October 1, 2015

RSET White Paper: Proposal to Revise Freshwater Sediment Screening Levels

October 2015: The DMMP has accepted Parts 1 and 3 of the tiered approach with the understanding that the RSET agencies will continue to work on technical issues identified in Part 2.

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As noted, Parts 1 and 3 will be applied; Part 2 is on hold until further notice

The three parts of this paper must be used in conjunction with each other; they may not be applied separately. Examples of how the three sets of screening levels will be applied appear in Appendix A, and Figure 1 presents a flow chart on how the values are applied. An impact analysis conducted for the Washington Dredged Material Management Program's 2013 Sediment Management Annual Review Meeting presentation on this approach is supplied in Appendix B.

Due to Endangered Species Act concerns, the following disclaimer was developed by the U.S. Fish and Wildlife Service and the National Marine Fisheries Services:

The revised freshwater sediment benthic toxicity screening levels were derived with the analytical tools used to develop the Washington State Sediment Management Standards (SMS) (WAC 173-204-563). The standards were developed by Washington with the intent to protect benthic invertebrate communities. The Regional Sediment Evaluation Team is proposing to adopt these as regional freshwater screening levels. The Washington SMS were not intended to address bioaccumulative impacts (potential effects to higher trophic levels such as fish, wildlife, or humans) or effects to listed species as required by the Endangered Species Act (ESA). When used as part of an overall evaluation framework, the standards proposed may address the fish prey base but not direct effects on species of fish or invertebrates listed as threatened or endangered. Fish and some sensitive invertebrates (particularly snails and mussels) respond to some contaminants in sediment in a way that may not be accounted for in benthic invertebrate tests, and impacts to fish can occur at lower concentrations than those considered protective of invertebrate communities. As well, benthic bioassays are more indicative of population-level or community-level effects, whereas the ESA requires analysis of effects to individuals within the population. Additionally, waters with more unique attributes or high-quality habitat may include certain species that are especially vulnerable to sediment contaminants and may not be protected by the revised benthic screening levels.

While the Sediment Evaluation Framework for the Pacific Northwest and the framework proposed in the 2014 RSET white paper advance the protection of most exposed benthic populations during and following a dredging event, it may not be adequately protective of more sensitive species or individuals from listed species. In some instances, subsequent or additional analyses may be required by the National Marine Fisheries Service or the U.S. Fish and Wildlife Service (the Services) during RSET review. In particular, the Services are concerned about the following:

- *The protectiveness of the proposed approach for petroleum compounds such as polyaromatic hydrocarbons (PAHs)*

- *Bioaccumulative compounds such as DDT and its metabolites and polychlorinated biphenyls*

- *The metals copper, lead, and, zinc, which in the dissolved form, can have particular effects to fish and the invertebrate prey base at low concentrations.*

Of particular concern to the Services is exposure of fish and the invertebrate prey base to contaminants remaining near the sediment surface post-dredging. The newly disturbed surface may not provide adequate protection for fish or listed invertebrate species, especially if the areas are within high quality habitat for these species.

To address some of these concerns, the Services will propose a sediment screening level and approach to evaluate PAHs that is considered protective of fish by the end of 2014, an approach to address specific bioaccumulative compounds by the end of 2015, and may require applicants to compare test results to Probable Effect Concentrations (PECs; MacDonald et al. 2000) for copper, lead and zinc.

Part 1: Benthic Screening Levels

Part 1 is accepted for implementation starting Oct 2015

INTRODUCTION

In the early 2000s, Ecology evaluated existing freshwater sediment benthic toxicity screening levels (SLs), and determined that the existing SLs either had extremely high false positive rates, or extremely high false negative rates, depending on how they were derived (SAIC and Avocet, 2002). In 2003, Ecology released a report that led to the 2006 freshwater SLs currently used by the Regional Sediment Evaluation Team (RSET) (SAIC and Avocet, 2003). These values were based on the Floating Percentile Method (FPM) and the dataset and endpoints available at the time. In 2007, the RSET began to revise the freshwater benthic toxicity SLs using FPM with a larger dataset and additional endpoints. The final FPM report was released in 2011 (Avocet, 2011). Through rulemaking, Ecology promulgated these freshwater sediment values in the Sediment Management Standards (SMS) as freshwater benthic sediment standards (WAC 173-204-563) on February 22, 2013. Revised standards were also adopted for freshwater bioassays. The RSET agencies review and consider new approaches and best available science whenever appropriate and are evaluating Washington's freshwater benthic sediment standards for incorporation into the *Sediment Evaluation Framework for the Pacific Northwest* (SEF) for use in evaluating freshwater sediments.

These standards were developed for the protection of benthic invertebrate communities, and were not intended to address bioaccumulative impacts; potential effects to higher trophic levels such as fish, wildlife or humans; effects to individual organisms as required under the federal Endangered Species Act (ESA); or other species with state protection. As a result, there are concerns that if the sediment benthic standards are used alone, they would not adequately protect aquatic communities including ESA-listed fish species. The RSET agencies agree that additional measures are needed to be more protective of the aquatic environment; for example, SLs must protect other ecological receptors such as federally-listed and non-listed fish in addition to benthic invertebrates, and must account for the potential effects of bioaccumulative compounds, as appropriate.

