

Chevron Environmental  
Management Company  
6001 Bollinger Canyon Rd, K2236  
P.O. Box 6012  
San Ramon, CA 94583-2324  
Tel 925-842-9559  
Fax 925-842-8370

Dana Thurman  
Project Manager

**RECEIVED**

By loprojectop at 3:18 pm, Nov 23, 2005

November 23, 2005  
(date)

**ChevronTexaco**

Alameda County Health Care Services  
1131 Harbor Bay Parkway, Suite 250  
Alameda, CA 94502-6577

Re: Chevron Service Station # 9-1924

Address: 4904 Southfront Road, Livermore, California

I have reviewed the attached report titled Response to Comments  
and dated November 22, 2005.

I agree with the conclusions and recommendations presented in the referenced report. The information in this report is accurate to the best of my knowledge and all local Agency/Regional Board guidelines have been followed. This report was prepared by Cambria Environmental Technology, Inc., upon whose assistance and advice I have relied.

This letter is submitted pursuant to the requirements of California Water Code Section 13267(b)(1) and the regulating implementation entitled Appendix A pertaining thereto.

I declare under penalty of perjury that the foregoing is true and correct.

Sincerely,



Dana Thurman  
Project Manager

Enclosure: Report

**RECEIVED**

By lopprojectop at 3:19 pm, Nov 23, 2005

**C A M B R I A**

November 22, 2005

Mr. Jerry Wickham  
Alameda County Health Care Services  
Environmental Health Services (ACEHS)  
1131 Harbor Bay Parkway, Suite 250  
Alameda, California 94502

Re: **Response to Comments**  
Chevron Service Station #9-1924  
4904 Southfront Road  
Livermore, California  
Fuel Leak Case No. RO0000477



Dear Mr. Wickham:

On behalf of Chevron Environmental Management Company (Chevron), Cambria Environmental Technology, Inc. (Cambria) has prepared this response to comments as requested in the September 27, 2005, ACEHS letter pertaining to the above referenced site (Figure 1). In that letter (Attachment A), the ACEHS requested additional information on the following:

- 1) a) Information regarding the location of water producing wells near the site from the Zone 7 Water Agency, and potential for future impact on groundwater use near the site;
- b) Information regarding influence of previously identified former irrigation and domestic wells near the site, and their potential for future impact on groundwater use near the site;
- 2) Information on potential impact to lower water-bearing zones beneath the site; and
- 3) Historic groundwater analytical data for ethylene dibromide (EDB).

## DISCUSSION

For responses to items 1 and 2, Cambria obtained information published in the September 2005 Livermore-Amador Valley groundwater basin plan (Jones & Stokes, 2005). Attachment B includes maps showing the location of the subject site in relation to Zone 7 water producing wells and main water producing basin, and Section 3 of the groundwater basin plan describing the water resources of the groundwater basin is included in Attachment C.

- 1) **a) Information regarding the location of water producing wells near the site from Zone 7 Water Agency, and potential for future impact on groundwater use near the site.**

The nearest Zone 7 water producing well is located approximately 1.5 miles southwest of the site, in the Mocho II Sub-basin (Attachment B). The subject site is located near the

**Cambria  
Environmental  
Technology, Inc.**

4111 Citrus Avenue  
Suite 12  
Rocklin, CA 95677  
Tel (916) 630-1855  
Fax (916) 630-1856



eastern boundary of the Mocho I Sub-basin, adjacent to the Spring Sub-basin. In the Mocho I Sub-basin, recent alluvium of the Upper Aquifer ranges from approximately 10 to 50 feet in thickness, overlying the Livermore Formation. The Lower Aquifer is not present in the Mocho I Sub-basin. There does appear to be hydraulic connectivity between the shallow alluvial deposits of the Mocho I and Mocho II Sub-basins. Water production from this sub-basin is primarily from the Main Basin portion of the Mocho II Sub-basin, which is present approximately 1.2 miles southwest of the subject site. The existing hydrocarbon and methyl tert-butyl ether (MTBE) plumes extending approximately 150 feet downgradient of the subject site (Figure 2) continue to show generally declining concentration trends, indicating that the plumes appear to be shrinking and are not extending further downgradient toward the water producing portion of the sub-basin. Because of limited groundwater resources present in the recent alluvium beneath the subject site, there does not appear to be a potential for future impact on groundwater use near the site, especially within the limited plume extent downgradient of the site.

**b) Information regarding influence of previously identified former irrigation and domestic wells near the site, and their potential for future impact on groundwater use near the site.**

The hydrocarbon and MTBE plumes extending downgradient of the subject site have generally declining concentration trends. Based on their current extent as shown on Figure 2 and that they appear to be shrinking, it is unlikely that the plumes will impact, or their migration will be influenced by the former irrigation and domestic wells identified in Delta Environmental Consultants, Inc., December 10, 2002, *Site Conceptual Model*. Additional information on these wells is not necessary as they have no bearing on the improving groundwater conditions at the site.

**2) Information on potential impact to lower water-bearing zones beneath the site.**

Only recent alluvial deposits of the Upper Aquifer appear present beneath the site. Although there is lateral hydraulic connectivity within the Upper Aquifer between the Mocho I Sub-basin and the water producing Main Basin portion of the Mocho II Sub-basin, lower water-bearing zones of the Lower Aquifer within the Mocho II Sub-basin are located approximately 1.2 miles southwest of the subject site, and vertical hydraulic conductivity between the Upper and Lower Aquifers is impeded by a relatively continuous silty clay aquiclude. Given that the hydrocarbon and MTBE plumes only

Mr. Jerry Wickham  
November 22, 2005

extent approximately 150 feet downgradient of the subject site (Figure 2) and appear to be shrinking, potential impact to lower water-bearing zones is unlikely.

**3) Historic groundwater analytical data for ethylene dibromide (EDB).**

Table 1 summarizes volatile organic compound analytical data from April and June 1989. EDB was non-detect in groundwater from all wells in both events.



**CLOSING**

If you have any questions or require additional information, please do not hesitate to contact me at (916) 630-1855 (ext. 112).

Sincerely,  
**Cambria Environmental Technology, Inc.**

David W. Herzog, P.G.  
Senior Project Geologist



Figures:           1 – Vicinity Map  
                      2 – Concentration Map September 28, 2005

