6. Sewage Monitoring

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Introduction

In 1995, the Livermore site discharged approximately 1.0 million liters (ML) per day of wastewater to the City of Livermore sewer system, an amount that constitutes 4.9% 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. In 1995, SNL / California generated approximately 14% of the total flow discharged from the Livermore site. The wastewater contains sanitary sewage and industrial effluent and is discharged in accordance with permit requirements and the City of Livermore Municipal Code.

The effluent is processed 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 the treated effluent 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 Quality 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.

Administrative and engineering controls at the Livermore site effectively 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 are used to collect wastewater from processes that might release contaminants in quantities sufficient to disrupt operations at the LWRP. Finally, to verify the success of training and control equipment, wastewaters are 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.

To ensure the integrity of the wastewater collection system, LLNL has pursued an aggressive assessment and rehabilitation program. (See Chapter 2, Compliance

Summary, for details.) Begun in 1992 and completed in 1995, the program tested all known building drains to determine their points of discharge. The identified deficiencies, considered to be illicit connections, were classified and corrected; major deficiencies were immediately remedied. Finally, preparatory to relining with a synthetic sock, the major laterals of the sanitary sewer system were videotaped and evaluated. Major line failures were repaired. In addition, the retention tank infrastructure at LLNL is undergoing comprehensive evaluation and rehabilitation (see Tank Management, Chapter 2).

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 has 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.

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 (as mentioned above), 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, since July 1990, automatically notifies the LWRP in the event that contaminants are detected. Trained staff respond to all alarms to evaluate the cause.

Two major upgrades were made to the continuous monitoring system in the first quarter of 1995. First, the monitoring system computer was replaced and a redesigned sewer monitoring software system implemented. The new computer is markedly faster, more reliable, and serviceable; the new software is cohesively structured and well-documented. Secondly, the mechanical aspects of the monitoring system were redesigned: plumbing was reorganized and brought up to waste handling standards, the floor layout was reconfigured, the floor was graded and sealed, and extraneous equipment was removed from the facility.

The mechanical upgrade reduces accidental contact with sensitive equipment and facilitates cleaning and maintenance of the continuous monitoring system.

On the basis of the continuous monitoring data, during 1995 there was one release of a corrosive contaminant above the warning levels (see the Environmental Impact section of this chapter) and no releases of metallic or radioactive contaminants that warranted a sewer diversion (see below). This single release is consistent with the results for 1994 and 1993, when one and no such releases, respectively, were detected, and contrasts markedly with the results for 1991 and 1992, when 15 and 13 such releases, respectively, were detected.

In 1991, LLNL completed construction of a diversion system that is automatically activated when the 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 the liquid is not hazardous or after the contamination level is adjusted, depending on analytical results), shipped for off-site disposal, or treated at LLNL's Hazardous Waste Management Facility. All diverted sewage in 1995 was returned to the sanitary sewer.

In 1991, LLNL completed the implementation of a system of 10 satellite monitoring stations that operates in conjunction with the sewer monitoring system (**Figure 6-1**). The satellite monitoring stations are 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 consists of an automatic sampler that collects samples on a time-proportional basis. If there is a release, these samples are analyzed. However, early in 1994, all but two (86B and 51A) of the satellite monitoring stations were taken off line pending ergonomic reengineering of the equipment used during routine maintenance. In 1995, one satellite monitoring station (163A) was restored to operation. This satellite monitoring station is located at the point of discharge of SNL/California wastewater to the LLNL collection system. The low level of unacceptable releases to the sewer has lowered the priority for this reengineering.

Radioactivity in Sewage

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 6-1**). The 1995 combined releases of tritium and alpha and beta sources were 5.4 GBq (0.15 C i). The total is based on the results shown in **Table 6-1**, reduced by reported SNL/California tritium releases of 0.9 GBq (0.02 Ci). The annual mean concentration of tritium in LLNL sanitary sewer effluent was 0.014 Bq/mL (0.38 pCi/mL).