To address these concerns, the RSET Freshwater Technical Working Group developed the following multi-tiered approach based on: 1) the revised benthic freshwater SLs; 2) water quality-based sediment SLs that would be more protective of the aquatic environment; 3) fish and wildlife-based SLs which include bioaccumulative compounds; and 4) background-based SLs for selected metals. While details of the multi-tiered approach were not finalized in time to be formally proposed at the 2013 RSET meeting, a presentation regarding future implementation was made. A discussion regarding the fish and wildlife-based bioaccumulative SLs ensued and concerns were expressed that the RSET agencies were considering implementation of these guidelines without appropriate public input. Further, concern was expressed that implementing of bioaccumulative SLs for freshwater sediment would set a precedent for their use in the marine environment.

Based on the feedback received at the RSET meeting, the RSET agencies decided to delay development of fish and wildlife-based SLs and proceed instead with adoption of the revised freshwater benthic SLs the water quality-based SLs, and the site-specific background SLs for some metals for use in the SEF. The present paper focuses on the first element – adoption of the revised freshwater benthic SLs for use in the SEF. The latter two elements are addressed in separate parts of this white paper. The fish and wildlife SLs and bioaccumulation concerns will be addressed in a separate process and will cover both freshwater and marine sediment evaluations.

PROBLEM STATEMENT

1. Freshwater SLs were not published in the May 2009 version of the SEF, and SEF users have been applying 2006 interim screening levels to determine dredged material suitability in freshwater environments. The 2006 interim SLs were developed using the FPM on a limited dataset (primarily from the Columbia and Lower Willamette Rivers) and did not include chronic bioassay data.

2. The 2009 SEF currently recommends only 10-day bioassays, while the revised Washington State standards require the use of at least one longer-term (20- or 28-day) exposure, which is a more sensitive bioassay.

APPROACH

The proposed approach includes the revised freshwater benthic SLs (Washington's FPM-based sediment management standards for benthic communities) and a bioassay over-ride. Similar to marine SLs, sediments failing the revised freshwater benthic SLs can be tested using bioassays to gather additional information for decision-making. Adoption of the revised benthic SLs in the SEF will also improve the results of bioassay testing by including a long-term exposure test.

The revised freshwater benthic SLs must be used in conjunction with the water-quality based SLs and the background concentration of metals outlined in Parts 2 and 3 of this white paper (Water Quality-based SLs, and Consideration of Background Concentrations of Metals). To be found suitable for in-water disposal, sediment must pass the revised freshwater benthic SLs (or bioassays if one or more SLs are exceeded). In addition, sediment concentrations must also be compared against the corresponding WQ-based SLs to ensure that water quality standards would not be exceeded. If the natural background for certain metals is higher than either the revised benthic or WQ-based SL, then the background value can be substituted as the SL.

DERIVATION OF THE VALUES

Development of Screening Levels for Benthic Communities

The revised freshwater benthic SLs are the combined result of the RSET Freshwater subgroup (2007 through 2009) and the Washington rule revision process that culminated in the adoption of the freshwater benthic SLs as standards in 2013 (WAC 173-204-563). The benthic SLs were derived using the FPM model, which is described in Ecology's publication #11-09-05, *Development of Benthic SQVs for Freshwater Sediments in Washington, Oregon, and Idaho* (Avocet, 2011).

PROPOSED VALUES AND APPLICATION FOR SEDIMENT EVALUATIONS

The proposed benthic SLs are presented in Table 1.

If project sediment data exceed one or more of the revised benthic SLs, then the material is considered unsuitable for in-water placement unless bioassays are conducted. However, sediments with sulfide and/or ammonia concentrations exceeding SLs, but with no other SL exceedances, may not require bioassays. Project proponents should consult with their local review team if sulfide and/or ammonia are present in sediments.

Tiered Biological Testing for Benthic Toxicity Assessment

If the revised benthic SLs are exceeded, then applicants may conduct bioassays to gather additional information for decision-making. These results may over-ride the benthic SL exceedances. Details for conducting bioassays are provided in Chapter 7 of the SEF. Bioassays should include three endpoints using both *Hyalella* and *Chironomus*, at least one chronic endpoint (20-day *Chironomus* or 28-day *Hyalella*), and at least one sub-lethal endpoint (growth). Three endpoints are required because the FPM numbers were developed using these bioassays.

Table 1. Proposed RSET Freshwater Benthic Screening Levels

Analyte	BENTHIC Screening Levels SL1	SL2
Metals (mg/kg)		
Arsenic	14	120
Cadmium	2.1	5.4
Chromium	72	88
Copper	400	1200
Lead	360	>1300
Mercury	0.66	0.8
Nickel	26	110
Selenium	11	>20
Silver	0.57	1.7
Zinc	3200	>4200
Organic contaminants (ug/kg)		
4-Methylphenol	260	2000
Benzoic acid	2900	3800
beta-Hexachlorocyclohexane	7.2	11
bis(2)-Ethylhexyl)phthalate	500	22000
Carbazole	900	1100
Dibenzofuran	200	680
Dibutyltin	910	130000
Dieldrin	4.9	9.3
Di-n-butyl-phthalate	380	1000
Di-n-octyl-phthalate	39	>1100
Endrin ketone	8.5	**
Monobutyltin	540	>4800
Pentachlorophenol	1200	>1200
Phenol	120	210
Tetrabutyltin	97	>97
DDDs	310	860
DDEs	21	33
DDTs*	100	8100
PAHs	17000	30000
PCB Aroclors	110	2500
Tributyltin	47	320
Bulk Petroleum Hydrocarbons (mg/kg) (NW-TPH method)		
TPH-Diesel	340	510
TPH-Residual	3600	4400
Conventionals (mg/kg)[3]		
Ammonia	230	300
Total sulfides	39	61

* Elutriate-based DDT value is based on the sum of sum of o,p'- and p,p'-DDXs
** no SL2 available
[1]SL1 corresponds to a concentration below which adverse effects to benthic communities would not be expected.

