7

Surface Water Monitoring

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Overview

In accordance with federal, state, and internal requirements, Lawrence Livermore National Laboratory monitors and protects surface water quality at and around the facility. This includes the Livermore site, surrounding regions of the Livermore Valley and Altamont Hills, and Site 300. Specifically in the Livermore vicinity, LLNL monitors reservoirs and ponds, the Livermore site swimming pool, the Drainage Retention Basin (DRB), rainfall, tap water, storm water runoff, and receiving waters. At Site 300 and its vicinity, surface water monitoring encompasses rainfall, cooling tower discharges, drinking water system discharges, storm water runoff, and receiving waters.

Given the diverse activities and environmental conditions at and around the LLNL sites, water samples are analyzed for several water quality parameters including radionuclides, high explosives, residual chlorine, total organic carbon, total organic halides, total suspended solids, conductivity, pH, chemical oxygen demand, total dissolved solids, oil and grease, metals, minerals, anions, temperature, nutrients, and a wide range of organic compounds. In addition, bioassays are performed annually on water entering and leaving the Livermore site via the Arroyo Las Positas, discharges from the DRB, and water contained in the DRB.

The following sections will describe in detail the surface water monitoring programs performed at and around LLNL.

Storm Water

This section provides a general introduction to the storm water program at LLNL, including information on permits, constituent comparison criteria, and building inspections, as well as sampling

methods and results. The goals of the storm water runoff monitoring program are to demonstrate compliance with permit requirements, aid in implementing the Storm Water Pollution Prevention Plans (SWPPPs) (Eccher et al. 1994a, b), assess the risk of storm water contamination from various potential sources, and evaluate the effectiveness of best management practices (BMPs) for preventing storm water contamination.

General Information

Permits

To assess compliance with permit requirements, LLNL monitors storm water at the Livermore site in accordance with Waste Discharge Requirements (WDR 95-174), National Pollutant Discharge Elimination System permit (NPDES Permit No. CA0030023), issued in 1995 by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB 1995). LLNL monitors storm water discharges at Site 300 in accordance with the Statewide General NPDES Permit for Storm Water Discharges Associated with Industrial Activity (WDR 97-03-DWQ, NPDES Permit No. CAS000001, SWRCB).

In addition, Site 300 storm water monitoring meets the requirements of the *Post-Closure Plan for the Pit 6 Landfill Operable Unit* (Ferry et al. 1998). These permits include specific monitoring and reporting requirements. In addition to the storm water quality constituents required by the permits, LLNL monitors other constituents to provide a more complete water quality profile. The current list of analyses conducted on storm water samples is given in **Table 7-1**.

Storm water monitoring follows the requirements in the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. DOE 1991) and meets the applicable requirements of DOE Order 5400.1, *General Environmental Protection Program*, and DOE Order 5400.5, *Radiation Protection of the Public and the Environment*.

NPDES permits for storm water require that LLNL sample effluent two times per year. In addition, LLNL is required to visually inspect the storm drainage system monthly during the wet season (defined as October of one year through April or May of the following year, depending on the permit), 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 at the Livermore site (a total of four sampling events) in support of DOE Orders 5400.1 and 5400.5. In addition, annual facility inspections are required to ensure that the best management practices are adequate and implemented.

LLNL also meets the storm water compliance monitoring requirements of the Statewide General NPDES Permit for Storm Water Discharges Associated with Construction Activity (Order 99-08- DWQ, NPDES Permit No. CAS000002) as modified by Resolution 2001-046 for construction projects that disturb two hectares of land or more (SWRCB 1999, 2001).

Constituent Criteria

Currently, there are no numeric criteria that limit concentrations of specific constituents in LLNL's storm water effluent. The Environmental Protection Agency (EPA) established parameter benchmark values but stressed that these concentrations were not intended to be interpreted as effluent limits (U.S. EPA 2000). Rather, the values are levels that the EPA has used to determine if storm water discharged from any given facility merits further monitoring. Although these criteria are not directly applicable, they are used as comparison criteria to help evaluate LLNL's storm water management

Table 7-1. Analyses conducted on storm water samples, 2001

Livermore site	Site 300
Chemical oxygen demand	Chemical oxygen demand
Dissolved oxygen	Cyanide
Oil and grease	Oil and grease
pH	pH
Specific conductance	Specific conductance
Total dissolved solids	Total dissolved solids
Total suspended solids	Total suspended solids
Anions	Ammonia
General minerals	Potassium
Metals	Metals
Polychlorinated biphenyls (PCBs)	Polychlorinated biphenyls (PCBs) and dioxins
Total organic carbon	Total organic carbon
Fish bioassay (fathead minnow)	Organic compounds
Diuron	Pesticides
Glyphosphate	Explosives (HE)
Herbicides	Total organic halides
Gross alpha and gross beta activity	Gross alpha and gross beta activity
Tritium	Tritium
Plutonium	Uranium

program. To further evaluate the storm water management program, LLNL established or calculated site-specific threshold comparison criteria for a select group of parameters. A value exceeds the threshold if it is greater than the 95% confidence limit computed for the historical mean value for a specific parameter (**Table 7-2**). The threshold comparison criteria are used to identify out-of-the-ordinary data that merit further investigation to determine if concentrations of that parameter are increasing in the storm water runoff.

For a better understanding of how LLNL storm water data relate to other target values, water samples are also compared with criteria listed in the *Water Quality Control Plan, San Francisco Bay Basin* (SFBRWQCB 1995), *The Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board, Central Valley Region, Sacramento and San Joaquin River Basins* (Longley et al. 1994), EPA maximum contaminant levels (MCLs), and ambient water quality criteria (AWQC). The greatest importance is placed on the site-specific comparison criteria calculated from historical concentrations in storm runoff.

In addition to chemical monitoring, LLNL is required by NPDES permit WDR 95-174 to conduct acute and chronic fish toxicity testing in Arroyo Las Positas (Livermore site) once per wet season. Currently, LLNL is not required to test for fish toxicity at Site 300.

Inspections

Each directorate at LLNL conducts an annual inspection of its facilities to verify implementation of the SWPPPs and to ensure that measures to

Table 7-2. Threshold comparison criteria for selected water quality parameters. The sources of values above these are examined to determine if any action is necessary.

Parameter	Livermore site	Site 300
Total suspended solids (TSS)	750 mg/L[a]	1700 mg/L[a]
Chemical oxygen demand (COD)	200 mg/L[a]	200 mg/L[a]
pH	<6.0, >8.5[a]	<6.0, >9.0[b]
Nitrate (as NO_3)	10 mg/L[a]	not monitored
Orthophosphate	2.5 mg/L[a]	not monitored
Mercury	above RL[c]	above RL[c]
Beryllium	0.0016 mg/L[a]	0.0016 mg/L[a]
Chromium(VI)	0.015 mg/L[a]	not monitored
Copper	0.026 mg/L[d]	not monitored
Lead	0.015 mg/L[e]	0.015 mg/L[e]
Zinc	0.35 mg/L[a]	not monitored
Diuron	0.014 mg/L[a]	not monitored
Oil and grease	9 mg/L[a]	9 mg/L[a]
Tritium	36 Bq/L[a]	3.17 Bq/L[a]
Gross alpha	0.34 Bq/L[a]	0.90 Bq/L[a]
Gross beta	0.48 Bq/L[a]	1.73 Bq/L[a]

a Site-specific value calculated from historical data and studies. These values are lower than the EPA benchmarks except for zinc, TSS, and COD.

b EPA benchmark

c RL = reporting limit = 0.0002 mg/L

d Ambient water quality criteria (AWQC)

e EPA primary maximum contaminant level (PMCL)

reduce pollutant loadings to storm water runoff are adequate. The Laboratory's associate directors certified in 2001 that their facilities complied with the provisions of WDR 95-174, WDR 97-03-DWQ, and the SWPPPs. LLNL submits annual storm water monitoring reports to the SFBRWQCB and to the CVRWQCB with the results of sampling, observations, and inspections (Campbell 2001a, b).

For each construction project permitted by Order 99-08-DWQ, the construction staff conducts visual observations of construction sites before, during, and after storms to assess the effectiveness of implemented BMPs. Annual compliance certifications summarize these inspections.

As in past years, the SFBRWQCB requested submission of compliance status reports for the Livermore site construction projects. (The CVRWQCB has never requested compliance status reports for projects located at Site 300.) The 2001 compliance certifications (and compliance status reports) covered the period of June 2000 through May 2001. During this period, three Livermore site projects were inspected: 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), was also inspected under this program. The CFF and DWTF projects were complete and their permits were terminated prior to the deadline; therefore, the annual compliance certifications were not filed for these two projects.

Sampling

For the purpose of evaluating the overall impact of the Livermore site and Site 300 operations on storm water quality, storm water flows are sampled at upstream and downstream locations. Because of flow patterns at the Livermore site, storm water at sampling locations includes runoff from other sources, such as neighboring agricultural land, parking lots, and landscaped areas. In contrast, storm water at Site 300 is sampled at locations that target specific industrial activities with no run-on from off-site sources. These samples provide information used to evaluate the effectiveness of LLNL's storm water pollution control program.

Construction site runoff is sampled to assess the impact of this type of runoff on the receiving water as specified in Resolution 2001-046. Two specific assessments are required by the permit: 1) when the runoff from the project directly enters a water body identified on the state of California's Clean Water Act 303(d) list as being impaired for sediment-related pollutants (siltation, sedimentation, or turbidity), samples must be collected for these pollutants; and 2) when construction site materials that cannot be visually detected are exposed to storm water, runoff must be sampled for the potential non-visible pollutants. LLNL projects do not have to sample for sediment-related pollutants because the receiving waters at neither the Livermore site nor Site 300 are currently identified as being impaired for sediment-related pollutants. To comply with the second required assesment, the specific nonvisible parameters to be sampled at each construction site are identified in the individual project SWPPP.

Livermore Site: As is commonly the case in urbanized areas, the surface water bodies and runoff pathways at LLNL do not represent the natural conditions. The drainage at the 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**).

The DRB was excavated and lined in 1992 to prevent infiltration of storm water that was dispersing groundwater contaminants. It also serves storm water diversion and flood control purposes. The DRB collects about one-fourth of the surface water runoff from the site and a portion of the Arroyo Las Positas drainage (**Figure 7-2**). When full, 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 drains and swales. Arroyo Seco cuts across the southwestern corner of the site. Arroyo Las Positas follows the northeastern and northern boundaries of the site and exits the site near the northwest corner.

The routine Livermore site storm water runoff monitoring network consists of ten sampling locations (**Figure 7-2**). Seven locations characterize storm water either entering (influent: ALPE, ALPO, ASS2, ASSE, and GRNE) or exiting (effluent: ASW and WPDC) 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. Additional locations were sampled beginning in 1999 and continuing through 2001 as part of a tritium source investigation and are described in the "Livermore Site Radioactive Constituents" section in this chapter.

Only the NIF construction site at the Livermore site required sampling in 2001. Four locations (**Figure 7-3**) were selected to characterize runoff flowing into the construction site (influent: NIF1, NIF2, NIF3) and runoff leaving the construction site (effluent: NIF0).

Site 300: Surface water at Site 300 consists of seasonal runoff, springs, and natural and man-made ponds. The primary waterway in the Site 300 area is Corral Hollow Creek, an ephemeral stream that borders the site to the south and southeast. No naturally continuously flowing streams are present in the Site 300 area. Elk Ravine is the major drainage channel for most of Site 300; it extends from the northwest portion of the site to the east-central area. Elk Ravine drains the center of the site into Corral Hollow Creek, which drains eastward

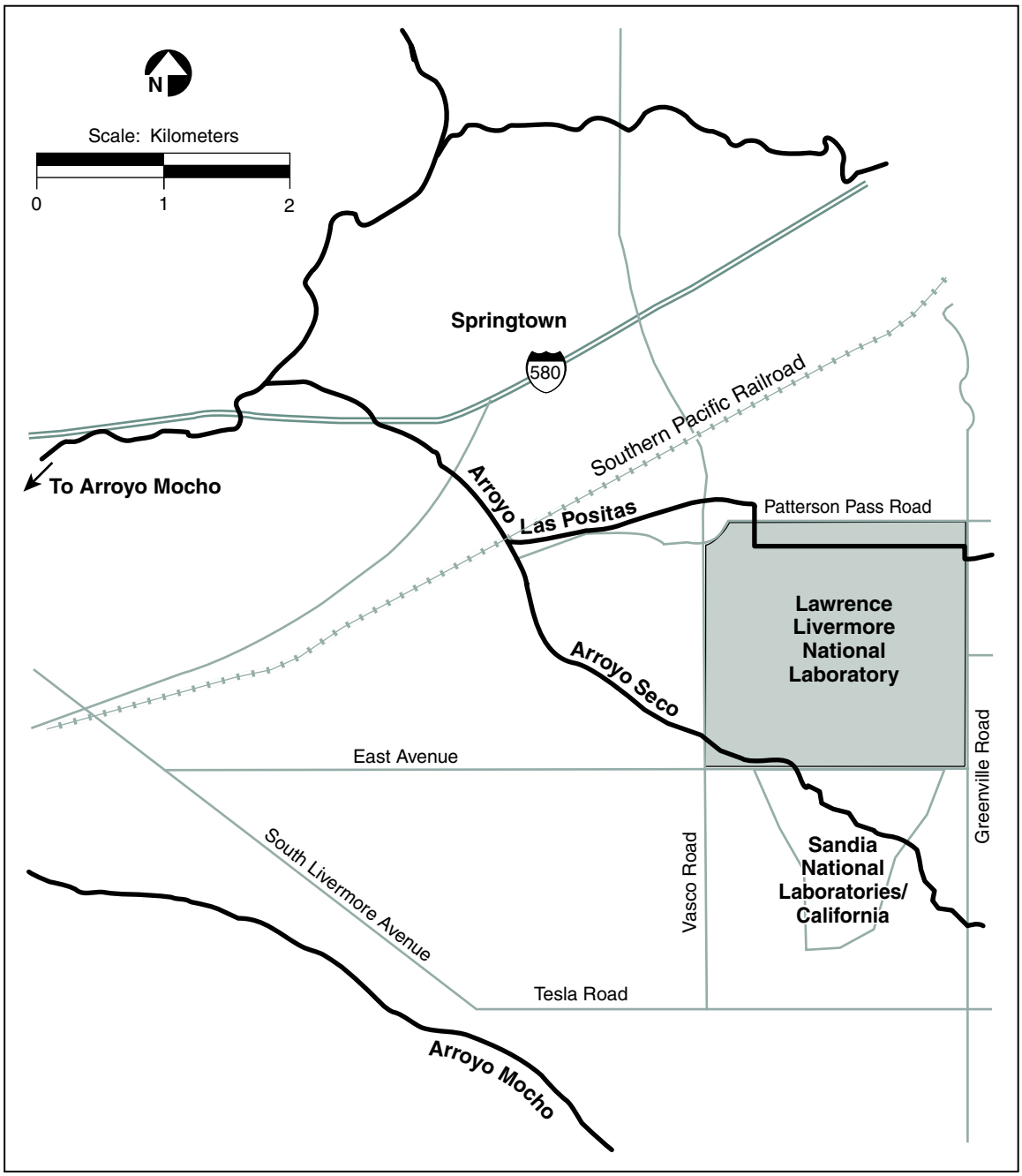

Figure 7-1. Surface waterways in the vicinity of the Livermore site

to the San Joaquin River Basin. Some smaller canyons in the northeast portion of the site drain to the north and east toward Tracy.

