

## Response to DEC Comments on the DMTS Fugitive Dust Risk Assessment Work Plan

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The following responses are provided in response to DEC comments on the revised DeLong Mountain Regional Transportation System (DMTS) Fugitive Dust Risk Assessment Work Plan dated February 3, 2004. The DEC comments were provided in a letter dated April 16, 2004. Each DEC comment is shown in italics and numbered as provided in the comment document. Responses are provided beneath each comment in regular type.

### Human Health Risk Assessment (Comments HH-1 to HH-33)

#### Comment HH-1

*Several changes to the screening method have been recommended. Since it is not known exactly what impact this will have on the Risk Assessment, the CSMs were not reviewed in detail. Any necessary changes that result from screening changes should be made to the CSMs.*

**Response:** Any modifications to the CSM necessitated by changes in the screening methodology will be reflected in the risk assessment report.

#### Comment HH-2

*Section 2.[1.]2 clarifies some of the DEC's earlier questions regarding past spills. However, Section 2.[1.]2 infers that Teck Cominco has reviewed the DEC spill report (from spills records since 1995) and Table 2-2 lists only those spills which occurred on the DMTS. DEC suggests that Section 2.[1.]2 be further clarified that the spills identified in the DEC spill report (thus Table 2-2) occurred within the DMTS and the port area that is subject to this risk assessment, i.e., not the mine area.*

*Section 2.1.2 refers the reader to Appendix A regarding sampling in the Tank 2 spill area. Review of Appendix A refers the reader to Table A-1 to determine what compounds were sampled; however, there is no referral to the actual laboratory sample data. Please address this issue and appropriately reference Figure A-5 and Table D-1.*

*During discussions with Exponent on February 24, 2004, Exponent indicated that the area where the spills occurred in the port area is now covered by asphalt. DEC suggests that you may wish to incorporate these activities into Section 2.1.2 and resultant impact to exposure to any remaining contamination.*

*See Comment #12 also below.*

**Response:** Further clarification will be added to Section 2.1.2 regarding the spills identified being those in the DMTS road and port areas subject to the risk assessment, but not including those within the mine, which is not part of the risk assessment.

Regarding sample data for the Tank 2 spill area, call-outs will be added to Section 2.1.2 and Appendix A for Figure A-5 and Tables D-1 through D-3. Additional detail regarding the Tank 2 spill area will be added to Section 2.1.2 as discussed below in the response to Comment HH-11.

In addition, further discussion will be added to Section 2.1.2 describing the pavement of the truck fill station area where spills have occurred historically, and stating that the pavement provides a barrier preventing exposure to any residual petroleum hydrocarbons. The concrete-paved area is associated with the spill containment system at the truck fill station. Because the integrity of the concrete pavement is necessary for containment, it will be maintained on an ongoing basis by Teck Cominco as part of their spill prevention program.

A figure will be provided to illustrate the truck fill area with its paved containment and the location of the former Tank 2 spill area.

### **Comment HH-3**

*Trustees for Alaska have previously made the comment that paving the road will not reduce fugitive dust originating from the beds of trucks.*

**Response:** Section 2.2.4 of the work plan states that paving was done in an effort to “minimize transport mechanisms from the DMTS road surface” and “may help to reduce the amount of mud picked up by the trucks, and ... reduce the tracking of metals-containing material along the road.” The work plan does not state that road paving will reduce fugitive dust originating from the beds of trucks. Teck Cominco has ongoing efforts to make operational improvements.

### **Comment HH-4**

*[Re: Section 2.3.1.2, Page 2-8]: Please give explanation why future residential development of land is not expected. Land ownership is an important factor in determining future land use as are existence of zoning restrictions. What is in place to prevent residential development in the future?*

**Response:** Additional land ownership and use discussion is provided in Section 2.3.1.1. The DMTS road and port facilities are state-owned regional industrial-use facilities, and are likely to remain so for the foreseeable future. The easement for the road was provided by the federal government, and the agreement is for 100 years. Mining at Red Dog is likely to continue approximately another 25 years based solely on current reserve deposit life. However, there are additional deposits that may be viable and continued mining is likely. There are currently no zoning restrictions on land use, and considering the likely continued use as an industrial facility, they are not likely to be necessary. However, zoning restrictions could be considered for certain areas if needed to protect future land users.

**Comment HH-5**

*Given that a portion of the site is north of 68° and the site seems to be underlain with continuous permafrost it is acceptable to treat the entire area as an arctic zone site and not evaluate groundwater.*

**Response:** Comment noted.

**Comment HH-6a**

*Exposure to metals in dust can occur through the ingestion and inhalation exposure routes. As mentioned in the work plan, ingestion of soil accounts for ingesting dust through hand-to-mouth activities as well as inhaling particles that are subsequently swallowed. Quantitative assessment of this pathway should be based on particle size. Based on the Draft Fugitive Dust Background Document (2002), 80% of the zinc concentrate is smaller than 23 microns and 80% of the lead concentrate is smaller than 20 microns. This pathway has been identified as a community concern (see Fugitive Dust Risk Assessment Work Plan comment #19.) Please clarify what portion of the ore can be reasonably be expected to be smaller than 1 micron.*

**Response:** As noted in Section 2.3.3.1 on page 2-13 of the work plan, “Particle size analysis of soil from the DMTS indicates that 98 percent of soil particles are larger than 1 micron in diameter. Thus, the majority of inhaled dust and soil at the DMTS would be expected to be ingested.” Approximately 80 percent of soil particles were larger than 10  $\mu\text{m}$ . These soil samples were taken along the length of the road from fine material at the toe of the road shoulder (Exponent 2002).

**Comment HH-6b**

*As methyl mercury is volatile, the inhalation pathway should be evaluated if this compound is present at the site. Please clarify which form of mercury is present.*

**Response:** Elemental mercury is the form of mercury that is volatile. Methyl mercury is not volatile in the environment. The form of mercury in site soils is inorganic mercury, which is also not volatile in the environment.

**Comment HH-7**

*In the discussion regarding DEC’s cleanup levels (top of page) please note the two exceptions for which DEC does have inhalation clean up levels, lead and mercury.*

**Response:** The soil inhalation cleanup level for mercury appears to be for elemental mercury, which is not present at the site. The chemical-specific parameters provided in Appendix C, Table 1, of the Clean Levels Guidance correspond to elemental mercury. Although those parameters were presumably used in Equation 7 of that guidance to calculate the mercury inhalation cleanup levels published in Table B1 of 18AAC75, we are unable to reproduce DEC’s mercury cleanup levels using those parameters. The form of mercury that would be in site soils is inorganic mercury, which is not volatile and does not have a reference concentration (RfC) for inhalation exposure, and thus does not have an inhalation cleanup level.

The lead cleanup level listed under the inhalation column is the default residential cleanup level for lead derived using EPA's IEUBK lead model and is not, strictly speaking, based on inhalation. Rather it is based on multipathway exposure and is primarily driven by soil ingestion, including the dust that is inhaled and subsequently ingested.

### Comment HH-8

*Please assure that dermal exposure is discussed in the uncertainty analysis of the Risk Assessment. Methyl mercury can easily be absorbed through the skin and dermal exposure should be evaluated if this compound is present at the site. Please provide information on the species of mercury present at the site to determine if dermal exposure to mercury should be investigated.*

**Response:** Currently, U.S. EPA (2002) only provides dermal absorption fractions for two metals, arsenic and cadmium, and recommends that other inorganics be treated qualitatively in the uncertainty section. Dermal exposure will be discussed in the uncertainty section of the risk assessment report.

### Comment HH-9

*The method for developing SQS does not guarantee that they are protective of human consumption of fish.*

**Response:** There are, unfortunately, no sediment screening criteria available that are specifically derived to be protective of human health. However, criteria that are conservatively protective of aquatic life are likely to also be protective of human health.

Sediment samples are being collected from the shiploader area and analyzed for CoPCs as part of the Phase II field sampling and analysis program for the DMTS risk assessment. These data will be used to assess current conditions and temporal trends in CoPC concentrations. The data will be screened using the more conservative ERLs rather than the SQS, as requested by DEC. Extra sediment volume will be collected during the sampling and archived for possible use in sediment toxicity testing, pending review of analytical results for the sediment samples. Further details on the sediment sampling and on the criteria under which toxicity testing would be conducted are provided in the revised field sampling plan (Exponent 2004).

As discussed in the comment resolution conference call of May 13, 2004, a decision on whether and how to evaluate the marine environment for potential impacts on human health is pending the results of 2004 sampling program. If toxicity testing is performed (per the criteria described in the revised field sampling plan), and the results indicate toxicity from marine sediment is present in the port area, then further review will be made to determine whether modeling of risk from consumption of marine subsistence food resources may be needed.

### Comment HH-10

*Of the initial list of compound used for COPC screening, bismuth, calcium, chloride, gallium, germanium, gold, silicon, sulfate, and sulfur are initially screened out because of reasons listed in Section 3.1. The reasons listed are that the compounds are not listed in DEC's tables, there*

*are no relevant human health or ecological toxicity criteria, and data has not been collected for most of these constituents. Screening out compounds for these reasons are not appropriate based on the DEC RAPM and EPA's Risk Assessment Guidelines for Superfund (RAGS), Part A.*

*The DEC RAPM indicates that compounds without risk-based benchmarks are retained for a more detailed evaluation in the remainder of the risk assessment process. These compounds should be evaluated qualitatively (briefly address toxic potential), and discussed in the uncertainty section.*

**Response:** Per agreement with DEC, further discussion of these compounds will be provided in the CoPC selection section of the risk assessment report. However, the ability to discuss their toxic potential is limited by the lack of information available. In most cases, it is this lack of information, along with their perceived lack of significant toxicity, that is responsible for EPA abstaining from conducting hazard assessments on these compounds.

*In 2003 comments on the work plan, information was requested regarding the pH levels in environmental media in order to evaluate whether sulfur might be present as sulfide. Please see comment in eco portion (Comment Eco-2)*

**Response:** As agreed upon in discussions with DEC, pH will be measured on tundra soil samples and at all surface water bodies where sampling will occur in the 2004 field season. Recognizing that pH will likely vary naturally in different tundra environments, pH will also be measured at reference area stations to provide data for further comparison and evaluation. Additional detail on sampling locations is provided in the field sampling plan.

## **Comment HH-11**

*Please expand on petroleum contamination and/or spills in regards to the paved area.*

*The Tank #2 spill is the largest petroleum spill listed in Table 2-2. The residual range organics (RRO) concentrations in this area are above the Arctic Zone cleanup levels listed in Table B2. Diesel range organics (DRO) are above one-tenth the Arctic Zone cleanup levels. According to the DEC RAPM Section 4.2.3 these compounds should be retained as COPCs. Additional information on previous controls (i.e. paving) that reduces exposure to these compounds is needed to evaluate if RRO and DRO should be retained as COPCs. (see also Comment #2)*

**Response:** Regarding the paved area, please refer to the response to Comment HH-2. Regarding the tundra soil samples in the Tank 2 spill area, these samples were collected from a localized tundra area adjacent to the Tank 2 containment. Samples were collected at three depth intervals, the first of which is the first 0 to 2 cm beneath the live vegetation mat. The second was collected between 2 cm and the bottom of the organic tundra soils, and the third was collected from inorganic substrate soils below the organic tundra soils (if present), or from just above the permafrost. Samples were collected from similar depth intervals in a reference area away from any anthropogenic activity. Although there were some samples in the Tank 2 area with RRO and DRO concentrations elevated above one-tenth Arctic Zone cleanup levels, there are several reasons why this does not warrant retaining DRO and RRO as CoPCs: 1) The former Tank 2 spill area is very localized; it is not a large area. 2) It is important to recognize

that a significant portion of the DRO and RRO concentrations are the result of naturally-occurring organic matter. This is illustrated by the results for the reference samples. All three of the RRO and two of the three DRO results in the reference samples are above one-tenth of the Arctic Zone cleanup levels. 3) The depth intervals in which the elevated values occur are the deeper sample intervals, not the shallow samples. Therefore, there is not a complete exposure pathway for humans or animals that might cross this tundra area. 4) Degradation will continue to reduce residual hydrocarbon concentrations in this area. 5) No activities are planned in this area. However, in the event that any development were to occur in this tundra area, such development would involve placement of additional fill, rather than excavation. Engineering requirements dictate that facilities in this region are constructed on fill above the permafrost. Any utilities would be either within the gravel fill or above grade, because of the presence of permafrost.

Beneath the containment area around the tank, any residual hydrocarbons that may remain after historical excavation and treatment activities are at least several feet below the current grade, under clean gravel.

### **Comment HH-12**

*It would be helpful for the reviewer if a more detailed rationale of why particular studies listed in Table 3-2 were not included as part of the risk assessment. It would be appropriate to include this discussion in the risk assessment. The data usability criteria in Section 3.2.2 appear appropriate.*

*A table of what data would be used in the risk assessment as well as how that data will be incorporated would be helpful for the reader.*

**Response:** Additional discussion and clarification will be added to the risk assessment report.

### **Comment HH-13**

*Data Quality Review – Please explain why data sets were not validated and if unvalidated data in the data set was used for screening.*

**Response:** Teck Cominco has regularly sampled stream water during the period each year when the streams are running. Although these stream water data were available for use in the risk assessment, they did not include all of the analytes needed for the CoPC screening. During the Phase I risk assessment sampling program in 2003, results were obtained for all of the desired analytes in one sampling event, and most of the analytes in a second event. These stream data sets with the most complete analyte lists needed for screening were the ones validated. Rather than excluding the other stream data sets collected in 2003 that had the more limited analyte lists (mainly lead, zinc, and cadmium), these were included in the screening without validation. These data were consistent with the validated data sets. One other small data set that was included in the screening without validation was the USGS 2002 stream water sampling results. Insufficient information was available to validate this data set.

The other data set that was included in the screening without validation was the Teck Cominco 2003 data set, which included soil and tundra soil around the port site. This data set provided

more detailed coverage in areas where we already had validated data sets, and showed results consistent with the known conditions in these areas. Rather than excluding this additional data set, it was included in the screening without validation.

#### **Comment HH-14**

*Based on the information provided in Appendix A regarding reference sample locations and the reference sample concentrations listed in Appendix C, the reference locations appear to be chosen appropriately.*

**Response:** The comment is noted.

#### **Comment HH-15**

*It seems the second paragraph in this section [3.2.4.2] should have a separate heading as it is about Site Stream Surface Water.*

**Response:** A separate heading will be added in the risk assessment report for this paragraph, as suggested in the comment.

#### **Comment HH-16a**

*Background or reference concentrations were not determined in the manner recommended by the ADEC (2003) Determining Background Concentrations in Soil.*

*The results of the statistical comparisons between site and reference area data sets are not presented. The reader cannot review the results of the ANOVA and Wilcoxon tests. There is no presentation of cases when the parametric and nonparametric did not agree, and therefore, the reader does not know how the more "reliable" method was selected.*

*It is requested that given the low number of samples for some tests and the high degree of variability that you select 0.1 as the p value to determine significant difference.*

*It should be noted at this point that future comments about dividing the site into operable units might render this method of determining background impracticable. Another method may have to be selected.*

**Response:** Revised statistical and screening tables have been provided to DEC and will be included in the risk assessment report. As requested, a p-value of 0.1 is now used as a cutoff to determine statistical significance of differences between site and reference data. The p-values are provided on the tables so that the reader can see how the results of the parametric and non-parametric tests agreed or disagreed. Footnote modifications and additions were made to clarify the tables. A copy of the revised statistical comparison and human health screening tables is included as Attachment A. The revised tables were originally submitted to DEC on April 26, 2004.

## Comment HH-16b

*In addition, some chemicals were eliminated as COPCs if there were no screening criteria available for the specific media, even if the compound was retained as a COPC in another media. For instance, lead was eliminated as a COPC in surface and lagoon water (Table 3-16 and 3-17) because no screening criteria were available for that media. According to DEC's RAPM, if no criteria are available the compound should be retained as a COPC for more detailed evaluation. In the example with lead, lead is assumed to be a site contaminant and therefore should be retained as a COPC.*

*Chemicals that were infrequently detected above the screening level or had no screening criteria should be retained as COPCs. Qualitative assessment of the compounds and discussion in the uncertainty section may be appropriate.*

**Response:** The CoPC screening has been modified based on DEC's recommendations. Infrequency of screening criteria exceedance is no longer used to screen out CoPCs. In addition, as noted in response to HH-16a, a p-value of 0.1 is now used to test statistical significance of differences between site and reference concentrations. The modifications resulted in lead and thallium being retained as CoPCs in the freshwater environment. All other CoPCs in the terrestrial environment were screened out of the freshwater environment because they were below screening levels and/or consistent with reference concentrations. None of the three chemicals (fluoride, molybdenum, and tin) screened out of the freshwater environment because they lacked fish consumption screening criteria were CoPCs in the terrestrial environment, nor were they freshwater CoPCs for protection of drinking water. Based on those two points and the relative lack of toxicity of fluoride, molybdenum, and tin, there is no reason to further evaluate these three compounds. The site lagoons do not provide potable water for human consumption, nor do they serve as a resource of fish for human consumption. Therefore, lagoon water was not included in the human health screening.

A copy of the revised statistical comparison and human health screening tables is included as Attachment A. The revised tables were originally submitted to DEC on April 26, 2004.

## Comment HH-17

*Combining sample data for the road and port to calculate both site concentrations for comparison to reference levels and the exposure point concentrations (EPC) can have the effect of "smoothing" the site data. The highest contaminant levels are found at the port site. Concentrations along the road are considerably lower than concentration at the port site (area highlighted in inset of maps) as depicted in Figures 3-6 through 3-11. The site average (or 95 UCL) will be biased low by combining both the road and port data when exposure is assessed at the port.*

*For human health, it is more appropriate to divide the site into operable units, as recommended by DEC on June 9, 2003, or calculate EPCs based on exposure areas. Addressing the site in this way may also assist with any risk management decisions that may be warranted following assessment. Exposure of one receptor to multiple exposure areas will need to be considered if this method is used.*



**Response:** At typical Superfund sites it is sometimes beneficial to separate the site into operable units (OUs) if exposure patterns are distinct between different areas, and/or there are different receptors being exposed in the different areas. In the case of the DMTS, it is much more appropriate to view the site as a whole because a person's exposure during subsistence activities would be integrated over the whole site. In fact, treating the site as one unit is more conservative because in reality much less subsistence activity would occur where concentrations are highest (i.e., at the port site), even after taking into account the relative size of the areas. The relative exposure to different metals concentrations in different areas can be addressed by calculating area-weighted exposure concentrations. In this way, exposure concentrations can more realistically integrate the relative amounts of time of exposure to different concentrations without artificially dividing the site. As DEC points out, if the site were split into OUs then "exposure of one receptor to multiple exposure areas will need to be considered." This is a more complicated methodology and does not fit the actual exposure patterns at the site.

Although evaluating the site as a complete unit will assist in overall risk management decisions, it does not exclude the possibility of addressing smaller areas during the risk management process. For example, if one aspect of risk management were to identify specific areas for cleanup to agreed upon cleanup levels, those cleanup levels would be calculated independent of actual site concentrations.

### **Comment HH-18**

*Three potential operable units include the port facility as the area west of the NANA land and NANA easement border (see Figure 1-5), the DMTS near mine area as the area east of the state land and NANA land boundary to the solid waste permit boundary, and the DMTS road as the area in-between. These three areas have distinct exposure and contaminant distributions.*

**Response:** Please see response to comment HH-17.

### **Comment HH-19**

*Eliminating compounds that were infrequently detected and that were infrequently in excess of screening levels are not appropriate screening methodologies for compounds that are associated with site activities (i.e. in the ore or part of the ore processing).*

**Response:** All of the compounds in the ore concentrate are metals that are present naturally in the environment and so are also associated with background conditions. Thus, a metal being present in the concentrate does not necessarily imply that it is associated with site activities. While screening out metals based on infrequent exceedance of screening levels is not standard in Superfund risk assessment, it is consistent with the aim of in Section 5.9.5 of EPA's *Risk Assessment Guidance for Superfund* (U.S. EPA 1989). "The objective of this screening procedure is to identify the chemicals in a particular medium that...are most likely to contribute significantly to risks...so that the risk assessment is focused on the 'most significant' chemicals." Nevertheless, at DEC's direction, this screening procedure will not be used.

