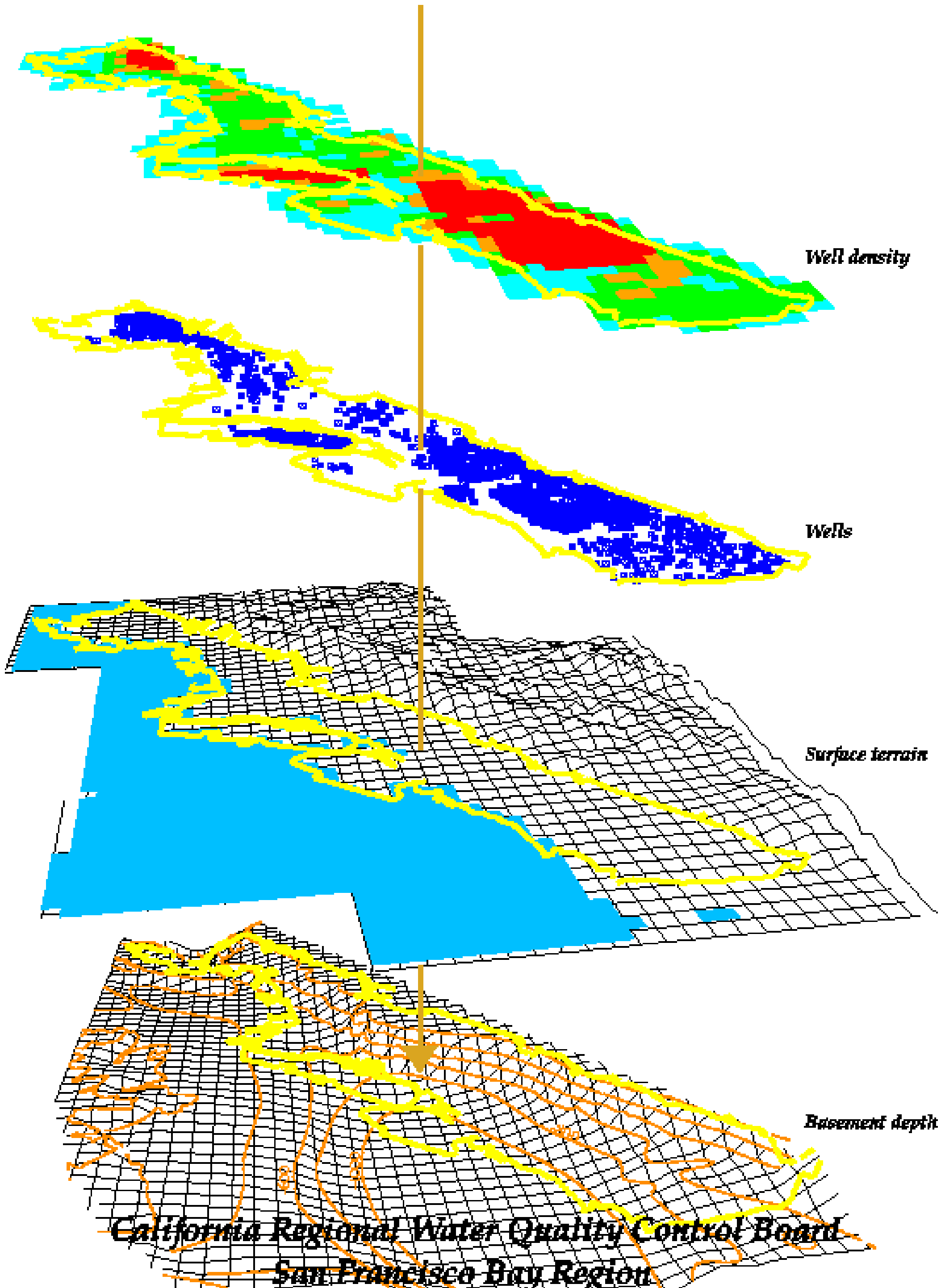
East Bay Plain Groundwater Basin Beneficial Use Evaluation Report

Alameda and Contra Costa Counties, CA



California Regional Water Quality Control Board

San Francisco Bay Region

Groundwater Committee

June 1999

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EXECUTIVE SUMMARY

All regulatory agencies rely on the groundwater beneficial use designations for establishing soil and groundwater cleanup levels at individual contaminated sites. The San Francisco Bay Basin Water Quality Control Plan (Basin Plan), adopted through a public hearing process in 1992, includes alternatives for improving beneficial use designations. Since 1992, The San Francisco Bay Regional Water Quality Control Board's (Regional Board) Groundwater Committee (Committee) has undertaken regional groundwater basin projects to better understand and improve beneficial use designations. This report presents a comprehensive evaluation of the beneficial uses of groundwater in the East Bay Plain Groundwater Basin (East Bay Plain). The purpose of this project is to better define current and future East Bay Plain beneficial uses. This project, when combined with a California Environmental Quality Act (CEQA) analysis, will be the technical basis for a future amendment to the Basin Plan. For agencies, consultants, businesses, and the public, the project provides a broader context in which to evaluate site-specific cleanup issues within the East Bay Plain.

STUDY AREA and PROJECT DESIGN

Located on the eastern shore of San Francisco Bay, the Basin is long (25 miles), narrow (2 to 7 miles) and includes all or portions of the cities of Richmond, San Pablo, El Cerrito, Albany, Berkeley, Emeryville, Piedmont, Alameda, Oakland, San Leandro, San Lorenzo and Hayward. Over 900,000 people live in the East Bay Plain. There are approximately 1300 leaking underground fuel sites and 130 non-fuel sites with identified pollution. While most of this pollution is limited in extent, there are 13 groundwater pollution plumes over 1,000 feet long.

The East Bay Plain project was conducted by the Committee, which was originally established by the Board's Executive Officer in 1990. For this project, its membership was expanded to include staff from the Alameda County Flood Control and Water Conservation District (ACFCWCD), East Bay Municipal Utility District (EBMUD), the Port of Oakland, the U.S. Navy and the cities of Oakland and San Leandro. The Committee initiated the study in 1996 to answer the following six key questions:

1. What are the current and planned future groundwater beneficial uses of the East Bay Plain?
2. Can the East Bay Plain be subdivided into Sub-Areas based on hydrogeology?
3. Where is the use of the East Bay Plain limited?
4. Can the shallow and deeper zones have different designations?
5. Should any current beneficial use designations change?
6. Are there areas requiring special protection programs?

Current, published reports were not detailed enough to answer the key questions. This is due, in part, to the population's reliance on surface water. However, pre-1930's data was available. At that time, groundwater supplied a significant portion of the water demand. In recognition of this, the Committee sought out a comprehensive review of historical groundwater use. The Friends of the San Francisco Estuary, in cooperation with the Regional Board, retained a consultant to complete a report on the historic groundwater use and current hydrogeologic framework of the East

Bay Plain (Figuers, 1998). Building upon this report, Committee members have compiled the best available information on beneficial uses, analyzed the information, developed a conceptual groundwater framework, and recommended revisions for beneficial use designations.

FINDINGS

Based on the key questions posed, the following findings were made:

1. Approximately 3,400 acre-feet of groundwater is extracted annually, based on 1995 estimates. Although safe yield estimates are somewhat crude, this volume is about 40% of the available yield. With a current demand of over 162,000 acre-feet/year, groundwater supplies about 2% of the total water used within the East Bay Plain.

2. There are approximately 4,700 existing wells in the East Bay Plain used for agricultural, industrial and municipal use, based on the records of ACFCWCD and EBMUD. Many of these wells are inactive. Well permit applications for Alameda County indicate that nearly all of the wells are used for "backyard" or commercial irrigation (91%) with less utilization for industrial process water (8.6%) and municipal drinking water supply (0.4%). Current uses of groundwater, by beneficial use designation category are:

   - Municipal and Domestic Water Supply: There are 6 permitted small water system wells that serve, collectively, over 200 individual users, primarily for backyard irrigation. Hayward also has 5 stand-by wells planned in the event of an emergency. Individual domestic drinking water wells are more difficult to account for due to gaps in databases in the permitting agencies. However, it is believed that there are very few wells used for domestic drinking water. Of the 1422 wells permitted since July 17, 1973 by ACFCWCD, 1417 (99.6%) are for non-drinking water purposes, primarily backyard irrigation. While these backyard irrigation wells are primarily intended for landscape and garden irrigation, incidental ingestion can occur. Therefore, backyard wells are considered a Municipal and Domestic Supply Beneficial Use.
   - Industrial/Process Water Supply: There are 10 active permitted industrial wells that service food processing and product manufacturing operations.
   - Agricultural Water Supply: Groundwater is used at two golf courses, three cemeteries and by several high schools, colleges, parks, and nurseries.

3. In addition to these designated categories, there are over 60 groundwater extraction systems at contaminated sites that collectively are pumping about 800 acre-feet per year.

4. Water service in the East Bay Plain is provided by the City of Hayward and EBMUD in the remaining area (San Lorenzo north to Richmond). Future potential beneficial uses include the use of the Basin's aquifers for storage of imported surface water by EBMUD. This storage is intended for use during a drought or an earthquake. Additional potential uses by EBMUD include municipal extraction wells and non-potable irrigation wells. Based on the Committee's review of general plans for the cities and at a workshop attended by most cities, no groundwater wells are planned for future emergency use other than by Hayward and EBMUD.

5. The East Bay Plain can be subdivided into seven Sub-Areas based on previously defined boundaries and geologic factors. Distinct characteristics are the potential for vertical contaminant migration and the potential for water supply development.

6. Groundwater use is limited in the East Bay Plain by several factors, including a) readily available high quality imported surface water, b) existing high salts in shallow bay margin groundwater, c) the potential for saltwater intrusion, and d) contamination in shallow aquifers. In particular, shallow groundwater use is limited in artificial fill and shallow bay-margin deposits in Richmond and Oakland because these units are largely saturated by brackish Bay water. In San Leandro, shallow groundwater use is limited by extensive shallow groundwater pollution by industrial solvents.

7. At this time, it does not appear prudent to change designations for most of the shallow water bearing units. The geologic relationships between deeper, potentially productive aquifers and shallow water bearing units are not defined well enough to change subregional designations. Furthermore, there were over 15,000 historical groundwater wells that were never appropriately decommissioned. These wells are potential pathways of shallow pollution to deeper aquifers. It is estimated that 8% of these wells are deeper than 200 feet. However, localized changes in some designations are feasible.

RECOMMENDATIONS

As a result of the findings of the regional analysis, the Committee has made specific recommendations to direct better decision-making at polluted sites. Also, the need for groundwater protection and monitoring measures to prevent further pollution is recommended. Some of the recommendations call for specific actions by the Regional Board or its staff, while others require the cooperation of other agencies.

Recommendations requiring action by the Regional Board or its staff:

- The Regional Board should amend the Basin Plan to include the East Bay Plain Basin Sub-Areas.

- The East Bay Plain should be subdivided into three management zones to prioritize groundwater remediation and dedesignate beneficial uses (see Figure 19). Subdivisions were developed by utilizing information on water quality, historic, existing and probable-future beneficial uses, and hydrogeology. The subdivisions are:

  <u>Zone A - Significant drinking water resource.</u> - Groundwater in these areas is an existing or probable drinking water resource. The basin is deep, with depths ranging from 500 to over 1000 feet. Well yields are generally sufficient for municipal supply. Cleanup strategies should be focused on actively maintaining or restoring groundwater quality to drinking water standards. Cleanup, spill prevention and education efforts within the source water protection zones of existing municipal wells should be the top priority of local and state programs.

Also areas with a high density of potential conduit wells and/or shallow backyard wells may need to receive higher priority and be subject to more detailed investigations than other areas.

Zone B - Groundwater that is unlikely to be used as a drinking water resource. In this area the basin is shallow, with depths generally less than 300 feet. Well yields are generally not sufficient for municipal supply. There are no current or planned uses of groundwater as a drinking water source. However, groundwater in these areas is used for backyard irrigation, industrial supply and commercial irrigation. Therefore, dedesignating beneficial uses in this area is not recommended. Remedial strategies should reflect the low probability that groundwater in this zone will be used as a public water supply in the foreseeable future. However, other beneficial uses/exposure pathways exist and should be actively protected. These include domestic irrigation, industrial process supply, human health, and ecological receptors. The potential for exposure via incidental ingestion from back yard wells should be evaluated.

Zone C - Shallow, nonpotable groundwater proposed for dedesignation of the Municipal Supply Beneficial Use. The Regional Board should locally dedesignate the municipal beneficial use for brackish, shallow groundwater in Bay-front artificial fill, young bay mud and the San Antonio Formation/Merritt Sand. This groundwater meets the exemption criteria of the State Water Resources Control Board's (SWRCB's) Sources of Drinking Water Policy because the groundwater could not reasonably be expected to serve a public water supply and exceeds the 3000 mg/L total dissolved solids criteria. Cleanup should be protective of ecological receptors and human health. Pursuant to SWRCB Resolution 92-49, pollution sites will continue to be required to demonstrate 1) that reasonably adequate source removal has occurred, 2) the plume has been reasonably defined both laterally and vertically and 3) a long-term monitoring program is established to verify that the plume is stable and will not impact ecological receptors or human health

- Within the East Bay Plain, there are groundwater pollution plumes that may warrant less aggressive remediation on a case-by-case basis. In certain cases, aggressive cleanup may not be warranted when the plume is shallow, concentrations are declining and no beneficial uses are threatened. The requirement for aggressive cleanup can pose a serious obstacle to redevelopment of blighted urban areas in the East Bay. This report outlines “basin specific” situations where less aggressive remediation may be warranted. Ultimately, the remedial options that would be part of a less aggressive strategy depend on site specific conditions. However, likely options would include restricting groundwater remediation to the source area only, allowing monitored natural attenuation, or implementing pump-and-treat solely to limit plume migration.

- Regional Board staff should encourage the use of aquifers in the East Bay Plain for groundwater storage. If groundwater from existing sources or surface water is stored in these aquifers (either from surface water sources in wet years or from treated wastewater), demand on limited surface water resources can be reduced.
- The methods required for conducting a Vertical Conduit Study and Well Search in the East Bay Plain should be formalized by Regional Board staff.
- Regional Board staff should encourage the establishment of a basin-wide groundwater management program.
- The GIS coverages displayed in this report should be updated regularly and placed on the Internet.

Recommendations requiring follow-up in cooperation with other agencies:

- The five agencies that maintain well databases within the East Bay Plain should make the data accessible to the public at a single agency.
- The existing ACFCWCD regional groundwater monitoring network should be expanded to include more wells, sampled more frequently, and monitored for a larger list of chemicals of concern. A similar network is also needed in the Contra Costa County portion of the East Bay Plain.
- Regulatory agencies should request that both ACFCWCD and EBMUD well databases are searched for current well locations as part of groundwater pollution site investigations.
- Well abandonment programs should be undertaken by appropriate Alameda and Contra Costa agencies in areas where groundwater resources are at risk.
- Together with ACFCWCD and EBMUD, the Regional Board staff should encourage the establishment of a basin-wide groundwater management program.

EAST BAY PLAIN GROUNDWATER BASIN
BENEFICIAL USE EVALUATION REPORT

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AVAILABLE UPON REQUEST

1.0 INTRODUCTION

The in-house Groundwater Committee (Committee) for the San Francisco Bay Regional Water Quality Control Board (Regional Board), and other State and local agencies completed the *San Francisco and Northern San Mateo County Pilot Beneficial Use Designation Project* in April 1996. The 1996 project evaluated alternatives to the current framework of groundwater beneficial use designation. As a result of this project, the Regional Board staff recommended that the preferred alternative, the Hydrogeologic Framework, should be tested in other groundwater basins. The East Bay Plain Groundwater Basin (East Bay Plain) was highlighted as a good test candidate. The goal of this project is to better define groundwater beneficial uses in the East Bay Plain. Located between San Francisco Bay and the East Bay Hills, the East Bay Plain is a highly urbanized groundwater basin (Figure 1).

1.1 About This Report

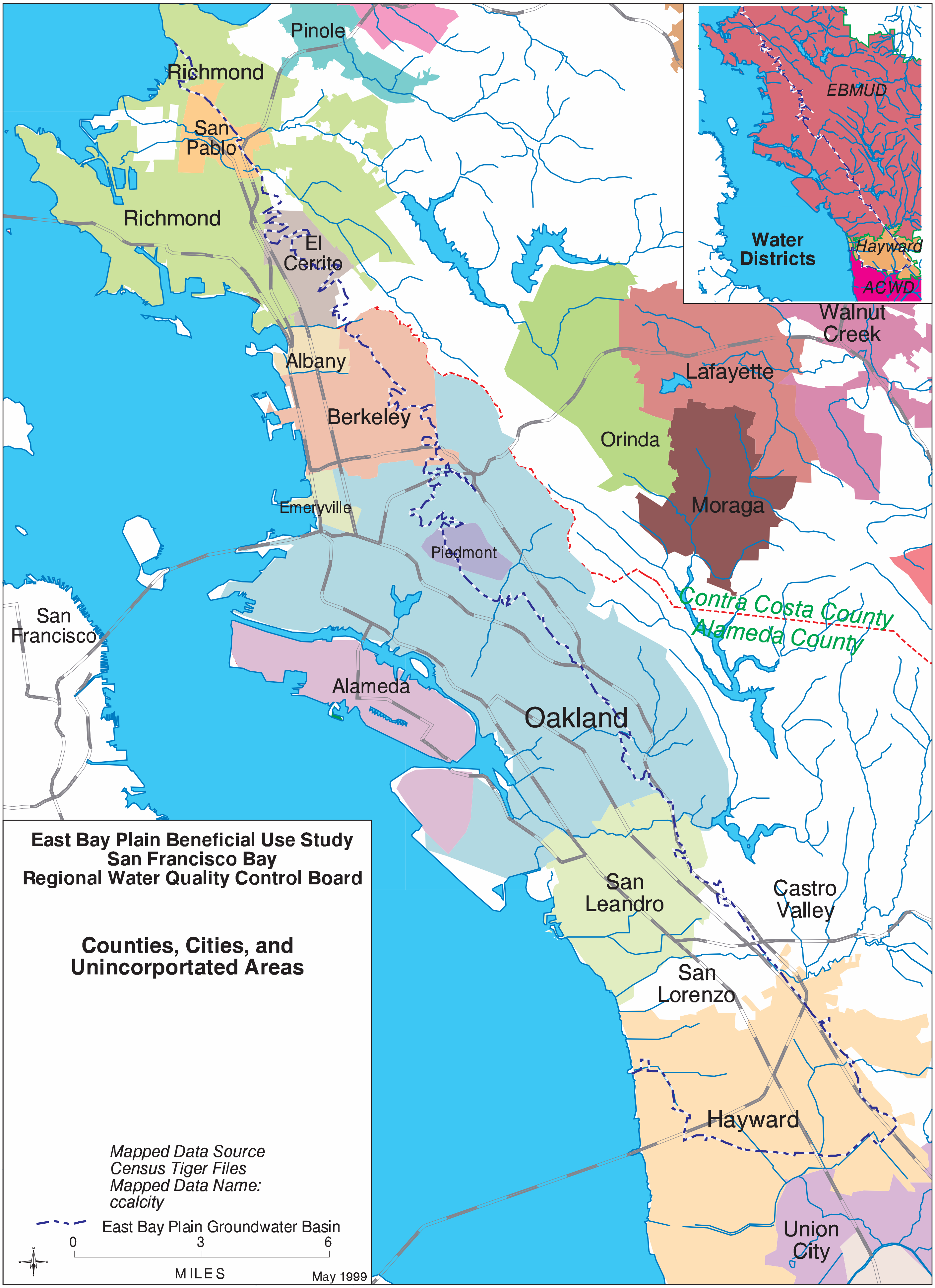
This report leads the reader through the steps that were followed to complete the beneficial use project. Sections 1-5 provide the background and context of the project. Sections 6-13 cover the physical and chemical characteristics of the East Bay Plain. Historic and current groundwater beneficial uses are analyzed in sections 12-13. Section 14 highlights local redevelopment and regulatory initiatives in Oakland, Berkeley, Emeryville and Richmond. The key findings and recommendations are presented in Sections 15-17. The proposed revisions and an accompanying CEQA analysis will be brought before the Regional Board for consideration of a Water Quality Control Plan (Basin Plan) Amendment.

1.2 Background

The urbanized East Bay Plain includes 12 cities, the five largest being Oakland, Berkeley, Hayward, Richmond and San Leandro. The total population within the Plain is over 900,000. From the 1860's to the 1930's, all water supplies to the East Bay Plain area were provided by groundwater, springs, and local reservoirs (Figures 2 and 3). As a result of the development of various Sierra Nevada water supplies in the 1920's and 1930's, all local East Bay Plain municipal water supplies were abandoned. Since then, the East Bay Plain has not been a regional source of water. However, the East Bay Plain is used locally for irrigation, industrial and emergency water supply purposes and as a limited drinking water supply.

There are areas of the East Bay Plain where beneficial use is limited due to brackish water quality, low sustainable yields, or the presence of pollution. This project seeks to balance the need to protect existing and potential future groundwater resources with the need to develop realistic cleanup goals for polluted groundwater in areas of limited beneficial use. To achieve this balance we framed the following key questions:

- What are the current and planned future groundwater beneficial uses of the East Bay Plain?
- Can the East Bay Plain be subdivided into Sub-Areas based on hydrogeology?
- Where is the use of the East Bay Plain limited?
- Can the shallow and deeper zones have different designations?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San Lorenzo
Hayward
Union City
Orinda
Lafayette
Walnut Creek
Moraga
Contra Costa County
Alameda County
EBMUD
Water Districts
Hayward
ACWD
East Bay Plain Beneficial Use Study
San Francisco Bay
Regional Water Quality Control Board
Counties, Cities, and Unincorporated Areas
Mapped Data Source
Census Tiger Files
Mapped Data Name:
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East Bay Plain Groundwater Basin
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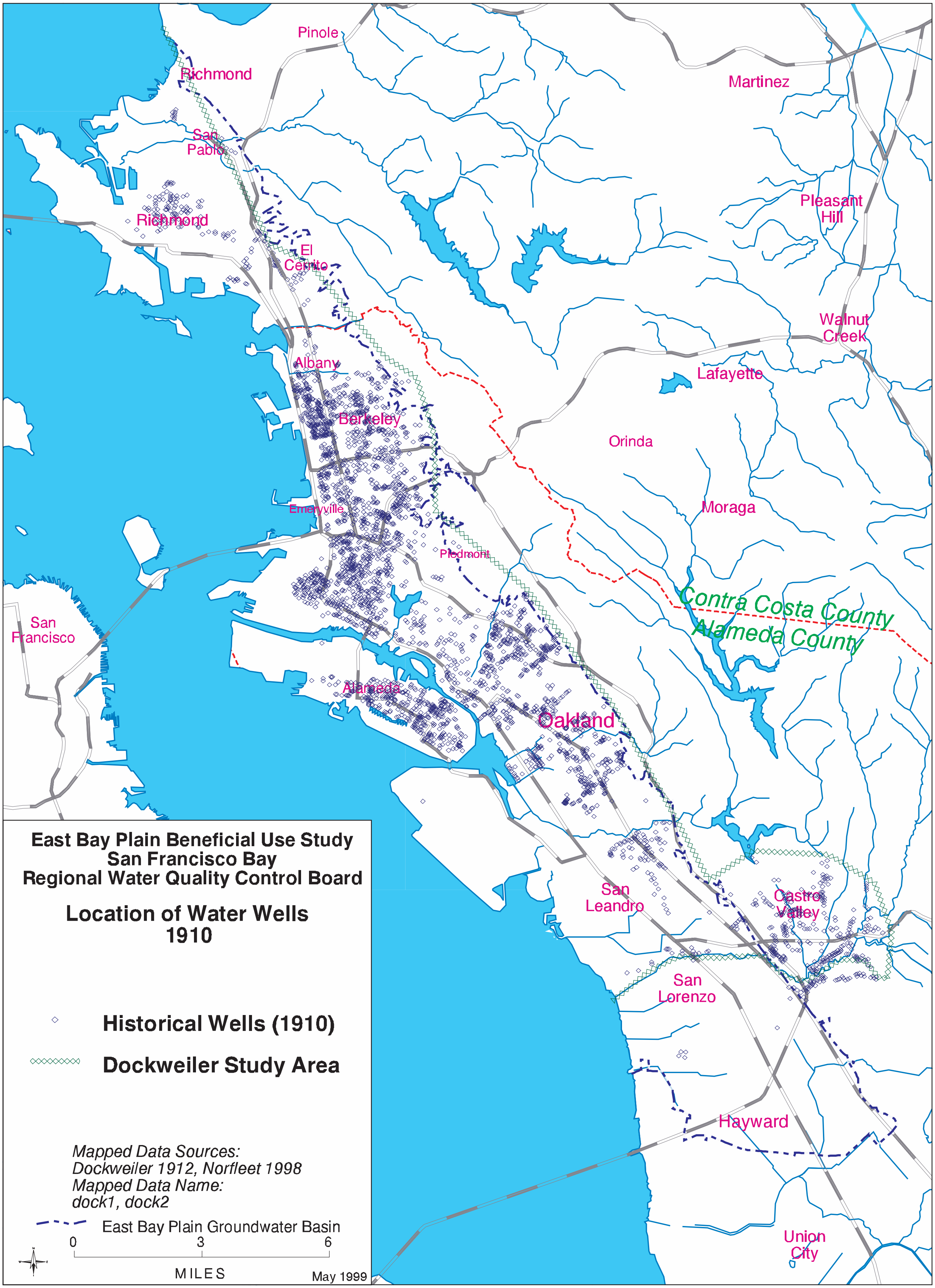
Figure 1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Contra Costa County
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San Francisco
Alameda
Oakland
San Leandro
Castro Valley
San Lorenzo
Hayward
Union City
East Bay Plain Beneficial Use Study
San Francisco Bay
Regional Water Quality Control Board
Location of Water Wells
1910
Historical Wells (1910)
Dockweiler Study Area
Mapped Data Sources:
Dockweiler 1912, Norfleet 1998
Mapped Data Name:
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East Bay Plain Groundwater Basin
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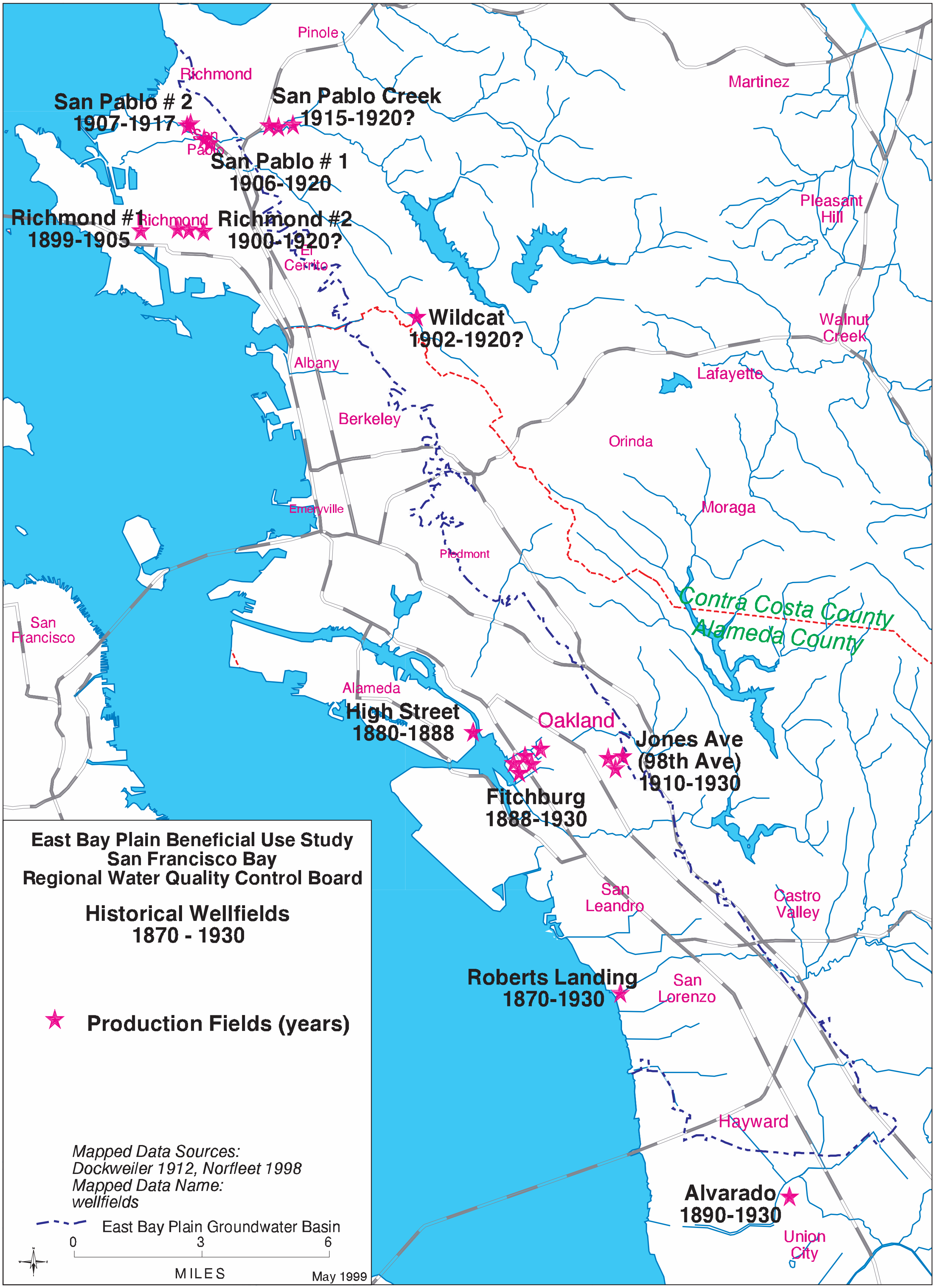
Figure 2


Pinole
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San Pablo # 2
1907-1917
San Pablo Creek
1915-1920?
Martinez
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1906-1920
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Richmond #2
1900-1920?
El Cerrito
Pleasant Hill
Wildcat
1902-1920?
Walnut Creek
Albany
Lafayette
Berkeley
Orinda
Emeryville
Moraga
Piedmont
Contra Costa County
Alameda County
San Francisco
Alameda
High Street
1880-1888
Oakland
Jones Ave
(98th Ave)
1910-1930
Fitchburg
1888-1930
San Leandro
Castro Valley
Roberts Landing
1870-1930
San Lorenzo
Hayward
Alvarado
1890-1930
Union City
East Bay Plain Beneficial Use Study
San Francisco Bay
Regional Water Quality Control Board
Historical Wellfields
1870 - 1930
Production Fields (years)
Mapped Data Sources:
Dockweiler 1912, Norfleet 1998
Mapped Data Name:
wellfields
East Bay Plain Groundwater Basin
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May 1999

Figure 3

- Should any current beneficial use designations change?
- Are there areas requiring special protection programs?

1.3 Selection of East Bay Plain as Study Area

The Plain offers an excellent opportunity to conduct a groundwater beneficial use evaluation as a follow up to the Regional Board's San Francisco/ Northern San Mateo County Project (Regional Board, 1996). Information is available on current beneficial uses of groundwater, and largely forgotten historical information has been brought to light. The East Bay Plain includes areas that currently provide drinking water and areas that are unlikely to. U.S. EPA's Brownfields Programs are being studied for Emeryville, Oakland and Richmond, which could potentially benefit from this project. Simultaneously, the East Bay Municipal Utility District (EBMUD) is studying the feasibility of using the East Bay Plain for conjunctive use. EBMUD's study of using Aquifer Storage Recovery technology to inject imported surface water into the East Bay Plain raises important questions about its future beneficial uses (see Section 13.5).

Lastly, given the large number of groundwater pollution sites, a better definition of beneficial uses could focus expenditure of public and private resources on groundwater remediation on areas that are either existing or probable future drinking water sources. Correspondingly, in areas where no groundwater use exists and its future use is unlikely, remediation could be driven by human health and environmental risks associated with non-potable users.

1.4 Groundwater Committee

The Committee recommends policy on groundwater issues, conveys and shares new information and events related to groundwater pollution cleanup, and fosters internal consistency on groundwater policy implementation. The Committee normally consists of Regional Board line staff, supervisors, and managers from all five staff divisions.

The Committee's first major project was the groundwater Basin Plan Amendment adopted by the Board in 1992. Significant portions of this amendment have been used by the State and other regional boards in their Basin Plan updates. It highlights the Board's experience with groundwater cleanup since the early 1980's and includes a recommendation to evaluate the Board's existing approach to managing site cleanups. This includes a review of the beneficial use designations for each of the Region's groundwater basins.

In 1994, the Committee conducted a survey among its members and other interested Board staff to identify the primary unresolved issues in dealing with groundwater pollution cleanup within the Region. The results of the survey identified inconsistencies in applying the State Board's "Sources of Drinking Water" Policy (Sources Policy) to groundwater pollution cleanup and the corresponding need for refinement of beneficial use designations. This was similar to the Basin Plan's recommendation to streamline Board programs by developing "cleanup levels and policies for individual groundwater basins or Sub-Areas based on designated beneficial uses."

The Committee then embarked on its first pilot beneficial use project, which was San

Francisco and Northern San Mateo County. Between 1994 and 1996, the Committee designed and completed a comprehensive evaluation of hydrogeology, future groundwater uses, and alternatives for revised beneficial use designations. At the April 16, 1996, Regional Board meeting, staff presented the project summary report titled, "The San Francisco and Northern San Mateo County Pilot Beneficial Use Designation Project." The draft staff report provided the following recommendations:

- Three different methods for defining beneficial uses were evaluated. For groundwater basins in the study area, the Hydrogeologic Framework is the preferred alternative.
- Portions of the seven groundwater basins within the study area should retain their existing designations.
- Beneficial uses should be changed for the Downtown San Francisco Basin and portions of other basins composed of Franciscan Bedrock, artificial fill or bay mud.
- Corrective action strategies should match revised beneficial use designations. These strategies include aggressive cleanup to drinking water standards, passive cleanup with drinking water standards achieved as a long-term goal, and cleanup and management to goals defined by risk analysis.

After this pilot project was completed, the Committee decided to test the Hydrogeologic Framework in other basins. In late 1996, a second pilot project was initiated in the East Bay Plain.