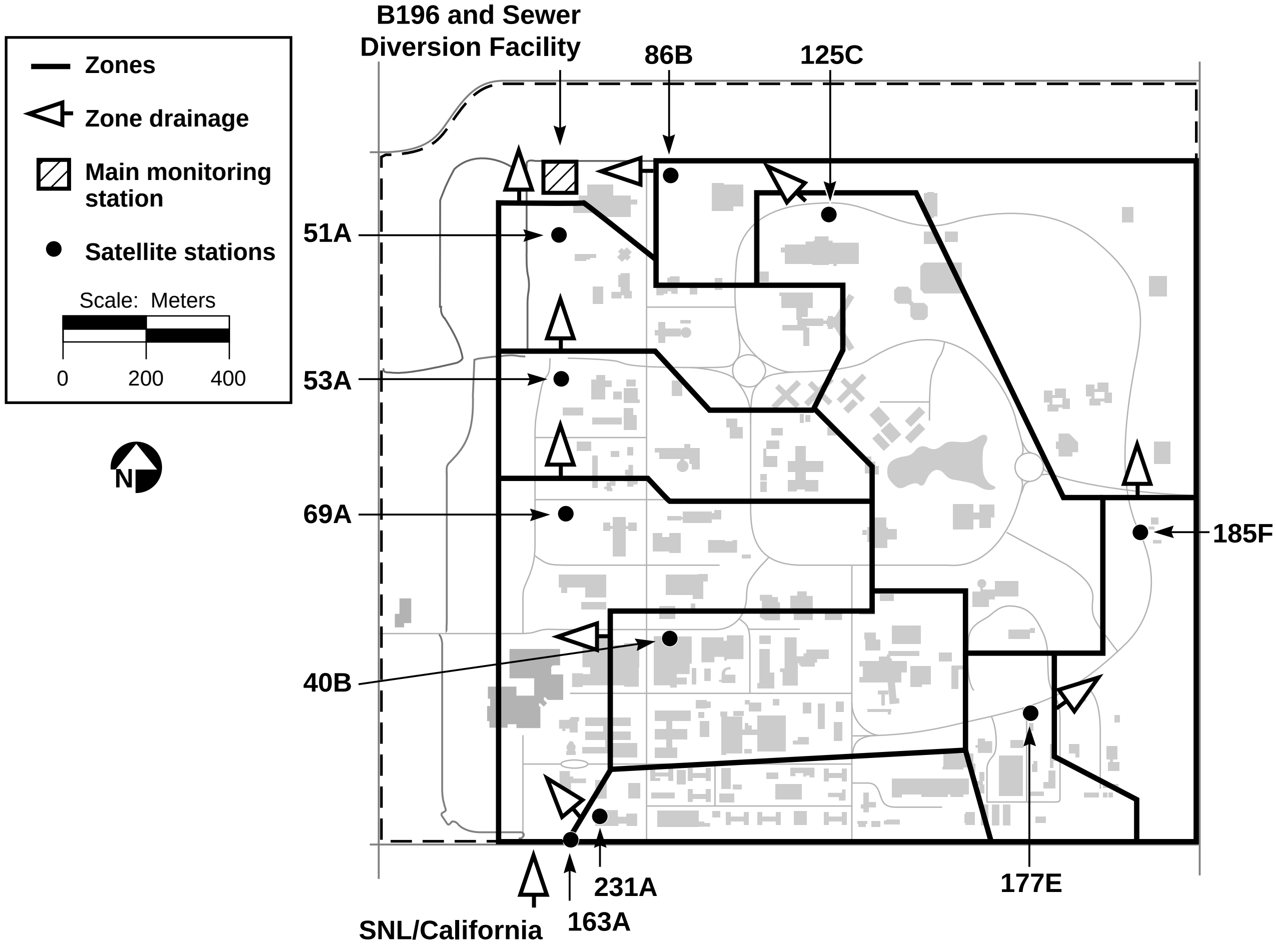

Figure 6-1. Sewer monitoring network.

Table 6-1. Estimated total radioactivity in sanitary sewer effluent, LLNL, 1995.

Radioactive emitter	Estimate based on effluent concentration (GBq)[a]	Limit of sensitivity (GBq)[a]
Tritium	6.0[b]	3.9
Alpha sources	0.065	0.062
Beta sources	0.24	0.066

a GBq = 10^9 Bq or 0.027 Ci.

b 6.0 GBq includes 5.1 GBq from LLNL plus 0.9 GBq from SNL/California.

