TECHNICAL EVALUATION OF THE REPORT TITLED DEVELOPMENT OF A SEDIMENT REMEDIATION FOOTPRINT TO ADDRESS RISKS TO BENTHIC INVERTEBRATES AND FISH IN THE VICINITY OF THE SHIPYARDS SITE IN SAN DIEGO BAY, CALIFORNIA, PREPARED BY MACDONALD ENVIRONMENTAL SCIENCES, LTD. (OCTOBER 2009)

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INTRODUCTION

My name is Dr. D. Scott Becker and I have been retained by BAE Systems to conduct a technical evaluation of the San Diego Shipyards Report prepared by MESL (2009). My evaluation in the present expert report focuses on risks to the benthic macroinvertebrate communities that reside at the Shipyards Site.

The primary objectives of this technical review of MESL (2009) are the following:

- Determine whether the report achieved the stated objectives
- Determine whether the report used the scientifically accepted methods that are commonly used by sediment quality practitioners to assess contaminated sediments in the U.S.
- Determine whether the methodologies and conclusions expressed in the testimony of Donald MacDonald at a deposition held on October 20 and 21 in San Diego, California, are consistent with the report, as well as with the methods commonly used by sediment quality practitioners in the U.S.
- Determine whether the results of the report have sufficient scientific merit to be used to evaluate remedial options at the Shipyards Site.

Stated Purpose of MESL (2009)

According to MESL (2009), the primary objective of the Shipyards Report was to identify *"a remediation footprint for the Shipyards Site that would address impacts on benthic invertebrates and benthic fish utilizing aquatic habitats in the vicinity of the site"* (p. 1, lines 19–21). The implication of this objective is that sediments within the footprint require remediation. In fact, in the "Summary and Conclusions" section of MESL (2009), it is stated that *"the remedial footprint presented in Figure 3 identifies the polygons that require remediation to address risks to benthic invertebrates and/or fish"* (p. 38, lines 17–18).

Although MESL (2009) states that the results of this report identified areas that required remediation, MacDonald in his deposition testified to the contrary. When asked to explain the meaning of the polygons related to the remediation footprint, he stated that "*I've characterized them in terms of the relative priority that should be assigned to each of these areas for remediation rather than indicating that these areas, for example, must be remediated or are required to be remediated*" (MacDonald deposition, Vol. 1, p. 106, lines 24–25, p. 107, lines 1–3). Therefore, in his testimony, MacDonald admitted that the results of MESL (2009) do not actually identify a remediation footprint.

Actual Contents of MESL (2009)

The work presented in MESL (2009) is actually an ecological risk assessment for sediments at the Shipyards Site, and therefore cannot be used alone to identify a remediation footprint. Inspection of Figure 3 (a graphic of the Shipyards Site with polygons that identify areas of various kinds of risk) confirms that the report is an assessment of risk, because the title of the figure (i.e., "Risks to the benthic invertebrate or benthic fish communities associated with exposure to contaminated sediments in the vicinity of the Shipyards Site, San Diego Bay") describes it as a presentation of risks to the benthic invertebrate or benthic fish communities at the Shipyards Site, and the legend defines the polygons as areas of uncertain, low, moderate, and high risk. MESL (2009) by its own terms in defining the polygons therefore documents that the report is actually a risk assessment. Because the word risk implies that uncertainty is attached to the designation, it is inappropriate to extrapolate from the risk results to sediment remediation without considering numerous other relevant factors. For example, within the context of remedial investigations and feasibility studies (RI/FSs) as part of the U.S. Environmental Protection Agency's (EPA) Superfund Program, risks to ecological receptors (such as benthic macroinvertebrate communities) from exposure to chemical contaminants are quantified in a baseline ecological risk assessment, but remedial decisions are made later in the feasibility study where multiple factors are considered, such as the magnitude of risk, the likelihood of natural recovery, and the technical feasibility, costs, and net environmental benefits of remediation (USEPA 1988, 1989, 1997, 1999, 2005). Areas targeted for active remediation are identified only after all of the relevant factors are considered, with risk to ecological receptors being only one of the factors. It therefore is inappropriate and counter to the precedents set by the EPA Superfund Program to go directly from risk identification to active remediation.

In his deposition, MacDonald contradicted the results of MESL (2009) and stated that "*I fully understood that there are a wide range of considerations that need to be sort of brought into the mix and evaluated before you can come up with a remedial footprint*" (MacDonald deposition, Vol. 1, p. 108, lines 9–12). Despite this testimony that numerous considerations other than ecological risk must be factored in to the identifications of a remediation footprint, MESL (2009) concluded on the sole basis of risks to benthic macroinvertebrates and benthic fishes, that the polygons in Figure 3 of that report identify areas that require remediation (p. 38, lines 17–18). MESL (2009) therefore departed from the established practice of sediment quality practitioners, when it identified the remediation footprint. In summary, MESL (2009) did not achieve the objective of identifying a valid sediment remediation footprint. Instead, the report identifies areas of risk to benthic macroinverebrates and benthic fishes that may or may not require active remediation, depending on additional evaluations and considerations. As acknowledged in MacDonald's testimony, none of these other considerations were addressed in MESL (2009).

Role of the California Sediment Quality Objectives

In addition to failing to appropriately identify a remediation footprint at the Shipyards Site, numerous aspects of the methods used by MESL (2009) to evaluate risks to benthic macroinvertebrates from exposure to chemical contaminants are flawed. They also are inconsistent with the methods recommended by many sediment quality experts in both California and throughout the U.S.

MESL (2009) claims that the methods used in the report are consistent with the California SQO guidance (CSWRCB 2009). For example, MESL (2009) states that the approach used in the evaluation of risks to benthic macroinvertebrate communities "*was based on the guidance provided by the CSWRCB (2008) and is considered reliable for California bays and estuaries*" (p. 33, lines 4–5). The 2008 SQO document referred to by MacDonald was an earlier draft of the final 2009 document, which had no major differences from the 2009 document. Despite the assertion by MESL (2009) that the methods in that report were consistent with the SQO guidance, numerous departures from the guidance were made. The most significant of these departures are discussed in the present expert report.

MESL (2009) also stated that *"[t]he procedures used in this evaluation are based on interpretations of a robust data set for the State of California by highly qualified sediment quality practitioners (CSWRCB 2008). Therefore, the procedures used in this evaluation are considered to be reliable."* (p. 33, lines 9–12.) However, when MacDonald was asked in his deposition if he agreed that the California SQOs were developed by regional sediment experts (p. 360, lines 7–9), he replied: *"I don't know the names of everyone who was involved in the development of those SQOs. So it would be hard for me to give you a categorical answer in that respect."* (MacDonald deposition, Vol. 2, p. 360, lines 10–13.) Therefore, MacDonald's testimony contradicted the statement made in MESL (2009). If the SQOs were developed by regional sediment quality experts, and the procedures set forth in the SQO guidance are considered reliable, as MESL (2009) states, MacDonald should have provided convincing and valid justification for any departures from that guidance. However, as will be shown in this expert report, none of the justifications provided by MESL (2009) for the departures from the SQO guidance were valid.

