DRAFT

WEIR DISCHARGE EVALUATION WORK PLAN

PORT OF PORTLAND TERMINAL 4 EARLY ACTION
PORTLAND, OREGON

Prepared for
Port of Portland
June 7, 2007

Prepared by
Maul Foster & Alongi, Inc.
3121 SW Moody Avenue, Suite 200
Portland, Oregon 97239
Project No. 0288.01.01

Draft
Weir Discharge Evaluation Work Plan
Port of Portland Terminal 4 Early Action
Portland, Oregon

The material and data in this work plan were prepared under the supervision and direction of the undersigned.

Maul Foster & Alongi, Inc.

Neil R. Alongi, PE
Principal Engineer

Ada H. Banasik, EIT
Staff Engineer

CONTENTS

TABLES

Following Work Plan:

Tables

ACRONYMS AND ABBREVIATIONS

AOC	Administrative Order of Consent
ARARs	applicable and relevant or appropriate requirements
°C	degrees Celsius
Anchor	Anchor Environmental, LLC
BBL	Blasland, Bouck, & Lee, Inc.
BMP	best management practice
CDF	confined disposal facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMC	criterion maximum concentration
CMZ	chronic mixing zone
COC	chemical of concern
COE	U.S. Army Corps of Engineers
CORMIX	Cornell Mixing Zone Expert System
DDT	dichloro-diphenyl-trichloroethane
DEQ	Oregon Department of Environmental Quality
Ecology	Washington State Department of Ecology
ELGs	effluent limitation guidelines
IMD	Internal Management Directive
kg/m^3	kilograms per cubic meter
LWG	Lower Willamette Group
MDL	method detection limit
MET	modified elutriate test
$m^{0.67}/s^2$	$meters^{0.67}$ per $second^2$
µg/L	micrograms per liter
OAR	Oregon Administrative Rule
PCB	polychlorinated biphenyl
PH	Portland Harbor
Port	Port of Portland
RMZ	regulatory mixing zone
Testing Manual	USEPA Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S.
TSD	USEPA Technical Support Document for Water Quality-Based Toxics Control

ACRONYMS AND ABBREVIATIONS (Continued)

TSS	total suspended solids
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VP	Visual Plumes
WQC	water quality criteria
ZID	zone of immediate dilution

1 INTRODUCTION

1.1 Background

In December 2000, the U.S. Environmental Protection Agency (USEPA) added the Portland Harbor Superfund Site to the National Priorities List. The Port of Portland (Port) entered into an Administrative Order of Consent (AOC) with the USEPA with ten other potentially responsible parties. The AOC allows for early actions to be conducted to address known contamination at specific locations in the Portland Harbor (PH). Contamination found in the Port Terminal 4 (Lower Willamette River miles 4.1 through 4.5) sediment samples during a remedial investigation directed by the Oregon Department of Environmental Quality (DEQ) led to a determination that a removal action at Terminal 4 is warranted.

The selected removal action includes dredging most of Slip 3 and placing the dredged sediment in a confined disposal facility (CDF) constructed in Slip 1, capping various areas, and monitored natural recovery (USEPA, 2006). The CDF is an engineered structure designed to contain the dredge material and isolate the sediment contaminants from the aquatic environment. The Terminal 4 CDF will consist of an earthen berm at the mouth of Slip 1, including a CDF overflow weir, layers of dredge materials, and a surface cap.

As the dredge material is placed in the CDF via hydraulic dredge, large volumes of water are expected to be mixed in with the sediment. As the sediment settles out, the supernatant water and groundwater will discharge through the berm. Occasionally, during Slip 3 dredging, supernatant water may also discharge through a CDF overflow weir structure. The discharges through the weir are expected to be relatively short-term in duration (see Section 4.2). After the CDF is completed to grade with the surface cap, the CDF is designed to allow groundwater movement through the earthen berm for the life of the CDF.

1.2 Water Quality Compliance Approach

Because the Terminal 4 Early Action is being conducted pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulations, all on-site actions are exempt from acquiring permits. Preliminary identified applicable and relevant or appropriate requirements (ARARs) for the USEPA-selected alternative must be complied with to the extent practicable. Section 401 of the Clean Water Act and the Oregon water-quality standards were determined by the USEPA to be potentially applicable to discharges related to dredging and capping activities (USEPA, 2006). This work plan outlines an approach to demonstrate compliance of the weir discharge with applicable water quality standards, as follows:

Step 1. The Weir Discharge Evaluation Study will first establish potential highest and best practicable engineering and operational controls and best management practices (BMPs) based on anticipated effluent characteristics (water quality, duration of discharge, etc.). Various potential BMPs and practicable engineering and operational controls will be defined and will be evaluated in terms of effectiveness, practicability, and cost.

Step 2. Evaluate the weir effluent to determine whether the discharge through the weir has a reasonable potential to exceed water-quality criteria (WQC) at the end of pipe.

- Estimate volumes and flow rates of weir discharge over the duration of Slip 3 dredging.
- Estimate the total suspended solids (TSS) concentrations inside the CDF at the point of weir overflow.
- Estimate the water quality (chemicals of concern [COCs] concentrations) inside the CDF at the point of weir overflow.
- Screen estimated weir end-of-pipe COCs concentrations against applicable WQC.

As discussed in Section 4, a preliminary finding is that the weir discharge has reasonable potential to exceed the applicable WQC. A reasonable potential analysis (RPA) will be completed, in accordance with DEQ's *Reasonable Potential Analysis for Toxic Pollutants Internal Management Directive* (IMD), to confirm the preliminary finding (Fitzpatrick and Nusrala, 2005). Additional MET analysis is being conducted and these results will be evaluated to confirm the initial results.