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

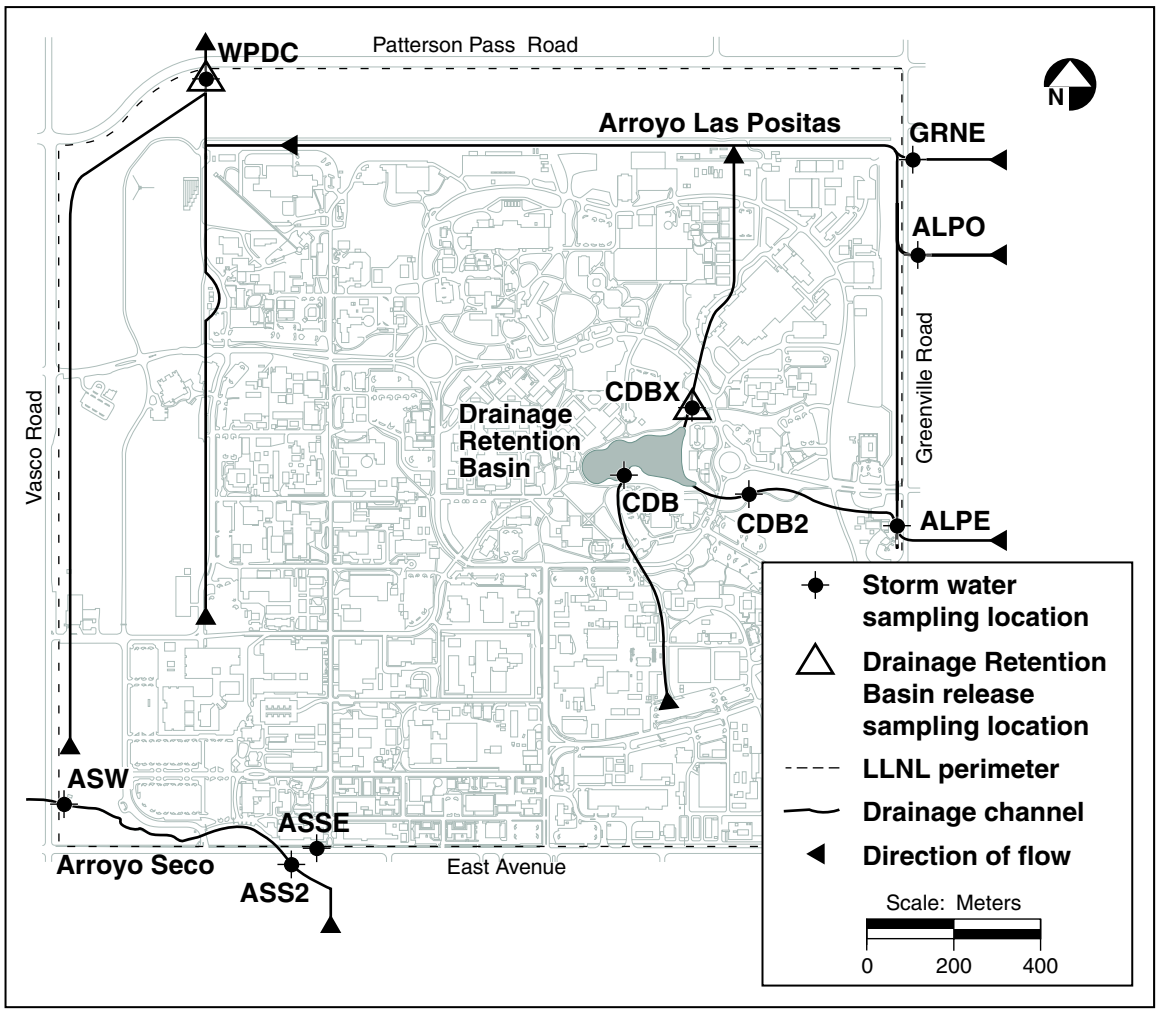

Figure 7-2. **Storm water runoff and Drainage Retention Basin sampling locations, Livermore site, 2001**

vegetation. Numerous artificial surface water bodies are present at Site 300. 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) surface water impoundments are located to the west in the Explosives Process Area. Monitoring results associated with these facilities are reported in Chapter 9. Three wetlands created by now discontinued flows from cooling towers located at Buildings 827, 851, and 865 are currently maintained by discharges of potable water.

The on-site Site 300 storm water sampling network began in 1994 with six locations and now consists of seven locations (**Figure 7-4**). Locations were selected to characterize storm water runoff at locations that could be affected by specific Site 300 activities.

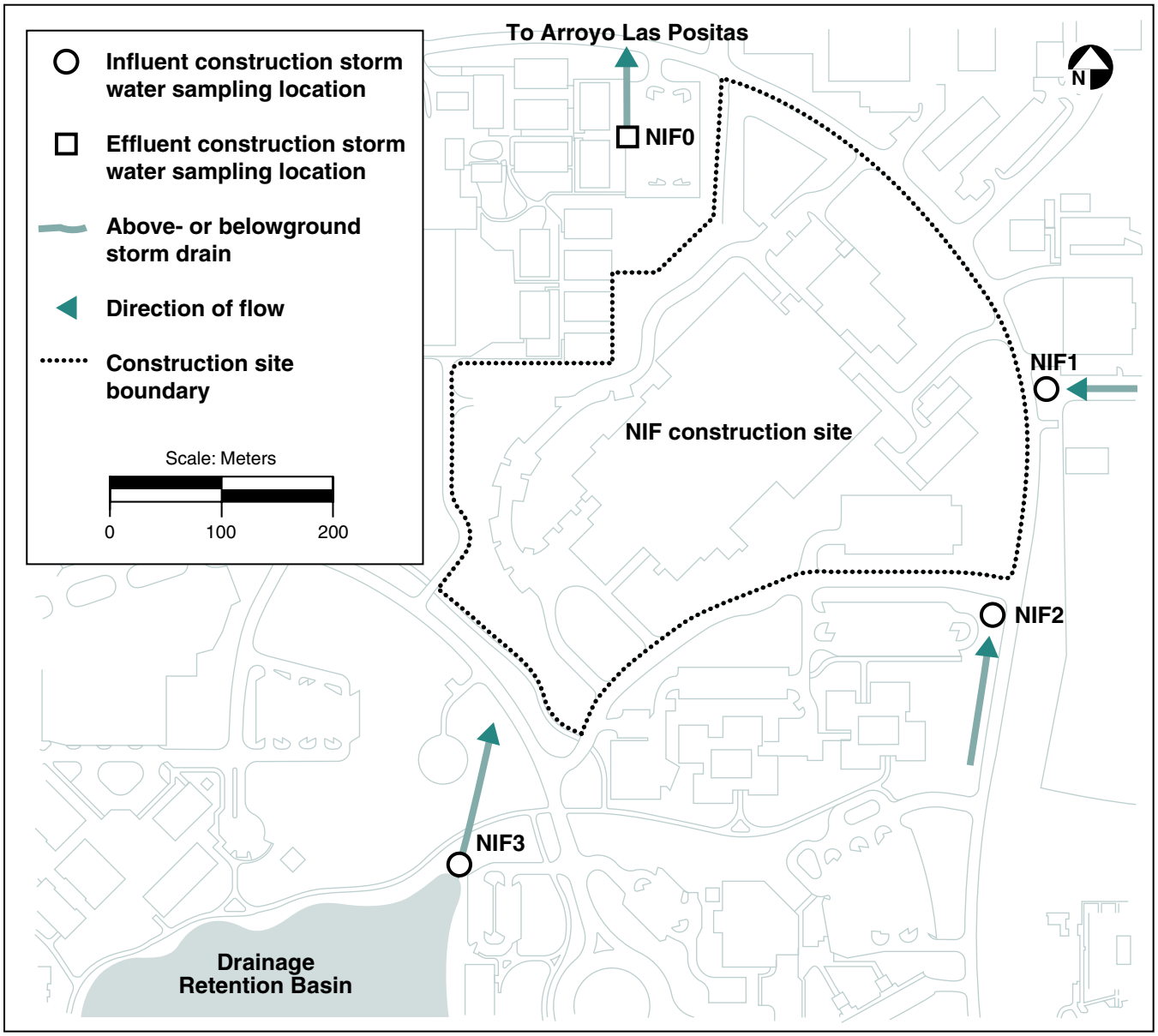

Figure 7-3. Storm water sampling locations for NIF construction project

Off-site location CARW is used to characterize runoff in Corral Hollow Creek upstream and therefore is unaffected by Site 300 industrial activities. Location GEOCRK is used to characterize runoff in Corral Hollow Creek, downstream of Site 300.

No construction projects at Site 300 required storm water sampling in 2001.

Methods

At all monitoring locations at both the Livermore site and Site 300, including construction sites, samples are collected by grab sampling from the

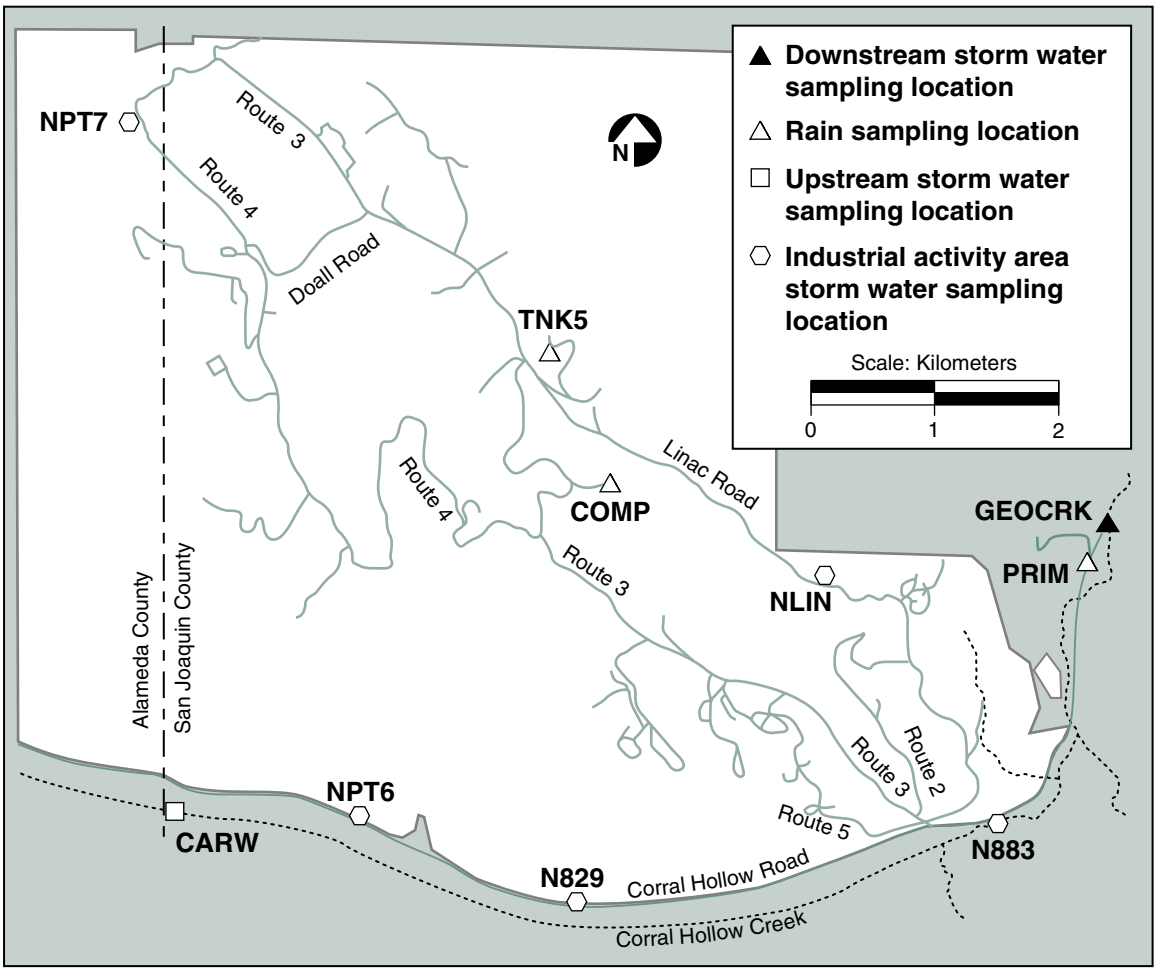

Figure 7-4. Storm water and rainwater sampling locations at Site 300, 2001

storm runoff flowing in the stream channels. Standard sample bottle requirements, special sampling techniques, and preservation requirements for each analyte are specified in the *Environmental Monitoring Plan* (Tate et al. 1999) and summarized below.

Grab samples are collected by partially submerging sample bottles directly into the water and allowing them to fill with the sample water. If the water to be sampled is not directly accessible, a stainless-steel bucket or an automatic water sampler is used for sampling. The bucket is triple-rinsed with the water to be sampled, then dipped or submerged into the water, and withdrawn in a smooth motion. Sampling is conducted away from the edge of the arroyo to minimize the collection of sediment with water samples. Sample vials for volatile organics are filled before sample vials for all other constituents and parameters.

Results

Inspections

The Associate Director for each of the directorates certified that their facilities conducted the 2001 annual inspection of its facilities to verify implementation of the SWPPP and ensure that measures

to reduce pollutant loading to storm water runoff are adequately and properly implemented. Each directorate documents and keeps on file the annual inspection results (as required by WDR 95-174 and 97-03-DWQ). These records include the dates, places, and times of the site inspections and the names of individuals performing the inspections. Because of the large number of facilities inspected (more than 500 buildings and trailers), the detailed inspection results are not included in this report, but the individual inspection records are available for review.

All inspections were completed; findings and deficiencies are summarized in Campbell (2001a,b). There were 11 minor issues listed as the result of the inspections that were not consistent with the BMPs identified in the SWPPP. All of these issues have either been corrected or are in the process of being corrected. All other inspections at both Site 300 and the Livermore site indicated that the applicable BMPs were implemented correctly and adequately.

Additionally, LLNL conducted the permit-required inspections before, during, and after rain events at each of the permitted construction sites: three at the Livermore site and one at Site 300. The findings of these inspections indicated compliance with the permit and the construction site SWPPPs, with one exception documented in the 2000/2001 annual compliance certifications filed in July 2001 for the period of June 2000 through May 2001; the project personnel failed to document some rain event inspections and failed to perform some inspections.

Livermore Sampling

LLNL collected samples at all ten Livermore site locations on February 12, March 2, April 6, November 11, and December 12, 2001. Earlier samples were collected from five locations on January 8, and the remaining five locations were collected on January 10, 2001. The fish and algae toxicity analyses were conducted during the January 8 and 10 samplings, and then again on the November 11 sampling in order to catch the first flush of runoff that occurs at the beginning of the wet season.

Toxicity Monitoring: As required by WDR 95-174, grab samples were collected and analyzed for acute and chronic toxicity using fathead minnows (*Pimephales promelas*) as the test species. In the acute test, 96-hour survival is observed in undiluted storm water collected from location WPDC.

The permit states that an acceptable survival rate is 20 percent lower than a control sample. The testing laboratory provides water for the quality control sample. As specified by the permit, upstream water samples from influent locations ALPO, ALPE, and GRNE are used as additional controls. Thus, a difference of more than 20 percent between location WPDC and the upstream control sample with the lowest survival rate is considered a failed test. If the test is failed, the permit requires LLNL to conduct toxicity testing during the next significant storm event. After failing two consecutive tests, LLNL must perform a toxicity reduction evaluation to identify the source of the toxicity.

During 2001, survival in the acute test at WPDC (January 8 and November, 12) ranged from 95 to 100%, while all influent locations (ALPE, ALPO, and GRNE) ranged from 80 to 100%.

In the chronic fish toxicity test, storm water dilutions of 0 (Lab Control), 6.25, 12.5, 25, 50, and 100 percent (undiluted storm water) were used to determine a dose-response relationship, if any, for both survival and growth of the fathead minnow (**Table 7-3**). This test is only required at effluent location WPDC and not conducted with water from corresponding influent locations. From these

data, no observed effect concentrations (NOECs) and lowest observed effect concentrations (LOECs) were calculated using EPA/600/4-91-002. The NOECs and LOECs for survival and growth were 100 percent. Thus, both the acute and chronic fish toxicity test indicated that storm water had no effect on survival or growth of fathead minnows.

Table 7-3. Fish chronic toxicity test results, Livermore site, January 2001

Sample concentration (%)	7-day survival		7-day weight [a]	
	Avg. (%)	Standard deviation	Avg. (mg)	Standard deviation
Lab control	98	5.0	0.70	0.10
6.25	85	12.9	0.54	0.08
12.5	70	24.5	0.45	0.08
25	93	9.6	0.51	0.07
50	90	8.2	0.48	0.05
100	98	5.0	0.45	0.02

a Weight of the fathead minnows at the end of the 7-day toxicity test.

In addition to the fish toxicity testing, LLNL performed chronic toxicity testing with freshwater algae (*Selenastrum capricornutum*) using water collected from Arroyo Las Positas on January 8, 2001. This chronic test uses the same set of dilutions of storm water as the fathead minnow test. In the algae test, cell counts at each dilution are compared with cell counts in the laboratory control waters.

The algae test indicated toxicity in storm water, with a NOEC of <6.25% and a LOEC of 6.25% (**Table 7-4**). Because this test was conducted at only a single sampling location, it was difficult to determine if the effects should be attributed to LLNL or to upstream water quality. Therefore, additional samples were collected for chronic algae toxicity tests at both the effluent (WPDC) and influent (GRNE, ALPO, and ALPE) locations during the next significant storm event on February 12, 2001. The results of this second sample date indicated that algae growth was more inhibited in water from the influent locations (**Table 7-5**). An investigation into the potential causes of the algae toxicity identified a likely source, a pre-emergent herbicide, diuron.

Table 7-4. Algae chronic toxicity test results, Livermore site, January 2001

Sample concentration (%)	96-hour growth	
	Count (10^6 cells/mL)	Variance (%)
control	1.76	10.3
6.25	0.94	6.5
12.5	0.75	5.4
25	0.38	14.9
50	0.10	4.0
100	0.04	7.6

On January 8, diuron concentrations at the effluent WPDC were 14 µg/L, while at influent sample locations GRNE, ALPO, and ALPE the values were 1600 µg/L, 4.6 µg/L, and 4.5 µg/L, respectively. The obviously high diuron concentration at GRNE makes the pesticide a likely source for the observed toxicity. This hypothesis was verified on February 12 when diuron concentrations were 10.0 µg/L, 79.0 µg/L, 80.0 µg/L, and 3.6 µg/L for WPDC, GRNE, ALPO, and ALPE, respectively.

