7

Surface Water

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Introduction

Lawrence Livermore National Laboratory monitors surface water at the Livermore site, in surrounding regions of the Livermore Valley, and at Site 300 and vicinity in the nearby Altamont Hills. At the first two locales, LLNL monitors reservoirs and ponds, the Livermore site swimming pool, the Drainage Retention Basin (DRB), treated ground water discharges, rainfall, tap water, and storm water runoff. At Site 300 and vicinity, surface water monitoring encompasses rainfall, cooling tower discharges, and storm water runoff. The water samples are analyzed for radionuclides, high explosives, total organic carbon, total organic halides, total suspended solids, conductivity, pH, chemical oxygen demand, total dissolved solids, oil and grease, metals, minerals, anions, and a wide range of organic compounds. In addition, fish bioassays are performed annually on water entering and leaving the Livermore site via the Arroyo Las Positas pathway, discharges from the DRB, and water contained in the DRB.

Storm Water

Storm water (runoff water) monitoring is driven by the requirements in the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. Department of Energy 1991); DOE Order 5400.1, General Environmental Protection Program; DOE Order 5400.5, Radiation Protection of the Public and the Environment; two National Pollutant Discharge Elimination System (NPDES) permits issued under the authority of the Federal Clean Water Act; and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Record of Decision (ROD).

Storm water comes in contact with a large number of potential pollution sources and has the potential to disperse contaminants across broad areas. To evaluate the overall impact of Livermore site and Site 300 operations on storm water quality, storm water flows are sampled where they leave the site. These samples provide information used to evaluate the effectiveness of LLNL's storm water pollution control program. The NPDES permits for storm water (WDR Order No. 95-174, NPDES Permit No. CA0030023

for the Livermore site, and WDR Order No. 94-131, NPDES Permit No. CA0081396 for Site 300) require that LLNL conduct effluent sampling two times per year and conduct visual inspections of the storm drainage system monthly during the wet season, whenever significant storms occur, and twice during the dry season to identify any dry weather flows. Influent sampling is also required at the Livermore site. LLNL monitors up to two more storm events each year (a total of four sampling events) in support of DOE Orders 5400.1 and 5400.5. In addition, annual facility inspections are required to assure that the necessary management measures, known as best management practices (BMPs), are adequate and implemented. The goals of the storm water monitoring program are to demonstrate compliance with permit requirements, aid in implementing the Storm Water Pollution Prevention plans (SWPPPs) (Eccher 1994a and b), and measure the effectiveness of the BMPs in preventing contamination of storm water discharges.

LLNL first monitored storm water runoff at the Livermore site in 1975. The original monitoring network, designed to detect pesticides, was expanded in 1990 to cover new locations and additional water quality parameters (i.e., radioactivity, metals, and additional organic compounds). Additional changes during 1993 complied with the National Pollutant Discharge Elimination System General Industrial Activities Storm Water Permit (NPDES General Permit). In October 1993, also in response to the NPDES General Permit, LLNL established a storm water monitoring program at Site 300. In 1995, the San Francisco Bay Regional Water Quality Control Board (RWQCB) issued a Waste Discharge Requirements and National Pollutant Discharge Elimination System Permit (NPDES Permit No. CA0030023, WDR 95-174) for the Livermore site, which replaced coverage under the Statewide General NPDES Permit for Storm Water Discharges Associated with Industrial Activities (Order No. 91-13-DWQ). The new permit includes specific monitoring and reporting requirements. The current list of analyses requested for storm water samples is given in **Table 7-1**. Flow patterns at the site are such that storm water at sampling locations includes flow from other sources, such as neighboring agricultural land, parking lots, and landscaped areas. Because of this, and because wide-ranging activities are conducted at the Livermore site, it is necessary to analyze storm water for a wide variety of constituents at the Livermore site. In contrast, storm water at Site 300 is sampled at locations that target specific industrial activities, and a smaller range of analyses is sufficient.

Currently, there are no numerical criteria that limit concentrations of specific constituents in storm water effluent. In the federal multisector storm water permit, the Environmental Protection Agency (EPA) established benchmark values for 41 parameters, but stressed that these concentrations (see **Table 7-2**) were not intended to be interpreted as effluent limitations. Rather, they are levels that the EPA has used

Table 7-1. Requested analyses for storm water samples, 1997.

Livermore site	Site 300
pH	pH
Total suspended solids	Total suspended solids
Specific conductance	Specific conductance
Oil and grease	Total organic carbon
Total organic carbon	Gross alpha and beta
Gross alpha and beta	Tritium
Tritium	Uranium
Plutonium	Total organic halides
Chemical oxygen demand	Explosives
General minerals	
Anions	
Metals	
Herbicides—EPA Method 507	
Glycophosphate—EPA Method 547	
Diuron—EPA Method 632	
Fish bioassay (fathead minnow)	

to determine if storm water discharged from any given facility merits further monitoring. Other water quality criteria developed by California and the federal government were used as comparisons with LLNL storm water analytical results in this report. However, these criteria are defined for other purposes, and are therefore not directly applicable to storm water effluent. Nevertheless, use of a broad range of criteria can help to evaluate LLNL's storm water management program and to allow LLNL to ensure high quality in its storm water effluent.

Storm water sample results for the Livermore site were compared with criteria listed in the *Water Quality Control Plan, San Francisco Bay Basin* (San Francisco Bay RWQCB 1995), and results for Site 300 were compared with criteria listed in *The Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board, Central Valley Region* (Longley et al. 1994). Criteria in the basin plans include surface water quality objectives for the protection of aquatic life and water quality objectives for waters designated for use as domestic or municipal supply or agricultural supply. These criteria include, by reference, California Maximum Contaminant Levels (MCLs) for drinking water. In addition, results were compared with EPA MCLs and ambient water quality criteria (AWQC), as well as California AWQC. Criteria not specifically listed in the basin plans were obtained from *A Compilation of Water Quality Goals* (Marshack 1995). Criteria are summarized in **Table 7-2**.

Table 7-2. Storm water comparison criteria for constituents of concern at the Livermore site.

Constituent	MCL	AWQC	Benchmark
Radioactive (Bq/L)			
Tritium	740 (EPA)	none	none
Gross alpha	0.56 (EPA)	none	none
Gross beta	1.85 (EPA)	none	none
Elements (mg/L)			
Aluminum	1.0 (CA)	0.75	0.75
Antimony	0.006 (EPA)	0.088	0.636
Barium	1.0 (EPA)	none	none
Beryllium	0.004 (EPA)	none	0.13
Boron	none	none	none
Cadmium	0.005 (EPA)	0.0016[a]	0.0159[b]
Calcium	none	none	none
Chromium, total	0.05 (CA)	none	none
Chromium(VI)	none	0.015	none
Copper	1.3/1.0 (EPA[c])	0.026[a]	0.0636[b]
	0.5 (SF[d] Ag[e])		
Iron	0.3 (EPA)	none	1.0
Lead	0.15 (EPA)	0.11[a]	0.0816[b]
Manganese	0.5 (EPA)	none	1.0
Mercury	0.002 (EPA)	0.0024	0.0024
Molybdenum	0.05 (SF[d] Ag[e])	none	none
Nickel	0.1 (EPA)	2.111[a]	1.417[b]
Potassium	none	none	none
Selenium	0.05 (EPA)	0.02	0.2385
Silver	0.01 (EPA)	0.0091[a]	0.0318[b]
Sodium	none	none	none
Thallium	0.002 (EPA)	none	none
Vanadium	0.1 (SF[d] Ag[e])	none	none
Zinc	5 (EPA)	0.17[a]	0.117[b]
Miscellaneous (mg/L)			
Bicarbonate alkalinity (as Ca CO_3)	none	none	none
Biochemical oxygen demand (BOD)	none	none	30
Bromide	none	none	none
Carbonate alkalinity (as Ca CO_3)	none	none	none
Chemical oxygen demand	none	none	120

Table 7-2. Storm water comparison criteria for constituents of concern at the Livermore site (concluded).

Constituent	MCL	AWQC	Benchmark
Miscellaneous (mg/L)			
Chloride	250 (EPA)	860	860
Fluoride	1.4 (CA)	none	1.8
	0.8 (SF)		
Nitrate (as NO_3)	45 (EPA)	none	3.01
Nitrate (as N)	10 (EPA)	none	0.68
Nitrate plus nitrite (as NO_3)	45 (EPA)	none	3.01
Nitrate plus nitrite (as N)	10 (EPA)	none	0.68
Nitrite (as N)	1.0 (EPA)	none	0.68
Oil and grease	none	none	15
pH (pH units)	<6.5, >8.5 (EPA)	<6.5, >9.0	<6.5, >9.0
Specific conductance (µmho/cm)	900 (CA)	none	none
Sulfate	250 (EPA)	none	none
Total alkalinity (as $CaCO_3$)	none (EPA)	<20	none
Total dissolved solids (TDS)	500 (CA)	none	none
Total hardness (as Ca CO_3)	none	none	none
Total organic carbon	none	none	2.0
Total suspended solids (TSS)	none	none	100
Organics (µg/L)			
2,4-D	0.07 (EPA)	none	none
2,4,5-T	none	none	none
Acetone	none	none	none
Benzene	1.0 (CA)	none	10
Benzo[*a*] pyrene	0.2 (EPA)	none	none
Bis(2-ethylhexyl)phthalate	4 (EPA)	400	none
Bromacil	none	none	none
Butylbenzylphthalate	none	none	none
Chloroform	100 (EPA)	none	none
Chloromethane	none	none	none
Diazinon	none	0.009	none
Simazine	4 (EPA)	none	none

[a] Hardness dependent; based on receiving water hardness of 160 mg/L.

[b] Hardness dependent benchmark at assumed 100 mg/L $CaCO_3$.

[c] 1.3 is U.S. primary maximum contaminant level (PMCL), not to be exceeded in more than 10% of samples; 1.0 is U.S./CA secondary maximum contaminant level (SMCL).

[d] SF = San Francisco Bay Basin Plan.

[e] Ag = Criteria for agricultural use.

Each LLNL directorate inspected its facilities to verify that the best management practices (BMPs) identified in LLNL's Storm Water Pollution Prevention plans (SWPPPs) were in place, properly implemented, and adequate. LLNL implements BMPs at construction sites and at facilities that use significant materials (as defined by the storm water regulations) to prevent storm water from being contaminated. LLNL submits annual storm water monitoring reports to the San Francisco Bay RWQCB and to the Central Valley RWQCB, reporting the results of sampling, observations, and inspections. Inspections noted a leaking low-conductivity water valve, which was shut off to stop the leak. An oil stain was found near a vacuum pump and cleaned up. Additionally, service vehicles were parking over a storm drain near Building 153. To correct this, striping was added to the area around the storm drain to make it a no parking zone. No other findings or deficiencies at the Livermore site or Site 300 were noted in the annual site inspections.

LLNL also meets the storm water compliance monitoring requirements of the General Construction Activity Storm Water Permit for construction projects disturbing two hectares of land or more. Monitoring for these construction projects included visual observations of sites before and after storms to assess the effectiveness of implemented BMPs. Annual compliance certifications summarize these inspections. The 1997 compliance certifications covered the period of June 1996 through May 1997. During this period, four Livermore site projects were inspected: Building 132 (the new Nonproliferation, Arms Control & International Security building); the Decontamination and Waste Treatment Facility (DWTF); the National Ignition Facility (NIF); and the areas associated with the Soil Reuse Project. One Site 300 project, the Contained Firing Facility (CFF), had obtained permit coverage, but construction had not started. Therefore, no inspections were performed.

As they did in 1996, the San Francisco Bay RWQCB requested submission of compliance status reports for the four Livermore site projects. Since the inception of the General Construction Activity Storm Water Permit, the Central Valley RWQCB has not requested these reports for projects located at Site 300.

The compliance certification for the CFF project noted that no construction had occurred. No compliance issues were noted in the annual compliance certifications for the NIF, Soil Reuse, or DWTF projects. Four compliance issues were noted in the compliance certification of the Building 132 construction:

- A lapse in the inspection program during an interior subcontract package.
- Materials inappropriately left on the construction site, resulting in a spill.
- Commencement of work on a subcontract package prior to the submission and certification of an SWPPP.
- Late preparation of the annual certification.

Building 132 was constructed under eight different subcontractor packages. After the completion of Package Five (an external construction package), internal work (such as the installation of boilers and cabinets) occurred. No materials were stored outdoors. A small area of the site (approximately 0.5 hectare) remained unstabilized. During this period the construction staff was reduced to a minimal level, and storm water inspections were not performed. LLNL will reexamine its construction storm water program and implement procedures to prevent a recurrence of this lapse in the inspection program when there are no subcontractors on the job site. Runoff from this construction site flows into the LLNL Livermore site storm water drainage system and no abnormal discharges were noted in the industrial storm water monitoring program during this period.

On April 15, 1997, LLNL discovered four containers left on the Building 132 construction site. Three of the containers may have been left behind by the subcontractor. Two of the containers were open, filled with rainwater, and had overflowed, depositing an oily water mixture onto the ground. LLNL estimated that approximately 1 L of oily water was released, affecting an area of soil approximately 1.5 m^2. LLNL excavated the affected soil and collected samples to verify the cleanup. Contaminated soil and the drums were disposed of as hazardous waste.

Package Eight, the final exterior construction package, began in May 1997 prior to the subcontractor submitting an SWPPP. This was due to the notice to proceed being issued in advance of the SWPPP submittal. LLNL plans to augment its procurement process to prevent the start of construction prior to submittal and certification of the SWPPP. On June 9, the subcontractor submitted a revision to the project SWPPP that was certified on June 24, 1996; however the subcontractor implemented BMPs and performed inspections from the beginning of construction package in May.

Due to difficulties in obtaining the inspection records from the Package Five subcontractor, the compliance certification was prepared late.

Livermore Site

The natural drainage at the LLNL Livermore site was altered by construction activities several times up to 1966 (Thorpe et al. 1990) so that the current northwest flow of Arroyo Seco and the westward flow of Arroyo Las Positas do not represent historical flow paths. About 1.6 km to the west of the Livermore site, Arroyo Seco merges with Arroyo Las Positas, which continues to the west to eventually merge with Arroyo Mocho (see **Figure 7-1**). An abandoned stream channel is visible on air-photo

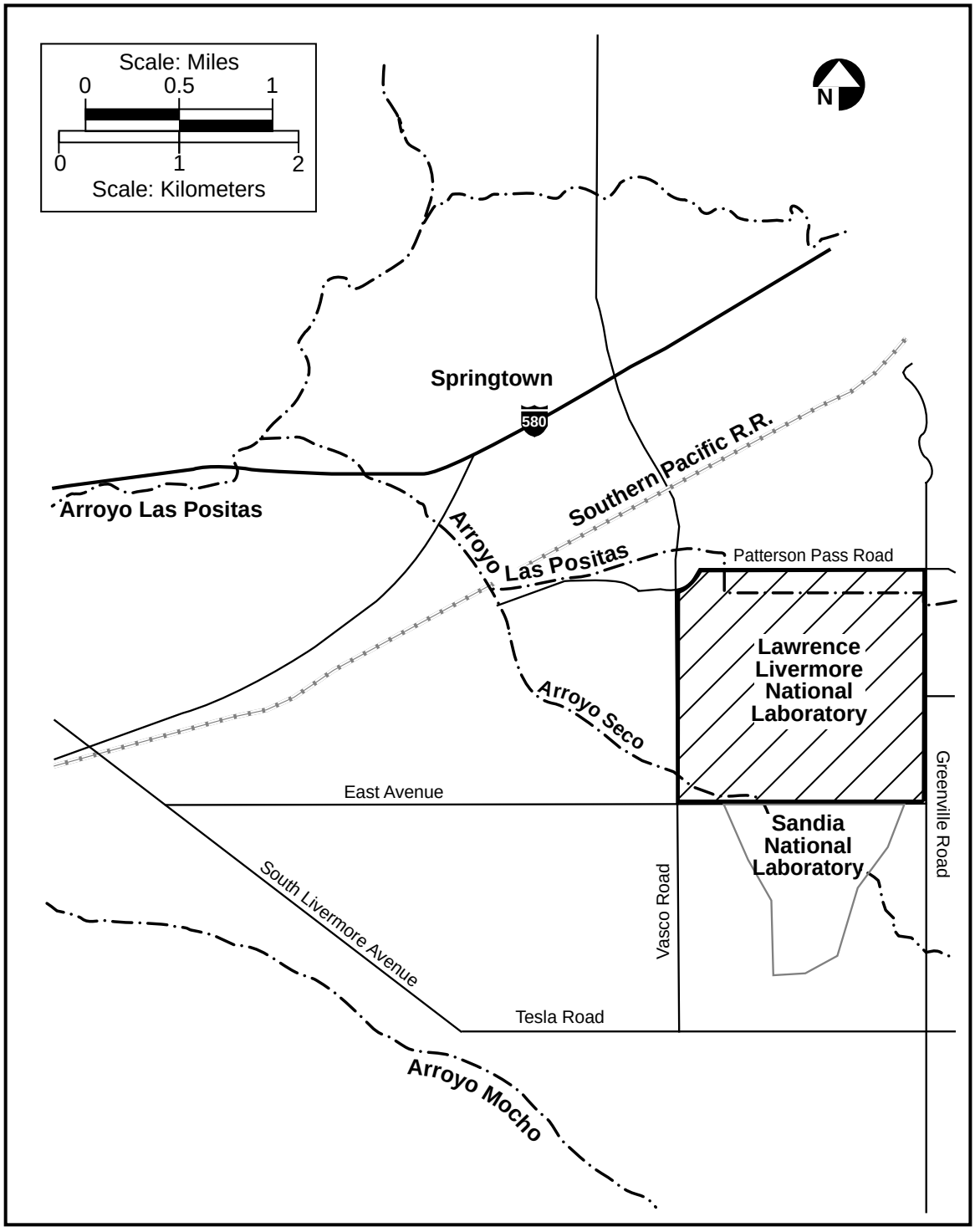

Figure 7-1. Surface water flow in the vicinity of LLNL.

maps of the site east of the present alignment of Arroyo Seco (Carpenter et al. 1984). A Drainage Retention Basin (DRB) was excavated and constructed for storm water diversion and flood control. It collects about one-fourth of the surface water runoff from the site and a portion of the Arroyo Las Positas drainage (**Figure 7-2**). This basin was lined to prevent infiltration.