2.0 STAKEHOLDER PARTICIPATION

On January 29, 1997, the Committee held a workshop for all potential agency stakeholders in the East Bay Plain Region. Included were municipal and county elected officials, water agencies, flood control districts, planning agencies, health and regulatory agencies, and city managers, as well as the East Bay Regional Park District, the Port of Oakland, U.S. Geological Survey, U.S. EPA, U.S. Navy; dischargers, and state agencies: Department of Water Resources, CALTRANS, Department of Toxic Substances Control, State Water Resources Control Board, and Department of Health Services. Stakeholders were invited to participate in the pilot project to update the beneficial use designation of groundwater in the East Bay Plain. Fifty-six individuals representing thirty-one agencies attended this workshop. The attendees are listed in Appendix C.

Participants were asked to give their input in the initial planning phases of the project and to share any information regarding their current or planned use of groundwater in the project area. The Committee also asked to review any evaluations of groundwater supplies that stakeholders might have. Input was also requested about how best to clean up and manage polluted groundwater.

The Committee felt that it was very important to include all of the agency stakeholders in the preliminary stage of this pilot project. After the initial workshops, agency representatives from EBMUD, Port of Oakland, DTSC, US Navy, the Alameda County Flood Control and Water Conservation District, the City of Oakland, and the City of San Leandro became active participants with Regional Board staff on the Committee.

3.0 METHODS

The methods used for this Pilot Project (Figure 4) were similar to those used in the San Francisco/San Mateo Beneficial Use Study (Regional Board, 1996). First, the best information available was compiled on beneficial uses and existing water quality. This information was compiled and analyzed on an ArcView GIS database. Second, a conceptual groundwater framework was developed that identified major aquifers and aquicludes, recharge areas, discharge areas, storage, potential for vertical migration, groundwater flow direction, etc. Third, findings were made regarding the overall condition of the East Bay Plain and its ability to meet all of the beneficial uses documented in the Basin Plan (RWQCB, 1995).

3.1 Investigation by Norfleet Consultants

One of the key resources that the Committee used for the beneficial use analysis was a comprehensive study on the area prepared by Sandy Figuers, Ph.D. (1998). This study provides a geologic, hydrologic and historical framework of the East Bay Plain.

The report, titled "Groundwater Study and Water Supply History of the East Bay Plain, Alameda and Contra Costa Counties, CA.," built upon the previous work by Dr. Figuers (Rogers and Figuers, 1991). Figuers' work included an in-depth search for and review of documents held in 12 libraries that yielded over 250 contemporary and historical references. In addition, he evaluated the subsurface geology, created the first basin-wide subsurface bedrock map, delineated areas of historical groundwater use, and proposed subdividing the basin into Sub-Areas.

Figuers' work expands on the efforts by previous workers including notably Muir (1993, 1996, 1997), Maslonkowski (1988) and the California Department of Water Resources (1963, 1994) to create the principal reference on East Bay Plain geology, hydrogeology and groundwater history.

3.2 Geographic Information System (GIS) Analysis

The GIS analysis in this report was performed by the staff of EBMUD and the Regional Board using Arc/INFO 7.2.1 and ArcView 3.0a software. Coverages were collected and compiled from a variety of sources and agencies, including the Regional Board, EBMUD, U.S. Geological Survey, U.S. Navy, Association of Bay Area Governments, Division of Toxic Substances Control, Norfleet Consultants and the County of Alameda. Where necessary, coverages were modified in consultation with one-meter resolution digital orthophotographs to enable proper overlay and display. SLIC and LUST data were geocoded by the Regional Board based on 1993 TIGER street data. The minimum coverage scale is 1:100000.

The proximity analysis of the well and toxic site data was performed at distances of 660 feet (approximately 1/8 mile), 1000 feet and 2000 feet. The lowest number was assumed to be the minimum possible distance for which accurate results could be obtained as the wells in the Alameda County Well Database are referenced by Township-Range quartersection coordinate, whose diagonal distance is 660 feet. Since the 660-foot distance is also approximately the same length as the average city block, it is assumed that the distance also provides sufficient flexibility to account

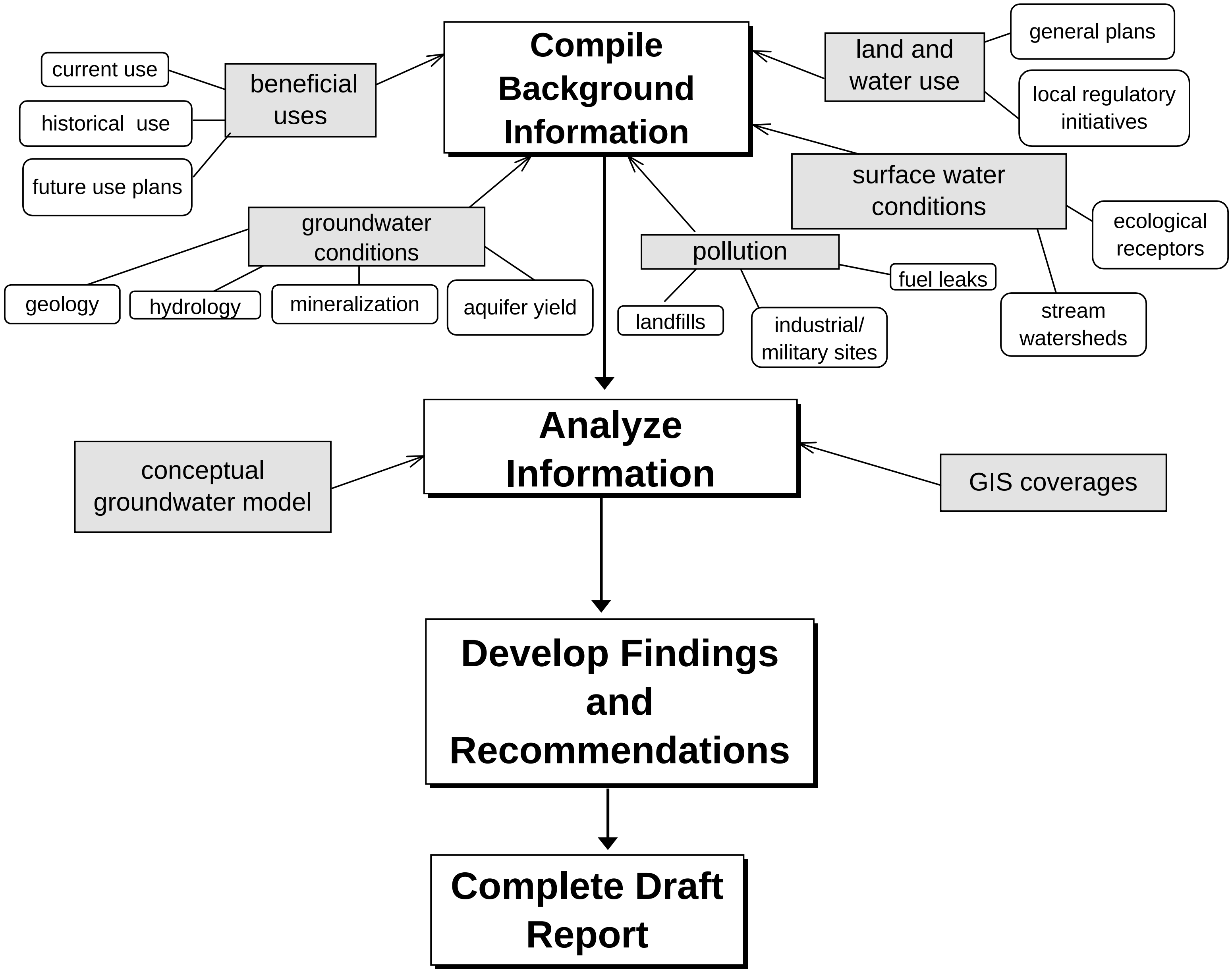


Figure 4. Methods for the East Bay Plain Groundwater Beneficial Use Evaluation

for most variation in accuracy.

4.0 CURRENT STATE WATER RESOURCES CONTROL BOARD POLICIES FOR GROUNDWATER

4.1 Resolution 68-16, "Statement of Policy with Respect to Maintaining High Quality of Waters in California"

Adopted in 1968, the Policy requires that where water quality objectives are set by Basin Plans or the Porter Cologne Act, existing water quality must be maintained. The resolution says:

> "1. Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial use of such water and will not result in water quality less than that prescribed in the policies.
>
> 2. Any activity which produces or may produce a waste or increased volume or concentration of waste and which discharges or proposes to discharge to existing high quality waters will be required to meet waste discharge requirements which will result in the best practicable treatment or control of the discharge necessary to assure that (a) a pollution or nuisance will not occur and (b) the highest water quality consistent with maximum benefit to the people of the state will be maintained.
>
> 3. In implementing this policy, the Secretary of the Interior will be kept advised and will be provided with such information as he will need to discharge his responsibilities under the Federal Water Pollution Control Act."

This implies cleanup must be made to non-detect or background levels. Background is the lowest concentration limit required for groundwater protection. Chemical specific objectives for bacteria, organic and inorganic constituents, radioactivity, and taste and odor define the upper limit that is protective of beneficial uses. These objectives are based on Federal and State published standards and guidelines. Other site-specific limits are risk-based. The Policy does provide conditions under which a change in water quality is allowable. A change must:

- Be consistent with maximum benefit to the people of the state;
- Not unreasonably affect present and anticipated beneficial uses of water; and
- Not result in water quality less than that prescribed in the water quality policies.

4.2 Resolution 88-63, Sources of Drinking Water Policy (Sources Policy)

The Sources Policy was adopted by the State Board in 1988, following the passage of Proposition 65, which required public notification when specific cancer-causing chemicals were discharged into "sources of drinking water." The Sources Policy was incorporated into the Basin Plan in 1989 (Regional Board Order No. 89-39). The Sources Policy assigns municipal and domestic supply designations to all waters of the state with certain exceptions. The Sources Policy specifies that "any body of water that is not currently designated as MUN (municipal and domestic supply) but, in the opinion of the Regional Board, is presently or potentially suitable for MUN and domestic water, the Regional Board shall include MUN in the beneficial use designation." The Sources Policy allows for exceptions if the Regional Board has previously assigned specific designations or if specific exemption criteria are met. These exemption criteria are as follows:

- The total dissolved solids (TDS) exceed 3,000 mg/l (5,000 uS/cm, electrical conductivity) and it is not reasonably expected by the Regional Board that the groundwater could supply a public water system; *or*,

- There is contamination, either by natural processes or by human activity (unrelated to a specific pollution incident), that cannot reasonably be treated for domestic use using either Best Management Practices or best economically achievable treatment practices; *or*,

- The water source does not provide sufficient water to supply a single well capable of producing an average, sustained yield of 200 gallons per day; *or*,

- The aquifer is regulated as a geothermal energy producing source or has been exempted administratively pursuant to 40 CFR Section 146.4 for the purpose of underground injection of fluids associated with the production of hydrocarbon or geothermal energy, provided that these fluids do not constitute a hazardous waste under 40 CFR Section 261.3.

Basin Plan Table 2-9 (Appendix A), applies the beneficial use designations to groundwaters. In this table, each of the Region's groundwater basins is identified, and their existing and potential beneficial uses are designated. Identification of the groundwater basins is based on the Department of Water Resources (DWR) Bulletin 118-80. In addition to these designations, the Basin Plan further states that all subsurface waters are considered suitable, or potentially suitable, for municipal or domestic supply. Therefore, groundwater that falls outside of the identified basins was included within this designation.

4.3 Resolution 92-49, Policies and Procedures for Investigation and Cleanup and Abatement of Discharges under Water Code, Section 13304.

This Resolution was enacted in June 1992, amended in April 1994 and again in October 1996. Resolution 92-49 establishes policies and procedures for the oversight of investigations and cleanup and abatement activities resulting from discharges of hazardous substances. It requires regional boards to meet the highest levels reasonably attainable where, at a minimum, water quality objectives, established in the Basin Plans, must be met. If it is not reasonable to restore water quality to background levels, case by case cleanup levels may be specified, depending on the water quality provisions of a regional board's Basin Plan, beneficial uses of the waters, and maximum benefit to the people of the state.

4.4 Resolution 96-79, Adoption of Containment Zone Policy

Adopted October 2, 1996, Resolution 96-79 amends Resolution No. 92-49 to include the Containment Zone Policy. In recent years, the State Board and the regional boards have found that, in some circumstances, compliance with water quality objectives for groundwater as part of cleanup actions cannot be reasonably achieved. Since there were no procedures to address the inability of meeting Basin Plan objectives, Resolution 92-49 was further amended to include the Containment Zone Policy. This Policy establishes conditions under which a regional board may establish containment zones. That is, specific portions of groundwater-bearing units where water quality objectives cannot be reasonably achieved. The amendment therefore recognizes that some pollutants will remain within the containment zone for a period of time.

Since there is a potential for the migration of polluted water into uncontaminated waters, the amendment requires the discharger to contain pollutants within the area of the containment zone. The containment zone designation will be revoked if chemicals migrate outside of that area.

The amendment also includes an environmental document, the Functional Equivalent Document (FED). The FED is intended to be "functionally equivalent" to the CEQA process, therefore fulfilling the requirement for preparing Environmental Impact Reports, Negative Declarations, and Initial Studies.

5.0 GROUNDWATER REGULATORY AGENCIES

5.1 Federal

5.1.1 U.S. Environmental Protection Agency (EPA)

EPA has the regulatory lead for the National Priorities List (NPL) Superfund sites. They also provide grant funding for other regulatory programs.

5.1.2 U.S. EPA's Groundwater Classification Guidelines

Under State Water Board Resolution 88-63 (see Section 4.2), all state waters are considered to be potential drinking water unless either the total dissolved solids (TDS) exceeds 3000 mg/l and the Regional Water Board makes a determination that the water is not reasonably expected to supply a public water system, or the yield is less than 200 gal/day. However, EPA's Groundwater Classification Guidelines use a stricter standard of 10,000 mg/l TDS or less and a yield of 150 gal/day to define a potential drinking water source. The National Contingency Plan (NCP) Preamble directs EPA to use the Guidelines when determining the appropriate remediation for contaminated groundwater at CERCLA (Superfund) sites and EPA's OSWER Directive #9283.1-09 directs EPA to defer to the NCP Preamble and the Guidelines when a state does not have an EPA endorsed Comprehensive State Groundwater Protection Program (CSGWPP). EPA's definition is based on the importance of maintaining broad protections of potential drinking water sources in light of the growing demands on drinking water supplies. Since California does not have a CSGWPP, the federal definition of potential drinking water (10,000 ppm TDS or less and a yield of 150 gal/day) has recently been required by USEPA at CERCLA sites. Of the 1430 groundwater contamination sites in the East Bay Plain, CERCLA sites accounted for 3% by number and roughly 10% by area. These CERCLA sites consist primarily of closing Navy bases that are undergoing investigation and remediation as part of base reuse.

5.2 State of California

The major California laws regulating cleanup of pollution sites are contained in the Health and Safety Code and the Water Code. The nature of these chemicals and their effects on human health and the environment has long involved multi-agency oversight for the cleanup of these sites. In addition to the state agencies, several county and city agencies participate in regulatory activities. The state agencies usually have the lead in overseeing the cleanup of these sites.

5.2.1 Regional Water Quality Control Board (Regional Board)

The mission of the Regional Board is to protect the beneficial uses of the Region's surface and groundwater. Beneficial uses are the resources, services, and qualities of aquatic ecosystems that are the ultimate goals of protecting and achieving water quality. The Board works with local public entities and industry to ensure that they comply with the policies and objectives of the Water Quality Control Plan (Basin Plan) which is intended to guide local officials. The Regional Board will consider any proposed alternative actions that are consistent with the Basin Plan. The Regional Board oversees many programs with and without local program participation.

5.2.1.1 The "Spills, Leaks, Investigation and Cleanup" (SLIC) Program

SLIC is the program term used by the State Water Resources Control Board and Regional Boards to define those sites with groundwater polluted by chemicals other than total petroleum hydrocarbon (TPHs) that are used as fuels. These chemicals include, but are not limited to, polyaromatic hydrocarbons (PAHs), volatile organic chemicals (VOCs), PCBs, metals and pesticides. Most of the 32 SLIC sites in the study area are located on the western side in old industrial areas.

Because of the nature of these chemicals and their effects on human health and the environment, a group of agencies has long been involved in overseeing the cleanup of these sites. In addition to state agencies, several county and city agencies have had a significant role in the process. Usually, a state agency has the lead for overseeing the cleanup of SLIC and other toxic sites, but because of local agencies participating actively in determining cleanup levels and time frames, the role of the lead agency becomes less distinct. One reason is that SLIC sites do not have a Local Oversight Program like the leaking underground storage tank sites (LUSTs) program (see below).

5.2.1.2 Non-SLIC Regional Board-lead groundwater cleanup sites

This class of sites includes the Unocal Oil Terminal in Richmond and the PG&E facility in Oakland that use aboveground tanks for storing petroleum hydrocarbons; and the groundwater cleanup under the Chevron refinery in Richmond (the only refinery located on the Plain). Although the Regional Board is the lead agency for these sites, the corresponding County Health Departments are consulted on soil cleanup issues.

Although the Regional Board has the authority to protect groundwater quality, the non-distinguishable relationships between human health, the environment, land-use, and economic considerations have complicated the regulatory roles of all agencies involved in site cleanup. Occasional inconsistencies in cleanup requirements, and the lack of coordination and information sharing between these agencies, have resulted in regulatory oversight that is not as efficient as it could be. Table 1 provides a breakdown of the number and types of cases each agency regulates. This "multi-agency" approach to regulating groundwater pollution presents both advantages and disadvantages. The advantage is that it allows each agency to use the unique skills and legal tools that it possesses and it makes the best use of limited resources to provide oversight of the thousands of sites in the East Bay Plain. The main disadvantage is the lack of a coordinated "watershed" approach to prioritizing sites, compiling data, and sharing information. For example, in San Leandro four agencies need to be contacted to get information on groundwater pollution sites. The East Bay Plain is essentially a large unmanaged basin with pollution sites regulated by any of eight different environmental agencies.

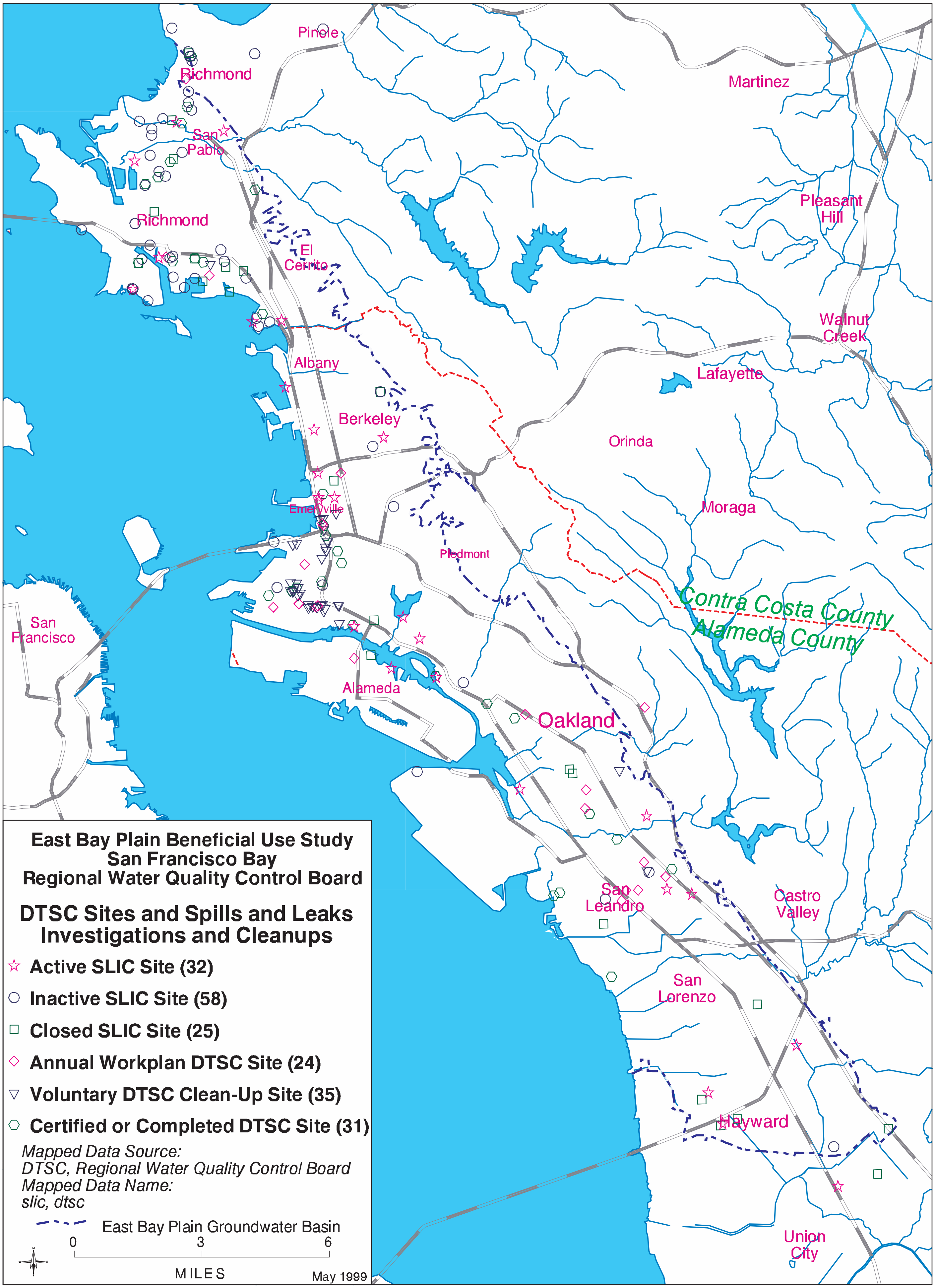
Table 1. Summary of Groundwater Cleanup Regulatory Agencies in the East Bay Plain

Agency	Types of Groundwater Pollution Cases Regulated	Number of active cases in East Bay Plain except where noted otherwise [1]	Comments
U.S. EPA	Superfund Sites, DoD Sites/Emergency Response	52 Fuel Sites 19 VOC Sites	Oversight of cleanup at closing military bases and DC Metals
CA Department of Toxic Substances Control	VOCs, metals, RCRA, state lead for DoD Sites	90	From Calsites Database
CA Regional Water Quality Control Board	VOCs, Metals, coordinates LUFT Program, Landfills, Refineries, consults on DoD Sites	Active LUFT: 1310 [2] Nonfuel/SLIC: 32 Landfills: (1 active and 10 closed)	
Alameda County Environmental Health Services	Local Oversight Program for Fuels, also active in SLIC Sites	1235	
Contra Costa County Department of Environ. Health	Non-Local Oversight Program for Fuels	686 within entire county	RWQCB is lead for all sites.
City of Berkeley, Planning and Development Department, Toxics Management Division	Non-Local Oversight Program for Fuels	194	
San Leandro Fire Department	Non-Local Oversight Program for Fuels	121	
Hayward Fire Department	Non-Local Oversight Program for Fuels	256	

1Total number of sites as of January 1998.
2 LUFT total includes fuel sites regulated by other agencies.

5.2.2 Department of Toxic Substances Control (DTSC) protects public health and the environment from the effects of hazardous substances as required by Chapter 6.8 of the California Health and Safety Code. They are required to ensure that contaminated sites are cleaned up in accordance with state and federal laws and they regulate the generation, storage, treatment, transportation, handling, and disposal of hazardous wastes. DTSC is organized into two separate programs, Site Mitigation and Hazardous Waste Management Program (Figure 5).

5.2.2.1 Site Mitigation Program oversees the investigation and remediation of hazardous substance release sites, including military facilities as well as private party sites. According to the


Pinole
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San Pablo
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El Cerrito
Pleasant Hill
Walnut Creek
Albany
Lafayette
Berkeley
Orinda
Moraga
Emeryville
Piedmont
Contra Costa County
Alameda County
San Francisco
Alameda
Oakland
San Leandro
Castro Valley
San Lorenzo
Hayward
Union City
East Bay Plain Beneficial Use Study
San Francisco Bay
Regional Water Quality Control Board
DTSC Sites and Spills and Leaks
Investigations and Cleanups
Active SLIC Site (32)
Inactive SLIC Site (58)
Closed SLIC Site (25)
Annual Workplan DTSC Site (24)
Voluntary DTSC Clean-Up Site (35)
Certified or Completed DTSC Site (31)
Mapped Data Source:
DTSC, Regional Water Quality Control Board
Mapped Data Name:
slic, dtsc
East Bay Plain Groundwater Basin
0
3
6
MILES
May 1999

Figure 5

"CALSITES LIST" database, DTSC currently oversees the investigation and cleanup of 90 sites in the East Bay Plain. Responsibility includes the oversight of remediation of both soil and groundwater contamination. Larger projects include the DWA Plume (San Leandro), Barbary Coast (Emeryville), Cypress Freeway Reconstruction Projects (Oakland), and the Liquid Gold Site (Richmond).

5.2.2.2 Hazardous Waste Management Program is responsible for permitting corrective action, and enforcement for sites that handle hazardous wastes. This includes generators, transporters, as well as those who accept offsite waste for treatment or disposal.

5.2.3 Landfills

Landfills are regulated by the Regional Board in coordination with the California Integrated Waste Management Board and the Local Oversight Agency (Alameda County and Contra Costa County Health Departments). Of the eleven regulated landfills in the East Bay Plain, only one (West Contra Costa Landfill) is still open and accepting waste. See Section 9.4 and Table 3B for more information on landfills.

5.2.4 Department of Health Services

The Drinking Water Source Assessment and Protection (DWSAP) Program was prepared in response to 1996 amendments to the federal Safe Drinking Water Act (SDWA). These amendments included requirements for states to develop a program to assess sources of drinking water and encourage states to establish drinking water protection programs. The Department of Health Services (DHS) Division of Drinking Water and Environmental Management is the lead agency for development and implementation of the DWSAP Program.

The drinking water source assessment is the first step in developing a complete drinking water source protection program. The assessments enable determinations to be made as to whether a drinking water source may be vulnerable to contamination. Assessments are to be completed between November 1999 and May 2003.

California's DWSAP Program addresses both groundwater and surface water sources, and draws upon EPA guidance, DHS' experience from related programs and advice from advisory committees and the public. The groundwater portion of the DWSAP will serve as the State's wellhead protection program. The surface water components of the DWSAP will be developed using DHS' experience with other activities such as watershed sanitary surveys.

Although DHS is responsible for performing the assessments, some public water systems may wish to perform their own. In such cases, the assessments must be conducted in conformance with DHS procedures.

A copy of the DWSAP can be found on the internet at http://www.dhs.cahwnet.gov.

5.3 Local Agencies (Counties, Cities and Special Districts)

Local oversight differs from county to county and city to city:

(a) Contra Costa County and Cities - sites within the Study Area are overseen by the Regional Board or DTSC, with some assistance from the County Health Services Department.

(b) Alameda County and Cities - involvement varies from city to city.

San Leandro - DTSC, the Alameda County Health Services Department (ACHSD), the Regional Board and the City of San Leandro all assume lead roles for various sites in San Leandro.

Hayward - the Regional Board is usually the lead agency with ACHSD taking the lead on some pesticide-polluted sites. The City of Hayward is the lead agency for most fuel sites in Hayward.

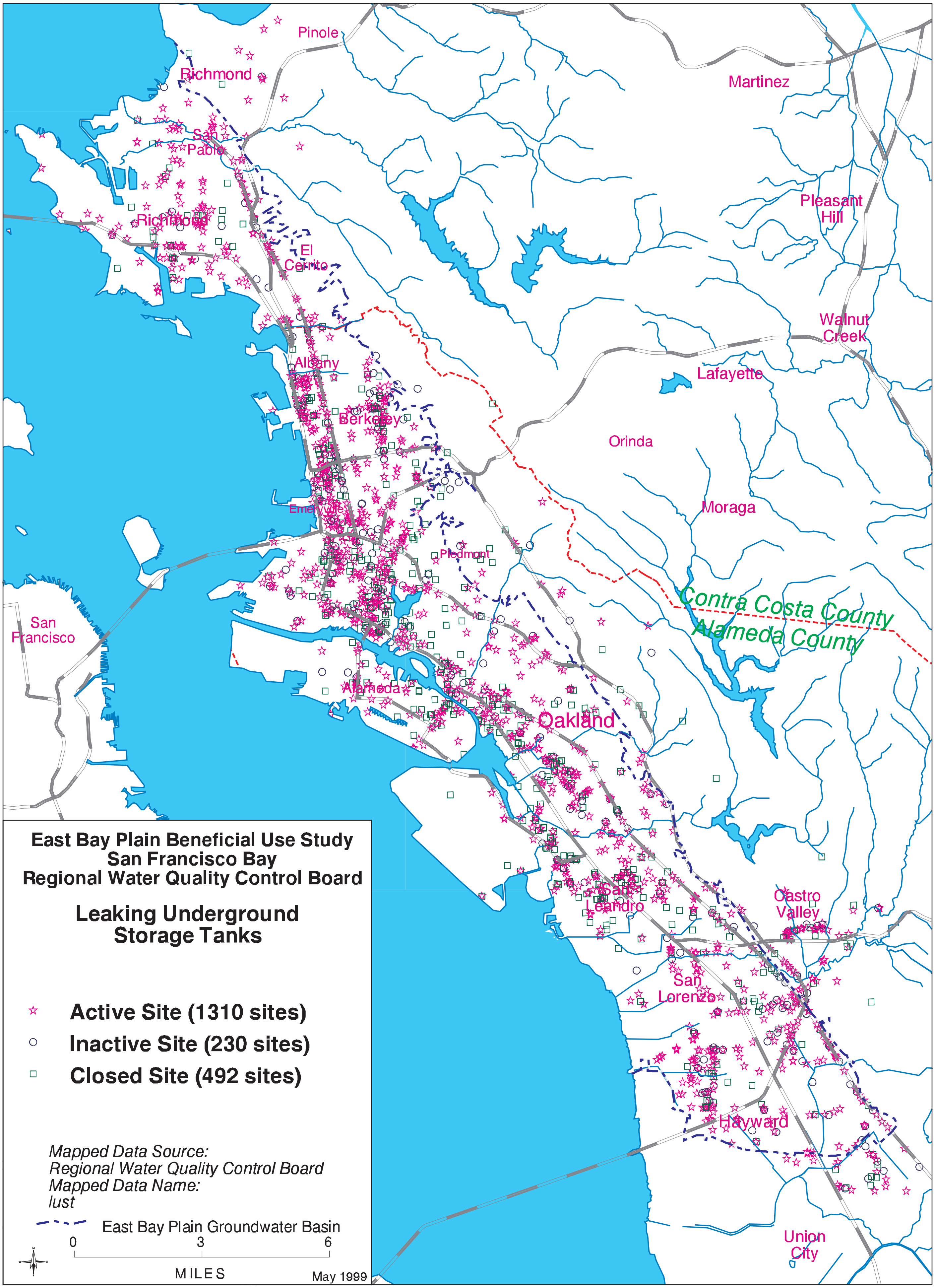
Emeryville and Oakland - the lead is usually a joint effort between the Regional Board and ACHSD, with DTSC taking the lead in several large pollution sites, such as the Cypress Freeway Project.

Berkeley - the City of Berkeley, Planning and Development Department, Toxics Management Division (TMD), oversees the cleanup of pollution sites; the Regional Board provides technical and regulatory support for the agency.

5.3.1 Local Oversight Program (LOP) for Leaking Underground Fuel Tank Sites

The Local Oversight Program (LOP) and the Local Implementing Agencies (LIAs, see below) were formed to oversee the closing of Leaking Underground Fuel Tanks (LUFTs) in the State. As of January 1998, the Regional Board had 1310 sites (see Table 1 and Figure 6). Developed in the late 1980's as a pilot program the LOP was codified in 1990 in Section 25297.1 of Chapter 6.7 of the Health and Safety Code. Under Section 25283 of this Code ("Underground Storage of Hazardous Substances"), counties or local agencies are required to implement the conditions of the chapter as they relate to permitting, inspection, and monitoring of Underground Storage Tanks (USTs). Under the LOP program, the State Water Resources Control Board (SWRCB) contracted with local agencies, including Alameda County, that agreed to oversee the remediation of unauthorized releases of fuels from USTs. The agreement focuses only on fuel USTs, specifically exempting solvent cases, because of Federal and State funding restrictions. The primary source of funding for the program comes from the Federal LUST Grant and the State's UST Cleanup Fund (USTCF). Most costs to a responsible party are reimbursable by the UST Cleanup Fund if the responsible party remains in compliance. USTCF is funded by a 1.2-cent tax per gallon of gasoline sold.

The LOP provides a framework to implement the cleanup of LUFTs and requires that work


East Bay Plain Beneficial Use Study
San Francisco Bay
Regional Water Quality Control Board
Leaking Underground
Storage Tanks
Active Site (1310 sites)
Inactive Site (230 sites)
Closed Site (492 sites)
Mapped Data Source:
Regional Water Quality Control Board
Mapped Data Name:
lust
East Bay Plain Groundwater Basin
0
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MILES
May 1999
Pinole
Richmond
San Pablo
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El Cerrito
Martinez
Pleasant Hill
Walnut Creek
Lafayette
Albany
Berkeley
Orinda
Moraga
Emeryville
Piedmont
Contra Costa County
Alameda County
San Francisco
Alameda
Oakland
San Leandro
Castro Valley
San Lorenzo
Hayward
Union City

Figure 6

performed under the agreement be consistent with cleanup standards specified by the State and Regional Boards. The Local Agency is encouraged to do its own enforcement. Appeals arising from disputes between the LOP agency and the responsible party are heard by petition at the SWRCB, although some technical disputes may be handled informally by Regional Board staff. Unless a case has been assigned to the Regional Board, the LOP agencies oversee day to day cleanup activities and prepare final closure packages for Regional Board review and concurrence.

Alameda County Environmental Health Services is the only LOP within the East Bay Plain and has jurisdiction over all of Alameda County, except for the areas covered by the three non-LOP agencies described below. In January 1998, the County had 1235 sites.