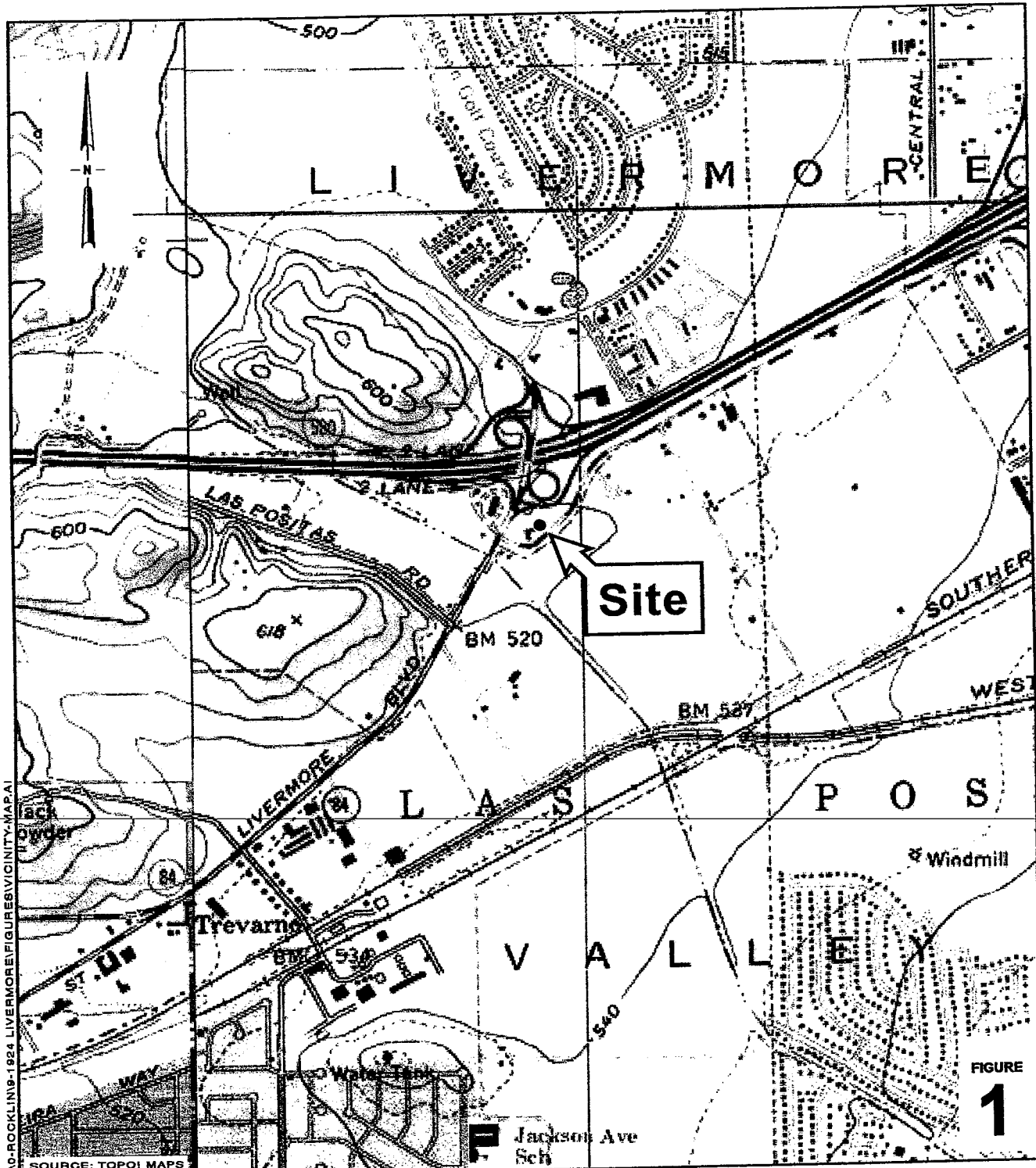
Tables:            1 – Groundwater Analytical Data

Attachments:    A – ACEHS September 27, 2005 Letter  
                      B – Livermore-Amador Valley Groundwater Basin Map and Cross Section  
                      C – Chapter 3 Water Resources of the Zone 7 Groundwater Basin

cc:                Mr. Dana Thurman, Chevron Environmental Management Company, P.O. Box 6012, San Ramon, CA 94583

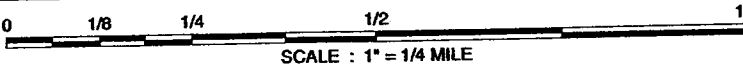
**REFERENCES**

Jones & Stokes, 2005, *Groundwater Management Plan for Livermore-Amador Valley Groundwater Basin*, Prepared for Zone 7 Water Agency. Sacramento, California: Jones & Stokes.



1:10-ROCKLIN-1924 LIVERMORE FIGURES VICINITY-MAP-A1

SOURCE: TOPOI MAPS



**Chevron Service Station 9-1924**  
 4904 Southfront Road  
 Livermore, California



C A M B R I A

**Vicinity Map**

FIGURE  
**1**

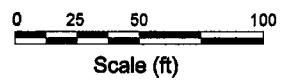
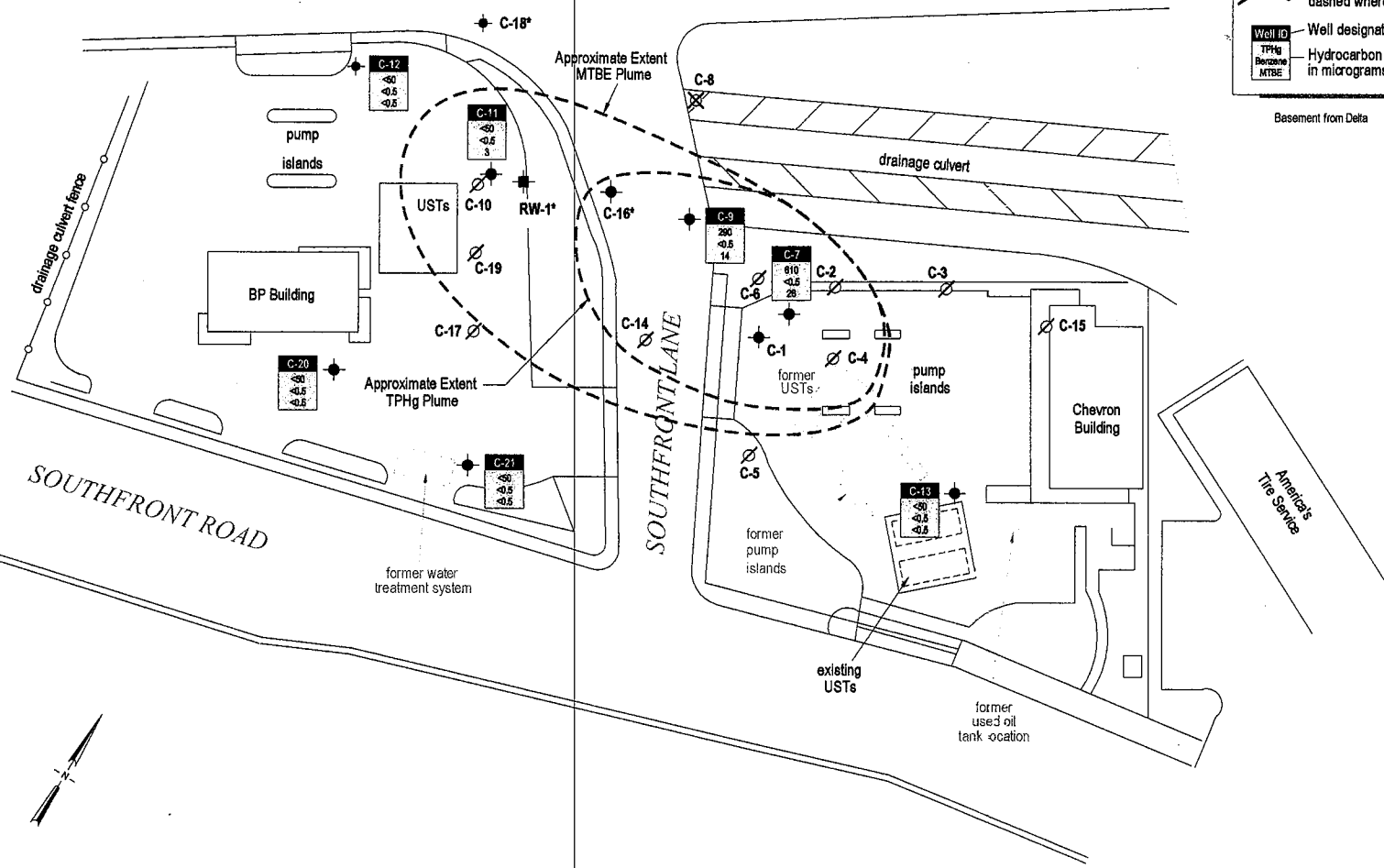
FIRST STREET (HIGHWAY 84)

