Dan Griffin

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DIVISION OF
WATER QUALITY

FINAL

ECOLOGICAL RISK ASSESSMENT FOR

ATI TITANIUM

12633 North Rowley Road
North Skull Valley, Tooele County, Utah

July 15, 2008
26OT.52001.08

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Comments on the ATI Titanium Ecological Risk Assessment
May 15, 2008

1. **The assessment should be revised wherever a UDEQ reference is given. The permit applicant is responsible for the application and supporting documents, not UDEQ. UDEQ staff did discuss several issues regarding the ATI assessment but these discussions were not prescriptive and in no way relieve ATI's responsibility to produce a scientifically sound ecological risk assessment conducted using current USEPA methodology. If ATI selects a certain methodology based on conversations with UDEQ staff, that is ATI's choice. ATI may reference conversations with UDEQ staff but these conversations do not necessarily represent UDEQ's or the UDWQ's position and should not be referenced as UDEQ.**

Response: Comment acknowledged. All references to personal communications with UDEQ's toxicologist were changed. The following list of references were changed.

- Utah Department of Environmental Quality (UDEQ). 2008a. Project Meeting and Site Visit on March 4, 2008.
  Keep UDEQ, 2008a.

- UDEQ. 2008b. Personal Communication between Xuannga (Sonia) Mahini, SECOR now Stantec, and Chris Bittner of UDEQ, March 11, 2008.
  Changed to SECOR, 2008c.

- UDEQ. 2008c. Project Meeting and Site Visit, March 18, 2008.
  Changed to UDEQ, 2008b.

- UDEQ. 2008d. Personal Communication between Xuannga (Sonia) Mahini, SECOR now Stantec, and Chris Bittner of UDEQ, March 25, 2008.
  Changed to SECOR, 2008d

- UDEQ. 2008e. Rule R317-2. Standards of Quality for Waters of the State. http://www.rules.utah.gov/publicat/code/r317/r317-002.htm
  Changed to UDEQ, 2008c

- UDEQ. 2008f. Emails from Chris Bittner, UDEQ to Xuannga (Sonia) Mahini, SECOR now Stantec, April 10, 2008 and April 15, 2008 regarding ATI Ecological Risk Assessment.
  Changed to SECOR, 2008e.

- Utah Fish and Wildlife Services (UFWS). 2008a. Personal Communication between Ms. Paula Weyen-Gellner, SECOR now Stantec, and Chris Cline of UFWS, March 10, 2008.
  Changed to SECOR, 2008a.

- UFWS. 2008b. Personal Communication between Xuannga (Sonia) Mahini, SECOR now Stantec, and Chris Cline of UFWS, March 10, 2008.
  Changed to SECOR, 2008b.

2. **The ATI assessment uses Kennecott Copper's 1998 Ecological Risk Assessment for the Great Salt Lake (conducted for the North Zone Superfund Remedial Investigation) as an authoritative source for determinations such as "shorebirds' and waterfowls' exposure to sediment via ingestion has an intermediate potential (not a high potential) (EPTI, 1997 and 1998)" (Section 2.2.3, page 23). While these documents were accepted as "final" by a regulatory agency, these statements are not supported by independent research presented within the reports (therefore they are conclusions, not "results"), and they were not scientifically peer-reviewed. ATI should support statements such as this with peer-reviewed references or specific measurements. The recent GSL Selenium workgroup investigations (including work both by Kennecott's consultants, and work by independent researchers, both of which were peer-reviewed by the GSL Se Science Committee) are a more preferred source of data.**

Response: Comment acknowledged. At the time of the ERA planning, SECOR was informed by UDEQ's toxicologist about the Kennecott's studies. Since the Kennecott's studies were final, we thought that the results were already reviewed and accepted by UDEQ. The GSL Selenium study was recently released/revised in May 2008, around the time the ERA reported was submitted to UDEQ. Based on UDEQ's comment No. 2, SECOR incorporated the results of the GSL Selenium Program Final Report. Based on the GSL Final Report Selenium Program (UDEQ, 2008d), and removed certain referenced statements from the Kennecott's studies, where appropriate (see tracked changes in the Final ERA). If the results of the GSL Selenium Program confirmed the Kennecott's studies a decade ago, the Kennecott's results were retained in the Final ERA. In addition, information extracted from the GSL Final Report Selenium Program (UDEQ, 2008d) was updated in the final ERA. For example, shorebirds were assumed to inadvertently consume shore-zone sediment as 5 percent of their diet (UDEQ, 2008d).

3. **Please justify the proposed limits based on lowest-observed-adverse effects levels (LOAELs) instead of no-observed-adverse effects levels. The LOAELs do not appear consistent with the testable hypotheses.**

Response: ATI Titanium and SECOR believe that LOAELs are adequately protective given the fact that site-relate CPECs are not bioaccumulative and the ERA results are conservative. However, as an alternative we would like to propose the NOAEL-based ERBLs to be chronic average discharge limits (i.e., monthly averages) and the LOAEL-based ERBLs to be maximum acute discharge limits (i.e, daily maximums). The text was revised accordingly. The following table was changed in the Executive Summary and Section 4.0 Conclusions based on revised exposure parameters (e.g., soil ingestion rates of 5% for migratory birds [UDEQ, 2008d], food ingestion rate for mallard duck based on allometric equations) and toxicity values (revised LOAEL TRV for titanium).

Metal	Monthly Average Discharge Level (mg/L)	Daily Maximum Discharge Level (mg/L)
Arsenic	0.76	3.05
Chromium III	0.89	3.6
Iron	9.55	27.29
Nickel	5.55	7.67
Titanium	90.86	218.03

4. How large is the anticipated mud flat going to be as a result of the discharge, and what vegetation is expected to grow there? (DWQ)

Response: The anticipated mud flat as a result of the discharge is expected to be less than 0.5 acre. In Section 2.1.1 of the ERA, it was stated, "Literature review indicated that in the saline marsh environment of the GSL, cattails and tules are the dominant emergent vegetation, while pond weeds and smart weeds are to be found floating in most areas of standing, open water. Open flat lands are often covered with goosefoot. In higher areas, saltgrass and woody chenopods can be found (Weber State University, 2008)."

As shown in the "Notification of 'No Adverse Impact' on State-listed Species" letter dated June 17, 2008 (SECOR, 2008f) listed in Appendix E, a SECOR/Stantec field ecologist conducted a field survey on April 30 and May 5, 2008 to identify wetlands and other water features and to evaluate the potential for the occurrence of State-sensitive species.

A majority of the Site is heavily disturbed and characterized by a dirt access road that eventually intersects the northern-most point of the stormwater drainage. From that point north the Site is situated in an area characterized by playas. The areas surrounding the Site include sagebrush scrub to the south, playa to the east, and the heavily disturbed US Mag property including the plant and former waste water pond to the north.

Dominant vegetation identified during the field survey within the Site includes Clasping Pepperweed (Lepidium perfoliatum), Russian Thistle (Salsola kali), Glasswort (Salicornia utahensis), Cheatgrass (Bromus tectorum), Greasewood (Sarcobatus vermiculatus) and Rubber Rabbitbrush (Chrysothamnus nauseosus). Vegetation was limited to less than 20% cover at all of the sample points. It was often below 5% total ground cover. A state-listed noxious weed species, Saltcedar (Tamarix ramosissima) was also identified in the area but outside of the proposed pipeline.

Information in the "Notification of 'No Adverse Impact' on State-listed Species" letter dated June 17, 2008 (SECOR, 2008f) is added to Section 2.1.1 of the ERA. This letter is added as Appendix E of the final ERA.

Due to the constant planned discharge of effluent water from the pipe, ATI expects that within a few years a common GSL marsh environment will begin to develop. ATI does not propose any planting or seeding activities in the 0.5-acre discharge area. Dominant emergent species within the 0.5-acre discharge area will likely be cattails and bullrush (tules), with pond weeds and smart weeds emerging as dominant macrophytes. Salicornia and saltgrass will likely populate the margins of the inundated area.

5. Is the vegetation expected to be conducive to nesting and if so ho many nests are expected and of what species? (DWQ)

Response: The vegetation observed at the Site should not be conducive to shorebird nesting, based on similar observation at Saltair (Cavitt, 2007). Based on the GSL Final Report Selenium Program (UDEQ, 2008d), there were few birds that were nesting at Saltair, the Kennecott wastewater discharge area at the south shore of the GSL (similar GSL southshore setting) (Cavitt, 2007). For example, only 13 American avocet nests were found to nest in the Saltair study area. Black-necked stilt was not found to nest in Saltair, although one pair of black-necked stilt was found foraging in the area. Black-necked stilt was found nesting only at Ogden Bay. Two snowy plover birds were found only at the Antelope Island Bridger Bay site (Cavitt, 2007), not at Saltair. This information was added to Section 2.1.2.5 of the Final ERA.

It is unlikely that more nests than observed at the Saltair site will be observed at the ATI site. The ATI effluent discharge area will encompass approximately 0.5 acre and will be surrounded by open, essentially, unvegetated playa, therefore limiting potential nesting habitat. Over time, as the permanently ponded area and vegetation become more established, nesting habitat may increase from year to year but will still be influenced overall by factors such as flooding and predation, rather than the new discharge

6. What kind of hatching success reduction is anticipated from the created effluent dominated wetland? (DWQ)

Response: Shorebirds hatching success from created effluent dominated wetlands is based on several factors, not related to chemicals found in the effluent. For example, based on the GSL Final Report Selenium Program (Cavitt, 2007), at Saltair (the Kennecott wastewater discharge area at the south shore of the GSL - similar GSL southshore setting) (Cavitt, 2007), the major sources of nest failure was a flooding event (from rain), since the bird nests were found along the GSL shoreline and predation (by California gulls). Based on the GSL Final Report Selenium Program (Cavitt, 2007), collection of eggs at four newly initiated nests in Saltair for the GSL selenium study (after the flooding event) also resulted in the abandonment of nests due to human disturbance (Cavitt, 2007). As a result, hatching success was not determined for birds nesting at Saltair (Cavitt, 2007). However, it was found that despite elevated levels of selenium found within the American avocet tissues (selenium is known to bioaccumulate in tissues), their corresponding egg selenium concentrations were relatively low, similar to background levels (Cavitt, 2007). UDEQ has recommended that water quality standard for selenium should be a tissue-based standard, based upon the selenium concentration found in the eggs of birds using the open waters of the GSL (UDEQ, 2008d) (not selenium found in bird tissues). For inference purposes, since CPECs at the Site are not known to bioconcentrate in invertebrates, there should not be concern for the adverse effects posed by site-related CPECs to bird eggs, especially the cumulative HI to the birds themselves are below one. This information was added to Section 3.3.5 of the Final ERA.

Based on a similar effluent discharge study at Saltair, ATI does not expect hatching success to be negatively impacted by effluent discharge alone. Potential disturbances to hatching success are more likely to include flooding/water level variation, predation, and human disturbance that may or may not relate to the pipeline (vehicle traffic on access roads, discharge maintenance etc.).

Flooding or water level variation is difficult to predict for the GSL. The GSL is a dynamic water body dependent on a wide variety of variables that affect physical characteristics such as water levels (UDEQ, 2008d). For example, during the Selenium study (between May 2006 and September 2007) lake water elevation fluctuated approximately 3.0 feet (UDEQ, 2008d). Lake elevation has fluctuated historically more than 20 feet between 1963 and 1986 (UDEQ, 2008d). In any given year, it is probable that lake elevation could fluctuate enough to impact active nests within the 0.5-acre area. For instance, the major source of nest failure at the Saltair site studied by Cavitt in 2007 was a 2-day flooding event.

Predation from species such as California Gulls or Common Ravens may also affect the hatching success rate of any nesting shore birds within the effluent area. In study sites from Cavitt 2007, Antelope Island had the highest predation rate which contributed to a near 50% loss of hatching success. This site also had the largest population of nesting birds. Nest predation was the second largest factor contributing to loss of hatchlings at the Ogden Bay site. The Saltair site was also slightly affected by predation. If loss from flooding or direct abandonment does not directly affect the ATI project site it is likely that predation will have some affect on the hatching success of any species that nest within the project area.

According to ATI, planned **human disturbance** will be minimal. It is likely that ATI would only need to conduct an annual visual inspection of the outfall area to ensure riprap is in-place and erosion is not occurring. This inspection can be scheduled outside of the nesting area. Furthermore, according to US Mag, the access road is near the discharge area is used infrequently. The only routine travel on the access road occurs once a month when US Mag performs a visual inspection of the area.

7. **Section 2.1.1 Preliminary Evaluation. Please explain the City storm water drainage because the location is unincorporated Tooele County with no close cities or towns.**

Response: The observed storm water drainage was a natural hill drainage or a historical storm water diversion for the area topography. The term "City" was deleted in three instances from Page 7 of the ERA.

8. **The process flow diagram concentrates on the water, which is appropriate for an ERA done to support a UPDES/NPDES permit. What will be the disposition**

of the two other waste streams: a) the scrubber blowdown sludge, and b) the RO brines. Will either of these be disposed of onsite? (i.e., scrubber sludge to land, or RO brine to the GSL)?

Response: All those waste streams have been included in the wastewater discharge and have been evaluated in the ERA. None of the waste streams will be disposed of on site.

9. What is the source of electricity for the ATI plant?

Response: The source of electricity for the ATI plant is from Rocky Mountain Power. There is no on-site co-generation. This information is added to Section 1.2 of the final ERA.

10. Section 2.1.1 Preliminary Evaluation. "Small mammal species are not of concern from regulatory standpoints....". Please clarify the text. Small mammal populations are often assessment endpoints for ecological risk assessments in Utah. Small mammals are not assessment endpoints for the ATI ecological risk assessment because their loss would result in an indirect effect on predatory species. This assessment is focused on an introduced water source rather than impacts to a naturally occurring ecosystem. Therefore, impacts to a previously existing prey-base does not require evaluation.

Response: Following the UDEQ comment above, the referenced text was revised to "Although small mammal populations are often assessment endpoints for ERAs in Utah, small mammals are not assessment endpoints for the ATI ERA because their loss would result in an indirect effect on predatory species for shorebirds. Since this assessment is focused on an introduced water source rather than impacts to a naturally occurring ecosystem, impacts to a previously existing prey-base does not require evaluation." This revised statement was added to Section 2.1.1 of the Final ERA.

11. Section 2.1.2.3 Potential Exposure Pathways. Sources and Release Mechanisms. "According to UDEQ, it is also almost impossible to model sediment concentrations at the Site...." This sentence should be revised or deleted. Sediment concentrations could be modeled albeit with a large degree of uncertainty based on the methods familiar to this reviewer. ATI needs to determine the need and feasibility of modeling sediment concentrations from effluent concentrations. The Executive Summary should also be revised in response to this comment.

Response: Following the UDEQ comment above, the referenced sentence in Section 2.1.2.3 was deleted from the text of the Final ERA. The similar text in Section 2.2.3 was changed to "Modeling sediment concentrations from discharge water contains a large degree of uncertainty due to lack of available information (soil concentrations, site-specific sediment-water partition coefficient, resuspension and deposition rates, [sedimentation], etc.)."

12. **Section 2.1.2.3 Potential Exposure Pathways. Sources and Release Mechanisms and Section 3.3. Exposure Pathways "...the remaining CPECs in the treated effluent will be inherently soluble and not available for the sediment exposure pathway except through evaporation." This statement needs to be supported. Solubility is affected by several factors such as presence and concentration of other solutes, temperature, redox potential, and pH. All of these factors are may change after the water treatment when the effluent is discharged. For instance, see the discussion in Section 3.1.9.5 for titanium tetrachloride (if present) that is expected to hydrolyze to titanium dioxide. The text should be revised or supporting analyses provided.**

Response: This effluent is expected to be in equilibrium with the clarifier sludge generated from the wastewater treatment system. The characteristics of the waste water are not expected to change significantly along the discharge pipe due to the short residence time in the pipe and near ambient conditions of the water and discharged at a pH of 7. The pH control of the precipitation of wastewater is the chief determining factor of the solubility of CPECs in the waste water effluent, and the potential for precipitation is expected to be minimal. The other determinants of solubility, such as other solutes, temperature and redox potential, are much-less significant.

Temperature of the effluent will be essentially that of the ambient atmosphere throughout the discharge system, thus there will be no change in temperature that could change solubility. Similarly, the redox potential will exhibit minimal change, since we may assume aerated water throughout the system. The redox potential is thus fixed by the concentration of oxygen of the air, in the absence of redox-active factors, i.e., lack of significant concentrations of either oxidizing or reducing agents. No precipitation will occur as a result of changes in temperature or redox potential.

The Eh-pH conditions are such that mineral phases are unlikely to be present, and therefore, unlikely to precipitate. No ionic species will be present in solution, or accessible thereto, which could act as potential complexing agents leading to precipitation.

Once the effluent is released into the channel bed on the floor of the Great Salt Lake, it is a reasonable expectation that its chemistry will exhibit little change. The natural conditions of the area are alkaline playa silt and clay carbonate soils (NRCS, 2000) in contact with slightly alkaline water (average pH 7.975, minimum pH 6.76, maximum pH 8.46, and median pH 8.13) in the South Arm of the Great Salt Lake (SECOR, 2008g). The effluent will exhibit a pH (7 to 9) similar to the natural pH conditions and ultimately contact the same alkaline playa soils. Under these expected pH conditions, Baes and Mesmer, (1976), show that the effluent will be at or near the highest solubility for Ti (p.24); Fe (p. 237); Ni (p. 247) and Cr (p. 219).

13. **Section 2.1.2.5 Indicator Species Selection Mallard Duck. The ingestion rate for the mallard was based on laboratory studies. Free living metabolic rates are two to three times higher than the basal existence metabolic rate (USEPA, 1993). The mallard food ingestion rates may be underestimated. In the**

absence of field studies, the allometric estimates of food ingestion may provide a better estimate of food ingestion. The text discussing the conservatism of the allometric estimates of food ingestion based on a comparison to laboratory-based feeding studies should be revised.

Response: The referenced text was revised to: "Mallards are often used in laboratory studies, and several papers cite measured food ingestion rates for mallards. Food ingestion rates for mallards were reported ranging from 0.091 kg ww/day to 0.139 kg ww/day (Davison and Sell, 1974; Heinz et al., 1987; Piccirillo and Quesenberry, 1980; White and Dieter, 1978; White and Finley, 1978). A food ingestion rate of 0.139 kg ww/day was reported for birds weighing an average of 1.25 kg (Piccirillo and Quesenberry, 1980). A similar food ingestion rate of 0.13 kg ww/day was reported for birds weighing an average of 1.23 kg (Davison and Sell, 1974). If the allometric equation for non-passerine birds is used to estimate the average food ingestion rate of mallards (USEPA, 1993), it would be 0.269 kg ww/day (nearly twice as the experimentally measured value). Since free living metabolic rates are two to three times higher than the basal existence metabolic rate (USEPA, 1993), UDEQ (2008e) stated that laboratory-measured mallard food ingestion rates may be underestimated. In the absence of field studies, the allometric estimates of food ingestion may provide a better estimate of food ingestion. For this ERA, the conservative food ingestion rate of 0.269 kg ww/day (USEPA, 1993) (instead of the highest laboratory-measured value of 0.139 kg ww/day [USEPA, 2005a]) was assumed for mallards." As a result, the NOAEL-based and the LOAEL-based HI for the mallard duck increases by nearly a factor of 2.

14. **Section 3.1.8 Invertebrate Bioaccumulation Sediment Factor from Sediment. Please explain the assumption that gastropods and insects were water column dwellers and crustaceans were sediment dwellers. The salinity of the Great Salt Lake limits the ecological diversity. Crustaceans in the Great Salt Lake are probably best represented by the brine shrimp living in the water column. In any case, the ecosystem that results from the lower salinity effluent is uncertain. The invertebrate community in the discharge ditch will likely be a mix of the endemic species associated with the GSL (brine shrimp and also brine-flies) but also species from the fringe wetlands on the east side (birds can transport a variety of species such as gastropods and larval invertebrates on their feet and feathers), with those that survive being those that best tolerate the conditions present in the ditch. For the purposes of modeling, the known receptors, brine shrimp, brine flies, corixids (water boatmen) have the least number of uncertainties. How sensitive are the exposure results to the dietary proportions assumptions? One way to evaluate the sensitivity is to calculate exposures assuming exclusive diets along with the mixed diets.**

Response: Since the reference section is related to food items from sediment, crustacea were assumed to be more of bivalves or sediment dwelling organisms with shells, not brine shrimp. This was supported by the lower percentage of crustacea in the mallard duck diet (7.9% to 15.1% from April to June). Tables 11 and 12 in the ERA show the NOAEL- and LOAEL-based HI for indicator species as a result of consuming food 100% from the water column (exclusive diet of brine shrimp or brine flies). Tables 11A and 12A in Appendix D assume certain percentage of food come from sediment (which can contain higher concentrations of metals – mixed diet). The risk results from these two scenarios are comparable, indicating not much difference between food from the water column or food from sediment.

15. **Section 3.3.5 Bioaccumulation Factors. The biota-sediment accumulation factors (BSAFs) from the literature vary over two orders of magnitude. In general, the geometric mean was selected for the BSAF. How can the conclusion be made that the bioaccumulation factors overestimate exposures?**

Response: To address UDEQ comment, the statement "However, these values are conservative in nature and were unlikely to underestimate potential risks to ecological receptor populations" was changed to "However, since geometric mean was selected for BAFs, these values are adequately protective and were unlikely to underestimate potential risks to ecological receptor populations."

16. **Section 3.1.9.5 Titanium. The USEPA default uncertainty factor for extrapolating from a LOAEL to a NOAEL is a factor of 10. A factor of 10 is usually protective (Dourson et al., 1996). However, this same data shows that a factor of 10 to extrapolate from a NOAEL to LOAEL as proposed may not be protective. The proposed NOAEL for titanium has a high degree of uncertainty but is likely protective. Extrapolation to a LOAEL from this uncertain NOAEL is likely too uncertain to be useful for establishing discharge limits.**

Response: Comment acknowledged. The draft text "Since the true NOAEL can be higher than 568 mg/kg-day, the LOAEL for protection of avian species is proposed to be 10 times higher, which is 5,680 mg/kg-day. This level is roughly the same as the NOAEL for mammalian species" was changed to "The proposed NOAEL for titanium has a high degree of uncertainty but is likely protective (UDEQ, 2008e). According to UDEQ (2008e), the USEPA default uncertainty factor for extrapolating from a LOAEL to a NOAEL is a factor of 10, as a factor of 10 is usually protective (Dourson et al., 1996). However, this same data shows that a factor of 10 to extrapolate from a NOAEL to LOAEL may not be protective. Therefore, the geometric mean of the difference between the LOAEL and NOAEL of the other four CPECs: arsenic, chromium, iron, and nickel (2.4) was used. As such, the proposed LOAEL for titanium is 1,363 mg/kg-day, which is lower than the NOAEL of 4,307 mg/kg-day for mammalian species."

17. **Section 3.3.3 Exposure Pathways. Please add text to explain that relative bioavailability is the parameter of interest. Relative bioavailability is the bioavailability in the sediment compared to the bioavailability of metals in the toxicity test on which the toxicity reference value is based. For instance, if the absolute bioavailability in the toxicity test and the sediment is one percent, the risks would not be underestimated even though the absolute bioavailability is very low.**

Response: As suggested, the following text was added to Section 3.3.3 "Currently, there is not enough information to compute the relative bioavailability of CPECs in sediment. Relative bioavailability is the bioavailability in the sediment compared to the bioavailability of metals in the toxicity test on which the toxicity reference value is based. For instance, if the absolute bioavailability in the toxicity test and the sediment is 1 percent (resulting in a relative bioavailability of 100 percent), the risks would not be underestimated even though the absolute bioavailability is very low (UDEQ, 2008e)."

18. Section 3.3. Exposure Pathways. "Additionally, the sediment area in contact with ATI Titanium's discharge wastewater that is available for ingestion by migratory bird species is relatively small given that the surveyed channel to the GSL is narrow (12 feet wide) with sloping sides." Please elaborate on the significance of this statement. Include a discussion of the potential for the discharge to alter the morphology of the channel. Could habitat develop that will be attractive to waterfowl? Riparian zones typically support high species diversity and abundance relative to their areal extent. How sensitive are the hazard quotients to this assumption? Alternatively, the statement can be deleted.

Response: The referenced sentence was intended to present the advantage of having a narrow discharge channel versus an open pond to minimize surface area for shorebird exposure. As suggested, this statement was deleted from the Final ERA.

19. Section 3.3.1. *Selection CPECs and Representative Concentrations.* Please add an evaluation of the uncertainties with arsenic sediment concentrations. Background sediment samples identified as mining related were excluded. The Oquirrh Mountains are highly mineralized as evidenced by the large scale copper mining and elevated levels of arsenic would be expected. The higher sediment concentrations of arsenic from the Great Salt Lake may be naturally occurring or mining-related. What would be the impacts to the hazard indices if the elevated sediment arsenic concentrations are not excluded.

Response: In the USGS Water Quality in the Great Salt Lake Basins: Utah, Idaho, and Wyoming, 1998-2001 (USGS, 2003a) report, arsenic sediment concentrations measured at Station No. 19 (19-20 mg/kg) can be representative of the GSL southshore levels near the Kennecott wastewater discharge area. These levels are consistent with arsenic sediment levels in and under the Kennecott tailings impoundment (range from 4 to 42 mg/kg, with mean value of 14 mg/kg (EPTI, 1997, reproduced from U.S. Army Corps of Engineers, 1995). Arsenic sediment levels at Stations 7 to 10 (50-440 mg/kg) were found at Silver Creek and Weber River Basin (more inland and in mountainous areas) and are not representative of the southshore GSL. When the sediment representative concentration for arsenic was changed from 6.5 mg/kg (draft ERA) to 20 mg/kg (Station No. 19), the NOAEL-based cumulative HI for the black-necked stilt increases only 1.2%, which is still much less than 1. This information was added to Section 3.3.1.

20. Avocets, stilts, and plovers were assumed to reside at the Great Salt Lake for a fraction of the year. The evaluated receptors (indicator species) are intended to be protective or representative of all species present. Please include a discussion if any other species in the same feeding guild are present all year round.

Response: Based on the April 7, 2008 letter from the State of Utah, Department of Natural Resources (UDNR, 2008c) regarding species of concern near the Great Salt Lake, Tooele County, occurrence for the American white pelican was found within a 0.5-mile radius of the Site and burrowing owl, ferruginous hawk, and long-billed curlew were found within a 10-mile radius of the Site. Since burrowing owl and ferruginous hawk consume small mammals and vertebrates, they are not relevant for the purpose of the ERA. American white pelican (consuming mostly fish) and long-billed curlew (consuming diverse food items such as crustaceans, mollusks, worms, toads, the adults and larvae of insects, berries, and nesting birds) are both migratory birds. Due to their diet composition and occurrence in the Great Salt Lake, the potential risks to these birds are not expected to be higher than those evaluated in the ERA (black-necked stilt, American avocet, mallard duck, and snowy plover).

Based on the GSL Final Report Selenium Program (Conover et al., 2007), it was shown that the high selenium concentration in blood of adult California gulls breeding on the Great Salt Lake do not seem to be impairing their health or reproductive ability (selenium is known to bioaccumulate in tissues). All 100 chicks examined appeared normal. For inference purposes, since CPECs at the Site are not known to bioconcentrate in invertebrates, there should not be concern for the adverse effects posed by site-related CPECs to bird eggs of the American white pelican or long-billed curlew. Since the black-necked stilt and American avocet were selected as the shorebirds of concern to be studied in the GSL Final Report Selenium Program (Cavitt, 2007) and based on the results of the California gulls study (Conover et al., 2007), indicator species evaluated in the ERA are expected to be protective of most, if not all migratory and resident bird species in the Great Salt Lake. This information was added to Section 3.3.2.

21. **Section 4.0 Conclusions (page 60). In discussion of chromium and nickel (fourth paragraph), there is a statement "... use of current Utah sediment concentrations [of chromium and nickel] are conservative because these metal levels have been shown to decrease significantly in lakes (Mahler et al., 2006)." The discussion of this study found on page 34 of the ERA implies that these decreases are a function of time (i.e., decreasing concentration with decreasing depth in lake sediment cores potentially due to decreases in global/local emissions) rather than a function of some sort of chemical/biological fate-transport mechanism that would decrease concentrations of these metals from those originally present. This statement should be clarified or changed.**

Response: The phrase "potentially due to decreases in global/local emissions" was added to the end of the reference sentence.

22. **Section 4.0 Conclusions (page 62). Paragraph 2, regarding interpretation of HQs and HIs: Again, caution is warranted in using Ecological Risk Assessments prepared to support decisions at another regulated facility (in this case, Kennecott Utah Copper Corporation's North Zone Wetland Superfund Remedial Investigation) as an unbiased, open literature source for the reasons noted above in comment #6. Please clarify the text.**

Response: The information related to the EPTI reference in the text has been changed to the conclusion from the GSL Selenium Project (UDEQ 2008d), as appropriate.

References

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LIST OF SYMBOLS AND ABBREVIATIONS

>	greater than
%	percent
°C	degrees Celsius
°F	degrees Fahrenheit
µg	microgram
µm	micrometer
ADD	average daily dose
ADD_{fw}	average daily dose from ingestion of aquatic food source
ADD_w	average daily dose from ingestion of water
ADI	acceptable daily intake
ADSTR	Agency for Toxic Substances and Disease Registry
Ar	argon
As	arsenic
AUF	area use factor
ATI Titanium	ATI Titanium, LLC
BAF	bioaccumulation factor
BCF	bioconcentration factor
BSAF	sediment bioaccumulation factor
$BSAF_i$	sediment bioaccumulation factor for invertebrates
$BSAF_p$	sediment bioaccumulation factor for aquatic plants
BW	body weight
C	concentration
$CaCO_3$	calcium carbonate
CPEC	chemical of potential ecological concern
CLO	Cornell Laboratory of Ornithology
cm	centimeter
CO_2	carbon dioxide
Cr	chromium
C_s	concentration adsorbed on sediment surface
CV	chronic value
C_w	concentration in water
DC	diet composition
dw	dry weight
EC_{20}	20% effects concentration
EC_{50}	equivalent median effective concentration
Eco-SSL	United States Environmental Protection Agency Ecological Soil Screening Level
EFSA	European Food Safety Authority
EPTI	Ecological Planning and Toxicology, Inc.
ERA	ecological risk assessment
ERBL	ecological risk-based level
ESL	United States Environmental Protection Agency Environmental Screening Level
ET	exposure time
FAC	final acute-chronic ratio

LIST OF SYMBOLS AND ABBREVIATIONS

(continued)

FAV	final acute value
FCM	food chain multiplying factor
Fe	iron
FR	fraction ingested from contaminated source
g	gram
g/L	grams per liter
gpm	gallons per minute
GSL	Great Salt Lake
ha	hectares
H_0	null hypothesis
H_2	hydrogen
HCl	hydrochloric acid
HI	hazard index
HQ	hazard quotient
HSDB	Hazardous Substances Data Bank
IR_f	food ingestion rate
IR_w	water ingestion rate
JECFA	Joint Expert Committee on Food Additives of the Food and Agriculture Organization/World Health Organization
K_d	sediment-water partition coefficient
kg	kilogram
kg/kg	kilogram per kilogram
km	kilometer
L	liter
LC_{50}	48- to 96-hour median lethal concentration
LD	lethal dose
LD_{50}	dose causing death to 50% of the organisms being tested
LCV	lowest chronic value
L/day	liters per day
lbs	pounds
lbs/year	pounds per year
LOAEL	lowest observed adverse effect level
MBEIR	Mono Basin Environmental Impact Report
Mg	magnesium
$MgCl_2$	magnesium chloride
MgO	magnesium oxide
mg/kg	milligram per kilogram
mg/L	milligram per liter
ml	milliliter
NAWQA	National Ambient Water Quality Assessment
NAWQC	National Ambient Water Quality Criteria
NCI	National Cancer Institute
Ni	nickel
NLM	National Library of Medicine

LIST OF SYMBOLS AND ABBREVIATIONS

(continued)

NOAA	National Oceanic and Atmospheric Administration
NOAEL	no observed adverse effect level
ODEQ	Oregon Department of Environmental Quality
OPRD	Oregon Parks and Recreation Department
ORNL	Oak Ridge National Laboratory
OSWER	United States Environmental Protection Agency Office of Solid Waste and Emergency Response
PAM	Pesticide Analytical Manual
PVC	polyvinyl chloride
RAIS	Risk Assessment Information System
RO	reverse osmosis
SAB	Science Advisory Board
SAV	secondary acute value
SCV	secondary chronic value
SEAM	Superfund Exposure Assessment Manual
SECOR	SECOR International Incorporated, now Stantec Consulting, Inc.
SCM	site conceptual model
SFSU	San Francisco State University
SIC	Standard Industrial Classification
SSINA	Specialty Steel Industry of North America
SQL	sample quantitation limit
T&E	threatened and endangered
THQ	target hazard quotient
Ti	titanium
$TiCl_2$	titanium chloride
$TiCl_4$	titanium tetrachloride
TiO_2	titanium dioxide
TPW	Texas Parks and Wildlife Service
TRV	threshold reference value
TRVDP	titanium reduction and vacuum distillation process
TSS	total suspended solids
UFWS	Utah Fish and Wildlife Service
UDEQ	Utah Department of Environmental Quality
UDNR	Utah Department of Natural Resources
UDWR	Utah Division of Wildlife Resources
UPDES	Utah Pollutant Discharge Elimination System
U.S.	United States
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
US Mag	US Magnesium, LLC
UTM	Universal Transverse Mercator
WSTB	Water Science and Technology Board

LIST OF SYMBOLS AND ABBREVIATIONS

(continued)

WHO	World Health Organization
ww/day	wet weight per day

EXECUTIVE SUMMARY

At the suggestion of the Utah Department of Environmental Quality (UDEQ) and on behalf of the ATI Titanium, LLC (ATI Titanium), SECOR International Incorporated now Stantec, Inc. (SECOR), prepared this ecological risk assessment (ERA), as part of the Utah Pollutant Discharge Elimination System (UPDES) permit for the ATI Titanium facility located at 12633 North Rowley Road, North Skull Valley, Tooele County, Utah 84029.

The purpose of the ERA is to evaluate the potential ecological risks to the environment as a result of planned constant discharge of treated process water directly into the Great Salt Lake (GSL). The results of the ERA are used to derive the ecological risk-based levels (ERBLs) of the chemicals of potential ecological concern (CPECs) in treated process water that are protective of the environment – to provide the basis for suitable UPDES discharge limits. The discharge water will have about 1 percent (%) salinity and is not considered as freshwater. For the purpose of the ERA, the effluent discharge area, which is over 3 miles northeast of the ATI Titanium manufacturing facility, is considered as the Site or Study Area.

Based on the proposed location of the effluent discharge pipe and outfall, the daily rate of effluent discharge, and the presence of a historical channel between the discharge pipe outfall and the GSL, it was estimated that the potential water depth in the discharge channel will be around 9 inches, with a channel width of 12 feet wide, for a flow of 300 gallons per minute (gpm). The effluent will flow from the pipe by gravity to the north, where it will be within a few hundred feet of the GSL water line as it exists currently.

This ERA was conducted in accordance with the current U.S. Environmental Protection Agency (USEPA) risk assessment guidance (USEPA, 1997) and UDEQ guidance and recommendations (UDEQ, 2008a, 2008b, and 2008c; SECOR, 2008c, 2008d, and 2008e). This ERA report encompasses a screening level ERA, which includes Step 1 (Screening-level Problem Formulation and Ecological Effects Evaluation) and Step 2 (Screening-level Exposure Estimates and Risk Calculation) of the 8-step ERA defined by the USEPA (USEPA, 1997).

During Step 1 of the ERA, selection of CPECs was conducted to select those site-related chemicals likely to be associated with adverse ecological effects. The list of CPECs for the Study Area includes: arsenic, chromium III, iron, nickel, and titanium. Note that arsenic was detected in source groundwater, but not in reverse osmosis (RO) concentrate. It is therefore likely to be background-related. Comparison of CPEC Site samples in source water and RO concentrate/blowdown to State and federal marine and freshwater screening criteria indicate no exceedance.

To be complete, all CPECs were carried forward to Step 2 of the ERA. For the purpose of the Step 2 of the ERA, representative concentrations of CPECs in effluent discharge water are the highest of either the detected levels of CPECs in source groundwater or in RO concentrate/inlet or performance criteria set for the on-site wastewater treatment system. Although concentrations of CPECs within the effluent discharge water may fluctuate, the use of the treatment performance criteria (for arsenic, chromium, nickel, and titanium) and the potential highest concentration detected in drinking water (iron, for which there is no treatment performance criterion) will ensure that the estimated risks are at the upper possible range.

The selection of potential sediment concentrations is conservative in a way that these levels represent equilibrium conditions in the surface water bodies, not new discharge situation. Since arsenic in effluent discharge water is expected to be background-related, Utah-specific average background sediment level was used. For CPECs that are expected to be found at low levels (chromium and nickel) in effluent discharge water, use of current Utah sediment concentrations are conservative because these metal levels have been shown to decrease significantly in lakes. For CPECs that are considered major elements (iron and titanium), sediment concentrations were selected from larger datasets and with comparable surface water concentrations.

At the direction of UDEQ, ecological receptors of concern evaluated in the Step 2 ERA are: American avocet, black-necked stilt, Mallard duck, and snowy plover. It is noted that the American avocet and black-necked stilt were selected as shorebirds of concern evaluated in the recent peer-reviewed GSL Selenium Program. Since CPECs at the Site are not known to biomagnify in the food chain, higher trophic avian species were not considered. The exposure pathways of concern for these four receptors are: ingestion of surface water, ingestion of food from water, and ingestion of sediment. Ingestion of food from sediment was also evaluated in an Appendix. To be conservative the fraction ingested from source (FR) or area use factor (AUF) was assumed to be one. Extensive literature review was performed to identify CPEC-specific bioaccumulation factor (BAFs) from surface water and threshold reference values (TRVs) for toxic effects. Potential risks to ecological receptors of concern, expressed as CPEC-specific hazard quotient (HQ) and cumulative hazard index (HI) were computed by dividing the average daily doses (ADDs) by the TRVs.

Results of the Step 2 ERA indicated that that all avian species of concern at the Site will not incur unacceptable risks, since the hazard indices (HIs) for all receptors are less than unity or one. The species with the highest cumulative HI is the snowy plover, with a cumulative NOAEL-based HI of 0.584. The NOAEL-based HI for the American avocet, black-necked stilt, and mallard duck are 0.409, 0.411, and 0.462, respectively. The LOAEL-based HIs of the American avocet, black-necked stilt, mallard duck, and snowy plover are 0.131, 0.132, 0.147, and 0.187, respectively. It is noted that the HI for the black-necked stilt is similar to that of the American avocet. This is due to the fact that intake rates for both species were derived based on allometric equations (USEPA, 1993), for which weight is an important parameter. The HI for the snowy plover is about 42% higher than that of the black-necked stilt and American avocet..

Results of the Step 2 ERA also showed that for NOAEL-based HIs, the risk-driving CPECs across all evaluated pathways at the Site are iron and arsenic, accounting up to a total of 38.4% and 35.1%, respectively, of the cumulative HI in the black-necked stilt, American avocet, and snowy plover. Chromium and titanium each contributes around 13.5 to 14.4% to the cumulative HI. Nickel contributes the least to the cumulative HI. The fact that iron is the risk-driving CPEC should provide a warning that the ERA results are conservative. This is due to the fact that iron is an essential nutrient and there is scarce toxicity information on iron. The selected NOAEL for iron may not be the true NOAEL, which can be much higher. The dominant pathway for all species of concern is the food ingestion from surface water uptake (66.3-73%), followed by sediment ingestion (26.5-33.2%).

Although the food (aquatic plants and invertebrates) from sediment exposure pathway is considered insignificant, an evaluation has been made and is included as Appendix D to this document. If food sources from sediment are evaluated (aquatic plants and invertebrates), the estimated HIs are slightly higher (from 3.4% [for stilts and avocets] to 11.3% [for mallard ducks] higher) than the values assuming 100% ingestion of invertebrates from surface water. The HI for the snowy plover is slightly lower. The results presented in Appendix D showed that all avian species of concern at the Site will not incur unacceptable risks, since the HIs for all receptors are also less than unity or one. The species with the highest cumulative HI is still the snowy plover, with a cumulative NOAEL-based HI of 0.573. The NOAEL-based HI for the American avocet, black-necked stilt, and mallard duck are 0.423, 0.425, and 0.514, respectively. The LOAEL-based HIs of the American avocet, black-necked stilt, mallard duck, and snowy plover are 0.140, 0.140, 0.175, and 0.184, respectively. The risk-driving CPEC across all evaluated pathways at the Site is iron, accounting up to a total of 43.9-74.4% of the cumulative HI all species of concern. The dominant pathway for all species of concern is the ingestion of food from sediment, followed by sediment ingestion. However, since the cumulative HIs based on 100% consumption of aquatic vertebrates from surface water uptake are not too much different from the HIs from consumption of aquatic vertebrates from surface water uptake and consumption of aquatic plants and invertebrates from sediment uptake, the simplified assumption of 100% consumption of aquatic vertebrates from surface water uptake is adequately protective.

The pathways evaluated in the Step 2 ERA were assumed to have the most significant contribution to the total risk (ingestion of surface water, ingestion of food from surface water uptake, and ingestion of sediment). Of all pathways evaluated, the evaluation of the sediment ingestion pathway is very conservative because it did not take into account the bioavailability of CPECs in sediment. If bioavailabilities of CPECs are taken into account (mid range of CPEC non-bioavailability in sediment 80% - this is similar to the oral absolute bioavailability of 20% for metals [Water Science and Technology Board (WSTB), 2003), the cumulative potential risks for the American avocet and black-necked stilt will reduced by a factor of 2; whereas the potential risks for the snowy plover and mallard duck will reduce by a factor of 1.5 and 1.3, respectively. Also, wastewater from ATI Titanium's well-operated, well-maintained metal precipitation, clarification, and filtration treatment system will not provide insoluble metals that can purport to sediment. In other words, the remaining CPECs in the treated effluent will be inherently soluble and not available for the sediment exposure pathway. Additionally, the sediment area in contact with ATI Titanium's discharge wastewater that is available for ingestion by migratory bird species is relatively small given that the surveyed channel to the GSL is narrow (12 feet wide) with sloping sides.

For all avian receptors of concern, it was also assumed that the receptors would spend 100% of their time within the area of the discharge, and that 100% of water and food consumption would be obtained from the discharge area. This is a conservative assumption that would likely overestimate exposure doses by up to two orders of magnitude. For example, if average home ranges for species of concern are taken into account, the fraction injected from source (FR) for black-necked stilts and American avocets is 1/283.5 or 4E-03, FR for snowy plover is 1/35 or 2.8E-2, and FR for mallard ducks is 1/580 or 2E-03. Thus, potential risks to species of concern can be 35 (for snowy plover), 283 (for black-necked stilt and American avocet), or 580 (for Mallard duck) times lower than the estimated values. Even if FR is based on the non-conservative fraction of the foraging length over the length of the channel (1.5 km), the FR for the stilts and avocets is 1.5 km/4.5 km = 0.33, for the snowy plover is 1.5 km/3 km = 0.5, and for the mallard duck is 0.165 (since the home range for the mallard duck is almost twice as that of the stilt). This means that the potential risks to species of concern can be 2 (for snowy plover), 3 (for black-necked stilt and American avocet), or 6 (for Mallard duck) times lower than the estimated values.

Based on the discussion above, it is likely that exposure concentrations and doses used in the Step 2 ERA overestimated actual exposures by ecological receptors of concern. In addition, the effects characterization was designed so that uncertainties are expected to overestimate, rather than underestimate, actual toxicity. The toxicity values used in the Step 2 ERA quantitative assessment are conservative values representing NOAEL. Therefore, risks tend to be overestimated. In general, HQs and HIs exceeding the negligible risk threshold of 1.0 do not necessarily imply significant risks. In fact, actual risks to aquatic wildlife often are very low (i.e., affecting only a few percent of all species) even when HQs are 3, 5, or higher. This is because actual risks depend on bioavailability of metals, as well as fraction ingested from source, frequency and duration of exposure. When these probabilities are factored into risks, actual risks are often much lower.

Based on the Step 2 ERA, the NOAEL-based ecological risk-based levels (ERBLs) (proposed as monthly average discharge limits) for arsenic, chromium III, iron, nickel, and titanium are: 0.76 mg/L, 0.89 mg/L, 9.55 mg/L, 5.55 mg/L, and 90.86 mg/L, respectively. The LOAEL-based ERBLs (proposed as daily maximum discharge limits) for arsenic, chromium III, iron, nickel, and titanium are: 3.05 mg/L, 3.6 mg/L, 27.29 mg/L, 7.67 mg/L, and 218.03 mg/L, respectively. If the ingestion of sediment pathway is not taken into account, NOAEL- and LOAEL-based ERBLs will be much higher.

As the actual threshold for toxic effects in wildlife lies somewhere between the NOAEL and the LOAEL, and the cumulative NOAEL-based and LOAEL-based HIs are below one, actual risks to all species of concern are negligible and very low. This is because actual risks depend on bioavailability of metals in sediment, as well as fraction ingested from source, food availability, and frequency and duration of exposure. When these probabilities are factored into risks, actual risks to species of concern are often much lower than the estimated values.

