

1 **4.3 HYDROLOGY AND WATER QUALITY**

2 This Section provides a general description of the surface water and sediment
3 characteristics of the San Francisco Bay (Bay) and Sacramento-San Joaquin River
4 Delta (Delta) estuary (Bay-Delta estuary) and the relevant contributing areas, and
5 evaluates the potential impacts to hydrology, geomorphology, and water quality that
6 could result from implementation of the proposed San Francisco Bay and Delta Sand
7 Mining Project (Project). The proposed Project would extend the existing sand mining
8 operations of Hanson Marine Operations (Hanson) and Jerico Products, Inc./Morris
9 Tug & Barge (Jerico) (the applicants) for another 10 years.

10 **4.3.1 Environmental Setting**

11 **Regional Setting and Climate**

12 The Bay-Delta estuary is located on the west coast of California, within the Coast
13 Range geomorphic province.¹ The watershed area of the Bay-Delta estuary comprises
14 approximately 40 percent of the land surface within California (about 60,000 square
15 miles). The estuary is the largest coastal embayment on the Pacific Coast of the United
16 States (approximately 480 square miles in extent) (Conomos et al. 1985). It is one of the
17 largest and most productive ecosystems for fish and wildlife habitat in the United States
18 (State Water Resources Control Board [SWRCB] 2006).

19 The climate in the Bay-Delta estuary and surrounding areas is transitional between the
20 coastal and inland extremes, and is highly variable because of the effects of local
21 topography and the continuous interaction of maritime and continental air masses.
22 Inland central California is characterized by hot, dry summers and cool, wet winters; this
23 would characterize much of the eastern Delta area. In contrast, the climate of the
24 California coast is dominated by the Pacific Ocean and, as such, has relatively warmer
25 winters and cooler, foggy summers and a small annual temperature range; this would
26 characterize the Bay region and much of the western Delta. Average annual
27 precipitation in the Bay-Delta estuary is approximately 20 inches per year (Western
28 Regional Climate Center [WRCC] 2009). The strong winds typical during summer
29 afternoons and winter storms exert considerable stress on the Bay's surface and
30 generate waves that are an integral part of physical and biological processes.

¹ Geomorphic provinces are naturally defined geologic regions that display a distinct landscape or landform; 11 provinces are distinguished in California with each region displaying unique, defining features based on geology, faults, topographic relief, and climate (CGS 2002).

1 **Surface Water Hydrology and Drainage**

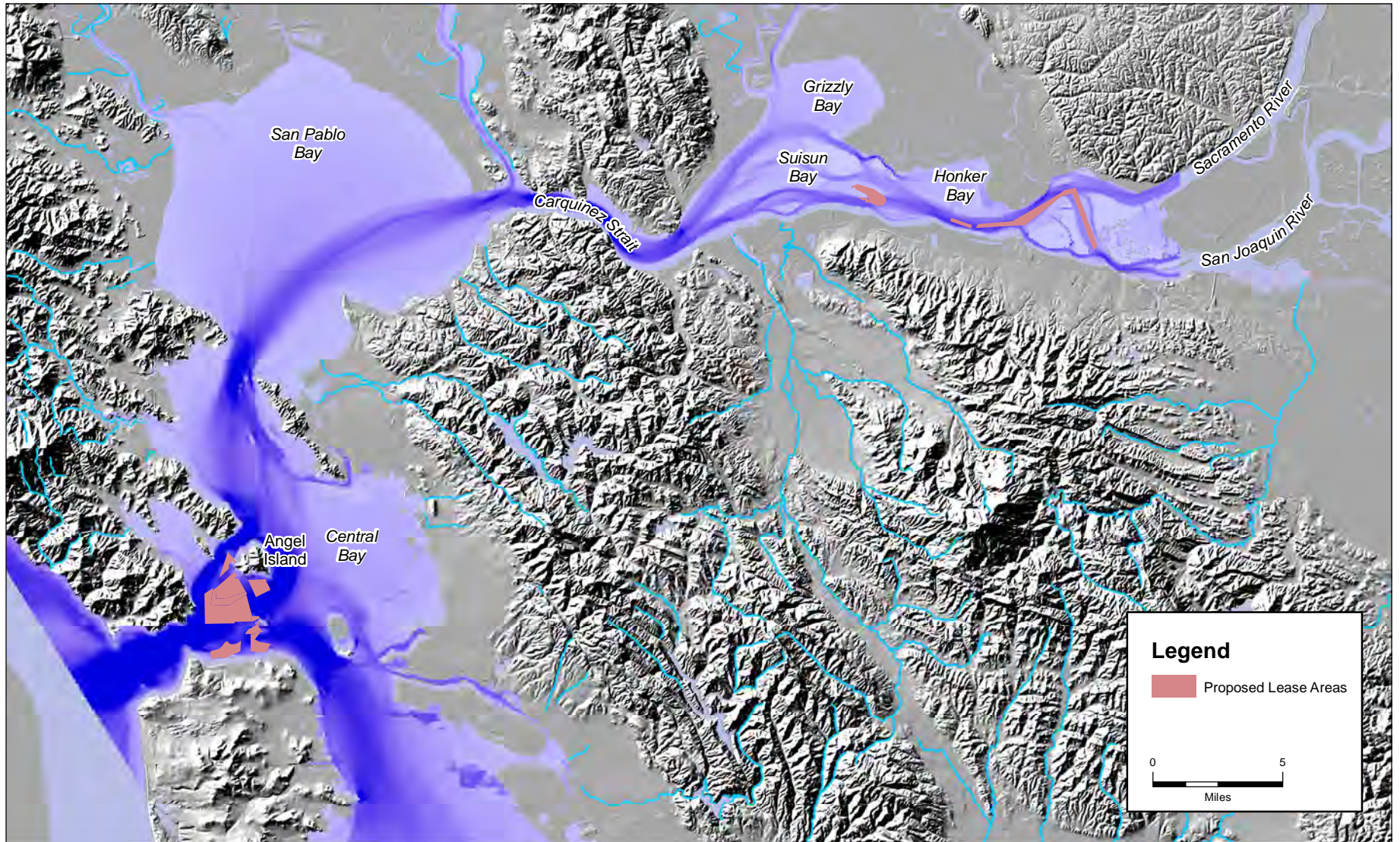
2 The Bay and the Delta form a network of interconnected embayments, rivers, channels,
3 sloughs, and marshes/wetlands. Most of the freshwater inflow to the Bay comes through
4 the Delta, with the remainder derived from local streams and rivers directly tributary to
5 the Bay. Ocean water moves in and out of the Bay through the Golden Gate channel,
6 an exchange driven by daily and seasonal tidal fluctuations. Freshwater and salt water
7 constantly mix in a dynamic manner, driving the physical and ecological characteristics
8 of the Bay-Delta estuary.

9 The general areas of interest with respect to the Project are Central Bay and the
10 northern reach of the Bay-Delta estuary (i.e., San Pablo Bay, Carquinez Strait, Suisun
11 Bay, and the Delta) (Figure 4.3-1). The sand mining lease areas are located in Central
12 Bay, within approximately 16 miles of the tidal entrance at the Golden Gate channel,
13 and in Suisun Bay, approximately 45 to 50 miles inland of the Golden Gate channel and
14 just downstream of the Delta. Suisun Bay is joined on the north by Grizzly Bay and
15 Honker Bay, and surrounding these areas (and generally to the north) is the Suisun
16 Marsh. These bays and the Suisun Marsh comprise a unique and important ecological
17 environment, occupying the transition zone from the Delta to the Bay. Connected by the
18 narrow and deep Carquinez Strait, San Pablo Bay is the next large water body west of
19 Suisun Bay. Central Bay lies immediately south of San Pablo Bay, and adjacent to
20 Central Bay on the west, is the Golden Gate channel.

21 *The Delta – Sacramento and San Joaquin River Watershed*

22 Ninety percent of the annual freshwater inflow to the Bay comes through the Delta from
23 the Sacramento-San Joaquin River watershed (most of which is derived from the
24 Sacramento River watershed) (Conomos et al. 1985). The variable and highly seasonal
25 inflow from the Delta is composed primarily of rainfall-derived runoff during the winter
26 and snowmelt-derived runoff during the spring and early summer. The majority of the
27 Sacramento-San Joaquin River watershed comprises streams and rivers draining from
28 the Sierra Nevada Range. The Sacramento River has its headwaters on the flank of
29 Mt. Shasta, and flows south through the northern portion of the State. Its major
30 tributaries include the Feather River, the Yuba River, and the American River. The
31 San Joaquin River flows north through the Central Valley and is fed by the following
32 major tributaries: the Merced River, the Tuolumne River, and the Stanislaus River. The
33 two rivers meet in the complex of islands and channels that is the Delta (where they are
34 joined by the Mokelumne River and Calaveras River) and collectively discharge into the
35 eastern end of the Bay-Delta estuary at Suisun Bay.

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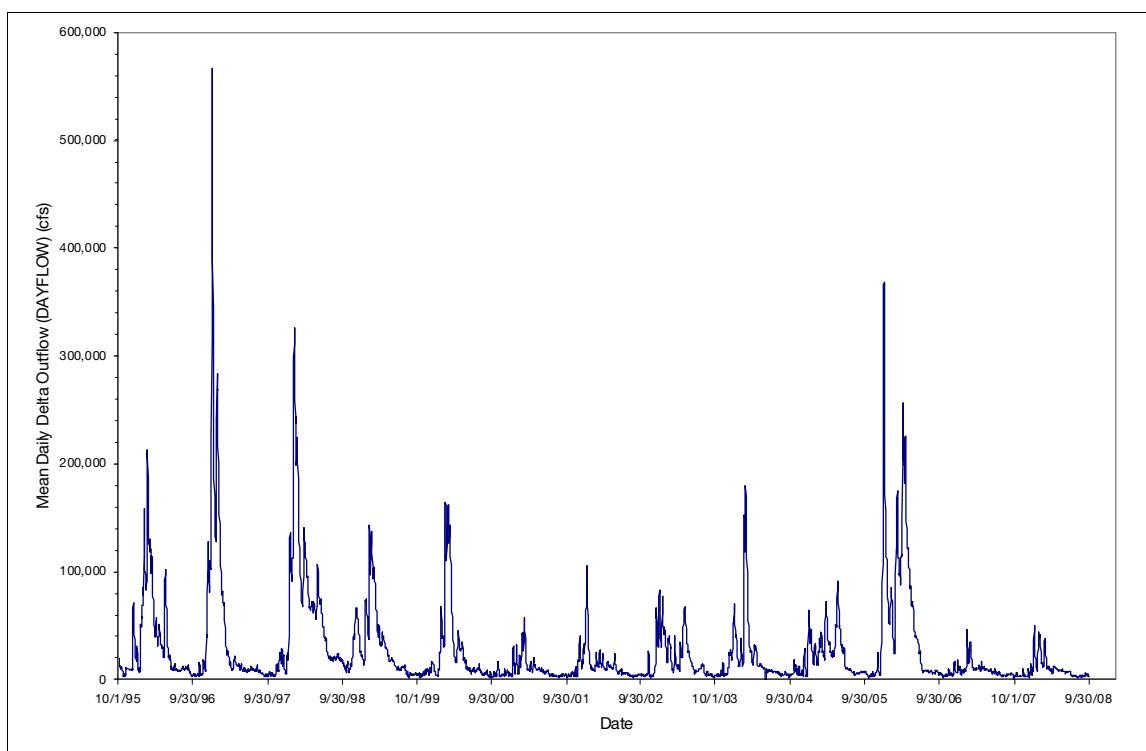


SOURCE: USGS 2009c; ESA 2011; ESRI 2009

San Francisco Bay and Delta Sand Mining EIR . 207475

Figure 4.3-1
Central and Northern Bay-Delta Estuary

1 The outflow from the Delta to the Bay is controlled to a notable degree by a number of
2 human actions. Most of the major rivers in the Sacramento-San Joaquin River
3 watershed are dammed for flood control, water storage, and/or hydroelectric power. In
4 addition, water is diverted from the rivers for local irrigation as well as for export to
5 central and southern California. Approximately half of California's surface water supply
6 falls as rain or snow within the Sacramento-San Joaquin River watershed, and about
7 half of that is eventually diverted for consumptive use (Cohen 2000). With what remains,
8 the Sacramento-San Joaquin River watershed discharges just over 18 million acre-feet
9 from the Delta to the Bay on an average annual basis (or 25,000 cubic feet per second
10 [cfs]). The mean daily outflow from the Delta to the Bay-Delta estuary for water years
11 1996-2008 is shown in Figure 4.3-2.



12 Source: DWR 2009

13 **Figure 4.3-2**
14 Delta Outflow (Water Years 1996 To 2008)

15 *Major Bay Area Watersheds*

16 Though most of the input of freshwater and sediment to the Bay-Delta estuary comes
17 from the Sacramento-San Joaquin River watershed, other local watersheds around the
18 Bay contribute notably to the input of water and sediment, including: Sonoma Creek, the
19 Napa River, Walnut Creek, Alameda Creek, and the Santa Clara Valley watershed (e.g.,

1 the Guadalupe River and Coyote Creek). Aside from the Sacramento and San Joaquin
2 River watersheds, the largest contributing watersheds to the Bay-Delta estuary are
3 Alameda Creek and Coyote Creek, both of which drain into South Bay.

