the lower Snake River segment, historically contributes about 39 percent of the combined flow in the lower Snake River reach (BPA, 1995). The USGS maintains a gaging station at Spalding, Idaho, 18 km (11.6 mi) upstream from the confluence with the Snake River. The peak monthly flow generally occurs in May and averages between 45 and 50 kcfs. The low-flow period typically occurs in September when the average monthly flows range between 3 and 5 kcfs. Flows from the mainstem Clearwater River, along with the recent additional releases from Dworshak Dam on the North Fork of the Clearwater River can comprise close to 50 percent of the lower Snake River flows during periods of low flow.

3.2 WATER QUALITY

3.2.1 General Description

The water quality of the Snake River changes as it flows through the basin (USACE, 2005). The U.S. Environmental Protection Agency (EPA) has described the middle Snake River reach as having marginal water quality due primarily to nonpoint pollution sources such as irrigation return flow and runoff from grazing areas. The Idaho Department of Health and Welfare has also reported an increasing trend in bacteria, nutrients, and suspended sediment concentrations as the river flows from Marsing (SNR-240) to Weiser (SNR-351.3). Although both the bacteria and sediment levels were noted to decrease as the river flows through the Hells Canyon reservoir, elevated nutrient levels continued to be of concern downstream along with occasional low dissolved oxygen levels (BPA, 1995). Agriculture in the drainage basin has an impact on water quality both in terms of reduced flows due to irrigation withdrawals and increased nutrients, salts, sediments, and pesticides from the return flow. As the river continues through the Lewiston-Clarkston area (SNR-140), the river water quality cam also be affected by urban runoff, secondary-treated wastewater effluent, and the changes in land use associated with human habitation.

The water quality of the Clearwater River is considered exceptional, better than the lower and middle portions of the Snake River. The Clearwater River, which contributes as much as 50 percent of the lower Snake River flow during low-flow periods, generally has a beneficial effect on the lower Snake River water quality. The USGS and recent USACE data indicate that the Clearwater River is quite low in dissolved solids, nutrients, and productivity and lacks any inorganic and organic contaminants (BPA, 1995). This is attributable to the largely granitic geology and minimal urban development or agriculture within its watershed. Dworshak Dam, located on the North Fork of the Clearwater River, is a relatively large dam with a structural height of 219 m (717 ft) and a reservoir with a storage capacity of approximately 3,700 million cubic meters (3 million acre-feet). The reservoir thermally stratifies every year with a summer thermocline at about 12 to 15 m (40 to 50 ft) deep (BPA, 1995). Water temperatures below this depth remain constant throughout the year at about 4 to 5°C (39 to 41°F). The USACE has initiated controlled flow releases of this deep cooler water during July and August to reduce water temperatures in the lower Snake River. This added flow from the Clearwater River has had some effect on the water quality and biological productivity in the lower Snake River (Normandeau, 1999) as well as in the mainstem of the Clearwater River downstream from Ahsahka, Idaho.

Within the lower Snake River, water temperatures and TDG currently represent the primary water quality concerns. Numerous studies and measures have been implemented over the years to alleviate elevated levels of both parameters. Spillway deflectors (flip-lips) have been installed at the face of spillways to reduce dissolved gas entrainment caused by the plunging effect into the stilling basins. As discussed earlier, cooler-temperature water from within the Dworshak reservoir has been released during the summer months for temperature control. These flow augmentations lowered the maximum July through August water temperatures by an average of 4°C (7.2 °F) in the Clearwater River at the USGS Spalding gaging station, and 2.5°C (4.5 °F) at the Lower Granite Dam tailwater station, with diminishing effects downstream on the Snake River. Other water quality concerns include turbidity and nutrient levels. Increased nutrient concentrations can lead to greater productivity in the impoundments, reduced water clarity, and

lower dissolved oxygen levels in the bottom waters. Extensive blue-green algal blooms have also occurred periodically throughout the lower Snake River, especially in forebays and swim areas (Normandeau, 1999).

3.2.2 Water Quality Standards

The states of Washington and Idaho have established surface water quality standards. The State of Idaho has standards for the eastern half of the Snake River above the confluence with the Clearwater River, as well as the Clearwater River above the confluence. The State of Washington standards apply to all of the Snake River from its mouth at the Columbia River to the mouth of the Clearwater River, and along the western half of the remaining Snake River to the Oregon border. Each of the state standards is typically based on, and sometimes more stringent than, the EPA water criteria that were developed for the protection of aquatic life and beneficial water uses.

The State of Washington's Water Quality Standards (Washington Administrative Code [WAC] 173-201A; Rev: November 20, 2006) are based on designated uses. The designated aquatic life use for the lower Snake River from its mouth at the Columbia River to the Oregon border (SNR-176.1) is salmonid spawning, rearing and migration. This designation primarily determines the criteria applied to temperature, dissolved oxygen, total dissolved gas, pH, and turbidity (Table 3-1). The water in various reaches of the lower Snake River are on the State's 303(d) Category 5 list for temperature, pH, and dissolved oxygen (http://www.ecy.wa.gov/ programs/wq/303d/ index.html).

Table 3-1. Applicable Idaho and Washington water quality standards.

Parameter	Idaho	Washington
Temperature	≤ 22 ºC with a max daily average ≤ 19 ºC[a] ≤ 13 ºC with a max daily average ≤ 9 ºC[b]	≤ 20 ºC
Dissolved Oxygen	≥ 6.0 mg/L	≥ 8 mg/L
Total Dissolved Gas	≤ 110%	≤ 110% [c] ≤ 115% and ≤ 120% [d] ≤ 125% [e]
pH	6.5 – 9.0 units	6.5 – 8.5 units
Turbidity	≤ 50 NTU increase instantaneously [f] ≤ 25 NTU increase for more than 10 days [f]	≤ 5 NTU increase [g] 10% increase [h]

[a] Clearwater and Snake River cold water criteria
[b] Criteria applicable to the Clearwater River during salmonid spawning and incubation
[c] During the non-fish spill season when river flows are < 7Q10
[d] Average 115% forebay and 120% tailwater allowance during voluntary fish spill season
[e] Maximum one-hour average
[f] Measured below applicable mixing zone
[g] As measured below mixing zone when background is ≤50 NTU
[h] As measured below mixing zone when background is >50 NTU

The State of Idaho also incorporates aquatic life designations in their water quality standards (Idaho Administrative Code IDAPA 58.01.02). The eastern side of Lower Granite pool on the Snake River above the confluence with the Clearwater River is designated as "Cold Water". The lower reach of the Clearwater River that is also part of the Lower Granite pool is also designated as "Cold Water". However, the free-flowing reach of the river above Lower Granite pool to Dworshak Dam is designated for "salmon spawning" in addition to the "cold water" designation. Idaho numerical standards for several key parameters are also presented in Table 3-1.

3.2.2.1 Temperature

Washington's water quality standards specify that water temperatures in the lower Snake River shall not exceed 20 °C (68 °F) within the study reach as a result of human activity. In addition, temperature increases due to human activity in the lower Snake River (*i.e.*, below the Clearwater River) shall not exceed:

$$t = 34/(T+9), \text{ where}$$

t = change in temperature, and

T = background temperature (°C)

For example, if the background temperature were 20 °C (68 °F), then the maximum allowable temperature increase due to human activity would be 1.17°C (2.1 °F). Above the confluence with the Clearwater River (SNR-139.3), increases over 0.3 °C (0.5 °F) caused by human activity from a single source are not allowed, and increases over 1.1 °C (2 °F) from all activities are not allowed when the background stream temperature is over 20 °C (68 °F).

Idaho's temperature criterion for the Clearwater River is influenced by salmonid spawning. During the time of year when salmon are spawning and the eggs are incubating, the maximum water temperature is set at 13 °C (55 °F) with a maximum daily average no greater than 9 °C (48.2 °F). The standard reverts to the cold-water criteria of a maximum water temperature of 22°C (72 °F) with daily averages no greater than 19 °C (66 °F) when salmonid spawning and incubation does not occur. The Idaho cold-water standard also applies to the mainstem of the Snake River above the confluence of the Clearwater River (SNR-139).

3.2.2.2 Dissolved Oxygen

Dissolved oxygen criteria can be expressed in milligrams per liter (mg/L) or percent saturation. The Washington standard states that concentrations must be equal to or greater than 8 mg/L during all times of the year. The Idaho cold-water criteria states that the dissolved oxygen concentrations shall exceed 6 mg/L at all times. During salmonid spawning, the water must have a minimum concentration of 6.0 mg/L or 90 percent saturation, whichever is greater.

3.2.2.3 Total Dissolved Gas (TDG)

According to Chapter 173-201 WAC, the State of Washington water quality standards for surface waters from the mouth of the Snake River to the Washington-Oregon border, "shall not exceed 110 percent of saturation at any point of sample collection." However, this criterion does not apply when the stream flow exceeds the 7Q10, and is adjusted to aid fish passage over hydroelectric dams between 1 April and 31 August. This exemption for salmonid migration sets the average (calculated using the twelve highest consecutive hourly readings in one day) forebay

and tailwater values at 115 percent and 120 percent, respectively. The maximum one hour average must not exceed 125 percent at any location.

The Idaho TDG standard is more restrictive. The general criteria states that the total concentration of dissolved gas must not exceed 110 percent at the point of sample collection. Allowances for higher gas saturation levels are made when involuntary spill occurs for flood control purposes.

3.2.2.4 Turbidity

Turbidity is measured in nephelometric turbidity units (NTU). The applicable aquatic life criteria in Washington specifies that increases in turbidity levels below the mixing zone shall not exceed 5 NTU when the background level is 50 NTU or less, or increase by 10 percent when the background is more than 50 NTUs. The point of compliance is identified as three hundred feet downstream of the activity causing the turbidity. The State of Idaho requires that the measurement below the applicable mixing zone set by the Department of Environmental Quality not exceed 50 NTUs instantaneously, or 25 NTUs for more than ten consecutive days.

3.2.2.5 pH

The pH criteria for both states are similar. The Washington pH standard applicable to the study area specifies that pH shall be within the range of 6.5 to 8.5 with a human-caused variation of less than 0.5 units. The Idaho criteria states that pH values should not vary from the 6.5 to 9.0 units range due to human activities.

3.2.3 Summary of Existing Water Quality Conditions

The following sections provide a synopsis of the relevant hydrologic, physical, chemical, and biological parameters that can be used to characterize water quality conditions within the area of interest.

3.2.3.1 Hydrologic Characteristics

The hydrologic characteristics of the Clearwater and Snake Rivers influence the limnological characteristics of the rivers themselves, as well as the downstream reservoirs. The primary river gauging stations utilized for this report are the ones operated by the USGS near Spalding, Idaho, on the Clearwater River (CLW-11.6) and near Anatone, Washington, on the Snake River (SNR-167.2). Additionally, discharge rates from Dworshak Dam recorded by the USACE will be utilized to help evaluate the effect of project operations on downstream water quality.

Dworshak Dam is a high-head facility with a maximum forebay depth close to 650 ft (198 m) and develops strong thermal stratification during the summer. That attribute, in addition to the multi-level outlet structure facilitates the withdrawal of cold water at selected depths. The outflow water is usually regulated to be within a temperature range of 6-12 ºC (42.8-53.6 ºF) since it is utilized by the Dworshak National Fish Hatchery. In 1992, a summer flow augmentation program from Dworshak reservoir was implemented as part of an effort to improve lower Snake River temperature conditions for anadromous fish. Each year thereafter, the Dworshak augmentation flow procedure was adjusted and essentially standardized in 1995 for downstream flow and temperature control. The Corps currently releases 1,500 million cubic meters (1.2 million acre-feet) of cold water from July through the end of August for downstream flow augmentation and temperature control. An additional 247 million cubic meters (200,000

acre-feet is released during the first two weeks of September as part of the Snake River Basin Adjudication – Nez Perce Tribe Water Rights Settlement. Discharge during the summer release period can be as high as 14 kcfs without exceeding the State of Idaho's total dissolved gas standard. The actual amount released is determined by the Regional Technical Management Team (TMT) with input from Walla Walla Districts CE-QUAL-W2 model results. The net effect is that during July and August the project has released an average of 6.9 kcfs, and up to 10.2 kcfs, more water during the 1992-2010 period when compared to the 1975-1991 period Figure 3-1.

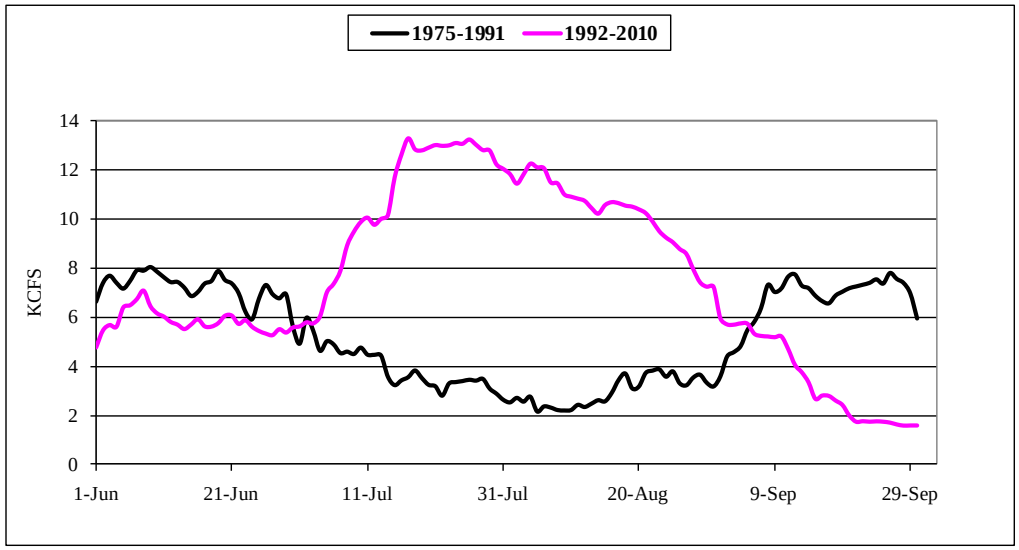


Figure 3-1. Average total outflow from Dworshak Dam during the summer from 1975 through 1991 and 1992 through 2010.

The impact of this operational change at the downstream Spalding gaging station is displayed in Figure 3-2. The graph shows that from 1992 to 2010 the releases from Dworshak comprise, on average, up to 80 percent of the flow in the Clearwater River during August.

The effect on the lower Snake River was diminished, but still visible. Between 1975 and 1991, the Clearwater River, on average, constituted about 26 percent of the flow in the Snake River at Lower Granite Dam (Figure 3-3). However, after the flow augmentation program from Dworshak Dam was implemented, the average rose to 40 percent. This difference in the origin of the water may initially appear inconsequential, but due to the dissimilar physical and chemical properties of the Snake River and Clearwater River, the end result was apparent in water-quality conditions of the lower Snake River. These effects will be discussed in subsequent sections of this report.

3.2.3.2 Water Temperature

Temperature represents one of the most important characteristics of river water. It affects other physical properties, such as dissolved oxygen, TDG, and also influences the chemical and biological reactions that take place in aquatic systems.

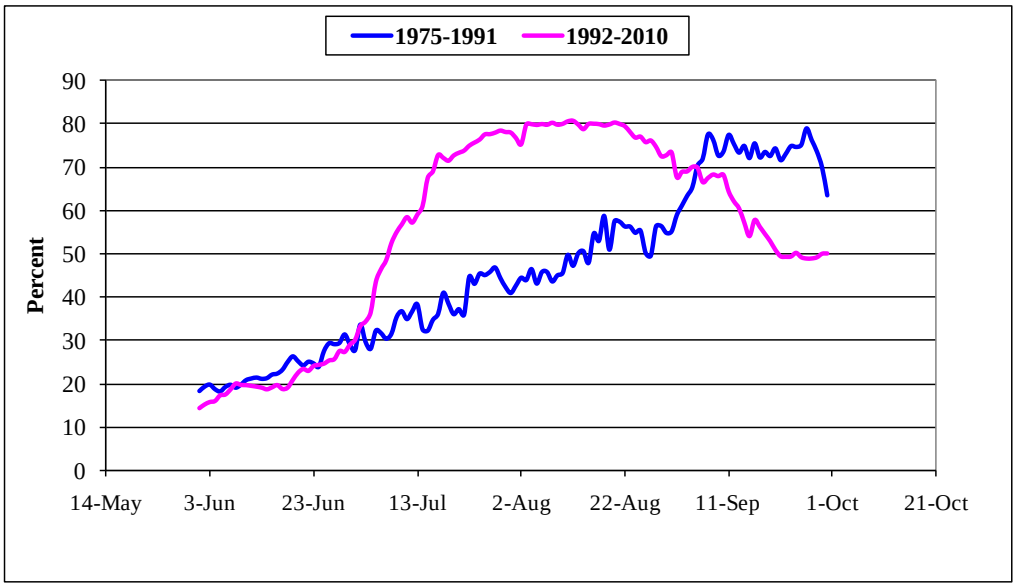


Figure 3-2. Percent of the flow at the USGS Spalding gage originating from Dworshak Dam during the summer from 1975 through 1991 and 1992 through 2010.

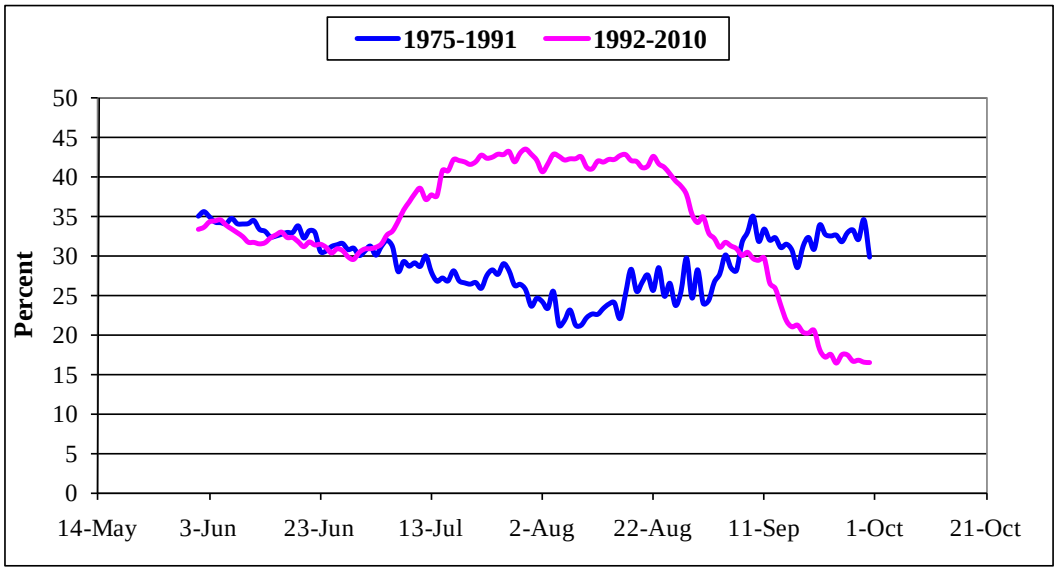


Figure 3-3. Percent of the Lower Granite Dam outflow originating from the Clearwater River during the summer from 1975 through 1991 and 1992 through 2010.

Recent and historical water temperature data were evaluated to quantify water temperature conditions through the reservoir system. The study reach considered is from the mouth of the Snake River upstream to the Anatone gaging station above Clarkston, Washington, on the Snake River, the Spalding gaging station above Lewiston, Idaho, on the Clearwater River, and at Dworshak Dam on the North Fork Clearwater River.

The evaluation is divided into the following parts:

- Water temperatures above the lower Snake River reservoir system
- Water temperatures within the lower Snake River reservoir system
- A comparison of water temperatures above and below the reservoir system

3.2.3.2.1 Water Temperatures Above the Lower Snake Reservoir System

Water temperature data in the lower Snake River upstream of the reservoirs have been collected through routine monitoring programs since at least 1959. Construction of the lower Snake River reservoir projects began in 1956 at the Ice Harbor Dam site. To support construction and future project data requirements, the USGS began collecting water temperature data at the following gaging stations:

- The river gaging station near Anatone, Washington (SNR-167.2, approximately 13 km [8 mi] east of Anatone)
- The river gaging station near Clarkston, Washington (SNR-134)
- The river gaging station near Spalding, Idaho (CLW-11.6, approximately 18 km [11 mi] above Lewiston, Idaho).

Hourly water temperature data are transmitted via the Geostationary Operational Environmental Satellite (GOES) system near real-time. The data collected by the USGS at these three stations are published in its annual Water Resources Data Report for Washington and Idaho. The quality of these data is controlled by the USGS using its standards, and the record is considered to be very good and representative of the river at these locations. The Snake River station near Clarkston was discontinued in 1964; therefore, only the Anatone and Spalding station data were used in this evaluation. The annual USGS publications list maximum and minimum temperatures for each day of the period. During this period of record, there were a number of changing reservoir conditions upstream from both the Anatone and Spalding gages. The Idaho Power Company Hells Canyon reservoir complex (Brownlee, Oxbow, and Hells Canyon) construction was completed on the Snake River in 1967. Dworshak Dam construction was completed in 1973 on the North Fork of the Clearwater River (approximately 56 km [35 miles] above the Spalding station). By 1974, upstream reservoir development above Lewiston, Idaho, was completed on both the Snake and Clearwater Rivers and the upstream reservoirs were being operated under their normal operating criteria (as defined before special reservoir operations began for threatened and endangered fish species).

Where possible for this evaluation, data graphs are plotted beginning in 1975 to best represent the current level of upstream reservoir development. Data are analyzed by comparing each year in the record and also by preparing period averages for each record.

The average daily maximum water temperatures at the USGS Anatone station for the periods 1975 through 1991 and 1992 through 2010 are very similar (Figure 3-4). Maximum daily temperatures exceeded 20 °C (68 °F) each year for 35 to 91 days (an average of 56 percent of the time) between 1 June and 1 October (Table 3-2).

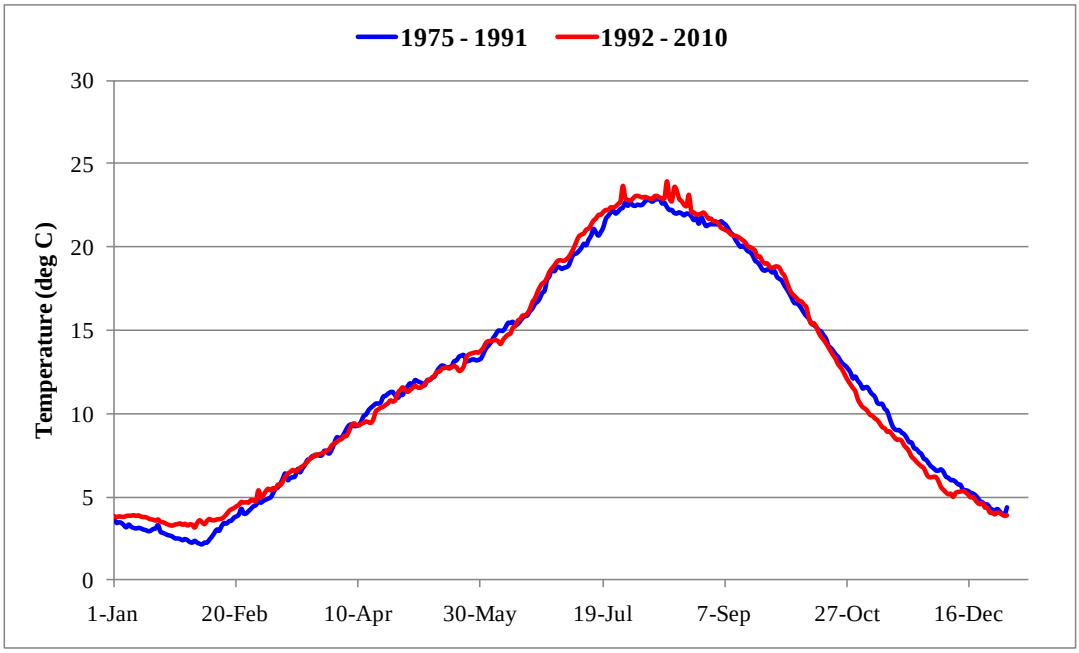


Figure 3-4. Average daily maximum water temperatures for the USGS gaging station at Anatone, 1975 through 1991 and 1992 through 2010.

The analogous graph for daily maximum water temperatures recorded at the USGS gaging station at Spalding on the Clearwater River shows a different pattern (Figure 3-5). This is because summer cold-water releases from Dworshak Reservoir were initiated in 1992. The temperature of these supplemental July, August, and September discharges ranges from 6 °C (43 °F) to 12 °C (54 °F). The purposes for these below-equilibrium temperature releases are to improve water temperature regimes and increase velocities in the four lower Snake River reservoirs; conditions thought to aid emigration of juvenile salmonids. These releases were first conducted on an experimental basis, but have since become part of the operational program. The augmentation flow usually begins in early July so that temperatures in the Lower Granite Dam tailrace (the compliance point used to evaluate temperature conditions in the lower Snake River) do not exceed 20°C (68 °F). The 1992-2010 trace in Figure 3-5 shows that average maximum water temperatures peak in late June near 17 ºC (62.6 ºF) and the mean July and August temperatures were less than 20 ºC (68 ºF). In fact, the average maximum daily water temperatures were up to 6 ºC (10.8 ºF) less in July and August during this recent interval. The average number of days per year with elevated temperatures was 15 for the early period, and ranged from zero in 1983 to 52 in 1990 (Table 3-2).

Table 3-2. Number of days at USGS Anatone and Spalding gaging stations when the maximum daily temperature exceeded 20 °C between 1 June and 1 October, 1975 through 2010.

