Preliminary Feasibility Assessment of Ground Water in the Martini Creek, McNee Ranch and Upper Montara Creek Area

Interim Status Report

Balance Hydrologics, Inc.

March 1999

Technical Memo

To: George Irving, Montara Sanitary District

From: Mark Woyshner and Barry Hecht

Date: March 1, 1999

Subject: **Preliminary Feasibility Assessment of Ground Water in the Martini Creek, McNee Ranch and Upper Montara Creek Area Interim Status Report**

Background

The California Department of Water Resources (1999) is concluding a study that examined potential options for improving the reliability of water supply serving the Montara area (DWR, 1999). It concluded that ground-water development and/or negotiation of water transfers appears to be most favorable, with the former being the most economically attractive. Additionally, with regard to ground-water development, the report recommended exploring the McNee Ranch area and additional wells in the upper Montara Creek area, north of the Wagner Well. A copy of an initial draft of the DWR study is attached as Appendix A.

Balance Hydrologics has been retained by the Montara Sanitary District (MSD) to further research and elaborate upon the general findings of the DWR overview report. Balance staff have conducted several ground-water studies for public entities in the Montara and Mid-Coast areas (Laduzinsky and others, 1988; Hecht and others, 1989,1992), and have performed a number of other investigations bearing upon the hydrologic needs for habitat, water-supply, aesthetic and recreational uses throughout the region. We were invited to attend the August 6, 1998 Montara Sanitary District Board meeting, when the DWR report was presented. We subsequently prepared a work scope to further evaluate the feasibility of ground-water supply. At the request of MSD, the scope was modified to encompass three discrete phases. This interim status report summarizes work to date, providing information to assist MSD decisions into whether or where to proceed further with ground-water exploration and evaluation.

The objectives of the work were to:

- Develop a preliminary feasibility assessment for McNee Ranch, Martini Creek, adjacent unnamed basins, and Montara Creek aquifer upstream of the Wagner Well.
- Provide initial guidance on where to drill to obtain water or to maximize water availability during drought periods.

- Assess initial compatibility with other water uses that exist in the basins.

The first phase of our study has two tasks: (1) information gathering, and (2) preliminary water budget.

This report is an interim document. It is interim because (a) significant revisions are being made to the California Department of Water Resources report which was to have preceded our work, (b) there may be immediate need for the information we have developed to date, due to possible contamination of the Wagner #3 and Drake wells[1], (c) we anticipate substantial additional information on surface runoff to come available[2] shortly after March 1, and (d) only a short status report was envisioned for the end of this initial phase of Balance's envisioned scope of work, with significant report development reserved for the end of the third phase. Release of the information we have collected and synthesized becomes useful to the MSD board and staff in evaluating the further findings of the DWR study and in addressing potential immediate water-supply needs as a result of the detection of possible constituents of concern in the two wells.

Information gathered

We visited the San Mateo County Health Services and copied the well logs, pump test sheets and water quality data for residents in the Montara area. These were compiled in an accompanying document, "Well Logs of the Montara Area." A summary of well construction and performance is found in Appendix B.

We contacted Caltrans for borehole logs or watershed information. Two individuals were contacted in the Oakland office: Bob Banks (286-4818) in the geotechnical division, and Joe Peterson (286-6377) in hydraulics. Caltrans has conducted many borings along Highway 1 (and especially in the Devil's Slide area). Most of the data from the slide area is in highly disturbed materials and is not representative of our site. The many shallow borings near bridges and other infrastructure as well were generally not useful. No well logs which may have been obtained by

[1] An initial meeting to outline potential responses to this emerging issue is to be held March 3, 1999 at the Montara Sheriff's stations. This report can not, therefore, include information or materials resulting from this meeting, nor is it our intent to have this interim information made available prior to suitable review by MSD staff and board members.

[2] As part of stream gaging programs on Denniston and Apanolio Creeks sponsored by the Landowners' group (approvals pending) and the San Mateo County RCD, respectively.

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Caltran in the course of acquiring the right-of-way were found in the agency's files. Watershed information collected by Caltrans Staff (drainage areas, 100-yr. flows, etc.) is found in Appendix C.

A search for color-infrared red (CIR) aerial photography was conducted and two photos were purchased: 8/16/82 a wet year, and 6/22/87 a dry year. CIR aerial photographs can be very helpful in locating of seeps and springs, and for defining fracture trends and photolinears for us in for proposed well location.

Meteorological data used in the water balance are summarized in Appendix D. These data include records of rainfall at Half Moon Bay airport (NCDC data), isohyetal maps (Rantz, 1971; SCS, 1961), rainfall/runoff relation, runoff maps (Rantz, 1974), and U.C. cooperations extension evapotranspiration data for Half Moon Bay (Snyder and others, 1991).

Reports reviewed are listed in the reference section. Some pertinent maps and figures from these reports are found in Appendix E.

Water Balance

One of the conclusions of the DWR report was that the amount of ground water available may not be sufficient to provide for all projected future demands for water in the Montara area. A preliminary water balance was conducted to address this concern. The water balance method is similar to that described in the 1998 Kleinfelder investigation of El Granada Ground-water and the Montara-Moss Beach Water Well EIR (Hecht and others, 1989). In brief, it is an accounting of the flow of water (inflows – outflows) to estimate an unknown (or less certain) parameter, in this case recharge to the water-table aquifer. The water table responds to recharge by rising, as more water is stored in the aquifer. Outflows from the aquifer include flow to the ocean, consumptive use by vegetations drawing upon ground water ("phreatophytes") and ground-water extraction by well pumping.

The water balance method was used to predict infiltration to the aquifer for three scenarios:

- Normal (steady state) conditions, where water-level fluctuation is averaged over time and all inflows are equal to outflows, leaving net ground-water storage unchanged;
- 1981, a dry year; drier than about 75 percent of all years; and

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- 1977, a critically dry year and the driest year in recent memory

The first part of the analysis was to estimate recharge to the water table, which is rainfall less runoff and evapotranspiration. This is tabulated in Appendix F for the areas of interest, as well as for Apanolio Creek basin, a watershed similar to Martini in relief, size and geology but with more rainfall. Supporting information is included. Given that we measured runoff in Apanolio Creek, certain checks to the water balance were possible.

The recharge and runoff estimates (in Appendix F) were applied to delineated areas on Figure 1 to estimate total recharge and runoff in acre-feet[3]. The sub-areas were totaled to give theoretical maximum recharge to the resource. Effectively, only a portion of the total can be utilized. Depending on the placement of the production wells, ponds and reservoirs, perhaps half of the water could reasonably be utilized.

The annual recharge and runoff for normal conditions, dry and critically dry years are summarized in Table 1. The steady state analysis shows means of 630 acre-feet per year recharge and 758 acre-feet per year runoff. If half of this amount were developable, about 700 acre-feet per year should be available, an average, for water supply. Domestic use for 2030 is predicted to be 645 acre-feet. Therefore, if every year had an average amount of rainfall, then there would appear to be an adequate supply. The 700 acre-feet estimate does not include the 740 acre-feet per year currently supplied by CUCC from other supplies (i.e. the Montara Creek and airport wells).

During dry years, such as 1981, recharge will diminish to about two-thirds of the long-term average, and during critically dry years recharge is effectively zero. Outflows (water pumped or flowing from the aquifer) are sustained from ground-water in storage. Normal storage was estimated in Table 2 and summarized in Table 1. During drought years, the storage is depleted by flow towards the ocean and by any extraction. There appears to be a limited amount of storage that may likely support extraction during a couple years of severe drought. An extended drought would likely severely limit supply. Detailed analysis can firm up these estimates. Water level information indicates that storage is replenished relatively quickly at the end of a severe drought (DWR, 1998), which also suggests limited storage. We saw in streamflow records form Apanolio Creek that the decomposed granitic soils, like those in the Martini area, tend to easily absorb rain

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[3] An acre-foot is an acre of water that is one foot in depth, 43560 cubic feet or 325,851 gallons. One acre-foot per year is 892 gallons per day or 0.62 gallons per minute. One acre-foot per day is 0.5 cubic feet per second (cfs) flow.

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and limit runoff peaks (refer to the Apanolio hydrograph in Appendix F). The soils also tend to drain easily.

Other uses would draw on the resources, most notably two pending applications by the State of California to divert up to 1.05 cfs (760 acre-feet) per year from Martini Creek (DWR, 1998). Details of the applications are unknown and should be clarified. Similar applications are listed in Appendix G. Other uses include a permit to store 25 acre-feet for irrigation by the landowner group, and about 25 acre-feet for riparian vegetation.

Not estimated is storage in deep fractures. Some of the high producing wells plotted in Figure 1 draw from densely-fractured granitic rocks. Others have high yields from highly conductive alluvial gravels. Although not noted in the well log, the Wagner well seems to be positioned along a fracture.

It should also be noted that because runoff was estimated based on a rainfall/runoff relations observed in other basins, and not directly with gaging records, the accuracy of the recharge estimate is largely reduced. The estimate of recharge could be improved by measuring flow in Martini Creek. Likewise, ground-water outflow estimates could be improved, as professionally hydrogeologic information becomes available with a drilling campaign.

Criteria to guide potential well locations

In order to supply 645 acre-feet per year to meet the year 2030 use prediction (DWR, 1999), a pumping rate of 400 gallons per minute (gpm) would need to be achieved. This rate could arbitrarily be met with 10 wells that pump 40 gpm. The average specific capacity of the Montara terrace is 0.23 gpm per foot, and the average saturated thickness of the aquifer is 192 feet (Appendix B); multiplied together, gives an average potential yield of about 40 gpm. The exact placement wells would need further study to evaluate radii of capture and flow conditions. It is clear that higher average yields are found from wells in alluvium, deeply weathered and fractured granite.

Well performance information for the Montara wells was ranked and the 15 highest producers and 15 lowest producers plotted in Appendix B. The wells were located on the hydrology map (Figure 1). Highest producers appear to be located in alluvial gravels and along fractures, or where

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conductive materials overlap. For example, where fractured granitics underlie alluvial gravels, as in the Cedar and Harte Roads area, or where fractures co-occur where deeply weathered granitics and/or alluvium, as in the Wagner well area. Other high yielding wells appear to be positioned along a fault or fracture trace.

Color-infrared-red aerial photographs were analyzed for locations of seep, springs, and geographic trends. Major seeps and wooded areas were transferred to Figure 1. Potential well locations would ideally be positioned along the fractures, seep trends, discharge areas, and deeply weathered granite and alluvium areas. A preliminary evaluation of some potential locations is found in Figure 2. Further study including a field reconnaissance would be required to finalize sites for a drilling campaign. The locations of above- and below-ground utilities should, of course, be considered when siting the wells.

Concluding remarks

We concur with the conclusion in the DWR 1998 draft report that states "the amount of groundwater available in the Montara area may not be sufficient to provide all of the future demands of water in the Montara area", particularly during an extended drought. Hydrologic information is limited, and supply predictions to meet demand in 2030, although theoretically possible, leave little room for inaccuracies or well limitations. However, a reasonably substantial water resource exists and merits exploration. The resource should provide a large portion of the demand (Table 1). In additions, conjunctive use options would be sensible to augment recharge during most years but these options may likely be limited during droughts.

We suggest that a field reconnaissance be conducted to select potential drilling sites that would focus on fracture flow, areas of deep alluvium and decomposed granite, seeps and discharge areas. Some preliminary sites are mapped on Figure 2. We also recommend a modest gaging program on Martini Creek to firm up the recharge estimates and a multi-year water balance to predict supplies through a drought.

Limitations

This report was prepared in general accordance with the accepted standard of practice existing in Northern California at the time the investigation was performed. No other warranties, expressed

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or implied, are made. It should be recognized that interpretation and evaluation of subsurface conditions and water balance predictions is a difficult and inexact art. Judgment leading to conclusions and recommendations are general made with an incomplete knowledge of the conditions present. More extensive studies, including gaging of Martini Creek and collection of subsurface information in the area of interest, can reduce the inherent uncertainties associated with such studies. If the client wishes to reduce the uncertainty beyond the level associated with this study, Balance should be notified for additional consultation.

Balance Hydrologics has prepared this report for the client's exclusive use on this particular project. The report is based in part on work performed by experts in related fields, information provided by the client, and/or upon reference values commonly used in the area or developed by sources generally held to be reliable. We have not independently verified their validity, accuracy or representatives to this or other sites. The recommendations provided in this report are based on the assumption that an appropriate and adequate follow-up program will be conducted, and that our firm will be retained at key stages in the project to revise the findings and recommendations described in this report.

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References

California Department of Water Resources, 1974, Evaluation of ground water resources: Livermore and Sunol Valleys, DWR Bulletin No. 118-2, 153 p.

California Department of Water Resources, 1982, Inventory of instream flow requirements related to stream diversions: Bulletin 216. December 1982. 301 p.

California Department of Water Resources, 1998, Draft Montara Water Supply Study: Unpublished report prepared for Montara Sanitary District.

Camp Dresser & McKee, Inc., Balance Hydrologics, Inc., David Keith Todd Consulting Engineers, Geoconsultants, Inc., Luhdorff & Scalmanini Consulting Engineers, March 1994. Comprehensive hydrological study. Prepared for Rancho San Carlos Combined Development Permit Application.

Earth Sciences Associates and Luhdorff and Scalmanini, Consulting Engineers, 1991, Half Moon Bay Airport/Pillar Point Marsh ground water basin, Phase I study report: Preliminary report prepared for Citizens Utility Company of California and Coastside County Water District. Phase II, 25 p. + 2 appendices

Geoconsultants, 1989, Annual report 1988-1989 ground-water resources, Half Moon Bay, California: Prepared for City of Half Moon Bay, 21 p.

Hecht, B., and Esmaili, H., 1984, Pajaro basin groundwater management study: HEA, A Division of J.H. Kleinfelder & Associates consulting report prepared for the Association of Monterey Bay Area Governments: Final report, July 1984. 238 p. + appendices

Hecht, B., O'Connor, M., Renshaw, D., and Petersen, T., 1989, Draft Montara-Moss Beach water well EIR: Report by Kleinfelder in association with Balance Hydrologics, Inc., Thomas Reid Associates and Diane Renshaw, Biologist, to the San Mateo County Department of Environmental Management, 157 p. + 4 appendices.

Hecht, B., White, C., and Knudsen, K., 1992, Initial identification of hydrogeologic and water-quality opportunities and constraints: Proposed County golf course at the Cowell- Torello Property, Moss Beach, California. 25 p.

Henry Hyde Associates, 1986, Montara-Moss Beach water system: Report to County of San Mateo, Multipaged.

Laduzinsky, D., Hecht, B., and Woyshner, M., 1988, El Granada ground water investigation report: Kleinfelder report to the County of San Mateo Department of Health Services. 53 p. + 3 appendices.

Lowney-Kaldveer Associates, 1974, Ground water investigation, Denniston Creek vicinity, San Mateo County, California: Unpublished report, 12 p.

Pampeyan, E.H., 1994, Geologic map of the Montara mountain and San Mateo 7-1/2' quadrangles, San Mateo County, California: U.S. Geological Survey Map I-2390.

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Rantz, S.E., 1971, Precipitation depth-duration-frequency relations for the San Francisco Bay Region, California. U.S. Geological Survey Professional Paper 750-C.

Rantz, S.E., 1974, Mean annual runoff in the San Francisco Bay region, California 1931-70, U.S. Geological Survey Misc. Field Studies Map MF-613.

Thornthwaite, C.W., and Mather, J.R, 1957, Instructions and tables for computing potential evapotranspiration and the water balance. Drexel Institute of Technology, Publications of Climatology, Vol. X, No. 3

University of California Cooperative Extension, Division of Agriculture and Natural Resources, Leaflet 21426.

USDA Soil Conservation Service, 1961, Soil Survey, San Mateo area, California, Series 1954, No. 13, 111 p.

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Attachments

Table 1. Summary of water resources and uses in the Martini and Montara Creek area.
Table 2. Estimated ground-water storage in the Martini and Montara Creek area.

Figure 1. Hydrology map of the area north of Montara.
Figure 2. Production well location map.

Accompaning Document : Well logs of the Montara area.

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Table 1. Summary of water resources and uses in the Martini and Montara Creek area

	Acre-feet per year	gpm
Annual recharge		
Normal (steady state)	635	393
1981 dry year	425	263
1977 critically dry year	28	17
Annual runoff		
Normal (steady state)	758	470
1981 dry year	505	313
1977 critically dry year	152	94
Storage (average estimate)	4135	--
Terrace and valley alluvium	2484	--
Upland slopes	1651	--
Deep fractures	?	--
Domestic use (CUCC master plan)		
1995 (5,705 people @ 80 gpd)	511	317
2030 (7,194 people @ 80 gpd)	645	400

Other uses

1) The State of California had filed two applications to divert up to 1.05 cfs (760 af/yr) from Martini Cr (DWR 1998 draft).
2) The landowner group has a permit to store 25 af for irrigation (DWR 1998 draft).
3) Evapotranspiration from xeric vegetation has been accounted for in the estimate of recharge; however, riparian and other phreatophytic vegetation would require about 20 to 25 af/yr.

Other sources

CUCC currently extracts about 460 gpm (available yield) or about 740 ac-ft per year from current production wells (i.e. Montara Creek and the Airport wells).

Notes

1) Principal outflows from the aquifer are flow to the ocean and pumping. Under normal (steady state) conditions with no pumping, infiltration should equal flow to the ocean. Given this, average transmissivity (the least accurate and precise parameter in the water balance) should be 2360 gpd/ft. The 1989 Kleinfelder report (Hecht and others) estimated 1,800 gpd/ft. The maximum transmissivity in the terrace well logs was 1545 gpd/ft.
2) Storage was estimated from water level information when the well was tested for yield. Water levels may drop 10 ft during a dry year and 20 ft during a critically dry year in the terrace and alluvium (Laduzinsky and others, 1988). A typical multi-year drought may reduce the storage by half or more (ESA and Luhdorff & Scalmanini, 1992), an important assessment to be developed during the next phase of work.

Table 2. Estimated ground-water storage in the Martini and Montara Creek area

Watershed	Area acres	Saturated Depth feet	Specific Yield	Ground-water Storage (acre-feet)
Ground-water storage (sub-areas A-H)				
Terrace and valley alluvium	230	120	0.08	2208
Fractured/weathered bedrock beneath terrace/alluvium	230	120	0.01	276
Upland slopes	1376	120	0.01	1651
Total	1606			**4135**
Deep Fractures				?
Upper Martini Creek (Sub-area A)				
Terrace and valley alluvium	33	120	0.08	321
Fractured/weathered bedrock beneath terrace/alluvium	33	120	0.01	40
Upland slopes	482	120	0.01	579
Total	516			**940**
Deep Fractures				?
Upper Montara Creek (Sub-area G)				
Terrace and valley alluvium	44	120	0.08	422
Fractured/weathered bedrock beneath terrace/alluvium	44	120	0.01	53
Upland slopes	445	120	0.01	534
Total	489			**1010**
Deep Fractures				?

Notes

See watershed area table and map for area details.

Average saturated depth of aquifer was based on well depth and water level information (see well summary table for details).

Specific yield is the amount of water released from a water table aquifer with a unit lowering of the water level. Estimates are based on values observed in similar materials in nearby areas.

Ground-water storage = area * depth * specific yield

Appendix A.

Conclusions to the Montara Water Supply Study (DWR 1999)

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State of California **DEPARTMENT OF WATER RESOURCES** The Resources Agency

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COMMENTS:

Mark:
Attached is the text from the Montara Water Supply Study, final draft, related to current and future water use, that you requested. I am also attaching our Conclusions, Recommendations and Literature Cited, for your information. The Literature Cited includes the reference for the Citizens Utilities report. We are planning to publish in the next week or so.

Please contact me if you have any questions.

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Montara Water Supply Study
for
Montara Sanitary District

San Mateo County, California

Department of Water Resources
Central District

January 1999

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due to the moratorium and customer's concerns about the high cost of water. Montara Sanitary District, as a public agency, would require significant public participation in developing a water supply option for the community. MSD, as a water developer, may provide additional opportunities and other advantages in developing water supply options. For example, a public agency may have greater access to low-interest loans for studies and/or project development and is tax exempt.

The administrative approach of interested parties will be very important in implementing a water supply reliability improvement solution. Montara Sanitary District can implement a wide variety of solutions in cooperation with Citizens Utilities. For example, the district could act as a water wholesaler by developing a water supply solution and then selling the water to Citizens Utilities for retail. There are some legal constraints on the types of actions that Montara Sanitary District can take in implementing water supply reliability improvement solutions. For example, the California Public Utilities Code protects the investments of private utilities regulated by the State PUC. The Service Duplication Act (Section 1501 ff.) states, "that it is necessary for the public health, safety, and welfare that privately owned public utilities regulated by the state be compensated for damages that they may suffer by reason of political subdivisions extending their facilities into the service areas of such privately owned public utilities." This and the following sections would specifically protect CUCC from damages caused by MSD developing an additional water supply and retailing it within the CUCC service area. Since Citizens' and MSD's service areas are very similar, options that would retail water in the communities may be subject to the Service Duplication Act.

WATER USE

An important first step in developing a supplemental water supply is to analyze water use and water supply. A comparison of water use and supply indicate the reliability of a water supply system. Water use is typically determined by evaluating population and per capita use associated with a service area. Population and per capita use is then projected to estimate future water use. A number of local factors will affect future population, the most significant of which may be the water connection moratorium. Citizens Utilities' master plan estimates current (1995) system water use to be 511 acre feet per year. This estimate is based on a population of 5,705 and a per capita use of 80 gallons per capita per day. As previously mentioned, the master plan focuses on a comparison of the system's reliable capacity (310 gallons per minute) against maximum day demand (471 gpm), which indicates a need for greater source capacity. This comparison does not include improvements to the system subsequent to publication of the master plan. As the population within the service area grows, system water use will increase proportionally. Linear growth (at an annual rate of 0.7 percent) from 1995 through 2030 would increase the population to 7,194 and water use to 645 acre feet per year. This estimated growth alone would require an additional 134 acre feet per year.

This study will not attempt to reevaluate CUCC's reliability assessment, but will instead focus on evaluation of feasible options to increase the system's water supply. In addition, this study could not accurately determine what the future population growth within the water system service area will be due to uncertainties related to the moratorium and other growth control issues. The sanitary district should work closely with Citizens Utilities, the State PUC, San

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Mateo County, as well as interested members of the public on matters related to the water system and population growth. MSD and the above entities need to decide how much growth the water system should support. This determination will significantly affect the feasibility and comparative appropriateness of the supplemental water supply options presented herein. For example, if growth is relatively rapid, pursuing small local ground water options may not be appropriate. If growth were very slow, pursuing a larger imported water supply would probably be cost prohibitive.

Conclusions

The following are noteworthy conclusions derived during the development of the Montara Water Supply Study;

- According to the entities involved, the Montara water system is inadequate for the current level of development. Water needs exceed the available water supply. In addition, during peak demand periods, the water system capacity is not sufficient to meet water needs. The inadequacies are primarily related to water source capacity. DWR did not evaluate water supplies, needs, and shortages, but concurs with the entities that a water system deficiency currently exists.

- Future water needs are highly dependent upon the future population connected to the Montara water system. Future population changes will be influenced by the water system connection moratorium, the San Mateo County Local Coastal Plan limitations, and the county development review process (including the public response to development proposals). Based on Citizens Utilities projections, yearly water demands will increase by approximately 130 acre feet by 2030. This projected demand increase does not include the existing system shortage described above.

- Water development in and surrounding the Montara area has historically been very difficult. Water resources are limited, water development can be competitive, and anti-growth sentiment is significant. Cooperation between various interests and agencies is an important tool that can provide cost savings, improved protection of resources, and increased opportunities.

- Montara Sanitary District has attained legal status as a county water district with the ability to develop, acquire, and sell water. The benefits of public agency status include compliance with the Raker Act private utility exclusion, improved potential of increased public participation in the planning process, and independence of PUC regulation.

- Hydrologic information and data (both surface water and groundwater) for the area in and surrounding Montara is limited. In many cases, the data and information currently available may not be sufficient for making water management decisions.

- A number of water supply development options to augment the Montara area water system supply appear to be feasible. Feasible options include local surface water development, ground water development, desalination, and negotiation of a water transfer.

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- After cursory review, ground water development and negotiation of a water transfer appear to be most favorable. The most easily developed option appears to be ground water development. The economic component of the ground water option is especially attractive, as the cost of preliminary investigation and cost per acre foot are apparently significantly less than other options.

- Exploratory drilling can answer a number of immediate questions related to feasibility of the ground water options at minimal cost. A pump test, hydrogeologic information derived during the drilling, and minimal analysis should provide adequate information to decide whether to proceed with a design.

- The amount of additional ground water available may not be sufficient to provide for all projected future demands for water in the Montara area. Cursory estimates by DWR of the yield from the "McNee Ranch Well Field" and the "New Well North of the Wagner Well" options indicate an annual supplemental supply of 120 acre feet. This supplemental yield is slightly less than the additional supply estimated by CUCC as necessary to meet future population needs.