An electrical transfer station upstream of the Livermore site on Greenville Road contributes significant storm water to the GRNE sampling location and some to the sampling location ALPO. A plot of historical concentrations of diuron entering the site from GRNE and leaving LLNL at WPDC reveals that influent (GRNE) concentrations are most often higher than at the effluent (WPDC) (**Figure 7-5**). There are a number of

Table 7-5. Chronic algae toxicity test results in Arroyo Las Positas storm water on February 12, 2001

Sample concentration (%)	96-hour growth	
	Count (10^6 cells/mL)	Variance (%)
WPDC		
control	1.349	8.7
6.25	1.683	5.8
12.5	1.399	7.9
25	0.991	6.7
50	0.623	9.5
100	0.174	9.7
GRNE		
control	1.456	6.9
6.25	0.067	9.3
12.5	0.026	5.1
25	0.017	9.3
50	0.014	10.6
100	0.013	13.9
ALPO		
control	1.355	6.3
6.25	1.221	11.9
12.5	0.534	4.3
25	0.205	9.4
50	0.048	19.8
100	0.024	9.5
ALPE		
control	1.414	11.56
6.25	1.510	7.17
12.5	1.597	19.88
25	1.028	8.30
50	0.684	2.49
100	0.178	6.67

high diuron values coming on-site from an off-site source, but the values in January and December 2001 are more than two orders of magnitude greater than the comparison threshold of 14 µg/L (**Table 7-2**).

A source evaluation study was performed by LLNL that provided additional evidence that the upstream electrical transfer station was indeed the source of the pesticide. A complete summary of the source evaluation is presented in Campbell et al. (2002). The operators of the electrical transfer station have been contacted and informed of our findings in the pesticide source evaluation.

Livermore Site Radioactive Constituents: Storm water sampling and analysis were performed for gross alpha, gross beta, plutonium, and tritium. Storm water gross alpha, gross beta, and tritium results are summarized in **Table 7-6.** Complete results are in Data Supplement Tables 7-1, 7-2, and 7-3. Tritium activities at effluent locations were less than 1% of the MCL. Radioactivity in the storm water samples collected during 2001 was generally low, with medians around background levels.

LLNL began analyzing for plutonium in storm water in 1998. Samples were analyzed from the Arroyo Seco and Arroyo Las Positas effluent locations (ASW and WPDC). The unfiltered water was analyzed when the samples were low in suspended sediments. When the analytical laboratory determined that water samples contained sufficient sediment (as it did on January 8, 2001), a portion of the runoff was analyzed unfiltered, and the remaining runoff was filtered. The filtrate and filtered water were analyzed (three analyses total from each location). Plutonium was not above the detection limit for either the liquid or sediment portion of the storm water samples in 2001. Thus, there is no evidence in the data to indicate that LLNL has contributed plutonium to runoff.

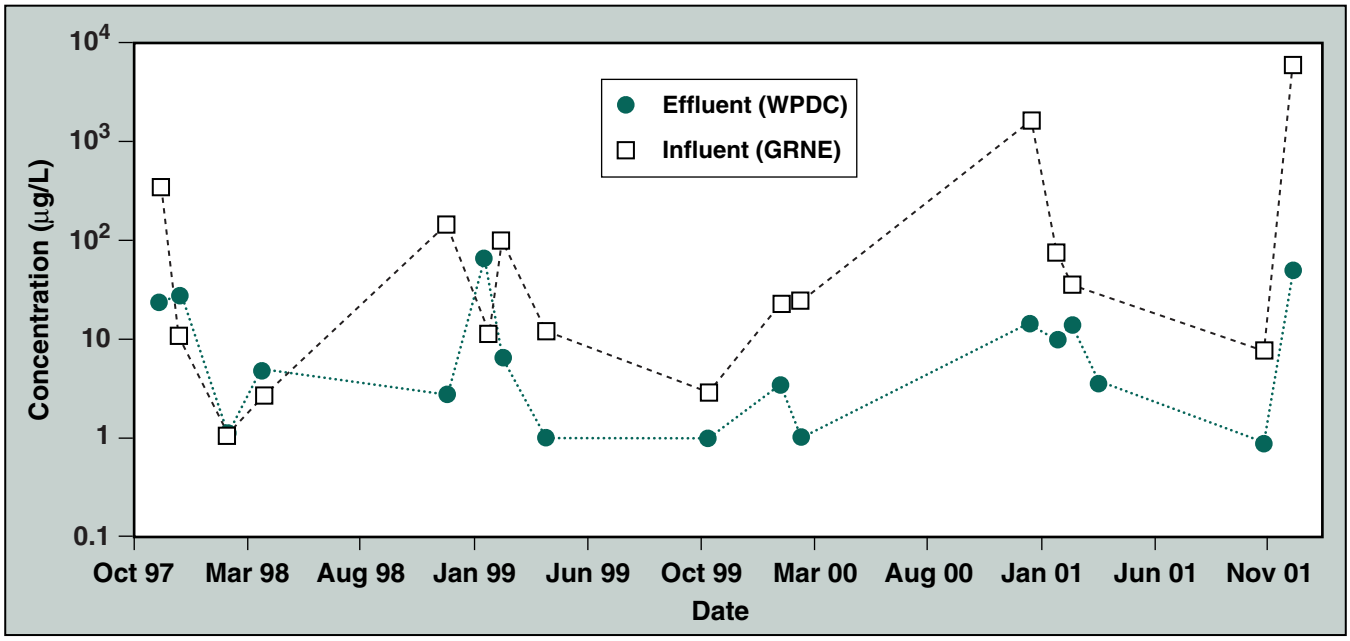

Figure 7-5. Diuron concentrations in Arroyo Las Positas storm water 1997–2001

Table 7-6. Radioactivity in storm water from the Livermore site, 2001[a]

Parameters	Tritium (Bq/L)	Gross alpha (Bq/L)	Gross beta (Bq/L)
MCL	740	0.555	1.85
Influent			
Median	–0.04	0.02	0.09
Minimum	–2.41	–0.01	–0.19
Maximum	2.44	0.14	0.55
Effluent			
Median	0.32	0.01	0.09
Minimum	–2.51	–0.25	0.02
Maximum	–6.48	0.06	0.13

a See Chapter 14 for a complete explanation of calculated values.

Beginning with the 1996/1997 season, the tritium activity in Arroyo Las Positas was observed to be higher in storm water leaving the site than in storm water entering the site. On May 23, 1997, at location WPDC, where effluent is measured, a single higher-than-typical result for tritium in storm water (359 Bq/L) was measured. The historical trend in tritium levels at location WPDC is presented in Figure 7-6.

In response to the elevated effluent tritium levels, additional tritium investigations were initiated in the fall of 1998 to identify potential sources of tritium to the storm runoff. The initial approach taken to evaluate tritium flow patterns across the Livermore site was to evaluate four locations upstream of WPDC (WPDW, 196S, WPDS, and 196E), where the storm drainage channels join the main Arroyo Las Positas channel and leave the Livermore site (Figure 7-7). Samples were collected at these junctures on November 30, 1998, and reported in the *Environmental Report 1998* (Larson et al. 1999). Tritium was not detected in 2 of the 3 incoming channels (calculated values of 2.0 and 0.9 Bq/L at WPDW and 196S, respectively), but was detected at 31 Bq/L in the main Arroyo Las Positas channel.

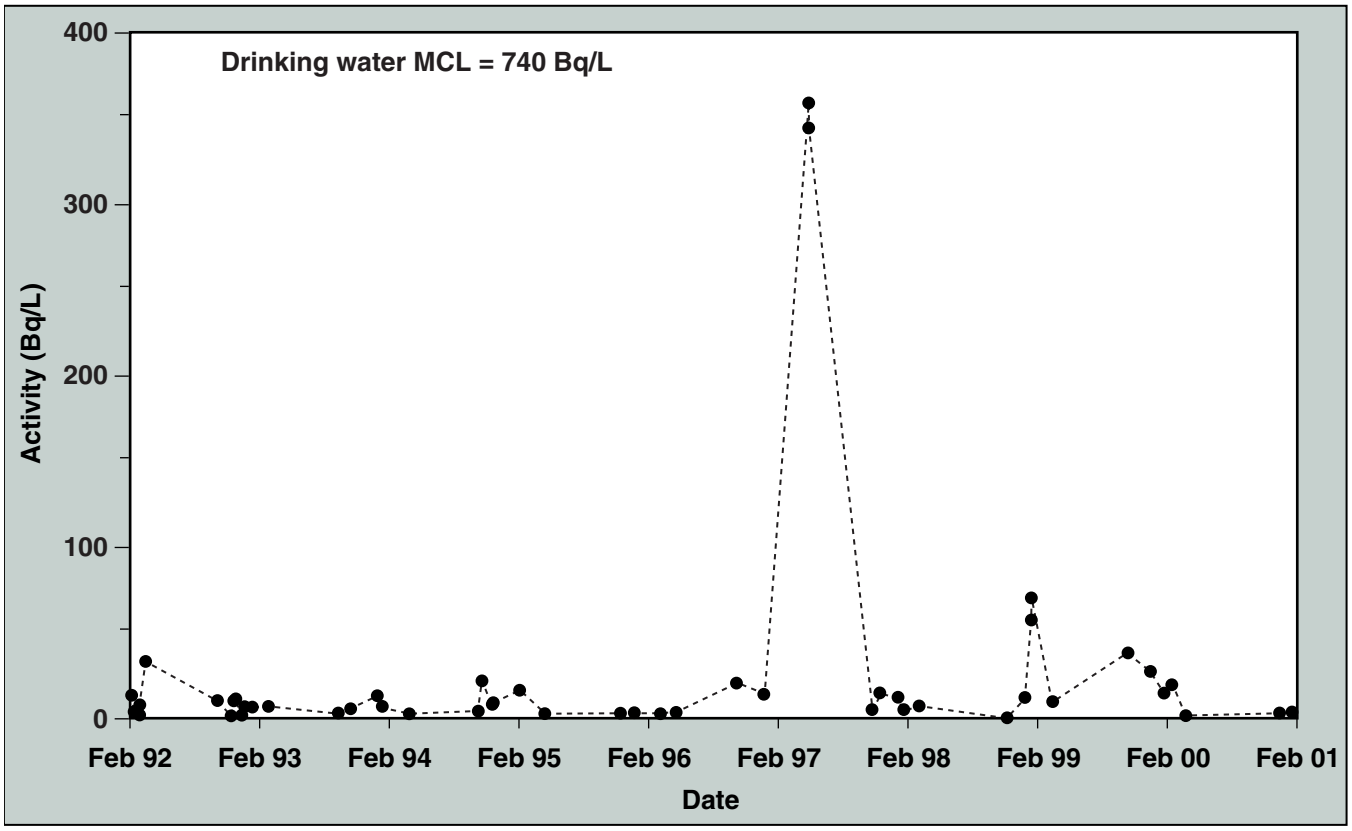

Figure 7-6. Tritium activity in Livermore storm water samples from the Arroyo Las Positas (location WPDC) 1992–2001

Detailed tritium observations from locations in the vicinity of Building 331 (Figure 7-7) and in the associated north-south storm drain, found increased tritium activities revealing the location of the source. Specifically, higher levels were found at location 3726 near Buildings 331 and 343. The source of elevated tritium was tracked to a transportainer containing materials exposed to tritium.

Sampling of surface runoff in the vicinity of the transportainer near Building 343 found tritium concentrations as high as 41,100 Bq/L in April 2000. These samples were taken in the parking lot directly down gradient from the transportainer. This radioactivity was significantly diluted in the overall site runoff so that samples collected at the site outlet (WPDC) on the same day were not more than 4% of the drinking water standard for tritium (740 Bq/L). Continued monitoring of both surface runoff near Building 343 and sampling in the storm channels have demonstrated a rapid decrease in measured tritium activities since the transportainer was removed in August 2000 (Figure 7-8). Monitoring of this network in 2001 demonstrated that tritium activities in the north-south storm drain near Building 343 have returned to near-background levels (Figure 7-9).

Concurrent with the environmental investigation of the source of tritium in the environment, programmatic personnel conducted a conscientious and thorough review of operations, and identified

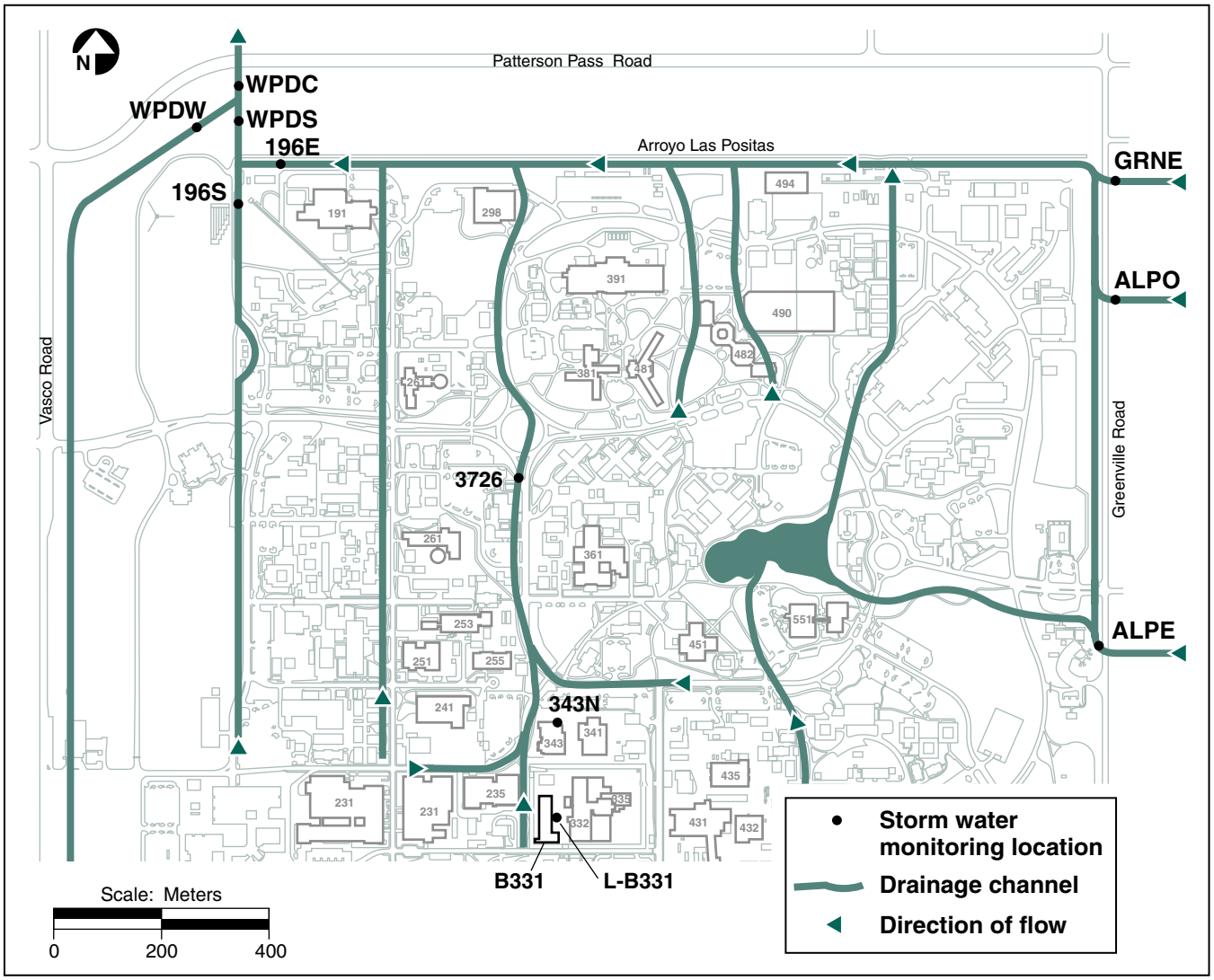

Figure 7-7. Sampling locations for the special tritium studies performed at Livermore site

mechanisms and implemented plans to prevent similar releases in the future.

Livermore Site Nonradioactive Constituents: In addition to data on radioactivity, the results for other water quality parameters were analyzed. Sample results were compared with the comparison criteria in Table 7-2; of greatest concern are the constituents that exceed comparison criteria at effluent points and whose concentrations are lower in influent than in effluent. If influent concentrations are higher than effluent concentrations, the source is generally assumed to be unrelated to LLNL operations; therefore, further investigation is not warranted. Constituents that exceeded comparison criteria for effluent and influent locations are listed in Table 7-7.