5.3.2 LIA Programs – Cities of San Leandro, Berkeley, Hayward, and Contra Costa County

Some local agencies chose not to participate in the LOP program and elected instead to implement cleanup oversight authority themselves. These agencies are known as Local Implementing Agencies (LIAs). There are four LIAs in the East Bay Plain: the Cities of Berkeley, Hayward and San Leandro, and Contra Costa County. These agencies do not have enforcement authority, rather the agency or County District Attorney refers cases to the Regional Board. The agency submits its recommendation for closure to the Regional Board (the only agency that can officially close a case) along with a summary checklist. Regional Board staff provides technical guidance, general support, and enforcement, as required. Staff maintains case files, reviews closure recommendations and prepares the final closure letter and transmittal packages.

Berkeley (Toxics Division) currently has 194 cases. Funding sources include hourly fee schedules, permit fees, and work plan review fees.

Hayward (Hayward Fire Department) covers the incorporated part of Hayward and has 256 cases. Alameda County handles cases located in unincorporated areas. Funding sources are the annual permit fees for hazardous materials storage and cost recovery.

San Leandro (Hazardous Materials Division) has 121 cases and is the lead agency for all but one. The Regional Board is the lead agency for the other case. The funding source is reimbursement for direct oversight.

Contra Costa County (Department of Health Services) has 686 LUST cases, which are under the lead of the Regional Board. The funding source is UST Permit Fees and cost recovery in special cases.

5.3.3 Alameda County Flood Control and Water Conservation District (ACFCWCD) was formed in 1949 to address the flood control and water supply problems of the rapidly developing southern and eastern portions of the County. Within its boundaries, ACFCWCD has monitored and protected groundwater since 1955. This includes a continuous program of well measurements and water quality sampling. These boundaries are exclusive of the Alameda County Water District, which is a separate agency.

ACFCWCD collects information on water levels and water quality from 50 private wells in the Alameda County portion of the East Bay Plain (30 for water levels, 20 for quality). Water levels are measured semi-annually, quality biannually, and half of the wells are sampled every other year. The Department of Water Resources (DWR) analyzes the samples for inorganic compounds. The monitoring program does not analyze for synthetic organic chemicals such as solvents or fuel compounds.

The present network (Figure 7) was established by DWR in the 1950's and 1960's to study saltwater intrusion. The data is kept on file with ACFCWCD in both hard copy and computerized form.

On July 17,1973, Alameda County enacted a groundwater protection ordinance, No. 73-68, to regulate the construction of water wells. Permits for well construction or destruction are obtained from the county at no cost. The purpose of the ordinance was to protect the quality of the groundwater from contamination either from surface pollutants or from groundwater sources of lesser quality. The ordinance is administered and enforced by ACFCWCD in the unincorporated areas of the County and in the Cities of Alameda, Albany, Hayward, Oakland, Piedmont, Emeryville, and San Leandro. ACFCWCD has information on over 10,000 wells. These "driller logs" are filed by State well numbers, which are stored on a computer data base (dBASE) linked to a mapping software (MapInfo).

6.0 GEOLOGIC SETTING

The study area has a Mediterranean climate. Most rainfall occurs between November and March. The average annual rainfall across the entire area is 23 inches. The upland watershed area for the East Bay Plain is over 100 square miles along the western slope of the Coast Ranges. The major drainages in the watershed are San Pablo Creek, Wildcat Creek, San Leandro Creek, and San Lorenzo Creek (see Figure 8). In addition, there are thirteen minor creeks within the watershed. This study does not include groundwater in the upland watersheds.

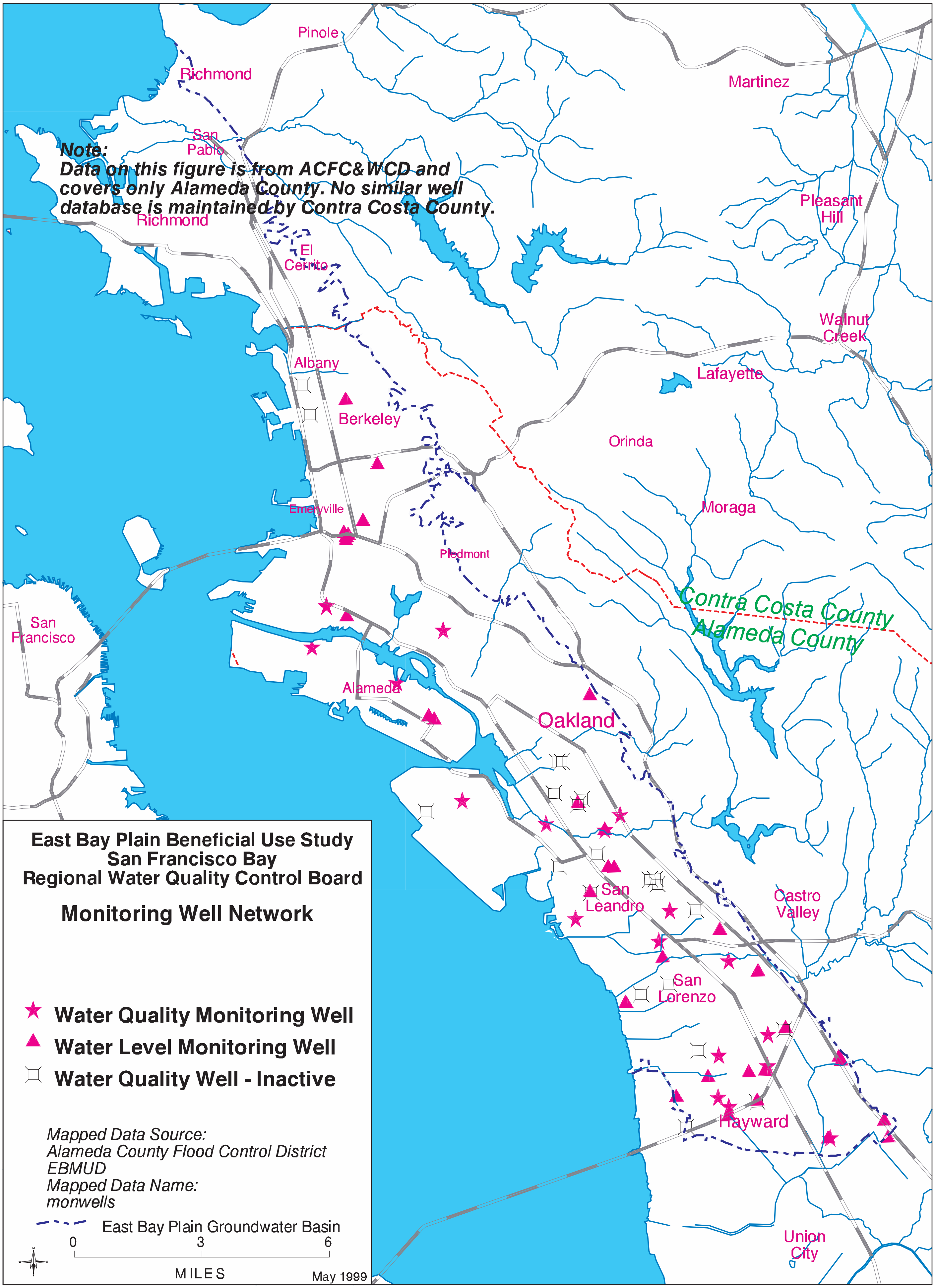
This section describes the geologic setting including structural features and stratigraphic units within the East Bay Plain.

6.1 Previous Investigations

Several reports and investigations exist detailing the stratigraphy and structure of the East Bay Plain. They are the product of extensive field investigations, including geotechnical borings, well borings, and field mapping. Recently other authors have compiled, summarized, and synthesized previous investigations. Muir (1993, 1997) and Figuers (1998) were the primary reports used in the compilation of this section.

6.2 Structural Geology

The East Bay Plain overlies a flank of a broad Franciscan bedrock depression, the core of which is roughly centered under San Francisco Bay (Figuers, 1998). The Hayward Fault and the


Note:
Data on this figure is from ACFC&WCD and covers only Alameda County. No similar well database is maintained by Contra Costa County.
Pinole
Richmond
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San Pablo
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Pleasant Hill
El Cerrito
Walnut Creek
Albany
Lafayette
Berkeley
Orinda
Emeryville
Moraga
Piedmont
Contra Costa County
Alameda County
San Francisco
Alameda
Oakland
San Leandro
Castro Valley
San Lorenzo
Hayward
Union City
East Bay Plain Beneficial Use Study
San Francisco Bay
Regional Water Quality Control Board
Monitoring Well Network
Water Quality Monitoring Well
Water Level Monitoring Well
Water Quality Well - Inactive
Mapped Data Source:
Alameda County Flood Control District
EBMUD
Mapped Data Name:
monwells
East Bay Plain Groundwater Basin
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May 1999

Figure 7


East Bay Plain Beneficial Use Study
San Francisco Bay
Regional Water Quality Control Board
Significant Hydrology
Sub-Watersheds
Significant Waters
Mapped Data Sources
USGS & RWQCB
Mapped Data Name:
sigwats, subwats
East Bay Plain Groundwater Basin
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MILES
May 1999
Pinole
Rodeo Creek
Richmond
Martinez
Pinole Creek
San Pablo
San Pablo Creek
Wildcat Creek
Richmond
Briones Reservoir
Pleasant Hill
Suisun Bay
El Cerrito
Walnut Creek
San Pablo Reservoir
Albany
Lake Anza
Lafayette
Lafayette Lake
Berkeley
Orinda
Moraga Valley Creek
Moraga
Emeryville
Piedmont
Redwood Creek
San Leandro Reservoir
Kaiser Creek
San Francisco
Alameda
Oakland
Cull Canyon Reservoir
Lake Chabot
San Leandro Creek
Crow Creek
San Leandro
Castro Valley
San Lorenzo Creek
San Lorenzo
Alameda Creek
Hayward
Union City

Figure 8

San Andreas Fault form the eastern and western boundaries of the depression. The Hayward Fault is the dominant structural feature in the Plain, trending parallel to the long axis of the East Bay Plain in a northwest direction.

Within the East Bay Plain, Figuers (1998) finds that there are two, separate basins based on the presence of two structural depressions (Figure 10). The San Francisco Basin extends north from the Dumbarton Bridge to the shoreline south of Richmond. There is a well-defined bedrock ridge separating the San Francisco Basin from the San Pablo Basin. The San Pablo Basin extends from Richmond north to the Petaluma area. The Hayward-Rogers Creek fault system crosses the basin, but it is unknown how this fault system has affected the sediments or groundwater flow patterns within the Basin. Figure 11 illustrates the structural contours for the bedrock, and clearly indicates the two basins.

6.3 Major Stratigraphic Units

The geologic units can be divided into two groups: 1) consolidated bedrock of Jurassic, Cretaceous, and Tertiary age and 2) unconsolidated sediments of Pleistocene and Holocene age (Muir, 1993). Recently, the U.S. Geological Survey compiled a surficial geological map of Alameda and Contra Costa Counties (USGS, 1999) (See Figure 9).

Bedrock forms the bottom and eastern boundary of the Basin. The bedrock is structurally complex and includes the Franciscan Complex (melanges, serpentines, and ultramafic rocks) and the Great Valley Sequence (shale, sandstone, and conglomerate). The unconsolidated sediments have a variable thickness, but are up to 1000 feet thick in their deepest areas. The nomenclature applied to the unconsolidated sediments has varied over time. For the purposes of this report, we use the nomenclature from Figuers (1998). From oldest to youngest, the unconsolidated sediments are 1) Santa Clara Formation 2) the Alameda Formation (including Yerba Buena Mud, San Antonio, Merritt, and Young Bay Mud Members 3) Temescal and 4) Artificial Fill (Figure 12).

For discussion purposes, shallow groundwater-bearing units are defined as the units above the Yerba Buena Mud (Artificial Fill, San Antonio/Merritt/Posey Member, and Temescal Formation). Deeper groundwater-bearing units are defined as the units below the Yerba Buena Mud (Unnamed member of the Alameda Formation and Santa Clara Formation).

6.3.1 Santa Clara Formation

This formation name has not been consistently applied to the deep units north of the Santa Clara Valley. This early Pleistocene formation is continental in origin and includes alluvial fans deposits interfingered with lake, swamp, river channel, and flood plain deposits. The formation is between 300 to 600 feet thick. Overall, this formation is very poorly understood. Figuers (1998) reports that this section has only been sampled within the past year or so by Caltrans borings along the San Mateo and Bay Bridges. Historically, municipal well fields were completed in this formation. Its thickness is up to 600 feet. This formation is of interest to EBMUD for their aquifer storage program, so additional stratigraphic information may be forthcoming.


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San Francisco
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Martinez
Pleasant Hill
Walnut Creek
Lafayette
Orinda
Moraga
Contra Costa County
Alameda County
San Leandro
Castro Valley
San Lorenzo
Hayward
Union City
East Bay Plain Beneficial Use Study
San Francisco Bay
Regional Water Quality Control Board
Surficial Geology
Bedrock
Alluvium
Beach and Dunes
Stream Channels
Bay Muds
Artificial Fill
Mapped Data Source: USGS 1997
Mapped Data Name:
quantgeo, related table: quantgeo.lut
East Bay Plain Groundwater Basin
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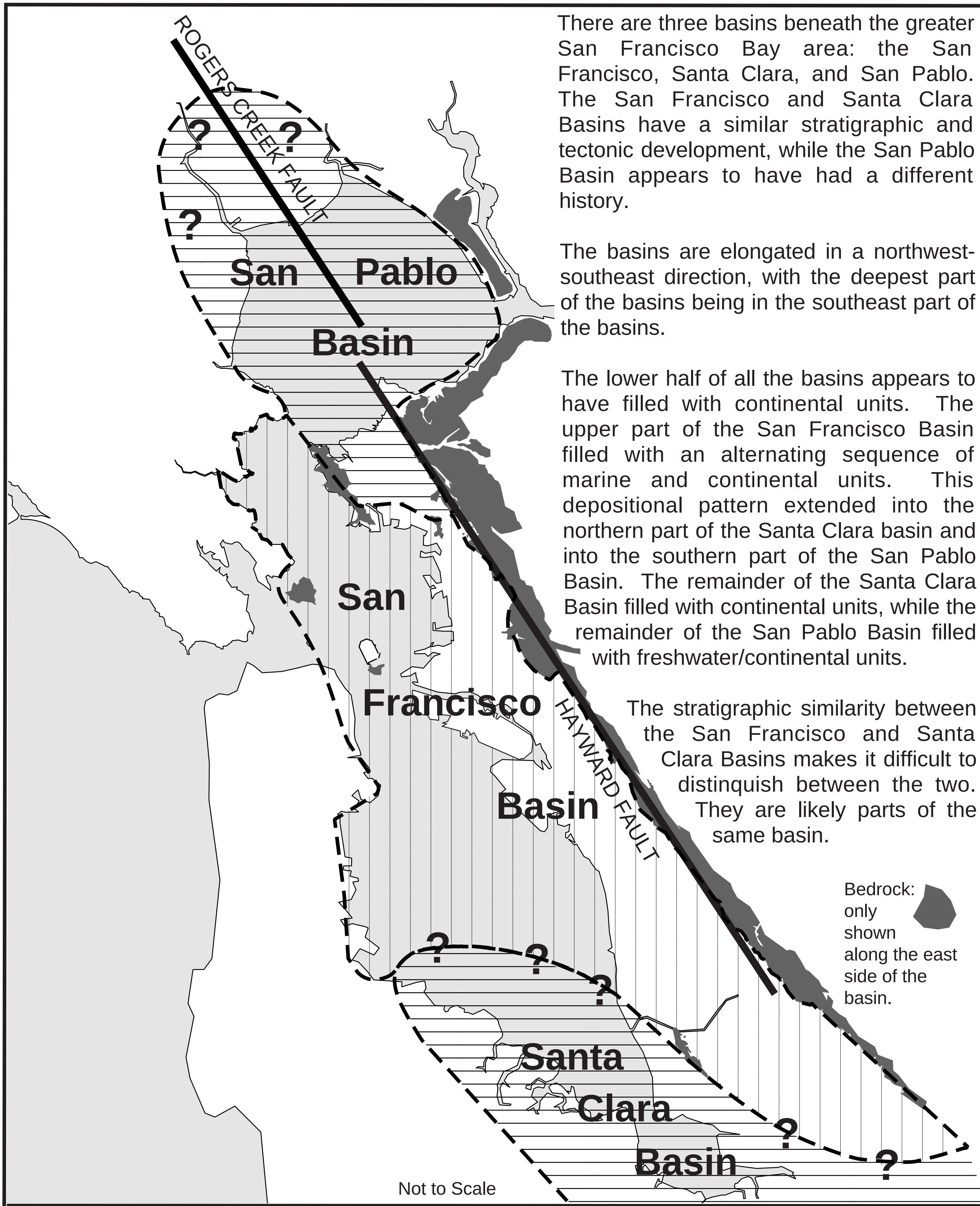
May 1999

Figure 9



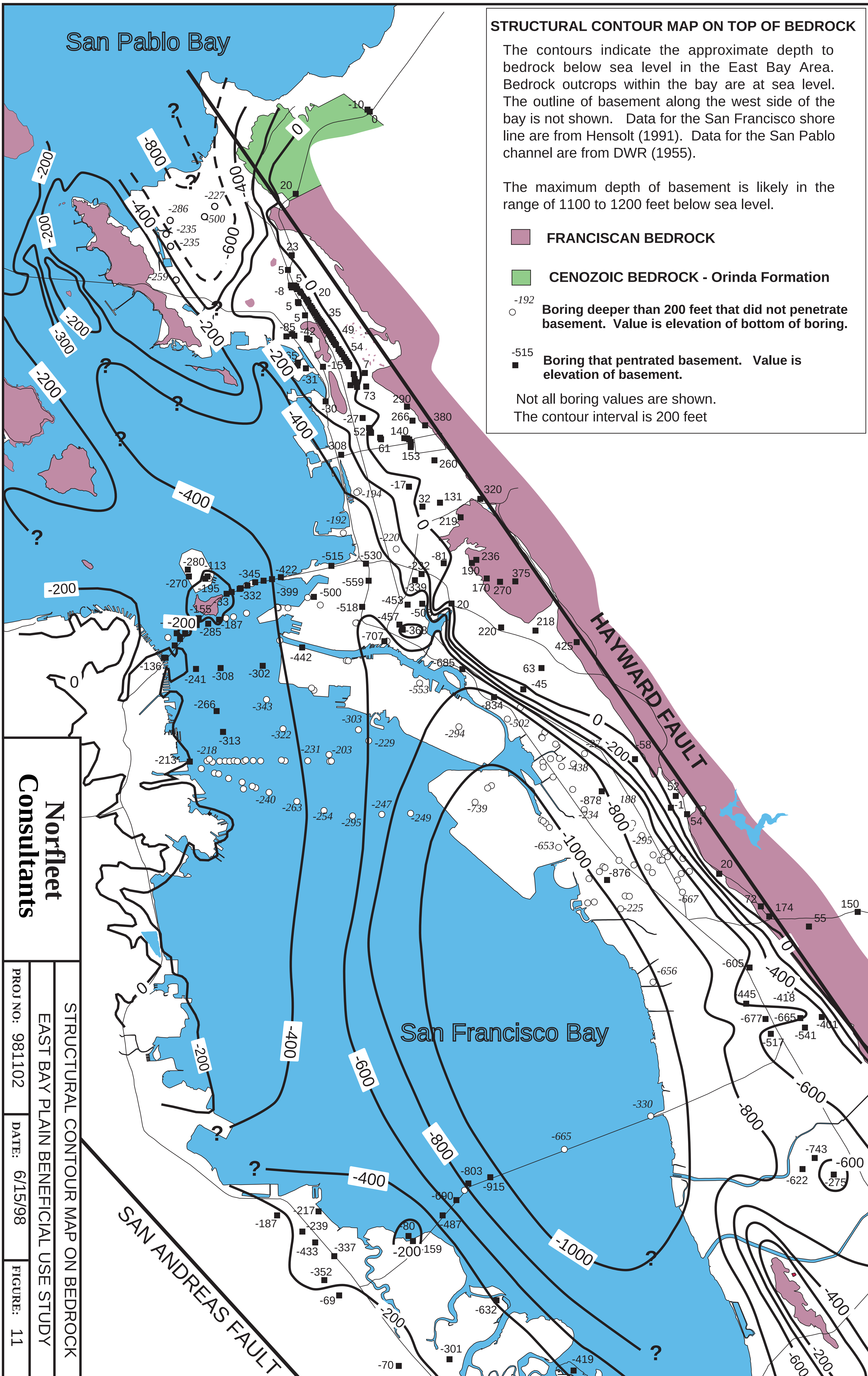
There are three basins beneath the greater San Francisco Bay area: the San Francisco, Santa Clara, and San Pablo. The San Francisco and Santa Clara Basins have a similar stratigraphic and tectonic development, while the San Pablo Basin appears to have had a different history.

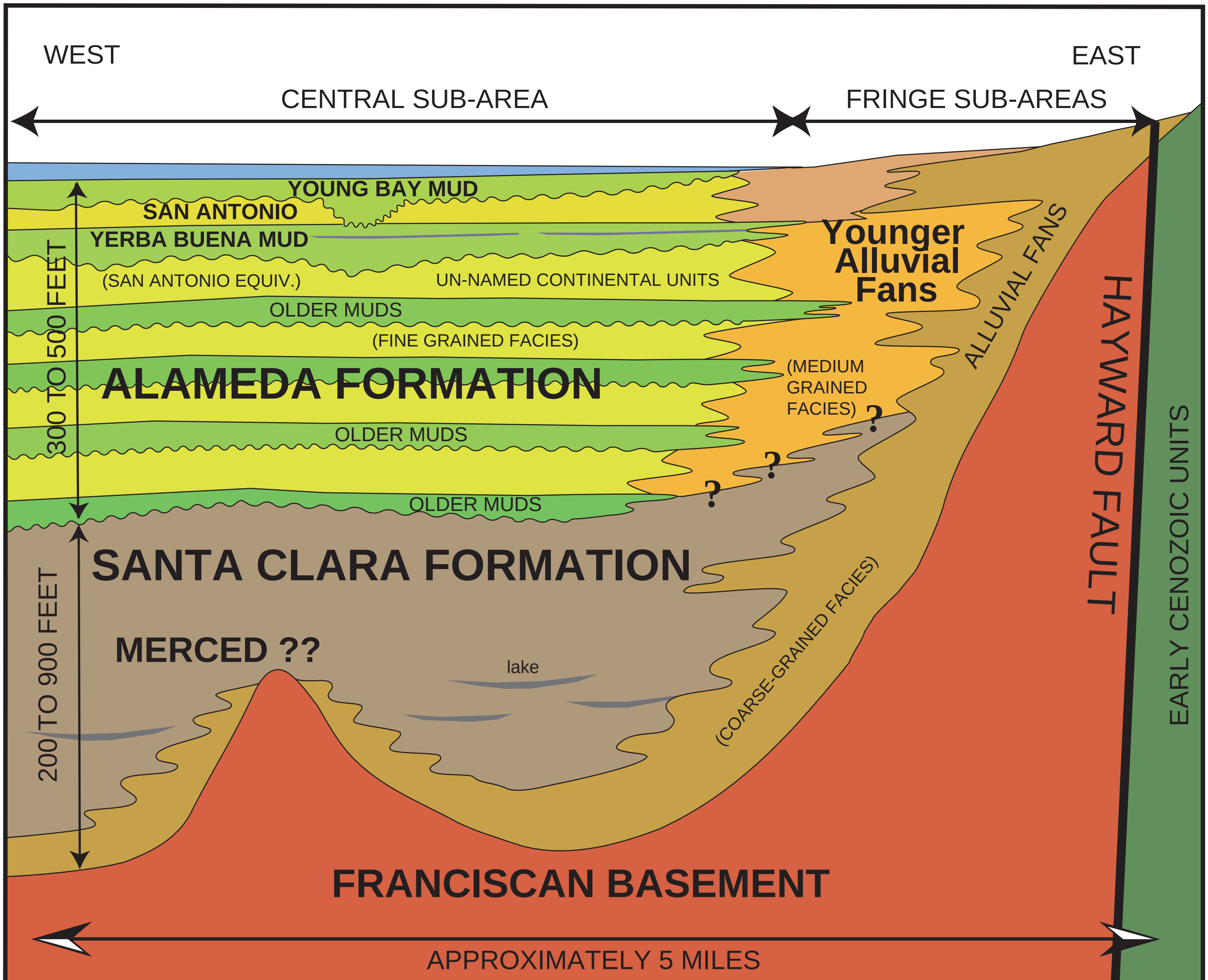
The basins are elongated in a northwest-southeast direction, with the deepest part of the basins being in the southeast part of the basins.

The lower half of all the basins appears to have filled with continental units. The upper part of the San Francisco Basin filled with an alternating sequence of marine and continental units. This depositional pattern extended into the northern part of the Santa Clara basin and into the southern part of the San Pablo Basin. The remainder of the Santa Clara Basin filled with continental units, while the remainder of the San Pablo Basin filled with freshwater/continental units.

The stratigraphic similarity between the San Francisco and Santa Clara Basins makes it difficult to distinquish between the two. They are likely parts of the same basin.

Norfleet Consultants	OUTLINE OF MAIN BASINS
	EAST BAY PLAIN BENEFICIAL USE STUDY
	PROJ NO: 981102 · DATE: 6/15/98 · FIGURE: 10


STRUCTURAL CONTOUR MAP ON TOP OF BEDROCK
The contours indicate the approximate depth to bedrock below sea level in the East Bay Area. Bedrock outcrops within the bay are at sea level. The outline of basement along the west side of the bay is not shown. Data for the San Francisco shore line are from Hensolt (1991). Data for the San Pablo channel are from DWR (1955).
The maximum depth of basement is likely in the range of 1100 to 1200 feet below sea level.
FRANCISCAN BEDROCK
CENOZOIC BEDROCK - Orinda Formation
-192
Boring deeper than 200 feet that did not penetrate basement. Value is elevation of bottom of boring.
-515
Boring that pentrated basement. Value is elevation of basement.
Not all boring values are shown.
The contour interval is 200 feet
San Pablo Bay
San Francisco Bay
HAYWARD FAULT
SAN ANDREAS FAULT
Norfleet Consultants
STRUCTURAL CONTOUR MAP ON BEDROCK
EAST BAY PLAIN BENEFICIAL USE STUDY
PROJ NO: 981102
DATE: 6/15/98
FIGURE: 11



Schematic cross-section of stratigraphic relationships along the east side of the San Francisco Basin (15-20:1 vertical exaggeration). The Alameda Formation is restricted to the marine transgression(s) (including the current transgression), and local names (San Antonio, Yerba Buena Mud, etc.) are members within the Alameda Formation. There were six to eight transgressions of the late Pleistocene seas within the Alameda Formation. The upper two are well defined, but little is known about the earlier transgressions.

The units below the Alameda are likely Santa Clara and possibly Merced formation. The units on the side of the basin are Holocene and late Pleistocene alluvial fans and related deposits. The location of the boundary between the Santa Clara and the Younger fans is unknown.

Basement knobs (hills) are scattered throughout the Basin. Some are exposed (e.g. Yerba Buena Island), but the majority are buried. All basement knobs affected sedimentation patterns laterally and vertically. Basement topography is self replicating through time. The current shape of the bay and the location of the major streams and embayments mimic basement topography.

Norfleet Consultants	SCHEMATIC STRATIGRAPHIC SECTION
	EAST BAY PLAIN BENEFICIAL USE STUDY
	PROJ NO: 981102 · DATE: 6/15/98 · FIGURE: 12

6.3.2 Alameda Formation

This formation is differentiated from the underlying Santa Clara Formation by nature of its estuarine origins. The members of this formation include:

Yerba Buena Mud Member: This member, originally named Old Bay Mud, has subsequently been renamed. The black, organic clay averages 25 to 50 feet thick with a gravel/sand/shell layer commonly in the middle of the unit.

San Antonio/Merritt/Posey Member: This 0 to 120 foot thick member contains a sequence of alluvial fan deposits between the Young Bay Mud and the Yerba Buena Mud. Given a discontinuous nature and the wide array of materials found in this member (sands, gravels, and silts) the units are difficult to correlate. A distinctive facies within this member is the Merritt Sand. Found on Alameda Island and western Oakland, this facies is fine grained, well sorted, aeolian sand. It ranges between 0 to 60 feet thick. Figuers (1998) reports that it was deposited at the same time as the upper San Antonio/Posey.

Young Bay Mud: Ranging in thickness from less than 1 foot to 75 feet, this member is a black, organic-rich clay being deposited today in the San Francisco Bay. It contains occasional gravel and sand layer, shell fragments/layers, peat, and organic debris.

6.3.3 Temescal Formation

The Temescal is an early Holocene alluvial deposit that varies from 1 to 50 feet thick, thinning toward the bay. It consists primarily of silts and clays, but near Alameda, the base of the unit is a layer of gravel with cobbles up to 8 inches thick.

6.3.4 Artificial Fill

The fill varies from 1 to 50 feet in thickness and generally thickens toward the Bay. Most of the fill was placed in the bay front and wetland areas. Much of the Oakland and Alameda fill is derived from sediment dredged during the completion of Oakland Inner Harbor. Other common sources of artificial fill include rock from the Leona Heights Quarry, construction and demolition debris, and municipal waste.

7.0 HYDROGEOLOGY

This section describes what is known about the East Bay Plain's hydrogeology including the storage, recharge, and yield amounts.

7.1 East Bay Plain Boundaries

The East Bay Plain is an elongated, northwest trending flat alluvial plain encompassing about 115 square miles (Figure 9). The East Bay Plain, as defined by DWR (1980), is bounded on the west by San Francisco Bay, by San Pablo Bay to the north, and by the Hayward Fault to the east.

The southern boundary is defined as the northern boundary of the Alameda County Water District. Figuers (1998) suggests that the eastern boundary is better defined by the contact with the Franciscan bedrock. He also suggests that the basin extends under San Francisco Bay (Figure 10).

7.2 East Bay Plain Depth

The base of the East Bay Plain is defined at the contact between unconsolidated materials and bedrock. As illustrated on Figure 11 (Depth to Bedrock), this surface is variable across the study area. As described above, Figuers (1998) identifies two main basins, the San Pablo and the San Francisco (Figure 10). There is not as much geologic information to define the depth of San Pablo Basin. Water well depths suggest that the basin is 600 feet or more below ground surface. Moving southerly from Richmond into the San Francisco Basin, the unconsolidated materials thicken to greater than 1,000 feet. The deepest sections of the East Bay Plain are underneath San Francisco Bay. To the east, the East Bay Plain thins out rapidly.

7.3 Sub-Area Hydrogeology

The East Bay Plain is regionally subdivided into two major basins, the San Pablo and the San Francisco Basins. Further subdivisions have been previously reported by Muir (1993). Refinements were recently made by Figuers (1998). Figure 13 illustrates the seven Sub-Areas. Because of the East Bay's reliance of surface water supplies, little data is available to characterize the hydrogeologic characteristics of the Sub-Areas. In recognition of this, the Committee commissioned a comprehensive review of historical groundwater use. The results of this review are reported in Figuers (1998). Sub-Areas have been defined based on geologic, geomorphic and geographic factors. The hydrogeologic characteristics of each Sub-Area can be summarized below.

7.3.1 Richmond Sub-Area is located at the southern end of the San Pablo Basin. It is estimated to contain at least 600 feet of unconsolidated deposits. The deposits are primarily alluvial materials, but there is evidence of estuarine clays between 60 to 125 feet below sea level. These clays and the younger bay muds may be limited in extent. Given what appears to be a lack of widespread clay layers, regionally the shallow and deep water bearing layers can be considered to be interconnected. Historically, there were well fields in this Sub-Area that likely tapped significant gravel deposits that occur 100 to 150 feet below ground surface. The historical wells were only operated for 12 to 16 years before they were shut down due to saltwater intrusion.

7.3.2 Berkeley Sub-Area contains a series of alluvial fans deposited on a west sloping bedrock surface. The alluvial deposits range from 10 to 300 feet deep, averaging 100 to 200 feet deep. There is no historical evidence that groundwater supplies are sufficient for municipal use, primarily due to low recharge rates.

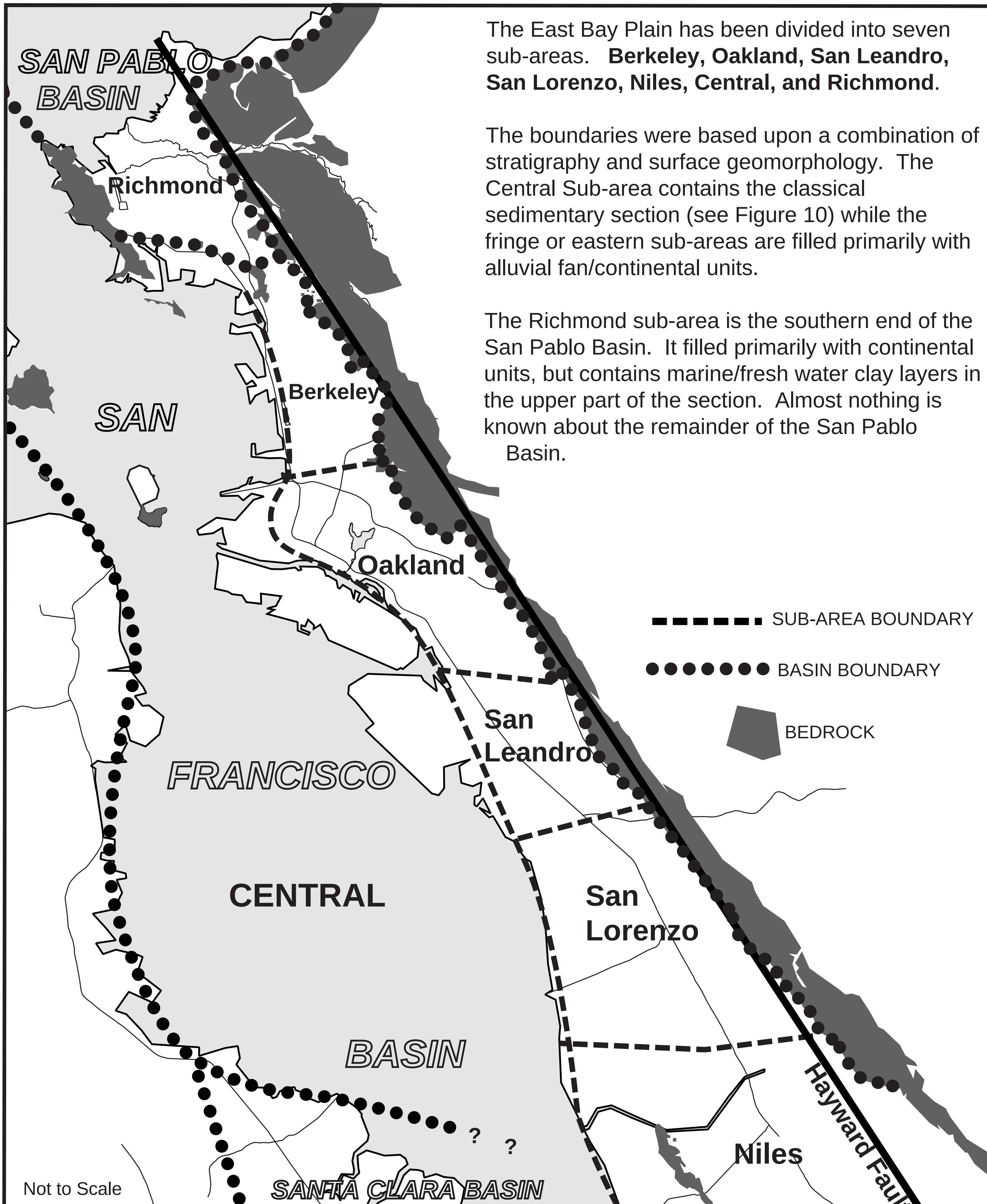
There are no reported clay units that function as major aquitards. However, in the Berkeley Sub-Area the first encountered groundwater is frequently semi-confined, particularly in West Berkeley.

