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Sewerable Water

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Introduction

In 1997, the Livermore site discharged approximately 0.91 million liters (ML) per day of wastewater to the City of Livermore sewer system, an amount that constitutes 4.4% of the total flow to the system. This volume includes wastewater generated by Sandia National Laboratories / California (SNL / California), which is discharged to the LLNL collection system and combines with LLNL sewage before it is released at a single point to the municipal collection system (**Figure 6-1**). In 1997, SNL / California generated approximately 20% of the total effluent discharged from the Livermore site. LLNL's wastewater contains sanitary sewage and industrial wastewater and is discharged in accordance with permit requirements and the City of Livermore Municipal Code, as discussed below in the Pretreatment and Categorical Discharges section.

The effluent is treated at the Livermore Water Reclamation Plant (LWRP). As part of the Livermore-Amador Valley Wastewater Management Program, the treated sanitary wastewater is transported out of the valley through a pipeline and discharged into San Francisco Bay. A small portion of this treated wastewater is used for summer irrigation of the adjacent municipal golf course. Sludge from the treatment process is disposed of in sanitary landfills.

LLNL receives water from two suppliers. LLNL's primary water source is the Hetch-Hetchy Aqueduct. Secondary or emergency water deliveries are taken from the Alameda County Flood Control and Water Conservation District Zone 7. This water is a mixture of ground water and water from the South Bay Aqueduct of the State Water Project. Water quality parameters for the two sources are obtained from the suppliers and are used to evaluate compliance with the discharge permit conditions that limit changes in water quality between receipt and discharge.

Preventive Measures

Administrative and engineering controls at the Livermore site are designed to prevent potentially contaminated wastewater from being discharged directly to the sanitary sewer. Waste generators receive training on proper waste handling. LLNL personnel review facility procedures and inspect processes for inappropriate discharges. Retention tanks collect wastewater from processes that might release contaminants in quantities sufficient to disrupt operations at the LWRP. Ground water generated from remediation treatment, hydraulic tests, and volatile organic compound (VOC) treatability studies is analyzed for pollutants of concern and must meet permitted criteria or LWRP approval must be obtained before it can be discharged to the sanitary sewer. Finally, to verify the success of training and control equipment, wastewater is sampled and analyzed not only at the significant points of generation, as defined by type and quantity of contaminant generated, but also at the point of discharge to the municipal sewer system.

For facilities with installed retention tank systems, collected wastewater is discharged to the sanitary sewer only if analytical laboratory results show that pollutant levels are within allowable limits (Grandfield 1989). LLNL developed internal discharge guidelines for specific sources and operations to ensure that sewer effluent for the entire site complies with LLNL's waste discharge permit. If pollutant levels exceed permissible concentrations, the wastewater is treated to reduce pollutants to the lowest levels practical and below LLNL guidelines, or it is shipped to an off-site treatment or disposal facility. Liquids containing radioactivity are handled on site and may be treated using processes that reduce the activity to levels well below those required by DOE Order 5400.5. Internal guidelines for retention tank systems and specific sources and operations are discussed below in the "Pretreatment and Categorical Discharges" section.

For the year as a whole, the monitoring data reflect the success of LLNL's discharge control program in preventing any significant impact on the operations of Livermore's treatment plant and are generally consistent with past values.

Continuous Monitoring

LLNL's sanitary sewer discharge permit requires continuous monitoring of the effluent flow rate and pH. Samplers collect flow-proportional composite samples and instantaneous grab samples that are analyzed for metals, radioactivity, toxic chemicals, and water-quality parameters. In addition, as a best management practice, the outflow to the municipal collection system is sampled continuously and analyzed in real time for conditions that might upset the LWRP treatment process or otherwise impact the public welfare. The effluent is continuously analyzed for pH, selected metals, and radioactivity. If concentrations above warning levels are detected, an alarm is registered at the LLNL Fire Dispatcher's Station, which is attended 24 hours a day. The monitoring system provides a continuous check on sewage control and automatically notifies the LWRP in the event that contaminants are detected. Trained staff respond to all alarms to evaluate the cause and take appropriate action.

Diversion System

LLNL operates and maintains a diversion system that is automatically activated when the continuous monitoring system sounds an alarm. The diversion system ensures that all but the first few minutes of the affected wastewater flow is retained at LLNL, thereby protecting the LWRP and minimizing any required cleanup. Up to 775,000 L of potentially contaminated sewage can be held pending analysis to determine the appropriate handling method. The diverted effluent may be returned to the sanitary sewer (if it meets LLNL's wastewater discharge permit limits), shipped for off-site disposal, or treated at LLNL's Hazardous Waste Management Facility. The majority of all diverted sewage in 1997 was returned to the sanitary sewer.

Satellite Monitoring

In 1991, LLNL completed the implementation of a network of 10 satellite monitoring stations that operated in conjunction with the sewer monitoring station (**Figure 6-1**). The satellite monitoring stations were positioned at strategic locations within the main sewer system to help pinpoint the on-site area from which a release might have originated. Each station consisted of an automatic sampler that collected samples on a time-proportional basis. If there was a release, these samples were analyzed. In October 1997, this satellite monitoring station network was decommissioned. In addition to ergonomic issues associated with the routine maintenance of the sampling equipment, the network did not prove to be sufficiently helpful in identifying an on-site area as the source of a release. An alternative to the network will be installed in 1998. This alternative will mitigate the most frequent type of inadvertent discharges (low pH) observed in 1996 and 1997 (see Chapter 2, **Table 2-10**).

