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Acronyms

ADD	average daily dose
AOC	area of concern
ASTM	American Society for Testing and Materials
AWQS	Ambient Water Quality Standard
BAF	bioaccumulation factor

Basin Plan	Water Quality Control Plan for San Francisco Bay Basin
BCF	bioconcentration factor
bgs	below ground surface
BSAF	biota-sediment accumulation factor
Cal-EPA	California Environmental Protection Agency
CCC	criterion continuous concentration
CCMVCD	Contra Costa Mosquito and Vector Control District
CCME	Canadian Council of Ministers of the Environment
CFR	Code of Federal Regulations
CNDDB	California Natural Diversity Database
COC	chemical of concern
CSM	Conceptual Site Model
DF	dilution factor
DQO	data quality objective
DTSC	Department of Toxic Substances Control (Cal-EPA)
EPC	exposure point concentration
ERA	Ecological Risk Assessment
ER-M	Effects Range – Median
ER-Mq	Effects Range – Median quotient
E-SSTL	Ecological Site-Specific Target Level
FS	Feasibility Study
HHRA	Human Health Risk Assessment
HI	hazard index
HLA	Harding Lawson Associates
HQ	hazard quotient
H-SSTL	Human Health Site-Specific Target Level
HEAST	Health Affects Assessment Summary Tables (USEPA)
IRIS	Integrated Risk Information System (Database) (USEPA)
K_d	equilibrium soil or sediment-water partitioning coefficient
LOAEL	lowest-observable-adverse-effects level
mER-Mq	mean ER-M quotient
µg/L	microgram(s) per liter

mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
MOCOCO	Mountain Copper Mining Company
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no-observable-adverse-effects level
POC	point of compliance
PQL	practical quantitation limit
PRG	(USEPA Region 9) Preliminary Remediation Goals
PUF	plant uptake factor
QA/QC	Quality Assurance/Quality Control
RA	Risk Assessment
RBCA	risk-based corrective action
RBSL	risk-based screening level
RfD	reference dose
RME	reasonable maximum exposure
RMP	Regional Monitoring Program
RWQCB	(San Francisco Bay) Regional Water Quality Control Board
SQG	sediment quality guideline
SSTL	site-specific target level
TOC	total organic carbon
TRV	toxicity reference value
TSS	total suspended sediments
URS	URS Corporation
USEPA	United States Environmental Protection Agency
WASP6	(USEPA's) Water Quality Analysis Simulation Program 6.0

A portion of Peyton Slough (5,500 feet in length), located in Martinez and flowing into Carquinez Strait, has been designated as a toxic "hot spot" by the San Francisco Bay Regional Water Quality Control Board (RWQCB). The designation was based on elevated concentrations of copper and zinc in the Existing Slough, attributed to historical activities associated with disposal of mine spoils, cinders, and slag by Mountain Copper Mining Company. The property, now owned by Rhodia Inc., is the subject of a RWQCB Order requesting that human health and ecological risk assessments be conducted at the Site and Existing Slough along with an evaluation of groundwater quality. On behalf of Rhodia Inc., URS Corporation (URS) has prepared this human and ecological risk assessment and groundwater evaluation to comply with the RWQCB Order.

In compliance with the RWQCB Order, the three objectives of this report are to:

- Evaluate the results of the tiered risk assessment to refine potential areas of concern (AOCs) presented in the *Addendum to the Feasibility Study and Conceptual Remedial Action Plan* (FS; URS 2002).
- Evaluate groundwater conditions adjacent to the Existing and New Sloughs to determine points of compliance for the New Slough alignment and groundwater concentrations (groundwater trigger levels) that may trigger additional action.
- Propose target cleanup levels for soil/sediment that may remain in place after the remedial alternative is implemented.

Among the remedial alternatives presented in the FS, Alternative 7 – realignment of the Existing Slough and backfilling/capping the Existing Slough – has been identified as the preferred alternative. Therefore, in addition to evaluating conditions in the Existing Slough, the risk assessment and groundwater evaluation include a limited evaluation of the proposed alignment for the New Slough.

Existing Slough

After identifying data gaps in the historical data, URS collected additional samples to characterize the Site in 2001 and 2002, including soil, sediment, surface, groundwater, plant tissue, and invertebrate tissue samples. Toxicity tests based on sediment elutriates and bioaccumulation studies were also performed.

Refinement of the potential AOCs was conducted through a tiered approach to risk assessment that focused the assessment on the areas that warrant remedial attention. In Tier 1 (screening level), Risk-Based Screening Levels (human health) or Effects-Range Median (ER-Ms) (Long et al. 1995) ecological, were used to screen representative concentrations in media from the existing and New Sloughs. In Tier 2, site-specific target levels (SSTLs) were developed for human and ecological receptors and for exposure scenarios that were appropriate for the Site.

The results of the Ecological Risk Assessment indicated that the majority of the dredge spoil piles along the northern and southern portions of the Existing Slough exceeded ER-Ms for copper and zinc. In addition, all the samples from the spoil piles that were subjected to toxicity testing proved to be significantly toxic. SSTLs for food-web-based ecological receptors also were exceeded in many areas of the spoil piles. Similarly, sediments in the bed of the Existing Slough, and to a lesser extent, in the embankments along the sides, had numerous exceedances of

ER-Ms. The human health SSTLs for the higher elevation upland portions of the Site were not exceeded by Site concentrations of copper and zinc. However, sediments in portions of the Existing Slough north of the tide gate did exceed the human health SSTLs for fish consumption. Therefore, based on their potential for impacts to human health and the environment, the dredge spoil piles along the sides of the length of the Existing Slough are proposed as AOCs. Additionally, sediments and surface water in the Existing Slough, where risk-based SSTLs are exceeded are also proposed as AOCs.

The groundwater evaluation assessed the potential for groundwater from the vicinity of the Existing Slough to impact sediment and surface water quality in the New Slough. The results of this evaluation indicate that, provided the dredge spoil piles and underlying root mat that may be impacted are removed from areas south of the tide gate, groundwater impacts to the New Slough alignment (both north and south of the levee) will not be significant.

An absence of vegetation and biota living in the piles also supports this conclusion. In addition, the results of the Ecological Risk Assessment confirm that sediments of the Existing Slough bottom and sidewalls are AOCs and should be managed through remedial action. Risks through exposure to surface water will be eliminated when the Existing Slough is rerouted into the New Slough alignment. During remedial design and capping, the lowest of the E-RMs, E-SSTLs, and construction worker H-SSTLs may be used as target levels to evaluate the residual concentrations of chemicals in the cap for the Existing Slough.

<u>For the wetland habitat</u>, a two-step process is proposed for the use of target cleanup levels for soil and sediment that may remain in place after the remedial alternative is implemented. In the first step, sediments with residual concentrations of chemicals where the probability of adverse effects is high will be identified for removal or remediation efforts (i.e, concentrations exceed the lower of the ER-Ms or lowest-observable-adverse-effects level [LOAEL]-based SSTLs). In the second step, sediments with residual concentrations where the potential for adverse effects is moderate will be proposed for in-place risk management or for other risk reduction measures that may not necessarily include removal (i.e, concentrations are lower than ER-Ms or LOAEL-based E-SSTLs but exceed no-observable-adverse-effects level [NOAEL]-based E-SSTLs).

The target cleanup goals were selected after review of the SSTLs for all the evaluated wetland receptors. The target cleanup goals that are proposed for the first step (effect-based SSTLs) are 270 milligrams per kilogram (mg/kg) for copper and 410 mg/kg zinc for wetland habitats, based on the ER-Ms. Exceedance of these values indicates the potential for toxicity to the benthic community. Sediments that exceed these values would be proposed for active remediation. The target values that are proposed for the second step are 239 mg/kg for copper and 251 mg/kg for zinc in the wetland habitat (protective of the salt marsh harvest mouse). Sediments that exceed these values but that are below the ER-Ms may be recommended for in-place management and/or risk reduction.

<u>For the aquatic habitats</u>, only one set of target cleanup levels is proposed, the ER-Ms (270 mg/kg for copper and 410 mg/kg for zinc). Because the NOAEL-based E-SSTLs for the aquatic habitat were higher than the ER-Ms, use of the NOAEL-based E-SSTLs to identify areas suitable for in-place management may not be protective of the benthic community. Therefore, sediments exceeding the ER-Ms in aquatic habitats would be proposed for active remediation.

New Slough

Overall, concentrations of chemicals of concern detected in the New Slough vicinity are lower than the concentrations detected in the Existing Slough, and pH levels are also higher in the New Slough sediments. The reason for this decrease in these concentrations in the New Slough is the differences in sediment characteristics between the two areas. Sediments in the New Slough alignment are expected to be primarily native sediments of the marsh and have little or no association with the mineralized and exposed dredge spoil piles along the sides of the Existing Slough. The deeper sediments of the New Slough are also expected to have different physical and chemical characteristics (e.g., grain size, total organic carbon, sulfide) than the dredge spoil piles in ways that are likely to decrease the bioavailability of chemicals in these sediments.

Conditions in the area of the New Slough were evaluated in the shallow sediments (0-4 feet bgs) and deeper sediments (below 4 feet bgs) based on limited initial sampling. Materials in the shallow sediments that may be considered for use as cap material for the Existing Slough do not pose a threat to human health but may be of some concern to ecological receptors if exposure pathways are complete in the cap material. Deeper sediments in the New Slough are also not of concern from a human health standpoint but may exceed some of the more conservative target levels for ecological receptors. The bioavailability of chemicals in the deeper sediments would be influenced by factors such as total organic carbon, grain size, and sulfides. The bioavailability of these chemicals is being evaluated as part of the cap design. Therefore, the exceedance of some E-RMs or E-SSTLS does not necessarily mean that adverse effects are likely or will be observed. The potential for sediment and surface water in the New Slough to be adversely impacted by groundwater transport of contaminants is negligible as long as the assumptions of the modeling effort are met. The lowest of the E-RMs, E-SSTLs, and angler-based H-SSTLs may be used as target levels to evaluate the exposure concentrations for sediments that will be exposed after construction of the New Slough.

A portion of Peyton Slough, located in Martinez and flowing into Carquinez Strait, has been designated as a toxic “hot spot” by the San Francisco Bay Regional Water Quality Control Board (RWQCB). The designation was based on elevated concentrations of copper and zinc in the Existing Slough, attributed to historical activities associated with disposal of mine spoils, cinders, and slag by Mountain Copper Mining Company (MOCOCO). The property, now owned by Rhodia Inc., is the subject of a Section 13267 letter from the RWQCB requesting remedial action as well as an Order, Site Cleanup Requirements for Rhodia Inc. (2001), requesting that a human health and ecological risk assessment (RA) be conducted at the Site and Existing Slough along with an evaluation of groundwater quality to establish cleanup standards under Task C.2. On behalf of Rhodia Inc., URS Corporation (URS) has prepared this RA and groundwater evaluation to comply with the RWQCB Order.

Rhodia operates a sulfuric acid regeneration facility located at 100 Mococo Road in Martinez, California. The property is composed of approximately 114 acres immediately east of Interstate 680 on the south shore of Carquinez Strait, adjacent to the southern end of the Benicia Bridge (Figures 1-1, 1-2). It has been in continuous industrial use since the early 1900s and was originally owned by MOCOCO. MOCOCO operated a copper ore smelter until 1966. Waste by-products from the smelting operation, including cinders and slag, were disposed in piles on the property. Stauffer Chemical Company purchased the property from MOCOCO in 1968 and constructed a sulfuric acid regeneration and manufacturing facility, which has been in operation since 1970. Rhodia currently owns and operates the sulfuric acid regeneration and manufacturing facility.

As shown on Figure 1-2, the subject portion of the Existing Slough (“the Site”) is located between Waterfront Road and Carquinez Strait. The Site is composed of an approximately 5,500-foot-long segment of the north-flowing slough. The Site has been subdivided into the “north slough” and the “south slough,” which are separated by a tide gate located approximately 2,400 feet south of Carquinez Strait. The Existing Slough, particularly the northern segment, has been the subject of several environmental investigations to evaluate metals concentrations in soil and sediment. Copper and zinc have been identified as the primary chemicals of concern (COCs) and are used as indicators of metals contamination at the Site. The low levels of pH in groundwater and soil/sediment are also of concern and contribute to the release of the metals, adding complexity to the assessment of metal transport to the Existing Slough from groundwater and dredge spoil piles. Based on the results of previous studies conducted at the Site, the RWQCB Bay Protection Toxic Cleanup Program has identified the Existing Slough as one of the “toxic hot spots” within the San Francisco Bay Area (RWQCB 1999). Subsequently, under Section 13267 of the California Water Code, the RWQCB requested that Rhodia develop a remedial action plan that addresses the COCs within the Existing Slough.

To comply with the requirements of the RWQCB request, URS prepared a Feasibility Study (FS) that identified potential areas of concern (AOCs) based on areas containing sediment concentrations in exceedance of levels (effects range-median [ER-M]) at which probable adverse effects to marine benthic organisms would occur (Long et al. 1995). Subsequently, the RWQCB prepared a Final Order (2001).

In compliance with the RWQCB Order, the three objectives of this report are to:

1. Evaluate the results of the tiered RA to refine potential AOCs presented in the *Addendum to the Feasibility Study and Conceptual Remedial Action Plan* (FS; URS 2002).

2. Evaluate groundwater conditions adjacent to the Existing and New Sloughs to determine points of compliance (POCs) for the New Slough alignment and groundwater concentrations (groundwater trigger levels) that may trigger additional action.
3. Propose target cleanup levels for soil/sediment that may remain in place after the remedial alternative is implemented.

Among the remedial alternatives presented in the FS, Alternative 7 – realignment of the Existing Slough and backfilling/capping the Existing Slough – has been identified as the preferred alternative. Therefore, in addition to evaluating conditions in the Existing Slough, the RA and groundwater evaluation include a limited evaluation of the New Slough alignment (Figure 1-2).

As part of this effort, additional data were collected to better evaluate groundwater and sediment conditions, refine the AOCs that may require remediation, and determine groundwater and risk-based trigger values that are protective of human and ecological health. Groundwater and soil data collected along the New Slough alignment assisted in these endeavors.

This report presents the findings of the two-tiered RA (described in Section 3.1) that was conducted to evaluate the potential risks to human health and the environment posed by the COCs identified during previous environmental investigations. Benchmarks for direct toxicity and Site-specific target levels (SSTLs; i.e., COC concentrations in soil/sediment and groundwater that are safe for human and ecological receptors) were developed for the Site. The SSTLs for groundwater and soil/sediment were based on protection of the following elements: human and ecological health, waters of the state, and beneficial uses of the Site. The groundwater evaluation assessed the potential for groundwater from the vicinity of the Existing Slough to adversely impact surface water and sediment in the New Slough. Based on the results of the RA and groundwater evaluation, AOCs were identified that pose an unacceptable risk and were considered for potential remedial or risk management actions.

The remainder of this report is organized as follows:

- Section 2: Project Description
- Section 3: Project Approach
- Section 4: Results of Recent Data Collection
- Section 5: Human Health Risk Assessment
- Section 6: Ecological Risk Assessment
- Section 7: Groundwater Evaluation and Cleanup Standards
- Section 8: Identification of Areas of Concern
- Section 9: Evaluation of New Slough Alignment
- Section 10: Summary and Conclusions
- Section 11: Recommendations
- Section 12: References

2.1 SITE DESCRIPTION

The Site is located adjacent to the Rhodia Property and is approximately 5,500 feet long, extending from Carquinez Strait to Waterfront Road (Figure 1-2). A key function of the Existing Slough is to provide tidal exchange between Carquinez Strait and McNabrey Marsh, located to the south of Waterfront Road. The Existing Slough is surrounded by marshlands on the east from Carquinez Strait to Waterfront Road. The Existing Slough continues south under Waterfront Road to McNabrey Marsh. However, the portion of the Existing Slough subject to this RA is located beween Waterfront Road and Carquinez Strait.

2.1.1 Site History

Rhodia operates a sulfuric acid regeneration facility at the Site in Martinez, California. The property comprises approximately 114 acres immediately east of Interstate 680 on the south shore of Carquinez Strait, adjacent to the southern end of Benicia Bridge. The Site has been in continuous industrial use since the early 1900s. MOCOCO used the Site for smelting copper ore until 1966. Waste by-products from the smelting operation, including cinders and slag, were disposed in piles on Site. Stauffer Chemical Company purchased the property from MOCOCO in 1968 and constructed a sulfuric acid and oleum manufacturing facility, which has been in operation since 1970. In 1988, Rhone-Poulenc Inc., acquired Stauffer and in 1998 Rhodia Inc. was created as an independent corporation of Rhone-Poulenc to which the Site and operations were transferred.

The entire Existing Slough has been dredged repeatedly in the past. Dredge spoils were placed along both banks of the Existing Slough in linear piles of unknown thickness. Currently, portions of the piles rise to +5 feet NGVD-29, and some remain without vegetation. The unvegetated portions range in size and are located directly adjacent and parallel to the Existing Slough.

2.1.2 Land Use

The property owned by Rhodia Inc. is currently industrial and is expected to remain under this land use indefinitely. The *Water Quality Control Plan for the San Francisco Bay Basin* (Basin Plan [RWQCB 1995]) lists existing and potential beneficial uses of Peyton Slough as a tributary to Carquinez Strait. The listed beneficial uses include:

- Ocean, Commercial and Sport Fishing
- Industrial process supply or service supply
- Water contact and noncontact recreation
- Wildlife habitat
- Fish migration and spawning
- Navigation
- Estuarine habitat

- Preservation of rare and endangered species

The cleanup standards developed are to protect human and ecological health, the waters of the State of California, and the beneficial uses listed above.

2.1.3 Geology/Hydrology

The Site is located in California's east-central Coast Range geomorphic province. The topographically elevated portions of the Site reside on artificially graded hills that are Cretaceous and Paleocene shale and sandstone. Topographic lows are Quaternary Bay Muds, sands, and peats of the Sacramento/San Joaquin fluvial-deltaic system. The low-lying areas were variously filled or otherwise covered with mining wastes composed of cinders and slag (Class B mining waste). Portions of the cinder and slag piles have sunk into the Bay Mud and remain buried.

The Site is located in the McNabrey Marsh/Peyton Slough Groundwater Basin, to the west of the Ygnacio Valley Groundwater Basin and to the east of the Alhambra Valley Groundwater Basin. Potential beneficial uses for the Ygnacio Valley Groundwater Basin include (1) municipal and domestic water supply, (2) industrial process water supply, (3) industrial service water supply, and (4) agricultural water supply (RWQCB 1995). Due to high total dissolved solids and salinity, the groundwater beneath and adjacent to Peyton Slough is not considered a source of drinking water, and no drinking water wells are located within a mile of the Site. The Site is primarily located just above sea level, with shallow groundwater found zero to 12 feet below the topographic lows. Groundwater flow is controlled by topography, flowing from highs to lows.

During the site investigation performed by URS, trenches were excavated in the west bank of the Existing Slough from the tide gate to approximately 700 feet south of the tide gate. In summary, the trenches were composed of three layers of material: (1) the upper surface layer consisting of imported fill, (2) the intermediate layer consisting of intermixed fill and clay, and (3) the saturated or deeper layer consisting of undisturbed Bay Mud.

Site hydrology plays a role in the continuing contamination of Peyton Slough. The sediments in Peyton Slough are impacted by copper and zinc that are conveyed into the Slough as dissolved constituents in groundwater that flows through preferential pathways or as overland flow into Peyton Slough.

Some time after the MOCOCO copper smelting operation began, the original meandering Slough was straightened and redredged to the current alignment. A review of historic photographs taken in the 1950s and 1960s shows that the original Slough was left open and most likely had some continuing hydraulic connection to the realigned Slough. When the copper smelting operation ceased, the old (paleo) Slough alignment as well as other low spots on the site were filled to grade with copper smelter slag and cinders taken from a nearby cinder/slag pile and then covered with imported fill material. The portion of the cinder/slag pile that subsided below grade was also covered in place.

Observations made at the site suggest that the cinder-filled paleo-Slough may be contributing contaminated groundwater that seeps into the Existing Slough immediately south of the tide gate. Shallow groundwater samples collected from this area contain high levels of copper and zinc (URS 2002). The subgrade portions of the old cinder/slag piles also contribute contaminated groundwater to the flow through a shallow near-surface zone made up of cinders/slag and fill. Groundwater in the shallow zone is believed to flow into Peyton Slough south of the tide gate.

During periods of high rainfall, when groundwater levels are at their highest, this shallow groundwater flow surfaces and enters the slough as overland flow south of the tide gate. Rainfall falling on unpaved portions of the site contributes to the shallow groundwater flow as well as to overland flow into the slough.

Geotechnical analysis was performed on 20 sediment samples from five stations north of the tide gate and five stations south of the tide gate. The sample descriptions indicated that all samples consist of clay (Bay Mud) ranging in color from grayish brown to black and usually with organics or peat.

2.1.4 Ecological Setting

The Site has been subdivided into the "north slough" and the "south slough," which are separated by a tide gate and levee located approximately 2,400 feet south of Carquinez Strait. The central portion of the Existing Slough, in the vicinity of the tide gate area, lies within the Rhodia property. The State of California owns both the northern and southern portions of the Existing Slough. An easement, controlled by the State of California, exists for the portion of the Existing Slough running through the Shore terminals property. (The New Slough realignment will have similar features to the Existing Slough and will not be described separately.) Purchase of the property to the west of the New Slough is expected as part of the alternative (Figure 1-2).

The following subsections describe the ecological conditions and potential species associated with the two main areas in the Existing Slough: north slough and south slough.

2.1.4.1 North Slough (from the Tide Gate to Carquinez Strait)

The north slough is 2,400 feet long, generally 30 to 40 feet wide and extends from Carquinez Strait to the tide gate. The tide fluctuates approximately 6 feet from mean high to mean low tide. At low tide, minimum water depth is approximately 2 feet and most of the Existing Slough embankments have a vertical face approximately 3 to 5 feet high. The east and west embankments of the north slough are densely vegetated. The vegetation adjacent to the north slough is predominantly tule reeds (common bullrush [*Scirpus acutate*] and wool grass [*Scirpus cyperinus*]). The tule reeds extend from the Existing Slough-bank back to about 40 to 50 feet inland. The embankments become inundated due to their low elevation, and the water line extends up to approximately 20 feet into the vegetation. Several tributary sloughs intersect the eastern embankment of the Existing Slough. A large marsh occupies the area east of the north slough.

The Existing Slough is surrounded by marshland with soft sediment. The east side of the Existing Slough is virtually inaccessible. Only a small portion is accessible by vehicle near the Rhodia Polishing Pond on the eastern side of the tide gate. No other access routes to the cinder and dredge spoil piles exist on the eastern embankment, with the exception of the Existing Slough itself. Based upon a site reconnaissance conducted by URS, biological surveys performed by Avocet Research Associates, and a review of historical data, a number of species were found to be present. Transitional benthos include predominantly oligochaetes (78%), chronomids (10%), *Ilyocryptus pinifer*, calanoid copepods, and more pollution-tolerant amphipods (*Corophium spinicorne*) (Hunt et al. 2001; URS field observations; Hagar and Demgen 1987; Kitting 2000). (Further information on the benthic assemblage is described in Section 6.5.) The majority of fish collected between 1986 and 1987 included *Gambusia affinis* (mosquito fish, 67%), *Gasterosteu aculeatus* (threespine stickleback, 14%), and *Cyprinus carpio* (common carp, 10%), and Sacramento beachfish (*Orthodon microlepidotus,* 5%) (Hagar and Demgen 1987). Fish species such as the delta smelt (*Hyposmesus transpacificus*), yellow split-tail (*Pogonicthys acrolepidotus*), and sturgeon (*Acipenser* spp.) are also known or likely to use this Slough for spawning.

2.1.4.2 South Slough (from the Tide Gate to Waterfront Road)

The south slough is 3,150 feet long and averages approximately 50 feet wide. Under the current tide gate function, the influence by tides in the south slough is minor. The water level varies by approximately ½ foot. The width ranges from less than 10 feet wide at the southern end near the culvert under the railroad embankment to approximately 60 feet near the tide gate. The vegetation adjacent to the south slough is predominantly common cattails (*Typha angustifolia*) and grass. The cattails are usually in a thin band adjacent to the Existing Slough and in a thick band up to 30 to 40 feet wide in the former paleochannels. The tops of the embankments are vegetated with coyote brush (*Baccharis pilularis*) and grass.

Benthic species in the south slough include primarily oligochaetes (80%) and ostracods (12%). Fifteen fish species, five of which were native, were recently collected in the south slough near the entrance into McNabney Marsh. These native species included a chinook salmon (*Oncorhynchus tshawytscha*) smolt, but no Delta smelt or split-tail (Kitting 2000). The majority of fish collected in the south slough between 1986 and 1987 included goby (*Acanthogobius flavimanus,* 32%), split-tail (*Pogonichthys macroleptidotus,* 23%), threespine stickleback (*Gasterosteus aculeatus,* 20%), and inland silversides (*Menidia berrylina,* 8%) (Hagar and Demgen 1987).

The Existing Slough has been realigned to reflect its present course. The paleochannels of the current dredged Slough intersect both the east and west banks (Figure 2-1). The paleochannels are low, marshy areas with dense cattails. Slightly higher, grassy areas adjacent to and on Zinc Hill to the east of the south slough are grazed by cattle. The slopes of Zinc Hill lie within 150 feet of the east bank. A freshwater seasonal marsh lies adjacent to the west bank of the south slough to the south of the property fenceline.

Currently, no access to the paleochannels on the east side of the Existing Slough by vehicles and equipment is available except in the vicinity of the tide gate as discussed above. Portions of the banks have tall vegetation, limited to the shoreline. These areas are interspersed with grassy areas on the embankments that are easily accessible by boat. An overgrown vehicle track exists along the base of Zinc Hill, on Shore terminal's property.

2.2 HISTORICAL DATA QUALITY SUMMARY

Seven sediment sampling events took place from 1986 to 2000 at the Site. Previous environmental investigation work has been performed by CH2M Hill, the RWQCB, Harding Lawson Associates (HLA), and URS. Data collected were generally of good quality and were used in their entirety for the RA and groundwater evaluation as appropriate.

URS took additional samples from the Existing Slough sidewalls, dredge spoil piles, and shallow trenches to identify potential AOCs. The goal of this study was to investigate the contribution of bank sediment and dredge spoil piles to the concentration of copper and zinc in the Existing

Slough. The remaining studies focused on evaluating the extent of sediment contamination. In all, 28 north slough and seven south slough sediment samples were taken from the Site at approximately 22 different locations (Figure 2-2). Five north and five south slough embankment locations were sampled on the east and west side of the Existing Slough and analyzed at up to two depths, for a total of 26 samples. Nine north and 11 south slough dredge spoil sample locations were collected, and 24 trench soil samples were collected from the 12 trenches created. Sample locations are presented on Figures 2-3 through 2-5.

