May 2009

This paper was not implemented but is included here as background. A modified paper was presented at SMARM 2010 and subsequently finalized and implemented.

DMMP ISSUE PAPER – SMARM 2009

PROPOSAL TO REVISE THE OPEN-WATER DISPOSAL GUIDELINES FOR DIOXINS IN DREDGED MATERIAL

INTRODUCTION

The Dredged Material Management Program (DMMP) agencies require chemical testing for projects involving dredged material disposal at one of the eight open-water disposal sites in Puget Sound. Routine testing includes 62 chemicals of concern (COCs). In addition to the routinely tested COCs there are chemicals of concern for limited areas. Dioxins are in the latter category and have been tested on a case-by-case basis for dredging projects in Puget Sound.

The term "dioxins," in the context of the DMMP testing requirements, includes the group of 17 chlorinated dioxins and furans of known concern for health effects in fish, wildlife, and humans. Dioxin compounds are produced unintentionally from many industrial processes and persist in the environment where they tend to concentrate in fats, and magnify in the food web. These compounds are carcinogenic and toxic, although there is scientific controversy regarding how to estimate effects at low doses.

Historical discharges from industries such as chlorine pulp mills, wood treatment, and pesticide manufacturing provided sources for dioxins in sediments. Anthropogenic sources of dioxins are now largely controlled, but the compounds persist for a long time in the environment. Dioxins are also produced by natural events, including forest fires and volcanic activity. Dioxins are ubiquitous, due to global distribution of anthropogenic and natural sources. They are present throughout the world in aquatic and terrestrial environments, and in most foods that we eat.

Dioxin concentrations are typically presented as parts per trillion (pptr) TEQ, which is a measure of the toxic equivalence. The TEQ represents the combined toxicity of the 17 individual dioxins and furans for an environmental sample.

Until 2006, the maximum concentration of dioxins that could be present in dredged material being disposed at open-water disposal sites in Puget Sound was 15 pptr TEQ. This was based on a 1991 risk assessment that was done in Grays Harbor.

PROBLEM IDENTIFICATION

In the early years of DMMP implementation, the 15 pptr TEQ guideline was deemed adequate. Three Puget Sound projects were tested for dioxin, all in the vicinity of kraft pulp and paper mills in Everett. Concentrations of dioxin were relatively low, ranging from 0.6 to 8.7 pptr TEQ.

Then, in 2006, a proposal to dredge the navigation channel and berthing areas in Olympia Harbor triggered a requirement for dioxin testing due to the close proximity of the Cascade Pole Model Toxics Control Program (MTCA) cleanup site. High concentrations of dioxin were found. In light of the evolution of knowledge regarding the risks posed by dioxin, the DMMP agencies determined that the guidelines developed in 1991 needed to be re-evaluated.

The problem with using the 1991 Grays Harbor risk assessment is that it was based on seafood consumption by recreational fishers and did not reflect the risk to subsistence fishers in Puget Sound. Since its publication, much work had been done regarding tribal consumption rates in

Puget Sound. In addition, the U.S. Environmental Protection Agency (EPA) published a draft dioxin reassessment report in 2003, which underscored the risks from dioxin. Based on an evaluation of the latest data and risk assessment guidance, the DMMP agencies determined that the dioxin guidelines derived from the 1991 Grays Harbor risk assessment were no longer valid for Puget Sound.

For the Olympia Harbor project, a risk-based approach was attempted for the Anderson/Ketron open-water disposal site, but ultimately a background-based framework was adopted using concentrations of dioxin in the area surrounding the disposal site. This approach was expanded to include the other non-dispersive sites and is currently in effect, but the DMMP agencies acknowledged that this was an interim solution. A process was needed to develop longer term guidelines.

THE DIOXIN PROJECT

The DMMP agencies established a workgroup in the summer of 2007 with the purpose of developing a revised dioxin framework for dredged material. The effort came to be called the "Dioxin Project." The dioxin workgroup included staff-level employees from all four DMMP agencies, with periodic review and direction provided by agency managers and directors. Legal review was provided by state and federal attorneys. The Puget Sound Partnership became involved in the project in 2008. Work was facilitated by Floyd|Snider.

General approaches for development of revised guidelines were generated, including various background and risk-based options. In the fall of 2007 these options were presented, and input received, at seven regional public meetings and two technical workshops. Tribal input was received at a meeting with the Northwest Indian Fisheries Commission in March 2008. Public updates and formal comment opportunities were provided at the 2007 and 2008 Sediment Management Annual Review Meetings (SMARMs).

In the spring of 2008, the DMMP agencies recognized that insufficient data existed regarding background levels of dioxin in Puget Sound. Therefore, in the summer of 2008, the agencies collected sediment samples throughout the Sound using the EPA ocean research vessel Bold. The samples were analyzed for a suite of chemicals, including dioxins.

In the fall of 2008, a statistics workshop was convened by the Regional Sediment Evaluation Team (RSET). A panel of experts provided recommendations regarding assessment of dioxin data and development of guidelines based on background data.

In the winter of 2008/2009, the DMMP agencies refined the background and risk-based options based on input received from the public, the Puget Sound background data from the Bold survey, and recommendations from the statistics workshop. The other options considered in addition to the agency proposal are presented in Attachment 1.

The DMMP agencies' goal was to develop a framework for dioxin in light of the fact that unacceptable human health risk associated with seafood consumption exists at concentrations below Puget Sound background. The Regulatory and Policy Technical memorandum that is provided in Attachment 2 presents an overview of the state and federal regulatory requirements applicable to the disposal of dredged material at the open-water disposal sites managed by the DMMP agencies. The memorandum discusses the relationships between the Puget Sound Dredged Disposal Analysis (PSDDA) program guidelines and the Sediment Management Standards. The agencies made a number of choices and assumptions when preparing the

proposal. These choices reflect a combination of scientific and policy determinations. The technical and policy rationale for the decisions that were made in preparing the proposal are also presented in Attachment 2.

Calculations by the DMMP agencies determined that the incremental lifetime cancer risk (ILCR) for Puget Sound seafood consumers is greater than 10^{-6} and, for some populations, greater than 10^{-4}. In such a situation, the Sediment Management Standards allow adoption of a background-based approach. Attachment 3 documents the decisions made in performing a calculation of background risk, and shows the results by consumer group considered. Several stakeholders suggested evaluation of an alternative allowing an additional incremental risk above background. However, any approach above background would require the implementation of Sediment Impact Zones, which the agencies were not in favor of for many reasons, as described in Attachment 2.

The DMMP agencies evaluated the options in a deliberative manner, taking into account a variety of factors such as consistency with regulations (or modification of regulations to accommodate an alternative), benefits for the environment (reduction of dioxin concentrations at dredged material disposal sites), projected economic impacts, and administrative issues (site encumbrance, potential for inter-bay transfers, difficulty obtaining shoreline permits, and program funding). The original options that were considered either did not balance these factors well—for instance, they would cause undue economic hardship—or would require significant alteration of existing regulations that would need to go through additional public process and federal Clean Water Act review. Therefore, the DMMP agencies developed a hybrid option, which became the basis for the following proposal.

PROPOSED REVISIONS TO THE DIOXIN GUIDELINES

The DMMP agencies propose the following open-water disposal guidelines for dioxins in Puget Sound dredged material:

For Non-Dispersive Disposal Sites in Puget Sound:

<u>Volume-Weighted Background Approach Based on Comparison to Puget Sound Main Basin and Reference Area Concentrations:</u> The agencies propose to set volume-weighted *dredged material suitability guidelines* for all dredging projects so that material disposed at non-dispersive sites in Puget Sound would not result in disposal site surface concentrations that exceed a *disposal site management objective* that is based on background levels measured in the Puget Sound Main Basin and Reference Areas (not including urban bays, and away from point sources).

> *<u>Disposal Site Management Objective:</u>* The agencies propose to establish a target disposal site concentration for all non-dispersive disposal sites at a level based on the Puget Sound Main Basin and Reference Areas background concentrations. The value proposed for the Disposal Site Management Objective is 4 pptr TEQ, which is the nonparametric estimation of the 90% upper confidence limit for the 90th percentile of the distribution of the background data set.
>
> *<u>Dredged Material Suitability Guideline:</u>* The agencies propose to establish suitability guidelines (pass-fail criteria) that would be used to evaluate individual projects. The suitability guidelines would have two components: (1) The volume-weighted average concentration of dioxin/furan in material from each dredging project could not exceed the

disposal site management objective of 4 pptr TEQ, and (2) dioxin/furan concentrations could not exceed a maximum concentration of 10 pptr TEQ in any single Dredged Materials Management Unit (DMMU).

For Dispersive Disposal Sites in Puget Sound: The agencies propose that dioxin/furan concentrations could not exceed a maximum concentration of 4 pptr TEQ (the Disposal Site Management Objective) in any single DMMU.

Bioaccumulation Testing

The DMMP agencies are looking into the possibility of a test-out option involving bioaccumulation testing. The dredging proponent would have the option of pursuing bioaccumulation testing to determine whether or not the DMMUs could qualify for open-water disposal. It should be noted that a test-out option was available under the former guidelines.

A target tissue level (TTL) to be used in the bioaccumulation evaluation has not been determined for dioxins at this time. In the absence of a TTL, the dredging proponent would include a reference sediment in the bioaccumulation test. Concentrations in the project test-sediment tissue would be compared against concentrations in the reference-sediment tissue. The DMMP agencies are continuing to evaluate a bioaccumulation test-out option in the revised dioxin guidelines.

Revisions to Dioxin Testing Requirements

Testing for dioxins will continue to be required on a case-by-case basis in areas where there is reason to suspect presence of these chemicals. Factors which could trigger a “reason-to-believe” determination include the following:

- Located within an urban bay and having no historical information showing that dioxin is below levels of concern
- Proximity to current or historical point sources, such as outfalls
- Proximity to chlor-oxide bleach process pulp mills, chlor-alkali or chlorinated solvent manufacturing plants, former wood treatment sites, phenoxy herbicide manufacture and/or use and handling areas
- Proximity to areas with high polychlorinated biphenyl (PCB) concentrations
- Proximity to hog fuel burners/boilers and areas with previous fires or incineration sources
- Proximity to areas previously sampled that showed elevated levels of dioxin

Dioxin testing will be required for all projects meeting one or more of the reason-to-believe factors described above. Deeper underlying sediments, which are confirmed as “native,” will be exempt from testing, except as follows: the top 4 to 8 feet of a native sediment layer underlying sediments that are being tested for dioxins will also be required to be tested for dioxins.

These updated guidelines are consistent with the reason-to-believe requirements implemented in the last several years. Guidance for sampling density per project will remain unchanged.

The agencies recognize that dioxin analysis is expensive. The agencies are evaluating potential use of alternative assay-based testing methods, but those evaluations are still in progress.

Verification of Compliance with the Disposal Site Management Objective

The DMMP program would continue to implement best management practices (BMPs) for sequencing of disposal operations. Recent data from the Anderson-Ketron disposal site have shown that application of these BMPs has resulted in disposal site surface concentrations well below the current interim suitability guidelines for dioxins.

The agencies would increase the number of on-site monitoring samples collected at each disposal site from 3 to 10 to allow statistical comparisons to be made with Main Basin/Reference Areas concentrations. Otherwise, the site monitoring program would be very similar to the current program, with monitoring frequency based on site disposal volumes.

Monitoring results would be tracked over time to determine whether the disposal sites are coming into compliance with the new site management objective. If necessary, the suitability guideline will be adjusted to ensure the management objective is being met.

Impact on Open-Water Disposal Fees

A periodic disposal site fee increase due to inflation is being evaluated by the Department of Natural Resources in a separate process. The fee increase would also account for the increased program costs related to dioxins. It should be noted, however, that the increased program costs related to dioxins account for a very small portion of the overall disposal fee increase, and that the fee increase was scheduled to occur regardless of the revision to the dioxin guidelines.

The cost increases related to dioxins would include the following:

- Increased cost associated with the collection and analyses of additional samples for non-dispersive site monitoring as described above
- Potential increased cost for periodic re-evaluation of Puget Sound background concentrations

PROJECT-IMPACT AND CONCEPTUAL LEVEL ECONOMIC ANALYSIS

The DMMP agencies performed an analysis of potential project impacts under the proposed guidelines using data from all Puget Sound dredging projects since the inception of the DMMP, covering a period of 21 years. During this time well over 200 projects were evaluated for open-water disposal. Of these, 20 projects had at least some material that was tested for dioxins, the tested quantity consisting of approximately 1.8 million cubic yards, or 6.2 percent of the total volume.

The 20 projects that have had some level of dioxin testing were used as the basis for the evaluation of the pass/fail impact of the proposed dioxin guidelines. When the data from these 20 projects is compared, on a DMMU basis to the former dioxin guideline of 15 pptr, 82% of the material passes, and would be designated as suitable for open-water disposal. Under the proposed non-dispersive site guidelines, the pass rate is estimated to drop from 82% to 78% of the total tested volume. However, this compares to a pass rate of 69% under the current interim guidelines. In terms of number of projects, of the 20 projects, 7 projects would have been

impacted under the former guideline, while 10 and 13 projects would be affected under the proposed and interim guidelines, respectively. For those projects that would use the dispersive open-water disposal sites, the proposed (and interim) dispersive guidelines would impact 6 of the 7 projects, while under the former guideline only 2 projects would have been impacted. The impact analysis is presented in greater detail in Attachment 4.

The results from the impact analysis were also used to estimate a conceptual level economic impact that might occur from implementation of the proposed dioxin framework. The updated reason-to-believe guideline associated with the proposal will result in dioxin testing for the majority of dredging projects, particularly those located in urban bays. Therefore, there will be an increase in the cost of sediment characterization associated with the testing of dioxins and an increase in the total amount of material defined as unsuitable for open water disposal. Over the 21-year history of the DMMP program, approximately 6% of the project volume (10% of projects) has required dioxin testing. Over the last three years, with additional concern regarding dioxins, 33% of the project volume (38% of projects) has required dioxin testing. It is estimated that approximately 55% of the project volume would require dioxin testing under the proposed dioxin guidelines.

Under the proposed dioxin guidelines there will also be an increase in the volume of material that will be determined to be unsuitable for open-water disposal relative to the former 15 pptr guideline. Therefore, there will be additional costs associated with the alternative disposal of unsuitable material. Using the estimated failure rate of 22% under the proposed non-dispersive guideline and the annual average dredge volume over the last 21 years of 1.4 million cubic yards (CY), as described above and presented in Attachment 4, it is estimated that the annual average volume of material that would fail the proposed dioxin guideline is approximately 167,000 CY. The comparative costs of disposal for the predicted failed volume, relative to the cost of open-water disposal, includes the following:

- Annual average cost of open-water disposal at $8.40/CY = $1.4 Million
- Annual average low-end cost of upland disposal at $38/CY = $6.3 Million
- Annual average high-end cost of upland disposal at $130/CY = $21.7 Million

The agencies acknowledge the fact that in lieu of upland disposal, the predicted impacted projects with increased failed material could be cancelled, with significant associated economic impacts. These impacts are highly project-specific and the “tipping point” for project cancellation would likely be a lower threshold for smaller projects. The agencies have not attempted to calculate program-wide secondary impacts associated with this proposal vs. the previous or interim dioxin guidelines.

GEOGRAPHIC LIMITATIONS OF THE PROPOSAL

The Dioxin Project has focused on developing revised guidelines for Puget Sound only. Dioxin suitability guidelines for areas outside of Puget Sound (e.g., Grays Harbor and Columbia River) will need to be revisited as well. There are significant differences between other systems and Puget Sound that may require adjustments to the proposed framework.

OTHER BIOACCUMULATIVE COMPOUNDS

The adjusted framework for dioxin could have implications for other bioaccumulative compounds, especially dioxin-like PCBs. This is an issue that the agencies have begun to discuss, but have not yet determined a recommended path forward. The DMMP's long-term goal is to develop revised guidelines for all key bioaccumulative compounds.

NEXT STEPS

In the March Fact Sheet and March 11 public workshop, the DMMP agencies presented the proposal for advance review and input. Additional feedback was provided by several entities after the workshop, and this issue paper incorporates some of the comments received.

It is very important to recognize that the proposal presented in this issue paper does not represent the final decision by the agencies. Rather, it provides the basis for further discussion and evaluation. To that end, the DMMP agencies have set aside 3 meeting days in May and June to obtain additional input from stakeholders. Based on the comments received to date, the agencies think it would be productive to structure those meetings around the following topics:

May 18: Regulatory context, project objectives, and risk assessment

May 28: Material pass/fail analyses and impacts to dredging

June 3: Other implementation issues and additional discussions (if needed) on issues from earlier meetings

The May 18 meeting will be held at the Department of Ecology in Lacey in the ROA-36 Auditorium from 10:30am to 3:30pm. The May 28 and June 3 meetings will be held at the U.S. Army Corps of Engineers (USACE), Seattle District office on East Marginal Way South in Seattle in the Galaxy Room from 10:00am to 2:00pm. The meetings will be set up to stimulate dialogue and exchange information.

The DMMP would also like to receive written comments on the proposal. Written comments should be submitted to: dioxin.project@floydsnider.com.

The DMMP will review the meeting input and written public comments. The length of time needed to complete that review will depend on the types of comments and issues raised at the May meetings. Based on that review, the DMMP may modify its proposal based on the interactions and input. The DMMP will release an adjusted proposal for the dioxin guidance and implementation approach for formal public comment. Public comments on the revised proposal will be accepted for 60 days. After the public comment period, the agency Directors will make a final decision following consideration of public comments.

ATTACHMENTS

Attachment 1 – Options Considered in Addition to the Agency Proposal for Establishing Dioxin Suitability Guidelines for Open-Water Disposal

Attachment 2 – Dioxin Project Regulatory and Policy Technical Memorandum

Attachment 3 – Dioxin Project Risk Assessment Technical Memorandum

May 2009

Attachment 4 – Dioxin Project Impact Analysis Technical Memorandum

Proposal to Revise the Open-water Disposal Guidelines for Dioxins in Dredged Material

Attachment 1
Options Considered in Addition to the Agency Proposal for Establishing Dioxin Suitability Guidelines for Open-Water Disposal

Options Considered in Addition to the Agency Proposal for Establishing Dioxin Suitability Guidelines for Open-Water Disposal at Non-Dispersive Sites

In addition to the Agency proposal (described separately) the DMMP Agency group evaluated variations on the following options as methods for establishing suitability guidelines for open-water disposal of dredged material containing dioxin.

1. No Detectable Levels of Dioxins: Agencies would allow material to be disposed at open-water sites if there are no detectable levels of dioxin/furan compounds.

2. Background Approach Based on Comparison to Reference Area Concentrations: Agencies would allow material to be disposed at open-water sites if the levels of dioxin/furan compounds are less than or equal to existing concentrations in rural reference bays (approximately 2 ngTEQ/kg).

3. Background Approach Based on Comparison to Puget Sound Main Basin and Reference Area Concentrations: Agencies would allow material to be disposed at open-water sites if the levels of dioxin/furan compounds are less than or equal to existing concentrations in the Puget Sound Main Basin and Reference Areas, not including urban bays (approximately 4 ngTEQ/kg).

4. Background Approach Based on Comparison to Concentrations in the Puget Sound Main Basin and Urban Bays Away from Point Sources: Agencies would allow material to be disposed at open-water sites if the levels of dioxin/furan compounds are less than or equal to existing concentrations in the Puget Sound Main Basin and urban bay locations away from known point sources (between approximately 4 and 17 ngTEQ/kg depending upon the method selected for combining the non-urban and urban data sets).

5. Background Approach Based on Comparisons to Concentrations in Areas in the Vicinity of the Disposal Site (Current Interim Framework): Agencies would allow material to be disposed at open-water sites if the levels of dioxin/furan compounds are less than or equal to existing concentrations in the vicinity near, but not influenced by, existing disposal sites (individual site values vary between 4 and 12, with a geometric mean of 7 ngTEQ/kg). This option would result in different suitability criteria for the different disposal sites.

6. Incremental Risk Approach: Agencies would allow material to be disposed at open-water sites if the levels of dioxin/furan compounds do not pose an incremental risk greater than $1x10^{-6}$ above background concentrations calculated using "Puget Sound Main Basin" data. (Individual site values vary between 6 and 12, with a geometric mean of 7 ngTEQ/kg.) This option would result in different suitability criteria for the different disposal sites.

Note: Approximate suitability guidance values for Options 1, 2, 4, & 5 above were determined with statistical methods that calculated the 90th percentile of the background data sets. Approximate suitability guidance values for Option 3 and the Agency proposal (presented separately) were determined with updated statistical methods that calculated the 90th percentile of the distribution at the 90% upper confidence interval of the background data set.

Proposal to Revise the Open-water Disposal Guidelines for Dioxins in Dredged Material

Attachment 2
Dioxin Project Regulatory and Policy Technical Memorandum

Dioxin Project Regulatory and Policy Technical Memorandum

Dredged Material Management Program

April 29, 2009

This page left intentionally blank.

Table of Contents

	Page
Introduction	1
Regulatory Framework for Open-Water Disposal of Dredged Material	3
Key Risk Management Choices and Assumptions	8
Description of the Agencies Proposal	17
Rationale for the Agencies Proposal	19
Rationale for the Proposed Suitability Guideline	25
References	27

This page left intentionally blank.

Introduction

Background

The Dredged Material Management Program (DMMP) agencies require chemical testing for projects involving dredged material disposal at eight open-water disposal sites in Puget Sound. Routine testing includes 62 chemicals of concerns. There are additional chemicals of concern where testing is required for limited areas. Dioxins have historically been in the latter category.

Until 2006, the maximum concentration of dioxins that could be present in dredged material being disposed at open-water disposal sites in Puget Sound was 15 pptr TEQ. This was based on a 1991 risk assessment that evaluated health risks to recreational fishers in the Grays Harbor area. Since 1991, there has been considerable research on tribal consumption rates in Puget Sound. In addition, EPA published a draft dioxin reassessment report in 2003, which underscored and revised the risk estimates for dioxin mixtures. In 2006, the DMMP agencies determined that the dioxin guidelines derived from the 1991 Grays Harbor risk assessment were no longer valid for Puget Sound. Over the last two years, the DMMP agencies have worked to update the suitability guidelines for dioxins and furans.