Table 6-2. Various radionuclides in sanitary sewer effluents, LLNL and LWRP, 1995.

Month	^{3}H (mBq/mL)		^{137}Cs (µBq/mL)		^{239}Pu (nBq/mL)		^{239}Pu (mBq/dry g)
	LLNL	**LWRP**	**LLNL**	**LWRP**	**LLNL**	**LWRP**	**LWRP sludge[(a)]**
January	24 ± 1	1.9 ± 1.2	0.9 ± 0.4	<0.3	217 ± 46	0.73 ± 8.47	
February	8.4 ± 2.2	3.6 ± 3.6	1.7 ± 0.4	<0.6	134 ± 38	9.25 ± 9.66	
March	6.1 ± 5.0	3.0 ± 3.0	1.0 ± 0.4	<0.6	143 ± 30	0.00 ± 6.48	0.82 ± 0.08
April	5.1 ± 3.7	–2.3 ± –2.3	1.3 ± 0.4	<0.5	130 ± 32	3.63 ± 6.96	
May	12 ± 3	–0.20 ± –0.20	1.2 ± 0.5	<0.5	995 ± 162	19.3 ± 19.3	
June	13 ± 5	2.0 ± 2.0	1.3 ± 0.5	<0.5	392 ± 70	13.7 ± 10.4	0.51 ± 0.05
July	5.3 ± 3.9	0.053 ± 0.053	1.4 ± 0.5	<0.7	223 ± 56	3.41 ± 3.92	
August	11 ± 4	1.7 ± 1.7	2.4 ± 0.4	<0.4	496 ± 80	7.5 ± 11.1	
September	14 ± 4	–0.94 ± –0.94	1.9 ± 0.5	0.5 ± 0.2	932 ± 116	2.86 ± 9.66	0.74 ± 0.09
October	16 ± 4	–0.61 ± –0.61	1.5 ± 0.5	<0.7	214 ± 54	–1.3 ± 12.0	
November	8.3 ± 3.4	2.2 ± 2.2	7.2 ± 0.6	1.3 ± 0.5	181 ± 43	4.55 ± 7.03	
December	3.3 ± 3.3	0.13 ± 0.13	4.8 ± 0.6	0.6 ± 0.3	1110 ± 130	3.66 ± 7.51	0.82 ± 0.08
Median	**10**	**0.90**	**1.4**	**<0.6**	**220**	**3.64**	**0.78**
Interquartile range	**7**	**2.3**	**0.8**	**—[(b)]**	**434**	**5.59**	**0.14**
	pCi/mL[(c)]						**pCi/dry g[(c)]**
Median	**0.26**	**0.024**	**3.9×10^{-5}**	**$<1.5 \times 10^{-5}$**	**6.0×10^{-6}**	**9.9×10^{-8}**	**0.021**
Interquartile range	**0.20**	**0.063**	**2.1×10^{-5}**	**—[(b)]**	**1.2×10^{-5}**	**1.5×10^{-7}**	**0.004**
	Annual total discharges by radioisotope						
	^{3}H[(d)]		**^{137}Cs**		**^{239}Pu**		**Total[(d)]**
Bq/y	**5.1×10^{9}**		**7.5×10^{5}**		**1.2×10^{5}**		**5.1×10^{9}**
Ci/y[(c)]	**0.14**		**2.0×10^{-5}**		**3.2×10^{-6}**		**0.14**
	Fraction of limit						
DOE	**3.9×10^{-5}**		**3.7×10^{-6}**		**9.0×10^{-7}**		**3.8×10^{-5}**
10 CFR	**0.028**		**2.0×10^{-5}**		**—**		**—**

Note: Radionuclide results are reported ±2σ; see Chapter 15, Quality Assurance.

a 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.

b Because of the large number of nondetections, the interquartile range is omitted. See Chapter 15, Quality Assurance.

c 1 Ci = 3.7×10^{10} Bq.

d Not including SNL/California discharges of 0.9×10^{9} Bq (0.024 Ci). Does not include gross alpha and beta results shown in **Table 6-1**.

The concentrations of ^{239}Pu, ^{137}Cs, and tritium measured in the sanitary sewer effluent from LLNL and LWRP are presented in **Table 6-2**. 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 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 plot in **Figure 6-2** indicates a well-controlled tritium discharge, one well below the DOE tritium limit and not necessarily driven by a decreasing trituium inventory at the Livermore site.

