4.3 HYDROLOGY AND WATER QUALITY

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

4.3.1 Environmental Setting

Regional Setting and Climate

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

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

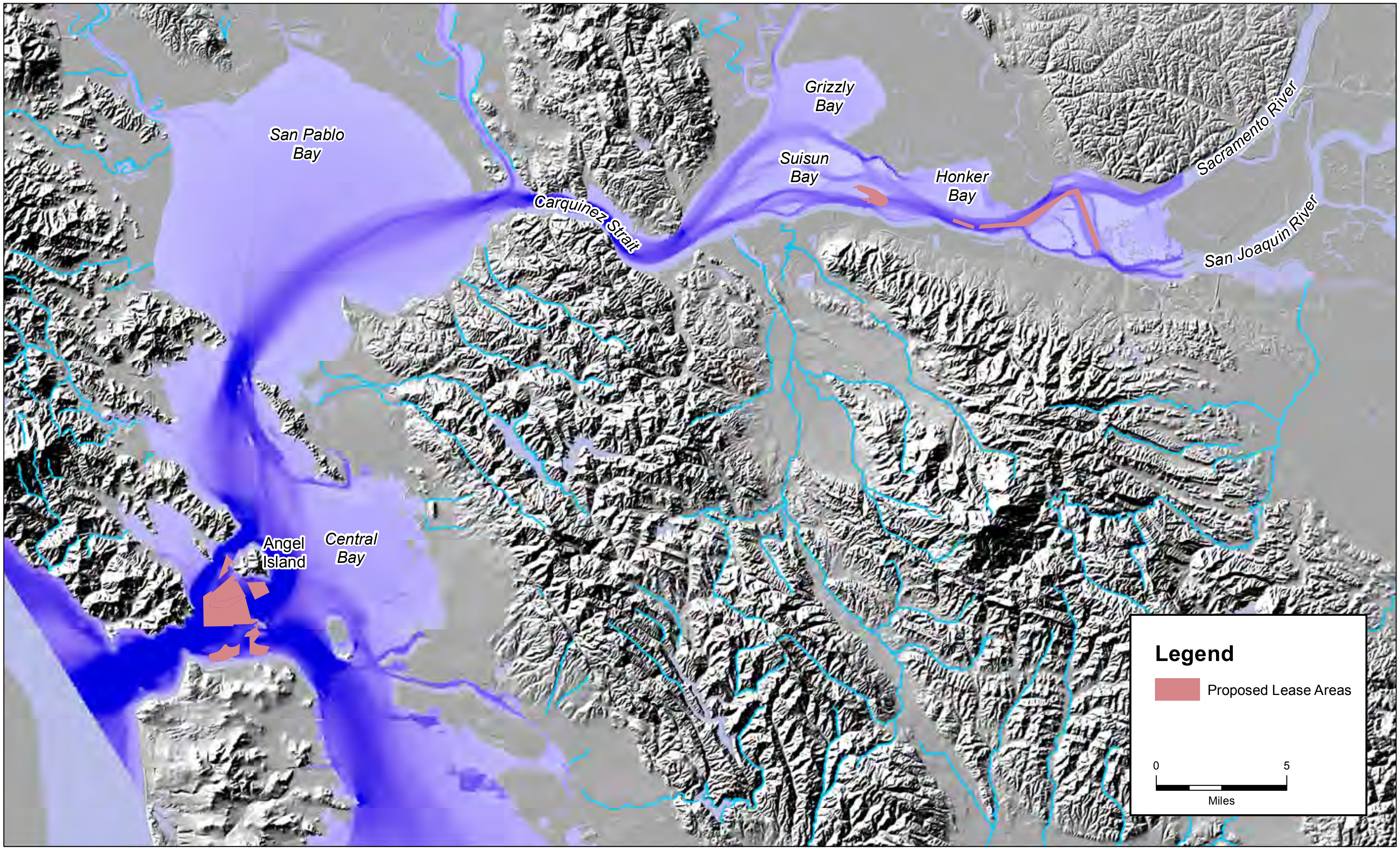
Surface Water Hydrology and Drainage

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

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

The Delta – Sacramento and San Joaquin River Watershed

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



SOURCE: USGS 2009c; ESA 2011; ESRI 2009

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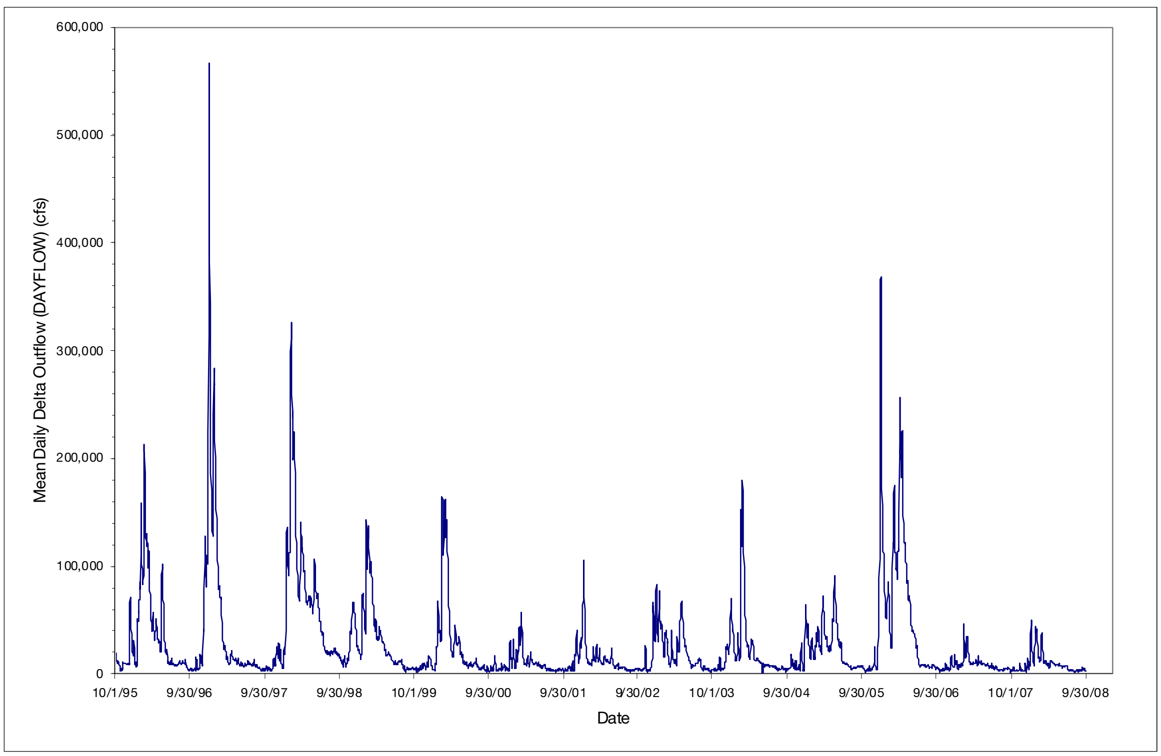
Figure 4.3-1
Central and Northern Bay-Delta Estuary

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



Source: DWR 2009

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

Major Bay Area Watersheds

Though most of the input of freshwater and sediment to the Bay-Delta estuary comes from the Sacramento-San Joaquin River watershed, other local watersheds around the Bay contribute notably to the input of water and sediment, including: Sonoma Creek, the Napa River, Walnut Creek, Alameda Creek, and the Santa Clara Valley watershed (e.g., the Guadalupe River and Coyote Creek). Aside from the Sacramento and San Joaquin River watersheds, the largest contributing watersheds to the Bay-Delta estuary are Alameda Creek and Coyote Creek, both of which drain into South Bay.

Ocean Water Input and Tides

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

Estuarine Circulation

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

Sediment Dynamics

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

Sediment Distribution and Transport

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

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

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