Accordingly, maximum discharge limits set at the LOAEL-based ERBLs and average daily discharge limits set at the NOAEL-based ERBLs will not result in an unacceptable ecological risk for the Site. The LOAEL-based and NOAEL-based ERBLs are as follows:

Metal	Monthly Average Discharge Level (mg/L)	Daily Maximum Discharge Level (mg/L)
Arsenic	0.76	3.05
Chromium III	0.89	3.6
Iron	9.55	27.29
Nickel	5.55	7.67
Titanium	90.86	218.03

1.0 INTRODUCTION

SECOR International Incorporated (SECOR), now Stantec Consulting Corporation, is pleased to submit this ecological risk assessment (ERA) report, as part of the Utah Pollutant Discharge Elimination System (UPDES) permit, for the ATI Titanium, LLC (ATI Titanium) facility located at 12633 North Rowley Road, North Skull Valley, Tooele County, Utah 84029 (Figure 1).

For the purpose of the ERA, the effluent discharge area, which is where the discharge pipe ends (about 3 miles northeast of the ATI Titanium manufacturing facility), releasing treated effluent into a straight historical channel that extends towards the Great Salt Lake (GSL), is considered as the Site or Study Area. Location of the ATI Titanium effluent discharge location is depicted with a triangle on Figure 2.

1.1 Purpose and Scope of work

The objective of this ERA is to evaluate the likelihood of adverse ecological effects to the environment as a result constant discharge of ATI Titanium's treated process water directly from the discharge pipe into a historical channel directing to the GSL. The effluent discharge water will have about 1% salinity (10 grams per liter [g/L]) and is not considered as freshwater.

The goal of the ERA is to derive the risk-based acute and chronic concentrations of the chemicals of potential ecological concern (CPECs) in treated effluent water that are protective of the environment and to provide information that would assist risk managers to make informed decision regarding effluent discharge water and to form the basis for suitable UPDES discharge limits.

This ERA was conducted in accordance with the current U.S. Environmental Protection Agency (USEPA) risk assessment guidance (USEPA, 1997) and the Utah Department of Environmental Quality (UDEQ) guidance and recommendations (UDEQ, 2008a, 2008b, and 2008c; SECOR, 2008c, 2008d, and 2008e). This ERA report encompasses a screening level ERA, which includes Step 1 (Screening-level Problem Formulation and Ecological Effects Evaluation) and Step 2 (Screening-level Exposure Estimates and Risk Calculation) of the 8-step ERA defined by the USEPA (USEPA, 1997).

1.2 Site Background

The ATI Titanium facility is located in Tooele County near Rowley, Utah. The purpose of the facility is to manufacturer titanium (chemical formula Ti) sponge (Allegheny Technologies Inc., 2007). The facility is located within approximately 883 acres, 40 miles west of Salt Lake City and 15 miles north of exit 77 of Interstate 80. The property, previously owned by US Magnesium Corporation (US Mag), was purchased by ATI Titanium in December 2006. The address is 12633 North Rowley Road, North Skull Valley, Utah 84029. The Universal Transverse Mercator (UTM) coordinates of the facility are: 353,719.78 meters east, 4,530,280.32 meters north, Zone 12N. The designated standard Industrial classification (SIC) is 3339. The proposed facility is bordered to the Northeast by Desert Power (a power plant) and

US Magnesium (a magnesium [chemical formula Mg] manufacturing plant) (ATI Titanium, 2007). The remaining adjacent property is open rangeland used for cattle grazing.

The ATI Titanium facility will have a nameplate capacity of 40 million pounds per year (lbs/year) of titanium sponge production. The source of electricity for the ATI plant is from Rocky Mountain Power. There is no onsite co-generation. The titanium manufacturing process consists of the following steps, including description of process flow for water usage (ATI Titanium, 2007):

1. Raw Material Usage (titanium tetrachloride [chemical formula $TiCl_4$], molten magnesium, fuels, inert gases, and other chemicals used in minor amounts)
2. Titanium Reduction and Vacuum Distillation Process (TRVDP)
3. Titanium Sponge Processing & Packaging
4. Process Flow for Water Usage

1. Raw Materials Usage: The ATI Titanium facility uses titanium tetrachloride as the primary raw material in the titanium manufacturing process. Titanium tetrachloride, a liquid at ambient temperatures, is delivered in 16-gallon rail cars, which are unloaded into storage tanks. There are five fixed-roof storage tanks at 25,000 gallons each. The design capacity of 40 million pounds (lbs) of titanium sponge per year requires 160 million lbs of titanium tetrachloride per year. The titanium tetrachloride is pumped to the sponge plant where it is reduced to titanium metal. The titanium tetrachloride will react with the humidity in the air to form titanium dioxide [chemical formula TiO_2] and hydrochloric acid [chemical formula HCl]. Wet scrubbers will capture acid vapors and titanium oxide particulate from the tank storage area. The scrubber blowdown will be treated via the on-site wastewater treatment system.

Magnesium is the second primary raw material. Molten magnesium for use in the TRVDP process is transported in closed vessels from the nearby US Magnesium. The molten magnesium is added to a reaction vessel by transferring it with inert gas pressure from a closed insulated pot. The amount of magnesium required to produce 40 million lbs of titanium sponge/year is approximately 40 million pounds per year (lbs/year).

2. TRVDP: Titanium is produced via a chemical reduction process at 800 degrees Celsius (^{o}C) as follows:

$$\mathbf{2\ Mg + TiCl_4 \rightarrow Ti + 2\ MgCl_2}$$

In the TRVDP, a sealed reduction vessel is first heated in an electric furnace, then molten magnesium metal, transported from the adjacent US Mag facility to a holding furnace, is added by transferring it with inert gas pressure from a closed insulated pot. Titanium tetrachloride from storage tanks is subsequently injected into the closed vessel where it reacts with the molten magnesium to form titanium metal sponge and magnesium chloride ([chemical formula $MgCl_2$]). Pressure is relieved periodically from the reactor and vented to a wet scrubber control device to prevent excessive pressure build-up. Emissions consist of hydrogen ([chemical formula H_2]), argon ([chemical formula Ar]), hydrochloric acid, titanium tetrachloride, lower chlorides of titanium (e.g., titanium chloride [chemical formula $TiCl_2$]), and magnesium oxide [chemical formula MgO]. Valves are opened and the magnesium chloride is transferred to a transportable vessel or holding furnace by argon gas pressurization. A fume shroud encloses the charge port and the discharging piping. Emissions resulting from the transfer of the magnesium chloride are primarily fine particles of magnesium chloride salts that are collected via this shroud and vented to the emission control system. The wet scrubber blowdown will be treated via the on-site wastewater treatment system.

When the reduction cycle is completed, piping on the top of the reduction vessel is connected to a second vessel (condenser). The condenser is cooled with groundwater from wells that was treated via reverse osmosis (RO) and a vacuum is applied while the reduction vessel is heated. The blowdown from the RO unit will be managed via the on-site wastewater treatment system. Heating the reduction vessel causes remaining magnesium and magnesium chloride to vaporize while leaving behind titanium sponge. The magnesium and magnesium chloride vapors pass to the cooled vessel where they condense. This process removes the residual magnesium and magnesium chloride from the titanium sponge. The condenser is then moved to a furnace where it is heated and charged with molten magnesium to start the cycle again. The condenser is essentially converted to a new reduction vessel. There is some magnesium and magnesium chloride remaining at the end of the reduction cycle because all the chlorides can not be removed by tapping and an excess of magnesium metal is added to the reduction vessel to eliminate the possibility of unreacted titanium chlorides remaining at the end of the reduction cycle. The TRVDP uses electrically heated furnaces so no combustion products are emitted. To produce 40 million lbs of Ti sponge per year, approximately 160 million lbs/year of magnesium chloride will be generated as a by-product to be used a feed stock for the production of magnesium by US Magnesium. US Magnesium produces molten magnesium metal for use in ATI Titanium's titanium production process by electrolyzing molten magnesium chloride.

In the retort repair area there will be up to three natural gas-fired furnaces for preparing and assembling retorts. There is also a cleaning pad where retorts, lids, valves, pumps, etc. can be washed with water for repair and/or reuse. Titanium oxide and magnesium chlorides will be present in the wastewater generated from this washing activity. This washwater will be treated via the on-site wastewater treatment system.

3. Titanium Sponge Processing and Packaging: After completion of a production cycle, the reduction vessel is cooled, the bottom is removed by cutting, and the titanium sponge is pushed out as a solid mass by a hydraulic ram. The bottom is then re-welded to the vessel, which is used as a condenser for condensing magnesium and magnesium chloride vapors to repeat the cycle. The sponge is then sheared, crushed, screened and sorted mechanically to size the titanium sponge. All of the sponge processing activities will be conducted inside a building. Following crushing, the titanium sponge is distributed into containers and a portion is inspected. The containers are prepared for shipment/storage. The containerized titanium sponge is shipped off-site.

4. Process Flow for Water Usage: The use of water in the titanium production process is detailed in Figure 3. Groundwater from wells (that are currently used by US Magnesium) will be treated via RO and will be used: 1) as plant process water; 2) for cooling tower; and 3) for scrubbers. Blowdowns from the RO unit and from three usages above are sent directly to the wastewater treatment unit designed by Siemens. Treated wastewater is discharged to the GSL via a polyvinyl chloride (PVC) pipe of approximately 12 inches in diameter. The discharge rate is estimated at a maximum of 500,000 gallons per day.

ATI Titanium's effluent characterization is described as follows:

- A majority of the expected wastewater volume is comprised of noncontact water from the source groundwater well.
- The source groundwater is the same as that currently in use at US Mag.
- The source groundwater, RO inlet, and RO concentrate (blowdown) were sampled to obtain the list of metals and nutrients expected to be present, and to exclude bio-persistent metals of concern not present. Table 1 presents the analytical results of groundwater source and RO concentrates. Metals of concern that were detected in source groundwater are: Arsenic (chemical formula As) (0.04 milligrams per liter [mg/L]) and magnesium (110 mg/L). Metals of concern that were detected in RO blowdown are: Chromium III (chemical formula Cr III) (0.03 mg/L) and magnesium (110 mg/L). RO inlet sample showed the presence of iron (chemical formula Fe) (0.25 mg/L) and magnesium (38 mg/L).
- There are metals that are not present in source groundwater but are expected to be introduced as a result of the titanium manufacturing process: chromium III, nickel (chemical formula Ni) (from the use of stainless steel in the reactor vessel, wet scrubbers, and equipment washing), and titanium. According to the Stainless Steel Information Center, Specialty Steel Industry of North America (SSINA) (SSINA, 2008), the chemical composition of stainless steel is included as Table 2.
- All wastewater generated at the ATI Titanium facility will pass through treatment prior to discharge. A treatment performance guarantee is provided for the metals that are introduced into the process, which is reflected in the expected maximum influent concentrations presented in Table 3.

1.3 ERA Process and Report Organization

Performance of this ERA included Steps 1 and 2 of the 8–step Ecological Risk Assessment Process for Superfund, as described in the Interim Final Ecological Risk Assessment Guidance for Superfund (USEPA, 1997), and incorporated recommendations by UDEQ (UDEQ, 2008a, and 2008c; SECOR, 2008c, 2008d, and 2008e).

Consistent with USEPA guidance, the ERA included the following phases:

1.3.1 Step 1 ERA

The first phase of the ERA, detailed in Section 2, consisted of a qualitative evaluation that addressed elements of problem formulation (as described below in Section 2.1), including the following components:

- Preliminary data evaluation (e.g., description of sources, natural areas, and potential habitats at the discharge area);

- Development of the preliminary ecological site conceptual model (SCM) (e.g., fate and transport mechanisms from source(s) to contaminated media [migration pathways], potential on-site ecological receptors, complete and potentially complete exposure pathways, and exposure routes);

- Identification of assessment and measurement endpoints; and

- Selection of CPECs (defined as site-related chemicals that have the potential to adversely impact the existing or future ecosystems or habitats).

- Performance of a qualitative screening assessment. The qualitative screening assessment included efforts to establish conservative thresholds for adverse ecological effects (e.g., screening benchmark values).

- Screening-level ecological effects evaluation, as described by USEPA 1997, is included in Step 2 below.

1.3.2 Step 2 ERA

The second phase of the ERA, presented in Section 3, consisted of a quantitative screening ERA (USEPA, 1997). The purpose of this phase was to estimate potential risks associated with those CPECs identified in the Step 1 ERA as requiring further evaluation. Many preliminary SCM assumptions developed in Step 1 ERA were refined in Step 2 of the ERA. The quantitative ERA included screening-level exposure analysis and risk characterization (as described below in Section 3), and consisted of the following components:

- Screening-level exposure assessment, including refined quantitative estimations of intake (and/or uptake), and representative concentrations of CPECs in site media;

- Screening-level effect assessment, or identification and development of refined CPEC-specific no-effect doses for each relevant ecological receptor;

- Screening-level risk estimation (or calculation of potential risks); and

- Risk description (or evaluation of the magnitude and uncertainties of the potential risks).

2.0 STEP 1 - ERA

The USEPA (1997) defines the Step 1 of the 8-step ERA to include screening-level problem formulation and screening-level ecological effects evaluation. For purpose of this ERA, the screening-level ecological effects evaluation is included in the second phase of the ERA (Section 3).

2.1 Problem Formulation Phase

During the problem formulation phase, currently available data on potential communities, habitats, and ecosystems were collected and evaluated to describe the potential ecological systems at risk, known or suspected contamination, and fate and transport of these contaminants. Then assessment endpoints (i.e., environmental values such as species, ecological resource, or habitat type to be protected) were selected for ecological receptors of concern and to form the basis for the development of the ecological SCM. Within the SCM framework, complete and potentially complete exposure pathways were identified for each receptor of concern. Finally, chemical stressor data were screened for selection of CPECs, which were subsequently evaluated quantitatively in Step 2 (Screening-level Analysis and Risk Characterization) of the ERA.

2.1.1 Preliminary Evaluation

Available data concerning the effluent discharge area that is relevant to the focus of this ERA was assessed. Results of Site visits and discussion with UDEQ were incorporated into the SCM for the Site to address the following areas:

- Potential habitats;
- Significant Site features;
- Immediate contiguous area;
- Nearby National Wildlife Refuge areas;
- Vegetative cover types at the Site;
- Suspected and/or observed wildlife; and
- Federally or state listed threatened or endangered species identified at the Site (if any).

A Site visit and field review of environmental resources at the Site were conducted on March 4, 2008, by Ms. Paula Weyen-Gellner, SECOR Biologist, Ms. Janet Roemmel, SECOR Project Manager, Ms. Xuannga (Sonia) Mahini, SECOR Toxicologist, Mr. Chris Bittner, UDEQ Toxicologist, Ms. Dan Griffin, UDEQ Project Manager/Environmental Engineer, and Mr. Lee Weber, ATI Wah Chang Director of Environmental Services. The group walked out to the stake which marks the meandering water line: Stake waypoint, N 40°51'15.1" W 112°38'15.0". The end access road waypoint (100 yards South of stake) N 40°56'11.0" W 112°42'14.9". Pictures of the Site on March 8, 2008 are shown in Appendix A.

As shown in the pictures taken on March 4, 2008, the snow melt conditions had created vast areas of open water surrounding the meandering water line (e.g., storm water drainage and US Mag waste water pond). However, this condition is not permanent and the Site is known to be a rather desert-like and dry area (SECOR, 2008a and 2008b). This was confirmed on the second Site visit on March 18, 2008 (Ms. Xuannga (Sonia) Mahini, SECOR Toxicologist, Ms. Dan Griffin, UDEQ Project Manager/Environmental Engineer, Dr. Bill Moellmer, UDEQ Environmental Scientist, and Mr. Lee Weber, ATI Wah Chang Director of Environmental Services), when water levels of the storm water drainage and the US Mag waste water pond were significantly reduced.

The observations during the Site visits are as follows:

- No historically significant structures are present in the Site, or the immediate contiguous area.
- The Site is not located within a National Wildlife Refuge and no refuges are located within a mile of the Site.
- The Site is not located in the vicinity of any wild or scenic river.
- Vegetative cover types at the Site are unrecognizable due to winter and snow conditions.
- As observed on March 4, 2008 and March 18, 2008, the potential for the Site to provide significant habitats to wildlife is limited. Only two ducks were observed on March 4, 2008 along the storm water drainage and no mammalian wildlife was observed on March 18, 2008. The single observed burrow could be that of the prairie dog (SECOR, 2008c).

Literature review indicated that in the saline marsh environment of the GSL, cattails and tules are the dominant emergent vegetation, while pond weeds and smart weeds are to be found floating in most areas of standing, open water. Open flat lands are often covered with goosefoot. In higher areas, saltgrass and woody chenopods can be found (Weber State University, 2008).

Additional field surveys were conducted on April 30 and May 5, 2008 by a SECOR/Stantec field ecologist to identify wetlands and other water features and to evaluate the potential for the occurrence of State Sensitive Species.

According to the Natural Resources Conservation Service *electronic* Field Office Technical Guide (eFOTG) (http://www.nrcs.usda.gov/technical/efotg), on a macro level, the Site falls within the land resource region classified as the Western Range and Irrigated Region, with the major land resource area classified as the GSL Area (28A). On a micro level, the Site is situated on the west-southwest side of the GSL south of Currington Bay near Rowley, in Tooele County, Utah. The elevation of the Site is approximately 4,220 feet above mean sea level (upper elevation is around 4,225 feet, low elevation is new 4,202 feet at proposed outfall).

A majority of the Site is heavily disturbed and characterized by a dirt access road, which eventually intersects the northern-most point of the storm water drainage. From that point north the Site is situated in an area characterized by playas. The areas surrounding the Site include sagebrush scrub to the south, playa to the east, and the heavily disturbed US Mag property including the plant and former waste water pond to the north.

Dominant vegetation identified during the field survey within the study area includes Clasping Pepperweed (*Lepidium perfoliatum*), Russian Thistle (*Salsola kali*), Glasswort (*Salicornia utahensis*), Cheatgrass (*Bromus tectorum*), Greasewood (*Sarcobatus vermiculatus*) and Rubber Rabbitbrush (*Chrysothamnus nauseosus*). Vegetation was limited to less than 20% cover at all of the sample points. It was often below 5% total ground cover. A state-listed noxious weed species, Saltcedar (*Tamarix ramosissima*) was also identified in the area but outside of the proposed pipeline.

Based on the review of the lists of Federal Threatened and Endangered (T&E) Species and Utah Sensitive Species (Utah Department of Natural Resources [UDNR], 2008a) recorded for Tooele County and maps of species occurrences in various State reports (UDNR, 1999, 2000, 2003, 2005; Utah Division of Wildlife Resources [UDWR], 1998a and 1998b) on plants, invertebrate and vertebrate species, it was found that none of the Federal T&E Species were found at the Site and very few State Sensitive Species may have the potential to be found in areas surrounding the Site. Most State Sensitive Species that may be found in the surrounding areas of the Site are of higher trophic levels (e.g., Bald Eagle, Ferruginous Hawk, and Short-eared Owl) and are not of concern since CPECs at the Site are not known to bioaccumulate and biomagnify in the food chain (UDEQ, 2008a; SECOR, 2008b and 2008c). Those avian species that may have the potential to be present in the areas surrounding the Site have not been observed during different Site visits.

Based on the April 7, 2008 letter from the State of Utah, Department of Natural Resources (UDNR, 2008c) regarding species of concern near the Great Salt Lake, Tooele County, occurrence for the American white pelican was found within a 0.5-mile radius of the Site and burrowing owl, ferruginous hawk, and long-billed curlew were found within a 10-mile radius of the Site. Since burrowing owl and ferruginous hawk consume small mammals and vertebrates, they are not relevant for the purpose of the ERA. American white pelican (consuming mostly fish) and long-billed curlew (consuming diverse food items such as crustaceans, mollusks, worms, toads, the adults and larvae of insects, berries, and nesting birds) are both migratory birds. Due to their diet composition and occurrence in the Great Salt Lake, these birds were not evaluated in the ERA.

Although small mammal populations are often assessment endpoints for ERAs in Utah, small mammals are not assessment endpoints for the ATI ERA because their loss would result in an indirect effect on predatory species for shorebirds. Since this assessment is focused on an introduced water source rather than impacts to a naturally occurring ecosystem, impacts to a previously existing prey-base does not require evaluation." (UDEQ, 2008a and 2008e; SECOR, 2008a,,2008b, and 2008c). Table 4 shows the results of the Federal T&E and State Sensitive Species analysis.

2.1.2 Preliminary Ecological Site Conceptual Model

An ecological SCM identifies potential sources of chemical stressors, ecological receptors, and relevant pathways to be considered in the ERA. This preliminary SCM was developed based on a review of existing information regarding the nature and extent of possible chemical release, potential habitat types, and flora/fauna in the Site, and on a one-day site visit on March 6, 2008. Its purpose is to identify the types of sources, receptors, and pathways that are likely to be relevant and to facilitate completion of the final SCM. The final SCM for the Site will be refined, consistent with regulatory agencies' comments on the ERA, and as additional data become available.

The following topics are addressed in this section:

- Preliminary data evaluation;
- Habitats and receptors;
- Exposure pathways;
- Complete and potentially complete exposure pathways; and
- Indicator species selection.

A summary of metals that may be detected in effluent discharge water is presented below. In the SCM section (Section 2.1.2), relevant habitats and ecological receptors of concern potentially present in the Site are described in the context of the freshwater/saline habitat. In addition, elements of a complete exposure pathway are discussed, and complete/potentially complete exposure pathways are identified for receptors potentially living within the described habitats. Indicator species selected for evaluation in the ERA and the preliminary SCM, including receptors and exposure pathways to be evaluated, are also presented.

2.1.2.1 Preliminary Data Evaluation

Prior to detail design and actual effluent generation, ATI Titanium wastewater characterization is based on the following:

- A majority of the expected wastewater volume is comprised of noncontact water from groundwater wells.
- The source groundwater is the same as currently in use at US Mag. Data considered also include the concentrate from the RO unit in operation at the US Mag facility.
- The source groundwater and RO concentrate (blowdown) were sampled to obtain the list of metals and nutrients expected to be present, and to exclude metals of concern (e.g., selenium, mercury, and lead).
- Metals of concern that were detected in source groundwater are: Arsenic (0.04 mg/L) and magnesium (110 mg/L). Metals of concern that were detected in RO blowdown are:

Chromium III (0.03 mg/L) and magnesium (110 mg/L). RO inlet sample showed the presence of iron (0.25 mg/L) and magnesium (38 mg/L).

- Metals above the detection limit (arsenic, chromium III, and iron) or believed to be part of the process (e.g., chromium III, iron, nickel, and titanium) are added to the list of CPECs and UPDES application. Chromium III, nickel, and titanium are metals that are not present in source groundwater but are expected to be introduced as a result of the titanium manufacturing process. Chromium III, nickel and titanium from the process are expected to be introduced to wastewater in small amounts from minor leaching of stainless steel used in the reactor vessels. These process metals enter wastewater from the blowdown of the wet scrubbers and equipment washing.

- All wastewater generated will pass through treatment prior to discharge. A treatment performance guarantee is provided for the metals that will be introduced into the process. This guarantee is given based on expected maximum influent concentrations.

Table 1 presents the list of all metals analyzed and their measured concentrations in source groundwater, RO blowdown, and RO inlet. Acute and chronic National Ambient Water Quality Criteria (NAWQC) and State criteria for freshwater and salt water in dissolved concentrations are also presented. These dissolved criteria were converted to total recoverable levels for arsenic, cadmium, chromium III, copper, lead, nickel, selenium, and zinc, based on the USEPA-recommended maximum hardness or calcium carbonate ($CaCO_3$) concentration of 400 mg/L (UDEQ, 2008c; USEPA, 2008a) (Table 1). Although magnesium was detected in source groundwater, both UDEQ and UFWS are not concerned about the presence of magnesium in the discharged water since it is found at background levels in groundwater and at concentrations much below the background levels of the GSL (SECOR, 2008b and 2008c).

Acute NAWQCs are calculated by the USEPA as half the Final Acute Value (FAV), which is the fifth percentile of the distribution of 48- to 96-hour median lethal concentration (LC_{50}) values or equivalent median effective concentration (EC_{50}) values for each criterion chemical (Stephan et al., 1985). Acute NAWQCs are intended to correspond to concentrations that would cause less than 50% mortality in 5% of exposed populations in a brief exposure. They may be used as a reasonable upper screening benchmark because waste site assessments are concerned with sublethal effects and largely with continuous exposures, rather than the lethal effects and episodic exposures to which the acute NAWQCs are applied. Chronic NAWQCs are the FAVs divided by the Final Acute-Chronic Ratio (FAC), which is the geometric mean of quotients of at least three LC_{50}/CV ratios from tests of different families of aquatic organisms (Stephan et al., 1985). It is intended to prevent significant toxic effects in chronic exposures and is used as a lower screening benchmark. Acute and chronic NAWQCs for several metals are functions of water hardness. NAWQC values for hardness-dependent metals default to 100 mg $CaCO_3$/L, but equations are provided to obtain values based on site-specific hardness values.

2.1.2.2 Habitats and Receptors

Existing information was reviewed and UDEQ and UFWS were contacted to identify habitat type(s) and species of concern that are present or potentially present in the Site (UDEQ, 2008b). A one-day site walk was conducted on March 6, 2008, to identify the locations and extent of various habitat types and to identify potential receptor locations. A general description of the habitat types potentially impacted by effluent discharge and the potential ecological receptors associated with the relevant habitat type(s) is presented below.

Aquatic/Terrestrial Habitat and Potential Receptors

Information on the wetlands for the Site is not yet available. Based on the proposed location of the effluent discharge pipe, the daily rate of effluent discharge, and the presence of a historical channel between the discharge pipe and the GSL, it was estimated that the potential water depth in the discharge channel will be around 9 inches, with a channel width of 12 feet wide, for a flow of 300 gallons per minute (gpm). The effluent will flow by gravity north from the pipe, where it will be within a few hundred feet of the GSL water line as it exists currently. Despite the desert-like nature of the habitat, use of the Study Area by wildlife is possible, but limited. Wildlife expected to occur in this area may include invertebrates (e.g., brine shrimp and brine flies) and birds (e.g., black-necked stilts, American avocet, and mallard ducks). Small mammals (e.g., prairie dogs) may be present but its use of the saline discharge water may be limited. Amphibians may not be expected to reproduce within the saline discharge area. No Federal T&E and State sensitive species have been observed and are expected to inhabit the saline Study Area.

Per Ms. Weyen-Gellner's conversation with Ms. Chris Cline at the UFWS on 3/10/08 (SECOR, 2008a), Ms. Cline suggested three species of concern for the Site: 1) American avocet; 2) mallard duck; and 3) snowy plover (which is a State-listed sensitive species, although not listed for the County of Tooele [UDNR, 2008a]). In the late 1990s, the American avocet, black-necked stilt, and mallard duck were evaluated as species of concern for the Kennecott Southshore Wetlands; and the black-necked stilt was considered to be an indicator species for the snowy plover (Ecological Planning and Toxicology, Inc. [EPTI], 1997). A decade later, the American avocet and black-necked stilt remained the shorebirds of concern evaluated in the recent peer-reviewed GSL Selenium Program (Cavitt, 2007; UDEQ, 2008d).

Due to the narrow width of the proposed effluent channel (12 feet wide) and potential depth of standing water (9 inches deep), use of the narrow discharged channel by species of concern is limited. Since snowy plovers have a small and short beak, they cannot reach down to sediment at 9 inches deep. They also prefer to nest at the margins of alkaline lakes or on alkali flats in the vicinity of springs, seeps, artesian wells, or freshwater streams (EPTI, 1997). As such, the discharged water channel does not provide a suitable nesting habitat or a typical foraging habitat for snowy plovers, although snowy plovers may be observed in the area. In addition, snowy plovers can be found up to 3 kilometers (km) or 1.9 miles away from its nest (Aldrich and Paul, 2002). Similar to the *Ecological Risk Assessment Southshore Wetlands* (EPTI, 1997; Toll et al., 2005), UDEQ has agreed that the black-necked stilt could be evaluated to be an indicator species for the snowy plover (UDEQ, 2008b; SECOR, 2008e). To be conservative, the snowy plover was quantitatively evaluated in this ERA to determine whether the stilt could still be an indicator species for the snowy plover, as concluded by EPTI (EPTI, 1997). As a result, the four species of concern for the Site are: 1) American avocet; 2) black-necked stilt; 3) mallard duck (UDEQ, 2008b); and 4) snowy plover.

It should be noted that the selection of species of concern for the Site is conservative since vegetation observed at the Site should not be conducive to shorebird nesting, based on similar observation at Saltair (Cavitt, 2007). Based on the results of the recent peer-reviewed GSL Selenium Program (UDEQ, 2008d), there were few birds that were nesting at Saltair, the

Kennecott wastewater discharge area at the south shore of the GSL (similar GSL southshore setting) (Cavitt, 2007). For example, only 13 American avocet nests were found to nest in the Saltair study area. Black-necked stilt was not found to nest in Saltair, although one pair of black-necked stilt was found foraging in the area. Black-necked stilt was found nesting only at Ogden Bay. Two snowy plover birds were found only at the Antelope Island Bridger Bay site (Cavitt, 2007), not at Saltair.

2.1.2.3 Potential Exposure Pathways

A review of existing data describing the nature and extent of chemical release in the Site was conducted to identify potential exposure pathways. According to USEPA, a complete exposure pathway consists of the following four elements: sources and release mechanisms, retention and transport media, exposure points, and exposure routes (USEPA, 1989). If any of these elements is missing, the pathway is considered incomplete. These four elements are described below.

Sources and Release Mechanisms

Potential sources of chemical contamination in the Site relevant to ecological receptors include effluent discharge water along the historical channel to the GSL. Once arriving to the GSL, low levels of metals in effluent discharge water may not be of concern since it has been observed that over geologic time, the GSL has developed an efficient mechanism for sequestration of metals and metalloids in sediments, making them less available to the GSL ecosystem, as long as the salinity remains high and the sediments are relatively undisturbed (EPTI, 1998).

Within the discharge channel, volatilization is not possible due to the non-volatile nature of metals. Metals present in the channelized water are subject to precipitation and adsorption to sediment, which is influenced by solubility limits, pH, and absorbent concentrations, and complex ligands, etc. (USEPA, 1985). Due to the low concentrations of metals expected in the pH-neutral effluent discharge water and the low levels of total suspended solids (TSS) (<5 mg/L per Siemens' guaranteed performance), it is not expected that significant sedimentation will occur since arsenic and nickel will be mostly in dissolved form (~60-70%) (USEPA, 1985). This conclusion is further supported by the fact that wastewater from ATI Titanium's well-operated, well-maintained metal precipitation, clarification, and filtration treatment system will not provide insoluble metals that can purport to sediment. In other words, the remaining CPECs in the treated effluent will be inherently soluble and not available for the sediment exposure pathway except through evaporation.

The potential release mechanisms for chemicals present in the effluent discharge water (and potentially sediments) are uptake by aquatic plants and animals and transfer through the food chain. In the late 1990s, it has been shown with biomonitoring studies of the GSL and surrounding areas that except mercury (chemical formula Hg) and selenium (chemical formula Se), other metals in surface water and sediment do not bioconcentrate significantly in brine shrimp and brine fly (EPTI, 1998). UDEQ has also confirmed these finding results (UDEQ, 2008a; SECOR, and 2008c). A decade later, the results of the recent peer-reviewed GSL Selenium Program confirmed that although there was over a thousand-fold bioconcentration between selenium dissolved in the water and the periphyton of the biostromes, the limited data collected suggested that there was no further bioconcentration between periphyton and the brine fly (Wurtsbaugh, 2007; UDEQ, 2008d). For inference purposes, since CPECs at the Site are not known to bioconcentrate in invertebrates, there should not be concern for bioaccumulation of site-related CPECs in the birds' primary food chain (brine shrimp and brine fly).

Retention and Transport Media

As discussed above, the effluent discharge water provides a retention and transport medium for chemical stressors at the Site. Transport via the air medium is not possible due to the non-volatile nature of metals.

Exposure Points

For purposes of the ERA, ecological receptors may be in contact with site-related chemical stressors within the Study Area, along the historical channel and around the discharge area near the GSL shoreline.

Exposure Routes

The possible exposure route for ecological receptors is ingestion of the effluent discharge water. This observation is true for metal CPECs. The inhalation exposure route is not complete. Although pathways such as ingestion of plants and algae are potentially complete for aquatic organisms (invertebrates) and avian species, these pathways were not quantitatively addressed in ERA. Toxicity values for exposure of aquatic organisms to sediments and surface water are expressed as concentrations, and not doses. As previously discussed, it has been shown with the late 1990s biomonitoring studies of the GSL that except mercury and selenium, other metals do not bioconcentrate significantly in invertebrates (brine shrimp and brine flies) (EPTI, 1998). The recent 2008 peer-reviewed GSL Selenium Program results also showed that although there was over a thousand-fold bioconcentration between selenium dissolved in the water and the periphyton of the biostromes, the limited data collected suggested that there was no further bioconcentration between periphyton and the brine fly (Wurtsbaugh, 2007; UDEQ, 2008d). As such, only the ingestion of invertebrates by avian species was considered to be more dominant and was quantitatively evaluated, based on available literature information on either freshwater or saline water-to-invertebrate bioaccumulation factors (BAF).

Based on UDEQ suggestion, the sediment ingestion pathway by species of concern should also be evaluated (SECOR, 2008e). Recognizing the large uncertainty of modeling sediment concentrations from effluent discharge levels, UDEQ proposed an alternative that this pathway could be evaluated in a backward manner to arrive at acceptable sediment concentrations (SECOR, 2008c and 2008e). In this ERA, SECOR evaluated the sediment ingestion pathway based on expected sediment concentrations and the fate and transport characteristics of CPECs in the surface water environment.

2.1.2.4 Summary of Complete and Potentially Complete Exposure Pathways

Information gathered during the data evaluation and biological site characterization was used to characterize exposure pathways in the Site as incomplete, complete, or potentially complete. According to USEPA guidance (USEPA, 1989 and 1992b), complete or potentially complete exposure pathways are evaluated quantitatively. Complete or potentially complete pathways may be considered insignificant (due to either low levels of chemical constituents, low exposure frequency, or insignificance as compared to other risk-driving pathways). Pathways considered insignificant are discussed in the ERA, but are not quantified.

Complete and potentially complete pathways for ecological receptors present in the Site are presented in Figure 4 for aquatic/terrestrial habitat, respectively, and are discussed below.

Aquatic/Terrestrial Habitat Receptors

Potentially complete exposure pathways for plants/algae, invertebrates, birds, and mammals are shown in Figure 4. Potential exposure of aquatic/terrestrial receptors to chemicals in the Site is discussed below.

1. Plants/algae in the area may be exposed to chemicals via uptake from effluent discharge water.
2. Invertebrates in the area may be exposed to chemicals via ingestion of and direct contact/uptake from effluent discharge water and ingestion of impacted plant/algae tissue from sediment.
3. Birds in the area may be exposed to chemicals via ingestion of effluent discharge water, or potentially impacted sediment, or potentially impacted plant and animal tissues.
4. Mammals in the area may be exposed to chemicals via ingestion of effluent discharge water (less likely due to saline characteristics), or potentially impacted animal tissues.

Based on a review of the data and consideration of the receptors likely to be present in the Site, the inhalation pathway was not quantitatively evaluated. Of the potentially complete pathways above, the ingestion of effluent discharge water, ingestion of potentially impacted sediment, and ingestion of potentially impacted food (from water and sediment) are quantitatively evaluated in the Phase II ERA for avian receptors (UDEQ, 2008b; SECOR, 2008e).

2.1.2.5 Indicator Species Selection

Indicator species evaluated in the ERA were selected from communication with UDEQ and UFWS based on the receptor groups identified in the SCM (Figure 4). Other criteria used to select indicator species included:

- Availability of relevant exposure and toxicity data for the indicator species;
- Availability of suitable test protocols (e.g., bioassay protocols);
- Sensitivity to chemicals detected in Site media;
- High potential for exposure (e.g., based on feeding habits or life history);
- Whether or not the species is a special-status species; and
- Whether or not the species was observed on-site.

Indicator species that were selected for evaluation in the ERA are: American avocet, black-necked stilt, mallard duck, and snowy plover (UDEQ, 2008b). Black-necked stilt and American avocet were chosen as indicator species for all medium size insectivorous shorebirds in the recent peer-reviewed GSL Selenium Program (Cavitt, 2007; UDEQ, 2008d) (and could potentially as surrogates for the snowy plover). Snowy plover is a State-listed sensitive species, although not listed for the County of Tooele, where the Site is located (UDNR, 2008a). Note that during the recent peer-reviewed GSL Selenium Program, only two snowy plover birds were found at the Antelope Island Bridger Bay site (Cavitt, 2007), not at GSL southshore area. Mallard ducks were chosen as indicator species for all omnivorous birds. The selection of these indicator species is conservative. Based on the GSL Final Report Selenium Program (UDEQ, 2008d), there were few birds that were nesting at Saltair, the Kennecott wastewater discharge area at the south shore of the GSL (similar GSL southshore setting) (Cavitt, 2007). For example, only 13 American avocet nests were found in the Saltair study area. Black-necked stilt was not found to nest in Saltair, although one pair of black-necked stilt was found foraging in the area. Black-necked stilt was found nesting only at Ogden Bay (Cavitt, 2007). Two snowy plover birds were found only at the Antelope Island Bridger Bay site (Cavitt, 2007), not at Saltair.

Receptor characteristics used in the exposure assessment are discussed below and summarized in Table 5. Photographs of these four indicator species are presented in Figure 5.

<u>American Avocet (Recurvirostra Americana) – Insectivorous Bird</u>

American avocets and black-necked stilts are found in greatest numbers in the salt-rich GSL region. A single-day count of American avocets and black-necked stilts have exceeded 250,000 and 65,000, respectively. The GSL provides both breeding and migratory habitats for avocets and stilts. Avocet nesting on GSL is often concurrent with that of black-necked stilts (Aldrich and Paul, 2002).

The American avocet is a long-legged, large shorebird being 43-47 centimeters (cm) in height (17-19 inches) and having a wingspan of up to 72 cm (28 inches) (Cornell Laboratory of Ornithology [CLO], 2008). It is characterized by a long, thin bill that curves upward. In the female avocet, the bill curves up a little bit more. This shorebird has a distinctive black and white striped pattern on its back and sides. During the breeding season, their head and neck are a pinkish-tan and during the winter they are a grayish-white color. The avocet also has bluish-gray legs and feet; thus its colloquial name was "blue shanks" (Texas Parks and Wildlife [TPW], 2008).

The American avocet is known to breed in the mud flats of the wetlands associated with the GSL. American avocets are migratory birds arriving in Utah in late March and leaving for wintering grounds beginning in August until September (staying in Utah for 7 months out of the year). A small number of avocets sometimes winter within the northern breeding areas in Utah, Nevada, and Oregon (UDNR, 2008a).

American avocets nest in colonies of 10 to 12 from April to June, constructing nests that are merely depressions on the sand or platforms of grass on mudflats. Should the water rises, the breeding pair will raise their nest up to a foot or more with sticks, weeds, bones and feathers to keep the eggs above water. The avocet pair incubates three to four olive-colored eggs for 22 to 24 days. The downy young not only feed themselves soon after hatching, but they can also swim. A female American avocet may lay one to four eggs in the nest of another female, who then incubates the eggs. American avocets may parasitize other species' nests; single American avocet eggs have been found in the nests of Mew Gulls. Other species may also parasitize avocet nests. Avocets have incubated mixed clutches of their own eggs and those of common terns or black-necked stilts. The avocets reared the stilt hatchlings as if they were their own (CLO, 2008).

The diet of the American avocet consists primarily of:

- Aquatic invertebrates of the water column and sediment, including waterboatmen (*Corixidae*), beetle larvae (*Coleoptera*), fly larvae (*Diptera*), and midges (*Chironomidae*);
- Terrestrial invertebrates including grasshoppers, caterpillars, and spiders; and
- Other foods sources including small fish, aquatic vegetables, and seeds, especially sago pondweed and bulrushes.

In the more saline wetlands of Utah, avocets also feed on brine shrimp and brine flies. Brine flies can provide up to 63-79% of the avocet's diet (Aldrich and Paul, 2002). It was estimated that on the average about 2/3 of the American avocet's diet (or 67%) is animal foods (Stanford University, 2008). Based on the results of the most recent peer-reviewed GSL Selenium Program (Cavitt, 2007; UDEQ, 2008d), the diet of the American avocet (data collected from late April to August 2006) varies among different study sites. For example, at Antelope Island, 65% of the food recovered from the entire digestive tract (mouth, esophagus, proventriculus, and ventriculus) were brine fly, whereas 34% were seeds. At Ogden Bay, midges, brine fly, and waterboatmen were 52%, 18%, and 16% of the American avocet's total diet, respectively. At Saltair (GSL southshore near the Kennecott wastewater discharge area), 34% of the food consumed was midges, 30% was brine fly, and 11% was wasp (*Bracondidae*). Other food included beetle, house fly (*Muscidae*), and miscellaneous tree bugs (cicadas, aphids, leafhoppers, etc. - *Hemiptera*) (Cavitt, 2007).

American avocet's foraging areas are situated in open water with depths around 3-9 inches. Avocets have three visual feeding methods: pecking, plunging, and snatching; and six tactile feeding methods: bill pursuit, filtering, scraping, single scything (in which the bill is held open slightly at the muddy substrate surface and moved from one side to the other), multiple scything, and dabble scything. Scything has been noted as the hallmark strategy for avocets (UDNR, 2008a).

The American avocet has an average body weight of 315 grams (g) (Wild Birds Unlimited, 2008) (the reported weight ranging 275-350 g [CLO, 2008]). An average water consumption rate for the avocet is estimated at 0.0272 liters per day (L/day), based on an allometric equation for non-passerine birds (USEPA, 1993). Its average food ingestion rate is estimated at 0.103 kilograms of wet weight per day (kg ww/day), based on an allometric equation for birds (USEPA, 1993). It should be noted that food ingestion rates (and potential water ingestion rates) based on allometric equations are conservative (see the discussion on the mallard duck below) (USEPA, 1993). A sediment ingestion rate specific to the American avocet could not be identified; therefore, a sediment ingestion rate of 5 % of their diet was assumed, based on the most recent peer-reviewed GSL Selenium Program (UDEQ, 2008d). Information on the home range for the American avocets could not be identified. Since American avocets and black-necked stilts are closely allied ecologically, the mean home range of the black-necked stilts in the San Francisco Bay estuary (283.5 hectares [ha]) (Hickey et al., 2007) was assumed for American avocets. To be conservative, area use factor (AUF) or fraction ingested from contaminated source (FR) by species of concern at the Site is assumed to be 1 in the ERA (SECOR, 2008e). Potential species-specific AUF or FR is further discussed in the Uncertainty Analysis (Section 3.3).

Black-necked Stilt (Himantopus Mexicanus) – Insectivorous Bird

Black-necked stilts are closely allied with American avocets ecologically and associate with them at breeding sites and some winter sites (Aldrich and Paul, 2002). The black-necked stilt can reach a height of 35-39 cm (14 to15 inches), with a 71 cm (28 inches) wingspan (CLO, 2008). Adult males have black backs, white bellies, black bills and long red or pinkish legs. Adult females look the same as males, but have brownish backs. Both males and females have long, pointed black wings and a slender bill that curves slightly upward.

The distribution of the black-necked stilt is like that of the American avocet, which is highly dependent on suitable local habitat. It is known to nest in areas with salt or brackish ponds, potholes, salt marshes, wet pastures, or shallow alkaline wetlands. It also breeds in the mud flats of the wetlands associated with the GSL (Aldrich and Paul, 2002). Based on the results of the recent peer-reviewed GSL Selenium Program (UDEQ, 2008d), while 13 American Avocet pairs were found to nest in the Saltair study area (the Kennecott wastewater discharge area at the south shore of the GSL (similar GSL southshore setting). Black-necked stilt was not found to nest in Saltair, although one pair of black-necked stilt was found foraging in the area. Black-necked stilt was found nesting only at Ogden Bay (Cavitt, 2007). Two snowy plover birds were found only at the Antelope Island Bridger Bay site (Cavitt, 2007), not at Saltair.

Black-necked stilts are migratory birds arriving in Utah in early April and leaving for wintering grounds beginning in August until September. In comparison to the avocets on the GSL, black-necked stilts arrive a week or two later and leave several weeks before (Aldrich and Paul, 2002) (staying in Utah for approximately 6 months out of the year). Their mating season lasts from April through August. Nests are built on the ground near water, and are made of sticks, mud, or shells, or scrapes in the ground, and may be lined with grass, twigs, and shells. Females lay three or four tan-colored eggs with dark brown or black irregular spots. Incubation is 22 to 26 days. Chicks are able to run, walk and swim as soon as their down is dry, which is usually within 24 hours of hatching. The black-necked stilt reaches sexual maturity at one year. Their lifespan is approximately 20 years. Foxes, gulls, skunks, coyotes, and other birds prey on the stilts.

The stilts feed in open water generally fresher than that chosen by avocets, from 0-15 centimeters deep, or on dry ground (UDNR, 2008a).

The diet of the black-necked stilts consists primarily of:

- Aquatic invertebrates of the water column and sediment (worms, insects such as brine flies, brine shrimp, and water boatmen); and
- Other foods sources including small fish, crayfish, shrimp, mollusks, tadpoles, and floating seeds.

Like the American avocets, black-necked stilts rely heavily on brine flies and brine shrimp for food on the GSL (Aldrich and Paul, 2002). Based on the results of the most recent peer-reviewed GSL Selenium Program (Cavitt, 2007; UDEQ, 2008d), the diet of the black-necked stilt (data collected from late April to August 2006) at Ogden Bay consists of beetles (30%), Odonata (26%), waterboatmen (13%), house fly (12%), brine fly (9%), and others.