Risk Management Question

Dioxin and furans are widely recognized as hazardous substances that pose threats to human health and the environment. There is also widespread agreement among scientists, policy makers and the public that reasonable steps should be taken to reduce and/or prevent exposure to these substances. The dilemma facing the DMMP agencies revolves around how to make regulatory determinations in the face of the scientific uncertainties about the health risks at different levels of exposure.

Scientific information has guided the agencies' consideration of this issue. However, scientific information is only one of several factors considered by the agencies. In that sense, the agencies' deliberations have been focused on answering the following question:

How should the DMMP agencies revise the suitability guidelines for dioxins and furans, given:

- *Current statutory and regulatory framework for making decisions on the placement of dredged material at the open water disposal sites;*
- *Current scientific information on the threats to human health and the environment posed by dioxins and furans and the uncertainties surrounding those threats;*
- *Variability in exposures and susceptibility among individuals;*
- *Multiple sources and background concentrations and exposure levels; and*
- *Potential costs of different management options (e.g., open water, upland, etc.) and the uncertainties surrounding current cost estimates.*

Purpose of the Technical Memorandum

The DMMP agencies presented the proposal at a public workshop held on March 11, 2009. Attendees identified a wide range of concerns with the proposal. Based on the questions and concerns raised at the workshop, the agencies have decided to hold further meetings to discuss various risk assessment, economic impact and regulatory issues. This technical memorandum is designed to support review and discussion of the agencies proposal. It has been written to achieve three main purposes:

- Describe the regulatory and policy rationale for the agencies proposal;
- Describe key choices and assumptions underlying the agencies proposal; and
- Promote discussions with interested parties on key choices and assumptions.

Organization of the Technical Memorandum

This technical memo is organized into five main sections:

- Regulatory Framework for Open Water Disposal of Dredged Material: This section provides an overview of state and federal regulatory requirements applicable or relevant to agency decision-making on the disposal of dredged material at the open water disposal sites.
- Key Risk Management Choices and Assumptions: In preparing the proposal, the agencies needed to make a number of choices and assumptions. This section summarizes some of the key choices underlying the proposal and provides the technical and policy rationale for those choices.
- Description of the Proposal: This section summarizes the scope and key elements of the proposal.
- Rationale for the Proposal and the Site Management Objective: The agencies considered a wide range of factors when evaluating whether and how to revise the suitability guidelines for dioxins and furans. This section provides the technical and policy rationale for the agencies proposal.
- Rationale for the Proposed Suitability Guidelines: The agencies proposal includes revised suitability guidelines (pass-fail criteria) that would be used to evaluate individual projects. This section provides the technical and policy rationale for the proposed values.

Regulatory Framework for Open Water Disposal of Dredged Material

This section provides an overview of state and federal regulatory requirements applicable or relevant to agency decision-making on the disposal of dredged material at the open water sites. The DMMP believes it is important to understand current requirements including key constraints and areas of flexibility.

Puget Sound Dredged Disposal Analysis (PSDDA)/Dredged Material Management Program (DMMP)

The DMMP has established guidelines for unconfined, open water disposal sites for dredged material. These guidelines provide a comprehensive set of procedures for the sampling, testing, and evaluation of dredged material to ensure that such material is acceptable for unconfined, open-water disposal. The original evaluation procedures and the rationale for the procedures (*Evaluation Procedures Technical Appendix – Phase I (Central Puget Sound))* were published in June 1988 (PSDDA 1988a). Several times over the last 20 years, the DMMP agencies have updated the original guidelines based on new scientific information. The most current procedures are described in the *Dredged Material Evaluation and Disposal Procedures (Users Manual)* published in July 2008 (DMMP 2008). These evaluation procedures are used to assess projects conducted under Sections 401 and 404 of the Clean Water Act. Key features that are relevant to the current project include the following:

- Decision-Making Framework: Chemical disposal guidelines developed by the DMMP to evaluate dredged material established two chemical guideline values, the screening level (SL) and the maximum level (ML) for making decisions on dredged material suitability. The SL is defined for each chemical-of-concern (COC) as a guideline that establishes chemical concentrations[1] below which there is no reason-to-believe that dredged material disposal would result in unacceptable adverse effects to benthic organisms. ML guidelines established for DMMP chemicals corresponds to the concentration of a given chemical in dredged material, above which there is a reason-to-believe that the dredged material would be unacceptable for unconfined, open-water disposal. No bioassay testing is required when chemical levels are less than the SL. Above the SL and below the ML, routine toxicity testing is required. For a selected number of chemicals with bioaccumulative human health and/or ecological health concerns, the DMMP has established a bioaccumulation trigger (BT). Bioaccumulation testing is required if the BT is exceeded in dredged material. If a chemical exceeds the ML, biological testing is required. However, ML exceedances generally result in sediments that are found to be unsuitable for unconfined-open-water disposal. Most dredging applicants generally decline to conduct biological effects testing when one or more MLs are exceeded, and accept the material as unsuitable for open-water disposal at a DMMP site.
- Site Management Conditions: During the initial PSDDA studies, the agencies established management goals for the disposal sites. These goals are referred to as "site management conditions" or simply "site conditions."
    - Site Condition I (no adverse effects) applies to dispersive sites, and is defined as no benthic biological effects may exceed acute or chronic toxicity guidelines, and human health risks are not greater than 1 in 100,000 estimated incremental lifetime cancer risk.
    - Site Condition II (minor adverse effects) applies to non-dispersive sites, and is defined as some benthic biological effects may exceed acute or chronic toxicity guidelines (but limits the number

[1] The SLs are set at the Lowest Apparent Effects Levels (LAET) established for each chemical from a range of biological indicators, and the ML is established at the Highest Apparent Effects Threshold (HAET) level for each chemical expressed from a range of biological indicators (PSSDA, 1988, page II-208).

and intensity of these exceedances), and human health risks are not greater than 1 in 100,000 estimated incremental lifetime cancer risk.

- Evaluation Procedures for Human Health: The PSDDA agencies included human health screening methods and policies in the original technical protocols (PSDDA, 1988a). Specifically, a cancer risk of 1E-05 was selected for the derivation of risk-based tissue screening values that were used to evaluate the results from bioaccumulation tests. In developing the guidelines, the agencies noted that risk-based screening values may be lower than background concentrations. In these situations, the agencies recommended that decisions be based on a comparison to background concentrations. One chemical known to require such a comparison was arsenic:

  Arsenic is unique in that both reference and nonreference tissue levels in Puget Sound exceed the indicator value. Arsenic is high in reference tissues primarily because arsenic is naturally elevated in seawater in the north-eastern Pacific (including Puget Sound) and is bioaccumulated by organisms. This condition implies that the indicator value would not be useful in interpreting bioaccumulation tests on dredged material because control, reference and test tissues are likely to exceed the HI. Consequently, arsenic tissue concentrations should be interpreted by the use of statistically significant elevations above reference (EAR) concentrations as a measure of pollutant effects that are a concern for human health. This is, if tissue concentrations for test organisms are significantly above tissue concentrations for reference organisms, the dredged material would be considered unacceptable for unconfined, open-water disposal. (pp. II-127 & 128)

- Interim Guidelines for Dioxins and Furans: DMMP has not established a Screening Level (SL) and Maximum Level (ML) for dioxins and furans based on benthic toxicity. Consequently, reviews of dioxin data are done on a project-specific basis using interim guidelines. The interim guidelines were adopted by the Directors of the DMMP agencies in March 2007 to serve as a clear and consistent process for making suitability determinations until programmatic revisions are completed (DMMP 2008). Key features of the interim guidelines include:

  - Non-dispersive sites in Puget Sound: The evaluation approach is based on a comparison of dioxin in test sediments to disposal-site background. "Background" is defined using disposal-site sediment dioxin data generated as part of DMMP site monitoring. Under the interim approach, dioxin concentrations in any given dredged material management unit may not exceed the maximum of measured concentrations surrounding the site (off-site stations). In addition, the average dioxin concentrations (weighted to the volume of each dredged material management unit) cannot exceed the mean concentration surrounding the site (off-site locations). Bioaccumulation testing for dioxin is currently not used to determine suitability for nondispersive sites in Puget Sound.

  - Dispersive sites in Puget Sound: The evaluation approach is based on a comparison of dioxin in test sediments to reference background. "Background" is defined using sediment dioxin data from the nearest reference site. In the past, the available reference site dioxin data have been limited to Carr Inlet and Sequim Bay. Under the interim guidelines, it is the dredger's responsibility to sample the nearest reference site if data are not available. Bioaccumulation testing for dioxin is currently not used to determine suitability for dispersive sites in Puget Sound.

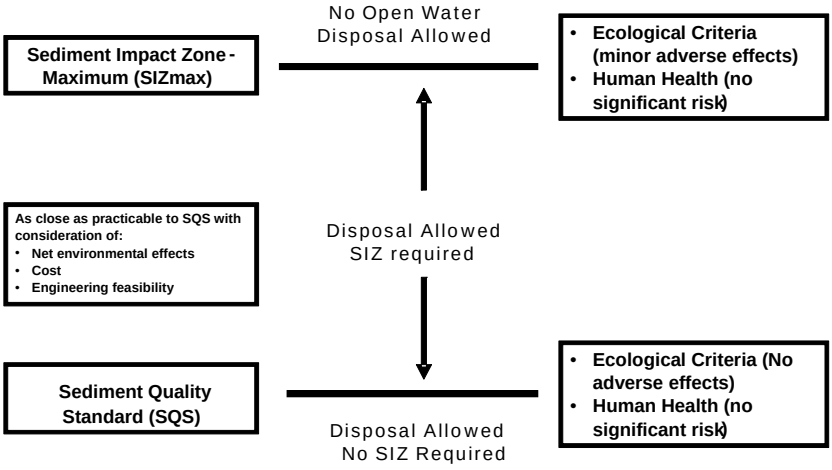
  - Dispersive sites in Grays Harbor: Under the interim guidelines, the DMMP uses a dioxin concern level of 5 ng/kg 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and a total toxic equivalency (TEQ) of 15 ng/kg as a trigger for requiring bioaccumulation testing. These concern levels were derived from a dioxin risk assessment performed by the COE (1991) for Grays Harbor in 1991. NOTE: The current proposal only applies to Puget Sound sites. The Grays Harbor guidelines will be updated at a future date.

Sediment Management Standards Requirements for DMMP Sites

The Sediment Management Standards (SMS) rule was published in 1991 to implement Ecology's responsibilities under the Water Pollution Control Act (90.48 RCW), the Model Toxics Control Act (70.105D RCW), and several other state laws.[2] EPA has approved the SMS rule as one part of Washington's water quality standards required under the Federal Clean Water Act. Part IV of the SMS rule establishes requirements that are applicable to the open water sites managed by the DMMP. The SMS rule incorporates the DMMP (formerly PSDDA) sediment characterization requirements by reference. Important features include:

- Decision-Making Framework: The SMS rule includes a two-tiered decision-making framework (Figure 1). The Sediment Quality Standards (SQS) represent the lower (more protective) tier in the SMS framework. SQS values are defined as sediment contamination that poses "no adverse effects" to sediment organisms and "no significant human health risk". The Sediment Impact Zone maximum (SIZmax) standards represent the higher (less protective) tier in the SMS framework. SIZ max values are defined as sediment contamination that pose "minor adverse effects" to benthic organisms and "no significant human health risk".

Figure 1: Open Water Disposal Sites
Two-Tier Decision-making Framework



Dredged material cannot be taken to open-water disposal sites if the material will cause site conditions that exceed the SIZmax. While the SMS rule authorizes Ecology to designate open-water disposal sites as Sediment Impact Zones if disposal activities result in sediment concentrations above the SQS, the results of monitoring over the last 20 years demonstrate that onsite chemistry and bioassay results are largely below SQS for benthic effects. Consequently, Ecology has concluded that it is not necessary to establish Sediment Impact Zones for the DMMP disposal sites based on benthic toxicity.

[2] Ecology has initiated a rulemaking process to amend the SMS rule and the Model Toxics Control Act (MTCA) Cleanup Regulation (Chapter 173-340 WAC). That rulemaking is focused on issues related to cleanup standards and actions. However, some of those issues are similar to issues that the DMMP agencies have considered during the current project.

- Chemical and Biological Criteria Based on Sediment Toxicity: The SMS rule includes chemical and biological tests that are used to identify sediments that pose "no adverse effects" and "minor adverse effects" to benthic organisms. The current chemical and biological tests focus on acute and sub-chronic effects in benthic organisms. Consequently, the current criteria and tests do not directly address risks to fish, wildlife and humans posed by the bioaccumulation in the food web.
- Human Health Narrative Standard: The SMS rule states that the SQS and SIZmax must both be established at levels that are "…below levels which correspond to a significant health risk to humans" (WAC 173-204-320(1)(a) and 173-204-420(1)(a), respectively). Determinations on what concentrations satisfy this narrative standard are made on a case-by-case basis when making suitability determinations for individual projects.
- Requirements for Open Water Disposal Sites: The SMS rule states that Ecology will establish requirements for dredging activities and disposal sites that include the testing and disposal requirements developed by the Puget Sound Dredged Disposal Analysis (PSDDA) program and cited in various PSDDA documents[3]. The SMS rule also states that (when necessary) Ecology may authorize sediment impact zones of PSDDA sites through administrative orders issued under Chapter 90.48 RCW.

Sediment Management Standards (SMS) Requirements for Sediment Cleanup

The Sediment Management Standards (SMS) rule also establishes requirements for identifying cleanup sites and selecting cleanup standards/cleanup actions. While these requirements are not immediately applicable to the DMMP sites, the agencies have considered the relationships between the various SMS provisions when making decisions on whether and how to revise the suitability guidelines for dioxins and furans. Key features of the SMS sediment cleanup provisions include:

- Decision-Making Framework: The SMS rule includes a two-tiered framework for establishing sediment cleanup standards that is conceptually identical to the two-tiered approach developed for open-water disposal sites. The lower (more protective) tier is the Sediment Quality Standard (SQS). This is defined as a sediment concentration that poses "no adverse effects" to sediment organisms and no significant risk to human health. The higher tier represents the regulatory limit. The SMS rule includes two types of regulatory limits applicable to sediment cleanup:
  - Cleanup Screening Levels: The CSL defines the maximum degree of sediment contamination allowed before a contaminated sediment site cleanup is required.
  - Minimum Cleanup Levels: The MCUL defines the maximum degree of sediment contamination allowed to be left in place after active cleanup.

  As with the SIZmax, MCULs and CSLs are set at sediment concentrations that pose "minor adverse effects" to benthic organisms and no significant risk to human health.
- Chemical and Biological Criteria Based on Sediment Toxicity: The SMS rule includes chemical and biological tests that are used to identify sediments that pose "no adverse effects" and "minor adverse effects" to benthic organisms. The current chemical and biological tests focus on acute and sub-chronic effects in benthic organisms. Consequently, the current criteria and tests do not directly address risks to fish, wildlife and humans posed by the bioaccumulation in the food web.

[3] WAC 173-204-410(7)(a) states that the SMS guidelines shall include testing and disposal guidelines cited in several PSDDA documents including (1) Management Plan Report – Unconfined Open Water Disposal of Dredged Material, Phase I, (Central Puget Sound), June 1988, or as amended; (2) Management Plan Report – Unconfined Open Water Disposal of Dredged Material, Phase II, (North and South Puget Sound), September 1989, or as amended; and (3) Users Manual for Dredged Material Management in Puget Sound, November 1990, or as amended.

- Human Health Narrative Standard: The SMS rule requires that sediment cleanup standards must be established at levels that are "…below levels which correspond to a significant health risk to humans" (WAC 173-204-320(1)(a) and 173-204-420(5), respectively). Determinations on what concentrations satisfy this narrative standard are made on a case-by-case basis when establishing sediment cleanup standards at individual sites.
- Cleanup Site Identification: The SMS rule includes a process for identifying sediment cleanup sites. Under this process, areas with sediment concentrations above the CSL are defined as cleanup sites. Ecology currently uses the SMS chemical and biological criteria to define cleanup sites.
- Cleanup Standards: Cleanup standards are established on a site-specific basis at levels that are as close as practicable to the SQS taking into account net environmental protection, feasibility and cleanup costs. The MCUL defines the upper constraint (least stringent) for site-specific cleanup standards. Ecology currently uses the SMS chemical and biological criteria to define cleanup sites. Ecology also performs site-specific interpretation of the human health narrative standard.

The Model Toxics Control Act (MTCA) provides the statutory basis for the majority of site cleanup actions conducted/overseen by Ecology. Consequently, sediment cleanup actions must comply with the general requirements in the MTCA Cleanup Regulation. This includes the requirement that cleanup standards for dioxin mixtures are based on a cancer risk level of one-in-one million (10^{-6}).

Relationships Between SMS Requirements Applicable to Dredging and Cleanup

Ecology evaluated the interrelationships between dredging and sediment cleanup when developing the SMS rule. When publishing the rule, the agency attempted to align the requirements for dredging, cleanup and source control. Ecology's overall goal was to create a regulatory framework that allows different programs to be implemented without conflict and in ways that complement each other. The Final Environmental Impact Statement for the SMS rule (Ecology 1991b) discussed key relationships between the regulatory limits applicable to dredging and sediment cleanup. In particular, Ecology stated that "…[t]he quality of dredged material that meets current disposal guidelines for unconfined, open-water disposal should not result in the need for future active cleanup. Therefore, the CSL should be established at or above the current PSDDA disposal guidelines." (p. 2-6). The DMMP has considered the relationships between dredging and sediment cleanup when evaluating options for updating the suitability guidelines for dioxin mixtures.

Key Risk Management Choices and Assumptions

The agencies made a number of choices and assumptions when preparing the proposal. These choices generally reflect a combination of scientific and policy determinations. The agencies recognize that there is not always a clear separation between scientific and regulatory policy determinations and that multiple interpretations are inevitable given the wide range of situations and fact patterns that arise at specific disposal sites and for specific dredging projects. Consequently, the agencies have tried to provide a clear rationale for the key scientific and policy choices that helped to shape the DMMP proposal. This section summarizes the technical and policy rationale for some of the more important choices.

Focus on High Exposure Populations

The DMMP agencies evaluated the cancer risks associated consuming seafood with background levels of dioxin (see the companion Dioxin Risk Assessment Technical Memorandum). To help guide that evaluation, the agencies developed a conceptual site model which was used to select the exposure pathways and population groups considered during the risk evaluation. Based on that site model, the agencies decided to characterize the health risks for a range of consumers, including the general population, recreational or medium-exposure groups and high-exposure population groups. With respect to the latter, the agencies evaluated the potential health risks to tribal populations[4] who catch and consume fish and shellfish from embayments in which the DMMP sites are located. The rationale for this choice includes:

- The DMMP sites are located in the Usual and Accustomed (U&A) fishing areas for one or more Puget Sound tribes. The PSDDA agencies described the site locations relative to U&A areas in the Phase I and Phase II Environmental Impact Statements (PSDDA 1988c; PSDDA 1989b). The information in the EIS documents is consistent with more recent information compiled by the Washington State Department of Transportation (WSDOT 2008).
- Available information on fish consumption rates indicates that many tribal members consume much larger amounts of local fish and shellfish than recreational fishers or the general public. Several researchers have completed surveys of tribal fish consumption habits and patterns. The agencies used the results from two surveys from Puget Sound tribes (Suquamish Tribe, 2000; and Toy et al. 1996) when preparing the risk evaluations for this project (see Table 1 in Dioxin Risk Assessment Technical Memorandum). The information from Puget Sound tribal surveys are consistent with studies summarized in the EPA guidance documents (EPA 1997; EPA, 2006). The fish consumption rates and other exposure parameters specified in these studies and guidance documents are much higher than rates for recreational fishers and the general public.
- Use of a tribal exposure scenario is consistent with federal guidance for water quality standards: EPA has approved the SMS rule as part of Washington's water quality standards. Consequently, EPA guidance (EPA 2000) for developing water quality standards is applicable to the interpretation of the SMS narrative standard. EPA recommends that states consider high exposure population groups when establishing state water quality standards.
- Use of a tribal exposure scenario is consistent with MTCA policies that are applicable to sediment cleanup actions: Under the Model Toxics Control Act (MTCA) Cleanup Regulation,

[4] When designing the risk evaluation, the agencies recognized that other population groups may also consume large amounts of fish and shellfish from Puget Sound. However, available studies indicate that tribal consumptions rates are similar to or higher than those for nontribal fishers (e.g., ethnic minority populations and recreational anglers). Consequently, the agencies concluded that use of tribal consumption rates is a health protective approach for evaluating health risks.

cleanup levels are based on estimates of the "reasonable maximum exposure" (RME).[5] The RME is designed to represent a high end (but not worst case) estimate of individual exposures and provides a conservative estimate that falls within a realistic range of exposures. This requirement applies to all environmental media including sediments. The MTCA rule also includes specific methods for establishing media-specific cleanup levels for ground water, surface water, soil and air. The methods for establishing surface water cleanup levels are conceptually similar to methods used to establish sediment cleanup levels because they are both based on preventing health risks associated with the consumption of contaminated fish and shellfish. The reasonable maximum exposure (RME) for MTCA surface water cleanup standards is generally based on a recreational angler exposure scenario.[6] However, Ecology has made site-specific determinations that a recreational angler exposure scenario is not appropriate at several sites located within one or more U&A areas (Ecology 2008). Ecology has based sediment cleanup requirements for these sites on a tribal exposure scenario.[7]

- Use of a tribal exposure scenario facilitates integration of policies for dredging and cleanup actions: The SMS rule requires Ecology to implement the SMS requirements for DMMP sites "…so as to prevent the creation of new contaminated sediment cleanup sites identified under WAC 173-340-530(4)…".[8] As noted above, MTCA cleanup standards are often based on a tribal exposure scenario. Ecology believes that using a tribal exposure scenario will promote integration of requirements for dredging and cleanup actions.
- Use of a tribal exposure scenario is consistent with EPA Region 10 guidance for Superfund cleanup actions: EPA Region 10 has published a decision-making framework for selecting and using tribal consumption data to establish cleanup requirements at federal Superfund sites (EPA 2007a). The framework identifies a four-tiered hierarchy of preferred data sources. Under the EPA Framework, exposure estimates for particular tribes can be based on fish consumption surveys from other tribes (Suquamish or Tulalip Tribes) with similar dietary habits.
- Use of a tribal exposure scenario is consistent with Title VI of the Civil Rights Act of 1964, federal trust responsibilities and tribal treaty rights. Title VI of the Civil Rights Act of 1964 and EPA's implementing regulations (40 CFR 7.25) state that federal grant recipients should not use criteria or methods that have the effect of inequitably treating members of a protected group. Under the federal rules, protected groups include "American Indians" and "Asian and Pacific Islanders".

