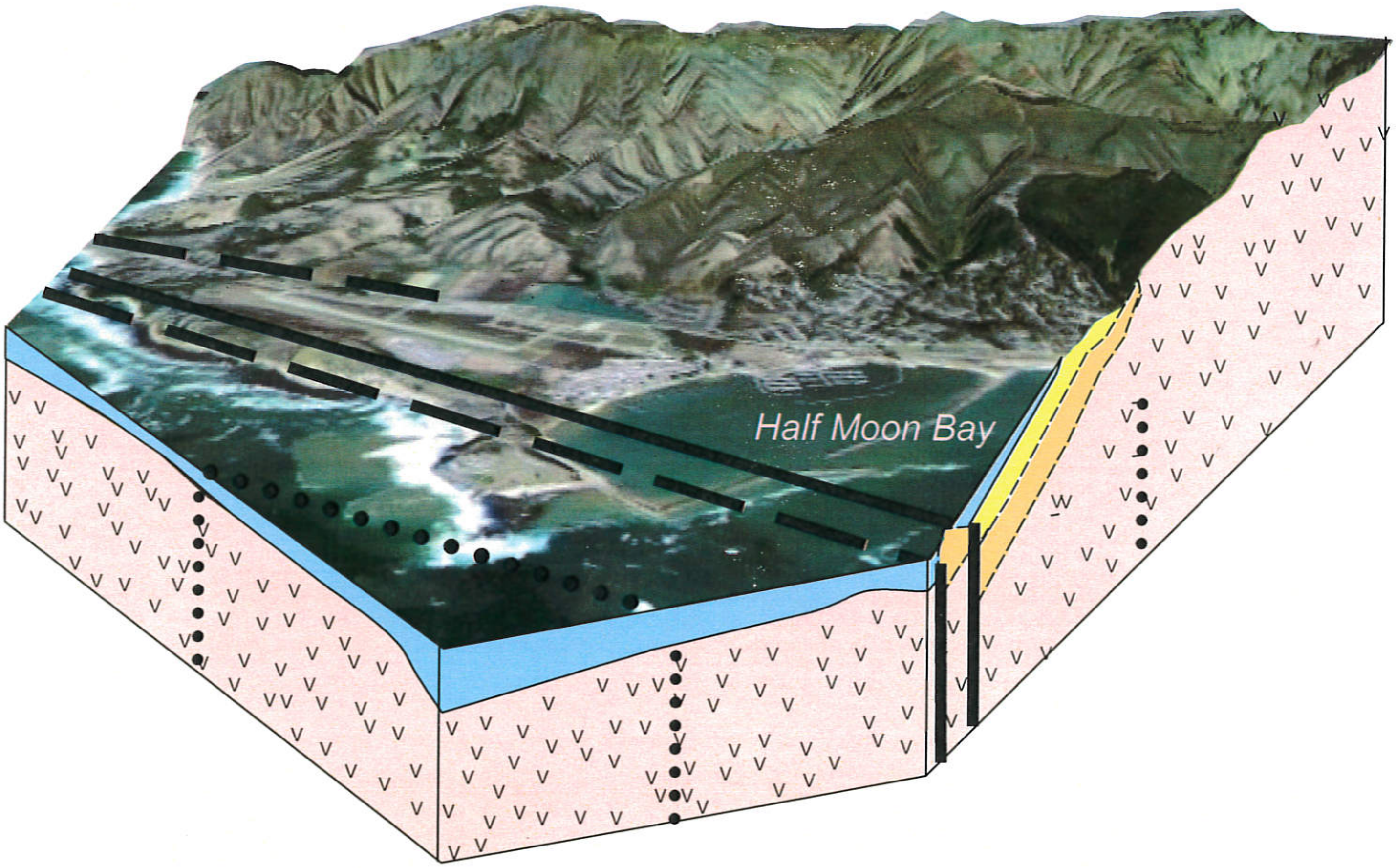
Midcoast Groundwater Study
Phase II – Volume I



County of San Mateo

The Promise of the Peninsula

KLEINFELDER

VOLUME I
SAN MATEO COUNTY MIDCOAST GROUNDWATER STUDY, PHASE II
SAN MATEO COUNTY, CALIFORNIA

Kleinfelder, Inc.
2011 N. Capitol Avenue
San Jose, California 95132

January 8, 2007

KLEINFELDER

January 8, 2007
File No.: 26848

Ms Lisa Aozasa
County of San Mateo
Planning Services Department
455 County Government Center
Redwood City, California 94063

SUBJECT: **San Mateo County Midcoast Groundwater Study, Phase II, San Mateo County, California**

Dear Ms Aozasa:

Kleinfelder is pleased to present this Hydrogeologic Report for the San Mateo County Midcoast Groundwater Study, Phase II. Our investigation has consisted of 1) collecting, assessing, and editing water-well and other databases provided by the County, 2) reviewing readily available hydrogeologic reports conducted by other investigators in the vicinity of the project area, 3) conducting limited site reconnaissance, 4) compiling and assessing well logs from the County's files, 5) reviewing and editing a hydrogeologic graphic information system (GIS) database, 6) measuring water levels and conducting pumping tests in selected available private wells, 7) analyzing the collected data, and 8) preparing this report that presents our methods, analyzes, findings, and recommendations.

The purpose of the Midcoast Groundwater Phase II Study is to evaluate groundwater conditions and to assess the suitability of long-term, and sustainable water supplies within the study area. Based on the soil-moisture-accounting model used in this study, groundwater in the Midcoast marine terraces (Miramar, El Granada, Airport, and Moss Beach) should remain relatively in balance under current and moderate increases in pumpage. Additional pumping will lower the water table but long-term balance should be achieved assuming pumping is moderate. This balance is sustained because outflow to the ocean is variable, i.e., increased pumping will lower the water table, which will decrease outflow to the ocean. However, increased pumping over long periods and during drier years will increase the number of years that the water table falls to or below sea level and this condition increases the risk of saltwater intrusion.

The accompanying report summarizes the project findings and conclusions. The Midcoast Groundwater Study Phase II report is presented in two volumes. Volume I

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contains discussions about the project area, geologic and hydrogeologic conditions, groundwater analysis for the Midcoast Subbasins, along with our conclusions and recommendations for further study. Volume II provides the backup data for the soil-moisture-accounting model analysis. If you have any questions, please contact the undersigned.

Respectively submitted,

KLEINFELDER, INC.

Michael Clark, C.E.G. 1264, C.Hg. 161
Senior Hydrogeologist

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A Report Prepared for:

County of San Mateo
Planning Services Department
455 County Government Center
Redwood City, California 94063

Attention: Lisa Aozasa, Planning Director

SAN MATEO COUNTY MIDCOAST GROUNDWATER STUDY, PHASE II SAN MATEO COUNTY, CALIFORNIA

Kleinfelder Project No.: 26848
January 8, 2007

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SAN MATEO COUNTY
MIDCOAST GROUNDWATER STUDY, PHASE II
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Important Information About Your Geoenvironmental Report

Geoenvironmental studies are commissioned to gain information about environmental conditions on and beneath the surface of a site. The more comprehensive the study, the more reliable the assessment is likely to be. But remember: Any such assessment is to a greater or lesser extent based on professional opinions about conditions that cannot be seen or tested. Accordingly, no matter how many data are developed, risks created by unanticipated conditions will always remain. *Have realistic expectations.* Work with your geoenvironmental consultant to manage known and unknown risks. Part of that process should already have been accomplished, through the risk allocation provisions you and your geoenvironmental professional discussed and included in your contract's general terms and conditions. This document is intended to explain some of the concepts that may be included in your agreement, and to pass along information and suggestions to help you manage your risk.

Beware of Change; Keep Your Geoenvironmental Professional Advised

The design of a geoenvironmental study considers a variety of factors that are subject to change. Changes can undermine the applicability of a report's findings, conclusions, and recommendations. *Advise your geoenvironmental professional about any changes you become aware of.* Geoenvironmental professionals cannot accept responsibility or liability for problems that occur because a report fails to consider conditions that did not exist when the study was designed. Ask your geoenvironmental professional about the types of changes you should be particularly alert to. Some of the most common include:

- modification of the proposed development or ownership group,
- sale or other property transfer,
- replacement of or additions to the financing entity,
- amendment of existing regulations or introduction of new ones, or
- changes in the use or condition of adjacent property.

Should you become aware of any change, *do not rely on a geoenvironmental report.* Advise your geoenvironmental professional immediately; follow the professional's advice.

Recognize the Impact of Time

A geoenvironmental professional's findings, recommendations, and conclusions cannot remain valid indefinitely. The more time that passes, the more likely it is that important latent changes will occur. *Do not rely on a geoenvironmental report if too much time has elapsed since it was completed.* Ask your environmental professional to define "too much time." In the case of Phase I Environmental Site Assessments (ESAs), for example, more than 180 days after submission is generally considered "too much."

Prepare To Deal with Unanticipated Conditions

The findings, recommendations, and conclusions of a Phase I ESA report typically are based on a review of historical information, interviews, a site "walkover," and other forms of noninvasive research. When site subsurface conditions are not sampled in any way, the risk of unanticipated conditions is higher than it would otherwise be.

While borings, installation of monitoring wells, and similar invasive test methods can help reduce the risk of unanticipated conditions, *do not overvalue the effectiveness of testing.* Testing provides information about actual conditions only at the precise locations where samples are taken, and only when they are taken. Your geoenvironmental professional has applied that specific information to develop a general opinion about environmental conditions. *Actual conditions in areas not sampled may differ (sometimes sharply) from those predicted in a report.* For example, a site may contain an unregistered underground storage tank that shows no surface trace of its existence. *Even conditions in areas that were tested can change,* sometimes suddenly, due to any number of events, not the least of which include occurrences at

Accordingly, when geoenvironmental professionals indicate in their reports that they have performed a service "in general compliance" with one standard or another, it means they have applied professional judgement in creating and implementing a scope of service designed for the specific client and project involved, and which follows some of the general precepts laid out in the referenced standard. To the extent that a report indicates "general compliance" with a standard, you may wish to speak with your geoenvironmental professional to learn more about what was and was not done. *Do not assume a given standard was followed to the letter.* Research indicates that that seldom is the case.

Realize that Recommendations May Not Be Final

The technical recommendations included in a geoenvironmental report are based on assumptions about actual conditions, and so are preliminary or tentative. Final recommendations can be prepared only by observing actual conditions as they are exposed. For that reason, you should retain the geoenvironmental professional of record to observe construction and/or remediation activities on site, to permit rapid response to unanticipated conditions. *The geoenvironmental professional who prepared the report cannot assume responsibility or liability for the report's recommendations if that professional is not retained to observe relevant site operations.*

Understand That Geotechnical Issues Have Not Been Addressed

Unless geotechnical engineering was specifically included in the scope of professional service, a report is not likely to relate any findings, conclusions, or recommendations about the suitability of subsurface materials for construction purposes, especially when site remediation has been accomplished through the removal, replacement, encapsulation, or chemical treatment of on-site soils. The equipment, techniques, and testing used by geotechnical engineers differ markedly from those used by geoenvironmental professionals; their education, training, and experience are also significantly different. If you plan to build on the subject site, but have not yet had a geotechnical engineering study conducted, your geoenvironmental professional should be able to provide guidance about the next steps you should take. The same firm may provide the services you need.

Read Responsibility Provisions Closely

Geoenvironmental studies cannot be exact; they are based on professional judgement and opinion. Nonetheless, some clients, contractors, and others assume geoenvironmental reports are or certainly should be unerringly precise. Such assumptions have created unrealistic expectations that have led to wholly unwarranted claims and disputes. To help prevent such problems, geoenvironmental professionals have developed a number of report provisions and contract terms that explain who is responsible for what, and how risks are to be allocated. Some people mistake these for "exculpatory clauses," that is, provisions whose purpose is to transfer one party's rightful responsibilities and liabilities to someone else. Read the responsibility provisions included in a report and in the contract you and your geoenvironmental professional agreed to. *Responsibility provisions are not "boilerplate."* They are important.

Rely on Your Geoenvironmental Professional for Additional Assistance

Membership in ASFE exposes geoenvironmental professionals to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a geoenvironmental project. Confer with your ASFE-member geoenvironmental professional for more information.

ASFE

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SAN MATEO COUNTY
MIDCOAST GROUNDWATER STUDY, PHASE II
SAN MATEO COUNTY, CALIFORNIA

1.0 INTRODUCTION

The San Mateo Midcoast area is a scenic stretch of California coastline extending along US Highway 1 from north of Half Moon Bay in the south to north of the town of Montara (Project Area Map, Plate 1). The study area encompasses the communities of Montara, Moss Beach, Seal Cove, Princeton, El Granada, and Miramar. The land surface rises from the Pacific Ocean along wave-cut terraces, slopes gently upward to the east, then steepens along the granitic slopes of Montara Mountain. Surface topography is interrupted at several places in its assent upslope by geomorphic features created by tectonic (fault offset) and fluvial (stream erosion) processes.

The lower, flatter portions of the Midcoast area consist predominately of marine terraces deposited during the last oceanic high-water stand during the Sangamon interglacial period of the Pleistocene Age (11,000 to 1.6 million years ago, see Geologic Time Scale, Appendix, Plate A-1). As the ocean has withdrawn from its higher elevations during Holocene time (the latest 11,000 years), streams flowing from the highlands of Montara Mountain have eroded narrow valleys into the mountain's granite slopes and into the marine terrace deposits. The alluvium within the valleys and the terrace deposits generally consists of loose, unconsolidated, coarse- and medium-grained sand eroded from the granitic rocks of Montara Mountain. These sediments are the storage reservoirs for most groundwater in the Midcoast area. Most groundwater in the Midcoast area is derived from the alluvial and coastal terrace deposits and weathered granite that are recharged by rain falling on the coastal plains and in the mountains to the east.

The San Mateo County Board of Supervisors has determined that because of the rapid growth within the Midcoast area of the county and the potential limited groundwater source in the area, a new comprehensive study of the hydrogeologic conditions of the area should be conducted. The Midcoast groundwater study was proposed to be conducted in phases. The Board contracted with Balance Hydrologics, Inc. to conduct the Phase I portion of the Midcoast Groundwater Study. The Phase I study consisted of a literature and data review (Balance, April 2002).

The purpose of Balance's Phase I report was to provide a base-line list and review of publications, reports and other documents pertaining to the hydrogeologic conditions of the Midcoast area. The report gives a summary of regional hydrogeology and conditional aquifer boundaries, generalized groundwater occurrence by subbasin and a list of data sources and possible data gaps. Using a "broad-reaching watershed approach," Balance separated out four subbasins in the Midcoast area watershed. The subbasins were designated 1) Martini Creek south to Dean Creek, which includes Montara Creek; 2) San Vicente south to Denniston Creek, including the airport aquifer; 3) El Granada area; and 4) Arroyo de en Medio south to Frenchmans Creek.

1.1 PURPOSE AND SCOPE OF SERVICES

The San Mateo County Board of Supervisors retained Kleinfelder to conduct the Phase II portion of the San Mateo County Midcoast Groundwater Study. The purposes of the Midcoast Groundwater Phase II Study are to evaluate groundwater conditions and to assess the suitability, long-term and sustainable water supplies within the study area. The County has requested this hydrogeologic evaluation of the Midcoast area to assist in long-term basin and watershed planning. It is anticipated that this hydrogeologic study will aid in forming appropriately controlled and efficient permitting of new water wells in the study area.

Beginning with the subbasins defined by Balance, we refined the basin boundaries and defined subareas within the subbasins based on consideration of geologic structural and stratigraphic relationships, topography, known or inferred hydraulic characteristics, and watershed boundaries. In most cases, the subareas are shown to possess distinct hydrogeologic characteristics that should prove useful in future groundwater management. The watershed areas previously defined by Balance Hydrologics have been modified and will be distinguished from smaller areas established in our study, which are referred to herein as "subareas." As noted in this report, the subareas described do not necessarily follow only the margins of watersheds but also include other boundaries such as lithologic contacts and fault traces.

This final report for the Phase II Midcoast Groundwater Study consists of previous memorandum and communications with the County that have been compiled with our analysis of water-level measurements and aquifer pumping tests to provide a hydrogeologic assessment to be used by the County in managing groundwater resources in the Midcoast Study Area. The general scope of the Midcoast hydrogeologic investigation was developed to follow the County's original request of project approach. The scope of the project was modified from its original concept (in conference with the County) based in part on the general condition and quantity of well data provided by the County. This study also included developing Excel worksheets that have been designed to assist County personnel analyze well database information to show proximity of a proposed well to other pre-existing wells in the Midcoast area and to provide well-production information of nearby wells.

1.2 Investigative Methods

The following are descriptions of Kleinfelder's research program that have been used to conduct the San Mateo County Midcoast Groundwater Study.

Data used in groundwater studies are generally estimates made circumspectly but are nonetheless estimates and generally subject to some range of error. Throughout this study, data are rounded for practicality and may not exactly match every listing of that data.

1.2.1 Report and Document Review

Our hydrogeologists reviewed readily available published reports, maps, and other technical documents, which are listed in the attached References section. Research for this hydrogeologic assessment included compiling documents that relate to the Midcoast Study Area. Additional documents reviewed include selected meteorological and agricultural sources. Stereo-paired aerial photographs of the Midcoast area were analyzed for landforms and as an aid in geologic interpretation. Our senior engineering geologist and hydrogeologist conducted mapping of some areas to verify local geologic conditions based on published maps that were relevant to the study. The map data were checked against existing published maps where available to assist in our hydrogeologic interpretations.

1.2.2 Data Management

Kleinfelder received information regarding wells and septic tanks from the San Mateo County Health Services Agency. The data sets included Graphic Information System (GIS) layers and data tables. The well data came from the County in several data sets over an extended period. These data sets included well locations, ownership, correspondence information, and well construction information that the County considered all of their readily available data. The usefulness of the original data was limited because there was no unique identifier for each and every well. In some cases, information about individual wells was in more than one County data set but lacked any consistent link between the related records. Consequently, Kleinfelder created a new field and assigned a unique identification number to each well. To find the related records in the smaller datasets provided by the County, Kleinfelder searched for fields common to both datasets and used fields for latitude and longitude that occurred in both sets. Kleinfelder compared the values in both fields of each record of one dataset with the values in each record of the other. The combination of latitude and longitude proved to be useful in identifying the related records. The remaining records represented cases where two or more wells had the same latitude and longitude. Kleinfelder reviewed the data for each of these groups to determine if duplicate records existed. In cases where duplicates existed, the duplicate was removed from the dataset. In cases where there was clearly more than one well which shared the exact same latitude and longitude, Kleinfelder assigned a unique Well identification number to each and changed the value of latitude by 0.0000001 decimal degree. For all practical purposes, the two wells still plot to the same place on the map but are otherwise treated as unique.

The larger datasets were also edited to separate out records for wells that do not occur in the study area or within the watersheds above the study area. The data were not deleted because they will be returned to the County and may be useful in later studies. Kleinfelder did not field verify data provided by the County except in a very small number of cases. Other that the adjustments made as described above, we used the data as provided by the County. Any inherent errors in the original data remain.

1.2.3 Geographic Information System (GIS)

GIS is a software application that combines the benefits of detailed maps and databases. It allows the organization of data in layers, each containing a set of geographic features and information associated with them. Each layer contains the location and information relating to a single subject such as well locations or geologic formations. The layers used in this study include wells locations, septic tanks, precipitation, topography, land use, soils, and geology. Additional layers were added as appropriate to aid in the hydrogeologic analysis. Each feature in a layer has a unique position on the map represented by a point, a line or a two-dimensional shape. Information about the feature is stored in associated tables of data. Wells, for example, are shown on the maps as points. Information about how the wells are constructed, including total depth, diameter, date drilled, and static water level, is stored in a related data table.

The GIS allows layers to be stacked, like sheets of clear film, over a map. The features of one layer can be used to query or categorize features in another layer. For example, Kleinfelder has delineated hydrogeologic subareas based on criteria given above. We then use these subareas as controls to analyze relationships. For example: how many and where are the wells in a given area that have a depth greater than 100 feet, which wells in a given subarea produce more than 5 gallons per minute, how much rain falls annually in the El Granada Subarea?

The value of the GIS is that we can collect and map data about single subjects in the manner most appropriate for that subject. Then, by overlaying features from many layers on a map, we can explore the special relationships between the attributes of different datasets.

2.0 GEOLOGIC SETTING

The following descriptions of geologic conditions were derived from published reports and from our area investigations. To assist with the definitions of Geologic Time Scale, Plate A-1 is included in Appendix A.

2.1 REGIONAL GEOLOGIC SETTING

The Midcoast Study Area lies within the Coast Ranges Geomorphic Province, which is a discontinuous series of northwest-southeast trending mountain ranges, ridges, and intervening valleys characterized by complex folding and faulting. The general geologic framework of the Central Coast Area of California is illustrated in studies by Jennings and Strand (1958), Page (1966), California Geological Survey (2002) included as the Regional Geologic Map (Plate 2), and Brabb, Graymer, and Jones (1998) included as the Subbasins and Geologic Map (Plate 3).

Geologic structures within the Coast Ranges Province are generally controlled by a major tectonic transform plate boundary defined by the San Andreas fault system. This right-lateral strike-slip fault system extends from the Gulf of California, in Mexico, to Cape Mendocino, off the coast of Humboldt County in northern California and forms a portion of the boundary between two global tectonic plates. In this portion of the Coast Ranges Province, the Pacific Plate moves north relative to the North American Plate, which is located east of the transform boundary. Deformation along this plate boundary is distributed across a wide fault zone that is referred to as the San Andreas fault system. The general trend (about N30-45W) of the faults within this system is responsible for the strong northwest-southeast structural grain of most geologic and geomorphic features in the Coast Ranges Province.

The large wedge of geologic rock west of the San Andreas fault, that generally is underlain by Cretaceous Age (about 140 to 65 million years old) basement of granitic and high-grade metamorphic rock, is referred to as the Salinian Block (Regional Geologic Map). This is a tectonic sub-province defined as a northwest trending, elongate slice of the Coast Ranges. The Salinian Block is bounded by the San Andreas fault on the east and on the west by tectonic features off the coast of California, including the Nacimiento fault zone (Page, 1966). The basement rock crops out in the mountainous portion of the Midcoast Study Area.

2.1.1 Lithologic Units

Lithologic associations in San Mateo County have been divided into ten assemblages by Graymer, Jones, and Brabb (1994). The assemblages are large, fault-bounded blocks that contain unique stratigraphic and lithologic sequences. Each stratigraphic sequence differs from that of neighboring assemblages by containing different rock units, or by different stratigraphic relationship among similar rock units. The current adjacent location of the different assemblages reflects the juxtaposition of basins or parts of basins by large offsets along the faults that bound the assemblages. In general, in San Mateo County, the Tertiary strata rest with angular unconformity on complexly deformed Mesozoic rock complexes. West of the Pilarcitos fault, the Salinian complex, which is composed of granitic plutonic rocks and inferred gabbroic plutonic rocks at depth, overlain in places by Cretaceous strata, forms the Mesozoic bedrock. These plutonic rocks are part of a batholith that has been displaced northward by offset on the San Andreas fault system (Brabb, Graymer, Jones, 1998).

2.1.2 Structure

Faults of San Mateo County are characterized by both strike-slip and dip-slip components of displacement. There are three major fault systems in the County that display large right-lateral offsets, the San Andreas, the Pilarcitos, and the Seal Cove/San Gregorio fault zones, Plate 2. These fault systems trend roughly N30°W and include several fault strands in a broad zone. Offset is distributed on the various faults in the zones, and the locus of fault movement associated with a fault zone has changed through geologic time. The Seal Cove/San Gregorio fault zone, which lies near the base of the terrace adjoining the west side of the Half Moon Bay airport, has strands that display Holocene offset and are, therefore, considered by the State of California to be part of an active fault system.

Pleistocene age terraces are not observed to be folded, but are tilted and uplifted in several places. Late Pleistocene and Holocene surficial deposits retain most of their original depositional shape, but the Pleistocene alluvium and marine terrace deposits have been uplifted as much as several tens of feet in places throughout the County (Brabb, Graymer, Jones, 1998).

2.1.2.1 Airport Graben

The land lying west of US 1 and north of Half Moon Bay is bounded by faults that have displaced the ground surface. The area of the Half Moon Bay Airport is dropped down between an east-bounding fault, which extends on land at Montara Point, and the westbounding Seal Cove / San Gregorio fault (Plates 2 and 3). The down-dropped land between these two faults is geologically described as a "graben." The strip of raised coastside west of the Half Moon Bay Airport and west of the Seal Cove / San Gregorio fault where Pillar Point and the community of Seal Cove are located is geologically referred to as a "horst." This area has been tectonically uplifted west of the Seal Cove / San Gregorio faults. The barrier caused by earthquake forces along the Seal Cove / San Gregorio fault, to some extent, has hydrogeologically isolated this uplifted land west of the fault from the mainland groundwater sources. Because the Seal Cove / San Gregorio fault acts as a partial groundwater barrier, only minor quantities of water are believed to flow from the Airport Subarea to the uplifted block west of the fault. Likewise, the fault barrier impedes seawater from intruding significantly into the Airport Subarea along this block boundary. Section 7.2.3.3 Change in Storage describes groundwater conditions near Pillar Point Marsh and how it may be affected by saltwater intrusion.

2.2 MIDCOAST GEOLOGIC SETTING

2.2.1 Midcoast Stratigraphy

Mapped geologic units and formations within the Midcoast area as described by Brabb, Graymer, Jones (1998), and depicted on the Subbasins and Geology Map, Plate 3, are presented below.

Qcl Colluvium (Holocene)--Loose to firm, friable, unsorted sand, silt, clay, gravel, rock debris, and organic material in varying proportions. This material veneers steeper slopes in the County and is deposited by slow downslope movement of soil mixed with weathered rock. Colluvium generally exists as a thin (a few feet thick) veneer on slopes and generally is not considered as a groundwater source.

Qyf Younger (inner) and Qyfo Younger (outer) alluvial fan deposits (Holocene)--Unconsolidated fine- to coarse-grained sand, silt, and gravel, coarser grained at heads of fans and in narrow canyons. These deposits can store comparatively large quantities of water.

Qmt Marine terrace deposits (Pleistocene)--Poorly consolidated and poorly indurated well- to poorly-sorted sand and gravel. Thickness variable but usually are less than 90 feet. Marine terrace deposits in the Midcoast area have historically been a predominate source of groundwater.

Tp Purisima Formation (Pliocene and upper Miocene)--Predominantly gray and greenish-gray to buff fine-grained sandstone, siltstone, and mudstone, but also includes some porcelaneous shale and mudstone, chert, silty mudstone, and volcanic ash. Water quantity and quality from these deposits has been found to be marginal, at best.

Tm Monterey Formation (middle Miocene)--Grayish-brown and brownish-black to very pale orange and white, porcelaneous shale with chert, porcelaneous mudstone, impure diatomite, calcareous claystone, and with small amounts of siltstone and sandstone near base. Monterey closely resembles parts of Purisima Formation. Thickness ranges from about 300 to 1300 feet at the surface and up to 1800 feet in the subsurface west of the Seal Cove/San Gregorio fault. The porcelaneous and indurated nature of the Purisima and Monterey Formations generally make these rock formations poor sources of water. In addition, groundwater sourced from Tertiary formations is generally of lower quality than that from Quaternary units in the Midcoast Area.

Kgr Granitic rocks of Montara Mountain--Very light gray to light brown, medium- to coarsely-crystalline foliated granitic rock, largely quartz diorite with some granite. These rocks are highly fractured and deeply weathered. Foliation is marked by an alignment of dark minerals and dark dioritic inclusions. Tabular bodies of aplite and pegmatite generally parallel foliation. Narrow valleys incised in the granite of Montara Mountain rise from the base level of the Pacific Ocean to nick points within the pluton. Fractured crystalline rock is not generally considered a source rock for groundwater. Water stored in fractures is generally unreliable over long-terms. However, recently drilled wells in the Upper Montara Subbasin have reportedly tapped large sources of good quality water.

3.0 HYDROGEOLOGY

3.1 HYDROGEOLOGIC SETTING

For groundwater resource evaluation, geologic formations in the Midcoast area have been grouped into the following four units: 1) alluvium in the valley troughs and overlying low-lying terrace deposits, 2) marine terrace deposits, 3) Tertiary Age Purisima and Monterey Formations and 4) granitic bedrock.

Where sufficiently thick, Quaternary Age deposits are the better-quality long-term sources of groundwater in the Midcoast area. The Quaternary units are not as lithified or naturally cemented as the older Tertiary and Mesozoic rocks and contain abundant interconnecting pore spaces that act as reservoirs that store and easily give up water to wells.

Because of the fine-grained nature and cementation of the Monterey and Purisima Formations and the intergrown crystalline structure of the Montara granite, little primary porosity and water storage is expected in the unfractured bedrock. Fractured bedrock holds water in its cracks that have formed from folding and faulting of the brittle rock. Water enters the fractured bedrock by means of off-site through-flow and downward percolation of surface water.

Groundwater dynamics of fractured bedrock aquifers are not well understood and it is challenging to solve water-resource problems in bedrock settings. Flow and storage occurs primarily in bedrock fractures, joints, and foliation planes. The matrix porosity and permeability is very low or close to zero, with higher permeability in the fractures.

Many groundwater issues are amplified in fractured-rock aquifers because responses to pumping stresses and contamination can be more rapid than in alluvial aquifers. Significant features of fractured-rock aquifers include: 1) flow of groundwater across surface-water divides is rarely observed; 2) aquifer parameters like storativity and transmissivity often show erratic variations over small areas; 3) the saturated portion of the mantle of weathered rock or alluvium overlying the fractured rock often makes a significant contribution to the yield obtained from a well; 4) only a modest quantity of groundwater is generally available in any one well; and 5) drawdown in a pumping well is often almost equal to the total saturated thickness of the aquifer.

The volume of water stored in fractured hard rock is generally estimated to be less than two percent of the rock volume (DWR, 1991). This percentage decreases with depth as fractures become narrower and farther apart. The total amount of water in storage in the rock surrounding a hard rock well is small, so that the groundwater level and the well's yield can decline dramatically in response to pumping or drought.

The available volume of water stored in many alluvial soils can amount to 10-15 percent of the volume of the alluvium (DWR, 1991). In areas where alluvium overlying the hard rock is saturated with water, the alluvium provides additional water storage for nearby hard-rock wells. This situation most often occurs in valleys.

Groundwater sourced from fractured bedrock generally is limited by a finite interconnected system of open spaces. The interconnected fractures form a reservoir for water storage and migration. Water may flow freely (even turbulently) from such a reservoir and may be pumped for a limited duration but may not have a sustainable yield.

4.0 DESCRIPTION OF THE CONCEPTUAL-MODELING PARAMETERS

4.1 HYDROGEOLOGIC UNITS OF THE MIDCOAST STUDY AREA

A hydrogeologic conceptual model generally includes a graphic representation of the hydrogeologic flow system in the form of plan maps and geologic cross-sections (Plate 4) and block diagrams (Plate 5), These graphic representations are used to identify and describe the relationships between various components of a hydrogeologic flow system. The purpose of a conceptual model is to simplify the field problem and organize the field data such that the system can be analyzed more readily. Simplification is necessary because complete reconstruction of the field system is not feasible.

For the San Mateo County Midcoast study, Kleinfelder used a GIS to develop plan maps for the conceptual model. The process was carried out as follows:

Published and open-file reports were reviewed to draw from previous work in the study area and assess known hydrogeologic relationships and the amount of usable data available.

The County's well database was acquired and reviewed, culled of references that could not be adequately located or contained no significant data, and sorted for parameters of interest. A plan map was prepared using the GIS to delineate the entire Midcoast Study Area and the major hydrogeologic units and their contributing watersheds. The nomenclature of the hydrogeologic units used in this report is as follows:

- Midcoast Study Area (shown enclosed in a blue line on Plate 3)
- Subbasins (shown enclosed in red lines on Plates 3 and 6)
- Subareas (consisting of terraces, uplands (watersheds), and stream valley numbered and color highlighted on Plate 6.

Starting with the broad-scope evaluation by Balance Hydrologics (2002), the Midcoast Study Area was divided into eight distinct Subbasins each consisting of one or more definable Subareas. For this present study, each of the eight Midcoast Subbasins was subdivided into Subareas (terraces, uplands, and stream Valleys) based on hydrogeologic information (similar geologic units through which groundwater flows, with similar groundwater behavior, and considering structural features), available well data, topography, and other controlling features. Below is a listing of the Subbasins and component Subareas:

TABLE 1
MIDCOAST SUBBASINS AND SUBAREAS

Subbasins / Subareas	
Frenchmans Subbasin	
1	Frenchmans Terrace Subarea
2	Frenchmans Upland Subarea
3	Frenchmans Stream Valley Subarea
Arroyo de en Medio Subbasin	
4	Miramar Terrace Subarea
5	Arroyo de en Medio Upland Subarea
6	Arroyo de en Medio Stream Valley Subarea
El Granada Subbasin	
7	El Granada Terrace Subarea
8	El Granada Upland Subarea
Airport Subbasin	
9	Airport Terrace Subarea
10	Denniston Upland Subarea
11	Denniston Stream Valley Subarea
13	San Vicente Upland Subarea *
14	San Vicente Stream Valley Subarea *
Moss Beach Subbasin	
12	Lower Moss Beach Subarea
13	San Vicente Upland Subarea *
14	San Vicente Stream Valley Subarea *
15	Dean Creek Subarea
19	Upper Moss Beach Subarea
20	Lighthouse Subarea
Montara Creek Subbasin	
16	Portola Subarea
17	Montara Creek Upland Subarea
18	Lower Montara Creek Subarea
21	Wagner Valley Subarea
22	Montara Terrace Subbasin
23	Martini Upland Subbasin

Notes: Numbers in the left column refer to Subareas shown on Plate 6.

* Although San Vicente upland and stream valley is shown as a separate subbasin defined by watershed boundaries on Plate 3, because its water flows to both Moss Beach and Airport Subbasins, it is treated in this report as parts of the adjacent subbasins.

The Subbasins listed above and shown on the Plate 3 are generally consistent with those described by Kleinfelder (1988, 1989), Balance Hydrologics (2002), and California DWR (1999). Lowney-Kaldveer (1974) studied the Denniston Creek area adjacent to the airport in 1974. In their investigation, they distinguish three subareas in the airport aquifer: San Vicente fan area, Denniston Creek fan area, and the Half Moon Bay airport area. These subdivisions were not made in the current study because these fan areas are relatively small, not easily distinguishable and are an integral part of the Airport Aquifer Subarea. Further subdivision of this area may be made in the future, as necessary, following further assessment of the area.

Defined Subareas used in this study listed by category of hydrogeologic unit, along with selected physical parameters are listed in the following table.

TABLE 2.
SUBAREA DATA

Hydrogeologic Units (Subareas)		Number of wells	Number of Septic tanks	Area (acres)	APNs		Ocean Frontage (ft)
					Number Developed	Number Undeveloped (Plate 7)	
Terraces							
1	Frenchman	7	2	313	0	414	3,318
4	Miramar	93	4	264	0	700	3,684
7	El Granada	260	2	453	596	774	7,280
9	Airport	91	2	871	1	800	3,616
12	Lower Moss Beach	54	2	189	134	465	3,640
19	Upper Moss Beach	20	1	71	254	53	------
20	Lighthouse	0	0	17	7	1	
Upland areas							
2	Frenchman	7	0	2556	0	36	------
5	Arroyo de en Medio	7	1	703	0	50	------
8	El Granada	103	5	1056	286	555	------
10	Denniston	0	0	9018	1	15	------
13	San Vicente	1	1	1001	0	9	------
15	Dean Creek	55	31	25	27	192	------
16	Portola	35	18	157	0	129	------

TABLE 2.
SUBAREA DATA
(CONTINUED)

Hydrogeologic Units (Subareas)		Number of wells	Number of Septic tanks	Area (acres)	APNs		Ocean Frontage (ft)
					Number Developed	Number Undeveloped (Plate 7)	
17	Upper Montara Creek	3	2	506	0	26	------
22	Montara	184	11	438	2	1,160	4,726
23	Martini	6	5	991	0	34	3,943
Stream valleys							
3	Frenchman	0	0	132	0	12	------
6	Arroyo de en Medio	1	1	52	0	6	------
11	Denniston	1		10	0	3	------
14	San Vicente	1	1	14	0	5	------
18	Montara Creek	8	3	58	34	36	------
21	Wagner Valley	9		79	0	26	------
Totals:		946	92	18,9746	1,342	5,501	30,207

Numbers in left column refer to Hydrogeologic Units depicted on Plate 6.

The data above include numbers of wells, septic tanks, developed and undeveloped lots that were provided by the County of San Mateo. The number of wells above reflects a modified database provided by the County. The original number of wells was pared down, based on confidence of measurements, to about 500 for use in our analysis. Later, the wells not considered accurately located were added back to the database to show a reasonable, full accounting (i.e. potential pumping demand) of wells in the study area. The sources of other parameters above are described in this report.

4.2 PRELIMINARY EVALUATION OF AVAILABLE DATA

Kleinfelder reviewed the County's well database to determine what information was available from this source, and assessed the usefulness of the data. Beginning with 1087 well records for the Midcoast area, 539 were deemed useable for the purposes of this study (See Section 1.2.2). Records were generally eliminated if the location of the wells could not be determined with any reasonable degree of certainty. After the list was pared down, the wells were plotted using the GIS to observe the distribution of the wells. Plate 6 shows the distribution of the reduced set of wells in the County's database in the Midcoast area. The plot indicates generally good coverage in the areas of interest.

