

# **CHAPTER 9**

## **GEOLOGY, SOILS, FAULTS, SEISMICITY, AND MINERAL RESOURCES**

This chapter describes the geology, soils, faults, seismicity, and mineral resources in the study area and potential changes that could occur due to implementation of the alternatives. All of the alternatives would require the construction of facilities that could affect local geologic, soil, and drainage conditions, and all of the alternatives would require the construction of major structures such as Perimeter Dikes, Barriers, Sedimentation/Distribution Basins, Saline Habitat Complex, pumping plants, and canals, which could be affected by local faults and seismic activity.

As described in Chapter 3, all of the alternatives would require earth materials (soil and rock) for construction of the facilities. The source of much of this material is not known at this time. Therefore, the Draft Programmatic Environmental Impact Report (PEIR) focuses on the environmental impacts of the construction and operations and maintenance of facilities in the Salton Sea and its immediate surroundings, and provides a general overview of the types of activities and potential impacts to geologic resources that would occur to obtain the required material.

It is assumed that all imported materials would be provided from permitted quarries or other sites. During project-level analyses, if adequate amounts of soil and rock are not available from permitted facilities or if new facilities are required, then the environmental analyses would evaluate the related effects. Assumed volumes of rock, gravel, and soil required for construction of alternatives are summarized in Chapter 3 and Appendix H. If new facilities are required to provide imported soil and rock, then the relative impacts can be considered based upon the relative amounts of imported material described in this PEIR.

### **STUDY AREA**

The study area is defined as the geographical area within which the large majority of impacts are expected. The study area for the geology, soils, faults, seismicity, and mineral resources is shown in Figure 1-1.

### **REGULATORY REQUIREMENTS**

The following State and local regulatory requirements may be applicable to the alternatives:

- Alquist-Priolo Earthquake Fault Zone Act – The Alquist-Priolo Earthquake Fault Zone Act (Public Resources Code Sections 2621 et seq.) was passed in 1972 to prevent buildings from being constructed astride active faults. The act is designed to mitigate surface fault rupture by preventing construction of buildings for human occupancy across an active fault. It requires State zoning of active faults, and local review and regulation of development within the zones;
- Several of the fault zones in Southern California are considered active by the California Geological Survey (CGS; formerly the California Department of Conservation, Division of Mines and Geology). Alquist-Priolo special study zones (A-P zones) have been established for the majority of these faults and fault zones in accordance with the Alquist-Priolo Special Studies Zones Act of 1972. A-P zones are areas established along and parallel to the traces of active faults. The delineation of A-P zones on topographic maps is the responsibility of CGS. The purpose of A-P zones is to prohibit the location of structures on the traces of active faults, thereby mitigating potential damage from fault surface rupture;

- Seismic Hazards Mapping Act – The Seismic Hazards Mapping Act and related regulations establish a statewide minimum public safety standard for mitigation of earthquake hazards (CGS, 1994). According to this act, the minimum level of mitigation should reduce the risk of ground failure during an earthquake to a level that does not cause the collapse of buildings for human occupancy, but, in most cases, not to a level of no ground failure at all. Nothing in the act precludes public agencies from enacting more stringent requirements, or from requiring a higher level of performance;
- Surface Mining and Reclamation Act – The Surface Mining and Reclamation Act was enacted by the California Legislature to address the need for a continuing supply of mineral resources, and to prevent or minimize the negative impacts of surface mining to public health, property and the environment. The Department of Conservation’s Office of Mine Reclamation and the State Mining and Geology Board are jointly charged with ensuring proper administration of the act’s requirements. However, the act is administered at the local city and county level through adopted ordinance for land use permits with oversight from the State Mining and Geology Board. The act requires approval of a mining permit by the local land use agency, a reclamation plan for returning the land to a usable condition after mining, and financial assurances to guarantee costs for reclamation. The act’s requirements apply to anyone, including government agencies, engaged in surface mining operations in California (including those on federally managed lands) which disturb more than one acre or remove more than 1,000 cubic yards of material;
- California Department of Water Resources Division of Safety of Dams (DSOD) – DSOD reviews plans and specifications for the construction of new dams or for the enlargement, alteration, repair, or removal of existing dams. DSOD must grant written approval before construction can proceed on any dam under DSOD jurisdiction. Dams under the jurisdiction of DSOD are defined in the California Water Code (Division 3, Dams and Reservoirs; Part 1, Supervision of Dams and Reservoirs; Chapter 1, Definitions);
  - “Dam” means any artificial barrier, together with appurtenant works, which does or may impound or divert water, and which either (a) is or will be 25 feet or more in height from the natural bed of the stream or watercourse at the downstream toe of the barrier, as determined by the DSOD, or from the lowest elevation of the outside limit of the barrier, as determined by the DSOD, if it is not across a stream channel or watercourse, to the maximum possible water storage elevation or (b) has or will have an impounding capacity of 50 acre-feet or more; and
  - Any such barrier which is or will not be in excess of 6 feet in height, regardless of storage capacity, or which has or will have a storage capacity not in excess of 15 acre-feet, regardless of height, shall not be considered a dam; and
- California Building Code, 2001 Edition including Title 24 California Code of Regulations (based on the Uniform Building Code, 1997) would be used to develop design criteria. The Salton Sea is located in Seismic Zone 4 according to the California Building Code. Therefore, the seismic performance objectives for the alternatives would be as follows for both building and non-building structures:
  - To sustain minimal or no damage under minor earthquake ground motion;
  - To limit damage to non-structural features under moderate level earthquake ground motion; and
  - To limit damage to structural and non-structural features without collapse under major level earthquake ground motion.

The general plans of Imperial and Riverside counties contain goals and policies for protection of geologic features, soil resources, and avoidance of geologic hazards. Building codes and grading ordinances establish specific regulations for construction procedures, including erosion control measures.

## **HISTORICAL PERSPECTIVE**

The natural soil and rock formations around the Salton Sea area have affected the development pattern and may have restricted the types of development that has occurred near the Salton Sea. Soils on the south and north sides of the Salton Sea have provided for widespread agriculture with the aid of irrigation water.

## **DATA SOURCES**

Information regarding the geology, soils, faults, ground motions, seismicity, and mineral resources was obtained from published sources and previous planning documents. Specific data sources are cited in the text and full citations are provided in Attachment B.

## **DATA LIMITATIONS**

Locations of faults are based on U.S. Department of the Interior, Geological Survey (USGS) maps and observations of surface exposures. Many areas are covered with alluvial materials from the nearby mountains and therefore some faults may be concealed. In addition, there is limited information on the soils below the Salton Sea.

## **EXISTING CONDITIONS**

The Salton Sea occupies a portion of the interior-draining Salton Basin. The southern end of this basin has been blocked by the deposition of deltaic sediments from the Colorado River effectively preventing drainage from the basin to the Gulf of California. The several subbasins that drain into the Salton Sea include the Whitewater River from the Transverse and Peninsular Ranges to the north-northwest, Salt Creek from the Orocochia and Chocolate Mountains to the east, and San Felipe Creek which drains the Peninsular Range to the West. The largest flow into the Salton Sea comes from the Imperial Valley to the south via the New and Alamo rivers. These rivers primarily convey drainage flows from irrigated lands. The major geologic and seismic features in the Salton Basin are shown in Figure 9-1.

## **Geologic Structure**

The Salton Basin is located in the Salton Trough, a deep north-west trending structural depression that extends from San Geronio Pass to the Gulf of California. The Salton Trough is the northern portion of the rift zone that occurs where the North American (east) and Pacific (west) plates converge. The rift zone includes the Salton Trough, the Colorado River Delta, and the Gulf of California. The rift zone, a low-lying area that occurs because of the downward movement of land between two fault zones, formed during late Cenozoic time. The accumulation of the Colorado River Delta sediments separates the trough from the southern portion of the Gulf of California (Planert and Williams, 1995).

The Salton Trough is bounded to the north by the Transverse Ranges geomorphic province, to the northeast by the Mojave Desert geomorphic province, and to the west by the Peninsular Ranges geomorphic province. Northwest-trending faults and associated folding cross the Salton Basin, the Imperial Valley, and the mountains to the west. These faults are predominately right-lateral and can be divided into three main fault zones, the San Andreas, San Jacinto, and Elsinore. These faults are discussed in the "Faults" section below.

