RECORD OF DECISION

SELECTED REMEDIAL ACTION

For

FORMER PORTLAND GAS MANUFACTURING

PORTLAND, OREGON

Prepared By

OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY
Northwest Region Cleanup Section

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# TABLE OF CONTENTS

1 INTRODUCTION AND PURPOSE ........................................................................................................ 3

2 SUMMARY OF SELECTED REMEDIAL ACTION ........................................................................... 3

3 SITE DESCRIPTION .......................................................................................................................... 4

   3.1 SITE HISTORY ............................................................................................................................ 4
      3.1.1 General ............................................................................................................................. 4
      3.1.2 Blocks 5 and 6 .................................................................................................................. 5
      3.1.3 Block 7 ............................................................................................................................ 6
      3.1.4 Block 15 .......................................................................................................................... 6
      3.1.5 Block 23 .......................................................................................................................... 6

   3.2 PHYSICAL SETTING ................................................................................................................... 6
      3.2.1 General ............................................................................................................................ 6
      3.2.2 Geology/Hydrogeology .................................................................................................... 7
      3.2.3 In-Water Environment .................................................................................................... 7
      3.2.4 Proximity to Portland Harbor Superfund Site ................................................................. 8

4 SITE INVESTIGATION ...................................................................................................................... 8

   4.1 PRE-2009 INVESTIGATION ...................................................................................................... 9
   4.2 POST-2009 INVESTIGATION .................................................................................................. 10

5 NATURE AND EXTENT OF CONTAMINATION ............................................................................ 11

   5.1 UPLAND SOIL .......................................................................................................................... 11
   5.2 UPLAND GROUNDWATER ....................................................................................................... 12
   5.3 WILLAMETTE RIVER SEDIMENT ......................................................................................... 14
   5.4 WILLAMETTE RIVER TRANSITION ZONE AND SURFACE WATER .................................... 16

6 RISK SCREENING .......................................................................................................................... 16

   6.1 LOCALITY OF THE FACILITY ................................................................................................. 16
   6.2 BENEFICIAL LAND AND WATER USE DETERMINATIONS .................................................. 16
   6.3 DEVELOPMENT OF RISK SCREENING LEVELS .................................................................. 17
   6.4 RISK ANALYSIS ...................................................................................................................... 18
      6.4.1 Soil .................................................................................................................................. 18
      6.4.2 Groundwater ................................................................................................................... 18
      6.4.3 Willamette River Sediment ............................................................................................. 18
      6.4.4 Willamette River Transition Zone and Surface Water .................................................... 19
      6.4.5 Potential Stormwater Migration ...................................................................................... 19
      6.4.6 Hot Spots ....................................................................................................................... 19

7 FEASIBILITY STUDY ....................................................................................................................... 20

   7.1 FEASIBILITY STUDY STRUCTURE ....................................................................................... 20
   7.2 AREAS AND VOLUME OF CONTAMINATED SEDIMENT ...................................................... 21
   7.3 AREAS AND VOLUME OF HOT SPOT MATERIAL ................................................................. 21
   7.4 SEDIMENT DECISION UNITS ............................................................................................... 18
   7.5 NATURAL RECOVERY ANALYSIS ...................................................................................... 22
   7.6 CAP MODELING ANALYSIS .................................................................................................. 23
   7.7 CAP EROSION PROTECTION EVALUATION ....................................................................... 25
SECTION 1 - INTRODUCTION AND PURPOSE

This document presents the Oregon Department of Environmental Quality (DEQ) selected in-water remedial action associated with the former Portland Gas Manufacturing (PGM) Site located in Portland, Oregon. The remedial action was chosen in accordance with Oregon Revised Statute (ORS) 465.200 et. seq. and is based on the administrative record for this site. This Record of Decision (ROD) summarizes the more detailed information presented in the remedial investigation, risk assessment, feasibility study, and other documents in the administrative record.

The selected final remedy for sediments outlined in this staff report also addresses source control concerns related to the former PGM. The 2009 Consent Order (Order) signed in 2009 required NW Natural to “determine the nature and extent of releases and potential source of hazardous substances…to the Willamette River, including sediments, and to evaluate, select and implement remedial measures to address such releases, if necessary, in a manner that complies with the applicable provisions of ORS 465.200 through 465.420 and regulations promulgated thereto.”

Investigations under the Order focused primarily on in-water investigation, determining the extent to which manufactured gas plant (MGP) operations have impacted Willamette River sediment, porewater, and ambient water quality. Upland investigation including extensive groundwater sampling, focused on determining the extent to which MGP contamination might migrate to and impact the Willamette River via groundwater or stormwater. Bankline erosion is not a viable release mechanism, nor was impacted stormwater determined to be a concern. The risk posed by residual soil and groundwater contamination to upland receptors (property occupants or users) through direct contact is not addressed in this ROD and the remedy selected herein. Responsible party NW Natural, or current owners of upland property formerly occupied by PGM operations, may pursue a no further action for upland parcels at a later date. At present the upland is considered a low priority for further action based on post-PGM filling and development.

SECTION 2 - SUMMARY OF SELECTED REMEDIAL ACTION

Selected remedial actions for site-related contamination in Willamette River sediment include a combination of dredging, capping with an activated treatment element (granular activated carbon, or GAC), enhanced and non-enhanced natural recovery, and engineering and institutional controls. The selected remedy is illustrated in Attachment 1 and tabulated in Attachment 2 to this ROD. The remedial action area has been divided into twelve individual Sediment Decision Units (SDUs), labeled A through E, with the letters representing different in-water areas and remedial elements. A- and B-series SDUs are located adjacent to the City of Portland seawall, while C- through F-series SDUs are located off-shore of the seawall.

The selected remedial action includes the following:
Excavation and upland disposal of a “hot spot” consisting of a surface layer of tar-like material and high-concentration shallow sediment in offshore SDU E, and installation of a minimum 1-foot thick treatment cap (sand, amended with GAC) following removal, and a minimum 1-foot thick rock armor layer.

Excavation and upland disposal of contaminated shallow sediment in SDUs C1, C2, and D1, and installation of a minimum 1-foot GAC-amended treatment cap. SDUs C2 and D1 are to include a minimum 1-foot rock armor layer.

Installation of a minimum 1-foot GAC-amended treatment cap, without dredging, in SDUs D2 and D3, to be covered with a minimum 1-foot rock armor layer.

Installation of a minimum 1-foot GAC amended treatment cover in SDU A2.

Enhanced monitored natural recovery (EMNR) in offshore SDUs A1, B2, C3, and F, including placement of minimum 1-foot (non-amended) sand cover to accelerate the natural recovery processes.

Monitored natural recovery (MNR) in SDU B1.

Institutional controls, and long-term inspection and maintenance in all SDUs.

The selected remedy will address the potential for ecological and human receptors in the river to be exposed to site-related contamination in sediment and porewater through either direct contact or bioaccumulation through the food chain. Treatment caps will also address contaminant migration from the adjacent upland via groundwater-to-surface water discharge.

A more detailed description of selected action can be found in Section 10: DEQ Selected Remedial Action. While this ROD outlines guidelines for remedial elements including removal depths and areas; cap locations, types, and thicknesses; and amendment types and concentrations, final details will be developed in the forthcoming remedial design documents, and will incorporate the results of additional pre-design investigation.

SECTION 3 - SITE DESCRIPTION

3.1 Site History

3.1.1 General. The former PGM Site is located along the west bank of the Willamette River, on a 0.2-mile reach (RM12.1 to RM 12.3) between the Burnside Bridge and the Steel Bridge in downtown Portland (see Attachment 3 for location). The Site was the location of a manufactured gas plant (MGP) that occupied a number of city blocks, generally bounded by NW Davis Street on the south, NW Second Avenue on the west, NW Glisan Street on the north, and the Willamette River on the east, as described in the Historical Summary Report (Hahn 2009). From 1860 until the early 1900s, gas manufacturing by the Portland Gas Light Company was largely on Block 5, adjacent to and on a wharf over the Willamette River, with office space and coal storage located on a second city block (Block 6). By 1913, operations had been expanded to include all or portions of additional city blocks 7, 15, and 23. MGP operations for 1886 and 1908, respectively, are illustrated in Attachments 4 and 5. In the attachments, development information from Sanborn Maps is superimposed over a 2003 aerial photograph of the Site area. The 1886 figure shows MGP operations largely confined to waterfront Block 5, with some non-manufacturing operations extending onto Block 6. In the 1908 figure, expansion of MGP operations onto adjoining blocks is shown with: purifiers, scrubbers, and a small gas holder on Block 6; an oil tank on northern Block 7; coal storage on Block 15; and a reheat plant, purifiers, and a large gas holder on Block 23.
Gas at the Site was manufactured from coal from 1860 until the late 1890s. In subsequent years carbureted water was used as a feedstock, and coal was gradually phased out in the early 1900s. From 1906 through shutdown in 1913, gas was produced largely from oil. In 1913, all operations were moved downriver to the Gasco site (DEQ Environmental Cleanup Site Information [ECSI]# 84) and the PGM site was closed. Site gasworks structures were dismantled or demolished at various times between 1913 and 1960. Specific information on historical use of the five blocks comprising the upland PGM site follows.

Initial PGM operations are surmised to have involved the heating of coal in retorts. Volatile constituents of coal would be driven off as a gas, which was collected, cooled, and purified in creating a usable gas mixture. The solid portion of the coal would become a granular material called coke. Coke was a valuable fuel for many industrial uses and home heating and would likely have been sold. Coal sheds, a retort house, and a purifying house are all shown as being located on Block 5 (Attachment 4) in 1889. A coal shed is also shown on Block 6 during this time. There is no evidence of on-site gas storage at this time.

As was common in the late 1800s, PGM appears to have shifted to the carbureted water gas process, in which coke or coal were heated into a retort into which steam was injected. A chemical reaction took place which produced a flammable gas mixture; petroleum was then sprayed into the hot gas mixture, creating another chemical reaction in which petroleum constituents were “cracked” to create methane, which increased the energy value of the gas. Attachment 5 shows expanded MGP operations in 1908, shortly before closure in 1913. The addition of large gas holders, additional purifiers, and crude oil tanks indicates both an expansion of gas manufacturing activity and the switch to a carbureted water process. Primary waste products associated with Site operations would have included coal tar and purifier waste. Most coal tar was commonly collected for sale or reuse, while tar/water emulsions might be discharged to local surface water bodies. Purifier was commonly discarded or used as fill material. Carbon soot (lampblack) was generated during later manufacturing, and a lampblack shed is shown in the 1908 illustration. Prior to 1911, records indicate that lampblack was used as fuel for operations boilers. In approximately 1911 lampblack was used for the production of briquettes for sale. The PGM facility was apparently cited in 1906 by US Army District Engineer for discharging oil and tar to the Willamette River. A tar well is shown on Block 5 in a 1901 Sanborn map (not included in this ROD), located immediately east of the retort houses. It was common for MGP facilities to include such a structure, which would typically consist of a subsurface tank or other vessel (rather than a “well”) used to accumulate tar. The fate of the tar well is not known, but is likely to have been removed during construction of the Portland seawall.

3.1.2 Blocks 5 and 6. As noted above, MGP activities starting in 1860 were confined to Block 5. Features in the late 1800s, as shown on Attachment 4, included retort houses, coal sheds, and a purifying house. At Block 6, expansion of MGP activities is shown in Attachment 5, with the addition of a crude oil tank, purifiers, scrubbers, and a gas holder prior to 1908. Two small gas holders were subsequently added on Block 6.

Demolition of Block 5 and 6 structures began in 1918, but may not have been completed until after 1928. The City of Portland (City) constructed the Willamette River seawall between 1927 and 1929, which required demolition of riverbank structures and the placement of fill behind the seawall to raise the ground surface. According to historical documents and photographs, a portion of the plant collapsed into the river in 1928 during construction of the seawall.

In the 1940s, the City acquired much of the Site for redevelopment, and by 1950 the construction of existing roadways and bridge access ramps for the Steel Bridge was completed, reconfiguring Blocks 5 and 6 and adjoining (off-Site) Blocks 4 and 21. Waterfront Park was developed in the non-roadway
portions of Blocks 5 and 6 in the 1970s, and the roadways and access ramps were modified at that time. Usage of these two “core” blocks of MGP activity has not changed significantly since that time.

3.1.3 Block 7. The northern portion of Block 7 appears to have been a peripheral part of the gasworks, owned by the Portland Gas Light Company at the start of MGP operations, but not containing MGP structures/operations until the early 1900s. The Site Historical Summary Report (Hahn; June 11, 2009) shows an oil tank first present on the block in 1908, presumably containing oil feedstock carbureted water manufacturing operations. A 1926 Sanborn map shows the tank to have been removed. By 1936 the block was occupied by several commercial structures not related to MGP operations. In 1952, Broadway Cab Company acquired the block, with uses including automotive fueling and repair. Two 10,000-gallon and one 5,000-gallon petroleum underground storage tanks (USTs) were present during Broadway Cab operations (1952 to 1985); these tanks and a 375-gallon waste oil UST were decommissioned in place in the 1980s. In 1985, the property was purchased by the City and structures demolished. Environmental investigation by the City revealed petroleum impacts to soil and groundwater, including coal tar constituents discussed in Section 4 below. The existing Old Town Parking Garage was constructed on Block 7 in 1989. The property is listed in DEQ Cleanup files as Old Town Parking/Helistop Structure, ECSI# 383. A site alias is Broadway Cab, and the property remains active in DEQ’s Cleanup Program files. Discussion of site investigation work is presented below.

3.1.4 Block 15. Gasworks-related structures (a former coal storage building and freight house) were demolished by 1969, and the block paved for surface parking. A large commercial building was constructed in 2000, capping the entire block. An analysis of residual contamination on the block was completed starting in 2013 under DEQ’s Voluntary Cleanup Program, including analysis of soil and groundwater data. While significant (residual) contamination was noted, it was determined that contaminants including volatile- and semi-volatile organic compound (VOCs and SVOCs) were capped and/or immobile, and did not pose a residual risk to public health given the presence of the building and minor landscape cover. A conditional no further action (cNFA) determination was issued for Block 15 in 2015 by DEQ’s Northwest Region Cleanup Program. Ongoing cap inspection and maintenance are required.

3.1.5 Block 23. MGP structures were used as a Northwest Natural (NWN) fleet garage from 1917 through at least the 1930s. As noted above, the gas holder occupying most of the block was demolished in 1960, and in 1961 the existing commercial building was constructed by NWN for use as administrative offices. The building was sold in 1983 and is currently owned and occupied by the Oregon Department of Transportation.