Step 3. Conduct Mixing Zone Analysis – The mixing zone analysis is an iterative process that helps evaluate the potential BMPs, operational and engineering controls that may be needed at the site. The analysis includes testing the sensitivity of various discharge conditions (e.g., outfall size and orientation) on mixing and dilution in the Willamette River. The mixing zone analysis will follow the approach outlined below:

- Determine level of regulatory mixing zone (RMZ) information needed per the DEQ *Regulatory Mixing Zone Draft Internal Management Directive* (DEQ, 2006).
- Define receiving water (i.e., ambient) conditions.
- Define discharge characteristics such as flow, temperature, and density.
- Conduct mixing zone modeling.
- Prepare environmental mapping of the proposed outfall area.
- Prepare report of findings.

1.3 Purpose of Work Plan

The purpose of this work plan is to present a proposed approach to evaluating the weir discharge, including the following:

- Describe approach for identifying and evaluating best practicable engineering and operational controls.
- Describe and evaluate available mixing-zone models and identify the model to be used to calculate the available dilution.
- A description of the mixing-zone modeling approach.
- A summary of the outfall configurations to be modeled.
- A list of contaminants to be modeled.
- A summary of ambient and effluent model input parameters and values.

2 BEST PRACTICABLE TREATMENT/CONTROL

2.1 Approach

The DEQ has established a requirement for "best practicable treatment and/or control" of discharges as part of the water-quality rules (Oregon Administrative Rule [OAR] 340-41-0007[1] Statewide Narrative Criteria). As it applies to industrial discharges, this requirement is addressed in the state of Oregon through the application of BMPs, which can include operational controls and practices, as well as treatment. For industrial discharges that do not have USEPA-established effluent limitation guidelines (ELGs), best professional judgment is used to establish the appropriate technology-based effluent limitations (DEQ, 2006).

Water-balance calculations and modeling have been completed in order to estimate the volumes and durations of potential discharges through the CDF weir. The predicted short-term duration of the weir discharge (i.e., less than two days) is based on conservative assumptions and should be considered, along with industry economic and engineering practices, in the selection of BMPs that could reasonably be considered as practical to apply to the CDF operation and the weir discharge.

The Port is evaluating various BMPs to meet the intent of the rules and minimize the concentrations of potential contaminants in the effluent prior to discharge. To further protect water quality in the Willamette River, the Port will use the information developed as part of this evaluation to optimize the design of the outfall and assist in defining operational BMPs for the CDF. Some examples of potential BMPs that have already been identified for further evaluation are discussed in the following sections.

2.2 Potential Operational Best Management Practices

2.2.1 Weir Invert Elevation

The weir invert elevation can be set higher (e.g. more than 15 feet) than the river stage elevation typical during filling of the CDF (July through October). This BMP will increase the ponding depth and residence time inside the CDF, maximizing the settling potential of suspended solids. It will direct most (if not all) of the CDF water to discharge through the CDF earthen berm, utilizing the filtering capacity of the berm, avoiding or minimizing weir overflow altogether.

2.2.2 Type of Diffuser

The Contractor can use a special diffuser, which reduces the energy of the dredge slurry during discharge, lowering the amount of mixing with the water column. These types of diffusers commonly have a 90 degree bend and discharge below the water column closer to the sediment bed reducing the travel distance in the water column.

2.2.3 Location of Dredge Discharge Diffuser

Hydraulic dredging and/or the unloading of dredge materials from barges will result in the discharge of sediment-laden water into the CDF. Sediment will begin to settle out immediately after discharge. Maximizing the residence time of the supernatant water inside the CDF will result in improved water quality prior to a potential weir discharge. Based on conditions during dredging operations, the dredge discharge diffuser may be moved to the back of the CDF (i.e., away from the CDF berm and weir discharge point) during and immediately prior to any weir discharges in order to increase residence time and settling inside the CDF.

2.2.4 Manage Weir Discharge Operational Hours

Low ambient receiving water currents, sometimes caused by tidal influence, could create a worst-case scenario for mixing and if discharges during low flow conditions can be minimized, water quality impacts may be lessened. Therefore, in the event that a discharge through the weir is warranted or anticipated, it may be beneficial to discharge during specific hours of the day during which ambient flow is favorable, so that the need to discharge during critical ambient flow conditions may be avoided. Modeling of the mixing conditions in the receiving water will provide guidance for this potential BMP.

If the CDF capacity is close to being exceeded during the critical low ambient flow conditions, the dredging rate and hours of operation may be adjusted to temporarily reduce the volume of dredge filling and the immediate need for discharging through the weir during the critical ambient (river) conditions.

Control of dredge operational hours may also be considered as a BMP to allow discharge through the berm in lieu of a discharge through the weir. This BMP could be useful under a variety of conditions to maintain water-quality compliance.

2.2.5 Manage Weir Discharge Rates

The rate of gravity-discharge through the weir could vary from very low to significant flows depending on the dredging operations and the discharge through the CDF earthen berm. A potential BMP could incorporate pumping or otherwise managing the discharge through the weir to control the effluent flow at a rate that is most beneficial for mixing.

The optimum effluent flow rate will be determined by mixing-zone modeling, as described in subsequent sections.

2.3 Potential Treatment Best Management Practices

2.3.1 Add Baffle Curtains

Since the retention time within the CDF has a direct impact on CDF water quality, the CDF interior could be equipped with movable baffle curtains, similar to baffles inside of water-quality vaults. The baffles would result in a more circuitous path for the water and improve water quality by preventing short-circuiting of the flow. This BMP may be more applicable when it is necessary to deposit dredge sediment in locations closer to the weir outlet structure.

2.3.2 Provide Treatment for Suspended Solids

A flocculation-enhancing polymer could be mixed into the CDF water destined for weir discharge to enhance settling. This approach could be used in addition to the baffles so that the clarified water from inside the CDF would flow circuitously toward the weir discharge point. This treatment BMP would enhance sedimentation inside the CDF, resulting in lower effluent concentrations for particulate-borne contaminants and TSS. The practicality of this option needs to be considered against the short-term duration of the discharges through the weir.