- The amount of water available through negotiation of a water transfer is limited by conveyance space in relevant pipelines and aqueducts. A water transfer is a negotiated agreement, and therefore can be most effectively and efficiently implemented in a spirit of cooperation.

- Conjunctive use may provide significant benefits to local water users including protection of environmental resources, stabilization of ground water levels, and increased water supply. In the Denniston sub-basin, these benefits may be available if a surface water source can be identified for recharge, and regulators and water users can reach agreement on alternative management strategies.

- Traditional conjunctive use does not appear to be feasible under current ground water management practices for the Denniston sub-basin, due primarily to an apparent lack of available storage space. However, traditional conjunctive use may be feasible if the sub-basin can be pumped to lower levels without adversely impacting Pillar Point Marsh.

- A more limited approach to conjunctive use in the Denniston sub-basin may provide more limited benefits. Recharge and recovery of surface water during a specific drought year would provide the above-mentioned benefits, excluding increased water supply. This type of management approach may provide improved flexibility, but no additional supply as compared to simply delivering the surface or imported supply directly to the water system.

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Recommendations

The Montara Sanitary District Board of Directors and more specifically the district's customers will now need to assess the communities' water supply and make a number of decisions regarding the future. As stated previously, the future of the water supply may significantly impact the Montara Sanitary District. The district should work closely with Citizens Utilities in this decision-making process. Following is a listing of recommendations, which are significantly derived from this study and report's conclusions:

- An important preliminary step for Montara Sanitary District will be to work closely with members of the community and San Mateo County to determine the amount of additional development residents would be willing to support.
- Montara Sanitary District needs to make every effort to work cooperatively with the appropriate organizations to circumvent potential political roadblocks. Organizations include Citizens Utilities, Coastside County Water District, San Mateo County, various landowners, as well as the public. Dialogue with each of these entities should begin as soon as practical.
- As a county water district, Montara Sanitary District must develop and encourage public participation and support during the supplemental water supply planning process.
- Montara Sanitary District should support any efforts to improve water resource data and information (esp. data collection) for the area in and surrounding the water system service area. The district should also monitor current efforts by the landowner group and Coastside County Water District to develop local surface and ground water hydrology data and information.
- Discussions should be initiated with landowners regarding the potential ground water development options. If an agreement can be reached for further investigation of a specific option, exploratory drilling should proceed. If the exploratory drilling and review indicates a feasible option, an agreement to develop the option should be negotiated and design should proceed.
- Discussions should be initiated among local water entities regarding potential water transfer options. If participants can agree on terms for additional investigation, a water marketing consultant should be retained to assist in negotiations.

FINAL DRAFT

Literature Cited

California Department of Water Resources. 1993. *Compilation of Federal and State Drinking Water Standards and Criteria*. Quality Assurance Technical Document 3. 35 p.

California Department of Water Resources. 1998. *California Water Plan Update, Bulletin 160-98, Volume 1.*

California Environmental Protection Agency, Regional Water Quality Control Board, Central Valley Region. 1998. *A Compilation of Water Quality Goals.*

California Public Utilities Commission. 1997. *CPUC Decision 97-12-097.*

Citizens Utilities Company of California, for California Coastal Commission. 1995. *Alternatives for Managing Groundwater Resources in the Pillar Point Groundwater Basin, Feasibility Report.*

Coastside County Water District. 1997. *Coastside County Water District, Water Supply Evaluation, Calendar Year 1996 Report.*

Earth Sciences Associates and Luhdorff and Scalmanini Consulting Engineers (ESA and LSCE). 1987. *Half Moon Bay Airport/Pillar Point Marsh Ground-Water Basin – Phase I Study Report.* 18 p.

T. Grove, D. Loomis and S. Guiney, Memorandum to California Coastal Commissioners, March 3, 1994.

Hargrove, Mark. FAX transmittal to Jim Wieking. June 30, 1998.

Kleinfelder. 1989. *Draft Montara-Moss Beach Water Well EIR.* 157 p.

Luhdorff and Scalmanini Consulting Engineers and Earth Sciences Associates. 1991. *Half Moon Bay Airport/Pillar Point Marsh Ground-Water Basin Report Phase II.*

Luhdorff and Scalmanini Consulting Engineers and Earth Sciences Associates. 1992. *Half Moon Bay Airport/Pillar Point Marsh Ground-Water Basin Report Phase II Supplemental Data.*

Montgomery Watson. 1996. *Citizens Utilities Company of California 1996 Water System Master Plan Update for the Montara District.*

Nelson, Gene. Letter to Robert J. Swartz. December 4, 1997.

Norris, R.M. and R.W. Webb. 1991. *Geology of California.* 2nd ed. John Wiley & Sons, New York. 541 p.

FINAL DRAFT

Pampeyan, E. H. 1994. *Geologic Map of the Montara Mountain and San Mateo 7-1/2' Quadrangles, San Mateo County, California.* U.S. Geological Survey Miscellaneous Investigation Series Map I-2390. 19 p.

San Mateo County, Environmental Services Agency. 1992. *Local Coastal Program, Policies.*

Smits, Kornelius, Ed. 1994. *Means Heavy Construction Cost Data.* 9th annual ed. R.S. Means Company, Inc. 408 p.

U.S. Army Corps of Engineers. 1988. *Engineering and Design, Civil Works Construction Cost Index System.*

Appendix B.

Summary of Well Logs in the Montara Area

900 Modoc St, Berkeley, CA, 94707-2208
Phone 510-527-0727: Fax 510-527-8531

Summary of well construction and performance by sub-area, Montara area.

	Total Depth ft	Depth to Water ft	Specific Capacity gpm/ft	Transmissivity gpd/ft	Saturated Thickness ft	Hydraulic Conductivity gpd/ft2	cm/s	Specific Conductance umhos/cm @ 25C
All Wells								
Average	224	63	0.42	782	153	7.58	3.6E-04	639
Std.Dev.	99	40	0.63	1168	74	13.45	6.3E-04	271
Maximum	500	180	2.92	5425	342	68.89	3.2E-03	1280
Median	215	55	0.21	395	140	2.90	1.4E-04	595
Minimum	56	4	0.01	24	52	0.09	4.1E-06	270
Sample Size	76	68	67	67	67	67	67	52
Montara Terrace (between Hwy 1 & Birch St)								
Average	266	71	0.23	419	192	3.66	1.7E-04	864
Std.Dev.	99	37	0.22	416	83	5.11	2.4E-04	200
Maximum	440	127	0.83	1545	342	21.76	1.0E-03	1280
Median	250	65	0.16	291	185	1.21	5.7E-05	900
Minimum	73	6	0.02	39	67	0.11	5.3E-06	500
Sample Size	25	23	23	23	23	23	23	18
Lower Montara Terrace (between Hwy 1 & East Ave.)								
Average	229	62	0.28	516	167	4.87	2.3E-04	917
Std.Dev.	89	40	0.24	454	75	5.90	2.8E-04	179
Maximum	390	115	0.83	1545	326	21.76	1.0E-03	1280
Median	236	47	0.24	440	185	4.19	2.0E-04	925
Minimum	73	6	0.03	48	67	0.17	8.2E-06	590
Sample Size	15	15	15	15	15	15	15	14
Upper Montara Terrace (between East Ave and Birch St)								
Average	321	88	0.13	238	241	1.40	6.6E-05	678
Std.Dev.	91	26	0.15	274	82	1.87	8.8E-05	168
Maximum	440	127	0.45	845	342	5.64	2.7E-04	900
Median	325	97	0.08	145	256	0.76	3.6E-05	655
Minimum	200	50	0.02	39	145	0.11	5.3E-06	500
Sample Size	10	8	8	8	8	8	8	4
Upper Montara Creek (east of Birch St)								
Average	198	57	0.65	1213	123	12.49	5.9E-04	467
Std.Dev.	97	48	0.78	1445	44	18.30	8.6E-04	159
Maximum	500	180	2.92	5425	252	68.89	3.2E-03	780
Median	175	39	0.34	641	120	4.67	2.2E-04	430
Minimum	56	4	0.04	67	52	0.59	2.8E-05	270
Sample Size	36	30	29	29	29	29	29	25
Southwest of Alamo Street								
Average	182	65	0.14	261	118	3.11	1.5E-04	668
Std.Dev.	80	25	0.18	334	65	4.06	1.9E-04	337
Maximum	370	120	0.63	1163	250	13.84	6.5E-04	1240
Median	160	60	0.10	183	90	2.18	1.0E-04	520
Minimum	100	30	0.02	46	60	0.19	8.8E-06	270
Sample Size	10	10	10	10	10	10	10	8
Montara Heights								
Average	283	62	0.54	1000	221	6.02	2.8E-04	658
Std.Dev.	52	19	1.06	1968	67	11.96	5.6E-04	
Maximum	350	80	2.43	4517	295	27.38	1.3E-03	658
Median	300	65	0.05	101	235	0.40	1.9E-05	658
Minimum	220	33	0.01	24	140	0.09	4.1E-06	658
Sample Size	5	5	5	5	5	5	5	1

Notes

Specific capacity (Cs) = Yield (gpm) / Drawdown (ft); a way to evaluate the relative performance of a well, compared with others in the area.
Transmissivity (T) = Hydraulic Conductivity (K) * Saturated Thickness (b). It was calculated from Specific Capacity (Cs) using the equation T = 1860 C (DWR Bulletin No. 118-2, June 1974).
Hydraulic conductivity (K) = T/b, where b is the distance from the summer water level to bottom of the well.
Specific conductance is the electrical conductivity of the water at 25 degrees C, which is related to the salinity of the sample.

Well construction and performance, Montara area.

Location	APN	Date Drilled	Logged Material	Total Depth ft	Perforated Interval ft	Sanitary Seal ft	Depth to Water ft	Pump Test gpm	Total Drawdown ft	Specific Capacity gpm/ft	Transmissivity gpd/ft	Aquifer Thickness ft	Hydraulic Conductivity gpd/ft2	Hydraulic Conductivity cm/s	Specific Conductance umhos/cm @ 25C
Lower Montara Terrace (between Hwy 1 & East Ave.)															
246 2nd St	036-014-130	Sep-87	Terrace/Granite	135	25-130	22	37.5	5	9	0.556	1033	98	10.60	5.0E-04	670
5th St	036-021-220	May-98	Terrace/Granite	250	85-250	23	107	10.7	30.5	0.351	653	143	4.56	2.2E-04	990
5th St	036-021-260	May-98	Terrace/Granite	225	80-225	20	113	14.3	31	0.461	858	112	7.66	3.6E-04	980
6th St	036-022-290	Jun-90	Terrace/Granite	300	40-300	25	115	2.5	6	0.417	775	185	4.19	2.0E-04	870
320 6th St	036-022-300	Mar-90	Terrace/Granite	305	205-305	25	110	4.8	70	0.069	128	195	0.65	3.1E-05	1000
6th St	036-022-310	May-90	Terrace/Granite	300	40-300	25	115	2.5	5	0.500	930	185	5.03	2.4E-04	850
361 10th St	036-025-250	May-91	Terrace/Granite	250	80-210	25	47	2.5	60	0.042	78	203	0.38	1.8E-05	
11th St	036-033-370	Jul-90	Terrace/Granite	300	20-300	20	22	2.7	104	0.026	48	278	0.17	8.2E-06	1050
202 11th St	036-034-050	Jul-98	Terrace/Granite	228		25	28	4.5	164	0.027	51	200	0.26	1.2E-05	1280
12th St	036-034-070,080	Mar-90	Terrace/Granite	236	20-236	20	32	2.5	36	0.069	129	204	0.63	3.0E-05	1100
2nd & Main	036-047-100	Jun-98	Terrace/Granite	115	55-115	25	44	10.3	12.4	0.831	1545	71	21.76	1.0E-03	940
1401 Main St	036-053-090,100,110	Sep-91	Terrace/Granite	390	210-390	30	64.3	8	49.7	0.161	299	326	0.92	4.3E-05	900
9th St	036-058-130	Nov-97	Terrace/Granite	73	35-73	25	6	7.8	21.6	0.361	672	67	10.02	4.7E-04	910
462 4th St	036-062-140	Feb-90	Terrace/Granite	100	40-100	20	21	2.6	11	0.236	440	79	5.57	2.6E-04	590
5th St	036-066-260	May-98	Terrace/Granite	228	125-225	20	70	5	98	0.051	95	158	0.60	2.8E-05	710
Upper Montara Terrace (between East Ave and Birch St)															
8th St	036-095-230	Aug-91	Granitic	210	130-210	20	65	5.56	35.55	0.156	291	145	2.01	9.5E-05	620
8th St	036-095-310	Jan-98	Granitic	220	40-220	25	62	6.5	63	0.103	192	158	1.21	5.7E-05	
8th St	036-095-340	Dec-89	Granitic	400	100-400	100	108	5	240	0.021	39	292	0.13	6.3E-06	
8th Lot 5, btwn Le Conte & Audubon	036-095-380	May-98	Granitic	440	105-440	25	98	4	192	0.021	39	342	0.11	5.3E-06	
8th Lot 7, btwn Le Conte & Audubon	036-095-390	May-98	Granitic	420	95-420	28	95	7.5	141	0.053	99	325	0.30	1.4E-05	
8th St Lot 6, btwn East & Le Conte	036-095-390	Oct-97	Granitic	390	80-390	25	101	5	214	0.023	43	289	0.15	7.1E-06	
1292 Birch St near 8th St	036-102-220	Jun-91	Granitic	282	222-282	20									500
1392 Birch St (at end of street)	036-102-240	Sep-91	Granitic	350	100-250	20	127	2.77	14.4	0.192	358	223	1.60	7.6E-05	690
935 Corona St	036-126-010	Apr-86	Granitic	200	100-200	20	50	5	11	0.455	845	150	5.64	2.7E-04	900
1162 Tamarind St	036-320-090	Jan-97	Granitic	300	80-280	20									
Upper Montara Creek (east of Birch St)															
744 Harte near Cedar	036-104-040	Jun-90	Granitic	160	20-160	20	33.6	10	4.6	2.174	4043	126	31.99	1.5E-03	720
Portola off 6th (at end of street)	036-104-	Nov-83	Granitic	110	50-110	20	10	10	40	0.250	465	100	4.65	2.2E-04	470
1412 Cedar St	036-104-300	Apr-87	Granitic	120	40-100	20	23	5.5	50	0.110	205	97	2.11	9.9E-05	300
1400 Cedar St	036-104-300	Apr-87	Granitic	80	20-80	20	26	60	30	2.000	3720	54	68.89	3.2E-03	270
1370 Cedar St	036-104-400	May-98	Granitic	138	30-138	30	37	50	53	0.943	1755	101	17.37	8.2E-04	
1380 Cedar St	036-104-410	May-98	Granitic	120	30-120	28									
1321 Cedar at 8th St	036-111-230	Nov-89	Alluvium	84	20-84	20	9	10	4	2.500	4650	75	62.00	2.9E-03	780
1400 Hill St	036-113-420	Feb-91	Granitic	180	40-140	35	80	8.1	29	0.279	520	100	5.20	2.5E-04	650
1024 Cedar N of Franklin St	036-123-140	Aug-87	Granitic	220	140-220	35	28	30	67	0.448	833	192	4.34	2.0E-04	570
844 Cedar St N of Drake	036-132-220	Feb-91	Granitic	180	40-180	30	45	2.5	3	0.833	1550	135	11.48	5.4E-04	
725 San Pedro Mt Rd	036-132-260	Jun-93	Granitic	275	175-275	25	65	12	9.2	1.304	2426	210	11.55	5.4E-04	320
Cedar St	036-132-290-2	Jun-98	Granitic	169			54	3.4	94	0.036	67	115	0.59	2.8E-05	385
Alta Loma St	036-142-020	Dec-95	Granitic	390	140-390	30	138	7	33	0.212	395	252	1.57	7.4E-05	310
Alta Vista Dr	036-143-050	Aug-87	Granitic	310	170-310	20	168	14	19	0.737	1371	142	9.65	4.6E-04	770
Alta Vista Dr	036-145-	Jul-87	Granitic	300	200-300	50	180	5	100	0.050	93	120	0.78	3.7E-05	350
Date and Edison	036-151-130	May-90	Granitic					2.5							
Franklin E of Date	036-152-210	Mar-98	Granitic	200	40-200	20	19								
Cedar St	036-161-160	Apr-88	Granitic	110	50-110	20	25	16	75	0.213	397	85	4.67	2.2E-04	460
947 Cedar St btwn Edison & Drake	036-161-190	Oct-85	Granitic	140	60-140	20	18	15	37	0.405	754	122	6.18	2.9E-04	
861 Edison St	036-161-290														490
Date and Edison	036-161-300	Feb-90	Granitic	143	20-140	20	32	5	18	0.278	517	111	4.65	2.2E-04	360

Location	APN	Date Drilled	Logged Material	Total Depth ft	Perforated Interval ft	Sanitary Seal ft	Depth to Water ft	Pump Test gpm	Total Drawdown ft	Specific Capacity gpm/ft	Transmissivity gpd/ft	Aquifer Thickness ft	Hydraulic Conductivity gpd/ft2	Hydraulic Conductivity cm/s	Specific Conductance umhos/cm @ 25C
Cedar & Date	036-161-320	Feb-90	Terrace/Granite	138	20-138	20	38	2.5	52	0.048	89	100	0.89	4.2E-05	320
Date near Edison	036-161-	May-90	Terrace/Granite	140	20-140	20	39	2.5	40	0.063	116	101	1.15	5.4E-05	560
905 Cedar St	036-161-410	Apr-98	Granitic	150	70-150	50									
991 Elm St near Edison	036-163-020	Feb-91	Granitic	260	60-260	25	101	3	21	0.143	266	159	1.67	7.9E-05	430
Alta Vista Rd	036-173-030	Jul-87	Granitic	200	45-200	42	70	15	50	0.300	558	130	4.29	2.0E-04	
Vallecitos Dr	036-175-010	Mar-88	Granitic	290	190-290	20	140	18	77	0.234	435	150	2.90	1.4E-04	270
Riviera & Vallecitos	036-175-060	Feb-92	Granitic	280	120-280	25	129	3.1	9	0.344	641	151	4.24	2.0E-04	390
Montara Blvd East	036-180-100	Apr-88	Alluvium	80	10-80	10	15	20	40	0.500	930	65	14.31	6.7E-04	
1213 Alamo near Grant	036-235-110	Dec-90	Granitic	175	55-175	20	51	15	41	0.366	680	124	5.49	2.6E-04	
1275 Alamo near Grant	036-235-120	Mar-87	Granitic	175	60-175	30	45	30	55	0.545	1015	130	7.80	3.7E-04	
Wagner #3	Citizens Utilities	Feb-72	Granitic	145	72-144	50	44	70	24	2.917	5425	101	53.71	2.5E-03	320
Drake Well	Citizens Utilities	Jun-76	Granitic	194	21-162	21	36	32	130	0.246	458	158	2.90	1.4E-04	370
Park Well	Citizens Utilities	Oct-64	Alluvium	56	17-56	17	4	23	54	0.426	792	52	15.24	7.2E-04	620
Portola I	Citizens Utilities	Mar-79	Terrace/Granite	332	120-160	120		10							
Portola II	Citizens Utilities	Apr-79	Granitic	300	170-300	170		10							
Portola III	Citizens Utilities	Apr-79	Terrace/Granite	300	65-300	65		30							600
Portola IV	Citizens Utilities	Apr-79	Terrace/Granite	500	175-500	175		20							590
Southwest of Alamo Street															
Sunshine Valley Rd	036-252-070	Nov-87	Granitic	125	70-125	20	53	3.5	34	0.103	191	72	2.66	1.3E-04	520
1479 Ivy St	036-261-140	Sep-83	Hard Granite	370	110-350	20	120	5	200	0.025	47	250	0.19	8.8E-06	1000
Alamo & Avery	036-262-070	Feb-87	Granitic	160	80-160	20	65	15	77	0.195	362	95	3.81	1.8E-04	
1401 Alamo St	036-270-070	Nov-87	Granitic	168	50-168	50	90	2.5	25	0.100	186	78	2.38	1.1E-04	400
Sunshine Valley Rd & Hawthorne Rd	036-283-190	May-98	Hard Granite	275	20-275	20	57	4.5	183	0.025	46	218	0.21	9.9E-06	1240
Sunshine Valley Rd & Hawthorne Rd	036-283-180	May-98	Hard Granite	150	50-150	20	58	7.1	73	0.097	181	92	1.97	9.3E-05	900
1385 Sunshine Valley Rd	036-285-080	Apr-87	Granitic	100	20-100	20	40	7.5	50	0.150	279	60	4.65	2.2E-04	
Avery St	036-291-160,300,310	Apr-88	Granitic	160	100-160	50	71.5	3	70	0.043	80	89	0.90	4.2E-05	490
Alamo St	036-291-240	Oct-87	Granitic	145	75-145	20	61	10	16	0.625	1163	84	13.84	6.5E-04	520
Alamo 1/4 E of Ivy	036-293-070		Granitic	170	20-170	20	30	5.5	144	0.038	71	140	0.51	2.4E-05	270
Montara Heights															
Audubon Ave Lot 29	036-310-010	Sep-83	Granitic	243	140-240	40	78	17	7	2.429	4517	165	27.38	1.3E-03	
East & 8th St	036-310-040	Apr-86	Granitic	220	80-220	20	80.3	10	70	0.143	266	140	1.90	9.0E-05	
12 East St	036-310-050	Nov-93	Granitic	350	190-350	20	55	12	222	0.054	101	295	0.34	1.6E-05	658
East & 8th St	036-310-090	Jun-89	Granitic	300	80-300	20	65	5	100	0.050	93	235	0.40	1.9E-05	
850 Montana St	036-310-100	Nov-86	Granitic	303	60-300	20	33	3.125	247	0.013	24	270	0.09	4.1E-06	

Notes

Specific capacity (Cs) = Yield (gpm) / Drawdown (ft); a way to evaluate the relative performance of a well, compared with others in the area.

Transmissivity (T) = Hydraulic Conductivity (K) * Saturated Thickness (b). It was calculated from Specific Capacity (Cs) using the equation T = 1860 C (DWR Bulletin No. 118-2, June 1974).

Hydraulic conductivity (K) = T/b, where b is the distance from the summer water level to bottom of the well.

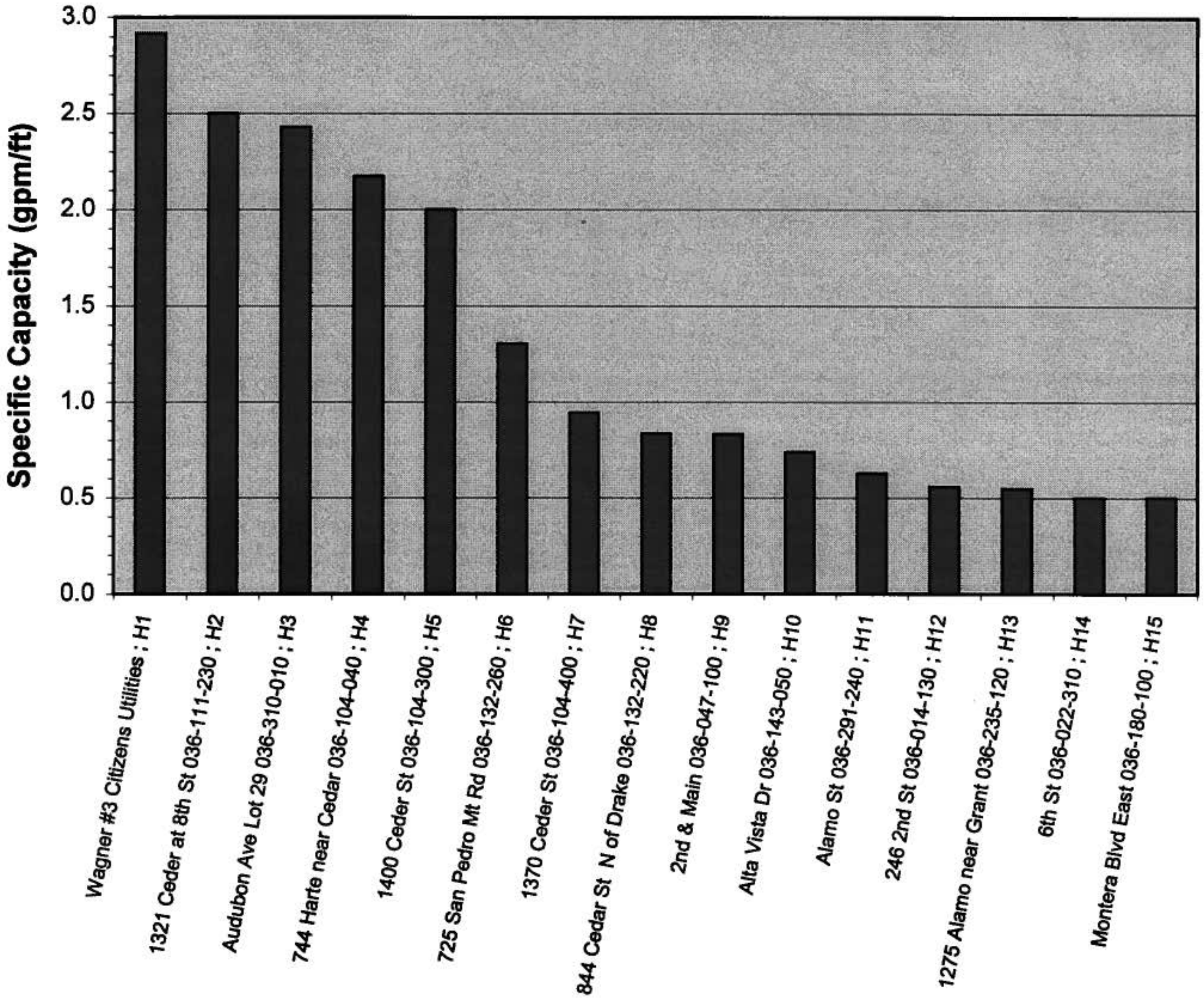
Specific conductance is the electrical conductivity of the water at 25 degrees C, which is related to the salinity of the sample.