The DRB discharges north to a culvert that leads to Arroyo Las Positas. The remainder of the site drains either directly or indirectly into the two arroyos by way of storm sewers and ditches. Arroyo Seco cuts across the southwestern corner of the site. Arroyo Las Positas, diverted from its natural course, follows the northeastern and northern boundaries of the site and exits the site near the northwest corner.

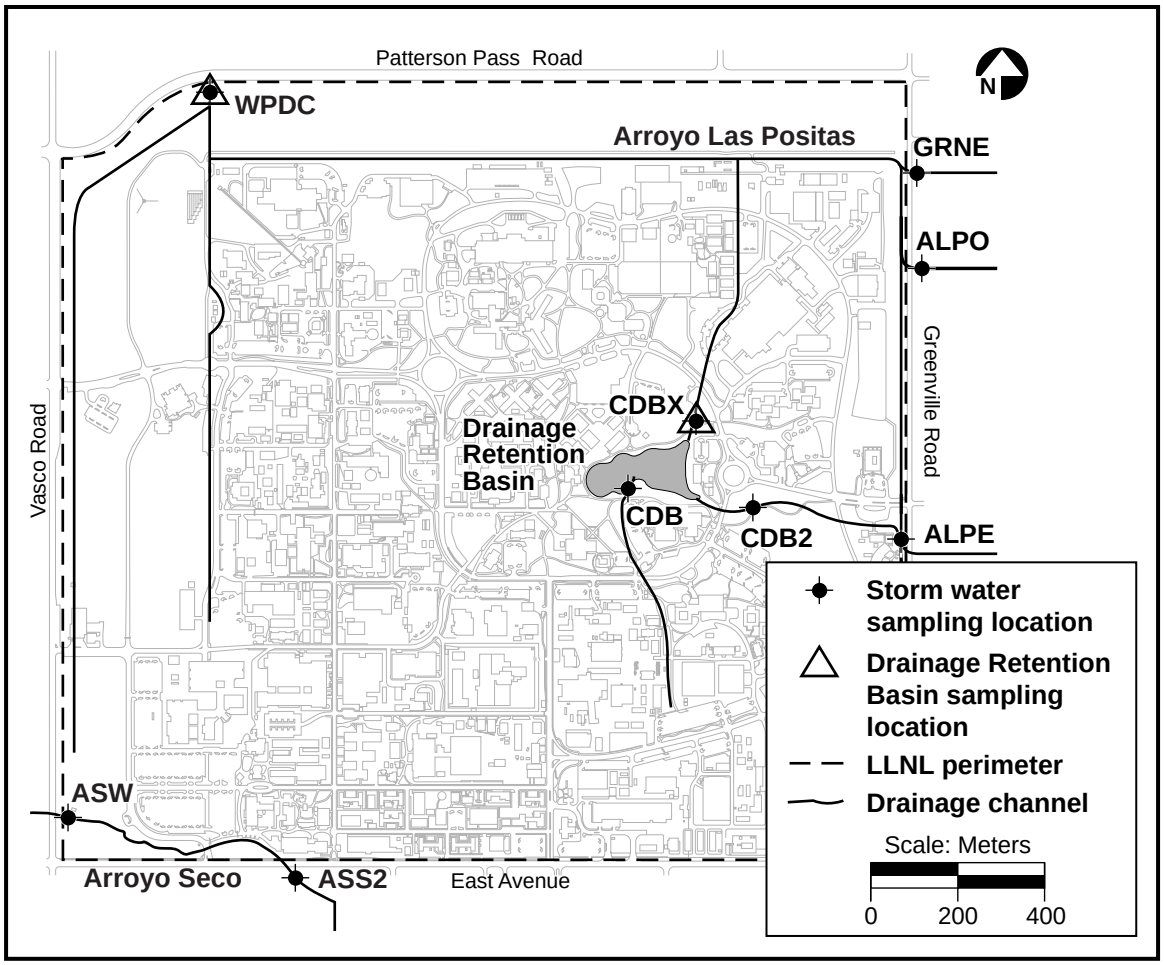

Figure 7-2. Storm water runoff and Drainage Retention Basin (DRB) discharge sampling locations, Livermore site and vicinity, 1997.

Although before 1995 Arroyo Seco and Arroyo Las Positas only flowed when it rained, dry weather observations at the Livermore site noted that water flowed in Arroyo Las Positas throughout 1996 and 1997. This water originated from two sources: natural flow of water from off site that entered LLNL property at the ALPO influent location (**Figure 7-2**), and permitted discharges from on-site ground water treatment facilities.

The Livermore site storm water runoff sampling network consists of nine locations (**Figure 7-2**). Six locations characterize storm water either entering (influent: ALPE, ALPO, GRNE, and ASS2) or exiting (effluent: WPDC and ASW) the Livermore site. Locations CDB and CDB2 characterize runoff from the southeastern quadrant of the Livermore site entering the DRB, and location CDBX characterizes water leaving the DRB. LLNL collected storm water samples at all Livermore site locations on January 15, November 15, and December 8, 1997.

Toxicity Testing. In addition to chemical-specific monitoring, LLNL is required by NPDES permit (WDR 95-174, NPDES Permit No. CA0030023) to conduct acute and chronic fish toxicity testing once per "wet season" (defined as October of one year through April of the following year). In the acute toxicity test, 96-hour survival of fathead minnows (*Pimephales promelas*) in undiluted storm water collected from effluent location WPDC was observed. The San Francisco Bay RWQCB has set a criterion of 20% survival compared with the control as an acceptable level. The testing laboratory provides water to use in the control sample. In addition, in agreement with Regional Board guidance, storm water from influent locations ALPO, ALPE, and GRNE are used as added controls. Thus, a difference of more than 20% between location WPDC and the control sample with the lowest survival is considered a failed test. For example, if survival in the laboratory control is 95%, and survival in water from ALPO, ALPE, and GRNE is 80%, 75%, and 85%, respectively, then survival of less than 55% in WPDC water would be a failed test. If the test is failed, LLNL is required to sample the next runoff event. If two consecutive tests are failed, LLNL is required to perform a toxicity reduction evaluation to identify the source of the toxicity.

In this year's acute toxicity test (based on the December 8, 1997, sample), 100% of the minnows survived in the WPDC, ALPO, ALPE, and GRNE waters. In addition, a sample for the acute bioassay from location ASS2, LLNL's influent in the Arroyo Seco pathway, was submitted. Although testing at this location was not required, the results were included for the sake of completeness. Survival in ASS2 water was 90%.

In the chronic test, various dilutions of storm water ranging from 0% storm water (lab control) to 100% (undiluted) storm water are used to determine a dose-response relationship, if any, for both survival and growth of the fathead minnow. No criteria were set by the San Francisco Bay RWQCB for this test; it was performed for

information purposes only. Also, because this test was only required at effluent location WDPC, and not conducted with water from corresponding influent locations, there was no way to determine if an effect should be attributed to LLNL or to upstream water quality.

Two samples were collected for chronic toxicity testing in 1997, one on May 23 to fulfill the requirement for the 1996/1997 wet season, and one on December 23 for the 1997/1998 wet season. The samples were collected at location WPDC, the only location where this test was required. Our standard procedure is to use water from the same storm event for both the fish toxicity test and the chemical analyses so that if toxicity is noted, the chemical analyses can aid in identifying the source of the toxicity. However, the chronic fish toxicity test in the spring was not done concurrently with chemical analyses because the testing laboratory was running at capacity and therefore was not able to schedule the test. It was not until the May 23, 1997, storm that LLNL was able to run the chronic toxicity test. (The acute fish toxicity test for the 1996/1997 wet season was conducted in October of 1996.)

For each concentration, four replicates were used, with 10 fish per replicate. Data are summarized in **Table 7-3**. For survival, a 50% no observed effect concentration (NOEC) and 100% lowest observed effect concentration (LOEC) were calculated according to EPA/600/4-91-002. For growth, the EPA calculation returned a value of >50% for both the NOEC and LOEC. The reason for this result seems to be that the dose-response is extremely flat up to and including the 50% dilution. (There is only a 0.03 mg difference between the control and the lowest survival group.) Yet there is a much larger difference (0.2 mg) between the control and the 100% storm water. Therefore, the dose-response curve could not be accurately defined. The results can be interpreted, however, as an NOEC of 50% or more (that is, there is no observed effect at 50%, but the NOEC may be higher) and an LOEC of 100% or less (that is, there is an observed effect at 100%, but the LOEC may be lower). Since no dilutions between 50% and 100% were conducted, further refinement is not possible. Thus, LLNL storm water had an effect on growth at dilutions between 50% and 100%.

For the 1997/1998 wet season, the chronic toxicity test was conducted concurrently with other samples on December 23, 1997. Results are also presented in **Table 7-3**. For this sample, both the NOEC and LOEC for both survival and growth were 100%, indicating that storm water had no effect on survival or growth of the fathead minnow.

Table 7-3. Chronic fish toxicity test results.

Sample concentration (%)	7-day survival		7-day weight	
	Average (%)	Standard deviation	Average (mg)	Standard deviation
5/23/97 (1996/1997 wet season)				
Lab control	100	0	0.72	0.057
5	90	14.1	0.79	0.065
10	98	5.0	0.71	0.074
25	98	5.0	0.71	0.098
50	83	12.6	0.69	0.089
100	83	5.0	0.52	0.047
12/23/97 (1997/1998 wet season)				
Lab control	95	10.0	0.69	0.128
6.25	88	18.9	0.67	0.158
12.5	95	5.8	0.73	0.059
25	98	5.0	0.66	0.074
50	80	28.3	0.57	0.278
100	93	15.0	0.62	0.182

Radioactive Constituents. Storm water tritium, gross alpha, and gross beta results are summarized in **Table 7-4**. Median activities were 10% or less than the respective MCLs. **Figures 7-3** and **7-4** show the historical trend in storm water gross alpha and gross beta, respectively. In these and other storm water historical trend figures in this chapter, all available data for the influent and effluent locations of the two runoff pathways through the Livermore site have been aggregated. Also, data have been aggregated on a wet season basis—that is, October of one year through May of the next—rather than on a calendar year basis. Thus, data on storm plots labeled 96/97 represent October 1996 through May 1997, and data labeled 97 represent October through December 1997. The

Table 7-4. Radioactivity (in Bq/L) in storm water runoff, Livermore site, 1997.

	Tritium	Gross alpha	Gross beta
Median	1.91	0.049	0.191
Minimum	1.24	0.004	0.019
Maximum	358.53	0.154	0.611
Interquartile range	8.34	0.056	0.165
MCL	740	0.555	1.85

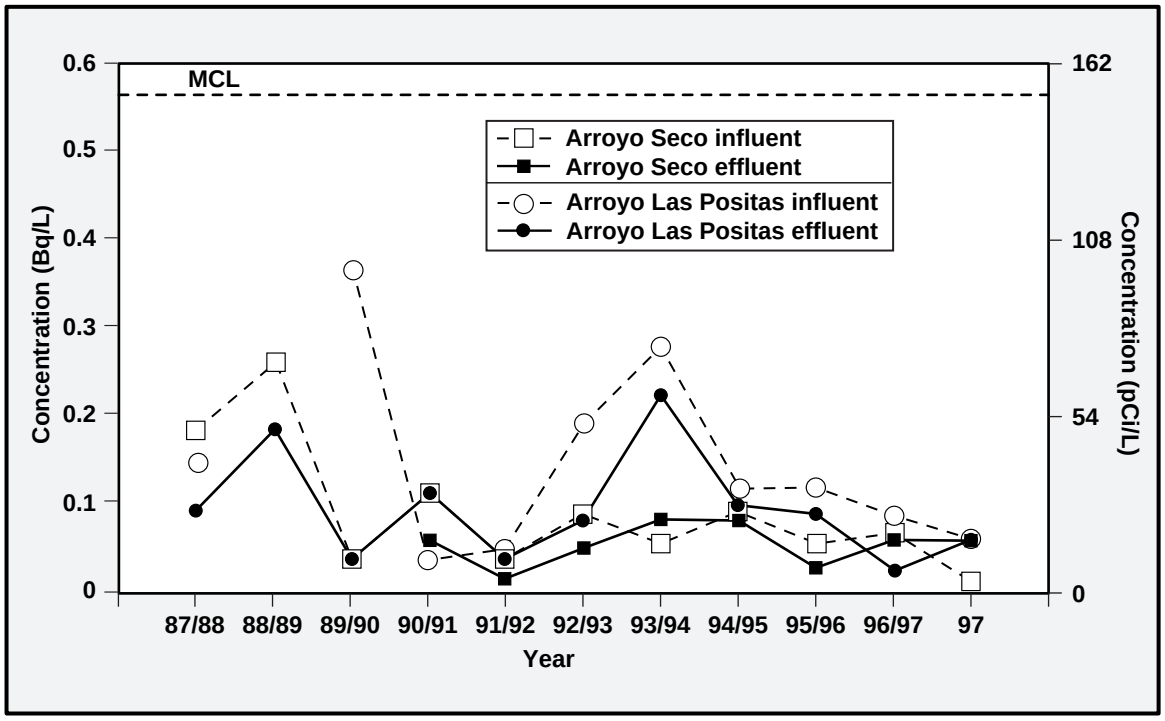

Figure 7-3. Annual median gross alpha in LLNL storm water compared with the maximum contaminant level (MCL).

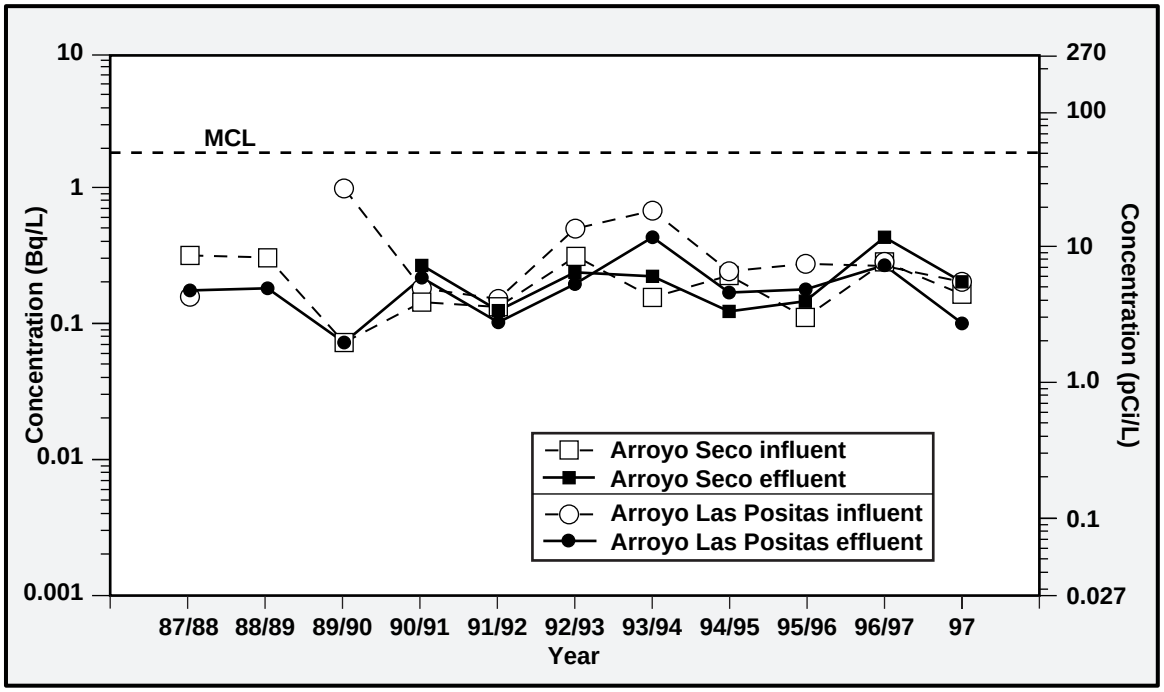

Figure 7-4. Annual median gross beta in LLNL storm water compared with the maximum contaminant level (MCL).