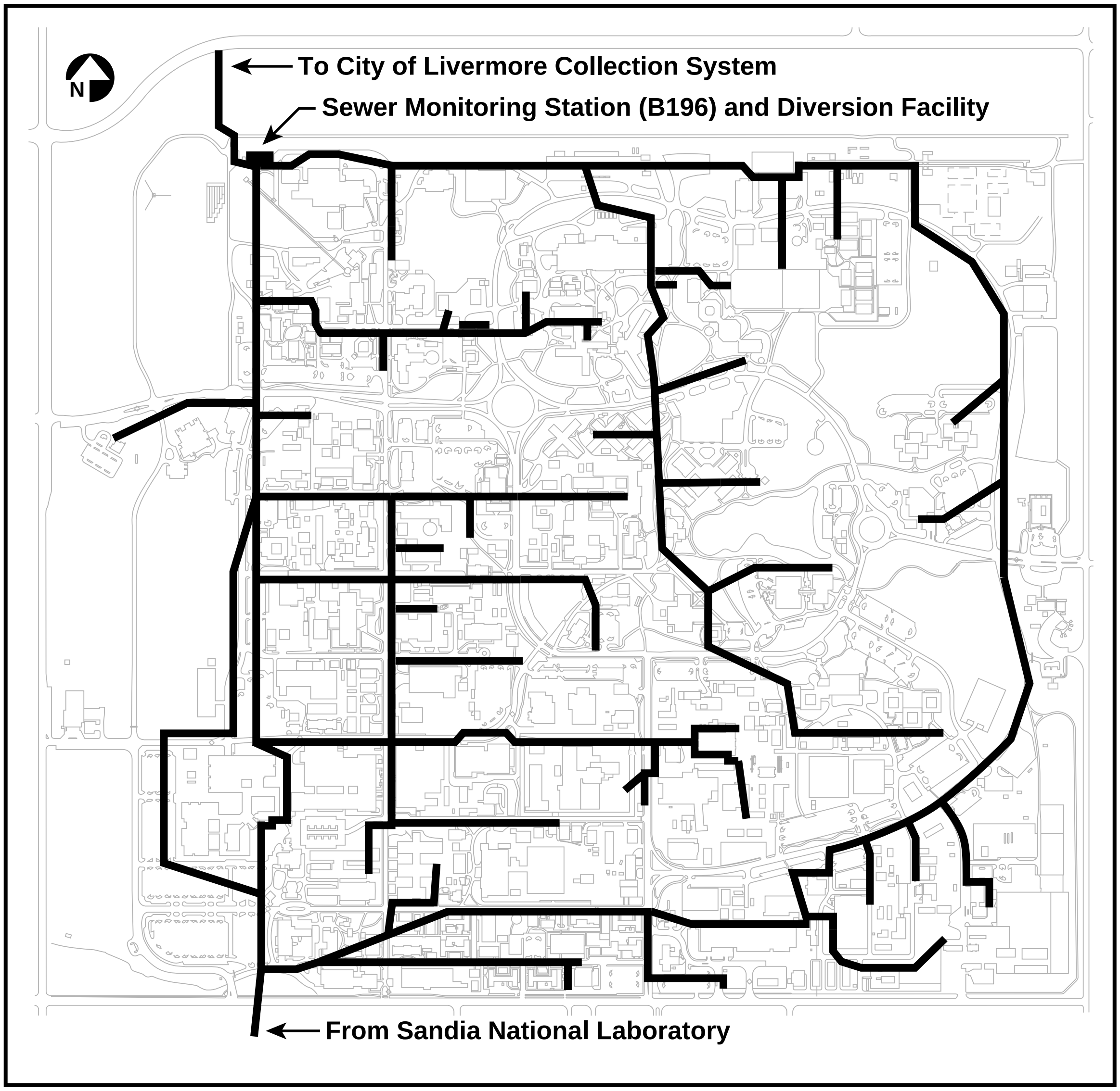

Figure 6-1. Sanitary sewer system including trunk laterals and monitoring station.

Pretreatment and Categorical Discharges

The General Pretreatment Regulations establish both general and specific standards for the discharge of prohibited substances (40 CFR 403.5) that apply to all industrial users. Self-monitored pretreatment programs are required at both the Livermore site and Site 300 by the LWRP under the authority of San Francisco Bay Regional Water Quality Control Board. The sampling and monitoring of nondomestic, industrial sources covered by pretreatment standards defined in 40 CFR 403 is required in the 1997–1998 Wastewater Discharge Permit (No. 1250) issued for the discharge of wastewater from

LLNL into the City of Livermore sewer system. Permit 1250 discharge limits are listed in **Table 6-1**. These limits are applied at the site boundary before wastewater enters the municipal collection system (see **Figure 6-1**).

Table 6-1. Limits under permit 1250 for discharges into the municipal sewer.

Constituent	Discharge limit
Metals (mg/L)	
Arsenic	0.06
Cadmium	0.14
Copper	1.0
Chromium (total)	0.62
Lead	0.20
Mercury	0.01
Nickel	0.61
Silver	0.20
Zinc	3.0
Cyanide (mg/L)	0.04
Toxic organics (total)	1.0
pH (pH units)	5–10

Categorical Standards are published by the Environmental Protection Agency (EPA) as separate regulations and contain numerical limits for the discharge of pollutants from specified processes (or industrial categories). The LWRP has identified specific LLNL wastewater generating processes that fall under the definition of two Categorical Standards: electrical and electronic components (40 CFR 469), and metal finishing (40 CFR 433). The discharge limits for these standards are shown in **Table 6-2**.

During 1997, LLNL maintained compliance with categorical standard discharge limits for significant industrial processes that discharge to the sanitary sewer by reviewing retention-tank data prior to discharge and applying the appropriate categorical discharge limits. This monitoring data is reported to the LWRP in semiannual reports.

In December 1996, LLNL was notified of EPA's decision regarding the request for exemption from the Categorical Standards in a report of their 1995 Clean Water Act (CWA)/ NPDES inspection of LLNL's Livermore site. The EPA report stated that although they do exempt research laboratories from regulation under the categorical standards, they do not exempt operations in support of research, such as parts fabrication or waste handling. Therefore, LLNL resumed self-monitoring of its federally regulated discharges in 1997 as prescribed in the Wastewater Discharge Permit (No. 1250).

Tables 6-2 and **6-3** show LLNL's internal discharge limits for wastewaters discharged to the sanitary sewer. Those processes that discharge to the sanitary sewer are subject to the pretreatment self-monitoring program specified in the Wastewater Discharge Permit issued by the LWRP. In 1997, 13 exceptions to the pollutant limitations of the discharge permit were observed and are discussed below in the "Environmental Impact of Nonradioactive Liquid Effluents" section.

Table 6-2. Discharge limits for nonradioactive pollutants in wastewaters at point of discharge into LLNL sewer.

Parameter	Discharge limits			
	Internal[(a)]	Metal finishing[(b)]	Electric components[(b)]	Permit 1510G
Metals (mg/L)				
Arsenic	NA[(c)]	NA	0.83	0.06
Cadmium	0.9	0.26	—[(d)]	0.14
Chromium (total)	4.9	1.71	—[(d)]	0.62
Copper	10	2.07	—[(d)]	1.00
Lead	4.9	0.43	—[(d)]	0.20
Mercury	0.05	—[(d)]	—[(d)]	0.01
Nickel	5	2.38	—[(d)]	0.61
Silver	1	0.24	—[(d)]	0.20
Zinc	15	1.48	—[(d)]	3.00
Organics (mg/L)				
TTO[(e)]	4.57	2.13	1.37	1.00
BTEX[(f)]	NA	NA	NA	NA
Other (mg/L)				
Cyanide[(g)]	5	0.65	—[(d)]	0.04
pH (pH units)	5-10	5-10	5-10	5-10

Note: Permit 1510G is discussed in the following section, Discharges of Treated Ground Water.

a These standards were established to meet the City of Livermore's requirements at the point of discharge to the Municipal Sewer (Building 196).

b These standards were specified by EPA. By regulation, the EPA or City of Livermore limit is used, whichever is lower. Internal limits apply where no standard is specified.

c NA = Not applicable.

d Noncategorical limits apply.

e Total toxic organics, as defined by the Livermore Municipal Code.

f Benzene, toluene, ethyl benzene, and xylene.

g Limits apply to cyanide discharges other than cyanide salts. CN salts are classified by the State of California as "extremely hazardous waste" and cannot be discharged to the sewer.

Table 6-3. LLNL's internal discharge limits for radioisotopes in wastewaters. There is no gross gamma limit; isotope-specific limits apply.

Parameter	Individual discharges	Total daily limit for site
Gross alpha	11.1 Bq/L (0.3 nCi/L)	185 kBq (5.0 µCi)
Gross beta	111 Bq/L (3.0 nCi/L)	1.85 MBq (50.0 µCi)
Tritium	185 kBq/L (5.0 nCi/L)	3.7 GBq (100.0 mCi)

Discharges of Treated Ground Water

LLNL's ground water discharge permit (1510G, 1997) allows ground water from hydraulic tests and VOC treatability studies to be discharged to the City of Livermore sanitary sewer in compliance with **Table 6-2** effluent limitations taken from the Livermore Municipal Code. Through negotiation with the LWRP, in 1997 the conditions of the two permits (1508G and 1510G) previously issued for discharge of treated ground water to the sanitary sewer were combined to create a single permit, 1510G.

During 1997, over 5.7 ML of ground water from sitewide CERCLA cleanup activities was discharged to the sanitary sewer. Discharges were primarily from start-up operations associated with portable treatment unit construction and testing. Twelve separate discharges were sampled and discharged to the sewer during this period, all in compliance with the total toxic organic (TTO) self-monitoring permit provisions of self-monitoring permit 1510G. Concentrations of regulated compounds were all below discharge limits. Complete monitoring data are presented in the Data Supplement, Chapter 6.

Radioactive Pollutants in Sewage

Monitoring Results

Determination of the total radioactivity released from tritium, alpha emitters, and beta emitters is based either on the measured radioactivity in the effluent or on the limit of sensitivity, whichever is higher (see **Table 6-4**). The 1997 combined releases of tritium and alpha and beta sources were 9.4 GBq (0.25 Ci). The total is based on the results shown in **Table 6-4**; unlike the years prior to 1996, the total does not include a contribution from Sandia National Laboratories (SNL)/California, which concluded all of its tritium research activities as of October 1994. The cleanup activities at their former tritium research laboratories were completed by October 1995. The annual mean concentration of tritium in LLNL sanitary sewer effluent was 0.027 Bq / mL (0.73 pCi / mL).