4 *Ocean Water Input and Tides*

5 Salt water input to the Bay-Delta estuary is derived from the Pacific Ocean, and this
6 input is driven largely by a consistent and predictable variation in tides. Semi-diurnal
7 tides, with two unequal high tides and two unequal low tides in each approximately
8 25-hour period, are typical of the Bay-Delta estuary and the West Coast. Twice a day,
9 on each tidal cycle, a huge volume of salt water moves in and out of the Bay-Delta
10 estuary (a quantity typically termed the *tidal prism* – i.e., the volume of water between
11 high and low water elevations), averaging approximately 1.3 million acre-feet (or nearly
12 one quarter of the estuary's entire volume) (Cohen 2000). In contrast, the average daily
13 flow of freshwater into the Bay-Delta estuary is about 50,000 acre-feet (i.e., 25,000 cfs).
14 The volume of water carried in by the tides is split about evenly between the northern
15 and southern reaches of the Bay-Delta estuary. In the northern reach the tidal range
16 (i.e., the difference in height between high water and low water) decreases with
17 distance from the ocean, from a mean range of about 5.5 feet at the Golden Gate
18 channel to 3 feet at Sacramento (Cohen 2000). The tides with the greatest range
19 (spring tides) occur during full and new moons, and those with the smallest tidal range
20 (neap tides) occur during the moon's quarters. Tide ranges also vary over the year, with
21 the highest highs and the lowest lows typically occurring around June and December.

22 **Estuarine Circulation**

23 In the channels of the northern reach of the Bay-Delta estuary, fresh river water flows
24 downstream near the surface (fresh water is lighter, or less dense, than salty ocean
25 water) and a net current of saltier water flows upstream near the bottom. The presence
26 of water masses with distinct characteristics at different depths is termed stratification.
27 These currents meet and eventually cancel-out in the null zone, the exact location of
28 which is variable and driven primarily by the magnitude of freshwater inflow (higher
29 inflows push this zone west, lower inflows allow the zone to move further east). An
30 entrapment zone, where small particles and organisms accumulate, may form at and
31 just downstream of the null zone. This entrapment zone is sometimes characterized by
32 a longitudinal maximum in the suspended solids concentration, commonly termed the
33 estuarine turbidity maximum (ETM) (Schoellhamer and Burau 1998). However, the
34 dynamics of the ETM as well as the null zone are complex, and these phenomena are
35 not always co-located.

1 **Sediment Dynamics**

2 Sediment dynamics within the Bay-Delta estuary is a complicated process linking
3 sediment distribution, transport and supply with different physical drivers, such as
4 freshwater inflows and tidal exchange. All of these processes are important with respect
5 to the proposed Project.

6 *Sediment Distribution and Transport*

7 Most of the sediments on the bottom of the Bay-Delta estuary are fine-grained (i.e., fine
8 sand, silt, and clay – much of the silt- and clay-sized sediments are referred to as *bay*
9 *mud* in geologic nomenclature), but there are localized areas within the estuary that
10 contain notable deposits of coarse sediments suitable for construction-grade aggregate
11 (i.e., sand and gravel). Sand deposits on the floor of the Bay-Delta estuary are generally
12 restricted to two principal areas: a narrow “eastern zone” along the deepest part of the
13 main navigation channel through Suisun Bay, Carquinez Strait, and San Pablo Bay,
14 ending northeast of Point San Pedro, and a discontinuous “western zone” in Central
15 Bay that generally coincides with deeper water, extending from the Richmond –
16 San Rafael Bridge to south of the San Francisco – Oakland Bay Bridge, and extending
17 through and outside of the Golden Gate channel. The coarse sediments tend to
18 accumulate in areas that are relatively deep and experience relatively high current
19 velocities, driven by either freshwater inflow or tidal exchange. Areas of sand deposition
20 occur primarily within the deeper navigational channels in the Suisun Bay area, which
21 experience relatively high water velocities. Sand deposits within Central Bay appear to
22 be strongly correlated with tidal velocities.

23 For the most part, freshwater inflow from the rivers, in combination with tidal exchange
24 from coastal marine waters, drives sediment and sand transport within the Bay-Delta
25 estuary. Yet, a variety of other factors (e.g., channelization, channel maintenance,
26 sediment grain size and sorting) all interact to affect the physical processes in
27 determining the geographic distribution of various sediment types and patterns of
28 accretion and depletion within the estuary. Sediments may be transported within high-
29 energy channel areas (e.g., much like a stream or river – where net transport typically
30 occurs in one direction), stored for extended periods of time in low-energy or shallow
31 areas, or moved back and forth with little net transport in any direction. The actual
32 mechanism in any given place is likely some combination of these different processes.
33 Sediment transport within the estuary is further complicated by turbulent mixing and
34 sediment suspension resulting from wind and wave action.

1 Ultimately, the sand deposits in locations where commercial sand mining occurs may
2 have been delivered from the Sacramento and San Joaquin River watersheds, smaller
3 local watersheds, coastal marine sources west of the Golden Gate channel (e.g.,
4 sediments transported from the San Francisco ebb-tidal delta [San Francisco Bar] or
5 Ocean Beach [Battalio and Trivedi 1996]), or from some combination thereof.

6 Further, sand deposits may also be derived, in part, from the floor of the Bay-Delta
7 estuary (i.e., from weathering or emplacement in an earlier geologic period). In the
8 Suisun Bay/Delta and Middle Ground Shoal lease areas, the sand-sized material mined
9 for aggregate is primarily bed material delivered, at some point in time, by the
10 Sacramento River (and, to a lesser degree, the San Joaquin River). The origin of the
11 present sand-sized sediment in Central Bay is more complicated, as it is likely derived
12 from a number of the sources previously discussed, but the relative contribution of these
13 various sources is not well understood.

14 *Supply of Sediment to the Bay-Delta Estuary*

15 The principal source of sediment to the entire Bay-Delta estuary is the Sacramento-San
16 Joaquin River watershed. Over the last few centuries, the supply of sediment from this
17 watershed has varied widely in response to major changes and disturbance. Yet, most
18 evidence suggests that, for at least the last 50 years, the sediment (including sand)
19 supply from the Sacramento-San Joaquin River watershed to the Bay-Delta estuary has
20 been decreasing (McKee et al. 2002; Wright and Schoellhamer 2004; Krone 1996;
21 Kondolf 2001). Concurrently, Suisun Bay and Central Bay have experienced a net loss
22 of sediment volume, much of which is attributable to the decrease in supply (Fregoso et
23 al. 2008; Cappiella et al. 1999).

24 Human activities over the past few centuries have greatly modified or overwhelmed the
25 natural sediment processes in the Sacramento and San Joaquin River systems (McKee
26 et al. 2002). During the Gold Rush era, hydraulic mining in the Sierra Nevada foothills
27 dramatically increased the supply of sediment to the Central Valley and, subsequently,
28 to the Bay-Delta estuary. In contrast, since at least the 1950s, human influences have
29 caused a net decrease in the sediment load delivered from the Sacramento and
30 San Joaquin Rivers (McKee et al. 2002; Wright and Schoellhamer 2004). Many of the
31 tributary rivers in the Central Valley have been dammed for irrigation and water supply,
32 and more than 95 percent of this reservoir storage capacity has been built since 1921
33 (McKee et al. 2002). Export of water from the Delta tributaries commenced in 1929. A
34 fraction of the incoming sediment supply is exported along with this water. Further,
35 particularly on the Sacramento River, bank protection efforts, levee construction and

1 aggregate mining from channel and floodplain areas may also contribute to reducing the
2 available sediment supply and the transported volume. In addition, winter floods have
3 been reduced by 40 to 90 percent, reducing the capacity of the rivers to transport
4 sediment (Kondolf 2001). Reductions in peak annual discharge and changes in the
5 seasonal flow regime, as well as the trapping of sediments behind reservoirs and Delta
6 sinks, have led to reductions in the natural flow of sediments entering the Bay via the
7 Delta (Krone 1979). Once estimated to account for up to 90 percent of the total Bay-
8 Delta estuary sediment input, McKee et al. suggest that the Central Valley now supplies
9 about 57 percent of the total sediment flux to the Bay-Delta estuary (McKee et al. 2002).

10 Natural sand replenishment to the Bay-Delta estuary could come from material
11 delivered from the Delta, from local sources such as eroding bedrock, or from sediment
12 carried in from beyond the Golden Gate channel (Chin et al. 2004). A number of studies
13 and analyses exist with respect to the annual amount of sediment delivered from the
14 Delta to the Bay, yet most do not distinguish between the sand-fraction and the fine-
15 fraction (i.e., silts and clays) of the total suspended sediment load. However, for the
16 Sacramento River, Porterfield estimated that approximately 55 percent of the average
17 daily total sediment discharge was comprised of sand (Porterfield 1980).² Based on
18 previous studies, the average volume of total sediment delivered to the Bay from the
19 Delta each year may now be on the order of 2.6 to 6.2 million cubic yards. McKee et al.
20 suggest the low-end of this range may be the most accurate estimate of existing,
21 average conditions (McKee et al 2002).³ Of this total annual sediment load, 1.4 to
22 3.4 million cubic yards might be sand-sized sediment (based upon the fraction derived
23 from Porterfield [1980]). Krone estimated that 43 percent of the average annual total
24 suspended sediment inflow to the Bay-Delta estuary is transported west of the Golden
25 Gate channel and lost to the ocean (Krone 1996). Further, some percentage of the total
26 sediment input from the northern reach of the estuary is also likely deposited in South
27 Bay. The average annual contribution of total sediment to the Bay-Delta estuary from
28 local tributaries (i.e., the sources other than the Sacramento-San Joaquin River
29 watershed) is estimated to be approximately 2 million cubic yards (McKee et al. 2002).
30 The flux of sediment and sand derived from within the Bay-Delta estuary (i.e., from
31 weathering or emplacement in an earlier geologic period) or from beyond the Golden
32 Gate channel, has yet to be reliably quantified or estimated.

² This estimate is for the Sacramento River at Sacramento, California, from 1906 to 1966. Over this time period, the average daily sand discharge was estimated to be 5,560 tons/day, and the average daily total sediment discharge was estimated to be 10,200 tons/day.

³ This range is derived from suspended sediment flux estimates provided by McKee et al. from 1994 to 1998, and assumes that the suspended sediment load is 95 percent of the total sediment load (McKee et al. 2002, citing Randal Dinehart of the United States Geological Survey [USGS]).

1 **San Francisco Bay – Bathymetry and Morphology**

2 The Bay-Delta estuary, including sand mining areas in both Central Bay and Suisun
3 Bay, is generally shallow and floored by sediment deposits that are controlled by
4 complex and dynamic processes. The average water depth of the Bay-Delta estuary as
5 a whole is 20 feet below mean lower low water (MLLW; the average height of the lower
6 of the two daily low tides, used as a standard reference plane for hydrographic surveys
7 and charts [Conomos et al. 1985]). Topographic constrictions whose depths are
8 maintained by strong tidal currents, such as those that occur at the Golden Gate
9 channel and within Carquinez Strait, are the deepest sections of the Bay-Delta estuary.
10 The Golden Gate channel attains a maximum depth of approximately 330 feet. Strong
11 tidal currents flow through the Golden Gate channel and continually sweep away mud
12 and fine sediment. The South Bay and the northern reach of the estuary have an
13 average depth of 10 to 13 feet MLLW, with relatively deep tidal channels incised to 30 to
14 65 feet MLLW (Chin et al. 2004). In contrast, Central Bay has an average water depth of
15 approximately 36 feet MLLW. Because of its greater average water depth, Central Bay
16 also has the largest water volume, even though its surface area is less than half that of
17 the South Bay (Chin et al. 2004).

18 *Central Bay*

19 The bottom morphology of Central Bay has been extensively modified and influenced by
20 human activities, including dredging, shoreline stabilization, extensive filling, blasting of
21 rocks, and industrial and urban development (Chin et al. 2004). The western portion of
22 Central Bay is the deepest part of the Bay-Delta estuary and is characterized by the
23 coarsest sediment in the entire estuary. In this area, the bay floor is molded into a
24 variety of topographic features (bedforms) that are the result of the interaction of
25 sediment, tidal currents, and water depth, as well as the influence of human activities.
26 These bedforms are typically manifest as sand waves, and are the defining features of
27 areas such as the Point Knox, Presidio, and Alcatraz Shoals. Water depth ranges for
28 these shoal areas are 20 to 65 feet, 36 to 60 feet, and 50 to 75 feet, respectively (Chin
29 et al. 2004). There are also large areas that lack bedforms and are relatively flat. Other
30 areas are replete with forms that can be described as “pocks” or small craters, which
31 Chin et al. attribute to sand mining activities (Chin et al. 2004). Finally, there are a few
32 places where the bottom is comprised of outcropping bedrock knobs.

1 *Suisun Bay*

2 Water flowing westward out of the Delta first passes into Suisun Bay. Suisun Bay is
3 generally shallow (less than 30 feet deep; one third of Suisun Bay is less than 6 feet
4 deep at MLLW) except for two relatively deep channels, which are dredged to maintain
5 shipping access to the Delta (Hanson Environmental 2004). Sand wave bedforms have
6 also been observed in bathymetric profile surveys of the channel adjacent to Middle
7 Ground Shoal and within other channels in Suisun Bay and the western Delta (Hanson
8 Environmental 2004).

9 *Bathymetry Changes*

10 Recent studies suggest that Suisun Bay, the Central Bay, and to a lesser degree
11 San Pablo Bay, have experienced a net loss in sediment volume during the last half
12 century (i.e., since about the 1950s) (Fregoso et al. 2008; Capiella et al. 1999; Jaffe et
13 al. 1998). For the period 1942 to 1990, Capiella et al. estimate that Suisun Bay
14 experienced a net loss of sediment volume in excess of 79 million cubic yards (Capiella
15 et al 1999).⁴ Within the region of Central Bay that also contains the Project lease areas
16 (i.e., the western portion of Central Bay), Fregoso et al. estimate a net loss of sediment
17 equivalent to about 31 million cubic yards from 1947 to 1979 (Fregoso et al 2008). The
18 erosion in these bays is likely, in part, a result of reduced sediment supply from the
19 Central Valley (McKee et al. 2002). However, most of the erosion in Central Bay was
20 attributed to borrow pit excavation and sand mining activities (Fregoso et al. 2008).
21 More recently, Coast and Harbor Engineering (CHE) estimated that the net change in
22 volume within the Central Bay sand mining lease areas was a loss of approximately
23 11.6 million cubic yards of sediment from 1997 to 2008; this volumetric loss is roughly
24 equivalent to the reported volume of sand mined from the Central Bay lease areas over
25 this same time period (CHE 2009 [Appendix G]).