The most significant departure from the SQO guidance was the failure to integrate the multiple lines of evidence (MLOE) on sediment chemistry, sediment toxicity, and benthic community impairment that were collected at the Shipyards Site. As stated in the SQO guidance, "[*p]ollutants in sediment shall not be present in quantities that, alone or in combination, are toxic to benthic communities in bays and estuaries of California. This narrative objective shall be implemented using the integration of multiple lines of evidence (MLOE).*" (p. 3, lines 3–5.) The use of a weight-of-evidence approach based on MLOE is consistent with the manner in which many sediment quality evaluations are currently conducted in the U.S. by sediment quality practitioners (e.g., Burton et al. 2002a,b; Chapman and Anderson 2005; Chapman et al. 2002; Forbes and Calow 2004, SFF 2007; Bay and Weisberg 2011).

MESL (2009) recognized the value of using a weight-of-evidence approach and stated that "*while individual indicators of sediment quality each have an inherent level of uncertainty associated with their applications, the uncertainty associated with an overall assessment of sediment quality conditions can be reduced by integrating information from each of these individual indicators*" (p. 25, lines 25–26; p. 26, lines 1–2). MESL (2009) also stated that "*integration of multiple tools using a* *weight-of-evidence approach has the potential to substantially reduce uncertainty associated with risk assessments of contaminated sediment and, thereby, improve management decisions*" (p. 26, lines 6–8). Despite these statements, MESL (2009) departed from the SQO guidance, as well as the common practice of sediment quality practitioners, and based the assessments of sediment chemistry, sediment toxicity, and benthic community alterations at stations in the Shipyards Site on single LOEs (i.e., the ones that suggested the greatest amount of adverse biological effects). That is, MESL (2009) failed to integrate the various LOEs in a weight-of-evidence approach, and therefore ignored the valuable information provided by the LOEs that were not considered.

Major Methodological Deficiencies of MESL (2009)

In addition to the basic flaw of failing to integrate the MLOE available for the Shipyard Site, there are a number of other deficiencies with the analyses conducted by MESL (2009) that render the results and conclusions of the report unreliable with respect to their use in making remedial decisions for the Site. These deficiencies are discussed in detail below with respect to each major kind of LOE used by MESL: sediment chemistry, sediment toxicity, and benthic macroinvertebrate communities. Prior to the discussion of these deficiencies, the general SQO guidance is discussed with respect to its implications for the Shipyards Site. Although the SQOs are not legally applicable to the Site (CRWQCB 2011), they represent the consensus of the regional experts on sediment quality assessment in California and are adopted by the CSWRCB.

The following deficiencies in the methods used by MESL (2009) are discussed in the remaining sections of this expert report:

- General failure to use a complete weight-of-evidence approach, as recommended by the SQO guidance
- Failure to use the chemical score index (CSI) in conjunction with the Pmax index when evaluating whole-sediment chemistry, as recommended by the SQO guidance
- Failure to determine the site-specific predictive ability of the Pmax at the Shipyards Site, as recommended by many sediment quality practitioners, including MacDonald
- Failure to evaluate site-specific concentration-response relationships between the Pmax and the various biological LOEs at the Shipyards Site, as recommended by many sediment quality practitioners, including MacDonald
- Failure to consider the site-specific bioavailability of chemicals at the Shipyards Site, as recommended by many sediment quality practitioners, including MacDonald
- Failure to conduct statistical comparisons with the negative control results for the toxicity tests, as recommended by the SQO guidance
- Failure to use the mean toxicity designations of all three toxicity LOEs in determining the overall toxicity designation for each station, as recommended by the SQO guidance

- Failure to use the median benthic disturbance designations of all three benthic community LOEs in determining the overall benthic disturbance designation for each station, as recommended by the SQO guidance.

Each of these methodological flaws is discussed in the following sections.

SEDIMENT QUALITY OBJECTIVES

According to CSWRCB (2009), the SQOs for California's bays and estuaries were developed *"to protect benthic communities"* (Resolution No. 5). That statement demonstrates that the SQOs focus on healthy *in situ* benthic invertebrate communities as the primary concern with respect to sediment contamination, rather than sediment chemistry or toxicity. The primary purpose of the latter two LOEs is to evaluate whether any observed benthic community alterations are likely due to chemical toxicity, as opposed to nonchemical factors such as sediment grain size distribution or physical disturbance (e.g., from prop wash).

CSWRCB (2009) also states that the SQOs *"utilize an approach based upon multiple lines of evidence"* (Resolution No. 5). That statement demonstrates that the SQOs emphasize the use of MLOE, rather than single indicators of sediment quality, which is consistent with the methods used by many sediment quality practitioners in the U.S. (as discussed in the "Introduction" section). Finally, according to CSWRCB (2009), the SQOs *"provide adequate protection for the most sensitive aquatic organisms"* (Resolution No. 12). This statement means that additional LOEs or methods are not necessary for the SQOs to be sufficiently protective of benthic invertebrate communities in California bays and estuaries.

The first proposed ecosystem objective identified by MESL (2009) is to *"protect and, where necessary, restore benthic conditions that will support a healthy and diverse benthic invertebrate community"* (p. 5, lines. 24–25). This objective is therefore consistent with the SQO guidance, as described above. However, despite the focus of MESL's proposed ecosystem objective on benthic invertebrate communities, and despite the fact that consensus-based scientifically defensible SQO guidance exists for the protection of benthic communities in the bays and estuaries of California, MESL elected to use a mixture of methods to evaluate the sediment quality information for the Shipyards Site. Some of those methods were consistent with the SQO guidance and some of them departed from that guidance. The most critical departure was the fact that MESL (2009) failed to use a weight-of-evidence approach based on the integration of MLOE, and instead focused only on the individual LOEs that predicted the maximum degree of adverse biological effects, which is contrary to the SQO guidance and the methods commonly used by sediment quality practitioners. The scientific credibility of the basic approach used by MESL (2009) to evaluate sediment quality at the Shipyards Site is therefore inadequate for evaluating remedial options.