7.3.3 Oakland Sub-Area is similar to the Berkeley Sub-Area in that it contains a sequence of alluvial fans. However, the basement is deeper and the alluvial fill is thicker (300 to

The East Bay Plain has been divided into seven sub-areas. **Berkeley, Oakland, San Leandro, San Lorenzo, Niles, Central, and Richmond**.

The boundaries were based upon a combination of stratigraphy and surface geomorphology. The Central Sub-area contains the classical sedimentary section (see Figure 10) while the fringe or eastern sub-areas are filled primarily with alluvial fan/continental units.

The Richmond sub-area is the southern end of the San Pablo Basin. It filled primarily with continental units, but contains marine/fresh water clay layers in the upper part of the section. Almost nothing is known about the remainder of the San Pablo Basin.



Norfleet Consultants	SUB-AREAS
	EAST BAY PLAIN BENEFICIAL USE STUDY
	PROJ NO: 981102 · DATE: 6/15/98 · FIGURE: 13

700 feet). There are no well-defined aquitards such as the estuarine muds. The largest and deepest wells in this Sub-Area historically pumped 1 to 2 million gallons per day at a depth greater than 200 feet. Upland areas historically had shown little groundwater potential beyond single family use. Overall, sustainable yields are low due to low recharge potential. The Merritt Sand outcrop in west Oakland was an important part of the early water supply for Oakland. It is shallow (up to 60 feet) and before the turn of the century, septic systems contaminated the water supply wells. Other high production wells were located from the southwestern side of Alameda to the Oakland Coliseum. The wells tapped gravels below the Yerba Buena Mud. EBMUD has drilled a test well near San Leandro Bay in the Oakland Sub-Area to explore the potential for aquifer storage of injected surface water.

7.3.4 San Lorenzo and San Leandro Sub-Areas are very similar in hydrogeologic characteristics, but can be separated based the surface trace of the junction between the San Leandro and San Lorenzo alluvial fans. The Sub-Areas are primarily filled with alluvial fans, but unlike the Sub-Areas to the north, the Yerba Buena Mud extends west into the San Lorenzo and San Leandro Sub-Areas. It has been proposed that a clay layer forms an extensive east-west aquitard across this basin. Historically there were municipal supply wells in these Sub-Areas that produced from upper Alameda gravels. These Sub-Areas were distinct from the Niles Cone basin to the south, in that the alluvial fans are finer-grained and produce less groundwater. The City of Hayward has emergency supply wells in the San Lorenzo Sub-Area. Also, EBMUD has drilled test wells in the San Lorenzo Sub-Area to explore the potential for aquifer storage of injected surface water.

7.3.5 Central Sub-Area extends beneath San Francisco Bay. The boundaries of the Sub-Area are based on the Young Bay Mud. The Young Bay Mud has a sharp “edge” in some areas, and in other areas, the boundary is less well-defined. Alameda and Bay Farm Islands are located along the northeastern edge of the Sub-Area. Historically there were artesian wells in the Sub-Area that produced from gravels below the Yerba Buena Mud, but saltwater intrusion shut down these wells. Single family residences historically relied on the Merritt Sand for water supply. However, contamination from septic systems and some saltwater intrusion resulted in localized contamination. More recently, deep wells (700 to 1000 feet deep) were drilled at the Alameda City Golf Course. Production rates were lower than expected but this is believed due to drilling problems. Water quality was satisfactory for irrigation.

7.4 Groundwater Flow Direction

Throughout most of the Alameda County portion of the East Bay Plain, Hayward north to Albany, water level contours show that the direction of groundwater flow is east to west, or from the Hayward Fault to San Francisco Bay. Groundwater flow direction generally correlates to topography. Flow direction and velocity are also influenced by buried stream channels that typically are oriented in an east-west direction. In the very southern end of the study area, in the San Lorenzo Sub-Area, the direction of flow may not be this simple. The small set of water level measurements available seem to show that the groundwater in the upper aquifers may be flowing south, with the deeper aquifers, the Alameda Formation, moving north (Muir, 1996).

In the northern portion of the Richmond Sub-Area, investigations showed flow in the San Antonio Aquifer to be toward San Pablo Bay. In the southern portion of the Richmond Basin, groundwater flows south between both the Hayward and San Pablo Faults to San Francisco Bay (EBMUD, 1986). In the Richmond Sub-Area, the EBMUD report used an average field measured transmissivity value at Richmond UC Field Station wells of about 4000 gallons per day per foot, and a hydraulic gradient of 0.003 to calculate a volume flow rate south to San Francisco Bay on the order of 135 acre-feet per year.

7.5 Groundwater Storage

DWR (1994) examined over 350 wells in Alameda County to evaluate the storage capacity in the Alameda County portion of the East Bay Plain. The study area consisted of the area north of Hayward, (about 114 square miles). DWR estimates: 1) total groundwater storage capacity of the East Bay Plain, 2) amount of storage in the East Bay Plain, and 3) usable storage in the East Bay Plain. Potential storage beneath San Francisco Bay was not considered.

DWR examined the thickness and equivalent specific yield of the various sediment types within 50-foot horizontal sections of the study area to approximate the three above properties. The estimated storage capacity of the study area is approximately 2,670,000 acre-feet. Of this amount, roughly 2,560,000 acre-feet of groundwater is currently stored. This is the total current storage in the Plain, as not all of the aquifers are 100 % saturated.

The storage for the Richmond sub-basin has not been quantitatively evaluated, but is assumed to be much lower than the storage for Alameda County, given the much smaller area and thinner section of unconsolidated sediments (EBMUD, 1986).

7.6 Recharge and Discharge Estimates

Muir (1993) summarized the different types and overall amounts of recharge for the Alameda County portion of the East Bay Plain. The study area comprised approximately 114 square miles between Albany and Hayward, and the Bay and the Hayward Fault. Sources of recharge were: rainfall infiltration, stream seepage, pipe leakage, agriculture return water, and subsurface inflow. Rainfall infiltration was defined as the rainfall left over after surface runoff and evapotranspiration that percolates through the soil strata and recharges the groundwater reservoir. The report evaluated the recharge potential of various sub-basins, rainfall data, and evapotranspiration data to determine the amount of rainfall that recharges groundwater. It looked at the unlined length of streams, the streambed recharge potential, stream gradients, and stream area to determine the potential seepage rates for each stream in cubic feet per day. These rates were multiplied by the average time per year in which there would be flow and summed to total the amount of stream seepage. Muir then analyzed EBMUD's water meter readings to determine the annual water loss from water supply lines in the area. For loss from sewer pipes, he used discharge records of four sewer treatment plants that serve the East Bay, and the records of potable water usage for the same study area. Agricultural return runoff and subsurface inflow were assumed to be small.

Based on the above considerations, Muir broke down recharge accordingly:

Table 2. Groundwater Recharge in the East Bay Plain (Alameda County Portion Only)

Recharge Sources	Recharge (Acre-feet per Year)
Rainfall Infiltration	3,700
Stream Seepage	6,200
Sewer Pipe Leakage	4,500
Water Pipe Leakage	5,400
Agriculture Return Water	200
Subsurface Inflow	200
Total	20,200

The Richmond Sub-Area recharge was assumed to be much lower than the above figure, due to dense urbanization in Richmond and San Pablo (EBMUD, 1986).

In another Muir study, "Groundwater Discharge in the East Bay Plain Area, Alameda County" (July, 1996), he approximated the outflow, or discharge, in the study area. This was the same area used to calculate recharge. Muir identified evapotranspiration and subsurface discharge as the two natural forms of discharge and pumpage as the means of artificial discharge. The report determined evapotranspiration by using long term climatic data from the East Bay Plain and correlating this data with evapotranspiration studies made in comparable areas of California and calculated a total of 25,780 acre-feet for 1995. This is equivalent to about 8 inches a year, or about 38 percent of the annual rainfall of the area. Evapotranspiration, although an important discharge element in the overall hydrologic budget, does not remove groundwater from aquifer storage. In other words, this is rainfall that evapotranspires before it enters the subsurface aquifer. The report next assumed that most of the subsurface discharge occurred at the Bay margins. To determine subsurface discharge, Muir examined the thickness of unconsolidated deposits at the Bay margins for various sub basins, the width of the sub basins, and the amount of saturation. Muir concluded a subsurface discharge of 13,500 acre-feet for 1995. Finally, the report determined groundwater pumpage for agricultural, domestic and industrial uses. The total for 1995 was approximately 3,350 acre-feet per year.

7.7 Groundwater Basin Yield

The yield of the East Bay Plain is the rate at which water can be withdrawn annually, without decreasing groundwater in storage to the point where the intrusion of saltwater from San Francisco Bay would occur. It is related to the groundwater storage of the East Bay Plain. Storage can be depleted by pumping until water levels near the Bay are drawn down to near sea level. When this occurs, the average annual pumpage should not exceed a quantity equal to the long-term average inflow to the reservoir minus the quantity of subsurface discharge that must flow to the Bay annually to maintain a barrier against saltwater intrusion. This would be the groundwater yield of the East Bay Plain Area (Muir, 1993). Muir (1996) estimated that the groundwater safe yield for the Alameda County portion of the East Bay Plain at 10,000 acre-feet/year based on 1965 to 1995 data for rainfall from Niles and Berkeley, hydrographs of selected wells, and the historical water use..

8.0 GROUNDWATER QUALITY

This Section summarizes the findings presented in the Alameda County Flood Control and Water Conservation District report titled “Groundwater Quality of the East Bay Plain, Alameda County California” authored by Kenneth Muir in December 1997, and presents a survey of Total Dissolved Solids (TDS) concentration data collected from 15 sites along the East Bay Plain shoreline.

The Committee recognizes that a complete groundwater quality assessment of the East Bay Plain would identify and evaluate the past and present groundwater chemistry facies specific to each groundwater aquifer. From a regulatory perspective, the single most important groundwater quality parameter directly influencing a beneficial use determination is the TDS concentration. Resolution 89-39, Sources of Drinking Water, exempts the Municipal and Domestic Supply Beneficial Use designation for groundwaters with TDS concentrations greater than 3,000 mg/l and are not reasonably expected by the Regional Board to supply a public water system (note that USEPA uses the 10,000 mg/l TDS value in determining potential drinking water sources). This section includes a review of the available inorganic data and an evaluation of TDS groundwater values along the East Bay shoreline.

8.1 East Bay Plain Inorganic Groundwater Quality

Muir (1997) prepared a study of inorganic groundwater quality of the East Bay Plain. His study area extents from Albany in the north to Hayward in the south and is bounded by the Hayward Fault in the east and the bay shoreline in the west. He identified seven Sub-Areas within the East Bay Plain but limited his study to five Sub-Areas: the Berkeley Alluvial Plain, the Merritt Sand Outcrop, the Oakland Upland and alluvial Plain, the San Leandro Cone, and the San Lorenzo Cone. He divided the aquifer system into two depth zones: Shallow Zone aquifers (0 to 200 feet) and Deep Zone aquifers (200 to 1,000 feet). The inorganic water quality data was collected from 16 shallow zone wells and 13 deep zone wells.

The Shallow Zone groundwater is generally a calcium-bicarbonate type of water. TDS concentrations in the 16 wells assessed by Muir ranged from 364 to 1,020 mg/l. Along the Oakland Inner Harbor and adjacent to the Bay, Shallow Zone deposits appear to be in contact with saltwater, as indicated by the magnesium-sodium-chloride type waters found in these areas.

The Deep Zone groundwater is generally a sodium-bicarbonate type water. TDS concentrations in 13 Deep Zone wells ranged from 313 to 1,420 mg/l. Water from two Deep Zone wells in the Oakland alluvial plain were classified as sodium-chloride type water. Water in the northern part of the San Leandro Cone was the only water in those areas studied with a calcium-chloride type water. Water from this area also had the highest TDS, with values exceeding 1,300 mg/l in the three wells studied. TDS concentrations exceeded the secondary Maximum Contaminant Level (MCL) of 500 mg/l in 15 of the 29 wells.

Based on historic data (1940-1970), nitrate concentrations have exceeded the MCL of 45 mg/l in many Shallow Zone wells, though few currently exceed the standard. Nitrate concentrations in deep wells historically have been low.

Historically, saltwater intrusion has occurred in portions of deeper aquifers as a result of large scale historic pumping prior to 1930 (Figuers, 1998). Saltwater intrusion occurred at the High Street Well Field in Alameda, San Pablo Well Fields No. 1 and No. 2 in Richmond and the Fitchburg Well Field in Oakland.

8.2 East Bay Plain Shoreline Total Dissolved Solids Concentrations

The Committee surveyed 15 facilities along the East Bay Plain shoreline for shallow groundwater chemistry data. Appendix E provides a groundwater chemistry data summary table for each site surveyed. A total of 399 data points are reported, where the concentrations of TDS ranged from 24 to 55,333 mg/l. TDS values were both measured analytically and calculated from conductivity measurements. All groundwater data was collected from groundwater monitoring wells screened in the shallow units, primarily from 10 to 60 feet below ground surface.

Several other studies have been performed to determine tidal influence. Work at Oakland Army Base (Draft Base-wide Hydrogeologic Study, 1998) showed that the effects of San Francisco Bay on facility groundwater were seen up to 600 feet from the Bay margins. The study focused on the artificial fill and Merritt Sand aquifers. Hydrogeologic studies at Alameda Point indicate that tidal influence is up to 1500 feet inland and that saltwater intrusion has occurred up to 250 feet inland within the artificial fill and 1500 feet inland within the unconfined Merritt Sand. In their groundwater storage feasibility study in the Roberts Landing area of Hayward, EBMUD observed a pressure variation in their wells due to tidal influence. This included wells screened in the deeper Alameda Formation.

The landward extent of saltwater intrusion in shallow aquifers along the East Bay Plain appears related to the anthropogenic deposition of the overlying sediment, the connectivity of an aquifer to the San Francisco Bay, the amount of fresh water recharge, the hydraulic isolation of the aquifer, and any active landward pumping of groundwater. Existing saltwater intrusion is limited and correlates with shallow aquifers contained in artificial fill and hydraulically isolated aquifers (e.g., Merritt Sand) in direct contact with the Bay. In the north, the deeper fresh water aquifer systems (e.g., Alameda Formation) appear to be hydraulically isolated from the shallow aquifer systems along the East Bay Plain margin by the Yerba Buena Mud. However, in the southern portion, the water quality values in the San Leandro and San Lorenzo Sub-Areas indicate probable vertical migration from the Shallow Zone to the Deep Zone aquifer (Muir, 1997).

9.0 GROUNDWATER CONTAMINATION

9.1 Fuels and Solvents

Some shallow groundwater has been impacted by historical and current releases of fuels and solvents. A review of case files from the Regional Board, Department of Toxic Substances Control, Alameda County, City of Berkeley, and City of San Leandro reveal that, as of January 1998, there were a total of 1310 active leaking underground fuel tanks and 130 non-fuel cases (typically solvents) in the East Bay Plain. These totals do not include the numerous groundwater pollution sites at former DoD facilities in the East Bay Plain.

A map showing the location of groundwater plumes longer than 1000 feet is shown on Figure 14 and the following table summarizes information about each plume.

Table 3A. Major Areas of Existing Groundwater Pollution in the East Bay Plain

Site Name	Location	Chemicals	Boundary	Date	Lead Agency
Thermofustion	Hayward	VOCs	10 ppb	6/6/97	RWQCB
CHEMCentral	Hayward	VOCs	100 ppb	12/19/96	RWQCB
DWA Plume	San Leandro	VOCs	Above MCL's	Dec-95	DTSC
Caterpillar Facility	San Leandro	PCE/TCE	5 ppb	Feb-97	DTSC
Kaiser Aerotech	San Leandro	1,2-DCE	100 ppb	Nov-96	San Leandro
1964 Williams St.	San Leandro	TCE	10 ppb	11/7/96	RWQCB
Site 4, Alameda Point Navy Base	City of Alameda	TCE	1 ppb	1998	DTSC
Site 5, Alameda Point Navy Base	City of Alameda	TCE	1 ppb	1998	DTSC
Lawrence Berkeley	Berkeley	Diesel, Tritium	Detection Limit	1997	DTSC
WRE/ColorTech	Berkeley	Chromium	Detection Limit	1998	TMD
GE site	Oakland	TCE	10 ppb	1998	DTSC
Santa Fe Railway	Richmond	Petroleum Hydrocarbons	Detection Limit	1993	RWQCB
Chevron Refinery	Richmond	Petroleum Hydrocarbons	Detection Limit	1997	RWQCB

Ambient monitoring data on common organic pollutants within the deeper groundwater (i.e., deeper than about 100 feet) is very limited. Based on this limited data, the overall water quality of the deeper in the East Bay Plain is good. Much more data is available on the water quality of shallow groundwater (i.e., less than about 100 feet). Some shallow groundwater has been impacted by historical and current releases of fuels and solvents.

Groundwater pollution in the East Bay Plain appears to generally be restricted to portions of the shallow aquifers. Typically, site investigations require that groundwater plumes be defined in both the lateral and vertical dimension. In almost all cases, groundwater pollution appears limited to less than 50 feet below the ground surface.

However, recently one of EBMUD’s aquifer storage test wells detected contamination at a depth of over 200 feet below ground surface. Volatile organic compounds were detected in a test well located west of Interstate 880 about one mile north of the Oakland Coliseum. TCE was detected in the test well at 50-70 ppb that was screened between 260 and 350 feet below ground surface. Prior to this detection, no pollution had ever been detected above trace levels at depths greater than 140 feet. The source and migration pathway for the TCE contamination is currently under investigation by DTSC.

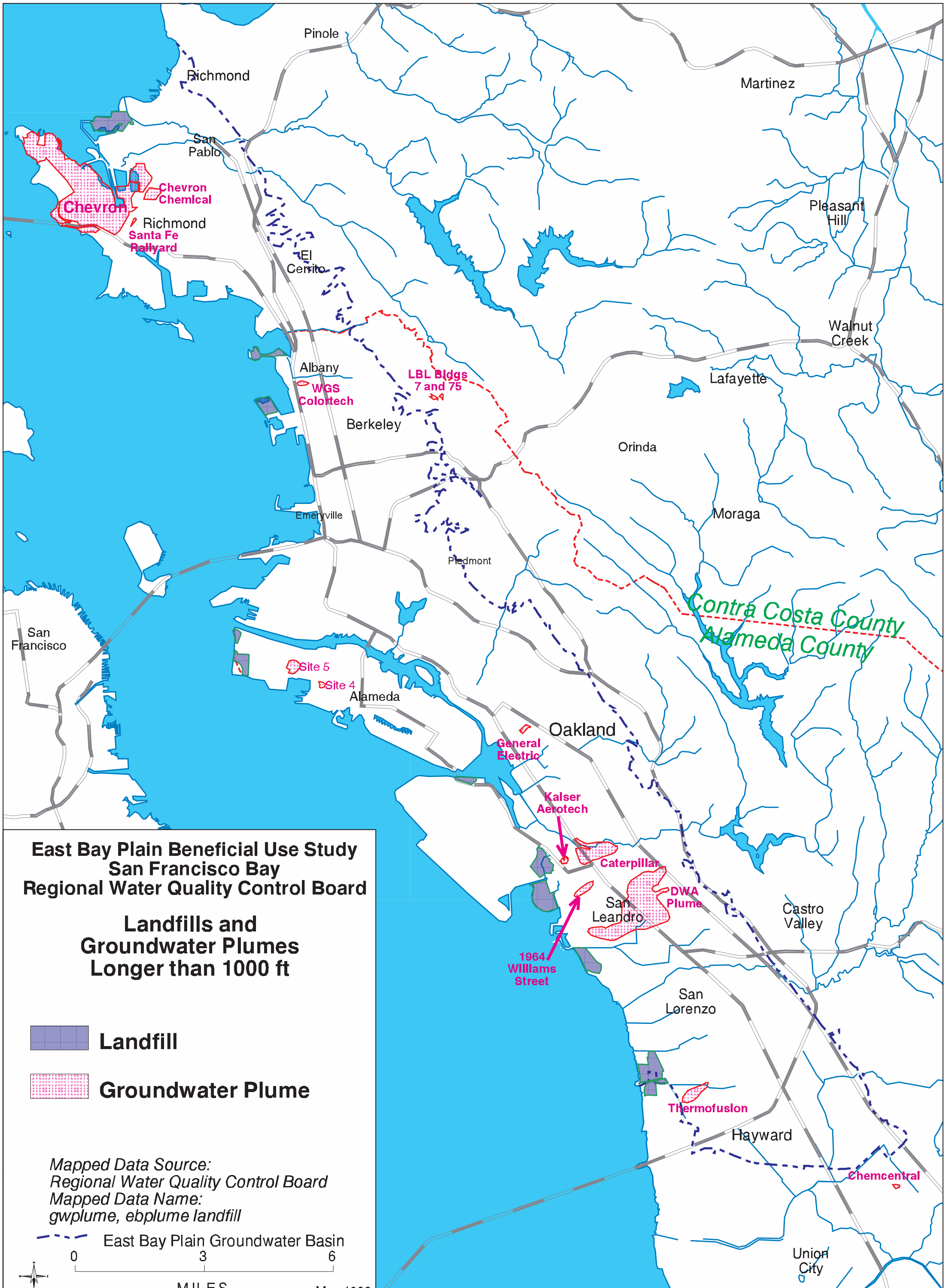
Although the source of the deep groundwater contamination has not been defined, it may illustrate the potential for connection between the shallow deposits and deeper aquifers. Moreover, given that there are very few existing wells pumping from the deeper aquifer, and the numerous historical wells in the East Bay Plain that could be vertical conduits, if the number of wells pumping from the deeper aquifer increases, there is a potential that shallow pollution could be drawn down into the deeper aquifers.

Water quality testing data for common organic pollutants in the East Bay Plain is very limited. In October 1997, eight water supply wells were sampled and tested for volatile organic compounds, metals and inorganic parameters in a joint project between ACFCWCD, EBMUD and the Regional Board. Two of the wells showed trace levels of carbon tetrachloride, chloroform, methylene chloride, naphthalene, and trichloroethene. However, the results are considered suspect because these two wells were not fully functional when the water samples were taken. Confirmation sampling is recommended when these wells are repaired. The contaminants may be related to residual chemicals used to lubricate the pumps in the wells. No volatile organic compounds were detected in the other six wells (see Appendix E).

Nearly all of the 32 active Regional Board SLIC Sites have volatile organic compounds (VOCs) in groundwater. Generally, VOC groundwater pollution has been regulated less aggressively in the East Bay Plain because the basin is not used as a current municipal source of drinking water. At a minimum, source control, plume delineation and long-term monitoring is typically required. A number of sites have also implemented soil vapor extraction and groundwater pump-and-treat systems.

9.2 Fuel Pipelines

Potential impacts to groundwater resources from leaking or ruptured fuel pipelines are recognized as significant areas of concern, especially in the seismically active East Bay Plain. Development of a GIS pipeline database is being performed by the State Fire Marshal’s Office. This information, when completed, should be made available to stakeholders in the East Bay Plain.



Pinole
Richmond
Martinez
San Pablo
Chevron Chemical
Chevron
Richmond
Santa Fe Railyard
Pleasant Hill
El Cerrito
Walnut Creek
Albany
LBL Bldgs 7 and 75
WGS Colortech
Lafayette
Berkeley
Orinda
Emeryville
Moraga
Piedmont
Contra Costa County
Alameda County
San Francisco
Site 5
Site 4
Alameda
Oakland
General Electric
Kaiser Aerotech
Caterpillar
DWA Plume
San Leandro
Castro Valley
1964 Williams Street
San Lorenzo
Thermofusion
Hayward
Chemcentral
Union City
East Bay Plain Beneficial Use Study
San Francisco Bay
Regional Water Quality Control Board
Landfills and
Groundwater Plumes
Longer than 1000 ft
Landfill
Groundwater Plume
Mapped Data Source:
Regional Water Quality Control Board
Mapped Data Name:
gwplume, ebplume landfill
East Bay Plain Groundwater Basin
0
3
6
MILES
May 1999

Figure 14

9.3 Vertical Conduits

Improperly abandoned wells (vertical conduits) are included in this section on Groundwater Pollution Sources. While vertical conduits are not "pollution sources" in the conventional sense, they can provide a potential pathway for contamination to migrate from shallow to deeper aquifers.

In the East Bay Plain, it is likely that numerous historical wells drilled prior to the importing of Sierra water are potential vertical conduits. J.H. Dockweiler (1912) provided a detailed snapshot of water supply and usage in the East Bay area in the fall of 1911 and identified a total of 3,573 wells. Of these wells, only 1,930 had data on well depth. In the study area overall, about 8% of the wells with depth data had a total depth of 200 feet or deeper. About 30% of the wells with depth data were 100 feet deep or more (see Section 12.1 for additional discussion)

The Yerba Buena Mud forms a major aquitard between the shallow and deep aquifers throughout much of the southwest portion of the East Bay Plain. However, the integrity of the aquitard may be locally compromised due to the drilling of wells in the 1890-1930 time frame. In Oakland, it is estimated that there are over 200 wells that penetrated the Yerba Buena Mud. It is surmised that virtually none of these wells was properly destroyed. In the remaining portions of the East Bay Plain, the Yerba Buena Mud is not present and no other major aquitards separate the shallow and deep aquifers.

One exception is the area along the extreme western East Bay Plain shoreline, south of the Bay Bridge, where artificial fill was placed after 1930. In this area, the Yerba Buena Mud is considered continuous and should form a natural barrier to minimize the downward spread of pollution.

9.4 Landfills

A total of about 1150 acres of bay-front wetlands were used for municipal waste disposal (see Figure 14). The landfills were constructed using earthen levees and filling the interiors with waste. Fill elevations range from approximately 20 to 150 feet above sea level. Most of the landfills are unlined and were built directly over Young Bay Mud. Typically, groundwater gradients are upward into the waste fill due to the weight of the overlying waste pile. The most significant water quality issue at these landfills is seepage of leachate from the base of the fill directly into San Francisco Bay. Minor low level VOC groundwater pollution is present at most of the landfills. Nearly all of the landfills are closed and capped and several have leachate extraction systems in place. The following table summarizes landfill data in the East Bay Plain.

Table 3B. Summary of Regulated Landfills in the East Bay Plain Groundwater Basin

Landfill Name and Regional Board Order No.	City	Years Operated	Acres	Water Quality Issues
Alameda Naval Air Station Landfill No. 93-129	Alameda	30-40 years until 4/93	Two landfills (12 and 110 acres respectively)	Primarily surface water issues.
Alameda City Doolittle Landfill No. 95-189	Alameda	1953-1985	40	No leachate detected below or off-site.
Albany Landfill	Albany	1963-83	75	Primarily surface water issue.
Berkeley Landfill No. 86-041	Berkeley	Approx. 1900-1985	90	Low levels of metals in groundwater and leachate within landfill footprint.
Oyster Bay/Davis Street Landfill	San Leandro	1942-1980	247	Shallow groundwater pollution. Leachate extraction planned to contain seeps.
Galbraith Landfill No. 94-187	Oakland	1930's-1960's	110	Fuels in shallow groundwater. Perimeter slurry wall installed. Currently used for dredged sediment disposal by Port of Oakland.
Oakland Scavenger Construction Debris Landfill, North Field, Oakland Airport	Oakland	1957-1960	21	
Tony Lema No. 95-129	San Leandro	1958-1977		Landfill gas found in groundwater wells in 1993.
West Contra Costa Landfill No. 96-079	Richmond	1953 – 1999	188	Fuels and VOCs in shallow groundwater. Slurry wall and leachate extraction system in place.
Winton Avenue Landfill	Hayward		approx. 200	Primarily surface water issues.
West Winton Landfill No. 95-088	Hayward	1938-1974	57	Seepage to surface water controlled by leachate extraction.

In addition to the regulated landfills discussed above, about 17,000 acres (26 sq. mi.) of bay-front wetlands and mudflats along the western edge of the East Bay Plain were filled with dredged material, construction debris, rock from various quarries, and other unknown sources. These fills were not previously regulated, but are now becoming an issue for regulatory review as the land use changes (e.g., Alameda Naval Air Station, the East Bay Shoreline State Park, and the Port of Oakland).

9.5 Department of Defense Sites

This subsection provides a summary of activities and releases to groundwater at four DoD facilities in the East Bay Plain: Naval Fuel Depot Point Molate, Fleet Industrial Supply Center Oakland (FISCO), Alameda Annex, and Alameda Point.

9.5.1 Naval Fuel Depot Point Molate

Naval Fuel Depot (NFD) Point Molate is located in the Potrero Hills along the northeastern shore of San Francisco Bay on the San Pablo Peninsula. Bulk fuel storage was provided at NFD Point Molate from 1943 until fuel transfer and storage ceased in May 1995. Several different fuels and wastewater have been stored in the 24 fuel tanks at the facility including Navy special fuel oil, marine diesel fuel, jet propellant (JP)-5, motor gasoline, mixed fuels, oil reclamation, lube and turbine oil, JP-8, ballast, wastewater, and sludge. Currently, four active Investigation Remediation (IR) sites are located at NFD Point Molate with three sites releasing contaminants to groundwater. Releases to groundwater include (1) oil, fuel, and sludge from leaking tanks, pipelines, and valve boxes, and (2) contaminated fuels, tank bottom sludges, and Bunker fuel from a former sump pond. Total petroleum hydrocarbons (primarily JP-5), PAHs, BTEX, and VOCs were the most commonly detected contaminants in groundwater. Five fuel-related and three chlorinated VOC-related plumes exist at NFD Point Molate. The fuel-related plumes range from approximately 50 feet in width by 75 feet in length up to 440 feet in width by 1750 feet in length and extend to the bottom of the artificial fill, approximately 22 feet below ground surface. The chlorinated VOC-related plumes range from approximately 50 feet by 50 feet up to 50 feet in width by 125 feet in length and also extend to the bottom of the artificial fill.

The Navy will be investigating the soil and groundwater around the large Underground Storage Tanks (USTs) and underground fuel pipelines in future investigations. There is the potential that other fuel plumes occur in the hillsides or near the shoreline due to previous spills from the USTs and fuel pipelines. The Navy is investigating approximately 20 two-million gallon USTs and approximately 20 miles of underground fuel pipeline, analyzing the soil and groundwater for TPH, VOCs, and SVOCs. Groundwater flow in the vicinity of NFD Point Molate is west to southwest, generally toward San Francisco Bay. The majority of the shallow groundwater at NFD Point Molate contains concentrations of total dissolved solids (TDS) below 3,000 mg/l. (Draft Final Evaluation of Beneficial Uses for Groundwater for NFD Point Molate, June 26, 1998, Table 1) The only portion of the facility that has shallow groundwater with a high TDS (up to 27,000 mg/l) is a portion of the shoreline. While the shallow aquifers are generally capable of maintaining a sustained yield of 200 gallons per day near the bay margin, pumping induced intrusion of saltwater would further degrade water quality. An extraction trench has been installed along the shoreline to capture floating fuel and remove contaminated groundwater for treatment.

9.5.2 Fleet Industrial Supply Center Oakland

Fleet Industrial Supply Center Oakland (FISCO) is located in Oakland just south of the San Francisco-Oakland Bay Bridge, and within the Port of Oakland. FISCO was commissioned in 1941 as the principal supply facility supporting DoD activities in the Pacific Basin and was the Navy’s largest west coast supply point. Currently, ten active Investigation Remediation sites are located at FISCO with eight sites releasing contaminants to groundwater. Releases to groundwater include (1) leaking fluids from a scrapyard and storage area, (2) disposal of waste materials (lubricants, solvents, paints), (3) leaking sumps and waste oil USTs, (4) spills from redrumming and overpacking operations, (5) discharges from a wash rack, and (6) spills due to poor drum handling and slow leaks from older drums. Chlorinated VOCs, BTEX, SVOCs, and TPH were the most commonly detected contaminants in groundwater. No fuel-related plumes exist at FISCO. One chlorinated VOC-related plume exists at FISCO and is approximately 350 feet long and 260 feet wide and extends to 12 feet bgs. The VOC contaminant plume is located within the artificial fill hydrostratigraphic unit. Groundwater flow in the vicinity of FISCO is west to southwest, generally toward San Francisco Bay. The groundwater typically contains moderate to high concentrations of total dissolved solids (405 to 36,000 mg/l) as a result of saltwater intrusion from San Francisco Bay. Lenses of fresh water exist near the ground surface as a result of leaking water supply distribution pipes and rainwater infiltration. While the shallow aquifers are generally capable of maintaining a sustained yield of 200 gallons per day near the bay margin, pumping induced intrusion of saltwater would further degrade water quality.

Regional Board staff have recently reviewed and commented on the Navy's groundwater beneficial use evaluation at FISCO (see Appendix G). As part of the review, staff found that the brackish quality of the shallow groundwater beneath FISCO is such that the water is not a potential source of drinking water pursuant to SWRCB Resolution 88-63 (Sources of Drinking Water Policy).