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

Supply of Sediment to the Bay-Delta Estuary

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

Human activities over the past few centuries have greatly modified or overwhelmed the natural sediment processes in the Sacramento and San Joaquin River systems (McKee et al. 2002). During the Gold Rush era, hydraulic mining in the Sierra Nevada foothills dramatically increased the supply of sediment to the Central Valley and, subsequently, to the Bay-Delta estuary. In contrast, since at least the 1950s, human influences have caused a net decrease in the sediment load delivered from the Sacramento and San Joaquin Rivers (McKee et al. 2002; Wright and Schoellhamer 2004). Many of the tributary rivers in the Central Valley have been dammed for irrigation and water supply, and more than 95 percent of this reservoir storage capacity has been built since 1921 (McKee et al. 2002). Export of water from the Delta tributaries commenced in 1929. A fraction of the incoming sediment supply is exported along with this water. Further, particularly on the Sacramento River, bank protection efforts, levee construction and aggregate mining from channel and floodplain areas may also contribute to reducing the available sediment supply and the transported volume. In addition, winter floods have been reduced by 40 to 90 percent, reducing the capacity of the rivers to transport sediment (Kondolf 2001). Reductions in peak annual discharge and changes in the seasonal flow regime, as well as the trapping of sediments behind reservoirs and Delta sinks, have led to reductions in the natural flow of sediments entering the Bay via the Delta (Krone 1979). Once estimated to account for up to 90 percent of the total Bay-Delta estuary sediment input, McKee et al. suggest that the Central Valley now supplies about 57 percent of the total sediment flux to the Bay-Delta estuary (McKee et al. 2002).