2.3.3 Provide Treatment for Dissolved Constituents

Although, in theory, elutriate water could be treated to reduce effluent contaminant concentrations using more intensive treatment methods such as electrocoagulation or physical-chemical treatment, the practicality of these options needs to be considered against the short-term duration of the discharges through the weir.

2.4 Best Management Practices Approach

Along with additional BMPs that could be identified and determined “practicable”, the potential BMPs will be developed into a response hierarchy that can be implemented depending on the conditions within the CDF, ambient conditions, and the dredging operations. Water-quality monitoring within the CDF will provide guidance to determine which BMPs could be implemented to improve effluent water quality.

3 MIXING-ZONE MODELS

3.1 Regulatory Mixing Zones

Section 401 of the Clean Water Act requires that all discharges, including dredge-related discharges, into waters of the United States must be certified as complying with applicable water quality standards. Chapter 40 of the Code of Federal Regulations 230.10(b) states that "no discharge of dredge or fill material shall be permitted if it: (1) Causes or contributes, after consideration of disposal site dilution and dispersion, to violations of any applicable State water quality standard." WQC therefore apply after consideration of dilution and dispersion.

Oregon's mixing zone rule, OAR 340-041-0053, is a component of Oregon's water quality standards. As defined by OAR 340-041-0053, a RMZ is an area where the discharge undergoes dilution and mixing in the receiving stream and WQC are suspended or lessened, provided that the integrity and uses of the receiving water body as a whole are protected.

The below description of RMZs and mixing processes is based on the guidance presented in the DEQ RMZ IMD (DEQ, 2006). A RMZ consists of a chronic mixing zone (CMZ) and may also include a zone of immediate dilution (ZID). The ZID is an area immediately around the outfall and within the CMZ where numerical acute WQC, or criterion maximum concentration (CMC), may be exceeded. The CMC must be met at the edge of the ZID. The ZID, or "acute mixing zone," is a component of the RMZ. The CMZ is the area encompassed by the entire RMZ. Chronic WQC for protection of aquatic life, or the criterion continuous concentration, may be exceeded inside the CMZ, but must be met at the edge and outside of the CMZ limits.

The mixing behavior of a discharge plume is governed by the interaction of ambient conditions and effluent/discharge conditions. Ambient conditions in the receiving body include bathymetry around the outfall (e.g., width, depth, and vertical cross-sectional area), ambient velocity, temperature, and density distribution. Ambient (background) contaminant concentrations are also considered. Discharge conditions include outfall configuration (e.g., size, orientation, depth) and effluent characteristics (e.g., effluent flow, temperature, density). Effluent contaminant concentrations will be used to design the outfall structure, based on the dilution necessary to meet WQC at the edge of the mixing zone.

The mixing process is described by two distinct regions: near-field and far-field. Discharge conditions control the mixing process in the near-field (i.e., initial dilution) region. Ambient conditions control the mixing process in the far-field region, characterized by the longitudinal dispersion of the plume by the ambient current.

Plume contact with a boundary condition inhibits mixing, since water is not available for mixing on all sides of the plume. Instabilities in the near-field caused by surface or bottom interactions can cause re-entrainment and a build-up of pollutant concentrations, reducing the amount of dilution occurring. Therefore, boundary interaction is a critical process to be modeled.

3.2 Mixing Zone Models

Two mixing-zone models, USEPA Visual Plumes (VP) and the Cornell Mixing Zone Expert System (CORMIX), were evaluated for dispersion and dilution modeling of the CDF weir discharge. A discussion of each model is presented below.

3.2.1 Visual Plumes

The description below of VP is partially based on the VP Manual titled ***Draft Dilution Models for Effluent Discharges, 4th Edition*** (Frick et al., 2001) and the Washington State Department of Ecology's (Ecology) ***Permit Writer's Manual*** (Bailey, 2004).

VP is a Windows-based software application for simulating single and merging submerged aquatic plumes in arbitrarily stratified ambient flow and buoyant surface discharges. VP supports five models for near-field simulation: UM3; DKHW; PDS; NRFIELD; and DOS PLUMES. The Brooks far-field algorithm is used to simulate far-field behavior.

UM3 is a three-dimensional Lagrangian integral model for simulating near-field behavior of steady-state single- and multi-port submerged discharges. The model quantifies the rate at which mass is incorporated into the plume in the presence of an ambient current and calculates the flux-average dilution, plume trajectory, size, and pollutant concentrations in the near-field region. UM3 performs sequential calculations of both dilution and plume distance from the outfall until initial dilution is completed. The output is used to evaluate the dilution, plume size, and pollutant concentrations at the edge of the ZID. Far-field behavior must be modeled with a subsequent far-field model to calculate the dilution and plume size at the RMZ boundary.

DKHW uses a fourth-order Eulerian integration routine along the centerline of the effluent plume to predict average dilution, plume trajectory, size, and pollutant concentrations in the near-field region. DKHW is limited to positively buoyant plumes and is therefore not applicable for the discharges from the CDF weir, which are expected to be negatively-buoyant, due to the high suspended-solids content relative to the receiving water.

PDS is a three-dimensional plume model for surface discharges and is therefore not applicable for the discharges through the weir. NRFIELD is an empirical model for multi-port diffusers (i.e., at least four ports must be specified), based on experimental studies on multi-port diffusers in stratified currents. It is unlikely that the weir-discharge outfall design will include more than four diffuser ports; therefore, this model is not applicable. DOS PLUMES is the direct predecessor of VP that is linked to VP to allow importing of previously developed files into VP and utilization of some of the DOS PLUMES unique capabilities within VP (e.g., developing numerical relationships between variables).

The Brooks far-field algorithm is a simple dispersion calculation that is a function of travel time and initial waste-field width. It can incorporate time-dependent parameters (i.e., time series), making it useful, valuable for estimating the effect of highly variable systems, such as bacteria decay, and far-field behavior.

The UM3 model and the Brooks algorithm are potential models to use for the CDF weir discharge evaluation. UM3 may be used to simulate initial dilution (near-field), and the Brooks algorithm may be used to model the far-field dilution.