3.2 Physical Setting

3.2.1 General. As noted above, the Site is located on the west bank of the Willamette River in downtown Portland. The upland area comprising the former gasworks area is physically separated from the river by a seawall that was constructed by the City of Portland between 1927 and 1929. Seawall construction consists of an open-lattice timber crib foundation, floated into place and backfilled with gravel and sand dredged from the river. A “facing deck” was constructed for the seawall consisting of 12” by 12” timbers stacked flush and with tight joints. The timber crib and facing are present from -30.8 feet COP (City of Portland datum) to +6 feet COP. For the section of the wall between NW Burnside and NW Glisan Street, wooden sheet piles, consisting of 20-foot long interlocking wooden planks, were embedded at the wall footing to approximately -44 feet COP. The final concrete “riser” portion of the seawall was constructed of concrete, rising to +32.5 feet COP. Following construction, the area behind the seawall was backfilled with dredge fill consisting of silt, sand, and gravel. A seawall schematic is presented as Attachment 6.

Blocks 5 and 6, where nearly all manufacturing occurred, are currently occupied by parkland and roadways, and zoned as open space (OSdr). Land is generally flat to gently sloped, and stormwater is
managed through a combination of infiltration (in grassy areas) and storm sewers. A small amount of runoff from the concrete walkways immediately adjacent to the seawall could discharge to the river by flow through openings in the seawall. Blocks 7, 15, and 23 are zoned for commercial use (Cxd) by the City and are largely occupied by buildings or paving. A minor amount of stormwater infiltration might occur in perimeter landscape strips on the blocks, but would otherwise run into street or interior catchbasins and discharge at City Outfall #9 to the south.

3.2.2 Geology/Hydrogeology. Geologic materials beneath the site, extending to the maximum depth of (recent) exploration at approximately 125 feet below ground surface (bgs), consist of alternating sequences of silt, sand, and gravel. In the seawall vicinity, mixed fill materials (gravelly sand, sand and silt) extend to approximately 70 feet below ground surface. Underlying the fill is native alluvium deposited by the (ancestral) Willamette River, which may include original or reworked sedimentary material associated with the Missoula floods (catastrophic flood deposits of late Pleistocene age).

Shallowest groundwater is present at approximately 25 to 30 feet below ground surface (bgs), occurring as an unconfined water table aquifer. Geologic materials enclosing this aquifer are a mixture of fine and coarser-grained material. No evidence of cementation was noted during exploration work. Near the river, the water table is present in dredged fill material, but it is more commonly present in native alluvium away from the river. For the purposes of Site investigation, groundwater monitoring and sampling was conducted in upper fill (25-35 feet bgs), intermediate fill (45-55 feet bgs), lower fill (65-75 feet bgs) and deep alluvium (115 to 125 feet bgs).

Groundwater flow, based on both manual and electronic water level measurements, is easterly (towards the Willamette River) as would be expected. While the deep alluvium is in hydraulic connection with the river, a transducer study completed at the site indicates that groundwater contaminant flux through the fill material is significantly attenuated by the solid wood facing of the seawall, and associated timber sheet piling at the base of the seawall, as indicated by dampened hydraulic response to tidal fluctuations in riverbank fill wells. Groundwater is “deflected” outward into the offshore riverbed. This is supported by seepage measurements collected in 2012 and 2014, with minimal seepage observed adjacent to the seawall. Positive flux has been measured outboard of the seawall area and appears to be related to both groundwater flux and sediment grain size. Geology/hydrology cross sections are presented and discussed later in the ROD.

3.2.3 In-Water Environment. Adjacent to the upland Site, river sediment composition and morphology are variable, comprised of finer-grained materials (silt- and sand-dominated) near the seawall, and transitioning to gravels outboard of the seawall. Approximately 200 feet riverward of the seawall, an area of debris is present, most notably offshore of Block 5 and roughly paralleling the seawall. Debris includes cement, metal, and brick, and appears to include remnants of the PGM buildings, presumably “side-cast” to its current location during construction of the seawall. Within the debris field, tar-like material has been observed at mudline.

The elevation of the riverbed adjacent to Block 5 varies, ranging from approximately -20 feet City of Portland datum (COP) near the seawall, to -40 feet COP approximately 300 feet to the east in the main body of the river. Debris is elevated above the local riverbed to approximately -25 feet COP. The depth of dredging that occurred along the seawall in 1989 is approximately -27 feet COP. Attachment 7 illustrates riverbed bathymetry in the Site area.

There is significant evidence of sediment deposition within the in-water portion of the PGM site, most notably adjacent to the seawall. This is perhaps best illustrated by comparing multibeam bathymetric surveys completed in 2004 and 2009 for the Portland Harbor Superfund Site. Differences in riverbed elevation are exhibited in Attachment 8, showing net deposition in nearly all of the PGM in-water area. Across the river near the east bank, a more erosional regime is seen. These measurements are consistent with what would be expected along a left-bending meander of a river, with net erosion along the outer
bank and deposition along the inner bank. Maintenance dredging that occurred along the seawall in 1989 supports evidence of ongoing deposition at the site, in particular adjacent to the seawall.

3.2.4 Proximity to Portland Harbor Superfund Site. In December 2000, the U.S. Environmental Protection Agency (EPA) identified the Portland Harbor area of the lower Willamette River as a Superfund site and placed it on the National Priorities List. A risk assessment and feasibility study were subsequently completed by the Lower Willamette Group under EPA authority. For the Portland Harbor Superfund site (PHSS), the initial study area was defined as extending from river mile (RM) 3.5 to RM 9.2. Ultimately, the area was expanded upstream and downstream over the course of the RI as additional site characterization data and upland source information were compiled and evaluated. The final study area for the RI was determined to be a 10-mile stretch of the lower Willamette River, located north of downtown and extending from the Broadway Bridge (RM 11.8) to Sauvie Island (RM 1.9). PGM is located a short distance (approximately 0.3 miles) upstream of the final PHSS study area. This includes both the upland site, and the extent of in-water contamination as defined in Site remedial investigation work. DEQ is overseeing both upland and in-water investigation and cleanup activities at sites outside the PHSS; EPA Region 10 staff overseeing PHSS work have been kept abreast of site activities, and will be engaged, along with federal and state partners, in conjunction with (in-water) permitting. During remedial design/remedial action planning, consideration will be given to implementing selected remedial actions (such as dredging) in such a manner as to prevent/minimize contaminant releases that might impact the PHSS. DEQ expects that the PGM remedy will be implemented well before the PHSS remedial action begins on an area-wide basis, eliminating the risk of downstream recontamination of the PHSS.

Information and data generated from within the so-called “Downtown Reach” of the Willamette River, including in the vicinity of PGM, have proven useful in completing the Site in-water remedial investigation. These include geophysical mapping of the river bottom near the Site, and collection of shallow sediment data for contaminant analysis. Where relevant, these previously collected data are discussed in subsequent sections of this document, along with more comprehensive data collected by NW Natural during the sediment investigation, upland source control investigation, and feasibility study.

SECTION 4 - SITE INVESTIGATION

Discussion of upland and in-water sediment investigation is presented below, and divided into Pre-2009 and Post-2009 categories. Pre-2009 sampling of upland soil and groundwater was completed by a number of different parties, and for differing reasons (both environmental and development-related). Post-2009 soil and groundwater investigation in the PGM vicinity was completed by NW Natural, with oversight from DEQ, and primarily focused on determining the nature and extent of groundwater contamination in the vicinity of the downtown seawall (the downgradient margin of the upland site).

Pre-2009 in-water investigations of the Downtown Reach were performed under DEQ and EPA oversight (GSI 2009; LWG 2011). Historical soil and groundwater data are presented in the 2009 Historical Summary Report, Revised Final (Hahn and Associates, 2009). Sample locations are shown in Attachment 9 and field observations from upland borings presented in Attachment 10. Data are summarized below. Both Pre- and Post-2009 sediment data are presented in the Integrated Sediment Investigation/Source Control Evaluation Report (Anchor, 2013b).

4.1 Pre-2009 Investigation

Site assessment work completed by EPA and DEQ during this time period included the following:
Preliminary Assessment, Portland Gas Manufacturing Site (Ecology & Environment, Inc.; May 1987). This preliminary assessment (PA) was completed by a contractor for EPA Region 10. According to the report, the Site consisted of four city blocks (5, 6, 15, and 23). Sampling was not performed. EPA’s contractor concluded the MGP wastes had been historically disposed on-site or in the river, and would likely have stabilized or degraded given their age. No CERCLA-level threat to human health or the environment was identified, and a No Further Remedial Action Planned (NFRAP) determination made for the subject blocks. The PA recommended that further excavation or construction activities in the area be monitored for MGP waste.

DEQ Site Assessment Program Strategy Recommendation (DEQ; 1992 and 2000). Site Assessment Program staff evaluated all blocks comprising the former MGP operations in 1992 and assigned a low priority for further action, in part based on information presented in EPA’s 1987 PA. DEQ re-evaluated the risk associated with Site contamination in 2000, and designated the Site a high priority for further action based on a number of factors including the likelihood of contaminant releases to the adjacent Willamette River and the presence of threatened/endangered salmonid species within the river reach.

Sampling was performed by consultants including Century West, GRI, Hart Crowser, and Hahn and Associates in the 1986 through 2003 time period. Within the 5-block PGM “footprint,” focused investigation work was completed on Blocks 7 and 15. Sampling was also performed in the NW Front Avenue (now Naito) right-of-way to support construction of the West Side CSO.

On Block 7, two 10,000-gallon gasoline USTs and one 5,000-gallon UST were decommissioned (in-place) in 1983. A 375-gallon waste oil UST was decommissioned in 1986. All were associated with long-term use of the site by Broadway Cab (1952 to 1985), including car repair and fueling activities. Block 7 investigation of soil and groundwater was completed by environmental consultant GRI in 1987, and subsequently by RETEC in 1994. Impacted soil and groundwater were detected, apparently related to both fuel releases and the presence of MGP waste. As part of block development, 7,800 cubic yards of contaminated soil were removed, while deeper contamination was left in place. A vapor barrier and active soil vapor collection system were installed sub-slab, during development of the parking garage that now occupies the site. To date, DEQ Cleanup has not issued a No Further Action (NFA) determination for Block 7, but it was determined to be a lower priority for further action.

On Block 15, Phase I and II Environmental site Assessments (ESAs) were conducted by Hahn and Associates, Inc. for NWN. The Phase II ESA included the advancement of 7 borings to between 20 and 40’ bgs, with soil samples collected for analysis. In 1997, Hart Crowser completed additional investigation, including advancing 10 borings to 32 feet bgs. Soil and groundwater samples were collected. Coal fragments, woody debris, and petroleum impacts were noted in a number of soil samples.

No pre-2009 investigation data have been found for Block 23, while data for Blocks 5 and 6 are very limited for this time period. A number of soil and groundwater investigation locations are present in the right-of-way downgradient (east) of Blocks 6 and 23, as shown in Attachment 9. JG- and PB-series borings were completed in 2001/2002 in support of the West Side CSO construction. Samples were analyzed for a wide range of contaminants including those present in MGP waste. Elevated PAHs were detected in subsurface soil, notably at the JG-B2 and JG-B4 locations situated between Blocks 6 and 5.

Pre-2009 riverbank-area data are represented by locations BH-3 to BH-6, located on Blocks 4, 5, and 21. Sample results are for a 1989 EMCON investigation. Sample analytes appear to have been limited to TPH and BTEX, none of which were detected.

As part of the PHSS investigation, a number of shallow sediment samples were collected in 2007 adjacent PGM operational areas. These include the following locations/samples: G780, C781, C782, G783, UG07, and UG08. Sampling locations and notable in-water features are shown in Attachment 11. Analysis included selected MGP contaminants (metals and PAHs) as investigation was not focused on the PGM...
site. PAHs were notably elevated at the G783 location (0-26 cm). Data from this investigation effort have been considered within the broader context of the more comprehensive post-2009 in-water data set.

A multibeam bathymetry survey was conducted by David Evans and Associates for the Lower Willamette Group investigation of the PHSS; bathymetry from this work is presented in figures illustrating contaminant conditions in the latter portions of this staff report. The most notable bathymetric features within the in-water portion of the Site are a series of debris piles located approximately 150 to 250 feet offshore from the seawall. These are believed to be remnants of construction debris from seawall construction, perhaps material that had sloughed into the seawall trench and was excavated and sidecast offshore. A diagonal trench cuts through the debris piles, offshore of Block 4, apparently associated with installation of a City sanitary force main in the 1950s.

4.2. Post-2009 Investigation

Under DEQ’s Northwest Region Cleanup Program, multiple phases of upland and in-water investigation were completed for the PGM site, focused on determining: a) the nature and extent of in-water MGP contamination; b) potential impacts to upland groundwater that might discharge to the Willamette River near the Site; and c) past and current potential for MGP contaminant releases via (preferential) migration through stormwater conveyances. Documents presenting investigation results include the following:

- *Depth-Discrete Groundwater Sampling Results, Phase 2 Upland Source Control Investigation*. Anchor QEA; January 2011.

Results of iterative Site investigation work completed between 2009 and 2014 are compiled and summarized in the 2013 and 2014 documents cited above.

In total they present: a) the results of four rounds of river sediment and source control investigation and testing; b) the results of quarterly groundwater monitoring and testing in the PGM uplands; c) an evaluation of the potential risks posed by contaminated sediment and porewater in the river to aquatic life, wildlife, and humans; d) an assessment of upland sources and whether they may be impacting the beneficial uses of the river; and e) recommendations as to whether sediment remediation and upland source control actions are necessary.

Data presented in the reports include the following:

- Sediment quality data from four rounds of investigation completed for NW Natural in 2009, 2011, 2012, and 2014, along with previously-existing data from investigations by the Lower Willamette Group, City of Portland, DEQ, and others. Cores were collected at 27 locations and typically advanced to 20 feet below mudline with continuous sampling.
• Upland source investigation results, including quarterly monitoring results from 24 groundwater wells located in nine well clusters. Groundwater samples were collected at various depths from the water table (~25 feet below ground surface [bgs]) to a maximum of 125 feet bgs.
• Results from porewater and near-bottom surface water analyses, riverbed seepage measurements, a tidal hydraulics study, geophysical surveys, and diver riverbed and debris observations.
• An assessment of stormwater lines beneath and adjacent to the PGM upland contamination area, and the potential for groundwater contaminants to infiltrate stormwater lines and discharge to the Willamette River.

Upland and in-water investigation included known or suspected MGP contaminants including VOCs, SVOCs (including polynuclear aromatic hydrocarbons [PAHs]), total petroleum hydrocarbons (TPH), metals, and cyanide.

Investigation locations are shown in Attachment 11, and results discussed below.

SECTION 5 - NATURE AND EXTENT OF CONTAMINATION

PGM-related contamination is present in upland soil and groundwater, Willamette River sediment, and sediment porewater (limited). The nature and extent of contamination in each of these media are summarized below. The Locality of the Facility (LOF) is defined as the five-block upland area where PGM activities historically occurred, and the adjoining portion of the Willamette River where MGP indicator contaminants have been observed and are or suspected to be associated with site releases.