26 **Water and Sediment Quality**

27 Over many decades (even centuries), human activities have had a substantial influence
28 upon the water and sediment quality of the Bay-Delta estuary. Water quality within the
29 Bay-Delta estuary depends in large part upon the level of salinity and suspended solids,
30 which are driven mostly by the relative inputs of freshwater and ocean water.
31 Contaminant levels (e.g., metals, chlorinated compounds) are typically more of a
32 concern for the sediments, but can become an issue in the water column depending
33 upon (among other factors) the level of salinity and suspended solids (e.g., if high

⁴ This estimate does not include the net change in sediment volume within Grizzly Bay.

1 current velocities are suspending and mobilizing bottom sediments). Contaminants in
 2 small quantities in the water column can accumulate in bottom sediments, resulting in
 3 much higher concentrations. The primary pollutants and stressors for the Bay-Delta
 4 estuary and its major tributaries include trace elements and metals (mercury, selenium,
 5 and nickel), chlorinated organic compounds (poly-chlorinated biphenyls [PCBs], dioxins,
 6 and furan compounds), pesticides (dieldrin, chlordane, and DDT), and polycyclic
 7 aromatic hydrocarbons (PAHs). The contaminants of greatest concern are high levels of
 8 mercury and PCBs in fish, water, and sediment (Bay Conservation and Development
 9 Commission [BCDC] 2011).

10 The San Francisco Estuary Institute (SFEI) has been implementing and managing the
 11 Regional Monitoring Program (RMP) in the Bay-Delta estuary since 1993. The SFEI has
 12 published numerous monitoring reports, including annual summaries of sediment and
 13 water quality information for the Bay-Delta estuary gathered from sampling cruises
 14 conducted twice per year. Table 4.3-1 and Table 4.3-2 summarize water and sediment
 15 quality data collected from 2002 to 2007 for the principal pollutants and stressors of
 16 concern in the Bay-Delta estuary.

17 **Table 4.3-1. Average Pollutant/Stressor Concentrations in Water, 2002-2007**

Analyte	San Francisco Bay	Central Bay	Lower South Bay	San Pablo Bay	South Bay	Suisun Bay
Suspended Sediment Concentration (SSC) (mg/L)	29.1	13.9	25.3	66.3	12.5	49.3
Mercury ($\mu\text{g/L}$)	0.0094	0.0055	0.0118	0.0183	0.0067	0.0122
Methylmercury (ng/L)	0.0634	0.0577	0.1097	0.0617	0.0794	0.0659
Selenium ($\mu\text{g/L}$)	0.125	0.124	0.253	0.116	0.135	0.124
Nickel ($\mu\text{g/L}$)	3.25	1.94	4.84	5.88	2.75	4.77
Total PCBs (pg/L)	409.80	417.16	727.00	431.30	436.99	233.30
Dieldrin (pg/L)	38.921	33.264	53.379	42.134	37.964	60.231
Total Chlordanes (pg/L)	26.86	19.60	78.60	41.53	23.91	38.94
Total DDTs (pg/L)	197.17	138.67	233.53	330.52	100.87	357.27
Total PAHs (pg/L)	48,077	44,127	71,967	57,092	49,186	43,363

Notes:

mg/L: milligrams per liter

$\mu\text{g/L}$: micrograms per liter

ng/L: nanograms per liter

pg/L: picograms per liter

Source: SFEI 2009

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19

1 **Table 4.3-2 Average Pollutant/Stressor Concentrations in Sediment, 2002-2007**

Analyte	San Francisco Bay	Central Bay	Lower South Bay	San Pablo Bay	South Bay	Suisun Bay
Total Nitrogen (%)	0.117	0.115	0.143	0.117	0.133	0.085
Mercury (mg/Kg)	0.2347	0.2372	0.2646	0.2625	0.2187	0.1746
Methylmercury ($\mu\text{g/Kg}$)	0.5543	0.6658	0.7464	0.2914	0.7640	0.2072
Selenium (mg/Kg)	0.236	0.237	0.307	0.238	0.239	0.208
Nickel (mg/Kg)	76.48	72.96	89.81	86.32	68.35	83.54
Total PCBs ($\mu\text{g/Kg}$)	5.73	6.95	7.45	4.21	6.51	2.02
Dieldrin ($\mu\text{g/Kg}$)	0.12	0.08	0.09	0.12	0.22	0.08
Total Chlordanes ($\mu\text{g/Kg}$)	0.33	0.13	0.35	0.40	0.67	0.15
Total DDTs ($\mu\text{g/Kg}$)	1.94	1.93	2.16	2.17	1.70	1.89
Total PAHs ($\mu\text{g/Kg}$)	2,116	3,263	1,565	887	1,935	398

Notes:

mg/Kg: milligrams per kilogram

 $\mu\text{g/Kg}$: micrograms per kilogram

Source: SFEI 2009

2

3 *Salinity*

4 Both water exchange through the Golden Gate channel and freshwater inflow determine
5 the seasonal changes in the salinity distribution within the Bay-Delta estuary. Much of
6 the large seasonal variations in salinity are driven by the variability of freshwater inflow
7 from the Delta. In the Bay-Delta estuary, the salinity gradient generally increases from
8 east to west and from north to south, with Suisun Bay generally having the lowest
9 salinity levels while salt concentrations are highest in Central Bay (which connects with
10 the ocean through the Golden Gate channel) and the South Bay (a large, shallow lobe
11 extending off the Central Bay [Cohen 2000]). The fresh water flowing in through the
12 Delta has salinity concentrations generally less than 1 part per thousand (ppt). Salinity
13 in Suisun Bay, from 1981 to 2001, ranged from approximately 0 to 12 ppt and was less
14 than 10 ppt most of the time (Hanson Environmental 2004). The salinity increases
15 downstream, usually reaching approximately 30 ppt (close to the salinity of ocean
16 water) near the mouth of the Bay at the Golden Gate channel. Salinity in Central Bay,
17 from 1981 to 2001, ranged from approximately 5 to 35 ppt and was greater than 20 ppt
18 most of the time (Hanson Environmental 2004). The salinity gradient also tends to be
19 vertically stratified, with freshwater essentially flowing over the top of the denser salt
20 water, yet the degree of stratification is influenced by river discharge, tides and location.

1 *Suspended Sediments*

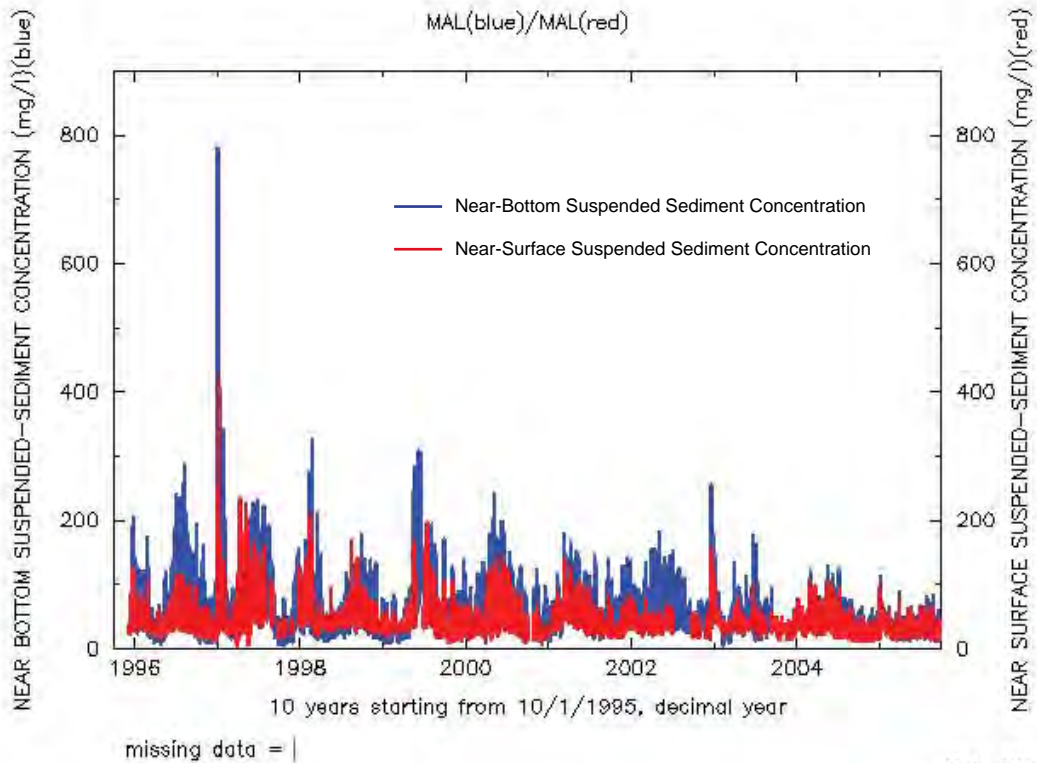
2 In general, concentrations of suspended sediment in the Bay-Delta estuary are driven
3 by discharge from the Delta, tidal advection and suspension, and wind-wave action (and
4 the associated wind-induced shear stress at the sediment-water interface). Further,
5 salinity influences the concentration and deposition of suspended sediment by
6 increasing cohesion and turbulence, forming aggregates, and increasing settling
7 velocities (Krone 1979; Schoellhamer and Burau 1998). The suspended sediment
8 concentration (SSC) in the Bay-Delta estuary tends to peak in the period from
9 December through March. The northern portion (i.e., Suisun Bay, Delta) typically shows
10 sharp spikes in SSC in direct response to Delta outflow, while areas downstream of
11 Suisun Bay tend to experience less pronounced spikes (though these locations may
12 experience higher overall concentrations).

13 For a number of years, the USGS collected continuous suspended sediment data at a
14 number of locations throughout the Bay-Delta estuary (USGS 2009a, 2009b; Buchanan
15 and Lionberger 2009).⁵ In Suisun Bay, the USGS Mallard Island (MAL) station is just
16 downstream of the Suisun lease area and just east of the Middle Ground Shoal lease
17 area (see Figure 4.3-1). Continuous SSC data have been collected at this location since
18 1995, and these data are representative of the existing water quality conditions near the
19 Suisun Bay lease areas. In Central Bay, the USGS Alcatraz (ALC) station is located just
20 east of the Central Bay lease areas. The continuous SSC record is shorter for this
21 location, but it nonetheless is a good indication of the existing variability in SSC values
22 near the Central Bay lease areas. Figure 4.3-3 displays the suspended sediment data
23 reported for the MAL and ALC stations.

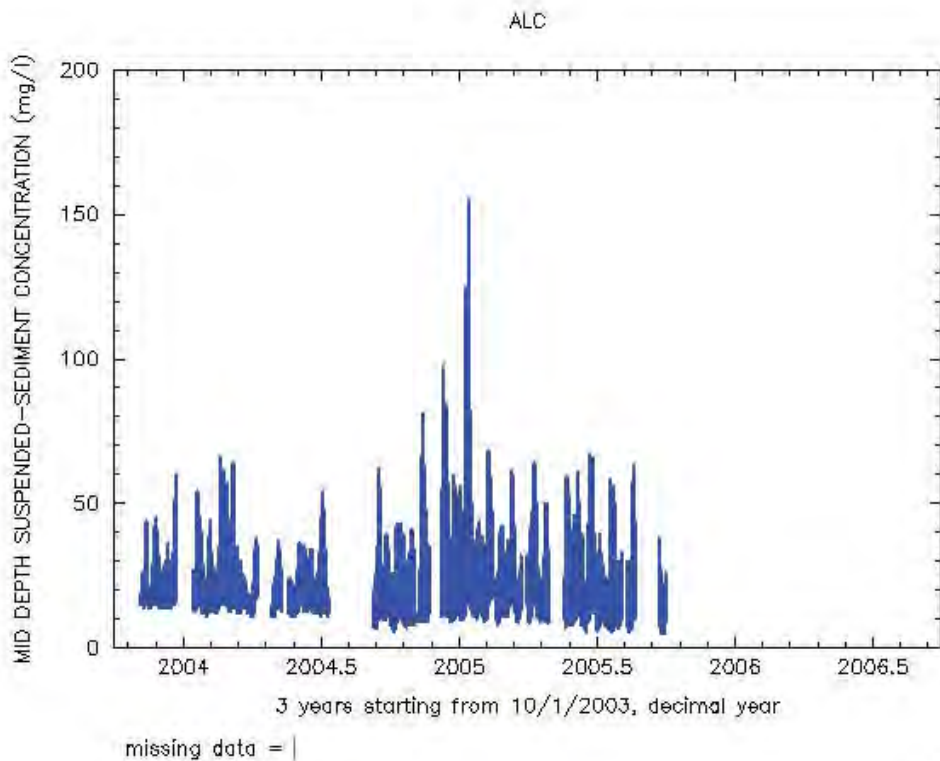
24 Data from the MAL station are indicative of the strong influence of the Sacramento and
25 San Joaquin Rivers at this point in the Bay-Delta estuary (Figure 4.3-3), in that the SSC
26 values are driven primarily by flow from the Delta. In the Sacramento River and Suisun
27 Bay, SSC values generally fluctuate seasonally, within a range of 20 milligrams per liter
28 (mg/l) to 200 mg/l, in close correlation with Delta outflow. Peak concentrations typically
29 occur during two general time frames each year, responding to storm runoff (winter) and
30 snow-melt runoff (spring or summer), and decrease to a more predictable ambient level
31 in the interim. Concentrations during non-peak periods rarely exceed 100 mg/l and are
32 less than 50 mg/l most of the time.

