



Water Quality Trends for Surveillance Monitoring Sites

L. Flint Hall
Environmental Scientist

Idaho Falls
900 N. Skyline Dr. Ste C
Idaho Falls, ID 83402
Phone (208) 528-2600
Fax (208) 528-2605

Boise
1410 N. Hilton
Boise, ID 83706
Phone (208) 373-0498
Fax (208) 373-0429

World Wide Web
<http://Oversight.state.id.us>
Toll Free: 800-232-4635

Abstract

The State of Idaho's Idaho National Engineering and Environmental Laboratory Oversight Program (INEEL OP) Environmental Surveillance Program (ESP) monitors the air, surface water, groundwater, soil, milk, and external radiation levels at selected sites on and near the INEEL to verify and supplement U.S. Department of Energy (DOE) monitoring. The INEEL OP Environmental Surveillance Program began monitoring water in 1993, comparing results for co-sampled sites with the U.S. Geological Survey (USGS) and DOE's off-site surveillance contractor, currently the S.M. Stoller Corporation.

The INEEL OP monitors selected INEEL locations upgradient of facilities, near facilities in the south-central portion of the DOE Laboratory, near the southern boundary of the INEEL, at selected drinking water wells on the INEEL, and at sites downgradient and distant from the INEEL. Samples are analyzed for selected common ions, nutrients, trace metals, gross radioactivity, and radionuclides at these sites. Summaries of 2000 results with comparisons to background concentration, and Trend graphs with historical results for selected analytes are presented, as are trends for radiological "blank" samples.

Review of trends for 2000 sample results suggests that at some south-central INEEL sites, concentrations continue to decline for tritium and strontium-90, chromium, chloride and sodium, while these and other INEEL ground water contaminants (including nitrate plus nitrite and sulfate) remained elevated but and unchanged from previous years.

Table of Contents

Abstract	2
Water Quality Trends for Surveillance Monitoring Sites	9
1.0 Introduction	9
2.0 Program Design	9
2.1 Sample sites	9
2.2 Analytes	10
3.0 Monitoring Results	11
3.1 Common Ions	14
3.1.1 Calcium	14
3.1.2 Magnesium	14
3.1.3 Sodium	15
3.1.4 Potassium	15
3.1.5 Chloride	16
3.1.6 Fluoride	17
3.1.7 Sulfate	17
3.1.8 Alkalinity	18
3.1.9 Total Dissolved Solids and Silica	18
3.2 Nutrients	18
3.2.1 Total Nitrate Plus Nitrite As Nitrogen	19
3.2.2 Total Phosphorus	19
3.3 Trace Metals	19
3.3.1 Barium	20
3.3.2 Chromium	20
3.3.3 Zinc	21
3.3.4 Lead and Manganese	21
3.3.5 Other trace metals	22
3.4 Gross Radioactivity	22
3.4.1 Gross Alpha Radioactivity	22
3.4.2 Gross Beta Radioactivity	22
3.4.3 Gamma Spectroscopy	23
3.5 Tritium	23
3.5.1 Standard Tritium	23
3.5.2 Enriched Tritium	24
3.6 Strontium-90	25
3.7 Technitium-99	25
3.8 Trends for radiological QA samples	25
3.8.1 Gross Alpha and Gross Beta Radioactivity Blanks	26
3.8.4 Standard and Enhanced Tritium Blanks	26
4.0 Summary	27
5.0 References	27

Table of Figures

Figure 1 INEEL Facilities	10
Figure 2 Oversight Program monitoring sites.....	12
Table 1. Water surveillance monitoring summary of current analyses methods, and minimum detectable concentrations.....	13
Figure 3 Dissolved calcium, south-central INEEL water monitoring sites.	30
Figure 4 Dissolved calcium, INEEL drinking water monitoring sites.....	30
Figure 5 Dissolved calcium, upgradient INEEL water monitoring sites.....	31
Figure 6 Dissolved calcium, INEEL southern boundary water monitoring sites.	31
Figure 7 Dissolved calcium, distant water monitoring sites.....	32
Figure 8 Dissolved calcium, surface water monitoring sites.....	32
Figure 9 Dissolved magnesium, south-central INEEL water monitoring sites.....	33
Figure 10 Dissolved magnesium, INEEL drinking water monitoring sites.....	33
Figure 11 Dissolved magnesium, upgradient INEEL water monitoring sites.....	34
Figure 12 Dissolved magnesium, INEEL southern boundary water monitoring sites.....	34
Figure 13 Dissolved magnesium, distant water monitoring sites.	35
Figure 14 Dissolved magnesium, surface water monitoring sites.....	35
Figure 15 Dissolved sodium, south-central INEEL water monitoring sites.	36
Figure 16 Dissolved sodium, INEEL drinking water monitoring sites.....	36
Figure 17 Dissolved sodium, upgradient INEEL water monitoring sites.....	37
Figure 18 Dissolved sodium, INEEL southern boundary water monitoring sites.....	37
Figure 19 Dissolved sodium, distant water monitoring sites.....	38
Figure 20 Dissolved sodium, surface water monitoring sites.....	38
Figure 21 Dissolved potassium, south-central INEEL water monitoring sites.	39
Figure 22 Dissolved potassium, INEEL drinking water monitoring sites.....	39
Figure 23 Dissolved potassium, upgradient INEEL water monitoring sites.....	40
Figure 24 Dissolved potassium, INEEL southern boundary water monitoring sites.....	40
Figure 25 Dissolved potassium, distant water monitoring sites.....	41
Figure 26 Dissolved potassium, surface water monitoring sites.....	41
Figure 27 Chloride, south-central INEEL water monitoring sites.....	42
Figure 28 Chloride, INEEL drinking water monitoring sites.....	42
Figure 29 Chloride, upgradient INEEL water monitoring sites.....	43
Figure 30 Chloride, INEEL southern boundary water monitoring sites.....	43
Figure 31 Chloride, distant water monitoring sites.	44
Figure 32 Chloride, surface water monitoring sites.	44
Figure 33 Fluoride, south-central INEEL water monitoring sites.	45
Figure 34 Fluoride, INEEL drinking water monitoring sites.....	45
Figure 35 Fluoride, upgradient INEEL water monitoring sites.....	46
Figure 36 Fluoride, INEEL southern boundary water monitoring sites.....	46
Figure 37 Fluoride, distant water monitoring sites.....	47
Figure 38 Fluoride, surface water monitoring sites.....	47
Figure 39 Sulfate, south-central INEEL water monitoring sites.....	48
Figure 40 Sulfate, INEEL drinking water sites.....	48
Figure 41 Sulfate, upgradient INEEL water monitoring sites.....	49

Figure 42	Sulfate, INEEL southern boundary water monitoring sites.....	49
Figure 43	Sulfate, distant water monitoring sites.	50
Figure 44	Sulfate, surface water monitoring sites.....	50
Figure 45	Dissolved nitrate plus nitrite, south-central INEEL water monitoring sites.	51
Figure 46	Dissolved nitrate plus nitrite, INEEL drinking water monitoring sites.	51
Figure 47	Dissolved nitrate plus nitrite, upgradient INEEL water monitoring sites.	52
Figure 48	Dissolved nitrate plus nitrite, INEEL southern boundary monitoring sites.	52
Figure 49	Dissolved nitrate plus nitrite, distant water monitoring sites.....	53
Figure 50	Dissolved nitrate plus nitrite, surface water monitoring sites.....	53
Figure 51	Total alkalinity, south-central INEEL water monitoring sites.....	54
Figure 52	Total alkalinity, INEEL drinking water monitoring sites.	54
Figure 53	Total alkalinity, upgradient INEEL water monitoring sites.	55
Figure 54	Total alkalinity, INEEL southern boundary water monitoring sites.	56
Figure 55	Total alkalinity, distant water monitoring sites.....	56
Figure 56	Total alkalinity, surface water monitoring sites.	57
Figure 57	Dissolved barium, south-central INEEL water monitoring sites.	57
Figure 58	Dissolved barium, INEEL drinking water monitoring sites.....	58
Figure 59	Dissolved barium, upgradient INEEL water monitoring sites.....	58
Figure 60	Dissolved barium, INEEL southern boundary water monitoring sites.....	59
Figure 61	Dissolved barium, distant water monitoring sites.	59
Figure 62	Dissolved barium, surface water monitoring sites.....	60
Figure 63	Dissolved chromium, south-central INEEL water monitoring sites.....	60
Figure 64	Dissolved chromium, INEEL drinking water monitoring sites.....	61
Figure 65	Dissolved chromium, upgradient INEEL water monitoring sites.....	61
Figure 66	Dissolved chromium, INEEL southern boundary water monitoring sites.....	62
Figure 67	Dissolved chromium, distant water monitoring sites.	62
Figure 68	Dissolved chromium, surface water monitoring sites.....	63
Figure 70	Dissolved zinc, INEEL drinking water sites.....	64
Figure 71	Dissolved zinc, upgradient INEEL water monitoring sites.....	65
Figure 72	Dissolved zinc, INEEL south boundary water monitoring sites.	65
Figure 73	Dissolved zinc, Distant water monitoring sites.	66
Figure 74	Dissolved zinc, Surface water monitoring sites.....	66
Figure 75	Gross alpha, south-central INEEL water monitoring sites.	67
Figure 76	Gross alpha, INEEL drinking water monitoring sites.	67
Figure 77	Gross alpha, upgradient INEEL water monitoring sites.	68
Figure 78	Gross alpha, INEEL southern boundary water monitoring sites.	68
Figure 79	Gross alpha, distant water monitoring sites.....	69
Figure 80	Gross alpha, surface water monitoring sites.....	69
Figure 81	Gross beta, south-central INEEL water monitoring sites.....	70
Figure 82	Gross beta, INEEL drinking water monitoring sites.	70
Figure 83	Gross beta, upgradient INEEL water monitoring sites.	71
Figure 84	Gross beta, INEEL southern boundary water monitoring sites.	71
Figure 85	Gross beta, distant water monitoring sites.....	72
Figure 86	Gross beta, surface water monitoring sites.	72
Figure 87	Tritium, south-central INEEL water monitoring sites.	73
Figure 88	Tritium, INEEL drinking water monitoring sites.	73

Figure 89	Tritium, upgradient INEEL water monitoring sites.	74
Figure 90	Tritium, INEEL southern boundary water monitoring sites.	74
Figure 91	Tritium, distant water monitoring sites.....	75
Figure 92	Tritium, surface water monitoring sites.	75
Figure 93	Enhanced tritium, upgradient INEEL water monitoring sites.	76
Figure 94	Enhanced tritium, southern boundary water monitoring sites.....	76
Figure 95	Enhanced tritium, distant water monitoring sites.....	77
Figure 96	Enhanced tritium, Surface water monitoring sites.....	77
Figure 97	Enhanced tritium, INEEL water monitoring sites with lower tritium activity..	78
Figure 98	Enhanced tritium, INEEL water monitoring sites with higher tritium activity.	79
Figure 99	Strontium-90 for selected locations.....	79
Figure 100	Technetium-99 for selected locations.....	80
Figure 101	Gross alpha radioactivity for DI water submitted blind to ISU-EML.	81
Figure 102	Gross beta radioactivity for DI water submitted blind to ISU-EML.	81
Figure 103	Tritium for DI water submitted blind to ISU-EML.....	82
Figure 104	Enhanced tritium for DI water submitted blind to ISU-EML.	82

Water Quality Trends for Surveillance Monitoring Sites

1.0 Introduction

The State of Idaho's INEEL OP Environmental Surveillance Program was established 1993-1994 to monitor the air, surface water, groundwater, soil, and external radiation levels for sites on and near the INEEL, and to collect milk samples representative of dairies near the INEEL. The program was designed to verify and selectively supplement surveillance information gathered by other surveillance programs. For groundwater and surface water surveillance monitoring, this includes the U.S. Geological Survey (USGS) and DOE's off-site surveillance contractor (Radiological and Environmental Sciences Laboratory 1994 and prior, the Environmental Science and Research Foundation, 1994 – 2000, and the S.M. Stoller Corporation, 2000 to the present). This document gives a brief description of surveillance water monitoring and presents general trends for selected constituents and discusses specific observations of data collected in 2000.

2.0 Program Design

The Environmental Surveillance Program (ESP) verifies by co-sampling selected groundwater and surface water sites monitored by the U.S. Geological Survey and by DOE's off-site surveillance contractor and comparing results, and by collecting samples for selected water quality parameters and INEEL contaminants to discern general impacts from INEEL activities. The ESP supplements DOE monitoring by regularly sampling for selected analytes that DOE either samples for less frequently or does not sample for at all. Taken together, these analytes give a general picture of water quality for the Eastern Snake River Plain Aquifer not seen through other regular DOE monitoring. The specific design of the surveillance water sampling portion of the ESP, including objectives, sample sites, analytes, and quality assurance are detailed in the Sampling and Analysis Plan for Water Surveillance Monitoring activities (Hall, 2001)

2.1 Sample sites

The INEEL OP monitors for the same analytes at all sites; upgradient of the INEEL, in the south-central portion of the INEEL (where the INEEL facilities, Test Reactor Area, Idaho Nuclear Technologies and Engineering Center, Central Facilities Area, and the Radioactive Waste Management Complex are located) selected drinking water sites on the INEEL (Central Facilities Area, Radioactive Waste Management Complex, and the Highway 20/26 rest area at the Big Lost River), near the INEEL southern boundary, surface water, and at distant sites over time to discern INEEL groundwater influences from local ambient or background conditions. Analytes sampled for are widely present in the aquifer and come from natural and anthropogenic sources. Results are compared with the co-sampling agencies. INEEL facilities are shown in **Figure 1**.

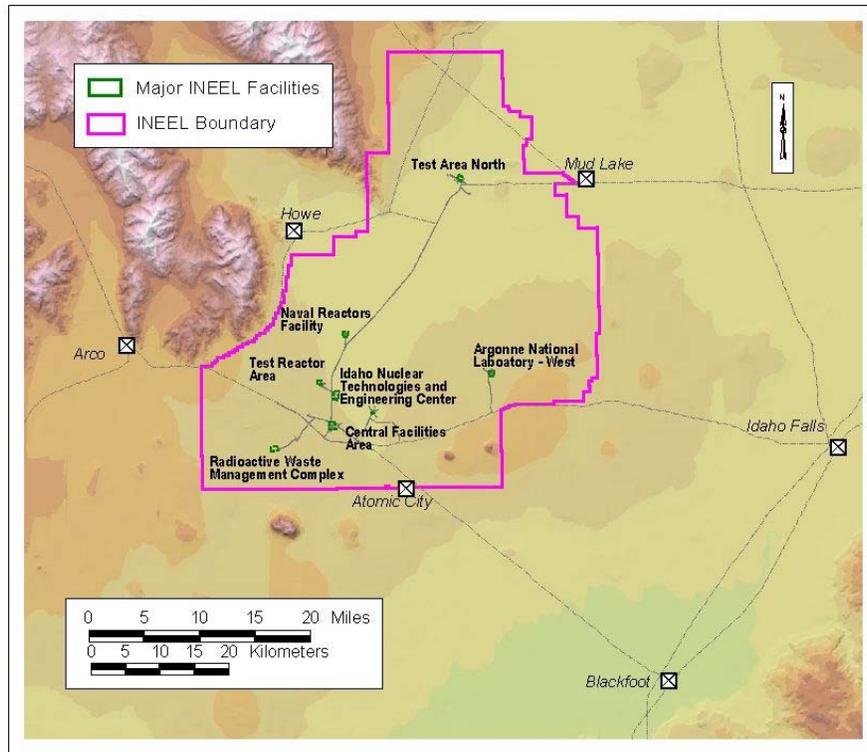


Figure 1 INEEL Facilities

The INEEL OP collects water samples from 76 wells, 8 springs, and 3 surface water locations on and off the INEEL. Of these sites, 6 are located upgradient of the INEEL or INEEL facilities, 8 sites are located in the south-central portion of the INEEL, 4 are INEEL drinking water sites, 8 are located near the INEEL southern boundary, and five are sites distant from the INEEL in the Magic Valley. The remaining 55 sites are from the region south of the INEEL and are sampled on a rotating three-year schedule, with about one-third sampled each year. Results for these 55 sites are reported in an annual, cooperative report published by the USGS and Idaho Department of Water Resources. These data are also presented along with all other ESP water monitoring results in regular ESP quarterly and annual reports, but are not discussed in this document. Sample locations have been reviewed, with one site dropped and two sites added in 1998. Upgradient, south-central INEEL, INEEL drinking water, southern boundary, surface water, and distant monitoring sites are presented in **Figure 2**.

2.2 Analytes

The range of analytes sampled for by the INEEL OP includes non-radiological analytes (major or common ions, nutrients, and trace metals), gross radiological measures (gross alpha and gross beta radioactivity, gamma spectroscopy), and specific radionuclides (tritium, strontium-90, and technitium-99). The selection of analytes does not attempt to duplicate DOE's sampling network nor sample for all known contaminants, but to allow a comparison with a number of analytes and parameters verify and to supplement monitoring results. The range of analytes sampled by the

INEEL OP was selected to provide a basis for data comparison, and in part to ensure that a more complete picture of the groundwater quality is presented.

The selection of nonradiological analytes was designed to reflect sampling by the USGS, both on the INEEL (Bartholomay and others, 2000) and in their Magic Valley sampling program (Wegner and Campbell, 1991), and by Idaho Department of Water Resources, State Wide Ground Water Monitoring Program (Crockett, J.K., 1995; Neely, 1994; Neely and Crockett, 1992). Four years after the initiation of the INEEL OP water surveillance monitoring program, trace metals, nutrients, and common ion results for this period, 1993-1997, were reviewed. The list of 13 metals initially sampled was reduced to five, based upon what had been detected in samples from the previous four years. Adjustments were also made in the list of common ions and nutrients.

The selection of radiological analytes, likewise, was designed to reflect DOE's surveillance monitoring, both on and near the INEEL, as well as distant, Magic Valley sampling. Gross radioactivity measures (gross alpha and gross beta radioactivity) are used to screen for INEEL contaminants. Specific nuclides are sampled for where previous monitoring and screening measures indicate that gross radioactivity may be outside the range typical for the Eastern Snake River Plain Aquifer. Selected sites on the INEEL are sampled for strontium-90 and technetium-99, based on historic detections for these radionuclides, and gross beta radioactivity levels that are greater than typically observed for the central portion aquifer beneath the INEEL. Tritium occurs naturally as well as due to INEEL waste disposal; this radionuclide is sampled for at all sites. Samples from sites where tritium levels are less than the detection level using standard analysis methods are reanalyzed using a method that concentrates the tritium in the samples first.

3.0 Monitoring Results

The results of INEEL OP monitoring for common ions, nutrients, trace metals, gross radioactivity, tritium, strontium-90, and technetium-99 are presented as graphics of trends for those analytes that are regularly detected at all or nearly all sites. Detection is based on the laboratory reporting level for non-radiological samples, and by the sample-specific detection criteria for radiological samples. Trends of all radiological samples are presented, not just those exceeding the criteria for detection (approximated by 3 times the 1s sample error). Where possible, an estimate of the range of concentrations observed for sites not obviously influenced by INEEL or other anthropogenic sources (referred to as the "background" range), based on Knobel and others (1992), or Knobel and others (1999), where the 1992 volume did not include that specific analyte¹. Also presented are trends for blank samples analyzed for gross radioactivity and tritium.

¹. The "background" range for Knobel and others (1992) was defined by the lowest value observed and the median value, to minimize impacts from sites that might have an anthropogenic influence. The background range is defined by the same criteria (lowest value to the median value) where Knobel and others (1999) is referenced.

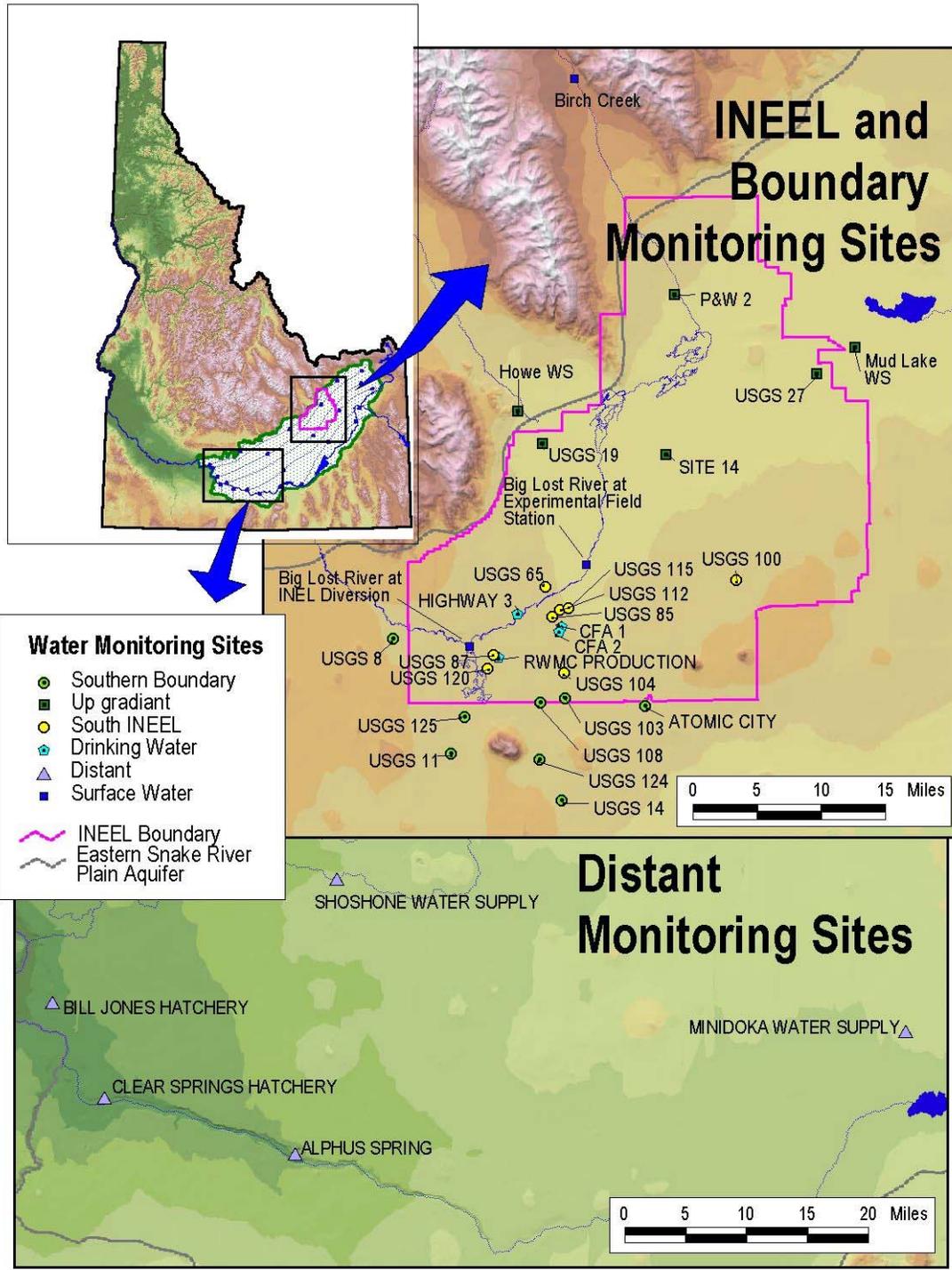


Figure 2 Oversight Program monitoring sites

Table 1. Water surveillance monitoring summary of current analyses methods, and minimum detectable concentrations.

Type of Analysis	Analytical method	Minimum Detectable Concentration
Radiological - ISU EML^a		
Alpha	Gas-flow proportional counting	2-3 pCi/L
Beta	Gas-flow proportional counting	2-3 pCi/L
Gamma	Germanium detector gamma spectroscopy	6-10 pCi/L
Tritium	Liquid Scintillation, electrolytic enhancement and Liquid Scintillation	160 pCi/L (15-20 pCi/L for electrolytically enriched)
Sr-90	Chemical separation, proportional counting	3-4 pCi/L
Tc-99	Chemical separation, liquid scintillation	4-5 pCi/
Non-radiological - IBL^b		
Common Ions		
Total Alkalinity	2320B	1.0 mg/L
Calcium	200.7	0.1 mg/L
Chloride	300.0	2.0 mg/L
Fluoride	300.0,4500FE ^c	0.1 mg/L
Magnesium	200.7	0.05 mg/L
Potassium	3111B	0.1 mg/L
Sodium	3111B	0.1 mg/L
Sulfate	300.0	2-4.5 mg/L
Nutrients		
Nitrate + Nitrite as Nitrogen	353.2	0.005 mg/L
Phosphorus	365.4	0.05 mg/L
Trace Metals		
Barium	200.7	1 µg/L
Chromium	200.7	2 µg/L
Lead	200.9	5 µg/L
Manganese	200.7	10 µg/L
Zinc	200.7	5 µg/L
a -- Idaho State University – Environmental Monitoring Laboratory		
b -- Idaho Bureau of Laboratories, Boise.		
c -- Both methods are used by IBL, dependant on matrix interferences observed.		

3.1 Common Ions

Calcium, magnesium, sodium, potassium, chloride, and sulfate were detected in some groundwater samples collected on the INEEL at concentrations believed to represent contamination from activities on the site. These ions, along with total alkalinity and total nitrate typically comprise about 99% of all dissolved ions in groundwater and are referred to as the common ions or major ions (Hem, 1985). Among these common ions are also the major waste constituents by mass released to the aquifer by INEEL activities.

3.1.1 Calcium

Concentrations of calcium at onsite wells ranged from 24.4 to 90.6 mg/L, with the median concentration of 45.2 mg/L much the same as the median value of 43 mg/L reported by Knobel and others (1999). However, at wells CFA 1, CFA 2, USGS 65, USGS 85, and USGS 112, calcium concentrations ranged from 58.9 to 90.6 mg/L, most likely reflecting disposal of wastewater derived from water deionization at TRA and INTEC. While calcium is not identified as being a constituent in wastewater, it is elevated compared to upgradient groundwater levels. Similarity with trends of other wastewater components such as sulfate suggests that calcium levels at the identified wells may be waste-disposal related. This could also be a result of the evaporation of aquifer waters concentrating aquifer levels in waters discharged. Such a relationship has been observed for waters impacted by irrigation return that has been modified by evaporation (Hall, 2000).

Calcium concentrations in samples from boundary, distant, and surface water sites ranged from 9.0 to 56.9 mg/L with a median concentration of 40.4 mg/L. At these sites, all concentrations measured were within natural background levels, about 5 – 43 mg/L, from Knobel and others (1999), or exhibited concentrations that may be attributable to agriculture or other anthropogenic sources.

3.1.2 Magnesium

Magnesium concentrations in samples from onsite wells ranged from 11.8 to 27.6 mg/L. Results from well CFA 2 exceeded the estimated background level of 23 mg/L from Orr and others, 1991, but fell within the range of magnesium concentrations found in INEEL OP samples from the Eastern Snake River Plain Aquifer, making it difficult to clearly determine if they reflect an impact from INEEL activities. Magnesium trends for some wells tend to reflect sulfate and other known INEEL waste constituents. The median concentration for onsite locations was 16.3 mg/L.

Boundary and distant well samples contained magnesium at concentrations generally falling below the estimated background, ranging from 2.8 to 19.9 mg/L with a median concentration of 14.8 mg/L. Concentrations of magnesium in samples from Mud Lake Water Supply averaged 2.9 mg/L while all other boundary, distant, and surface water locations averaged 15.6 mg/L.