The black-necked stilt has an average body weight of 167 g (Whatbird, 2008) (ranging from 136-220 g) (CLO, 2008). Its average water consumption rate is estimated at 0.0178 L/day, based on an allometric equation for non-passerine birds (USEPA, 1993). Its average food ingestion rate is estimated at 0.064 kg ww/day, based on an allometric equation for birds (USEPA, 1993). A sediment ingestion rate specific to the black-necked stilt could not be identified; therefore, a sediment ingestion rate of 5 % of their diet was assumed, based on the most recent peer-reviewed GSL Selenium Program (UDEQ, 2008d). The mean home range of the black-necked stilts in the San Francisco Bay estuary was measured to be 283.5 ha and movement from capture sites was 4.5 kilometers (km) (Hickey et al., 2007).

Mallard Duck (Anas platyrrhynchos) – Omnivorous Bird

The mallard is a common surface-feeding duck of freshwater and saltwater wetlands. They breed throughout much of Canada, the United States, and Mexico, and often interbreed with domestic ducks as well as with black ducks. The mallard is a common breeder in Utah; it can be found statewide throughout the year (UDNR, 2008a). Mallards average 58 cm from bill tip to tail tip, with a wingspan of up to 82-95 cm (32-37 inches) (CLO, 2008). Male mallards are generally heavier than females and have iridescent green head, rusty chest, and gray body; female mallards are mottled brown (USEPA, 1993).

Mallards are opportunistic feeders that consume grains, aquatic plants, seeds, terrestrial insects, aquatic invertebrates, and small fishes. Mallards are extremely popular with waterfowl hunters, likely being the most commonly pursued duck species in Utah (UDNR, 2008a). Mallards prefer upland to marsh habitats for their nest sites. Studies indicated that mallard nests are typically found within 100 miles of water (Bellrose, 1976). Mallard eggs vary on color from grayish buff to greenish buff. Incubation occurs for 26 to 30 days, with a 28 days average. As soon as the ducklings are dry, the hen leads them to water. Nest failure is an important factor affecting mallard populations. Mammalian predation is the main cause of nest failure, followed by human disturbance. Mammalian predators include fox, badger, and skunk; crows also prey on mallard nests (USEPA, 1993). The maximum recorded life span of the mallards is 23 years, 5 months (Clapp et al., 1982).

A dietary composition of 28 to 98.4% of plants and 1.6 to 72% of invertebrates has been reported for mallards (USEPA, 1993). In winter, mallards feed primarily on seeds, but also on invertebrates, mast, agricultural grains, and to a lesser extent, on leaves, buds, stems, rootlets, and tubers. In spring, the females shift from a largely herbivorous diet to primarily invertebrates in order to obtain enough protein for their molt and subsequent egg production. Macroinvertebrates comprised 72% by volume of the diet for female mallards during egg laying season (Swanson et al., 1985). The animal diet continues throughout summer (April, May, June) as females produce new clutches to those that have been destroyed (renest). Ducklings also consume aquatic fauna almost exclusively (Chura, 1961). In general, laying females eat about 2 times more animal food than males or nonlaying females (Stanford University, 2008). For this ERA, it was assumed that an average mallard's diet consists of 75.5% of vegetation and 24.5% invertebrates from the water bodies (67.8%, 66.8%, and 89.4% of invertebrates during April, May, and June and 7.8% of invertebrates for the rest of the year). These values are close to the USEPA's diet composition estimates of 79% of vegetation and 21% of invertebrates for mallard ducks (USEPA, 2005a). The moisture content of mallard's food is assumed to be 60%, based on its diet composition (USEPA, 2005a) and the water content of various wildlife foods (USEPA, 1993).

Availability of open water and food are limiting factors controlling the distribution and abundance of mallard ducks and other waterfowl in winter. The freshwater bodies and marshes of the GSL normally freeze by the first week in December, eliminating access to most aquatic food sources (Aldrich and Paul, 2002). Mallards are known to switch to alternative habitats and food sources and remain in the GSL in significant numbers during winters. They can exploit waste grains in adjacent agricultural areas as long as they remain snow-free, or utilize riverine habitats or discharge areas where flowing freshwater remains open and food persists.

The mallard has a mean body weight of 1.134 kilograms (kg) (average between males and females) (USEPA, 1993). Mallards are often used in laboratory studies, and several papers were found that cited measured food ingestion rates for mallards. Food ingestion rates for mallards were reported ranging from 0.091 kg ww/day to 0.139 kg ww/day (Davison and Sell, 1974; Heinz et al., 1987; Piccirillo and Quesenberry, 1980; White and Dieter, 1978; White and Finley, 1978). A food ingestion rate of 0.139 kg ww/day was reported for birds weighing an average of 1.25 kg (Piccirillo and Quesenberry, 1980). A similar food ingestion rate of 0.13 kg ww/day was reported for birds weighing an average of 1.23 kg (Davison and Sell, 1974). If the allometric equation for non-passerine birds is used to estimate the average food ingestion rate of mallards (USEPA, 1993), it would be 0.269 kg ww/day (nearly twice as the experimentally measured value). Since free living metabolic rates are two to three times higher than the basal existence metabolic rate (USEPA, 1993), UDEQ (2008e) stated that laboratory-measured mallard food ingestion rates may be underestimated. In the absence of field studies, the allometric estimates of food ingestion may provide a better estimate of food ingestion. For this ERA, the conservative food ingestion rate of 0.269 kg ww/day (USEPA, 1993) (instead of the highest laboratory-measured value of 0.139 kg ww/day [USEPA, 2005a]) was assumed for mallards. A species-specific water ingestion rate could not be found for the mallard. An average water consumption rate is estimated at 0.065 L/day, based on an allometric equation (USEPA, 1993). The mallard's sediment ingestion rate is estimated to be 2% of their diet (USEPA, 1993; Beyer et al., 1997). Home range sizes reported for mallards vary from 38.1 ha (or 94 acres) for a laying female to 1,440 ha (3,557 acres) for an adult non-laying female in Minnesota (USEPA, 1993). An average home range of 580 ha (average between males and females) was selected for this ERA.

<u>Snowy Plover (*Charadrius alexandrinus*) – Insectivorous Bird</u>

The snowy plover is a small shorebird that is found in much of the world, including the United States, Central America, South America, Eurasia, and Africa. These birds are common in Utah, and the GSL has the largest known concentration of snowy plovers in interior North America (about 5,000 birds in Utah, out of 16,000 birds in North America and the Caribbean (NatureServe Explorer, 2008). Utah populations migrate to the California coast and Mexico for winter (UDNR, 2008a). Based on the results of the recent peer-reviewed GSL Selenium Program (UDEQ, 2008d), only two snowy plover birds were found at the Antelope Island Bridger

Bay site (Cavitt, 2007), not at Saltair (the Kennecott wastewater discharge area at the south shore of the GSL - similar GSL southshore setting) (Cavitt, 2007).

The average length of the snowy plover is about 15 to 17 cm (6 to 7 inches), with a wingspan of 34 cm (13 inches). It has a short neck, moderately long legs, a pale tan back, white underparts, and dark patches on sides of neck (CLO, 2008).

The Snowy plover eats insects (brine flies) and other small invertebrates (brine shrimp) in the GSL) that are captured in sand, mud, or shallow water (UDNR, 2008a). Snowy plovers are primarily visual foragers, and will look, run, stop, and then peck at prey items from the surface of the beach. They feed on terrestrial and marine invertebrates found above and below the mean high tide line, often in wrack (seaweed) washed up on the shore. They will occasionally probe in the sand at the base of low growing plants for insects (Oregon Parks and Recreation Department [OPRD], 2007).

Snowy plovers begin to arrive at the GSL in late March and early April and nearly all depart by late September (NatureServe Explorer, 2008). They breed and feed in the same habitat type, even though they may not do both in the same location (Aldrich and Paul, 2002). Some plovers have been observed greater than 1.9 miles (3 km) from the nest. The snowy plovers frequently raise two broods a year (clutch size is usually three), and sometimes three in places where the breeding season is long. Their eggs are buffy-sandy or olive color. Young chicks leave their nest within three hours of hatching. Predation (by red fox, gulls, common raven, skunk, raccoon, or coyote) seems to be a major contributor to plover mortality. The mean survival rate for an adult snowy plover at the GSL is 2.7 years (Aldrich and Paul, 2003; NatureServe Explorer, 2008), although a bird of 15 years of age has been observed.

The snowy plover has a mean body weight of 42.2 g (Cal/Ecotox Database, 2008) (range from 34 to 54 g [CLO, 2008]). Its water consumption rate is estimated at 0.0071 L/day based on an allometric equation for non-passerine birds (USEPA, 1993). Its food ingestion rate is estimated at 0.028 kg ww/day based on an allometric equation for non-passerine birds (USEPA, 1993). A sediment ingestion rate specific to the snowy plover could not be identified, therefore, a sediment ingestion rate of 5 % of their diet was assumed, based on the most recent peer-reviewed GSL Selenium Program (UDEQ, 2008d). The least sandpiper has similar characteristics and behaviors to the snowy plover. They tend to favor the mud and sand flats in the tidal estuaries at low water (Birdzilla, 2008), and tend to feed by picking up insects or probing for larvae in the mud and shallow water.

Although diet information is limited for the snowy plover, it is known that they feed primarily on aquatic vertebrates and are opportunistic in choice of prey. The major foods of snowy plovers at inland sites are the brine flies (*Ephydra hians*) and to some extent brine shrimp (*Artemia*) (U.S. Fish and Wildlife Service [USFWS], 1985). At coastal areas, plovers feed on a wider range of invertebrates. In inland California, plovers are not found where brine flies are absent (USFWS, 1985). There is no available information on the home range of the snowy plover. Its home range can be approximate to be that of the golden plovers (averaging 10 to 59 ha, with a median of 35 ha) (NatureServe Explorer, 2008). Also, plovers have been observed to be up to 3 km away from its nest.

Food Web for the Indicator Species

The food web for the southern part of the GSL is simple. There are 7 species of green algae, 17 diatom species, one dinoflagellate, and 15 taxa of bacteria in the GSL (EPTI, 1998). The primary producers of these species convert sunlight into biomass that floats near the GSL surface. These are eaten by brine shrimp (*Artemia franciscana*) and brine flies (*Ephydra cinerea*). The brine shrimp and larvae brine flies provide a large animal food sources for resident and migratory shorebirds and gulls. In addition, corixids (*Tricorixia verticalis*), or water boatmen that are commonly found in freshwater, can also be found as true inhabitants in the GSL.

From the unpublished 1994 USFWS study (cited by EPTI, 1998) and from the biomonitoring studies for the Kennecott site, it was found that none of the brine shrimp and brine fly samples had tissue concentrations high enough to exceed avian toxicity thresholds (EPTI, 1998). In addition, Dillon et al. (1995) examined 15 metals and metalloids (arsenic, boron, cadmium, chromium, cobalt, copper, lead, mercury, methylmercury, molybdenum, nickel, selenium, tin, vanadium, and zinc) and concluded that only three had the potential for biomagnification (arsenic, mercury, and selenium). The finding for arsenic had a caveat: It was limited to second and third order consumers. Because trophic transfer coefficients ranged from 0.1 to less than 1.0 at lower trophic levels, arsenic would not be expected to biomagnify in the GSL brine shrimp, occupying trophic level two as first-order consumers (EPTI, 1998). A decade later, the recent 2008 peer-reviewed GSL Selenium Program results also showed that although there was over a thousand-fold bioconcentration between selenium dissolved in the water and the periphyton of the biostromes, the limited data collected suggested that there was no further bioconcentration between periphyton and the brine fly (Wurtsbaugh, 2007; UDEQ, 2008d). For inference purposes, since CPECs at the Site are not known to bioconcentrate in invertebrates, there should not be concern for bioaccumulation of site-related CPECs in the birds' primary food chain of brine shrimp and brine fly and other invertebrates.

Brine Shrimp. The type of brine shrimp found in the GSL (*Artemia franciscana*) is also found in the San Francisco Bay. Brine shrimp live in hypersaline lakes in which the salt content may be up to 25% (250 g/L), where predators and competitors are few and algal production is high (U.S. Geological Survey [USGS], 2008a). The life cycle of *Artemia* begins from a dormant cyst that contains an embryo in a suspended state of metabolism (known as diapause). The cysts are very hardy and may remain viable for many years if kept dry. Water-temperature and salinity changes in the GSL occur in about February and cause the cysts to rehydrate and open to release the first growth stage, known as a nauplius larva. Depending on the water temperature, the larvae remain in this stage for about 12 hours, subsisting on yolk reserves before molting to the second nauplius stage, which feeds on small algal cells and detritus using hair-like structures on the antennae known as setae.

Although the cysts are very small (about 200 micrometers (µm) in diameter; 50 could fit on the head of a pin) at times they become so numerous that they form large red-brown streaks on the surface of the GSL. Under optimum conditions of food supply and lack of stress from increasing salinity or decreasing dissolved oxygen, fertilized female shrimp may produce eggs that hatch soon after emerging from the ovisac to produce nauplius larvae, which is known as ovoviparous reproduction. If the environmental conditions are perfect, the female shrimp can live as long as 3 months and produce as many as 300 live nauplii or cysts every 4 days. However, the cold spring-time temperatures and variable food supply in the GSL usually limit the population to two or three generations per year.

The nauplii molt about 15 times before reaching the adult size of about 10 millimeters in length. Adult male shrimp are easily identified by the large pair of "graspers" on the head end of the animals. Whereas some species of *Artemia* exhibit parthenogenesis (a reproductive mode in which only females are present that give rise to young females in the absence of males), the population of *Artemia franciscana* in the GSL has both males and females present. Adult shrimp feed primarily on phytoplankton (algae) suspended in the water but can also "graze" on benthic algae such as blue-greens called *Dunaliella* or diatoms growing on the bottom of the GSL in shallow areas. They also may reprocess fecal pellets excreted earlier in the year when large numbers of phytoplankton present in their diet were incompletely processed. A recent study showed that the shrimp can graze on diatoms that colonize shrimp exoskeleton parts released from their many molts. As the food supply becomes exhausted, the salinity increases, dissolved oxygen decreases, or a combination of these conditions occurs, the female shrimp switch from producing live young to producing cysts through oviparous reproduction.

In the GSL, the adult shrimp typically die from lack of food or low temperature during December. Although live brine shrimp have been observed in the lake at a water temperature of 3 degrees Celsius (°C) or 37 degrees Fahrenheit (°F), it is unlikely they can reproduce at that temperature. Research has shown that the maximum salt tolerance for adults is around 30% salinity, which is near the saturation level of 28%. Optimal salinity levels for cyst production are 14%-17%. For reference, most seawater is around 3-4%.

The cysts, which in the GSL are lighter than the lake water, float on the water surface where they may be harvested or may overwinter to form the source of shrimp for the following year (USGS, 2008a). Fluctuations in salinity of the south arm of the GSL as the lake periodically floods or evaporates can change the viability of harvested brine shrimp eggs. For example, in 1966, when the density of the brine in the south arm was 1,175 g/L, the viability rate of eggs harvested was 90%. In 1975, the brine density was 1,087 g/L, reducing the viability rate to only 5%, which made the eggs unmarketable (EPTI, 1998). Nearly 10-21 million pounds of brine shrimp eggs are harvested each winter and sold to aquaculturists and laboratories for bioassay testing of toxins, drugs, and other chemicals. The brine shrimp harvest is regulated by UDNR.

The quantity and quality of the shrimp cysts depends on many environmental factors, but salinity of the water is very important (USGS, 2008a). Although the cysts from the GSL will hatch at 2 to 3% salinity in the lake environment (similar to the salinity of the ATI Titanium effluent discharge water), there is greater production of cysts (and shrimp) at salinity levels above 10%. Low salinity levels tend to cause cysts to crack prematurely, which may partially explain the influence of spring runoff in hatch timing. Low salinities also allow other competitors to invade areas that were once unsuitable and can alter phytoplankton composition and interrupt food chains.

Artemia require 10% salinities, or less, to initiate hatching. Generally, spring runoff and precipitation lower surface salinities to these levels, but cysts in higher salinities must float in order to take advantage of surface precipitation. Within the GSL, cysts found in water of 16-28% salinity had a lower density than those found in the 10-14% range, causing them to float to the surface where less salty water would be found. As lake salinities drop near 5 to 6%, the cysts lose buoyancy, sink, and are more difficult to harvest. During the flood years of 1983-1987, when record flows of freshwater entered the GSL, the salinity of the south arm of the lake (also called Gilbert Bay) dropped to about 5.5% and the commercial shrimp industry moved to the part of the lake north of the railroad causeway (called Gunnison Bay) where most of the shrimp were located. By about 1989, the salinity in the south part of the lake increased to near 10% and the industry again relocated to the southern arm of the GSL.

The harvest of cysts in 1995-1997 was about 15 million pounds gross weight (about half is suitable for final product). In 1997, declining salinity (to 11%) resulted in a shift in the algal community to large diatoms which were not a good food source for *Artemia* (USGS, 2008a). The 1997-1998 harvest was stopped after about 3 weeks and only 6.1 million pounds of cysts were harvested. Based on this information, the effluent discharge area, with an average salinity level of 1%, would not provide an optimum environment for growth for the brine shrimp. Therefore, the density of brine shrimp in the Study Area may be much less than that of the GSL, providing a much less attractive habitat for migratory birds. Also, based on the results of the most recent peer-reviewed GSL Selenium Program (Cavitt, 2007; UDEQ, 2008d), the diet of the American avocet and black-necked stilt (data collected from late April to August 2006) consisted more of brine fly and other invertebrates than brine shrimp. Brine shrimp was absent in the diet of both American avocet and black-necked stilt (Cavitt, 2007; Wurtsbaugh, 2007).

Brine Flies. *There are two main species of brine flies in the GSL: Ephydra cinerea*, and a larger species, *Ephydra hians*. The former is more abundant in the south arm of the GSL, outnumbering its larger counterpart by 100:1. Brine flies and their larvae and pupae support an enormous number of shorebirds in the GSL. Brine flies can tolerate salinity as high as 30% (300 g/L). The adult flies have an average life span of 3-5 days. They eat the surface algae whenever possible, but mostly spend their lives floating on the water surface offshore without feeding (USGS, 2008a). Based on the results of the most recent peer-reviewed GSL Selenium Program (Cavitt, 2007; UDEQ, 2008d), the diet of the American avocet and black-necked stilt (data collected from late April to August 2006) consisted more of brine fly and other invertebrates than brine shrimp.

Eggs of brine fly are laid continuously through the summer at the surface of water. The eggs hatch quickly in about 6 days into larvae on the bottom of the GSL. Larvae live in the bottom sediments under water that is at least 2 feet deep (EPTI, 1998), but are never found in the deep, extreme saline portion of the GSL. These larvae are free-swimming and feed off the algal and bacterial community on the bottom, on rocks, or on logs until they are large and fat. Larvae go through three stages before pupating. This takes from 18 days to over 200 days. They then find a good substrate (bioherms/biostromes or anything floating) to attach to for their pupae life stage. Just like caterpillars, brine fly larvae form a "chrysalis", or casing, before they turn into adult flies. At the GSL, brine flies seem to prefer a bioherm/biostrome substrate. Bioherm or biostrome is a mound of calcium and magnesium carbonate deposits that are produced by the blue-green algae *Apthanothece packardii*. Bioherms/biostromes dominate the shallow water and shore areas where wave activity is strong. They can be as small as a few inches and as tall as 3–4 feet and 12 feet in diameter. The pupae trap air bubbles which cause them to float and be transported to the shore by the wind, hence the enormous windrows of pupae on shore. As the adult flies emerge, peak numbers have been reported in the billions, causing coal black clouds of flies on the GSL shore (UDNR, 2008b).

When spring arrives, very little light reaches the lake bottom due to massive, un-grazed algal blooms (as a result of no shrimp or flies to eat it over the winter). Brine shrimp eat an enormous amount of algae with the warming temperatures, and thus allow light to penetrate the water far deeper. The clear water provides sunlight for blue-green algae growth on the bottom of the lake, the brine fly larvae preferred food source. They start hatching in April/May and continue through October/November, usually peaking about 2 or 3 times. Brine fly larvae can ultimately consume up to 120,000 tons of algae and organic matter (UDNR, 2008b).

As discussed above, the optimum brine fly habitat requires hard substrates and right salinity (San Francisco State University [SFSU], 2000). Beach rock, bedrock, or bioherm/biostrome all consist of hard substrates. Hard substrates typically provide a much higher density of larvae and pupae than soft substrates of mud, sand, and silt. Hard substrates provide the brine fly larvae more nutritious food (algae) and offer protection from waves and currents, predators, and shifting sands (Little et al. 1989). Based on the results of the most recent peer-reviewed GSL Selenium Program (Wurtsbaugh, 2007; UDEQ, 2008d), it was found that in contrast to biostromes or bioherm, the sand and mud substrates that were sampled had relatively few brine flies associated with them. Also, salinity in the lake has a direct effect on algae, which directly has an influence on brine fly growth and development rates (see brine shrimp above). In waters of high salinity, the survival rate of brine flies tends to be greater since the high level of salinity cannot support other insects or competitors to the brine flies such that there is no immediate danger from other predators. In addition, the high level of salinity also reduces the parasitism and diseases (Mono Basin Environmental Impact Report [MBEIR], 1993). At other lakes when the salinity is low, beetles, damselfly larvae, and dolichopodid larvae prey on the brine flies (SFSU, 2000).

Since the salinity level of the effluent discharge is about 1% and the depth of the effluent discharge channel is only 9 inches deep with little available hard substrates, it is not expected that the Study Area (effluent discharge channel) will provide an attractive environment for brine flies to optimally reproduce and to provide adequate food source for the four avian species of concern.

Corixids. Corixids are predatory aquatic insects referred to as "water boatmen" commonly found in the freshwater environment. It was first believed that the corixids found in the GSL were simply transported to the lake from nearby freshwater marshes. The consensus now seems to be that they are indeed true inhabitants of the GSL and can exist both in the freshwater and saltwater environments. Corixids prey on the brine shrimp as well as the larvae of the two species of brine flies. The ecological impact of this predation is being investigated by the State of Utah.

2.2 Assessment and Measurement Endpoints

An important aspect of determining significance or relevance of potential effects is an evaluation of whether or not the effects are observed in designated assessment or measurement endpoints. This is a crucial element as these endpoints must be specific and relevant and should be limited to organisms that spend a significant portion of their life or derive a significant portion of their diet or physiological needs from the Site.

2.2.1 Assessment Endpoints

Assessment endpoints are formal expressions of the actual environmental value to be protected from risk (Suter et al., 1993). Assessment endpoints are typically specific and are tied directly to specific ecological values needing protection. Further, assessment endpoints provide a clear logical connection between regulatory policy goals and anticipated ecotoxicological investigations. They are selected based on the ecosystems, communities and/or species that are of particular concern at a site.

Assessment endpoint selection for this ERA focused on those ecological features or resources that have substantial aesthetic, social, or economic value or are important in the biological functions or biodiversity of the system. The definition of an appropriate assessment endpoint will avoid making a decision on the basis of trivial or insignificant effects. Thus, it is conceivable that observable effects could be detected in a system, but because they occur in organisms or processes deemed relatively unimportant, they may be discounted as a cause for action.

The principal objective of development of an assessment endpoint is in establishing a connection between the ecological health of the Site and regulatory policy actions. For purposes of the ERA, since there are no confirmed endangered and threatened species and habitats that are protected by federal or state regulations identified for the Site, the assessment endpoints were conservatively defined as protection of certain species of concern (e.g., bird populations).

For the Site, the assessment endpoints are phrased as the following questions:

- Are concentrations of CPECs in effluent discharge water high enough to impair reproductive success or adversely affect the health and survival of species of concern?
- Are concentrations of CPECs potentially present in sediment high enough to impair reproductive success or adversely affect the health and survival of species of concern?

For this ERA, aquatic macroinvertebrate communities were not expected to be altered by CPECs such that they reduce the quantity or quality of food available to species of concern. This is based on results of available 1997 biomonitoring studies performed for the GSL and Southshore wetlands (EPTI, 1997 and 1998) and the results of the most recent 2008 peer-reviewed GSL Selenium Program (Wurtsbaugh, 2007; UDEQ, 2008d). For example, Wurtsbaugh found that although there was over a thousand-fold bioconcentration between selenium (a known bioaccumulative metal) dissolved in the water and the periphyton of the biostromes, the limited data collected suggested that there was no further bioconcentration between periphyton and the brine fly (Wurtsbaugh, 2007; UDEQ, 2008d). For inference purposes, since CPECs at the Site are not known to bioconcentrate in invertebrates, there should not be concern for bioaccumulation of site-related CPECs in the birds' primary food chain of brine shrimp, brine fly, and other invertebrates. As discussed earlier, the abundance of brine shrimp and brine flies may not be at optimum within the discharge channel due to low salinity (1%).

2.2.2 Testable Hypotheses

For each of the assessment endpoints identified, the null (H_o) hypothesis was tested. This hypothesis presumes that any CPECs identified in the Site would not be present in sufficient concentrations in abiotic media to induce adverse ecological effects in designated assessment endpoints. In order to test this hypothesis during later phases of the ERA, site-specific exposure data were compared with literature-derived no-observed-adverse-effect-level (NOAEL) or lowest-observed-adverse-effect-level (LOAEL) values. If the ratio of actual values to literature-derived values exceeds one, the null hypothesis is rejected.

2.2.3 Measurement Endpoints

Generally, assessment endpoints cannot be directly measured. Therefore, a measurement endpoint related to the assessment endpoint must be evaluated. Measurement endpoints are quantitative expressions of an observed or measurable effect and must correspond or predict assessment endpoints. An important aspect in determining significance or relevance of potential effects is the evaluation of whether the effects are observed in designated measurement endpoints.

The selection of measurement endpoints needs to be appropriate to the potential exposure pathways, and correspond to the abiotic-biotic dynamics perceived to be ongoing at a site. They are readily measurable phenomena and appropriate for the assessment endpoints, temporal dynamics of exposure, and scale of the site being evaluated. In the ERA, measurement endpoints that reflect the assessment endpoints discussed above include measurement of CPECs concentrations in effluent discharge water. Using literature-derived BAFs, estimated tissue concentrations of invertebrates were also calculated.

Modeling sediment concentrations from discharge water contains a large degree of uncertainty due to lack of available information (soil concentrations, site-specific sediment-water partition coefficient, resuspension and deposition rates, [sedimentation], etc.). The currently available US Mag soil concentrations may not be representative of soil levels at the discharge area. Possible CPEC levels in sediment at the Site were identified based on measured sediment concentrations in Utah and other areas and characteristics of effluent discharge water (discussed later in Section 3.1.2).

Past intensive biomonitoring studies of the GSL and Southshore wetlands showed that there was high temporal and spatial heterogeneity in CPEC concentrations in surface water and sediment. Surface water concentrations recorded at various sites have spanned four orders of magnitude, whereas sediment concentrations can span up to two orders of magnitude. However, macroinvertebrate tissue residues were relatively constant over time, although significant heterogeneity occurred among sample sites. Correlation between water/sediment CPEC concentrations and tissue residues was low (ETPI, 1997). The results of the most recent 2008 peer-reviewed GSL Selenium Program (Cavitt, 2007; UDEQ, 2008d) confirmed some of the late 1990s findings. For example, Cavitt found that although the selenium content of water samples taken from Saltair (near the GSL southshore Kennecott waste water discharge area) were significantly higher than those taken from either Antelope island or Ogden Bay, sediment samples did not differ significantly (Cavitt, 2007).

2.3 Selection of Chemicals of Potential Ecological Concern

Selection of CPECs is generally conducted to select those site-related chemicals likely to be associated with adverse ecological effects. In the preliminary screening assessment, general selection criteria have been discussed earlier in Section 2.1.2.1 (Preliminary Data Evaluation). Thus, the list of CPECs for the Study Area includes: Arsenic, chromium III, iron, nickel, and titanium. Note that arsenic was detected in source groundwater but not in RO concentrate. It is therefore likely to be background-related.

These metalloid (arsenic) and metal CPECs (chromium III, iron, nickel, and titanium) are present in the environment in many different chemical forms. In general, the elemental forms as occasionally found in rocks, soils, or metallic forms, are relatively inert and are not bioavailable to plants and animals. Upon exposure to oxygen, they can become oxidized (lose electrons) and form various salts or compounds that are more soluble than their elemental states and thus can become more bioavailable to plants and animals. They can also be reduced (gain electrons) under certain environmental conditions. The reduced forms are less soluble than the oxidized forms and thus have lower bioavailability. A brief description of these CPECs is presented below.

2.3.1 Arsenic

Arsenic is a steel-gray, brittle, crystalline metalloid (52^{nd} crustal abundance) with three allotropic forms that are yellow, black, and gray. Arsenic is widely distributed in the earth's crust, with an abundance of about 5 milligrams per kilogram (mg/kg) (ranging from <0.1 to 97 mg/kg). The most common oxidation states for arsenic are –III (arsine), 0, III (arsenite), and V (arsenate). Arsenic is used primarily for its toxic properties. Arsenic has been used as herbicides, pesticides, and also as feed additive to poultry (Adriano, 1986; Kabata-Pendias and Pendias, 1992). By 1960s, the use of inorganic arsenic compounds in agriculture disappeared (Hazardous Substances Data Bank [HSDB], 2008).

Arsenic as a free element (0 oxidation state) is rarely encountered in natural waters; arsenic in water exists primarily as a dissolved ionic species. Arsenic occurs primarily as arsenic (V) in oxidizing environment of surface water and sediment and as arsenic (III) in reducing conditions of groundwater (Agency for Toxic Substances and Disease Registry [ATSDR], 2007). Arsenic was found in the finished water of 83 U.S. cities at levels from non-detect to 0.05 mg/L. However, some small systems contain more (up to 0.393 mg/L) (Carson et al., 1987.) Concentrations of arsenic in surface waters of the U.S. range from 0.005 to 0.340 mg/L, with a mean value of 0.064 mg/L (Koop, 1969, as cited by USEPA, 1985). Surveys of arsenic concentrations in rivers and lakes indicated that most values are below 0.01 mg/L, although individual samples may range up to 1 mg/L (ATSDR, 2007). Arsenic in groundwater averages about 0.001 to 0.002 mg/L, except in some Western states with volcanic rock and sulfide mineral deposits high in arsenic, where arsenic levels up to 3.4 mg/L have been observed. Adsorption of arsenic to particulates generally decreases with increasing pH, indicating that adsorption is more likely to be important in acidic water (USEPA, 1985). In neutral water, such as the effluent discharge water, particulates account for less than 1% of the total measurable arsenic in surface water (ATSDR, 2007). Much of the arsenic present in fish and shellfish exists in an organic form that is essentially nontoxic. However, some of the arsenic in these foods can be in inorganic form (0.1 to 41%) (ATSDR, 2007). It does not appear that arsenic biomagnifies through the food chain (ATSDR, 2007).

Different plants have different degrees of tolerance to arsenic in soil. In general, arsenic mobility and phytotoxicity is greater in sandy than in clayey soils. Arsenic sorbs strongly to sediment, especially in acidic and neutral waters. Most sediment arsenic concentrations reported for U.S. rivers, lakes, and streams range from 0.1 to 4,000 mg/kg, but much higher levels may occur in areas of contamination (ATSDR, 2007). It has been reported that much of the arsenic in the oxidized layers of sediment is associated with (coprecipitated or adsorbed) the hydrous iron and manganese oxide fraction or is present as $Fe_3(AsO_4)$. Under these conditions, the amount of arsenic in pollution potentially bioavailable forms in oxidized sediment pore water is low; and 65 to 98% is present as the less bioavailable arsenate (Masscheleyn et al., 1991). In uncontaminated or slightly contaminated oxidized sediments, most of the non-residual arsenic is adsorbed to iron oxyhydroxides and is relatively unavailable.

Arsenic may be absorbed by ingestion, inhalation, or through permeation of the skin or mucous membrane. Most absorbed arsenic will be excreted in a few days. Solubility of arsenic in water and bodily fluids appear to be directly related to its toxicity. The toxicity of arsenic compounds conforms to the following orders from the greatest to the least toxicity: arsines > inorganic arsenites > organic arsenic (III) or arsenoxides >inorganic arsenates > organic pentavalent compounds > arsonium compounds > elemental arsenic (Eisler, 1988).

2.3.2 Chromium

Chromium, a steel-gray, lustrous, hard, brittle metal, is the 21st most common element in the earth's crust. Chromium can occur in any of the oxidation states, from –II to VI, but it is not commonly found in oxidation states other than 0, III, and VI, with III being the most stable in the environment. Chromium is used in the production of stainless steel, wood preservation, leather tanning, pigments, and refractories (Adriano, 1986; Kabata-Pendias and Pendias, 1992).

Chromium levels in soil vary greatly, depending on the composition of the parent rock from which the soils were formed. Basalt and serpentine soils, ultramafic rocks, and phosphorites may contain chromium as high as a few thousand mg/kg. The concentration range of chromium in 1,319 samples of soils and other surficial materials collected in the conterminous U.S. was 1 to 2,000 mg/kg, with a geometric mean of 37 mg/kg. In most soils, chromium is present predominantly in the chromium (III) state.

Released into water, most chromium compounds will ultimately be deposited in sediments. Chromium (VI) predominates under highly oxidizing conditions, whereas chromium (III) predominates under reducing conditions. Chromium (VI) can be readily reduced to chromium (III) in the presence of iron (III) and dissolved sulfides. A very small percentage of chromium can be present in water in both soluble and insoluble forms. Soluble chromium generally accounts for a very small percentage of the total chromium in water (HSDB, 2008). Chromium in wastewater can range up to 0.5 mg/L, which is near the solubility of chromium at neutral pH (USEPA, 1985). Chromium levels in the finished water of the 100 largest U.S. cities were as high as 0.035 mg/L (Carson et al., 1987). Chromium concentrations in U.S. river water usually range from <0.001 to 0.03 mg/L, with a median value of 0.01 mg/L. Chromium concentrations in lake generally do not exceed 0.005 mg/L. The potential for bioconcentration and biomagnification of chromium (III) in aquatic organisms is low (ATSDR, 2000).

In the suspended materials and sediment of water bodies, chromium levels ranged from 1 to 500 mg/kg (HSDB, 2008). Chromium in 541 streambed-sediment samples collected from 20 study areas across the conterminous U.S. had the median and range of 64 mg/kg, and <1 to 700 mg/kg, respectively. Much of the chromium in sediments is associated with the clay fraction, as indicated by a close correlation between aluminum and chromium concentrations (Schropp et al., 1990). More than 70% of the chromium in uncontaminated sediments may be associated with the non-bioavailable, residual fraction (Prohic and Kniewald, 1987), that is associated primarily with the heavy minerals chromite, chromiferous magnetite, spinels, and aluminosilicate lattice of clays) (Mayer and Fink, 1980).

Marine and freshwater organisms have evolved efficient mechanisms for regulating chromium and other essential trace metals (e.g., arsenic, chromium, copper, nickel, and zinc) (Chapman et al., 1996). Sediment feeding tower shell *Cerithium vulgatum* (marine snails) were found to sequester chromium, iron, nickel, and titanium in insoluble fecal pellets. Pellets (retaining the original load or more of metals) of *C. vulgatum* are durable, membrane-bound structures and they reduce metal bioavailability to food chains by compartmentalization (Nott and Nicolaidou, 1996).

Food is the major environmental source for chromium. Chromium has been shown to be an essential nutrient for humans and animals. Chromium III has been shown to have antioxidative properties *in vivo* and it is integral in activating enzymes and maintaining the stability of proteins and nucleic acids. Its primary metabolic role is to potentiate the action of insulin through its presence in an organometallic molecule called the glucose tolerance factor. Chromium (VI) is absorbed three to five times better in the intestine compared to chromium (III). Some evidence suggested that ingested orally, most chromium (VI) is believed to be reduced to chromium (III) before reaching sites of absorption in the small intestines (USEPA, 2005a). Less than 1% of an oral dose of chromium (III) is absorbed (Carson et al., 1987). Chromium (III) has low toxicity due to poor membrane permeability and noncorrosivity. Chromium toxicity includes severe congestion and inflammation of the digestive tract, kidney and liver damage, with the precipitating properties of chromium believed to be the basis of the tissue damage.

2.3.3 Iron

Iron is the second most abundant metal and the fourth most abundant element in the earth crust. In soils, iron occurs mainly as oxides and hydroxides. The most common range of iron from soil is from 0.5 to 5% (5,000 to 50,000 mg/kg) (Adriano, 1986; Kabata-Pendias and Pendias, 1992). Iron is used primarily in the production of steel and alloys. In addition, it is also used as catalysts, pigments, drugs, as well as in agriculture, nutrition, and leather tanning. Common oxidation states of iron under environmental conditions are iron (II) and iron (III), with the iron (III) state being preferred under oxidizing conditions and predominate under most normal environmental conditions.

The average amount of iron in soils and other surficial materials in the U.S. was reported to be 26,000 mg/kg, with a range of 100 mg/kg to 100,000 mg/kg (HSDB, 2008). Surface sediment samples (upper 15 centimeters [cm]) collected at ten locations along a 9 kilometers (km) reach of the West Branch of the Grand Calumet River in Indiana-Illinois were found to contain iron ranging from 36,600 mg/kg to 45,500 mg/kg (HSDB, 2008). Iron ions are retained on organic matter (humic and fuvic acid) found in environmental waters.

Iron concentrations in surface waters range widely, from 61 to 2,680 mg/L (HSDB, 2008). Iron concentrations in groundwater have been reported to range from <0.5 to 100 mg/L; higher values have been found in the absence of oxygen and in the presence of organic matter. Some drinking waters are high in iron (Carson et al., 1987). Mean iron concentrations in drinking water were reported as 1.4 mg/L (standing overnight) and 0,27 mg/L (running, 30-second flush) in water from Seattle, Washington (HSDB, 2008). Grab samples (3,834) of household tap water collected in July 1974 from 35 geographical areas in the U.S. contained iron concentrations ranging from 0.0489 mg/L to 1.564 mg/L (HSDB, 2008). Iron compounds, both ferrous (+2) and ferric (+3) have generally low solubilities in water. The major exceptions are the halides and nitrates (Carson et al., 1987). Iron is found in virtually every food source with higher concentrations in animal tissues than in plants (Carson et al., 1987). As discussed in the chromium section above, marine animals (snails) can sequester iron in insoluble granules that are not bioavailable to predators of these marine animals (Nott and Nicolaidu, 1996).

Iron an essential element that is required by all forms of life. It is considered to be the key metal in energy transformations (e.g., a constituent of hemoglobin) needed for syntheses and other life processes of the cells (Kabata-Pendias and Pendias, 1992). Recently, iron was found to be a nutrient that is believed to limit primary productivity in about 30 to 40% of the ocean's surface waters, including much of the northern North Pacific, where iron addition has been shown to stimulate plankton growth. By facilitating phytoplankton blooms, iron supply to surface waters may lead to a transfer of carbon to the deep sea and thus decrease the concentration of atmospheric carbon dioxide (chemical formula CO_2) (USGS, 2008b). As a result, private companies have begun to express interest in iron "fertilization" of the ocean because of the value of atmospheric CO_2 reduction in the carbon-offset market.

In humans, the recommended daily allowance of iron is 10 mg for men and 18 mg for women. Intestinal absorption of iron, especially ferrous iron, is a complicated active process. The rate of uptake is inversely related to the state of body's iron store (Carson et al., 1987). The disposition of ingested iron is regulated by a complex mechanism that maintains homeostasis. Therefore, bioconcentration in biota is not a significant process for iron. Iron deficiency in plants causes retarded plant growth and yield. Adverse effects of iron toxicity may include renal failure and hepatic cirrhosis (Shacklette and Boerngen, 1984).

2.3.4 Nickel

Nickel is a hard, silvery metal abundant in the earth's crust (23rd most common element) and is heavily used in industries to form metal mixtures called alloys and stainless steel, in electroplating, nickel-cadmium batteries, fuel cells, electronic circuitry, and other applications. Normally, nickel occurs in the 0 and II oxidation states, although I, III, and IV states can exist under certain conditions (Adriano, 1986; Kabata-Pendias and Pendias, 1992). The most important valence state of nickel is II.

The soil content of nickel is extremely variable, with the world's average around 40 mg/kg. Normal soils are reported to contain from 5 to 500 mg/kg of nickel. It is not uncommon for soils derived from ultrabasic igneous rocks to contain 5,000 mg/kg of nickel (Adriano, 1986). Soils derived from serpentine rock may contain up to 25,000 mg/kg of nickel, although a more typical value is 1000 mg/kg (HSDB, 2008).

Nickel is one of the most mobile of the heavy metals in the aquatic environment, as compared with other metals (USEPA, 1985). At pH of 7, practically all of the nickel is present on the free divalent cation and that only a small amount was adsorbed (Vuceta and Morgan, 1978, as cited by USEPA, 1985). Typical nickel concentrations in freshwater are between 0.015 to 0.02 mg/L. A study of 969 U.S. water supplies found the average nickel level to be about 0.0048 mg/L (Carson et al., 1987). Partitioning into biota is not a dominant fate process. In soil and water environments, nickel compounds that are soluble in water such as nickel chlorides and nickel nitrates are generally more mobile than insoluble nickel compounds such as nickel oxides and nickel sulfides. Although aquatic organisms may accumulate nickel from their surroundings, there is little evidence for significant biomagnification of nickel levels along the food chains (HSDB, 2008). Water-soluble nickel compounds are poorly absorbed by most living organisms (ATSDR, 2005; HSDB, 2008).

Nickel was detected in non-polluted sediments of the Great Lakes, Puget Sound, and Yaquina Bay at <20, 13, and 14.5 mg/kg, respectively (HSDB, 2008). In oxidized sediments, much of the potentially bioavailable nickel is complexed to iron and manganese oxides (Luther at al., 1986). Most of nickel (more than 90%) in relatively uncontaminated sediments is in the residual fraction that is associated with oxide minerals, such as magnetite, spinels, and silicates (Loring, 1982). Thus, the bioavailability of nickel in sediments usually is low. As discussed in the chromium section above, marine animals (snails) can sequester nickel in insoluble granules that are not bioavailable to predators of these marine animals (Nott and Nicolaidu, 1996).

The major of nickel uptake is in food. In general, when nickel concentrations in vegetative tissues of plants exceed 50 mg/kg (dry weight basis), plants may suffer excess nickel and exhibit toxicity symptoms. The toxicity symptoms produced by nickel are similar to those produced by several heavy metals and consists of 1) chlorosis (yellowing of the leaves) caused by iron-induced deficiency and 2) specific effects of the metal itself (Adriano, 1986; Kabata-Pendias and Pendias, 1992).

Nickel compounds have low absorption capability from the gastrointestinal tract; therefore, they have relatively higher water quality standards compared to other heavy metals such as arsenic, beryllium, cadmium, lead, mercury, and thallium. The organs which are most affected by exposure to nickel compounds are nasal cavities, lung, and skin (Irwin et al., 1997).

2.3.5 Titanium

Titanium is a lustrous, whitish metal that is the 9th most abundant element in the earth's crust (Adriano, 1986). It is almost always present in igneous rocks and igneous-derived sediments. Titanium is present in the earth crust at about 3,600 mg/kg and in normal soils at the range of 1,000 to 10,000 mg/kg (Adriano, 1986) or 20,000 mg/kg (HSDB, 2008). It has oxidation states of II, III, or IV, with the latter being the most prevalent. Titanium is produced and used in alloys, pigments (e.g., titanium dioxide), catalysts, and structural metals (for submarines and aircrafts).

In general, titanium is fairly insoluble in soil in the pH range of 4 to 8. Released to soils, titanium compounds are expected to be immobile. Released to water, soluble titanium ions are easily hydrolyzed into hydrated titanium oxides (e.g., titanium dioxide) and basic oxo salts, which are insoluble. Titanium dioxide is not acutely toxic in fish. In addition to forming insoluble oxides, titanium also forms a considerable number of materials called titanates (e.g., ilmenite $FeTiO_3$, perovskite $CaTiO_3$). Titanium has been reported in all samples from 15 rivers in the U.S. and Canada in concentrations ranging from 0.002 to 0.107 mg/L. In groundwater, titanium was found in 20 of 216 stations in the National Contaminant Occurrence Database with an average dissolved concentration of 0.015 mg/L (HSDB, 2008). Titanium compounds are not expected to bioconcentrate in aquatic organisms (HSDB, 2008; ATSDR, 1997). As discussed in the chromium section above, marine animals (snails) can sequester titanium in insoluble granules that are not bioavailable to predators of these marine animals (Nott and Nicolaidu, 1996).

Although titanium levels in food items vary widely, food accounts for practically all of the daily titanium intake (Carson et al., 1987). Titanium is not considered to be essential for the growth of higher plants; however, it does seem to play a role in increasing the yield of some crops (legumes) (Adriano, 1986). Since titanium is only sparingly soluble in soils, plant toxicity under field conditions should not be encountered.

When titanium tetrachloride, the primary raw material at the ATI Titanium plant, is in contact with water or moist air, it rapidly hydrolyzes to hydrochloric acid, titanium oxychloride, and titanium dioxide. Titanium oxychloride usually further hydrolyzes to hydrochloric acid and titanium dioxide (ATSDR, 1997). Since titanium dioxide is insoluble in water, it may be captured by the water treatment process and little is released in the discharged process water. Residues of titanium dioxide, a very inert compound, are likely to settle out to the sediment (ATSDR, 1997). Titanium dioxide also occurs naturally in the environment.

According to the USEPA (USEPA, 2005b), titanium dioxide is a widely used inorganic white pigment, primarily in the production of paints, printing inks, paper and plastic products. It is also used in many white or colored products including foods, cosmetics, UV skin protection products, ceramics, fibers, and rubber products. Both the Joint Expert Committee on Food Additives of the Food and Agriculture Organization/World Health Organization (JECFA) and the European Food Safety Authority (EFSA) evaluations of titanium oxide noted that there is no absorption or tissue storage of titanium oxide. As a result, establishment of an acceptable daily intake (ADI, which is an estimate by the JECFA of the amount of a food additive, expressed on a body weight basis, that can be ingested daily over a lifetime without appreciable health risks) was not needed and there are no safety concern associated with the use of titanium dioxide as a food additive at levels ranging up to 3% (30,000 mg/kg) (USEPA, 2005b).