After grouping the well data by each aquifer-study area, the relevant hydraulic data from the County records were tabulated (Table 2) and assessed. Well depth and depth to water frequency distributions of wells were plotted for portions of the Montara Subbasin (Montara Terrace and Montara Heights), Moss Beach, Airport, El Granada, and Miramar Subbasins. These frequency distribution plots are included in Plates 8 and 9.

4.3 Evaluation of Depth to Water

A USGS digital elevation model (DEM) with 10-meter accuracy was used with the GIS in an attempt to assess the depth to water and water-elevation data in the County's database. This assessment was performed by first estimating with the DEM the wellhead elevation of each of the wells (since little actual elevation data are available for the wells), then calculating the groundwater surface elevations using the depth-to-water data. The resultant groundwater surface elevation data were graphically displayed by plotting color-coded well groundwater surface elevation ranges (e.g. –25 to 0 feet elevation, 1 to 25 feet elevation etc.).

The DEM-based wellhead plot showed that the predicted elevations have increasing error with increasing elevation in upslope areas. In addition, the subsequent plots of water-surface elevation show significant scatter in the data. Some scatter in the generated water-surface elevation data was expected because the depth-to-water data from which it was derived were collected at different times of the year, in different years, and it is not known whether the measurements were made following periods of pumping. However, the plots showed groundwater elevation in such extremes that the data were considered inappropriate and were not used in this analysis. The depth to water data, although qualitatively interesting, for the reasons stated above was deemed not reliable for detailed assessment.

The County data also contains limited information on pumping rates, availability of boring logs, water quality etc. Where depth-to-water data were available for a well, there generally is pumping rate information available. Collectively, these data were used to estimate the specific capacity (gallons per minute / feet of drawdown) of wells with sufficient data. Specific capacity has been used by investigators to derive a rough estimate of an aquifer's transmissivity. The parameter of transmissivity is important in assessing the volumetric rate of groundwater flow to a well, and an estimate of drawdown at the well during pumping. In a few cases, actual long-term pumping test data are available, reported with the well logs or found in Midcoast area reports. The specific capacity data are useful for generalizing groundwater production.

4.4 DISTANCE TO SURROUNDING WELLS SPREADSHEET

Included with this report is an Excel spreadsheet titled "Distance to Surrounding Wells." A disk with the spreadsheet is contained in a pocket at the end of this report. A description on the use and modification of the spreadsheet is included in Appendix B. This spreadsheet can be used by County personnel to search for wells contained in the database and within a given distance from the approximate center of any APN in the Midcoast area.

5.0 FIELD DATA COLLECTION

To assist in evaluating hydrogeologic conditions in the San Mateo County Midcoast area, Kleinfelder conducted water-elevation monitoring in 26 selected wells. In preparation for measuring depths to groundwater in the Midcoast area, over 400 letters were mailed to well owners in the Midcoast area requesting use of their wells for water-depth monitoring. Twenty-six wells were selected from the approximately 50 positive responses for the groundwater measurement program. The selection of wells to monitor was in part based on distribution throughout the study area, on each wells possible representation of aquifers, accessibility, and other related factors. Access to each well was verified and a measurement point was marked at the top of each well casing. Muir Consulting, a civil engineering survey firm, was contracted to survey the locations of the wells and to determine the elevation of each wellhead. The survey was conducted by means of GPS to a horizontal and vertical accuracy of 0.01 foot. Wells that were not accessible for GPS measurement were surveyed by conventional sight techniques to the same degree of accuracy.

The groundwater-elevation monitoring program extended over a period of about one year from September 2004 to October 2005. Nine water-level measurement events were conducted in most of the wells during that time. Generally, measurements were concentrated during the winter and spring months and spaced out more in the summer months because the response to rain predominately in the winter would be important to the study. Some measurements were missed at some wells due to access problems.

The results of the water level monitoring program are displayed graphically in Plates 10, 11, and 12 and discussed in Section 7 of this report.

During the period of the water-level measurements, Kleinfelder sent letters to the 26 well owners to request authorization to conduct pumping tests on their wells. From the approximately 10 positive responses received, four of the wells monitored for water elevations were selected for conducting pumping tests. Where possible, the test well was selected based on it being representative of one of the Subbasins. The general locations of the wells tested are shown on Plate 6. Due to limitations imposed by well owners, the pumping tests were conducted for 24 hours only. The test at each well consisted of installing transducers in the casing to measure the change in water level during pumping and attaching an electronic meter to the discharge pipe. The transducers and discharge monitor were linked to a laptop computer secured at the well-head site to collect the data in real time.

Before the pumping test was run, a short-term step-drawdown test was conducted to estimate the rate that the well could be pumped at a constant discharge. After the step-drawdown test, the wells were pumped continuously at a constant discharge when possible. However, the primary limitations to the continuous pumping phase of the tests were caused by some of the wells going dry even at very low pumping rates.

A discussion of the pump testing work and results of the tests are presented in Section 6.0.

6.0 HYDROGEOLOGIC ANALYSIS

6.1 PUMPING-TEST ANALYSIS

Constant-rate discharge pumping tests can be used to calculate the transmissivity and storativity values of aquifers. Once these factors are obtained, well and aquifer performance under different pumping regimes can be modeled (predicted). Four selected wells were used to analyze well and aquifer characteristics in the Midcoast Study Area. The wells used in our pumping tests were selected based on a limited number of wells made available for testing by well owners in the area and locations that were considered most beneficial to our study. We attempted to locate wells that were close enough together so that one could be monitored during pumping of the other. However, due to the limited permission to allow access to wells in the study area the four pumping tests were conducted without the benefit of a monitoring well. The lack of monitoring wells means that storativity was not calculated in this study. The general locations of the pumped wells are shown on Plate 6.

Aquifer characteristics were evaluated using the pumped well-test data (Plates 13 and 14) by applying approximations of the Theis equation. The Theis equation relates drawdown or recovery of groundwater head to the rate of discharge or addition of water and to the hydraulic characteristics of an aquifer. Standard assumptions of the Cooper-Jacob approximation of the Theis non-equilibrium well equation were adopted (Kruseman and DeRidder, 1983; Todd, 1980) for use in the analyses presented here. The Cooper-Jacob approximation of the Theis equation can be used to calculate aquifer transmissivity. It can also be used to estimate aquifer storativity, if an observation well is present.

To apply the Cooper-Jacob equations, several assumptions of pumping systems have to be met. Two of the Cooper-Jacob assumptions that warrant specific consideration for the wells in the Midcoast area are:

- The aquifer is confined;
- Well diameters are small such that well casing storage can be neglected; and
- The pumped well fully penetrates and is screened over the entire aquifer thickness resulting in assumed laminar horizontal flow to the well during pumping.

Casing storage becomes a concern for wells with relatively low aquifer transmissivity and associated low well yields relative to well-casing diameter. This was the case for the four wells tested. Although the casing diameters in the wells at the site are small, the transmissivity generally is also low. Therefore, analysis of pumping-test data requires consideration of the critical time after which casing storage no longer affects drawdown in the pumped well, i.e. when discharge from the well is effectively all from the aquifer and not partially from water stored in the casing. Use of data prior to the critical time in any given well typically results in artificially high values of transmissivity. The equation used to calculate the critical time for casing-storage removal (t_c in minutes) is given by Shafer (1978):

$$t_c = [0.6\,(d_c^2 - d_p^2)]/(Q/s)$$

where

d_c	=	inside diameter of well casing (in.)
d_p	=	outside diameter of pump column (in.)
Q	=	constant pumping rate (gpm)
s	=	drawdown at time t_c

This equation provides the minimum time expected to generally exceed casing-storage effects. Calculations of aquifer transmissivity described below are based on time-drawdown data recorded after the minimum critical time for casing-storage removal.

The second assumption of the Cooper-Jacob approximation is that the pumped well fully penetrates and is screened over the entire aquifer thickness, resulting in horizontal flow to the well during pumping. For the Midcoast wells, the standard Cooper-Jacob method could not be used for appropriate calculation of storativity because the well screens only partially penetrate the aquifer and observation well data is not available. Partial penetration induces significant vertical flow components, which violate the assumption of horizontal flow. For this reason, a modified Cooper-Jacob method that accounts for the effects of partial penetration (Kruseman and DeRidder, 1983) was used in this study.

6.1.1 Transmissivity

Transmissivity *(T)* is the rate at which water flows in gallons per minute through a one foot wide, saturated vertical section of an aquifer under a hydraulic gradient of 1. In this report, units of Transmissivity are given in gallons per day per foot of aquifer (gpd/ft). Generally, if an aquifer has a transmissivity of less than 1,000 gpd/ft, it may be only sufficient to supply water for domestic wells (Driscoll, 1989).

The graphs of drawdown against log of pumping time for the pumping test for the four tested wells are presented on Plates 13 and 14. These graphs are used to estimate

Transmissivity *(T)* and hydraulic conductivity *(K)*. Transmissivity is estimated from the pumping rate and the slope of the time-drawdown graph using the following relationship (Driscoll, 1989):

$$T = \frac{264Q}{\Delta s}$$

where

T = coefficient of transmissivity, in gpd/ft.
Q = pumping rate, in gpm
Δs = change in drawdown measured over one log graph cycle of time

6.1.2 Hydraulic Conductivity

Hydraulic conductivity is a measure of the capacity of a porous medium to transmit water. Higher values of hydraulic conductivity represent a greater ease of water movement through the medium. For the four wells from which we could obtain pumping test data, the value of hydraulic conductivity *(K)* ranged from of 0.05 to 11.5 gpd/ft^2. These values were estimated by dividing transmissivity by screen length. The range of hydraulic conductivity is considered low for natural aquifer material (Driscoll, 1989) and is generally consistent with terrace deposits encountered at the site by others.

6.1.3 Pumping Tests

The following sections describe details of the pumping tests conducted on four wells in the Midcoast Study Area. Log time/drawdown plots of the pumping tests are presented on Plates 13 and 14. Pumping durations were limited by requirements of the well owners. When possible, the pumping test was run for a minimum of 24 hours. At each well head, the pumping-piping system to the residence was temporarily disconnected and a flow meter was attached to the discharge piping. An Instrumentation Northwest PT2X submersible pressure/temperature Smart Sensor containing a built-in datalogger was placed in the well to maximum possible attainable depth. No nearby wells could be located for use as observation wells. The pumped water was discharged down-slope into drainages at least 100 feet from the well.

6.1.3.1 Well 1342, Dean Creek Subarea

The well is located approximately 100 feet from the apex of a low hill. The well is the primary source of water for the residence, as well as three horses on-site. An initial assessment of the well/pump revealed dual safety cut-off switches for the well pump and an external pump used to refill the horse watering troughs.

Due to a lack of information regarding the well/aquifer parameters before the test was begun, an initial flow rate of 7.9 gpm was selected. At this pump rate, the water column within the well drew completely down to the top of the pump within 10 minutes. The water was allowed to recover completely to its pre-pump level. A second flow rate of 1.5 gpm was then tested with complete drawdown of the water column within 90 minutes. The water was again allowed to recover to pre-test level. A minimum possible flow rate of 0.65 gpm (constrained by the pump and safety cut-off switch) was applied for the duration of the pumping test. The test was started at 2:15 pm with negligible variations in flow rate throughout the test. The pump was shut-off at 2:45 pm the following day and permitted to recover until the initial water level returned to 67.88 feet.

6.1.3.2 Well 342, Airport Subarea

Well 342 is located in the Airport Subarea near the border of the El Granada Subarea. Well 342 is located beneath the patio behind the primary residence, approximately 200 feet from a seasonal stream channel. The well is situated in the center of the yard and is used for irrigation only. The home is connected to the city water system.

An initial assessment of the well/pump revealed a safety cut-off switch for the well pump. A flow meter was attached to the piping and the transducer datalogger was placed in the well to the maximum possible attainable depth. A nearby well was located on the adjacent property for possible use as an observation well but after several attempts, the cover could not be removed. The pumped water was discharged into the concrete rain gutter approximately 100 feet from the well.

County well information regarding the well/aquifer parameters indicated a sustainable flow rate of 6.5 gpm and an earlier aborted 24-hour test the prior week showed the well could perform at a significantly higher level of at least 10 gpm. The test was started at 3:15 pm with negligible variations in flow rate throughout the test. During the test, the water was extracted at the maximum possible flow rate of the pump (15 gpm) for a minimum of 24-hours. The pump was shut-off at 2:42 pm the following day and permitted to recover until the water level stabilized.

6.1.3.3 Well 1347, Moss Beach Subarea

Well 1347 is located in an open field south of the primary residence, approximately 100 feet east of an actively flowing stream. The well is used for irrigation only; the home is supplied by city water.

An initial assessment of the well/pump revealed frayed wiring and a damaged control box leading to the pump. A flow meter was attached to the piping and the transducer with datalogger was placed in the well to the maximum possible attainable depth. No nearby wells could be located for use as observation wells. The pumped water was discharged into a large storage tank approximately 75 feet from the well. Throughout the test, the storage tank was continually emptied by an external pump supplying water to the far side of the property for irrigation.

County well information regarding the well/aquifer parameters indicated a sustainable flow rate of 1.5 gpm but based on the location of the well within the watershed and knowledge of the subsurface materials, a significantly higher flow rate was selected. The test was started at 11:20 am with negligible variations in flow rate throughout the test. During the test, the water was extracted at the maximum possible flow rate of the pump (7.6 gpm) for a minimum of 24-hours. The pump was shut-off at 11:35 am the following day and the well was permitted to recover until the water level stabilized.

6.1.3.4 Well 163, El Granada Subarea

Well 163 is located along the side of the primary residence, approximately 75 feet from a non-flowing ephemeral stream. The residence is on city water and the well is currently not used as a source of water.

An initial assessment of the well and pump revealed an empty casing with no available power source. After speaking with the owner, we were granted permission to use electricity from the home. A flow meter was attached to the piping and a transduced with a datalogger was placed in the well to the maximum possible attainable depth. In addition, a submersible pump was placed in the well for the duration of the test. No nearby wells could be located for use as observation wells. The pumped water was discharged into the creek channel 100 ft. from the well.

Based on County well information regarding the well/aquifer parameters and an initial test a sustainable flow rate of 5.8 gpm was selected. The test was begun at 8:30 am with the initial flow rate of 5.8 gpm. Due to unknown characteristics of the well and aquifer, after continued monitoring for three hours, the flow rate was decreased to 5.2 gpm in order to prevent pumping the well dry during the test. After an additional five hours of monitoring, the flow was decreased to 4.5 gpm to prevent pumping the well dry. The pump was shut-off at 8:30 am the following day and the well was permitted to recover until the water level stabilized.

6.1.4 Summary of Pumping Test Results

The following table presents a summary of results from pumping tests conducted for this study.

TABLE 3.
PUMP TEST ANALYSIS RESULTS

KA Well ID No.	Well location	Δs	Q (g/min)	T (g/da/ft)
1342	Dean Creek	21.5	0.65	8
342	Airport / El Granada Terrace	0.8	15.00	4,950
163	El Granada Terrace / Uplands	24	4.50	50
1347	Moss Beach	1.2	7.60	1,672

If an aquifer has a transmissivity of less than 1,000 gpd/ft., such as seen at the tested wells in the Dean Creek and El Granada Terrace Subareas (Plate 6), it can supply only sufficient water for domestic wells or other low-yield uses. Pumping tests that show low yield might be the result of a clogged annular pack or screen or by poor construction or poor development. Such low-yield wells may not be indicative of actual aquifer conditions and may be improved by re-development. The pumping-test results show that aquifers tapped by one of the wells in the Airport / El Granada Terrace Subareas and one in the Moss Beach Subarea have relatively high yields and may be marginally adequate for municipal, or irrigation purposes.

7.0 SUBAREA WATER-BALANCE ASSESSMENT

A hydrologic budget (or water budget) describes the balance of atmospheric moisture, surface water, and groundwater in a defined area over a time frame of interest under inferred or measured conditions. For the Midcoast hydrogeologic study, hydrologic budgets were developed for subareas within the seven subbasins (Plate 3) and the urban limit lines shown on Plate 1.

The generalized groundwater budget equation is:

$$dS_g/dt = I + G_{in} - G_{out} - Q_g - E_g - T_g$$

Where dS_g/dt is the change in volume of groundwater over the period of interest, I is infiltration rate, G_{in} and G_{out} are groundwater flow rates in and out of the control volume over the period of interest, Q_g is groundwater rate of flow into or out of surface streams, E_g is surface evaporation rate, T_g is plant transpiration rate of surface moisture. The equation is expressed in terms of volumes per unit time. Using net mass exchanges and simplifying for the project conditions, the equation can be presented as:

$$\Delta S = Qp + P \pm R_o - ET$$

Where ΔS is the change in total water volume over the period of interest, Qp is pumpage, P is the precipitation (Plate 15), R_o is the combined effect of water flow across and through the area of interest, ET is a combined evapotranspiration term that represents an estimate of evapotranspiration. The following sections generally describe the methods used in the hydrologic budget for the Midcoast Study Area.

7.1 METHODOLOGY OF THE HYDROGEOLOGIC ANALYSIS

After data collection described in Section 4.3 above, the hydrogeologic analysis of the Midcoast Study Area moved to the development of conceptual models and water balance assessment. The water balance assessment involves assembling available information of water quantities that enter and exit the groundwater reservoir system and aquifer geometry. The difference between the volumes of water entering and water leaving the system gives the quantity retained in storage. Over time this provides rates of storage depletion or storage increase. The complexity of each subarea assessment is dependent upon the extent and quality of the available data upon which the assessment was based, aquifer geometry, and subarea interconnection. With the exception of the Montara Terrace Subbasin, to conduct our analysis, the groundwater Subbasins were divided into two general areas:

- Upland areas where shallow bedrock consists primarily of granite and where groundwater is stored and flows in rock fractures and weathered granite.
- Terrace / alluvial areas where significant groundwater that is available to wells is stored in coarse-grained marine terrace deposits and alluvial deposits along the margins of the terraces.

Due to the significant slopes and generally rapid water drainage and the relatively limited storage capacity (and lack of data to define it) it is assumed that the storage of percolated water in the weathered and fractured granite is relatively short lived and that water travels as underflow to the terrace deposits where it accumulates. Difficulties of analyzing groundwater conditions in fractured bedrock are described in the Hydrogeologic Setting, Section 3.1 above. Water is lost from the terrace areas primarily by pumpage, outflow to the ocean, and evapotranspiration. The rate of outflow generally is dependent on the volume of water in storage. For our water-balance model, it was assumed that groundwater inflow from the terrace deposits of adjacent groundwater basin areas to the north and south is negligible and that no groundwater flows across the topographic watershed divides.

In the Montara Terrace Subbasin, an upland area does not exist; therefore, a more simplistic approach was taken as described in subbasin's respective section.

7.1.1 Water-Balance Models

7.1.1.1 Rainfall-Runoff-Percolation (Soil Moisture Accounting) Model

The amount of water available to percolate into the upland and terrace areas was estimated using a rainfall-runoff-percolation soil-moisture accounting model. The model was developed using 55 years (1950 – 2005) of monthly rainfall data from a measuring station located in Half Moon Bay about two miles to the south of the Midcoast Study Area. The Half Moon Bay rainfall data were adjusted to account for orographic effects using the parameter–elevation regression on independent slopes model (PRISM) (USDA-NRCS, 1998). Runoff was estimated using the Soil Conservation Service (now NRCS, Natural Resource Conservation Service) curve-number method (NRCS national Engineering Handbook, Part 630 Hydrology). Curve numbers were selected based on hydraulic properties of local soils reported by the NRCS. Available soil moisture was tracked on a monthly basis through 55 years assuming an available soil-moisture holding capacity within the root zone estimated from NRCS soil data. In the soil-moisture-accounting model, soil moisture in excess of the available water holding capacity of the soil and evapotranspiration demand is available to percolate to groundwater. Evapotranspiration data used were unadjusted average monthly potential evapotranspiration data taken from U.C. Berkeley Cooperative Extension Leaflet 21426 (1986).

7.1.1.2 Terrace Aquifer Water-Balance Model

The terrace aquifer water-balance model was developed for use in the El Granada, Miramar, and Lower Moss Beach subareas as described below.

After the annual percolation amounts for both the upland and terrace areas were derived using the rain-fall-runoff-percolation model described above, these amounts were combined on an annualized basis to yield the total input into the groundwater system[1]. Annual pumpage from wells was then subtracted from the percolated water totals. The amount of pumpage was estimated based on the number of known / permitted wells obtained from San Mateo County records and using an average-connection usage value developed by the Coastside County Water District (Todd, 2003). The Coastside County Water District value (244 gallons per day per connection) was rounded up to 250 gallons per day in the model. The net amount of water (percolation minus pumpage) provides an estimate of the annual input of water to the terrace area aquifer.

Channel and pond seepage of runoff water was set at three percent, consistent with values used by others (Todd, 2003). The seepage values were added to the estimated total aquifer inputs prior to ocean discharge.

The average annual amount of water in storage in the terrace aquifer above sea level was calculated on an annual basis by adding the annual input of water to the preexisting amount of water in storage, then subtracting the amount of water that flows to the ocean. The amount that flows to the ocean was estimated for each water year assuming Darcian flow. The outflow was projected using a calculated hydraulic gradient; transmissivity estimates obtained from previous studies and Kleinfelder

[1] It should be noted that the time lag from when the precipitation hits the ground to when it enters the groundwater body of interest is assumed to be zero. This lag can be substantial, but no data are available to estimate this lag.

pumping test results; and the horizontal distance along the coastline. The hydraulic gradient was evaluated for each water year using an average hydraulic head value in the terrace for each modeled water year and the measured horizontal distance between the coast and approximately half way up the terrace (vicinity of the wells monitored by Kleinfelder). The hydraulic-head values used were the average of head values based on the total annual input plus the pre-existing amount of water in storage, and the head value from the preexisting storage amount of water. The average hydraulic-head values were also calculated based on a specific yield of 0.08 (Balance 2003); and the measured area of the terrace.

7.1.2 Calibration / Validation

Groundwater surface elevations measured by Kleinfelder in selected wells were used to calibrate the terrace aquifer water-balance model to the extent possible. Calibration was performed by adjusting hydraulic parameters (principally transmissivity and curve number) within an expected / reasonable range of values until the final groundwater surface elevations (hydraulic-head values) and average hydraulic gradients matched or came as close as possible to the measured data. Water levels measured by Kleinfelder during the 2004-2005 water year were used to “calibrate,” to the extent possible, the water-balance model. The wells that were selected for this purpose were those that exhibited similar behavior and similar water-surface elevations over the 2004-2005 water year (see Hydrographs, Plates 10, 11, and 12) and are located approximately half way up the terrace from the ocean. “Validation” was accomplished by comparison of available water-level data from previous years to the predicted hydraulic head in each of those respective years.

Adjusting the transmissivity within the range of expected values is reasonable given that transmissivity estimates for the terrace aquifers vary from place to place, given the observed heterogeneity of the water-bearing sediments, and because transmissivity varies proportionally with saturated thickness of the water-bearing zone. Also, the saturated thickness varies seasonally and from year to year. Most estimates of transmissivity for the marine terrace have been made based on specific capacity of the wells, because few formal pumping tests have been performed in the Midcoast area. Where possible, transmissivity rates from our 24-hour pumping tests were used to supplement the transmissivities estimated from specific capacity.

Based on NRCS soil data for the area, and assuming Type II conditions (antecedent soil-moisture conditions) curve numbers (CN) were estimated between 11 and 13 for the upland areas and 1 and 2 for the coastal terrace areas. Best fit with the coupled rainfall-runoff-percolation and terrace aquifer water-balance models was achieved with a CN of 11 for the El Granada upland area, which resulted in an average runoff of about 20 percent over the 55-year model period. This runoff estimate compares well with observations made by others for the San Mateo coast area (Todd, 2003; Kleinfelder, 1988, Balance 2002). The runoff in the coastal terrace area averaged about 65 percent, which is largely due to the proportion of impermeable surfaces (structures, roads, etc.).

7.1.3 Results

The rainfall-runoff-percolation (soil moisture accounting) model was used to assess ground water conditions in each subarea evaluated in this study. The terrace aquifer accounting model was only used where applicable or where data were available to support it.

Plates 16 through 19 show plots of annual precipitation (derived from data shown on Plate 15) vs. predicted groundwater-surface elevation for the E lGranada, Miramar and Moss Beach Subarea terrace deposits. The predicted groundwater-surface elevations in each plot represents "average" annual water level throughout the respective terrace area. In actuality, water levels will vary significantly from location to location in the terrace area due to the density of pumping wells and natural variations in aquifer characteristics. Also, groundwater surface elevations in wells will generally be higher near the upland area where primary recharge of the terrace aquifer occurs and lower near the ocean where discharge to the ocean occurs.

Plate 15 shows plots of annual precipitation (derived from data shown on Plate 15) vs. the change in available groundwater storage (estimated percolation minus pumpage) for the Montara subbasin and Portola subarea.

Details of the analysis in each subbasin are described in Section 7.2

7.2 SUBBASIN ANALYSIS

The following sections describe the results of our Subbasin analyses. The order in which the analyses are presented generally follows a progression from the least complex model to the more complex models.

7.2.1 El Granada Subbasin Water Balance

The El Granada Subbasin includes the subareas of El Granada Uplands and El Granada Terrace. The water balance methods described in Section 7.1.1 were used to estimate (model) the volume of ground water in storage in the El Granada terrace over time.

7.2.1.1 El Granada Subbasin Water Balance Calibration / Validation

As observed by Kleinfelder in 2004-2005 the water levels in monitored wells tended to be lower in the northern end of the El Granada Terrace Subarea and higher in the central and southern end of the terrace. Because the water balance was calibrated using data primarily from the northern half of the terrace area, the model likely under estimates the total volume of water in storage terrace-wide.

Following the calibration phase, the model derived 2004-2005 hydraulic-head value was 23.3 feet above sea level, while the average of the four selected well-water surface elevations was 23.5 feet. The model estimated hydraulic gradient was 0.022 and the average hydraulic gradient from the selected wells to the ocean was 0.021. For purposes of validation, the final hydraulic head in 1986 was estimated by the model to be 20 feet and the average hydraulic head of the two monitored wells constructed in that year was 23 feet. The model hydraulic head in 1987 was 12 feet and the average hydraulic head of the two monitored wells measured in that year was 19 feet. Collectively the comparison data suggest that the water-balance hydraulic head predictions are within +/- 7 feet in a given year in the area of the terrace where this calibration / validation process was possible (northern end of terrace).

Specific-capacity estimates have resulted in an estimated average transmissivity of 1,700 gpd/ft. Kleinfelder's pumping test near the edge of the El Granada area resulted in an estimated transmissivity of about 4,950 gpd/ft. Accordingly, for calibrating the El Granada water-balance model, the transmissivity was varied between 500 and 5,000 gpd/ft, and the best fit with the actual data was achieved at 3,450 gpd/ft.

7.2.1.2 Water Balance Results

The El Granada terrace aquifer water-balance spreadsheet is included on Plate 16. The model suggests that over the last 55 years, the average terrace-area water table ranged from about -1 to 44 feet above mean sea level (MSL) with an average groundwater surface elevation of about 15.5 feet above MSL. The annual volume in storage in the terrace aquifer Subarea *above* MSL ranged from about 0 to 1,583 acre feet (ac-ft) with an average of about 561 ac-ft. This compares well with the estimate of 876 ac-ft made by Kleinfelder using a different approach in 1988. Outflow to the ocean is estimated to vary from about 49 to 1,563 ac-ft per year with an average ocean outflow of about 610 ac-ft per year.

Table 4 includes a summary of the El Granada Subbasin water balance results.

TABLE 4
EL GRANADA SUBBASIN WATER BALANCE

	Very Dry Year[1] (1976 / 77)	Dry Year[1] (1987 / 88)	55 Year[1] Average (1950-2005)
Half Moon Bay Precipitation[2,3] (Inches)	14.61	20.02	26.43
Water Budget Inputs			
Precipitation[4]			
Upland[5] (acre feet)	1486	2036	2751
Terrace[6] (acre feet)	568	778	1051
Water Budget Input Total	2054	2814	3802
Water Budget Outputs			
Runoff			
Upland (acre feet)	20	206	526
Terrace (acre feet)	227	445	677
Evapotranspiration			
Upland (acre feet)	1467	1472	1525
Terrace (acre feet)	340	333	375
Pumpage			
Upland (acre feet)	27	27	27
Terrace (acre feet)	66	66	66
Ocean Outflow	49	407	610
Water Budget Output Total	2196	2956	3806
Balance			
Change in Storage (acre feet)	-142	-142	-4
Estimated Groundwater Surface Elevation			
in Terrace Area (feet MSL)[7]	-0.7	8.4	15.5
Estimated Volume in Storage Above Sea			
Level in Terrace Area (acre feet)	-26	303	561

Notes:
1 Water year defined as October to September.
2 Missing data during water years 2001/02 and 2003/03 were estimated using data from San Gregorio recording station.
3 NOAA recording station in Half Moon Bay
4 Precipitation amounts estimated using Half Moon Bay precipitation data and adjusting for orographic effects.
5 El Granada watershed (Upland) acreage estimated at 1043.2 acres
6 El Granada terrace acreage estimated at 452.9 acres.
7 For a hypothetical well 1100 feet from the ocean.

The model results suggest that each year about as much groundwater flows from the El Granada aquifers to the ocean as is stored in the terrace area. This would indicate that water moves rapidly through the terrace deposits. Although water levels fluctuate significantly, groundwater nonetheless appears to be currently in general long-term balance in the El Granada Terrace Subarea.

The estimated model groundwater levels suggest that on four occasions during the last 55 years, groundwater-surface elevations in the El Granada Terrace Subarea may have approached or dropped below sea level. These occasions include the water years 1960-1961, 1971-1972, 1975-1977, and 1989-1991. This observation is made assuming that all of the known and permitted wells in existence today were operational and productive over the period of the rainfall record, which may not be the case. The model indicates that the most severe drops in water levels occurred after two or more consecutive dry years. In the identified dry years, wells located near to the coast may have had water levels below sea level and the El Granada Terrace aquifers may have been intruded to a limited extent by seawater.

The model assumes that wells are evenly spaced throughout the area and reflects conditions in the aggregate. However, water levels lower than the "average" elevation should be assumed in areas of high well density.

The model does not predict water levels in the upland area. Water levels in the upland are quite variable as indicated by Kleinfelder's 2004-2005 water level data (wells 42, 116, 138, 163, 171, and 305, Plate 10) and storage in the upland area is not quantifiable based on current information.

7.2.2 Arroyo de en Medio / Frenchmans Subbasins Water Balance

Because the Arroyo de en Medio and Frenchmans Subbasins drain to the terrace at Miramar, these two subbasins and associated subareas are both discussed in this section. The Subbasins include the Subareas of Frenchmans Terrace, Frenchmans Upland, Frenchmans Stream Valley, Miramar Terrace, Arroyo de en Medio Upland and Arroyo de en Medio Stream Valley. The Frenchmans Subbasin was not modeled in detail due to the limited information in that area (e.g. lack of wells). Given the similarities in the two areas, the general conclusions included in Section 8.2 for the Arroyo de en Medio Subbasin may be applicable to the Frenchmans Subbasin.

Given the similarities of the Arroyo de en Medio Subbasin and the El Granada Subbasin, the Arroyo de en Medio water balance was developed using the same general methods as for the El Granada Subbasin. The model consists of a soil-moisture accounting model to estimate rainfall runoff and percolation for both the upland and terrace areas coupled with a terrace-aquifer groundwater-storage accounting model. See Section 7.1 of this report for a more detailed description on the model. Plate 17 contains the model spreadsheet for the Arroyo de en Medio Subbasin water-balance model.

As with the El Granada model, 55 years of monthly precipitation data (1950-2005) from Half Moon Bay were adjusted for orographic and other affects and used as the historic input to the model. The mean annual rainfall in the Arroyo de en Medio Upland Subarea was estimated to be approximately 31.9 inches. The mean annual rainfall in the Miramar Terrace was estimated at 27.8 inches.

Agricultural acreage was estimated using aerial photography, California Department of Water Resources (DWR) land-use data, and the GIS. Crop patterns and sources of water for agricultural crops were determined using the DWR land-use data (Plate 20). Applied water demand was estimated by assuming un-met potential ET, as determined in the soil-moisture accounting model, was satisfied by irrigation. In practice, applied water to field / truck crops generally exceeds ET, but the majority of this applied water is assumed to return to groundwater. In the Arroyo de en Medio Stream Valley Subarea, irrigation water is assumed to come from surface water sources as indicated by the DWR (Plate 20). In the terrace area, irrigation water is assumed to be primarily derived from groundwater pumping.

Based on San Mateo County well records, it is assumed six wells are active in the upland area and 80 wells (other than agricultural wells) are active in the terrace areas. Pumpage rates for these wells are assumed the same as for the El Granada Subbasin.

Other model input factors as used in the El Granada Subbasin such as soils (runoff curve numbers), specific yield, and surface-water return flow are used in the Arroyo de en Medio model.

The major assumptions made in the Arroyo de en Medio model are the same as those used in the El Granada model. Key assumptions include: 1) a single average groundwater-surface elevation in the terrace aquifer and 2) upland groundwater storage is limited and is in relatively rapid-flow connection with the terrace area, recharging the terrace aquifer (i.e. there is no lag in recharging the terrace aquifer). The long and narrow alluvial areas along Arroyo de en Medio act to slow the migration of water to the Miramar Terrace Subarea from the upland watershed, however no data are available to adequately characterize these areas for incorporation into the model. This assumption (rapid inflow into the terrace aquifer) will tend to make the annual results (groundwater surface elevations and estimates of groundwater in storage) during wet years more extreme than they might otherwise be.

7.2.2.1 Arroyo de en Medio Subbasin Calibration / Validation

Calibration of the model was performed in the same manner as the El Granada Subbasin model. Water level data collected in the 2004/2005 water year by Kleinfelder in three wells (lower figure on Plate 10) were used to calibrate the model. An average groundwater surface elevation in the terrace at the end to the 2004/2005 water year was assumed to be 30.5 feet. Hydraulic gradients from the three wells monitored to the ocean ranged from 0.02 to 0.03 during the water year. Data from well 1453 were used to calibrate the model as it was assumed to represent mid-terrace conditions. The calibration process was carried out until the resultant average hydraulic head and hydraulic gradient was achieved in the terrace aquifer.

Best fit to the measured data was achieved with the transmissivity set at 3,975 gpd/ft and a specific yield of 0.09. The transmissivity and specific yield values are within the ranges of expected values in the Arroyo de en Medio Subbasin.

Validation of the model was not possible due to the lack of reliable historic data from which to compare and assess the performance of the model. Given the similarities in the hydrogeology and the good results of the model in the El Granada Subbasin suggests that the model will adequately describe the general behavior of the terrace aquifer in the Arroyo de en Medio Subbasin. However, as noted for the El Granada model, the model is unconstrained by aquifer geometry (i.e. the thickness of the aquifer) and the curve number rainfall-runoff method underestimates extreme precipitation events, consequently groundwater predictions from the peak water years are probably not realistic.

7.2.2.2 Arroyo de en Medio Results

The results of the water-balance model are summarized in following table. The overall behavior of the subbasin as predicted by the model is illustrated on Plate 17 and summarized below in Table 5.

TABLE 5
ARROYO DE EN MEDIO SUBBASIN WATER BALANCE

	Very Dry Year[1] (1976 / 77)	Dry Year[1] (1987/ 88)	55 Year[1] Average (1950-2005)
Half Moon Bay Precipitation[2,3] (Inches)	14.61	20.02	26.43
Water Budget Inputs			
Precipitation[4]			
Upland[5] (acre feet)	1062	1455	1965
Terrace[6] (acre feet)	331	453	612
Water Budget Input Total	1393	1908	2577
Water Budget Outputs			
Runoff			
Upland (acre feet)	15	150	380
Terrace (acre feet)	132	259	394
Evapotranspiration			
Upland (acre feet)	1047	1046	1083
Terrace (acre feet)	192	167	200
Pumpage			
Upland (acre feet)	2	2	2
Terrace (acre feet)	167	167	167
Ocean Outflow	47	261	331
Water Budget Output Total	1602	2052	2557
Balance			
Change in Storage (acre feet)	-209	-144	20
Estimated Groundwater Surface Elevation in Terrace Area (feet MSL)[7]	-2	13	21
Estimated Volume in Storage Above Sea Level in Terrace Area (acre feet)	-37	309	502

Notes:
1 Water year defined as October to September.
2 Missing data during water years 2001/02 and 2003/03 were estimated using data from San Gregorio recording station.
3 NOAA recording station in Half Moon Bay
4 Precipitation amounts estimated using Half Moon Bay precipitation data and after adjusting for orgraphic effects.
5 Miramar watershed (Arroyo de en Medio, Upland) acreage estimated at 739 acres
6 Miramar terrace acreage estimated at 264 acres.
7 For a hypothetical well 1300 feet from the ocean.

The table above provides a summary of results for the Arroyo de en Medio water-balance model. Listed in the table are water-balance component estimates for the driest water year in the last 55 years (1976/77), a dry year (1987/88), and the 55-year average for comparison. Both of the dry years listed in the table were the second of two consecutive dry years and hence the change in storage value indicated in the table is negative. As can be seen in the table, there are indications that groundwater surface levels fell below sea level during the very dry years of 1976 / 77 and groundwater surface levels in other dry years were close to sea level. Given that the model assumes that all of the known and permitted wells in existence today were operational and productive over the period of the rainfall record, subbasin water levels may not have approached sea level at that time. However, in the identified dry years, wells located nearer to the coast than the hypothetical average well simulated in the model may have had water levels close to or below sea level and some seawater intrusion may have occurred. The seawater intrusion (if it occurred) was probably not of significant extent and duration to have long-term adverse impacts.