**EXPLANATION**

- C-1 ◆ Monitoring well location
- C-2 ∅ Destroyed monitoring well location
- C-8 ✕ Abandoned monitoring well location
- RW-1 ◆ Recovery well location
- 10 Hydrocarbon concentration contour, dashed where inferred

Well ID	Well designation
TPHg	Hydrocarbon concentrations are in micrograms per liter (µg/L)
Benzene	
MTBE	

Basement from Delta



FIGURE

**2**



**Attachment A**  
**ACEHS September 27, 2005 Letter**

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ALAMEDA COUNTY  
HEALTH CARE SERVICES

AGENCY  
DAVID J. KEARS, Agency Director



OCT 03 2005  
9H 56

ENVIRONMENTAL HEALTH SERVICES  
ENVIRONMENTAL PROTECTION  
1131 Harbor Bay Parkway, Suite 250  
Alameda, CA 94502-6577  
(510) 567-6700  
FAX (510) 337-9335

September 27, 2005

Mr. Dana Thurman  
Chevron Environmental Management Company  
6001 Bollinger Canyon Road  
P.O. Box 6012  
San Ramon, CA 94583-2324

Subject: Fuel Leak Case No. RO0000477, Chevron #9-1924, 4904 Southfront Road, Pleasanton, CA

Dear Mr. Thurman:

I have been assigned as case worker for the above referenced site. Please send future correspondence for this site to my attention. Alameda County Environmental Health (ACEH) staff have reviewed the fuel leak case file for the above-referenced site and the documents entitled, "Request for Closure," dated February 21, 2005, "Closure Request," dated May 27, 2004, and "Site Conceptual Model," dated December 8, 2002. Chevron Environmental Management Company has requested site closure based upon review of site conditions and comparison to the low-risk fuel site criteria described in the January 5, 1996 Regional Water Quality Control Board memorandum, "Interim guidance on Required Cleanup at Low-Risk Fuel Sites." Residual fuel hydrocarbons are present in soil and groundwater at the site and extend off-site beneath Southfront Lane and a BP service station on the opposite side of Southfront Lane.

Based upon our review of the case file and the above cited documents, we request additional information prior to making a determination regarding case closure. We request that you address the technical comments below and provide the requested information in a response to comments by **November 15, 2005**. Case closure will be considered following submittal of the information requested in the technical comments below.

**TECHNICAL COMMENTS**

1. **Water Wells near the Site.** The "Site Conceptual Model," (SCM) dated December 8, 2002 describes the results of a California Department of Water Resources (DWR) well search that identified five irrigation wells and one domestic well within 2,000 feet of the site (Table 4). The SCM also indicates that the five irrigation wells and one domestic well were destroyed. No information on the total depth of the wells or well construction is presented. We request that you also obtain well information from Zone 7 Water Agency to confirm that no other water supply wells exist within 2,000 feet of the site and to confirm that the irrigation and domestic wells were destroyed. In addition, we request that well construction information, particularly the depth at which the water supply wells in the area were screened, be presented in order to help assess potential future impacts on groundwater use near the site. Please present this information using maps and tables as necessary in the Response to Comments requested below.

2. **Impact to Lower Water-Bearing Zones.** The Closure Report states that deeper drinking water aquifers are not likely to be impacted by dissolved hydrocarbons at the site. However, no soil or groundwater samples have been collected below 30 feet bgs at the site to confirm that soil and groundwater has not been impacted at greater depths. Please expand upon the discussion of potential impact to lower water-bearing zones using, but not limited to, additional information on the stratigraphy, depth to water-bearing zones, likely vertical gradients, and historic water level fluctuations. Please present regional and site-specific information as necessary to support your discussion. The DWR well search in the May 27, 2004 SCM indicates that a Zone 7 monitoring well is located in close proximity to the site. The Zone 7 monitoring well may be a source of useful information to help address the above items. Please incorporate this information as appropriate in the Response to Comments requested below.
3. **Groundwater Monitoring.** Since a fuel leak was reported at the site in 1984, there is a potential for lead scavengers to be contaminants of concern. The lead scavenger 1,2-dichlorethane has been detected in groundwater at concentrations up to 30 µg/L. However, no analyses appear to have been conducted for ethylene dibromide. Please provide historic groundwater data for ethylene dibromide, obtain data for ethylene dibromide during the next groundwater monitoring event, or provide the rationale as to why analyses for ethylene dibromide are not needed.

#### TECHNICAL REPORT REQUEST

Please submit technical reports to Alameda County Environmental Health (Attention: Jerry Wickham), according to the following schedule:

- **November 15, 2005** – Response to Comments
- **February 15, 2006** - Quarterly Report for the Fourth Quarter 2005

These reports are being requested pursuant to California Health and Safety Code Section 25296.10. 23 CCR Sections 2652 through 2654, and 2721 through 2728 outline the responsibilities of a responsible party in response to an unauthorized release from a petroleum UST system, and require your compliance with this request.

#### ELECTRONIC SUBMITTAL OF REPORTS

ACEH's Environmental Cleanup Oversight Programs (LOP and SLIC) now request submission of reports in electronic form. The electronic copy is intended to replace the need for a paper copy and is expected to be used for all public information requests, regulatory review, and compliance/enforcement activities. Instructions for submission of electronic documents to the Alameda County Environmental Cleanup Oversight Program FTP site are provided on the attached "Electronic Report Upload Instructions." Submission of reports to the Alameda County FTP site is an addition to existing requirements for electronic submittal of information to the State Water Resources Control Board (SWRCB) Geotracker website. In September 2004, the SWRCB adopted regulations that require electronic submittal of information for groundwater cleanup programs. For several years, responsible parties for cleanup of leaks from underground storage

tanks (USTs) have been required to submit groundwater analytical data, surveyed locations of monitoring wells, and other data to the Geotracker database over the Internet. Beginning July 1, 2005, electronic submittal of a complete copy of all reports is required in Geotracker (in PDF format). Please visit the State Water Resources Control Board for more information on these requirements ([http://www.swrcb.ca.gov/ust/cleanup/electronic\\_reporting](http://www.swrcb.ca.gov/ust/cleanup/electronic_reporting)).

#### **PERJURY STATEMENT**

All work plans, technical reports, or technical documents submitted to ACEH must be accompanied by a cover letter from the responsible party that states, at a minimum, the following: "I declare, under penalty of perjury, that the information and/or recommendations contained in the attached document or report is true and correct to the best of my knowledge." This letter must be signed by an officer or legally authorized representative of your company. Please include a cover letter satisfying these requirements with all future reports and technical documents submitted for this fuel leak case.

#### **PROFESSIONAL CERTIFICATION & CONCLUSIONS/RECOMMENDATIONS**

The California Business and Professions Code (Sections 6735, 6835, and 7835.1) requires that work plans and technical or implementation reports containing geologic or engineering evaluations and/or judgments be performed under the direction of an appropriately registered or certified professional. For your submittal to be considered a valid technical report, you are to present site specific data, data interpretations, and recommendations prepared by an appropriately licensed professional and include the professional registration stamp, signature, and statement of professional certification. Please ensure all that all technical reports submitted for this fuel leak case meet this requirement.

#### **UNDERGROUND STORAGE TANK CLEANUP FUND**

Please note that delays in investigation, later reports, or enforcement actions may result in your becoming ineligible to receive grant money from the state's Underground Storage Tank Cleanup Fund (Senate Bill 2004) to reimburse you for the cost of cleanup.

#### **AGENCY OVERSIGHT**

If it appears as though significant delays are occurring or reports are not submitted as requested, we will consider referring your case to the Regional Board or other appropriate agency, including the County District Attorney, for possible enforcement actions. California Health and Safety Code, Section 25299.76 authorizes enforcement including administrative action or monetary penalties of up to \$10,000 per day for each day of violation.