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

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[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]).

San Francisco Bay – Bathymetry and Morphology

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

Central Bay

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

Suisun Bay

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

Bathymetry Changes

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

Water and Sediment Quality

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

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

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

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 (µg/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 (µg/L)	0.125	0.124	0.253	0.116	0.135	0.124
Nickel (µg/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
µg/L: micrograms per liter
ng/L: nanograms per liter
pg/L: picograms per liter

Source: SFEI 2009

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 (μg/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 (μg/Kg)	5.73	6.95	7.45	4.21	6.51	2.02
Dieldrin (μg/Kg)	0.12	0.08	0.09	0.12	0.22	0.08
Total Chlordanes (μg/Kg)	0.33	0.13	0.35	0.40	0.67	0.15
Total DDTs (μg/Kg)	1.94	1.93	2.16	2.17	1.70	1.89
Total PAHs (μg/Kg)	2,116	3,263	1,565	887	1,935	398

Notes:
mg/Kg: milligrams per kilogram
μg/Kg: micrograms per kilogram

Source: SFEI 2009

Salinity

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

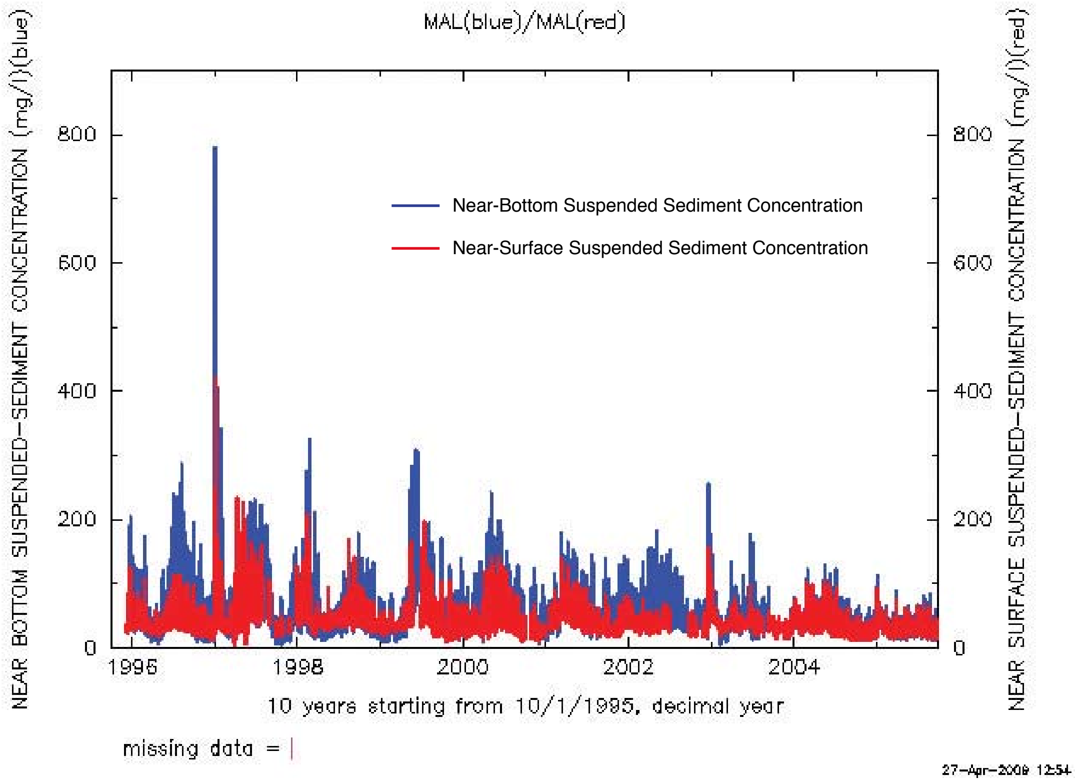
Suspended Sediments

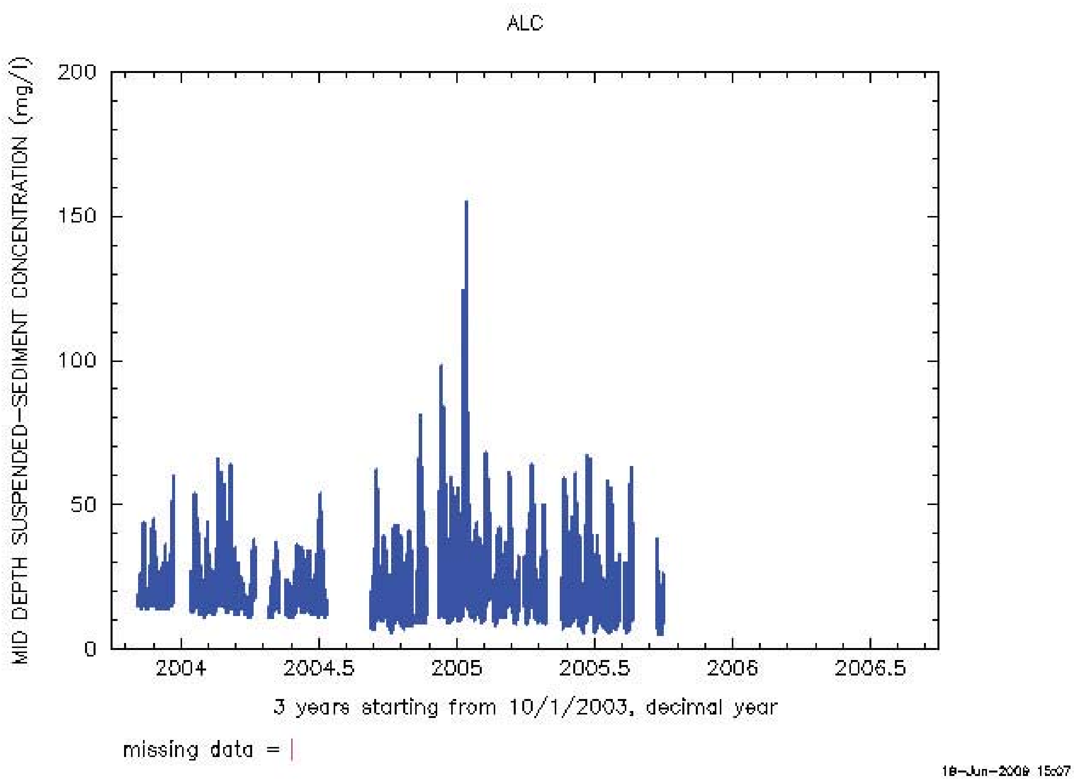
In general, concentrations of suspended sediment in the Bay-Delta estuary are driven by discharge from the Delta, tidal advection and suspension, and wind-wave action (and the associated wind-induced shear stress at the sediment-water interface). Further, salinity influences the concentration and deposition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

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

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

[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).





SOURCE: USGS 2009a, 2009b

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Figure 4.3-3
Suspended Sediment Data

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

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

Sediment Contamination

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

4.3.2 Regulatory Setting