The model predicts that the groundwater in the Arroyo de en Medio Subbasin is in general long-term balance. A linear regression trend line is included in the precipitation plot on Plate 17, which indicates that precipitation rates have increased over the last 55 years. The 55-year average precipitation balance is positive which may correspond to the long-term general increase in precipitation noted with the Half Moon Bay precipitation data.

The peak water levels predicted in the model are likely not realistic because the model is not constrained by actual physical conditions in the aquifer, and the curve-number method for estimating rainfall runoff under-estimates rainfall from intense rain events, as observed, for example in the 1982/83 water year.

7.2.3 Airport SubArea Water Balance

7.2.3.1 Location

The Airport Terrace Subarea covers about 871 acres, which is generally bounded by faults on the east and west, a groundwater divide near San Vicente Creek and Half Moon Bay to the south. The down-dropped graben that constitutes the Airport Terrace Subarea is described above in Section 4.1. Although the land area ends in the south at Half Moon Bay, the earth materials that make up the Airport Terrace Subarea (marine terrace deposits) continue to the south under the bay. Watersheds contributing water to the Airport Terrace Subarea include the San Vicente watershed at 1,012 acres and the Denniston Creek watershed at 2,424 acres. Pillar Point marsh and the community of Princeton are at the south end of the land area that extends north to the vicinity where San Vicente Creek enters the graben.

The hydrologic study areas of the Airport Subbasin are shown in Plate 6. Subareas included in the Airport Subbasin are Airport Terrace, Denniston Upland, and Denniston Stream Valley. Also, the San Vicente Creek Watershed contributes to the Airport Subbasin as discussed below.

7.2.3.2 Water Balance

7.2.3.2.1 Precipitation / Runoff / Deep Percolation

Precipitation that falls directly on the Airport Terrace Subarea directly recharges the basin. Based on the 55-year Half Moon Bay rainfall record and adjusting for orographic and other affects (using methods described in Section 7.1) the average annual rainfall in the Airport Terrace Subarea is estimated at 26 inches. Over the past 55 years, that precipitation is estimated to have ranged from about 14 inches (1976 -1977 water year) to 50 inches (1982 - 1983 water year). Using Airport Terrace Subarea soil data from the NRCS and using the soil-moisture accounting model to estimate runoff and percolation (described in Section 3.1) we estimate that an average of about 600 ac-ft of water derived from precipitation runs off and about 120 ac-ft percolates to groundwater each year. The balance of the rainfall evaporates.

Using the same 55-year precipitation record and adjustment methods, we project weighted average annual precipitation in the Denniston Creek watershed (above the Airport Subarea) at 35 inches. Over the 55 years of record, the precipitation in the watershed ranged from about 19 inches to 68 inches. Using the soil-moisture accounting model, water potentially available to enter the Airport Subarea from the Denniston Creek watershed (deep percolation plus runoff amount; considering evapotranspiration losses, but not surface diversion of other consumptive use) averages about 3,450 ac-ft and has ranged from 220 ac-ft to 9,450 ac-ft over the 55-year period.

The weighted-average precipitation in the San Vicente watershed is about 32 inches and the annual average precipitation ranged from about 17 inches to 62½ inches over the last 55 years. The volume of water that could potentially leave the watershed and enter the Airport Subarea (deep percolation plus runoff amount; considering evapotranspiration losses but not diversion of other consumptive use) is about 1,225 ac-ft and ranges from 45 ac-ft to 3,485 ac-ft. However, of these totals, none of the San Vicente Creek channel flow and only a small fraction of the groundwater inflow is believed to enter the Airport Subarea as discussed below.

7.2.3.2.2 Airport Subbasin Ground- and Surface-Water Inflow

Groundwater flows into the Airport Subbasin from a number of sources. North of the Half Moon Bay airport subsurface water from San Vicente Creek watershed enters the Airport terrace graben. Most of this groundwater is believed to flow north through the Moss Beach Subarea. However, some of the groundwater flow in the alluvium from the San Vicente watershed also flows south into the graben. In 1974, Lowney-Kaldveer Associates drilled eleven borings in and around the Airport Terrace Subarea, installed piezometers in the borings, and created a groundwater-surface-elevation contour map of the basin to assess groundwater flow patterns. The contour map indicated that a groundwater divide exists in the vicinity of where San Vicente Creek enters the Airport Terrace Subarea. Based on the Lowney-Kaldveer Associates map and flow-net analysis, Kleinfelder estimates that about 15 percent of the groundwater that enters the Airport graben from the San Vicente watershed flows south into the Airport Terrace Subarea, and the remaining approximately 85 percent flows north to the Lower Moss Beach Subarea.

Groundwater flow through the mouth of San Vicente Creek watershed may be limited by a geologic-controlled structural constriction. The constriction, if it exists, could be due to more resistance rocks uplifted along an unmapped fault. Groundwater flow in excess of the physical capacity of the alluvium to transmit water appears as surface water in the creek channel. Assuming a cross-sectional area of 300 feet by 75 feet, we estimate groundwater flow from San Vicente Creek may be limited to about 250 ac-ft per year in this location. Based on these factors, the volume of groundwater that flows into the Airport Terrace Subarea from the San Vicente watershed area is estimated to be about 38 ac-ft per year.

Surface water from San Vicente Creek is diverted by local landowners for irrigation purposes in the Airport Terrace Subarea. This diverted water is pumped to a series of ponds and from there it is used to irrigate fields. Some groundwater from the San Vicente watershed may be used to supplement this supply. Land owners in the San Vicente / Airport Terrace Subareas have retained rights to divert and store up to 49 ac-ft in the ponds (California Department of Water Resources, 1999). Some water stored in the ponds seeps into the ground and recharges the groundwater in the Airport Terrace Subarea. Also, excess applied irrigation water (water applied in excess of evapotranspiration demands and the infiltration capacity of the soil) in the Airport Terrace Subarea may also recharge the aquifer. This excess applied water percolates past the rooting zone to groundwater or runs off from the fields (tail water) and finds its way into ditches or low areas and percolates to groundwater (Luhdorff and Scalmanini Consulting Engineers, Earth Science Associates, 1991). Kleinfelder estimates that the volume of water that infiltrates in this manner is about ten percent of the applied demand or about 5 ac-ft / year. Little or no groundwater is estimated to flow from the west out of consolidated rocks across the Seal Cove/San Gregorio Fault, nor is groundwater assumed to flow west from the Airport Terrace Subarea across the fault.

The volume of groundwater that flows to the Airport Terrace Subarea from upland areas to the east is not known but is considered small in comparison to that which flows from Denniston Creek alluvium and/or infiltrates from Denniston creek below the point at which it enters the Airport graben. Denniston Creek is perennial upstream of the Airport Terrace Subarea but because of diversions; the creek is ephemeral as it crosses the Subarea (Luhdorff and others, 1991). Stream gauging data are limited, but data that are available suggest that recharge from creek infiltration can be considerable. In March 1989, stream-flow measurements made by Luhdorff and Scalmanini / ESA indicated a recharge rate of about 29 ac-ft/day and Luhdorff and others (1991) suggest that potential recharge could exceed 2,000 acre feet / year. At that time, they noted that more than half the observed recharge occurred below the Highway 1 Bridge where the creek is flatter and the bed is more permeable. On another occasion, the California Department of Water Resources reported measurement of Denniston Creek flow near Highway 1 on January 28, 1998 at 6.62 cfs or 13.1 ac-ft/day which could potentially recharge the aquifer.

Coastside County Water District (CCWD) diverted between 300 and 900 ac-ft / year from Denniston Creek for area distribution between 1975 and 1985 (Luhdorff and others, 1991). In the later part of the 1980s, diversions were small due to drought conditions. Since 1992, CCWD has diverted an average of 540 ac-ft/yr (CCWD, 2003) from channel flow in Denniston Creek

7.2.3.2.3 Airport Subbasin Outputs

Groundwater outflow from the Airport Subbasin occurs as pumpage, outflow to the ocean, and evapotranspiration. Evapotranspiration was accounted for in the soil-moisture accounting model in the estimation of the volume of water available for deep percolation referenced above. The annual evapotranspiration from the San Vicente watershed is about 1,480 ac-ft, from the Denniston Creek watershed about 3,620 ac-ft, and from the Airport Subarea about 1,165 ac-ft.

Both the CCWD and Montara Water and Sanitary District (MWSD) have production wells in the Airport Subarea. CCWD's wells are located near Denniston Creek and elsewhere in the Airport Subarea. Between 1987 and 1996, the DWR estimated that CCWD pumped an average of 137.41 ac-ft (DWR, 1999) from its Airport Subarea wells. Recently CCWD reports that normal yield from CCWD wells in the area is about 169 ac-ft (CCWD, 2003). This water is generally exported from the subbasin and distributed to customers in the Midcoast Area.

The MWSD has three production wells along Highway 1 and near the airport. DWR reported that between 1987 and 1996, Citizens Utility Company of California (CUCC), predecessor to the MWSD, pumped an average 224.47 ac-ft from the Airport Subarea. This water is generally exported from the subbasin.

Review of San Mateo County well-log data indicates that there are 122 well permits in the Airport Subbasin. Of these, 25 well permits are for wells owned by CUCC and CCWD, six are for agricultural wells, and three are listed as abandoned. Not all of these wells are believed to be active. Luhdorff and others (1999) state that all irrigation in the area was carried out with surface water, principally from San Vicente Creek. However, the DWR 1987 land use maps for the area indicate that the majority of the irrigated acreage is supplied from both surface and groundwater sources. It is believed that the agricultural wells are used to supplement the surface water supply. The remaining 87 wells are domestic or other wells. If it is assumed that each of these domestic wells are pumped at a rate of 250 gallons per day the total annual pumpage is about 24 ac-ft / year.

Groundwater from the Airport Subbasin discharges to the ocean at Pillar Point Harbor and Pillar Point Marsh. The rate of groundwater outflow to the ocean is dependent on the hydraulic gradient near the ocean. Luhdorff and others (1999) reviewed hydrographs for water-level measurements made by the DWR in one well (5S/6W-10J1) dating back to 1953 and 25 other wells in the area. Luhdorff and others (1999) estimates an outflow hydraulic gradient of 0.0077 during the period they monitored groundwater conditions (1987 to 1990), a period of below normal rainfall on the Midcoast. Based on this hydraulic gradient estimate, transmissivity estimates from pumping tests performed by Earth Sciences Associates in 1989 and Luhdorff and Scalmanini in 1990 (T=700 ft^2/day), and the estimated ocean frontage length (3,000 ft.), Luhdorff and others estimated that outflow during that below normal rainfall period was about 136 ac-ft. In Kleinfelder's analysis, we estimate an average year outflow of about 507 ac-ft. This estimate of average conditions is based on long-term average precipitation conditions, roughly precipitation 40 percent higher than during the years Luhdorff and others (1999) estimate hydraulic conditions.

7.2.3.3 Change in Storage

Lowney-Kaldveer and Luhdorff and Scalmanini / Earth Sciences Associates concluded that the Airport Subbasin was in general long-term balance. The 50+ years of water-level data from the DWR well, as well as groundwater surface elevation data from 25 other wells led them to this conclusion. During drought years, water levels have been observed to drop, particularly in the vicinity of the CCWD production wells. However, during those years the outflow to the ocean also lessens, reducing the impact of drought conditions. In contrast, water-table conditions were observed to rebound relatively rapidly during wet years. Luhdorff estimated that during the period from May 1987 to December 1990 total storage depletion in the Airport Basin Aquifer was about 246 ac-ft or about 69 ac-ft per year. Despite that drop, Luhdorff noted that hydraulic gradients at the Pillar Point Marsh continued to be upward during those dry years. The observation that even in dry years groundwater appears to discharge to the ocean indicates that seawater intrusion under current groundwater withdrawal conditions is not likely. Groundwater quality in the Pillar Point area should be monitored to evaluate quantities of water that may be removed from the local aquifers without detrimentally affecting the source.

Although water levels were observed to drop during the period of time Luhdorff monitored them, Luhdorff like Lowney-Kaldveer, concluded that additional groundwater could be pumped from the Airport Subbasin without detrimental impacts. Luhdorff's estimated additional safe yield was less than Lowney-Kaldveers, at 45 to 87 ac-ft / year. Both investigators recommended that any increases in pumping be carried out in a phased manner and monitoring be performed to assess the impacts of that increased pumping.

Kleinfelder monitored water levels in two wells in the Airport Subbasin. One of the wells was located near the approximate border between the Airport Subbasin and the El Granada Subbasin and the other in the Princeton area (Plate 3). Kleinfelder's data were collected during an above normal precipitation year. Hydrographs for these wells are shown in the upper figure of Plate 11. The seasonal recharge is evident in the hydrographs, particularly near the border between the Airport Subbasin and the El Granada Subbasin in which water levels rose about 12 feet, but water levels returned to near pre- water year levels by the end of the year.

7.2.3.4 Water Balance

Based on the data discussed above, a long-term general water balance for the Airport Subbasin was complied. The overall balance is based on the observation that the Airport Subbasin appears to be in long-term hydrologic balance. The estimated input and outputs of the balance are summarized below:

TABLE 6
AIRPORT SUBBASIN WATER BALANCE

	Acre-Feet / Year
INFLOWS	
Precipitation in Airport Subbasin	1880
Groundwater and runoff inflow from Denniston Creek watershed	790
Groundwater inflow and pond seepage From San Vicente watershed	110
TOTAL	2780
OUTFLOWS	
Evapotranspiration from Airport Subbasin	1160
Runoff from Airport Subbasin to the ocean	600
CCWD pumpage and export	169
MSWD pumpage and export	224
Other domestic pumpage	24
Agricultural pumpage	96
Groundwater flow to the ocean	507
TOTAL	2780
CHANGE IN STORAGE	0

The balance above was developed based on the 55 year precipitation record for the area, runoff estimates based on soil-moisture curve-number accounting model, and information included in preceding sections of this report. However, the most significant recharge factor in the Airport Subbasin is infiltration recharge from Denniston Creek and groundwater inflow from the Denniston Creek watershed. Denniston Creek flow data are limited to measurement on a handful of days and do not provide any information on the overall seasonal magnitude of this hydrologic input much less the response of the watershed to rainfall. Kleinfelder's estimates of inflow from Denniston Creek are based on Luhdorff's March 16, 1989 flow measurements and opinion that potential recharge from Denniston Creek that year may be about 2000 ac-ft. Kleinfelder recommends a long-term stream flow gauging program be implemented to better define the hydrology in the area.

7.2.4 Moss Beach Subbasin Water Balance

7.2.4.1 Location

The Moss Beach Subbasin is located north of the Half Moon Bay Airport and south of the community of Montara (Plate 3). In this study, the Moss Beach Subbasin was divided into Lower Moss Beach (or Moss Beach Terrace), Upper Moss Beach, and Dean Creek Subareas, based on hydrogeologic characteristics (Plate 6). The San Vicente Creek Subarea contributes to the Moss Beach Subbasin. Lower Moss Beach Subarea is the low-lying northern extension of the Airport graben and covers approximately 187 acres. Upper Moss Beach Subarea is the hill area separating Lower Moss Beach from Lower Montara Creek and covers and area of approximately at 70 acres. Both Dean and San Vicente Creeks flow through the Lower Moss Beach Subarea. The watersheds for Dean and San Vicente Creeks are 267 acres and 1,012 acres in size, respectively. Upper Moss Beach Subarea and the Dean and San Vicente watersheds each contribute water to the Lower Moss Beach Subarea aquifer.

7.2.4.2 Hydrogeology

Groundwater in Lower Moss Beach Subarea occurs in terrace deposits that are underlain by granite north of Highway 1 and in the Purisima Formation south of Highway 1. The terrace deposits are reported to be about 50 to 70 feet thick. Water contained in the terrace deposits primarily comes from local precipitation, groundwater that flows in from Upper Moss Beach Subarea and the Dean and San Vicente watersheds and surface water infiltrating in the channels of Dean and San Vicente Creeks.

The Upper Moss Beach Subarea has a surficial cover of marine terrace deposits (perhaps 40 feet thick) that is underlain by granitic bedrock. Wells located in Upper Moss Beach Subarea draw water from weathered and fractured granitic rock. Water contained in the weathered and fractured bedrock underlying Upper Moss Beach Subarea originates as precipitation that falls directly on the Upper Moss Beach Subarea. Groundwater in the Dean Creek watershed similarly originates as precipitation and is contained in weathered granite.

The San Vicente Creek watershed is a long alluvial valley extending from the crest of Montara Mountain at an elevation of over 1,500 Feet. The lower west end of the

Using the same 55-year precipitation record and adjustment methods, the weighted average annual precipitation in the Dean Creek watershed (above the community of Moss Beach) is 27.70 inches. Over the 55 years of record, the precipitation in the watershed ranged from 14.97 inches to 53.90 inches. According to the soil-moisture accounting model, water potentially available to enter the Moss Beach Subarea from the Dean Creek watershed (deep percolation plus channel runoff that may percolate) averages about 51 ac-ft and ranges from <1 ac-ft to 181 ac-ft over the 55-year period.

The weighted average precipitation in the San Vicente watershed is 32.07 inches and the annual average precipitation ranged from 17.32 inches to 62.40 inches over the last 55 years. The volume of water that could potentially leave the watershed and enter the Lower Moss Beach Subarea (groundwater flow plus channel runoff that may percolate and not considering diversions) averages about 1220 ac-ft and ranges from 21 ac-ft to 3483 ac-ft.

7.2.4.3.2 Lower Moss Beach Subarea Ground- and Surface-Water Inflow

As noted above, groundwater flows into the Lower Moss Beach Subarea from Upper Moss Beach Subarea, Dean Creek watershed, and the San Vicente watershed. In the Upper Moss Beach Subarea, groundwater that is pumped is sourced from weathered and fractured granite. Groundwater that accumulates in Upper Moss Beach Subarea is water that falls as precipitation less evapotranspiration and surface runoff. Based on the soil data from the NRCS and the soil-moisture accounting model, the amount of water that annually percolates to groundwater in the Upper Moss Beach Subarea is about 21 ac-ft. Of that amount, about six ac-ft is pumped for domestic use (assuming 250 gpd per well). The remainder either seeps toward Lower Montara Creek Subarea or flows as groundwater toward the Lower Moss Beach Subarea. Given the relatively long borders between Upper Moss Beach Subarea and Lower Montara Creek Subarea and Lower Moss Beach Subarea, we estimate that about half of the residual percolated water flows to the Lower Moss Beach Subarea and the other half flows toward Lower Montara Creek Subarea. Therefore, resultant groundwater inflow to the Lower Moss Beach Subarea from this source is about eight ac-ft.

As in the Upper Moss Beach Subarea, groundwater in Dean Creek is also derived from percolating precipitation. In this case, approximately 98 ac-ft of precipitation percolates to groundwater each year and about 16 ac-ft of this water is pumped for domestic or other purposes from 55 wells. However, associated with many of these wells are 31 permitted septic tanks and leach fields where a portion of the pumped water is returned to the subsurface. Assuming about half of the pumped water from each well with an associated septic tank returns to the subsurface, the net pumpage in Dean Creek watershed is about 11 ac-ft. Also, like the Upper Moss Beach Subarea, groundwater may flow out of the watershed to the north and northwest into Lower Montara Creek and the Portola Subareas. For the purpose of this analysis, we assume about 60 percent of the groundwater that isn't captured by wells in the Dean Creek Subarea flows toward the Lower Moss Beach Subarea. Based on this assessment, annual groundwater inflow to Lower Moss Beach is about 53 ac-ft.

South of the Lower Moss Beach Subarea, San Vicente Creek enters the Airport graben and flows northwest toward the Lower Moss Beach Subarea. Also, groundwater contained in alluvium in the San Vicente watershed flows into the graben. As discussed previously in Section 4.1, Lowney-Kaldveer Associates (Lowney, 1974) drilled eleven borings and assessed groundwater flow patterns in the Airport Subarea. Lowney reported that groundwater flowing out of the San Vicente watershed enters the graben then the flow divides; most of groundwater flows northwest and the remainder flows to the southwest toward the airport. Based on our review of groundwater surface contour maps prepared by Lowney, we estimate that about 85 percent of the groundwater that enters the graben from the San Vicente creek watershed flows toward the Lower Moss Beach Subarea. Also, the volume of groundwater that may enter the graben at that point may be limited by aquifer geometry (i.e. there is a constriction at the point of entry). Assuming a width of about 300 feet and depth of about 75 feet, the volume of groundwater flow out of the San Vicente watershed may be limited to about 250 ac-ft per year. If this is the case, the volume of water leaving the watershed in excess of that amount will appear as surface water and discharge in San Vicente Creek. Given this limitation and divergence of groundwater flow below the mouth of the watershed, the annual groundwater inflow from San Vicente Creek to Lower Moss Beach Subarea is estimated at about 195 ac-ft.

Kleinfelder in 1988 (Kleinfelder, 1988) estimated that given the perennial nature of flow in San Vicente Creek and an assumed channel area, about 66 ac-ft (less in drought years) of the water in San Vicente Creek infiltrates as the creek traverses the Lower Moss Beach Subarea.

7.2.4.3.3 Outputs from Lower Moss Beach Subarea

Groundwater outflow from the Lower Moss Beach Subarea occurs as a result of pumpage, ocean discharge, and evapotranspiration. The estimated annual evapotranspiration from the San Vicente watershed is 1,485 ac-ft, from the Dean Creek watershed is it is 378 ac-ft, and from combined Upper and Lower Moss Beach Subareas it is 341 ac-ft.

Review of San Mateo County well log data indicates that there are 54 permitted wells in the Lower Moss Beach Subarea. Of these wells, 33 are listed as domestic, nine agricultural, and 14 listed as other. It is not known whether all of these wells are active. DWR 1987 land use maps for the area indicate no irrigated acreage in the area. If it is assumed that each of these 54 wells are pumped as domestic wells, the average annual pumpage is about 15 ac-ft.

Groundwater from the Lower Moss Beach Subarea discharges to the ocean to the northwest. The rate of groundwater outflow to the ocean is dependent on the magnitude of the hydraulic gradient near the ocean. Based on the calculated hydraulic gradient estimate, Kleinfelder's transmissivity estimate from pump tests and other data (2500 gpd/ft), and the estimated ocean-frontage distance (3,600 ft.), the average out flow is about 330 ac-ft. This estimate is based on a water balance performed using the 55-year precipitation data set and estimated inflows and estimated groundwater surface elevations in the Lower Moss Beach Subarea.

7.2.4.3.4 Change in Storage in Lower Moss Beach Subarea

No long-term water-level data are available for the Lower Moss Beach Subarea with which to assess long-term groundwater trends. Kleinfelder monitored water levels in four wells (nos. 1220, 1282, 1323, and 1347) in the Lower Moss Beach Subarea during the 2004/2005 water year. Over the course of the year, water levels fluctuated little and by the end of the water year water levels were only slightly higher compared with the beginning of the year in three of the four wells.

According to 55-year precipitation data and water-balance modeling results, water levels have not varied by much more than about 15 feet, suggesting the Lower Moss Beach Subarea is in general balance. Estimates of water in storage above sea level include 719 ac-ft for an average year, 332 ac-ft following two very dry years (1975/1976 and 1976/1977).

7.2.4.3.5 Lower Moss Beach Subarea Water-Balance Summary

Based on the model data discussed above, Kleinfelder estimated the long-term general water balance for the Lower Moss Beach Sub area. The estimated input and outputs of the balance are summarized below:

TABLE 7
LOWER MOSS BEACH SUBAREA WATER-BALANCE

INFLOWS	Average Year Acre-Feet /Year	Very Dry Year (1976 / 1977) Acre-Feet / Year
Precipitation on Lower Moss Beach Subarea	399	215
Groundwater and runoff inflow from Dean Creek watershed	53	0
Groundwater inflow from Upper Moss Beach Subarea	8	0
Groundwater inflow and channel seepage from Saint Vicente watershed	260	0
TOTAL INFLOW	**720**	**215**
OUTFLOWS		
Evapotranspiration from Lower Moss Beach Subarea	245	197
Runoff from Lower Moss Beach area to ocean	136	18
Other domestic pumpage	15	15
Agricultural pumpage	0	0
Groundwater flow to the ocean	322	191
TOTAL OUTFLOW	**718**	**421**
CHANGE IN STORAGE	**2**	**-206**

The water balance presented above for the Lower Moss Beach Subarea was developed using essentially the same methods used to develop water balances in the El Granada and Arroyo de en Medio Subbasins. The balance is based on the 55-year precipitation record for the area and runoff estimates based on a soil-moisture accounting, rainfall-runoff model. According to this assessment, about 75 percent of the water that recharges the aquifer at Lower Moss Beach Subarea comes from the San Vicente watershed. However, San Vicente Creek surface and groundwater flow gauging data are not available to validate the model. Given that surface and groundwater flows from San Vicente Creek watershed appear to constitute the majority of water sources, Kleinfelder recommends a long-term stream flow and gauging program be implemented to better define the hydrology in the area.

7.2.4.3.6 Upper Moss Beach and Dean Creek Subareas Water Balance

Groundwater available for pumping in the Dean Creek and the Upper Moss Beach Subareas is stored in weathered or fractured granite and comes from percolating rainfall. According to the soil moisture accounting model the Dean Creek watershed in nine of the 55 years (16%) of precipitation record, percolation recharge was less than the total pumping volume. However, on average the volume of recharge is about nine times the pumping demand. In the Upper Moss Beach Subarea, recharge was less than pumping demand in 13 out of the 55 years (24%). In one eleven year period (1953-1964) in Upper Moss Beach Subarea, seven years are estimated to have had recharge rates at less than the pumping demand, but the average estimated recharge rate during that period was over double the pumping demand. Given that natural groundwater discharge rates (groundwater outflow to surrounding areas or the creeks) from these areas are unknown, it is not possible to adequately assess long-term storage in these areas. The data suggest that each of these subareas is in long-term balance. During extended droughts, water in these subareas may drop significantly.

Hydrographs for the two monitored wells in the Dean Creek watershed and the Upper Moss Beach Subarea indicate net gains in the volume of water in storage during the above-normal (136 percent of normal) 2004 / 2005 water year. Water levels rose 2.3 feet in the Upper Moss Beach well and about 10 feet in the Dean Creek well. Also, the water-level response pattern in each well indicates that current year rainfall percolates to the groundwater table. These data suggest that the water bearing zones in each of these subareas can rebound from dry periods in a relative quick manner given sufficient rainfall and/or rainfall that occurs during relatively short periods so that it overcomes evapotranspirative demands.

7.2.5 Montara Subbasin Water Balance

The community of Montara is located north of Moss Beach near the northern end of the MidCoast Study Area. For the purposes of this study, the boundaries of the Montara Creek Subbasin include the Pacific Ocean to the west, Kanoff Creek and the Martini Creek watersheds to the north, Montara Creek and Wagner Valley to the east and the deep ravine of Montara Creek to the south (Plate 6). Within the Montara Creek Subbasin, the top of the hill bounded by Montara Creek, 6th Street and Farallone Avenue has been referred to as Montara Heights in previous studies. The area below Montara Heights is referred to as Montara Terrace.

In the Montara Terrace area, many of the wells are believed to have been completed in the marine terrace deposits that overlie weathered granitic bedrock. In the Montara Heights Subarea, water in wells is derived primarily from the granitic aquifer. Groundwater that exists in the Montara Subbasin is largely derived from infiltration and percolation of rainwater that falls on the area. Because the groundwater within the

Montara Terrace and Heights is from the same source, the transition between the granitic and marine terrace aquifers is not well defined and given the relatively small size of the Montara Heights area, the two units are treated together in this report.

The marine terrace deposits tend to thicken down slope. Along with the thickening of the deposits, the down-slope area may also have a higher volume of water in storage. Higher yields are found in lower Montara area, near Highway 1 and near the upper end of Montara near Cedar Street (Balance, 1999). The higher yields in lower Montara may be due to the more water in storage there. Higher yields in the vicinity of Cedar Street may potentially reflect some, yet undefined, connection with water contained in the alluvium along Montara Creek and Wagner Valley.

7.2.5.1 Water Surface Elevations in Wells

Kleinfelder monitored water levels in three wells in the Montara area during the 2004 / 2005 water year. The wells were located in lower Montara near Main Street (well 10002), Montara Heights area (well 10003), and northeastern Montara (well 1299). Hydrographs for the wells are included on Plate 12. The three wells illustrate distinct hydrogeologic conditions discussed below.

The lower Montara well (well 10002) showed generally stable water levels with a peak water-surface elevation occurring in April, at the end of the rainy season. (The initial water level in the well is not believed to be representative as the measurement may have been made following pumping.)

Water levels in the Montara Heights well (well 10003) peaked at the end of the monitoring period (October 2005). The lowest water levels in the Montara Heights well were observed in December 2004 and January 2005. The water level in well 10003 rose about 25 feet between January 2005 and October 2005. The water-level pattern observed in the Montara Heights well and the depth to water (90 to 115 feet) suggests that there is approximately six-month lag in recharge to this well. Also the rise in the water level may indicate that the water-bearing zone intercepted by the well is primarily contained in the secondary porosity of the granitic rocks it was drilled in (i.e. fractures). A rise of approximately 2 to 3 feet would have been expected following the rainy season, if the well were screened in alluvium.

Water levels in the well in northeastern Montara (well 1299) peaked in March 2005; a rise of about 14 feet followed by a ten-foot drop a month later (April 2005). Water levels are not available after April in the well. The more rapid rise suggests closer connection to areas of recharge and the lesser rise, in comparison to the Montara Heights, suggests that this well may be screened in weathered bedrock as opposed to fractured rock.

7.2.5.2 Water Balance

The average annual rainfall in the Montara Subbasin is about 27 inches and has ranged over the last 55 years from 14 inches (1976 / 1977 water year) to 52 inches (1982 / 1983 water year). Rain that falls on the area runs off, is lost to evapotranspiration, or infiltrates and percolates to groundwater. The groundwater discharges to the ocean, discharges to Montara or Kanoff Creeks then discharges to the ocean, or is pumped (184 wells) and consumed. Some of the water that is pumped returns to the subsurface via septic tanks (11 septic tanks).

The volume of water that runs off, evapotranspirates or percolates in the Montara Subbasin was estimated using the soil-moisture accounting rainfall-runoff model and using 55 years of adjusted rainfall data is summarized below. From the estimated annual percolation volume, pumpage is subtracted and the remainder is assumed to be available for groundwater storage and/or discharge to the ocean. Assuming the 184 wells area are all present and pumping 250 gallons per day (gpd) and 11 septic tanks return half the water from 11 of the wells, it is estimated that 50 ac-ft are consumed and the remaining groundwater either directly discharges to the ocean or discharges to Montara or Kanoff Creeks then discharges to the ocean. Below is a summary of the results:

TABLE 8
MONTARA AREA WATER BALANCE SUMMARY

	55 -Year Average (ac-ft)	Dry Year 1987 / 1988 (ac-ft)	Very Dry Year 1976 / 1977 (ac-ft)
INFLOW			
Precipitation	963	713	520
OUTFLOW			
Evapotranspiration	600	563	507
Runoff	219	94	13
Net Pumpage	50	50	50
GROUNDWATER SURPLUS / DEFICIT			
Surplus	94	6	0
Deficit	0	0	-50

The model-generated data from this assessment are summarized in Plate 19. Assuming all of the 184 permitted Montara Subbasin wells were pumping over the last 55 years, the model estimates that in 14 of the 55 years (25%) of record there would have been a deficit where water would have to be drawn from storage and increased drawdowns in wells would occur. The magnitude of the drawdown would depend on the proximity of individual wells, localized hydrological characteristics (e.g. fractures or weathered bedrock), volume of water in storage prior to the dry years, and numbers of consecutive dry years. Further, given the relatively step gradient of the Montara aquifer system wells at higher elevations would likely be at more risk of increased drawdown and going dry.

Although there have been wide swings year-to-year between surplus and deficit in the Montara Subbasin, in general, the area appears to be in long term balance. The water balance performed in this study would suggest that overall limited additional water could be pumped from groundwater overall, however there would be significant risk of localized well interference, large well drawdowns in dry years and the risk of individual wells going dry in dry and very dry years.

7.2.5.3 Water Balance Parameters

A NRCS curve number of 55 was used to reflect soil series in the Montara Subbasin. Potential evapotranspiration (ET) rates used were derived from data available for the Half Moon Bay area. Because the model accounts for available soil moisture, actual ET rates are predicted to be lower than potential ET. Average ET was estimated to be about 17 inches. Runoff averages about 23 percent of rainfall. The ET and rainfall runoff estimates compare well with 17.5 inches ET and 24 percent runoff stated by Balance Hydrologics for a small watershed near Half Moon Bay (Balance, 1999).

7.2.6 Portola Subarea Water Balance

The Portola Subarea is located east of Montara Creek and Wagner Valley and north of the Dean Creek watershed (Plate 6). The area covers approximately 155 acres. Groundwater that exists in the Portola Subarea is believed to be present in weathered and fractured granitic rocks. Groundwater is recharged by the infiltration and percolation of rainwater that falls on the area. Near the western edge of the area, groundwater from the Wagner Valley alluvium may also seep into the weathered granitic rocks to an unknown extent.

The average annual rainfall in the area is 29.17 inches and has ranged over the last 55 years from 15.75 inches (1976 / 1977 water year) to 56.74 inches (1982 / 1983 water year). Rain that falls on the area runs off, is lost to evapotranspiration, or infiltrates and percolates to groundwater. The groundwater either naturally discharges to the ocean by way of Montara Creek, or is pumped out and consumed. Some of the water that is pumped returns to the subsurface via septic tanks and irrigation.

The volume of water that runs off, evapotranspirates or percolates in the Portola Subarea was estimated using the same methods used for the Montara Subbasin. In the Portola Subarea, it is assumed that the 35 permitted wells were pumped for the 55 years of rainfall record. These include two Montara Water and Sanitary District (MWSD) production wells pumping full time at their capacities as reported by Montgomery Watson (Citizens Utilities CUCC Montara District Water System Master Plan Update, October 2000). Also, it assumes that 18 permitted septic tanks have been actively returning about 50 percent of the pumped domestic water. Finally, soil properties are assumed to be similar to those found in the Montara area. Below is a summary of the water balance results:

TABLE 9
PORTOLA SUBAREA WATER BALANCE SUMMARY

	55 –Year Average (ac-ft)	Dry Year 1987 / 1988(ac-ft)	Very Dry Year 1976 / 1977(ac-ft)
INFLOW			
Precipitation	377	279	203
OUTFLOW			
Evapotranspiration	220	208	197
Runoff	94	43	7
Net Pumpage	44	44	44
GROUNDWATER SURPLUS / DEFICIT			
Surplus	19	0	0
Deficit	0	-16	-45

The model-generated data from this assessment are summarized on Plate 19. Assuming all of the 35 permitted Portola Subarea wells were pumping over the last 55 years, the model indicates that in 21 of the 55 years (38%) of record there would have been a deficit where water would have to be drawn from storage and increased drawdown in wells would occur. The magnitude of the drawdown would depend on the proximity of individual wells, localized hydrological characteristics (e.g. water generated from fractures or weathered bedrock), volume of water in storage prior to the dry years, and numbers of consecutive dry years. Further, given the relatively steep gradient of the Portola aquifer system (groundwater flows toward Montara Creek), wells at higher elevations would probably be at more risk of increased drawdown or of going dry.

Although there have been wide swings year-to-year between surplus and deficit in the Portola Subarea, in general, the area appears to be in long-term balance. Additional pumping in this area runs the significant risk of localized well interference, large well drawdowns in dry years and the risk of individual wells going dry in dry and very dry years.

8.0 CONCLUSIONS

Groundwater in the Midcoast marine terraces (Frenchman, Miramar, El Granada, Airport, Moss Beach, Upper Moss Beach, and Lighthouse) should remain relatively in balance under current and moderate increases in pumpage. Additional pumping will lower the water table but long-term balance should be achieved assuming pumping is moderate. This balance is attained because outflow to the ocean is variable, i.e., increased pumping will lower the water table, which will decrease outflow to the ocean. However, increased pumping over long periods and during drier years will increase the number of years that the water table falls to or below sea level and this condition increases the risk of saltwater intrusion.

Storage estimates for the subbasins have been made where data allowed (e.g. Arroyo de en Medio, El Granada, and Moss Beach Subbasins). However, some areas do not have sufficient data to make these estimates. These areas of insufficient data include the Airport Terrace, Montara, Portola, Dean Creek, and Upper Moss Beach Subareas.

The following sections provide a review of the findings of the hydrogeologic investigation of the Midcoast Study Area and summarize the conclusions reached.

8.1 EL GRANADA SUBBASIN

The hydrogeologic model for the El Granada Subbasin suggests that over the last 55 years the average water table in the terrace area ranged from about -1 to 44 feet above MSL with an average groundwater surface elevation of about 15.5 feet above MSL. The annual volume in storage in the El Granada Terrace Subarea *above* MSL ranged from about 0 to 1,580 acre feet (ac-ft) with an average of about 560 ac-ft. Outflow to the ocean varies from about 0 to 1,583 ac-ft. per year with an average ocean outflow of about 610 ac-ft per year. The data suggest that the El Granada Subbasin is in general long-term balance.