Use of detection frequency to eliminate CoPCs is consistent with Section 5.9.3 of EPA's *Risk Assessment Guidance for Superfund* (U.S. EPA 1989) and, although its use is at the discretion of the project manager, it is commonly used in Superfund assessments. Regardless, only those

metals that were not detected in any sample were screened out of a medium on the basis of detection frequency. Section 5.3.5 of RAGS states that the screening can “eliminate those chemicals that have not been detected in any samples of a particular medium.” Accordingly, the footnote indicating that a chemical was eliminated on this basis has been changed to ND (not detected in any site sample) in Tables 3-15 through 3-18 of the risk assessment work plan. A copy of the revised tables is included as Attachment A. The revised tables were originally submitted to DEC on April 26, 2004.

### **Comment HH-20**

*Screening values used for lagoon water, marine surface water and marine sediment may not be appropriate. The plan uses Washington state sediment screening values instead of NOAAs, as well as WA water screening values, and some EPA AWQC values. Please explain why Alaska water quality values were not used. Screening values for fish consumption are unlikely to represent subsistence users in Northwest Alaska.*

**Response:** The sediment screening has been modified to rely on NOAA benchmarks. The surface water screening (fresh, marine, and lagoon) has been modified to use screening criteria specific to Alaska (DEC 2003) where available, and to Washington State criteria where there are no Alaska criteria. Use of the Alaska screening criteria does not modify the results of the screening.

### **Comment HH-21**

*The RAPM requires that the work plan include toxicity criteria. These were requested in the comments on the work plan provided in June 2003.*

**Response:** The toxicity criteria to be used in the risk assessment were identified in Section 4.3 of the work plan for each of the four CoPCs identified. Toxicity criteria for CoPCs added as a result of DEC-required screening modifications will be taken directly from EPA’s IRIS database and will be identified in the risk assessment report.

### **Comment HH-22**

*The student’s t-statistic UCL equation is incorrectly written. The standard deviation should not be within the parentheses with the t-value.*

**Response:** The equation is correct as written in the work plan. It would be mathematically equivalent if the standard deviation were outside the parentheses, as suggested in DEC’s comment.

### **Comment HH-23**

*Although this section [4.2.1] generally describes how exposure point concentrations will be calculated (the 95%UCL of the mean for most CoPCs, the arithmetic mean for lead), it does not provide any specific information about the site data that will be used in the calculations. Presumably, the exposure point concentrations for each exposure medium will be calculated from the concentrations measured in the medium. As mentioned above, use of one combined*

*data set could substantially underestimate potential exposures of individuals whose activities routinely occurred in more highly contaminated areas near the mine site or the port area. (See Comment #19.).*

**Response:** Additional maps and tables were provided to DEC to clarify the datasets and sample locations that will be used in the risk assessment. As discussed in response to Comment HH-17, much less subsistence activity would occur where concentrations are highest (i.e., at the port site), even after taking into account the relative size of the areas. Also, the relative exposure to different metals concentrations in different areas can be addressed by calculating area-weighted exposure concentrations. In this way, exposure concentrations can more realistically integrate the relative amounts of time of exposure to different concentrations without artificially dividing the site. Furthermore, the overall soil dataset is conservatively biased high by over-sampling in areas of known impact.

### **Comment HH-24**

*It is not clear how contamination levels will be determined in subsistence foods, please explain.*

**Response:** As agreed upon with DEC, the existing berry, sourdock, caribou, and fish metals concentrations datasets identified in the work plan will be used in the risk assessment. Metals for which there are no data in these biota (i.e., barium, antimony, and thallium) will be estimated when necessary using the known ratios of these chemicals to lead, zinc, and cadmium in soil to predict the biota concentrations. All CoPCs will be analyzed in ptarmigan as part of the 2004 field sampling plan.

### **Comment HH-25**

*The proposed alternative lead absorption values are acceptable as a basis for comparison to default. However please include a short discussion of the uncertainty associated with the use of the referenced lead bioavailability study to estimate absorption values.*

**Response:** A short discussion of uncertainties will be provided in the risk assessment report.

### **Comment HH-26**

*Second paragraph, last sentence [Section 4.2.2.1]. The phrase “95 percent UCL of the maximum detected concentration” should be just “the maximum detected concentration”.*

**Response:** The text will be modified as requested in the risk assessment report.

### **Comment HH-27**

*Under the intake equation, incorrect input values are listed for AT for children. It should be 6 years (2190 days)*

*For the subsistence scenario, an IR of 100 mg/day for adult (the residential value) would be more appropriate.*

**Response:** The text citing the incorrect averaging time for children will be modified in the risk assessment report as recommended by DEC.

On page 4-21 of *Exposure Factors Handbook*, U.S. EPA (1997) recommends 50 mg/day as “a reasonable central estimate of adult soil ingestion.” U.S. EPA (1997) acknowledges the uncertainties in the adult soil ingestion database and further states that “...a recommendation for an upper percentile value would be inappropriate.” Furthermore, the degree of soil ingestion that would occur during subsistence hunting and gathering should not be equated with residential soil ingestion. A residential exposure parameter assumes daily, long-term exposure of the type that would not occur during hunting and gathering activities, where exposed soil is minimal. Exposures during hunting and gathering activities would more properly be equated with occupational exposures. However, at the request of DEC, an adult soil ingestion rate of 100 mg/day will be used for the subsistence scenario.

For the combined worker/subsistence scenario, the soil ingestion rate will integrate a rate of 100 mg/day for one-third of the time (i.e., the amount of time a worker is offsite, at home) and a rate of 50 mg/day for two-thirds of the time (i.e., the amount of time a worker is onsite).

### Comment HH-28

*It is not completely clear how the FI factor is going to be used for the worker scenario and what the different values in the equation represent. However 50mg/day is the ADEC default value for worker ingestion intended to suit the typical working day. Multiplying this rate by 2/3 is inappropriate, unless the work week at Red Dog is unusually different from the standard, as it already takes into account that an individual spends only a fraction of their time at work. The soil ingestion that occurs during subsistence activity is in addition to the 50 mg/day.*

**Response:** Individuals work only 2 out of every 3 weeks at Red Dog (i.e., 2 weeks on, 1 week off). Thus, it is appropriate to multiply the soil ingestion rate of 50 mg/day by two-thirds to determine the portion of a worker’s soil ingestion that occurs during the 2 weeks on. The soil ingestion that occurs during subsistence activity would occur during the 1 out of 3 weeks that a person is off work. As discussed in response HH-27, a soil ingestion rate of 100 mg/day will be used for the one-third of the time that a worker is off shift. So for the worker, the total soil ingestion equals the amount of soil ingested at work 2 of every 3 weeks *plus* the soil ingested during subsistence activities the other 1 out of 3 weeks.

### Comment HH-29

*Please clarify equation at the top of the page [4-11]. It appears that the diet portion of the formula does not include a food consumption rate.  $IR_s$  is denoted as the food consumption rate, but is used as the soil consumption rate.*

**Response:** Although the equation is correct, the first parameter in the list directly below the equation should be  $IR_f$ , which is then correctly identified as the “food item consumption rate.” The risk assessment report text will reflect this correction.

### Comment HH-30

*It appears the first full paragraph on this page [4-17] is written to clarify that some toxic effects from cadmium seem to be correlated with specific routes of exposure. However, this paragraph could be misinterpreted as a marginalization of community concern about cadmium exposure from fugitive dust. Since no biomarkers of exposure are being used in this risk assessment, other sources of cadmium exposure are not relevant. Please summarize the main point of this paragraph and eliminate all unnecessary text regarding cigarette smoke.*

**Response:** This paragraph will be revised in the risk assessment report as requested by DEC.

### Comment HH-31

*[Re: Tables 3-5 through 3-13]: Statistical methods used to compare site concentrations and reference concentrations are of concern, especially when there is a small sample size or high variability. In some of cases the site concentration is determined to be less than or equal to the reference concentration even though there is a high maximum and mean site concentration in comparison to reference. In some cases lead, cadmium, and zinc have been attributed to background because of this in sediment and surface water samples.*

*For instance, the maximum and mean site concentration for lead in pond sediment is 1,810 mg/kg and 484 mg/kg, respectively. The reference maximum and mean concentrations are 20.3 mg/kg and 11.6 mg/kg. Because of the high variability and/or small sample size lead is considered to be attributable to background.*

**Response:** This comment is similar to eco-risk Comment Eco-4. As explained in the response to Eco-4, the statistical comparisons have been revised based on DEC comments (e.g., HH-16, Eco-4, Eco-5). In the revised statistical comparison tables (see Attachment A), comparisons are not made in cases where there are high frequencies of undetected results, or in cases where the confidence interval for the site mean straddles zero as a result of small sample size or high variability. This situation applies for lead in tundra pond sediment, which is identified as an example in this comment. Tables 3-4 through 3-13 have been revised to show the new results based on this re-evaluation, and a copy of these tables is included as Attachment A. The revised tables were originally submitted to DEC on April 26, 2004.

### Comment HH-32

*Please indicate why EPA's AWQC have been used as screening criteria rather than Alaska's water quality criteria (18 AAC 70). In many instances Alaska's water quality criteria are equal to EPA's AWQC. When comparing EPA's AWQC and Alaska's water quality criteria it does not appear that using Alaska's criteria would affect which compounds were retained as COPCs, but this should be reviewed.*

*Please note the consumption of fish near this site exceeds the consumption level used by EPA to calculate the AWQC levels.*

**Response:** The surface water screening (fresh, marine, and lagoon) has been modified to use screening criteria specific to Alaska (DEC 2003) where available, and to Washington State

where there are no Alaska criteria. The results of the screening are not altered by use of the Alaska criteria, or by using site-specific consumption rates.

### **Comment HH-33**

*It does not appear that the screening toxicity values were adjusted to a HQ=0.1 as indicated in the footnote. The values in the Tables 3-17 and 3-18 have been adjusted but not in Table 3-16. Antimony would screen in as a COPC if the adjusted screening level were used.*

**Response:** The modified Table 3-16 includes Alaska-specific screening values adjusted to an HQ=0.1. A copy of the modified table is attached (see Attachment A). Revised screening tables were originally submitted to DEC on April 26, 2004.

## **Ecological Risk Assessment (Comments ECO-1 to ECO-24)**

### **Comment Eco-1**

*The issues described in the specific comments should be addressed in all areas of the report where they occur, not only where they are called out in the comments that follow. Typically, the specific comments identify the first occurrence of a problem or the section where it is discussed at length.*

*The draft report should be revised and reissued consistent with the specific comments below so ADEC and other stakeholders can verify that the deficiencies have been addressed.*

**Response:** Comment noted. Identified issues will be addressed at all relevant occurrences in the work plan. As agreed in our teleconference discussion of April 21, 2004 with DEC, the work plan will not be reissued. However, the agreed-upon changes will be documented in these comment responses, as well as in the response to comments on the field sampling plan (submitted to DEC on June 1, 2004), and changes will also be reflected in the draft risk assessment report when that is submitted.

### **Comment Eco-2**

*Sulfur was inappropriately eliminated as a chemical of potential concern (COPC). Section 1.1 (Site Overview) indicates that the Red Dog deposit is a zinc and lead sulfide ore body. As shown in Table 2-1, total sulfur is a significant component of the ore concentrates. Because only a small fraction of total sulfur in the ore concentrates is sulfate (see Table 2-1), one must assume that sulfide is the primary form of sulfur in the concentrates. Sulfide minerals can be oxidized when exposed to air and water to yield sulfuric acid. Sulfur should not be eliminated as a COPC until it is shown that habitats that received inputs of ore dust do not exhibit depressed pH compared with background. Depressed pH can adversely affect many types of ecological receptors.*

*Has pH been measured in any of the surface water bodies (e.g. creeks, tundra ponds, lagoons) that were sampled thus far? If so, the data should be made available to DEC. If not, pH measurements should be made during the 2004 field season.*

**Response:** As agreed upon in discussions with DEC, pH will be measured on tundra soil samples and at all surface water bodies where sampling will occur in the 2004 field season. Recognizing that pH will likely vary naturally in different tundra environments, pH will also be measured at reference area stations to provide data for further comparison and evaluation. Additional detail on sampling locations is provided in the field sampling plan.

### Comment Eco-3

*It is unclear from this section where the reference inorganic soil samples were collected. Were they collected from the terrestrial reference area or somewhere else?*

**Response:** Reference inorganic soils were collected from borrow-material sites that were used to provide material for road construction, and which are currently being used for ongoing road repair and maintenance. The material sites being used are MS-2, -3, -5, -6, and -9, and their locations are illustrated in Figure A-4 of the risk assessment work plan.

### Comment Eco-4

*We recommend that the "site" be divided into three operable units for the eco risk assessment when making comparisons to background, as follows: (1) port site versus background, (2) DMTS road versus background, and (3) DMTS road near mine versus background. In general, the level of contamination in sediment, soil, and water is much greater near the port than along the DMTS road (except near the mine). The smoothing effect has been discussed in the comments on the HHRA.*

*For example, Table 3-8 indicates that lead is not elevated in tundra pond sediment compared with background. However, a review of the data in Tables C-9 and C-10 shows that lead in tundra pond sediment near the port (average= 1805 mg/kg) is 100 times greater than background (average = 11.6 mg/kg). To correctly identify contamination above background, it will be necessary to separate the site into operable units. If doing so results in too few samples to conduct statistical testing, then a non-statistical method should be used to judge whether contamination is present above background (see ADEC 2003), or additional samples should be collected in the 2004 field season.*

**Response:** As agreed upon in discussions with DEC, the site will not be divided into operable units for the ecological screening assessment. Reasons included the fact that receptors with large home ranges would be exposed across the area as a whole, and for those with small home ranges, point estimates of risk may be made.

Note that the statistical comparisons have been revised based on DEC comment Eco-5 (see below). In the revised statistical comparison tables, comparisons are not made in cases where there are high frequencies of undetected results, or in cases where the confidence interval for the site mean straddles zero as a result of small sample size or high variability. This situation applies for lead in tundra pond sediment, which is identified as an example in this comment. Tables 3-4 through 3-13 have been revised to show the new results based on this re-evaluation, and a copy of these tables is included as Attachment A. The revised tables were originally submitted to DEC on April 26, 2004.

## Comment Eco-5

*The p value for each site-to-reference comparison should be provided in the tables. Alpha = 0.1 should be used as a cutoff for statistical significance.*

*The tables should indicate which comparisons are based on Wilcoxon's test (a nonparametric procedure) and which are based on parametric statistical procedures.*

**Response:** Tables 3-4 through 3-13 have been revised to show the *p*-values and to indicate which comparisons are based on parametric or nonparametric comparisons. An alpha value of 0.1 is used as the significance level for identifying site concentrations that are greater than reference concentrations. A copy of the revised tables is included as Attachment A. The revised tables were originally submitted to DEC on April 26, 2004.

## Comment Eco-6

*For lead, this table indicates that 4 of 5 site samples exceeded the freshwater Criteria Continuous Concentration (CCC) of 3.2 ug/L. However, the lead concentration in all five samples was less than 3.2 ug/L. This apparent discrepancy appears to be related to the low hardness of the pond samples and the fact that the hardness-adjusted lead criterion was much less than 3.2 ug/L. Table 3-23 should list a range for those criteria that are hardness dependent (Cd, Cu, Pb, Ni, Ag, Zn) instead of a single value based on a hardness of 100 mg/L as calcium carbonate.*

**Response:** All concentrations of hardness-dependent metals were adjusted using sample-specific hardness values prior to comparison against criteria. Ranges of hardness-dependent criteria that were used in these screening comparisons will be identified in revised screening summary tables that will be included in the baseline ecological risk assessment report.

## Comment Eco-7

*The screening-level assessment for the snipe and plover used a biota-sediment accumulation factor (BSAF) of unity for all metals. This is not adequately conservative for all metals. Instead, the recommendation from Bechtel Jacobs (1998) should be used to estimate concentrations of metals in aquatic-invertebrate prey of the snipe and plover. According to Bechtel Jacobs (1998, page 29), the 90th percentile BASFs or 95% upper prediction limits (UPLs) should be used as a preliminary screening tool. This recommendation will result in BASFs greater than unity for several metals. A BSAF of 1 is appropriate for metals not addressed by Bechtel Jacobs (1998).*

**Response:** Snipe and plover food web models were revised to use the 90<sup>th</sup> percentile BASFs from Bechtel Jacobs (1998) for As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn for estimating metals concentrations in invertebrate prey. Based on this approach, cadmium, mercury, and zinc are identified as CoPCs for avian invertivores foraging in freshwater creeks and streams, in addition to lead, which was previously identified as a CoPC in this habitat. There are no changes for tundra ponds based on this approach, as cadmium, lead, mercury, thallium, and zinc remain as CoPCs for avian invertivores (arsenic and barium are also added as CoPCs due to screening of maximum soil concentrations as well as maximum sediment concentrations). In coastal



lagoons, cadmium is now identified as a CoPC, in addition to lead and zinc, which were previously identified as CoPCs.

### **Comment Eco-8**

*The No Effect Concentrations (NECs) developed by Ingersoll et al. (1996) for freshwater sediments are not sufficiently conservative for use in a screening-level ecological risk assessment. The NECs are analogous to apparent effects thresholds (AETs) and thus have a high false-negative rate compared with other sediment benchmarks. Hence, the NECs should not be used to eliminate chemicals from further consideration in Section 3.*

**Response:** For this risk assessment, screening has been revised to compare metal concentrations in freshwater sediment with threshold effect concentrations of MacDonald et al. (2000) rather than NECs of Ingersoll et al. (1996) as the basis of identifying chemicals for further consideration. Table 3-40 has been revised to show CoPCs identified in freshwater sediment based on this re-assessment. This revised table was submitted to DEC on April 26, 2004, and a copy is attached to this response (see Attachment A).

### **Comment Eco-9**

*See comment Eco-8 on Section 3.5.2.1 regarding the NECs.*

**Response:** See response to Comment Eco-8.

### **Comment Eco-10**

*The Washington State Sediment Management Standards (SQSs) are not sufficiently conservative for use in a screening-level ecological risk assessment. The SQSs were developed using the AET approach and thus have a high false-negative rate compared with other sediment benchmarks. Hence, the SQSs should not be used to eliminate chemicals from further consideration in Section 3. Generally speaking the RAPM advocates a conservative screening approach, so NOAA screening values are preferable.*

**Response:** For this risk assessment, screening has been revised to compare metals concentrations in marine sediment with ER-L values of Long et al. (1995), not Washington State SQSs, as the basis of identifying chemicals for further consideration. Table 3-40 has been revised to show CoPCs identified in marine and lagoon sediment based on this re-assessment. This revised table was submitted to DEC on April 26, 2004, and a copy is attached to this response (see Attachment A).

### **Comment Eco-11**

*See comment Eco-10 on Section 3.5.4.1 regarding the SQSs.*

**Response:** See response to Comment Eco-10.

## Comment Eco-12

*Lead should be included as a COPC in pond water near the port. The data in Tables C-11 and C-12 show that lead levels in pond water near the port are 2 to 10 times higher than in the reference ponds. In addition, the surface-water lead concentration in one pond near the port exceeds the hardness-adjusted chronic water quality criterion by a factor of five. It appears that lead was not identified as a COPC in pond water because samples near the site were combined with samples from along the haul road and then compared with background. As described above (see comment Eco-4 on Section 3.2.8), to correctly identify contamination above background, it will be necessary to separate the site into operable units. If doing so results in too few samples to conduct statistical testing, then a non-statistical method should be used to judge whether contamination is present above background (see ADEC 2003), or additional samples should be collected in the 2004 field season.*

**Response:** Based on the revised statistical comparisons requested by DEC and outlined in responses to Comments Eco-4 and Eco-5, lead concentrations in pond water are not significantly greater at the site than at the reference area. As such, lead is not included as a CoPC in pond water, as indicated on the revised Table 3-40. This revised table was submitted to DEC on April 26, 2004, and a copy is attached to this response (see Attachment A).

