TESTABLE HYPOTHESES

ON THE CONCEPTUALIZATION OF

LAKE MERCED AND THE WESTSIDE GROUND-WATER BASIN

December 3, 2002

This memorandum categorizes and discusses key parts, or elements, of the Lake Merced and the Westside Ground-Water Basin conceptualization and describes certain hypotheses which have been developed and have evolved out of that work. It also describes tests which are currently being, or are planned to be, conducted to verify, refine, or modify those hypotheses and associated conceptual model elements. The hypotheses are categorized according to three conceptual aspects: 1) the lake-aquifer setting, 2) the potential for seawater intrusion, and 3) ground-water basin continuity. Under each category, there are multiple hypotheses that have been developed and reported through the construction of the conceptual model of the lake-aquifer system by LSCE (March 2002) and subsequent work. Tests of some of the hypotheses are possible through expanded monitoring around Lake Merced (lakes and aquifers), and expanded monitoring at sites in Daly City and San Bruno. Other tests are in the forms of exploratory drilling activities (for example, where well control is needed to support or revise geologic correlations) and interpretation of observations of how the system reacts to water addition and in-lieu recharge activities that have recently been initiated.

For the purposes of this memorandum, shallow aquifer materials refer to the unconfined aquifer system within which Lake Merced appears to be incised. Active production wells in the Westside Basin are considered to be completed in a deeper, confined system herein referred to as deep aquifer materials.

1) Lake-Aquifer Setting

Under this category, the following tests and hypotheses relate to key parts of the conceptual model:

Hypothesis: The lakes are an expression of the shallow ground-water system.

Tests: Ongoing ground-water and lake water level monitoring is providing evidence that is consistent with this hypothesis. Data from an expanded monitoring network plus use of continuous measurement and recording equipment are also consistent with the hypothesis that lake levels and the adjacent water table are substantially, if not completely, connected. The monitoring network and associated continuous measurements have also indicated a consistent distinction in the response of the deeper aquifer system to pumping, flow gradients, and interpreted seasonal trends. Finally, drilling and logging of several shallow monitoring wells around the lakes in 2002 support the hypothesis that the lakes are incised within shallow aquifer materials and that the lake surface is at the same elevation as the ground water that occurs in these materials. Additional testing of this hypothesis is occurring through observation of lake and ground-water levels during planned supplemental water additions to the lake in fall 2002 and spring 2003.

Hypothesis: The lakes, shallow ground-water table, and ground-water in the deep aquifer system are hydraulically connected in the greater Westside Basin (i.e., on a regional scale) but respond as distinct, or separate systems, under certain conditions in one or more localities of the basin (e.g., beneath Lake Merced).

Tests: This hypothesis is based on interpretation of subsurface geology which to date reveals no complete barrier between lakes and the shallow or deep aquifer systems. Additional well control, through exploratory test hole drilling and additional monitoring well installations, has been proposed to further evaluate the geology and hydraulic connectivity. In particular, a multiple piezometer monitoring well has been proposed in Daly City to assess the relationship between the shallow water table and the piezometric head of the deep aquifer, which are seen to be in equilibrium north of Lake Merced.

Hypothesis: Confining strata between shallow and deep aquifer materials restrict flow and isolate the impact of pumping from deeper strata that extend directly beneath the lakes.

Tests: Tests of this hypothesis include ongoing monitoring in the lakes, shallow aquifers, and the deep aquifer (where local irrigation pumping and adjacent municipal pumping occur). Further, direct supplemental water additions to the lakes and delivery and use of substitute surface water in lieu of pumping (e.g., through the pilot conjunctive use program) will be used as opportunities to test this hypothesis by measuring actual lake and aquifer response using the existing monitoring network and continuous measurements in lakes and wells.

Hypothesis: Shallow ground water around Lake Merced flows predominantly horizontally: westward to the ocean as well as southward to a pumping depression in the deeper aquifer system where separation between the two systems (shallow and deep), due to confining strata, appears to be less substantial.

Tests: Use the newly expanded monitoring network to develop contour maps of equal ground water elevations in the shallow and deep aquifer systems to assess flow directions and gradients.

Hypothesis: Due to localized confining strata which separate the shallow and deep aquifers, actions such as direct water addition to the lakes can be used to manage lake levels.

Tests: Empirically observe the response of the lakes, shallow ground water, and deep ground water prior to, during, and after water addition events. Compare the response to that described in the report on water addition scenarios (LSCE/May 2002). Monitor future planned water additions to further evaluate the conceptualization and to develop conclusions as to the viability of using water additions to manage lake conditions.

Hypothesis: In-lieu recharge activities planned for Daly City, South San Francisco, and San Bruno will not cause a corresponding rise in lake levels.

Tests: Using monitoring locations in Daly City and Lake Merced vicinity, observe and record the response in lake levels to reduced ground-water pumping associated with in-lieu recharge pilot testing and subsequent programs.

2) Seawater Intrusion

Under this category, hypotheses regarding pathways for seawater intrusion are considered. The geologic conceptualization has indicated that geologic structure poses barriers to intrusion into pumping depressions that are significantly below sea level from Daly City to San Bruno.

Hypothesis: Seawater intrusion into the deep aquifer system directly west of Daly City pumping is impeded by geologic structure features including dipping and folded beds and an interpreted outcropping in the ocean that extends as far as 25 miles offshore.

Tests: Incorporate new geophysical data from Daly City's coastal monitoring well project (AB303) at Thornton Beach. Monitor water levels in new wells and at Fort Funston (already being performed) to determine if changes in pumping associated with ground-water substitution (i.e., in-lieu recharge) propagate to the coast and indicate hydraulic continuity to the ocean.

Design and conduct an aquifer test to detect presence or lack of a barrier between Daly City production wells and the coast.

Hypothesis: Seawater intrusion north of Lake Merced is constrained by the lack of a gradient for onshore flow and also by projections of offshore structural features.

Tests: Expand continuous monitoring northward into the Sunset area to assess hydraulic continuity inland to the coast (i.e., similar to tests of previous hypothesis).

Hypothesis: There is no direct pathway (i.e., through geologic strata) for seawater intrusion to occur from the San Francisco Bay into the San Bruno portion of the Westside Basin.

Tests: Propose and conduct exploratory drilling and monitoring well installation to assess correlations of deep aquifer materials toward and under the bay. Seek to observe water levels in the bayside monitoring well in response to changes in pumping associated with in-lieu recharge.

3) Ground-Water Basin Continuity

An expanded conceptualization of the physical features of the Westside Basin has revealed an apparent transition in the occurrence and character of the deep aquifer between Daly City and San Bruno. Though limited well control data are available, including gaps of a mile or more where geophysical data are lacking, the preliminary interpretation suggests an hypothesis that the southernmost portion of the ground-water system may be partially, or wholly, distinct. This may translate to hydraulic isolation and may be consistent with observed water quality and well yield variations.

Hypothesis: Ground-water used for municipal purposes in San Bruno occurs in a distinct sub-basin that may be partially, or wholly, isolated from the rest of the basin.

Tests: This hypothesis is most limited by lack of well control. Initial testing of the hypothesis requires selection of sites to conduct exploratory drilling and geophysical logging. Where warranted, test holes should be converted to monitoring wells to delineate the existence, or lack, of hydraulic continuity between San Bruno and northern parts of the basin. Planned reductions in ground-water pumping through in-lieu recharge offers the opportunity to further test this hypothesis through observations of water levels in each area during the ground-water substitution periods.