	Snake River Near Anatone, WA		Clearwater River at Spalding, ID	
Year	Days Over 20°C	Days Missing	Days Over 20°C	Days Missing
1975	+	97	10	12
1976	43	0	8	0
1977	60	0	16	0
1978	35	0	22	0
1979	79	0	1	0
1980	51	0	9	0
1981	72	0	6	0
1982	47	0	2	0
1983	47	0	0	16
1984	—	122	+	44
1985	—	122	13	0
1986	80	4	17	0
1987	83	0	39	0
1988	76	0	26	0
1989	71	0	16	0
1990	88	0	52	0
1991	68	0	36	0
1992	64	2	41	3
1993	39	2	+	109
1994	78	2	22	0
1995	64	2	5	0
1996	48	3	0	0
1997	63	0	13	0
1998	84	1	8	0
1999	64	0	0	0
2000	76	0	0	3
2001	87	9	4	0
2002	80	0	0	0
2003	91	0	0	9
2004	76	0	1	0
2005	68	0	0	0
2006	75	2	1	0
2007	84	0	0	0
2008	67	0	0	0
2009	82	0	0	0
2010	56	0	0	3

Notes:

1. Days Missing based on the period of 1 June to 1 October (122 total days)
2. Missing days may skew the maximum temperature and number of days over 20°C
3. -- = Data missing for indicated periods
4. + = Insufficient Record

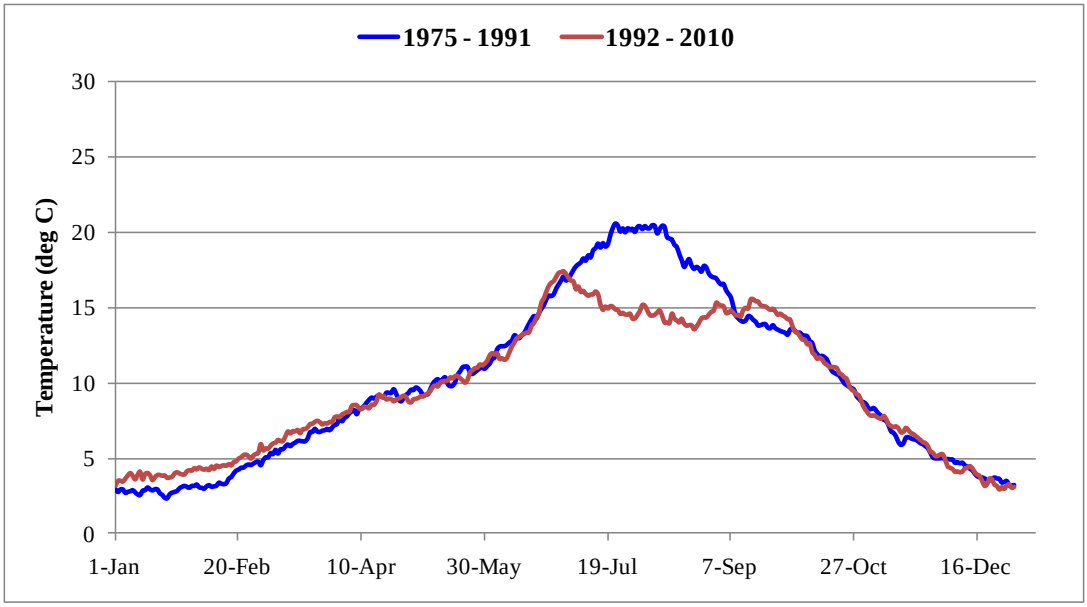


Figure 3-5. Average daily maximum water temperatures for the USGS gaging station at Spalding, 1975 through 1991 and 1992 through 2010.

3.2.3.2.2 Water Temperatures at Lower Granite Dam Tailwater

The effect at Lower Granite Dam of releasing cooler Dworshak Reservoir water during the summer is very apparent in Figure 3-6. The 1978 through 1991 period is represented by project scrollcase temperatures. These temperatures were recorded at the projects prior to the in-river sensors we now have and were recorded once or twice a day. Because the turbine intakes are located relatively deep in the water column, this data does not represent maximum thermal conditions, but rather something closer to average. However, it is the only historic time series project data available and does show that water temperatures were greater than 20 ºC (68 ºF) between the beginning of July and the first part of September at Lower Granite Dam. The 1995 through 2010 trace shows that the average of the daily maximum temperatures recorded at the Lower Granite Dam fixed monitoring system (FMS) tailwater station were less than 20 ºC (68 ºF).

Managing the environmental flow regimen from Dworshak Dam has been enhanced by recent water temperature modeling efforts. The National Marine Fisheries Service (NOAA Fisheries) issued a Biological Opinion (BiOp) dated 21 December 2000, entitled "Endangered Species Act Section 7 Biological Opinion on the Re-initiation of Consultation on Operation of the Federal Columbia River Power System, Including the Juvenile Fish Transportation Program, and 19 Bureau of Reclamation Projects in the Columbia Basin." One of the measures identified within the BiOp was Reasonable and Prudent Alternative (RPA) action item 143. This measure states, "The Action Agencies shall develop and coordinate with NOAA Fisheries and EPA on a plan to model the water temperature effects of alternative Snake River operations. The modeling plan shall include a temperature data collection strategy developed in consultation with EPA, NOAA Fisheries and state and tribal water-quality agencies. The data collection strategy shall be sufficient to develop and operate the model and to document the effects of project operations."

To address this RPA measure in a cooperative manner, the Regional Water Quality team established a technical workgroup to develop the plan called for by the action item. One of the outcomes was the development and implementation of a water quality model (CE-QUAL-W2) that could be used to help optimize Dworshak Dam releases for downstream temperature benefits. CE-QUAL-W2 is a two-dimensional laterally averaged model and was put into use by Walla Walla District in 2006.

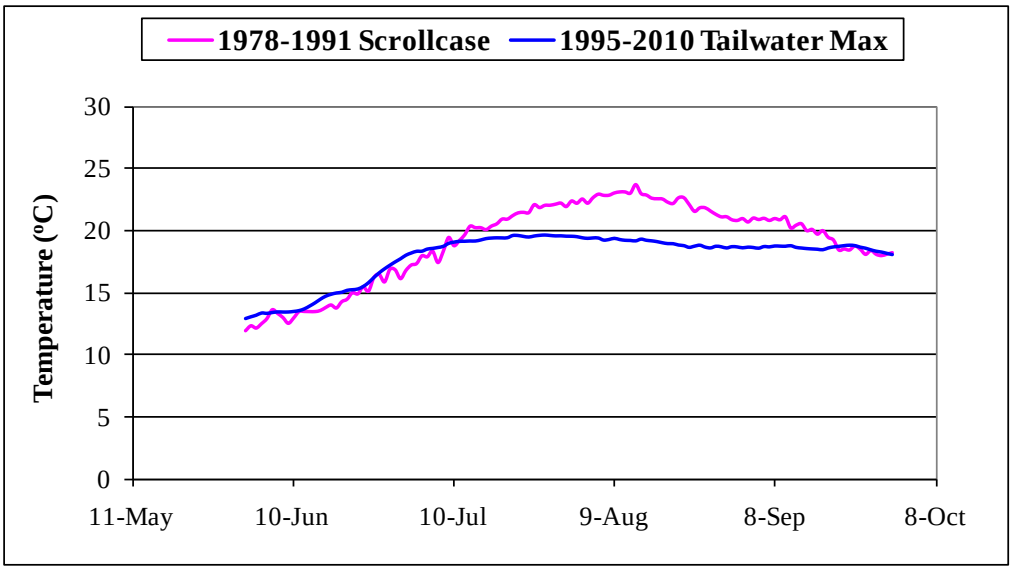


Figure 3-6. Comparison of the 1978-1991 scrollcase temperatures and the 1995-2010 tailwater FMS station temperatures at Lower Granite Dam.

3.2.3.2.3 Water Temperatures Within the Lower Snake River Reservoir System

The lower Snake River reservoirs do not stratify thermally to the extent that Dworshak Reservoir and other deep lakes do. Significant temperature differences between the surface and bottom waters are generally rare in running waters. A frequently used rule-of-thumb is that a water body has to have a mean depth greater than 10 m (33 ft) and a mean annual hydrologic residence time in excess of 20 days before strong thermal stratification develops. The mean depths of the lower Snake River reservoirs are greater than 10 m (33 ft), but the average annual residence time for each pool is about five days. The calculated retention time can approach 20 days during the summer and fall of low-flow years and facilitate the development of vertical temperature differences. However, wind- and flow-induced turbulent diffusion, along with convective mixing prevents that from happening most of the time.

However, with the advent of the summer augmentation flows described above, vertical thermal gradients are more pronounced in the lower Snake River now than they were in the past. Since Lower Granite Dam is the upper most USACE project on the lower Snake River, the summer thermal gradient is more apparent in that forebay. Based on hourly data from temperature stings that were installed in the forebays of each lower Snake River dam in 2004, the average temperature difference between 2005 to 2010 during 15 July through 31 August at 1 m (3.3 ft)

and 30 m (98 ft) was 4.1 ºC (7.4 ºF). This difference has been as high as 8 ºC (14.4 ºF). The thermal influence of summer cold-water releases from Dworshak Dam decreases downstream (Figure 3-7) and varies from year-to-year, but the average difference at Little Goose Dam for the same time period was 2.1 ºC (3.8 ºF) and 1.6 ºC (2.9 ºF) at Lower Monumental Dam and Ice Harbor Dams.

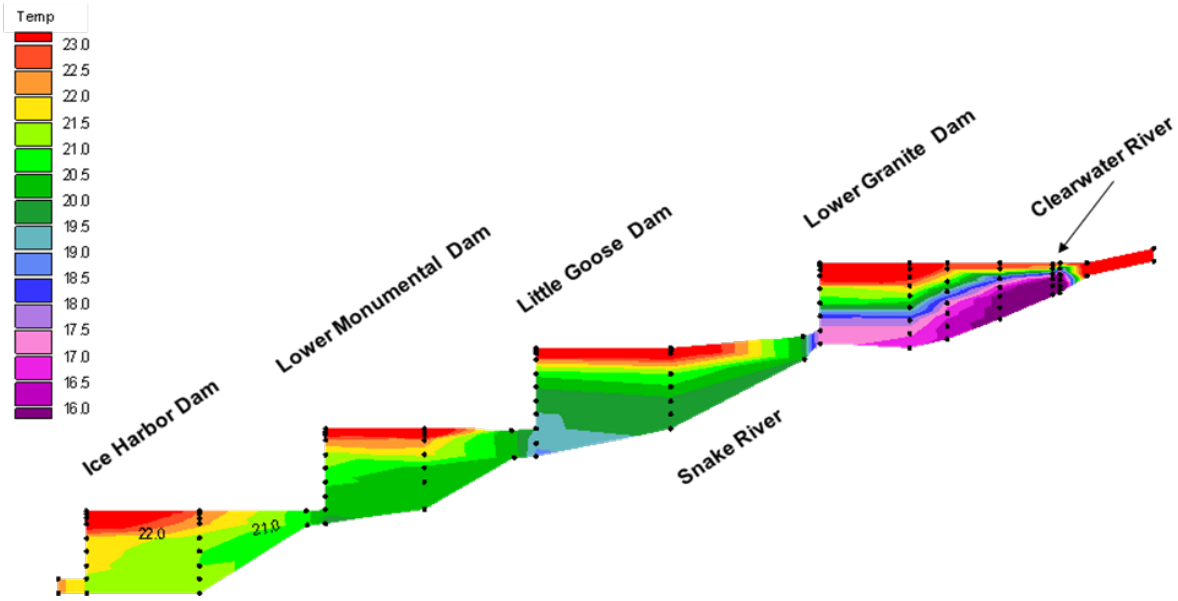


Figure 3-7. Downstream water temperature gradients in the four lower Snake River reservoirs based on 2006 data.

3.2.3.2.4 Comparison Between Above and Below the Lower Snake River Reservoir System

Another perspective of the thermal benefits of the summer flow augmentation program can be seen by comparing water temperature conditions above the lower Snake River reservoir system to selected tailwater stations. Figure 3-8 displays an upstream versus downstream temperature summary comparison using daily maximum temperatures measured from 1995 through 2010. During July and August, the mean difference between maximum daily temperatures at Anatone and Lower Granite Dam tailwater was 3.5 ºC (6.3 ºF), but was as high as 4.9 ºC (8.8 ºF). The maximum and mean temperature differences between Anatone and Ice Harbor Dam tailwater were less at 2.4 ºC (4.3 ºF) and 1.3 ºC (2.3 ºF), respectively.

3.2.3.3 Dissolved Oxygen

3.2.3.3. 1 2008-2010 Data

Dissolved oxygen is critical to the ecology of both riverine and reservoir systems. Foremost among the functions that it performs is the sustenance of most biological life. Nearly as important, oxygen is the key element in many chemical processes in water. Through oxidation and reduction reactions, the concentration of oxygen has the ability to influence the concentration of many dissolved substances in water. These chemical processes include the decomposition of organic matter, the cycling of nutrients, and the transformation and transport of substances within the water column and between the sediments and the water column.

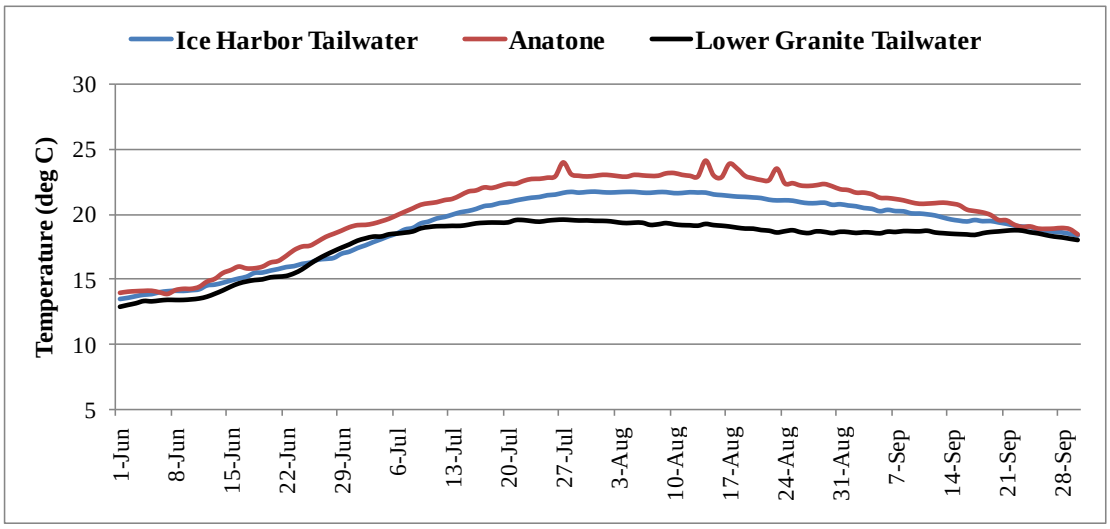


Figure 3-8. Average maximum temperatures measured at Anatone, Lower Granite Dam tailwater and Ice Harbor Dam tailwater between 1995 and 2010.

The biochemical processes of photosynthesis and respiration by living organisms provide a means by which the aquatic community can regulate the amount of oxygen in the aquatic environment, within limits. Most organisms cannot survive with too little oxygen while the solubility of oxygen generally limits the maximum amount that can be dissolved in water under most conditions. Supersaturation of water with oxygen does occur during periods of intense photosynthetic activity and as a result of dissolution of oxygen under high hydrostatic pressure in the plunge pools of high head dams (Bowie *et al.*, 1985). Both of these situations occur, at times, in the lower Snake River.

Box plots of the hourly dissolved oxygen data recorded at the four floating water quality monitoring stations that were deployed from 2008-2010 is shown in Figure 3-9. The oxygen content of the water was greatest at CLW-1 where the median concentration for the study period was11.5 mg/L (101.1 percent saturation). Hourly data at this station ranged from 9.4 mg/L to a maximum of 15.6 mg/L (125.4 percent saturation) that was recorded in January 2009. The data for the stations at SNR-141 and SNR-2 were similar to each other with calculated medians of 10.8 mg/L (101.3 percent saturation) and 10.9 mg/L (105.3 percent saturation), respectively. Individual data points at these two stations that represent the inflowing and outflowing Snake River for the reservoir system ranged from 7.2 mg/L to 15.2 mg/L. The data from the station at SNR-108 was slightly depressed relative to the other three. The median concentration at the forebay location was 10.1 mg/L with individual data points ranging from 5.8 mg/L to 13.7 mg/L. The seasonal lows may be due to senescing algae descending in the water column. Dissolved oxygen concentrations exceeded 160 percent in the forebay surface waters in August 2008, and reached 140 to 150 percent in August and September 2009 as a result of prolific algal growth.

Dissolved oxygen concentrations also displayed a pronounced annual cycle. This was due in large part to the very strong negative correlation (greater than 0.95) between dissolved oxygen and temperature. Figure 3-10 shows traces of the available daily data from SNR-141 and

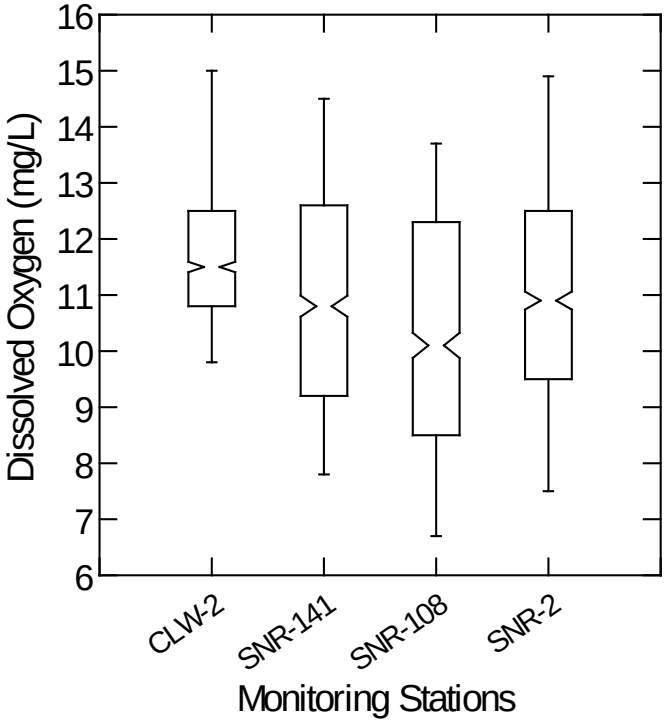


Figure 3-9. Box plots of the dissolved oxygen concentrations measured at the four floating water quality monitoring stations.

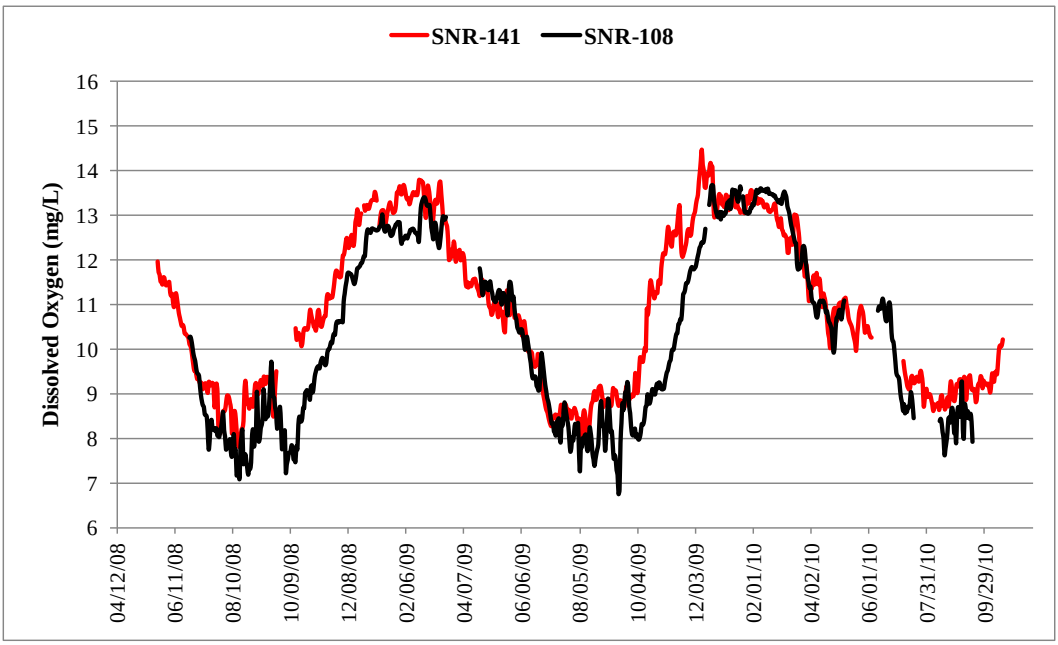


Figure 3-10. Annual cycle for the dissolved oxygen concentrations measured at SNR-141 and SNR-108.

SNR-108 as examples. A slight phase shift is apparent when the two data sets are compared. Annual minimum concentrations were encountered at the inflowing station in late August compared to late August to early October at the reservoir site. Additionally, mean daily concentrations increased faster at SNR-141and were 0.5 mg/L to 1.0 mg/L higher during the winter months.

The frequency distributions for the hourly 2008-2010 dissolved oxygen concentrations illustrate a few distinct spatial differences (Figure 3-11). None of the hourly data points recorded at CLW-2 were less than 9 mg/L, and 81 percent of the data was between 10 mg/L and 13 mg/L, with 33 percent in the 11 to 12 mg/L category. At the upper SNR-141 site, 1.2 percent of the data was less than 8 mg/L, and 98 percent of the data was distributed fairly evenly between 8 mg/L and 14 mg/L. Almost 10 percent of the hourly data recorded at the water quality float at SNR-108 were less than 8 mg/L. Since the sensor was located near the middle of the water column, the frequency of reduced dissolved oxygen conditions was probably due to senescing algae as previously mentioned. Almost two percent of the data at SNR-2 was less than 8 mg/L, but this was also the only floating water quality monitoring station where greater than 20 percent of the data was between 12 mg/L and 13 mg/L.

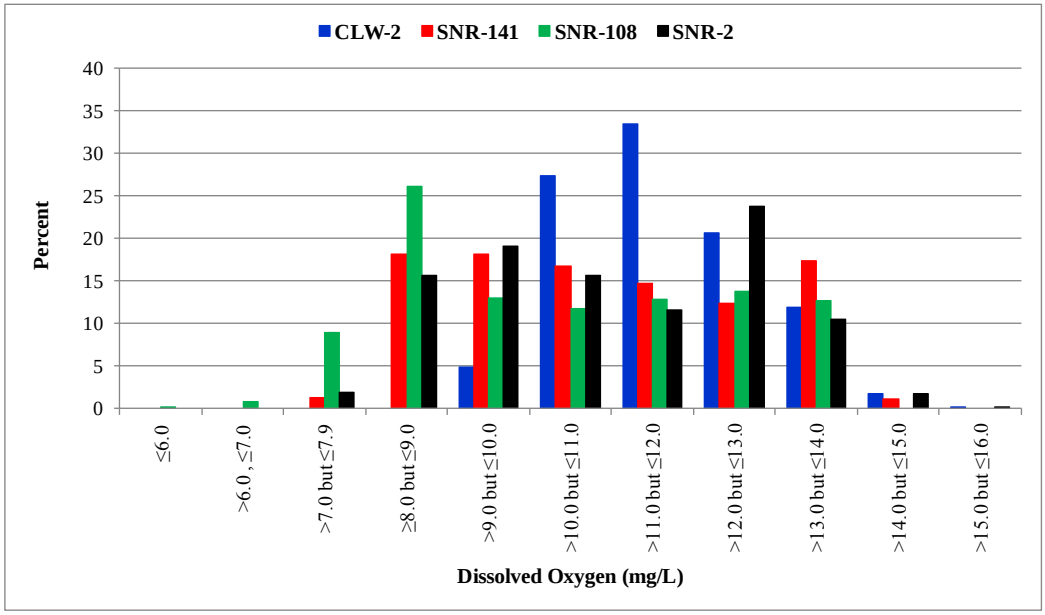


Figure 3-11. Frequency distributions for the hourly dissolved oxygen concentrations measured at the four floating water quality monitoring stations.

3.2.3.3.2 2005- 2006 Navigation Channel Maintenance Data

Water quality monitoring floats were deployed upstream and downstream from the dredge during the 2005-2006 channel maintenance project (Dixon Marine Services, 2006). These floats were initially anchored at fixed distances from the dredge and relocated when the dredge moved. However, during the first month of operation this set-up was changed to provide a 1,000 foot long by 600 foot wide monitoring zone that allowed the dredge to proceed along a prescribed

cutline without repositioning the monitors as often (Figure 3-12). Multi-parameter sondes were deployed near the surface and bottom of the water column from each float. A background reference monitoring station (Station 100) was located 300-ft (91-m) upstream of all dredging activity at a distance from shore recommended by the Contractor that best fit the circumstance. Two compliance monitoring stations (Stations 300 and 400) were located at points no less than 100-ft (30.5-m) apart and 300-ft (91-m) downstream of monitoring zone. Compliance monitoring stations were located in the main direction of river flow and, to the extent practical, in the direct path of the plume. In addition to the two downstream compliance monitoring stations, a remote monitoring station (Station 900) was located 600-ft (183-m) downstream from the edge of the zone. Data at all of these stations was collected every five minutes and hourly averages were calculated for compliance purposes.