As with calcium, Magnesium is not identified as a major INEEL waste constituent. Natural levels of magnesium in ground water can also be concentrated in wastes due to evaporation of those wastes concurrent with or prior to disposal. Background is estimated as 1 – 15 mg/L.

3.1.3 Sodium

Although no established drinking water standard exists for sodium, 100 mg/L has been proposed as a standard (Salvato, 1992). The sodium concentrations at wells sampled on the INEEL ranged from 7 to 69 mg/L. Samples from all but three sites were at background levels of less than 20 mg/L. The highest sodium concentrations were 63 to 69 mg/L at USGS 112, reflecting contamination from INTEC. Wells CFA 1, and CFA 2 also exhibited higher levels of sodium as a result of activities at INTEC. The sources of the elevated concentrations of sodium in samples collected from USGS 120 (40 to 49 mg/L) are not known. Sodium concentrations for samples from USGS 120 are the same as 1999, however 1999 levels are elevated about 30% from 1998. This may be related to the significant recharge to the Big Lost River spreading areas just south of USGS 120 that occurred during 1998-1999.

In general, the boundary, distant, and surface water samples demonstrated sodium concentrations falling within background levels. Concentrations for these sites ranged from 5.4 to 37 mg/L, with a median concentration of 13 mg/L. Results from two sites, Mud Lake Water Supply and Alpheus Spring, exceeded 30 mg/L. Sodium levels from Alpheus Spring are likely elevated due to evaporation of irrigation water (as evidenced by the nitrate plus nitrite concentrations at this site exceeding background levels), while local geological conditions appear to be the most likely source for the Mud Lake Water Supply well (Robertson and others, 1974). The median value for other boundary, distant, and surface water sites was 12 mg/L.

Sodium is a major waste constituent with nearly a million and a half pounds of sodium a year discharged to the aquifer by INEEL facilities. Sodium is also characteristic of water from differing recharge sources, such as for the Mud Lake Water Supply. Background for sodium is given as 5.4 – 14 mg/L.

3.1.4 Potassium

Drinking water standards have not been established for potassium, but the concentration of dissolved potassium in groundwater samples collected by the INEEL OP is typically less than 4 mg/L, varying as a result of geologic conditions, waste disposal at the INEEL, or other anthropogenic influences.

Concentrations of potassium in samples from onsite wells ranged from 1.1 to 6 mg/L, with a median of 3.2 mg/L. Trends in potassium concentrations for CFA 1, CFA 2, and USGS 112 tend to mirror trends for sodium at these locations, suggesting that while not significantly greater than the expected background levels (at 3.1 - 4.9 mg/L), at least some portion of the potassium present is due to past disposal activities at INTEC. This

same correlation between sodium and potassium concentration trends is also apparent for USGS 120. The highest potassium concentrations observed (6 mg/L) were for samples from upgradient well USGS 27, just inside the INEEL boundary near Mud Lake.

Boundary, distant, and surface water concentrations for potassium ranged from 1.1 to 6.6 mg/L. The highest concentration 6.6 mg/L, was measured at Alpheus Spring. The Mud Lake Water Supply well, near USGS 27, reported potassium concentrations 4.8 to 5.2 mg/L and has no indication of anthropogenic influences, thus much of the potassium observed for USGS 27 may represent local ambient concentrations. Both sites show some indication of impact from irrigation or other anthropogenic sources, based largely on nitrate concentrations. The median potassium concentration for boundary, distant, and surface water sites is 2.8 mg/L, and for all sites is 3.0 mg/L. Background for potassium is given as 1 - 3.1 mg/L.

3.1.5 Chloride

The secondary maximum contaminant level (SMCL) for chloride is 250 mg/L. Chloride has historically been a major constituent of INEEL chemical wastes. Elevated chloride can also be an indication of impacts from surface water, irrigation, or other anthropogenic impacts (Hem, 1985).

Chloride concentrations for onsite wells range from 6.7 to 157 mg/L. Groundwater concentrations for wells USGS 112, 115, 85, CFA 1, and CFA 2 average 94 mg/L while the median concentration for all onsite locations is 13.5 mg/L. The elevated concentrations for these wells south of INTEC indicate contamination from waste disposal at this facility. The maximum chloride concentration measured, 172 mg/L, was from a sample collected from well USGS 112, located about 1.2 km south of INTEC. At USGS 115, near the eastern edge of the contaminant plume at INTEC, chloride concentrations have been relatively constant. Chloride concentrations at USGS 85, between INTEC and CFA 1, are above background levels but generally decreasing. As suggested by the elevated levels detected in these wells, the chloride plume from INTEC extends south beyond CFA 1 and CFA 2, but is not distinguishable from ambient concentrations at USGS 104.

Samples collected from the boundary wells and surface water sites range from 3.4 to 41.7 mg/L, with the median concentration of 10.2 mg/L. Concentration for distant sites Alpheus, Clear Springs, and Minidoka water supply range from 29.6 to 41 mg/L. Levels of other constituents suggest that Alpheus and Clear Springs have some degree of impact due to anthropogenic sources that are not associated with the INEEL. Minidoka water supply chloride concentrations are likely due to natural sources and local conditions, with no indication of impact from INEEL activities. Chloride can also be concentrated by evaporation of infiltrating surface water.

Chloride is also a major waste constituent for several INEEL facilities, with 1.6 million pounds disposed to ponds at INTEC and 1.1 million pounds disposed of to the land surface at NRF, 1996-98, with even larger quantities disposed in previous years

(Frederick and others, 1998, Bartholomay and others, 2000). Background for chloride is given as 2.6 - 16 mg/L.

3.1.6 Fluoride

Samples collected from onsite locations yielded fluoride concentrations ranging from 0.130 mg/L to 0.790 mg/L. The most commonly observed value for all onsite locations was 0.220 mg/L.

Fluoride concentrations for boundary, distant, and surface water sites range from 0.100 to 1.07 mg/L, with a median of 0.360 mg/L. The greatest fluoride values are from USGS 14, Atomic City, Mud Lake water supply, Minidoka water supply, Clear Springs, Alpheus Spring, and Bill Jones Hatchery. The distribution of fluoride concentrations appears to be related more to regional aquifer conditions and sources of aquifer recharge, as sites to the east of the INEEL tend to have higher concentrations, while those to the west, including the sites in the central portion of the INEEL, are less. As other major ions seem to be concentrated in Alpheus and Clear Spring waters, attributable to concentration by evaporation of irrigation waters, the same may be the case for fluoride. Background is given as 0.4 – 0.5 mg/L for the Eastern Snake River Plain Aquifer.

3.1.7 Sulfate

The secondary maximum contaminant level (SMCL) for sulfate is 250 mg/L. Samples collected from onsite locations yielded sulfate concentrations ranging from 17.2 mg/L to 166 mg/L. The most commonly observed value for all onsite locations was 28.6 mg/L.

The highest sulfate concentrations, 159 to 166 mg/L, were detected in samples collected from USGS 65, where water quality has been impacted by waste disposal at TRA. Concentrations for wells USGS 112, 120, CFA 1, and CFA 2 all exceed the 28.5 mg/L median concentration for onsite locations, and are indicative of INEEL impacts. Sites USGS 112, 85, CFA 1, and CFA 2 are all impacted by TRA-INTEC waste disposal. Well USGS 120 is likely impacted by recharge from the Big Lost River spreading areas, well construction, or wastes from RWMC (Pittman and others, 1988). Upgradient onsite wells, Site 14 and P&W 2, show concentrations at about 22-29 mg/L, while USGS 27, upgradient from all INEEL impacts, averaged 40 mg/L.

Sulfate concentrations for boundary, distant, and surface water sites range from 8.1 to 57.9 mg/L, with a median of 22.1 mg/L. The greatest sulfate values are from Alpheus, Clear Springs, and Minidoka water supply, the same distant sites that also show greater chloride concentrations. These sulfate results for Alpheus and Clear Spring are also attributable to a combination of anthropogenic influences including concentration by evaporation of irrigation waters. Sulfate for Minidoka water supply may be related to local aquifer conditions, as other parameters do not indicate anthropogenic impacts.

Sulfate is a major waste constituent in discharges from the Test Reactor Area (TRA), with 210,000 pounds disposed of each year, 1996-98, and much larger quantities disposed of historically, as much as 17 million pounds annually, prior to 1990 (Frederick and

others, 1998, Bartholomay and others, 2000). Background for sulfate is given as 2 - 24 mg/L.

3.1.8 Alkalinity

Alkalinity is a measure of the ability of a solution to react with and neutralize an acid (Hem, 1985). For most natural groundwater of the Snake River Plain Aquifer, the primary anion is dissolved carbon dioxide. The alkalinity results from the IBL are reported as total alkalinity as CaCO_3 . From 1994 to 1997, the IBL reported alkalinity as carbonate alkalinity and bicarbonate alkalinity. After this time, alkalinity was reported as a “total alkalinity” (carbonate plus bicarbonate alkalinity) (INEEL OP 2000). Total alkalinity as CaCO_3 accounts for 70% to 85% of the total anionic strength of natural waters for most of the Snake River Plain Aquifer, as such, this water quality parameter is necessary to determine an ionic balance for waters sampled. The ionic balance can aid in interpreting the validity of water quality samples.

Total alkalinity for onsite samples ranged from 106 to 163 mg/L, with a median of 132 mg/L. The range and median for the combined boundary, distant, and surface water sites was 90 to 176 mg/L, and 140 mg/L. As carbon dioxide was not identified as an INEEL waste disposal product, the total alkalinity does not reflect the impacts of INEEL waste disposal. However, as total alkalinity gives a measure of the ionic strength and buffering capacity of the groundwater, this water quality parameter is the basis for an index of how waste disposal has impacted the chemical nature of the aquifer. Total alkalinity provides about 35% to 44% of the anionic strength for wells USGS 65, 112, CFA 1 and CFA 2, in contrast to the above-referenced range of 70% to 85%. This implies that waste constituents, the chief contributors being sulfate and chloride, have a significant influence on aquifer water chemistry at these sites. Background for alkalinity (reported as total alkalinity as HCO_3) ranges from 41 - 169 mg/L.

3.1.9 Total Dissolved Solids and Silica

Total dissolved solids and silica were determined for all monitoring locations from 1994-1997. These parameters were dropped at the end of 1997. Total dissolved solids was reflective information gained by reviewing chloride and sulfate results. For the period of 1994-97, a median of 243 mg/L was observed for locations on the INEEL, with a median of 221 mg/L for all boundary, distant, and surface water sites. Dissolved silica, also dropped at the end of 1997, showed a median of 25 mg/L for sites on the INEEL, and 29 mg/L for all other sites. Dissolved silica is not identified as a product of INEEL waste disposal, and show flat trends for all sites. Dissolved silica typically does not act as a dissolved ion in natural groundwater (Hem, 1985). The background range for dissolved silica is estimated at 10 – 26 mg/L.

3.2 Nutrients

Total nitrate plus nitrite (as nitrogen) and total phosphorus are compounds beneficial to biological growth, and as such are referred to as nutrients. Nitrogen occurs in water as nitrate or

as nitrite, with nitrate being the dominant form in well-oxygenated waters like the eastern Snake River Plain aquifer. Phosphorus typically occurs in ground water as the phosphate ion. Both nutrients were detected above background levels at a limited number of onsite locations in 2000.

3.2.1 Total Nitrate Plus Nitrite As Nitrogen

The MCL for nitrate plus nitrite (as nitrogen) is 10 mg/L. Concentrations greater than 1-2 mg/L are typically indicative of anthropogenic impacts to groundwater of the Eastern Snake River Plain Aquifer (Rupart, 1997).

Concentration of nitrate plus nitrite (as nitrogen) for onsite sample locations ranged from 0.389 to 4.14 mg/L, with a median value of 0.912 mg/L. Nitrogen concentrations are elevated (> 1 mg/L) for seven onsite locations, and greatest for wells CFA 1 and CFA 2 (average of 3.66 mg/L), and range from 2.7 to 3.4 mg/L for well USGS 112. Elevated concentrations at these and other sites (USGS 65, 85, and 115) are the result of past wastewater disposal at INTEC and TRA. Nitrate levels at well USGS 100 may be reflective of waste disposal at ANL-W. Nitrates are not specifically identified as a major constituent in wastes from ANL-W. However, nitrates have been identified in effluent to the facilities industrial waste pond. The highest concentration detected in groundwater is from well CFA 2. Upgradient site USGS 27 (average concentration of 2.49 mg/L) shows impacts from anthropogenic sources, likely agricultural impacts.

Concentrations for boundary, distant, and surface water sites range from 0.008 to 1.93 mg/L, with a median value of 0.761 mg/L. Six sites exceed the 1 mg/L background concentration, including Alpheus and Clear Springs, already discussed as having concentrations of other constituents indicative of anthropogenic impacts.

3.2.2 Total Phosphorus

Total phosphorus concentrations exceeded the MDC (0.005 mg/L) for most locations. Total phosphorous concentrations for onsite wells ranged from 0.006 to 0.028 mg/L, with a median value of 0.015 mg/L. The highest concentrations were observed for USGS 85 and 112, ranging from 0.02 to 0.03 mg/L.

Boundary, distant, and surface water sites ranged from 0.008 to 0.039 mg/L, with a median concentration of 0.014 mg/L. The highest concentrations are for samples from Mud Lake Water Supply. Other chemical parameters suggest that water from this site has not been influenced by anthropogenic impacts, thus total phosphorous concentrations must be related to local hydrogeologic conditions. Background for total phosphorus ranges from less than detection to 0.02 mg/L.

3.3 Trace Metals

Analyses of the groundwater samples collected by INEEL OP in 2000 detected five of the trace metals identified as waste constituents at the INEEL. As suggested in **Table 6-1**, only two of these trace metals, barium and chromium, can be definitively linked to INEEL activities. Elevated concentrations of barium exhibited by a few wells near INTEC and CFA remained

below the MCL of 2,000 µg/L, but appeared to demonstrate INEEL impacts. Chromium concentrations exceeded the MCL of 100 µg/L at one well, and displayed levels attributable to waste disposal at TRA (and to a lesser extent INTEC) in several other wells.

Concentrations of lead, manganese, and zinc were also detected but these measurements may be related to well construction materials and natural concentrations in the environment, as well as to activities or operations at the INEEL.

3.3.1 Barium

In all 2000 water samples, barium concentrations measured considerably lower than the MCL of 2,000 µg/L. Barium concentrations ranged from 27 to 233 µg/L for onsite locations, with the median result of 49 µg/L. Concentrations from onsite locations USGS 112, USGS 85, and CFA 1 were highest at 179 to 233 µg/L, 96 µg/L, and 91 to 98 µg/L respectively. Additionally, wells CFA 2, USGS 19, USGS 27, and USGS 115 also showed barium concentrations above the median value for onsite locations. As barium has historically been a waste product from INTEC, the concentrations observed for wells south of INTEC, USGS 112, 115, 85, CFA 1 and CFA 2, are likely influenced by historical waste disposal. Concentrations for upgradient sites USGS 19 and 27 are reflective of regional ambient concentrations.

Concentrations for boundary, distant, and surface water sites ranged from 17 to 116 µg/L, with the median result of 36.5 µg/L. The highest concentrations observed were for Big Lost River sites at the INEEL Diversion and the Experimental Field Station, 113 and 116 µg/L. The observed variability in barium concentrations for INEEL OP sites is similar to that reported for the Snake River Plain Aquifer by others, 5 to 140 µg/L, with a median concentration of 50 µg/L (Knobel and others, 1992). Review of onsite and boundary sites suggests that ambient concentrations for the Snake River Plain aquifer in the vicinity of the INEEL range from 30 to 50 µg/L. Background for barium ranges from 50-70 mg/L according to Knobel and others (1992).

3.3.2 Chromium

Chromium concentrations for onsite locations ranged from 2 to 155 µg/L, with a median concentration of 9 µg/L. Samples from one well, USGS 65, located south of TRA exceeded the MCL of 100 µg/L.

The primary source of chromium contamination at the INEEL is TRA, where it was used as a corrosion inhibitor. Lesser amounts of chromium, used for the same purpose, was disposed of at INTEC. Wells located upgradient from these facilities report chromium concentrations ranging from less than the MDC to 4 µg/L. Wells south of TRA-INTEC and USGS 65 ranged from 3 to 14 µg/L. The remaining onsite wells ranged from less than the MDC of 2 to 5, with a median result of 3 µg/L. Thus, chromium in excess of about 5 µg/L for samples from onsite locations downgradient from TRA-INTEC is likely due to historical waste.

Chromium for boundary, distant, and surface water sites ranged from less than detection (2 µg/L) to 7 µg/L with a median of 4.5 µg/L. All surface water and distant sites were at or less than the detection level. Concentrations for boundary sites USGS 11, 14, 103, 108, 124, and 125 ranged from 3 to 7 µg/L with a median of 5 µg/L. Levels for these sites could be indicative of INEEL impacts, or possibly contamination from well materials, or natural fluctuations in background. Background concentrations for the Snake River Plain Aquifer are estimated at 2 to 3 µg/L.

3.3.3 Zinc

Zinc concentrations for onsite locations ranged from 2 to 620 µg/L, with a median of 45 µg/L. Highest zinc concentrations were observed for monitoring locations USGS 115 and USGS 65, with values ranging 419 to 620, and 354 to 370 µg/L for these sites. All concentrations are less than the 2,000 µg/L secondary MCL for this constituent. Zinc is identified as a waste constituent in several INEEL waste streams and may also be added to the groundwater by leaching from well construction materials.

Boundary, distant, and surface water sites together ranged from 2 to 336 µg/L, with a median result of 61 µg/L. Surface water and distant sites ranged only from 2 to 15 µg/L. Wood and Low (1988) presented results for selected trace metals from the Snake River Plain Aquifer, including zinc. Results ranged from 3 to 610 µg/L, with a median of 40 µg/L. Background concentrations based on Knobel and others (1999) suggest a range of <3 – 10.5 µg/L. For INEEL OP monitoring results, the sites with the highest zinc concentrations are wells with dedicated pumps that tend to have lower pumping rates when the well is purged. Thus, the elevated zinc levels for some wells may reflect a degree of contamination related to the well construction and pumping.

3.3.4 Lead and Manganese

Lead and manganese have historically appeared in some INEEL waste streams and are detected in a limited number of INEEL monitoring wells. Concentrations for lead were above the detection level of 5 µg/L at two wells on the INEEL (USGS 100, USGS 104), ranging up to 16 µg/L. Manganese results were higher than the detection level for ten sites. Four of these sites are located on the INEEL and the remaining are boundary or distant sample locations. Manganese concentrations ranged from the detection level (1 µg/L) to 5 µg/L onsite and 37 µg/L for boundary locations. While both of these contaminants are or have been present in INEEL waste waters historically, observed concentrations are within that reported by others for the Eastern Snake River Plain Aquifer (Wood and Low, 1989). These levels are likely due to conditions local to the well or natural variability and not INEEL impacts. Knobel and others (1992) reported a background range of <5 µg/L for lead. Knobel and others (1999) gives a corresponding range of <3 µg/L for manganese.

3.3.5 Other trace metals

An expanded list of trace metals, including arsenic, cadmium, copper, iron, nickel, silver, selenium, and mercury was monitored for 1994-1997. For most of these metals, analysis results were less than the detectable concentration. Arsenic was detectable in samples from only one location. Cadmium was detected in one sample. At the detection level, silver, selenium, and mercury were not detected in any samples over that time frame. Iron was detected in samples from several onsite locations, however, the results were not reflective of waste disposal. Copper was detected in samples from several onsite, boundary, and distant sites, but again, not reflective of INEEL waste disposal. These parameters were dropped at the end of 1997. Knobel and others (1992) give backgrounds of 2 – 3 µg/L for arsenic, < 1 µg/L for cadmium, silver and selenium, and < 0.1µg/L for mercury. Busenberg and others (2000) found copper < 7.7 µg/L for all their sample sites on and around the INEEL. Knobel and others (1999) suggest a background range of 4 – 16 µg/L for iron.

3.4 Gross Radioactivity

3.4.1 Gross Alpha Radioactivity

Samples from five locations visited during 2000 returned results for gross alpha radioactivity exceeding the MDC (approximately 2.5 pCi/L). All results were well below the MCL of 15 pCi/L for gross alpha radioactivity.

Samples from two onsite locations exceeded the MDC for gross alpha radioactivity. The highest observed value, 4.6 ± 2.6 pCi/L was from USGS 120, one other sample from this site also exceeded the MDC at 3.6 ± 2.1 pCi/L. The median result was less than the MDC. Samples from one boundary site and one distant site also exceeded the MDC, with values of 3.9 ± 2.0 and 5.1 ± 2.0 pCi/L.

Gross alpha radioactivity levels for all sites were within the range observed by others (Orr and others, 1991) for naturally occurring radioactivity due to uranium and thorium decay products in the aquifer and illustrate the range of activity typical for the Eastern Snake River Plain. Background was defined by Knobel and others (1992) as 0 -- 3 pCi/L.

3.4.2 Gross Beta Radioactivity

Samples from 27 of 33 onsite, boundary and distant locations visited during 2000 returned results for gross beta radioactivity exceeding the MDC of approximately 1.4 pCi/L. Drinking water MCLs are based on an exposure limit equivalent to 4 millirem per year to the whole body. Resulting pCi/L concentrations of specific beta-emitting radionuclides are dependent on the energy of the beta particles given off and whether that radioisotope tends to concentrate in specific parts of the body.

Gross beta radioactivity measured in samples collected from onsite wells ranged from less than the MDC to 48 ± 2.0 pCi/L. The highest activities were from samples from observation wells USGS 85 and USGS 112, where groundwater is known to have been impacted by historical waste disposal practices at INTEC. The median gross beta activity for onsite wells was 2.35 ± 0.9 pCi/L.

Gross beta radioactivity measured in samples collected from the boundary, distant, and surface water sites ranged from less than the MDC to 4.8 ± 0.8 pCi/L, with a median result of 1.85 ± 0.8 pCi/L, just greater than the typical MDC. The median result for surface water sites was lower than either boundary or distant sites at less than the detection level. While ambient concentrations for gross beta radioactivity across the Eastern Snake River Plain Aquifer can vary considerably, typical values range from less than the MDC to about 7 pCi/L (Knobel and others, 1992).

3.4.3 Gamma Spectroscopy

Gamma spectroscopy results for cesium-137 are reported for all samples and for any other identified gamma-emitter. No cesium-137 results exceeded the MDC. In 2000, results for naturally occurring potassium-40 were also reported. Most sample results were below the MDC, however, results from five sites exceeded the potassium-40 MDC with the highest value being 153 ± 57 pCi/L. Approximately 0.01% of all potassium naturally consists of radioactive potassium-40. Sampling reported in Knobel and others (1992) suggested a background range for naturally-occurring potassium-40 of 0 – 6 pCi/L. Potassium-40 is the predominant radioactive component in normal foods and human tissues (Eisenbud and Gesell, 1997). No other gamma-emitting radionuclides were identified.

3.5 Tritium

4.5.1 Standard Tritium

Tritium concentrations for onsite monitoring locations did not exceed the MCL of 20,000 pCi/L for any sample collected in 2000. Concentrations for onsite samples ranged from less than the MDC to $14,760 \pm 260$ pCi/L. Nine onsite wells yielded tritium concentrations above the approximately 150 pCi/L MDC for all samples collected during 2000, indicating impact from INEEL wastes. The median concentration for onsite locations was 1305 ± 110 pCi/L. The highest concentrations were observed for USGS 65, which, in previous years had exceeded the MDC. The remaining INEEL sites with detectable tritium are USGS 112, 115, 85, 87, 104, CFA 1, CFA2, and RWMC Production. One sample from well USGS 120 yielded a concentration at the MDC during 2000.

Samples from boundary, distant, and surface water sites were less than the MDC with the exception of one location, USGS 124. Samples from this well ranged from just less than the MDC at 110 ± 80 pCi/L, to 150 ± 80 pCi/L, just above the MDC, showing INEEL

impact. Ambient levels of tritium in the Snake River Plain Aquifer range from 0 to 40 pCi/L (Knobel and others 1992).

The onsite wells with detectable tritium are all downgradient from TRA-INTEC and are known to have been impacted by historical waste disposal at those facilities. Tritium concentrations for most of these wells continued to decrease through 2000. Wells USGS 112 and USGS 115 near INTEC decreased about 10% from 1999 levels, while USGS 65, south of TRA, fluctuated during 1999.

3.5.2 Enriched Tritium

Samples that did not yield detectable tritium using the standard liquid scintillation analysis method were reanalyzed using an electrolytic enhancement process to concentrate the tritium in the sample prior to reanalysis by liquid scintillation. This procedure reduces the MDC to less than 25 pCi/L, within the expected range for background tritium levels.

Onsite locations reanalyzed using the enhanced tritium method ranged from less than detectable levels to 136 ± 9 pCi/L, with a median concentration of 33 pCi/L. Samples from seven onsite locations were reanalyzed. Results from two locations, USGS 120 and Highway 3 were clearly above expected ambient concentrations, with an average of 100 pCi/L and 85 pCi/L for samples from these sites. The remaining sites, P&W 2, Site 14, USGS 19, and USGS 27, showed concentrations reflective of some degree of recent recharge, but low enough that INEEL impacts are not suspected.

Enhanced tritium analysis of boundary sites showed concentrations indicative of some degree of INEEL tritium contamination for some sites. Concentrations again ranged from less than detection to 196 ± 9 pCi/L, with a median value of 17 ± 6 pCi/L for all sites reanalyzed. Tritium samples from USGS 108, 124, and 125 all showed results greater than that expected for ambient conditions, with concentrations for these sites ranging from the 196 ± 9 at USGS 124 to the 79 ± 7 at USGS 125. Sites USGS 8, 11, and 14 show detectable tritium concentrations ranging from 47 ± 6 to 15 ± 6 pCi/L. Historic sampling at USGS 11 has revealed the presence of INEEL contaminants, chlorine-36 and iodine-129, and although the tritium concentrations at this site are less than that observed at other boundary locations, such as USGS 8, the presence of these contaminants suggest that the tritium at this site is from INEEL waste disposal. Tritium concentrations for USGS 8 average about 40 pCi/L, consistent with concentrations observed for Big Lost River sites, and other sites that are influenced by surface waters or irrigation.

Low-level tritium results for distant sites Alpheus Spring and Shoshone water supply average 40-45 pCi/L and also show nitrate values 1.5 to 2.0 mg/L, indicative of some degree of influence by surface water and irrigation. The tritium values observed for distant sites overall ranged from less than the MDC to 55 ± 8 with a median result of 15 pCi/L

Rupart (1997) suggested that where tritium concentrations in the Eastern Snake River Plain aquifer exceeded about 4.5 pCi/L, at least some portion of that groundwater had been recharged since the advent of nuclear testing in the early 1950s. Differing degrees of mixing older and recent (post-1950's) waters result in the range of background tritium concentrations observed. Thus, for groundwater in the central portion of the Eastern Snake River Plain Aquifer where sources of recent recharge are absent or minimal, tritium concentrations should be very low (less than the ISU-EML MDC for enhanced tritium analysis).