Table 6-4. Estimated total radioactivity in LLNL sanitary sewer effluent, 1997.

Radioactive emitter	Estimate based on effluent activity (GBq)[(a)]	Limit of sensitivity (GBq)
Tritium	9.1	3.7
Alpha sources	0.062	0.060
Beta sources	0.23	0.052

a 37 Gbq = 3.7×10^{10} Bq = 1 Ci.

The concentrations of ^{239}Pu, ^{137}Cs, and tritium measured in the sanitary sewer effluent from LLNL and LWRP are presented in **Table 6-5**. The tritium numbers are based on the flow-weighted average of the individual daily sample results for a given month. The plutonium and cesium numbers are the direct result of analysis of monthly composite samples of LLNL and LWRP effluent, and quarterly composites of LWRP sludge. At the bottom of the table, the total activity released is given by radioisotope. This was calculated by multiplying each sample result by the total flow volume over which the sample was collected, and summing up over all samples. The total activity released for each radioisotope is a conservative value; the limit of sensitivity was used in the calculation when the limit of sensitivity was greater than the actual activity reported. Also included in the table are fractions of DOE and 10 CFR 20 limits, discussed in the Environmental Impact section of this chapter.

The historical trend in the monthly average concentration of tritium is shown in **Figure 6-2**. Also included in the figure is the DOE tritium limit (370 Bq / mL), discussed in the Environmental Impact section of this chapter. The trend indicates a well-controlled tritium discharge, orders of magnitude below the DOE tritium limit.

Figure 6-3 shows the average monthly plutonium and cesium concentrations in sewage since 1988. The annual mean concentration of ^{137}Cs was 4.5 µBq / mL (1.2×10^{-4} pCi / mL); the annual mean ^{239}Pu concentration was 0.63 µBq / mL (1.7×10^{-5} pCi / mL).

Environmental Impact

During 1997, no inadvertent releases exceeded any discharge limits for release of radioactive materials to the sanitary sewer system.

Table 6-5. Various radionuclides in sanitary sewer effluents, LLNL and Livermore Water Reclamation Plant (LWRP), 1997.

Month	^{3}H (mBq/mL)[(a)]		^{137}Cs (μBq/mL)[(a)]		^{239}Pu (nBq/mL)[(a)]		^{239}Pu (mBq/dry g)[(a)]
	LLNL	LWRP	LLNL	LWRP	LLNL	LWRP	LWRP sludge[(b)]
Jan	13 ± 5	–3.0	2.1 ± 0.4	<0.38	287 ± 62	–18.0 ± 23.9	
Feb	77 ± 7	–3.2	36 ± 2	1.17 ± 0.04	4370 ± 592	17.3 ± 38.5	
Mar	88 ± 6	4.1	10 ± 1	0.29 ± 0.23	1370 ± 144	–0.73 ± 9.40	1.2 ± 0.1
Apr	17 ± 6	2.3	0.92 ± 0.57	<0.62	159 ± 54	1.9 ± 13.3	
May	8.8	2.6	0.57	<0.73	169 ± 76	31.5 ± 40.0	
Jun	7.6	3.1	1.7 ± 0.4	<0.52	171 ± 54	1.8 ± 11.3	2.0 ± 0.2
Jul	8.9	–2.0	1.2 ± 0.4	<0.73	224 ± 55	–2.19 ± 8.18	
Aug	4.1	–3.4	1.1 ± 0.3	<0.40	147 ± 37	–1.78 ± 4.48	
Sep	28 ± 7	0.85	1.7 ± 0.6	<0.50	219 ± 53	1.79 ± 7.59	0.68 ± 0.11
Oct	3.5	1.4	1.4 ± 0.5	<0.47	389 ± 90	–11.8 ± 15.6	
Nov	2.5	–2.3	1.2 ± 0.9	<0.53	335 ± 66	–5.44 ± 5.99	
Dec	3.9	0.012	1.5 ± 0.7	<0.68	437 ± 84	3.31 ± 9.92	0.36 ± 0.07
Median	**9**	**0.4**	**1.4**	**0.53**	**256**	**–1.3**	**0.94**
IQR[(c)]	**16**	**4.8**	**0.6**	**—[(d)]**	**230**	**7.3**	**0.81**
	pCi/mL[(e)]						**pCi/ dry g[(e)]**
Median	**0.24**	**0.01**	**3.8×10^{-5}**	**$<1.4 \times 10^{-5}$**	**6.9×10^{-6}**	**-3.4×10^{-8}**	**0.025**
IQR[(c)]	**0.42**	**0.13**	**1.6×10^{-5}**	**—[(d)]**	**6.2×10^{-6}**	**2.0×10^{-7}**	**0.022**
	Annual total discharges by radioisotope						
	^{3}H		**^{137}Cs**		**^{239}Pu**		**Total[(f)]**
Bq/y	**9.1×10^{9}**		**1.5×10^{6}**		**2.1×10^{5}**		**9.1×10^{9}**
Ci/y	**0.25**		**4.1×10^{-5}**		**5.7×10^{-6}**		**0.25**
	Fraction of limit[(g)]						
DOE	**7.4×10^{-5}**		**8.1×10^{-6}**		**1.7×10^{-6}**		**7.4×10^{-5}**
10 CFR 20	**0.049**		**1.2×10^{-5}**		**8.5×10^{-5}**		**—[(h)]**

Note: Radionuclide results are reported ±2σ; see Chapter 13, Quality Assurance.

a Ranges are only listed for activities that are above the limit of sensitivity.

b Sludge from LWRP digesters is dried before analysis. The resulting data indicate the plutonium concentration of the sludge prepared by LWRP workers for disposal at the Livermore Sanitary Landfill.

c Interquartile range.

d Because of the large number of nondetections, the interquartile range is omitted. See Chapter 13, Quality Assurance.

e 1 Ci = 3.7×10^{10} Bq.

f Does not include gross alpha and beta results shown in **Table 6-4**.

g Fraction of limit calculations are based on the annual total discharge for a given isotope and the corresponding monthly concentration-based limit (multiplied by the annual volume of Livermore site effluent) or, preferably the annual limit, if one exists.

h The fraction of the 10 CFR 20 limit is not presented because tritium discharges have an annual limit and cesium and plutonium discharges have monthly concentration-based limits. See the individual fractions for each of these radioisotopes.