2.4 Ecological Screening Assessment

In the screening/qualitative phase of the ERA, if exposure point concentrations are less than conservative ecological screening values, it is suggested that the CPEC is unlikely to pose a significant risk to the ecological receptor. Conversely, concentrations of CPECs that exceed conservative ecological screening values may indicate the potential for toxicity to ecological receptors and may warrant further evaluation.

The screening values used in Step 1 of the ERA include:

- Freshwater and salt water screening values - protective of aquatic invertebrates, fish, aquatic plants, and wildlife; and
- Sediment screening values - protective of sediment-dwelling organisms, including aquatic invertebrates (discussed later in Section 3 and presented in Appendix B).

2.4.1 Surface Water Screening

As previously discussed, maximum detected metal concentrations or sample quantitation limit (SQL) for non-detected water samples were selected to be compared with surface water screening values. A number of sources are available for use as surface water-screening values (in dissolved concentrations) and the following hierarchy of values was used, when values for specific CPECs are available in the following sources:

- USEPA Acute NAWQC for Freshwater
- USEPA Chronic NAWQC for Freshwater
- UDEQ Acute Freshwater Aquatic Life Criteria
- UDEQ Chronic Freshwater Aquatic Life Criteria
- Tier II Secondary Acute Value (SAV) Surface Water Benchmarks
- Tier II Secondary Chronic Value (SCV) Surface Water Benchmarks
- 20% Effects Concentration (EC_{20}) Surface Water Benchmarks for Fish
- EC_{20} Surface Water Benchmarks for Bass Population
- Lowest Chronic Value (LCV) Surface Water Benchmarks for non-Daphnid Invertebrates
- LCV Surface Water Benchmarks for Aquatic Plants
- LCV Surface Water Benchmarks for Fish
- USEPA Office of Solid Waste and Emergency Response (OSWER) Ambient Water Quality Criteria Surface Water Benchmarks
- USEPA OSWER Tier II Surface Water Benchmarks
- USEPA Region IV Acute Surface Water Screening Benchmarks
- USEPA Region IV Chronic Surface Water Screening Benchmarks
- USEPA Region V Environmental Screening Levels (ESL) for Water
- Oregon Department of Environmental Quality (ODEQ) Level II water screening values for protection of aquatic life, birds, and mammals.

Description of these surface water screening values is presented in Appendix B.

2.4.2 Results of the Step 1 ERA – Surface Water Screening

Table 6 shows the freshwater ecological screening levels from different sources shown above, based on different endpoints. It was noted that metal concentrations in source groundwater and RO concentrate/inlet (Site samples) are reported as total recoverable metals, whereas screening levels are reported as dissolved concentrations. Comparison Site samples to these screening values, especially for chromium III and nickel (of which conversion factors are less than 1 based on water hardness), is conservative. Of all CPECs, there is no surface water screening values for titanium, which was not detected in groundwater samples. Also, although there are there are no analytical data for nickel, nickel may be present from the stainless alloy used in the reaction vessels.

For other CPECs, Site concentrations did not exceed these conservative screening criteria. To be complete, all CPECs were carried forward to Step 2 of the ERA.

3.0 STEP 2 – ERA

Step 2 ERA consists of the analysis phase and risk characterization phase to determine the likelihood of adverse ecological effects to species of concern as a result of exposure to CPECs in environmental media. Based on the estimated risk results, risk-based acute and chronic concentrations of CPECs in treated effluent discharge water that are protective of the environment are derived to form the basis for suitable UPDES discharge limits.

3.1 Analysis Phase

The purpose of the analysis phase of the Step 2 ERA is to further evaluate CPECs identified in the screening assessment using refined estimates from exposure assessment and toxicity (or effects) assessment. In the exposure assessment of the analysis phase, available data are evaluated estimate potential exposures to species of concern. The effects assessment evaluates data on the potential effects of the stressors on the ecological receptors, linking the receptors' exposure to the response being evaluated (stressor-response analyses).

3.1.1 Exposure Assessment

In the exposure assessment, representative concentrations of CPECs in different media of concern were first determined. To estimate potential risks to species of concern, exposure doses or intakes are quantified. The estimated exposure dose or average daily intake (ADD) was calculated for each species of concern by considering ingestion of potentially impacted surface water and ingestion of potentially impacted food (i.e. brine shrimp and brine flies). In addition, the ingestion of potentially impacted sediment and food (from sediment uptake) was also addressed.

3.1.2 Representative Concentrations of CPECs in Effluent Discharge Water

For the purpose of this ERA, representative concentrations of CPECs in effluent discharge water are the highest of either the detected levels of CPECs in source groundwater or in RO concentrate/inlet or performance criteria set for the on-site wastewater treatment system. These levels for surface water are presented in Table 7.

3.1.3 Representative Concentrations of CPECs in Site Sediment

The major processes by which metals can be transferred from surface water to another environmental medium such as sediment are adsorption and sedimentation (USEPA, 1988a). Contaminants dissolved in surface waters can adsorb onto solids suspended in the water or onto bed sediments (adsorption). This process, in effect, transfers the contaminant from the water to the sediment medium, and proceeds until an equilibrium point is reached. This equilibrium point (and the resulting water and sediment concentrations of the contaminant) is determined by the sediment-water partition coefficient (K_d, a parameter that is a function of sediment type, water pH, cation exchange capacity, and organic content of sediment) and the physicochemical properties of the substance. In general, metals have a high tendency to adsorb onto entrained or bottom sediment (USEPA, 1988a). The equation below shows the equilibrium relationship between contaminant concentrations in the water column and bed sediment (Dragun, 1988).

$$C_s = K_d \times C_w \text{ (Eq. 1)}$$

Where:

C_s = Concentration adsorbed on sediment surface (mg/kg);
K_d = Sediment-water partition coefficient, in liters per kilogram (L/kg);
C_w = Concentration in water (mg/L).

When the influx of contaminants in surface water is reduced so that the contaminants in bedded sediment is no longer in equilibrium with the contaminants in the water column, desorption will occur.

Once in the particulate form, contaminants will settle out over time and become mixed into the bottom sediment (sedimentation). The rate of sedimentation is governed by deposition (settling velocity) and resuspension (USEPA, 1988a). For the purpose of the ERA, adsorption and desorption are considered as the primary mechanisms of transporting metals between the water column and the bed sediment. The effects of resuspension and deposition (sedimentation) are not considered mainly because the time frame of interest here is likely to be months or years. Resuspension and deposition rates fluctuate considerably over extended time periods and tend to negate each other (USEPA, 1985).

The use of K_d values in estimating sediment concentrations under equilibrium conditions is conservative at the Site. It was because the Site represents a new discharge which begins operation on an assumed previously uncontaminated channel. Since there is generally no consistency as to "expected" values of K_d for a particular metal in the natural environment (some researchers reported relatively small K_d values, while some others reported significantly larger values) (USEPA, 1985), when possible, different literature sources were reviewed to determine the possible representative sediment concentrations at the Site, as described below.

In the GSL Basins study unit of the National Ambient Water Quality Assessment (NAWQA) program during 1998-1999 (USGS, 2004), the USGS collected streambed sediment and fish tissue samples concurrently at 11 sites and analyzed for 43 trace elements (including iron and titanium) and organic compounds. Concentrations of only 10 metals of concern were shown in the report: arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc. These sites include the Bear River Basin, Utah Lake/Jordan River Basin, and Weber River Basin. Of these 11 sites, site No. 7 and 8 on Silver Creek, sites No. 9 and 10 on Weber River, sites No. 15 and 16 on Little Cottonwood Creek, and sites No. 17 and 19 on the Jordan River seemed to be impacted with arsenic (maximum 440 mg/kg), cadmium (maximum 120 mg/kg), copper (maximum 774 mg/kg), lead (maximum 12,000 mg/kg), mercury (maximum 19 mg/kg), selenium (maximum 20 mg/kg), silver (maximum 96 mg/kg), and zinc (maximum 17,000 mg/kg) due to past mining activities. Chromium and nickel, however, seemed to be within tight detected ranges (47 to 72 mg/kg for chromium and 13 to 28 mg/kg for nickel) and not affected by past mining activities (USGS, 2003a). The arithmetic averages for chromium and nickel in the GSL Basins streambed sediment are 56.8 and 20.5 mg/kg, respectively. These levels are slightly below the national median for chromium (65 mg/kg) and nickel (29 mg/kg). Although levels for iron and titanium were not shown in the report, it is expected that these metals in sediment were not affected by past mining activities in Utah. Excluding arsenic samples from locations affected by mining activities (sites No. 7-10, 15-17, and 19), the average arsenic concentration in Utah streambed sediment is 6.5 mg/kg. This value is slightly below the arsenic national median of 7.5 mg/kg (Table B-1 of Appendix B) but within the typical range of uncontaminated nearshore estuarine and marine sediments (5 to 15 mg/kg dw).

The Utah average concentrations of arsenic (6.5 mg/kg, exclusion of sites impacted by past mining activities), chromium (56.8 mg/kg) and nickel (20.5 mg/kg) were selected as representative sediment concentrations for arsenic, chromium, and nickel at the Site. Since arsenic detected in source groundwater at the Site seemed to be background-related and chromium and nickel are not expected to be present at elevated levels in effluent discharge water, given the low suspended solid levels in effluent discharge water, these Utah sediment levels are considered to be adequately representative for the Site.

In a recent analysis of trends of seven metals (cadmium, chromium, copper, lead, mercury, nickel and zinc) in sediment cores from 35 reservoirs and lakes in urban and reference settings, it was shown that decreasing trends predominate for these metals (Mahler et al., 2006). Chromium and nickel (as well as cadmium and copper) are specific metals associated with industrial processes that are affected by wastewater or industrial emissions in locations around the globe (Mahler et al., 2006). In sediment core analysis, decreasing trends in chromium and nickel outnumbered increasing trends by 5:1 or more. The results for chromium is particularly striking in that no lake studied had an increasing trend. It may be in part that in the U.S., release of emissions and disposal of waste in industries is now controlled. A preponderance of decreasing trends in metals in lakes provides evidence of actions taken since 1970s to improve environmental quality of water and sediments. The median magnitude of decrease for chromium and nickel in sediment is -34% and -29%, respectively. Although technological advancements are responsible for much of decrease in release of several metals such as lead and cadmium, decreases in anthropogenic concentrations of chromium and nickel have no single identified source.

In the USGS Western U.S. Phosphate project (USGS, 2003b), nine stream sites in the Blackfoot river watershed in southeastern Idaho were sampled in September 2000 for water, surficial sediment, aquatic plants, aquatic invertebrates, and fish. Since the study area does not seem to be heavily impacted with metals (selenium was the only the metal of concern), the results of other metals provide a good source of data for sediment bioaccumulation factor (BSAF) values for the metals being studied. K_d values could not be derived and used for the Site since surface water samples were filtered and were mostly non-detected for several metals. The average concentrations of arsenic, chromium, iron, and nickel in streambed sediments are: 3.5 mg/kg, 34.4 mg/kg, 17,899 mg/kg, and 33.9 mg/kg, respectively. The BSAFs for arsenic, chromium, iron, and nickel in aquatic plants are: 0.35 kg/kg, 0.1 kg/kg, 0.19 kg/kg, and 0.13 kg/kg, respectively. The BSAFs for arsenic, chromium, iron, and nickel in aquatic invertebrates are: 0.56 kg/kg, 0.09 kg/kg, 0.03 kg/kg, and 0.25 kg/kg, respectively (Table C-2 of Appendix C).

Trace-element concentrations in 541 streambed-sediment samples collected from 20 study areas across the conterminous United States were examined as part of the NAWQA program of the USGS (USGS, 1999). Sediment samples were sieved and the <63 μm fraction was retained for determination of total concentrations of trace elements. About 10 or more of these sediment samples showed urban or industrial impact, such as lead concentrations of up to 6,300 mg/kg and zinc levels of up to 9,000 mg/kg. Iron and titanium, however, are typically considered to be major elements in the environment, and are evaluated in the same chemistry group as aluminum, calcium, and potassium (Mahler et al., 2006).

It was found in this 1999 USGS study that aluminum, iron, titanium, and organic carbon were weakly or not at all correlated with the nine trace elements examined: arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc. The sum of concentrations of trace elements characteristic of urban settings--copper, mercury, lead, and zinc--was well correlated with population density, nationwide. Median concentrations of seven trace elements (all nine examined except arsenic and selenium) were enriched in samples collected from urban settings relative to agricultural or forested settings. The average titanium concentration in sediment from this study is 4,100 mg/kg. Since this value is within the typical range of titanium in soil, it was selected to be representative concentration of titanium in sediment at the Site, given the fact that titanium was not detected in RO concentrate water.

Ali et al. (2005) determined concentrations of major and trace metals in water, sediment, benthos, and some common fish species from Lake Qarun in Egypt. Surface water and sediment samples were collected in the summer of 2003 at seven stations, where benthos and fish species were collected at three locations representing east, middle, and west of the lake. Although it was reported that the east part of the lake generally had higher contamination than the west, the study area did not seem to be heavily impacted with metals. As such, the results provide a good source of data for K_d and BSAF values for the metals being studied. The K_d values derived from this study are useable for the Site since surface water samples were not filtered (similar to the total recoverable concentrations reported for Site water). The average concentrations of chromium, iron, and nickel in surface water samples of the Lake Qarun are 0.067 mg/L, 0.436 mg/L, and 0.041 mg/L. These levels are close to the levels detected in Site RO water (0.04 mg/L, 0.25 mg/L, and not analyzed but SQL is 0.05 mg/L, respectively). The average concentrations of chromium, iron, and nickel in streambed sediments are: 14.4 mg/kg, 17,860 mg/kg, and 55.61 mg/kg, respectively. It is noted that nickel concentrations at Lake Qarun are higher than levels reported for Utah. Since the average iron concentration in sediment in this study is close to the value reported by the USGS for the Blackfoot watershed (USGS, 2003b), an average sediment concentration of 17,900 mg/kg was selected to be representative concentration of iron in sediment at the Site, given the fact that iron levels in Site water and this Qarun lake water are comparable. The sediment-water K_d value for chromium, iron, and nickel were derived to be: 220 L/kg, 41,208 L/kg, and 1,358 L/kg, respectively. The average BSAFs for chromium, iron, and nickel in aquatic invertebrates (*Annelida, Mollusca, and Crustacea*) are: 0.133 kg/kg, 3.01E-03 kg/kg, and 0.14 kg/kg, respectively (Table C-3 of Appendix C).

Based on the literature review above, the representative, yet conservatively considered sediment concentrations are presented in Table 7. These selected sediment concentrations are near or at equilibrium in their natural environments. Given the fact that effluent discharge water does not contain metals above concentrations detected in surface water where these sediment samples were collected, use of these sediment concentrations are conservative. Also, the Site represents a new discharge that is planned for operation on a presumably uncontaminated channel. Using K_d values of 220 L/kg, 41,208 L/kg, and 1,358 L/kg for chromium, iron, and nickel, respectively (Ali et al, 2005), with Site detected chromium, iron, and nickel levels of

0.03 mg/L, 0.25 mg/L, and <0.05 mg/L, respectively, the predicted sediment levels for chromium, iron, and nickel are 6.6 mg/kg, 10,302 mg/kg, and 67.9 mg/kg. Except nickel, most these predicted sediment levels are below the representative sediment concentrations selected above, therefore the selected sediment levels used in the ERA are conservative.

3.1.4 Ingestion of Surface Water

The equation used to determine chemical-specific ADD from ingestion of surface water, in milligrams of chemical per kilogram of body weight per day (mg/kg-day), of each CPEC was calculated as follows (USEPA, 1999):

$$ADD_w = \frac{C_w \times IR_w \times ET \times FR}{BW} \qquad \text{(Eq. 2)}$$

Where:

ADD_w = Average daily dose from ingestion of water, in mg/kg-day;

C_w = CPEC concentration in surface water, which is effluent discharge water, in mg/L;

IR_w = Water ingestion rate, in L/day;

ET = Exposure time out of a year, equals 0.5 for the stilts and snowy plovers (6 months/12 months), 0.58 for the avocets (7 months/12 months), and 1 for the mallards (12 months/12 months).

FR = Fraction of water from contaminated source, equals 1 (SECOR, 2008e). In realty, FR can be up to 1 ha/283.5 ha (or 4E-03) for the stilts and avocets, 1ha/35ha (or 2.8E-02) for snowy plovers, and 1 ha/580 ha (or 2E-03) for the mallards. Even if FR is based on the (non-conservative) fraction of the foraging length over the length of the channel (1.5 km), the FR for the stilts and avocets is 1.5 km/4.5 km = 0.33, for the snowy plover is 1.5 km/3 km = 0.5, and for the mallard duck is 0.165 (since the home range for the mallard duck is almost twice as that of the stilt).

BW = Body weight, in kg.

3.1.5 Ingestion of Food (Uptake from Surface Water)

The equation used to determine chemical-specific ADD from ingestion of aquatic food source, in mg/kg-day of each CPEC was calculated as follows (USEPA, 1999):

$$ADD_{fw} = \frac{C_w \times BAF \times IR_f \times ET \times FR}{BW} \qquad \text{(Eq. 3)}$$

Where:

ADD_{fw} = Average daily dose from ingestion of aquatic food source – uptake from surface water, in mg/kg-day;

C_w = CPEC concentration in surface water, which is effluent discharge water, in mg/L;

BAF = Bioaccumulation factor, in (mg/kg) food/(mg/L) water or L/kg;

IR_f = Food ingestion rate, in kg ww/day;

DC = Diet composition of aquatic invertebrates, 66.7% for stilts and avocets and 25% for mallards.

Other parameters are defined above.

Some exposure intake parameters for species of concern, such as body weights, dietary composition, food and water ingestion rates, and exposure time, are defined on the basis of available literature information. These have been described earlier in Section 2.1.2.5 (Indicator Species Selection) and presented in Table 4. The FR and BAF parameters are explained below.

3.1.6 Fraction from Contaminated Source

Although UDEQ has requested the FR or AUF to be one in the ERA for conservative evaluation of potential risks to species of concern, the true FR or AUF for these species can be much less than one. According to the USEPA (USEPA, 1993), the exposure equation for wildlife also includes the factor "FR", which is fraction of water or food ingestion from the contaminated source. This is based on home range or foraging home range, although its use was recommended to be exercised with caution because most animals do not drink or feed randomly within their home range (USEPA, 1993). For the Study Area, it was shown that the main food sources for species of concern (brine shrimp and brine flies) may not be found at optimum levels within the discharge channel, due to low salinity (1%), narrow channel, and lack of hard substrates. Since effluent water in the channel is discharged to the GSL shoreline, the GSL shoreline may provide a more attractive feeding area for these species. As such, the use of the FR factor in risk estimation should be supported and is presented in the Uncertainty Analysis (Section 3.3).

It is estimated that the length of the discharge channel from the discharge pipe location to the GSL shoreline is about 1.5 km, which is 4,921 feet. Given the average width of 12 feet for the channel, the open effluent water area is about 59,052 square feet, or 0.548 ha. This can be rounded up to 1 ha to account for potential fanning out near the GSL shore. As previously discussed, the home ranges for mallard ducks (USEPA, 1993) and black-necked stilts (Hickey et al., 2007) were estimated to be 580 ha and 283.5 ha, respectively. There is no available information on the home range of the American avocets. Since avocets and stilts co-exist ecologically, the home range of the American avocets can be approximated to be 283.5 ha as well. There is no available information on the home range of the snowy plover. Its home range can be approximate to be that of the golden plovers (averaging 10 to 59 ha, with a median of 35 ha) (NatureServe Explorer, 2008). As a result, FR for black-necked stilts and American avocets is 1/283.5 or 4E-03, FR for snowy plover is 1/35 or 2.8E-2, and FR for mallard ducks is 1/580 or 2E-03. Thus, potential risks to species of concern can be 283 to 580 times lower when FR based on species-specific home range is taken into account.

Even if FR is based on the (non-conservative) fraction of the foraging length over the length of the channel (1.5 km), the FR for the stilts and avocets is 1.5 km/4.5 km = 0.33, for the snowy plover is 1.5 km/3 km = 0.5, and for the mallard duck is 0.165 (since the home range for the mallard duck is almost twice as that of the stilt). Since UDEQ requested the ERA to be conducted based on an FR or AUF of 1, the uncertainty associated with the FR of 1 versus the potentially much smaller FR or AUF is discussed later in Section 3.3.

3.1.7 Invertebrate Bioaccumulation Factor from Surface Water

In the environment, contaminants present in surface water can be taken up by aquatic organisms and can concentrate in biological tissues at concentrations that could be greater than those found in water. Higher trophic organisms can therefore be exposed to contaminants in surface water through direct contact with, or ingestion of, surface water as well as through ingestion of food sources that have bioconcentrated or bioaccumulated contaminants in water.

Since species of concern at the Site feeds on aquatic organisms, the BAF can be used to estimate CPEC concentration in invertebrate tissue from concentration in water. The BAF is the ratio of concentration of a contaminant in tissue (mg/kg) to its concentration in water (mg/L), and expressed as L/kg (Sample et al., 1996). BAFs may be predicted by multiplying the bioconcentration factor (BCF), which is the ratio of concentration in food to concentration in water (L/kg) by the appropriate food chain multiplying factor (FCM) for different trophic levels. Since brine shrimp and brine flies are considered to be in Trophic Level 2, and for most inorganic metals, BCFs and BAFs are assumed to be equal, the FCM is considered to be 1 (Sample et al., 1996).

For the purposes of the ERA, site-specific tissue data were not collected to develop site-specific BAF values. The CPEC concentrations in surface water used in the assessment are representative concentrations described earlier. The concentration of each CPEC in the food (i.e. aquatic invertebrates, such as brine shrimp and brine flies) was calculated using representative water concentrations and BAF values provided in Table 8. Information concerning the bioconcentration and bioaccumulation of metals from the marine environment to aquatic invertebrates is limited. In the absence of suitable marine studies, freshwater BAF values were assumed for this assessment. The brief rationale for the BAF values selected to be used in the exposure assessment is described below. Please note that a thorough examination of the study design, assumptions and scientific merit was beyond the scope of this screening-level ERA and was not possible given the time and budgetary constraints.

Because animal food sources for most species of concern at the Site are mostly aquatic insects such as brine shrimp and brine flies, the ERA was evaluated based on the assumption of the dominance of consumption of invertebrates from surface water as food. At the direction of UDEQ, SECOR opted to evaluate this scenario to reflect the dominant food source. Modification of the ERA results to account for food sources from sediment is included in Appendix D for completeness. The following sections describe the derivation of invertebrate BAF for CPECs at the Site.

3.1.7.1 Arsenic

Grass shrimp *(Palaemonetes pugio)* exposed to water concentrations of arsenic ranging from 0.1 mg arsenic (V)/L (as arsenate) to 1.5 mg arsenic (V)/L (as arsenate) or to food (*Chlorella sp.*) concentrations containing 1940 mg total arsenic/kg contained arsenic residues ranging from 18.9 mg/kg dry weight (dw) to 31.8 mg/kg dw or 4.16 mg/kg ww to 7.00 mg/kg ww (Maeda et al., 1992). This resulted in predicted BAF values of 5 to 70 L/kg. Fowler & Ünlü (1978) reported BAFs of less than 10 L/kg for shrimp exposed to arsenate (^{74}As) concentrations of 0.02 mg arsenic (V)/L to 0.1 mg arsenic (V)/L for 14 days. Lindsay & Sanders (1990) found arsenate did not bioaccumulate from water (25 µg arsenic (V)/L) or from food for the grass shrimp (*Palaemonetes pugio*). Brine shrimp (*Artemia* sp.) grown in water concentrations of 0.025 mg arsenic (V)/L, had an average concentration of 17.8 mg/kg dw or 3.92 mg/kg ww, based on a water content of 78%. No accumulation was observed when brine shrimp were fed arsenic-contaminated food. At 0.025 mg/L, the BAF was 157 L/kg.

A BAF of 38.2 L/kg was used in this ERA based on the geometric mean of the BAFs identified in the above studies (i.e., BCFs of 5, 70, 10 and 157 mg arsenic/kg tissue ww/mg arsenic/L water). This BAF value is more conservative than the value of 17 L/kg proposed by Sample et al. (1996) and the UDEQ-suggested screening value of 1 L/kg (SECOR, 2008e).

3.1.7.2 Chromium (III)

BAF values of 116, 153, and 86 L/kg were reported for chromium (III) in freshwater in the American oyster, soft shell clam, and blue mussel, respectively (USEPA, 1983). Ali et al. (2005) reported the average BAFs for chromium in aquatic invertebrates (Annelida, Mollusca, and Crustacea) to be: 29.4 L/kg, 29.25 L/kg, and 26.8 L/kg, respectively (Table C-3 of Appendix C).

A BAF of 56.7 L/kg for chromium was used in this ERA based upon the geometric mean of the BAFs identified in the above studies (116, 153, 86, 29.4, 29.25, and 26.8). Note that Sample et al. (1996) listed an aquatic BAF of only 3 L/kg for chromium (VI). As discussed earlier, marine animals (snails) can sequester chromium in insoluble granules that are not bioavailable to their predators (Nott and Nicolaidu, 1996). The proposed BAF value of 56.7 L/kg for chromium is more conservative than UDEQ-suggested screening value of 1 L/kg (SECOR, 2008e).

3.1.7.3 Iron

Guo et al. (2002) examined the extent of metal partitioning between colloidal and dissolved phases and coagulations of selected metals (cadmium, cobalt, iron, mercury, silver, and zinc) to determine their effects on the bioavailability of these metals to American oysters (*Crassostrea virginica*) in sea water. The results indicated that more than 80% of iron and 70-80% of cobalt were found in the shells of the oysters. In contrast, 70 to 80% of silver and mercury were found in soft tissues (which is consistent with the bioaccumulation characteristics of mercury). The authors estimated the dry-weight based concentration factor of 3-15 L/kg for iron after 8 hours of exposure, which is consistent with high percentage of iron partitioned to the shell. The uptake constant for iron was estimated to be between 3 to 8.7 mL/g-hour, which is 24 to 70 L/kg for 8 hours.

In a 48-hour experiment, Lyon et al. (1984) determined the BAF value for iron ions (using 2-hydroxy-1,2,3-propanetricarboxylic acid, iron salt) in crayfish (*Austropotamobius pallipes*) to be 15 L/kg. A study of mosquito larvae (*A. aegypti*) by Pedrosa et al. (2000) showed that most iron uptake in mosquito larvae is retained in the larvae midgut lumen and excreted in an insoluble form as a feces component. Similarly, marine animals (snails) can sequester iron in insoluble granules that are not bioavailable to their predators (Nott and Nicolaidu, 1996). Ali et al. (2005) reported the average BAFs for iron in aquatic invertebrates (*Annelida, Mollusca, and Crustacea*) to be: 116.33 L/kg, 135.36 L/kg, and 125.86 L/kg, respectively (Table C-3 of Appendix C).

A BAF of 60.6 L/kg for iron was used in this ERA based upon the geometric mean of the BAFs identified in the above studies (24, 70, 15, 116.33, 135.36, and 125.86). The proposed BAF value of 60.6 L/kg for iron is more conservative than UDEQ-suggested screening value of 1 L/kg (SECOR, 2008e).

3.1.7.4 Nickel

A BAF value of 28 L/kg was obtained from the USEPA (1999) based on the geometric mean of BAF for freshwater and marine species. This BAF value is based on 4 data points (100, 250 [Thompson, Burton, Quinn, and Ng, 1972, as reported by USEPA, 1999], 2, and 12 L/kg [Watras, MacFarlane, and Morel, 1985, as reported by USEPA, 1999]). Sample et al. (1996) listed a BAF value of 106 L/kg for nickel. Ali et al. (2005) reported the average BAFs for nickel in aquatic invertebrates (*Annelida, Mollusca, and Crustacea*) to be: 181.57 L/kg, 211.36 L/kg, and 196.46 L/kg, respectively (Table C-3 of Appendix C).

A BAF of 68.34 L/kg for nickel was used in this ERA based upon the geometric mean of the BAFs identified in the above studies (2, 12, 100, 250, 106, 181.57, 211.36, and 196.46). As discussed earlier, marine animals (snails) can sequester iron in insoluble granules that are not bioavailable to their predators (Nott and Nicolaidu, 1996). The proposed BAF value of 68.34 L/kg for iron is more conservative than the UDEQ-suggested screening value of 1 L/kg (SECOR, 2008e).

3.1.7.5 Titanium

There is little information available on the bioaccumulation and bioconcentration of titanium in aquatic organisms. Schroeder et al. (1962) reported titanium concentrations in shrimp of 0.88 mg/kg with shrimp shells at 7.38 mg/kg. However, there is no information on the source of these shrimp or associated titanium concentrations in the water. If using the mid-range concentration of titanium typical found in surface water (0.002 to 0.107 mg/L [HSDB, 2008]), which is 0.05 mg/L, a BAF value of 18 can be derived for titanium.

Titanium has been reported as being absorbed and concentrated from the environment (by factors of 4 to 180) by algae, plankton, sponges, corals, starfish, and livers of crustaceans. Fish, however, absorb or store it poorly. The original source of these values, Vinogrado (1953) could not be located. As discussed earlier, marine animals (snails) can sequester titanium in insoluble granules that are not bioavailable to their predators (Nott and Nicolaidu, 1996). A BAF of 23.49 L/kg for titanium was used in this ERA based upon the geometric mean of the BAFs identified in the above studies (4, 18, and 180). This BAF value of 23.49 L/kg for titanium is more conservative than the UDEQ-suggested screening value of 1 L/kg (SECOR, 2008e).

Table 8 presents the BAFs for invertebrates in surface water used in this ERA. Note that UDEQ has suggested the use of a screening BAF of 1 for this pathway (SECOR, 2008e). Therefore, use of BAFs derived above is adequately protective. Table 9 show CPEC-specific and pathway-specific intake dose calculations for all four species of concern.

3.1.8 Invertebrate Bioaccumulation Sediment Factor from Sediment

Based on diet composition of mallard ducks (USEPA, 1993), it was found that species of concern also consume sediment-related invertebrates such as crustacean and annelids. For conservative purposes, all plants and seeds consumed by these species of concern are assumed to be aquatic plants growing from sediment. Invertebrates classified as "gastropods, insects" were assumed to be surface water-based, whereas invertebrates classified as "crustacean, annelids, and miscellaneous animals" were assumed to be sediment-based. Since brine shrimp, a water-based crustacea, was not the primary food for the American avocet and black-necked stilt (Wurtsbaugh, 2007; Cavitt, 2007), the assumption above remains protective. To take into account exposure to food source from sediment, the mallard ducks were assumed to ingest 10.7% invertebrates from surface water, 13.8% invertebrates from sediment, and 75.5% plants from sediment (USEPA, 1993 and 2005a). Assuming the mallards' ratio of invertebrates from surface water (43.6%) over invertebrates from sediment (56.4%), the black-necked stilts and American avocets were assumed to ingest 29% invertebrates from surface water, 37.7% invertebrates from sediment, and 33.3% plants from sediment (Stanford University, 2008). For the snowy plovers, it was assumed that their diet consist of 100% invertebrates. Using the same mallards' ratio of invertebrates from surface water (43.6%) over invertebrates from sediment (56.4%), the snowy plovers were assume to ingest 43.6% invertebrates from surface water and 56.4% invertebrates from sediment.

Derivation of CPEC-specific BSAFs for invertebrates ($BSAF_i$) and aquatic plants ($BSAF_p$) is discussed below.

3.1.8.1 Arsenic

Based on data from Ali et al. (2005), an average $BSAF_p$ of 0.35 kg/kg was derived for arsenic. The USEPA (1999) has recommended a $BSAF_p$ for aquatic plants of 0.036 kg/kg for arsenic, based on empirical data reported in the report *Technical Support Document for Land Application of Sewage Sludge* (USEPA, 1992a). The experimental parameters were not reported (USEPA, 1999). Since the USEPA (1999) also recommended the use of Baes et al., 1984 reference, a $BSAF_p$ of 0.04 kg/kg for arsenic was reported by Baes et al. (1984). The geometric mean of these three data points (0.35, 0.036, and 0.04) is used as the $BSAF_p$ (0.079 kg/kg) for arsenic in the ERA, Appendix D.

There is only one $BSAF_i$ value for sediment-dwelling invertebrates identified for arsenic (0.56 kg/kg) from the 2003 USGS study (USGS, 2003b). This value is used as the $BSAF_i$ for arsenic in the ERA, Appendix D.

3.1.8.2 Chromium

Based on data from Ali et al. (2005), an average $BSAF_p$ of 0.1 kg/kg for aquatic plants was derived for chromium. The USEPA (1999) has recommended a $BSAF_p$ of 0.0075 kg/kg for chromium, which is from the Baes et al. (1984) reference. The geometric mean of these two data points (0.1 and 0.0075) is used as the $BSAF_p$ (0.027 kg/kg) for chromium in the ERA, Appendix D.

The USEPA (1999) has cited five data points (0.39, 0.03, 0.07, 0.001, and 0.003 kg/kg) based on the Namminga and Wilhm (1977, as cited by USEPA, 1999) and Capuzzo and Sasner (1977, as cited by USEPA, 1999) as potential $BSAF_i$ for sediment-dwelling invertebrates for chromium total. Based on data from Ali et al. (2005), an average $BSAF_i$ of 0.133 kg/kg was derived for chromium. The 2003 USGS study (USGS, 2003b) also reported an average $BSAF_i$ of 0.09 kg/kg for chromium. The geometric mean of these seven data points is used as the $BSAF_i$ (0.031 kg/kg) for chromium in the ERA, Appendix D.

3.1.8.3 Iron

Based on data from Ali et al. (2005), an average $BSAF_p$ of 0.19 kg/kg for aquatic plants was derived for iron. A $BSAF_p$ of 0.004 kg/kg for iron was reported by Baes et al. (1984). The geometric mean of these two data points (0.19 and 0.004) is used as the $BSAF_p$ (0.0275 kg/kg) for iron in the ERA, Appendix D.

Based on data from Ali et al. (2005), an average $BSAF_i$ of 0.003 kg/kg was derived for iron. The 2003 USGS study (USGS, 2003b) also reported an average $BSAF_i$ of 0.03 kg/kg for iron. The geometric mean of these two data points (0.003 and 0.03) is used as the $BSAF_i$ (0.0095 kg/kg) for sediment-dwelling invertebrates for iron in the ERA, Appendix D.

3.1.8.4 Nickel

Based on data from Ali et al. (2005), an average $BSAF_p$ of 0.13 kg/kg for aquatic plants was derived for nickel. The USEPA (1999) has recommended a $BSAF_p$ of 0.032 kg/kg for nickel, based on the 1992 USEPA study (USEPA, 1992a). A $BSAF_p$ of 0.06 kg/kg for nickel was reported by Baes et al. (1984). The geometric mean of these three data points (0.13, 0.032, and 0.06) is used as the $BSAF_p$ (0.063 kg/kg) for nickel in the ERA, Appendix D.

Based on data from Ali et al. (2005), an average $BSAF_i$ of 0.14 kg/kg for sediment-dwelling invertebrates was derived for nickel. The 2003 USGS study (USGS, 2003b) also reported an average $BSAF_i$ of 0.25 kg/kg for nickel. The geometric mean of these two data points (0.14 and 0.25) is used as the $BSAF_i$ (0.187 kg/kg) for nickel in the ERA, Appendix D.

3.1.8.5 Titanium

There is only one $BSAF_p$ value identified for titanium (0.0055 kg/kg) from the Baes et al. study (Baes et al., 1984). To be conservative, the $BSAF_p$ value for iron (0.0275 kg/kg) was used to estimate the value for titanium, based on the BAF (surface water) fraction of iron and titanium (23.49/60.6). The value of 0.0107 kg/kg is used as the $BSAF_p$ for titanium in the ERA, Appendix D.

Similarly, the $BSAF_i$ value for iron (0.0095 kg/kg) was used to estimate the value for titanium, based on the BAF (surface water) fraction of iron and titanium (23.49/60.6). The value of 0.0037 kg/kg is used as the $BSAF_i$ for sediment-dwelling invertebrates for titanium in the ERA, Appendix D.

The $BSAF_p$ and $BSAF_i$ values for CPECs are presented in Table 8a of Appendix D. Equation No. 3 above was used to estimate intake doses from ingestion of invertebrates in sediment and aquatic plants in sediment, using the appropriate BSAFs described earlier. The evaluation of additional food source from sediment is presented in Appendix D, with related ERA tables modified to include a suffix "a" to the table numbers (e.g, Tables 5a, 8a, 9a, 11a, and 12a).

3.1.9 Effects Assessment

For all metal CPECs, available avian toxicity criteria, in the format of threshold reference values (TRVs) and expressed in units of intake dose of mg/kg-day, were obtained from guidance documents or from literature data. It is important to use toxicity data for effects and endpoints that are relevant and measurable for the species of concern evaluated in the ERA. According to USEPA (USEPA, 2005c), reproductive studies scored higher than lethality and growth, with sublethal changes and biomarkers scored lowest. As a result, the following effects, listed in the order of preference, were considered appropriate for evaluating potential adverse effects on mammalian populations:

1. Effects on reproductive or developmental processes;
2. Changes in growth;
3. Histopathological abnormalities, such as liver necrosis or tumorigenesis; and
4. Effects on survival.

The following toxicity endpoints were considered relevant for derivation of TRVs:

- NOAEL - The highest concentration or dose of a chemical resulting in no observed adverse effects; and
- LOAEL - The lowest concentration or dose of a chemical resulting in observed adverse effects.

Where data was available, both NOAEL- and LOAEL-based TRVs were developed. A search of the following resources was completed to locate relevant information:

- USEPA Regions' guidance;
- Other USEPA documents, including USEPA Eco-soil screening levels (Eco-SSL) (USEPA, 2005c to 2005f; USEPA, 2007);
- U.S. Army and U.S. Navy reports;
- Pesticide Analytical Manual (PAM) Pesticides Database;
- USEPA Ecotox Database;
- World Health Organization (WHO) Environmental Health Criteria;
- The HSDB from the National Library of Medicine (NLM);

- University of Guelph's Biological Science Journal Databases (e.g. Agricola); and
- The Oak Ridge National Laboratory (ORNL)'s Risk Assessment Information System (RAIS) (ORNL, 2008).

Derivation of relevant avian TRVs for CPECs is presented below.

3.1.9.1 Arsenic

Adult mallard ducks were exposed to four concentrations (0, 25, 100, and 400 mg sodium arsenate [V]/kg diet; 51.35% arsenic) for 115 to 128 days (Stanley et al., 1994). Ducklings were placed on the same diet as their parents for 14 days after hatching. At the levels tested, dietary arsenic did not affect hatching success or embryo deformities. Duckling production (defined as the number of ducklings alive at day 14 for nests producing more than one duckling) was significantly decreased in birds exposed to 400 mg/kg of sodium arsenate (205.4 mg/kg of arsenic); as such, this exposure concentration is identified as the LOAEL. An ingestion rate of 0.139 kg/day and adult body weight of 1.25 kg (Piccirillo and Quesenberry, 1980) were used to convert the mg/kg diet concentrations to units of 5.7 mg/kg-day (NOAEL) and 22.8 mg/kg-day (LOAEL) (USEPA, 2005a). Based on the ecological significance of the endpoint (reproduction) and the fact that arsenic (V) is the most dominant species in the oxidative environment of surface water, the TRVs from this study (NOAEL TRV of 5.7 mg/kg-day and LOAEL TRV of 22.8 mg/kg-day) was used to evaluate risk posed by arsenic to avian receptors.

Note that Sample et al. (1996) derived an avian NOAEL of 5.14 mg/kg-day and an avian LOAEL of 12.84 mg/kg-day based on a mallard study on sodium arsenite (III) (Heinz et al., 1989). In the Eco-SSL report for arsenic, the USEPA has identified five pertinent papers on avian toxicity of arsenic, with 16 results for biochemical, behavioral, pathology, reproduction, growth, and survival effects that met the Data Evaluation Score of >65 for use to derive TRV. A NOAEL TRV (lowest value of two available values) was developed for arsenic to be 2.24 mg/kg-day (USEPA, 2005d).

3.1.9.2 Chromium

Chromium (III) has long been used by humans and in birds' feed as a supplement. The results of these avian studies are summarized below:

- Piva et al. (2002) indicated that a diet high in chromium (III), regardless of the source, does not influence egg production or egg quality and does not result in abnormal levels of chromium in the yolk.
- Debski et al. (2004) performed an experiment on broilers at big farm conditions. These birds were fed 0.2 mg/kg of chromium (III) in diet had a lower mortality rate compared with the rate observed in the controls. Moreover, dietary chromium led to an improvement of carcass composition by increasing the weight of pectoral muscles; and meat of these broilers contained less amounts of fat and cholesterol. Hossain et al. (1999) found similar results at higher dietary levels (0.3 to 0.4 mg/kg).

- Sahin et al. (2001) studied the effects of dietary chromium picolinate on Japanese quails (*Coturnix coturnix japanica*). The results showed that chromium supplementation, particularly at the highest dose level of 1.2 mg/kg, increased the performance, egg quality, and serum insulin concentrations of Japanese quails.

- Rosomer et al. (1961) reported no adverse effects on survival, growth, or food utilization in domestic chickens fed diets containing up to 100 mg/kg (7.1 mg/kg-day) of chromium (VI) during a 32-day period.

- Kunishisa et al. (1966) demonstrated that diets containing less than 200 mg/kg (14.2 mg/kg-day) of chromium (VI) and 300 mg/kg (21.3 mg/kg-day) of chromium (III) had no adverse effects on young domestic chickens. An ingestion rate of 0.103 kg/day and adult body weight of 1.45 kg (USEPA, 1988b) were used to convert the mg/kg diet concentrations to units of mg/kg-day (USEPA, 2005a).

- Heinz and Haseltine (1981) exposed two to three year old breeding pairs of black ducks (*Anas rubripes*) to a diet containing 0, 20, or 200 mg/kg ww, (0, 2, or 20 mg/kg-day) of chromium (III) as chromium potassium sulfate for a period of approximately five months (until the onset of egg-laying by the females). Hatched ducklings were then fed a mash diet containing the same concentrations as their parents. Seven-day old chicks were tested for avoidance behavior in response to a fright stimulus; none of the chromium concentrations resulted in alteration of avoidance behavior. An ingestion rate of 0.125 kg/day (Heinz et al., 1989) and adult body weight of 1.25 kg (Dunning, 1993) were used to convert the mg/kg diet concentrations to units of mg/kg-day (USEPA, 2005a).

- Chung et al. (1985) evaluated the dietary toxicity of chromium (VI) and chromium (III) to young chickens, and the effects of manganese and molybdenum on the toxicity of chromium. Day-old broiler chicks were exposed to chromium (VI) as potassium chromate in the diet at concentrations of 0, 900, 1,200 and 1,500 mg/kg or to chromium (III) as chromium sulfate at concentrations of 0 and 4,000 mg/kg for 2 weeks. Mortality was significantly greater and growth was depressed in all chicks exposed to chromium (VI) (LOAEL of 900 mg/kg chromium (VI)). Addition of manganese or molybdenum at 500 mg/kg significantly reduced the mortality caused by the chromium (VI), but did not prevent the growth depression observed at the two highest chromium doses. No mortality was observed in chicks fed chromium (III), however growth was significantly depressed (LOAEL of 4,000 mg/kg chromium (III)). Tissue concentrations of chromium were higher in chicks fed diets containing only chromium (VI), indicating manganese and molybdenum may interfere with chromium absorption. An ingestion rate of 0.0075 kg/day and body weight of 0.066 kg (USEPA, 1988b) were used to convert the exposure concentrations to units of mg/kg-day (USEPA, 2005a). A LOAEL of 102.3 mg/kg-day and an estimated NOAEL of 10.2 mg/kg-day were calculated for chromium (VI), and a LOAEL of 455 mg/kg-day and an estimated NOAEL of 45.5 mg/kg-day were calculated for chromium (III) based on the results of this study.

- Haseltine et al. (1985), in an unpublished study reported by Eisler (1986), fed black ducks diets containing 10 or 50 mg/kg anionic chromium (III) as $Cr\ K(SO_4)_2.12H_20$ for five months. No effects were observed on survival, reproduction and blood chemistry. Ducklings produced by the treated groups were fed diets containing chromium at the original parental dosages; there was significant reduction in survival in the 50 mg/kg exposure group. An ingestion rate of 0.125 kg/day (Heinz et al., 1989) and adult body weight of 1.25 kg (Dunning, 1993) were used to convert the exposure concentration to units of mg/kg-day (USEPA, 2005a). A NOAEL of 1 mg/kg-day and LOAEL of 5-mg/kg-day were calculated based on the results of this experiment. Although Sample et al. (1996) proposed these NOAEL and LOAEL levels derived from this study for avian species, these values were not considered for this ERA due to reasons cited below:

- Because the Haseltine et al. (1985) study is unpublished, it was not adequately peer-reviewed. One could always question the strength and validity of an unpublished study.
- The NOAEL and LOAEL results in this study are markedly different from other studies on chromium (III) (a difference factor of 20 to 45).
- The NOAEL in this study (1 mg/kg-day) is within an order of magnitude compared to the beneficial levels of chromium (III) in birds. The NOAEL and LOAEL results in this study are also very low compared to those of other metals (e.g., arsenic or nickel that exert mostly toxic effects with no beneficial effects), considering that chromium (III) is a useful supplement in birds (and humans).