Ranking of wells in the Montara area by decreasing performance

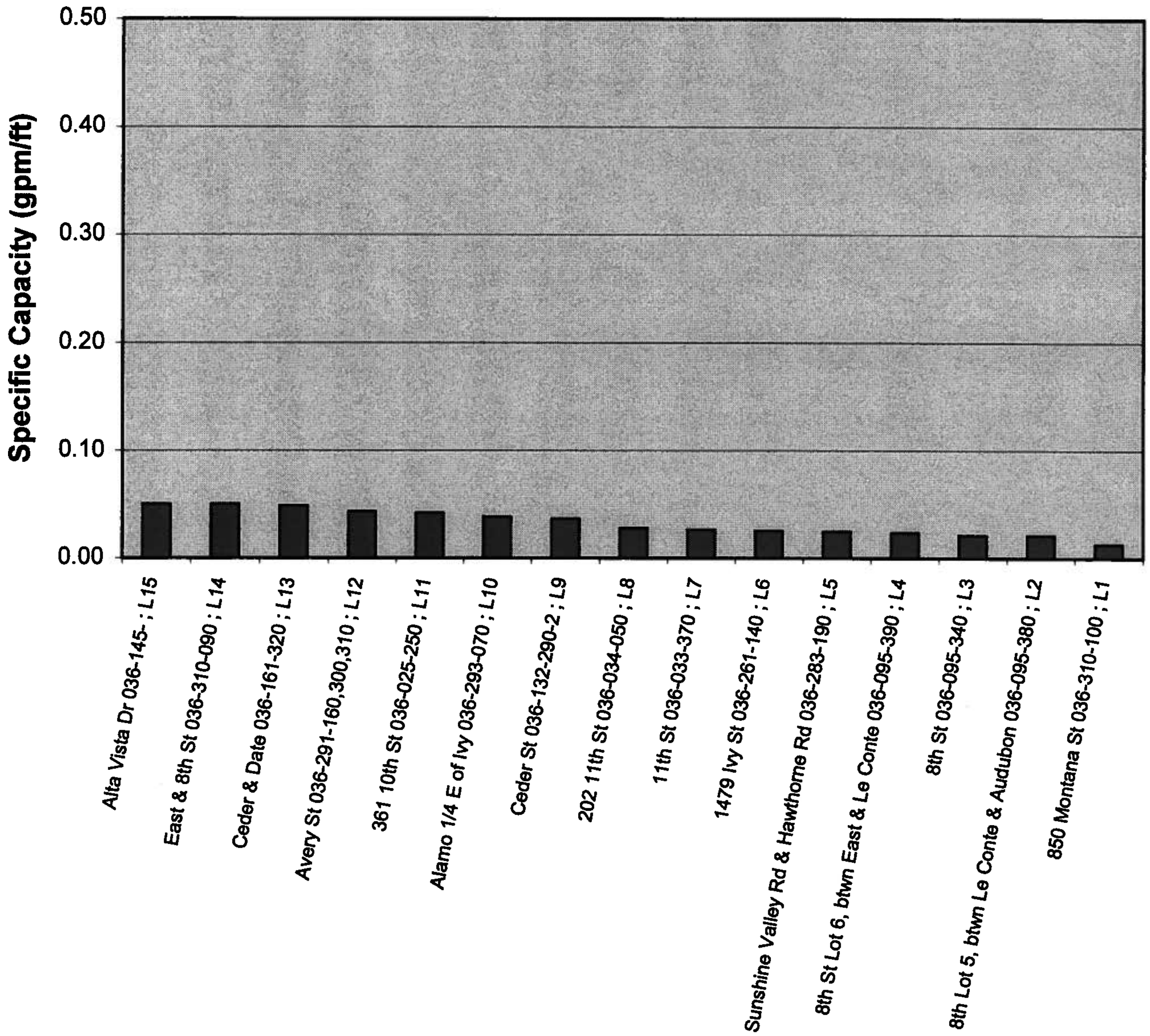
APN	Location	Specific Capacity gpm/ft	Transmissivity gpd/ft	Aquifer Type
Citizens Utilities	Wagner #3	2.92	5425	Montara Creek
036-111-230	1321 Ceder at 8th St	2.50	4650	Montara Creek
036-310-010	Audubon Ave Lot 29	2.43	4517	Montara Heights
036-104-040	744 Harte near Cedar	2.17	4043	Montara Creek
036-104-300	1400 Ceder St	2.00	3720	Montara Creek
036-132-260	725 San Pedro Mt Rd	1.30	2426	Montara Creek
036-104-400	1370 Ceder St	0.94	1755	Montara Creek
036-132-220	844 Cedar St N of Drake	0.83	1550	Montara Creek
036-047-100	2nd & Main	0.83	1545	Lower Montara Terrace
036-143-050	Alta Vista Dr	0.74	1371	Montara Creek
036-291-240	Alamo St	0.63	1163	SW of Alamo Street
036-014-130	246 2nd St	0.56	1033	Lower Montara Terrace
036-235-120	1275 Alamo near Grant	0.55	1015	Montara Creek
036-022-310	6th St	0.50	930	Lower Montara Terrace
036-180-100	Montera Blvd East	0.50	930	Montara Creek
036-021-260	5th St	0.46	858	Lower Montara Terrace
036-126-010	935 Corona St	0.45	845	Upper Montara Terrace
036-123-140	1024 Ceder N of Franklin St	0.45	833	Montara Creek
Citizens Utilities	Park Well	0.43	792	Montara Creek
036-022-290	6th St	0.42	775	Lower Montara Terrace
036-161-190	947 Ceder St btwn Edison & Drake	0.41	754	Montara Creek
036-235-110	1213 Alamo near Grant	0.37	680	Montara Creek
036-058-130	9th St	0.36	672	Lower Montara Terrace
036-021-220	5th St	0.35	653	Lower Montara Terrace
036-175-060	Riviera & Valicitos	0.34	641	Montara Creek
036-173-030	Alta Vista Rd	0.30	558	Montara Creek
036-113-420	1400 Hill St	0.28	520	Montara Creek
036-161-300	Date and Edison	0.28	517	Montara Creek
036-104-	Portola off 6th (at end of street)	0.25	465	Montara Creek
Citizens Utilities	Drake Well	0.25	458	Montara Creek
036-062-140	462 4th St	0.24	440	Lower Montara Terrace
036-175-010	Valicitos Dr	0.23	435	Montara Creek
036-161-160	Ceder St	0.21	397	Montara Creek
036-142-020	Alta Loma St	0.21	395	Montara Creek
036-262-070	Alamo & Avery	0.19	362	SW of Alamo Street
036-102-240	1392 Birch St (at end of street)	0.19	358	Upper Montara Terrace
036-053-090,100,110	1401 Main St	0.16	299	Lower Montara Terrace
036-095-230	8th St	0.16	291	Upper Montara Terrace
036-285-080	1385 Sunshine Valley Rd	0.15	279	SW of Alamo Street
036-163-020	991 Elm St near Edison	0.14	266	Montara Creek
036-310-040	East & 8th St	0.14	266	Montara Heights
036-104-300	1412 Ceder St	0.11	205	Montara Creek
036-095-310	8th St	0.10	192	Upper Montara Terrace
036-252-070	Sunshine Valley Rd	0.10	191	SW of Alamo Street
036-270-070	1401 Alamo St	0.10	186	SW of Alamo Street
036-283-180	Sunshine Valley Rd & Hawthorne Rd	0.10	181	SW of Alamo Street

APN	Location	Specific Capacity gpm/ft	Transmissivity gpd/ft	Aquifer Type
036-034-070,080	12th St	0.07	129	Lower Montara Terrace
036-022-300	320 6th St	0.07	128	Lower Montara Terrace
036-161-	Date near Edison	0.06	116	Montara Creek
036-310-050	12 East St	0.05	101	Montara Heights
036-095-390	8th Lot 7, btwn Le Conte & Audubon	0.05	99	Upper Montara Terrace
036-066-260	5th St	0.05	95	Lower Montara Terrace
036-145-	Alta Vista Dr	0.05	93	Montara Creek
036-310-090	East & 8th St	0.05	93	Montara Heights
036-161-320	Ceder & Date	0.05	89	Montara Creek
036-291-160,300,310	Avery St	0.04	80	SW of Alamo Street
036-025-250	361 10th St	0.04	78	Lower Montara Terrace
036-293-070	Alamo 1/4 E of Ivy	0.04	71	SW of Alamo Street
036-132-290-2	Ceder St	0.04	67	Montara Creek
036-034-050	202 11th St	0.03	51	Lower Montara Terrace
036-033-370	11th St	0.03	48	Lower Montara Terrace
036-261-140	1479 Ivy St	0.03	47	SW of Alamo Street
036-283-190	Sunshine Valley Rd & Hawthorne Rd	0.02	46	SW of Alamo Street
036-095-390	8th St Lot 6, btwn East & Le Conte	0.02	43	Upper Montara Terrace
036-095-340	8th St	0.02	39	Upper Montara Terrace
036-095-380	8th Lot 5, btwn Le Conte & Audubon	0.02	39	Upper Montara Terrace
036-310-100	850 Montana St	0.01	24	Montara Heights
036-102-220	1292 Birch St near 8th St			Upper Montara Terrace
036-320-090	1162 Tamarind St			Upper Montara Terrace
036-104-410	1380 Cedar St			Montara Creek
036-151-130	Date and Edison			Montara Creek
036-152-210	Franklin E of Date			Montara Creek
036-161-290	861 Edison St			Montara Creek
036-161-410	905 Cedar St			Montara Creek
Citizens Utilities	Portola I			Montara Creek
Citizens Utilities	Portola II			Montara Creek
Citizens Utilities	Portola III			Montara Creek
Citizens Utilities	Portola IV			Montara Creek

Wells in the Montara area showing the highest performance.



Wells in the Montarea showing the lowest performance.

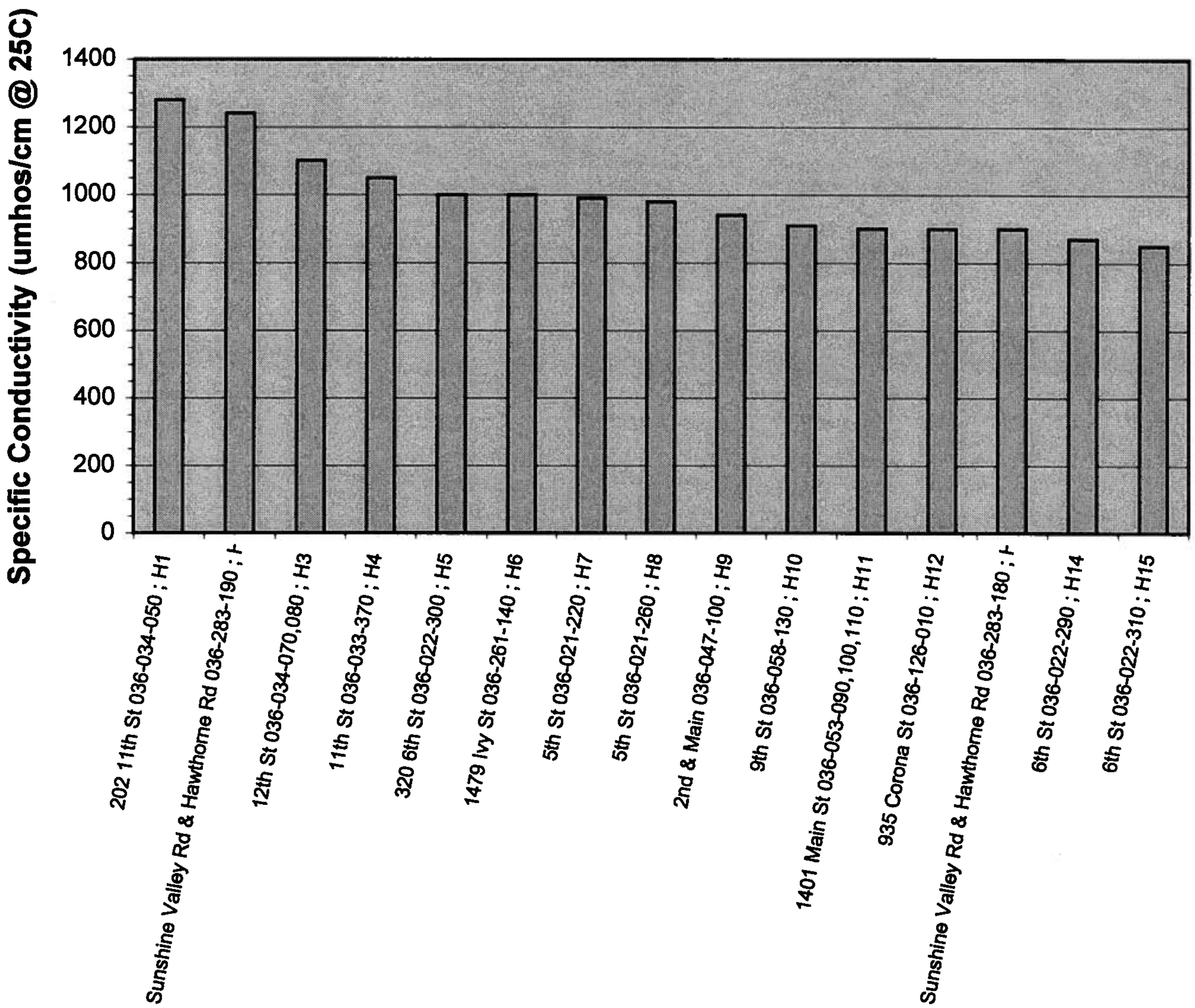


Ranking of wells in the Montara area by decreasing salinity.

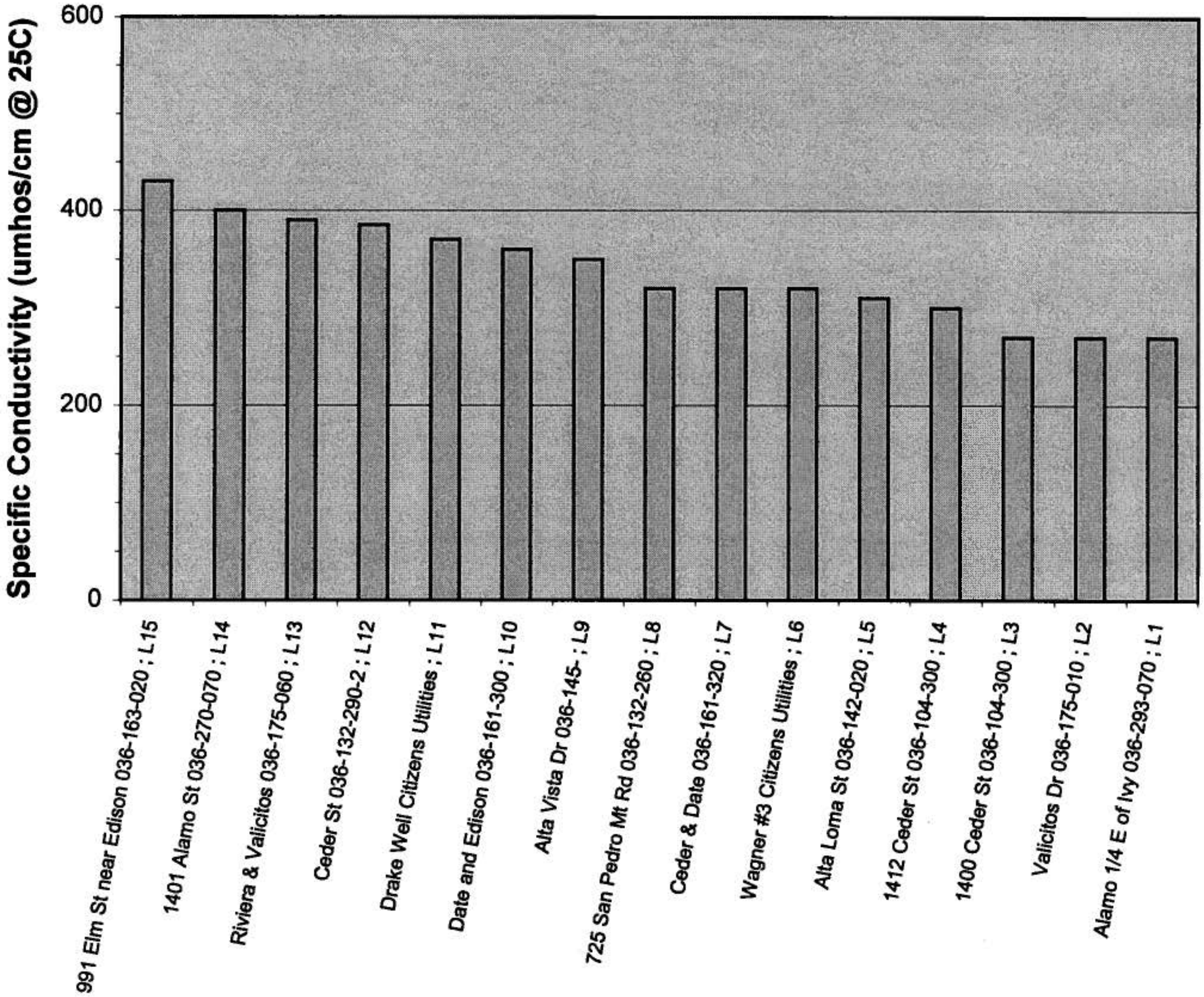
APN	Location	Specific Conductivity umhos/cm @ 25C	Aquifer Type
036-034-050	202 11th St	1280	Lower Montara Terrace
036-283-190	Sunshine Valley Rd & Hawthorne Rd	1240	SW of Alamo Street
036-034-070,080	12th St	1100	Lower Montara Terrace
036-033-370	11th St	1050	Lower Montara Terrace
036-022-300	320 6th St	1000	Lower Montara Terrace
036-261-140	1479 Ivy St	1000	SW of Alamo Street
036-021-220	5th St	990	Lower Montara Terrace
036-021-260	5th St	980	Lower Montara Terrace
036-047-100	2nd & Main	940	Lower Montara Terrace
036-058-130	9th St	910	Lower Montara Terrace
036-053-090,100,110	1401 Main St	900	Lower Montara Terrace
036-126-010	935 Corona St	900	Upper Montara Terrace
036-283-180	Sunshine Valley Rd & Hawthorne Rd	900	SW of Alamo Street
036-022-290	6th St	870	Lower Montara Terrace
036-022-310	6th St	850	Lower Montara Terrace
036-111-230	1321 Ceder at 8th St	780	Montara Creek
036-143-050	Alta Vista Dr	770	Montara Creek
036-104-040	744 Harte near Cedar	720	Montara Creek
036-066-260	5th St	710	Lower Montara Terrace
036-102-240	1392 Birch St (at end of street)	690	Upper Montara Terrace
036-014-130	246 2nd St	670	Lower Montara Terrace
036-310-050	12 East St	658	Montara Heights
036-113-420	1400 Hill St	650	Montara Creek
036-095-230	8th St	620	Upper Montara Terrace
Citizens Utilities	Park Well	620	Montara Creek
Citizens Utilities	Portola III	600	Montara Creek
036-062-140	462 4th St	590	Lower Montara Terrace
Citizens Utilities	Portola IV	590	Montara Creek
036-123-140	1024 Ceder N of Franklin St	570	Montara Creek
036-161-	Date near Edison	560	Montara Creek
036-252-070	Sunshine Valley Rd	520	SW of Alamo Street
036-291-240	Alamo St	520	SW of Alamo Street
036-102-220	1292 Birch St near 8th St	500	Upper Montara Terrace
036-161-290	861 Edison St	490	Montara Creek
036-291-160,300,310	Avery St	490	SW of Alamo Street
036-104-	Portola off 6th (at end of street)	470	Montara Creek
036-161-160	Ceder St	460	Montara Creek
036-163-020	991 Elm St near Edison	430	Montara Creek
036-270-070	1401 Alamo St	400	SW of Alamo Street
036-175-060	Riviera & Valicitos	390	Montara Creek
036-132-290-2	Ceder St	385	Montara Creek
Citizens Utilities	Drake Well	370	Montara Creek
036-161-300	Date and Edison	360	Montara Creek
036-145-	Alta Vista Dr	350	Montara Creek
036-132-260	725 San Pedro Mt Rd	320	Montara Creek
036-161-320	Ceder & Date	320	Montara Creek
Citizens Utilities	Wagner #3	320	Montara Creek
036-142-020	Alta Loma St	310	Montara Creek

APN	Location	Specific Conductivity umhos/cm @ 25C	Aquifer Type
036-104-300	1412 Ceder St	300	Montara Creek
036-104-300	1400 Ceder St	270	Montara Creek
036-175-010	Valicitos Dr	270	Montara Creek
036-293-070	Alamo 1/4 E of Ivy	270	SW of Alamo Street
036-180-100	Montera Blvd East		Montara Creek
036-235-110	1213 Alamo near Grant		Montara Creek
036-235-120	1275 Alamo near Grant		Montara Creek
036-025-250	361 10th St		Lower Montara Terrace
036-095-310	8th St		Upper Montara Terrace
036-095-340	8th St		Upper Montara Terrace
036-095-380	8th Lot 5, btwn Le Conte & Audubon		Upper Montara Terrace
036-095-390	8th Lot 7, btwn Le Conte & Audubon		Upper Montara Terrace
036-095-390	8th St Lot 6, btwn East & Le Conte		Upper Montara Terrace
036-320-090	1162 Tamarind St		Upper Montara Terrace
036-104-400	1370 Ceder St		Montara Creek
036-104-410	1380 Cedar St		Montara Creek
036-132-220	844 Cedar St N of Drake		Montara Creek
036-151-130	Date and Edison		Montara Creek
036-152-210	Franklin E of Date		Montara Creek
036-161-190	947 Ceder St btwn Edison & Drake		Montara Creek
036-161-410	905 Cedar St		Montara Creek
036-173-030	Alta Vista Rd		Montara Creek
Citizens Utilities	Portola I		Montara Creek
Citizens Utilities	Portola II		Montara Creek
036-262-070	Alamo & Avery		SW of Alamo Street
036-285-080	1385 Sunshine Valley Rd		SW of Alamo Street
036-310-010	Audubon Ave Lot 29		Montara Heights
036-310-040	East & 8th St		Montara Heights
036-310-090	East & 8th St		Montara Heights
036-310-100	850 Montana St		Montara Heights

Well in the Montara area showing highest salinity.



Wells in the Montara area showing lowest salinity.



Appendix C.

Watershed Information from Caltrans

900 Modoc St, Berkeley, CA, 94707-2208
Phone 510-527-0727: Fax 510-527-8531

To	From
Co.	Co.
Dept.	Phone #
Fax #	Fax #

4-SM-1 PM 34.0/41.0
4-210-120771
From Half Moon Bay
Airport to Linda Mar
Boulevard in Pacifica

LOCATION HYDRAULIC STUDY

for

ENVIRONMENTAL IMPACT STATEMENT

Devil's Slide Bypass

CALTRANS DISTRICT 4

HYDRAULICS SECTION

November 1983

Report Prepared By: Paul B. Wisney
Assistant Transportation Engineer
Hydraulics

Under the Supervision of: Hanley T. D. Fong
Associate Transportation Engineer
Hydraulics

B. SAN VICENTE CREEK WATERSHED Adopted Route - Sta 200+50 to 223+00±

1. DESCRIPTION OF SHED

The San Vicente Creek watershed, covering 1,079 acres sits on the southerly slope of the Montara Range with its peak at about 1,850 feet above sea level. It is 14,000 feet long and is 1,400 feet at its narrowest to 5,000 feet at its widest. The upper half of the shed is quite rugged and is fairly steep, while the lower half is relatively flat.