[2]SL2 corresponds to a concentration above which more than minor adverse effects may be observed in benthic organisms. Chemical concentrations at or below the cleanup screening level but greater than the sediment quality standard correspond to sediment quality that may result in minor adverse effects to the benthic community.

[3]Ammonia and sulfides are generally used only to inform bioassay testing; sediments only containing elevated ammonia and/or sulfides (and no other chemical exceedances) may be determined suitable for aquatic placement.

Part 2 is on hold until further notice; agencies continue to work on technical issues. However, these SLs and associated approaches may be applied on a case by case basis if deemed necessary by permitting agencies.

Part 2: Water Quality-based Screening Levels

INTRODUCTION

Part 1 of this white paper presented the history of development of freshwater benthic screening levels (SLs) and proposed revised benthic SLs based on recently promulgated standards for the State of Washington. As indicated in part 1, the RSET agencies agreed that additional measures are needed to be more protective of the wider aquatic environment, especially federally-listed and non-listed fish. This part proposes one such additional measure, the use of water quality-based SLs. Other measures, such as evaluation fish and wildlife-based SLs which include bioaccumulative compounds, are still under development.

PROBLEM STATEMENT

Sediment is resuspended in the water column during dredging and remains in suspension for short periods of time during in-water placement. Washington's benthic Sediment Management Standards, developed under the Floating Percentile Method (FPM) and proposed as revised benthic SLs for the SEF, only account for chemical toxicity to benthic invertebrate communities and may not be protective of sensitive fish species and other organisms during dredging and disposal. Since non-benthic species occur in the vicinity of nearly all dredging projects and dredged material placement sites in the Pacific Northwest, the RSET has identified the need to develop SLs that are protective of non-benthic receptors of concern.

APPROACH

As part of the requirements of the Clean Water Act, each state developed rules called water quality standards designed to meet the Clean Water Act requirements of fishable, swimmable water. Within these standards are numeric criteria developed to be protective of a wide range of receptors. Therefore, it is presumed that development of sediment SLs based on those criteria would protect species not covered by the proposed revised benthic SLs derived using the FPM approach. The approach proposed in this paper derives default SLs from EPA's recommended water quality criteria using typical values for hardness, pH, and TOC. These default SLs do not account for site-specific conditions or differences between state water quality standards and federal water quality criteria. The WQ-based SLs can easily be modified on a case-by-case basis to use state water quality standards and/or site-specific water quality values. As with the revised benthic SLs, tiered testing procedures (see "*Tiered Testing for Exceedances of Water Quality-based Screening Levels"* below) are included for the WQ-based SLs.

Part 2 is on hold until further notice; agencies continue to work on technical issues. However, these SLs and associated approaches may be applied on a case by case basis if deemed necessary by permitting agencies.

DERIVATION OF THE VALUES

Development of Screening Levels for Non-Benthic Receptors (Water Quality -based SLs)

For development of SLs that are protective of non-benthic receptors such as fish, RSET proposes using the same equilibrium partitioning approach that was used to develop the Elutriate Triggers (ETs) in Chapter 10 of the Sediment Evaluation Framework (SEF, 2009). Since 2009, the SLs have been expanded to include chronic water quality criteria, and these have been renamed "water quality-based SLs." The equations for calculating these triggers are described below.

Water Quality -based SLs for metals (in mg/kg) are derived using the following equation:

$$\textbf{WQ-based } SL_{metal} = \text{Log } K_d \times WQC/1000$$

where:

K_d is the metal partitioning coefficient in L/kg.

WQC is the water quality criterion in µg/L.

The calculation of Water Quality -based SLs for organic constituents is modified in two important ways. First, the equilibrium partitioning coefficients are expressed as a function of the organic carbon content of the sediments. Second, because organic constituents are regulated on a "total" basis (whereas metals are regulated on a "dissolved" basis), both the dissolved and the particulate fractions of the water column concentration need to be considered.

The Water Quality -based SLs for organics (in µg/kg-sed) are derived using the following equation:

$$\textbf{WQ-based } SL_{organic} = WQC / [(TSS_{inc} \times 10^{-6}) + (K_{oc} \times f_{oc})^{-1}]$$

where:

WQC is the water quality criterion in µg/L.

K_{oc} is the organic carbon partitioning coefficient in L/kg-oc.

f_{oc} is the decimal fraction of organic carbon in kg-oc/kg-sed.

TSS_{inc} is the incremental added mass of suspended solids in the water column generated by the dredging or placement action in mg/L.

10^{-6} is a conversion factor of milligrams per kilogram of sediment.

For the lower screening level (SL1), EPA chronic WQ criteria were used in the calculations; the higher screening level (SL2) used the EPA acute water quality criteria. This approach was used for all compounds that have EPA-promulgated water quality criteria. In order to develop generally-protective SLs for dredging sites and aquatic placement of dredged material, the parameters in the formula were assigned the following default values:

Part 2 is on hold until further notice; agencies continue to work on technical issues. However, these SLs and associated approaches may be applied on a case by case basis if deemed necessary by permitting agencies.