As noted above, the selected remedy does not address risk to upland human or ecological receptors. For the purposes of this remedial action, the primary concern for the upland portion of the Site, therefore, is whether soil contamination poses a potential leaching concern to shallow groundwater. Excluding Block 7, shallow groundwater does not show significant contaminant impacts, indicating that the leaching of MGP-related chemicals to groundwater is generally not of concern.

5.1 Upland Soil. Soil data from historical environmental sampling at PGM, and on adjoining blocks, are presented in selected tables and figures of the 2009 Historical Summary Report completed by Hahn and Associates for NWN. Sampling locations are presented (in red) on Attachment 9. As shown in this attachment, most investigation was completed on PGM Blocks 7 and 15, the former associated with investigation of the Broadway Cab/Old Town Parking Garage under DEQ. Boring summaries and field screening results are presented in Attachment 10. Debris including coal, brick, and concrete were observed in subsurface soil on both Site and non-Site properties, likely associated with both imported fill and MGP sources.

Contaminants including petroleum hydrocarbons (as gas, diesel, or heavy oil), PAHs, SVOCs, and metals were observed in soil samples from a number of upland borings. Notable detections include the following:

• In the right-of-way between Block 5 and Block 6, PAHs including benzo(a)pyrene (BaP) and naphthalene were significantly elevated (in the part per million [ppm] range) from 8 to 15 feet bgs in selected borings.
• On Block 7, PAHs were modestly elevated (below 1 ppm) in some borings, generally below 8 feet bgs. Arsenic was elevated above background (in the range of 13 to 30 mg/kg [ppm]) in most samples.

• Block 15 soil samples below 8 feet bgs contained elevated PAHs including BaP and naphthalene.

Observation and field screening results from upland properties are summarized as follows:

• There was little evidence of MGP-related contamination on Blocks 15, 16, 21, and 24. A few pieces of coal and tar were found along with debris including brick, glass, and wood. Isolated petroleum odors were noted. None of the observations suggest a significant unsaturated zone source that might pose a risk to the river.

• Block 5/Block 6 Area: no sheens, oil, tar, or cyanide staining (“Prussian blue”) were found. Coal or black granular material, along with wood debris, were observed in the subsurface, and “coal tar” odors noted in the 6 to 17’ bgs range. DEQ reviewed both boring logs and monitoring well results from the MW-3 and -4 well clusters, located near the eastern end of Block 5 and downgradient of the pre-2009 borings. Potential MGP impacts were confined to light to moderate petroleum odors. Only low levels of COCs were detected in shallow monitoring wells MW-3-35 and MW-4-37, indicating that a significant unsaturated zone source is not present in Blocks 5 or 6 that might impact the river. The unsaturated zone is largely composed of dredged material used for backfill behind the seawall.

• Block 7: the most significant field observations of chemical/petroleum contamination in the PGM upland were found at Block 7, and extended from ground surface to 60 feet bgs at some locations. None of the odors were identified as being “coal tar” in nature, and most of the contamination appears to be associated with known UST releases. DEQ reviewed both boring logs and monitoring well results from the MW-1 and -2 well clusters, located near the eastern end of Block 7 and downgradient of the pre-2009 borings. Potential MGP impacts were confined to light to moderate petroleum odors. Only low levels of COCs were detected in shallow monitoring wells MW-1-35 and MW-2-36, indicating that a significant unsaturated zone source is not present in Block 7 that might impact the river.

5.2 Upland Groundwater

There are two “categories” of groundwater data for the PGM upland area: data from various pre-2009 investigations, and the results of comprehensive shoreline-area investigation completed for NW Natural from 2009 through 2012 under DEQ oversight. The results of groundwater work are summarized below.

Pre-2009 Investigation. Limited sampling of shallow groundwater was completed prior to 2009; boring and well locations are shown in Attachment 9. Focused investigation was limited to Blocks 7 and 15, to support property redevelopment. With the exception of BH-3 through -6, sampling locations are at least 200 feet west (upgradient) of the riverbank and of limited value in assessing potential contaminant concentrations at the groundwater-surface water interface. More relevant data are presented in the post-2009 discussion. Pre-2009 data are summarized as follows:

• VOCs, PAHs, and TPH were detected in shallow groundwater on Block 7 in investigations completed in 1987 and 1994. Notable contaminants were benzene and naphthalene, detected to 18,000 and 9,900 ug/L respectively. 1,2-dichloroethane (maximum 270 ug/L) and 1,1,2-trichloroethane (1,900 mg/L) were also detected. Potential sources of contamination on Block 7
include releases from former gasoline and waste oil underground storage tanks (USTs), MGP and other historical industrial operations in the area, and possibly contaminated fill material. Arsenic was detected to a maximum of 270 ug/L

- Naphthalene (0.39 ug/L), cyanide (3,000 ug/L), and arsenic (5.3 ug/L) were observed in shallow groundwater within the right-of-way between Blocks 5 and 6.

- Modestly elevated concentrations of PAHs and metals were observed on Block 15.

NW Natural Investigation, 2009-2012. At the request of DEQ, comprehensive investigation of shallow and deeper groundwater was completed to evaluate the potential for groundwater contaminants to discharge to the Willamette River. Work included installation of 24 monitoring wells at depths ranging from 25 to 125 feet bgs. Twenty of the wells are present in 7 well clusters bordering the Willamette River seawall, positioned as far downgradient (i.e. close to the shoreline) of the upland Site as feasible (without being in the river). Two additional well clusters (of two wells each) are located on the downgradient portion of Block 6, and on Block 21 downgradient of Block 23 MGP features. The layout of wells relative to historical MGP operations and current development is shown in Attachment 12.

Wells were constructed to monitor, at a minimum, shallowest groundwater at approximately 25 to 35 feet bgs, and intermediate groundwater at 45 to 55 feet bgs. Deeper wells were constructed on and adjacent to Block 5 based on the detection of a contaminant “horizon” at 65 to 75 feet bgs in the Block 5 area. At the MW-3 and MW-4 locations on Block 5, wells were constructed to 125 feet bgs to sample deep native alluvium and confirm the vertical extent of contamination in the Block 5 source area. Groundwater samples were analyzed for MGP indicator contaminants including VOCs, PAHs, TPH, metals, and cyanide.

Attachment 12 and 13 illustrate analytical results for naphthalene and benzene from five groundwater sampling events in the 2009 to 2012 time period. A complete presentation of groundwater contaminant concentrations from newer shoreline area wells can be found in Attachment 14. Note that sampling events captured a full calendar year to reflect seasonal variability and potential Willamette River influence. Benzene and naphthalene data were illustrated in report figures submitted to DEQ based on their: a) being MGP “indicator” compounds, b) notable presence/concentration in groundwater media, c) mobility in the aquatic environment, and d) toxicity.

A summary of groundwater results for notable groundwater contaminants follows:

- Upper Fill wells (25-35 feet bgs). Benzene and naphthalene, and MGP contaminants in general, were not detected or present at very low concentrations in shallow groundwater samples. Benzene was detected at a single location (Block 5, MW-3-35) at a concentration of 0.28 ug/L. Naphthalene was detected to a maximum of 2.41 ug/L. TPH was generally not detected (maximum of 0.13 mg/L in the MGP area), while free cyanide was detected in well MW-3-35 on Block 5 to 0.34 mg/L.

- Intermediate Fill wells (45-55 feet bgs). Contaminants were very low or not detected outside of historical MGP activity areas. Within or downgradient of MGP operational areas, benzene and naphthalene were modestly elevated, with maximum detections of 24 and 27 ug/L, respectively. TPH was detected to 3.84, and cyanide to 0.69 mg/L. The highest detections were on Block 5 (MW-4) and the northernmost portion of Block 4 to the immediate south.
• Lower Fill wells (65-75 feet bgs). Contaminants were very low or not detected outside of historical MGP activity areas. On Block 5, COCs were notably elevated at this depth, with benzene and naphthalene detected to maximum concentrations of 2,020 ug/L and 3,320 ug/L, respectively, during the January 2012 sampling event. TPH was detected to 25.4 mg/L, and cyanide to 0.45 mg/L. Indicator contaminants were modestly elevated in northernmost Block 4 and the southern portion of Block 21, both adjoining Block 5, the locus of PGM manufacturing operations.

• Deep Alluvium wells (115 to 125 feet bgs). Deep wells were installed on Block 5 at the MW-3 and MW-4 locations to determine the vertical extent of contamination beneath the main PGM manufacturing area. At MW-3-125, TPH and cyanide were not detected during any of the sampling events. Naphthalene was detected at 1.54 ug/L during the last sampling, while benzene was not detected in latter sampling events. At MW-4-125, only naphthalene was detected, with the most recent detection less than 1 ug/L. Data indicate that concentrations in the deep alluvium wells are below levels of concern; therefore, the vertical extent of contamination has been identified.

Where MGP-related contaminants have been detected in groundwater, a variety of PAHs were observed including acenaphthene, benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, chrysene, Indeno(1,2,3-c,d)pyrene, phenanthrene, and dibenzofuran. Metals, notably zinc, are elevated in some groundwater samples and appear to be Site-related, although other historical sources of metals were also present on nearby properties.

COCs present in upland unsaturated soil are either not present, or present at low concentrations in shallow (water table) wells adjacent to the river. These data confirm that a significant source is not present in upland unsaturated soil that might impact the river. Groundwater impacts in the lower fill material, notably in the 65-75 feet bgs range near the seawall, do not appear to be related to leaching from unsaturated soil. For this reason, leaching-to-groundwater will not be addressed in the Section 6.0 risk screening discussion. The presence of MGP contaminants in groundwater in the lower fill material, however, necessitates evaluation of the groundwater-to-surface water migration pathway.

The presence of contamination in groundwater in lower fill material, and corresponding absence in shallow and intermediate fill, appears to be attributable to shallow riverbank area wells being installed in (relatively clean) dredge fill that was placed in association with construction of the Portland seawall in 1927-1929.

5.3 Willamette River Sediment

Four rounds of sediment investigation have been completed under DEQ oversight from 2009 through 2014. Barge-mounted (and diver assisted) coring equipment were used to collect sediment samples starting at mudline and typically extending to approximately 20 feet (450 cm) below mudline (bml). The purpose of the sampling was to define the vertical and horizontal extent of MGP impacts within river sediment. Investigation events are as follows: PGM-01 to -12 (2009); PGM-03b, -05b, -06b, 07b, 08b, -11b, and PGM-13 to -17 (2011); PGM-18 to -23 (2012); and PGM-24 to -29 (2014). A subset of the cores, including those with a “b” designation, reflect follow-up efforts where sediment recovery was insufficient during the first attempt. Sediment samples were collected from recovered core material and sampled on 60 cm intervals excluding surface sediment, which was sampled from 0 to 30 cm below mudline. Samples were analyzed for physical parameters (grain size and organic carbon) and a comprehensive suite of MGP-related constituents including petroleum, VOCs, SVOCs, metals, and cyanide. In addition, samples were inspected for evidence of sheen, oil droplets, tar-like material, or any
other unusual characteristics including color, odor, organic (woody) material, and the presence of anthropogenic debris.

Sampling results, including field evidence of sheen, oily, or tar-like material, are presented in Attachments 15a through 15e. These attachments illustrate analytical (“bulk chemistry”) results and field observation, presented by core location and sample depth. Separate illustrations are presented for: a) total PAHs; b) naphthalene; c) total BTEX; d) total cyanide; and d) total TPH; and e) TPH-diesel. Discussion of in-water data, including sediment results from earlier non-PGM investigations, is presented below.

Sampling results from NW Natural’s in-water sediment investigation indicate the following:

- MGP indicator contaminants are present at elevated concentrations in river sediment, being present from as shallow as the sediment surface to approximately 14 feet bml in some areas. At most sampling locations, the highest contaminant concentrations are in the subsurface, consistent with the presumed age of the releases (including PGM operations prior to 1913, and subsequent disturbance during seawall construction in the late 1920s) and evidence of natural recovery in the area (discussed later).

- The most significant contamination is off-shore of Block 5, extending over 250 feet from the seawall towards the river channel. Sediment contamination is present upstream of Block 5 (adjacent to Block 4) and more notably downstream. Both upstream and downstream of Block 5, contamination is largely present adjacent to (within ~125 feet) of the seawall.

- PAHs (total and individually) are most elevated, with total PAHs approaching or exceeding 1,000,000 ug/kg at a few locations. Total BTEX is likewise elevated, with a maximum detection of 154,100 ug/kg. TPH concentrations generally spatially correlate with PAHs. Cyanide is occasionally elevated with PAHs, to a maximum concentration of 41 mg/kg observed. Metals, notably zinc, are elevated in a few samples.

- Sheen, separate-phase oil, and tar-like material were observed in a number of samples as illustrated in the attachments. These observations of what appears to be MGP waste were, in almost all cases, off-shore of Block 5 and associated with high concentrations of PAHs, BTEX, and petroleum.

- A surface layer of weathered and hardened tar-like material was identified at mudline at the PGM-15 location. Tar-like material was also observed during diver survey work to the southeast, in an area of surficial debris. The estimated thickness of the material is approximately 1 foot or less. The location of the observed tar layer and nearby debris field is shown in Attachment 16.

- A debris field is present at (and elevated topographically above) mudline approximately 150 to 250 feet offshore of Block 5. Diver photographs indicate that some of the debris is from the PGM physical plant formerly located on Block 5. This material may have been “side-cast” to its current location (relocated from shoreline) during construction of the City seawall.

- One relatively isolated area of subsurface contamination is located well downstream of the site, at PGM-11B. Contamination is present from 1 to 5 feet bml, with maximum PAH concentrations observed at 3 to 5 feet bml.

In addition to sediment sampling, other sources of information were used by NW Natural in identifying the nature and extent of in-water contamination and sediment physical conditions that inform the nature
and extent determination. These include the development of new (side-scan sonar and sub-bottom
reflection profiling) and use of pre-existing (multi-beam bathymetry) geophysical survey data, diver
observation of the sediment surface, and seepage meter deployment and data collection.

Cross-sectional diagrams illustrating upland groundwater and in-water sediment (total PAHs) data
developed from investigation work are presented as Attachment 17. Cross sections are oriented both
parallel and transverse to the seawall, the latter extending through the most contaminated portions of the
upland (Block 5) and in-water areas, including the offshore surface tar material. Cross section locations
are shown in Attachment 11.

5.4 Willamette River Transition Zone and Surface Water

Two rounds of paired transition zone water (TZW) and surface water (SW) analyses were completed
during critical discharge conditions for upland groundwater, in September 2012 and June/July 2014.
Eight locations were sampled during each event. Samples were collected using “Trident” probes
(developed by Coastal Monitoring Associates of San Diego) inserted to approximately 1 foot below
mudline. Tubing was also fixed to allow for collection of a water sample at approximately 1 foot above
mudline at each location. As noted above, seepage measurements were also collected using “UltraSeep”
meters (also developed by Coastal Monitoring Associates), deployed over an approximately 48-hour
period to include several complete tidal cycles. Seepage rates are illustrated in Attachment 18.