2.2.1 Summary of Previous Studies

As mentioned previously, Peyton Slough has been the subject of several environmental investigations over the past 10 years. Environmental investigation work was performed by CH2M Hill in 1986, the Bay Protection and Toxic Cleanup Program in 1991, RWQCB in 1995 and 1997, HLA in 1998 and 1999, and URS in 2000. Previous investigations have focused on sediments in the north slough and found that the sediments contain elevated concentrations of metals (copper and zinc, primarily). URS, on behalf of Rhodia Inc., collected additional data in 2000 including Existing Slough sidewall, dredge spoil pile, and shallow trench samples to identify potential AOCs, as described below.

The original source of the metals is believed to be cinder and slag bodies, a product of historic copper smelting operations. The only investigation of the south slough involved the analysis of sediment samples from the bottom of the Existing Slough in 1999 by HLA. The URS investigation focussed on expanding HLA’s investigation to better characterize the distribution of metals in the south slough and to identify additional potential AOCs. Potential AOCs were previously defined as areas that contain elevated metals concentrations within the Existing Slough or immediately adjacent source areas that may potentially contribute metals into the Existing Slough.

Because bottom sediments were known from previous investigations to contain elevated concentrations of metals, URS did not chemically analyze additional bottom sediment samples (Figure 2-2). However, the extent of metals in the Existing Slough sidewalls was unknown. Therefore, soil samples were collected for analysis from various locations along the sides of the Existing Slough to evaluate whether the sides of the Existing Slough should be included in the future remedial dredging program. Previous dredging operations by the Contra Costa County Mosquito and Vector Control District and others deposited the dredge spoils from the bottom of the Existing Slough on the top of embankments adjacent to the Existing Slough. Much of this material remains unvegetated. URS collected samples of the side-cast dredge material for analysis to evaluate whether the material may be an ongoing source of elevated metals in the Existing Slough. In addition, URS excavated trenches adjacent to the Existing Slough to investigate whether cinders and surface fill are present in the Existing Slough sidewalls, and to determine the presence/absence of the former paleoslough channel.

The overall purpose of the investigation in 2000 was to identify any additional areas in, or immediately adjacent to, the Existing Slough with elevated concentrations of metals exceeding ER-M values. These areas were identified as potential AOCs. The potential AOCs identified included (1) the bottom of the Existing Slough from the mouth of the Existing Slough to approximately 2,500 feet south of the tide gate, (2) limited areas of the Existing Slough sidewall, and (3) dredge spoil piles located immediately adjacent to the Existing Slough (Figures 2-2 to

2-6). The sidewalls and dredge spoil piles are a potential concern because they may be an ongoing source of elevated metals to the Existing Slough.

In summary seven investigations have been performed at the Site. A total of 72 locations have been sampled to date. Based on the results of these sampling events, copper and zinc are identified as having a potential to cause adverse impacts within the Existing Slough. These chemicals tend to be concentrated in the groundwater, Slough sediment, and dredge spoil piles.

This section describes the overall approach for risk assessment that is proposed for the Site. The ultimate goal of this evaluation, per the RWQCB Order, is twofold: (1) to address the human health and ecological risk associated with the Existing Slough conditions and (2) evaluate the risk associated with any residual groundwater and/or soil/sediment contamination of copper and zinc or low levels of pH that would remain in place following implementation of the chosen remedial alternative. Among the remedial alternatives presented in the FS, Alternative 7 – realignment of the Existing Slough and backfilling/capping the Existing Slough – has been identified as the preferred alternative. Therefore, in addition to evaluating conditions in the Existing Slough, the RA and groundwater evaluation include a limited evaluation of the proposed alignment for the New Slough. The three specific objectives of this report were previously presented as follows:

- Refine the AOCs to be remediated or managed in place.
- Evaluate groundwater conditions adjacent to the Existing and New Sloughs to determine POCs and groundwater levels that may trigger additional action.
- Propose groundwater and soil/sediment cleanup standards for all compliance wells, and soil/sediment that may remain in place after the remedial alternative is implemented.

The proposed target values or cleanup levels determined for groundwater and soil/sediment were based on protection of the following: human and ecological health, waters of the state, and beneficial uses of the Site.

3.1 OVERVIEW OF TIERED APPROACH

The RA is based on a tiered framework that is consistent with guidance from the U.S. Environmental Protection Agency (USEPA 1998), Department of Toxic Substances Control (DTSC 1996), American Society for Testing and Materials (ASTM 2000), and the RWQCB. The tiered approach has been popularized by the use of the Risk-Based Corrective Action (RBCA) approach published by ASTM (2000) and includes several steps in site characterization and risk analysis. The advantages of this approach are:

- Each tier represents an increasingly site-specific and complex level of effort in evaluating the Site.
- At the end of each tier, a decision can be made on the AOCs, whether each area can be recommended for no further action or whether additional effort or remediation is necessary.
- Data collection involves only the quantity and quality of data needed to make a decision at each tier, ensuring that data collection is neither inadequate nor excessive but is optimally targeted to decision-making needs.

For the Site, the purpose of the tiered RA is to evaluate if the concentrations and distribution of chemicals detected in Site media (soil/sediment, surface water, and groundwater) warrant remedial action for the protection of human health and the environment. The objectives of the RA are:

- Apply a tiered approach to calculate acceptable chemical concentrations (SSTLs) in sediment/soil and groundwater that will not pose a risk to human health and the environment.

- Refine the AOCs on the basis of potential for risk to human or ecological receptors.
- Apply the results of the above to support risk management decisions that are appropriate for the Site.

3.2 SITE CHARACTERIZATION

Site characterization included examining existing data and collecting additional data to understand the distribution of copper, zinc, and pH on the Site. Groundwater analysis in existing and new wells and surface water and sediment samples collected from the Existing Slough allowed determination of groundwater flow and conditions on the Site. Biological testing, including toxicity and bioaccumulation tests, and review of biological surveys were used to evaluate the potential for biological impacts. Two tasks essential to the completion of the site characterization were: refinement of AOCs at the Existing Slough and characterization of the New Slough alignment. Existing and additional data were used to refine the AOCs in an effort to identify areas that will need active remediation or management in place. Data collected along the New Slough alignment helped in the determination of whether this area is an appropriate location for the New Slough and to ensure that concentrations of COCs do not pose unacceptable risks to human health and the environment.

Section 9 presents the additional data collected along the New Slough alignment and from the Existing Slough for purposes of site characterization and risk assessment.

3.2.1 Areas of Concern

Potential AOCs were initially identified in the FS (URS 2002) as those areas that exceeded the ER-M (Figure 2-6; Long et al. 1995). In Tier 1 of the RA, sample locations containing soil/sediment with a pH of less than 6.5, or COC concentrations exceeding the lower of the ER-M (Long et al. 1995) or human health-based Risk-based screening level (RBSL) for soil (RWQCB 2000) were identified as AOCs. If ambient sediment/soil concentrations for copper and zinc (RWQCB 1998 or Regional Monitoring Program [RMP] 1999 data) were above the ER-M and RBSL, exceedance of the ambient concentration was used to identify the AOC. The need to identify AOCs for groundwater was evaluated based on numerical groundwater quality limits that were developed using site-specific modeling and consideration of water quality objectives and sediment quality goals for copper and zinc in the New Slough (40 Code of Federal Regulation [CFR] Part 131, May 18, 2000; Long et al. 1995).

In Tier 2 the potential AOCs were refined to hone in on the areas that need to be remediated or managed in place. AOCs were identified primarily on the basis of point-by-point comparisons of data from individual sampling locations with four measures of risk: (1) sediment/soil concentrations in exceedance of the lowest SSTL (target value) among those calculated for ecological and human health receptors, (2) sediment/soil concentrations in exceedance of the ER-M, (3) sediment/soil indicates positive toxicity from bioassay results of dredge spoil sediments, or (4) surface or groundwater concentrations in exceedance of the criterion continuous concentration (CCC) after modeling or mass balance dilution and precipitation factors in groundwater are taken into account at the POC. Further investigation, monitoring, and fate and transport modeling may also be used in refining the exposure and risk evaluation prior to assessing need for remedial action.

3.2.2 New Slough Area

Additional characterization of soil and groundwater for the new alignment on the south side of the levee of Peyton Slough was conducted. The purpose of this work was to determine (1) the extent of soil contamination from surface soils that may have spread during periods of inundation, (2) groundwater quality, and (3) the thickness and depth of dredge spoils in the embankments along the eastern side of the Existing Slough that would be placed in the Existing Slough during remediation.

The data collected were used to determine the feasibility of the preferred remedial alternative, Alternative 7. Soil and groundwater grab samples were collected from twelve locations, three of which are located on the dredge spoil pile on the southeastern bank of the Existing Slough. Data collected for this effort were used in the groundwater evaluation to characterize groundwater transport to the New Slough and were included as data for the RA. Upon validation of the new data, the finalized data set was carried through the Tier 1 screening process as described below.

3.3 GROUNDWATER EVALUATION AND CLEANUP STANDARDS

The groundwater evaluation was performed to establish groundwater cleanup standards for Peyton Slough. A water quality protection strategy for maintaining beneficial water uses in Peyton Slough was developed, including the use of a groundwater monitoring well network with designated POCs and guard wells. Groundwater concentrations of copper and zinc that may limit the attainment of water quality goals for beneficial uses and/or environmental protection values in the new alignment of Peyton Slough were developed for use as Water Quality Protection Standards (i.e., numerical water quality limits).

A mathematical model was developed to simulate interactions between groundwater, tidal surface water flows, and benthic/sediment porewater in the new alignment of Peyton Slough. Based on site-specific input parameters, the model calculates copper and zinc groundwater concentrations at POCs that may lead to an incremental impairment of water or sediment quality by margins representing National Ambient Water Quality Criteria/California Toxics Rule concentrations in adjacent surface water or ER-M values in the benthic sediment layer of the New Slough.

3.4 RISK EVALUATION AND DEVELOPMENT OF SOIL/SEDIMENT CLEANUP STANDARDS

The risk evaluation process considered both human health and ecological risks as separate and parallel processes in a tiered approach. In Tier 1, a screening-level assessment was conducted based on sediment quality guidelines (SQGs), ambient water quality standards (AWQSs), or RBSLs. In Tier 2, SSTLs were developed for human health and ecological receptors. Risks to ecological and human receptors through trophic transfer through the food web are evaluated with SSTLs which represent acceptable concentrations in soil/sediments. These acceptable concentrations, or target values, are calculated by setting a hazard quotient (HQ) to one (1) and back-calculating a no observable effect level-based concentration for ecological receptors (E-SSTL). For human receptors, H-SSTLs are based on a target risk level of 1×10^{-6} for cancer risks and a HQ of 1.0 for noncancer effects. SSTLs are more readily comparable to site concentrations than forward-calculated HQs because they are expressed as concentrations in media (e.g., milligrams per kilogram [mg/kg] COC in sediment).

3.4.1 Human Health

For the Human Health Risk Assessment (HHRA), the Site was divided into an upland area and the Existing Slough area. The upland area is characterized by periodically inundated soil/sediment in the raised areas along the Existing Slough and the Rhodia plant where exposure scenarios for humans are limited to the maintenance and construction workers and the occasional upland recreator. The Existing Slough area is inaccessible to most people and exposure is most likely only for construction workers who may work on the Existing Slough itself and for recreational boaters/ anglers who may enter the existing or New Slough by boat from Carquinez Strait.

Site sediment and soil data were evaluated with respect to their exceedance above background concentrations, where background is defined as areas free of site-related chemicals. The purpose of this comparison is based on the understanding that naturally occurring chemicals (metals) cannot be remediated to levels lower than their background concentrations, even if such background exceeds theoretical conservative risk thresholds. For sediment at the Site, background concentrations were represented by the ambient concentrations in San Francisco Bay (RWQCB 1998) (Table 3-1) or 1999 RMP data collected from three locations in the vicinity of the Site (Pacheco Creek, Grizzly Bay, and Honker Bay). RMP data from these same locations were also used to develop background concentrations in surface water. Areas of the Site where copper, zinc, and pH levels are lower than or equal to ambient concentrations were dropped from further human health-based evaluation.

In Tier 1, copper and zinc concentrations in groundwater and soil were compared to the RWQCB (2000) RBSLs for surface and subsurface soils subject to commercial/industrial use where groundwater is not a source of water supply. COCs whose maximum concentrations were above the Tier 1 RBSLs were retained for the Tier 2 evaluation.

During the second tier of human health risk evaluation, H-SSTLs were developed that are less conservative and more site-specific than the Tier 1 RBSLs. SSTLs for soil/sediment were generated for three exposure scenarios: the maintenance worker and construction worker for the upland areas, and the construction worker and recreational boater/angler for the Existing Slough areas. Because copper and zinc are noncarcinogenic chemicals with no documented potential for dermal absorption or for inhalation-related chronic toxicity, SSTLs were developed on the basis of the ingestion exposure route alone. Additional soil/sediment samples taken along the Existing Slough east of the Polishing Pond area just over the tide gate augmented existing soil/sediment data in the evaluation of exposure by workers to dust and direct contact of soils in this area (Figure 3-1). The lowest H-SSTL estimated among the maintenance worker, construction worker, and angler (fish consumption) was used as the target value for human health. Sample locations that exhibited COC concentrations in exceedance of H-SSTLs were considered in the delineation of AOCs. These areas formed the basis for risk management and remedial decisions at the Site.

3.4.2 Ecological Health

In Tier 1, soil/sediment concentrations in the Existing Slough bottom, dredge spoils, and banks were compared against the higher of the San Francisco Bay ambient concentration (RWQCB 1998) and the ER-M (Long et al. 1995) to evaluate toxicity to benthic invertebrates. Surface water concentrations were compared against the marine CCC AWQSs to evaluate toxicity to aquatic plants, aquatic invertebrates, and fish (Table 3-1). These benchmarks focus on the protection of the benthic and aquatic communities existing in the Existing Slough and those that would occupy the New Slough. The benthic community, by virtue of its relative immobility and intimate contact with sediment is maximally exposed to site-related chemicals. Therefore, benchmarks that are protective of the benthic community are generally agreed to also be protective of more mobile or transiently exposed receptors (with the exception of bioaccumulative chemicals). The aquatic community includes plankton, aquatic invertebrates, and fish. Organisms in the water column are exposed to groundwater and dredge spoil piles leaching or eroding into the Existing Slough. The results of the Tier 1 screening were not used to eliminate sample locations or COCs (as is common in a tiered approach) because different receptors and pathways were evaluated in each tier. Potential adverse effects caused by direct contact with COC-impacted sediment or soil/sediment by benthic invertebrates and surface water by aquatic organisms were assessed in Tier 1. Since Tier 1 of the Ecological Risk Assessment (ERA) does not address bioaccumulative pathways whereby higher trophic level receptors are exposed to COCs through their diet, all areas of the Site were retained for the Tier 2 analysis regardless of the findings in the first tier. Since copper and zinc have been listed as potentially bioaccumulative (USACE, San Francisco District 1999), they were automatically carried through to the Tier 2 evaluation.

Ecological receptors evaluated in Tier 2 include those from the aquatic and the wetland habitats. Receptors selected for quantitative analysis of the Existing Slough (Aquatic Habitat) include the mallard duck, great blue heron, and the river otter. Receptors selected for the Wetland habitat include the salt marsh harvest mouse and California clapper rail. Exposure pathways included incidental ingestion of sediment/soil and water, ingestion of contaminated prey species, and ingestion of water. Inhalation and direct contact pathways were not evaluated quantitatively as these are typically insignificant when compared with ingestion pathways for ecological receptors.

In Tier 2, SSTLs for the aquatic and wetland habitat receptors were developed on the basis of exposure to food-web items and incidental ingestion of soil/sediment and water. The lowest SSTL for each habitat was selected as the ecological target value for soil/sediment. The SSTLs address the COC contribution from the dredge spoil piles and surrounding sediment/soil that may be left in place for adequate protection of surface water concentrations and receptor risk. Information from biological surveys that was relevant to the ERA was also reviewed to evaluate the potential for receptors to be exposed to chemicals at the Site.

Additionally, toxicity testing was conducted in Tier 2 on the dredge spoil samples, and included elutriate-based toxicity tests and whole sediment bioaccumulation studies (Section 6.6.2). Since the ER-Ms used in Tier 1 are generic and conservative, actual demonstration of toxicity is frequently not observed at chemical concentrations that may be significantly greater than the benchmarks. Therefore, toxicity tests are useful in confirming or denying the potential for toxicity.

Sample locations or areas where Tier 1 benchmarks were exceeded and toxicity was observed or where Tier 2 E-SSTLs were exceeded are recommended for inclusion within the AOCs. Other areas are proposed for no further action.

Additional details of the ERA approach are provided in Section 6.1.

3.5 CONCLUSION OF TIERED EVALUATION

The objectives of the RWQCB Order are met as follows:

- The ER-M or the lowest SSTL, whichever is lower, of each ecological habitat and human receptor will be identified as the soil/sediment target value for that area. The cleanup or trigger value will be determined by the lowest of the ER-M, human health RBSLs, and SSTLs, as long as the selected value is above ambient concentrations (RWQCB 1998, or similar wetland ambient concentrations) in each habitat. Cleanup values are also driven by feasibility considerations. The toxicity- and food-chain accumulation-based numbers (ER-Ms, RBSLs, SSTLs) are a starting point. The target value may not be the final cleanup goal that is selected.

- Areas with a pH of less than 6.5 or exceeding the lowest of the ER-M, human health RBSL, or ambient concentration for copper and zinc warrant consideration as AOCs. For groundwater, areas exceeding site-specific numerical groundwater quality limits warrant consideration as AOCs. Tier 2 identifies the AOCs as those areas that (1) show toxicity in test organisms, (2) exceed the lowest SSTL for soil/sediment for either human or ecological receptors, or (3) exceed the trigger value for groundwater at the POC.

This section describes the data collection process that was proposed for the RAs and the groundwater evaluation. The project-specific data quality objectives (DQOs) are described first. The sampling design then describes how the DQOs were met, so that only the type and quality of data needed were collected.

4.1 DATA QUALITY OBJECTIVES

DQOs are an integrated set of thought processes that define data quality requirements based on the end use of the data. The USEPA defines DQOs as qualitative and quantitative statements specified to ensure that data of known and appropriate quality are obtained during remedial response activities (USEPA 1992a). The tiered risk screening process for the Site uses a DQO-based approach to collect and review physical, chemical, and biological data of only the type and quality that are necessary for decision making at each step of the process. Therefore, it was critical that the design for data collection activities was framed to meet the three goals of the DQO process:

1. Identify decision types: The decision types to be made during the risk and groundwater evaluation process are the assignment of COCs, AOCs, or the Site as a whole to one of the two tiers described in Section 3.
2. Identify data uses and needs: The data that are needed to make these tiered decisions are primarily chemical concentration, physical, and some biological toxicity testing data from individual sampling locations at the Site. These data are then used to determine groundwater conditions and whether the parameters defining RA Tiers 1 and 2 are met.
3. Design data collection program: The single most important element of the data collection design for the groundwater and risk-based evaluation approach is to ensure that chemical concentration data are of a quality that is sufficient to make decisions for each AOC and the Site as a whole. The elements defining data quality include adequacy of sample size, sample locations, sampling methods and depths, analytical methods, quality assurance/quality control (QA/QC), and statistical robustness.

4.1.1 DQOs for Tier 1 Decisions

For Tier 1 screens, the chemical concentration data for each sampling location and depth should meet the following DQOs:

- Sample locations should be appropriate for representing the Site.
- Sample size should be adequate for representing the Site.
- Sample size should be adequate for one sample or two sample significance testing.
- Ambient concentrations for copper, zinc, and pH should be adequately defined.
- Elimination of copper, zinc, and pH from further consideration should be based on risk-based considerations.
- The human exposure pathways considered should be potentially complete pathways for the Site as a whole.

- For human health, the estimated exposure point concentrations (EPCs) should be conservative but Site-specific.
- The exposure factors should use conservative but reasonable values.
- Chemical-specific sediment benchmarks should be available for ecological screening.

4.1.2 DQOs for Tier 2 Decisions

For Tier 2 screens, the following DQOs should be met:

- For human health, refined exposure factors should be Site-specific.
- The ecological receptors considered should be present or potentially present (i.e., Occurrence of suitable habitat) at each AOC.
- The ecological exposure pathways considered should be potentially complete pathways for the Site as a whole.
- For ecological risk, the estimated EPCs should be conservative but Site-specific.
- The exposure factors should use conservative but reasonable values.
- Toxicity data should be available for the COCs being evaluated.
- The acceptable risk levels should represent conservative *de minimis* risks.

4.2 SAMPLING DESIGN

The sampling design and rationale for further site characterization included collection and analyses of data for the RA and groundwater evaluation. As described in Section 2.2, seven rounds of investigation have been performed to date. COCs include copper, zinc, and pH as originating from the Rhodia facility. The information collected during sampling was designed to build upon these previous studies, assist in understanding existing groundwater conditions near the Existing Slough and New Slough, and better define areas that may pose an unacceptable risk to human health and ecological receptors based on current site-specific conditions.

Existing data include soil, sediment, shallow trench groundwater, and one surface water sample as follows (Figures 2-2 through 2-6):

- Slough bottom sediment samples (35) from the north and south sloughs were analyzed for copper and zinc, down to 8 feet in some places. Few pH measurements were made. Sampling dates range from 1986 to 2000. The majority (24 out of 35) of samples were collected in 1986, 1998, and 1999.
- Twenty-five sediment/soil samples from the Existing Slough sidewalls were analyzed for copper, zinc, pH, and sulfide in 2000.
- Twenty dredge spoil soil samples were analyzed for copper, zinc, pH, sulfide, sulfate, and Acid Volatile Sulfides/Simultaneously Extractable Metals in 2000.

- Twenty-four soil/sediment samples from 12 trenches made on the west side of the Existing Slough were analyzed for copper, zinc, pH, and sulfide in 2000.
- Ten trench groundwater samples were analyzed for copper, zinc, pH, sulfide, and salinity in 2000.
- Hydraulic conductivity was estimated from trench filling rates during 2000.
- One water sample was analyzed for same parameters in 2000.

The data collection for the groundwater evaluation and RAs had multiple objectives including:

- Characterize groundwater COCs and physical parameters in existing and new wells.
- Understand groundwater processes including fate and transport of copper and zinc to the Existing and New Sloughs.
- Determine COCs and physical parameters in surface water.
- Determine horizontal/vertical extent of contamination in or around the dredge spoil piles that would indicate risk or toxicity to receptors.
- Determine whether toxicity and bioaccumulation of COCs from the sediment/soil would occur if media was left in place.
- Characterize soil in the Polishing Pond area for human receptors working near this area.
- Determine lower sediment to plant bioaccumulation factors (BAFs) with pickleweed sample collection than would be expected from literature-reviewed compounds.

The data collected were then utilized in the groundwater evaluation and RAs.

As outlined in Section 2.2.1, seven previous studies have been conducted at the Site from 1986 to 2000. Many of the samples were collected in 1986 and the data are almost 15 years old. Further more, many of the samples were collected for dredging or sediment characterization purposes, and do not include information on the form of COCs present, pH, total organic carbon (TOC), or sulfide/sulfate present. Additionally, much of the information will be critical to determine the bioavailability of the COCs. Surface water was not sampled to a large degree nor was groundwater monitored for COCs for all physical parameters necessary for the groundwater evaluation and RAs. Toxicity testing and simultaneous chemical analysis of dredge spoil piles and surrounding soil/sediment was conducted to indicate whether toxicity to invertebrates due to pH or COCs would be observed. This testing was a necessary component of the RA to evaluate whether dredge spoils and surrounding areas may be left in place.

The following outlines the sampling rationale for the Site (Table 4-1).

4.2.1 Sampling Locations and Rationale

The objective of sample collection was to obtain samples that were representative of the location being sampled. For the groundwater evaluation and to determine target levels for industrial workers, recreational boaters, an angler, and ecological receptors, the following samples were collected, including the rationale/justification for collection (Table 4-1):

- **Six surface water samples**, three in the North slough, three in the South slough, were collected, analyzed for hardness, TOC, total suspended solids (TSS), salinity, total and dissolved copper, total and dissolved zinc, pH, and total and dissolved sulfides and sulfate (see Figure 3-2 for locations). Collections were made at locations adjacent to the existing and new groundwater monitoring wells. Collection of water samples allowed more accurate calculation of site-specific water exposure to ecological organisms and potential direct contact to human receptors. The sample collection also allowed statistical determination of whether the north and south areas should be evaluated as two separate AOCs with sediment/soil data for better remediation. Sampling surface water was designed to further strengthen assumptions regarding groundwater mixing and dilution and assisted in calibrating the mass balance equations.

- **Fourteen groundwater data locations** from new monitoring wells along the New Slough alignment were collected and analyzed for total copper, total zinc, pH, hardness, salinity, and total and dissolved sulfides and sulfate (Figure 3-2). Pressure and tidal gages were used to accurately determine hydraulic conductivity for the mass balance equations. Data were needed to more closely characterize groundwater conditions and quantify groundwater target values (SSTLs) at the POC.

- **Nine guard well samples** were taken north of the Existing Slough and analyzed for TOC, TSS, salinity, total and dissolved copper, total and dissolved zinc, pH, and total and dissolved sulfide and sulfate.

- **Five soil samples** were taken around the Polishing Pond area and analyzed for TOC, copper, zinc, pH, and sulfide and sulfate (Figure 3-1). In this area workers or recreational boaters can be exposed to dust (inhalation) and direct contact to sediments by working off the unpaved roadway.

- **Twelve toxicity test soil/sediment samples** were conducted at two depths (surface to 0-6 inches, and 2 to 2.5 feet) at a number of dredge spoil soil/sediments locations or surrounding areas as no previous toxicity tests were performed (Figure 4-1). Testing was designed to assess the portion of dredge spoils that may be left in place for aquatic or wetland organisms to survive. In addition, bioaccumulation results from a subset of these locations (5) provide site-specific tissue concentrations for ecological SSTL models and BAFs that may be lower than those that would be predicted and used from the literature. The 24 soil sediment samples were analyzed for grain size, TOC, copper, zinc, pH, percent moisture, and sulfide and sulfate. Tissue samples from bioaccumulation tests were analyzed for copper, zinc, percent lipids, and dry weight.

- **Six pickleweed tissue samples** and six colocated sediment samples (including one duplicate) were analyzed for copper, zinc, pH, TOC, and moisture content. They were collected to enhance the RA for the salt marsh harvest mouse RBSLs and may indicate lower accumulation factors than would be present from the literature. Samples were collected along the north slough where pickleweed was present, near dredge spoil piles, and distant from piles, when possible. One sample was collected in the south slough. Copper and zinc are listed as "bioaccumulative chemicals" (USEPA 2000b) and are included in Public Notice 99-3, Table 3 Bioaccumulative Contaminants of Concern for San Francisco Bay (USACE 1999).

Sample sizes were determined as the number needed for statistical evaluation and to fill data gaps (e.g., surface water, sediment, and Polishing Pond samples). Collection of a minimal number of surface water and groundwater samples and performing toxicity testing on the sediment samples was designed to refine the RA for ecological and human health concerns. With these values, more site-specific modeling was conducted, which was designed to more accurately portray the risk to receptors due to metal and pH concentrations at Peyton Slough.