33

⁵ The USGS uses optical backscatter instruments to record continuous measurements concerning the light refraction properties of the water (i.e., turbidity). At most sites, optical sensors are positioned at two depths to define the vertical variability of SSC values (Buchanan and Lionberger 2009).



27-Apr-2009 12:54



18-Jun-2009 15:07

SOURCE: USGS 2009a, 2009b

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Figure 4.3-3
Suspended Sediment Data

1 According to the RMP data (SFEI 2009; see Table 4.3-1), the average SSC in Suisun
2 Bay is approximately 49 mg/l. Further downstream it appears that tidal influences
3 become a more important determinant of suspended sediment loads, particularly in the
4 Carquinez Strait, where ambient SSC values fluctuate between 20 mg/l and almost
5 500 mg/l and are highest at greater depth (Hanson Environmental 2004).

6 In the Central Bay, SSC values are generally lower than upstream of Carquinez Strait
7 and are not always clearly related to Delta outflow (Hanson Environmental 2004). The
8 SSC values reported for the ALC station appear slightly more variable (Figure 4.3-3),
9 likely reflecting the comparatively stronger influence of tidal action and variable
10 circulation patterns. The work conducted by MEC and Cheney also shows a high level
11 of variability within Central Bay for SSC values (MEC and Cheney 1990). However,
12 similar to the MAL station, most of the time, SSC values are below the 50 to 75 mg/l
13 range; peak SSC values in Central Bay rarely exceed 150 mg/l. According to the RMP
14 data, the average SSC in Central Bay is approximately 14 mg/l (SFEI 2009; see
15 Table 4.3-1).

16 *Sediment Contamination*

17 As evidenced by the RMP (SFEI 2008), contaminants within the sediments of the Bay-
18 Delta estuary have been a concern for many years (see Table 4.3-2 for a summary of
19 sediment quality data). Considering observed concentrations in relation to the potential
20 impact upon various organisms (including humans), mercury (and particularly
21 methylmercury)⁶ and PCBs are of primary concern with respect to sediment
22 contamination within the Bay-Delta estuary. Over the last few years (i.e., 2002 to 2007),
23 methylmercury concentrations in sediment have been highest south of the Bay Bridge,
24 while mercury concentrations have generally been highest in San Pablo Bay (SFEI
25 2008). Average PCB concentrations in Bay-Delta estuary sediments measured from
26 2004 to 2007 were highest in the southern reach of the estuary: lower South Bay
27 (7.5 parts per billion [ppb]), South Bay (6.5 ppb), and Central Bay (6.9 ppb). Due to the
28 geochemical properties of sediments, those with a higher proportion of fine particles
29 (i.e., clays and silts) tend to contain higher concentrations of most contaminants,
30 compared to sediments characterized by higher proportions of coarse and sandy
31 material (Hanson Environmental 2004).

⁶ Methylmercury is the form of mercury that is readily accumulated in the food web and poses a toxicological threat to exposed species (including humans). Methylmercury has a complex cycle, influenced by many processes that vary in space and time.

1 **4.3.2 Regulatory Setting**

2 The primary statutes that govern the activities under the proposed Project that may
3 affect water quality are the Federal Clean Water Act (CWA; 33 U.S. Code [U.S.C.],
4 § 1251 et seq.) and the Porter-Cologne Water Quality Control Act (Porter-Cologne; Wat.
5 Code, § 13000 et seq.). These acts provide the basis for water quality regulation in
6 California. The CWA and Porter-Cologne overlap in many respects, as the entities
7 established by Porter-Cologne are in many cases enforcing and implementing Federal
8 laws and policies. However, some regulatory tools are unique to Porter-Cologne.

9 **Federal**

10 *Rivers and Harbors Act*

11 Sand mining in the Bay-Delta estuary is regulated by the U.S. Army Corps of Engineers
12 (ACOE) under Section 10 of the Rivers and Harbors Act (33 U.S.C., § 401 et seq.).
13 Section 10 of the Rivers and Harbors Act requires authorization from the ACOE for the
14 construction of any structure in or over any navigable water⁷ of the United States, the
15 excavation/dredging or deposition of material in these waters or any obstruction or
16 alteration in a navigable waterbody. Structures or work outside the limits defined for
17 navigable waters of the United States require a Section 10 permit if the structure(s) or
18 work affects the course, location, condition, or capacity of the water body. Section 10
19 and CWA Section 404 overlap in some activities involving wetlands. Permits for
20 activities regulated under both are processed simultaneously by the ACOE.

21 *Water Quality Certification (CWA Section 401)*

22 CWA Section 401 requires that an applicant for any Federal permit (e.g., an ACOE
23 Section 404 permit) obtain certification from the State that the relevant project or action
24 will comply with other provisions of the CWA and with State water quality standards. For
25 example, an applicant for a permit under CWA Section 404 or Section 10 of the River
26 and Harbors Act must also obtain water quality certification per CWA Section 401.

27 *The National Toxics Rule and the California Toxics Rule*

28 Federal water quality criteria for priority toxic pollutants have been established for
29 non-ocean surface waters (including enclosed bays and estuaries) of California by the

⁷ Navigable waters of the U.S. are those subject to the ebb and flow of the tide shoreward to the mean high water mark and/or presently used, or have been used in the past, or are susceptible for use to transport interstate or foreign commerce. The term includes coastal and inland waters, lakes, rivers and streams that are navigable, and the territorial sea.

1 U.S. Environmental Protection Agency (U.S. EPA). Federal priority toxic pollutant
2 criteria have been promulgated for California by the U.S. EPA in the 1992 (amended in
3 1995) National Toxics Rule (NTR) (40 Code of Federal Regulations [CFR] 131.36) and
4 in the 2000 California Toxics Rule (CTR) (40 CFR 131.38). Except as specified in the
5 CTR, the Federal criteria apply to all waters assigned any aquatic life or human health
6 beneficial uses. The CTR establishes ambient aquatic life criteria for 23 priority toxics,
7 ambient human health criteria for 57 priority toxics, and a compliance schedule
8 provision which authorizes the State to issue schedules of compliance for new or
9 revised National Pollutant Discharge Elimination System (NPDES) permit limits based
10 on the Federal criteria when certain conditions are met.

11 **State**

12 *Porter-Cologne Water Quality Control Act*

13 Porter-Cologne is the basic water quality control law for California. It established the
14 SWRCB and its nine Regional Water Quality Control Boards (RWQCBs) as the principal
15 State agencies with primary responsibility for the coordination and control of water
16 quality. The SWRCB provides State-level coordination by establishing statewide policies
17 and plans for the implementation of State and Federal regulations and oversees
18 RWQCB operations. In addition to other regulatory responsibilities, the RWQCBs have
19 the authority to conduct, order, and oversee investigation and cleanup of discharges, or
20 threatened discharges, of waste to waters of the State⁸ that could cause pollution or
21 nuisance, including impacts to public health and the environment. The RWQCBs also
22 adopt and implement Water Quality Control Plans (or Basin Plans) that recognize the
23 unique characteristics of each region and that designate beneficial uses, establish water
24 quality objectives, and contain implementation programs and policies to achieve those
25 objectives for all waters addressed through the plan (Wat. Code, §§ 13240-13247).

26 *SFBRWQCB Basin Plan, Beneficial Uses, and Water Quality Objectives*

27 Beneficial use designations and the water quality objectives designed to protect them,
28 whether designated by the SWRCB or one of the RWQCBs, comprise water quality
29 standards in California. The San Francisco Bay RWQCB (SFBRWQCB) is responsible
30 for the protection of the beneficial uses of waters in the Bay-Delta estuary and Project
31 lease areas. The SFBRWQCB uses its planning, permitting, and enforcement authority
32 to meet this responsibility and adopted the Water Quality Control Plan for the San

⁸ "Waters of the State" are defined in the Porter-Cologne Act as "any surface water or groundwater, including saline waters, within the boundaries of the state" (Wat. Code, § 13050, subd. (e).)

1 Francisco Bay Basin (Basin Plan) (SFBRWQCB 2010) to implement water quality plans,
 2 policies, and provisions. The SWRCB may also develop and publish plans for specific
 3 geographic areas or regions of particular importance and has done so for the Bay-Delta.

4 In accordance with State policy for water quality control, the SFBRWQCB employs a
 5 range of beneficial use definitions for surface waters, marshes, and mudflats that serve
 6 as the basis for establishing water quality objectives and discharge conditions and
 7 prohibitions. The Basin Plan identifies existing and potential beneficial uses supported
 8 by different areas of the Bay-Delta estuary. The existing and potential beneficial uses
 9 designated in the Basin Plan for the surface water bodies relevant to the Project are
 10 identified in Table 4.3-3. The Basin Plan also includes water quality objectives that are
 11 protective of the identified beneficial uses; the beneficial uses and water quality
 12 objectives collectively make up the water quality standards for the Bay-Delta estuary.
 13 Under CWA Section 303(d), the SFBRWQCB is required to develop a list of impaired
 14 water bodies that do not meet the Basin Plan's water quality standards and objectives.
 15 Table 4.3-4 lists impaired water bodies relevant to the proposed Project area.

16 **Table 4.3-3. Beneficial Uses of Waters within the Project Area**

Beneficial Use	SF Bay Central	San Pablo Bay	Carquinez Strait	Suisun Bay	The Delta
Municipal and Domestic Supply (MUN)					X
Agricultural Supply (AGR)					X
Industrial Service Supply (IND)	X	X	X	X	X
Industrial Process Supply (PRO)	X			X	X
Groundwater Recharge (GWR)					X
Navigation (NAV)	X	X	X	X	X
Water Contact Recreation (REC 1)	X	X	X	X	X
Non-Contact Water Recreation (REC 2)	X	X	X	X	X
Estuarine Habitat (EST)	X	X	X	X	X
Commercial and Sport Fishing (COMM)	X	X	X	X	X
Wildlife Habitat (WILD)	X	X	X	X	X
Rare, Threatened, or Endangered Species (RARE)	X	X	X	X	X
Migration of Aquatic Organisms (MIGR)	X	X	X	X	X
Spawning, Reproduction, and/or Early Development (SPWN)	X	X	X	X	X
Shellfish Harvesting (SHELL)	X	X			
Aquaculture (AQUA)					

Source: SFBRWQCB 2010

1 **Table 4.3-4. 2006 CWA Section 303(d) List of Water Quality Limited Segments in**
 2 **the Project Area**

Pollutant/Stressor	Location	Potential Sources	Proposed TMDL¹ Completion
Chlordane	Central SF Bay, San Pablo Bay, Suisun Bay, the Delta	Nonpoint source	2008
DDT	Central SF Bay, San Pablo Bay, Suisun Bay, the Delta	Nonpoint source	2008
Dieldrin	Central SF Bay, San Pablo Bay, Suisun Bay, the Delta	Nonpoint source	2008
Dioxin compounds (including 2,3,7,8-TCDD)	Central SF Bay, San Pablo Bay, Suisun Bay, the Delta	Atmospheric deposition	2019
Exotic Species	Central SF Bay, San Pablo Bay, Suisun Bay, the Delta	Ballast water	2019
Furan compounds	Central SF Bay, San Pablo Bay, Suisun Bay, the Delta	Atmospheric deposition	2019
Mercury	Central SF Bay, San Pablo Bay, Suisun Bay, the Delta	Industrial point sources, municipal point sources, resource extraction, atmospheric deposition, natural sources, nonpoint source	completed; established by Section 7.2.2 (SFBRWQCB 2010)
Nickel	San Pablo Bay, Suisun Bay, the Delta	Source unknown	2019
PCBs	Central SF Bay, San Pablo Bay, Suisun Bay, the Delta	Unknown nonpoint source	completed; established by Section 7.2.3 (SFBRWQCB 2010)
PCBs (dioxin-like)	Central SF Bay, San Pablo Bay, Suisun Bay	Unknown nonpoint source	2019
Selenium	Central SF Bay, San Pablo Bay, Suisun Bay, the Delta	Industrial point sources, agriculture, natural sources, exotic species	2019
Nutrients	Suisun Marsh Wetlands	Agriculture, urban runoff/ storm sewers, flow regulation/ modification	2019
Organic Enrichment/Low Dissolved Oxygen	Suisun Marsh Wetlands	Agriculture, urban runoff/ storm sewers, flow regulation/ modification	2019
Salinity/TDS ² / Chlorides	Suisun Marsh Wetlands	Agriculture, urban runoff/ storm sewers, flow regulation/ modification	2019
Metals	Suisun Marsh Wetlands	Agriculture, urban runoff/ storm sewers, flow regulation/ modification	2019

¹ TMDL = Total Maximum Daily Load

² TDS = Total Dissolved Solids

Source: SFBRWQCB 2007; SFBRWQCB 2010

1 For those water bodies failing to meet standards, states are required to establish total
2 maximum daily loads (TMDL) (Table 4.3-4 also shows the TMDL status for each
3 identified pollutant). A TMDL defines how much of a specific pollutant a given water
4 body can tolerate and still meet relevant water quality standards. To date, TMDLs
5 concerning mercury and PCBs have been developed for the Bay-Delta estuary.
6 Quantitative or qualitative water quality objectives concerning most of the identified
7 pollutants/stressors are presented in the Basin Plan (SFBRWQCB 2010).