The model estimated groundwater levels suggest that in the water years 1960-1961, 1971-1972, 1975-1977, and 1989-1991 groundwater-surface elevations in the El Granada Subbasin may have approached or dropped below sea level. This result was found assuming that all of the known and permitted wells in existence today were operational and productive over the period of the rainfall record, which may not have been the case. The model indicates that the most severe drops in water levels occurred after two or more consecutive dry years. In the identified dry years, wells located near to the coast may have had water levels below sea level and the El Granada Terrace Subarea may have been intruded to a limited extent by seawater.

Our water balance model found that about 550 ac-ft of groundwater may remain in storage above sea level in the terrace aquifer following an "average rainfall year". Following a dry year (e.q. 1987 / 88) and very dry year (e.q. 1976 / 77) groundwater in storage above sea level was estimated to be about 300 ac-ft and 0 ac-ft, respectively. Under current pumping demands, the water balance model suggests that average terrace-wide groundwater levels dropped near (within five feet) or below sea level six times during the 55-year period of rainfall record used in this analysis (representing a 11 percent return frequency). If pumpage were to increase to about 300 ac-ft per year, the frequency of groundwater falling to levels near or below sea level would increase to more than 30 percent. A prolonged drop in groundwater levels in the El Granada terrace area to levels below sea levels may have detrimental impacts due to salt-water intrusion.

8.2 ARROYO DE EN MEDIO / FRENCHMANSSUBBASINS

The Arroyo de en Medio and Frenchmans Subbasins are described in this report and consist of the Subareas of Frenchmans Terrace, Frenchmans Upland, Frenchmans Stream Valley, Miramar Subarea, Arroyo de en Medio Upland, Arroyo de en Medio Stream Valley as shown on Plate 6. Hydrogeologic conditions in the Arroyo de en Medio Subbasin are similar to conditions in the El Granada Subbasin. The watersheds contributing flow to the Arroyo de en Medio and Frenchmans Subbasins are larger than that contributing to El Granada. The model predicts that the Arroyo de en Medio Subbasin is in general long-term balance.

The water-balance model suggests that the amount of groundwater remaining in storage above sea level in the Miramar subarea following each water-year during the modeled period of record averaged about 500 ac-ft. Following a dry year (1987 / 88) and very dry year (1976 / 77) groundwater in storage above sea level was estimated to have totaled about 310 ac-ft and 0 ac-ft, respectively. Under current pumping demand, the model suggests that average Miramar subarea-wide groundwater levels dropped near (within five feet) or below sea level four times during the 55-year period of rainfall record used in this analysis (representing a seven percent return frequency). If pumpage were to increase to about 300 ac-ft per year, the frequency of groundwater falling to levels near or below sea level would increase to more than 55 percent. A prolonged drop in groundwater levels in the Miramar subarea terrace aquifer to levels below sea level may have detrimental impacts due to salt water intrusion.

Frenchmans Terrace Subarea is contiguous with the Miramar Terrace Subarea with no apparent groundwater divide separating the two areas. Therefore, these two subareas should share the similar hydrogeologic properties and have similar quantities of water in storage. However, the Frenchmans Upland Subarea is larger than the Arroyo de en Medio Upland Subarea and extends to higher elevation, and therefore should provide somewhat more water to the Subarea.

8.3 AIRPORT SUBBASIN

Using the soil-moisture accounting model, water potentially available to enter the Airport Terrace Subarea from the Denniston Creek watershed averages about 3,450 ac-ft and has ranged from 220 ac-ft to 9,450 ac-ft over the 55-year period. Groundwater contribution from San Vincent Creek is relatively small. Little or no groundwater is estimated to flow from the west out of consolidated rock across the Seal Cove Fault.

Groundwater outflow from the area occurs as pumpage, out flow to the ocean, and evapotranspiration. Groundwater from the Airport Terrace Subarea that discharges to the ocean at Pillar Point Harbor and Pillar Point Marsh is estimated to be about 507 ac-ft per year. This estimate of average conditions is based on long-term average precipitation conditions, roughly precipitation 40 percent higher than during the years Luhdorf and Scalmanini / Earth Sciences Associates estimate hydraulic conditions.

Kleinfelder as well as Lowney-Kaldveer and Luhdorf and Scalmanini / Earth Sciences Associates conclude that the Airport Terrace Subarea is in general long-term balance. During drought years, water levels have been observed to drop, however during those years, the outflow to the ocean also lessens, reducing the impact of drought conditions. Water-table conditions were observed to rebound relatively rapidly during wet years. Luhdorf and Scalmanini / Earth Sciences Associates estimated that during the draught period from May 1987 to December 1990 total water-storage depletion in the airport basin aquifer was about 246 ac-ft or about 69 ac-ft per year. Despite that drop, Luhdorf noted that hydraulic gradients at the Pillar Point Marsh continued to be upward during those dry years.

Luhdorf and Scalmanini / Earth Sciences Associates and Lowney-Kaldveer, concluded that additional groundwater could be pumped from the Airport Terrace Subarea aquifer without detrimental impacts. Luhdorf's estimated additional safe yield was less than

Lowney-Kaldveers at 45 to 87 ac-ft / year, respectively. Kleinfelder monitored water levels in two wells in the Airport Subarea in an above normal precipitation year. The seasonal recharge is evident in the hydrographs, but water levels returned to near pre-water year levels by the end of the year.

8.4 MOSS BEACH SUBBASIN

South of the Lower Moss Beach Subarea, San Vicente Creek enters the Pillar Point Graben and then flows northwest toward Lower Moss Beach. We estimate that about 85 percent of the groundwater that enters the graben from the San Vicente Creek watershed flows toward the Lower Moss Beach Subarea. Based on this estimate, annual Subarea inflow from San Vicente Creek to Lower Moss Beach is estimated to average about 195 ac-ft.

Groundwater outflow from Lower Moss Beach Subarea occurs as a result of pumpage, ocean discharge, and evapotranspiration. Groundwater from the Lower Moss Beach Subarea discharges to the ocean to the northwest. Based on the hydraulic gradient estimate, transmissivity, and about 3,500 ft. of ocean frontage, we estimate an average out flow of about 330 ac-ft.

No long-term water level data are available for the Lower Moss Beach area with which to assess long-term Subarea trends. Kleinfelder monitored water levels in four wells in the Lower Moss Beach Subarea during the 2004/2005 water year. Over the course of the year, water levels fluctuated little and end of the water year water levels were only slightly higher compared with the beginning of the year in three of the four wells.

Based on 55-year precipitation data and water-balance modeling results, water levels were estimated to have not varied by much more than about 15 feet suggesting the Lower Moss Beach aquifer is in general balance. The water balance model suggests that the amount of groundwater remaining in storage above sea level in the Lower Moss Beach subarea following each water-year during the modeled period of record averaged about 720 ac-ft. Following a dry year (1987 / 88) and very dry year (1976 / 77) ground ater in storage above sea level was estimated to be about 500 ac-ft and 330 ac-ft, respectively. Assuming current pumping demand, the model indicats that average Lower Moss Beach subarea-wide groundwater would not have dropped lower than about 15 feet above sea level during the 55-year period of rainfall record used in this analysis. Although there is much uncertainty in model parameters used in this analysis ,the model would suggest that additional groundwater may be available for pumping in this subarea without significant salt water intrusion. Before that is carried out, estimates on the inputs and outputs to the groundwater basin should be refined and confirmed, particularly the volume of water that enters the subbasin from the San Vicente watershed.

8.5 Upper Moss Beach and Dean Creek Subareas

Groundwater available for pumping in the Dean Creek and Upper Moss Beach Subareas is that which is stored in either weathered or fractured granite and comes from percolating rainfall. Based on the 55-year precipitation record and soil-moisture accounting model, rainfall recharge in the Dean Creek watershed was less than the total pumping volume in nine of the 55 years (16%) of precipitation record. However, on average, the volume of recharge is estimated to be about nine times the pumping demand. In the Upper Moss Beach Subarea, recharge was less than pumping demand in 13 out of the 55 years (24%). In one eleven year period (1953-1964) in Upper Moss Beach, seven years are estimated to have had recharge rates at less than the pumping demand, but the average estimated recharge rate during that period was over double the pumping demand. Given that natural Subarea groundwater discharge rates (Subarea outflow to surrounding subareas or the creeks) from these Subareas are unknown, it is not possible to adequately assess aquifer storage in these areas. However, the data suggest that these subareas are in general long-term balance. During extended droughts, water in these subareas may drop significantly.

Hydrographs for the two monitored wells in the Dean Creek watershed and Upper Moss Beach Subarea both indicate net gains in the volume of water in storage during the above-normal 2004 / 2005 water year. Water levels rose 2.3 feet in the Upper Moss Beach well and about 10 feet in the Dean Creek area well. These data suggests that the water-bearing zones in each area can rebound from dry periods in a relative quick manner given sufficient rainfall and/or rainfall that occurs during relatively short periods that it overcomes evapotranspirative demands.

8.6 Montara Subbasin

In the Montara Subbasin area many of the wells are believed to have been completed in the marine terrace deposits that overlie weathered granitic bedrock. In the Montara Heights portion of the area, water in wells is derived primarily from the granitic aquifer. Groundwater that exists in the Montara Subbasin area is largely derived from infiltration and percolation of rainwater that falls on the area.

Our analysis suggests that, averaged over the entire Montara Subbasin, groundwater that is available for additional pumping (with all known existing wells assumed to be providing water to residences) ranges from about 94 ac-ft. in average rainfall years to about 6 ac-ft or less in dry years. However, our analysis also suggests that in very dry years, the area may have been over stressed by as much as 50 ac-ft.

The magnitude of the drawdown in wells would depend on the proximity of individual wells, localized hydrological characteristics (e.g. fractures or weathered bedrock), volume of water in storage prior to a drought, and numbers of consecutive dry years. Further, given the relatively steep gradient of the Montara aquifer system, wells at higher elevations would be at more risk of increased drawdown or dewatering problems.

Although there have been wide swings year to year between surplus and deficit in the Montara Subasin, in general, the area appears to be in long term balance. The water balance performed in this study would suggest that overall limited additional water could be pumped from groundwater overall, however there would be significant risk of localized well interference, large well drawdowns in dry years and the risk of individual wells going dry in dry and very dry years.

8.7 PORTOLA SUBAREA

Assuming all of the 35 permitted Portola Subarea wells were pumping over the last 55 years, Kleinfelder estimates that in 21 of the 55 years (38%) of record there would have been a deficit where water would decrease storage and increased drawdowns in wells. The magnitude of the drawdown would depend on the closeness of individual wells, localized hydrological characteristics (e.g. water generated from fractures or weathered bedrock), volume of water in storage prior to the drought, and numbers of consecutive dry years in a row. Further, given the relatively step gradient of the Portola aquifer system (Subarea flows toward Montara Creek) wells at higher elevations would probably be at more risk of increased drawdown or dewatering problems.

This analysis suggests that groundwater, averaged over the entire Portola Subarea that is available for additional pumping (with all known existing wells assumed providing water to residences) is less than about 20 ac-ft. in average rainfall years. Our analysis also suggests the area may be over stressed by 16 ac-ft. in dry years and as much as 45 ac-ft in very dry years. Although there have been wide swings year-to-year between surplus and deficit in the Portola Subarea, in general, the area appears to be in long term balance. Additional pumping in this area runs the significant risk of localized well interference, large well drawdowns in dry years and the risk of individual wells going dry in dry and very dry years.

8.8 MARTINI CREEK UPLAND SUBBASIN, WAGNER VALLEY SUBAREA, AND MONTARA CREEK UPPER AND LOWER SUBAREAS

Because of the absence of near-future, large-scale development and absence of sufficient water data, groundwater evaluations were not conducted for the Martini Creek Upland Subbasin, Wagner Valley Subarea, and Montara Creek Upper and Lower Subareas. Although these areas are in the greater Midcoast area, they are not included in the study area as presented by the County and as shown on the Project Area Map, Plate 1.

9.0 RECOMMENDATIONS

Many of the remedial actions that the County can apply to improve groundwater availability in the Midcoast Study Area have political implications and will need to be tailored and approved through political processes and evaluation of cost effectiveness. The following section presents recommendations that may be considered by the County of San Mateo to improve the long-term groundwater use is the area.

- Because surface flows from upslope watersheds appear to constitute the majority source of water in the Midcoast Study Area, a long-term stream flow gauging program should be implemented to better define the hydrology in the area.
- The well data in the County's database should be carefully evaluated and corrected where possible. A survey of well owners should be considered to upgrade existing databases. Given that a majority of the more than 400 letters that Kleinfelder sent to well owners listed in the database provided by the County were returned because of wrong addresses, a door-to-door canvas may be needed to correctly update the databases. This would help in correctly locating wells, recording well characteristics, and assessing actual pumping demands.
- Wells found during the survey that are not in use should be considered for destruction in compliance with County and State guidelines.
- The County should select strategic index wells in each Subbasin or Subarea to be monitored on a long-term, periodic basis. Consideration should be given for constructing monitoring wells in strategic areas in order to collect representative groundwater data.
- In areas of marginal or limited groundwater production such as the Montara Terrace, Upper Moss Beach, Dean Creek, and Portola Subareas, the County may consider metering water use and monitoring water levels.
- Generally, fractured bedrock wells are unpredictable but may on occasion intercept reservoirs of interconnecting fractures and joints that can provide reliable quantities of water. Recently completed deep wells in granitic bedrock in the Upper Montara Subbasin are reported to produce large quantities of good quality water in tests. Based on the possible success of

the Montara Creek Subarea test wells, continued assessment of fractured granitic rock sources in that area should be considered.

- Updated well information should be incorporated in the Distance-to-Wells spreadsheet and the spreadsheet should be used along with well site observation to evaluate minimum distances between proposed and existing wells. The Distance-to-Wells database can be upgraded to include complaints from well owners regarding instances of pumping interference.
- Expanded distribution systems may be considered to even out groundwater supplies in the Midcoast area. However, as noted in the report, even areas with considerable surplus water in average years can have a deficit in dry and very dry years. In the event of extended lean rainfall years, alternative sources of water, including imported water, should be considered.

10.0 LIMITATIONS

Our discussion, conclusions and recommendations presented in this report are based upon the following:

- San Mateo County supplied well and GIS data.
- Water-level measurements and pumping-test data from selected available private wells.
- Limited site reconnaissance.
- Referenced hydrogeologic documents.

Kleinfelder prepared this report in accordance with generally accepted standards of care that exist in San Mateo County at this time. This report may be used only by the County, and made available for information purposes only to the County's public. The report can only be used for the purposes stated in the report within a reasonable time from its issuance, but in no event later than four years from the date of the report. All information gathered by Kleinfelder is considered confidential and will be released only upon written authorization of the County of San Mateo or as required by law. Non-compliance with any of these requirements by the County or anyone else, unless specifically agreed to in advance by Kleinfelder in writing, will release Kleinfelder from any liability resulting from the use of this report by any unauthorized party and the County of San Mateo agrees to defend, indemnify, and hold harmless Kleinfelder from any claim or liability associated with such unauthorized use or non-compliance.

Kleinfelder offers various levels of investigative and engineering services to suit the varying needs of different clients. It should be recognized that definition and evaluation of geologic, hydrogeologic, and environmental conditions are a difficult and inexact science. Judgments leading to conclusions and recommendations are generally made with incomplete knowledge of the subsurface conditions present. Although risk can never be eliminated, more-detailed and extensive investigations yield more information, which may help understand and manage the level of risk. Since detailed investigation and analysis involves greater expense, our clients participate in determining levels of service that provide adequate information for their purposes at acceptable levels of risk. More extensive studies, including subsurface investigations or field tests, may be performed to reduce uncertainties. Acceptance of this report will indicate that the County of San Mateo has reviewed the document and determined that it does not need or want a greater level of service than provided.

Regulations and professional standards applicable to Kleinfelder's services are continually evolving. Techniques are, by necessity, often new and relatively untried. Different professionals may reasonably adopt different approaches to similar problems. As such, our services are intended to provide San Mateo County with a source of professional opinions and recommendations. Our professional opinions and recommendations are based on our limited number of field observations and tests, collected and performed in accordance with the generally accepted hydrogeologic practice that exists at the time and may depend on, and be qualified by, information gathered previously by others and provided to Kleinfelder. Consequently, no warranty or guarantee, expressed or implied, is intended or made.

11.0 BIBLIOGRAPHY

Atwater, B.F., 1975, Generalized geologic map of the uplands east of the San Andreas and Pilarcitos faults, South San Francisco Bay Area, California. Stanford University, Thesis (M.S.) - Dept. of Geology, Stanford University, scale 1:62500.

Balance Hydrologics, Inc, 2/1/1999, Wells Logs of the Montara Area, San Mateo County

Balance Hydrologics, Inc, 3/1/1999, Preliminary Feasibility Assessment of Groundwater in the Martini Creek, McNee Ranch and Upper Montara Creek Area, Interim Status Report

Balance Hydrologics, Inc, 4/1/2002, San Mateo County Midcoast Aquifers: Literature and Data Review

Brabb, E.E. and Hanna, W.F., 1981, Maps showing aeromagnetic anomalies, faults, earthquake epicenters, and igneous rocks in the southern San Francisco Bay region, California: U.S. Geological Survey, Geophysical Investigations Map GP-932, scale 1:125000.

Brabb, E.E. and Olson, J.A., 1986, Map showing faults and earthquake epicenters in San Mateo County, California: U.S. Geological Survey, Miscellaneous Investigations Series Map I-1257-F, scale 1:62500.

Brabb, E.E. and Pampeyan, E.H., 1983, Geologic map of San Mateo County, California: U.S. Geological Survey, Miscellaneous Investigations Series Map I-1257-A, scale 1:62500.

Brabb, E.E., 1983, Map showing direction and amount of bedding dip of sedimentary rocks in San Mateo County, California: U.S. Geological Survey, Miscellaneous Investigations Series Map I-1257-C, scale 1:62500.

Brabb, E.E., Clark, J.C., and Throckmorton, C.B., 1977, Measured sections of Paleogene rocks from the California coast ranges: U.S. Geological Survey, Open-File Report OF-77-714, scale 1:62500.

Brabb, E.E., Graymer, R.W., and Jones, D.L., 1998, Geology of the onshore part of San Mateo County, California: a digital database: U.S. Geological Survey, Open-File Report OF-98-137, scale 1:62500.

Brabb, E.E., Graymer, R.W., and Jones, D.L., 2000, Geologic Map and Map Database of the Palo Alto 30' X 60' Quadrangle, California

Brabb, E.E., Pampeyan, E.H., and Bonilla, M.G., 1972, Landslide susceptibility in San Mateo County, California: U.S. Geological Survey, Miscellaneous Field Studies Map MF-360, scale 1:62500.

Brabb, E.E., Roberts, S., Cotton, W.R., Kropp, A.L., Wright, R.H. and Zinn, E.N. (2000): Possible Costs Associated with Investigation and Mitigating some Geologic Hazards in Rural Parts of San Mateo County, California; Geology of the Half Moon Bay Quadrangle, San Mateo County, California,; US Geological Survey; derived from the map by Brabb, E.E., Graymer, R.W. and Jones, D.L. (1998); Digital Database by Sebastian Roberts and Suzanne K. Mills; Plot derived from Open-File Report 00-127 Sheet 8 of 22; http://geopubs.wr.usgs.gov/open-file/of00-127/

Brady/LSA, 5/1/2002, Fitzgerald Marine Reserve Master Plan, Geological / Geotechnical Conditions

Buechel, S.W. and Wagner, A.F., 1996, Map showing vegetation in San Mateo County, California: U.S. Geological Survey, Miscellaneous Investigations Series Map I-1257-N, scale 1:62500.

California Division of Mines and Geology, 1976, Official map of Alquist-Priolo Earthquake Fault Hazard Zones, Half Moon Bay Quadrangle: California Division of Mines and Geology, scale 1:24000.

California Division of Mines and Geology, 1982, Revised official map of Alquist-Priolo Earthquake Fault Hazard Zones, Montara Mountain Quadrangle: California Division of Mines and Geology, scale 1:24000.

Coastside County Water District, 2001, 2001 Annual Water Quality Report

Davis, F.F., 1955, Mines and mineral resources of San Mateo County, California: California Division of Mines and Geology, California Journal of Mines and Geology v.51 no.4, p.401-458, scale 1:123500.

Dept of Water Resources, January 1, 1999, Final Draft, Montara Water Supply Study for Montara Sanitary District, San Mateo County, California

Dept of Water Resources, April 1991, Groundwater in Fractured Hard Rock, Water Facts No. 1

DMG Staff, 2000, Digital images of Official Maps of Alquist-Priolo Earthquake Fault Zones of California, central coast region: California Division of Mines and Geology, CD 2000-004, scale 1:24000.

Earth Metrics Inc., 12/1/1987, Administrative Draft, Environmental Impact Report for the Proposed Farallon Vista Water Supply Development Project.

Earth Sciences Associates, 8/12/1986, Evaluation of Ground-Water Development Potential in the Half Moon Bay and El Granada Areas

Emily K Youcha, Michael R. Lilly, Larry D. Hinzman, 2002, Geohydrologic Properties of Fractured Bedrock Aquifer Systems: A Review and Application to Ester Dome, Alaska American Water Resources Association, Alaska Section Annual Meeting, April 8-10, 2002, Soldotna, Alaska. Oral.

F. Beach Leighton & Associates, 10/15/1971, Geologic Report of Seal Cove & Moss Beach Area, County of San Mateo

Hedlund, C. (2003): Hydrogeology and Geochemistry of the Northern Groundwater Basin, San Mateo County, California; Master Thesis at San Francisco State University.

Helley, E.J., Lajoie, K.R., Spangle, W.E., Blair, M.L., and William Spangle & Associates, 1979, Flatland deposits of the San Francisco Bay region, California - their geology and engineering properties, and their importance to comprehensive planning: U.S. Geological Survey, Professional Paper 943, scale 1:125000.

Kennedy, G.L, Lajoie, K. R., Blunt, D.J. and Mathieson, S.A. (1982): Half Moon Bay Terrace, California, and the age of its Pleistocene invertebrate faunas, Western Society of Malacologists Annual Report, 14, 2p.

Kleinfelder, 2/6/1989, Administrative Draft, Montara - Moss Beach Water Well EIR, Partial Administrative Draft

Kleinfelder, 3/24/1988, El Granada Ground-Water Investigation

Kleinfelder, 4/1/1988, El Granada Ground-water Investigation Report

Kleinfelder, 6/6/1996, Water Use Assessment, Pigeon Point Inn, San Mateo County, California

Kleinfelder, 8/9/1989, Final Montara-Moss Beach Water Well EIR

Kleinfelder, October 1991, Rural Area Water Use Study, Final Report

Knudsen, K.L., Noller, J.S., Sowers, J.M., and Lettis, W.R., 1997, Quaternary geology and liquefaction susceptibility, San Francisco, California 1:100,000 quadrangle: a digital database: U.S. Geological Survey, Open-File Report OF-97-715, scale 1:100000.

Lajoie, K.R., Helley, E.J., Nichols, D.R., and Burke, D.B., 1974, Geologic map of unconsolidated and moderately consolidated deposits of San Mateo County, California: U.S. Geological Survey, Miscellaneous Field Studies Map MF-575, scale 1:62500.

Larue, D., Steel, R.J (eds), 5/18/1983, Cenozoic Marine Sedimentation, Pacific Margin, SEPM

Leithton & Assoc, 5/26/1905, Official Map, County of San Mateo, State of California

Lowney-Kaldveer Associates, 4/4/1974, Groundwater Investigation, Denniston Creek Vicinity, San Mateo County, California

Luhdorff and Scalmanini / Earth Sciences Assoc, 6/1/1987, Half Moon Bay / Piller Point Marsh Ground-Water Basin Report, Phase I

Luhdorff and Scalmanini / Earth Sciences Assoc, 9/1/1991, Half Moon Bay / Piller Point Marsh Ground-Water Basin Report, Phase II

Luhdorff and Scalmanini, no date, Preliminary Well Profile, for Kingsley Management, El Granada Mobile Home Park, Moss Beach, California, 102 Celurra, APN 134-131-410

Mark, R.K., Newman, E.B., and Brabb, E.E., 1988, Slope map of San Mateo County, California: U.S. Geological Survey, Miscellaneous Investigations Series Map I-1257-J, scale 1:62500.

Moore, D.E. and Byerlee, J., 1989, Active faults, probable active faults and associated fracture zones, San Mateo County, California: U.S. Geological Survey, Open-File Report OF-89-347, scale 1:62500.

Napier, Gene, Perkins, J.B., Moreland, Roberta, Mark, Robert, and Brabb, E.E., 1992, Map showing land use and land cover in San Mateo County, California: U.S. Geological Survey, Miscellaneous Investigations Series Map I-1257-L, scale 1:62500.

Nelson, E, no date, Phase II of Lower Pilarcitos Creek Groundwater Investigation, Half Moon Bay, California

Nicole Pullman (San José State paper), 5/20/1987, Initial Study of Ground-Water Assessment of El Granada

Page, Ben M. (1966): Geology of the Coast Ranges of California, in: Bailey, E.H. (1966): Geology of Northern California; California Division of Mines and Geology Bulletin 190; p.255-276.

Pampeyan, E.H., 1981, Geologic map of the Montara Mountain quadrangle, San Mateo County, California: U.S. Geological Survey, Open-File Report OF-81-451, scale 1:12000.

Pampeyan, E.H., 1994, Geologic map of the Montara Mountain and San Mateo 7.5' quadrangles, San Mateo County, California: U.S. Geological Survey, Miscellaneous Investigations Series Map I-2390, scale 1:24000.

San Mateo County, 5/22/2002, Midcoast Groundwater Study Phase 1 Report; Proposed Revisions to County Well Regulations for the Midcoast

San Mateo County, 5/6/2002, Status report of the Board Subcommittee on Wells and Aquifers and Review of Phase I of the Midcoast Aquifer Study

San Mateo County, 7/18/2002, Request for Proposal, Groundwater Basin Geotechnical & Economic Feasibility Study, Lower Pilarcitos Creek Groundwater Basin Project

San Mateo County, 8/24/2002, Report to the Board Subcommittee on Wells and Aquifers on Introduction Ordinance Amending the County Well Ordinance for the Midcoast Area

San Mateo County, Environmental Services Agency, 6/30/1998, Local Coastal Program, Policies

San Mateo County, no date, An Ordinance Amending Chapter 4.68 Wells, San Mateo County Ordinance Code

Sedlock, R. (1995): Tectonic Framework, Origin and Evolution of the San Francisco Bay Region; in: Recent Geologic Studies in the San Francisco Bay Area, volume 76, edited by E.M. Sangines, D.W. Anderson, and A.V. Buising, pp. 1-18, Society of Economic Paleontologists and Mineralogists, Pacific Section; Los Angeles, California.

Terry Burnes, San Mateo Co, 8/15/2002, Request for Proposals (RFP), Midcoast Groundwater Study, Phase 2

Teter, J.S., 7/1/1998, Coastside County Water District, Preliminary Engineering Report, Phase II Water Supply Project

U.S. Geological Survey, 1973, Atlas of urban and regional change, San Francisco Bay region, California: U.S. Geological Survey, Open-File Report OF-73-322, scale 1:62500.

U.S. Geological Survey, 1976, Atlas of urban and regional change, San Francisco Bay region, land use change, 1970-72: U.S. Geological Survey, Open-File Report OF-76-396, scale 1:62500.

U.S. Geological Survey, 1978, Land use and land cover, 1976-77, Montara Mountain [quadrangle], California: U.S. Geological Survey, Open-File Report OF-78-739, scale 1:24000.

Webster, D.A., 1972, Maps showing areas in the San Francisco Bay region where nitrate, boron, and dissolved solids in groundwater may influence local or regional development: U.S. Geological Survey, Miscellaneous Field Studies Map MF-432, scale 1:125000.

Base Map, Portions of: U.S. Geologic Survey Half Moon Bay, Montara Mountain, San Mateo, and Woodside 7.5-Minute Topographic Quadrangles, San Mateo County, California. Original in Color

San Mateo County, Midcoast Groundwater Study Area, Phase II

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Compiled by: P. Holland	Date: 01/02/06
Reviewed by: M. Clark	Revision date:

Project Area Map
San Mateo County Midcoast Groundwater Study, Phase II
San Mateo County, California
PROJECT NO. 26848

PLATE
1

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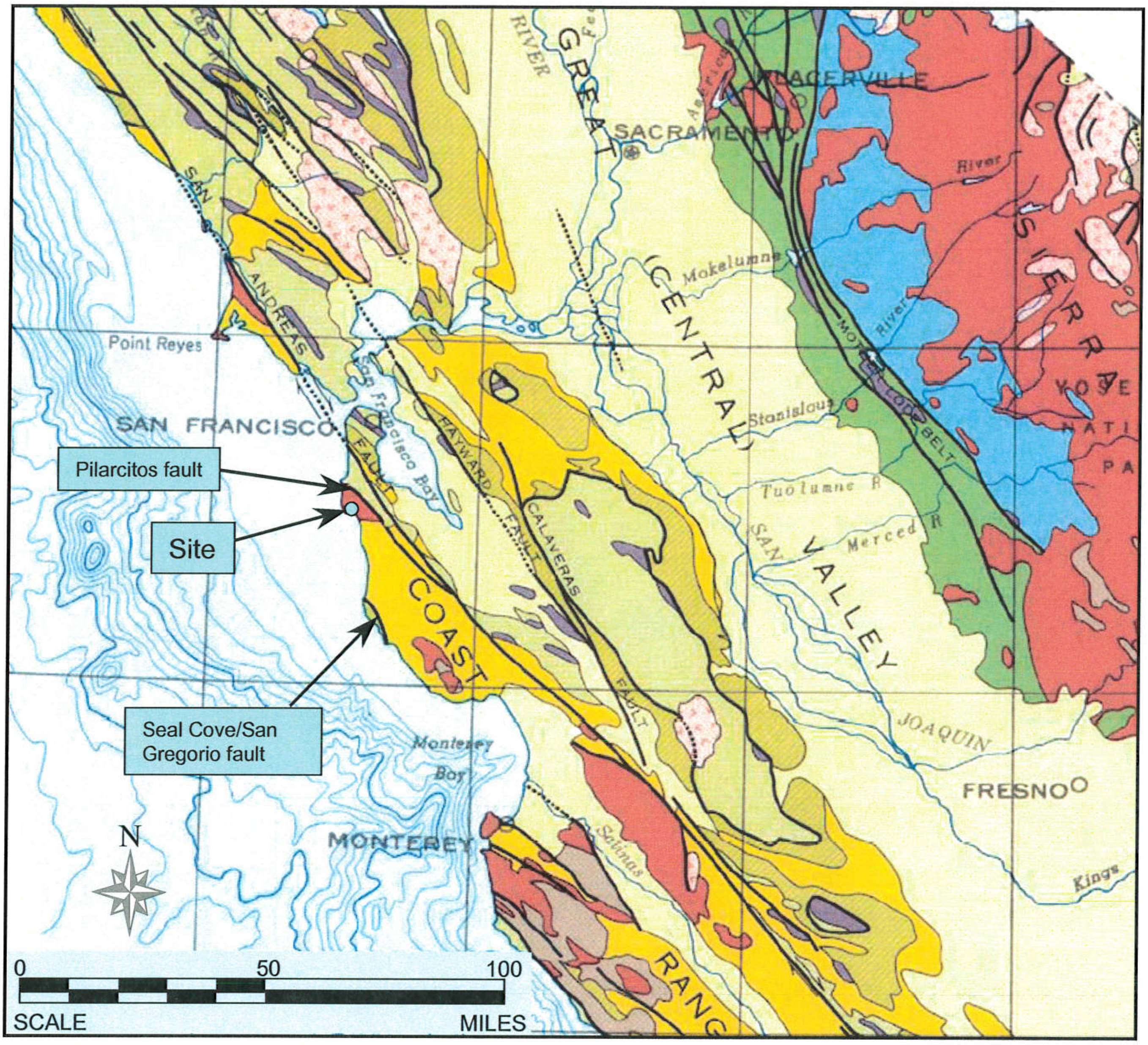

EXPLANATION
of units in SF Bay Area

- Cenozoic nonmarine
- Cenozoic marine
- Late Mesozoic shelf and slope
- Late Mesozoic of the Franciscan Formation
- Mesozoic Granitic rocks
- Mesozoic Ultramafic rocks
- Fault, dotted where concealed, arrows indicate direction of movement

Map source: California Geological Survey, 2002, Geologic Map of California, California Department of Conservation. Use with permission.