4.2.2 Laboratory Analysis

4.2.2.1 Chemical Analysis

Samples were analyzed for the constituents shown in Tables 4-1 and 4-2 according to the methods and detection limits shown in Table 4-2. Details of the chemical and physical analyses and QA/QC procedures are described in Appendix F.

4.2.2.2 Toxicity and Bioaccumulation Testing

Though ER-Ms were exceeded in many areas as shown in previous studies, toxicity has not been established in the existing sediment or in the dredge spoil piles that may remain in place after remediation. Therefore, in addition to chemical analysis, toxicity tests were conducted on RA samples 1-12 and a subset of these samples was tested for bioaccumulation (Figure 4-1). Table 4-3 shows the rationale for toxicity and bioaccumulation testing at each sampling location shown on Figure 4-1. Bioaccumulation testing was conducted on RA1, RA6, RA10, RA11, and RA12. Samples with a low pH – below that which the test organism could handle, or 6.5 (S. Ogle, pers. comm., 2001) – were buffered for purposes of the test to ensure that observed responses of the test organism were correlated with exposure to COC concentrations and not acidic conditions.

It will be assumed that the Existing Slough sediment will be covered by fill material and will not be bioavailable after remediation; thus, no sampling or further testing of this area was conducted. In addition, it was assumed that some portion or all of the dredge spoil piles will be covered with water during tidal or seasonal cycles to evaluate whether toxicity would occur during flooding from the Sanitary District or on opening the tide gate in the New Slough. Testing included suspended phase tests using the larval mussel *Mytilus edulis* (Table 4-2). The larval species represents water column (direct contact) and filter feeding exposure through ingestion. Bioaccumulation testing was desired for site-specific tissue concentrations to use in the ecological SSTL models, through calculation of food chain BAFs. The polychaete *Nereis virens* was used for its deposit-feeding strategy. Bioaccumulation tests was conducted to derive lower BAFs than the literature would predict for highly contaminated sites, resulting in higher SSTL calculations. As the pH of these spoil piles alone may be toxic to the organisms used, pH buffering to levels typical for survival was conducted in toxicity tests when pH was below that necessary for the organism’s survival (pH of approximately 6.5). These additional tests allowed evaluation of whether pH or chemicals were causing the resulting toxicity. Procedures were conducted according to appropriate methods as outlined in the Inland Testing Manual (ITM, USACE/USEPA 1998) as shown in Table 4-2.

Species selected for toxicity testing and bioaccumulation helped to evaluate sediment/spoil toxicity, resuspension into the water column and bioaccumulation to upper trophic level receptors. In addition, the absence of a number of species such as mollusks and pollutantintolerant amphipods suggests that pH and/or COC concentrations could be contributing to the lack of species observed (Hunt et al. 2001).

4.3 DATA USABILITY REVIEW

The data evaluation process involved multiple tasks that are geared to ensuring that the project DQOs have been attained and that the overall goals and objectives of the project can be met. The data collected during the sampling and data collection efforts were evaluated for compliance with the Quality Assurance Project Plan and the data will then be evaluated for the purposes of Site characterization, groundwater evaluation, and RA.

At the end of the data collection effort, an analytical data set was received from the laboratory in both electronic and hard-copy format. This data file was validated and reviewed by URS for acceptability with regard to detection limits, blank contamination, qualifiers, and compliance with the precision, accuracy, reproducibility, comparability, and completeness parameters as follows:

- Review the data set for compliance with these parameters as described in the Quality Assurance Project Plan.
- For chemicals that are not detected in any sample, verify that practical quantitation limits (PQLs) did not exceed risk-based detection limits and then eliminate those chemicals for further assessment.
- If PQLs did exceed risk-based detection limits, evaluate the exceedence with reference to exceedance frequency and magnitude of exceedance.
- For chemicals that are detected in at least one sample, eliminate those that fall within the "5-10" rule of blank contamination (USEPA 1989a).
- Resolve all qualifiers and document reasons for accepting or rejecting qualified data.
- Compile finalized data set of retained chemicals and assign a value of one-half the PQL for nondetects.

The finalized data set will be carried through the risk evaluation process as described in Sections 5 and 6.

This section presents the findings of the HHRA performed to evaluate the potential human health risk due to long-term (chronic) low-level exposure to chemicals detected in dredge spoils piles near the Existing Slough (soil/sediment samples), and from the bottom and embankment of the Existing Slough (sediment samples) at the Site. This HHRA was prepared to satisfy the requirements of the RWQCB Order. In particular, the RWQCB requested the development of H-SSTLs for the Site. H-SSTLs are site-representative concentrations that do not constitute a public health concern for the potential exposure scenarios relevant for the Site. H-SSTLs were used to identify AOCs at the Site that may need further consideration in terms of remedial or risk management actions. H-SSTLs were also used to evaluate the potential risk associated with the New Slough alignment.

The approach and methodology for this HHRA are presented in Section 5.1. The Tier 1 screening and the conceptual site model (CSM) are in Sections 5.2 and 5.3. Section 5.4 provides the Tier 2 evaluation including the calculations of Tier 2 H-SSTLs. The results, conclusions, and recommendations are in Section 5.5. Detailed calculations are included in Appendices A and B.

5.1 APPROACH AND METHODOLOGY

This HHRA is organized in a tiered structure as described in Section 3. In Tier 1, the Site environmental conditions are reviewed and the potential exposure scenarios are identified. The concentrations of chemicals detected at the Site are compared with conservative nonsite-specific criteria. These are called Tier 1 criteria and are considered to be protective of human health and the environment under conditions of unrestricted access and property use. The chemicals detected at concentrations that do not exceed the Tier 1 criteria are not considered any further with respect to human health. The chemicals that are found at concentrations that exceed the Tier 1 criteria are evaluated in more detail in Tier 2. In Tier 2, a set of H-SSTLs is developed based on relevant site-specific conditions. Comparison of representative chemical concentrations with H-SSTLs indicates whether a potential human health concern exists and if further consideration is needed in terms of additional investigation, assessment, and/or remediation.

5.2 TIER 1 SCREENING

For the Site, the COCs have been *a priori* identified by the RWQCB Order as copper and zinc. The COCs are metals that manifest a relatively low human toxicity and are not considered carcinogenic by the USEPA. According to the USEPA, they do not absorb through the skin. For dermal exposure to soil/sediments, the *Risk Assessment Guidance for Superfund* (USEPA 1991b) only requires evaluation of dermal exposure to arsenic and cadmium in soil. Moreover, the Region 9 *Preliminary Remediation Goals (PRGs)* (USEPA 2000c) assumes a dermal absorption factor of zero for copper and zinc. In addition, metals in water in general are not well absorbed through the skin; for instance, the preliminary endangerment assessment document (DTSC 1999) provides a list of chemical-specific permeability coefficient for skin absorption of chemicals in water but none for metals. Therefore, the dermal route of exposure for copper and zinc in soil and water is assumed to be insignificant. In addition, these metals do not have reference doses (RFDs) for inhalation noncancer effects. Due to the lack of RFDs for inhalation, it is not possible to quantify risk associated with the inhalation route. Based on the above, the only potentially significant human exposure route is by incidental ingestion of soil/sediment and consumption of fish captured either at the Site or in the vicinity. Concerning chemical-specific fate and transport parameters, copper and zinc may bioaccumulate in the food chain but with a relatively low potential for accumulation. In the subsurface, they also tend to bond to the soil matrix and, therefore, they migrate at a slower rate than the groundwater seepage velocity.

Tables 5-1 and 5-2 present the maximum concentrations detected in samples collected in dredge spoil piles near the Existing Slough (upland area), and from the bottom and embankment of the Existing Slough, respectively, and the ambient concentrations in San Francisco Bay according to RWQCB (1998). For the upland area, Table 5-1 also includes a comparison with the Tier 1 RBSLs that are protective of human health for soil exposure. Tier 1 RBSLs are published, protective ("conservative") generic benchmarks used to screen chemical constituents detected at a site. The Tier 1 RBSLs relevant for this Site include the Region 9 PRGs (USEPA 2000c) and the RBSLs from RWQCB (2000). The RBSLs selected for the comparisons were based on exposure to surface soil (<3 meters below ground surface [bgs]) for commercial/industrial scenario and shallow groundwater not considered as current or potential source of drinking water. As shown in Table 5-1, the maximum detected concentrations of copper and zinc (20,000 and 5,600 mg/kg) for soil/sediments in the upland area exceed ambient concentrations and exceed also the PRGs and the applicable RBSLs. As shown on Table 5-2, the maximum detected concentrations of copper and zinc (121,000 and 88,300 mg/kg, respectively) in the Existing Slough exceed the ambient concentrations. Based on the RWQCB requirements and on the outcome of this comparison, the two metals, copper and zinc, were carried to the next phase of this assessment consisting of a Tier 2 site-specific evaluation.

5.3 CONCEPTUAL SITE MODEL

The CSM developed for the Site is illustrated on Figure 5-1 and laid out schematically in flowchart format on Figure 5-2. The CSM describes the relationship among sources of chemicals, release mechanisms, exposure media and intake routes, and the potentially exposed receptor populations relevant for the Site. The mechanistic processes by which human exposures occur are called "exposure pathways." In general, quantitative evaluations are performed only for potentially complete exposure pathways and scenarios. An exposure pathway is considered complete if and only if all of the four following elements are present:

- A source of chemicals
- A mechanism of release from the source into an environmental medium
- A mechanism for direct contact with the chemicals or for transport of the chemicals to the receptor exposure point
- An exposure route (e.g., ingestion, inhalation, dermal contact, etc.) through which the chemicals can enter the human body

As shown in the CSM on Figure 5-1, the primary chemical sources are represented by copper and zinc contained in the dredge spoil piles and slag piles. Copper and zinc were released from the piles to the soil/sediments due to several mechanisms including leaching, erosion, and disturbances. As a result of these releases copper and zinc are found in soil/sediment, in surface water, and in shallow groundwater. From these secondary sources copper and zinc may enter exposure media such as air particulate due to wind erosion of soil and other soil disturbances, soil/sediments, shallow groundwater, surface water due to leaching and runoff, and fish due to uptake of benthic organism living in contact with the sediments.

The following potential exposure scenarios were considered relevant for the Site:

- Upland Area scenario involving workers (including site employees, maintenance workers, and construction-excavation workers) potentially exposed to metals in dredge spoil piles and slag, and hypothetical recreators that may use the area for jogging or walking activities.
- Existing Slough involving anglers and recreators potentially exposed to copper and zinc due to consumption of fish that have been in direct contact with sediments from the Existing Slough.

On Figure 5-2, each combination of receptor and exposure route is evaluated and classified in terms of the completeness and importance of the exposure pathway. Only the pathway marked by a solid circle is considered potentially significant enough to warrant a quantitative evaluation. H-SSTLs are developed only for this important pathway. Since the COCs are not dermally absorbed and no RfD exists for inhalation, the only pathway that is relevant for this assessment is based on ingestion of soil and ingestion of fish as shown on Figure 5-2. Figure 5-2 shows that the incidental ingestion of water pathway is evaluated as minor for all receptors because of the low frequency and low contact rate associated with this pathway. Concerning an angler's exposure, the only important pathway is considered to be through ingestion of fish. Inhalation of particulate and incidental ingestion of soil are evaluated as minor due to the fact that the receptor is usually in a vegetated area near the shore and is removed from the bare soil area of the Site.

The potential health effects associated with the human exposure scenarios described above were quantitatively evaluated by developing H-SSTLs as presented in the following sections.

5.4 TIER 2 SITE-SPECIFIC EVALUATION

This section describes the Tier 2 evaluation and the development of H-SSTLs that were used to evaluate if the chemicals detected in the subsurface pose an unacceptable risk to human health due to long-term (chronic) low-level chemical exposure. H-SSTLs are a conservative but reasonable starting point for the development of cleanup goals for the Site. H-SSTLs may serve as preliminary goals for remediation planning purposes. In general, where H-SSTLs are not exceeded, no further consideration of potential health risks is warranted. If H-SSTLs are exceeded, the potential occurs for human health concern, and additional evaluation of site-specific exposure conditions and the reasonableness of the exposure assumptions may be warranted. The exceedance of H-SSTLs does not necessarily indicate the existence of a significant risk because the risk assessment models and exposure parameters are applied in a conservative way, which generally leads to overpredicting actual risk. Moreover, H-SSTLs do not consider other factors that can affect risk management decisions. Those additional factors typically include overall protection of human health and the environment, technical implementability, short-term and long-term effectiveness, cost, reliability, and regulatory and public acceptability (USEPA 1990b). Further investigation, monitoring, and fate and transport modeling may also be used in refining the exposure and risk evaluation prior to assessing the need for remedial action.

The Tier 2 health risk evaluation involves an in-depth analysis of the site-specific factors that influence human exposures to chemicals at the Site. For each of the relevant exposure scenarios, a set of Tier 2 H-SSTLs was developed using mathematical models that quantify human exposure.

5.4.1 Development of Tier 2 H-SSTLS

This section describes how human exposure models were combined with toxicity data to develop the site-specific Tier 2 H-SSTLs. The methodology used in this Tier 2 is based on guidance from DTSC (1992 [1996]), Cal-EPA's Office of Environmental Health Hazard Assessment (1994, 2000), San Francisco Estuary Institute (2000), and RWQCB (2000). In addition, ASTM (2000) guidance for RBCA and other guidance from USEPA (1989, 1990a, 1990b, 1991a, 1991b, 1992b, 2000a, 2000b) providing human exposure and toxicity evaluation methods were followed to select appropriate chemical transport-fate models (also known as fate and transport models) and model input parameters.

In addition to the EPC, the "exposure dose" depends on the frequency, duration, and route of exposure(s). The exposure assessment procedures applied in this study are based on the concept of reasonable maximum exposure (RME), which is defined as the highest exposure that can be reasonably expected to occur for the conditions being evaluated (DTSC 1992; USEPA 1989). The RME approach is designed to produce a highly conservative (and protective) estimate of health risk. As a precaution against underestimating actual risk, RME assumptions are intentionally biased toward safety with respect to the selection of exposure parameter values from statistical distributions that represent the parameters' uncertainty and/or variability. Exposure estimates calculated under RME mathematically combine some worst-case (e.g., 95th percentile) exposure factors with some average (e.g., 50th percentile) exposure factors (USEPA 1990a). It is important to keep in mind that the RME approach applied in this HHRA is intended to systematically overpredict the expected values for overall chemical exposure and health risk.

Table 5-3 presents the exposure parameters used in the four exposure scenarios of concern. Copper and zinc are not absorbed through the skin, and no toxicity parameters for inhalation exist. Therefore, the exposure parameters presented in Table 5-3 pertain only to soil ingestion and fish consumption. For the commercial/industrial scenario, exposure parameters from the USEPA guidance (USEPA 1991a, 1999a; ASTM 2000) were used, including an exposure duration of 25 years, an exposure frequency of 250 days/year, and a soil ingestion rate of 50 mg/day. For the construction/excavation scenario, an exposure duration of 7 years and frequency of 20 days/year were selected based on RWQCB (2000). A soil ingestion rate of 480 mg/day was adopted from USEPA (1997a) and RWQCB (2000) for the excavation worker. For the recreational scenario, an exposure duration of 24 years (USEPA 1991a; 1999a; DTSC 1999) was assumed with a frequency of 3 days/week. The recreational users are assumed to be adults from 6 to 30 years old. For this exposure scenario URS departed from the assumption of children exposure to evaluate noncancer exposure because the selected age range from 0 to 6 years old would not be representative of this kind of receptor. A soil ingestion rate of 100 mg/day was based on USEPA (1991a, 1997), ASTM (2000), and DTSC (1999). Detailed calculations presenting the exposure parameters used for each scenario are provided in Appendix A.

For the angler exposure scenario, the pathway considered potentially of concern for human health was the ingestion of fish caught locally. URS assumed that the fish had been in contact with the benthic environment at the Site and as a result had uptaken the COCs present in the sediment. The relationship between the concentration of metals in fish and sediment was based on a bioaccumulation model that is presented in Appendix B. This model is based on site-specific biota-to-sediment accumulation factors (BSAFs) (USEPA 1995). BSAFs were developed at a site that is characterized by environmental conditions similar to those found at Site by dividing the COC concentration measured in fish tissue (whole-body) by the concentration in the co-located sediment sample (URS 2001b). The BSAFs are based on whole-body fish measurements and probably overestimate the amount of chemical that is available for consumption. Studies on consumption habits of anglers in the area (i.e., Martinez Pier) show that the principal consumers (Caucasians) tend to predominately eat the fillets (USEPA 2000b). The exposure factors for an angler include an ingestion rate of 25 grams/day, an exposure duration of 24 years, and an exposure frequency of 50 days/year, assuming that anglers catch fish twice a week, but that only 50% of the fish caught is from the Site (USEPA 1991a; 1999a; DTSC 1999). Appendix B presents the detailed calculations for the fish consumption scenario.

Table 5-4 presents the chemical specific toxicity factors, the BSAFs, which were used in this HHRA. The toxicity values used in this study are the most current values available at the time of the writing of this document and come from up-to-date USEPA and Cal-EPAs Office of Environmental Health Hazard Assessment toxicity values to estimate potential noncancer health hazards. The following sources of RfDs and cancer slope factors were used, listed in priority order:

- USEPA Integrated Risk Information System (IRIS) Database (USEPA 2000a)
- Region 9 PRGs (USEPA 2000c)

Health risk for potentially carcinogenic chemicals is described in terms of the probability of developing cancer over a lifetime. For quantitative health risk assessments, this probability is defined as the incremental probability that an individual will develop cancer (i.e., the theoretical excess cancer risk above the background rate) over a lifetime as a direct result of the exposure in question (USEPA 1989).

Copper and zinc are noncarcinogenic chemicals. For noncarcinogenic chemicals, a HQ of one represents the cumulative target acceptable health risk level. The HQ is defined by the ratio of the estimated chemical intake to the RfD. When the HQs from multiple chemicals are added together, the result is called the hazard index (HI). The RfD is an estimate of a daily chemical intake per unit body weight that is likely to occur without deleterious effects during a lifetime or a portion of a lifetime (USEPA 1989). HQs (or HIs) of 1 or below indicate no adverse health effects are expected. HQs (or HIs) above 1 indicate a potential for adverse effects and that further evaluation of exposure conditions and toxicity is warranted in determining the need for remedial action.

Target organs and critical effects on human health for copper include liver and kidney damage and effects on the blood from long-term ingestion of high amounts of copper. Ingestion of large amounts of zinc, even for a short time, can cause stomach cramps, nausea, and vomiting. Long-term effects include anemia, pancreas damage, and lower levels of high-density lipoprotein cholesterol (the good form of cholesterol). Since the two COCs do not affect the same target organs, they were evaluated independently with respect to health hazard, i.e., the target HQ for each of them was set to 1.

The target risk levels used in the development of H-SSTLs were selected based on guidance from the USEPA (1989, 1991b) and DTSC (1992, 1999). For this HHRA and development of

H-SSTLs for individual chemicals and exposure pathways an HQ of 1 was used as the target risk level.

5.5 RESULTS AND DISCUSSION

Table 5-5 presents a summary of H-SSTLs calculated for copper and zinc for the scenarios of concern. Detailed calculations are presented in Appendix A for the commercial/industrial, construction/excavation, and recreational scenarios. Appendix B presents the detailed calculations for the angler scenario. The calculated H-SSTLs for copper were 75,832 mg/kg for the commercial/industrial scenario, 98,740 mg/kg for the construction/excavation scenario, and 63,194 mg/kg for the recreational scenario. For the commercial/industrial, construction/excavation, and recreational exposure scenarios, the calculated H-SSTLs for zinc exceeded the metal soil maximum concentration of 10% and, therefore, a ceiling value of 100,000 mg/kg was listed as H-SSTL. Finally, H-SSTLs for copper and zinc for the angler scenario are 24,945 mg/kg and 9,764 mg/kg, respectively.

Site chemical concentrations for the upland area and for the Existing Slough area were compared to the calculated H-SSTLs. The results of the comparison are presented in Table 5-6. No exceedances of H-SSTLs were observed in the upland area. The upland area soil data used for comparison with H-SSTLs include the samples collected in the vicinity of the Polishing Pond, which were collected specifically for the human health evaluation. For the Existing Slough area, H-SSTLs based on the angler exposure scenario were exceeded for both copper and zinc in samples 5N, 1S, 4S, for copper only in sample 7N, and for zinc only in sample 2S. The maximum concentrations exceeding the H-SSTL were 121,000 mg/kg for copper in sample 7N and 88,300 mg/kg for zinc in sample 1S.

Figure 5-3 presents a map of the Site with the sediment sample results from the Existing Slough and with the exceedances highlighted. Base on the fact that E-SSTLs are lower than minimum H-SSTLs, it is expected that any remedial action based on the ERA will also satisfy the human health concern. At any rate, it appears that exceedances of human health criteria occur in a relatively limited area near the tide gate and that the remainder of the Site does not represent a concern to human health.

5.5.1 Uncertainty and Variability in Risk Assessment

The quantitative methods and procedures described in this document for evaluating potential exposure and risk are based on a number of simplifying assumptions related to the characterization of the contaminant sources and of the subsurface environment. The exposure models are based on descriptions of relevant physical/chemical phenomena. Any mechanisms that are neglected, such as attenuation due to natural biodegradation, result in predictions of exposure and risk that are conservative relative to those likely to occur. In other words, the models are biased towards predicting exposure concentrations in excess of those likely to occur. Uncertainty and variability affect the input parameters of all of the exposure and fate and transport models. Conservative values of those input parameters are selected to deal with this uncertainty and variability. Since the exposure models are multiplicative, conservatism is compounded in the calculations. For this reason, the modeling results in this study are expected to overestimate exposure and risk, rather than underestimate the actual risk posed by the Site.

The degree of conservatism in this assessment is illustrated by the following: the target levels for the angler receptor scenario proposed in this study are estimated by the models to be protective of a receptor assumed to consume 25 grams/day of fish for 24 years with a frequency of twice per week, 50 weeks per year. The fish consumed is assumed to be 50% caught at the Site. The models estimate that if the Site's representative concentration does not exceed the SSTL such a receptor would not be subject to a significant hazard.

5.5.2 Use of Site-Specific Target Levels

H-SSTLs represent a conservative but reasonable starting point for the development of cleanup goals for the Site. In general, where H-SSTLs are not exceeded, no further consideration of potential health risk is warranted. If H-SSTLs are exceeded, the potential exists for human health concern, and additional evaluation of site-specific exposure conditions and the reasonableness of the exposure assumptions may be warranted. The exceedance of H-SSTLs does not necessarily indicate the existence of a significant risk because the risk assessment models and exposure parameters are applied in a conservative way, which generally leads to overpredicting actual risk. Moreover, H-SSTLs do not consider other factors that can affect risk management decisions. Those additional factors typically include overall protection of human health and the environment, technical implementability, short-term and long-term effectiveness, cost, reliability, and regulatory and public acceptability (USEPA 1990b). Further investigation, monitoring, and fate and transport modeling may also be used in refining the exposure and risk evaluation prior to assessing the need for remedial action.

This section of the report presents the findings of the tiered ERA that was conducted to evaluate the potential risks to the environment posed by site-related COCs identified during previous environmental investigations at the Site. The purpose of the ERA is to address concerns raised by the RWQCB about the potential risks to biological communities posed by Site media including dredge spoils (soil/sediment), sediment, and surface water. Specifically, the RWQCB has requested the development of E-SSTLs, i.e., COC concentrations in a specific medium that are safe for ecological receptors) for the Site. E-SSTLs take into account both direct toxicity and bioaccumulative impacts. Based on the results of the ecological evaluation for the Existing Slough, AOCs have been identified that pose an unacceptable risk and will be considered for potential remedial or risk management actions. E-SSTLs are also used to evaluate the potential ecological impacts that may be encountered subsequent to the construction of the New Slough. The discussion relevant to the New Slough alignment is provided in Section 9.

The ERA is based on a tiered risk-based framework that is consistent with guidance from the USEPA (1998), DTSC (1996) and RWQCB. Tier 1 corresponds to the USEPA's Problem Formulation approach and DTSC's Scoping Assessment phase and is a more generic, conservative analysis than the second tier. The Tier 2 evaluation is a more site-specific analysis whereby information regarding exposure and effects associated with the Site is used to characterize risks. The tiered approach to evaluating those specific chemical stressors at the Site that might pose a risk to ecological receptors was previously discussed in Section 3 and is summarized in the following subsections.

6.1 APPROACH AND METHODOLOGY

Based on previous investigations conducted at the Site, copper and zinc have been identified as the primary COCs (RWQCB 1999). Concentrations of these COCs detected in sediment and soil/sediment are well above the National Oceanic and Atmospheric Administration's (NOAA's) ER-M values, and toxicity test results provide evidence in support of these COCs as the main cause of effects to the benthic community. Mean effluent concentrations of these COCs discharging into Peyton Slough were also above chronic marine AWQSs (RWQCB 1999). Therefore, as per the RWQCB Order, copper and zinc are the only COCs evaluated in this ERA. pH was also quantitatively evaluated in the Tier 1 Evaluation of the current section as it is an additional stressor that might pose a risk to aquatic and benthic organisms at the Site, and also affects bioavailability.

6.1.1 Tier 1 Evaluation (Screening-Level)

Concentrations of copper and zinc (i.e., site-related COCs) were compared to Tier 1 RBSLs that are protective of benthic and aquatic organisms. Tier 1 RBSLs are published, protective ("conservative") generic benchmarks used to screen chemical constituents detected at a site. Examples of Tier 1 RBSLs include the ER-M sediment concentrations established by NOAA (Buchman 1999; Long and Morgan 1991; Long et al. 1995) and chronic AWQSs developed by the USEPA (40 CFR Part 131; May 18, 2000). The Tier 1 screening was conducted on a point by point basis; concentrations from each sample location were compared to the selected RBSLs. For reference purposes, the samples were also compared to ambient sediment concentrations developed for the Bay (RWQCB 1998).

To supplement the Tier 1 screening for sediment and soil/sediment at the Site, ER-M quotients (ER-Mqs) and mean ER-M quotients (mER-Mqs; sum of ER-Mqs divided by the number of chemicals) were calculated for each sample location. The mER-Mq provides a cumulative ratio for the COCs detected in each sample. Mean ER-Mqs above 1.5 are associated with a high probability of toxicity observed in marine amphipods (RWQCB 1997; NOAA 1999; Ross, pers. comm., 2001). Analyses by RWQCB have also noted a trend of sediment toxicity being seldom, if ever, observed at mER-Mq values below 0.5, occasionally seen at mER-Mq in the range of 0.51–1.5, and frequently seen at mER-Mq greater than 1.5 (RWQCB 1997).

The purpose of the Tier 1 screening was to evaluate potential effects from direct exposure to COCs by the benthic community and aquatic organisms. This tier of the ERA does not address bioaccumulative pathways whereby higher trophic level receptors are exposed to COCs through their diet. Therefore, all areas of the Site were retained for the Tier 2 analysis regardless of the findings in Tier1, and since copper and zinc have been listed as potentially bioaccumulative (USACE, San Francisco District 1999), they were automatically carried through to the next tier of the evaluation.