3.6 Strontium-90

Selected samples from four onsite wells were analyzed for strontium-90 to determine the contribution of that radionuclide to the gross beta radioactivity. Strontium-90 was detectable in samples from CFA 1 and CFA 2, at 5.3 ± 1.9 and 3.6 ± 1.6 pCi/L. Results for wells USGS 85 and 112 showed strontium-90 at 3.1 ± 0.03 to 17.2 ± 2 pCi/L. Strontium-90 levels have continued to decline for USGS 112 and at USGS 85, to a lesser degree. Observed levels for CFA 1 and CFA 2 have fluctuated, with typical results less than the detection level. Strontium-90 was disposed of to the injection well and percolation ponds at INTEC, and to infiltration ponds at TRA. While stable isotopes of strontium (strontium-86, 87) are detectable in ground water, with a range of 6 – 220 $\mu\text{g/L}$, strontium-90 is not naturally occurring and should not be detectable outside of anthropogenic impacts.

3.7 Technetium-99

Presumably introduced to the aquifer through the INTEC injection well and possibly through the TRA Warm Waste Ponds, technetium-99 is a fission product produced primarily in nuclear reactors, with a half-life of 2.1×10^5 years. This long half-life, coupled with the fact that technetium-99 does not occur naturally, makes this constituent useful as a tracer to evaluate groundwater movement through the aquifer.

Filtered and unfiltered samples were collected for technetium-99 analysis during 2000. Unfiltered samples were sent to a subcontract laboratory for analysis, and the filtered samples were processed and analyzed by ISU-EML. Analysis of unfiltered samples from CFA 1 and USGS 112 returned reportable values of 6.9 ± 3 , 24 ± 5 and 77 ± 6 pCi/L, with no technetium-99 detected in samples from CFA 1, USGS 85 and USGS 104. The five filtered samples yielded results above the detection level at four locations (CFA 1, USGS 85, 104, and 112), with values ranging from 1.8 ± 0.3 to 19.8 ± 0.6 pCi/L.

3.8 Trends for radiological QA samples

Samples of de-ionized water are submitted to the laboratory for analysis along with the regular samples. These quality assurance samples are termed “blanks” because these samples are expected to not contain the analytes that the laboratory is looking for. Samples are prepared by running tap water from the INEEL OP sample preparation laboratory in Idaho Falls through a 0.45 μm filter, and organic/colloidal and ultra-pure mixed-bed de-ionization columns. With a final electrical resistance of 18 mohms/cm, this process removes almost all dissolved ions from

the water. Blank samples are submitted without reference to their identity as a quality-assurance sample (submitted “blind”).

Blank samples allow evaluation of the sample collection, handling and analysis process, possibly identifying the introduction of sample contamination. Trends for radiological blank samples are included in this volume due to the special insight they give to the gross alpha and gross beta analysis sensitivity. As tritium is not removed by the de-ionization system, and tritium levels in the blank samples can act as an analysis standard concentration, and the source for the city of Idaho Falls municipal water system is consistent, tritium concentrations should remain relatively consistent from one sampling period to the next.

3.8.1 Gross Alpha and Gross Beta Radioactivity Blanks

Blanks for gross alpha and gross beta radioactivity provide an indication of the instrument background, and how that background fluctuates over time. Approximately ten blank samples have been submitted for analysis during each of the previous six years, sampling year 2000 included. The median gross alpha result for 2000 samples is -0.15 ± 0.6 pCi/L, with very little fluctuation for 2000, as well as the previous two or three years. The median gross beta result for 2000 samples is 0.2 ± 0.6 pCi/L, again with very little fluctuation for 2000. Wider error bars and greater fluctuation are observed for the gross beta blank samples, than gross alpha radioactivity blanks. This is reflective of the greater gross beta background that exists. Significantly larger fluctuations and wider error bars were observed for blanks prior to 1998, illustrating the improvement in the overall analysis process since 1998.

3.8.4 Standard and Enhanced Tritium Blanks

The same blank samples submitted for tritium analysis by the standard method, following this standard analysis, are processed by electrolytic enhancement and analyzed again. The MDC for this first analysis is about 150 pCi/L, and less than 25 pCi/L for this “enhanced” or “enriched” analysis. The median for standard tritium analysis of blanks was 15 ± 80 pCi/L for 2000 samples, and 42 ± 6 for these same samples by the enhanced method.

Review of tritium blank samples helped to confirm the presence of tritium contamination at the ISU-EML during 1998 – 1999. A number of blank samples exceeded the standard tritium MDC during this period, with the presence of this tritium contamination confirmed by the enhanced tritium results for these same samples. This contamination problem also resulted in tritium detections in samples that have not prior, or since had measurable tritium concentrations. For the entire period of record (1993 – 2000), the median tritium blank result, by enhancement, was 49 ± 8 pCi/L, and 50 ± 90 by the standard analysis method. In contrast, enhanced tritium results during this 1998 – 1999 period of contamination ranged from 68 ± 8 -- 159 ± 10 pCi/L. Blank results for 2000 suggest that ISU-EML did not have difficulties with tritium contamination during that period of record.

4.0 Summary

The State of Idaho INEEL OP Environmental Surveillance Program monitors surface water and ground water at 87 sites on, around and distant from the INEEL. Of these sites, 6 are located upgradient of the INEEL or INEEL facilities, 8 sites are located in the south-central portion of the INEEL, 4 are INEEL drinking water sites, 8 are located near the INEEL southern boundary, and five are sites distant from the INEEL in the Magic Valley. A summary of selected 2000 monitoring results for these sites are present in this document. The remaining 55 sites are not discussed here, but results from these sites are summarized in annual reports cooperatively produced by the U.S. Geological Survey and Idaho Department of Water Resources.

Samples were analyzed for selected common ions, nutrients, trace metals, gross radioactivity, and radionuclides. The selection of analytes reflects major and trace constituents in ground water of the Snake River Plain aquifer, many of which were also disposed of to the aquifer by the INEEL. A comparison with published estimates of background for the eastern Snake River Plain aquifer showed that calcium, sodium, potassium, chloride, sulfate, nitrate plus nitrite, total phosphorus, barium, chromium, zinc, gross beta radioactivity and tritium all exceeded background ranged for sample sites on the INEEL. Sites USGS 65, 112, 85, and CFA 1 and CFA 2 showed the greatest impacts, reflected in nearly all the previously listed analytes. Sites USGS 87, 104, 120, and RWMC Production, primarily show INEEL tritium at concentrations easily detected by the standard tritium analysis method. Sites USGS 108, 124, and 125 showed INEEL related tritium, only when analyzed by the enhanced tritium analysis method.

Trend plots for blank samples submitted for gross radioactivity and tritium analyses do not suggest any systematic laboratory or field contamination problems with samples submitted for analysis in 2000.

5.0 References

- Bartholomay, RC, Tucker B, Davis L, Greene MR. 2000. Hydrologic conditions and distribution of selected constituents in water, Snake River Plain Aquifer, Idaho National Engineering, and Environmental Laboratory, Idaho, 1996 through 1998. US Geological Survey Water-Resources Investigations Report 00-4192, DOE/ID 22167
- Busenberg, Eurybiades, Niel Plummer LN, Doughten MW, Widman PK, Bartholomay RC. 2000. Chemical and isotopic composition and gas concentrations of ground water and surface water from selected sites at and near the INEEL, 1994-1997. DOE/ID 22164, USGS Open-File Report 00-81.
- Crocket, J.K. 1995. Idaho statewide groundwater quality monitoring program— Summary of results 1991 through 1993. Idaho Department of Water Resources Water Information Bulletin No. 50 Part 2.
- Eisenbud, M. Gesell T. 1997. Environmental radioactivity from natural, industrial, and military sources. Academic Press. 4th Ed.

- Frederick, DB, Merritt AE, Fischer M, Campbell LJ. 1998. Wastewater disposal at the Idaho National Engineering and Environmental Laboratory, Idaho. State of Idaho INEEL Oversight Program.
- Hall, LF. 2000. Major ion water chemistry for wells near the northeast corner of the Idaho National Engineering and Environmental Laboratory, and implications for aquifer flow in the Mud Lake region, Idaho. Journal of the Idaho Academy of Science, 36:5-21.
- Hall, LF. 2001. Sampling and analysis plan for environmental surveillance program water surveillance monitoring activities; State of Idaho, INEEL Oversight Program.
- Hem, JD. 1985. Study and interpretation of the chemical characteristics of natural water. U.S. Geological Survey Water-Supply Paper 2254.
- [INEEL OP] Idaho Nuclear Engineering and Environmental Laboratory Oversight Program. 2000. 1999 Environmental Surveillance Report; A compilation and explanation of data collected by the INEEL Oversight Program during 1999. State of Idaho. OP-01-01
- Knobel, LeRoy, Bartholomay RC, Tucker B, Williams L, Cecil LD. 1999. Chemical constituents in ground water from 39 selected sites with an evaluation of associated quality assurance data, INEEL and vicinity, Idaho. DOE/ID 22159, USGS Open-File Report 99-246 52
- Knobel LeRoy, Orr B, Cecil LD, 1992, Summary of background concentrations of selected radiochemical and chemical constituents in groundwater from the Snake River Plain Aquifer, Idaho, estimated from an analysis of previously published data. Journal of the Idaho Academy of Science, 28:48-60.
- Neely, KW. Crockett JK. 1992. Idaho's statewide ground water quality monitoring program. Status Report – 1991. Idaho Department of Water Resources. 22 p.
- Neely, K.W. 1994. Idaho statewide ground water quality monitoring program network design. Idaho Department of Water Resources Water Information Bulletin No. 50 Part 1.
- Orr, B.R. Cecil LD, Knobel LL. 1991. Background concentrations of selected radionuclides, organic compounds, and chemical constituents in groundwater in the vicinity of the Idaho National Engineering Laboratory, U.S. Geological Survey Water-Resources Investigations Report 91-4015 DOE/ID-22094

- Pittman, JR, Jensen JR, Fischer PR. 1988, Hydrologic conditions at the Idaho National Engineering Laboratory. 1982-1985. US Geological Survey Water-Resources Investigations Report 89-4008, DOE/ID-22078.
- Robertson, JB., Schoen R, Barraclough JT. 1974. The influence of liquid waste disposal on the geochemistry of water at the National Reactor Testing Station, Idaho:1952-1970, U.S. Geological Survey Open File Report IDO-22053.
- Rupert, MG. 1997. Nitrate ($\text{NO}_2 + \text{NO}_3 -\text{N}$) in ground water of the upper Snake River basin, Idaho and Western Wyoming, 1991-95. U.S. Geological Survey Water Resources Investigation Report 97-4174.
- Salvato, JA. Environmental engineering and sanitation, New York: J Wiley. 8th ed.
- Wegner, SJ, Campbell LJ. 1991. Radionuclides, chemical constituents, and organic compounds in water from designated wells and springs from the southern boundary of the Idaho Nation Engineering Laboratory to the Hagerman area, Idaho, 1989. U.S. Geological Survey Open-File Report 91-232, DOE/ID-22098.. 49 p.
- Wood, W.W., WH Low. 1988. Solute geochemistry of the snake river plain regional aquifer system, Idaho and eastern Oregon. Snake River Plain RASA Project. U.S. Geological survey Professional Paper 1408-D.

Dissolved Calcium

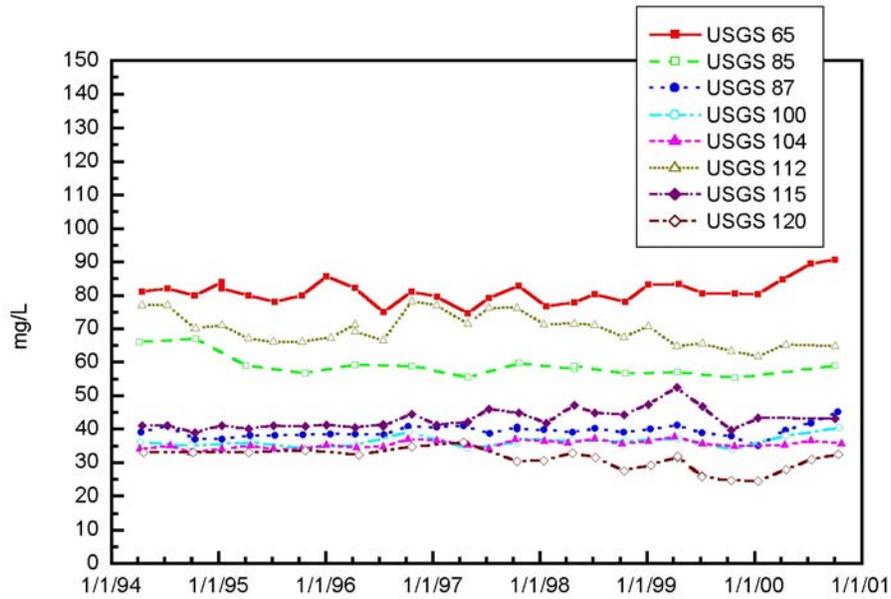


Figure 3 Dissolved calcium, south-central INEEL water monitoring sites.

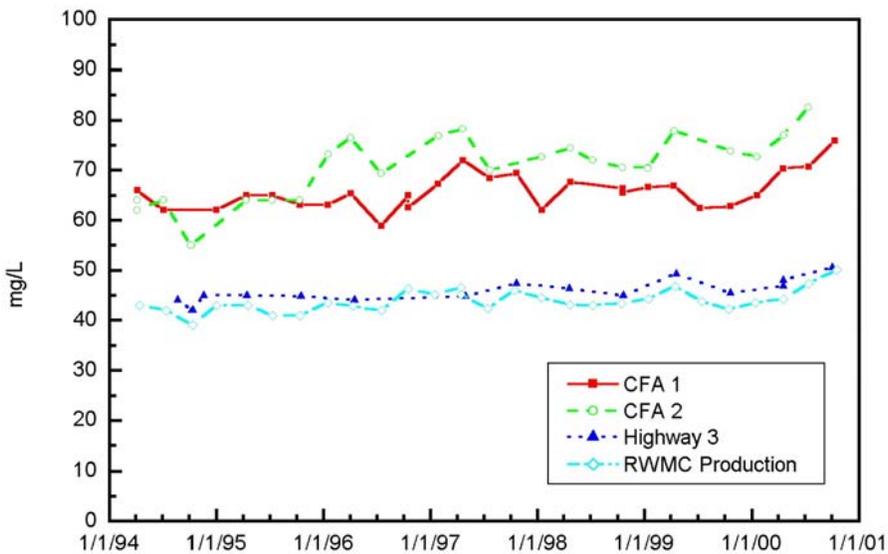


Figure 4 Dissolved calcium, INEEL drinking water monitoring sites.

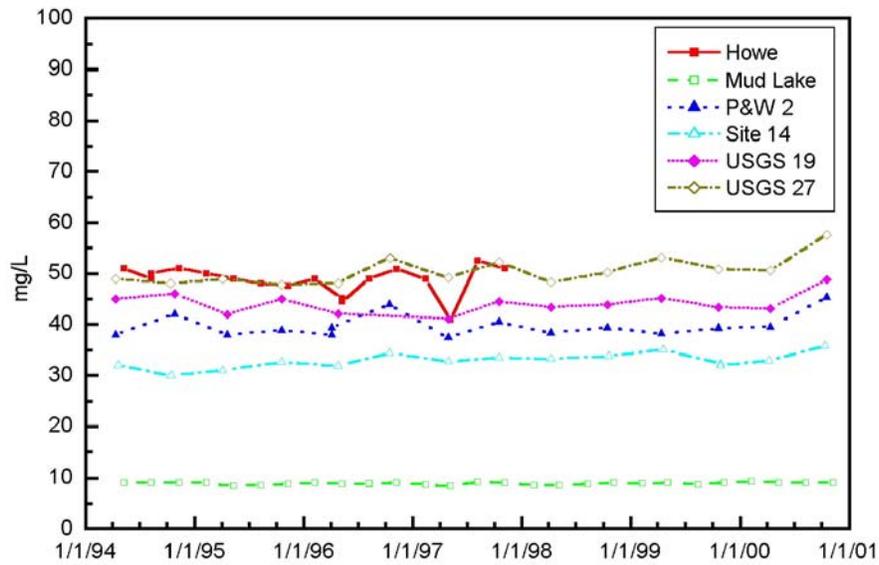


Figure 5 Dissolved calcium, upgradient INEEL water monitoring sites.

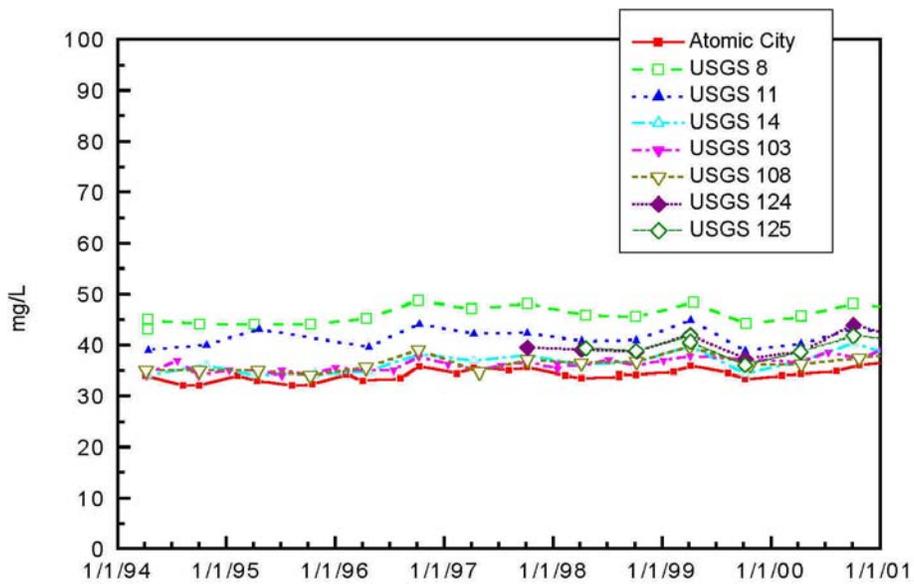


Figure 6 Dissolved calcium, INEEL southern boundary water monitoring sites.

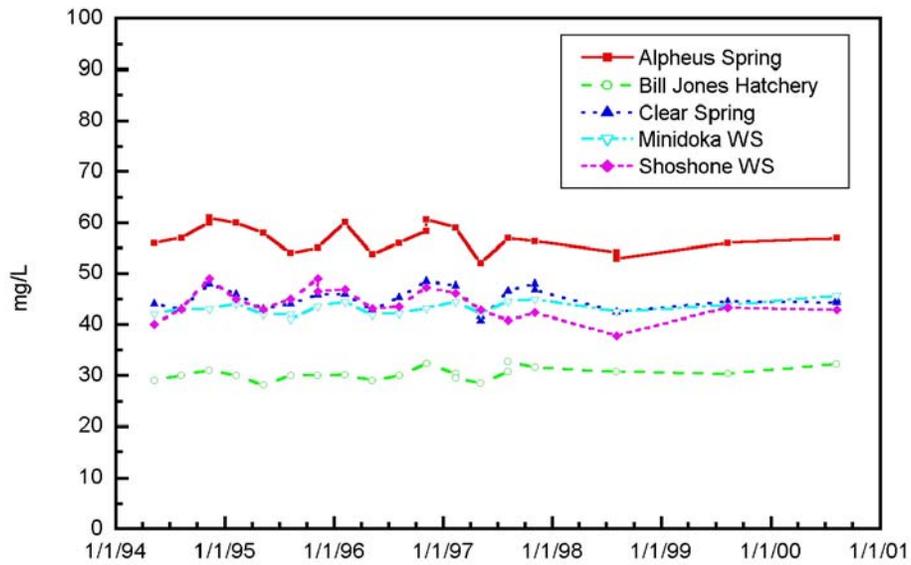


Figure 7 Dissolved calcium, distant water monitoring sites.

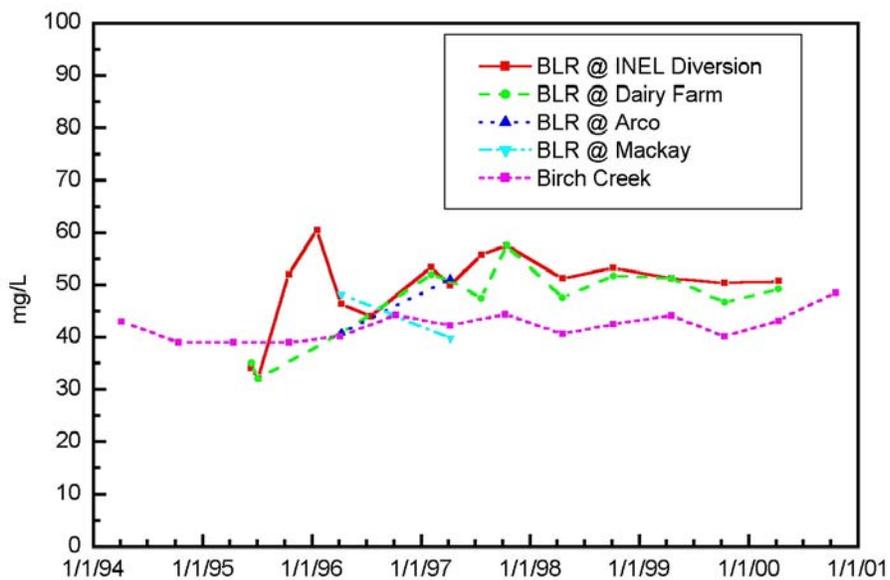


Figure 8 Dissolved calcium, surface water monitoring sites.

Dissolved Magnesium

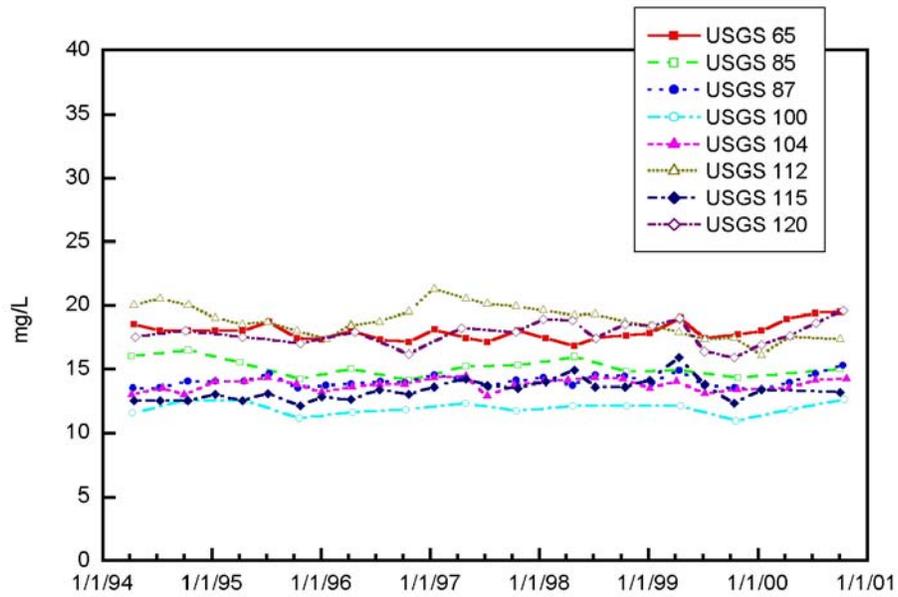


Figure 9 Dissolved magnesium, south-central INEEL water monitoring sites.

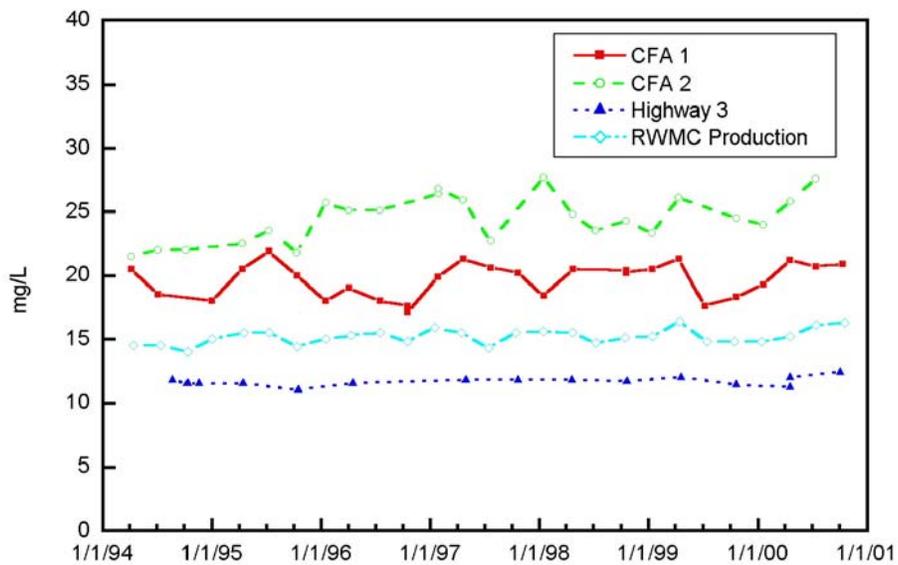


Figure 10 Dissolved magnesium, INEEL drinking water monitoring sites.

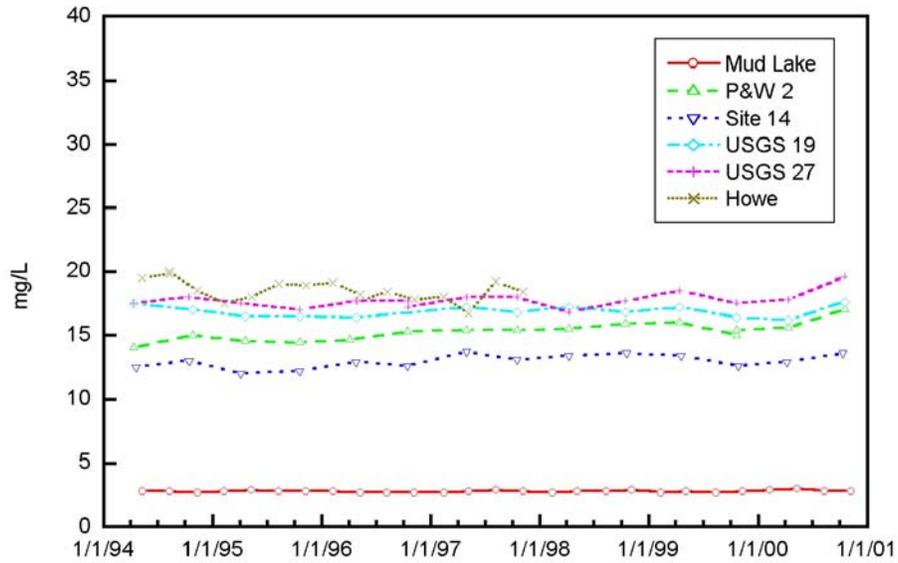


Figure 11 Dissolved magnesium, upgradient INEEL water monitoring sites.