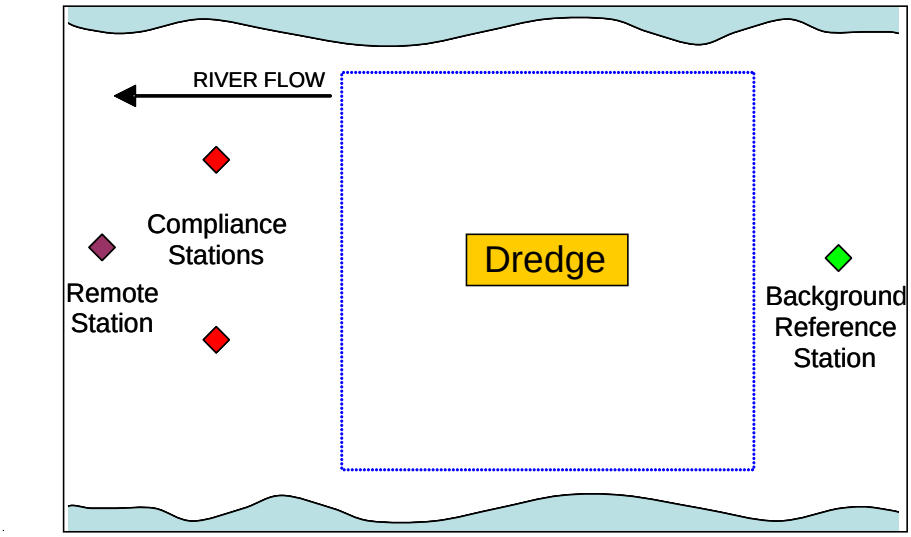


Figure 3-12. Station locations of the navigation channel maintenance water-quality monitoring platforms relative to the dredge – conceptual drawing not to scale (adapted from Dixon Marine Services, 2006).

Water quality monitoring at the in-water disposal site also included upstream and downstream sensors. A background station, two compliance monitors, and a lateral station (Station 700) that was intended to evaluate whether disposed material moved down-slope towards the thalweg before it was entrained in the river current constituted the array (Figure 3-13). The background reference station was located 300-ft upstream of the disposal area, the compliance stations were placed 300 ft (±30 ft) downstream in the main direction of river flow, and the lateral station was located 300 ft towards the thalweg. Each float consisted of two sondes, one shallow and one deep.

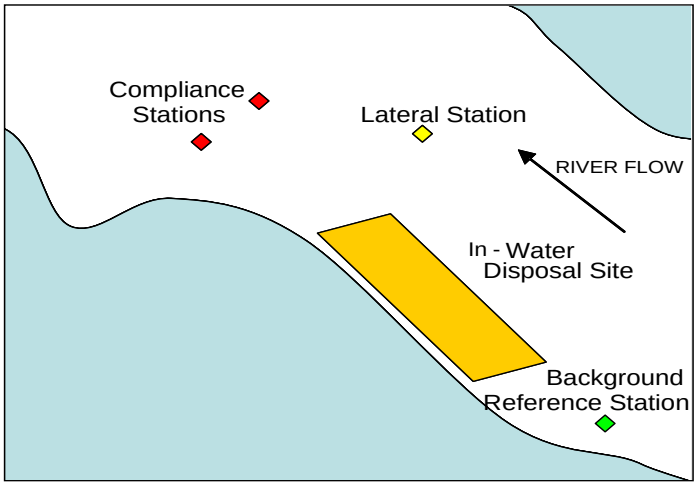


Figure 3-13. Station locations of the water-quality monitoring platforms at the in-water disposal site – conceptual drawing not to scale (adapted from Dixon Marine Services, 2006).

The protocol used to determine whether dredging should be halted if the water quality standard was exceeded was based on a four-hour period. If the one-hour trend for a given instrument exceeded the standard, the Contractor noted the incident in the daily quality control record. If the subsequent 1-hour trend continued to show elevated values above the background for the same instrument, the Contractor verified that the sonde was functioning properly. If the conditions persisted for the third hour, the Contractor altered the dredging operation and continued to monitor dissolved oxygen at the downstream locations. If the concentrations remained below the acceptable standard, the Contractor was instructed to halt operations and wait for the concentrations to increase before resuming dredging.

The dissolved oxygen concentrations recorded upstream and downstream from the dredge on the Clearwater River at the Port of Lewiston (POL)in Idaho and the Snake River at the Port of Clarkston (POC) in Washington were evaluated with respect to the applicable water quality standards[1]. At both locations, dissolved oxygen remained consistent relative to the temperature of the water and never approached action values during high turbidity events (Dixon Marine Services, 2006). Dredging at the Port of Lewiston on the Clearwater River occurred during four distinct periods. Background levels for the 5-min readings ranged from 11.8 mg/L to 15.0 mg/L during all four events. The minimum downstream concentration at the compliance point was 11.7 mg/L and 10.7 mg/L at the remote station. Maximum downstream 5-min values also

[1]When the water quality data from the 2005/2006 dredging project is discussed, the "Port of Lewiston" refers to the area encompassing the port as well as Clearwater River above the confluence with the Snake River. The "Port of Clarkston" designation refers to the reach of the Snake River that includes the port facilities and the federal navigation channel where dredging occurred.

reached 15 mg/L. Analogous dissolved oxygen concentrations at the compliance point near the Port of Clarkston on the Snake River ranged from 11.7 mg/L to 14.9 mg/L. The lowest concentration of 10.4 mg/L was again measured at the remote station. Background concentrations on the Snake River ranged from 11.6 to 15.0 mg/L. Since the hourly averages were clearly greater than 8 mg/L at both locations, the conclusion was reached that dissolved oxygen concentrations were not adversely affected by dredging.

The dissolved oxygen data from the in-water disposal site encompassed the period from 12 December 2005 to 6 March 2006. The minimum measurement recorded was 10.3 mg/L at the compliance boundary, while the maximum was 15.0 mg/L at the lateral station. Average values for the entire project period ranged from 12.6 mg/L to 12.8 mg/L, both at the compliance boundary.

3.2.3.4 Total Dissolved Gas

Nitrogen, oxygen, and argon compose about 78 percent, 21 percent, and 1 percent, respectively, of the elemental gases in dry air. When the pressure of every gas in the atmosphere reaches equilibrium with its dissolved form in water, the water is saturated. The pressures of gases in the air make up atmospheric pressure, and its counterpart in water is the total dissolved gas (TDG) pressure. If the TDG pressure is greater than atmospheric pressure, the water is supersaturated.

The 2008 National Oceanic and Atmospheric Administration (NOAA) Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp) relies on spill operations at USACE mainstem projects to benefit Endangered Species Act (ESA) listed juvenile salmon and steelhead passage. Currently, the spill operations during the juvenile fish passage season (generally early April into August) at USACE dams are consistent with court-ordered operations and the adaptive management provisions in the 2008 NOAA BiOp as implemented through the Adaptive Management Implementation Plan (AMIP). The intent of the spill operations is to help meet juvenile fish survival performance standards identified in the BiOp. These fish passage spills may result in the generation of TDG supersaturation in the lower Snake River at levels above current state and federal water quality standards. The state of Washington has authorized exceptions to these standards as long as the elevated TDG levels provide for improved fish passage through the spillway without causing more harm to fish populations than through other passage routes.

The general approach for TDG abatement activities focuses on limiting the entrainment of air into the water column, the water flow rate that encounters the bubble plume and thirdly, the effective depth of the air that does become entrained. Spillway flow deflectors, commonly referred to as flip lips, redirect the spill jet from a plunging flow that transports air bubbles deep into the stilling basin to a horizontal jet that maintains entrained air much closer to the water surface. The influence of spillway flow deflectors is also to transport highly aerated flow conditions well downstream of the stilling basin into the tailrace channel, promoting the exchange of atmospheric gasses at shallow depths. The effectiveness of spillway flow deflectors in abating TDG production has been consistently demonstrated at USACE projects on the Columbia and Snake Rivers. Other methodologies to reduce TDG loading below main-stem dams involve minimizing the use of spillways for involuntary spill. Limiting the entrainment of powerhouse flows into the turbulence bubbly flow in the stilling basin can also be an effective

method of TDG enhancement. A spill pattern that widely distributes spillway flows uniformly across the entire spillway has been found to lower TDG exchange rates.

All of the four lower Snake River Dams currently have spillway deflectors. Spillway deflectors were in place on all eight spillbays at Lower Granite Dam when the project was completed. The Little Goose and Lower Monumental projects were originally constructed with six of the eight possible deflectors installed. The final two deflectors were installed at Little Goose Dam in 2009. The Lower Monumental project had a full complement of eight deflectors by the winter of 2003-2004. Ice Harbor Dam, the first USACE dam that was built on the lower Snake River, did not include any spillway deflectors when it was originally built. However, by 2000 all ten bays had been retrofitted.

Walla Walla District currently operates fifteen TDG/temperature fixed-monitoring stations within the basin. The tailwater stations at the four lower Snake River dams, in addition to the one below Dworshak Dam, record data on an hourly basis throughout the year. The lower Snake River forebay stations, as well as the riverine stations, transmit hourly data throughout the fish passage season (i.e., 1 April through 31 August). This information is used by the Reservoir Control Center at NWD on a daily basis to adjust spill to meet the requirements of the Biological Opinion and State water quality standards.

Annual TDG and temperature reports are available at the USACE Northwestern Division (NWD) website (http://www.nwd-wc.usace.army.mil/TMT/wqwebpage/mainpage.htm). These reports are comprehensive, and include information such as the Fish Operations Plan for each year, quality assurance summaries from each District, and required court reports. Additionally, the number of TDG exceedances for each Snake River project are reported. Table 3-3 presents the eleven year average exceedance data for the four lower Snake River projects.

Table 3-3. Average number of instances when the 12-hour TDG criteria were exceeded at the four lower Snake River projects between 1999 and 2009.

Project	Forebay	Tailwater
Lower Granite	1	13
Little Goose	15	7
Lower Monumental	29	15
Ice Harbor	33	11

3.2.3.5 pH

3.2.3.5.1 2008-2010 Data

pH is a measure of the acidity or basicity of an aqueous solution. Solutions with a pH less than 7 units are considered acidic and solutions with a pH greater than 7 units are basic or alkaline.

The most intensive pH data set available for the lower Snake River system is the information that was measured at the four water quality floats deployed from 2008 through 2010 for this study. A box plot summary of this information shows that the Clearwater River station had the lowest

overall pH with a median value of 7.3 units (Figure 3-14). The Snake River at SNR-141 had the highest median for the study period at 8.2 units, followed by a slight downriver decrease; calculated medians at SNR-108 and SNR-2 were 8.1 and 7.9 units, respectively.

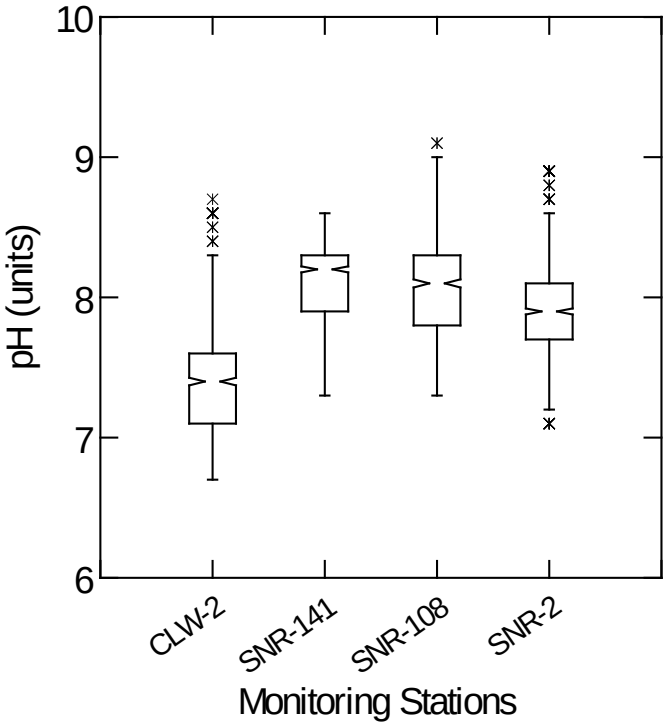


Figure 3-14. Box plots of the pH concentrations measured at the four floating water quality monitoring stations.

Frequency distributions of the hourly data sets illustrate some additional differences between the Snake and Clearwater Rivers (Figure 3-15). Almost 50 percent of the hourly data from the Clearwater River was between pH 7.0 and 7.5 units. An additional 26 percent was between pH 7.5 and 8.0 units. Only four data points (0.02 percent) measured in the Clearwater River were less than 6.5 units and none were greater than 9.0 units. The Snake River stations displayed markedly different pH frequency distributions than the one portrayed for the Clearwater River. Almost 89 percent and 92 percent of the hourly data recorded at SNR-141 and SNR-108, respectively, were between 7.5 and 8.5 units. The upper boundary of the Washington State standard of 8.5 units was exceeded 8.7 percent of the time at SNR-141, as well as 5.8 percent and 5.7 percent of the time at SNR-108 and SNR-2, respectively. These elevated values cannot be attributed to specific anthropogenic sources and have been documented in Snake River water quality studies as far back as the late 1960's and early 1970s. No hourly measurements exceeded pH 9.0 at SNR-141, but 101 (0.6 percent of the total) and 42 (0.2 percent of the total) of the values were between 9.0 and 9.5 units at SNR-108 and SNR-2, respectively. The elevated pHs at SNR-108 were associated with an algal bloom that occurred in August 2008 when the near-surface percent dissolved oxygen saturation exceeded 160 percent as a result of algal productivity. Eighty-four percent of the pH measurements at SNR-2 were between pH 7.5 and

8.5, and 42 (0.2 percent of the total) were greater than 9.0 units –a residual of the August 2008 algal bloom.

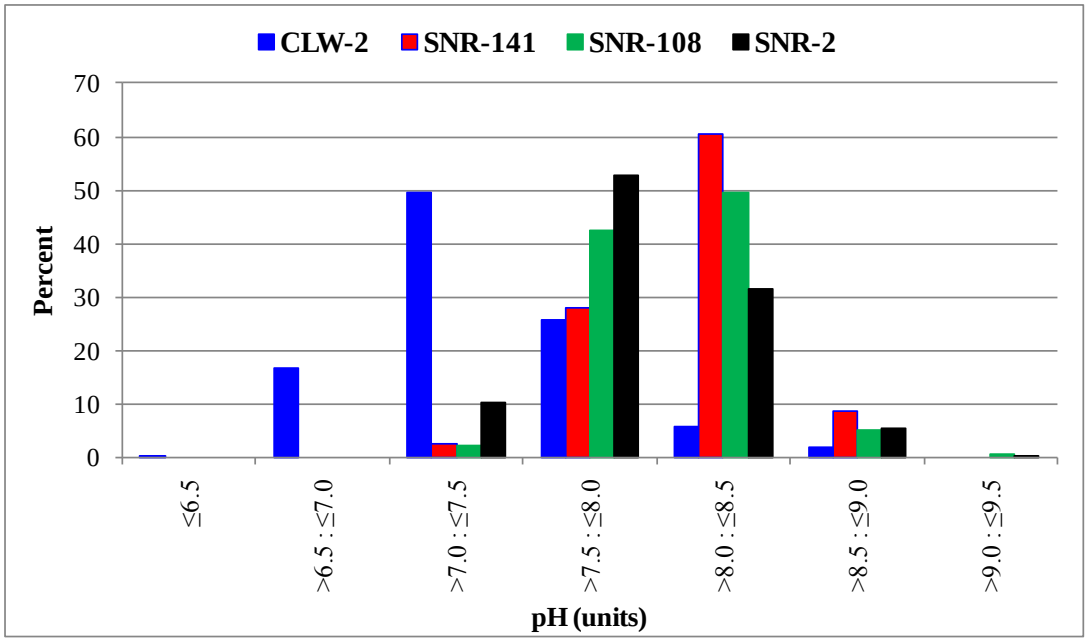


Figure 3-15. Frequency distribution for the hourly pH measured at the four floating water quality monitoring stations.

3.2.3.5.2 2005-2006 Navigation Channel Maintenance Data

Hourly pH values were calculated from the 5-min data that was collected during the navigation channel maintenance projects (Table 3-4). The 2005/2006 data showed that the pH of the Clearwater River was less than the values determined for the Snake River; the same conclusion that was reached for the 2008/2010 data, as well as previous investigations.

Dredging did not have a significant impact on water pH. The pH levels in both the Snake and Clearwater Rivers remained within regulatory guidelines during the project. The relatively few data points that were initially thought to exceed State standards were subsequently attributed to faulty reference solutions or probes, exposure to air during recalibration, and extraneous data spikes. The mean values presented in Table 3-4 are not significantly different at the background (100) versus the compliance monitoring (300 and 400) stations. Similarly, the frequency distributions for the hourly pH data from each of the Port of Lewiston and Port of Clarkston (Figures 3-16 and 3-17) do not show disparate results given that the pH probes had an accuracy of ±0.2 units. Finally, correlation analyses were completed for the twelve data sets representing background and compliance point sampling locations sondes to determine if there was a relationship between turbidity and pH. The coefficients calculated for the Snake River stations were all weak, ranging from -0.28 at the surface background and downstream 400 stations, to -0.53 at the deep-300 station. Since the deep-background station had a correlation coefficient of -0.47 it is not possible to attribute any downstream differences to turbidity caused by dredging.

The correlation coefficients determined for the Clearwater River stations were weaker, ranging from -0.15 to -0.30.

Table 3-4. Hourly minimum, maximum, and mean pH values determined for the data collected during channel maintenance projects at the Port of Lewiston, Port of Clarkston, and SNR-116.

Location	Shallow			Deep		
POC	Min	Max	Mean	Min	Max	Mean
100	7.9	8.5	8.3	8.1	8.4	8.2
300	7.5	8.5	8.2	8.1	8.5	8.3
400	7.9	8.5	8.2	8.0	8.5	8.3
POL						
100	7.3	8.4	7.6	7.3	8.5	7.6
300	7.1	8.1	7.5	7.3	8.3	7.6
400	7.1	8.5	7.6	7.2	8.3	7.6
SNR-116						
100	7.9	8.5	8.1	7.9	8.4	8.2
300	8.0	8.3	8.1	7.4	8.8	8.2
400	8.0	8.4	8.2	8.0	8.4	8.1
700	8.1	8.4	8.2	7.8	8.4	8.1

The pH environment at the in-water disposal site was similar to the one at the POC location in several respects. The calculated hourly averages ranged from 8.1 to 8.2 units (Table 3-4). A maximum value of 8.8 was determined for the deep station at the compliance boundary, but may have been due to a contaminated reference standard. The frequency distributions showed that the 56 to 100 percent of the measurements were between 8.0 and 8.5 units at the monitoring stations (Figure 3-18), exceeding 93 percent at five depths.

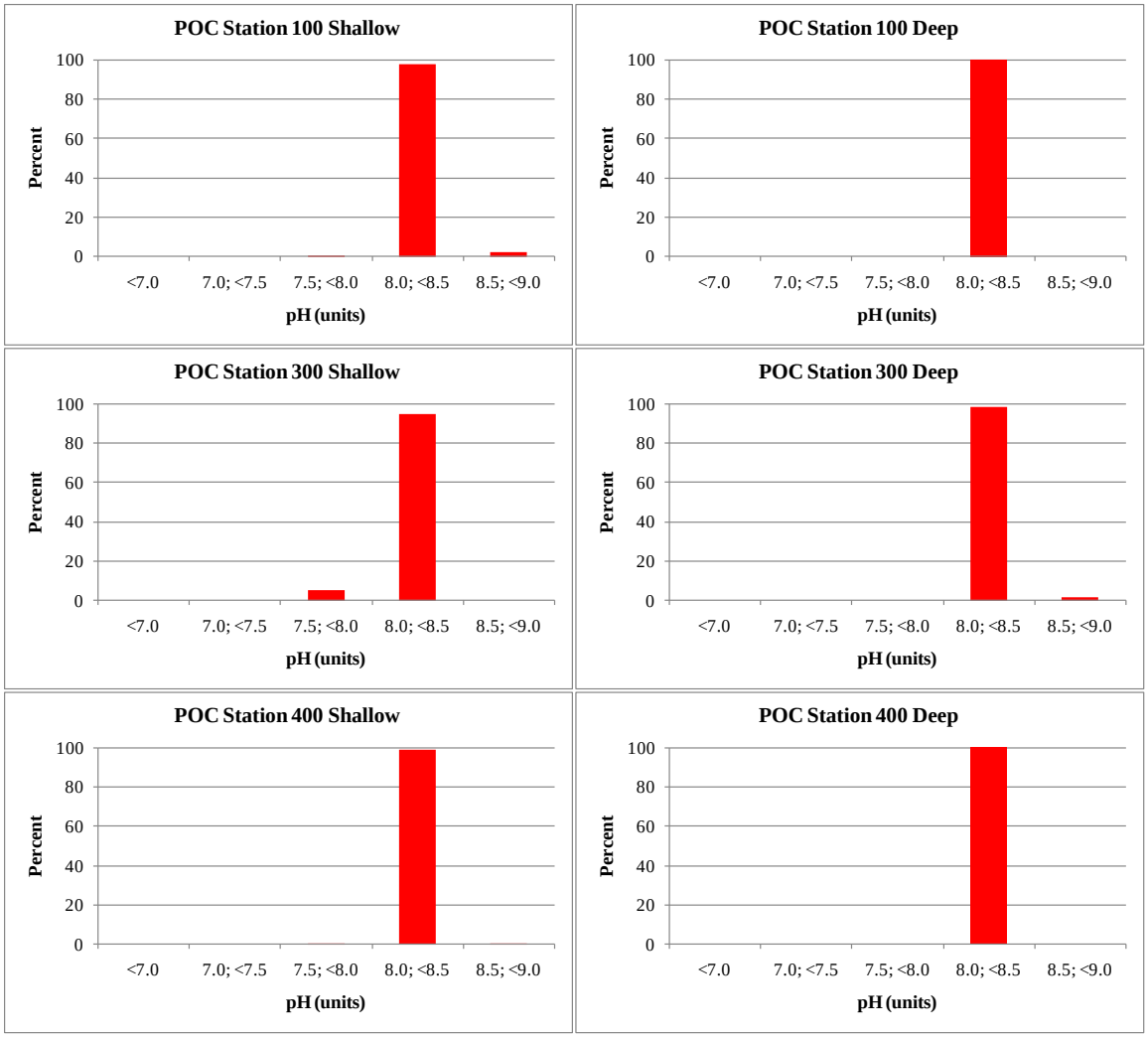


Figure 3-16. Frequency distributions for the hourly averaged background and compliance point pH data recorded during the 2006 channel maintenance project near the Port of Clarkston.

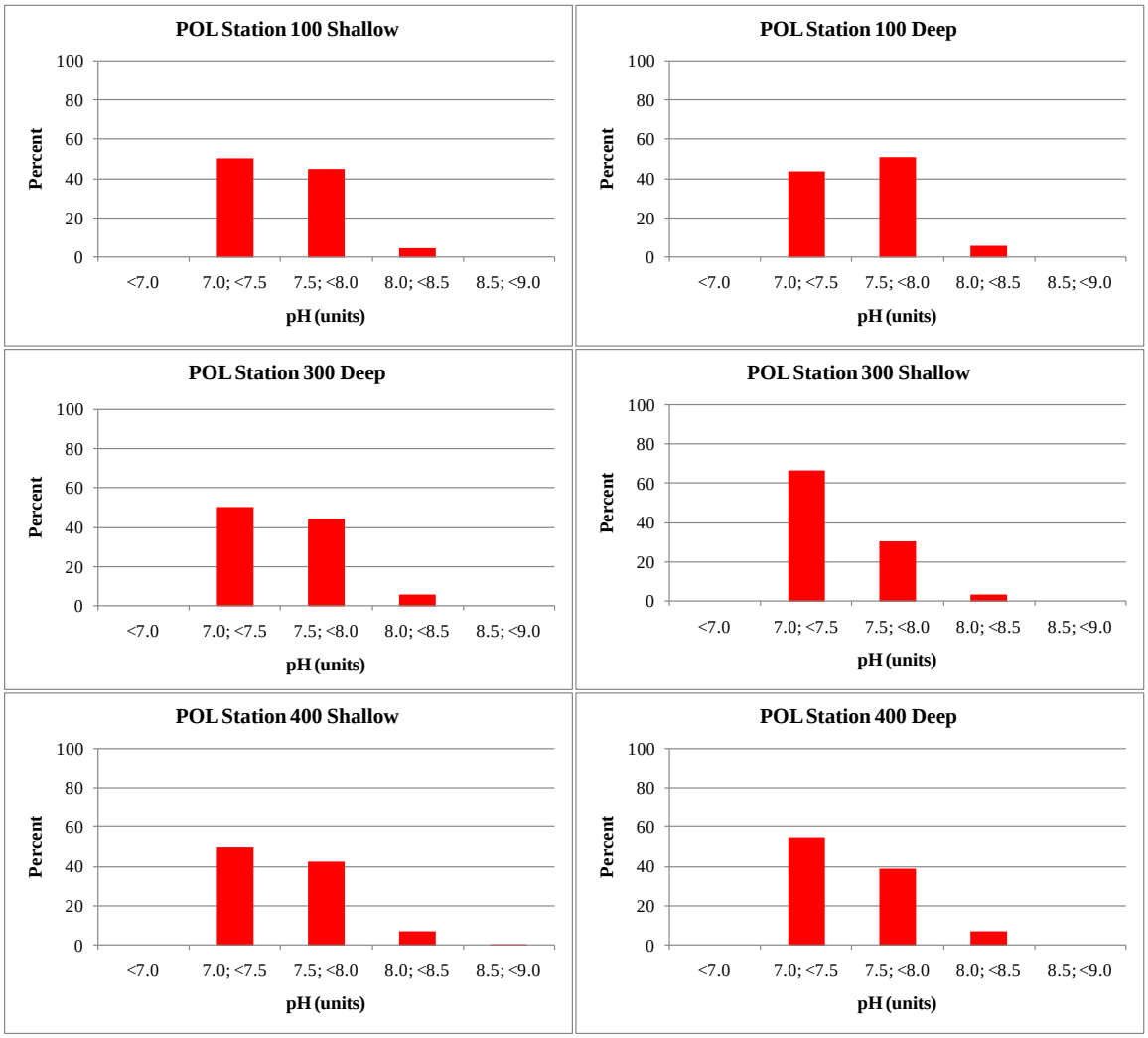


Figure 3-17. Frequency distributions for the hourly averaged background and compliance point pH data recorded during the 2005/2006 channel maintenance project near the Port of Lewiston.