Although the conservative NOAEL and LOAEL values in the Haseltine et al. (1985) study were not used in risk characterization, they were included in the calculation of geometric means. The geometric means of all chromium III NOAELs (21.3; 20; 45.5; and 1 mg/kg-day) and LOAELs (455 and 5 mg/kg-day) from the Kunishisa et al. (1966), Heinz and Haseltine (1981), Chung et al. (1985), and Haseltine et al. (1985) studies discussed above were used in the risk characterization of chromium. As a result, a NOAEL TRV of 11.73 mg/kg-day and a LOAEL TRV of 47.7 mg/kg-day were used in this ERA.

In the Eco-SSL report for chromium, the USEPA has identified 13 pertinent papers on avian toxicity of chromium (III), with 28 results for biochemical, behavioral, physiology, pathology, reproduction, growth, and survival effects that met the Data Evaluation Score of >65 for use to derive TRV. A geometric mean of the NOAEL values for reproduction and growth was calculated at 2.66 mg/kg-day, which is set to be the NOAEL TRV for chromium (III) (USEPA, 2005c). Avian TRVs for chromium (VI) could not be derived (USEPA, 2005e).

3.1.9.3 Iron

In the Eco-SSL report for iron, the USEPA did not propose any avian and mammalial TRVs for iron (USEPA, 2005f). In another ecological risk assessment report, the USEPA has proposed no avian TRVs for iron, but a NOAEL TRV of 350 mg/kg-day and a LOAEL TRV of 1,000 mg/kg-day for protection of mammalian species based on a study by Whittaker et al. (1997) using mice and rats (USEPA, 2005a). Available studies used to derive TRVs for mammalian species (USEPA, 2005a) are presented below.

Male weanling Sprague-Dawley rats were fed diets containing iron at concentrations of 4 (iron deficient), 35 (control), 350, 3,500 or 20,000 mg/kg for 12 weeks (Sobotka et al. 1996). Actual dietary iron concentrations were not measured. Rats exposed to the highest concentration lost significant weight, were significantly less active, and exhibited decreased startle reflex and conditioned avoidance-response performance. The nature and extent of behavioral changes observed reflected a marked decrease in the ability of the rats to respond appropriately to environmental stimuli. Similar behavioral effects were observed in iron-deficient animals, but body weight changes were less severe. Whole-brain non-heme iron was significantly reduced in iron-deficient animals, but increased only in the group which received the 20,000 mg/kg diet, suggesting homeostatic mechanisms regulate whole-brain iron more effectively under conditions of dietary overload than under conditions of dietary deficiency. An ingestion rate of 0.023 kg/day and body weight of 0.267 kg (USEPA, 1988b) were used to convert the exposure concentrations to units of mg/kg-day (USEPA, 2005a). A LOAEL of 1,723 mg/kg-day and a NOAEL of 301.5 mg/kg-day were calculated for iron based on the results of this study.

Differential responses of rodent species to dietary iron overload were evaluated by Whittaker et al. (1997). Weanling male B6C3F1 mice, C5YSF1 mice, and Fischer 344 rats were fed diets containing 35 (control), 1,500, 3,500 or 10,000 mg/kg carbonyl iron for 12 weeks. Nine of 12 rats exposed at the highest concentrations died (75% mortality); no mortality was observed in mice at any other exposure concentrations. In all animals, there was a dose-related increase in liver non-heme iron, and there was significant hypertrophy of the hepatocytes in B6C3F1 mice and Fischer 344 rats fed the 10,000 mg/kg diet. Rats in the 10,000 mg/kg dose group had marked dose-dependent nephropathy, testicular atrophy, and lack of mature sperm. Based on the observed mortality, testicular atrophy, and lack of mature sperm in rats exposed at a concentration of 10,000 mg/kg, this dose was selected as the LOAEL (USEPA, 2005a). An ingestion rate of 0.018 kg/day and body weight of 0.18 kg (USEPA, 1988b; values cited as time-weighted averages for male Fischer 344 rats from weaning to 90 days of age) were used to convert the exposure concentrations to units of mg/kg-day (USEPA, 2005a). A LOAEL of 1,000 mg/kg-day and a NOAEL of 350mg/kg-day were calculated for iron based on the results of this study (USEPA, 2005a). Based on the ecological significance of the endpoints (reproduction and survival) and because the LOAEL is the lowest cited adverse effect level for mammals, the TRV values from this study were used by the USEPA to evaluate the risk posed by iron to mammalian receptors (USEPA, 2005a).

An iron LD_{50} of >4500 mg/kg for avian receptors was obtained from the *Ecological-Screening Level Risk Assessment for the Lower Ottawa River* which was prepared for, and accepted by, the USEPA in 2001 (Parametrix, 2001). This iron LD_{50} was originally obtained from the USEPA's Office of Pesticide Programs; however, the original documentation of this LD_{50} was unavailable to SECOR.

Since the iron LD_{50} for avian species is within the same magnitude as the LOAEL in the Whittaker et al. (1997) study, the USEPA-proposed NOAEL TRV of 350 mg/kg-day and LOAEL TRV of 1,000 mg/kg-day for protection of mammalian species based on a study by Whittaker et al. (1997) (USEPA, 2005a) were used in this ERA for protection of avian species.

3.1.9.4 Nickel

Day-old Hubbard broiler chicks were fed diets containing nickel (as nickel sulfate or nickel acetate) at concentrations of 0, 100, 300, 500, 700, 900, 1,100 and 1,300 mg/kg for 4 weeks (Weber and Reid, 1967). Growth of chicks was significantly reduced at dietary concentrations of 700 mg/kg and greater. A food ingestion rate of 0.0126 kg/day and body weight of 0.121 kg (cited for 14-day old chicks, [USEPA, 1988b]) were used to convert the exposure concentrations to units of mg/kg-day (USEPA, 2005a). A LOAEL of 72.9 mg/kg-day and a NOAEL of

52 mg/kg-day were calculated based on the results of this experiment. Results from this experiment were not used to derive a TRV for this ERA as growth is not considered an ecologically significant endpoint.

Mallard ducklings were exposed to 0, 176, 774 and 1,069 mg/kg nickel as nickel sulfate in diet for 90 days (Cain and Paifford, 1981). No effects on growth or mortality were observed in ducklings exposed to up to 774 mg/kg nickel. Seventy percent mortality was observed in the group of ducklings which received the diet containing 1,069 mg/kg. An ingestion rate of 0.0578 kg/day (Sugden et al., 1981) and body weight of 0.782 kg (cited by authors) were used to convert the exposure concentrations to units of mg/kg-day (USEPA, 2005a). A LOAEL of 79 mg/kg-day and a NOAEL of 57.2 mg/kg-day were calculated. Based on the ecological significance of the endpoint (survival) and because the LOAEL is the lowest cited adverse effect level for birds, the USEPA selected the TRV values from this study to evaluate the risk posed by nickel to avian receptors (USEPA, 2005a).

It is noted that Sample et al. (1996) proposed the NOAEL and LOAEL TLVs of 77.4 and 107 mg/kg-day for nickel for protection of avian species, based on the same Cain and Paifford (1981) study. The difference between the NOAEL and LOAEL TRVs from the USEPA (2005a) and Sample et al. (1996) is that Sample et al. (1996) used an ingestion rate of 0.0782 kg/day and a body weight of 1.000 kg as food consumption of 45-day old ducklings to estimate daily nickel intake throughout the 90-day study period. The NOAEL and LOAEL TRVs from the Sample et al. (1996) were used in this ERA.

In the Eco-SSL report for nickel, the USEPA has identified 11 pertinent papers on avian toxicity of nickel, with 28 results for biochemical, behavioral, physiology, pathology, reproduction, growth, and survival effects that met the Data Evaluation Score of >65 for use to derive TRV. A geometric mean of the NOAEL values for reproduction, growth, or survival was calculated at 6.71 mg/kg-day, which is set to be the NOAEL TRV for nickel (USEPA, 2007).

3.1.9.5 Titanium

Released to effluent discharge water, any titanium tetrachloride or titanium ions present will rapidly hydrolyzes to form titanium dioxide (HSDB, 2008). Titanium dioxide is not bioavailable as it is not absorbed via the gastrointestinal tract or through the skin (USEPA, 2005b). Inhalation exposure to high concentrations of titanium dioxide particles has been shown to result in pulmonary effects in rats, but these effects may be rat-specific threshold phenomenon, and are of little relevance to humans. Titanium dioxide is not carcinogenic in chronic mice or rat dietary studies (130 weeks) and no adverse effects were observed in chronic rat studies at concentrations up to 5% in the diet (50,000 mg/kg) (Bernard et al., 1990, as cited by USEPA, 2005b). In a National Cancer Institute (NCI) carcinogenicity study, groups of 50 per sex of Fischer 344 rats and B6C3F1 mice were dosed at 0; 25,000; and 50,000 mg/kg diet for 103 weeks (NCI, 1979, as cited by USEPA, 2005b). Increased incidences of thyroid C-cell adenomas or carcinomas were observed in female rats but these increases were neither statistically significant nor considered to be related to the administration of the test compound. Tumor incidences in the other groups were not significantly higher than in controls. Given to mice in drinking water at low doses (5 mg/L), titanium caused an effect similar to chromium (III), which caused increased growth rates in both sexes (Schroeder et al., 1964).

No toxicity information was identified for titanium in avian species. However, titanium dioxide has been consistently used as a marker in feeding studies using birds because it is essentially indigestible. The recovery rate of titanium dioxide in digestibility studies with hens and chickens have been shown to be 97.5% and 98.7 to 99.7%, respectively (Sungwaraporn, 2004). This low level of dietary absorption of titanium dioxide in chicken is consistent with the levels reported in humans (3% or less) (Carson et al., 1987). Titanium dioxide has been added to feed at concentrations of 5,000 mg/kg for ducks and turkeys (Kluth and Rodehutscord, 2006). Titanium dioxide has also been legally added to feeds as a color additive in amounts that do not exceed 1% of the finished product. The available information suggests that TiO_2 is sufficiently indigestible such that it does not result in direct toxicity to avian species through oral exposure, even at moderately high concentrations in feed.

The available ecotoxicity data on titanium dioxide are primarily limited to acute aquatic studies. The acute aquatic LC_{50} of titanium dioxide in fathead minnows (*Leuciscus idus*) is >1,000 mg/L (USEPA, 2005b), indicating that ecotoxicity of titanium dioxide is low. The acute aquatic LC_{50} of titanium dioxide in Mummichog (*Fundulus heteroclitus*) is also >1,000 mg/L after up to 4 days of exposure (USEPA, 2008b). Mummichog is a small killifish found in the eastern U.S. It is capable of tolerating highly variable salinity and temperatures, and is found in estuaries and saltmarshes as well as less salty waters. In addition, there were no toxic effects observed in water fleas (*Daphnia magna*) at 1,000 mg/L (EC_{50} for measuring intoxication and immobility). Although Lovern and Klaper (2006) reported the acute aquatic LC_{50} of titanium dioxide in water fleas (*Daphnia magna*) at 5.5 mg/L, this value is not relevant for the Site because the study focused on titanium dioxide nanoparticles. In a one-week acute scud (*Hyalella azteca*) test using soft water and Burlington City tap water (Lake Ontario, Canada), Borgman et al. (2005) tested 65 metal concentrations of up to 1 mg/L (soft water) and 3.150 mg/L (tap water). The authors reported LC_{50} for titanium to be <0.272 mg/L and >3.150 mg/L in soft water and tap water, respectively. The reported LC_{50} of <0.272 mg/L for titanium in soft water is not reliable because the metal stock was supplied in 20% of hydrochloric acid and the toxicity measured for titanium was partly caused by the acid and not the metal (Borgman et al., 2005). In addition, acute toxicity tests based on *Hyalella azteca* are known to be too sensitive since the amphipods have small tissue mass (Ingersoll et al., 1996).

To summarize the toxicity of titanium oxide, the USEPA (2005b) states that "Based on the insoluble nature of titanium dioxide in water and the low acute toxicity of titanium dioxide to freshwater fish, there are no non-target aquatic species risk concerns resulting from the use of titanium dioxide as an inert ingredient. Based on the lack of absorption, as well as no identified toxicological effects of concern in animal testing, there are no risk concerns for nontarget terrestrial organisms resulting from the use of titanium oxide as in inert ingredient." As a result, it is proposed that the screening value for titanium as titanium oxide in water to be 1,000 mg/L.

Due to the lack of toxicity data for titanium in animals, as in the case of iron, concentration levels that did not show adverse effects to tested species were conservatively selected as NOAEL, even though the true NOAEL can be higher than the currently available data. If an ingestion rate of 0.023 kg/day and body weight of 0.267 kg for rats (USEPA, 1988b; USEPA, 2005b) were used to convert the exposure concentrations in the NCI study (USEPA, 2005b) to units of mg/kg-day (USEPA, 2005a), a conservative NOAEL of 4,307 mg/kg-day was calculated for titanium oxide for protection of mammalian species. If an ingestion rate of 0.0075 kg/day and body weight of 0.066 kg (USEPA, 1988) for young chicken were used to convert the exposure concentrations in the Kluth and Rodehutscord feeding study (2006) to units of mg/kg-day (USEPA, 2005a), a conservative NOAEL of 568 mg/kg-day was calculated for titanium oxide for protection of avian species. The proposed NOAEL for titanium has a high degree of uncertainty but is likely protective (UDEQ, 2008e). According to UDEQ (2008e), the USEPA default uncertainty factor for extrapolating from a LOAEL to a NOAEL is a factor of 10, as a factor of 10 is usually protective (Dourson et al., 1996). However, this same data shows that a factor of 10 to extrapolate from a NOAEL to LOAEL may not be protective. Therefore, the geometric mean of the difference between the LOAEL and NOAEL of the other four CPECs: arsenic, chromium, iron, and nickel (2.4) was used. As such, the proposed LOAEL for titanium is 1,363 mg/kg-day, which is lower than the NOAEL of 4,307 mg/kg-day for mammalian species.

A summary of the final NOAEL- and LOAEL-based TRVs is presented in Table 10.

3.2 Risk Characterization

The risk characterization phase of the quantitative ERA consists of two elements: risk estimation and risk description. Risk estimation involves integrating exposure and stressor-response profiles from the analysis phase to estimate the likelihood of adverse effects occurring in indicator species of concern as a result of exposure to CPECs.

Risk description involves a qualitative discussion of risks presented by the Site. It also addresses the uncertainty, assumptions, and limitations of the ERA. Because no one line of evidence can adequately define risks to complex ecological systems, a "weight-of-evidence" approach is used to compile and integrate data indicating the degree of risk posed by CPECs for each biological endpoint.

3.2.1 Risk Estimation

Risk estimation can be performed using a hazard quotient (HQ) methodology whereby ADD estimated in target receptors is divided by appropriate TRVs to calculate HQs, as follows:

$$HQ = \frac{ADD}{NOAEL\ or\ LOAEL} \qquad \text{(Eq. 4)}$$

Where:

HQ	=	Hazard quotient, unitless;
ADD	=	Average daily dose (mg/kg-day); and
NOAEL	=	No-observed-adverse-effect-level (mg/kg-day) for low or conservative HQ.
LOAEL	=	Lowest-observed-adverse-effect-level (mg/kg-day) for higher HQ.

The HQs can then be used as indicators of (but not as direct measures of) potential risk from a CPEC. An HQ of less than one (unity) indicates that the CPEC alone is unlikely to cause adverse ecological effects (USEPA, 1997). LOAEL-based TRVs were also used to provide high HQ values which show potential changes in growth or reproduction that can result in changes in the overall characteristics of populations. The NOAEL-based and LOAEL-based CPEC-specific and species-specific HQs are presented in Tables 11 and 12 of the ERA, respectively. In addition, species-specific hazard index (HI), which is the sum of the HQ for each CPEC, is also estimated. An HI of less than one also indicates that the group of CPECs is unlikely to cause adverse ecological effects (USEPA, 1997). As the uncertainty in the exposure concentrations and the NOAEL increase, there is greater confidence in the predictive value of the HQ to become a more certain pass/fail decision point.

From the results presented in Tables 11 and 12 of the ERA, it is noted that all avian species of concern at the Site will not incur unacceptable risks, since the HIs for all receptors are comparable and are less than unity or one. The species with the highest cumulative HI is the snowy plover, with a cumulative NOAEL-based HI of 0.584. The NOAEL-based HI for the American avocet, black-necked stilt, and mallard duck are 0.409, 0.411, and 0.462, respectively. The LOAEL-based HIs of the American avocet, black-necked stilt, mallard duck, and snowy plover are 0.131, 0.132, 0.147, and 0.187, respectively. It is noted that the HI for the black-necked stilt is similar to that of the American avocet. This is due to the fact that intake rates for both species were derived based on allometric equations (USEPA, 1993), for which weight is an important parameter. The HI for the snowy plover is about 42% higher than that of the black-necked stilt and American avocet..

As shown in Table 11 for NOAEL-based HIs, the risk-driving CPECs across all evaluated pathways at the Site are iron and arsenic, accounting up to a total of 38.4% and 35.1%, respectively, of the cumulative HI in the black-necked stilt, American avocet, and snowy plover. Chromium and titanium each contributes around 13.5 to 14.4% to the cumulative HI. Nickel contributes the least to the cumulative HI. The fact that iron is the risk-driving CPEC should provide a warning that the ERA results are conservative. This is due to the fact that iron is an essential nutrient and there is scarce toxicity information on iron. The selected NOAEL for iron may not be the true NOAEL, which can be much higher. The dominant pathway for all species of concern is the food ingestion from surface water uptake (66.3-73%), followed by sediment ingestion (26.5-33.2%).

If food sources from sediment are evaluated (aquatic plants and invertebrates – Tables 11a and 12a of Appendix D), the estimated HIs are slightly higher (from 3.4% [for stilts and avocets] to 11.3% [for mallard ducks] higher) than the values assuming 100% ingestion of invertebrates from surface water (Table 11 and Table 12). The HI for the snowy plover is slightly lower. The results presented in Tables 11a and 12a of Appendix D show that all avian species of concern at the Site will not incur unacceptable risks, since the HIs for all receptors are also less than unity or one. The species with the highest cumulative HI is still the snowy plover, with a cumulative NOAEL-based HI of 0.573. The NOAEL-based HI for the American avocet, black-necked stit, and mallard duck are 0.423, 0.425, and 0.514, respectively. The LOAEL-based HIs of the American avocet, black-necked stilt, mallard duck, and snowy plover are 0.140, 0.140, 0.175, and 0.184, respectively.

As shown in Table 11a for NOAEL-based HIs, the risk-driving CPEC across all evaluated pathways at the Site is iron, accounting up to a total of 43.9-74.4% of the cumulative HI all species of concern. The dominant pathway for all species of concern is the ingestion of food from sediment, followed by. sediment ingestion. However, since the cumulative HIs based on 100% consumption of aquatic vertebrates from surface water uptake (Tables 11 and 12) are not too much different from the HIs from consumption of aquatic vertebrates from surface water uptake and consumption of aquatic plants and invertebrates from sediment uptake (Tables 11a and 12a), the simplified assumption of 100% consumption of aquatic vertebrates from surface water uptake is adequately protective.

3.2.2 Risk Description

According to USEPA (USEPA, 1992b and 1998), the risk description step consists of a narrative evaluating the lines of evidence supporting or refuting the risk estimates and the potential of adverse effects. Five elements have been established by USEPA (1992b and 1998) for evaluating the potential for adverse effects:

- Nature of effects;
- Intensity of effects;
- Spatial scale;
- Temporal scale; and
- Potential for recovery.

Receptor-specific risk estimates were assessed according to the criteria listed above to evaluate the potential for adverse effects to ecological receptors of concern. This evaluation was used to make recommendations regarding effluent discharge at the Site.

The sections below discuss the factors listed above, as relevant, for each of the assessment endpoints and the lines of evidence.

3.2.3 Nature and Intensity of Effects

As all estimated HQs and HIs are below unity or one, it indicates that each CPEC alone and the group of CPECs is unlikely to cause adverse ecological effects (USEPA, 1997). The results of this ERA are very conservative based on the reasons cited below.

The evaluation of potential risks to the snowy plover resulted in the highest HI (NOAEL-based 0.584) among all receptors evaluated, with the majority of risks being due to potential arsenic impact of surface water to food uptake (~32.1-35.1% of the cumulative NOAEL-based HI). The other source of high HQ for the snowy plover are iron, chromium, and titanium. As discussed earlier, the fact that iron and background arsenic are the risk-driving CPECs should provide a warning that the ERA results are conservative. This is due to the fact that iron is an essential nutrient and there is scarce toxicity information on iron and arsenic in treated discharge wastewater is from background wells. The selected NOAELs for iron (and also titanium) may not be the true NOAELs, which can be much higher.

The evaluation of the sediment ingestion pathway is very conservative because it did not take into account the bioavailability of CPECs in sediment. Also, wastewater from ATI Titanium's well-operated, well-maintained metal precipitation, clarification, and filtration treatment system will not provide insoluble metals that can purport to sediment. In other words, the remaining CPECs in the treated effluent will be inherently soluble and not available for the sediment exposure pathway except through evaporation. Evaporation is an unlikely event given the nature of metals and the channel flow rate of 500,000 gpd. Additionally, the sediment area in contact with ATI Titanium's discharge wastewater that is available for ingestion by migratory bird species is relatively small given that the surveyed channel flow to the GSL is narrow (12 feet wide) with sloping sides.

Finally, it is highly likely that the sediment ingestion rate and food ingestion rate for all species of concern are highly conservative. In summary, the nature and magnitude of effects predicted based on the results of the ERA summarized above are relatively low, based on the conservative aspects of the ERA.

3.2.3.1 Spatial and Temporal Scales

The spatial scale includes the extent and pattern of effect as well as the context of the effect within the habitats and areas on-site, and the temporal scale describes changes expected to occur over time (USEPA, 1998). This section discusses the spatial factors relating to distribution of CPECs across the Site and the temporal scale of the ecological effects relative to the assessment endpoints. First, a FR or AUF of 1 was conservatively assumed for the ERA (SECOR, 2008e). If a realistic home range or foraging range is taken into account, the cumulative HIs can be up to 2 orders of magnitude lower.

Temporal factors that could affect the results of the ERA include:

- Species of concern are not expected to be significantly exposed to Site media unless they were breeding at the Site.
- Food availability within the Site may be limited during the time frame of bird migration, compared to the GSL shorelines. Given the low salinity of the effluent discharge water, the channel does not provide an optimum environment for brine shrimp and brine fly reproduction.

3.2.3.2 Potential for Recovery

Recovery is defined as the return of a population or community to the condition that existed before introduction of the stressor (USEPA, 1998). In considering the potential for recovery, it must be recognized that ecosystems are dynamic in nature. It is also important to consider the disturbance nature of the proposed discharge channel. Because of the low metal concentrations and low suspended solids in effluent discharge water, CPECs are not expected to cause irreversible effects to the existing ecosystem. Of all CPECs evaluated, arsenic is expected to be background-related; iron and titanium occur naturally at high levels in the environment; and chromium and nickel levels have been shown to decrease substantially in lake sediment due to technical advances in treatment techniques.

In addition, past intensive biomonitoring studies of the GSL and Southshore wetlands showed that although there was high temporal and spatial heterogeneity in metal concentrations in surface water and sediment, macroinvertebrate tissue residues were relatively constant over time, indicating limited metal uptake (ETPI, 1997; Nott and Nicolaidou, 1996).

3.2.3.3 Lines of Evidence

Based on the results of the ERA presented above, it is unlikely that concentrations of CPECs in the effluent discharge water pose potentially significant and irreversible risks to the populations of the ecological receptors of concern.

3.3 Uncertainty Analysis

Although more site-specific than the Step 1 screening level evaluation, the Step 2 ERA quantitative assessment is still conservative in nature. Therefore, the numerous uncertainties contained herein tend to overestimate potential risks to ecological receptors of concern. The uncertainties associated with the quantitative assessment of the ERA are present in the sections below, and their relevance to the calculated HQs and HIs, are discussed.

3.3.1 Selection of CPECs and Representative Concentrations

The selection of CPECs was designed to include all metals that are process related (chromium, iron, nickel, and titanium), including potential background arsenic. Although concentrations of CPECs within the effluent discharge water may fluctuate, the use of the treatment performance criteria (for arsenic, chromium, nickel, and titanium) and the potential highest concentration detected in drinking water (iron, for which there is no treatment performance criterion) will ensure that the estimated risks are at the upper possible range. The selection of potential sediment concentrations is also conservative in a way that these levels represent equilibrium conditions in the surface water bodies, not new discharge situation. Since arsenic in effluent discharge water is expected to be background-related, Utah-specific average background sediment level was used. In the USGS *Water Quality in the Great Salt Lake Basins: Utah, Idaho, and Wyoming, 1998-2001* (USGS, 2003a) report, arsenic sediment concentrations measured at Station No. 19 (19-20 mg/kg) can be representative of the GSL southshore levels near the Kennecott wastewater discharge area. These levels are consistent with arsenic sediment levels in and under the Kennecott tailings impoundment (range from 4 to 42 mg/kg, with mean value of 14 mg/kg (EPTI, 1997, reproduced from U.S. Army Corps of Engineers, 1995). Arsenic sediment levels at Stations 7 to 10 (50-440 mg/kg) were found at Silver Creek and Weber River Basin (more inland and in mountainous areas) and are not representative of the southshore GSL. When the sediment representative concentration for arsenic was changed from 6.5 mg/kg (draft ERA) to 20 mg/kg (Station No. 19), the NOAEL-based cumulative HI for the black-necked stilt increases only 1.2%, which is still much less than one. For CPECs that are expected to be found at low levels (chromium and nickel) in effluent discharge water, use of current Utah sediment concentrations are conservative because these metal levels have been shown to decrease significantly in lakes (Mahler et al., 2006), potentially due to reduced global or local emissions. For CPECs that are considered major elements (iron and titanium), sediment concentrations were selected from larger datasets and with comparable surface water concentrations. The uncertainties associated with selection of CPECs and representative concentrations are low.

3.3.2 Indicator Species

Indicator species or receptors of concern were selected on the basis of habitat surveys, regulatory guidance, and the likelihood of exposure to CPECs in Site media (surface water and sediment). These bird species (American avocet, black-necked stilt, Mallard duck, and snowy plover) were expected to be maximally exposed to CPECs in Site media due to their food sources and foraging methods. Based on the April 7, 2008 letter from the State of Utah, Department of Natural Resources (UDNR, 2008c) regarding species of concern near the GSL, Tooele County, occurrence for the American white pelican was found within a 0.5-mile radius of the Site and burrowing owl, ferruginous hawk, and long-billed curlew were found within a 10-mile radius of the Site. Since burrowing owl and ferruginous hawk consume small mammals and vertebrates, they are not relevant for the purpose of the ERA. American white pelican (consuming mostly fish) and long-billed curlew (consuming diverse food items such as crustaceans, mollusks, worms, toads, the adults and larvae of insects, berries, and nesting birds) are both migratory birds. Due to their diet composition and occurrence in the GSL, the potential risks to these birds are not expected to be higher than those evaluated in the ERA (black-necked stilt, American avocet, mallard duck, and snowy plover).

Based on the results of the recent peer-reviewed GSL Selenium Program (Conover et al., 2007), it was shown that the high selenium concentration in blood of adult California gulls breeding on the GSL do not seem to be impairing their health or reproductive ability (selenium is known to bioaccumulate in tissues). All 100 chicks examined appeared normal. For inference purposes, since CPECs at the Site are not known to bioconcentrate in invertebrates, there should not be concern for the adverse effects posed by site-related CPECs to bird eggs of the American white pelican or long-billed curlew. Since the black-necked still and American Avocet were selected as the shorebirds of concern to be studied in the recent peer-reviewed GSL Selenium Program (Cavitt, 2007) and based on the results of the California gulls study (Conover et al., 2007), indicator species evaluated in the ERA are expected to be protective of most, if not all migratory and resident bird species in the GSL.

In short, exposure to other species potentially occurring on-site (e.g., mammalian species) is not expected to exceed that of the species quantified. Although this is an inherently uncertain assumption, exposure assumptions were conservatively developed for indicator species in an attempt to minimize the potential for underestimating exposure by another species that is not evaluated herein. Since CPECs at the Site are not known to biomagnify in the food chain, higher trophic avian species were not considered.

3.3.3 Exposure Pathways

The pathways evaluated in the Step 2 ERA were assumed to have the most significant contribution to the total risk (ingestion of surface water, ingestion of food from surface water uptake, and ingestion of sediment). Pathways not evaluated (e.g., dermal exposure) were expected to have an insignificant impact on total risks to the indicator species. Of all pathways evaluated, the evaluation of the sediment ingestion pathway is very conservative because it did not take into account the bioavailability of CPECs in sediment. If bioavailabilities (the fraction of dose absorbed systemically) of CPECs are taken into account (mid range of CPEC non-bioavailability in sediment 80% - this is similar to the oral absolute bioavailability of 20% for metals [Water Science and Technology Board (WSTB), 2003), the cumulative potential risks for the American avocet and black-necked stilt will reduced by a factor of 2; whereas the potential risks for the snowy plover and Mallard duck will reduce by a factor of 1.5 and 1.3, respectively. Currently, there is not enough information to compute the relative bioavailability of CPECs in sediment. Relative bioavailability is the bioavailability in the sediment compared to the bioavailability of metals in the toxicity test on which the toxicity reference value is based. For instance, if the absolute bioavailability in the toxicity test and the sediment is 1 percent (resulting in a relative bioavailability of 100 percent), the risks would not be underestimated even though the absolute bioavailability is very low (UDEQ, 2008e). Also, wastewater from ATI Titanium's well-operated, well-maintained metal precipitation, clarification, and filtration treatment system will not provide insoluble metals that can purport to sediment. In other words, the remaining CPECs in the treated effluent will be inherently soluble and not available for the sediment exposure pathway.

3.3.4 Area Use Factor

For all avian receptors of concern, it was assumed that the receptors would spend 100% of their time within the area of the discharge, and that 100% of water and food consumption would be obtained from the discharge area. This is a conservative assumption that would likely overestimate exposure doses by up to two orders of magnitude. For example, if average home ranges for species of concern are taken into account, the FR for black-necked stilts and American avocets is 1/283.5 or 4E-03, FR for snowy plover is 1/35 or 2.8E-2, and FR for mallard ducks is 1/580 or 2E-03. Thus, potential risks to species of concern can be 35 (for snowy plover), 283 (for black-necked stilt and American avocet), or 580 (for Mallard duck) times lower than the estimated values. Even if FR is based on the non-conservative fraction of the foraging length over the length of the channel (1.5 km), the FR for the stilts and avocets is 1.5 km/4.5 km = 0.33, for the snowy plover is 1.5 km/3 km = 0.5, and for the mallard duck is 0.165 (since the home range for the mallard duck is almost twice as that of the stilt). This means that the potential risks to species of concern can be 2 (for snowy plover), 3 (for black-necked stilt and American avocet), or 6 (for Mallard duck) times lower than the estimated values.

It was also assumed that 100% of the bird's food would be aquatic invertebrates. However, of the four receptors, the snowy plover will also feed on terrestrial invertebrates, and the American avocet, black-necked stilts, and the mallard duck will ingest a variety of food items including terrestrial insects, plants and fish. The assumption of 100% aquatic invertebrates in the diet may overestimate but not underestimate exposure (based on the sediment-to-food uptake analysis included in Appendix D).

3.3.5 Bioaccumulation Factors

While literature-derived BAFs were used, they are much more conservative that the UDEQ-suggested screening default value of one. BAFs and screening benchmarks are commonly developed through the use of laboratory experiments with sensitive species. As these studies do not consider all species that may be present at the Site, they represent a source of uncertainty. However, since geometric mean was selected for BAFs, these values are adequately protective and were unlikely to underestimate potential risks to ecological receptor populations. Also, there is some uncertainty in the BAFs of the majority of the CPECs, due to the availability of limited information on the uptake of metals within the marine environment. In addition, the uptake of metals can be influenced by surface water characteristics which have not been addressed as part of this evaluation (e.g. water hardness and pH). These uncertainties are not significant since existing biomonitoring studies of more impacted sites near the GSL

(EPTI, 1997 and 1998) have shown that the macroinvertebrate tissue residues were relatively constant over time, although significant heterogeneity occurred among sample sites. In addition, it was also observed from those extensive biomonitoring studies that except for selenium, other metals did not accumulate in eggs of the indicator species studied (American avocet, black-neckled stilt) (Cavitt, 2007). The nesting surveys conducted also found no difference in clutch size, hatchability, or fledging success between birds using the impacted sites and those in the reference areas, indicating no obverved reproductive risks to bird species using these study areas impacted with metal contamination (EPTI, 1997; Cavitt, 2007; Conover et al., 2007).

It is noted that shorebirds hatching success from created effluent dominated wetlands is based on several factors, not related to chemicals found in the effluent. For example, based on the recent peer-reviewed GSL Selenium Program (Cavitt, 2007), at Saltair (the Kennecott wastewater discharge area at the south shore of the GSL - similar GSL southshore setting) (Cavitt, 2007), the major sources of nest failure was a flooding event (from rain) since the bird nests were found along the GSL shoreline and predation (by California gulls). Based on the recent peer-reviewed GSL Selenium Program (Cavitt, 2007), collection of eggs at four newly initiated nests in Saltair for the GSL selenium study (after the flooding event) also resulted in the abandonment of nests due to human disturbance (Cavitt, 2007). As a result, hatching success was not determined for birds nesting at Saltair (Cavitt, 2007). However, it was found that despite elevated levels of selenium found within the American Avocet tissues (selenium is known to bioaccumulate in tissues), their corresponding egg selenium concentrations were relatively low, similar to background levels (Cavitt, 2007). UDEQ has recommended that water quality standard for selenium should be a tissue-based standard, based upon the selenium concentration found in the eggs of birds using the open waters of the GSL (UDEQ, 2008d) (not selenium found in bird tissues). For inference purposes, since CPECs at the Site are not known to bioconcentrate in invertebrates, there should not be concern for the adverse effects posed by site-related CPECs to bird eggs, especially the cumulative HI to the birds themselves are below 1.

Based on the discussion above, it is likely that exposure concentrations and doses used in the Step 2 ERA quantitative assessment overestimated actual exposures by ecological receptors.

3.3.6 Bioavailability and Tolerance

First, bioavailability of metals in surface water and sediment was not considered in the ERA, resulting in very conservative risk estimates. The biologically available forms of metals tend not to persist in aquatic systems (Paquin et al., 2003). Typically, metals are less bioavailable in the natural environment than in laboratory settings, which generally do not consider metal-complexing ligands in the environment (Chapman et al., 2003). For example, a recent study of the Lake Michigan showed that total dissolved copper exists predominantly (more than 98%) as stable, largely non-bioavailable organic complexes (such as dissolved organic carbon) (Bazzi et al, 2002). As discussed in Section 2.3 (Selection of Chemicals of Potential Ecological Concern), it has been reported that much of the arsenic in the oxidized layers of sediment is associated with (coprecipitated or adsorbed) the hydrous iron and manganese oxide fraction or is present as $Fe_3(AsO_4)$. Under these conditions, the amount of arsenic in potentially bioavailable forms in oxidized sediment pore water is low; and 65 to 98% is present as the less bioavailable arsenate (Masscheleyn et al., 1991). Similarly, much of the chromium in sediments is associated with the clay fraction, as indicated by a close correlation between aluminum and chromium concentrations (Schropp et al., 1990). More than 70% of the chromium in uncontaminated sediments may be associated with the non-bioavailable, residual fraction (Prohic and Kniewald, 1987), that is associated primarily with the heavy minerals chromite, chromiferous magnetite, spinels, and aluminosilicate lattice of clays (Mayer and Fink, 1980). Additionally, most of nickel (more than 90%) in relatively uncontaminated sediments is in the residual fraction that is associated with oxide minerals, such as magnetite, spinels, and silicates (Loring, 1982). In short, all CPECs are not expected to be bioavailable in the aquatic environment and bioconcentrate in aquatic organisms (HSDB, 2008; ATSDR, 1997).

Secondly, tolerance was not considered and evaluated in the ERA. The term tolerance includes both acclimation (non-genetic tolerance) and adaptation (genetic tolerance). Since the Site represents a new discharge which begins operation on an assumed previously uncontaminated channel (USEPA, 1985), any potential impact of CPECs is introduced gradually, providing opportunity for ecological receptors such as invertebrates and fish to develop tolerance. Metallothionein (MT) induction is one way by which organisms of various types acclimate to elevated metal concentrations (Chapman et al., 2003). Induction of MT in the gut offers a means of retaining dietary metal in gut tissues with subsequent excretion through sloughing of intestinal epithelial cells, thus limiting absorption and potential toxicity to internal organs (Clearwater et al., 2002). The tolerance of marine biota living around and depending on hydrothermal vents, which release large quantities of metals into the surrounding environment, is based partly on MT induction as well as sequestration of bioavailable metals into nonbioavailable forms (Cosson, 1997; Rapoport et al., 2002). For example, marine animals (e.g., snails) can sequester chromium, iron, and titanium in insoluble granules that are not bioavailable to predators of these marine animals (Nott and Nicolaidu, 1996).

3.3.7 Interaction of CPECs and Other Metals

The toxicity of metal mixtures cannot reliably be predicted based on the toxicity of individual metals. In the ERA, additivity was assumed for all CPECs to estimate the cumulative HI. This is generally a reasonable worst-case assumption (Mowatt and Bundy, 2002) for CPECs, in the presence of other metals in the environment, as well. For example, arsenic tends to reduce the effects of selenium and vice versa (ATSDR, 2007). Also, studies of rats exposed to arsenic, lead, and cadmium, alone or in combination, have revealed mainly additive or subadditive effects on body weight, hematological parameters, and enzymes of heme synthesis (Mahaffey and Fowler, 1977; Mahaffey et al., 1981; as cited by ATSDR, 2007). These data do not suggest that arsenic toxicity is likely to be significantly influenced by concomitant exposure to these metals. However, supplementation with zinc or chromium may be useful in reducing chronic toxic effects by arsenic (ATSDR, 2007). Also, nickel has been shown to positively interact with other metals such as cadmium, chromium, iron, magnesium, manganese, and zinc. For example, nickel toxicity was mitigated by treatment with zinc and magnesium; manganese dust locally inhibits nickel subsulfide-induced carcinogenesis; and nickel was found to enhance the absorption of iron in iron-deficient rats (ATSDR, 2005). As some CPECs are essential for the biotic health of all or at least some organisms (chromium, iron, and nickel), there is a threshold for both deficiency and excess, resulting in a bimodal dose-response (Chapman et al., 2003).

3.3.8 Toxicity Effects

In addition to the uncertainties associated with exposure concentrations and exposure doses, scarce toxicity information is available for two CPECs iron and titanium (macroelements), resulting in conservative estimates because the NOAELs identified may not be the highest NOAELs. As a result, much of the uncertainty in this Step 2 ERA lies in the assessment of potential effects. The effects characterization was designed so that uncertainties are expected to overestimate, rather than underestimate, actual toxicity. The toxicity values used in the Step 2 ERA quantitative assessment are conservative values representing NOAEL. Therefore, risks tend to be overestimated. Assumptions that may introduce uncertainty into the development of TRVs for wildlife include the following:

- Endpoint and duration extrapolation accurately relate subchronic exposures to chronic exposures and LOAELs to NOAELs;
- Interspecies extrapolation accurately reflects differences in species sensitivity;
- Data from laboratory species are accurately extrapolated to species in the natural environment;
- The form of the chemical used in the literature study has the same level of bioavailability as the chemical form(s) occurring in the environment; and
- The indicator species are equally sensitive, or more sensitive, to the toxic effects of chemicals than other species that may be in the Site.

Of the assumptions listed above, the interspecies extrapolation may have a large contribution to the uncertainty of the TRVs. In using interspecies extrapolation, it is automatically assumed that the indicator species are more sensitive than the test species. However, it is likely that just the opposite is true, especially where laboratory-reared animals are used. Laboratory animals are often bred to be particularly sensitive to specific chemicals.

The use of NOAEL-based TRVs is also conservative because the actual threshold for toxic effects lies somewhere between the NOAEL and the LOAEL.

In general, HQs and His exceeding the negligible risk threshold of 1.0 do not necessarily imply significant risks. In fact, actual risks to aquatic wildlife often are very low (i.e., affecting only a few percent of all species) even when HQs are 3, 5, or higher (EPTI, 1997). This is because actual risks depend on bioavailability of metals, as well as fraction ingested from source, frequency and duration of exposure. When these probabilities are factored into risks, actual risks are often much lower.

3.3.9 Toxicity Tests

In general, since metals are not readily soluble, toxicity tests are typically conducted with soluble salts, which will overestimate both bioavailability and toxicity under real world conditions (USEPA, 2002). Similarly, the lack of dissolved organic carbon in toxicity tests results in conservative results. In addition, toxicity tests conducted with organisms that are not pre-acclimated to natural metal concentrations in water and food will also result in unrealistically low toxicity endpoints (Muyssen and Janssen, 2001a and 2001b). Further, there are possibly problems with existing metal toxicity data, including information on chemical metal form, possible shifts in forms during testing, and adequate control of pH (Wolterbeek and Verburg, 2001). As a result, the use of uncensored toxicity data from the literature will generally result in very conservative input to risk assessments (Batley et al., 1999).

3.4 Derivation of Ecological Risk-based Levels

Since the snowy plover and black-necked stilt have not been observed to nest along the southshore of the GSL and the mallard duck were not evaluated in the recent peer-reviewed GSL Selenium Program (Cavitt, 2007), ecological risk-based levels (ERBLs) were derived based on the American avocet's exposures. ERBL for each CPEC is estimated using the following equation:

$$ERBL = \frac{C \times THQ}{HQ} \qquad \text{(Eq. 5)}$$

Where:

ERBL	=	Ecological risk-based level in water (mg/L), multi-pathway, including sediment exposure;
C	=	Representative CPEC-specific concentration evaluated in the ERA (mg/L);
THQ	=	Target hazard quotient, assumed 1; and
HQ	=	CPEC-specific HQ based on cumulative pathways, NOAEL- or LOAEL-based.

Table 13 presents NOAEL- and LOAEL-based ERBLs for CPECs in effluent discharge water, including the ingestion of sediment pathway. The NOAEL-based ERBLs (proposed as monthly average discharge limits) for arsenic, chromium III, iron, nickel, and titanium are: 0.76 mg/L, 0.89 mg/L, 9.55 mg/L, 5.55 mg/L, and 90.86 mg/L, respectively. The LOAEL-based ERBLs (proposed as daily maximum discharge limits) for arsenic, chromium III, iron, nickel, and titanium are: 3.05 mg/L, 3.6 mg/L, 27.29 mg/L, 7.67 mg/L, and 218.03 mg/L, respectively. If the ingestion of sediment pathway is not taken into account, NOAEL- and LOAEL-based ERBLs will be much higher, as shown in Table 14.

4.0 CONCLUSIONS

The purpose of the ERA is to evaluate the potential ecological risks to the environment as a result constant discharge of treated process water directly into the Great Salt Lake (GSL). The results of the ERA are used to derive the ERBLs of the CPECs in treated process water that are protective of the environment – to provide the basis for suitable UPDES discharge limits. This ERA was conducted in accordance with the current USEPA risk assessment guidance (USEPA, 1997) and the UDEQ guidance and recommendations (UDEQ, 2008a, 2008b, and 2008c; SECOR, 2008c, 2008d, and 2008e). This ERA report encompasses a screening level ERA, which includes Step 1 (Screening-level Problem Formulation and Ecological Effects Evaluation) and Step 2 (Screening-level Exposure Estimates and Risk Calculation) of the 8-step ERA defined by the USEPA (USEPA, 1997).

During the Step 1 of the ERA, selection of CPECs was conducted to select those site-related chemicals likely to be associated with adverse ecological effects. The list of CPECs for the Study Area includes: arsenic, chromium III, iron, nickel, and titanium. Note that arsenic was detected in source groundwater but not in RO concentrate. It is therefore likely to be background-related. Comparison of CPEC Site samples in source water and RO concentrate/blowdown to State and federal marine and freshwater screening criteria indicate no exceedance (Table 6). To be complete, all CPECs were carried forward to Step 2 of the ERA.

For the purpose of the Step 2 of the ERA, representative concentrations of CPECs in effluent discharge water are the highest of either the detected levels of CPECs in source groundwater or in RO concentrate/inlet or performance criteria set for the on-site wastewater treatment system. Although concentrations of CPECs within the effluent discharge water may fluctuate, the use of the treatment performance criteria (for arsenic, chromium, nickel, and titanium) and the potential highest concentration detected in drinking water (iron, for which there is no treatment performance criterion) will ensure that the estimated risks are at the upper possible range.

The selection of potential sediment concentrations is conservative in a way that these levels represent equilibrium conditions in the surface water bodies, not new discharge situation. Since arsenic in effluent discharge water is expected to be background-related, Utah-specific average background sediment level was used. For CPECs that are expected to be found at low levels (chromium and nickel) in effluent discharge water, use of current Utah sediment concentrations are conservative because these metal levels have been shown to decrease significantly in lakes (Mahler et al., 2006) potentially due to decreases in global/local emissions. For CPECs that are considered major elements (iron and titanium), sediment concentrations were selected from larger datasets and with comparable surface water concentrations.

At the direction of UDEQ, ecological receptors of concern evaluated in the Step 2 ERA are: American avocet, black-necked stilt, Mallard duck, and snowy plover. Since CPECs at the Site are not known to biomagnify in the food chain, higher trophic avian species were not considered. The exposure pathways of concern for these four receptors are: ingestion of surface water, ingestion of food from water, and ingestion of sediment. Ingestion of food from sediment was also evaluated in an Appendix. To be conservative the FR or AUF was assumed to be one (SECOR, 2008e). Extensive literature review was performed to identify CPEC-specific BAFs from surface water and TRVs for toxic effects. Potential risks to ecological receptors of concern, expressed as CPEC-specific hazard quotient (HQ) and cumulative hazard index (HI) were computed by dividing the average daily doses (ADDs) by the TRVs.