3.2.2 Cornell Mixing Zone Expert System

The description below of CORMIX is partially based on the CORMIX Manual (Jirka et al., 1996) and Ecology's *Permit Writer's Manual* (Bailey, 2004).

CORMIX is a software system for the analysis and prediction of point-source discharge plumes into various water bodies, assuming steady-state conditions. It is an empirical model based on experimentally-derived curve fit equations that predict dilution and verify the accuracy of theoretical models. The model emphasizes prediction of the near-field geometry and dilution, although it also predicts the behavior of the discharge plume beyond initial mixing (i.e., far-field). The CORMIX system consists of three subsystems: CORMIX1, CORMIX2, and CORMIX3.

CORMIX1 predicts plume geometry and dilution for submerged single-port outfall configurations assuming a rectangular receiving water cross section. CORMIX1 predicts near-field and far-field plume trajectory, shape, pollutant concentration, and dilution. The outfall is assumed to be near the bottom (i.e., port elevation should not exceed one-third of total water depth) of the water body; therefore, CORMIX1 should be used with caution, and it may be necessary to modify some parameters (e.g., port elevation) for near-surface discharges and positively buoyant plumes. CORMIX1 is capable of modeling a wide variety of discharge conditions, including boundary interactions, such as bottom attachments and shoreline contact. CORMIX1 is a potential model for the CDF weir discharge evaluation.

CORMIX2 predicts plume geometry and dilution for submerged multi-port outfall configurations. CORMIX2 may be used to model the CDF weir discharge only if the preliminary outfall design is revised to include multiple diffusers. CORMIX3 models the mixing behavior of buoyant surface discharges and is therefore not applicable for modeling of the CDF weir discharges.

3.3 Model Evaluation and Selection

CORMIX and VP use similar integral approaches to simulate near-field mixing in a stable-discharge condition (i.e., strong buoyancy, weak momentum, and deep water) without near-field boundary interactions/attachment and where density-current mixing is not relevant. In these cases, both methods will give similar near-field dilution estimates.

One advantage of using CORMIX is that the model considers the effect of boundary interactions on the mixing processes in the near-field. CORMIX accounts for vertical (e.g., river bottom and water surface) and lateral (e.g., shoreline) boundaries through schematization, a process of describing a receiving water body's actual geometry with a rectangular cross section, to account for vertical and lateral boundaries.

Because of the absence of schematization, VP does not address the effects of boundaries (e.g.; shorelines) on mixing or on discharge stability in the near-field and assumes that the ambient water body is infinite with no boundary near the outfall.

Additionally, CORMIX simulates density-current mixing in the far-field. Density currents are gravity- and buoyancy-driven far-field flows that collapse into thin horizontal layers and resist the transition to passive diffusion. In passively diffusing flows, the turbulence in the ambient environment becomes the dominating mixing mechanism in the far-field and the plume grows in width and in thickness until it interacts with a boundary. CORMIX uses length-scale methods to simulate upstream buoyant intrusions while density-current flows are simulated with an integral model approach.

VP does not consider the existence of density-current mixing and that assumes passive diffusion always occurs after the completion of near-field mixing. Whereas a density current will vertically collapse within a thin layer, a passive diffusion process can only increase in vertical plume dimension.

Based on the above discussion, it is anticipated that CORMIX will be used to evaluate the discharge.

4 PROPOSED MODELING APPROACH

4.1 Applicable Water Quality Criteria

According to Section 1 of the USEPA/COE *Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S.* (Testing Manual):

> For dredged material discharges which only occur periodically, water quality standard compliance in the mixing zone is generally focused on aquatic life, not on human health, which is based on long-term exposures to contaminants…Acute or chronic standards may be appropriate, depending on the duration of discharge and characteristics of the discharge site (USEPA and COE, 1998).

Although the Slip 3 dredge material will not be discharged directly into the receiving water, the durations of the potential discharges through the CDF weir are comparable to the above-mentioned short-term duration of direct dredge-material discharges. Slip 3 dredging and related CDF filling operations are expected to last approximately 11 days, assuming relatively high dredging rates (Anchor Environmental, LLC [Anchor], 2006). Weir discharges are expected not to occur at all or to occur only during a short portion of the Slip 3 hydraulic dredging activity, and will therefore be relatively short-term at the most (i.e., water-balance calculations and modeling estimate weir discharge durations at less than two days). It is possible, although unlikely, that the weir discharges will last longer than 96 hours (i.e., four days).

Based on the predicted discharge durations, only WQC for protection of aquatic life are applicable to this type of discharge. Predicted effluent concentrations will be screened against acute (i.e., less than 96-hour discharge) and chronic (i.e., longer than 96-hour discharge) WQC, as listed in OAR Tables 20, 33A, and 33C. For those parameters not listed in OAR Tables 20, 33A, and 33C, USEPA National Recommended Water Quality Criteria values will be used. USEPA National Recommended Water Quality Criteria that are more stringent than the OAR table values will also be evaluated. The numerical acute and chronic WQC are presented in Table 4-1, following this work plan.

As stated in the USEPA/COE Testing Manual (USEPA and COE, 1998), human-health criteria are not applicable for this short-term duration discharge, since the numerical human-health criteria listed in the state and federal regulations are risk-based values calculated assuming long-term (e.g., 70 years) exposure rates.

4.2 Chemicals of Concern

COCs in Terminal 4 sediment were identified and are discussed in detail in the following documents:

- USEPA Portland Harbor Sediment Investigation Report (Weston, 1998)
- Willamette River Channel Maintenance Characterization Study (COE, 1999)
- Remedial Investigation Report, Terminal 4, Slip 3 Sediments (Hart Crowser, 2000)
- Terminal 4 Early Action Engineering Evaluation and Cost Analysis (Blasland, Bouck, & Lee, Inc. [BBL], 2005)
- Design Analysis Report (Prefinal 60 Percent Design Deliverable), Terminal 4 Early Action (Anchor, 2006)

A MET was completed by Anchor (Anchor, 2006) to predict contaminant concentrations in the CDF weir effluent at the point of discharge (end of pipe). Table 4-1, following this work plan, shows the results of the MET. Additional MET analysis will be conducted and this data will be incorporated into the weir discharge evaluation.