## Regional Geology

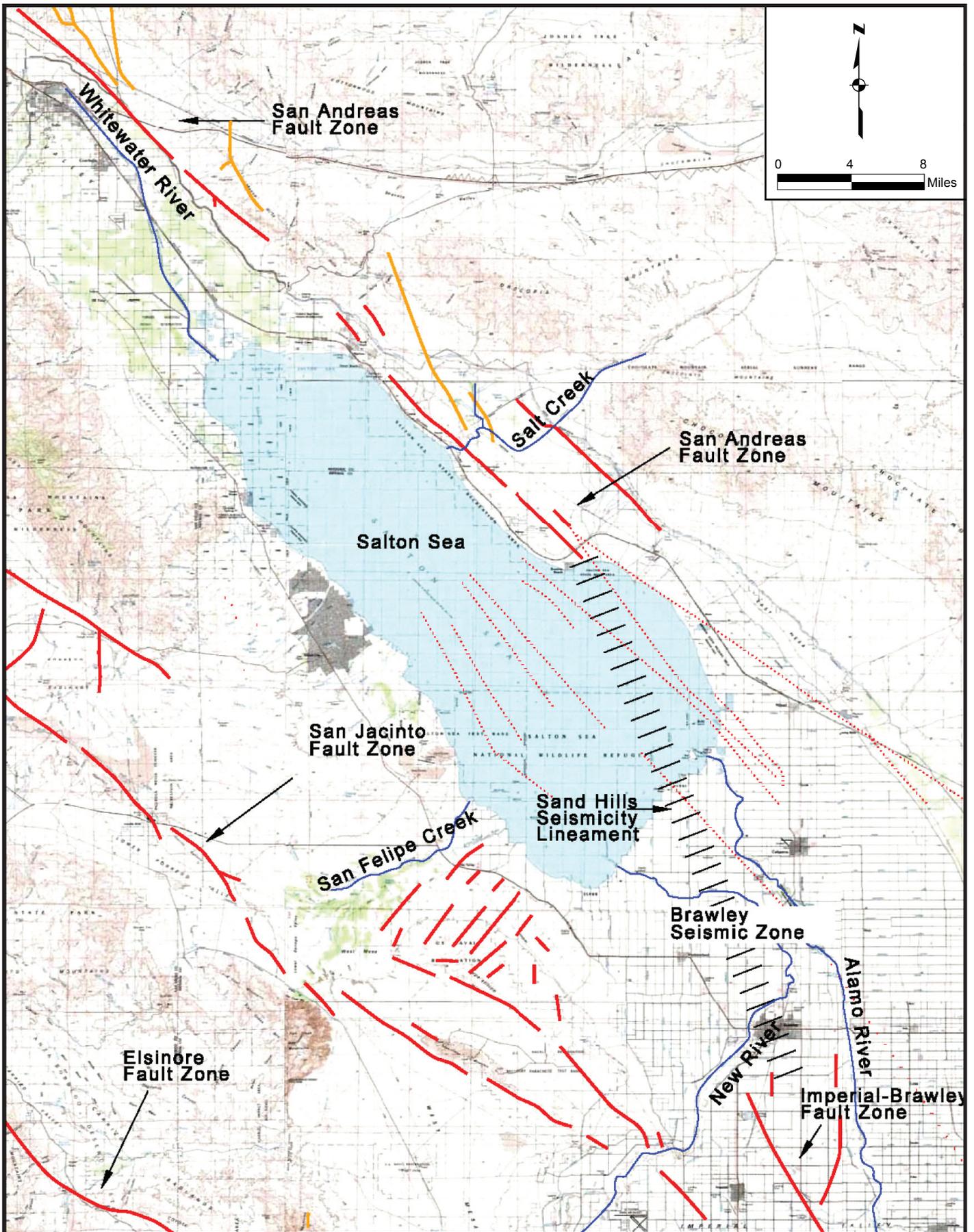
The oldest exposed rocks in the region surrounding the Salton Trough are Precambrian gneisses, anorthosites, and schists, as shown in Table 9-1. These rocks are in turn intruded by younger Paleozoic to Cenozoic plutonic rocks. The sediments within the Salton Trough range in age from Miocene to Holocene. The Salton Trough is a large structural depression that has filled with about 19,500 feet or 3.7 miles of sediment since the late Cenozoic.

**Table 9-1  
 Geologic Time Scale**

| Eon         | Era         | Period        | Epoch         | Age in Million Years Before Present |            |
|-------------|-------------|---------------|---------------|-------------------------------------|------------|
| Phanerozoic | Cenozoic    | Quaternary    |               | Recent (Holocene)                   | 0 to 0.01  |
|             |             |               |               | Pleistocene                         | 0.01 to 2  |
|             |             | Neogene       | Tertiary      | Pliocene                            | 2 to 5     |
|             |             |               |               | Miocene                             | 5 to 24    |
|             |             | Paleogene     |               | Oligocene                           | 24 to 37   |
|             |             |               |               | Eocene                              | 37 to 58   |
|             |             |               |               | Paleocene                           | 58 to 66   |
|             | Mesozoic    | Cretaceous    |               |                                     | 66 to 144  |
|             |             | Jurassic      |               |                                     | 144 to 208 |
|             |             | Triassic      |               |                                     | 208 to 245 |
|             | Paleozoic   | Permian       |               |                                     | 245 to 286 |
|             |             | Carboniferous | Pennsylvanian |                                     | 286 to 320 |
|             |             |               | Mississippian |                                     | 320 to 360 |
|             |             | Devonian      |               |                                     | 360 to 408 |
|             |             | Silurian      |               |                                     | 408 to 438 |
| Ordovician  |             |               | 438 to 505    |                                     |            |
| Cambrian    |             |               | 505 to 570    |                                     |            |
| Precambrian | Proterozoic |               |               | 570 to 2,500                        |            |
|             | Archean     |               |               | 2,500 to 3,800                      |            |
|             | Pre-Archean |               |               | 3,800 to 4,600                      |            |

The oldest sediments are coarse clastic sediments derived from the surrounding crystalline rocks. These deposits are overlain by essentially continuous deposits of volcanics, lacustrine, evaporites, marine, fluvial and deltaic sediments. The greatest source of sediment is from the Colorado River.

The only marine formation, the Imperial Formation, was deposited during a marine incursion that occurred not long after the initiation of the opening of the Gulf of California about 5,000,000 years ago. Discontinuous outcrops of the formation are found from just south of the international border to San Geronio Pass. This formation may be as old as late Miocene but is generally considered to be Pliocene. The marine rocks at the northern end of the formation are thought to be Miocene and may not be correlative with the marine rocks found to the south. These rocks may predate the opening of the Gulf of California and represent a proto-Gulf (McDougal et al., 1999).



**FIGURE 9-1  
MAJOR GEOLOGIC AND SEISMIC  
FEATURES IN THE SALTON BASIN**

Source: DWR, 1999

## Geologic History

The Salton Trough is located in a tectonically complex area. Prior to the formation of the present-day Salton Trough, the region was landward of a back arc resulting from the subduction of the Farallon plate beneath the North American plate (McKibben, 1993). Volcanics formed during this time are found today in the highlands that define the present day rift zone (Hulen et al, 2000), as well as Precambrian metamorphics. Units exposed in the mountain ranges near the Salton Trough include the San Gorgonio complex, the Chuckwalla complex, and the Orocopia schist (DWR, 1964).

Deposition of early Tertiary sedimentary units occurred in the region prior to the opening of the present day rift basin. These units are consolidated and primarily non-marine in origin. Major units include the Coachella fanglomerate and the Hathaway, Imperial, and Mecca formations. Interlayered with some of the sedimentary units, such as the Coachella fanglomerate, may be intervals of basalt (DWR, 1964), probably originating from the volcanism associated with the back arc setting.

The Imperial Formation is the only major marine sedimentary unit exposed in the Salton Trough and preserves the occurrence of the proto-Gulf of California (Deméré, 2004). It is up to 3,700 feet thick (Morton, 1977) and was deposited 5,000,000 to 7,000,000 years ago (Deméré, 2004).

The rift basin that occurs today from the San Gorgonio Pass south into the Gulf of California formed about 4,000,000 years ago (Hulen et al, 2000). It is bounded on both sides by a series of fault zones. The downward movement of the land between the fault zones and the subsequent infilling of the trough has resulted in a thick sequence of highly variable sediments. Once the rift basin formed, sediments were deposited originating from the Colorado River, which has flowed both south (its current course) and north into the rift valley (McKibben, 1993), as well as from alluvial material eroded from the surrounding mountain ranges (DWR, 1964). As a result of this periodic inundation of the rift valley and subsequent evaporation of the lakes, lacustrine (lake) evaporites (deposits) are the dominant sediment type in the northern portion of the Salton Trough (McKibben, 1993). Downward percolation of water through these saline units has resulted in the occurrence of rift basinal brines, which characterize the Salton Sea and Brawley geothermal systems (McKibben, 1993).

Most recent geologic units are lacustrine and alluvial sediments originating from the uplands adjacent to the rift basin. Wind action frequently influences surficial units, often resulting in dunes such as the Sand Hills, a 40-mile-long by 5-mile-wide series of wind blown deposits extending along the east side of the Coachella Canal from the United States-Mexico border (IID and Reclamation, 2002a) and the Tule Wash barchan dune located west of the Salton Sea.

Lake Cahuilla is a collective name representing the numerous times the Salton Trough has been flooded by water from the Colorado River. The Colorado River has drained the interior of the North American plate since before the formation of the current rift zone. Because of the natural deposition of sediments at the delta that formed where the Colorado River enters the rift zone, thick accumulations of sediments near the upper zones of the delta could result in the river changing course. When this happened, the river would flow into the rift valley until the river again changed course. The occurrence of the deltaic sediments also prevents the Gulf of California from inundating the Salton Trough, which is below sea level.

The sedimentary record within the Salton Trough documents well the previous occurrences of Lake Cahuilla. Deposition of light-colored calcium carbonate along the cliffs of the present day valley show that the most recent shoreline was about 40 feet above sea level (Mendenhall, 1909). Anthropologic, geologic, and fresh water mollusk data indicate that Lake Cahuilla first appeared about 700 and occupied the basin until about 300 years ago (Salton Sea Authority, 2006). At its largest, the lake is estimated to have been six times the size of the current Salton Sea - 100 miles long and 35 miles across. Although Salton Sink was a dry lake bed when Europeans first explored the valley in 1774, the Colorado River is

known to have flooded the area at least eight times between 1824 and 1904 resulting in earlier versions of the Salton Sea (Salton Sea Authority, 2006).