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

Federal

Rivers and Harbors Act

Sand mining in the Bay-Delta estuary is regulated by the U.S. Army Corps of Engineers (ACOE) under Section 10 of the Rivers and Harbors Act (33 U.S.C., § 401 et seq.). Section 10 of the Rivers and Harbors Act requires authorization from the ACOE for the construction of any structure in or over any navigable water[7] of the United States, the excavation/dredging or deposition of material in these waters or any obstruction or alteration in a navigable waterbody. Structures or work outside the limits defined for navigable waters of the United States require a Section 10 permit if the structure(s) or work affects the course, location, condition, or capacity of the water body. Section 10 and CWA Section 404 overlap in some activities involving wetlands. Permits for activities regulated under both are processed simultaneously by the ACOE.

Water Quality Certification (CWA Section 401)

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

The National Toxics Rule and the California Toxics Rule

Federal water quality criteria for priority toxic pollutants have been established for 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.

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

State

Porter-Cologne Water Quality Control Act

Porter-Cologne is the basic water quality control law for California. It established the SWRCB and its nine Regional Water Quality Control Boards (RWQCBs) as the principal State agencies with primary responsibility for the coordination and control of water quality. The SWRCB provides State-level coordination by establishing statewide policies and plans for the implementation of State and Federal regulations and oversees RWQCB operations. In addition to other regulatory responsibilities, the RWQCBs have the authority to conduct, order, and oversee investigation and cleanup of discharges, or threatened discharges, of waste to waters of the State[8] that could cause pollution or nuisance, including impacts to public health and the environment. The RWQCBs also adopt and implement Water Quality Control Plans (or Basin Plans) that recognize the unique characteristics of each region and that designate beneficial uses, establish water quality objectives, and contain implementation programs and policies to achieve those objectives for all waters addressed through the plan (Wat. Code, §§ 13240-13247).