4.2.1 Weir-Discharge Evaluation Approach

The weir-discharge evaluation approach is based primarily on the tiered approach described in the USEPA Testing Manual (USEPA and COE, 1998) and the USEPA *Technical Support Document for Water Quality-Based Toxics Control* (TSD) (USEPA, 1991). The mixing-zone modeling approach is largely based on the DEQ RMZ IMD (DEQ, 2006).

The purpose of the weir-discharge evaluation is to assess compliance with applicable water quality standards. The USEPA Testing Manual presents a tiered approach in evaluating whether discharges from CDFs will meet applicable water quality standards. Tier I is a comprehensive analysis of all existing and readily available, assembled, and interpreted information on the dredging project, including all previously collected physical, chemical, and biological monitoring data and testing for both the dredged-material excavation site and the proposed disposal site.

Tier II incorporates an initial evaluation of water-column effects based on bulk sediment chemistry, assuming that all of the contaminants in the dredged material are released into the water column during the discharge operations. This is a conservative assumption, since most of the contaminants remain with the dredge material. However, the analysis is performed because if the bulk sediment data comply with applicable WQC, no further analysis is necessary.

In the event that bulk sediment data exceed applicable WQC, as is the case for certain COCs in the Slip 3 sediment, an elutriate test is performed to estimate the concentrations of contaminants in the CDF elutriate (i.e., supernatant water that may be discharged through the CDF weir). The elutriate concentrations, representing estimated effluent concentrations at the end of pipe, are then screened against applicable WQC. Table 4-1, following this work plan, shows elutriate concentrations and applicable WQC. Additionally, column-settling tests are performed and the results are modeled to estimate the suspended-solids concentrations in the supernatant water, based on the CDF design ponding depth and surface area.

If the elutriate concentrations meet applicable WQC at the end of pipe, a mixing evaluation is not necessary. Otherwise, dilution calculations are performed for each pollutant that exceeds applicable WQC. According to Appendix C of the USEPA Testing Manual (USEPA and COE, 1998), a mixing evaluation need only be made for the contaminant requiring the greatest dilution to meet the applicable WQC. However, to fully evaluate the weir discharge, mixing-zone modeling will be completed to calculate dilution for copper, lead, total dichloro-diphenyl-trichloroethane (DDT), and polychlorinated biphenyls (PCBs) (i.e., the COCs that may exceed WQC at the end of pipe).

Ambient and discharge parameter values (see Section 5) will be input into the mixing-zone model to yield dilution ratios at the edge of the ZID and CMZ. The value of the weir outfall modeling effort is the ability to test a variety of outfall designs and optimize the design to provide the necessary dilution (see Section 4.3 below). The results of the mixing-zone modeling will be summarized in a mixing-zone study report, which will evaluate whether WQC will be met at the edge of the RMZ. The mixing-zone study report will include environmental mapping showing the location of the outfall and extent of the plume, a description of the outfall and plume/mixing behavior, a summary of ambient conditions and discharge characteristics (i.e., model inputs), and mixing-zone modeling results and analysis.

4.3 Outfall Location and Configuration

The location of the outfall within the receiving water body has a significant effect on the size and behavior of the mixing zone. Various outfall locations will be modeled to ensure that the mixing zone is sized to provide adequate dilution and avoid sensitive and/or impractical areas.

Alternative outfall and diffuser configurations will be modeled to investigate the mixing behavior and performance and aid in completion of the final design of the outfall structure. This approach is an iterative process that allows evaluation of a number of configurations and ultimately will identify the most advantageous, while practical, outfall design that generates rapid initial dilution and minimizes the size of the RMZ.

4.4 Sensitivity Analysis

Understanding model predictions and exploring the sensitivity of model results to input assumptions is critical to modeling, since slight changes in certain input parameter values can yield significantly different results. A sensitivity analysis is performed by changing one input variable at a time and evaluating its effect on model results. The analysis will show the effect of various ambient (e.g., critical flow velocities) and discharge (e.g., outfall size and orientation) conditions on mixing, examine the impact of assumptions on results, and evaluate whether boundary conditions will have an effect on mixing. Additionally, the results of the sensitivity analysis will be used to design the outfall to maximize dilution and minimize water quality impacts.

5 MODEL INPUT PARAMETERS AND VALUES

Ambient and discharge/effluent model input parameters and values were determined in accordance with the guidance presented in the DEQ RMZ IMD (DEQ, 2006) and the USEPA TSD (USEPA, 1991).

5.1 Ambient Input Parameters and Values

Ambient input parameters include the geometric and dynamic characteristics of a receiving water body (i.e., Willamette River) that impact mixing-zone processes. These include river bathymetry (i.e., width and depth), vertical cross sections, Manning's roughness coefficient, ambient (background) contaminant concentrations, ambient velocity, density, temperature, and salinity.

5.1.1 Critical Ambient Conditions

RMZs must be modeled under reasonable potential critical flow conditions in the water body to ensure that impacts to receiving waters are minimal and beneficial uses are protected. The applicable critical ambient conditions represent hydraulic conditions that result in worst-case mixing, depending on the type of WQC being evaluated. In river systems, worst mixing typically occurs during low-flow conditions. The DEQ IMD (DEQ, 2006) recommends using the lowest one-day flow with an average recurrence frequency of once in ten years (1Q10) for acute toxicity in the ZID, and the lowest average seven-consecutive-day low flow with an average recurrence frequency of once in ten years (7Q10) for chronic toxicity in the CMZ.