Risk Assessment Methodology

The concept of risk can be very confusing and people often have different opinions on the best ways to measure and characterize risk. This was highlighted by Lyndon (1989) who observed that "…risk is a slippery concept; it has no simple meaning, but varies in content according to circumstances."

[5] MTCA defines the RME as the "…the highest exposure that can be reasonably expected to occur for a human or other living organisms at a site under current and potential future site use." CERCLA provides a similar definition "…the highest exposure that is reasonably expected to occur at a Superfund site…"

[6] WAC 173-340-730(1)(e) states that "…[t]he department may require more stringent cleanup levels than specified in this section where necessary to protect other beneficial uses or otherwise protect human health and the environment."

[7] Ecology has established (or in the process of establishing) sediment cleanup requirements for a wide range of sites located in usual and accustomed fishing areas of one or more tribes. In these situation, Ecology has used a tribal exposure scenario to establish cleanup standards. Sites include Bellingham Bay (Whatcom Waterway), Alcoa Vancouver and the former Rayonier mill site in Port Angeles.

[8] WAC 173-204-410(1)(c).

This observation is particularly relevant to the agency and public discussions on the dioxin suitability guidelines. A certain amount of confusion has been created on this topic because people have suggested several approaches for characterizing health risks. The agencies have reviewed these approaches and found that all of the approaches are based on the standard risk assessment methods. Indeed, the various assessments use many of the same exposure and toxicity parameters and assumptions.

Another common feature is that all of the approaches represent some form of "incremental" risk assessment. In other words, the assessments produce estimates of increased risks associated with sediment-related exposure relative to an underlying risk baseline. However, the approaches differ in terms of the risk baseline considered in the assessment. These distinctions are briefly described below.

- Background Risks: The DMMP agencies prepared a risk assessment to characterize the health risks posed by background levels of dioxins in fish and shellfish tissue (see the companion Dioxin Risk Assessment Technical Memorandum).[9] This background risk assessment is designed to answer the question "What are the estimated cancer risks associated with eating fish and shellfish with background levels of dioxins? " The background risk assessment involves estimating the risks over and above the risk due to non-Puget Sound fish/shellfish exposures (e.g. dairy products, meat, etc). The agencies decided that this background approach is appropriate when attempting to interpret the Sediment Quality Standard (SQS) human health narrative standard. This type of risk baseline is typically used by environmental agencies when establishing media-specific standards. For example, EPA uses this type of baseline when establishing water quality standards for carcinogenic substances (EPA 2000):

  > *The 2000 Human Health Methodology uses different approaches for addressing non-water exposure pathways in setting AWQC for the protection of human health depending on the toxicological endpoint of concern. With those substances for which the appropriate toxic endpoint is carcinogenicity based on a linear low-dose extrapolation, only two water sources (e.g. drinking water and fish ingestion) are considered in the derivation of the AWQC. Non-water sources are not considered explicitly. In the case of carcinogens based on linear low dose extrapolation, the AWQC is being determined with respect to the incremental lifetime risk posed by a substance's presence in water, and is not being set with regard to an individual's total risk from all sources of exposure. Thus, the AWQC represents the water concentration that would be expected to increase an individual's lifetime risk of carcinogenicity from exposure to the particular pollutant by no more than one chance in one million, regardless of the additional lifetime cancer risk due to exposure, if any, to that particular substance from other sources (pp. 4-3 and 4-4)*[10]

- Site-Specific Risks: Several people have suggested that the agencies establish dioxin guidelines at sediment concentrations where site-specific health risks do not exceed a target risk level. Under this approach, risk assessments would be designed to answer the question "What are the estimated cancer risks associated with eating fish that could be exposed to dredged material placed at the unconfined open-water disposal sites? With this question, the agencies would estimate the incremental risks posed by the disposal site relative to a baseline created by dioxin exposures created by other activities (including fish/shellfish exposures that are unrelated to the

[9] The agencies based the assessment of background risks on dioxin measured in fish and shellfish tissue collected from reference/non-urban locations in Puget Sound.

[10] Many other state and federal programs use this type of incremental risk assessment approach to establish regulatory requirements. For example, EPA (2007b, 2008b) recently elected to lower the primary National Ambient Air Quality Standard (NAAQS) for lead from 1.5 ug/m^3 to 0.15 µg/m^3. EPA acknowledged that there are multiple sources of lead exposure, but focused on the air-related impacts on neurological development. The underlying policies used to update the NAAQS for lead (e.g. focus on incremental air-related exposures) are conceptually similar to the human health methods for water quality standards.

DMMP sites)[11]. This approach is consistent with the Evaluation Procedures Technical Appendix (EPTA) published by the PSDDA agencies (PSDDA 1988a). The EPTA guidelines are designed to characterize health risks associated with eating fish "…that could have been exposed to dredged material placed at the unconfined, open water, disposal sites…" (p. II-125).[12] The agencies decided that this approach is not appropriate for evaluating compliance with the Sediment Quality Standard (SQS) human health narrative standard. However, this approach may be appropriate when establishing site-specific requirements within a sediment impact zone because of the similarities to the EPTA guidelines. The practical implications of using this type of approach are unclear in situations where background concentrations are associated with cancer risks that already exceed benchmark cancer risk levels.

- Background + Site-Specific Risks: Several individuals who provided comments in 2007 suggested that the agencies establish guidelines at sediment concentrations that represent the sum of background levels and site-specific levels corresponding to a target risk level. In some ways, this type of assessment combines elements of the background and site-specific assessments. This type of risk assessment is designed to answer the question "What site sediment concentrations will produce a small site-specific risk relative to the risks posed by background levels of sediment contamination?" As discussed below (Zero Increment above Background), the agencies have decided not to use an approach that involves adding a non-zero increment of risk to background levels that already exceed benchmark cancer risk levels.

Cancer Risk Levels- Sediment Quality Standards

When making decisions on carcinogenic substances, a key policy choice is the target or reference cancer risk level. When interpreting the human health narrative standard for the Sediment Quality Standards, the DMMP agencies chose to define "no significant health risk to humans" as an increased risk of one-in-one million (10^{-6}). The rationale for this choice includes:

- The use of a 10^{-6} cancer risk level is consistent with the cancer risk level used to establish Washington water quality standards: In December 1992, EPA completed a rulemaking (the National Toxics Rule) to establish chemical-specific numeric criteria based on human health protection applicable to 14 states (including Washington) (EPA 1992). The risk-based criteria for Washington are based on a cancer risk of one-in-one million (10^{-6}). Ecology subsequently completed a state rulemaking to reference the National Toxics Rule and specify that risk-based criteria for carcinogenic substances shall be based on a 10^{-6} cancer risk level (Chapter 173-201 WAC).
- The use of a 10^{-6} cancer risk level will promote integration of policies for dredging and cleanup actions: The MTCA rule establishes a target cancer risk level (10^{-6}) that is applicable to sediment cleanup actions. While the MTCA rule is not directly applicable to decisions on open-water disposal, using a target cancer risk level of 10^{-6} to implement the SQS narrative standard will promote integration of requirements for dredging and cleanup actions.
- The use of a 10^{-6} cancer risk level is consistent with approaches used by other state agencies: State and federal agencies use several target cancer risk levels when establishing regulatory requirements. One-in-one million is the most commonly used risk metric. For example, the Association of State and Territorial Solid Waste Management Officials (ATSWMO 2006) recently completed a survey of state action levels. They found that 20 of the thirty-four states

[11] Site-specific risks can be calculated using either sediment or tissue data.
[12] While not directly applicable to decisions at the DMMP open water sites, this approach is also consistent with risk assessment procedures specified in the MTCA rule.

completing the survey establish remedial action requirements using a 10^{-6} cancer risk level. Twelve of the thirty-four states use a one-in-one hundred thousand risk level (10^{-5}).

Default to Background Concentrations

The DMMP agencies are proposing to use a background-based approach for the updated dioxin suitability guidelines because the risks associated with consumption of seafood with background levels of dioxin are greater than the SQS narrative target level of 10^{-6} (see the companion Dioxin Risk Assessment Technical Memorandum). The rationale for this a background-based approach includes:

- This approach is consistent with the decision-making framework in the Evaluation Procedures Technical Appendix (EPTA). The PSDDA agencies included human health screening methods and policies in the original technical protocols. The protocols include risk-based tissue screening values that were used to evaluate the results from bioaccumulation tests. In developing the guidelines, the agencies noted that risk-based screening values may fall below reference concentrations. In these situations, the agencies recommended that decisions be based on a comparison to reference or background concentrations (See earlier discussion on DMMP requirements on pp. 7-8).[13]
- This approach is consistent with the case-by-case decision-making frameworks used to interpret the SMS narrative standards at sediment cleanup sites. Ecology has made case-by-case decisions interpreting the SMS narrative standards at many sites. The department has established background based standards in situations where the risk-based values are below reference area concentrations.
- This approach is consistent with the general MTCA requirements applicable to sediment cleanup actions. The MTCA rule establishes methods and policies for establishing risk-based cleanup levels. The MTCA rule states that site cleanup levels should be based on either the risk-based concentration or natural background levels, whichever is higher.[14]

Statistical Measure Used to Characterize Background Levels

Estimates of background levels in Puget Sound sediments are based on data from sediment investigation conducted in August 2008, monitoring results from areas surrounding the Anderson Ketron DMMP site and previously-collected data from Puget Sound reference areas. This combined dataset provides the most current and comprehensive information for characterizing background sediment concentrations in Puget Sound. The DMMP agencies have chosen to characterize background levels using an estimate of the upper end of the range of measurements from the main basin of Puget Sound and reference areas. Specifically, the agencies have chosen to use a number that corresponds to the 90 % upper confidence interval on the 90th percentile of the distribution of background measurements. The rationale for this choice includes:

[13] Note: The DMMP and MTCA approaches both include procedures for defaulting to background concentrations when the background risks exceed the applicable target risk concentrations. In both cases, background concentrations are used in lieu of the risk-based concentrations. Under those procedures, the risk-based concentrations are not added to the background concentrations.

[14] WAC 173-340-700(6)(d) states "…[i]n some cases, cleanup levels calculated using the methods specified in this chapter are less than natural background levels or levels that can be reliably measured. In those situations, the cleanup level shall be established at a concentration equal to the practical quantitation limit or natural background concentration, whichever is higher…"

- It is consistent with approaches that have been used to implement the SMS narrative provisions. Ecology and EPA have traditionally used the 90th percentile of reference area measurements to characterize background concentrations. (PSEP, 1991).
- It is consistent with MTCA requirements applicable to sediment cleanup actions. The MTCA rule defines methods and policies for establishing risk-based cleanup levels. The rule states that site cleanup levels should be based on either the risk-based concentration or natural background levels, whichever is higher. The MTCA rule generally uses the 90th percentile to characterize background concentrations.
- It minimizes the chance that DMMUs that fall within the background range of concentrations will be considered unsuitable for open-water disposal (reduces false positives).

Use of Sediment Impact Zones

The SMS rule states that Ecology may authorize sediment impact zones for PSDDA sites (WAC 173-204-410(7)(c) and (d)). SIZ authorizations provide the flexibility to establish disposal guidelines that take into account costs, net environmental protection and technical feasibility. However, the agencies did not pursue options that would require a SIZ authorization. The rationale for this choice includes:

- The proposed approach is designed to ensure that dredged material placed at the open water sites will not reach levels that trigger the need for cleanup site designation and active cleanup.
- The agencies evaluated the need for SIZs at the DMMP sites in the early 1990's and again in 2008. During those reviews, the agencies identified several implementation issues. These include the need for a closure plan, increased management of disposal sites during their operational life, potential encumberances on the use of state-owned land, need for a mechanism to address potential state liabilities and uncertainty on local permitting requirements.
- The agencies evaluated the impacts of the proposed guidelines relative to previous guidelines. That evaluation is currently being reviewed by the dredging community and the agencies intend to update the evaluation based on public comments. However, the initial impact analysis indicates that the volume of sediments passing the proposed guidelines is similar to the volume that would be acceptable for open water disposal using the previous guidelines (e.g., 15 pptr TEQ).
- Given the current impact analysis, the agencies concluded that the benefits of using a SIZ were unlikely to outweigh the liabilities and added complexities associated with establishing an SIZ at one or more DMMP sites. The agencies have not discussed whether or how an updated impact analysis would affect this conclusion.

If there are future discussions on options that include an SIZ authorization, Ecology believes that there are several important constraints/factors that will need to be considered:

- <u>SIZs cannot be used to authorize the disposal of material that would result in site concentrations that exceed the SIZmax standards in WAC 173-204-420.</u> The SIZmax standards include (1) chemical and biological criteria based on "minor adverse effects" and (2) a narrative standard for human health protection (i.e. no significant risk to human health).
- <u>SIZs for disposal sites cannot be used to authorize disposal of materials that would result in a site-specific cancer risk level greater than one-in-one hundred thousand (10^{-5}).</u> Ecology (1991) chose to establish the SMS regulatory limits (SIZmax, CSL, MCUL) at a level that is functionally equivalent to the guidelines established by the PSDDA program for unconfined, open water disposal of contaminated sediments (e.g. Site Condition II). WAC 173-204-410(7)(a) states that disposal guidelines must include testing and disposal requirements developed by PSDDA.

Consequently, the SMS rule appears to preclude SIZmax conditions that exceed the PSDDA guidelines for human health protection that are based on a site-specific cancer risk level of 10^{-5}.

- Sediment impact zones must be designed to achieve site sediment concentrations that are as close as practicable to the Sediment Quality Standards. The determination of what is "close as practicable" can take into account costs, net environmental protection and technical feasibility. As noted above, there are several implementation requirements (e.g. closure plan, management plan, etc.) that would need to be met when using this regulatory mechanism.

Managing Uncertainty in Toxicity Information

The DMMP agencies used the current EPA cancer slope factor (150,000 mg/kg/day^{-1}) when evaluating the cancer risks associated with dioxin-contaminated sediments. The rationale for this choice includes:

- The Environmental Protection Agency recommends that this value be used pending completion of the agency review and response to the National Research Council review of the EPA dioxin reassessment. EPA has initiated a process to review the National Research Council's (NRC 2006) recommendations on the cancer slope factor for dioxins. In the interim, EPA recommends that EPA risk assessors continue to use the cancer slope factor published in the Health Effects Assessment Summary Table (HEAST).
- The HEAST value falls within the range of values developed by credible scientific organizations. The HEAST value is less stringent than the cancer slope factor (1,000,000 mg/kg/day^{-1}) in the EPA Dioxin Reassessment (EPA 2003) and more stringent than the value calculated by the California Environmental Protection Agency (26,600 mg/kg/day^{-1}) (California EPA 2007).
- There are a range of scientific opinions on the practical significance of the NRC findings. The agencies recognize that a recent National Research Council (NRC, 2006) committee has concluded that the dose response relationship for low-level dioxin exposure is likely to be non-linear. Under the current EPA Cancer Guidelines (EPA 2005), a margin of exposure approach is typically used for carcinogens with a non-linear dose response relationship. The use of this methodology would generally produce a less-stringent toxicity value. However, the agencies are also aware that a more recent NRC (2008) committee charged with reviewing the EPA risk assessment policies and procedures has concluded that it may still be appropriate to use a linear extrapolation model for compounds like dioxin because of background exposures and variability in human susceptibility.

Managing Variability in Exposure

Exposure to hazardous substances is influenced by a wide range of factors and there are often wide ranges in exposures within a given population. Agencies may have some information on the range of values for a particular parameter (e.g. fish consumption rates). However, agencies must also decide which value within the range to use to characterize the range of values (e.g. average or upper end of exposure range). Choosing a summary measure to characterize population exposure reflects an explicit (or implicit) policy choice on the appropriate balance between over- or underestimating exposure levels for particular individuals within the population group. The DMMP agencies have chosen to estimate exposure levels using a combination of parameters that produce an estimate of the upper end of the exposure spectrum (although not worst case). The rationale for this choice includes:

- This approach is consistent with the laws that provide the underlying basis for the SMS rule and other implementing regulations.

- This approach is consistent with the policies and procedures for establishing water quality standards.
- This approach is consistent with the MTCA policies and procedures applicable to sediment cleanup activities.

This page left intentionally blank

Description of the Agencies Proposal

Non-dispersive Disposal Sites in Puget Sound

The agencies are proposing to set volume-weighted (dioxin concentrations weighted to the volume of each Dredged Material Management Unit (DMMU)) *dredged material suitability guidelines* for all dredging projects so that material disposed at non-dispersive sites in Puget Sound would not result in disposal site surface concentrations that exceed a *disposal site management objective*.

> *Disposal Site Management Objective:* The agencies propose to establish a target disposal site concentration for all non-dispersive disposal sites at a level that is not significantly different than concentrations measured in the Puget Sound Main Basin and Reference Areas. The value proposed for the Disposal Site Management Objective is 4 pptr TEQ, which is the nonparametric estimation of the 90% upper confidence limit for the 90th percentile of the distribution of the background data set.
>
> *Dredged Material Suitability Guideline:* The agencies propose to establish suitability guidelines (pass-fail criteria) that would be used to evaluate individual projects. The suitability guidelines would have two components: 1) The volume-weighted average concentration of dioxin/furan in material from each dredging project could not exceed the disposal site management objective of 4 pptr TEQ; and 2) dioxin/furan concentrations could not exceed a maximum concentration of 10 pptr TEQ in any single DMMU.

Dispersive Disposal Sites in Puget Sound

The agencies are proposing that dioxin/furan concentrations should not exceed a maximum concentration of 4 pptr TEQ (the Disposal Site Management Objective) in any single DMMU.

Bioaccumulation Testing

The DMMP agencies are looking into the possibility of a test-out option involving bioaccumulation testing. The dredging proponent would have the option of pursuing bioaccumulation testing to determine whether or not the DMMUs could qualify for open-water disposal. It should be noted that a test-out option was available under the former guidelines.

A target tissue level (TTL) to be used in the bioaccumulation evaluation has not been determined for dioxins at this time. In the absence of a TTL, the dredging proponent would include a reference sediment in the bioaccumulation test. Concentrations in the project test- sediment tissue would be compared against concentrations in the reference-sediment tissue. The DMMP agencies are continuing to evaluate a bioaccumulation test-out option in the revised dioxin guidelines.

Revisions to Dioxin Testing Requirements

Testing for dioxins will continue to be required on a case-by-case basis in areas where there is reason to believe that dioxins and furans are present in the project sediments. Factors which could trigger a "reason-to-believe" determination include the following:

- Located within an urban bay and having no historical information showing that dioxin is below levels of concern
- Proximity to current or historical point sources, such as outfalls

- Proximity to chlor-oxide bleach process pulp mills; chlor-alkali or chlorinated solvent manufacturing plants, former wood treatment sites; phenoxy herbicide manufacture and/or use and handling areas
- Proximity to areas with high PCB concentrations
- Proximity to hog fuel burners/boilers, and areas with previous fires or incineration sources
- Proximity to areas previously sampled that showed elevated levels of dioxin

Dioxin testing will be required for all projects meeting one or more of the reason-to-believe factors described above. Deeper underlying sediments, which are confirmed as "native", will be exempt from testing, except as follows: the top 4 to 8 ft of a native sediment layer underlying sediments that are being tested for dioxins will also be required to be tested for dioxins.

These updated guidelines are consistent with the "reason to believe" requirements implemented in the last several years. Guidance for sampling density per project will remain unchanged.

The agencies recognize that dioxin analysis is expensive. The agencies are evaluating potential use of alternative assay-based testing methods, but those evaluations are still in progress.

Verification of Compliance with the Disposal Site Management Objective

The DMMP program would continue to implement best management practices (BMPs) for sequencing of disposal operations. This type of sequencing will help to ensure that site concentrations do not exceed the site management objective (4 pptr). Recent data from the Anderson-Ketron disposal site has shown that application of these types of BMPs has resulted in final site surface concentrations well below the current interim suitability guidelines for dioxins.

The agencies would increase the number of on-site monitoring samples collected at each disposal site from 3 to 10 to allow statistical comparisons to be made with Main Basin/Reference Areas concentrations. Otherwise, the site monitoring program would be very similar to the current program, with monitoring frequency based on site disposal volumes.

Monitoring results would be tracked over time to determine whether the disposal sites are coming into compliance with the new site management objective. If necessary, the suitability guideline will be adjusted to ensure the management objective is being met.

Geographic Limitations of the Proposal

The Dioxin Project has focused on developing revised guidelines for Puget Sound only. Dioxin suitability guidelines for areas outside of Puget Sound (e.g. Grays Harbor, Columbia River) will need to be revisited as well. There are significant differences between other systems and Puget Sound that may require adjustments to the proposed framework.

Other Bioaccumulative Compounds

The adjusted framework for dioxin could have implications for other bioaccumulative compounds, especially dioxin-like PCBs. This is an issue that the agencies have begun to discuss, but have not yet determined a recommended path forward. The DMMP's long-term goal is to develop revised guidelines for all key bioaccumulative compounds.