SFBRWQCB Basin Plan, Beneficial Uses, and Water Quality Objectives

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

[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).)

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

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

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

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

Pollutant/Stressor	Location	Potential Sources	Proposed TMDL[1] 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

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

SWRCB Bay-Delta Plan

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

State Implementation Policy (SIP)

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

Waste Discharge Requirements

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

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

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

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

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

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

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

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

The Bay Plan (BCDC)

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

CALFED Bay-Delta Program

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

4.3.3 Significance Criteria

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

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

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

4.3.4 Impact Analysis and Mitigation

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

Impact HYD-1: Potentially adverse effects on water quality

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

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

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

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

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

A number of previous studies have assessed the impacts that sand mining and maintenance dredging have on water quality with respect to suspended sediments and other potential contaminants within the Bay-Delta estuary. These studies were undertaken typically in relation to maintenance dredging or sand mining, or both. Sustar et al. found that the suction head of the hopper dredge had relatively little impact on SSC levels (considering just the turbidity induced by the suction head and not the overflow plume (Sustar et al. 1976).[12] The overflow plume of the hopper dredge had a relatively large impact upon SSC, but the elevated values fell to background levels generally within 15 minutes and/or 100 meters. For example, Sustar et al. measured SSC values near an operating hopper dredge (e.g., 50 and 100 meters away from the dredge) at various depths (ranging from 1 meter to 10 meters (Sustar et al 1976). All but two of 11 SSC measurements were less than 55 mg/l at a distance of 50 to 100 meters from the dredge. Based upon previous studies, 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, which is likely a very conservative estimate for impact analysis purposes (Hanson Environmental 2004). The SSC values (i.e., 50 to 100 mg/l) associated with the overflow plume a few hundred feet from the dredge are within the typical range of variability for both Suisun Bay and Central Bay. As such, the effect of sand mining upon ambient SSC is temporary (i.e., typically lasting on the order of minutes to a few hours), localized, and not substantial with respect to the induced SSC values.

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

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

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

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

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

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

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

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

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

- **Bathymetry Analysis:** The bathymetry analysis used available bathymetric data to compare bed topography of the Bay-Delta estuary from different times and to calculate and assess the relative trends and changes in volume. In other words, assessing the impact of the existing operations (i.e., over the last 10 years) would help predict the potential impact of future operations (i.e., over the next 10 years). This assessment was based upon hydrographic survey data from multiple sources; the data were compiled, processed, filtered, and gridded to produce realistic bottom surfaces from which volume changes could be calculated.

- **Numerical Model:** A numerical model was used to assess the potential changes in hydrodynamics (e.g., water depths and velocities), salinity, and sediment transport as a result of implementing the proposed Project. Impacts were evaluated by comparing the existing condition with two Project-condition scenarios.

Bathymetry Analysis

The bathymetry analysis (as well as the resource evaluation, also discussed in Section 4.2, Mineral Resources) relied upon the following bathymetric data sets: USGS multi-beam data (from 1997 and 2008), E-Trac single-beam data (from 2007), and partial least-square (PLS) calibrated single-beam data (from 1996 to 2007). The USGS multi-beam data are the highest resolution and most accurate, but the PLS single-beam data, for example, cover many more years and are more appropriate for detecting trends or rates of change. All bathymetry data were quality-checked and processed in order to perform analysis of sediment resources in the Central Bay and Suisun Bay lease areas. Control sites (i.e., sites outside of the lease areas) were established relevant to both locations in order to establish a basis for detected changes or trends within the lease areas.

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

- After consideration of actual mining locations and other factors (such as expected bulking after mining), the reported mining volumes are approximately equal to the measured erosion from 1997 to 2008. This indicates that at least for the purposes of the proposed 10 years of additional mining, Central Bay mining resources are basically limited to sand already in place.

- Net bottom erosion due to sand mining has largely been contained within the lease and immediately adjacent areas. This indicates that the mining holes migrated or expanded only over short lateral distances, and erosion did not spread outside the immediate vicinity of the lease areas.

- Since the vast majority of the mined material (approximately 95 percent) has been accounted for immediately adjacent to the lease areas, it appears that sand mining in Central Bay is not likely to cause measurable sediment depletion in areas outside the mining areas.
- Since the Project can be expected to further deepen the mining holes, there is the potential that these holes will attract and trap more sediment in the future. Analysis should be performed prior to subsequent issuance of leases for mining these areas.