Figure 6-3 shows the average monthly plutonium and cesium concentrations in sewage since 1985. The annual mean concentration of ^{137}Cs was 2.1 µBq / mL (5.7×10^{-5} pCi / mL); the annual mean ^{239}Pu concentration was 0.33 µBq / mL (8.9×10^{-6} pCi / mL).

Nonradioactive Pollutants in Sewage

Table 6-3 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 quite typical of the values seen during previous years, with the exception of arsenic. The arsenic results are discussed below in the Environmental Impact section.

Results of monthly monitoring for metals and other physical and chemical characteristics of the sanitary sewer effluent are provided in **Table 6-4**. Note that—although the samples were analyzed for bromide, carbonate alkalinity (as $CaCO_3$), hydroxide alkalinity as ($CaCO_3$), the full suite of polychlorinated biphenyls, the full suite of organochlorine pesticides, beryllium, cadmium, and cyanide—those analytes were not detected in any sample acquired during 1995, and so are not presented in the table. The results are quite typical of those seen in previous years.

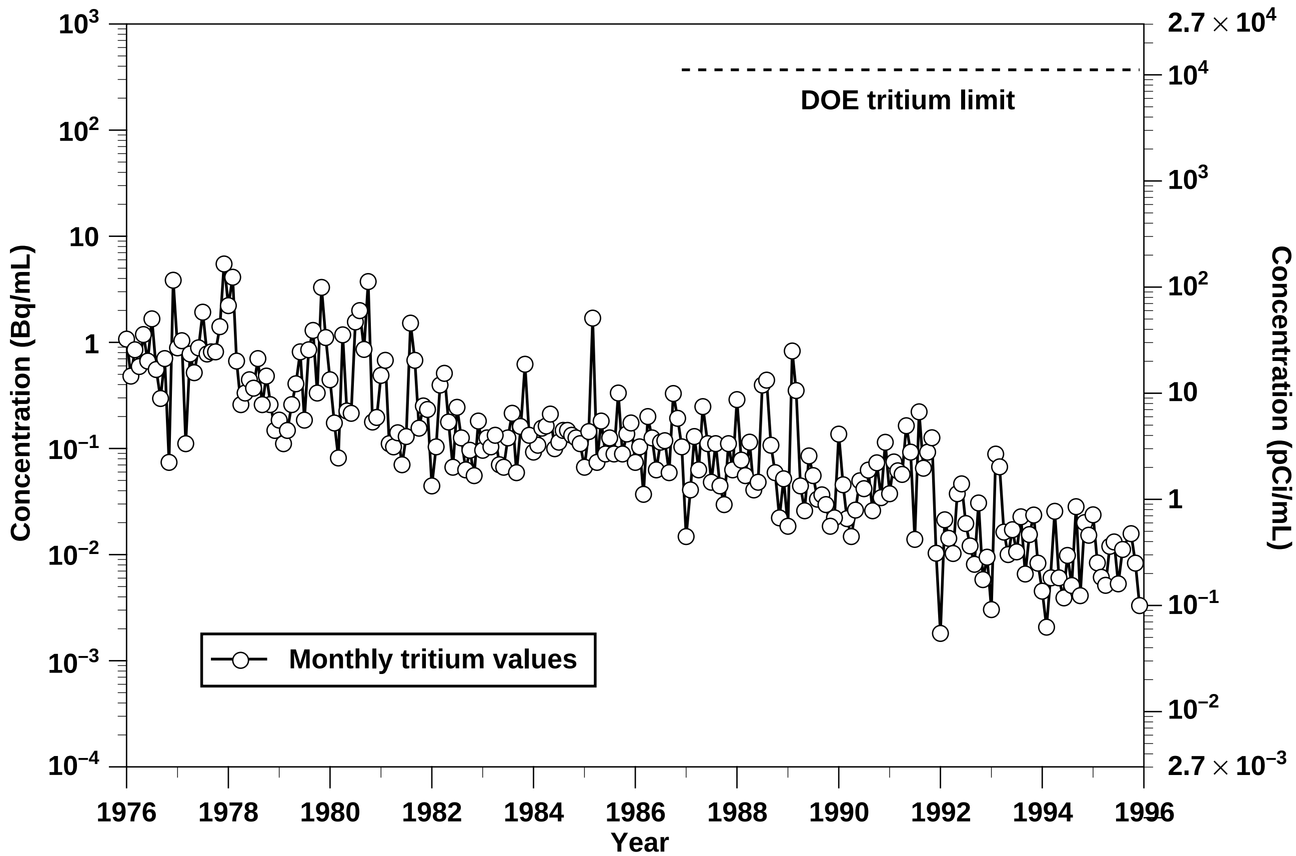

Figure 6-2. Historic trend in tritium concentration in LLNL sewage.