Porewater and surface water samples were analyzed for a wide range of MGP-related constituents.
Excepting the TZW-06 location (near the surficial tar deposit on the debris field), PAHs and BTEX were
either not detected or below screening levels. Free cyanide was detected at two TZW locations slightly
exceeding screening levels, both adjacent to the seawall. Sampling results for naphthalene, BaP, BTEX,
and free cyanide are illustrated in Attachment 19a through 19d). Based on these data, seepage of
contaminants into the river through TZW/pore water is considered to be of limited concern but is
nevertheless addressed as part of the remedy selection process. Maximum exceedance ratios for TZW
and surface water at each sampling location are presented in Attachments 20 and 21. The basis for risk
screening values used in the Site FS are discussed in the following section.

SECTION 6 - RISK SCREENING

6.1 Locality of the Facility

The upland LOF includes the five-block area historically occupied by MGP operations (Blocks 5, 6, 7,
15, and 23). For the purposes of remedy selection, the upland LOF has been expanded to include the
southern portion of Block 21 and the northern portion of Block 4 where groundwater impacts have also
been observed in the lower fill material.

Initial identification of the in-water LOF was based on sediment detections: a) exceeding Threshold
Effect Concentrations (TECs; MacDonald 2000); and b) appearing to be attributable to Site releases rather
than representing ambient contaminant levels in the river. Screening values for transition zone water
(TZW, aka porewater) and surface water were also considered. TECs were ultimately not determined to
be adequate in defining Site- versus non Site-related in-water contamination. The final in-water LOF was
largely defined as the area of surface or subsurface sediment concentrations exceeding MacDonald et al.
(2000) Probable Effect Concentrations (PECs) in consideration with ambient contaminant levels in the
river (i.e., upstream inputs that are not site related).
6.2 Beneficial Land and Water Use Determination

Current land uses in the upland area are open space (park with some roadway coverage) and commercial. Use is not expected to change. The identified area of in-water contamination supports a variety of human and ecological uses, including recreation, subsistence fishing, and habitat for a variety of benthic and non-benthic fauna. Threatened, endangered, and candidate species that may be present within the in-water LOF include Chinook, chum, Coho, and sockeye salmon.

There is no use of groundwater for drinking or (human) uses within the upland locality as defined for either soil or groundwater. Groundwater is, however, acknowledged to provide a benefit, in terms of the contribution of water, to the adjacent Willamette River.

6.3 Development of Risk Screening Levels

In conjunction with DEQ, risk screening levels were developed using published regulatory criteria and guidelines to identify Site contaminants of concern (COC), to delineate the nature and extent of contamination and the LOF, and to develop preliminary remediation goals (PRGs) for the evaluation and selection of remedial alternatives. Presentation of primary and secondary screening values follows; secondary screening levels were used to develop PRGs only for those COCs lacking primary screening values.

For sediment, the primary screening levels are:

- MacDonald et al. PECs.
- DEQ Bioaccumulative Screening Level Values (SLVs; DEQ 2007).

Ambient/background levels of contamination in the river were also considered from a qualitative standpoint. Secondary screening values were identified as Sediment Quality Values (SQVs; Avocet 2011), which were later promulgated as State of Washington Sediment Cleanup Objectives (WAC 173-204-563).

For TZW and surface water, the following primary and secondary screening values were approved:

- Primary – DEQ Water Quality Criteria; EPA Water Quality Criteria; and EPA Final Chronic and Acute Values for PAHs (EPA 2003).
- Secondary – DEQ Level 2 SLVs (DEQ 2001) and Oakridge National Laboratory Tier 2 Chronic Values (ORNL 1996).

Screening levels for upland groundwater are based on the potential for contaminated groundwater to discharge to the Willamette River, and impact receptors exposed to either porewater or river water. The receptors are the same as those that would be impacted by the sediment contaminants. Groundwater screening in the 2013 Integrated Sediment Investigation/Source Control Evaluation Report thus relies on the same sources of screening values discussed above. COCs at the PGM Site were determined through risk screening of analytical results from 33 sediment core or boring locations, and two rounds of TZW or surface water sampling at eight locations. COCs were determined to be:

- Polynuclear aromatic hydrocarbons (individual and total)
- Free cyanide
- Benzene, toluene, ethylbenzene, and xylene (BTEX)
- Total petroleum hydrocarbons
- Selected metals (lead, mercury, and zinc)
Human and ecological receptors determined to be potentially impacted by Site contaminants in groundwater and in-water media include the following:

- Benthic organisms – direct contact and ingestion for sediment and TZW
- Fish and wildlife – direct contact and ingestion of surface water, and bioaccumulation from exposure to sediment
- Humans – bioaccumulation through fish ingestion (via contaminated sediment and surface water), dermal contact and incidental ingestion of surface water

A risk pathway summary identifying receptors, contaminated media, exposure pathways, and chemicals of concern is included in the Site FS. Note that groundwater for drinking purposes was not identified as a viable exposure pathway.

6.4 Risk Analysis

Results of source control and in-water risk screening are discussed below, by contaminated medium, based on comparisons to PRGs and hot spot criteria presented in Attachment 22. Risk screening results are presented in the Integrated Sediment Investigation/Source Control Evaluation Report (Anchor QEA 2013), the Supplement to the Integrated Sediment Investigation/Source Control Evaluation Report (Anchor QEA 2014a), and the Feasibility Study Data Report (Anchor QEA 2014b).

6.4.1 Soil. Soil contamination associated with the PGM site, to the extent present in the uplands area, is isolated from the Willamette River by the downtown seawall and surface development. At present, upland soil within the former MGP operations area is covered by a combination of buildings, roadways, parking lots and other hardscaping, and developed parkland. There is no significant potential for soil contaminants to migrate to the river. The risk to upland receptors (building occupants and park users) has not been formally evaluated outside of Block 15, where a block-specific NFA was issued by DEQ.

6.4.2 Groundwater. Contaminated groundwater is present in the PGM uplands, adjacent to the Willamette River, exceeding risk-based screening values. Analytical results and risk screening are presented in Table 6-3 of the August 2013 Source Control Evaluation Report (Anchor 2013b). PRGs are the same as those for TZW and SW, because the primary pathway of concern is discharge of groundwater to TZW and SW.

The risk posed by COCs in groundwater was addressed in the Site Source Control Evaluation by comparing detections in downgradient shoreline wells to TZW cleanup levels. As shown in Attachment 14, groundwater data tables, significant exceedances were confined to intermediate-depth groundwater (i.e. at the base of the fill material, at 65-75 ft. bgs) at and immediately adjacent to Block 5.

While screening exceedances were noted, the 2013 report concluded that on a weight-of-evidence basis, contaminated groundwater in the uplands did not appear to be causing significant adverse impacts to sediment or river quality. Lines of evidence supporting this conclusion included the effects of the seawall on contaminant migration, seepage data, and the limited detection of MGP-related contaminants in TZW. However, due to considerably elevated concentrations of MGP constituents detected in the approximately 64-75’ foot bgs depth range, DEQ determined that contaminated groundwater needed to be “carried forward” into the FS.

6.4.3 Willamette River Sediment. Surface and subsurface sediment contain MGP contaminants exceeding screening values adjacent to and downstream of the former PGM operational areas, as shown in Attachment 23. In the figures and for risk screening, surface sediment has been defined as approximately 0 to 30 cm below mudline (approximately 1 foot); subsurface sediment data extend from 30 cm to a maximum of 600 cm below mudline (~20 feet). As noted in the figures, contamination is present within river sediment adjacent to Blocks 4, 5, and 21, extending a linear distance of approximately 750 feet.
adjacent and parallel to the seawall. Offshore of Block 5, screening levels are exceeded extending approximately 275 feet into the river, but remain well outside of the Willamette River navigational channel.

The “exceedance” footprint is significantly larger for subsurface sediment, which is largely attributable to the age of the releases (MGP operations prior to 1913, subsequently disturbed by seawall construction in the late 1920s) and ongoing natural recovery. Excluding the surface product layer on the offshore debris area, the highest concentrations of contaminants are present well below mudline. For example, at core locations PGM-05 and -06 adjacent to the seawall, the highest concentration of total PAHs (in excess of 1,000,000 ug/kg) are 3 or more feet below mudline. Offshore a bit at PGM-18, a maximum concentration of 281,000 ug/kg is present at 7 to 9 feet bml. At offshore location PGM-16, near the surface product layer (tar deposit) and within the debris field, the highest total PAH detections are 3 to 7 feet bml (>500,000 ug/kg).

6.4.4 Willamette River Transition Zone and Surface Water. TZW data from 2012 and 2014 were analyzed for PAHs, BTEX, and cyanide, and screened against PRGs approved by DEQ. Results are as follows:

- There were no exceedances of PRGs for BTEX. Detections were generally less than 1 ug/L, with maximum detections in the low ug/L range. The highest detections were near the surface tar feature.
- There were single low-level exceedances (presented as an “exceedance quotient” or EQ) of PRGs (EQ=1.2) for free cyanide in unfiltered samples from both the 2012 and 2014 events (TZW-02 and -03, respectively). No cyanide was detected in filtered samples from either event.
- There were PAH exceedances in both sampling events, notably at TZW-06 near the surface product layer. Exceedances were highest in the 2012 event (maximum EQ=3.9), including naphthalene (280 ug/L), phenanthrene (33 ug/L), fluorantheme (8.8 ug/L), and benzo(a)pyrene (1.4 ug/L).

Near-bottom surface water data were collected concurrent with TZW samples at approximately 1 foot above mudline and co-located on the same probe. No exceedances of human health or ecological PRGs were observed.

6.4.5 Potential Stormwater Migration. Source control work included an analysis of the potential for subsurface utilities to act as conduits for preferential migration of site contaminants to the Willamette River. Stormwater conveyances within the upland LOF are shown in Attachment 24, and include storm, sanitary, and combined sewer mains. The blocks comprising the upland Site have been capped with a combination of landscape and hardscape under recent development; therefore, migration of shallow soil contamination via erosion into catchbasins is not a concern. The infiltration of contaminated groundwater into storm sewers, and subsequent discharge to river, is a potentially complete pathway and was evaluated in the 2013 Source Control Evaluation Report (Anchor, 2013b) approved by DEQ. Investigation determined that all sewer lines in blocks adjoining the seawall are well above the water table during all times of the year. A storm line west of NW Naito Avenue may be seasonally inundated; significant groundwater contamination has not been observed in the vicinity of the sewer excepting in the Block 7 area. Based on an absence of risk, this pathway was not carried forward into the FS.

6.4.6 Hot Spots. Consistent with State of Oregon rule and statute, an evaluation of potential contamination hot spots was part of risk screening. Hot spot criteria (screening values) for sediment and TZW based on the “highly concentrated” criterion are presented in Attachment 22. Hot spot screening focused on: a) the presence MGP waste in the form of tar; and b) total PAH concentrations exceeding the designated PRG (22,800 ug/kg) by a factor of 10x or more (>228,000 ug/kg). An analysis of potential
groundwater hot spots based on the groundwater-to-surface water pathway, and using TZW hot spot criteria for screening, was completed by DEQ and is presented below.

- None of the TZW or surface water detections exceeded hot spot criteria.
- A hot spot is present at the surface of the site in the form of a surface product layer and adjacent sediment in the off-shore debris area. The surface product layer is estimated to be approximately 8,000 square feet (0.18 acre) in size. Assuming an estimated depth of one foot, the total volume of material would be approximately 300 cubic yards.
- PAHs exceed hot spot concentration criteria at a number of subsurface sediment locations offshore of Block 5. Total PAH concentrations exceeding 228,000 ug/kg (228 mg/kg) are present offshore of Block 5 approximately 200 feet into the debris/product area. Perpendicular to shoreline, potential buried sediment hot spots are present for a length of approximately 250 feet, centered off of Block 5. As with contaminant trends in general, sediments exceeding hot spot concentration criteria are largely confined to the subsurface (excluding the surface product layer, described above). For example, the highest PAHs detections along the seawall are generally buried 3 to 13 feet below mudline. At the PGM-05 location, a maximum nearshore total PAH concentration of 4,581,000 ug/kg at 5 to 7 feet bml, exceeds the hot spot criterion by a factor of 20.
- In upland groundwater, naphthalene exceeds the TZW hot spot criterion (1,940 ug/L) at a single location and depth – MW-3 at 65 to 75 feet bgs. The well is located on Block 5 and this sampling interval represents the highest concentrations of MGP contaminants detected in the upland.
- Subsurface sediments exceeding hot spot concentration criteria were carried forward in the FS and evaluated for their potential to impact human or ecological river receptors via groundwater migration; erosion by floods, waves, and propwash; and future dredging activities.

SECTION 7 – FEASIBILITY STUDY

7.1 Feasibility Study Structure

A Feasibility Study (FS) was completed by Anchor QEA on the behalf of NW Natural in the 2015/2016 timeframe, encompassing both draft submittals and a final FS (Integrated Feasibility Study, former Portland Gas Manufacturing Site [Anchor, August 2016] approved by DEQ). The FS identifies the nature and extent of Site contamination exceeding PRGs for human and ecological receptors, and addresses both upland (groundwater) and in-water contamination associated with the Site. The FS outlines remedial action objectives, includes a preliminary screening of remedial alternatives, selection of remedial options for detailed analysis, and final selection and analysis of a proposed remedial approach to address site risk.

Appendices to the FS include a Natural Recovery Analysis (Appendix A), Cap Modeling Analysis (Appendix B), Cap Erosion Protection Evaluation (Appendix C), and Preliminary Habitat Impact Evaluation (Appendix D). These were developed to support FS decision-making including: the type and thickness of amended and non-amended capping elements necessary to isolate sediment (and porewater) contamination; the stability of capping elements and size of armoring necessary to be resistant to flooding and vessel disturbance; the extent to which sedimentation and natural recovery might occur (short- and longer-term) in the remediation area, and the extent to which aquatic habitat quality might be affected by the implementation of the remedy.
The evaluation of remedial action alternatives is founded on the following three criteria memorialized in Environmental Cleanup statues and rules:

- The protectiveness of the alternative based on the standards of OAR 340-122-0040;
- The feasibility of the alternative based on the balancing factors set forth in OAR 340-122-0090(3);
- Treatment or removal of hot spots of contamination to the extent feasible based on the criteria set forth in OAR 340-122-0090(4).

Following revisions to draft FS documents submitted to DEQ in December 2015 (Anchor, 2015) and June 2016 (Anchor 2016), a final FS (Integrated Feasibility Study, former Portland Gas Manufacturing Site; Anchor, August 2016) was approved by DEQ. Discussion of information presented in the approved FS document follows.