## Comment Eco-13

*It is not clear from the information presented in the February 2004 work plan how repeated measurements at the lagoon sediment stations were handled when conducting statistical analyses. Tables C-13 and C-14 show that many lagoon sediment stations were sampled multiple times on different dates. Were the repeated measurements averaged into a single value for each station or treated individually during statistical analyses?*

*Based on an independent analysis of the lagoon sediment data, lead, cadmium, and zinc were found to be significantly greater ( $p=0.057$  for Cd,  $p=0.003$  for Pb,  $p=0.003$  for Zn) in sediment from Port Lagoon North compared with background (Mann Whitney U test). In addition, zinc was significantly greater in sediment from the North Lagoon compared with background ( $p=0.040$ , Mann Whitney U test). To avoid pseudo-replication (Hurlbert 1984), stations with repeated measurements from different dates were averaged into single station value for the analysis. Based on this analysis, it is recommended that lead and cadmium be considered COPCs in coastal lagoon sediment.*

*In addition, Figures 3-9 to 3-11 show that Port Lagoon North, and to a lesser extent the North Lagoon and north arm of Port Lagoon South, have received inputs of fugitive dust. Sediment concentrations of cadmium, nickel, and zinc often exceed the ERL, and at some locations exceed the ERM. Sediment toxicity may be necessary to determine if these elevated sediment metal concentrations are associated with toxicity. The samples should be collected along a gradient in contamination near the port and also from uncontaminated background lagoons. The resulting data could be presented in the baseline risk assessment to provide a more definitive assessment of risk to benthic life in the coastal lagoons.*

**Response:** Based on revisions to the statistical comparisons and the CoPC screening (requested by DEC in previous comments and discussed in responses Eco-5, 7, 8, and 10, and HH-16), lead

and cadmium were included as CoPCs in lagoon sediment, as requested in this comment. The revised CoPC screening results are provided in Table 3-40. This revised table was submitted to DEC on April 26, 2004, and a copy is attached to this response (see Attachment A).

Potential effects on benthic invertebrates in coastal lagoons will be evaluated through analysis of benthic community parameters at multiple locations along a CoPC concentration gradient in port lagoons and at multiple reference lagoon stations. Sediment toxicity tests are proposed as an alternate measurement endpoint in coastal lagoons if sampling indicates that benthic invertebrates are scarce or absent at site and reference lagoon stations. Details on methods and sampling locations are provided in the revised field sampling plan.

### **Comment Eco-14**

*Two of five unfiltered water samples from the North Lagoon had a zinc concentration from 2 to 4 times greater than the maximum background concentration, and one sample from the North Lagoon exceeded the salt-water chronic water quality criterion for zinc. Based on these data, zinc should be considered a COPC in water in the North Lagoon.*

*The lagoon surface-water data presented in the work plan is for unfiltered samples only. Consequently, it is possible that the elevated concentrations observed in the North Lagoon could be due to suspended solids. DEC recommends that any future surface-water sampling include collection of both filtered and unfiltered samples.*

**Response:** Based on the revised statistical approaches requested by DEC and outlined in responses to Comments Eco-4 and Eco-5, zinc concentrations in coastal lagoon water are not significantly greater at the site than at the reference area. As such, zinc is not included as a CoPC in coastal lagoon water, as indicated on the revised Table 3-40. This revised table was submitted to DEC on April 26, 2004, and a copy is attached to this response (see Attachment A). The comment about collecting filtered and unfiltered water samples in any future water sampling is noted. If necessary, filtered samples could be collected. However, as discussed with DEC in subsequent conference calls, the surface water bodies being sampled are very clear (very low turbidity), so the difference between total and dissolved results is expected to be small. In addition, using the unfiltered sample data adds an element of conservatism to the results, and simplifies the field data collection in these remote locations. Given these considerations, collection of filtered data is generally not warranted for this assessment. However, in the event any further water data collection is conducted, consideration will be given to the possible value of collecting filtered data in certain circumstances.

### **Comment Eco-15**

*This section states that screening could not be performed for terrestrial carnivores due to lack of data on COPC levels in prey. Why were the small-mammal uptake models presented in Sample et al. (1998) not used?*

*This section states that the screening results for freshwater piscivores are assumed to be protective of marine piscivores. This assumption does not consider the fact that the concentrations of cadmium, lead, zinc, and other metals in sediment from the coastal lagoons near the port are considerably greater than in the streams and creeks along the haul road.*

*Potential risks to piscivorous wildlife that utilize the coastal lagoons should be evaluated. If necessary, collection and analysis of fish from the coastal lagoons near the port should be undertaken. Also, a better description of the ecology of coastal lagoons would be extremely helpful (i.e. what fish species are found in the lagoons, what wildlife species use the lagoons for feeding or other activities, etc.).*

*See comment Eco-16 regarding Table 3-28.*

*See comment Eco-23 regarding allometric scaling.*

*COPC selection for wildlife will need to be modified based on these comments.*

**Response:** Screening to identify CoPCs for terrestrial wildlife was performed using food web models for tundra voles where maximum metals concentrations measured in site soil and vegetation (i.e., moss) were used to estimate exposure through the diet and through incidental soil ingestion. This approach, which maximizes use of existing site data, was considered preferable to use of generic uptake factors, such as those in Sample et al. (1998) as a means of identifying CoPCs. Because the tundra vole screening models identified 14 metals as CoPCs that will be evaluated for all terrestrial receptors (herbivores, invertivores, and carnivores), this approach is believed to provide a comprehensive list of CoPCs for all terrestrial wildlife receptors.

The work plan has been revised to indicate that risk to piscivorous wildlife receptors that potentially forage in coastal lagoons will also be evaluated. Prey fish will be collected from several coastal lagoon ponds and will be evaluated for the same suite of 14 CoPCs that are being evaluated for terrestrial wildlife. Additional detail on the ecology of coastal lagoons will be provided in the baseline ecological risk assessment report.

## Comment Eco-16

**General Comment on Table 3-28:** *The TRVs proposed for the following COPCs are acceptable: aluminum, barium, cadmium, copper, fluoride, manganese, mercury (except the avian NOAEL), molybdenum, nickel, selenium, tin, and vanadium.*

**Response:** Comment noted.

**Arsenic:** *Please make available for review your derivation of the avian NOAEL and LOAEL from the study of Stanley et al. (1994). For mammals, DEC recommends that the NOAEL and LOAEL be based on Nemeč et al. (1998) rather than Schroeder and Mitchener (1971). The Nemeč et al. (1998) study is preferable because it is more recent and the NOAEL can be derived directly from one of the test treatments without use of an uncertainty factor. The following NOAEL and LOAEL derivation is based on Nemeč et al. (1998):*

<i>Compound:</i>	<i>Arsenic</i>
<i>Form:</i>	<i>Arsenate (H<sub>3</sub>AsO<sub>4</sub>)</i>
<i>Reference:</i>	<i>Nemeč et al. (1998)</i>
<i>Test Species:</i>	<i>Rabbit</i>
	<i>Body wt: 4.396 kg</i>
<i>Exposure Duration:</i>	<i>Days 6-18 of gestation (critical stage = chronic)</i>

*Endpoint:*                    *Reproduction*  
*Exposure Route:*        *Oral Gavage*  
*Dosage:*                    *4 dose levels (concentrations as H<sub>3</sub>AsO<sub>4</sub>)*  
                                  *H<sub>3</sub>AsO<sub>4</sub> is 52.78% As by weight*  
                                  *0, 0.19, 0.75, and 3 mg/kg-d as H<sub>3</sub>AsO<sub>4</sub>*  
                                  *0, 0.1, 0.396, and 1.58 mg/kg-d as As*

*Comments:*                *Reproductive and maternal effects were observed only at the highest dose level, which resulted in mortality for 7 of 20 does. No maternal mortality was observed at any other dose level. Number of fetuses/litter decreased and fetal resorptions increased at the highest dose level, but the differences were not statistically significant. Because the study considered exposure during a critical life stage, the 1.58 mg/kg-d dose was considered to be a chronic LOAEL.*

*Final NOAEL:*            0.396 mg/kg-d  
*Final LOAEL:*            1.58 mg/kg-d

**Response:** Attachment B provides the derivation of avian and mammalian toxicity reference values to be used for arsenic.

**Cobalt:** Please provide a copy of Nation et al. (1983).

**Response:** A copy has been provided.

**Chromium:** *The avian and mammalian TRVs for chromium are based on studies with hexavalent chromium. This is appropriate for the screening-level assessment. However, for the baseline assessment, the chromium TRVs should be based on the actual form of chromium present at the site. Has hexavalent chromium been analyzed or is it presumed present in environmental media at the site? If hexavalent chromium has not been sampled for and is not likely on site a limited number of water, soil, and sediment samples should be analyzed for both hexavalent and total chromium in 2004. If no hexavalent chromium is detected or known not to exist at the site, then the TRVs for the baseline assessment should be based on studies with trivalent chromium.*

*However if you elect not to pursue the above suggestion, given that treating total chromium as hexavalent is the conservative approach, it will be accepted in the risk assessment.*

**Response:** The form of chromium present in environmental media at the site has not been analyzed, and therefore a mammalian TRV for hexavalent chromium was used as a conservative measure of effects in the screening food web models. The avian TRV is based on a study with trivalent chromium, as no suitable avian TRV for hexavalent chromium was found. Determination of the form of chromium in media at the site is not planned at this time, as results of the screening food web models suggest that chromium is unlikely to constitute a risk when more realistic exposure assumptions are used in food web models in the baseline ecological risk assessment, even using the conservative hexavalent chromium TRV. The influence of differential toxicity of trivalent and hexavalent chromium on risk estimates will be discussed in the risk characterization section of the ecological risk assessment report.

**Lead:** *For mammals, Table 3-28 lists a NOAEL and LOAEL of 11 and 90 mg/kg-day, respectively, based on the study of Azar et al. (1973). Sample et al. (1996) used the same study*

*to derive a NOAEL and LOAEL of 8 and 80 mg/kg-day, respectively. Please use the TRVs from Sample et al. (1996) or explain the discrepancy.*

**Response:** Sample et al. (1996) used the concentration of lead added to the diet as the dose concentration for the derivation of the TRV. However, the results in Azar et al. (1973) indicate that the actual concentration measured in the food was slightly higher than the intended dose concentration (e.g., the 100 ppm added to the food resulted in a measured concentration of 141 ppm, and the 1,000 ppm added to the food resulted in a measured concentration of 1,130 ppm). Using the measured dose, rather than the nominal dose, in the derivation results in the higher TRVs noted in Table 3-28.

**Mercury (as methylmercury):** *Please make available for review your derivation of the avian NOAEL of 0.032 mg/kg-day from the work of Heinz. Sample et al. (1996) derived an avian NOAEL of 0.0064 mg/kg-day from the study of Heinz (1979). Please use this NOAEL or defend the use of the greater NOAEL (0.032 mg/kg-day) given in Table 3-28.*

*Has methylmercury been analyzed for in environmental media at the site? If not, a limited number of water, soil, and sediment samples should be analyzed for both total and methylmercury in 2004. The results of the baseline assessment will be more informative if the actual form of mercury present at the site is known and used in the exposure and risk calculations.*

**Response:** Sample et al. (1996) applied an LOAEL to NOAEL uncertainty factor (UF) of 0.1 to derive the NOAEL of 0.0064. U.S. EPA (1995b), when deriving TRV from the same study, used a UF of 0.5 “because the LOAEL appeared to be very near the threshold for effects of mercury on mallards.” According to U.S. EPA (1995a) the EPA’s recommended range for UF is 0.1 to 1. Furthermore, U.S. EPA (1995a) states that, “In cases where a NOAEL cannot be quantified and only an unbounded LOAEL is available, determination of the appropriate value for the UF must be done on a chemical specific and test-specific basis with the use of best professional judgment.” U.S. EPA (1995a) provides additional guidance that a larger value for the UF (closer to 1) could be used for an unbounded LOAEL that is judged to be at or near the dose-response threshold for the endpoint being evaluated. Data from the Heinz (1979) study showed that the reduction in productivity occurred in only one of the three generations, indicating that the LOAEL dose is near the dose-response threshold. Therefore, based on the limited magnitude of effects seen study that is the basis of this TRV, a ten-fold uncertainty factor as used by Sample et al. (1996) is an overly-conservative estimate of the true no-effects threshold, and the two-fold factor as recommended by U.S. EPA (1995b) is more appropriate.

For discussion of methylmercury, please see response to comment Eco-24.

**Silver:** *Please consult Walker (1971) for mammalian toxicity data for silver.*

**Response:** The study by Walker (1971) is not very appropriate for derivation of the TRV for a number of reasons. The study did not have a control group and there are no statistical analyses performed to test for significance of the results. The study mentions that there was mortality in one dosing group; however, that dosing level was discontinued. The endpoints of the study for

the remaining dosing groups were membrane deposits of silver and not related to population effects such as growth, mortality, or reproduction.

**Thallium:** For mammals, Table 3-28 lists a NOAEL and LOAEL of 0.074 and 0.74 mg/kg-day, respectively, based on the study of Formigli et al (1986). Sample et al. (1996) used the same study to derive a NOAEL and LOAEL of 0.0074 and 0.074 mg/kg-day, respectively. The NOAEL and LOAEL from Sample et al. (1996) should be used.

**Response:** The difference between the TRVs derived by Sample et al. (1996) and Exponent result from Sample et al. (1996) applying a subchronic-to-chronic uncertainty factor of 0.1.

Sample et al. (1996) notes that an uncertainty factor of <1 may be applied to a subchronic exposure to estimate a chronic exposure based on U.S. EPA (1995a) and that U.S. EPA (1995a) does not provide a stringent definition of the dividing line between subchronic and chronic dosing.

U.S. EPA (1995a) defines chronic exposure as an exposure period of sufficient length to reveal most adverse effects that occur, or would be expected to occur over the entire lifetime of the organism. However, the need to take into account the properties of the substance and the lifestage of the organism is stressed. U.S. EPA (1995a) notes that it is important to apply UFs to studies if: the study is too short to quantify adverse effects; the substance takes a long time period to reach equilibrium; a sensitive life stage is not included. If these circumstances are met, then the selection of the UF should include consideration of the amount of time required for the substance to reach equilibrium in the tissues.

The author of the study and Exponent, based on the recommendations of U.S. EPA (1995a), consider the study to be a chronic study because: the reproductive endpoint could potentially effect a sensitive life stage (reproduction), the duration of the study was sufficient to demonstrate effects; and the substance does not take a long time period to reach equilibrium. Therefore, we believe that the ten-fold uncertainty factor applied by Sample et al. (1996) results in overly conservative estimates of the true no-effect and lowest-effect levels.

**Zinc:** For birds, Table 3-28 lists a NOAEL of 130 mg/kg-day based on the study of Stahl et al. (1990). Sample et al. (1996) used the same study to derive a NOAEL of 13 mg/kg-day. The NOAEL from Sample et al. (1996) should be used.

**Response:** Sample et al. (1996) states that in the study by Stahl et al. (1990), there was a reduction in egg hatchability at the highest dose (2,000 mg/kg zinc) and used that dose to derive a LOAEL of 130 mg/kg-day. Hatchability was only reduced in one of two studies conducted by Stahl et al. (1990). In study 1, the hatchability of birds feeding on a diet containing 2,000 mg/kg zinc was higher than the hatchability of control birds (85.9 percent versus 81.5 percent). In study 2, hatchability of the zinc-fed birds was 69.8 percent versus 86.5 percent for the control birds. However, Stahl et al. (1990) stated “the fertility and hatchability of the eggs incubated during the two studies were not affected significantly by the level of Zn in the diet.” Additionally, no significant differences were noted in hen weight, feed consumed, egg production, or progeny growth rates. The authors concluded that “The zinc treatments have no effect on hen performance or reproductive performance.” Therefore, given the minor level of

effects noted, and the lack of statistically significant differences between control and treatment groups, Exponent believes that Sample's classification of the highest dose as representing a LOAEL is unsupported by results of the study. This dose more accurately represents a NOAEL, and therefore, 130 mg/kg-d is the appropriate NOAEL TRV based on the results of Stahl et al. (1990).

Based on subsequent discussions with DEC reviewers in preparation of a response to this comment, Exponent has also reviewed a paper by Jackson et al. (1986) that did find significant adverse effects (reduced food consumption, body weight, and egg production) for a diet with 2,000 mg/kg zinc added, but no adverse effects for a diet with 1,000 mg/kg zinc added. Data presented in this paper were used to derive a chronic NOAEL and LOAEL from the study of 70 and 124 mg/kg-day, respectively. The results of the Stahl et al. (1990) and Jackson et al. (1986) papers indicate that dose levels of 1,000 mg/kg to 2,000 mg/kg appear to bracket the true effects threshold, at least in chickens, and depending on the endpoint chosen, either dose could be the NOAEL. Therefore, Exponent proposes to use both sets of TRVs in the risk assessment. Implications of results based on the alternate TRV values will be discussed in the risk characterization section of the baseline ecological risk assessment report.

### **Comment Eco-17**

*In addition to being exposed to chemicals in surface water, fish can be exposed to sediment contamination, especially fish that feed on benthic invertebrates. This exposure pathway should be considered and evaluated.*

*The level of sediment contamination in the coastal lagoons is much greater than in streams and creeks along the haul road. Consequently, the screening results for freshwater piscivores cannot be assumed to be protective of piscivores that use the coastal lagoons. Potential risks to piscivorous wildlife that use the coastal lagoons should be evaluated.*

**Response:** The exposure pathway from sediment to fish will be considered in the baseline ecological risk assessment. As indicated above in the response to Comment Eco-15, potential risks to piscivorous wildlife foraging in coastal lagoons will be evaluated in the baseline ecological risk assessment.

### **Comment Eco-18**

*Figures 3-9 to 3-11 indicate that cadmium, lead, and zinc are highly elevated in sediment at the end of the shiploader. The concentrations at this location are high enough to result in adverse impacts to benthic life. What controls are being implemented to ensure that the zone of impact does not expand? What future monitoring activities are planned for this location to confirm that the controls are effective?*

*Table C-17 shows that nearly all the exceedances of the ERL for cadmium are due to samples collected in August 2000. The August 2000 samples have a ten-fold higher cadmium concentration than offshore sediment samples collected on other dates. Did the data from August 2000 undergo the same level of QA/QC applied to data from other sampling trips? Please check to see that a factor-of-ten error was not made when calculating the sample concentration from the laboratory instrument output for the August 2000 samples. If the data*



*are sound, then it appears that cadmium contamination in sediment exists well offshore from the shiploader.*

**Response:** Although no error is apparent in the QA documentation, August 2000 cadmium data do not agree with the results from numerous other field sampling events. Sediment samples are being collected from the shiploader area and analyzed for CoPCs as part of the Phase II field sampling and analysis program for the DMTS risk assessment. These data will be used to assess current conditions and temporal trends in CoPC concentrations. The data will be screened using the conservative ERLs, as requested by DEC. Extra sediment volume will be collected during the sampling and archived for possible use in sediment toxicity testing, pending review of analytical results for the sediment samples. Further details on the sediment sampling and on the criteria under which toxicity testing would be conducted are provided in the field sampling plan submitted to DEC on June 1, 2004.

### **Comment Eco-20 (Comment Eco-19 not provided)**

*The third full paragraph in this section begins by stating that “mean” COPC concentrations in biota, water, sediment, and soil will be used to calculate dietary exposure in the baseline ERA. The 95% upper confidence limit (UCL) on the mean concentration should be used, as described in USEPA (2002).*

**Response:** The baseline ecological risk assessment will calculate dietary exposure using both mean and 95 percent UCL CoPC concentrations in biota and media samples. Hazard quotients will be calculated separately for each exposure estimate, and a discussion of risk estimates using both approaches will be provided in the risk characterization section of the baseline ecological risk assessment report.