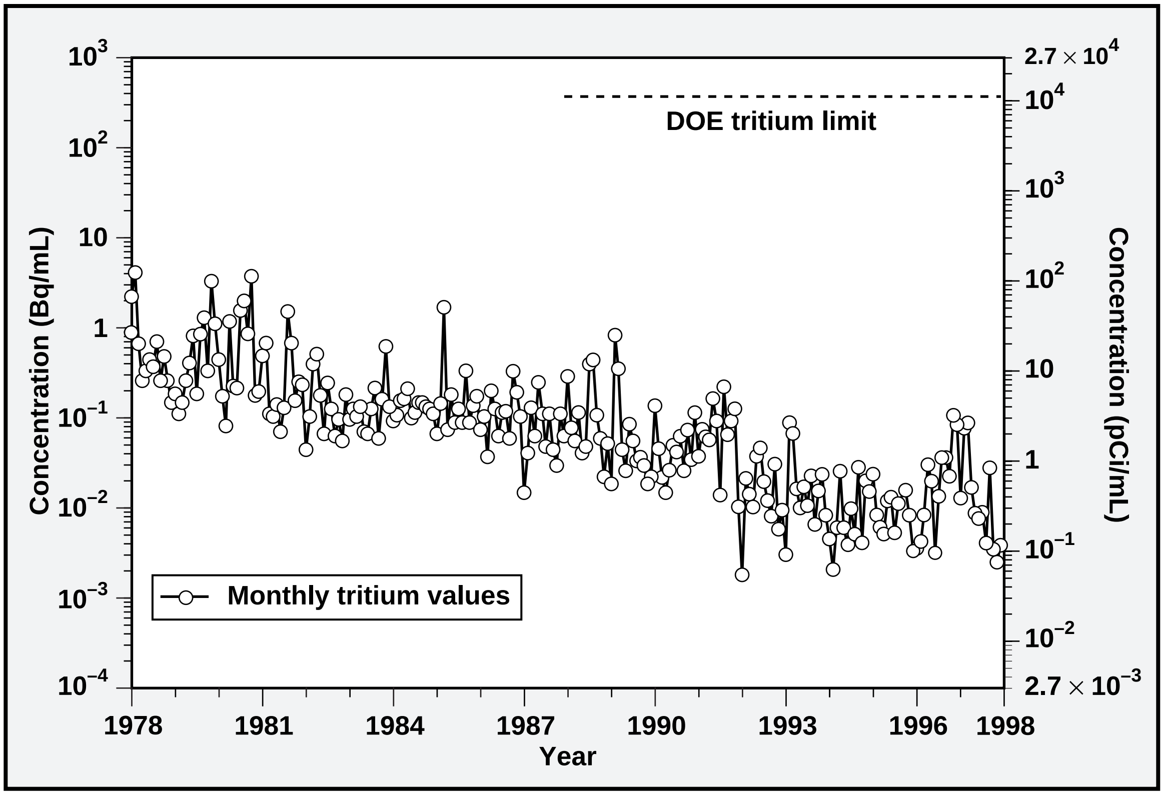

Figure 6-2. Historical trend in tritium concentration in LLNL sewage.

DOE Order 5400.5 established DOE policy requiring that radiological releases to the sanitary sewer comply with legally applicable local and state regulations and that LLNL implement standards generally consistent with those of the Nuclear Regulatory Commission. The most stringent of these limits was adopted in Title 17 of the California Code of Regulations. As a federal facility, LLNL is formally exempt from the requirements of state regulations but follows those requirements under the guidance of DOE. Title 17 contained a limit on discharges of radioactivity in sewage of 37 GBq (1 Ci) each year; it also listed limits on the daily, monthly, and annual concentration for each specific radionuclide.

In 1994, the discharge requirements previously found in Title 17 were removed and the requirements in Title 10 of the Code of Federal Regulations, Part 20, incorporated by reference. Title 10 contains a limit for the total discharge activity of tritium (185 GBq or 5 Ci), carbon-14 (37 GBq or 1 Ci), and all other radionuclides combined (37 GBq or 1 Ci); in addition, it specifies that the discharge material must be soluble and lists limits on monthly concentrations.

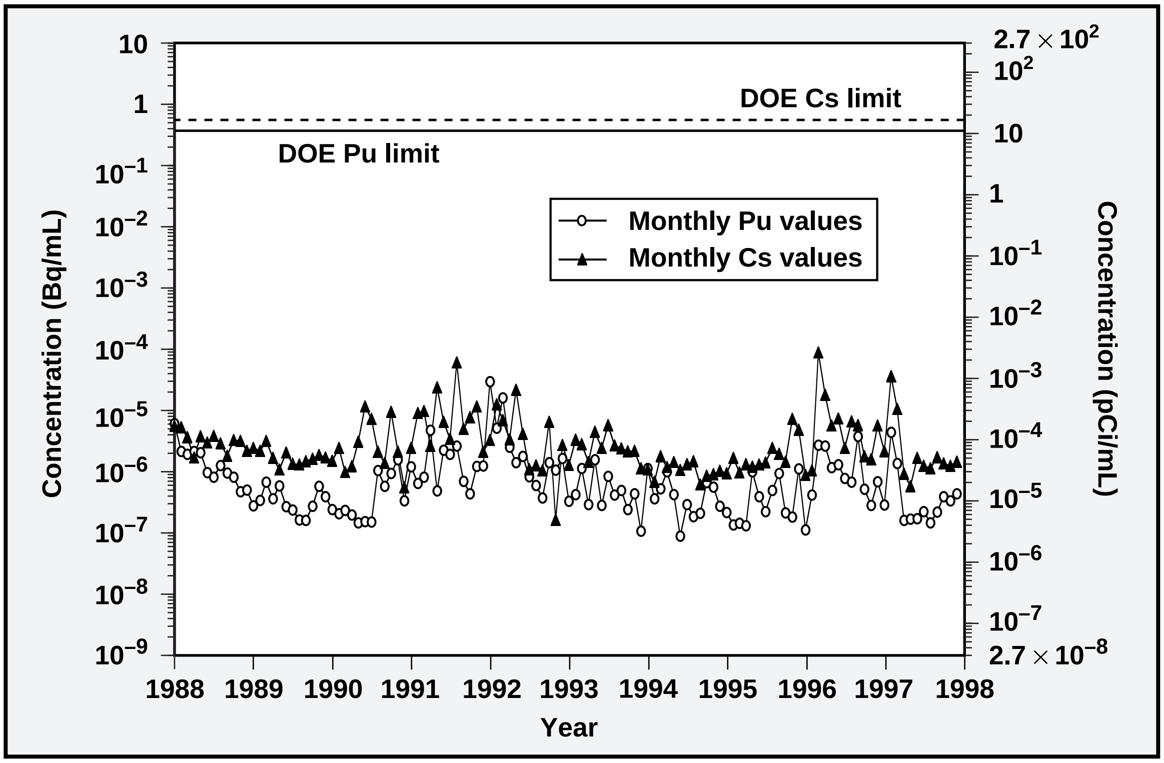

Figure 6-3. Historical trends in plutonium and cesium concentration in LLNL sewage.

Table 6-6 summarizes the discharge requirements of Title 10. Because Title 10 permits and therefore applies to only soluble discharges, and because the plutonium in LLNL effluent is in both the soluble and insoluble forms, LLNL follows the discharge requirements for ^{239}Pu in DOE Order 5400.5. This assumption is supported by our experience during the sewer system evaluation, when increased cleaning led to higher plutonium concentrations in LLNL sewage (Gallegos et al. 1992). This indicates that a portion of the plutonium discharges from LLNL facilities is deposited on the sewer pipes, and when these deposits are liberated and discharged from the LLNL site, they are, by their nature, insoluble.

Table 6-6 also includes the total activity that could have been discharged by LLNL during a given period (monthly and annually) using 10 CFR 20 monthly concentrations in conjunction with the annual caps and assuming the 1997 average monthly flow rate and total flow volume. As the table shows, the Title 10 concentration limits for tritium for facilities such as LLNL that generate wastewater in large volumes are overridden by the limit on total tritium activity (185 GBq) dischargeable

Table 6-6. Sewer discharge release limits for ^{3}H, ^{137}Cs, and ^{239}Pu.

	^{3}H	^{137}Cs	^{239}Pu
10 CFR 20 concentrations used to establish release limits (Bq/mL)	370	0.37	0.0074
10 CFR 20 (GBq)			
Monthly	185[a]	10	0.21
Yearly	185[a]	37[b]	2.5
DOE annualized discharge limit for application of BAT[c] (Bq/mL)	370	0.56	0.37

a 10 CFR 20 imposes a 185-GBq (5-Ci) limit for the tritium radiation released.

b 10 CFR 20 imposes a 37-GBq (1-Ci) combined limit on the total of all radiation released (excluding tritium and C^{14}, which have separate 10 CFR 20 limits of 185 GBq and 37 GBq, respectively); i.e., the total release of all isotopes must not exceed 37 GBq. If a total of 37 GBq of a particular isotope were released during the year, this would require that no other isotopes be released.

c The DOE annualized discharge limit for application of best available technology (BAT) is five times the Derived Concentration Guide (DCG; ingested water) for each radionuclide released.

during a single year. In 1997, the total LLNL tritium release was 4.9% of the corresponding Title 10 limit. Total LLNL releases (**Table 6-4**), in the form of alpha and beta emitters (excluding tritium), were 0.79% of the corresponding Title 10 limit.