Three concepts critical to the FS process – the areas and volumes of contaminated sediment, areas and volumes of hot spots, and sediment management areas – are discussed in the following subsections

7.2 Areas and Volume of Contaminated Sediment

Surface and subsurface sediment exceeding PRGs are shown in Attachments 25 and 26, contoured over the Sediment Decision Units (SDUs) discussed in the following section. The total area of the LOF is 140,500 square feet (3.23 acres). Approximately 52% of this area (72,510 square feet, or 1.66 acres) contains surface sediment that is already below PRGs. In general, contaminant concentrations are significantly higher in the subsurface (excluding the surface product layer), reflecting the historical nature of contaminant releases and ongoing burial of contamination via sediment deposition. The depth of contamination within the LOF is shown in Attachment 15 illustrations, the depth of contamination corresponding to the bottom of the deepest contaminated interval in each sediment core. Using AutoCAD Civil 3D, the total volume of contaminated sediment has been estimated to be approximately 40,000 cubic yards.

Much of the deeper, and most highly-concentrated, contamination occurs at depth along the Portland seawall. Contaminated sediments extend 17 to 19 feet bml at PGM-03, -05, -06, and -08. These deeper pockets of contamination cannot be removed without potentially undermining the stability of the seawall. Other areas of deeper contamination are associated with the offshore debris mound, extending 10 to 17 feet bml at PGM-15, -16, -18, and -24.

7.3 Areas and Volume of Hot Spot Material

“Highly concentrated” hot spot criteria for sediment are applicable to surface sediment and subsurface sediment with potential to impact the beneficial uses of the river (particularly for contamination in close proximity to the sediment surface). Contaminant concentrations in surface sediment exceeding hot spot values (for total PAHs) are present at the PGM-16 location. Also, a surface product layer in the form of aged and hardened tar-like material is present at the PGM-15 location as corroborated by diver observations within the offshore debris mound. The estimated area is approximately 8,000 square feet (0.18 acres) and has been designated as SDU “E” (see below for further discussion). Assuming the depth of the hot spot is approximately 2 feet (including approximately one foot of product and one foot of underlying sediment), the estimated volume of the surface hot spot is approximately 600 cubic yards. The extent of the tar-like deposits and hot spot concentrations will be further refined during pre-remedial design work with additional diver surveys and sediment cores.
Highly-concentrated contaminants in the sediment subsurface represent potential hot spots given their proximity to the river bottom and the dynamic environment in which they are located, where both erosion or human disturbance of overlying sediment might occur, making them available for exposure. In the FS, “highly mobile” and “not reliably containable” criteria were considered, in addition to the highly concentrated criterion, in assessing the potential for subsurface sediment to represent hot spots. Based on pore water sampling results, subsurface contamination does not appear to be highly mobile. On average, the in-water contamination area is largely depositional, however a potential exists for flood-based scour and human disturbance (dredging has previously occurred within the LOF for navigation purposes).

Subsurface sediments exceeding hot spot values (for total PAHs) are present along the seawall at 1 to 5 feet bml at PGM-05, -06, and -08. If maintenance dredging were to occur in this area as was performed in 1989 (to -30 feet Columbia River Datum), some buried sediment could be exposed.

Areas of surface and subsurface sediment where maximum contaminant concentrations exceed PRGs by a factor of 10 or more, representing hot spot (surface) or potential hot spot (subsurface) concentrations, are presented in Attachments 25 and 26 as blue or purple shading.

7.4 Sediment Decision Units

Within the LOF, SDUs were delineated in the FS for evaluation and application of remedial technologies. [Note that Anchor’s 2016 FS used the acronym “SMA” (sediment management areas). DEQ is using the SDU acronym in the ROD to avoid confusion with SMA referencing in Portland Harbor Superfund Site documents.] The delineation of SDUs was based on the following considerations:

- Magnitude and number of exceedances of PRGs in surface sediments.
- Magnitude and number of exceedances of PRGs in subsurface sediments.
- Surface sediments designated as hot spots based on the presence of a surficial tar-like layer or chemical concentrations exceeding hot spot criteria.
- Operational considerations for maintaining berthing access for marine vessels, including water depth and proximity to the seawall.
- Potential for buried contaminants to become exposed to aquatic receptors in surface sediments, surface TZW, or the overlying water column via extreme river currents, propwash, or maintenance dredging actions.
- Potential for buried contaminants to be mobilized in upwelling groundwater.

SDUs were delineated (see Attachments 25 and 26) for the purpose of applying appropriate remedial technologies in various combinations to develop remedial action alternatives (RAAs). The rationale for delineating these SDUs includes the following:

**SDU A1 and A2.** These are situated along the base of the seawall. The width of the SDUs is comparable to the width of the breasting barges that are used to offset U.S. Navy vessels from the seawall during Fleet Week docking, a critical navigation consideration. SDU A2 includes the area adjacent to the former PGM plant in the Block 5 area and contains high concentrations of buried MGP-related contaminants, whereas SDU A1 is a peripheral area upstream of Block 5. If maintenance dredging were conducted in SDU A2, sediments exceeding hot spot criteria could potentially become exposed at the surface.

**SDU E.** This includes material designated as a hot spot based on the presence of surficial tar-like deposits or highly concentrated sediments in excess of the hot spot criteria.
SDU D1, D2, and D3. This area is associated with the offshore debris mound and typically contains areas of relatively higher contamination at various depths below the mudline intermixed with large demolition debris. SDU D2 and D3 are two lobes of the offshore debris mound in water sufficiently deep that cap placement would not impinge on the 1989 berthing depth, whereas SDU D1 would require pre-dredging prior to cap placement to maintain the 1989 berthing depth.

SDU C1, and C2, and C3. This area contains moderately contaminated sediments between the seawall and the offshore debris mound. SDU C1 and C2 are separated by a low bench in the bathymetry that provides a practical nearshore limit for placing a fully armored treatment cap below the 1989 berthing depth. SDU C3 has a unique contaminant profile and composition (i.e., PGM-07 is dominated by a subsurface lead exceedance) that warrants a separate engineering analysis.

SDUB1, B2, and F. These more peripheral areas containing low to moderate levels of contamination may be more suitable for passive remedial technologies. Each of these areas has a unique contaminant composition and profile that warrants a separate engineering analysis. In particular, the contamination in SDU B2 (represented by PGM-10) may be associated with a different and more recent source based on the contaminant “fingerprint”, but has been included in the FS because of its proximity to site contamination and uncertainty regarding the source.

The total combined area of all SDUs is 83,725 square feet (1.92 acres) or approximately 60% of the LOF. The remainder of the LOF consists of areas that already meet the PRGs and do not require remedial action. The SDUs are the basis for development of RAAs, as discussed below.

7.5 Natural Recovery Analysis.

Appendix A of the approved FS provides an evaluation of MNR for the Site. The evaluation was performed in accordance with USEPA’s Contaminated Sediment Remediation Guidance (USEPA 2005), the Interstate Technology Regulatory Council Remedies Selection for Contaminated Sediments (ITRC 2014), and the Remediation Technologies Development Forum’s Weight-of-Evidence Approach for Evaluating Monitored Natural Recovery (RTDF 2004). Evidence of physical recovery processes, i.e., deposition of clean material over contaminated areas resulting in reduced exposure, were reviewed within the LOF, including observed sedimentation rates (through bathymetric comparisons and historical berthing observations), estimates of post-dredging sediment accumulation, and assessment of sediment stability. Chemical and biological processes that might contribute to natural recovery (e.g. biodegradation) were also considered.

Natural recovery predictions were developed for the Site using three lines of evidence: 1) regression analysis of chemical profiles in sediment cores; 2) use of the ITRC (2014) sediment recovery equation; and 3) use of a 1-D contaminant transport model based on Boudreau (1997). The results of these three different prediction methods are presented, supporting the conclusion that active natural recovery is occurring in a number of areas, notably at and near the seawall. Average deposition rates of 3 cm/year were observed (with up to 7 cm/year adjacent to the seawall), significantly exceeding the ITRC “threshold” of 0.5 cm/year considered favorable for MNR. The potential for sediment scour by natural or human activities was determined to be minimal in prospective MNR and EMNR areas. MNR recovery periods estimated through modeling ranged from 2 to 17 years. The addition of a sand cover (EMNR) reduces this recovery time to 0 to 7 years, averaging 2.7 years for the proposed remedy. MNR and EMNR were determined to be appropriate remedial technologies for SDUs A1, A2, B1, B2, C3, and F. SDUs C1, C2, D and E were determined to require more active remedial measures, and all but C1 will also require armoring to resist propwash.
Appendix B of the approved FS presents the results of cap modeling analyses completed to assess the feasibility/effectiveness of in-situ containment (capping and amended capping) to isolate contaminated sediment within portions of the in-water Site. The primary goal of the modeling was to simulate transport of MGP contaminants, including PAHs, BTEX, and selected metals, through the cap, with results used to identify the appropriate composition and thickness of cap material that would provide long-term protection to aquatic receptors (human and ecological).

Cap modeling analyses were performed in accordance with the EPA *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments* (Palermo et. al, 1998). The primary modeling tool used was a one-dimensional transient numerical model for chemical transport developed by Dr. Danny Reible (Reible 2012; Lampert and Reible 2009; Go et. al, 2009), which has been used to support the design of numerous caps around the US. The specific model code used included several enhancements made in collaboration with Dr. Reible for the Onondaga Lake, New York cleanup site. Modeling was used to identify an appropriate composition and thickness for cap material, maintaining contaminant concentrations in the biologically active zone (0-10 cm) below PRGs for at least 100 years. Important factors affecting modeling results included groundwater seepage velocity, dispersion, bioturbation, chemical partitioning coefficients, sediment contaminant profiles, and contaminant degradation rates. A model sensitivity analysis was also completed. Cap evaluation areas are shown in Attachment 27.

Model simulations were conducted starting with a cap layer of 6 inches of sand with nominal organic carbon content. Subsequent model simulations were conducted with different cap thicknesses and percentages of adsorptive treatment amendments, including GAC and organoclay, to meet PRGs over a 100-year time frame. Treatment amendments help to bind and sequester contaminants, reducing their mobility and toxicity. Naphthalene, with a low partitioning coefficient (i.e. high mobility) and high initial concentrations in some areas, was a primary “driver” of risk. A cap layer composed of 6 inches of sand (plus a 4-inch bioturbation layer, which is part of the overlying 12-inch armor layer) was found to be adequate for meeting PRGs in A2, B1, B2, C3, and F. Caps amended with GAC were determined to be needed in SDUs C2, D1, D2, D3, and E. Cap requirements in SDUs D1 and D2 are based on model predictions for SDU E assuming the top 2 feet of sediment (and tar-like material) were removed. Granular activated carbon (GAC) was selected for amended caps rather than organoclay given its higher adsorptive capacity. Less aggressive remedial options were determined to be potentially applicable in certain in-water areas (SDU A1).

At the request of DEQ, long-term cap model simulations were extended out to 1,000 years to better define peak concentrations and source depletion. In doing so, anaerobic degradation of contaminants (PAHs) and the effects of ongoing sedimentation were considered. Four critical locations and their “driving” contaminants were included in the modeling as follows: naphthalene at PGM-16; naphthalene at PGM-15; fluorene at PGM-18; and naphtalene at PGM-24. [Three of the four represent the off-shore debris mound, the fourth a nearshore part of the proposed treatment cap area]. Long-term model prediction curves are presented in the FS. Assuming both biodegradation and 1-meter of sedimentation, PRGs would not be exceeded at PGM-15 and -16, representing worst-case conditions, at 290 and 500 years, respectively. Note that sorbed-phase biodegradation was only modeled in the subsurface sediments beneath the cap, so the beneficial effects of biodegradation in the newly deposited cover sediments are not captured in this model. Retardation caused by the new sediment layer would provide additional time for sediment biodegradation to further reduce contaminant concentrations, which should be sufficient to maintain surface concentrations below PRGs in perpetuity.
Note that modeling and cap design were based on the goal of achieving Site TZW PRGs within the biologically active zone (0-10 cm below mudline). Modeling results were used in a qualitative fashion to show that SW PRGs would be achieved based on expected order-of-magnitude reductions in the contaminant flux to the river as a result of carbon-amended capping.

### 7.7 Cap Erosion Protection Evaluation

Appendix C of the FS evaluates the physical forces that could potentially erode the isolation layer of sediment caps and identifies appropriate thicknesses and compositions of armor materials to provide long-term protectiveness of the sediment cap. Critical elements of this evaluation included: an evaluation of the hydrodynamics associated with a 100-year flood over the remediation area; the potential for sediment disturbance by propwash; and a wind and vessel wave analysis. Representative particle sizes resistant to a 100-year flood event were estimated using methods presented in *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments: Appendix A: Armor Layer Design* (Maynard 1998), which uses current velocity and water depth. Based on a calculated maximum depth-averaged water velocity ranging from 7.1 to 7.4 (foot per second or fps), a mean (D<sub>50</sub>) stable particle size in the 2.7 to 3-inch range would be necessary to withstand infrequent river currents in SDUs C, D, and E.

An analysis of the potential for propwash disturbance was conducted using the previous-cited Maynard 1998 guidance document, assuming the critical propwash scenario would be use of large tugboats to position military vessels along the seawall during Portland’s Fleet Week. It was determined that docking vessels would be moored against breasting barges, with tugs operating no closer than 50 feet to the seawall. Information on vessel types, propeller shaft depths, water depth, vessel horsepower, etc. is presented in the FS, with analyses completed for SDUs D1/D2, D3, and E. A range of river elevations were considered (1<sup>st</sup>, 15<sup>th</sup>, and 50<sup>th</sup> percentile) to account for both average and critically low river stage conditions. Modeling results indicate that gravel- to cobble-sized materials with D<sub>50</sub> between 1 and 4 inches would be required to withstand propwash forces in SDUs D and E, which are susceptible to such forces.

All of the information presented above for Section 7 was carried forward into the development of remedial alternatives in the FS.

### SECTION 8 – DEVELOPMENT OF REMEDIAL ALTERNATIVES

The development of remedial action alternatives typically includes the identification of Remedial Action Objectives (RAOs) and General Response Actions (GRAs); the identification and screening of remedial technologies; and the assembly of remedial action alternatives for detailed analysis. Work concludes with identification of a proposed remedial action and an evaluation of residual risk associated with the proposed remedy. FS work is based on both EPA’s *Guidance for Conducting Remedial Action Investigations and Feasibility Studies Under CERCLA* (EPA/540/G-89/004) and DEQ’s *Final Guidance for Conducting Feasibility Studies* (July 1998, subsequently updated).

#### 8.1 Remedial Action Objectives

RAOs are medium-specific goals for protecting human health and the environment. RAOs provide the framework for developing and evaluating remedial action alternatives, as any remedy which the DEQ selects or approves must achieve these site-specific goals. The two criteria which much be considered
when developing RAOs include:

- Remedial actions must achieve the standards for “protectiveness” specified in OAR 340-122-0040(2). Furthermore, remedial action shall prevent or minimize future releases of hazardous substances to the environment, and shall not result in greater environmental degradation than that existing when the remedial action is commenced (unless short-term degradation is approved by the Director or designate).