### **Comment Eco-21**

*The baseline assessment should use both NOAEL-based and LOAEL-based TRVs when assessing wildlife risks, not only LOAEL-based TRVs.*

**Response:** A LOAEL-based TRV represents the lowest dose above which adverse effects may first occur. Therefore, use of this value is appropriate in a baseline assessment, where the objective is not to screen out chemicals from further consideration, but to identify chemicals that may pose an adverse risk to wildlife populations. However, for the baseline risk assessment we will compare wildlife receptor exposure estimates to both NOAEL-based and LOAEL-based TRVs. The relevance of exceedances of the LOAEL and/or the NOAEL will be discussed in the risk characterization section of the baseline ecological risk assessment report.

### **Comment Eco-22**

*Probabilistic modeling is not acceptable for ecological risk assessment. ADEC RAPM specifies that it may only be used for human health risk assessment.*

**Response:** It is noted that DEC risk assessment guidance does not allow use of probabilistic modeling in ecological risk assessments, although we would like the opportunity to discuss the merits of this technique further with DEC. Probabilistic risk assessment was proposed for use in

cases where deterministic models suggest an unacceptable level of risk to terrestrial receptors, as a means of more accurately characterizing the likelihood of various levels of risk to receptor populations. As such, probabilistic models would help to better characterize ecological risk and would provide additional information for use by DEC in making risk management decisions.

### Comment Eco-23

*There is a large difference in body weight between several of the wildlife receptors being evaluated (e.g., moose) compared with the test animals (e.g., mouse) used to develop the TRVs in Table 3-28. Consequently, allometric scaling of TRVs should be performed for both the screening-level and baseline ERA. Despite the limitations mentioned by Sample and Arenal (1999), allometric scaling is still recommended by these authors and is standard practice in the field of ecological risk assessment (e.g. Sample and Suter 2002).*

**Response:** As discussed in the risk assessment work plan, there is no conclusive evidence presented in Sample and Arenal (1999) that any allometric scaling value other than 1.0 should be used for chronic avian and mammalian TRVs for the metals that are CoPCs in this risk assessment, even though the generic scaling factors they develop based on acute exposure to a range of organic and inorganic chemicals differ from unity. Furthermore, although allometric scaling is sometimes used in ecological risk assessments, it is not common practice, and often relies on untested assumptions about how toxic effects scale relative to metabolism. Potential sources of error in risk estimates due to extrapolation of TRVs between test species and wildlife receptors will be evaluated as part of the uncertainty analysis in the baseline ecological risk assessment report.

### Comment Eco-24

*In addition to the sampling recommended in the February 2004 work plan, the following sampling should be undertaken:*

*1. A limited number of water, soil, and sediment samples should be analyzed for both total and methylmercury to develop an understanding of mercury speciation at the site. This information is needed to select the appropriate TRV for the baseline risk assessment for wildlife.*

**Response:** Speciation of mercury in environmental media is not planned. As the majority of the total exposure for wildlife species is through dietary exposure, and as the majority of mercury in tissue is typically methylated, use of a methylmercury TRV represents the best means of comparing exposure and effects, and represents a conservative approach to estimating risk. The uncertainty in risk estimates associated with the use of a methylmercury TRV will be discussed in the uncertainty analysis.

*2. pH should be measured in surface-water bodies impacted by ore concentrate to determine if oxidation of sulfides in the ore concentrate is impacting surface-water pH.*

**Response:** pH will be measured in surface water bodies sampled in 2004, as indicated in the response to Comment Eco-2.

3. *Site-specific data on trace-metal bioavailability in sediment would be useful. In 2004, sediment toxicity tests may need to be conducted with sediment from coastal lagoons near the port, specifically Port Lagoon North, and reference lagoons.*

**Response:** Site-specific evaluation of metals bioavailability in sediment is not planned at present. Sediment toxicity testing may be conducted with sediment from coastal lagoons, as indicated in the response to Comment Eco-13.

4. *Collection and analysis of sediment and water from additional tundra ponds near the port and along the haul road should be conducted. Currently, data are available only for two ponds near the port and two along the haul road. This number of sampling locations will be inadequate to support the statistical approach described in the work plan if the site is partitioned into operable units.*

**Response:** No additional statistical evaluation of chemical concentrations in site versus background locations beyond what has been presented in the revised work plan tables is planned. During the 2004 field sampling, sediment will be collected from tundra pond locations where plant tissue samples will be collected, but only to provide an evaluation of relative CoPC concentrations in media and plant tissue.

5. *Any future surface water sampling should include collection of both filtered and unfiltered samples so the effect of suspended solids can be evaluated.*

**Response:** Comment noted. Please see response to comment Eco-14. No additional water sampling is planned at present.

6. *Fish may need to be collected from coastal lagoons near the port so potential risks to piscivorous wildlife that feed in this habitat can be evaluated. A reference lagoon should also be sampled in this case.*

**Response:** Fish sampling will be performed in coastal lagoons during the 2004 sampling event to provide data for evaluating risk to piscivorous wildlife. Details on sampling locations and methods are provided in the field sampling plan.

## References for Papers Cited in Responses to Comments

Azar, A., H.J. Trochimowicz, and M.E. Maxfield. 1973. Review of lead studies in animals carried out at Haskell laboratory-two-year feeding study and response to hemorrhage study. pp. 199–210. In: Environmental Health Aspects of Lead. D. Barth, A. Berlin, R. Engel, et al. (eds). Commission of the European Communities, Luxembourg.

Bechtel Jacobs. 1998. Biota sediment accumulation factors for invertebrates: Review and recommendations for the Oak Ridge Reservation. Prepared for U.S. Department of Energy, Office of Environmental Management. Bechtel Jacobs Company LLC, Oak Ridge, TN.

Byron, W.R., G.W. Bierbower, J.B. Brouwer, and W.H. Hansen. 1967. Pathologic changes in rats and dogs from a two-year feeding study of sodium arsenite or sodium arsenate. Toxicol. Appl. Pharmacol. 10: 132–147.

- DEC. 2003. Alaska water quality criteria manual for toxic and other deleterious organic and inorganic substances. Alaska Department of Environmental Conservation.
- Exponent. 2002. Fugitive dust data report, DeLong Mountain Regional Transportation System, Alaska. Draft. Prepared for Teck Cominco Alaska Incorporated, Anchorage, AK. Exponent, Bellevue, WA.
- Exponent. 2004. Phase II field sampling and analysis plan for the DMTS fugitive dust risk assessment. Prepared for Teck Cominco Alaska Incorporated, Anchorage, AK. Exponent, Bellevue, WA.
- Heinz, G.H. 1979. Methyl mercury: Reproductive and behavioral effects on three generations of mallard ducks. *J. Wildl. Mgmt.* 43:394–401.
- Heinz, G.H., D.J. Hoffman, and L.G. Gold. 1989. Impaired reproduction of mallards fed an organic form of selenium. *J. Wildl. Mgmt.* 53:418–428.
- Ingersoll, C.G., P.S. Haverland, E.L. Brunson, T.J. Canfield, F.J. Dwyer, C.E. Henke, N.E. Kemble, and D.R. Mount. 1996. Calculation and evaluation of sediment effect concentrations for the amphipod *Hyalella azteca* and the midge *Chironomus riparius*. *J. Great Lakes Res.* 22(3):602–623.
- Jackson, N., S.W. Gibson, and M.H. Stevenson. 1986. Effects of short- and long-term feeding of zinc oxide-supplemented diets on the mature, female domestic fowl with special reference to tissue mineral content. *British J. Nutrition* 55:333–349.
- Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. *Environ. Manage.* 19(1):81–97.
- MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Arch. Environ. Contam. Toxicol.* 39:20–31.
- Nemec, M.D., J.F. Holson, C.F. Farr, and R.D. Hood. 1998. Developmental toxicity assessment of arsenic in mice and rabbits. *Reprod. Toxicol.* 12: 647–658.
- Sample, B.E., and C.A. Arenal. 1999. Allometric models for interspecies extrapolation of wildlife toxicity data. *Bull. Environ. Contam. Toxicol.* 62:653–663.
- Sample, B.E., J.J. Beauchamp, R.A. Efrogmson, and G.W. Suter. 1998. Development and validation of bioaccumulation models for small mammals. ES/ER/TM-219. Oak Ridge National Laboratory, Oak Ridge, TN.
- Sample, B., D. Opresko, and G. Suter. 1996. Toxicological benchmarks for wildlife: 1996 Revision. ES/ER/TM-86/R3. Oak Ridge National Laboratory, Health Sciences Research Division, Risk Assessment Program.

Schroeder, H.A., and M. Mitchener. 1971. Toxic effects of trace elements on the reproduction of mice and rats. *Arch. Environ. Health* 23:102–106.

Stahl, J.L., J.L. Greger, and M.E. Cook. 1990. Breeding-hen and progeny performance when hens are fed excessive dietary zinc. *Poult. Sci.* 69:259–263.

Stanley, T.R., J.W. Spann, G.J. Smith, and R. Rosscoe. 1994. Main and interactive effects of arsenic and selenium on mallard reproduction and duckling growth and survival. *Arch. Environ. Contam. Toxicol.* 26:444–451.

U.S. EPA. 1989. Risk assessment guidance for Superfund. Volume I: Human Health Evaluation Manual (Part A). Interim Final Report. EPA/540/1-89/002. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

U.S. EPA. 1995a. Great Lakes water quality initiative technical support document for wildlife criteria. EPA-820-B-95-009. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

U.S. EPA. 1995b. Great Lakes water quality initiative criteria documents for the protection of wildlife. EPA-820-B-95-008. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

U.S. EPA. 1997. Exposure factors handbook. EPA/600/P-95/002Fa. U.S. Environmental Protection Agency.

U.S. EPA. 2002. Risk assessment guidance for Superfund (RAGS), Volume I: Human health evaluation manual (Part E, Supplemental guidance for dermal risk assessment). Interim. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response.

U.S. FWS. 1964. Pesticide-wildlife studies, 1963: A review of Fish and Wildlife Service investigations during the calendar year. FWS Circular 199.

Walker, F. 1971. Experimental argyria: A model for basement membrane studies. *Brit. Exptl. Path.* 52:589–593.

WDOE. 1995. Sediment management standards. Chapter 173-204 WAC. Washington State Department of Ecology.

## **Attachment A**

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### **Revised Risk Assessment Work Plan Tables**

**Table 3-4. Statistical comparison of site and reference soil data**

Chemical	Reference					Site					Site > Reference? <sup>a</sup>	p-values <sup>b</sup>	
	N	Min	Max	Mean	Stdev	N	Min	Max	Mean	Stdev		non-para.	parametric
Aluminum	10	1,640	12,400	6,963	4,351	51	1,180	16,600	7,392	3,281	no	0.38	0.42
Antimony											≥50% ND Site		
Arsenic	10	4.2	35.0	12.6	9.8	75	1.3	93.6	12.2	15.1	no	0.76	0.47
<b>Barium</b>	5	109	622	249	213	40	357	7,090	2,137	1,830	<b>yes</b>	0.0002	<0.0001
<b>Cadmium</b>	10	0.24	3.6	1.1	1.1	478	0.40	388	25.2	37.8	<b>yes</b>	<0.0001	<0.0001
Chromium	5	4.9	19.3	11.8	5.7	40	4.9	24.0	15.0	5.1	no	0.12	0.16
Cobalt	5	7.3	20.6	13.5	5.1	40	4.2	27.0	11.3	5.0	no	0.86	0.32
<b>Copper</b>	5	14.3	46.5	23.7	13.0	40	9.8	109	36.0	20.3	<b>yes<sup>f</sup></b>	0.067	0.17
<b>Fluoride</b>	5	0.30	0.50	0.42	0.084	12	0.40	1.3	0.73	0.30	<b>yes</b>	0.018	0.025
Iron	10	5,750	72,600	29,872	18,432	51	2,650	35,000	20,682	7,572	no	0.99	0.20
<b>Lead</b>	10	8.8	142	38.5	38.5	479	8.5	48,300	1,157	2,795	<b>yes</b>	<0.0001	<0.0001
Manganese	5	250	4,080	1,489	1,589	40	280	1,000	513	186	no	0.76	0.0076 <sup>d</sup>
<b>Mercury</b>	5	0.050	0.18	0.11	0.053	12	0.10	1.7	0.45	0.51	<b>yes</b>	0.012	0.030
Molybdenum											≥50% ND Site		
Nickel	5	23.5	51.4	34.2	12.6	40	17.3	56.8	29.1	10.0	no	0.80	0.28
Selenium											≥50% ND Site		
<b>Silver</b>	5	0.050	0.25	0.13	0.089	40	0.14	8.3	2.2	2.0	<b>yes</b>	0.0004	<0.0001
<b>Strontium</b>	5	9.3	63.6	31.0	21.2	20	36.2	90.1	63.2	15.5	<b>yes</b>	0.0054	0.0001
<b>Thallium</b>	5	0.10	0.24	0.16	0.055	12	0.11	1.3	0.47	0.36	<b>yes</b>	0.026	0.041
Tin											≥50% ND Site		
<b>Vanadium</b>	5	5.6	19.2	11.9	5.4	40	7.9	31.8	14.7	4.8	<b>yes<sup>e</sup></b>	0.15	0.098
<b>Zinc</b>	10	72.5	753	181	204	479	37.4	64,300	4,140	6,201	<b>yes</b>	<0.0001	<0.0001

**Note:** CoPC - chemical of potential concern

ND - not detected

Concentrations are given in mg/kg dry weight.

Undetected values are included at one-half the detection limit. In cases where greater than or equal to 50 percent of the site values or 100 percent of the reference values were undetected, statistical analyses were not performed. Further summary information is provided in the CoPC screening tables, including detection limits and detection frequencies.

Field replicates were averaged prior to statistical analysis.

<sup>a</sup> Results of statistical comparison. Bold indicates chemicals for which statistical testing indicated site concentrations to be greater than reference concentrations at a significance level of alpha = 0.10.

<sup>b</sup> P-values associated with comparison of site and reference mean concentrations.

Non-para. - Wilcoxon rank-sum one-sided test for determining if the site mean is significantly greater than the reference mean concentration.

Parametric - overall ANOVA model for determining if the site and reference mean concentrations are significantly different (higher or lower).

<sup>c</sup> Comparison not made because 90 percent confidence interval for the site mean concentration spans zero, due to small sample size and/or high variability.

<sup>d</sup> ANOVA p-value indicates reference mean is significantly higher than site mean concentration.

<sup>e</sup> Assumptions of ANOVA model were met, thus conclusions result from parametric p-value.

<sup>f</sup> Assumptions of ANOVA model were not met, thus conclusions result from non-parametric p-value.

**Table 3-5. Statistical comparison of site and reference tundra soil data**

Chemical	Reference					Site					Site > Reference? <sup>a</sup>	p-values <sup>b</sup>	
	N	Min	Max	Mean	Stdev	N	Min	Max	Mean	Stdev		non-para.	parametric
Aluminum	10	368	11,300	3,651	3,347	31	358	18,900	5,329	4,822	no	0.22	0.39
Antimony	10	0.11	0.28	0.17	0.062	25	0.15	25.8	6.2	6.1	c	<0.0001	<0.0001
<b>Arsenic</b>	10	0.40	6.8	2.3	1.9	31	0.30	150	17.7	26.6	<b>yes</b>	0.0002	0.0003
Barium	10	108	624	315	196	25	53.0	5,060	945	1,306	c	0.032	0.10
<b>Cadmium</b>	10	0.12	0.88	0.35	0.22	224	0.30	258	15.3	31.7	<b>yes</b>	0.0016	0.0002
Chromium	10	1.6	19.7	6.8	6.1	25	1.0	33.2	10.4	8.7	no	0.19	0.33
Cobalt	10	0.96	28.3	8.6	10.6	25	0.50	35.0	11.0	9.3	c	0.14	0.36
<b>Copper</b>	10	4.3	16.9	8.2	4.0	25	2.9	58.3	21.0	15.5	<b>yes</b>	0.0027	0.0050
Fluoride											≥50% ND Site		
Iron	10	912	45,100	12,909	13,600	31	593	181,000	26,417	35,855	no <sup>e</sup>	0.095	0.19
<b>Lead</b>	10	2.9	23.3	8.9	6.7	264	7.0	16,000	665	1,816	<b>yes</b>	<0.0001	<0.0001
Manganese	10	33.5	6,620	918	2,013	25	28.6	3,400	825	882	c	0.078	0.27
Mercury	10	0.070	0.15	0.11	0.026	12	0.10	4.2	0.71	1.2	c	0.0003	0.0015
<b>Molybdenum</b>	10	0.34	2.3	0.85	0.60	25	0.59	3.9	1.5	0.91	<b>yes</b>	0.0048	0.013
Nickel	10	4.3	36.8	16.2	10.6	25	1.6	37.5	18.7	10.7	no	0.32	0.76
Selenium											≥50% ND Site		
Silver	10	0.020	0.35	0.14	0.13	25	0.040	14.7	2.5	3.3	c	<0.0001	<0.0001
<b>Strontium</b>	10	7.3	39.6	16.1	11.3	17	4.8	150	52.2	40.2	<b>yes</b>	0.0027	0.0031
Thallium	10	0.024	0.12	0.062	0.032	12	0.014	1.6	0.45	0.50	c	0.0031	0.0074
Tin											≥50% ND Site		
Vanadium	10	1.3	24.7	9.7	7.6	25	0.70	46.5	14.5	12.4	c	0.19	0.52
<b>Zinc</b>	10	47.8	111	66.1	24.2	264	22.3	48,700	2,127	4,880	<b>yes</b>	<0.0001	<0.0001

**Note:** CoPC - chemical of potential concern

ND - not detected

Concentrations are given in mg/kg dry weight.

Undetected values are included at one-half the detection limit. In cases where greater than or equal to 50 percent of the site values or 100 percent of the reference values were undetected, statistical analyses were not performed. Further summary information is provided in the CoPC screening tables, including detection limits and detection frequencies.

Field replicates were averaged prior to statistical analysis.

<sup>a</sup> Results of statistical comparison. Bold indicates chemicals for which statistical testing indicated site concentrations to be greater than reference concentrations at a significance level of alpha = 0.10.

<sup>b</sup> P-values associated with comparison of site and reference mean concentrations.

Non-para. - Wilcoxon rank-sum one-sided test for determining if the site mean is significantly greater than the reference mean concentration.

Parametric - overall ANOVA model for determining if the site and reference mean concentrations are significantly different (higher or lower).

<sup>c</sup> Comparison not made because 90 percent confidence interval for the site mean concentration spans zero, due to small sample size and/or high variability.

<sup>d</sup> ANOVA p-value indicates reference mean is significantly higher than site mean concentration.

<sup>e</sup> Assumptions of ANOVA model were met, thus conclusions result from parametric p-value.

<sup>f</sup> Assumptions of ANOVA model were not met, thus conclusions result from non-parametric p-value.