1997 points represent a partial wet season, pending collection of 1998 data, and are based on only one or two sampling events for each location. Finally, plots include all available storm water influent and effluent data for each constituent. The gross alpha and gross beta data show no discernible pattern.

On May 23 at location WPDC, there was a single, higher than typical result for tritium in storm water, 359 Becquerels per liter (Bq/L). The next highest tritium result in storm water was 21.13 Bq/L. The May 23 sampling was a nonroutine sample collection, because the storm occurred outside of the wet season (October 1 of one year through April 30 of the next), as defined by the State Water Resources Control Board. Therefore, influent samples and rain samples were not collected. In response to this single high storm water tritium result, on-site rain monitoring frequency was increased, but no further indication of a tritium source was found. (The highest rainfall tritium level was 65 Bq/L.) In addition, subsequent storm water samples had tritium levels in the low range typically seen in the past several years. Furthermore, although 359 Bq/L is a higher level than that generally seen in LLNL storm water, it is still less than 50% of the MCL for tritium (740 Bq/L).

The historical trend in tritium levels (**Figure 7-5**), which correlates with decreased emissions (see Chapter 5), indicates generally decreasing tritium levels in storm water from a peak in the 1988/1989 season. An exception to the trend is Arroyo Las Positas effluent for the 1996/1997 season and for the fall of 1997. This seems to indicate that the tritium concentration is higher when storm water leaves the site than when it enters the site. However, because "grab sampling" is used, it is not possible to be certain. In grab sampling, a technician is dispatched to the sampling location and manually collects a sample from the flow. The sample therefore represents only a particular point in time during the storm and is generally not representative of the entire flow. More sophisticated, automated methods exist which are capable of sampling during the entire storm event. In addition, the upstream sample and the downstream sample generally do not represent the same portion of the storm. For example, if tritium concentrations fluctuate during the storm event, it would be quite possible to collect an influent sample at a point in the flow during which the concentration is low, and the effluent sample at a point in the flow during which the concentration is high. Nevertheless, additional tritium investigations will be designed for the 1998/1999 rainy season, in order to confirm or contradict the current evidence that effluent tritium concentration is greater than influent tritium concentration, and to identify sources for the higher tritium concentrations, if they are confirmed. These investigations may include:

- Review of site operations to identify potential tritium sources.
- Review of air tritium sampling results.

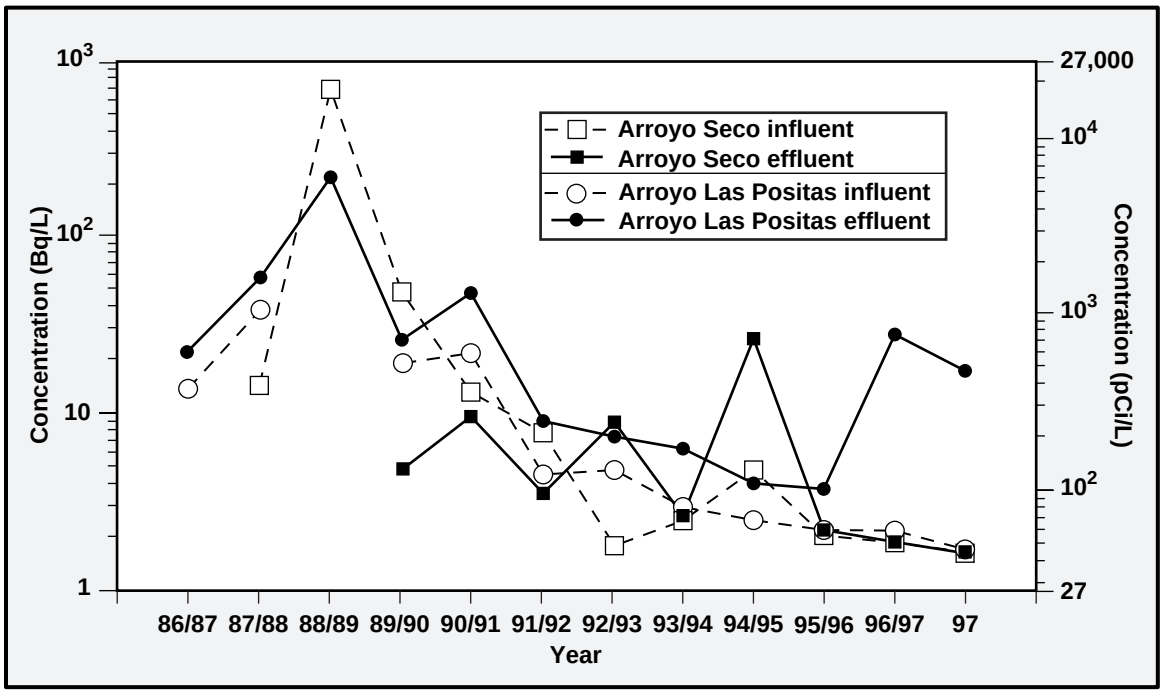

Figure 7-5. Annual median tritium concentrations in LLNL storm water.

- Increased frequency and number of locations of rain sampling.
- Increased frequency and number of locations of storm water sampling.
- Evaluation of tritium concentrations in approved discharges to surface (for example, treated ground water).

Metals Source Identification. Table 7-5 lists nonradioactive constituents found above comparison criteria in Livermore site storm water. (Complete storm water results are presented in Tables 7-2 through 7-4 of the Data Supplement.) Of greatest concern are constituents that exceeded comparison criteria at effluent points, but for which the influent concentrations were less than the corresponding effluent concentrations. The metals identified were aluminum, chromium, copper, iron, lead, manganese, nickel, and zinc. If influent concentrations were greater than effluent concentrations, the source was assumed to be unrelated to LLNL operations, so further analysis was not warranted. Previous historical trend plots indicated that concentrations of some of these constituents were increasing over time. However, further review of the data indicated that the apparent increases were possibly due to a shift from analyses that only recovered dissolved metals, to analyses that recovered the total metal concentrations (dissolved plus suspended) in the water. Due to ambiguities in past laboratory practices, it is difficult to determine explicitly which type of analysis (dissolved or total)

Table 7-5. Nonradioactive constituents above comparison criteria (see **Table 7-2**) in storm water runoff, Livermore site, 1997.

Parameter	Storm date	Dissolved or total	ALPE	ALPO	ASS2	ASW	CDB	CDB2	CDBX	GRNE	WPDC
Metals (mg/L)											
Aluminum	1/15	Dissolved				0.78					
		Total							3.7		3.8
		Total							4		3.8
	11/15	Total	14	5.9	5.3	60	6.3	14		70	15
		Total	9.9	0.76	1.4	6.5	1.7	2.4		7.4	2.6
	12/8	Total	3	7.3	2.3	8.1	3	5.6	1.1	5.2	7.3
		Total	2.8	7	1.2	4.8	2.1	5.1	1.5	6.1	5.2
Chromium	11/15	Total	0.024		0.017	0.11	0.016	0.032		0.1	0.021
	12/8	Total				0.018				0.017	0.016
Copper	11/15	Total	0.029			0.12		0.031		0.059	
		Total								0.059	0.029
Iron	1/15	Dissolved	0.46					0.39	0.41		
		Total							3.2		3.2
		Dissolved	0.57	0.37	0.42	0.62		0.39	0.36		0.35
		Total							3.3		3.2
	11/15	Total	11	5.2	5.9	63	5.8	13		62	15
		Total	9.6	1	1.6	5.6	1.8	2.3		5.4	2.7
	12/8	Total	2.6	6.7	2.3	10	3	5.2	1.3	5.1	7.9
		Total	2.4	6.3	1.3	6.6	2.5	5.0	1.7	6.3	5.9
Lead	11/15	Dissolved									
		Total				0.064				0.026	
Manganese	11/15	Total				1.3					
		Total				1				0.84	0.27
Nickel	11/15	Total				0.13				0.11	
		Total								0.113	
Vanadium	11/15	Total		0.13							
Zinc	11/15	Total			0.14	0.46	0.18	0.17		0.34	0.35
		Total			0.13	0.47	0.18	0.15		0.25	0.24
	12/8	Total				0.15	0.17				0.17
		Total				0.22	0.17				0.24

Table 7-5. Nonradioactive constituents above comparison criteria (see **Table 7-2**) in storm water runoff, Livermore site, 1997 (continued).

Parameter	Storm date	Dissolved or total	ALPE	ALPO	ASS2	ASW	CDB	CDB2	CDBX	GRNE	WPDC
Miscellaneous (mg/L)											
Chemical oxygen demand	1/15	Total				122					
	12/8	Total	128								
Chloride	12/8	Total	700					282			
	12/8	Total	700					312			
Fluoride	1/15	Total		0.88							
	12/8	Total	1								
	1/15	Total		0.89							
	12/8	Total	1								
Nitrate (as N)	1/15	Total		2.6	3.5	3.5				3	1.2
		Total									1.2
	11/15	Total	1.2		1.1		0.79	0.77		4.9	
	12/8	Total		2.1	0.74	0.8	0.77	0.68	0.74	8.9	1.3
	1/15	Total	0.2	2.6	3.4	3.5	0.5	0.2	0.6	2.4	1.2
	11/15	Total	1	0.79	1	0.39	0.7	0.77		4.9	0.53
	12/8	Total		2			0.77		0.74	8.6	1.3
Nitrate (as NO_3)	1/15	Total		11.5	15.5	15.5				13.3	5.3
		Total									5.3
	11/15	Total	5.3	3.7	4.9		3.5	3.4		22	
	12/8	Total		9.3	3.3	3.5	3.4		3.3	39	5.8
	1/15	Total		11.5	15.1	15.5				10.6	5.3
	11/15	Total	4.4	3.5	4.4		3.1	3.4		22	
	12/8	Total		8.9			3.4		3.3	38	5.8
Sulfate	12/8	Total	580				254				
Total alkalinity (as $CaCO_3$)	1/15	Total					11.4				
	11/15	Total			14	14	12	19			
	12/8					15					

Table 7-5. Nonradioactive constituents above comparison criteria (see **Table 7-2**) in storm water runoff, Livermore site, 1997 (concluded).

Parameter	Storm date	Dissolved or total	ALPE	ALPO	ASS2	ASW	CDB	CDB2	CDBX	GRNE	WPDC
Miscellaneous (mg/L) (cont'd)											
Total dissolved solids (TDS)	1/15	Total		890	740	735					
	11/15	Total		705							
	12/8	Total	2420					1020			
Total suspended solids (TSS)	1/15	Total		125	606	612		191			
	11/15	Total	155	139		978		150		1150	204
	12/8	Total				306				174	121
General indicator parameters											
pH (pH units)	11/15	Total			6.45						
Specific conductance (µmho/cm)	1/15	Total		1420	1090	1060					
	11/15	Total		1200							
	12/8	Total	3810					1670			
EPA Method 507 (µg/L)											
Simazine	11/15	Total		7.5						6.8	
	12/8	Total		71		8.3				6	6.7

was used in the historical record. During the 1997/1998 rainy season, source investigations were conducted to determine how much of these metals were present in the liquid (dissolved) and how much in sediments (suspended) were being transported during storm water flow events. The source identification study also evaluated how much of the loading in each fraction (dissolved and suspended) originates off site, and how much is contributed by on-site sources. Finally, the study related concentrations of constituents in storm water from a particular storm and location to the concentration of total suspended solids from the same storm and location. To accomplish these goals, samples for applicable constituents were collected in duplicate. One sample was analyzed for total concentration (i.e., dissolved and suspended) of the constituents of interest. The second sample was passed through a 0.45-µm filter in order to evaluate the dissolved component. Although particles smaller than 0.45 µm (i.e., not dissolved) will

of course pass through this filter, this removes the majority of the sediments, and is therefore adequate for evaluation of the dissolved fraction of the storm water. Preliminary results of the source identification have confirmed that the apparent increasing trend in concentrations is due to a shift from analyses that recover the dissolved fraction to analyses that recover total concentrations. For example, total concentrations were often much higher than dissolved concentrations (see **Table 7-6**). In addition, exceedances noted at the Arroyo Seco effluent location (ASW) were attributed to samples with high sediment load. Because half of the data for this source investigation were collected in 1998, the full analysis will be presented in the 1998 Site Annual Environmental Report.

Table 7-6. Annual median values for dissolved and total concentrations of selected metals.

Metal (mg/L)	Dissolved or total	Arroyo Las Positas		Arroyo Seco	
		Influent	Effluent	Influent	Effluent
Chromium	Dissolved	0.0013	0.0014	<0.001	<0.001
	Total	0.0061	0.016	0.01085	0.064
Copper	Dissolved	0.0085	0.0081	0.0095	0.0075
	Total	0.017	0.015	0.01565	0.0715
Iron	Dissolved	<0.05	<0.05	<0.05	0.072
	Total	5.85	4.55	1.95	8.3
Zinc	Dissolved	0.016	0.059	0.0505	0.043
	Total	0.0495	0.205	0.1045	0.34

Other Nonradiological Parameters. Other nonradiological parameters, which were above comparison criteria (see **Table 7-5**) and for which influent concentrations were lower than effluent concentrations, were chemical oxygen demand, simazine, and total suspended solids.

A number of other constituents in LLNL runoff were also above comparison criteria. In every case, however, when the concentration exceeded a criterion at an effluent point, there was a corresponding influent point with a higher concentration, indicating an off-site or possibly naturally occurring source. These constituents were chloride, fluoride, nitrate, sulfate, total dissolved solids, pH, specific conductance, and vanadium. Organics detected (but not above criteria) in 1997 LLNL runoff were benzo[*a*]pyrene, bromacil, diazinon, diethylhexylphthalate, and diuron.

Site 300

The topography of Site 300 is much more irregular than that of the Livermore site; steep hills and ridges oriented along a generally northwest/southeast trend are separated by intervening ravines. The elevation ranges from approximately 150 m above sea level at the southeast corner of the site to approximately 538 m in the northwestern portion.

Surface water at Site 300 consists of seasonal stream runoff, springs, and natural and man-made ponds. The primary drainage in the Site 300 area is Corral Hollow Creek, an ephemeral stream that borders the site to the south and southeast. No continuously flowing streams are present in the Site 300 area. Elk Ravine is the major drainageway for most of Site 300; it extends from the northwest portion of the site to the east-central area. Corral Hollow Creek and Elk Ravine drain eastward to the San Joaquin River Basin. Some smaller canyons in the northeast portion of the site drain to the north and east toward Tracy. A small portion of Site 300 drains to Alameda County before flowing into Corral Hollow Creek, but is not included in the storm water sampling because there are no industrial activities in the associated drainages.

There are at least 23 springs at Site 300. Nineteen are perennial, and four are intermittent. Most of the springs have very low flow rates and are recognized only by small marshy areas, pools of water, or vegetation. Vegetation surrounding the springs includes cattails, nettles, willows, and grass. Only three of the springs have flow rates greater than 4 L/min. The significance of individual springs is discussed in the *Final Site-Wide Remedial Investigation Report, Lawrence Livermore National Laboratory Site 300*, hereafter referred to as the Final SWRI Report (Webster-Scholten 1994). A vernal pool is present in the northwest corner of Site 300. It is a seasonal pool created by ponding of water in a natural depression.

A number of surface water bodies are present at Site 300 and vicinity. A sewage evaporation pond and a sewage percolation pond are located in the southeast corner of the site in the General Services Area (GSA), and two lined high explosives (HE) process water impoundments are located to the west in the Explosives Process Area. (Monitoring associated with these facilities is contained in Chapter 8.) There is a pond in the residence area of the Carnegie State Vehicular Recreation Area located off site just east of Pit 6 at the mouth of Middle Canyon. In addition, four small off-site stock watering ponds are present just north of Site 300.

Other surface water flow at Site 300 results from blowdown water from cooling towers in the East Firing Area, the West Firing Area and other areas. Cooling tower discharges and their potential impact are discussed in the Final SWRI Report (Webster-Scholten 1994).