## Faults

There are three main fault zones (San Andreas, San Jacinto, and Elsinore) in the Salton Sea Trough. The Coachella Segment of the San Andreas Fault forms the northeastern boundary of the Salton Trough. The fault is evident on the ground surface from north of the Salton Sea to just north of Bombay Beach located on the east shore of the Salton Sea, but is not evident on the ground surface to the southeast of the Salton Sea. The latest break on this segment is likely greater than 300 years ago (Sieh and Williams, 1990). With an estimated accumulated strain of about 25 millimeters/year, there is a possibility that this segment could produce an earthquake with a magnitude of about 7.5 or larger with over twenty feet of offset. The San Jacinto Fault Zone is located just to the west of the Salton Sea and is comprised of a complex system of faults including the San Jacinto, San Felipe Hills, Santa Rosa, San Felipe, Superstition Hills, Superstition Mountain, Coyote Creek, and the Imperial (Morton, 1977). The Imperial Valley, located just south of the Salton Sea, is one of the most seismically active regions in Southern California. The Imperial Fault produced a magnitude 6.9 earthquake in 1940. The Elsinore Fault Zone is located west of the San Jacinto Fault Zone and borders the southwest face of the Coyote Mountains. These fault zones are discussed in more detail below and shown on Figure 9-1.

### San Andreas Fault

The San Andreas Fault enters the Salton Trough at the northwest end of the Coachella Valley. This fault system constitutes the main structural boundary between the Pacific and North American plates. Today, the San Andreas Fault Zone is traceable from the Gulf of California northward to Shelter Cove Coast in Humboldt County. Regionally, it is traceable from the town of Niland east of the Salton Sea northward through San Geronimo Pass. The fault zone continues southward into Mexico as the Sand Hills and Algodones Fault. The San Andreas Fault is right-lateral with an approximate offset of 200 miles. The offset in Southern California is estimated to have begun in the late Miocene and early Pliocene (5,000,000 to 10,000,000 years ago) (Van Gilder, 2000).

### San Jacinto Fault Zone

The San Jacinto Fault Zone is a major strand of the San Andreas Fault System. It extends southeastward from Cajon Pass as a series of splays into the Salton Trough.

The San Jacinto Fault is an extremely active system. Right lateral displacement on the San Jacinto Fault Zone is about 19 miles. Vertical separations along the zone exceed 8,000 feet in the Santa Rosa Mountains. The San Jacinto Fault is thought to be Plio-Pleistocene based on vertebrate and plant remains but may be younger than 1,000,000 years as indicated by lateral offset of the late Pleistocene Ocotillo Conglomerate (Van Gilder, 2000).

### Elsinore Fault Zone

The Elsinore Fault Zone extends from the northern Peninsular Range southward to the Gulf of California. The fault zone is parallel and west of the San Jacinto Fault Zone. Right lateral displacement along the main fault trace is about 30 miles. Vertical displacement and relief features along this fault reach as much as 9,000 feet. The Elsinore Fault Zone is considered to be older than the San Jacinto Fault, between 1,800,000 and 2,700,000 years ago (Van Gilder, 2000).

### Brawley Seismic Zone

The Brawley Seismic Zone is comprised of the Imperial-Brawley fault system and is a zone of high seismicity extending from the northern reach of the Imperial Fault northwest into the Salton Sea. This

zone is marked by parallel or near-parallel, closely-spaced, step-like, right-lateral faults that trend northwest and are linked by conjugate left-lateral structures (Larson and Reilinger, 1991). The Sand Hills Seismicity Lineament extends southeast from the southern tip of the San Andreas Fault within this seismic zone and may represent the southern extension of the San Andreas Fault.

## Historical Earthquakes

The Imperial Valley portion of the Salton Trough has had more small to moderate earthquakes than any other portion of the San Andreas Fault system (Hill et al, 1975). In addition to these smaller earthquakes, nine earthquakes with magnitudes of 6.0 or greater have occurred along the San Jacinto Fault and three of greater than 6.0 have occurred along the Imperial Fault between 1890 and 1972 (Hill et al, 1975). Two additional earthquakes with magnitudes greater than 6.0 have occurred since 1972. One was on the Imperial Fault (magnitude 6.5, 1979) and the other was on the Superstition Hill Fault (magnitude 6.6 in 1987) (McKibben, 1993). Two strong earthquakes (both magnitude 7.1) have been recorded on the Cerro Prieto Fault in the Mexicali Valley. These earthquakes occurred in 1915 and 1934. Although earthquakes also occur in the Coachella Valley, the northern portion of the Salton Trough is less active seismically than the southern portion (Salton Sea Authority and Reclamation, 2000). Figure 9-2 shows the earthquakes of magnitude 2.0 or greater within 50 miles of the middle of the Salton Sea. Figure 9-3 shows the earthquakes of magnitude 4.0 or greater within 50 miles of the middle of the Salton Sea.

## Soils

### Soils Adjacent to the Salton Sea

Soil units within the Salton Trough have formed on fine-grained sediments associated with the occurrence of Lake Cahuilla and alluvial fans from the adjacent highlands. A wide range of desert and alluvial soil types are present, including well-drained sands to silty clay loams in the area adjacent to the Salton Sea (IID and Reclamation, 2002a; DOE and BLM, 2004). The general location of different soil types is provided in Figure 9-4.

### In-Sea Soils

In-Sea soils consist of soils derived from lacustrine (lake) evaporites (deposits). These soils are summarized below and described in detail in the *Preliminary In-Sea Geotechnical Investigation, Salton Sea Restoration Project Report* (URS, 2004). The summary descriptions provided below are based on this report:

- **Sea Floor Deposits** – The first layer, Salton Sea Floor Deposits, is composed of recently deposited, very soft to loose, highly plastic clays to silty fine sands. The thickness of this layer ranges from zero to 21 feet with the greatest thickness occurring in the southern and mid-Sea areas;
- **Soft Lacustrine Deposits** – The Soft Lacustrine Deposits were found to underlie the seafloor deposits over much of the Salton Sea’s area. These materials consist of highly plastic, soft to very soft clays ranging in thickness from zero to 26 feet. The thickest deposits were found in the Whitewater River delta and the mid-Sea’s easterly area;
- **Upper Alluvial Deposits** – The Upper Alluvial Deposits are interspaced between the Soft and Stiff Lacustrine Deposits and are predominant near the Salton Sea’s perimeter. These deposits are described as composed of loose to dense silty fine sands with interbedded silt and sand lenses ranging in thickness from zero to 26 feet. The thickest deposits were found in northeast, southwest, and west-central margins of the Salton Sea;
- **Upper Stiff Lacustrine Deposits** – The Upper Stiff Lacustrine Deposits underlying both the Soft Lacustrine and Upper Alluvial Deposits, are comprised of predominantly stiff to very stiff, highly

plastic clays ranging in thickness from four to 31 feet. The thickest deposits were found in the mid-Sea's eastern and southeastern areas, the latter near the Alamo River delta;

- **Lower Alluvial Deposits** – The Lower Alluvial Deposits are similar to the Upper Alluvial Deposits except that their density is greater, ranging in consistency from medium dense to dense. These deposits were predominant in the southern area of the Salton Sea, ranging from zero to 22 feet in thickness; and
- **Lower Stiff Lacustrine Deposits** – The Lower Stiff Lacustrine Deposits likely underlies the entire Salton Sea having a thickness much greater than 100 feet. This layer is primarily hard plastic clay.

## Mineral Resources

Minerals found throughout Imperial County include gold, gypsum, sand, gravel, lime, clay, and stone. These resources are extracted through commercial enterprises (County of Imperial, 1993a). Industrial materials are also extracted commercially, including kyanite, mineral fillers (clay, limestone, sericite, mica, and tuff), salt, potash, calcium chloride, manganese, and sand. A variety of mining/reclamation areas exist in the Imperial County portion of the study area, primarily near the Coachella and East Highline canals (County of Imperial, 1993a).

Riverside County has extensive deposits of clay, limestone, iron, sand, and aggregates (County of Riverside, 2003a). Many mining/reclamation areas exist in the Riverside County portion of the study area.