Rationale for the Agencies Proposal

Overview

The proposal represents that agencies' initial answer to the risk management question identified earlier in this document:

How should the DMMP agencies revise the suitability guidelines for dioxins and furans, given:

- *The current statutory and regulatory framework for making decisions on the placement of dredged material at the open water disposal sites;*
- *Current scientific information on the threats to human health and the environment posed by dioxins and furans and the uncertainties surrounding those threats;*
- *Variability in exposures and susceptibility among individuals;*
- *Multiple sources and background concentrations and exposure levels; and*
- *Potential costs of different management options (e.g. open water, upland) and the uncertainties surrounding current cost estimates.*

The agencies' rationale for the proposal rests on four main determinations:

- The agencies concluded that the proposed site management objective (in combination with other elements of the proposal) represents an environmentally protective approach and will support a healthier Puget Sound and safer seafood consumption when compared to the old guideline of 15 pptr. The agencies recognize that people have a wide range of opinions on health risk assessment issues. The agencies plan to meet with interested parties to discussed these issues during the public comment period following the annual review meeting on May 6th.
- The agencies concluded that the draft proposal is consistent with applicable environmental regulations and addresses state land ownership concerns. The agencies recognize that some of the SMS rule requirements should be clarified through rule amendments.
- The agencies' evaluation of past dredging projects indicates that the percentage of sediments passing the proposed guidelines is not significantly less than the percentage that would be acceptable for open water disposal using the previous guidelines (e.g. 15 ng/kg total TEQ). The agencies recognize that several dredging proponents have raised questions about whether use of data from past projects represents a reasonable approach for predicting future impacts. The agencies will be working with interested parties to update the agency impact analysis based on additional data and review of key assumptions.
- The agencies concluded that the proposal can be implemented within the existing DMMP structure.

These points are discussed in greater detail below.

Environmental Protection

A key feature of the agencies proposal is the site management objective (4 pptr). The proposed value is an estimate of the 90th percentile of the sediment concentrations measured in the main basin of Puget Sound and the reference areas traditionally used by the DMMP agencies. Agencies commonly use background concentrations to define regulatory requirements in situations where background or reference area risks exceed applicable regulatory benchmarks (see discussion on risk management choices). The agencies believe that the proposed site management objective (in combination with other elements of the proposal) represents an environmentally protective approach and will support a healthier Puget Sound and safer seafood consumption.

1. The agencies proposal will contribute to overall efforts to reduce levels of dioxins in Puget Sound. The proposal is one part of a broader strategy for dealing with bioaccumulative chemicals. In developing the proposal, the agencies have recognized the practical limitations posed by regional and global sources of dioxin compounds. Consequently, the long-term success of this approach depends on additional measures to deal with ongoing sources (point, non-point and global contributions) and cleanup of historic releases. The DMMP proposal includes review and adjustments to the site management objective as background levels decline.

2. The actual condition of the sites is expected to be better than what is allowed by the proposed guidelines. The agencies do not expect that all projects will have average concentrations of 4 pptr. It is likely that much of the dredged material will be cleaner than the proposed guideline and, consequently, the actual condition of the sites will be comparable to the background distribution, which is generally lower than 4 pptr.[15] This expectation is consistent with statements in the Environmental Impact Statements prepared to evaluate the potential impacts associated with the Phase I (Central Puget Sound) and Phase II (North and South Puget Sound) open water sites. It is also consistent with site monitoring performed by the Department of Natural Resources (DNR). Based on monitoring conducted between 2005 and 2007, DNR (2008) reported that concentrations at the DMMP sites were generally lower than the 15 pptr guideline that was used to evaluate projects prior to 2006.

3. The agencies have used the most current information on sediment background concentrations to prepare the proposal. Estimates of background levels in Puget Sound sediments are based on a sediment investigation conducted in August 2008 as well as earlier data from reference sites. The DMMP agencies have chosen to characterize background levels using an estimate of the upper end of the range of measurements from the main basin of Puget Sound and reference areas. Specifically, the agencies have chosen to use a number that corresponds to the 90% upper confidence interval on the 90th percentile of the range of background measurements.

4. The agencies proposal includes several implementation mechanisms that will help to ensure compliance and continued reductions in dioxin concentrations at open water sites. The proposal includes the following elements:

    - Short-term exceedances of the site management objective are unlikely, but would be confined to the disposal sites where they can be monitored and managed as necessary.
    - Increases testing requirements for dioxins
    - Adaptive Management process uses site monitoring data to validate that non-dispersive sites are meeting the goal and (if necessary) to make adjustments to suitability guidelines. This also allows the agencies the ability to review and (if necessary) modify the suitability guidelines based on improvements in Puget Sound background levels.

5. The proposal is consistent with regulatory guidelines being used in other parts of the United States. Other agencies have developed guidelines for open water sites. For example, the proposal is similar to a range for background used in San Francisco Bay. That range (2-4 pptr) is the median and mean of a data set (n=56) that was collected from background locations within San Francisco Bay (Brian Ross, pers. comm. February 2009).

[15] Ecology has evaluated the dioxin data from historic projects. Volume-weighted average concentrations for projects complying with the agencies proposal ranged from 1.8 to 3.4 ng/kg.

Regulatory Consistency

The DMMP guidelines and the Sediment Management Standards provide the primary regulatory foundation for the agencies proposal. These regulatory provisions include a clear set of criteria for regulatory decision-making based on benthic toxicity. However, the provisions have less detailed requirements applicable to the bioaccumulation pathway and human health risks. Consequently, much of the DMMP's evaluation focused on the SMS narrative standard that states that sediment quality standards must be set at or below "levels which correspond to a significant risk to human health". As discussed in Section 2 of this paper, the agencies used a two-step evaluation process when interpreting this provision. First, the agencies selected a benchmark cancer risk level (10^{-6}) that was used in evaluating the narrative standard. The agencies then determined that background levels of dioxin in Puget Sound main basin sediments exceed this risk benchmark (see Dioxin Risk Assessment Technical Memorandum). Given those results, the agencies chose to base the suitability guidelines on background concentrations. As discussed in Section 2, the agencies chose a background concentration that falls at the upper end of the distribution of dioxin in background samples.

The agencies believe that the proposal is consistent with applicable environmental regulations and addresses state land ownership concerns. In particular:

1. <u>The agencies believe the proposal complies with applicable requirements in the Sediment Management Standards (SMS) rule</u>. The draft Site Management Objective represents a case-by-case interpretation of the narrative Sediment Quality Standard (SQS) for human health protection. Compliance with the SMS rule requirements will not require Sediment Impact Zones (SIZs) because the draft Site Management Objective compiles with the SQS requirements.
2. <u>The agencies believe the proposal complies with the applicable provisions of the DMMP Users Manual</u>. The agencies recognize that the target cancer risk level used to interpret the SQS narrative standards for human health (10^{-6}) is more stringent than the cancer risk level used by PSDDA to define Site Conditions I and II (10^{-5}). However, as noted above, use of a 10-5 cancer risk level would lead to the same decision process and resulting proposal.
3. <u>The agencies believe the proposal will not create added state cleanup liabilities</u>. The SMS rule has a two-tiered sediment cleanup decision-making framework similar to the framework for open water disposal sites. The upper tier (less protective) is used to identify cleanup sites. The lower tier (more protective) defines the cleanup objective. Sediment cleanup standards are established on a site-specific basis at levels that are as close as practicable to the cleanup objective. The draft Site Management Objective is equivalent to the sediment cleanup objective. Compliance with the draft Site Management Objective will ensure that site concentrations remain below levels that would trigger cleanup site designation.

Economic Impacts

The agencies' evaluation of past dredging projects indicates that the percentage of sediments passing the proposed guidelines is not significantly less than the percentage that would be acceptable for open water disposal using the previous guidelines (e.g. 15 pptr total TEQ). Based on that evaluation, the agencies have concluded that the proposal will continue to provide dredged material disposal options similar to those available under the previous guidelines. In reaching that conclusion, the agencies recognize that several dredging proponents have raised questions about whether data from past projects represents a reasonable approach for predicting future impacts. The agencies will be working with interested parties to update the agency impact analysis based on additional data and review of key assumptions. However, the agencies conclusions regarding the proposal are based on the following factors:

1. <u>The agencies' evaluation of past dredging projects indicates that the volume of sediments passing the proposed guidelines is similar to the volume that would be acceptable for open water disposal</u>

using the previous guidelines (e.g., 15 pptr total TEQ).[16] The DMMP agencies reviewed the data from twenty past and current projects where dioxin testing has been performed. The twenty projects include 113 DMMUs with a cumulative total of 1,778,978 cubic yards of dredged material. The agencies compared the pass-fail rates for individual DMMUs using the previous guideline (15 pptr), the interim guidelines, and the proposal. Based on that evaluation, the agencies estimate that 78% of dredged material will pass under the proposal. The percentage of material passing under the proposal is similar to the percentage passing with the previous guidelines (82%) and is higher than the percentage of sediments with the current interim guideline (69%). The results of the agency evaluation are presented in a separate technical memorandum (Dioxin Project Impact Analysis Technical Memorandum).

2. The estimated pass/fail rates are also similar to projections made by the PSDDA agencies when establishing the original guidelines for unconfined open water disposal sites. The agencies recognize that there are many factors that influence whether the pass/fail rates should be considered reasonable. Pass/fail rates and cost impacts were considered by the PSDDA agencies when selecting Site Condition II as the management condition for unconfined, open-water disposal at the Central Puget Sound sites. Many things have changed in the last twenty years in terms of information on sediment concentrations, economic climate and information and attitudes on health risks. However, when evaluating the reasonableness of the proposal, it is instructive to compare the estimated passing rates in the table above with estimates considered by the PSDDA agencies when selecting Site Condition II. As shown in the table below, the estimated passing rates for the dioxin guidelines are somewhat higher than the passing rates considered reasonable by the PSDDA agencies when they selected Site Condition II for the non-dispersive sites in Central Puget Sound .

Summary of PSDDA Evaluations Considered During Selection of Site Management Condition II for Phase I Sites

	Total Forecasted Volume	Volume Passing	Volume Failing	% Passing
Commencement Bay	3,929,000	3,160,000	769,000	80.4%
Elliott Bay	10,525,000	3,374,000	7,151,000	32.1%
Port Gardner	4,943,000	4,684,000	259,000	94.8%
Total (all areas)	19,397,000	11,218,000	8,179,000	57.8%

3. The estimated volume-weighted passing rates fall slightly below the lower end of the yearly averages compiled by the Corp of Engineers. When evaluating reasonableness, it is also instructive to look at the overall experience over the last twenty-one years. Over that period, the percentage of tested sediment found to be acceptable for disposal at the DMMP sites has ranged from 81% to 100% (on a volume basis). Over the last 10 years, 93.7% of tested material has been found to be acceptable for disposal at the DMMP sites. For this ten-year interval, the passing rate falls to approximately 90% when native material is excluded from the evaluation.

4. The DMMP agencies recognize that reduction in state remedial action grants will increase local agency costs. The agencies recognize that many dredging projects have been conducted as part of sediment cleanup projects that have been partially funded through the Local Toxics Control Act. These grants cover 50-75% of remedial action costs. The Washington Legislature is currently

[16] The DMMP pass-fail evaluation has been posted on the DMMP website.

working to complete the state budget for 2009-2011. Current budgets being considered by the Legislature have significantly less monies for remedial action grants.

5. The agencies proposal reflects recent changes in applying the "reason to believe" criteria that are used to determine when dioxin testing is required. Over the last few years, the DMMP agencies have required more projects to conduct dioxin testing. In general, the decision to require more frequent testing is applicable to all of the options being considered by the agencies.
6. The agencies proposal is based on a volume weighted average. This provides additional flexibility for dredging proponents and should result in lower overall project costs.

Program Implementation

The agencies have concluded that the proposal is workable and can be implemented within the existing DMMP structure. It provides clear, predictable and equitable criteria for all disposal sites. It incorporates current procedures and best management practices (i.e., thoughtful and controlled sequencing of project DMMU disposal). In addition, site management objective and suitability guidelines are above the analytical range of uncertainty where analytical variability and accuracy impact data analyses.

This page left intentionally blank.

Rationale for the Proposed Suitability Guideline

The DMMP agencies are proposing to establish suitability guidelines (pass-fail criteria) that would be used evaluate individual projects. The proposed suitability guidelines have two main components:

- The volume weighted average concentration of material from each dredging project could not exceed the disposal site standard (4 pptr TEQ); and
- No single DMMU concentrations could exceed 10 pptr TEQ.

The DMMP agencies are proposing a sediment concentration of 10 pptr TEQ as a pass-fail guideline that would be used to evaluate the suitability of individual DMMUs for disposal at the DMMP open water sites in Puget Sound. This choice is based on several lines of reasoning:

1. Site monitoring data (SAIC, 2008) indicates that historic practices using a 15 pptr suitability guideline have resulted in average site concentrations similar to 4 pptr at several of the non-dispersive sites managed by the DMMP agencies. However, it is important to recognize that a relatively small number of on-site samples have been analyzed.

DMMP Site Monitoring Data (pptr) (based on target zone (Z) or site samples (S))		
DMMP Site	Year Sampled	Average (+/- SD)
Anderson/Ketron Island	2005	3.11 (n=1)
Bellingham Bay	2007	6.1 (n=1)
Commencement Bay	2007	5.56 (+/- 7.61)
Elliott Bay	2005/2007	6.37 (+/- 6.24)
Elliott Bay (site samples)	2005	2.99 (+/- 3.25)
Elliott Bay (site samples)	2007	9.74 (+/- 7.25)
Port Gardner	2006	1.78 (+/- 0.95)

2. The DMMP agencies have evaluated the potential impacts of using the10 pptr suitability guideline. Specifically, the agencies evaluated past projects and other available sediment data in order to estimate the cumulative effect of multiple projects. This analysis took into account projects that include native material that has been minimally impacted by current regional and global releases. The agencies' analysis indicates that a pass-fail criterion of 10 pptr could be expected to result in average site concentrations that are below the proposed site management objective (4 pptr).
3. The proposed maximum value (10 pptr) is within the range of values found in the Main Basin and Reference Areas data set. In the recent sampling, the maximum concentration detected in the Main Basin of Puget Sound was 11.6 pptr (with undetected values assigned a value of ½ the detection limit).
4. Use of the 10 pptr guideline will provide additional project flexibility that will enable completion of projects that provide nearshore environmental benefits.
5. Agencies will increase testing requirements and continue to implement BMPs (e.g. sequencing) to reduce chances that site concentrations will exceed 4 pptr.

This page left intentionally blank.

References

Association of State Territorial Solid Waste Management Officials (ASTSWMO). 2006. Report of State Action Levels. Prepared by CERCLA Training and Technology Transfer (T3) Focus Group.

California Environmental Protection Agency. 2007. Public Health Goal for TCDD in Water (DRAFT for Public Review). Prepared by the Pesticide and Environmental Toxicology Branch, Office of Environmental Health Hazard Assessment. June 2007.

Dredged Material Management Program. 2008. Dredged Material Evaluation and Disposal Procedures (Users' Manual). Prepared by Dredged Material Management Office. U.S. Army Corps of Engineers. Seattle District. July 2008.

Lyndon, M. L. 1989. Risk Assessment, Risk Communication and Legitimacy: An Introduction to the Symposium. Columbia Journal of Environmental Law 14:289.

National Research Council. 2006. Health Risks from Dioxin and Related Compounds: Evaluation of the EPA Reassessment. Committee on EPA's Exposure and Human Health Reassessment of TCDD and Related Compounds. National Academy of Sciences. National Academy Press. Washington DC.

National Research Council. 2008. Science and Decisions: Advancing Risk Assessment. Committee on Improving Risk Analysis Approaches Used by the U.S. EPA. National Academy of Sciences. National Academy Press. Washington DC.

Puget Sound Dredged Disposal Analysis (PSDDA). 1988a. Evaluation Procedures Technical Appendix – Phase I (Central Puget Sound), June 1988,

Puget Sound Dredged Disposal Analysis (PSDDA). 1988b. Management Plan Report – Unconfined Open Water Disposal of Dredged Material, Phase I, (Central Puget Sound), June 1988.

Puget Sound Dredged Disposal Analysis (PSDDA). 1988c. Final Environmental Impact Statement. Unconfined Open Water Disposal for Dredged Material, Phase I (Central Puget Sound), June 1988.

Puget Sound Dredged Disposal Analysis (PSDDA). 1989a. Management Plan Report – Unconfined Open Water Disposal of Dredged Material, Phase II, (North and South Puget Sound), September 1989.

Puget Sound Dredged Disposal Analysis (PSDDA). 1989b. Final Environmental Impact Statement. Unconfined Open Water Disposal for Dredged Material, Phase II (North and South Puget Sound), September 1989.

Puget Sound Dredged Disposal Analysis (PSDDA). 1990. Users Manual for Dredged Material Management in Puget Sound, November 1990.

Puget Sound Estuary Program (PSEP). 1991. Reference Area Performance Standards for Puget Sound. Prepared by PTI for USEPA and Washington Department of Ecology. September 1991.

Science Applications International Corporation. 2008. Dioxin/Furan Concentrations at the Non-Dispersive Open-Water Dredged Material Disposal Sites in Puget Sound. Prepared for the Washington Department of Natural Resources

Suquamish Tribe. 2000. Fish Consumption Survey of the Suquamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound Region.

Toy, K, N.L. Polissar, S. Liao, G. Mittelstadt. 1996. A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region.

U.S. Army Corps of Engineers. 1991. Human Health Risk Assessment of Seafood Consumption Related to Disposal of Federal Channel Maintenance Dredged Material at South Jetty/Point Chehalis –

Grays Harbor, Washington (Final Draft). Seattle District. Prepared by BCI under contract to Shapiro and Associates, Inc. April, 1991.

U.S. Environmental Protection Agency. 1992. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; State's Compliance. 40 CFR 131. Published December 22, 1992 (57 FR 60848)

U.S. Environmental Protection Agency. 1997. Exposure Factors Handbook. National Center for Environmental Assessment. Office of Research and Development. August 1997. Available at: http://www.epa.gov/ncea/efh/.

U.S. Environmental Protection Agency, Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000), EPA-822-B-00-004, EPA. 2000. Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health.

U.S. Environmental Protection Agency. 2003. Exposure and Human Health Reassessment of 2,3,7,8 Tetrachlorodibenzo-p-dioxin (TCDD) and Related Compounds. NAS Review Draft. National Center for Environmental Assessment. EPA/600/P-00/001Cb.

U.S. Environmental Protection Agency. 2004. An Examination of EPA Risk Assessment Principles and Practices. EPA/100/B-04/0001.

U.S. Environmental Protection Agency. 2005. Guidelines for Carcinogen Risk Assessment. Risk Assessment Forum. EPA/630/P-03/001F.

U.S. Environmental Protection Agency. 2006. Child-Specific Exposure Factors Handbook (External Review Draft). National Center for Environmental Assessment. Office of Research and Development. EPA/600/R/06/096A.

U.S. Environmental Protection Agency. 2007a. EPA Region 10 Framework for Selecting and Using Tribal Fish and Shellfish Consumption Rates for Risk-Based Decision Making at CERCLA and RCRA Cleanup Sites in Puget Sound and the Strait of Georgia, August 2007.

U.S. Environmental Protection Agency. 2007b. Lead: Human Exposure and Health Risk Assessments for Selected Case Studies, Volume I. Human Exposure and Health Risk Assessments—Full-Scale and Volume II. Appendices. Office of Air Quality Planning and Standards, Research Triangle Park, NC. EPA–452/R–07–014a and EPA–452/R–07–014b.

Washington Department of Ecology. 1990. Final Environmental Impact Statement for the Washington State Sediment Management Standards – Chapter 173-204 WAC. Publication Number 90-50. December 1990.

Washington Department of Ecology. 2008. Site-Specific Proposal for Modifying the Default MTCA Fish Consumption Exposure Parameters. Questions and Background Information Prepared the MTCA Science Advisory Board. March 2008.

Washington State Department of Transportation (WSDOT). 2008. WSDOT Model Comprehensive Tribal Consultation Process for the National Environmental Policy Act. Appendix B includes summaries of U&A areas prepared by the Washington Attorney General's Office.

Proposal to Revise the Open-water Disposal Guidelines for Dioxins in Dredged Material

Attachment 3
Dioxin Risk Assessment Technical Memorandum

Dioxin Project Risk Assessment Technical Memorandum

Dredged Material Management Program

April 29, 2009

This page intentionally blank.

Table of Contents

1. Introduction 1

2. Risk Associated With Exposure to Background Concentrations of Dioxin in Puget Sound Seafood 4
   2.1 Risk Estimation Approach 4
   2.2 Formulation of Seafood Consumption Exposure Scenarios 5
      2.2.1 Tribal Consumption Rates and Species Composition 5
      2.2.2 General Population Consumption 6
      2.2.3 Exposure Duration 6
      2.2.4 Body Weight 8
      2.2.5 Seafood Diet Fraction (SDF) 8
      2.2.6 Background Tissue Dioxin from Puget Sound Seafood Species 8
   2.3 Risk Characterization for Human Exposure to Background Levels of Dioxin in Seafood 14
      2.3.1 Toxicity Characterization: Cancer Slope Factor 14
      2.3.2 Risk Characterization 14
      2.3.3 Uncertainty Characterization 14

3. Discussion of Dioxin Risk in Background Puget Sound Tissues 16

References Cited 17

Tables

Table 1. Exposure Information Used for Various Consumer Groups
Table 2. Synopsis of Tissue Dioxin Data Representing Background in Puget Sound
Table 3. Estimated Background Risk for Several Consumer Groups and Consumed Species Categories
Table 4. Uncertainty Analysis of Background Risk Characterization

Figures

Figure 1. Conceptual Illustration of Puget Sound Background
Figure 2. Sites Used for Background Tissue Concentrations
Figure 3. Comparison of Sediment Dioxin from Main Basin with Anderson-Ketron Vicinity Dioxin

This page intentionally blank.

1. Introduction

This memorandum is one of several that provide the Dredged Material Management Program (DMMP) agencies' rationale for development of a suitability framework for determining unconfined, open-water disposal of sediments containing polychlorinated dibenzodioxins and dibenzofurans (jointly referred to here as "dioxin," and expressed as TEQ or toxicity equivalents of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin). Because the agencies' current focus is on a dioxin suitability framework, this memorandum does not consider effects associated with other compounds, such as polychlorinated biphenyls (PCBs) that have "dioxin-like" effects.