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Regional Geologic Map
San Mateo County Midcoast Groundwater Study, Phase II
San Mateo County, California

PLATE
2

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Legend

Original in Color

Subbasins

Midcoast Watershed Area

Structure

- fault, approx. located
- fault
- fault, concealed
- ?-------? fault, concealed, queried

Base Map, Portion of: Brabb, E.E., Graymer, R.W., and Jones, D.L., 1998, Geology of the onshore part of San Mateo County, California: a digital database: U.S. Geological Survey, Open-File Report OF-98-137, scale 1:62500

Geologic Units

- Water
- Artificial Fill
- Alluvium (Holocene)
- Collvium (Holocene)
- Basin Deposits (Holocene)
- Dune Sand and Beach Deposits (Holocene)
- Younger (inner) Alluvial Fan Deposits (Holocene)
- Younger (Outer) Alluvial Fan Deposits (Holocene)
- Marine Terrace Deposits (Pleistocene)
- Older Alluvial Fan Deposits (Pleistocene)
- Purisima Formation (Mio-Pliocene)
- San Gregario Sandstone Member (Pliocene)
- Lompico Sandstone (Miocene)
- Monterey Formation (Miocene)
- Marbles and Hornfels (Paleozoic)
- Granitic Rocks of Montara Mountain

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Subbasins and Geologic Map

San Mateo County Midcoast Groundwater Study, Phase II

San Mateo County, California

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PLATE 3

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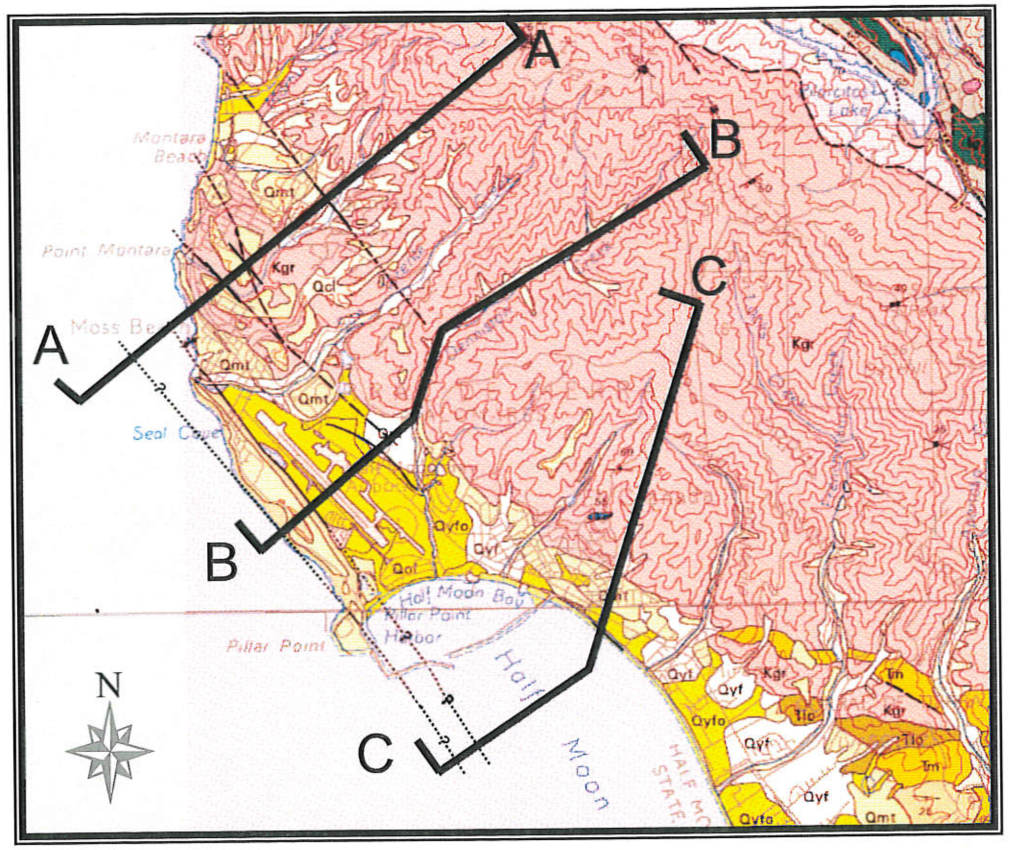
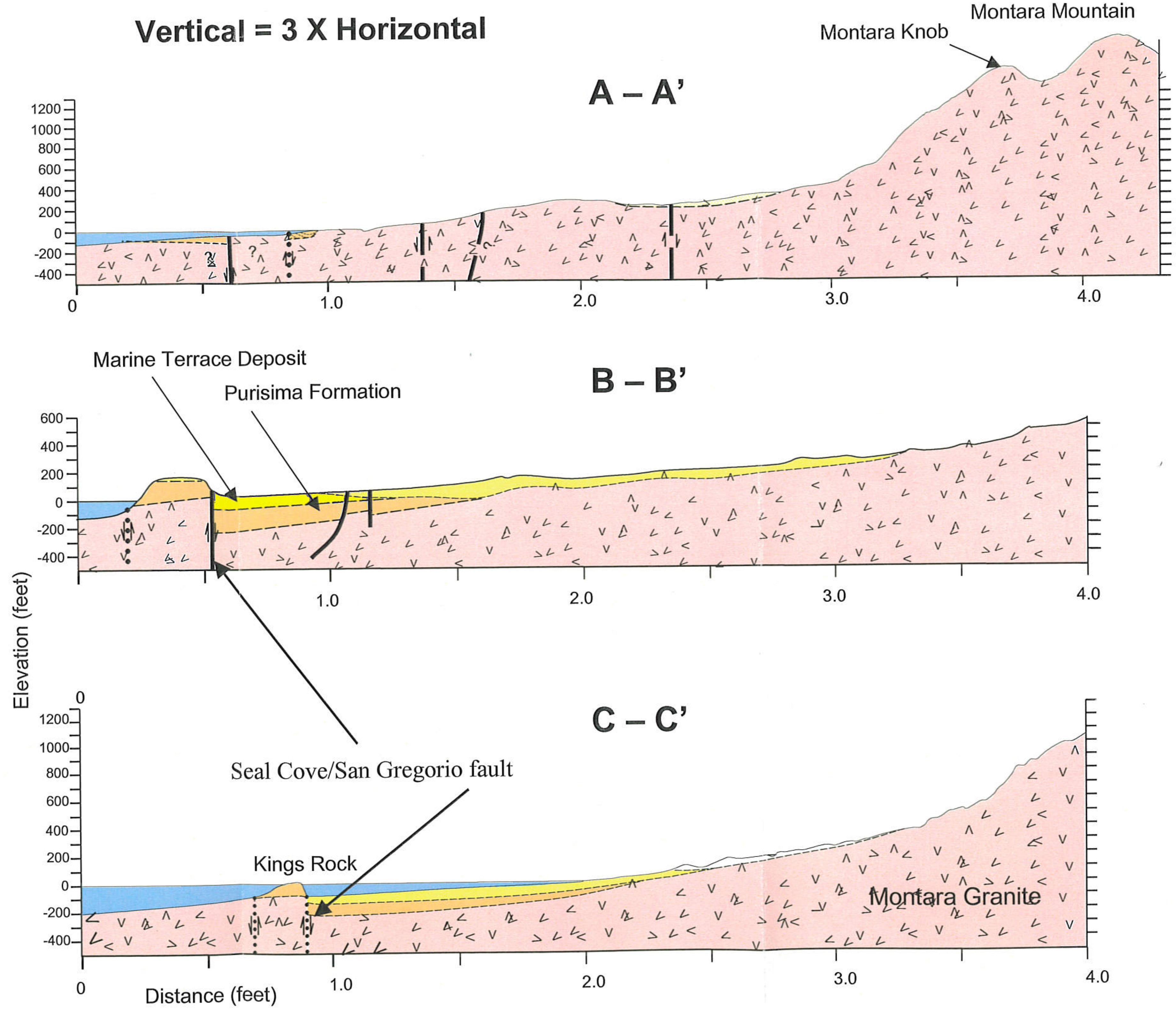


Fault traces:
solid = known location
Dashed = inferred location
Dotted = buried location



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Geologic Cross Sections

San Mateo County Midcoast Groundwater Study, Phase II

San Mateo County, California

PLATE 4

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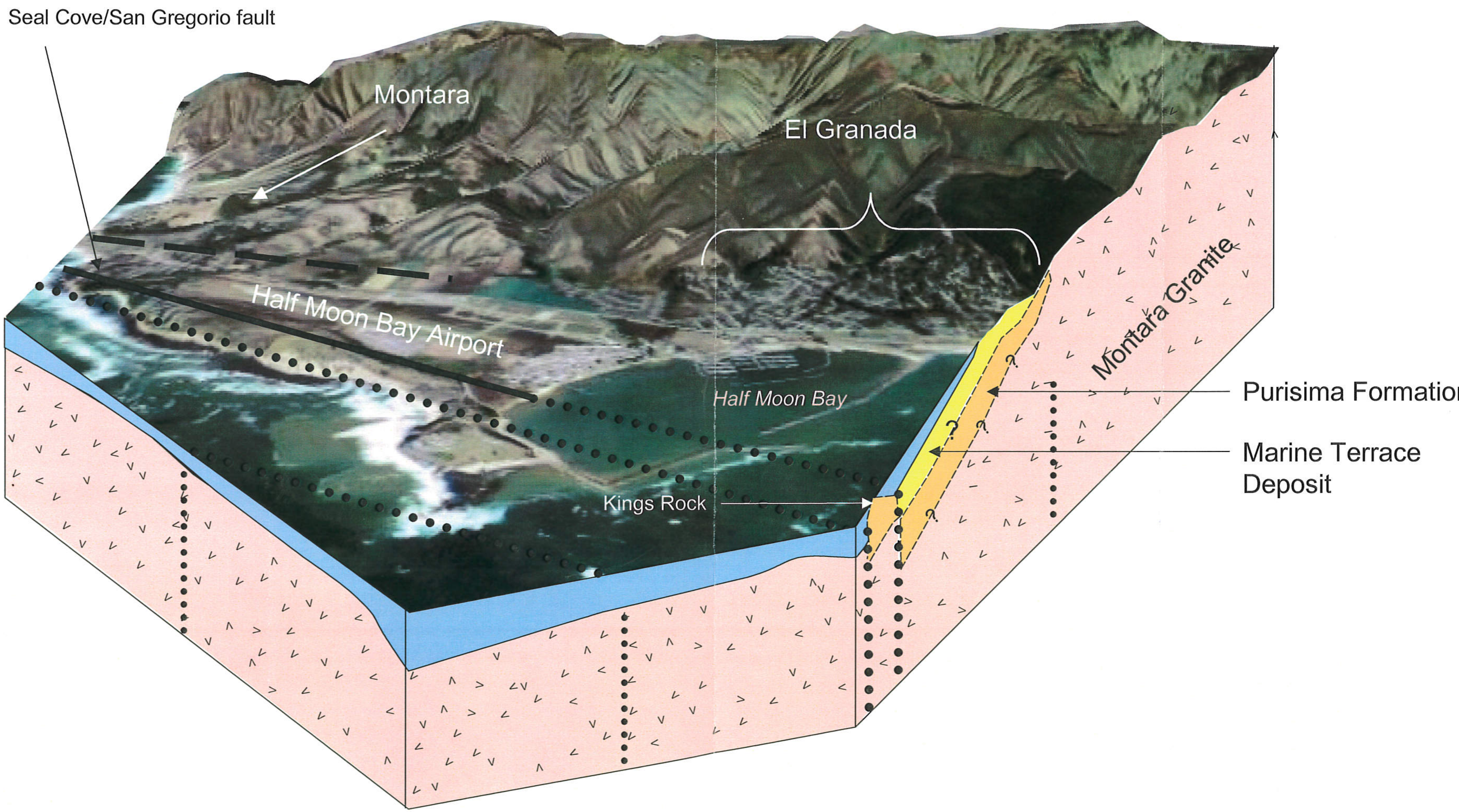

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Study Area Block Diagram

San Mateo County Midcoast Groundwater Study, Phase II

San Mateo County, California

PLATE

5

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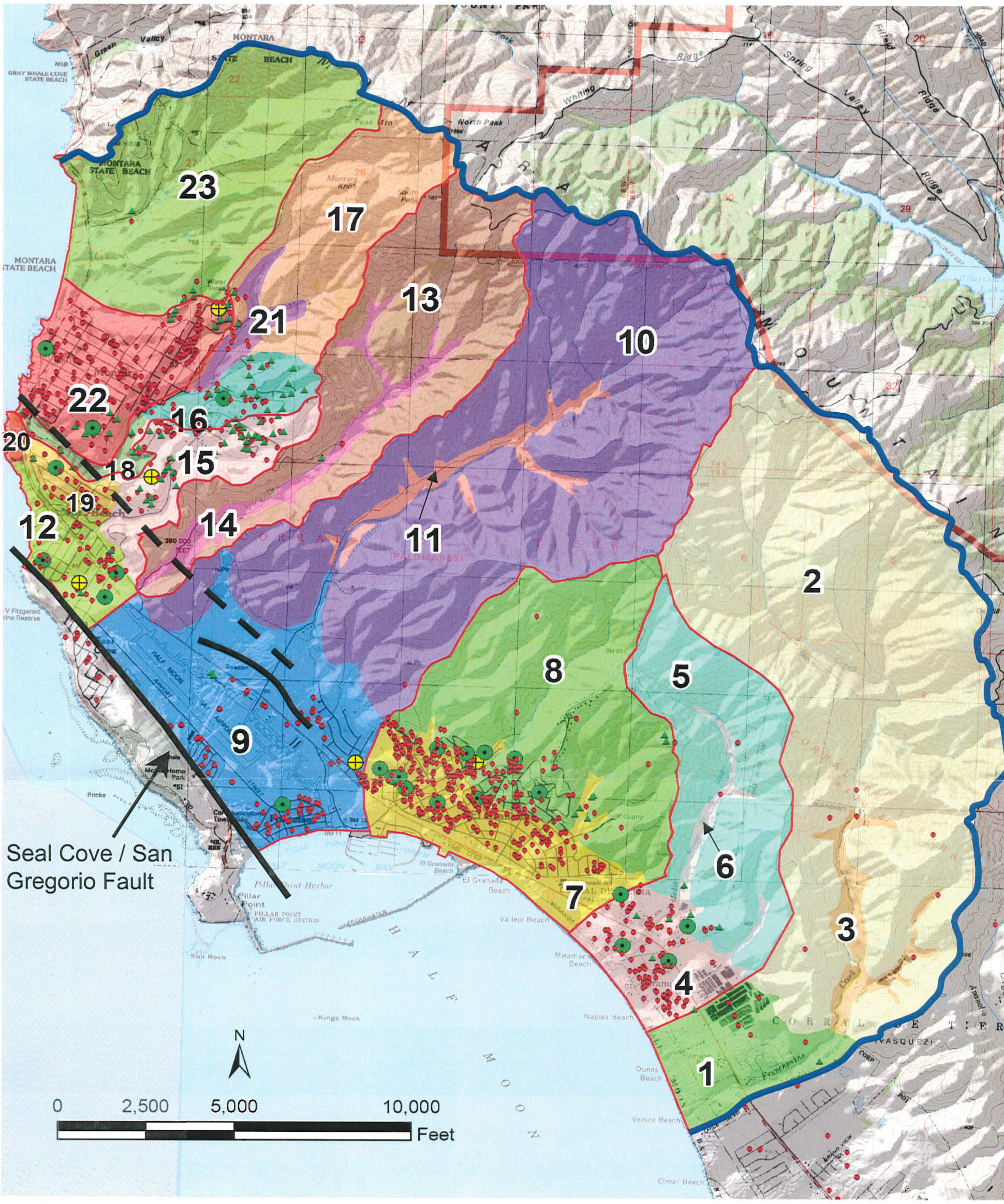

Legend

Well Types

- Monitor Wells (This Study)
- Monitor/Pump Wells (This Study)
- Other
- Septic Tanks
- Watersheds
- Midcoast watershed
- Fault (dashed where approximate)

Original in Color

Groundwater Subareas

1	Frenchmans Terrace	9	Airport Terrace	17	Montara Knob
2	Frenchmans Uplands	10	Denniston Uplands	18	Montara Creek
3	Frenchmans Stream Valley	11	Denniston Stream Valley	19	Upper Moss Beach
4	Miramar Terrace	12	Lower Moss Beach	20	Lighthouse
5	Arroyo Medio Uplands	13	San Vincente Uplands	21	Wagner Valley
6	Arroyo Medio Stream Valley	14	San Vincente Stream Valley	22	Montara Terrace
7	El Granada Terrace	15	Dean Creek	23	Martini Uplands
8	El Granada Uplands	16	Portola		

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Midcoast Subareas, Wells, Septic Tanks

San Mateo County Midcoast Groundwater Study, Phase II

San Mateo County, California

PLATE 6

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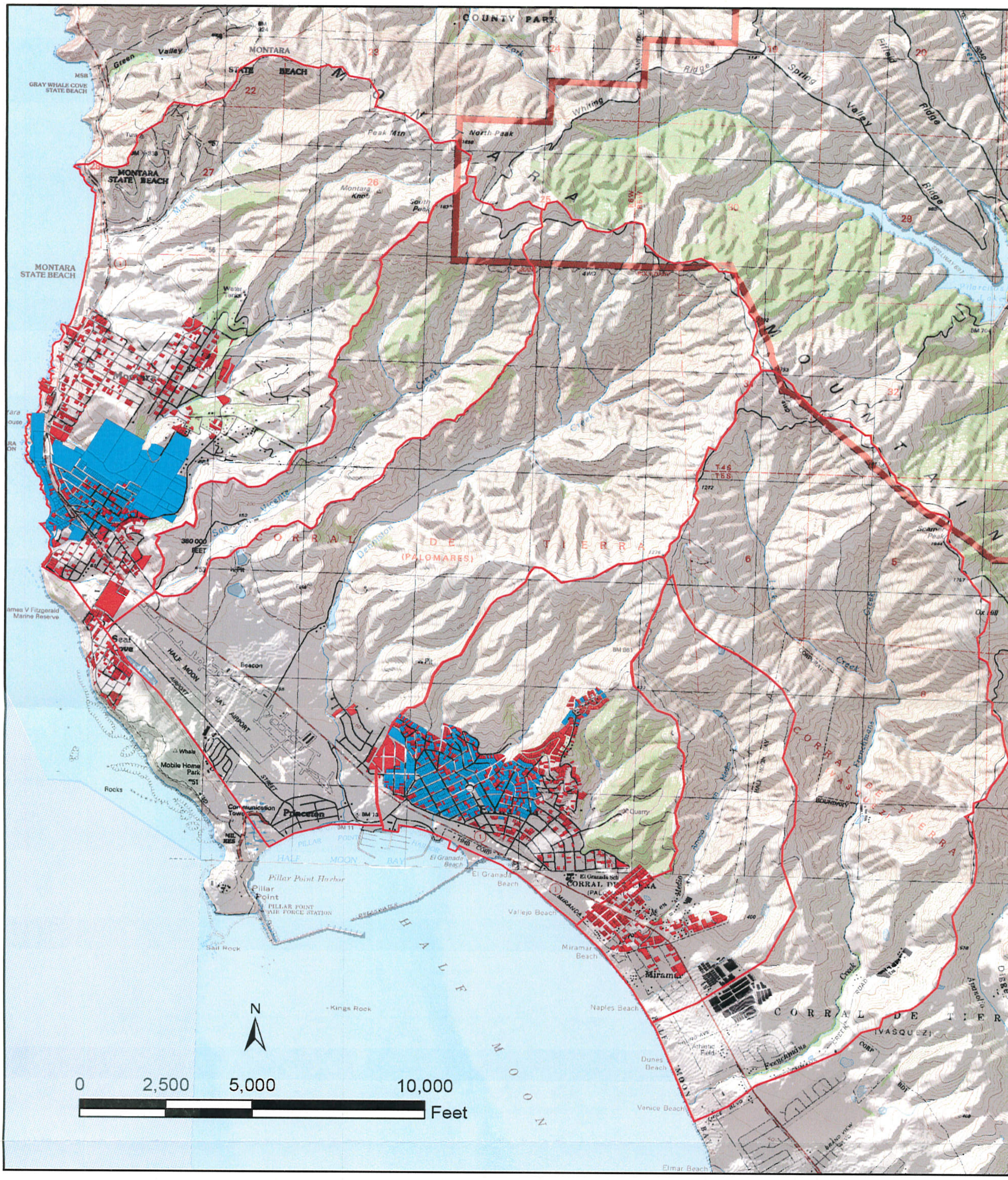

Legend

APNs

- Developed Lots
- Vacant
- Major Watersheds

Developed and undeveloped lots derived from data provided by the County of San Mateo

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Developed and Undeveloped APNs

San Mateo County Midcoast Groundwater Study, Phase II

San Mateo County, California

PLATE 7

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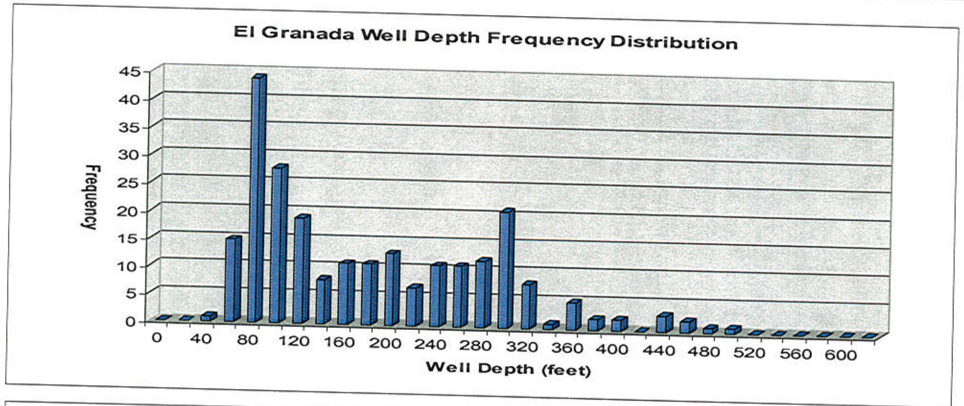

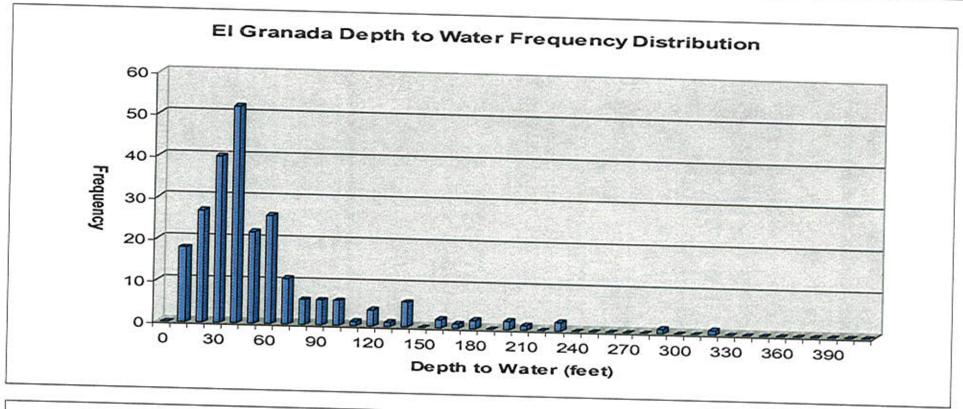

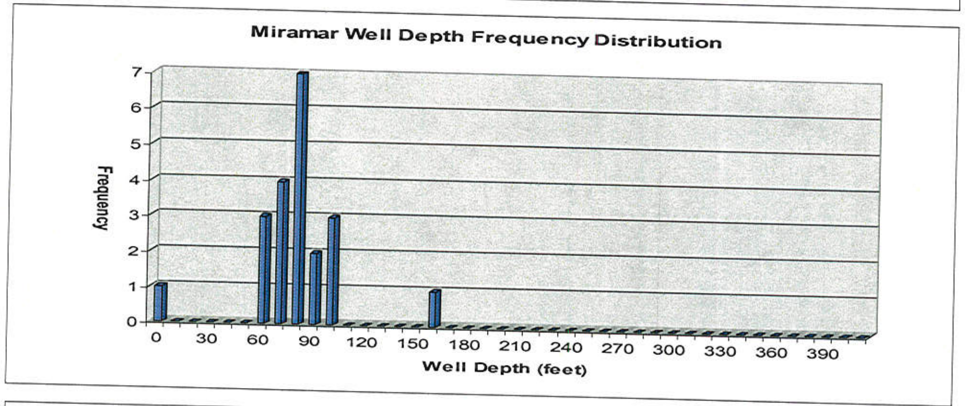

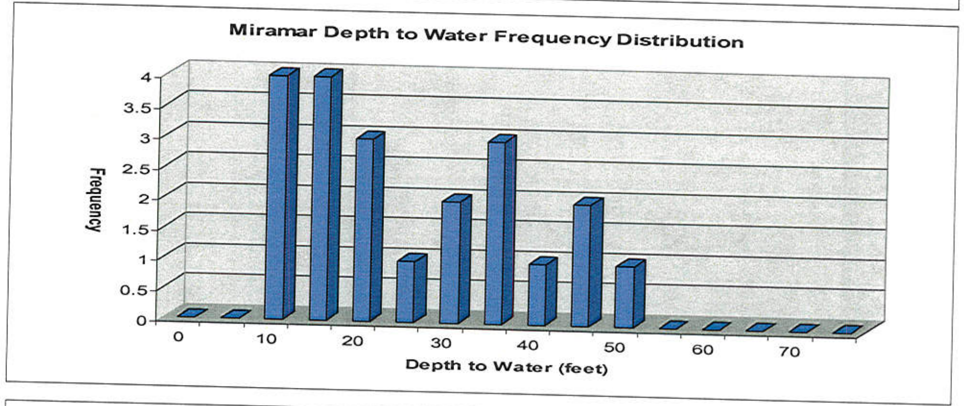

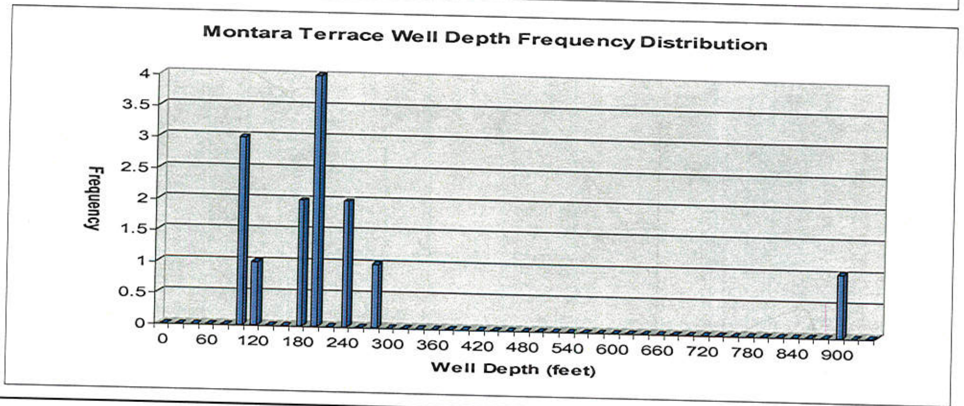

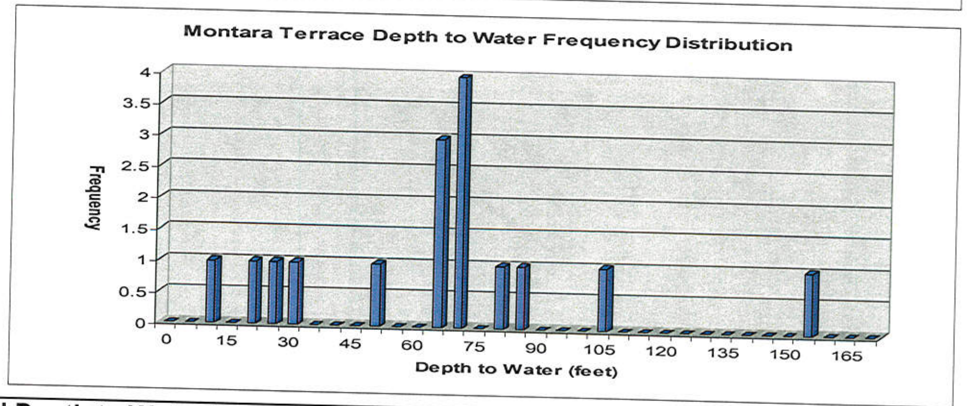

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Well-Depth and Depth to Water Frequency Distributions by Sub-Areas (1)
San Mateo County Midcoast Groundwater
Study Area Phase II
San Mateo County, California

PLATE
8

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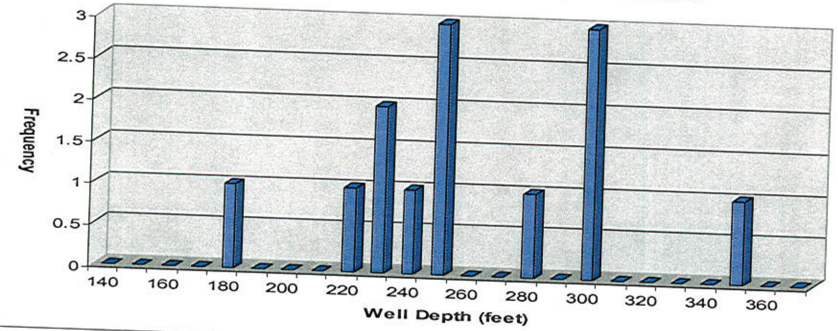
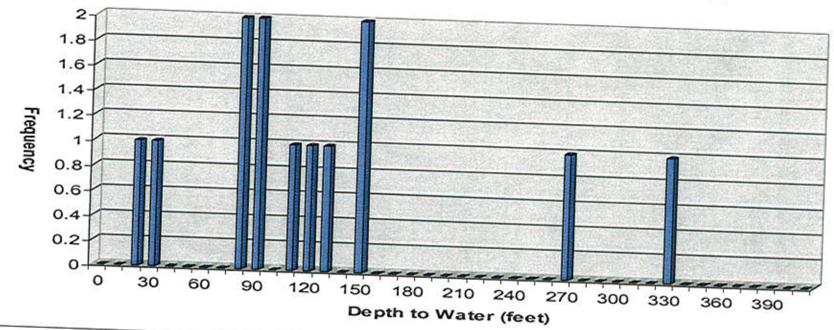
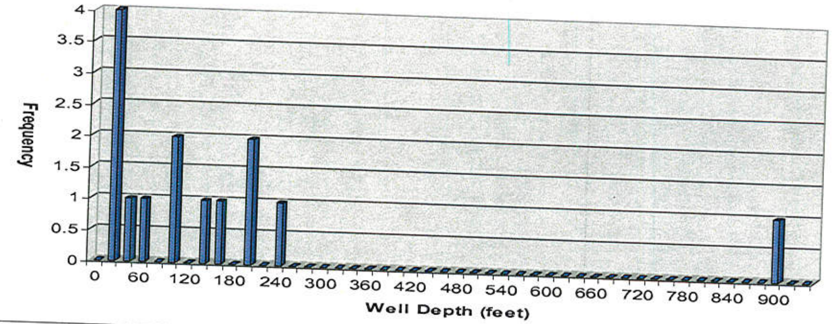
Montara Heights Well Depth Frequency Distribution



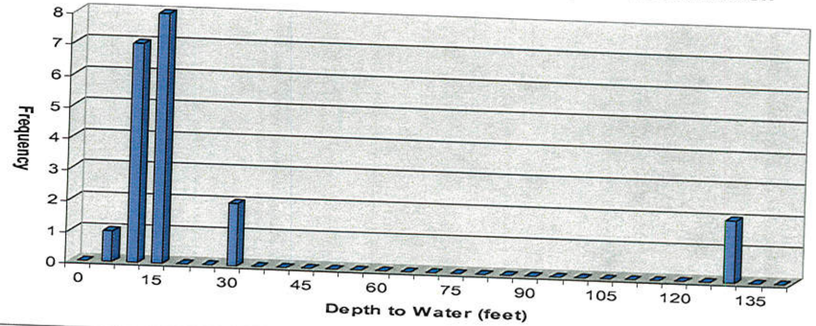
Montara Heights Depth to Water Frequency Distribution



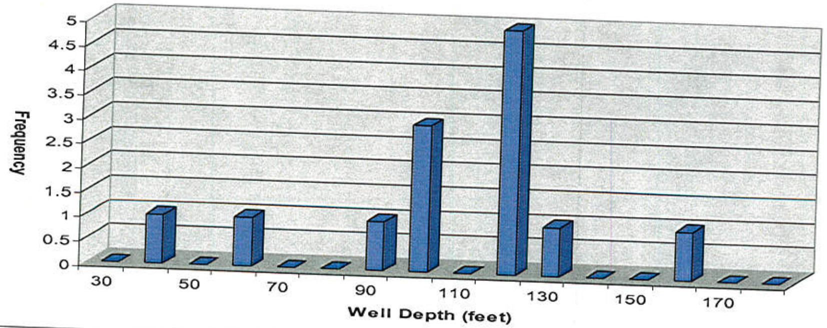
Lower Moss Beach Terrace Well Depth Frequency Distribution



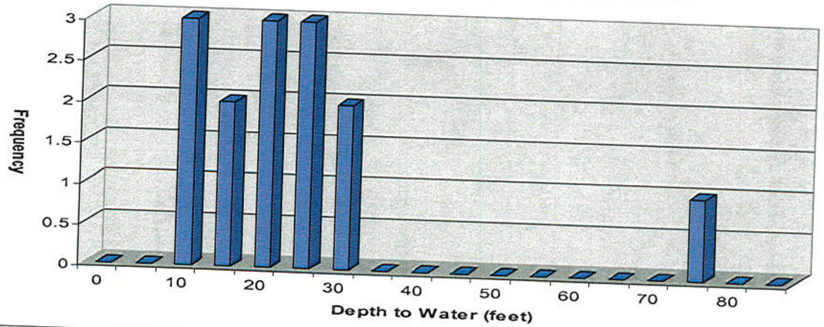
Lower Moss Beach Terrace Depth to Water Frequency Distribution



Airport Area Well Depth Frequency Distribution



Airport Area Depth to Water Frequency Distribution



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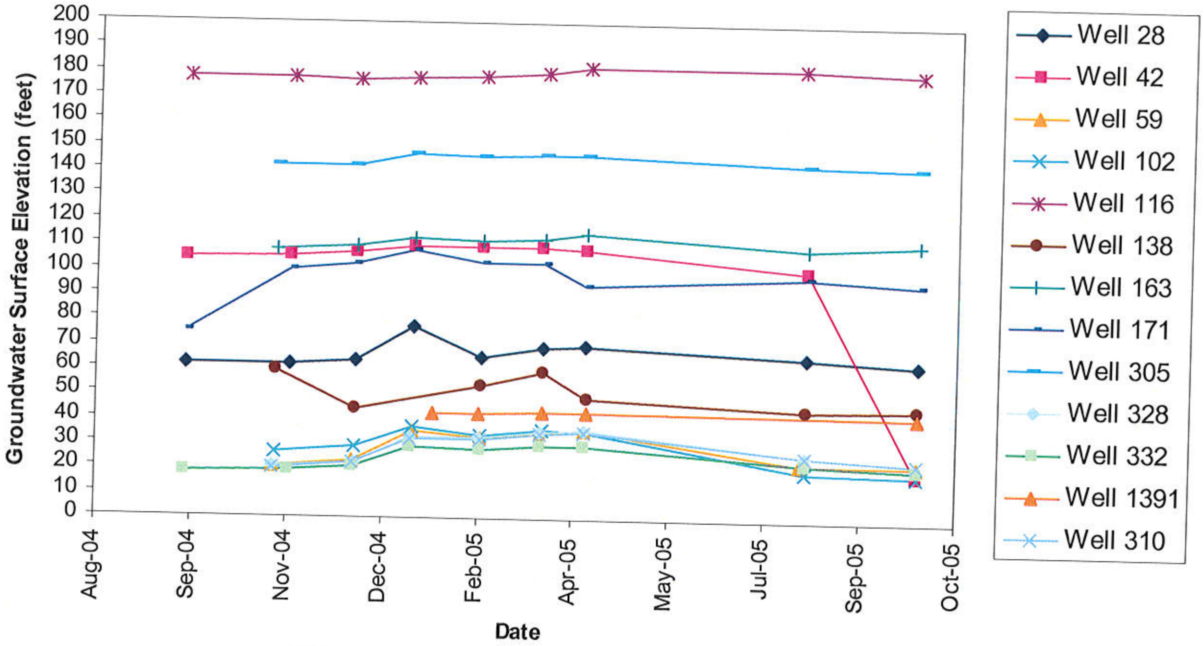
Well-Depth and Depth to Water Frequency Distributions by Sub-Areas (2)
San Mateo County Midcoast Groundwater
Study Area Phase II
San Mateo County, California

PROJECT NO. 26848

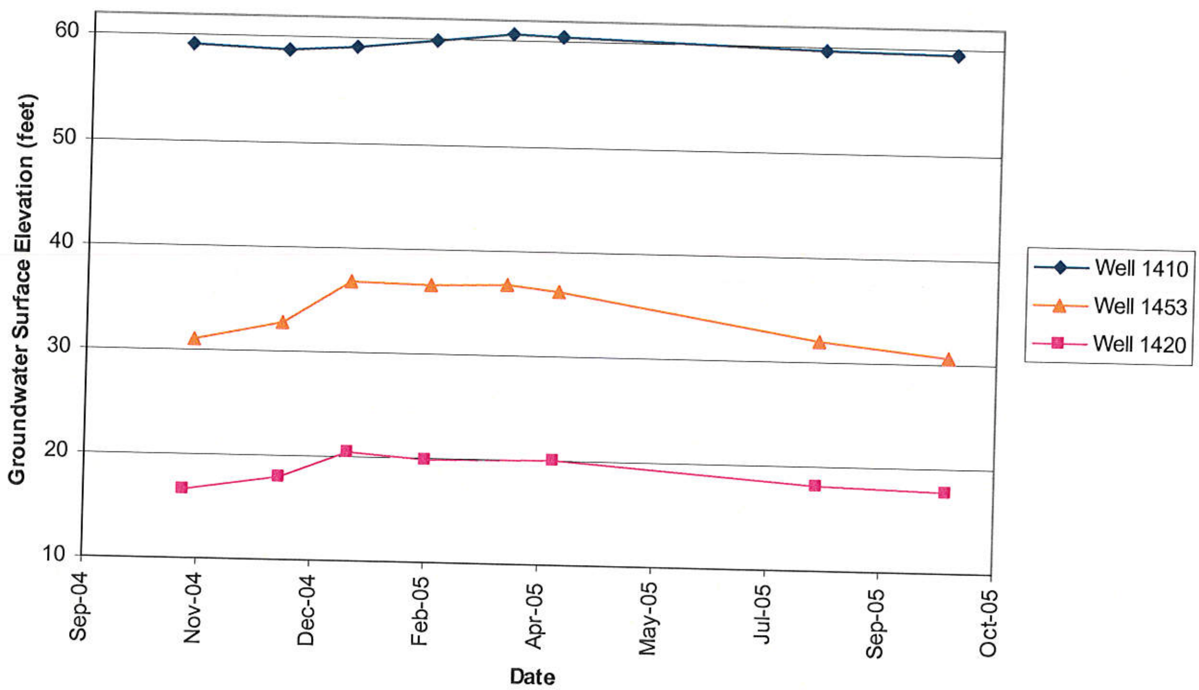
PLATE

9

El Granada - Groundwater Surface Elevations



Miramar - Groundwater Surface Elevations



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Subareas Groundwater Elevation Monitoring
El Granada and Miramar

San Mateo County Midcoast Groundwater Study
San Mateo County, California

PLATE
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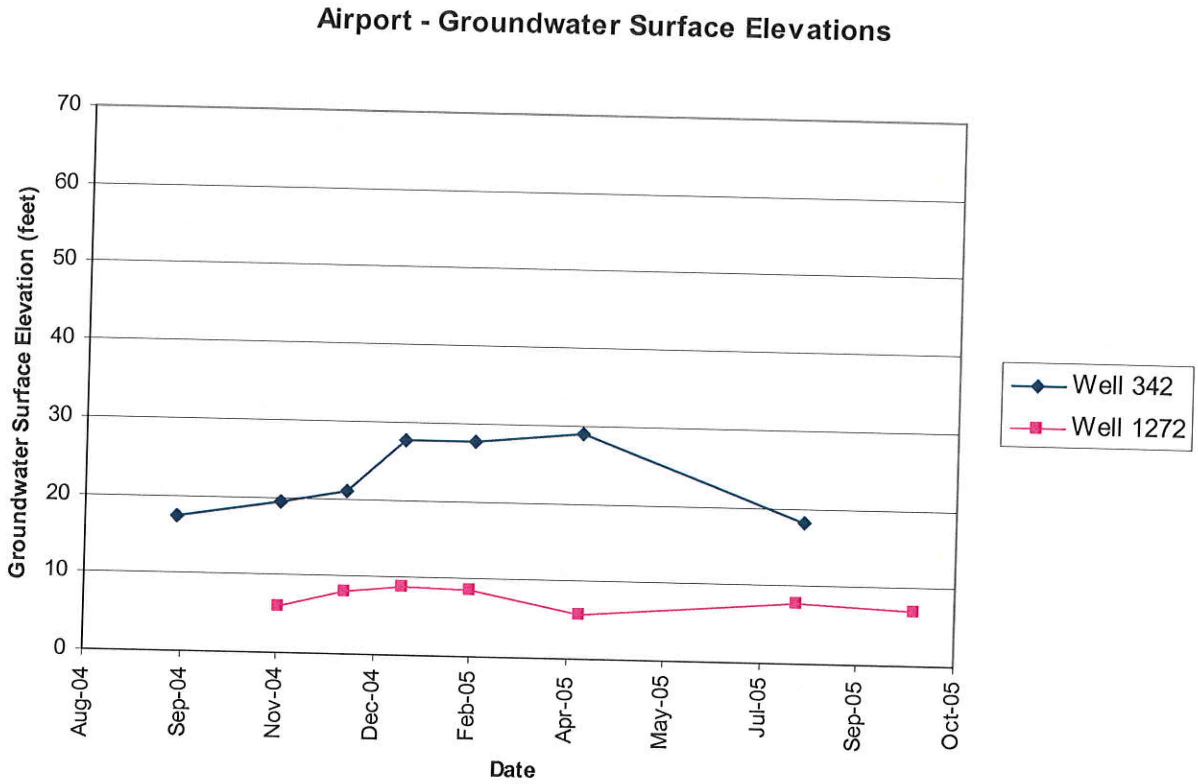

