1.1 PURPOSE OF THE REPORT

The purpose of this report is to identify the changes in the physical and chemical environments, and biological communities, of San Francisco Bay (the Bay) that may result from the runway reconfiguration alternatives under consideration for San Francisco International Airport (SFO). This report focuses on potential project-related changes in hydrodynamics, hydrology, aquatic sediments, water quality, and aquatic biotic communities.

Potential impacts on Bay hydrology, sediment transport, water quality, and biological communities were among the largest public concerns raised during the scoping process for the environmental review of the proposed project. Because of the complexity of these environmental issues, public comments also requested an independent technical review of the adequacy of the science used to evaluate potential project-related impacts to the Bay. This report has been prepared to document the scientific approach, assumptions, and analyses used to predict changes in the Bay that could be caused by construction of the principal components of the project alternatives; i.e., reconfigured runways, in-Bay fill borrow pits, and in-Bay fill material rehandling basins (refer to Section 4 for a summary description of project alternatives). The information provided in this report will be used to assess some of the potential impacts associated with project alternatives in the Environmental Impact Report (EIR) and Environmental Impact Statement (EIS) for the proposed project. It should be understood that this report does not address all of the potential hydrology, water quality, and biological effects of project alternatives on the environment. Other studies are being conducted on the potential effects of alternative project facilities that are not located in the Bay, such as alternative fill borrow sites in the San Francisco Bar Ship Channel, Columbia River, or British Columbia; and the potential effects to the Bay of ancillary project facilities such as construction material fabrication sites at either Pier 94-96 or the former Hunters Point Naval Ship Yard. Studies are also being conducted on potential project effects to other Bay resources such as recreation. The EIR and EIS prepared for the proposed project will address potential direct, indirect, and cumulative impacts in all environmental discipline areas for all alternative project components. This technical report addresses critical environmental issues associated with the proposed project but is not intended to be the full disclosure document of all environmental issues. That information will be provided in the EIR and EIS.

1.2 ORGANIZATION OF THE REPORT

The following portions of Section 1 of this report present a discussion of the relationship of the physical and chemical environments, and biological communities, that may be affected by the runway reconfiguration. A general conceptual model is presented as part of this discussion to do the following:

- Illustrate the relationships of physical and chemical conditions in the Bay to existing aquatic biological communities.
- Identify those physical, chemical, and biological parameters that may be affected by the proposed reconfiguration and those parameters not likely to be affected.

- To illustrate how changes in physical and chemical conditions that may result from the construction of the reconfigured runways might affect biological communities in the Bay.

More detailed conceptual models of the relationship between physical, chemical, and biological conditions are presented in Sections 2, 5, and 6 to explain several specific analyses and assessments.

Section 2 of the report presents a description of the existing biological communities in and adjacent to those portions of the Bay most likely to be affected by the development of a new runway layout at SFO. This section includes discussions of the various habitat types found in this area of the Bay, descriptions of the existing planktonic, benthic, and plant communities, and descriptions of the fish, amphibians, reptiles, birds, and mammals known to exist in this portion of the Bay.

Some appendices, tables, and figures associated with Section 2 include data on locations that are not part of the assessment of potential changes to the Bay that is the subject of this report. These data were collected for the broader EIR and EIS assessments prior to the decision to prepare this report. Examples of such data include data on in-Bay borrow areas no longer under consideration, data on the San Francisco Bar Ship Channel area, and data on upland biotic communities at potential fabrication sites. In preparing this report it was determined to be more efficient to leave unchanged such appendices, tables, and figures, even though they contain data not discussed in this report. As applicable, this report includes notations where this has been done either in the text or through footnotes.

Section 3 of the report presents a description of the existing hydrodynamic, hydrologic, sediment, and water quality conditions in the Bay in the vicinity of SFO. These discussions address tides, circulation, waves, freshwater inflow, bathymetry, sea-level rise, sediment transport, sediment quality, water quality, and residence time. The purpose of this discussion is to identify the existing physical and chemical conditions that support the existing biological communities described in Section 2.