The Site 300 storm water sampling network began in 1994 with six locations and now consists of eight locations (**Figure 7-6**). Location CARW is used to characterize runoff in Corral Hollow Creek upgradient and therefore unaffected by Site 300 activities. Location GEOCRK is used to characterize runoff in Corral Hollow Creek, downgradient of Site 300. The remaining locations were selected to characterize storm water runoff at locations that could be affected by specific Site 300 activities.

LLNL procedures specify sampling of a minimum of two storms per rainy season from Site 300. For the 1996/1997 rainy season, samples were collected on October 29, 1996, and January 2, 1997, while for the 1997/1998 rainy season, all samples were collected in 1998. Therefore, only one storm was sampled in 1997 (**Table 7-7**). Typically, a given

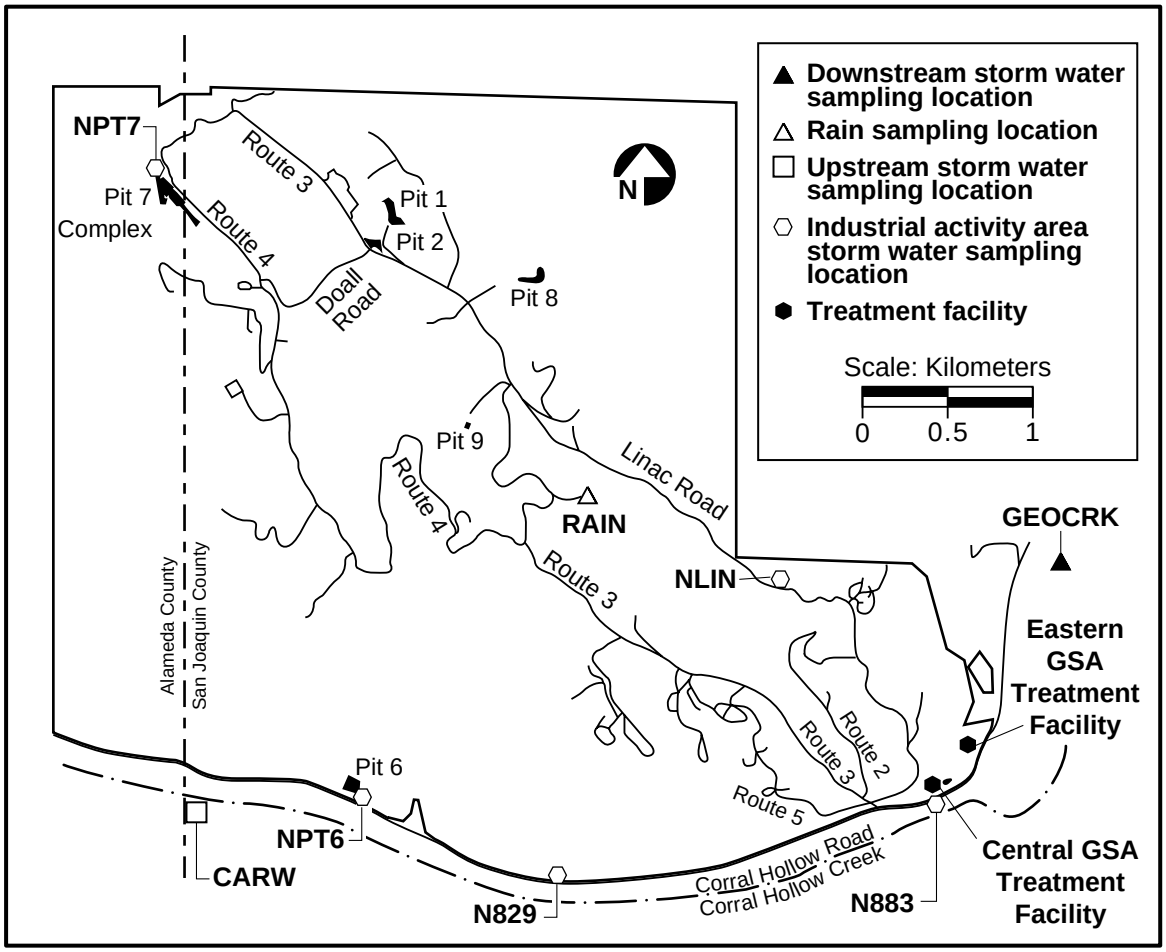

Figure 7-6. Rain and storm water runoff sampling locations, Site 300 and vicinity, 1997.

storm will not produce runoff at all Site 300 locations because Site 300 receives relatively little rainfall and is largely undeveloped. Therefore, at many locations, a series of large storms is required to saturate the ground before runoff occurs.

The maximum tritium concentration in Site 300 storm water was 2.44 Bq/L (**Table 7-7**), or 0.3% of the 740 Bq/L MCL (see **Table 7-2**). Maximum gross alpha and gross beta were 0.27 and 0.47 Bq/L, respectively, approximately 50% and 25% of their MCLs (0.56 and 1.85 Bq/L). Although total suspended solids, or TSS (**Table 7-7**), were above the EPA benchmark (100 mg/L) (see **Table 7-2**) at on-site location N883 (307 mg/L), they were well below concentrations at the off-site upstream locations NSTN and CARW (2010 and 1500 mg/L, respectively). Total suspended solids downstream of Site 300 at location GEOCRK (1530 mg/L) were also less than concentrations at the off-site upstream locations. Historically, background total suspended solids have been as high as 20,000 mg/L, indicating that these values are due to erosion typical of the region. All other nonradioactive parameters were below comparison criteria.

Table 7-7. Analysis for Site 300 storm water runoff, 1997.[a]

Parameter	CARW	GEOCRK	N883	NPT7	NSTN
Radioactive (Bq/L)					
Tritium	2.42 ± 2.42	2.33 ± 2.33	2.44 ± 2.44	2.39 ± 2.39	2.42 ± 2.42
Gross alpha	0.23 ± 0.052	0.27 ± 0.067	0.019 ± 0.023	0.020 ± 0.025	0.19 ± 0.048
Gross beta	0.35 ± 0.074	0.47 ± 0.085	0.10 ± 0.063	0.077 ± 0.074	0.29 ± 0.081
Uranium-234	0.027 ± 0.0067	0.060 ± 0.010	0.0011 ± 0.0037	0.016 ± 0.0052	0.029 ± 0.0067
Uranium-235	0.0037 ± 0.003	0.0030 ± 0.0033	-0.0004 ± 0.0022	0.0011 ± 0.0022	0.00074 ± 0.0026
Uranium-238	0.026 ± 0.0067	0.060 ± 0.01	0.0033 ± 0.0037	0.013 ± 0.0048	0.018 ± 0.0052
Nonradioactive					
Total organic carbon (mg/L)	11.7	11.9	6.4	3.3	11.3
Total suspended solids (mg/L)	1500	1530	307	26.5	2010
pH (pH units)	8.14	8.24	7.04	8.18	8.1
Specific conductance (µmho/cm)	322	487	27	149	323
Total organic halides (µg/L)	<20	<20	<20	<20	<20

[a] All samples taken on January 2, 1997.

Rainfall

Livermore Site

Rainfall is sampled for tritium according to written procedures in Appendix A of the *Environmental Monitoring Plan* (Tate et al. 1995). Historically, the tritium activity measured in rainfall in the Livermore Valley has resulted primarily from atmospheric emissions of tritiated water vapor (HTO) from stacks at LLNL's Tritium Facility (Building 331), and Sandia National Laboratories / California's former Tritium Research Laboratory. The Building 343 rain sampling location is near the Tritium Facility (Building 331), where LLNL personnel have reduced operations in recent years and performed significant inventory reduction and cleanup activities. The total measured atmospheric emission of HTO from LLNL facilities in 1997 was 9.8 Terabecquerels (TBq), equal to 267 curies (Ci) (see Chapter 5, Air Monitoring).

The rain sampling station locations are shown on **Figure 7-7.** The fixed stations are positioned to record a wide spectrum of tritium activities in rainfall, from the maximum expected down to background levels.

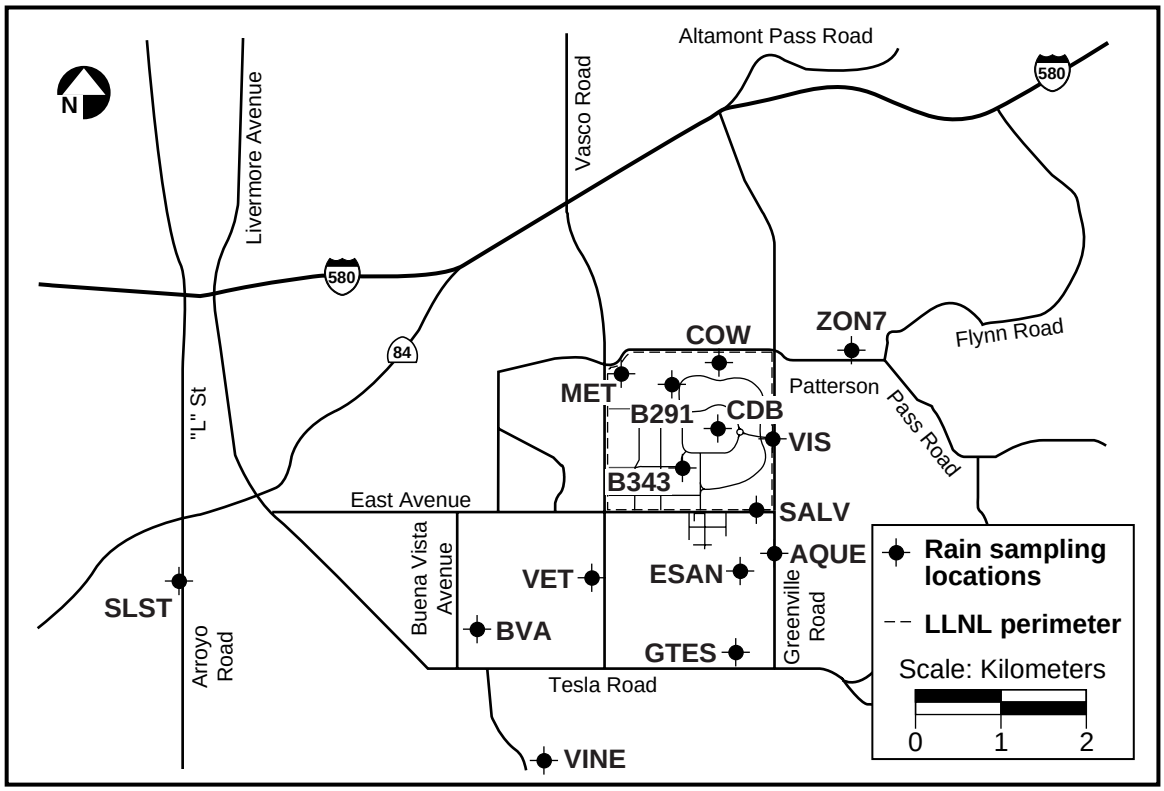

Figure 7-7. Rain sampling locations, Livermore site and Livermore Valley, 1997.

LLNL collected rainfall samples eight times in 1997. Complete data are shown in Table 7-5 of the Data Supplement. The Livermore site rainfall has exhibited elevated tritium activities in the past (Gallegos et al. 1994). During 1997, however, measurements of tritium activity in rainfall were all far below the 740 Bq/L (20,000 pCi/L) MCL established by the EPA for drinking water. The highest overall activity was 65 Bq/L (see **Table 7-8**) measured on November 20, 1997, near Building 343, just to the north of the on-site Tritium Facility. This value is approximately 9% of the MCL for tritium. The highest off-site activity was 7 Bq/L, recorded in a sample collected from station VET on January 15, 1997.

Tritium activity in rainfall at the Livermore site has decreased during the past eight years. This decrease mirrors the downward trend in total HTO emissions from LLNL's Tritium Facility and the closure of SNL/California's former Tritium Research Laboratory. These trends are shown in **Figure 7-8**. Values for median tritium activity are derived from the six on-site rain sampling locations (Building 343, Building 291, CDB, SALV, VIS, and COW) that historically have given the highest activities. A more than threefold decrease in total HTO emissions has occurred since 1990, down from 34.9 TBq (943 Ci) to 9.8 TBq (267 Ci). This decrease is mirrored by a more than tenfold decrease in median tritium activity measured in rainfall on site at LLNL: down from 65.9 Bq/L (1780 pCi/L) to 3.85 Bq/L (104 pCi/L).

Table 7-8. Tritium activities (in Bq/L) in rainfall for the LLNL Livermore site and the Livermore Valley.

	Livermore site	Livermore Valley	Overall
Median	3.85	1.81	2.51
Maximum	65.12	9.73	65.12
Minimum	1.23	0.89	0.89
Interquartile range	7.86	1.42	4.06
Number of samples	54	24	78

Site 300

One central location is used to collect rainfall for tritium activity measurements at LLNL's Experimental Test Site, Site 300 (**Figure 7-6**). Rainfall is composited (added together) for each month and analyzed when there is sufficient volume. During 1997, samples were analyzed for January, March, November, and December, with tritium activities of 1.45, 1.38, 1.21, and 1.28 Bq/L, respectively. Over the past 25 years, 160 measurements of rainfall samples collected at this location give a maximum tritium activity of only 9.1 Bq/L. The tritium activity measured in rainfall at Site 300 has been indistinguishable from atmospheric background levels over the past 25 years.

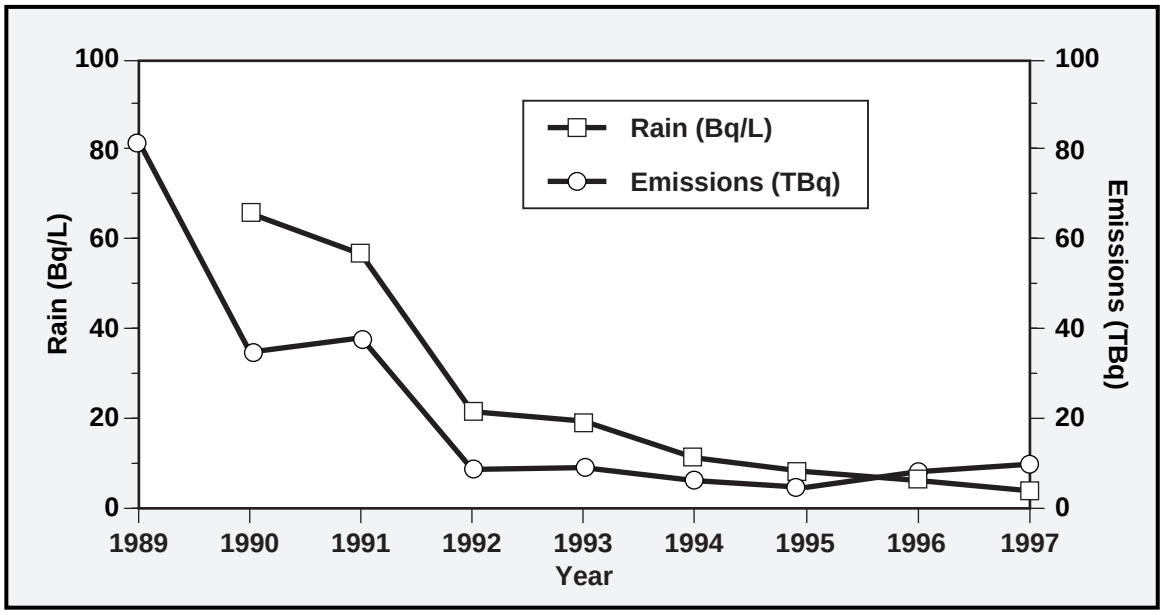

Figure 7-8. Trends of median tritium activity in rain and total stack emissions of HTO from the LLNL Livermore site and SNL/California, 1990 to 1997. (Emissions in 1996 and 1997 are only from LLNL.)

Livermore Site Drainage Retention Basin

The Drainage Retention Basin (DRB) was constructed and lined in 1992 after remedial action studies indicated that infiltration of storm water from the existing basin increased dispersal of ground water contaminants. Located in the center of the Livermore site, the DRB can hold approximately 53 ML (43 acre-feet) of water.

After the basin was lined, LLNL adopted the *Drainage Retention Basin Management Plan* (The Limnion Corporation 1991). The focus of the management plan was to implement a long-term biological monitoring and maintenance program and to address water quality problems by bioremediation and nutrient load reduction. The management plan identified two water sources to fill and maintain the level of the DRB. The primary water source was intended to be water reclaimed from ground water treatment units and discharged to the basin either through the existing storm water collection system or piped directly to the DRB. The secondary water source was intended to be storm water runoff. However, since the start of operation in 1992, storm water runoff has been the primary source of water entering the DRB. In 1997, treated ground water began significantly contributing to the dry weather flow into the DRB with occasional discharges from Treatment Facility D, Treatment Facility E-East, and portable treatment units (PTUs).