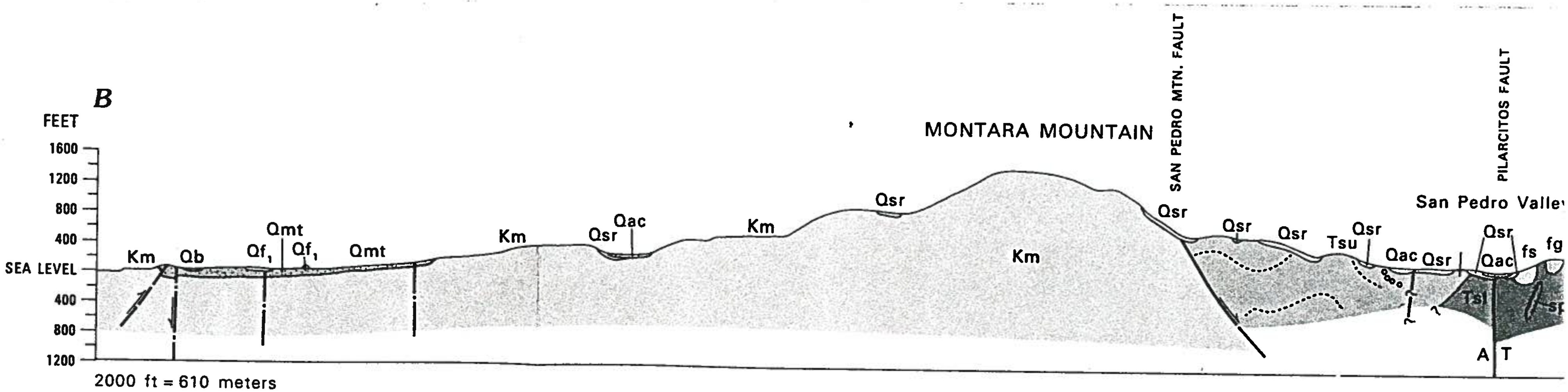
2. EXISTING DRAINAGE (EXHIBIT A)

Starting from the Montara Range, runoff collects and flows into three watercourses that carry the runoff to the valley. The southerly and middle branches form their confluence about 11,000 feet upstream of Route 1. The northerly branch joins the system 1,500 feet downstream before the watercourse flows into the long narrower valley corridor towards Etheldore Street.

The main channel of this perennial stream generally flows along the northerly side of the valley floor until it crosses the access structure to the Buttle Stable. Thereafter, it meanders towards and hugs the southerly side of the valley and, finally, flows toward the Etheldore Street culvert which is in the middle of the valley floor. Flooding of the flood plain below the Buttle Stable access road usually occurs during the rainy season according to a personnel of the Buttle Stables. A 100 year flow through that area would cover about 150 feet of a 225± feet flood plain with about 2 feet of water and about 6 feet at the main channel. The heavy 1982 and 1983 storms have cause flooding of the stable. The extremely congested main channel due to debris and overgrowth probably exacerbated the effect by limiting the ability of the water to flow downstream quickly. At the Adopted Route area, a 100 year flow would cause water to flow about 2 feet in depth and cover about one half of the 220± feet wide flood plain with about 6 feet depth at the main channel.

The USGS Flood Prone Map of 1971 (Reference 11) showed inundation of the entire flood plain. However, the Flood Insurance Study of 1982 (Reference 26) showed a narrower area flooded in contrast to our preliminary calculation. More detail investigation is needed to establish the 100 year flow water level.

Source: Pampeyan 1994.



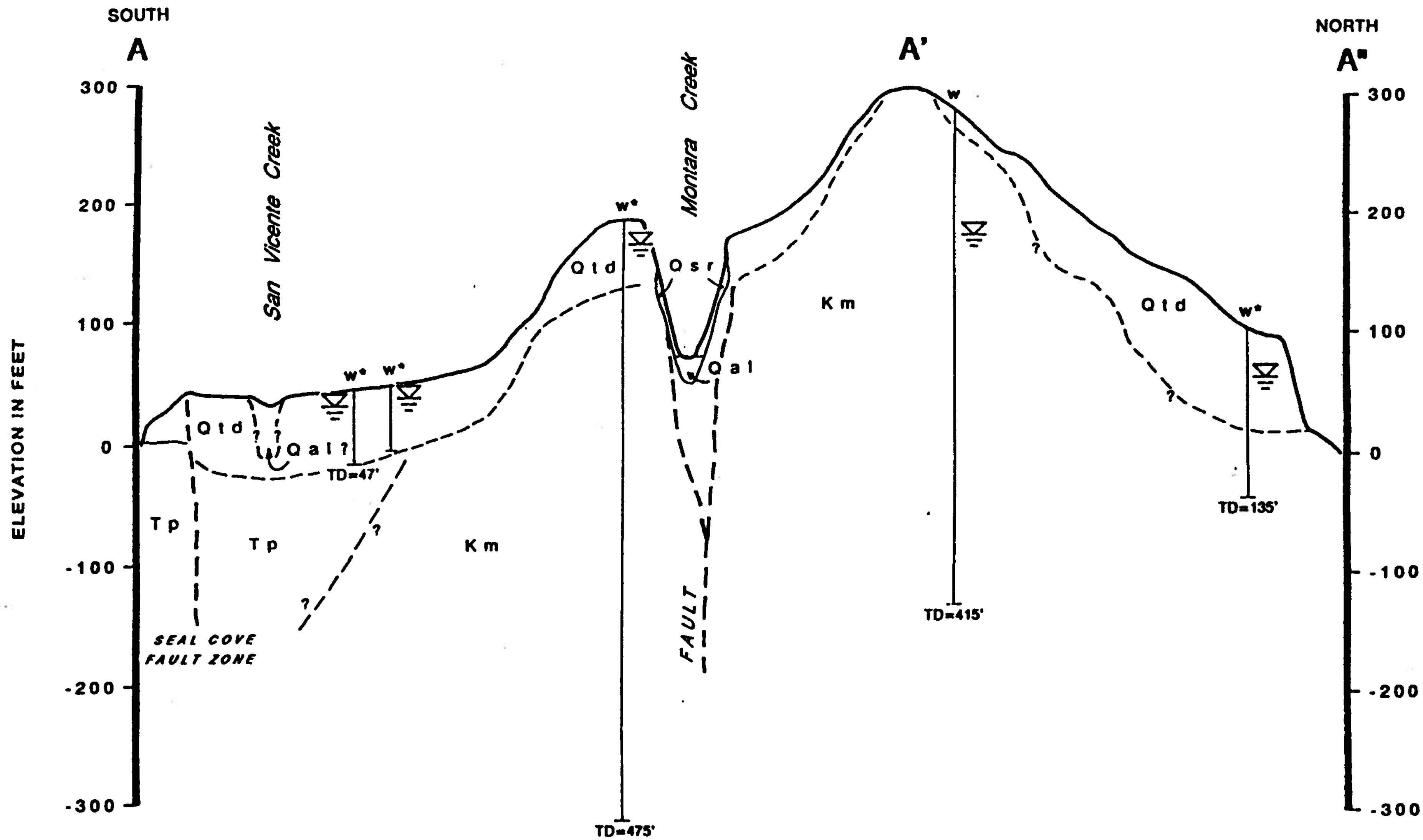


Figure 8. Hydrogeologic Section A - A' - A"; Moss Beach to Montara

Qsr	Slope and Ravine Deposits
Qal	Alluvium
Qtd	Marine Terrace Deposits
Tp	Purisima Formation
Km	Montara Quartz Diorite
▽	Static Water Level Recorded on Driller's Log
	w = well; b = boring; * = projected onto section

See Figure 5 (Geologic Map) for detailed description of units.

1000 feet
100 feet
10X Vertical Exaggeration

At Etheldore Street a partly silted triple 30 inch corrugated steel pipe culvert conveys the flow to two 48 inch reinforced concrete pipes under the State highway. Since the triple 30 inch culverts can only handle about 90 cubic feet per second (cfs) with a free outfall condition, 987 cfs, the excess of the 100 year flow, would overflow the Etheldore Street culverts and the Route 1 double 48 inch culverts. Flooding downstream of Route 1 occurs due to inadequate culverts there.

3. PROPOSED ADOPTED ROUTE

The proposed Adopted Route traverses this watershed about 2,500 feet to the east of Route 1. Here, 957 acres will generate runoff that needs to pass under the highway grade. The structure to pass this runoff will be designed to maintain upstream water depth for the 100 year storm so that the water surface is raised a maximum of 1 foot. Some erosion control system will be placed at the outfall to reduce erosive velocity when it is determined necessary during design. Possible structures to be studied will include reinforced concrete boxes, arches, and bridges.

D. MONTARA CREEK WATERSHED Adopted Route Sta 236+00 to 280+00±

1. DESCRIPTION OF SHED

The Montara Creek Watershed is a 1,025± acres rectangularly shaped basin about 15,000 feet long by about 3,000 feet wide. The northern half of the shed which begins at an elevation of 1,898 feet at North Peak includes the highest peaks and the southern slopes of the Montara Range. The central area contains the eastern edge of the Town of Montara and the flat farm land bordered by moderately sloping hills. The southern portion contains the valley corridor which is situated between the Towns of Moss Beach and Montara to the area along the existing Highway.

2. EXISTING DRAINAGE (EXHIBIT A)

Montara Creek, with its headwaters in the Montara Range, flows basically in a south-west direction about 3 miles to its outlet at the ocean.

The northern section is a rugged mountain watercourse with slopes up to 50%. The watercourse then flattens and collects runoff from the flat agricultural lands bordered by steep side slopes.

Near the eastern section of Montara the watercourse winds through a broad agricultural area collecting runoff from these farms and the storm drains and ditches of the city. About 600 feet upstream of the George Street Bridge is an approximately 15 foot high dam which stores water for irrigational use.

Between the dam and George Street the watercourse is extremely congested with debris and brush. The 6 foot diameter culvert at George Street is over half filled with silt and when clean can pass only about 300 cfs of the estimated 100 year peak flow of about 902 cfs. During the 1982/83 storm, a dam above Hermosa Avenue failed and caused the silt burden to move downstream (Reference 35).

The amount of silt appears to increase downstream from George Street. At the Harte Street crossing, the apparent double 66 inch culverts are virtually filled with silt leaving only about an inch high opening. Almost any runoff would overflow and flood Harte Street and its surrounding areas before returning to the watercourse downstream. Inspections made along the watercourse at various locations showed that the heavy silt burden has moved downstream beyond Harte Street.

The residential areas east of Cedar Street in Montara drains in a generally southerly direction through a series of pipes and ditches with the majority of the runoff entering Montara Creek near Harte Street.
1,000 feet downstream from Harte Street the watercourse turns west and flows through a corridor which has 2 1/2:1 sides slopes. It collects runoff from the grassy fields south of Montara and the tree covered area bordering the creek.

Montara Creek flows under the existing State Route 1 through a 60 inch reinforced concrete pipe culvert at mile post 35.89, and then discharges into the ocean.

The Federal Emergency Management Agency (FEMA) draft Flood Insurance Study shows the area bordering Montara Creek from about 3,000 feet upstream of the George Street Bridge to the ocean as a 100 year flood zone (Reference 26). Their report states that some residential area affected by the flooding at Harte Street, and that the State Highway embankment forms a dam resulting in deep flooding, but affecting no structures.

G. MARTINI CREEK WATERSHED

Adopted Route-Sta 309+00 to 347+00±

Martini Creek Alignment

Sta 295+00 to 347+00±

1. DESCRIPTION OF SHED

The Martini Creek watershed is a leaf shaped shed covering about 640 acres of the western slopes of the Montara Range. It is about 9,000 feet long and between 2,000 and 4,000 feet wide with mostly rugged, highly vegetated, mountainous terrain.

A divide that runs westerly from the Montara Range near Peak Mountain to the location of the proposed routes separates the shed into two general areas.

The southerly portion is long and narrow and contains about one-fourth of the shed area. The upper portion is broad and typically leaf shaped with a valley through the middle. The hills and valleys on the lower half appears to be folded since they are aligned about 45 to 90 degrees to the creek and almost parallel to the existing highway.

$Q_{100} = \frac{1000}{640} = 1.56$ cfs/ac

2. EXISTING DRAINAGE (EXHIBIT A)

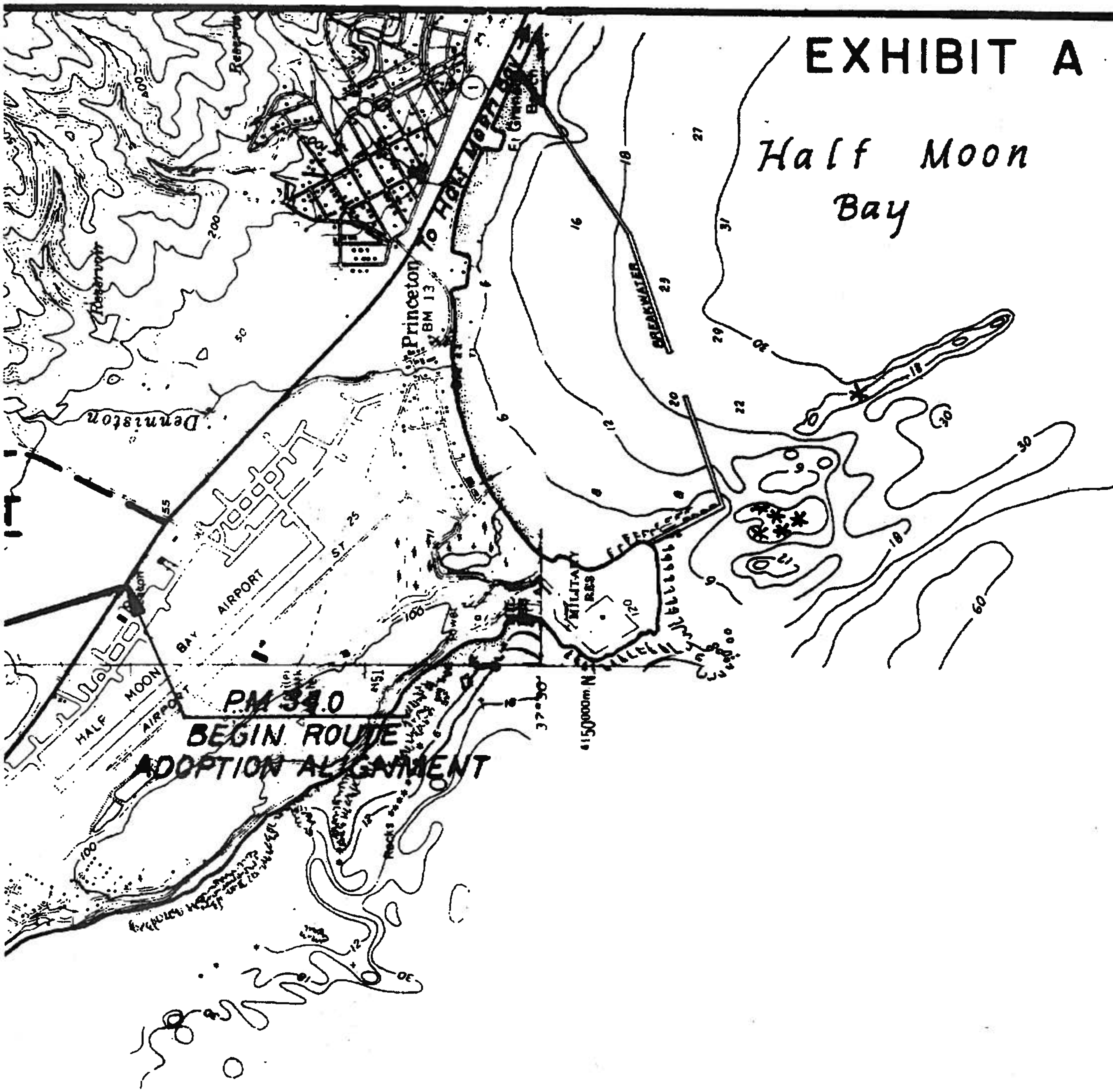
Within the narrow southerly portion of the watershed, a watercourse delivers the runoff westerly from the mountains toward the narrow flat flood plain area which extends to existing Route 1. About 2,800 feet upstream of Route 1, the watercourse is joined by the major watercourses of the northern portion. Runoff from 3 other subsheds in the lower half of the northerly portion of the shed and 2 subsheds from the southerly portion contributes discharge to the watercourse as the flow makes its way to existing Route 1. The watercourse is well defined and highly vegetated on the banks. About 450 feet upstream of Route 1 a small concrete dam with a 3 feet by 2.5 feet rectangular opening through its wall, retards low flows in its 1/4 acre-foot pond. Flows greater than 110 cfs would overtop the structure.

At Route 1, the newly placed 84 inch reinforced concrete pipe will allow ponding up to about elevation 40 feet for the 100 year flow of 1000 cfs.

3. PROPOSED ADOPTED ROUTE, IMPACT AND MITIGATION

As conceived, the Adopted Route traverses the

EXHIBIT A



MAJOR WATERSHEDS & DEVILS SLIDE BYPASS ALTERNATIVES

Scale: 1:24,000

0 1 2

Scale in Statute Miles

04-SM-1 04210 120771


SAN VICENTE
CREEK
MONTARA
CREEK
DEAN
CREEK
AIRPO
CULTI
VATED
ROUTE
MONTARA
TOWN
MARTINI
CREEK
CREEK
MONTARA
Moss Beach
Montara Beach
PM 36.5
BEGIN MARTINI
CREEK ALIGNMENT
32'30"
Point Montara
Lighthouse
POINT MONTARA
LIGHT STATION
380 000
FEET
i f i c
O c e a n

TABLE OF CONTENTS

Appendix D.

Rainfall, Runoff and Evapotranspiration Data

900 Modoc St, Berkeley, CA, 94707-2208
Phone 510-527-0727: Fax 510-527-8531

Monthly total rainfall at Half Moon Bay, CA
Latitude N37:28:00, Longitude W122:27:00, Elevation 11 ft.

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1948										0.00	0.00	0.04	
1949	0.55	0.66	4.99	1.73	3.91	4.96	0.00	0.41	0.00	0.00	0.17		
1950	0.00				2.24	1.34	2.12	0.37	0.14	0.00	0.00	0.08	
1951	1.95	5.46	6.01	5.11	2.98	2.84	0.91	0.98	0.17	0.12	0.00	0.28	26.81
1952	1.16	4.15	11.30	9.31	2.20	6.21	0.62	0.45	1.14	0.03	0.00	0.15	36.72
1953	0.27	2.66	11.36	4.55			3.17	0.60	0.56	0.00	0.53	0.12	
1954	0.67	3.33	1.04	4.18	2.58	5.03	1.49	0.06	0.64	0.10	0.55	0.08	19.75
1955	0.23	1.96	4.53	5.06	1.37	0.28	2.50	0.36	0.07	0.17	0.12	0.28	16.93
1956	0.21	2.32	13.81	11.38	2.81	0.00	1.88	1.37	0.07	0.25	0.45	0.45	35.00
1957	1.75	0.00	0.57	3.31	4.42	5.98	1.65	4.10	0.08	0.00	0.08	1.08	23.02
1958	3.17	1.78	3.88	6.23	10.79	9.38	5.83	0.68	0.71	0.38	0.00	0.18	43.01
1959	0.27	0.50	1.89	5.07	5.64	0.64	0.42	0.36	0.00	0.00	0.21	3.66	18.66
1960	0.40	0.00	1.97	5.29	4.66	1.90	1.27	0.71	0.00	0.00	0.00	0.00	16.20
1961	0.88	5.12	1.70	2.98	1.89	3.25	1.06	1.73	0.22	0.00	0.10	0.57	19.50
1962	0.12	3.66	3.18	2.09	8.64	3.52	0.82	0.24	0.00	0.00	0.29	0.51	23.07
1963	10.97	0.60	3.57	3.44	3.65	4.33	5.08	0.64	0.00	0.00	0.03	0.09	32.40
1964	2.48	4.00	1.04	5.32	0.52	2.46	0.23	0.47	0.58	0.00	0.00	0.00	17.10
1965	1.89	3.11	7.50	4.41	1.40	1.58	5.22	0.00	0.06	0.00	0.23	0.00	25.40
1966	0.00	5.58	4.96	3.77	3.51	0.68	0.71	0.20	0.00	0.12	0.27	0.25	20.05
1967	0.00	5.18	3.62	10.44	0.25	6.18	7.43	0.25	1.44	0.00	0.00	0.00	34.79
1968	0.76	2.13	2.89	6.19	2.62	5.78	0.61	0.24	0.00	0.00	0.28	0.00	21.50
1969	0.65	2.69	5.90	8.06	8.68	2.07	2.76	0.06	0.40	0.00	0.00	0.21	31.48
1970	1.73	0.76	4.55	8.49	2.31	2.04	0.32	0.27	0.21	0.00	0.00	0.00	20.68
1971	0.90	8.41	7.67	1.61	0.76	3.49	1.51	0.53	0.08	0.28	0.36	0.40	26.00
1972	0.23	2.29	5.10	1.27	1.33	0.19	1.25	0.11	0.28	0.00	0.00	0.98	13.03
1973	6.90	6.49	3.17	8.78	7.33		0.23	0.21	0.05	0.00	0.09	0.62	
1974	3.04	9.50	6.32	4.87	2.16	7.20	3.22	0.01	0.50	1.01	0.13	0.00	37.96
1975	1.36	0.64	3.64	2.95	4.88	7.11	2.14	0.10	0.28	0.52	0.59	0.02	24.23
1976	4.49	0.85	0.69	0.52	2.54	1.13	2.04	0.13	0.04	0.14	1.56	0.59	14.72
1977	0.30	1.73	2.41	2.26	1.31	3.15	0.20	1.23	0.00	0.16	0.27	1.59	14.61
1978	0.47	3.37	5.60	9.01	5.62	5.58	4.50	0.00	0.00	0.00	0.00	0.00	34.15
1979	0.05	3.04	0.83	8.11	6.27	4.83	0.89	0.85	0.00	0.29	0.13	0.00	25.29
1980	3.23	3.97	5.76	5.40	7.49	1.90	1.88	0.32	0.03	0.07	0.05	0.18	30.28
1981	0.18	0.65	2.44	7.48	2.42	4.71	0.24	0.33	0.00	0.00	0.42	0.37	19.24
1982	3.98	7.08	6.00	12.01	5.11	7.91	5.02	0.00	0.42	0.00	0.15	1.73	49.41
1983	3.82	7.03	5.41	8.98	9.14	13.05	3.33	0.89	0.03	0.00	0.14	0.80	52.62
1984	1.12	8.07	9.46	0.26	2.15	2.12	1.09	0.20	0.46	0.06	0.33	0.18	25.50
1985	3.81	9.86	3.20	1.02	2.90	5.07	0.13	0.32	0.47	0.31	0.05	0.40	27.54
1986	1.51		3.18	4.98	11.48	7.12	0.50	0.84	0.09	0.08	0.25	2.20	
1987	0.42	0.32	3.10	5.10	3.87	4.16	0.95	0.06	0.08	0.00	0.10	0.00	18.16
1988	2.13	2.63	6.03	4.48	0.58	0.12	3.04	0.69	0.29		0.01	0.02	
1989	0.94	3.55	5.17	2.01	1.30	7.95	1.83	0.31	0.10	0.13	0.27	0.95	24.51
1990	2.05	1.95	0.03	4.29	2.52	1.33	0.29	2.82	0.46	0.24	0.14	0.33	16.45
1991	0.55	0.74	2.58	0.56	4.19	8.81	0.90	0.67	0.32	0.27	0.92	0.25	20.76
1992	2.63	1.01	3.60	3.18	8.70	3.45	0.40	0.06	0.84	0.02	0.18	0.12	24.19
1993	2.88	0.67	8.10	9.21	5.59	2.79	1.68	1.38	0.48	0.06	0.17	0.21	33.22

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1994	0.62	1.55	2.77	2.63	5.61	0.77	1.85	1.64	0.11	0.13	0.17	0.09	17.94
1995	0.08	5.34	3.93	11.38	0.26	8.71	2.35	1.54	0.78	0.05	0.05	0.15	34.62
1996	0.07	0.30	8.25	8.27	7.05	3.34	1.98	2.16	0.13	0.06	0.07	0.20	31.88
1997	1.47	2.71	8.83	9.86	0.29	0.59	0.96	0.44	0.57	0.13	0.77	0.08	26.70
1998	0.77	7.84	3.65	12.13	15.70	2.58	2.73	4.01	0.30	0.18	0.06	0.25	50.20
Mean	1.62	3.18	4.66	5.35	3.96	3.98	1.85	0.66	0.27	0.11	0.21	0.42	26.16
Cumulative	1.62	4.80	9.45	14.81	18.76	22.74	24.59	25.25	25.52	25.63	25.84	26.26	
Maximum	10.97	9.86	13.81	12.01	11.48	13.05	7.43	4.10	1.44	1.01	1.56	3.66	52.62
Minimum	0.00	0.00	0.03	0.26	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.03
Sta. Dev.	2.003	2.614	3.005	3.185	2.886	2.949	1.673	0.784	0.321	0.178	0.284	0.670	9.130
Skew	2.646	0.937	0.971	0.366	0.867	0.791	1.462	2.458	1.615	3.184	2.739	3.103	0.993
Kurtosis	9.511	0.157	0.995	-0.804	0.034	0.452	1.954	7.547	2.928	13.385	9.927	11.574	0.885
Sample Size	49	47	48	48	48	47	49	49	49	49	50	49	43