SEDIMENT CHEMISTRY

Exclusion of the Chemical Score Index (CSI)

According to Section 6.0 of MESL (2009), information on sediment chemistry *"does not, by itself provide a basis for determining if the ecosystem goals and objectives are being achieved"* (p. 11, lines 25–26). This statement is consistent with the SQO guidance, which specifies that this line of evidence *"is intended only to evaluate overall exposure risk from chemical pollutants"* (p. 3, line 36–37), and that it *"does not establish causality associated with specific chemicals"* (p. 3, lines 37–38). Nevertheless, MESL (2009, Table 6) uses sediment chemistry alone to evaluate sediment quality for 65 of the 117 sediment samples from the Shipyards Site. In addition, although MESL (2009) used two chemical indicators—1) the Pmax for whole-sediment chemistry, which was available for all 117 samples, and 2) porewater chemistry—the latter indicator was available for only 38 of the 117 samples. Therefore, 79 of the 117 sediment samples from the Shipyards Site were evaluated on the basis of a single indicator of sediment quality (i.e., the Pmax), which is contrary to the SQO guidance. It is clear that use of the CSI, as specified by the SQO guidance, would have benefited these analyses, by providing a second whole-sediment chemical LOE that was available for all 117 samples.

In the absence of biological information, the use of sediment chemistry data alone to identify areas for potential remediation should, at a minimum, use chemical indicators that are documented to be reliable in predicting biological effects on a site-specific basis. MESL (2009) did not conduct such a site-specific validation of the chemical indicators used to evaluate sediments at the Shipyards Site, despite the fact that MacDonald has followed that practice at other sediment sites. For example, MacDonald has conducted or recommended site-specific validation of chemical indices for the Calcasieu Estuary of Louisiana (MESL 2002), the Tri-State Mining District of Missouri, Oklahoma, and Kansas (MacDonald et al. 2009), and the Portland Harbor Superfund site in Oregon (MacDonald and Landrum 2008).

As discussed above, MESL (2009) used the Pmax value to evaluate whole sediments at the Shipyards Site. That index was determined from application of the California Logistic Regression Model to 12 chemicals or chemical groups. The maximum probability of toxicity from the individual chemical models (i.e., the Pmax) at each station was then used as the single chemical index of potential biological effects for whole sediments at each station. The SQO guidance specifies that the CSI also be evaluated, to provide two LOEs with respect to evaluating the chemistry of whole sediments. However, MESL (2009) failed to consider this second index and therefore based all of the whole-sediment evaluations on a single index (i.e., the Pmax).

In his deposition, MacDonald stated that he was provided with CSI values for the Shipyards Site (MacDonald deposition, Vol. 2, p. 372, lines 12–13), but decided not to use that information. Given the fact that MacDonald had the CSI values in hand and that the SQO guidance recommends that they be used in conjunction with the Pmax values to evaluate whole-sediment chemistry, there is no valid reason why the CSI values were not used in the analyses presented in MESL (2009). Nevertheless, MacDonald stated that he relied initially on the Pmax values and evaluated how well they worked for data from San Diego Bay in general (MacDonald deposition, Vol. 2, p. 372, lines19–21). Based on that evaluation (presented at Table 2 of MESL [2009]), he concluded in his deposition that the Pmax "*provided a reliable basis for evaluating exposure based on whole sediment chemistry data*" (MacDonald deposition, Vol. 2, p. 372, lines 21−23). He stated that he therefore determined that "*there was not a need for a second indicator to represent whole sediment chemistry*" (MacDonald deposition, Vol. 2, p. 372, lines 23−25). This rationale was invalid for two reasons. First, it is inconsistent with the SQO guidance, which recommends that MLOE be evaluated regardless of how well any single LOE performs. Second, as is shown below, the rationale was invalid because the Pmax was an inadequate predictor of sediment toxicity at the Shipyards Site, regardless of how well it performed for the larger database from San Diego Bay in general. The failure of MESL (2009) to include the CSI as a second LOE for whole-sediment chemistry was therefore a major deficiency of the methods used by MESL (2009).

Predictive Ability of the Pmax

As the justification for using the Pmax as the only indicator of whole-sediment chemistry at the Shipyards Site, MESL (2009) stated that the Pmax provided a reliable basis "*for evaluating impairment of the benthic invertebrate community in San Diego Bay sediment (i.e., based on Benthic Response Index Scores; Table 2)*" (p. 13, lines 4–5). However, the analysis provided below demonstrates that this conclusion was erroneous with respect to San Diego Bay in general, and that the Pmax is an inadequate site-specific predictor of biological effects at the Shipyards Site.

In at least three publications where MacDonald was the lead author or a co-author, a minimum predictive ability of 75 percent was used as the measure of whether a chemical indicator was a reliable predictor of sediment toxicity (MacDonald et al. 2000; Long et al. 1995, 1998). That is, if at least 75 percent of the stations predicted to be toxic using a chemical indicator are actually found to be toxic using biological tests, the indicator was considered a reliable predictor of toxicity. However, this implies that if its predictive ability is less than 75 percent, it is not a reliable predictor of toxicity.

When the 75-percent reliability criterion of MacDonald et al. (2000) is applied to the benthic community impairment results identified above, it is clear that the Pmax is not a reliable predictor of benthic community effects in San Diego Bay. For example, as presented in the sixth column of Table 2 of MESL (2009), 61 of the San Diego Bay stations had Pmax values of 0.67 to 1.0, which according to MESL (2009) indicated high exposure to chemicals. However, only 27 of those 61 stations had Benthic Response Index (BRI) values indicative of moderate or high benthic impairment. Therefore, the predictive ability of the Pmax was only 44.3 percent, which is far less that the minimum value of 75 percent used by MacDonald et al. (2000) and Long et al. (1995, 1998) to identify reliable chemical indicators. In fact, the Pmax predictions were incorrect more frequently than correct (i.e., 55.7 vs. 44.3 percent, respectively). Therefore, based on benthic community impairment, MacDonald's conclusion that the Pmax provided a reliable basis for evaluating exposure based on whole sediment chemistry data from San Diego Bay is incorrect, and invalidates his conclusion that there was no need for a second chemical indicator to represent whole-sediment chemistry.

Aside from the low predictive ability of the Pmax for benthic community impairment in San Diego Bay, the use of baywide chemical and biological results to draw conclusions related to the site-specific conditions in a localized portion of the bay, such as the Shipyards Site, is highly questionable. For example, the bioavailability of chemicals in sediments in a localized site may differ substantially from the bioavailability found in other portions of the bay, thereby invalidating the use of baywide data to make site-specific predictions.