The San Francisco Bay RWQCB regulates discharges from the DRB according to the Livermore site CERCLA Record of Decision (ROD), as modified by the Explanation of Significant Differences for Metals Discharge Limits at the Lawrence Livermore National Laboratory, Livermore site (Berg, 1997c). The CERCLA ROD establishes discharge limits for all remedial activities at the Livermore site. In 1992, LLNL developed a sampling program for the DRB, which was approved by the San Francisco Bay RWQCB. The program consists of sampling discharges from the DRB (location CDBX) and the corresponding site storm water outfall (location WPDC) during the first release of the rainy season from the DRB and a minimum of one additional storm (chosen in conjunction with storm water runoff monitoring). This sampling plan was modified in a letter to the San Francisco Bay RWQCB dated December 9, 1997, modifying analytes and including a dry season sampling plan. Discharge sampling locations CDBX and WPDC are shown in **Figure 7-2**. Samples are collected at CDBX to determine compliance with discharge limits. Sampling at WPDC is done to identify any change in water quality as DRB discharges travel through the LLNL storm water drainage system and leave the site. Effluent limits for discharges from the DRB, applied at CDBX, are found in **Table 7-9**.

By agreement with the San Francisco Bay RWQCB, every quarter LLNL submits a report summarizing weekly, monthly, quarterly, semiannual, and annual monitoring of the basin as specified in the *Drainage Retention Basin Management Plan* (The Limnion Corporation 1991). Sampling to determine whether water quality management objectives are met is conducted at several points within the DRB. Dissolved oxygen (DO) content and temperature are measured at eight locations (**Figure 7-9**). Because of limited variability among sampling locations, all samples, other than those for DO and temperature, are routinely collected from CDBE, located at the middle depth of the DRB. The routine management constituents are identified in **Table 7-10**. LLNL requested and the San Francisco Bay RWQCB approved changes to the analytes monitored at the DRB in a letter dated December 9, 1997. These changes were implemented in 1998.

During 1997, discharges from the DRB were sampled four times. Three discharges were wet season discharges and one discharge occurred during the dry season. For purposes of determining discharge monitoring requirements and frequency, the wet season is defined in the December 9, 1997, letter as October 1 through May 31, the period when rain-related discharges usually occur. All discharges were below the discharge limits.

Table 7-9. Treated ground water and Drainage Retention Basin discharge limits identified in CERCLA ROD as amended for outfalls CDBX, TFB, TFC, TFD, TFE, TFF, TFG, TF406, and TF518.

Constituent	Effluent discharge limits	
	Dry season Apr 1–Nov 30	Wet season Dec 1–Mar 31
Metals (μg/L)		
Antimony	6	not applicable[a]
Arsenic	50	10
Beryllium	4	not applicable[a]
Boron	not applicable[b]	not applicable[a]
Cadmium	5	2.2
Chromium (total)	50	not applicable[a]
Chromium(VI)	not applicable[b]	22
Copper	1300	23.6
Iron	not applicable[b]	not applicable[a]
Lead	15	6.4
Manganese	not applicable[b]	not applicable[a]
Mercury	2	2
Nickel	100	320
Selenium	50	10
Silver	100	8.2
Thallium	2	not applicable[a]
Zinc	not applicable[b]	220
Organics (μg/L)		
1,1-Dichloroethane	5	5
1,1-Dichloroethene	5	5
1,2-Dibromoethane	0.02	0.02
1,2-Dichloroethane	5	5
Base/neutral and acid extractable compounds and pesticides	5	5
Benzene	0.7	0.7
Carbon tetrachloride	5	5
cis-1,2-Dichlorethene	5	5
Ethyl benzene	5	5
Polynuclear aromatic hydrocarbons	15	15
Tetrachloroethene	4	4
Toluene	5	5
Total petroleum hydrocarbons	50	50
Total trihalomethanes	5	5
trans-1,2-Dichloroethene	5	5
Trichloroethene	5	5
Vinyl chloride	2	2
Volatile organic compounds (total)	5	5
Xylenes (total)	5	5

Table 7-9. Treated ground water and Drainage Retention Basin discharge limits identified in CERCLA ROD as amended for outfalls CDBX, TFB, TFC, TFD, TFE, TFF, TFG, TF406, and TF518 (concluded).

Constituent	Effluent discharge limits	
	Dry season Apr 1–Nov 30	Wet season Dec 1–Mar 31
Physical		
pH (pH units)	6.5 to 8.5	6.5 to 8.5
Toxicity		
Aquatic survival bioassay (96 hours)	Median of 90% survival and a 90 percentile value of not less than 70% survival for 96-hour bioassay.	Median of 90% survival and a 90 percentile value of not less than 70% survival for 96-hour bioassay.
Radioactivity		
Tritium	740 Bq/L	740 Bq/L

[a] No limit is established for aquatic life protection; however, aquatic life is protected by bioassay analysis.

[b] No MCL is established for this metal.

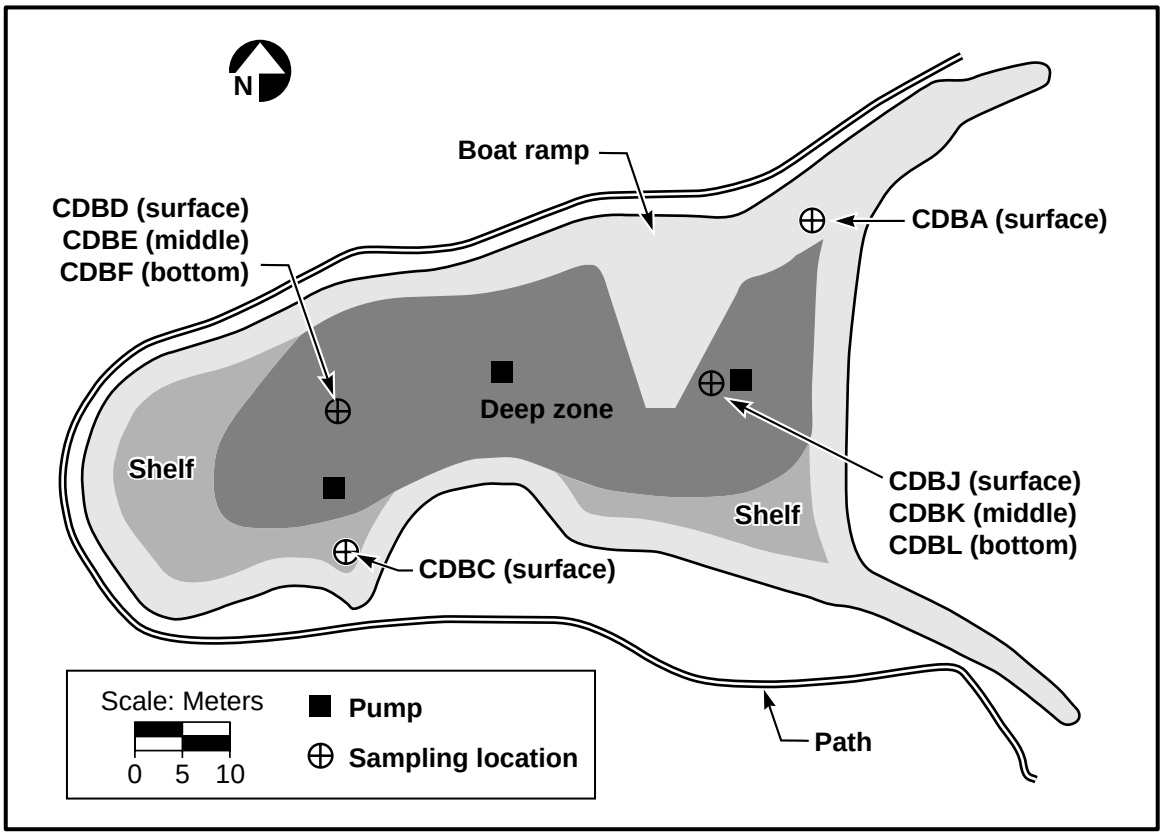

Figure 7-9. Sampling locations within the Drainage Retention Basin, 1997.

Table 7-10. Routine water quality management levels for the Drainage Retention Basin.

Constituent	Location	Frequency	Management action levels	
			Dry season Apr 1–Nov 30	Wet season Dec 1–Mar 31
Physical				
Dissolved oxygen (mg/L)	CDBA, CDBC, CDBD, CDBE, CDBF, CDFJ, CDBK, CDBL	Weekly	<80% saturation and <5 mg/L	<80% saturation and <5 mg/L
Temperature (°C)	CDBA, CDBC, CDBD, CDBE, CDBF, CDFJ, CDBK, CDBL	Weekly	<15 and >26	<15 and >26
Total alkalinity (as $CaCO_3$) (mg/L)	CDBE	Monthly	<50	<50
Chlorophyll-a (mg/L)	CDBE	Monthly	>10	>10
pH (pH units)	CDBA, CDBC, CDBD, CDBE, CDBF, CDFJ, CDBK, CDBL	Weekly	<6.0 and >9.0	<6.0 and >9.0
Total dissolved solids (mg/L)	CDBE	Monthly	>360	>360
Turbidity (m)	CDBE	Monthly	<0.91	<0.914
Chemical oxygen demand (mg/L)	CDBE	Quarterly	>20	>20
Oil and grease (mg/L)	CDBE	Quarterly	>15	>15
Conductivity (μmho/cm)	CDBE	Monthly	>900	>900
Nutrients (mg/L)				
Nitrate (as N)	CDBE	Monthly	>0.2	>0.2
Nitrite (as N)	CDBE	Monthly	>0.2	>0.2
Ammonia nitrogen	CDBE	Monthly	>0.1	>0.1
Phosphate (as P)	CDBE	Monthly	>0.02	>0.02
Microbiological (MPN[(a)]/0.1L)				
Total coliform	CDBE	Quarterly	>5000	>5000
Fecal coliform	CDBE	Quarterly	>400	>400
Metals (μg/L)				
Antimony	CDBE	Monthly	>6	not applicable
Arsenic	CDBE	Monthly	>50	>10
Beryllium	CDBE	Monthly	>4	not applicable
Boron	CDBE	Monthly	>7000	>7000
Cadmium	CDBE	Monthly	>5	>2.2
Chromium, total	CDBE	Monthly	>50	not applicable
Chromium(VI)	CDBE	Monthly	not applicable	>22

Table 7-10. Routine water quality management action levels for the Drainage Retention Basin (concluded).

Constituent	Location	Frequency	Management action levels	
			Dry season Apr 1–Nov 30	Wet season Dec 1–Mar 31
Copper	CDBE	Monthly	>1300	>23.6
Iron	CDBE	Monthly	not applicable	not applicable
Lead	CDBE	Monthly	>15	>6.4
Manganese	CDBE	Monthly	not applicable	not applicable
Mercury	CDBE	Monthly	>2	>2
Nickel	CDBE	Monthly	>100	>320
Selenium	CDBE	Monthly	>50	>10
Silver	CDBE	Monthly	>100	>8.2
Thallium	CDBE	Monthly	>2	not applicable
Zinc	CDBE	Monthly	not applicable	>220
Organics (μg/L)				
Total volatile organic compounds	CDBE	Semiannually	>5	>5
Benzene	CDBE	Semiannually	>0.7	>0.7
Tetrachloroethene	CDBE	Semiannually	>4	>4
Vinyl chloride	CDBE	Semiannually	>2	>2
Ethylene dibromide	CDBE	Semiannually	>0.02	>0.02
Total petroleum hydrocarbons	CDBE	Semiannually	>50	>50
Polynuclear aromatic hydrocarbons	CDBE	Semiannually	>15	>15
Base/neutral acid extractable compounds	CDBE	Semiannually	>5	>5
Pesticides and herbicides	CDBE	Quarterly	not applicable	not applicable
Radiological (Bq/L)				
Gross alpha	CDBE	Semiannually	>0.555	>0.555
Gross beta	CDBE	Semiannually	>1.85	>1.85
Tritium	CDBE	Semiannually	>740	>740
Toxicity (% survival/96-hour)				
Aquatic bioassay fathead minnow	CDBE	Annually	90% survival median, 90 percentile value of not less than 70% survival	90% survival median, 90 percentile value of not less than 70% survival
Chronic bioassay fathead minnow	CDBE	Annually	not applicable	not applicable
Chronic bioassay selanastrum	CDBE	Annually	not applicable	not applicable

[a] Most probable number.

Samples collected during 1997 within the DRB at CDBE did not meet the management action levels (MALs) for dissolved oxygen, temperature, turbidity, nitrate, ammonia, and phosphorus (**Table 7-11**). No action was taken to adjust nutrient levels. Operating the pumps to increase the DO level resulted in increased turbidity. No action was taken in response to the temperature changes since the low temperatures were consistent with normal seasonal patterns.

Table 7-11. Summary of Drainage Retention Basin monitoring at sampling location CDBE exceeding management action levels.

Constituent	Management action levels	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dissolved oxygen (mg/L), monthly average	<80% saturation and >5 mg/L	—	73%	68%	—	—	50% 4.4	75%	—	—	56%	34%	38% 4.5
Temperature (°C), monthly average	<15.6 >26.7	8.8	11.6	14.1	14.2	—	—	—	—	—	—	—	8
Turbidity (Secchi disk) (m), monthly average	<0.914	0.203	0.381	0.499	0.590	0.804	—	0.491	0.711	0.677	0.372	0.679	0.457
Nitrate (as N) (mg/L)	≥0.2	0.5	0.5	0.5	0.4	—	—	0.4	—	—	0.29	0.72	0.56
Ammonia nitrogen (mg/L)	>0.1	—	0.12	—	—	—	—	—	—	—	0.44	—	0.26
Phosphate (as P) (mg/L)	≥0.02	0.66	0.57	0.64	0.54	0.46	0.37	0.32	0.31	0.49	0.24	0.21	0.20
Total dissolved solids (mg/L)	>350	—	—	—	—	—	—	—	—	414	440	463	355
Chemical oxygen demand (mg/L)	>20	52.2	—	—	32.2	—	—	34	—	—	27	—	—
Fecal coliform (MPN/100mL)	>500	>1600	—	—	—	—	—	—	—	—	—	—	—

DO concentrations varied around the MAL of at least 80% saturation of oxygen in the water for most of the year and dropped below the MAL of 5 mg/L several times during 1997 (**Figure 7-10**). During the late summer through the end of the year, the primary DO meter that LLNL uses began providing questionable data. Careful meter calibration initially resulted in more realistic results. However, comparative testing using back-up

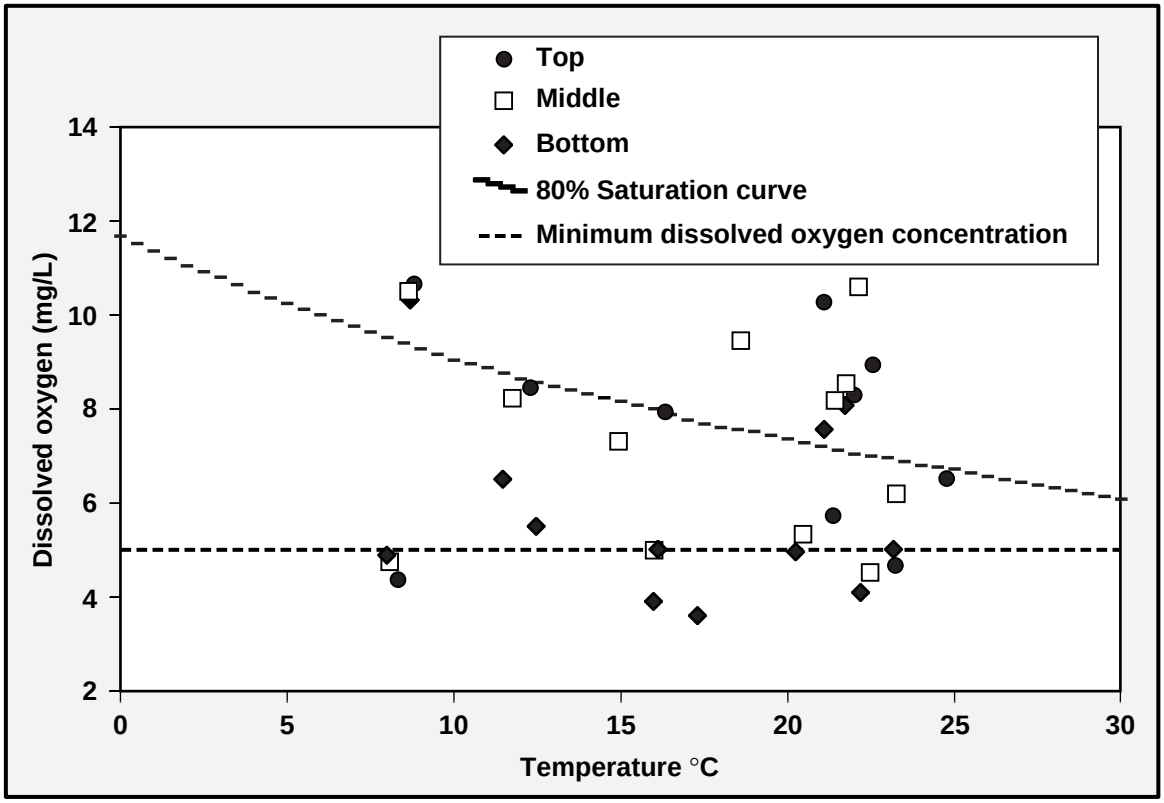

Figure 7-10. Monthly average dissolved oxygen vs. temperature at each depth location in the Drainage Retention Basin from January through December 1997.

meters and wet chemistry methods to measure the dissolved oxygen indicated that the meter was providing readings as much as 2 mg/L below the comparison values. So the majority of the dissolved oxygen readings collected from June through December are probably not accurate. The meter was replaced with a new one in 1998.