Section 4 presents a description of the runway reconfiguration alternatives under consideration in the EIR and EIS that may affect the physical, chemical, and biological conditions in the Bay. This description does not include all the alternative methods to meet the need for and purpose of the runway reconfiguration that will be addressed in the EIR and EIS. Rather, this description focuses on those aspects of the construction and configuration of the runway alternatives that clearly have the potential to affect the existing physical conditions in the Bay. Included in this description are:

- Runway reconfiguration alternatives BX-6, A-3, and BX-R
- Two alternative types of runway platforms (all fill, fill/pile-supported hybrid)
- Potential in-Bay dredging or borrow areas
- Potential in-Bay dredged material reuse and disposal areas
- Possible in-Bay fill material rehandling basins
- Alternative types of dredging operations

- Alternative types of marine construction activities
- Projected construction schedules for each of the reconfiguration alternatives

Section 5 of this report presents a description of the changes in hydrodynamics, hydrology, sediments, and water quality that are projected to occur as a result of the implementation of each alternative. This section begins with an extensive description of the assessment and modeling methodologies used to identify potential changes, including conceptual models and modeling scenarios, decision tree analyses, descriptions of models, model set-up and calibration, and assumptions regarding hydraulic conditions used in the analyses. This section then presents the results of the assessments and modeling for both the final configuration of each alternative and the construction process for each. Projections are provided for changes in circulation, tidal elevations and phase, waves, sediment transport, water quality, and flooding.

Section 6 presents an assessment of the changes to the biological communities discussed in Section 2 that are projected to result from the changes to physical and chemical conditions discussed in Section 5. This discussion uses the general conceptual model presented in this section as well as more specific conceptual models to explain the mechanisms by which physical and chemical changes resulting from the runway reconfiguration alternatives may affect future biological communities in the Bay.

Section 7 presents a summary of the findings of the analyses presented in the previous sections of the report.

One of the principal purposes of the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA) is to include consideration of the environmental implications of a project in the project planning and development process. By conducting the environmental review early in the project development process, findings of that review can be used to improve project designs with regard to potential environmental impacts. In accordance with that approach, the studies presented in this report are based on preliminary engineering designs and construction concepts for project alternatives. During the course of environmental studies, engineering design has continued and project alternatives have been refined with an eye toward continuing to improve airfield operational efficiency and safety, and minimize Bay fill. The changes to the runway reconfiguration alternatives that have resulted from continued engineering review are presented in Section 8 of the report. The hydrodynamic, sediment transport, water quality, and biological implications of these design changes will be evaluated, as appropriate, using the same scientific approach presented in this report for earlier preliminary project designs. The results of those studies will be summarized in the EIR and EIS.

1.3 CONCEPTUAL MODEL OF THE RELATIONSHIP BETWEEN THE PHYSICAL AND BIOLOGICAL ENVIRONMENTS

1.3.1 Purpose of the Model

The conceptual model presented in this report is not intended or designed to represent a comprehensive analysis of all the interactions of physical, chemical, and biological conditions that operate within the Bay. Such a model is beyond the scope of the EIR and EIS processes.

Rather, the model presented herein is designed as a tool to help clarify for the reader the mechanisms and relationships that must be considered in assessing the effects of potential changes in the physical and chemical conditions of the Bay that may result from each of the runway reconfiguration alternatives on the biological communities of the Bay.

1.3.2 Design of the Model

1.3.2.1 Introduction

A graphic representation of the conceptual model is presented on Figure 1.3.2-1. As described above, the conceptual model presented in this report is focused on those physical, chemical, and biological conditions that should be considered when assessing potential changes caused by the proposed project. A number of other physical and chemical conditions are important to the overall functioning of the Bay, but would not be affected by project activities. The external inputs shown on Figure 1.3.2-1 (e.g., sunlight, freshwater inputs, ocean-water levels, meteorology) represent some of the important factors that control or modify the physical, chemical, and biological conditions in the vicinity of the proposed project. However, none of these would be affected by the proposed project and are, therefore, not considered in detail in the discussions in the following sections that address key relationships among controlling factors (physical, chemical, and biological).

An underlying assumption of the model is that a number of key physical drivers control the physical and chemical environment of the Bay. The physical drivers control a set of physical and chemical conditions (biological drivers) that in turn control the biological communities that exist in the Bay – in concert with a variety of biological factors. There are a wide variety of global, regional, and Bay-wide biological processes that do or may affect the same biological communities that may be affected by the biological drivers under study – the effects of which may be far greater than potential project-related impacts. An additional assumption of this model is that the runway reconfiguration would result in changes to the physical structure of, and chemical input to, the Bay, which then would result in changes in the physical and chemical conditions, which would in turn result in changes in biological communities in the Bay.