In MacDonald's deposition, he was asked whether he had assumed that the bioavailability of chemicals in sediment at the Shipyards Site was similar to the bioavailability in San Diego Bay in general. He stated that MESL (2009) "*is explicitly silent on that topic*" (MacDonald deposition, Vol. 2, p. 373, line 22). He stated further that he had "*not done an evaluation to determine whether or not one or more of the chemicals of potential concern or contaminants of concern at the Shipyard Sediment Site are more or less bioavailable than they are in other locations in San Diego Bay*" (MacDonald deposition, Vol. 2, p. 374, lines 7–11). Therefore, although it is considered essential by many sediment quality practitioners to consider chemical bioavailability when assessing sediment quality (e.g., Ankley et al. 1996; Di Toro et al. 1991, 2001, 2005; Maruya et al. 2011) , MESL (2009) ignored this important consideration, thereby implicitly assuming that bioavailability at the Shipyards Site was similar to that for San Diego Bay in general.

Given the uncertainty regarding bioavailability of chemicals in sediment at the Shipyards Site, it would have been more valid technically to determine the predictive ability of the Pmax using the site-specific information on biological effects collected at the 30 stations at the Shipyards Site, rather than using the data set for San Diego Bay in general. In conducting evaluations of the predictive ability of sediment quality guidelines (SQGs) that MacDonald et al. (2000) developed for freshwater sediments, the authors specified that "*the various SQGs were considered to be reliable only if a minimum of 20 samples were included in the predictive ability evaluation*" (p. 24, lines 2–4). Therefore, given that 30 and 27 stations were sampled for sediment toxicity and benthic community effects at the Shipyards Site, respectively, there was no valid reason that MESL (2009) could not have evaluated the site-specific predictive ability of the Pmax at the Site. This evaluation was therefore conducted as part of the present review, and the predictive abilities of the Pmax were determined relative to the results for the three toxicity tests and three metrics of benthic impairment evaluated at the Site (see Tables 3 and 4 of MESL [2009]).

The Pmax values at all 30 stations at the Shipyards Site sites predicted moderate to high levels of chemical exposure (see Table 1 of MESL [2009]), with most values predicting the latter degree of exposure. However the predictive ability of the Pmax for the three toxicity tests ranged from 0 to 50 percent, and the predictive ability for the three metrics of benthic impairment ranged from 0 to 52 percent (Table 1). These values are very low relative to the minimum predictive ability of 75 percent for a reliable chemical indicator. In fact, the highest predictive abilities for the toxicity and benthic indicators (i.e., 50 and 52 percent, respectively) were no better than a random coin toss (i.e., 50 percent). These results show that the Pmax was not a reliable predictor of either sediment toxicity or benthic community impairment at the Shipyards Site, and document that the Pmax should not be used as a standalone indicator of adverse biological effects at the Site.

Table 1. Predictive Ability of the Pmax in Relation to the Biological Indicators Evaluated at the Shipyards Site

Biological Indicator	Predictive Ability (percent)
Toxicity Tests	27
Amphipod survival test	50
Mussel normality test	0
Sea urchin fertilization test	
Benthic Metrics	
Benthic Response Index (BRI)	22
Index of Biotic Integrity (IBI)	0
Relative Benthic Index (RBI)	52

Concentration–Response Relationships with the Pmax

In addition to having a high predictive ability, chemical indicators should also exhibit a concentration–response relationship (or dose–response relationship) with the measures of adverse biological effects at a site. That is, as the chemical indicator increases in magnitude, the magnitude of biological effects should also increase. Figure 1 provides a hypothetical example of the kind of concentration–response relationship that would be expected if the Pmax was a valid predictor of biological effects. Figure 1 shows that amphipod survival is relatively high (i.e., > 80 percent) at the lowest values of Pmax, but steadily declines as the Pmax value (and degree of chemical contamination) increases, until the survival values become very low (i.e., (< 20 percent) at the highest Pmax values. This kind of concentration–response relationship increases confidence that the chemical indicator is related to the biological effects. However, if a concentration–response relationship is not found, the usefulness of the chemical indicator is called into question. MacDonald has conducted or recommended site-specific evaluations of concentration-response relationships for the Calcasieu Estuary of Louisiana (MESL 2002), the Tri-State Mining District of Missouri, Oklahoma, and Kansas (MacDonald et al. 2009), and the Portland Harbor Superfund site in Oregon (MacDonald and Landrum 2008). However, despite the fact that MacDonald recognizes the importance of these evaluations, MESL (2009) did not conduct site-specific evaluations of concentration–response relationships for the Shipyards Site.

Because MESL (2009) did not evaluate potential concentration-response relationships between the Pmax and the measures of biological effects at the Shipyards Site, it is unknown whether such relationships exist. Therefore, as part of the present review, the relationships between the

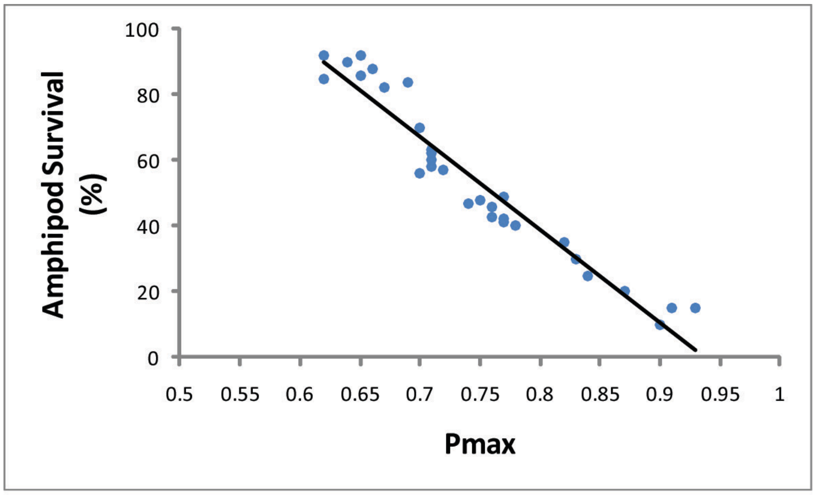

Figure 1. Hypothetical Example of a Concentration-response Relationship Between Amphipod Survival and P_{max}

Pmax and the three measures of sediment toxicity and three metrics of benthic community impairment determined at the Site were evaluated. As shown in Figures 2 and 3, there were no concentration–response relationships for any of the six biological indicators. That is, as the Pmax increased, there were no consistent increases in the magnitude of biological effects. For example, with respect to amphipod toxicity, survival at the lowest Pmax value of 0.62 ranged from 82 to 89 percent, whereas survival at the highest Pmax values above 0.9 exhibited a similar range (i.e., 88 to 94 percent). Therefore, toxicity did not increase with increasing Pmax values, demonstrating that the Pmax values were not predictive of the biological effects. Similar results were found for the other five indicators of biological effects. These results are consistent with the low site-specific predictive ability of the Pmax shown in Table 1, and demonstrate that the Pmax cannot be used to reliably predict the presence of sediment toxicity or benthic community impairment at the Shipyards Site.