Dissolved oxygen concentrations are controlled manually with aeration pumps, which are started whenever oxygen concentrations at any level of the DRB drop close to or below the critical MAL of 5 mg/L. In 1997, these pumps were operated continuously from June through December. During the winter, the pumps were started as needed.

Pump operation was probably responsible for the relatively uniform distribution of dissolved oxygen at the surface, middle, and bottom elevations seen throughout the five years of DRB operation. Adequate DO concentrations prevent decaying organic matter in bottom sediments from releasing nutrients into the DRB water column. When the pumps were not operated in 1997 until June, oxygen concentrations began to drop in the lower level of the DRB (**Figure 7-11**). Temperature, the other important parameter in determining how much oxygen is dissolved in water, showed characteristic seasonal

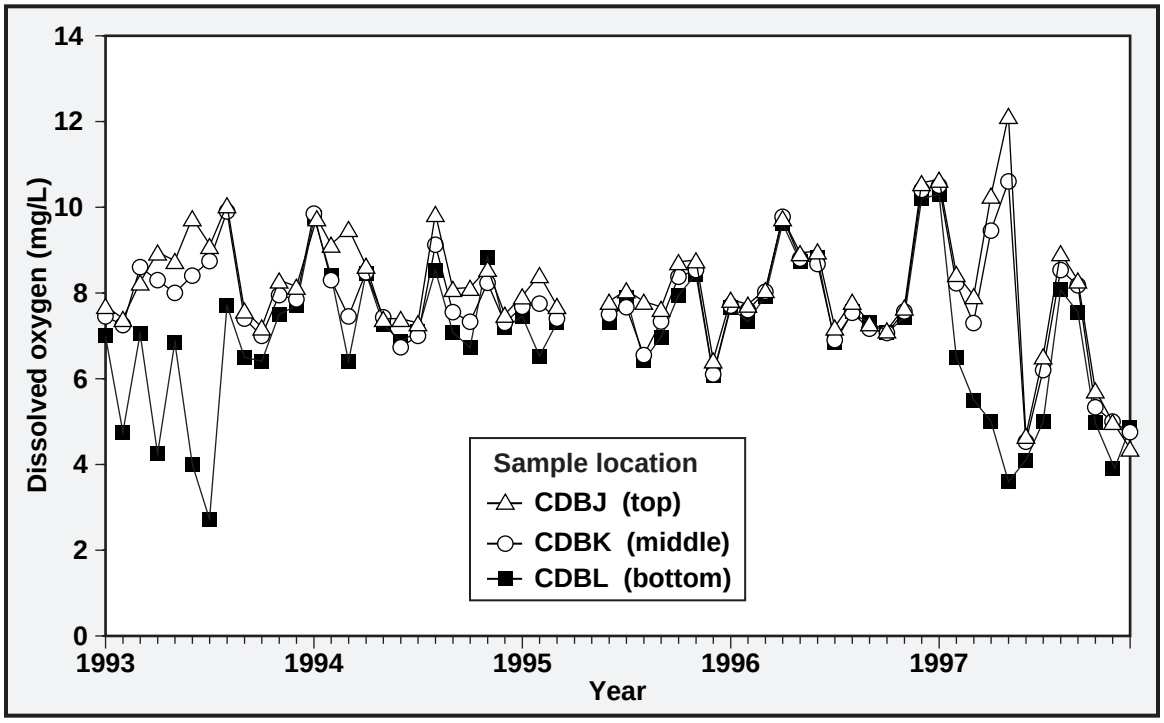

Figure 7-11. Dissolved oxygen concentration variations from the beginning of DRB operations.

trends (**Figure 7-12**). The uniform distribution of temperature in the top, middle, and bottom elevations reflects the uniform mixing achieved by the operation of the pumps. This uniform mixing provides further evidence that the low dissolved oxygen readings seen in the last half of 1997 were not accurate.

Turbidity rose above acceptable management levels during the 1993/1994 wet season, and remained above them throughout 1994 and 1995. Wet season turbidity probably results from sediments that pass through the sediment traps discharging into the DRB. Turbidity seen during the warmer summer months of 1994 was most likely the result of algae growth (Harrach et al. 1996). This was confirmed by high chlorophyll-a values and visual observations during the 1994 summer months. However, during 1995, though turbidity continued to be high, chlorophyll-a values were just above detection, indicating very little algae growth. This was confirmed by visual observations. The inhibition of algae growth continued through 1996. In 1997, the DRB again began showing higher chlorophyll-a levels and visible algae growth.

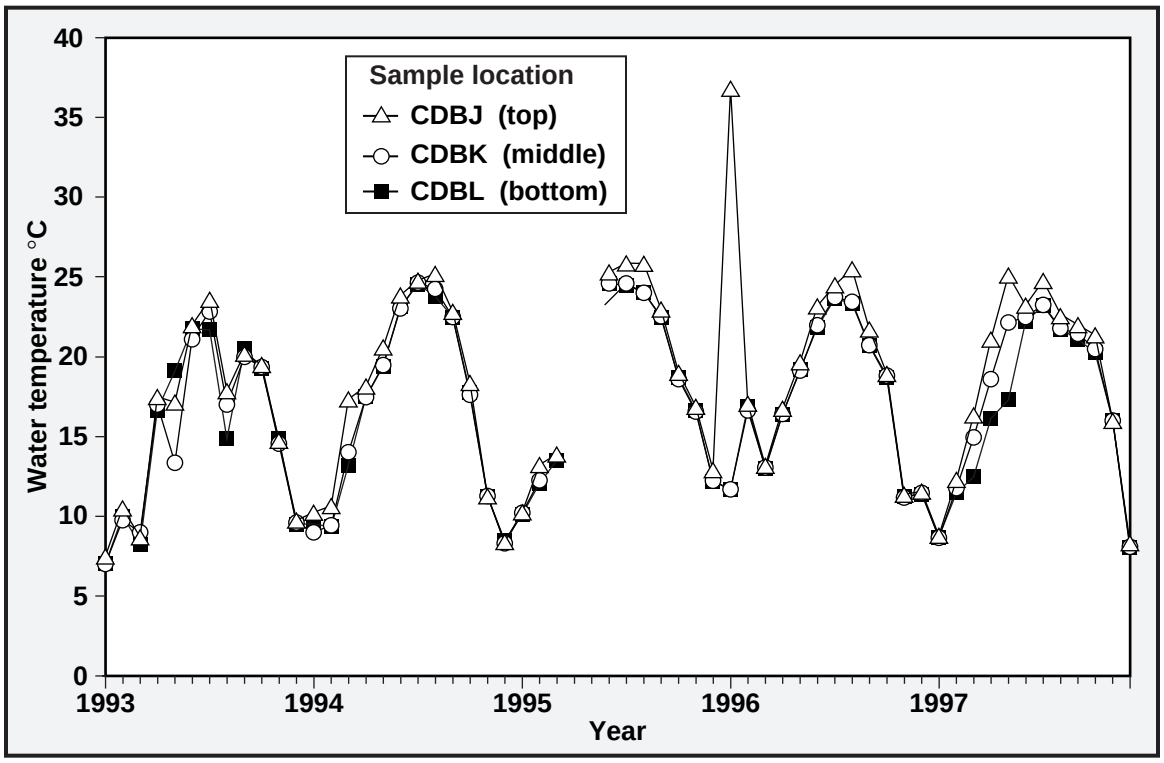

Figure 7-12. Seasonal temperature variation measured at sample top, middle, and bottom levels from the start of operation in 1993. No measurements are available for April and May 1995.

During 1996/1997, LLNL began conducting studies to explain decreased algae growth observed during 1995 and 1996. LLNL did additional toxicity monitoring and some informal toxicity reduction evaluation studies using the algae *Selanastrum capricornum*. The studies looked for negative effects on the algae growth when metals were present in water collected from the DRB and when organic compounds were present. Reduced algae growth rates were observed in the collected water samples containing organic compounds. Further studies to confirm which organic compounds might be impacting algae growth in the DRB looked at the algae growth response to tan bark extract and two herbicides, diuron and bromacil. These studies showed statistically significant differences ($p=0.0001$) between the control and water containing extract from the tan bark spread near the DRB and water containing the active ingredients of the two herbicides. Diuron and bromacil are used commonly around the Livermore site to control weeds growing in the drainage channels. However, samples containing these pesticides showed greater toxic effects than samples containing the tan bark extract. Toxic effects on the algae were evident when these herbicides were found in water samples collected from the DRB in October 1995 and September 1997.

In 1997, diuron was introduced into the DRB due to a misapplication of this pesticide. Toxicity testing after the influx of this material showed a toxic effect of greater than 20 toxicity units in DRB water containing a diuron concentration of 33 µg/L. Diuron continued to be seen in the DRB, discharges into the DRB, and in discharges at WPDC through the end of the year. Concentrations ranged approximately from 18 µg/L to 40 µg/L.

LLNL began monitoring the flow discharging from the DRB in 1996 (for 1997 flow, see **Figure 7-13**). Storm water runoff accounts for the majority of the water entering the DRB. Discharges normally occur only in the wet season, and are usually associated with storms. However, in 1997 one manual discharge occurred during the dry season when additional discharges from Treatment Facility F were routed to the DRB to prevent discharges into the storm drainage system while the construction of the National Ignition Facility temporarily made the downstream storm drain inaccessible. A total of 142 ML (37.6 million gal) of water was discharged from the DRB in the months of January, February, September, November, and December. The largest discharge occurred on January 1, 2, and 22, when 40 ML (10.6 million gal) were released. This accounted for 28% of the total annual discharge.

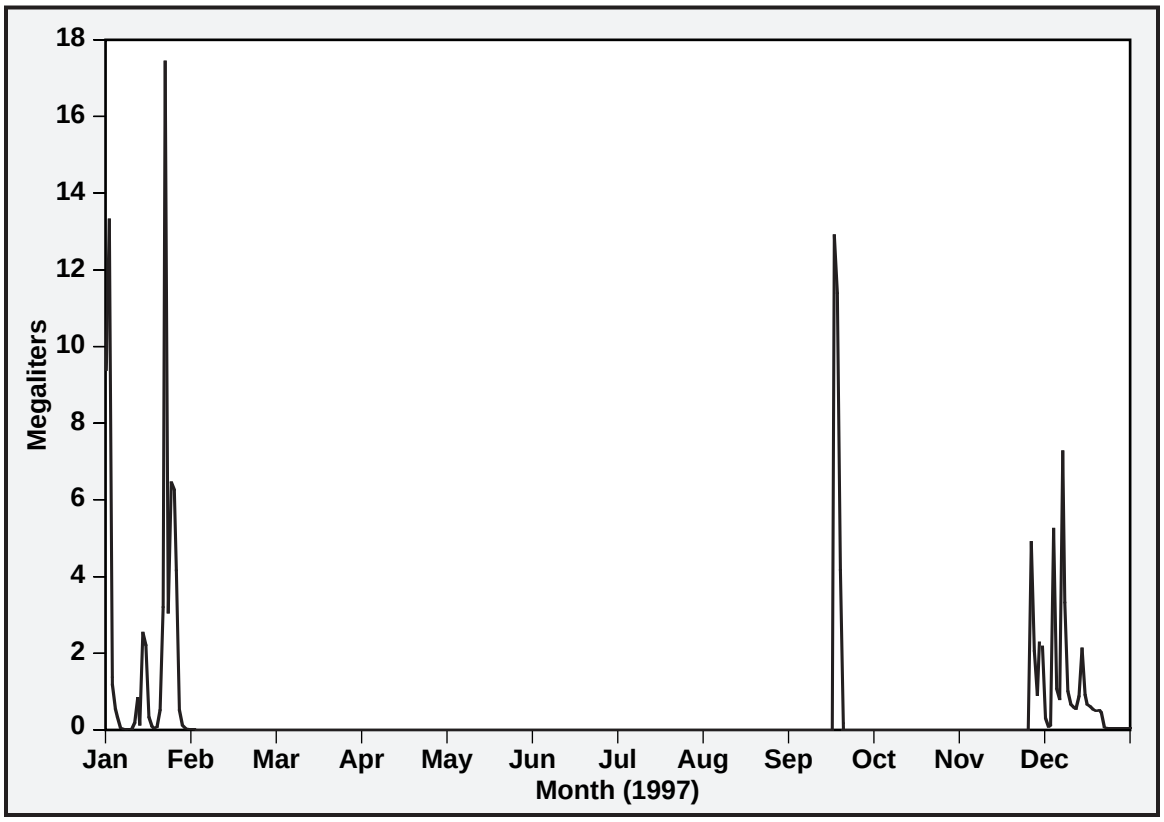

Figure 7-13. Water discharged from the Drainage Retention Basin in 1997.

Nevertheless, mass loadings for discharges from the DRB, determined from flow and analytical data, show that the total measurable mass of metals and organics released from the DRB is small (see Table 7-6 of the Data Supplement).

Data for maintenance monitoring at sampling locations CDBX, WPDC, CDBA, CDBC, CDBD, CDBE, CDBF, CDBJ, CDBK, and CDBL are presented in Tables 7-6, 7-7a, b, and c, 7-8, and 7-9 in the Data Supplement.

Treatment Facilities

The Livermore Site Ground Water Project (GWP) complies with provisions specified in a federal facility agreement (FFA) and in the CERCLA ROD entered into by the Environmental Protection Agency (EPA), DOE, the California EPA's Department of Toxic Substances Control (DTSC), and the San Francisco Bay Regional Water Quality Control Board (RWQCB). As required by the FFA, the project addresses compliance issues through investigations of potential contamination source areas (such as suspected old release sites, solvent handling areas, and leaking underground tank systems), continued monitoring of ground water, and remediation. The ground water constituents of concern are volatile organic compounds (VOCs), primarily trichloroethene (TCE) and tetrachloroethene (or perchloroethylene [PCE]). The primary treatment technology employed at the LLNL Livermore site to remediate contaminated ground water is ground water pump-and-treat. This technology employs a dense network of ground water extraction wells, monitoring wells, pipelines, and surface treatment facilities.

At Site 300, ongoing remedial investigations, feasibility studies, engineering evaluation and cost analyses, and remedial actions are being performed by the Environmental Restoration Program and Division. Site 300 investigations and remedial actions are conducted under the combined oversight of the EPA, Central Valley RWQCB, and DTSC, and under the authority of an FFA for the site. (There are separate agreements for Site 300 and the Livermore site.) Pump-and-treat technology is utilized for ground water treatment.

Livermore Site

Livermore site treatment facilities that discharge to surface water drainage courses (**Figure 7-14**) are discussed in this section.