Long-term human-health impacts for continuous discharges (e.g., municipal treatment plants) are typically evaluated on a longer-term flow statistic: the lowest average 30-consecutive-day low flow with a recurrence interval of five years (30Q5) for non-carcinogenic criteria and the harmonic mean flow for carcinogenic criteria. However, since the discharges through the CDF weir will be short in duration, as discussed in Section 4.2, the long-duration human-health flow statistics and human-health WQC are not applicable.

Critical flow values are based on U.S. Geological Survey (USGS) Willamette River Station Number 14211720 mean daily stream flow measurements, recorded between October 1, 1972, and April 25, 2007 (USGS, 2007). Statistical critical flow values were calculated using DFLOW 3.1, a Windows-based software tool developed to estimate design stream flows for low-flow analysis utilizing downloaded USGS data files. Calculated critical flow values are presented in Table 5-1, following this work plan.

Bathymetric cross-sectional areas were computed using bathymetric survey data collected by the Lower Willamette Group in February 2004. Cross sections at related critical flow river stage were used to calculate ambient velocities at specific low-flow conditions.

5.1.2 Ambient Concentrations and Ambient Properties

Ambient (i.e., surface water) contaminant concentration data is available from a variety of sources. Water-quality data from USGS Station 14211720 (i.e., downtown Portland at the Morrison Bridge) and from the Lower Willamette Group (LWG) was evaluated for use in the weir discharge evaluation to establish background COCs concentrations, in accordance with the DEQ *Reasonable Potential Analysis for Toxic Pollutants Internal Management Directive* (Fitzpatrick and Nusrala, 2005).

For aquatic-life protection and COCs with three or more sample results, the 90th percentile concentration value is recommended as background. For aquatic-life protection and COCs with fewer than three sample results, the maximum detected concentration is recommended. In the event that all sample results do not show detected concentrations above the method detection limit (MDL), the highest MDL should be used to represent the ambient concentration. A summary of the ambient (i.e., background) COCs concentrations is presented in Table 5-2, following this work plan.

5.1.2.1 United States Geological Survey Data

USGS Station 14211720 is located downtown Portland, at the Morrison Bridge, several miles upstream of the Port. The USGS Station 14211720 water-quality data set is a record of numerous sampling events collected between 1974 and 2005. The data set for metals is relatively extensive, however, the data set for organic parameters (e.g., DDT, PCBs) is relatively limited in number of samples and outdated (i.e., most recent results are from 1997) and is therefore not necessarily representative of current ambient concentrations.

However, the USGS Station 14211720 temperature-monitoring data is extensive (i.e., 150 July through October ambient temperature measurements are on record), relatively recent (i.e., through summer of 2005) and is therefore applicable to use for average ambient temperature calculations. The average daily ambient temperature recorded between July and October (the season during which dredging will occur) of each year on record was used to calculate the mean summer temperature. The average summer temperature was calculated to be 19.4 degrees Celsius (˚C).

Ambient water density corresponding to the ambient temperature of 19.4˚C is 998 kilograms per cubic meter (kg/m^3), assuming physical properties of pure water.
The ambient salinity is assumed to be zero.

5.1.2.2 Lower Willamette Group Data

Ambient water-quality data is also available from the LWG. The LWG database includes surface-water water-quality data collected from 2004 to 2005 from various locations in and around the PH. The LWG water-quality data is more recent and incorporates the results of surface water sampling in close vicinity to the Port project site. Therefore, the LWG data set is likely more representative of current ambient conditions.

Surface water COC data from samples collected at Willamette River water-column transect locations (i.e., LWG sampling locations W005, W011, and W023) was used to calculate ambient (i.e., background) concentrations. Surface-water data from near-shore locations was not included, as the near-shore concentrations represent localized water-quality impacts and are therefore not appropriate for ambient-concentrations calculations. The results of three sampling events are available for each of the above three river transect sampling locations. Therefore, nine sample results were available for each COC and the background concentration for each COC was assumed to be equal to the maximum detected COC concentration. A summary of the ambient (i.e., background) COCs concentrations is presented in Table 5-2, following this work plan.

5.1.3 Ambient Coefficient Values

The DEQ RMZ IMD recommends using a Manning's roughness coefficient of 0.035 for the Willamette River (DEQ, 2006).

Far-field diffusion coefficient of 0.0003 meters$^{0.67}$ per second^2 ($m^{0.67}/s^2$) will be input into the initial model, although more conservative values (0.0001 $m^{0.67}/s^2$ - low turbulence) and less conservative values (0.0005 $m^{0.67}/s^2$ - high turbulence) will be evaluated as part of the sensitivity analysis (Frick et al., 2001). Far-field diffusion coefficient of 0.0003 $m^{0.67}/s^2$ is considered to be a default value for modeling, although for water bodies with high energy dissipation and where there are no constraints (e.g., large and deep embayment), a value of 0.000453 $m^{0.67}/s^2$ is commonly used.

5.2 Effluent Input Parameters and Values

Discharge input parameters include the geometric and flux characteristics of an outfall structure that affect mixing processes. These include outfall diameter and cross-sectional area, outfall elevation above the river bottom and orientation with respect to ambient flow, predicted effluent COC concentrations, effluent discharge flow rate, temperature, and density.

5.2.1 Effluent Flows and Outfall Geometric Configuration

Initially, the preliminary design discharge configuration will be modeled with a 17-inch diameter outfall, a horizontal discharge perpendicular to the ambient flow, and outfall centerline located 1.5 feet above the river bottom. Several alternate outfall configurations will be modeled to determine if improvements in dilution would result from a redesign (see Section 4.4).

The discharge flow will vary for a gravity weir structure from just above zero up to some maximum predicted flow. The maximum hydraulic dredge output is estimated to be approximately 25 cubic feet per second. The maximum weir flow will be based on the maximum dredge rate minus a conservatively estimated low flow through the CDF berm. Detailed CDF water-balance calculations are currently under way to estimate the potential range of discharge flows. Additionally, the Port may consider pumping the weir effluent at a constant rate, if the model results show that such a design would be beneficial to mixing and dilution. It is anticipated that critical conditions for mixing will likely occur at lower discharge rates due to lower discharge velocities, which can result in poorer mixing. A range of flows will be modeled to determine the critical discharge condition and to aid in outfall design and operational recommendations.