Results of the Step 2 ERA indicated that that all avian species of concern at the Site will not incur unacceptable risks, since the hazard indices (HIs) for all receptors are less than unity or one. The species with the highest cumulative HI is the black-necked stilt, with a cumulative no-observed-adverse-effect-level (NOAEL)-based hazard index (HI) of 0.765. The NOAEL-based HI for the American avocet, mallard duck, and snowy plover are 0.761, 0.24, and 0.673, respectively. The lowest-observed-adverse-effect-level (LOAEL)-based HIs of the black-necked stilt, American avocet, mallard duck, and snowy plover are 0.225, 0.224, 0.066, and 0.19, respectively. It is noted that the HI for the black-necked stilt is similar to that of the American avocet. This is due to the fact that intake rates for both species were derived based on allometric equations (USEPA, 1993), for which weight is an important parameter. The HI for the snowy plover is lower than that of the black-necked stilt and American avocet. This proves that the black-necked stilt can adequately serve the indicator species for the snowy plover. The HI for the mallard duck is the lowest. This is possibly due to the more realistic intake rate for mallard ducks based on experimental data (USEPA, 2005a).

The Step 2 ERA results also show that the risk-driving CPEC across all evaluated pathways at the Site is iron, accounting up to a total of 57.3% of the cumulative HI in the black-necked stilt and American avocet. Arsenic, chromium III, and titanium each contributes around 10.9 to 18% to the cumulative HI. Nickel contributes the least to the cumulative HI. The fact that iron is the risk-driving CPEC should provide a warning that the ERA results are conservative. This is due to the fact that iron is an essential nutrient and there is scarce toxicity information on iron. The selected NOAEL for iron may not be the true NOAEL, which can be much higher. The dominant pathway for the stilts and avocets is the sediment ingestion (64%), followed by ingestion of food from surface water uptake (35.6%). The dominant pathway for the snowy plovers and mallard ducks is the food ingestion from water uptake (57.6% and 72.7%, respectively), followed by ingestion of sediment (42% and 26.4%, respectively).

The pathways evaluated in the Step 2 ERA were assumed to have the most significant contribution to the total risk (ingestion of surface water, ingestion of food from surface water uptake, and ingestion of sediment). Of all pathways evaluated, the evaluation of the sediment ingestion pathway is very conservative because it did not take into account the bioavailability of CPECs in sediment. If bioavailabilities of CPECs are taken into account (mid range of CPEC non-bioavailability in sediment 80% - this is similar to the oral absolute bioavailability of 20% for metals (WSTB, 2003), the cumulative potential risks for the American avocet and black-necked stilt will reduced by a factor of 2; whereas the potential risks for the snowy plover and Mallard duck will reduce by a factor of 1.5 and 1.3, respectively. Also, wastewater from ATI Titanium's well-operated, well-maintained metal precipitation, clarification, and filtration treatment system will not provide insoluble metals that can purport to sediment. In other words, the remaining CPECs in the treated effluent will be inherently soluble and not available for the sediment exposure pathway. Additionally, the sediment area in contact with ATI Titanium's discharge wastewater that is available for ingestion by migratory bird species is relatively small given that the surveyed channel flow to the GSL is narrow (12 feet wide) with sloping sides.

For all avian receptors of concern, it was also assumed that the receptors would spend 100% of their time within the area of the discharge, and that 100% of water and food consumption would be obtained from the discharge area. This is a conservative assumption that would likely overestimate exposure doses by up to two orders of magnitude. Based on the discussion above, it is likely that exposure concentrations and doses used in the Step 2 ERA overestimated actual exposures by ecological receptors of concern. In addition, the effects characterization was designed so that uncertainties are expected to overestimate, rather than underestimate, actual toxicity.

In general, HQs and HIs exceeding the negligible risk threshold of 1.0 do not necessarily imply significant risks. In fact, actual risks to aquatic wildlife often are very low (i.e., affecting only a few percent of all species) even when HQs are 3, 5, or higher (EPTI, 1997). This is because actual risks depend on bioavailability of metals, as well as fraction ingested from source, frequency and duration of exposure. When these probabilities are factored into risks, actual risks are often much lower. In addition, it was also observed from the extensive biomonitoring studies for the most impacted areas of the GSL that except for selenium, other metals did not accumulate in eggs of the indicator species studied (American avocet, black-necked stilt, and Mallard duck). In the late 1990s, the nesting surveys conducted also found no difference in clutch size, hatchability, or fledging success between birds using the impacted sites and those in the reference areas, indicating no observed reproductive risks to bird species using these study areas impacted with metal contamination (EPTI, 1997). A decade later, the recent peer-reviewed GSL Selenium Program found that despite elevated levels of selenium found within the American Avocet tissues (selenium is known to bioaccumulate in tissues), their corresponding egg selenium concentrations were relatively low, similar to background levels (Cavitt, 2007). And UDEQ has recommended that water quality standard for selenium should be a tissue-based standard, based upon the selenium concentration found in the eggs of birds using the open waters of the GSL (UDEQ, 2008d) (not selenium found in bird tissues). For inference purposes, since CPECs at the Site are not known to bioconcentrate in invertebrates, there should not be concern for the adverse effects posed by site-related CPECs to bird eggs, especially the cumulative HI to the birds themselves are below one.

Based on the Step 2 ERA, NOAEL- and LOAEL-based ERBLs for CPECs in effluent discharge water, including the ingestion of sediment pathway, were estimated. The NOAEL-based ERBLs (proposed as monthly average discharge limits) for arsenic, chromium III, iron, nickel, and titanium are: 0.76 mg/L, 0.89 mg/L, 9.55 mg/L, 5.55 mg/L, and 90.86 mg/L, respectively. The LOAEL-based ERBLs (proposed as daily maximum discharge limits) for arsenic, chromium III, iron, nickel, and titanium are: 3.05 mg/L, 3.6 mg/L, 27.29 mg/L, 7.67 mg/L, and 218.03 mg/L, respectively. If the ingestion of sediment pathway is not taken into account, NOAEL- and LOAEL-based ERBLs will be much higher.

As the actual threshold for toxic effects in wildlife lies somewhere between the NOAEL and the LOAEL, and the cumulative NOAEL-based and LOAEL-based HIs are below one, actual risks to all species of concern are negligible and very low. This is because actual risks depend on bioavailability of metals in sediment, as well as fraction ingested from source, food availability, and frequency and duration of exposure. When these probabilities are factored into risks, actual risks to species of concern are often much lower than the estimated values.

Accordingly, maximum discharge limits set at the LOAEL-based ERBLs and average daily discharge limits set at the NOAEL-based ERBLs will not result in an unacceptable ecological risk for the Site. The LOAEL-based and NOAEL-based ERBLs are as follows:

Metal	Monthly Average Discharge Level (mg/L)	Daily Maximum Discharge Level (mg/L)
Arsenic	0.76	3.05
Chromium III	0.89	3.6
Iron	9.55	27.29
Nickel	5.55	7.67
Titanium	90.86	218.03

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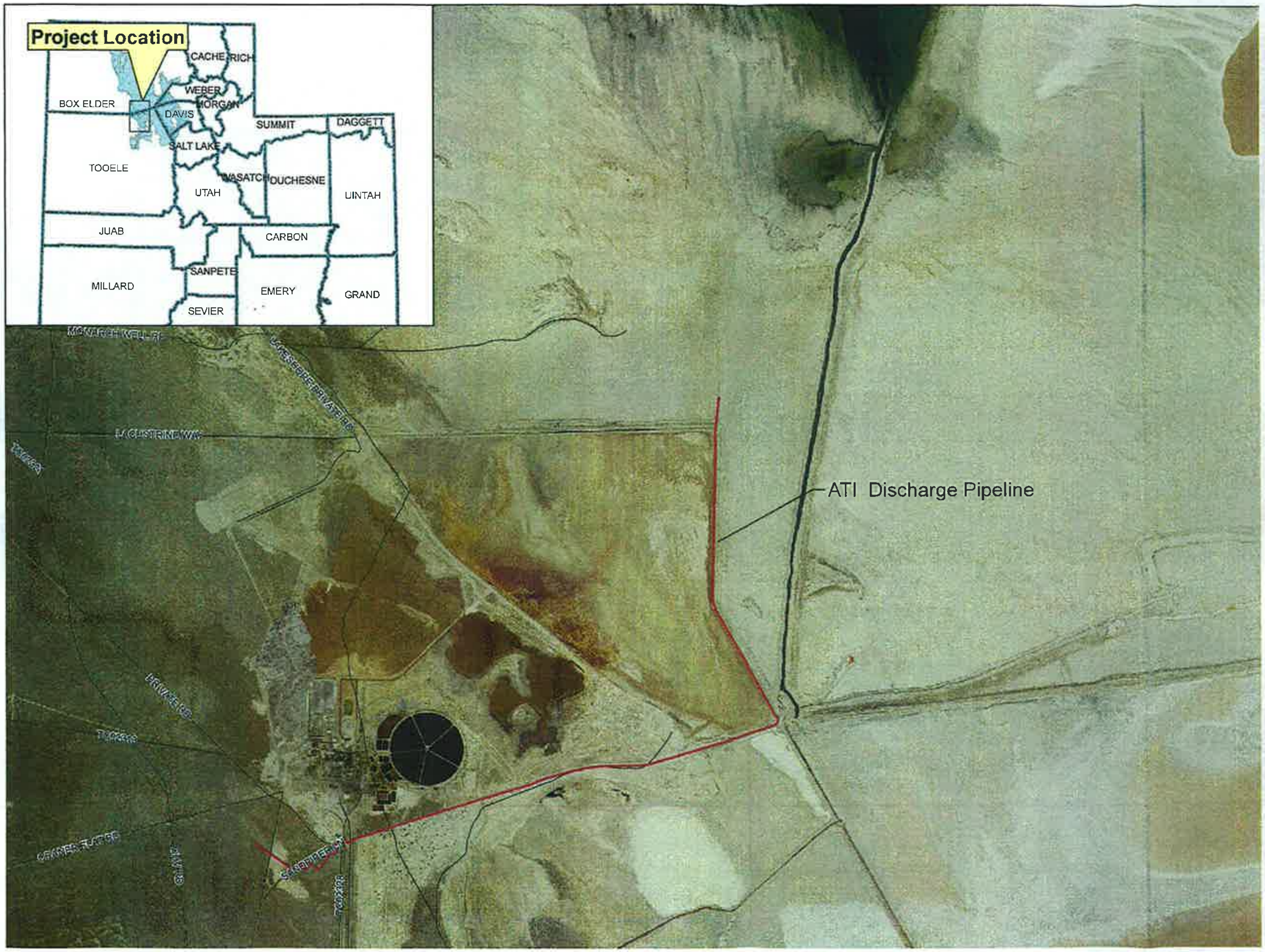

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SECOR

Legend

Pipeline Alignment

N

Graphic Scale
0 2,000
(in feet)
1 inch equals 2,000 feet

Notes

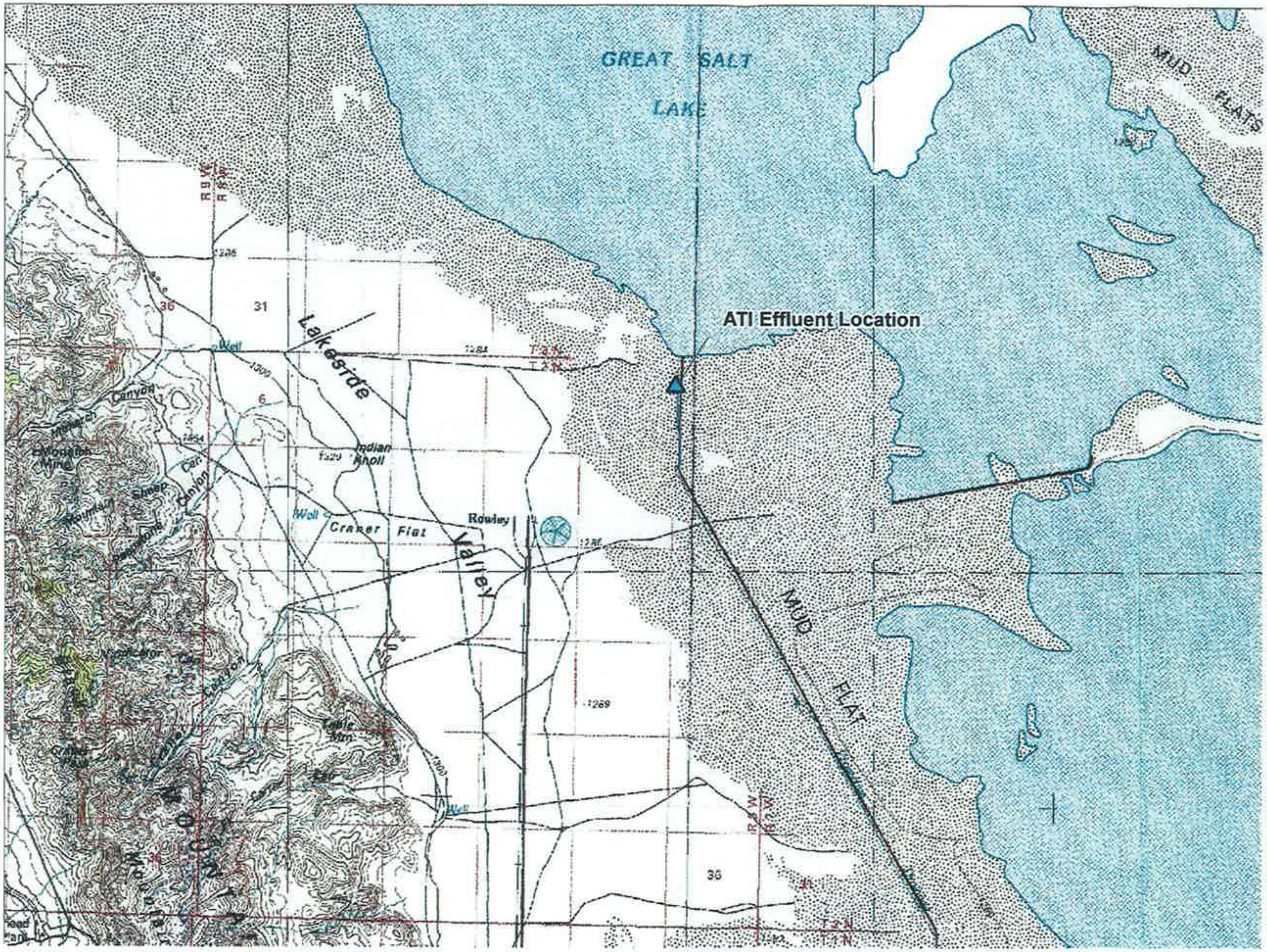
Aerial Imagery - Utah AGRC
National Agricultural Imagery Program
NAIP 2006, 1m

Client/Project
ATI Titanium LLC

12633 Rowley Road
North Skull Valley, UT
Tooele County, Utah

Title
Site Location Map

Project No.	Scale	
20OT.52001.08	1 inch equals 2,000 feet	
Figure No.	Sheet	Revision
1		0



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Notes

Utah Water Rights
Tooele USGS Quadrangle
1:100,000 scale

Client/Project

ATI Titanium LLC
Ecological Risk Assessment

12366 Rowley Road
North Skull Valley
Tooele County, Utah

Title

Topographic Map

Project No.	Scale
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Figure No.	Sheet	Revision
2		0

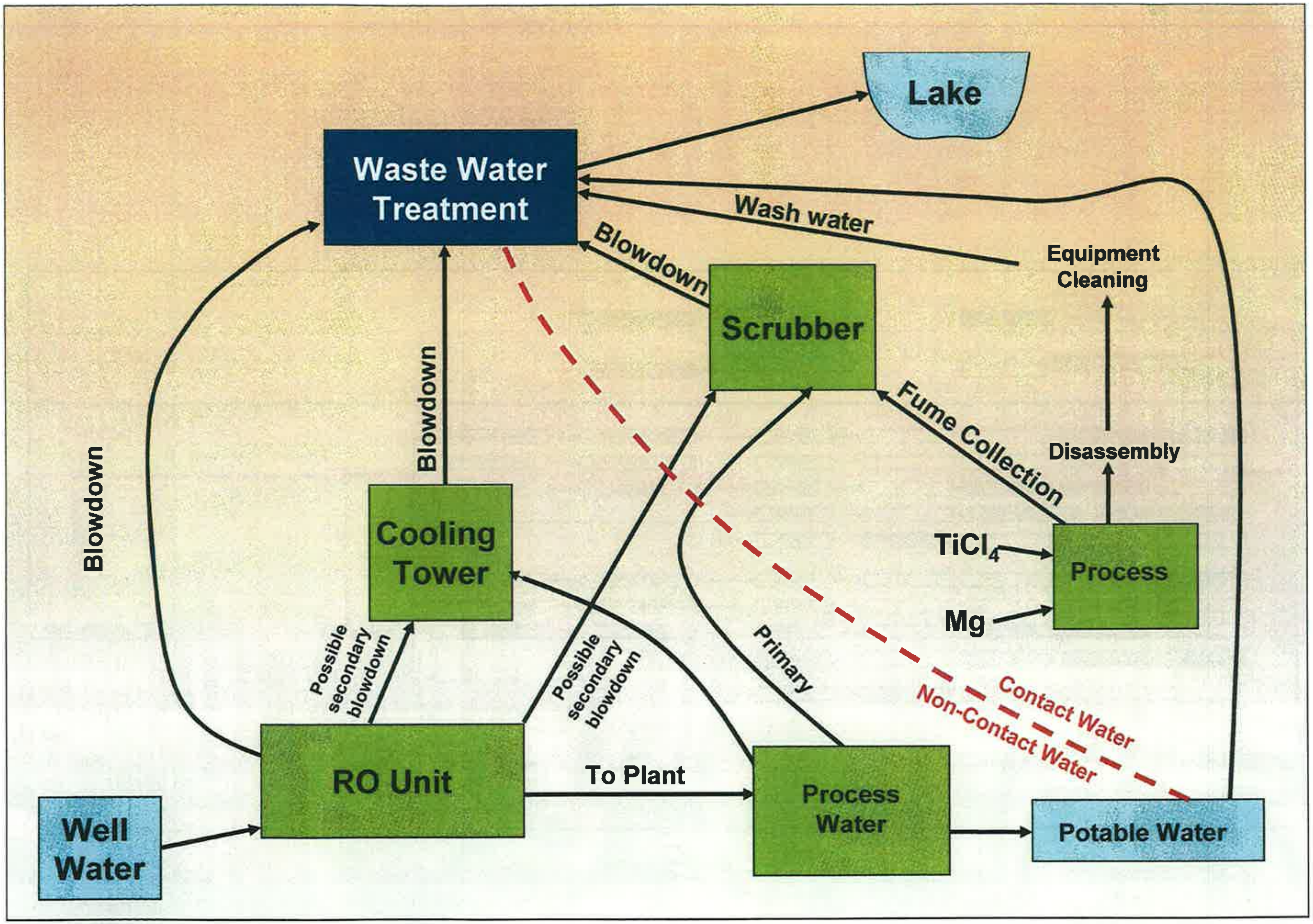

Figure 3: Process water flow diagram

FIGURE 4
Ecological Site Conceptual Model
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

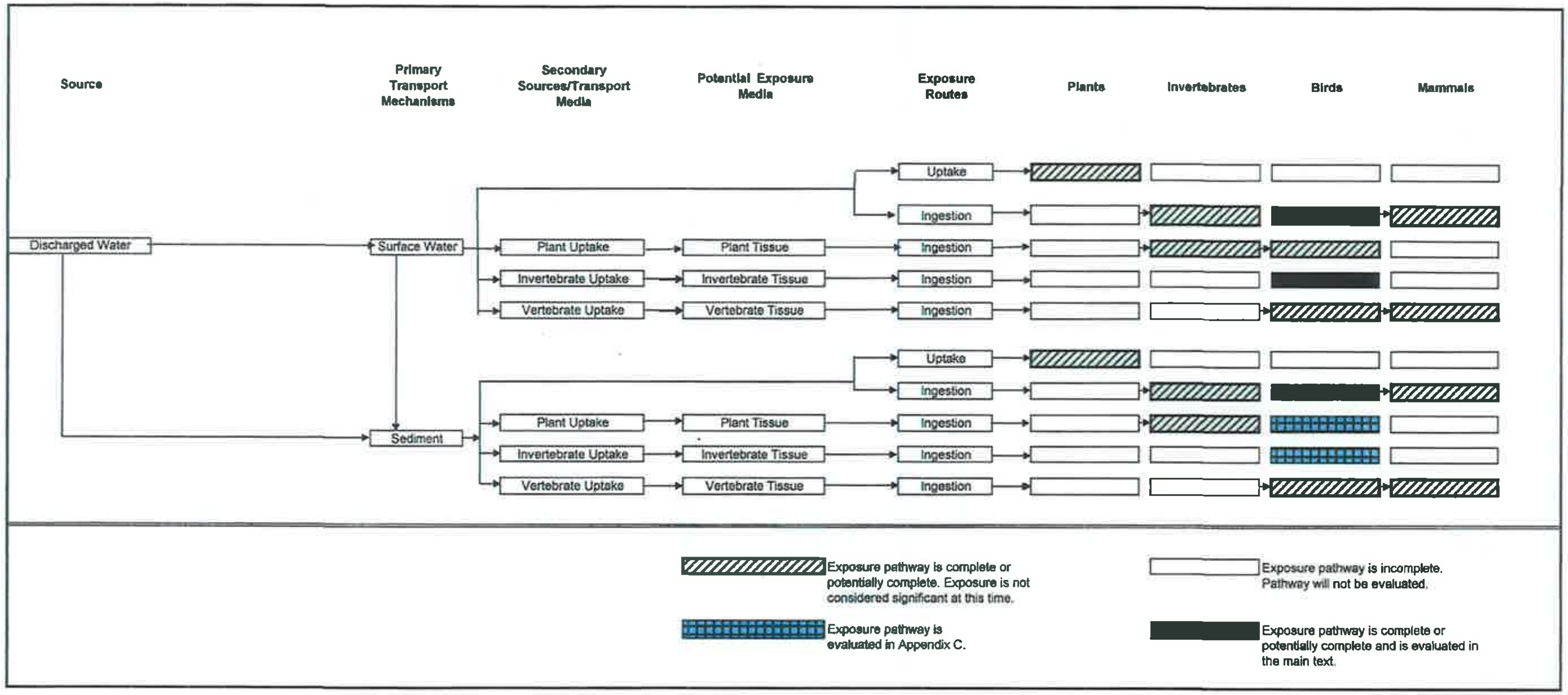

Figure 5: Four indicator species considered in the risk assessment.

ATI ERA Indicator Species.ppt

TABLES

TABLE 1
Comparison of Water Data
Groundwater Data, Reverse Osmosis Data, and Discharged Data to Federal and State Freshwater and Saltwater Criteria
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Parameter	Daily Maximum - Total (~Acute)	Average Daily - Total (~Chronic)	Background Great Salt Lake	Observation	CPEC? Reason	Groundwater Well	RO Blowdown	RO	RO Inlet	Utah Criteria for Aquatic Wildlife (Dissolved)		Utah Criteria for Aquatic Wildlife (Total Recoverable)		National Freshwater Criteria (Dissolved)		National Freshwater Criteria (Total Recoverable)		National Salt Water Criteria (Dissolved)		National Salt Water Criteria (Total Recoverable)	
Metals	Initially in UPDES Permit		Prof. Bill Johnson							1-hr Ave Acute	4-day Ave Chronic	1-hr Ave Acute	4-day Ave Chronic	CMC Acute	CCC Chronic	CMC Acute	CCC Chronic	CMC Acute	CCC Chronic	CMC Acute	CCC Chronic
	(mg/L)	(mg/L)	(mg/L)			(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Aluminum (Al)	<1.0	<0.1	95	ND and MDL << GSL level	No	<1	<1	<1	<1	0.7500	0.0870			0.7500	0.0870						
Antimony (Sb)				ND and no Criteria	No	<0.05	<0.05	<0.05	<0.05							0.0880	0.0300			1.5000	0.5000
Arsenic (As)	<0.02	<0.01		Background Detect < Criteria	**Yes, but background-related**	0.04	<0.02	<0.02	<0.02	0.3400	0.1500	0.3400	0.1500	0.3400	0.1500	0.3400	0.1500	0.0690	0.0360	0.0690	0.0360
Beryllium (Be)				ND and no Criteria	No	<0.005	<0.005	<0.005	<0.005												
Boron (B)				ND and no Criteria	No	<1	<1	<1	<1												
Cadmium (Cd)				ND and MDL > Criteria	No, not process-related	<0.01	<0.01	<0.01	<0.01	0.0020	0.0003	0.0023	0.0003	0.0020	0.0003	0.0023	0.0003	0.0400	0.0009	0.0402	0.0009
Chromium (Cr III)	<0.5	<0.05	0.012 (T)	Detect < Criteria	**Yes, may be process-related**	<0.01	0.03	<0.01	<0.01	0.5700	0.0740	1.8038	0.0860	0.5700	0.0740	1.8038	0.0860				
Cobalt (Co)				ND and no Criteria	No	<0.02	<0.02	<0.02	<0.02												
Copper (Cu)				ND and MDL > Criteria	No, not process-related	<0.02	<0.02	<0.02	<0.02	0.0130	0.0090	0.0135	0.0094	0.0130	0.0090	0.0135	0.0094	0.0048	0.0031	0.0058	0.0037
Iron (Fe)	<2	<1	0.095	Detect < Criteria	**Yes**	<0.05	<0.05	<0.05	0.25	1 Max	1 Max			1.0000					0.3000		
Lead (Pb)				ND and MDL<Criteria	No	<0.003	<0.003	<0.003	<0.003	0.0650	0.0025	0.1104	0.0042	0.0650	0.0025	0.1104	0.0042	0.2100	0.0081	0.2208	0.0085
Magnesium (Mg)	<10	<5	4,750	No Criteria, Background << GSL	No, not regulatory concern	110	110	<0.1	38												
Manganese (Mn)				ND and no Criteria	No	<0.02	<0.02	<0.02	<0.02					2.3000	0.1200						
Mercury (Hg)				ND and MDL < Fed. Criteria	No	<0.0002	<0.0002	<0.0002	<0.0002	0.0024	0.000012	0.0028	0.000014	0.0014	0.0008	0.0016	0.0009	0.0018	0.0009	0.0021	0.0011
Molybdenum (Mo)	<1	<0.5		ND and no Criteria	No	<0.02	<0.02	<0.02	<0.02												
Nickel (Ni)	<0.5	<0.05	0.005	Not analyzed, KEEP	**Yes, may be process-related**	NA	NA	NA	NA	0.4680	0.0520	0.4689	0.0522	0.4700	0.0520	0.4709	0.0522	0.0740	0.0082	0.0747	0.0083
Nitrogen as N				pH and temperature dependent	No	<0.5	<0.5	<0.5	<0.5												
Selenium (Se)				ND and MDL<Criteria	No	<0.005	<0.005	<0.005	<0.005	0.0184	0.0046				0.0050			0.2900	0.0710	0.2906	0.0711
Sulfur (S)				Criteria for Hydrogen Sulfide	No	160	78	<0.25	43												
Tin (Sn)	<2	<1		ND and no Criteria	No	<1	<1	<1	<1												
Titanium (Ti)	<10	<5		ND and no Criteria	**Yes, process-related**	<0.03	<0.03	<0.03	<0.03												
Vanadium (V)			0.006	ND and no Criteria	No	<0.01	<0.01	<0.01	<0.01												
Zinc (Zn)	<0.5	<0.1	0.019	ND and MDL<Criteria	No	<0.02	<0.02	<0.02	<0.02	0.1200	0.1200	0.1227	0.1217	0.1200	0.1200	0.1227	0.1217	0.0900	0.0810	0.0951	0.0856
Others																					
Oil and Grease	<10	<5				NA	NA	NA	NA												

Notes:
CPEC = Chemical of Potential Ecological Concern
Bold = Metals selected as CPECs
Yellow highlighted = Positive detection
GSL = Great Salt Lake
ND = not detected
MDL = method detection limit
CMC = used for acute criteria; Criteria Maximum Concentration
CCC = used for chronic criteria; Criteria Continuous Concentration
NA = Not Applicable

RO = reverse osmosis
mg/L = milligrams per liter
UPDES = Utah Pollution Discharge Elimination System

2) Total levels were estimated based on dissolved levels and USEPA standard conversion factors.
Total recoverable levels were estimated based on dissolved levels and USEPA/UDEQ standard conversion factors listed below.
Conversion factors freshwater CMC and CCC and saltwater CMC and CCC for arsenic are 1.0 (USEPA, 2008a).
Conversion factors freshwater CMC and CCC for cadmium (hardness dependent) are calculated to be 0.886 and 0.851, respectively based on 400 mg/L of $CaCO_3$ hardness. Conversion factors saltwater CMC and CCC for cadmium are 0.994 (USEPA, 2008a; UDEQ, 2008c).
Conversion factors freshwater CMC and CCC for chromium III are 0.316 and 0.86, respectively. Conversion factors saltwater CMC and CCC for chromium III are not available (USEPA, 2008a; UDEQ, 2008c).
Conversion factors freshwater CMC and CCC for copper are 0.960. Conversion factors saltwater CMC and CCC for copper are 0.83 (USEPA, 2008a; UDEQ, 2008c).
Conversion factors freshwater CMC and CCC for lead (hardness dependent) are calculated to be 0.589 based on 400 mg/L of $CaCO_3$ hardness. Conversion factors saltwater CMC and CCC for lead are 0.951 (USEPA, 2008a; UDEQ, 2008c).
Conversion factors freshwater CMC and CCC for nickel are 0.998 and 0.997, respectively. Conversion factors saltwater CMC and CCC for nickel are 0.990 (USEPA, 2008a; UDEQ, 2008c).
Conversion factors freshwater CMC and CCC for selenium are not available. Conversion factors saltwater CMC and CCC for selenium are 0.998 (USEPA, 2008a).
Conversion factors freshwater CMC and CCC for zinc are 0.978 and 0.986, respectively. Conversion factors saltwater CMC and CCC for zinc are 0.946 (USEPA, 2008a; UDEQ, 2008c).

TABLE 2
Chemical Composition of Stainless Steel
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Chemical Consituents	Stainless Alloy 304 (mg/Kg)	Stainless Alloy 316 (mg/Kg)	Stainless Alloy 321 (mg/Kg)
Carbon	0.08	0.03	0.08
Manganese	2	1	1
Phosphorus	0.045	0.04	0.04
Sulfur	0.03	0.03	0.03
Silicon	1	1	1
Chromium	18.00-20.00	16.00-18.00	17.0-19.0
Nickel	8:00-10.50	10.0-14.0	9.0-12.0

Notes:
mg/Kg = milligram per kilogram

TABLE 3
Siemens Water Treatment System Performance Guarantee
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Wastewater Characteristics	Unit	Maximum Influent to WTS	Siemens/WTS Effluent Water Quality Standard
pH	2.0 to 8.0	2.0 to 8.0	7.0 to 8.0
Temperature	°F	<105	<105
Total Dissolved Solids (TDS)	mg/L	<6,000	<5,500
Total Suspended Solids (TSS)	mg/L	<100	<5.0
Arsenic	mg/L	<1	<0.1
Chromium (III)	mg/L	<25	<0.05
Copper	mg/L	<0.05	<0.5
Nickel	mg/L	<25	<0.05
Silica	mg/L	<200	<50.0
Sulfur	mg/L	<300	<50.0
Titanium	mg/L	<130	<5.0
Oil and Grease	mg/L	<1,375	≤5.0
Biological Oxygen Demand (BOD)	mg/L	<5.0	<5.0
Total Organic Carbon (TOC)	mg/L	<5.0	<5.0
Hardness	mg/L	<2,000	<1,000
Turbidity	NTU	<10	<10

Notes:
WTS = Water Treatment System
NTU = No Treatment Unit

TABLE 4
Threatened, Endangered, and Candidate Species
Federal- and State-Listed Species for Tooele County
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Common Name	Scientific Name	Type	Status	Can be found on or near Site?
Federal-Listed				
Ute Ladies'-tresses	*Spiranthes diluvialis*	Plant	Threatened	No
Yellow-billed Cuckoo - Possibly	*Coccyzus americanus*	Bird	Candidate	No
State-Listed				
Utah Physa	*Physella utahensis*	Snail	SPC	Not known, no data identified
Bonneville Cutthroat Trout	*Oncorhynchus clarkii Utah*	Fish	CS	No
Bonytail	*Gila elegans*	Fish	LE	No
Least Chub	*Lotichthys phlegethontis*	Fish	CS	No
Columbia Spotted Frog	*Rana luteiventris*	Amphibian	CS	No
California Floater	*Anodonta californiensis*	Snail	SPC	No
Eureka Mountainsnail	*Oreohelix eurekensis*	Snail	SPC	No
Lyrate Mountainsnail	*Oreohelix haydeni*	Snail	SPC	Found in limestone rocks, No
Southern Bonneville Springsnail	*Pyrgulopsis transversa*	Snail	SPC	Not known, no data identified
Southern Tightcoil	*Ogaridiscus subrupicola*	Snail	SPC	No or potential nearby
American White Pelican	*Pelecanus erythrorhynchos*	Bird	SPC	May be
Bald Eagle	*Haliaeetus leucocephalus*	Bird	S-ESA	May be
Bobolink	*Dolichonyx oryzivorus*	Bird	SPC	No or potential nearby
Burrowing Owl	*Athene cunicularia*	Bird	SPC	No
Ferruginous Hawk	*Buteo regalis*	Bird	SPC	May be
Grasshopper Sparrow	*Ammodramus savannarum*	Bird	SPC	No or potential nearby
Greater Sage-Grouse	*Centrocercus urophasianus*	Bird	SPC	No
Lewis's Woodpecker	*Melanerpes lewis*	Bird	SPC	No
Long-billed Curlew	*Numenius americanus*	Bird	SPC	Potentially Yes, potential nesting site
Northern Goshawk	*Accipiter gentilis*	Bird	CS	No
Short-eared Owl	*Asio flammeus*	Bird	SPC	May be
Yellow-billed Cuckoo	*Coccyzus americanus*	Bird	S-ESA	No
Dark Kangaroo Mouse	*Microdipodops megacephalus*	Mammal	SPC	No
Kit Fox	*Vulpes macrotis*	Mammal	SPC	Potentially Yes
Preble's Shrew	*Sorex preblei*	Mammal	SPC	Potentially Yes
Pygmy Rabbit	*Brachylagus idahoensis*	Mammal	SPC	May be
Townsend's Big-Eared Bat	*Corynorhinus townsendii*	Mammal	SPC	No
Northwest Bonneville Pyrg	*Pyrgulopsis variegata*	Snail	SPC	Not known, no data identified

Notes:
SPC = Wildlife Species of Concern
S-ESA = Federally-listed or candidate species under the Endangered Species Act
CS = Species receiving special management under a Conservation Agreement in order to preclude the need for Federal listing

TABLE 5
Receptor Characteristics and Exposure Assumptions for Wildlife
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Parameter / Comments	Black-Necked Stilt	Reference	American Avocet	Reference	Mallard Duck	Reference	Snowy Plover	Reference
Body Weight (kg)	0.167	Cal/Ecotox Database, 2008	0.315	Wild Birds Unlimited, 2008	1.13	USEPA, 1993	0.0422	Cal/Ecotox Database, 2008
Composition of Diet								
Estimated percent sediment (dry weight)	5	Average of 4 types of sandpipers	5	Average of 4 types of sandpipers	2.0	USEPA, 1993	6.0	USEPA, 1993
Estimated percent invertebrates from water column	100	Sample and Suter II, 1994	100	Terres, 1991	100	Terres, 1991	100	Terres, 1991
Estimated percent invertebrates from sediment	0	Sample and Suter II, 1994	0	Terres, 1991	0	Terres, 1991	0	Terres, 1991
Estimated percent plants/seeds from sediment	0	Sample and Suter II, 1994	0	Terres, 1991	0	Sample and Suter II, 1994	0	USEPA, 2003e
Exposure Time (months/12 months of year)	0.5		0.6		1		0.5	
Time on Site	Apr-Sep		Mar-Sep		Year Round		Apr-Sep	
Food Ingestion Rate - Total (kg/day wet weight)	0.084	USEPA, 1993, allometric equation	0.103	USEPA, 1993, allometric equation	0.269	USEPA, 1993	0.023	USEPA, 1993, allometric equation
Fraction water content of food	0.78	Sample and Suter II, 1993	0.78	Sample and Suter II, 1993	0.6	USEPA, 2005a	0.78	Sample and Suter II, 1993
Food Ingestion Rate (kg/day)								
Sediment	0.000704	calculated	0.001133	calculated	0.002152	calculated	0.000253	calculated
Invertebrates from water column (brine shrimp, fly)	0.084000	calculated	0.103000	calculated	0.269000	calculated	0.023000	calculated
Invertebrates from sediment	0.000000		0.00000		0.000		0.000	
Plants/seeds from sediment	0.000000		0.00000		0.000		0.000	
Drinking Water Ingestion (L/day)	0.0178	Allometric equation; USEPA, 1993	0.0272	Allometric equation; USEPA, 1993	0.085	Allometric equation; USEPA, 1993	0.007	Allometric equation; USEPA, 1993
Home Range (ha)	2.84E+02	Hickey et al., 2007	2.84E+02	Assume to be equal to the stilt	5.89E+02	USEPA, 1993	3.50E+01	NatureServe Explorer, 2008
Fraction from the Site	1.00E+00		1.00E+00		1.00E+00		1.00E+00	

Notes: Data reported for males and females has been averaged
kg = kilogram
g = gram
L = liter
NA = Not applicable
ha = hectare

TABLE 6
Ecological Freshwater Screening Values (Dissolved) from Different References
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

METALS	Site Detected Concentration or <MDL (Total Recoverable)		National Ambient Water Quality Criteria (a)		Utah State Freshwater Aquatic Life Criteria (p)		Tier II SAV Surface Water Screening Benchmark (b)	Tier II SCV Surface Water Screening Benchmark (b)	EC20 Fish Surface Water Screening Benchmark (b)	EC20 Bass Population Surface Water Screening Benchmark (b)	LCV Non-Daphnid Inverts Surface Water Screening Benchmark (b)	LCV Aquatic Plants Surface Water Screening Benchmark (b)	LCV Fish Surface Water Screening Benchmark (b)	OSWER Ambient Water Quality Criteria (b)	OWSER Tier II Secondary Surface Water Screening Benchmark (b)	USEPA Region 4 Acute Surface Water Screening Benchmark (b)	USEPA Region 4 Chronic Surface Water Screening Benchmark (b)	SW EPA R6 ESL Surface Water Screening Benchmark (b)	SW EPA R6 FW Surface Water Screening Benchmark (b)	SW EPA R6 Mar Surface Water Screening Benchmark (b)	USEPA Region 5 (c)		ODEQ Level II Screening Values (d)					
			Acute	Chronic	Acute	Chronic																	Aquatic		Bird		Mammal	
	Source/RO Water (mg/L)		Water (mg/L)	Water (mg/L)	Water (mg/L)	Water (mg/L)	Water (mg/L)	Water (mg/L)	Water (mg/L)	Water (mg/L)	Water (mg/L)	Water (mg/L)	Water (mg/L)	Water (mg/L)	Water (mg/L)	Water (mg/L)	Water (mg/L)	Water (mg/L)	Water (mg/L)	Water (mg/L)	Water (mg/L)	Note	Water (mg/L)	Note	Water (mg/L)	Note	Water (mg/L)	Note
Arsenic	0.04	j	0.34	0.15	0.34	0.15	-	-	2.13	2	-	2.32	2.95	0.19	-	0.36	0.19	0.148	0.19	0.078	0.148		0.15	i,o	18	g,o	6	f,h,o
Chromium (n)	0.03	j	0.57	0.074	0.57	0.074	-	-	0.089	0.126	-	0.397	0.0686	0.18	-	0.98432	0.11732	0.042	0.1008	0.103	0.042	e	0.074	i,n	7.2	g	21,000	f
Iron	0.25	j		1	1								1.3	1			1		1				1	i,k,l				
Nickel	NA		0.47	0.052	0.468	0.052	-	-	0.062	0.215	0.128	0.005	0.035	0.16	-	0.789	0.08771	0.0289	0.0874	0.0131	0.0289	e	0.052	i	582	g	38	f,h
Titanium	<0.03																											

Notes:

a USEPA. 2006. National Recommended Water Quality Criteria :200. Office of Water, U.S. Environmental Protection Agency, Washington, D.C. November (based on hardness of 100 mg/L (CaCO$_3$)
b Benchmarks from ORNL, http://risk.lsd.ornl.gov/homepage/benchmark.shtml
c USEPA Region 5 Ecological Screening Levels. August 22, 2003.
d Oregon Department of Environmental Quality Level II Screening Level Values; exposure concentrations deemed acceptable for ecological receptors (ODEQ, 1998)
e Value based USEPA National Recommended Water quality Criteria: 2006 and for hardness dependent metals (including cadmium, chromium, copper, lead, and nickel) a total hardness of 50 mg/L as CaCO$_3$.
f NOAEL equivalent concentration in drinking water (i.e. the level of a chemical in the drinking water of an animal that would result in a dose equivalent to the NOAEL, assuming no other exposures) for mammals. Calculated per ORNL TM-86/R3 (1996)
g NOAEL equivalent concentration in water for birds (American Robin) from ORNL TM-86/R3 (1996)
h Reflects limited re-assessment (based on new and/or different toxicology data) of values originally appearing in ORNL TM-86/R3 (1996).
i ORNL TM-96/R2 (1996) Table 1 (NAWQC chronic value)
j Detected concentration
k ORNL TM-96/R2 (1996) Table 1 (Tier II secondary chronic value).
l Oregon Water Quality Criteria (1992) Freshwater chronic criteria (OAR 340-41)
n Chromium screening values are based conservatively on Chromium VI screening values.
o Arsenic screening levels are for arsenic III.
p Utah State Freshwater Aquatic Life Criteria

MDL = Method Detection Limit
mg/L = milligrams per liter
NA = Not Applicable
USEPA = US Environmental Proection Agency
NOAEL = No Observable Adverse Effect level
ORNL = Oak Ridge National Laboratory
EC$_{20}$ = Effect Concentration for 20 percent of the tested population
* = See text for additional explanation of terminology and references.

[yellow box] Benchmark value exceeded

TABLE 7
Estimation of Representative Concentrations in Surface Water and Sediment
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Metal	Surface Water (mg/L)	Note	Sediment (mg/kg dw)	Note
Arsenic	1.00E-01	Detected in source groundwater (0.04 mg/L), treatment performance criterion used (0.1 mg/L)	6.50E+00	(USGS, 2004), average for Utah
Chromium (III)	5.00E-02	Detected in RO blowndown (0.03 mg/L), treatment performance criterion used (0.05 mg/L)	5.68E+01	(USGS, 2004), average for Utah
Iron	1.50E+00	Detected in RO Inlet (0.25 mg/L), no treatment performance criterion, highest level in drinking water used (1.5 mg/L), although freshwater criterion is 1 mg/L	1.79E+04	(USGS, 2003b; Ali et al., 2005)
Nickel	5.00E-02	Not analyzed, treatment performance criterion used (0.05 mg/L)	2.05E+01	(USGS, 2004), average for Utah
Titanium	5.00E+00	Not detected, treatment performance criterion used (5.0 mg/L)	4.10E+03	(USGS, 1999), nation-wide average

Notes:
mg/L = milligrams per liter
mg/kg dw = milligrams per kilogram dry weight

TABLE 8
Invertebrate Bioaccumulation Factors from Surface Water
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Metals	Bioaccumulation Factor (BAF) for Invertebrates in Water (L/kg)
Arsenic	38.2
Chromium (III)	56.7
Iron	60.6
Nickel	68.34
Titanium	23.49

Notes:
L = liter
kg = kilogram

TABLE 9
Intakes for Wildlife - Quantitative Assessment
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Metals	Black-Necked Stilt Intakes (mg/kg-day)					American Avocet Intakes (mg/kg-day)					Mallard Duck Intakes (mg/kg-day)					Snowy Plover Intakes (mg/kg-day)				
	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Food Ingestion from Sediment	Total Intake	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Food Ingestion from Sediment	Total Intake	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Food Ingestion from Sediment	Total Intake	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Food Ingestion from Sediment	Total Intake
Arsenic	5.33E-03	1.37E-02	7.32E-01	NE	7.51E-01	5.04E-03	1.38E-02	7.29E-01	NE	7.47E-01	5.73E-03	1.23E-02	9.08E-01	NE	9.24E-01	8.41E-03	1.95E-02	1.04E+00	NE	1.07E+00
Chromium (III)	2.66E-03	1.20E-01	5.43E-01	NE	6.66E-01	2.52E-03	1.19E-01	5.41E-01	NE	6.62E-01	2.87E-03	1.08E-01	6.73E-01	NE	7.83E-01	4.21E-03	1.70E-01	7.73E-01	NE	9.47E-01
Iron	7.99E-02	3.77E+01	1.74E+01	NE	5.52E+01	7.56E-02	3.76E+01	1.73E+01	NE	5.50E+01	8.60E-02	3.40E+01	2.16E+01	NE	5.56E+01	1.26E-01	5.37E+01	2.48E+01	NE	7.86E+01
Nickel	2.66E-03	4.32E-02	6.55E-01	NE	7.01E-01	2.52E-03	4.30E-02	6.52E-01	NE	6.97E-01	2.87E-03	3.89E-02	8.11E-01	NE	8.52E-01	4.21E-03	6.15E-02	9.31E-01	NE	9.97E-01
Titanium	2.66E-01	8.64E+00	2.25E+01	NE	3.14E+01	2.52E-01	8.60E+00	2.24E+01	NE	3.13E+01	2.87E-01	7.78E+00	2.79E+01	NE	3.59E+01	4.21E-01	1.23E+01	3.20E+01	NE	4.47E+01

Notes:
mg/kg-day = milligrams per kilogram per day
NE = not evaluated

TABLE 10
Summary of Threshold Reference Values for Wildlife
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Metals	NOAEL-Based (mg/kg-day)		LOAEL-Based (mg/kg-day)	
	Avian	Ref.	Avian	Ref.
Arsenic	5.7	a	22.8	a
Chromium (III)	11.73	b	47.7	b
Iron	350.0	b	1000.0	b
Nickel	77.4	c	107	c
Titanium	568	b	1363	b

References:
a USEPA, 2005a.
b See text.
c Sample et al. (ORNL), 1996. Toxicological Benchmarks for Wildlife: 1996 Revision.