6.1.2 Tier 2 Evaluation (Site-Specific)

The Tier 2 evaluation involved the characterization of potential adverse effects caused by chemical exposure by deriving media concentrations protective of receptors (E-SSTLs). The E-SSTL approach was used to characterize concentrations of chemicals in media and in the food web based on risk (i.e., "back-calculating" acceptable media concentrations for receptors via the identified exposure pathways). E-SSTLs are more readily comparable to Site concentrations than forward-calculated HQs based on doses to receptors (mg/kg-bw/day) because they are expressed as concentrations in media (e.g., mg/kg COC in sediment).

The E-SSTL approach was used to assess risks to wildlife through potential exposure to bioaccumulative chemicals by the process of trophic level transfer through the food web. E-SSTLs were generated by use of toxicity reference values (TRVs) based on no-observable-adverse-effect levels (NOAELs) and TRVs based on lowest-observable-adverse-effect levels (LOAELs; Region 9 TRVs, DTSC 2000). For wildlife, TRVs represent exposure doses that are associated with an observed adverse response by a test organism, or a lack of response (NOAEL), upon exposing the test organism to a measured chemical concentration.

The Tier 2 screening was also conducted on a point by point basis, whereby COC concentrations from each sample location were compared to E-SSTLs. Sediment or soil/sediment sample locations that exhibit COC concentrations below the NOAEL-based E-SSTLs were eliminated from further evaluation, as these locations do not pose an unacceptable risk to wildlife (i.e., higher trophic level receptors). Locations with COC concentrations that are above NOAEL-based E-SSTLs but below LOAEL-based E-SSTLs were recommended for remediation or risk management actions. Finally, locations where sediment or soil/sediment concentrations exceed the LOAEL-based E-SSTLs were identified as AOCs that were recommended for remediation.

At the Tier 2 level, the potential for toxicity from direct exposure was further evaluated on the basis of toxicity and bioaccumulation test results for a selected subset of soil/sediment samples collected from the spoil piles along the Existing Slough. Toxicity test results provide a better understanding of the actual capacity of the sediments at the Site to exert toxicity (Appendix D).

Locations where significant toxicity was demonstrated or where mER-Mqs (developed in the Tier 1 evaluation) exceeded 1.5 were identified as AOCs.

The next few sections describe the habitats, species, and food-web characteristics of the Site that were considered in this ERA. Potential ecological exposure pathways and the CSM are discussed and significant pathways are identified.

6.2 POTENTIALLY EXPOSED BIOLOGICAL COMMUNITIES AND SPECIAL-STATUS SPECIES

The Site consists of two habitat types that are surrounded by industrialized and open-space lands. These habitat types constitute discrete zones for independent evaluation (i.e., exposure units) in the ERA. One exposure unit is represented by the wetland habitat that resides along the western and eastern sides of the Existing Slough, where dredge spoil piles have been placed. The marsh adjacent to the eastern side of the Existing Slough is much larger than the marsh area to the western side of the Existing Slough, which is more disturbed and is confined by a chain-linked fence and access road. The second exposure unit is the brackish aquatic habitat of the Existing Slough itself. Although it is assumed that the Existing Slough will be capped, eliminating the presence of an aquatic habitat at that location, this habitat was included in the tiered evaluation to confirm that unacceptable risks to ecological receptors are posed by the COC-impacted sediment and surface water of the Existing Slough. This information is intended to evaluated the selected alternative for remedial action (i.e., construction of a New Slough alignment) that is proposed in the FS (URS 2002).

A general description of the wetland and aquatic habitats and their flora and fauna was provided in Section 2.1.4.1. The following subsections provide a brief summary of the ecological receptors considered in the selection of the receptors of interest that were quantitatively evaluated in the ERA. Information from surveys conducted at the Site and immediate vicinity by qualified biologists (November 2001; Evens 2000, 2001; CCMVCD 1997; McGinnis, pers. comms., 2000, 2001; Hagar and Demgen 1987) was incorporated into the discussion on protected species.

6.2.1 Aquatic Habitat

Aquatic receptors considered for the ERA include the range of trophic levels, from producers through consumers.

Algae and Phytoplankton Communities. Algae and phytoplankton are the primary producers in the aquatic ecosystem, responsible for the photosynthetic conversion of solar energy to chemical energy. These types of organisms are obviously critical in the initial creation of energy inputs to the aquatic ecosystem and thus are in a crucial role and may be potentially affected by chemical stressors.

Benthic- and Epibenthic-Invertebrate Communities. Benthic invertebrates live in sediment and epibenthic invertebrates live on the sediment; both types of invertebrates generally feed on detritus or other sediment-dwelling organisms. Because of this direct contact with sediment, these types of organisms are a highly exposed group of organisms useful for evaluating sediment-bound chemicals. Benthic- and epibenthic-invertebrates are important primary and higher-order consumers in many estuarine systems and are important prey species for resident fish, amphibian, and bird communities. Consequentially, the direct contact that benthic invertebrates have with sediment results in a highly exposed group of receptors.

Fish and Aquatic Invertebrate Community. A variety of fish species are common to the San Francisco Bay and its tributaries, and these species include the entire range of trophic levels, from primary and secondary consumers up through higher-order carnivorous and omnivorous fish. Fish are primarily exposed to chemicals in surface water, but they may also be exposed to chemicals in sediment, depending on the life habits of the fish (e.g., free-swimming or bottom-dwelling), and to chemicals that may accumulate in their prey. Concentrations of chemicals in surface water are subject to flow and tidal conditions that constrain any measured data to be merely a snapshot in time of conditions in the waterbody. Although sediment is a long-term reservoir of chemical constituents, the fish and aquatic invertebrate communities do not have as much intimate contact with the sediment as does the benthic invertebrate community.

Amphibian Community. The early life stages of amphibians are aquatic, while the adult stage of amphibian taxa such as frogs, forage in aquatic habitats. Amphibians are potentially exposed to chemicals in water, sediment, and their prey, but are not expected to be particularly abundant at the Site. In addition, toxicological data are relatively scarce for amphibians, and even if exposure could be quantified, no corresponding effect-based data are available for comparison.

Reptile Community. Aquatic reptiles (primarily aquatic snakes) are potentially exposed to chemicals in surface water, sediment, and their prey. However, data are not available relating exposure to chemicals to effects in reptile species. Therefore, the ERA does not directly address risks to reptiles due to the lack of appropriate toxicity information. It is assumed that the evaluations for other groups are sufficiently indicative of ecological risk to wildlife species and would be applicable to reptiles.

Detritivores and Decomposers. Detritivores and decomposers are ultimately responsible for the recycling of chemical and nutrient energy back into simpler forms for reuse in the ecosystem, and include bacteria and fungi, as well as a diversity of invertebrate species. The macroscopic invertebrates that serve this function may also serve as important food resources for higher-order consumers.

Wetland and Aquatic Wildlife. A description of the wildlife community that may inhabit the aquatic and wetland habitats is provided in Section 6.2.2 below.

6.2.2 Wetland Habitat

Ecological roles in the wetland system are parallel to those for the aquatic system: producers, consumers, and decomposers.

Plant Community. The description of algae and phytoplankton communities provided in Section 6.2.1 for the aquatic habitat also is relevant to the plant community of the wetland habitat.

Benthic- and Epibenthic-Invertebrate Communities. The description of benthic invertebrate communities provided in Section 6.2.1 for the aquatic habitat is also relevant to the wetland habitat.

Detritivores and Decomposers. The description of detritivores and decomposers provided in Section 6.2.1 for the aquatic habitat is also relevant to the wetland habitat.

Wetland and Aquatic Wildlife. In addition to the plant, benthic invertebrate, and decomposer communities, the wildlife community of the region includes a diversity of species of amphibians, reptiles, birds, and mammals, with a correspondingly diverse array of life-history habits. To characterize ecological risks to the wildlife community, individual species are identified within each group of organisms that are representative of the major types of life-history habits for that group (primarily based on trophic level and foraging strategy). Although the exposure and toxicity assessments for a particular wildlife species are specific to that species (e.g., a species-specific ingestion rate and toxicity value), the chosen receptor species (described in Section 6.3) are assumed to be representative of all the wildlife that share a common taxonomy and life-history.

The wildlife community of reptiles, birds and mammals can be differentiated into two general food web categories: those that forage in the wetland (i.e., terrestrial) habitats and those that forage in the aquatic environment. For these organisms, ingestion of site-related analytes (in food, soil or sediment, and surface water) is the primary route of exposure to reptiles, birds, and mammals. Although dermal and inhalation exposures occur, these routes are poorly characterized for most wildlife species and are also expected to be much less important than ingestion with respect to chemical intake. Dietary preferences of the reptiles, birds, and mammals can then be broadly divided into a few general types, depending on the environment in which the organism generally feeds:

- Wildlife feeding in aquatic environments consume, in the broad sense, fish, aquatic or benthic invertebrates (e.g., aquatic insects, crustaceans, mollusks, marine worms), or aquatic (wetland) plants.
- Wildlife feeding in the wetland environment generally feed on wetland plants or terrestrial and benthic invertebrates (e.g., beetles, spiders, benthic and epibenthic fauna), and, if the species is a higher-level carnivore, on vertebrate prey such as small mammals and birds, reptiles, and amphibians.

Wildlife receptor-groups dependent on the aquatic and wetland environments that were considered in the selection of receptors of interest for the ERA include the semiaquatic bird, semiaquatic mammal, and reptile communities:

Semiaquatic Bird Community. Birds that forage in aquatic environments may feed on aquatic plants, sediment-dwelling or aquatic invertebrates, fish, and other organisms that may be present in such an environment. Birds that forage in the marsh may feed on wetland plants, sediment-dwelling or terrestrial invertebrates, mammals, and other birds that may be present. Some species are more limited in the kinds of prey items consumed, for example, shorebirds are nearly exclusive consumers of sediment-dwelling invertebrates, while others are more generalized; for example, a hawk is likely to forage on anything it can catch: bird, mammal, fish, amphibian, reptile, crayfish, etc. Piscivorous birds that have been observed foraging at the Site include herons and egrets, and waterfowl (e.g., ducks) are also known to utilize the Existing Slough.

Semiaquatic Mammal Community. Although true "aquatic mammals" include only the whales, dolphins, and porpoises, several mammalian species are dependent upon aquatic organisms for food. For example, footprint tracks of raccoons in the marsh verify that omnivorous mammals utilize the aquatic and wetland areas as foraging habitat. Herbivorous and carnivorous mammals that spend a large portion of the lives in the aquatic environment have been observed at the Site, including otters, muskrats, and beavers. Other mammals that may forage in the wetland and aquatic habitats include small herbivorous and insectivorous rodents, such as mice and voles, wide-ranging omnivores like skunks and opossums, and wide-ranging carnivores like fox.

Reptile Community. Reptiles are potentially exposed to chemicals in the wetland habitat, in their prey, sediment, and water. However, data are not available relating chemical exposures to effects in reptile species; in addition, reptiles have generally slower metabolic rates than do birds and mammals and would be expected to ingest less food and receive less exposure to chemicals in food than would birds and mammals. Therefore, the ERA tiers do not address directly the ecological risks to reptiles. It is assumed that the evaluations for birds and mammals, receptor groups that receive greater exposures and for which toxicity data are available, are adequate to characterize ecological risks to reptiles.

6.2.3 Protected Species

An on-line search of the CNDDB (CDFG 2001) was performed for the U.S. Geological Survey Vine Hill quadrangle that encompasses the Site. The results of the search are provided in Appendix C. Figure 6-1 illustrates the federally and state-listed species, and the habitats that potentially harbor listed species, that are known to be present at the Site and in the vicinity. The reported occurrences of special-status species and communities were reviewed in relation to habitat requirements and the habitats actually present at the Site. The following species were identified as being present or potentially present within a 1-mile radius of the Site:

- Salt marsh harvest mouse (*Reithrodontomys raviventris raviventris*)
- Soft bird's beak (*Cordylanthus mollis* spp. *mollis*)
- Robust monardella (*Monardella villosa* ssp. *globosa*)

Other protected species that were reported by CNDDB in the vicinity of the Site (i.e., north central Contra Costa County) include two avian species, the California clapper rail (*Rallus longirostris obsoletus*) and California black rail (*Laterallus jamaicensis coturniculus*), and one plant species Mason's lilaeopsis (*Lilaeopsis masonii*).

Two subspecies of the federally and state-endangered salt marsh harvest mouse (*Reithrodontomys raviventris raviventris* [in the North Bay] and *Reithrodontomys raviventris halicoetes* [in the Central and South Bay]) inhabit pickleweed marshes in the San Francisco Bay area. They are found to be most abundant when the pickleweed forms thick cover and salinity is greater than normal full-strength seawater, as around salt pans (Geissel et al. 1988). No salt pan areas were found at the Site. Salt marsh harvest mice feed on the green vegetative growth of pickleweed and on seeds. Western harvest mice (*R. megalotis*), California voles (*Microtus californicus*), and house mice (*Mus musculus*) are competitors where salinity is lower, and so, may be the dominant rodents within the Site. Salt marsh harvest mice are dependent upon thick pickleweed cover, and only when new growth of saltgrass provides cover do salt marsh harvest mice utilize this resource. The occurrence of salt marsh harvest mice has been recorded in McNabrey Marsh, southeast of the intersection of Highway 680 and Waterfront Road, which is located approximately 0.5 mile from the Site. These harvest mice were found in small areas of pickleweed between September 17 and November 14, 1989 (CNDDB 2001), and a viable population of harvest mice is believed to persist in this area. During small mammal field sampling conducted in 1997, small resident populations of salt marsh harvest mice were found in narrow bands of pickleweed along I-680, confirming their presence adjacent to the Rhodia property in McNabrey Marsh (CCMVCD 1997).

A large variety of birds utilize baylands, but few inhabit or feed in pickleweed marshes. Three subspecies of salt marsh song sparrow (*Melospiza melodia pusillula*, *M. m. sameulis*, and *M. m. maxillaris*) are residents of pickleweed marsh and establish territories along sloughs and channels. The state-threatened California black rail is fairly common in pickleweed marshes of the Bay Area where they feed on insects and crustaceans (Jones and Stokes 1979). The state- and federally endangered California clapper rail utilizes small tidal sloughs for foraging and nests in either cordgrass or pickleweed. Pacific cordgrass forms the best cover and nesting material for California clapper rails. They feed largely on animals, including ribbed mussels, Baltic clams, yellow shore crabs, and also may consume small mammals like harvest mice. Clapper rail and black rail surveys were conducted at the Site and immediate vicinity during the 2001 breeding season (Evens 2000, 2001). No clapper rails were detected in the marshes and small tributaries associated with Peyton Slough over the duration of the survey (March 22 through June 9) and did not appear to be utilizing the Existing Slough bed or banks in the 2001 breeding season. Black rails were detected during the survey in moderate densities (0.76 rail per hectare) in the higher emergent marshlands immediately east of the Existing Slough and are expected to be year-round residents in that habitat (Evens 2000, 2001). California black rails and clapper rails require similar habitat conditions for foraging and nesting. Therefore, it is likely that the marsh in the vicinity of the Site offers suitable habitat for both of these rail species.

Three special-status plant species were identified during the CNDDB search: robust monardella, Mason’s lilaeopsis, and soft bird’s-beak. A rare plant reconnaissance was conducted by URS at the Site on November 6, 2001. Although potential habitat was identified for Mason’s lilaeopsis and soft bird’s-beak, neither was observed at the Site during the reconnaissance. Soft bird’s-beak surveys conducted in the marshes west and east of the Martinez Marina between 1991 and 1993 confirm this finding (CNDDB 2001). Robust monardella also was identified as having the potential to be present at the Site. However, due to the disturbed nature of the wetlands adjacent to the Existing Slough, the potential for presence of this species at the Site is negligible. As a result, robust monardella was not included in the rare plant reconnaissance (URS 2001a).

Although special-status fish species were not identified for Contra Costa County during the CNDDB search, four anadromous fish species have the potential to be present in the Existing Slough: Sacramento splittail (*Pogonicthys acrolepidotus*), steelhead (*Oncorhynchus mykiss*), chinook salmon (*Oncorhynchus tshawystscha*), and Delta smelt (*Hyposmesus transpacificus*) (McGinnis, pers. comms., 2000, 2001; Hagar and Demgen 1987). Steelhead and chinook salmon winter-run and fall/late-fall run migrate through Carquinez Strait, and therefore, may potentially be affected by proposed activities on the Site and may mistakenly enter the Existing Slough during migration activities. Delta smelt and Sacramento splittail migrate through Carquinez Strait and may also potentially be affected by proposed activities on the Site upon entering the Existing Slough while feeding and seeking refuge.

6.3 RECEPTORS SELECTED FOR ECOLOGICAL ASSESSMENT

The identification of the potential ecological receptors at the Site was performed by noting the type and quality of habitats occurring at the Site and vicinity, and on the basis of field visits to document the species present or potentially present. Receptors of interest were selected on the basis of their occurrence at the Site, habitat and dietary preference, trophic level, sensitivity to Site COCs, availability of toxicity data and societal value. The receptor identification process was based on the following:

- Site reconnaissance by biologists (November 2001; Evens 2000, 2001; CCMVCD 1997; McGinnis, pers. comms. 2000, 2001; Hagar and Demgen 1987)
- Search of the CNDDB (2001) for aquatic and wetland special-status species reported at the Site and vicinity
- Field observations during sampling

Receptors identified include benthic invertebrates, fish and pelagic invertebrates, herbivorous mammals, dabbling waterfowl, piscivorous mammals, and probing and wading shorebirds. The receptors selected for the quantitative risk analysis represent species in major consumer groups of the food web that might come into contact with contaminated media at the Site.

6.3.1 Receptors of the Aquatic Habitat

Tier 1 Evaluation. The receptors selected for the Tier 1 evaluation of the aquatic habitat are:

- Aquatic plants
- Fish
- Pelagic invertebrates
- Benthic invertebrates

Because endangered fish species have been observed in the Existing Slough, the quality of surface water was evaluated. Fish are also an important food source for many wading shorebirds and piscivorous mammals, such as herons, egrets, and otters, which have been observed at the Site.

Benthic invertebrates (both infaunal invertebrates living buried in the sediments and epibenthic invertebrates residing on the surface of the sediment) are the primary food base for most semiaquatic avian and mammalian consumers, therefore, sediment quality of the aquatic habitat was also assessed. Because of their stationary nature and detritivorous/ planktivorous feeding habits, invertebrates are also exposed to sediment-associated chemicals for long exposure durations. Therefore, they are appropriate receptors for evaluation of the secondary trophic level of the food web (Suter 1993).

Tier 2 Evaluation. The Tier 2 aquatic habitat receptors are:

- Mallard ducks
- Great blue herons
- River otters

Mallards are known to forage in the Existing Slough and represent dabblers that were quantitatively assessed in the ERA. These waterfowl are dependent on the benthic community and aquatic plants as a food source and are an important game species (high societal value).

Great blue herons are wading piscivorous shorebirds that also forage at the Site and were modeled to consume fish residing in the Existing Slough. The final receptor considered in the Tier 2 evaluation of the aquatic habitat is the river otter. These carnivorous mammals are ubiquitous to the Site, as is confirmed by the otter slides and scat (primarily consisting of crayfish exoskeletons) found along the entire extent of the Existing Slough. Herons and otters are representative of top-level predators that may utilize the aquatic habitat, and the suitability of habitat conditions required by these higher trophic level receptors provides a measure of the overall health of the ecosystem.

6.3.2 Receptors of the Wetland Habitat

Tier 1 Evaluation. Benthic invertebrates were evaluated in the Tier 1 evaluation for the wetland habitat. As mentioned above for the aquatic habitat, the stationary nature and detritivorous/ planktivorous feeding habits characteristic of the benthic community make them appropriate receptors for examination of the secondary trophic level of the food web (Suter 1993). They are also a primary food source for shorebirds and carnivorous mammals that have been observed foraging in the sediment of the tidal wetlands adjacent to the north side of the Existing Slough.

Tier 2 Evaluation. The salt marsh harvest mouse and California clapper rail are the receptors selected for the Tier 2 evaluation. Due to the presence of pickleweed within the brackish wetland habitat, environmental conditions suitable to harbor salt marsh harvest mice may exist. This herbivorous mammal was selected as a receptor of interest based on its societal value (listed federal and state endangered species) and dependence on tidal salt marsh plants, mainly pickleweed, for food. Although it is unlikely to occur at the Site due to a lack of high-quality habitat (distribution of pickleweed is highly fragmented in the marsh), viable populations are known to exist in the tidal marshes adjacent to the Rhodia property (i.e., McNabrey Marsh; CCMVCD 1997; CNDDB 2001). Salt marsh harvest mice were also chosen to represent other herbivorous small mammals such as voles and mice that are likely to be present.

The California clapper rail is another federally and state listed species that was selected for the quantitative assessment. It was selected as a receptor of interest because of its dependence on benthic invertebrates (both infaunal and epibenthic) as a food source, societal value as a protected species, and its representation of semiaquatic, avian secondary trophic level carnivores. Although no clapper rails were observed during the spring surveys conducted at the Site (Evens 2001), due to the presence of other probing birds that require salt marsh habitat with areas of higher elevations for cover (black rails and Virginia rails), the clapper rail is an appropriate receptor for this ERA.

6.3.3 Assessment Endpoints

The protective goals of the ERA process are known as assessment endpoints. Specifically, assessment endpoints are explicit expressions of the actual environmental value to be protected, and may be perceived as an environmental characteristic, which, if found to be significantly affected, can trigger further action. The assessment endpoints selected for the ecological receptors are as follows:

- Protection of the aquatic community (aquatic invertebrates and plants and fish) that may be exposed to COCs in surface water

- Protection of benthic organisms (epibenthic and benthic invertebrates) that may be exposed to COCs in sediment and porewater
- Protection of resident wildlife species populations that may be exposed through the aquatic food web, as represented by the mallard duck, great blue heron, and river otter in the aquatic habitat.
- Protection of special-status species (on an individual basis) that may be exposed through the wetland food web, as represented by the salt marsh harvest mouse and California clapper rail

6.4 CHARACTERIZATION OF EXPOSURE

An exposure pathway is considered complete when and only when all four of the following elements are present: site-related source of a chemical; a mechanism of release of the chemical from the source to the environment; a mechanism of transport of the chemical to the ecological receptor exposure point; and a route by which the receptor is exposed to the chemical. This evaluation was performed for each of the pathways identified for the Site. Only complete exposure pathways are considered relevant in an ERA, as no effects can occur without exposure.

The following subsections describe the exposure routes associated with the complete exposure pathways identified for receptors of interest at the Site.

6.4.1 Conceptual Site Model

A CSM was developed for the Site to provide a schematic representation of the links between sources, release and transport mechanisms, affected media, exposure routes, and potentially exposed ecological receptors (Figure 6-2). The CSM includes habitats and receptors and considers the potential for chemicals to bioaccumulate. In addition, professional judgment was used to determine the completeness of the pathways identified on the CSM. The predominant exposure pathways for the Site are related to COCs in soil/sediment associated with the dredge spoil piles along the Existing Slough, sediment from the Existing Slough bottom and embankments, and surface water within the Existing Slough. Potential exposure pathways from sediment or soil/sediment include direct contact with and incidental ingestion of sediment, soil/sediment, or surface water, and indirectly by consumption of prey that has been exposed to media containing COCs at the Site.

Figure 6-2 illustrates the potential chemical exposure scenarios for ecological receptors at the Site. The importance of each exposure route associated with each receptor is represented by a solid circle for potentially significant (complete) pathways, by the letters "IC" for incomplete pathways, and by an open circle for complete but insignificant pathways. The significance of each complete exposure pathway and the manner in which they were addressed in the ERA is discussed below.

6.4.2 Assessment of Pathways

Although several complete exposure pathways may exist, not all pathways are comparable in magnitude or significance. The significance of a pathway as a mode of exposure depends on the identity and nature of the chemicals involved and the magnitude of the likely exposure dose. Some pathways, although potentially complete and significant, cannot be quantitatively evaluated in the ERA due to the absence of exposure or toxicity information (i.e., toxicological data for amphibians and reptiles). Exposure routes for ecological receptors may include inhalation, ingestion, and dermal contact with COCs, but ingestion is generally the most significant route of exposure for wildlife. Food-web exposures become significant only if chemicals with a tendency to bioaccumulate or biomagnify are present. Although the inhalation pathway is a potentially complete exposure pathway, it is less significant compared to the ingestion pathway and is difficult to quantify due to a lack of scientific data in this area (USEPA 1993). Dermal contact is another potentially complete but minor pathway due to the barriers offered by fur and feathers. Intake of chemicals due to preening and grooming are included within the ingestion pathway as incidental ingestion of sediment, soil/sediment, or surface water.

Groundwater is generally inaccessible to ecological receptors and is considered a medium of exposure only after it exits the ground and discharges to the surface. Since surface water data from the Existing Slough are available, these data were used to assess risks posed to aquatic plants, fish, and pelagic invertebrates under current conditions at the Site. Potentially complete and significant exposure pathways at the Site include:

- Gill absorption and dermal uptake from surface water by aquatic invertebrates and fish
- Dermal uptake from sediment (soil/sediment) by benthic invertebrates
- Ingestion of sediment (soil/sediment) by benthic invertebrates and fish
- Root uptake from the sediment (soil/sediment) by wetland plants
- Ingestion of biotic food (aquatic or wetland plants, aquatic invertebrates, benthic invertebrates, or fish) and incidental ingestion of surface water and sediment (soil/sediment) by wildlife receptors, including higher trophic level fish species

6.4.3 Chemical Concentrations in Abiotic and Biotic Exposure Media

The basic unit of exposure for ecological receptors is the exposure point concentration (EPC), defined as the concentration of a chemical in a specific environmental medium at the point of contact for the receptor, i.e., the concentration of a chemical in soil/sediment or in surface water at a sampling location that could serve as habitat for the receptor. For example, the EPC for stationary receptors expected to contact sediment (e.g., benthic invertebrates) is simply the chemical concentrations measured in the sediment. For higher trophic level receptors, exposure is estimated as a function of the chemical concentrations in relevant environmental media and several other parameters. These parameters are related to biotransfer through the food web and the manner in which receptors use the Site (e.g., length of time a receptor is expected to forage/nest at the Site based on their home range size and seasonal behavior, dietary composition, food ingestion rates). COC concentrations measured at each sediment, soil/sediment, or surface water sample location represent the EPCs used in the tiered risk evaluation. Although measured COC concentrations in surface water were used in the Tier 1 evaluation to assess potential risks to fish and aquatic invertebrates from direct exposure, these concentrations were not used in the Tier 2 evaluation for the calculation of E-SSTLs. Instead, COC concentrations in surface water (ingested by wildlife receptors) were assessed as a function of the concentration in soil/sediment. Partitioning coefficients (K_d) were applied to soil/sediment concentrations and a conservative dilution factor (DF) was incorporated into the equation:

$$C_{surface\ water}\ (mg/L) = \frac{C_{sediment}\ (mg/kg\text{-}dw)}{K_d\ (L/kg)} \times DF \qquad \textbf{(6-1)}$$

The K_d values for copper and zinc are based on studies specific to San Francisco Bay (Sanudo-Wilhelmy et al. 1996) and are presented in Table 6-1. A conservative DF of 0.1 was used to estimate surface water concentrations from sediment (via porewater) concentrations, which has been accepted by Cal-EPA and RWQCB in other evaluations around SF Bay (URS Greiner Woodward Clyde 2000).