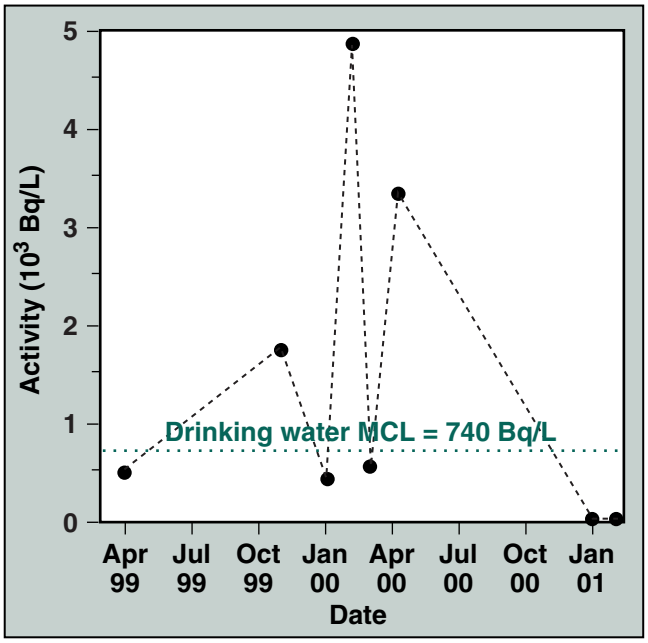

Figure 7-8. Tritium activities in storm water samples from the downstream storm drain location 3729 near the Tritium Facility

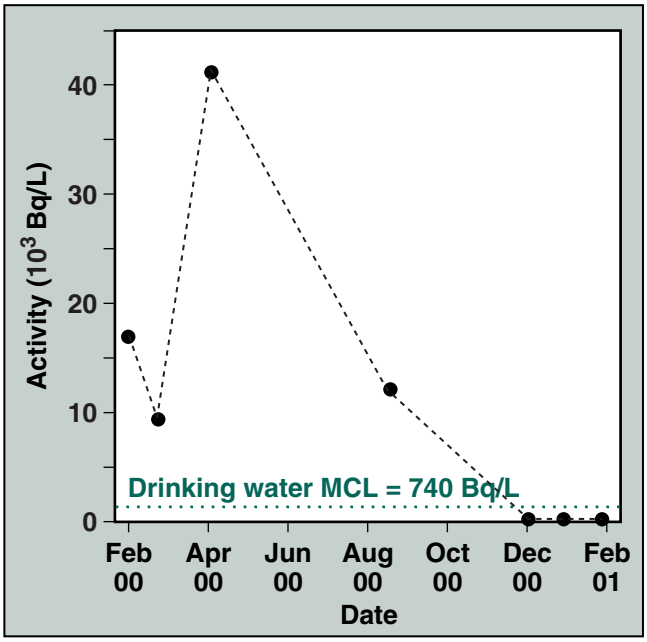

Figure 7-9. Tritium activities in storm water samples from the storm drains near Building 343

Many of the effluent values listed in Table 7-7 were recorded at influent tributaries to Arroyo Las Positas and Arroyo Seco. In particular, nitrate values in storm water flowing on site in 2001 appear to be elevated. Upstream activities near the Livermore site include cattle ranching that is a potential source for nitrogen. Another influent contaminant is the herbicide diuron that was involved in the previously discussed algae toxicity.

The particularly high value of diuron at location GRNE on December 20 is the highest on record. The upstream electrical transfer station operators have been notified of this problem. A single high oil and grease value was measured at effluent location WPDC on January 8; this was an isolated incident likely resulting from roadway runoff.

Complete storm water results for nonradioactive constituents are presented in Data Supplement Table 7-3.

To enhance the storm water monitoring program, in 2000 LLNL began to examine using easily measured water quality parameters as indicators for those not as easily measured. Many basic chemical characteristics (e.g., pH, dissolved oxygen, and specific conductance) of storm water may be monitored in the stream channel in real time. As a precursor to designing a storm water monitoring system to collect regular data over short sampling intervals, relationships between water quality parameters and an indicator, such as pH, must first be examined. To this end, LLNL performed regression analysis on the water quality data to relate pH and other storm water constituents.

Last year, significant correlations were found to exist between specific conductivity and other water quality parameters (Biermann et al. 2001). In 2001, various parameters were compared to pH and linear regression models, and the relative fits (R^2 values) of that model were estimated.

Table 7-7. Water quality parameters above the threshold comparison criteria shown in Table 7-2 from both the Livermore site and Site 300 in 2001

Parameter	Date	Location	Influent or Effluent	Result (mg/L)	LLNL threshold criteria (mg/L)
Livermore Site					
Nitrate (as NO_3)	1/8	ALPO	Influent	12	10
	2/12	ALPO	Influent	13	10
	3/2	ALPO	Influent	14	10
	4/6	ALPO	Influent	11	10
	11/12	ALPO	Influent	10	10
	12/20	ALPO	Influent	22	10
	1/10	CDB	DRB	12	10
	2/12	CDB	DRB	12	10
	4/6	CDB	DRB	13	10
	11/12	CDB	DRB	13	10
	3/2	CDBX	DRB	10	10
	12/20	CDBX	DRB	15	10
	1/10	GRNE	Influent	37	10
	2/12	GRNE	Influent	10	10
	3/2	GRNE	Influent	10	10
	11/12	GRNE	Influent	69	10
	12/20	GRNE	Influent	19	10
	1/8	WPDC	Effluent	19	10
	12/20	WPDC	Effluent	12	10
Oil and Grease	1/8	WPDC	Effluent	14	9
Chemical Oxygen Demand	11/12	ALPO	Influent	275	200
	12/20	CDB2	DRB	210	200
Bromacil	1/10	GRNE	Influent	2.5	none
	2/12	GRNE	Influent	1.2	none
	3/2	GRNE	Influent	0.65	none
	11/12	GRNE	Influent	0.3	none
	12/20	GRNE	Influent	6.9	none

Table 7-7. Water quality parameters above the threshold comparison criteria shown in Table 7-2 from both the Livermore site and Site 300 in 2001 (continued)

Parameter	Date	Location	Influent or Effluent	Result (mg/L)	LLNL threshold criteria (mg/L)
Diuron	2/12	ALPO	Influent	0.08	0.014
	3/2	ALPO	Influent	0.093	0.014
	4/6	ALPO	Influent	0.018	0.014
	4/6	CDB	DRB	0.021	0.014
	4/6	CDB	DRB	0.021	0.014
	3/2	CDB2	DRB	0.014	0.014
	12/20	CDB2	DRB	0.015	0.014
	1/10	GRNE	Influent	1.6	0.014
	2/12	GRNE	Influent	0.079	0.014
	3/2	GRNE	Influent	0.036	0.014
	12/20	GRNE	Influent	5.3	0.014
	1/8	WPDC	Effluent	0.014	0.014
	12/20	WPDC	Effluent	0.051	0.014
Copper	11/12	ALPO	Influent	0.055	0.026
Zinc	2/12	ASS2	Influent	0.39	0.35
Site 300					
Total suspended solids (TSS)	12/20	CARW	Influent	21000	1700
	12/20	NPT7	Effluent	2300	1700
Chemical Oxygen Demand	12/20	CARW	Influent	740	200
	12/20	NPT7	Effluent	490	200
Lead	12/20	CARW	Influent	0.14	0.015
Mercury	12/20	CARW	Influent	0.00035	0.0002

Good correlations were observed for total hardness, chloride, fluoride, sodium, specific conductivity, and sulfate with correlation coefficients (R^2) ranging from 0.65 to 0.53. All of these are likely correlated due to the groundwater source issue. No significant correlations exist with aluminum, iron, zinc, orthophosphate, and nitrate. This exercise demonstrates that the potential exists to use a few easily measurable water quality parameters to represent the transport distributions of other chemical components in storm runoff. Both pH and specific conductance have been established to be reasonable indicators for general minerals (ions), some metals, total hardness, and sulfates in the storm water in the Arroyo Las Positas.

Livermore Site Construction Runoff: The NIF Construction SWPPP (Mathews 2001) documents the evaluation of the potential for nonvisible pollutants to contaminate construction site runoff.

The SWPPP includes evaluations of both the construction phase and potential previousLY existing pollutants. The SWPPP identifies PCBs as the only potential previously existing pollutant. No construction phase pollutants are identified because BMPs prevent exposure of the materials to storm water runoff.

Storm water samples were collected from the first three runoff-generating storm events. Samples collected on November 12 and 29, and December 20, 2001, indicated results of <0.2 µg/L of PCBs in all influent and effluent samples. The results of the this sampling, conducted during the 2001/2002 rainy season, will be reported to the SFBRWQCB in the July 2002 annual compliance certification

Site 300 Sampling

LLNL procedures specify sampling a minimum of two storms per rainy season from Site 300. Typically, a single storm does 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. In 2001, samples were collected at locations with flow on March 2, April 6, and December 20. There was no tritium above the minimum detectable activity in Site 300 storm water during 2001. The maximum values of all gross alpha and gross beta results were 0.31 and 0.96 Bq/L, respectively, approximately 55% and 52% of the drinking water MCLs (0.56 and 1.85 Bq/L). These gross alpha and gross beta values recorded on December 20, were the highest recorded for the year. Although these values are higher than those at the Livermore site, they are not unusual. This area has had relatively high background gross alpha and beta levels in stream flow that are closely associated with suspended sediment (Harrach et al. 1996).

Sampling at Pit 6 includes analyses required as part of the postclosure sampling; however, no storm runoff was sampled as the drains did not produce any runoff to collect in 2001.

Specific conductance and TSS at Site 300 locations were at times above internal comparison criteria and EPA benchmarks. However, effluent levels were lower than levels at the upstream location CARW, indicating that the levels observed in effluent are typical for the area. Suspended sediment is an issue in Corral Hollow Creek, but it is clear that activities at Site 300 are not producing a majority of that sediment. In fact, storm water from the site appears to be contributing to the dilution of the upstream water that contains higher sediment loads (Table 7-8).

Table 7-8. Total suspended solids in storm water samples from Site 300 in 2001

Sampled date	Location	Total suspended solids (mg/L)
3/2	CARW	94
3/2	GEOCRK	5.8
4/6	GEOCRK	32
4/6	NPT7	28
12/20	CARW	21000
12/20	GEOCRK	12
12/20	N883	31
12/20	NPT7	2300

All the values over the thresholds in Table 7-7 at Site 300 are associated with high suspended sediment. Of particular concern is the high total suspended solids at sampling location NPT7. This sediment was reported to be fine particles resuspended from sediment traps. Regular maintenance of these traps is performed; however, in this case the mainteneance was not in time to clear the sediment before this storm. In the future, careful

attention will be given to ensure sediment is removed for the traps prior to the start of the rainy season.

The valley floor is dominated by an off-road motorcycle use area and ranching activities that are potential sources for sediment. All other Site 300 results were below comparison criteria.

Rainfall

This section discusses general information about rainfall in the Livermore site, Livermore Valley, and Site 300, as well as methods for sampling rainfall and the sampling results. Rain water is collected and analyzed for tritium activities in support of DOE Orders 5400.1 and 5400.5. Currently only tritium activity measurements are required in this network as emissions from the Tritium Facility are the only activity associated with operations at LLNL that has the potential to impact rain water quality.

General Information

Livermore Site and Livermore Valley

Historically, the tritium activity measured in rainfall in the Livermore Valley results primarily from atmospheric emissions of tritiated water (HTO) from stacks at LLNL's Tritium Facility (Building 331), and from the former Tritium Research Laboratory at the Sandia National Laboratories/ California (Sandia/California). The total measured atmospheric emission of HTO from the Tritium Facility at LLNL in 2001 was 0.68 TBq (18.3 Ci) (see Chapter 4).

The rain sampling locations are shown in **Figure 7-10**. The fixed stations are positioned to record all ranges of trituim activity including the maximum activity expected through background levels. The Building 343 rain sampling location is near the Tritium Facility (Building 331) and has historically recorded the maximum tritium activity in rainfall.

Site 300

One off-site location (PRIM) and two on-site locations (COMP and TNK5) are used to collect rainfall for tritium activity measurements at Site 300 (**Figure 7-4**).

Methods

Rainfall is sampled for tritium according to written procedures described in Appendix B of the *Environmental Monitoring Plan* (Tate et al. 1999) and summarized here. Rainfall is collected in stainless-steel buckets at specified locations. The buckets are placed in open areas and are elevated about 1 m above the ground to prevent collection of splash-back water. Rainwater samples are decanted into 250-mL amber glass bottles with Teflon-lined lids. The tritium activity of each sample is measured by scintillation counting (EPA Method 906).

Results

Livermore Site and Livermore Valley

During 2001, LLNL collected sets of rain samples following 4 rainfall events at the Livermore site (31 total routine samples obtained) and Site 300 (12 total routine samples obtained). The tritium activities of rainwater samples obtained during 2001 are listed in Table 7-6 of the Data Supplement.

The Livermore site rainfall has exhibited elevated tritium activities in the past (Gallegos et al. 1994). During 2001, however, no measurements of tritium activity in rainfall were above the 740 Bq/L MCL established by the EPA for drinking water. The activities of most samples were very low, and most were at background level. As in the past, the on-site rainfall sampling location 343N (the sampling location nearest the Tritium Facility)

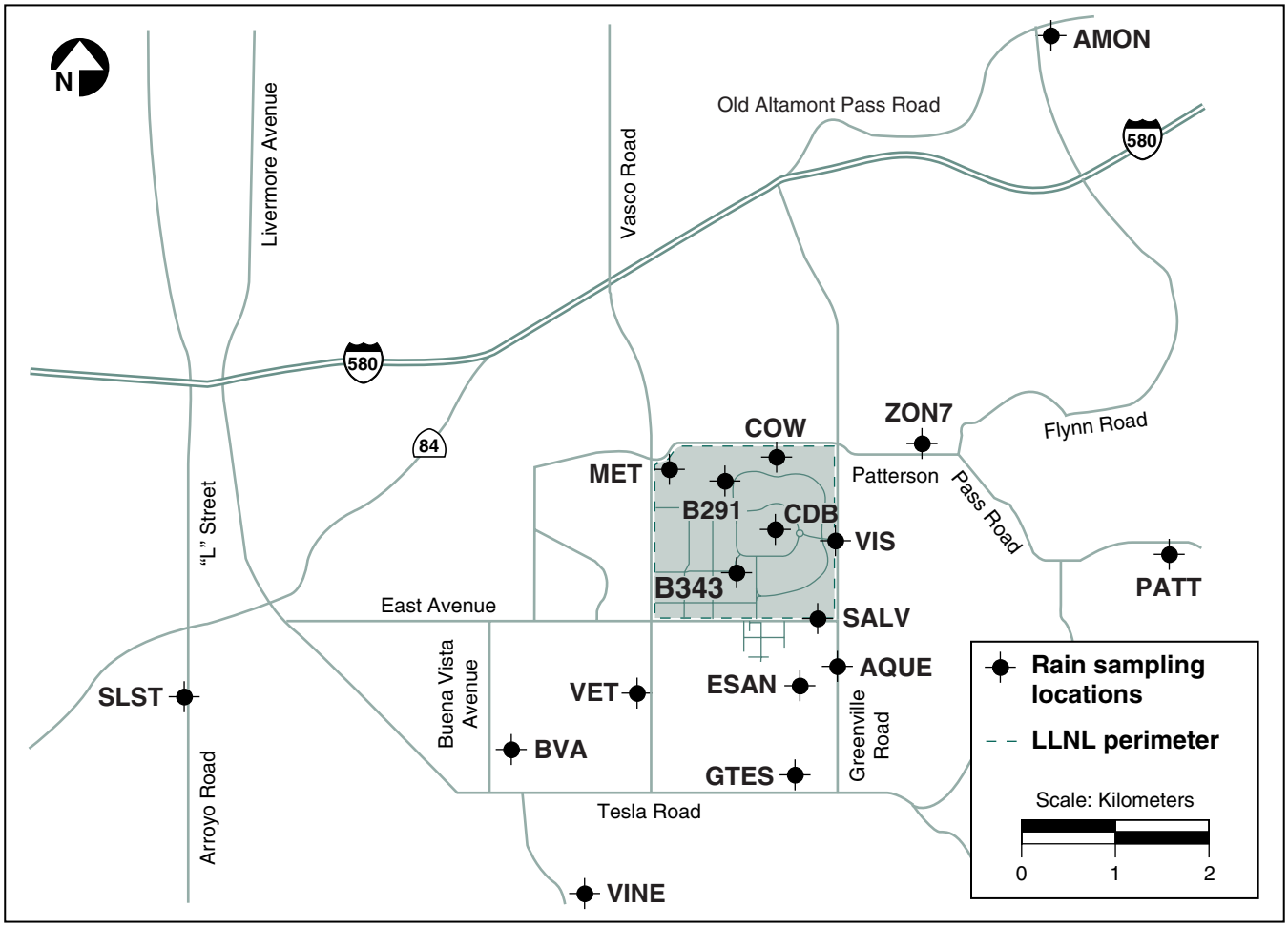

Figure 7-10. Rain sampling locations, Livermore site and Livermore Valley, 2001

showed the highest tritium activity for the year: 14.1 Bq/L (see Table 7-9) for the rainfall event that immediately preceded the February 12 collection date. The highest off-site tritium activity, measured in a routine sample during 2001, was less than 2.4 Bq/L (this sample was collected March 2 at location ESAN). All of the off-site routine rainfall samples measured during 2001 showed tritium activities less than 0.4% of the tritium MCL for drinking water.