Summary of Pmax Evaluations

The results of the site-specific Pmax evaluations described above indicate that the predictions of impairment to benthic communities for the samples in Table 6 of MESL (2009) where the Pmax was the only sediment quality indicator cannot be considered reliable. These results also refute MacDonald's conclusions, described above, that the Pmax provided a reliable basis for evaluating exposure based on whole-sediment chemistry data at the Shipyards Site, and that there was no need for a second indicator of whole-sediment chemistry.

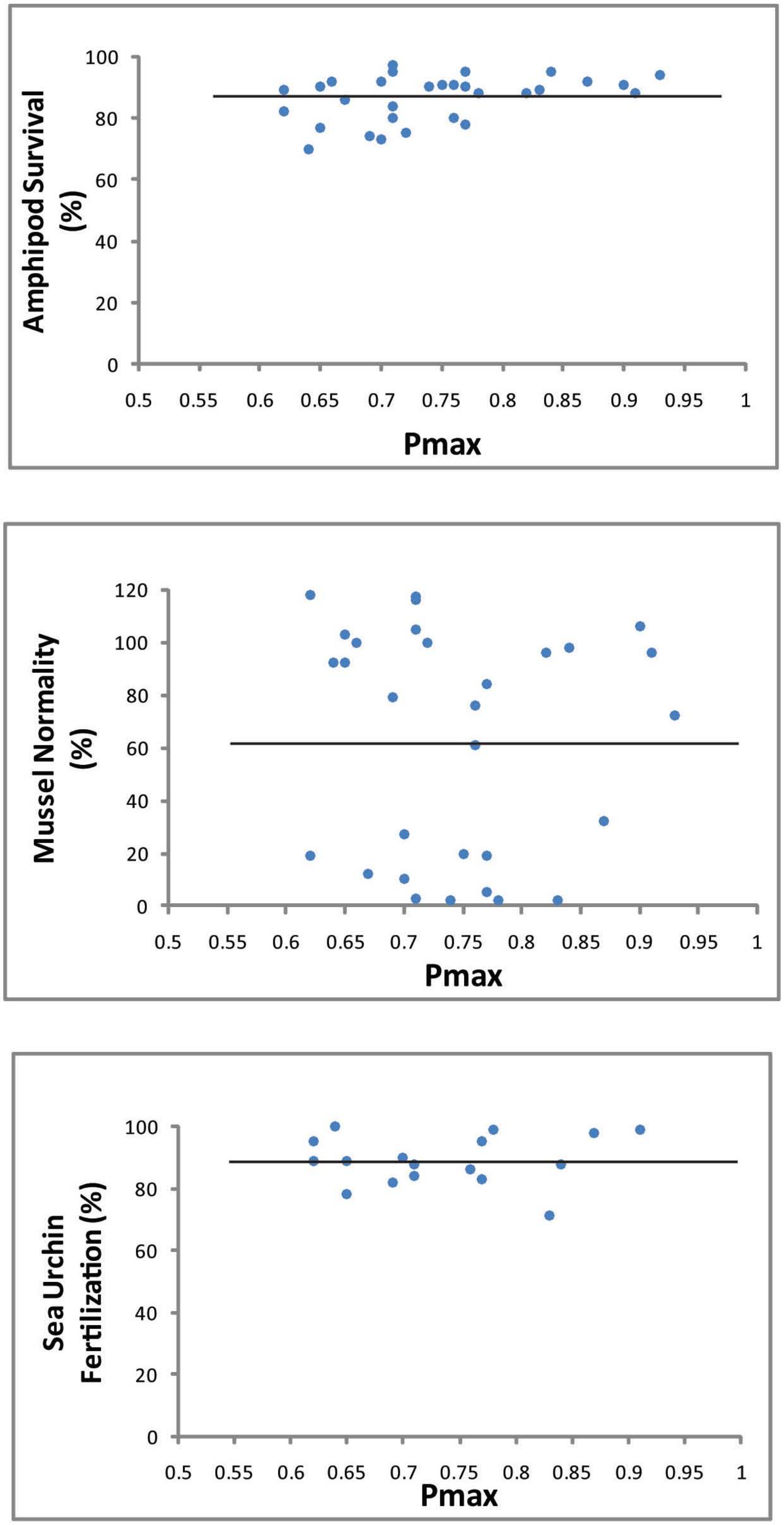

Figure 2. Relationships Between Sediment Toxicity Results and P_{max} at the Shipyards Site