DOE has also established criteria for the application of best available technology to protect public health adequately and minimize degradation of the environment. These criteria (the Derived Concentration Guides, or DCGs) limit the concentration of each specific radionuclide discharged to publicly owned treatment works. If a measurement of the monthly average concentration of a radioisotope exceeded its concentration limit, LLNL would be required to improve discharge control measures until concentrations were again below the DOE limits. **Table 6-6** presents the DCGs for the specific radioisotopes of most interest at LLNL.

The annual average concentration of tritium in LLNL sanitary sewer effluent was 7.4×10^{-5} (that is, 0.0074%) of the DOE DCG (and the Title 10 limit); the annual average concentration of ^{137}Cs was 8.1×10^{-6} (0.00081%) of the DOE DCG (and 1.2×10^{-5} or 0.0012% of the Title 10 limit); and the annual average ^{239}Pu concentration was 1.7×10^{-6} (0.00017%) of the insoluble ^{239}Pu DOE DCG, 1.2×10^{-4} (0.012%) of the soluble ^{239}Pu DOE DCG, and 8.5×10^{-4} (0.085%) of the Title 10 limit. The combined discharges were therefore 8.4×10^{-5} (0.0084%) and 2.0×10^{-4} (0.020%) of the DCG, assuming exclusively insoluble and soluble ^{239}Pu contributions, respectively. As discussed earlier in this section, the plutonium in LLNL effluent is assumed to be present both in the soluble and insoluble forms.

LLNL also compares annual discharges with historical values to evaluate the effectiveness of ongoing discharge control programs. **Table 6-7** summarizes the radioactivity in liquid effluent released over the past 10 years. During 1997, a total of 9.1 GBq (0.25 Ci) of tritium was discharged to the sanitary sewer. As indicated earlier in this chapter, this release does not include a contribution from SNL / California; LLNL therefore discharged 9.1 GBq (0.25 Ci), an amount that is well within environmental protection standards and is comparable to the amounts reported for the last several years. Moreover, the total tritium released by LLNL in 1997 (and the years from 1992 through 1996) is below the range reported prior to 1992.

Table 6-7. Radioactive liquid effluent releases from the Livermore site, 1988–1997.

	Liquid effluents (GBq)	
Year	^{3}H	^{239}Pu
1988	56	8.1×10^{-4}
1989	59	1.8×10^{-4}
1990[(a)]	25	2.3×10^{-4}
1991	32	6.1×10^{-4}
1992	8	1.9×10^{-3}
1993	13	2.6×10^{-4}
1994[(b)]	6.9	1.9×10^{-4}
1995	6.0	1.2×10^{-4}
1996	12	4.2×10^{-4}
1997	9.1	2.1×10^{-4}

Note: The 1996 and 1997 totals for tritium do not include contributions from Sandia National Laboratories/California (SNL/CA); in 1995, SNL/CA ceased all tritium facility operations.

a The 1990 DOE Order 5400.5 required compliance with legally applicable local and state regulations. California Title 17 mandated a 37 GBq (1 Ci) combined limit on the total of all radiation released.

b In 1994, the discharge requirements previously found in Title 17 were changed to correspond to the requirements in Title 10 of the Code of Federal Regulations, Part 20. Title 10 contains a limit for the total discharge activity of tritium (185 GBq or 5 Ci), carbon-14 (37 GBq or 1 Ci), and all other radionuclides combined (37 GBq or 1 Ci).

Figure 6-3 summarizes the ^{239}Pu monitoring data over the past 10 years. The historical levels observed since 1988 average 1 μBq / mL (3×10^{-5} pCi / mL). These historical levels generally are two-tenthousandths (0.0002) and three-millionths (0.000003) of the DOE DCGs for the soluble and insoluble forms of ^{239}Pu, respectively. The greatest part of the plutonium discharged in LLNL effluent is ultimately concentrated in LWRP sludge, which is dried and disposed of at a landfill. The median plutonium concentration observed in 1997 sludge (**Table 6-5**), 0.94 mBq / dry g (0.025 pCi / dry g), is approximately

100 times lower than the EPA preliminary remediation goal for residential soil (93 mBq / dry g) and is nearly 400-times lower than the remediation goal for industrial or commercial soil (370 mBq / dry g).

As first discussed in the Environmental Report for 1991 (Gallegos et al. 1992), plutonium and cesium concentrations were slightly elevated during 1991 and 1992 over the lowest values seen historically. As was established in 1991, the overall upward trend was related to sewer cleaning with new, more-effective equipment. During 1993, as utility personnel worked to complete an assessment of the condition of the sewer system, cleaning activity around the site was less extensive, resulting in slightly lower plutonium and cesium concentrations in LLNL effluent. During 1994, in conjunction with the installation of the synthetic sock lining in the sewer system, the cleaning activity around the site was more extensive than in 1993. However, by the end of 1993 the new sewer cleaning equipment had been used on LLNL's entire sewer system; this was reflected in 1994 and the majority of 1995 by the continuation of the slightly lower plutonium and cesium concentrations that were observed in the 1993 effluent.

The plutonium and cesium concentrations in 1996 and the first quarter of 1997 are slightly higher than the concentrations observed in 1993 through 1995, and slightly lower than the observed concentrations of 1990 through 1992, with the exception of a cesium peak early in 1997. This peak, pictured in **Figure 6-3** and reported in **Table 6-5**, is attributable to a controlled release from an LLNL retention tank system and is well below the applicable DOE DCG. The slightly higher plutonium and cesium concentrations of 1996 and the first quarter of 1997 are well below applicable DOE DCG's and remain indicative of well-controlled discharges. The final three quarters of 1997 plutonium and cesium concentrations are comparable to the concentrations observed in 1993 through 1995, and, as such, are also well below the applicable DOE DCGs.

Nonradioactive Pollutants in Sewage

Monitoring Results

Table 6-8 presents monthly average metal concentrations in LLNL's sanitary sewer effluent. The averages were obtained by a flow-proportional weighting of the results from analysis of the weekly composite samples and the 24-hour composites collected each month. Each result was weighted by the total flow volume for the period during which the sample was collected. The results are typical of the values seen during previous years, 1994–1996 (**Figure 6-4**), except for arsenic, mercury and lead

Table 6-8. Average monthly results for metals in LLNL sanitary sewer effluent (in mg/L), 1997 summary.

Month	Ag	Al	As	Be	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn
Jan	0.010	0.29	0.0035	<0.00050	<0.0050	0.016	0.095	1.0	0.00056	0.0054	0.013	0.22
Feb	0.027	0.42	0.0021	<0.00050	0.0050	0.015	0.098	1.3	0.00082	0.017	0.013	0.24
Mar	0.017	0.52	0.010	<0.00050	<0.0050	0.019	0.12	2.1	0.0010	0.024	0.015	0.27
Apr	0.022	0.97	0.0021	<0.00050	<0.0050	0.029	0.16	3.0	0.0016	0.0086	0.024	0.35
May	0.017	0.74	0.0027	<0.00050	0.0052	0.028	0.17	2.4	0.0006	0.0097	0.030	0.33
Jun	0.013	0.60	0.0035	<0.00050	<0.0050	0.015	0.15	1.8	0.0012	0.016	0.036	0.30
Jul	0.016	0.51	0.0024	<0.00050	<0.0050	0.014	0.13	1.3	0.0033	0.0069	0.024	0.26
Aug	0.010	0.58	0.0025	<0.00050	<0.0050	0.013	0.16	1.6	0.0007	0.0081	0.042	0.47
Sep	<0.010	0.65	0.0029	<0.00050	0.0058	0.015	0.13	1.5	0.0012	0.0062	0.039	0.35
Oct	0.009	0.60	0.0035	<0.00044	<0.0044	0.017	0.13	1.4	0.0006	0.0060	0.040	0.29
Nov	<0.010	0.56	0.0045	<0.00050	<0.0050	0.017	0.14	1.6	0.0009	0.0061	0.045	0.37
Dec	<0.010	0.72	0.0051	<0.00050	<0.0050	0.016	0.11	1.9	0.0006	0.0084	0.026	0.29
Median	**0.012**	**0.59**	**0.0032**	**<0.00050**	**<0.0050**	**0.016**	**0.13**	**1.6**	**0.0009**	**0.008**	**0.028**	**0.30**
IQR[a]	**0.007**	**0.13**	**0.0013**	**—[b]**	**—[b]**	**0.003**	**0.04**	**0.6**	**0.0006**	**0.006**	**0.018**	**0.08**
EPL[c]	**0.2**	**—[d]**	**0.06**	**—[d]**	**0.14**	**0.62**	**1.0**	**—[d]**	**0.01**	**0.61**	**0.2**	**3.0**
Fraction of EPL	**0.06**	**—[d]**	**0.05**	**—[d]**	**<0.04**	**0.03**	**0.13**	**—[d]**	**0.09**	**0.01**	**0.14**	**0.10**