The median tritium activity measured in rainfall at LLNL decreased from 3.7 Bq/L in 2000 to 1.97 Bq/L in 2001. This was primarily because of an overall reduction of on-site HTO emissions (see Chapter 4). The median tritium activity for rainfall at LLNL during 2001 reached its lowest level in the twelve-year period beginning in 1990 when it was 65.9 Bq/L. This decrease mirrors the downward trend in total HTO emissions from LLNL's Tritium Facility (shown in Figure 7-11).

Table 7-9. Tritium activities in rainfall for the Livermore site, Livermore Valley, and Site 300, 2001

Parameter	Livermore site (Bq/L)	Livermore Valley (Bq/L)	Site 300
Median	1.97	–0.69	0.34
Minimum	–2.65	–2.46	–2.19
Maximum	14.10	2.39	0.54
Number of samples	31	36	12

Note: Tritium activities are presented relative to a low activity standard or "dead water." As a result, it is possible to have negative values or measurements that are lower than the reference "dead water" standard.

Tritium activities shown in **Figure 7-11** are derived from the on-site and valley rain sampling locations and have been placed in five groups based on their direction from the Tritium Facility. Onsite there have been elevated tritium activities in the last three years (particularly at those close to the Tritium Facility at the on-site sampling location B343 that are the likely result of the transportainer issue already discussed in the Livermore Site Radioactive Constituents section of the "Storm Water" section of this chapter). Grouping the sampling locations in this manner reveals the major direction the wind moves tritium from the stacks at the tritium facility. The locations southwest and northwest of the facility have the lowest tritium activities in rainfall. The highest tritium activities not in areas of known contamination are those northeast and southeast of the facility.

The higher values at the northeast and southeast directions are the result of tritium emissions from the Tritium Facilities at LLNL and Sandia/California. Operations at LLNL were significantly reduced after 1991, when the administrative limit for the LLNL Tritium Facility was reduced from 300 g to 30 g. Operations at the Sandia/California Tritium Facility ceased in October 1994. The reduced measurements of tritium in rain reflect the reduction of emissions from the facilities.

Site 300

As in the past, none of the twelve routine rain samples obtained from monitoring locations at Site 300 during 2001 showed tritium activities above background activity, which is approximately 2 Bq/L (see Table 7-6 in the Data Supplement).

Livermore Site Drainage Retention Basin

This section discusses general information about the DRB, sampling methods, and sampling results.

General Information

Previous environmental reports detail the history of the construction and management of the DRB (see Harrach et al. 1995, 1996, 1997). Beginning in 1997, LLNL discharges to the DRB included routine treated groundwater from Treatment Facilities D and E, and from related portable treatment units. These discharges contribute a year-round source of water entering and exiting the DRB. Storm runoff still dominates wet weather flows through the DRB, but discharges from the treatment facilities now constitute a substantial portion of the total water passing through the DRB.

The SFBRWQCB regulates discharges from the DRB within the context of the Livermore site CERCLA *Record of Decision* (ROD) (U.S. DOE 1993), as modified by the *Explanation of Significant Differences for Metals Discharge Limits at the Lawrence Livermore National Laboratory Livermore Site* (Berg et al. 1997). The CERCLA ROD establishes discharge limits for all remedial activities at the Livermore site to meet applicable, relevant, and appropriate requirements derived from laws and regulations identified in the ROD, including the

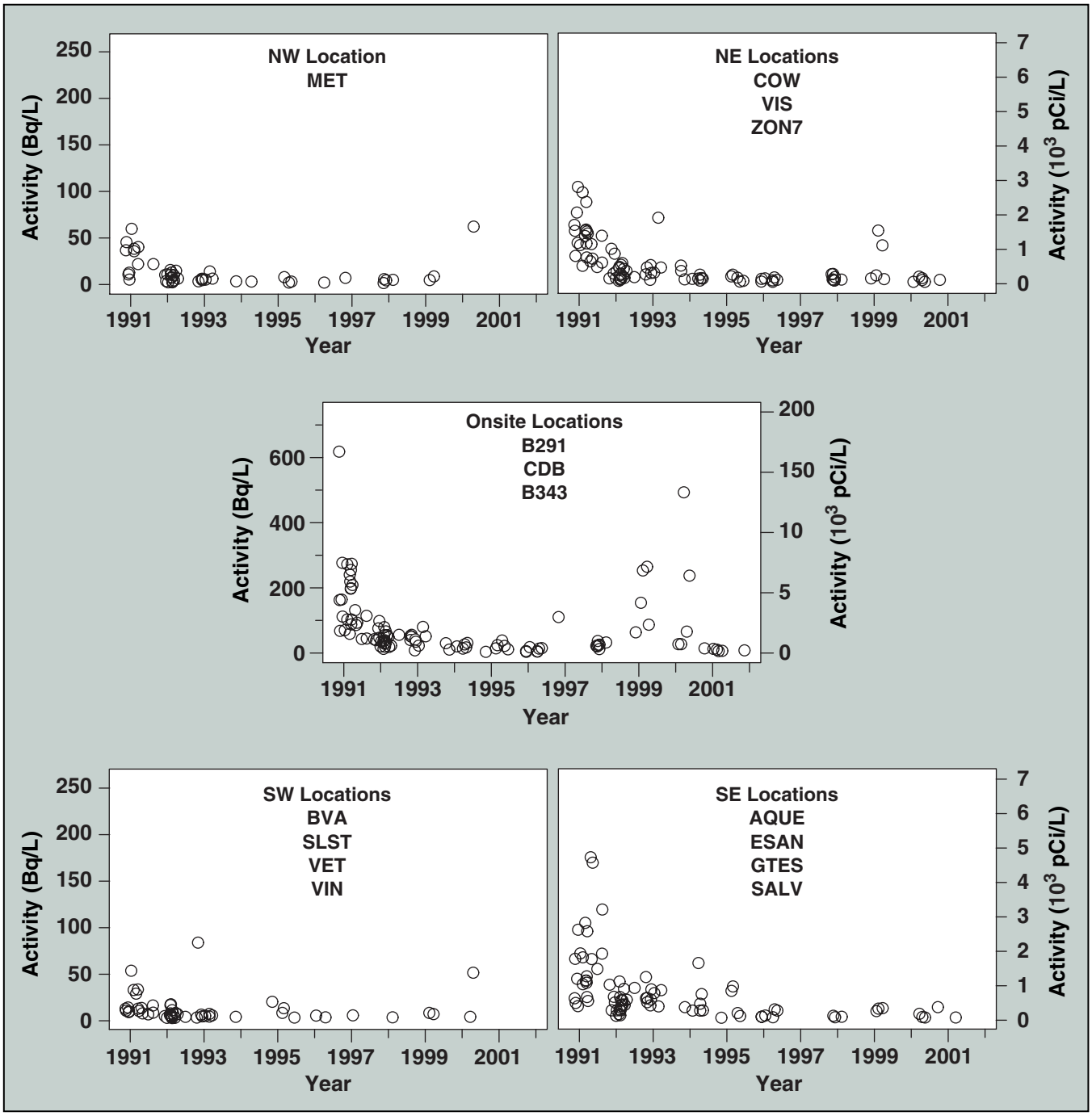

Figure 7-11. **Mean tritium activities (detections only) in rain at locations in the Livermore vicinity grouped by direction from the Tritium Facility, 1990-2001**

Federal Clean Water Act, the Federal and State Safe Drinking Water Acts, and the California Porter-Cologne Water Quality Control Act.

The DRB sampling program implements requirements established by the SFBRWQCB. The program consists of monitoring wet and dry weather releases for compliance with discharge limits, monitoring DRB water quality to support management actions established in the *Drainage Retention Basin Management Plan* (DRB Management Plan) (Limnion Corporation 1991), characterizing water quality before its release, and performing routine reporting. For purposes of determining discharge monitoring requirements and frequency, the wet season is defined as October 1 through May 31, the period when rain-related discharges usually occur (Galles 1997). Discharge limits are applied to the wet and dry seasons as defined in the *Explanation of Significant Differences for Metals Discharge Limits at the Lawrence Livermore National Laboratory Livermore Site* (Berg et al. 1997) (wet season December 1 through March 31, dry season April 1 through November 30).

To characterize wet-season discharges, LLNL samples DRB discharges (at location CDBX) and the corresponding site outfall (at location WPDC) during the first release of the rainy season, and from a minimum of one additional storm (chosen in conjunction with storm water runoff sampling). During the dry season, samples are collected, at a minimum, from each discrete discharge event. Discharge sampling locations CDBX and WPDC are shown in **Figure 7-2**. LLNL collects samples at CDBX to determine compliance with discharge limits. Sampling at WPDC is done to identify any change in water quality as the DRB discharges travel through the LLNL storm water drainage system and leave the site. Sampling frequencies for CDBX and WPDC and effluent limits for discharges from the DRB, applied at CDBX, are found in Table 7-7 of the Data Supplement.

The routine management constituents, management action levels, and monitoring frequencies that apply to water contained in the DRB are identified in Data Supplement Table 7-8 and were established based on recommendations made in the DRB Management Plan. LLNL collects samples at the eight locations identified in **Figure 7-12** to determine whether water quality management objectives are met. Dissolved oxygen content and temperature are measured at the eight locations, while samples for the remaining chemical and physical constituents are collected from sample location CDBE because of the limited variability for these constituents within the DRB. CDBE is located at the middle depth of the DRB.

The DRB Management Plan identifies biological and microbiological surveys that are used as the primary means to assess the long-range environmental impact of DRB operations. LLNL monitors plant and animal species at the DRB, the drainage channels discharging into the DRB, and downstream portions of Arroyo Las Positas. LLNL's biologist conducts semiannual surveys to identify the presence or absence of amphibians, birds, and fishes, and annual surveys for mammals and plants.

Beginning in December 2000 and continuing into January 2001, LLNL drained the DRB as part of LLNL's bullfrog control strategy related to managing facility operation impacts on the California red-legged frog (*Rana aurora draytonii),* a federally listed threatened species. The draining was conducted following a plan submitted to and approved by the SFBRWQCB. Sediment-laden discharges were routed through sediment filter bags prior to discharging to the storm drainage system.

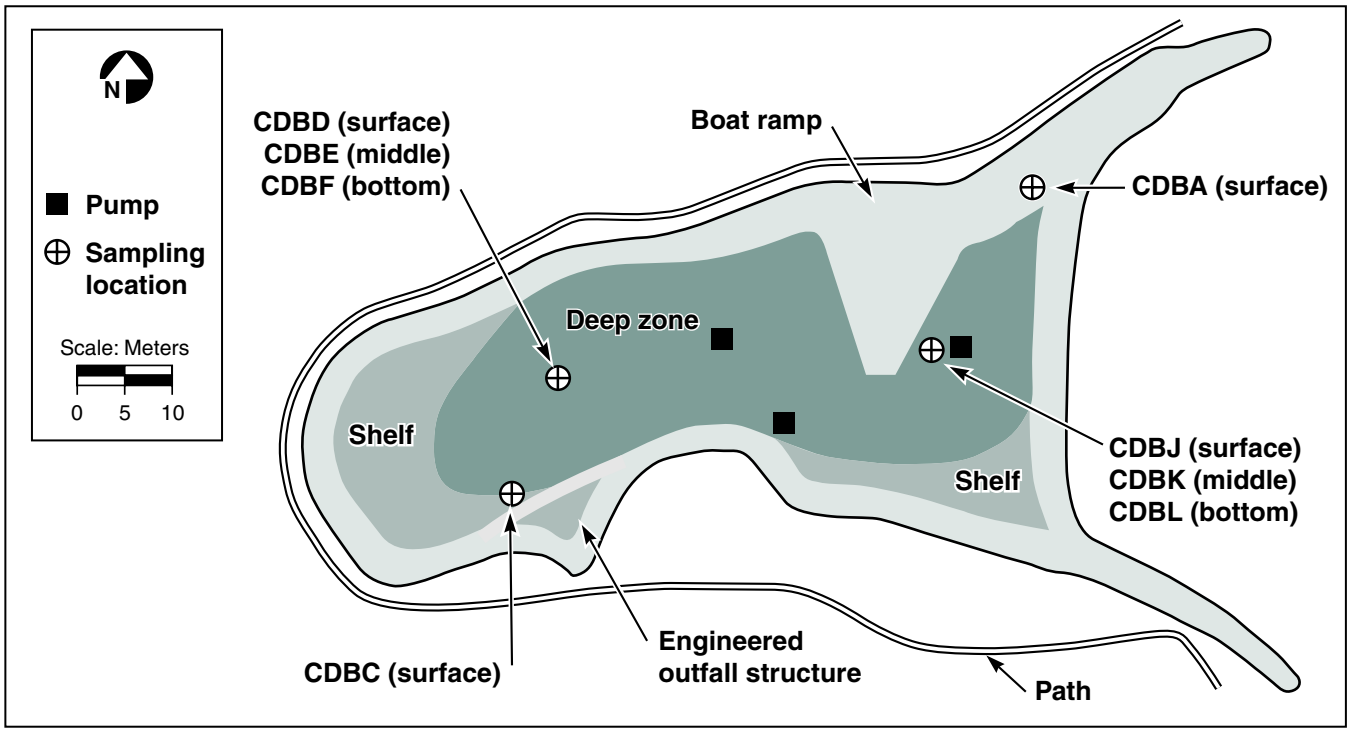

Figure 7-12. Sampling locations within the Drainage Retention Basin, 2001

Methods

Sample collection procedures are discussed in Appendix B of the *Environmental Monitoring Plan* (Tate et al. 1999). All samples from the DRB are collected as grab samples. Field measurements for dissolved oxygen and temperature are made using a dissolved oxygen/temperature meter, turbidity is measured using a Hach brand test kit, and transparency is measured using a Secchi disk. Certified laboratories analyze the collected samples for additional chemical and physical parameters.

Biological and microbiological methods are discussed in detail in the *Environmental Monitoring Plan* (Tate et al. 1999). Biological surveys are conducted by LLNL's biologist. Animal surveys follow standard survey protocols such as *Raptor Management Techniques Manual* (Pendleton et al. 1987), *Inventory and Monitoring of Wildlife Habitat* (Cooperrider et al. 1986), and *Wildlife Management Techniques Manual* (Schemnitz 1980). Vegetation surveys use protocols identified in the *U.S. Army Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987). Because of a lack of resources, LLNL was again unable to conduct the microbiological survey in 2001.

Results

Samples collected during 2001 within the DRB at CDBE for dissolved oxygen saturation, temperature, transparency, nitrate (as N), total dissolved solids (TDS), total phosphorus (as P), ammonia nitrogen (as N), chemical oxygen demand, pH, and specific conductance (**Table 7-10**) did not meet the management action levels and triggered

administrative review. Water releases were scheduled to adjust nutrient levels. Samples collected at CDBX and WPDC exceeded only the pH discharge limit (**Table 7-10**).

Data for maintenance and release monitoring at sampling locations CDBA, CDBC, CDBD, CDBE, CDBF, CDBJ, CDBK, CDBL, CDBX, and WPDC, and from the biological survey are presented in Tables 7-11 through 7-14 in the Data Supplement.

Chemical and Physical Monitoring

Monthly averages for surface-level dissolved oxygen saturation were at or above the management action level of at least 80% oxygen saturation for 4 of 12 months. Oxygen saturation represents the oxygen available to aquatic organisms and is determined by the water temperature and the dissolved oxygen concentration. Dissolved oxygen concentrations can be manually increased using aeration pumps. These pumps are started whenever oxygen concentrations at any level of the DRB drop close to or below the management action level of 5 mg/L.

Chemical oxygen demand was above management action levels during the third and fourth quarters of 2001. Chlorophyll-a, though below the management action level of 10,000 µg/L, had one summer peak indicating an algae bloom (**Figure 7-13**).

The chlorophyll-a levels can be used as an indicator of algae populations and of the duration and intensity of algae blooms. The elevated pH level within the DRB corresponds to the peak of the fall bloom and may be associated with the occurrence of increased photosynthesis. The highest pH readings seen in the DRB discharge samples also correspond to the peak of the fall bloom.

Beginning during the summer of 1994, transparency was below the management action level of 0.91 meters. Through January 2001, it continued to be mostly below 0.91 meters clarity (**Figure 7-14**). However, throughout the remainder of 2001, the transparency in the DRB began to increase, with July and December showing the only measurements exceeding the action level. (Secchi disk depth readings became larger, indicating clearer water). The loss of transparency seen during the warmer summer months is most likely the result of algae growth (Harrach et al. 1996).

Beginning in the 1999/2000 wet season and throughout 2001, LLNL began to operate the DRB to minimize the water level fluctuations and maintain the water level as much as possible between 1 and 2 feet above the shelf. This management strategy allowed both submergent and emergent vegetation to be established throughout the DRB for the first time, which may explain the trend toward increased clarity.