- Total organic carbon: 1%
- Total suspended solids: 100 mg/L
- Water hardness: 25 mg/L $CaCO_3$
- pH: 7.0

The default value of 25 mg/L $CaCO_3$ for water hardness differs from the 2009 SEF default (100 mg/L $CaCO_3$), and is based on a survey of water hardness in the Willamette River (Portland Harbor RI/FS August 29, 2011). This change generated lower SLs and was considered more realistic and protective than the SEF default.

PROPOSED VALUES AND APPLICATION FOR SEDIMENT EVALUATIONS

The water quality-based SLs must be used in conjunction with the revised benthic SLs and the background concentration of metals outlined in parts 1 and 3 of this white paper (Benthic SLs, and Consideration of Background Concentrations of Metals). Sediment may pass the revised benthic SLs and therefore not require bioassays for determining suitability for in-water disposal or for new surface material toxicity evaluation. Sediment concentrations should also be compared against the corresponding WQ-based SL to ensure that water quality standards would not be exceeded. If the natural background for certain metals exceed either the WQ-based SLs or benthic SLs, then the background value can be substituted as the SL.

WQ-based SLs may be modified with agency approval using local or site-specific water quality information regarding hardness, pH, and sediment TOC. These parameters can be used to calculate water quality-based SLs that are specific to a project. Site specific values may be required if your location contains ESA-listed species or some other unique characteristic revealed during development of the conceptual site model. If local water quality data are available, then you may be directed to use it. Keep in mind that SLs are not designed to protect beneficial uses beyond those of aquatic life uses (e.g., recreation, domestic water supply, etc.), there may be other considerations depending on your location.

The primary intent of the WQ-based approach is to augment the revised benthic SLs to better address potential contaminant exposure to fish in the water column. Because contaminants within sediment porewater or adhered to sediment particles become liberated (released) when sediment is disturbed, they can impact organisms in the water column near the area of disturbance (i.e., at the dredge or inwater disposal site). WQ-based SLs provide an estimate of porewater concentrations that could be harmful to aquatic life when compared to the sediment chemistry concentrations analyzed in a dredge prism sample. Typically, when WQ-based SLs are exceeded in the dredge prism sample, elutriate testing would then be conducted to provide a more accurate estimate of porewater contaminants. Because fish in the water column would not be exposed directly to porewater, additional modeling may be considered before or after conducting elutriate tests to provide a better estimate of contaminant concentrations released into the water column from dredging or inwater disposal.

Part 2 is on hold until further notice; agencies continue to work on technical issues. However, these SLs and associated approaches may be applied on a case by case basis if deemed necessary by permitting agencies.

A secondary goal of the WQ-based SLs is to protect fish with sediment-dwelling life stages. In particular, juvenile pacific lamprey (ammocoetes), which live and feed on algae directly within the sediment (Kastow 2002), could be exposed directly to porewater contaminants when colonizing the surface sediment exposed by dredging. Lamprey ammocoetes would be the fish most at risk from this type of exposure due to their unique burrowing and feeding behavior. Using the WQ-based SLs for ammocoetes would be considered protective because they appear to be generally as sensitive as salmonids to specific contaminant groups based on water exposure tests (Anderson et. al 2010). To better address risk to lamprey ammocoetes, contaminants in both the dredge prism and new surface material samples (when analyzed) should be compared against WQ-based SLs, especially in cases where contaminants in the underlying surface (i.e., area that will be exposed after dredging) exceed SLs or exceed concentrations in the dredge prism sample. Exceedance of WQ-based SLs in the dredge will trigger elutriate testing, or in some cases modeling, which is further described below.

The proposed default WQ-based SL values are presented in Table 2. Typically, projects are screened against the SL1; the use of SL2 values will depend on project-specific variables, including project design and duration of the project. If sediment concentrations are below the applicable WQ-based SLs, then the material may be suitable for in-water disposal (keep in mind that the material must also pass the revised benthic SLs). If the sediment concentrations for one or more chemical exceed the applicable SLs, then the project proponent may opt to undergo tiered testing as described below.

Tiered Testing for Exceedances of Water Quality-based Screening Levels

Tiered testing procedures for WQ-based SL exceedances may use several approaches, depending on the concerns at the dredge and placement sites. These could include elutriate testing (discussed below), development of site-specific water quality SLs, or site-specific mixing zone modeling to determine if water quality would be met at the point of compliance.

Elutriate Testing

Elutriate testing attempts to mimic conditions during dredging and in-water disposal so water column pollutant concentrations can be predicted in the laboratory. There are several tests developed to determine water quality consequences. If the concern is for suspension of pollutants during dredging, then the dredging elutriate test (DRET) should be used (Di Giano et al., 1995). To evaluate potential impacts at in-water placement sites, the standard elutriate test should be used (EPA/USACE, 1998). Results from elutriate testing are then compared to the applicable water quality criteria (acute or chronic). If concentrations exceed the applicable criteria, then modeling should be conducted to determine if the criteria will be met at the project's point of compliance. If the criteria cannot be met at the point of compliance, then other disposal options or special project Best Management Practices (BMPs), such as silt curtains, would be considered.

Part 2 is on hold until further notice; agencies continue to work on technical issues. However, these SLs and associated approaches may be applied on a case by case basis if deemed necessary by permitting agencies.