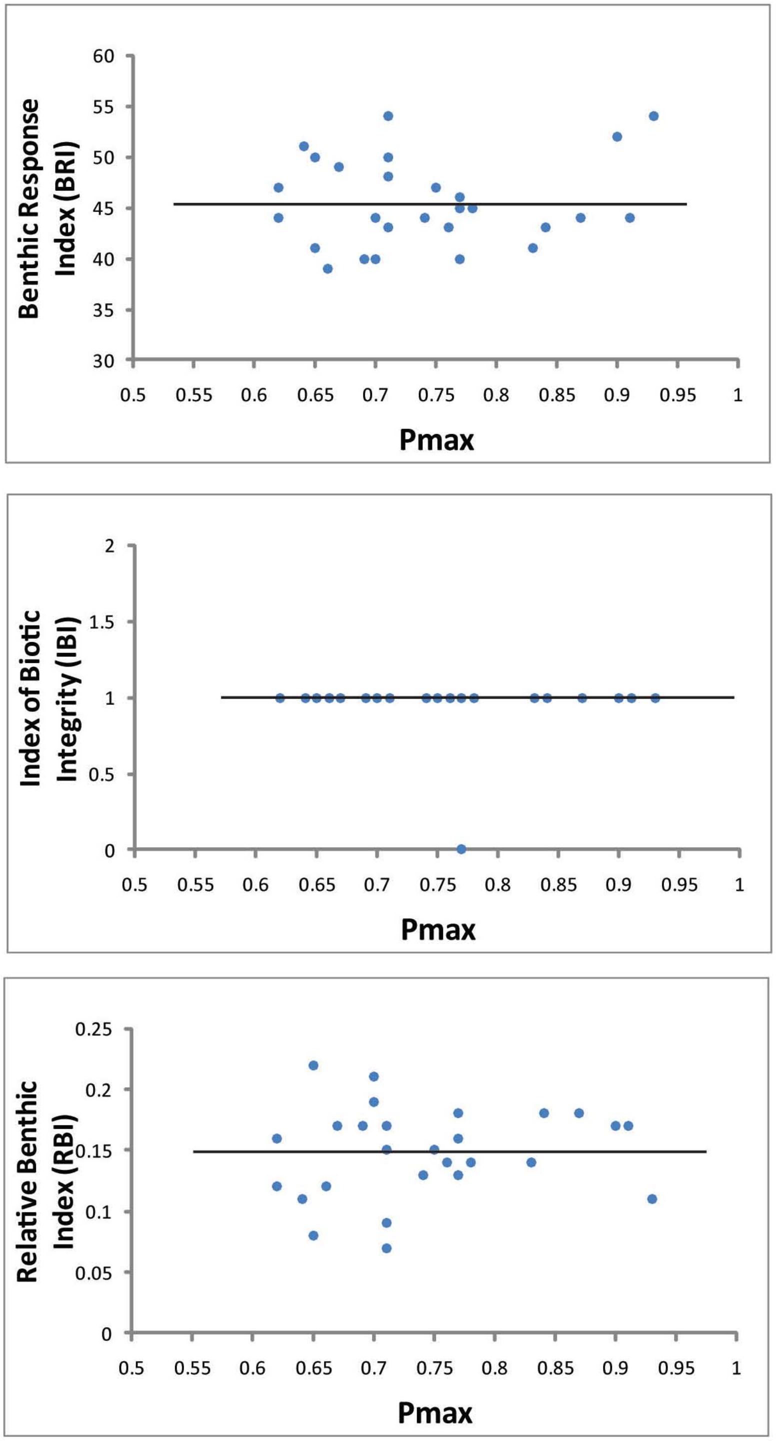

Figure 3. Relationships Between Benthic Community Metrics and P_{max} at the Shipyards Site

SEDIMENT TOXICITY

Absence of Negative Control Comparisons

Although MESL (2009) used information for all three of the sediment toxicity tests evaluated at the Shipyards Site (i.e., the amphipod, mussel, and sea urchin tests), the manner in which the data were evaluated and combined was different from the specifications of the SQO guidance. In determining the toxicity classifications for the stations at the Shipyards Site, MESL (2009) used the ranges of values identified in the SQO guidance for results that differ significantly ($P \leq 0.05$) from the negative control values. This resulted in a considerably more conservative assessment than for results that do not differ significantly ($P > 0.05$) from the negative control results. For example, the range of amphipod survival values indicative of low toxicity is 82 to 89 percent for the former samples, but 59 to 81 percent for the latter samples. As another example, the range of mussel normality values indicative of low toxicity is 77–79 percent for the former samples, but 42–76 percent for the latter samples. In addition to the SQO guidance, this initial comparison to the negative control results was recommended at a workshop of sediment toxicity practitioners recently conducted in British Columbia (SFF 2007) that was chaired by MacDonald and is discussed in MESL (2009) (p. 16, lines 11–16). Nevertheless, there is no indication that this SQO guidance was followed by MESL (2009).

Lack of LOE Integration

In addition to deviating from the SQO guidance and recommendations of sediment toxicity practitioners with respect to the methods of determining significant toxicity, MESL (2009) also deviated from the SQO guidance with respect to integrating the three kinds of sediment toxicity LOEs to provide a single index of toxicity in a weight-of-evidence approach. The SQO guidance states that "*the average of all test response categories shall determine the final toxicity LOE category*" (p. 6, lines 1–2). Instead, MESL (2009) used the highest toxicity category for any of the three toxicity tests to represent the overall toxicity category for each station. The justification provided by MESL (2009) was that "*each of the three toxicity tests provides unique information on the toxicity of contaminated sediment to benthic invertebrates*" (p. 30, lines 20–21). However, the fact that each test does provide unique information indicates that they all three should be included in the development of the final sediment toxicity designations, to provide a more holistic assessment of sediment toxicity, and to be consistent with the SQO guidance. For example, the SQO states that "*each LOE produces specific information that, when integrated with the other LOEs, provides a more confident assessment of sediment quality*" (p. 4, lines 4–5). MESL (2009) states that use of the highest toxicity category for each station was a "*procedure for integrating the toxicity test results*" (p. 30, lines 19–20). However, the use of a single indicator is actually contrary to the concept of integrating the LOEs as used by most sediment quality practitioners, which would be to combine the information provided by independent LOEs in some manner. Instead of combining the information provided by the three toxicity tests evaluated at the Shipyards Site, MESL (2009) ignored the information provided by two of the three tests at each station, which is inconsistent with the SQO guidance.

MESL (2009) also stated that the *absence* of data on the toxicity of site sediments to benthic invertebrates in longer-term exposures increases uncertainty in the level of protection afforded benthic invertebrates (p. 30, lines 23–26). However, this concern is unwarranted because the benthic community evaluations conducted at the Shipyards Site provided a direct measure of long-term exposures, since most of the benthic macroinvertebrates at the Shipyard Site had spent most or all of their lives at the Site. In addition, the three toxicity tests conducted at the Site can be considered protective of benthic communities because two of the tests were the same ones identified in Tables 2 and 3 of the SQO guidance as being acceptable lethal and sublethal tests: the 10-day amphipod test and the 48-hour mussel test. As stated in the SQO guidance, the SQOs *"provide adequate protection for the most sensitive aquatic organisms"* (Resolution No. 12). The inclusion of a third sediment toxicity test that evaluated a reproductive endpoint at the Shipyards Site (i.e., the sea urchin fertilization test) went beyond the recommendations of the SQO guidance and increased the protectiveness of the suite of toxicity tests used at the Site. Therefore, there was no valid reason for MESL (2009) to default to the maximum toxicity level at each station, and ignore the information provided by the other two toxicity tests.

BENTHIC INVERTEBRATE COMMUNITIES

Lack of LOE Integration

Although MESL used three of the four indicators of benthic invertebrate community impairment identified in the SQO guidance (i.e., BRI, IBI, and RBI scores), the method of integrating the results provided by the guidance was not applied. The SQO guidance states that "*the median of all benthic index response categories shall determine the benthic LOE category*" (p. 6, lines 40–42). As for the sediment toxicity LOEs, MESL (2009) used only the maximum benthic index score to classify each station with respect to benthic effects. However, inspection of Table 2 of the May 2009 preliminary draft of the Shipyards Report prepared by MESL shows that the SQO guidance for integrating the benthic LOEs was followed (i.e., the final station designations were based on the median of the three benthic LOEs). The reason that this integration method was abandoned in the final report was not explained in MESL (2009), and is a cause for concern with respect to the validity of the methods used in MESL (2009), as this revision greatly expanded the areas of high risk.