8 *SWRCB Bay-Delta Plan*

9 The Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin
10 Delta Estuary (Bay-Delta Plan; SWRCB 2006) establishes water quality standards for
11 the Bay-Delta estuary. The Bay-Delta Plan focuses on the control of salinity and water
12 project operations to protect beneficial uses, and it assigns a portion of the responsibility
13 for doing so to water rights holders and water users (though, it should be noted, the
14 Bay-Delta Plan does not establish the responsibility of water rights holders). For the
15 geographic area of the Bay-Delta estuary, the Bay-Delta Plan is complimentary to the
16 other water quality control plans and policies adopted by the SWRCB and the
17 RWQCBs; yet, in the event of any conflicts, Basin Plans are superseded by the Bay-
18 Delta Plan.

19 *State Implementation Policy (SIP)*

20 The State Policy for Implementation of Toxics Standards for Inland Surface Waters,
21 Enclosed Bays, and Estuaries of California (also known as the State Implementation
22 Policy [SIP]) applies to discharges of toxic pollutants into the inland surface waters,
23 enclosed bays, and estuaries of California subject to regulation under the Porter-
24 Cologne Act and the CWA. Such regulation may occur through the issuance of NPDES
25 permits, the issuance or waiver of waste discharge requirements (WDRs), or other
26 relevant regulatory approaches (SWRCB 2005). The goal of the SIP is to establish a
27 standardized approach for permitting discharges of toxic pollutants (to non-ocean
28 surface waters); the SIP also serves as a tool to ensure achievement of water quality
29 standards (e.g., water quality criteria or objectives, as well as the State and Federal
30 anti-degradation policies). The SIP establishes implementation provisions for priority
31 pollutant criteria promulgated in the NTR and the CTR, as well as for priority pollutant
32 objectives established by the RWQCBs in their Basin Plans (the SIP also establishes
33 chronic toxicity control provisions). Implementation provisions are established through
34 the development of water quality-based effluent limitations and determining compliance
35 with priority pollutant criteria (and/or objectives) and water quality-based effluent

1 limitations. The provisions within the SIP have full regulatory effect and, for the most
2 part, supersede Basin Plan provisions with respect to priority pollutant standards.

3 *Waste Discharge Requirements*

4 Actions that involve, or are expected to involve, discharge of waste are subject to water
5 quality certification under Section 401 of the CWA (e.g., if a Federal permit is being
6 sought or granted) and/or WDRs under the Porter-Cologne Act. Chapter 4, Article 4 of
7 the Porter-Cologne Act (Wat. Code, §§ 13260-13274) states that persons discharging or
8 proposing to discharge waste that could affect the quality of waters of the State (other
9 than into a community sewer system) shall file a Report of Waste Discharge with the
10 applicable RWQCB.

11 For discharges directly to surface water, an NPDES permit is required, which is issued
12 under both State and Federal law; for other types of discharges, such as waste
13 discharges to land (e.g., spoils disposal and storage), erosion from soil disturbance, or
14 discharges to waters of the State (such as isolated wetlands), WDRs are required and
15 are issued exclusively under State law. WDRs typically require many of the same Best
16 Management Practices (BMPs) and pollution control technologies as required by
17 NPDES-derived permits.

18 For the Bay-Delta estuary, the SFBRWQCB must provide the water quality certification
19 pursuant to CWA Section 401, along with the associated requirements and terms, which
20 is required to minimize or eliminate the potential water quality impacts associated with
21 the action(s) requiring a Federal permit. In some cases, WDRs issued by the RWQCB
22 would satisfy the requirements of CWA Section 401. The Applicants operate under
23 existing WDRs that satisfy CWA Section 401 requirements.

24 *General WDRs for Sand Mining (SFBRWQCB Order No 95-177 and 00-048)*

25 General WDRs have been issued by the SFBRWQCB to the Applicants for sand mining
26 operations occurring in the Bay-Delta estuary.⁹ The SFBRWQCB had authorized the
27 Applicants' previous sand mining operations (i.e., the volumes currently permitted)
28 under this general permit, which (1) regulates the discharge of overflow water resulting
29 from sand mining operations; and (2) implements the water quality objectives of the
30 Basin Plan (SFBRWQCB 2010). By means of stipulating specific discharge prohibitions,
31 conditions, receiving water limitations, and provisions for operations governed by the
32 permit, the SFBRWQCB implemented measures that would prevent the violation of

⁹ SFBRWQCB Order No. 95-177, as amended by SFBRWQCB Order No. 00-048.

1 water quality standards defined in the Basin Plan (SFBRWQCB 2010). A self-monitoring
2 program is also required to be implemented according to the provisions of this general
3 permit. By issuing a general WDR permit to the Applicants, the SFBRWQCB
4 determined that the overflow plume from the Applicants' sand mining operation does not
5 cause waters of the State to exceed the following quality limits downstream of the zone
6 of discharge:

- 7 • Dissolved Oxygen: 5.0 mg/l minimum;
- 8 • Dissolved Sulfide: 0.1 mg/l maximum;
- 9 • pH: a variation of natural ambient pH by more than 0.2 pH units; and
- 10 • Toxic or other deleterious substances: None are present in concentrations or
11 quantities that could cause deleterious effects on aquatic biota, wildlife or
12 waterfowl, or which render any of these unfit for human consumption either at
13 levels created in the receiving waters or as a result of biological concentrations.

14 The water quality of, and resulting from, the overflow plume would still be regulated by
15 this WDRs permit (or a revised version of this WDRs permit) and would be required to
16 comply with existing water quality standards. The Applicants shall notify the
17 SFBRWQCB of the proposed change in permitted sand volumes and confirm continuing
18 authorization to operate under this general permit.

19 *The Bay Plan (BCDC)*

20 The BCDC has regulatory authority over the proposed Project, and the Project is
21 required to be consistent with the findings and policies of the San Francisco Bay Plan
22 (Bay Plan) (see Section 4.7, Land Use and Recreation). The Bay Plan was prepared by
23 the BCDC to guide the long term protection and use of the Bay and its shoreline. The
24 BCDC was created by the McAteer-Petris Act of 1965 (Gov. Code, § 66650 et seq.),
25 initially to prepare the plan and submit it to the California Legislature. The Legislature
26 received the Bay Plan and acted upon its recommendations in 1969, amending the
27 McAteer-Petris Act to make BCDC the agency responsible for maintaining and carrying
28 out the provisions of the law and the Bay Plan and to incorporate the policies of the Bay
29 Plan into State law. Because of the regulatory authority of the SWRCB, SFBRWQCB,
30 U.S. EPA, and ACOE, the Bay Plan does not deal extensively with the problems and
31 means of pollution control. The BCDC is authorized to control both Bay filling and
32 dredging and Bay-related shoreline development. The Bay Plan sets forth a number of
33 findings and policies implementing the BCDC's authority.

1 CALFED Bay-Delta Program

2 The California Bay-Delta Act of 2003 established the California Bay-Delta Authority
3 (CBDA) that oversees the CALFED Bay-Delta Program. The Bay-Delta program is a
4 cooperative interagency effort of 25 State and Federal agencies working cooperatively
5 to improve the quality and reliability of California's water supplies while restoring the
6 Bay-Delta ecosystem. The mission of the CALFED Bay-Delta Program is to develop
7 and implement a long-term comprehensive plan that will restore ecological health and
8 improve water management for beneficial uses of the Bay-Delta System. The proposed
9 Project is under the jurisdiction of the SWRCB and the ACOE, both of which are
10 member agencies of the CALFED Bay-Delta Program; however, the Project is not a
11 CALFED project nor is it connected to the CALFED Program.

12 4.3.3 Significance Criteria

13 Significance criteria, or thresholds, are used as a basis to determine the significance of
14 potential impacts due to the proposed Project. Based on relevant criteria in Appendix G
15 of the State CEQA Guidelines, the Project would have a significant hydrology- or water
16 quality-related impact on the environment if:

- 17 • The water quality objectives promulgated by the SFBRWQCB are exceeded;
- 18 • The water quality criteria contained in the California Toxics Rule are exceeded;
- 19 • Project operations or discharges change background levels of chemical and
20 physical constituents or elevate turbidity levels such that long-term changes in
21 the receiving environment of the site, area or region occur, or such that beneficial
22 uses of the receiving water are impaired or degraded;
- 23 • Contaminant levels in the water column, sediment, or biota are increased to
24 levels shown to have the potential to cause harm to marine organisms even if the
25 levels do not exceed formal objectives; or
- 26 • It altered the topography of an area in a manner which would result in substantial
27 erosion or sedimentation.

28 This impact analysis focuses on foreseeable changes to the baseline condition (i.e.,
29 conditions that include the effects of mining operations at a level equivalent to that
30 occurring, on average, from 2002 to 2007 and the physical effects of past mining
31 operations on Bay and Delta water quality, bathymetry, geomorphology, and
32 hydrodynamics) in the context of the significance criteria presented above. Impacts of
33 the proposed Project in relation to these general topics and criteria were assessed.

1 **4.3.4 Impact Analysis and Mitigation**

2 This Section examines the potential for the Project to cause a significant impact to
3 hydrology and water quality. The first impact (HYD-1) considers potential effects on
4 water quality, and addresses the first four significance criteria listed above. The second
5 impact (HYD-2) addresses the final significance criterion listed above. Table 4.3-5,
6 located at the end of Section 4.3.4, summarizes impacts for the hydrology and water
7 resources issue area.

8 **Impact HYD-1: Potentially adverse effects on water quality**

9 **The overflow plume generated during sand mining operations may impact water**
10 **quality through localized increases in turbidity and suspended solids, through**
11 **possible increases in associated nutrients, metals, and organic matter, and**
12 **localized decreases in dissolved oxygen from oxidation of suspended organic**
13 **material (Less than Significant, Class III).**

14 In the process of suction dredge sand mining, sediments are disturbed on the bottom by
15 the suction dredge head as well as reintroduced into the water column as part of the
16 overflow plume. The sand miners preferentially seek coarse-grained sediment (i.e.,
17 sand having a low percentage of fine material such as silts, clay, and mud), and much
18 of the sediment that is disturbed in the process is sucked-up by the dredge head. As a
19 result, the level of turbidity induced near the bottom in proximity to the suction dredge
20 head is relatively small and subject to almost immediate dilution. The majority of
21 remaining fine-grained sediment is typically taken-up into the collection barge (or
22 hopper) and ultimately rejected as water is discharged from the barge, creating an
23 overflow plume. The overflow plume produced by sand mining results in localized
24 increases in SSC and turbidity which typically disperse after three to four hours
25 following completion of a mining event (Hanson Environmental 2004).¹⁰ The spatial
26 extent of the overflow plume is typically a few hundred feet wide (on either side of the
27 barge) by several hundred feet long (behind the barge).¹¹ The fine-grained sediments
28 contained in the plume have the potential to impact water quality through localized
29 increases in turbidity and suspended solids, through possible increases in associated

¹⁰ In its analysis of sand mining impacts, Hanson Environmental assumed that a worst-case scenario would be a duration of 9.5 hours and a concentration of 100 mg/l for the overflow plume (Hanson Environmental 2004).

¹¹ These general dimensions are based upon observations made by ESA staff as well as upon the work of Sustar et al. (Sustar et al. 1976). The dimensions presented by Sustar et al. were for a more fine-grained overflow plume (as compared to that which results from sand mining) and are likely conservative for purposes here.

1 nutrients, metals, and organic matter, and through localized decreases in dissolved
2 oxygen from oxidation of suspended organic material.

3 The frequency and duration of the overflow plume resulting from sand mining
4 operations, as well as the sediment and/or other pollutant concentration within the
5 plume, generally depend upon the size and quality of the bottom sediments and the
6 frequency and duration of the mining events. The proposed Project would not change
7 the duration of a typical sand mining event. In addition, as the existing operations and
8 the proposed Project preferentially seek areas that contain a high proportion of sands,
9 there is not a substantial difference in the size distribution of the bottom sediments
10 among the lease areas that are mined. Furthermore, the sand mining lease areas,
11 which are generally characterized by the coarse sediments desirable for the aggregate
12 industry, have a relatively low potential for accumulation of sediment-borne
13 contaminants as compared to other parts of the Bay-Delta estuary characterized by a
14 finer overall sediment distribution.

15 Overall, the proposed Project could extract as much as 43 percent more sand from the
16 Bay-Delta estuary in any year during the proposed 10-year lease period, as compared
17 to the average annual volume mined during the baseline period (2002 to 2007), but the
18 difference in proposed sand volumes varies by location (see Table 2-1 in Section 2,
19 Project Description). The proposed Project would increase by approximately 35 percent
20 the volume of sand mined from the Central Bay, and by approximately 250 percent the
21 volume of sand mined from the CSLC Suisun Bay/Delta lease area compared to
22 baseline volumes. The volume of sand proposed to be mined from the private Middle
23 Ground Shoal lease areas would be about the same as that mined annually (on
24 average) during the baseline period. If the increased frequency of sand mining in the
25 CSLC lease areas would result in a substantial change in the nature of the overflow
26 plume (e.g., substantially changing SSC, suspended contaminant concentration, etc.)
27 compared to the existing condition, then a potentially adverse impact would exist. This
28 is not expected to occur, however, as sand mining methods, equipment, and the
29 duration of individual mining events are expected to stay the same.