Use of Site-Specific Water Quality Parameters

If site-specific data are available, then the proponent may be required to, or have the option to, calculate site-specific screening levels using water quality data from the dredging or placement site. Site-specific SLs can be developed using the spreadsheet provided in Attachment 1, where site organic carbon and expected suspended sediments can be taken into account. Site-specific ambient water chemistry (hardness and pH) can also be collected and used in this spreadsheet to further refine the site-specific screening levels. Development of site-specific SLs is subject to approval by the RSET agencies.

Table 2. Proposed Water Quality-based Screening Levels

	WQ-BASED SLs (EPA)[1]	
Analyte	SL1 chronic	SL2 acute
Metals (mg/kg)		
Arsenic	1900	3400
Cadmium[2]	4.7	26
Chromium(III)[2]	2998	23047
Copper[2]	137	182
Lead[2]	215	5527
Mercury	154	279
Nickel[2]	641	5769
Silver[2]	--	24
Zinc[2]	4595	4595
Organic contaminants (ug/kg)		
Pentachlorophenol	39	51
DDTs[3]	7	7970
PCB Aroclors	33	4722
Tributyltin	18	113

[1]U.S. EPA National Recommended Water Quality Criteria (2006) have been used to calculate table values. You may be required to use state-specific water quality standards. In coordination with the local review team, you may also be able to use site-specific parameters (pH, sediment TOC, hardness) to adjust the water quality-based SLs using the spreadsheet available at the following webpage: http://www.nws.usace.army.mil/Missions/CivilWorks/Dredging/SMARMs.aspx

Contact the applicable agency for this information. Other water quality values used to derive these screening levels were a pH of 7.0 and a sediment total organic carbon content of 1.00% dry weight.

[2]A hardness of 25mg/L calcium carbonate was used to calculate the water quality criteria for these metals; arsenic and mercury are not affected by changes in water hardness.

[3]Elutriate-based DDT value is based on the sum of o,p'- and p,p'-DDXs

Part 3: Consideration of Background Concentrations of Metals

Part 3 is accepted for implementation starting Oct 2015

INTRODUCTION

Part 1 of this white paper presented the history of development of freshwater benthic screening levels (SLs) in Washington and the addition of these benthic SLs to the *Sediment Evaluation Framework of the Pacific Northwest*. The benthic SLs were calculated using the floating percentile method on a database of freshwater chemical and bioassay testing results and provide the best available science regarding chemical thresholds for adverse effects on benthic communities. Part 2 presented water quality-based SLs for the protection of non-benthic species. However, thoughtful implementation of the benthic and WQ-based SLs also requires consideration of background concentrations for chemicals of concern, particularly metals. The development of a background approach for metals in freshwater sediment is presented in this part.

PROBLEM STATEMENT

The Pacific Northwest region is known to have naturally elevated metals concentrations, in large part due to the volcanic nature of this region. In some areas, the background sediment concentrations of metals can exceed the benthic and WQ-based SLs. Therefore, background concentrations must be taken into account when evaluating dredging projects in these areas. However, background concentrations vary between regions, watersheds, and water body types. Very little natural background data exist for freshwater sediments and, while substantially more data are available for soil background values near freshwater areas, the applicability of soil background to sediments has not previously been defined in policy for Washington or Oregon.

APPROACH

The background-based SLs must be used in conjunction with the benthic and water quality SLs outlined in parts 1 and 2 of this white paper (benthic SLs, and WQ-based SLs). Where background metals are above other proposed SLs, the SL will default to background. Because metals background varies geographically, and the rules for the participating states differ, each state has its own proposed background approach, based on a combination of soil or sediment background.

DERIVATION OF THE VALUES

Development of RSET Freshwater Sediment Background Concentrations for Use in Oregon State

For dredging projects on the Lower Willamette River, the Willamette upstream sediment natural background metals values calculated for the Portland Harbor Superfund area will be used (LDWG 2012). Sediment natural background concentrations may also be calculated for other areas of the state if sufficient data are available. If no sediment background data are available, local soil background will be used in other parts of Oregon (ODEQ, 2013).

Development of RSET Freshwater Sediment Background Concentrations for Washington State

Based on data in Ecology's publication #09-03-032 (*Baseline Characterization of Nine Proposed Freshwater Sediment Reference Sites*, 2008), many metals in Washington sediment had higher concentrations compared to the background values from the Willamette, thus Willamette background may not be appropriate for Washington.

Using available sediment data for Washington State and performing outlier analysis, only nickel appears to clearly have sediment background higher than a benthic or WQ-based screening level – in this case, the benthic SL1 (see Appendix C). However, more freshwater sediment data are needed before a statistically robust background concentration can be calculated.

Since it appears that the Willamette sediment background may not be appropriate for Washington sediments, and sufficient Washington sediment data are not yet available, the DMMP agencies developed interim background values using Washington State soil data from Ecology's publication #94-115 (*Natural Background Soil Metals Concentrations in Washington State*, 1994). Using this data set, nickel had a background concentration (90th percentile = 38 mg/kg) higher than the benthic SL1 (see Appendix A). In Washington, the DMMP agencies propose using this value for the nickel SL1 until sufficient sediment data are available to calculate background.