## Geologic Hazards

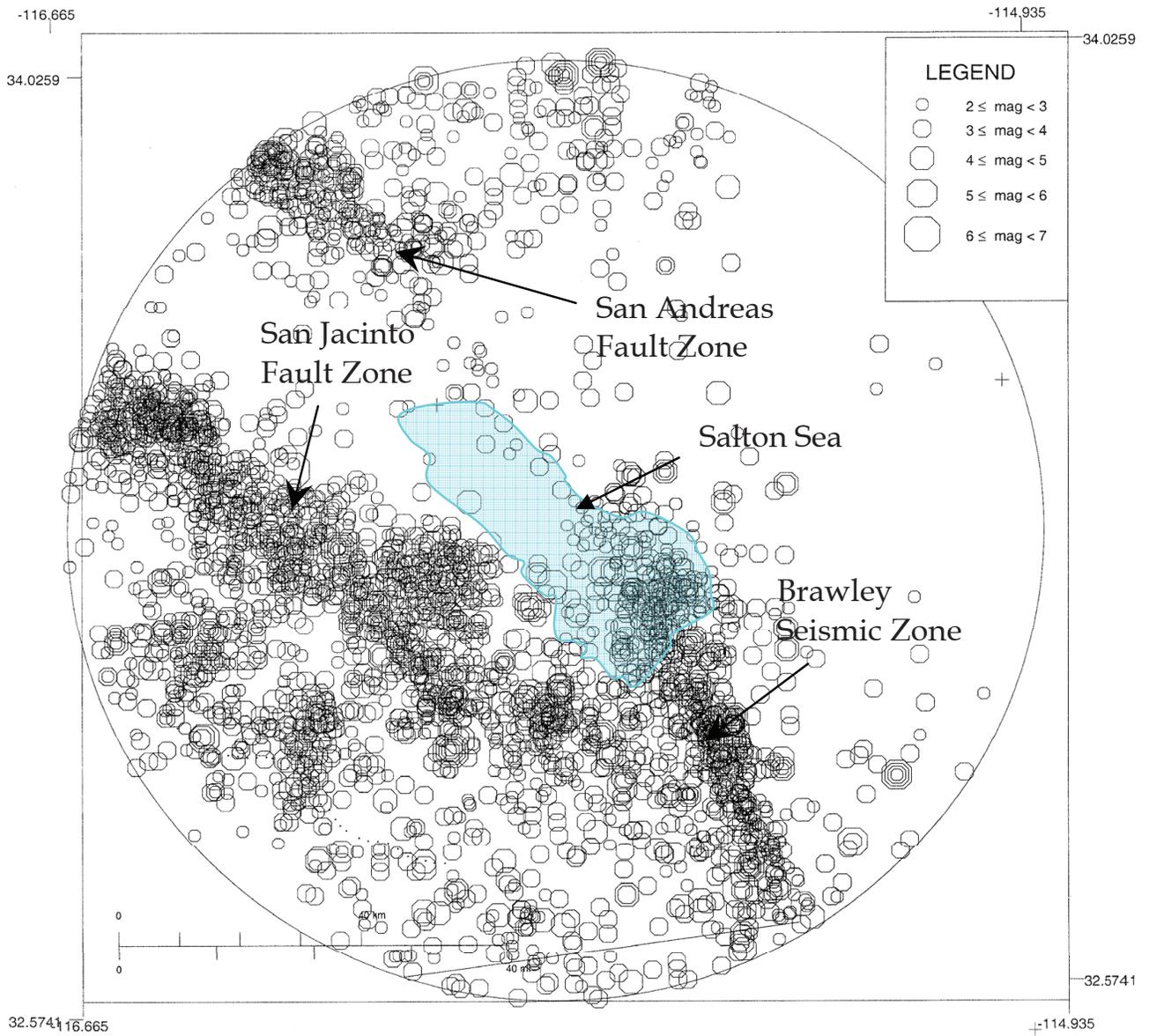
Geologic hazards that may occur in the Salton Trough include: potential for earthquake rupture or shaking (discussed under “Faults” above), subsidence as a result of groundwater overdraft, liquefaction of loose saturated soils during earthquakes, landslides in areas of steep topography, lateral spreading, seiches, and volcanic hazards.

### Subsidence

Subsidence can occur when pore pressure within a groundwater system is reduced (usually as a result of groundwater extraction) to the point that the aquifer framework compresses. This is more common in systems where finer-grained sediments such as clay or silt dominate the aquifer framework. Subsidence can also occur as a result of tectonic activity or reservoir loading.

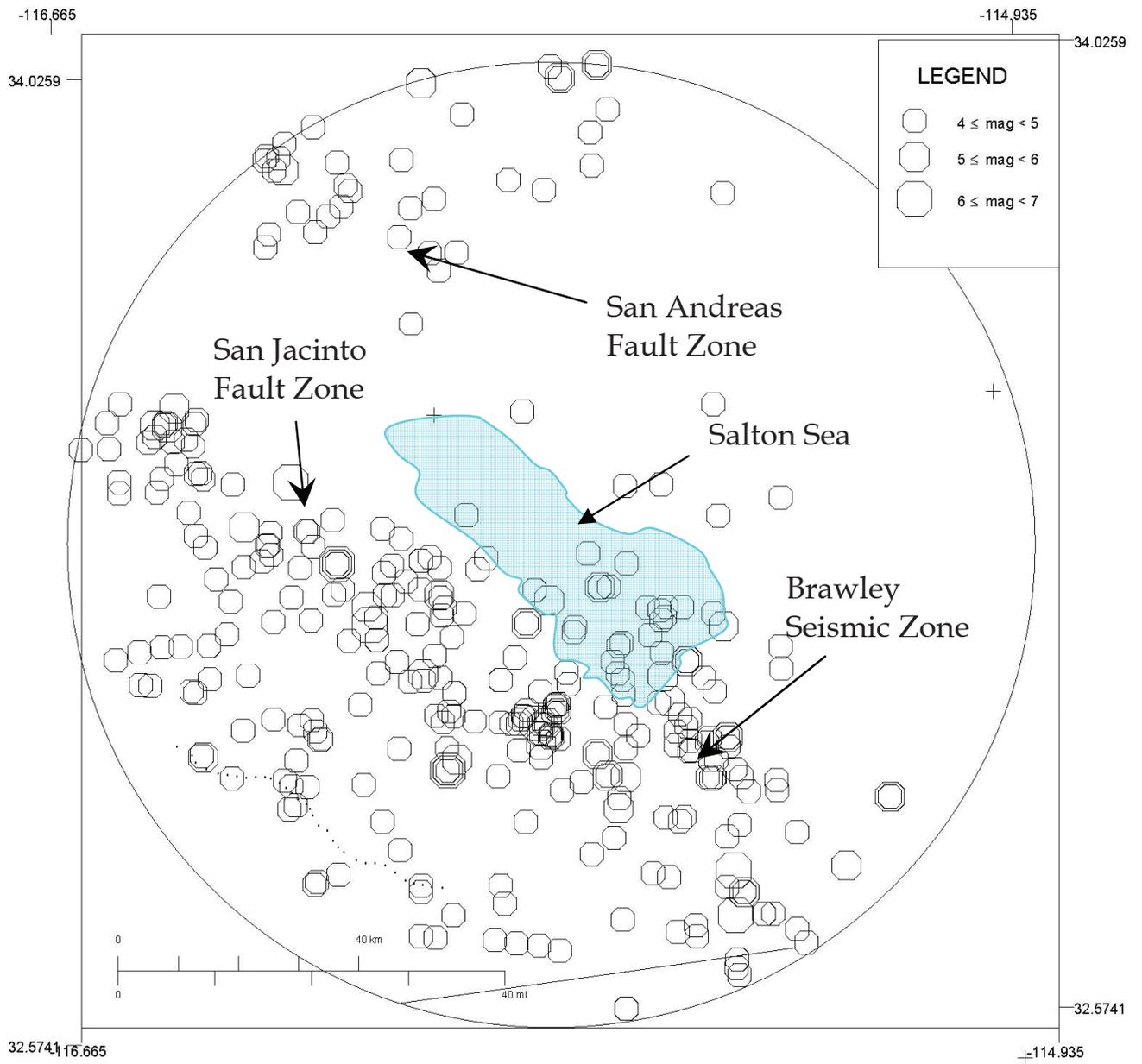
Recent subsidence investigations in the Coachella Valley (Ikehara et al, 1997; Sneed et al, 2001) have focused on the southern portion of the valley near the Salton Sea. Increased groundwater pumping to meet increasing water demands makes the area susceptible to subsidence. Subsidence of up to 0.5 feet has occurred for the period 1928 to 1996 (Ikehara et al, 1997). Additional subsidence of up to 0.13 feet may have occurred between 1996 and 1998 (Sneed et al, 2001).

Recent investigations in the Imperial Valley evaluated potential subsidence due to geothermal energy generation activities along the southern Salton Sea shoreline. These studies determined that subsidence was not occurring in this area because the water was being reinjected following energy generation (CalEnergy, 2003).