Environmental Impact of Radioactivity in Sewage

During 1995, no inadvertent releases exceeded any discharge limits for release of radioactive materials to the sanitary sewer system.

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 applied by 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.

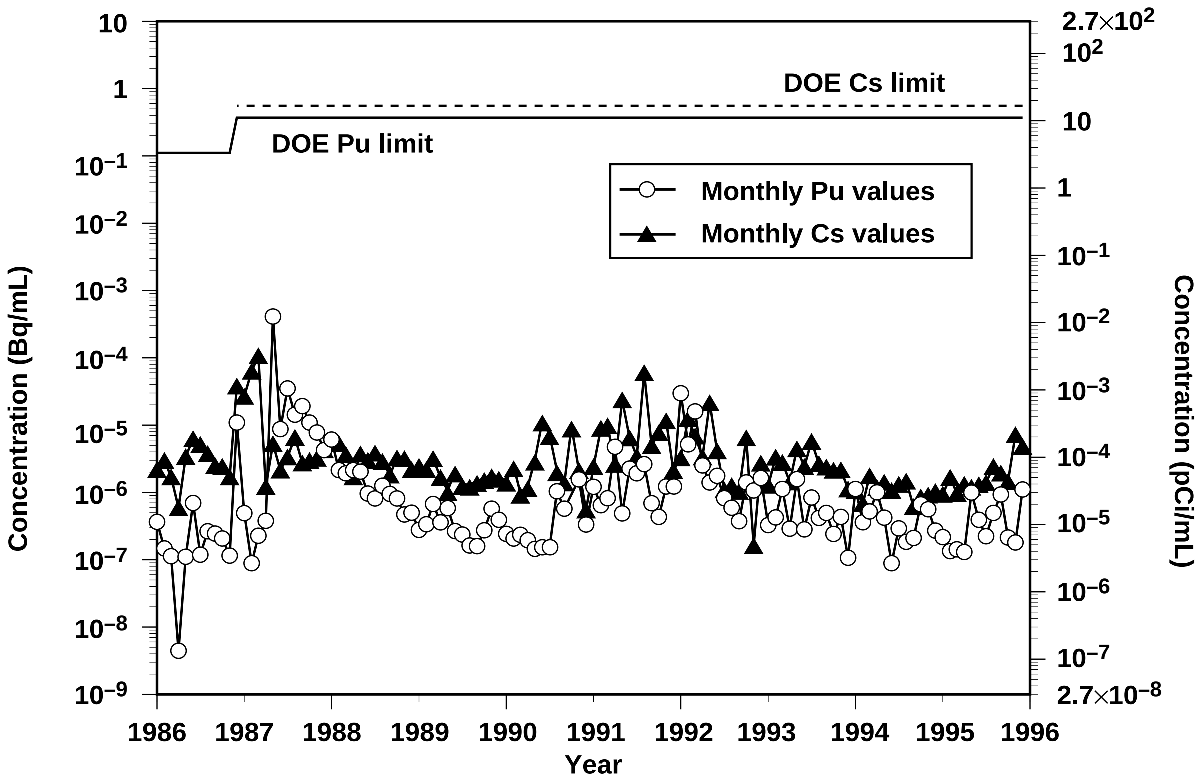

Figure 6-3. Historical trends in plutonium and cesium concentrations in LLNL sewage.

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); in addition, it specifies that the discharge material must be soluble and lists limits on monthly concentrations.

Table 6-5 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 the insoluble form, there is no applicable discharge requirement for ^{239}Pu. 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. 1992a). This indicates that the bulk of plutonium discharged is liberated from deposits on the sewer pipes, which are, by their nature, insoluble.