9.5.3 Alameda Annex

The Fleet and Industrial Supply Center, Oakland, Alameda Facility/Alameda Annex (hereafter referred to as the Annex) is located along the southern shore of the Oakland Inner Harbor in Alameda, California. It is situated about 1 mile southeast of the FISCO main base and less than ½ mile east of Alameda Point. Currently, seven active Investigation Remediation sites are located at the Annex with four sites releasing contaminants to groundwater. Releases to groundwater include (1) leaking fluids from a screening lot and scrapyard, (2) a diesel fuel spill, and (3) paint and solvent spills at a paint spray booth. Chlorinated VOCs, SVOCs, and TPH were the most commonly detected contaminants in groundwater. Five fuel-related plumes also exist at the Annex. The fuel-related plumes range from approximately 400 feet to 2000 feet long by 300 to 1000 feet wide and extend to the bottom of the artificial fill, approximately 10 to 12 feet bgs. All contaminant plumes are located within the artificial fill hydrostratigraphic units. Groundwater flow in the vicinity of the Annex is north to northwest toward the Oakland Inner Harbor. The groundwater typically contains moderate to high concentrations of total dissolved solids (500 to 36,000 mg/l) as a result of saltwater intrusion from the San Francisco Bay. Small lenses of fresh water exist near the ground surface as a result of leaking water supply distribution pipes and rainwater infiltration. While the shallow aquifers are generally capable of maintaining a sustained yield of 200 gallons per day near the bay margin, pumping induced intrusion of saltwater would further degrade water quality.

9.5.4 Alameda Point

Alameda Point (formerly Naval Air Station Alameda) is located on the western end of Alameda Island. Alameda Point was a major active naval base between 1936 and 1997. The installation and its tenants supported several activities that generated wastes including, but not limited to, industrial solvents, acids, paint strippers, degreasers, caustic cleaners, metal plating wastes, used oil, fuel, and asbestos. Other installation activities that generated hazardous wastes in the past include (1) repair of aircraft components for transient and tenant aircraft which may have produced contamination from fuel products and cleaning solvents; (2) air operations related fuel spills and fuel dumps; (3) waste oils stored in underground tanks from automotive service stations; (4) wastes related to receiving, issuing, storing, and shipping ammunition, ammunition components, and explosives; and (5) fueling support service activities.

Currently, twenty-five active Investigation Remediation sites are located at Alameda Point with seventeen sites releasing contaminants to groundwater. Releases to groundwater include (1) leachate from a 12 acre and a 110 acre landfill, (2) jet fuel from a former fuel storage area, solvents and heavy metals from paint stripping and plating operations, (3) solvents from parts cleaning, operations and equipment washing, (4) spills or leaks associated with underground storage tanks, fuel pipelines, and fuel pump islands, (5) spills and releases of petroleum products related to the former refinery, and (6) spills or leaks from hazardous waste container storage area. Chlorinated VOCs, BTEX, SVOCs, TPH, PAH, and heavy metals were the most commonly detected contaminants in groundwater. At least seventeen fuel-related and fourteen chlorinated VOC-related plumes exist at Alameda Point. The fuel-related plumes range from approximately 125 to 1,100 feet long by 125 to 600 feet wide and extend up to at least 27 feet bgs. The chlorinated VOC-related plumes range from approximately 125 to 1,800 feet long by 190 to 1,800 feet wide and extend up to at least 27 feet bgs. All contaminant plumes are located within the artificial fill and Merritt Sand hydrostratigraphic units, which comprise the first and second water bearing zones at Alameda Point. Generally, groundwater flow in the vicinity of Alameda Point is radial from the center of the facility toward the San Francisco Bay, Oakland Inner Harbor, and the Seaplane Lagoon. The first water bearing zone (fill aquifer) along the shoreline contains concentrations of total dissolved solids greater than 3000 mg/l, as a result of saltwater intrusion. However, the first water bearing zone in the central and southeastern portions of Alameda Point is primarily fresh water (<3000 mg/l TDS) and is recharged by rainwater infiltration and leaking water supply distribution pipes. The second water bearing zone (Merritt Sand) contains total dissolved solids greater than 3000 mg/l, except in the southeastern portion of Alameda Point. The southeastern portion of Alameda Point is distinctive due to the absence of a bay mud aquitard. The single water bearing zone (fill + Merritt Sand) contains mainly fresh (<3000 mg/l TDS) that is recharged by rainwater infiltration and groundwater flowing from eastern, upgradient portions of the Merritt Sand aquifer.

The size of fresh groundwater lenses may change during future property development at Alameda Point. On the one hand, the size of the fresh groundwater lenses may increase when the paved surfaces are removed. On the other hand, the size of the fresh groundwater lenses may decrease because redevelopment will include replacement of the leaking water supply and sanitary sewer pipelines, which currently are believed to provide the majority of fresh water recharge. The current safe yields for aquifer development exceed 200 gallons per day in the western, central and southeastern areas of Alameda Point. In the southeastern portion of Alameda Point, the current safe yield exceeds 8,000 gallons per day.

9.5.5 Oakland Army Base

Oakland Army Base (OARB) is a former active U.S. Army installation located in an industrialized area of Oakland. The installation was constructed on fill in a shallow tideland water area on the eastern shore of San Francisco Bay. OARB sits adjacent to the toll plaza of the San Francisco-Oakland Bay Bridge, and is surrounded by the Fleet Industrial Supply Center Oakland, the Port of Oakland, and the Southern Pacific Rail Terminal. It was constructed and began performing its duties as a military transportation port and distribution terminal in the early 1940s. Most of the site is approximately 10 feet above sea level. Seven operable units for investigation and remediation have been identified at OARB. They are all currently being investigated. These operable units include a railroad roundhouse site, a chlorinated solvent release site, and a housing area containing some petroleum tank sites. Chlorinated VOCs, SVOCs, and TPH were the most commonly detected contaminants in groundwater. The contamination has affected the artificial aquifer, and additional work is being conducted to investigate the potential that shallow contamination has migrated into the deeper Merritt Sand aquifer.

The natural groundwater gradient for the artificial fill is west toward San Francisco Bay. The total dissolved solids (TDS) of the artificial fill groundwater is high (up to 25,000 mg/l) in background borings that are in paved areas. The TDS of the shallow aquifer is below 3,000 mg/l in much of the unpaved, grassy areas of OARB. However, geochemical studies conducted by the Army have pointed to the source of the relatively fresh water as lawn watering, and leaking pipes at the base. The shallow artificial fill aquifer generally can sustain pumping rates of at least 200 gallons per day. Deeper groundwater studies and the potential for shallow groundwater contamination to migrate vertically to the Merritt Sand are being investigated, on a site-by-site basis, in the seven designated operable units.

9.6 Davis-Washington-Alvarado (DWA) Plume

The largest groundwater plume in the East Bay Plain is the Davis-Washington-Alvarado (DWA) Plume in San Leandro (Figure 14). The VOC plume (primarily TCE and PCE) is 2 miles long and over 1 mile wide. Since 1993, DTSC has been conducting soil and groundwater investigations to determine the extent of the plume and possible sources. DTSC has determined that the groundwater pollution could not be attributable to any one site but is coming from multiple sources. The extent of the groundwater plume has been defined and soil remediation has been conducted at several sites.

Many San Leandro residents use private wells in the vicinity of the plume for landscape and garden irrigation. DTSC has conducted a risk assessment and determined that shallow groundwater in the plume can be safely used for irrigation and other outside uses, but should not be used in the home for domestic purposes such as drinking, cooking, showering or bathing. An intensive public education campaign was conducted in the early 1990’s to warn residents of the risks associated with drinking the shallow groundwater and to encourage and facilitate residents that were using shallow wells for domestic purposes to connect to the EBMUD water system. Currently, DTSC is investigating eight potential sources of pollution within the DWA plume and developing a coordinated plan for long-term management of the plume.

9.7 Chevron Richmond Refinery

The Chevron Richmond Refinery is located on the peninsula of the Potrero-San Pablo Ridge in northwestern Richmond. It consists of a large refining complex and appurtenant tank fields and manufactures and stores approximately 12 primary refined petroleum products including propane, gasoline, jet fuel, fuel oils, diesel, lube oil, solvents and other byproducts.

The refinery was built at the turn of the century. There are four geologic zones: Alluvial, Flats (marsh covered by fill), Ridge (deformed Franciscan Complex), and Transition Zone (between Flats and Ridge) on more than 2,900 acres. The City of Richmond lies south and east of the facility, where there are industrial, residential, commercial and agricultural land use operations. It is classified as an integrated refinery as defined by the U.S. Environmental Protection Agency in 40 CFR 419.50. Remediation of the site is regulated by the Regional Board under Order No. 93-109. Groundwater pollution at the refinery is prevented from migrating off site by a four-mile long slurry wall/groundwater interceptor trench. Within the refinery property, groundwater and soil contaminated sites are being remediated. However, restoration of groundwater beneath the entire refinery is not a requirement due to the infeasibility of remediating significant pollution related to nearly 100 years of operation and the absence of any historical, existing or planned municipal beneficial use.

9.8 Port of Oakland

The Port of Oakland is a semi-autonomous department of the City of Oakland that is responsible for the management of the Marine Terminals, Oakland International Airport, and commercial real estate. The Port has jurisdiction over the Port Area, defined as extending immediately south of the Bay Bridge to the City of San Leandro northern boundary and including approximately 23 miles of shoreline. Geographically the Port is situated at the boundary between the East Bay Plain and San Francisco Bay.

Prior to the arrival, in the mid-1800’s, of the transcontinental railroad, the Oakland shoreline was relatively unaltered. Subsequently, deep water shipping channels were dredged and the intertidal and shallow near-shore Bay waters were filled with dredged materials, some refuse materials, and imported soils. The new land was mostly utilized for both marine and heavy industrial activities. Typical industrial usages included railyards, shipbuilding, gas and electric generation, lumber yards, grain milling and storage, petroleum tank farms, and a number of smaller industries. With the arrival of World War II, the US military filled additional Port Baylands to create large installations to support the war effort. Beginning in the 1960’s, the conversion of the ocean-going shipping industry from break-bulk to containerization resulted in wholesale changes in the Marine Terminals landscape. Timber wharves and finger piers, transit sheds, and near shore industries were replaced by marginal concrete wharves, container cranes, and large paved container storage yards.

The industrial legacy has left a mark upon the soils and shallow groundwater under the Port Area. Past industrial releases have typically and locally impacted some sites with petroleum hydrocarbons, i.e. gasoline and diesel fuels derived from underground and above ground storage tanks, and atypically, polynuclear aromatic hydrocarbons associated with residues from gas and power generation plants. The most significant sites at the Port include a former wood treatment plant at Embarcadero Cove (State Superfund Site), fuel pollution at Berth 24, and a former Coal Gasification Plant. There are 12 leaking underground storage tank sites at the Port; six have been remediated and are closed, five are on quarterly monitoring and one site is undergoing active remediation.

The Port recently conducted a hydrogeologic investigation of the Marine Terminals area. The purpose of the study was to assess the potential for saltwater intrusion from San Francisco Bay as a result of a proposed deepening of the shipping channels. The study concluded that the proposed deepening would have minimal impact on the Alameda Formation aquifer. However, the study demonstrated that shallower water-bearing units, the Merritt Sand and saturated fill soils, have already been invaded by salty Bay water.

9.9 Oakland Central District Redevelopment Area

The Oakland Central District Redevelopment Area, often referred to as the Uptown Theater District, encompasses Oakland's historic downtown. This area, which is anchored by the historic Fox Theater, was almost completely abandoned by business over the last three decades. Significant groundwater contamination has been identified in large portions of the area and must be addressed prior to redevelopment.

9.10 Bacteriological Contamination

Leaking sewer pipes are estimated to account for 20% of the groundwater recharge in the East Bay Plain. Shallow groundwater frequently contains elevated levels of fecal coliform. Both of these findings are typical for highly urbanized areas. California State Well Standards require a minimum 50-foot deep well seal for drinking water wells to guard against exposure to such contamination.

10.0 ECOLOGICAL IMPACTS

In the East Bay Plain, groundwater may discharge directly to the Bay or to freshwater features such as lakes, creeks, or manmade culverts or channels, which in turn discharge to the Bay. Over the last hundred or more years, a great deal of industrial activity has occurred along the Bay margin, and has resulted in many instances of groundwater contamination. This section looks at sites where groundwater contamination exists near a surface water body where there is the potential for impacts to aquatic receptors. To summarize the findings of the section, there are a number of sites where concentrations of chemicals in groundwater exceed numerical water quality objectives for individual constituents or levels of mixtures shown to have impacts in aquatic receptor tests. At the present time, while the potential for impact exists, studies to establish a link between these sites and impacts to aquatic receptors have not been completed or performed.

10.1 Ecological Impacts from Petroleum Hydrocarbons

In the East Bay Plain, most documented releases of contaminants to the subsurface that have resulted or could result in degradation of groundwater quality are associated with underground fuel storage tanks. A preliminary assessment of the potential for such sites to reach surface water was conducted using the information presented in Figure 6. To make this assessment, the number of sites located within about 250 feet of a surface water body was estimated. Surface water bodies included the Bay, surface water drainages shown on Figure 6, and wetlands (the latter primarily in the most southerly and northerly portions of the East Bay Plain). The distance of 250 feet was selected for fuel sites based on the Lawrence Livermore National Laboratory (LLNL) finding that 90% of groundwater plumes at fuel sites stabilize within about 250 feet of the source of the release. Thus, the class of sites more than 250 feet from surface water bodies are judged to have a small potential for impacts to ecological receptors via a groundwater pathway. About 40 sites were identified within 250 feet of the Bay or wetlands adjacent to the Bay. About 60 sites were identified within 250 feet of surface water drainages.

An example of a site where discharge of petroleum hydrocarbons to surface water has been documented is located at 1138 Glascock Street on the Oakland side of the Oakland-Alameda estuary. A 20,000-gallon diesel tank and a 4,000-gallon diesel tank were removed from the property in 1993. Samples collected in the last 12 months from a well located adjacent to the estuary have shown concentrations of TPH-diesel and TPH-motor oil ranging from 1 to 10 mg/l and 1 to 8 mg/l, respectively.

The Chevron refinery in Richmond is another facility in the East Bay Plain where petroleum hydrocarbons in groundwater have discharged to the surface waters of San Francisco Bay. An assessment of ecological impacts associated with releases from the refinery and associated activities to surface water and sediment of the Bay is in the planning stages.

At sites where groundwater containing petroleum hydrocarbons is discharging to surface water, the potential for impacts to aquatic receptors exists. While the nature and degree of any such impacts is not well characterized at this time, studies conducted at other Bay margin sites indicate that water with TPH concentrations in the range of 100-1,000 ug/L can result in significant effects on test organisms.

10.2 Ecological Impacts from Chlorinated Solvent Plumes

There are an estimated 90 sites in the East Bay Plain where chlorinated solvents have been identified in groundwater. Of these sites, about 19 are located within 1000 feet of the Bay or a surface water feature. Major plumes in the East Bay Plain are shown on Figure 14. In general, the major solvent plumes do not extend to the Bay or discharge to surface water. The potential for impacts to ecological receptors from chlorinated solvents would appear to be limited.

10.3 Ecological Impacts from Pesticides

There appears to be little evidence of discharge of pesticides to surface water via a groundwater pathway. As an example, at the United Heckathorn site on the Lauritzen Canal, Richmond, crystalline DDT (100% DDT) was observed in shallow soils while concentrations in sediments ranged to 633 mg/kg. Groundwater investigations revealed little in the way of dissolved pesticides. This observation is consistent with the generally strong sorption characteristics of many pesticides. Direct discharge or transport of pesticides with suspended sediment in surface water appears to be much more significant migration pathways to aquatic ecological receptors than migration as a dissolved phase in groundwater.

10.4 Ecological Impacts from Metals

This section illustrates the potential impact to aquatic receptors via elevated metals concentrations in groundwater through brief discussions of two sites: the Volvo-GM site in Oakland and the Zeneca Ag Products site in Richmond.

The Volvo-GM site is located at 5050, 5051, and 5200 Coliseum Way, Oakland. The site was formerly a paint manufacturing facility. Several metals including arsenic, cadmium, cobalt, copper, lead, nickel, and zinc are contaminants of concern. The site is bordered on the west by subsurface culverts and a stormwater drainage channel. Groundwater elevation contours and contaminant distribution maps indicate groundwater discharges to the culverts or channel. The channel discharges to San Leandro Bay. Groundwater contaminant concentrations of zinc have exceeded Basin Plan water quality objectives by factors of up to 20,000. Concentrations of cadmium, copper, and nickel have exceeded objectives by factors of 100 to 1,000. Storm sewer samples have shown elevated nickel and zinc concentrations. An ecological risk assessment is planned at this site.

The Stege Marsh site (owned by Zeneca Ag Products) is located at 1415 South 47th Street, Richmond. The site occupies about 75 acres and is bordered to the south by a tidal basin connected to San Francisco Bay. A variety of chemicals has been manufactured at the facility. Chemicals associated with plant activities have been identified in Quaternary Alluvium to depths up to 20 feet below Mean Sea Level, and include arsenic, cadmium, copper, lead, zinc, and several chlorinated volatile organics. Maximum measured metals concentrations in wells adjacent to the tidal basin exceed Basin Plan water quality objectives by factors of up to about 500. An ecological risk assessment is planned for this site, although groundwater discharge is not considered to be the most important route of exposure to aquatic receptors.

11.0 REGULATORY ISSUES

11.1 Lawrence Livermore National Laboratory LUFT Report

In October 1995, Lawrence Livermore National Laboratory (LLNL), under contract to and at the request of the State Board, submitted written recommendations to the State Board for improving the cleanup process for California's leaking underground fuel storage tanks (LUFTs) for fuels without MTBE or other oxygenates. The recommendations were the result of an 18-month review of the regulatory framework and cleanup procedures currently applied to LUFTs. Under current regulation, the minimum cleanup standards for cases affecting groundwater are the maximum contaminant levels (MCLs) for drinking water. Numeric cleanup standards are not established for residual fuel hydrocarbons (FHC) in soil.

The main findings of the LLNL study were: 1) if an FHC source is removed, passive bioremediation processes act to naturally reduce the mass of dissolved constituents in groundwater, and to eventually complete the FHC cleanup, 2) dissolved benzene plumes in groundwater tend to stabilize at relatively short distances from the FHC release site, 3) in 90% of the cases, benzene concentrations greater than 10 ppb extended no more than about 250 feet from release sites, and 4) a review of the state's database of over 28,000 cases showed that 136 sites (0.5%) reportedly have affected drinking water wells.

The LLNL study also found that remediation alternatives that use pump and treat technologies were ineffective at reaching MCL groundwater cleanup standards for FHC constituents in many geologic settings. Although contaminated groundwater can be removed, contaminants sorbed to soil particles act as a continuing source to groundwater, making it difficult to reach MCLs. The LUFT historical case study conducted by LLNL, as well as other historical case studies, found that once an FHC source is removed, the time for passive bioremediation to reduce a dissolved FHC plume by a factor of 10 is about 1 to 3 years. LLNL recommended that passive bioremediation be used as a remediation alternative for LUFTs whenever possible; pump and treat remediation should not be used unless its effectiveness can be demonstrated.

From a regulatory perspective, the LLNL study concluded that the current LUFT decision-making process does not result in cost-effective site closures. As an alternative, a Risk-Based Corrective Action (RBCA) approach to LUFT cleanups was recommended to provide guidance to reasonably manage risks to human health, ecosystems, and groundwater beneficial uses, while considering technical and economic feasibility.

The RBCA approach is tiered. Lower tiers use conservative assumptions and historical or screening level data to make decisions. Tier 1 evaluations rely on a generic approach and are applicable to most LUFT cases and sites. Higher tier evaluations require more intensive, site-specific data as a trade-off for the conservative Tier 1 assumptions. By using a modified American Society of Testing and Materials (ASTM) RBCA approach, LUFT cases can be evaluated on the basis of exposure pathways, (e.g., proximity of drinking water wells and depth to groundwater). A modified Tier 1 approach could encompass a majority of California's LUFT cases, and encourage the use of passive remediation. LLNL recommends that a modified ASTM RBCA framework be applied to cases where FHCs have affected soil but do not threaten groundwater, and that SWRCB policies be modified to allow the consideration of risk-based cleanup goals higher than MCLs. The Regional Board concurs with the submitted recommendations, and implements them for LUFT cases on a case-by-case basis.

11.2 Methyl-tert-butyl-ether (MTBE)

Methyl-tert-butyl-ether (MTBE) is an oxygenate additive to gasoline intended to reduce combustion emissions. MTBE is more soluble, less volatile, less well adsorbed, and apparently significantly less biodegradable than gasoline mixtures or benzene. As a consequence, releases of gasoline to the subsurface have resulted in MTBE migration in groundwater that is much more extensive than the migration of the gasoline or other constituents of concern in gasoline. In addition, MTBE imparts an unpleasant taste and odor to water at very low concentrations. Given its migration characteristics and its low taste and odor threshold, the potential for impacts to water supply wells is higher for MTBE than for gasoline or BTEX constituents. The concern would be greatest for wells completed in shallow aquifers, as is the case for some domestic wells included in the ACFCWCD or EBMUD well database.

The Department of Health Services has proposed a taste and odor secondary MCL of 5 ppb for MTBE. The Office of Environmental Health Hazards Assessment proposed a Public Health Goal of 14 ppb in August 1998. The primary MCL for MTBE must be adopted by DHS by July 1, 1999, and could be as low as 14 ppb.

The use of MTBE in reformulated gasoline to satisfy the federal Clean Air Act has sparked considerable controversy in California and elsewhere. On November 12, in conformance with SB 521, the University of California (UC) issued a report to the Governor, “Health and Environmental Assessment of Methyl Tertiary-Butyl Ether (MTBE)”, which found that the air quality benefits of reformulated gasoline containing MTBE were not significant on exhaust emissions from advanced technology vehicles. However UC did find that there are significant risks and costs associated with water contamination due to the use of MTBE. The UC report recommends a gradual phase out of MTBE over several years as well as other strategies to minimize the risks associated with MTBE. On March 25, 1999, after peer review and public hearings, in accordance with SB 521, the Governor issued Executive Order D-5-99 that mandated the California Air Resources Board develop a timetable by July 1, 1999 for the removal of MTBE from reformulated gasoline at the earliest possible date, but no later than December 31, 2002.

12.0 HISTORICAL GROUNDWATER BENEFICIAL USES

Groundwater was a major part of the water supply for the East Bay during the period from 1860 to 1930, before Sierra water was imported to the area. Groundwater may have supplied up to 15,000,000 gallons of water per day for short periods, and was the sole supply for months on end during times of drought. Approximately half of the groundwater was pumped from the study area (Figuers, 1998). Most of this was produced from a band of well fields stretching from the southeastern end of Alameda Island to 98th Street in Oakland. Groundwater was used widely for municipal supply. It is estimated that 15,000 wells were drilled in the Basin between 1860 and 1950 (Figuers, 1998). Most of these wells were less than 50 feet deep, but many were 200 to 500 feet deep, with some extending as deep as 1000 feet below ground surface (see Figures 2 and 3).

While the development of local groundwater supplies was instrumental in the early development of the East Bay Plain, by the late 1920's the supply was too small to meet the growing population. In addition, wells often became contaminated by seepage or saltwater intrusion. Thus faced with an increasingly degraded and insufficient water supply, East Bay civic leaders turned to imported supplies to meet the growing demand for water. Early alternatives for such a supply included a joint effort in developing the Hetch Hetchy Reservoir with the City of San Francisco, pumping surface water from the Sacramento Delta and developing its own Sierran supply. Ultimately the decision was made to develop a Sierran supply by building Pardee Reservoir. For a detailed and colorful account of the East Bay Plain water supply history, see Figuers (1998).

In addition to using the East Bay Plain for a source of drinking water, it was used for agricultural and industrial supply. An estimated 15,000 acres of land were in agricultural production in 1963 (Muir, 1994). If all of this acreage was irrigated with an average of 3 acre-feet/year, agricultural usage would have been an estimated 45,000 acre-feet in 1963. It is not known what portion of historical agricultural usage may have been supplied by groundwater. Groundwater has also been used for industrial processes, though no estimates of historical usage were obtained for this report.

12.1 Dockweiler Report

J.H. Dockweiler (1912) provided a detailed snapshot of water supply and usage in the East Bay area in the fall of 1911. During the period August to October 1911, Dockweiler hired a corps of canvassers to identify all wells in the territory between Richmond and Hayward. Canvassers went house to house and recorded the address, use and number of people served, depth to water and depth of water in the well. Dockweiler estimates that 80% of the wells were recorded, the remainder being small wells with hand pumps.

Excluding those in Castro Valley, a total of 3,573 wells were identified (see Figures 2 and 3). Of these wells, only 1,930 had data on depth to water or height of water in well. It is assumed that the depth to water in the well plus the height of water in the well would be equal to the total depth of the well. The data was put into a spreadsheet to examine statistics on the number of deep wells in each city area. Table 4 summarizes the results of this analysis. In the study area overall, about 8% of the wells with depth data had a total depth of 200 feet or deeper. About 30% of the wells with depth data were 100 feet deep or more.

Looking at each city area individually and estimating the area of the city canvassed, an approximate deep well density for 1911 can be calculated. This calculation shows the highest density of wells 200 feet deep or more to be in the areas of Alameda and Oakland, with densities of 6 to 10 deep wells per square mile. These cities were fairly densely developed, so these numbers may accurately reflect the density of the time. In Alameda, there are reports of saltwater intrusion of the shallow groundwater, so the density of deeper wells may be due to pursuit of clean, deeper aquifers. Other developed areas were Berkeley and Emeryville, where the deep well density was fairly low, around 1 deep well per square mile. This low density reflects the shallow bedrock in this area. Any deep wells were likely installed close to the Bay shore.

Richmond was partially developed and the San Leandro/San Lorenzo and Hayward areas were rural (undeveloped) in 1911. These areas had low deep well densities (zero deep wells in the hamlet of Hayward and about 1 deep well per 2 square miles in Richmond and San Leandro/San Lorenzo). The low deep well density in Richmond even with the partial development at the time may reflect the successful service of the water companies there and their wellfields in Richmond and San Pablo. The deep well densities in all those areas are likely to have increased due to development between 1911 and the early 1930s when EBMUD began supplying imported surface water to the region.

Table 4. Summary of Well Data Recorded in the Dockweiler Report

Area	Total Wells Reported	Wells deeper than 199 ft	Wells deeper than 99 ft	Approximate Area Canvassed (sq. mi.)	Ratio Wells > 199 ft Deep wells per Sq. Mile
Alameda	362	16%	55%	6	10.2
Berkeley	642	1%	9%	12	0.6
Emeryville	77	3%	5%	2	1.2
Hayward	55	0%	2%	1	0.0
Oakland	1762	12%	36%	35	6.0
Richmond	238	5%	51%	26	0.5
San Leandro/ San Lorenzo	437	2%	13%	16	0.5
Overall	3573	8%	30%		

Note: Well canvassing took place in 1911. Canvassers recorded depth to water and height of water in well for 1,930 of the 3,573 wells recorded (percentage of wells are based on these 1,930 records). "Depth to water" and "feet of water in well" were added to calculate the well depth and this data was analyzed for wells depth statistics. The approximate area canvassed was measured roughly off the map on page 141 from the Dockweiler report.

13.0 CURRENT GROUNDWATER BENEFICIAL USES

13.1 Industrial Use

Using a variety of sources, Muir (1996) compiled information on groundwater use in the Alameda County portions of the basin, including the amount of groundwater pumped by industrial concerns and remediation projects. EBMUD, DTSC, the Environmental Compliance Department of the San Leandro Water Pollution Control District, and the Hayward Sewage Treatment Plant supplied data that were critical to determine this pumpage. He also used a county list of industrial wells and contacted individual industrial concerns to determine if they used groundwater.

Muir found that only ten industrial concerns used groundwater. They pumped a total of 1015 acre-feet in 1995, which came from wells deeper than 200 feet. This was used mainly in food processing and product manufacturing. He estimated that there were about 60 remediation projects in operation in the East Bay Plain in any one year, pumping about 800 acre-feet, generally from wells less than 100 feet deep. Thus, estimated total industrial use in 1995 was 1815 acre-feet.

13.2 Agricultural Use

Muir (1996) compiled information on agricultural groundwater use in the Alameda County portion of the East Bay Plain as follows:

In 1995, five elements were considered: golf courses, cemeteries, schools and colleges, parks, and crops. Data from DWR Bulletins No. 113-3 (DWR, 1975) and No. 113-4 (DWR, 1986) and Sunset (1961) were used to estimate agricultural pumpage.

Golf Courses – Only two golf courses used wells for irrigation; all others used either reclaimed sewage water or water stored in lakes from captured rainfall runoff. It was estimated that the two golf courses pumped 390 acre-feet of groundwater.

Cemeteries – Three cemeteries used approximately 450 acre-feet of well water for irrigation.

Schools and Colleges – Several high schools and colleges use well water to irrigate athletic fields. Their total pumpage for 1995 was estimated to be only 20 acre-feet.

Parks – A number of parks in the East Bay Plain have wells for irrigation purposes, but a total of only 25 acre-feet were used.

Crops – There were only 14 acres of row crops and several hot houses in the area; their estimated pumpage totaled 25 acre-feet.

Table 5. Groundwater Pumpage for Agricultural Use in the East Bay Plain, 1995

Use	Acre-Feet
Golf Courses	390
Cemeteries	450
Schools and Colleges	20
Parks	25
Crops	25
Total Agricultural Usage	910

13.3 Domestic Use

13.3.1 EBMUD Survey

EBMUD staff conducted an agency survey to identify small drinking water systems (2 or more connections) in the East Bay Plain (excluding Castro Valley):

- Alameda County Department of Environmental Health oversees water systems of 2 to 14 connections (Personal communication, Ron Torres).
- California DHS Division of Drinking Water and Environmental Management oversees water systems of 15 and higher connections in Alameda County (John Andrew at 510-540-3227).

- Contra Costa County DEH oversees water systems of 2 to 199 connections (William Alejandro at 925-646-5225 x212).

Although other systems may exist, agency files only indicate several small drinking water systems in Alameda County that rely on groundwater. There are no known small water systems in Contra Costa County. The water systems are grouped below by oversight agency.

Alameda County DEH records indicate two small water systems that rely on groundwater for drinking water:

- The Venice Court Housing Group, located on Venice Court off Dutton in the northern part of San Leandro. One well serves 7 houses. Well depth is unknown.

- 24180 Saklan, off Winton Avenue on the outskirts of Hayward. One well serves 4 or 5 units. The well was deepened in 1989, although well construction details are not known.

DHS ODW records indicate several groundwater-based water systems with 15 or more connections (see Figure 15):

- 2399 East 14th Street, San Leandro. The Trailer Haven trailer park has a 290-foot deep well. Although the site is located near the source of the DWA Plume, solvents have not been detected in water from the well (per Karen Toth, DTSC).

- 28111 Harvey Street in Hayward. One well serves 6 units. Well construction details are not known.

- 6901 Sobrante Road, Oakland, off Skyline. One well serves 4 homes and is pumped at 40 gpm. The well is 275 feet deep. This system is not in the East Bay Plain.

- The Mohrland Mutual Water Company in Mt. Eden, an unincorporated area near Hayward. It serves about 180 connections with one well that is approximately 800 feet deep.

The City of Hayward has installed 4 emergency supply water wells with one more planned. The 5 wells are expected to supply 10,000 gpm for use over 7 days should an earthquake damage the San Francisco Water Department's Hetch Hetchy aqueduct, which is the main drinking water source for the city. The wells range in depth from 464 to 600 feet.

In addition, there may be households with a single well connection using groundwater for drinking water. The following agencies were contacted to identify single connection domestic-use wells:

- Alameda County Flood Control and Water Conservation District (ACFCWCD) issues well permits for much of Alameda County except Berkeley and the areas covered by Zone 7 and the

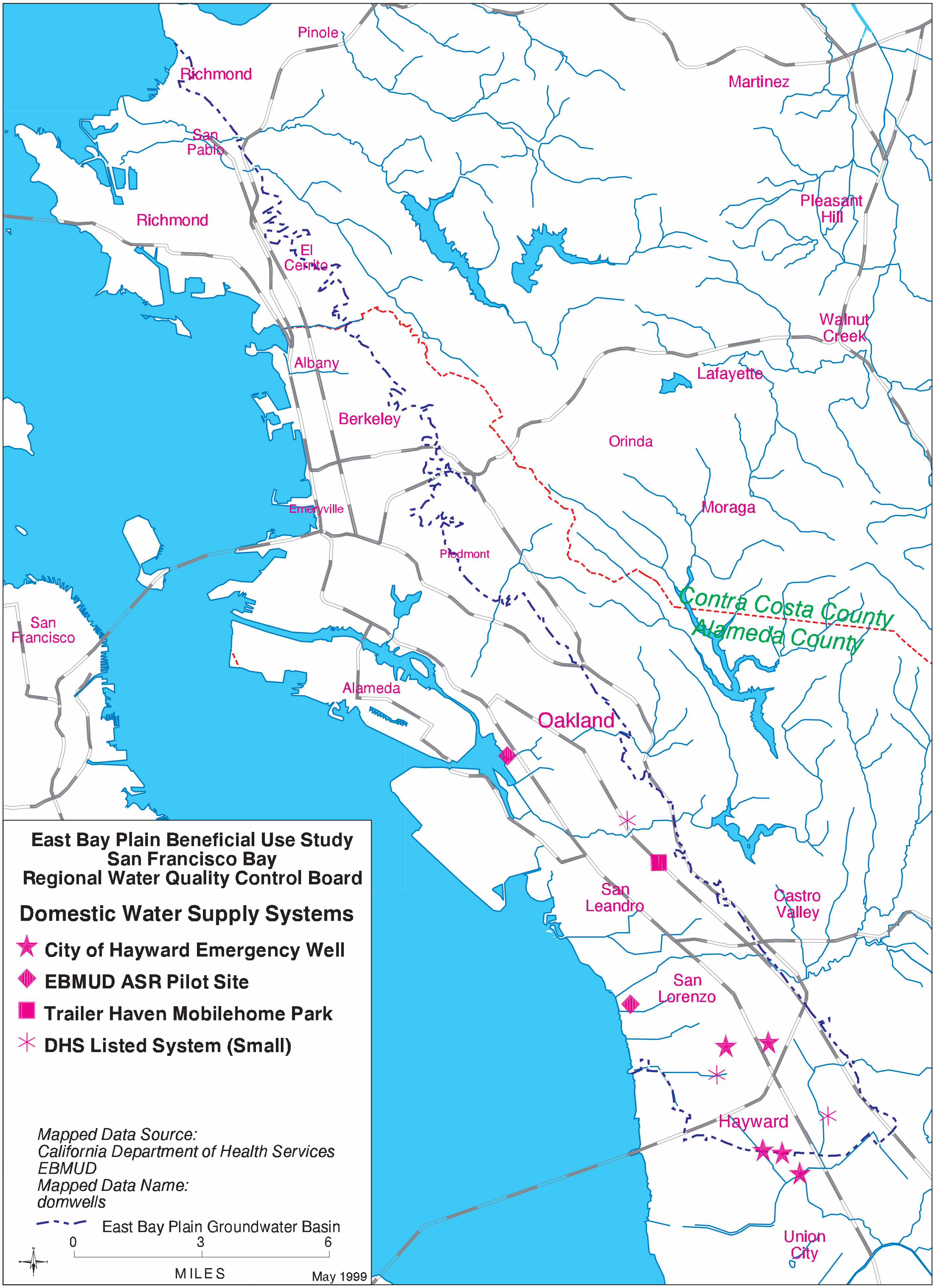

Pinole
Richmond
Martinez
San Pablo
Richmond
Pleasant Hill
El Cerrito
Walnut Creek
Albany
Lafayette
Berkeley
Orinda
Moraga
Emeryville
Piedmont
Contra Costa County
Alameda County
San Francisco
Alameda
Oakland
San Leandro
Castro Valley
San Lorenzo
Hayward
Union City
East Bay Plain Beneficial Use Study
San Francisco Bay
Regional Water Quality Control Board
Domestic Water Supply Systems
City of Hayward Emergency Well
EBMUD ASR Pilot Site
Trailer Haven Mobilehome Park
DHS Listed System (Small)
Mapped Data Source:
California Department of Health Services
EBMUD
Mapped Data Name:
domwells
East Bay Plain Groundwater Basin
0
3
6
MILES
May 1999

Figure 15

Alameda County Water District (contact: Andreas Godfrey at 510-670-5575).