30 A number of previous studies have assessed the impacts that sand mining and
31 maintenance dredging have on water quality with respect to suspended sediments and
32 other potential contaminants within the Bay-Delta estuary. These studies were
33 undertaken typically in relation to maintenance dredging or sand mining, or both. Sustar
34 et al. found that the suction head of the hopper dredge had relatively little impact on
35 SSC levels (considering just the turbidity induced by the suction head and not the

1 overflow plume (Sustar et al. 1976).¹² The overflow plume of the hopper dredge had a
2 relatively large impact upon SSC, but the elevated values fell to background levels
3 generally within 15 minutes and/or 100 meters. For example, Sustar et al. measured
4 SSC values near an operating hopper dredge (e.g., 50 and 100 meters away from the
5 dredge) at various depths (ranging from 1 meter to 10 meters (Sustar et al 1976). All but
6 two of 11 SSC measurements were less than 55 mg/l at a distance of 50 to 100 meters
7 from the dredge. Based upon previous studies, Hanson Environmental assumed that a
8 worst-case scenario would be a duration of 9.5 hours and a concentration of 100 mg/l
9 for the overflow plume, which is likely a very conservative estimate for impact analysis
10 purposes (Hanson Environmental 2004). The SSC values (i.e., 50 to 100 mg/l)
11 associated with the overflow plume a few hundred feet from the dredge are within the
12 typical range of variability for both Suisun Bay and Central Bay. As such, the effect of
13 sand mining upon ambient SSC is temporary (i.e., typically lasting on the order of
14 minutes to a few hours), localized, and not substantial with respect to the induced SSC
15 values.

16 Schoellhamer, in assessing the potential basin-scale effects of dredging operations in
17 comparison to natural processes, concluded that natural processes (e.g., wind-wave
18 suspension and sediment supply) control SSC values at Point San Pablo even when
19 dredging operations are occurring (Schoellhamer 2002). The dredging operations
20 assessed under this study were typically excavating much larger volumes of sediment
21 than would be excavated from any one of the general lease areas (i.e., Central Bay or
22 Suisun Bay), either under baseline conditions or Project conditions.

23 Work managed by the SFEI serves to illustrate that the potential for dredging impacts
24 related to the suspension of contaminated (or otherwise degraded) sediments, or to
25 reactions such sediments may elicit once in the water column, is relatively low. The
26 SFEI assessed the short-term water quality impacts due to dredging and disposal on
27 sensitive fish species in the Bay-Delta estuary; the following contaminant groups were
28 assessed: dissolved oxygen, sulfide, heavy metals, organic contaminants (including
29 PCBs, PAHs, and pesticides), and ammonia (SFEI 2008). Their review indicated that
30 direct, short-term effects on sensitive fish by contaminants associated with dredging
31 plumes are probably minor, especially in comparison with other potential impacts such
32 as the long-term effects due to bioaccumulation or immediate physical effects of

¹² The study conducted and data collected by Sustar et al. were mostly in relation to fine sediments (i.e., sediments with a higher proportion of silts and clays than would be expected in the lease areas) (Sustar et al. 1976). As such, the values reported by Sustar et al. are likely conservative (i.e., an overestimate) with respect to the potential impacts of sand mining.

1 suspended solids on fish health and habitat (SFEI 2008). According to the RMP data
2 (SFEI 2009; Tables 4.3-1 and 4.3-2), Suisun Bay sediments and water generally exhibit
3 the lowest concentrations of the primary pollutants of concern in the Bay-Delta estuary
4 compared to other locations.

5 As a requirement of the original WDRs for sandmining issued by the SFBRWQCB to the
6 Applicants, MEC studied and measured the water quality of the overflow plume and
7 found no substantial impacts to water quality (MEC 1993). Concerning dissolved
8 oxygen, pH, total suspended solids, heavy metals, and toxicity, no substantial
9 differences between ambient water quality and the quality of water within the discharge
10 plume were observed, though percent transmittance displayed slight plume-related
11 trends (MEC 1993). For RMP data collected near the MEC 1993 study area, the
12 average values (from 1993 to 2000) show an equal range of variation between sample
13 dates for the trace metal concentrations as that observed from the MEC 1993 surveys
14 (Hanson Environmental 2004).

15 Through the issuance of WDRs to the Applicants, the SFBRWQCB has determined that
16 the sand mining overflow plume does not violate water quality standards when
17 operations are consistent with the terms and provisions of the WDRs. Under the Project,
18 the quality of water, and water quality effects of the overflow plume would still be
19 regulated by the WDRs (or a revised version of the WDRs) and would be required to
20 comply with existing water quality standards. The existing WDRs authorize a total
21 mining volume (1,990,000 cubic yards) almost equal to the volume proposed (2,040,000
22 cubic yards) under the Project. Therefore, the existing WDRs, applied to the proposed
23 Project, would assure compliance with existing water quality standards.

24 There is no evidence to suggest that the overflow plume generated as part of the
25 Project would result in water quality impacts beyond those already reviewed and
26 analyzed in previous studies. The studies and information reviewed have indicated that
27 the sand-mining overflow plume does not have a substantial impact upon water quality.
28 The proposed Project would mine the same sized sediment within the same general
29 locations as the Applicants have done for at least the last 10 years. The frequency of
30 the overflow plume could change within certain general locations, but the water quality
31 resulting from the overflow plume would not change in any measurable way. Assuming
32 that the existing permit requirements (i.e., CSLC, BCDC, ACOE and SFBRWQCB)
33 would remain in place, the impact would be less than significant.

1 **Impact HYD-2: Potentially adverse effects on the hydrology and geomorphology**
2 **of the Bay and Delta**

3 **Sand mining could result in pronounced changes to the hydrodynamics (e.g.,**
4 **current speeds), salinity, sediment transport, and/or bottom morphology of the**
5 **Bay-Delta estuary. Such changes could impact water quality and/or lead to**
6 **substantial erosion or sedimentation within or beyond the Bay-Delta estuary**
7 **(Less than Significant, Class III)**

8 CHE performed a sand mining resource evaluation and impact assessment for the
9 proposed Project (CHE 2009; see Appendix G for the complete report and analysis).
10 CHE's work consisted of a bathymetric assessment and hydrodynamic modeling of a
11 wide range of physical processes, including tidal and river flow circulation, salinity,
12 sediment transport, and morphology. Potential impacts resulting from the proposed
13 Project were evaluated in terms of changes in morphology, hydrodynamics, salinity, and
14 sediment transport outside of the lease areas. In particular, it has been suggested in
15 prior studies that aggregate mining in the Bay could possibly be contributing to the
16 observed erosion of the San Francisco Bar (Barnard and Kvitek 2010; Dallas and
17 Barnard 2011), and this potential impact was evaluated as well. Two general types of
18 analyses were used to evaluate potential impacts of the Project:

- 19 • **Bathymetry Analysis:** The bathymetry analysis used available bathymetric data
20 to compare bed topography of the Bay-Delta estuary from different times and to
21 calculate and assess the relative trends and changes in volume. In other words,
22 assessing the impact of the existing operations (i.e., over the last 10 years)
23 would help predict the potential impact of future operations (i.e., over the next
24 10 years). This assessment was based upon hydrographic survey data from
25 multiple sources; the data were compiled, processed, filtered, and gridded to
26 produce realistic bottom surfaces from which volume changes could be
27 calculated.
- 28 • **Numerical Model:** A numerical model was used to assess the potential changes
29 in hydrodynamics (e.g., water depths and velocities), salinity, and sediment
30 transport as a result of implementing the proposed Project. Impacts were
31 evaluated by comparing the existing condition with two Project-condition
32 scenarios.

33 *Bathymetry Analysis*

34 The bathymetry analysis (as well as the resource evaluation, also discussed in
35 Section 4.2, Mineral Resources) relied upon the following bathymetric data sets: USGS
36 multi-beam data (from 1997 and 2008), E-Trac single-beam data (from 2007), and
37 partial least-square (PLS) calibrated single-beam data (from 1996 to 2007). The USGS

1 multi-beam data are the highest resolution and most accurate, but the PLS single-beam
2 data, for example, cover many more years and are more appropriate for detecting
3 trends or rates of change. All bathymetry data were quality-checked and processed in
4 order to perform analysis of sediment resources in the Central Bay and Suisun Bay
5 lease areas. Control sites (i.e., sites outside of the lease areas) were established
6 relevant to both locations in order to establish a basis for detected changes or trends
7 within the lease areas.

8 For the Central Bay, bathymetric changes were most readily assessed using multi-beam
9 data collected by the USGS in 1997 and 2008. The USGS multi-beam data provided a
10 highly detailed map of bed elevations and relative changes. Changes in bed elevation
11 between 1997 and 2008 were calculated and assessed in relation to the location of
12 actual mining events carried out by the Applicants over this same time period. In Central
13 Bay, a clear correlation appears between areas with measured erosion and the
14 locations of mining events (CHE 2009). The calculated net change in bed sediment
15 volume within the areas that were mined (i.e., within the lease areas and some areas
16 immediately adjacent that were also mined) indicates that approximately 11.6 million
17 cubic yards of sediment was eroded (or lost) from this area during the 1997 to 2008
18 period. Considering that the Applicants reported a total Central Bay dredging volume of
19 13.5 million cubic yards (as reportedly measured in the barges after bulking), and
20 considering a likely bulking factor on the order of 10 percent, it appears that the volume
21 of material that was mined during this period is nearly equivalent to the measured
22 erosion inside and surrounding the lease areas. According to this calculation, only
23 approximately 5 percent of the material in the lease areas that was mined has been
24 replaced by natural processes (CHE 2009). CHE also measured changes in bathymetry
25 in several control sites in the vicinity of the mining leases. For the Central Bay
26 bathymetry and resources evaluation, CHE concludes the following:

- 27 • After consideration of actual mining locations and other factors (such as
28 expected bulking after mining), the reported mining volumes are approximately
29 equal to the measured erosion from 1997 to 2008. This indicates that at least for
30 the purposes of the proposed 10 years of additional mining, Central Bay mining
31 resources are basically limited to sand already in place.
- 32 • Net bottom erosion due to sand mining has largely been contained within the
33 lease and immediately adjacent areas. This indicates that the mining holes
34 migrated or expanded only over short lateral distances, and erosion did not
35 spread outside the immediate vicinity of the lease areas.

1 • Since the vast majority of the mined material (approximately 95 percent) has
2 been accounted for immediately adjacent to the lease areas, it appears that sand
3 mining in Central Bay is not likely to cause measurable sediment depletion in
4 areas outside the mining areas.

5 • Since the Project can be expected to further deepen the mining holes, there is
6 the potential that these holes will attract and trap more sediment in the future.
7 Analysis should be performed prior to subsequent issuance of leases for mining
8 these areas.

9 For Suisun Bay and Middle Ground Shoal, bathymetric changes were assessed
10 primarily using the single-beam PLS data (only one of the USGS multi-beam survey
11 data sets was available for the Suisun Bay area). Volumetric changes through time
12 were calculated and assessed for the Suisun Bay and Middle Ground Shoal lease areas
13 and compared to similar calculations for the control sites. Sediment volumes, and
14 changes thereto, were calculated above a bottom elevation of -90 feet MLLW and below
15 -3 feet MLLW, corresponding to the depths at which sand mining is permitted to occur in
16 the Bay-Delta estuary.

17 For the Suisun Bay (excluding Middle Ground Shoal), the observed sediment volume
18 changes (i.e., over the last five to 10 years) in each lease area and for most of the
19 control sites do not exhibit a clear pattern over time. However, most of the control sites,
20 particularly Control Site 2 (upstream of the lease area, at the confluence of the
21 Sacramento and San Joaquin Rivers), and other lease areas show a noticeable
22 depletion of sediment following the December 2005/January 2006 flood event (the New
23 Year's flood). This appears to indicate that large floods carried by the Sacramento
24 and/or San Joaquin Rivers tend to cause net sediment erosion within the main channel
25 areas of Suisun Bay. This finding is consistent with the relatively low maintenance
26 dredging volumes reported by the ACOE (CHE 2009), the estimated decrease in
27 sediment supply to the Delta (Kondolf 2001; Wright and Schoellhamer 2004); and the
28 estimated net loss of sediment from Suisun Bay over recent decades (Capiella et al.
29 1999). Further, most of the control sites and the lease areas show relatively large
30 changes in sediment volume, with respect to both erosion and deposition, which do not
31 appear to be related to large flood events on the Sacramento or San Joaquin Rivers.
32 The range of variability with respect to the annual change in the volume of sediment
33 above -90 feet (MLLW), both in terms of erosion and deposition, is approximately seven
34 times greater than the sand mining volume proposed for the Suisun Bay lease areas as
35 part of the Project (and approximately 20 times greater than the existing mining
36 volume).

1 Given the apparent net erosion in the control sites and lease areas following the New
2 Year's flood and, within the lease areas, instances of substantial sediment deposition
3 seemingly independent of flood or flow magnitude, it seems likely that sedimentation in
4 the lease areas and navigation channels in recent years is mostly a result of localized
5 sediment transport processes.