Table 6-3. Metals discharged to sanitary sewer system (in mg/L), 1995 summary.

Month	Ag	Al	As	Be	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn
January	0.012	0.37	0.0045	<0.00050	<0.0050	0.013	0.08	1.1	0.0013	0.0063	0.009	0.16
February	0.014	0.27	0.0032	<0.00050	<0.0050	0.013	0.11	0.9	0.00043	0.0062	0.017	0.22
March	0.013	0.61	0.0043	<0.00050	<0.0050	0.010	0.09	1.2	0.00071	0.0065	0.014	0.22
April	0.011	0.42	0.0025	<0.00050	<0.0050	0.010	0.10	1.2	0.00027	0.0062	0.014	0.18
May	0.018	0.37	0.0020	0.00057	<0.0050	0.011	0.11	1.4	0.00036	0.0092	0.027	0.21
June	0.020	0.31	0.0029	<0.00050	<0.0050	0.010	0.08	1.0	0.00046	0.0050	0.010	0.18
July	0.012	0.35	0.0025	<0.00050	<0.0050	0.014	0.12	1.1	0.00053	0.0052	0.018	0.35
August	0.017	0.53	0.0032	<0.00050	<0.0050	0.014	0.14	1.2	0.00043	0.0065	0.025	0.24
September	0.010	0.48	0.0021	<0.00050	<0.0050	0.015	0.16	1.4	0.00072	0.0053	0.025	0.22
October	0.010	0.59	0.0023	<0.00050	<0.0050	0.014	0.12	1.4	0.00064	0.0065	0.022	0.23
November	0.011	0.59	0.0024	<0.00050	<0.0050	0.014	0.09	1.3	0.00034	0.0089	0.016	0.23
December	0.007	1.2	0.0048	<0.00050	<0.0020	0.013	0.16	1.6	0.00024	0.0086	0.038	0.35
Median	**0.012**	**0.45**	**0.0027**	**<0.00050**	**<0.0050**	**0.013**	**0.11**	**1.2**	**0.00045**	**0.0064**	**0.017**	**0.22**
IQR	**0.004**	**0.22**	**0.0011**	**—[(a)]**	**—[(a)]**	**0.003**	**0.03**	**0.3**	**0.00030**	**0.0011**	**0.011**	**0.03**
DCL[(b)]	**0.2**	**—[(c)]**	**0.06**	**—[(c)]**	**0.14**	**0.62**	**1.0**	**—[(c)]**	**0.01**	**0.61**	**0.2**	**3.0**
Fraction of DCL	**0.06**	**—[(c)]**	**0.05**	**—[(c)]**	**0.04**	**0.02**	**0.11**	**—[(c)]**	**0.04**	**0.01**	**0.09**	**0.07**

a Because of the large number of nondetects, the interquartile range could not be calculated for these analytes. See Chapter 15, Quality Assurance.

b Discharge Concentration Limit (City of Livermore Ordinance 13.32).

c No established limit for analyte.

Table 6-4. Positively detected parameters in LLNL sanitary sewer effluent, 1995.

Positively detected parameter	Detection[(a)] frequency	Minimum	Maximum	Median	IQR[(b)]
Composite sample parameters (mg/L)					
Oxygen demand					
Biochemical oxygen demand	12/12	90	340	210	80
Chemical oxygen demand	11/11	60	530	180	320
Solids					
Total settleable solids (mL/L/h)	12/12	5	34	26	7
Total dissolved solids	12/12	170	470	255	95
Total suspended solids	12/12	22	410	215	120
Volatile solids	12/12	44	110	81	24
Anions					
Nitrate (as N)	3/11	<0.1	1.1	<0.5	—
Nitrate (as NO_3)	3/11	<0.5	<5	<0.5	—
Nitrite (as N)	1/11	<0.2	<1.5	<0.5	—
Nitrite (as NO_2)	1/11	<0.5	<5	<0.8	—
Chloride	11/11	30	78	49	31
Sulfate	11/11	16	66	22	27
Alkalinity					
Total alkalinity (as $CaCO_3$)	11/11	130	290	190	53
Bicarbonate alkalinity (as $CaCO_3$)	11/11	130	290	190	53
Nutrients					
Ammonia nitrogen (as N)	11/11	0.3	48	37	12
Total Kjeldahl nitrogen	10/10	36	65	45	17
Total phosphorus (as P)	11/11	1.1	8.2	4.4	3.1
Organic carbon					
Total organic carbon (TOC)	11/11	29	78	45	22
Total metals					
Aluminum	11/12	<0.2	1.4	0.65	0.33
Arsenic	4/12	<0.002	<0.005	<0.002	—
Calcium	12/12	9.4	35	14	12
Chromium	8/12	<0.01	0.027	0.018	0.010
Copper	12/12	0.067	0.16	0.13	0.050
Iron	12/12	0.36	2.7	1.4	0.45