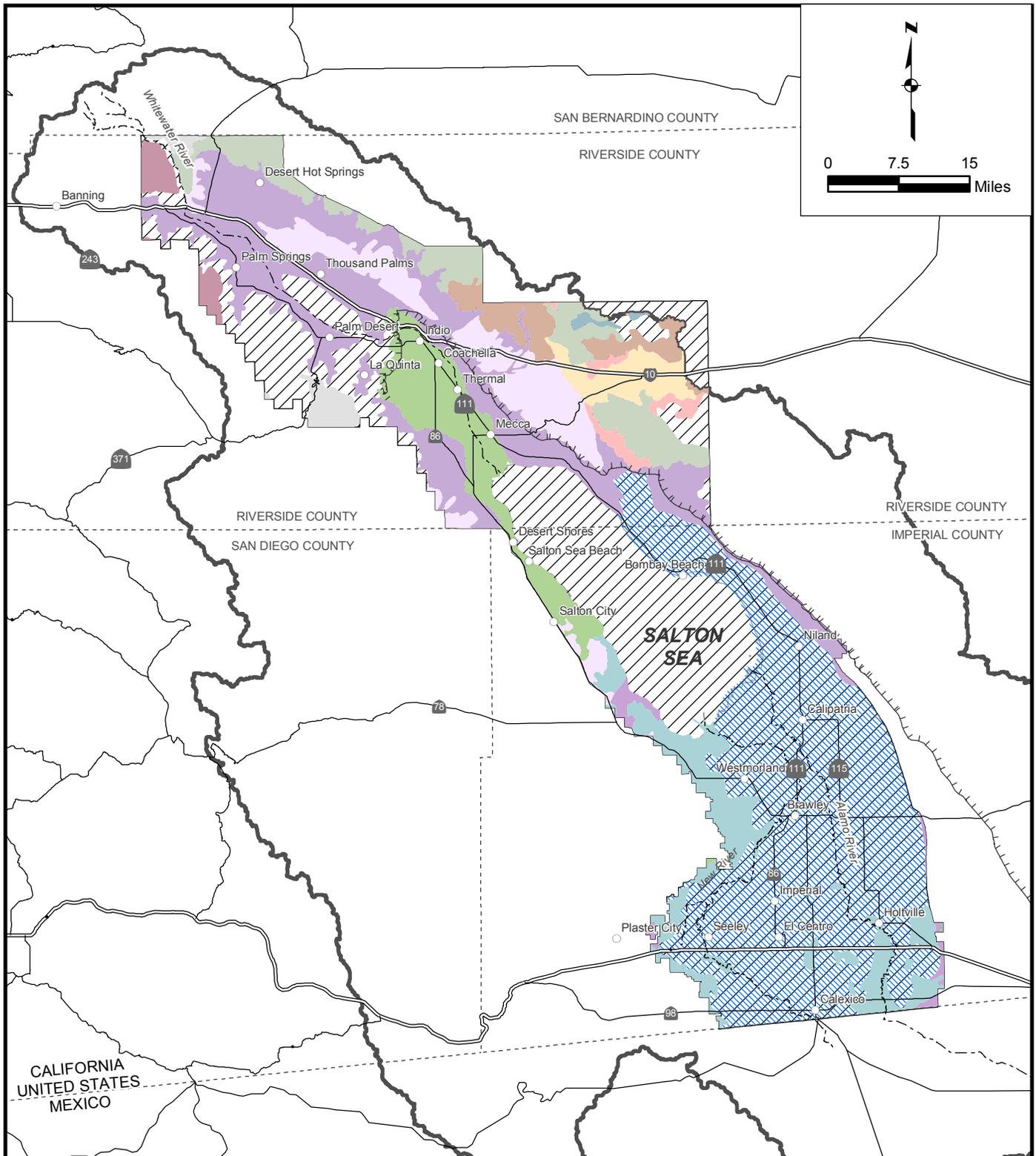
**FIGURE 9-2  
EARTHQUAKES OF MAGNITUDE 2.0  
OR GREATER WITHIN 50 MILES OF  
THE SALTON SEA**

Source: DWR, 1999



**FIGURE 9-3  
EARTHQUAKES OF MAGNITUDE 4.0  
OR GREATER WITHIN 50 MILES OF  
THE SALTON SEA**

Source: DWR, 1999



**LEGEND**

|                                      |                                      |
|--------------------------------------|--------------------------------------|
| Study Area                           | Gilman-Indio-Coachella               |
| Salton Sea Watershed                 | Gunsight-Rillito-Chuckwalla          |
| Salton Sea                           | Imperial-Glenbar-Gilman              |
| Towns and Cities                     | Meloland-Vint-Indio                  |
| County Boundary                      | Rock Outcrop-Lithic Torriorthents-Ca |
| Badland-Beeline-Rillito              | Rock Outcrop-Tecopa-Lithic Torriorth |
| Carrizo-Rositas-Gunsight             | Rositas-Carrizo-Orita                |
| Carsitas-Myoma-Carrizo               | Rositas-Carsitas-Dune Land           |
| Cherioni-Hyder-Cipriano              | Sheephead-Rock Outcrop-Bancas        |
| Etsel Family-Rock Outcrop-Springdale |                                      |

**FIGURE 9-4  
SOIL ASSOCIATIONS IN  
THE STUDY AREA**

Source: Reclamation, 2003

## **Liquefaction**

Liquefaction may occur when shallow (less than 50 feet below grade), saturated, unconsolidated material is subjected to shaking. The shaking causes pore water pressure to increase, the material to lose its structural integrity, and behave as a liquid (Bausch and Brumbaugh, 1996). It commonly occurs where shallow groundwater occurs, near surface water bodies, or in filled areas. Shallow groundwater occurs in extensive areas of the Salton Trough, and liquefaction is considered to be a hazard in both the Imperial (IID and Reclamation, 2002a) and Coachella valleys (Salton Sea Authority and Reclamation, 2000).

## **Landslides**

Landslides most commonly occur in areas of and adjacent to steep slopes. They may often be triggered by earthquakes. Within the Salton Trough region, landslide potential is greatest along the margins of the valleys. It could also occur on a minor scale along embankments that often occur along canals. Because of the broad, low-lying character of the study area, landslide potential throughout the area is low.

## **Lateral Spreading**

Lateral spreading is the separating or rupturing of the ground surface as a result of strong ground shaking. Lateral spreading commonly occurs along drainage banks, cliffs, or other areas with steep or nearly vertical slopes, where generally loose sediments collapse due to lack of lateral support. Lateral spreading does not necessarily take place along an active fault, but rather is generally associated with liquefaction caused by seismically induced ground shaking. Within the study area, lateral spreading is most likely to occur along river, creek, and drain banks. The potential for lateral spreading to occur along the steep channel slopes of the New and Alamo Rivers in the more southern portions of the study area is moderate to high. However, the potential for lateral spreading to occur in areas near the Salton Sea is relatively low as the rivers, creeks and drains tend to have generally gentle to moderately sloping banks near the Salton Sea.

## **Seiches**

Seiches are large waves in lakes produced by either wind or seismic activity. Although there are no documented occurrences of seiches at the Salton Sea, due to the shallowness of the Salton Sea and the seismic activity in the area, there is the potential for a seiche to occur (Salton Sea Authority, 2004).

## **Volcanic Hazards**

Volcanoes, rhyolite domes, geothermal fields, mud pots, and hot springs are indicators that volcanism exists in the Salton Trough. These features are located primarily in the Mexicali and Imperial valleys.

### ***Volcanoes, Mud Volcanoes, and Mud Pots***

The Cerro Prieto volcano is located southeast of Mexicali, near the Cerro Prieto Fault and the Cerro Prieto geothermal field. The volcano is a prominent feature in the area, but is not related to the geothermal field, (Quijano-Léon and Gutiérrez-Negrín, 2003). The volcano last erupted between 10,000 and 100,000 years ago (Smithsonian, 2004). Mud pots, mud volcanoes, geysers, and fumaroles also occur near the Cerro Prieto volcano. An active geyser occurred in the area for several months as recently as 1991 (San Diego Association of Geologists, 2004).

Mud pots and mud volcanoes are located southeast of the Salton Sea near Niland. The mud volcanoes that occur in this area are 3 to 6 feet in height and up to 10 feet wide. The mud pots are smaller than the mud volcanoes (no more than a couple of feet high or wide). The mud in the mud volcanoes is generally hotter than in the mud pots. Anecdotal observations from local residents report variations in carbon dioxide and temperature variation that may be controlled by seasonal changes or earthquake activity.

### ***Holocene Rhyolite Domes***

Extrusive rhyolite domes are located near the mud pots along the southern edge of the Salton Sea. Obsidian Butte is the largest and southernmost rhyolite dome and is estimated to be between 2400 and 8500 years old. It is located on the shoreline of the Salton Sea and is composed of rhyolite, obsidian, and pumice. Ancestral shorelines of Lake Cahuilla can be observed at Obsidian Butte. The other domes are located at Rock Hill, Red Island, and Mullet Island (Hunter, 1998a).

### ***Hot Springs***

Hot springs are located in several areas throughout the Salton Trough. They are often associated with the spreading centers of major regional faults.

One prominent area of hot springs occurs to the east of Bombay Beach, on the eastern shore of the Salton Sea. The area is referred to as the Hot Mineral Spa Geothermal Resource Area. Numerous wells have been drilled in the area, several of which exhibit artesian flow. Water produced at these wells is from a common source, are meteoric, and are produced from a narrow band of sediments located between the crystalline bedrock of the Chocolate Mountains and the Hot Spring Fault (Hunter, 1998b).

Hot springs occur throughout the region, including near Jacumba, Holtville, Canon de Guadalupe, and the City of Desert Hot Springs (Boardman, 1998).

## **ENVIRONMENTAL IMPACTS**

### **Analysis Methodology**

The impact assessment methodology used to support the geology and soils analysis presented in this chapter is based on the proximity of active faults, frequency and types of seismic events, existing ground acceleration data and models, and the type of existing soils. In addition, the susceptibility and/or contribution of the alternatives to geologic hazards are described in terms of their potential impact on the public or geological resources.

### **Measuring Seismic Hazards**

Earthquakes are normally classified as to severity according to their magnitude. Magnitude is usually classified using the Richter scale, a logarithmic scale used to measure the maximum motions of the seismic waves as recorded by a seismograph. A magnitude 8 (Richter) earthquake is not twice as large as a magnitude 4 earthquake; it is 10,000 (i.e.,  $10^4$ ) times larger.