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

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

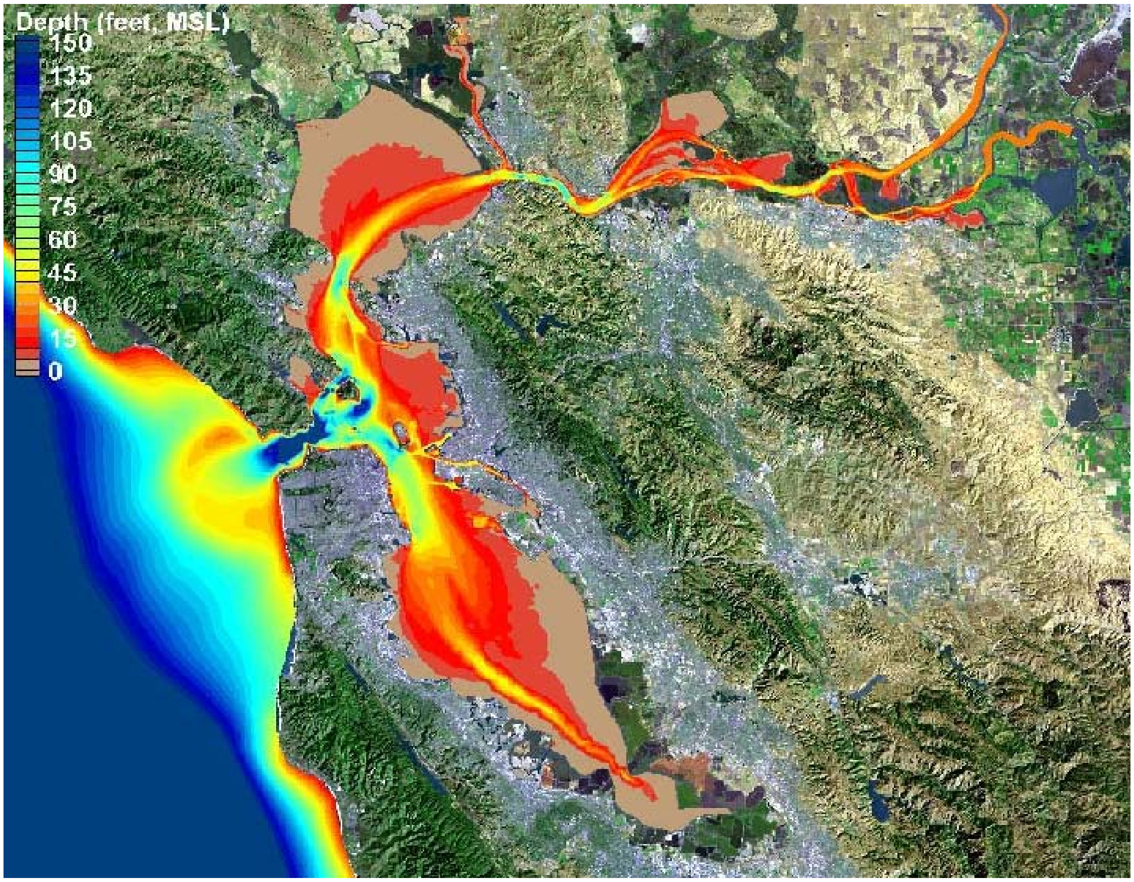
Given the apparent net erosion in the control sites and lease areas following the New Year's flood and, within the lease areas, instances of substantial sediment deposition seemingly independent of flood or flow magnitude, it seems likely that sedimentation in the lease areas and navigation channels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

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

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

Numerical Modeling

The goal of the numerical modeling analysis was to provide an additional methodology for evaluation of the potential impacts of sand mining on hydrodynamics, sediment transport, and salinity within the Bay-Delta estuary on a short-term and longer-term basis (CHE 2009 [Appendix G]). A number of hydrodynamic models were evaluated to determine which model most accurately reflects the important processes within the Bay-Delta estuary and would be most appropriate to assess the potential impacts of the proposed Project. Ultimately, the SELFE model (Zhang and Baptista 2005) was selected. This model includes three-dimensional (3-D) simulation of flow, water surface elevation, salinity, and temperature (Figure 4.3-4 depicts the entire modeling domain). Further, numerical modeling of sediment transport and bottom morphology was performed with the two-dimensional (2-D) LAGRSED model (Maderich and Brovchenko 2004). The LAGRSED model used the hydrodynamic calculations from the SELFE model as input.



Source: CHE 2009 [Appendix G]

Figure 4.3-4
Modeling Domain

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

- **Scenario 1:** 10 years of mining occurs all at once,[13] covering the entire lease 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).