Return Period	Exceedence Frequency	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
100	1.0%	9.43	10.99	13.71	13.61	12.45	12.50	7.40	3.66	1.37	0.83	1.33	3.14	53.79
50	2.0%	7.72	9.75	12.26	12.50	11.13	11.20	6.41	3.02	1.17	0.66	1.08	2.50	49.35
20	5.0%	5.56	8.04	10.27	10.90	9.29	9.39	5.08	2.21	0.90	0.45	0.77	1.72	43.25
8	12.5%	3.55	6.20	8.13	9.06	7.30	7.40	3.72	1.44	0.63	0.26	0.48	1.01	36.70
4	25.0%	2.16	4.65	6.33	7.38	5.61	5.70	2.65	0.90	0.42	0.14	0.29	0.55	31.22
2	50.0%	0.92	2.78	4.18	5.16	3.55	3.60	1.46	0.40	0.19	0.04	0.11	0.17	24.70
1.33	75.0%	0.33	1.28	2.47	3.11	1.86	1.85	0.63	0.14	0.04	0.00	0.03	0.03	19.51
1.14	87.5%	0.17	0.41	1.49	1.77	0.88	0.80	0.22	0.06	-0.03	0.00	0.01	0.00	16.58
1.05	95.0%	0.13	-0.33	0.66	0.46	0.01	-0.13	-0.08	0.03	-0.08	0.00	0.01	0.00	14.09
1.02	98.0%	0.13	-0.83	0.10	-0.55	-0.58	-0.79	-0.25	0.03	-0.10	-0.01	0.01	-0.01	12.43
1.01	99.0%	0.11	-1.12	-0.21	-1.20	-0.93	-1.17	-0.32	0.03	-0.11	-0.02	0.01	-0.04	11.51

Notes:

Table 1. Continued   Ave ETo

County	City	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
SAN DIEGO	Warner Springs	1.59	2.65	3.66	4.72	5.74	7.56	8.30	7.6[illegible]	6.26	4.03	2.48	1.34
SAN FRANCISCO	San Francisco	1.46	1.32	2.44	2.95	3.66	4.61	4.88	4.76	4.13	2.81	1.30	0.73
SAN JOAQUIN	Farmington	1.46	1.49	2.93	4.72	6.22	7.56	8.06	6.83	5.31	3.30	1.42	0.73
	Lodi	0.85	1.54	2.93	5.08	6.47	6.97	7.69	7.69	5.20	3.05	1.30	0.73
	Manteca	1.46	1.49	2.99	4.72	6.35	7.56	8.06	6.83	5.31	3.30	1.42	0.61
	Stockton	0.79	1.54	2.93	4.72	6.22	7.44	8.06	6.83	5.31	3.23	1.42	0.61
	Tracy	0.98	1.54	2.93	4.49	6.10	7.32	7.93	6.71	5.31	3.17	1.30	0.73
SAN LUIS OBISPO	Arroyo Grande	1.95	2.20	3.17	3.78	4.27	4.72	4.27	4.64	3.78	3.17	2.36	1.71
	Atascadero	1.22	1.54	2.81	3.90	4.52	6.02	6.71	6.22	4.96	3.17	1.65	0.98
	Morro Bay	1.95	2.20	3.11	3.54	4.27	4.49	4.64	4.58	3.84	3.48	2.13	1.71
	Paso Robles	1.59	1.98	3.17	4.25	5.49	6.26	7.32	6.71	5.08	3.66	2.13	1.40
	San Luis Obispo	1.95	2.20	3.17	4.13	4.88	5.31	4.64	5.49	4.37	3.54	2.36	1.71
	San Miguel	1.59	1.98	3.23	4.25	5.00	6.38	7.44	6.83	5.08	3.66	2.13	1.40
	San Simeon	1.95	1.98	2.93	3.54	4.15	4.43	4.58	4.27	3.54	3.05	2.01	1.71
SAN MATEO	Half Moon Bay	1.46	1.65	2.44	2.95	3.91	4.25	4.27	4.15	3.54	2.81	1.30	0.98
	Palo Alto	1.46	1.76	2.81	3.84	5.19	5.31	6.22	5.61	4.96	3.17	1.65	0.98
	Redwood City	1.46	1.76	2.87	3.84	5.19	5.31	6.22	5.61	4.84	3.11	1.65	0.98
SANTA BARBARA	Carpenteria	1.95	2.43	3.17	3.90	4.76	5.20	5.49	5.74	4.49	3.42	2.36	1.95
	Guadalupe	1.95	2.20	3.17	3.66	4.88	4.61	4.52	4.58	4.13	3.30	2.36	1.71
	Los Alamos	1.83	1.98	3.17	4.13	4.88	5.31	5.74	5.49	4.43	3.66	2.36	1.59
	Lompoc	1.95	2.20	3.17	3.66	4.76	4.61	4.88	4.76	3.90	3.17	2.36	1.71

33.7"

Continued

Table 1. Continued

County	City	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
SANTA BARBARA	Santa Barbara	1.95	2.54	3.17	3.78	4.64	5.08	5.49	4.49	3.42	2.36	1.83	1.83
	Santa Maria	1.83	2.20	3.17	4.02	5.00	5.08	5.13	5.13	4.49	3.54	2.36	1.71
	Solvang	1.95	1.98	3.30	4.25	5.00	5.55	6.10	5.61	4.37	3.66	2.24	1.59
SANTA CLARA	Gilroy	1.34	1.76	3.05	4.13	5.25	5.55	6.10	5.49	4.72	3.42	1.65	1.10
	Los Gatos	1.46	1.76	2.81	3.90	5.00	5.61	6.22	5.49	4.72	3.17	1.65	1.10
	San Jose	1.46	1.76	3.05	4.13	5.49	5.79	6.47	5.86	5.20	3.30	1.77	0.98
SANTA CRUZ	Santa Cruz	1.46	1.76	2.56	3.54	4.27	4.37	4.76	4.39	3.78	2.81	1.65	1.22
	Watsonville	1.46	1.76	2.69	3.66	4.64	4.49	4.88	4.15	4.02	2.93	1.77	1.22
SHASTA	Burney	0.73	0.99	2.14	3.54	4.88	5.91	7.44	6.41	4.37	2.93	0.94	0.61
	Fall River Mills	0.61	0.99	2.07	3.66	5.00	6.14	7.81	6.71	4.61	2.81	0.94	0.49
	Glenburn	0.61	0.99	2.07	3.66	5.00	6.26	7.81	6.71	4.72	2.81	0.94	0.5[illegible]
	Redding	1.22	1.43	2.62	4.13	5.61	7.09	8.54	7.32	5.31	3.23	1.42	0.85
SIERRA	Downieville	0.73	0.99	2.26	3.54	5.00	6.02	7.44	6.22	4.72	2.81	0.94	0.61
	Sierraville	0.73	1.10	2.20	3.19	4.52	5.91	7.32	6.35	4.25	2.62	0.94	0.49
SISKIYOU	Happy Camp	0.49	0.88	1.95	2.95	4.27	5.20	6.10	5.25	4.13	2.44	0.94	0.49
	Mt. Shasta	0.49	0.88	1.95	2.95	4.52	5.31	6.71	5.74	4.02	2.20	0.71	0.49
	Tulelake	0.49	0.88	2.07	3.43	5.25	5.91	7.93	6.71	4.37	2.69	0.94	0.49
	Weed	0.49	0.88	1.95	2.48	4.52	5.31	6.71	5.49	3.66	1.95	0.94	0.49
	Yreka	0.61	0.88	2.14	2.95	4.88	5.79	7.32	6.47	4.25	2.50	0.94	0.49
SOLANO	Fairfield	1.10	1.65	2.81	4.02	5.49	6.14	7.81	5.98	4.84	3.05	1.42	0.85
	Rio Vista	0.85	1.65	2.81	4.37	5.86	6.73	7.93	6.47	5.08	3.17	1.30	0.73

Continued

TABLE 2–58. ESTIMATED EVAPOTRANSPIRATION FOR TYPES OF VEGETATION IN THE WESTERN UNITED STATES

Vegetation Type	Annual Evapotranspiration, Inches
Forest:	
Lodgepole pine	19
Engelmann spruce-fir	15
White pine-larch-fir	22
Mixed conifer	22
True fir	24
Aspen	23
Pacific Douglas-fir-hemlock-redwood	30
Interior ponderosa pine	17
Interior Douglas-fir	21
Chaparral and woodland:	
Southern California chaparral	20
California woodland-grass	18
Arizona chaparral	17.5
Piñon-juniper	14.5
Semiarid grass and shrub	10.6
Alpine	20

Source: Select Committee on National Water Resources, U.S. Senate, 1960

TABLE 2–59. CONSUMPTIVE USE IN A MUNICIPAL AREA

[Data for Raymond Basin, Los Angeles County, Calif.]

Cultural Classification	Consumptive Use in Feet	Cultural Classification	Consumptive Use in Feet
Estates	2.07	Reservoir sites	1.34
Class A residential	1.92	Park	2.40
Class B residential	1.88	Schools	1.63
Rural residential	1.78	River wash	0.99
Semicommercial	1.32		

Source: California Department of Water Resources

BLANEY-CRIDDLE CONSUMPTIVE USE FORMULA

The consumptive use of an irrigated crop in which ample water supply is available can be estimated by the Blaney-Criddle formula. For a given month the consumptive use is given by

$$u = k\,(tp) \qquad (1)$$

where u is the monthly consumptive use measured in inches, k is a monthly consumptive use coefficient dependent on the crop and location, t is the mean monthly temperature in degrees Fahrenheit, and p is the monthly percentage of daytime hours of the year.

Because t and p can be found from climatic data at a given location, they are often combined into a monthly consumptive use factor f, so that Equation (1) becomes simply

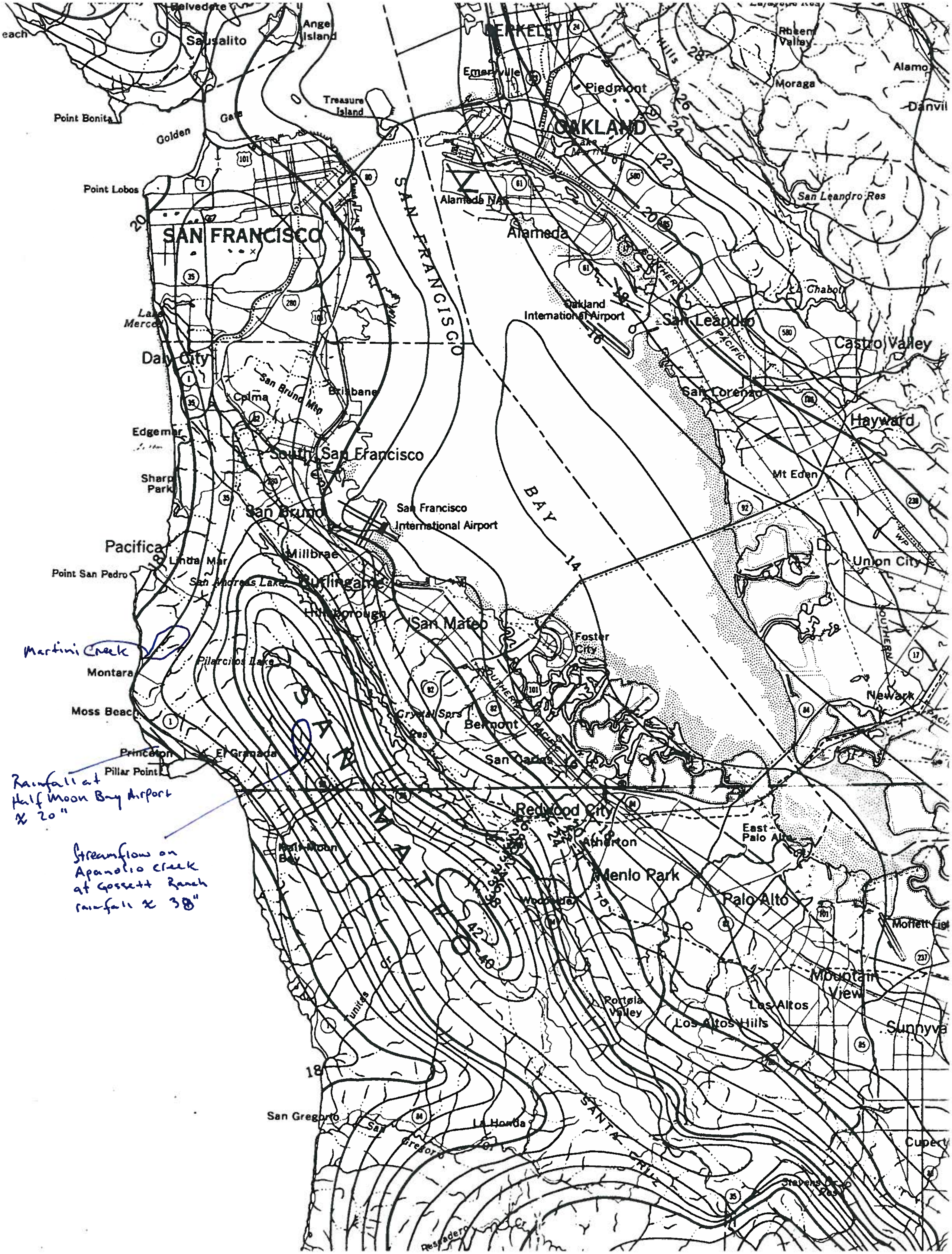
$$u = kf \qquad (2)$$

For an entire growing season the consumptive use is given by

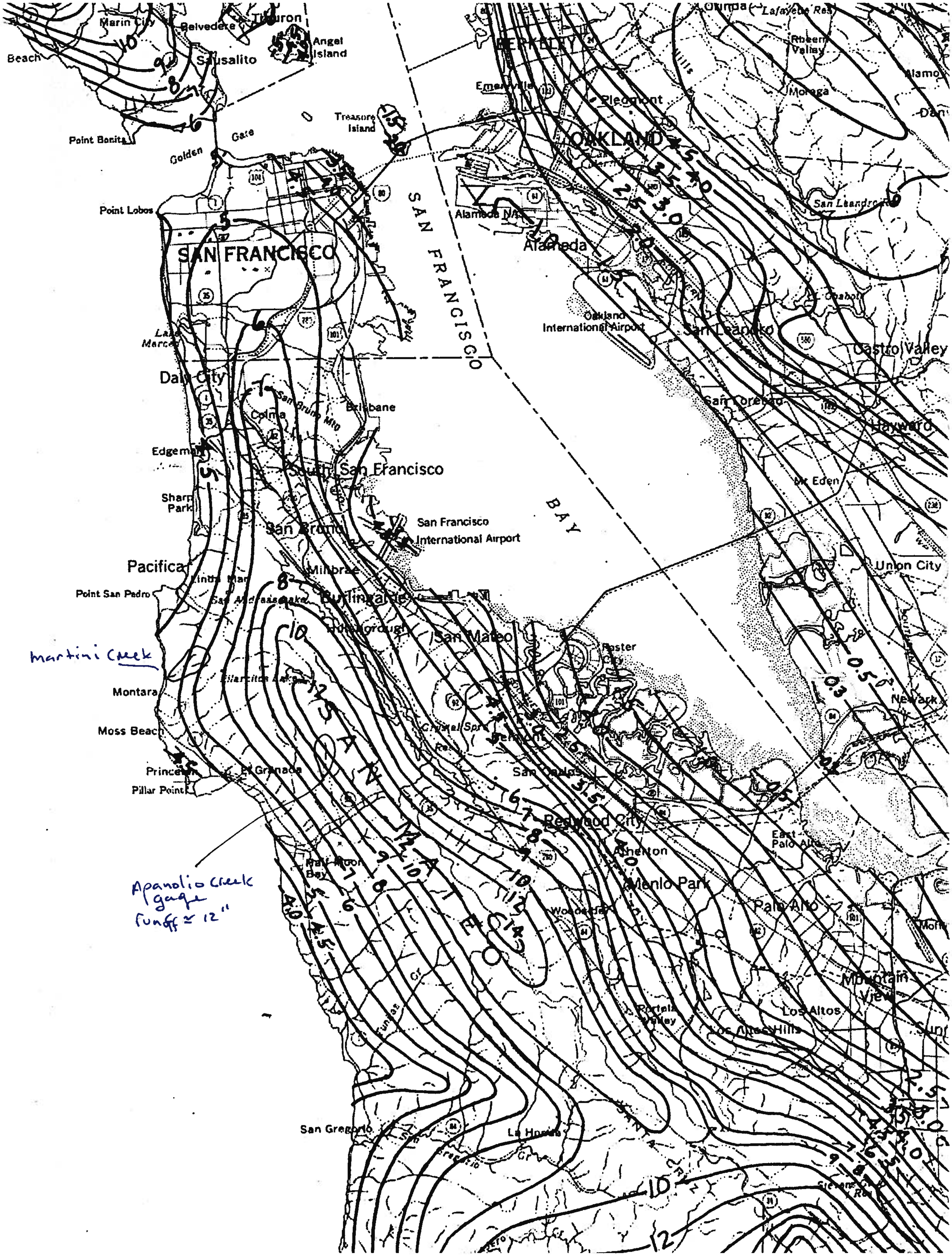
$$U = KF \qquad (3)$$

where U is the seasonal consumptive use measured in inches, K is a seasonal consumptive use coefficient, and F is the sum of the monthly consumptive use factors.

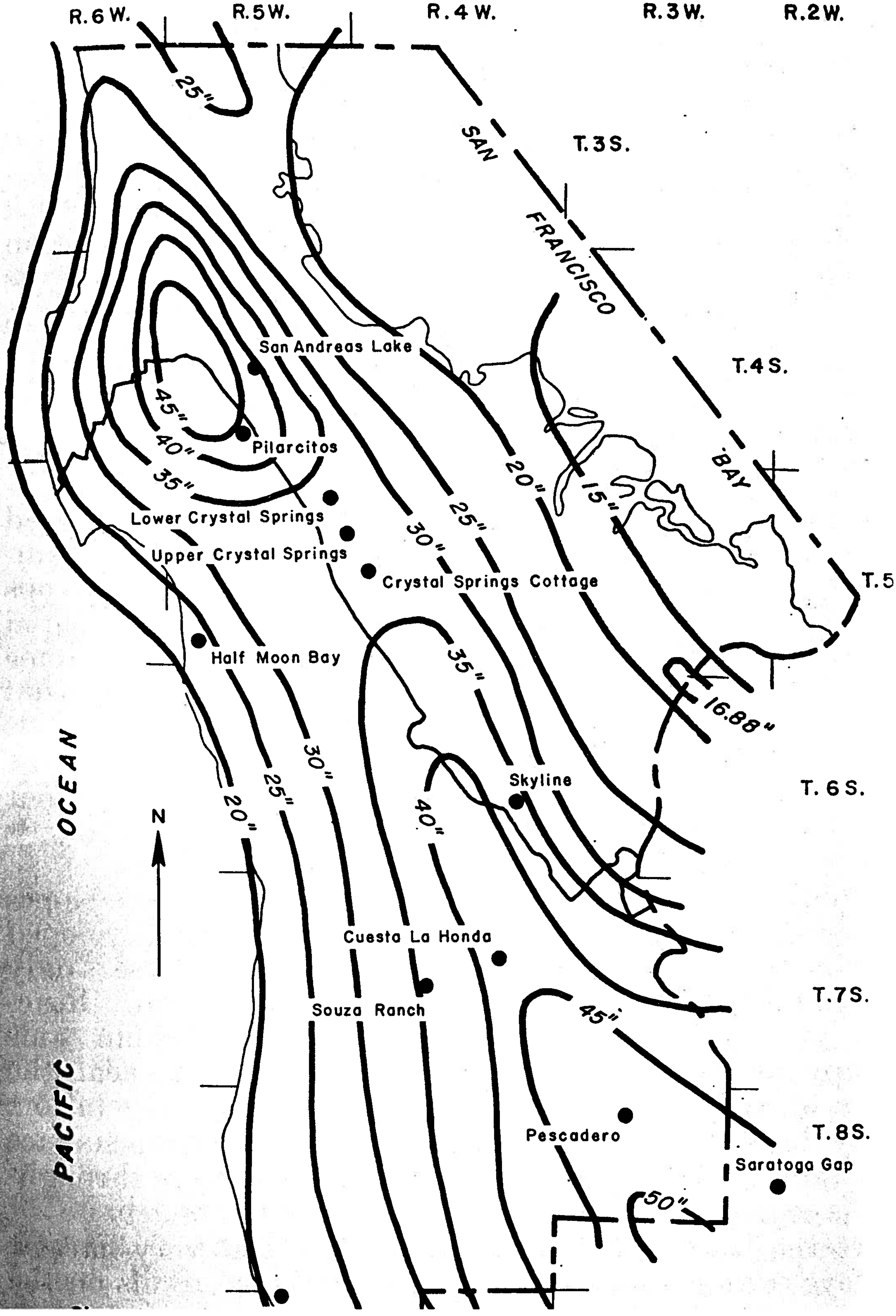
Values for the Western United States of k are given in Table 2–60, K in Table 2–61, p in Table 2–63, and f in Table 2–64.