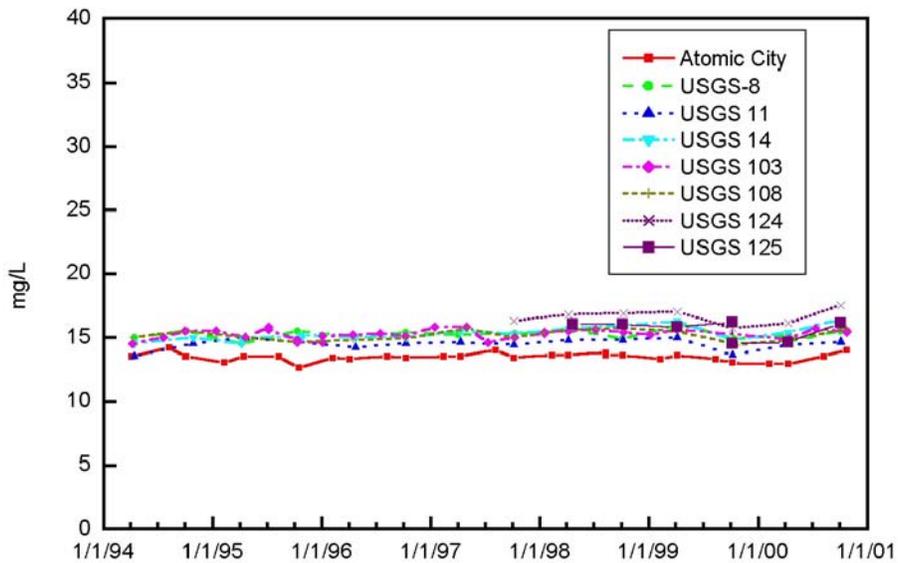


Figure 12 Dissolved magnesium, INEEL southern boundary water monitoring sites.

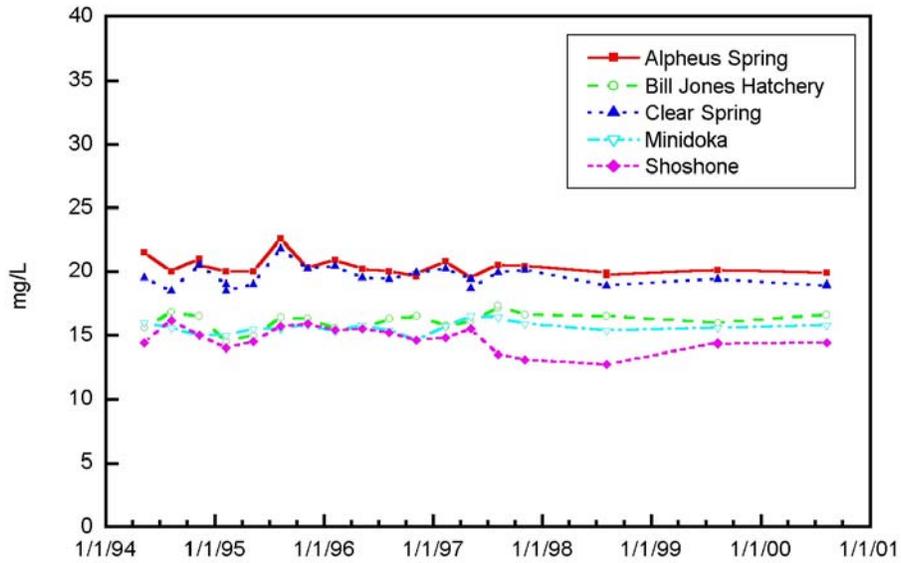


Figure 13 Dissolved magnesium, distant water monitoring sites.

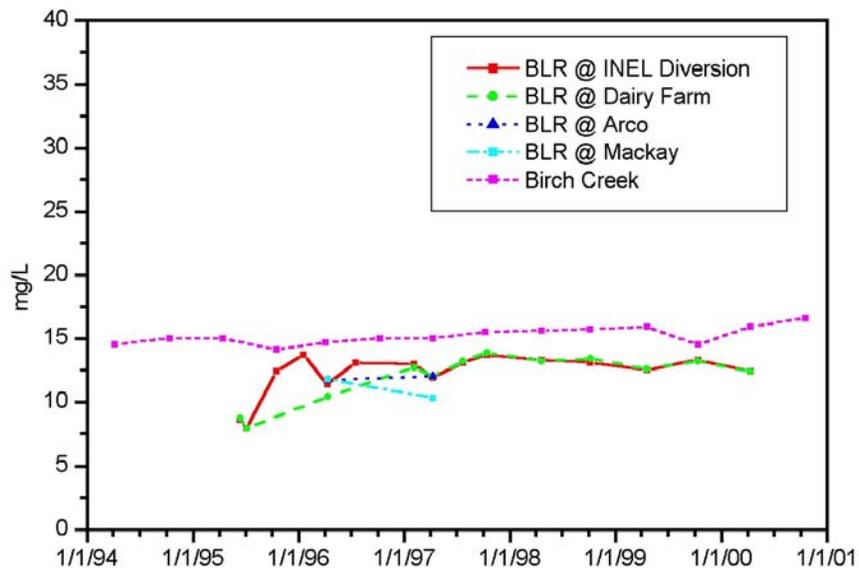


Figure 14 Dissolved magnesium, surface water monitoring sites.

Dissolved Sodium

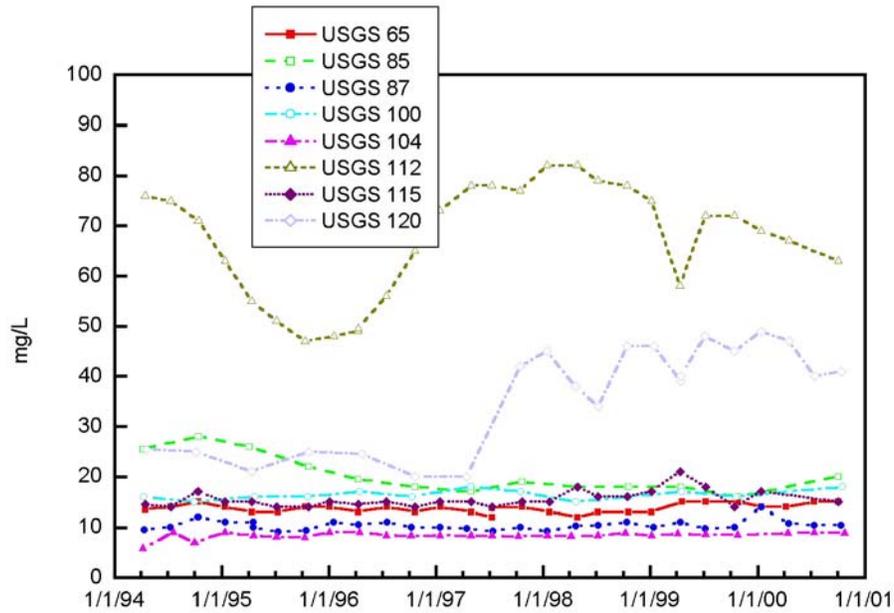


Figure 15 Dissolved sodium, south-central INEEL water monitoring sites.

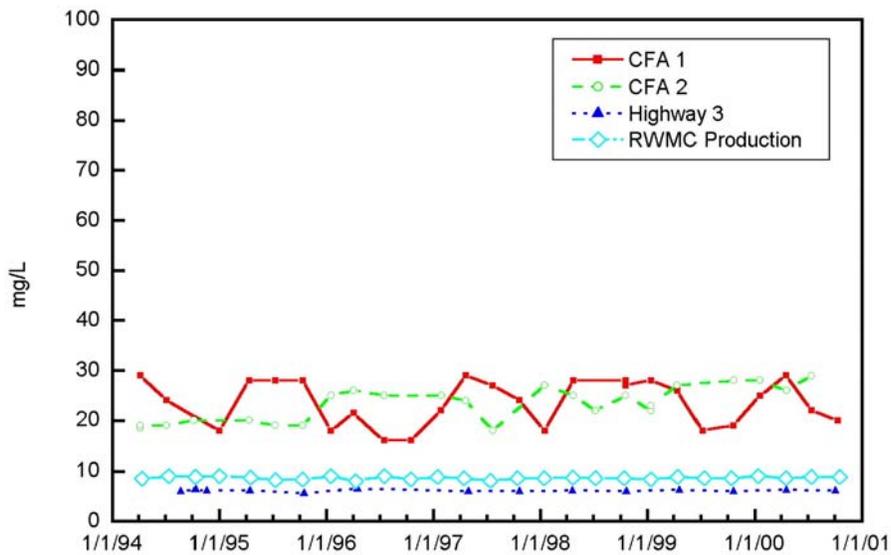


Figure 16 Dissolved sodium, INEEL drinking water monitoring sites.

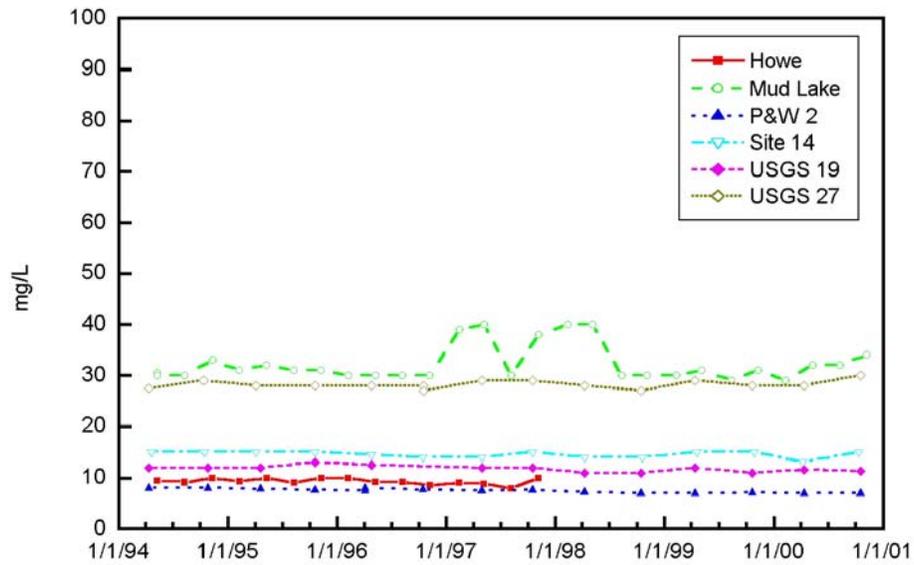


Figure 17 Dissolved sodium, upgradient INEEL water monitoring sites.

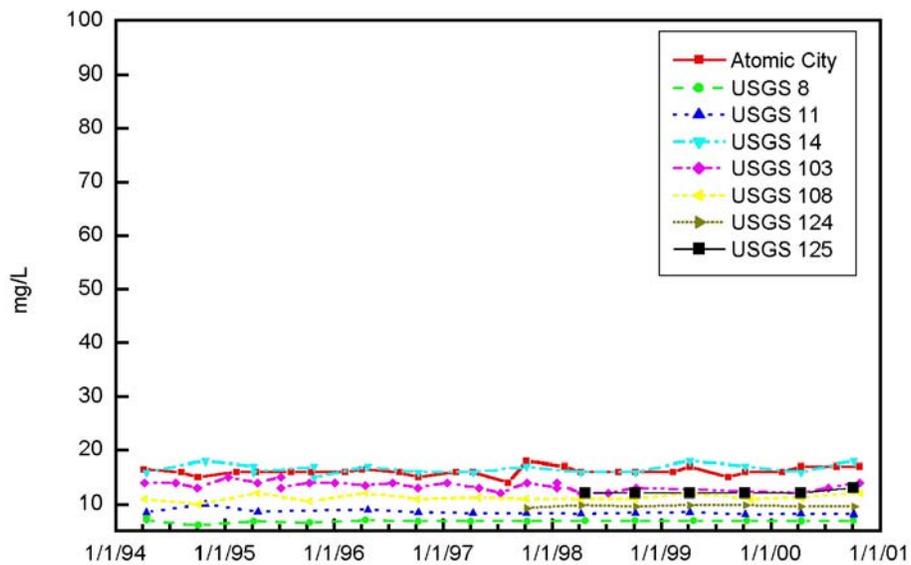


Figure 18 Dissolved sodium, INEEL southern boundary water monitoring sites.

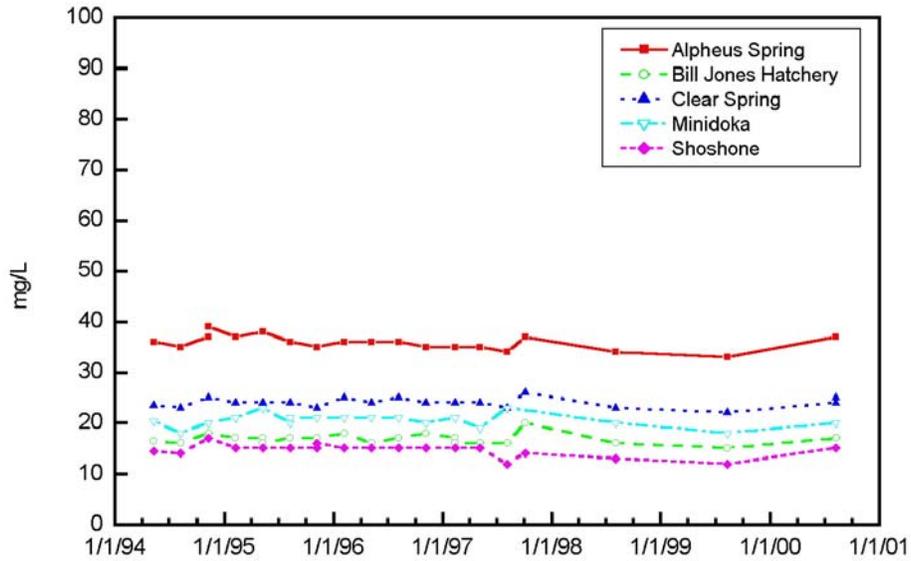


Figure 19 Dissolved sodium, distant water monitoring sites.

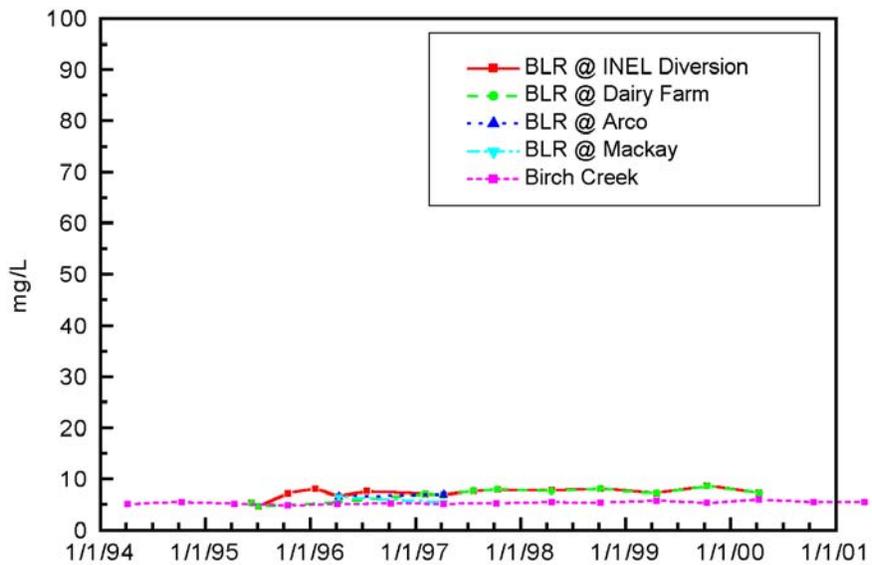


Figure 20 Dissolved sodium, surface water monitoring sites.

Dissolved Potassium

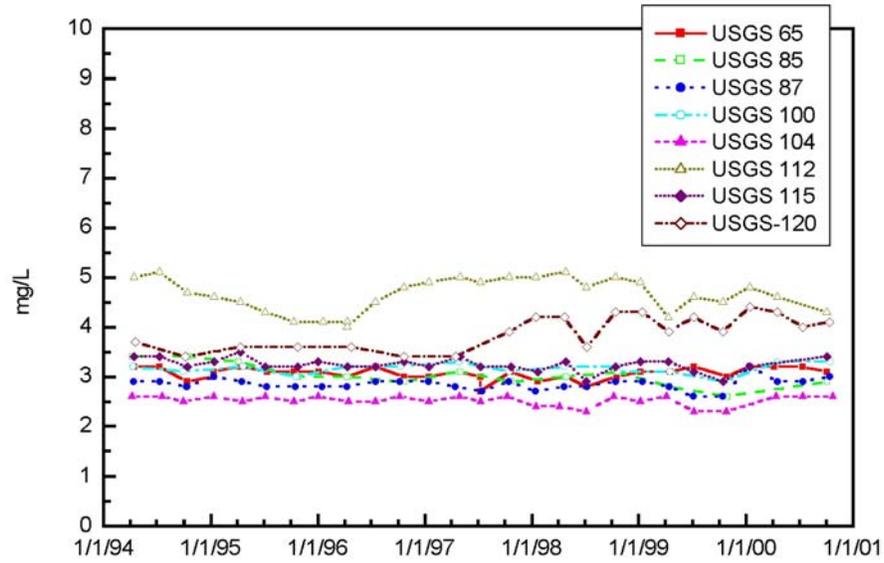


Figure 21 Dissolved potassium, south-central INEEL water monitoring sites.

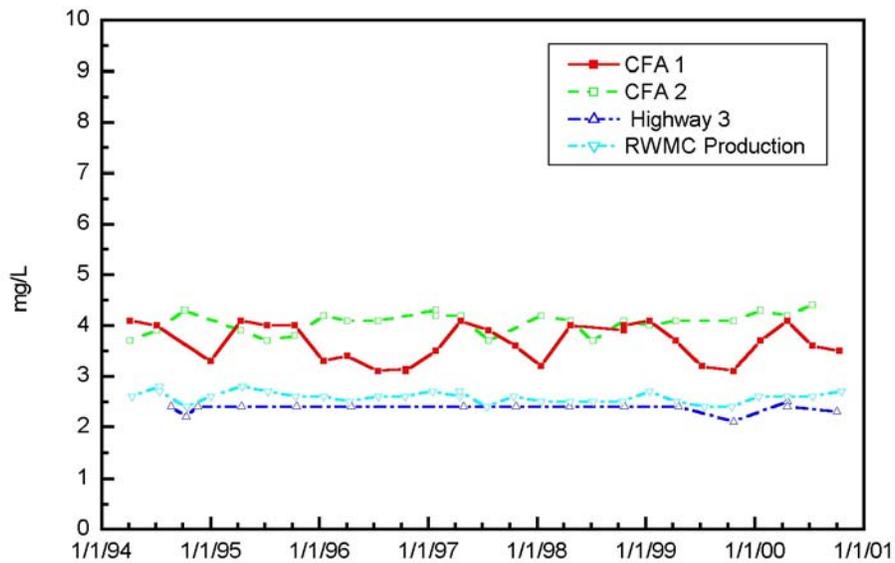


Figure 22 Dissolved potassium, INEEL drinking water monitoring sites.

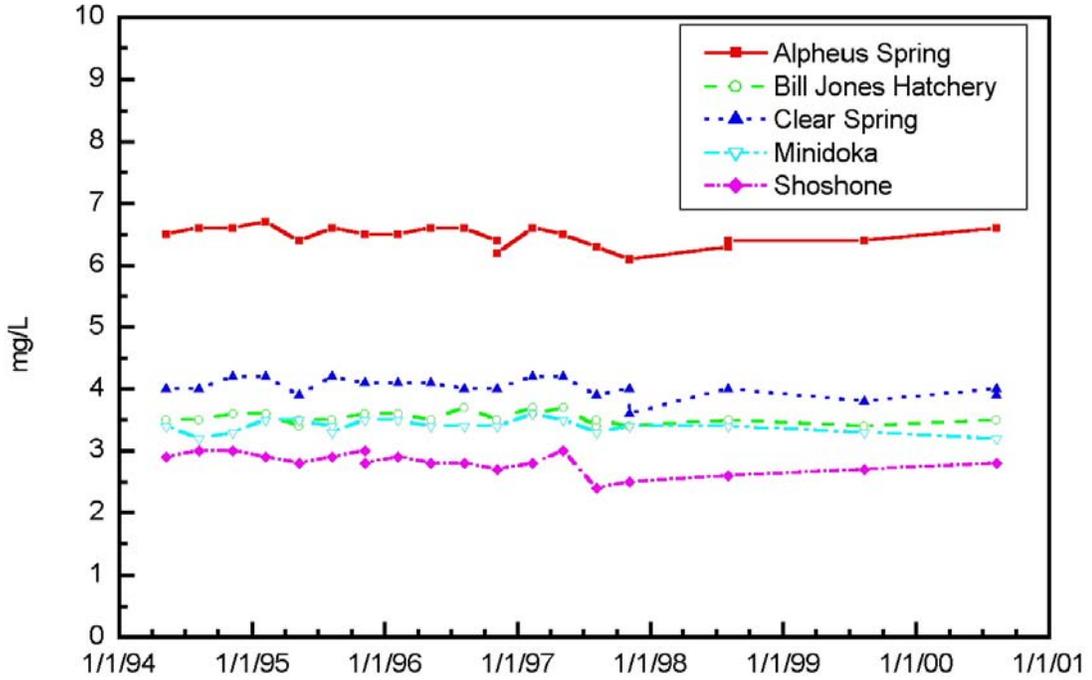


Figure 23 Dissolved potassium, upgradient INEEL water monitoring sites.

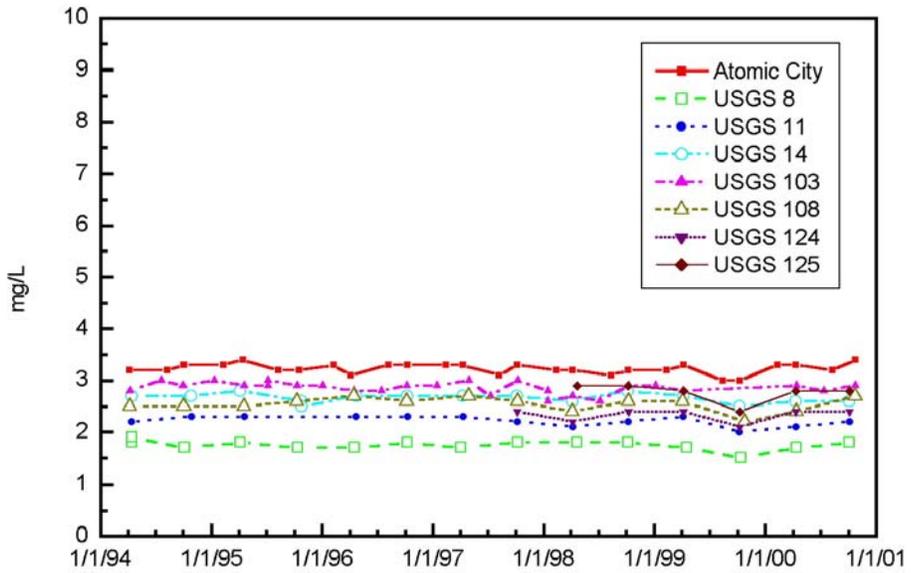


Figure 24 Dissolved potassium, INEEL southern boundary water monitoring sites.

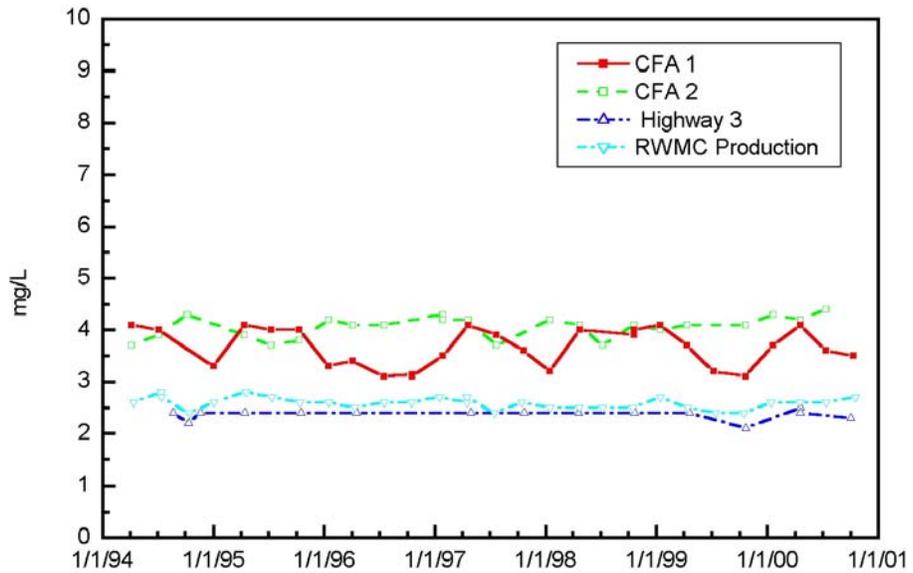


Figure 25 Dissolved potassium, distant water monitoring sites.

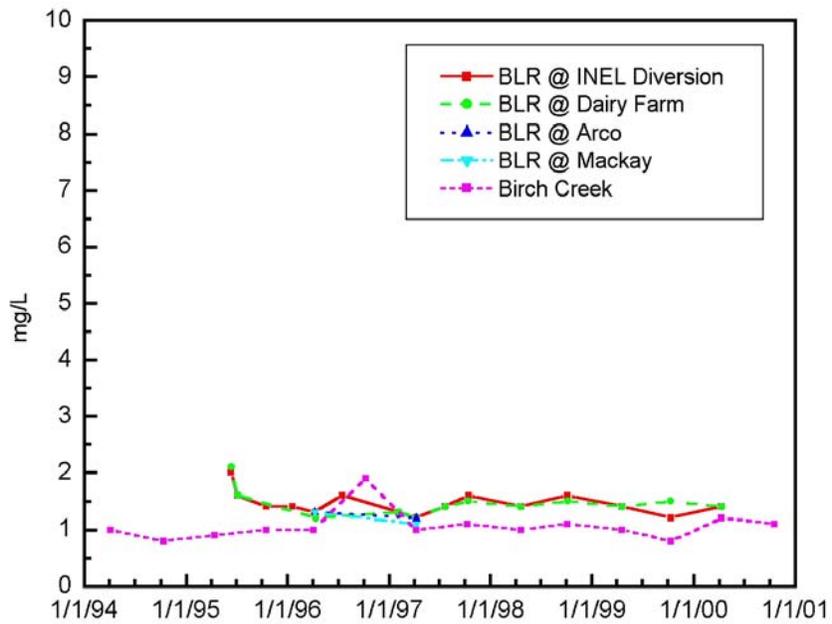


Figure 26 Dissolved potassium, surface water monitoring sites.

Chloride

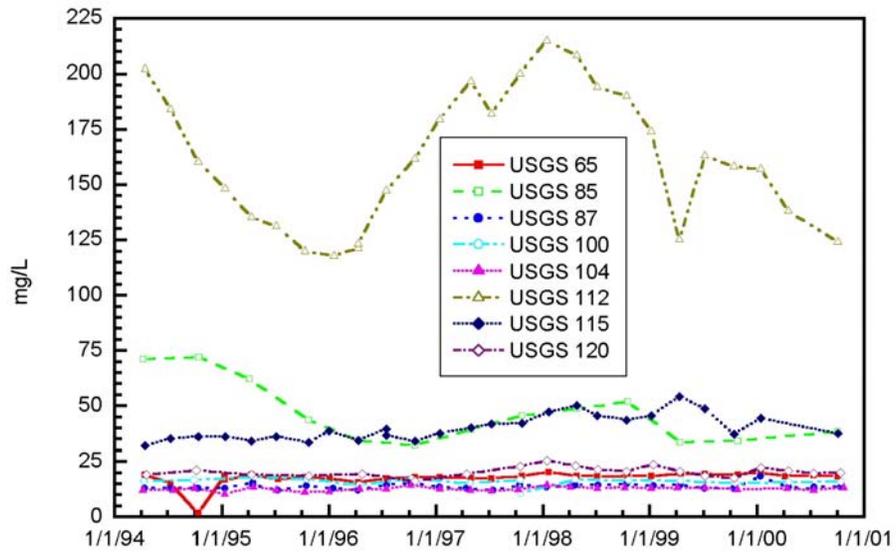


Figure 27 Chloride, south-central INEEL water monitoring sites.