Nutrient levels continued to be high during 2001 (**Figure 7-15**). Concentrations were well above management action levels throughout the year, but decreased concentrations occurred in the periods when chlorophyll-a was high (**Figure 7-13**), possibly indicating an uptake of nutrients during algae growth. Total phosphorus remained fairly constant throughout 2001, ending in concentrations near the management action levels. Sources of nitrate and phosphorous include external sources, storm water runoff, treated groundwater discharges, and an internal source of nutrient cycling related to algae and plant growth.

During 2001, total dissolved solids continued to exceed the management action levels with the concentration exceeding 360 mg/L in all 11 months when samples were collected. Specific conductance exceeded the management action

Table 7-10. Summary of Drainage Retention Basin monitoring not meeting management action levels

Parameter	Management action level	Jan	Feb	Mar	Apr	May	June
Sampling location CDBE							
Ammonia nitrogen (as N) (mg/L)	>0.1	0.3	—[a]	—[a]	—[a]	—[a]	—[a]
Dissolved oxygen saturation (%)[b]	<80% saturation	70	—[a]	—[a]	—[a]	—[a]	—[a]
Temperature (degrees C)[b]	<15 and >26	9.4	10.3	14.6	—[a]	—[a]	—[a]
Transparency (m)[b]	<0.91	0.254	0.749	—[a]	—[a]	—[a]	—[a]
Nitrate (as N) (mg/L)	>0.2	2.3	—[c]	2	1.7	1.1	0.66
Specific conductance (μS/cm)	>900	—[a]	—[c]	—[a]	—[a]	—[a]	950
Total dissolved solids (TDS) (mg/L)	>360	423	—[c]	503	490	470	563
Total phosphorus (as P) (mg/L)	>0.02	0.14	—[c]	0.06	0.07	<0.05	0.18
Chemical oxygen demand (mg/L)	>20	—[a]	—[d]	—[d]	—[a]	—[d]	—[d]
		July	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Sampling location CDBE (continued)							
Dissolved oxygen saturation (%)[b]	<80% saturation	—[a]	—[a]	70	—[a]	64	79
Temperature (degrees C)[b]	<15 and >26	—[a]	—[a]	—[a]	—[a]	—[a]	10.7
Transparency (m)[b]	<0.91	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]
Nitrate (as N) (mg/L)	>0.2	—[a]	—[a]	—[a]	1.8	1.5	—[a]
pH (pH units)	not <6.0 and >9.0	9.04	—[a]	9.06	—[a]	—[a]	—[a]
Specific conductance (μS/cm)	>900	991	1070	1070	1120	1100	1040
Total dissolved solids (TDS) (mg/L)	>360	580	617	690	663	667	613
Total phosphorus (as P) (mg/L)	>0.02	0.06	0.06	0.06	0.07	0.1	0.07
Chemical oxygen demand (mg/L)	>20	41	—[d]	—[d]	22	—[d]	—[d]
	Discharge limit	2 Mar	26 Jun	11 Jul	6 Aug	6 Sep	12 Nov
Sampling location CDBX							
pH (pH units)	not <6.5 and >8.5	—[a]	8.66	9.07	8.93	9.02	—[a]
Sampling location WPDC							
pH (pH units)	not <6.5 and >8.5	—[a]	—[a]	9.03	8.72	—[a]	—[a]
		20 Dec					
Sampling location CDBX							
pH (pH units)	not <6.5 and >8.5	—[a]					
Sampling location WPDC							
pH (pH units)	not <6.5 and >8.5	—[a]					

a Concentrations met management action level or discharge limit.

b Monthly average, measurements taken weekly

c February samples were collected on January 30, 2001.

d Chemical oxygen demand was analyzed once per quarter.

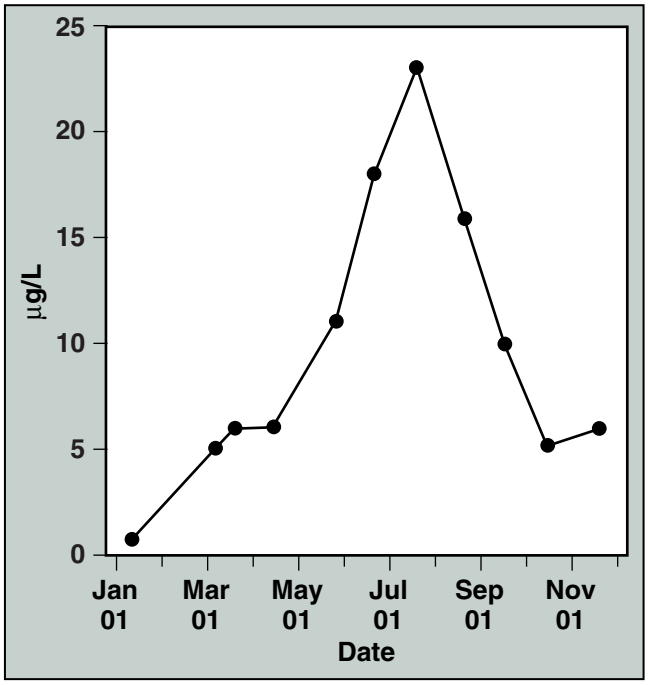

Figure 7-13. Monthly chlorophyll-a in the Drainage Retention Basin, 2001

level of 900 µS/cm for 7 months, showing a relation between the increase in TDS and the increase seen in specific conductance.

LLNL collects and analyzes samples for acute fish toxicity and for the chronic toxicity of three species (fathead minnow, water flea, and algae) a minimum of once per year from sample location CDBE and upon the first wet-season release at CDBX. In addition, LLNL collects acute fish toxicity samples from each discrete dry-season release. Samples collected in October from sample location CDBE showed minor algae toxicity (2 toxic units). All other toxicity samples collected showed no toxic effects.

Biological Monitoring

Biological monitoring has not been conducted long enough to identify any trends resulting from operation of the DRB. However, biological monitoring has revealed an expansion in the wetland areas in Arroyo Las Positas; this increase appears to be a result of the continuous discharges of water from the DRB and other sources of treated groundwater throughout the dry season. The California red-legged frog is found in Arroyo Las Positas and the DRB. A number of other species routinely use the DRB, its tributaries, and receiving water; they are listed in Data Supplement Table 7-14.

Site 300 Cooling Towers

This section discusses general information about the Site 300 cooling towers, sampling methods, and sampling results.

General Information

The CVRWQCB rescinded WDR 94-131, NPDES Permit No. CA0081396, on August 4, 2000, which previously governed discharges from the two primary cooling towers at Site 300. The CVRWQCB determined that these cooling towers discharge to the ground rather than to surface water drainage courses. Therefore, the CVRWQCB is amending WDR 96-248 to incorporate these cooling tower discharges, and other low-threat discharges, going to ground. Pending the incorporation of the cooling tower discharges into WDR 96-248, LLNL continues to monitor the cooling tower wastewater discharges following the WDR 94-131 monitoring requirements.

Two primary cooling towers, located at Buildings 801 and 836A, regularly discharge to the ground. Cooling tower locations are shown in Figure 7-16. Blowdown flow is monitored biweekly from the cooling towers located at Buildings 801 and 836A. TDS and pH are monitored quarterly at both of these locations.

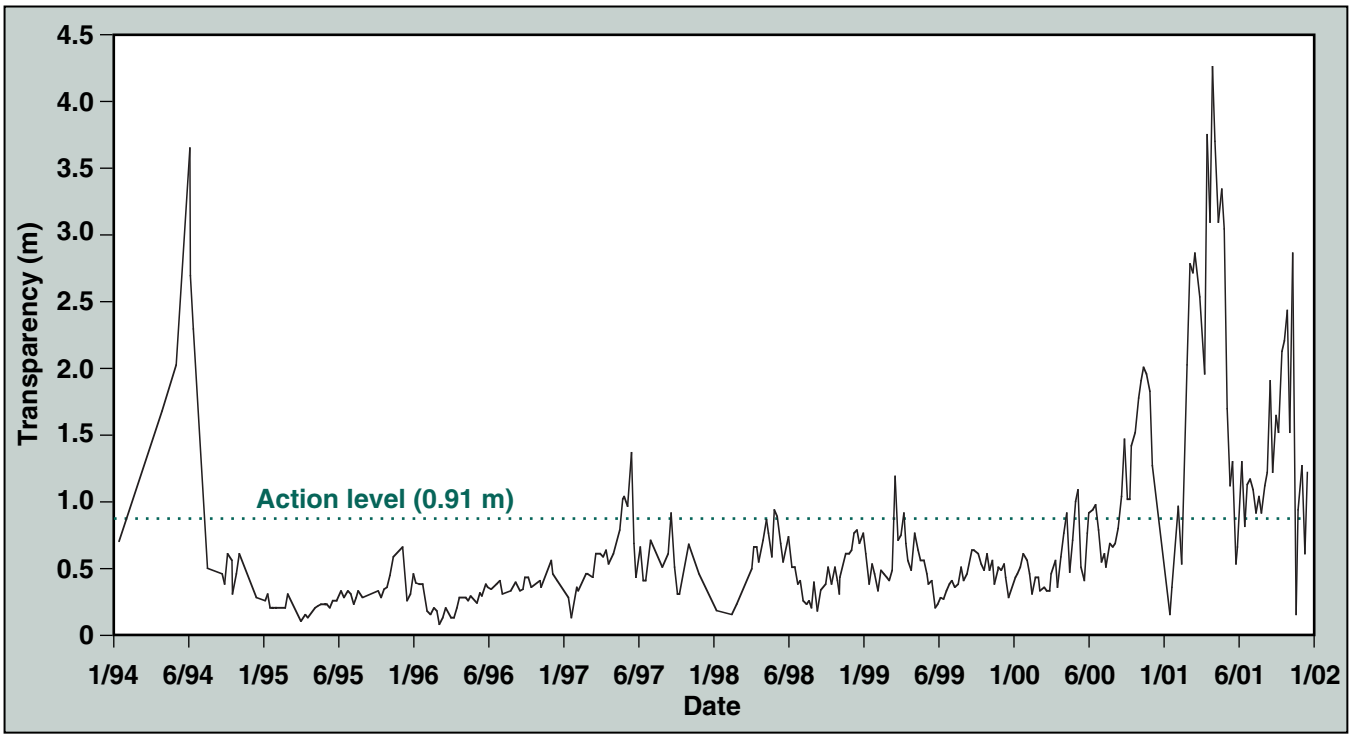

Figure 7-14. Transparency in Drainage Retention Basin, 1994–2001

The 13 secondary cooling towers routinely discharge to percolation pits under a waiver of Waste Discharge Requirements from the CVRWQCB. However, the percolation pit at Building 827A malfunctioned on October 3, 2000, and construction of a new percolation pit was not completed until March 2001. During the demolition and construction processes, blowdown from cooling towers 827-1 and 827-2 was recirculated or otherwise discharged to ground to prevent discharge to surface water. During this period, blowdown from the Building 827A cooling towers was monitored for flow, TDS and pH. These results are discussed below. On March 21, 2001, blowdown from the Building 827A cooling towers was routed into the new percolation pit.

Methods

Sample collection procedures are discussed in Appendix B of the *Environmental Monitoring Plan* (Tate et al. 1999) and summarized here. To determine the effects of the cooling tower blowdown on Corral Hollow Creek, the permit requires quarterly pH monitoring of the creek, both upstream (background) and downstream of the cooling tower discharges, whenever the creek is flowing. CARW is the upstream sampling location, and GEOCRK is the downstream sampling location (**Figure 7-16**).

The GEOCRK sampling location is also fed by discharges of treated groundwater from LLNL. Therefore, even when the upstream location is dry, there is often flow at GEOCRK. Field pH measurements, taken by LLNL technicians using calibrated

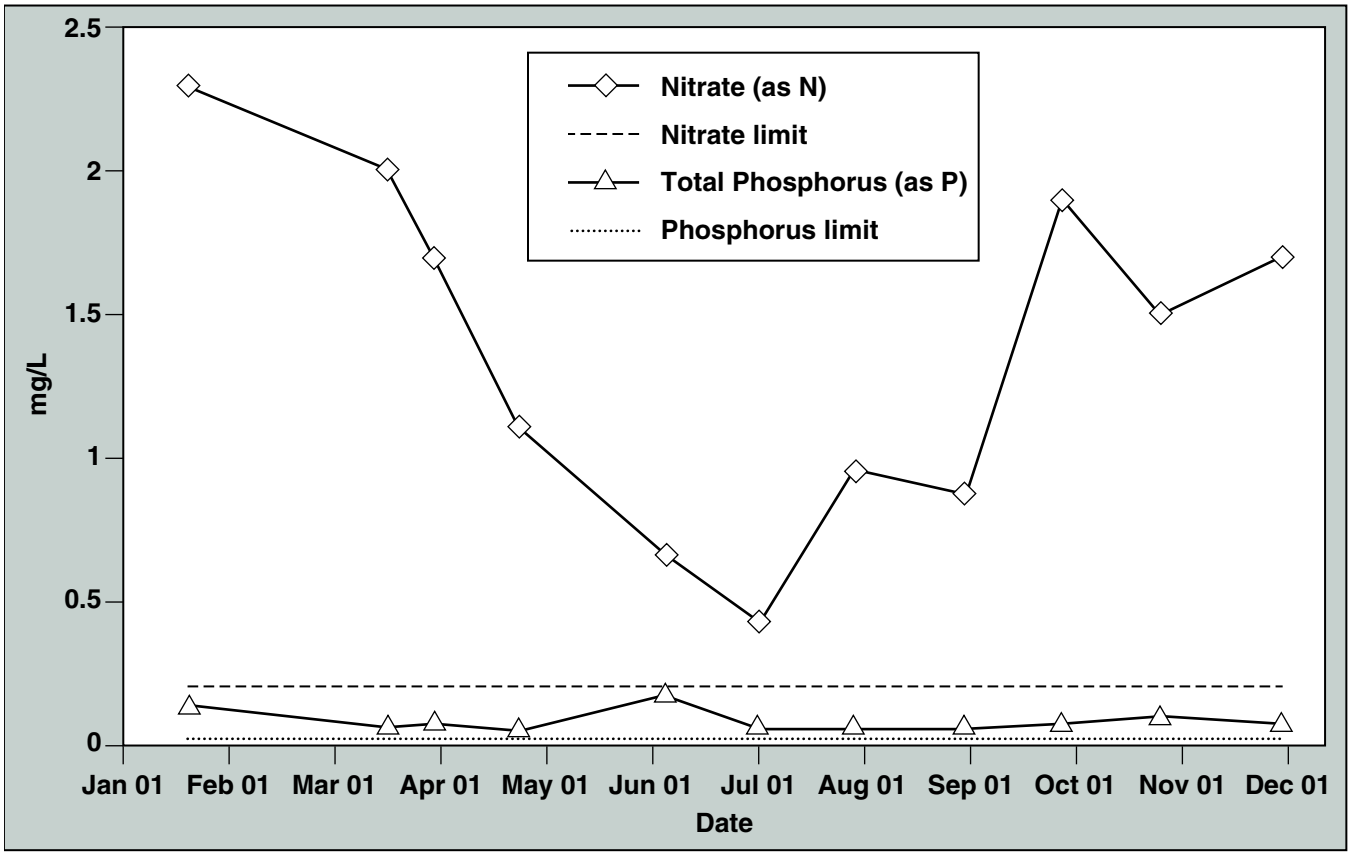

Figure 7-15. Nutrient levels in the Drainage Retention Basin, 2001

meters, are used to monitor Corral Hollow Creek. These technicians also perform the required visual observations that are recorded on the field tracking forms along with the field pH measurements.

If the blowdown flow from any of the 13 secondary cooling towers is diverted to a surface water drainage course, the discharge is sampled for pH and TDS immediately. If the discharge continues, that location is monitored for the same constituents and on the same schedule as the primary cooling towers.

Results

Monitoring results indicate that all discharges from the Buildings 801 and 836A cooling towers were below the maximum permitted values, previously imposed for discharges to surface water drainage courses, under WDR 94-131. Table 7-11 summarizes the data from the quarterly TDS and pH monitoring, as well as the biweekly measurements of blowdown flow. Because the Building 801 cooling tower was out of service during the first quarter of 2001 for installation of a new cooling tower, and flow meters on the new tower were not operational until June, the Table 7-11 summary data for tower 801 consist of only June through December monitoring results.