It should be noted that the potential effects or changes to the Bay suggested by this conceptual model and discussed in this report include both temporary effects that would occur only during the construction phase (e.g., increased turbidity during dredging operations, construction noise), and permanent changes to the Bay (e.g., permanent alternation of habitat due the placement of runway structures).

1.3.2.2 Underlying External Inputs, Physical Drivers, and Relationship to Biological Drivers

The external inputs as shown on Figure 1.3.2-1 may affect biological components directly or indirectly through interactions with physical components. However, in neither case would the external inputs be affected by potential project activities. Physical/chemical conditions that contribute to an overall functioning of the Bay but that would not be affected by project activities include:

- *Ocean-water levels*. The ocean-water levels are governed by differences in the attractive forces of celestial bodies (sun, moon, and others to a lesser extent) upon different parts of the rotating earth. None of these parameters will be affected by the proposed project.
- *Freshwater inputs.* Any runoff from the proposed runway extensions would have naturally landed in the Bay. Therefore, no additional freshwater input enters the Bay.
- *Meteorology.* The overall wind and meteorological parameters that govern Bay Area weather are driven by high and low pressure systems which develop over the Pacific Ocean. The project may change local wind patterns at the end of the runways. The extent of this change is discussed later in this report.
- *Sediment load from Bay tributaries.* The sediment load to the Bay is primarily from the Delta. However, and particularly in the South Bay, sediment also enters via local tributaries. None of these sources of sediment will be affected by the proposed project.
- *Sunlight*. The amount of sunlight reaching the Bay is not expected to change due to the proposed project except on the actual footprint of the runway expansion.
- *Nutrient input.* Nutrient inputs to the South Bay (nitrogen, phosphorous) are primarily derived from discharges of treated sewage from wastewater treatment plants. Additional sources of nutrients include tributary inputs from major creeks, ocean water, Delta water, releases from previously deposited sediments, and atmospheric deposition. As described in the phytoplankton conceptual model, primary production in the Bay is not generally limited by the availability of nutrients except sometimes during the end of the spring phytoplankton bloom. The proposed project is not expected to measurably alter the major nutrient inputs to the South Bay.
- *Water temperature.* Water temperature is primarily governed by solar radiation or sunlight. Surface waters that are exposed to sunlight are traditionally warmer than bottom waters that receive less sunlight. Given that sunlight will not be affected by the proposed project, the temperature of the Bay will not be affected. It should be noted that in areas where depth increases or decreases, the temperature at the bottom may be warmer or colder respectively.
- *Salinity.* The salinity of the Bay is governed by freshwater inputs and the salinity of the ocean. Neither of these is affected by the proposed runway expansion. Therefore, the overall salinity (i.e., the amount of salt in the Bay) will not be affected. However, this is not to say that the vertical stratification or that the horizontal distribution of salinity will not be affected.

Five general sets of physical drivers have been defined for the model:

- Constituents in water and sediments - including salt, contaminants, nutrients, and other organic and inorganic compounds
- Hydrodynamics - including circulation, waves, and water levels in the Bay
- Structure and bathymetry - the basic existing shape of the Bay and structures within it (such as piers and groins)
- Physical characteristics of Bay sediments - primarily geologic characteristics

- Other physical conditions - such as noise, vibration, and human disturbance

These physical drivers work in combination to create or control the physical and chemical conditions that are biological drivers. The hydraulic drivers (circulation, waves, and water levels in the Bay) combined with the physical bathymetry of the Bay determine sediment transport in the Bay. Constituent input to the Bay, Bay circulation, and sediment characteristics determine water quality in the Bay. The bathymetry and structure of the Bay controls the extent of various habitat types within the Bay, but habitat is also influenced by sediment characteristics and water circulation. Basic sediment properties combined with constituent input, water circulation and habitat determine sediment quality in the Bay.

The model also recognizes that a number of parameters are important to aquatic biological communities that are not directly related to the physical and chemical processes. The levels of noise, vibration, and human disturbance may affect biological communities in the Bay separately from water circulation and water chemistry influences.