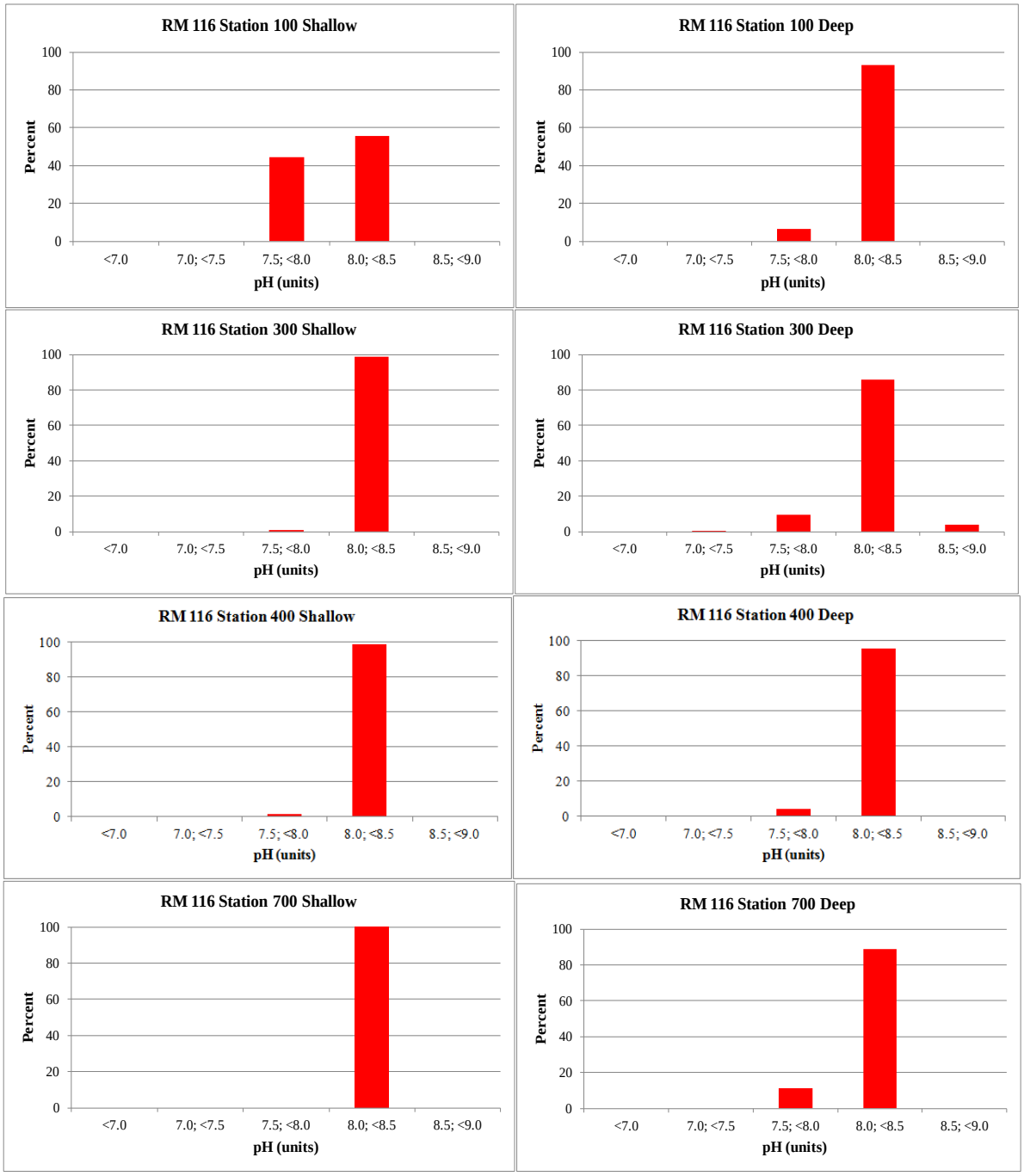


Figure 3-18. Frequency distributions for the hourly averaged background, compliance, and lateral point pH data recorded during the 2005/2006 channel maintenance project at the in-water disposal site.

3.2.3.6 Specific Conductance

Specific conductance, or conductivity, is the reciprocal of resistance and is a measure of the waters ability to conduct an electric current. It varies both with the number and type of ions in solution.

There were significant differences between the conductivity of the Snake and Clearwater Rivers, as well as within the lower Snake River (Figure 3-19). The median conductivity of the Clearwater River, as measured at the 2008-2010 water quality monitoring float, was 31µS/cm, and hourly data points ranged from 15 µS/cm to 68 µS/cm (Figure 3-20). Minimum values occurred during the spring runoff period, typically May and June, while maximum conductivity was measured during low-flow conditions in December and January. The conductivity measured at SNR-141 was the highest of any location monitored, and the calculated median was 289 µS/cm while hourly data ranged from 79 µS/cm to 445 µS/cm. Conductivity decreased progressively downstream in the lower Snake River with calculated medians at SNR-108 and SNR-2 of 225 µS/cm and 179 µS/cm, respectively. Figure 3-20 also shows that, as was the case with dissolved oxygen, the conductivity of the water at SNR-141 increased earlier in the year than it did and SNR-108.

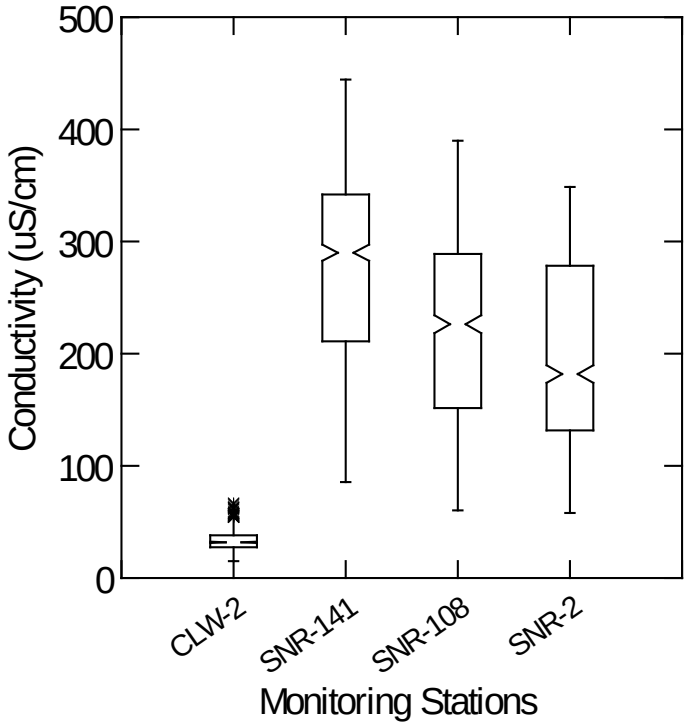


Figure 3-19. Box plots of the conductivity measured at the four floating water quality monitoring stations.

An analysis of the frequency distributions for the conductivity data showed some interesting patterns (Figure 3-21). Seventy five percent of the hourly data recorded at CLW-1 was between 25 µS/cm and 50 µS/cm. The data from the three lower Snake River stations was distributed

over a larger range and there was a slight difference between the station at SNR-141 and the two lower reservoir sites. At the upstream end of Lower Granite Reservoir, almost 29 percent of the data was between 300 µS/cm and 350 µS/cm. Near the mouth of the Snake River, almost 46 percent of the data was in the 100 µS/cm to 200 µS/cm range. The station in between these two at SNR-108 had the most uniform frequency distribution.

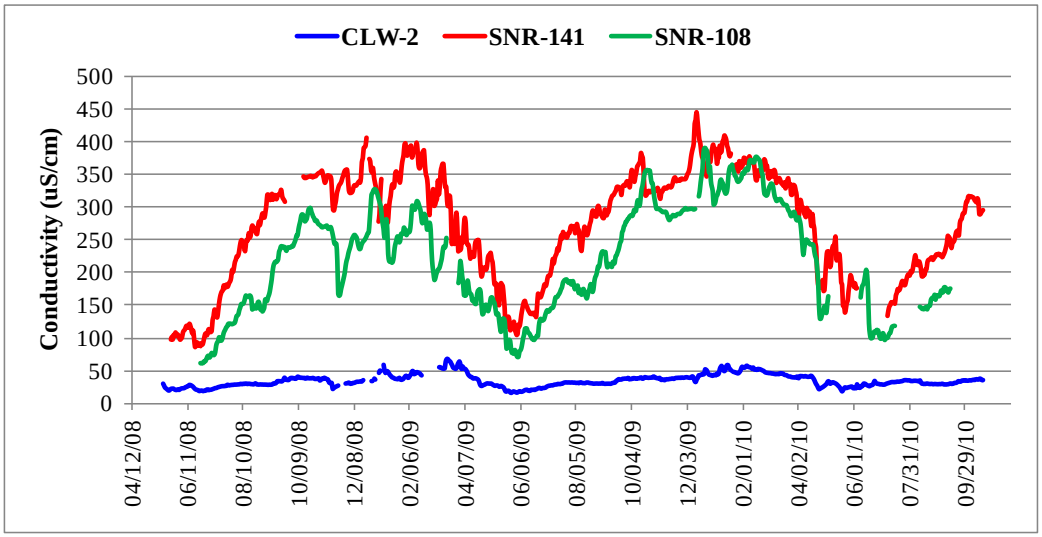


Figure 3-20. Annual cycle for the specific conductance measured at SNR-141, SNR-108, and CLW-2.

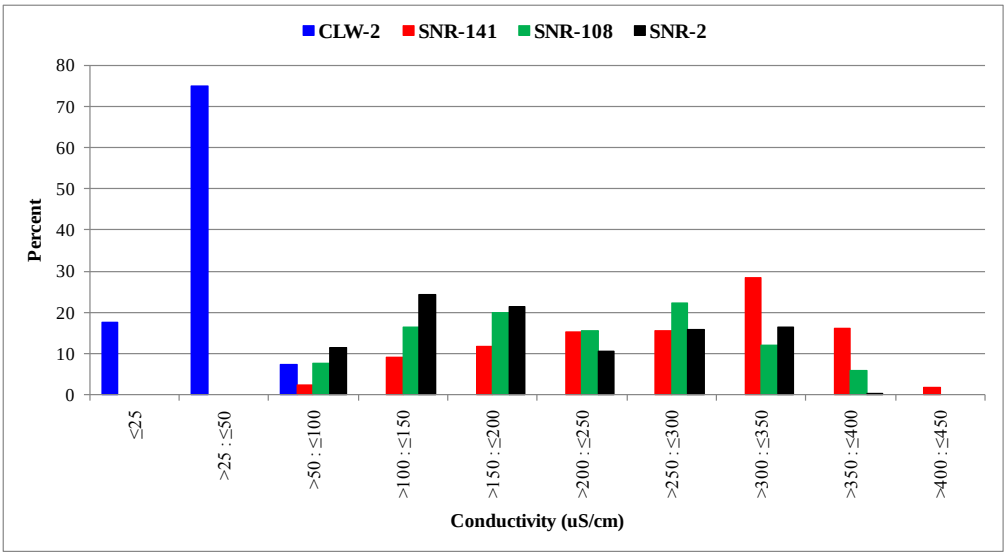


Figure 3-21. Frequency distributions for the hourly conductivity measured at the four floating water quality monitoring stations.

3.2.3.7 Major Ions, Alkalinity, and Hardness

Since the conductivity of the water is dependent on ionic constituents, it is not surprising that the annual fluctuations in the concentrations of individual ions mimicked the one set by conductivity. The minimum, maximum, and median concentrations of the major ions, along with alkalinity and hardness, in the water are presented in Table 3-5. The lowest median alkalinity and hardness values were determined for the Clearwater River where they were both less than 15 mg/L. Silica, calcium, and sodium were the three ions that were present in the greatest concentrations at CLW-3. The highest ionic concentrations within the study area were usually determined for the inflowing Snake River at SNR-147 where the median and maximum values for alkalinity and hardness were 76 mg/L and 93 mg/L, respectively. The three most prevalent ions at this location in order of decreasing concentration were calcium, sulfate, and sodium. The parameters alkalinity, hardness, chloride, sulfate, potassium, calcium, and magnesium generally displayed decreasing downstream concentrations through SNR-82 and then increased at the downstream sampling locations. The remaining ions, iron, manganese, silica, and aluminum did not display a distinct spatial pattern in the lower Snake River.

3.2.3.8 Turbidity

3.2.3.8.1 2008-2010 Data

Turbidity is the cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye, similar to smoke in air. Fluids can contain suspended solid matter consisting of particles of many different sizes. While some suspended material will be large enough and heavy enough to settle rapidly to the bottom of the container if a liquid sample is left to stand (the settable solids), very small particles will settle only very slowly or not at all if the sample is regularly agitated or the particles are colloidal. These small solid particles cause the liquid to appear turbid.

The hourly turbidity data recorded at the four 2008-2010 water quality floats is a detailed source of information. A box plot of the data shows that there was a slight downriver increase in turbidity (Figure 3-22). Calculated medians started at 2.4 NTU and 3.0 NTU at CLW-2 and SNR-141, respectively, and increased to 3.7 NTU and 4.5 NTU at SNR-108 and SNR-2, respectively. This trend can also be seen in the frequency distribution (Figure 3-23) which shows that 73 percent of the hourly turbidity measurements were less than or equal to 5 NTU in the Clearwater River. This statistic decreased to 57 percent near the mouth of the Snake River.

The duration that turbidity remained above a certain threshold in the Snake and Clearwater Rivers was also evaluated. Table 3-6 shows the number of times that consecutive hourly turbidity data recorded at the Clearwater River station CLW-2 was greater than the given thresholds. For example, there were forty-eight instances when the turbidity was greater than 20 NTU for a period of one to five hours, and there were thirteen instances when measured turbidity was greater than 200 NTU for the same time period. There was also one instance when the turbidity was greater than 20 NTU for a period of 493 consecutive hours. Table 3-7 presents the same analysis for the hourly Snake River data recorded at SNR-141. In this case, there were twenty-eight instances when turbidity was greater than 20 NTU for a period of one to five hours and only one instance when it was greater than 150 NTU for the same time period. The longest

Table 3-5. Concentrations (mg/L) of the major ions, alkalinity, and hardness analyzed between 2008 and 2010.

Station	Statistic	Alk	Hard	Cl	SO_4	Na	K	Ca	Mg	Fe	Mn	Si	Al
CLW-3	Min	6	8	0.1	0.1	1.3	0.4	2.2	0.5	0.03	0.001	0.1	0.02
	Max	40	19	1.8	2.0	3.3	1.0	5.4	1.4	0.32	0.008	7.6	0.34
	Median	10	13	0.5	0.8	2.1	0.6	3.8	0.9	0.11	0.003	5.4	0.12
SNR-147	Min	48	59	3.4	9.8	10.0	1.7	15.0	4.6	0.04	0.001	0.1	0.01
	Max	130	155	16.0	39.0	30.5	4.3	39.0	15.0	0.90	0.036	14.0	0.92
	Median	76	93	8.1	22.0	17.0	2.9	23.0	8.7	0.10	0.016	8.3	0.09
SNR-129	Min	32	37	2.3	6.1	7.0	1.2	10.0	2.8	0.05	0.001	0.1	0.01
	Max	120	129	15.0	34.0	28.0	3.8	32.0	12.0	0.73	0.026	11.0	0.72
	Median	56	63	6.6	18.5	14.0	2.5	16.0	5.5	0.11	0.013	7.9	0.10
SNR-119	Min	33	33	2.3	6.2	6.2	1.2	9.4	2.4	0.06	0.002	0.1	0.01
	Max	120	127	16.0	35.0	25.0	3.5	32.0	12.0	0.67	0.025	11.0	0.81
	Median	57	59	7.0	18.5	13.0	2.5	15.0	5.4	0.17	0.012	8.1	0.16
SNR-108	Min	30	32	2.4	3.7	6.2	1.2	8.7	2.4	0.03	0.001	0.1	0.01
	Max	110	138	28.0	65.0	27.0	3.6	34.0	13.0	1.08	0.051	13.7	1.30
	Median	56	60	6.7	18.4	12.0	2.0	16.0	5.2	0.16	0.014	8.3	0.09
SNR-82	Min	24	32	2.4	6.7	6.7	1.2	8.7	2.5	0.03	0.003	0.1	0.01
	Max	110	123	13.0	34.0	25.0	3.4	31.0	11.0	0.52	0.042	11.0	0.49
	Median	53	55	6.0	17.5	12.0	2.0	14.0	4.9	0.22	0.015	7.9	0.19
SNR-42	Min	23	26	1.6	4.9	5.2	1.0	7.2	1.9	0.04	0.001	0.1	0.01
	Max	100	123	14.0	35.0	24.0	3.4	31.0	11.0	0.68	0.019	12.0	0.69
	Median	68	80	6.7	18.5	15.0	2.4	21.0	6.9	0.17	0.013	7.5	0.16
SNR-18	Min	26	26	1.8	5.0	5.1	1.1	7.3	2.0	0.03	0.005	0.1	0.01
	Max	110	129	13.0	35.0	24.0	3.8	32.0	12.0	5.59	0.298	17.0	3.79
	Median	69	75	6.9	19.0	15.0	2.4	19.0	6.6	0.18	0.013	7.7	0.22
SNR-2	Min	26	26	1.8	4.8	5.0	1.0	7.3	1.9	0.04	0.006	0.1	0.01
	Max	100	134	18.0	43.0	26.0	3.9	34.0	12.0	0.73	0.020	12.0	0.72
	Median	68	74	6.2	18.0	15.0	2.3	19.0	6.3	0.14	0.010	7.5	0.16

Alk = total alkalinity
Hard = hardness
Cl = chloride
SO_4 = sulfate
Na = sodium
K = potassium
Ca = calcium
Mg = magnesium
Fe = iron
Mn = manganese
Si = silica
Al = aluminum

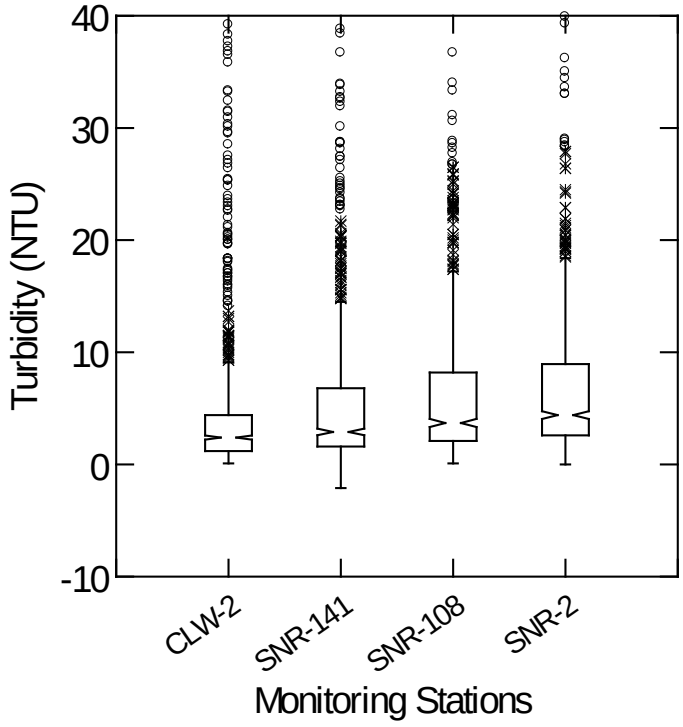


Figure 3-22. Box plots of the turbidity measured at the four floating water quality monitoring stations.

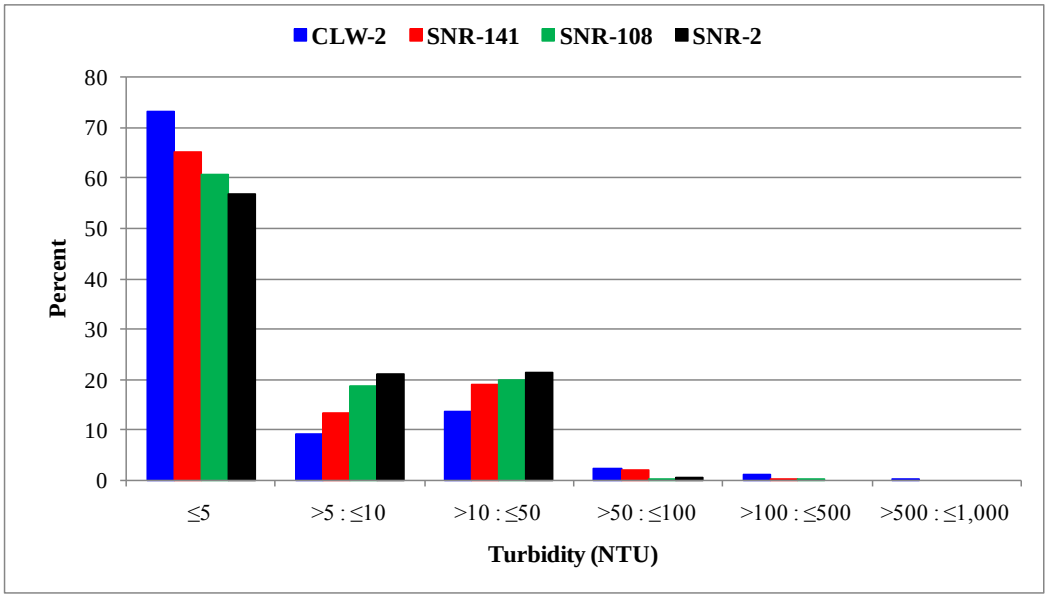


Figure 3-23. Frequency distributions for the hourly turbidity measured at the four floating water quality monitoring stations.

duration of elevated turbidity at the Snake River station was 342 hours when it was greater than 20 NTU.

Correlation coefficients were also calculated to investigate the relationship between turbidity, river discharge, and total suspended solids (TSS). Based on daily averages from the floating water quality monitoring stations, there was a 0.72 correlation between turbidity and river discharge at SNR-141, but only a 0.32 correlation at CLW-2. The weak correlation in the Clearwater River is probably due to the summer flow augmentation program when low-turbidity water is released from Dworshak Dam. The relationship with river discharge at SNR-2 was intermediate at 0.55. The correlations between turbidity and TSS ranged from 0.78 at CLW-2 and SNR-108, to 0.64 at SNR-2, and 0.48 at SNR-141.

Table 3-6. Number of times a turbidity threshold was exceeded for a range of consecutive hours at CLW-2 between May 2008 and October 2010.

	Turbidity Threshold				
Consecutive Hours	**>20 NTU**	**>50 NTU**	**>100 NTU**	**>150 NTU**	**>200 NTU**
1	79	61	39	34	9
>1 : ≤5	48	28	26	19	13
>5 : ≤10	9	9	5	5	8
>10 : ≤25	13	17	4	7	2
>25 : ≤50	11	6	1	0	0
>50 : ≤100	4	1	0	0	0
>100 : ≤200	3	0	0	0	0
>200 : ≤300	0	0	0	0	0
>300 : ≤400	0	0	0	0	0
>400 : ≤500	1	0	0	0	0

Table 3-7. Number of times a turbidity threshold was exceeded for a range of consecutive hours at SNR-141 between May 2008 and October 2010.