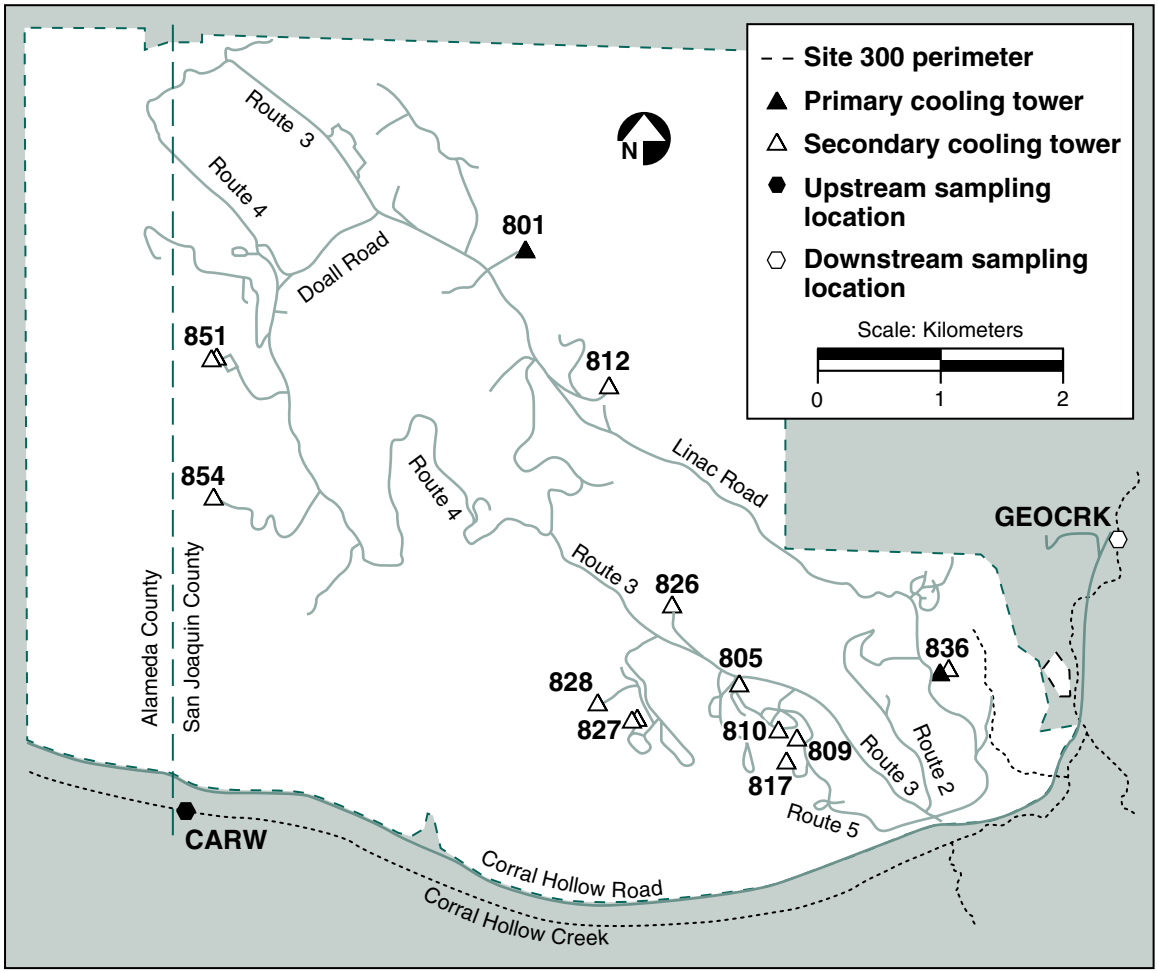

Figure 7-16. Cooling tower locations and receiving water monitoring locations, Site 300, 2001

As previously discussed, blowdown from cooling towers 827-1 and 827-2 was recirculated or otherwise discharged to ground to prevent discharge to surface water during the demolition and reconstruction of the Building 827A percolation pit. On March 21, 2001, blowdown from the Building 827A cooling towers was routed into the new percolation pit. Prior to that date, first quarter pH and TDS samples had been collected and six biweekly flow measurements had been recorded.

Independent analytical results were 9.5 pH and 5600 mg/L TDS for the combined discharge from both cooling towers. The pH value of 9.5 is below the former limit of 10 for discharge to surface waters. Although the TDS value is above the former limit (5000 mg/L) for discharges to surface waters, LLNL biweekly field measurements, performed during the first quarter of 2001, report TDS values ranging from 750 to 5000 mg/L for blowdown from the Building 827A towers. Furthermore, the CVRWQCB has determined that these now rescinded WDR 94-131 limits do not apply to cooling tower discharges to the ground. Biweekly flow data, prior to March 21, 2001, show a range of 1356 to 9429 L/day discharged from the combined operation of towers 827-1

Table 7-11. Summary data from monitoring of primary cooling towers, Site 300, 2001

Test	Tower no.	Minimum	Maximum	Median	Interquartile range	Number of samples
Total dissolved solids (TDS) (mg/L)	801	1400	1400	1400	—[a]	3
	836A	1200	1400	1400	—[a]	4
Blowdown flow (L/day)	801	1802	13783	7022	9244	15
	836A	0	3149	1348	1536	26
pH (pH units)	801	9.0	9.1	9.1	—[a]	3
	836A	8.8	9.1	9.0	—[a]	4

a Not enough data points to determine

and 827-2, below the former permit limit of 11,355 L/day for the combined flow from these two towers.

The biweekly observations at CARW and GEOCRK reported conditions ranging from low flow to dry for both sampling locations throughout 2001. Only on March 1 was there adequate flow to measure pH. The resulting field pH measurements were 8.85 and 8.93 for CARW and GEOCRK locations, respectively, indicating essentially no change between the upstream and downstream locations. Visual observations of Corral Hollow Creek were performed each quarter, and no visible oil, grease, scum, foam, or floating suspended materials were noted in the creek during 2001.

Site 300 Drinking Water System Discharges

This section discusses general information about the monitoring requirements for discharges from the Site 300 drinking water system, including permit information, sampling methods, and sampling results.

General Information

LLNL samples large-volume discharges from the Site 300 drinking water system that reach surface water drainage courses in accordance with the requirements of WDR 5-00-175, NPDES General Permit No. CAG995001. LLNL obtained coverage under this general permit for drinking water system discharges to surface waters when WDR 94-131 was rescinded in August 2000. The monitoring and reporting program that LLNL developed for these discharges was approved by the CVRWQCB.

Discharges that are subject to sampling under WDR 5-00-175 include:

Drinking Water Storage Tanks: monitor all discharges that have the potential to reach surface waters.

System flushes: monitor one flush per pressure zone per year for flushes that have the potential to reach surface waters.

Dead-end flushes: semiannually monitor all flushes that have the potential to reach surface waters, and for any discharge that continues for more than four months.

Discharges must comply with the effluent limits for residual chlorine established by the permit, which require that it must not be greater than 0.02 mg/L, and that the pH must be between 6.5 and 8.5. Discharges are also observed to ensure that no erosion results and no other pollutants are washed into surface waters. To meet the chlorine limit, drinking water system discharges with the potential to reach surface waters are dechlorinated.

Methods

Sample collection procedures are discussed in *Lawrence Livermore National Laboratory Site 300 Water Suppliers' Pollution Prevention and Monitoring and Reporting Program* (Mathews 2000). Grab samples are collected in accordance with Operations and Regulatory Affairs Division (ORAD) procedures EMP-W-S and EMP-WSS-WSD. Residual chlorine and pH are immediately analyzed in the field, using a spectrophotometer and calibrated pH meter, respectively.

Samples are collected at the point of discharge and at the point where the discharge flows into a surface water. If the discharge reaches Corral Hollow Creek, samples are collected at the upstream sampling location, CARW, and the downstream sampling location, GEOCRK (see **Figure 7-17**).

Results

Monitoring results are detailed in the quarterly self-monitoring reports to the CVRWQCB. No drinking water system discharges occurred under the requirements of WDR 5-00-175 in calendar year 2001.

Other Waters

This section discusses general information about monitoring network requirements, sampling methods, and sampling results.

General Information

Additional surface water monitoring is required 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 Livermore site and in the Livermore Valley are sampled at the locations shown in **Figure 7-18**. Sampling locations DEL, ZON7, DUCK, ALAG, SHAD, and CAL are surface water bodies; of these, DEL, ZON7, and CAL are drinking water sources. BELL, GAS, PALM, ORCH, and TAP are drinking water outlets. Location POOL is the on-site swimming pool. Radioactivity data from drinking water sources and drinking water outlets are used to calculate drinking water statistics (see **Table 7-12**) and doses.

Methods

Samples are analyzed for gross alpha, gross beta, and tritium, according to procedures set out in Appendix B of the *Environmental Monitoring Plan* (Tate et al. 1999). LLNL sampled these locations semiannually, in February and July 2001, for gross alpha, gross beta, and tritium. The on-site swimming pool location (POOL) was sampled semiannually for gross alpha and gross beta, and quarterly for tritium.

Results

The median activity for tritium in surface and drinking waters, with the exception of one of the quarterly POOL samples, was estimated from calculated values to be below the laboratory's

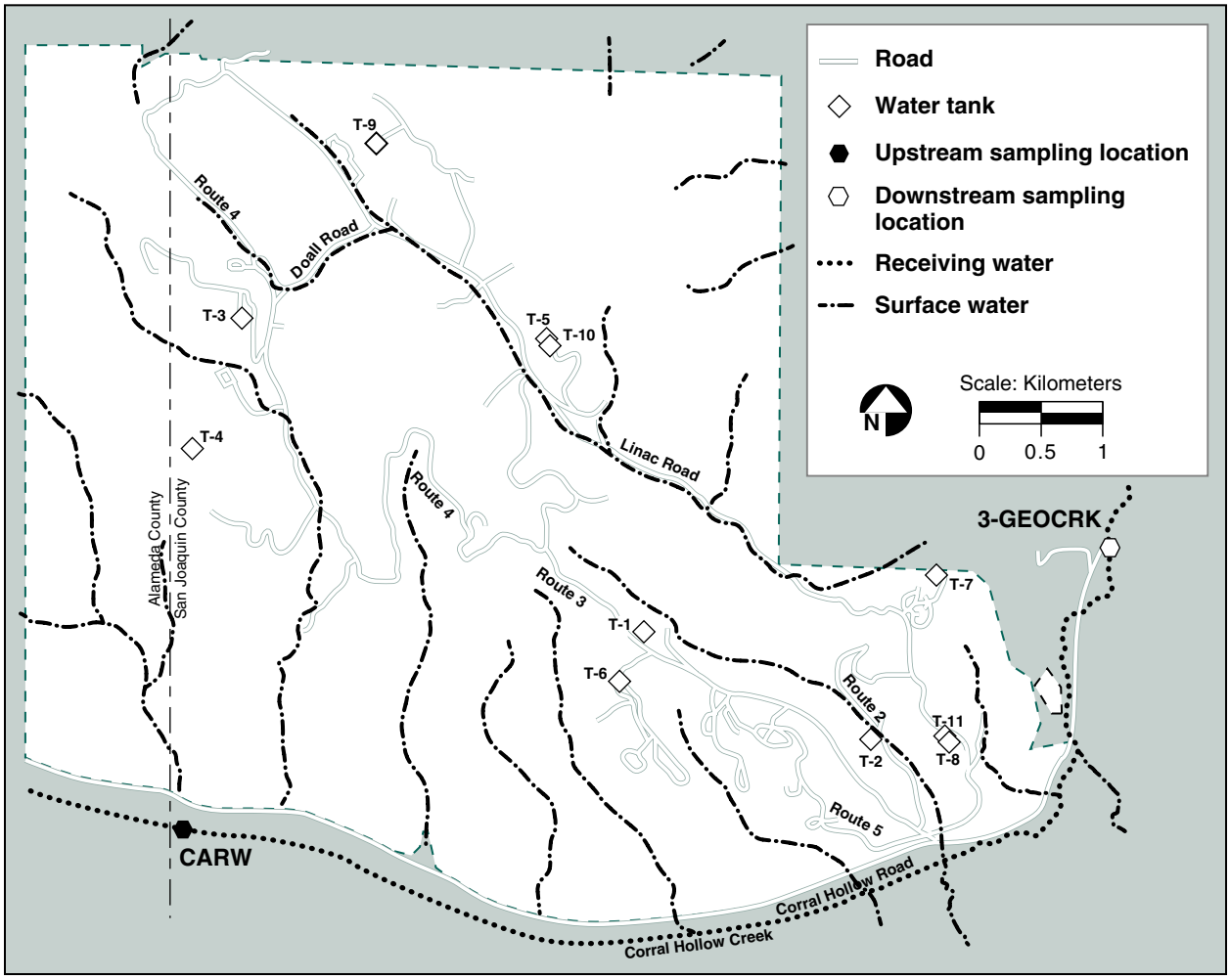

Figure 7-17. Site 300 surface waters, drinking water tanks, and receiving water monitoring locations

minimum detectable activities, or minimum quantifiable activities. The maximum tritium activity detected was less than 0.5% of the MCL in LLNL's on-site swimming pool. Median activities for gross alpha and gross beta radiation in surface and drinking water samples were both less than 5% of their respective MCLs. However, maximum activities detected for gross alpha and gross beta, respectively, were 0.099 Bq/L and 0.177 Bq/L; both less than 20% of their respective MCLs (see Table 7-12). Detailed data are in Table 7-15 of the Data Supplement. Historically, gross alpha and gross beta radiation have fluctuated around the laboratory minimum detectable activities. At these very low levels, the counting error associated with the measurements are nearly equal to the measured values so that no trends are apparent in the data.

Historical median tritium values in surface and drinking waters in the Livermore Valley since 1988 are shown in Figure 7-19. Since 1988, when measurements began, water in the LLNL swimming pool has had the highest tritium activities because it is closest to tritium sources within LLNL. The highest individual tritium activity measured in the pool was 87.3 Bq/L in a sample collected in the

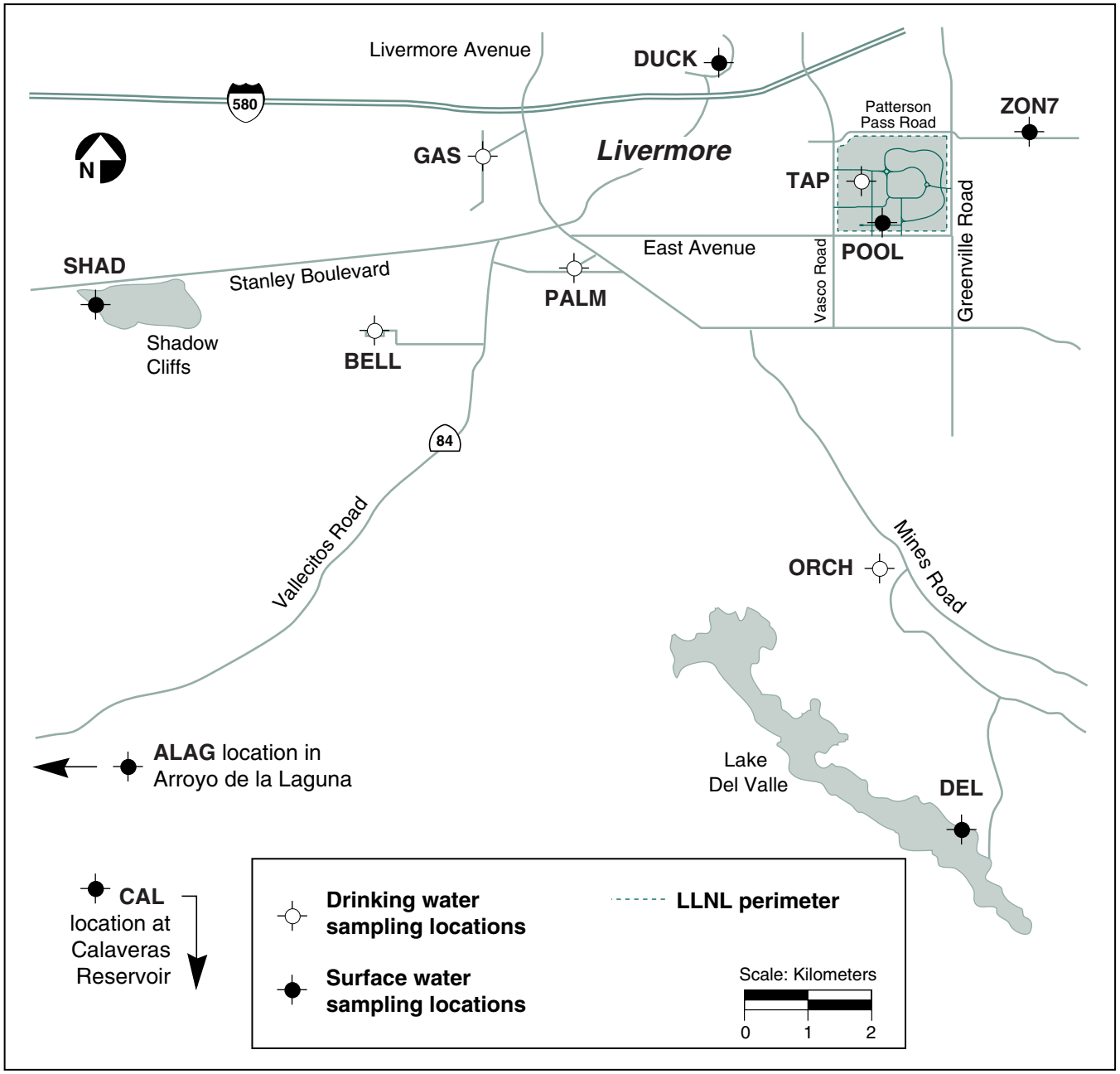

Figure 7-18. Surface and drinking water sampling locations, Livermore Valley, 2001

second quarter of 1988 (equal to about 12% of the drinking water MCL). The highest historical drinking water activity measured for tritium was 3.03 Bq/L or about 0.4% of MCL, in a first quarter 1988 sample from location ORCH, a well used for drinking water. Tritium activities in the LLNL pool and in the other surface and drinking water locations have been decreasing since that time.