MESL (2009) justified using only the maximum benthic index score to classify each station at the Shipyards Site using the same rationale as that used for the sediment toxicity tests (i.e., because each index provides unique information). That rationale is invalid for the same reason identified above for the sediment toxicity tests. That is, if each indicator does provide unique information, they all should be included in the development of the final benthic impairment designations, to provide a more holistic assessment of the status of the communities, and to be consistent with the SQO guidance. As with the sediment toxicity LOEs, the approach used by MESL (2009) for the benthic community LOEs effectively ignored the information provided by two of the three benthic LOEs at each station, which is inconsistent with the SQO guidance.

SUMMARY AND CONCLUSIONS

The remediation footprint identified for the Shipyards Site by MESL (2009) is invalid because it was developed solely on the basis of an ecological risk assessment for benthic macroinvertebrates and benthic fishes, and ignores the many other relevant considerations that need to be addressed in the development of such a footprint (e.g., as would be addressed in a feasibility study). Although MESL (2009) concluded that some of the polygons in the report represent areas that require remediation, MacDonald in his deposition contradicted that conclusion and stated that the final risk determinations in MESL (2009) did not identify areas that require remediation, and that a wide range of considerations need to be addressed before a remediation footprint can be identified. The results of MESL (2009) therefore identify areas of ecological risk that warrant further evaluation, and do not identify a remediation footprint.

The risk assessment methods used in MESL (2009) have many deficiencies. Although MESL (2009) stated that the methods were consistent with SQO guidance, there were numerous departures from that guidance that were not adequately justified, and were counter to the methods used by many sediment quality practitioners in California and throughout the U.S. The most critical deficiency in the methods used by MESL (2009) was the rejection of the SQO guidance and the recommendations of many regional and national sediment quality practitioners to use MLOE when evaluating risks to benthic macroinvertebrate communities. Instead, MESL (2009) used inappropriate methods, with which most of the sediment toxicity and benthic community LOEs were ignored, and the classifications of biological effects at individual stations defaulted to the maximum effect categories.

Additional deficiencies in the methods used by MESL (2009) included:

- Failure to use the CSI in conjunction with the Pmax index when evaluating whole-sediment chemistry, as recommended by the SQO guidance
- Failure to determine the site-specific predictive ability of the Pmax at the Shipyards Site, as recommended by many sediment quality practitioners, including MacDonald
- Failure to evaluate site-specific concentration-response relationships between the Pmax and the various biological LOEs at the Shipyards Site, as recommended by many sediment quality practitioners, including MacDonald
- Failure to consider the site-specific bioavailability of chemicals at the Shipyards Site, as recommended by many sediment quality practitioners, including MacDonald
- Failure to conduct statistical comparisons with the negative control results for the toxicity tests, as recommended by the SQO guidance
- Failure to use the mean toxicity designations of all three toxicity LOEs in determining the overall toxicity designation for each station, as recommended by the SQO guidance

- Failure to use the median benthic disturbance designations of all three benthic community LOEs in determining the overall benthic disturbance designation for each station, as recommended by the SQO guidance.

The deviations from the SQO guidance made by MESL (2009) render the results and conclusions of that report unreliable, and inconsistent with the consensus guidance provided by regional experts in sediment quality assessment. Many of these deviations are also inconsistent with the recommendations of many sediment quality practitioners throughout the U.S. The results and conclusions of MESL (2009) should therefore be rejected with respect to both the determination of areas of risk to benthic macroinvertebrate communities, and the identification of a remediation footprint.

STATEMENT OF QUALIFICATIONS FOR D. SCOTT BECKER

Dr. Becker holds a Ph.D. in Fisheries from the University of Washington School of Aquatic and Fishery Science, where his dissertation topic was predator–prey relationships between demersal fishes and benthic macroinvertebrate communities in contaminated portions of Puget Sound, Washington. He also holds an M.S. in Marine Environmental Science and a B.S. in Biology from the State University of New York. Dr. Becker is a Certified Fisheries Scientist of the American Fisheries Society. He has been working on sediment quality assessments throughout the U.S. for the past 30 years, including a number of sites in California. He is a co-developer of the Apparent Effects Threshold approach for establishing SQGs, and he used that approach to help the Washington State Department of Ecology develop the Sediment Management Standards for Washington State. Those promulgated standards have been used to drive sediment assessment and cleanup evaluations in the marine waters of the State for the past 15 years. When Dr. Becker was employed at Exponent in the early 2000s, he was part of the technical team that evaluated the San Diego Shipyards Site for BAE Systems and NASSCO, and he is co-author of the resulting Detailed Sediment Evaluation prepared by Exponent (2003). Dr. Becker also was selected by the scientific journal *Integrated Environmental Assessment and Management* to conduct a peer review of the publication by Bay and Weisberg (2011) that presents the scientific basis of the California SQO guidance, so he is intimately familiar with that guidance.

Dr. Becker's full curriculum vita is attached.

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PROFESSIONAL PROFILE

Dr. Scott Becker is an ecotoxicologist specializing in sediment quality evaluations, sediment toxicity testing, benthic ecology, fish ecology, and fish pathology. He has directed a wide variety of projects related to the ecological effects of toxic chemicals in freshwater, estuarine, and marine sediments throughout the United States. Dr. Becker has conducted numerous ecological risk assessments (ERAs) and natural resource damage assessments (NRDAs) to evaluate potential injuries to benthic macroinvertebrates, fishes, and aquatic-dependent wildlife at a variety of Superfund, RCRA, and other kinds of sediment sites. He is a co-developer of the apparent effects threshold (AET) approach for establishing sediment quality guidelines (SQGs), and he used that approach to help develop the sediment management standards for Washington State. Dr. Becker has used the most recent advances in sediment science to evaluate chemical toxicity at various sediment sites, including development of site-specific SQGs, use of the SQG quotient approach, use of toxicity identification evaluations (TIEs), and evaluation of metals bioavailability using acid volatile sulfide (AVS), simultaneously extracted metals (SEM), chemical speciation and electron microprobe analysis.

Dr. Becker has also evaluated the effects of sewage disposal, pulp mill effluents, and dredge-spoil dumping on sedimentary environments. He has authored a variety of journal publications and technical reports, and has chaired regional workshops to develop standardized environmental sampling protocols for Puget Sound. Dr. Becker has given technical presentations to numerous state and federal agencies, and he has participated in negotiations of remedial actions with multiple stakeholder groups. He has helped design remediation plans that included dredging, containment capping, thin layer placement, and monitored natural recovery (MNR). He has also helped design remedial plans that optimize habitat, including enhancements of macrophyte beds, soft-bottom benthic habitat, fish spawning and nursery areas, wetlands, and shoreline stabilization.