Notes:
NOAEL = No Observed Adverse Effects Level
LOAEL = Lowest Observable Adverse Effects Level
mg/kg-day = milligram per kilogram per day

TABLE 11
NOAEL-Based Hazard Quotient to Wildlife
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Metals	Black-Necked Stilt Hazard Quotient				American Avocet Hazard Quotient				Mallard Duck Hazard Quotient				Snowy Plover Hazard Quotient			
	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Total	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Total	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Total	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Total
Arsenic	9.35E-04	2.40E-03	1.28E-01	1.32E-01	8.84E-04	2.39E-03	1.28E-01	1.31E-01	1.01E-03	2.16E-03	1.59E-01	1.62E-01	1.48E-03	3.42E-03	1.83E-01	1.88E-01
Chromium (III)	2.27E-04	1.02E-02	4.63E-02	5.67E-02	2.15E-04	1.02E-02	4.61E-02	5.65E-02	2.44E-04	9.19E-03	5.73E-02	6.68E-02	3.59E-04	1.45E-02	6.59E-02	8.07E-02
Iron	2.28E-04	1.08E-01	4.98E-02	1.58E-01	2.16E-04	1.07E-01	4.95E-02	1.57E-01	2.46E-04	9.71E-02	6.16E-02	1.59E-01	3.61E-04	1.53E-01	7.08E-02	2.24E-01
Nickel	3.44E-05	5.58E-04	8.46E-03	9.05E-03	3.25E-05	5.56E-04	8.42E-03	9.01E-03	3.70E-05	5.03E-04	1.05E-02	1.10E-02	5.43E-05	7.94E-04	1.20E-02	1.29E-02
Titanium	4.69E-04	1.52E-02	3.96E-02	5.53E-02	4.43E-04	1.51E-02	3.94E-02	5.50E-02	5.05E-04	1.37E-02	4.91E-02	6.33E-02	7.41E-04	2.16E-02	5.63E-02	7.87E-02
Total HQ				**4.11E-01**				**4.09E-01**				**4.62E-01**				**5.84E-01**

Metals	Black-Necked Stilt % of Total				American Avocet % of Total				Mallard Duck % of Total				Snowy Plover % of Total			
	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Total	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Total	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Total	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Total
Arsenic	0.2%	0.6%	31.3%	32.1%	0.2%	0.6%	31.3%	32.1%	0.2%	0.5%	34.4%	35.1%	0.3%	0.6%	31.3%	32.1%
Chromium (III)	0.1%	2.5%	11.3%	13.8%	0.1%	2.5%	11.3%	13.8%	0.1%	2.0%	12.4%	14.4%	0.1%	2.5%	11.3%	13.8%
Iron	0.1%	26.3%	12.1%	38.4%	0.1%	26.3%	12.1%	38.4%	0.1%	21.0%	13.3%	34.4%	0.1%	26.2%	12.1%	38.4%
Nickel	0.0%	0.1%	2.1%	2.2%	0.0%	0.1%	2.1%	2.2%	0.0%	0.1%	2.3%	2.4%	0.0%	0.1%	2.1%	2.2%
Titanium	0.1%	3.7%	9.6%	13.5%	0.1%	3.7%	9.7%	13.5%	0.1%	3.0%	10.6%	13.7%	0.1%	3.7%	9.6%	13.5%
Total of %	**0.5%**	**33.2%**	**66.4%**	**100.0%**	**0.4%**	**33.2%**	**66.4%**	**100.0%**	**0.4%**	**26.5%**	**73.0%**	**100.0%**	**0.6%**	**33.1%**	**66.3%**	**100.0%**

Notes:
% = percent

TABLE 12
LOAEL-Based Hazard Quotient to Wildlife
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Metals	Black-Necked Stilt Hazard Quotient				American Avocet Hazard Quotient				Mallard Duck Hazard Quotient				Snowy Plover Hazard Quotient			
	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Total	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Total	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Total	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Total
Arsenic	2.34E-04	6.01E-04	3.21E-02	3.29E-02	2.21E-04	5.98E-04	3.20E-02	3.28E-02	2.51E-04	5.41E-04	3.97E-02	4.05E-02	3.69E-04	8.55E-04	4.57E-02	4.69E-02
Chromium (III)	5.59E-05	2.51E-03	1.14E-02	1.40E-02	5.28E-05	2.50E-03	1.13E-02	1.39E-02	6.01E-05	2.26E-03	1.41E-02	1.64E-02	8.82E-05	3.57E-03	1.62E-02	1.99E-02
Iron	7.99E-05	3.77E-02	1.74E-02	5.52E-02	7.56E-05	3.76E-02	1.73E-02	5.50E-02	8.60E-05	3.40E-02	2.16E-02	5.56E-02	1.26E-04	5.37E-02	2.48E-02	7.86E-02
Nickel	2.49E-05	4.04E-04	6.12E-03	6.55E-03	2.35E-05	4.02E-04	6.09E-03	6.52E-03	2.68E-05	3.64E-04	7.58E-03	7.97E-03	3.93E-05	5.74E-04	8.70E-03	9.32E-03
Titanium	1.96E-04	6.34E-03	1.65E-02	2.30E-02	1.85E-04	6.31E-03	1.64E-02	2.29E-02	2.10E-04	5.71E-03	2.04E-02	2.64E-02	3.09E-04	9.02E-03	2.35E-02	3.28E-02
Total HQ				**1.32E-01**				**1.31E-01**				**1.47E-01**				**1.87E-01**

Metals	Black-Necked Stilt % of Total				American Avocet % of Total				Mallard Duck % of Total				Snowy Plover % of Total			
	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Total	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Total	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Total	Water Ingestion	Sediment Ingestion	Food Ingestion from Water	Total
Arsenic	0.2%	0.5%	24.4%	25.0%	0.2%	0.5%	24.4%	25.0%	0.2%	0.4%	27.1%	27.6%	0.2%	0.5%	24.4%	25.0%
Chromium (III)	0.0%	1.9%	8.6%	10.6%	0.0%	1.9%	8.6%	10.6%	0.0%	1.5%	9.6%	11.2%	0.0%	1.9%	8.6%	10.6%
Iron	0.1%	28.6%	13.2%	41.9%	0.1%	28.7%	13.2%	41.9%	0.1%	23.1%	14.7%	37.9%	0.1%	28.6%	13.2%	41.9%
Nickel	0.0%	0.3%	4.6%	5.0%	0.0%	0.3%	4.6%	5.0%	0.0%	0.2%	5.2%	5.4%	0.0%	0.3%	4.6%	5.0%
Titanium	0.1%	4.8%	12.5%	17.5%	0.1%	4.8%	12.5%	17.5%	0.1%	3.9%	13.9%	17.9%	0.2%	4.8%	12.5%	17.5%
Total of %	**0.4%**	**36.1%**	**63.4%**	**100.0%**	**0.4%**	**36.1%**	**63.4%**	**100.0%**	**0.4%**	**29.2%**	**70.4%**	**100.0%**	**0.5%**	**36.1%**	**63.4%**	**100.0%**

Notes:
% = percent

TABLE 13
Ecological Risk-Based Levels for Surface Water (Including Sediment Exposure)
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Metals	American avocet		Ecological Risk-Based Level
	HQ NOAEL-Based	Representative Concentration (mg/L)	(mg/L)
Arsenic	1.3E-01	0.10	0.76
Chromium	5.6E-02	0.05	0.89
Iron	1.6E-01	1.50	9.55
Nickel	9.0E-03	0.05	5.55
Titanium	5.5E-02	5.00	90.86
Total HI	**4.1E-01**		

Metals	American avocet		Ecological Risk-Based Level
	HQ LOAEL-Based	Representative Concentration (mg/L)	(mg/L)
Arsenic	3.3E-02	0.10	3.05
Chromium	1.4E-02	0.05	3.60
Iron	5.5E-02	1.50	27.29
Nickel	6.5E-03	0.05	7.67
Titanium	2.3E-02	5.00	218.03
Total HI	**1.3E-01**		

Notes:
Risk-based level for metal in surface water is based on an HQ of 1, and includes exposure to sediment.
HQ = Hazard Quotient
HI = Hazard Index
mg/L = milligram per liter

TABLE 14
Ecological Risk-Based Levels for Surface Water (No Sediment Exposure)
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Metals	American avocet HQ NOAEL-Based	American avocet Representative Concentration (mg/L)	Ecological Risk-Based Level (mg/L)
Arsenic	1.3E-01	0.10	0.78
Chromium	4.6E-02	0.05	1.08
Iron	5.0E-02	1.50	30.15
Nickel	8.5E-03	0.05	5.91
Titanium	4.0E-02	5.00	125.36
Total HI	**2.7E-01**		

Metals	American avocet HQ LOAEL-Based	American avocet Representative Concentration (mg/L)	Ecological Risk-Based Level (mg/L)
Arsenic	3.2E-02	0.10	3.11
Chromium	1.1E-02	0.05	4.39
Iron	1.7E-02	1.50	86.14
Nickel	6.1E-03	0.05	8.18
Titanium	1.7E-02	5.00	300.83
Total HI	**8.4E-02**		

Notes:
Risk-based level for metal in surface water is based on an HQ of 1, and does not include exposure to sediment.

HQ = Hazard Quotient
HI = Hazard Index
mg/L = milligram per liter

APPENDIX A
SITE PHOTOGRAPHS

ECOLOGICAL RISK ASSESSMENT
ATI TITANIUM
12633 North Rowley Road
North Skull Valley, Tooele County, Utah
26OT.52001.08
July 15, 2008

Photo 1: Looking north toward the GSL water line (beyond the horizon) from the meandering water line stake.

ATI ERA Photographs May 2008

Photo 2: Looking south at US Magnesium stack and storm water drainage (approximately 30-foot-wide).

ATI ERA Photographs May 2008

Photo 3: Burrow of unknown species.

Photo 4: Looking south where the effluent discharge pipe will extend along the road.

ATI ERA Photographs May 2008

Photo 5: Looking north at the stake where the pipe will discharge at 100 yards beyond the stake into an historical ditch.

ATI ERA Photographs May 2008

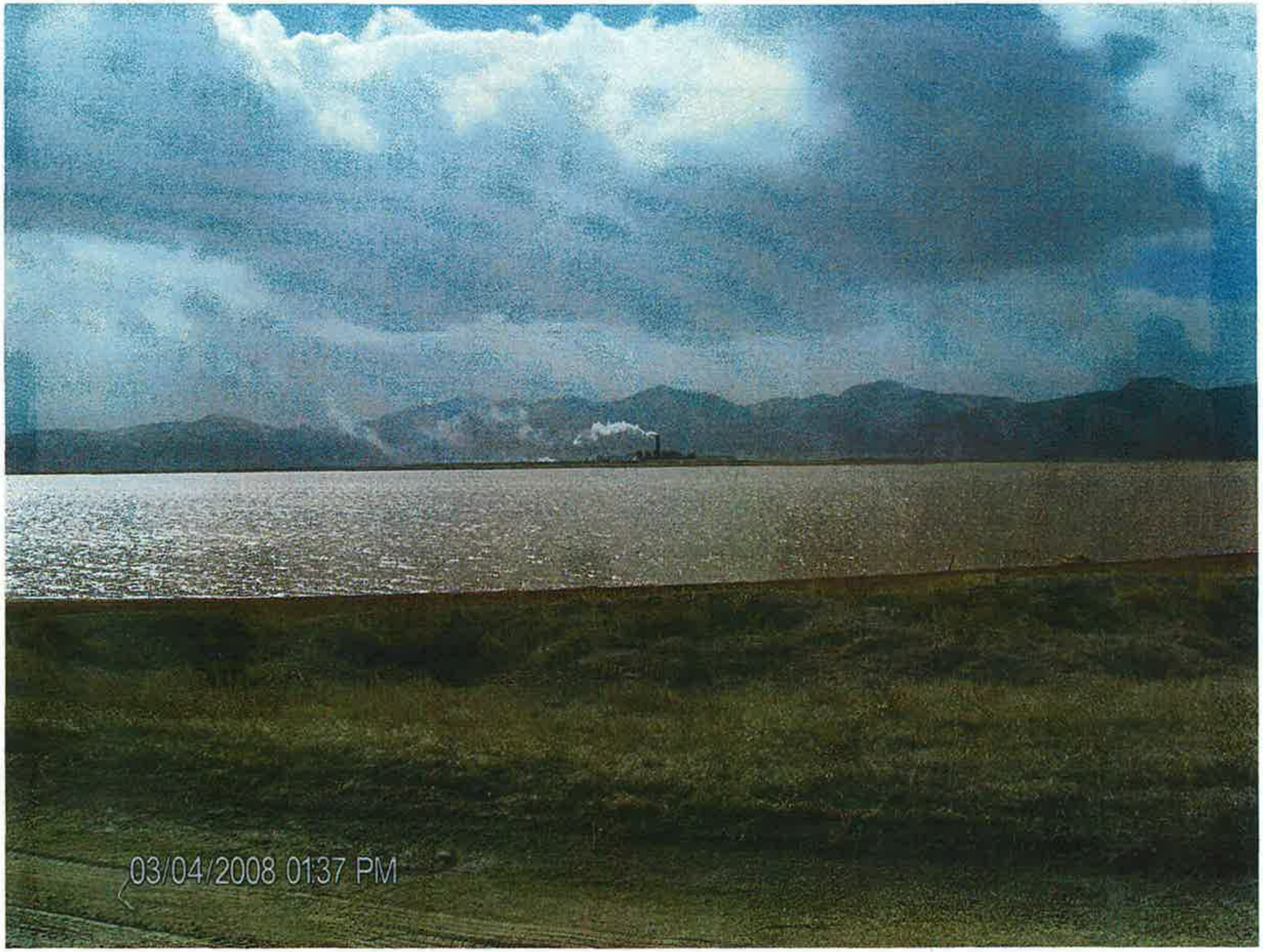

Photo 6: Looking west at US Magnesium waste water pond.

ATI ERA Photographs May 2008

Photo 7: Observed waterfowl on east bank of storm water drainage ditch.

ATI ERA Photographs May 2008

APPENDIX B
ECOLOGICAL BENCHMARKS

ECOLOGICAL RISK ASSESSMENTATI TITANIUM
12633 North Rowley Road
North Skull Valley, Tooele County, Utah
26OT.52001.08
July 15, 2008

TABLE B-1
Sediment Screening - Comparison of Projected Site Sediment Concentrations with Sediment Screening Benchmarks
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Metals	Projected Concentration for Site (mg/kg)	ARCS NEC (mg/kg)	ARCS PEC (mg/kg)	ARCS TEC (mg/kg)	Consensus PEC (mg/kg)	Consensus TEC (mg/kg)	NOAA ERL (mg/kg)	NOAA ERM (mg/kg)	OSWER Ecotox Thresholds (mg/kg)	SD EPA R6 Mar (mg/kg)	Washington MAEL (mg/kg)	Washington NEL (mg/kg)
Arsenic	6.46	92.9	57	12.1	33	9.79	8.2	70	8.2	8.2	93	57
Chromium	56.76	312	159	**56**	111	**43.4**	81	370	81	81	270	260
Iron	17,900											
Nickel	20.47	37.9	38.5	39.6	48.6	22.7	20.9	51.6	21	20.9		
Titanium	4,100											

Notes:
See Appendix A for explanation of terminology and references.
Bold-Highlight Exceedance of sediment screening benchmark
mg/kg = milligram per kilogram

APPENDIX B
SURFACE WATER ECOLOGICAL BENCHMARKS

EC_{20} Fish
This benchmark is the lowest test EC_{20} (20% effects concentration) values for fish. It represents the highest tested concentration not causing a reduction of as much as 20% in the reproductive output of female test organisms.

Suter, G.W. II. 1996. *Toxicological benchmarks for screening contaminants of potential concern for effects on freshwater biota*. Environ. Toxic. Chem. 15:1232-1241.

EC_{25} Bass Population
This benchmark consists of estimates of the concentration causing a 25% reduction in the recruit abundance of a population of largemouth bass.

Suter, G.W. II. 1996. *Toxicological benchmarks for screening contaminants of potential concern for effects on freshwater biota.* Environ. Toxic. Chem. 15:1232-1241.

USEPA Region 4- Acute
These benchmarks, derived by the USEPA's Southeastern region, are criteria or test endpoints divided by a factor of 10. The Region IV surface water screening values were obtained from Water Quality Criteria documents and represent the chronic ambient water quality criteria values for the protection of aquatic life. They are intended to protect 95% of the species, 95% of the time. If there was insufficient information available to derive a criterion, the lowest reported effect level was used with the application of a safety factor of 10 to protect for a more sensitive species. A safety factor of 10 was also used to derive a chronic value if only acute information was available. Since these numbers are based on conservative endpoints and sensitive ecological effects data, they represent a preliminary screening of site contaminant levels to determine if there is a need to conduct further investigations at the site. Note that equations for hardness dependent metals do not match those in USEPA NAWQC (2008). See the website link at: **http://www.epa.gov/region04/waste/ots/ecolbul.htm#tbl1**.

USEPA Region 4- Chronic
These benchmarks, derived by the USEPA's Southeastern region, are criteria or test endpoints divided by a factor of 10. The Region IV surface water screening values were obtained from Water Quality Criteria documents and represent the chronic ambient water quality criteria values for the protection of aquatic life. They are intended to protect 95% of the species, 95% of the time. If there was insufficient information available to derive a criterion, the lowest reported effect level was used with the application of a safety factor of 10 to protect for a more sensitive species. A safety factor of 10 was also used to derive a chronic value if only acute information was available. Since these numbers are based on conservative endpoints and sensitive ecological effects data, they represent a preliminary screening of site contaminant levels to determine if there is a need to conduct further investigations at the site. Note that equations for hardness dependent metals do not match those in USEPA (2008). See **http://www.epa.gov/region04/waste/ots/ecolbul.htm#tbl1**.

APPENDIX B
(continued)
SURFACE WATER ECOLOGICAL BENCHMARKS

USEPA Region 5 ESLs - SW

The ESL reference database consists of Region 5 media-specific (soil, water, sediment, and air) Ecological Screening Levels (ESLs) for RCRA Appendix IX hazardous constituents. The ESLs are initial screening levels with which the site contaminant concentrations can be compared. The ESLs help to focus the investigation on those areas and chemicals that are most likely to pose an unacceptable risk to the environment. ESLs also impact the data requirements for the planning and implementation of field investigations. ESLs alone are not intended to serve as cleanup levels. See the August 2003 revision of the ESLs (formerly EDQLs) at **http://www.epa.gov/reg5rcra/ca/ESL.pdf**

USEPA Region 6 Ecological Screening Benchmarks: Freshwater

USEPA Region 6 recommends use of surface water benchmarks developed for the Texas Natural Resource Conservation Commission (TNRCC). These benchmarks are conservative screening level values intended to be protective of aquatic biota. Values were compiled from a prioritized list of published values. The primary benchmarks are chronic criteria obtained from Texas surface water quality standards or the most current federal National Ambient Water Quality Criteria. Additional benchmarks were derived using the LC50 approach. TNRCC Water Quality Division chronic values, ORNL secondary chronic values (Suter and Tsao 1996), or EPA Region 4 chronic screening values, in that order, were consulted to expand the number of chemicals with acceptable benchmarks. Values for hardness-dependent metals assume a hardness of 50 mg/L. Values for arsenic, cadmium, chromium, copper, lead, nickel, silver, uranium, and zinc apply to dissolved concentrations.

Texas Natural Resource Conservation Commission (TNRCC). 2001. *Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas.* Toxicology and Risk Assessment Section, Texas Natural Resource Conservation Commission, Austin, TX. RG-263 (revised).

LCV Aquatic Plants

The lowest chronic value (LCV) for aquatic plants is based on the geometric mean of the Lowest Observed Effect Concentration (LOEC) and the No Observed Effect Concentration (NOEC). Chronic values are used to calculate the chronic NAWQC, but the lowest chronic value may be lower than the chronic NAWQC. Because of the short generation time of algae and the relative lack of standard chronic tests for aquatic plants, USEPA guidelines are followed in using any algal test of at least 96-hour duration and any biologically meaningful response for the plant values.

Suter, G.W. II and C.L. Tsao 1996. *Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota: 1996 revision.* ES/ER/TM-96/R2. Oak Ridge National Laboratory, Oak Ridge, TN. **(http://www.hsrd.ornl.gov/ecorisk/tm96r2.pdf)**

APPENDIX B
(continued)
SURFACE WATER ECOLOGICAL BENCHMARKS

LCV Fish

The LCV for fish is based on either the geometric mean of the LOEC and the NOEC or an extrapolation from 96-hour LC50s using equations from Suter et al (1987) and Suter (1993).

The equation for a fish CV for a metallic contaminant is:

$$\text{Log CV} = 0.73 \log \text{LC50} - 0.70 \ (\text{PI} = 1.2)$$

For a non-metallic contaminant:

$$\text{Log CV} = 1.07 \log \text{LC50} - 1.51 \ (\text{PI} = 1.5)$$

The LC50 is the lowest species mean 96-hour EC50 for fish. The 95% prediction interval is log CV +- the PI value (95% prediction intervals contain 95% of observations).

Suter, G.W. II and C.L. Tsao 1996. *Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota: 1996 revision.* ES/ER/TM-96/R2. Oak Ridge National Laboratory, Oak Ridge, TN. (**http://www.hsrd.ornl.gov/ecorisk/tm96r2.pdf**)

Suter, G.W. II, A.E. Rosen, E. Linder, and D.F. Parkhurst 1987. *End points for responses of fish to chronic toxic exposures.* Environmental Toxicology and Chemistry 6:793-809.

Suter, G.W. II. 1993. Ecological Risk Assessment. Lewis Publishers, Chelsea, MI.

LCV Non-Daphnid Inverts

The LCV for aquatic plants is based on the geometric mean of the LOEC and the NOEC. Chronic values are used to calculate the chronic NAWQC, but the lowest chronic value may be lower than the chronic NAWQC. Because of the short generation time of algae and the relative lack of standard chronic tests for aquatic plants, EPA guidelines are followed in using any algal test of at least 96-hour duration and any biologically meaningful response for the plant values.

Suter, G.W. II and C.L. Tsao 1996. Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota: 1996 revision. ES/ER/TM-96/R2. Oak Ridge National Laboratory, Oak Ridge, TN. (**http://www.hsrd.ornl.gov/ecorisk/tm96r2.pdf**)

USEPA NAWQC- Acute

Acute National Ambient Water Quality Criteria (NAWQC) are applicable regulatory standards. The NAWQC are calculated by the USEPA as half the Final Acute Value (FAV), which is the fifth percentile of the distribution of 48- to 96-hour LC50 values or equivalent median effective concentration (EC50) values for each criterion chemical (Stephan et al. 1985). The acute NAWQC are intended to correspond to concentrations that would cause less than 50% mortality in 5% of exposed populations in a brief exposure. They may be used as a reasonable upper screening benchmark because waste site assessments are concerned with sublethal effects and largely with continuous exposures, rather than the lethal effects and episodic exposures to which the acute NAWQC are applied. NAWQC for several metals are functions of water hardness. Values for hardness-dependent metals default to 100 mg $CaCO_3$/L, but equations are provided to obtain values based on site-specific hardness values. Recommended values for metals are expressed in terms of dissolved metal in the water column.

United States Environmental Protection Agency. 2008. *National Recommended Water Quality Criteria*. Office of Water, U.S. Environmental Protection Agency, Washington, D.C.

USEPA. NAWQC- Chronic

Chronic NAWQC are applicable regulatory standards. The chronic NAWQC are the FAVs divided by the Final Acute-Chronic Ratio (FAC), which is the geometric mean of quotients of at least three LC50/CV ratios from tests of different families of aquatic organisms (Stephan et al. 1985). It is intended to prevent significant toxic effects in chronic exposures and is used as a lower screening benchmark. NAWQC for several metals are functions of water hardness. Values for hardness-dependent metals default to 100 mg CaCO3/L, but equations are provided to obtain values based on site-specific hardness values. Recommended values for metals are expressed in terms of dissolved metal in the water column.

United States Environmental Protection Agency. 2008. *National Recommended Water Quality Criteria.* Office of Water, U.S. Environmental Protection Agency, Washington, D.C.

OSWER AWQC

These are values from USEPA Office of Solid Waste and Emergency Response (OSWER) (1996). The AWQC are NAWQC or FCV's (final chronic values) as of 1996.

OSWER Tier II

These are secondary chronic values derived using USEPA's Tier II methodology.

Tier II SAV

Tier II values were developed so that aquatic benchmarks could be established with fewer data than are required for NAWQC. The Tier II Secondary Acute Value (SAV) is derived by taking the lowest genus mean acute value from data meeting specified criteria and dividing it by a Final Acute Value Factor whose value depends on the number of acute data requirements that are met. Values provided here are from Suter and Tsao (1996).

Suter, G.W. , II, and C.L. Tsao. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 104pp. ES/ER/TM-96/R2. **http://www.esd.ornl.gov/programs/ecorisk/documents/tm96r2.pdf**.

Tier II SCV

Tier II values were developed so that aquatic benchmarks could be established with fewer data than are required for NAWQC. The Tier II Secondary Chronic Value (SCV) is derived by dividing the Secondary Acute Value (see above) by the Secondary Acute-Chronic Ratio. Values provided here are from Suter and Tsao (1996).

APPENDIX B
(continued)
SURFACE WATER ECOLOGICAL BENCHMARKS

Suter, G.W. , II, and C.L. Tsao. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 104pp. ES/ER/TM-96/R2. **http://www.esd.ornl.gov/programs/ecorisk/documents/tm96r2.pdf**.

APPENDIX B
(continued)
SEDIMENT ECOLOGICAL BENCHMARKS

ARCS NEC

U.S. EPA Assessment and Remediation of Contaminated Sediments Program. The representative effect concentration selected from among the high no-effect-concentrations for Hyalella azteca and Chironomus riparius are presented in EPA (1996). It is a concentration above which statistically significant adverse biological effects always occur. Effects may occur below these levels. The majority of the data are for freshwater sediments.

EPA (U.S. Environmental Protection Agency) 1996. *Calculation and evaluation of sediment effect concentrations for the amphipod Hyalella azteca and the midge Chironomus riparius. EPA 905/R96/008.* Great Lakes National Program Office, Chicago, IL. (**http://www.cerc.usgs.gov/clearinghouse/data/brdcerc0004.html**) (**http://www.cerc.usgs.gov/pubs/sedtox/sec-dev.html**)

ARCS TEC

U.S. EPA Assessment and Remediation of Contaminated Sediments Program. The representative effect concentration selected from among the ER-Ls and TELs for Hyalella azteca and Chironomus riparius are presented in EPA (1996). The TEC is the geometric mean of the 15th percentile in the effects data set and the 50th percentile in the no effects data set. It is a concentration that represents the upper limit of the range dominated by no effects data. Concentrations above the TEC may result in adverse effects to these organisms; concentrations below the TEC are unlikely to result in adverse effects. The majority of the data are for freshwater sediments. These are possible-effects benchmarks.

EPA (U.S. Environmental Protection Agency) 1996. *Calculation and evaluation of sediment effect concentrations for the amphipod Hyalella azteca and the midge Chironomus riparius. EPA 905/R96/008.* Great Lakes National Program Office, Chicago, IL. (**http://www.cerc.usgs.gov/clearinghouse/data/brdcerc0004.html**) (**http://www.cerc.usgs.gov/pubs/sedtox/sec-dev.html**)

ARCS PEC

U.S. EPA Assessment and Remediation of Contaminated Sediments Program. The representative effect concentration selected from among the ER-MS and PELs for Hyalella azteca and Chironomus riparius are presented in EPA (1996). The PEC is the geometric mean of the 50th percentile in the effects data set and the 85th percentile in the no effects data set. It represents the lower limit of the range of concentrations usually associated with adverse effects. A concentration greater than the PEC is likely to result in adverse effects to these organisms. The majority of the data are for freshwater sediments. These are probable-effects benchmarks.

EPA (U.S. Environmental Protection Agency) 1996. *Calculation and evaluation of sediment effect concentrations for the amphipod Hyalella azteca and the midge Chironomus riparius. EPA 905/R96/008.* Great Lakes National Program Office, Chicago, IL. (**http://www.cerc.usgs.gov/clearinghouse/data/brdcerc0004.html**) (**http://www.cerc.usgs.gov/pubs/sedtox/sec-dev.html**)

APPENDIX B
(continued)
SEDIMENT ECOLOGICAL BENCHMARKS

Consensus PEC
Consensus-based Sediment Quality Guidelines (SQG) represent the geometric mean of published SQGs from a variety of sources. Sources for Probable Effect Concentrations (PEC) include probable effect levels, effect range median values, severe effect levels, and toxic effect thresholds (see MacDonald et al. 2000 for references). PECs are intended to identify contaminant concentrations above which harmful effects on sediment-dwelling organisms are expected to occur more often than not.

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.

Consensus TEC
Consensus-based Sediment Quality Guidelines (SQG) represent the geometric mean of published SQGs from a variety of sources. Sources for Threshold Effect Concentrations (TEC) include threshold effect levels, effect range low values, lowest effect levels, minimal effect thresholds, and sediment quality advisory levels (see MacDonald et al. 2000 for references). TECs are intended to identify contaminant concentrations below which harmful effects on sediment-dwelling organisms are not expected.

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.

EPA Region 6 Ecological Screening Benchmarks: Freshwater Sediment
U.S. EPA Region 6 recommends use of benchmarks developed for the Texas Natural Resource Conservation Commission. These benchmarks are conservative screening level values intended to be protective of benthic biota. Values were compiled from a prioritized list of published values. The primary benchmarks are Threshold Effects Levels (TELs) from Smith et al. (1996), but values for antimony and silver are Effect Range-Low (ER-L) values from Long and Morgan (1990), values for iron, manganese, total PAHs, several pesticides, and PCBs are Lowest Effects Levels (LELs) from Persaud et al. (1993), anthracene, dibenz(a,h)anthracene, and naphthalene are Threshold Effect Concentrations (TECs) from MacDonald et al. (2000), and sum DDT, DDE, and DDD values are from Environment Canada (1997).

Texas Natural Resource Conservation Commission. 2001. Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas. Toxicology and Risk Assessment Section, Texas Natural Resource Conservation Commission, Austin, TX. RG-263 (revised).

NOAA ERL
1. NOAA's National Status and Trends Program. Sediment Quality Guidelines. (Values for As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Zn, DDE, PAHs, total DDT, total PCBs, and total PAH

were obtained from this source.) http://response.restoration.noaa.gov/cpr/sediment/SPQ.pdf.

2. 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: 81-97. (Values for metals and organics not listed in 1 or 3 were obtained from this source.)
3. Long, E. R. and L. G. Morgan. 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program, National Oceanographic and Atmospheric Administration, Tech. Memorandum NOS OMA 52, August 1991. Seattle, Washington. (Values for DDD, DDT, Antimony, Chlordane, Dieldrin, and Endrin were obtained from this source.)

NOAA ERM

1. NOAA's National Status and Trends Program. Sediment Quality Guidelines. (Values for As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Zn, DDE, PAHs, total DDT, total PCBs, and total PAH were obtained from this source.) http://response.restoration.noaa.gov/cpr/sediment/SPQ.pdf.
2. 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: 81-97. (Values for metals and organics not listed in 1 or 3 were obtained from this source.)
3. Long, E. R. and L. G. Morgan. 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program, National Oceanographic and Atmospheric Administration, Tech. Memorandum NOS OMA 52, August 1991. Seattle, Washington. (Values for DDD, DDT, Antimony, Chlordane, Dieldrin, and Endrin were obtained from this source.)

NOAA SQUIRT

http://response.restoration.noaa.gov/cpr/sediment/squirt/squirt.html)

OSWER

OSWER (Office of Solid Waste and Emergency Response). 1996. Ecotox thresholds. U.S. Environmental Protection Agency. ECO Update 3 (2):1-12. (http://www.epa.gov/superfund/programs/risk/eco_updt.pdf)

Washington NEL

Washington NEL Sediment Quality Standards (WAC 172-204-320) are used as a sediment quality goal for Washington state sediments. These are "no effects" level values. No effects means a concentration that does not result in acute or chronic adverse effects to biological resources relative to reference [WAC 173_204_200(3)] and does not result in significant human health risk. Washington lists criteria for organics other than phenol, 2-methyl phenol, 4-methyl phenol, 2,4-dimethyl phenol, benzyl alcohol, and benzoic acid on a total organic carbon basis. The values included in SADA have been converted to mg/kg sediment assuming 1% organic carbon (criteria from Washington table were multiplied by 0.01). The value for Low Molecular Weight PAHs (LPAH) applies to the sum of concentrations of

APPENDIX B
(continued)
SEDIMENT ECOLOGICAL BENCHMARKS

Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, and Anthracene. The value for High Molecular Weight PAH's (HPAH) applies to the sum of Fluoranthene, Pyrene, Benz(a)anthracene, Chrysene, total Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene, and Benzo(g,h,i)perylene. Total Benzofluoranthenes represents the sum of the b, j, and k isomers.

Washington Department of Ecology, Sediment Management Unit, Sediment Quality Chemical Criteria, updated 8/9/2001 **http://www.ecy.wa.gov/programs/tcp/smu/sed_chem.htm**

Washington MAEL

Washington MAEL represent Sediment Impact Zone Maximum Level (WAC 173-204-420) and Sediment Cleanup Screening Level/Minimum Cleanup Level (WAC 173-204-520) values. These are used as an upper regulatory level for source control and cleanup decision making. They are "minor adverse effects" level values. Minor adverse effect levels are concentrations that result in an acute or chronic adverse effect to biological resources relative to reference in no more than one appropriate biological test [WAC 173_204_200(3)], result in a significant response relative to reference [WAC 173_204_200(3)], and do not result in significant human health risk. Washington lists criteria for organics other than phenol, 2-methyl phenol, 4-methyl phenol, 2,4-dimethyl phenol, benzyl alcohol, and benzoic acid on a total organic carbon basis. The values included in SADA have been converted to mg/kg sediment assuming 1% organic carbon (criteria from Washington table were multiplied by 0.01). The value for Low Molecular Weight PAHs (LPAH) applies to the sum of concentrations of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, and Anthracene. The value for High Molecular Weight PAH's (HPAH) applies to the sum of Fluoranthene, Pyrene, Benz(a)anthracene, Chrysene, total Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene, and Benzo(g,h,i)perylene. Total Benzofluoranthenes represents the sum of the b, j, and k isomers.

Washington Department of Ecology, Sediment Management Unit, Sediment Quality Chemical Criteria, updated 8/9/2001 – **http://www.ecy.wa.gov/programs/tcp/smu/sed_chem.htm**

APPENDIX C
LITERATURE DATA

ECOLOGICAL RISK ASSESSMENT
ATI TITANIUM
12633 North Rowley Road
North Skull Valley, Tooele County, Utah
26OT.52001.08
July 15, 2008

TABLE C-1
Trace Elements and Organic Compunds in Sediment and Fish Tissue
from the Great Salt lake Basins Utah, Idaho, and Wyoming, 1998-99 (USGS, 2004)
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Site No.	Location	Arsenic (mg/kg)	Chromium (III) (mg/kg)	Iron* (mg/kg)	Nickel (mg/kg)	Titanium* (mg/kg)
				Not Reported		Not Reported
1	Bear River	6.3	58		21	
2	Bear River	5.1	54		17	
4	Cub River	6.1	58		22	
5	Bear River	5.6	52		20	
6	Upstream Weber River	4.8	52		16	
7	Silver Creek/mining	440	72		28	
8	Silver Creek/mining	110	59		17	
9	Weber River/mining	67	47		13	
10	Weber River/mining	58	50		17	
11	Mouth of Weber River	8.6	53		19	
11	Mouth of Weber River	8	49		18	
15	Little Cottonwood Creek/mining	51	58		23	
16	Little Cottonwood Creek/mining	74	60		23	
17	Jordan River	225	60		22	
18	Red Butte Creek (reference site)	7.2	68		27	
19	Jordan River	20	55		23	
19	Jordan River	19	60		22	
	Average	**6.46**	**56.76**		**20.47**	
	National median	**7.5**	**65**		**29**	
	National 90th percentile	**20**	**120**		**62**	

Notes: * Analyte was analyzed, but results were not reported
Average of arsenic did not included highlighted cells (potential impacted sites)

TABLE C-2
Selenium and Other Trace Elements in Water, Sediment, Aquatic Plants, Aquatic Invertebrates, and Fish from Streams in Southern Idaho Near Phosphate Mining Operations (USGS, 2003) - Blackfoot River Watershed
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Metal	Sediment dw (mg/kg), Summer 2003									Average
	ACM	UEMC	LEMC	TC	USC	LSC	ShpC	DVC	LBR	
Arsenic	0.015	0.012	0.011	*0.0025*	0.017	0.011	0.014	0.01	*0.0025*	0.0106
Chromium	*0.0015*	*0.0015*	*0.0015*	*0.0015*	*0.0015*	*0.0015*	*0.0015*	*0.0015*	*0.0015*	0.0015
Iron	*0.01*	*0.01*	*0.01*	0.023	*0.01*	*0.01*	0.055	*0.01*	*0.01*	0.0164
Nickel	*0.003*	*0.003*	*0.003*	*0.003*	*0.003*	*0.003*	*0.003*	*0.003*	*0.003*	0.0030

* The values in *blue italics* reflect concentrations that were Non-Detects; half the value of the ND is therefore used in the calculations.

Metal	Sediment dw (mg/kg), Summer 2003									Average
	ACM	UEMC	LEMC	TC	USC	LSC	ShpC	DVC	LBR	
Arsenic	4.1	4.3	3.9	2	5.1	1.8	3.7	3.6	2.8	3.48
Chromium	30	67	61	19	28	21	23	41	20	34.44
Iron	25,400	15,800	15,700	15,400	14,400	10,890	20,600	25,100	17,800	17,899
Nickel	29	57	53	15	23	12	24	76	16	33.89

Reported to be potentially impacted.

Metal	Sediment dw (mg/kg), Summer 2003									Average
	ACM	UEMC	LEMC	TC	USC	LSC	ShpC	DVC	LBR	
Arsenic	1	1	2	1	1	1	1	1	1	1.11
Chromium	1	8	8	2	4	5	1	1	2	3.56
Iron	870	810	2,580	2,840	8,650	3,264	1,010	2,800	4,210	3,003.78
Nickel	3	8	5	2	2	4	3	5	2	3.78

Metal	Sediment dw (mg/kg), Summer 2003									Average
	ACM	UEMC	LEMC	TC	USC	LSC	ShpC	DVC	LBR	
Arsenic	0.24	0.23	0.51	0.50	0.20	0.56	0.27	0.28	0.36	0.35
Chromium	0.03	0.12	0.13	0.11	0.14	0.24	0.04	0.02	0.10	0.10
Iron	0.03	0.05	0.16	0.18	0.60	0.30	0.05	0.11	0.24	0.19
Nickel	0.10	0.14	0.09	0.13	0.09	0.33	0.13	0.07	0.13	0.13

Metal	Sediment dw (mg/kg), Summer 2003									Average
	ACM	UEMC	LEMC	TC	USC	LSC	ShpC	DVC	LBR	
Arsenic	1	1	1	1	2	5	0	1	1	1.44
Chromium	3	6	10	1	2	2	2	2	2	3.33
Iron	802	1,220	581	308	377	251	320	670	750	586.56
Nickel	7	2	7	4	5	8	3	18	5	6.56

Metal	Sediment dw (mg/kg), Summer 2003									Average
	ACM	UEMC	LEMC	TC	USC	LSC	ShpC	DVC	LBR	
Arsenic	0.24	0.23	0.26	0.50	0.39	2.78	0.00	0.28	0.36	0.56
Chromium	0.10	0.09	0.16	0.05	0.07	0.10	0.09	0.05	0.10	0.09
Iron	0.03	0.08	0.04	0.02	0.03	0.02	0.02	0.03	0.04	0.03
Nickel	0.24	0.04	0.13	0.27	0.22	0.67	0.13	0.24	0.31	0.25

Notes:
See Appendix B for explanation of terminology and references.