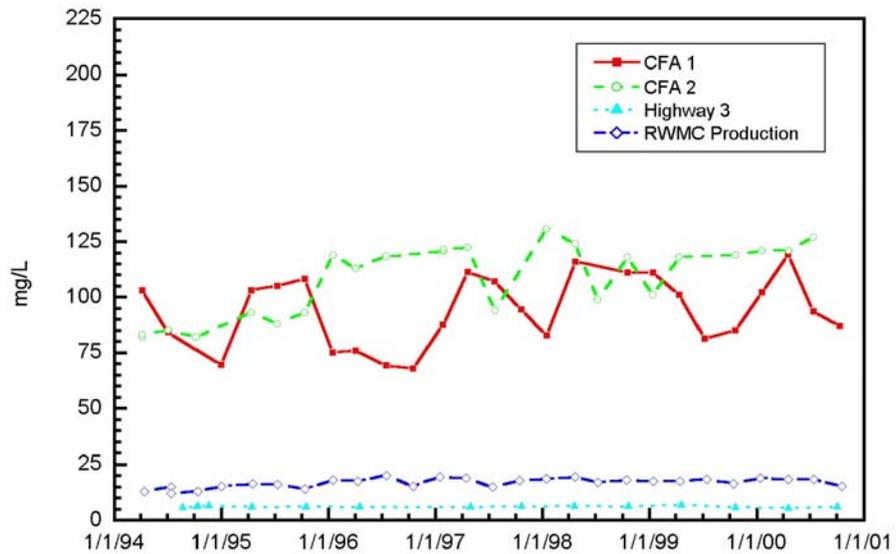


Figure 28 Chloride, INEEL drinking water monitoring sites.

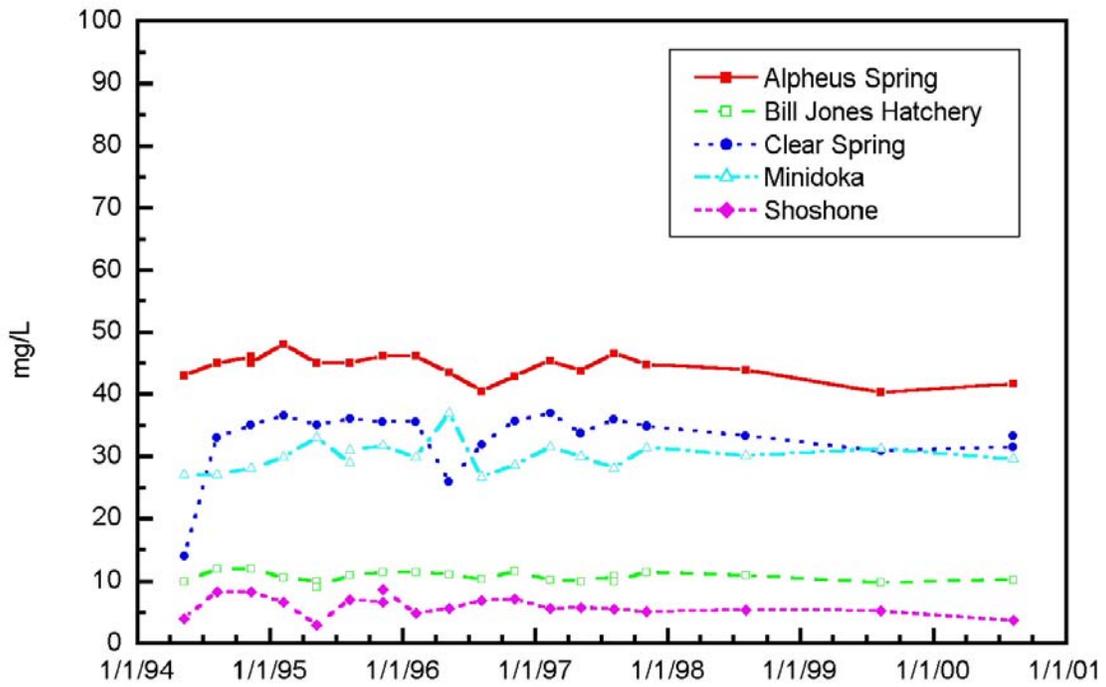


Figure 29 Chloride, upgradient INEEL water monitoring sites.

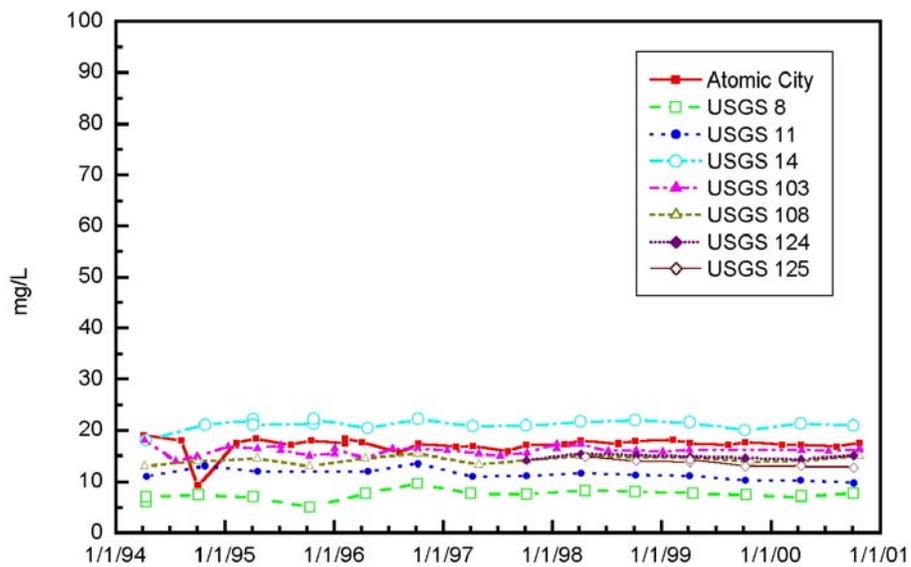


Figure 30 Chloride, INEEL southern boundary water monitoring sites.

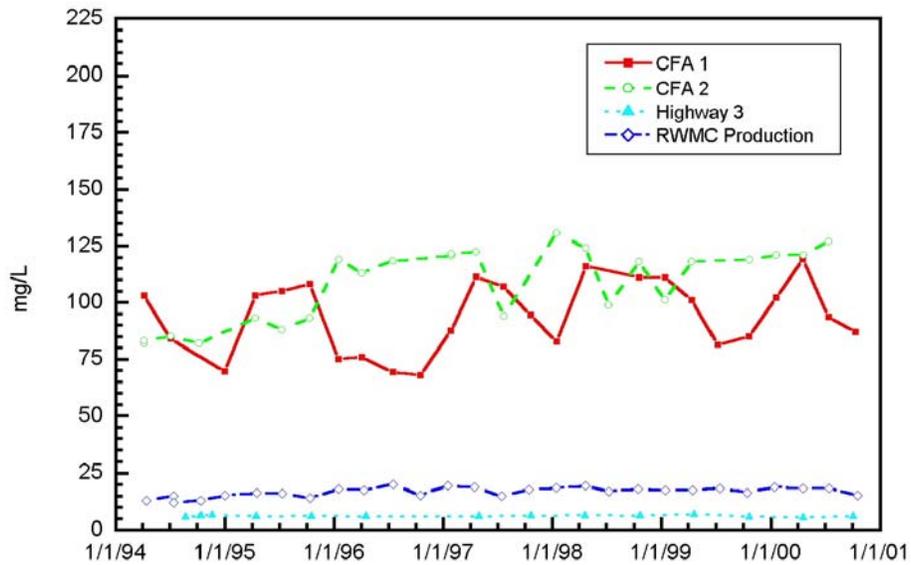


Figure 31 Chloride, distant water monitoring sites.

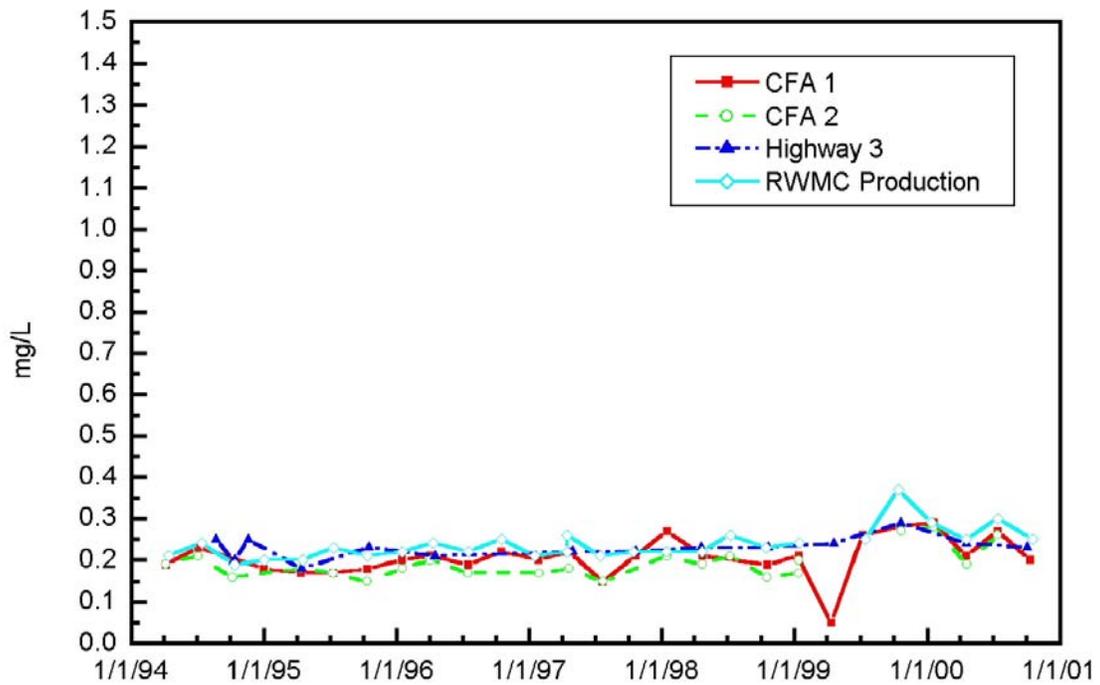


Figure 32 Chloride, surface water monitoring sites.

Fluoride

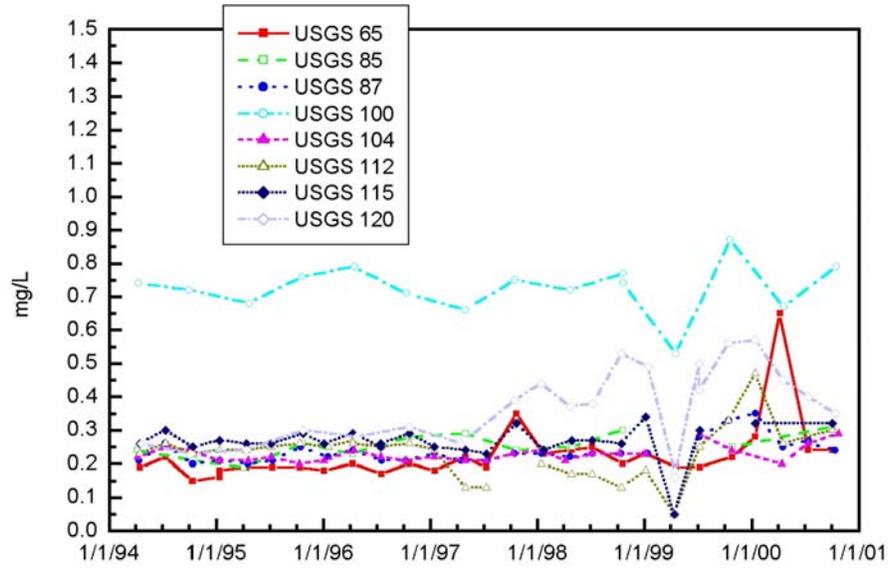


Figure 33 Fluoride, south-central INEEL water monitoring sites.

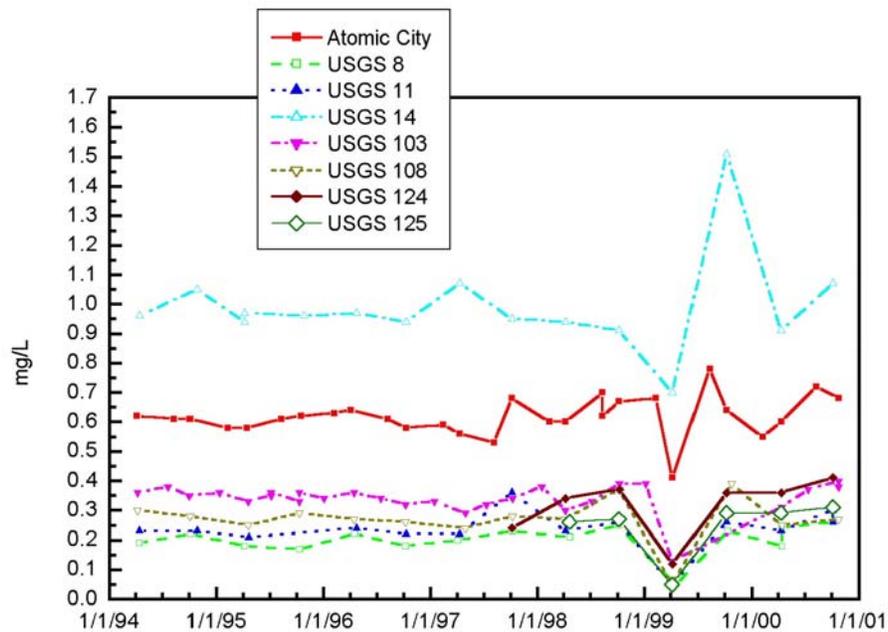


Figure 34 Fluoride, INEEL drinking water monitoring sites.

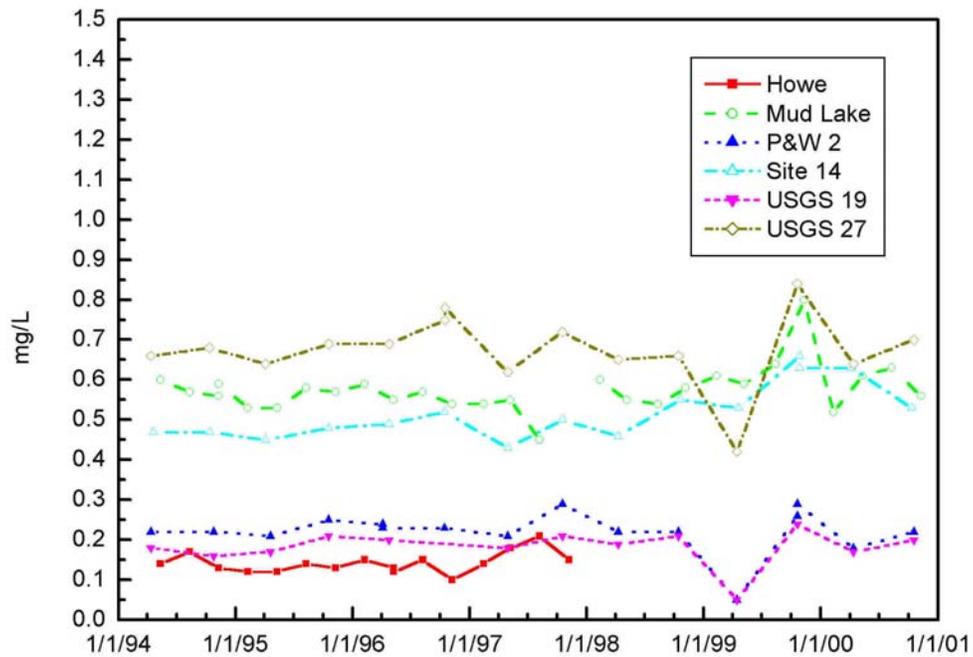


Figure 35 Fluoride, upgradient INEEL water monitoring sites.

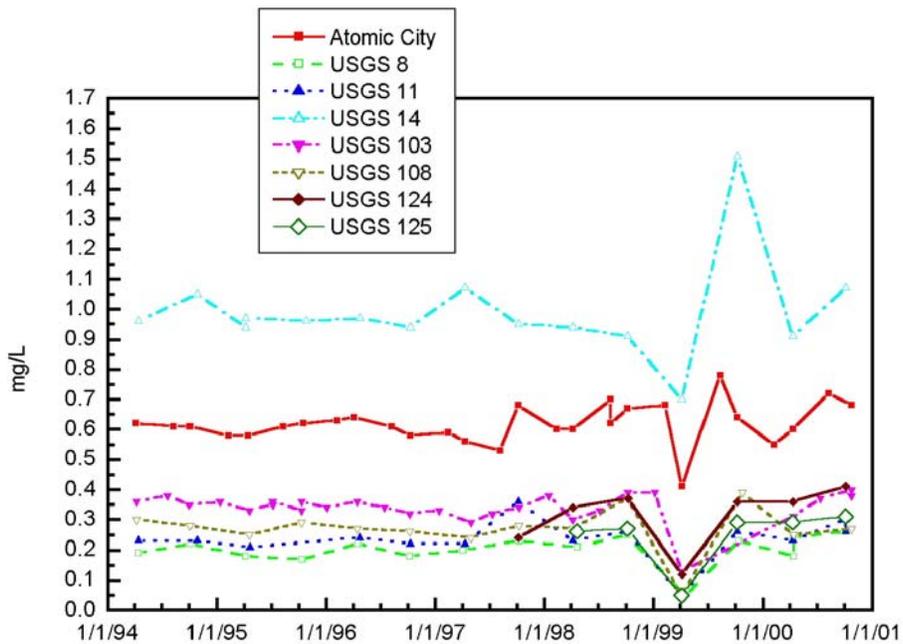


Figure 36 Fluoride, INEEL southern boundary water monitoring sites.

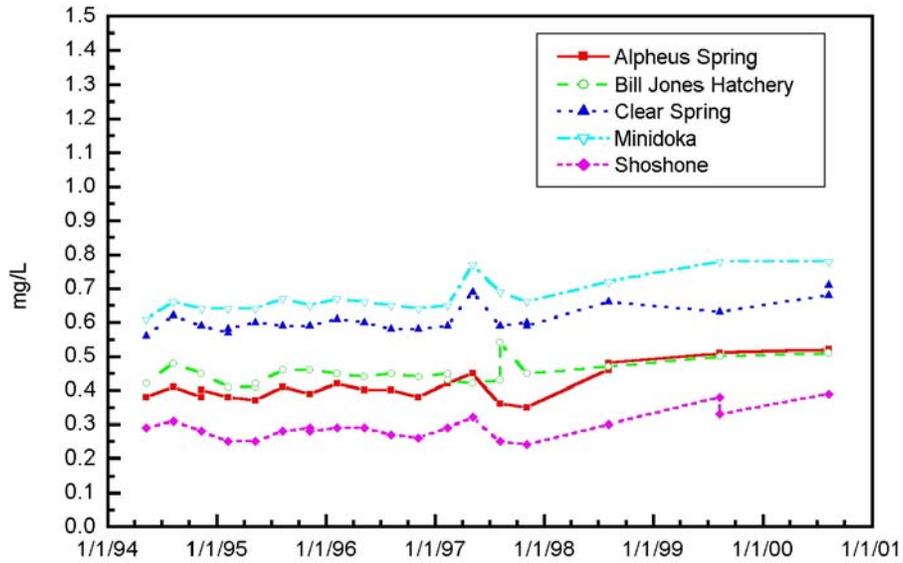


Figure 37 Fluoride, distant water monitoring sites.

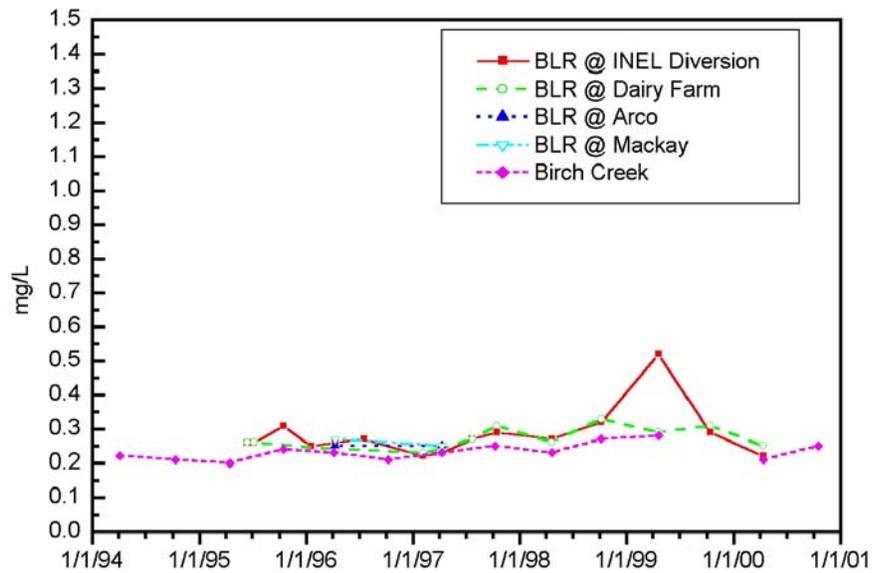


Figure 38 Fluoride, surface water monitoring sites.

Sulfate

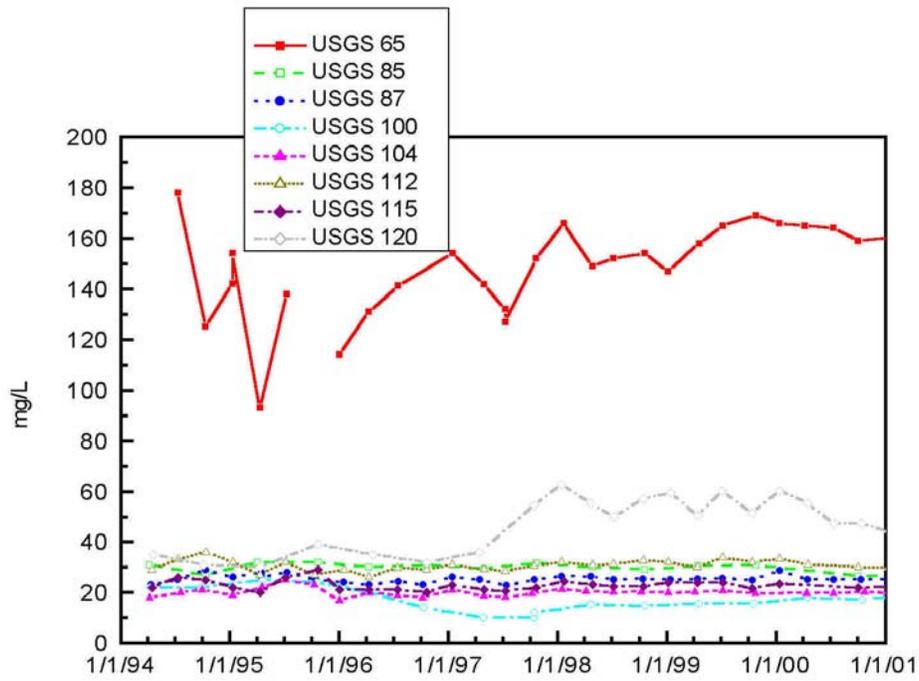


Figure 39 Sulfate, south-central INEEL water monitoring sites.

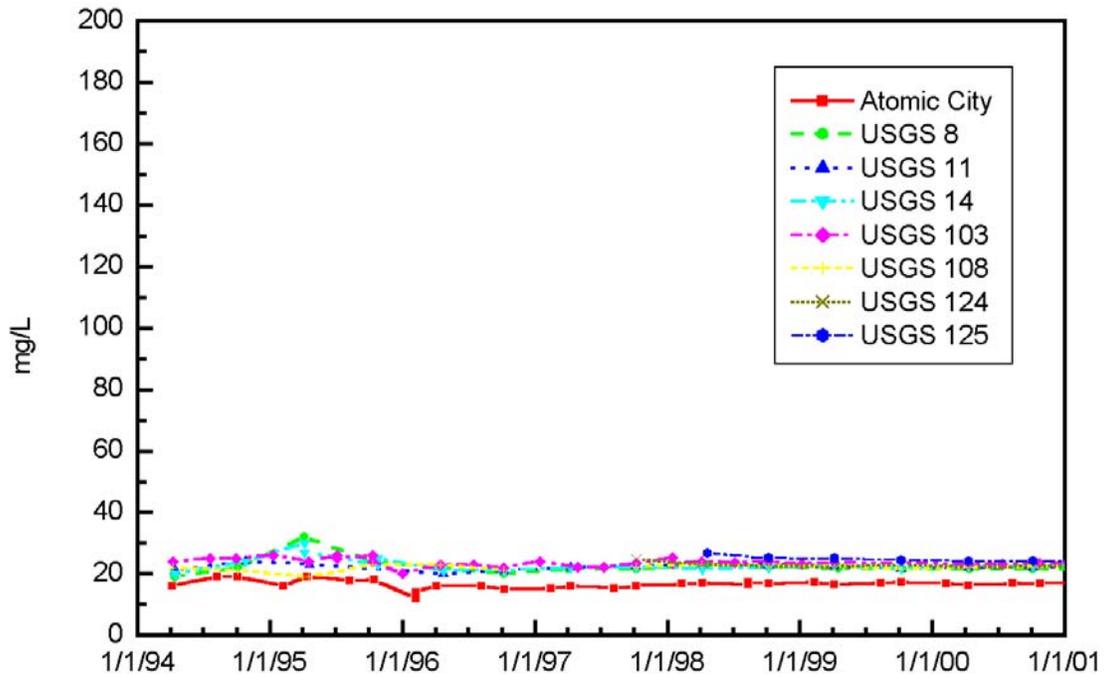


Figure 40 Sulfate, INEEL drinking water sites.

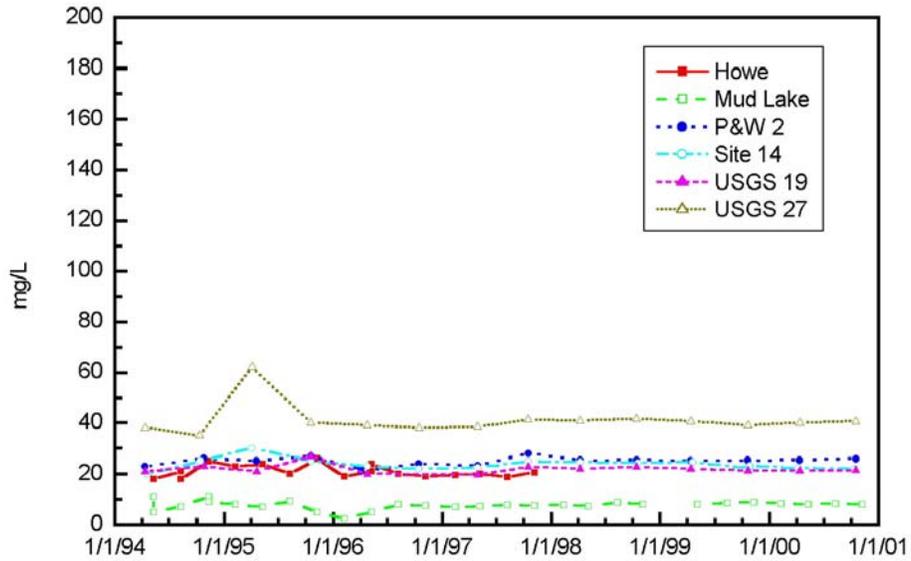


Figure 41 Sulfate, upgradient INEEL water monitoring sites.