Table 7-12. Radioactivity in surface and drinking water in the Livermore Valley, 2001

Locations	Tritium (Bq/L)	Gross alpha (Bq/L)	Gross beta (Bq/L)
All locations			
Median	–0.568	0.008	0.064
Minimum	–2.3	–0.031	–0.026
Maximum	2.89	0.099	0.177
Interquartile range	1.055	0.035	0.084
Drinking water locations			
Median	–0.689	0.015	0.040
Minimum	–1.8	–0.016	0.000
Maximum	0.918	0.040	0.177
Interquartile range	0.624	0.018	0.082
Drinking water MCL	740	0.56	1.85

Note: Radioactivities are reported as the measured concentration and either an uncertainty ($\pm 2\sigma$ counting error) or as being less than the detection limit. If the concentration is less than or equal to the uncertainty or the detection limit, the result is considered to be a nondetection.

Arroyo Las Positas Maintenance Project

This section discusses general information about the monitoring requirements for discharges occurring during maintenance activities within Arroyo Las Positas, including permit information, sampling methods, and sampling results.

General Information

LLNL performs annual maintenance activities within the flood-control channel that diverts the flow of Arroyo Las Positas around the perimeter of the Livermore site. Maintenance activities include phased desilting of the 7000-linear-foot stretch of Arroyo Las Positas on LLNL property over five years, trimming cattail heights, and conducting bank stabilization/erosion control activities. These activities are regulated by:

- WDR 99-086 issued by the SFBRWQCB in 1999
- A Biological Opinion issued by U.S. Fish and Wildlife Service in 1999
- A streambed alteration agreement issued by California Department of Fish and Game in 1998
- A nationwide permit for the construction of six check dams issued by the Army Corps of Engineers in 2000

Work is done in pre-identified zones (**Figure 7-20**). Each year, no more than 20% of the arroyo length is desilted following the pre-identified patchwork pattern. During August and early September 2001, LLNL conducted maintenance work in Zones 3H, 5H, 2H, Area 5, and the eastern portion of Area 19.

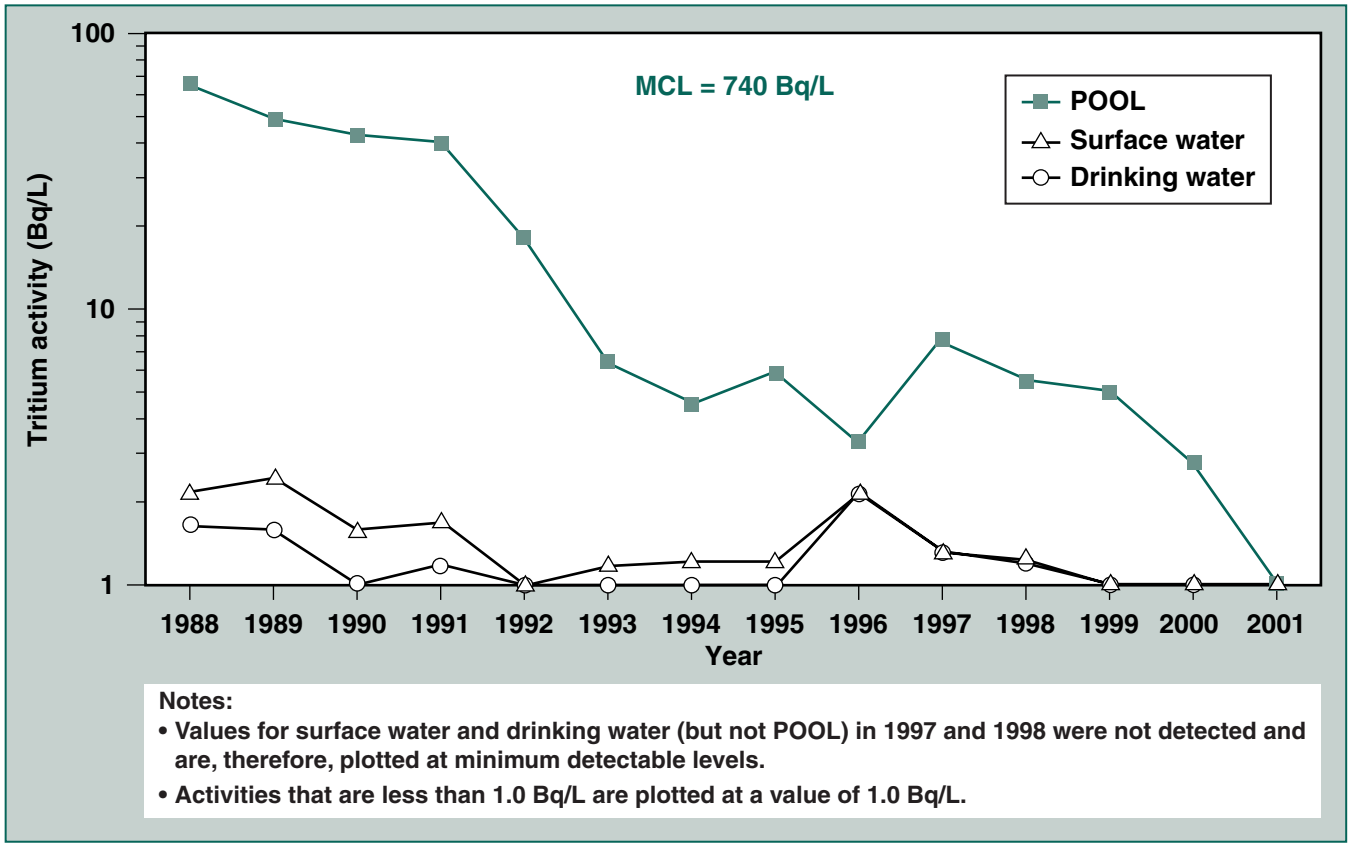

Figure 7-19. Annual median tritium activity in Livermore Valley surface and drinking water, 1988 to 2001

Discharges occur as a result of dewatering or water diversions, but they cannot cause the receiving water limits, specified in WDR 99-086, to be exceeded. Monitoring is conducted following requirements established in Self-Monitoring Program 99-086 to document compliance with effluent requirements and prohibitions established in WDR 99-086. LLNL submits self-monitoring reports to the SFBRWQCB annually when any receiving water limit is exceeded while work occurred.

Methods

Samples are collected following procedure EMP-W-S and Water Sampling Supplement EMP-WSS-ALP SOP, set up by ORAD. Turbidity, pH, and dissolved oxygen are immediately analyzed in the field using calibrated meters. Weekly duplicate samples are collected and sent to a certified laboratory for analysis.

Receiving water (downstream) samples are collected at the work site twice a day at times evenly spaced during work hours. Receiving water samples are collected no more than 50 feet downstream of the work site while water is diverted around or dewatered from the work site. Upstream samples are collected to characterize background conditions. These samples are collected at least 500 feet above the work site. Prestart background samples are also collected to characterize the receiving water and help evaluate the impact of discharges on the receiving water.

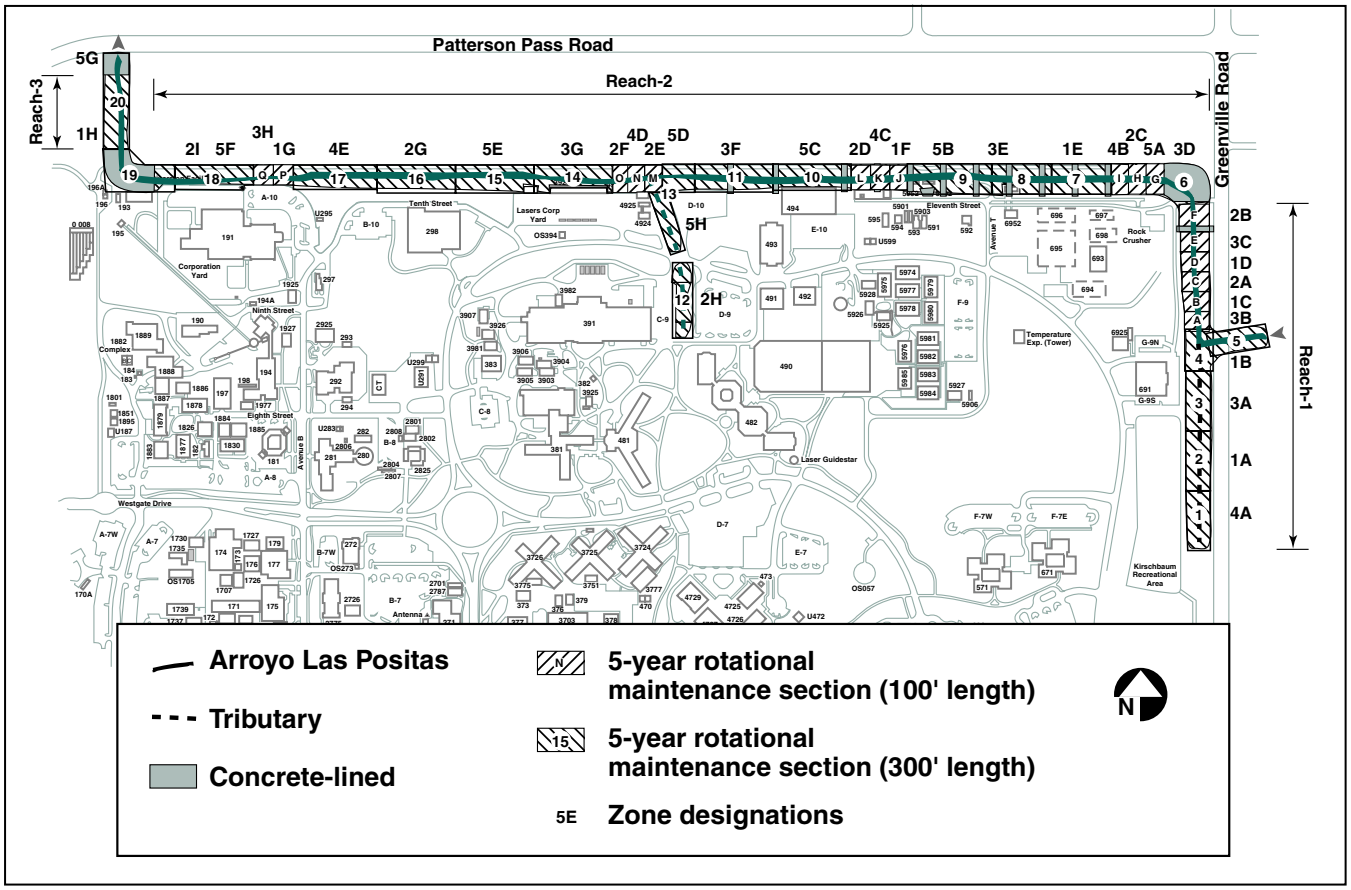

Figure 7-20. Arroyo Las Positas maintenance zones

Results

Monitoring results are presented in Table 7-13. Annual self-monitoring reports are required if any of the receiving water limits are exceeded. When the background turbidity is greater than 50 NTU, discharges from the Arroyo Las Positas maintenance project cannot exceed 10% of the background measurement. These discharges must also have a dissolved oxygen concentration of 5.0 mg/L, unless natural factors cause a lower concentration of dissolved oxygen. If background samples do have a dissolved oxygen concentration less than 5.0 mg/L, the Arroyo Las Positas maintenance activities cannot cause further reduction in the concentration of dissolved oxygen at the point of discharge. Furthermore, the pH at the point of discharge cannot vary from the background pH by more than 0.5 pH units. No receiving water limits were exceeded in 2001 so no annual self-monitoring report to the SFBRWQCB was required. Water diversion during desilting activities occurred only at Zone 3H and Area 19. All other sections were dry during the work period, and monitoring was not required.

No flow diversions were required around Zones 2H and 5H. The majority of irrigation flows and treated groundwater discharges were reduced during the duration of the Arroyo Las Positas maintenance project. Sandbag cofferdams and rubber plugs in upstream storm drains prevented

Table 7-13. Arroyo Las Positas maintenance project monitoring data, 2001

Location and Date	Time	Turbidity (NTU)	pH (pH units)	Dissolved oxygen (mg/L)
Location: Area 19, prestart (background)				
August 6, 2001	1430	8.0	8.92	6.2
Location: Area 19, downstream				
August 8, 2001	1500	14.3	8.89	7.5
August 8, 2001	1500	7.2	8.2	8.0
Location Zone 3H, prestart (background)				
August 6, 2001	1024	2.7	8.13	6.9
Location: Zone 3H, upstream				
August 27, 2001	1340	8.5	8.64	6.4
August 27, 2001	1340	7.0	8.79	9.7
August 27, 2001	1530	2.8	9.0	10.8
August 28, 2001	0912	3.1	7.95	15.4
August 29, 2001	0938	2.1	8.30	6.0
Location: Zone 3H, downstream				
August 27, 2001	1300	17.8	8.27	7.1
August 27, 2001	1300	6.0	8.60	11.6
August 27, 2001	1510	2.6	8.8	11.9
August 28, 2001	0856	3.9	7.89	12.0
August 28, 2001	1300	2.9	8.20	6.5
August 29, 2001	0900	2.6	7.89	5.0

remaining irrigation flows from discharging to the Arroyo Las Positas. A water-bag cofferdam and straw-bale cofferdam were used at Zone 3H and Area 19 respectively, where water was diverted around the work area. Flow from Arroyo Las Positas coming onto the Livermore site was successfully held behind a straw-bale cofferdam installed just upstream of Area 5.

Environmental Impacts

This section discusses the environmental impacts of storm water, rainfall, the DRB, cooling towers, and other waters.

Storm Water

Storm water runoff from the Livermore site and Site 300 did not have any apparent environmental impacts in 2001. Tritium activities in storm water runoff effluent (location WPDC) were less than 1% of the drinking water MCL during 2001. Most values were below detection limits for tritium. Gross alpha and gross beta activities in Livermore site storm water effluent were both less than 11% of their respective MCLs.

Storm water quality runoff from Site 300 is similar to background levels. Although some 2001 storm water results were above comparison criteria at the

Livermore site, there is no evidence of any impact to off-site biota. The acute and chronic fish toxicity tests conducted during 2001 showed no toxicity in Livermore site storm water runoff, further supporting this conclusion. Algae toxicity tests did reveal growth inhibition for algae in the storm water. However, it has been demonstrated that this was caused by upstream pesticide applications not associated with LLNL activities.

Construction site storm water sampling results indicate that the NIF construction site is not contributing PCBs to storm water runoff as a result of construction activities.

Rainfall

Tritium in rainfall had a negligible impact on the environment at the Livermore site, in the Livermore Valley, and at Site 300. The median tritium activity measured in rainfall at LLNL decreased from 3.7 Bq/L in 2000 to 1.97 Bq/L in 2001. The measured tritium activities of rainfall samples taken at Site 300 were all less than the minimum detectable activity (or less than the 2σ counting uncertainty). The tritium activity measured in rainfall at Site 300 continues to be indistinguishable from atmospheric background levels (2 Bq/L).

Drainage Retention Basin

There is no evidence of adverse environmental impact resulting from releases from the DRB. Because of the frequent dry season discharges that occurred from the DRB, discharges from groundwater treatment facilities, and the wetter rainfall years that occurred from 1997 through 1999, wetland vegetation has increased both upstream and downstream of the DRB. The federally listed threatened California red-legged frog has colonized these wetland areas.

Cooling Towers

During 2001, the monitoring results for flow, pH, and TDS from both primary cooling towers remained within previously established (WDR 94-131) limits. Because blowdown flow from the cooling towers does not reach Corral Hollow Creek, it is unlikely to have a negative impact on the receiving water.

Site 300 Drinking Water System Discharges

There were no releases from the Site 300 drinking water system during 2001.

Other Waters

The potential impact of tritium on drinking water supplies was estimated by determining the effective dose equivalent (EDE) (see Appendix A). Maximum tritium activity in drinking waters was 0.918 Bq/L. The EDE to an adult who ingested 2 L/day of water at this maximum concentration for a year would be 0.012 µSv, or 0.03% of the DOE standard allowable dose of 40 µSv for drinking water systems. Gross alpha and gross beta activities (as well as tritium activities) were below their MCLs. The sample data indicate that the impact of Livermore site operations on surface and drinking waters in the Livermore Valley is negligible.

Arroyo Las Positas Maintenance Project

Discharges of diverted water related to the Arroyo Las Positas maintenance project did not adversely impact receiving water quality. No receiving water quality criteria were exceeded throughout the duration of the project.