- Remedial actions must treat or excavate hot spots of contamination to the extent feasible based on the remedy selection balancing factors. Hot spots are defined in OAR 340-122-0115.

Site-specific remedial action objectives (RAOs) developed for the Site are:

- Assure protection of ecological receptors (i.e., fish and invertebrates) and humans from risks associated with contaminated sediment, TZW, and SW, through the achievement of acceptable risk levels as defined in OAR 340-122-0115. The primary risk pathways that will be controlled as part of this remedial action include the following:
  - Direct risk to benthic organisms from surface sediment and TZW (via direct contact and ingestion) for PAHs, TPH, and, to a lesser degree, target metals and free cyanide;
  - Bioaccumulation risk to fish from PAHs in sediment; and
  - Bioaccumulation risk to humans from PAHs in sediment and, to a lesser degree, SW.

- Prevent or minimize future releases and migration of COCs in subsurface sediment and groundwater into the zone of exposure for ecological and human receptors. TZW contamination derived from both local impacted sediments and from upland groundwater sources may be commingled and will be addressed at the point of discharge through the in-water remedy.

- Remove or treat hot spots of contamination if feasible.

- Ensure protection is maintained over time through long-term monitoring, maintenance, and periodic review as appropriate of the selected remedy elements.

General response actions (GRAs) describe those actions that will satisfy the RAOs. The FS must develop a range of remedial action alternatives acceptable to DEQ. As specified in OAR 340-122-0085(2), this range is based on the following GRAs: a) no action; b) engineering and/or institutional controls; c) treatment; d) excavation and off-site disposal; and e) any combination of the above as appropriate.

A range of GRAs were evaluated for their ability to address the RAOs cited above and presented in Section 5.1 of the FS. GRAs that were determined to be appropriate for the Site were identified, and remedial technologies within these GRAs screened for use in developing remedial alternatives. GRAs and remedial technologies are summarized in Attachment 28. Remedial technology screening is summarized in Attachment 29. In addition to No Action, GRAs that were specifically evaluated for the PGM Site included: a) engineering and institutional controls; b) natural recovery; c) in-situ containment; d) in-situ treatment; e) removal with off-site disposal; and f) removal with ex-situ treatment and disposal.

8.2 Identification and Screening of Remedial Technologies

After the GRAs have been identified, potentially suitable remedial technologies are developed and screened based on the RAOs and available information from remedial investigation, including the concentrations and physical properties of COCs and the physical characteristics of the Site.

Each of these general response actions are presented in Section 7 of the 2016 FS. A variety of engineering and institutional controls were considered, but many determined to be infeasible for the in-water environment; restrictions on dredging were considered potentially most relevant. Potential natural recovery options considered included monitored natural recovery (MNR) and enhanced MNR (e.g. a thin
sand cover). Conventional sand capping was evaluated for in-situ containment, while GAC-amended caps and covers, with or without armoring, were selected for in-situ treatment. Both dredging with off-site disposal and dredging with treatment were identified as removal response actions.

Screening of remedial technologies is presented in Section 7.2 of the FS.

Remedial Technology Screening

The general response actions and associated technologies and screening results are presented and discussed in the FS. The technologies were screened in accordance with OAR 340-122-0085, having to meet the threshold criterion of protecting human health and the environment and considering their relative merits/drawbacks with respect to the balancing criteria including: level of effectiveness, ease of implementation, and relative cost. Attachment 30 explains the rationale for eliminating general response actions and/or technologies from being carried forward for detailed evaluation.

In addition to the general screening criteria, additional consideration was given to site-specific conditions including the following:

- The location of the remediation area within the Willamette River, with limited access, and limited availability for staging equipment and materials from the upland;
- That caps (traditional or treatment) may be constrained in order to preserve vessel clearance and berthing depth along the seawall;
- That removal or disturbance of sediments adjacent to the seawall could impact stability of the structure;
- That in-place remedial technologies (e.g. capping) might be affected by scour and erosion caused by river currents (including flood currents) and propwash from vessel traffic; and
- The presence of large demolition debris in the offshore area where sediment impacts and tar-like material are observed.

The following technologies were screened out:

- Conventional upland controls (fences, barriers, etc.) which are not applicable to in-water remedies.
- Conventional (un-amended) capping technology, which could require caps several feet thick to achieve protectiveness in some in-water areas, and would be problematic in terms of navigation and flood-rise considerations.
- Removal with ex-situ treatment and disposal (outside of SDU E), which would be challenging from an implementation standpoint, and of substantially higher cost.

Technologies that were carried forward and combined to develop comprehensive Remedial Action Alternatives (RAAs) included the following:

- Institutional Controls. These can include legal actions such as deed restrictions, dredging restrictions, fish consumption advisories, or public access restrictions to reduce exposure to hazardous substances, with the most likely being restrictions on dredging.
- Monitored Natural Recovery (MNR). Under this technology, contaminated sediments are allowed to recover without intervention. Environmental monitoring data are collected over time to measure the progress of natural recovery towards achieving RAOs.
• **Enhanced MNR (EMNR).** A thin layer of sand is placed over contaminated areas to provide an immediate reduction in surface sediment concentrations and accelerate the natural recovery process. The sand layer may mix with sediments and does not necessarily isolate them.

• **GAC-Amended Treatment Cover.** A thin layer of GAC-amended sand is placed over contaminated areas. The technology is similar to EMNR, but the sand is amended with a sorptive medium such as granular activated carbon (GAC) or organoclay, providing a treatment component. The sorptive amendment helps to sequester contaminants that may be upwelling in Site groundwater.

• **GAC-Amended Treatment Cap.** This involves the placement of a layer of sand or other material between contaminated sediment and the water column, forming a cap. The cap is amended with a sorptive and reactive material such as GAC or organoclay which provides treatment (sorption) of contaminated porewater that may be moving through the cap, making contaminants less bioavailable to benthic organisms and reducing contaminant loading to the river. In high-energy areas, the cap may include an armor layer to prevent scour and erosion.

• **Removal with Off-Site Disposal.** This technology involves the physical removal of contaminated sediment, commonly by mechanical dredging, and transport of sediment to an approved off-site disposal facility such as a permitted landfill. Removal technologies may incorporate stabilization of dredged materials with cement or other additives, or de-watering, to achieve a consistency suitable for disposal. Management of demolition debris will also be necessary.

• **Removal and Ex-Situ Treatment (SDU E [hot spot] only).** Removal of the SDU E hot spot sediments allows for treatment of dredged material to potentially meet disposal requirements for non-hazardous (RCRA Subtitle D) landfill disposal. Various treatment technologies are available to reduce, remove, bind, or destroy contaminants. Treatment of contaminants with cement is an ex-situ treatment process that would likely be evaluated during remedial design.

These technologies have been assembled into five RAAs, including No Action, evaluated in the FS and discussed in the following section.

**SECTION 9 – ASSEMBLY AND EVALUATION OF REMEDIAL ALTERNATIVES**

RAAs were developed using the remedial technologies that were determined to be applicable to the Site through the technology screening process described above. RAAs were built by applying various combinations of remedial technologies to the SDUs.

Applicable remedial technologies for each SDU and the supporting rationale for these applications are summarized below. Technology applications were determined based on the nature, magnitude, and depth of surface and subsurface exceedances of PRGs and on the prevailing groundwater seepage rates and sedimentation rates. The technology applications are further supported by detailed core-by-core evaluations of MNR and EMNR (see Appendix A of the FS), GAC-amended cap and cover designs (see Appendix B of the FS), and a hydrodynamic analysis of erosion potential (see Appendix C of the FS).

The following RAAs were developed for the PGM Site:
- RAA-1 – No Action
- RAA-2 – Monitored Natural Recovery Focus
- RAA-3 – Treatment Cap Focused
- RAA-4 – Partial Dredge and Treatment Cap
• RAA-5 – Dredging Focus

Descriptions of the RAAs are provided in this section. Attachment 31 includes a narrative summary of the RAAs and the remedial technologies applied to each SDU. Attachment 32 summarizes the areas and volumes associated with removal (i.e., dredging) and fill technologies (i.e., capping and covering) for each of the alternatives, and the specifications (thickness and amendment ratios, if required) of caps and covers. Attachment 33 shows the distribution of the remedial technologies (locations and extents) in plan view. Attachment 34 shows the depths and grades of remedial technologies in a representative cross-sectional view through the center of the Site (Section A-A’; see Attachment 10 for location).

Each of the remedial alternatives is discussed below. Note that RAA-2 through -5 all include the following common elements: a) surface product and related debris removal and disposal in the hot spot area (SDU E); b) institutional controls to prevent dredging along the seawall, where remedial action is not feasible; and c) long-term monitoring activities to confirm that remedial actions are meeting site-specific RAOs. Each of these actions was determined to be necessary to meet RAOs and confirm RA effectiveness. Given their inclusion in all RAAs except No Action, these common elements are generally not included in the balancing factor discussion below.

Note the following regarding items a, b, and c in the preceding paragraph:

a) An estimated 600 cubic yards of tar-like material would be removed based on current site information, along with an estimated 500 cubic yards of contact sediment and debris, representing surface hot spot material. Additional sediment coring and diver surveys would be completed in pre-design investigation which may result in a modification to this (estimated) volume.

b) At present, there is sufficient water depth for berthing along the seawall, even though the sediment level is slightly above the 1989 dredge depth, because large vessels are offset from the seawall with breasting barges.

c) For FS purposes, long-term monitoring has been assumed to consist of seven events – a baseline post-construction event (Year 0) followed by monitoring events every 5 years for a total of 30 years. It is further assumed that monitoring events would include the following components:
   o A multi-beam bathymetry survey to assess sedimentation and/or erosion;
   o Collection of sediment samples to assess the progress of natural recovery, with analysis including site constituents of concern (COCs), grain size, TOC, etc. and
   o Data validation, reporting, and assessment of remediation goals.

A final decision on appropriate short- and longer-term monitoring requirements would be made during the (post-ROD) remedy design process.

A description of each of the remedial action alternatives as outlined in the 2016 Final Integrated Feasibility Study approved by DEQ follows. Note that for each of the capping alternatives, the cap thickness identified is a minimum, and does not include construction overplacement allowance, which helps to augment the effectiveness of this technology. For example, a typical 12-inch sand cap (amended or non-amended) would have an accompanying overplacement allowance of 6-inches, making the total cap thickness up to 18 inches. The potential for overplacement would similarly apply to any armoring layers, and will be addressed in greater detail in the site remedial design document.

9.1 RAA-1; No Action. This action does not include any remedial action, institutional controls, monitoring, or other activity to address contamination. It serves as a baseline for comparison to the remaining four remedial alternatives that follow.

9.2 RAA-2; Monitored Natural Attenuation Focus. This alternative uses MNR to a greater extent than
the other RAAs and includes the following elements:

- **MNR.** MNR would be applied throughout the Site except in SDUs D and E where more active technologies are applied to meet RAOs.

- **Treatment Cap.** In situ treatment would be applied in SDUs D and E, in the form of a 6-inch thick isolation layer amended with 5% GAC by weight. The treatment cap would be finished with a 12-inch armor layer of 3-inch to 4-inch rock to protect against current and propwash erosion. Large surficial debris would be removed to prepare the surface for capping.

- **Common Elements.** Surface product removal and off-site disposal (in SDU E), institutional controls on dredging, and a long-term monitoring program would be implemented as described above.

9.3 RAA-3; Treatment Cap Focus. This alternative utilizes in situ treatment in the form of GAC-amended capping to its maximum practicable extent and includes the following elements:

- **Treatment Cap.** In situ treatment would be applied in SDUs A2, C, D and E, in the form of an amended 6-inch thick isolation layer. The isolation layer would be amended with 3% GAC by weight in SDUs A2 and C, and 5%GAC by weight in SDUs D and E. The treatment cap would be finished with a 12-inch armor layer of 3-inch to 4-inch rock to protect against current and propwash erosion. Large surficial debris would be removed to prepare the surface for capping.

- **MNR and EMNR.** Areas with sufficiently high sedimentation rates and weaker groundwater advection would be addressed using MNR (SDUs A1 and B1) and EMNR (SDUs B2 and F).

- **Institutional Controls.** Additional dredging restrictions would be required in areas where the armored treatment cap projects slightly above the 1989 dredging elevation.

- **Common Elements.** Surface product removal and off-site disposal (in SDU E), institutional controls on dredging, and a long-term monitoring program would be implemented as described above.

9.4 RAA-4; Partial Dredge and Treatment Cap. This alternative includes partial dredging and off-site disposal to preserve berthing depth, followed by the application of a GAC-amended treatment caps and covers, as well as EMNR and MNR in peripheral areas, and includes the following elements:

- **Dredging and Off-site Disposal.** Partial dredging actions would occur in SDUs C1, C2, and D1 prior to the placement of GAC-amended treatment caps and covers to allow the final surface of the caps and covers to be finished below the 1989 dredging elevation, allowing for future maintenance dredging. The final elevation of the armor layer on treatment caps in SDUs C2 and D1 would be placed 24 inches below the 1989 dredging elevation, and the final elevation of treatment covers in SDUs C1 would be placed 18 inches below the 1989 dredging elevation. Because GAC-amended cover material is intended to be dispersed and mixed with in-situ sediment, a slightly smaller dredging buffer is assumed for SDU C1. Removal would occur to -29.7 feet City of Portland vertical datum (COP) in SDU C1 and to -31.7 feet COP in SDUs C2 and D1 to allow cap or cover placement, allowance for overdredging and overplacement, and a sufficient dredging buffer for future maintenance dredging. The nearshore boundary of SDU C1 would be dredged to a more stable 3:1 side slope to prevent sloughing along the seawall (other side slopes are assumed 2:1). Contaminated sediments would be disposed off site at a Subtitle D landfill.

- **Treatment Cap.** In situ treatment would be applied in SDUs C2, D, and E in the form of an amended 6-inch thick isolation layer. The isolation layer would be amended with 3% GAC by weight in SDU C2 and 5% GAC by weight in SDUs D and E. The treatment cap would be finished with a 12-inch armor layer of 3-inch to 4-inch rock to protect against current and propwash erosion. Dredging would occur prior to cap placement in SDUs C2, and D1, and the western edge of SDU E to preserve berthing depth, whereas SDU D2, D3, and most of SDU E are
sufficiently deep that the caps can be placed below the dredging elevation with sufficient buffer and without a need for pre-dredging.

- **Treatment Cover.** SDUs A2 and C1 would be remediated with a 6-inch sand cover amended with 3% GAC by weight. SDU C1 would first be pre-dredged to maintain berthing depth.

- **MNR and EMNR.** Areas with sufficiently high sedimentation rates and weaker groundwater advection would be addressed using MNR (SDU B1) and EMNR (SDUs A1, B2, C3, and F). Compared to RAA-3, EMNR covers are more broadly applied in this alternative to further address dredging residuals that may be associated with the removal actions.

- **Common Elements.** Surface product removal and off-site disposal (in SDU E), institutional controls on dredging, and a long-term monitoring program would be implemented as described above.