**Table 3-6. Statistical comparison of site and reference stream sediment data**

Chemical	Reference					Site					Site > Reference? <sup>a</sup>	p-values <sup>b</sup>	
	N	Min	Max	Mean	Stdev	N	Min	Max	Mean	Stdev		non-para.	parametric
Aluminum	5	3,620	12,100	6,848	3,652	14	4,080	17,100	7,846	3,560	no	0.27	0.46
<b>Antimony</b>	5	0.030	0.050	0.036	0.0089	14	0.050	0.64	0.20	0.16	<b>yes</b>	0.0008	0.0002
<b>Arsenic</b>	5	3.5	8.1	5.1	1.8	14	3.3	11.4	7.8	2.1	<b>yes</b>	0.023	0.023
Barium	5	135	483	291	146	14	91.2	922	302	260	no	0.76	0.68
<b>Cadmium</b>	5	0.070	0.30	0.22	0.088	14	0.18	1.4	0.49	0.34	<b>yes</b>	0.017	0.030
Chromium	5	7.2	19.9	12.7	5.0	14	7.4	22.6	14.6	4.9	no	0.20	0.46
<b>Cobalt</b>	5	7.3	11.0	9.3	1.4	14	7.9	17.6	12.3	2.9	<b>yes</b>	0.013	0.031
<b>Copper</b>	5	6.0	18.5	11.3	4.6	14	9.7	28.2	15.9	4.8	<b>yes</b>	0.039	0.041
Fluoride											≥50% ND Site		
<b>Iron</b>	5	21,300	27,300	24,500	2,279	14	22,800	45,700	30,479	5,898	<b>yes</b>	0.015	0.030
<b>Lead</b>	5	5.1	9.2	7.6	1.7	14	8.2	142	31.7	44.4	<b>yes</b>	0.0013	0.032
<b>Manganese</b>	5	268	859	548	259	14	471	2,140	995	542	<b>yes</b>	0.029	0.040
Mercury											≥50% ND Site		
<b>Molybdenum</b>	5	0.28	0.52	0.37	0.094	14	0.34	2.3	0.82	0.54	<b>yes</b>	0.0054	0.014
<b>Nickel</b>	5	20.8	35.0	29.7	5.3	14	24.8	57.3	40.4	8.8	<b>yes</b>	0.015	0.020
<b>Selenium</b>	5	0.10	0.70	0.44	0.22	14	0.40	2.5	1.2	0.65	<b>yes</b>	0.0078	0.0049
<b>Silver</b>	5	0.030	0.12	0.07	0.036	14	0.050	0.42	0.19	0.12	<b>yes</b>	0.0087	0.011
<b>Strontium</b>	5	4.9	15.0	11.6	4.1	14	11.0	155	45.5	42.6	<b>yes</b>	0.057	0.033
<b>Thallium</b>	5	0.023	0.070	0.050	0.019	14	0.031	0.322	0.10	0.076	<b>yes</b>	0.048	0.079
Tin											≥50% ND Site		
Vanadium	5	10.7	24.8	18.2	5.1	14	8.8	27.1	16.7	5.9	no	0.63	0.55
<b>Zinc</b>	5	43.7	69.7	62.4	10.7	14	58.4	259	139	52.0	<b>yes</b>	0.0024	0.0004

**Note:** CoPC - chemical of potential concern

ND - not detected

Concentrations are given in mg/kg dry weight.

Undetected values are included at one-half the detection limit. In cases where greater than or equal to 50 percent of the site values or 100 percent of the reference values were undetected, statistical analyses were not performed. Further summary information is provided in the CoPC screening tables, including detection limits and detection frequencies.

Field replicates were averaged prior to statistical analysis.

<sup>a</sup> Results of statistical comparison. Bold indicates chemicals for which statistical testing indicated site concentrations to be greater than reference concentrations at a significance level of alpha = 0.10.

<sup>b</sup> P-values associated with comparison of site and reference mean concentrations.

Non-para. - Wilcoxon rank-sum one-sided test for determining if the site mean is significantly greater than the reference mean concentration.

Parametric - overall ANOVA model for determining if the site and reference mean concentrations are significantly different (higher or lower).

<sup>c</sup> Comparison not made because 90 percent confidence interval for the site mean concentration spans zero, due to small sample size and/or high variability.

<sup>d</sup> ANOVA p-value indicates reference mean is significantly higher than site mean concentration.

<sup>e</sup> Assumptions of ANOVA model were met, thus conclusions result from parametric p-value.

<sup>f</sup> Assumptions of ANOVA model were not met, thus conclusions result from non-parametric p-value.

**Table 3-7. Statistical comparison of site and reference stream surface water data**

Chemical	Reference					Site					Site > Reference? <sup>a</sup>	p-values <sup>b</sup>	
	N	Min	Max	Mean	Stdev	N	Min	Max	Mean	Stdev		non-para.	parametric
Aluminum	3	17.3	2,770	937	1,588	230	2.5	4,060	90.4	413	no	0.88	0.038 <sup>d</sup>
Antimony											≥50% ND Site		
Arsenic											≥50% ND Site		
Barium	3	86.1	222	159	68.5	14	12.2	266	83.6	73.9	c	0.94	0.12
Cadmium											≥50% ND Site		
Chromium											≥50% ND Site		
Cobalt	3	0.12	2.7	1.0	1.5	14	0.010	0.33	0.13	0.094	no	0.94	0.057 <sup>d</sup>
Copper	3	0.60	5.4	2.2	2.7	18	0.11	1.2	0.74	0.33	no	0.71	0.15
<b>Fluoride</b>	3	30.0	40.0	36.7	5.8	31	40.0	120	57.4	17.1	<b>yes</b>	0.0047	0.0092
Iron	3	64.2	6,710	2,295	3,823	230	2.6	10,300	318	1,078	no	0.83	0.10
Lead											≥50% ND Site		
Manganese	3	4.9	128	46.0	71.0	18	0.48	36.0	5.7	8.2	c	0.91	0.054
Mercury											≥50% ND Site		
<b>Molybdenum</b>	3	0.020	0.17	0.080	0.079	14	0.18	2.3	0.74	0.69	<b>yes</b>	0.0048	0.0015
Nickel	3	1.1	10.5	4.5	5.2	14	0.26	6.7	2.1	1.8	no	0.76	0.32
Selenium											100% ND Ref.		
Silver											≥50% ND Site		
Strontium	3	32.5	81.1	54.9	24.5	14	19.4	172	83.0	55.5	no	0.29	0.61
Thallium											≥50% ND Site		
Tin											≥50% ND Site		
Vanadium											≥50% ND Site		
Zinc											≥50% ND Site		

**Note:** CoPC - chemical of potential concern

ND - not detected

Concentrations are given in µg/L unfiltered.

Undetected values are included at one-half the detection limit. In cases where greater than or equal to 50 percent of the site values or 100 percent of the reference values were undetected, statistical analyses were not performed. Further summary information is provided in the CoPC screening tables, including detection limits and detection frequencies.

Field replicates were averaged prior to statistical analysis.

<sup>a</sup> Results of statistical comparison. Bold indicates chemicals for which statistical testing indicated site concentrations to be greater than reference concentrations at a significance level of alpha = 0.10.

<sup>b</sup> P-values associated with comparison of site and reference mean concentrations.

Non-para. - Wilcoxon rank-sum one-sided test for determining if the site mean is significantly greater than the reference mean concentration.

Parametric - overall ANOVA model for determining if the site and reference mean concentrations are significantly different (higher or lower).

<sup>c</sup> Comparison not made because 90 percent confidence interval for the site mean concentration spans zero, due to small sample size and/or high variability.

<sup>d</sup> ANOVA p-value indicates reference mean is significantly higher than site mean concentration.

<sup>e</sup> Assumptions of ANOVA model were met, thus conclusions result from parametric p-value.

<sup>f</sup> Assumptions of ANOVA model were not met, thus conclusions result from non-parametric p-value.

**Table 3-8. Statistical comparison of site and reference pond sediment data**

Chemical	Reference					Site					Site > Reference? <sup>a</sup>	p-values <sup>b</sup>	
	N	Min	Max	Mean	Stdev	N	Min	Max	Mean	Stdev		non-para.	parametric
Aluminum	5	3,730	17,100	9,908	5,750	4	1,920	4,330	3,288	1,214	no	0.97	0.039 <sup>d</sup>
<b>Antimony</b>	5	0.030	0.11	0.062	0.036	4	0.19	9.0	2.4	4.4	<b>yes</b>	0.0097	0.033
Arsenic	5	2.6	13.0	6.6	4.2	4	2.6	7.5	4.7	2.1	no	0.69	0.53
Barium	5	121	772	430	257	4	281	498	372	95.3	no	0.73	0.96
<b>Cadmium</b>	5	0.27	0.66	0.39	0.16	4	0.93	101	26.2	49.9	<b>yes</b>	0.010	0.056
Chromium	5	9.6	28.0	19.4	8.6	4	9.0	13.0	10.3	1.8	no	0.97	0.078 <sup>d</sup>
Cobalt	5	1.8	21.9	10.3	7.4	4	2.7	24.1	14.2	10.7	c	0.36	0.70
Copper	5	8.0	20.7	14.8	4.8	4	6.5	45.5	23.4	16.6	no	0.27	0.51
Fluoride											≥50% ND Site		
Iron	5	17,900	43,700	27,140	11,232	4	16,000	51,900	29,300	15,682	no	0.45	0.88
Lead	5	7.5	20.3	11.6	5.0	4	9.0	1,810	484	885	c	0.070	0.10
Manganese	5	15.9	1,870	515	766	4	79.8	745	290	312	c	0.73	0.98
Mercury	5	0.030	0.070	0.054	0.018	4	0.060	1.1	0.35	0.50	c	0.042	0.080
<b>Molybdenum</b>	5	0.38	1.4	0.70	0.40	4	1.1	2.4	1.7	0.66	<b>yes</b>	0.033	0.024
Nickel	5	12.0	70.3	39.0	21.0	4	17.6	38.9	27.6	8.7	no	0.86	0.52
Selenium	5	0.50	3.1	1.2	1.1	4	0.75	3.0	1.6	0.97	no	0.14	0.35
Silver											≥50% ND Site		
<b>Strontium</b>	5	4.2	25.4	12.2	8.1	4	17.1	86.0	37.5	32.5	<b>yes</b>	0.056	0.053
Thallium	5	0.056	0.17	0.12	0.051	4	0.021	1.6	0.43	0.81	no	0.91	0.74
Tin											≥50% ND Site		
Vanadium	5	14.9	94.5	40.8	31.1	4	12.2	28.3	17.8	7.2	no	0.94	0.11
<b>Zinc</b>	5	23.4	138	76.7	41.7	4	143	21,900	5,623	10,851	<b>yes</b>	0.010	0.083

**Note:** CoPC - chemical of potential concern

ND - not detected

Concentrations are given in mg/kg dry weight.

Undetected values are included at one-half the detection limit. In cases where greater than or equal to 50 percent of the site values or 100 percent of the reference values were undetected, statistical analyses were not performed. Further summary information is provided in the CoPC screening tables, including detection limits and detection frequencies.

Field replicates were averaged prior to statistical analysis.

<sup>a</sup> Results of statistical comparison. Bold indicates chemicals for which statistical testing indicated site concentrations to be greater than reference concentrations at a significance level of alpha = 0.10.

<sup>b</sup> P-values associated with comparison of site and reference mean concentrations.

Non-para. - Wilcoxon rank-sum one-sided test for determining if the site mean is significantly greater than the reference mean concentration.

Parametric - overall ANOVA model for determining if the site and reference mean concentrations are significantly different (higher or lower).

<sup>c</sup> Comparison not made because 90 percent confidence interval for the site mean concentration spans zero, due to small sample size and/or high variability.

<sup>d</sup> ANOVA p-value indicates reference mean is significantly higher than site mean concentration.

<sup>e</sup> Assumptions of ANOVA model were met, thus conclusions result from parametric p-value.

<sup>f</sup> Assumptions of ANOVA model were not met, thus conclusions result from non-parametric p-value.

**Table 3-9. Statistical comparison of site and reference pond surface water data**

Chemical	Reference					Site					Site > Reference? <sup>a</sup>	p-values <sup>b</sup>	
	N	Min	Max	Mean	Stdev	N	Min	Max	Mean	Stdev		non-para.	parametric
Aluminum	3	14.5	170	91.9	77.8	4	11.4	177	102	73.6	no	0.57	0.91
Antimony	3	0.020	0.10	0.057	0.040	4	0.020	0.20	0.085	0.083	c	0.50	0.78
Arsenic	3	0.50	0.90	0.63	0.23	4	0.40	1.3	0.70	0.41	no	0.57	0.93
Barium	3	48.4	133	91.6	42.3	4	39.4	73.6	57.5	17.0	no	0.94	0.23
Cadmium	3	0.0050	0.060	0.038	0.029	4	0.020	0.27	0.10	0.11	c	0.18	0.33
Chromium	3	0.18	2.0	0.96	0.92	4	0.44	5.2	2.2	2.1	c	0.30	0.33
Cobalt	3	0.19	0.70	0.37	0.29	4	0.13	1.6	0.76	0.61	no	0.30	0.46
Copper	3	0.70	2.5	1.9	1.0	4	0.40	2.7	1.3	0.98	no	0.70	0.48
Fluoride	3	10.0	50.0	26.7	20.8	4	20.0	60.0	32.5	18.9	no	0.29	0.57
Iron	3	361	1,500	808	608	4	685	1,220	1,021	238	no	0.30	0.35
Lead	3	0.060	0.56	0.37	0.27	4	0.44	1.6	0.95	0.52	no	0.11	0.15
Manganese	3	4.2	71.2	32.1	34.9	4	2.9	132	53.5	58.5	c	0.57	0.82
Mercury											≥50% ND Site		
Molybdenum	3	0.020	0.22	0.097	0.11	4	0.020	0.090	0.060	0.032	no	0.57	0.84
Nickel	3	2.1	6.4	3.6	2.4	4	3.0	5.3	4.3	1.1	no	0.30	0.44
Selenium											≥50% ND Site		
Silver											≥50% ND Site		
Strontium	3	10.6	27.5	18.7	8.5	4	10.4	422	114	205	no	0.70	0.68
Thallium											≥50% ND Site		
Tin											≥50% ND Site		
Vanadium	3	0.17	2.4	1.2	1.1	4	0.24	0.64	0.37	0.18	no	0.81	0.33
Zinc	3	0.59	5.0	2.8	2.2	4	6.1	99.0	36.7	42.9	c	0.026	0.048

**Note:** CoPC - chemical of potential concern

ND - not detected

Concentrations are given in µg/L unfiltered.

Undetected values are included at one-half the detection limit. In cases where greater than or equal to 50 percent of the site values or 100 percent of the reference values were undetected, statistical analyses were not performed. Further summary information is provided in the CoPC screening tables, including detection limits and detection frequencies.

Field replicates were averaged prior to statistical analysis.

<sup>a</sup> Results of statistical comparison. Bold indicates chemicals for which statistical testing indicated site concentrations to be greater than reference concentrations at a significance level of alpha = 0.10.

<sup>b</sup> P-values associated with comparison of site and reference mean concentrations.

Non-para. - Wilcoxon rank-sum one-sided test for determining if the site mean is significantly greater than the reference mean concentration.

Parametric - overall ANOVA model for determining if the site and reference mean concentrations are significantly different (higher or lower).

<sup>c</sup> Comparison not made because 90 percent confidence interval for the site mean concentration spans zero, due to small sample size and/or high variability.

<sup>d</sup> ANOVA p-value indicates reference mean is significantly higher than site mean concentration.

<sup>e</sup> Assumptions of ANOVA model were met, thus conclusions result from parametric p-value.

<sup>f</sup> Assumptions of ANOVA model were not met, thus conclusions result from non-parametric p-value.

**Table 3-10. Statistical comparison of site and reference lagoon sediment data**

Chemical	Reference					Site					Site > Reference? <sup>a</sup>	p-values <sup>b</sup>	
	N	Min	Max	Mean	Stdev	N	Min	Max	Mean	Stdev		non-para.	parametric
Aluminum	3	7,440	14,800	11,147	3,680	8	2,450	14,300	7,574	4,548	no	0.91	0.25
<b>Antimony</b>	3	0.010	0.12	0.077	0.059	8	0.070	0.27	0.16	0.073	<b>yes<sup>e</sup></b>	0.11	0.071
<b>Arsenic</b>	3	2.6	4.9	4.0	1.2	8	5.3	17.9	7.8	4.2	<b>yes</b>	0.0093	0.042
Barium	3	164	271	226	55.5	8	54.1	350	234	97.8	no	0.38	0.87
Cadmium	13										≥50% ND Site		
Chromium	3	12.5	24.9	19.6	6.4	8	4.1	27.2	13.8	8.6	no	0.82	0.29
Cobalt	3	5.0	9.7	6.8	2.5	8	3.9	11.8	7.1	2.8	no	0.62	0.96
Copper	3	9.9	18.7	14.7	4.5	8	3.0	28.2	14.2	8.6	no	0.54	0.66
Fluoride	3										≥50% ND Site		
Iron	3	14,000	22,200	19,233	4,546	8	10,100	75,000	27,150	21,985	no	0.62	0.71
<b>Lead</b>	28	2.4	31.0	11.1	6.6	26	4.7	302	44.4	68.8	<b>yes</b>	0.0017	0.0008
<b>Manganese</b>	3	75.5	129	99.9	27.1	8	97.9	274	158	55.9	<b>yes</b>	0.041	0.069
Mercury	3	0.030	0.060	0.050	0.017	8	0.0040	0.096	0.049	0.032	no	0.38	0.63
Molybdenum	3	0.46	0.98	0.77	0.28	8	0.41	3.4	1.4	1.2	no	0.30	0.48
Nickel	3	18.7	37.0	27.2	9.2	8	12.0	39.0	24.2	10.0	no	0.76	0.58
Selenium	3	0.60	1.4	1.1	0.44	8	0.10	2.2	1.0	0.69	no	0.73	0.58
Silver	3	0.010	0.11	0.067	0.051	8	0.020	0.27	0.12	0.083	no	0.15	0.32
Strontium	3	20.9	40.0	31.9	9.9	8	10.4	108	51.8	32.6	no	0.30	0.53
Thallium	3	0.038	0.10	0.081	0.037	8	0.018	0.18	0.075	0.056	no	0.73	0.65
Tin	3										≥50% ND Site		
Vanadium	3	16.8	31.5	25.2	7.6	8	8.5	35.1	21.7	10.7	no	0.73	0.51
<b>Zinc</b>	28	16.0	371	92.7	63.8	26	36.0	1,590	242	319	<b>yes</b>	0.0033	0.0026

**Note:** CoPC - chemical of potential concern

ND - not detected

Concentrations are given in mg/kg dry weight.

Undetected values are included at one-half the detection limit. In cases where greater than or equal to 50 percent of the site values or 100 percent of the reference values were undetected, statistical analyses were not performed. Further summary information is provided in the CoPC screening tables, including detection limits and detection frequencies.

Field replicates were averaged prior to statistical analysis.

<sup>a</sup> Results of statistical comparison. Bold indicates chemicals for which statistical testing indicated site concentrations to be greater than reference concentrations at a significance level of alpha = 0.10.

<sup>b</sup> P-values associated with comparison of site and reference mean concentrations.

Non-para. - Wilcoxon rank-sum one-sided test for determining if the site mean is significantly greater than the reference mean concentration.

Parametric - overall ANOVA model for determining if the site and reference mean concentrations are significantly different (higher or lower).

<sup>c</sup> Comparison not made because 90 percent confidence interval for the site mean concentration spans zero, due to small sample size and/or high variability.

<sup>d</sup> ANOVA p-value indicates reference mean is significantly higher than site mean concentration.

<sup>e</sup> Assumptions of ANOVA model were met, thus conclusions result from parametric p-value.

<sup>f</sup> Assumptions of ANOVA model were not met, thus conclusions result from non-parametric p-value.