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Table 6-4. Positively detected parameters in LLNL sanitary sewer effluent, 1995 (concluded).

Positively detected parameter	Detection[(a)] frequency	Minimum	Maximum	Median	IQR[(b)]
Lead	12/12	0.01	0.054	0.023	0.017
Magnesium	12/12	2	16	3.3	5.2
Mercury	10/12	<0.0002	0.0076	0.00062	0.00037
Nickel	8/12	<0.005	0.013	0.0061	0.0024
Potassium	12/12	12	24	18	2.5
Selenium	2/12	<0.002	<0.005	<0.002	—
Silver	5/12	<0.005	0.019	<0.010	—
Sodium	12/12	25	140	42	21
Zinc	12/12	0.12	0.57	0.23	0.090
Grab sample parameters					
Volatile organic compounds (µg/L)					
Acetone	10/12	<40	290	95	110
Bromodichloromethane	3/12	<1	3.2	<1	—
Chloroform	12/12	5.3	26	10	5.2
Dibromochloromethane	1/12	<1	1.4	<1	—
Methylene chloride	3/12	<1	1.8	<1	—
Semivolatile organic compounds (µg/L)					
Benzyl alcohol	6/12	<20	1100	<27	32
Bis(2-ethylhexyl)phthalate	5/12	<10	<100	<11	—
m- and p-Cresol	1/12	<10	<100	<10	—
Phenolics (mg/L)					
Total recoverable phenolics	12/12	0.017	0.52	0.027	0.021
Oil and grease (mg/L)					
Total oil and grease (average)	12/12	11	34	20	12

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 Where the detection frequency is less than 50%, the interquartile range is omitted.

Table 6-5. 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	NA[(a)]
10 CFR 20			
Monthly	185[(b)]	11	—
Yearly	185[(b)]	37[(c)]	—
DOE annualized discharge limit for application of BAT[(d)] (Bq/mL)	370	0.56	0.37

a 10 CFR 20 imposes a discharge limit for soluble ^{239}Pu released. Evidence supports the insolubility of LLNL's plutonium discharges. Refer to the Environmental Impact section of this chapter.

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

c 10 CFR 20 imposes a 37-GBq (1-Ci) combined limit on the total of all radiation released (excluding tritium and ^{14}C, 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.

d 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.

Table 6-5 also includes the total activity that could have been discharged by LLNL during a given period (monthly and annually) using 10 CFR 20 concentrations with the annual cap and assuming the 1995 average monthly flow rate. 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 (18.5 Gbq) dischargable during a single year. In 1995, the total LLNL tritium release was 2.8% of the corresponding Title 10 limit. Total LLNL releases (**Table 6-1**), in the form of alpha and beta emitters (excluding tritium), were 0.82% 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 that is discharged to publicly owned treatment works. If a measurement of the monthly average concentration of a radioisotope exceeds its concentration limit, LLNL would be required to improve discharge control measures until concentrations were again below the DOE limits. **Table 6-5** presents the DCGs for the specific radioisotopes of most interest at LLNL.

The annual average concentration of tritium in LLNL sanitary sewer effluent was 0.000038 (that is, 0.0038%) of the DOE DCG (and the Title 10 limit); the annual average concentration of ^{137}Cs was 3.8×10^{-6} of the DOE DCG (and 5.7×10^{-6} of the Title 10 limit); and the annual average ^{239}Pu concentration was 8.9×10^{-6} of the DOE DCG. The combined discharges were therefore 4.3×10^{-6} of the DCG.