Dana Thurman  
September 27, 2005  
Page 4

If you have any questions, please call me at (510) 567-6791.

Sincerely,



Jerry Wickham  
Hazardous Materials Specialist

Enclosure: ACEH Electronic Report Upload (ftp) Instructions

cc: Colleen Winey, QIC 80201  
Zone 7 Water Agency  
100 North Canyons Parkway  
Livermore, CA 94551

Danielle Stefani  
Livermore-Pleasanton Fire Department  
3560 Nevada Street  
Pleasanton, CA 94566

Bruce Eppler  
Cambria Environmental Technology, Inc.  
4111 Citrus Avenue, Suite 12  
Rocklin, CA 95667

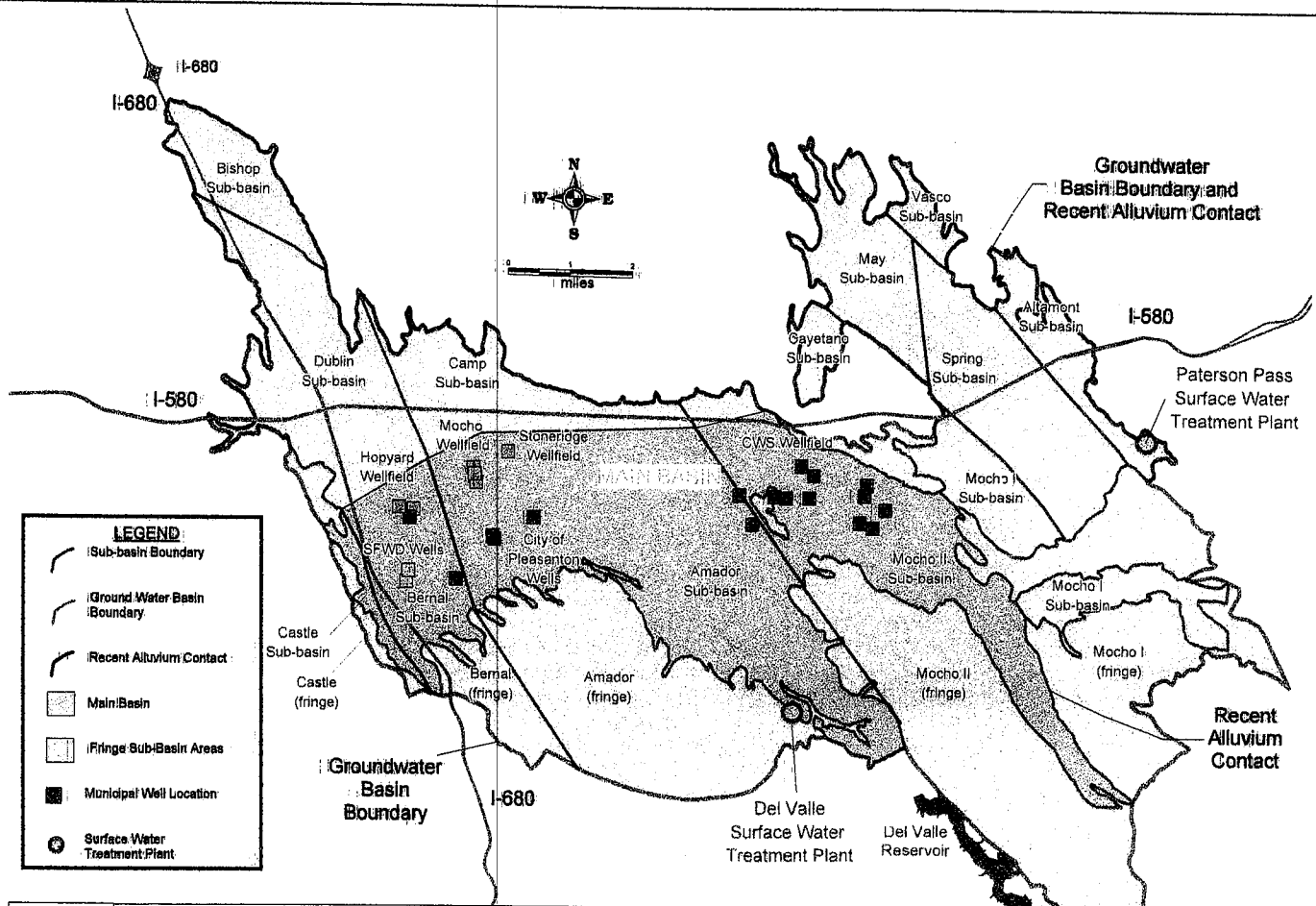
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Donna Drogos, ACEH  
Jerry Wickham, ACEH  
File

**Attachment B**

**Livermore-Amador Valley Groundwater Basin Map  
and Cross Section**

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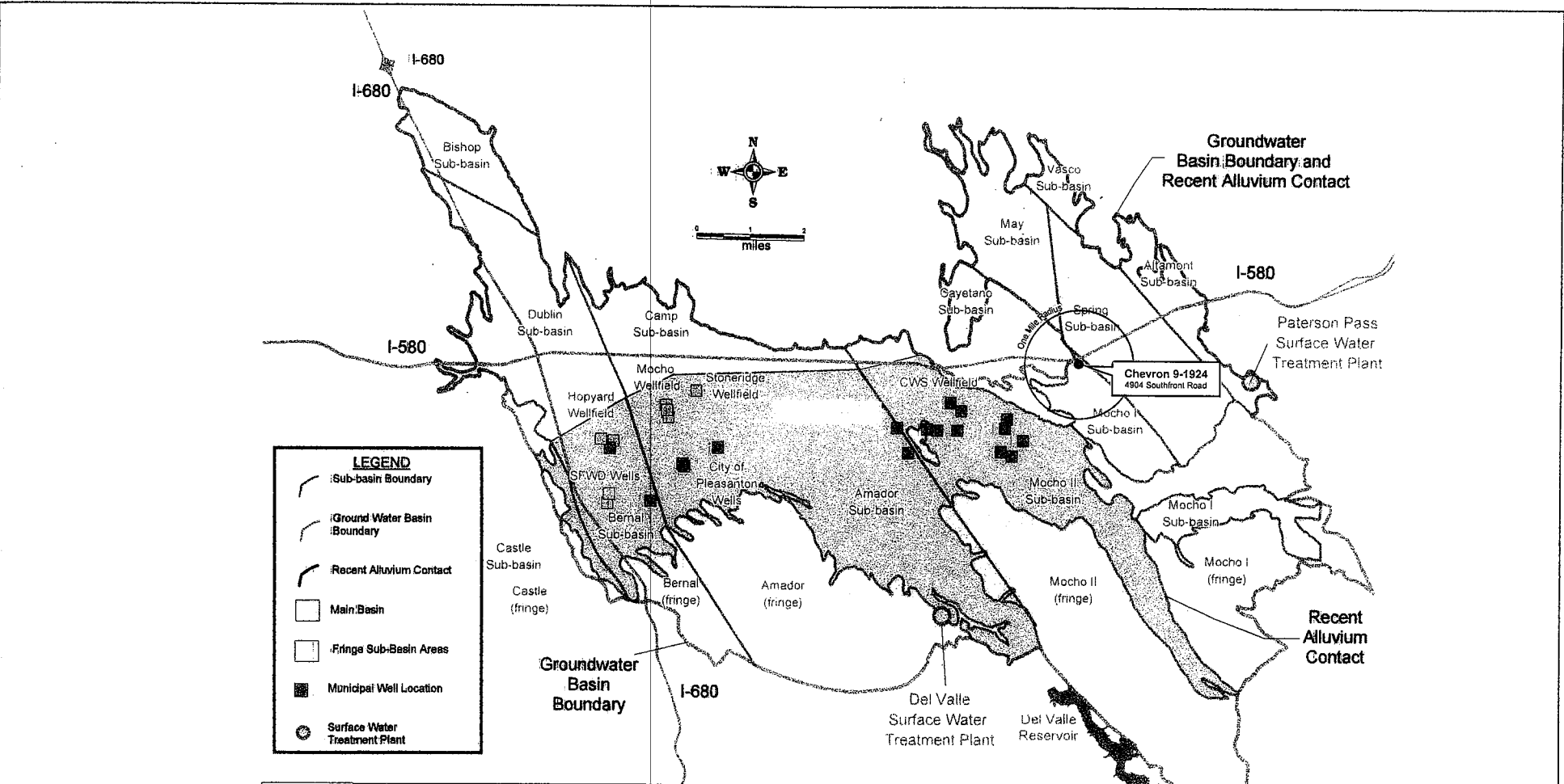
	<b>ZONE 7 WATER AGENCY</b> 100 NORTH CANYONS PKWY, LIVERMORE, CA 94551	DRAWN: GERALD GATES TOM ROOZE	<b>GROUNDWATER BASIN MAP</b>  Groundwater Annual Monitoring Report	SCALE: 1" = 2 Miles
		DESIGNED: GERALD GATES STEPHANIE SMITH		DATE: October 31, 2003
		CHECKED: DAVID LUNN		FILE NO.: E:\water\GM2003\y\Annual\Figure
		APPROVED: DAVID LUNN		