**Table 3-11. Statistical comparison of site and reference lagoon surface water data**

Chemical	Reference					Site					Site > Reference? <sup>a</sup>	p-values <sup>b</sup>	
	N	Min	Max	Mean	Stdev	N	Min	Max	Mean	Stdev		non-para.	parametric
Aluminum	3	53.5	434	182	218	8	19.7	247	81.6	77.6	no	0.91	0.34
<b>Antimony</b>	3	0.11	0.13	0.12	0.010	8	0.19	0.63	0.32	0.15	<b>yes</b>	0.0093	0.0059
Arsenic	3	52.9	98.8	76.3	23.0	8	4.5	126	56.2	48.4	no	0.76	0.32
Barium	3	144	168	156	12.0	8	112	413	233	118	no	0.13	0.35
Cadmium	5	0.050	0.26	0.15	0.10	14	0.040	0.30	0.13	0.10	no	0.65	0.66
Chromium	3	6.0	8.2	7.2	1.1	8	1.7	4.5	2.7	1.1	no	0.99	0.0017 <sup>d</sup>
Cobalt	3	3.7	5.4	4.4	0.86	8	0.45	1.4	0.90	0.35	no	0.99	0.0002 <sup>d</sup>
Copper	3	0.40	1.4	0.80	0.53	8	0.50	1.4	0.96	0.29	no	0.27	0.35
<b>Fluoride</b>	3	10.0	20.0	13.3	5.8	8	50.0	200	114	73.3	<b>yes</b>	0.0083	0.0010
Iron	3	290	693	427	230	8	200	723	445	211	no	0.62	0.97
<b>Lead</b>	5	0.095	0.85	0.29	0.32	14	0.40	2.3	1.0	0.72	<b>yes</b>	0.0091	0.0015
Manganese	3	492	801	598	176	8	13.9	277	84.5	98.3	c	0.99	0.0043 <sup>d</sup>
Mercury											≥50% ND Site		
<b>Molybdenum</b>	3	0.070	0.090	0.080	0.010	8	0.30	2.4	1.2	0.85	<b>yes</b>	0.0095	0.0009
Nickel	3	9.2	15.2	11.5	3.2	8	3.5	10.6	7.1	2.7	no	0.96	0.077 <sup>d</sup>
Selenium											100% ND Ref.		
Silver	3	0.020	0.030	0.023	0.0058	8	0.010	0.25	0.11	0.092	c	0.090	0.14
Strontium	3	991	1,470	1,157	271	8	505	1,850	1,226	546	no	0.46	0.92
Thallium											≥50% ND Site		
Tin											≥50% ND Site		
Vanadium											100% ND Ref.		
Zinc	5	17.0	30.1	21.3	5.3	14	3.1	110	25.1	32.6	no	0.83	0.33

**Note:** CoPC - chemical of potential concern

ND - not detected

Concentrations are given in µg/L unfiltered, except for cadmium, lead, and zinc, which are µg/L dissolved.

Undetected values are included at one-half the detection limit. In cases where greater than or equal to 50 percent of the site values or 100 percent of the reference values were undetected, statistical analyses were not performed. Further summary information is provided in the CoPC screening tables, including detection limits and detection frequencies.

Field replicates were averaged prior to statistical analysis.

<sup>a</sup> Results of statistical comparison. Bold indicates chemicals for which statistical testing indicated site concentrations to be greater than reference concentrations at a significance level of alpha = 0.10.

<sup>b</sup> P-values associated with comparison of site and reference mean concentrations.

Non-para. - Wilcoxon rank-sum one-sided test for determining if the site mean is significantly greater than the reference mean concentration.

Parametric - overall ANOVA model for determining if the site and reference mean concentrations are significantly different (higher or lower).

<sup>c</sup> Comparison not made because 90 percent confidence interval for the site mean concentration spans zero, due to small sample size and/or high variability.

<sup>d</sup> ANOVA p-value indicates reference mean is significantly higher than site mean concentration.

<sup>e</sup> Assumptions of ANOVA model were met, thus conclusions result from parametric p-value.

<sup>f</sup> Assumptions of ANOVA model were not met, thus conclusions result from non-parametric p-value.

**Table 3-12. Statistical comparison of site and reference marine sediment data**

Chemical	Reference					Site					Site > Reference? <sup>a</sup>	p-values <sup>b</sup>	
	N	Min	Max	Mean	Stdev	N	Min	Max	Mean	Stdev		non-para.	parametric
Aluminum	15	1,970	8,000	5,043	1,731	18	1,990	6,070	4,700	1,164	no	0.72	0.75
Antimony											≥50% ND Site		
Arsenic	21	5.6	13.0	8.7	1.9	69	3.1	14.5	7.3	1.8	no	1.0	0.0047 <sup>d</sup>
<b>Barium</b>	21	22.0	431	207	100	69	79.5	639	239	98.0	<b>yes<sup>e</sup></b>	0.15	0.048
<b>Cadmium</b>	21	0.020	0.23	0.068	0.044	129	0.020	52.9	1.0	4.7	<b>yes</b>	<0.0001	<0.0001
<b>Chromium</b>	21	1.4	18.0	11.9	4.4	69	2.4	33.5	14.6	5.7	<b>yes</b>	0.092	0.055
Cobalt	9	4.2	8.7	7.2	1.7	18	3.2	8.9	6.8	1.3	no	0.80	0.57
<b>Copper</b>	21	3.0	10.2	6.4	1.7	69	3.7	34.8	7.8	4.4	<b>yes</b>	0.064	0.067
Fluoride	9	0.40	2.0	1.3	0.51	16	0.40	1.5	1.1	0.29	no	0.74	0.55
Iron	15	8,150	22,700	15,149	4,973	18	9,960	19,300	15,987	2,570	no	0.21	0.33
Lead	21	2.7	11.2	5.3	1.7	129	1.6	5,620	58.5	494	c	<0.0001	0.0003
Manganese	9	187	389	301	71.7	18	161	363	276	59.6	no	0.77	0.42
Mercury											≥50% ND Site		
Molybdenum	9	0.44	0.83	0.57	0.12	18	0.37	1.4	0.58	0.26	no	0.77	0.77
Nickel	15	9.8	34.8	22.5	7.2	18	11.3	33.3	24.3	6.3	no	0.21	0.43
Selenium											≥50% ND Site		
<b>Silver</b>	21	0.020	0.49	0.12	0.17	69	0.030	2.1	0.50	0.61	<b>yes</b>	0.0007	0.013
<b>Strontium</b>	9	13.0	29.0	24.0	5.5	17	24.4	33.8	28.0	2.5	<b>yes</b>	0.073	0.018
Thallium	9	0.025	0.052	0.037	0.0096	17	0.026	1.1	0.098	0.27	no	0.66	0.65
Tin											≥50% ND Site		
Vanadium	9	13.0	33.9	22.2	6.6	41	9.1	46.0	27.9	9.7	no <sup>e</sup>	0.045	0.19
<b>Zinc</b>	21	25.0	56.8	42.2	8.5	129	5.5	2,550	87.3	237	<b>yes</b>	0.0032	0.070

**Note:** CoPC - chemical of potential concern

ND - not detected

Concentrations are given in mg/kg dry weight.

Undetected values are included at one-half the detection limit. In cases where greater than or equal to 50 percent of the site values or 100 percent of the reference values were undetected, statistical analyses were not performed. Further summary information is provided in the CoPC screening tables, including detection limits and detection frequencies.

Field replicates were averaged prior to statistical analysis.

<sup>a</sup> Results of statistical comparison. Bold indicates chemicals for which statistical testing indicated site concentrations to be greater than reference concentrations at a significance level of alpha = 0.10.

<sup>b</sup> P-values associated with comparison of site and reference mean concentrations.

Non-para. - Wilcoxon rank-sum one-sided test for determining if the site mean is significantly greater than the reference mean concentration.

Parametric - overall ANOVA model for determining if the site and reference mean concentrations are significantly different (higher or lower).

<sup>c</sup> Comparison not made because 90 percent confidence interval for the site mean concentration spans zero, due to small sample size and/or high variability.

<sup>d</sup> ANOVA p-value indicates reference mean is significantly higher than site mean concentration.

<sup>e</sup> Assumptions of ANOVA model were met, thus conclusions result from parametric p-value.

<sup>f</sup> Assumptions of ANOVA model were not met, thus conclusions result from non-parametric p-value.

**Table 3-13. Statistical comparison of site and reference marine surface water data**

Chemical	Reference					Site					Site > Reference? <sup>a</sup>	p-values <sup>b</sup>	
	N	Min	Max	Mean	Stdev	N	Min	Max	Mean	Stdev		non-para.	parametric
Aluminum	6	25.0	336	170	148	9	25.0	205	102	69.7	no	0.74	0.66
Antimony	6	0.20	1.7	0.70	0.62	9	0.20	1.9	0.64	0.55	no	0.52	0.97
Arsenic	6	1.1	7.5	3.8	2.9	9	1.5	6.0	3.2	1.7	no	0.57	0.91
Barium	6	9.9	38.1	23.2	14.1	9	12.1	39.4	21.3	10.6	no	0.38	0.96
Cadmium	6	2.3	4.7	3.5	1.2	9	1.6	4.6	2.9	1.3	no	0.94	0.34
Chromium											≥50% ND Site		
Cobalt	6	4.0	4.5	4.3	0.17	9	3.9	4.6	4.2	0.22	no	0.76	0.61
Copper											≥50% ND Site		
Fluoride	6	600	800	700	110	9	500	900	733	158	no	0.31	0.75
Iron	6	33.6	643	314	306	9	52.3	375	171	133	no	0.52	0.80
Lead	6	0.76	1.3	0.99	0.18	9	0.80	1.3	1.0	0.21	no	0.48	0.88
Manganese	6	10.1	25.5	17.0	7.3	9	13.1	31.9	19.2	5.9	no	0.34	0.40
Mercury											≥50% ND Site		
Molybdenum	6	8.3	10.6	9.5	0.93	9	8.4	11.0	9.9	1.1	no	0.14	0.47
Nickel											≥50% ND Site		
<b>Selenium</b>	6	0.20	0.50	0.28	0.12	9	0.20	1.0	0.49	0.24	<b>yes</b>	0.027	0.047
<b>Silver</b>	6	0.10	0.27	0.18	0.066	9	0.10	0.95	0.40	0.28	<b>yes<sup>f</sup></b>	0.082	0.11
<b>Strontium</b>	6	4,530	5,290	4,900	369	9	4,420	5,600	5,128	444	<b>yes<sup>f</sup></b>	0.088	0.33
Thallium											≥50% ND Site		
Tin											≥50% ND Site		
Vanadium											≥50% ND Site		
Zinc											≥50% ND Site		

**Note:** CoPC - chemical of potential concern

ND - not detected

Concentrations are given in µg/L unfiltered.

Undetected values are included at one-half the detection limit. In cases where greater than or equal to 50 percent of the site values or 100 percent of the reference values were undetected, statistical analyses were not performed. Further summary information is provided in the CoPC screening tables, including detection limits and detection frequencies.

Field replicates were averaged prior to statistical analysis.

<sup>a</sup> Results of statistical comparison. Bold indicates chemicals for which statistical testing indicated site concentrations to be greater than reference concentrations at a significance level of alpha = 0.10.

<sup>b</sup> P-values associated with comparison of site and reference mean concentrations.

Non-para. - Wilcoxon rank-sum one-sided test for determining if the site mean is significantly greater than the reference mean concentration.

Parametric - overall ANOVA model for determining if the site and reference mean concentrations are significantly different (higher or lower).

<sup>c</sup> Comparison not made because 90 percent confidence interval for the site mean concentration spans zero, due to small sample size and/or high variability.

<sup>d</sup> ANOVA p-value indicates reference mean is significantly higher than site mean concentration.

<sup>e</sup> Assumptions of ANOVA model were met, thus conclusions result from parametric p-value.

<sup>f</sup> Assumptions of ANOVA model were not met, thus conclusions result from non-parametric p-value.



**Table 3-14. Human health chemical of potential concern screening results for surface soil**

Scenario Timeframe: Current/Future  
 Medium: Soil  
 Exposure Medium: Surface Soil

Exposure Point	Chemical	Minimum Detected Concentration	Maximum Detected Concentration	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening <sup>a</sup>	Reference Range <sup>b</sup>	Residential Screening Toxicity Value <sup>c</sup>	Frequency of Detected Values Exceeding Criteria	Frequency of Reference Values Exceeding Criteria	Non-Residential Screening Toxicity Value <sup>d</sup>	CoPC Flag (Y/N)	Rationale for Selection or Deletion
<b>All Site Surface Soil</b>															
	Aluminum	1,180	16,600	mg/kg	RF-05	51/51	--	16,600	1,640–12,400	13,688 N	2/51	0/10	255,500 N	No	REF
	Antimony	0.38 <i>J</i>	14.8	mg/kg	CAG-W29	13/40	5–26	14.8	0.17–0.6	5.5 N	1/40	0/5	102 N	Yes	ASL
	Arsenic	1.3	93.6	mg/kg	CAG-H30	54/75	10–51	93.6	4.15–35	0.8 C	54/75	10/10	77 C	No	REF
	Barium	357	7,090	mg/kg	RF-07	40/40	--	7,090	109–622	960 N	35/40	0/5	17,885 N	Yes	ASL
	Cadmium	1.0	388 <i>J</i>	mg/kg	CAG-H30	430/478	0.4–2.5	388	0.24–3.59	14 N	236/478	0/10	256 N	Yes	ASL
	Chromium	4.86	24	mg/kg	RF-05	40/40	--	24	4.94–19.3	41 N	0/40	0/5	767 N	No	REF/BSL
	Cobalt	4.21	27	mg/kg	RF-05	39/40	5–5	27	7.28–20.6	274 N	0/40	0/5	5,110 N	No	REF/BSL
	Copper	9.76	109	mg/kg	RAT5-0NA	40/40	--	109	14.3–46.5	548 N	0/40	0/5	10,220 N	No	BSL
	Fluoride	0.5 <i>J</i>	1.3 <i>J</i>	mg/kg	RF-16	9/12	0.4–0.4	1.3	0.3–0.5	821 N	0/12	0/5	15,330 N	No	BSL
	Iron	2,650	35,000	mg/kg	CAG-W29	51/51	--	35,000	5,750–72,600	4,106 N	49/51	10/10	76,650 N	No	REF
	Lead	13.5	48,300	mg/kg	1007468	467/479	8.5–12	48,300	8.75–142	400 N	279/479	0/10	1,000 N	Yes	ASL
	Manganese	280	1,000	mg/kg	170_C1	40/40	--	1,000	250–4,080	329 N	37/40	4/5	6,132 N	No	REF
	Mercury	0.1	1.69	mg/kg	RF-107	12/12	--	1.69	0.05–0.18	2.6 N	0/12	0/5	77 N	No	BSL
	Molybdenum	0.35	3.3	mg/kg	RF-07	16/40	0.9–5.1	3.3	0.27–2.8	68 N	0/40	0/5	1,278 N	No	BSL
	Nickel	17.3	56.8	mg/kg	RC-06-A	40/40	--	56.8	23.5–51.4	270 N	0/40	0/5	5,110 N	No	REF/BSL
	Selenium	0.3 <i>J</i>	3 <i>J</i>	mg/kg	RF-107	12/30	10–51	3	0.5–1	68 N	0/30	0/5	1,278 N	No	BSL
	Silver	0.14	8.3	mg/kg	RAT5-0NA	21/40	0.9–5.1	8.3	0.05–0.25	68 N	0/40	0/5	1,278 N	No	BSL
	Strontium	36.2	90.1	mg/kg	RF-16	20/20	--	90.1	9.3–63.6	8,213 N	0/20	0/5	153,300 N	No	BSL
	Thallium	0.112	1.32	mg/kg	RF-32	12/12	--	1.32	0.1–0.24	0.9 N	1/12	0/5	17 N	Yes	ASL
	Tin	3.9 <i>J</i>	6 <i>J</i>	mg/kg	RF-27	2/27	2.25–26	6	ND	8,213 N	0/27	0/5	153,300 N	No	BSL
	Vanadium	7.94	31.8	mg/kg	RF-05	40/40	--	31.8	5.62–19.2	96 N	0/40	0/5	1,789 N	No	BSL
	Zinc	37.4	64,300	mg/kg	CAG-H30	479/479	--	64,300	72.5–753	4,100 N	158/479	0/10	76,650 N	Yes	ASL

**Note:** All results reported as dry weight.

For the purposes of screening, field replicates have been averaged.

- - not applicable
- C - carcinogenic based on a cancer risk of  $1 \times 10^{-6}$
- CoPC - chemical of potential concern
- J* - estimated value
- N - noncarcinogenic based on hazard quotient of 0.1
- ND - not detected

  - indicates a change relative to 2/3/04 Draft Risk Assessment Work Plan results

**Rationale Codes:**

**Selection Reason:**

- ASL - above screening levels

**Deletion Reason:**

- BSL - below screening level
- REF - below or consistent with reference levels

<sup>a</sup> The maximum detected soil concentration was used for screening CoPCs.

<sup>b</sup> The reference range corresponds to road material site soil samples from areas not affected by fugitive dust.

<sup>c</sup> Residential screening toxicity values represent arctic zone soil cleanup levels (from 18 AAC 75.341, Table B1) divided by 10. Where no Table B1 value exists, screening values were calculated based on residential formulas and input parameters provided in DEC (2002).

<sup>d</sup> Non-residential screening toxicity values using industrial formulas and input parameters provided in DEC (2000).

**Table 3-15. Human health screening results for drinking water ingestion in stream surface water**

Scenario Timeframe: Current/Future  
 Medium: Water  
 Exposure Medium: Stream Surface Water for Drinking Water Ingestion

Exposure Point	Chemical	Minimum Detected Concentration	Maximum Detected Concentration	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening <sup>a</sup>	Reference Range <sup>b</sup>	Screening Toxicity Value <sup>c</sup>	Potential ARAR/TBC Value	Potential ARAR/TBC Source <sup>d</sup>	Frequency of Detected Values Exceeding Criteria	Frequency of Reference Values Exceeding Criteria	CoPC Flag (Y/N)	Rationale for Selection or Deletion
<b>All Site Stream Surface Water</b>																
	Aluminum	6.45	4,060	µg/L	StrRd	133/230	2.52–10	4,060	17.3–2,770	3,650 N	50–200	MCL	2/230	0/3	No	REF
	Antimony	0.14	0.6	µg/L	NHDowRd	6/14	0.063	0.6	ND–0.08	0.6 N	6	MCL	1/14	0/3	No	BSL
	Arsenic	ND	ND	µg/L	--	0/14	0.482	ND	ND–2.2	5 C	50	MCL	ND	0/3	No	ND/BSL
	Barium	12.2	266	µg/L	NHNFUp	14/14	--	266	86.1–222	200 N	2,000	MCL	1/14	1/3	No	REF
	Cadmium	0.03	0.40	µg/L	Various	24/229	0.02–0.25	0.4	0.01–0.07	0.5 N	5	MCL	0/229	0/3	No	BSL
	Chromium	ND	ND	µg/L	--	0/18	0.4	ND	0.17–3.71	10 N	100	MCL	ND	0/3	No	ND/BSL
	Cobalt	0.03	0.33	µg/L	NHRoad	12/14	0.01	0.33	0.12–2.72	73 N	--	--	0/14	0/3	No	BSL/REF
	Copper	0.3	1.2	µg/L	OmiDowRd	16/18	0.11	1.2	0.6–5.4	130 N	1,300	MCL	0/18	0/3	No	BSL/REF
	Fluoride	40	120	µg/L	NHRoad	27/31	50	120	30–40	219,000 N	--	--	0/31	0/3	No	BSL
	Iron	6	10,300	µg/L	StrRd	186/230	2.57–25	10,300	64.2–6,710	1,095 N	300	MCL	11/230	1/3	No	REF
	Lead	0.0	7.34	µg/L	StrDowRd	84/230	0.02–0.401	7.34	0.02–1.91	1.5 N	15	MCL	5/230	1/3	Yes	ASL
	Manganese	0.56	36	µg/L	MudLkCr	18/18	--	36	4.87–128	87.6 N	50	MCL	0/18	1/3	No	BSL/REF <sup>e</sup>
	Mercury	ND	ND	µg/L	--	0/14	0.0179	ND	ND	0.2 N	2	MCL	ND	ND	No	ND/BSL
	Molybdenum	0.37	2.27	µg/L	NHDowRd	11/14	0.178	2.27	0.05–0.17	18.25 N	--	--	0/14	0/3	No	BSL
	Nickel	0.26	6.71	µg/L	NHRoad	14/14	--	6.71	1.06–10.5	10 N	100	MCL	0/14	1/3	No	BSL/REF
	Selenium	0.067	1.24	µg/L	TutMth	15/29	0.0201	1.24	ND	5 N	50	MCL	0/29	ND	No	BSL
	Silver	ND	ND	µg/L	--	0/14	0.023	ND	ND–0.03	18 N	100	MCL	ND	0/3	No	ND/BSL
	Strontium	19.4	172	µg/L	NHDowRd	14/14	--	172	32.5–81.1	2,190 N	--	--	0/14	0/3	No	BSL/REF
	Thallium	0.04	0.55	µg/L	AufRd	9/29	0.0155–0.07	0.55	ND–0.014	0.2 N	2	MCL	1/29	0/3	Yes	ASL
	Tin	1.3	5.33	µg/L	OmiNFUp	5/14	0.59	5.33	ND	2,190 N	--	--	0/14	ND	No	BSL
	Vanadium	0.67	0.93	µg/L	ARC-U	4/14	0.335	0.93	0.16–5.57	26 N	--	--	0/14	0/3	No	BSL/REF <sup>e</sup>
	Zinc	1.0	60.1	µg/L	TutDowRd	107/230	0.5–5	60	0.31–9.84	1,100 N	5,000	MCL	0/230	0/3	No	BSL

**Note:** All results reported as unfiltered.  
 For the purposes of screening, field replicates have been averaged.  
 -- - not applicable  
 ARAR - applicable or relevant and appropriate requirement  
 C - carcinogenic based on a cancer risk of 1x10<sup>-6</sup>  
 CoPC - chemical of potential concern  
 J - estimated value  
 MCL - maximum contaminant level  
 N - noncarcinogenic based on hazard quotient of 0.1  
 ND - not detected  
 TBC - to be considered  
 [Yellow Box] - indicates a change relative to 2/3/04 Draft Risk Assessment Work Plan results

**Rationale Codes:**  
 Selection Reason:  
 ASL - above screening levels  
 Deletion Reason:  
 BSL - below screening level  
 ND - not detected in any site sample  
 REF - below or consistent with reference levels

<sup>a</sup> The maximum detected stream surface water concentration was used for screening CoPCs.