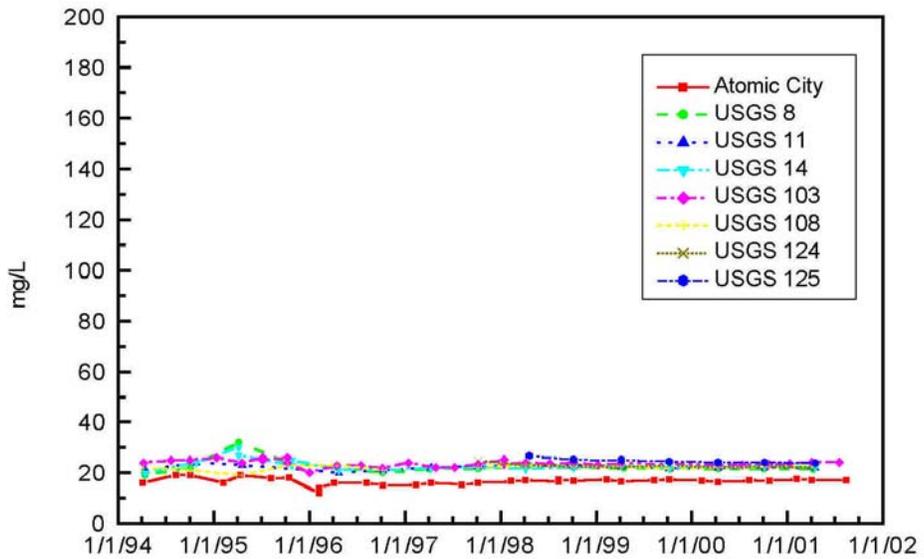


Figure 42 Sulfate, INEEL southern boundary water monitoring sites.

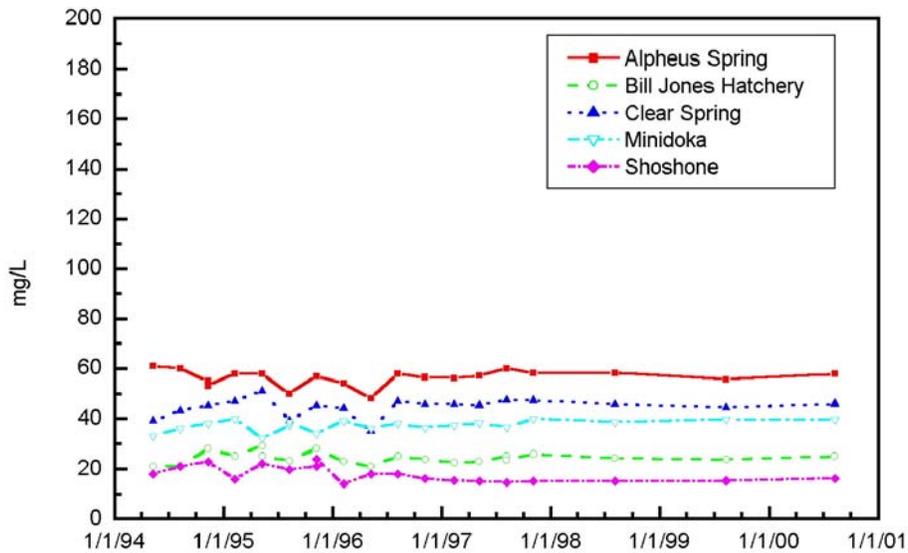


Figure 43 Sulfate, distant water monitoring sites.

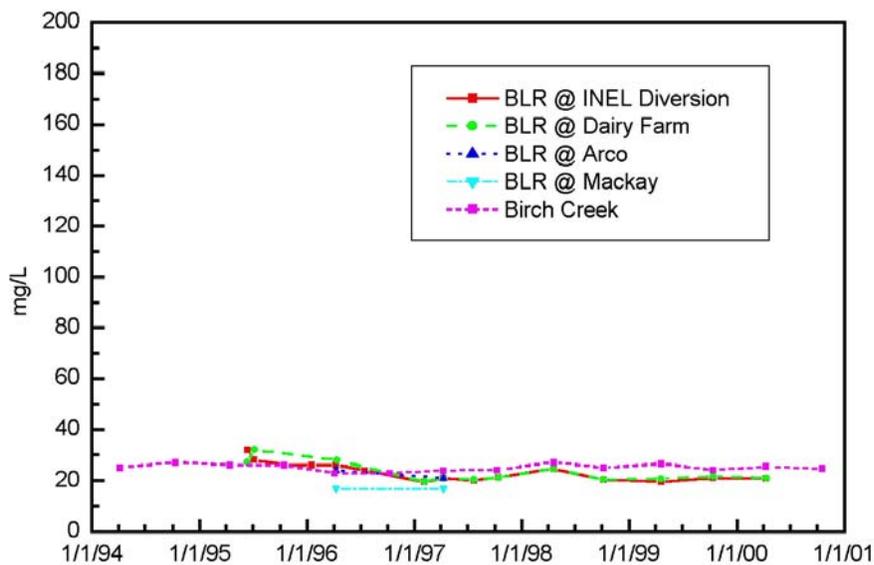


Figure 44 Sulfate, surface water monitoring sites.

Dissolved nitrate plus nitrite

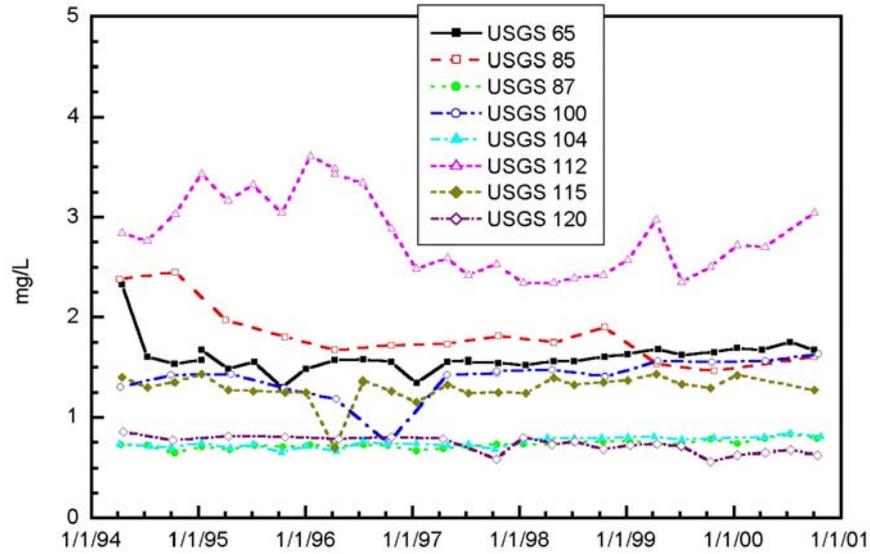


Figure 45 Dissolved nitrate plus nitrite, south-central INEEL water monitoring sites.

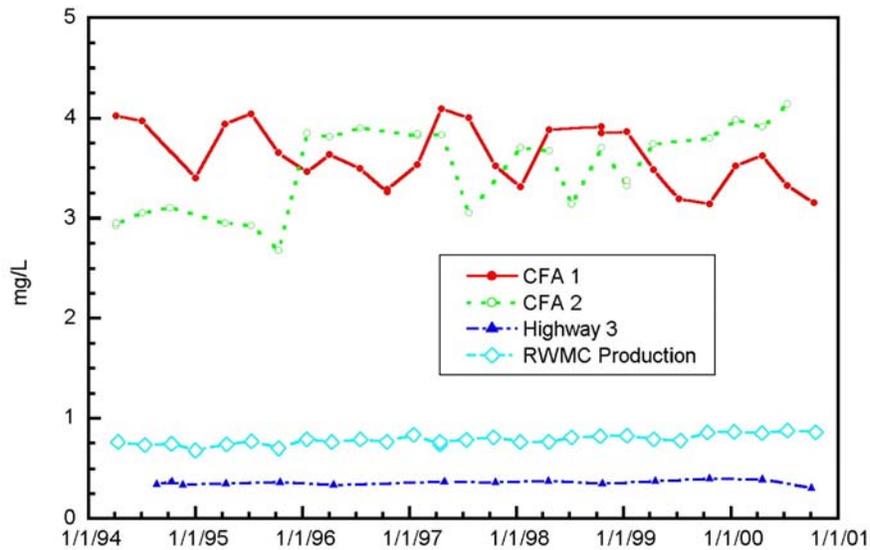


Figure 46 Dissolved nitrate plus nitrite, INEEL drinking water monitoring sites.

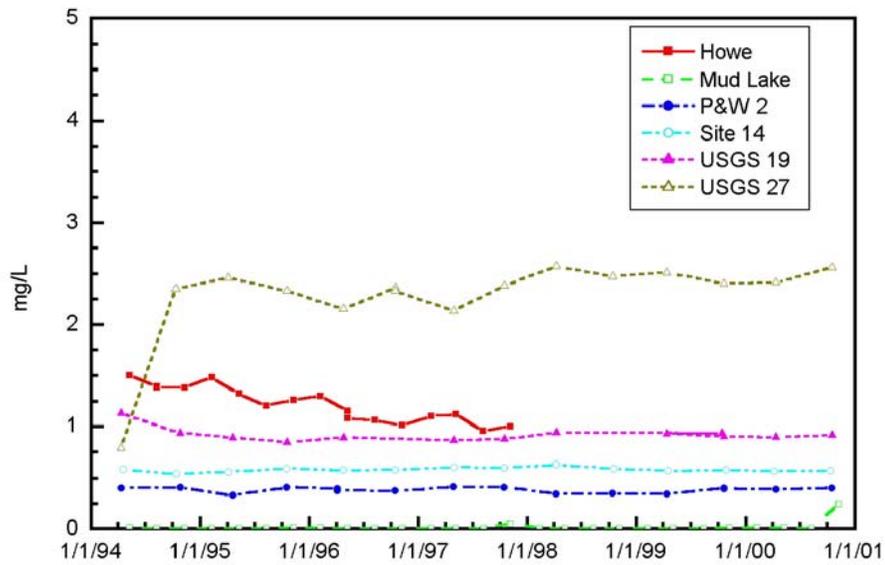


Figure 47 Dissolved nitrate plus nitrite, upgradient INEEL water monitoring sites.

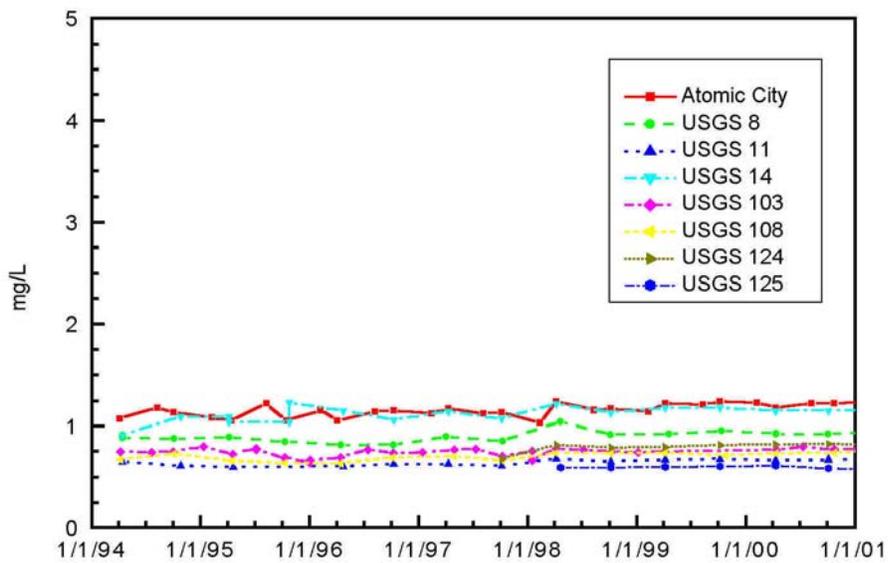


Figure 48 Dissolved nitrate plus nitrite, INEEL southern boundary monitoring sites.

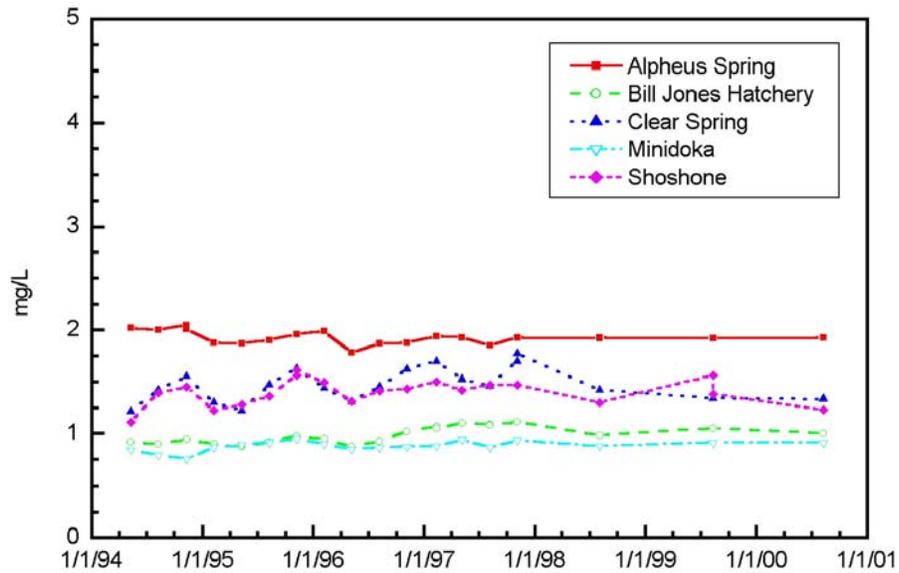


Figure 49 Dissolved nitrate plus nitrite, distant water monitoring sites.

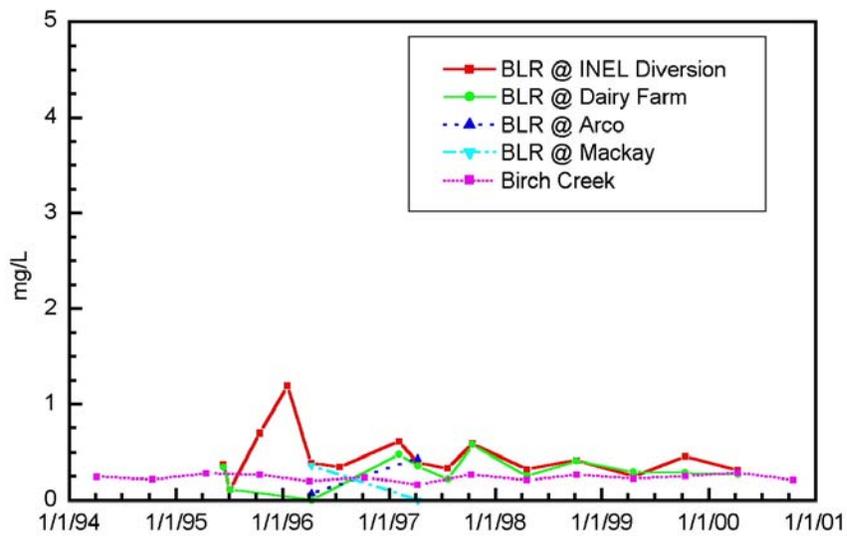


Figure 50 Dissolved nitrate plus nitrite, surface water monitoring sites.

Total alkalinity

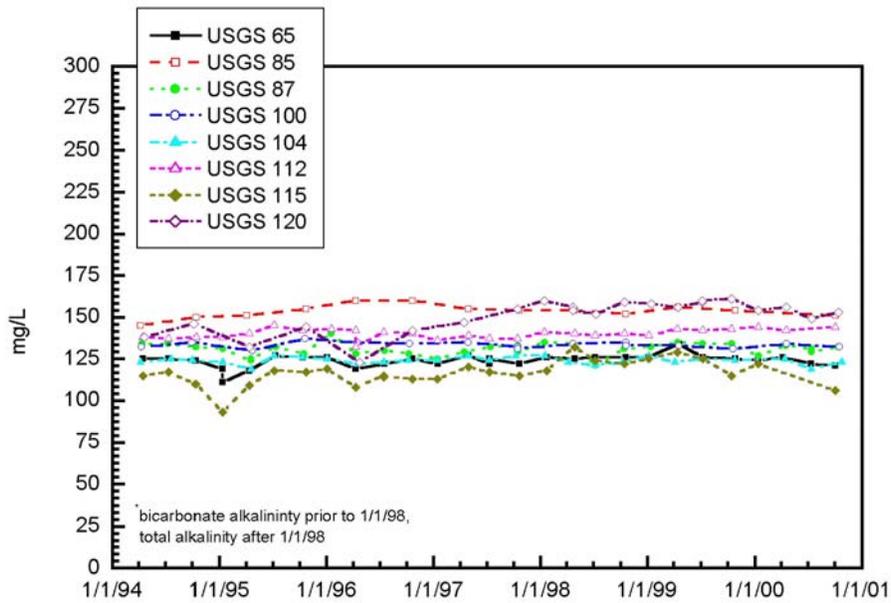


Figure 51 Total alkalinity, south-central INEEL water monitoring sites.

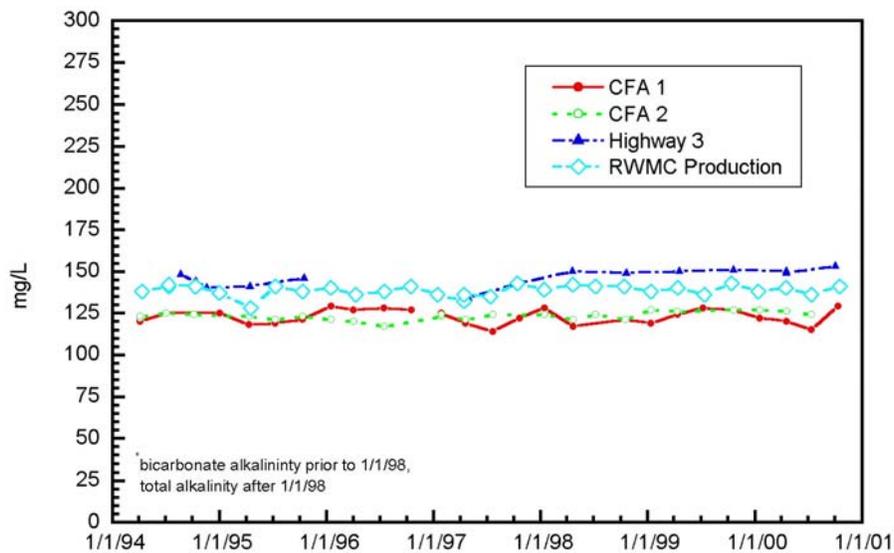


Figure 52 Total alkalinity, INEEL drinking water monitoring sites.

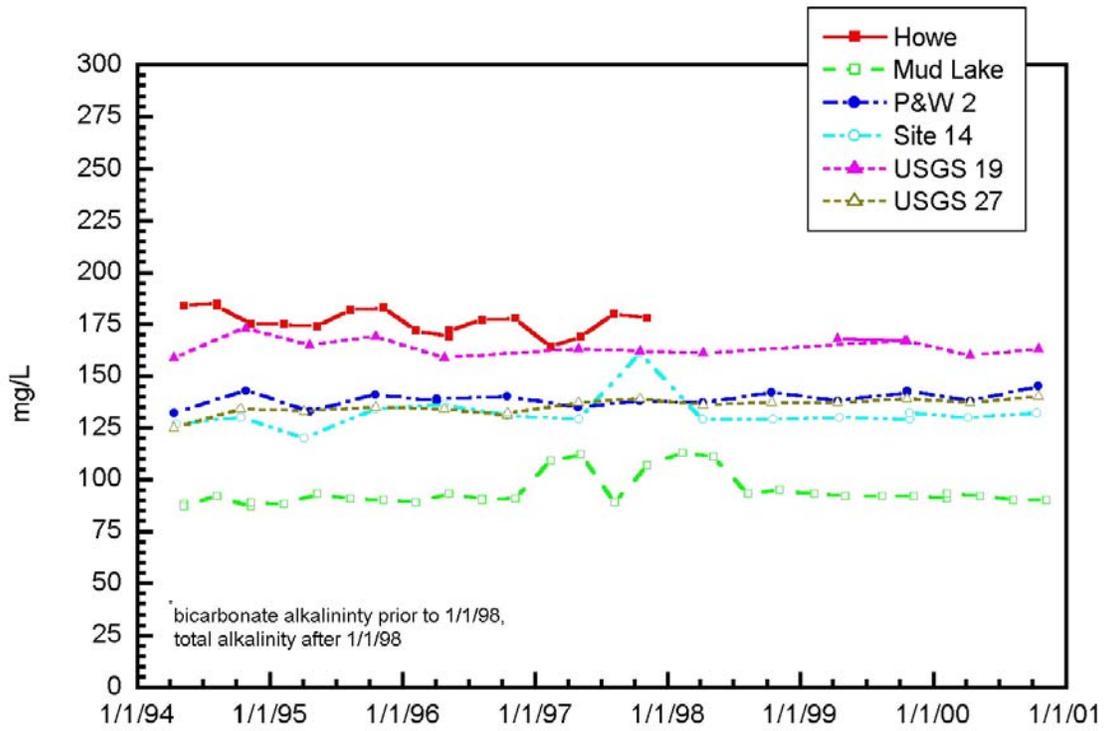


Figure 53 Total alkalinity, upgradient INEEL water monitoring sites.

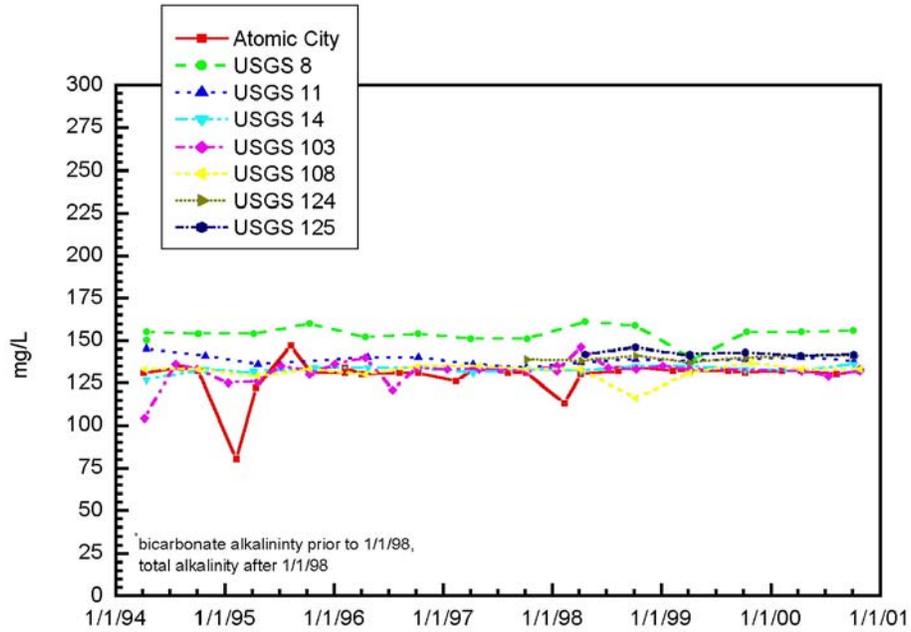


Figure 54 Total alkalinity, INEEL southern boundary water monitoring sites.

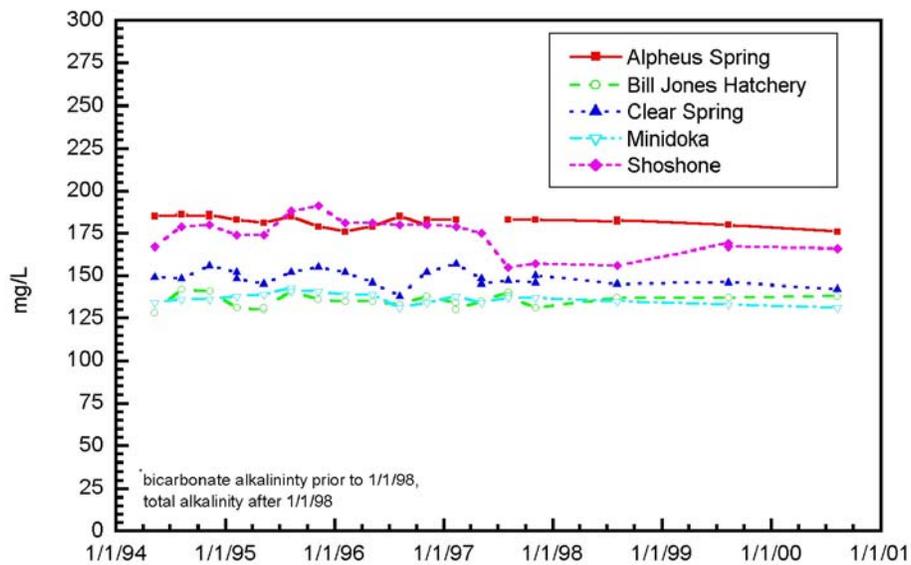


Figure 55 Total alkalinity, distant water monitoring sites.

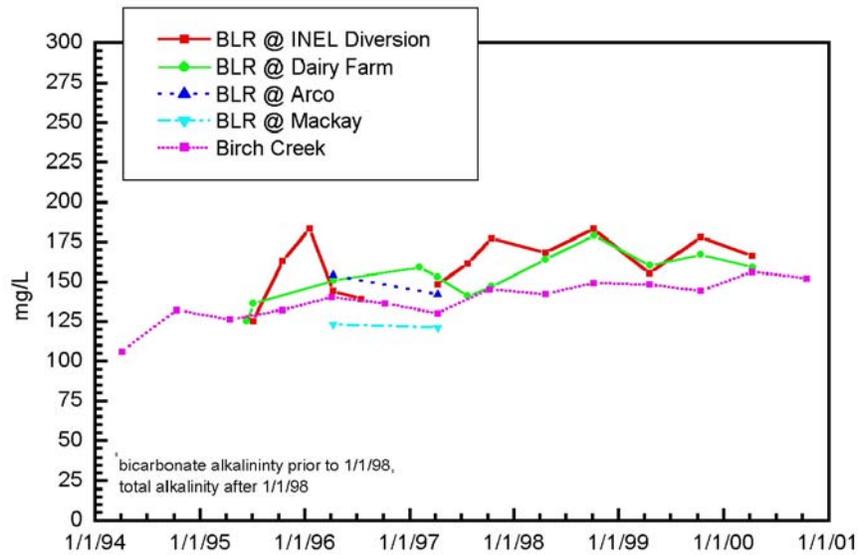


Figure 56 Total alkalinity, surface water monitoring sites.