5.2.2 Effluent Concentrations and Effluent Properties

Effluent concentrations are based on the COC concentrations predicted by the MET completed by Anchor (Anchor, 2006) and presented in Table 4-1, following this work plan. Table 4-1 will be updated with the new MET results, following agency approval. The USEPA Testing Manual recommends using dissolved concentrations in effluent evaluations, since the dissolved fractions are more readily available to aquatic life and because WQC are expressed in terms of dissolved concentrations (USEPA and COE, 1998).

Weir effluent temperature is assumed to be 1˚C higher than the ambient temperature (20.4 ˚C). Slightly higher and lower effluent temperatures will also be modeled to evaluate model sensitivity to the effluent temperature assumption.

Water density corresponding to the effluent temperature of 20.4˚C is 998 kg/m^3. However, effluent density has to take into account the estimated concentration of total suspended solids (1,113 milligrams per liter—see Table 3-1, following this work plan) in the effluent. The effluent density will be adjusted to account for the suspended-solids content.

LIMITATIONS

The services described in this work plan were performed consistent with generally accepted professional consulting principles and practices. No other warranty, express or implied, is made. These services were performed consistent with our agreement with our client. This work plan is solely for the use and information of our client unless otherwise noted. Any reliance on this report by a third party is at such party's sole risk.

Opinions and recommendations contained in this work plan apply to conditions existing when services were performed and are intended only for the client, purposes, locations, time frames, and project parameters indicated. We are not responsible for the impacts of any changes in environmental standards, practices, or regulations subsequent to performance of services. We do not warrant the accuracy of information supplied by others, nor the use of segregated portions of this work plan.

REFERENCES

Anchor. 2006. Design analysis report (prefinal 60 percent design deliverable), Terminal 4 early action, Port of Portland, Portland, Oregon. Anchor Environmental, LLC, Portland, Oregon. December.

Bailey, G. 2004. Water quality program permit writer's manual. Washington State Department of Ecology, Olympia, Washington. July.

BBL. 2005. Terminal 4 early action engineering evaluation/cost analysis, public review draft. Blasland, Bouck, & Lee, Inc., Port of Portland, Portland, Oregon.

COE. 1999. Willamette River sediment data—1997 CRCD project. U.S. Army Corps of Engineers.

DEQ. 2006. Regulatory mixing zone draft internal management directive. Parts 1 and 2. Oregon Department of Environmental Quality. April.

Fitzpatrick, M., and Nusrala, J. 2005. Reasonable potential analysis for toxic pollutants internal management directive. Oregon Department of Environmental Quality. September.

Frick, W. E., P.J.W. Roberts, L. R. Davis, J. Keyes, D. J. Baumgartner, and K. P. George. 2001. Draft dilution models for effluent discharges. 4th ed. (Visual Plumes). U.S. Environmental Protection Agency Environmental Research Division, Office of Science and Technology, Athens, Georgia. July 18.

Hart Crowser. 2000. Remedial investigation report, Terminal 4, Slip 3 sediments, Port of Portland, Portland, Oregon. Hart Crowser. April 18.

Jirka, G. H., R. L. Doneker, and S. W. Hinton. 1996. User's manual for CORMIX: a hydrodynamic mixing zone model and decision support system for pollutant discharges into surface waters. Cornell University, Ithaca, New York. September.

USEPA. 1991. Technical support document for water quality-based toxics control. U.S. Environmental Protection Agency, Washington DC. March.

USEPA and COE. 1998. Evaluation of dredged material proposed for discharge in waters of the U.S.—inland testing manual. U.S. Environmental Protection Agency and U.S. Army Corps of Engineers. Washington DC. February.

USEPA. 2006. Action Memorandum for a Removal Action at the Port of Portland Terminal 4 site within the Portland Harbor Superfund Site, Portland, Multnomah County, Oregon. U.S. Environmental Protection Agency. May 11.

USGS. 2007. National water information system. U.S. Geological Survey. http://waterdata.usgs.gov/or/nwis/. April 26.

Weston, 1998. Portland Harbor sediment investigation report. Multnomah County, Oregon. Roy F. Weston, Inc.

TABLES

Table 4-1
Modified Elutriate Test Effluent Concentrations
Port of Portland Terminal 4 Early Action
Portland, Oregon