Martini Creek
Rainfall at Half Moon Bay Airport ≈ 20"
Streamflow on Apanolio Creek at Gossett Ranch rainfall ≈ 38"
SAN FRANCISCO
SAN FRANCISCO BAY
SAN MATEO
OAKLAND
BERKELEY
Sausalito
Belvedere
Angel Island
Treasure Island
Golden Gate
Point Bonita
Point Lobos
Emeryville
Piedmont
Moraga
Alamo
Danville
Alameda NAS
Alameda
San Leandro Res
Chabot
Oakland International Airport
San Leandro
Castro Valley
San Lorenzo
Hayward
Mt Eden
Union City
Newark
Lake Merced
Daly City
San Bruno Mtn
Colma
Brisbane
Edgemar
South San Francisco
Sharp Park
San Bruno
San Francisco International Airport
Pacifica
Linda Mar
Point San Pedro
Millbrae
San Andreas Lake
Burlingame
Hillsborough
San Mateo
Foster City
Montara
Pilarcitos Lake
Moss Beach
Crystal Sprs Res
Belmont
Princeton
Pillar Point
El Granada
San Carlos
Redwood City
Atherton
East Palo Alto
Half Moon Bay
Menlo Park
Palo Alto
Woodside
Moffett Field
Mountain View
Portola Valley
Los Altos
Los Altos Hills
Sunnyvale
San Gregorio
La Honda
Cupertino
Stevens Creek Res
Pescadero Cr
SANTA CRUZ
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42



Marin City
Belvedere
Tiburon
Angel Island
Beach
Sausalito
Point Bonita
Golden Gate
Treasure Island
Point Lobos
SAN FRANCISCO
Emeryville
Piedmont
OAKLAND
Lafayette Res
Rheem Valley
Moraga
Alamo
Alameda NAS
Alameda
Oakland International Airport
San Leandro
Castro Valley
San Lorenzo
Hayward
Mt Eden
Union City
Newark
SAN FRANCISCO BAY
Lake Merced
Daly City
Colma
San Bruno Mtn
Brisbane
South San Francisco
Edgemar
Sharp Park
San Bruno
San Francisco International Airport
Pacifica
Point San Pedro
Millbrae
Burlingame
Hillsborough
San Mateo
Foster City
martini creek
Montara
Moss Beach
Princeton
Pillar Point
El Granada
Belmont
San Carlos
Redwood City
East Palo Alto
Atherton
Menlo Park
Palo Alto
Half Moon Bay
Woodside
Portola Valley
Los Altos Hills
Los Altos
Mountain View
San Gregorio
La Honda
SAN MATEO
Apanolio Creek gage runoff ≈ 12"

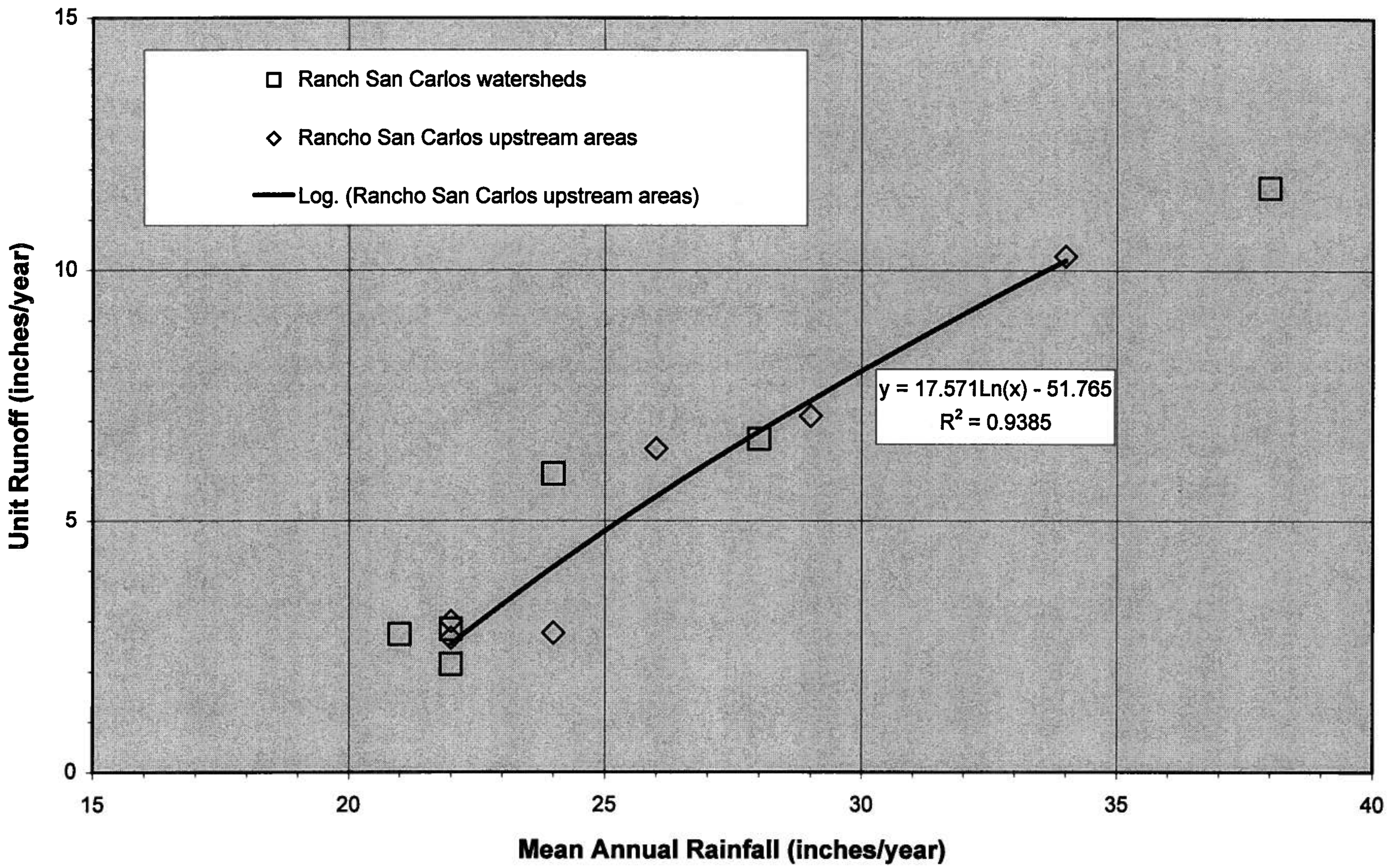


R.6 W.
R.5W.
R.4 W.
R.3W.
R.2W.
T.3S.
T.4S.
T.5
T. 6S.
T.7S.
T. 8S.
SAN FRANCISCO BAY
PACIFIC OCEAN
N
25"
45"
40"
35"
20"
15"
25"
30"
35"
16.88"
20"
25"
30"
40"
45"
50"
San Andreas Lake
Pilarcitos
Lower Crystal Springs
Upper Crystal Springs
Crystal Springs Cottage
Half Moon Bay
Skyline
Cuesta La Honda
Souza Ranch
Pescadero
Saratoga Gap

Streamflow concentrations in basins similar to Montara Mountain watersheds.

Watershed	Area	Rainfall		Streamflow	
	acres	inches/year	ac-ft/year	inches/year	ac-ft/year/sq.mi.
Ranch San Carlos watersheds					
Hitchcock Canyon	2800	22	500	2.1	114
Las Garzas Creek	8500	28	4700	6.6	354
Potrero Canyon	3800	22	900	2.8	152
Pobinson Canyon	3500	21	800	2.7	146
San Clemente Creek	10200	38	9900	11.6	621
San Jose Creek	9100	24	4500	5.9	316
Total	37900	28	21300	6.7	360
Rancho San Carlos upstream areas					
Hitchcock Canyon	1300	24	300	2.8	148
Las Garzas Creek	7100	29	4200	7.1	379
Potrero Canyon	3600	22	900	3.0	160
Pobinson Canyon	2700	22	600	2.7	142
San Clemente Creek	3500	34	3000	10.3	549
San Jose Creek	5400	26	2900	6.4	344
Total	23600	27	11900	6.1	323

Rainfall/Runoff Relation, Rancho San Carlos, near Carmel, CA



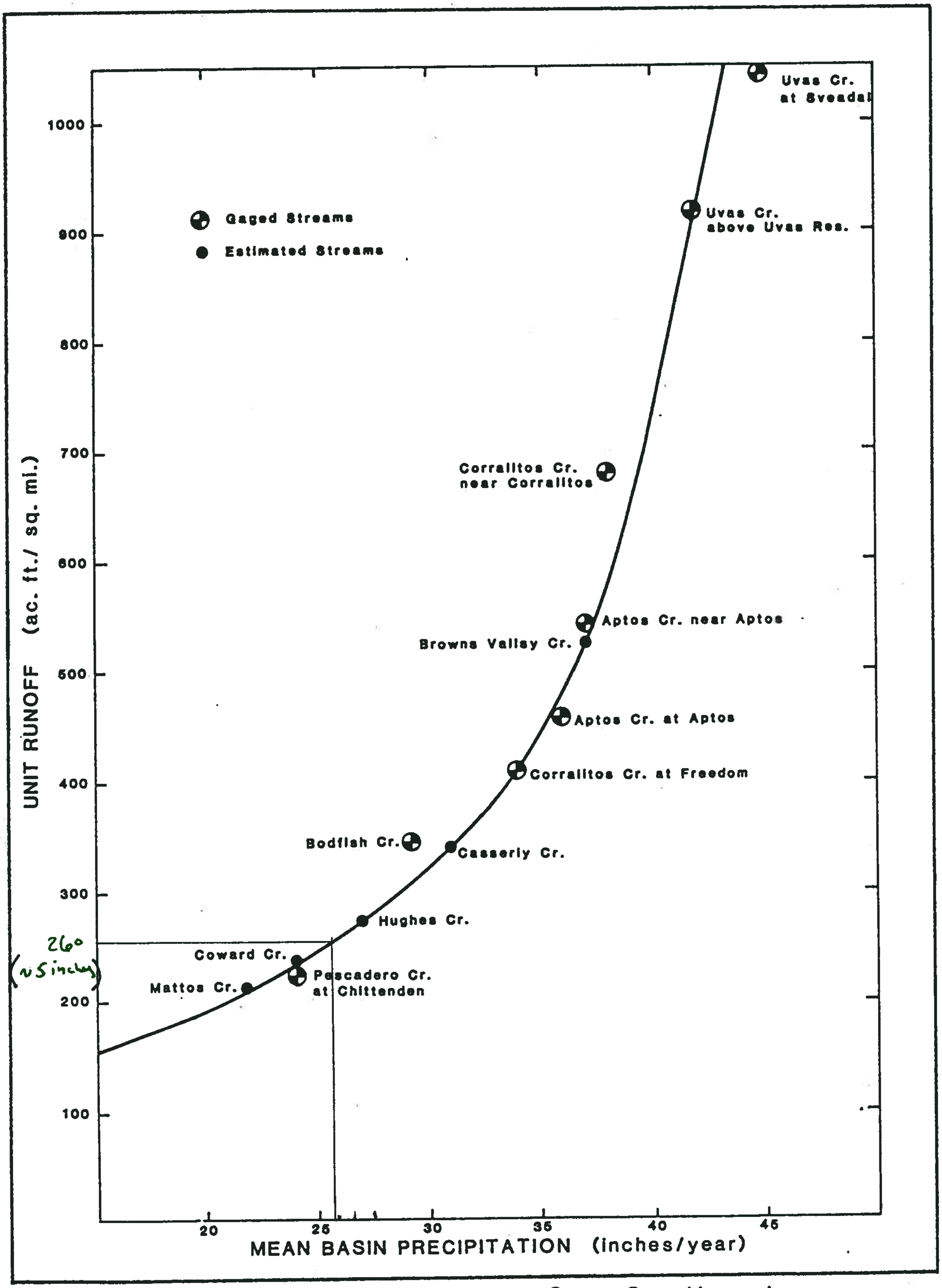
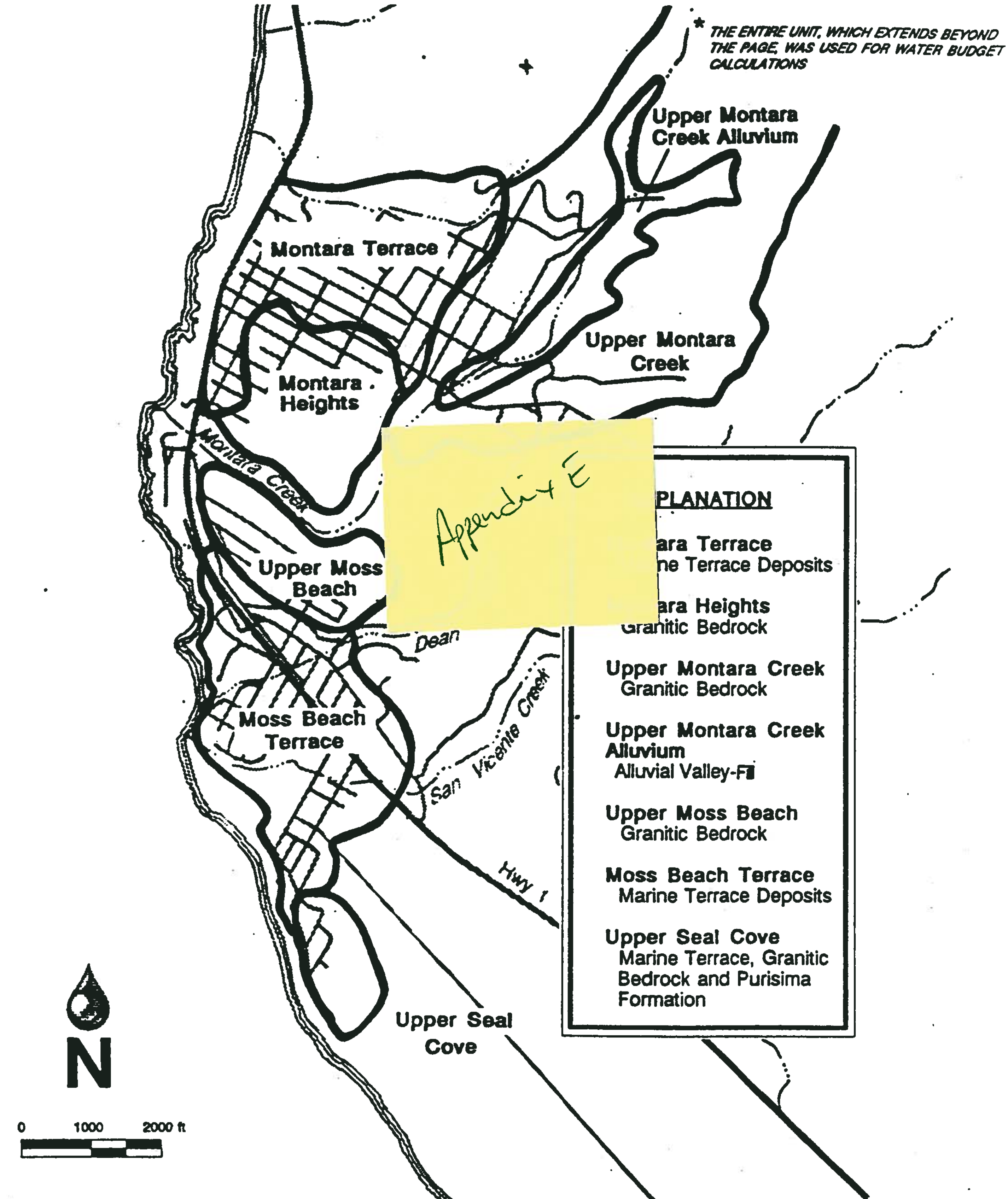


Figure 9. Rainfall/Runoff relation, Eastern Santa Cruz Mountains

Appendix E.

Referenced Maps and Figures

900 Modoc St, Berkeley, CA, 94707-2208
Phone 510-527-0727: Fax 510-527-8531



NOTE: Hydrogeologic sub-units are defined on the basis of recharge patterns and differences in composition of aquifer from which water will be withdrawn.

Figure 1. Location of Hydrogeologic Sub-Units

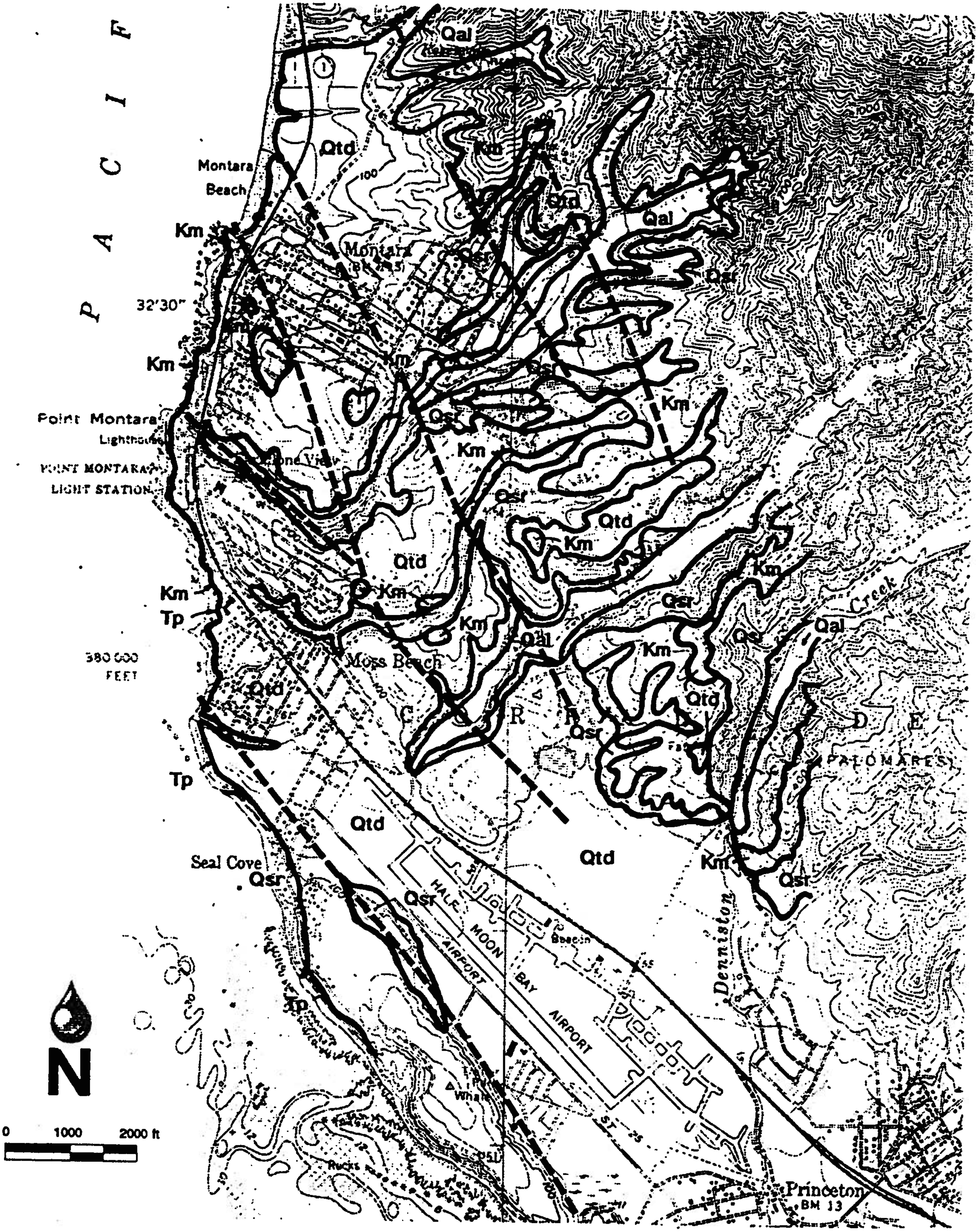


Figure 6. Geologic Map of Montara and Moss Beach Vicinity
See following page for legend.

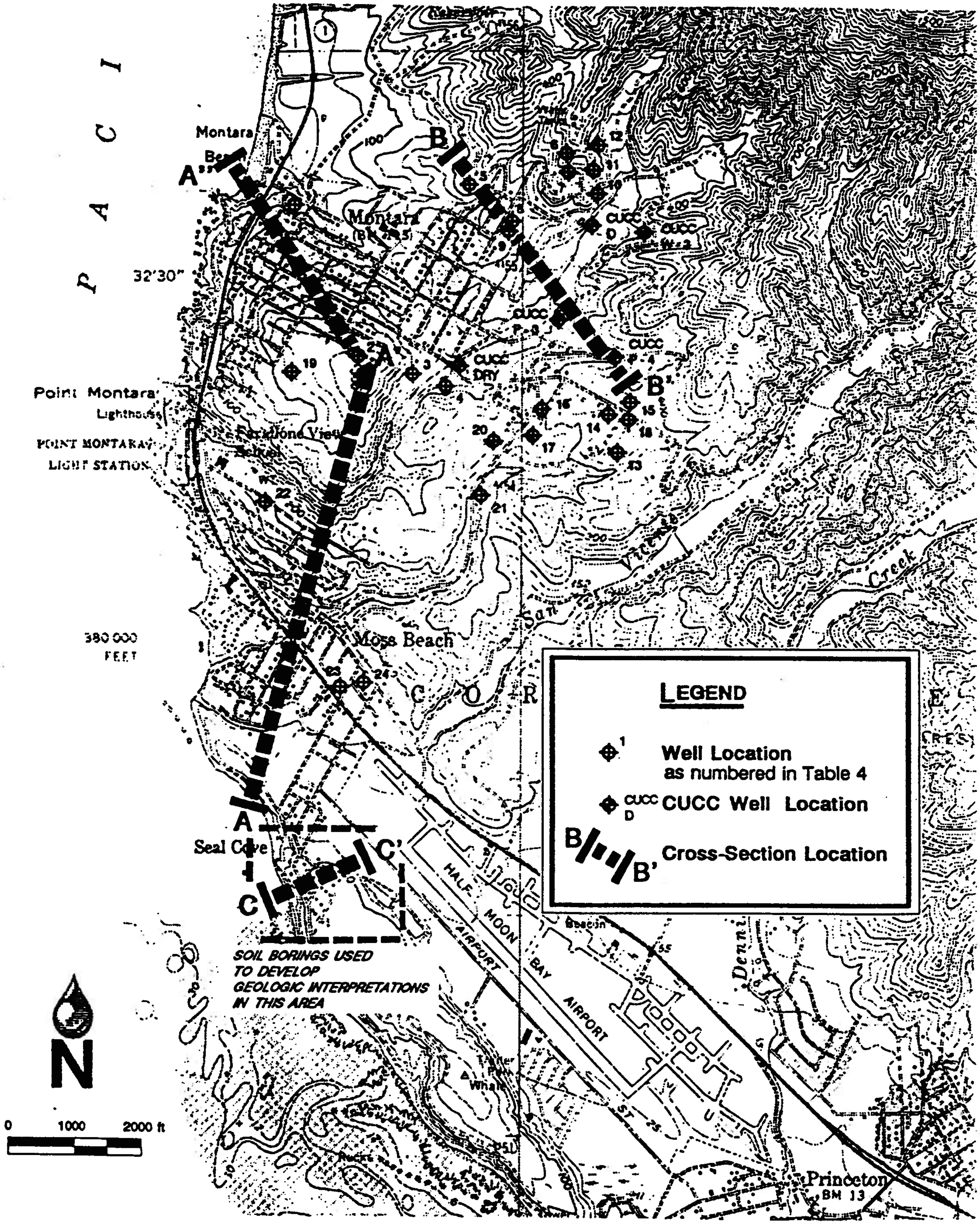


Figure 7. Locations of Wells and Cross-Sections

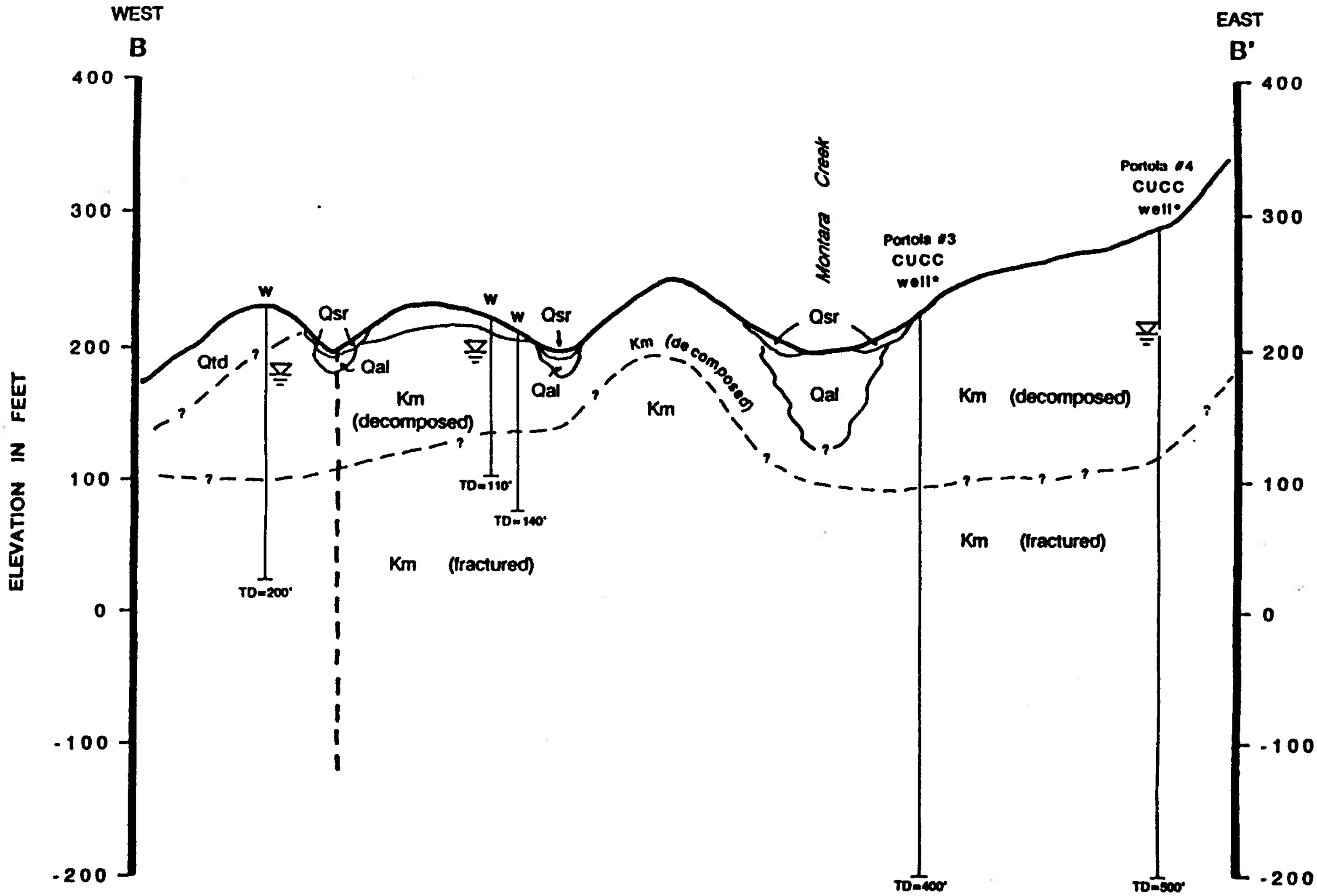


Figure 9. Hydrogeologic Section B - B'; Upper Montara

Qsr	Slope and Ravine Deposits
Qal	Alluvium
Qtd	Marine Terrace Deposits
Tp	Purisima Formation
Km	Montara Quartz Diorite
▽	Static Water Level Recorded on Driller's Log
	w = well; b = boring; * = projected onto section

See Figure 5 (Geologic Map) for detailed description of units.

500 feet

100 feet

5X Vertical Exaggeration

mid-1970s. Water levels recovered in the early 1980s and were at near historical high levels in 1986 (LSCE and ESA 1992).