	Turbidity Threshold				
Consecutive Hours	**>20 NTU**	**>50 NTU**	**>100 NTU**	**>150 NTU**	**>200 NTU**
1	93	30	3	0	2
>1 : ≤5	28	8	3	1	0
>5 : ≤10	17	7	1	2	1
>10 : ≤25	11	7	2	0	0
>25 : ≤50	9	1	1	0	0
>50 : ≤100	1	1	0	0	0
>100 : ≤200	2	1	0	0	0
>200 : ≤300	1	0	0	0	0
>300 : ≤400	1	0	0	0	0
>400 : ≤500	0	0	0	0	0

3.2.3.8.2 2005-2006 Navigation Channel Maintenance Data

Turbidity data was also recorded upstream and downstream of the dredge during the 2005-2006 navigation channel maintenance project as described in Section 3.2.3.3.2. Frequency distributions for hourly averaged data from the background monitoring stations in the Clearwater River near the Port of Lewiston and the Snake River near the Port of Clarkston during 2006 are compared to January/February 2009 and 2010 data recorded at the CLW-2 and SNR-141 floating water quality monitoring stations in Figure 3-24 to evaluate inter-annual variability. Ninety-six percent of the hourly 2006 background data from the Clearwater River was determined to be less than or equal to 5 NTU. The percentage of data in the same category decreased to 65 percent in the 2009/2010 data set. Half of the remaining 35 percent was in the 5-10 NTU category and three percent of the data was determined to be greater than 100 NTU. The data collected from the Snake River during comparable time periods in 2006 and 2009/2010 displayed disparate distributions. Seventy-one percent of the hourly 2006 background Snake River data was in the

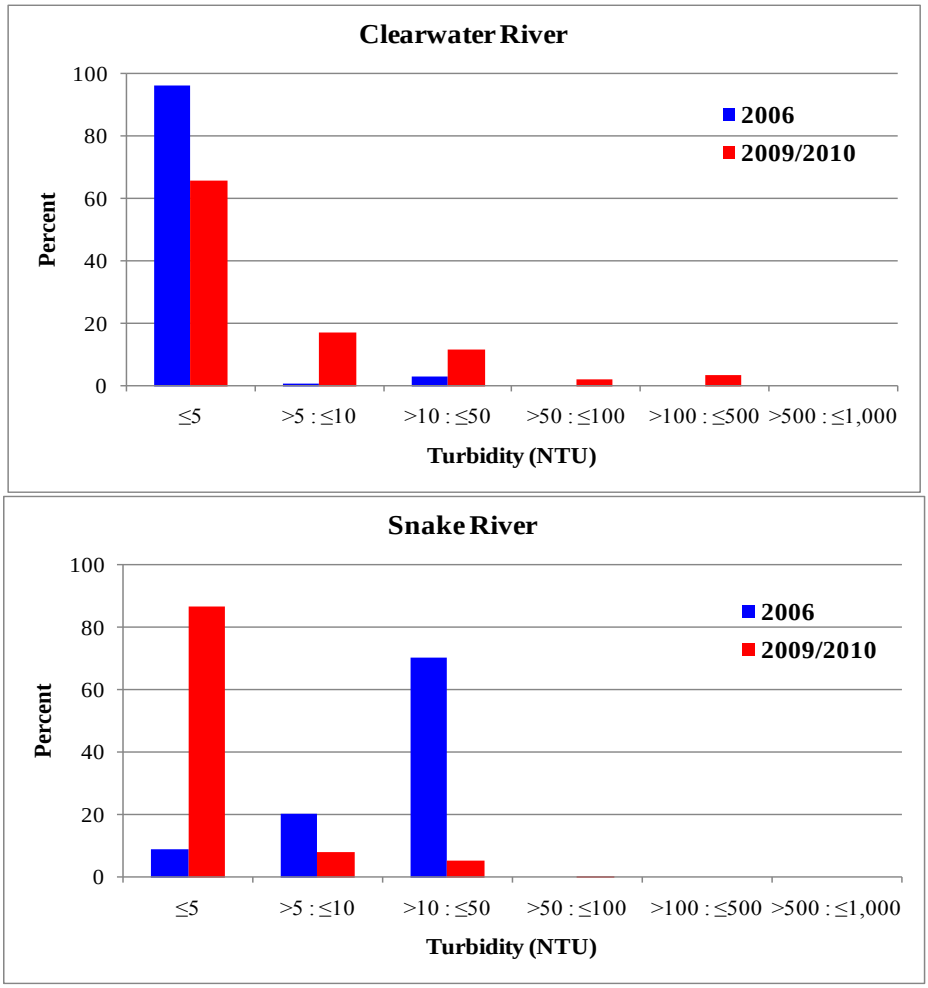


Figure 3-24. Frequency distributions for the background turbidity data recorded at the upstream Snake and Clearwater River monitoring stations during the 2005-2006 navigation channel maintenance project and the 2009/2010 data for the same time period.

10-50 NTU category and only 9 percent was less than 5 NTU. This trend was reversed in 2009/2010 when 86 percent of the data was less than 5 NTU and 5 percent was in the 10-50 NTU categories.

Turbidity was the principal parameter that was influenced by the dredging activity in the Snake and Clearwater Rivers and is largely dependent on sediment type and grain size. Five-minute turbidity values measured in the field were compared to background values as an hourly average. If an hourly average exceeded the background average by 5.0 NTU in the Snake River and 50 NTU in the Clearwater River, an alarm was signaled to the water quality staff. Turbidity exceedances did not occur near the Port of Lewiston on the Clearwater River following this criterion. Hourly exceedances, however, did occur at the Port of Clarkston as shown in Table 3-8. The deep sondes generally reported higher turbidity values than the shallow ones, and the sondes at station 400 had the highest incidence of elevated turbidity readings. This difference was a function of the nature of the very fine silts and sands in the sediments dredged and the hydraulics at that location. The Port of Clarkston is located on the inside bend of the river which creates a low velocity, high depositional environment. Field observations suggested that the majority of the Port is located within a localized eddy where the near shore flow direction was upstream, creating a hydraulic feature that increased the time required for turbidity values to drop below the criteria.

Table 3-8. Frequency of hourly turbidity measurements relative to background conditions that occurred during the 2006 dredging at the Port of Clarkston, Washington.

			Hours per NTU Interval		
Station	**Depth**	**Total Hours**	**≤0**	**>0 but ≤5**	**>5**
300	Shallow	841	336	476	29
	Deep	759	220	457	82
400	Shallow	833	97	530	206
	Deep	761	33	424	304
900	Shallow	837	118	632	87
	Deep	760	146	489	124

The decision to stop dredging due to elevated turbidity was based on the four-hour protocol described in Section 3.2.3.3.2 for dissolved oxygen. Figure 3-25 shows the percent of time that the hourly averaged turbidity data measured at the six sondes downstream from the dredge exceeded the criteria for four consecutive hours. The deep sonde at station 400 again had the highest number of instances when turbidity was greater than 5 NTU above background. However, based on the four-hour protocol that was one of the conditions in the State of Washington 401 certification, the project was able to proceed at least 91 percent of the time.

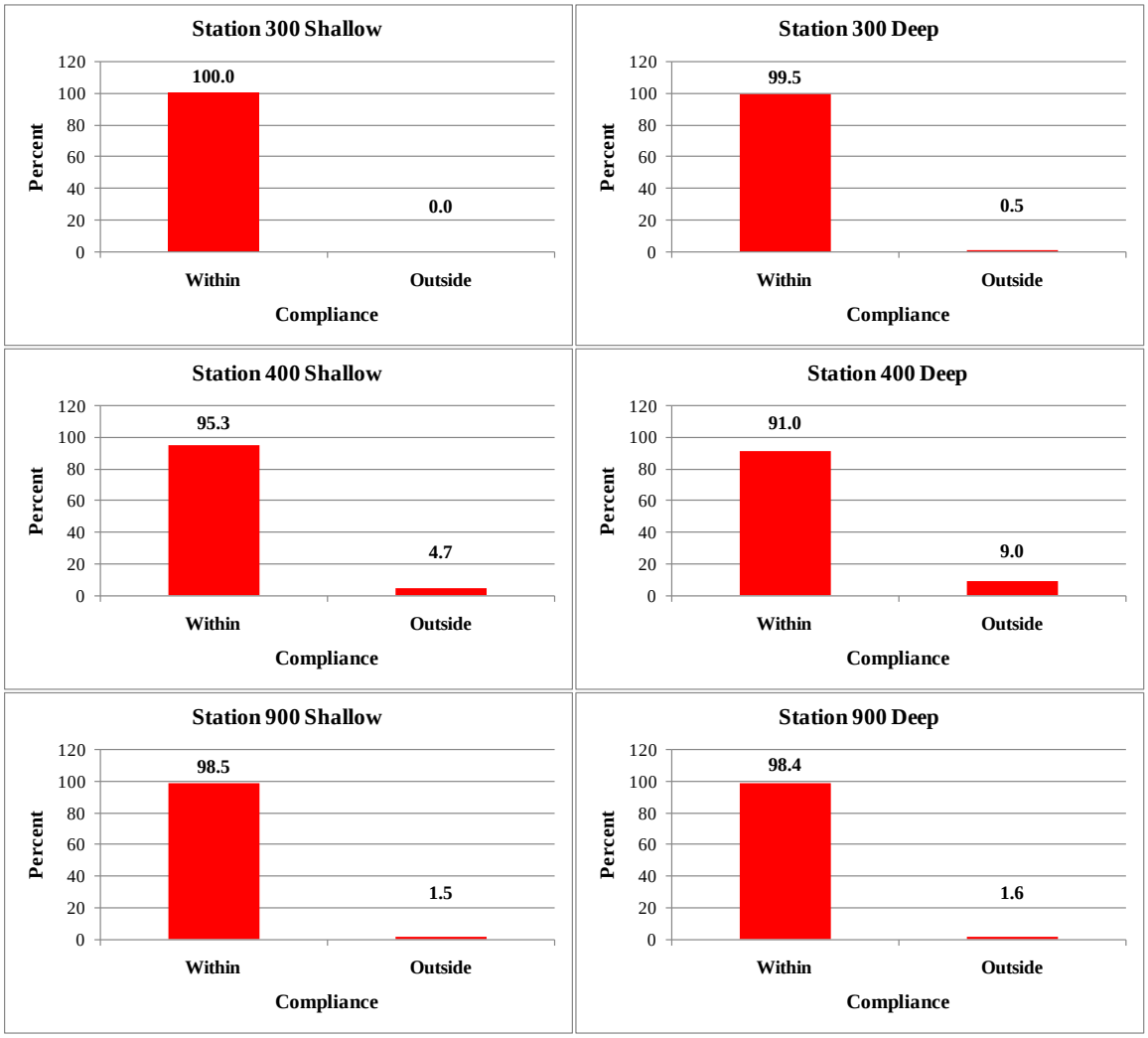


Figure 3-25. Percentage of time that each of the six sondes downstream from the Port of Clarkston dredging activity were within compliance based on four consecutive one-hour turbidity averages.

The protocol for water quality monitoring at the in-water disposal site at RM116 was similar to the one used at the dredging locations. There were two water quality floats at the compliance boundary (stations 300 and 400), and a lateral station (Station 700) located between the disposal site and the thalweg. Each float included two sondes, one shallow and one deep. The frequency that the one-hour averages were within the 5 NTU criteria ranged from 85 percent to 98 percent (Table 3-9). As noted for the POC dredge area, higher turbidity values were measured by the deep sondes when compared to those near the surface. The highest turbidity values were recorded at the deep lateral location where five hourly averages (0.3 percent) were greater than 50 NTU above background and 40 averages (2.8 percent) were greater than 25 NTU above background. It is also important to note that for 27 to 41 percent of the cases, the hourly average was less at the compliance boundary or lateral station than at the background location.

Table 3-9. Frequency of hourly turbidity measurements relative to background conditions that occurred during the 2006 dredging at the in-water disposal site at RM116.

			Hours per NTU Interval		
Station	**Depth**	**Total Hours**	**≤0**	**>0 but ≤5**	**>5**
300	Shallow	1,519	502	872	145
	Deep	1,180	373	640	167
400	Shallow	1,448	429	957	62
	Deep	1,547	415	944	198
700	Shallow	1,491	600	855	36
	Deep	1,433	583	631	219

Turbidity data collected downstream of the disposal location during the 2005/2006 channel maintenance project also showed instances of elevated turbidity. During the two and a half months when monitoring occurred 24-hrs per day, the four-hour criterion was exceeded 0.6 percent of the time at the compliance boundary and 2.3 percent of the time at the lateral location. The sondes located deeper in the water column recorded higher turbidities than the ones near the surface – analogous to the monitoring results from the POC dredge location. When the hourly data is considered, the deeper turbidity sensors recorded turbidity values greater than 5 NTU above the background 12 to 14 percent of the time at the compliance boundary and 15 percent of the time at the lateral location. The lateral bottom station also experienced the highest percentage of hourly values greater than 20 NTUs above the background with a frequency of 4 percent. The surface sondes at the compliance boundary exceeded the 4-hour criterion 0.1 and 1.1 percent of the time, compared to 1.5 percent at the remote station (Figure 3-26). The deeper sonde at the lateral station exceeded the criterion 2.5 percent of the time compared to 1.1 percent and 3.1 percent of the time at the compliance boundary. Elevated turbidity events were primarily attributed to scows releasing dredged material and reshaping of the dredge material. It should be noted that between scows, which arrived approximately every six hours, turbidity levels returned to background levels for several hours prior to the subsequent barge. Additionally, it is also noteworthy that the background hourly turbidity averages exceeded the comparable downstream values 27 to 41 percent of the time – an indicator of the inherent variability associated with low-level turbidity measurements.

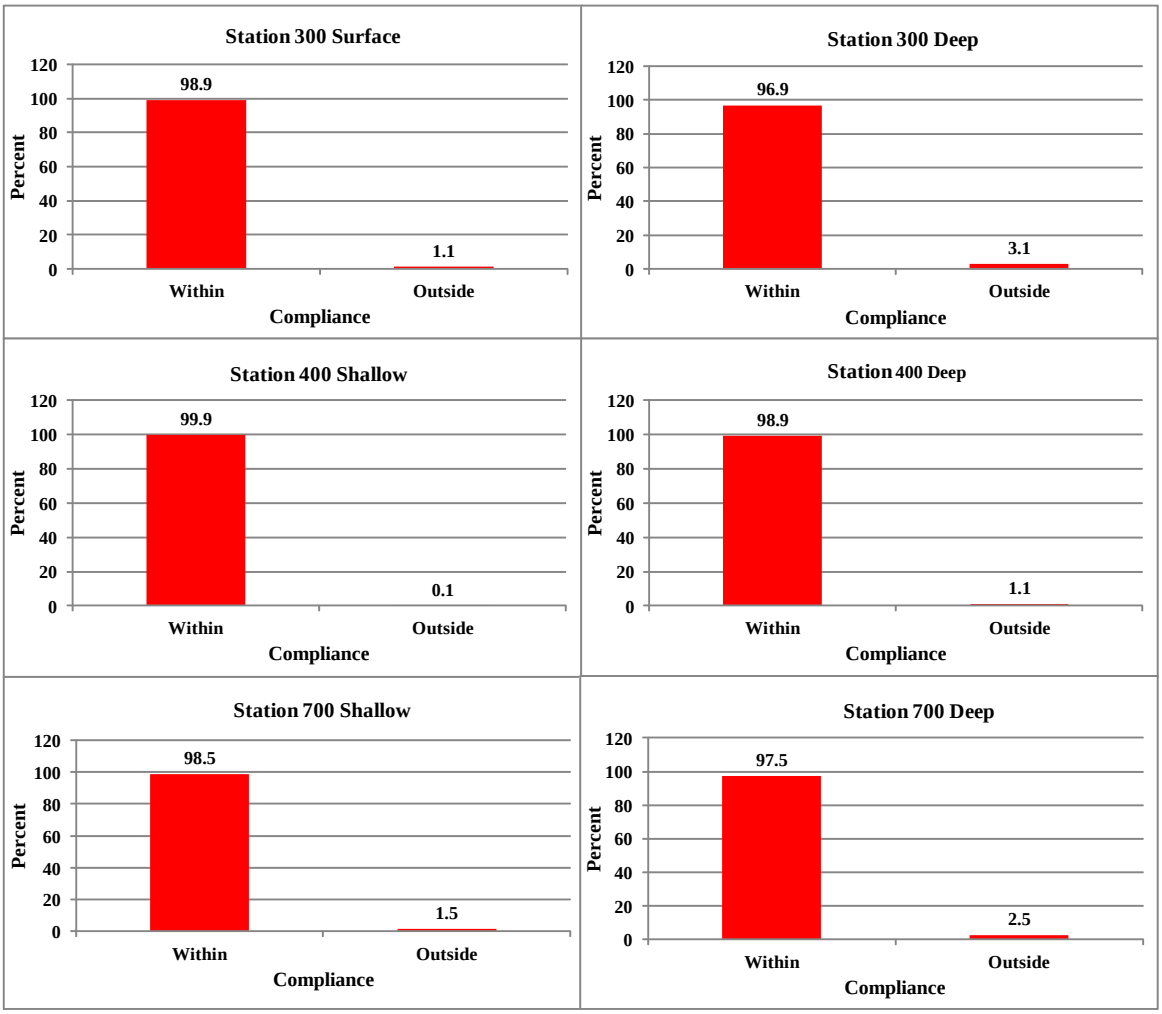


Figure 3-26. Percentage of time that each of the six sondes downstream from the RM116 in-water disposal activity were within compliance based on four consecutive one-hour turbidity averages.

3.2.3.9 Total Suspended Solids

Total suspended solids are solid materials, organic and inorganic, that are suspended in the water and can include silt, plankton, and urban wastes. The general consensus of previous lower Snake River investigations is that larger particles transported by the rivers settle out in the transition zone in the vicinity of Lewiston, Idaho/ Clarkston, Washington, and downstream in Lower Granite reservoir. Finer material that passes Lower Granite Dam remains suspended. The highest concentrations are generally observed at deeper sampling depths, but elevated concentrations occasionally occur near the surface in the reservoirs as a result of localized algal blooms, port operations, and tributary inflows.

Total suspended solids concentrations displayed several similarities, and some differences, throughout the monitored system. The median concentrations at all of the Snake River sampling stations were essentially the same, ranging from 4.7 to 5.0 mg/L (Figure 3-27). The median concentration at the Clearwater River sampling station was lower at 2.0 mg/L. Concentrations

were typically highest during the spring freshet. In June 2010, for example, inflowing concentrations reached 160 mg/L in the Snake River and 100 mg/L in the Clearwater River. The water-column averages at the reservoir stations during this same event ranged from 21.7 mg/L at SNR-42 to 104.7 mg/L at SNR-108. A frequency analysis showed that 54 percent of the data

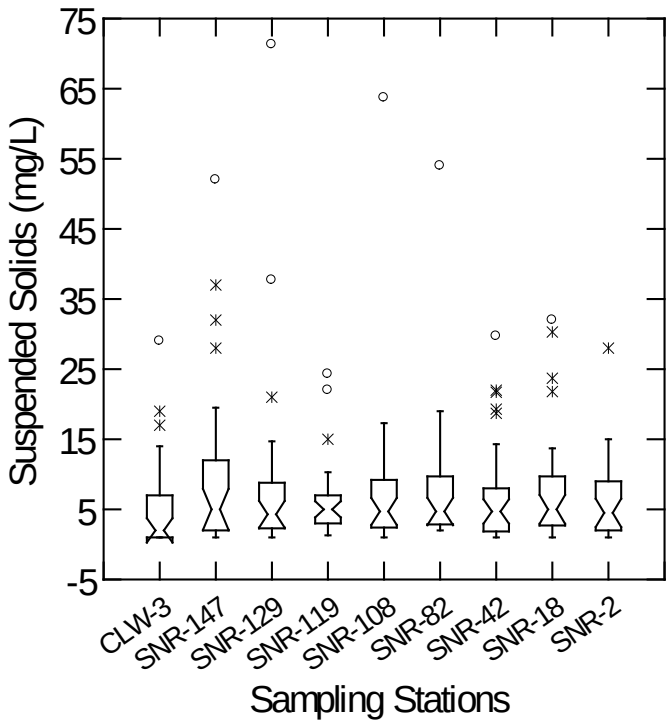


Figure 3-27. Box plots of the total suspended solids concentrations measured at the 2008-2010 sampling stations.

points from the reservoir stations were ≤ 5 mg/L and 79 percent were ≤ 10 mg/L. These statistics are very close to the information gathered for the inflowing Snake River station where 53 percent of the data was ≤ 5 mg/L and 71 percent were ≤ 10 mg/L. In the Clearwater River, 68 percent of the data was ≤ 5 mg/L and 81 percent was ≤ 10 mg/L.

3.2.3.10 Light Attenuation

Light attenuation in the water column is dependent on the type and quantity of dissolved or suspended material. One of the traditional field methods for determining this parameter is Secchi disc depth. The median Secchi depths for all stations ranged from 2.1 m at SNR-2 to 2.8 m at SNR-129 (Figure 3-28). Given that range of data points available for each station, any differences between stations are not considered to be statistically significant. Greatest water transparency typically occurred during late summer and through autumn. Conversely, minimum light transparency was usually associated with higher runoff events during late spring and early summer.

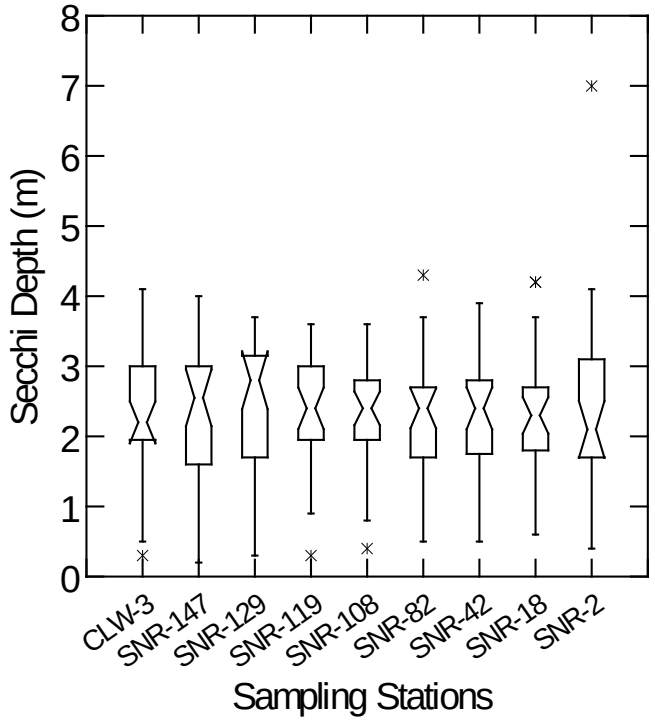


Figure 3-28. Box plots of the Secchi depth measured at the 2009-2010 sampling stations.

The Secchi disc depth can also be used as a measure of the trophic state of a lake or reservoir. Oligotrophic conditions represent high-quality waters with good water clarity and low algal production, while eutrophic conditions represent high nutrient levels, excessive algal growth, and poor water clarity. Mesotrophic conditions are somewhere in the middle and typically represent moderate levels of algal production, water clarity, and light transparency. The Carlson Trophic State index (TSI) is a widely used method of classification where values <30-40, 40-50, and 50-70 represent oligotrophic, mesotrophic, and eutrophic conditions, respectively (Chapra and Reckow, 1983). The calculated TSI for the reservoir stations, using summer growing season measurements, ranged from 40 at SNR-40 to 52 at SNR-108. Based on this method, the reservoirs would be considered mesotrophic to lower eutrophic.

3.2.3.11 Nitrogen and Phosphorus

3.2.3.11.1 Nitrogen

3.2.3.11.1.1 2008-2010 Data

Of the various soluble inorganic forms of nitrogen, nitrate plus nitrite nitrogen ($NO_3 + NO_2$-N) (hereafter referred to as nitrate) was the principal component, comprising more than 90 percent of the soluble fraction in the Snake River and 73 percent in the Clearwater River. Two important issues were identified regarding the inorganic nitrogen species. First, the lowest nitrate concentrations were consistently identified in Clearwater River samples, and higher values were usually determined for the free-flowing Snake River (Figure 3-29). The median nitrate concentration at the Clearwater River station was 0.03 mg/L compared to a relatively uniform range of 0.32 mg/L to 0.42 mg/L through the four reservoir reach. The inflowing Snake River had a higher median nitrate concentration of 0.56 mg/L.

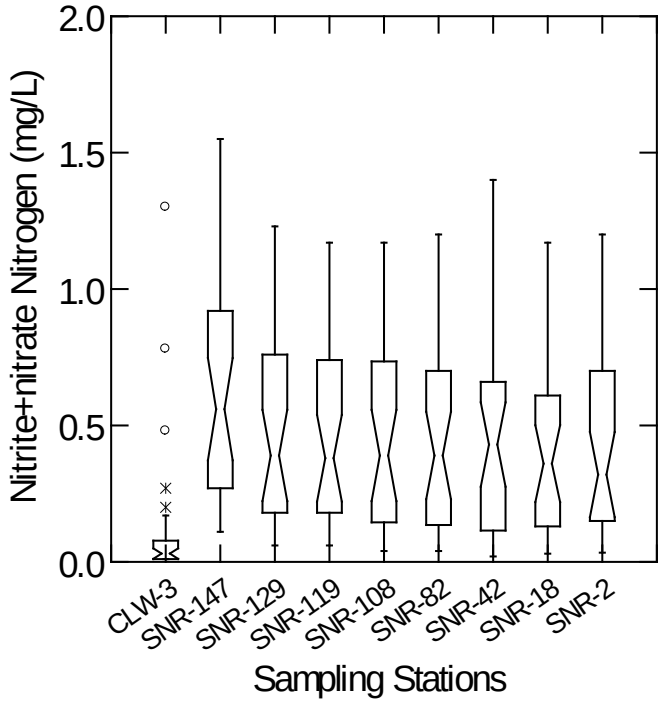


Figure 3-29. Box plots of the nitrite plus nitrate-nitrogen concentrations measured at the 2008-2010 sampling stations.

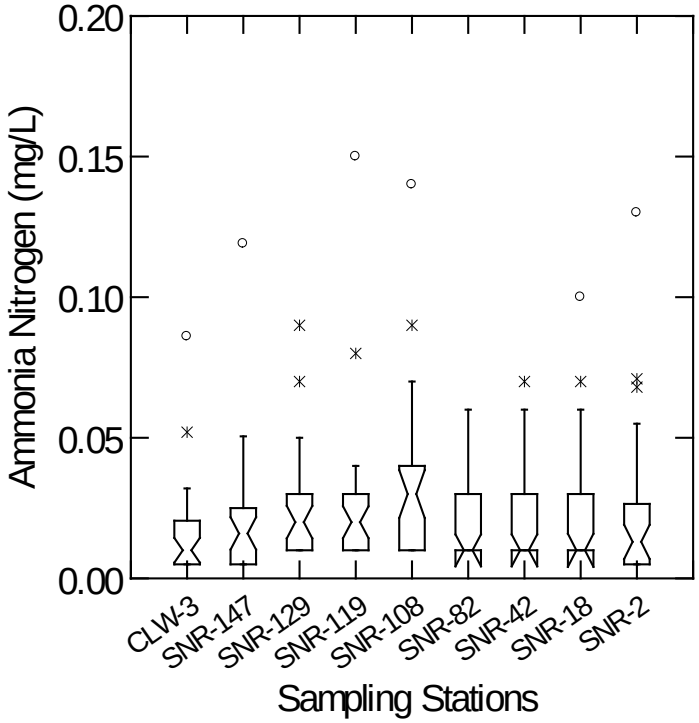


Figure 3-30. Box plots of the ammonia-nitrogen concentrations measured at the 2008-2010 sampling stations.