Parameter	Freshwater Criteria			Elutriate Concentrations [1]		Ambient Concentration [2]
	Acute	Chronic	Notes	Total	Dissolved	
Conventionals (mg/L)						
Total Suspended Solids				1,113	5 U	25
Metals (µg/L)						
Arsenic	340	150	[5]	15.5	2.6	
Cadmium*	0.52	0.09	[5]	2.05	0.01 U	
Chromium*	183	24	[5]	118	3.4	
Copper*	3.6	2.7	[5]	250	15.9	0.83
Lead*	13.9	0.5	[6]	178	4.7	0.03
Mercury	1.4	0.77	[6]	0.60	0.04 U	
Nickel*	145	16	[5]	89	2.6	
Silver*	0.3	1	[5]	2.0	0.2	
Zinc*	36.2	36	[6]	573	13	
Semivolatile Organics (µg/L)						
Naphthalene	807	194	[7]	0.064 UJ	0.064 U	
2-Methylnaphthalene	300	72	[7]	0.054 UJ	0.054 U	
Acenaphthylene	1,277	307	[7]	0.09 J	0.11 J	
Acenaphthene	233	56	[7]	0.10 J	0.43	
Fluorene	162	39	[7]	0.39 J	0.11 J	
Phenanthrene	79	19	[7]	0.27 J	0.064 U	
Anthracene	87	21	[7]	0.05 J	0.021 U	
Fluoranthene	30	7.1	[7]	0.46 J	0.17 J	
Pyrene	42	10	[7]	0.85 J	0.10 J	
Benz(a)anthracene	9.2	2.2	[7]	0.11 J	0.042 U	
Chrysene	8.3	2.0	[7]	0.17 J	0.025 U	
Benzo(b)fluoranthene	2.8	0.68		0.39 J	0.390 U	
Benzo(k)fluoranthene	2.7	0.64		0.09 J	0.390 U	
Total benzofluoranthenes				0.50 J	0.039 U	
Benzo(a)pyrene	4.0	0.96	[7]	0.39 J	0.032 U	
Indeno(1,2,3-cd)pyrene	1.2	0.28	[7]	0.042 UJ	0.042 U	
Dibenz(a,h)anthracene	1.2	0.28	[7]	0.033 UJ	0.033 U	
Benzo(g,h,i)perylene	1.8	0.44	[7]	0.074 UJ	0.074 U	
Dimethyl phthalate				0.26 UJ	0.26 U	
Diethyl phthalate				0.29 UJ	0.29 U	
Di-n-butyl phthalate				0.37 UJ	0.37 U	
Butylbenzyl phthalate				0.47 UJ	0.47 U	
Bis(2-ethylhexyl) phthalate				1.90 UJ	1.90 U	
Di-n-octyl phthalate				0.63 UJ	0.63 U	
Total PAHs**				2.6 J	0.92	
Pesticides (µg/L)						
4,4'-DDE	1.1	0.0010	[5]	0.015 J	0.002 J	0.000077
4,4'-DDD	1.1	0.0010	[5]	0.011 J	0.0019 U	0.000033
4,4'-DDT	1.1	0.0010	[6]	0.007 J	0.0012 U	0.000010
Total DDT**	1.1	0.0010	[5]	0.033 J	0.002 J	0.000151

Table 4-1
Modified Elutriate Test Effluent Concentrations
Port of Portland Terminal 4 Early Action
Portland, Oregon

Parameter	Freshwater Criteria			Elutriate Concentrations [1]		Ambient Concentration [2]
	Acute	Chronic	Notes	Total	Dissolved	
PCBs (µg/L)						
Aroclor 1016	2	0.014	[6]	0.022 U	0.022 U	0.0002
Aroclor 1221	2	0.014	[6]	0.039 U	0.039 U	0.0001
Aroclor 1232	2	0.014	[6]	0.055 U	0.055 U	0.0001
Aroclor 1242	2	0.014	[6]	0.084 U	0.084 U	0.0726
Aroclor 1248	2	0.014	[6]	0.022 U	0.022 U	0.0001
Aroclor 1254	2	0.014	[6]	0.098 U	0.034 U	0.0809
Aroclor 1260	2	0.014	[6]	0.082 J	0.014 U	0.0201
Total PCBs**	2	0.014	[6]	0.082	0.084	0.1690

NOTES:

Shaded parameters exceed freshwater water quality criteria.

J = analyte was positively identified; associated concentration is estimated value.

mg/L = milligrams per liter.

µg/L = micrograms per liter.

PAH = polycyclic aromatic hydrocarbon.

PCB = polychlorinated biphenyl.

U = analyte not detected above the reporting limit.

UJ = analyte not detected above the reporting limit. Reporting limit is approximate.

USEPA = U.S. Environmental Protection Agency.

[1] Modified Elutriate Test (MET) concentrations based on MET test by Anchor Environmental, LLC conducted in April 2004.

[2] Source: Lower Willamette Group Round 2 Surface Water Data (Integrated Water Column Transect Locations W005, W011, and W023). Parameters with ten samples or fewer should use the maximum concentration as background/ambient concentration.

[3] USEPA National Recommended Water Quality Criteria; http://www.epa.gov/waterscience/criteria/wqcriteria.html.

[4] Oregon Administrative Rule 340-041, Table 20.

[5] Guideline values presented in USEPA 2003; USEPA/600/R-02/013, Table 3-4.

*Hardness-based metals criteria recalculated for Willamette River hardness (25 mg/L).

**Summations performed using detected concentrations of individual constituents.

Table 5-1
Statistical Critical Flows
Port of Portland Terminal 4 Early Action
Portland, Oregon

Flow Statistic	Flow Rate (cfs)	Criteria
1Q10 Flow	5,530	Acute toxicity—ZID
7Q10 Flow	6,270	Chronic toxicity—CMZ

NOTES:

1Q10 Flow = lowest one-day flow with average recurrence frequency of once in ten years.

7Q10 Flow = lowest average seven-consecutive-day low flow with average recurrence frequency of once in ten years.

cfs = cubic feet per second.

CMZ = chronic mixing zone.

ZID = zone of immediate dilution.

Table 5-2
Ambient Concentrations
Port of Portland Terminal 4 Early Action
Portland, Oregon

Parameter	Number of Samples	Ambient Concentration[1] (µg/L)
TSS	9	25
Copper	9	0.83
Lead	9	0.03
Aroclor 1016	9	0.0002
Aroclor 1221	9	0.0001
Aroclor 1232	9	0.0001
Aroclor 1242	9	0.0726
Aroclor 1248	9	0.0001
Aroclor 1254	9	0.0809
Aroclor 1260	9	0.0201
Σ PCBs*	9	0.1690
4,4-DDD	9	0.000077
4,4-DDE	9	0.000033
4,4-DDT	9	0.000010
Σ DDx*	9	0.000151

NOTES:

Data Source: Lower Willamette Group Round 2 Surface Water Data (Integrated Water Column Transect Locations W005, W011, and W023).

[1]Parameters with ten samples or fewer utilize the maximum detected concentration as background/ambient concentration.

DDD = dichloro-diphenyl-dichloroethane.

DDE = dichloro-diphenyl-dichloroethylene.

DDT = dichloro-diphenyl-trichloroethane.

µg/L = micrograms per liter.

PCB = polychlorinated biphenyl.

TSS = total suspended solids.

*Summations performed using detected concentrations of individual constituents.