- City of Berkeley Department of Public Works Permit Service Center 510-883-6555 and City of Berkeley Planning Department Toxics Division (contact: Nabil Al-Hadithy at 510-705-8155).

- Contra Costa County DEH issues well permits for Contra Costa County (contact: William Alejandro at 925-646-5225 x212).

- EBMUD maintains a database of well owners for their Backflow Prevention Program.

EBMUD obtained a copy of ACFCWCD's well database as of January 1, 1997. This compilation of wells is incomplete and may include wells abandoned or destroyed. The well database includes wells permitted by the agency and installed in the Alameda County portion of the Plain (excluding Berkeley) starting in July 17, 1973, with sporadic records of wells installed prior to that. For wells destroyed or abandoned, it is difficult to cross-check installation with destruction records.

As part of the evaluation of beneficial uses in the East Bay Plain, the ACFCWCD data for all wells coded as Domestic, Municipal, Irrigation, and Industrial was analyzed (see Figures 16 and 17). ACFCWCD codes wells as Domestic, Irrigation, Municipal, and Industrial. Of the 1421 wells permitted since July 17, 1973 by ACFCWCD, 1417 (99.6%) are for non-drinking water purposes. A summary of the number of wells in each category is shown below:

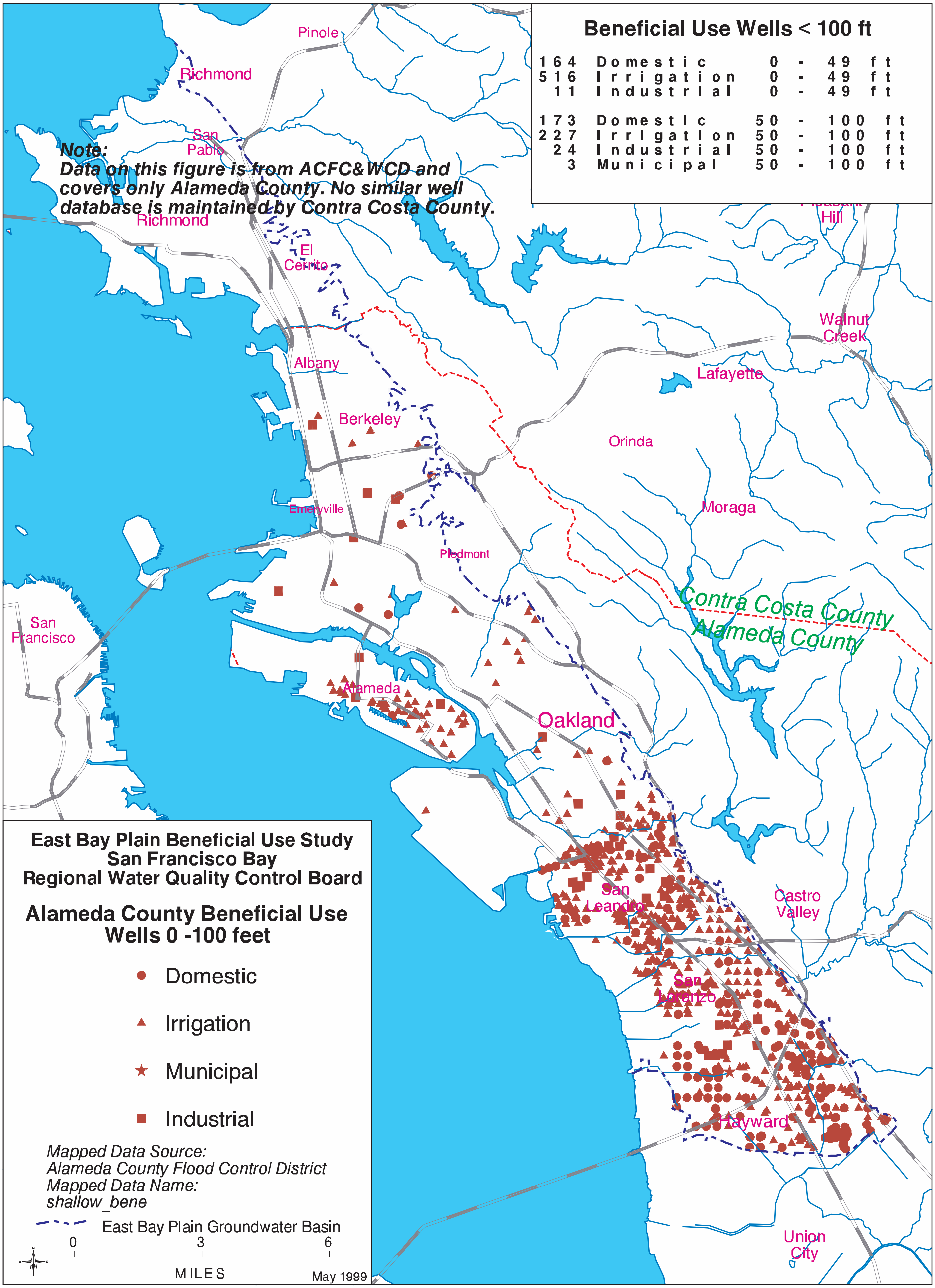
Table 6. Number of Permitted ACFCWCD Wells Classified as Domestic, Irrigation, Municipal or Industrial

Use Code and Description	Total Number of wells <100 ft. deep	Total Number of wells >100 ft. deep	Sub Total
Domestic – Small scale irrigation well (e.g. private backyard irrigation well)	331	61	392
[1] Municipal – Large scale drinking water well	2	11	13
Irrigation – Large scale irrigation well	730	169	899
Industrial – Industrial process supply well	38	79	117
TOTAL	1101	320	1421

[1] Of these 13 wells, only 7 are known to be for drinking water supply. These 7 wells consist of 3 owned by the Mohrland Mutual Water Company in Hayward (one of which is active), 2 owned by EBMUD, and 2 owned by the City of Hayward. The remaining 6 wells are not believed to be used for drinking water purposes.

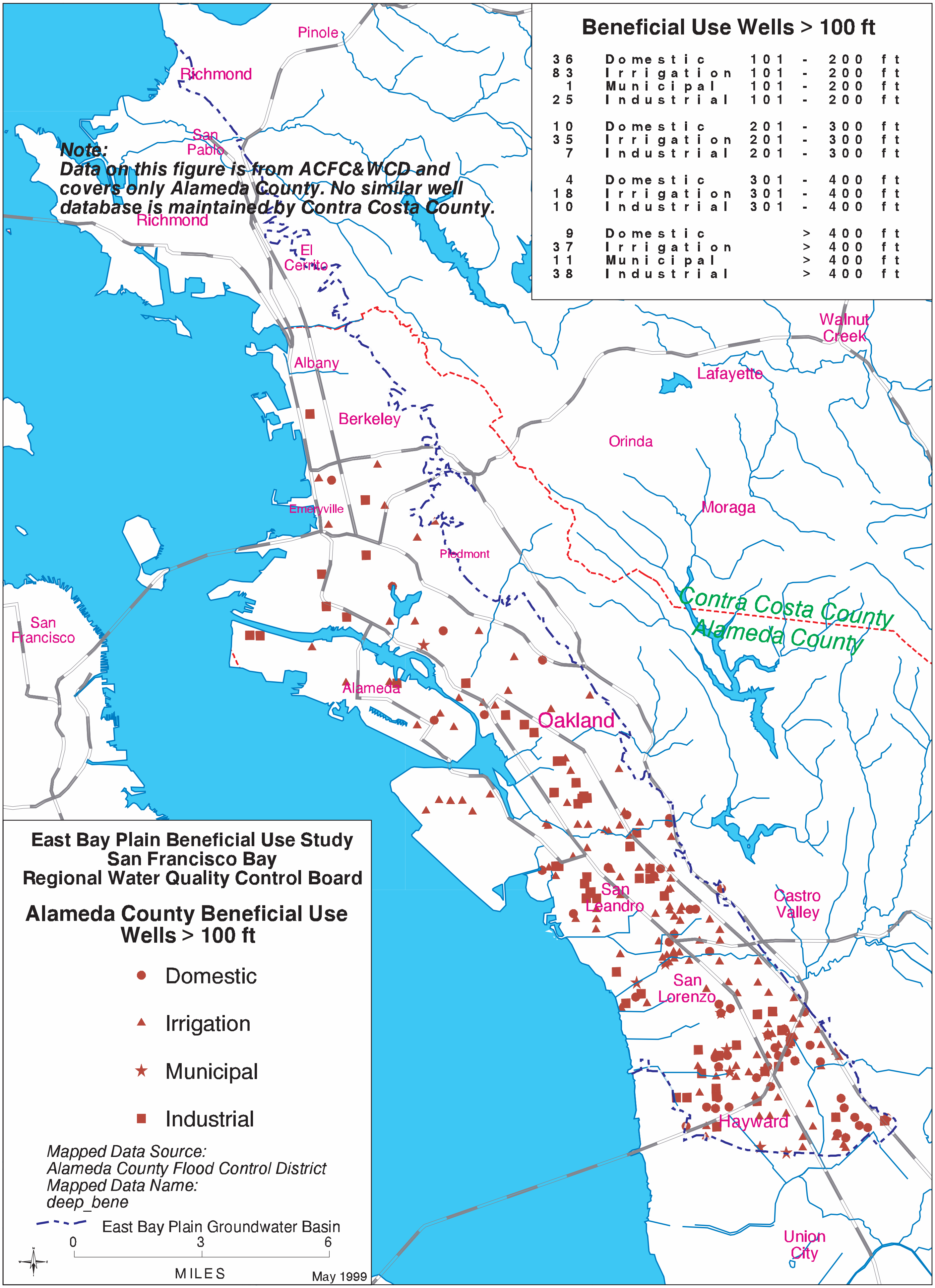
For the following cities, the number of wells indicated as "domestic use" (defined as small scale irrigation wells, e.g. private backyard irrigation wells) or "municipal use" (defined as large scale drinking water wells) are as follows:

- Alameda: 2 wells, 60 and 325 feet deep
- Albany: 0 wells
- Berkeley (although ACFCWCD does not issue permits for Berkeley): 2 wells, 180 and 204 feet deep
- Emeryville: 0 wells



Beneficial Use Wells < 100 ft
164 Domestic 0 - 49 ft
516 Irrigation 0 - 49 ft
11 Industrial 0 - 49 ft
173 Domestic 50 - 100 ft
227 Irrigation 50 - 100 ft
24 Industrial 50 - 100 ft
3 Municipal 50 - 100 ft
Note:
Data on this figure is from ACFC&WCD and covers only Alameda County. No similar well database is maintained by Contra Costa County.
Pinole
Richmond
San Pablo
Richmond
El Cerrito
Albany
Berkeley
Emeryville
Piedmont
Orinda
Moraga
Lafayette
Walnut Creek
Hill
Contra Costa County
Alameda County
San Francisco
Alameda
Oakland
San Leandro
Castro Valley
San Lorenzo
Hayward
Union City
East Bay Plain Beneficial Use Study
San Francisco Bay
Regional Water Quality Control Board
Alameda County Beneficial Use Wells 0 -100 feet
Domestic
Irrigation
Municipal
Industrial
Mapped Data Source:
Alameda County Flood Control District
Mapped Data Name:
shallow_bene
East Bay Plain Groundwater Basin
0
3
6
MILES
May 1999

Figure 16



Beneficial Use Wells > 100 ft

36	Domestic	101 - 200 ft
83	Irrigation	101 - 200 ft
1	Municipal	101 - 200 ft
25	Industrial	101 - 200 ft
10	Domestic	201 - 300 ft
35	Irrigation	201 - 300 ft
7	Industrial	201 - 300 ft
4	Domestic	301 - 400 ft
18	Irrigation	301 - 400 ft
10	Industrial	301 - 400 ft
9	Domestic	> 400 ft
37	Irrigation	> 400 ft
11	Municipal	> 400 ft
38	Industrial	> 400 ft

Figure 17

- Hayward: 357 wells, depths range from 18 to 763 feet
- Oakland: 32 wells, depths range from 33 to 533 feet
- Piedmont: 24 wells, depths range from 83 to 300 feet
- San Leandro: 76 wells, depths range from 12 to 596 feet
- San Lorenzo: 14 wells, depths range from 30 to 834 feet.

Note that the total wells listed above are greater than shown in Table 6. This is because some wells located in the above cities are outside (i.e., east) of the East Bay Plain basin boundary.

The City of Berkeley issues permits for monitoring wells through its Toxics Division but does not maintain a publicly accessible well database. It is possible that several units near San Pablo Ave. in Berkeley use groundwater for drinking water (per Nabil Al-Hadithy, City of Berkeley). Before approximately 1993, the City of Emeryville issued well permits; now they are issued by ACFCWCD.

Contra Costa County DEH has recorded permitted wells in their database since 1992. However, at the time that this report was prepared, Contra Costa County DEH was not able to provide information from their well database.

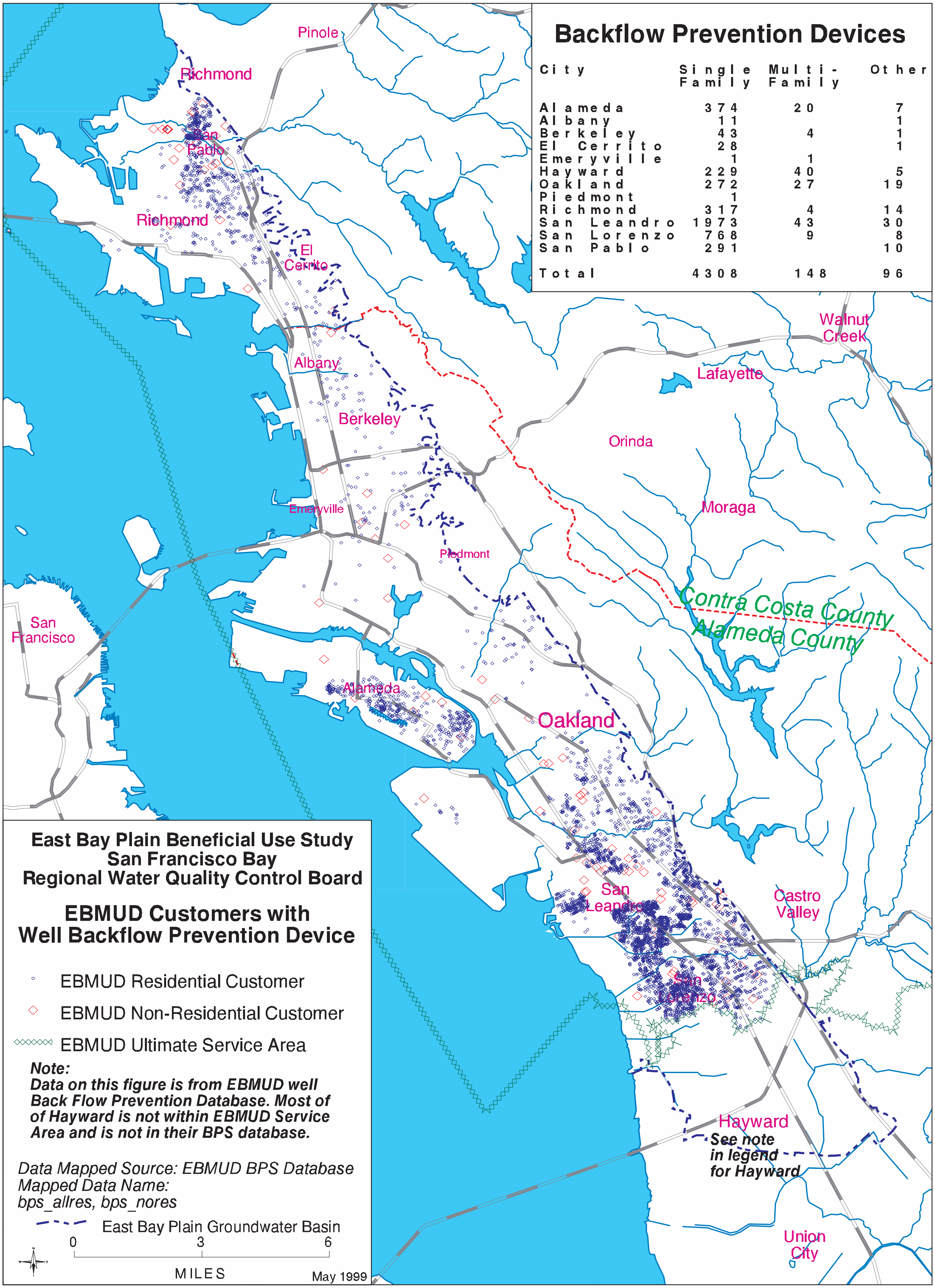
EBMUD has a database of well owners in its area for their Backflow Prevention Program. In about 1990, EBMUD used mailings with utility bills to ask customers with wells to contact EBMUD. Backflow devices are installed at houses with a well, regardless of whether the well is in use or tied into the customer's water system. Although no data are collected on the well, customer type is known. The table below shows numbers of wells in the backflow database for each city for several customer classifications.

A map of the location of well owners with backflow prevention devices is shown on Figure 18.

Table 7. EBMUD Customers with Backflow Prevention Devices

City	Single Family	Multi-Family	Other
Alameda	374	20	7
Albany	11	0	1
Berkeley	43	4	1
El Cerrito	28	0	1
Emeryville	1	1	0
Hayward	229	40	5
Oakland	272	27	19
Piedmont	1	0	0
Richmond	317	4	14
San Leandro	1973	43	30
San Lorenzo	768	9	8
San Pablo	291	0	10
Total	4308	148	96

Note: Data in this table is from EBMUD well Backflow Prevention Database. Most of Hayward is not within EBMUD Service Area and is not in EBMUD's BPS database.



Backflow Prevention Devices

City	Single Family	Multi-Family	Other
Alameda	374	20	7
Albany	11		1
Berkeley	43	4	1
El Cerrito	28		1
Emeryville	1	1	
Hayward	229	40	5
Oakland	272	27	19
Piedmont	1		
Richmond	317	4	14
San Leandro	1973	43	30
San Lorenzo	768	9	8
San Pablo	291		10
Total	4308	148	96

East Bay Plain Beneficial Use Study
San Francisco Bay
Regional Water Quality Control Board

EBMUD Customers with Well Backflow Prevention Device

EBMUD Residential Customer
EBMUD Non-Residential Customer
EBMUD Ultimate Service Area

Note:
Data on this figure is from EBMUD well Back Flow Prevention Database. Most of of Hayward is not within EBMUD Service Area and is not in their BPS database.

Data Mapped Source: EBMUD BPS Database
Mapped Data Name:
bps_allres, bps_nores

East Bay Plain Groundwater Basin

0 3 6
MILES

May 1999

Figure 18

13.3.2 City of San Leandro

In 1994, the City set out to determine if any properties in San Leandro were being serviced by domestic wells. First, the City used existing sources, such as DTSC, to identify all known domestic wells. The City also asked EBMUD to identify all lots in San Leandro that were not being billed. Each of these lots was checked to verify that it was being supplied by EBMUD. Most of the lots were industrial double lots or were an entry error.

After several weeks of investigation, the City was satisfied that all existing residences with no domestic water service other than groundwater had been identified. A total of ten residences were identified. All were offered City assistance to obtain an EBMUD hookup, including homes outside of the known plume areas. By 1995, all but four of the homes were hooked up to EBMUD or had been demolished. In 1998, one of the four homes was additionally connected to EBMUD using private party funds.

The only three potential remaining domestic wells in San Leandro are all outside of the known plume areas.

13.3.3 City of Hayward

ACFCWCD records show there are several "islands" of unincorporated land within the City of Hayward. Over the years, the size and quantity of these "islands" has decreased. As land is incorporated into the City of Hayward, infrastructure is added, including imported water supplied by Hayward. These remaining "islands" represent areas where groundwater is currently being used (i.e. Mohrland Mutual Water Company) or areas with a high probability of use.

13.4 Municipal Use

13.4.1 Hayward emergency wells

The City of Hayward depends on the San Francisco Water Department's Hetch Hetchy aqueduct for its municipal water supply. Since a major earthquake could disrupt this supply for periods of days, Hayward has installed an emergency water supply well system. To date, 4 wells have been installed of a planned 5-well, 10,000-gpm system. In the event of an earthquake, the wells are expected to be in use for no more than 7 days.

Hayward overlies the San Lorenzo Cone, which contains an upper and a lower aquifer. The emergency water supply well screens are generally perforated across several intervals in the Lower Hayward Aquifer, between 350 and 550 feet below grade. The wells are 18 inches in diameter and were installed using reverse rotary drilling equipment. Although manganese concentrations are above the secondary maximum concentration level (MCL), DHS has given the City approval to use the wells in an emergency. Well water is chlorinated at each wellhead with sodium hypochlorite.

Hayward selected well sites that were generally on City property and adjacent to water transmission pipelines of 12-inch diameter or larger. The City historically operated a wellfield near

Hesperian and Industrial Boulevards; it was phased out of service starting in 1962, when Hetch Hetchy water became available. Only Well No. 9 remains operable (but inactive). Two of the four emergency wells installed to date (Wells B and C) are located near this former wellfield. The fifth well will replace Well No. 9.

13.4.2 East Bay Municipal Utility District (EBMUD)

Background: EBMUD was created in 1923 to provide a public water supply to East Bay communities. By 1929, EBMUD was providing imported water to the East Bay from Pardee Reservoir on the Mokelumne River in the Sierra Nevada Mountains. The reservoir provided a high-quality, reliable supply that soon eliminated the need for local groundwater wells. The District has expanded its boundaries as development has occurred, with demands increasing as agricultural areas with wells were converted into residential communities relying upon EBMUD for water.

EBMUD currently provides water to approximately 1.2 million customers in Alameda and Contra Costa Counties, including all of the East Bay Plain, except for portions of the City of Hayward, which receive water from the City of San Francisco's Hetch Hetchy Project. Average District-wide water consumption is approximately 200 million gallons per day (MGD). Of this, approximately 70-75% is delivered to customers in areas tributary to the East Bay Plain.

Pardee Reservoir provides 95% of EBMUD's water supply, with a small amount of water also contributed by local runoff collected in Briones, San Pablo, and Upper San Leandro Reservoirs in the East Bay hills. Lafayette and Chabot Reservoirs are available for emergency use only.

Normalized current EBMUD demand is expected to rebound to 220 MGD. Gross demand of 277 MGD is projected for the year 2020, much of which will be offset by aggressive conservation and reclamation programs. Supply from Pardee Reservoir is projected as 228 MGD in 2020.

Previous Investigations: For nearly seventy years, EBMUD has benefited from a reliable, high-quality water supply. Therefore, the District did not actively pursue local groundwater as a supplemental supply. In recent years, however, as more demands have been placed on Pardee Reservoir by senior water rights holders and environmental needs, it has become apparent that EBMUD must develop storage to meet customer demands during drought periods. The East Bay Plain Groundwater Basin is currently being considered by EBMUD as a water storage alternative.

In 1986 and again in 1993, the District performed reconnaissance level studies of groundwater resources within its East Bay service area. The study results indicated that at the time, other, higher quality resources might be available. The 1986 study compiled existing water quality information and aquifer characteristics and concluded that the southern part of the East Bay Plain and the San Ramon Valley were most promising for municipal use. In 1993, the District developed a Water Supply Management Program, which included a brief evaluation of local groundwater resources. The study concluded that total yield from local groundwater resources was not likely to meet the District's need for drought water supplies.

In 1997, based on improvements in dual purpose injection/extraction well technology, the District decided to evaluate whether the East Bay Plain could serve as storage for at least a part of the District's dry year supply.

Aquifer Storage and Recovery Pilot Project/Potential Future Beneficial Use: In 1997, EBMUD started a pilot project to evaluate the use of dual-purpose injection/extraction wells in the East Bay Plain. The technology, also known as aquifer storage recovery (ASR), may enable the District to store excess high-quality Sierra water supply underground for future use during a drought or earthquake. By using the same well for both injection and extraction, the District plans to extract virtually the same high quality water supply as was injected.

Exploratory borings were installed at the first project site in western San Lorenzo in the Fall of 1997. The borings indicated the presence of a significant aquifer zone at a depth of 550 to 660 feet below the ground surface. The borings were converted into monitoring wells, which were used to perform preliminary aquifer tests and water quality analyses. The results of these tests indicate that the aquifer appears to be suitable for ASR. Therefore, a more detailed pilot project is being undertaken with a larger well. The well will be tested by alternating cycles of injection and extraction to determine whether ASR may be feasible for EBMUD. In addition, a second pilot test is being initiated at EBMUD's Oakport property across Highway 880 from the Oakland Coliseum. The pilot project reports will be complete in the Spring of 1999 and will present an assessment of the feasibility of using ASR wells in the Plain for emergency water supply purposes.

The results of the pilot projects, along with an assessment of local groundwater resources, will be used to determine EBMUD's future plans for beneficial use of the Plain. Potential beneficial uses by EBMUD include ASR wells, municipal extraction wells, and non-potable irrigation wells. The actual locations of these facilities are not known, but may include any part of the East Bay Plain within the EBMUD service area where high potential for extraction or storage is available.

13.5 East Bay Plain City General Plans for Groundwater Use

In 1996, Regional Board Staff reviewed the General Plans for the East Bay Plain Cities of Alameda, Albany, El Cerrito, Berkeley, Emeryville, Hayward, Oakland, Piedmont, Richmond, and San Leandro, along with the Alameda County Resource Conservation District, the ACFCWCD, the North Richmond Shoreline, and Alameda County (see Appendix F). None of these cities had any plans to develop local groundwater resources for drinking water purposes, because of existing or potential saltwater intrusion, contamination, or poor or limited quantity. Only the City of Hayward is currently developing groundwater as an emergency drinking water supply. General plans for Richmond and El Cerrito acknowledge the potential for groundwater use in an emergency. However, both plans lack any specific details on such use.

However, the lack of interest by East Bay cities to install emergency groundwater wells may actually reflect confidence in EBMUD's role as water supplier rather than general disinterest.

13.6 Freshwater Replenishment

The ultimate points of discharge of groundwater in the East Bay Plain are surface water bodies including streams, lakes and San Francisco Bay. Freshwater bodies and the Bay support a range of aquatic life. Groundwater in the East Bay Plain retains the beneficial use of freshwater replenishment because groundwater discharge helps maintain surface water quantity and quality.

14.0 LOCAL REGULATORY INITIATIVES

14.1 City of Oakland Urban Land Redevelopment (ULR) Program

The ULR is a program designed to facilitate the cleanup and redevelopment of contaminated properties by clarifying investigation requirements, standardizing the regulatory process and establishing pre-approved cleanup standards for qualifying sites based on physical and chemical characteristics, land and water use, and potential for contaminant migration. The program is based on the premise that contaminated properties in Oakland pose not only a public health threat, but also affect the social and economic health of communities. Frequently, contaminated sites remain vacant, unremediated, and undeveloped because remediation and redevelopment efforts are stunted by liability issues, a confusing regulatory framework, and uncertainty surrounding cleanup costs.

Members of the ULR Oversight Committee include representatives from: EPA Region 9, State Board, Regional Board, DTSC, Alameda County EHD, and the City of Oakland. In addition, volunteers from consulting firms participate as non-voting members.

The ULR Program employs a tiered decision-making approach for evaluating sites that contain, or are suspected to contain, soil or groundwater contamination. The first tier consists of comparing site concentrations of chemicals of concern with a Tier 1 look-up table containing cleanup levels applicable at all Oakland sites. The second tier involves characterizing site geology and consists of comparing site concentrations of chemicals of concern with one of three Tier 2 look-up tables that contain cleanup levels based on geological setting. The Tier 2 process takes into account potential for contaminant retardation and migration in three different Oakland soil types: Merritt Sands, sandy silts and clayey silts. The Tier 3 process involves an extensive, site-specific analysis.

In Tiers 1 and 2, the property owner/developer has three options:

1. Clean up to the concentrations in the applicable look-up table.
2. Implement engineering controls that eliminate or sufficiently reduce exposure via pathways of concern
3. Undertake more site-specific analysis in a higher tier.

Cleanup levels for contaminated groundwater are partially dependent on the potential beneficial uses of the groundwater basin. Most groundwater in Oakland is currently designated as a potential source of drinking water, requiring the highest levels of protection. This has a direct impact on the determination of groundwater cleanup levels and, therefore, on development costs and the prospects for economic revitalization in the Downtown and other commercial/industrial areas of the city.

In developing the ULR Program, a Community Review Panel was formed consisting of individuals who constituted a representative cross-section of the Oakland community. The ULR Program Community Review Panel Report indicates that Oakland's shallow groundwater is not currently, nor is it expected to be, utilized as a source of drinking water in Oakland. Further, it acknowledges that, due to historic contamination and alternative sources, groundwater in much of Oakland is neither a healthy nor a cost-effective source of drinking water. With this in mind, the Community Review Panel supports the Regional Board's study and a possible redesignation of the beneficial uses of some portions of Oakland's groundwater on the condition that the following recommendations are implemented:

- Ensure that the redesignation is based on sound hydrogeologic data;
- Show that it will have a positive impact;
- Demonstrate that it will have an equitable impact on the various socio-economic and ethnic groups within Oakland;
- Ensure that a viable plan exists for providing drinking water to Oakland residents in the case of any foreseeable emergency;
- Demonstrate an openness to innovative technologies for providing clean, fresh water;
- Undertake a public education campaign to inform Oakland residents of the potential health hazards associated with the use of groundwater from private wells;
- Increase the minimum well sanitary seal depth required to obtain a well construction permit;
- Ensure that standards for future polluting activities will not be relaxed based on the redesignation of the beneficial uses.

Contacts:
Mark Gomez, City of Oakland, Environmental Services Division, (510) 238-7314
mmgomez@oaklandnet.com
Matt Small, U.S. EPA-Region 9, Underground Storage Tank Program, (415) 744-2078
small.matthew@epamail.epa.gov

14.2 Berkeley City Council Actions

In March, 1996, the Berkeley City Council responded to what they perceived as a weakening of the State Board Resolution 92-49 in State Board's Executive Officer Walt Pettit's proposed amendment to the resolution and in the recommendations found in the LLNL Report. Berkeley took the position that Resolution 92-49 gave Regional Boards authority to suspend remediation requirements on a case-by-case basis and suggested that any further loosening of these requirements not be adopted. Berkeley felt that "the initial intent of a containment zone policy was to provide a process for the closure of sites that had undergone remediation but for technological and financial considerations were unable to achieve drinking water standards but would still protect human health and the environment. The containment zone policy as currently proposed does not reflect this goal. Therefore, the City of Berkeley will not adopt these policies, as currently proposed."

Existing Toxics Management Division (TMD) policy is to preserve the water resource, where technologically and financially feasible, and this is consistent with existing State policy and with Berkeley policy set by Council in 1996. In the City's position (discussed in Council in 1996), the resource is identified first and if found to not be of quality, then a lower level of clean up is required. Berkeley's policy has several significant benefits, it reduces dependence on EBMUD water, less water is diverted from Sierra and Delta regions and provides an emergency resource if needed in the future. TMD proposes taking it further by actually correctly identifying and encouraging the use of groundwater for irrigation or industry, where possible. This indicates a commitment of maintaining high environmental and health standards.

14.3 U.S. EPA Brownfields Projects

A "brownfield" is a property, or portion thereof, that has actual or perceived contamination and an active potential for redevelopment or reuse. EPA's Brownfields Economic Redevelopment Initiative is designed to allow states, communities and other stakeholders in economic redevelopment to work together in a timely manner to prevent, assess, safely clean up, and sustainably reuse brownfields. Between 1995 and 1996, EPA funded 76 National and Regional Brownfields Assessment Pilots, at up to $200,000 each, to support creative two-year explorations and demonstrations of brownfields solutions. The pilots are intended to provide EPA, States, Tribes, municipalities, and communities with useful information and strategies as they continue to seek new methods to promote a unified approach to site assessment, environmental cleanup, and redevelopment. EPA has designated three municipalities within the Plain (Emeryville, Oakland and Richmond) as pilot project cities.