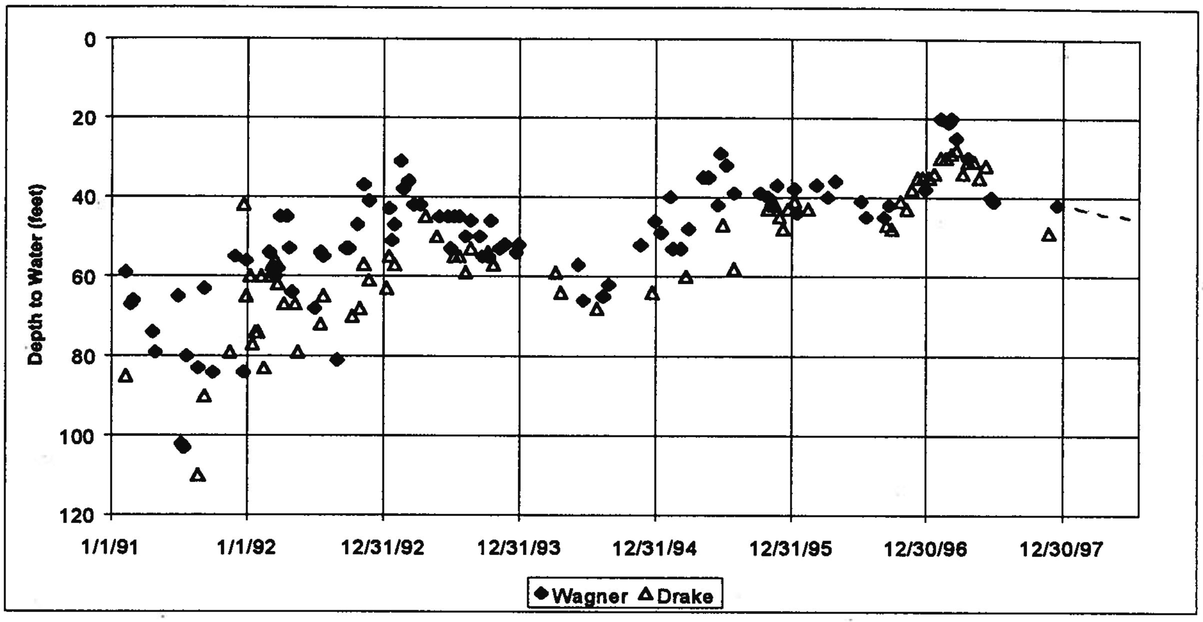


Figure _. Depth to groundwater in CUCC Wagner and Drake production wells, Montara Area.

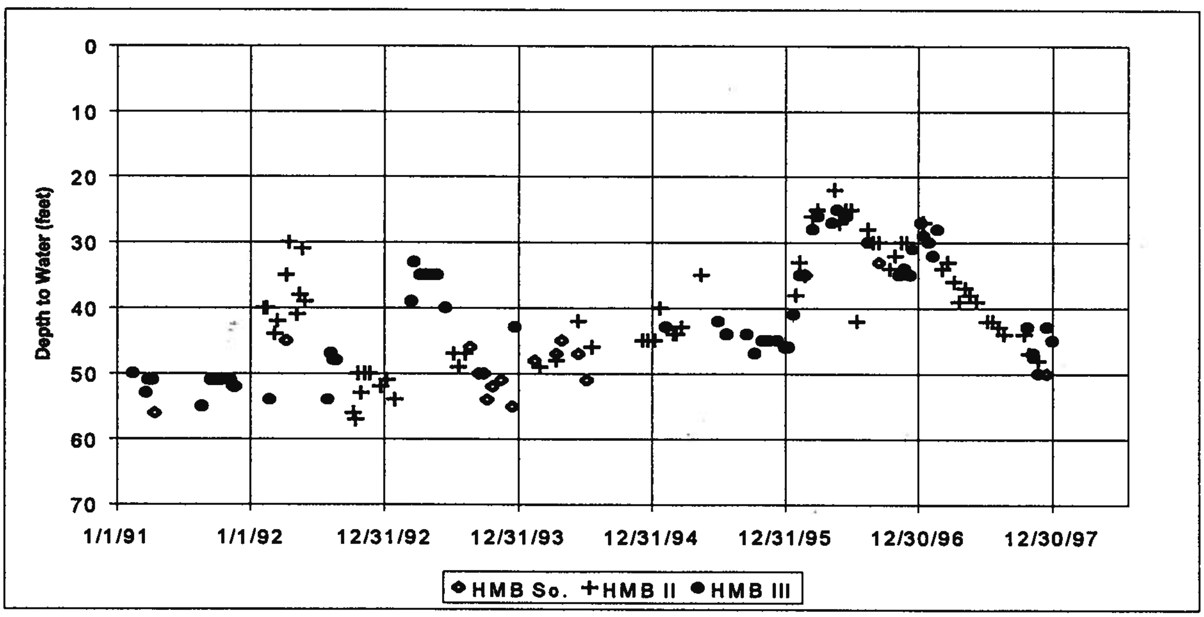


Figure _. Depth to groundwater in CUCC Half Moon Bay Airport production wells, Denniston sub-basin.

Another drought period from the late 1980s through the early 1990s resulted in declining groundwater levels. Limited data made available by CCWD from both monitoring and

Appendix F.

Ground-water Recharge Estimates

900 Modoc St, Berkeley, CA, 94707-2208
Phone 510-527-0727: Fax 510-527-8531

Estimated annual recharge and runoff for ground-water sheds in the Martini and Montara Creek area

Watershed	Area acres	Normal Steady State	1981 Dry Year	1977 Critically Dry Year
Ground-water Recharge				
Inches		4.74	3.17	0.21
A (ac-ft)	516	203.9	136.4	8.8
B (ac-ft)	108	42.8	28.6	1.9
C (ac-ft)	54	21.5	14.4	0.9
D (ac-ft)	86	34.1	22.8	1.5
E (ac-ft)	82	32.5	21.8	1.4
F (ac-ft)	47	18.6	12.4	0.8
G (ac-ft)	489	193.4	129.4	8.4
H (ac-ft)	223	88.0	58.9	3.8
Total (ac-ft)		*635*	*425*	*28*
Deep fractures		?	?	?
Runoff				
Inches		5.66	3.78	1.13
A (ac-ft)	516	243.5	162.3	48.7
B (ac-ft)	108	51.1	34.0	10.2
C (ac-ft)	54	25.7	17.1	5.1
D (ac-ft)	86	40.7	27.1	8.1
E (ac-ft)	82	38.9	25.9	7.8
F (ac-ft)	47	22.2	14.8	4.4
G (ac-ft)	489	230.9	154.0	46.2
H (ac-ft)	223	105.1	70.1	21.0
Total (ac-ft)		*758*	*505*	*152*
Recharge + Runoff				
Total (ac-ft)		*1393*	*930*	*179*

Notes

See accompanying table on the estimation of recharge and runoff in inches.

Planimetered watershed areas in the Martini and Montara Creek area

Sub-Area	Total Watershed acres	Terrace or Alluvium acres	Upland Slopes acres
A	516	33	482
B	108	26	82
C	54	0	54
D	86	64	22
E	82	49	34
F	47	0	47
G	489	44	445
H	223	14	209
Total	*1606*	*230*	*1376*

Notes

See accompanying map for locations of sub-areas.

Estimated recharge to a small granitic ground-water shed in the Montara area.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
Rainfall at Half Moon Bay Airport (inches)													
Normal	1.62	3.18	4.66	5.35	3.96	3.98	1.85	0.66	0.27	0.11	0.21	0.42	26.27
1991 (4-year recurrence dry year)	0.18	0.65	2.44	7.48	2.42	4.71	0.24	0.33	0	0	0.42	0.37	19.24
1977 (16-year recurrence dry year)	0.3	1.73	2.41	2.26	1.31	3.15	0.2	1.23	0	0.16	0.27	1.59	14.61
Runoff													
Mean annual runoff (inches), runoff for normal rainfall / 75%													7.6
Runoff for year of normal rainfall (inches), rainfall/runoff relation at Rancho San Carlos													5.7
Runoff for year of normal rainfall (% of rainfall)													22%
Estimated normal runoff (inches)	0.35	0.69	1.00	1.15	0.85	0.86	0.40	0.14	0.06	0.02	0.05	0.09	5.66
Runoff for 1981 (inches), 50% mean annual runoff													3.78
Runoff for year of normal rainfall (% of rainfall)													20%
Estimated normal runoff (inches)	0.04	0.13	0.48	1.47	0.47	0.92	0.05	0.06	0.00	0.00	0.08	0.07	3.78
Runoff for 1977 (inches), 15% mean annual runoff													1.13
Runoff for year of normal rainfall (% of rainfall)													8%
Estimated normal runoff (inches)	0.02	0.13	0.19	0.18	0.10	0.24	0.02	0.10	0.00	0.01	0.02	0.12	1.13
Infiltration (inches) = Precipitation - Runoff													
Normal	1.27	2.49	3.66	4.20	3.11	3.12	1.45	0.52	0.21	0.09	0.16	0.33	20.61
1991 (4-year recurrence dry year)	0.14	0.52	1.96	6.01	1.95	3.79	0.19	0.27	0.00	0.00	0.34	0.30	15.46
1977 (16-year recurrence dry year)	0.28	1.60	2.22	2.08	1.21	2.91	0.18	1.13	0.00	0.15	0.25	1.47	13.48
Evapotranspiration from coastal scrub covered watershed by Thornthwaite method (inches)													
Normal	1.27	1.30	0.98	1.46	1.65	2.44	2.73	0.28	2.76	0.50	0.16	0.33	15.86
1991 (4-year recurrence dry year)	0.14	0.52	0.98	1.46	1.65	2.44	2.22	1.47	0.51	0.26	0.34	0.30	12.29
1977 (16-year recurrence dry year)	0.28	1.30	0.98	1.46	1.32	2.44	1.35	1.71	0.46	0.25	0.25	1.47	13.27
Ground-water recharge (inches) = Infiltration - Evapotranspiration													
Normal	0.00	1.19	2.68	2.74	1.46	0.68	-1.28	0.24	-2.55	-0.41	0.00	0.00	4.74
1991 (4-year recurrence dry year)	0.00	0.00	0.98	4.55	0.30	1.35	-2.03	-1.20	-0.51	-0.26	0.00	0.00	3.17
1977 (16-year recurrence dry year)	0.00	0.30	1.24	0.62	-0.11	0.47	-1.17	-0.58	-0.46	-0.10	0.00	0.00	0.21

Notes

Runoff for a year of normal rainfall was estimated from a rainfall/runoff relation for Rancho San Carlos near Carmel, CA, which also has watersheds dominated by granite and similar groundwater conditions (eg well specific capacity).

For a year of average rainfall, runoff is less than average runoff because the first 7 to 9 inches of seasonal rainfall is absorbed by dry vegetation and the soil surface.

Runoff for normal rainfall, 1981 dry year, and 1977 very dry year, was estimated at 75, 50 and 15 percent of normal (see Table A2-2, Kleinfelder 1988).

Estimated evapotranspiration of coastal scrub in the Montara area by Thornthwaite method.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
Normal evapotranspiration (inches)													
PET at Half Moon Bay	2.81	1.30	0.98	1.46	1.65	2.44	2.95	3.91	4.25	4.27	4.15	3.54	33.71
Infiltration - PET	-1.54	1.19	2.68	2.74	1.46	0.68	-1.50	-3.39	-4.04	-4.18	-3.99	-3.21	
Cumulative Infiltration - PET	-21.85					0.00	-1.50	-4.89	-8.93	-13.11	-17.10	-20.31	
Soil moisture storage	0.00	1.19	3.87	4.00	4.00	4.00	2.72	2.96	0.41	0.00	0.00	0.00	
Change in soil moisture storage	0.00	1.19	2.68	0.13	0.00	0.00	-1.28	0.24	-2.55	-0.41	0.00	0.00	
Estimated evapotranspiration	1.27	1.30	0.98	1.46	1.65	2.44	2.73	0.28	2.76	0.50	0.16	0.33	15.86
1981 a 4-year recurrence dry year (inches)													
PET at Half Moon Bay	2.81	1.30	0.98	1.46	1.65	2.44	2.95	3.91	4.25	4.27	4.15	3.54	33.71
Infiltration - PET	-2.67	-0.78	0.98	4.55	0.30	1.35	-2.76	-3.64	-4.25	-4.27	-3.81	-3.24	
Cumulative Infiltration - PET						0.00	-2.76	-6.40	-10.65	-14.92	-18.73	-21.98	
Soil moisture storage	0.00	0.00	0.98	4.00	4.00	4.00	1.97	0.77	0.26	0.00	0.00	0.00	
Change in soil moisture storage	0.00	0.00	0.98	3.02	0.00	0.00	-2.03	-1.20	-0.51	-0.26	0.00	0.00	
Estimated evapotranspiration	0.14	0.52	0.98	1.46	1.65	2.44	2.22	1.47	0.51	0.26	0.34	0.30	12.29
1977 a 15-year recurrence dry year (inches)													
PET at Half Moon Bay	2.81	1.30	0.98	1.46	1.65	2.44	2.95	3.91	4.25	4.27	4.15	3.54	33.71
Infiltration - PET	-2.53	0.30	1.24	0.62	-0.44	0.47	-2.77	-2.78	-4.25	-4.12	-3.90	-2.07	
Cumulative Infiltration - PET					-2.61	-2.14	-4.91	-7.68	-11.93	-16.05	-19.95	-22.03	
Soil moisture storage	0.00	0.30	1.54	2.16	2.05	2.31	1.14	0.56	0.10	0.00	0.00	0.00	
Change in soil moisture storage	0.00	0.30	1.24	0.62	-0.11	0.26	-1.17	-0.58	-0.46	-0.10	0.00	0.00	
Estimated evapotranspiration	0.28	1.30	0.98	1.46	1.32	2.44	1.35	1.71	0.46	0.25	0.25	1.47	13.27

Notes

PET is potential (or reference) evapotranspiration, which approximates the evapotranspiration of a large uncut pasture that is not water stressed.

PET values were taken from U.C. Berkeley Cooperative Extension Leaflet 21426 (1987).

Soil moisture storage were estmated using Table 15 from Thornthwite and Mather (1957), based on 4 inches of moisture retention in coastal scrub root zone.

TABLE A2-2
Bases For Estimating Runoff Coefficients For Normal, Dry and Critical Drought Years for Normal, Dry, and Critical Drought Years

Stream	General Rock Type	Period of Record	Mean Annual Runoff (ac.ft/yr.)	Normal Rainfall 1975 Runoff (ac. ft/yr.)	Normal Rainfall 1975 % M.A.R.	Dry Rainfall 1981 Runoff (ac. ft/yr.)	Dry Rainfall 1981 % M.A.R.	Very Dry Rainfall 1977 Runoff (ac. ft/yr.)	Very Dry Rainfall 1977 % M.A.R.
San Lorenzo R. at Bigtrees	Mixed lithology, incl. much weathered crystalline rock and Santa Margarita sandstone	1936-1984	101400	82000	81	39000	38	10000	10
Pescadero Cr.	Weathered indurated Sandstones	1951-1984	32800	26000	79	9640	29	1250	4
Scott Cr. near Davenport	Primarily fractured gramtics and extensive alluvial storage	1937, 1939-41, 1999-73 Data synthesized from gauged record	23850	19490	82	7990	36	1660	7
San Vicente Cr. near Davenport	Weathered gramtic rock and minor cavernous limestone	1969-1984	7030	4860	69	2200	31	602	9
Pilarcitos Cr. at Half Moon Bay	Moderately to well consolidated sandstone, appreciable alluvial storage	1966-1984	12320	6500	53	2580	21	372	3
San Gregorio Cr. at San Gregorio	Moderately consolidated sandstones minor volcanics and alluvium	1969-1984	32170	19020	59	9250	29	840	3
Laguna Cr. near Davenport	Moderately consolidated sandstone	1970-1976 Data for 1977, 1981 synthesized from gauged record	3640	2750	76	1370	38	340	9
Majors Cr. near Santa Cruz	Moderately consolidated sandstone	1970-1976 Data for 1977, 1981 synthesized from gauged record	3070	2420	79	1420	46	580	19
					$\bar{x}=72$		$\bar{x}=33.5$		$\bar{x}=8$

Estimation of recharge to a small granitic ground-water shed in the Half Moon Bay area.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
Rainfall at Half Moon Bay Airport (inches)													
Normal	1.62	3.18	4.66	5.35	3.96	3.98	1.85	0.66	0.27	0.11	0.21	0.42	26.27
1998 (50-year recurrence wet year)	0.77	7.84	3.65	12.13	15.70	2.58	2.73	4.01	0.30	0.18	0.06	0.25	50.20
Rainfall in the Apanolio Creek catchment (inches)													
Normal, Rantz (1971) isohyetal map													38.00
Estimated normals	2.34	4.60	6.74	7.74	5.73	5.76	2.68	0.95	0.39	0.16	0.30	0.61	38.00
Estimated 1998 (50-year recurrence wet year)	1.11	11.34	5.28	17.55	22.71	3.73	3.95	5.80	0.43	0.26	0.09	0.36	72.62
Streamflow in Apanolio Creek at Gossett Ranch (1.1 sq.mi.catchment)													
1998 gaged (acre-feet), preliminary data	*4*	*50*	*59*	476	888	165	107	61	30	29	14	7	1889
1998 gaged (inches), preliminary data	*0.07*	*0.85*	*1*	8.11	15.13	2.82	1.82	1.04	0.52	0.50	0.23	0.13	32.20
1998 gaged (percent of rainfall)	*6%*	*7%*	*19%*	46%	67%	76%	46%	18%	120%	191%	266%	35%	44%
Mean annual runoff (inches), Rantz (1971)													12
Runoff for year of normal rainfall (inches), 75% mean annual runoff													9
Runoff for year of normal rainfall (% of rainfall)													24%
Estimated normal runoff (inches)	0.56	1.09	1.60	1.83	1.36	1.36	0.63	0.23	0.09	0.04	0.07	0.14	9.00
Infiltration = Precipitation - Runoff, (inches)													
Normal	1.79	3.51	5.14	5.91	4.37	4.39	2.04	0.73	0.30	0.12	0.23	0.46	29.00
1998 (50-year recurrence wet year)	1.04	10.49	4.28	9.44	7.58	0.91	2.13	4.77	-0.09	-0.24	-0.14	0.24	40.41
Evapotranspiration from coastal scrub covered watershed (inches)													
Normal (Thornthwaite method)	1.79	1.30	0.98	1.46	1.65	2.44	2.86	2.52	1.18	0.53	0.33	0.46	17.50
1998 (Thornthwaite method)	1.04	1.30	0.98	1.46	1.65	2.21	2.65	3.91	1.73	0.38	0.14	0.24	17.70
California woodland-grass													18.00
Southern California chaparral													20.00
Ground-water recharge (inches)													
Normal	0.00	2.21	4.16	4.45	2.72	1.95	-0.82	-1.79	-0.88	-0.41	-0.10	0.00	11.50
1998 (50-year recurrence wet year)	0.00	9.19	3.30	7.98	5.93	-1.30	-0.52	0.86	-1.82	-0.62	-0.28	0.00	22.72

Notes

Monthly rainfall in Apanolio Creek catchment was proportioned based on Half Moon Bay normals.

Streamflow estimates are *italicized*; otherwise gaged data were used.

Annual evapotranspiration for California woodland and chaparral was estimated utilizing data summarized in The Water Encyclopedia (1991).

Estimation of evapotranspiration of coastal scrub in the Half Moon Bay area by Thornthwaite method.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
Normal evapotranspiration (inches)													
PET at Half Moon Bay	2.81	1.30	0.98	1.46	1.65	2.44	2.95	3.91	4.25	4.27	4.15	3.54	33.71
Infiltration - PET	-1.02	2.21	4.16	4.45	2.72	1.95	-0.91	-3.18	-3.95	-4.15	-3.92	-3.08	
Cumulative Infiltration - PET	-20.21					0.00	-0.91	-4.09	-8.04	-12.19	-16.11	-19.18	
Soil moisture storage	0.00	2.21	4.00	4.00	4.00	4.00	3.18	1.39	0.51	0.10	0.00	0.00	
Change in soil moisture storage	0.00	2.21	1.79	0.00	0.00	0.00	-0.82	-1.79	-0.88	-0.41	-0.10	0.00	
Estimated evapotranspiration	1.79	1.30	0.98	1.46	1.65	2.44	2.86	2.52	1.18	0.53	0.33	0.46	17.50
1998 a 50-year recurrence wet year (inches)													
PET at Half Moon Bay	2.81	1.30	0.98	1.46	1.65	2.44	2.95	3.91	4.25	4.27	4.15	3.54	33.71
Infiltration - PET	-1.77	9.19	3.30	7.98	5.93	-1.53	-0.82	0.86	-4.34	-4.51	-4.29	-3.30	
Cumulative Infiltration - PET	-19.70				0.00	-1.53	-2.35	-1.49	-5.83	-10.33	-14.63	-17.93	
Soil moisture storage	0.00	4.00	4.00	4.00	4.00	2.70	2.18	2.72	0.90	0.28	0.00	0.00	
Change in soil moisture storage	0.00	4.00	0.00	0.00	0.00	-1.30	-0.52	0.54	-1.82	-0.62	-0.28	0.00	
Estimated evapotranspiration	1.04	1.30	0.98	1.46	1.65	2.21	2.65	3.91	1.73	0.38	0.14	0.24	17.70

Notes

PET is potential (or reference) evapotranspiration, which approximates the evapotranspiration of a large uncut pasture that is not water stressed.

PET values were taken from U.C. Berkeley Cooperative Extension Leaflet 21426 (1987).

Soil moisture storage were estmated using Table 15 from Thornthwite and Mather (1957), based on 4 inches of moisture retention in coastal scrub root zone.

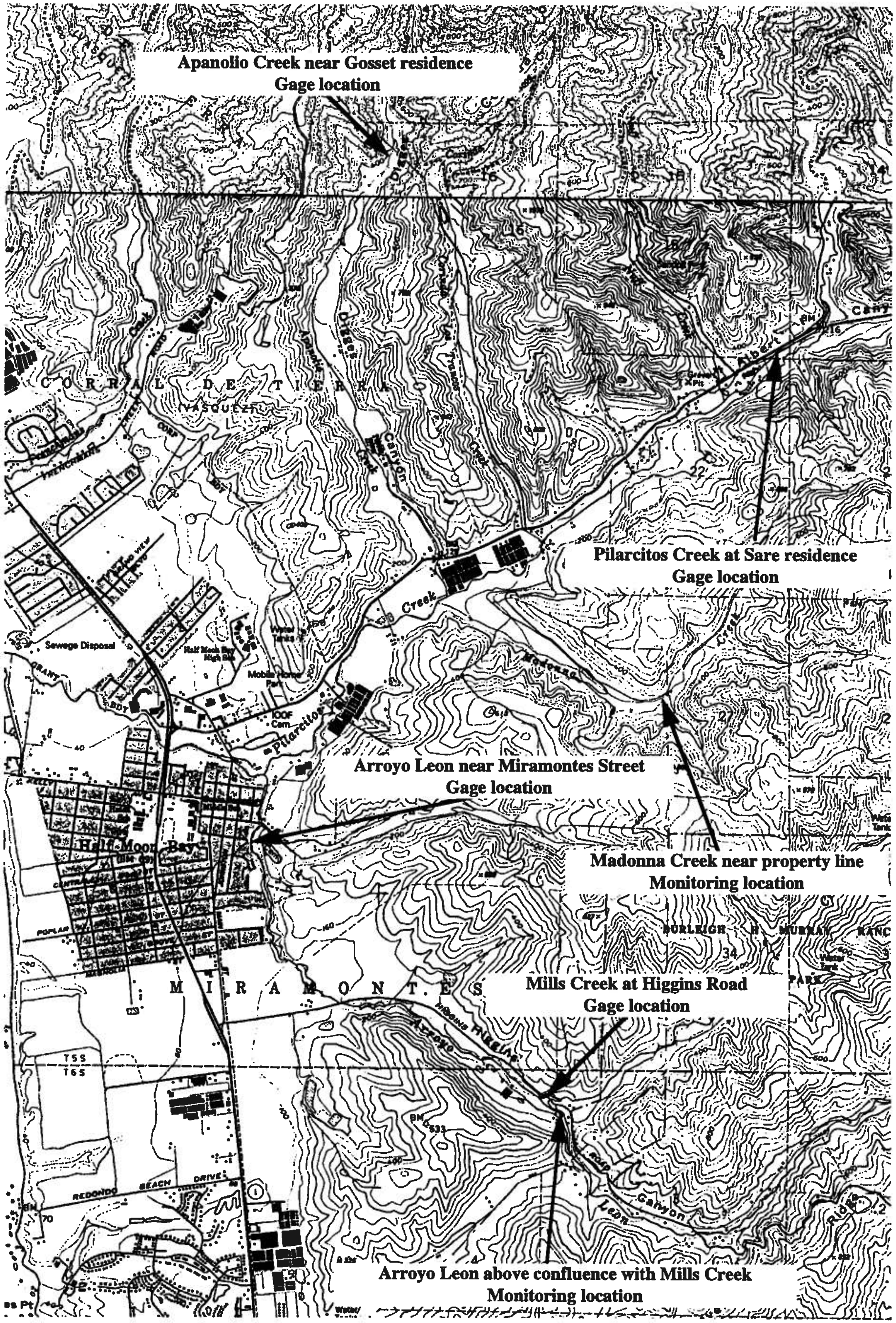


Figure __. Location map

preliminary and subject to revision

Annual Hydrologic Record

Water Year:	1998
Stream:	Apanolio Creek
Station:	at Gossett Ranch

Station Location / Watershed Descriptors

Latitude: 37° 30' 08", Longitude: 122° 24' 58" near Half Moon Bay, San Mateo County, CA. Gage is located on Apanolio Creek's left bank at upstream extent of Gosset Property. Approximately 50 feet d/s of concrete weir and ~ 50 feet u/d of a road crossing culvert. Land use includes forested open space, pasture, and low-density residential development. Drainage area upstream of gage is 1.1 square miles.