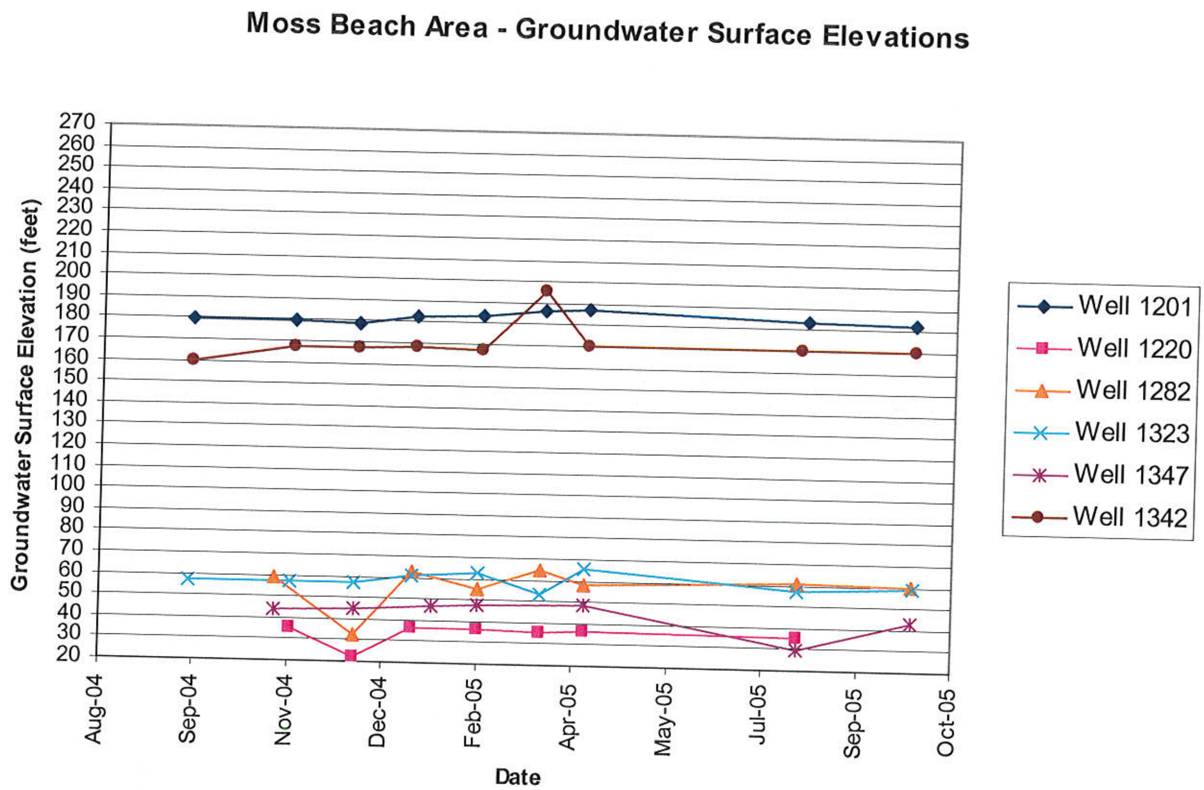

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Subareas Groundwater Elevation Monitoring Airport and Moss Beach

San Mateo County Midcoast Groundwater Study

San Mateo County, California

PLATE

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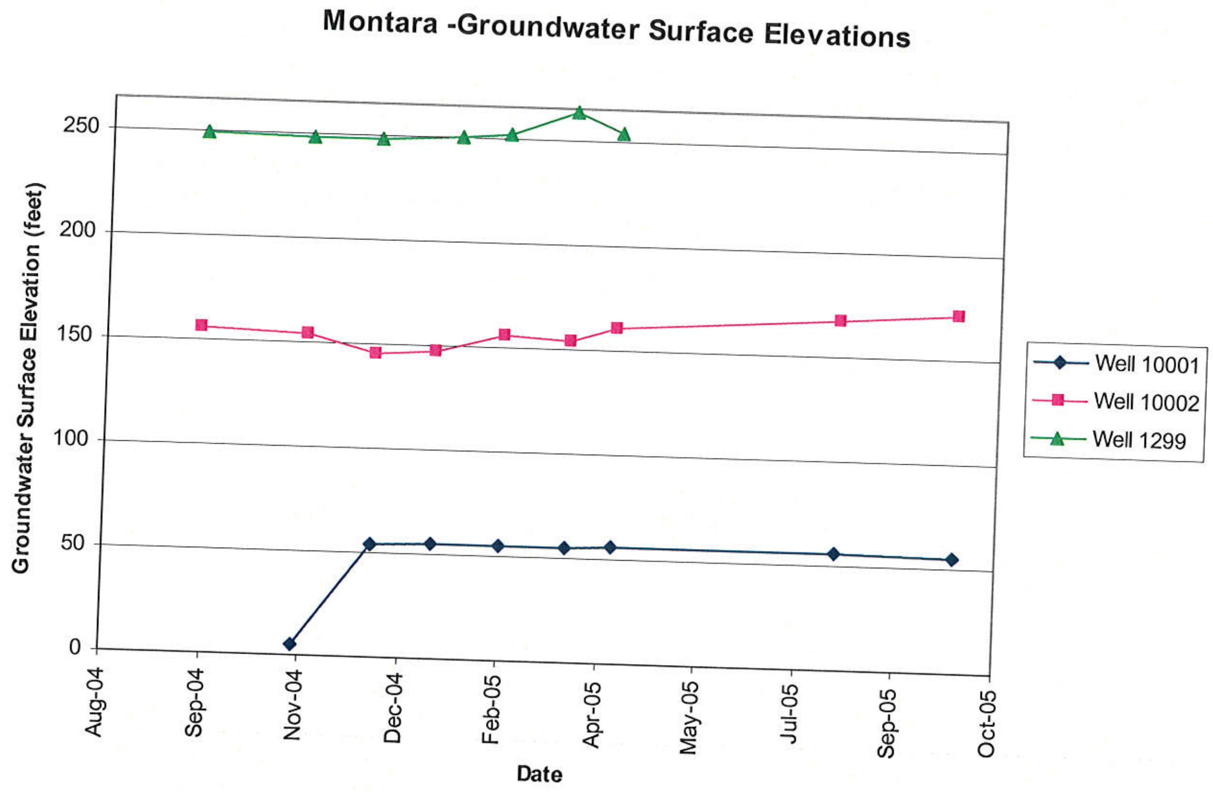

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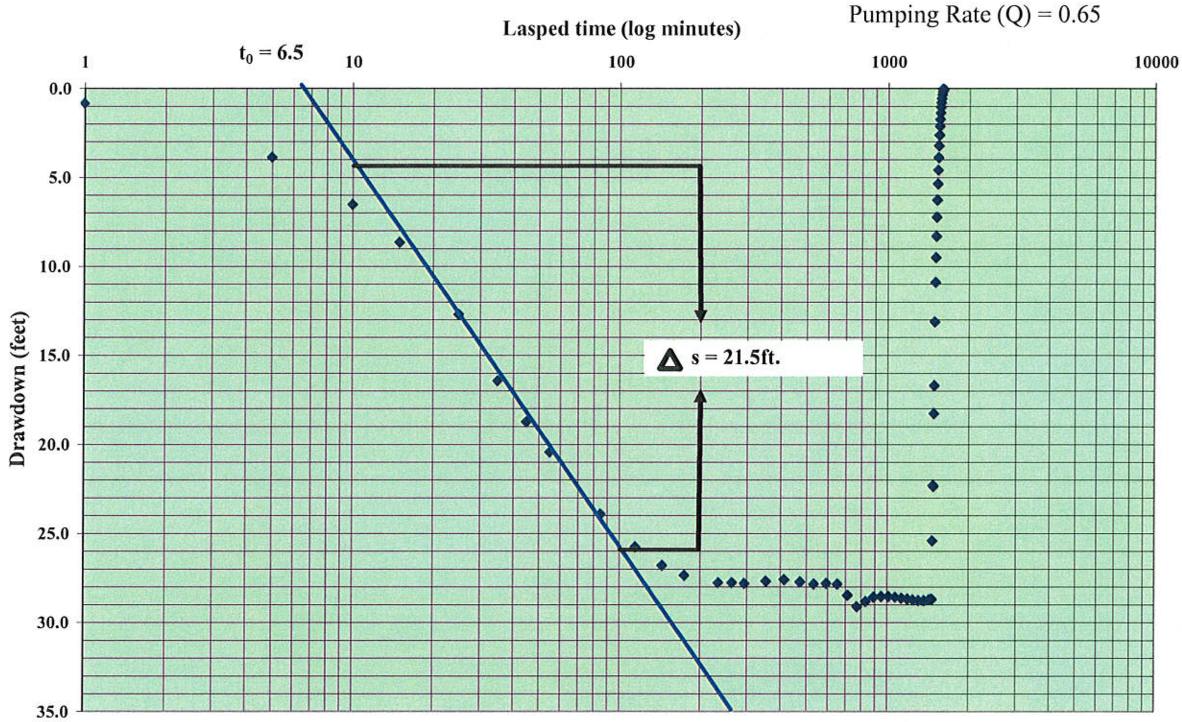
Subareas Groundwater Elevation Monitoring
Montara

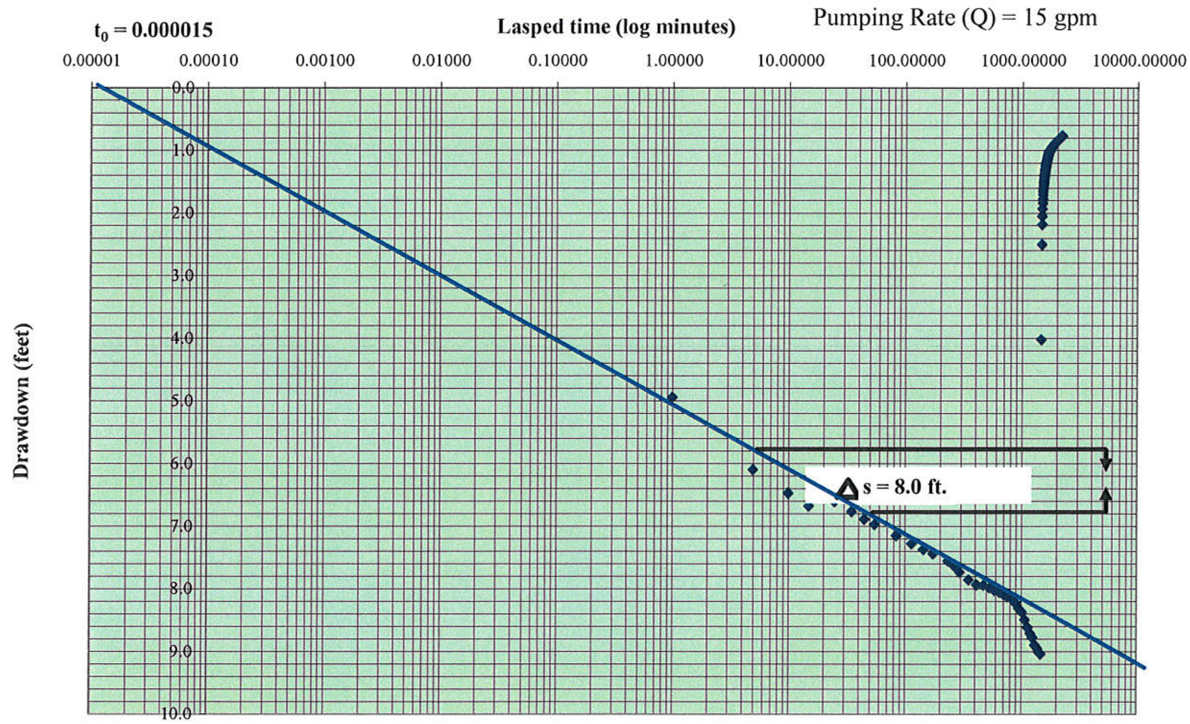
San Mateo County Midcoast Groundwater Study
San Mateo County, California

PLATE
12

Well 1342 Montera Heights (pump and recovery)



Well ID # 342 (pump and recovery)



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Pumping-Test Plots, Wells 1342 and 342

San Mateo County Midcoast Groundwater Study, Phase II

San Mateo County, California

PLATE

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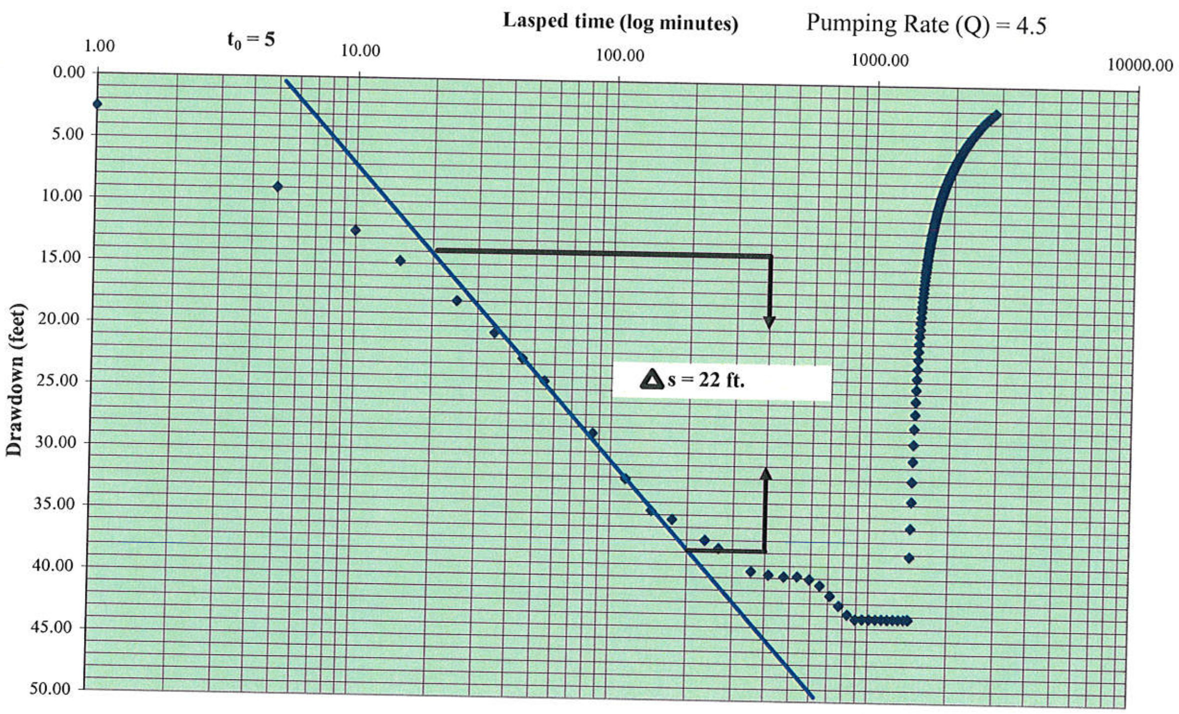
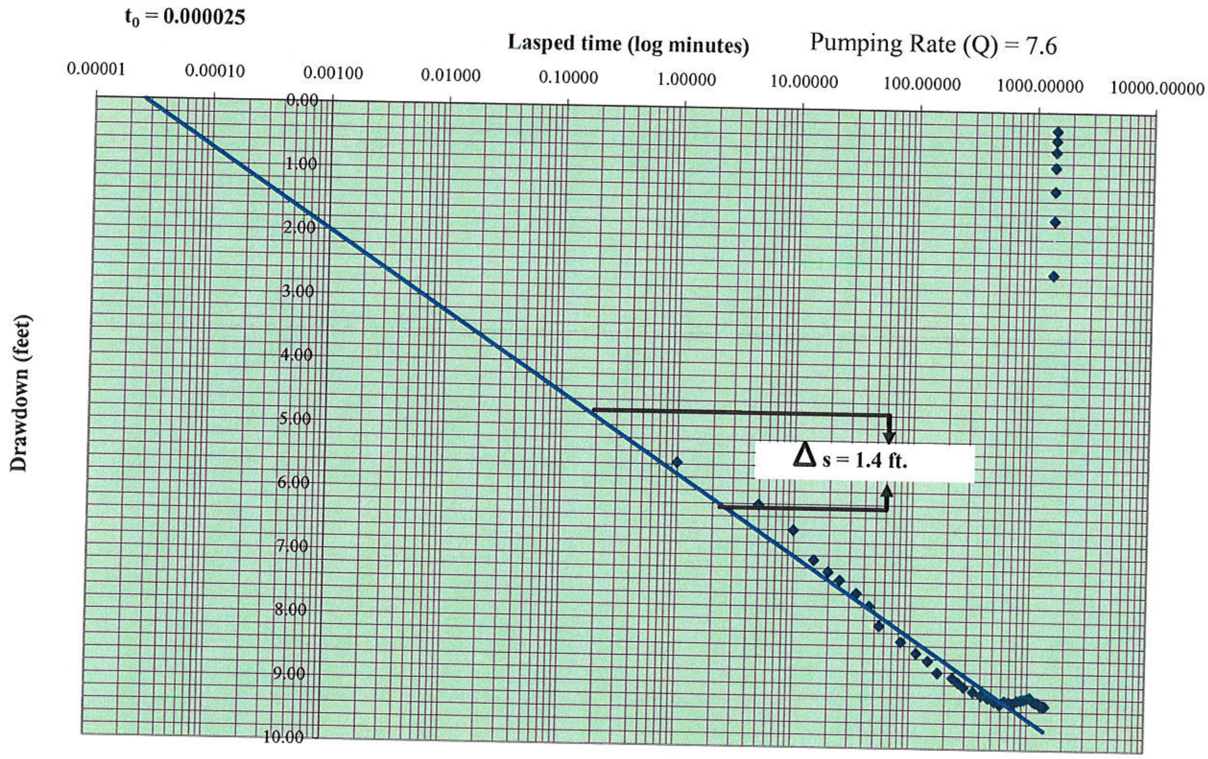
Well ID 163 (pump and recovery)



Well ID 1347 (pump and recovery)



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Pumping-Test Plots, Wells 163 and 1347

San Mateo County Midcoast Groundwater Study, Phase II

San Mateo County, California

PLATE

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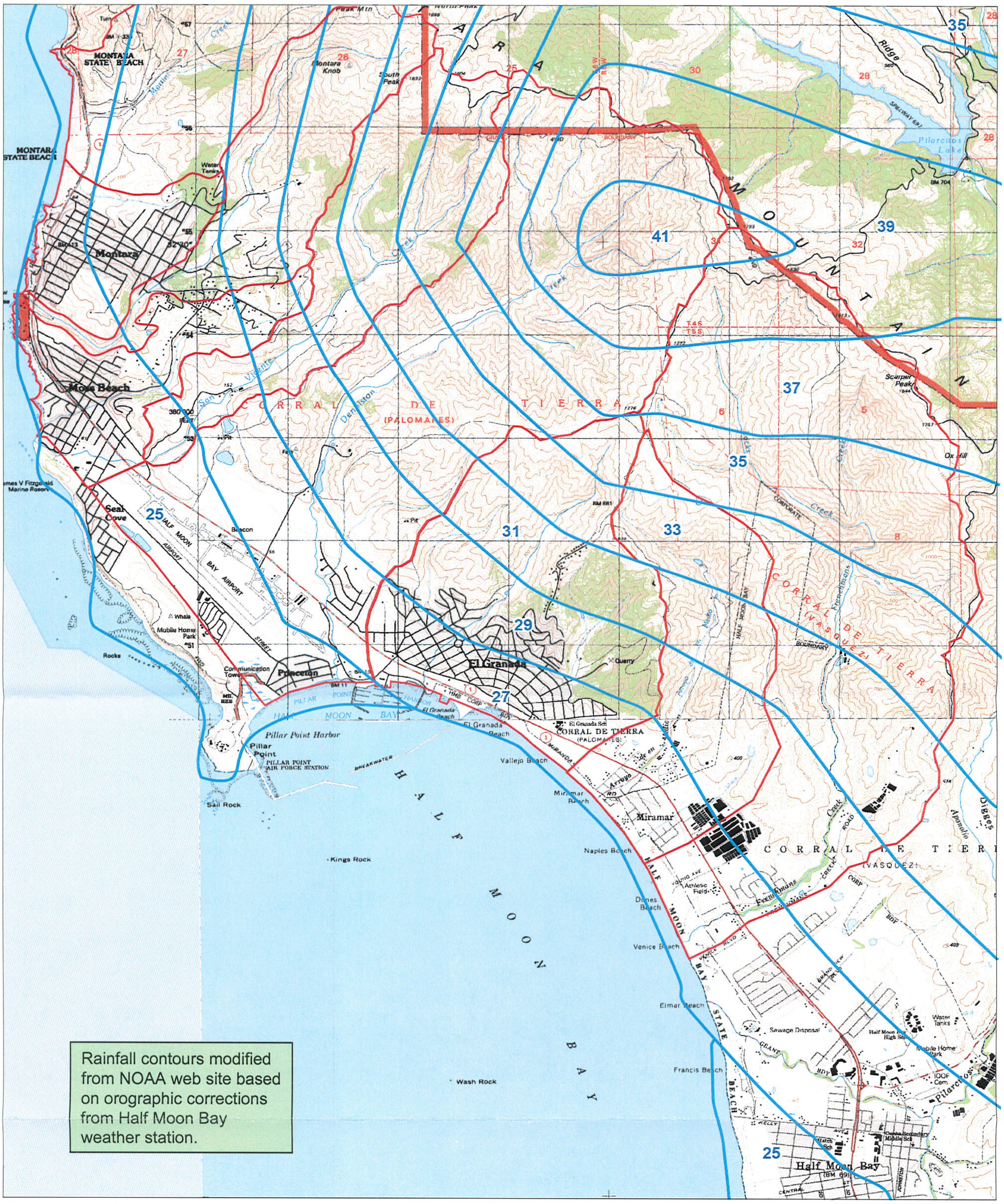
Library file: L:\2006\library\projects\26848*.ppt



KLEINFELDER 2011 North Capitol Avenue San Jose, California 95131 Phone: (408) 536-7611 Fax: (408) 536-7688	**Precipitation Contour Map** **San Mateo County Midcoast Groundwater Study, Phase II** San Mateo County, California	PLATE **15**
Compiled by: P. Holland / Date: 02/22/06		
Reviewed by: M. Clark / Revision date:	PROJECT NO. 26848	

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EL GRANADA WATER BALANCE

Inputs	
Terrace Area (acres)	452.9
Upland area (acres)	1043.2
Transmisivity (gpd/ft)	3450
Width of terrace area (ft)	7280
Length (gradient)	1100
Porosity (Sy)	0.08
Number of wells Upland	97
Number of wells terrace	237
Pumping rate Upland (gal/day)	250
Pumping rate Terrace (gal/day)	250
RO channel seepage(fraction of	0.01

Intermediate calcs

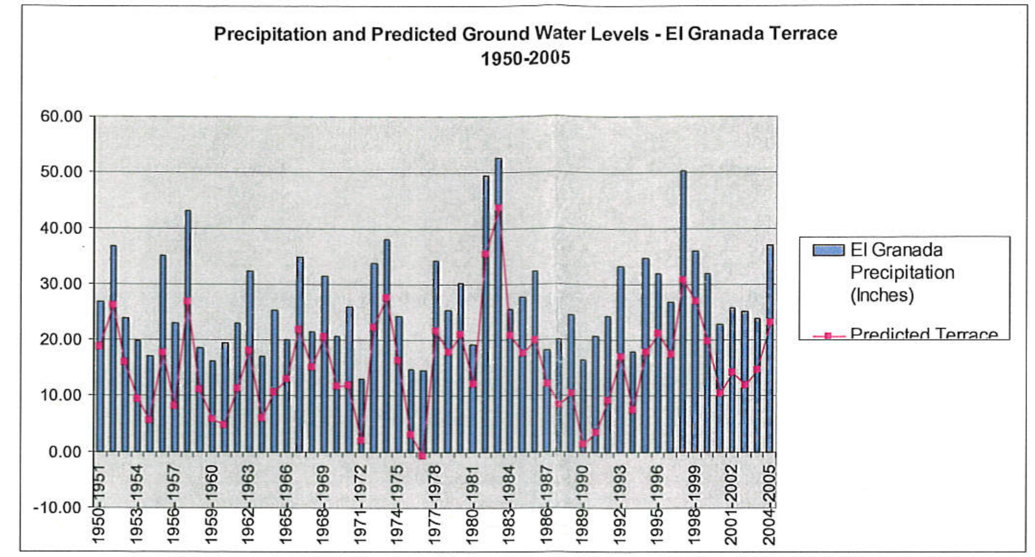
Pumpage Q1 (AF/yr)	27.17
Pumpage Q2 (AF/yr)	66.37

	S	CN	RO%
S - Terrace		1.7	64%
S - Upland		11	19%

Calculated values	
Number of years	55
Total Head (avg)	15.49
Total Head (min)	-0.73
Total Head (max)	43.69
Ocean outflow (avg)	610.0
Ocean outflow (min)	48.8
Ocean outflow (max)	1562.7
Storage volume (average)	561.1
Storage volume (min)	-26.3
Storage volume (max)	1582.8
Average gradient to ocean (for outfall calc)	0.022
Average gradient to ocean (at end of period)	0.014
Avg prelim head gradient to ocean	0.029

Year	Input from Upland and Terrace sheets: Upland Perc(1) (in/yr)	RO1 (in/yr)	Terrace perc(2 (in/yr)	RO2 (in/yr)	Upland perc(1) minus pumpage (GW flow to terrace) AF/yr	Terrace Perc minus pumpage (Perc2) AF/yr	Terrace Change in Storage AF/yr	Prelim Total Storage AF	Prelim Change in Head (high) ft	Prelim Total Head (high) ft	Avg head ft	Ocean Outflow AF	Final Total Storage AF	Revised Change in Head ft	Final Total Head ft
Initial settings													751		20.7
1950-1951	9.24	3.83	0.00	16.60	779.75	-64.94	714.81	1465.81	19.7	40.5	30.591837	782.47	683.34	-1.9	18.9
1951-1952	14.20	11.48	0.00	26.75	1217.27	-62.08	1155.19	1838.53	31.9	50.7	34.801651	890.15	948.38	7.3	26.2
1952-1953	6.36	6.51	0.00	16.35	531.20	-63.94	467.26	1415.64	12.9	39.1	32.623407	834.43	581.21	-10.1	16.0
1953-1954	4.04	1.74	0.00	10.54	325.59	-65.72	259.87	841.07	7.2	23.2	19.627449	502.02	339.05	-6.7	9.4
1954-1955	2.85	1.68	0.00	9.32	222.14	-65.74	156.39	495.44	4.3	13.7	11.515963	294.55	200.89	-3.8	5.5
1955-1956	11.27	13.51	0.00	26.13	964.45	-61.32	903.13	1104.02	24.9	30.5	18.007746	460.60	643.43	12.2	17.8
1956-1957	2.88	2.81	0.00	13.73	225.77	-65.32	160.45	803.87	4.4	22.2	19.972645	510.85	293.02	-9.7	8.1
1957-1958	16.62	12.53	0.00	31.48	1428.17	-61.69	1366.48	1659.50	37.7	45.8	26.944615	689.18	970.32	18.7	26.8
1958-1959	3.15	2.53	0.00	10.94	248.88	-65.43	183.46	1153.77	5.1	31.8	29.312321	749.74	404.03	-15.6	11.2
1959-1960	2.75	1.80	0.00	9.12	213.61	-65.70	147.91	551.94	4.1	15.2	13.192352	337.43	214.51	-5.2	5.9
1960-1961	3.04	1.31	0.00	9.76	238.24	-65.88	172.36	386.87	4.8	10.7	8.2989995	212.27	174.60	-1.1	4.8
1961-1962	7.43	4.11	0.00	14.53	622.42	-64.84	557.58	732.18	15.4	20.2	12.513538	320.07	412.11	6.6	11.4
1962-1963	10.47	7.66	0.00	22.71	889.63	-63.51	826.12	1238.23	22.8	34.2	22.774662	582.52	655.71	6.7	18.1
1963-1964	1.60	1.62	0.00	9.24	113.03	-65.77	47.26	702.97	1.3	19.4	18.749621	479.57	223.39	-11.9	6.2
1964-1965	6.81	4.28	0.00	16.33	568.53	-64.77	503.75	727.15	13.9	20.1	13.117457	335.51	391.63	4.6	10.8
1965-1966	7.40	2.76	0.00	12.32	618.22	-65.34	552.88	944.52	15.3	26.1	18.438855	471.62	472.90	2.2	13.1
1966-1967	12.56	10.08	0.00	26.03	1073.90	-62.61	1011.30	1484.19	27.9	41.0	27.007704	690.79	793.40	8.8	21.9
1967-1968	6.71	3.11	0.00	13.09	558.51	-65.21	493.30	1286.69	13.6	35.5	28.705145	734.21	552.48	-6.6	15.2
1968-1969	11.42	7.78	0.00	22.06	972.78	-63.47	909.32	1461.80	25.1	40.3	27.796988	710.98	750.82	5.5	20.7
1969-1970	4.66	3.91	0.00	12.88	381.72	-64.91	316.81	1067.62	8.7	29.5	25.094415	641.86	425.77	-9.0	11.8
1970-1971	6.55	5.99	0.00	16.57	547.60	-64.14	483.46	909.23	13.3	25.1	18.422906	471.21	438.01	0.3	12.1
1971-1972	0.11	0.98	0.00	6.01	-16.64	-66.01	-82.65	355.37	-2.3	9.8	10.948608	280.04	75.33	-10.0	2.1
1972-1973	14.97	9.76	0.00	25.42	1282.43	-62.73	1219.71	1295.03	33.7	35.7	18.910882	483.70	811.34	20.3	22.4
1973-1974	14.49	9.10	0.00	26.82	1240.31	-62.97	1177.34	1988.68	32.5	54.9	38.640035	988.32	1000.35	5.2	27.6
1974-1975	6.42	3.50	0.00	14.48	534.01	-65.07	468.94	1469.30	12.9	40.6	34.081072	871.71	597.58	-11.1	16.5
1975-1976	0.00	0.72	0.00	6.33	-26.54	-66.11	-92.65	504.94	-2.6	13.9	15.214712	389.16	115.78	-13.3	3.2
1976-1977	0.00	0.23	0.00	6.02	-26.97	-66.29	-93.26	22.52	-2.6	0.6	1.9085632	48.82	-26.29	-3.9	-0.7
1977-1978	15.12	8.21	0.00	25.03	1294.45	-63.31	1231.14	1204.84	34.0	33.3	16.263948	415.99	788.85	22.5	21.8
1978-1979	8.36	5.51	0.00	16.92	704.47	-64.31	640.16	1429.01	17.7	39.4	30.606359	782.84	646.17	-3.9	17.8
1979-1980	11.20	5.54	0.00	20.27	951.42	-64.30	887.12	1533.29	24.5	42.3	30.076467	769.29	764.01	3.3	21.1
1980-1981	4.84	3.28	0.00	11.74	396.09	-65.15	330.95	1094.95	9.1	30.2	25.653565	656.16	438.80	-9.0	12.1
1981-1982	21.36	14.87	0.00	37.55	1842.33	-60.82	1781.52	2220.31	49.2	61.3	36.695567	938.59	1281.72	23.3	35.4
1982-1983	22.25	18.24	0.00	40.89	1923.35	-59.56	1863.79	3145.51	51.4	86.8	61.095709	1562.69	1582.83	8.3	43.7
1983-1984	6.10	6.85	0.00	17.00	508.80	-63.81	444.99	2027.82	12.3	56.0	49.826767	1274.45	753.37	-22.9	20.8
1984-1985	8.39	5.92	0.00	18.13	707.65	-64.16	643.49	1396.86	17.8	38.6	29.672956	758.96	637.89	-3.2	17.6
1985-1986	10.53	8.96	0.00	22.69	895.79	-63.02	832.77	1470.66	23.0	40.6	29.097849	744.26	726.40	2.4	20.0
1986-1987	5.11	2.05	0.00	10.86	418.60	-65.61	353.00	1079.40	9.7	29.8	24.919927	637.39	442.00	-7.8	12.2
1987-1988	4.12	2.37	0.00	11.79	333.36	-65.49	267.87	709.87	7.4	19.6	15.895846	406.58	303.29	-3.8	8.4
1988-1989	6.17	4.08	0.00	14.68	512.43	-64.85	447.59	750.88	12.4	20.7	14.547575	372.09	378.79	2.1	10.5
1989-1990	0.00	0.73	0.00	7.84	-26.53	-66.10	-92.63	286.15	-2.6	7.9	9.1761533	234.70	51.45	-9.0	1.4
1990-1991	3.02	4.03	0.00	11.94	239.22	-64.87	174.35	225.80	4.8	6.2	3.8260196	97.86	127.94	2.1	3.5
1991-1992	6.29	4.18	0.00	15.11	523.20	-64.81	458.39	586.33	12.7	16.2	9.8568824	252.12	334.21	5.7	9.2
1992-1993	10.25	8.09	0.00	22.67	871.04	-63.35	807.69	1141.90	22.3	31.5	20.370314	521.03	620.88	7.9	17.1
1993-1994	2.61	1.39	0.00	9.04	201.03	-65.85	135.18	756.06	3.7	20.9	19.00161	486.02	270.04	-9.7	7.5
1994-1995	11.06	10.49	0.00	25.31	943.35	-62.45	880.90	1150.94	24.3	31.8	19.609436	501.56	649.37	10.5	17.9
1995-1996	11.24	8.42	0.00	22.92	957.67	-63.23	894.45	1543.82	24.7	42.6	30.265991	774.13	769.69	3.3	21.2
1996-1997	8.18	7.82	0.00	17.97	690.51	-63.45	627.06	1396.74	17.3	38.5	29.896632	764.69	632.06	-3.8	17.4
1997-1998	17.41	19.51	0.00	39.10	1503.21	-59.08	1444.13	2076.19	39.9	57.3	37.373658	955.93	1120.26	13.5	30.9
1998-1999	12.40	10.91	0.00	25.72	1060.29	-62.30	998.00	2118.26	27.5	58.5	44.691346	1143.10	975.16	-4.0	26.9
1999-2000	8.64	8.30	0.00	21.42	731.09	-63.27	667.82	1642.97	18.4	45.3	36.130095	924.12	718.85	-7.1	19.8
2000-2001	4.04	3.43	0.00	13.67	327.44	-65.09	262.35	981.20	7.2	27.1	23.460598	600.07	381.13	-9.3	10.5
2001-2002	8.17	5.81	0.00	16.76	687.89	-64.20	623.69	1004.82	17.2	27.7	19.126064	489.20	515.62	3.7	14.2
2002-2003	6.69	5.12	0.00	16.36	558.50	-64.46	494.04	875.17	13.6	24.2	17.33686	443.44	431.73	1.4	11.9
2003-2004	8.24	5.38	0.00	15.70	693.84	-64.36	629.48	1061.21	17.4	29.3	20.602498	526.96	534.24	2.8	14.7
2004-2005	13.16	7.84	0.00	25.39	1123.33	-63.44	1059.89	1594.13	29.3	44.0	29.371469	751.25	842.88	8.5	23.3
Count															
55	8.05	6.05	0.00	17.93	678.22	-64.11	614.1	1171.1	16.9	32.3	23.8	610.0	561.1	0.1	15.5

Note chart uses San Gergorio estimated values for 2001-2003 (see "printable rainfall sheet")



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El Granada Subbasin Water Balance

San Mateo County Midcoast Groundwater Study, Phase II

San Mateo County, California

PLATE **16**

Compiled by: P. Holland	Date: 02/22/06	
Reviewed by: M. Clark	Revision date:	PROJECT NO. 26848

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Arroyo de en Medio Water Balance

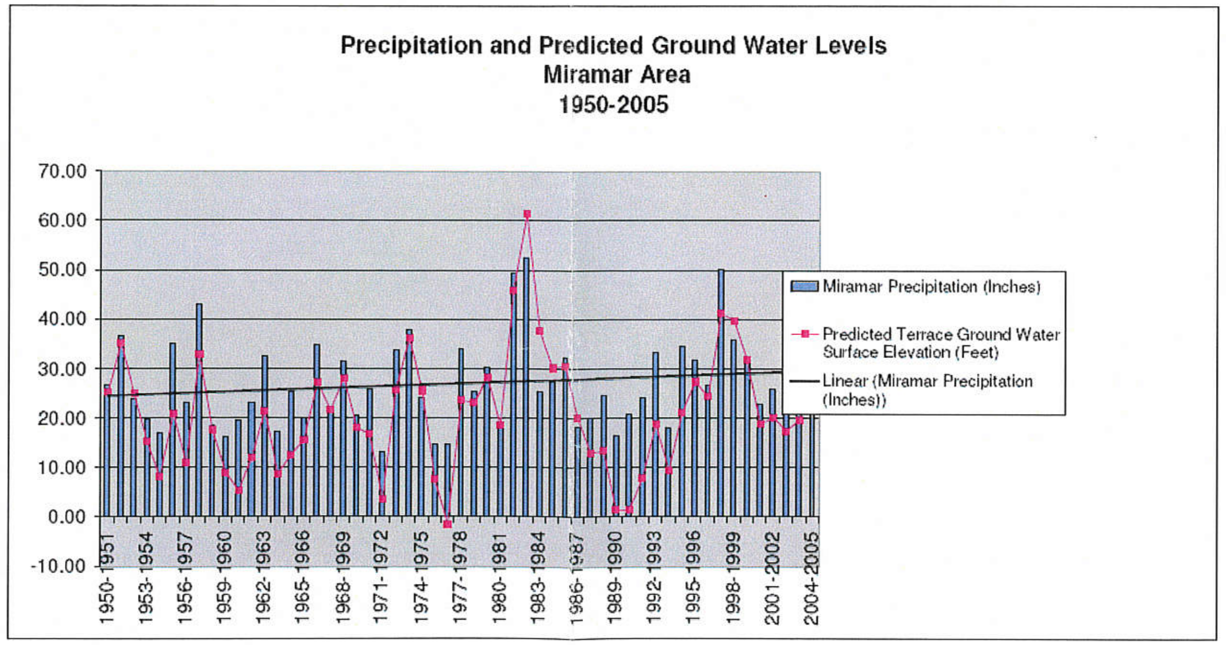
Inputs	
Terrace Area (acres)	264
Upland area (acres)	739
Transmisivity (gpd/ft)	3975
Width of terrace area (ft)	3684
Length (gradient)	1390
Porosity (Sy)	0.09
Number of wells Upland	6
Number of wells terrace	80
Pumping rate Upland (gal/day)	250
Pumping rate Terrace (gal/day)	250
RO channel seepage(fraction of RO)	0
Irrigation pumpage upland (AF)*	0
Irrigation pumpage terrace (AF)*	145
Water District pumpage (upland) (AF)	0
Water District pumpage (terrace) (AF)	0