6.4.3.1 Aquatic Habitat

For the aquatic habitat, direct contact with surface water by algae, phytoplankton, aquatic invertebrates, and fish and direct contact with sediments by the benthic invertebrate community are the exposure pathways quantified during the Tier 1 evaluation.

In Tier 2, exposure to COCs as they transfer through the food web were assessed by evaluating the bioaccumulation potential in each food source for the wildlife receptors. The following list summarizes the biotic items that comprise the diets of each receptor of concern as they forage in the aquatic habitat:

- Mallard duck: aquatic macrophytes and epibenthic invertebrates,
- Great blue heron: fish, and
- River otter: epibenthic invertebrates and fish.

Measured and estimated COC concentrations in these dietary items were used to evaluate exposure to the appropriate receptors. The following subsections provide the equations used to estimate tissue concentrations of the above dietary items.

Aquatic Macrophytes. For the diet of the mallard duck, COC concentrations in macrophytes may be estimated by applying the concentration in surface water by the literature derived bioconcentration factor (BCF) that is based on exposure to macrophytes or aquatic plants:

$$C_{macrophytes}\ (mg/kg\text{-}dw) = C_{surface\ water}\ (mg/L) \times BCF\ (L/kg) \qquad \textbf{(6-2)}$$

Table 6-1 presents the macrophyte-based BCFs.

Benthic and Epibenthic Invertebrates. For the diets of the mallard duck and river otter, COC concentrations were measured in infaunal invertebrates (*Nereis virens*) used in bioaccumulation tests that were conducted for the Site (Section 6.5.3 describes toxicity and bioaccumulation tests). Invertebrate-based BSAFs were estimated from the COC concentrations in polychaete tissue (five samples) and their co-located sediment samples (Table 6-2; see Figure 4-1 for sample locations). For inorganic chemicals, BSAFs represent the ratio of the measured COC concentration in polychaete tissue to the concentration in the co-located sediment sample. The following equation may be used to estimate the COC concentration in benthic (and epibenthic) invertebrates, whereby the BSAF is applied to the concentration in sediment:

$$C_{invertebrates}\ (mg/kg\text{-}dw) = C_{sediment}(mg/kg) \times BSAF(kg/kg) \qquad \textbf{(6-3)}$$

Table 6-1 presents the invertebrate-based BSAFs.

Fish. For the diets of the great blue heron and river otter, COC concentrations in fish tissue were estimated from BSAFs developed at a site that is characterized by environmental conditions similar to those found at the Site. The tidal salt marsh, western Stege Marsh, at this site (Richmond Field Station, owned by the University of California, Berkeley) has been impacted as a result of the disposal of pyrite cinders that have caused pH levels in sediment to substantially drop. Low pH levels have contributed to high concentrations of trace metals that have leached into the groundwater and surface water at the Richmond Field Station, which has also occurred at the Site. The fish were caught in a slough that lies adjacent to western Stege Marsh and discharges into San Francisco Bay, and in small tributaries that extend into the marsh. Small forage fish such as bullheads, yellowfin gobys, staghorn sculpins, and three-spine sticklebacks were collected and analyzed for metals and other analytes. BSAFs were developed by dividing the COC concentration measured in fish tissue (whole-body) by the concentration in the co-located sediment sample (URS 2001b). Given the similarities between the habitats, potential ecological receptors, source materials, and COCs found at the Richmond Field Station and Rhodia sites, these fish-based BSAFs were deemed appropriate for use in the current ERA. The following equation may be used to estimate the COC concentration in fish, whereby the BSAF is applied to the concentration in sediment:

$$C_{fish}\ (mg/kg\text{-}dw) = C_{sediment}(mg/kg\text{-}dw) \times BSAF(kg/kg) \qquad \textbf{(6-4)}$$

Table 6-1 presents the fish-based BSAFs.

6.4.3.2 Wetland Habitat

For the wetland habitat, direct contact with sediments and porewater by the benthic invertebrate community is the exposure pathway quantified during the Tier 1 evaluation.

In Tier 2, exposure to COCs as they transfer through the food web were assessed by evaluating the bioaccumulation potential in each food source for the wildlife receptors. The following list summarizes the biotic items that comprise the diets of each receptor of concern as they forage in the wetland habitat:

- Salt marsh harvest mouse: wetland plants (e.g., pickleweed)
- California clapper rail: benthic and epibenthic invertebrates

Measured and estimated COC concentrations in these dietary items were used to evaluate exposure to the appropriate receptors. The following subsections provide the equations used to estimate tissue concentrations of the above dietary items.

Wetland Plants. For the diet of the salt marsh harvest mouse, COC concentrations were measured in pickleweed samples collected from vegetated areas adjacent to spoil piles found north and south of the levee (see Figure 4-1 for sample locations). The tips of pickleweed plants were gathered from five sample locations, as this part of the plant is consumed by the harvest mouse, and analyzed for copper and zinc. Plant uptake factors (PUFs) were estimated from the COC concentrations in pickleweed tissue and their co-located sediment samples (Table 6-3). For inorganic chemicals, PUFs represent the ratio of the measured COC concentration in plant tissue to the concentration in the co-located sediment sample. The following equation may be used to estimate the COC concentration in wetland plants, whereby the PUF is applied to the concentration in sediment:

$$C_{plant}\ (\text{mg/kg-dw}) = C_{sediment}(\text{mg/kg-dw}) \times \text{PUF(kg/kg)} \qquad \textbf{(6-5)}$$

Table 6-1 presents the PUFs for pickleweed.

Benthic and Epibenthic Invertebrates. For the diet of the California clapper rail, COC concentrations were measured infaunal invertebrates (*Nereis virens*) used in bioaccumulation tests that were conducted for the Site. Invertebrate-based BSAFs were used to estimate COC concentrations in epibenthic and benthic invertebrates, as described above for receptors of the aquatic habitat (Equation 6-3). Table 6-1 presents the invertebrate-based BSAFs and Table 6-2 provides the data used to develop the BSAFs.

Section 6.5.2.1 provides a description of the methods used to back-calculate safe concentrations in soil/sediment, i.e., E-SSTLs, for each receptor based on exposure to COCs through their diet (including incidental ingestion of sediment and surface water). These methods incorporate the equations above used to estimate biota tissue concentrations and manipulates them to conform to the equation used to calculate E-SSTLs.

6.4.4 Exposure Factors

The potentially complete and significant exposure pathways identified in Sections 6.4.1 and 6.4.2 form the basis for deriving exposure doses to each ecological receptor at the Site. The exposure dose, i.e., average daily dose (ADD), is a component of the E-SSTL equation and represents the average amount of a chemical that an individual member of a receptor population ingests under the assumption that the population forages primarily at the Site. The ADD is a function of a receptor's foraging behavior and is dependent upon life history strategies such as home range size, dietary preferences, food ingestion rates, and seasonal behavior. Diets of the selected wildlife receptors were assumed to consist of some combination of relevant food types: aquatic plants, wetland plants, fish, or benthic invertebrates. The receptor-specific exposure factors that were applied to the dose portion of the E-SSTL equation (Section 6.5.2.1) are presented in Table 6-4.

6.5 CHARACTERIZATION OF EFFECTS

The identification of toxic effects and chronic toxicity thresholds resulting from exposure to COCs comprises the effects assessment phase of the ERA. In Section 6.3.3, the assessment endpoints relevant to the selected ecological receptors were presented.

Assessment endpoints must have measurable characteristics that allow an evaluation of whether or not the ecological resource is being sufficiently protected. The measurable attributes of the Tier 1 assessment endpoints include the following:

- Survival of the aquatic community based on protection of 95% of aquatic taxa (USEPA's Ambient Water Quality Criteria documents that were used in the development of AWQSs)
- Survival of the benthic community based on a 50% incidence of effects (Long and Morgan 1991)
- Survival, growth, and reproduction of resident populations of mallard, great blue heron, and river otter
- Survival, growth, and reproduction of individual salt marsh harvest mice and clapper rail, since these are protected species with a high value placed on the protection of the individual

As part of risk characterization (Section 6.6), these measurable attributes were used to support conclusions about whether the protection of ecological resources, expressed as the assessment endpoints, is being achieved at the Site. If sufficient protection is not being provided, then further analysis is necessary.

6.5.1 Tier 1 Screening Benchmarks

Surface Water. The AWQSs, protective of aquatic invertebrates and fish at the Site (40 CFR Part 131; May 18, 2000), were selected as the Tier 1 RBSLs. Marine AWQSs based on filtered surface water samples (for inorganics) analyzed under a chronic exposure scenario were used in the Tier 1 analysis. These criteria are generic, conservative values that represent ecologically safe levels of a chemical, and are set to protect 95% of aquatic taxa. The CCCs are chronic surface water screening values, as they correspond to the highest acceptable Tier 1 COC concentrations for a 4-day average exposure. The CCC for copper is 0.0031 milligrams per liter (mg/L) and for zinc is 0.081 mg/L.

Sediment (Soil/Sediment). ER-M values, protective of benthic invertebrates (Buchman 1999; Long and Morgan 1991; Long et al. 1995), were selected as the Tier 1 RBSLs for sediment and soil/sediment at the Site. The ER-Ms for copper and zinc are 270 mg/kg and 410 mg/kg, respectively. The ER-Ms were used as screening benchmarks that correspond to observed toxic effects in marine organisms in the field, and they are calculated as the 50th percentile of the distribution of adverse-effect concentrations in sediment. A comparison of individual chemical concentrations with their respective ER-Ms does not always correspond with demonstrated sediment toxicity (Thompson et al. 1997; NOAA 1999; Hunt et al. 2001). As illustrated in NOAA (1999), high toxicity was observed 32% of the time when 1 to 5 ER-Ms were exceeded, 52% of the time when 6 to 10 ER-Ms were exceeded, and 85% of the time when 11 to 20 ER-Ms were exceeded. This pattern indicates that, in most cases, observed toxicity was most closely correlated with multiple COCs occurring at concentrations exceeding their respective ER-Ms at a location.

To supplement the ER-M screening, ER-Mqs were estimated (sample concentration divided by the ER-M) for each COC and a mER-Mq (sum of ER-Mqs divided by the number of chemicals) was developed for each sample. The mER-Mq provides a cumulative ratio for the COCs detected in each sample. Generally, the mER-Mq has proven to be a reliable predictor of toxicity, as is apparent upon comparisons of mER-Mqs and toxicity testing results (Long et al. 2000; RWQCB 1997). Mean ER-Mqs above 1.5 are associated with a high probability of toxicity (approximately 75% of the time) observed in marine amphipods (NOAA 1999; Ross, pers. comm., 2001). Analyses by RWQCB have also noted a trend of sediment toxicity being seldom, if ever, observed at mER-Mq values below 0.5, occasionally seen at mER-Mq in the range of 0.51–1.5, and frequently seen at mER-Mq greater than 1.5 (RWQCB 1997).

6.5.2 Tier 2 Ecological Site-Specific Target Levels

For the Tier 2 evaluation, risks to wildlife through potential exposure to bioaccumulative chemicals by the process of trophic level transfer through the food web were assessed. This assessment was achieved through the development of E-SSTLs, which represent concentrations in media that are protective of higher trophic level ecological receptors. As stated previously, E-SSTLs are more readily comparable to site concentrations than forward-calculated HQs because they are expressed as concentrations in media (e.g., mg/kg COC in sediment). E-SSTLs were generated by use of TRVs based on NOAELs and TRVs based on LOAELs. A NOAEL-based TRV represents a chronic toxicity threshold that is derived from a theoretical threshold dose corresponding to an estimate of no adverse effects to organisms or species. The chronic toxicity threshold is a dose below which adverse effects would not be expected to occur. Whereas, LOAEL-based TRVs correspond to an estimated dose that is attributed to an observed effect in the test organism.

Sediment or soil/sediment sample locations that exhibit COC concentrations below the NOAEL-based E-SSTLs were eliminated from further evaluation, as these locations do not pose an unacceptable risk to wildlife (i.e., higher trophic level receptors). Locations with COC concentrations that are above NOAEL-based E-SSTLs but below LOAEL-based E-SSTLs were recommended for remediation or risk management actions. Finally, locations with sediment or soil/sediment concentrations in exceedance of LOAEL-based E-SSTLs were identified as AOCs that were recommended for remediation.

E-SSTLs were developed for sediment and soil/sediment only, assuming that these COC-impacted media are the primary source of contamination at the Site. Remedial actions conducted as a result of the findings of the ERA will be focused on soil/sediment removal and not on surface water remediation. Since the proposed alternative identified in the FS (URS 2002) involves excavation of AOCs defined by the dredge spoil piles along the Existing Slough and capping the Existing Slough, surface water in the Existing Slough will no longer present a potential source of risk to ecological receptors. The aquatic habitat will be eliminated from this location and will be reconstructed at a new location on the property.

6.5.2.1 Development of Ecological Site-Specific Target Levels

Risks to the salt marsh harvest mouse, California clapper rail, mallard duck, great blue heron, and river otter were characterized by estimating potential exposure to COCs at the Site via a simplified trophic model. The model accounts for transfer of chemicals from environmental media to the receptors either directly (e.g., incidental ingestion of soil or ingestion of water) or indirectly (e.g., consumption of food sources that have accumulated concentrations of COCs) and, when coupled with appropriate TRVs, allows an indication of risk. To characterize environmental conditions that would be without appreciable risk to receptors, E-SSTLs were developed which represent concentrations in sediment or soil/sediment that would result in an exposure equal to the selected TRV. The following paragraphs provide a step by step depiction of the equations used in the development of E-SSTLs. To simplify the equations, the term "sediment" was used to represent both sediment and soil/sediment at the Site.

First, estimation of E-SSTLs for wildlife receptors begins with the general equation for calculation of an ADD of a COC to a receptor, for "i" food types:

$$ADD = \frac{\left[IR_{food} \sum_{i=1}^{n_i} \left(C_{food_i} \times df_i \right) + \left(IR_{sediment} \times C_{sediment} \right) + \left(IR_{water} \times C_{water} \right) \right] \times AUF \times SF}{BW} \quad \textbf{(6-6)}$$

where:

ADD	=	Average daily dose of a COC to a receptor that forages at the Site (mg COC ingested per kg body weight per day)
IR_{food}	=	Ingestion rate of food (kg food dry weight ingested per day)
n_i	=	Number of food types
C_{foodi}	=	Concentration of COC in food type "i" (mg COC / kg food type "i" dry weight)
df_i	=	Dietary fraction (proportion in the diet) of food type "i" (unitless; $\Sigma i = 1$)
$IR_{sediment}$	=	Ingestion rate of sediment (kg sediment dry weight ingested per day)
$C_{sediment}$	=	Concentration of COC in sediment (mg COC / kg sediment dry weight)
IR_{water}	=	Ingestion rate of water (L water ingested per day)
C_{water}	=	Concentration of COC in water (mg COC / L)
BW	=	Body weight of the receptor (kg)
AUF	=	Area Use Factor, home range size ÷ site area size (unitless)
SF	=	Seasonality Factor, as a fraction of one year (unitless)

Secondly, it is necessary to set the exposure dose (ADD) equal to the selected TRV. In a forward risk assessment this step would be equivalent to setting the HQ equal to one. This interim step to the back-calculation process is expressed below:

$$THQ = 1 = \frac{ADD}{TRV} \quad \text{or} \quad \text{TRV = ADD} \quad \textbf{(6-7)}$$

Where

THQ	=	Target HQ set to one (unitless indicator that exposure exceeds toxicity value)
ADD	=	Average daily dose of COC to a receptor (mg/kg BW–day)
TRV	=	NOAEL- or LOAEL-based TRV (mg/kg BW–day)

When substituting in the elements for the ADD, Equation 6-7 may be reexpressed as follows:

$$TRV \times BW = \left[IR_{food} \sum_{i=1}^{n_i} \left(C_{food_i} \times df_i \right) + \left(IR_{sediment} \times C_{sediment} \right) + \left(IR_{water} \times C_{water} \right) \right] \times AUF \times SF \quad \textbf{(6-8)}$$

Because concentrations in food types can be expressed as functions of sediment concentrations (that is, through "Accumulation Factors": PUFs, BCFs, and BSAFs), this equation can be reexpressed as:

$$TRV \times BW = \left[IR_{food} \sum_{i=1}^{n_i} \left(\left[C_{sediment} \times AF_i \right] \times df_i \right) + \left(IR_{sediment} \times C_{sediment} \right) + \left(IR_{water} \times C_{water} \right) \right] \times AUF \times SF \quad \textbf{(6-9)}$$

Finally, this equation can be presented to solve for $C_{sediment}$:

$$E - SSTL = C_{\text{sediment}} = \frac{TRV \times BW}{\left[IR_{food} \left(\left[AF_1 \times df_1 \right] + \left[AF_2 \times df_2 \right] + \ldots \right) + IR_{\text{sediment}} + \left(IR_{water} \times \frac{DF}{k_d} \right) \right] \times AUF \times SF} \quad \textbf{(6-10)}$$

where other variables have been defined previously, and:

$E\text{-}SSTL_{Sediment}$ = Ecological Site-Specific Target Level in sediment (=$C_{sediment}$) (mg COC per kg sediment dry weight).

Notice that the concetration in surface water is a function of the concentration in sediment, and, therefore, Equation 6-1 is used to solve for $C_{sediment}$. Since the K_d values for copper and zinc are so high (Table 6-1), COC intake via surface water ingestion is insignificant.

NOAEL-based E-SSTLs protective of wildlife receptors in the wetland and aquatic habitats are presented in Tables 6-5 and 6-6, respectively, and LOAEL-based E-SSTLs are in Tables 6-7 and 6-8, respectively. The Tier 2 screening was conducted on a point by point basis, whereby COC concentrations from each sample location were compared to the lowest NOAEL- and LOAEL-based E-SSTLs (protective of the most sensitive receptor from each habitat). The following section describes the TRVs that were applied to Equation 6-10 to derive E-SSTLs.

6.5.2.2 Toxicological Reference Values

The Region 9 TRVs for birds and mammals (DTSC 2000) are the selected wildlife TRVs used in the development of E-SSTLs for the current assessment and are presented in Table 6-1. The DTSC Region 9 TRVs (Region 9 TRVs; DTSC 2000) are toxicity benchmarks for mammals and birds that were originally developed by an interagency group, the Biological Technical Assistance Group, on behalf of the U.S. Navy (Engineering Field Activity, West, 1998) for potential general use in ERAs in California. Low-dose and high-dose values were developed, representing doses consistent with an available NOAEL and LOAEL, respectively. The NOAEL-based TRVs are intended for screening use, and if estimated exposures are less than the this value, no adverse effects are expected. If estimated exposure exceeds the LOAEL-based

TRV, then a potential risk to birds or mammals occurs. When estimated exposure falls somewhere between the NOAEL- and LOAEL-based TRVs, further information is needed before conclusions about risk can be specified.

The Region 9 TRVs represent generally conservative values drawn from a review of the toxicological literature. Rather than selecting TRVs from individual toxicological studies that are relevant to the ecological receptors and exposure routes at a particular site, these TRVs represent a more general approach whereby a single representative TRV is allometrically adjusted (i.e., based on the difference between the body weight of the test species upon which the TRV was derived versus that of the receptor) to a site-specific receptor. Specifically, if the body weight of the receptor is “two orders of magnitude” greater or lesser than the body weight of the study species, then an allometric conversion of the TRV should be performed (DTSC 2000).

Although this method may ensure that each TRV is drawn from an individual study that meets specified criteria for high-quality data, the approach suffers several disadvantages because the form of the chemical administered, the exposure duration and routes, the phylogeny of the test species, and other factors may have little or no relevance to the conditions and receptors selected for a particular site. Further more, the utility of allometric adjustments for avian toxicity data has been questioned (Mineau et al. 1996; Sample and Arenal 1998). Lastly, the application of interspecies UFs in preference to using a source study where the test species is closely related phylogenetically to the ecological receptor of interest at a particular site is also a subject for scientific debate. Nonetheless, these TRVs have direct utility for risk assessment, but should be used with recognition of their underlying assumptions and limitations.

As previously stated, the Region 9 TRVs for birds and mammals are the selected wildlife TRVs used in the development of E-SSTLs for the current assessment. Because the body weight of the river otter is two orders of magnitude greater than the body weight of the test species (a mouse) used in the copper study, the NOAEL- and LOAEL-based TRVs for copper were allometrically adjusted to derive values appropriate for the otter.

6.5.3 Toxicity and Bioaccumulation Test Results

Toxicity tests were conducted on RA samples 1-12 and a subset of these samples were tested for bioaccumulation (Figure 4-1). RA samples were collected from the dredge spoil piles and surrounding soil/sediment adjacent to the Existing Slough. The results of these tests provide a better understanding of the actual capacity of the soil/sediment at the Site to exert toxicity to benthic invertebrates (Appendix D). Samples collected for the toxicity and bioaccumulation tests are illustrated on Figure 4-1, and Table 6-9 presents the test results. A description of the benthic community present at the Site it presented prior to the discussion of toxicity test results.

Description of Benthic Community. Past biological surveys conducted on Peyton slough, scientific literature and other public documentation were reviewed to assess the benthic community analysis in the Existing Slough and the surrounding dredge spoil piles.

Species assemblages in the Upper Peyton Slough (North slough) consisted of predominantly (98%) oligochaetes (78%), chronomids (10%), *Ilyocryptus pinifer* and calanoid copepods (Hagar and Demgen 1987). Lower Peyton Slough (South slough) consisted of oligochaetes (80%), ostracods (12%), harpacticoids (2%), chironomids, and *Corphium spinicorne*, (Hagar and Demgen 1987; Hunt et al. 2001). Hunt et al. (2001) reported that the presence of *Capitella* *capitata*, *Corphium spinicorne*, oligochaetes and the absence of mollusks suggested that the environment was transitional and disturbed. *Capitella* and oligochaetes also “thrive in disturbed, polluted, or marginal environments and are generally not found in less disturbed communities” (Hunt et al. 2001). The environment was also described as transitional as a pollutant-tolerant amphipod species in large abundance in the South slough area. Upstream in the Shell/McNabney Marsh, large densities of invertebrates and fish were found. Amphipods, insects and isopods were most common, followed by snails of the pulmonate and prosobranch gastropod variety (Hagar and Demgen 1987).

Review of tolerance values created by USFWS suggests that species assemblages present in the Existing Slough are more tolerant of disturbed environments. Oligochaetes and chronomids (midges) are particularly tolerant of low oxygen environments, and some species are ranked as moderately to highly tolerant of contaminated environments (Ode 2000). Similarly, copepods, such as cyclopoids and harpacticoids are ranked as more highly tolerant of contaminated environments by USFWS.

Description of Toxicity Test Results. The potential for adverse effects from COCs to the aquatic and wetland communities may result from two types of exposures: direct toxicity to benthic and aquatic biota resulting from contact with COCs in sediment and water, and indirect, or food-web-based toxicity resulting from ingestion of prey which includes benthic and aquatic biota.

Direct toxicity is of primary concern for the benthic invertebrate community because of the maximal exposure associated with the stationary habits of invertebrates. Food-web-based toxicity is of concern for higher trophic level receptors such as aquatic and wading birds and mammals particularly for bioaccumulative and biomagnifying chemicals such as PAHs, PCBs and mercury.

For this ERA, it was assumed that the dredge spoil piles and surrounding areas would be exposed to tidal, marine or flooding events at least part of the year. Marine-based toxicity and bioaccumulation tests were conducted with this assumption in mind. Soil/sediment found in dredge spoil piles may not be of the same consistency, grain size, and organic content as sediment found in the Existing Slough proper, however, and caution must be used in analyzing the results for artificial toxicity and confounding factors such as grain size, ammonia, organic carbon content and salinity.

The rationale for selection of locations for toxicity and bioaccumulation test was then determined through examination of historical results and chemical concentrations. Since many areas exhibited a low pH, it was desired to fully examine the causes of benthic invertebrate toxicity as that from metals or from pH. Sample locations were designed to measure areas that exhibited copper and/or zinc concentrations:

- Below the ER-M with both high and low pH
- Slightly elevated above the ER-M with high and low pH
- Moderately elevated above the ER-M with high or low pH

Table 4-3 shows the rationale for toxicity and bioaccumulation testing at each sampling location shown on Figure 4-1. Bioaccumulation testing was conducted on RA1, RA6, RA10, RA11, and RA 12. Samples with a low pH - below that which the test organism could handle, or 6.5 (Ogle

2001) – were buffered for purposes of the test to ensure that observed responses of the test organism were correlated with exposure to COC concentrations and not acidic conditions.

An elutriate toxicity test was conducted on each sample, using embryos of the bivalve *Mytilus edulis*, with percent normal development as the endpoint. The elutriate test was performed on serially diluted elutriates representing 6.25%, 12.5%, 25%, 50% and 100% of added soil/sediment. Control sediment using clean laboratory sediment was used for statistically comparison to the Existing Slough soil/sediment samples.

For the bivalve tests, the mean percent normal development was reported for each dilution (Appendix D, Table 6-9). In addition, the EC25 was calculated, which represents the percent concentration (dilution level) of elutriate corresponding to 25% of the organisms showing an adverse response in the bivalve test. The 25% response represents an acceptable threshold level that is commonly used by the RWQCB as a not-to-exceed toxicity target goal when developing cleanup levels for groundwater and discharges. The no-observed-effects concentration also was estimated and reported as a percent concentration of the elutriate.

The results of the toxicity tests are presented in Appendix D and Table 6-9 and were reviewed as follows:

- Did the elutriate-based *Mytilus* tests indicate statistically significant toxicity relative to control?
- Could observed toxicity be attributed to chemical concentrations, acidity, or both?

In Tier 2, the results of toxicity tests are used with Tier 1 screening results as follows:

- Did chemical concentrations in the tested samples exceed their respective ER-Ms and acceptable mER-Mq ranges?
- Does any correlation exist between observed toxicity or lack thereof and magnitude of ER-M exceedances and mER-Mq?

Results of the sediment elutriate toxicity tests showed that of the 13 samples tested, normal development of *Mytilus edulis* bivalve embryos was significantly lower than the control in all tests using 6.25-100% elutriate, with the exception of RA3-2 (6.25%) and RA1-2 (6.25%). RA1-2 and RA3-2 had better survival at 50% and 100% dilutions respectively, but were still significantly less than the control.

In some of the tested samples, normal development was improved at lower elutriate concentrations, but survivability and normal development endpoints were still significantly less than the control. Whether these effects are due to the COCs copper and zinc is unknown. Because pH-buffered samples also showed significantly different toxicity from the control, pH was not seen to be causing toxicity to the organism, though pH buffering may have enhanced development somewhat in these organisms.