As discussed earlier in this section, when calculating the contribution from plutonium, the plutonium in LLNL effluent is assumed to be in the insoluble form (the DCG for soluble forms of plutonium is 70 times less than the DCG for insoluble plutonium).

LLNL also compares annual discharges against historical values to evaluate the effectiveness of ongoing discharge control programs. **Table 6-6** summarizes the radioactivity in liquid effluent released over the past 10 years. During 1995, a total of 6.0 GBq (0.16 Ci) of tritium was discharged to the sanitary sewer. This is the combined release from the Livermore site and from SNL / California, whose records account for 0.9 GBq (0.02 Ci) of this amount; LLNL therefore released 5.1 GBq (0.14 Ci), an amount that is well within environmental protection standards and is comparable to the amount reported in 1994. Moreover, the total tritium released by LLNL in 1995 (and 1994) is less than the range reported in the past.

Table 6-6. Radioactive liquid effluent releases from the Livermore site, 1986–1995.

Year	Liquid effluents (GBq)	
	^{3}H	^{239}Pu
1986	74	5.5×10^{-4}
1987	52	2.6×10^{-2}
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	12.6	2.6×10^{-4}
1994	6.9	1.9×10^{-4}
1995	6.0	1.2×10^{-4}

a The 1990 DOE Order 5400.5 required compliance with legally applicable local and state regulations such as California Title 17, which mandated a 37 GBQ (1 Ci) limit.

Figure 6-3 summarizes the ^{239}Pu monitoring data over the past 10 years. The historical levels observed since 1986 average 2 µBq / mL (6×10^{-5} pCi / mL), with the exception of a peak in 1987. Even this peak is well below the applicable DOE DCG. Historically, levels generally are six-millionths (0.000006) of that limit. 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 plutonium concentration observed in 1995 sludge (**Table 6-2**), 0.78 mBq / dry g (0.02 pCi / dry g), is more than 600 times lower than the proposed EPA guideline for unrestricted use of soil (480 mBq / dry g).

As first discussed in the *Environmental Report for 1991* (Gallegos et al. 1992a), 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 is 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 by the continuation of the slightly lower plutonium and cesium concentrations that were observed in the 1993 effluent. The 1995 plutonium and cesium concentrations are comparable to 1994 concentrations except for the final two months of 1995 cesium concentrations, pictured in **Figure 6-3** and reported in **Table 6-2**. These two slightly elevated cesium values are not indicative of a trend towards increased concentrations; data for January and February 1996 reflect a return to the concentration levels reported for the majority of 1995.

Environmental Impact of Nonradioactive Liquid Effluents

Table 6-3 presents monthly average metal concentrations in LLNL's sanitary sewer effluent. At the bottom of the table, the annual average concentration for each metal is compared to the discharge limit. The metals that approached closest to the discharge limits were copper and lead at 11% and 9%, respectively.

Although well below discharge limits, the slightly elevated arsenic levels first seen in 1992 continued through 1995. First discussed in the *Environmental Report for 1993* (Gallegos et al. 1994), the elevated arsenic levels were the subject of an extended investigation during 1993. While arsenic occurs naturally in Livermore site ground water (see Chapter 9), the 1993 study 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 slightly elevated arsenic levels were seen less frequently.

The continuous monitoring system detected one inadvertent discharge during 1995 (as compared to 1, 0, and 13 such discharges in 1994, 1993, and 1992, respectively); this incident was reported to the LWRP. Specifically, on January 23, 1995, the continuous monitoring system detected a brief alkaline discharge above alarm limits. The maximum pH was 10.7, as compared to a pH of 10.0, the effluent pollutant limit for alkalinity contained in LLNL's sewer permit. The estimated duration of the incident was 3 minutes. The Sewer Diversion Facility was activated and approximately 1000 gallons of effluent was diverted during the three-minute incident. (Uncontained pH releases above the effluent pollutant limit could disrupt treatment plant operations or cause the treated wastewater to exceed allowable concentration limits for discharge to the San Francisco Bay.) Later analysis of the diverted effluent showed that the average pH of 10.1 was sufficiently low to allow release of the wastewater back to the sanitary sewer. This incident did not represent a threat to the integrity of the operations at the LWRP.

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. The results demonstrate good compliance with the effluent pollutant limitations of LLNL's sewer permit, and are generally consistent with values seen in the past.