Ammonia (NH_3-N) concentrations were consistently lower than nitrate values, often by an order of magnitude, at all stations. The median ammonia concentration at SNR-147 was 0.02 mg/L and increased to 0.03 mg/L at SNR-108 (Figure 3-30). However, downstream from Lower Granite Dam the median concentrations declined to 0.01 mg/L, the same as the calculated concentration in the Clearwater River.

Total nitrogen (TN) includes inorganic and organic components. Figure 3-31 illustrates the spatial pattern of TN concentrations at the stations monitored during this project. The pattern is very similar to the one displayed for nitrate, and in fact nitrate comprises 65 to 70 percent of the TN in the Snake River and 33 percent in the Clearwater River. Total nitrogen concentrations at the upstream Snake River station (SNR-147) were generally higher than those observed at the other sampling locations, having a range of 0.26 mg/L to 2.30 mg/L and a calculated median of 0.82 mg/L. Concentrations were lower, but relatively uniform throughout the lower Snake River where median values ranged from 0.51 mg/L to 0.62 mg/L.

Total nitrogen concentration in the lower Snake River also exhibited seasonal variability. Summer water column averages range from about 0.03 to 0.04 mg/L. Concentrations increased considerably in the fall and winter. Winter water column averages ranged from 1.1 to 1.3 mg/L, but peaked at values as high as 2 to 3 mg/L. This late-season increase may have been due to a reduction in plant uptake associated with aquatic plant and algae senescing or going dormant, as well as agricultural practices in the watershed. Early fall rains after prolonged dry periods can also increase nutrient concentrations. Significant correlations between TSS and total nitrogen concentrations were not determined for any of the sampling stations.

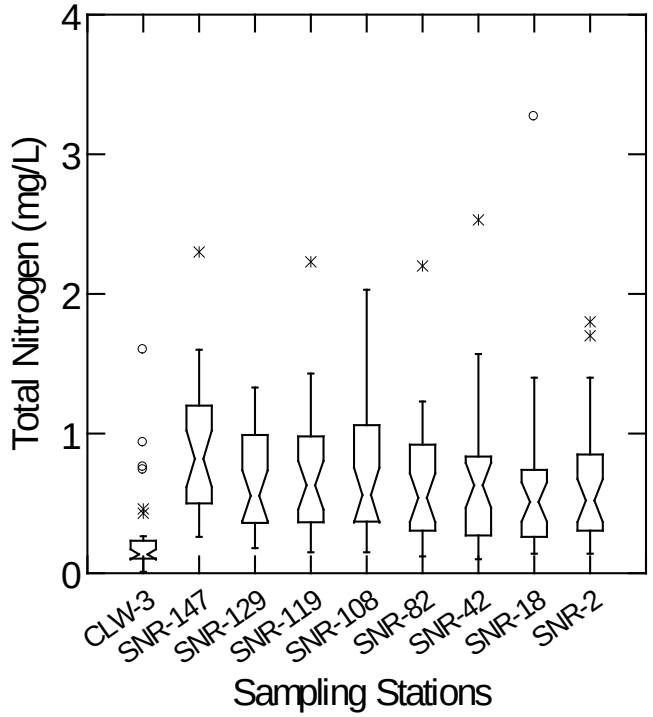


Figure 3-31. Box plots of the total nitrogen concentrations measured at the 2008-2010 sampling stations.

3.2.3.11.1.2 2005-2006 Navigation Channel Maintenance Data

Each of the water quality sondes deployed during the 2005-2006 navigation channel maintenance project was fitted with an ammonia probe. This parameter was included in the monitoring program as a result of a supposition regarding sediment ammonia concentrations and salmon toxicity that was presented in an earlier USACE document (USACE, 2002).

Hourly averages of the 5-min ammonia data recorded during the Port of Lewiston and Port of Clarkston dredging projects were calculated. Figure 3-32 shows that 90 percent, or more, of the hourly concentrations calculated for six of the Port of Lewiston water quality monitoring locations were less than 0.1 mg/L. The one exception was the shallow background station where 68 percent of the determinations were less than 0.1 mg/L. The hourly values calculated for the

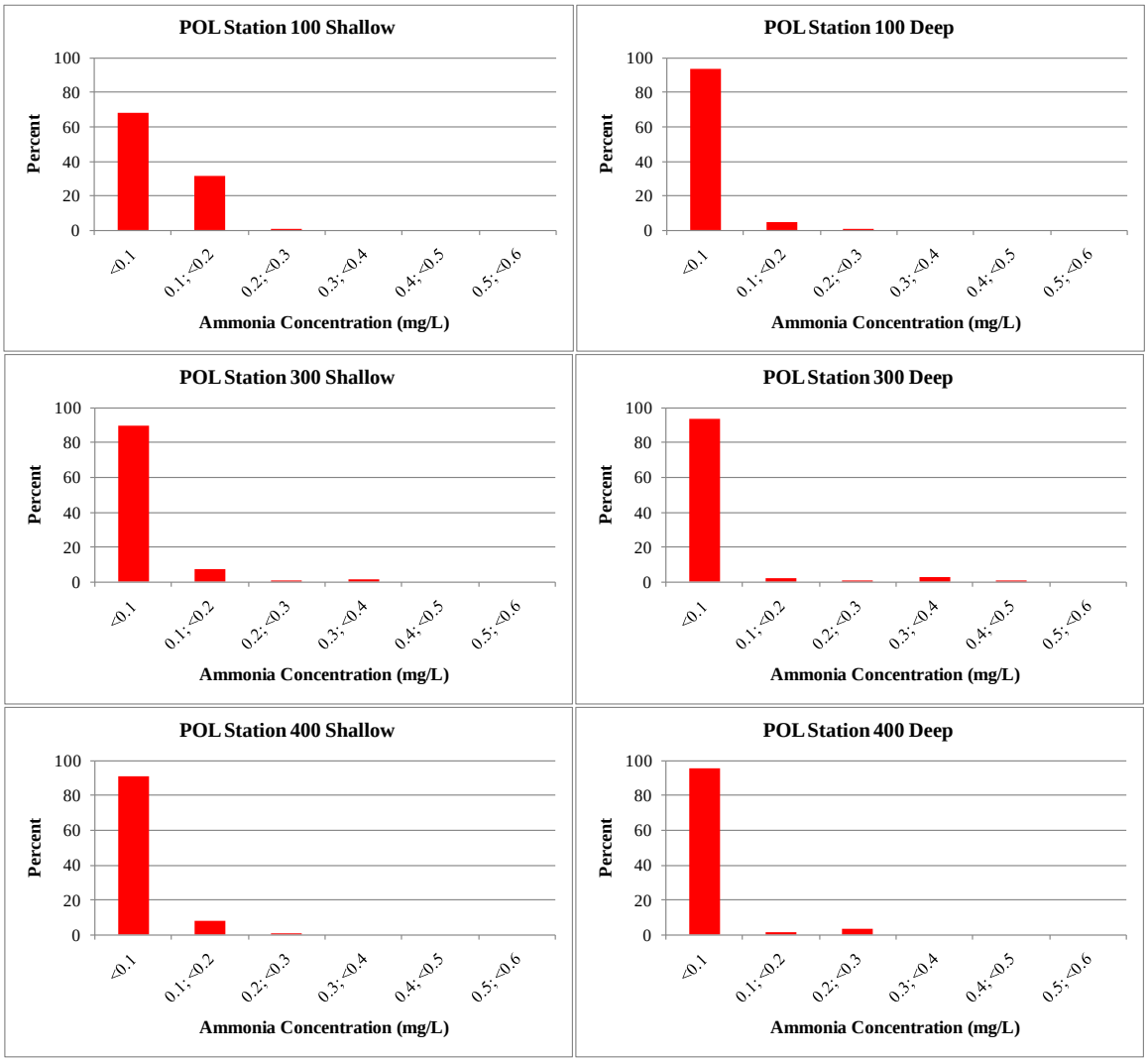


Figure 3-32. Frequency distributions for the hourly averaged background and compliance point ammonia data recorded during the 2005/2006 channel maintenance project near the Port of Lewiston.

Port of Clarkston stations displayed a greater distribution of the data at the six corresponding locations, and less than 70 percent of the data could be categorized within one grouping (Figure 3-33). The one exception was the deep background station where 96 percent of the hourly data was between 0.1 and 0.2 mg/L. Table 3-10 presents the maximum, minimum, and overall averages for the shallow and deep probes at the Port of Lewiston and Port of Clarkston at the 100 (background), 300 (compliance monitor 1), 400 (compliance monitor 2) stations.

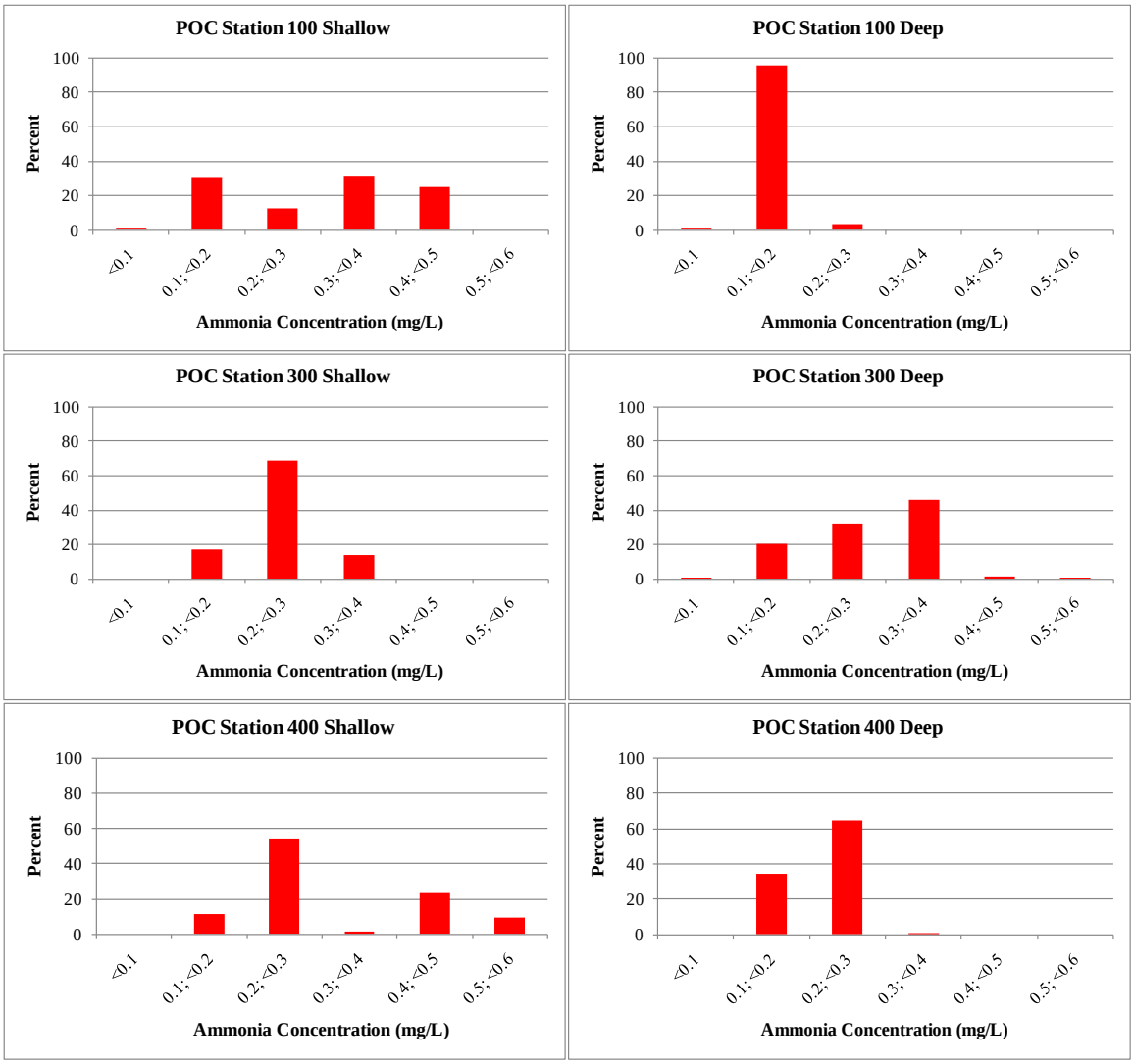


Figure 3-33. Frequency distributions for the hourly averaged background and compliance point ammonia data recorded during the 2006 channel maintenance project near the Port of Clarkston.

Correlation coefficients between the hourly pH and ammonia data were calculated for both rivers and yielded interesting results. All of the coefficients for both locations were comparatively weak (Table 3-11). The coefficients determined near the Port of Clarkston ranged from -0.04 to

-0.62. The shallow background and deep compliance station number 400 were essentially equal at -0.54 and -0.55, respectively. However, in the Clearwater River the only negative correlation coefficient was -0.22 for the deep background station. The remaining five Port of Lewiston stations showed positive, albeit weak, correlations ranging from 0.14 to 0.50.

Table 3-10. Hourly minimum, maximum and mean ammonia concentrations (mg/L) determined for the data collected at the Port of Lewiston, Port of Clarkston, and SNR-116.

Location	Shallow			Deep		
POC	Min	Max	Mean	Min	Max	Mean
100	0.06	0.46	0.30	0.06	0.22	0.16
300	0.11	0.32	0.25	0.08	0.53	0.28
400	0.12	0.55	0.32	0.13	0.34	0.22
POL						
100	0.03	0.26	0.09	0.02	0.21	0.05
300	0.05	0.31	0.09	0.03	0.47	0.08
400	0.01	0.25	0.06	0.01	0.28	0.05
SNR-116						
100	<0.01	0.41	0.26	0.07	0.41	0.22
300	0.04	0.36	0.14	0.11	0.55	0.23
400	0.07	0.47	0.19	0.07	0.50	0.32
700	0.08	0.43	0.29	0.17	0.85	0.28

Table 3-11. Correlation coefficients between pH and ammonia calculated for the hourly data collected at the Port of Lewiston and Port of Clarkston during the channel maintenance project.

Location	Shallow	Deep
POC		
100	-0.54	-0.04
300	-0.11	-0.27
400	-0.62	-0.55
POL		
100	0.19	-0.22
300	0.40	0.50
400	0.34	0.14

The ammonia concentrations measured at the in-water disposal site were relatively low. Calculated frequency distributions showed that 98 to 100 percent of the hourly data was less than 0.4 mg/L at five of the sonde locations (Figure 3-34). The percentages for the three remaining stations ranged from 91 to 96 percent. The highest ammonia concentration was 0.85 mg/L that was determined for the deep lateral station during one hour.

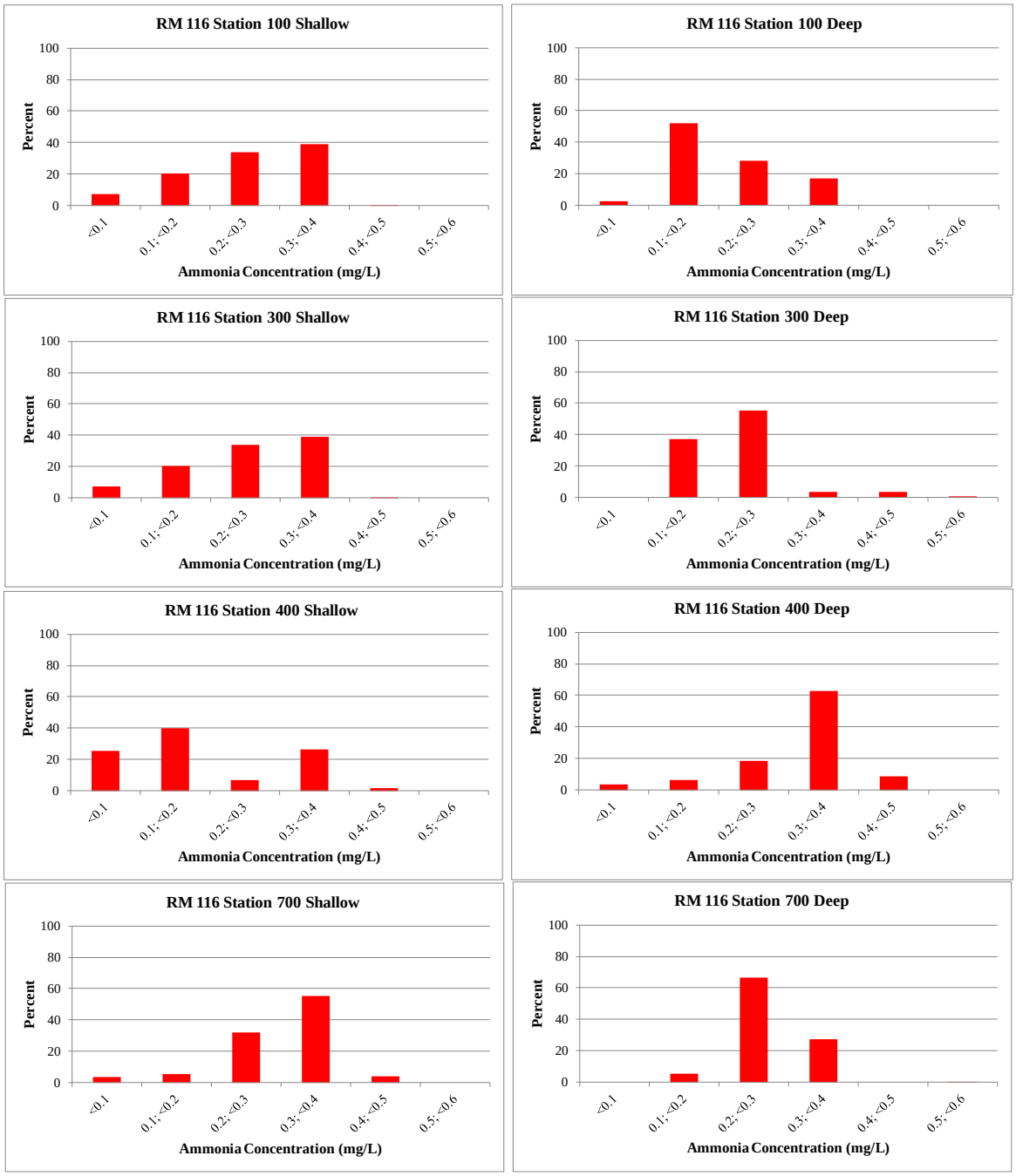


Figure 3-34. Frequency distributions for the hourly averaged background, compliance, and lateral point ammonia data recorded during the 2006 channel maintenance project at the in-water disposal site.

Acute ammonia toxicity is a function of concentration and water pH as shown in Table 3-12. The maximum hourly pH values calculated for the channel maintenance project in the Clearwater River ranged from 8.3 units to 8.6, units and in the Snake River they ranged from 8.4 units to 8.9 units (Table 3-4). The corresponding maximum ammonia concentrations ranged from 0.21 mg/L to 0.47 mg/L in the Clearwater River and 0.22 mg/L to 0.53 mg/L in the Snake River (Table 3-10). In no instance did the ammonia concentrations in either river exceed the acute criteria for the corresponding pH.

Table 3-12. Acute one-hour allowable ammonia thresholds prescribed by the EPA (1999) to prevent salmonid toxicity.

pH	Ammonia (mg/L)	pH	Ammonia (mg/L)
6.5	32.61	7.8	8.11
6.6	31.28	7.9	6.77
6.7	29.76	8.0	5.62
6.8	28.05	8.1	4.64
6.9	26.15	8.2	3.83
7.0	24.10	8.3	3.15
7.1	21.94	8.4	2.59
7.2	19.73	8.5	2.14
7.3	17.51	8.6	1.77
7.4	15.34	8.7	1.47
7.5	13.28	8.8	1.23
7.6	11.37	8.9	1.04
7.7	9.64	9.0	0.88

3.2.3.11.2 Phosphorus

Phosphorus is generally expressed in terms of total phosphorus and orthophosphorus. Orthophosphorus (ortho-P) represents the inorganic soluble fraction of the total phosphorus in water and is generally considered to be more readily available for biological uptake than is total phosphorus. Total phosphorus (total-P) consists of both the soluble fraction and that portion adsorbed to sediments or tied up with biological materials in the water column. Since phosphorus readily attaches to and travels with sediments, adsorbed or biological quantities usually represent the largest portion of total phosphorus. Phosphorus is often the limiting nutrient for plant growth in freshwater systems (Wetzel, 2001).

Orthophosphorus concentrations in the lower Snake River tend to be highest in the fall and winter, with relatively low concentrations in the summer. The lower values determined during the summer are most likely due to biological uptake by aquatic plants and algal growth. As plant growth diminishes in the fall, the phosphorus levels increase as a result of less uptake and biological senescence. Ortho-P concentrations in the Clearwater River were relatively low,

ranging from 0.001 mg/L (the same as the median value) to 0.075 mg/L in December 2009 (Figure 3-35). The concentrations in the inflowing Snake River were considerably higher. The calculated median at SNR-147 was 0.026 mg/L, with individual values ranging from 0.006 to 0.072 mg/L. Ortho-P levels were very similar throughout the lower Snake River reach where median concentrations at six of the stations ranged from 0.020 to 0.023 mg/L. The one exception was SNR-82 where the calculated median was 0.015 mg/L, but given the range of data values this was not a statistically significant difference.

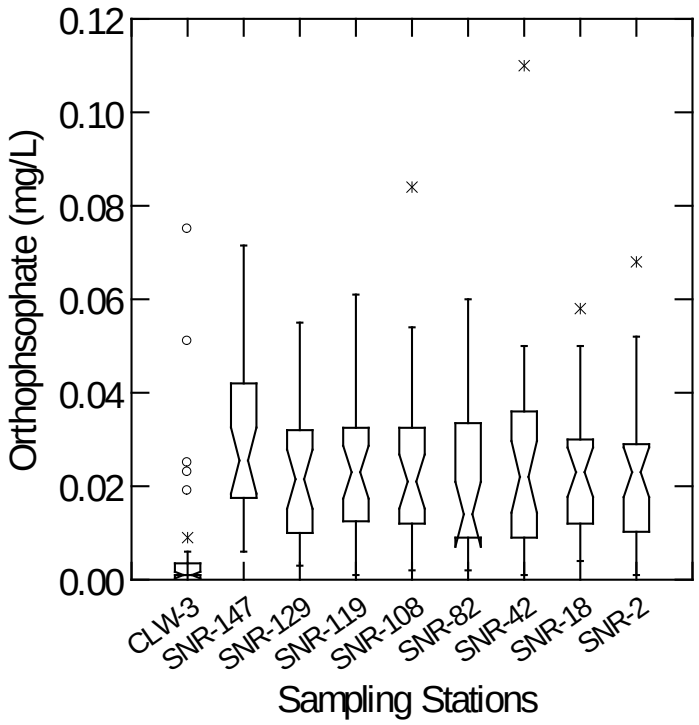


Figure 3-35. Box plots of the orthophosphate concentrations measured at the 2008-2010 sampling stations.

Total phosphorus (total-P) concentrations generally followed the spatial pattern set by ortho-P (Figure 3-36). This occurred because, on average, 49 to 57 percent of the total-P concentrations in the Snake River were ortho-P. In the Clearwater River, this relationship was not as strong and the median value was 14 percent. The median total-P concentration in the Clearwater River was relatively low at 0.011 mg/L. Median total-P levels for the reservoir system ranged from 0.037 mg/L to 0.041 mg/L. The inflowing Snake River was higher, with a median value of 0.049 mg/L. The highest total-P concentrations generally occurred during the fall and winter when the concentrations of most ions increased due to less dilution, and during runoff events when suspended solids concentrations increased.

Total phosphorus concentrations are often used as trophic state indicators. According to the State of Washington water quality standards for lakes in the Columbia Basin Ecoregion, total phosphorus levels greater than 0.020 to 0.035 mg/L are considered to be indicative of upper mesotrophic conditions, and if the concentration exceeds 0.035 mg/L a lake specific study should

be initiated. A Carlson TSI can also be calculated using total phosphorus concentrations. The results from using summer average water column concentrations provided TSI's that ranged from 54 at SNR-42 and SNR-82 to 58 at SNR-119 and SNR-129. Based on this metric, the lower Snake River reservoirs would be classified as lower eutrophic.

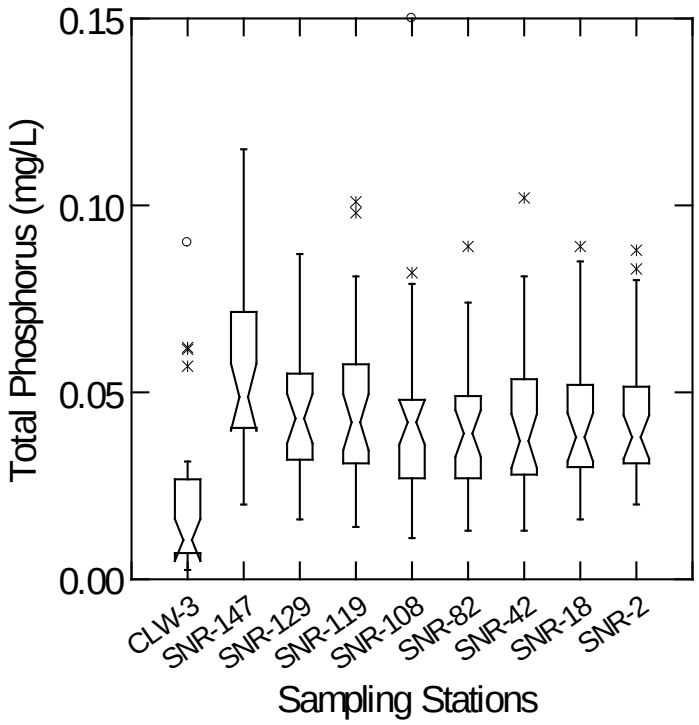


Figure 3-36. Box plots of the total phosphorus concentrations measured at the 2008-2010 sampling stations.