Intermediate calcs	
Pumpage Qu (AF/yr)	1.68
Pumpage Qt (AF/yr)	22.40
Total upland pumpage	1.68
Total terrace pumpage	167.40

	S		RO%
S - Terrace	1.7	RO%	64%
S - Upland	11	RO%	19%

Calculated values	
Total Head (avg)	21.12
Total Head (min)	-1.56
Total Head (max)	61.52
Ocean outflow (avg)	330.6
Ocean outflow (min)	22.2
Ocean outflow (max)	843.9
Storage volume (average)	501.9
Storage volume (min)	-37.0
Storage volume (max)	1461.7
Average gradient to ocean (for outfall calc)	0.020
Average gradient to ocean (at end of period)	0.015
Avg prelim head gradient to ocean	0.025
Number of years	55

Water Year	Input from Upland and Terrace sheets Perc1 (in/yr)	RO1 (in/yr)	Perc2 (in/yr)	RO2 (in/yr)	Upland percolation (incl RO seepage) AF/yr	Upland perc. less pumpage AF/yr	Terrace percolation incl RO seepage AF/yr	Terrace perc less pumpage AF/yr	Change in Storage AF/yr	Prelim Total Storage AF	Prelim Change in Head (high) ft	Prelim Total Head (high) ft	Avg head	Ocean Outflow AF	Final Total Storage AF	Revised Change in Head ft	Final Total Head ft
Initial settings															580		24.4
1950-1951	9.38	3.93	0.00	16.57	577.42	575.74	0.00	-167.40	408.33	988.33	17.2	41.6	33.00	389.50	598.83	0.8	25.2
1951-1952	14.33	11.68	0.00	26.70	882.69	881.01	0.00	-167.40	713.60	1312.44	30.0	55.2	40.22	474.67	837.77	10.1	35.3
1952-1953	6.44	6.63	0.00	16.32	396.34	394.66	0.00	-167.40	227.25	1065.02	9.6	44.8	40.04	472.56	592.46	-10.3	24.9
1953-1954	4.15	1.79	0.00	10.52	255.75	254.07	0.00	-167.40	86.66	679.12	3.6	28.6	26.76	315.80	363.32	-9.6	15.3
1954-1955	2.93	1.73	0.00	9.30	180.17	178.49	0.00	-167.40	11.09	374.41	0.5	15.8	15.52	183.22	191.19	-7.2	8.0
1955-1956	11.37	13.72	0.00	26.09	700.23	698.55	0.00	-167.40	531.14	722.34	22.4	30.4	19.22	226.88	495.46	12.8	20.9
1956-1957	2.96	2.88	0.00	13.71	182.44	180.76	0.00	-167.40	13.35	508.81	0.6	21.4	21.13	249.41	259.40	-9.9	10.9
1957-1958	16.80	12.76	0.00	31.42	1034.52	1032.84	0.00	-167.40	865.44	1124.83	36.4	47.3	29.13	343.78	781.06	22.0	32.9
1958-1959	3.23	2.59	0.00	10.92	198.64	196.96	0.00	-167.40	29.56	810.62	1.2	34.1	33.49	395.30	415.32	-15.4	17.5
1959-1960	2.83	1.85	0.00	9.10	174.08	172.40	0.00	-167.40	5.00	420.32	0.2	17.7	17.58	207.53	212.79	-8.5	9.0
1960-1961	3.15	1.35	0.00	9.74	194.13	192.45	0.00	-167.40	25.04	237.83	1.1	10.0	9.48	111.91	125.92	-3.7	5.3
1961-1962	7.56	4.20	0.00	14.50	465.30	463.62	0.00	-167.40	296.22	422.14	12.5	17.8	11.53	136.11	286.03	6.7	12.0
1962-1963	10.64	7.81	0.00	22.67	654.95	653.27	0.00	-167.40	485.87	771.89	20.4	32.5	22.26	262.74	509.16	9.4	21.4
1963-1964	1.68	1.66	0.00	9.22	103.68	102.00	0.00	-167.40	-65.40	443.75	-2.8	18.7	20.05	236.66	207.10	-12.7	8.7
1964-1965	6.95	4.37	0.00	16.29	427.90	426.22	0.00	-167.40	258.81	465.91	10.9	19.6	14.16	167.14	298.77	3.9	12.6
1965-1966	7.50	2.83	0.00	12.29	462.14	460.46	0.00	-167.40	293.06	591.82	12.3	24.9	18.74	221.18	370.64	3.0	15.6
1966-1967	12.71	10.27	0.00	25.98	782.59	780.91	0.00	-167.40	613.50	984.15	25.8	41.4	28.51	336.46	647.68	11.7	27.3
1967-1968	6.83	3.18	0.00	13.07	420.59	418.91	0.00	-167.40	251.51	899.19	10.6	37.8	32.55	384.17	515.02	-5.6	21.7
1968-1969	11.58	7.93	0.00	22.02	712.96	711.28	0.00	-167.40	543.88	1058.90	22.9	44.6	33.12	390.89	668.01	6.4	28.1
1969-1970	4.74	3.98	0.00	12.85	292.03	290.35	0.00	-167.40	122.94	790.95	5.2	33.3	30.70	362.34	428.62	-10.1	18.0
1970-1971	6.66	6.10	0.00	16.54	410.08	408.40	0.00	-167.40	241.00	669.61	10.1	28.2	23.11	272.75	396.86	-1.3	16.7
1971-1972	0.17	1.01	0.00	6.00	10.66	8.98	0.00	-167.40	-158.43	238.43	-6.7	10.0	13.37	157.78	80.66	-13.3	3.4
1972-1973	15.11	9.94	0.00	25.38	930.38	928.70	0.00	-167.40	761.30	841.95	32.0	35.4	19.42	229.13	612.82	22.4	25.8
1973-1974	14.67	9.28	0.00	26.77	903.59	901.91	0.00	-167.40	734.50	1347.32	30.9	56.7	41.25	486.81	860.52	10.4	36.2
1974-1975	6.53	3.58	0.00	14.45	401.94	400.26	0.00	-167.40	232.86	1093.37	9.8	46.0	41.12	485.25	608.12	-10.6	25.6
1975-1976	0.00	0.74	0.00	6.31	0.00	-1.68	0.00	-167.40	-169.08	439.03	-7.1	18.5	22.04	260.06	178.97	-18.1	7.5
1976-1977	0.00	0.24	0.00	6.01	0.00	-1.68	0.00	-167.40	-169.08	9.89	-7.1	0.4	3.97	46.90	-37.02	-9.1	-1.6
1977-1978	15.29	8.37	0.00	24.98	941.47	939.79	0.00	-167.40	772.38	735.36	32.5	30.9	14.70	173.44	561.93	25.2	23.7
1978-1979	8.48	5.62	0.00	16.89	522.18	520.50	0.00	-167.40	353.09	915.02	14.9	38.5	31.08	366.80	548.22	-0.6	23.1
1979-1980	11.34	5.66	0.00	20.23	698.28	696.60	0.00	-167.40	529.19	1077.41	22.3	45.3	34.21	403.73	673.68	5.3	28.4
1980-1981	4.94	3.35	0.00	11.72	303.98	302.30	0.00	-167.40	134.90	808.58	5.7	34.0	31.19	368.12	440.46	-9.8	18.5
1981-1982	21.55	15.15	0.00	37.48	1327.36	1325.67	0.00	-167.40	1158.27	1598.73	48.7	67.3	42.91	506.44	1092.29	27.4	46.0
1982-1983	22.45	18.56	0.00	40.82	1382.42	1380.74	0.00	-167.40	1213.34	2305.63	51.1	97.0	71.51	843.88	1461.75	15.5	61.5
1983-1984	6.15	6.97	0.00	16.97	379.03	377.35	0.00	-167.40	209.95	1671.69	8.8	70.4	65.94	778.20	893.50	-23.9	37.6
1984-1985	8.53	6.04	0.00	18.10	525.58	523.90	0.00	-167.40	356.50	1249.99	15.0	52.6	45.11	532.34	717.65	-7.4	30.2
1985-1986	10.64	9.12	0.00	22.65	655.05	653.37	0.00	-167.40	485.96	1203.61	20.5	50.7	40.43	477.15	726.46	0.4	30.6
1986-1987	5.21	2.11	0.00	10.84	321.01	319.33	0.00	-167.40	151.92	878.39	6.4	37.0	33.77	398.57	479.82	-10.4	20.2
1987-1988	4.20	2.43	0.00	11.77	258.78	257.10	0.00	-167.40	89.70	569.52	3.8	24.0	22.08	260.60	308.91	-7.2	13.0
1988-1989	6.28	4.16	0.00	14.65	386.84	385.16	0.00	-167.40	217.76	526.67	9.2	22.2	17.58	207.52	319.15	0.4	13.4
1989-1990	0.00	0.75	0.00	7.82	0.00	-1.68	0.00	-167.40	-169.08	150.07	-7.1	6.3	9.87	116.53	33.54	-12.0	1.4
1990-1991	3.11	4.11	0.00	11.92	191.38	189.70	0.00	-167.40	22.30	55.83	0.9	2.3	1.88	22.19	33.64	0.0	1.4
1991-1992	6.43	4.27	0.00	15.08	395.74	394.06	0.00	-167.40	226.65	260.29	9.5	11.0	6.19	73.00	187.29	6.5	7.9
1992-1993	10.36	8.24	0.00	22.63	638.06	636.38	0.00	-167.40	468.98	656.27	19.7	27.6	17.75	209.50	446.77	10.9	18.8
1993-1994	2.70	1.43	0.00	9.02	166.31	164.63	0.00	-167.40	-2.77	444.00	-0.1	18.7	18.75	221.22	222.77	-9.4	9.4
1994-1995	11.17	10.68	0.00	25.26	688.09	686.41	0.00	-167.40	519.01	741.78	21.8	31.2	20.30	239.55	502.23	11.8	21.1
1995-1996	11.36	8.58	0.00	22.88	699.39	697.71	0.00	-167.40	530.31	1032.54	22.3	43.5	32.30	381.16	651.37	6.3	27.4
1996-1997	8.26	7.95	0.00	17.94	508.54	506.86	0.00	-167.40	339.45	990.83	14.3	41.7	34.56	407.84	582.98	-2.9	24.5
1997-1998	17.59	19.82	0.00	39.03	1083.17	1081.49	0.00	-167.40	914.09	1497.07	38.5	63.0	43.77	516.59	980.48	16.7	41.3
1998-1999	12.55	11.10	0.00	25.67	772.99	771.31	0.00	-167.40	603.91	1584.39	25.4	66.7	53.97	636.99	947.40	-1.4	39.9
1999-2000	8.78	8.44	0.00	21.39	540.42	538.74	0.00	-167.40	371.33	1318.73	15.6	55.5	47.69	562.80	755.93	-8.1	31.8
2000-2001	4.15	3.51	0.00	13.65	255.46	253.78	0.00	-167.40	86.38	842.31	3.6	35.5	33.63	396.93	445.38	-13.1	18.7
2001-2002	8.29	5.92	0.00	16.73	510.50	508.82	0.00	-167.40	341.42	786.80	14.4	33.1	25.93	306.02	480.78	1.5	20.2
2002-2003	6.82	5.22	0.00	16.33	420.17	418.49	0.00	-167.40	251.09	696.47	10.6	29.3	24.03	283.58	412.89	-1.4	17.4
2003-2004	8.34	5.49	0.00	15.67	513.83	512.15	0.00	-167.40	344.75	757.64	14.5	31.9	24.63	290.70	466.93	2.3	19.7
2004-2005	13.31	8.00	0.00	25.35	819.80	818.12	0.00	-167.40	650.71	1117.64	27.4	47.0	33.35	393.53	724.11	10.8	30.5
55yr avg	8.17	6.16	0.00	17.89	502.93	501.25	0.00	-167.40	333.84	832.47	14.05	35.04	28.01	330.58	501.89	0.14	21.12



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Arroyo de en Medio Subbasin Water Balance

San Mateo County Midcoast Groundwater Study, Phase II

San Mateo County, California

PLATE 17

Compiled by: P. Holland	Date: 02/22/06	
Reviewed by: M. Clark	Revision date:	PROJECT NO. 26848

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MOSS BEACH AREA WATER BALANCE

Inputs	
Moss Beach area (acres)	187
Dean Area (acres)	270
San Vicente area (acres)	1012
Upper Moss Beach	70
Transmisivity (gpd/ft)	2500
Width of terrace area (ft)	3528
Length (gradient)	1200
Porosity (Sy)	0.12
Number of dom. wells Moss Beach	54
Pumping rate Moss Beach (gal/day)	250
Number of dom. wells Dean	55
Pumping rate Dean (gal/day)	250
Number of dom. wells San Vicente	2
Pumping rate San Vicente (gal/day)	250
Number of dom. wells U. Moss Beach	20
Pumping rate U. Moss Beach (gal/day)	250
Irrigation pumpage Moss Beach (AF)	0
Irrigation pumpage Dean(AF)*	0
Irrigation pumpage San Vicente (AF)*	0
Montara Water District pumpage (AF)	0
Coastside Water District pumpage (AF)	0
Coastside Water District Diversion (AF)	0
RO channel seepage(fraction of RO)	0
Est. Annual PET	33.71
Dean Creek area septic tanks	31

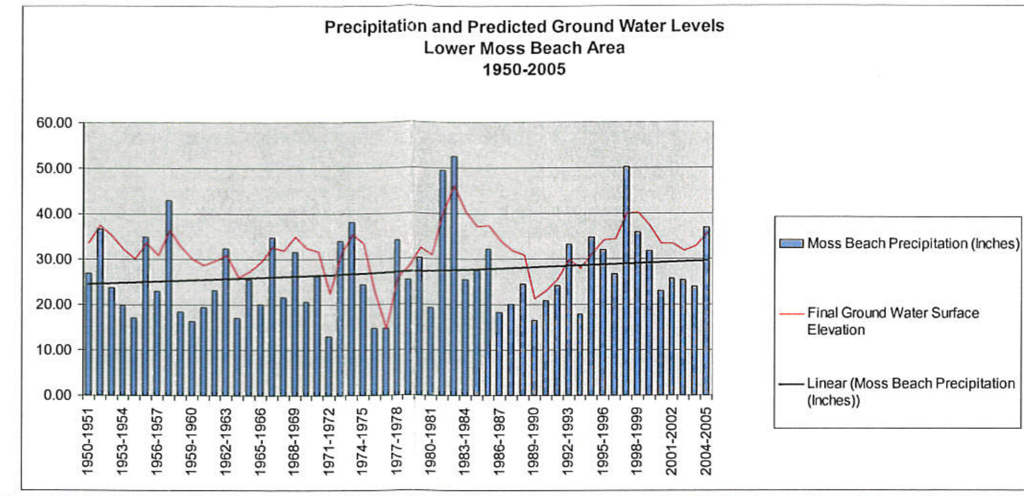
Ag. acres Moss Beach	
Ag. acres Dean	0
Ag. acres San Vincente	0
Ag Acres Upper Moss	0

Intermediate calcs	
Pumpage Qmoss beach (AF/yr)	15.12
Pumpage Qdean Dean Creek(AF/yr)	15.40
Pumpage Qsv San Vicente(AF/yr)	0.56
Pumpage Qu Upper Moss Beach (AF/yr)	5.60
Total Moss Beach pumpage (AF/yr)	15.12
Net Dean pumpage (AF/yr)	11.06
Total San Vicente pumpage (AF/yr)	0.56
Total U Moss Beach pumpage (AF/yr)	5.60

CN	S	%RO
S - San Vicente	11	19%
S - Dean Ck.	8	24%
S- L. Moss Beach	5	34%
S- U. Moss Beach	8	22%

Fraction San Vicente ground water inflow	0.85
Fraction Upper Moss Beach GW to Moss Beach	0.5
Fraction Dean Creek GW outflow to Moss beach	0.6
Initial storage at Moss Beach Terrace (AF)	730

Calculated values	
Total Head (avg)	32.03
Total Head (min)	14.77
Total Head (max)	46.33
Ocean outflow (avg)	322.6
Ocean outflow (min)	190.5
Ocean outflow (max)	438.7
Storage volume (average)	718.7
Storage volume (min)	331.5
Storage volume (max)	1039.6
Average gradient to ocean (for outfall calc)	
Average gradient to ocean (at end of period)	0.027
Avg prelim head gradient to ocean	
Number of years	55



INPUT FROM SHEETS

Water Year	Dean Creek Adjusted Precip.	Dean Creek RO (in/yr)	Dean Creek Percolation (in/yr)	San Vicente Adjusted Precip.	San Vicente RO (in/yr)	San Vicente Percolation (in/yr)	Moss Beach Adjusted Precip.	Moss Beach RO (in/yr)	Moss Beach Percolation (in/yr)	Upper Moss Beach Adjusted Precip.	Upper Moss Beach RO (in/yr)	Upper Moss Beach Percolation (in/yr)
Initial settings												
1950-1951	27.46	4.54	5.29	31.79	3.98	9.45	25.35	6.85	1.50	25.35	3.71	4.35
1951-1952	37.61	11.97	8.87	43.54	11.79	14.41	34.72	14.82	3.42	34.72	10.28	7.95
1952-1953	24.40	6.85	3.41	28.25	6.69	6.48	22.52	8.67	0.42	22.52	5.86	2.87
1953-1954	20.23	2.22	1.20	23.42	1.81	4.22	18.68	3.71	0.00	18.68	1.76	0.39
1954-1955	17.44	2.09	0.83	20.19	1.75	2.97	16.10	3.40	0.00	16.10	1.67	0.29
1955-1956	35.85	13.52	6.86	41.50	13.84	11.43	33.10	15.74	2.36	33.10	11.81	6.18
1956-1957	23.58	3.39	0.45	27.30	2.92	3.01	21.77	5.30	0.00	21.77	2.74	0.00
1957-1958	44.06	13.29	9.88	51.00	12.89	16.91	40.67	16.92	3.40	40.67	11.34	8.62
1958-1959	19.11	3.02	0.96	22.13	2.63	3.27	17.64	4.57	0.00	17.64	2.45	0.42
1959-1960	16.59	2.17	0.66	19.21	1.87	2.87	15.32	3.40	0.00	15.32	1.76	0.13
1960-1961	19.97	1.69	0.49	23.12	1.37	3.22	18.44	3.01	0.00	18.44	1.33	0.00
1961-1962	23.63	4.62	3.85	27.36	4.25	7.63	21.81	6.51	0.30	21.81	3.85	2.96
1962-1963	33.19	8.37	5.15	38.42	7.90	10.73	30.64	11.21	0.00	30.64	7.05	3.98
1963-1964	17.52	2.04	0.00	20.28	1.69	1.73	16.17	3.36	0.00	16.17	1.62	0.00
1964-1965	26.02	4.88	2.84	30.12	4.43	7.03	24.02	7.02	0.04	24.02	4.04	2.11
1965-1966	20.54	3.35	4.21	23.78	2.87	7.57	18.96	5.14	1.02	18.96	2.71	3.45
1966-1967	35.64	10.79	7.04	41.25	10.38	12.79	32.90	13.87	1.37	32.90	9.17	6.05
1967-1968	22.02	3.65	3.31	25.50	3.22	6.90	20.33	5.45	0.00	20.33	2.98	2.43
1968-1969	32.24	8.43	7.02	37.33	8.02	11.67	29.77	11.13	2.68	29.77	7.12	6.27
1969-1970	21.18	4.28	2.08	24.52	4.03	4.79	19.56	5.86	0.00	19.56	3.60	1.54
1970-1971	26.63	6.41	3.06	30.83	6.17	6.72	24.59	8.33	0.12	24.59	5.45	2.54
1971-1972	13.35	1.19	0.00	15.45	1.02	0.21	12.32	1.90	0.00	12.32	0.96	0.00
1972-1973	34.69	10.51	9.45	40.16	10.05	15.19	32.03	13.63	3.77	32.03	8.91	8.48
1973-1974	38.88	9.95	8.35	45.01	9.39	14.78	35.89	13.31	3.08	35.89	8.38	7.30
1974-1975	24.82	4.08	3.17	28.73	3.62	6.59	22.91	6.03	0.00	22.91	3.35	2.42
1975-1976	15.08	0.96	0.00	17.46	0.75	0.00	13.92	1.77	0.00	13.92	0.74	0.00
1976-1977	14.97	0.42	0.00	17.32	0.25	0.00	13.82	1.17	0.00	13.82	0.29	0.00
1977-1978	34.98	9.12	9.29	40.50	8.47	15.38	32.29	12.42	3.35	32.29	7.64	8.13
1978-1979	25.90	6.10	4.41	29.99	5.69	8.55	23.91	8.25	0.44	23.91	5.12	3.58
1979-1980	31.02	6.33	6.68	35.91	5.74	11.42	28.63	9.07	2.44	28.63	5.24	5.72
1980-1981	19.71	3.72	1.92	22.82	3.39	4.99	18.19	5.28	0.00	18.19	3.09	1.21
1981-1982	50.61	15.84	13.53	58.59	15.31	21.67	46.72	20.26	5.50	46.72	13.49	12.17
1982-1983	53.90	18.99	14.11	62.40	18.74	22.56	49.76	23.38	6.27	49.76	16.32	12.84
1983-1984	26.12	7.18	3.28	30.24	7.04	6.19	24.11	9.00	0.34	24.11	6.15	2.89
1984-1985	28.21	6.50	4.05	32.66	6.11	8.62	26.04	8.76	0.00	26.04	5.46	3.05
1985-1986	33.01	9.45	6.18	38.22	9.22	10.70	30.48	11.98	1.72	30.48	8.08	5.42
1986-1987	18.60	2.59	2.20	21.53	2.14	5.27	17.17	4.20	0.00	17.17	2.06	1.45
1987-1988	20.51	2.89	1.81	23.74	2.46	4.25	18.93	4.57	0.00	18.93	2.33	1.25
1988-1989	25.11	4.56	2.79	29.06	4.21	6.35	23.18	6.39	0.00	23.18	3.80	1.96
1989-1990	16.85	1.06	0.00	19.51	0.77	0.00	15.56	2.16	0.00	15.56	0.79	0.00
1990-1991	21.26	4.37	0.33	24.62	4.15	3.16	19.63	5.78	0.00	19.63	3.69	0.00
1991-1992	24.78	4.72	2.98	28.69	4.32	6.51	22.87	6.67	0.00	22.87	3.92	2.24
1992-1993	34.03	8.70	5.98	39.39	8.33	10.42	31.41	11.38	1.81	31.41	7.38	5.22
1993-1994	18.38	1.72	0.46	21.27	1.45	2.75	16.96	2.92	0.00	16.96	1.38	0.00
1994-1995	35.46	11.00	6.28	41.05	10.78	11.24	32.74	13.78	1.38	32.74	9.43	5.50
1995-1996	32.65	9.06	6.74	37.80	8.67	11.42	30.15	11.83	2.10	30.15	7.68	5.97
1996-1997	27.35	8.12	4.76	31.66	8.03	8.30	25.25	9.97	1.25	25.25	6.99	4.21
1997-1998	51.42	19.74	10.80	59.53	20.00	17.69	47.47	23.37	4.82	47.47	17.16	9.99
1998-1999	36.69	11.32	7.39	42.48	11.21	12.64	33.87	14.03	2.48	33.87	9.74	6.49
1999-2000	32.57	8.73	4.16	37.71	8.53	8.85	30.07	11.08	0.55	30.07	7.46	3.53
2000-2001	23.41	3.95	0.95	27.10	3.56	4.21	21.61	5.77	0.00	21.61	3.26	0.26
2001-2002	26.49	6.26	4.34	30.67	5.98	8.36	24.45	8.25	0.87	24.45	5.30	3.59
2002-2003	25.82	5.61	2.72	29.89	5.28	6.90	23.84	7.62	0.00	23.84	4.72	1.74
2003-2004	24.44	5.84	4.75	28.29	5.55	8.40	22.56	7.75	1.22	22.56	4.94	4.02
2004-2005	37.77	8.71	7.74	43.72	8.10	13.40	34.86	11.94	2.25	34.86	7.29	6.64
55yr avg	27.70	6.56	4.35	32.07	6.23	8.23	25.58	8.73	1.13	25.58	5.54	3.63
AF / area	623.3	147.6	97.8	2704.8	525.6	694.3	398.6	136.0	17.6	149.2	32.3	21.2
ETa (AF)	377.9			1484.9			244.9			95.7		
% perc+RO	39.4			45.1			38.5			35.9		

Water Year	Dean Creek Perc + RO seepage AF/yr	Dean Creek less dom. pumpage AF/yr	Dean Creek Outflow amount Residual Prec less ag pumpage AF/yr	Dean Creek Fraction to Moss Beach AF/yr	San Vicente Perc + RO seepage AF/yr	San Vicente less dom. pumpage AF/yr	Crop ET demand AF/yr	Avail surface water AF/yr	Ag pumpage	Residual perc less ag pumpage) AF/yr	Subsurface Geomerty outflow limit	Fraction S. Vicente GW to Moss Beach
Initial settings												
1950-1951	119.0	103.6	103.6	62.2	797.2	796.7	0.0	335.7	0.0	796.7	250.0	212.5
1951-1952	199.6	188.6	188.6	113.2	1215.3	1214.7	0.0	994.6	0.0	1214.7	250.0	212.5
1952-1953	76.8	65.7	65.7	39.4	546.6	546.0	0.0	564.5	0.0	546.0	250.0	212.5
1953-1954	27.1	16.0	16.0	9.6	355.8	355.2	0.0	153.0	0.0	355.2	250.0	212.5
1954-1955	18.6	7.5	7.5	4.5	250.4	249.8	0.0	147.8	0.0	249.8	249.8	212.4
1955-1956	154.4	143.3	143.3	86.0	963.8	963.2	0.0	1166.9	0.0	963.2	250.0	212.5
1956-1957	10.0	-1.0	0.0	0.0	253.8	253.2	0.0	246.0	0.0	253.2	250.0	212.5
1957-1958	222.3	211.2	211.2	126.7	1425.7	1425.1	0.0	1087.4	0.0	1425.1	250.0	212.5
1958-1959	21.5	10.5	10.5	6.3	275.7	275.2	0.0	221.8	0.0	275.2	250.0	212.5
1959-1960	14.9	3.9	3.9	2.3	242.1	241.5	0.0	158.1	0.0	241.5	241.5	205.3
1960-1961	10.9	-0.1	0.0	0.0	271.4	270.8	0.0	115.4	0.0	270.8	250.0	212.5
1961-1962	86.6	75.6	75.6	45.3	643.3	642.8	0.0	358.5	0.0	642.8	250.0	212.5
1962-1963	115.8	104.8	104.8	62.9	905.0	904.5	0.0	666.0	0.0	904.5	250.0	212.5
1963-1964	0.0	-11.1	0.0	0.0	146.3	145.7	0.0	142.1	0.0	145.7	145.7	123.8
1964-1965	63.9	52.8	52.8	31.7	592.8	592.2	0.0	373.3	0.0	592.2	250.0	212.5
1965-1966	94.8	83.7	83.7	50.2	638.2	637.6	0.0	242.4	0.0	637.6	250.0	212.5
1966-1967	158.3	147.3	147.3	88.4	1078.7	1078.1	0.0	875.4	0.0	1078.1	250.0	212.5
1967-1968	74.5	63.4	63.4	38.1	582.0	581.5	0.0	271.7	0.0	581.5	250.0	212.5
1968-1969	158.0	147.0	147.0	88.2	983.8	983.3	0.0	676.2	0.0	983.3	250.0	212.5
1969-1970	46.9	35.8	35.8	21.5	403.7	403.2	0.0	339.8	0.0	403.2	250.0	212.5
1970-1971	68.8	57.7	57.7	34.6	566.8	566.3	0.0	520.0	0.0	566.3	250.0	212.5
1971-1972	0.0	-11.1	0.0	0.0	17.6	17.1	0.0	86.0	0.0	17.1	17.1	14.5
1972-1973	212.6	201.5	201.5	120.9	1281.0	1280.4	0.0	847.7	0.0	1280.4	250.0	212.5
1973-1974	187.8	176.8	176.8	106.1	1246.4	1245.8	0.0	791.7	0.0	1245.8	250.0	212.5
1974-1975	71.2	60.2	60.2	36.1	555.7	555.1	0.0	305.6	0.0	555.1	250.0	212.5
1975-1976	0.0	-11.1	0.0	0.0	0.0	-0.6	0.0	63.4	0.0	0.0	0.0	0.0
1976-1977	0.0	-11.1	0.0	0.0	0.0	-0.6	0.0	20.7	0.0	0.0	0.0	0.0
1977-1978	209.1	198.1	198.1	118.8	1297.5	1296.9	0.0	714.6	0.0	1296.9	250.0	212.5
1978-1979	99.2	88.2	88.2	52.9	720.9	720.3	0.0	479.9	0.0	720.3	250.0	212.5
1979-1980	150.2	139.2	139.2	83.5	963.0	962.4	0.0	483.7	0.0	962.4	250.0	212.5
1980-1981	43.1	32.1	32.1	19.2	421.2	420.6	0.0	286.2	0.0	420.6	250.0	212.5
1981-1982	304.4	293.4	293.4	176.0	1827.4	1826.8	0.0	1290.8	0.0	1826.8	250.0	212.5
1982-1983	317.6	306.5	306.5	183.9	1902.6	1902.0	0.0	1580.6	0.0	1902.0	250.0	212.5
1983-1984	73.8	62.7	62.7	37.6	521.9	521.3	0.0	593.6	0.0	521.3	250.0	212.5
1984-1985	91.1	80.1	80.1	48.0	726.7	726.1	0.0	515.2	0.0	726.1	250.0	212.5
1985-1986	139.0	128.0	128.0	76.8	902.4	901.8	0.0	777.3	0.0	901.8	250.0	212.5
1986-1987	49.5	38.5	38.5	23.1	444.8	444.2	0.0	180.6	0.0	444.2	250.0	212.5
1987-1988	40.7	29.6	29.6	17.8	358.2	357.7	0.0	207.6	0.0	357.7	250.0	212.5
1988-1989	62.7	51.6	51.6	31.0	535.4	534.9	0.0	355.4	0.0	534.9	250.0	212.5
1989-1990	0.0	-11.1	0.0	0.0	0.0	-0.6	0.0	64.7	0.0	0.0	0.0	0.0
1990-1991	7.4	-3.6	0.0	0.0	266.2	265.6	0.0	350.2	0.0	265.6	250.0	212.5
1991-1992	67.0	55.9	55.9	33.5	548.7	548.1	0.0	364.2	0.0	548.1	250.0	212.5
1992-1993	134.6	123.5	123.5	74.1	879.2	878.6	0.0	702.5	0.0	878.6	250.0	212.5
1993-1994	10.4	-0.7	0.0	0.0	232.2	231.6	0.0	122.4	0.0	231.6	231.6	196.9
1994-1995	141.4	130.3	130.3	78.2	947.9	947.3	0.0	909.5	0.0	947.3	250.0	212.5
1995-1996	151.7	140.6	140.6	84.4	963.3	962.7	0.0	731.3	0.0	962.7	250.0	212.5
1996-1997	107.2	96.1	96.1	57.7	700.3	699.8	0.0	677.4	0.0	699.8	250.0	212.5
1997-1998	243.0	231.9	231.9	139.1	1492.1	1491.6	0.0	1686.3	0.0	1491.6	250.0	212.5
1998-1999	166.4	155.3	155.3	93.2	1066.0	1065.5	0.0	945.1	0.0	1065.5	250.0	212.5
1999-2000	93.6	82.6	82.6	49.5	746.7	746.2	0.0	719.3	0.0	746.2	250.0	212.5
2000-2001	21.4	10.3	10.3	6.2	354.9	354.4	0.0	299.8	0.0	354.4	250.0	212.5
2001-2002	97.7	86.6	86.6	52.0	705.1	704.5	0.0	504.7	0.0	704.5	250.0	212.5
2002-2003	61.2	50.1	50.1	30.1	582.1	581.6	0.0	444.9	0.0	581.6	250.0	212.5
2003-2004	106.9	95.8	95.8	57.5	708.7	708.2	0.0	467.8	0.0	708.2	250.0	212.5
2004-2005	174.1	163.0	163.0	97.8	1130.3	1129.7	0.0	682.8	0.0	1129.7	250.0	212.5
55yr avg	97.8	86.7	87.8	52.7	694.3	693.7	0.0	525.6	0.0	693.7	229.7	195.3