Figure 3-1  
Groundwater Annual Monitoring Report



**ZONE 7 WATER AGENCY**  
 100 NORTH CANYONS PKWY, LIVERMORE, CA 94551

DRAWN	GERALD GATES TOM ROOZE
DESIGNED	GERALD GATES STEWART SMITH
CHECKED	DAVID LUNN
APPROVED	DAVID LUNN

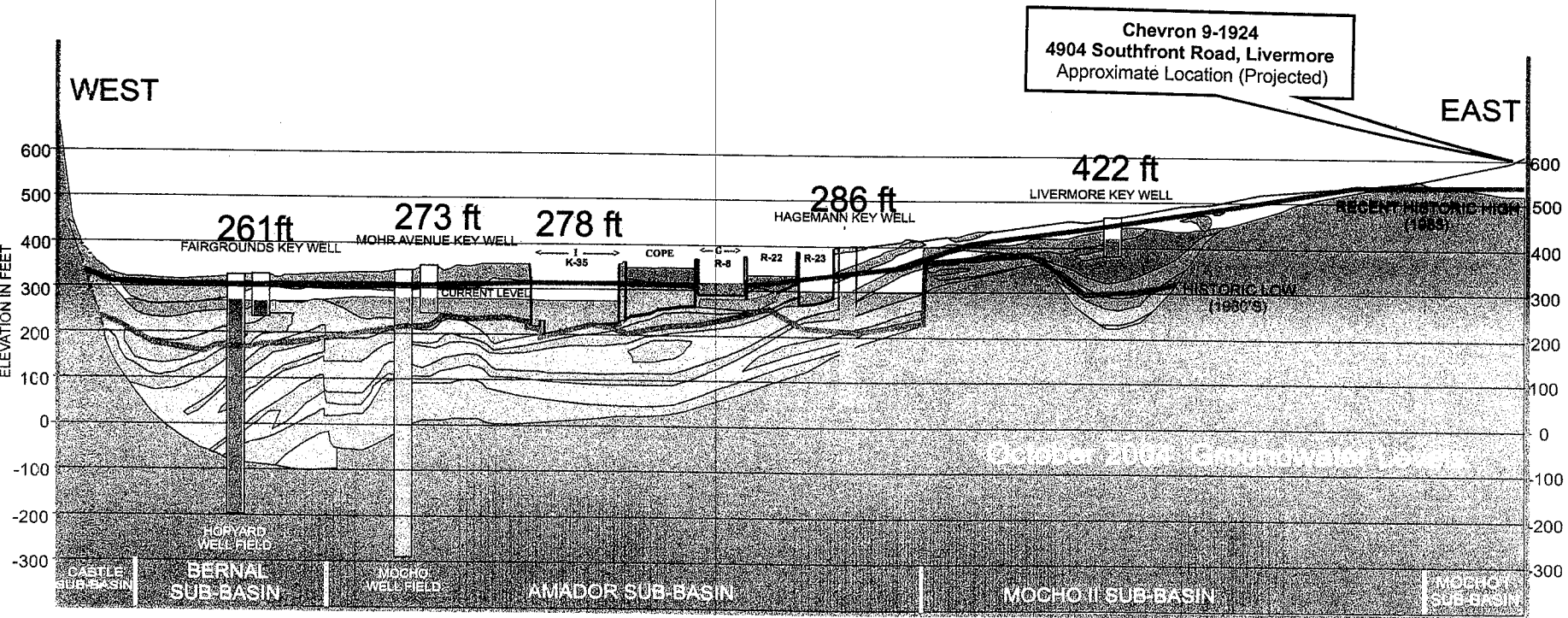
**GROUNDWATER BASIN MAP**  
 Groundwater Annual Monitoring Report

SCALE	1" = 2 Miles
DATE	October 31, 2003
FILE NO.	E:\water\GM\2004y\Annual\Figure

04/22/04 GMP File 08105

Fig 4-1

# LIVERMORE-AMADOR VALLEY GROUNDWATER BASIN WEST-EAST CROSS-SECTION



	Bernal	Amador	Mocho II	Total
Area (Ac)	3,100	9,900	4,300	17,300
Saturated Thickness (ft)	246	159	98	168
Storage Coefficient	0.07	0.08	0.06	0.07
Groundwater Vol. (A-F)	53,000	126,000	25,000	204,000
Available Operational Storage	12,000	43,000	22,000	77,000

FIGURE 4-1



**Attachment C**

**Chapter 3 Water Resources of the Zone 7 Groundwater Basin**

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## **3.1 Description of Zone 7 Groundwater Basin**

### **3.1.1 Overview**

The Livermore Valley, an east-west trending, inland structural basin located in northeastern Alameda County, is surrounded primarily by north-south trending faults and hills of the Diablo Range. The valley covers about 42,000 acres, extends approximately 14 miles in an east-west direction and varies from 3 to 6 miles in width. It is separated from San Francisco Bay by several northwesterly trending ridges of the California Coast Ranges, including the Pleasanton Ridge. The valley floor slopes gently west and southwest from an elevation of approximately 700 feet above sea level in the east to approximately 320 feet above sea level in the southwest.

The Livermore Valley Watershed covers more than 400 square miles (250,000 acres) and extends north almost to Mt Diablo and south almost to Mt Hamilton. Six principal streams flow into and/or through the valley, and join in the southeast where the Arroyo de Laguna flows out of the valley. The other five arroyos, namely the Arroyo Valle, Arroyo Mocho, Arroyo Las Positas, Tassajara Creek, and Alamo Creek, are essentially tributaries to the Arroyo de Laguna. Average precipitation rates range from 16 inches per year at the valley floor to over 20 inches per year in the southeast and northwest portions of the valley.

The Livermore-Amador Groundwater Basin is located in the heart of the Livermore Valley and watershed and extends south into the hills south of Pleasanton and Livermore. It includes 65,000 acres occupied by both the Livermore Valley (42,000 acres) and the Livermore uplands (23,000 acres). The Basin is designated DWR 2-10 in Bulletin 118 and includes the areas occupied by both Livermore Valley and Livermore uplands (see Figure 3-1).