<sup>b</sup> The reference range corresponds to stream surface water samples taken from areas not affected by fugitive dust.

<sup>c</sup> Screening toxicity values represent arctic zone drinking water cleanup levels (from 18 AAC 75.345, Table C) divided by 10. Where no Table C value exists, screening values were calculated based on residential drinking water formulas and input parameters provided in DEC (2002).

<sup>d</sup> An ARAR listed as an MCL is a maximum contaminant level derived by EPA, and is considered protective of the water body for use as the sole domestic drinking water source.

<sup>e</sup> The maximum site concentration of the analyte was less than the maximum reference concentration.

**Table 3-16. Human health screening results for fish consumption in stream surface water**

Scenario Timeframe: Current/Future  
 Medium: Water  
 Exposure Medium: Stream Surface Water for Fish Consumption

Exposure Point	Chemical	Minimum Detected	Maximum Detected	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening <sup>a</sup>	Reference Range <sup>b</sup>	Screening Toxicity Value <sup>c</sup>	Potential ARAR/TBC Value	Potential ARAR/TBC Source <sup>d</sup>	Frequency of Detected Values Exceeding Criteria	Frequency of Reference Values Exceeding Criteria	CoPC Flag (Y/N)	Rationale for Selection or Deletion
		Concentration	Concentration										Criteria	Criteria		
<b>All Site Stream Surface Water</b>																
	Aluminum	6.45	4,060	µg/L	StrRd	133/230	2.52–10	4,060	17.3–2,770	--	--	--	--	--	No	REF
	Antimony	0.14	0.6	µg/L	NHDowRd	6/14	0.063	0.6	ND–0.08	1.4 N	--	--	0/14	0/3	No	BSL
	Arsenic	ND	ND	µg/L	--	0/14	0.482	ND	ND–2.2	0.018 C	0.00982	WDOE	ND	1/3	No	ND/BSL
	Barium	12.2	266	µg/L	NHNFUp	14/14	--	266	86.1–222	--	--	--	--	--	No	REF
	Cadmium	0.03	0.40	µg/L	Various	24/229	0.02–0.25	0.4	0.01–0.07	--	5.06	WDOE	--	--	No	BWC
	Chromium	ND	ND	µg/L	--	0/18	0.4	ND	0.17–3.71	--	203	WDOE	--	--	No	ND/BWC
	Cobalt	0.03	0.33	µg/L	NHRoad	12/14	0.01	0.33	0.12–2.72	--	--	--	--	--	No	REF
	Copper	0.3	1.2	µg/L	OmiDowRd	16/18	0.11	1.2	0.6–5.4	130 N	2,660	WDOE	0/18	0/3	No	BSL/REF
	Fluoride	40	120	µg/L	NHRoad	27/31	50	120	30–40	--	--	--	--	--	No	NSC
	Iron	6	10,300	µg/L	StrRd	186/230	2.57–25	10,300	64.2–6,710	--	--	--	--	--	No	REF
	Lead	0.0	7.34	µg/L	StrDowRd	84/230	0.02–0.401	7.34	0.02–1.91	--	--	--	--	--	No	NSC
	Manganese	0.56	36	µg/L	MudLkCr	18/18	--	36	4.87–128	5 N	--	--	--	--	No	REF <sup>e</sup>
	Mercury	ND	ND	µg/L	--	0/14	0.0179	ND	ND	0.005 N	--	--	--	--	No	ND
	Molybdenum	0.37	2.27	µg/L	NHDowRd	11/14	0.178	2.27	0.05–0.17	--	--	--	--	--	No	NSC
	Nickel	0.26	6.71	µg/L	NHRoad	14/14	--	6.71	1.06–10.5	61 N	1,100	WDOE	0/14	1/3	No	BSL/REF
	Selenium	0.067	1.24	µg/L	TutMth	15/29	0.0201	1.24	ND	17 N	--	--	0/29	ND	No	BSL
	Silver	ND	ND	µg/L	--	0/14	0.023	ND	ND–0.03	--	6,480	WDOE	--	--	No	ND/BWC
	Strontium	19.4	172	µg/L	NHDowRd	14/14	--	172	32.5–81.1	--	--	--	--	--	No	REF
	Thallium	0.04	0.55	µg/L	AufRd	9/29	0.0155–0.07	0.55	ND–0.014	0.17 N	1.56	WDOE	3/29	0/3	Yes	ASL
	Tin	1.3	5.33	µg/L	OmiNFUp	5/14	0.59	5.33	ND	--	--	--	--	--	No	NSC
	Vanadium	0.67	0.93	µg/L	ARC-U	4/14	0.335	0.93	0.16–5.57	--	--	--	--	--	No	REF <sup>e</sup>
	Zinc	1.0	60.1	µg/L	TutDowRd	107/230	0.5–5	60	0.31–9.84	910 N	16,500	WDOE	0/230	0/3	No	BSL

**Note:** All results reported as unfiltered.  
 For the purposes of screening, field replicates have been averaged.  
 -- - not applicable  
 ARAR - applicable or relevant and appropriate requirement  
 AWQC - Alaska water quality criteria  
 C - carcinogenic based on a cancer risk of 1x10<sup>-6</sup>  
 CoPC - chemical of potential concern  
 J - estimated value  
 N - noncarcinogenic based on hazard quotient of 0.1  
 ND - not detected  
 TBC - to be considered  
 WDOE - Washington State Department of Ecology  
 [Yellow Box] - indicates a change relative to 2/3/04 Draft Risk Assessment Work Plan results

**Rationale Codes:**  
 Selection Reason:  
 ASL - above screening levels  
 Deletion Reason:  
 BSL - below screening level  
 BWC - no AWQC available, but below WDOE surface water criteria for bioaccumulation in fish  
 ND - not detected in any site sample  
 NSC - no screening criteria  
 REF - below or consistent with reference levels

<sup>a</sup> The maximum detected stream surface water concentration was used for screening CoPCs.  
<sup>b</sup> The reference range corresponds to stream surface water samples taken from areas not affected by fugitive dust.  
<sup>c</sup> Screening toxicity values represent the AWQC protective for human consumption of fish/shellfish and domestic drinking water usage from the water body (ADEC 2003). The AWQC were modified, when necessary, to assume a target hazard quotient of 0.1. The arsenic screening toxicity value is a federal ambient water quality criteria (U.S. EPA 2002c) and assumes a target risk of 10<sup>-6</sup>. The ARAR represents the Washington State cleanup level for surface water and is protective of bioaccumulation into, and human consumption of, seafood (WDOE 1996).  
<sup>d</sup> The ARARs represent the Washington State Department of Ecology cleanup level for surface water and are protective of bioaccumulation into, and human consumption of, fish (WDOE 1996).  
<sup>e</sup> The maximum site concentration of the analyte was less than the maximum reference concentration.

**Table 3-17. Human health screening results for lagoon water**

Scenario Timeframe: Current/Future  
 Medium: Lagoon Water  
 Exposure Medium: Lagoon Water

Exposure Point	Chemical	Minimum Detected Concentration	Maximum Detected Concentration	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening <sup>a</sup>	Reference Range <sup>b</sup>	Screening Toxicity Value <sup>c</sup>	Potential ARAR/TBC Value	Potential ARAR/TBC Source <sup>d</sup>	Frequency of Detected Values Exceeding Criteria	Frequency of Reference Values Exceeding Criteria	CoPC Flag (Y/N)	Rationale for Selection or Deletion
<b>Lagoon Water</b>																
	Aluminum	19.7	247	µg/L	IP-04	8/8		247	53.5–434	--	--	--	--	--	No	REF
	Antimony	0.19	0.63	µg/L	PLNL	8/8		0.63	0.11–0.13	430 N	--	--	0/8	0/3	No	BSL
	Arsenic	4.5	126	µg/L	IP-04	8/8		126	52.9–98.8	0.14 C	0.00982	WDOE	8/8	3/3	No	REF
	Barium	112	413	µg/L	PLNL	8/8		413	144–168	--	--	--	--	--	No	REF
	Cadmium	0.04 J	0.3	µg/L	NLH	11/14	0.1	0.3	ND–0.26	--	5.06	WDOE	--	--	No	REF/BWC
	Chromium	1.69	4.49	µg/L	IP-04	8/8		4.49	5.96–8.22	--	203	WDOE	--	--	No	REF/BWC
	Cobalt	0.45	1.38	µg/L	PLNL	8/8		1.38	3.7–5.35	--	--	--	--	--	No	REF
	Copper	0.5 J	1.4	µg/L	IP-03	8/8		1.4	0.4–1.4	--	2,660	WDOE	--	--	No	REF/BWC
	Fluoride	50 J	200	µg/L	IP-01,IP-02,IP-04	8/8		200	ND–20	--	--	--	--	--	No	NSC
	Iron	200	723	µg/L	PLNN	8/8		723	290–693	--	--	--	--	--	No	REF
	Lead	0.4	2.3	µg/L	PLNP	14/14		2.3	ND–0.85	--	--	--	--	--	No	NSC
	Manganese	13.9	277	µg/L	PLNN	8/8		277	492–801	10 N	--	--	--	--	No	REF
	Mercury	ND	ND	µg/L	ND	0/8		ND	ND	0.005 N	--	--	--	--	No	ND
	Molybdenum	0.3	2.41	µg/L	IP-04	8/8	0.1	2.41	0.07–0.09	--	--	--	--	--	No	NSC
	Nickel	3.5	10.6	µg/L	IP-01	8/8		10.6	9.9–15.2	460 N	1,100	WDOE	0/8	0/3	No	REF/BSL
	Selenium	0.3 J	0.6 J	µg/L	PLNN	5/8	0.4	0.6	ND	1,100 N	--	--	0/8	0/3	No	BSL
	Silver	0.01 J	0.25	µg/L	PLNL	7/8	0.1	0.25	0.02–0.03	--	6,480	WDOE	--	--	No	BWC
	Strontium	505	1,850	µg/L	PLNN	8/8		1,850	991–1,470	--	--	--	--	--	No	REF
	Thallium	0.007 J	0.07 J	µg/L	NLF,PLNL	4/8	0.026-0.06	0.07	0.006–0.009	0.63 N	1.56	WDOE	0/8	0/3	No	BSL
	Tin	23.7 J	23.7 J	µg/L	NLF	1/8	20	23.7	ND	--	--	--	--	--	No	NSC
	Vanadium	0.22	0.85 J	µg/L	IP-04	5/8	0.36-0.8	0.85	ND	--	--	--	--	--	No	NSC
	Zinc	3.09 J	110	µg/L	NLH	14/14		110	ND–30.1	6,900 N	16,500	WDOE	0/14	0/3	No	REF/BSL

**Note:** All results reported as unfiltered.

For the purposes of screening, field replicates have been averaged.

-- - not applicable

ARAR - applicable or relevant and appropriate requirement

AWQC - ambient water quality criteria

C - carcinogenic based on a cancer risk of  $1 \times 10^{-6}$

CoPC - chemical of potential concern

J - estimated value

N - noncarcinogenic based on hazard quotient of 0.1

ND - not detected

TBC - to be considered

WDOE - Washington State Department of Ecology

Yellow box - indicates a change relative to 2/3/04 Draft Risk Assessment Work Plan results

**Rationale Codes:**

**Selection Reason:**

ASL - above screening levels

**Deletion Reason:**

BSL - below screening level

BWC - no AWQC available, but below WDOE surface water criteria for bioaccumulation in fish

ND - not detected in any site sample

NSC - no screening criteria

REF - below or consistent with reference levels

<sup>a</sup> The maximum detected lagoon surface water concentration was used for screening CoPCs.

<sup>b</sup> The reference range corresponds to lagoon surface water samples taken from areas not affected by fugitive dust.

<sup>c</sup> Screening toxicity values represent the AWQC protective for human consumption of fish/shellfish and domestic drinking water usage from the water body (ADEC 2003). The AWQC were modified, when necessary, to assume a target hazard quotient of 0.1. The arsenic screening toxicity value is a federal ambient water quality criterion (U.S. EPA 2002c) and assumes a target risk of  $10^{-6}$ . The ARAR represents the Washington State cleanup level for surface water and is protective of bioaccumulation into, and human consumption of, seafood (WDOE 1996).

<sup>d</sup> The ARARs represent the Washington State Department of Ecology cleanup level for surface water and are protective of bioaccumulation into, and human consumption of, fish (WDOE 1996).

**Table 3-18. Human health screening results for marine surface water**

Scenario Timeframe: Current/Future  
 Medium: Marine Water  
 Exposure Medium: Marine Surface Water

Exposure Point	Chemical	Minimum	Maximum	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening <sup>a</sup>	Reference Range <sup>b</sup>	Screening Toxicity Value <sup>c</sup>	Potential ARAR/TBC Value	Potential ARAR/TBC Source <sup>d</sup>	Frequency of Detected Values	Frequency of Reference Values	CoPC Flag (Y/N)	Rationale for Selection or Deletion
		Detected Concentration	Detected Concentration										Exceeding Criteria	Exceeding Criteria		
<b>Marine Water</b>																
	Aluminum	43	205	µg/L	NML	8/9	25	205	ND-336	--	--	--	--	--	No	REF
	Antimony	0.30 <i>J</i>	1.88 <i>J</i>	µg/L	NML	5/9	0.2-0.4	1.88	ND-1.67	430 <i>N</i>	--	--	0/9	0/6	No	REF/BSL
	Arsenic	1.5 <i>J</i>	6.0 <i>J</i>	µg/L	NMAA	7/9	3	6	ND-7.5	0.14 <i>C</i>	0.00982	WDOE	7/9	5/6	No	REF
	Barium	12.1	39.4	µg/L	NMK	9/9	--	39.4	9.91-38.1	--	--	--	--	--	No	REF
	Cadmium	1.6	4.6	µg/L	NML	9/9	--	4.6	2.27-4.69	--	5.06	WDOE	--	--	No	REF/BWC
	Chromium	ND	ND	µg/L	--	0/9	1-2	ND	ND	--	203	WDOE	--	--	No	ND/BSL
	Cobalt	3.85	4.60	µg/L	NMG	9/9	--	4.6	4.03-4.48	--	--	--	--	--	No	REF
	Copper	1.0	3.6	µg/L	NML	4/9	4	3.6	ND-2.6	--	2,660	WDOE	--	--	No	BWC
	Fluoride	500	900	µg/L	NMAA, NMG, NML	9/9	--	900	600-800	--	--	--	--	--	No	REF
	Iron	52	375	µg/L	NMAA	9/9	--	375	33.6-643	--	--	--	--	--	No	REF
	Lead	0.8 <i>J</i>	1.34	µg/L	NMAA	9/9	--	1.34	0.76-1.25	--	--	--	--	--	No	REF
	Manganese	13.1	31.9	µg/L	NMK	9/9	--	31.9	10.1-25.5	10 <i>N</i>	--	--	--	--	No	REF
	Mercury	ND	ND	µg/L	--	0/9	0.05	ND	ND	0.005 <i>N</i>	--	--	--	--	No	ND/BSL
	Molybdenum	8.4	11	µg/L	NMAA, NMG, NML	9/9	--	11	8.26-10.6	--	--	--	--	--	No	REF
	Nickel	ND	ND	µg/L	--	0/9	2-10	ND	ND	460 <i>N</i>	1,100	WDOE	0/9	0/6	No	ND/BSL
	Selenium	0.3 <i>J</i>	1 <i>J</i>	µg/L	NMG	8/9	0.2	1	ND-0.5	1,100 <i>N</i>	--	--	0/9	0/6	No	BSL
	Silver	0.4	0.95	µg/L	NMAA	5/9	0.1-0.2	0.95	ND-0.27	--	6,480	WDOE	--	--	No	BWC
	Strontium	4,420	5,600 <i>J</i>	µg/L	NMG, NML	9/9	--	5,600	4,530-5,290	--	--	--	--	--	No	NSC
	Thallium	0.09 <i>J</i>	0.09 <i>J</i>	µg/L	NMAA	1/9	0.05-0.1	0.09	ND-0.133	0.63 <i>N</i>	1.56	WDOE	0/9	0/6	No	BSL/REF <sup>e</sup>
	Tin	23.3 <i>J</i>	23.3 <i>J</i>	µg/L	NMAA	1/9	3-10	23.3	ND-26.4	--	--	--	--	--	No	REF <sup>e</sup>
	Vanadium	4.44 <i>J</i>	5.27 <i>J</i>	µg/L	NMK	2/9	1.4-2	5.27	ND-8.44	--	--	--	--	--	No	REF <sup>e</sup>
	Zinc	ND	ND	µg/L	--	0/9	1	ND	ND	6,900 <i>N</i>	16,500	WDOE	0/9	0/6	No	ND/BSL

**Note:** All results reported as unfiltered.

For the purposes of screening, field replicates have been averaged.

-- - not applicable

ARAR - applicable or relevant and appropriate requirement

AWQC - ambient water quality criteria

C - carcinogenic based on a cancer risk of  $1 \times 10^{-6}$

CoPC - chemical of potential concern

*J* - estimated value

N - noncarcinogenic based on hazard quotient of 0.1

ND - not detected

TBC - to be considered

WDOE - Washington State Department of Ecology

  - indicates a change relative to 2/3/04 Draft Risk Assessment Work Plan results

**Rationale Codes:**

**Selection Reason:**

ASL - above screening levels

**Deletion Reason:**

BSL - below screening level

BWC - no AWQC available, but below WDOE surface water criteria for bioaccumulation in fish

ND - not detected in any site sample

REF - below or consistent with reference levels

<sup>a</sup> The maximum detected marine surface water concentration was used for screening CoPCs.

<sup>b</sup> The reference range corresponds to marine surface water samples taken from areas not affected by fugitive dust.

<sup>c</sup> Screening toxicity values represent the AWQC protective for human consumption of fish/shellfish and domestic drinking water usage from the water body (ADEC 2003). The AWQC were modified, when necessary, to assume a target hazard quotient of 0.1. The arsenic screening toxicity value is a federal ambient water quality criterion (U.S. EPA 2002c) and assumes a target risk of  $10^{-6}$ . The ARAR represents the Washington State cleanup level for surface water and is protective of bioaccumulation into, and human consumption of, seafood (WDOE 1996).