### 9.5 RAA-5: Dredging Focus

This alternative includes dredging to the depth of PRG exceedances in SDUs where complete removal is feasible and effective, followed by off-site disposal at a permitted landfill, and includes the following elements:

- **Dredging.** Deep dredging to achieve complete removal of sediment containing contaminants at concentrations exceeding PRGs would occur in SDUs C1, C2, D1, D2, and E. Removal would occur to elevation -39.5 feet COP in SDUs C1 and C2, to elevation -36.5 feet COP in SDU D1 and the inner portion of SDU E, and to elevation -44 feet COP in SDU D2 and the outer portion of SDU E. This corresponds to dredging depths of 7 to 11 feet bml. Such deep dredging would likely encounter demolition debris throughout much of the sediment column, especially in SDUs D1, D2, and E. The nearshore boundary of SDU C1 would be dredged to a slightly more stable 2.5:1 side slope to minimize sloughing along the base of the seawall. Note that a shallower side slope, such as 3:1, would intersect and potentially destabilize the seawall because of the deeper dredge cut in this alternative. Dredged areas would receive a 6-inch sand cover to control possible dredging residuals. Contaminated sediments would be disposed offsite at a Subtitle D landfill.

- **Treatment Cap.** Consistent with the other alternatives, a treatment cap would be applied in SDU D3 in the form of a 6-inch thick isolation layer amended with 5% GAC by weight, and finished with a 12-inch armor layer of 3-inch to 4-inch rock to protect against current and propwash erosion. Due to the contaminant profile in this area (i.e., PAH contamination in the 3- to 5-foot interval, likely associated with a thin seam of oily wood chips at 3.7 feet bgs, overlain by 3 feet of clean sediment), removal to the depth of PRG exceedances is not an effective remedial technology.

- **Treatment Cover.** SDUs A2 and C1 would be remediated with a 6-inch sand cover amended with 3% GAC by weight. SDU C1 represents the inner side slope of the dredge cut (see Figure 8-2); a GAC-amended cover would be placed in this area to control possible lateral migration of buried contaminants that are present along the base of the seawall and cannot be fully removed due to structural concerns.

- **EMNR.** SDUs A1, B1, B2, C3, and F would receive a 6-inch sand cover. This cover material would serve both to accelerate natural recovery processes (EMNR) and also to control possible dredging residuals that may have spread laterally from the dredging areas.

- **Common Elements.** Surface product removal and off-site disposal (in SDU E), institutional controls on dredging and anchoring, and a long-term monitoring program would be implemented as described above.

### 9.6 Analysis and Comparison of Remedial Action Alternatives

As recommended in DEQ’s *Guidance for Conducting Feasibility Studies* (DEQ 1998a),
alternatives were evaluated in the FS on an individual basis and by comparing them against one another. Individually, each alternative was evaluated against the protectiveness requirement as required under OAR 340-122-0084(4), the preference for treatment or removal of hot spots of contamination, and the balancing criteria described in OAR 340-122-0090.

9.6.1 Protectiveness. The No Action alternative does not meet the protectiveness requirement and therefore was not considered further except as a basis for comparison to the other RAAs. The remaining four alternatives comply with the protectiveness threshold criterion as the remedial technologies assigned to the various SDUs are expected to be effective at meeting RAOs and PRGs and reducing Site risk to acceptable levels.

9.6.2 Preference for Treatment or Removal of Hot Spots. The No Action alternative does not address hot spots. The remaining four alternatives meet the Oregon hot spot requirements and the preference for treatment or removal of hot spots because the surface product layer in SDU E, as well as adjacent high-concentration surface sediments where exposure is expected to occur, would be removed and disposed off site. In RAA-3 and RAA-4, potential subsurface hot spots in SDU E would be addressed with a treatment cap amended with GAC. The installation of a treatment cap will ensure that deeper contamination, including potential hot spot material, will remain buried and isolated from aquatic receptors, with upwelling groundwater to be treated to meet water quality criteria through GAC adsorption. In RAA-5, contaminated subsurface sediments exceeding highly-concentrated hot spot criteria beneath the SDU E hot spot area would be fully removed and disposed off site, so follow-on treatment would not be needed for this alternative. Subsurface sediment contamination exceeding highly-concentrated hot spot criteria, notably along the base of the seawall at 1 to 5 feet bml in SDU A2, is largely buried by cleaner sediment in an area where natural recovery is ongoing and groundwater seepage rates are minimal. Therefore, treatment is not necessary in this area to comply with hot spot regulations; however, GAC treatment is nevertheless being applied to this area because it is an effective technology for the site conditions.

9.6.3 Remedy Selection Balancing Criteria. According to OAR 340-122-0090(3)(a) through OAR 340-122-0090(3)(e), the five balancing criteria that are to be used to compare remedial alternatives are effectiveness, long-term reliability, implementability, implementation risk, and reasonableness of cost.

An evaluation and ranking of remedial action alternatives in the FS is included as Attachment 34. A comparison of remedial alternative based on each of the five “balancing factors” is presented below, followed by a discussion of alternatives from the perspective of DEQ and EPA Green Remediation guidance. Conceptual cost estimates for each alternative are developed in Appendix E of the FS and summarized in Attachment 35. Costs were developed in general agreement with USEPA guidance (2000). The total cost includes engineering design and permitting; estimated DSL access fees; mobilization/demobilization; project management and construction management; material, labor, and equipment costs to implement hot spot removal, capping, dredging, MNR and EMNR; and long-term site monitoring.

Effectiveness. In the FS, RAA-3 through -5 are all ranked as having equal effectiveness in achieving long-term goals for protectiveness (through a combination of dredging, capping, and MNR/EMNR), with RAA-2 having a lower grade due to the longer time-frame that would be expected to be necessary to achieve protection in areas where MNR is applied. It was acknowledged that remedial alternatives with larger dredging components would result in the release of dredge residuals. DEQ considers RAA-5 and -4 to have the highest level of effectiveness from the standpoint of achieving remedial action objectives within the shortest timeframes, through the most extensive use of dredging and amended capping in
higher sediment contamination areas. There is also greater uncertainty as to whether MNR proposed for SDUs C1, C2, and C3 under RAA-2 will be effective within a reasonable timeframe.

**Long-term Reliability.** This factor considers the reliability of treatment technologies, engineering and institutional controls, uncertainties associated with long-term management (including maintenance and monitoring of the remedy). In the FS, RAA-4 was ranked highest, because of concerns associated with how dredging proposed under RAA-5 might compromise sediment stability, including highly-contaminated subsurface sediment in the seawall vicinity. The apparent concern is that creation of a moderately-steep side-cut on the inner boundary of the removal, adjoining seawall sediment, might compromise slope stability in seawall sediments that cannot be removed. This concern would have to be addressed in remedial design; DEQ agrees that it represents a point of uncertainty from both a long-term reliability and implementability standpoint. RAA-5 was ranked second-highest given that removal would preclude the need for long-term monitoring/maintenance outside of the seawall. RAA-2 and -3 were ranked lowest, in part because of the greater reliance on natural recovery to achieve protectiveness, and because capping without pre-dredging would result in caps being placed above or in proximity to the 1989 dredge limit, making them more vulnerable to disturbance and requiring a higher level of institutional controls. DEQ finds the rankings acceptable.

**Implementability.** This factor considers: a) the practical, technical, and legal difficulties associated with construction and implementation of remedial measures; b) the ability to monitor remedy effectiveness; c) consistency with regulatory requirements and the ability to obtain authorization for work; and the availability of necessary services, equipment, etc. to facilitate remedy implementation. In the FS, RAA-4 ranked highest for implementability, and RAA-5 lowest. The high ranking for RAA-4 is based on the use of well-established methods and materials, achieving target depths for navigational use (i.e., below 1989 dredge depth), and represents a more balanced cut-and-fill (a regulatory concern for floodplain protection). The factors that drive the low ranking for RAA-5 include dredging complications associated with known debris, the longer construction duration required for large-scale removal, and turbidity control challenges. The implementability scores for RAA-2 and -3 are lower based in large part on the inadequate clearance from the 1989 dredge depth and associated regulatory challenges. DEQ finds this ranking acceptable.

**Implementation Risk.** Considerations under this factor include potential impacts on community, workers, and the environment associated with remedy implementation, and the time until remediation is complete. Implementation risk was lowest for the least intrusive of the remedial alternatives (RAA-2), which relies most heavily on MNR, and highest for the most intrusive alternative (RAA-5) which relies on extensive dredging. RAA-3 and -4 represent intermediate implementation risk with a more balanced application of dredging, treatment capping, EMNR and MNR. DEQ concurs with the assessment that increased dredging, particularly associated with large-scale removal outlined in RAA-5, represents a significant implementation risk given that it occurs at significant depth within the main body of the Willamette River where “incidental” release of contaminated sediment would prove difficult to prevent, and such releases would be exacerbated by the abundance of large debris in the project area. Dredging also incurs increased risk to workers, community, and the environment, and increased burden on infrastructure, as a result of handling and transporting the dredged material. DEQ finds this ranking acceptable. With regard to in-water ecological receptors, remedial actions with a larger dredging component (notably RAA-5) would be more disruptive of existing habitat substrate and have a greater potential for release of contaminants downriver (including Portland Harbor) during implementation.

**Reasonableness of Cost.** In addition to capital costs, maintenance and monitoring costs, periodic review costs, and net present value, this factor considers proportional benefits (to human health and the environment) and cost uncertainty. The higher threshold in evaluating the reasonableness for treatment of
hot spots is also considered. Costs for RAA-2 through RAA-5 progressively increase, and range from $7.0 million dollars (M) to $12.9M. Reasonableness of cost ranked lowest for RAA-5 in the FS, based on factors including the potential for water quality impacts during dredging, impacts to the public during transport of contaminated sediment, and the high monetary cost associated with remedy implementation, with no greater effectiveness or reliability. This alternative is 45-50% higher than RAA-3 and -4, which are expected to be equally protective and less invasive. RAA-4 provides a higher proportionate benefit to public health and the environment than RAA-2 and -3 through more immediate risk reduction, and less potential for contaminant release associated with dredging. DEQ considers the reasonableness of cost ranking to be highest for RAA-4 given that the $8.9M value only modestly exceeds that for RAA-2 and -3 ($7.0M and $8.5M, respectively) while resulting in removal of a larger volume of contaminated sediment (through partial dredging in SDUs C2, D1, and D2, representing approximately 1,960 cubic yards of sediment) in addition to removing hot spot material in SDU E.

Green Remediation. Under DEQ’s 2011 Green Remediation Policy, the agency will:

- Evaluate methods to assess energy and natural resource use, emissions, waste generation and other potential impacts to communities and air, land and water quality associated with cleanup work.
- Identify green remediation guidelines, best management practices and other resources that DEQ staff and stakeholders can use as tools in project design and implementation.
- Implement practical green remediation strategies in investigation and remediation work performed by DEQ staff and their contractors.
- Encourage the regulated community to evaluate and implement greener approaches to investigation and remediation.
- Incorporate the efforts of other organizations towards advancement of DEQ green remediation policy and guidance.
- Collaborate with Oregonians on implementation of this policy for a healthy, sustainable environment.

Portions of the policy salient to the remedy selection process are italicized above. As part of DEQ’s evaluation of remedial alternatives, consideration was given to the extent each of the remedial alternatives, and the proposed alternative presented in Section 10 below, adhered to the policy. The 2009 EPA Region 10 Superfund, RCRA, LUST, and Brownfields Clean and Green Policy was likewise considered, including the focus on minimizing impacts to water quality and water resources, reducing air toxics emissions and greenhouse gas production, minimizing waste production, and conserving natural resources and energy.

As has been illustrated through site investigation and risk assessment work, in-water contamination related to historical PGM operations (1861-1913) has been partially remediated through decades of ongoing natural recovery, specifically deposition of cleaner Willamette River sediment from upriver of the site. Natural recovery has been confirmed through multiple lines of evidence, including historical site information, bathymetric surveys, sediments cores, dredging records, and hydrodynamic analysis. Given this, and green remediation goals, consideration was given in remedy selection to remedial alternatives that take advantage of ongoing natural recovery, and minimize disturbance of the Willamette River environment to the extent practicable. Minimization of greenhouse gas production was likewise considered.

RAA-1 (No Action) has no environmental “footprint”, but does not achieve protectiveness, and therefore was not considered further from a green remediation perspective. RAA-2 and -3 are protective, but require longer timeframes to achieve protectiveness, with some element of uncertainty in particular for
RAA-2. From a green remediation perspective these are most preferable as they do not involve dredging (outside of SDU E, estimated 1,800 cubic yards), eliminating the need for equipment for dredging, contaminant transport, and disposal, and their associated fuel consumption, waste generation and air emissions. RAA-4 involves a higher volume of sediment removal (estimated total 3,760 cubic yards), with an accompanying larger environmental “footprint”. RAA-5 has, by far, the largest footprint from an equipment use and emission generation standpoint, with an estimated 12,340 cubic yards of contaminated sediment to be dredged. In addition to air emissions, large-scale removal represents a much greater risk from short-term releases to the Willamette River associated with both the greater volume and depth of sediment to be removed. Green remediation was qualitatively addressed in the FS. DEQ would rate the impacts lowest for RAA-2 and -3, moderate for RAA-4, and highest for RAA-5.

SECTION 10 – DEQ SELECTED REMEDIAL ACTION

10.1 Description of the Selected Alternative.
DEQ’s selected remedial action for the site is generally consistent with RAA-4 presented in the FS and the 2016 Staff Report prepared by the Agency. After consideration of comments from EPA and the Tribes, and cleanup values and initial design information presented in the 2017 Portland Harbor ROD, one significant change was made to the selected remedial action. Cap and cover (EMNR) thicknesses were increased from a minimum of 6 inches to 1 foot. Rock armoring will likewise be a minimum of 1 foot thick. The selected Site remedy is as follows:

- Removal of surface tar-like material and adjacent high-concentration sediment in SDU E, followed by placement of a GAC-amended treatment cap and rock armor layer, each a minimum of 1-foot in thickness. Final delineation of the SDU E removal area will be determined after pre-design diver survey work and additional core sampling. DEQ will consider in remedial design whether to increase the depth of dredging in this area to remove highly contaminated sediment below and proximal to surface contamination; however, the dredge depth is not expected to extend deeper than 5-feet below mudline.
- Partial dredging actions in SDUs C1, C2, and D1 followed by placement of GAC-amended treatment cap and armored rock cover, each layer being a minimum 1-foot thickness. Dredging will allow for installation of treatment cap and armoring below the 1989 dredging elevation, providing the opportunity for future maintenance dredging as necessary. Based on initial design, the top elevation of the armor layer on treatment caps would be 2 feet below the 1989 dredging elevation in SDUs C2 and D1, and the top elevation of the treatment layer would be 1.5 foot below the 1989 dredging elevation in SDU C1.
- Placement of a minimum 1-foot GAC-amended cover in SDU A2 (in-situ treatment).
- Placement of a minimum 1-foot sand cover in SDUs A1, B2, C3, and F (EMNR).
- Monitored natural recovery (MNR) in SDU B1.
- Development and recording of institutional controls including a prohibition on upland groundwater use and limitations on dredging below the 1989 dredge depth and along the seawall. ICs will be fully developed in remedial design.
• Implementation of short- and long-term monitoring. Monitoring will be conducted to evaluate short- and long-term effectiveness of the remedy before, during, and after construction. Monitoring requirements will be fully developed in remedial design.