Map

Mean Daily Flow

Mean monthly flows for WY 1998 are presented below.

Peak Flows

Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)	Date	Time (24-hr)	Gage Ht. (feet)	Discharge (cfs)
1/12/98	6:15	2.65	65	2/19/98	11:45	1.667	16
1/15/98	12:00	1.59	13	2/21/98	16:15	1.906	25
1/18/98	13:15	2.93	82	2/23/98	9:00	1.762	19
1/20/98	3:15	2.29	43	1/29/98	3:15	1.327	7
2/3/98	6:00	3.46	113	1/31/98	8:15	1.315	7
2/7/98	13:15	2.17	37	2/6/98	12:15	1.834	22

Extreme for Period of Record: 113 cfs on Feb 3, 1998.

Period of Record

Staff plate and water-level recorder installed Dec.17, 1997.
Gaging sponsored by San Mateo Resource Conservation District.

WY 1998 Mean Daily Flow (cubic feet per second)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
1	...	...	...	0.29	5.27	5.33	1.74	1.28	0.64	0.55	0.27	0.08
2	...	...	...	1.19	11.39	4.85	1.84	1.26	0.63	0.62	0.30	0.07
3	...	...	...	1.18	83	4.42	1.90	1.28	0.64	0.70	0.38	0.13
4	...	...	...	1.41	55	4.23	1.95	1.25	0.61	0.66	0.37	0.16
5	...	...	...	1.25	18	3.91	2.05	1.17	0.62	0.65	0.35	0.13
6	...	...	...	1.16	18.95	3.65	2.11	1.14	0.64	0.61	0.35	0.10
7	...	...	...	1.17	22.00	3.46	2.14	1.16	0.63	0.60	0.34	0.13
8	...	...	...	1.08	20.48	3.25	2.21	1.10	0.63	0.59	0.30	0.13
9	...	...	...	1.06	16.66	3.08	2.23	1.06	0.67	0.56	0.27	0.11
10	...	...	...	2.24	14.47	2.92	2.24	1.08	0.64	0.55	0.24	0.08
11	...	...	...	5.83	12.47	2.79	2.23	1.10	0.63	0.52	0.21	0.05
12	...	...	...	44.34	10.96	2.75	1.88	1.00	0.63	0.50	0.20	0.06
13	...	...	...	14.07	9.79	2.56	1.86	0.96	0.61	0.49	0.19	0.11
14	...	...	...	7.49	9.47	2.44	1.93	0.98	0.58	0.45	0.23	0.14
15	...	...	...	10.54	8.63	2.37	1.90	0.98	0.57	0.49	0.21	0.12
16	...	...	...	11.10	8.23	2.33	1.90	0.97	0.56	0.50	0.23	0.11
17	...	...	0.72	9.32	7.77	2.26	1.90	1.02	0.57	0.47	0.23	0.07
18	...	...	0.61	19.75	7.18	2.21	1.86	1.08	0.57	0.44	0.24	0.05
19	...	...	0.56	23.00	9.15	2.17	1.80	1.02	0.55	0.46	0.23	0.08
20	...	...	0.54	22.59	9.49	2.09	1.70	1.00	0.53	0.46	0.20	0.10
21	...	...	0.50	9.06	13.61	2.01	1.70	0.97	0.53	0.45	0.18	0.07
22	...	...	0.46	7.47	13.22	2.26	1.65	0.94	0.53	0.43	0.16	0.11
23	...	...	0.44	6.31	12.77	2.25	1.56	0.93	0.54	0.42	0.15	0.15
24	...	...	0.42	5.31	11.13	2.15	1.48	0.89	0.00	0.40	0.19	0.19
25	...	...	0.40	4.69	9.64	2.10	1.41	0.86	0.00	0.37	0.18	0.20
26	...	...	0.39	4.33	8.35	2.01	1.35	1.03	0.00	0.36	0.14	0.22
27	...	...	0.38	3.99	7.45	1.96	1.33	0.97	0.00	0.35	0.13	0.21
28	...	...	0.36	3.74	6.58	1.86	1.33	0.71	0.58	0.36	0.13	0.26
29	...	...	0.34	5.22	5.85	1.81	1.31	0.70	0.51	0.37	0.13	0.29
30	...	...	0.32	4.60		1.88	1.30	0.68	0.53	0.33	0.12	0.00
31	...		0.30	4.96		1.77		0.66		0.31	0.10	
MEAN	...	...	0.45	7.73	15.43	2.78	1.79	1.02	0.51	0.49	0.23	0.12
MAX	...	...	0.72	44.34	83.38	5.33	2.24	1.28	0.67	0.70	0.38	0.29
MIN	...	...	0.30	0.29	5.27	1.81	1.30	0.68	0.00	0.33	0.12	0.00
cfs days	...	...	6.72	239.74	447.47	83.37	53.80	30.62	15.35	14.70	6.84	3.74
ac-ft	...	...	13.34	475.53	887.56	165.36	106.71	60.74	30.45	29.16	13.56	7.41

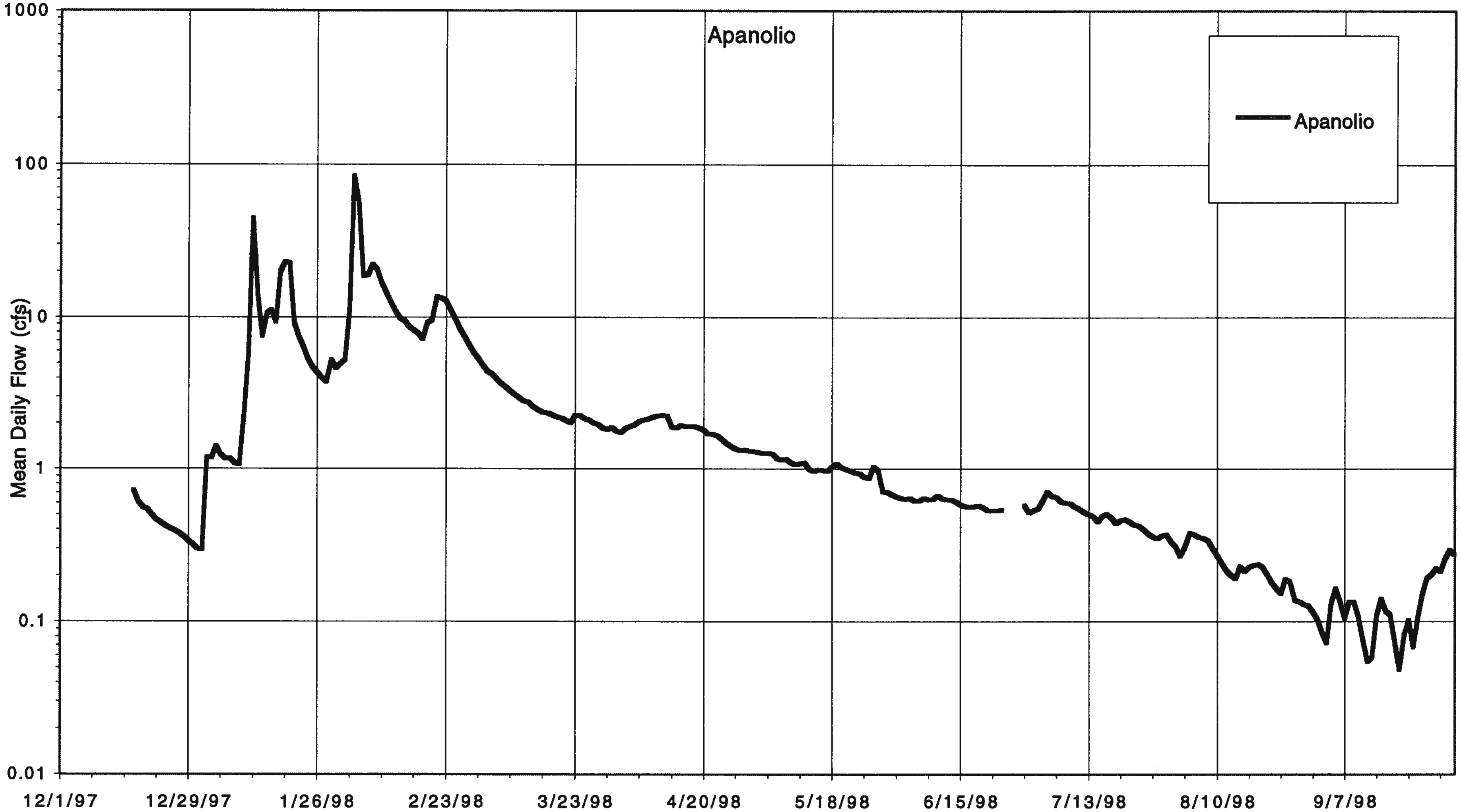
Monitor's Comments

1. Water-level record (at 15 minute intervals) from 12/17/97 to 10/1/98.
2. Multiple stage shifts were applied to the rating equation. Stage shifts adjust for local scour and fill.
3. Daily values with more than 2 to 3 significant figures result from electronic calculations. No additional precision is implied.

Partial Year Period of Record 1998 Totals:	
Mean	...
Max.	83.4
Min.	0.10
cfs-days	899
ac-ft	1782

Balance Hydrologics, Inc. 900 Modoc Street, Berkeley, CA 94707 (510) 527-0727; fax: (510) 527-8531

Data are preliminary and subject to review.

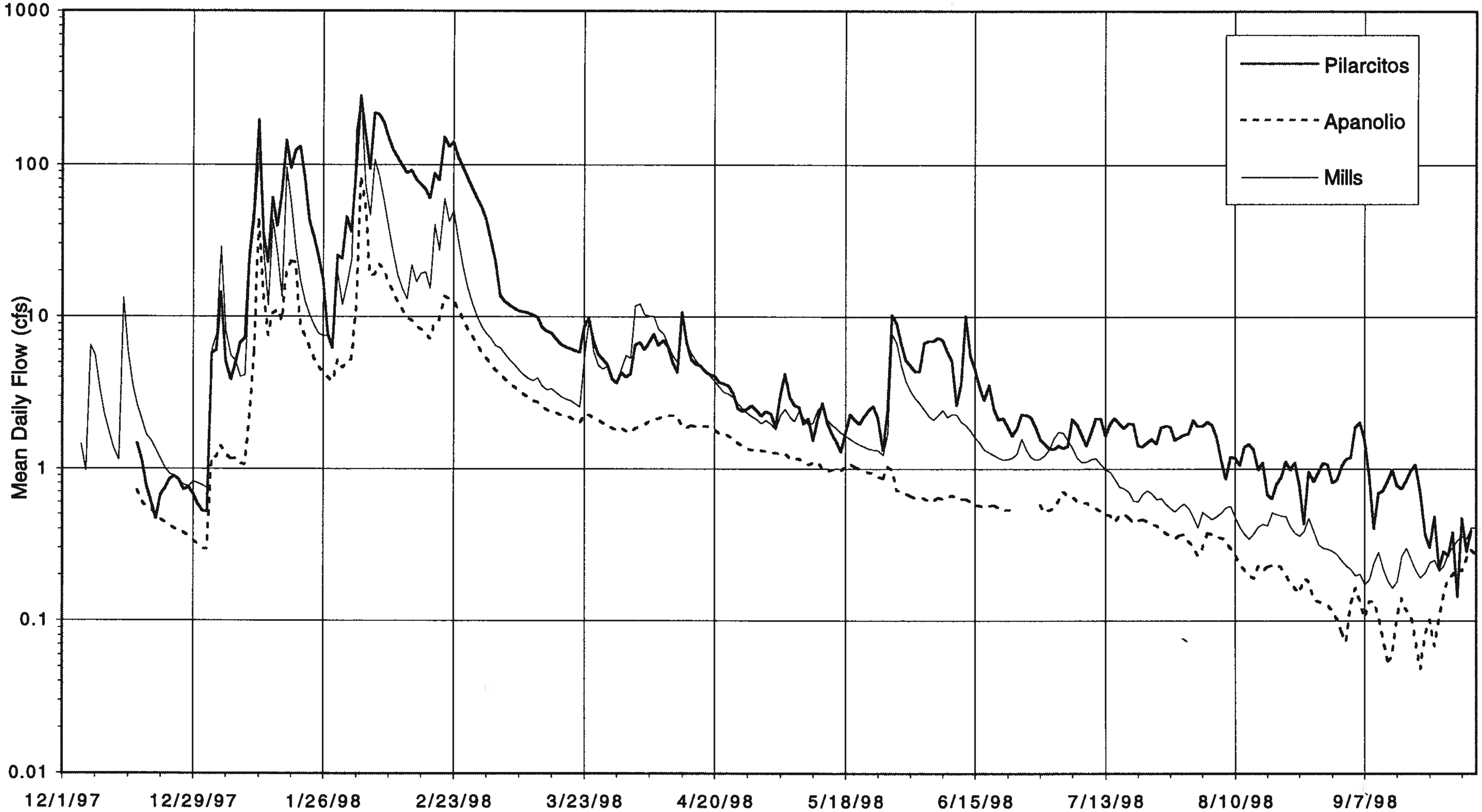


Note that the flow axis is logarithmic.

Balance Hydrologics, Inc.

Figure _.
Preliminary Mean Daily flow hydrograph for partial WY1998:
Apanolio Creek near Gosset residence

Data are preliminary and subject to review.



Note that the flow axis is logarithmic.

Balance Hydrologics, Inc.

Figure _.
Preliminary Mean Daily flow hydrograph for partial WY1998:
Combined: Pilarcitos, Apanolio and Mills Creeks

Appendix G.

Water Rights Applications

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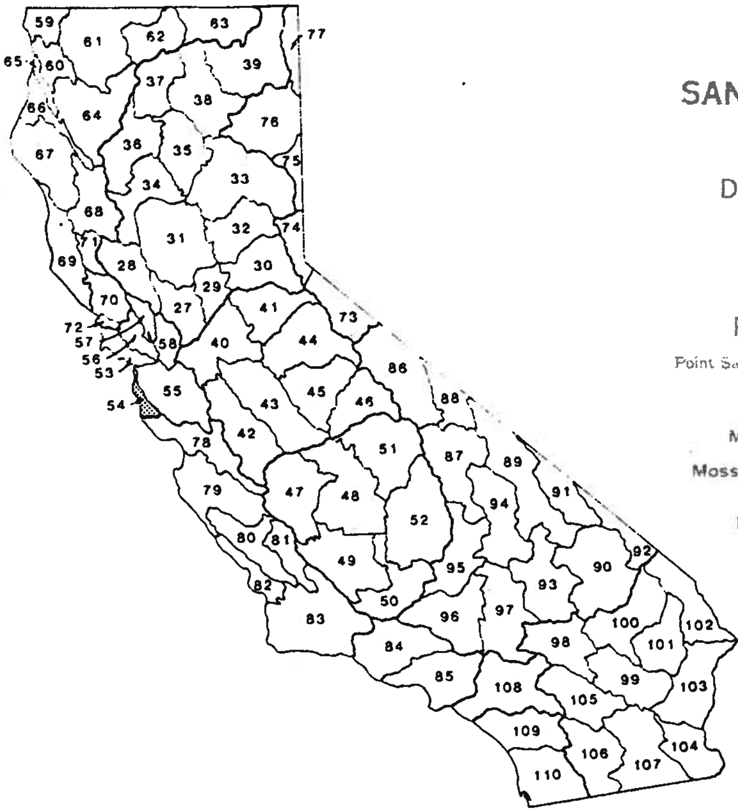
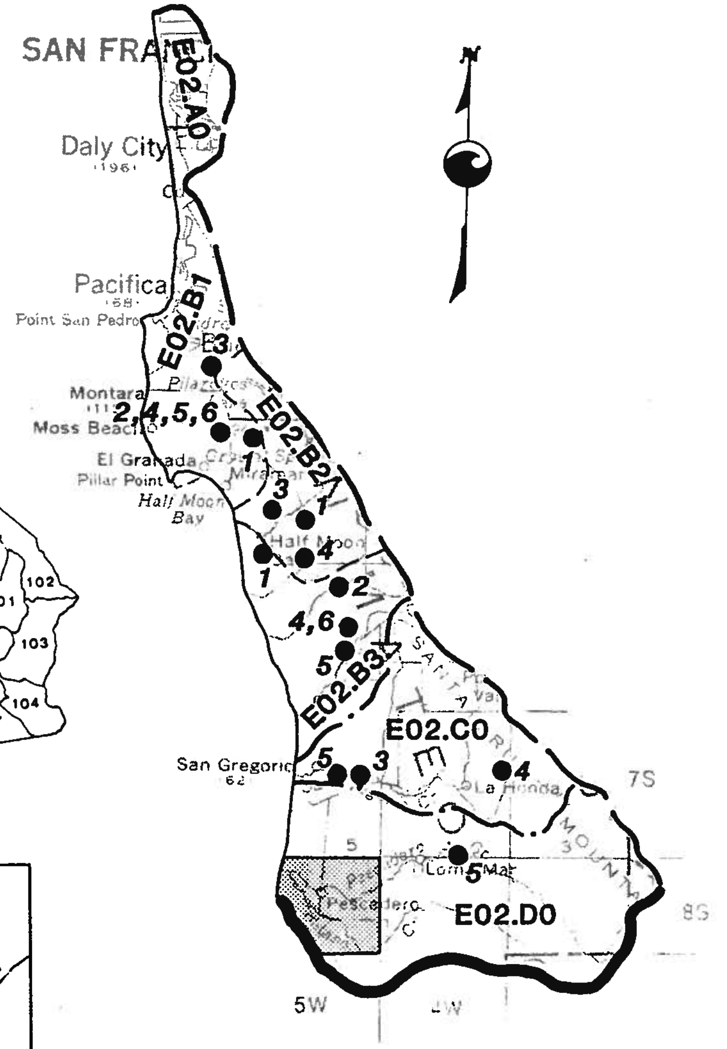
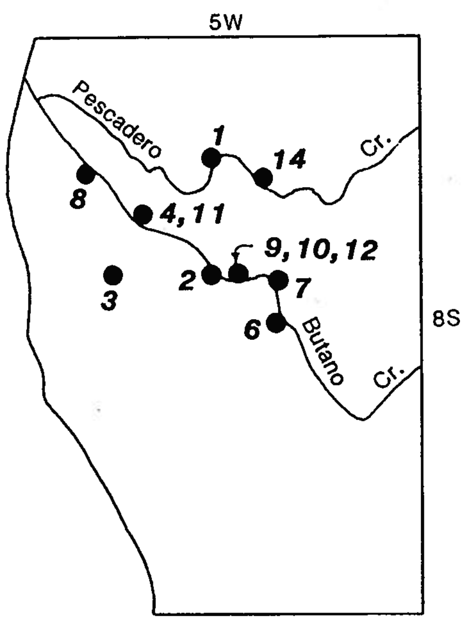
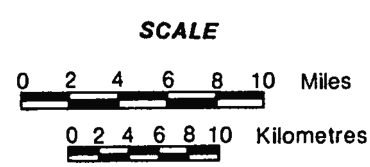



SAN FRA
E02.A0
Daly City
Pacifica
Point San Pedro
E02.B1
Montara
Moss Beach
El Granada
Pillar Point
Half Moon Bay
E02.B2
E02.B3
San Gregorio
E02.C0
La Honda
Pescadero
Loma Mar
E02.D0
7S
8S
5W
4W


5W
Pescadero Cr.
Butano Cr.
8S
1
14
8
4,11
9,10,12
2
7
3
6


SCALE
0 2 4 6 8 10 Miles
0 2 4 6 8 10 Kilometres

E02

Identity Number	Stream Name / Water Rights Application Number / License Number	Location / Agreement Date	FERC Project Number	Diversion Name / Water Rights Applicant	Minimum Instream Flows Under Agreement
HYDROLOGIC UNIT - E0200 - SAN MATEO					
E02.B1-1	Locks Creek	SW1/4 of SE1/4 S6, T5S, R5W, MD		——	Dec. 1 - Apr. 1; bypass half of the surface flow when flow is $\leq$ 3 cfs or n.f. where flow is less than above
	23846	04-21-81	——	Figone, Louie	
E02.B1-2	Denniston Creek	SE1/4 of SW1/4 S2, T5S, R6W, MD		——	Dec. 1 - Mar. $\geq$ 1 cfs or n.f. where flow is less than above
	25461	12-01-80	——	Half Moon Bay Properties	
E02.B1-3	S.F. San Pedro Creek	NE1/4 of SW1/4 S24, T4S, R6W, MD		——	At all times bypass min 0.15 cfs or the total flow of S.F. San Pedro Creek, whichever is less, at the point of diversion
	23733	03-23-71	——	North Coast County Water Dist.	
E02.B1-4	Denniston Creek	SE1/4 of SW1/4 S2, T5S, R6W, MD		——	Bypass from Dec. 1 - Mar. 31 $\geq$ 1 cfs or n.f. whichever is less
	25469	08-17-77	——	Half Moon Bay Properties, Inc.	
E02.B1-5	Trib. to Denniston Creek	SW1/4 of NE1/4 S2, T5S, R6W, MD SE1/4 of NW1/4 S2, T5S, R6W, MD		——	Bypass from Dec. 1 - Mar. 31 $\geq$ 1 cfs or n.f. whichever is less
	25468	08-17-77	——	Half Moon Bay Properties, Inc.	
E02.B1-6	Trib. to Denniston Creek	NE1/4 of NE1/4 S2, T5S, R6W, MD		——	Bypass from Dec. 1 - Mar. 31 $\geq$ 1 cfs or n.f. whichever is less
	25467	08-17-77	——	Half Moon Bay Properties, Inc.	

Identity Number	Stream Name / Water Rights Application Number / License Number	Location / Agreement Date	FERC Project Number	Diversion Name / Water Rights Applicant	Minimum Instream Flows Under Agreement
E02.B2-1	Pilarcitos Creek 25407	SW1/4 of NW1/4 S28, T5S, R5W, MD 11-16-77	----	---- California Evergreen Nursery	At all times flow must be ≥ 5 cfs or n.f. No diversion when creek, at the point of diversion, is between 10 & 17 cfs
E02.B2-3	Frenchmans Creek 25470	S18, T5S, R5W, MD 09-20-78	----	---- Half Moon Bay Properties	Dec. 1 - Mar 31 ≥ 3 cfs or where flow is less than above
E02.B2-4	Arroyo Leon 25463, 25464, 25465	NW1/4 of SW1/4 S33, T55, R5W, MD 08-17-77	----	---- Half Moon Bay Properties, Inc.	Shall not divert from Arroyo Leon when streamflow at USGS gage on Pilarcitos Creek is between 10 and 20 cfs or when during Mar. 15 - Apr. 30 at mentioned gage flow is at or below 5 cfs
E02.B3-1	Arroyo Leon 25462	NE1/4 of SE1/4 S32, T5S, R5W, MD 02-01-80	----	---- Half Moon Bay Properties	No diversion when streamflow on Pilarcitos Creek is between 10 & 20 cfs. No diversion from Mar. 15 - Apr. 30 when streamflow on Pilarcitos Creek is ≤ 5 cfs or n.f. where flow is less than above
E02.B3-2	Purisima Creek 18508 L9456	SW1/4 of SE1/4 S2, T6S, R5W, MD 01-27-59	----	---- Minaichis, John Minaichas, Tom & Sue	At all times bypass ≥ 0.5 cfs or the n.f. whenever flow is less at the point of diversion

Attachments

Table 1. Summary of water resources and uses in the Martini and Montara Creek area.
Table 2. Estimated ground-water storage in the Martini and Montara Creek area.

Figure 1. Hydrology map of the area north of Montara.
Figure 2. Production well location map.

Accompaning Document : Well logs of the Montara area.

Appendix A. Conclusions to the Montara Water Supply Study (DWR 1999)
Appendix B. Summary of Well Logs in the Montara Area
Appendix C. Watershed Information from Caltrans
Appendix D. Rainfall, Runoff and Evapotranspiration Data
Appendix E. Referenced Maps and Figures
Appendix F. Rainfall, Runoff and Evapotranspiration Data
Appendix G. Water Rights Applications

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