The Main Basin is bounded on the:

- west by northwesterly trending ridges of the California Coast Ranges (including Pleasanton Ridge) and the Calaveras fault,
- north by the Tassajara Uplands and the steeply dipping east west trending Tassajara Formation,

- east by the Greenville Fault and by the marine formations exposed in the Altamont Hills, and
- south by the Verona Fault and Livermore Uplands and the steeper Livermore Highlands.

The Main Basin (described in more detail in the following subsections) is a portion of the Livermore-Amador Groundwater Basin (DWR 2-10). The Main Basin covers 17,000 acres and contains the highest yielding aquifers and best quality water within the DWR Basin 2-10.

### 3.1.2 Hydrogeology

Structural uplift of the entire Coast Ranges occurred during the late middle Pliocene and Pleistocene, causing extensive folding and faulting of the region. The Livermore Valley, a structural valley formed by a faulted, asymmetric syncline, was created as a result of downwarping of the Miocene-Pliocene sandstones and conglomerates between the western bordering Calaveras Fault and the eastern bordering Greenville Fault. Continued deposition, uplift, and faulting have led to the current Livermore Valley stratigraphy.<sup>1</sup>

The valley is partially filled with Pleistocene-Holocene age (recent alluvium) alluvial fan, stream and lake deposits, which range in thickness from a few feet along the margins to nearly 400 (and possibly 800) feet in the west-central portion. The alluvium consists of unconsolidated gravel, sand, silt, and clay. The southern region of the Livermore Valley, the most important groundwater recharge area, consists mainly of sand and gravel that was deposited by the ancestral and present Arroyo Valle and Arroyo Mocho.

The eastern and northern regions of the valley contain thinner deposits and consist of alternating layers of gravel, sand, silt, and clay that are laterally discontinuous and resulted from the deposition of smaller streams. The western region of the valley has extensive gravel layers alternating with thick clay beds totaling approximately 400 feet in thickness. The alternation of sand/gravel layers and silt/clay layers form the basic aquifers for the area.<sup>2</sup>

In general, multiple aquifers are recognized in the alluvium of the Livermore Valley. The alluvium increases in thickness from east to west across the basin and thins both north and south at its boundaries. The alluvium also thickens from north to south to the central portion of the groundwater basin and then thins from the center toward the south. Although the upper portions of the alluvium appear to be very thick and continuous in the middle of the basin, the deeper aquifers are often discontinuous and/or poorly interconnected.

The Livermore Formation consists of beds of clayey gravels and sands, silt, and clay that are unconsolidated to semi-consolidated and estimated to be 4,000 feet

<sup>1</sup> California Department of Water Resources 1964b, 1974; Crane 1988; Hall 1958.

<sup>2</sup> California Department of Water Resources 1966, 1974, and Zone 7.

thick in the southern and western portion of the basin.<sup>3</sup> These sediments display lower yields in the upland areas. Groundwater from this formation is sodium bicarbonate in nature and of moderately good quality. Minor amounts of groundwater are believed to move along the strike of the beds to the northwest and enter the Main Basin (see detailed description below) at the southern portions of the Bernal and Amador sub-basins.

The Tassajara and Green Valley Formations, located in uplands north of the valley, are roughly Pliocene in age and were deposited under both brackish and freshwater conditions. They basically consist of sandstone, tuffaceous sandstone/siltstone, conglomerate, shale, and limestone. Water movement from these formations to the Main Basin is precluded by either structural alteration where beds dip away from the general groundwater flow of the valley or by non-water bearing stringers (tuff and clay particles). The near-vertical structural dip of the Tassajara and Green Valley formations is believed to prevent the commingling of waters among these formations and the alluvium, essentially cutting this water off from the groundwater basin.<sup>4</sup> Groundwater from these formations is sodium bicarbonate in nature and of moderately good quality.

### 3.1.3 Aquifer Zones

Within the groundwater basin, there is often a difference in water level fluctuations and water quality with depth. This difference is attributable to the existence of multiple aquifers that are poorly interconnected. Although multiple aquifers have been identified, wells have been classified generally as being in one of two aquifer zones:

- **Upper Aquifer Zone**—The upper aquifer zone consists of alluvial materials, including primarily sandy gravel and sandy clayey gravels. These gravels are usually encountered underneath the surficial clays (typically 20 to 40 feet below ground surface [bgs]) to about 80–150 feet bgs. This aquifer extends throughout the majority of the groundwater basin. Groundwater in this zone is generally unconfined. In the center portion of the groundwater basin, the upper aquifer is underlain by a relatively continuous, silty clay aquiclude up to 50 feet thick which is underlain by the Lower Aquifer Zone. In the eastern portion of the groundwater basin, the Livermore Formation underlies the upper aquifer. In the Zone 7 groundwater model, the Upper Aquifer Zone is referred to as Layer 1.
- **Lower Aquifer Zone**—Because of a lack of detailed hydrostratigraphic evaluation, all materials encountered below the clay aquiclude/aquitard in the center portion of the basin have been known collectively as the Lower Aquifer Zone. The aquifer materials consist of semi-confined to confined, leaky, coarse-grained, water-bearing units interbedded with relatively impermeable, fine-grained units. Based on localized hydrostratigraphic evaluation in the vicinity of Zone 7 well fields and as additional geologic information and hydrologic data become available, it is possible that this

<sup>3</sup> California Department of Water Resources 1964h.

<sup>4</sup> California Department of Water Resources 1966, 1974; Zone 7 files.

zone can be further subdivided into more laterally extensive, distinct hydrostratigraphic units. Currently the Zone 7 groundwater model groups the entire lower aquifer zone into Layer 3, with the aquiclude/aquitard zone as Layer 2.

### 3.1.4 Main Basin

The groundwater basin has been divided into two major parts based on importance. For the past 20 years the term *Main Basin* has been used for that portion of the groundwater basin covering the 17,000 acres that contain the highest-yielding aquifers and best quality water within the Livermore-Amador Groundwater Basin. The less important area is called the fringe basin. The Main Basin is located in the central and southwestern portion of the groundwater basin. This area has a much larger capacity than the surrounding areas to store and convey groundwater, particularly in the lower zone. Since the early 1900s, this area has been very significant for the local groundwater supply. Prior to 1985, this area was called the central basin. Since 1985, the central basin, except for the eastern portion of Livermore, has been referred to as the Main Basin (see Figure 3-1).

Several subsurface barriers to lateral groundwater movement form the boundaries of the Main Basin. Observations and investigations by Zone 7 and others continue to confirm the existence of these groundwater barriers. Faults are the major structural features known to have marked effects on the movement of groundwater in this region. Faults in this region tend to act as barriers to the lateral movement of groundwater.

The Main Basin is comprised of the Castle, Bernal, Amador and Mocho Sub-Basins and is bounded on the:

- north by the Parks Boundary (which was initially considered to be fault-related, but may actually be a depositional boundary between recent alluvium and older material);
- west by shallow bedrock;
- south by shallow bedrock and the Livermore Uplands; and
- west by the Coastal Ranges and the Calaveras Fault.

Particular Sub-Basin boundaries and features are shown on Figure 3-1 and described in more detail, below.

The portion of the groundwater basin that is outside the Main Basin is called the fringe basin. The majority of the connectivity between the fringe and Main Basins is through the Upper Aquifer Zone. Subsurface inflow from the Lower Aquifer Zone is considered negligible.