3.2.3.12 Biological

3.2.3.12.1 Chlorophyll a

Chlorophyll *a* is a specific form of chlorophyll used in oxygenic photosynthesis. It absorbs most of its energy from wavelengths of the violet-blue and orange-red light range. It is essential for photosynthesis in most algae and green plants and is often used as a trophic state indicator, and as an indirect measure of phytoplankton biomass.

Chlorophyll *a* concentrations in the inflowing Clearwater and Snake Rivers differed from each other. The median concentration in the Clearwater River for the study period was 2.0 µg/L (Figure 3-37), with one value exceeding 12 µg/L in May 2010. Minimum values of 1 µg/L, or less, were often noted during the summer when cold-water releases occurred from Dworshak Dam. The inflowing Snake River at SNR-147 had a calculated median of 3.6 µg/L, but concentrations exceeding 10 µg/L were observed during four field events during March and April of each year.

Median concentrations in the lower Snake River reservoir system ranged from 2.8 µg/L at SNR-2 to 5.5 µg/L at SNR-82 (Figure 3-37). The highest measurement occurred at SNR-108 where a concentration of 18.0 µg/L was determined in August 2010. Values exceeding 16 µg/L were documented during the same sampling event at SNR-119 and SNR-82. The general trend in the Snake River was a progressive decline in concentrations in the downstream direction from SNR-108 to SNR-2.

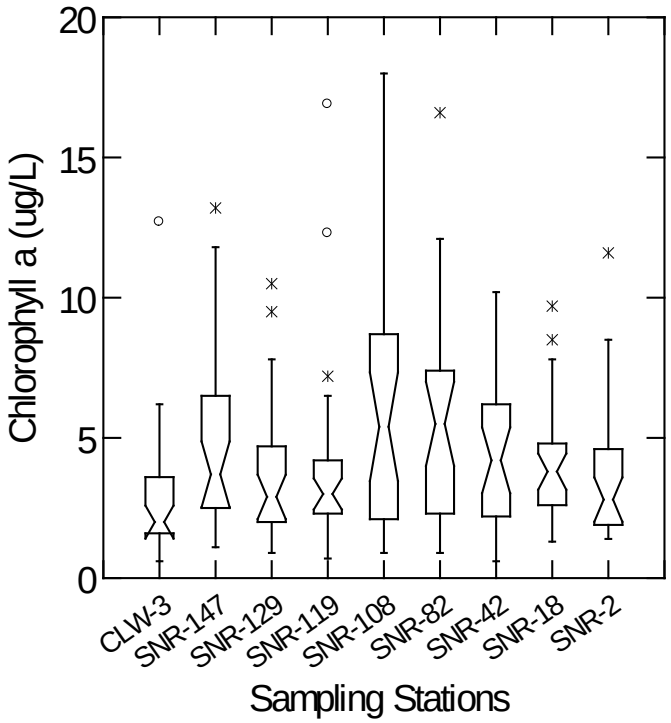


Figure 3-37. Box plots of the chlorophyll *a* concentrations measured at the 2008-2010 sampling stations.

Chlorophyll *a* concentrations, as well as calculated Carlson TSIs, are measures of a lake or reservoirs trophic state. Published literature from some water bodies suggests that average chlorophyll *a* levels above 5.0 and 14.5 µg/L are indicative of mesotrophic and eutrophic conditions, respectively (USACE, 2005). Wetzel (2001) provides broader ranges, stating that annual mean chlorophyll *a* levels between 3.0 and 11.0 µg/L indicate mesotrophic conditions, while a range of 3.0 to 78.0 µg/L represents eutrophic conditions. The calculated Carlson TSIs range from 40 at SNR-129 to 52 at SNR-108 which also suggest mesotrophic to lower eutrophic conditions.

3.2.3.12.2 Phytoplankton

Phytoplankton, also called algae, are small, photosynthetic organisms found floating in the water column. They lack any roots, stems, or leaves, thereby separating them from higher plants. Planktonic algae are found in unicellular, colonial, or filamentous forms, and range in size from 5 µm across to over 100 µm in diameter. They are found in all lakes, slow-flowing rivers, estuaries, and oceans. Their role as primary producers makes them an important part of aquatic ecosystem. Algae utilize inorganic compounds to make complex organic molecules through the

photosynthetic process, and are an essential link to higher trophic levels of the food web. As necessary as they are to the aquatic system, phytoplankton can also be a nuisance. If conditions in a body of water shift to favor a particular species, algal blooms of 5-50 million cells per liter can occur. This sometimes results in lower water quality, specifically, poor taste, odor, and color (Horne and Goldman, 1994).

Phytoplankton are the most important primary producer in the lower Snake River. At the foundation of the food web, they transform light and nutrients into energy for herbivores such as zooplankton, which in turn support higher trophic levels. Phytoplankton grow best in low-velocity waters with warm temperatures and high nutrient availability, particularly phosphorus. Phytoplankton growth is generally limited in stream or riverine systems, which have much greater flow velocities. In evaluating phytoplankton data, a relative increase in species diversity or richness under similar habitat conditions is often considered a positive indication of improving ambient water quality conditions. In contrast, the dominance of certain robust species, such as some species of blue-green algae, can often be indicative of poor water quality conditions. To evaluate the importance of phytoplankton as a food source, the volume or quantity of algae available for consumption is often the most critical parameter to be considered. For this reason, phytoplankton data are typically expressed in terms of overall biovolume (*i.e.*, $\mu m^3/L$) as well as species composition.

The phytoplankton biovolume determined for each sampling station is shown in Figure 3-38. There were no significant differences between the medians calculated for each of the eight Snake River sampling stations with values ranging from 3.70×10^9 $\mu m^3/L$ at SNR-119 to 5.18×10^9 $\mu m^3/L$ at SNR-18. The stations at SNR-82 and SNR-108 had more data points in the higher range with maximum total biovolumes of 3.68×10^{10} $\mu m^3/L$ (August 2009) and 2.93×10^{10} $\mu m^3/L$ (August 2008), respectively. The Clearwater River had significantly less algal biovolume at a calculated median of 1.81×10^9 $\mu m^3/L$.

The phytoplankton composition of the Clearwater River was dominated by Bacillariophyta (diatoms), followed by less than one percent Chlorophyta (green algae) and Cryptophytes (Figure 3-39 and Table 3-13). *Synedra* sp. were consistently present in the samples and constituted 22 percent of the overall diatom biovolume, and did reach a maximum of 67 percent in April 2008. *Synedra ulna* was the major species and often represented 100 percent of the Synedra population and had a median biovolume of 3.39×10^8 µm/L for the study period. *Didymosphenia geminata* (also known as "rock snot" and "didymo") is a single-celled diatom that can form large mats on the bottom of lakes, rivers and streams and is considered to be a nuisance species. It was present in most of the samples collected from the Clearwater River and constituted a median of 9 percent (7.55×10^7 $\mu m^3/L$) of the diatom biovolume. *Fragilaria* sp. was the third most prevalent group comprising 5 percent of the diatom biovolume on a median basis. *Fragilaria capucina* and *Fragilaria crotonensis* were not present in every sample analyzed but had median biovolumes for the study period of 4.54×10^7 $\mu m^3/L$ and 1.25×10^7 $\mu m^3/L$, respectively. Additional diatoms in order of decreasing median biovolume were *Hannaea arcus* (4 percent or 4.75×10^7 $\mu m^3/L$) and *Achnanthidium minutissimum (*3 percent or 3.76×10^7 $\mu m^3/L$). The green algae *Pyramimonas tetrarhynchus* was not ubiquitous, but it was the most consistent Chlorophyte present and comprised a median of 21 percent, or 1.29×10^6 $\mu m^3/L$, of that Divisions biovolume. *Sphaerocystis schroeteri* and *Ulothrix* sp. were identified in

less than half of the samples and reached maximum biovolumes of 5.38 x 10^7 µm/L and 1.08 x 10^9 µm/L, respectively. *Rhodomonas* sp. was the dominant Cryptophyte with a median biovolume of 6.67 x 10^6 µm^3/L.

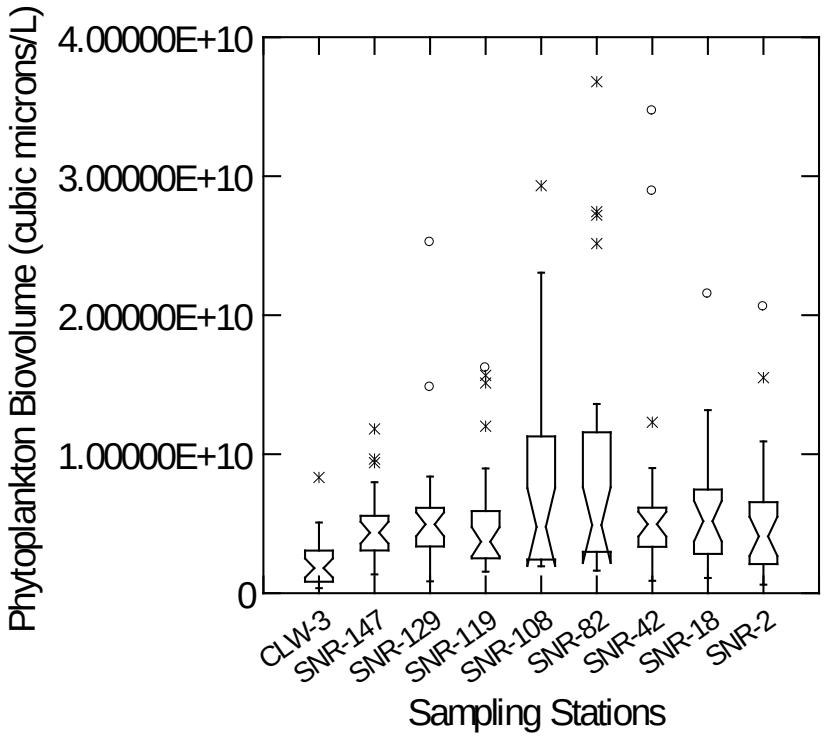


Figure 3-38. Box plots of total phytoplankton biovolume calculated for data collected at the 2008-2010 sampling stations.

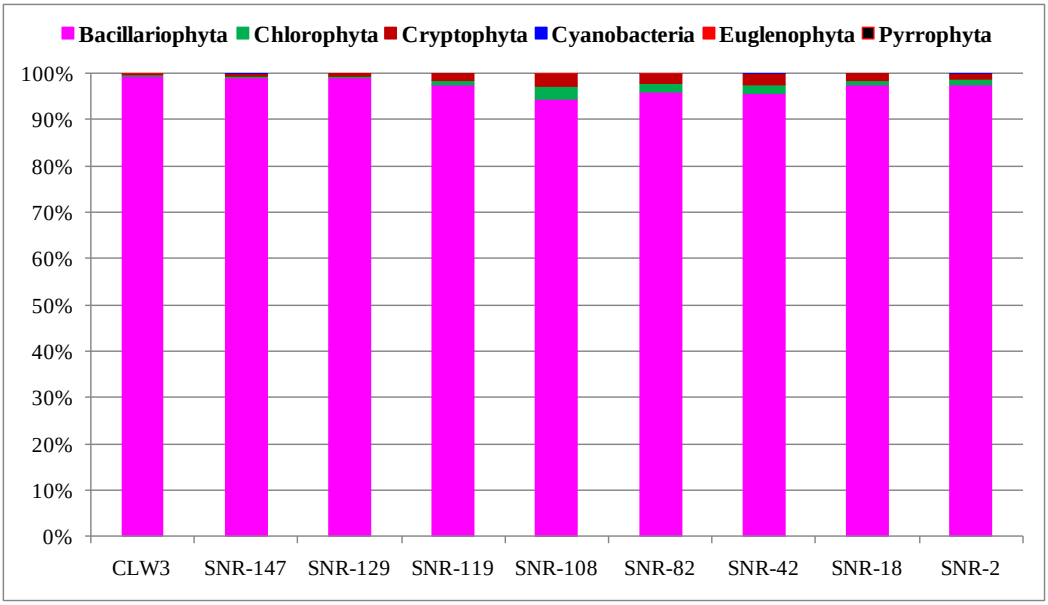


Figure 3-39. Phytoplankton assemblage percent composition at each 2008-2010 sampling station based on median values.

Table 3-13. Median biovolume (µm^3/L) estimates for the major Bacillariophytes, Chlorophytes, and Cryptophytes identified in the 2008 through 2010 samples.

	Bacillariophyta						Chlorophyta	Cryptophyta
Station	Total	Aulacoseira	Fragilaria	Melosira	Stephanodiscus	Synedra	Total	Total
CLW-3	1.69 x 10^9	3.10 x 10^7	1.52 x 10^8	2.57 x 10^7	NSD	4.19 x 10^8	4.66 x10^6	6.67 x10^6
SNR-147	4.45 x 10^9	3.90 x 10^8	7.43 x 10^8	5.25 x 10^7	5.53 x 10^8	3.02 x 10^8	1.44 x 10^7	2.34 x 10^7
SNR-129	4.60 x 10^9	7.22 x 10^8	3.91 x 10^8	5.30 x 10^7	2.99 x 10^8	3.51 x 10^8	1.59 x 10^7	2.74 x 10^7
SNR-119	3.51 x 10^9	6.08 x 10^8	3.40 x 10^8	3.36 x 10^7	1.67 x 10^8	3.07 x 10^8	3.70 x 10^7	5.15 x 10^7
SNR-108	4.39 x 10^9	6.55 x 10^8	5.89 x 10^8	2.58 x 10^6	3.84 x 10^8	1.77 x 10^8	1.26 x 10^8	1.27 x 10^8
SNR-82	4.68 x 10^9	1.74 x 10^9	3.26 x 10^8	1.33 x 10^6	6.19 x 10^8	2.36 x 10^8	8.59 x 10^7	1.10 x 10^8
SNR-42	4.46 x 10^9	1.65 x 10^9	1.53 x 10^8	1.05 x 10^6	5.04 x 10^8	1.32 x 10^8	7.94 x 10^7	1.19 x 10^8
SNR-18	4.86 x 10^9	1.57 x 10^9	7.70 x 10^7	1.90 x 10^7	6.42 x 10^8	1.25 x 10^8	4.47 x 10^7	8.02 x 10^7
SNR-2	3.43 x 10^9	8.54 x 10^8	8.31 x 10^7	4.53 x 10^7	5.08 x 10^8	1.73 x 10^8	4.64 x 10^7	3.94 x 10^7

The phytoplankton biovolume in the inflowing Snake River was greater than the corresponding metric in the Clearwater River, but the community was still dominated by diatoms, followed by less than one percent Cyanobacteria (blue-green algae), cryptophytes, and green algae (Figures 3-39 and 3-40). The genus *Fragilaria* was identified in each sample throughout the study with a median biovolume of 7.43 x 10^8 µm^3/L, or 19 percent of the diatom total. *Fragilaria crotonensis* was the prevailing species, comprising 98 percent (6.16 x 10^8 µm^3/L) of the *Fragilaria* sp. biovolume. *Pyramimonas tetrarhynchus* was again the green algae that was consistently present and comprised a median 29 percent (4.83 x 10^6 µm^3/L) of the Chlorophyte biovolume. Additional species that prevailed during individual sampling events included *Ulothrix* sp., *Staruastrum* sp., *Pediastrum duplex, Scenedesmus* sp., and *Coelastrum microporum*. *Rhodomonas* sp. was again the central Cryptophyte with a mean biovolume of 2.33 x 10^7 µm^3/L and represented almost 100 percent of this Divisions total biovolume. Blue-green algae presence was ephemeral and the major species changed from one sampling event to the next, but species and maximum biovolumes included *Anabaenopsis circularis* (6.08 x 10^8 µm^3/L), *Pseudanabaena* sp. (8.84 x 10^7 µm^3/L), and *Cylindrospermopsis raciborskii* (4.48 x 10^7 µm^3/L). A distinguishing feature of the inflowing Snake River algal data is that the median biovolume for the entire data set was not significantly different from the other Snake River stations (Figures 3-38 and 3-40), but the seasonal maxima was not at high as at the reservoir stations (Figure 3-41) that will be discussed in the next section.

Diatom biovolume was very similar throughout the four lower Snake River reservoirs, albeit with reductions at SNR-119 and SNR-2 (Figure 3-40). *Aulascoseira* sp. biovolume generally exceeded the contribution from other individual diatom genera and reached a study period maximum at SNR-82 (Table 3-12). The highest biovolumes were determined during the months of August, September, and October at all stations (Figure 3-41). Median *Fragilaria* sp. biovolume (primarily *Fragilaria crotonensis)* increased from SNR-129 to a maximum of 5.89 x 10^8 µm^3/L at SNR-108 and then decreased at the downstream reservoir stations. Median

Stephanodiscus sp. (primarily *Stephanodiscus niagarae* and to a lesser extent *S. hantzschii* and *S. parvus*) biovolume was less than that of *Fragilaria* sp. at the Lower Granite pool stations, but were greater at the three lower reservoir stations (Table 3-13). The median biovolume attributable to *Synedra* sp. (primarily *Synedra ulna*) within the reservoir system was greatest at SNR-129 (3.51 x 10^8 µm^3/L) and decreased downstream.

The median Chlorophyte, Cryptophyte, and Cyanophyte biovolumes in the four lower Snake River reservoirs for the study period were each less than 3 percent of the total algal biovolume. The median green algae (primarily *Pyramimonas tetrarhynchus*) and Cryptophyte (primarily *Rhodomonas* sp.) biovolume were both greatest at SNR-108 (Table 3-13). The blue-green algae population was ephemeral with shifts in dominant species. The largest concentration of blue-green algae was documented at SNR-82 on 23 September 2008 when *Cylindrospermopsis* sp. attained a biovolume of 3.84 x 10^9 µm^3/L (Figure 3-41). A month earlier on 18 August 2008 the blue-green *Cylindrospermopsis raciborskii* attained a biovolume of 7.82 x 10^8 µm^3/L at the same station, yet downstream at SNR-42 *Anabaenopsis* sp. was the dominant blue-green at 4.69 x 10^8 µm^3/L on the same date. At SNR-108, *Anabaenopsis circularis* reached a biovolume of 5.99 x 10^8 µm^3/L on 15 July 2009, but a year earlier the prevailing blue-green was Aphanocapsa elachista at 4.52 x 10^8 µm^3/L.

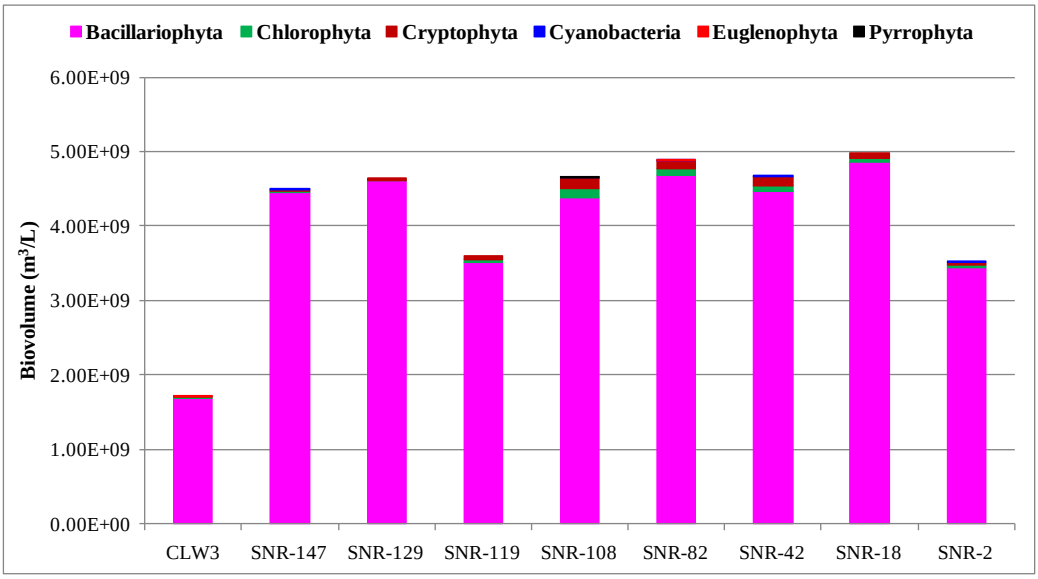


Figure 3-40. Median biovolume for the major phytoplankton divisions at each 2008-2010 sampling station.

3.2.3.12.3 Primary Productivity

Primary productivity is a measure of the amount of carbon per unit time produced by all aquatic plants. As primary producers form the base of the food chain, the level of primary productivity ultimately dictates the productivity of the entire ecosystem. Primary productivity rates were not determined for this management plan, but were evaluated during previous investigations in 1994,

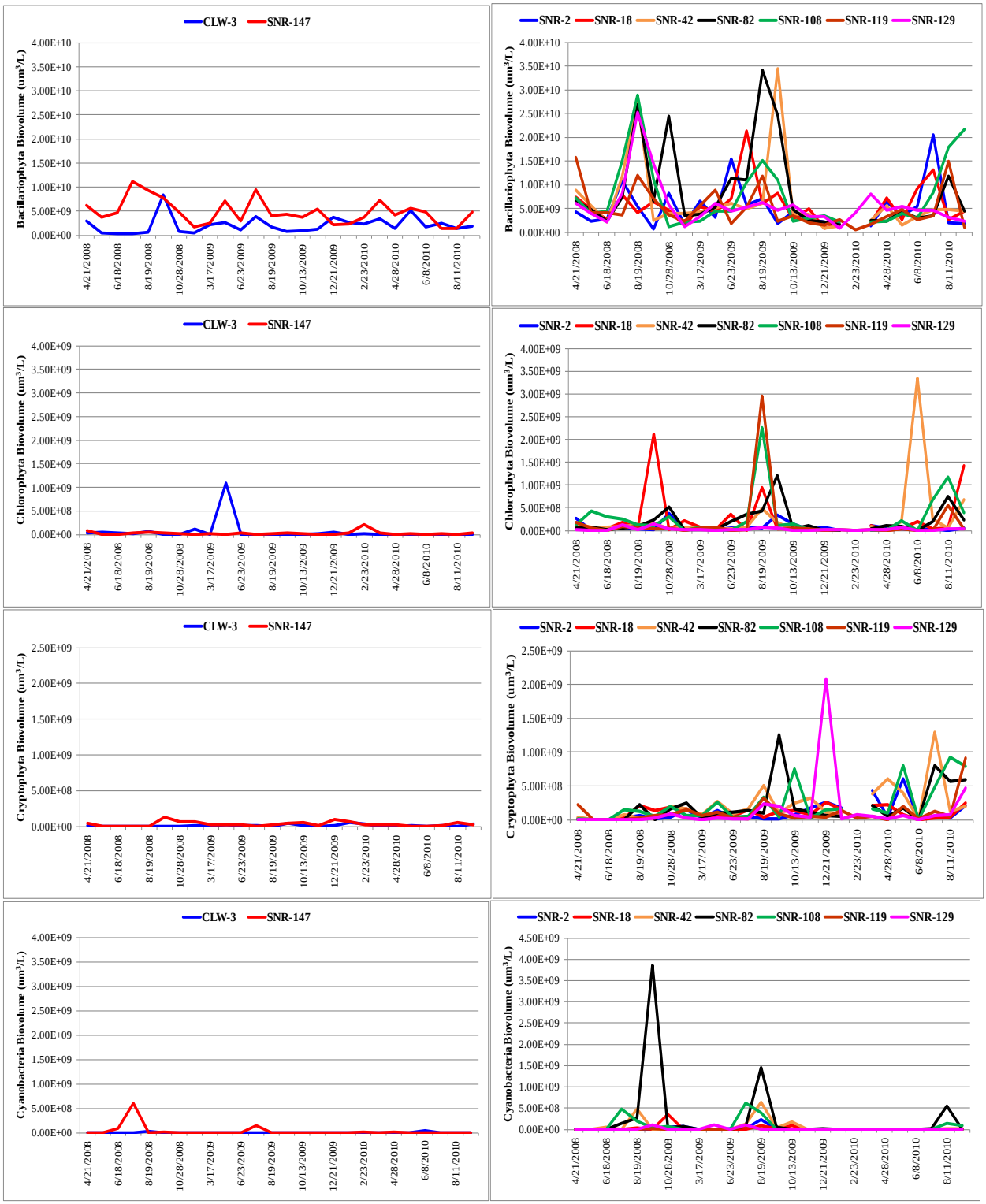


Figure 3-41. Time-series biovolume plots for the major phytoplankton groups identified during the 2008-2010 study.

1995, and 1997 (USACE, 2005). Using the most recent results as an example, the free-flowing reach of the Clearwater River had the lowest median volume weighted hourly rate of 1.97 mg $^{12}C/m^3$/hr. In contrast, the corresponding value for the free-flowing Snake River was significantly higher at14.49 mg $^{12}C/m^3$/hr. The general pattern in the reservoirs was for primary productivity to increase in Lower Granite pool, reaching a median value of 15.87 mg $^{12}C/m^3$/hr at SNR-118. Thereafter, the rate displayed a gradual downstream decrease with the calculated median value at river mile six of 9.49 mg $^{12}C/m^3$/hr.

3.2.3.12.4 Attached Benthic Algae

Attached benthic algae (ABA) refers to unicellular and filamentous forms of algae that attach to rocks and other hard substrate in water depths where sunlight penetrates to the bottom of the photic zone. As with phytoplankton, ABA represent the base of the food chain and are an important food source for zooplankton, benthic animals (*i.e.*, crayfish, amphipods, oligochaetes), aquatic insects, and benthivorous fishes. ABA are a secondary source of primary productivity in the impounded reaches of the rivers, but a primary source in free-flowing reaches.