A comparison of these toxicity test results with their corresponding ER-Mqs and mER-Mqs is provided in Section 6.6.2.

Description of Bioaccumulation Test Results. Six RA samples were run for bioaccumulation testing using *Nereis virens*, including RA1, RA6, RA10, RA11 and RA12. Five replicates of each sample were conducted to produce tissue concentrations and mean survival values that could be statistically evaluated.

High mortality was observed in many samples, most particularly RA6, RA10, RA 11 and RA 12. Two replicates of RA 6, RA11 and RA12, and three replicates of RA10 had enough polychaete tissue to analyze. As a result of the high mortality, tissue samples were combined from five samples to three by Columbia Analytical (Christian 2001) after appropriate instruction from URS and the bioassay laboratory (Pacific EcoRisk, Martinez, CA). Mean survival of these three replicates for each sample is provided in Table 6-9. Survival was greatest in the control sample and sample RA1 at 22 polychaetes out of 26 tested.

Data suggest that significant toxicity was observed to the polychaete *Nereis virens* as few organisms in RA6, RA10, RA11 and RA12 survived through the 28 days of the test. Mean survival in these samples was well below 40% in all cases.

Table 6-2 presents the bioaccumulation data results for the polychaete *Nereis virens* in the aquatic habitat. As evidenced by the data, accumulation of metals by this invertebrate occurs to a limited extent for copper, and more so for zinc. BSAFs for copper ranged from 0.1 to 0.8, whereas for zinc, BSAFs ranged from 0.1 to 1.2.

Table 6-3 presents similar data for pickleweed in the wetland habitat. Copper concentrations were quite low in these samples, and accumulation by these plants occurs only to a limited extent. PUFs ranged from 0.006 to 0.02 for copper, and 0.04 to 0.2 for zinc. Accumulation of zinc occurs to a more significant extent in these plants.

6.6 RISK CHARACTERIZATION OF EXISTING SLOUGH

Risk characterization is the final phase of the ERA, and involves three critical steps: (1) risk estimation, (2) risk interpretation, and (3) uncertainty assessment (of the risk estimate). In risk estimation, the exposure and effects assessment are integrated to describe the potential or likelihood of adverse effects to the assessment endpoints. During the risk interpretation phase, the results of the risk estimate are presented in a scientific context that can be used to support the decision-making process for management of the environmental issues at the Site. Risk estimates are interpreted using various lines of evidence that address the risk estimates and the uncertainties and variabilities. The primary purpose of the uncertainty assessment is to provide a context for the influences of the assumptions inherent to the risk assessment process. The conclusions of the Tier 1 and Tier 2 evaluations are used in decisionmaking to manage the environmental conditions at the Site.

For the Existing Slough, COC concentrations detected in the following media were included in the quantitative analysis: sediments from the bottom and embankments of the Existing Slough, soil/sediment from the dredge spoil piles, and surface water from the Existing Slough. The tiered risk evaluation was conducted on a point-by-point basis, and the results of this effort are discussed below.

6.6.1 Results of Tier 1 Screening

The Tier 1 screening was conducted by comparing concentrations of copper, zinc, and pH to SQGs (ER-Ms, Long et al. 1995) or Water Quality Standards (AWQSs, 40 CFR Part 131; May 18, 2000). To supplement the Tier 1 screening for sediment and soil/sediment at the Site, ER-Mqs and mER-Mqs were calculated for each sample location. In addition, physical parameters were measured to aid in the groundwater evaluation to aid in understanding the form of the metals present.

6.6.1.1 Sediment

Slough Bottom Samples. Table 6-10 presents the historical data collected from 1998 to 2000 in the north and south sloughs. Only the last 10 years of data are included in the results as older data are typically not used and is often obsolete due to physical changes and inputs that may have occurred at the site. Such changes include weather (storm events, freshwater inputs, etc.), flow changes from runoff, floods, and physical changes which may have occurred at the site due to biological reworking of the sediment.

Six out of 12 samples (50%) in the north slough proper (excluding side channels) exceeded ER-Ms for both copper and zinc. RWQCB (1998) ambient concentrations were exceeded in all samples but sample 8N. Concentrations ranged from 51 to 121,000 mg/kg copper, and 81 to 21,700 mg/kg zinc. pH testing was not conducted for these samples. North slough channel (SL1 and SL2 samples) samples collected by URS did not exceed ER-Ms or ambient concentrations for either copper or zinc (Figure 6-3a). pH was not below the 6.5 screening level.

In the south slough sediment samples (1-7), six of seven samples (86%) exceeded ER-Ms for both copper and zinc. Concentrations of copper ranged from 156 to 53,900 mg/kg, and 398 to 88,300 mg/kg zinc (Figure 6-3a). No pH analysis was conducted.

ER-Mqs were calculated for these samples, and the mER-Mq exceeded 1.5 (RWQCB 1997; NOAA 1999; Ross, pers. comm., 2001) in all but north slough sample 8N, and samples taken from SL-1 and SL-2. In the south slough, only sample 6S did not exceed the ER-Mq of 1.5 (Table 6-10).

Embankment samples. Table 6-10 also presents results for the embankment samples collected by URS in 2000 and Figure 6-3b illustrates these results. As described in the FS (URS 2002), five of 26 samples (19%) exceeded the ER-M and 21 of 26 samples (81%) exceeded the RWQCB ambient concentrations for copper.

Eight of 26 samples (31%) exceeded the ER-M for either copper or zinc, and 15 of 26 samples (58%) exceeded ambient concentrations (RWQCB 1998) for zinc. The mER-Mq of 1.5 was exceeded in six of the 26 samples and include samples S1W-0, S1W-2, S2E-0, S3W-0, N1E-0, N4E-0. 14 of 26 samples exceeded the mER-Mq of 0.5.

pH was below the 6.5 screening level in only seven of 26 samples (27%). Samples below the detection limit of 10 mg/kg include five of these 10 samples (50%), suggesting that pH was a factor in the ionic form of the metals in these five samples. The majority of the solid form of these metals is on the east side of the south slough, whereas in the north slough, no trend can be observed on the form of the metals.

6.6.1.2 Soil/Sediment

Dredge Spoil Piles. Previous dredge spoil pile soil/sediment collected by URS was reviewed in the FS (URS 2002; Table 6-11). Only two of 20 samples (N5-0 and N6-0) did not exceed either the ER-M or the RWQCB ambient concentrations for sediment. mER-Mqs were below both screening levels of 0.5 and 1.5 for these two samples. pH was above the 6.5 screening level for N6-0, but not N7-0.

The majority (8 of 11 south, 8 of 20 total) of the ER-M exceedances for copper existed in the south slough (Figures 6-4a and 6-4b). Concentrations ranged from 33 to 5,900 mg/kg (sample N9-0) in the north slough and 170 to 1,800 mg/kg (S7-0) in the south slough. All 11 samples in the south slough, and seven of nine samples in the north slough exceeded RWQCB ambient concentrations for copper (RWQCB 1998).

Similar results were seen for zinc. All 11 samples in the south slough, and seven of nine samples in the north slough exceeded RWQCB ambient concentrations for zinc (RWQCB 1998). Fewer ER-M exceedances were observed, however: six of 11 in the south slough, and five of nine in the north slough exceeded the ER-M. Concentrations ranged from 290 to 3,800 mg/kg in the south slough, and 77 to 910 mg/kg in the north slough.

In the south slough, the mER-Mq of 0.5 was exceeded in all but two samples, and eight of 11 samples (excluding S1-0, S3-0, and S11-0) exceeded the mER-Mq of 1.5. In the north slough, three samples (N7-0, N8-0, and N9-0) exceeded the mER-Mq of 1.5, seven of nine exceeded the 0.5 mER-Mq.

Risk Assessment Samples. RA samples collected in and surrounding the dredge spoil piles indicated copper concentrations ranging from 63 (RA12, 2-2.5’) to 5,500 (RA5, 0-0.5’) mg/kg, and zinc concentrations of 150 (RA1 0-0.5’) to 2,400 (RA11, 0-0.5’) mg/kg (Table 6-11; Figures 6-4a and 6-4b). 22 of 24 samples exceeded the ambient concentration for copper of 68.1 mg/kg (only RA1, 0-0.5’ and RA12, 2-2.5’ did not, RWQCB 1998). The ER-M for copper was exceeded in 15 of these samples. RA1, RA3, and the subsurface samples for RA2, RA4, RA7, RA8, and RA12 were below the ER-M.

Only one sample, RA1 (0-0.5’), was below the ambient concentration for zinc (RWQCB 1998). 14 or 24 samples exceeded the ER-M, samples RA1, RA7, RA9, RA12 and subsurface samples of RA2, and RA8 were below the ER-M for zinc (Table 6-11; Figures 6-4a and 6-4b).

Of the 24 surface and subsurface RA samples, 50% exceeded the mER-Mq of 1.5. These included, RA5, RA6, RA11, subsurface sample of RA3, and surface samples of RA2, RA8, RA9, RA10, and RA12. All but surface sample RA1 and subsurface sample RA12 exceeded the mER-Mq of 0.5 (Table 6-11).

pH was below the 6.5 screening level in 18 of 24 samples, 10 of which were surface samples. Only location RA6 show pH levels above 6.5 at both sampling depths. RA3 and RA5 had pH levels above 6.5 in the subsurface samples.

TOC concentrations were higher in surface samples, and ranged from 1.1 to 7.2% (RA2 and RA9, respectively). Maximum subsurface TOC was 4.6% at RA12. Percent moisture ranged from 6 to 64%, generally increasing with depth of the sample. RA10 and RA1 exhibit a reverse trend.

Transect Samples. All transect samples collected by URS in 2001 exceed the ER-M for copper and zinc, and all samples were below the pH screening level of 6.5 (Table 6-11). Moisture content of these samples ranged from 15-33%.

Co-located Pickleweed Soil/Sediment Samples. Pickleweed was collected primarily in the North slough where it could be found. Soil/sediment samples were collected in the same location. Seven samples were collected and analyzed for TOC, copper, zinc, and pH. All of these samples exceeded the RWQCB ambient concentration of 68.1 mg/kg for copper, and all but sample (PWS-LH-4) exceeded the ambient concentration of 158 mg/kg for zinc. Four samples exceeded the copper ER-M of 270 mg/kg (PWS-HL-1A and 1B, PWS-ML-2, PWS-XY-6). Only PWS-XX-5 and PWS-XY-6 exceeded the zinc ER-M of 410 mg/kg (Table 6-11).

Concentrations of copper ranged from 85 to 1,000 mg/kg and 150 to 2,200 mg/kg zinc. pH in four samples were below the 6.5 screening level (PWS-HL-1A, -1B, and –ML-2). Five ER-Mqs (PWS-HL-1A and 1B, PWS-ML-2, PWS-XX-5, PWS-XY-6) exceeded the 1.5 screening level; LH-4 did not exceed the 0.5, but HL-3 was slightly above 0.5 (Table 6-11).

Trench Samples. Trench sample locations exceeded both the ambient concentrations and the ER-M for copper and zinc in nearly all locations. T5-S-0.5, T7-S-0.5, T12-S-0.5, and T12-S-1 were below the ER-M, and T7-S-0.5 and T12-S-0.5 were also below the RWQCB ambient concentrations for copper. Samples T1-S-3, T5-S-0.5, T7-S-0.5, T12-S-0.5, and T12-S-1 were below the ER-M for zinc, and T7-S-0.5, and both T12 samples were below ambient concentrations for zinc (RWQCB 1998) (Table 6-11).

pH for all but two samples (T7-S-0.5, T11-S-0.3) were well below the 6.5 screening level.

6.6.1.3 Surface Water

Nine surface water samples were collected from 2000-2001 (Table 6-12). Six samples were analyzed for a whole suite of compounds as described in Section 4.

As illustrated on Figure 6-5, five of the six samples exceeded the AWQS for dissolved copper, and no surface water samples exceeded the AWQS for dissolved zinc (40 CFR Part 131; May 18, 2000). pH levels ranged from 6.9 (SG-3) to 8.1 (SW6) and were in the range indicated by EPA (2000). TOC and TSS concentrations ranged from 1.4 (SW1) to 18 (SW6) mg/L and 51 (SW2) to 270 (SW6) mg/L, respectively. Total hardness was high in most samples, ranging from 1,900 to 2,700 mg/L as is typical for tidal waters. SW5 and SW6 were 790 and 700 mg/L, respectively.

6.6.2 Results of Tier 2 Screening

The Tier 2 screening has two components: comparison of site concentrations against E-SSTLs and evaluation of ER-Mqs, mER-Mqs, and toxicity test results. The results of the E-SSTL screening for sediment (collected from Slough bottom and embankments) and soil/sediment (collected from the dredge spoil piles along the Existing Slough) are presented below. A discussion of the ER-Mqs and mER-Mqs in comparison to toxicity test results associated with a particular sample is also provided in this section.

6.6.2.1 Results of E-SSTL Screening

The lowest of the NOAEL- and LOAEL-based E-SSTLs developed for wildlife receptors in the wetland and aquatic habitats were used in the Tier 2 E-SSTL screening. This method was chosen to ensure that potential risks to wildlife relevant to each habitat were evaluated independently. As described in Section 6.5.2, sediment or soil/sediment sample locations that exhibit COC concentrations below the NOAEL-based E-SSTLs were eliminated from further evaluation, as these locations do not pose an unacceptable risk to higher trophic level receptors. Locations with COC concentrations that are above NOAEL-based E-SSTLs but below LOAEL-based E-SSTLs were recommended for remediation or risk management actions. Finally, locations with sediment or soil/sediment concentrations in exceedance of LOAEL-based E-SSTLs were identified as AOCs that were recommended for remediation. The figures presented in this section corresponding to the E-SSTL screening for each media type (i.e., sediment and soil/sediment) only reflect sample location exceedances of LOAEL-based E-SSTLs, as these locations are automatically subject to removal. The NOAEL-based E-SSTLs are very conservative values, similar to effects range-low, and locations in exceedance of these benchmarks do not necessarily warrant remediation.

For copper, the lowest NOAEL-based and LOAEL-based E-SSTLs for the wetland habitat are 46 and 1,081 mg/kg which are protective of the California clapper rail (Tables 6-5 and 6-7). The lowest NOAEL-based and LOAEL-based E-SSTLs for the aquatic habitat are 412 and 9,365 mg/kg which are protective of the great blue heron (Tables 6-6 and 6-8).

For zinc, the lowest NOAEL-based and LOAEL-based E-SSTLs for the wetland habitat are 251 and 2,959 mg/kg which are protective of the salt marsh harvest mouse and California clapper rail, respectively. The lowest NOAEL-based and LOAEL-based E-SSTLs for the aquatic habitat are 678 and 6,777 which are protective of the heron.

Sediment. As reported in Table 6-13, the majority of samples collected from the Existing Slough bottom contain concentrations of copper and zinc in excess of the NOAEL-based E-SSTLs for both wetland and aquatic habitats. However, six of the samples (8N, North SL1, North SL1 Mouth, North SL2 A, North SL2 B, and North SL2 C) collected from the Existing Slough bottom on the north side of the tide gate exhibit minimal exceedances of NOAEL-based E-SSTLs for the wetland habitat, if any. These less-impacted sample locations are not the northern most samples near the mouth of the Existing Slough, as may be expected due to the tidal influence of the Bay, but are closer to the tide gate than to Carquinez Strait. Although COC concentrations detected in the Existing Slough embankment samples are much lower than concentrations detected at the bottom of the Existing Slough (Table 6-13), most of the COC concentrations from the Existing Slough embankments are above the NOAEL-based E-SSTLs for the wetland habitat. A few of these locations contain concentrations that exceed NOAEL-based E-SSTLs for the aquatic habitat as well. With the exception of sample location N4E, the embankment locations in exceedance of NOAEL-based E-SSTLs for both habitats occur at or south of the tide gate.

Figure 6-6a provides a visual representation of the sample locations at the bottom of the Existing Slough in exceedance of LOAEL-based E-SSTLs (see Table 6-14 for screening results). The northern most sample collected from the Existing Slough bottom (1N), near the mouth of the Existing Slough, contains a copper concentration above the LOAEL-based E-SSTL for the clapper rail (wetland habitat). Copper and zinc E-SSTLs protective of the clapper rail are the most stringent of the LOAEL-based E-SSTLs for either habitat. Other locations from the Existing Slough bottom on the north side of the tide gate that exhibit exceedances of only the copper LOAEL-based E-SSTL for the clapper rail include 1N, 3N, and 6N. Samples 4N, 5N, and 7N contain the highest COC concentrations in Slough bottom sediments north of the tide gate. COC concentrations at these locations exceed LOAEL-based E-SSTLs for both habitats. Of the seven samples collected from the Existing Slough bottom south of the tide gate, five of the samples exhibit exceedances of LOAEL-based E-SSTLs. Samples 1S, 2S, and 4S contain COC concentrations above LOAEL-based E-SSTLs for both habitats.

As illustrated on Figure 6-6b, only two samples (N1E-0 and S1W-2) collected from the Existing Slough embankment contain COC concentrations above the LOAEL-based E-SSTLs for the wetland habitat (neither location exceeded values for the aquatic habitat). Both samples were collected in the vicinity of the tide gate. Concentrations at these locations are above the most stringent E-SSTLs only, which are protective of the clapper rail.

Soil/Sediment. As reported in Table 6-15, the majority of samples collected from the dredge spoil piles and surrounding areas contain concentrations of copper and zinc in excess of the NOAEL-based E-SSTLs for both the wetland and aquatic habitats. Exceedances were found in the subsurface as well as the surface soils. In some cases, concentrations of copper and zinc decrease with depth in the samples taken from the dredge spoil piles. COC concentrations vary with depth in samples taken from the trench sample locations. Five of the samples (N5-0, N6-0, PWS-HL-3, PWS-LH-4, and T7-S-0.5) collected from the dredge spoil piles and surrounding areas exhibit minimal exceedances of NOAEL-based E-SSTLs for the wetland habitat, if any. Four of these samples (with the exception of T7-S-0.5) were taken from sample locations north of the tide gate. The T7-S sample location is less than 400 feet southeast of the tide gate. Samples taken from T7-S at depths greater than 0.5 foot exhibit COC concentrations in exceedance of the NOAEL-based E-SSTLs for wetland and aquatic habitats. Although COC concentrations detected in the subsurface soil samples are often lower than concentrations detected in surface soil samples (Table 6-15), most of the COC concentrations from the subsurface soils are above the NOAEL-based E-SSTLs for the wetland habitat. Several of these subsurface samples are in exceedance of NOAEL-based E-SSTLs for the aquatic habitat as well.

Figure 6-7a provides a visual representation of the surficial samples collected from dredge spoil piles that were found to be in exceedance of LOAEL-based E-SSTLs, and Figure 6-7b shows the subsurface samples collected from the piles that exceed these screening levels (see Table 6-16 for screening results). Three sample locations (RA-5, N9, and T-12) north of the tide gate produced samples containing copper concentrations above the LOAEL-based E-SSTL for the clapper rail (wetland habitat; Figure 6-7a). As previously stated, E-SSTLs protective of the clapper rail are the most stringent of the LOAEL-based E-SSTLs for either habitat. Exceedances of the copper LOAEL-based E-SSTL at location N9 were found only in the surface soils, in subsurface soils at a depth of 2.5 feet at T-12, and in both surface and subsurface soils at RA-5. None of these locations contain zinc concentrations above E-SSTLs (Table 6-16).

Of the twenty-three samples collected from dredge spoil piles south of the tide gate, seven of the samples exhibit exceedances of LOAEL-based E-SSTLs. Copper concentrations in samples taken from sample locations S7, S8, S9, S10, RA10, and RA12, and the zinc concentration of the sample taken from S4 are above the LOAEL-based E-SSTL for wetland habitat. No exceedances were exhibited in samples taken from subsurface soils, and no exceedances of values occurred for the aquatic habitat.

Of the six transect samples (Trans 1 through Trans 6) located south of the tide gate, all six contain copper concentrations above the LOAEL-based E-SSTL for wetland habitat, but none of these samples exceed values for the aquatic habitat.

Of the 20 samples collected from trench sample locations south of the tide gate, copper concentrations in nine samples (T1-FILL, T1-S-3, T2-SPOILS, T3-S-1, T3-S-2, T4-FILL, T5-S-

1, T7-S-1, and T9-S-1), zinc concentrations in one sample (T11-S-0.5), and both copper and zinc concentrations in one sample (T1-S-1.5) are above the LOAEL-based E-SSTL for wetland habitat. Copper results in samples T1-FILL, T1-S-1.5, and T3-S-1 exceed the LOAEL-based E-SSTL for aquatic habitat.

6.6.2.2 Comparison of Toxicity Test Results with ER-Mqs and mER-Mqs

For this ERA, the ER-Mq (sample concentration divided by the ER-M) for copper and zinc was determined, and then the mER-Mq (sum of ER-Mqs divided by the number of chemicals) was developed for each sample. Table 6-11 provides the ER-Mqs and mER-Mqs for all dredge spoil pile samples (RA, trench and transect samples) along the Existing Slough. Toxicity tests were only taken on the RA samples, however, and these data were further evaluated to delineate AOCs and assist in developing recommendation regarding removal or risk management. For this project, the number of ER-M exceedances, pH, and the mER-Mq were all relatively good predictors of toxicity for COCs copper and zinc.

As Tables 6-9 and 6-11 indicate (see also Figures 6-4a and 6-4b), trends in the data can be observed. If either the mER-Mq was above 0.5 (Long et al. 2000), pH was below 6.5, or copper or zinc concentrations were above the ER-M, toxicity in *Mytilus edulis* was observed. Only samples RA1-2 and RA3-2 showed good survival, but significant toxicity was observed at 100% elutriate and 50% elutriate dilutions, respectively. RA1-2 showed concentrations of copper and zinc above ambient levels, but below the ER-M for both compounds. pH was above the 6.5 screening level, and the mER-Mq for zinc was 0.6 and for copper was 0.4.

RA3-2 showed similar results, but the zinc concentration of 1,400 mg/kg was above the ER-M and ambient concentration. mER-Mqs for copper and zinc were 0.6 and 3.4, respectively; mER-Mq for the sample for these two compounds was 2.0.

The remaining 11 samples that showed toxicity to *Mytilus edulis* (Table 6-9) can be summarized as follows:

Sample Location	Copper >ER-M	Zinc >ER-M	pH < 6.5	mER-Mq > 0.5	mER-Mq ≥ 1.0
RA2-0	X	X	X		X
RA2-2			X	X	
RA3-0		X	X		X
RA4-2		X	X	X	
RA6-2	X	X			X
RA7-0	X		X		X
RA8-0	X	X	X		X
RA9-0	X		X		X
RA9-2	X		X		X
RA10-2	X	X	X		X
RA12-2			X		

See Table 6-11 for Tier 1 screening results.

These data are consistent with prior *Mytilus edulis* test results at project sites with high copper and zinc concentrations (Ogle 2002). The data are also consistent with Long et al. (2000) which suggests moderate to high toxicity in samples with mER-Mqs from 0.5-1.0.

Data results from the bioaccumulation data (Table 6-9) suggest that copper and zinc concentrations above the ER-M are toxic to the polychaete *Nereis virens*.

From these data, it is recommended that the screening criteria for benthic invertebrate protection be ER-Ms, pH less than 6.5, and mER-Mqs greater than 1.0.

6.7 QUALITATIVE UNCERTAINTY ASSESSMENT

Any risk assessment has a number of limitations, including degree of success in meeting objectives, the range of conditions over which conclusions can be applied, and the certainty with which conclusions can be drawn (USEPA 1989a). The conclusions of a risk assessment are useful once they have been placed in perspective relative to the uncertainties associated with the evaluation. While the uncertainty is recognized, it does not prevent risk management decisions based on the findings of the ERA. A qualitative discussion of the uncertainties pertinent to the ERA are discussed below.

6.7.1 General Sources of Uncertainty

Due to the multiplicity of potential receptor species and general lack of knowledge regarding their life cycles, feeding habits, and relative toxicological sensitivity, the uncertainty surrounding estimates of ecological risk may be substantial. The generic criteria used in this assessment are intended to provide conservative benchmarks for screening purposes. It is important to note that no one approach to criteria derivation is adequate for all sites and chemicals. With the exception of the sediment screening benchmarks, the other criteria used in this assessment are all chemical-specific and as such cannot address the additive, antagonistic, or synergistic effects of the mixtures of chemicals typically found in the environment. Further, they do not take into account the nature and constitution of the ecosystem present at the Site, site-specific conditions regulating chemical contact and bioavailability, the potential toxicity of other constituents that were not quantified, or the pervasive influence of physical stressors associated with the long-term disruption by human activities that is characteristic of an industrial environment.

6.7.2 Specific Sources of Uncertainty

In addition to the broadly influential general sources discussed above, several discrete components, readily identifiable in each of the major phases of an ERA, can significantly influence conclusions about ecological risks.

6.7.2.1 Simplification of the Ecological Setting

Lacking complete knowledge of the Site ecosystem, simplifications have to be made to allow any sort of analysis to occur. For example, a presumption of linearly related feeding relationships is clearly not realistic; however, such simplification is mandatory if needs for decision making about ecological resources exist.

6.7.2.2 Temporal and Spatial Distribution of COCs

The analytical database has inherent uncertainties. For example, because the general objective of the sampling and analysis plan was to characterize potentially contaminated conditions at the Site, sampling was generally concentrated in areas anticipated to have elevated concentrations, i.e., dredge spoil piles and Slough bottom and embankments. This type of directed sampling leads to estimates of the underlying distribution of chemicals that may be conservatively biased.

6.7.2.3 Exposure Assessment

Although it is unrealistic to assume that any wildlife receptor would forage at one location throughout its entire life span, COC concentrations measured at each sample location were compared to E-SSTLs that were developed to address exposure of birds and mammals through their diet (i.e., bioaccumulation). This may cause risks to wildlife receptors to be underestimated some of the time. However, since the strategy of the sampling event for the ERA was to characterize areas at the Site that are known to be impacted by COCs (i.e., dredge spoil piles and Slough bottom and embankments), as mentioned above, a point-by-point comparison to E-SSTLs will most likely cause an overestimation of exposure and risks to receptors of concern.

Other elements of uncertainty related to the exposure assessment include assumptions that are made upon extrapolating life history parameters directly from the literature or developing these parameters from generic equations. For example, the food ingestion rate for the California clapper rail was calculated from an allometric equation generic to nonpasserines. This type of equation is based on regression statistics and allows a food ingestion rate to be derived for a specific bird species by applying the body weight of that particular species to the appropriate equation. Incidental sediment ingestion rates and water ingestion rates are often derived in a similar manner. Also, the diet of the receptor species may be more variable in the composition and proportion than assumed. Other parameters, such as a species home range or their seasonal duration at a site, are usually generated based on conservative estimates or even by assuming the species is at the Site throughout their entire life span.