Note: Monthly values are presented with less than signs when all weekly and 24-hour composite sample results for the month are below the detectable concentration.

a Interquartile range.

b Because of the large number of nondetects, the interquartile range could not be calculated for these metals. See Chapter 13, Quality Assurance.

c Effluent pollutant limit (LLNL Wastewater Discharge Permit 1996–1997 and 1997–1998).

d No established limit for metal.

results, as discussed in the following section, Environmental Impact. Weekly and 24-hour composite sample concentrations of metals in LLNL sewage are each presented as a percentage of the corresponding effluent pollutant limit (EPL) in **Figures 6-5a** and **6-5b**. The EPL is equal to the maximum pollutant concentration allowed per 24-hour composite sample, as specified by the LLNL wastewater discharge permit. When a weekly sample concentration is at or above 50% of its EPL, the corresponding daily (24-hour composite) samples must be analyzed to determine if any of their concentrations are above the EPL.

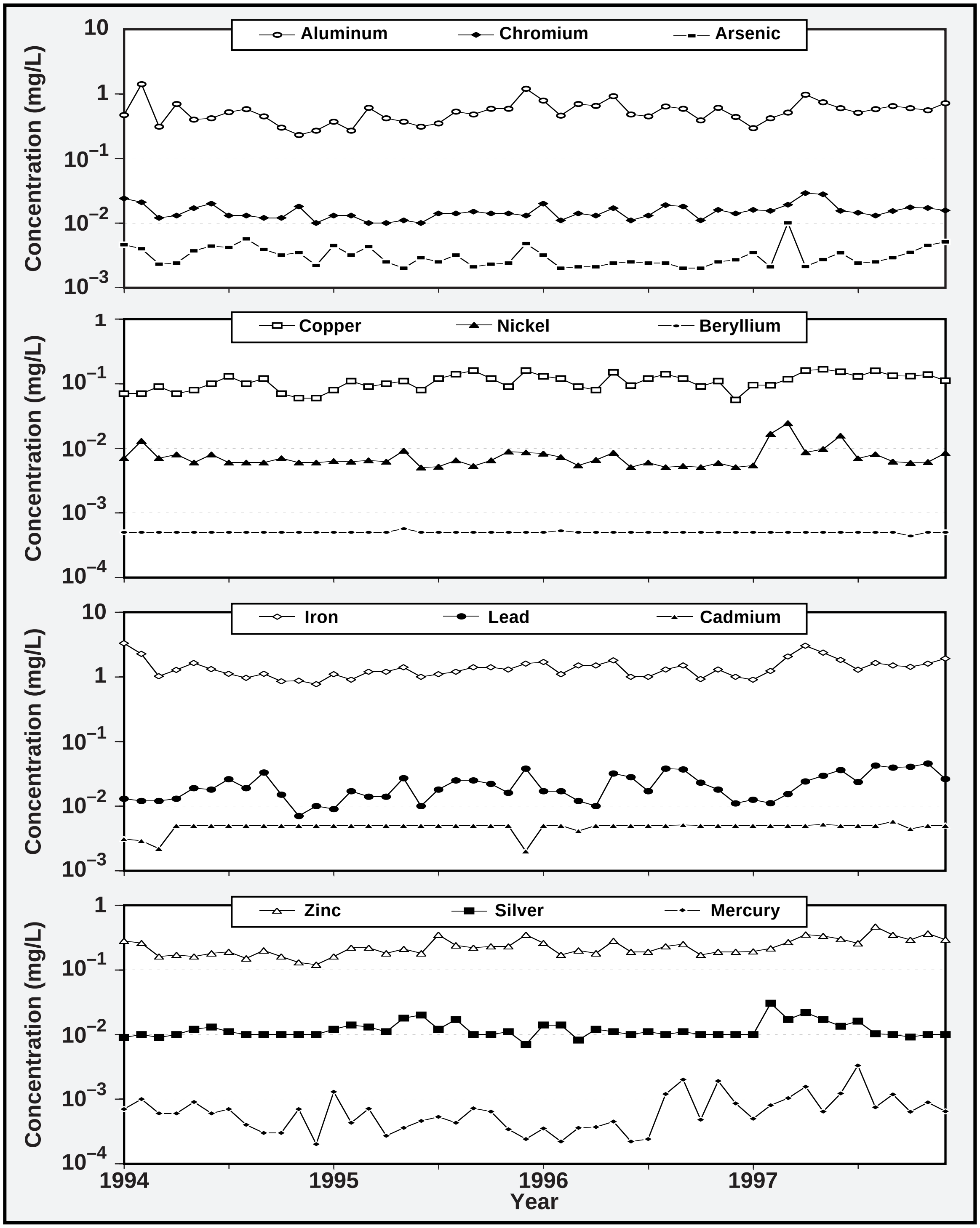

Figure 6-4. Average monthly concentrations of 12 metals in LLNL sanitary sewer effluent showing trends from 1994 through 1997.