Peak ground acceleration (PGA) is a measure of earthquake acceleration. Unlike the Richter magnitude scale, it is not a measure of the total size of the earthquake, but rather how hard the earth shakes in a given geographic area. PGA can be measured in terms of gravity (the acceleration due to gravity) or in meters/second squared.

The level of destruction of an earthquake at a particular location is commonly reported using a seismic intensity scale. Based on reports of ground shaking and damage caused by past earthquakes, seismic intensities are subjective classifications. The commonly used Modified Mercalli Intensity scale has 12 levels of intensity; the higher the number, the greater the ground-shaking intensity and/or damage. Earthquakes have only one magnitude, but they have variable intensities that generally decrease with increasing distance from the source. Additionally, other factors, such as building type, shallow groundwater, and local geology, affect the intensities of earthquakes at a location.

### **California Department of Water Resources, Division of Safety of Dams**

Some of the alternatives include structures that would fall under the jurisdiction of the DSOD. The DSOD uses several criteria when evaluating new and existing dams, including probabilistic and deterministic

seismic hazard analyses. A probabilistic seismic hazard analysis takes into consideration the uncertainties in the size and location of earthquakes and the resulting ground motions that can affect a particular site. A deterministic seismic hazard analysis identifies nearby faults and assesses their activity. For each seismic source, an earthquake scenario consisting of the maximum magnitude a fault is capable of generating at the closest distance to the site under consideration is specified as the basis for the ground motion estimate (DSOD, 2001).

The DSOD guidelines suggest that the 50th and 84th percentile of both PGA and spectral accelerations be determined as a function of magnitude, distance, fault type, and site condition. Directivity effects, which typically result in the amplification of long period energy generally in directions perpendicular to the fault rupture plane, are also evaluated.

To aid in the determination of the appropriate statistical level of ground motion to use, DSOD has developed a Consequence-Hazard Matrix, as shown in Table 9-2. This matrix considers the consequence of a dam failure and the likelihood of an earthquake. The slip rate of the causative fault is used to determine the likelihood of an earthquake, while an assessment of potential damage is used to assess the consequence of dam failure (DSOD, 2002).

**Table 9-2**  
**Division of Safety of Dams Consequence-Hazard Matrix**

|   | <b>Very High Slip Rate<br/>(Greater than or<br/>equal to 9 mm/yr)</b> | <b>High Slip Rate<br/>(8.9-1.1 mm/yr)</b> | <b>Moderate Slip Rate<br/>(1.0-0.1 mm/yr)</b> | <b>Low Slip Rate<br/>(Less than<br/>0.1 mm/yr)</b> |
|---|---|---|---|--|
| Extreme Consequence<br>Total Class Weight 31-36 | 84th  | 84th                                      | 84th  | 50th to 84th                                       |
| High Consequence<br>Total Class Weight 19-30    | 84th  | 84th                                      | 50th to 84th                                  | 50th to 84th                                       |
| Moderate Consequence<br>Total Class Weight 7-18 | 84th  | 50th to 84th                              | 50th to 84th                                  | 50th   |
| Low Consequence<br>Total Class Weight 0-6       | 50th  | 50th                                      | 50th  | 50th   |

Source: DSOD, 2002

Note: Matrix used to determine the appropriate statistical level of acceleration for deterministic hazard analysis.

For the purposes of the PEIR, it is assumed that the Hazard Classification for jurisdictional barriers within the Salton Sea would constitute a hazard of “Moderate Consequence,” as described in Appendix H-4. This classification, in conjunction with a “High Slip Rate” for Coachella Segment of the San Andreas Fault, suggests a 50th to 84th percentile level of acceleration.

The Department of Water Resources (DWR) conducted both a probabilistic and deterministic seismic hazard analyses in compliance with the DSOD guidelines, as described in Appendix H-4.

### ***Deterministic Seismic Hazard Analysis***

DWR conducted a Deterministic Seismic Hazard Analysis using the Coachella Segment of the San Andreas Fault with the assumption of a multiple segment rupture because of its proximity to any location within the Salton Sea and its potential for about a magnitude 7.5 to magnitude 7.8 earthquake. For the analysis, the weighted average of PGA from the three attenuation relationships was determined for specific areas on the eastern shore, the western shore, and the middle of the Salton Sea. The attenuation relationships used come from Seismological Research Letters (SRL) and include several researchers: Abrahamson and Silva (1997); Boore, Joyner, and Fumal (1997); and Sadigh et al. (1997). A magnitude 7.8 event on the San Andreas Fault was used as the seismic source for all three areas. The results for the PGAs for the Deterministic Seismic Hazard Analysis for a magnitude 7.8 earthquake on the southern San Andreas Fault are provided in Table 9-3.

**Table 9-3  
Deterministic Seismic Hazard Peak Ground Accelerations for a Magnitude 7.8 Earthquake  
on the Southern San Andreas Fault**

| Location                                    | Source      | Distance<br>(miles) | Peak Ground Acceleration<br>(as a measure of gravity) |      |         |
|---|-------------|---------------------|---|------|---------|
|   |             |                     | 50th  | 84th | Average |
| Western Shore about<br>middle of Salton Sea | San Andreas | 10.7                | 0.29  | 0.45 | 0.37    |
| Middle of Salton Sea                        | San Andreas | 6.3                 | 0.39  | 0.61 | 0.5     |
| Eastern Shore about<br>middle of Salton Sea | San Andreas | 2                   | 0.57  | 0.9  | 0.74    |

***Probabilistic Seismic Hazard Analysis***

A Probabilistic Seismic Hazard Analysis was conducted using the USGS National Seismic Hazard Mapping Project Website. The calculations from the USGS website assume a uniform site condition of firm rock. To account for the soft lacustrine and alluvial deposits, the CGS Probabilistic Seismic Hazards Mapping Ground Motion Website uses soil corrections to determine the PGA for alluvial sites. The PGA was determined for the same three sites using the USGS website for firm rock and the CGS website for alluvium and for about a 475 year return period (10 percent probability of exceedance in 50 years). The results for the PGAs for the Probabilistic Seismic Hazard Analysis are provided in Table 9-4.

**Table 9-4  
Probabilistic Seismic Hazard Peak Ground Accelerations for about a 475-Year Return Period**

| Location                                    | Annual Exceedence<br>Rate (%) | Mean Return<br>Time<br>(years) | Firm Rock PGA<br>(as a measure of<br>gravity) | Alluvium PGA<br>(as a measure of<br>gravity) <sup>a</sup> |
|---|-------------------------------|--------------------------------|---|---|
| Western Shore about<br>middle of Salton Sea | 2.1                           | 475                            | 0.43  | 0.46  |
| Middle of Salton Sea                        | 1.6                           |                                | 0.61  | 0.53 <sup>b</sup>   |
| Eastern Shore about<br>middle of Salton Sea | 2.1                           |                                | 0.78  | 0.7 <sup>b</sup>  |

Notes:

<sup>a</sup> Alluvium PGA based on the CGS Probabilistic Seismic Hazards Mapping Ground Motion soil corrections to determine the PGA for alluvial sites

<sup>b</sup> Selected seismicity units not used in the analysis, resulting in a lower PGA. See Appendix H-4 for more information.

A comparison of probabilistically and deterministically determined PGAs corrected for alluvium is shown in the Table 9-5. The deterministically determined accelerations are based on DSOD guidelines which suggest an averaging of the 50th and 84th percentile. Except for the eastern shore, the deterministic values are slightly lower than the probabilistically determined accelerations and correspond to return periods ranging from about 300 to 500 years. This information was used in development of the alternatives and associated cost estimates as described in Appendix H-7.

**Table 9-5  
Comparisons of Peak Ground Accelerations**

|  | <b>Probabilistic PGA with a<br/>475 Year Return Period<br/>(as a measure of gravity)</b> | <b>Deterministic PGA, 50th and<br/>80th Average<br/>(as a measure of gravity)</b> |
|--|--|---|
| Western Shore about middle of Salton Sea | 0.46   | 0.37  |
| Middle of Salton Sea                     | 0.53   | 0.50  |
| Eastern Shore about middle of Salton Sea | 0.7  | 0.74  |

## Significance Criteria

The following significance criteria were based on CEQA and air quality regulatory agency guidance and used to determine if changes as compared to Existing Conditions and the No Action Alternative would:

- Expose people, property, or structures to potential substantial adverse impacts, including the risk of loss, injury, or death involving:
  - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault;
  - Strong ground shaking;
  - Ground failure resulting from soil liquefaction, including loss of bearing capacity and flow failure of slopes; and
  - Landslides;
- Result in substantial soil erosion or the loss of topsoil;
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the alternatives, and potentially result in a landslide, lateral spreading, subsidence, liquefaction, or collapse; or be located on expansive or unstable soils, as defined in the Uniform Building Code, creating substantial risks to life or property; and
- Result in the substantial loss of availability of a known mineral resource that would be of value to the region and the residents of the state; or a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan.