The question addressed in this memorandum is, "What are the estimated cancer risks associated with eating fish and shellfish with background levels of dioxin from Puget Sound?" This background risk provides the context for policy decisions by the agencies as to whether any and/or what amount of additional risk would be acceptable.

Some key issues associated with this evaluation and discussed below include the following:

- What is meant by "Puget Sound background risk?"
- What is considered to be "acceptable" risk in context of background?
- What specific consumers are being evaluated for protection? Who in the population (e.g., an average consumer or an upper bound consumer) sets the seafood ingestion rate?
- What kinds of seafood are being considered? For instance, should species that spend only part of their time in Puget Sound (e.g., salmon) be included?
- What cancer potency factor will be used in the evaluation? What is the role of uncertainty in the cancer potency factor?

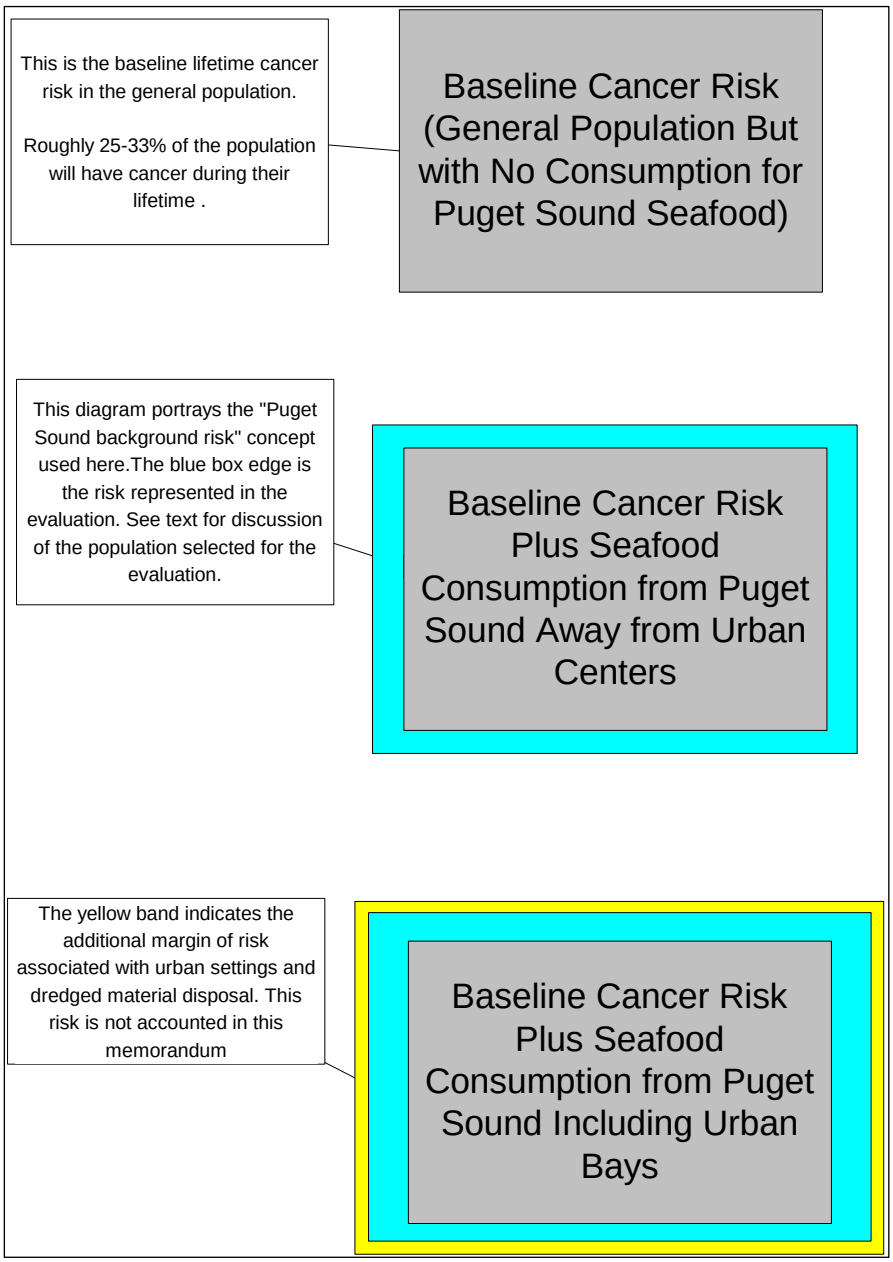
There are various ways to define background, and Figure 1 attempts to show options that the agencies considered. The gray box entitled "baseline cancer risk (general population)" represents risk associated with consumption of dairy, meat, and agricultural products not associated with Puget Sound seafood. The risks associated with other than Puget Sound seafood are not considered in this focused evaluation; this approach for risk evaluation is often used by environmental agencies when establishing media-specific standards.[1] The blue border in the middle box of Figure 1 represents the "background risk" that is the subject of this evaluation. Background risk, as defined and evaluated in this memorandum, does not include risks associated with consumption of seafood reflecting urban dioxin exposure. In the bottom part of Figure 1, these risks are depicted by the yellow border around the gray and blue

[1] As an example of this, EPA (2000) uses this type of baseline consideration when establishing water quality standards for carcinogenic substances.

boxes. This is because of the focus on non-urban areas associated with the regulations (see Regulatory and Policy Technical memorandum). The agencies wish to use this information to assess the importance of seafood consumption related risk in interpreting the Sediment Quality Standard (SQS) human health narrative standards, which describe non-anthropogenic or globally-distributed background risks as a potential regulatory threshold under certain conditions.

For the purpose of this memorandum, background risk is being determined using tissue dioxin data from reference areas and other non-urban locations in the Puget Sound main basin away from point sources of contamination. As described further below, these data are derived from “reference area” data associated with cleanup projects, Puget Sound Estuarine Program sampling, and from DMMP monitoring in the vicinity of Anderson and Ketron Islands. This data set is, however, limited in size and not as widely-representative of the main Puget Sound basin as are available sediment data for dioxin. A comprehensive characterization of dioxin in background sediments of Puget Sound has been recently completed by the DMMP agencies (SAIC 2009). However, these sediment data were not used to estimate background risk because there are currently no well established quantitative relationships between sediment and tissue dioxin for most of the seafood species considered.

Figure 1. Conceptual Illustration of Puget Sound Background



2. Risk Associated With Exposure to Background Concentrations of Dioxin in Puget Sound Seafood

Sediment-associated dioxin may move through the food chain and into the seafood consumed by various groups of people. The baseline or "background" risk associated with consumption of dioxin in Puget Sound seafood reflects exposure to main basin/reference conditions outside of urban areas.

2.1 Risk Estimation Approach

The DMMP agencies used a standard seafood-consumption equation from EPA (1989) with regional adjustments to estimate the cancer risk associated with various levels of consumption of seafood containing background concentrations of dioxin. The exposure parameter values used are presented in Table 1. The Chronic Daily Intake (CDI) was calculated using either equation 1 or equation 2 depending on the availability of species-specific ingestion rates for a given exposure group.

---

(1) Chronic Daily Intake (CDI) = $\frac{(IR_{seafood} \times Dioxin_{seafood}) \times ED \times EF \times SDF}{BW \times AT}$

---

(2) Chronic Daily Intake (CDI) =

$$\frac{[(WF_{crab} \times IR_{shellfish} \times Dioxin_{crab}) + (WF_{clam} \times IR_{shellfish} \times Dioxin_{clam}) + (IR_{finfish} \times Dioxin_{finfish})] \times UCF \times ED \times EF \times SDF}{BW \times AT}$$

Equation 2 can be rearranged and expressed as follows:

(3) CDI =

$$\frac{[IR_{shellfish} (WF_{crab} \times Dioxin_{crab} + WF_{clam} \times Dioxin_{clam}) + (IR_{finfish} \times Dioxin_{finfish})] \times UCF \times ED \times EF \times SDF}{BW \times AT}$$

Where:

CDI	= Chronic daily intake (mg/kg·day)
$IR_{seafood}$	= Ingestion rate for seafood (g/day) used when species-specific ingestion rates are not known
$IR_{finfish}$	= Ingestion rates for finfish (g/day)
$IR_{shellfish}$	= Ingestion rates for shellfish (g/day)
$WF_{crab/clam}$	= Shellfish weighting factor (fraction of total shellfish consumption represented by crab or clams)
$Dioxin_{seafood}$	= Tissue dioxin in consumed seafood (non species specific) (mg TEQ /kg wet)
$Dioxin_{crab, finfish, or clam}$	= Tissue dioxin in crab, finfish, and clams (mg TEQ /kg wet)

BW	= Average consumer body weight (kg)
AT	= Averaging time (years)
UCF	= Unit Conversion factor (0.001kg/g)
ED	= Exposure duration (years)
EF	= Exposure frequency (days/year)
SDF	= Seafood Diet Fraction: fraction of total seafood in diet obtained from Puget Sound

---

The cancer risk associated with the Chronic Daily Intake of a seafood consumer population was derived using equation 4.

---

(4) Risk = CDI x CSF

Where:

Risk	= Calculated risk level (incremental lifetime cancer rate, ILCR)
CSF	= Cancer slope factor $(mg/kg \cdot day)^{-1}$

2.2 Formulation of Seafood Consumption Exposure Scenarios

Risk was calculated for three different exposure groups in order to provide a range of background risk estimates. The low-end of the exposure range was represented by the general public consumption, mid-range by the Tulalip tribe, and the high-end of the range by the Suquamish tribe. Risks were assessed using exposure parameter values selected using a “reasonable maximum exposure” (RME) paradigm (EPA, 1989a). RME assessment uses a blend of average and upper bound estimates for exposure parameters to produce an estimate of exposure that is high-end, but not worst case. Details on the variables used and their basis are presented in the following sections.

2.2.1 Tribal Consumption Rates and Species Composition

There are a number of groups that consume large amounts of seafood, including tribes, ethnic minorities, and recreational anglers. All DMMP disposal sites are located within the Usual and Accustomed fishing areas of one or more tribes. Consideration of tribal seafood consumption is therefore important for insuring that the guidelines derived are appropriately protective of the most highly exposed populations. As noted in the companion Regulatory and Policy Memorandum, tribes that consume seafood at the subsistence level are the most exposed to the hazards associated with dioxins. Therefore, the DMMP agencies calculated background risk using tribal consumption rates as a conservative estimate of high-end exposures.

There is variation between different tribes in both the species consumed and rates of consumption. Several consumption studies have been conducted for tribes fishing in Puget Sound (Toy et al., 1996; The Suquamish Tribe, 2000, 2007). Using these studies, EPA Region 10 recently developed a framework for selecting and using tribal fish and shellfish consumption rates for risk-based decision making (EPA, 2007). While EPA's Consumption Framework is intended for use in Comprehensive Environmental Restoration, Compensation, and Liabilities Act (CERCLA) and the Resource Conservation Recovery Act (RCRA) cleanup sites, it nevertheless provides a basis for policy choices used to predict seafood consumption risks in other contexts. The DMMP agencies decided that it was appropriate and important to use the exposure information from EPA's Consumption Framework for both the Tulalip and Suquamish tribes to generally cover a range of exposures to sensitive populations and specifically to estimate background risks to tribal consumers who derive a large percentage of their seafood from Puget Sound (Table 1).

2.2.2 General Population Consumption

Consumption rates associated with the general population represent a lower degree of exposure to seafood from Puget Sound than that associated with tribes, ethnic minorities, and recreational anglers. The DMMP used a consumption rate of 54 g/day from MTCA, representing a 90th percentile of the general population in coastal states (WAC 173-340-730).[1] Since there are no species-specific consumption values available for this category of consumer, a range of risk for the general population was derived by assuming that all consumption was of whole body crab, clams, or English sole.

2.2.3 Exposure Duration

The DMMP used the 70-year exposure duration for tribal consumers (Table 1) recommended in EPA's Consumption Framework (2007). This exposure duration is longer than the 30-year duration typically used for the general public. The 30-year general public's exposure duration is intended to reflect an upper-bound (90th percentile) period at one residence (EPA 1989b). The assumption that changing residence will eliminate exposure is not valid for tribal members, particularly given that individuals may relocate and continue to visit the same Usual and Accustomed fishing areas.

[1] According to the Responsiveness Summary for the MTCA promulgation, a 90th percentile on the mean is the RME. In EPA guidance, the 95th percentile Upper Confidence Limit is typically used.

Table 1. Exposure Information Used for Various Consumer Groups

Consumer Group	Body Weight (kg)	Exposure Duration (years)	Total Seafood Ingestion Rate (g/day)	Shellfish Ingestion Rate (g/day)	Percentage of Shellfish IR represented by Clams/Crabs[1] (%)
Tulalip[2]	81.8	70	194	81.9	54/46
Suquamish[3]	79	70	767	498.4	88/12
General Population[4]	70	30	54	Not Applicable	Not Applicable

[1] Personal Communication Lon Kissinger, 4/2009; based on Lower Duwamish Waterway Group (2007). Weighting contribution of individual species contaminant concentrations on the basis of species-specific consumption rates determined using guidance in EPA (2007).
[2] Exposure information from EPA (2007)
[3] Exposure information from EPA (2007)
[4] MTCA (WAC 173-340-730)

2.2.4 Body Weight

For estimates of risk to tribal consumers, the DMMP used the recommended tribe-specific body weights provided in the Consumption Framework (EPA, 2007). For estimates of risk to the general population, the DMMP used the EPA (1989b) default of 70 kg (Table 1).

2.2.5 Seafood Diet Fraction (SDF)

This represents the percentage of the total fish and/or shellfish in an individual's diet that is obtained or has the potential to be obtained from a specific location. The SDF was developed for recreational exposures based on comments received during MTCA rule development. However, the DMMP did not apply an SDF in estimates of background risk for any of the consumer groups evaluated.

The tribal consumption rates used to estimate risk to central and high-end consumers reflect harvest from Puget Sound only. Given that the goal of these calculations was to estimate the risk associated with exposure to background levels of dioxin in Puget Sound fish/shellfish tissue, it is appropriate to assume that 100% of all fish consumed are from Puget Sound for every level of consumer.

2.2.6 Background Tissue Dioxin from Puget Sound Seafood Species

There is limited data documenting dioxin in shellfish and finfish tissue from non-urban areas of Puget Sound. Ecology's EIM database was queried and the results screened to exclude data in the vicinity of sediment remedial activities (e.g., CERCLA or MTCA sites). The agencies also decided not to use nearly 19-year old crab data (PTI, 1991), as they do not likely represent current conditions in Puget Sound. Most of the accepted data were from north Puget Sound - Padilla Bay, Samish Island, and Dungeness and Freshwater Bays (Figure 2). The latter two locations are reference areas associated with cleanup studies.

Tissue data from site monitoring at the Anderson-Ketron (A/K), non-dispersive dredged material disposal site were also included in the data set used to estimate background dioxin in tissue. Specifically, English sole and clam data collected from offsite locations in 2006 and 2007 were included.[1] The A/K site is the only non-dispersive disposal site located in a non-urban area (Figure 2).

[1] Although Dungeness crab data is also available from the 2007 A/K site monitoring, the dioxin concentrations in whole body crab (4.5 ng/kg TEQ wet) are noticeably elevated in comparison to that observed at other disposal sites as well as to reference locations reported in Table 2. The reason for this elevation has yet to be determined, but may be the result of foraging activities extending into contaminated areas of the South Sound. As it appears to be an outlier, the A/K crab data were not used here. Note that all tissue data used were collected prior to 2008 disposal of dredged material from the COE's Port of Olympia maintenance dredging activities.

There are no known sources of dioxin contamination in the vicinity of the site, and prior to 2008, it had received a relatively low volume of dredged material (approx 33,000 CY since designation in 1989) in comparison to other disposal sites. The sediment dioxin data collected in the immediate site vicinity were within the range of dioxin the main basin and reference areas of Puget Sound (Figure 3). The Anderson-Ketron data are the only tissue dioxin information from South Sound.

Figure 2. Sites Used for Background Tissue Concentrations

Figure 3. Comparison of Sediment Dioxin from Main Basin with Anderson-Ketron Vicinity Dioxin

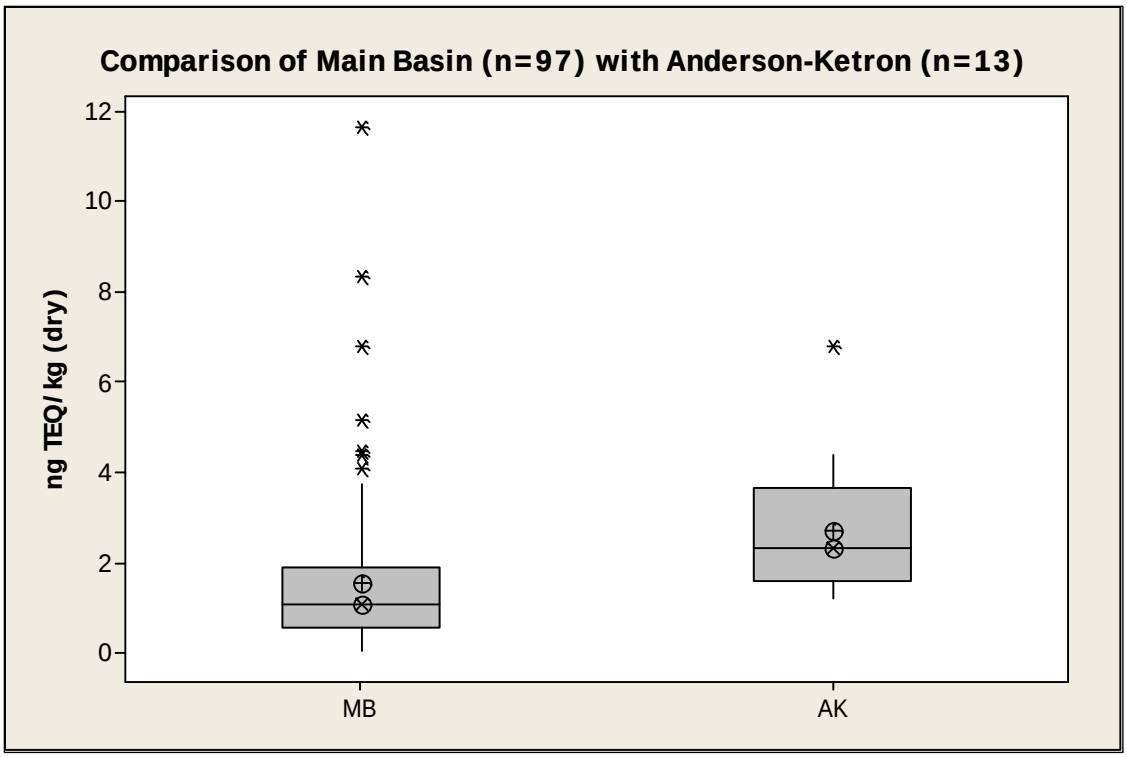


Figure Legend. AK is Anderson-Ketron; MB is Main Basin Plus Reference Bays compiled by the DMMP to calculate Puget Sound sediment background. The "box" is the second and third quartile. The "whiskers" are the first and fourth quartiles. The median for each location is shown by an X in a circle, and the mean is shown by a cross in a circle. The AK data are present in both summations because they are regarded as being in the Main Basin**.**

Table 2 summarizes the dioxin tissue data that were used in this risk assessment to represent background in Puget Sound. The fish data included Rock sole (whole and skinless filet), English sole (whole), and Starry flounder (whole and skinless fillet). Fillet data were used to generate an average fish concentration for the general population risk estimate; whole-fish concentrations were used for tribal consumers. Dungeness crab data have been calculated to whole crab based on weight proportions of edible meat and viscera (hepatopancreas) observed in the Lower Duwamish Remedial Investigation. The clam species used include Butter clam, Littleneck clam, Horse clam, Geoduck, *Yoldia*, *Macoma*, and *Compsomyax*. The latter three species are not commonly eaten, but represent species at deeper (subtidal) locations in Puget Sound which could be eaten.

Table 2. Synopsis of Tissue Dioxin Data Representing Background in Puget Sound

	Species	Organs	Locations	Number of Samples, n	Mean TEQ[8]	Std Error of Mean[9]	Survey[10]
Clams	Little neck clam	Whole	Padilla Bay - Pearson Rd.	1	0	NC	AJOH0012
	Butter clam	Whole	Samish Bay - Samish Is.	1	0.002	NC	AJOH0012
	All Geoduck[11]	Muscle (some), Viscera (some)	Dungeness, Freshwater Bays	22	0.007	0.002	RAYON05 PAMILLRI
	Horse Clam	Muscle (some), Viscera (some)	Dungeness, Freshwater Bays	38	0.009	0.0042	RAYON05 PAMILLRI
	Yoldia	Whole	Anderson-Ketron	1	0.516	NC	AK2007
	Compsomyax	Whole	Anderson-Ketron	4	0.014	0.0002	AK2007
	Macoma	Whole	Anderson-Ketron	1	0.096	NC	AK2007
	Sample-weighted Clam Mean[12]			*68*	*0.017*	--	
Fish	Rock Sole	Whole	Dungeness, Freshwater Bays	4	0.021	0.0121	RAYON05
	English Sole	Whole	Anderson-Ketron	3	0.266	0.0651	AK2007
	Whole English and Rock Sole Sample-weighted Mean			*7*	*0.127*	--	--
	Rock Sole	Skinless Fillet	Freshwater Bay	2	0.009	0.0092	RAYON05
	Starry Flounder	Skinless Fillet	Dungeness Bay	2	0.091	0.0912	RAYON05
	Skinless Fillet Sample-weighted Mean			*4*	*0.050*	--	--
Crab	Whole Dungeness Crab[13]		Dungeness and Freshwater Bays	23	*0.241*	0.051	PAMILLRI DIOXCRAB PSEPCRAB RAYON05

[8] TEQ determined by the Kaplan-Meier method (see text).
[9] Standard error of the mean is calculated by standard deviation of samples /square root of n.
[10] With the exception of AK2007 (Anderson-Ketron 2007), these are the survey codes from EIM.
[11] All tissue data for horse clam and geoduck were considered without respect to tissue type analyzed.
[12] Sample-weighted means for each category are derived by multiplying the species-specific tissue data by the associated number of samples, summing them by category, and divided by the total sum of the samples in that category.
[13] Crab data include muscle and hepatopancreas; these were combined into a "whole crab" by assuming 31% hepatopancreas by total tissue weight.