1.3.2.3 Biological Drivers and Relationship to Biological Communities

Five types of physical and chemical conditions have been identified as "biological drivers" in the model; all are physical parameters or conditions that often are measured to indicate the condition of the Bay. These parameters include:

- Water quality - including both chemical composition and physical properties of Bay waters
- Sediment transport - including erosion, deposition, and resuspension of sediments
- Habitat - including the area or volume of several habitat types such as mudflats, marshes, and open water
- Sediment quality - including both the physical and chemical composition of sediments
- Other forms of disturbance - such as noise and human disturbance

These conditions play significant roles in the existence of biological communities in the Bay. Benthic biotic communities are largely controlled by sediment quality, water quality, sediment transport, and habitat area, as well as by interaction with other biological communities. Water quality, hydrodynamics, habitat volume, and various types of disturbance control pelagic communities, along with interaction with other biological communities. The avian and mammal communities are controlled by habitat area, various forms of disturbance, and by the availability of various food source communities (such as the benthic community) that are more directly controlled by physical parameters such as water and sediment quality.

1.3.2.4 External Biological Factors

In addition, some biological communities within the Bay are strongly influenced by broader regional and global factors affecting specific species. For example, the local populations of migratory and pelagic species may be more influenced by factors such as conditions in breeding grounds outside the Bay, oceanic water temperatures, oceanic plankton blooms, etc. than by any potential effects associated with the proposed runway reconfiguration. Anthropogenic factors (such as commercial fishery catch) may also influence populations in the Bay. Four broad

categories of regional and global factors that comprise the background for interactions with physical and biological drives include the following:

Long-Term Regional Habitat Succession

Within the Bay, long-term changes in shoreline habitat, mudflats, tidal marsh have occurred and will continue to occur with or without the proposed project. Another example from a broader regional scale is nesting habitat for migrant birds that winter in the Bay. The nesting habitat for winter migrants is located well outside the limits of the Bay and, thus, habitat conditions and succession would not be affected by project activities.

Bioaccumulation

Many sources of contaminants within and outside the Bay control the existing background contaminant levels in biological communities, and these sources would not be affected by the proposed runway reconfiguration. In Section 6.2.7 the potential local contribution from project activities is discussed.

Coastal/Regional Migration Behavior

Many fish (e.g., salmonids), mammals (gray whale), and birds (wintering waterfowl) exhibit migration patterns that are external to the Bay. These patterns would not be affected by the proposed project. Local movements within South and Central bays are addressed in Section 6.2.

Population Dynamics

Several factors that are regional or global in scale may influence local Bay populations:

- Population changes influenced by global oceanic water temperature (e.g., El Niño events)
- Increases in the number of invasive species introduced to the Bay
- Cyclical predator/prey relationships
- Oceanic breeding and reproductive success
- Evolutionary/genetic changes

The regional and global factors are addressed here for three reasons:

- First, in many cases (e.g., oceanic breeding and reproductive success) these factors would not be affected by project activities and are not evaluated further in this document.
- Second, where interactions would occur between global/regional factors and project activities (e.g., regional Baywide shoreline changes interacting with local project-caused changes in deposition/erosion), the regional influence may be much larger than the influence from project activities.
- Third, in some cases (e.g., El Niño events that may affect pelagic fish populations and eventually Bay fish populations), the interactions between external inputs and local population effects cannot be evaluated because of the uncertainty regarding the global/regional factors.

1.3.2.5 Relationships Between Biological Communities

As indicated on Figure 1.3.2-1, complex biological relationships influence the individual biological communities concurrent with the influence of physical and chemical conditions. Figure 1.3.2-1 is not intended to indicate all of these relationships. To do so would make the model so complex that it would be reduced in value. Rather, the model is intended to illustrate general relationships of biological communities, such as the dependence of marine mammal populations on the availability of food sources represented by the benthic and pelagic communities. The discussion of key relationships between biological communities is presented in Section 6 of this report.

1.3.2.6 Operation of Project Effects Within the Model

The model is based on the premise that a project such as the runway reconfiguration would modify the relationship of the underlying physical and chemical drivers with the biological drivers. The key affected areas considered include:

- Changes in bathymetry due to fill placement (or structures) for runways, or dredging of access channel or borrow areas, would modify the interaction of bathymetry with hydraulic drivers, thus changing water circulation.
- New structures in the Bay would directly create new areas of one type of habitat (hard bottom) while displacing others (open water and soft bottom).
- Dredging operations would result in resuspension of bed sediments and associated contaminants, thus modifying the input of constituents to the water column and affecting water quality during the period of dredging operations.
- Sediment disturbance from dredging operation would modify the characteristics of surficial bed sediments, and may contribute to changes in the area of some kinds of benthic or intertidal habitats.
- Modified stormwater runoff characteristics (in terms of volume, location, timing, and contaminant load) may change the constituent loading to the Bay, thus changing water quality and sediment quality.
- The additional human activity associated with construction and operation of the new runways would modify the existing levels of disturbance that affect some biological communities such as fish, birds, and mammals.