## 3.1.5 Main Basin Sub-Basins

### 3.1.5.1 Castle Sub-Basin

The Castle sub-basin is a thin strip that extends along the southwestern portion of the Main Basin. It is bounded to the south, west, and north by marine sediments of the Coastal Range and to the east by the Calaveras Fault. While usually included in the Main Basin, this sub-basin is not used for municipal groundwater production. Only small production wells are located in this area. Not much is known of this sub-basin as there are not many wells in this area; however, the water appears to occur in both shallow valley fill sediments and the Livermore Formation. The water from the Livermore Formation is of a sodium bicarbonate nature. This sub-basin functions as a westward extension of the Bernal sub-basin.

### 3.1.5.2 Bernal Sub-Basin

The Bernal sub-basin is located in the southwestern portion of the groundwater basin and is bounded to the west by branches of the Calaveras Fault, to the east by the Pleasanton Fault, to the north by the Parks Boundary, and to the south in part by contact with non-water-bearing formations and partly by contact with the Verona Fault. Both unconfined and confined aquifers exist in the water-bearing sediments. Waters from the northern and central portions of this sub-basin are of fair to excellent quality. However, much of the upper aquifer water has high TDS exceeding 600 mg/l. The water from the northern and southern portions of the sub-basin are of sodium bicarbonate nature, while the central portion is of the magnesium bicarbonate type and the western and south-central portions are of calcium bicarbonate character.

The area overlying the Bernal sub-basin is the point of convergence for all major streams that drain the Livermore Valley. The area overlying the sub-basin is subsequently drained by the Arroyo de la Laguna. Like surface water, groundwater also historically converges in this sub-basin, which allows for the mixing of the dominant cations of sodium, magnesium, and calcium.

The Quaternary alluvium is estimated to have a thickness of at least 800 feet in this sub-basin and overlies the Livermore Formation. Well production (primarily by Zone 7 and the City of Pleasanton) in this sub-basin ranges up to 3,500 gallons per minute (gpm), and specific capacities range from 3 to 260 gpm per foot of drawdown. Historically, this Sub-Basin was overdrafted but has since been partially refilled and is used less for regional supply due to Zone 7's groundwater management efforts, including the importation of surface water from the SWP.

### 3.1.5.3 Amador Sub-Basin

The Amador sub-basin is located in the west central portion of the groundwater basin and is bounded to the west by the Pleasanton Fault, to the east by the Livermore Fault, to the north by a permeability barrier of inter-fingering of alluvial deposits and partly by the Parks Boundary, and to the south by the drainage divide and partly by contact with non-water-bearing formations. This sub-basin is host to the majority of high production wells and has both unconfined and confined aquifers. Waters from this sub-basin are of good to excellent quality, characterized by sodium bicarbonate, magnesium bicarbonate, and calcium bicarbonate with few instances of elevated levels of boron and nitrate.

This sub-basin of Quaternary alluvium has a maximum thickness of approximately 800 feet and overlies the Livermore Formation, which may be up to 4,000 feet thick. Well production (primarily by Zone 7 and the City of Pleasanton) in this sub-basin ranges from 42 to 2,820 gpm and specific capacities of 1.1 to 217 gpm per foot of drawdown.

### 3.1.5.4 Mocho Sub-Basin

The Mocho sub-basin has been divided into two distinct areas, Mocho I and Mocho II, by a line of very low hills thought to be exposures of the Livermore Formation. The basins are further distinguished by a change in aquifer characteristics from a sodium bicarbonate (Mocho I) to a magnesium bicarbonate water type (Mocho II).

Of the entire Mocho sub-basin, only a portion of the Mocho II sub-basin is in the Main Basin. This portion of the Mocho II sub-basin is located in the east central portion of the groundwater basin and is bounded to the west by the Livermore Fault, to the east by thinning young alluvium and exposed Livermore Formation, to the north by the Tassajara Formation that is not hydraulically connected to the sub-basin and the Parks Boundary, and to the south by the Livermore Uplands and contact with non-water-bearing marine formations.

Both unconfined and confined aquifers exist in the water-bearing sediments. Waters from this sub-basin are of fair to excellent quality sodium bicarbonate (Mocho I) and magnesium bicarbonate character (Mocho II), with some instances of elevated boron and sodium ions.

The recent alluvium ranges in thickness from approximately 10–50 feet in Mocho I and up to 150 feet in Mocho II. In both sub-basins the alluvium overlies the Livermore Formation, both conformably and unconformably. The silty/clayey overburden is mostly missing. The Upper Aquifer is exposed at the surface in much of the area. Mocho I and Mocho II appear to be hydraulically connected only in the shallow alluvial deposits. Well production in this sub-basin (primarily by CWS) ranges up to 950 gpm with specific capacities of 2 to 50 gpm per foot of drawdown.

## 3.2 Groundwater Levels and Storage

Historically, much of the Main Basin experienced artesian conditions. In the late 1800s, the pre-development groundwater levels in the basin created a gradient, causing groundwater to flow from east to west and naturally exit the basin as surface flow in the Arroyo de la Laguna. In the early and mid-1900s, groundwater began to be extracted in appreciable quantities, causing groundwater levels to drop throughout the basin. As a result, groundwater levels dropped below the point where groundwater would naturally rise into Arroyo de la Laguna and exit the basin via streamflow.<sup>5</sup> Water levels continued to drop in the Main Basin through the 1960s. The trend began to reverse when Zone 7 Water Agency began importing water from the SWP as well as capturing and storing local runoff in Lake Del Valle. The first imports were stored in an off-stream recharge facility called Las Positas Pit. This facility was operated from 1962 until the late 1970s.

Thus, after experiencing historical groundwater lows in the 1960s (see Figure 3-2), Main Basin water levels stabilized in the late 1960s and started to rise in the early 1970s with the advent of regional groundwater management programs. Groundwater levels approached the “historic low” again during the 1977 and 1987–1992 droughts.

Today groundwater in both aquifer zones generally follows a westerly flow pattern, like the surface water streams, along the structural central axis of the valley toward municipal pumping centers. The majority of subsurface inflow, however, occurs across the northern boundaries of the Main Basin—in particular the Dublin and western Camp sub-basins—and flows in a southerly direction.<sup>6</sup> These sources of groundwater commingle in the Bernal and Amador sub-basins and have a general flow toward municipal or gravel mining company groundwater pumping wells or pits.<sup>7</sup>

The relatively low hydraulic conductivity of the aquitard layers impedes the vertical movement of groundwater between the Upper and Lower Aquifer Zones. The exchange between the two aquifers, as indicated by the groundwater monitoring data, varies depending upon the thickness and permeability of the separating aquitard and the potential gradient. Even though the movement of water and salts from the upper aquifer to the lower aquifer is slow, it is still the major sources of recharge to the lower aquifer.<sup>8</sup>

The Main Basin has a storage capacity of more than 250,000 acre-feet. The Main Basin was full in early 1900 and full again in 1983. Groundwater has been withdrawn down to historical low storage in 1962 and 1966 with an estimated remaining storage of 128,000 acre-feet. (Groundwater levels approached the “historic low” in some parts of the basin during the droughts of 1977 and 1987–1992.) In 1987, Zone 7 adopted a Groundwater Management Policy (see

<sup>5</sup> Zone 7 2004b.

<sup>6</sup> Zone 7 2004b.

<sup>7</sup> Zone 7 2004b.

<sup>8</sup> Zone 7 2004b.



Appendix E) that included maintaining groundwater levels high enough to provide emergency reserves adequate for the worst credible drought. For planning purposes, Zone 7 maintains this reserve above historical lows. The remaining half of the groundwater (that portion above historical lows) is actively managed for supply reliability and is used for water supply storage, and recovery during times of drought or emergency.<sup>9</sup> In 2002, as part of the development of Zone 7's Well Master Plan, Zone 7 further defined "historic lows" as a piezometric surface used to manage groundwater levels.