6.7.2.4 Effects Assessment

Toxicity data used to evaluate effects and "safe concentrations" (or doses) of chemicals to ecological receptors are subject to numerous uncertainties and limitations associated with experimental methods, routes of exposure, methods of dose administration, form of chemical used, intraspecies and interspecies variability in response, extrapolation of high-dose short-term experiments to low-dose, long-term exposures and application of laboratory-collected data to field populations. While most of these sources of uncertainty are unavoidable and difficult to quantify, the net effect is that the potential for toxicity to field populations may be overestimated or underestimated, but the application of uncertainty factors leads to an overestimate (i.e., conservative) of toxic effects.

One approach to estimating safe concentrations was the development of guideline values, criteria, and/or standards for the various receiving media – water, sediment, and soil. AWQSs (based on multiple species bioassays), SQGs (based on correlation analyses of adverse effects and chemical concentrations), and Soil Quality Standards (based on multiple species bioassays) have been proposed as surrogates of safe concentrations.

In general, AWQSs have undergone the most refinement and are the best established of the standards that have been developed for environmental media. Nevertheless, although AWQSs have undergone sufficient scrutiny to be promulgated into law, they do not adequately account for bioavailability of the COCs.

Because of the high degree of uncertainty associated with sediment toxicity data, SQGs remain as guidelines only. In fact, a Canadian regulatory agency, the Canadian Council of Ministers of the Environment (CCME 1995), states that the scientific data required to develop national SQGs are not currently available. All authors caution that SQGs should only be used in the preliminary screening of sediments to ascertain which chemicals are more likely to cause toxicity than others. The authors of a variety of SQGs have clearly stated that such guidelines are screening values only (Long et al. 1995; MacDonald 1994) and are not indicative of any particular causal relationship between an individual chemical and toxicity to benthic organisms.

Despite these shortcomings, the available guidelines, criteria, and standards probably err on the conservative side; they often predict toxicity where none is found in nature.

Uncertainties inherent to E-SSTLs tend to promote overestimation of risks to wildlife as well. Assumptions related to exposure, like the length of time a receptor forages at a particular site (overestimated) and the items they consume (oversimplified to emphasize a certain dietary pathway), are conservative parameters built into the E-SSTL equation (Equation 6-10). As discussed in detail in the effects characterization section (Section 6.5.2.2), the Region 9 TRVs (DTSC 2000) represent generally conservative values drawn from a review of the toxicological literature. These TRVs are not site-specific, meaning the form of the chemical administered, the exposure duration and routes, the phylogeny of the test species, and other factors may have little or no relevance to the conditions and receptors selected for a particular site. Thus, their limitations should be recognized.

6.7.2.5 Risk Characterization

The use of screening benchmarks and E-SSTLs to characterize risk assumes that Site concentrations of chemicals are linearly related to the potential for effects. However, as pointed out in earlier sections, the screening benchmarks do not necessarily correlate well with actual demonstrations of toxicity in the field. Therefore, risk characterization based on exceedances of these benchmarks may overestimate or underestimate the potential for adverse effects. In general, the risk characterization process is intentionally biased towards being more likely to overestimate than underestimate risk.

6.8 SUMMARY AND CONCLUSIONS

A two-tiered evaluation was performed using available data collected from areas of the Site that have the potential for ecological exposure. The Site was separated into two discrete habitats for purposes of the ERA: wetland habitat and aquatic habitat. The environmental medium examined within the wetland habitat includes soil/sediment of the dredge spoil piles that have been cast along the both sides of the Existing Slough. For the aquatic habitat, sediment samples collected from the Existing Slough bottom and embankments were analyzed. Copper and zinc were identified as the primary COCs at the Site during previous investigations (RWQCB 1999) and, thus, were the only COCs evaluated in this ERA (along with pH). The tiered screening were conducted on a point by point basis, where concentrations from each sample location were compared to the appropriate screening values. The following subsections summarize the Tier 1 and Tier 2 evaluations and discuss the implications of these results in terms of AOC identification.

6.8.1 Tier 1 Evaluation (Screening Level)

In Tier 1 (screening level), screening benchmarks were compared to representative concentrations in media from the two habitats. Sediment concentrations from the Existing Slough bottom and embankments of the aquatic habitat and soil/sediment concentrations from the dredge spoil piles of the wetland habitat were screened against ER-Ms developed by NOAA (Buchman 1999; Long and Morgan 1991; Long et al. 1995). Surface concentrations from the Existing Slough were screened against AWQSs (40 CFR Part 131; May 18, 2000). Based on the Tier 1 screening, most of the surface water samples exceeded the AWQS for copper and none were above the AWQSs for zinc. Roughly half of the sediment samples from the Existing Slough bottom north of the tide gate exhibited minimal exceedances of ER-Ms, and most concentrations from south of the tide gate were above the benchmarks (Figure 6-3a). Sediment concentrations from the Existing Slough embankments are lower than those collected from the Existing Slough bottom and, consequentially contain fewer ER-M exceedances (Figure 6-3b). For the dredge spoil piles, the majority of samples collected exceeded ER-Ms regardless of sample depth or location in proximity to the tide gate (Figures 6-4a and 6-4b). However, a few soil/sediment sample locations at the northern portion of Slough (near the mouth) do not contain concentrations above ER-Ms. Toxicity and bioaccumulation testing was conducted on a subset of samples collected from the dredge spoil piles to gain a better understanding of the actual capacity of the sediments at the Site to cause toxicity. The results of the toxicity testing indicate normal development of bivalve embryos (*Mytilus edulis*) was significantly lower than the control in all tests using 6.25-100% elutriate, with the exception of RA1-2 and RA3-2.

6.8.2 Tier 2 Evaluation (Site-Specific)

In Tier 2 (site-specific analysis), E-SSTLs were developed for the avian and mammalian ecological receptors identified for each habitat. The receptors of concern at the Site included in the Tier 2 evaluation are listed below:

- Wetland habitat – salt marsh harvest mouse and California clapper rail
- Aquatic habitat – mallard duck, great blue heron, and river otter

Sediment concentrations from the Existing Slough bottom and embankments of the aquatic habitat and soil/sediment concentrations from the dredge spoil piles of the wetland habitat were screened against the Tier 2 E-SSTLs. The lowest E-SSTL developed for each receptor and habitat was used in the screening process to ensure that potential risks to the most sensitive receptors were evaluated. Two sets of E-SSTLs were generated for each receptor corresponding to NOAEL-based E-SSTLs and LOAEL-based E-SSTLs. Sediment or soil/sediment sample locations that exhibit COC concentrations below the NOAEL-based E-SSTLs were eliminated from further evaluation. Locations with COC concentrations that are above NOAEL-based E-SSTLs but below LOAEL-based E-SSTLs were recommended for remediation or risk management actions. Finally, locations with sediment or soil/sediment concentrations above LOAEL-based E-SSTLs were identified as AOCs that were recommended for remediation.

With the exception of a few sample locations just north of the tide gate, the majority of samples collected from the Existing Slough bottom contain concentrations of copper and zinc in excess of the NOAEL-based E-SSTLs for both wetland and aquatic receptors. The Existing Slough embankment samples in exceedance of NOAEL-based E-SSTLs for both habitats occur at or south of the tide gate, excluding one location that is north of the tide gate. Figures 6-6a and 6-6b illustrate the sample locations at the bottom of the Existing Slough and Slough embankments in exceedance of LOAEL-based E-SSTLs, respectively. Slough bottom samples collected near the mouth of the Existing Slough exhibit minimal exceedances of LOAEL-based E-SSTLs. Of the seven samples collected from the Existing Slough bottom south of the tide gate, five of the samples exhibit exceedances of LOAEL-based E-SSTLs. Only two samples collected from the Existing Slough embankments contain COC concentrations above the LOAEL-based E-SSTLs, and the exceeded E-SSTLs are the most stringent values from either habitat (protective of the California clapper rail).

The majority of samples collected from the dredge spoil piles contain concentrations of copper and zinc in excess of the NOAEL-based E-SSTLs for both the wetland and aquatic habitats. Exceedances were found in the subsurface as well as the surface soils. Figure 6-7a illustrates the surficial samples collected from dredge spoil piles that were found to be in exceedance of LOAEL-based E-SSTLs, and Figure 6-7b shows the subsurface samples collected from the piles that exceed these screening levels. Three samples from locations north of the tide gate contained copper concentrations above the LOAEL-based E-SSTL for the clapper rail, the most stringent E-SSTL, but none of these samples were above the zinc E-SSTL. These exceedances occur between the depths of 0 to 2.5 feet bgs. Of the 23 samples collected from dredge spoil piles south of the tide gate, seven of the samples exhibit exceedances of LOAEL-based E-SSTLs for the clapper rail. No exceedances were exhibited in samples taken from subsurface soils, and no exceedances of values occurred for the aquatic habitat.

In the second phase of the Tier 2 evaluation, number of ER-M and mER-Mqs were compared to the results of the toxicity tests that were conducted on a subset of the RA samples collected from the dredge spoil piles. Table 6-11 provides the ER-M screening results and mER-Mqs for all dredge spoil pile samples along the Existing Slough, and Table 6-9 presents the results of the toxicity tests. For this project, the number of ER-M exceedances, pH, and the mER-Mq were all relatively good predictors of toxicity for COCs copper and zinc.

6.8.3 Identification of Areas of Concern

Based on the results of the tiered evaluations, soil/sediment of all dredge spoil piles pose unacceptable risks to ecological receptors at the Site. Dredge spoil piles located along the Existing Slough constitute AOCs, as these materials contain high concentrations of copper and zinc (and low pH levels) and are not characteristic of substrates associated with a healthy marsh. Although a few samples from piles located near the mouth of the Existing Slough do not exceed generic sediment benchmarks protective of benthic invertebrates (i.e., ER-Ms) and E-SSTLs that are protective of wildlife, toxicity results indicate that these sediments may pose an unacceptable risk to the benthic community. An absence of vegetation and biota living in the piles also supports this conclusion. In addition, the results of the ERA confirm that sediments of the

Existing Slough bottom and sidewalls are AOCs should be managed through remedial action. Risks through exposure to surface water will be eliminated when the Existing Slough is rerouted into the new alignment.

7.1 WATER QUALITY PROTECTION STRATEGY

Pursuant to Task 2 of the RWQCB Order this groundwater evaluation was performed to establish groundwater cleanup standards for Peyton Slough. A water quality protection strategy for maintaining high quality beneficial water uses in the realigned Peyton Slough is outlined, which includes the use of a groundwater monitoring well network with designated POCs and guard wells (Figure 7-1). Groundwater concentrations of copper and zinc that may limit the attainment of water quality goals for beneficial uses and/or environmental protection values in the new alignment of Peyton Slough were developed for use as numerical groundwater quality limits.

A mathematical model was developed to simulate interactions between groundwater, tidal surface water flows, and benthic sediment porewater in the new alignment of Peyton Slough. Based on site-specific input parameters, the model calculates copper and zinc groundwater concentrations at POCs that may lead to exceedance of National Ambient Water Quality Criteria/ California Toxics Rule concentrations in adjacent surface water or ER-M values in benthic sediments (defined as the top 2 feet of solids beneath the water column). According to Finding 12(b) of the RWQCB Order, groundwater underlying and adjacent to the Site has never been a potential source of drinking water due to a naturally high concentration of sodium chloride in the alluvial aquifer and bedrock. Municipal supply for drinking water therefore was not considered a potential beneficial use for groundwater in Peyton Slough. Existing and potential beneficial uses of Peyton Slough (as a tributary to Carquinez Strait) listed in the RWQCB Order include:

- Ocean, commercial, and sport fishing
- Industrial process supply or service water
- Water contact and noncontact recreation
- Wildlife habitat
- Fish migration and spawning
- Navigation
- Estuarine habitat
- Preservation of rare and endangered species

7.2 HYDROGEOLOGIC SETTING AND CONCEPTUAL MODEL

The Martinez facility and adjacent Peyton Slough are located in California's eastcentral Coast Range geomorphic province. Topographically higher portions of the facility reside on a graded hill composed of Cretaceous and Paleocene shale and sandstone. Topographic lows at the facility are composed on flat-lying Quaternary Bay Muds, sands, and peats of the Sacramento/San Joaquin fluvial-deltaic depositional system.

In portions of the Rhodia Martinez facility and adjacent Peyton Slough where mining wastes (cinders and slag) have been deposited, concentrations of copper and zinc in groundwater are significantly higher than background levels. West of the Existing Slough channel, cinders and slag had previously been piled and some material remains sunken into the Bay Mud sequence.

Side-cast dredge material from Peyton Slough may release copper and zinc into soil porewater in underlying and adjacent vegetated/root zone saturated soils that are perched above Bay Mud.

Groundwater flow in the upper most water-bearing unit (the water table unit) at the facility and adjacent Peyton Slough is largely controlled by topography, with the potentiometic surface outcropping into the Existing Slough channel. Beneath the alluvial water table unit lies the bedrock unit and, in the vicinity of the southern portion of the facility, an intervening lower intermediate/peat unit. The water quality protection strategy presented herein is limited in scope to water-bearing zones that surround the New Slough alignment, which includes sediments above bedrock that may be hydraulically continuous with copper- and zinc-impacted groundwater.

An illustrated conceptual model to describe groundwater interaction with surface water and benthic/sediment porewater in the New Slough alignment is presented on Figure 7-2. In the conceptual model, intermedia transfers of aqueous fluids are represented at the interfaces between environmental media:

- Lateral groundwater seepage at the aquifer outcrop into the Existing Slough sidewall
- Vertical upward groundwater seepage into benthic sediment
- Porewater exchanges between surface water and benthic sediment interstices

A mathematical model was developed that calculates the intermedia exchange rates and quantitative relationships between groundwater and surface water concentrations and benthic sediment (see Section 7.4.3).

7.3 PROPOSED POINT OF COMPLIANCE LOCATIONS

Although they have not yet been constructed, the groundwater POCs eventually will be located along the western perimeter of the New Slough alignment. A network of guard wells, whose function is to provide an early warning of groundwater contaminant migration toward the POCs, has already been installed in Peyton Slough. Guard well locations were selected with the aim of providing representative coverage of the New Slough perimeter while targeting specific locations of potential vulnerability with respect to lateral groundwater migration. When constructed, individual POC wells will be paired with specific guard wells. The actual locations where POC wells are to be installed will depend on the final alignment of the New Slough channel. A map showing the layout of existing guard wells and approximate future locations of POC wells in Peyton Slough is shown on Figure 7-1.

7.4 PROPOSED NUMERICAL GROUNDWATER QUALITY LIMITS

For the purpose of protecting water quality in the New Slough, site-specific numerical groundwater water quality limits were developed. Groundwater physical and chemical interactions with surface water and benthic sediment in the New Slough channel were evaluated and limiting concentrations of copper and zinc were calculated. Based on the assumption that the Existing Slough alignment will be closed, groundwater quality limits are proposed for application only relative to the New Slough alignment.

7.4.1 Water Quality Objectives

As part of a system of functioning tidal marshlands, Peyton Slough historically connected Carquinez Strait with McNabney Marsh, which lies to the south. Restoration of tidal flows in Peyton Slough is one of the objectives of the remedial design effort being undertaken as part of Task 3 of the RWQCB Order. As an estuarine slough, water quality objectives for both freshwater and saltwater may be potentially applicable.

The most stringent water quality goals listed in the RBSL guidance (RWQCB 2000) are 2.4 and 23 micrograms per liter (μg/L) for copper and zinc, respectively. These RBSLs are also included in the Basin Plan (RWQCB 1995) and apply to total metal concentrations. However, more recent criteria for these constituents are found in the California Toxics Rule (USEPA 2000d). For this groundwater evaluation, dissolved metals concentrations are considered to form a more appropriate basis for developing groundwater quality objectives with respect to the receiving water body. The numerical limits established in the California Toxics Rule for copper (3.1 μg/L) and zinc (81 μg/L), which apply to dissolved saltwater concentrations, were therefore considered to be the applicable water quality objectives for the receiving water body (i.e., the water column in the New Slough).

The rate of groundwater discharge into Peyton Slough is limited by the permeability of groundwater-bearing units and the hydraulic gradients that exist in the water table aquifer. Copper and zinc concentrations in groundwater that are higher than the surface water quality objectives may discharge slowly into the tidal channel without causing exceedance of water quality objectives there, provided that sufficient channel flow is maintained. Limiting concentrations of copper and zinc in groundwater that may discharge into the New Slough without causing an incremental impairment by a margin representing the California Toxics Rule numerical limits were calculated using a mathematical model (see Section 7.4.3).

7.4.2 Sediment Quality Considerations

Sediment quality criteria are not as well defined as surface water quality goals in existing California and national guidance and regulations. In the site-specific ERA, the ER-M values for marine sediment were more stringent than the LOAEL-based SSTLs. For risk management purposes, the ER-Ms generally are considered applicable sediment quality objectives to address potential ecological toxicity.

Groundwater discharge directly into benthic sediment interstices may serve as a source of chemical loading to benthic sediments. Benthic organisms that may reside in or near the bottom of the Existing Slough channel (0 to 14 inches beneath the base of the water column) are potentially exposed to solids and/or porewater. Chemical partitioning between porewater and solids is an important consideration that was addressed through site-specific modeling, as described below.

7.4.3 Site-Specific Groundwater/Surface Water/Benthic Interaction Model

Site specific modeling was performed to quantitatively evaluate relationships between groundwater and surface water and benthic sediment in the New Slough. Numerical groundwater quality limits for groundwater at POCs were back-calculated using the model. These numerical limits correlate to limiting sediment quality concentrations (ER-Ms) and surface water copper and zinc concentrations that meet applicable water quality objectives. Details of the modeling effort are described below.

7.4.3.1 Model Description

USEPA's Water Quality Analysis Simulation Program 6.0 (WASP6) formed the basis for site-specific modeling of groundwater/surface water/benthic interactions in the New Slough alignment. The governing equations for WASP6 were solved analytically and entered into an EXCEL spreadsheet model for ease of use and overall transparency. A schematic diagram of the model mass balance and overall layout is presented on Figure 7-3. Back-calculation of numerical groundwater quality limits involved performing a series of iterative model runs, which could be completed in far less time using the spreadsheet model (versus the WASP6 computer code). All final modeling results, however, were confirmed using WASP6 runs. The derivation of the analytical model and model validation results are presented in Appendix E.

URS performed the modeling in two steps. First, for a specified groundwater seepage rate, a series of chemical concentrations entering the New Slough were simulated and the resulting chemical concentrations in the water column and the underlying benthic sediment were calculated. In the second step, the modeled water column and benthic sediment concentrations were compared against numerical limits representing the selected surface water and sediment quality objectives. For each stream segment, a numerical groundwater quality limit was obtained from the input groundwater chemical concentration for which the calculated instream concentrations matched the most stringent numerical limit for either surface water of sediment quality.

7.4.3.2 Input Parameters

The modeling approach employed in WASP6 divides the water body into multiple segments. For this modeling evaluation, 20 water column segments were assigned along the length of Peyton Slough between Carquinez Strait and the railroad crossing (see Figure 7-4). Each water column segment was underlain by a benthic layer segment, for a total of 40 segments simulated within the model domain. Several segment groupings are established within the model so that potential discharges at individual POCs can be evaluated separately for each guard well.

Copper and zinc loading rates are represented by model input parameters for groundwater flow and concentration at segment boundaries. Groundwater seepage calculations were performed to obtain the flow terms for sidewall seepage and benthic underflow seepage. The seepage calculations were performed using Darcy's law. The independent variables governing seepage rates are shown schematically on Figure 7-5 and the values assigned to these calculation parameters are shown in Table 7-1.

The widths and heights of each segment are listed in Table 7-2 and the segment lengths are described in Appendix E. Additional input parameters used for modeling groundwater/surface water/benthic interaction are listed in Table 7-2 and include sediment-water sorption (or distribution) coefficients, the surface water flow rate, and the benthic porewater exchange rate. The source and/or rationale for each selected parameter value also are included in Table 7-2.

7.4.3.3 Assumptions

Several assumptions about the Existing Slough hydrologic system are represented in the modeling. Key assumptions are listed below and associated uncertainties are discussed.

- Continuous source of contaminants – The modeling assumes that if contaminated groundwater reaches the New Slough, an inexhaustible supply of dissolved contaminants results. This assumption is conservative and reflects a worst-case situation.
- Tidal prism volume experiences two passes – Tidewaters may actually contact the Existing Slough channel two times (once on incoming tide and again on outgoing tide). The equivalent daily "new water" flow passing through the Existing Slough was represented using a preliminary estimate of one-half the tidal prism volume.
- Low-permeability embankments – South slough sidewalls were assumed to have permeability equivalent to Bay Mud. At present, some areas where root mat materials are present in the south slough may have higher permeability. The modeling assumes that those higher permeability soils (or root mat materials) and side-cast dredge spoils will be removed prior to construction of the New Slough. The north slough is assumed to have a high permeability embankment (equivalent to clean sand).
- Porewater exchange rates – Modeling of benthic sediment porewater and solids concentrations assumes continuous circulation of surface water into sediment interstitial porewater. While this phenomenon is not fully understood scientifically, recent research (Huettel and Rusch 2000, Huettel and Webster 2000) suggests that the porewater pumping rates calculated based on tide-driven pore pressure gradients are reasonable for permeable sediments (~ 10^{-7} cm^2).
- Linear and reversible sorption – Binding of metals to benthic sediments is assumed to occur via a sorption process in which the relationship between the sorbed concentration and the dissolved concentration is liner. The sorption process also is assumed to be reversible (i.e., metal sorption and desorption occur in proportion to a single distribution coefficient).

7.4.3.4 Model Results

Summaries of modeling results for copper and zinc obtained from the groundwater/ surface water/benthic interaction simulations are presented in Tables 7-3 and 7-4, respectively. Detailed modeling results are presented in Appendix E. The modeling results summaries present the maximum groundwater concentrations that could seep into the New Slough without exceeding copper and zinc concentration margins equal to the adopted surface water and sediment quality objectives. The calculated maximum groundwater concentrations were higher for segments in the south slough because the assumed permeability of the embankment was lower than for the north slough (as explained in the discussion of assumptions). Based on these modeling results, site-specific numerical groundwater quality limits are proposed in the next section.

7.4.4 Numerical Criteria for Groundwater

Site-specific modeling of groundwater/surface water/benthic interactions produced estimates of the maximum groundwater concentrations that can be allowed to seep into the New Slough through sidewalls and benthic underflow without exceeding marginal contributions equal to applicable surface water and sediment quality objectives. These limiting groundwater concentration values are proposed for use as site-specific numerical groundwater quality limits to be applied at POCs that will be designated along the perimeter of the New Slough (Table 7-5). Based on these proposed numerical criteria, URS performed an evaluation of existing groundwater quality data for Peyton Slough (see Section 7.5 below) and developed a conceptual monitoring approach for the New Slough alignment (see Section 7.6).

7.5 EVALUATION OF EXISTING GROUNDWATER QUALITY RELATIVE TO THE NEW SLOUGH

A comparison of detected copper and zinc concentrations in existing guard wells versus the site-specific numerical groundwater quality limits proposed for the New Slough in Section 7.4.3 is presented in Table 7-6. None of the copper or zinc guard well concentrations observed during the one completed round of groundwater sampling exceed the proposed numerical limits. Based on these results, it will be possible to achieve acceptable surface water and sediment quality within the New Slough with ongoing sidewall and benthic underflow seepage of extant groundwater copper and zinc concentrations, provided that the modeling assumptions are met following construction of the New Slough channel.

It should be noted that several of the existing guard wells have screen intervals that cross between the upper root map zone and underlying Bay Mud. For areas of the south slough (upstream from the levee) where side-cast dredge spoils have been deposited, the upper soil layer will be removed as part of AOC remedial activities. After those removal measures are completed, any guard wells whose screens are exposed will be rebuilt with screen extending into underlying Bay Mud. The conclusions presented in this groundwater evaluation are based, in part, on the assumptions that (1) any preferential flow paths to the south slough (such as paleochannel oxbows) will be blocked using appropriate engineering controls, and (2) south slough sidewalls remaining after dredge spoils removal will have a hydraulic conductivity of equal to or less than 1×10^{-8} m/s.

7.6 MONITORING APPROACH FOR NEW SLOUGH ALIGNMENT

Proposed approximate locations of guard wells and POC wells are shown in relation to the New Slough alignment on Figure 7-1. As indicated in Tables 7-5 and 7-6, each guard well and POC well pair has an associated site-specific proposed set of numerical groundwater quality limits. A schedule for Peyton Slough groundwater monitoring and a decision diagram for evaluating ongoing compliance will be presented in a forthcoming groundwater monitoring plan, to be submitted with the Remedial Design Report in Spring 2002.

Based on the results of a preliminary screening presented in the FS (URS 2002), whereby ER-Ms (Long and Morgan 1991; Long et al. 1995) and Industrial PRGs (USEPA 2000) were compared to concentrations of copper and zinc detected in environmental media at the Site, potential AOCs were identified. One of the primary objectives of this report was to refine the AOCs through a tiered risk-based approach and identify the areas that warrant remedial attention.

8.1 AREAS OF CONCERN

The existing dataset for the Site was supplemented with surface and subsurface samples collected from the dredge spoil piles that were analyzed for copper, zinc, pH, and a few general parameters (e.g., sulfide, sulfate, TOC). In Tier 1 (screening level), RBSLs that are protective of human health and ER-Ms that are protective of benthic organisms were used to screen representative COC concentrations in media from the Existing Slough. In Tier 2, SSTLs were developed for human health and ecological receptors based on exposure scenarios that are appropriate for the Site. The results of the RA were evaluated in an effort to further refine the AOCs.

8.1.1 Upland Areas

In general, H-SSTLs were much higher than E-SSTLs. The human health evaluation for the upland exposure areas was not relevant for further delineation of the potential AOCs, as all COC concentrations in that area were below H-SSTLs. Therefore, upland areas are not included within AOCs.

8.1.2 Existing Slough and Dredge Spoil Piles

H-SSTLs developed for the angler scenario, E-SSTLs, and ER-Ms (supplemented with toxicity test data) were more useful parameters for the AOC delineation. The results of the ERA indicate that the majority of the dredge spoil piles along the northern and southern portions of the Existing Slough exceed ER-Ms for copper and zinc. In addition, all samples from the spoil piles that were subjected to toxicity testing proved to be significantly toxic. E-SSTLs for food web-based ecological receptors were also exceeded in many areas of the spoil piles. Similarly, sediments in the bed of the Existing Slough, and to a lesser extent, its sidewalls, had numerous exceedances of ER-Ms. Sediments in the north slough also exceed H-SSTLs for fish consumption. Therefore, based on their potential for ecological toxicity, the dredge spoil piles along the sides of the Existing Slough are proposed as AOCs. Because the dredge spoil piles appear to have spread over the area between the Existing and New Sloughs south of the levee, this area is identified as an AOC. The cause of this spread of spoil materials on the southeastern side of the Existing Slough is due to the low elevation of 3 feet below mean sea level in this area. Additionally, sediments and surface water in the Existing Slough, where risk-based SSTLs are exceeded, are also proposed as AOCs.