While it is generally accepted that anadromous fish such as salmon gain most of their PCB body-burden from open-ocean exposure, there is a relative paucity of evidence to suggest that this is true of dioxin. Two recent studies measured dioxin in adult and juvenile salmon from the Puget Sound/Georgia Basin region (Kelly et al., 2007; Cullon et al., 2009). The latter reported mean dioxin/furan in returning adult Chinook salmon from the Duwamish river (0.23 ng mammalian TEQ/kg wet; n=3) and from the Deschutes River (0.56 ng mammalian TEQ/kg wet; n=4). Dioxins were undetected in single composite sample of smolts collected from Puget Sound. Based on these findings as well as data from the Strait of Georgia, the authors estimated that 97–99% of the body burden of dioxins and furans in returning adult Chinook were accumulated during their time at sea. However, there are Puget Sound resident Chinook populations that do not go into the open ocean, and about which we have no information on dioxin in tissues. For the purposes of these background risk estimates, dioxin in bottom fish were presumed to represent exposure to all forms of finfish (including salmon).

The method used for summarizing species-specific TEQs in Table 2 was the Kaplan-Meier nonparametric method described in the Statistics Workshop Report (RSET 2008).[14] For reasons cited in that publication, this is widely considered to be an improved technique over the typical substitution of one-half the limit of detection for below-detection-limit values. This same process was used in evaluating the R/V Bold sediment dioxin data (SAIC, 2009). The method consisted of converting all of each sample's 17 dioxin congeners' concentrations to TEQ by multiplying by the Toxicity Equivalence Factor; retaining the identity of detected and non-detected values by a separate column of 1 or 0 (respectively); and using ProUCL (version 4 .00.2) (Singh and Singh 2007a, b) to derive a nonparametric mean TEQ concentration. Since by definition the sum is the mean times the number of samples, the derived nonparametric mean was then multiplied by the number of congeners (17) to derive a TEQ sum for that sample. This method will only function when there is more than one detected congener in a sample. For this data evaluation, when this occurred, if there were no detections, a value of zero was used for the tissue TEQ concentration; if only one detected congener occurred, that single value was used for the sum.

Table 2 also shows the mean tissue concentrations (shaded rows) for each seafood category derived using the species-specific data. Sample-weighted means for each category were derived by multiplying the species-specific tissue data by the associated number of samples, summing them by category (clam, fish, or crab), and dividing by the total sum of the samples in that category. The resulting mean food-category dioxin tissue values were used in the background risk estimates.

[14] https://www.nwp.usace.army.mil/pm/e/RSET/SEF/2009-StatisticalWorkshopReport.pdf

2.3 Risk Characterization for Human Exposure to Background Levels of Dioxin in Seafood

2.3.1 Toxicity Characterization: Cancer Slope Factor

The consensus decision of the DMMP agencies (see the companion Regulatory and Policy Memorandum) was to use a cancer slope factor (CSF) of 150,000 $(mg/kg \cdot d)^{-1}$ (EPA 1995). Use of this value is consistent with recommendations from the EPA Office of Water and Office of Solid Waste and Emergency Response. All Superfund and State dioxin remediation in this region have used this CSF.

2.3.2 Risk Characterization

Estimates of excess cancer risk associated with exposure to background concentrations of dioxin in Puget Sound seafood are presented in Table 3 for various exposure groups. Clam-, crab-, and fish-specific consumption data are not available for the general population. Therefore, the 54 g/d ingestion rate was separately applied to the three seafood categories to estimate the general population's risk for each case. The range of risk estimates derived for the general population were from 8 in 10 million (8.4E-07) for clam-only consumption to 1.2 in 100,000 (1.2E-05) for crab-only consumption; fish-only consumption was near 1 in one million. All excess risks estimated for tribal fishers were greater than 1E-05; for the Suquamish Tribe, they were greater than one-in-ten-thousand increased cancer risk (up to 2.7E-04).

Table 3. Estimated Background Risk for Several Consumer Groups and Consumed Species Categories

Consumer Group	Fish & Shellfish Ingestion	Fish Only	Crab Only	Clams Only
Tulalip	4.4E-05	Not Applicable	Not Applicable	Not Applicable
Suquamish	2.7E-04	Not Applicable	Not Applicable	Not Applicable
General Population	Not Applicable	2.5E-06	1.2E-05	8.4E-07

2.3.3 Uncertainty Characterization

Table 4 describes the prospective differences that assumptions or uncertainties might have made to the risk values above.

Table 4. Uncertainty Analysis of Background Risk Characterization

Uncertainty	Effect on Risk Estimate
Bottom-fish dioxin representing tissue background for all consumed pelagic fish.	Use of bottom fish data may over or under represent Puget Sound background dioxin in anadromous fish. Based on a small amount of data characterizing dioxin in returning adult Chinook salmon fish from Puget Sound, use of bottom fish dioxin could under estimate risk. However, there is no conclusive information documenting to what extent these residues are acquired during their time at sea. Furthermore, there are no dioxin data available for resident salmon. If body burden trends are similar to that observed with PCBs, dioxin in resident populations may be higher than ocean-going populations.
Use of mean (versus upper percentile) tissue dioxin concentrations from Background data set.	May under estimate exposure. EPA's Consumption Framework for CERCLA/RCRA risk assessments directs use of the 95% UCL on the mean for tribal consumers to derive the exposure concentration rather than the average as was done here.
Use of the 30 yr exposure duration for calculating risk to the General Population.	Likely under estimates exposure. 30 years is potentially an under estimate of exposure duration for recreational anglers because individuals may change residences over a limited area and still visit the same seafood harvest locations. For example, in assessing risks to consumers of fish from the Hudson River, it was found that the 90th percentile of residency time in counties bordering the Hudson was 40 years (L. Kissinger, EPA, pers. comm.).
Assumption that the general population consumes only clams, crabs, or fish.	While the scenarios are not very likely, the consumption information is limited, and in conjunction with the probable low bias of a "general coastal population" consumption rate, may either over or under estimate risk.

3. Discussion of Dioxin Risk in Background Puget Sound Tissues

The risk estimates presented in this memo were derived using exposure assumptions for various populations who consume seafood derived from Puget Sound. For all consumer groups, exposure to dioxins from seafood reflecting background conditions (away from urban embayments and clean-up areas) were greater than the one-in-one-million (1E-06) ILCR which is the limit of acceptable risk for dioxins under the Model Toxics Control Act, and greater than the one-in-one-hundred thousand (1E-05) ILCR threshold for significant impacts to human health in the DMMP dredging guidance. For subsistence consumers (represented by the Suquamish Tribe), cancer risks exceed one-in-ten thousand (1E-04) ILCR, which is the highest allowable risk in the Superfund "risk range," and is often interpreted as reason for initiating cleanup in Federal projects under CERCLA and RCRA.

Since the background dioxin cancer risk associated with consumption of Puget Sound seafood exceeds acceptable risk benchmarks, the agencies have concluded that a background-based regulatory framework, as opposed to a risk-based framework, would be appropriately protective and more effectively implemented. See the companion Regulatory and Policy Memorandum for further discussion of the statutory drivers and related policy decisions used for this risk evaluation.

References Cited

Cullon, D.L., M.B. Yunker, C. Alleyne, N.J. Dangerfield, S. O'Neill, M.J. Whiticar, P.S. Ross (2009) Persistent organic pollutant in chinook salmon (*Oncorhynchus tshawytscha*): Implications for resident killer whales of British Columbia and adjacent waters. Environmental Toxicology and Chemistry 28(1): 148-161. http://www.allenpress.com/pdf/ENTC_28.1_148.pdf

EPA. 1995 (Updated 1997). Health Effects Assessment Summary Tables (HEAST).

EPA. 1989a. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Part A. Interim Final. EPA/540/1-89//002.

EPA. 1989b. Exposure Factors Handbook. Office of Health and Environmental Assessment. EPA/600/8-89/043.

EPA. 2000. Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000), EPA-822-B-00-004.

EPA. 2007. Framework for Selecting and Using Tribal Fish and Shellfish Consumption Rates for Risk-Based Decision Making at CERCLA and RCRA Cleanup Sites in Puget Sound and the Strait of Georgia, EPA Region 10 Offices of Environmental Cleanup; Air, Waste and Toxics; and Office of Environmental Assessment. Revision 00.

SAIC. 2008. 2007 Site Monitoring Report, Dioxin/Furan Concentrations at the Non-dispersive Open-Water Dredged Material Disposal Sites in Puget Sound. Prepared for the Dredged Material Management Program.

SAIC. 2009. Puget Sound Sediment PCB and Dioxin 2008 Survey . Data Report. Prepared by DMMP (US EPA, US Army Corps of Engineers Seattle District, Science Applications International Corp. (SAIC), Avocet Consulting, and Terrastat.

Kelly, B.C., S.L Gray, MG Ikonomou, J.S. Macdonald, S.M. Bandiera, and E.G. Hrycay (2007) Lipid reserve dynamics and magnification of persistent organic pollutants in spawning sockeye salmon (*Oncorhynchus nerka)* from the Fraser River, British Columbia. Environ. Sci. & Technol. 2007, *41* (9), pp 3083–3089.

Lower Duwamish Waterway Group (LDWG). 2007. Draft Lower Duwamish Waterway Remedial Investigation.

PTI Environmental Services. 1991. Dioxin and Furan Concentrations in Puget Sound Crabs. Prepared for EPA Region 10, Doc. No. EPA 910/9-01-040. 43 pages plus appendices.

Personal Communications, Lon Kissinger, Office of Environmental Assessment, EPA Region 10.

Singh, A. and Singh, A.K. 2007a. ProUCL Version 4.0 User Guide. Publication EPA/600/R-07/038. April 2007,

Singh, A. and Singh, A.K. 2007b. ProUCL Version 4.0 Technical Guide. Publication EPA/600/R-07/041. April 2007

The Suquamish Tribe. 2000. Fish Consumption Survey of the Suquamish Indian Tribe of The Port Madison Indian Reservation, Puget Sound Region. August.

The Suquamish Tribe. 2007. Selected Suquamish Tribe Seafood Ingestion Rates, Consumers Only. June 29. Prepared by Nayak Polissar, Ph.D. and Shiquan Liao, Ph.D.

Toy, K.A., N.L. Polissar, S. Liao, and G.D. Mittelstaedt. 1996. A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region. Tulalip Tribes, Department of Environment, Marysville, WA.

Background Risk Calculations for Dioxin Risk Assessment Technical Memorandum (4/29/09)

	Tulalip	Comments	**Suquamish**	Comments	**General Population in Coastal State (MTCA)**	Comments	**General Population in Coastal State (MTCA)**	Comments	**General Population in Coastal State (MTCA)**	Comments
Chronic daily intake[1]	2.93E-10		1.78E-09		1.65E-11		7.96E-11		5.62E-12	
Background Avg WB Fish TEQ conc mg/kg ww Kaplan-Meier method	1.26E-07	Fish value used in risk calculation	1.26E-07	Fish value used in risk calculation	1.26E-07		1.26E-07		1.26E-07	
Background Avg fillet (no skin) Fish TEQ conc mg/kg ww Kaplan-Meier method	5.00E-08		5.00E-08		5.00E-08	Fish value used in risk calculation	5.00E-08		5.00E-08	
Background Avg "whole" Crab TEQ conc mg/kg ww nd=0.5 DL method	2.41E-07		2.41E-07		2.41E-07		2.41E-07		2.41E-07	
Background Avg bivalve TEQ conc mg/kg ww Kaplan-Meier method	1.70E-08		1.70E-08		1.70E-08		1.70E-08		1.70E-08	
BW	81.8		79		70		70		70	
AT	25550		25550		25550		25550		25550	
EF	365		365		365		365		365	
ED	70		70		30		30		30	
SDF	1		1		1		1		1	
CSF	150000		150000		150000		150000		150000	
IR finfish	112.1		268.6							
IR Shellfish	81.9		498.4							
IR Total	194		767		54		54		54	
WF - bivalve	0.54		0.12							
WF - crab	0.46		0.88							
Cancer Risk [2]	4.39E-05		2.67E-04		2.48E-06	Risk for fish	1.19E-05	Risk for crabs	8.43E-07	Risk for bivalves

[1] Chronic Daily Intake (CDI) = $\frac{[IR_{shellfish} * (WF_{crab} \times Dioxin_{crab} + WF_{clams} \times Dioxin_{clams}) + (IR_{finfish} \times Dioxin_{finfish})] \times UCF \times ED \times EF \times SDF}{BW \times AT}$

[2] Risk = CDI x CSF

Where:

CDI	= Chronic daily intake (mg/kg·day)
$WF_{crab/clams}$	= Weighting Factor (fraction of total shellfish consumption represented by crab or bivalves)
$IR_{shellfish/fin\ fish}$	= Ingestion rates for shellfish or fin fish (g/day)
$Dioxin_{crab/clams/finfish}$	= Tissue dioxin in crab, clams and finfish (mg/kg wet)
UCF	= Unit conversion factor (0.001kg/g)
EF	= Exposure frequency (days/year)
ED	= Exposure duration (years)
BW	= Average consumer body weight (kg)
AT	= Averaging time (years)
Risk	= Calculated risk level (incremental lifetime cancer rate, ILCR)
CSF	= Cancer slope factor $(mg/kg \cdot day)^{-1}$
SDF	= Seafood Diet Fraction: fraction of total seafood in diet obtained from Puget Sound

Proposal to Revise the Open-water Disposal Guidelines for Dioxins in Dredged Material

Attachment 4
Dioxin Project Impact Analysis Technical Memorandum

Dioxin Project Impact Analysis Technical Memorandum

Dredged Material Management Program

April 29, 2009

This page intentionally blank.

Table of Contents

1. Introduction 1

2. Puget Sound Projects with Dioxin Data 1

3. Pass/Fail Analysis 2
   3.1 Nondispersive Guidelines 3
   3.2 Dispersive Guidelines 5
   3.3 Differential Impact of Proposed Guidelines 6

4. A Broader Look at DMMP Projects and Puget Sound Dioxin Data 7
   4.1 Review of all DMMP Projects 7
   4.2 Review of Additional Urban Dioxin Surveys 8
   4.3 Results of the Analysis 9

5. Implications for Future Projects 9

Figures 11

Appendix A – Dioxin Data for Individual Projects ..... A - 1

Tables

Table 1. Dredging Projects Tested for Dioxin in Puget Sound
Table 2. Former, Interim and Proposed Guidelines
Table 3. Nondispersive Interim Guidelines
Table 4. Project Impacts – Comparison of Nondispersive Guidelines
Table 5. Project Impacts – Comparison of Dispersive Guidelines

Figures

Figure 1. DMMP Projects with Dioxin Data
Figure 2. Guideline Comparison – Pass/Fail Volume
Figure 3. Guideline Comparison – Impacted Projects
Figure 4. Guideline Comparison – Projects Less Than 50,000 CY
Figure 5. Guideline Comparison – Projects More Than 50,000 CY
Figure 6. Comparison of Failed Volumes – Former and Proposed Guidelines

This page intentionally blank.

1. Introduction

This memorandum provides analysis of potential project impacts associated with implementation of the dioxin proposal. For this analysis, all Puget Sound dredging projects since the inception of the Dredged Material Management Program (DMMP) were reviewed, covering a period of approximately twenty-one years. During this time well over 200 projects were evaluated for open-water disposal. Of these, 20 projects had at least some material that was tested for dioxins, the tested quantity consisting of some 1.8 million cubic yards, or 6.2 percent of the total volume.

2. Puget Sound Projects with Dioxin Data

Table 1 lists the DMMP projects with dioxin data, arranged by year. In the early years of DMMP implementation, only projects in the vicinity of Kraft-process pulp and paper mills were tested for dioxin. In Puget Sound this included just three projects in Everett. Dioxin concentrations were relatively low for these projects. In recent years, however, concern for dioxins has increased. The "reason to believe" guidelines have evolved with this increase in concern, resulting in a growing number of projects requiring dioxin testing. Thus, most of the dioxin testing has occurred in the last five years.

Table 1. Dredging Projects Tested for Dioxin in Puget Sound

Project	Volume Tested for Dioxin (cy)	Year[1]	Range of Dioxin Concentrations (pptr TEQ, u = ½ DL)
Port of Everett 10th Street Boat Ramp	12,340	1992	6.7
Port of Everett 12th Street Marina	80,500	1992	0.6–8.7
US Navy Everett Homeport – Element II	39,200[2]	1993	1.2–8.4
Dakota Creek Industries – Anacortes	64,000[2]	2005	3.1–3.9
Port of Bellingham I&J Waterway	15,770	2006	21.1–32.4
Port of Olympia East Bay Marina	27,664	2006	5.6–56.0
MJB Properties – Anacortes	67,825	2007/2009	0.9–14.0
Port of Bellingham Squalicum Gate 3	49,884	2007	6.2–47.1
USACE/Port of Olympia	448,317	2007	0.1–52.6
Delta Marine Industries – Duwamish River	6,534	2008	0.8–3.5
Port of Anacortes Cap Sante Marina – Phase 3	40,900	2008	3.5–52.6
Port of Tacoma East Blair Cutback	317,017[2]	2008	0.3–7.3
USACE Duwamish	54,104	2008	1.7–3.9
Port of Seattle T5	6,900	2009	4.3–12.1

[1] The year refers to the dredging year (the dredging year begins on June 16) in which the DMMP suitability determination was finalized or, for those projects without a suitability determination, the year in which sampling occurred.
[2] There was additional native material for this project that was not tested for dioxin.

Project	Volume Tested for Dioxin (cy)	Year[1]	Range of Dioxin Concentrations (pptr TEQ, u = ½ DL)
Port of Seattle T18	6,800	2009	21.7
Port of Seattle T115	3,750	2009	23.2–29.9
Port of Tacoma Washington United Terminal	95,700[2]	2009	0.6–3.0
Puyallup Tribal Terminal – Blair Waterway	376,523[2]	2009	0.2–8.2
Skyline Marina – Anacortes	64,000	2009	1.3–6.4
USACE Port Townsend Marina Navigation Channel	1,250	2009	1.4–4.7

Things to note about these projects:

- Of the projects listed in Table 1, five had large volumes of native material that were not tested for dioxin. However, four of these five projects did include dioxin testing for some of the native material (Dakota Creek was the exception).
- Preliminary dioxin testing was conducted for Skyline Marina before a sampling and analysis plan was submitted to the DMMP agencies. The volume shown is an estimate.
- MJB Properties consists of three components: north dock, south dock, and boat ramp. These three components were tested separately, but have been combined for the purpose of this analysis.
- The Port of Everett 12th Street Marina project was known as the 12th Street Barge Channel at the time of testing.

Appendix A includes the dioxin concentration for each individual project sample used in the analysis. Figure 1 shows the projects that were tested for dioxin.

3. Pass/Fail Analysis

Dioxin concentrations from the 20 projects were compared to the former guideline, the interim guideline and the proposed guideline. Analysis for all projects was conducted using the nondispersive guidelines, and for five of the projects using the dispersive guidelines. Table 2 compares the three sets of guidelines. Table 3 provides the site-specific interim guidelines for the five DMMP nondispersive sites. Under the former and proposed guidelines, any DMMU exceeding the bioaccumulation trigger would be considered to have “failed” for this analysis. The DMMP agencies are looking into the possibility of a test-out option involving bioaccumulation testing. The dredging proponent would have the option of pursuing bioaccumulation testing to determine whether or not the DMMUs could qualify for open-water disposal. It should be noted that a test-out option was available under the former guidelines.

Table 2. Former, Interim and Proposed Guidelines

Guideline	Nondispersive	Dispersive
Former	Bioaccumulation Trigger (BT) = 15 pptr TEQ[3]	BT = 15 pptr TEQ
Interim	Disposal-site specific guidelines with a maximum concentration and volume-weighted average for the project (see Table 3)	Comparison to reference
Proposed	BT = 10 pptr TEQ Volume-weighted average <= 4 pptr TEQ	BT = 4 pptr TEQ

Table 3. Nondispersive Interim Guidelines (pptr TEQ with u = ½ DL)

Disposal Site	Volume-weighted Average	Maximum
Port Gardner	4.1	5.2
Anderson Ketron	3.6	6.8
Bellingham Bay	6.9	10.5
Elliott Bay	8.7	12.2
Commencement Bay	2.4	5.2

It should be noted that only dioxin results were considered. Failures due to other chemicals, bioassays, or bioaccumulation testing were not considered. Thus, a DMMU might have passed under the dioxin guidelines, but failed for other reasons. Therefore, the "pass" rates resulting from this analysis are not necessarily reflective of the actual pass rates when all test results are considered.

3.1 Nondispersive Guidelines

Table 4 includes the pass/fail results under the former, interim and proposed nondispersive guidelines. While five of the projects are closer to a dispersive site than to a nondispersive site, for the purpose of this analysis the nearest nondispersive site was used. Thus, the "proposed" and "interim" columns in Table 4 refer to the suitability for disposal at the nearest nondispersive site.

Under the former guideline, any DMMU with a TEQ (u = ½ DL) of 15 pptr or less would have been suitable for open-water disposal (in addition, the 2,3,7,8-TCDD concentration would have needed to be at or below 5 pptr). Under the proposed guidelines, the maximum TEQ for any individual DMMU would be 10 pptr, and the volume-weighted average of the DMMUs taken to a disposal site would need to be less than or equal to 4 pptr. The results in Table 4 reflect this 2-tiered screening process. The interim guidelines, while site-specific, were applied in a similar 2-tiered fashion.