Development of RSET Freshwater Background Sediment Concentrations for Idaho State:

Natural background concentrations of metals in sediments exceeding benthic or WQ-based screening levels may indicate the character of highly mineralized soils and the variable composition of sediment parent material found in many Idaho watersheds. In the event that natural sediment background levels are not available, soils and parent material representative of watershed sediment could be used as a reference for screening level thresholds. In certain circumstances, use of site specific screening levels for the protection of beneficial uses may override considerations for application of background sediment concentrations as screening thresholds. Idaho will examine this issue on a case by case basis as it arises.

Examples for sources of this information include the following:

U.S. Environmental Protection Agency. *Record of Decision Bunker Hill Mining and Metallurgical Complex OU 3*. September 2002.

U.S. Geological Survey. *Geochemical and Mineralogical Data for Soils of the Conterminous United States.* 2013.

Idaho Geological Survey Maps. http://www.idahogeology.org/Products/MapCatalog/

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U.S. Environmental Protection Agency/US Army Corps of Engineers. 1998. Evaluation of dredged material proposed for discharge in waters of the U.S. – Testing manual. EPA-823-B-98-004, Washington, D.C.

U.S. Environmental Protection Agency. *Record of Decision Bunker Hill Mining and Metallurgical Complex OU 3*. September 2002.

U.S. Geological Survey. *Geochemical and Mineralogical Data for Soils of the Conterminous United States.* 2013.

Glossary of Terminology

Benthic Screening Levels (Benthic SLs): Sediment screening levels based on regional data and the Floating Percentile Model (Avocet, 2011).

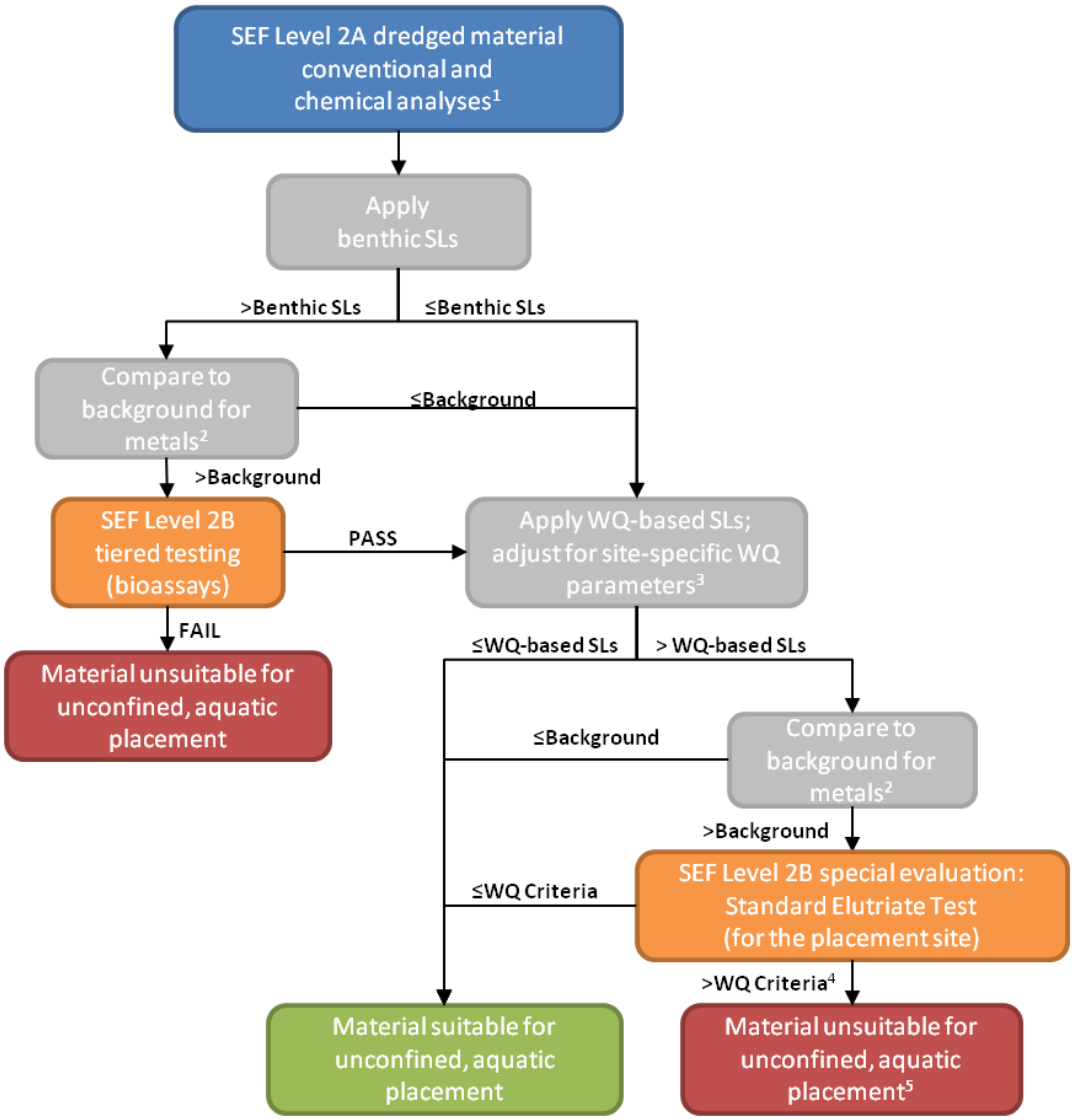
Elutriate Test: A sediment test where water and sediment are shaken, allowed to settle for a pre-determined amount of time, and the overlying water and suspended sediments are analyzed for chemical concentrations.