1.3.3 Application of the Model

The thought process behind the development of this conceptual model has guided the development of the methodologies used in the assessment described in the following sections. The model has been used to identify key relationships between the controlling factors, physical and chemical conditions likely to be affected, and biological communities of concern. The model has been used to insure that the analyses performed provided a sound scientific basis for assessing the cumulative changes that would result from the runway reconfiguration alternatives.

1.3.3.1 Projection of Changes in Physical/Chemical Parameters

Changes associated with modifications to the Bay (i.e., platform footprint and dredging activities) may alter hydraulic, sediment, and water quality parameters. For instance, alteration of the platform footprint will change the hydrodynamics in and around the proposed platform. These changes include modified current speed and direction, namely increased current speed and altered current direction off the tips of the new runways. Conversely, currents in regions near the existing platform footprint may slow down behind the new runway sections creating more quiescent hydrodynamic conditions.

Changes to hydraulic parameters will most likely modify existing sediment parameters, including suspended sediment concentrations and depositional/erosional patterns. An increase in current speed increases the capacity for the water to suspend and transport sediments from the immediate vicinity, causing a subsequent increase in suspended sediment concentrations as well as increased erosion to those areas. Conversely, a decrease in current speed will lessen the capacity for the water to suspend and transport sediments, which will cause a decrease in erosion due to decreased shear stresses. Modification to existing current directions could alter suspended sediment distributions within the Bay and subsequent deposition/erosional patterns.

The hydrodynamic changes that lead to potential changes in sediment parameters may in turn lead to changes in water quality parameters. An increase in suspended sediment concentration due to increased current speed may lead to an increase or decrease in total contaminant concentration depending on relative contaminant concentration gradients. If relatively "dirty" sediment, or more contaminated sediment, is released into the water column, the likelihood of desorption of contaminants, or "sloughing" of the contaminants into the aqueous phase increases, increasing the dissolved contaminant concentration. Conversely, if relatively "clean" sediment, or less contaminated sediment, is released into the water column, the likelihood of adsorption of contaminants, or "scavenging" of contaminants from the aqueous phase in water column to the sediment particles in the water columns increases, resulting in a decreased dissolved contaminant concentration. The same potential effects apply to sediments released during dredging activities. Erosional and depositional pattern changes could also change water quality patterns. Physical and chemical processes such as resuspension, adsorption and desorption, and diffusion are shown in more detail on Figure 5.2.1-5, a conceptual biogeochemical model of San Francisco Bay. Changes to hydrodynamic parameters may lead to a chain effect on sediment and water quality parameters, which may lead to potential changes to biological communities with the Bay.

1.3.3.2 Projection of Changes to Biological Communities Resulting from Changes to Physical/Chemical Parameters

The use of models to project changes in biological communities that would result from changes in the physical and chemical environment is less quantitative than for physical or chemical conditions. These assessments reflect the professional conclusions of experts using their understanding of the life history requirements of the species involved and empirical evidence from previous observations and measurements of similar or functionally comparable physical changes. This difference in approach reflects normal differences between the biological sciences and the physical or chemical sciences, rather than any deliberate approach to this assessment.

A linkage table presented in Section 6 (Table 6.1-1) summarizes changes in biological communities that may result from both construction activities and operation of the reconfigured runways. The changes are discussed for the various linkages between biological drivers and food-web components. The linkages identified by letters and numbers on Figure 1.3.2-1 correspond to those identified in the linkage table. The purpose of the conceptual model and linkage table is to identify all of the relationships considered, and to illustrate for the lay reader the relationships of physical and chemical changes to changes in biological communities.

One example of the way physical and chemical changes might affect biological communities is presented on Figure 6.2.7-1. This conceptual exposure model shows how contaminants could be released from bedded sediment into the water column during dredging, resulting in increased exposure and potential effects to various biological communities, including aquatic organisms, piscivorous birds, and marine mammals.