14.3.1 Emeryville

Background

Historically, heavy industry was the predominant land use in Emeryville, but the majority of these companies left the area in the 1970s. Currently, 234 acres are vacant or under-used, and 213 acres are known to have soil and groundwater contamination. Nearly half of the City's citizens are low-income, and more than half are minorities. Most of the City's poor live in neighborhoods bordered by brownfields. Although there is demand for residential and commercial development, the cost and risk associated with brownfields have impeded their redevelopment. The result for the City over the past five years has been a loss of $13.3 million in tax revenues and about 450 jobs.

Objectives

The aim of Emeryville's Brownfields effort is to encourage residential and commercial development by building stakeholder confidence in a risk management-based model for brownfields redevelopment. The model will incorporate an emerging State of California regulatory policy based on using an area-wide rather than a parcel-by-parcel approach to environmental cleanups.

Accomplishments and Activities

The Emeryville Pilot has:

- Selected ten brownfields sites for potential redevelopment. Collectively, these sites cover approximately 180 acres;
- Compiled hydrogeologic, soil, and groundwater information from available sources to develop geographical information system (GIS) and developed a Conceptual Groundwater Model (Geomatrix, 1998);
- Achieved a 50% completion milestone in development of a GIS model that incorporates environmental, economic, land use, and zoning information
- Convened a broad-based Community Task Force to serve as a forum for community participation in decision making related to brownfields redevelopment;
- Drafted a regulatory framework for a Mitigation and Risk Management Plan to incorporate a City-wide approach to groundwater cleanup.

Experience with the Emeryville Pilot has been a catalyst for related activities including the following:

- The Chiron Corporation, the second largest biotechnology firm in the country, will redevelop an unused research facility. Chiron will construct 12 new buildings over the span of 20 years to house their biotech firm, creating more than 3,000 jobs during this time.
- Catellus Development Corporation will construct 200 units of mixed income housing on a four-acre Brownfields site, considerably decreasing the City's housing shortage.

Contacts:
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Jim Hanson, U.S. EPA – Region 9, (415) 744-2237

14.3.2 Oakland

Background

Oakland selected two catalyst sites for redevelopment projects in its commercial and industrial centers: the 2-acre Central District Redevelopment Area and a 17-acre portion of the Coliseum Redevelopment Area of East Oakland.

The Central District Redevelopment Area, often referred to as the Uptown Theater District, encompasses Oakland's historic downtown. This area, which is anchored by the historic Fox Theater, was almost completely abandoned by business over the last three decades. Significant groundwater contamination has been identified in large portions of the area and must be addressed prior to redevelopment.

During the past two decades over 20,000 manufacturing jobs have been lost in the Coliseum Area due to plant closure and relocation. Over 600 acres in the Coliseum Area were vacated or are under-used, and over 700 sites were identified as having known or suspected hazardous or toxic contamination. Most of the Coliseum Area is within a federally-designated Enhanced Enterprise Community.

In April 1997, an additional $100,000 was added to the Pilot grant, and is being used to encourage Brownfields redevelopment of the Fruitvale Bay Area Rapid Transit (BART) area's Transit Village project. This large-scale redevelopment project is designed to revitalize the neighborhood with shops, offices, and housing in a pedestrian-oriented setting. This is a local, community-driven project for which EPA is working in partnership with the Department of Housing and Urban Development (HUD), the Department of Health and Human Services (HHS), and the Department of Transportation (DOT) and private entities.

Objectives

The Oakland Pilot is seeking to revitalize the contaminated properties in the Central District and Coliseum Redevelopment Areas as well as the Fruitvale BART Station area. The major focus of the Pilot will be on completing Phase II site assessments and remediation planning. This information will assist Oakland's Redevelopment Agency in developing a strategy for redevelopment of the sites.

Accomplishments and Activities

The Oakland Pilot is:

- Reviewing existing data on two sites and completing site assessments;
- Completing health and safety plans, site surveys, and risk assessments, and preparing summary reports of the findings and recommendations; and
- Developing remedial plans and cost estimates.

Contacts:
Jeffrey Chew, Oakland Office of Economic Development and Employment, (510) 238-3629
Wally Woo, U.S. EPA – Region 9, (415) 744-1207

14.3.3 Richmond

Background

The project area is the 900-acre North Richmond Shoreline, which contains a variety of brownfields in a relatively compact area. Aging heavy industry, low-income housing, idle and vacant properties, and waste disposal facilities are concentrated in an area that borders a distressed neighborhood and an estuarine ecosystem known to support two endangered species. At least 36 properties (90 percent of the City's developable area) are contaminated with volatile organic compounds, polychlorinated biphenyls, and metals. The sector has a mix of thriving large businesses and struggling smaller ones. The presence of hazardous materials on the latter's property, combined with their shaky financial condition, has stymied growth in that sector.

Objectives

The focus of Richmond's brownfields effort is to stimulate economic growth and improve public health and the environmental quality of the Bay. To do this, the project is building on the intensive planning and cooperative partnerships that have evolved over the last five years. Richmond included a green component in its planning that will provide public recreation, open the shoreline for public use, and establish zoning standards to limit industrial activities that may endanger human health and the environment. Richmond is working to increase public awareness of contaminated sites and involve the community in remedial planning and redevelopment activities.

Accomplishments and Activities

Completed Activities:

- Created a computerized inventory of all properties within the project area. The listing includes assessor parcel number, site names, jurisdiction, address, property owner, and other site related information. A site inventory was distributed to interested parties;
- Developed site selection criteria and identified potential sites for matching funds from among the inventoried sites; and
- Held meetings with the North Richmond Industrial and Agricultural Association, the Municipal Advisory Committee, neighborhood councils, the League of Women Voters, and West County Toxics.

Current Activities:

- Completing preliminary site assessments of two to five sites within the North Richmond Shoreline;
- Developing financing mechanisms specifically to promote the City's brownfields process;
- Working to clarify jurisdictional authorities to promote coordination among the City, County, and State;
- Streamlining the regulatory process through cooperative partnerships with State and Federal authorities; and implementing community education and outreach programs to promote full stakeholder participation.

Related Activities:

- Several property owners, representing a number of large properties in the Pilot Project Area, are working together to explore issues of mutual concern such as regulatory cleanup processes and site assessments.
- The Pilot is working with Contra Costa College's Center for Science Excellence to develop information on the environmental status of each property in the inventory.

Contacts:
Nancy Kaufman, Planning Department, City of Richmond, (510) 620-6706
Wally Woo, U.S. EPA – Region 9, (415) 744-1207

14.3.4 Base Reuse Authority

There are a number of closing military facilities in the East Bay Plain. These include the Oakland Army Base, Alameda Naval Air Station, Fleet Industrial Supply Center Oakland, Oak Knoll Naval Hospital, and the Navy's Point Molate Fuel Depot. The facilities will be or have been taken out of military service and are intended for beneficial reuse. As part of the process leading to reuse, the facilities are being investigated and remediated to reduce impacts to human health and the environment to acceptable levels.

15.0 FINDINGS

This section summarizes the six key findings of the report.

15.1 Portions of the East Bay Plain currently support all of the groundwater beneficial uses listed in the Basin Plan.

Until the 1930s, the East Bay Plain Groundwater Basin historically was extensively used for drinking water, industrial, and agricultural supply. However, because of the lack of an adequate and dependable supply for a growing population, the East Bay now relies on imported surface water to satisfy nearly all drinking water and industrial demands. By far the most frequent current use of groundwater is for irrigation from "backyard" private shallow wells. It is estimated that East Bay Plain groundwater is used by over 4000 homeowners for irrigation. Groundwater is also still used by 10 businesses for industrial purposes and by several users to irrigate a few parks, golf courses, cemeteries and schools.

Groundwater is still used as source of drinking water by several small systems in the cities of Hayward, San Leandro and Oakland. A total of five permitted water systems (three in Hayward and two in San Leandro) are known to serve between 4 and 180 households each. The only known permitted system in Oakland is located in the Oakland Hills above the East Bay Plain Groundwater Basin. There are no permitted water supply systems north of Oakland.

In addition, according to Alameda County Flood Control & Water Conservation District's (ACFCWCD's) records, there are 507 wells that are classified as municipal or domestic wells. Nearly all of these wells are believed to be used for residential irrigation. However, there are still some individual private wells being used for drinking water.

The following table shows the existing and potential beneficial uses as determined by this evaluation for the Sub-Areas proposed by Figuers (1998).

Table 8. Existing and Potential Beneficial Uses in Sub-Areas of the East Bay Plain

Sub-Area	MUN – Municipal And Domestic Water Supply	AGR – Agricultural Water Supply	IND –Industrial Service Water Supply and PROC Industrial Process Supply
Richmond	E[1]	E	E
Berkeley	E[1]	E	E
Oakland	E[1]	E	E
San Leandro	E	E	E
San Lorenzo	E	E	E
Central	E[1,2]	E	E

P-Potential E-Existing

[1] No known existing drinking water wells, existing MUN designation based on backyard irrigation use.

[2] EBMUD has installed a pilot aquifer storage well in the Central Sub-Area, which, if successful, would result in an existing beneficial use.

15.2 A review of historical groundwater beneficial uses provides insight into future probable uses.

All water supplies in the East Bay were derived from wells and local runoff until the import of Sierra water into the area in 1930. Figuers (1998) searched for historical private and municipal wells as part of a comprehensive evaluation of groundwater conditions in the East Bay Plain for the Regional Board. In addition to municipal well fields, thousands of private wells supplied water to homes and businesses. In 1911, there was an extensive survey of all private and public wells in the East Bay area, locating and mapping more than 3400 active wells serving a population of about 232,150 (1910 census). Norfleet estimates that in the range of 15,000 wells were drilled in the East Bay Plain between 1860 and 1950. The majority of the wells were less than 50 feet deep, but many were 200 to 500 feet deep, with the deepest reaching 1000 feet below the ground surface. A few are still in use today, but most were abandoned and forgotten. Virtually none of these wells was properly destroyed.

Table 9. Summary of East Bay Plain Groundwater Basin Sub-Areas

Sub-Area	Approximate Basin Depth	Historic Municipal Groundwater Well Fields (circa 1890-1930)	Are Significant Aquitards Present?
Richmond	>600 ft.	Yes, San Pablo and Richmond Well Fields	No
Central	>1000 ft	Yes, High Street Well Field	Yes
Berkeley	< 300 ft.	No, but suitable for limited single family/industrial users. No historical evidence that groundwater supplies are sufficient for municipal use	No
Oakland	< 700 ft.	Yes, Fitchburg Well Field	Yes, along western portion
San Leandro	700-1100 ft.	No, however, area was primarily rural prior to 1930.	Yes, along western portion
San Lorenzo	700-1100 ft.	Yes, Roberts Well Field	Yes, along western portion

15.3 Shallow groundwater has been degraded locally in much of the East Bay Plain and regionally in the Cities of Emeryville and San Leandro. Deeper groundwater supplies are at risk given the number of abandoned wells.

Ambient monitoring data on common organic pollutants within the deeper groundwater (i.e., deeper than about 100 feet) is very limited. Based on this limited data, the overall water quality of deep groundwater in the East Bay Plain is good. Much more data is available on the water quality of shallow groundwater (i.e., less than about 100 feet). Some shallow groundwater has been impacted by historical and current releases of fuels and solvents. See Section 8.0 and 9.0 for a more detailed discussion on water quality.

Groundwater pollution in the East Bay Plain appears to generally be restricted to portions of the shallow aquifers. Typically, site investigations require that groundwater plumes be defined in both the lateral and vertical dimension. In almost all cases, groundwater pollution appears limited to less than 50 feet below the ground surface.

However, recently one of EBMUD's aquifer storage test wells detected contamination at a depth of over 200 feet below ground surface. Volatile organic compounds were detected in a test well located west of Interstate 880 about one mile north of the Oakland Coliseum. TCE was detected in the test well at 50-70 ppb that was screened between 260 and 350 feet below ground surface. Prior to this detection, no pollution had ever been detected above trace levels at depths greater than 140 feet. The source and migration pathway for the TCE contamination is currently under investigation by DTSC.

Although the source of the above deep groundwater contamination has not been defined, it may illustrate the potential for connection between the shallow deposits and deeper aquifers. Moreover, given that there are very few existing wells pumping from the deeper aquifer, and the numerous historical wells in the East Bay Plain that could be vertical conduits, if the number of wells pumping from the deeper aquifer increases, there is a potential that shallow pollution could be drawn down into the deeper aquifers.

15.4 Innovative remedial approaches are being developed to manage East Bay land that often contains soil and groundwater pollution.

Several significant land development and redevelopment initiatives may be affected by the regulatory recommendations resulting from this beneficial use evaluation. The initiatives are as follows:

- Closing Military Bases and Conversion to Civilian Uses;
- City of Oakland Urban Land Redevelopment Program; and

- US EPA's Brownfields Economic Redevelopment Initiative for Emeryville, Oakland, and Richmond.

These initiatives have a common interest in remediating and redeveloping East Bay land that often contains soil and groundwater pollution.

A legacy of intense urban and industrial development has contaminated some soil and portions of the shallow East Bay Plain aquifers. In general, addressing soil contamination issues is relatively straightforward compared to groundwater. For soil cleanup, most projects utilize a risk-based approach to establish cleanup levels. Then, based upon redevelopment, technical, and economic factors, the soil is either excavated to remove chemicals above a prescribed level or remediated in-situ. Groundwater cleanup, on the other hand, poses a much more difficult dilemma. First, groundwater contamination is usually much larger in areal extent than soil contamination and may underlie many other properties besides the source property. Second, since all groundwater is essentially currently designated with a municipal beneficial use, the groundwater cleanup objectives are set no greater than drinking water standards. Given the technical difficulty of restoring contaminated aquifers, most groundwater cleanup involves significant expenditures in the range of $100,000 - $1,000,000+, and time frames measured in decades (for VOCs). Compared to soil cleanups, costs for groundwater cleanups are much more difficult to forecast. The staggering costs and potential liability associated with cleaning up this contamination severely impacts local redevelopment efforts.

The uncertainty in projecting cost and cleanup time has resulted in financial institutions being unwilling or very risk-adverse when considering whether to invest in groundwater contaminated areas of the East Bay Plain. In addition, the uncertainty breeds delays in converting closing military bases to civilian uses including expanding the Port of Oakland's maritime facilities. Moreover, most groundwater contamination is located in shallow groundwater zones that are unlikely to ever be used as a source of drinking water and are often isolated from deeper or regional aquifers. The viewpoint of many of the parties involved in groundwater remediation is that society is essentially spending enormous amounts of money to remediate contaminated shallow groundwater even though it will take decades to restore, is unlikely to be used, is usually isolated from deeper and regional aquifers, and if used, will likely still need treatment to meet use requirements.

Additionally, several other essentially local programs and initiatives may have an impact upon groundwater cleanup: US EPA's Underground Injection Control program, wellhead protection programs, and source water protection programs under the amended Safe Drinking Water Act. At this time, none of these programs have been developed enough to indicate their impacts on redesignating beneficial uses.

15.5 East Bay Municipal Utilities District is considering using portions of the East Bay Plain for conjunctive use.

In 1997, EBMUD started a pilot project to evaluate the use of dual-purpose injection/extraction wells in the East Bay Plain. The technology, also known as aquifer storage recovery (ASR) may enable the District to store excess high-quality Sierra water supply underground for future use during a drought or earthquake. By using the same well for both injection and extraction, the District plans to extract virtually the same high quality water supply as was injected. The results of the pilot projects, along with an assessment of local groundwater resources, will be used to determine EBMUD's future plans for beneficial use of the Plain. Potential beneficial uses by EBMUD include ASR wells, municipal extraction wells, and non-potable irrigation wells. The potential locations of these facilities are not known, but may include nearly any part of the East Bay Plain within the EBMUD service area. Aquifers likely to be used would be below the Yerba Buena Mud.

15.6 EBMUD's Backflow Prevention Database can be used to supplement ACFCWCD well searches.

Two public databases that contain information on existing wells in the East Bay Plain yield notably different estimates. The ACFCWCD database covers the Alameda County portion of the East Bay Plain. EBMUD maintains a database of addresses where they have installed backflow prevention devices at residential or commercial properties that have volunteered that they have wells. EBMUD's database covers the entire East Bay Plain with the exception of Hayward, which is outside their service area. Comparisons between the two databases yield notably different estimates regarding the number of wells in different communities. The following table provides an example of the differences between the databases in the number of wells in selected cities.

Table 10. Comparison of EBMUD and ACFCWCD Well Databases

City	[1]EBMUD Backflow Prevention Database	[2]ACFCWCD Well Permit Database
Alameda	400	2
Oakland	400	32
San Leandro	1958	76
San Lorenzo	756	14

Note:
[1] EBMUD database only includes wells owned by property owners that voluntarily agreed to participate in its backflow prevention program.
[2] ACFCWCD database only includes wells drilled after 7/17/73 and wells documented by DWR for the groundwater investigation in Alameda County in the 1960's.
Above statistics are for all domestic, municipal, industrial and agricultural wells.

Currently, environmental consultants use the ACFCWCD database to search for active wells in the vicinity of groundwater pollution sites. Since the EBMUD backflow database has a greater number of wells, consultants should also search this database although there may be privacy issues to be resolved.

16.0 ANSWERS TO KEY QUESTIONS

At the outset of this beneficial use evaluation, the committee posed six key questions:

Question No. 1. What are the current and planned future groundwater beneficial uses of the East Bay Plain?

Answer: All groundwater beneficial uses currently exist in the East Bay Plain. However, the existing uses are relatively limited in certain Sub-Areas. The only firm plans for future use are by the City of Hayward for Emergency Supply (see Section 13.4.1). In addition, EBMUD is evaluating the potential for use of the East Bay Plain for storage of imported surface water and/or use of native groundwater (see Section 13.4.2).

Background: Groundwater was the major source of drinking water in the East Bay prior to the development and import of a Sierra water supply in the 1930s to serve a growing population and to solve water supply reliability problems. Since that time, groundwater has served only a minor role in water supply, primarily for industrial or irrigation purposes. However, following 60 years of near obscurity, there has been a recent resurgence in interest in using groundwater as a supplemental water supply (e.g., Hayward's emergency groundwater municipal supply system) and some others are being seriously considered (EBMUD's groundwater storage and retrieval project). A new test well was drilled by EBMUD in the San Lorenzo area during 1998. The 660-feet deep well was constructed to evaluate the potential for using the East Bay Plain aquifer to store imported surface water. The water would be used in the event of a drought or after a major earthquake. EBMUD is evaluating another well site near the Oakland Coliseum and may consider other sites within the East Bay Plain. Such storage is attractive because it would provide a reliable, although limited, emergency supply west of the Hayward Fault. The City of Hayward has in the past few years installed four wells as part of a five well project to provide a 7-day emergency municipal water supply in the event of an emergency (e.g., earthquake).

Question No. 2. Can the East Bay Plain be subdivided into Sub-Areas based on hydrogeology?

Answer: Yes, and it should be. The East Bay Plain has been subdivided by several previous investigators (Todd, 1986; Muir, 1988; Maslonkowski, 1988; Figuers 1998). Figuers' subdivision is a refinement and expansion of Muir and Maslonkowski's work. For this beneficial use evaluation, it is recommended that the Basin Plan be revised to incorporate the groundwater basin subdivisions of Figuers (1998).

Background:
The East Bay Plain can be subdivided into six Sub-Areas (Figuers, 1998), (Figure 13). The Sub-Areas laterally merge into one another, and there are few distinct subdivisions based upon depositional source. No distinct flow boundaries/barriers, topographic, or geologic features provide easily recognizable boundaries. The Sub-Areas were based on a combination of previously defined boundaries and a specific analysis requested by the Regional Board of Figuers of geologic, hydrogeologic, and geomorphic factors available from historical and contemporary data.

Question No. 3. Where is the use of the East Bay Plain limited?

Answer: Groundwater uses in portions of the East Bay Plain Sub-Areas are limited by several factors: 1) existing high TDS levels in shallow Bay Front aquifers, 2) the existing high TDS levels in artificial fills, 3) the potential for saltwater intrusion, 4) volatile organic compound groundwater contamination in portions of the shallow aquifers, 5) lack of significant water quantities and/or storage, and 6) shallow non-point source groundwater contamination from leaking sewer lines, septic systems and applied fertilizers.

Background:
Based upon an analysis of the available data, some limitations on the use of the Sub-Areas are as follows:

Table 11. Municipal Beneficial Use Limiting Factors in the East Bay Plain

Sub-Areas	Extensive Shallow VOC Groundwater Pollution	Existing High TDS Levels in Artificial Fill	Existing High TDS Level in Shallow Bay Front Aquifers
Richmond		√	√
Berkeley			
Oakland		√	√
San Leandro	√		
San Lorenzo			
Central		√	√

Question No. 4. Can the shallow and deep zones have different designations?

Answer: The question is applicable because most groundwater pollution in the Bay Area is shallow (i.e., less than 50 feet below the ground surface) and most use, other than for backyard irrigation, is from deeper aquifers, typically greater than 200 feet below ground surface. Based primarily upon available data, at this time it appears that the shallow and deep aquifers cannot have different designations in most of the East Bay Plain. However, there are localized situations where such differentiation can be made.

Background:
The Yerba Buena Mud forms a major aquitard between the shallow and deep aquifers throughout much of the southwest portion of the East Bay Plain. However, the integrity of the aquitard probably is compromised due to the drilling of wells in the 1890-1930 time frame. In Oakland, it is estimated that there are over 200 wells that penetrated the Yerba Buena Mud. Virtually none of these wells were properly destroyed. In the remaining portions of the East Bay Plain, the Yerba Buena Mud is not present and thus no natural aquitard separates the shallow and deep aquifers.

One exception is the area along the extreme western East Bay Plain Shoreline where artificial fill was placed after 1930. In this area the Yerba Buena Mud is continuous and should form a natural barrier to minimize the downward spread of pollution.

From a hydrogeologic standpoint, no aquitard is impermeable. However, for significant downward migration to occur several factors need to be present. First, a pollution source must be present with high enough residual concentrations to be detectable if it migrates from the shallow to the deeper aquifers. Second, there must be a pathway for the pollutants to migrate from the shallow to the deep aquifers. This pathway may be a man-made conduit such as an improperly installed or abandoned well, or natural discontinuities in the aquitard itself. Lastly, a gradient must be present that drives the contaminants downward. This can be due to hydraulic gradient downward caused by pumping from the lower aquifer, or a density gradient caused by the presence of dense non-aqueous phase liquids such as free phase solvents or PCBs.

In the Santa Clara Valley, shallow groundwater contamination has rarely migrated through the regional aquitard and effected the deeper aquifers. However, of the several sites with pollution below the regional aquitard, nearly all are believed to be due to vertical migration along abandoned or poorly destroyed wells.

Question No. 5. Should any current beneficial use designations change?

Answer: Groundwater beneficial uses should be changed in the vicinity of the Port of Oakland Alameda Point and the Chevron Refinery in Richmond for artificial fill. Such changes are described in Section 17.9.

Background:
The current Basin Plan designates all groundwater beneficial uses as "existing." While this designation is appropriate for the East Bay Plain as a whole, the designations do not apply when the basin is appropriately divided into Sub-Areas.

As outlined in the discussion of Question 3, municipal and domestic supply beneficial use is limited in several areas of the East Bay Plain. Most notably, the shallow artificial fill along the Bay-front is unlikely to be used as a source of drinking water due to the existing high TDS, potential for saltwater intrusion, and relatively low yield.

Question No. 6. Are there any areas requiring special protection programs?

Answer: Several areas should receive additional focus. First, the deeper portions of the basin in the San Lorenzo, San Leandro, Southern Oakland and Richmond Sub-Areas appear to be the most likely areas for future potential MUN beneficial use. Monitoring the deeper aquifers for organic pollutants is necessary. Second, a well destruction program should be initiated to locate and seal abandoned wells in the East Bay Plain. Former wells located near emergency water supply wells, and aquifer storage and recovery wells would be primary candidates for determining their location and destruction. Third, the existing water supply systems listed in Section 13.3 should be subject to a source water protection program.

17.0 RECOMMENDATIONS

Based on the analysis and findings of this report, the following recommendations are made:

17.1 The Regional Board should amend the Basin Plan to recognize the East Bay Plain Basin Sub-Areas. (As shown on Figure 13).

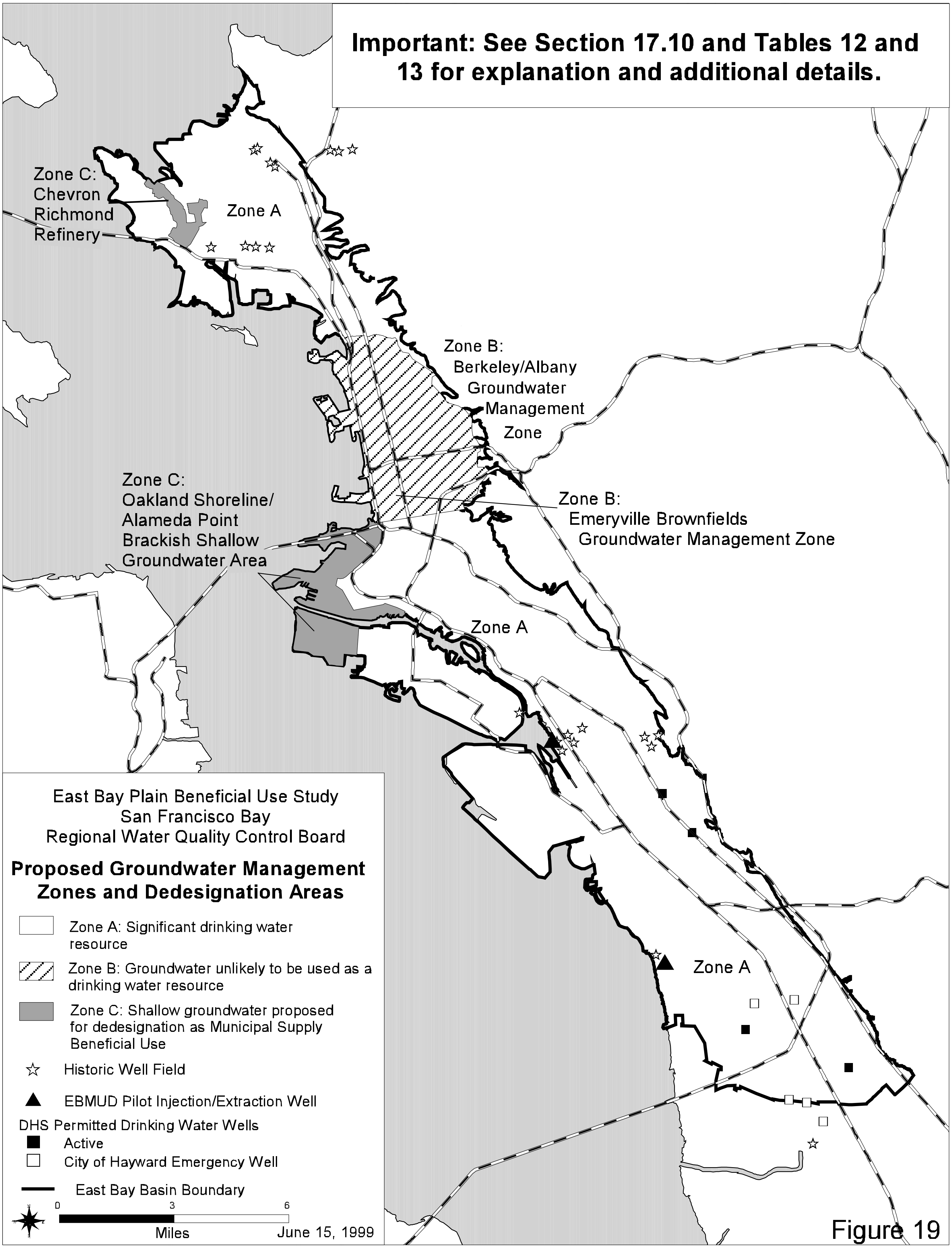
17.2 The existing ACFCWCD regional groundwater monitoring network should be expanded to include more wells, monitored more frequently, and for a larger list of chemicals of concern. A similar network is also needed in the Contra Costa County portion of the East Bay Plain.

Such a network could be modeled after the proposed monitoring program developed as part of a USEPA grant application (City of Emeryville, 1998). The grant was not funded, but the cooperating agencies are interested in the network. The grant sought to create the "East Bay Groundwater Awareness and Information Network" (GAIN). The objective of GAIN are (1) to design a community based, time relevant groundwater monitoring program network, (2) cultivate public interest in obtaining and using information, (3) complete a time relevant groundwater monitoring network, and (4) manage, process, and deliver groundwater monitoring data to the public. GAIN is designed to provide East Bay residents with the ability to gauge for themselves the overall "health" of their deep groundwater resources. GAIN also targets localized areas where groundwater is contaminated and residents have requested monitoring data to guide decisions affecting economic revitalization.

17.3 Agencies within the East Bay Plain should make their well databases more accessible to the public.

A well search is typically required as a part of a groundwater contamination investigation that involves a plume that has migrated offsite and beneath adjacent properties. The purpose is to determine if any groundwater wells could be impacted by the plume, and to notify the well owner if necessary. A well search may include a database review, door-to-door surveys and/or targeted mailings.

Five agencies maintain well databases in the East Bay Plain. ACFCWCD is the primary well permitting agency in the Alameda County Portion of the basin, and well searches can be requested by contacting Andreas Godfrey at 510-670-5575. EBMUD has a database of well owners in its area for their Backflow Prevention Program (see Figure 18). The Regional Board has a database of historic wells that are shown in Figure 2 of this report. Contra Costa County and the City of Berkeley both permit well installations in their respective jurisdictions, but, well searches are not currently publicly available. Both Contra Costa County and the City of Berkeley have plans to make their well databases more accessible in the future.


Important: See Section 17.10 and Tables 12 and 13 for explanation and additional details.
Zone C: Chevron Richmond Refinery
Zone A
Zone B: Berkeley/Albany Groundwater Management Zone
Zone C: Oakland Shoreline/ Alameda Point Brackish Shallow Groundwater Area
Zone B: Emeryville Brownfields Groundwater Management Zone
Zone A
Zone A
East Bay Plain Beneficial Use Study
San Francisco Bay
Regional Water Quality Control Board
Proposed Groundwater Management Zones and Dedesignation Areas
Zone A: Significant drinking water resource
Zone B: Groundwater unlikely to be used as a drinking water resource
Zone C: Shallow groundwater proposed for dedesignation as Municipal Supply Beneficial Use
Historic Well Field
EBMUD Pilot Injection/Extraction Well
DHS Permitted Drinking Water Wells
Active
City of Hayward Emergency Well
East Bay Basin Boundary
0
3
6
Miles
June 15, 1999
Figure 19

Plans are under way to coordinate EBMUD's backflow database and the historic well locations contained in Figuers (1998) with ACFCWCD's database and make all three databases available at one agency.

17.4 The Regional Board Staff should encourage the use of aquifers in the East Bay Plain for groundwater storage.

An increase in local storage capacity would be a small but significant step towards implementing the recommendations of the Comprehensive Conservation and Management Plan (CCMP) prepared by the San Francisco Estuary Project. The CCMP encourages the use of groundwater basins with the capacity to store additional water to be used as "water banks." Freshwater inflow is a major factor that determines environmental conditions in the Estuary. The volume and timing of freshwater inflow affects the Estuary's circulation and water quality, conditions for wildlife and the survival of aquatic species. If groundwater from existing sources or surface water is stored in these aquifers (either from surface water sources in wet years or from treated wastewater), demand on limited surface water resources can be reduced.

17.5 The Regional Board staff should encourage the establishment of a basin-wide groundwater management program.

This could take the form of a formal AB 3030 Groundwater Management Plan with a Wellhead Protection Plan included, a stand-alone Wellhead Protection Plan, or a regional plan that addresses issues specific to the East Bay Plain.

Currently, much historical and geological information is available on the past use of groundwater, water availability and quality, as well as problems encountered by past use. EBMUD is currently evaluating the potential of using the East Bay Plain for conjunctive use and has drilled two deep wells in the study area. At a minimum, it would be useful for both planning purposes and water quality protection to develop some type of plan that would address the specific issues within the potential capture zones of the new wells.

Elements of the management plan could address: saltwater intrusion, overdraft, delineation of the aquifer and its recharge areas, location of potential sources of contamination (e.g., a source water protection plan), a plan to decommission old wells, conjunctive use, proper well construction, coordination with local, state and federal agencies, and review of land use planning activities that might create a risk to groundwater.

If EBMUD's pilot groundwater storage project is successful, then they would be the obvious local agency to assume a management role in the East Bay Plain. In addition, the ACFCWCD charter provides the county with some groundwater management authority. By monitoring both groundwater levels and quality, ACFCWCD is practicing the first level of groundwater management.

17.6 The methods required for conducting a Vertical Conduit Study and Well Search in the East Bay Plain should be formalized by the Regional Board.

There is no formal guidance that describes the necessary tasks for conducting Vertical Conduit Studies or Well Searches in the East Bay Plain. Given the importance of such studies as part of groundwater contamination investigations, it is recommended that the information collected in this report as well as other references on the subject be compiled into a single document.

Cities within the East Bay Plain and Alameda and Contra Costa Counties should consider implementing a well abandonment program similar to the one developed by the Alameda County Water District. Such a program would require developers to destroy any abandoned wells prior to redevelopment.

17.7 The Regional Board should encourage the establishment of a vertical conduit location and abandonment program.

It is estimated that there are 15,000 historical wells in the East Bay Plain that were drilled between 1860 and 1950. Most of these wells have been abandoned but not properly destroyed. Some of these wells may pose a current threat to the East Bay Plain because they provide a potential vertical pathway for shallow contamination to migrate into the deeper zones. The program could be implemented by Contra Costa and Alameda counties.

17.8 The GIS coverages that were developed as part of this Beneficial Use Evaluation should be updated regularly and made accessible to the public on the Internet.

The databases include location information on groundwater pollution sites and historical and modern well locations. A dedicated funding source for maintaining these coverages will need to be located. The GIS analysis conducted for this project identifies areas where their efforts can be targeted.