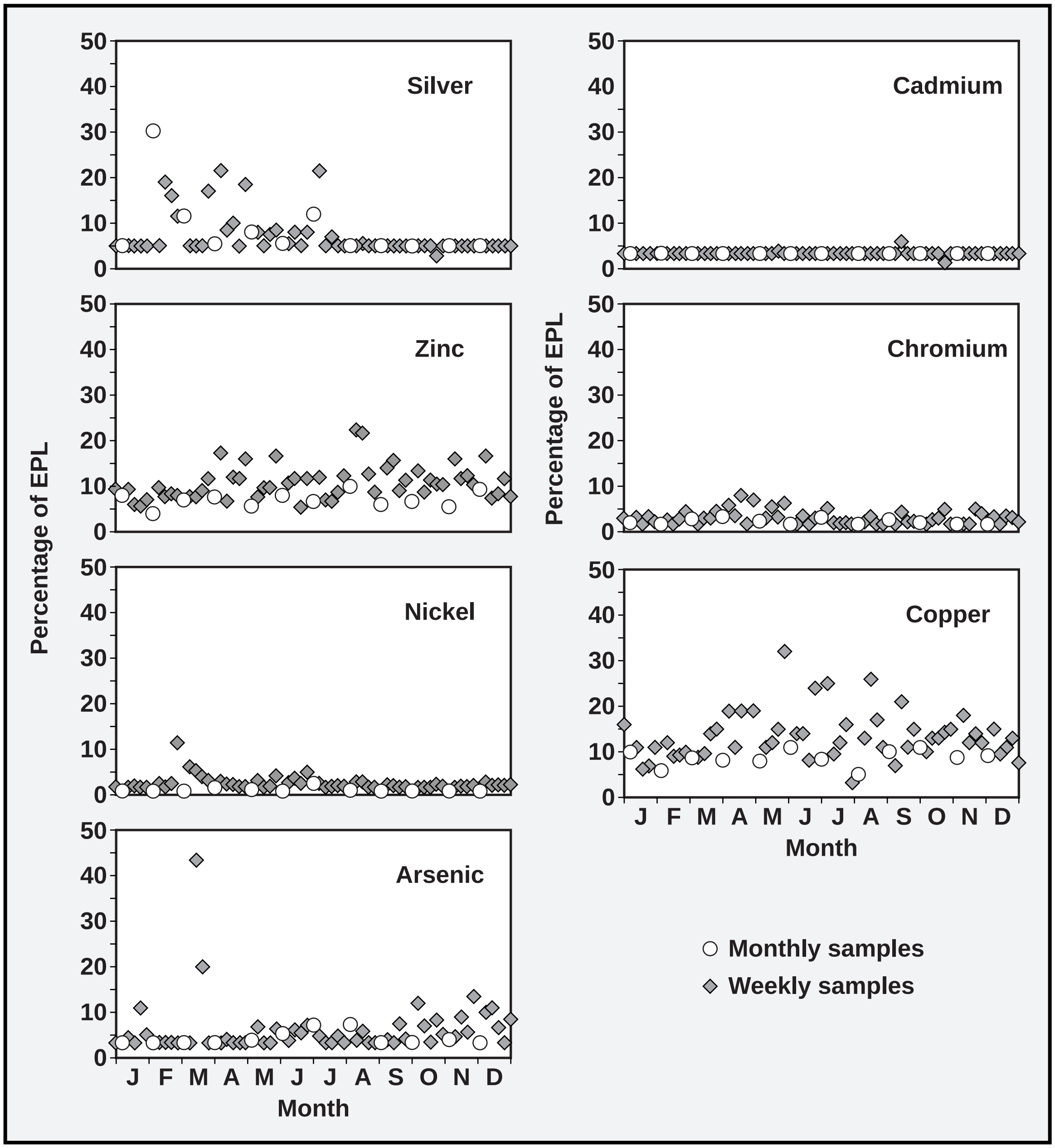

Figure 6-5a. Results as percentages of effluent pollutant limits (EPLs) for 7 of the 9 metals regulated in LLNL sewage.

Detections of anions, metals, and organic compounds and data concerning other physical and chemical characteristics of the sanitary sewer effluent are provided in **Table 6-9**. Although the samples were analyzed for bromide, nitrite (as N), carbonate

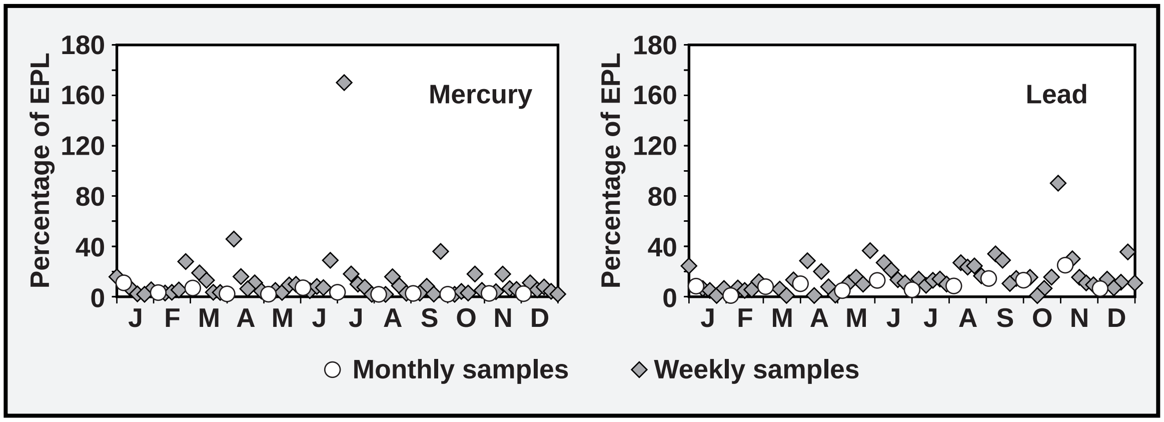

Figure 6-5b. Results as percentages of effluent pollutant limits (EPLs) for 2 of the 9 metals regulated in LLNL sewage.

alkalinity (as $CaCO_3$), hydroxide alkalinity (as $CaCO_3$), the full suite of polychlorinated biphenyls, the full suite of organochlorine pesticides, and cyanide, those analytes were not detected in any sample acquired during 1997, and so are not presented in the table. The results are quite typical of those seen in previous years.

Environmental Impact

At the bottom of **Table 6-8**, the annual median concentration for each metal detected in LLNL's sanitary sewer effluent is compared to the discharge limit. The metals that approached closest to the discharge limits were lead and copper at 14% and 13%, respectively.

Although well below discharge limits, slightly elevated arsenic levels were seen in 1992 through 1995. These levels did not continue in 1996. First discussed in the *Environmental Report 1993* (Gallegos et al. 1994), the elevated arsenic levels were the subject of an extended investigation during 1993, which concluded that the presence of arsenic in the sewer was associated with the ground water cleanup at the gas pad along the southern border of the site. The gas pad cleanup operation was continued in 1994, and the slightly elevated arsenic levels of 1993 continued in 1994. During 1995, the gas pad cleanup operations were reduced, and the elevated arsenic levels were seen less frequently. In 1996, the gas pad operations were concluded, and arsenic levels returned to pre-1992 concentrations. In 1997, gas pad operations were performed separately using portable treatment units, and the arsenic concentrations rose slightly.

Table 6-9. Monthly monitoring results for physical and chemical characteristics of the LLNL sanitary sewer effluent, 1997.

24-hour composite sample parameter (mg/L)	Detection frequency[a]	Minimum	Maximum	Median	IQR[b]
Alkalinity					
Bicarbonate alkalinity (as $CaCO_3$)	12/12	160	230	190	23
Total alkalinity (as $CaCO_3$)	12/12	160	230	190	23
Anions					
Chloride	12/12	41	71	48	10
Fluoride	12/12	0.054	0.16	0.12	0.04
Nitrate (as NO_3)	2/12	<0.5	1.1	<0.5	—
Nitrite (as NO_2)	4/12	<0.5	5.0	<0.5	—
Orthophosphate	12/12	2.3	44	19	16
Sulfate	12/12	12	65	17	12
Nutrients					
Ammonia nitrogen (as N)	12/12	35	82	48	15
Total Kjeldahl nitrogen	12/12	18	110	42	20
Oxygen demand					
Biochemical oxygen demand	12/12	170	730	310	150
Chemical oxygen demand	12/12	110	790	240	210
Solids					
Solid settling rate	12/12	8	70	23	9
Total dissolved solids (TDS)	12/12	130	470	250	48
Total suspended solids (TSS)	12/12	140	520	300	120
Volatile solids	12/12	120	470	250	95
Total metals[c]					
Calcium	12/12	12	22	16	2
Magnesium	12/12	2.4	6.9	3.6	0.6
Potassium	12/12	14	22	17	3
Selenium	2/12	<0.002	0.0040	<0.002	—
Sodium	12/12	26	57	33	5
Total organic carbon	12/12	31	110	62	39
Tributyltin (ng/L)	4/4	56	530	110	190

Table 6-9. Monthly monitoring results for physical and chemical characteristics of the LLNL sanitary sewer effluent, 1997 (concluded).

Grab sample parameters	Detection frequency[(a)]	Minimum	Maximum	Median	IQR[(b)]
Semivolatile organic compounds (µg/L)					
Benzoic acid	2/12	<25	250	<88	—
Benzyl alcohol	6/12	<10	170	<54	—
Bis(2-ethylhexyl)phthalate	4/12	<5	54	<14	—
Diethylphthalate	1/12	<5	50	<10	—
m- and *p*-Cresol	5/12	<5	110	<29	—
o-Cresol	3/12	<5	110	<17	—
Phenol	3/12	<5	<50	<18	—
Total oil and grease (average mg/L)	12/12	13	28	22	6
Total recoverable phenolics (mg/L)	11/12	<0.010	0.10	0.030	0.020
Volatile organic compounds (µg/L)					
Acetone	9/12	<40	400	100	110
Bromodichloromethane	2/12	<1	2.6	<1.0	—
Chloroform	12/12	3.6	16	11	3
Freon 113	4/12	<1	12	<1	—
Tetrachloroethene	1/12	<1	40	<1	—
Trichlorofluoromethane	1/12	<1	3.7	<1	—

a The number of times an analyte was positively identified, followed by the number of samples that were analyzed (generally 12, one sample for each month of the year).

b Interquartile range. Where the detection frequency is less than or equal to 50%, the interquartile range is omitted.

c The 24-hour composite sample results plotted in Figures 6-5a and b and reported in the Data Supplement, Chapter 6 are not reported in this table.