As was the case for primary productivity, the ABA community was not evaluated for this investigation, but data is available from 1997 and 1998 (USACE, 2005). During the high-flow year of 1997, the trichromatic chlorophyll *a* values ranged from 30 to 100 mg/m^2 at a depth of 1.5 m (4.9 ft). In the low-flow 1998, the range was 60 to 110 mg/m². At SNR-118 in the Lower Granite reservoir, the ABA chlorophyll *a* values ranged from 23.04 to 73.35 mg/m² but increased farther downstream at SNR-18 where they frequently exceeded 100 mg/m² from July through early September.

The ABA ash-free biomass results averaged 6.65 g/m² in 1997 and 7.95 g/m² in 1998. The mean biomass collected in 1997 followed a similar pattern as the chlorophyll a, with samples from SNR-148 ranging between 4.39 and 15.17 g/m² and increasing to 9.09 and 25.25 g/m² at SNR-118. The Ice Harbor reservoir station at SNR-18 had the highest biomass range of 10.94 to 37.09 g/m². The lower Snake River reservoirs apparently produce a considerable amount of ABA biomass along the littoral and shoreline areas. However, much of the system has accumulated fine sediments, which limit the amount of ABA and epilithic periphyton.

3.2.3.12.5 Zooplankton

The term zooplankton refers to invertebrate animals living in the water column of fresh-water bodies. These planktonic animals are typically divided into three major groups based on taxonomy: the phylum Rotifera, and two orders of the Crustacea, the cladocera and copepoda. Zooplankton feed by filtering and/or grazing, and are primary consumers that feed on algae, organic detritus, and bacteria, with a few predaceous species that also prey on smaller crustaceans and rotifers (Pennak, 1989). Zooplankton serve as a food base for larger crustaceans, aquatic insects, and planktivorous fish, and are therefore considered secondary producers (Pennak, 1989; Kerfoot and Sih, 1987). Zooplankton assemblages are expressed in terms of total biomass, population densities, or species composition. Species composition is usually determined first through enumeration and identification of the various organisms in a sample. Total biomass is then calculated through established length/width relationships for each species type.

The box plot of total zooplankton biomass for each sampling station is presented in Figure 3-42. Total zooplankton biomass was less in the Clearwater River than in the Snake River. The median biomass at CLW-3 was 0.093 µg/L while the maximum was only 1.879 µg/L. Median values at SNR-147 and SNR-129 were also comparatively low at 0.211 µg/L and 0.260 µg/L, respectively. Biomass increased at the next three downstream stations, reaching a system high of 5.173 µg/L at SNR-42. Median biomass at SNR-18 and SNR-2 decreased to 1.473 µg/L and 2.063 µg/L, respectively.

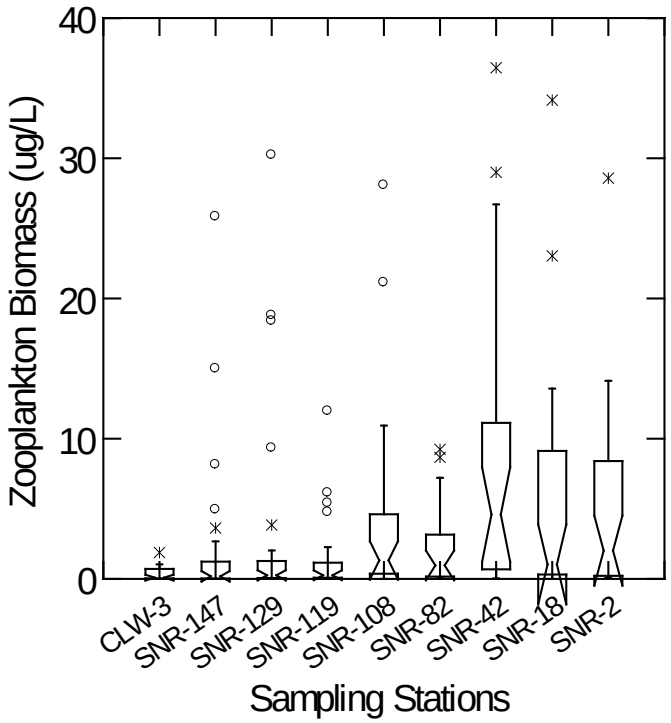


Figure 3-42. Box plots of total zooplankton biomass calculated for data collected at the 2008-2010 sampling stations.

The percent composition of the zooplankton community differed throughout the study area. The cladocerans were the primary group at the upstream Snake River sample station, comprising 53 percent of the median biomass at SNR-147 (Figure 3-43). The median biomass for this group decreased to 12.6 percent at SNR-129, increased to almost 49 percent at SNR-119, and then decreased throughout the remaining Lower Snake River. Median copepod biomass at the four upstream Snake River stations ranged from 30.4 percent to 41.2 percent, but then increased at each successive downstream sampling station beginning with 61 percent at SNR-82 and ending with 82 percent at SNR-2. The median percent composition of the rotifers was greatest at SNR-129 (46.2 percent) and SNR-108 (48.4 percent) but displayed a declining presence in the three Lower Snake River reservoirs analogous to the one exhibited by the cladocerans. The median zooplankton biomass in the Clearwater River was mainly due to copepods (56.4 percent) followed by cladocerans (28.9 percent) and rotifers (14.7 percent).

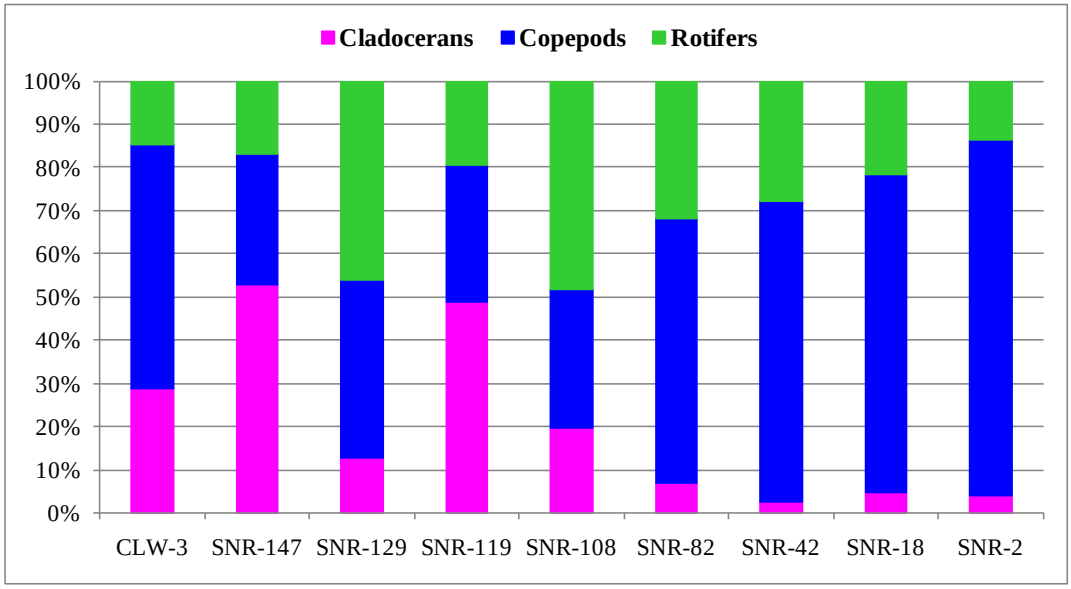


Figure 3-43. Zooplankton assemblage percent composition at each 2008-2010 sampling station based on median values.

Biomass estimates were plotted for each sampling location using median values for the three major taxonomic groups: rotifers, copepods, and cladocerans (Figure 3-44 and Table 3-14). The Clearwater River station had the least zooplankton biomass of any sampling location. Median biomass for the study period was 0.063 µg/L and more than half of that was due to the copepods. The primary representatives of this group were Cyclopoid copepodid, *Diacyclops thomasi*, and nauplii. Copepod abundance was typically greatest during the summer months with the exception of the April 2008 sampling event when Cyclopoid copepodid and *Diacyclops thomasi* biomass peaked at 0.53 µg/L and 0.47 µg/L, respectively, at CLW-3 (Figure 3-45). The cladoceran community in the Clearwater River included *Daphnia retrocurva*, *Daphnia galeata mendotae*, *Eubosmina hagmanni*, and *Bosmina longirostris*. None of these species were present year-round. As was the case with the copepods, the highest concentrations were more likely to occur during the summer with *Daphnia retrocurva*, *Daphnia galeata mendotae*, and *Bosmina longirostris* attaining maximum biomass values of 0.80, 0.38, and 0.55 µg/L, respectively, between June and September. Median biomass for the rotifers at CLW-3 was very low at 0.009 µg/L and was primarily attributable to *Brachionus calyciflorus*.

The zooplankton community in the inflowing Snake River displayed both similarities and dissimilarities to the one in the Clearwater River. Median biomass for the study period was still low at 0.08 µg/L. The rotifers were again the smallest contingent with a median biomass of 0.013 µg/L and *Brachionus calyciflorus* was the primary species. Similar to the situation in the Clearwater River, *Brachionus calyciflorus* were not present during each sampling event. However, the maximum biomass estimates for this species was higher in the Snake River with some determinations ranging from 4.57 to 36.07 µg/L during February, March, and April. The biomass relationship between the cladocerans and copepods observed in the Clearwater River was reversed in the Snake River where the median calculation for the cladocerans was 0.042 µg/L and for the copepods it was 0.024 µg/L. *Daphnia retrocurva* and *Eubosmina coregoni* presence were both ephemeral and a substantial fraction of the biomass for both

species occurred during February, March, and April. *Eubosmina coregoni* was enumerated on five of the twenty-seven sample events, and during four of those events their biomass ranged from 2.17 to 5.14 µg/L. *Daphnia retrocurva* was identified in nine of the samples and their maximum biomass of 3.45 µg/L was determined on 21 April 2009. Cyclopoid copepodid, *Diacyclops thomasi*, and nauplii were again the most common copepods, but their individual biomass contributions were small, ranging from zero to 1.21 µg/L.

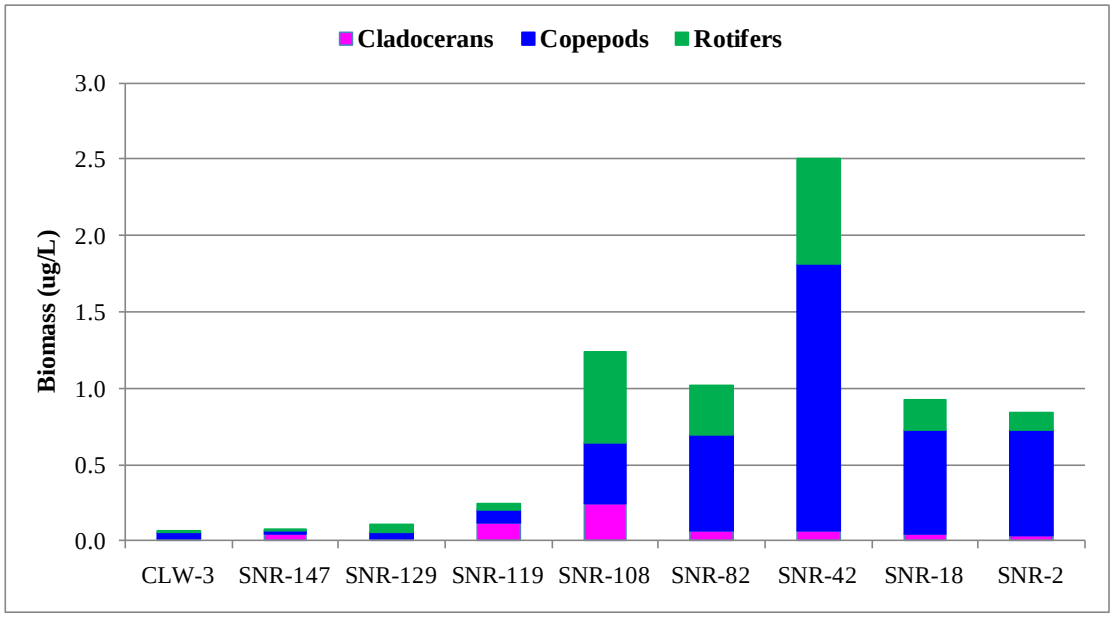


Figure 3-44. Median biomass for the major zooplankton divisions at each 2008-2010 sampling station.

Table 3-14. Median biomass (µg/L) estimates for the Cladocera, Copepoda, and Rotifera identified in the 2008 through 2010 samples.

Location	Cladocera	Copepoda	Rotifera
CLW-3	0.018	0.036	0.009
SNR-147	0.042	0.024	0.013
SNR-129	0.014	0.044	0.050
SNR-119	0.122	0.078	0.049
SNR-108	0.247	0.395	0.601
SNR-82	0.073	0.625	0.324
SNR-42	0.064	1.745	0.699
SNR-18	0.044	0.678	0.199
SNR-2	0.033	0.689	0.116

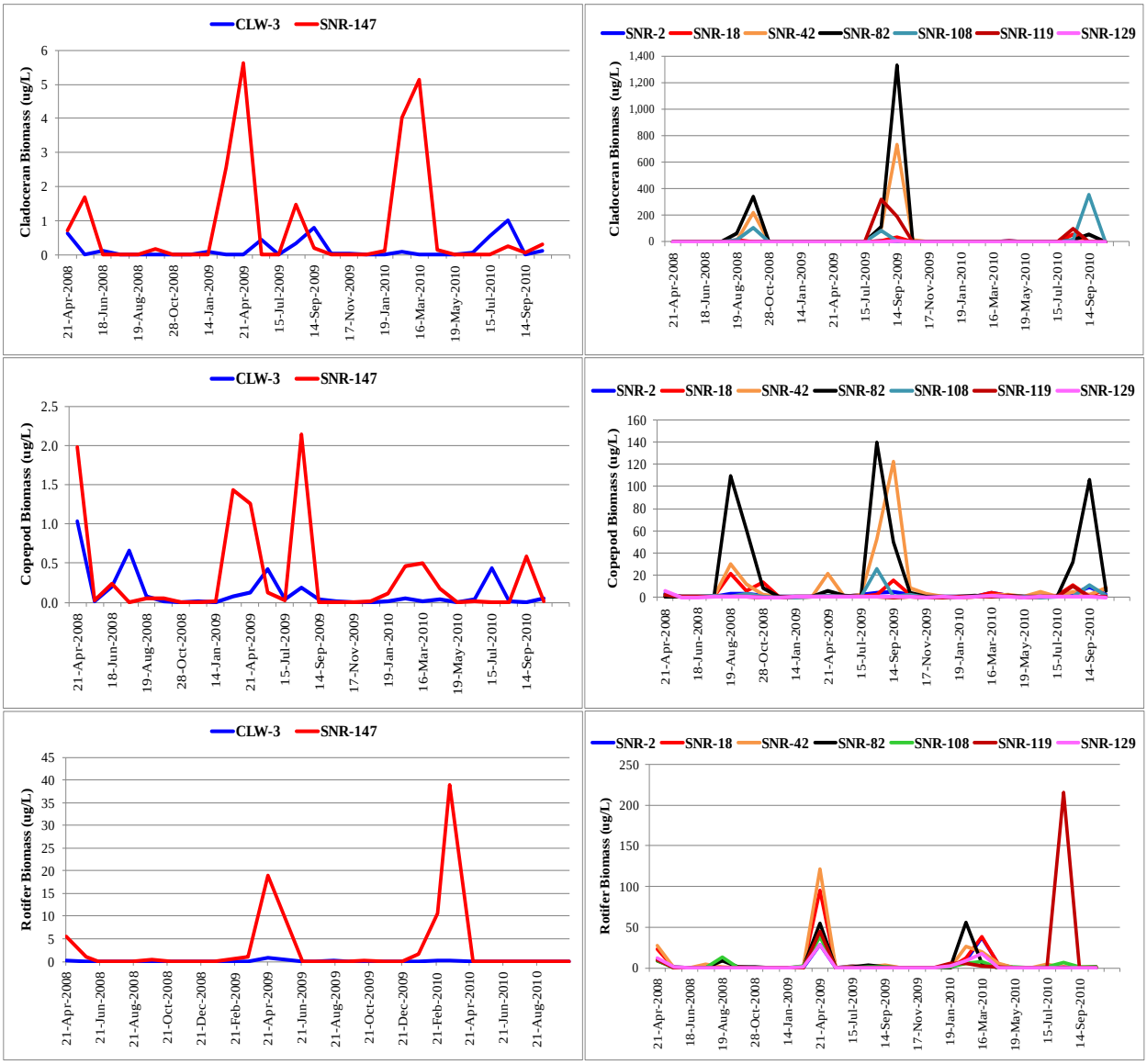


Figure 3-45. Time series biomass plots for the major zooplankton groups identified during the 2008-2010 study.

Zooplankton biomass increased as the river progressed through the upper reservoirs, reached a peak at SNR-42, and then declined at SNR-18 and SNR-2 (Figure 3-44 and Table 3-14). Median cladoceran biomass increased from 0.014 µg/L at SNR-129 to 0.247 µg/L at SNR-108, and then declined at the remaining stations, reaching 0.033 µg/L at SNR-2. Seasonality was very apparent in the cladoceran population (primarily *Daphnia retrocurva* with lesser contributions from *Daphnia galaeta*, *Eubosmina hagamanni* and *Eubosmina coregoni*), resulting in periodic increases in biomass to much greater levels (Figure 3-45). Biomass typically peaked during August, September, and October and study period maximum values of 1,328 µg/L (*Daphnia retrocurva*) and 732 µg/L (*D. retrocurva* plus *D. galaeta*) occurred at SNR-82 and SNR-42, respectively, during August 2009 (Figure 3-45). Maximum copepod biomass (106 to 140 µg/L)

was observed during August and September of each year at SNR-82, and at SNR-42 (123 µg/L) during September 2009. A mix of species contributed to the copepod pulses including *Acanthocyclops robustus*, *Diacyclops thomasi*, Cyclopoid copepodid, nauplii, and *Tropocyclops prasinus*. The rotifer population peaked earlier in the year at all sampling stations, with notable pulses during April 2009 and February 2010. *Brachionus calyciflorus,* along with a lesser contributions from *Brachionus urceolaris*, *Polyarthra vulgaris*, *Synchaeta pectinata*, and *Keratella* sp., were the primary representatives. *Asplanchna girodi* was determined at an unusually high biomass of 184 µg/L at SNR-119 during August 2010.

4.0 SUMMARY

A suite of limnological parameters were evaluated in the Clearwater River and Snake River between April 2008 and October 2010. The goal of this effort was to characterize the water quality conditions within the USACE project boundaries for the PSMP.

The two major tributaries that flow into the lower Snake River reservoirs varied with respect to the concentrations of abiotic and biotic constituents. The Clearwater River provided 14 to 69 percent of the inflow into the lower Snake River between 1992 and 2010 and typically had the lowest concentrations of ions, nutrients, and biological components. Water from Dworshak Reservoir enters the Clearwater River in Idaho, and during July and August 70 percent of the flow in the Clearwater River originated from this source; this action effectively lowers summer-time water temperatures in the lower Snake River. The Snake River above the confluence had significantly greater quantities of ions, nutrients, and biological attributes relative to the Clearwater River. The concentrations of soluble chemical constituents in the Snake River can vary be almost an order of magnitude between spring and summer minimum values and autumn maximums. Primary productivity and algal biovolume in the Snake River can also be unexpectedly high during the early part of the season, and are likely influenced by storage water released from upstream reservoirs.

The physicochemical and biological attributes of the lower Snake River were, to a large extent, governed by the inflowing Snake River. The concentrations of the ions and nutrients evaluated were not significantly different from one end of the system to the other (i.e. SNR-129 to SNR-2). Secchi disc depths decreased slightly downstream, but were usually between 2 m and 3 m. Median chlorophyll *a* concentrations increased from the upper end of Lower Granite Reservoir to the dam and mid-reaches of Lake Bryan, and then gradually declined at successive downstream monitoring sites. Median total algal biovolume was not significantly different at the reservoir sampling stations, but the highest individual values were determined at the Little Goose and Lower Monumental reservoir sampling stations. The phytoplankton community was dominated by the diatoms. Zooplankton biomass increased from the upper reaches of Lower Granite reservoir to the Lower Monumental sampling station and decreased thereafter. The copepods were consistently present and usually accounted for the largest percentage of the biomass when median values are considered. However, the cladocera, primarily *Daphnia retrocurva*, surpassed the combined biomass of all other zooplankters during the summer months.

Selected parameters from the water-quality monitoring that occurred during the 2005-2006 navigation channel maintenance project were also evaluated. The results showed that dissolved

oxygen, pH, and ammonia concentrations were not adversely affected by dredging. Turbidity was the only parameter influenced by the dredging program and did result in work stoppages on a few occasions.

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6.0 GLOSSARY

Allochthonous: Pertaining to substances (usually organic carbon) produced outside of and flowing into an aquatic or wetland ecosystem.

Anadromous fish: Fish, such as salmon or steelhead trout that hatch in fresh water, migrate to and mature in the ocean and return to fresh water as adults to spawn.

Anion: A negatively charged ion.

Anthropogenic: Changes made by human activity.

Basaltic: Having a texture of a hard, dense, dark volcanic rock.

Biomass: The total mass of living tissues (plant and animal).

Biota: The animal and plant life of a particular region considered as a total ecological entity.

Biovolume: Volume of an organism available for consumption.

Cation: A positively charged ion.

Chlorophyll *a*: A green plant pigment necessary for plants to produce carbon from sunlight.

Detritus: Dead plant material that is in the process of microbial decomposition (adjective: detrital).

Diatom: A unicellular or colonial algae (aquatic plant) having siliceous walls.

Dissolved gas supersaturation: Caused when water passing through a dam's spillway carries trapped air deep into the waters of the plunge pool, increasing pressure and causing the air to dissolve into the water. Deep in the pool, the water is "supersaturated" with dissolved gas compared to the conditions at the water's surface.

Endangered species: A native species found by the Secretary of the Interior to be threatened with extinction.

Eutrophic: A body of water in which the increase of mineral and organic nutrients reduces DO, producing an environment that favors plant over animal life.

Federal Columbia River Power System (FCRPS): Official term for the 14 Federal dams on the Columbia and Snake Rivers.

Flow augmentation: Increasing river flows above levels that would occur under normal operation by releasing more water from storage reservoirs upstream.

Forebay: The area of water directly upstream of a dam.

Freshet: A sudden overflow of a stream resulting from a heavy rain or thaw.

Gas bubble disease or trauma (GBD or GBT): Condition caused when dissolved gas in supersaturated water comes out of solution and equilibrates with atmospheric conditions, forming bubbles within the tissues of aquatic organisms. This condition can kill or harm fish.

Hydrology: The science dealing with the continuous water cycle of evapotranspiration, precipitation, and runoff.

Impoundment: Accumulated water in a reservoir.

Lacustrine: Of or pertaining to a lake.

Limnology: The study of the physical, chemical and biological aspects of lakes.

Littoral zone: The shore area along a body of water, usually a lake, down to the depth of 10 meters

Macroinvertebrate: Organism without a backbone generally measuring more than 0.5–1 millimeters in size.

Mesotrophic: A mesotrophic lake or reservoir is one with an intermediate level of productivity and nutrient content - greater than oligotrophic but less than eutrophic.

Metamorphic: Rock that has been greatly altered from its previous condition through combined action of heat and pressure.

Mitigation: To moderate or compensate for an impact or effect.

Oligotrophic: Nutrient poor waters with low productivity

Pelagic: Refers to the open water portion of a lake or reservoir.

pH: An index of the hydrogen ion concentration in water, measured on a scale of 0 to 14. A value of 7 indicates a neutral condition, values less than 7 indicate acidic conditions, and values greater than 7 indicate alkaline conditions.

Phytoplankton: Drifting plants such as microscopic algae that nourish themselves from the energy of the sun; they are at the base of the food chain and provide a food source for bacteria, water molds, and zooplankton.

Run-of-river: This describes hydropower facilities that do not have storage or the associated flood control capacity; run-of-river facilities essentially pass through as much water as they have coming in, either through the turbines or over the spillways.

Salmonid: Of or belonging to the family Salmonidae, which includes salmon, trout, and whitefishes.

Spawning: The reproductive process for aquatic organisms which involves producing or depositing eggs or discharging sperm.

Spill: Water released through the dam spillways, rather than through the turbines. Involuntary spill occurs when reservoirs are full and flows exceed the capacity of the powerhouse or power output needs. Voluntary spill is one method used to pass juvenile fish without danger of turbine passage.

Spillway flow deflectors (flip lips): Structures that limit the plunge depth of water over the dam spillway, producing a less forceful, more horizontal spill. These structures reduce the amount of dissolved gas trapped in the spilled water.

Stilling Basin: A concrete-lined pool below the dam where water dissipates energy prior to flowing downstream.

Substrate: Substances used by organisms for growth in a liquid medium; surface area of solids or soils used by organisms to attach.

Tailrace: The canal or channel that carries water away from a dam.

Tailwater: The water surface immediately downstream from a dam.

Taxon/Taxa: Any level of classification, as genus, species, *etc*.

Thermocline: A density gradient due to changing temperatures within a water body.

Total suspended solids (TSS): The portion of the sediment load suspended in the water column. The grain size of suspended sediment is usually less than one millimeter in diameter (clays and silts). High TSS concentrations can adversely affect primary food production and fish feeding efficiency. Extremely high TSS concentrations can impair other biological functions such as respiration and reproduction.

Transect: A line on the ground along where sample plots or points are established for data collection.

Trophic level: Position in the food chain determined by the number of energy-transfer steps to that level.

Turbidity: An indicator of the amount of sediment suspended in water. It refers to the amount of light scattered or absorbed by a fluid. In streams or rivers, turbidity is affected by suspended particles of silts and clays, and also by organic compounds like plankton and microorganisms. Turbidity is measured in nephelometric turbidity units.

Watershed: The area draining into a river, river system, or body of water.

Zooplankton: Tiny, floating animals that provide a food source for larger aquatic organisms such as snails and small fish.