17.9 Proposed Groundwater Management Zones and Dedesignation Areas

The East Bay Plain can be subdivided into three management zones for purposes of prioritizing groundwater remediation and dedesignating beneficial uses. Subdivisions were developed by utilizing the information presented in this report on water quality, historic, existing and probable-future beneficial uses, and hydrogeology.

The following subdivisions are proposed for preserving and restoring groundwater beneficial uses in the East Bay Plain. A description of each subdivision is included below, summarized on Tables 12 and 13 and shown graphically on Figure 19.

Zone A - Significant drinking water resource. Remedial strategies should be focused on actively maintaining or restoring groundwater quality to drinking water quality objectives. These areas historically supported a municipal beneficial use prior to the 1930's and likely could, with proper management, be used as a limited municipal source of drinking water in the future. In Hayward and San Leandro, there are five permitted small water system wells that serve, collectively, over 200 individual users. However, relatively low recharge rates limit the sustained yields. Cleanup, spill prevention and education efforts within the source water protection zones of existing municipal wells should be the top priority of local and state programs.

Portions of Zone A may warrant higher concern. For example, areas within Zone A with a high density of potential conduit wells and/or shallow backyard wells may need to receive higher priority and be subject to more detailed investigations than other areas. An example of delineating such areas is shown on Figure B-3 in Appendix B.

From a beneficial use perspective, these areas are of higher concern because 1) historic wells may act as vertical conduits and allow shallow contamination to migrate into deeper aquifers, 2) current backyard irrigation wells may represent an incidental drinking water exposure pathway to groundwater contamination as well as a non-drinking water pathway (e.g., volatilization or irrigation of fruits and vegetables), and 3) contamination sites within source water protection zones may impact existing or planned drinking water wells.

Investigation and remediation of groundwater contamination sites within areas of higher concern should be tailored to address the potential for beneficial uses to be impaired due to any of the three above issues. Depending on the site-specific circumstances, this may include a more in-depth investigation (to identify the location of historic or current wells) or more aggressive remediation (to protect current or planned drinking water wells). Groundwater contamination sites within source water protection zones should be the top priority of local and state programs.

Within Zone A, there are also areas that may warrant less aggressive remediation on a case-by-case basis. As a mechanism to both recognize that the shallow groundwater is unlikely to be used for drinking water, but still safe guard the deeper aquifers for future drinking water supply uses, a less aggressive remediation strategy is recommended. Criteria for allowing less aggressive remediation in Zone A areas is discussed in Recommendation 17.10.

Zone B - Groundwater that is unlikely to be used as a drinking water resource. While these areas meet the broad “sources of drinking water” criteria, limiting factors related to yield and water quality restrict practical uses. Remedial strategies should reflect the low probability that groundwater in this zone will be used as a source of drinking water in the foreseeable future. However, other beneficial uses/exposure pathways exist and should be protected. These include domestic irrigation, industrial process supply, human health, and ecological receptors. The potential for exposure via incidental ingestion from back yard wells should be evaluated. Appendix B highlights areas within Zone B that have the highest density of backyard wells. Zone B areas should utilize risk based corrective action in establishing groundwater cleanup standards. Passive remediation to restore MUN beneficial uses as a long-term goal is recommended.

Important Note - This report is not recommending beneficial use dedesignation for Zone B areas. Furthermore, these recommendations should not be considered as advocating a "No Action" approach to groundwater pollution. Rather, Zone B is an area where other, non-drinking water, exposure pathways are more likely to "drive" remediation.

Within the Easy Bay Plain, areas proposed for Zone B management are:

> **Berkeley Sub-Area Groundwater Management Zone:** Groundwater extraction for municipal drinking water supply is unlikely in the Berkeley Sub-Area due to the relatively thin aquifer (ranging from 10 to 300 feet thick, and averaging 100-200 feet thick) and limited groundwater recharge (Figuers, 1998). Accordingly, remedial strategies should be focused on actively protecting existing domestic irrigation and industrial uses and potential aquatic receptors rather than as a municipal drinking water supply. Achievement of drinking water objectives within a reasonable time period is an appropriate long-term goal. At a minimum, groundwater pollutant sites would be regulated pursuant to SWRCB Resolution 92-49, and need to demonstrate 1) that reasonably adequate source removal has occurred, 2) the plume has been reasonably defined both laterally and vertically and 3) a long-term monitoring program is established to verify that the plume is stable and will not impact ecological receptors or human health (e.g., from volatilization into trenches and buildings).

> **Emeryville Brownfields Groundwater Management Zone:** Groundwater is not currently used for any municipal, domestic, industrial, or agricultural purpose in Emeryville. No extractive beneficial uses are planned in the future. Remedial strategies should focus on protecting potential aquatic receptors and potential future irrigation or industrial uses. Achievement of drinking water objectives within a reasonable time period is an appropriate long term goal. Emeryville has developed a sub-regional groundwater monitoring plan that will provide information on both the shallow and deeper aquifer water quality. In addition, Emeryville has developed a detailed GIS system for tracking contaminated properties that will help to prevent inappropriate land uses. Lastly, Emeryville may consider assuming some of the liability for the groundwater pollution as well as overseeing smaller cleanups under an agreement with DTSC and the Regional Board.

Zone C - Shallow, nonpotable groundwater proposed for dedesignation of the Municipal Supply Beneficial Use. The Regional Board should locally dedesignate the municipal beneficial use for brackish, shallow groundwater in Bay-front artificial fill, young bay mud and the San Antonio Formation/Merritt Sand. This groundwater meets the exemption criteria of the State Water Resources Control Board's (SWRCB's) Sources of Drinking Water Policy because the groundwater could not reasonably be expected to serve as a public water supply and exceeds the 3000 mg/L total dissolved solids criteria. Cleanup should be protective of ecological receptors and human health. In addition, pollution sites will continue to be required to demonstrate 1) that reasonably adequate source removal has occurred, 2) the plume has been reasonably defined both laterally and vertically and 3) a long-term monitoring program is established to verify that the plume is stable and will not impact ecological receptors or human health (Pursuant to SWRCB Resolution 92-49. Remedial strategies should focus on other exposure pathways such as human health and ecological receptors.

In addition, for Zone C areas overlying more productive, although currently unused deeper aquifers, potential vertical conduits should be located and properly destroyed. Contamination in deep zones underlying Zone C would be subject to the requirements of Zone A.

Two shallow groundwater areas in the East Bay Plain are recommended for dedesignation. Any deep aquifers in these areas would continue to be designated as MUN.

Oakland Shoreline/Alameda Point Brackish Shallow Groundwater Zone: In this zone, shallow bay-front groundwater in the artificial fill, Young Bay Mud and San Antonio/Merritt Formations generally exceeds the 3000 mg/l TDS criteria (SWRCB Resolution No. 88-63). Dedesignation of the municipal beneficial use in this area is therefore warranted. While some artificial fill has TDS below 3000 mg/l (due to recharge from rainfall, landscape irrigation and leaking water pipes), most groundwater to a depth of 100 feet below ground surface is not a Resolution No. 89-39 source of drinking water. An evaluation of TDS data in the vicinity of the FISCO Navy Base, Port of Oakland and Alameda Point is included in Appendix G. A review of groundwater TDS data from other portions of the Port of Oakland High TDS Zone (i.e., Port of Oakland, Alameda Point, Oakland Army Base) shows similar results.

Chevron Richmond Refinery: This is a large refining complex and tankfield. Over 300 different refined petroleum products are manufactured and stored at the refinery. The refinery was built at the turn of the century. The 2900-acre refinery lies along the southern shore of San Pablo Bay in Contra Costa County. Portions of the property were created from bay fill.

Groundwater pollution at the refinery is prevented from migrating off site by a four-mile long slurry wall/ groundwater interceptor trench, known as the Groundwater Protection System (GPS). Groundwater extraction through the trenches and/or wells establishes and maintains a contiguous capture zone, which prevents migration of potentially contaminated shallow groundwater past the GPS alignment. A low permeability Bay Mud “floor” inhibits vertical transport of shallow contaminants to the underlying deeper aquifers (see Appendix D for more detail). Since 1988, Chevron has spent approximately $100 million on groundwater remediation at the Richmond Refinery.

Dedesignation of the municipal beneficial use of the shallow groundwater (to approximately 100 feet) is proposed beneath the “Flats Zone” which comprises the flatland marsh area bounded by San Pablo Bay to the north and extending south along the northeast side of Potrero-San Pablo Ridge. The Regional Board has previously found that the GPS is a satisfactory corrective action measure and protects beneficial uses of San Francisco Bay and underlying deeper aquifers.

17.10 Less Aggressive Remediation Approach

Within the East Bay Plain, there are groundwater pollution plumes that may warrant less aggressive remediation on a case-by-case basis. In general aggressive cleanup may not be warranted when the plume is shallow, concentrations are declining and no beneficial uses are threatened. The requirement for aggressive cleanup can possess a serious obstacle to redevelopment of blighted brownfields. The goal of the proposed Less Aggressive Remediation Approach is to outline “basin specific” situations where less aggressive remediation may be acceptable.

One example is pollution in shallow deposits above the Yerba Buena Mud. Groundwater in these shallow deposits is unlikely to be used as a source of drinking water (due to low yield, elevated levels of coliform from leaking sewer pipes, and requirement for a 50-foot well seal for new municipal wells). However, deeper aquifers beneath the Yerba Buena Mud do have a high potential for municipal development. Therefore, it is important that existing pollution in the shallow deposits is prevented from migrating into the deeper aquifers below the Yerba Buena Mud. As a mechanism to both recognize that the shallow groundwater is unlikely to be used for drinking water, and to safe guard the deeper aquifers for future drinking water supply uses, the following approach is recommended.

Ultimately, the remedial options that would be part of less aggressive strategy are dependent on site specific conditions. However, likely options could include restricting groundwater remediation to the source area only, allowing monitored natural attenuation, or implementing pump-and-treat solely to limit plume migration.

Less Aggressive Remediation Approach Criteria: The Regional Board should consider allowing less aggressive remediation within Zone A, on a case-by-case basis, provided that the responsible party demonstrates to the satisfaction of the Board, at a public meeting, that the following criteria are addressed:

1) the pollution is pre-existing and has not occurred subsequent to this policy;
2) pollutants are reasonably characterized both laterally and vertically;
3) the source is reasonably removed or remediated;
4) pollutant concentrations are stable or declining, and the requisite concentration levels will be attained within a reasonably defined time period;
5) the shallow aquifer is separated from the deeper aquifer by a continuous confining layer (the Yerba Buena Mud or its lateral equivalent aquitard);
6) potential vertical conduits are properly destroyed;
7) existing groundwater and surface water beneficial uses are not impacted by the pollutants;
8) the proposal is consistent with any local groundwater management plans and well head

protection areas (current or future).

The Regional Board should provide a 30-day public notice to all known, interested parties when considering taking such an action.

Comparison of "Less Aggressive Remediation Approach" to "Containment Zone Policy": Both the Containment Zone Policy and the proposed Less Aggressive Remediation Approach specify criteria to address existing pollution plumes. The following discussion provides a brief summary of the Containment Zone Policy and then contrasts key differences.

The Containment Zone Policy (SWRCB Order No. 92-49) provides a mechanism for regulating groundwater pollution where "attainment of applicable water quality objectives cannot reasonably be achieved," and is defined as a specific portion of a water bearing unit where the Regional Board finds that it is unreasonable to remediate to the levels that achieve water quality objectives.

The Containment Zone Policy establishes a number of conditions that must be satisfied before a containment zone may be adopted by a Regional Board. For instance, a containment zone applicant must "take all actions necessary to prevent the migration of pollutants beyond the boundaries of the containment zone in concentrations which exceed water quality objectives." Additionally, the applicant "must verify containment with an approved monitoring program and must provide reasonable mitigation measures to compensate for any significant adverse environmental impacts attributable to the discharge." Most significantly perhaps, the applicant "must propose and agree to implement a management plan to assess, cleanup, abate, manage, monitor, and mitigate the remaining significant human health, water quality, and environmental impacts to the satisfaction of the Regional Water Board."

There are two key differences between the Less Aggressive Remediation Approach and the Containment Zone Policy. The Less Aggressive Remediation Approach is a "basin-specific" approach that allows for management of plumes where requisite concentration levels will be attained within a reasonably defined time period. In contrast, the Containment Zone Policy is a statewide policy and addresses groundwater pollution where attainment of applicable water quality objectives cannot reasonably be achieved. Thus the Less Aggressive Remediation Approach differs because it based on local conditions and aimed at sites that will eventually meet applicable water quality objectives.

Table 12. Summary of Proposed East Bay Plain Groundwater Management Zones

Zone		Historical Public Water Supply	Historical Domestic Water Supply	Existing, Probable or Potential Drinking Water Source	Remediation Strategy	Location
A – Areas of Basin that have moderate to significant deep drinking watert resource	Shallow	Yes, but limited	Yes	Potential	For shallow pollution, goal is to maintain and restore drinking water quailty and actively prevent migration into deeper zones. Target areas of Special Concern shown on Table 13.	All of San Leandro and San Lorenzo Subareas; Bulk of Cen Oakland and Richmond Sub A
	Deep	Yes	Yes	Existing or Probable	For deeper aquifers require active remediation and hydraulic control to maintain and restore drinking water quality.	
B – Areas of basin that are unlikely to be used as a drinking water resource		No	Yes	Potential	Passive Remediation to restore drinking water quality as a long-term strategy while actively protecting private irrigation wells, human health and ecological receptors. Utilize risk based corrective action in establishing groundwater cleanup standards.	Berkeley Sub Area and Emery
C - Not a drinking water resource		No	No	Neither Existing, Probable or Potential	Protect human health and ecological receptors. Dedesignate MUN in Zone C. Utilize risk based corrective action in establishing groundwater cleanup standards. Locate and seal vertical conduits that extend into deeper portions of Zone B.	Shallow high TDS aquifers alo Oakland and Alameda Shorelin and at Chevron Refinery.

MUN - Municipal and Domestic Supply Beneficial Use
Shallow Zone - Groundwater within shallow deposits above the Yerba Buena Mud or its lateral equivalent.
Deep Zone - Groundwater below the Yerba Buena Mud or its lateral equivalent within the Alameda Formation or Santa Clara Formation as defined by Figuers (1998) .

Table 13. Proposed Strategy by Sub-Area for Addressing Groundwater Contamination in the East Bay Plain

Sub-Area	Vertical Subdivisions	Areas of special concern	Areas proposed for less aggressive or passive remediation.	Areas proposed for dedesignation
RICHMOND	*None*	Areas with a have high density of back yard irrigation wells in east central Richmond and western San Pablo (See Figure 17). North-central portion is deepest and potentially most productive (See Figure 10).	None defined, however, portions of Richmond Inner Harbor / South Shore Area may qualify. Bedrock is less than 200 feet deep in this area (See Figure 10).	Chevron Richmond Refinery
CENTRAL	*Shallow*	Area on Alameda Island with a high density of existing back yard irrigation wells pumping from Merritt Formation (See Figure 17). Bay front groundwater with potential to impact San Francisco Bay.	Shallow brackish artificial fill areas on a case-by-case basis (See Figure 17).	Portion of Alameda Point and Oakland Shorline
	Deep	Area south of the Bay Bridge where basin is deepest and potentially most productive (See Figure 10). High density of deep historic wells in City of Alameda (See Fig. 2 and Table 4).	None	None
BERKELEY	*None*	Areas with moderate density of back yard irrigation wells (see Figure 17).	Berkeley/ Albany Groundwater Management Zone. Emeryville Brownfields Groundwater Management Zone (see Figure 19).	None
OAKLAND	*Shallow*	Areas with moderate density of back yard irrigation wells (See Figure 17).	Regional Board will consider applicability of City of Oakland's Urban Land Redevelopment Protocol once it is finalized (see Section 14.1).	None
	Deep	Area south of Lake Merritt is deepest and historically most productive portion of the Oakland Sub-Area (See Figure 3). SWPZ for EBMUD aquifer storage and recovery test well near Oakland Coliseum (See Figure 14). High density of deep historic wells in City of Oakland (See Fig. 2 and Table 4).	None	None
SAN LEANDRO	*Shallow*	Areas with a high density of back yard irrigation wells (See Figure 17).	Shallow groundwater pollution sites that meet remediation and investigation criteria on a case-by-case basis (See Section 17.11).	None
	Deep	SWPZ for 2 small DHS Permitted Drinking Water Systems (See Figure 14).	None	None
SAN LORENZO	*Shallow*	Areas with a high density of back yard irrigation wells (Figure 17).	Shallow groundwater pollution sites that meet remediation and investigation criteria on a case-by-case basis (See Section 17.11).	None
	Deep	SWPZ for 2 small DHS Permitted Drinking Water Systems, 5 City of Hayward Emergency Supply Wells, and EBMUD aquifer storage and recovery test well near Ora Loma Waste Water Treatment Plant.	None	None

SWPZ – Source Water Protection Zone

18.0 REFERENCES

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Appendix A: Basin Plan -- Table 2-9

GROUNDWATER BASIN	COUNTY	DWR BASIN NO.	MUN[1]	PROC[2]	IND[3]	AGR[4]	FRESH[5]
Alameda Creek (Niles Cone)	Alameda	2 - 9.01	E[6]	E	E	E	
Castro Valley	Alameda	2 - 8	P[7]	P	P	P	
East Bay Plain	Alameda	2 - 9.01	E	E	E	E	
Livermore Valley	Alameda	2 - 10	E	E	E	E	
Sunol Valley	Alameda	2 - 11	E	E	E	E	
Arroyo Del Hambre Valley	Contra Costa	2 - 31	P	P	P	P	
Clayton Valley	Contra Costa	2 - 5	E	P	P	P	
Pittsburg Plain	Contra Costa	2 - 4	P	P	P	P	
San Ramon Valley	Contra Costa	2 - 7	E	P	P	E	
Ygnacio Valley	Contra Costa	2 - 6	P	P	P	P	
Novato Valley	Marin	2 - 30	P	P	P	P	
Sand Point Area	Marin	2 - 27	E	P	P	P	
San Rafael	Marin	2 - 29	P	P	P	P	
Ross Valley	Marin	2 - 28	E	P	P	E	
Napa Valley	Napa	2.2 & 2 - 2.01	E	E	E	E	
Islais Valley	San Francisco	2 - 33	P	E	E	P	
Merced Valley (North)	San Francisco	2 - 35	P	P	P	E	
San Francisco Sands	San Francisco	2 - 34	E	P	P	E	
Visitation Valley	San Francisco	2 - 32	P	E	E	P	
Half Moon Bay Terrace	San Mateo	2 - 22	E	P	P	E	
Merced Valley (South)	San Mateo	2 - 35A	E	P	P	E	
Pescadero Valley	San Mateo	2 - 26	E	P	P	E	
San Gregorio Valley	San Mateo	2 - 24	E	P	P	E	
San Mateo Plain	San Mateo	2 - 9A	E	E	E	P	
San Pedro Valley	San Mateo	2 - 36	P	P	P	P	
Santa Clara Valley (& Coyote)	Santa Clara	2 - 9B	E	E	E	E	
Suisun/Fairfield Valley	Solano	2 - 3	E	E	E	E	
Kenwood Valley	Sonoma	2 - 19	E	P	P	E	
Petaluma Valley	Sonoma	2 - 1	E	P	P	E	
Sebastopol-Merced Fm. Highlands	Sonoma	2 - 25	E	P	P	E	
Sonoma Valley	Sonoma	2 - 2.022	E	P	P	E	

NOTES:
(1) MUN = Municipal and domestic water supply.
(2) PROC = Industrial process water supply.
(3) IND = Industrial service water supply.
(4) AGR = Agricultural water supply.
(5) FRESH = Freshwater replenishment to surface water. (Designation will be determined at a later date; for the interim, a site-by-site determination will be made).
(6) E = Existing beneficial use; based on available information (see references listed in Table 2-8).
(7) P = Potential beneficial use; based on available information. There is no known use of the basin for this category; however, the basin could be used for this purpose (see references listed in Table 2-8).

Appendix B

Well Density Maps

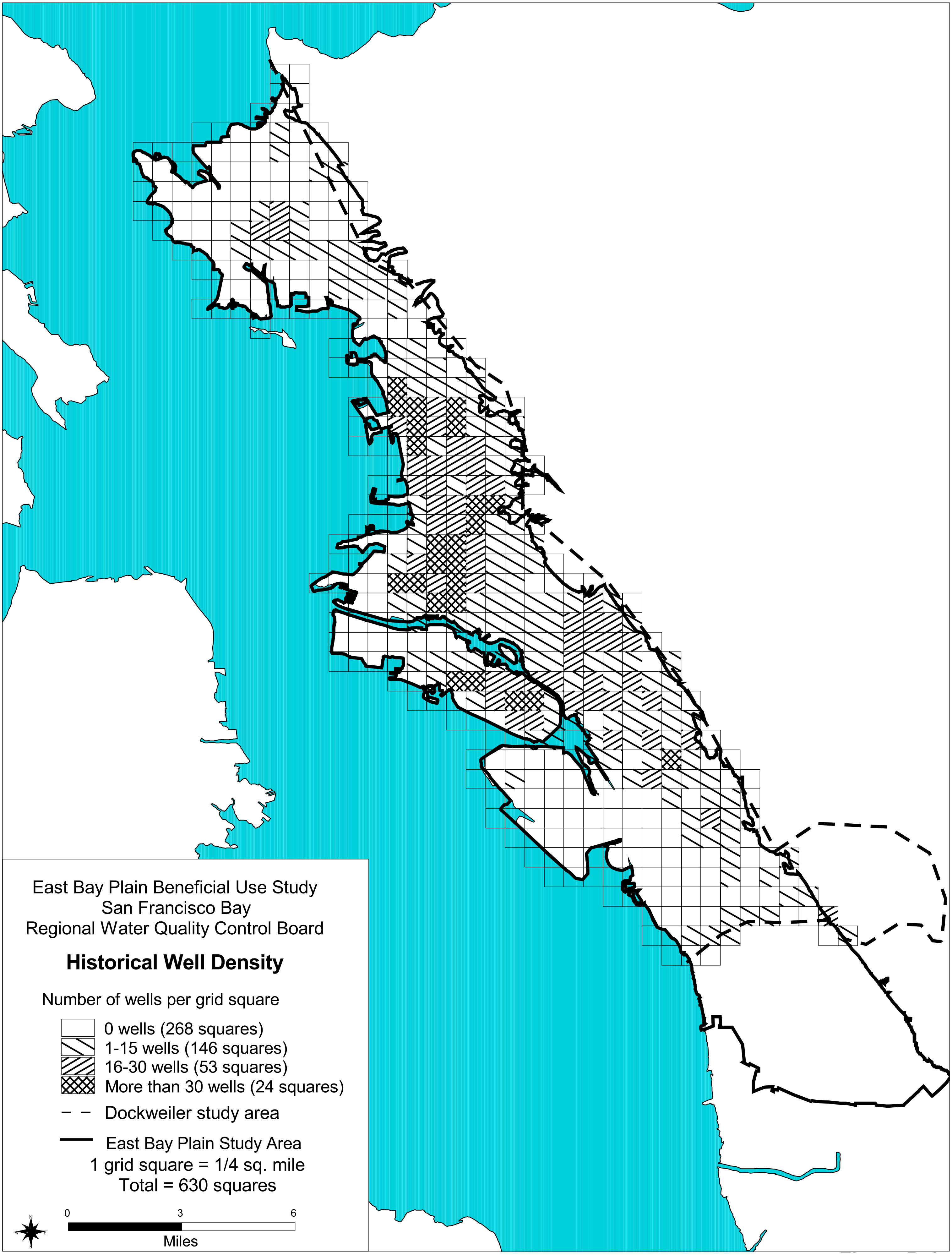
This section provides background on the GIS analysis of the density of historic and current wells in the East Bay Plain. Point locations for the historic and current wells used in the analysis are as shown on Figures 2, 15, 16 and 17 of this report. The density of the data points was computed on a ¼ square mile grid. The results are shown on Figures B-1 and B-2.

Historic Well Density: Wells used in this analysis are from the Dockweiler (1912) study discussed in Section 12.1 of the report. A total of 3,573 wells were identified (See Figure 2). In the study area overall, about 8% of the wells with depth data had a total depth of 200 feet or deeper. About 30% of the wells with depth data were 100 feet deep or more. The highest density of wells are in the cities of Oakland, Berkeley and Alameda (Figure B-1).

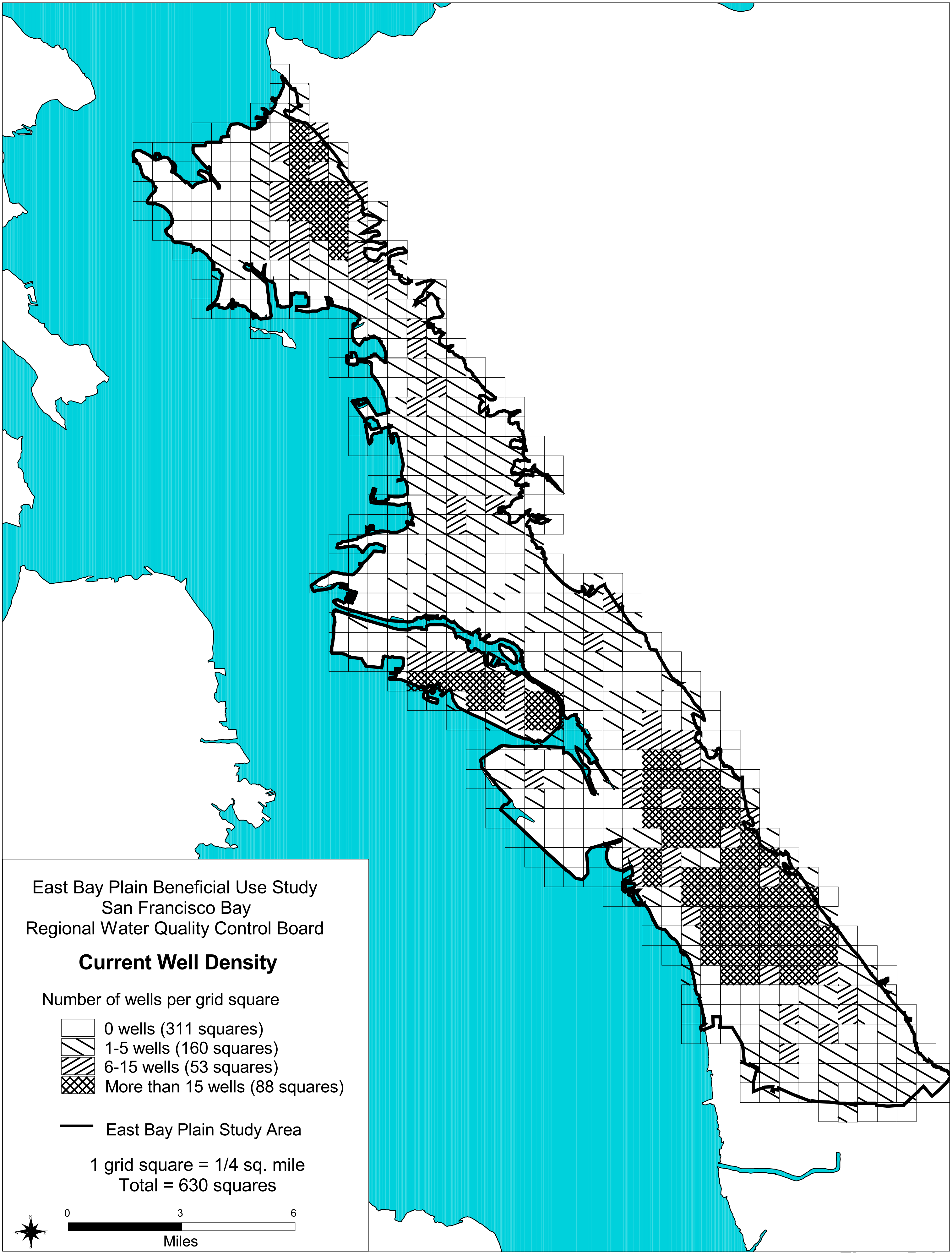
Current Well Density: Within the East Bay Plain, most current wells are used for residential irrigation. A smaller number of wells are used for commercial irrigation and industrial use. Only four wells are permitted for drinking water use (See Figures 14-17). Wells used in this analysis are a combination of coverages from the databases of ACFCWCD and EBMUD. EBMUD's database was used for the area between Richmond and San Leandro because it has a larger number of wells (See Section 13.3). ACFCWCD's was used for the area south of San Leandro, primarily within the City of Hayward, since EBMUD's jurisdiction does not cover this area. The highest density of current wells are in Richmond, Alameda, San Lorenzo, San Leandro, and Hayward (Figure B-2).

As an example of the utility of the well density maps discussed above, a composite map was generated that shows areas that have densities above the 80th percentile for each data set. For current wells, the 80^{th} percentile equates to a density of 5 or greater wells per ¼ square mile. For historic wells, the 80^{th} percentile equates to a density of 15 or greater wells per ¼ square mile. Figure B-3 delineates both of these areas. In addition, conceptual well head protection zones are shown.

From a beneficial use perspective, these areas are of higher concern because 1) historic wells may act as vertical conduits and allow shallow contamination to migrate into deeper aquifers, 2) current backyard irrigation wells may represent a non-drinking water exposure pathway to groundwater contamination (e.g., volatilization or irrigation of fruits and vegetables), and 3) contamination sites within well head protection zones may impact existing or planned drinking water wells.



East Bay Plain Beneficial Use Study
San Francisco Bay
Regional Water Quality Control Board
Historical Well Density
Number of wells per grid square
0 wells (268 squares)
1-15 wells (146 squares)
16-30 wells (53 squares)
More than 30 wells (24 squares)
Dockweiler study area
East Bay Plain Study Area
1 grid square = 1/4 sq. mile
Total = 630 squares
0
3
6
Miles


East Bay Plain Beneficial Use Study
San Francisco Bay
Regional Water Quality Control Board
Current Well Density
Number of wells per grid square
0 wells (311 squares)
1-5 wells (160 squares)
6-15 wells (53 squares)
More than 15 wells (88 squares)
East Bay Plain Study Area
1 grid square = 1/4 sq. mile
Total = 630 squares
0
3
6
Miles

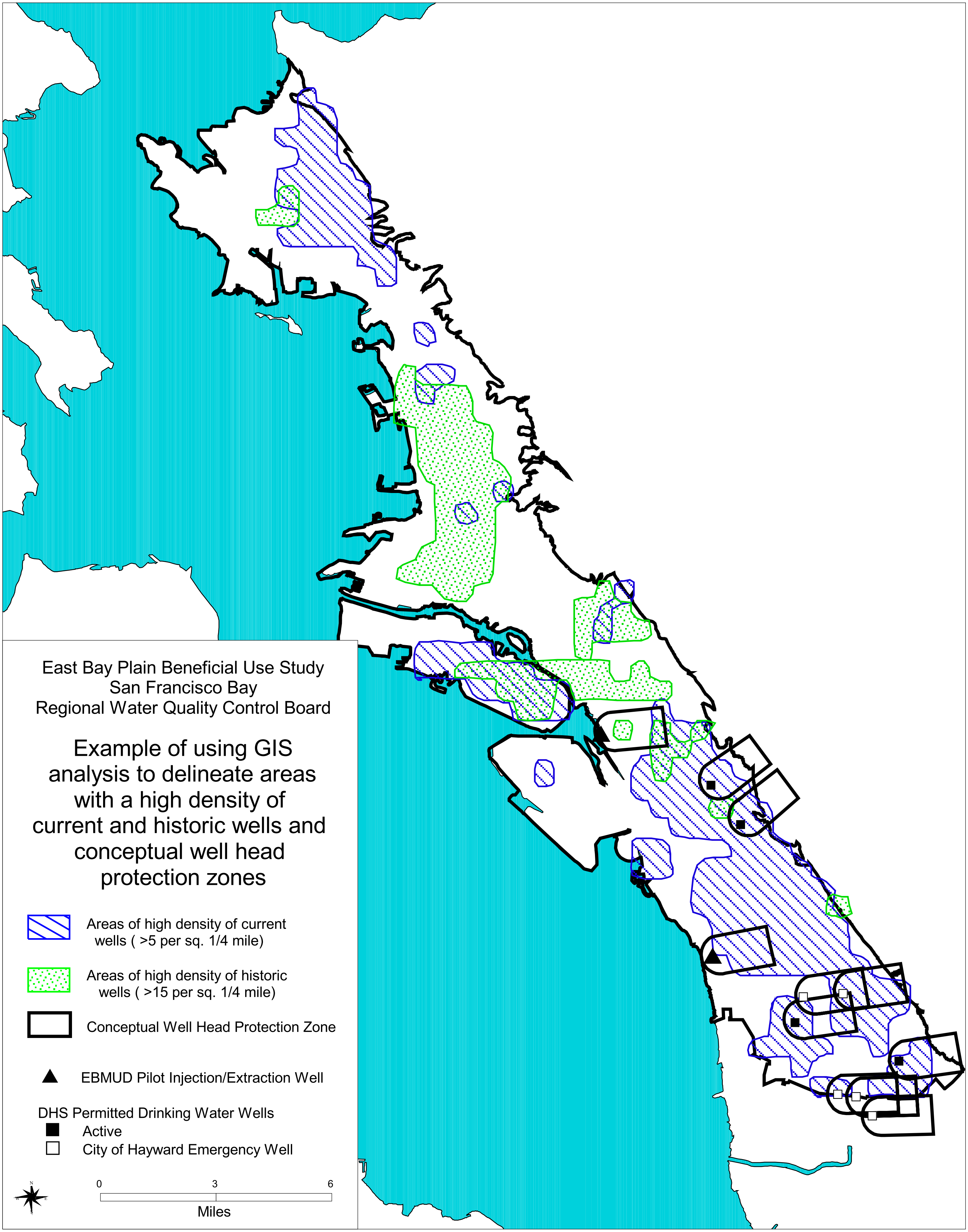

East Bay Plain Beneficial Use Study
San Francisco Bay
Regional Water Quality Control Board
Example of using GIS analysis to delineate areas with a high density of current and historic wells and conceptual well head protection zones
Areas of high density of current wells (>5 per sq. 1/4 mile)
Areas of high density of historic wells (>15 per sq. 1/4 mile)
Conceptual Well Head Protection Zone
EBMUD Pilot Injection/Extraction Well
DHS Permitted Drinking Water Wells
Active
City of Hayward Emergency Well
0
3
6
Miles

Figure B-3