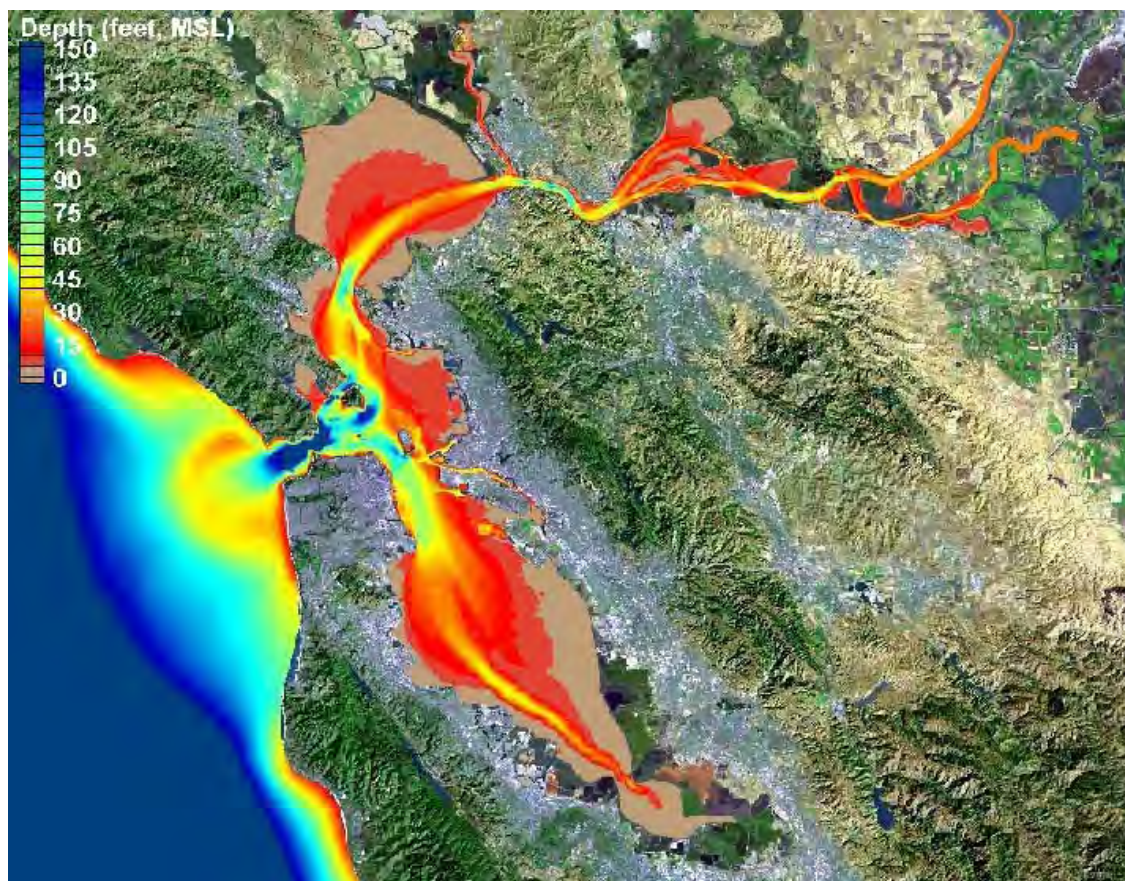
6 For Middle Ground Shoal, analysis of the available bathymetric data showed a clear
7 trend of reduced sediment availability over the last eight years. On average, the
8 available sediment in the Middle Ground Shoal lease area was reduced by
9 approximately 1 percent per year. Some deposition (or replenishment) is apparent in
10 this lease area, but the overall trend indicates a fairly consistent depletion of available
11 sediment. In summary, bathymetric change analysis in Suisun Bay and Middle Ground
12 Shoal indicates the following (CHE 2009):

- 13 • Considering that a recent large flood event caused erosion rather than accretion
14 in the reference sites for the Suisun Associates lease areas, it appears that the
15 material that was mined during this period (i.e., the last 10 years) had been
16 mostly deposited from surrounding areas.
- 17 • Bottom changes in the reference sites and outside the Suisun Associates lease
18 areas were generally small from survey to survey (with the exception of control
19 site 2), likely due to the large size of the surrounding areas that are contributing
20 sediment to the deepened lease areas.
- 21 • Continuation of sand mining in Suisun Bay during the proposed 10-year period is
22 not likely to cause measurable sediment depletion in areas outside the mining
23 areas, such as the reference sites and areas in San Pablo/Central Bay.
- 24 • Sand resources appear to be limited in the deeper areas of Middle Ground, but
25 have not been significantly reduced in the Suisun Associates lease areas. The
26 large surrounding areas of ongoing sand transport and lack of observed change
27 in surrounding morphology indicate that deposition in the mining areas is likely to
28 continue at similar rates.

29 *Numerical Modeling*

30 The goal of the numerical modeling analysis was to provide an additional methodology
31 for evaluation of the potential impacts of sand mining on hydrodynamics, sediment
32 transport, and salinity within the Bay-Delta estuary on a short-term and longer-term
33 basis (CHE 2009). A number of hydrodynamic models were evaluated to determine
34 which model most accurately reflects the important processes within the Bay-Delta
35 estuary and would be most appropriate to assess the potential impacts of the proposed
36 Project. Ultimately, the SELFE model (Zhang and Baptista 2005) was selected. This

1 model includes three-dimensional (3-D) simulation of flow, water surface elevation,
2 salinity, and temperature (Figure 4.3-4 depicts the entire modeling domain). Further,
3 numerical modeling of sediment transport and bottom morphology was performed with
4 the two-dimensional (2-D) LAGRSED model (Maderich and Brovchenko 2004). The
5 LAGRSED model used the hydrodynamic calculations from the SELFE model as input.



6 Source: CHE 2009

7 **Figure 4.3-4**
8 Modeling Domain

9 Circulation, salinity, and sediment transport were simulated for existing conditions and
10 the following two mining scenarios (or Project conditions [CHE 2009]):

- 11 • **Scenario 1:** 10 years of mining occurs all at once,¹³ covering the entire lease
12 area with a constant dredging thickness; and

¹³ This means that a volume equivalent to what would be mined over 10 years (i.e., the proposed, annual sand mining volume multiplied by 10 years) is extracted from the model bathymetry, and the model is subsequently run. This is essentially a worst-case scenario with respect to the volume of extracted sand (i.e., the model is run for a point in time assuming that 10 years of mining has occurred and none of the mined sand has been replaced by natural processes).

- 1 • **Scenario 2:** 10 years of mining occurs all at once, covering only those portions
2 of the lease areas that are actually mined (developed using tracking information
3 from past mining events) using a constant dredging thickness. Dredging
4 coverage was determined to be approximately 25 percent of the lease areas, on
5 average. The lease areas were dredged only over areas consistent with the
6 relevant sand mining regulatory permits.

7 The simulation period for the model was selected based upon available data and the
8 ability to adequately represent conditions and variability relevant to the impact
9 assessment of the Project. For each scenario, the model analysis was performed for
10 both a short-term (i.e., 15 days) and a long-term (full-year) simulation. The short-term
11 simulations (using hydrologic data from early December 1996) focused on details of
12 strong tidal flows with low river flows. The long-term simulations (using hydrologic data
13 from December 1996 to December 1997) focused on tidally-averaged flows and
14 included the extreme flood events that occurred in December 1996 and January 1997.

15 Current velocities (hydrodynamics), salinity, and sediment transport were simulated for
16 all conditions in order to calculate the relative change due to the two mining scenarios.
17 Short-term hydrodynamic changes induced by the Project were assessed using two
18 different analytical methods: plan-view differences in mid-depth velocities during peak
19 currents (i.e., comparing velocity grids for two or more conditions) and time series
20 analysis of mid-depth velocities at selected points surrounding the lease areas. For the
21 long-term simulations, hydrodynamic statistics, net values, and averages were
22 developed for each condition (i.e., existing condition, Scenario 1, and Scenario 2).
23 Short-term changes in salinity were assessed in a similar manner as the velocity
24 changes (i.e., looking at plan-view changes in spatial distribution as well as vertical
25 profiles at selected points outside the lease areas). The LAGRSED model was used to
26 estimate changes in total sediment transport during typical flood and ebb currents
27 (short-term) as well as changes in the net bedload transport over the course of a year
28 (long-term). Further, the LAGRSED model was used to predict bed morphology
29 changes occurring after the long-term transport simulation. No effort was made to
30 validate the predicted bed elevation changes. Rather, the model results are intended for
31 use in a qualitative sense to evaluate the relative magnitude of change with respect to
32 the existing condition and the proposed Project.

33 Results of numerical modeling indicate the following with regard to the potential impacts
34 of the proposed Project (CHE 2009):

- 35 • **Hydrodynamics:** Current velocity changes caused by sand mining Scenario 1 or
36 2 are limited to areas adjacent to the lease areas. Distances from the lease areas

1 where changes in flows are measurable are typically similar to the sizes of the
2 lease areas themselves.

3 • Salinity: Some short-term (e.g., during periods of weaker currents) increases in
4 near-bottom salinity within the mining holes may occur relative to existing
5 conditions. Results indicate that salinity changes outside the immediate vicinity of
6 the lease areas are not likely to occur. Since salinity is directly driven by
7 hydrodynamics, the changes cover roughly the same areas.

8 • Sediment Transport/Morphology: Short-term simulations indicate that the
9 changes in instantaneous transport patterns during both ebb and flood currents
10 are limited to areas immediately adjacent to the lease areas. Full-year
11 simulations indicate that the changes in net transport patterns are also limited to
12 areas immediately adjacent to these lease areas. In addition, comparison of bed
13 changes between existing and after-mining conditions indicates that no
14 morphological impacts (erosion or accretion) are likely outside the immediate
15 vicinity of the sand mining areas.

16 In summary, bathymetric analysis (CHE 2009) suggests the following:

17 • The Central Bay mining areas are generally not aligned along a path of net
18 seaward sediment transport;

19 • The net sediment transport along these transport pathways is not substantial;

20 • The hydrodynamics of the mining areas generally preclude sediment deposition
21 in the actively mined locations; and

22 • Only a very small amount (approximately 5 percent) of the material mined from
23 within the lease areas has been replaced by natural processes.

24 In addition, numerical modeling showed that very little sediment is transported from the
25 Central Bay mining areas to the outer coast (e.g., to the San Francisco Bar), and that
26 very low net bedload transport occurs within several heavily mined lease areas (such as
27 PRC 2036) (CHE 2009). Based upon the impact analysis performed by CHE, which
28 included a bathymetric analysis and numerical modeling of the Bay-Delta estuary, the
29 proposed Project would not have a substantial effect upon morphology, hydrodynamics,
30 salinity, or sediment transport outside of the lease areas. Therefore, this potential
31 impact is considered less than significant.

32

1 **Table 4.3-5. Summary of Hydrology and Water Quality Impacts and Mitigation**
 2 **Measures**

Impact	Mitigation Measures
HYD-1: Potentially adverse effects on water quality.	Less than Significant impact; no mitigation necessary.
HYD-2: Potentially adverse effects on the hydrology and geomorphology of the Bay and Delta.	Less than Significant impact; no mitigation necessary.

3 **4.3.5 Impacts of Alternatives**

4 **No Project Alternative**

5 The No Project Alternative would not result in the Applicants continuing to mine sand
 6 from the Bay-Delta estuary for the next 10 years. Therefore, the less-than-significant
 7 hydrology and water quality impacts described above for the proposed Project would
 8 not occur under the No Project Alternative.

9 **Long-Term Management Strategy (LTMS) Management Plan Conformance** 10 **Alternative**

11 This alternative would require proposed sand mining operations to comply with the
 12 temporal and spatial restrictions on dredging contained in the *Long-Term Management*
 13 *Strategy for the Placement of Dredged Material in the San Francisco Bay Region*
 14 *Management Plan 2001* (LTMS Management Plan). The LTMS Management Plan
 15 Conformance Alternative would restrict sand mining in the Central Bay lease sites to a
 16 five to six month period, and in the Suisun Bay and western Delta sites for a three
 17 month period each year. This alternative would only allow for the same volume of sand
 18 extraction as proposed for the Project. Under this alternative more mining would be
 19 expected to occur during the allowable work windows, then no mining for the remainder
 20 of the year. This could be expected to cause incrementally greater short-term water
 21 quality effects associated with the overflow plume. While incrementally greater, this
 22 impact would still be less than significant for the same reasons as stated in
 23 Impact HYD-1. Further, as this alternative would extract the same amount of sand as
 24 the proposed Project, the potential impact upon Bay-Delta estuary morphology,
 25 hydrodynamics, salinity, and sediment transport would be less than significant for the
 26 same general reasons as stated in Impact HYD-2. The contribution to a cumulative
 27 impact on sediment supply and transport would also remain the same as with the
 28 proposed Project; that is, it would be less than significant (see below).

1 **Clamshell Dredge Mining Alternative**

2 The Clamshell Dredge Mining Alternative would employ a method other than suction
3 dredge mining for recovering sand from the floor of the Bay-Delta estuary, the volume of
4 sand and lease sites mined would remain the same as for the proposed Project.
5 Because the clamshell method would involve raising the clamshell up through the entire
6 water column, this method would likely create a more extensive plume of elevated
7 turbidity and SSC values as compared to the proposed Project (i.e., suction dredge
8 mining). The clamshell method would also require more time per volume of sand
9 extracted as compared to suction dredge mining. However, Sustar et al. found that the
10 turbidity and suspended sediment characteristics of plumes resulting from clamshell and
11 suction head dredging were similar (i.e., the range of measured SSC values within the
12 plumes were similar (Sustar et al 1976). As such, the potential water quality impacts of
13 the Clamshell Dredge Mining Alternative would likely be the same as those previously
14 described for the proposed Project and would be less than significant. Further, as this
15 alternative would extract the same amount of sand as the proposed Project, the
16 potential impact upon Bay-Delta estuary morphology, hydrodynamics, salinity, and
17 sediment transport would be less than significant for the same general reasons as
18 stated in Impact HYD-2. The contribution to a cumulative impact on sediment supply
19 and transport would also remain the same as with the proposed Project; that is, it would
20 be less than significant (see below).

21 **Reduced Project Alternative**

22 The Reduced Project Alternative would reduce the allowable mining volumes in all lease
23 areas to a level equivalent to current baseline volumes (i.e., the average mined per year
24 at each Project parcel from 2002 to 2007), as described in Section 3.0, Alternatives and
25 Cumulative Projects. All other aspects of the Project would remain the same, including
26 mining methods, equipment, and locations. This alternative would result in less
27 discharge of turbid water to the Bay and Delta and remove less sediment from the
28 seafloor than would the Project, involving essentially no change compared to baseline
29 conditions. Therefore, this alternative would further reduce the severity of Impacts HYD-1
30 and HYD-2 (which are less than significant) and reduce the Project's less-than-
31 significant contribution to cumulative hydrology and water quality impacts (see below).