[3] A concentration of 5 pptr for 2,3,7,8-TCDD would also trigger bioaccumulation testing.

Table 4. Project Impacts – Comparison of Nondispersive Guidelines

	Guideline:	Former	Interim	Proposed
Project	Project Volume[4] (cy)	Volume Passing	Volume Passing	Volume Passing
USACE Port Townsend	1,250	1,250	1,250	1,250
Port of Seattle T115	3,750	0	0	0
Delta Marine Industries	6,534	6,534	6,534	6,534
Port of Seattle T18	6,800	0	0	0
Port of Seattle T5	6,900	6,900	6,900	*0*
Port of Everett 10th St. Boat Ramp	12,340	12,340	*0*	*0*
Port of Bellingham I&J Waterway	15,770	0	0	0
Port of Olympia East Bay Marina	27,664	3,750	*0*	*0*
US Navy Everett Homeport	39,200	39,200	*35,200*	39,200
Port of Anacortes Cap Sante Marina – Phase 3	40,900	15,200	15,200	15,200
Port of Bellingham Gate 3	49,884[5]	24,942	*12,471*	*0*
USACE Duwamish	54,104	54,104	54,104	54,104
Skyline Marina	64,000	64,000	64,000	64,000
Dakota Creek Industries	64,000	64,000	64,000	64,000
MJB Properties	67,825	67,825	*59,034*	*59,034*
Port of Everett 12th St. Marina	80,500	80,500	*62,500*	80,500
Port of Tacoma Washington United Terminal	95,700	95,700	95,700	95,700
Port of Tacoma East Blair Cutback	317,017	317,017	*278,189*	317,017
Puyallup Tribal Terminal	376,523	376,523	*278,625*	376,523
USACE/Port of Olympia	448,317	235,360	*191,724*	*210,083*
Total volume:	1,778,978	1,465,145	1,225,431	1,383,145
Percent passing:		82.4	68.9	77.7
Number of projects impacted:		7	13	10

Indicates an impacted project – i.e., at least one failed DMMU.
Indicates a change in project impact when compared to the old 15 pptr guideline.

When compared to the former guideline, the pass rate under the proposed guideline dropped from 82% to 78% of the total tested volume. But this compares to a pass rate of just 69% under the interim guidelines. In terms of number of projects, of the ten projects, seven projects would have been impacted under the former guideline, while thirteen and ten projects would be impacted under the interim and proposed guidelines respectively. The volume pass/fail rates are presented graphically in Figure 2, while the numbers of impacted projects are displayed in Figure 3.

[4] The project volume does not include native material that was not tested for dioxin.
[5] For the purpose of this analysis, the Gate 3 volume was split into four equal-volume portions.

Results for individual projects are presently graphically in Figures 4 and 5. A comparison of these figures indicates that smaller projects could be affected more significantly than larger projects under the proposed guidelines. This makes sense since smaller projects have fewer DMMUs to include in volume-weighted averaging, and are less likely to include native material. However, a number of the projects under 50,000 cubic yards would be impacted regardless of the guidelines used. Examples include the Port of Olympia's East Bay Marina, the Port of Anacortes' Cap Sante Marina, the Port of Bellingham's I&J Waterway, and the Port of Seattle's T115. All, or nearly all, of the dredged material from these projects would have been found unsuitable for open-water disposal under the former guidelines.

Large projects have more flexibility than smaller projects and would be the least likely to be negatively impacted by the proposed guidelines. This is especially true for large projects with significant volumes of native material, which would tend to reduce the volume-weighted average for the project.

One project, the Port of Seattle's T5, would clearly be impacted under the proposed guideline, while not impacted under either the former or interim guidelines. Impacts to the Port of Bellingham's Gate 3 project would also be greater under the proposed guidelines than under the other guidelines. This is because the interim guidelines for Elliott Bay and Bellingham Bay are less restrictive than the proposed guidelines. For the other three nondispersive sites, the interim guidelines are more restrictive than the proposed guidelines. For example, in the case of projects on the Blair Waterway in Tacoma, impacts under the proposed guidelines would generally be less than under the interim guidelines.

3.2 Dispersive Guidelines

Under the former guideline, dispersive and nondispersive sites were treated the same with respect to dioxin. DMMUs with TEQs less than or equal to 15 pptr could be disposed of at either a dispersive or nondispersive site. Under the proposed guidelines, any DMMU with a TEQ greater than 4 pptr would be unsuitable for dispersive-site disposal. Under the interim guidelines, a comparison to reference-bay sediment is required. However, statistical analysis of data from the OSV Bold survey of main-basin and reference sites in Puget Sound indicated that there is no significant difference between reference and main-basin dioxin concentrations. Therefore, for this analysis, the interim guidelines for dispersive disposal were assumed to be equivalent to the proposed guidelines, which are based on a combined main-basin and reference data set.

Table 5 includes the results from the dispersive-site analysis. The following projects were included: 1) projects for which the nearest site is dispersive, and 2) Port of Bellingham projects. The latter were included because the nondispersive site in Bellingham Bay is currently closed, plus the dispersive site in Rosario Strait is often used for at least a portion of the dredged material volume for projects in Bellingham.

Table 5. Project Impacts – Comparison of Dispersive Guidelines

	Guideline:	15 pptr	Interim	Proposed
Project	Project Volume (cy)	Volume Passing	Volume Passing	Volume Passing
USACE Port Townsend	1,250	1,250	*850*	*850*
Port of Bellingham I&J Waterway	15,770	0	0	0
Port of Anacortes Cap Sante Marina	40,900	15,200	15,200	15,200
Port of Bellingham Gate 3	49,884[6]	24,942	*0*	*0*
Skyline Marina	64,000	64,000	*32,000*	*32,000*
Dakota Creek Industries	64,000	64,000	64,000	64,000
MJB Properties	67,825	67,825	*48,725*	*48,725*
Total volume:	303,629	237,217	160,775	160,775
Percent passing:		78.1	53.0	53.0
Number of projects impacted:		2	6	6

Indicates an impacted project – i.e., at least one failed DMMU.
Indicates a change in project impact when compared to the old 15 pptr guideline.

Table 5 indicates that the proposed (and interim) dispersive guidelines would impact six of the seven projects. Under the former guideline only two projects would have been impacted.

A comparison of Tables 4 and 5 indicates that two projects, USACE Port Townsend and Skyline Marina, would be impacted under the proposed dispersive guidelines, while not impacted under the proposed nondispersive guidelines.

3.3 Differential Impact of Proposed Guidelines

Projects that would be impacted under the proposed dioxin guidelines were evaluated to see whether dioxin alone would have affected them, or whether results from bioassays or bioaccumulation testing would also have affected these projects. The projects can be categorized as follows:

- Two projects, Cap Sante Marina and USACE/Port of Olympia, would be impacted due to dioxin alone. However, these projects would also have been impacted under the former dioxin guidelines.
- Two projects, MJB Properties and 10th Street Boat Ramp, would be impacted due to dioxin alone. These projects would *not* have been impacted under the former guidelines.
- Two projects, T18 and T115, had screening level exceedances (T115 also had bioaccumulation trigger exceedances) for other chemicals of concern, but did not have bioassays conducted because all material failed under the interim dioxin

[6] For the purpose of this analysis, the Gate 3 volume was split into four equal-volume portions.

guidelines. These projects would also have been affected under the former dioxin guidelines.

- One project, T5, had a DMMU that failed toxicity testing. Therefore, this project would have been impacted even without dioxin testing.
- Data for three projects, I&J Waterway, Gate 3, and East Bay Marina, have not been submitted for review. It was not possible to determine whether toxicity or bioaccumulation testing would have been required for these projects due to other chemicals of concern. However, all three projects would have been impacted under the former guidelines.
- Ten projects would not be impacted by the proposed dioxin guidelines, nor would they have been impacted under the former guidelines.

4. A Broader Look at DMMP Projects and Puget Sound Dioxin Data

In addition to the project-specific impact analysis conducted using only those DMMP projects with dioxin data, a broader review of DMMP projects was undertaken to determine such things as urban vs. non-urban and native vs. non-native volumes. There were also dioxin data available from surveys other than those conducted for DMMP dredging projects. An attempt was made to incorporate both sets of data into a broader analysis.

4.1 Review of all DMMP Projects

All Puget Sound dredging projects since the inception of the Dredged Material Management Program were reviewed (not just those with dioxin data). Projects were categorized as urban or non-urban, and DMMP suitability determinations were reviewed to determine the quantities of native and non-native sediment. The following table summarizes the results:

Number of Projects	210
Years	1989–2009
Total Volume	28,923,345
Urban Non-native	15,749,506 (54.5%)
Urban Native	9,535,385 (33.0%)
Non-urban Non-native	3,638,454 (12.5%)
Non-urban Native	0

Urban areas included Olympia, Tacoma, Seattle, Bremerton, Everett, Anacortes, Bellingham, Port Townsend, and Port Angeles.

4.2 Review of Additional Urban Dioxin Surveys

A number of large surveys were reviewed to assist in determining concentrations of dioxin that might be encountered in urban embayments. The surveys included the following:

- Budd Inlet Sediment Characterization Study – Phases 1 and 2
- Lower Duwamish Human Health Risk Assessment
- Lower Duwamish Remedial Investigation – Phases 1 and 2
- Fidalgo Bay Sediment Investigation
- Port Angeles Harbor Sediment Investigation
- DMMP Disposal-Site Monitoring – Commencement Bay, Elliott Bay, Port Gardner, Bellingham Bay
- Surface Sediment and Fish Tissue Chemistry in Greater Elliott Bay (Seattle) – Urban Waters Initiative
- USACE/Port of Olympia – Olympia Harbor (this project was also included in the project-specific analysis)

Results from this analysis are summarized in the following table:

Number of Dioxin Samples	421
Range of TEQs in Screened Samples	0.11 to 4,213 pptr
Number of Samples at or below 4 pptr	169 (40%)
Number of Samples at or below 10 pptr	272 (65%)
Number of Samples at or below 15 pptr	315 (75%)

These surveys included numerous samples taken to determine the extent of dioxin contamination at cleanup sites. As such, they are not representative of what might be encountered in the “typical” urban-bay dredging projects. In an attempt to better define urban “background,” the samples from these surveys were screened using GIS. Samples that were within 500 meters of municipal and industrial outfalls, or within 500 meters of a cleanup site listed in Ecology’s facility database, were eliminated.

The following table summarizes the results from the screening exercise:

Number of Dioxin Samples	170
Range of TEQs in Screened Samples	0.11 to 89.7 pptr
Number of Samples at or below 4 pptr	77 (45%)
Number of Samples at or below 10 pptr	122 (72%)
Number of Samples at or below 15 pptr	145 (85%)

4.3 Results of the Analysis

The results from the screened urban-bay dataset generally support the evidence provided by analysis of the DMMP projects with dioxin data. That is, the fail rate for urban-type dredged material for projects with dioxin data was 22.3%. For the screened urban-bay dataset, 28% of the samples were above 10 pptr and would fail the first-tier screen under the proposed guidelines. Of the samples falling below 10 pptr, the mean concentration was 3.3 pptr. This means that, taken as a whole, if each sample were assigned an equal volume of dredged material, all samples falling below 10 pptr would pass under the volume-weighted average guideline of 4 pptr and the fail rate would remain at 28%. In reality, the samples would be distributed among dredging projects of various sizes and the fail rate would be something greater than 28%. Nevertheless, it is important to note that the fail rate resulting from independent analyses is similar (except for the Olympia Harbor data).

5. Implications for Future Projects

There are a number of implications for future projects:

- More projects will require testing. In the last 21 years, 6.2 percent of the Puget Sound dredged material volume has been tested for dioxin (from approximately 10% of the total number of projects). Based on the updated reason-to-believe guidelines, approximately 55% of the dredged material volume will require dioxin testing (this assumes that non-urban projects and deeper native sediment will not require testing). It is important to note though that the percentage of material being tested has already increased within the DMMP program. During the three year period of 2007-2009, 33% of the total volume was tested.
- A larger annual volume of material will be found unsuitable under the proposed guidelines. This is due to a slightly higher fail rate (compared to the former guideline), and a higher percentage of material being tested. Assuming that all native and non-urban material either passes under the proposed guidelines or does not require testing, and if the future fail rate under the proposed guidelines were to remain the same as the fail rate for the twenty projects with dioxin data (22.3%), the annual volume of material that would be found unsuitable under the proposed guidelines will be approximately 167,000 cy. The calculation of this volume is as follows:
    - Total annual volume = 1,377,302 cy
    - Annual volume of native material = 454,066 cy
    - Annual volume of non-urban material = 173,260 cy
    - Annual volume of non-native urban material = 749,976 cy
    - 749,976 x 0.223 = 167,245 cy

  A comparison of volumes requiring dioxin testing and volumes failing under the former and proposed guidelines can be seen in Figure 6.
- Based on past data, it should be noted that at least some of the material that will be found unsuitable under the proposed dioxin guidelines will also have other chemicals of concern exceeding DMMP screening levels or bioaccumulation triggers. Some of

the material would fail bioassays or bioaccumulation testing if these tests were to be conducted. The analysis provided in this memorandum did not attempt to quantify the overlap in failed volumes.

- Some projects will have DMMUs that fail for dioxin alone. This will have cost implications for dredging and disposal and could result in project delay or cancellation. The “tipping point” at which additional costs for managing dioxin-contaminated dredged material result in project cancellation depends on a number of factors including the financial wherewithal of the dredging proponent, costs vs. benefits, and the ratio of incremental to total project cost.
- There are potential secondary economic impacts associated with cancelled projects including job loss due to decreased viability of businesses that rely on navigable waterways. However, these impacts are highly project-specific and information provided to date does not allow calculation of program-wide secondary impacts associated with this proposal vs. the previous or interim dioxin guidelines.
- Smaller projects will likely be impacted to a greater extent than larger projects.
- Projects that are nearer dispersive sites will be more heavily impacted than projects that are near nondispersive sites due to the more restrictive guidelines at dispersive sites. This includes projects in Anacortes and Port Townsend. Haul distances would increase if dredged material from these projects were to be found suitable for nondispersive disposal but not for dispersive disposal. Also, volume-weighted averaging might result in material, which would otherwise be suitable for dispersive-site disposal, being hauled to a nondispersive site to meet the required project average.
- Upland disposal costs are much higher than open-water disposal costs. The additional cost per cubic yard depends on such things as project size, availability of dewatering and transloading facilities, access to rail lines, haul distance to the disposal site, and tipping costs. Differential costs (over and above what would be incurred for open-water disposal) have been submitted for past and current projects, ranging from a low of $30 per cubic yard for Portland Harbor to a high of $162 per cubic yard for Port of Seattle T30.

FIGURES

Figure 1. DMMP Projects with Dioxin Data

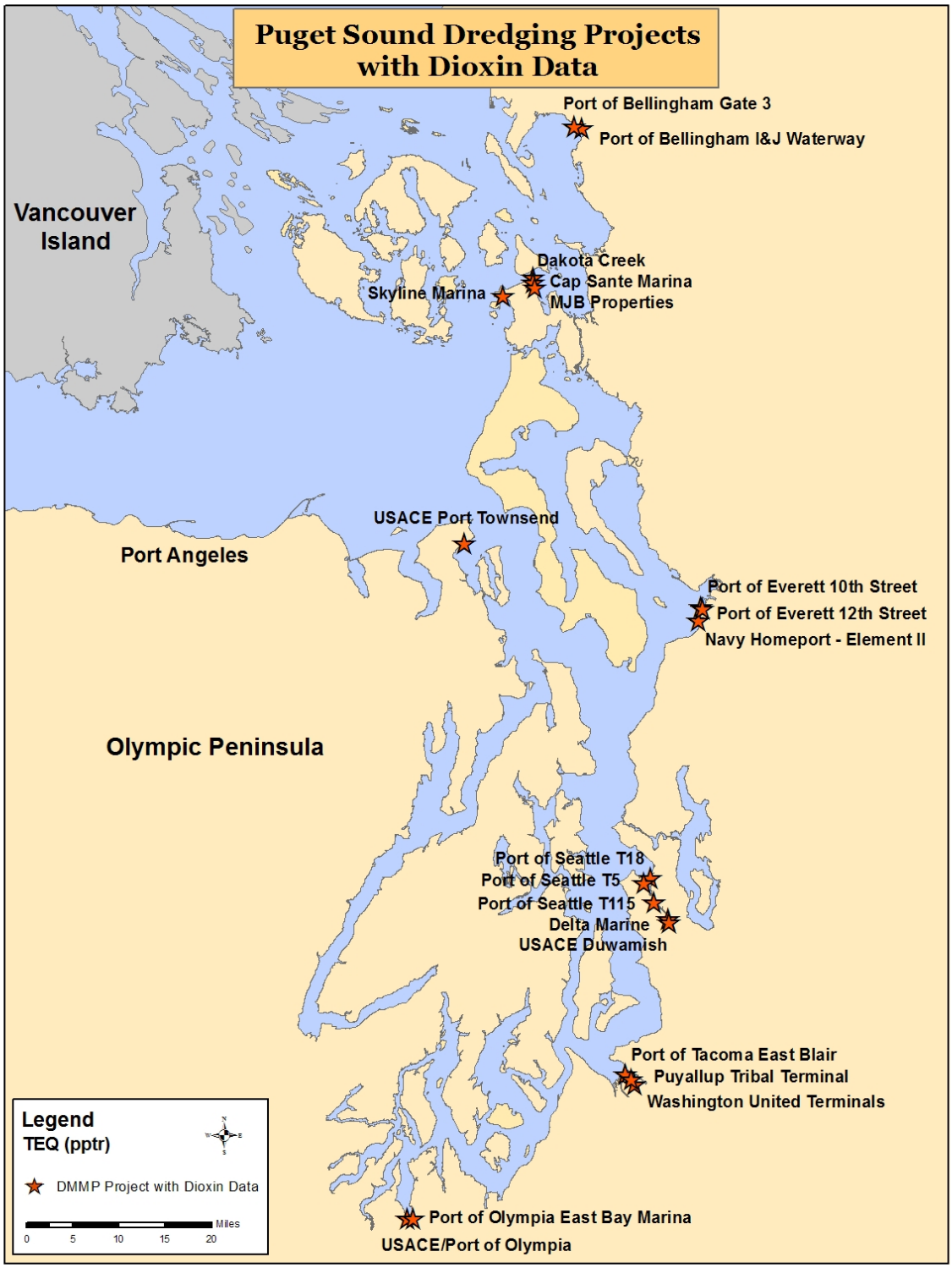
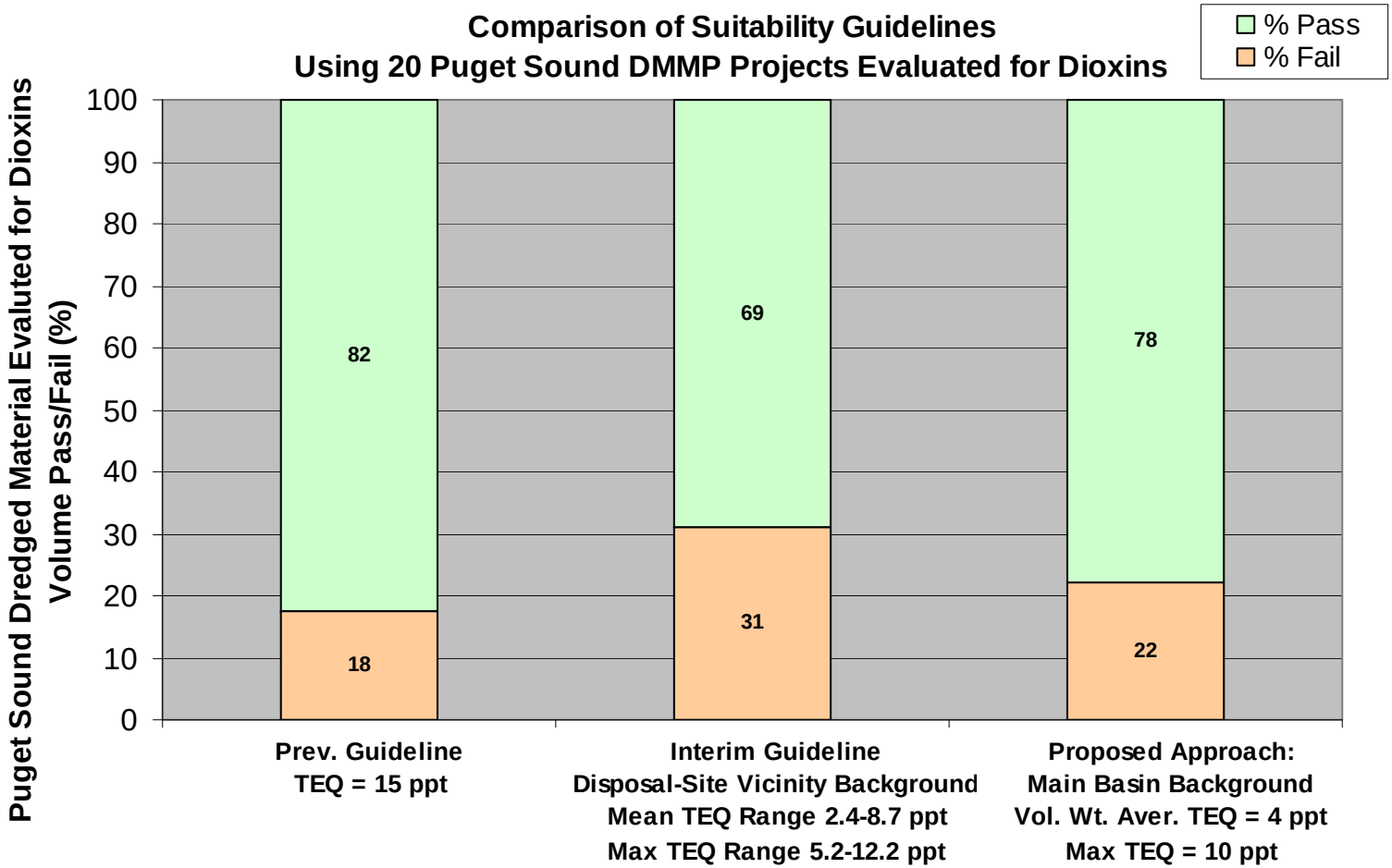
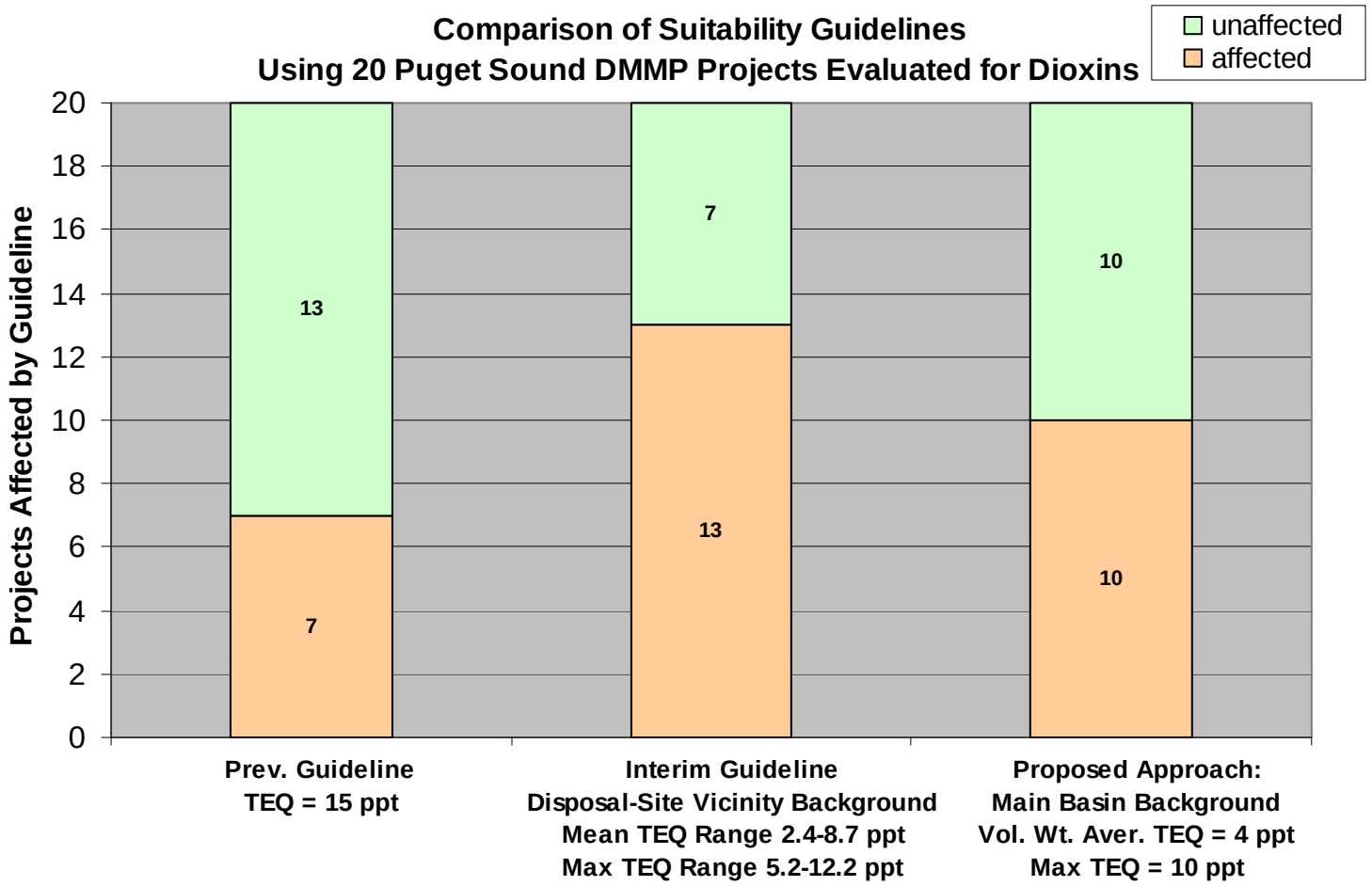