Dissolved Barium

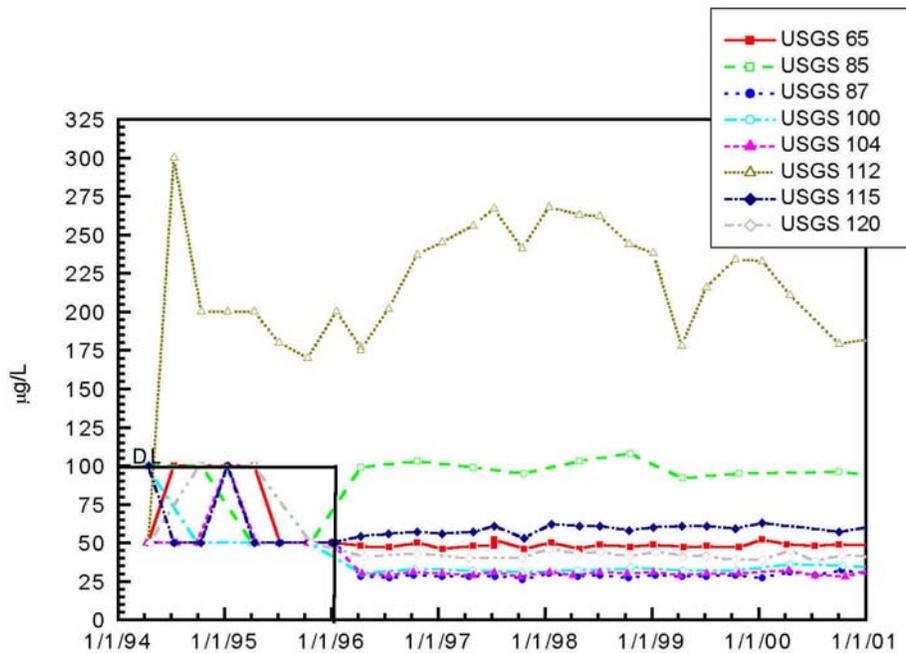


Figure 57 Dissolved barium, south-central INEEL water monitoring sites.

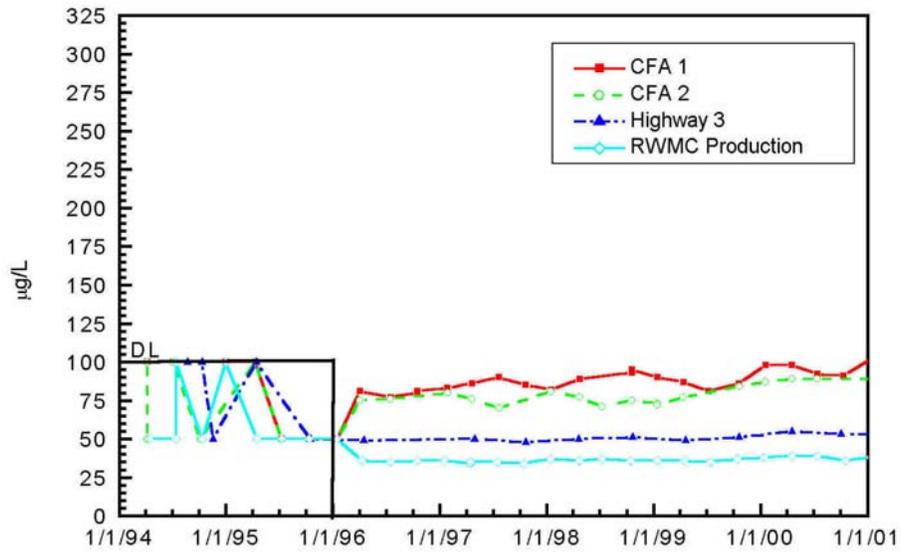


Figure 58 Dissolved barium, INEEL drinking water monitoring sites.

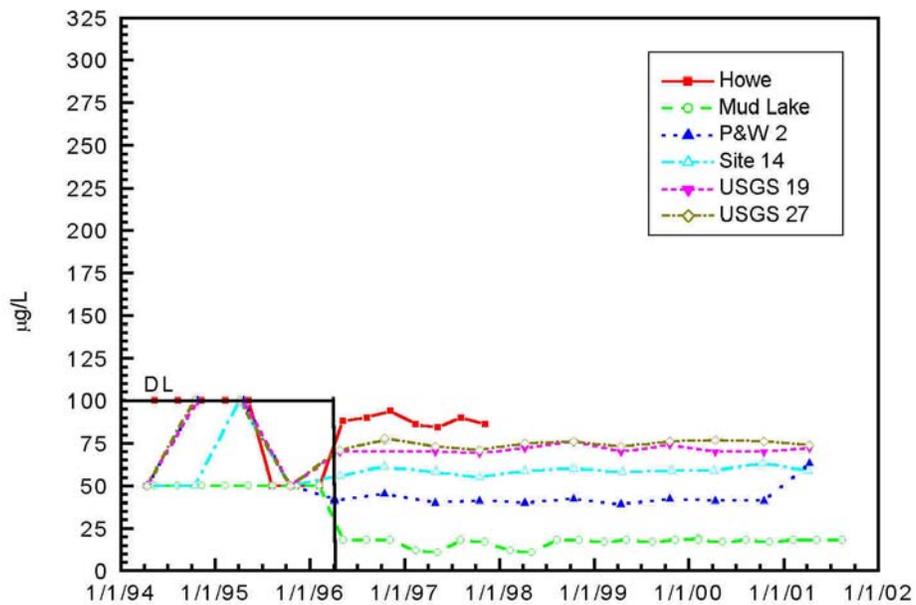


Figure 59 Dissolved barium, upgradient INEEL water monitoring sites.

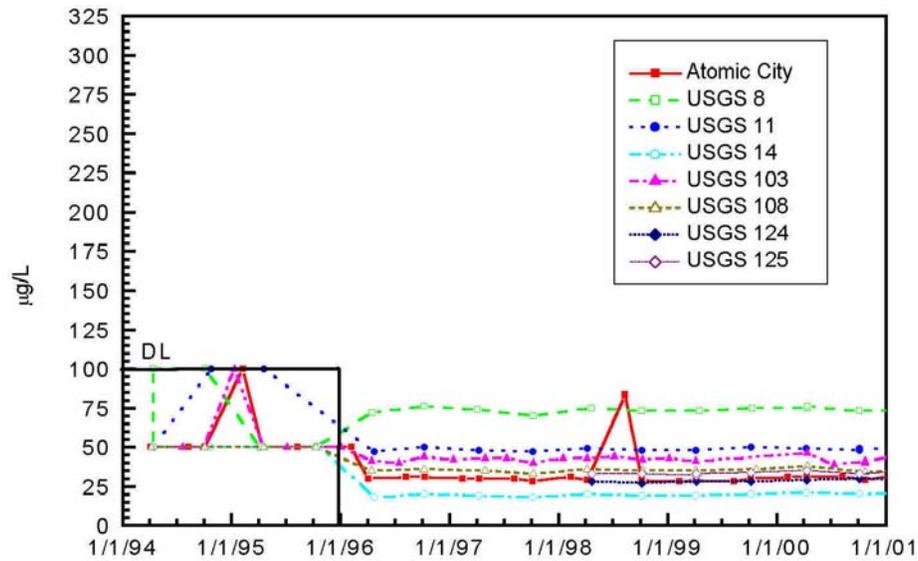


Figure 60 Dissolved barium, INEEL southern boundary water monitoring sites.

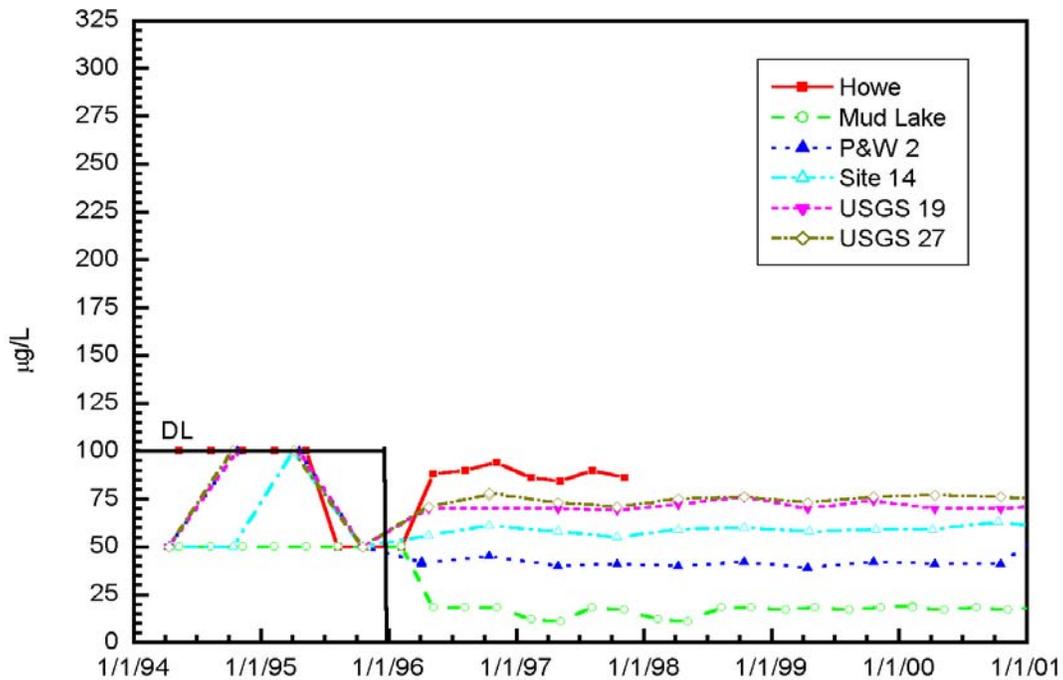


Figure 61 Dissolved barium, distant water monitoring sites.

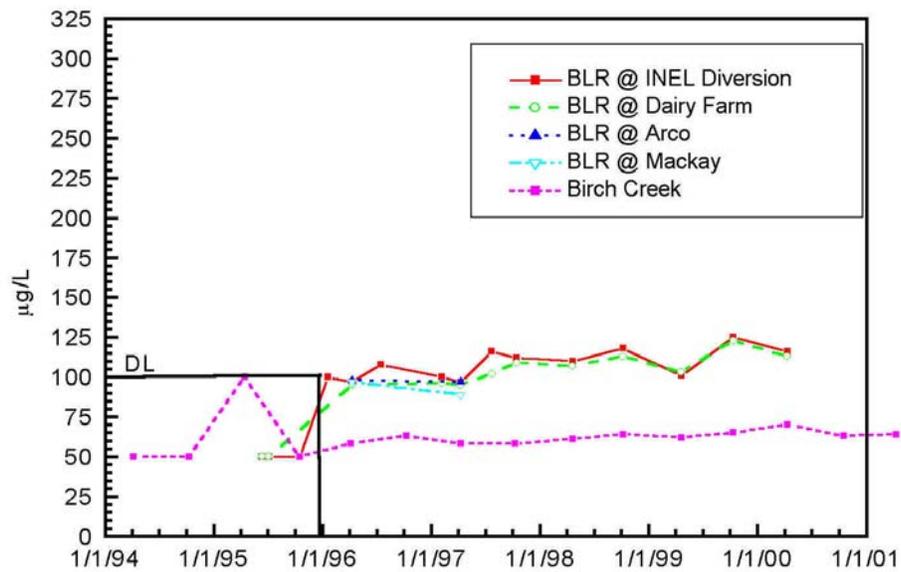


Figure 62 Dissolved barium, surface water monitoring sites.

Dissolved Chromium

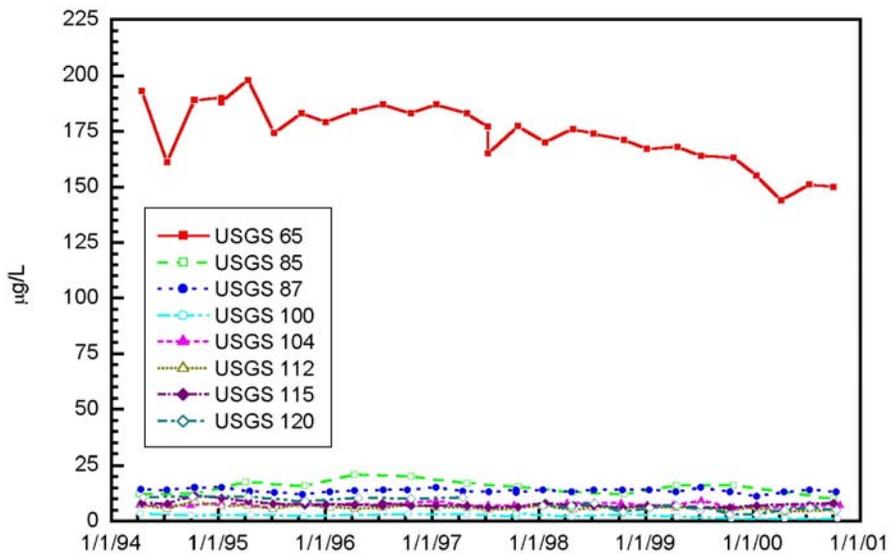


Figure 63 Dissolved chromium, south-central INEEL water monitoring sites.

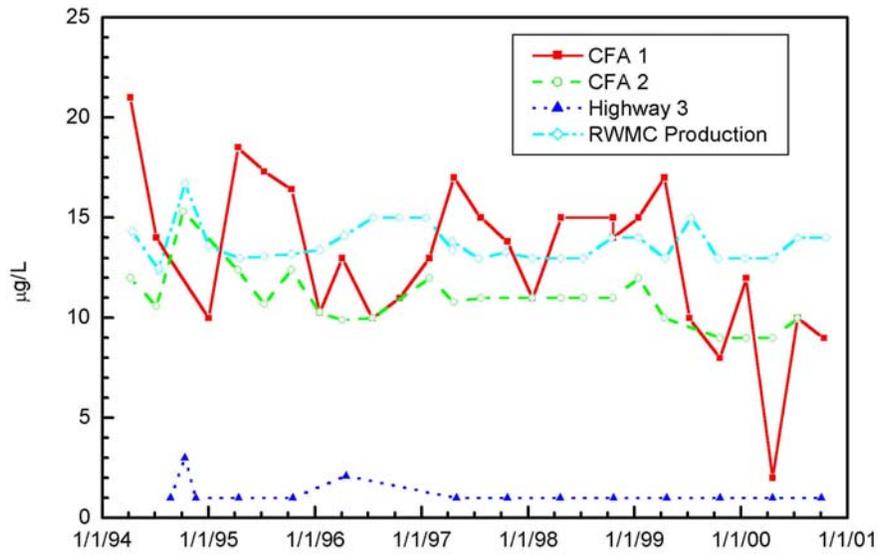


Figure 64 Dissolved chromium, INEEL drinking water monitoring sites.

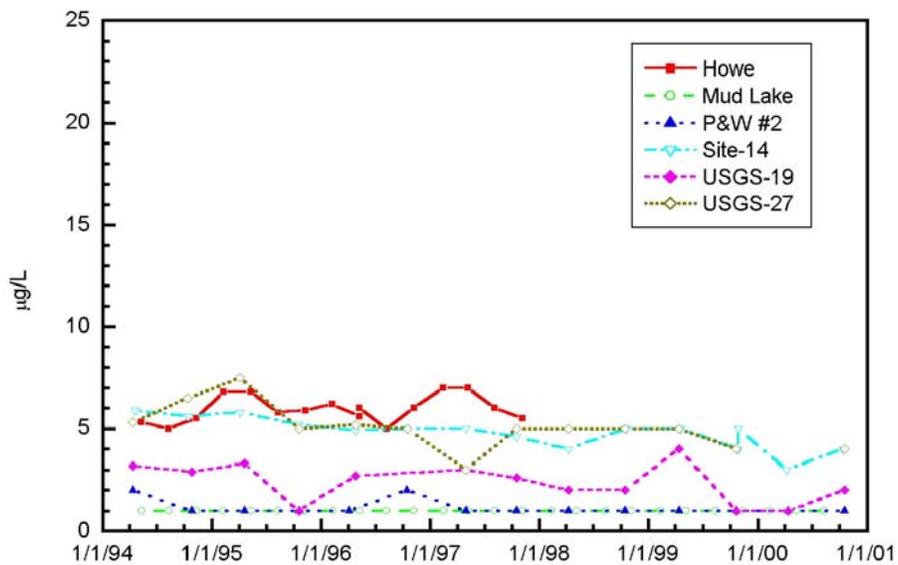


Figure 65 Dissolved chromium, upgradient INEEL water monitoring sites.

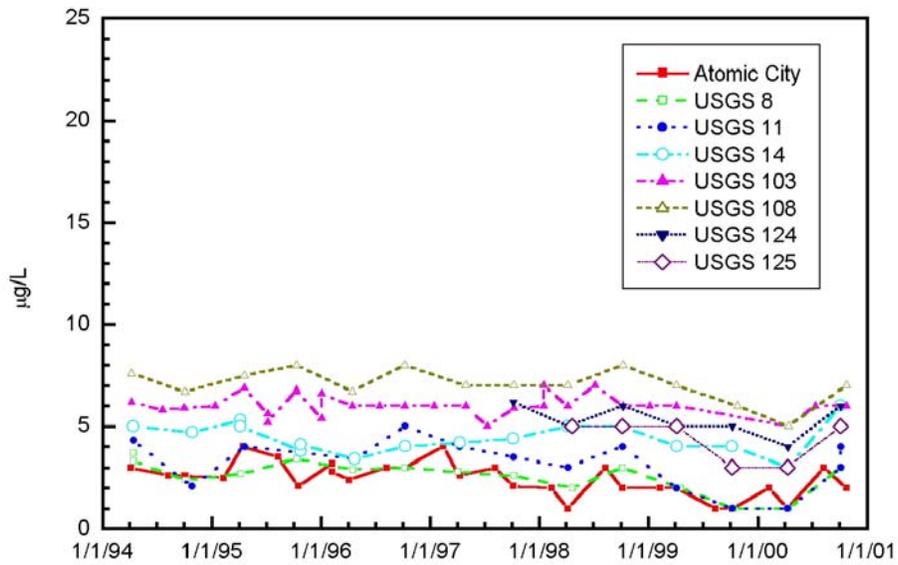


Figure 66 Dissolved chromium, INEEL southern boundary water monitoring sites.

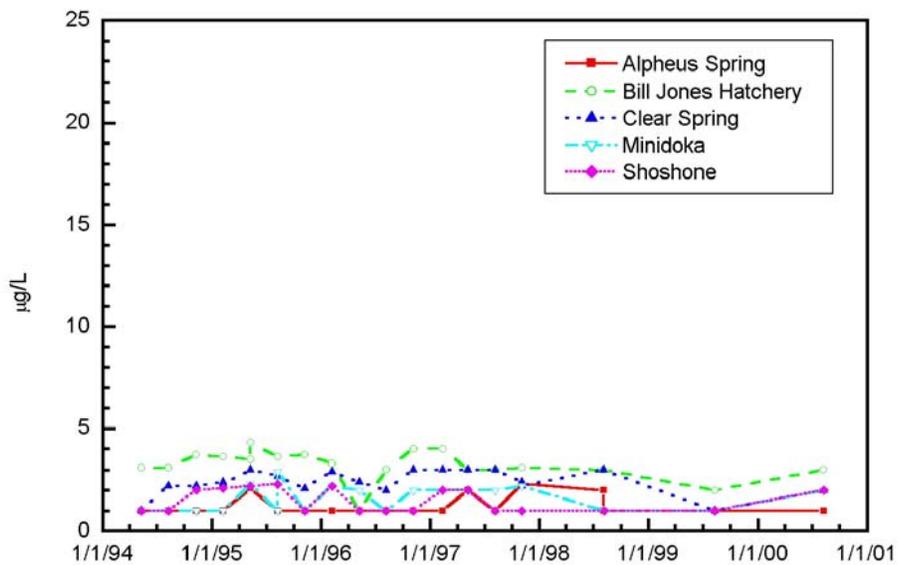


Figure 67 Dissolved chromium, distant water monitoring sites.

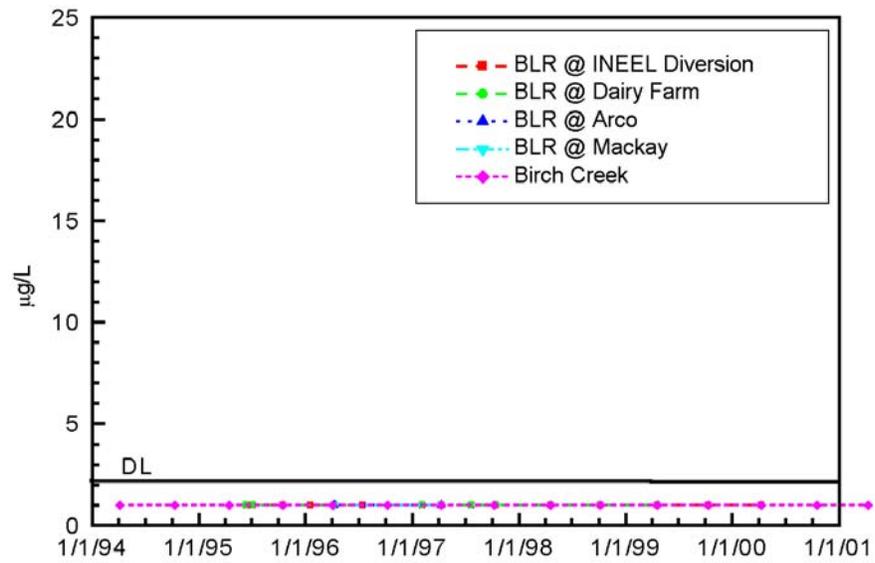


Figure 68 Dissolved chromium, surface water monitoring sites.

Dissolved Zinc

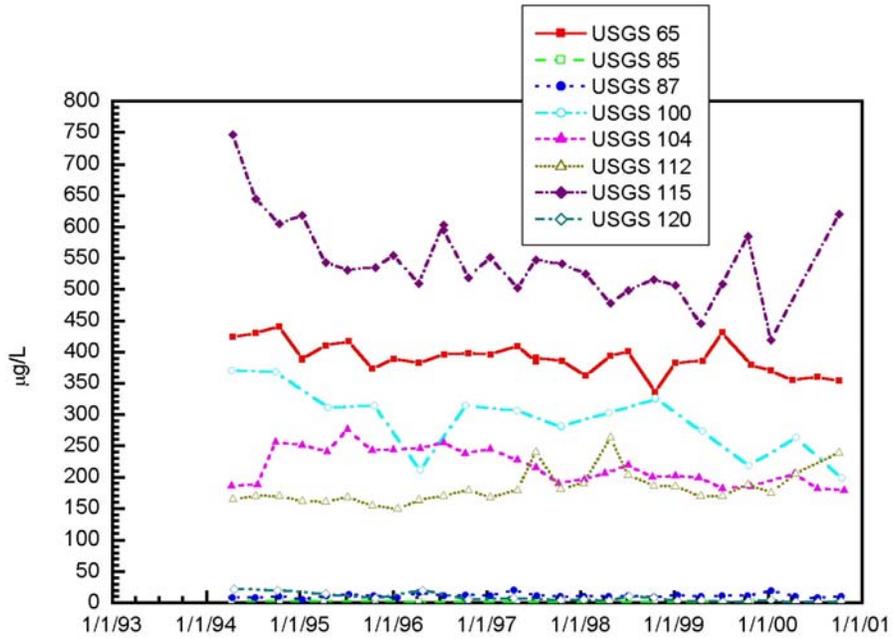


Figure 69 Dissolved zinc, south-central INEEL water monitoring sites.

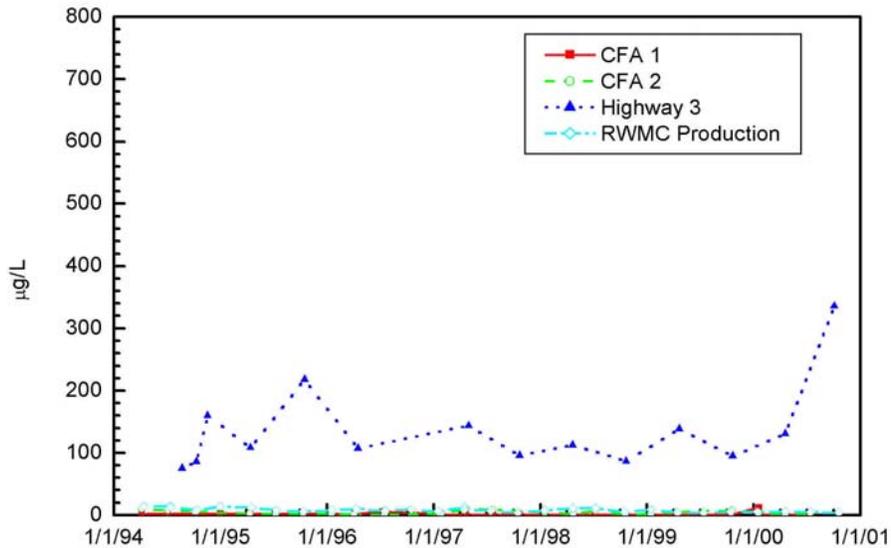


Figure 70 Dissolved zinc, INEEL drinking water sites

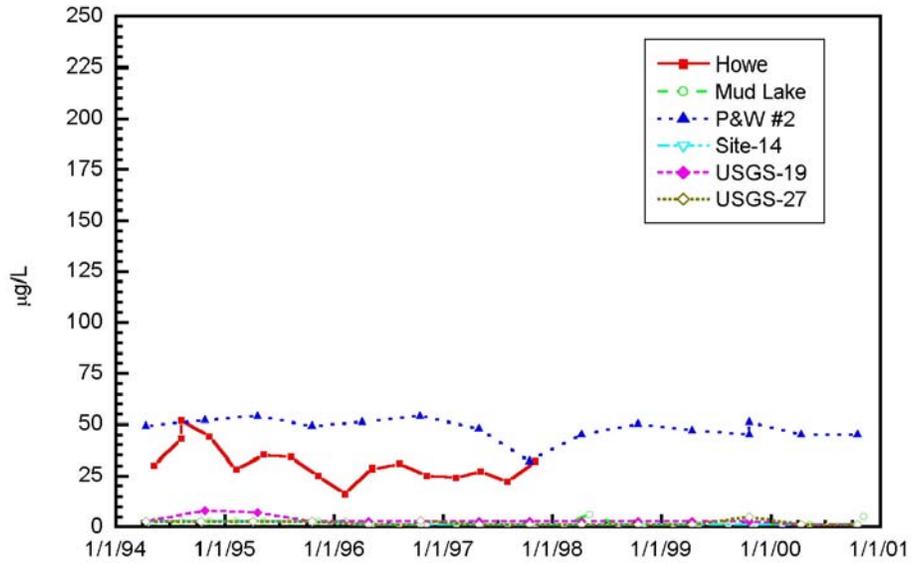


Figure 71 Dissolved zinc, upgradient INEEL water monitoring sites.