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

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

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

Results of numerical modeling indicate the following with regard to the potential impacts of the proposed Project (CHE 2009 [Appendix G]):

- Hydrodynamics: Current velocity changes caused by sand mining Scenario 1 or 2 are limited to areas adjacent to the lease areas. Distances from the lease areas where changes in flows are measurable are typically similar to the sizes of the lease areas themselves.

- Salinity: Some short-term (e.g., during periods of weaker currents) increases in near-bottom salinity within the mining holes may occur relative to existing conditions. Results indicate that salinity changes outside the immediate vicinity of the lease areas are not likely to occur. Since salinity is directly driven by hydrodynamics, the changes cover roughly the same areas.
- Sediment Transport/Morphology: Short-term simulations indicate that the changes in instantaneous transport patterns during both ebb and flood currents are limited to areas immediately adjacent to the lease areas. Full-year simulations indicate that the changes in net transport patterns are also limited to areas immediately adjacent to these lease areas. In addition, comparison of bed changes between existing and after-mining conditions indicates that no morphological impacts (erosion or accretion) are likely outside the immediate vicinity of the sand mining areas.

In summary, bathymetric analysis (CHE 2009 [Appendix G]) suggests the following:

- The Central Bay mining areas are generally not aligned along a path of net seaward sediment transport;
- The net sediment transport along these transport pathways is not substantial;
- The hydrodynamics of the mining areas generally preclude sediment deposition in the actively mined locations; and
- Only a very small amount (approximately 5 percent) of the material mined from within the lease areas has been replaced by natural processes.

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

Table 4.3-5. Summary of Hydrology and Water Quality Impacts and Mitigation 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.

4.3.5 Impacts of Alternatives

No Project Alternative

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

Long-Term Management Strategy (LTMS) Management Plan Conformance Alternative

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

Clamshell Dredge Mining Alternative

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

Reduced Project Alternative

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

4.3.6 Cumulative Projects Impact Analysis

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

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

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

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

Cumulative Effects on Sediment Transport and Coastal Morphology

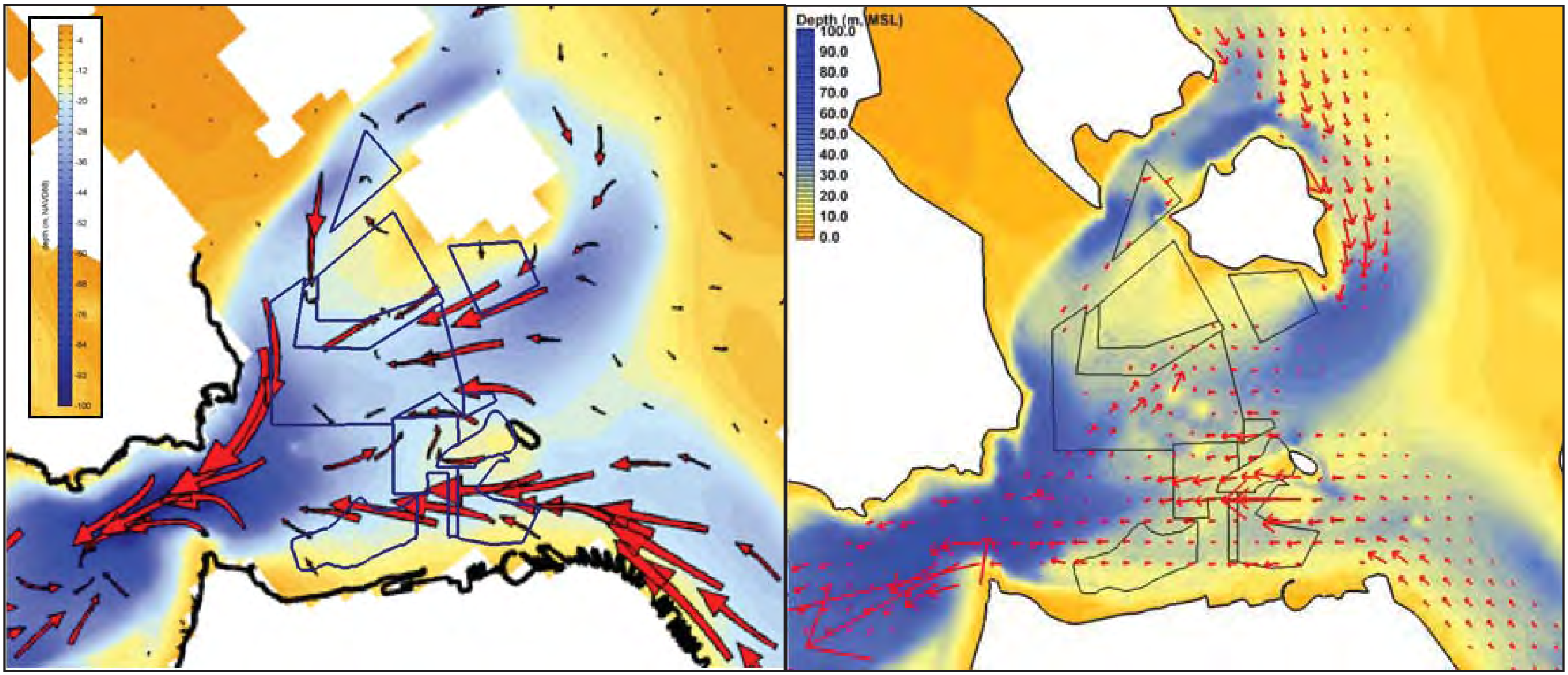
As discussed in Impact HYD-2, based on the CHE report, there is little replenishment of sediment in the Central Bay and Middle Ground deep channel mining sites; an additional 10 years of mining, combined with the last 10 years of mining and future maintenance dredging, is expected to further alter the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