## Application of Significance Criteria

Significance criteria have been applied to the alternatives considered in the PEIR. The following list summarizes the overall methodology in the application of the criteria to the alternatives:

- **Exposure of People to Risks Related to Fault Rupture, Seismic Shaking, and Seismic-Induced Ground Failure** – The primary risks to people would be associated with the failure of Barriers, Perimeter Dikes, and Berms during a seismic event. These facilities would contain large amounts of water that could flood lands located at lower elevations within the Sea Bed. Rockfill structures such as Barriers and Perimeter Dikes are best able to accommodate seismically-induced displacements as well as displacements due to fault offsets in the foundation. Barriers and Perimeter Dikes would be designed and constructed in accordance with the DSOD requirements, as described above, and therefore, the risk would be limited to extreme seismic events;

- **Substantial Soil Erosion or Loss of Topsoil** – The alternatives do not include changes in streambeds or water flows in streams in the watershed. The primary risk related to soil erosion or loss of topsoil would occur on the currently inundated Sea Bed soils that would be exposed as the water recedes. Erosion would be caused by the wind which could generate dust. The potential for wind erosion and associated impacts to air quality are described in Chapter 10 and are not discussed in this chapter;
- **Exposure of People to Risks Related to Unstable Soils** – Specific locations of facilities and unstable soils in the Sea Bed or along the shoreline are not known at this time. However, it is assumed that there would be areas with liquefiable soils and expansive soils, subsidence, and volcanic hazards. The risks due to unstable soils would be to workers inside structures such as pumping plants or treatment plants during seismic events, as described above. The primary risk of unstable soils due to volcanic hazards would be to workers during construction in areas with unstable soils and hot water or soil materials that could be exposed during construction. It should be noted that the facilities would be designed by registered engineers to withstand design loading conditions.

Construction under all alternatives would be limited to the Sea Bed or shoreline areas that are not located near buildings. Therefore, the analysis in the PEIR does not include an evaluation of impacts on existing structures; and

- **Loss of Availability of a Known Mineral Resource or a Locally Important Mineral Resource Recovery Site** – The loss of mineral resources or sites would be related to three different areas in the implementation of the alternatives. Potential losses related to two areas are described in this chapter: 1) soil/bedrock mineral resources at the construction sites in the Sea Bed or along the shoreline, and 2) mineral resources used to construct facilities such as rock, gravel, sand, metal, wood, glass, or petroleum products. The third type of mineral resource, geothermal resources, is related to potential power generation and the associated impacts are described in Chapter 21.

### Summary of Assumptions

The assumptions related to the descriptions of the alternatives are described in Chapter 3. The specific assumptions related to the analysis of geology, soils, faults, seismicity, and mineral resources are summarized in Table 9-6.

**Table 9-6**  
**Summary of Assumptions for Geology, Soils, Faults, Seismicity, and Mineral Resources**

| <b>Assumptions Common to All Alternatives</b>   |                                      |
|---|--------------------------------------|
| 1. Public access within the Sea Bed would only be allowed in the Marine Sea, Shoreline Waterway, and Saline Habitat Complex.  |                                      |
| 2. All facilities would be constructed in accordance with applicable engineering standards and practices and in compliance with the California Building Code and any applicable federal, State, regional, and local standards. Registered engineers or geologists would design structures to withstand design loading conditions using project-level geotechnical data. |                                      |
| 3. Erosion from exposed soils on new roads, berms, staging, parking, storage areas, and other high-travel/use areas would be minimized using gravel, rock-slope protection, soil stabilizer, vegetation, or some other means as described in Chapters 3 and 10 of the PEIR.   |                                      |
| <b>Assumptions Specific to the Alternatives</b>   |                                      |
| No Action Alternative and Alternatives 1, 2, 3, 4, 5, 6, 7, and 8   | No additional assumptions were made. |

## **Summary of Impact Assessment**

The assumptions related to the descriptions of the alternatives are described in Chapter 3. The specific assumptions related to the analysis of geology, soils, faults, seismicity, and mineral resources are summarized in Table 9-7. The primary differences between the alternatives, as shown in the table, are related to the risk associated with water stored by Barriers and Perimeter Dikes, amounts of land disturbed, Sea Bed material used for construction, and imported material used for construction.

### **No Action Alternative**

As described in Chapter 3, this alternative would involve construction and operations and maintenance activities for the Sedimentation/Distribution Basins, Air Quality Management, Pupfish Channels, and Salton Sea. The construction activities would be identical under the No Action Alternative-CEQA Conditions and the No Action Alternative-Variability Conditions. Therefore, impacts related to disturbance would be the same for both conditions.

Risks that could occur to people in extreme seismic events would include potential structural failure of the Air Quality Management pumping plants. This failure could cause risk to workers in the pumping plants at the time of the event following construction. Risks also could occur to workers and others located at elevations below the Sedimentation/Distribution Basin should Berms fail during an extreme seismic event. Under extreme seismic events, displacement of conveyance facilities could occur; however, there would be little or no risk to workers or the public. These facilities would be constructed in accordance with State and local design criteria to withstand seismic events.

There could be risk to workers during construction in areas with unstable soils or volcanic activity. The risk would be reduced due to geological testing that would be conducted prior to or during facility design.

No soil/bedrock mineral resources were identified along the shoreline. Specific information related to mineral resources in the Sea Bed was not found during the preparation of the PEIR; however, mineral resources may be present. The disturbance of about 35,800 acres of land, and the use of 5,050,000 cubic yards of Sea Bed soils could result in loss of mineral resources in the Sea Bed.

Construction of facilities under the No Action Alternative would require the import of mineral resources, including 1,680,000 cubic yards of rock and gravel for erosion control on Sedimentation/Distribution Basins and roads. Petroleum products would be used for fuel, pipelines, and drip irrigation. Metal and glass resources would be used for pumping plants, filtration, and conveyance equipment. Loss of these resources would occur in Phases I through III.

### **Alternative 1 – Saline Habitat Complex I**

As described in Chapter 3, this alternative would involve construction and operations and maintenance activities for the Sedimentation/Distribution Basins, Air Quality Management, Pupfish Channels, Saline Habitat Complex, and Brine Sink.

Risks that could occur to people in extreme seismic events would include potential structural failure of the pumping plants, as described under the No Action Alternative. Risks also could occur to workers and others located at elevations below the Saline Habitat Complex or Sedimentation/Distribution Basins if failures occurred during an extreme seismic event. Under extreme seismic events, displacement of conveyance facilities could occur; however, there would be little or no risk to workers or others. These risks would have a low probability because these facilities would be constructed in accordance with State and local design criteria to withstand severe seismic events. If the Berms failed during a seismic event, about 78,000 acre-feet would flow toward the Brine Sink and could cause risks to workers and others in the Sea Bed.

Risks due to unstable soils or volcanic activity would be similar to those described under the No Action Alternative.

Losses of mineral resources would be related to the disturbance of about 136,700 acres of land, and the use of 77,140,000 cubic yards of Sea Bed soils.

Loss of mineral resources due to import of materials would be related to the importation of 6,720,000 cubic yards of rock and gravel for erosion control as well as petroleum products, metals, glass, and other construction materials to be used in Phases I through III.

## **Alternative 2 – Saline Habitat Complex II**

As described in Chapter 3, this alternative would involve construction and operations and maintenance activities for the Sedimentation/Distribution Basins, Air Quality Management, Saline Habitat Complex, Shoreline Waterway, Saltwater Conveyance, and Brine Sink.

Risks that could occur to people in extreme seismic events would include potential structural failure of the pumping plants or Sedimentation/Distribution Basins, as described under the No Action Alternative. If the Berms failed during a seismic event, about 162,000 acre-feet would flow toward the Brine Sink and could cause risks to workers and others in the Sea Bed.

Risks due to unstable soils or volcanic activity would be similar to those described under the No Action Alternative.

Losses of mineral resources would be related to the disturbance of about 206,400 acres of land, and the use of 136,530,000 cubic yards of Sea Bed soils.

Loss of mineral resources due to import of materials would be related to the importation of 11,670,000 cubic yards of rock and gravel for erosion control as well as petroleum products, metals, glass, and other construction materials to be used in Phases I through III.

## **Alternative 3 – Concentric Rings**

As described in Chapter 3, this alternative would involve construction and operations and maintenance activities for the Sedimentation/Distribution Basins, Air Quality Management, First and Second rings, and Brine Sink.

Risks that could occur to people in extreme seismic events would include potential structural failure of the pumping plants or Sedimentation/Distribution Basins, as described under the No Action Alternative. If the Perimeter Dikes failed during a seismic event, about 336,000 acre-feet would flow toward the Brine Sink and could cause risks to workers and others in the Sea Bed.

Risks due to unstable soils or volcanic activity would be similar to those described under the No Action Alternative.

Losses of mineral resources would be related to the disturbance of about 155,450 acres of land, and the use of 18,810,000 cubic yards of Sea Bed soils.

Loss of mineral resources due to import of materials would be related to the importation of 85,150,000 cubic yards of rock and gravel for erosion control as well as petroleum products, metals, glass, and other construction materials to be used in Phases I through III.