Figure 2. Guideline Comparison – Pass/Fail Volume



Note: native material included only where tested.

Figure 3. Guideline Comparison – Impacted Projects



Note: affected projects have one or more DMMUs that fail the dioxin guideline.

Figure 4. Guideline Comparison – Projects Less Than 50,000 CY

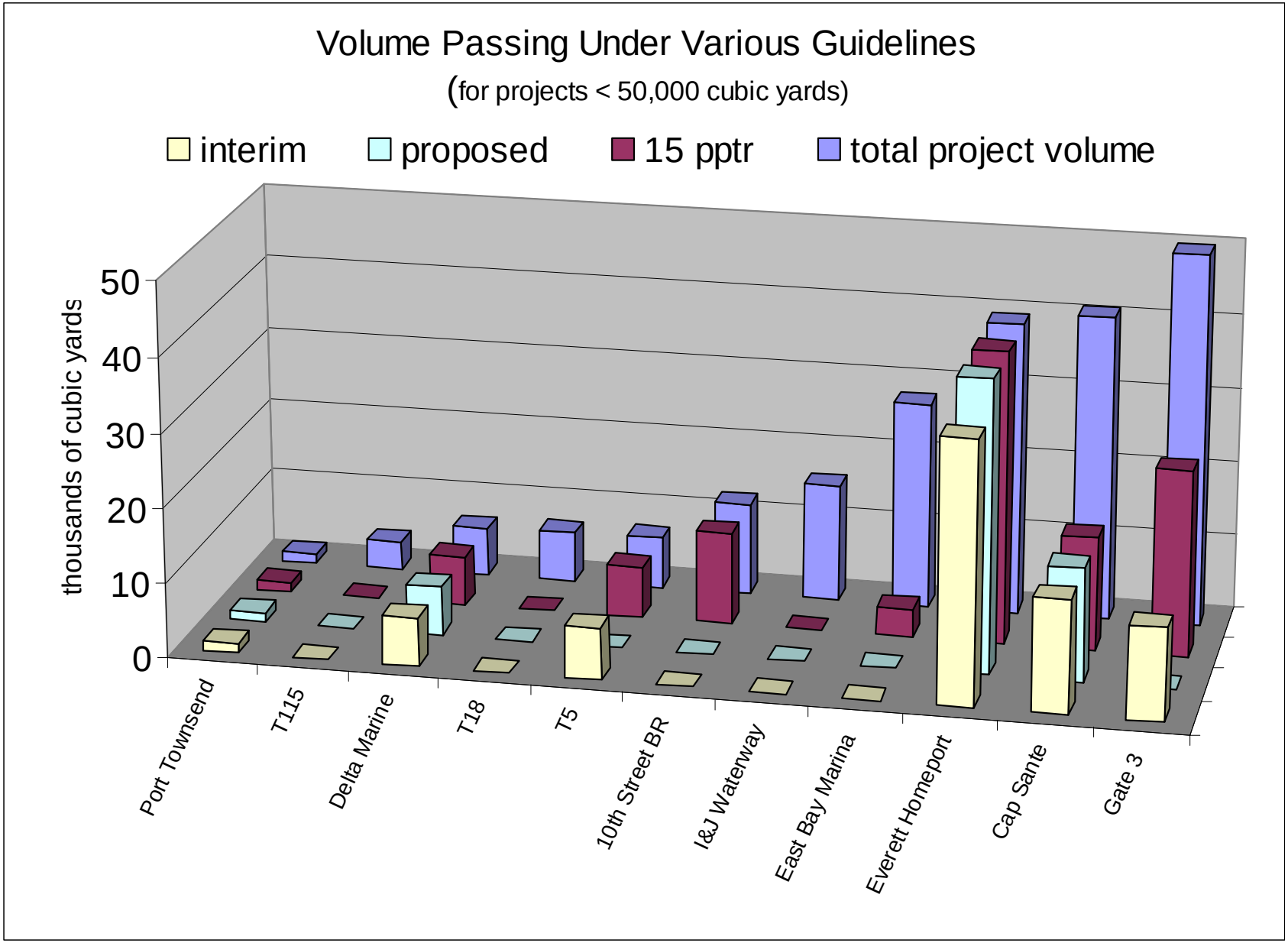


Figure 5. Guideline Comparison – Projects More Than 50,000 CY

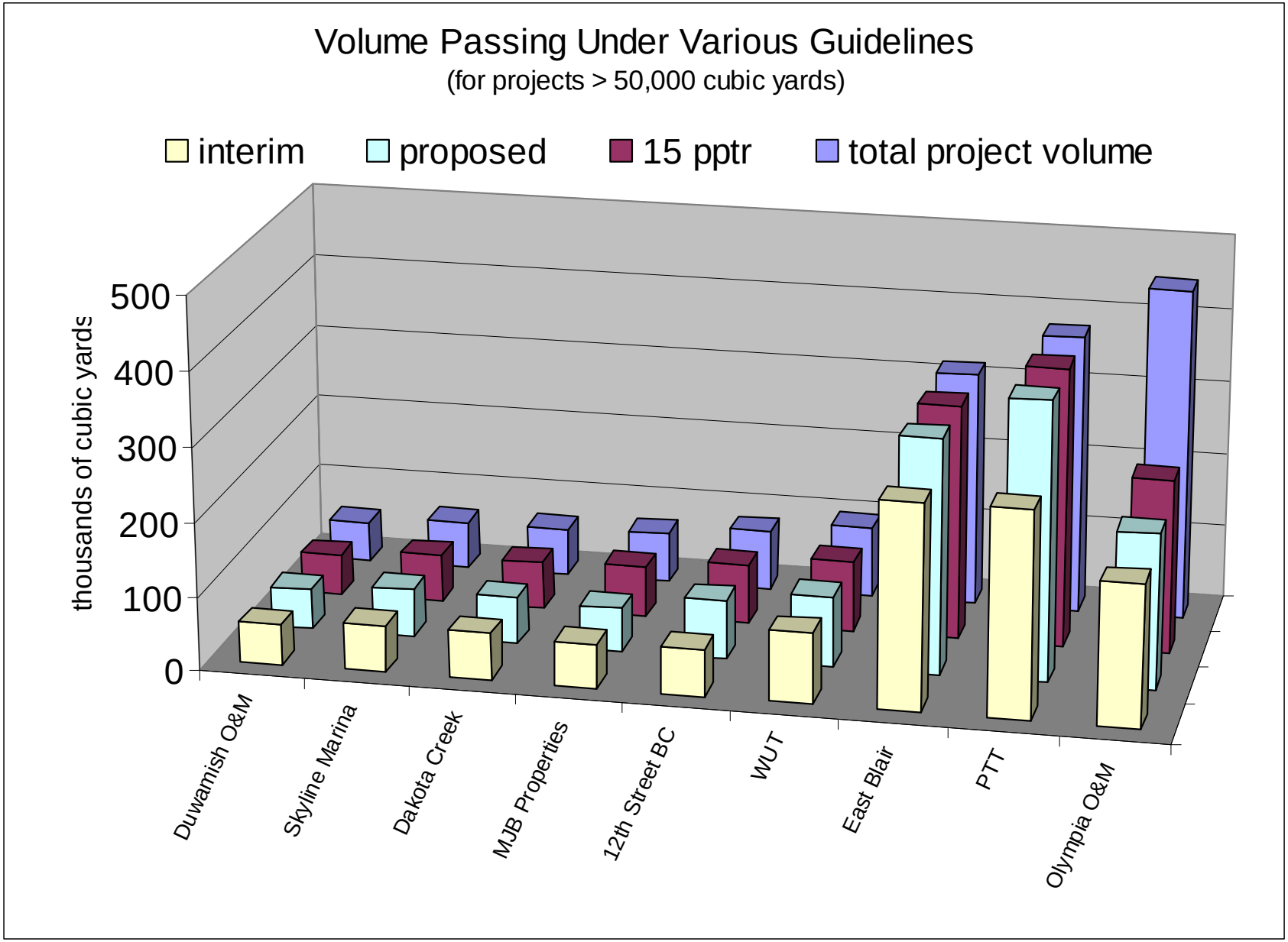
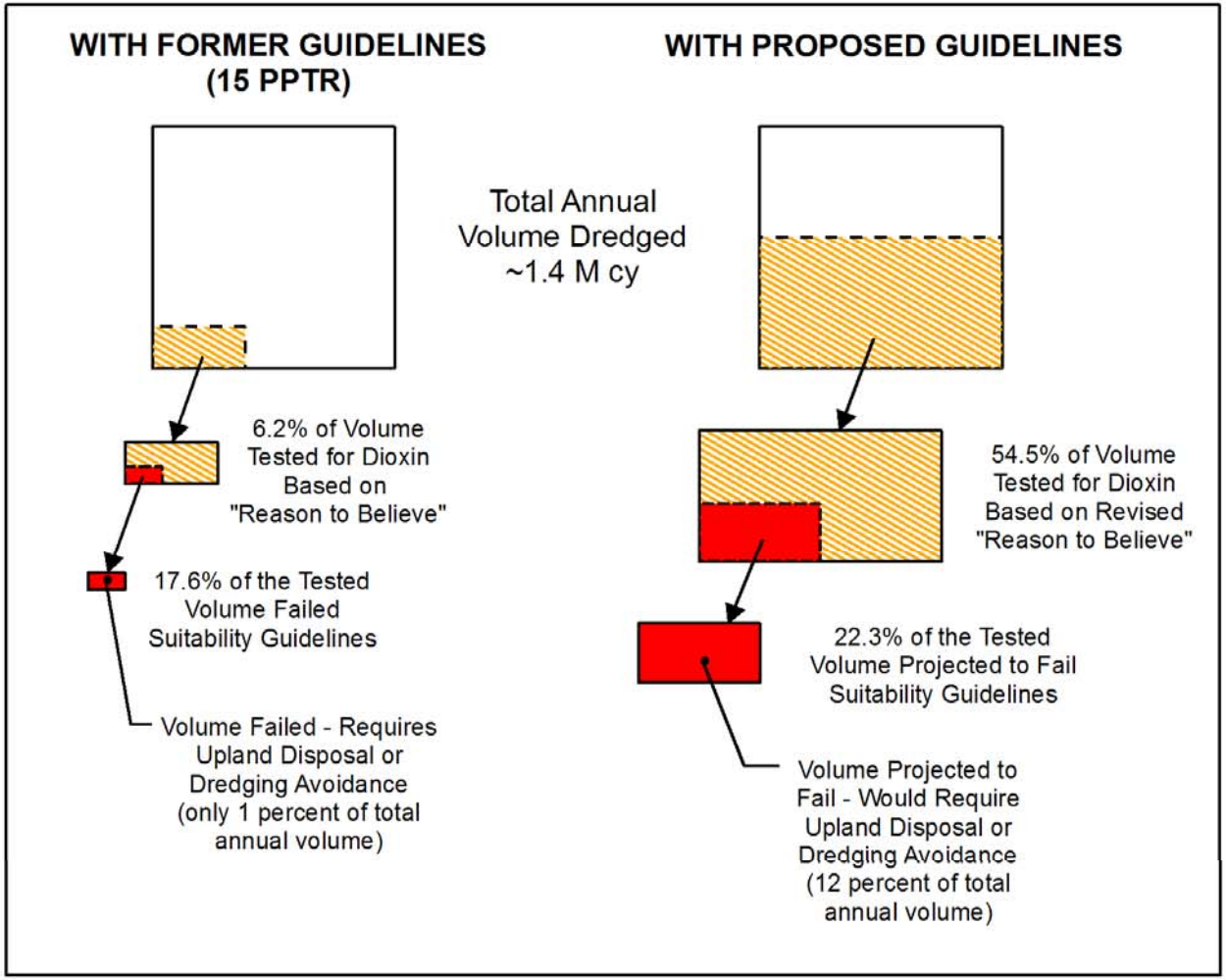


Figure 6. Comparison of Failed Volumes – Former and Proposed Guidelines



Appendix A – Dioxin Data for Individual Projects

Notes:
- Volumes are in cubic yards
- TEQ = toxic equivalents in parts per trillion
- DMMU = dredged material management unit

USACE/Port of Olympia

DMMU ID	Volume	TEQ
1a	7,547	1.9
2a	11,643	52.3
2b	6,752	1.6
3a	8,310	37.4
3b	5,898	2.0
4a	8,403	52.6
4b	9,264	4.6
5a	26,079	17.7
6a	29,434	16.9
7	25,277	10.8
8	21,716	19.2
9	18,422	18.8
10	29,062	25.6
11a	9,952	15.1
12a	13,827	5.3
11b	13,926	1.6
12b	27,864	0.2
13	20,774	31.2
14a	20,148	21.2
14b	24,056	0.7
15	21,283	3.2
16a	21,584	0.1
16b	31,771	0.1
17	18,359	6.9
18	9,014	32.3
19	7,952	6.4
total volume:	**448,317**	

Port of Anacortes Cap Sante Marina

DMMU ID	Volume	TEQ
1	3,000	34.3
2	15,200	3.51
3	14,500	52.6
4	8,200	44.4
total volume:	**40,900**	

Port of Bellingham Gate 3

Note: volumes are average for 4 DMMUs

DMMU ID	Volume	TEQ
1	*12,471*	6.24
2	*12,471*	10.6
3	*12,471*	27.3
4	*12,471*	47.1
total volume:	**49,884**	

Port of Bellingham I&J Waterway

DMMU ID	Volume	TEQ
DMMU3	3,650	22.3
DMMU4A	3,580	27
DMMU4B	2,240	21.1
DMMU5	3,760	29.8
DMMU6	2,540	32.4
total volume:	**15,770**	

USACE Port Townsend

DMMU ID	Volume	TEQ
DMMU1	400	4.71
DMMU2	850	1.36
total volume:	**1,250**	

Delta Marine Industries - Duwamish

DMMU ID	Volume	TEQ
DMMU3	2,629	3.53
DMMU4	3,905	0.821
total volume tested:	**6,534**	
DMMU 1/2	6,226	not tested

Port of Tacoma - Washington United Terminals

DMMU ID	Volume	TEQ
WUT5 high spot	5,600	0.633
WUT4 (maintenance dredge)	28,400	2.64
WUT 03 (native)	24,700	0.856
WUT 02 (cutback)	24,700	1.616
WUT 1 (cutback)	12,300	2.959
total volume tested:	**95,700**	
untested native volume:	138,300	

Port of Seattle T18

DMMU ID	Volume	TEQ
DMMU1	6,800	21.7
total volume:	**6,800**	

Port of Seattle T115

DMMU ID	Volume	TEQ
DMMU1	2,035	23.2
DMMU2	1,715	29.9
total volume:	**3,750**	

Port of Everett 10th Street

DMMU ID	Volume	TEQ
C2 10th St	12,340	6.71
total volume:	**12,340**	

Port of Everett 12th Street

DMMU ID	Volume	TEQ
C1 12th St	6,750	4.859
C2 12th St	6,750	0.615
C3 12th St	6,750	0.876
C4 12th St	6,750	3.266
C5 12th St	10,100	8.725
C6 12th St	7,900	6.545
C7 12th St	15,800	1.683
C8 12th St	19,700	1.73
total volume:	**80,500**	

U.S. Navy Everett Homeport - Element II (breakwater design)

DMMU ID	Volume	TEQ
S1	4,000	1.2
S2	1,200	1.7
S3	4,000	8.4
S4	12,000	2.9
S5	4,000	2
S6	14,000	1.6
total volume tested:	**39,200**	
untested native volume:	70,800	

Port of Tacoma East Blair Cutback

DMMU ID	Volume	TEQ
DMMU 1 (surface)	38,828	7.33
DMMU 2 (subsurf)	95,458	1.04
DMMU 3 (subsurf)	67,335	0.33
DMMU 4 (native)	115,396	0.32
total volume tested:	**317,017**	
untested native volume:	**1,282,983**	

Port of Olympia East Bay Marina

DMMU ID	Volume	TEQ
DMMU 1	3,999	56
DMMU 2	3,994	47
DMMU 3	3,881	41
DMMU 4	3,996	48
DMMU 5	3,750	5.6
DMMU 6	3,691	17
DMMU 7	2,403	31
DMMU 8	1,950	27
total volume:	**27,664**	

Dakota Creek Industries - Anacortes

DMMU ID	Volume	TEQ
DCI-1	16,000	3.9
DCI-2	16,000	3.5
P1-1	16,000	3.1
P1-2	16,000	3.1
total volume tested:	**64,000**	
untested native volume:	209,000	

Puyallup Tribal Terminal - Blair Waterway

DMMU ID	Volume	TEQ
H1, fill	61,083	8.2
H2, native	59,207	1.9
H3, native	65,879	1.23
H4, native	43,158	0.4
H5, native	42,330	2.55
H6, native	36,815	7.22
H7, native	43,694	0.45
H8, native	24,357	0.156
total volume tested:	**376,523**	
untested native volume:	1,373,477	

MJB Properties - Anacortes

DMMU ID	Volume	TEQ
ND-C1	13,591	1.7
ND-C2	14,091	3.1
ND-C3	9,841	1.1
ND-C4	11,202	0.9
SD-BCC-1	8,791	14
SD-BCC-2	8,309	9.87
SDBR-BRC-1	2,000	4.7
total volume:	**67,825**	

USACE Duwamish

DMMU ID	Volume	TEQ
DMMU 1	16,929	1.67
DMMU 2	16,580	2.75
DMMU 6	3,785	3.93
DMMU 8	3,459	2.77
DMMU 10	3,414	2.45
DMMU 12	3,370	2.03
DMMU 13	3,094	2.42
DMMU 14	3,473	3.52
total volume:	**54,104**	

Skyline Marina - Anacortes

DMMU ID	Volume	TEQ
SM-01	8,000	6.17
SM-02	8,000	6.39
SM-03	8,000	4.48
SM-04	8,000	4.86
SM-05	32,000	1.32
total volume:	**64,000**	

Port of Seattle T5

DMMU ID	Volume	TEQ
T5-S1	2,700	12.05
T5-S2	2,400	6.31
T5-S3	1,800	4.33
total volume:	**6,900**	