The monthly mercury values continued to reflect the slightly elevated trend that began in mid 1996. However, only one 1997 analytical result exceeded the action level in LLNL's Wastewater Discharge Permit, which states that archived daily composite samples must be analyzed for the pollutant of concern when the result for a weekly composite sample is 50% of, or greater than, the applicable effluent pollutant limit. The mercury analytical result (0.017 mg/L), which exceeded the action level (0.005 mg/L), occurred during July (see **Figure 6-5**). The archived daily samples that corresponded to the appropriate weekly composite sampling period of July 1-7 were submitted for mercury analysis. All of the analytical results for the daily samples were less than the effluent pollutant limit of 0.01 mg/L, with the exception of the result for July 4 of 0.017 mg/L, which exceeded the applicable effluent pollutant limit. The LWRP, the regulatory agency, issued a Notice of Violation (NOV) for the permit exceedance in September 1997. The corrective actions that LLNL has identified are outlined in Chapter 2, **Table 2-10**.

All of the 1997 results for lead were well below the applicable action level and the applicable effluent pollutant limit, with the exception of the October 28 through November 3 weekly composite sample. The lead concentration for this sample (0.18 mg/L) was above the criterion for the action level (0.1 mg/L). LLNL submitted the daily samples for lead analysis. The lead concentrations in two of the samples were slightly above the effluent pollutant limit of 0.2 mg/L. The concentrations in the October 31 and November 1 samples are 0.28 mg/L and 0.25 mg/L, respectively. The other five sample concentrations were below the permit discharge limit of 0.2 mg/L. The LWRP issued an NOV in January 1998, but because of the isolated nature of the discharge, did not suggest or require corrective action. For 1997 as a whole, the monthly lead values presented in **Table 6-8** are slightly higher than those reported in previous years.

Thirteen inadvertent discharges were detected in 1997 by the continuous monitoring system. These incidents did not represent a threat to the integrity of the operations at the LWRP. All of the incidents involved either a metal, an acid, or a base and were reported to the LWRP; LLNL is not permitted by the LWRP to discharge effluent above the effluent pollutant limits specific to each of nine regulated metals or with a pH below 5 or above 10.

Four of the 13 events were metals releases (**Table 6-10**) and the others were pH incidents (**Table 6-11**). Only one of the four inadvertent metals discharges (silver on February 5) resulted in a permit exceedance. Of the nine pH incidents, seven pH discharges below the permit limit of 5 and two were discharges above the permit limit of 10.

Table 6-10. Inadvertent metals discharges detected by the continuous monitoring system in 1997.

Date	Contaminant	Estimated duration (min)[a]	Estimated volume (L)[b]	Daily composite sample concentration (mg/L)	Permit limit (mg/L)
2/5[c]	Silver	20	61,000	0.56	0.2
3/18[c]	Lead	60	15000	0.033	0.2
3/21[c]	Lead	5	1200	<0.002	0.2
11/8[c]	Zinc	100	79,000	0.20, 0.52, 1.6, 0.77[d]	3.0

a For a metal contaminant, the estimated duration corresponds to the duration of the sewer diversion.

b For a metal contaminant, the estimated volume corresponds to the volume of LLNL effluent contained during the sewer diversion.

c All incidents initiated a sewer diversion. All wastewater retained by the sewer diversion facility was later returned to the sanitary sewer system with the exception of contaminated wastewater diverted on February 5 and March 18. The majority of the silver and lead bearing wastewater, contained on February 5 and March 18, respectively, was shipped off site for disposal. With the possible exception of the zinc bearing wastewater contained on November 8, the contaminant concentration of the wastewater returned to the sanitary sewer was only slightly above the EPLs (permission to return this wastewater to the sanitary sewer system was expressly granted by the LWRP). The zinc concentration is not known explicitly for the wastewater retained on November 8; see footnote g in Table 6-11.

d These values are the concentrations for the November 8, 9, 10, and 11 daily composite samples, respectively. The four daily samples submitted for analyses include all sample aliquots collected during the duration of the detected discharge and the return of diverted wastewater to sanitary sewer.

Table 6-11. Inadvertent pH discharges detected by the continuous monitoring system in 1997.

Date	Contaminant	Estimated duration (min)[a]	Estimated volume (L)[b]	Minimum or maximum pH	Permit limit
2/12[c,d]	Acid	8	9600	2.1	5
2/21[e]	Base	6	1800	10.1	10
4/7[e]	Base	6	1300	10.1	10
8/21[c,f]	Acid	14	29000	2.5	5
11/21[g]	Acid	1	1000	3.0	5
12/5[h]	Acid	15	11000	3.3	5
12/15	Acid	1	1000	4.8	5
12/19[h]	Acid	3	3300	3.2	5
12/24[c,i]	Acid	8	3100	2.9	5

a For an acid or a base contaminant, the estimated duration includes only the time during which the pH of LLNL effluent was below or above the permitted range of 5 to 10, respectively.

b For an acid or a base contaminant, the estimated volume includes only the volume of LLNL effluent that was below or above the permitted range of 5 to 10, respectively.

c This incident initiated a sewer diversion. All wastewater retained by the sewer diversion facility was later returned to the sanitary sewer. The contaminant concentration of all wastewater returned to the sanitary sewer was within the permitted range for pH.

d Based on a high sulfate concentration measured in an instantaneous sample acquired during the incident and the general usefulness of sulfuric acid in work, the most probable cause for this incident is assumed to be sulfuric acid.

e LWRP chose not to consider these incidents as enforceable exceedences because they did not exceed the duration criteria of 40 CFR 401.17 and these types of exceedances are not addressed in 40 CFR 403.5.

f Based on a high nitrate concentration measured in an instantaneous sample acquired during the incident and the general usefulness of nitric acid in chemical work, the most probable cause for this incident is assumed to be nitric acid.

g LWRP choose not to enforce this exceedence.

h This incident occurred during regularly scheduled maintenance activities and, consequently, did not initiate a sewer diversion.

i Based on a high orthophosphate concentration measured in an instantaneous sample acquired during the incident and the general usefulness of phosphoric acid in chemical work, the most probable cause for this incident is assumed to be phosphoric acid.

As summarized in **Tables 6-10** and **6-11** more than half of the inadvertent discharges warranted sewage diversion. (Unconfined pH and metals releases of sufficient concentration and duration outside of the effluent pollutant limits could disrupt treatment plant operations or cause the treated wastewater to exceed allowable concentration limits for discharge to the San Francisco Bay.) For comparison, 1, 1, 1, 0, and 13 such diversions occurred in 1996, 1995, 1994, 1993, and 1992, respectively. Subsequent analysis of the effluent diverted for pH incidents showed that the average pH was acceptable for release of the wastewater back to the sanitary sewer. All effluent diverted for metals incidents was either returned to the sanitary sewer or shipped off site for disposal.

As a result of several of these incidents, the LWRP issued three Notices of Violation. The first NOV, issued in March 1997, was for silver and pH exceedances on February 5 and 12, respectively. The NOV specifically targeted these two discharges, but treated the pH exceedance as a continuation of low pH exceedances in 1996. A second NOV was issued in October 1997 for the pH exceedance on August 21. The NOV specifically targeted the August 21 discharge, but considered the exceedance as part of a pattern of pH exceedances that began in January 1996. The final NOV, issued in January 1998, was for the four different pH exceedances in December 1997, although these exceedances were considered to be part of the pattern of pH exceedances discussed in the October NOV. Corrective actions taken by LLNL in response to these incidents and their associated NOVs are summarized in Chapter 2, **Table 2-10**.