The selected remedy meets RAOs outlined in Section 8.1 of this Record of Decision as follows:

• The selected remedy achieves protection (as defined in OAR 340-122-0040) through a combination of contaminant removal and upland (landfill) disposal, physical isolation, contaminant sequestration, and contaminant burial (where natural recovery is already occurring). Cleanup levels are expected to be achieved shortly after implementation in most areas, with an estimated maximum time of less than 10 years to achieve protective levels where the remedy is EMNR (SDUs A1, B2, C3, and F) and MNR (SDU B1). The remedy is expected to address all Site-related contaminants in all exposure media including sediment, porewater, and surface water.

• The selected remedy treats or excavates hot spots of contamination to the extent feasible based on the remedy selection balancing factors, as defined in OAR 340-122-0090 and DEQ’s hot spot guidance. Highly-concentrated surface sediment hot spots, specifically, a surface layer of hardened, tar-like material, will be excavated and disposed off-site in an upland landfill. An estimated 1,000 cubic yards of hot spot material, and an estimated 2,760 yards of sediment and debris, will be removed. During remedial design work, potential removal of highly-contaminated sediment proximal to and underlying tar-like material will be evaluated. Subsurface sediment exceeding the highly-concentrated criterion, extending in offshore areas to 14 or more feet below mudline, will be isolated with an amended cap, and the cap protected with armoring. Adjacent to the seawall, contaminated sediment including buried potential hot spot material will be treated with GAC-amended sand to sequester any contaminants that may be migrating in groundwater.

• The selected remedy, as a whole, rates highest when considering all of the balancing factors outlined in OAR 340-122-0090(3) (a-c), in particular when considering the age of the releases (pre-1913 operations followed by construction disturbance in the late 1920s) and the degree to which ongoing natural recovery (via sedimentation) has buried MGP-related contaminants, limiting human and ecological exposure. It is believed to represent an excellent, comprehensive, Site-appropriate combination of remedial technologies, incorporating removal, in situ treatment using caps and covers amended with GAC, EMNR, and MNR.

• Monitoring will be structured to assess the ability of the remedy to achieve Site RAOs and associated cleanup levels, reduce any contaminant load to the Willamette River, and provide information for cap maintenance activities and supporting data for five-year reviews. Long-term monitoring activities are expected to include: a) bathymetric and diver surveys to confirm cap stability and natural recovery through sedimentation; and b) collection of samples from in-water media including sediment, porewater, and/or surface water to confirm that Site RAOs are achieved within expected timeframes. Specific protocols for compliance monitoring will be developed during remedial design. Monitoring requirements will, in general, follow those outlined in CERCLA guidance documents, including monitoring during remedy construction and, on a long-term basis, following remedy construction.

• ICs will be developed and implemented to: a) prevent or minimize human or biota exposure to contaminated sediment and groundwater contained by capping; and b) maintain the integrity of the engineered components of the selected remedy. Both short- and long-term controls will be necessary at the Site. Short-term controls may take the form of temporary access restrictions to facilitate cleanup, and require coordination with the City of Portland, Oregon Division of State Lands (DSL), and the US Army Corps of Engineers. Long-term ICs are expected to include, at a minimum, a prohibition on upland groundwater use and dredging below the 1989 Dredge Limit or adjacent to the seawall. There are a number of other ICs that may be necessary, including restrictions on anchoring, limits on navigation, etc. which will be more fully addressed in
remedial design. ICs will generally conform to those outlined in Section 14.2.6 of the Harbor ROD, excepting that fish advisories and educational outreach are not expected to be necessary. The need for these ICs will be determined in remedial design.

- Construction best management practices (BMPs) will be implemented to prevent or minimize human and biota exposure to contamination during construction of the remedy.
- The total estimated net present value cost of the selected remedy is $9.9 million\(^1\) (versus $8.9 million presented in the DEQ Staff Report). The increased cost is largely associated with DEQ’s decision to increase (double) the required minimum thickness of caps and covers.
- It is expected that the remedy would be constructed in one year. A remedy implementation schedule will be developed during remedial design.

While the FS and this ROD outline guidelines for remedial elements including removal depths and areas; cap locations, types, and thicknesses; and amendment types and concentrations, final details will be worked out in the forthcoming remedial design documents, and will incorporate the results of additional pre-design investigation. This will include a determination of whether removal of highly-contaminated (potential hot spot) sediment underlying and proximal to surface contamination, notably in and around SDUs E and SDUs C2 and D1, is necessary. Remedial design work will also include a determination of points of compliance and timelines for performance monitoring, and an identification of contingency measures that may be implemented in the event that remedial measures prove to be ineffective or do not meet remedial objectives within specified time frames. The results of pre-design investigation work, expected to include coring and sediment analysis in the offshore debris areas (SDU D1, D2, and E) areas, additional tar and debris surveys, etc., will be incorporated into remedial design. Design work will include an assessment of whether ICs alone will be adequate in preventing sediment disturbance in non-armored remediation areas, notably where high concentrations of MGP contaminants are present in subsurface sediment offshore of the Block 5 area (SDUs A2 and C1). Consideration will be given to adding rock armoring to these areas as needed. If rock armoring is added, this could require pre-dredging to ensure that an adequate buffer is present between cap materials and the 1989 dredge limit. The remedial design documents will be completed on behalf of NW Natural after approval of the Record of Decision (ROD) by DEQ’s Northwest Region Administrator.

The selected remedial action is protective of human health and the environment. The remedy achieves acceptable levels of risk, as defined by OAR 340-122-0115, as demonstrated by discussion in this ROD and accompanying information presented in the FS previously approved by DEQ. Site remedial action objectives will be achieved through implementable and reliable remedial technologies including sediment dredging and in situ treatment (i.e. GAC-amended caps and covers). Surface and near-surface hot spots will be excavated and disposed offsite. To the extent that deeper sediment contamination including highly-concentrated hot spots represents a residual risk, they will be addressed by treatment capping and long-term monitoring to confirm effectiveness. The selected remedy is consistent with DEQ’s Green Remediation Policy, relying on a balanced approach of dredging, in situ treatment, EMNR, and MNR to achieve protection, and acknowledging that significant natural recovery has already occurred. RAA-4 represents a reasonable compromise between limited dredging (i.e., SDU E hot spot), as represented by RAA-2 and RAA-3, and dredging the full vertical and lateral extent of sediment contamination (excepting the seawall area, where dredging is not tenable), as represented by RAA-5. RAA-4 includes sufficient dredging to address accessible hot spots and maintain navigation, combined with extensive use of in situ treatment, thereby moderating the generation of greenhouse gases and other environmental impacts associated with contaminant handling, transport, and upland disposal, and limiting the potential for contaminant release during dredging. During remedy design, consideration will be given to the use of

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\(^1\) The net present value cost is based on a 3.4% discount rate for 30 years of long-term monitoring; the non-discounted total estimated cost of the selected remedy is $10.5 million. See FS Appendix E for further details.

37
protocols, equipment, etc. to minimize carbon emissions during remedy implementation work.

10.2 Contingency Measures.

In the event that the selected alternative is implemented and determined not to meet remedial action objectives, contingency measures may be necessary. These could potentially include: a) upgrading MNR areas to EMNR (i.e., applying sand cover material to MNR areas); b) upgrading EMNR areas to in situ treatment (i.e. applying GAC to EMNR areas); c) upgrading EMNR areas to capping; d) increasing cap or cover thickness and/or amendment concentrations; and e) localized dredging with or without capping. Additional administrative measures might also be considered. Monitoring results and decision criteria that would trigger an evaluation of contingency measures will be developed in the forthcoming remedial design document for PGM.

10.3 Residual Risk Analysis

A residual risk evaluation was performed to demonstrate that the selected remedial action meets RAOS, in accordance with OAR 340-122-0084(4). The residual risk evaluation is summarized in Attachment 36. Residual risk was evaluated for the three target metals (lead, mercury, and zinc) and the four PAHs with the highest exceedance ratios in Site sediments (napthalene, phenanthrene, pyrene, and benzo[a]pyrene). The residual risk analysis also documents risks associated with material that is managed on-site through engineering and institutional controls.

The results of the residual risk evaluation are as follows:

- Surfacial hot spots of contamination are present at PGM-15 and PGM-16 (SDU E). These surfacial hot spots will be removed as part of the remedial action and the surface replaced with an armored treatment cap that achieves PRGs at the completion of remedial construction.
- At Year 0, immediately following remedy construction, a majority of the surface sediment locations will have already met the sediment PRGs. There are expected to be exceedances of PRGs for some individual PAHs at 2 to 5 locations out of 23 locations (i.e., 9 to 22% of the samples), including napthalene (up to 1.7x at PGM-14), phenanthrene (up to 4.7x at PGM-10), pyrene (up to 3.3x at PGM-10), and benzo(a)pyrene (up to 1.3x at PGM-10). There are isolated, low-level exceedances of the PRGs for mercury (one exceedance at 1.2x) and zinc (one exceedance at 1.1x), and no exceedances of lead.
- At Year 10, there will be no exceedances of PRGs in surface sediment. Modeling indicates that the slowest area to recover is the EMNR application at PGM-14, which is projected to meet PRGs in less than 7 years.
- Pyrene is the most stringent of the sediment PRGs for bioaccumulation. At Year 0, the site-wide mean pyrene concentration (736 μg/kg) in surface sediment is well below the sediment bioaccumulative PRG (1,900 μg/kg); however, the 90% UCL on the mean (2,470 μg/kg) is slightly above the PRG. Because the 90% UCL is only 1.3x times the PRG, recovery is expected within a few years. By Year 10, the site-wide mean concentration and 90% UCL are projected to be nearly an order of magnitude lower than the sediment bioaccumulative PRG (the mean and 90% UCL are projected to be 11 percent and 15 percent of the PRG, respectively).
- By achieving surface sediment PRGs, it is expected that TZW and surface water PRGs will be achieved as well, and most likely much sooner. As discussed in Appendix B, sediment PRGs are more difficult to meet than TZW PRGs, and protecting sediment quality drives cap design at this Site. Furthermore, residual risk calculations in sediment do not account for the benefits of GAC applications over large portions of the Site that will reduce porewater concentrations and contaminant bioavailability.
In summary, some potential residual Site risks, primarily associated with PAHs, are expected to be present at the Site for a relatively short period of time (i.e., a few years) over a limited area (initially about 30% of the LOF) following completion of the remedial action. However, the limited residual Site risks are expected to be mitigated through natural recovery processes, and by Year 7, site-related risks are expected to be within acceptable levels throughout the in-water area. Residual risk estimates will be refined in forthcoming remedial design work. With the increase in cap element thicknesses to a minimum of 1 foot and the fact that most of (sand) capping elements will include a GAC amendment, restoration timeframes are, in general, expected to diminish.

10.4 Compliance with Legally-Applicable Requirements

Site work is performed in accordance with State Environmental Cleanup Law (ORS 465.200 et seq.). In general, the selected remedy is in compliance with legally applicable chemical-specific, location-specific, and action-specific requirements. A brief discussion is presented below, while a more complete assessment will be developed in remedial design.

Chemical-Specific Criteria. Cleanup criteria applied at the Site are protective of human and ecological health, and compliant with the Clean Water Act.

Location-Specific Criteria. Endangered Species Act/ Essential Fish Habitat requirements will be determined based on a Site-specific Biological Assessment, and coordination with federal regulatory agencies including NMFS and USFWS. Remediation will occur on property owned by Oregon DSL, and is expected to require a lease agreement for engineering and/or institutional controls. Cultural resources are not expected to be encountered/impacted during in-water work; however, “historical” debris associated with the former PGM gasworks will be encountered. This material is not expected to be NHPA-eligible, but will be given consideration in dredge planning for encountering NHPA-eligible material (inadvertent discovery plan).

Action-Specific Criteria. The Clean Water Act (Section 401 and 404) and Oregon's Water Quality Law would be applicable to in-water activities, specifically limiting or eliminating the release of dredged or fill material during remedy implementation. In water actions will be subject to a USACE permit which will include specifications addressing these criteria.

All dredged material and debris is expected to be disposed of at a Subtitle D or equivalent landfill following dewatering. MGP waste does not have a hazardous waste listing, and is not considered a characteristic hazardous waste based on toxicity [40 CFR §261.24(a); OAR 340-101-0001(2)]. While unlikely, MGP waste may be hazardous if it exhibits ignitable, corrosive, or reactive characteristics. Remedial waste is not expected to qualify as an Oregon special waste. None of the Site COCs are regulated under TSCA.

SECTION 11 - RESPONSE TO PUBLIC COMMENTS

Public comment on the recommended remedial action was initially held from November 1 through 30, 2016. During this period, a request was made by the Yakima Nation for extension of the public comment period an additional 60 days. The extension was granted, and the comment period extended through January 31, 2017.

During the November through January period, comments on the recommended remedy were received
from EPA Region 10, representatives for the Yakima Nation, the Five Tribes (Confederated Tribes of the Grande Ronde Community of Oregon, the Nez Perce Tribe, the Confederated Tribes of Siletz Indians, the Confederated Tribes of the Umatilla Indian Reservation, and the Confederated Tribes of the Warm Springs Reservation of Oregon), and one individual. Comments from EPA and tribal representatives are presented in Appendix C, and DEQ responses in Appendix D. The single citizen comment was received in November 2016, and is “covered” by EPA and tribal comments.

In addition to the DEQ comment responses provided in Appendix D, additional information has been added to a number of sections of the PGM ROD. The primary comment concern of consistency with the Portland Harbor ROD is addressed in Appendix E to this document.

DEQ is confident that the selected remedy for PGM, from the standpoint of residual in-water and upland contamination, is protective of public health and the environment. With implementation of the remedy and ongoing natural recovery, the Agency is confident that the Site will not represent a recontamination threat to the Harbor.

SECTION 12 - FINAL DECISION OF THE REGIONAL ADMINISTRATOR

The selected remedial action for the Portland Gas Mfg. site is protective of present and future public health, safety, and welfare, and of the environment; is based on the balancing of the remedy selection factors; and addresses hot spots of contamination to the extent feasible and necessary. The selected remedial action, therefore, satisfies the requirements of ORS 465-315 and OAR 340-122-0040 and 0090.

12.1 DEQ Signature

__________________________   _____________________________
Nina DeConcini, NWR Administrator   Date
Department of Environmental Quality