CREDENTIALS AND PROFESSIONAL HONORS

Ph.D., Fisheries, University of Washington, Seattle, Washington, 1984
M.S., Marine Environmental Science, State University of New York, Stony Brook, New York, 1978
B.S., Biology, State University of New York, Brockport, New York, 1973

Continuing Education and Training

Hazardous Waste Operations Management and Supervisor 8-hour Certification (2005)
Hazardous Waste Operations and Emergency Response 40-hour Certification (1984)
SCUBA Certification, Professional Association of Diving Instructors (1976)
New York State Teaching Certification, Secondary Science (1973)

Professional Affiliations

Society of Environmental Toxicology and Chemistry (SETAC)
American Fisheries Society (AFS)
American Institute of Fishery Research Biologists (AIFRB)
North American Benthological Society (NABS)

Relevant Experience

Ecological Risk Assessment

Upper Columbia River (UCR) Ecological Risk Assessment, Washington—Played a lead role in developing the RI/FS and ERA work plans to evaluate potential effects of metals on the UCR ecosystem. Made numerous stakeholder presentations on historical information and plans for future studies.

Onondaga Lake Baseline Ecological Risk Assessment, New York—Led ERA to determine the effects of metals (especially mercury) and organic compounds (i.e., polycyclic aromatic hydrocarbons [PAHs], polychlorinated biphenyls [PCBs], chlorinated benzenes) on phytoplankton, zooplankton, macrophytes, benthic macroinvertebrates, fishes, and aquatic-dependent wildlife in Onondaga Lake. Developed site-specific SQGs and used them in a quotient approach to identify sediments that warranted remediation.

Acid Brook Delta Ecological Evaluation, New Jersey—Directed an ERA on the effects of metals (especially mercury) on benthic macroinvertebrates, fishes and aquatic-dependent wildlife in Pompton Lake. Demonstrated that actual risks were less than those predicted using generic SQGs.

Ward Cove Sediment Investigation, Alaska—Led ERA on the effects of ammonia, sulfide, and 4-methylphenol on benthic macroinvertebrate communities near a pulp mill in Ward Cove. Used TIEs to demonstrate that sediment toxicity was the result of natural degradation products of organic matter and that thin layer placement, rather than containment capping, was an appropriate remedy.

Harris Lake Ecological Evaluation, Michigan—Managed ERA on the effects of metals on benthic macroinvertebrates, fishes, and aquatic-dependent wildlife in Harris Lake. Documented that remediation was warranted only in the littoral zone, because the profundal zone was adversely affected by hypoxia on an annual basis.

Ecological Risk Assessment, Texas—Directed an ERA on the effects of metals on benthic macroinvertebrates, fishes, and aquatic-dependent wildlife in a bayou system near Orange, Texas. Documented that metals were not bioavailable in most parts of study area and that remediation was warranted only near the discharge point.

Baseline Ecological Evaluation, New Jersey—Managed ERA on the effects of metals, PAHs, and PCBs on benthic macroinvertebrates in Gold Run. Documented that only a small portion of the site required additional assessment.

Evaluation of Effects of Mine Releases, Alaska—Served as technical lead for ERA on the effects of mine discharges on benthic macroinvertebrate communities in Gold Creek. Demonstrated that a previous fish kill was the result of stream drawdown by the City of Juneau rather than mine releases.

Natural Resource Damage Assessment

Injury Assessment for Freshwater Communities, New York—Led an NRDA to evaluate potential injuries to water, sediments, plankton, benthic macroinvertebrates, fishes, and aquatic-dependent wildlife in Onondaga Lake. Documented that the hypereutrophic conditions in the lake were more detrimental to most of the resident ecological communities than chemical releases.

Injury Assessment for Benthic Macroinvertebrates, New York—Directed an NRDA on the effects of PCBs on benthic macroinvertebrates in the Hudson River and prepared a critical evaluation of the sediment effect concentrations (SECs) for PCBs. Documented that adverse effects were not found at PCB concentrations that exceeded the SECs by a substantial margin.

Injury Assessment for Fishes, Montana—Served as technical lead for an NRDA on the effects of mining wastes on the trout fishery in the Clark Fork River. Documented that the services provided by the fishery were strongly limited by physical alterations of the river, rather than chemical releases.

Injury Assessment for Benthic Macroinvertebrates, Idaho—Directed an NRDA on the effects of metals and mine tailings on benthic macroinvertebrates in the Coeur d'Alene River. Documented that the physical effects of the mine tailings were more detrimental to the benthic communities than metals concentrations.

Injury Assessment for Benthic Macroinvertebrates, New York—Conducted NRDA evaluations on the effects of PCBs and PAHs on benthic macroinvertebrates in the St. Lawrence River. Conducted a detailed critical evaluation of the validity of the SECs for PCBs as part of this effort.

Injury Assessment for Marine Communities, California—Directed an NRDA on the effects of DDT and PCBs on benthic macroinvertebrates and demersal fishes offshore from Los Angeles for the National Oceanic and Atmospheric Administration (NOAA).

Other Kinds of Ecological Assessments

Evaluation of Chromium Bioavailability, New Jersey—Directed a focused field study to evaluate the toxicity and bioavailability of chromium associated with chromite ore processing residue using a concentration-response approach in the Hackensack River. Developed a site-specific no-effect level for chromium that was more than three times greater than the sediment criterion used by the State of New Jersey.

Onondaga Lake Feasibility Study—Developed a SQG quotient approach using site-specific SQGs to integrate the potential effects of 44 chemical of concern and delineate areas for sediment remediation and MNR in Onondaga Lake. The approach was calibrated using site-specific toxicity data and broke a long-term stalemate with the State of New York as to how to effectively address the large number of chemicals of concern identified at the site.

Commencement Bay Remedial Investigation/Feasibility Study, Tacoma, Washington—Directed studies of benthic macroinvertebrates and fish ecology/pathology for the Commencement Bay RI/FS; codeveloped the AET approach for developing SQGs, and helped to develop the sediment management standards for the Washington State Department of Ecology.

Puget Sound Estuary Program Technical Support (EPA Region 10), Washington—Directed studies of benthic macroinvertebrates and fish ecology/pathology for the Urban Bay Action Programs for Elliott Bay and Everett Harbor. Directed development of the Puget Sound protocols, conducted field evaluations of candidate sediment toxicity tests for use in Puget Sound, developed reference area performance standards for Puget Sound, evaluated effects of sediment storage time on sediment toxicity tests, and directed a study of PCB bioaccumulation in Puget Sound harbor seals.

Publications and Presentations

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