**Table 9-7  
Summary of Benefit and Impact Assessments to Geology, Soils, Faults, Seismicity, and Mineral Resources**

| Alternative  | Basis of Comparison   | Changes by Phase |    |     |    | Comments  | Next Steps  |
|--|-----------------------|------------------|----|-----|----|---|---|
|  |                       | I                | II | III | IV |   |   |
| <b>Criterion: Exposure of people to risks related to fault rupture, seismic shaking, and seismic-induced ground failure.</b> |                       |                  |    |     |    |   |   |
| No Action Alternative  | Existing Conditions   | S                | S  | S   | S  | Under extreme seismic events, risks to workers and others could occur at pumping plants and Sedimentation/Distribution Basins.  | Facilities would be constructed in accordance with the California Building Code and applicable design standards.  |
|  | No Action Alternative | NA               | NA | NA  | NA |   |   |
| Alternatives 1 - 8   | Existing Conditions   | S                | S  | S   | S  | Under extreme seismic events, risks to workers and others could occur at pumping plants and Sedimentation/Distribution Basins.<br><br>If Berms, Barriers, and Perimeter Dikes failed, water would flow toward the Brine Sink and could cause risks to workers and others under extreme seismic events.  | Same as No Action Alternative.  |
|  | No Action Alternative | S                | S  | S   | S  |   |   |
| <b>Criterion: Exposure of people to risks related to unstable soils.</b>   |                       |                  |    |     |    |   |   |
| No Action Alternative  | Existing Conditions   | S                | S  | S   | S  | Facilities may be located on areas with unstable soils or volcanic hazards. The facilities would be designed based on geotechnical studies by a registered engineer to minimize risk.   | Facilities would be constructed in accordance with the California Building Code and applicable design standards.  |
|  | No Action Alternative | NA               | NA | NA  | NA |   |   |
| Alternatives 1 - 8   | Existing Conditions   | S                | S  | S   | S  | Similar to No Action Alternative.   | Same as No Action Alternative.  |
|  | No Action Alternative | S                | S  | S   | S  |   |   |
| <b>Criterion: Loss of availability of a known mineral resource or a locally important mineral resource recovery site.</b>    |                       |                  |    |     |    |   |   |
| No Action Alternative  | Existing Conditions   | S                | S  | S   | S  | Existing mapping does not identify mineral resources along the shoreline. Locations of mineral resources under the Sea Bed are not known at this time. Disturbance and use of soils from the Sea Bed could result in loss of mineral resources in the Sea Bed. Construction of facilities would require imported mineral resources and reduce the availability of these resources for other uses, including gravel and rock. Petroleum, metal, and glass products also would be used for construction of the facilities. Major construction would occur in Phases I through IV. | Facilities could be sited to minimize disturbance of mineral resources that are identified as the water recedes.<br><br>In the future, different construction methods and materials may be able to minimize use of mineral resources. |
|  | No Action Alternative | NA               | NA | NA  | NA |   |   |

**Table 9-7  
 Summary of Benefit and Impact Assessments to Geology, Soils, Faults, Seismicity, and Mineral Resources**

| Alternative        | Basis of Comparison   | Changes by Phase |    |     |    | Comments   | Next Steps                     |
|--------------------|-----------------------|------------------|----|-----|----|--|--------------------------------|
|                    |                       | I                | II | III | IV |  |                                |
| Alternatives 1 - 8 | Existing Conditions   | S                | S  | S   | O  | Actions would be similar to those described for No Action Alternative; however, the extent of disturbance would be greater than described for No Action Alternative. | Same as No Action Alternative. |
|                    | No Action Alternative | S                | S  | S   | O  |  |                                |

Legend for Types of Benefits or Impacts in Each Phase:

- S = Significant Impact
- O = No Impact
- L = Less Than Significant
- B = Beneficial Impact
- NA = Not Analyzed

### **Alternative 4 – Concentric Lakes**

As described in Chapter 3, this alternative would involve construction and operations and maintenance activities for the Sedimentation/Distribution Basins; First, Second, Third, and Fourth lakes; and Brine Sink.

Risks could occur to workers located at elevations below the Sedimentation/Distribution Basins, as described in the No Action Alternative. If the Berms failed during a seismic event, about 324,000 acre-feet would flow toward the Brine Sink and could cause risks to workers and others in the Sea Bed.

Risks due to unstable soils or volcanic activity would be similar to those described under the No Action Alternative.

Losses of mineral resources would be related to the disturbance of about 96,950 acres of land, and the use of 154,215,000 cubic yards of Sea Bed soils.

Loss of mineral resources due to import of materials would be related to the importation of 7,420,000 cubic yards of rock and gravel for erosion control as well as petroleum products, metals, glass, and other construction materials to be used in Phases I through III.

### **Alternative 5 – North Sea**

As described in Chapter 3, this alternative would involve construction and operations and maintenance activities for the Sedimentation/Distribution Basins, Air Quality Management, Saline Habitat Complex, Shoreline Waterway, Saltwater Conveyance, Marine Sea, Marine Sea Recirculation Canal, and Brine Sink.

Risks could occur to workers located at elevations below the Sedimentation/Distribution Basins, as described in the No Action Alternative. If the Berms and Barrier failed during a seismic event, about 2,069,000 acre-feet would flow toward the Brine Sink and could cause risks to workers and others in the Sea Bed.

Risks due to unstable soils or volcanic activity would be similar to those described under the No Action Alternative.

Losses of mineral resources would be related to the disturbance of about 230,450 acres of land, and the use of 86,770,00 cubic yards of Sea Bed soils.

Loss of mineral resources due to import of materials would be related to the importation of 53,730,000 cubic yards of rock and gravel for erosion control as well as petroleum products, metals, glass, and other construction materials to be used in Phases I through III.

### **Alternative 6 – North Sea Combined**

As described in Chapter 3, this alternative would involve construction and operations and maintenance activities for the Sedimentation/Distribution Basin, Air Quality Management, Pupfish Channels, Saline Habitat Complex, Shoreline Waterway, Saltwater Conveyance, Marine Sea, Marine Sea Mixing Zone, Marine Sea Recirculation Canal, and Brine Sink.

Risks could occur to workers located at elevations below the Sedimentation/Distribution Basins, as described in the No Action Alternative. If the Berms, Perimeter Dikes, and Barrier failed during a seismic event, about 3,142,000 acre-feet would flow toward the Brine Sink and could cause risks to workers and others in the Sea Bed.

Risks due to unstable soils or volcanic activity would be similar to those described under the No Action Alternative.

Losses of mineral resources would be related to the disturbance of about 224,250 acres of land, and the use of 66,970,000 cubic yards of Sea Bed soils.

Loss of mineral resources due to import of materials would be related to the importation of 93,650,000 cubic yards of rock and gravel for erosion control as well as petroleum products, metals, glass, and other construction materials to be used in Phases I through III.

### **Alternative 7 – Combined North and South Lakes**

As described in Chapter 3, this alternative would involve construction and operations and maintenance activities for the Sedimentation/Distribution Basin, Air Quality Management using Protective Salt Flat on Exposed Playa below -255 feet msl, Exposed Playa without Air Quality Management above -255 feet msl, Saline Habitat Complex, Recreational Saltwater Lake, Recreational Estuary Lake, Marine Sea Recirculation Canal, IID Freshwater Reservoir, two Treatment Plants, and Brine Sink.

Risks could occur to workers located at elevations below the Sedimentation/Distribution Basins, as described in the No Action Alternative. If the Berms, Perimeter Dikes, and Barrier failed during a seismic event, about 3,098,000 acre-feet would flow toward the Brine Sink and could cause risks to workers and others in the Sea Bed.

Risks due to unstable soils or volcanic activity would be similar to those described under the No Action Alternative.

Losses of mineral resources would be related to the disturbance of about 131,950 acres of land, and the use of 33,522,000 cubic yards of Sea Bed soils.

Loss of mineral resources due to import of materials would be related to the importation of 79,650,000 cubic yards of rock and gravel for erosion control as well as petroleum products, metals, glass, and other construction materials to be used in Phases I through III.

### **Alternative 8 – South Sea Combined**

As described in Chapter 3, this alternative would involve construction and operations and maintenance activities for the Sedimentation/Distribution Basins, Air Quality Management, Saline Habitat Complex, Shoreline Waterway, Marine Sea, Marine Sea Recirculation Canal, and Brine Sink.

Risks could occur to workers located at elevations below the Sedimentation/Distribution Basins, as described in the No Action Alternative. If the Berms, Perimeter Dikes, and Barrier failed during a seismic event, about 1,545,000 acre-feet would flow toward the Brine Sink and could cause risks to workers and others in the Sea Bed.

Risks due to unstable soils or volcanic activity would be similar to those described under the No Action Alternative.

Losses of mineral resources would be related to the disturbance of about 209,550 acres of land, and the use of 47,230,000 cubic yards of Sea Bed soils.

Loss of mineral resources due to import of materials would be related to the importation of 100,270,000 cubic yards of rock and gravel for erosion control as well as petroleum products, metals, glass, and other construction materials to be used in Phases I through III.

## Next Steps

During the project-level analysis, detailed geotechnical field investigations would be conducted to determine specific geologic and soil characteristics. Registered engineers and/or geologists would use this information to develop design criteria consistent with the California Building Code to minimize the risk of damage and prevent injury or death during construction and operations and maintenance. Locations of facilities or excavation activities may need to be specified to avoid areas with unstable soils, volcanic activity, or mineral resources. The design could consider a range of materials and facility locations to minimize the need for mineral resources. For example, use of synthetic sheet piling may reduce the need for rock in Perimeter Dikes, although this could increase the need for petroleum products. The design could analyze different construction methods and materials.