32 **4.3.6 Cumulative Projects Impact Analysis**

33 Because the Bay-Delta estuary is a large and complex physical system, potential
34 cumulative impacts of the proposed Project are assessed at a relatively short-term, local

1 scale, as well as over a longer-term, more regional scale. The proposed Project could
2 contribute to cumulative hydrology and water quality impacts in the vicinity of the
3 proposed Project caused by other projects included in the cumulative analysis. Of the
4 cumulative projects identified in Section 3.0, Alternatives and Cumulative Projects, only
5 the LTMS project and the recently completed Oakland Harbor Navigation Improvement
6 (Oakland Harbor) project are relevant to the cumulative impact assessment at the local
7 scale, as these projects involve or involved actions (i.e., dredging) and potential impacts
8 similar to the proposed Project. Concerning sediment transport and continuity¹⁴ within
9 the Bay-Delta estuary system, a process that can only be characterized using relatively
10 broad spatial and temporal scales, the proposed Project could contribute to cumulative
11 impacts upon this process and, in particular, upon the sediment yield at the mouth of the
12 estuary to the outer coast. In this respect, other changes to the Bay-Delta system that
13 have occurred over the past 150 years should also be considered, in addition to the
14 cumulative projects listed in Section 3.0, Alternatives and Cumulative Projects. These
15 include hydraulic mining, major dam and levee construction, and previous dredging and
16 borrow pit mining activities, as well as more recent and present projects, such as
17 periodic dredging of ship channels, levee repairs and upgrades, and aggregate mining
18 from channels and floodplains in the Central Valley.

19 The Oakland Harbor project (completed in September 2009, eight years after dredging
20 commenced) was not located near any Project lease sites and is now becoming
21 separated temporally from the proposed Project. Most of the dredging and dredge
22 disposal activities of the LTMS project are well beyond the lease area boundaries and
23 no cumulative impacts would occur with respect to water quality, bottom morphology,
24 hydrodynamics, salinity, or sediment transport. For those LTMS-related projects that
25 would occur near the proposed Project lease sites, dredging depths or volumes are
26 likely to decrease compared to current practices, primarily because less sediment is
27 being delivered to the Bay-Delta estuary from the Central Valley, and Suisun Bay and
28 Central Bay have been shown to be net erosional in recent decades (Wright and
29 Schoellhamer 2004; Kondolf 2001; Capiella et al. 1999; Fregoso et al. 2008). Further,
30 plume-related turbidity (or suspended sediment) impacts have been shown to be
31 temporary and localized in extent, and sand-mining and maintenance dredging or
32 disposal activities rarely occur in close proximity to each other due to practical safety
33 issues and nautical rules. As such, there is little potential for two or more mining and
34 dredging plumes to interact in a cumulative manner with respect to turbidity and

¹⁴ *Sediment continuity* is a term that refers, generally, to the variation in transport capacity and supply from one sediment “reservoir” to another, or, in other words, the variation in net supply or deficit from one area to the next.

1 suspended sediment. Also, the potential for dredging operations to suspend pollutants
2 in such a way as to be harmful to aquatic life within the Bay-Delta estuary is low (SFEI
3 2008).

4 Because of the expected decrease in maintenance dredging and the physical
5 separation of maintenance dredging operations from sand mining operations, short-term
6 water quality effects are expected to be localized and temporary, and not to combine in
7 a cumulative manner. The proposed Project would therefore not be expected to result in
8 a significant contribution to cumulative water quality impacts.

9 **Cumulative Effects on Sediment Transport and Coastal Morphology**

10 As discussed in Impact HYD-2, based on the CHE report, there is little replenishment of
11 sediment in the Central Bay and Middle Ground deep channel mining sites; an
12 additional 10 years of mining, combined with the last 10 years of mining and future
13 maintenance dredging, is expected to further alter the morphology of the seabed in
14 these locations, with concomitant, though minor and less-than significant effects on
15 circulation, sediment transport, and water quality (CHE 2009). Several researchers
16 have, however, suggested that sand mining in the Bay could be contributing to the
17 observed erosion of the San Francisco ebb-tidal delta (San Francisco Bar) (Barnard and
18 Kvitek 2010; Dallas and Barnard 2011). Given that previous studies suggest the
19 San Francisco Bar plays a role in supplying sand-sized sediment to, and governing the
20 wave energy distribution along, adjacent open-coast beaches (Barnard and Kvitek
21 2010; Dallas and Barnard 2011), some of which have experienced (and continue to
22 experience) substantial erosion, such a contribution, even if relatively small, could be a
23 potentially significant cumulative impact of the proposed Project.

24 Regarding erosion of the San Francisco Bar, it is as yet unclear what part of this
25 process may be a large-scale, systemic response, and what part (if any) may be a more
26 localized, direct response (e.g., to sediment extraction from the Bay). However, a direct
27 or empirical causal link between commercial sand extraction from the Bay and erosion
28 of the San Francisco Bar has not been established. Rather, a number of plausible
29 causes have been put forth (Barnard et al. 2010; Dallas and Barnard 2011) to explain
30 the observed net erosion of the San Francisco Bar over the last approximately 50 years;
31 these include: an increase in wave height; a change in the tidal prism of the Bay; and a
32 decrease in sediment supply. Previous investigations focusing on both short- and long-
33 term trends in wave height suggest that waves are not the main driver of the long-term
34 contraction of the San Francisco Bar (Dallas and Barnard 2011). Yet, the potential
35 contribution of changes in wave height, though small, cannot be ruled out altogether.

1 Previous studies have documented a progressive reduction in the Bay-Delta estuary's
2 tidal prism over time, and published empirical relationships suggest that even a modest
3 decrease in the tidal prism of the Bay could lead to profound impacts on the size of the
4 ebb-tidal delta (Dallas and Barnard 2011).

5 A reduction in sediment supply is also a plausible explanation of the observed changes
6 in the morphology of the San Francisco Bar. Bedform analysis coupled with numerical
7 modeling strongly suggests net seaward-directed bedload sediment transport from the
8 Bay-Delta estuary (Barnard et al. 2010; Dallas and Barnard 2011), and, over the last
9 half-century, much of the Bay-Delta estuary and San Francisco Bar have experienced a
10 net loss of sediment (Jaffe et al. 1998; Fregoso et al. 2008; Capiella et al. 1999; Dallas
11 and Barnard 2011; Barnard et al. 2010). As such, a reduction in the supply of sediment
12 from the Bay-Delta estuary to the San Francisco Bar could be due, in part, to a
13 reduction in the supply of sediment to the Bay-Delta estuary itself, or the direct removal
14 of sediment from within the estuary, or a combination thereof. As discussed previously,
15 the overall decrease in the supply of sediment to the Bay-Delta estuary from the Central
16 Valley has been well documented (McKee et al. 2002; Wright and Schoellhamer 2004;
17 Krone 1996; Kondolf 2001). Yet, over approximately the last century, a substantial
18 amount of sediment has also been extracted directly from the Bay-Delta estuary by
19 dredging, borrow pit mining, and aggregate mining activities, and so these activities
20 have also contributed to the net loss of sediment from the estuary.

21 For example, in summarizing multiple previous studies, Barnard et al. estimated that the
22 average annual net loss of sediment from the Bay-Delta estuary (excluding the San
23 Francisco Bar) over the last 50 years is approximately 3.75 million cubic yards (Barnard
24 et al. 2010). By comparison, the average annual reported sand mining volume of 1.4
25 million cubic yards from 2002 to 2007 represents approximately 37 percent of this
26 average annual net loss estimate during this time period. However, the analysis by CHE
27 indicates that the mining areas likely have little influence on the supply of sediment to
28 the mouth of the estuary and the outer coast, including the San Francisco Bar (CHE
29 2009). Thus, although the average annual reported sand mining volume from 2002 to
30 2007 represents a substantial portion of the average annual net sediment loss value for
31 the Bay-Delta estuary, it is not clear if and how the losses due to mining translate to
32 observed changes in other areas within or just outside of the estuary, including at the
33 San Francisco Bar. For instance, figures presented by Barnard et al. and CHE
34 (Figure 4.3-5) depicting net bedload transport within the Bay illustrate that a substantial
35 variation in the direction and magnitude of sediment transport may occur over relatively
36 small spatial scales, and many areas within the Bay exhibit little-to-no net sediment

1 transport (Barnard et al. 2010; CHE 2009). As such, the erosion or removal of sediment
2 from one area versus another within the Bay may have a dramatically different effect on
3 the sediment yield at the mouth of the estuary, especially over a relatively short time
4 scale.

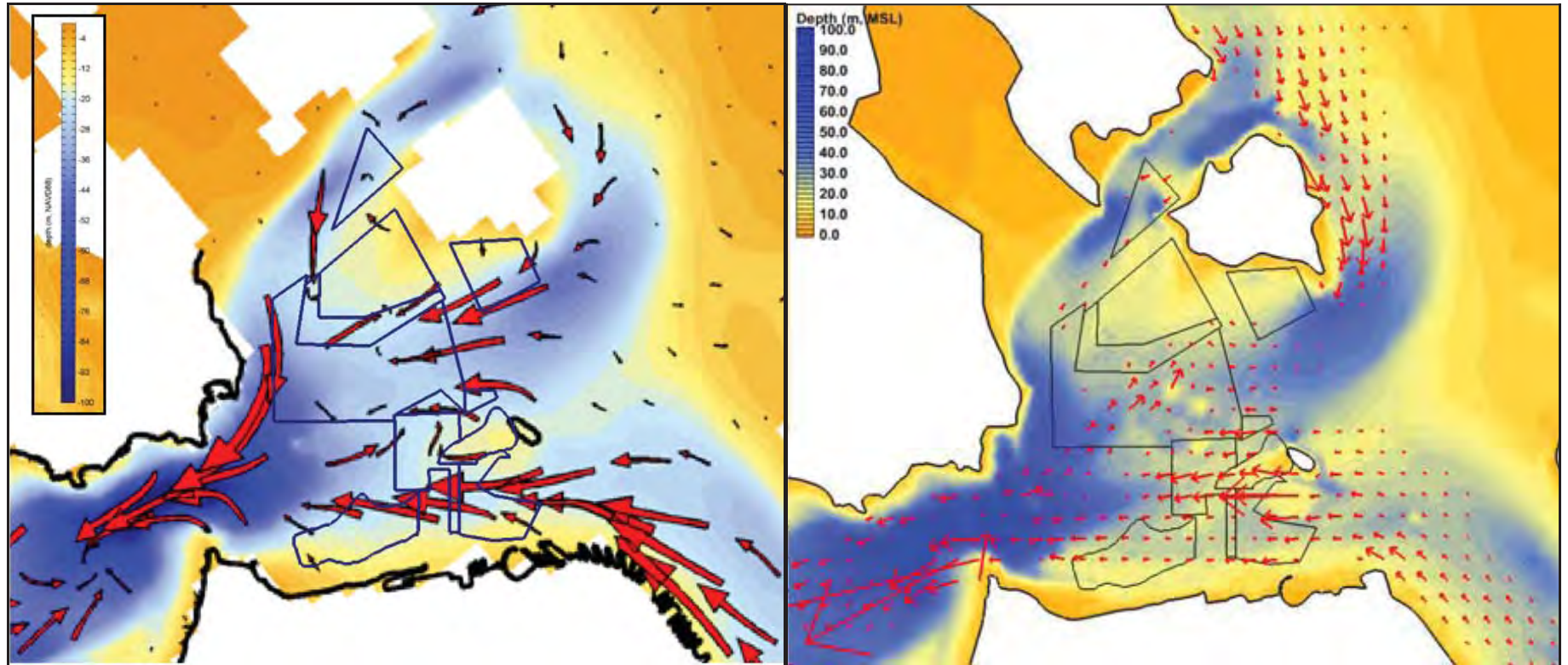
5 Many uncertainties remain regarding sediment transport and continuity within the Bay-
6 Delta estuary system and outer coast areas. Nonetheless, a reduction in the supply of
7 sediment from the Bay-Delta estuary is a possible (and plausible) cause of erosion
8 observed at the San Francisco Bar. Historically, high rates of sediment contribution to
9 the estuary's watershed, including hydraulic mining activities in the 19th century, may
10 have contributed substantially to the formation and evolution of the San Francisco Bar.
11 Thus, it may be shrinking over time simply due to a dramatic reduction in the supply of
12 sediment from the Central Valley. Still, it is not clear how erosion or removal of sediment
13 in different parts of the estuary, and over different temporal scales, may translate to a
14 reduction in sediment supply from the Bay-Delta estuary to the San Francisco Bar.

15 **Conclusion**

16 If the overall reduction in sediment supply in the Bay-Delta system is the cause, or a
17 contributing cause, of the erosion of the San Francisco Bar, it would be reasonable to
18 conclude that the Project could make a considerable contribution to this process. In the
19 absence of greater certainty regarding the physical processes at work, however, such a
20 conclusion is considered speculative, and the cumulative impact is therefore less than
21 significant. Current and future research¹⁵ may shed additional light on the causes of
22 erosion of the San Francisco Bar. Should the CSLC receive an application for new sand
23 mining leases beyond the period covered by the current Project, the CSLC shall
24 reexamine the effects of sand mining on sediment transport and coastal morphology.

25

¹⁵ See summary of research currently being undertaken by Patrick Barnard of the USGS and others at http://walrus.wr.usgs.gov/coastal_processes/sfbaycoastalsys/.



SOURCE: Barnard et al. 2010; CHE 2009

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Figure 4.3-5
Mean Total Sediment Transport (adapted from Barnard et al. 2010, left);
Net Bedload Transport (adapted from CHE 2009, right)