### 3.3 Groundwater Recharge

Management of groundwater recharge involves both quantity and quality aspects. The annual average natural recharge into the groundwater basin is approximately 13,400 af/y. Zone 7 artificially recharges the basin with additional surface water supplies by releasing water into the Arroyo Mocho and Arroyo Valle. The existing artificial recharge capacity ranges from 12,300 af/y to 20,000 af/y. In years when the streams are dry, there is more capacity. Adding artificial recharge essentially doubles the natural yield of the basin.<sup>10</sup> In addition, Zone 7 actively monitors the quality of water at many of the key stream recharge areas to ensure the protection of the quality of both surface and ground water.

Groundwater recharge from streams has the following components:

- natural recharge—rain runoff into streams,
- artificial recharge—releases from the SBA or Lake Del Valle into recharge streams, and
- gravel mining recharge—recharge from gravel mining pits or discharges into the streams.

Figure 3-3 shows the relative groundwater recharge capacity associated with each major stream in the watershed and the associated water quality (represented as concentration of TDS in mg/l). Note that the dashed lines represent areas of rising groundwater rather than areas of stream recharge. TDS in the local surface water varies significantly throughout the watershed from approximately 350 mg/l TDS to more than 1,000 mg/l. The highest quality surface water recharging the basin occurs through Arroyo Mocho and Arroyo Valle where the TDS is generally less than 500 mg/l. The poorest quality surface water recharging the basin has a TDS of approximately 1,000 mg/l and occurs in Arroyo Las Positas. On average, given 1997 land use conditions, approximately 2,700 af/y of natural recharge occurs via Arroyo Mocho, 1,200 af/y via Arroyo Las Positas, and 2,700 af/y via Arroyo Valle.

The Proposed Chain of Lakes Recharge Project will provide benefits by creating additional surface water storage and recharge capacity. This is a long-term project that involves Zone 7 acquisition of quarry pits dug by local mining

<sup>9</sup> Zone 7 2004b.

<sup>10</sup> Salt Management Plan 2004a.

companies. These former mining pits, as they get turned over to Zone 7, are incorporated into the regional water management programs. During wet weather, potentially low-cost, low-TDS surface water and/or runoff could be purchased/captured and stored/ recharged for future treated or untreated supply. Demineralized recycled water could potentially be stored in the Chain of Lakes area. The first two former mining pits, Lake-H and Lake-I, became available in May 2003. Plans for a diversion structure are still needed. The complete Chain of Lakes (all nine lakes) will not be available until about 2030.

### 3.4 Water Use

Zone 7 monitors water usage to ensure that adequate supply and quality is delivered to all its water retailers. Stored water pumped from the groundwater basin is a critical component of Zone 7's water supply. On average, 25% of the potable water produced is this groundwater supply. A conceptual diagram of the Livermore-Amador Valley water supply and use is included in Figure 3-4. This figure demonstrates how Zone 7's water sources are integrated with other pumping to meet regional water demands.

In addition to Zone 7's groundwater pumping (about 12,000 af/y), groundwater extractions from the basin include:

- dewatering and export of mining water from the gravel pits (~3,000 af/average year);
- municipal pumpage (~9,000 af/y) by retailers;
- private pumpage (Fairgrounds, San Francisco Public Utilities Commission [SFPUC], industrial supply, domestic supply, others, ~1,200 af/y); and
- agricultural pumpage for irrigation (~500 af/y);

### 3.5 Groundwater Quality

In general, groundwater quality throughout most of the Main Basin is suitable for most types of urban and agriculture uses with some minor localized water quality degradation. The primary constituents of concern are high TDS (or hardness), nitrate, boron, and organic compounds.<sup>11</sup> In the western Main Basin, groundwater is a calcium-magnesium-bicarbonate water type and has historically been considered "hard." The rising salinity is associated with several factors (see Salt Balance discussion, below) but is primarily associated with the saline fringe basin shallow groundwater flowing into the basin or flowing into recharging streams; imported water brings additional salts into the basin that are left in the soil as evapotranspiration occurs (subsequent flushing with rain or further irrigation transports salts to the groundwater table). Increased salinity

<sup>11</sup> California Department of Water Resources 2003.

attributable to irrigation in a semiarid region is another major issue (see Salt Balance Section).

Trace amounts of boron are present in the eastern fringe basins (associated with marine formations) and with shallow groundwater in the northern fringe basins. High boron levels and lower yields can limit the use of some fringe basins for extensive agricultural irrigation.<sup>12</sup> Zone 7 monitors all the wells in its groundwater quality monitoring program for boron and submits samples to the Zone 7 laboratory located at the Del Valle Water Treatment Plant.

The northern extent of the Livermore-Amador Valley is dominated by sodium-containing cation water (i.e., where sodium is the predominant cation), while much of the western part of the basin near Pleasanton has a magnesium-sodium cation characteristic (i.e., where both magnesium and sodium are dominant cations). The area along the eastern portion of the basin, beneath the Livermore area, has a magnesium-dominant as the predominant cation.<sup>13</sup> Local impairments include some areas experiencing boron concentrations exceeding 2 mg/l.

Nitrates have also impaired portions of the Main Basin. Nitrate levels between 30 and 65 mg/l have been identified in the nitrate study area, which covers an area of 670 acres of unincorporated residential and agricultural land in the South Livermore area. This issue is discussed in more detail in Section 5.1.4.4, Wastewater Management.

Releases of fuel hydrocarbons from leaking underground storage tanks and spills of organic solvents at industrial sites have caused minor-to-significant groundwater impacts throughout the region. Detailed discussion is presented in Section 5.1.4.5. Zone 7 participated in the development of the GAMA project, which analyzed water from municipal wells for volatile organic compounds (VOCs) at low levels not detectable by standard laboratory analyses. The results showed that very low levels of MTBE and other gasoline components were detected in a handful of wells. There are five fuel contamination sites within 2,000 feet of a municipal supply well that are being closely monitored. Proactive cooperation with regulatory agencies on site cleanup is helping to protect the basin from fuel contamination.

Chlorinated organic solvent releases to soil and groundwater are an issue in the region,<sup>14</sup> primarily in fringe basins and in upper aquifers in the region. Again, detailed description in Section 5.1.4.5. Cleanup programs at LLNL are in place to remediate this large superfund site from a 50-year-old plume associated with World War II activities. Zone 7 assisted LLNL during the initial year of cleanup and has been working cooperatively with them ever since. During the past decade LLNL has been providing valuable assistance to Zone 7 in the monitoring and analysis of groundwater conditions within the basin. The GAMA project and the Geotracker project have been very helpful to groundwater basin understanding and to the groundwater protection effort. The GAMA project

<sup>12</sup> California Department of Water Resources 2003.

<sup>13</sup> California Department of Water Resources 2003.

<sup>14</sup> California Department of Water Resources 2003.

detected tetrachloroethene (PCE), a chlorinated solvent commonly used in dry cleaning, in nine of the 12 municipal wells tested in Livermore. Two of these wells have PCE levels that are detectable with standard laboratory procedures. The water from these two wells is currently either being blended with clean water or treated at the well head to reduce the levels of PCE in the water. One supply well at the Alameda County Fairgrounds in Pleasanton has been impacted by PCE. The water from this well is treated to remove the PCE prior to use.

Zone 7 samples approximately 250 wells in the groundwater quality monitoring program and reviews results from site cleanup projects made available through Geotracker and from cleanup reports routinely sent to Zone 7 for review (additional information on the Toxic Site Program is presented in Chapter 5).