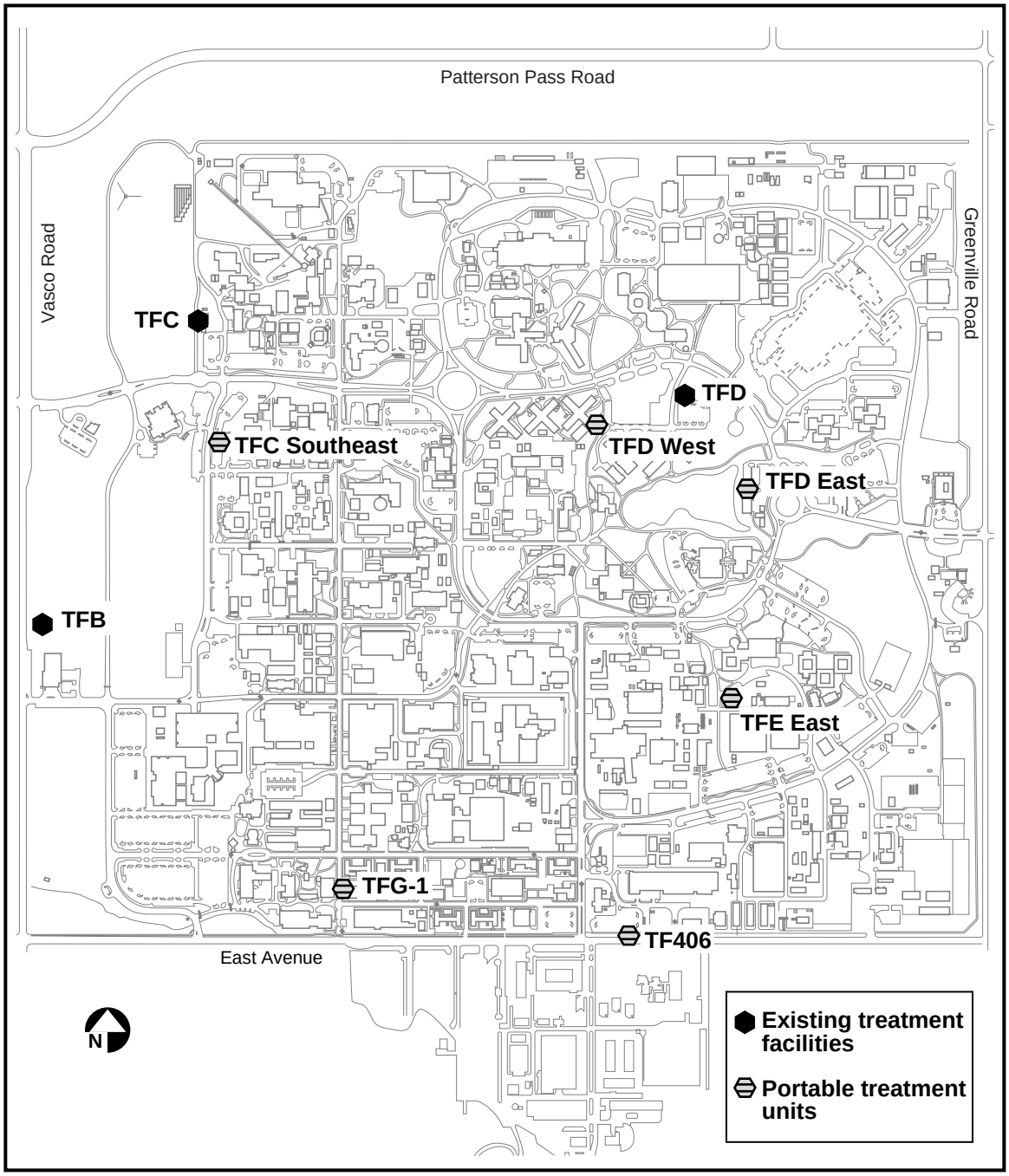

Figure 7-14. Location of treatment facilities that discharge to surface water drainage courses.

Treatment Facility B (TFB). Treatment Facility B (TFB), located along Vasco Road just north of Mesquite Way, processes ground water contaminated with chromium and VOCs. A combination of UV / H_2O_2 treatment and air-stripping technologies is used to treat VOCs. Hydrogen peroxide and carbon dioxide are used to reduce chromium(VI) to chromium(III). TFB's treated waters are discharged into a drainage ditch at the west perimeter of the site that feeds Arroyo Las Positas. TFB treated about 64 ML of ground water in 1997, removing and destroying approximately 6.8 kg of VOCs. Between system startup in 1990 and 1997, TFB processed 247 ML of ground water and removed about 25.5 kg of VOCs from the subsurface.

Self-monitoring analytical results of TFB effluent samples indicate that the VOC discharge limit of 5 ppb was not exceeded. During 1997, water discharged from TFB did not contain chromium(VI) in excess of the discharge limit of 22 ppb (µg / L) in accordance with the CERCLA ROD as amended (**Table 7-9**).

Treatment Facility C (TFC) and TFC Southeast. Treatment Facility C (TFC) is located in the northwest quadrant of LLNL and uses air-stripping and ion-exchange technologies to process ground water contaminated with VOCs and chromium. TFC includes a PTU, TFC Southeast. In 1997, a total of 9.4 kg of VOCs was removed from approximately 86 ML of ground water treated at TFC. Between system startup in October 1993 and 1997, TFC processed about 135 ML of ground water and removed about 15.4 kg of VOCs. The treated water from TFC is discharged into Arroyo Las Positas.

LLNL conducted samplings at TFC in compliance with the modified CERCLA ROD discharge limits (**Table 7-9**). The self-monitoring analytical results of TFC effluent samples indicate that the VOC discharge limit of 5 ppb was not exceeded during 1997. All regulated metals parameters were below discharge limits designated in the CERCLA ROD as amended.

Treatment Facility D. Treatment Facility D (TFD) is located in the northeast quadrant of LLNL and uses air-stripping and ion-exchange technologies to process contaminated ground water. TFD was activated on July 14, 1994, and began operating on September 15, 1994. Two additional extraction locations, TFD West (TFD-W) and TFD East (TFD-E) were activated in 1997 using portable treatment units (PTUs). Since startup, the combined TFD facilities have processed nearly 229 ML of ground water and removed about 73.4 kg of VOC mass from the subsurface. In 1997, the combined TFD facilities processed about 182 ML of ground water containing about 55 kg of VOCs. The treated water was discharged through storm water drainage channels into Arroyo Las Positas.

LLNL sampled TFD effluent in compliance with the modified CERCLA ROD. The self-monitoring analytical results indicated that metals and VOCs were within compliance discharge limits during 1997.

Treatment Facility E. Multiple PTUs will be located in the Treatment Facility East (TFE) area in the southeastern quadrant of the LLNL Livermore site. In 1997, one PTU, TFE East (TFE-E), was operating in the area. TFE-E is located west of Avenue H near Third Street in the east-central portion of the site (**Figure 7-14**). TFE-E treats ground water from extraction Well W-1109 (Hydrostatic Unit [HSU] 2) and extraction Well W-566 (HSU 5). TFE-E was operated at flow rates ranging from 15 to 20 gpm in 1997.

TFE-E processes ground water for treatment of VOCs using an air stripper. The effluent air is treated using granulated activated carbon (GAC) to remove VOCs prior to discharge to the atmosphere. Treated ground water from TFE-E is discharged into a drainage ditch flowing north into the DRB.

Since it was activated on November 26, 1996, TFE-E PTU has processed approximately 37.5 ML of ground water through the end of 1997, and removed an estimated 16.7 kg of VOC mass from the subsurface. In 1997, this facility processed approximately 36 ML of ground water and removed an estimated 15.9 kg of VOCs. Water treated at TFE East is discharged to a north-flowing drainage ditch that ultimately empties into the Drainage Retention Basin. TFE-E was in compliance with all permits throughout 1997.

Treatment Facility 406 (TF406). Located in the southeastern part of the LLNL Livermore site (**Figure 7-14**), TF406 consists of a PTU that uses air stripping to treat ground water. TF406 is designed to treat VOCs extracted from HSUs 4 and 5 beneath the former TFF area.

TF406 began operating on August 27, 1996. TF406 processes ground water extracted from Well W-1114, which is positioned to clean up and hydraulically control a TCE plume. In the spring of 1997, TF406 also began treating ground water from Well GSW-445.

During 1997, TF406 processed about 8.7 ML of ground water from Well W-1114 and Well GSW-445 at flow rates between 38 and 60 L/min. The total VOC mass removed during 1997 was about 0.9 kg. Since startup, TF406 has treated 10.2 ML of ground water and removed about 1.1 kg of VOCs. All treated ground water was discharged to a storm drain that leads to Arroyo Las Positas. There were no compliance violations associated with this discharge during 1997.

Treatment Facility G (TFG-1). Treatment Facility G-1 (TFG-1) is located about 90 m (300 ft) north of East Avenue in the south-central part of the LLNL Livermore site (**Figure 7-14**). TFG-1 consists of a PTU that utilizes air stripping and ion exchange to treat ground water from HSU 2 extraction Well W-1111.

During 1997, TFG-1 processed about 12.5 ML of ground water and removed 6.6 kg of VOCs. TFG-1 has removed an estimated 0.8 kg of VOCs from 16.3 ML of ground water since operation began on April 11, 1996. All treated ground water was discharged to a storm drain located about 15 m north of TFG-1, which empties into Arroyo Seco. There were no compliance violations associated with this discharge during 1997.

Site 300

Site 300 treatment facilities that discharge to surface drainage courses are discussed in this section. They are the Central General Services Area Treatment Facility and the Eastern General Services Area Treatment Facility (see **Figure 7-6**).

General Services Area

The central GSA ground water treatment system is operating under substantive requirements for wastewater discharge issued by the Central Valley RWQCB. The central GSA treatment facility discharges to bedrock in the eastern GSA canyon, where the water percolates into the ground. The eastern GSA ground water treatment system operates under NPDES Permit No. CA0082651, issued by the Central Valley RWQCB for discharges into Corral Hollow Creek. The system operated under WDR91-052 until December 5, 1997, when WDR 97-242 was issued. Permit requirements for the central and eastern GSA ground water treatment system are listed in **Table 7-12**. Both the central and eastern GSA treatment systems operated in compliance with regulatory requirements during 1997. The GSA operable unit is located in the southeastern corner of Site 300.

Since 1982, LLNL has conducted an intensive investigation in the GSA and off-site areas to locate VOC release points and to define the vertical and horizontal distribution of VOCs, primarily TCE and PCE, in the soil, rock, and ground water. According to the *Final Site-Wide Remedial Investigation* (Webster-Scholten 1994) and *Draft Remedial Investigation* (McIlvride et al. 1990) reports, VOCs in excess of drinking water MCLs have been identified in the shallow ground water beneath the GSA in two localities. Two small VOC plumes occur in the central GSA portion of the operable unit, and one VOC plume occurs in the eastern GSA section in the gravels of Corral Hollow Creek.

Table 7-12. General Services Area ground water treatment system surface discharge permit requirements.

Parameter	Treatment facility	
	Central General Services Area	**Eastern General Services Area**
VOCs	Halogenated and aromatic VOCs	Halogenated VOCs
Maximum daily	5.0 μg/L	5.0 μg/L
Monthly median	0.5 μg/L	0.5 μg/L
Dissolved oxygen	Discharges shall not cause the concentrations of dissolved oxygen in the surface water drainage course to fall below 5.0 mg/L.	Discharges shall not cause the concentrations of dissolved oxygen in the surface water drainage course to fall below 5.0 mg/L.
pH (pH units)	Between 6.5 and 8.5, no receiving water alteration greater than ±0.5 units.	Between 6.5 and 8.5, no receiving water alteration greater than ±0.5 units.
Temperature	No alteration of ambient receiving water conditions more than 3°C.	No alteration of ambient receiving water conditions more than 3°C.
Place of discharge	To ground water during dry weather and to surface water drainage course in eastern GSA canyon during wet weather.	Corral Hollow Creek.
Flow rate	272,500 L (30-day average daily dry weather maximum discharge limit).	272,500 L per day
Mineralization	Mineralization must be controlled to no more than a reasonable increment.	Mineralization must be controlled to no more than a reasonable increment.
Methods and detection limits for VOCs	EPA Method 601—detection limit of 0.5 μg/L. EPA Method 602—method detection limit of 0.3 μg/L.	EPA Method 601—detection limit of 0.5 μg/L.

Eastern GSA

The air-sparging ground water treatment unit, which began operation in June 1991 as a CERCLA Removal Action to remove VOCs from the eastern GSA ground water, was replaced in January 1997 by several aqueous-phase granular activated carbon (GAC) adsorption units. The GAC units were demonstrated to be effective in removing VOCs from ground water, less complex in both design and operation than air-sparging technology, and less expensive than the sparging tanks.

During 1997, 80.8 ML of ground water containing 0.35 kg of VOCs were removed and treated at the Eastern GSA ground water treatment system. The treated ground water was discharged off site to the Corral Hollow Creek, in accordance with NPDES Permit No. CA0082651.

Since cleanup was initiated, approximately 5 kg of VOCs have been removed from 410 ML of water, and the length of the eastern GSA TCE plume with concentrations over the cleanup standard of 5 ppb maximum contaminant level (MCL) has been reduced by over 1432 m (4700 ft). The off-site portion of the plume now extends only 30.5 m (100 ft) beyond the site boundary. TCE concentrations in influent from the Eastern GSA ground water treatment system were reduced from 64 ppb in January 1992 to below MCLs (5 ppb) in September 1997. During this same time, VOC concentrations in eastern GSA monitoring well samples were reduced by up to 84%. The number of off-site wells in the Eastern GSA with TCE concentrations over the cleanup standard of 5 ppb (MCL) was reduced from five wells to only one. LLNL estimates that eight more years of ground water extraction and treatment will be required to achieve and maintain ground water VOC concentrations below MCLs at the Eastern GSA.

Central GSA

The two VOC ground water plumes in the central GSA are present in alluvium and shallow bedrock and in deeper bedrock. Construction of an air-sparging ground water treatment system and a vapor extraction and treatment unit for a CERCLA Removal Action to remove VOCs from the central GSA ground water and soil vapor was completed in 1993. During 1993, ground water extraction and treatment began. In August 1997, the air-sparging treatment tanks were replaced with air strippers in a portable treatment unit (PTU). The PTU is more cost-effective than the sparging tanks; may be easily deployed to another Site 300 operating unit if a more innovative and effective technology is identified for use at the central GSA in the future; and reduces costs originally projected in the GSA Feasibility Study document.

From 1993 through the end of 1997, about 3.2 ML of ground water containing 5.6 kg of VOCs were treated. The treated ground water was collected and batch-discharged in a remote Site 300 canyon, in accordance with the Substantive Requirement for wastewater discharge. During 1997, 0.7 ML of ground water containing 0.73 kg of VOCs was removed and treated at the Central GSA ground water treatment system (GWTS). TCE concentrations in Central GSA GWTS influent were reduced from 9400 ppb in April 1993 to 380 ppb in October 1997.

Following dewatering of bedrock through ground water extraction, soil vapor extraction and treatment of VOCs began in 1994. From 1994 through the end of 1997, soil vapor was treated with carbon adsorption to remove 30.3 kg of VOCs. During 1997, 47,438 cubic meters of soil vapor were extracted and treated at the Central GSA soil vapor extraction (SVE) system to remove 0.72 kg of VOCs. VOC concentrations in the Central GSA SVE influent stream were reduced from 450 parts per million volume-per-volume ($ppm_{v/v}$) to below 5 $ppm_{v/v}$. VOC concentrations in individual Central GSA SVE wells have been significantly reduced.

Building 834 Complex

During the portion of the year that the GWTS was in full-scale operation, 90.8 ML of ground water were extracted and treated; 5.2 kg of VOCs and 133 g of organosilicate oil were removed. Of the VOCs, an average of 84% was TCE. The 834 GWTS is expected to resume operation in 1998.

Cooling Towers

LLNL samples cooling-tower wastewater discharges as required by the Self-Monitoring Program of WDR 94-131, NPDES Permit No. CA0081396, and reports the results of the compliance sampling to the Central Valley RWQCB quarterly.

The cooling towers, used to cool buildings and equipment at Site 300, discharge noncontact cooling water to man-made and natural drainage courses (**Figure 7-15**). These drainage courses flow into Corral Hollow Creek, a tributary of the San Joaquin River.

WDR 94-131 establishes effluent limits for three parameters: (1) Daily flow must not exceed the maximum design flow; (2) Total dissolved solids (TDS) must not exceed a monthly average of 2000 mg/L or a maximum daily limitation of 2400 mg/L; and (3) The pH must not exceed 10. Along with effluent monitoring, when Corral Hollow Creek is flowing, the permit requires LLNL to collect pH samples upstream and downstream of the cooling tower discharge points into the creek and to conduct visual observations of the creek. (On July 1, 1997, the upstream sampling location was changed from NSTN to CARW [**Figure 7-15**] to provide better sampling access.) Cooling tower discharges must not raise the pH of Corral Hollow Creek above 8.5 or alter the ambient pH by more than 0.5 unit.