Elutriate Trigger (ET): An elutriate trigger is a sediment screening level (SL) calculated by multiplying the applicable water quality criteria (µg/L) by the logarithm of an applicable equilibrium constant of the sediment (L/kg) divided by 1,000. The result is a screening level or elutriate test trigger in mg/kg. The equilibrium constant or K_d value, as it applies to dredged material, is a measure of how much of a metal or organic constituent remains bound to sediment particles and how much is expected to dissolve in the water column. These trigger levels were originally developed in the SEF for acute water quality criteria (WQC) only. This paper expanded the use to include chronic WQC, and re-named the resulting sediment SLs as the WQ-based SLs.

Tiered Approach: A structured, hierarchical procedure for determining data needs relative to decision-making, which involves a series of tiers or levels of intensity of investigation. Typically, tiered testing involves decreased uncertainty and increased available information with increasing tiers. This approach is intended to ensure the maintenance and protection of environmental quality, as well as the optimal use of resources. Specifically, least effort is required in situations where clear determinations can be made of whether (or not) unacceptable adverse impacts are likely to occur based on available information. Most effort is required where clear determinations cannot be made with available information.

Water Quality-based Screening Levels (WQC-based SLs): Sediment SLs based on water quality criteria and equilibrium partitioning.

Figure 1. Application of proposed freshwater screening levels for the aquatic placement of dredged materials.



1 - Specific to the state in which the project is located, this process may also be used to predict toxicity of the new surface material (i.e., the surface exposed after dredging) and address water quality concerns at the dredge area.
2 - Background concentrations are used only for metals and are specific to the state in which the project is located, as determined by the state water quality agency (WA - Ecology; OR - ODEQ; ID - IDEQ).
3 - In coordination with the local review team, site-specific total organic carbon, hardness, and pH may be used to adjust the water quality-based SLs at the dredge area and placement area.
4 - The standard elutriate test or modeling indicate WQ criteria would be exceeded at the dredged material placement site. Modeling efforts must be coordinated with local review team.
5 - Dredging with upland disposal may still be a viable option. The dredging elutriate test (DRET) and water-quality compliance modeling would need to be conducted to assess the effects of dredging at the dredge area. Depending on the results, modifications to the dredging project may be proposed to ameliorate adverse water quality effects in the dredge area.

Appendix A. Example projects

This appendix contains three examples of the application of the SLs presented in this paper.

Case 1 is for the Port of Vancouver (2008), where there were exceedances of both benthic SLs and WQ-based SLs. In this case, Berths 8/9 had several chemical exceedances. The Port opted out of bioassays, so the dredged material was considered unsuitable for in-water disposal. Additionally, the TBT exceeded the benthic SL2, as well as the elutriate trigger (now called the WQ-based SL, at that time it was the elutriate trigger for acute WQ criteria). The Port conducted DRET testing, and then modeled the resulting data to predict water quality during dredging.

Case 2 is from the Port of Anacortes, Pier 2 (2013), and is another example of TBT, where TBT was the only constituent that exceeded any SL. The memorandum below documents the process by which the Port of Anacortes evaluated the potential impacts to water quality. While this project is marine rather than freshwater, the evaluation is more thorough due to its more recent evaluation, and so was included as an example here.

Case 3 is from Chester Morse Lake Pump Plant (2014). The material was being evaluated for in-water disposal, and failed only the nickel benthic SL, triggering comparison to background (at this time, WQ-based SLs were not in place so were not evaluated). The DMMP suitability determination attached below describes the process by which the project was evaluated.

Appendix B. DMMP impact evaluation of the proposed SLs (from SMARM 2014)

IMPACT ANALYSIS

The DMMP agencies evaluated the potential impact of the proposed freshwater approach on projects. Data from DMMP freshwater projects over a five-year span (2009-2013) were compared to the new SLs, to determine if there would have been significant changes in the evaluation (suitable or non-suitable). There were 12 projects with 43 DMMUs, mostly in the Columbia River but also including Lake Union (one project, seven DMMUs) and Lake Washington (two projects, four DMMUs).

Of these 43 DMMUs, 25 DMMUs had no change in decisions (six passed both sets of SLs, 16 had detected exceedances of both sets of SLs, and three had non-detected exceedances of both sets of SLs) (Table 3). Two DMMUs passed the 2006 SLs but had detected proposed SL exceedances for nickel. These DMMUs would now require bioassays or site-specific background evaluation for nickel. Both of these were in the same project (South Lake Union).

Twelve DMMUs passed the 2006 SLs but had non-detects above SL (five for silver, five for pentachlorophenol (PCP), two for PCB) that previously had no exceedances of the 2006 guidance. These non-detect exceedances could be avoided for silver and PCP- the proposed silver (0.57 ppm) and PCB SLs (33 ppb) and are at or above the Ecology median PQLs (0.5 ppm and 33 ppb respectively) (Ecology draft SCUM II, appendix F). If sediment concentrations were actually present above the SL, the PCB exceedances would have triggered further evaluation based on the WQ-based SL (elutriate testing, modeling) and the silver exceedance would have triggered bioassays. For PCP, the standard methodology (typically SW8270D) PQL (265 ppb) and MDL (48 ppb) are above the proposed WQ-based SL (39 ppb). Non-detects exceeding the proposed PCP SL would normally trigger further evaluation (elutriate testing, modeling). Although an alternative method (EPA 8270 LL) could reach PQLs and MDLs below the proposed SL, unless there is a reason to believe that PCP is an issue at the project site, the agencies will not require the alternative method and instead will require reporting of PCP down to the MDL. Only detected exceedances of the WQ-based SL will trigger further evaluations.