TABLE C-3
Metal Concentrations for Sediment and Tissue from Lake Qarun, Egypt
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Metal	Station Water (mg/L), Summer 2003							Average
	Eastern 1	Eastern 2	3 (Middle)	4 (Middle)	5 (Middle)	Western 6	Western 7	
Chromium	0.06051	0.0635	0.0619	0.0647	0.0859	0.06854	0.06165	0.067
Iron	0.6	0.48	0.36	0.33	0.55	0.35	0.38	0.436
Nickel	0.044	0.04217	0.0405	0.0392	0.0396	0.04076	0.03881	0.041

Metal	Station Sediment (mg/kg) dw, Summer 2003							Average
	Eastern 1	Eastern 2	3 (Middle)	4 (Middle)	5 (Middle)	Western 6	Western 7	
Chromium	17.81	13.5	14.49	12.86	15	13.77	13.65	14.44
Iron	26,380	21,380	20,400	11,190	17,600	15,530	12,540	17,860
Nickel	83.6	55.84	56.49	47.94	66.47	40.12	38.78	55.61

Metal	Kd (L/kg), Summer 2003							Average
	Eastern 1	Eastern 2	3 (Middle)	4 (Middle)	5 (Middle)	Western 6	Western 7	
Chromium	294	213	234	199	175	201	221	220
Iron	43,967	44,542	56,667	33,909	32,000	44,371	33,000	41,208
Nickel	1,900	1,324	1,395	1,223	1,679	984	999	1,358

Metal	Annelida Tissue Concentrations (mg/kg) dw, Summer 2003						Average of 3 Species	
	East	Middle	West	Average	BAF (L/kg)	BSAF (kg/kg)	BAF (L/kg)	BSAF (kg/kg)
Chromium	2.29	1.67	1.92	1.96	29.40	0.14	28.48	0.133
Iron	68.16	43.19	40.71	50.69	116.33	0.0028	125.85	0.00301
Nickel	9.8	6.86	5.52	7.39	181.57	0.13	196.46	0.14

Metal	Mollusca Tissue Concentrations (mg/kg) dw, Summer 2003					
	East	Middle	West	Average	BAF (L/kg)	BSAF (kg/kg)
Chromium	1.63	1.96	2.26	1.95	29.25	0.14
Iron	78.38	50.53	48.03	58.98	135.36	0.0033
Nickel	11.27	8.03	6.52	8.61	211.36	0.15

Metal	Crustacea Tissue Concentrations (mg/kg) dw, Summer 2003					
	East	Middle	West	Average	BAF (L/kg)	BSAF (kg/kg)
Chromium	1.46	1.81	2.09	1.79	26.80	0.12
Iron	73.27	46.86	44.39	54.84	125.86	0.0031
Nickel	10.53	7.45	6.02	8.00	196.46	0.14

Notes:
mg/kg dw = milligram per kilogram, dry weight
kg/kg = kilogram per kilogram
mg/L = milligram per liter
L/kg = liter per kilogram
BAF = bioaccumulation factor
BSAF = sediment bioaccumulation factor

APPENDIX D
EVALUATION OF INVERTEBRATE AND PLANT INGESTION FROM SEDIMENT

ECOLOGICAL RISK ASSESSMENT

ATI TITANIUM

12633 North Rowley Road

North Skull Valley, Tooele County, Utah

26OT.52001.08

July 15, 2008

TABLE 5a
Receptor Characteristics and Exposure Assumptions for Wildlife
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Parameter	Comments	Black-Necked Stilt	Reference	American Avocet	Reference	Mallard Duck	Reference	Snowy Plover	Reference
Body Weight (kg)		0.167	Cal/Ecotox Database, 2008	0.315	Wold Birds Unlimited, 2008	1.13	USEPA, 1993	0.0422	Cal/Ecotox Database, 2008
Composition of Diet									
	Estimated percent sediment (dry weight)	5	UDEQ, 2008d	5	UDEQ, 2008d	2.0	USEPA, 1993	5.0	UDEQ, 2008d
	Estimated percent invertebrates from water column	29	See text	29	See text	11	See text	44	See text
	Estimated percent invertebrates from sediment	36	See text	38	See text	14	See text	56	See text
	Estimated percent plants/seeds from sediment	33	See text	33	See text	76	See text	0	See text
Exposure Time (months on site/12 months of year)		0.5		0.6		1		0.5	
Time on Site		Apr-Sep		Mar-Sep		Year Round		Apr-Sep	
Food Ingestion Rate - Total (kg/day wet weight)		0.084	USEPA, 1993, allometric equation	0.103	USEPA, 1993, allometric equation	0.269	USEPA, 1993, allometric equation	0.02	USEPA, 1993, allometric equation
	Fraction water content of food	0.78	Sample and Suter II, 1993	0.78	Sample and Suter II, 1993	0.6	USEPA, 2005a	0.78	Sample and Suter II, 1993
Food Ingestion Rate (kg/day)									
	Sediment	0.000704	calculated	0.001133	calculated	0.002152	calculated	0.000253	calculated
	Invertebrates from water column (brine shrimp, fly)	0.018560	calculated	0.029870	calculated	0.028729	calculated	0.010028	calculated
	Invertebrates from sediment	0.024128	calculated	0.038631	calculated	0.037203	calculated	0.012972	calculated
	Plants/seeds from sediment	0.021312		0.034299	calculated	0.203095	calculated	0.000000	
Drinking Water Ingestion (L/day)		0.0178	Allometric equation; USEPA, 1993	0.0272	Allometric equation; USEPA, 1993	0.065	Allometric equation; USEPA, 1993	0.007	Allometric equation; USEPA, 1993
Home Range (ha)		2.84E+02	Hickey et al., 2007	2.84E+02	Assume to be equal to the stilt	5.80E+02	USEPA, 1993	3.50E+01	NatureServe Explorer, 2008
	Fraction from the Site	1.00E+00	UDEQ, 2008f	1.00E+00	SECOR, 2008e	1.00E+00	SECOR, 2008e	1.00E+00	SECOR, 2008e

Notes: Data reported for males and females has been averaged
kg = kilogram
g = gram
L = liter
NA = Not applicable
ha = hectare

TABLE 8a
Invertebrate Bioaccumulation Factors from Surface Water and Sediment
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Metals	Bioaccumulation Factor (BAF) for Invertebrates in Water (L/kg)	Ref	Bioaccumulation Factor for Invertebrates (BSAFi) in Sediment (kg/kg)	Ref	Bioaccumulation Factor for Aquatic Plants (BSAFp) in Sediment (kg/kg)	Ref
Arsenic	38.2	a	0.5600	b	0.0790	a
Chromium (III)	56.7	a	0.0310	a	0.0270	a
Iron	60.6	a	0.0095	a	0.0275	a
Nickel	68.34	a	0.1870	a	0.0880	a
Titanium	23.49	a	0.0037	c	0.0107	c

Notes:
L = Liter
kg = Kilogram
a See text
b USGS, 2003b
c No value for titanium was available, therefore, the value for iron and ratio of 23.49/60.6 from BAF value was used

TABLE 9a
Intakes for Wildlife - Quantitative Assessment
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Metals	Black-Necked Stilt Intakes (mg/kg-day)					
	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total Intake
Arsenic	5.33E-03	1.37E-02	2.12E-01	2.63E-01	3.28E-02	5.27E-01
Chromium (III)	2.66E-03	1.20E-01	1.58E-01	1.27E-01	9.79E-02	5.05E-01
Iron	7.99E-02	3.77E+01	5.05E+00	1.23E+01	3.14E+01	8.66E+01
Nickel	2.66E-03	4.32E-02	1.90E-01	2.77E-01	1.15E-01	6.28E-01
Titanium	2.66E-01	8.64E+00	6.53E+00	1.09E+00	2.79E+00	1.93E+01

Metals	American Avocet Intakes (mg/kg-day)					
	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total Intake
Arsenic	5.04E-03	1.36E-02	2.11E-01	2.62E-01	3.26E-02	5.24E-01
Chromium (III)	2.52E-03	1.19E-01	1.57E-01	1.27E-01	9.74E-02	5.03E-01
Iron	7.56E-02	3.76E+01	5.03E+00	1.22E+01	3.13E+01	8.62E+01
Nickel	2.52E-03	4.30E-02	1.89E-01	2.76E-01	1.15E-01	6.25E-01
Titanium	2.52E-01	8.60E+00	6.50E+00	1.09E+00	2.78E+00	1.92E+01

Metals	Mallard Duck Intakes (mg/kg-day)					
	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total Intake
Arsenic	5.73E-03	1.23E-02	9.68E-02	1.19E-01	9.20E-02	3.26E-01
Chromium (III)	2.87E-03	1.08E-01	7.18E-02	6.78E-02	2.75E-01	5.15E-01
Iron	8.60E-02	3.40E+01	2.30E+00	5.58E+00	8.82E+01	1.30E+02
Nickel	2.87E-03	3.89E-02	8.68E-02	1.26E-01	3.23E-01	5.77E-01
Titanium	2.87E-01	7.78E+00	2.98E+00	4.95E-01	7.83E+00	1.94E+01

Metals	Snowy Plover Intakes (mg/kg-day)					
	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total Intake
Arsenic	8.41E-03	1.85E-02	4.54E-01	5.59E-01	0.00E+00	1.04E+00
Chromium (III)	4.21E-03	1.70E-01	3.37E-01	2.71E-01	0.00E+00	7.82E-01
Iron	1.26E-01	5.37E+01	1.06E+01	2.61E+01	0.00E+00	9.07E+01
Nickel	4.21E-03	6.15E-02	4.06E-01	5.89E-01	0.00E+00	1.06E+00
Titanium	4.21E-01	1.23E+01	1.40E+01	2.32E+00	0.00E+00	2.90E+01

Notes:
mg/kg-day = milligrams per kilogram per day

TABLE 11a
NOAEL-Based Hazard Quotient to Wildlife
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Metals	Black-Necked Stilt Hazard Quotient					
	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total
Arsenic	9.35E-04	2.40E-03	3.72E-02	4.61E-02	5.76E-03	9.25E-02
Chromium (III)	2.27E-04	1.02E-02	1.34E-02	1.08E-02	8.34E-03	4.31E-02
Iron	2.28E-04	1.08E-01	1.44E-02	3.51E-02	8.97E-02	2.47E-01
Nickel	3.44E-05	5.58E-04	2.45E-03	3.58E-03	1.49E-03	8.11E-03
Titanium	4.69E-04	1.62E-02	1.15E-02	1.92E-03	4.01E-03	3.40E-02
Total HQ						4.25E-01

Metals	American Avocet Hazard Quotient					
	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total
Arsenic	8.84E-04	2.39E-03	3.71E-02	4.59E-02	5.72E-03	9.20E-02
Chromium (III)	2.15E-04	1.02E-02	1.34E-02	1.08E-02	8.30E-03	4.28E-02
Iron	2.16E-04	1.07E-01	1.44E-02	3.49E-02	8.88E-02	2.46E-01
Nickel	3.25E-05	5.56E-04	2.44E-03	3.56E-03	1.48E-03	8.07E-03
Titanium	4.43E-04	1.51E-02	1.14E-02	1.91E-03	4.89E-03	3.33E-02
Total HQ						4.23E-01

Metals	Mallard Duck Hazard Quotient					
	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total
Arsenic	1.01E-03	2.16E-03	1.70E-02	2.10E-02	1.81E-02	5.72E-02
Chromium (III)	2.44E-04	8.19E-03	6.12E-03	4.92E-03	2.34E-02	4.39E-02
Iron	2.46E-04	8.71E-02	6.56E-03	1.59E-02	2.52E-01	3.72E-01
Nickel	3.70E-05	5.03E-04	1.12E-03	1.62E-03	4.17E-03	7.46E-03
Titanium	5.05E-04	1.37E-02	5.24E-03	8.72E-04	1.38E-02	3.41E-02
Total HQ						5.14E-01

Metals	Snowy Plover Hazard Quotient					
	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total
Arsenic	1.48E-03	3.42E-03	7.96E-02	9.82E-02	0.00E+00	1.83E-01
Chromium (III)	3.59E-04	1.48E-02	2.87E-02	2.31E-02	0.00E+00	6.67E-02
Iron	3.61E-04	1.53E-01	3.09E-02	7.47E-02	0.00E+00	2.59E-01
Nickel	5.43E-05	7.94E-04	5.25E-03	7.61E-03	0.00E+00	1.37E-02
Titanium	7.41E-04	2.16E-02	2.46E-02	4.09E-03	0.00E+00	5.10E-02
Total HQ						5.73E-01

Metals	Black-Necked Stilt % of Total					
	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total
Metals						
Arsenic	0.2%	0.6%	8.8%	10.9%	1.4%	21.8%
Chromium (III)	0.1%	2.4%	3.2%	2.6%	2.0%	10.1%
Iron	0.1%	25.4%	3.4%	8.3%	21.1%	58.2%
Nickel	0.0%	0.1%	0.6%	0.8%	0.3%	1.9%
Titanium	0.1%	3.8%	2.7%	0.5%	1.2%	8.0%
Total of %	0.4%	32.0%	18.6%	23.0%	25.9%	100.0%

Metals	American Avocet % of Total					
	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total
Metals						
Arsenic	0.2%	0.6%	8.8%	10.9%	1.4%	21.8%
Chromium (III)	0.1%	2.4%	3.2%	2.6%	2.0%	10.1%
Iron	0.1%	25.4%	3.4%	8.3%	21.1%	58.2%
Nickel	0.0%	0.1%	0.6%	0.8%	0.4%	1.9%
Titanium	0.1%	3.6%	2.7%	0.5%	1.2%	8.0%
Total of %	0.4%	32.1%	18.8%	23.0%	25.9%	100.0%

Metals	Mallard Duck % of Total					
	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total
Metals						
Arsenic	0.2%	0.4%	3.3%	4.1%	3.1%	11.1%
Chromium (III)	0.0%	1.6%	1.2%	1.0%	4.6%	8.6%
Iron	0.0%	16.9%	1.3%	3.1%	49.0%	72.3%
Nickel	0.0%	0.1%	0.2%	0.3%	0.8%	1.4%
Titanium	0.1%	2.7%	1.0%	0.2%	2.7%	6.6%
Total of %	0.4%	21.8%	7.0%	8.6%	60.1%	100.0%

Metals	Snowy Plover % of Total					
	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total
Metals						
Arsenic	0.3%	0.6%	13.9%	17.1%	0.0%	31.9%
Chromium (III)	0.1%	2.6%	5.0%	4.0%	0.0%	11.6%
Iron	0.1%	26.7%	5.4%	13.0%	0.0%	45.2%
Nickel	0.0%	0.1%	0.9%	1.3%	0.0%	2.4%
Titanium	0.1%	3.8%	4.3%	0.7%	0.0%	8.9%
Total of %	0.6%	33.6%	28.6%	36.2%	0.0%	100.0%

TABLE 12a
LOAEL-Based Hazard Quotient to Wildlife
ATI Titanium
12633 North Rowley Road
North Skull Valley, Utah

Metals	Black-Necked Stilt Hazard Quotient						American Avocet Hazard Quotient					
	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total
Arsenic	2.34E-04	6.01E-04	9.31E-03	1.15E-02	1.44E-03	2.31E-02	2.21E-04	5.98E-04	9.27E-03	1.16E-02	1.43E-03	2.30E-02
Chromium (III)	5.59E-05	2.51E-03	3.30E-03	2.67E-03	2.05E-03	1.06E-02	5.28E-05	2.50E-03	3.29E-03	2.65E-03	2.04E-03	1.05E-02
Iron	7.99E-05	3.77E-02	5.05E-03	1.23E-02	3.14E-02	8.66E-02	7.56E-05	3.76E-02	5.03E-03	1.22E-02	3.13E-02	8.62E-02
Nickel	2.49E-05	4.04E-04	1.77E-03	2.59E-03	1.08E-03	5.87E-03	2.35E-05	4.02E-04	1.77E-03	2.58E-03	1.07E-03	5.84E-03
Titanium	1.96E-04	6.34E-03	4.79E-03	8.00E-04	2.05E-03	1.42E-02	1.85E-04	6.31E-03	4.77E-03	7.97E-04	2.04E-03	1.41E-02
Total HQ						**1.40E-01**						**1.40E-01**

Metals	Mallard Duck Hazard Quotient						Snowy Plover Hazard Quotient					
	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total
Arsenic	2.51E-04	5.41E-04	4.24E-03	5.24E-03	4.03E-03	1.43E-02	3.69E-04	8.55E-04	1.99E-02	2.45E-02	0.00E+00	4.57E-02
Chromium (III)	6.01E-05	2.26E-03	1.51E-03	1.21E-03	5.76E-03	1.08E-02	8.82E-05	3.57E-03	7.06E-03	5.67E-03	0.00E+00	1.64E-02
Iron	8.60E-05	3.40E-02	2.30E-03	5.58E-03	8.82E-02	1.30E-01	1.26E-04	5.37E-02	1.08E-02	2.61E-02	0.00E+00	9.07E-02
Nickel	2.68E-05	3.64E-04	8.09E-04	1.18E-03	3.02E-03	5.39E-03	3.93E-05	5.74E-04	3.79E-03	5.51E-03	0.00E+00	9.91E-03
Titanium	2.10E-04	5.71E-03	2.18E-03	3.63E-04	5.74E-03	1.42E-02	3.09E-04	9.02E-03	1.02E-02	1.70E-03	0.00E+00	2.13E-02
Total HQ						**1.78E-01**						**1.84E-01**

Metals	Black-Necked Stilt % of Total						American Avocet % of Total					
	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total
Arsenic	0.2%	0.4%	6.6%	8.2%	1.0%	16.5%	0.2%	0.4%	6.6%	8.2%	1.0%	16.5%
Chromium (III)	0.0%	1.8%	2.4%	1.9%	1.5%	7.5%	0.0%	1.8%	2.4%	1.9%	1.5%	7.5%
Iron	0.1%	26.9%	3.6%	8.8%	22.4%	61.7%	0.1%	26.9%	3.6%	8.8%	22.4%	61.7%
Nickel	0.0%	0.3%	1.3%	1.8%	0.8%	4.2%	0.0%	0.3%	1.3%	1.8%	0.8%	4.2%
Titanium	0.1%	4.5%	3.4%	0.6%	1.5%	10.1%	0.1%	4.5%	3.4%	0.6%	1.5%	10.1%
Total of %	**0.4%**	**33.9%**	**17.3%**	**21.3%**	**27.1%**	**100.0%**	**0.4%**	**33.9%**	**17.3%**	**21.3%**	**27.1%**	**100.0%**

Metals	Mallard Duck % of Total						Snowy Plover % of Total					
	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total	Water Ingestion	Sediment Ingestion	Invertebrate Ingestion from Water	Invertebrate Ingestion from Sediment	Plant Ingestion from Sediment	Total
Arsenic	0.1%	0.3%	2.4%	3.0%	2.3%	8.2%	0.2%	0.5%	10.8%	13.3%	0.0%	24.8%
Chromium (III)	0.0%	1.3%	0.9%	0.7%	3.3%	6.2%	0.0%	1.9%	3.8%	3.1%	0.0%	8.9%
Iron	0.0%	19.4%	1.3%	3.2%	50.4%	74.4%	0.1%	29.2%	5.9%	14.2%	0.0%	49.3%
Nickel	0.0%	0.2%	0.5%	0.7%	1.7%	3.1%	0.0%	0.3%	2.1%	3.0%	0.0%	5.4%
Titanium	0.1%	3.3%	1.2%	0.2%	3.3%	8.1%	0.2%	4.9%	5.6%	0.9%	0.0%	11.6%
Total of %	**0.4%**	**24.5%**	**6.3%**	**7.8%**	**61.0%**	**100.0%**	**0.6%**	**38.6%**	**28.2%**	**34.6%**	**0.0%**	**100.0%**

APPENDIX E
NOTIFICATION OF 'NO ADVERSE IMPACT' ON STATE-LISTED SPECIES - SECOR'S LETTER TO UTAH DIVISION OF WILDLIFE RESOURCES, DATED JUNE 17, 2008

ECOLOGICAL RISK ASSESSMENT

ATI TITANIUM

12633 North Rowley Road

North Skull Valley, Tooele County, Utah

26OT.52001.08

July 15, 2008

SECOR
SECOR INTERNATIONAL INCORPORATED
www.secor.com
3995 South 700 East
Suite 300
Salt Lake City,
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June 17, 2008

Ms. Ashley Green
Habitat Manager, Central Region Office
Utah Division of Wildlife Resources
1115 North Main Street
Springville, Utah 84663

**RE: Notification of 'No Adverse Impact' on State-Listed Species
ATI Titanium Discharge Pipeline Project, Tooele County, Utah**

Dear Ms. Green:

SECOR International Incorporated, now Stantec (SECOR/Stantec), was retained by ATI Titanium, LLC (ATI Titanium) to provide environmental support regarding their project to extend a wastewater discharge pipeline from their titanium manufacturing facility to the shore of the Great Salt Lake (GSL), Utah. SECOR/Stantec is submitting this letter on behalf of ATI Titanium to request concurrence on our findings that the proposed project would have no adverse impact on any state-listed species. A similar letter was compiled for the U.S. Fish and Wildlife Service (USFWS) to request concurrence on a "no effect" finding to federally listed species.

This letter provides information on the project location, the habitat within and surrounding the study area, the list of special status species (SSS) that may occur in the study area, and recommended mitigation measures.

Project Location

The facility is located next to the US Magnesium Corporation (US Mag) plant 40 miles west of Salt Lake City and 15 miles north of exit 77 of Interstate 80 in the northeastern part of Tooele County. The address is 12633 North Rowley Road, North Skull Valley, Utah 84029. The Universal Transverse Mercator (UTM) coordinates of the facility are: 353,719.78 meters east, 4,530,280.32 meters north, Zone 12N.

The study area can be found on the Badger Island NW U.S. Geological Survey 7.5-minute quadrangle in the following locations from west to east:

- T2N, R8W, Sec15 (northeast corner)
- T2N, R8W, Sec14 (northwestern corner)
- T2N, R8W, Sec11 (southeastern and northeastern corners)
- T2N, R8W, Sec12 (western side)
- T2N, R8W, Sec 2 (eastern side)

The study area extends due east from the new manufacturing facility along a dirt road to the eastern edge of the US Mag waste treatment pond, and then runs north along the eastern edge of the US Mag waste treatment pond, where it crosses a stormwater drainage ditch and extends an additional 1,000 feet north (shown on Figure 1).

Project Description

ATI Titanium is currently constructing their manufacturing facility next to the US Mag plant in Rowley, Utah on the southwest side of the GSL. The purpose of the facility is to manufacture titanium (chemical formula Ti) sponge. The ATI Titanium facility will have a nameplate capacity of 40 million pounds per year of titanium sponge production. The manufacturing process consists of the following steps:

1. Raw Material Usage (titanium tetrachloride [chemical formula $TiCl_4$], molten magnesium, fuels, inert gases, and other chemicals used in minor amounts)
2. Titanium Reduction and Vacuum Distillation Process
3. Titanium Sponge Processing & Packaging

Habitat Description

A SECOR/Stantec field ecologist conducted a field survey on April 30 and May 5, 2008 to identify wetlands and other water features and to evaluate the potential for the occurrence of SSS.

According to the Natural Resources Conservation Service *electronic* Field Office Technical Guide (eFOTG) (http://www.nrcs.usda.gov/technical/efotg), on a macro level, the study area falls within the land resource region classified as the Western Range and Irrigated Region, with the major land resource area classified as the Great Salt Lake Area (28A). On a micro level, the study area is situated on the west-southwest side of the Great Salt Lake south of Currington Bay near Rowley, in Tooele County, Utah. The elevation in the study area is approximately 4,220 feet above mean sea level (upper elevation is around 4,225 feet, low elevation is new 4,202 feet at proposed outfall).

A majority of the study area is heavily disturbed and characterized by a dirt access road which eventually intersects the northern-most point of the stormwater drainage. From that point north the study area is situated in an area characterized by playas. The areas surrounding the study area include sagebrush scrub to the south, playa to the east, and the heavily disturbed US Mag property including the plant and former waste water pond to the north.

Dominant vegetation identified during the field survey within the study area includes Clasping Pepperweed (*Lepidium perfoliatum*), Russian Thistle (*Salsola kali*), Glasswort (*Salicornia utahensis*), Cheatgrass (*Bromus tectorum*), Greasewood (*Sarcobatus vermiculatus*) and Rubber Rabbitbrush (*Chrysothamnus nauseosus*). Vegetation was limited to less than 20% cover at all of the sample points. It was often below 5% total ground cover. A state-listed noxious weed species, Saltcedar (*Tamarix ramosissima*) was also identified in the area but outside of the proposed pipeline.

State of Utah Species of Concern

The Department of Natural Resources (DNR) Utah Natural Heritage Program (UNHP) conducted a record search of the Utah Division of Wildlife Resources (UDWR) database to determine if there were any SSS records of occurrence within 0.5-mile and 10-mile radius of the study area. The letter from the DNR is included in this letter report.

Table 1 lists all the State of Utah Species of Concern within Tooele County, and identifies which species are listed in the UDWR database within either a 0.5-mile or 10-mile radius of the study area.

Seven of the 28 species addressed in Table 1 have the possibility of occurring in, or very near, the study area, whereas the remaining 21 species are unlikely to occur directly within, or even near, the study area. Of these seven species, only the American white pelican has been recently recorded as occurring within 0.5 mile of the study area. The burrowing owl, ferruginous hawk, kit fox, and long-billed curlew have recent records of occurrence within 10 miles of the study area, whereas the pygmy rabbit has a historical record of occurrence within 10 miles of the study area. The other species is listed as having the possibility of occurring in, or very near, the study area based on their preferred habitat and foraging descriptions. These seven species are briefly discussed below in order that they are presented in the Table 1.

The **burrowing owl** has been recently recorded by the UDWR within a 10-mile radius of the project area. Though the species could fly through and potentially forage within the project area on route to suitable nesting grounds, it is very unlikely that the burrowing owl would nest within the project area due to the absence of suitable habitat. Therefore, the species is not likely to be adversely affected by the project.

The **ferruginous hawk** has been recently recorded by the UDWR within a 10-mile radius of the project area. The ferruginous hawk may occasionally utilize the study area to hunt for small mammal prey on route to suitable nesting grounds. It is highly unlikely that the ferruginous hawk would nest in the study area considering the absence of available suitable nesting habitat. Therefore, the species is not likely to be adversely affected by the project.

The **long-billed curlew** has been recently recorded by the UDWR within a 10-mile radius of the project area. The long-billed curlew may occasionally utilize the study area to forage for suitable preys especially on the northernmost end of the piping alignment. Since the project site lacks two of the four essential nesting habitat requirements, including short grass and shade, it is highly unlikely that the species would nest in the study area. This species also prefers to nest on margins of playas within grassy areas where the ground is fairly level. The slopes within the piping alignment would preclude use of the site by the long-billed curlew. Therefore, the species is not likely to be adversely affected by the project.

The **American white pelican** is the only species that has been recently recorded by the UDWR within a 0.5-mile radius of the project area. Hat Island is a known nesting area 10 miles to the east of the study area and the Timpie Springs Wildlife Management area is located approximately 12 miles to the southeast of the site. Specifically, American white pelicans prefer islands for nesting, and shallow lakes, marshlands, and rivers for foraging. It is possible that the species may forage in or near the northern reaches of the project area. It is unlikely that the species would nest in the project area. Therefore, the species is not likely to be adversely affected by the project.

The **pygmy rabbit** has been historically recorded by the UDWR within a 10-mile radius of the project area. This species prefers to live in sagebrush communities and primarily forages on sagebrush. Sagebrush surrounds the project area to the south and west.

It is possible that the pygmy rabbit may enter the project area on occasion, but likely rarely considering the lack of vegetation and cover from prey. Therefore, the species is not likely to be adversely affected by the project.

The **dark kangaroo mouse**, although not recorded recently or historically by the UDWR, could potentially occur within the study area. The species prefers to live in sagebrush communities and primarily forages on seeds and insects. Since sagebrush surrounds the project area to the south and west, it is possible that this species may enter the project area on occasion to forage. But it is unlikely that the dark kangaroo mouse lives directly within the project area due the lack of suitable habitat. Therefore, the species is not likely to be adversely affected by the project.

The **kit fox** is another species that has been recently recorded by the UDWR within a 10-mile radius of the project area. It is possible that the kit fox may cross through the study area during foraging considering that this species is a highly opportunistic feeder. Since no dens, or evidence of inhabitation, were identified during field work, this species is not likely to be adversely affected by the project.

Mitigation Measures

In order to minimize the potential for impacts to any of the above-mentioned species that may cross through the project area or utilize the project area for foraging, the following mitigation measures will be implemented:

- Best Management Practices (BMPs) will be used during all phases of construction to reduce impacts from sedimentation and erosion, including the use of berms, brush barriers, check dams, erosion control blankets, filter strips, sandbag barriers, sediment basins, silt fences, straw-bale barriers, surface roughening, and/or diversion channels (as appropriate).
- No equipment staging or storage of construction materials will occur within 50 feet of natural waterways.
- The use of chemicals, such as soil stabilizers, dust inhibitors, and fertilizers within 50 feet of natural waterways will be prohibited.
- Equipment will be refueled in designated contained areas, a minimum of 50 feet from natural waterways.

Conclusion

Based on our research, the field survey, and the implementation of the mitigation measures, it is our opinion that the project is not likely to have an adverse impact on the seven species identified as possibly occurring in the project area.

If you have any questions or concerns, or if you would like to discuss this project in more detail, please contact Paula Weyen-Gellner of SECOR/Stantec at (801) 261-0090 x 3153.

Sincerely,

SECOR International Incorporated, Now Stantec

Paula Weyen-Gellner
Associate Scientist

Janet Roemmel for
Matt Betts
Ecologist

cc: Janet Roemmel, SECOR
Lee Weber, ATI Wah Chang, Director, Environmental Services
Marty Banks, Stoel Rives

JON M. HUNTSMAN, JR.
Governor

GARY R. HERBERT
Lieutenant Governor

State of Utah

DEPARTMENT OF NATURAL RESOURCES

MICHAEL R. STYLER
Executive Director

Division of Wildlife Resources

JAMES F. KARPOWITZ
Division Director

April 7, 2008

Paula Weyen-Gellner
Stantec
308 4500 South, Suite 100
Murray, UT 84107

Subject: Species of Concern Near the Great Salt Lake, Tooele County

Dear Paula Weyen-Gellner:

I am writing in response to your email dated April 3, 2008 regarding information on species of special concern proximal to the right of way located near US Magnesium on the west side of the Great Salt Lake in Tooele County, Utah (Sections 2, 11, 12, and 15 of Township 2 North, Range 8 West).

Within a ½-mile radius of the project area noted above, the Utah Division of Wildlife Resources (UDWR) has recent records of occurrence for American white pelican. In addition, within a 10-mile radius there are recent records of occurrence for burrowing owl, ferruginous hawk, kit fox and long-billed curlew, and historical records of occurrence for pygmy rabbit. All of the aforementioned species are included on the *Utah Sensitive Species List*.

The information provided in this letter is based on data existing in the Utah Division of Wildlife Resources' central database at the time of the request. It should not be regarded as a final statement on the occurrence of any species on or near the designated site, nor should it be considered a substitute for on-the-ground biological surveys. Moreover, because the Utah Division of Wildlife Resources' central database is continually updated, and because data requests are evaluated for the specific type of proposed action, any given response is only appropriate for its respective request.

In addition to the information you requested, other significant wildlife values might also be present on the designated site. Please contact UDWR's habitat manager for the central region, Ashley Green, at (801) 491-5654 if you have any questions.

Please contact our office at (801) 538-4759 if you require further assistance.

Sincerely,

Sarah Lindsey

Sarah Lindsey
Information Manager
Utah Natural Heritage Program

cc: Ashley Green, CRO

1594 W. North Temple, Suite 2110, PO Box 146301, Salt Lake City, UT 84114-6301
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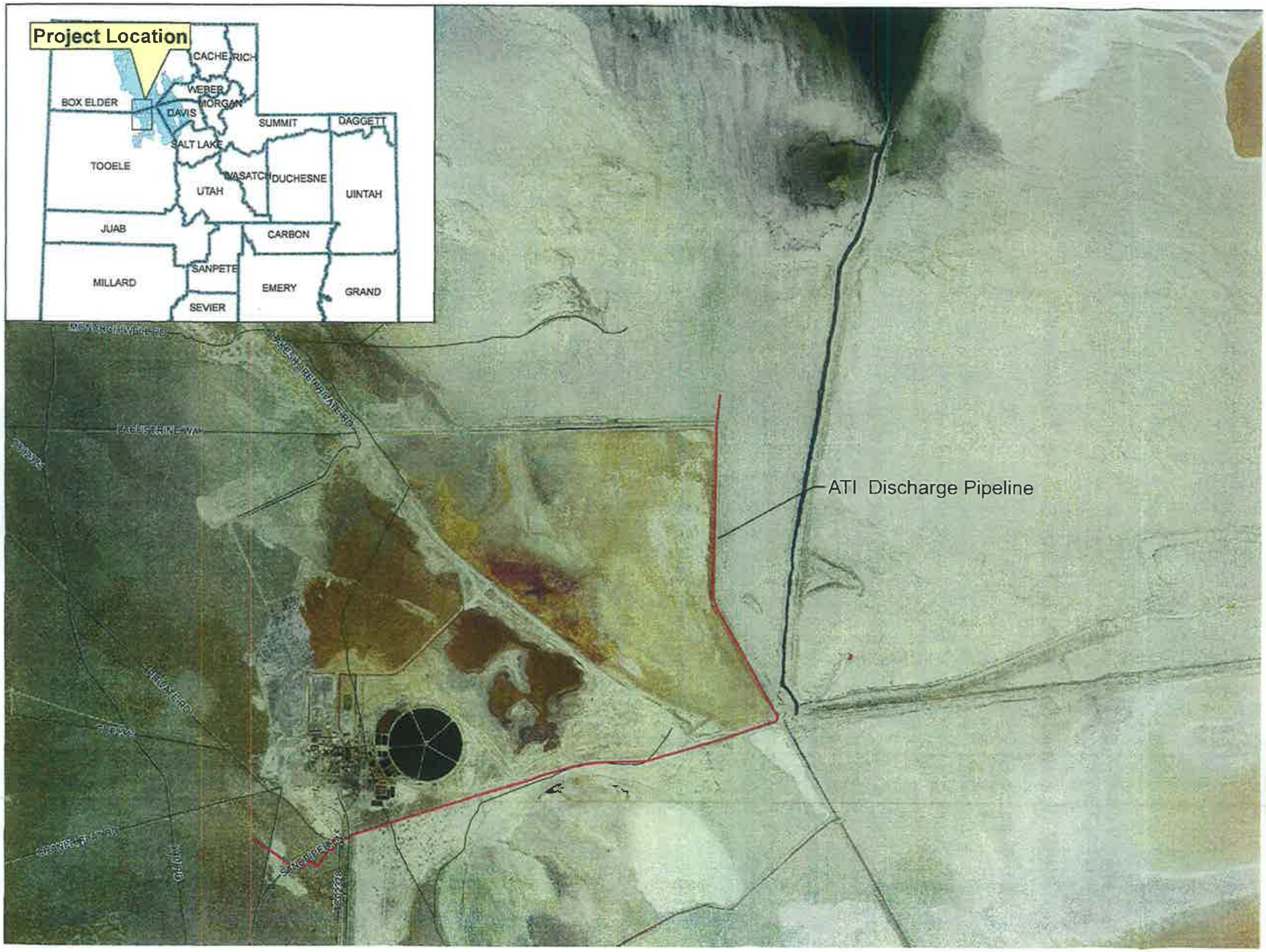
UTAH DNR WILDLIFE RESOURCES



Stantec

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SECOR

Legend

Pipeline Alignment

N

Graphic Scale

0 2,000

(in feet)

1 inch equals 2,000 feet

Notes

Aerial Imagery - Utah AGRC
National Agricultural Imagery Program
NAIP 2006, 1m

Client/Project

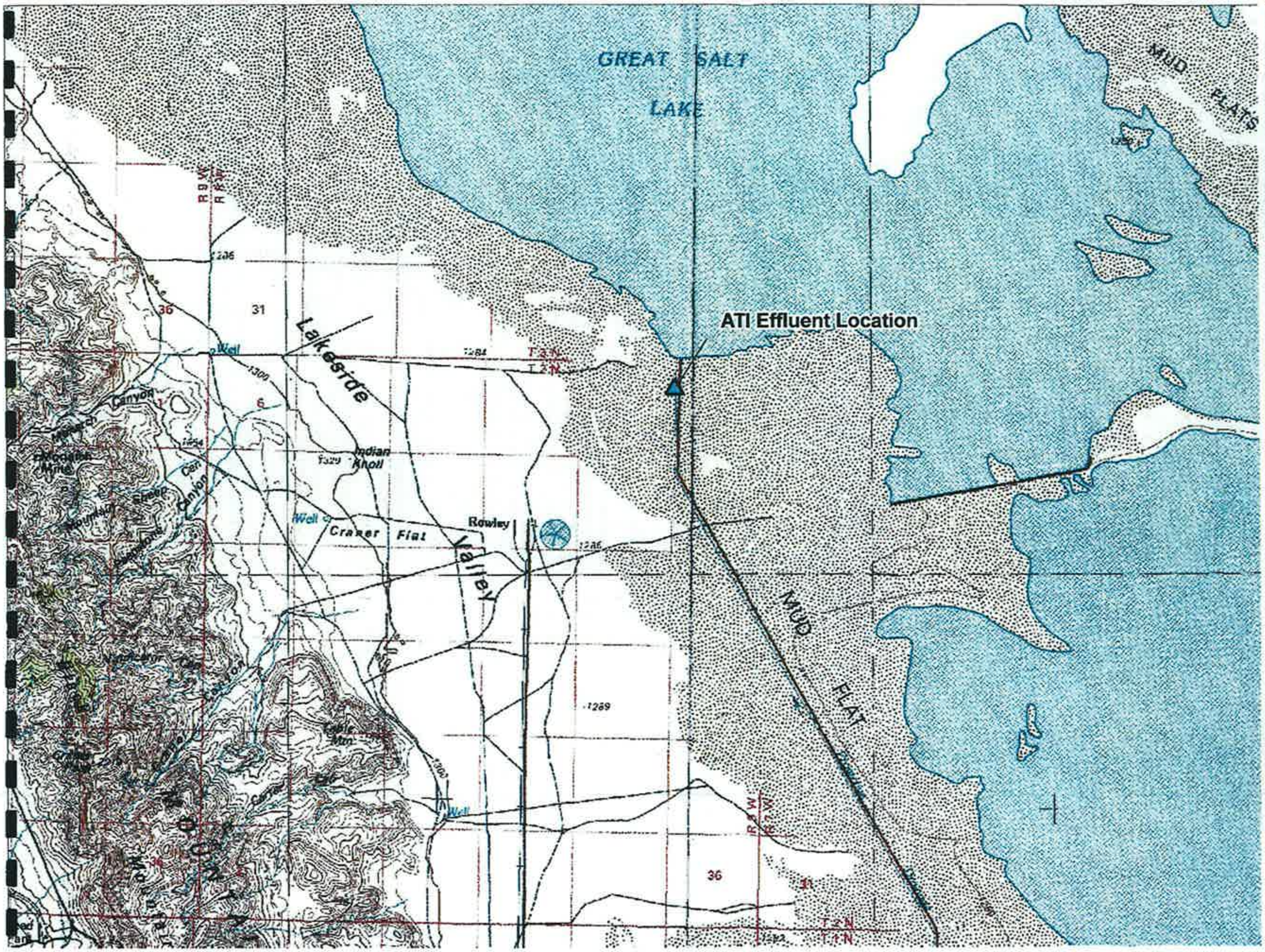
ATI Titanium LLC

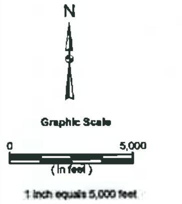
12633 Rowley Road
North Skull Valley, UT
Tooele County, Utah

Title

Site Location Map

Project No.	Scale	
25OT.52001.08	1 inch equals 2,000 feet	
Figure No.	Sheet	Revision
1		0





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Stantec

SECOR

Notes
Utah Water Rights
Tooele USGS Quadrangle
1:100,000 scale

Client/Project
ATI Titanium LLC
Ecological Risk Assessment

12366 Rowley Road
North Skull Valley
Tooele County, Utah

Title
Topographic Map

Project No.	Scale	
26OT.52001.08	1 inch equals 5,000 feet	
Figure No.	Sheet	Revision
2		0

TABLE 1
State-Listed Special Status Species in Tooele County
ATI Titanium, LLC
North Skull Valley, Tooele County

Common Name	Scientific Name	Status	Habitat[1]	Occurrence in Study Area[2]
Birds				
Northern goshawk	*Accipiter gentilis*	USPC	Prefers mature mountain forest and riparian zone habitats.	**Unlikely**; No suitable nesting or foraging locations; May fly over the study area on route to nesting/foraging habitat near the Lakeside Mountains.
Grasshopper Sparrow	*Ammodramus savannarum*	USPC	Build nests on ground at base of grasslands. Forage on the ground in vegetation mainly eating insects, especially grasshoppers, and seeds.	**Unlikely**; No suitable nesting or foraging locations directly within the study area; May nest in adjacent sagebrush areas to the south or in undisturbed areas to the west of the study area (Lakeside Mountains). May fly over the study area on route to nesting/foraging habitat.
Short-eared Owl	*Asio flammeus*	USPC	Found in grasslands, shrublands, and other open habitats. Nomadic. Forages for rodents.	**Unlikely**; No suitable nesting or foraging locations directly within the study area; May nest in adjacent sagebrush areas to the south or in undisturbed areas to the west of the study area (Lakeside Mountains). May fly over the study area on route to nesting/foraging habitat.
**Burrowing Owl	*Athene cunicularia*	USPC	Found in open grasslands and prairies as well as other open spaces (e.g. golf courses, etc.). Forages on terrestrial invertebrates and small vertebrates.	**Possible**; UDWR has recent records of occurrence within a 10-mile radius of the study area; Unlikely to use pipeline alignment due to lack of nesting or foraging locations directly within the study area; May nest in adjacent sagebrush areas to the south or in undisturbed areas to the west of the study area (Lakeside Mountains).
**Ferruginous hawk	*Buteo regalis*	USPC	Nests in grassland or shrub areas with flat and rolling terrain. Winters in open farmlands, grasslands, and deserts with abundant small mammal prey.	**Possible**; UDWR has recent records of occurrence within a 10-mile radius of the study area; Limited suitable nesting or foraging locations directly within the study area; May nest in adjacent sagebrush areas to the south or in undisturbed areas to the west of the study area (Lakeside Mountains).
Greater sage-grouse	*Centrocercus urophasianus*	USPC	Inhabit sagebrush plains, foothills, and mountain valleys. Sagebrush is the predominant plant of quality habitat.	**Unlikely**; Much of the sagebrush habitat adjacent to the study area is of lower quality; May nest in undisturbed areas to the west of the study area (Lakeside Mountains).
Yellow-billed Cuckoo	*Coccyzus americanus*	S-ESA	Nests in mature riparian woodland with dense understories of willow and other deciduous species. Nesting areas are large tracts (minimum of 3 hectares) of closed-canopy broad-leaved forest.	**Unlikely**; No suitable habitat identified within or near the study area.
Bobolink	*Dolichonyx oryzivorus*	USPC	Nest and forage in wet meadow (grasses and sedges), wet grassland, and irrigated agricultural (primarily pasture and hay fields) areas.	**Unlikely**; No suitable habitat identified within or near the study area. Wetland areas within the study consist primarily of unvegetated playas.
Bald eagle	*Haliaeetus leucocephalus*	S-ESA	Breeding generally occurs within 2.5 miles of large lakes, reservoirs, and major rivers in which there are adequate prey, perching areas, and nesting sites.	**Unlikely**; No suitable nesting, roosting or foraging locations, *no mature trees, high saline* conditions; May fly over study area.
Lewis's woodpecker	*Melenerpes lewis*	USPC	Attracted to burned-over Douglas-fir, mixed conifer, pinyon-juniper, riparian, and oak woodlands, also found in the fringes of pine and juniper stands, and deciduous forests, especially riparian cottonwoods.	**Unlikely**; No suitable nesting locations observed; May nest in undisturbed areas to the west of the study area (Lakeside Mountains).

TABLE 1
State-Listed Special Status Species In Tooele County
ATI Titanium, LLC
North Skull Valley, Tooele County

Common Name	Scientific Name	Status	Habitat[1]	Occurrence in Study Area[2]
**Long-billed curlew	*Numenius americanus*	USPC	Have four essential nesting habitat requirements in the northwestern United States: (1) short grass (less than 30-cm tall), (2) bare ground components, (3) shade, and (4) abundant vertebrate prey.	**Possible**; UDWR has recent records of occurrence within a 10-mile radius of the study area; May forage within the study area but unlikely to nest because short grass and shade requirements for nesting habitat are limited to absent directly in the study area. Slopes within pipeline greatly exceed preferred habitat for nesting for curlew.
*American White Pelican	*Pelecanus erythrorhynchos*	USPC	Preferred nesting habitats are islands. Preferred foraging areas are shallow lakes, marshlands, and rivers.	**Possible**; UDWR has recent records of occurrence within a 0.5-mile radius of the study area; Hat Island is a known nesting area 10 miles to the east and the Timpie Springs Wildlife Management Area is located 12 miles to the southeast of the project site. May fly over or land within study area on the way to suitable nesting and foraging areas.
Mammals				
**Pygmy Rabbit	*Brachylagus idahoensis*	USPC	Prefers areas with tall dense sagebrush and loose soils. Primarily forage on sagebrush, but other vegetation is also consumed.	**Possible**; UDWR has historical records of occurrence within a 10-mile radius of the study area; May inhabit adjacent sagebrush areas to the south or in undisturbed areas to the west of the study area (Lakeside Mountains).
Townsend's big eared Bat	*Corynorhinus townsendii*	USPC	Often found near forested areas. Caves, mines, and buildings are used for day roosting and winter hibernation. Forage on flying insects, particularly moths.	**Unlikely**; No suitable habitat identified within the study area.
Dark Kangaroo Mouse	*Microdipodops megacephalus*	USPC	Prefer sagebrush areas with sandy soils. Forage on seeds and insects.	**Possible**; May inhabit adjacent sagebrush areas to the south or in undisturbed areas to the west of the study area (Lakeside Mountains); May forage near or within study area.
Preble's Shrew	*Sorex preblei*	USPC	Found in many types of habitat, but the species is thought to have an affinity for wetland areas. Consumes insects, worms, mollusks, centipedes, and other small invertebrates.	**Unlikely**; This species is the rarest of Utah's 8 shrew species. Known Utah range includes only the southern shore of the Great Salt Lake.
**Kit Fox	*Vulpes macrotis*	USPC	Occurs in open prairie, plains, desert habitats. Opportunistic feeder, prefers small mammals, small birds, invertebrates and plant matter.	**Possible**; UDWR has recent records of occurrence within a 10-mile radius of the study area; May inhabit adjacent sagebrush areas to the south or in undisturbed areas to the west of the study area (Lakeside Mountains); May forage near or within study area.

TABLE 1
State-Listed Special Status Species in Tooele County
ATI Titanium, LLC
North Skull Valley, Tooele County

Common Name	Scientific Name	Status	Habitat[1]	Occurrence in Study Area[2]
Amphibians				
Columbia spotted frog	*Rana luteiventris*	CS	Prefer isolated springs and seeps that have a permanent water source. Individuals are known to move overland in spring and summer after breeding. Can occur up to 6,500 feet in elevation.	Unlikely; No suitable habitat identified within the study area.
Fish				
Bonytail	*Gila elegans*	S-ESA	Prefer freshwater eddies, pools and backwaters. Opportunistic feeders, eating insects, zooplankton, algae and higher plant matter.	Unlikely; No suitable habitat identified within the study area.
Least Chub	*Lotichthys phlegethontis*	USPC	Formerly occurred in many areas of the Bonneville Basin, including ponds and streams near Salt Lake City and the Great Salt Lake, it now occurs only in scattered springs and streams in western Utah. Prefers areas of dense vegetation in slow-moving water. Eat algae and small invertebrates.	Unlikely; No suitable habitat identified within the study area.
Bonneville cutthroat trout	*Oncorhynchus clarkii utah*	CS	Can be found in a number of habitat types, ranging from high-elevation mountain streams and lakes to low-elevation grassland streams; requires a functional stream riparian zone, which provides structure, cover, shade, and bank stability.	Unlikely; No suitable habitat identified within the study area.
Utah Physa	*Physella utahensis*	USPC	Prefer freshwater, pools and springs. Two extant occurrences of this species in Utah are known, both in northeastern Box Elder County.	Unlikely; No suitable habitat identified within the study area.
Mollusks				
California Floater	*Anodonta californiensis*	USPC	Little known. Muddy pond bottoms.	Unlikely; No suitable habitat identified within the study area.
Southern Tightcoil	*Ogaridiscus subrupicola*	USPC	Little known. Found in Clinton's Cave in Tooele County near the Great Salt Lake.	Unlikely; No suitable habitat identified within the study area.
Eureka Mountainsnail	*Oreohelix eurekensis*	USPC	Found at higher elevations in forested areas, and at the base of canyons.	Unlikely; No suitable habitat identified within the study area.
Lyrate Mountainsnail	*Oreohelix haydeni*	USPC	Found at the edges of coarse, angular limestone talus protected from rapid evaporation by overhanging bushes, formed the cover for some colonies.	Unlikely; No suitable habitat identified within the study area.
Southern Bonneville Pyrg	*Pyrgulopsis transversa*	USPC	Little known. Inhabits mineralized springs.	Unlikely; No suitable habitat identified within the study area.
Northwest Bonneville Pyrg	*Pyrgulopsis variegata*	USPC	Little known. Inhabits springs, that emerge from the ground as flowing streams.	Unlikely; No suitable habitat identified within the study area.

*Indicates species that the UDWR has recorded within a 0.5-mile radius from the study area.
**Indicates species that the UDWR has recorded within a 10-mile radius from the study area.
S-ESA = Federally listed or candidate species under the Endangered Species Act
USPC= State of Utah wildlife species of concern;
CS= State of Utah species receiving special management under a Conservation Agreement in order to preclude the need for Federal listing.
[1]Habitat descriptions from the UDWR Utah Conservation Data Center website species search pages (http:dwrcdc.nr.utah.gov/ucdc/)
[2]Occurence descriptions are based on the UDWR species searches results as well as presence or absence of habitat within the study area.