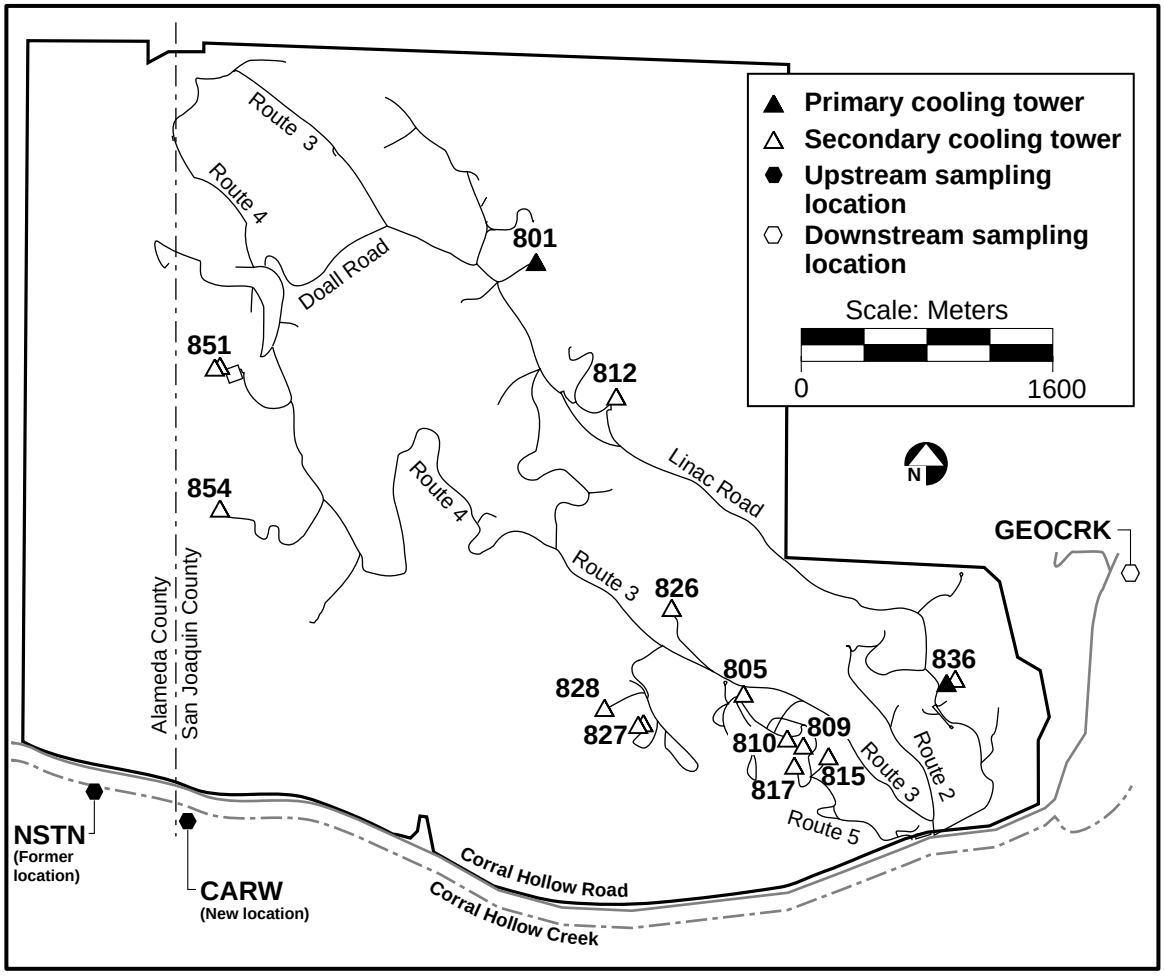

Figure 7-15. Site 300 cooling tower locations, 1997.

Two cooling towers, located at Buildings 801 and 836A, regularly discharge to surface water drainage courses. Fourteen other cooling towers routinely discharge to percolation pits under a waiver of waste discharge requirements from the Central Valley RWQCB. The permit establishes separate effluent limits (dissolved solids must not exceed a monthly average of 2000 mg/L or 5000 mg/L daily; pH must not exceed 10) for these 14 towers in the event that discharge to surface water drainage courses is necessary, such as during maintenance of the percolation pits. One such discharge occurred in August of 1997 when flow from the Building 812 cooling tower was diverted to the storm water drainage course for repair of a plugged line between the cooling tower and the percolation pit. Flow returned to the percolation pit by October 1997. Quarterly sampling (third quarter: 900 mg/L TDS, 8.9 pH; fourth quarter: 700 mg/L TDS, 8.57 pH) demonstrated compliance with the permitted limits. Although no compliance flow measurements were taken, maintenance mechanics' operational flow measurements demonstrated compliance.

The cooling towers at Building 851 were upgraded in March of 1997, and came back on line in mid-April 1997. This upgrade included replacing the chlorine biocide with an iodine biocide. The Central Valley RWQCB approved use of the new treatment chemical. Although these towers normally discharge to a percolation pit, occasional discharge to surface water drainages may occur. LLNL sampled the discharge and conducted a 96-hour fish toxicity study, using fathead minnow, which resulted in 100% survival. In addition to the toxicity study, LLNL analyzed samples for a variety of other constituents for comparison with cooling tower data in Attachment D of WDR 94-131. These analytes either do not have any identified water quality goals, or the results were well below water quality goals identified in the Central Valley RWQCB's staff report, *A Compilation of Water Quality Goals* (Marshack 1995). The analysis results were consistent with the cooling tower data noted in Attachment D of WDR 94-131, and were reported in the report to the Central Valley RWQCB for the second quarter of 1997.

In April 1997, residual water in the basin of the cooling tower at Building 865 was discharged to the surface water drainage course during the decommissioning process. Samples of the residual water taken prior to the discharge demonstrated compliance with permit limits (1600 mg/L TDS, 8.87 pH).

Monitoring results demonstrate that all cooling tower discharges were in compliance with all permitted limits (see **Tables 7-13** and **7-14**). LLNL reports operational values at the request of the CVRWQCB, but they are not used to determine compliance. All pH samples collected from the cooling tower discharges were below the permitted maximum of 10. TDS concentrations are consistently below both the daily maximum and monthly average limits. During the 1997 reporting period, flow occurred in Corral Hollow Creek during the first and second quarter. WDR 94-131 specifies that cooling tower discharges must not raise the pH of Corral Hollow Creek above 8.5 or alter the ambient pH by more than 0.5 unit. The first and second quarter downstream pH measurements (at location GEOCRK) of 8.42 and 8.47, respectively, were below the 8.5 pH requirement. Corresponding upstream pH measurements (at location CARW) of 8.36 and 8.58 for the first and second quarters, respectively, verify that the ambient pH did not change by more than 0.5 unit in either quarter.

Table 7-13. Summary data from compliance monitoring of Site 300 primary cooling towers, 1997.

Test	Tower no.	Minimum	Maximum	Median	Interquartile range	Number of samples
Total dissolved solids (mg/L)[a]	801	1300	1600	1400	—[e]	4
	836A	680	1400	1205	—[e]	4
Flow (L/day)	801[b]	0	12,756	4361	5954	24
	836A[c]	0	5760	1159	1756	24
pH (pH units)[d]	801	8.9	9.1	9.0	—[e]	4
	836A	7.7	9.0	8.9	—[e]	4

a Maximum permitted total dissolved solids = 2400 mg/L.

b Maximum permitted design flow = 16,276 L/day.

c Maximum permitted design flow = 8138 L/day.

d Maximum permitted pH = 10.

e Not enough data points to determine.

Table 7-14. Summary data from operational monitoring of Site 300 primary cooling towers, 1997.

Test	Tower no.	Minimum	Maximum	Median	Interquartile range	Number of samples
Total dissolved solids (mg/L)[a]	801	1000	1600	1400	150	26
	836A	1100	1500	1250	100	26
pH (pH units)[b]	801	8.7	9.1	9.0	0.1	26
	836A	8.6	9.1	8.8	0.3	26

a Maximum permitted total dissolved solids = 2400 mg/L.

b Maximum permitted pH = 10.

Other Waters

Additional surface water monitoring is driven by DOE Order 5400.1, General Environmental Protection Program, and DOE Order 5400.5, Radiation Protection of the Public and the Environment. Surface and drinking water near the LLNL Livermore site and in the Livermore Valley are sampled at locations shown in **Figure 7-16** according to procedures set out in Appendix A of the *Environmental Monitoring Plan* (Tate et al. 1995).

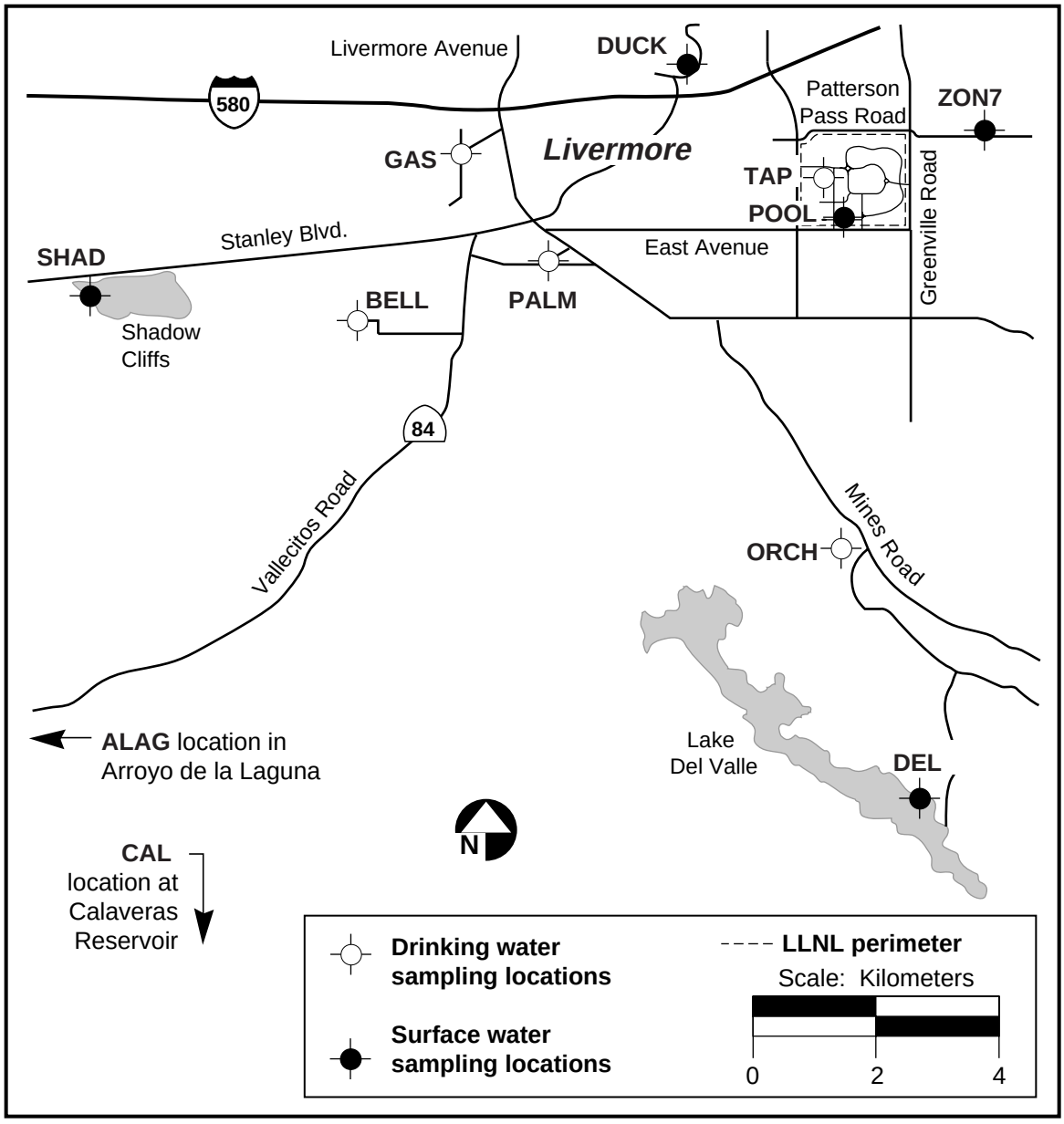

Figure 7-16. Surface and drinking water sampling locations, Livermore Valley, 1997.

Sampling locations DEL, ZON7, DUCK, ALAG, SHAD, and CAL are surface water sources; BELL, GAS, PALM, ORCH, and TAP are drinking water outlets. LLNL samples these locations for gross alpha, gross beta, and tritium. In the past, LLNL sampled these locations quarterly. Because past monitoring has consistently showed background levels of these constituents, samples were taken semiannually beginning in 1996. The on-site swimming pool POOL was also sampled, as described above, for gross

alpha, gross beta, and tritium. POOL sampling frequency was reduced from monthly to quarterly beginning in mid-1997.

Median activity for tritium was less than 0.2% of the drinking water maximum contaminant level (MCL); the maximum tritium activity was less than 2% of the MCL. Median activities for gross alpha and gross beta radiation in surface water samples were less than 10% of the MCL. However, maximum activities detected for gross alpha and gross beta, respectively, were 0.29 Bq/L (7.94 pCi/L) and 0.40 Bq/L (10.8 pCi/L), or 52% and 22% of their respective MCLs (see **Table 7-15**). Detailed data are in Table 7-10 of the Data Supplement. Historically, gross alpha and gross beta radiation have fluctuated about the laboratory reporting limits. At these very low levels, the error measurements are nearly equal to the measured values so that no trends are apparent in the data.

Table 7-15. Radioactivity (in Bq/L) in surface and drinking water in the Livermore Valley, 1997.

	Tritium	Gross alpha	Gross beta
Median	1.33	0.051	0.14
Minimum	1.09	0.0025	0.016
Maximum	13.62	0.29	0.40
Interquartile range	1.27	0.040	0.10

Environmental Impacts

There is no evidence of adverse environmental impact resulting from releases from the Drainage Retention Basin. Although internal measurements indicated that concentrations were above the management action levels for several constituents, no water was discharged with constituents above amended limits. Although diuron was discharged at concentrations above where we have seen toxic effects within the DRB, these discharges occurred during periods of high storm water flows, and there was no evidence that these discharges impacted downstream receiving waters.

The environmental impact of tritium measured in rainfall samples from the Livermore site was negligible. The highest tritium activity measured in 1997 rainfall was 65 Bq/L, about 9% of the MCL for tritium (740 Bq/L). However, the median tritium level was much lower, at 3.9 Bq/L (see **Table 7-8**). The potential impact of tritium on drinking water supplies was estimated by determining the effective dose equivalent (EDE). Appendix B presents the method to calculate dose. The EDE to an

adult who ingested two liters of water with 3.9 Bq/L tritium (the maximum rain concentration) per day for one year would be 0.0008 millisieverts (mSv), or 0.08 millirem (mrem), which is 0.08% of the DOE standard allowable dose of 1 mSv (100 mrem). Tritium activities measured in Livermore site and Livermore Valley surface and drinking water were even lower, with a maximum of 14 Bq/L, or about 2% of the MCL. The EDE to an adult who ingested two liters of this water per day for one year would be 0.0002 mSv (0.02 mrem), which is 0.02% of the DOE standard allowable annual dose of 1 mSv. Maximum activities for gross alpha and gross beta in Livermore site and Livermore Valley surface and drinking water were also below MCLs. The maximum activities for gross alpha and gross beta were 0.29 Bq/L and 0.40 Bq/L, or less than 11% of their respective MCLs (see **Table 7-15**). Maximum tritium activity in storm water (runoff) was 359 Bq/L, or 49% of the MCL (see **Table 7-4**). The EDE to an adult who ingested two liters of water at the maximum storm water tritium concentration for one year would be 0.0049 mSv (0.49 mrem), or 0.49% of the DOE standard allowable dose of 1 mSv. Tritium activities in subsequent samples were much lower, and the overall maximum, excepting the single high value of 359 Bq/L, was 21 Bq/L, or 3% of the MCL (see Table 7-1 of the Data Supplement). Drinking water at this level would result in an EDE of 0.0003 mSv (0.03 mrem), or 0.03% of the DOE standard allowable dose of 1 mSv. Maximum gross alpha and gross beta activities in storm water were 0.15 and 0.61 Bq/L, or 28% and 33% of their respective MCLs (see **Table 7-4**). Past studies, however, have indicated that the majority of the gross alpha and beta activities observed in runoff is due to naturally occurring radioisotopes carried by sediments in the runoff.

Concentrations of some metals in storm water seem to be increasing. Preliminary results indicate that these levels are related to suspended solids in the storm water. Further investigation into the source of these metals is planned. Samples collected during the 1997/1998 wet season for both dissolved and total metals will be evaluated to determine how much of the increase can be attributed to LLNL activities, to off-site sources, and to naturally occurring sediments. Although some 1997 storm water results were above criteria, there is no evidence that indicates any impact to off-site biota. The acute and chronic fish toxicity tests further support the conclusion that LLNL storm water has no adverse effect on off-site biota.

All Site 300 cooling towers that discharge to surface were within their permitted limits for flow, pH, and TDS. All discharges from treatment facilities that discharge to surface were within their compliance limits. Thus, data indicate no impact to surface waters from LLNL Livermore site treatment facilities and Site 300 cooling towers.

7 Surface Water

LLNL maintains an extensive monitoring network for surface water, which includes treatment facility and cooling tower discharges, rainwater, storm water, and both on- and off-site drinking water and water bodies. The sample data indicate that the impact of LLNL Livermore site and Site 300 operations on off-site surface water is negligible.