8.1.3 Target Cleanup Levels

For the wetland habitat, a two-step process is proposed for the use of target cleanup levels for soil and sediment that may remain in place after the remedial alternative is implemented. In the first step, sediments with residual concentrations of chemicals where the probability of adverse effects is high will be identified for removal or remediation efforts (i.e, concentrations exceed the lower of the ER-Ms or LOAEL-based SSTLs). In the second step, sediments with residual concentrations where the potential for adverse effects is moderate will be proposed for in-place risk management or for other risk reduction measures that may not necessarily include removal (i.e, concentrations are lower than ER-Ms or LOAEL-based E-SSTLs but exceed NOAEL-based E-SSTLs).

The target cleanup goals were selected after review of the SSTLs for all the evaluated wetland receptors. The target cleanup goals that are proposed for the first step (effect-based SSTLs) are 270 mg/kg for copper and 410 mg/kg zinc for wetland habitats, based on the ER-Ms. Exceedance of these values indicates the potential for toxicity to the benthic community. Sediments that exceed these values would be proposed for active remediation. The target values that are proposed for the second step are 239 mg/kg for copper and 251 mg/kg for zinc in the wetland habitat (protective of the salt marsh harvest mouse). Sediments that exceed these values but that are below the ER-Ms may be recommended for in-place management and/or risk reduction.

For the aquatic habitats, only one set of target cleanup levels is proposed, the ER-Ms (270 mg/kg for copper and 410 mg/kg for zinc). Because the NOAEL-based E-SSTLs for the aquatic habitat were higher than the ER-Ms, use of the NOAEL-based E-SSTLs to identify areas suitable for in-place management may not be protective of the benthic community. Therefore, sediments exceeding the ER-Ms in aquatic habitats would be proposed for active remediation.

8.2 CONCLUSIONS

The findings of the RA indicate that dredge spoil pile materials along the Existing Slough may pose an unacceptable risk to ecological receptors. An absence of vegetation and biota living in the piles also supports this conclusion. In addition, the results of the ERA confirm that sediments of the Existing Slough bottom and sidewalls are AOCs and should be managed through remedial action. Risks through exposure to surface water in the Existing Slough will be eliminated when the Existing Slough is rerouted into the new alignment. For the residual area of the marsh, recommended target levels are represented by ER-Ms and E-SSTLs.

The results of the groundwater evaluation indicate that, provided the dredge spoil piles and associated root mat that may be impacted are removed from areas south of the tide gate, groundwater impacts to the New Slough alignment (both north and south of the levee) will not be significant.

8.3 RECOMMENDATIONS

Field investigations (URS 2002) established that dredge spoil piles placed along the eastern bank of the Existing Slough, south of the tide gate, have been spread over the area between the Existing Slough and proposed New Slough alignment. This area has been defined as an AOC and is subject to remediation. Since the existing data from the Site do not allow sufficient horizontal and vertical delineation of the AOCs located north of the tide gate, further sampling is recommended to identify the boundaries of these AOCs.

The FS (2002) identifies the New Slough as the preferred remedial alternative and asked for an evaluation of the potential for groundwater from the Existing Slough area to contaminate the New Slough. As part of the initial assessment of the New Slough, this section provides an evaluation of sediments in the New Slough area in relation to human and ecological risk and also identifies the potential for recontamination from groundwater.

The conceptual remedial action plan calls for removal of up to 4 feet of sediments to construct the New Slough. The shallow sediments (from 0 to 4 feet bgs) will be considered for use as cap material for the Existing Slough. The deeper sediments that are currently at a depth of 4 feet will then comprise the future exposure and recruitment/recolonization area for human and ecological receptors. It is important to note that the sediments in the New Slough are not similar or comparable to the Existing Slough for several reasons. These sediments are expected to be primarily native sediments of the marsh and have little or no association with the mineralized and exposed dredge spoil piles along the sides of the Existing Slough. The deeper sediments of the New Slough are expected to have different physical and chemical characteristics (e.g., grain size, TOC, sulfide) than the dredge spoil piles in ways that are likely to decrease the bioavailability of chemicals in these sediments.

For the ERA, ER-Ms and E-SSTLs were used to identify potential ecological impacts that may be encountered subsequent to the construction of the New Slough. Protection of human health from exposure to chemicals present at the New Slough was based on H-SSTLs developed for the Site. To fulfill these requests, sediment samples collected from the vicinity of the New Slough were analyzed for copper, zinc, and pH to support a determination as to whether chemical concentrations in this area are below the Tier 1 and 2 comparison values used for the Existing Slough.

Predicted groundwater/surface water interactions in the area of the New Slough were used to back-calculate ecologically acceptable COC concentrations in groundwater based on AWQSs. This method was used to evaluate whether surface water in the New Slough will pose unacceptable risks to aquatic organisms that could occupy the New Slough. Section 7 provides a detailed discussion of the approach implemented to assess the quality of surface water that will occupy the New Slough in the future.

The following subsections present the human health and RAs that serve to quantify the risks that may be posed to human and ecological receptors upon construction of the New Slough. The results of these evaluations, including the groundwater evaluation (Section 7), may be used to make a determination as to whether construction of a New Slough is a favorable remedial alternative.

9.1 HUMAN HEALTH RISK ASSESSMENT

9.1.1 Exposure Characterization

Based on the available information about the features and location of the New Slough, it is reasonable to assume that the exposure scenarios of concern for the Existing Slough are applicable and relevant to represent environmental conditions at the New Slough. The most likely design alternative at the time of this writing consists of excavating the top 4-foot layer of sediment along the New Slough. The excavated material may be reused as cap material for the

Existing Slough. Therefore, the exposure scenarios applicable to the soil that was excavated are the upland scenarios represented by the upland commercial/industrial workers, excavation workers, and recreators that were described in Section 5. The sediments in the New Slough below 4 feet deep will remain in place and become the New Slough bottom. Therefore, the exposure scenario of concern for the sediment left in place at the bottom of the New Slough is represented by the angler fish consumption.

The exposure pathways illustrated in the CSM and described in Section 5.3 are relevant to the New Slough. The quantitative evaluation of these pathways was conducted by the development of H-SSTLs used to evaluate if the chemicals detected in the subsurface pose an unacceptable risk to human health due to long-term (chronic) low-level chemical exposure. H-SSTLs may serve as preliminary goals for construction planning purposes. In general, where H-SSTLs are not exceeded, no further consideration of potential health risks is warranted. If H-SSTLs are exceeded, the potential for human health concern exists, and additional evaluation of site-specific exposure conditions and the reasonableness of the exposure assumptions may be warranted.

As explained above, Tier 2 H-SSTLs prepared for the Existing Slough and the upland area (Chapter 5) are applicable to the evaluation of the New Slough and the capped Existing Slough (upland area), respectively. Concentrations from sediment data collected from a depth of 4 to 5 feet bgs were compared to H-SSTLs for angler receptors, because construction of the New Slough will entail removal of sediment to this depth. However, COC concentrations measured in sediments from the 4-foot depth and shallower were compared to H-SSTLs for commercial and construction workers and to recreator receptors to assess potential human health risks associated with sediments that may be placed as a cap material for the Existing Slough after excavation. The comparisons were conducted on a point-by-point basis and the results are discussed below.

9.1.2 Results and Conclusions

The results of the Tier 2 screening, where COC concentrations in sediment were compared to H-SSTLs, are provided in this section. The Tier 2 screening has two components: comparison of shallow sediment (0 to 4 foot bgs) concentrations against H-SSTLs for the upland receptor scenarios (capping the Existing Slough after remediation); and deeper sediment concentrations (below 5 feet bgs) against H-SSTLs based on fish consumption for the channel bottom of the New Slough. The results of the evaluations are presented in Table 9-1 and are summarized below.

No exceedances of H-SSTLs were observed in the shallow sediments or in the deeper sediments. For the upland area, the maximum detected concentration for copper (2,741 mg/kg) and for zinc (1,412 mg/kg) did not exceed the minimum H-SSTLs developed (63,194 mg/kg for copper and 100,000 mg/kg for zinc) for the receptors of concern. For the New Slough, the maximum detected concentrations for copper (1,200 mg/kg) and for zinc (1,145 mg/kg) did not exceed H-SSTLs developed for angler receptor (24,945 mg/kg for copper and 13,047 mg/kg for zinc). The results of the HHRA for the New Slough show that maximum detected concentrations are lower than the lowest H-SSTL, indicating that the detected concentrations do not represent a concern to human health under exposure scenarios considered relevant for the Site.

9.2 ECOLOGICAL RISK ASSESSMENT

9.2.1 Exposure Characterization

Since the New Slough will be constructed relatively close to the Existing Slough, which will be capped and restored to wetland habitat, the same habitat types and animal species described for the Existing Slough in Section 6.2 characterize future conditions of the New Slough. To reiterate, the following receptors of concern were identified for each habitat type present:

- Wetland Habitat - benthic invertebrates, salt marsh harvest mouse, and California clapper rail
- Aquatic Habitat - fish, aquatic invertebrates, mallard duck, great blue heron, and river otter

The complete and significant exposure pathways illustrated in the CSM (Section 6.4.1) and described in Section 6.4.2 are relevant to the New Slough. The quantitative evaluation of these pathways was conducted based on a tiered approach. The purpose of the first tier was to assess risks posed to benthic invertebrates from direct contact with sediment impacted by site-related COCs. In the second tier, bioaccumulative pathways were addressed by assessing risks posed to birds and mammals from exposure to COCs through their diet.

9.2.2 Effects Characterization

The Tier 1 sediment benchmarks (ER-Ms; Buchman 1999; Long and Morgan 1991; Long et al. 1995; Section 6.5.1) and Tier 2 E-SSTLs (Section 6.5.2) selected in the ERA prepared for the Existing Slough are applicable to the evaluation of the New Slough. In the Tier 1 analysis, ER-Mqs and mER-Mqs were also discussed relative to potential effects posed to the benthic community based on COC concentrations detected at each sample location of the New Slough. Sediment data collected from a depth of 4 to 5 bgs are emphasized in the Tier 1 and Tier 2 screening tables (the depths are accompanied by an asterisk) because construction of the New Slough will entail removal of sediment to this depth. However, COC concentrations measured in sediments from the 4-foot depth and shallower were still compared to sediment screening benchmarks in an effort to assess potential ecological risks associated with these sediments, as this material may be used to cap the Existing Slough after excavation. The tiered ERA was conducted on a point-by-point basis, and the results of this effort are discussed below.

9.2.3 Risk Characterization of the New Slough Alignment

For the Tier 1 screening, COC concentrations in sediment samples collected from the vicinity of the New Slough were compared to ER-Ms (Buchman 1999; Long and Morgan 1991; Long et al. 1995) to assess the potential exposure to sediment. To supplement the Tier 1 screening for sediment, ER-Mqs and mER-Mqs (sum of ER-Mqs divided by the number of chemicals; see Section 6.5.1) were calculated for each sample location. The mER-Mq provides a cumulative ratio for the COCs detected in each sample. Mean ER-Mqs above 1.5 are associated with a high probability of toxicity observed in marine amphipods (RWQCB 1997; NOAA 1999; Ross, pers. comm., 2001).

For the Tier 2 screening, potential chemical effects associated with the bioaccumulation pathway were assessed by deriving sediment concentrations protective of receptors (E-SSTLs) and comparing E-SSTLs with COC concentrations in sediment. The E-SSTL approach was used to characterize concentrations of chemicals in media and in the food web based on risk (i.e., "back-calculating" acceptable media concentrations for receptors via the identified exposure pathways). E-SSTLs are more readily comparable to Site concentrations than forward-calculated HQs because they are expressed as concentrations in media (e.g., mg/kg COC in sediment). Two sets of E-SSTLs were generated for each receptor corresponding to NOAEL-based E-SSTLs and LOAEL-based E-SSTLs. Sediment sample locations that exhibit COC concentrations below the NOAEL-based E-SSTLs were eliminated from further evaluation. Locations with COC concentrations that are above NOAEL-based E-SSTLs but below LOAEL-based E-SSTLs were recommended for risk management decisions. Finally, locations with sediment concentrations in exceedance of LOAEL-based E-SSTLs were identified as unsuitable areas for construction of the New Slough.

9.2.3.1 Results of Tier 1 Screening

The sediment benchmarks protective of benthic invertebrates that were selected for the Tier 1 screening are ER-Ms. These Tier 1 screening levels are described in Section 6.5.1. The ER-M for copper is 270 mg/kg and the ER-M for zinc is 410 mg/kg. A discussion of the ER-Mqs and mER-Mqs is included in the first tier results (Section 6.5.1). Table 9-2 displays the results of the Tier 1 analysis and a discussion of these results is presented below.

Fourteen locations were collected in the New Slough vicinity. Most samples were collected from at least three depths: 0-0.5 foot, 1.0-1.5 feet, and 4-4.5 feet (Table 9-2, Figures 9-1a and 9-1b). The total number of samples collected was 40. Of these samples, copper was present in 26 of 40 samples (65%) at concentrations above the RWQCB (1998) ambient concentrations. Fifteen of these 26 were also above the ER-M for copper of 270 mg/kg.

Twenty-eight of 40 (70%) samples showed zinc concentrations above the RWQCB (1998) ambient concentrations. Thirteen of these samples exceeded the ER-M for zinc of 410 mg/kg, however.

0- to 4-foot depth. The majority of the samples that exceeded ambient or ER-M concentrations were surface samples at depths up to 1.5 feet (Figures 9-1a, 9-1b). Fifteen of 40 samples exceeded the ER-Ms for either copper, zinc, or both. With the exception of samples SSB1-1, SSB1-2, and SSB3-4, high concentrations were seen in the New Slough south of the levee including the SSB4 location.

4- to 5-foot depth. Eight of ten samples at the 4-foot depth, with the exception of SSB2-4 and SSB8-4, showed exceedances of ambient concentrations for copper and/or zinc (RWQCB 1998). Six of these eight samples also exceeded the ER-M for copper or zinc. Samples SSB1-4 (north of the levee) and SSB10-4 (south of the levee) area were the exceptions that did not exceed ER-Ms (Figure 9-1b).

pH concentrations in the New Slough vicinity were slightly to moderately acidic (below the 6.5 screening level) beginning with SSB4 and moving southward. pH levels in these samples ranged from 3.2 to 6.3. Twenty of 40 samples (50%) had pH less than the 6.5 screening level. Only samples SSB1, SSB2, SSB3, SSB4-4, SSB8-4, SSB10, and SSB12-4 showed pH levels above the 6.5 screening level.

The 23 samples that showed mER-Mq exceedances of the 0.5 screening values were as follows:

Sample Location	Copper >ER-M	Zinc >ER-M	pH < 6.5	mER-Mq > 0.5	mER-Mq ≥ 1.0
SSB1-1				X	X
SSB1-2				X	
SSB3-1				X	
SSB3-2				X	
SSB3-4	X	X		X	
SSB4-0	X		X	X	
SSB4-0.5	X	X	X	X	
SSB4-4		X		X	
SSB5-3	X		X	X	X
SSB5-4	X	X	X	X	X
SSB6-0	X		X	X	
SSB6-4		X	X	X	
SSB7-3	X	X	X	X	X
SSB8-0	X	X	X	X	X
SSB8-0.5	X		X	X	
SSB9-0	X	X	X	X	X
SSB10-4				X	
SSB11-0.5	X		X	X	
SSB11-4	X	X	X	X	X
SSB12-1	X		X	X	
SSB12-4	X	X		X	X
SSB13-0	X		X	X	X
SSB14-0	X	X	X	X	X

See Table 9-2 for Tier 1 screening results.

9.2.3.2 Results of Tier 2 Screening

The results of the E-SSTL screening, where bioaccumulation impacts to higher trophic level receptors were evaluated, are provided below. Development of E-SSTLs and relevant input parameters are described in Section 6.5.2 and E-SSTLs are presented in Tables 6-5 through 6-8.

0- to 4-Foot Depth. Ecologically protective levels of copper and zinc were exceeded for some receptors in portions of the shallow sediments. Therefore, if the shallow sediments are used as cap material for the Existing Slough and exposure pathways to these receptors are complete, additional evaluation of these materials prior to use may be needed.

As reported in Table 9-3, samples collected from 13 of the 14 sample locations in the New Slough vicinity contain concentrations of copper and/or zinc in excess of the NOAEL-based E-

SSTLs for the wetland habitat. These exceedances occur at multiple depths at several of the sample locations. Of the three sample locations north of the levee (SSB1, SSB2, SSB3), i.e., north of the tide gate of the Existing Slough, concentrations of copper at all depths between 0 and 4 feet bgs at locations SSB1 and SSB3 were in excess of the NOAEL-based E-SSTLs for the wetland habitat. Concentrations of zinc between 1 to 2.5 feet at SSB1 and SSB3 were above the NOAEL-based E-SSTLs for the wetland habitat. The 1- to 1.5-foot sample at SSB1 also exceeded the zinc NOAEL-based E-SSTL for the aquatic habitat. No NOAEL-based E-SSTL exceedances were found for SSB2.

All the sample locations south of the levee contained COC concentrations in excess of NOAEL-based E-SSTLs for the wetland habitat in at least one sample depth. Most of these sample locations contained exceedances at multiple depths and many of them were also above the NOAEL-based E-SSTLs for the aquatic habitat. It should be noted that although the "SSB" samples were collected for purposes of characterizing environmental conditions present in the New Slough, not all these samples were taken directly from this area because the location of the proposed alignment was not finalized prior to the sampling event. The "SSB" samples collected south of the levee are much closer to the Existing Slough than those collected north of the levee, as the New Slough and Existing Slough are about 100 to 200 feet apart south of the levee and about 400 to 900 feet apart north of the levee. Therefore, it should be recognized that sample locations SSB5, SSB7, and SSB9 actually reside in or near dredge spoil piles close to the Existing Slough. For this reason, the results reported for these sample locations may not be representative of present conditions of the New Slough.

Figures 9-2a and 9-2b provide visual representations of the sample locations in the New Slough vicinity in exceedance of LOAEL-based E-SSTLs (see Table 9-4 for screening results). None of the samples collected from the New Slough north of the levee (SSB1, SSB2, SSB3) exhibit COC concentrations above LOAEL-based E-SSTLs. Three samples collected south of the levee from the 0- to 0.5-foot depth (SSB8, SSB9, SSB14) contained copper concentrations above the LOAEL-based E-SSTL for the clapper rail (wetland habitat) only. The E-SSTL protective of the clapper rail is the most stringent of the LOAEL-based E-SSTLs for either habitat. No other exceedances of LOAL-based E-SSTLs were reported for the 0- to 4-foot depth.

4- to 5-Foot Depth. Ecologically protective levels of copper and zinc were exceeded for some receptors in portions of the deeper sediments. Therefore, if the deeper sediments (currently at a depth of 4 feet) are to be used as the surficial sediment layer at the bottom of the New Slough and exposure pathways to these receptors are complete, additional evaluation of these materials prior to use may be needed.

Of the sample locations north of the levee, concentrations of copper at locations SSB1 and SSB3 (4- to 4.5-foot depth) were in excess of the NOAEL-based E-SSTLs for the wetland habitat (Table 9-3). The 4- to 4.5-foot sample depth for location SSB3 also contained zinc at a concentration above the NOAEL-based E-SSTL for the wetland habitat. No NOAEL-based E-SSTL exceedances were found for SSB2.

South of the levee, concentrations of copper detected in SSB5, SSB10, SSB11, and SSB12 were above NOAEL-based E-SSTLs for the wetland habitat; SSB5, SSB11, and SSB12 were also above the copper NOAEL-based E-SSTL for the aquatic habitat. At this same depth, SSB4, SSB5, SSB6, SSB10, SSB11, and SSB12 contained concentrations of zinc that were above

NOAEL-based E-SSTLs for the wetland habitat; SSB4 and SSB5 were also above the zinc NOAEL-based E-SSTL for the aquatic habitat.

Figure 9-2b illustrates the 4- to 4.5-foot samples from the New Slough vicinity in exceedance of LOAEL-based E-SSTLs (see Table 9-4 for screening results). None of the samples collected from the New Slough north of the levee exhibited COC concentrations above LOAEL-based E-SSTLs. The copper concentration in SSB5 (south of the levee) was above the LOAEL-based E-SSTL for the clapper rail (wetland habitat) only. No other exceedances of LOAL-based E-SSTLs were reported for the 4- to 4.5-foot sample depth.

9.3 SUMMARY OF TIERED SCREENING AND UNCERTAINTIES

The results of the tiered RAs are summarized below and uncertainties associated with the data collected from the New Slough alignment are also discussed. This information was used to develop conclusions regarding sediment quality in the New Slough vicinity and to identify areas that may require more characterization to quantify potential risks to human health and the environment.

9.3.1 Summary of Human Health and Ecological Tiered Screening

The results of the human health risk screening indicate that COC concentrations detected in sediments from the New Slough vicinity do not pose unacceptable risks to human health. Maximum concentrations of copper and zinc from all sample depths were below the most stringent H-SSTLs (Table 9-1). However, the results of the ERA indicate that potential risks to benthic invertebrates and, to a lesser extent, wildlife receptors (exposed through the food web) may be posed upon construction of the New Slough. Of the three sample locations north of the levee, minimal exceedances of ER-Ms (protective of benthic communities) occurred with the exception of the concentration of zinc from the 1- to 1.5-foot depth at location SSB1 (Table 9-2; Figures 9-1a and 9-1b). Sample locations south of the levee exhibit more substantial ER-M exceedances. Of the 11 sample locations south of the levee, COC concentrations were above corresponding ER-Ms in at least one depth from every location except SSB10. Exceedances of ER-Ms at the 4- to 4.5-foot sample depth occurred at SSB4, SSB5, SSB6, SSB11, and SSB12.

Exceedances of the NOAEL-based E-SSTLs for the wetland habitat occurred at multiple depths at several of the sample locations (Table 9-3). Of the three sample locations north of the levee, location SSB2 was the only location that did not exhibit any exceedances of NOAEL-based E-SSTLs for the wetland habitat. Exceedances of these target levels at the 4- to 4.5-foot sample depth are minimal at locations SSB1 and SSB3. All of the sample locations south of the levee contained COC concentrations in excess of NOAEL-based E-SSTLs for the wetland habitat in at least one sample depth. Most of these sample locations contained exceedances at multiple depths and many of them were also above the NOAEL-based E-SSTLs for the aquatic habitat.

None of the samples collected from the New Slough alignment north of the levee exhibit COC concentrations above LOAEL-based E-SSTLs (Table 9-4; Figures 9-2a and 9-2b). Four sample locations collected south of the levee contained copper concentrations above the LOAEL-based E-SSTL for the clapper rail (wetland habitat) only, the most stringent of the LOAEL-based E-SSTLs for either habitat. Of these four sample locations, only the sample from SSB5 was collected from the 4- to 4.5-foot depth. No other exceedances of LOAEL-based E-SSTLs were reported.

9.3.2 Uncertainties

Some uncertainties are associated with the data collected from the New Slough vicinity. As mentioned in Section 9.2.3.2, the “SSB” samples were collected for purposes of characterizing environmental conditions present in the New Slough alignment, but not all of these samples were taken directly from this area because the location of the alignment was not finalized prior to the sampling event. The “SSB” samples collected south of the levee are much closer to the Existing Slough than those collected north of the levee, as the New Slough and Existing Slough are about 100 to 200 feet apart south of the levee and about 400 to 900 feet apart north of the levee. Therefore, it should be recognized that sample locations SSB5, SSB7, and SSB9 actually reside in or near dredge spoil piles close to the Existing Slough.

Another uncertainty in the data originates from the conversion of chemical concentrations in sediment that were received by the laboratory in wet weight to dry weight concentrations. Because the SSB results were reported as wet weight values and percent moisture was not reported for the majority of these samples, the seven samples from the New Slough vicinity for which percent moisture was reported were used to convert the rest of the samples to dry weight. Percent moisture was available for one 2- to 5-foot composite sample collected north of the levee, four surficial samples (0.5- to 1-foot depth) from south of the levee, and two subsurface samples (2- to 5-foot depth) from south of the levee. These data were applied to the samples that lacked sample-specific percent moisture, according to the appropriate sample depth. Therefore, virtually all chemical concentrations reported for samples of the proposed alignment are estimated values. In addition, a level of uncertainty is associated with the SSB samples that is represented by two significant digits for the whole numbers. The estimated dry weight concentrations exceeding 100 are less precise than implied in the tables and may be rounded up or down to the nearest whole number. However, because this rounding does not change the findings of the Tier 1 and Tier 2 evaluations, this source of uncertainty is not significant in terms of data quality.

9.4 GROUNDWATER EVALUATION

As described in Section 7, a comparison of detected copper and zinc concentrations in existing guard wells versus the site-specific numerical groundwater quality limits proposed for the New Slough in Section 7.4.3 is presented in Table 7-6. None of the copper or zinc guard well concentrations observed during the one completed round of groundwater sampling exceed the proposed numerical limits. Based on these results, it will be possible to achieve high quality surface water and sediment values within the New Slough with ongoing sidewall and benthic underflow seepage of extant groundwater copper and zinc concentrations, provided that the modeling assumptions are met following construction of the New Slough channel.

9.5 CONCLUSIONS

Overall, COC concentrations detected in the vicinity of the New Slough are lower than the concentrations detected in the Existing Slough, and pH levels are also higher in the New Slough sediments. The reason for this decrease in COC concentrations in the New Slough is due to the differences in sediment characteristics between the two areas. Sediments in the New Slough alignment are expected to be primarily native sediments of the marsh and have little or no association with the mineralized and exposed dredge spoil piles along the sides of the Existing Slough. The deeper sediments of the New Slough are also expected to have different physical and chemical characteristics (e.g., grain size, TOC, sulfide) than the dredge spoil piles in ways that are likely to decrease the bioavailability of chemicals in these sediments.

In summary, conditions in the area of the New Slough were evaluated in the shallow sediments (0-4 feet bgs) and deeper sediments (below 4 feet bgs) based on limited initial sampling. Materials in the shallow sediments that may be considered for use as cap material for the Existing Slough do not pose a threat to human health but may be of some concern to ecological receptors if exposure pathways are complete in the cap material. Shallow sediments excavated from the New Slough will be evaluated to determine their suitability for use as fill or cap material.

Deeper sediments in the New Slough area are also not of concern from a human health standpoint but may exceed some of the more conservative target levels for ecological receptors (i.e., NOAEL-based E-SSTLs). Since the deeper sediments may also be altered during the process of New Slough construction, the residual exposure concentrations may be different from those identified in this initial evaluation. The bioavailability of chemicals in the deeper sediments would be influenced by factors such as TOC, grain size, and sulfides. The bioavailability of these chemicals is being evaluated as part of the cap design. Therefore, the exceedance of some E-RMs or E-SSTLS does not necessarily mean that adverse effects are likely or will be observed. The same target levels that are proposed for evaluation of residual concentrations in sediment after remedial action (see Section 8.1.3) are proposed for further evaluation of the New Slough, should it become necessary.

The potential for sediment and surface water in the New Slough to be adversely impacted by groundwater transport of contaminants is negligible as long as the assumptions of the modeling effort are met.

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TABLES

FIGURES

Appendix A

Appendix B

Appendix C

Appendix D

Appendix E

Appendix F