Three DMMUs that exceeded the 2006 SLs (Cd, Zn, and bis(ethylhexyl)phthalate) had no detected exceedances of the proposed SLs, but did have non-detected exceedances for PCP. Bioassays were not run on two of these DMMU, so it is not known whether the exceedances of the 2006 guidelines were associated with toxicity; however, bioassays were conducted and passed for the project with the Cd exceedance (Kitittas).

A single DMMU had a non-detect exceedance of the 2006 SLs (Hg) and a detected exceedance of the proposed nickel SL; either exceedance would have triggered bioassays.

Table 3. Matrix Comparing DMMU Evaluations for Impact Analysis

	All COCs are less than or equal to proposed SLs	One or more detected exceedance of proposed SLs	One or more non-detects exceed proposed SLs
All COCs are less than or equal to 2006 SLs	6	2 (Ni)	12 (5 Ag, 5 PCP, 2 PCB)
One or more detected exceedance of 2006 SLs	0	16	3 (PCP)
One or more non-detects exceeded 2006 SLs	0	1 (2006 Hg, proposed Ni)	3

Appendix C. Supplemental analysis of available sediment and soils data for Washington State.

Dredging projects need a way to determine when background concentrations of metals in freshwater sediments may be above the risk-based screening values (benthic SL or WQ-based SL). According to the SMS, when natural background concentrations are above risk-based values, background concentrations over-ride the screening values.

For freshwater, there are no established sediment natural background values. Data from both Washington state soil ("Natural background soil metals concentrations in Washington state", Ecology publication #94-115) and sediment data (Ecology's publication #09-03-032, "Baseline characterization of nine proposed freshwater sediment reference sites, 2008") were examined to determine which, if any, metals may need to default to natural background. Soil 90th percentile[1] and sediment 90/90 UTLs were compared to the sediment SLs (benthic, WQ-based) (Table 2). Only four metals had values higher than SL: Ni, As, Cu, and Hg, which could be the basis of an over-ride.

Because it is preferable to have a sediment background value for use in dredging rather than defaulting to soil values, the sediment data from publication #09-03-032 were examined more closely to determine whether that data could be used to generate Washington state freshwater background concentrations. The data were not normally distributed for any of the metals, and while outlier analysis indicated there may be some outliers, there is insufficient data for the non-normally distributed dataset to prove that the potential outliers were either in or out of the background distribution. For this analysis, outliers were removed from the data set, and the 90/90UTLs re-calculated and compared to their respective SLs. Only Ni remained higher than the risk-based SLs; no outliers had been identified for this metal.

In order to determine if sufficient nickel data were available, the approach used in the regional background studies was applied. The precision for the 95%UCL on the mean was higher than 25%, indicating more samples are needed to better characterize the upper part of the distribution that is used to set the background value.

The RSET FW technical group is proposing that the Willamette upstream natural background values calculated for the Portland Superfund area be used for metals natural background unless there are other data to support natural background for other regions. Based on data in Ecology's publication #09-03-032, many metals in Washington sediment had higher concentrations compared to the background values from the Willamette, thus Willamette background may not be appropriate for WA.
Using available sediment data for the state and biasing towards lower concentrations by using outlier analysis, only Nickel appears to clearly have sediment background higher than risk-based level.

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[1] 90th percentile reported in the publication was used for soil since the publication did not have the individual data values available to calculate the 90/90UTL.

However, statistics indicate that more freshwater sediment data are needed for nickel to better define the upper tail, which is what defines the background concentration. Since it appears that the Willamette sediment background may not be appropriate for WA sediments, but sufficient WA sediment data is not available, the DMMP needs an approach for assessing nickel in the interim. Either the 90th percentile of WA soil data or the 90/90UTL of existing WA sediment reference (Ecology's publication #09-03-032) data can be used in the interim. Given the uncertainties around the sediment data, and the fact that the soil data are lower than the sediment, the DMMP proposes to continue to use the soil background data for nickel until sufficient sediment background concentrations can be established.

Table A-1. Metals concentrations (ppm dry wt) in selected sediments and soil. More Washington state freshwater sediment data are needed to determine usable background concentrations. Nickel is the only metal where Washington sediment and soil were above the SL after outliers were removed.

Metal (lowest risk-based SL in parentheses)	Willamette sed bkg (95th %ile)	WA sed (all data) (90/90UTL)	WA sed (outliers removed) (90/90UTL)	WA soil (90th %ile)
Arsenic (14)	3.8	17	6.5	7
Cadmium (2.1)	0.2	0.7	0.5	1
Chromium (72)	32.7	60	no outliers	42
Copper (110)	38.0	146	49	36
Lead (160)	14.3	53	12	17
Mercury (0.66)	0.1	0.22	0.14	0.04
Nickel (26)	**26.1**	**57**	**no outliers**	**38**
Selenium (11)	0.4	2	0.6	na
Silver (0.6)	0.7	0.19	0.13	na
Zinc (3200)	105.0	110	no outliers	85