Water Year	Upper Moss Beach Perc AF/yr	Upper Moss Beach less pumpage AF/yr	Outflow amount Residual Prec less ag pumpage AF/yr	Fraction GW outflow AF/yr	Moss Beach Combined GW Inflow AF/yr	MB precip perc inflow AF/yr	SV Creek inflow	Total inflow AF/yr	Less Pumpage Less dom. Pumpage AF/yr	Prelim Storage Preexisting Storage AF	Combined Storage Amt. AF	Combined feet est.	Ocean outflow Averaged ocean outflow	rev ocean outflow	Revised Storage	Head Est
Initial settings															730	32.53
1950-1951	25.4	19.8	19.8	9.9	284.6	23.4	66.0	374.0	358.9	730.0	1088.9	48.5	333.7	333.7	755.2	33.7
1951-1952	46.4	40.8	40.8	20.4	346.0	53.2	66.0	465.3	450.2	755.2	1205.3	53.7	359.7	359.7	845.7	37.7
1952-1953	16.7	11.1	11.1	5.6	257.5	6.5	66.0	330.0	314.8	845.7	1160.5	51.7	368.0	368.0	792.5	35.3
1953-1954	2.3	-3.3	0.0	0.0	222.1	0.0	66.0	288.1	273.0	792.5	1065.4	47.5	340.8	340.8	724.6	32.3
1954-1955	1.7	-3.9	0.0	0.0	216.9	0.0	66.0	282.9	267.8	724.6	992.3	44.2	315.0	315.0	677.4	30.2
1955-1956	36.0	30.4	30.4	15.2	313.7	36.8	66.0	416.5	401.3	677.4	1078.7	48.1	322.2	322.2	756.5	33.7
1956-1957	0.0	-5.6	0.0	0.0	212.5	0.0	66.0	278.5	263.4	756.5	1019.9	45.5	325.9	325.9	694.0	30.9
1957-1958	50.3	44.7	44.7	22.3	361.6	53.0	66.0	480.6	465.5	694.0	1159.5	51.7	340.0	340.0	819.4	36.5
1958-1959	2.5	-3.1	0.0	0.0	218.8	0.0	66.0	284.8	269.6	819.4	1089.1	48.5	350.1	350.1	739.0	32.9
1959-1960	0.8	-4.8	0.0	0.0	207.6	0.0	66.0	273.6	258.5	739.0	997.5	44.4	318.6	318.6	678.9	30.3
1960-1961	0.0	-5.6	0.0	0.0	212.5	0.0	66.0	278.5	263.4	678.9	942.3	42.0	297.4	297.4	644.9	28.7
1961-1962	17.3	11.7	11.7	5.8	263.7	4.7	66.0	334.4	319.3	644.9	964.1	43.0	295.2	295.2	669.0	29.8
1962-1963	23.2	17.6	17.6	8.8	284.2	0.0	66.0	350.2	335.0	669.0	1004.0	44.7	306.9	306.9	697.1	31.1
1963-1964	0.0	-5.6	0.0	0.0	123.8	0.0	66.0	189.8	174.7	697.1	871.8	38.9	287.8	287.8	584.0	26.0
1964-1965	12.3	6.7	6.7	3.4	247.6	0.7	66.0	314.3	299.1	584.0	883.1	39.4	269.1	269.1	614.0	27.4
1965-1966	20.1	14.5	14.5	7.3	270.0	15.9	66.0	351.9	336.7	614.0	950.7	42.4	287.0	287.0	663.6	29.6
1966-1967	35.3	29.7	29.7	14.8	315.7	21.3	66.0	403.1	387.9	663.6	1051.6	46.9	314.7	314.7	736.9	32.8
1967-1968	14.2	8.6	8.6	4.3	254.9	0.0	66.0	320.9	305.7	736.9	1042.6	46.5	326.5	326.5	716.2	31.9
1968-1969	36.6	30.9	30.9	15.5	316.2	41.8	66.0	423.9	408.8	716.2	1125.0	50.1	337.8	337.8	787.2	35.1
1969-1970	9.0	3.4	3.4	1.7	235.7	0.0	66.0	301.7	286.6	787.2	1073.8	47.9	341.4	341.4	732.3	32.6
1970-1971	14.8	9.2	9.2	4.6	251.7	1.9	66.0	319.6	304.5	732.3	1036.8	46.2	324.6	324.6	712.2	31.7
1971-1972	0.0	-5.6	0.0	0.0	14.5	0.0	66.0	80.5	65.4	712.2	777.6	34.7	273.3	273.3	504.3	22.5
1972-1973	49.5	43.9	43.9	21.9	355.4	58.7	66.0	480.1	464.9	504.3	969.2	43.2	270.3	270.3	698.9	31.1
1973-1974	42.6	37.0	37.0	18.5	337.0	48.0	66.0	451.1	436.0	698.9	1134.9	50.6	336.4	336.4	798.4	35.6
1974-1975	14.1	8.5	8.5	4.2	252.9	0.0	66.0	318.9	303.7	798.4	1102.2	49.1	348.7	348.7	753.5	33.6
1975-1976	0.0	-5.6	0.0	0.0	0.0	0.0	63.4	63.4	48.2	753.5	801.7	35.7	285.3	285.3	516.4	23.0
1976-1977	0.0	-5.6	0.0	0.0	0.0	0.0	20.7	20.7	5.6	516.4	522.0	23.3	190.5	190.5	331.5	14.8
1977-1978	47.4	41.8	41.8	20.9	352.3	52.2	66.0	470.4	455.3	331.5	786.8	35.1	205.1	205.1	581.6	25.9
1978-1979	20.9	15.3	15.3	7.6	273.0	6.9	66.0	345.9	330.8	581.6	912.4	40.7	274.1	274.1	638.3	28.4
1979-1980	33.3	27.7	27.7	13.9	309.9	38.0	66.0	413.9	398.8	638.3	1037.1	46.2	307.4	307.4	729.7	32.5
1980-1981	7.0	1.4	1.4	0.7	232.5	0.0	66.0	298.5	283.3	729.7	1013.0	45.1	319.7	319.7	693.3	30.9
1981-1982	71.0	65.4	65.4	32.7	421.2	85.8	66.0	573.0	557.9	693.3	1251.2	55.8	356.7	356.7	894.4	39.9
1982-1983	74.9	69.3	69.3	34.6	431.1	97.7	66.0	594.8	579.6	894.4	1474.1	65.7	434.5	434.5	1039.6	46.3
1983-1984	16.8	11.2	11.2	5.6	255.7	5.3	66.0	327.0	311.9	1039.6	1351.5	60.2	438.7	438.7	912.8	40.7
1984-1985	17.8	12.2	12.2	6.1	266.6	0.0	66.0	332.6	317.5	912.8	1230.3	54.8	393.2	393.2	837.2	37.3
1985-1986	31.6	26.0	26.0	13.0	302.3	26.8	66.0	395.1	380.0	837.2	1217.1	54.2	376.9	376.9	840.3	37.4
1986-1987	8.5	2.9	2.9	1.4	237.0	0.0	66.0	303.0	287.9	840.3	1128.2	50.3	361.1	361.1	767.0	34.2
1987-1988	7.3	1.7	1.7	0.9	231.1	0.0	66.0	297.1	282.0	767.0	1049.1	46.7	333.2	333.2	715.9	31.9
1988-1989	11.4	5.8	5.8	2.9	246.4	0.0	66.0	312.4	297.3	715.9	1013.1	45.1	317.2	317.2	695.9	31.0
1989-1990	0.0	-5.6	0.0	0.0	0.0	0.0	64.7	64.7	49.5	695.9	745.5	33.2	264.4	264.4	481.0	21.4
1990-1991	0.0	-5.6	0.0	0.0	212.5	0.0	66.0	278.5	263.4	481.0	744.4	33.2	224.8	224.8	519.6	23.2
1991-1992	13.1	7.5	7.5	3.7	249.8	0.0	66.0	315.8	300.6	519.6	820.2	36.6	245.8	245.8	574.4	25.6
1992-1993	30.5	24.9	24.9	12.4	299.1	28.2	66.0	393.2	378.1	574.4	952.5	42.4	280.1	280.1	672.4	30.0
1993-1994	0.0	-5.6	0.0	0.0	196.9	0.0	66.0	262.9	247.7	672.4	920.1	41.0	292.2	292.2	628.0	28.0
1994-1995	32.1	26.5	26.5	13.2	303.9	21.5	66.0	391.4	376.3	628.0	1004.2	44.8	299.4	299.4	704.8	31.4
1995-1996	34.8	29.2	29.2	14.6	311.5	32.7	66.0	410.2	395.1	704.8	1099.9	49.0	331.1	331.1	768.8	34.3
1996-1997	24.6	19.0	19.0	9.5	279.6	19.5	66.0	365.1	350.0	768.8	1118.8	49.9	346.3	346.3	772.5	34.4
1997-1998	58.3	52.7	52.7	26.3	378.0	75.1	66.0	519.1	504.0	772.5	1276.5	56.9	375.9	375.9	900.6	40.1
1998-1999	37.9	32.3	32.3	16.1	321.8	38.6	66.0	426.4	411.3	900.6	1311.9	58.5	405.9	405.9	906.0	40.4
1999-2000	20.6	15.0	15.0	7.5	269.5	8.5	66.0	344.1	329.0	906.0	1234.9	55.0	392.8	392.8	842.2	37.5
2000-2001	1.5	-4.1	0.0	0.0	218.7	0.0	66.0	284.7	269.6	842.2	1111.7	49.5	358.5	358.5	753.3	33.6
2001-2002	20.9	15.3	15.3	7.7	272.2	13.6	66.0	351.8	336.6	753.3	1089.9	48.6	338.1	338.1	751.8	33.5
2002-2003	10.1	4.5	4.5	2.3	244.8	0.0	66.0	310.8	295.7	751.8	1047.5	46.7	330.1	330.1	717.4	32.0
2003-2004	23.5	17.9	17.9	8.9	278.9	19.1	66.0	364.0	348.9	717.4	1066.3	47.5	327.2	327.2	739.0	32.9
2004-2005	38.8	33.2	33.2	16.6	326.9	35.1	66.0	428.0	412.9	739.0	1151.9	51.3	346.9	346.9	805.0	35.9
55yr avg	21.2	15.6	16.9	8.4	256.4	17.6	65.1	339.1	324.0	717.3	1041.3	46.4	322.6	322.6	718.7	32.0

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Compiled by: P. Holland | Date: 02/22/06
Reviewed by: M. Clark | Revision date:
PROJECT NO. 26848

Moss Beach Subbasin Water Balance

San Mateo County Midcoast Groundwater Study, Phase II

San Mateo County, California

PLATE 18

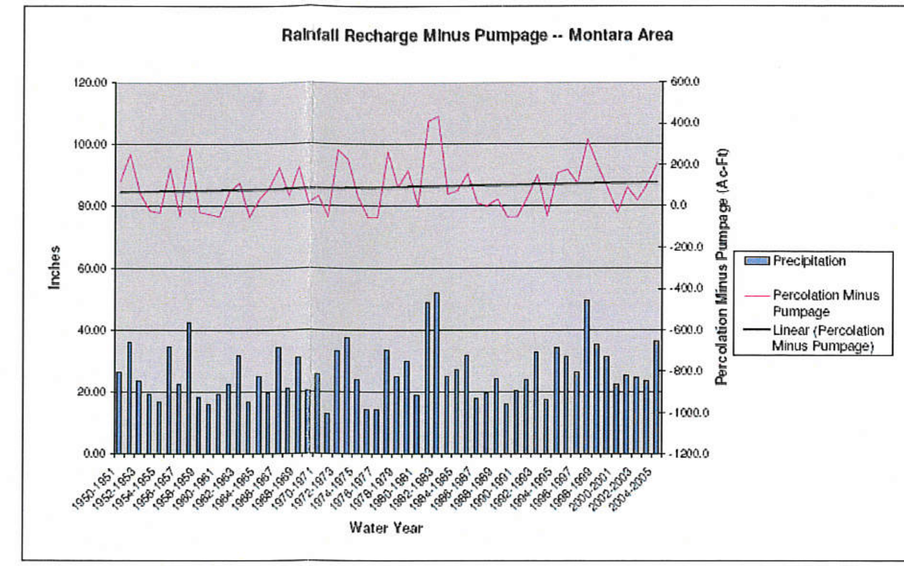
Library file: L:\2006\library\projects\26848*.ppt

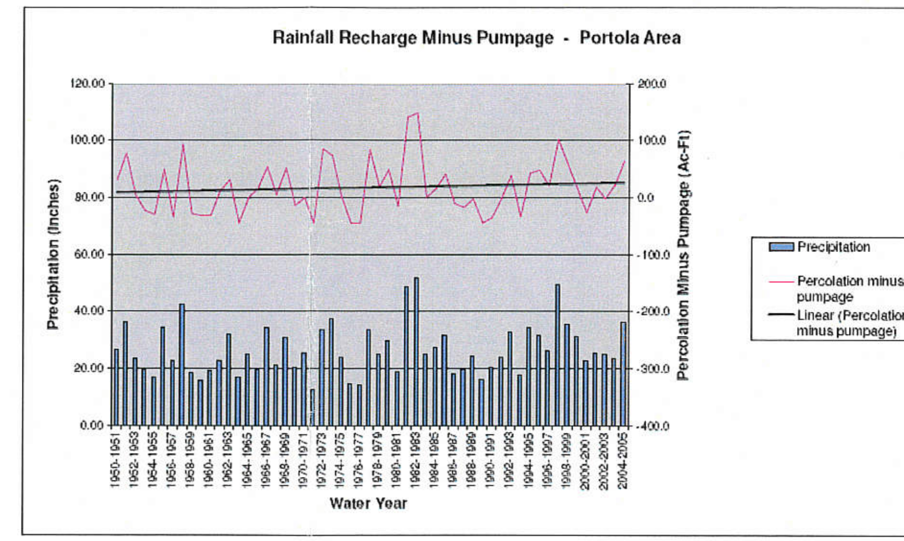
MONTARA / PORTOLA SUBAREAS WATER BALANCE

Inputs		Intermediate calcs	
Montara / Montara Heights Area (acres)	433	Pumpage Qdean Montara(AF/yr)	51.53
Portola Area (acres)	155	Pumpage Qav Portola(AF/yr)	9.80
Number of domestic wells - Montara	184		
Pumping rate - Montara (gal/day)	250	Net Montara pumpage (AF/yr)	49.99
Number of domestic wells - Portola	35	Total Portola pumpage (AF/yr)	44.28
Pumping rate - Portola	250		
Montara Water District pumpage (AF)	37		
Montara Area septic tanks	11		
Portola Area septic tanks	18		

	CN	S	%RO
S-Portola		8	25%
S - Montara		8	23%

Water Year	INPUT FROM SHEETS: Montara /Montara Heights: Adjusted Precipitation (in/yr)	Runoff (in/yr)	Percolation (in/yr)	Portola: Adjusted Precipitation (in/yr)	Runoff (in/yr)	Percolation (in/yr)	Montara: Percolation Amount AF/yr	Less dom. pumpage AF/yr	Potential Groundwater Outflow Amt. AF/yr	Portola: Percolation Amount AF/yr	Less pumpage AF/yr	Potential Groundwater Outflow Amt. AF/yr
1950-1951	26.45	4.13	4.85	28.91	5.16	5.90	175.0	125.0	125.0	76.2	31.9	31.9
1951-1952	36.23	11.15	8.44	39.60	13.17	9.47	304.6	254.6	254.6	122.3	78.0	78.0
1952-1953	23.50	6.37	3.16	25.69	7.56	3.76	113.9	63.9	63.9	48.6	4.3	4.3
1953-1954	19.49	1.99	0.82	21.30	2.56	1.74	29.6	-20.4	0.0	22.4	-21.9	0.0
1954-1955	16.80	1.88	0.57	18.36	2.40	1.17	20.7	-29.3	0.0	15.2	-29.1	0.0
1955-1956	34.53	12.69	6.54	37.74	14.73	7.30	236.0	186.0	186.0	94.3	50.0	50.0
1956-1957	22.71	3.07	0.18	24.82	3.87	0.82	6.4	-43.6	0.0	10.6	-33.7	0.0
1957-1958	42.43	12.34	9.28	46.38	14.68	10.70	334.8	284.8	284.8	138.3	94.0	94.0
1958-1959	18.41	2.74	0.70	20.12	3.42	1.30	25.4	-24.6	0.0	16.9	-27.4	0.0
1959-1960	15.98	1.97	0.41	17.47	2.47	1.01	14.9	-35.1	0.0	13.1	-31.2	0.0
1960-1961	19.24	1.51	0.10	21.03	1.96	1.02	3.6	-46.4	0.0	13.2	-31.0	0.0
1961-1962	22.76	4.25	3.43	24.88	5.18	4.43	123.9	73.9	73.9	57.2	12.9	12.9
1962-1963	31.97	7.73	4.60	34.94	9.32	5.91	165.9	115.9	115.9	76.3	32.1	32.1
1963-1964	16.87	1.83	0.00	18.44	2.35	0.03	0.0	-50.0	0.0	0.4	-43.8	0.0
1964-1965	25.06	4.47	2.41	27.39	5.49	3.50	87.0	37.0	37.0	45.2	0.9	0.9
1965-1966	19.78	3.04	3.85	21.62	3.82	4.71	139.1	89.1	89.1	60.8	16.5	16.5
1966-1967	34.32	10.00	6.57	37.52	11.94	7.67	237.2	187.2	187.2	99.1	54.9	54.9
1967-1968	21.21	3.32	2.90	23.18	4.13	3.89	104.5	54.5	54.5	50.2	5.9	5.9
1968-1969	31.06	7.79	6.67	33.95	9.36	7.51	240.6	190.6	190.6	97.0	52.8	52.8
1969-1970	20.40	3.95	1.83	22.30	4.78	2.44	65.9	15.9	15.9	31.5	-12.8	0.0
1970-1971	25.65	5.95	2.81	28.04	7.10	3.43	101.5	51.5	51.5	44.3	0.0	0.0
1971-1972	12.86	1.08	0.00	14.05	1.36	0.00	0.0	-50.0	0.0	0.0	-44.3	0.0
1972-1973	33.42	9.74	8.99	36.52	11.66	10.07	324.5	274.6	274.6	130.1	85.8	85.8
1973-1974	37.45	9.19	7.79	40.93	11.08	9.18	281.2	231.2	231.2	118.6	74.3	74.3
1974-1975	23.91	3.72	2.81	26.13	4.61	3.65	101.5	51.5	51.5	47.2	2.9	2.9
1975-1976	14.52	0.85	0.00	15.87	1.12	0.00	0.0	-50.0	0.0	0.0	-44.3	0.0
1976-1977	14.41	0.36	0.00	15.75	0.53	0.00	0.0	-50.0	0.0	0.0	-44.3	0.0
1977-1978	33.69	8.40	8.75	36.83	10.19	10.05	315.7	265.7	265.7	129.8	85.5	85.5
1978-1979	24.95	5.62	4.02	27.27	6.81	4.95	145.0	95.0	95.0	63.9	19.7	19.7
1979-1980	29.87	5.80	6.23	32.65	7.12	7.30	224.6	174.7	174.7	94.3	50.0	50.0
1980-1981	18.98	3.41	1.58	20.75	4.18	2.38	57.1	7.1	7.1	30.7	-13.5	0.0
1981-1982	48.75	14.70	12.89	53.28	17.51	14.41	465.2	415.2	415.2	186.1	141.8	141.8
1982-1983	51.92	17.70	13.49	56.74	20.88	14.97	486.8	436.8	436.8	193.3	149.1	149.1
1983-1984	25.16	6.68	3.10	27.50	7.91	3.53	111.7	61.7	61.7	45.6	1.3	1.3
1984-1985	27.17	6.00	3.58	29.70	7.24	4.70	129.1	79.1	79.1	60.8	16.5	16.5
1985-1986	31.80	8.79	5.82	34.76	10.43	6.67	210.2	160.2	160.2	86.1	41.8	41.8
1986-1987	17.92	2.33	1.85	19.58	2.98	2.69	66.7	16.7	16.7	34.8	-9.5	0.0
1987-1988	19.75	2.61	1.55	21.59	3.30	2.17	55.8	5.8	5.8	28.1	-16.2	0.0
1988-1989	24.18	4.19	2.40	26.43	5.11	3.33	86.5	36.5	36.5	43.0	-1.3	0.0
1989-1990	16.23	0.93	0.00	17.74	1.26	0.00	0.0	-50.0	0.0	0.0	-44.3	0.0
1990-1991	20.48	4.04	0.05	22.39	4.86	0.72	1.9	-48.1	0.0	9.3	-35.0	0.0
1991-1992	23.87	4.33	2.63	26.09	5.29	3.46	94.9	44.9	44.9	44.6	0.3	0.3
1992-1993	32.78	8.06	5.63	35.82	9.65	6.47	203.0	153.0	153.0	83.6	39.3	39.3
1993-1994	17.70	1.55	0.15	19.35	1.98	0.89	5.6	-44.4	0.0	11.5	-32.7	0.0
1994-1995	34.16	10.24	5.92	37.33	12.12	6.79	213.4	163.5	163.5	87.7	43.4	43.4
1995-1996	31.45	8.39	6.38	34.38	10.04	7.24	230.2	180.2	180.2	93.5	49.2	49.2
1996-1997	26.34	7.57	4.50	28.79	8.92	5.12	162.5	112.5	112.5	66.1	21.8	21.8
1997-1998	49.53	18.50	10.38	54.13	21.57	11.37	374.6	324.6	324.6	146.9	102.6	102.6
1998-1999	35.34	10.56	6.97	38.63	12.45	7.98	251.6	201.6	201.6	103.0	58.8	58.8
1999-2000	31.37	8.11	3.87	34.29	9.63	4.73	139.5	89.5	89.5	61.1	16.8	16.8
2000-2001	22.54	3.62	0.60	24.64	4.46	1.44	21.7	-28.3	0.0	18.6	-25.7	0.0
2001-2002	25.51	5.79	3.96	27.89	6.95	4.91	142.9	92.9	92.9	63.4	19.1	19.1
2002-2003	24.87	5.18	2.25	27.19	6.26	3.36	81.4	31.4	31.4	43.4	-0.9	0.0
2003-2004	23.54	5.40	4.41	25.73	6.50	5.22	159.1	109.1	109.1	67.5	23.2	23.2
2004-2005	36.38	8.02	7.22	39.76	9.73	8.45	260.6	210.6	210.6	109.1	64.8	64.8
55yr avg	26.69	6.07	4.00	29.17	7.29	4.83	144.3	94.3	104.6	62.4	18.2	28.0
AF / area	962.9	218.9	144.3	376.7	94.2	62.4						
Eta (AF)	599.7			220.1								
% perc+RO	37.7			41.6								





	Capacity (gpm)	Annual (AF)
Portola I	10	16.1
Portola IV	13	21.0
Totals	23.0	37.1

Portola II	0 (10)
Portola III	6

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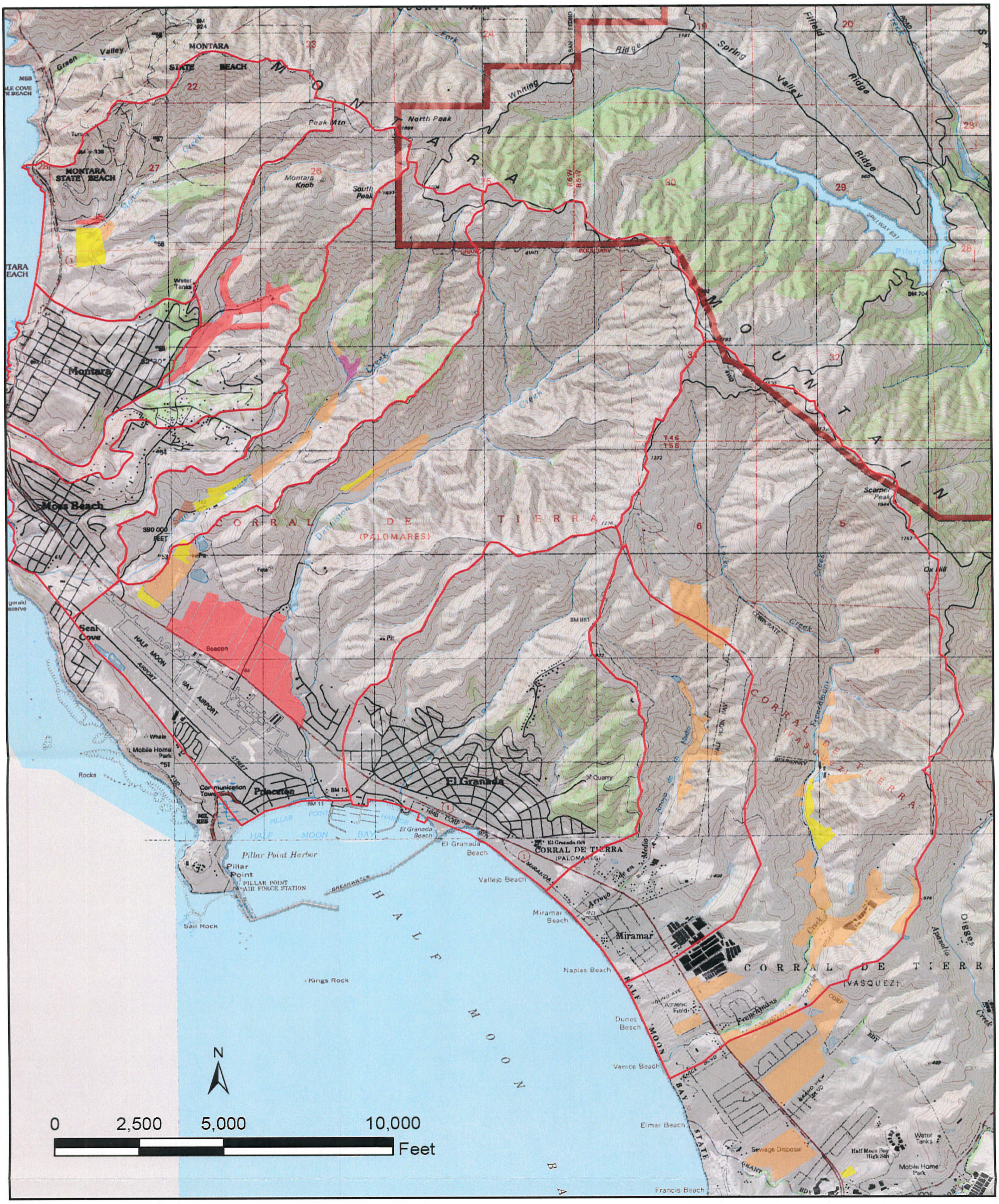
Montara Subbasin/ Portola Subbasin in Water Balance

San Mateo County Midcoast Groundwater Study, Phase II

San Mateo County, California

PLATE **19**

Compiled by: P. Holland | Date: 02/22/06
Reviewed by: M. Clark | Revision date:
PROJECT NO. 26848



Land and Water Use Data from California Department of Water Resources

Legend

- Watersheds

Agricultural Lands by Water Source

- No Data
- Surface Water
- Mixed Surface and Ground Water
- Ground Water
- Unknown Source

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Compiled by: Jim Walker	Date: 02/22/06	
Reviewed by: M. Clark	Revision date:	PROJECT NO. 26848

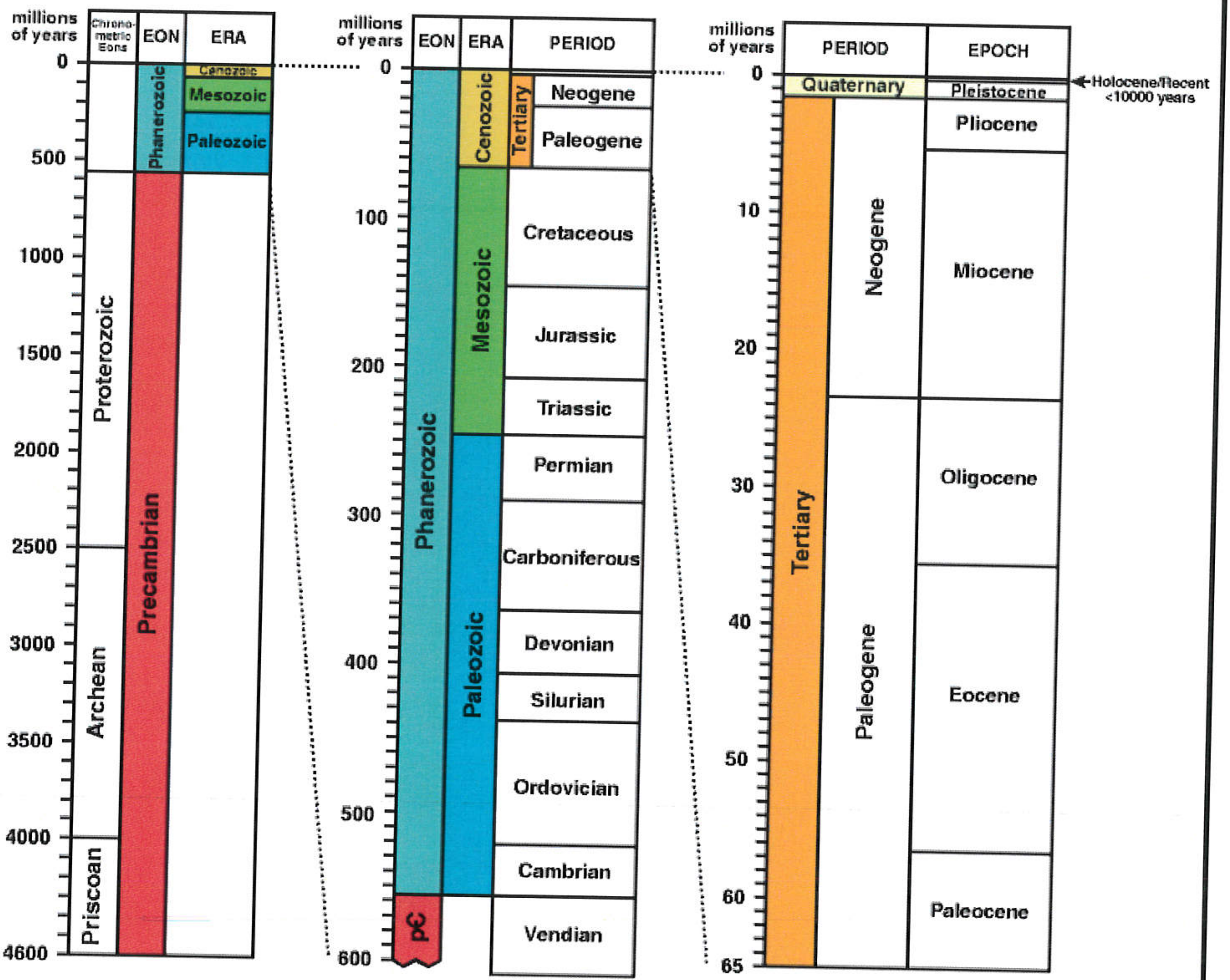
Agricultural Lands by Water Source

San Mateo County Midcoast Groundwater Study, Phase II

San Mateo County, California

PLATE 20

APPENDIX A



Source: http://www.geo.ucalgary.ca/~macrae/timescale/time_scale.gif

KLEINFELDER 2011 North Capitol Avenue San Jose, California 95131 Phone: (408) 536-7611 Fax: (408) 536-7688	Geologic Time Scale **San Mateo County Midcoast Groundwater Study Area Phase II** San Mateo County, California	PLATE A-1
Compiled by: P. Holland / Date: 02/22/04	PROJECT NO. 26848	

APPENDIX B

B.1 Distance to Surrounding Wells Spreadsheet

Included with Kleinfelder's Midcoast Groundwater Study, Phase 2 report is an Excel spreadsheet titled "Distance to Surrounding Wells." A disk with the spreadsheet is contained in a pocket at the end of this report. This spreadsheet can be used by County personnel to search for known wells within a given distance from the approximate center of any APN in the Midcoast area. The spreadsheet contains four worksheets (tabs at the bottom of the spreadsheet) consisting of 1) a query-entry and table-output page titled "Well-Distance Table" shown below (Figure 1), 2) a more comprehensive output page (containing potentially sensitive well information) titled "County use only," and two databases from which the well information is mined. The two database worksheets consist of 3) "APNs" containing locations, sizes, and other criteria of the assessor's parcels in the Midcoast area and 4) "Revised 2005 – Midcoast wells," which is modified from data provided to Kleinfelder by the County. The information presented on the "Well-Distance Table" is considered non-sensitive and, at the discretion of the County, can be printed out and given to the applicant/property owner.

The data presented in this table are dependent on information compiled at various times and under differing conditions and may not be accurate or up to date. These data are for general information only.

APN of the new well's location: 047274310

Search Radius: 500 feet

Latitude and Longitude of the center of the APN

Latitude: 37.5035981887 N

Longnitude: -122.464229431 W

Number of wells within 500 feet of the center of the APN: 9

Size of APN: 0.14 Appx. Acres

Sort list of wells by distance

Drag and drop APN Storage
047273380
047244040
047274310
048136190
037160100
048116090

Dist. (ft.) from center of APN	Type of Well	Date Drilled	Total Depth (ft)	Depth to Water (ft)	Date Measured	Pump Rate (gpm)
237 SE	D	03/20/86	95	82	03/20/86	
239 NE	D	8/3/92	73	55	8/6/92	2
240 NE	D	1/25/88	140	38	2/4/88	3
300 SE	D	8/23/86	377	36	8/23/86	3
359 SE	D	11/6/85	140	32	11/15/85	3
379 SE	D	8/16/86	300	40	8/16/86	3
412 SE	D	11/8/85	80	20	11/15/85	10
498 SE	D	11/11/85	190	40	11/29/85	3

B.2 Operation of the Spreadsheet

Searching for known wells within a circle of a given radius in the Midcoast area is accomplished by entering a target APN and the desired search distance into two entry cells on the "Well-Data Table" worksheet. The zoom of the spreadsheet may need to be adjusted (try 100% or 75%) so that all pertinent data is visible on the computer screen. The two entry cells are the only two operational entries allowed in the worksheet (no entries are allowed in the other worksheets). The APN must be entered with leading zeros and with no dashes or other punctuations (example 048116090). There is an area available to store APNs in a column to the right of the data entry portion of the spreadsheet. APNs can be entered in the storage area and copied to the entry cell using the left mouse button while holding down the Control key. The search should be limited to a radius of no more than 1,000 feet. Larger radii are allowed but such distances may have no meaning with respect to well interference or expected groundwater conditions in the Midcoast area. Based on the location of the target APN placed in the entry cell, the spreadsheet identifies all known wells within the given search radius and updates the table below the entry panel with up to 100 of the closest wells. The order of listed wells in the table may be random but can be sorted (by increasing distance from the center of the target APN) by using the mouse to select the gray sort button near the bottom of the entry panel.

The distances to wells are measured from the center of the target APN. These distances are calculated from latitude and longitude included in the well database provided by the County. The accuracy of the well locations and all other information about the wells are dependent on the accuracy of the data given in the County's database and have not been verified by Kleinfelder. Latitude and longitude in bold on the "Revised 2005 – Midcoast Wells" worksheet have been measured in the course of this study using corrected GPS technology to within a few inches in both horizontal and vertical planes.

When an APN is entered in the spreadsheet, not all expected data may be displayed in the accompanying tables because of absence of information in the database. Some of the reasons that data may not appear in the spreadsheet tables are presented in the following table.

Errors that may show up on the "Well-Data Table" worksheet	
Error	Possible cause
Blank blue or yellow spaces	Absence of data in the "Revised 2005 – Midcoast Wells" worksheet
#N/A	Incoherent data or wrong data type in the "Revised 2005 – Midcoast Wells" worksheet
Duplicate distances to two consecutive listings in the "Well-Data Table" after sorting.	Duplicate well entries in the "Revised 2005 – Midcoast Wells" worksheet
0	No data, but may be a real number such as 0 feet depth to groundwater.

If a known well exists on the target APN, two asterisks (**) will be displayed in the column showing the distance to the well. The "Type of Well" column displays the County's type designation consisting of the following symbols:

Well Type Symbol	Inferred meaning
D	Domestic, residential
A	Agricultural
M	Municipal
DA	Domestic and agricultural
Blank	No information
I, O, S, T, X, Y, Z, Z/Y	Unknown meaning

The total depth, depth to water, and pump rate given for nearby wells may give an indication of what might be expected for a well drilled on the target APN. Once the well information is displayed on the Well-Distance Table, the page can be printed out and given to the well permit applicant.

The "County use only" worksheet contains much more information than does the "Well-Distance Table." Included on the "County use only" worksheet is potentially sensitive information about surrounding wells. In our opinion, this information should not be shared with the public, but can be useful information to help the County evaluate possible well sites and permits.

Additional information about the wells can be found by going to the "Revised 2005 – Midcoast Wells" worksheet. If the sort button has been activated on the "Well-Distance Table" worksheet, all of the wells on the "Revised 2005 – Midcoast Wells" worksheet will be listed by increasing distance from the target APN and the numbered records in the "Order" column will correspond to those shown on the "Well-Distance Table" worksheet.

B.3 Modifying the Databases Spreadsheets

The "Revised 2005 – Midcoast Wells" worksheet contains the well data used in Kleinfelder's GIS modeling of the Midcoast area. In an effort to use all possible data provided by the County in our study, only obvious duplications or errors found in the data were deleted from the database. Incomplete data records were retained, but if an individual well record does not have latitude and longitude coordinates, it will not show up on the summary table (Figure 1). We recommend that the "Revised 2005 – Midcoast Wells" database be modified and updated as new well information becomes available to the County.

There are seven hidden columns on the left side of the "Revised 2005 – Midcoast Wells" worksheet that should remain hidden and should not be modified. The column headed "Order" shows the sequence of records displayed on the table (Figure 1); and the column headed "KA WellID" contains consecutive and unique numbers assigned to, and are used to identify, each well. To add a new well record (row), the entire page should be selected by pressing the cell to the left of the H column, then the spreadsheet can be sorted with Headers row checked and by selecting the "KA WellID" column to sort by. Information about a new well should be added to the bottom of the worksheet. Nothing should be entered in the "Order" column; the next higher consecutive number should be placed in the "KA WellID" column after the spreadsheet is sorted based on the well id column. The remainder of the columns should be filled in with information about the new well. However, if the latitude and longitude are not included with the new well information, the well will not show up on the summary table (Figure 1). Once the new information is added to the spreadsheet, it should be saved. There are a few empty columns that can be assigned new data names and used by the County as needed. The order of the columns should not be changed and no new columns should be added between existing columns. If the order of columns is altered, the information presented on the Well-Distance Table and County Use Only sheets will no longer be correct or complete. If additional columns are need in the "Revised 2005 – Midcoast Wells" worksheet, they can be added without interfering with the data displayed on the tables by adding columns to the far right of the spreadsheet.

All of the cells in the "APNs" worksheet are locked against modification and should not be changed.

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UTILIZATION SHEET
SAN JOSE GEOSCIENCES GROUP

Actual Week Ending: January 7, 2007

	Exempt/ Non-	Billable Hrs	O/H Hrs	PTO	Hrs Paid	Hrs Worked	Paid Util	Worked Util	Worked Goal	
Andrew Cheung	NE	29.5			29.5	29.5	100%	100%	95%	Goal!
Catherine Ellis	E	11	21	8.0	40	32	28%	34%	50%	
Collette Buzzone	NE	24.5	1		25.5	25.5	96%	96%	95%	Goal!
Dave Seymour	E	16	16	8.0	40	32	40%	50%	75%	
Dennis Haney	NE	29.5		11.0	40.5	29.5	73%	100%	88%	Goal!
Dickson Achiaw	NE			40.0	40				90%	
Finnegan Mwape	E	26	6	8.0	40	32	65%	81%	75%	Goal!
Jim Walker	E	21	3	16.0	40	40	53%	88%	80%	Goal!
Michael Clark	E	12	20	8.0	40	32	30%	38%	75%	
Nasir Ahmad	E	32		8.0	40	32	80%	100%	95%	Goal!
Parham Khoshkbari	E	16		24.0	40	16	40%	100%	85%	Goal!
Wade Blackard	E	36		8.0	40	36	90%	100%	90%	Goal!
		253.5	**67**	**139.0**	455.5	336.5	**56%**	**79%**	**81.6%**	

Utilization calculation does not include Holiday, PLT, Kin Care, or ESL time

Projection Week Ending: January 14, 2007

	Exempt/ Non-	Billable Hrs	O/H Hrs	PTO	Hrs Paid	Hrs Worked	Paid Util	Worked Util	Worked Goal
Andrew Cheung	NE	20			20	20	100%	100%	95%
Catherine Ellis	E	20	12	8.0	40	32	50%	63%	50%
Collette Buzzone	NE	20			20	20	100%	100%	95%
Dave Seymour	E	25	15		40	40	63%	63%	75%
Dennis Haney	NE	32			32	32	100%	100%	88%
Dickson Achiaw	NE	24		8.0	32	24	75%	100%	90%
Finnegan Mwape	E	32	8		40	40	80%	80%	75%
Jim Walker	E	34	6		40	40	85%	85%	80%
Michael Clark	E	20	20		40	40	50%	50%	75%
Nasir Ahmad	E	36	4		40	40	90%	90%	95%
Parham Khoshkbari	E	36	4		40	40	90%	90%	85%
Wade Blackard	E	36	4		40	40	90%	90%	90%
		335	**73**	**16.0**	**424**	**408**	**79%**	**82%**	**81.6%**

Utilization calculation does not include Holiday, PLT, Kin Care, or ESL time