<sup>d</sup> The ARARs represent the Washington State Department of Ecology cleanup level for surface water and are protective of bioaccumulation into, and human consumption of, fish (WDOE 1996).

<sup>e</sup> The maximum site concentration of the analyte was less than the maximum reference concentration.

**Table 3-39. Results of statistical comparison with reference data**

Chemical	Environment								
	Terrestrial	Streams		Ponds		Lagoons		Marine	
	Tundra Soil	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	Water
Aluminum	Pass	--	Pass	--	Pass	Pass	Pass	Pass	Pass
Antimony	NA	Fail	NA	Fail	NA	Fail	Fail	NA	Pass
Arsenic	Fail	Fail	--	--	--	Fail	Pass	Pass	--
Barium	NA	Pass	NA	Pass	Pass	Pass	Pass	Fail	Pass
Cadmium	Fail	Fail	NA	Fail	NA	NA	--	Fail	--
Chromium	Pass	--	--	--	--	--	--	--	--
Cobalt	NA	Fail	Pass	NA	Pass	Pass	Pass	Pass	Pass
Copper	Fail	--	--	Pass	Pass	--	--	Fail	NA
Fluoride	--	NA	Fail	NA	Pass	NA	Fail	Pass	Pass
Iron	Pass	--	Pass	--	Pass	Pass	Pass	Pass	Pass
Lead	Fail	Fail	NA	NA	Pass	Fail	--	NA	--
Manganese	NA	--	NA	--	NA	Fail	NA	Pass	Pass
Mercury	NA	--	--	NA	--	--	--	NA	--
Molybdenum	Fail	Fail	Fail	Fail	Pass	Pass	Fail	Pass	Pass
Nickel	Pass	Fail	--	Pass	--	Pass	Pass	Pass	NA
Selenium	NA	Fail	--	Pass	--	Pass	--	NA	--
Silver	NA	Fail	--	NA	--	--	--	Fail	--
Strontium	Fail	Fail	Pass	Fail	Pass	Pass	Pass	Fail	Fail
Thallium	NA	Fail	NA	Pass	NA	Pass	NA	Pass	NA
Tin	--	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	NA	Pass	NA	Pass	Pass	Pass	NA	Pass	NA
Zinc	Fail	Fail	NA	Fail	NA	Fail	Pass	Fail	--

- Note:**
- - chemical passed earlier screening tier
  - Fail - site concentrations significantly greater than reference concentrations
  - NA - not applicable; no statistical comparison was made because of high frequency of undetected results; or the confidence interval for the site mean straddles zero as a result of small sample size or high variability
  - Pass - site concentrations not significantly greater than reference concentrations
  - Yellow - indicates a change relative to 2/3/04 Draft Risk Assessment Work Plan results
  - Orange - additional change relative to 2/3/04 Draft RAWP results, resulting from use of lowest screening levels (Table 3-36)

**Table 3-40. Chemicals of potential concern retained for ecological risk analysis**

Chemical	Environment								
	Terrestrial	Streams		Ponds		Lagoons		Marine	
	Tundra Soil	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	Water
Aluminum	--	--	--	--	--	--	--	--	--
Antimony	Fail	NB	NB	NB	NB	NB	NB	NB	--
Arsenic	Fail	Fail	--	--	--	Fail	--	--	--
Barium	Fail	--	NB	--	--	--	--	NB	--
Cadmium	Fail	Fail	Fail	Fail	Fail	Fail	--	Fail	--
Chromium	--	--	--	--	--	--	--	--	--
Cobalt	Fail	NB	--	NB	--	--	--	--	--
Copper	Fail	--	--	--	--	--	--	Fail	Fail
Fluoride	--	ND <sup>a</sup>	NB	NB	--	NB	NB	--	--
Iron	--	--	--	--	--	--	--	--	--
Lead	Fail	Fail	Fail	Fail	--	Fail	--	Fail	--
Manganese	Fail	--	NB	--	NB	NB	NB	--	--
Mercury	Fail	--	--	Fail	--	--	--	Fail	--
Molybdenum	Fail	NB	NB	NB	--	--	NB	--	--
Nickel	--	Fail	--	--	--	--	--	--	ND <sup>b</sup>
Selenium	Fail	NB	--	--	--	--	--	NB	--
Silver	Fail	NB	--	NB	--	--	--	Fail	--
Strontium	NB	NB	--	NB	--	--	--	NB	NB
Thallium	Fail	NB	NB	--	NB	--	NB	--	NB
Tin	--	NB	NB	NB	NB	NB	NB	NB	NB
Vanadium	Fail	--	NB	--	--	--	NB	--	NB
Zinc	Fail	Fail	Fail	Fail	Fail	Fail	--	Fail	--

**Note:** -- - chemical eliminated from further evaluation

Fail - chemical retained as a CoPC for the baseline ERA

NB - no benchmark; chemical retained as a CoPC for the baseline ERA

ND - undetected in all samples; chemical retained as a CoPC for the baseline ERA

Yellow - indicates a change relative to 2/3/04 Draft Risk Assessment Work Plan results

Orange - additional change relative to 2/3/04 Draft RAWP results, resulting from use of lowest screening levels in Table 3-36

<sup>a</sup> No benchmark.

<sup>b</sup> Maximum value expressed as one-half of the detection limit is above the screening benchmark.

## **Attachment B**

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### **Derivation of Avian and Mammalian Toxicity Reference Values for Arsenic**



# Derivation of Avian and Mammalian Toxicity Reference Values for Arsenic

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This technical memorandum outlines the derivation and selection of arsenic toxicity reference values (TRVs) that will be used in food web models for avian and mammalian receptors as part of the baseline ecological risk assessment for the DeLong Mountain Regional Transportation System Fugitive Dust Risk Assessment. Capsule summaries are provided for each of the studies that were reviewed, and calculations used to derive TRVs are explained.

## Avian Studies

**Stanley et al. (1994)**—In this study, arsenic (as sodium arsenate) was fed to mallards (*Anas platyrhynchos*) in the diet for 115-128 days during reproduction at arsenic dose levels of 0, 25, 100, or 400 mg/kg. Arsenic did not affect hatching success or embryo deformity rates at any dose level; however, the highest dose resulted in an increase in the number of days between pairing and laying of the first egg, and a decrease in whole egg weight and shell thickness. Duckling production and growth decreased when diets were supplemented with 400 mg/kg arsenic. Thus, 400 mg/kg arsenic in the diet represents a lowest-observed-adverse-effect level (LOAEL) dose, whereas 100 mg/kg arsenic represents a no-observed-adverse-effect level (NOAEL) dose. The relevant information for calculating TRVs is:

Compound: Arsenic  
Form: Sodium arsenate  
Test Species: Mallard  
Body wt: 1.0 kg (from Heinz et al. 1989)  
Ingestion Rate: 0.100 kg/day (from Heinz et al. 1989)  
Exposure Duration: 115–128 days during reproduction (critical stage = chronic)  
Endpoint: Reproduction  
Exposure Route: Oral in diet  
Dosage: 4 dose levels (concentrations as As): 0, 25, 100, and 400 mg/kg

TRVs are calculated as:

$$[\text{Dosage (mg/kg)} \cdot \text{Ingestion Rate (kg/day)}] / \text{Body weight (kg)} \quad [\text{Equation 1}]$$

Therefore, the NOAEL TRV equals:

$$(100 \text{ mg/kg} \cdot 0.100 \text{ kg/day}) / 1.0 \text{ kg, or } 10 \text{ mg/kg-day.}$$

Based on this study, the NOAEL for arsenic (as arsenate) is 10 mg/kg-day, and the LOAEL is 40 mg/kg-day.

**U.S. Fish and Wildlife Service (1964)**—In this study, mallards were exposed to 100, 250, 500, and 1,000 ppm sodium arsenite (57.67 percent As<sup>+3</sup>) in their diet for 154 days (128 days for the

100-ppm group). Ducks in the 100-ppm group experienced no mortality. Ducks in the 250-ppm group experienced 12 percent mortality, but ducks in the control groups experienced an average of 13 percent mortality (control group 19-19b in Table D-1 of the USFWS study). Ducks in the 500-ppm group experienced 60 percent mortality. As shown in Table D-1, the daily toxicant consumption rate for birds in the 250-ppm dose group was 34 mg sodium arsenite (57.67 percent arsenic by weight) per kg body weight, or 20 mg arsenic per kg body weight. Since the average mortality in this group was no greater than the average mortality in the corresponding controls, 20 mg/kg-day was considered a chronic NOAEL. The 500-ppm dose was considered a LOAEL dose due to the elevated mortality. The daily intake rate in this group was 86 mg sodium arsenite per kg body weight (Table D-1), which equates to a LOAEL of 50 mg/kg-day arsenic.

## Mammalian Studies

**Schroeder and Mitchener (1971)**—In this study arsenic (as an arsenite salt) was provided to mice (CD strain) in drinking water at 5 mg As/L, along with trace amounts in the diet (0.06 mg As/kg). The study was run for three generations, and reproductive performance was monitored. No adverse effects for maternal survival and minimal effects on juvenile survival were observed. However, the number of small litters (i.e., two to five mice) in the arsenic dose group was significantly greater than in the control group, indicating decreased overall fecundity. Therefore, the single arsenic dose level tested represents a LOAEL dose. The relevant information for calculating TRVs is:

Compound: Arsenic  
Form: Arsenite  
Test Species: Mouse  
Body wt: 0.03 kg (from U.S. EPA 1988)  
Water Ingestion Rate: 0.0075 L/d (calculated from allometric equation in U.S. EPA 1988)  
Food Ingestion Rate: 0.0055 kg/day (calculated from allometric equation in EPA 1988)  
Exposure Duration: 3 generations (critical stage = chronic)  
Endpoint: Reproduction  
Exposure Route: Oral in water and incidental in diet  
Dosage: 5 mg/L in water and 0.06 mg/kg in food

Using the formula in Equation 1, the daily arsenic intake in water is 1.25 mg/kg-day, and the daily intake in the diet is 0.011 mg/kg-day, for a total intake of 1.3 mg/kg-day, which represents a LOAEL. No NOAEL can be calculated from this study, but Sample et al. (1996) estimated a chronic NOAEL of 0.13 mg/kg-day by applying a LOAEL-NOAEL uncertainty factor of 0.1.

**Nemec et al. (1998)**—In this study, the developmental toxicity of arsenic (arsenate in arsenic acid  $H_3AsO_4$ , 52.8 percent arsenic by weight) to mice (Swiss albino strain) and rabbits (New Zealand white strain) was evaluated. Mice were provided arsenic acid by oral gavage on gestation days (GD) 6 through 15 at 0, 7.5, 24, or 48 mg/kg-day and sacrificed for evidence of toxicity on GD 18. Rabbits were provided arsenic acid by oral gavage on GD 6 through 18 at 0, 0.19, 0.75, or 3.0 mg/kg-day and sacrificed on GD 29.

In mice, statistically significant effects were seen at the highest dose (48 mg/kg-day), including decreased maternal weight, decreased live fetuses per litter, decreased fetal weight, and increased resorptions. In the 24 mg/kg dose group, mean fetal weight was slightly decreased and one litter was totally resorbed, but these differences were not statistically significant. Nemec et al. (1998) conclude “A value of 7.5 mg/kg/d is a very conservative estimate of the prenatal mortality NOAEL for mice in the current study, as the single resorbed litter seen at the 24 mg/kg-day dose may be subjectively considered to have been a treatment effect.” However, they also note “interpretation of the significance of the single resorbed litter at 24 mg/kg-day is tenuous.” The lack of any other statistically significant effects at this dose level suggests that this represents a NOAEL in mice. Because arsenic is only 52.8 percent of the arsenic acid by weight, the actual arsenic NOAEL is 13 mg/kg-day. The 48 mg As/kg-day dose represents the LOAEL. Adjusting for the percentage of arsenic in the dose, the actual arsenic LOAEL is 25 mg As/kg-day.

In rabbits, maternal effects including mortality, slight decreases in body weight and clinical signs of toxicity occurred at the 3 mg/kg-day dose. There were no statistically significant effects on embryos or fetuses at this dose, although there was a slight decrease in the number of viable fetuses per litter. No maternal or offspring effects were seen at 0.75 mg/kg-day. Thus, 3 mg/kg-day represents a LOAEL, which, when adjusted for the proportion of arsenic, equates to 1.6 mg As/kg-day. The NOAEL is 0.40 mg As/kg-day. Nemec et al. (1998) note that the much greater sensitivity of rabbits than mice to arsenic is due to New Zealand White rabbits being much slower at metabolically converting (methylating) and excreting arsenic.

**Byron et al. (1967)**—In this study, the effects of sodium arsenite ( $\text{NaAsO}_2$ ) and sodium arsenate ( $\text{Na}_2\text{HAsO}_4 \cdot 7 \text{H}_2\text{O}$ ) were examined in rats (Osborne-Mendel strain). Effects were also studied in beagles, but there are insufficient data presented in the study to derive TRVs for this species. Rats were fed arsenic levels for sodium arsenite of 0, 15.63, 31.25, 62.5, 125, or 250 mg/kg or for sodium arsenate of 0, 31.25, 62.5, 125, 250, or 400 mg/kg. Feeding trials lasted 2 years. The study reports the effects on mean weight and mortality over the course of the 2-year trial for males and females. Effects on the bile duct were also examined at necropsy. No statistical analyses are presented in the paper; thus, the results presented here are based on interpretation of tables showing weight changes and mortality.

For sodium arsenite, there appeared to be higher rates of mortality in the 250-mg/kg dose group than in the control group for both males and females. Additionally, mortality appeared to occur earlier in this dose group. No consistent trend of increased or advanced mortality is apparent in other dose groups. Mean weight was consistently lower (< 90 percent of comparable control weight) for females in the 125- and 250-mg/kg dose groups than for control females throughout the 104-week dosing period. No consistent trend was seen at lower dose levels. For males, consistent decreases in weight were seen only in the 250-mg/kg dose group. Taken together, these results suggest that females are slightly more sensitive than males, and that 125 mg/kg represents a LOAEL dose for females, whereas 62.5 mg/kg represents a NOAEL dose. The TRV derivation is as follows:

Mean female body weight = 0.319 kg (control female weight at 52 weeks, midpoint of study period)  
Food ingestion rate = 0.026 kg/day (calculated from allometric equation in U.S. EPA 1988)  
NOAEL dose: 62.5 mg As/kg  
LOAEL dose: 125 mg As/kg

Using these values and the formula presented in Equation 1, the NOAEL TRV for arsenite is 5.2 mg/kg-day, and the LOAEL TRV for arsenite is 10 mg/kg-day.

For sodium arsenate there appeared to be generally higher rates of mortality in the 250- and 400-mg/kg dose groups than in the control group for both males and females. Additionally, mortality appeared to occur earlier in these dose groups. No consistent trend of increased or advanced mortality is apparent in other dose groups. Mean weight was consistently lower for females in the 125-, 250- and 400-mg/kg dose groups than for control females throughout the 104-week dosing period. No consistent trend was seen at lower dose levels. For males, consistent decreases in weight were seen only in the 400-mg/kg dose group. Taken together, these results suggest that females are slightly more sensitive than males, and that 125 mg/kg represents a LOAEL dose for females, whereas 62.5 mg/kg represents a NOAEL dose. The TRV derivation is as follows:

Mean female body weight = 0.339 kg (control female weight at 52 weeks, midpoint of study period)  
Food ingestion rate = 0.027 kg/day (calculated from allometric equation in U.S. EPA 1988)  
NOAEL dose: 62.5 mg As/kg  
LOAEL dose: 125 mg As/kg

Using these values and the formula presented in Equation 1, the NOAEL TRV for arsenate is 5.1 mg/kg-day, and the LOAEL TRV for arsenate is 10 mg/kg-day.

## **Selection of Arsenic TRVs for the Baseline Ecological Risk Assessment**

### **Avian TRVs**

For birds, TRVs can be calculated for arsenite and for arsenate. As outlined above, the arsenite TRVs are 20 mg/kg-day and 50 mg/kg-day (NOAEL and LOAEL, respectively), as derived from U.S. FWS (1964). The arsenate TRVs are 10 mg/kg-day and 40 mg/kg-day (NOAEL and LOAEL, respectively), as derived from Stanley et al. (1994). As agreed upon earlier, Exponent will use both sets of avian TRVs in the baseline ecological risk assessment. Implications of results based on the alternate TRV values will be discussed in the risk characterization section of the baseline ecological risk assessment report.

## Mammalian TRVs

For mammals, arsenite TRVs can be calculated from the studies by Schroeder and Mitchener (1971) and Byron et al. (1967), and arsenate TRVs can be calculated from the studies by Nemeč et al. (1998) and Byron et al. (1967). All of these studies have some technical limitations that limit their suitability for TRV derivation. Although Schroeder and Mitchener (1971) conducted a multigenerational study, they only tested one dose level, thus only an unbounded LOAEL can be derived directly from the study, and an uncertainty factor has to be applied to derive a NOAEL. Nemeč et al. (1998) tested multiple dose levels, and both a LOAEL and NOAEL can be taken directly from the study (the authors report doses on a daily intake rate). Although the study only dosed animals for about 2 weeks, the dosing was done during gestation, which represents a critical exposure stage. For both these studies, the main exposure route was in water (drinking water for Schroeder and Mitchener, oral gavage for Nemeč et al.). For wildlife at the DMTS, ingestion in food is likely to represent the major exposure pathway. Therefore, the study of Byron et al. (1967) would be preferable as that study had chronic exposure to arsenic through dietary exposure. However, the lack of statistical analyses in the Byron et al. paper makes selection of NOAEL and LOAEL dose levels subjective. Additionally, the arsenite and arsenate TRVs derived from this paper are higher than corresponding values from the other two papers, and therefore may not be protective for potentially sensitive species.

Two sets of arsenic TRVs will be used for mammals (the same approach as planned for birds). The arsenite TRVs will be 0.13 mg/kg-day and 1.3 mg/kg-day (NOAEL and LOAEL, respectively), as derived from Schroeder and Mitchener (1971). The arsenate TRVs will be 0.40 mg/kg-day and 1.6 mg/kg-day (NOAEL and LOAEL, respectively), as derived from Nemeč et al. (1998). Exponent will use both sets of mammalian TRVs in the baseline ecological risk assessment. Implications of results based on the alternate TRV values (including the higher values for other species) will be discussed in the risk characterization section of the baseline ecological risk assessment report.

## Literature Cited

- Byron, W.R., G.W. Bierbower, J.B. Brouwer, and W.H. Hansen. 1967. Pathologic changes in rats and dogs from a two-year feeding study of sodium arsenite or sodium arsenate. *Toxicol. Appl. Pharmacol.* 10:132–147.
- Heinz, G.H., D.J. Hoffman, and L.G. Gold. 1989. Impaired reproduction of mallards fed an organic form of selenium. *J. Wildl. Mgmt.* 53:418–428.
- Nemeč, M.D., J.F. Holson, C.F. Farr, and R.D. Hood. 1998. Developmental toxicity assessment of arsenic in mice and rabbits. *Reprod. Toxicol.* 12:647–658.
- Sample, B., D. Opresko, and G. Suter. 1996. Toxicological benchmarks for wildlife: 1996 Revision. ES/ER/TM-86/R3. Oak Ridge National Laboratory, Health Sciences Research Division, Risk Assessment Program.

Schroeder, H.A., and M. Mitchener. 1971. Toxic effects of trace elements on the reproduction of mice and rats. *Arch. Environ. Health* 23:102–106.

Stanley, T.R., J.W. Spann, G.J. Smith, and R. Rosscoe. 1994. Main and interactive effects of arsenic and selenium on mallard reproduction and duckling growth and survival. *Arch. Environ. Contam. Toxicol.* 26:444–451.

U.S. EPA. 1988. Recommendations for and documentation of biological values for use in risk assessment. EPA/600/6-87/008. U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office, Cincinnati, OH.

U.S. FWS. 1964. Pesticide-wildlife studies, 1963: A review of Fish and Wildlife Service investigations during the calendar year. FWS Circular 199. U.S. Fish and Wildlife Service.