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

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

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

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



SOURCE: Barnard et al. 2010; CHE 2009

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

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

Many uncertainties remain regarding sediment transport and continuity within the Bay-Delta estuary system and outer coast areas. Nonetheless, a reduction in the supply of sediment from the Bay-Delta estuary is a possible (and plausible) cause of erosion observed at the San Francisco Bar. Historically, high rates of sediment contribution to the estuary's watershed, including hydraulic mining activities in the 19th century, may have contributed substantially to the formation and evolution of the San Francisco Bar. Thus, it may be shrinking over time simply due to a dramatic reduction in the supply of sediment from the Central Valley. Still, it is not clear how erosion or removal of sediment in different parts of the estuary, and over different temporal scales, may translate to a reduction in sediment supply from the Bay-Delta estuary to the San Francisco Bar. However, supplemental analysis of the previous modeling effort and the results of new modeling presented in this EIR confirm the findings and conclusions previously reached for Impact HYD-2 and for cumulative effects of the Project on sediment transport, as reiterated below. The original CHE study presented in Appendix G of the EIR, and supplemental analyses confirm the EIR conclusions regarding Impact HYD-2 and the potential cumulative effects of the Project on sediment transport and coastal morphology. The results of these analyses clarify and quantify the conclusion reached in Appendix G of the EIR: if the Project is approved and sand mining continues at the proposed volume for a 10-year period, there is likely to be a reduction of 5,000-7,000 cubic yards of sediment transported from Central Bay through the Golden Gate annually. This range represents approximately 0.2 – 0.3 percent of the long-term rate of erosion of the Bar, as calculated by Hanes and Barnard (2007).[15] Consistent with the conclusions presented in this EIR, the CSLC considers this Project-associated reduction in sediment transport, and any secondary effects on coastal morphology, to be a less-than-significant impact, and a less-than-cumulatively considerable contribution to a cumulative impact.

Conclusion

~~If the overall reduction in sediment supply in the Bay-Delta system is the cause, or a contributing cause, of the erosion of the San Francisco Bar, it would be reasonable to~~

[15] Other, plausible reasons for the observed erosion rate of the Bar are summarized and discussed in the cumulative impact analysis of the EIR (Section 4.3.6).

~~conclude that the Project could make a considerable contribution to this process. In the absence of greater certainty regarding the physical processes at work, however, such a conclusion is considered speculative, and the cumulative impact is therefore less than significant.~~ The supplemental analysis of the previous modeling effort and the results of the new modeling effort conducted for this Final EIR both confirm the findings and conclusions reached in the Bathymetric and Hydrodynamic Study (Appendix G), in Impact HYD-2, and in this discussion of cumulative effects of the Project on sediment transport:

- the Project is not expected in itself, or in combination with other projects, to result in a substantial alteration of sediment transport patterns or the morphology of the seabed outside of the vicinity of the lease areas;
- the Project is not expected to result in a substantial decrease in the supply of sediment to the San Francisco Bar and Ocean Beach.

In summary, both the Project-level impact, and the contribution to a cumulative impact, would be less than significant. Current and future research[16] may shed additional light on the causes of erosion of the San Francisco Bar. Should the CSLC receive an application for new sand mining leases beyond the period covered by the current Project, the CSLC shall reexamine the effects of sand mining on sediment transport and coastal morphology.

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