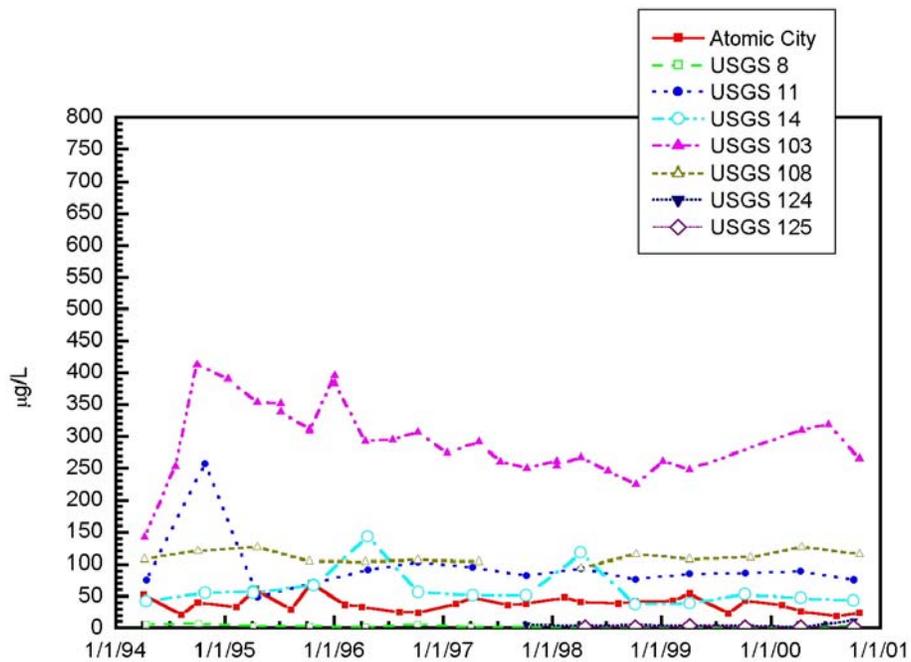


Figure 72 Dissolved zinc, INEEL south boundary water monitoring sites.

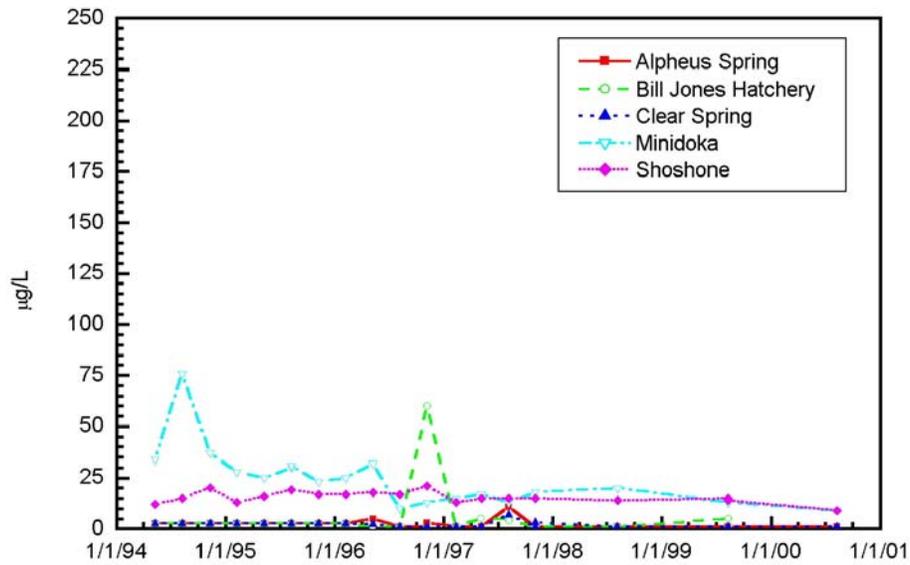


Figure 73 Dissolved zinc, Distant water monitoring sites.

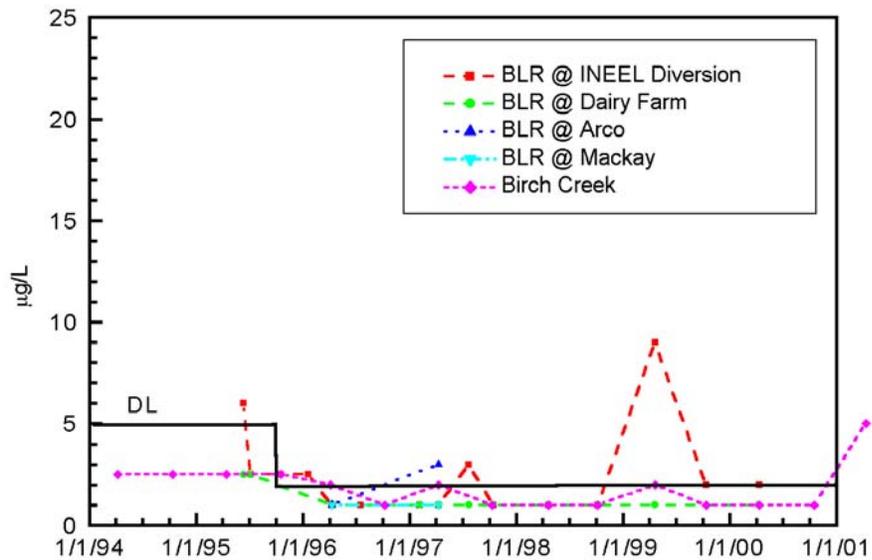


Figure 74 Dissolved zinc, Surface water monitoring sites.

Gross Alpha Radioactivity

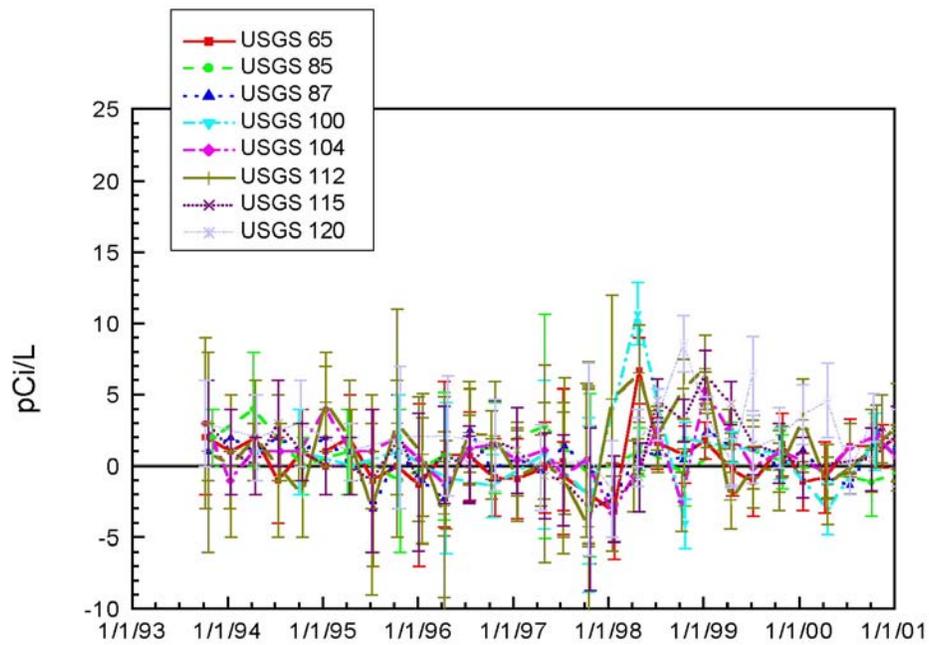


Figure 75 Gross alpha, south-central INEEL water monitoring sites.

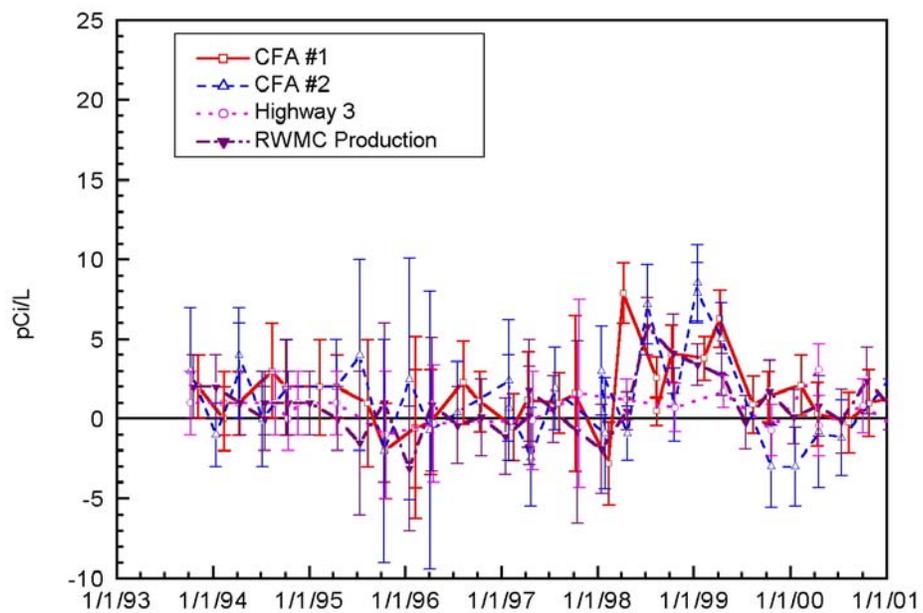


Figure 76 Gross alpha, INEEL drinking water monitoring sites.

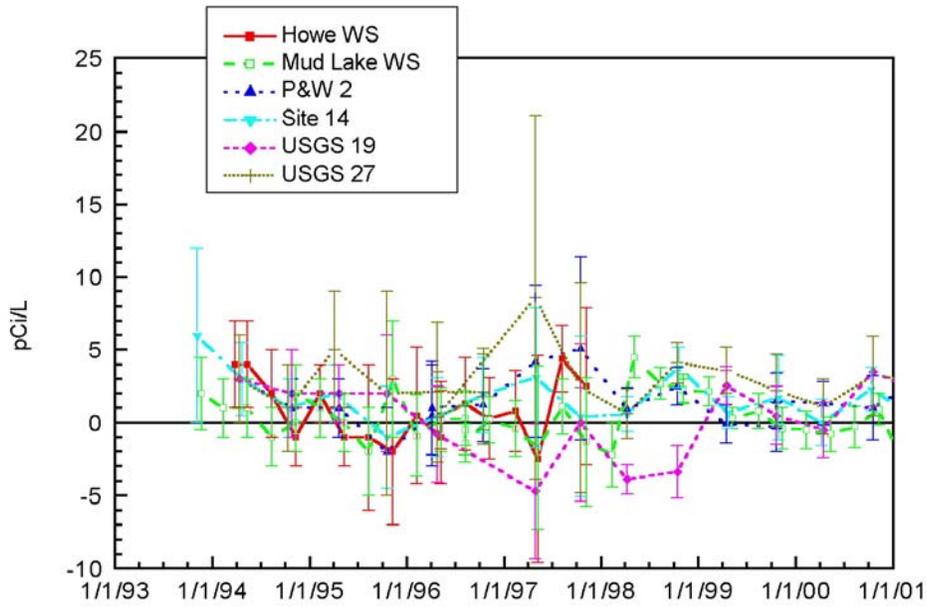


Figure 77 Gross alpha, upgradient INEEL water monitoring sites.

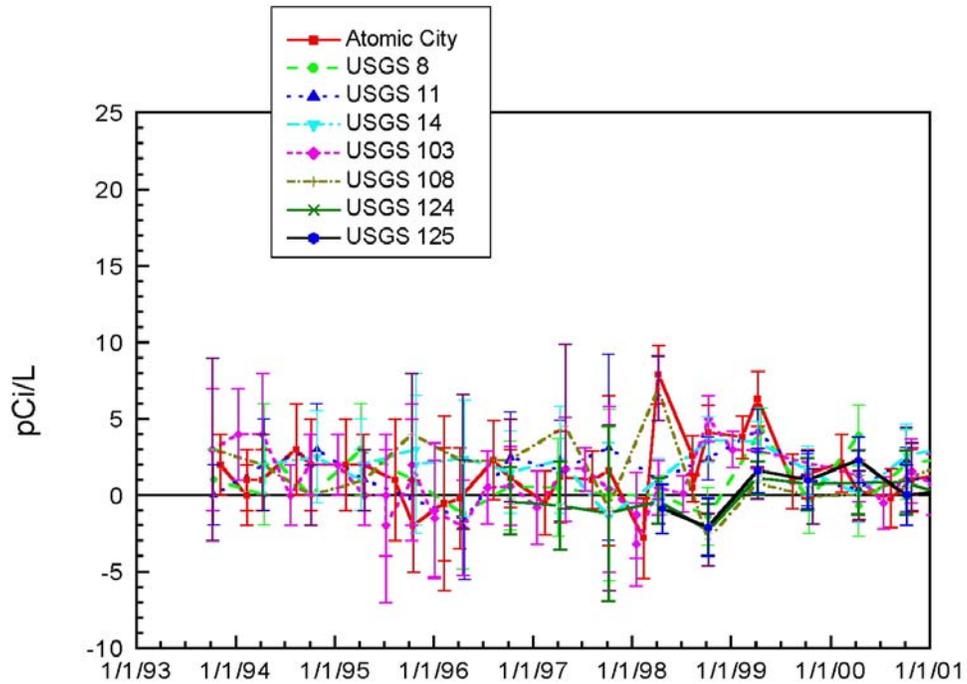


Figure 78 Gross alpha, INEEL southern boundary water monitoring sites.

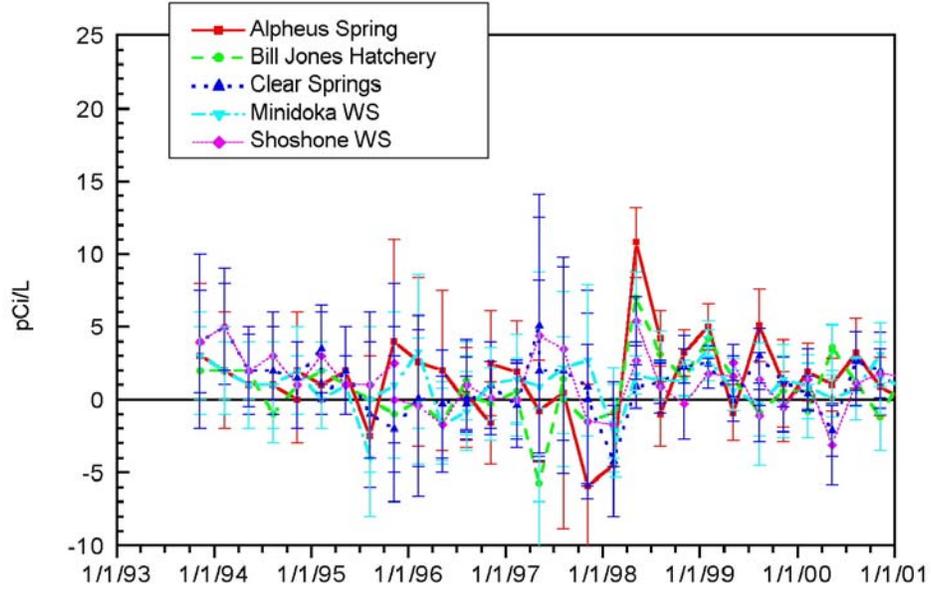


Figure 79 Gross alpha, distant water monitoring sites.

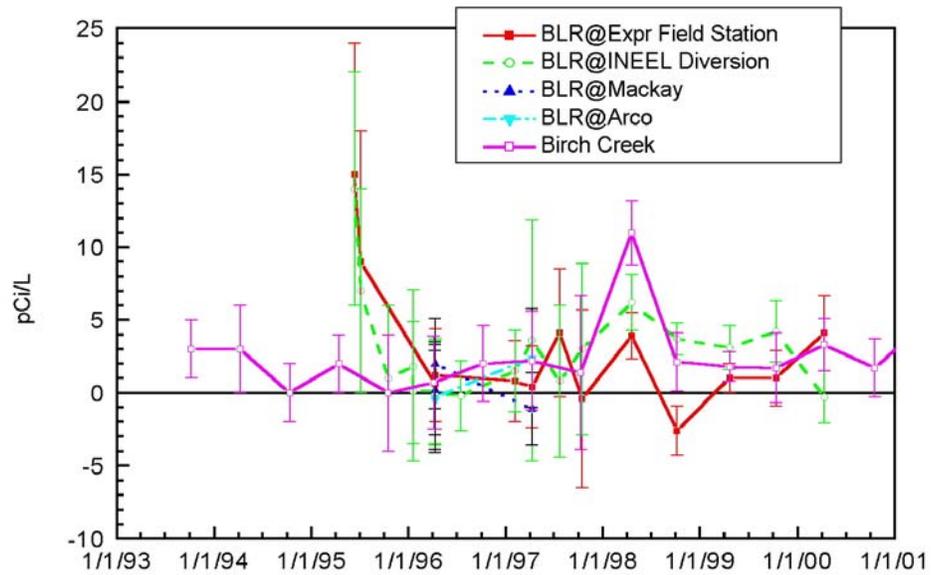


Figure 80 Gross alpha, surface water monitoring sites.

Gross Beta Radioactivity

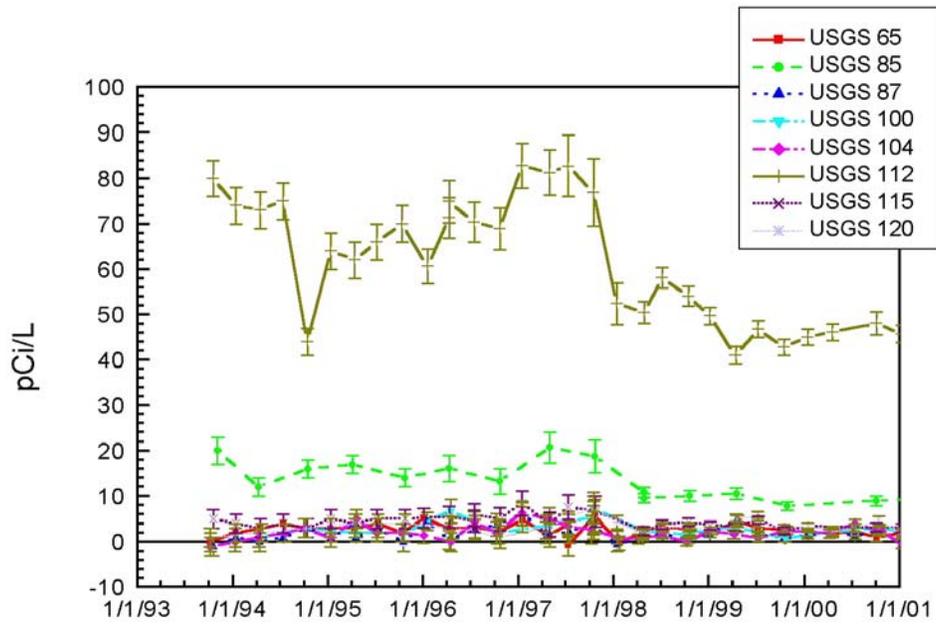


Figure 81 Gross beta, south-central INEEL water monitoring sites.

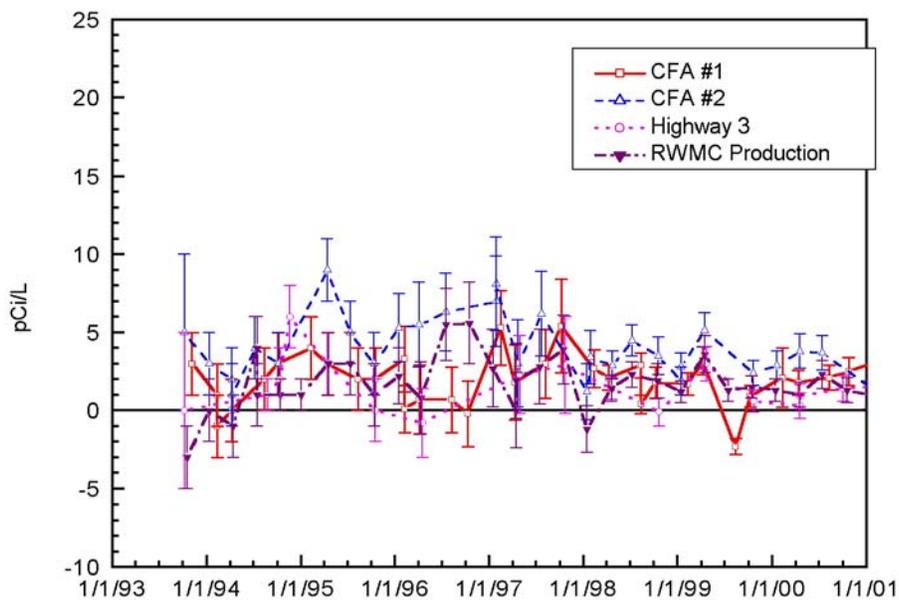


Figure 82 Gross beta, INEEL drinking water monitoring sites.

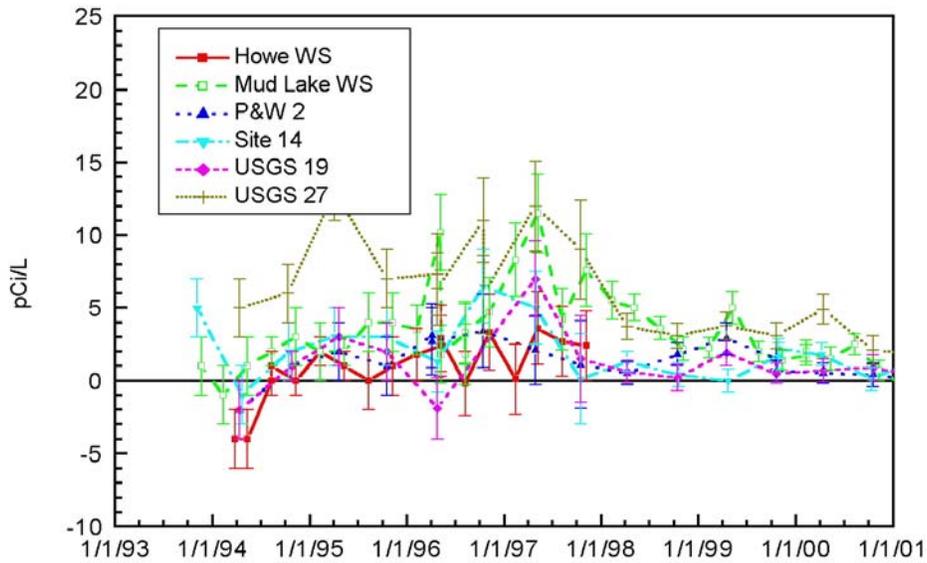


Figure 83 Gross beta, upgradient INEEL water monitoring sites.

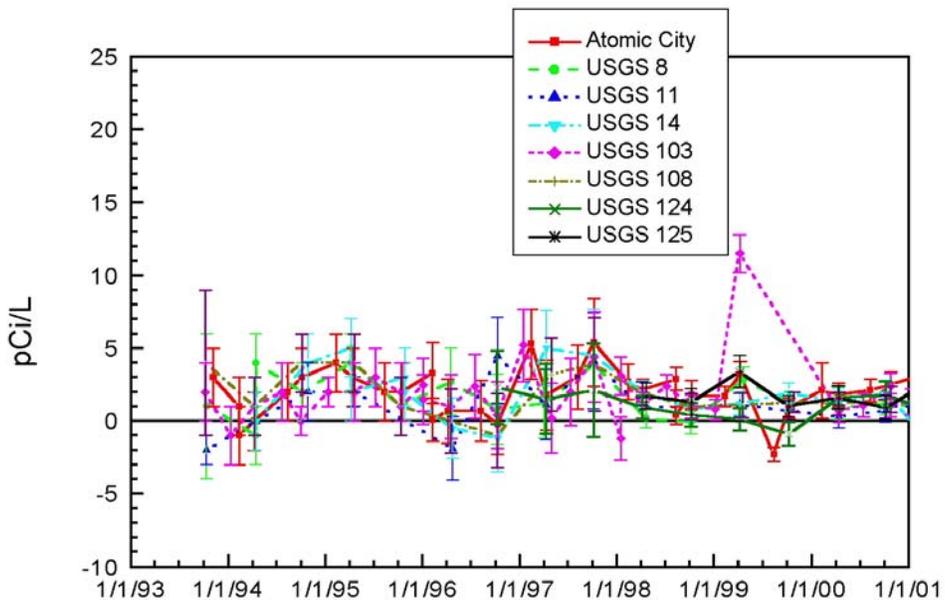


Figure 84 Gross beta, INEEL southern boundary water monitoring sites.

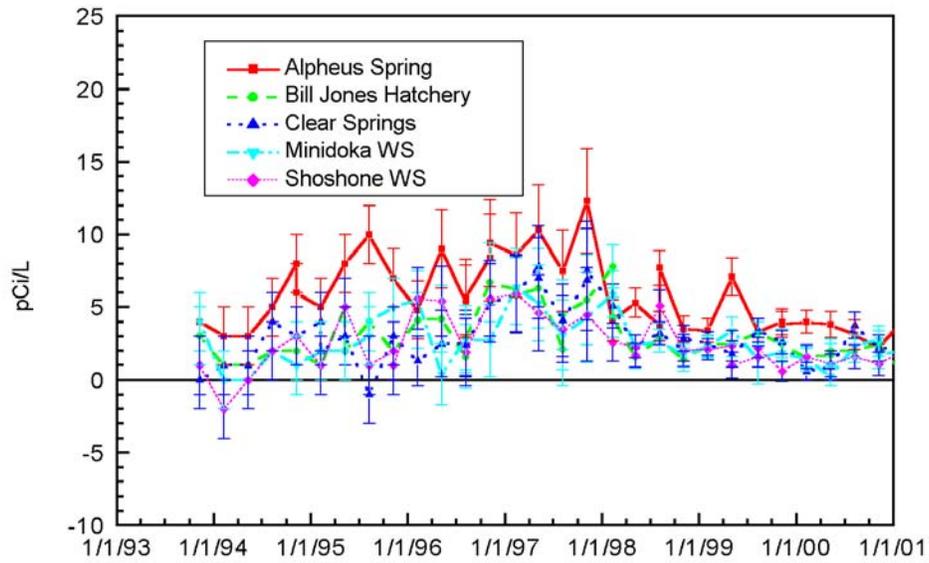


Figure 85 Gross beta, distant water monitoring sites.

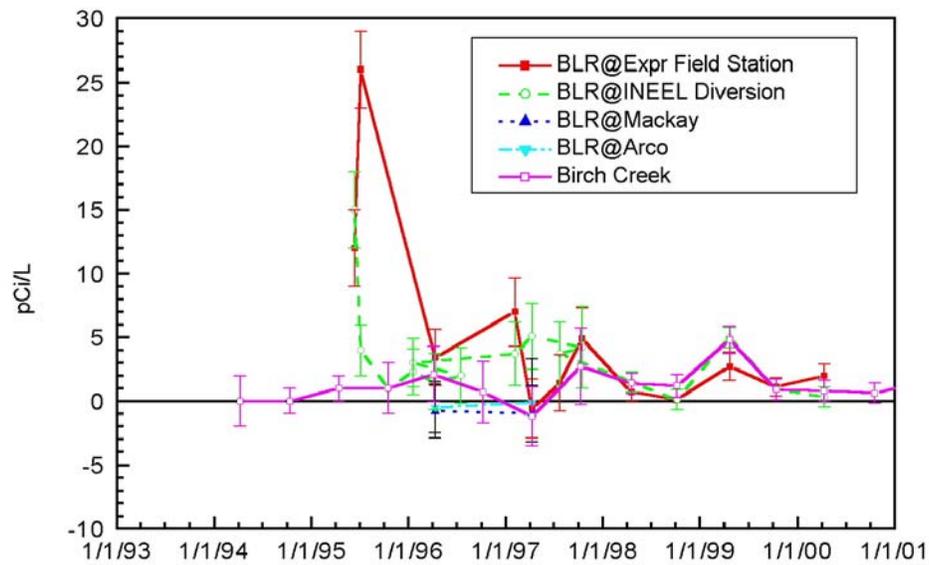


Figure 86 Gross beta, surface water monitoring sites.

Tritium

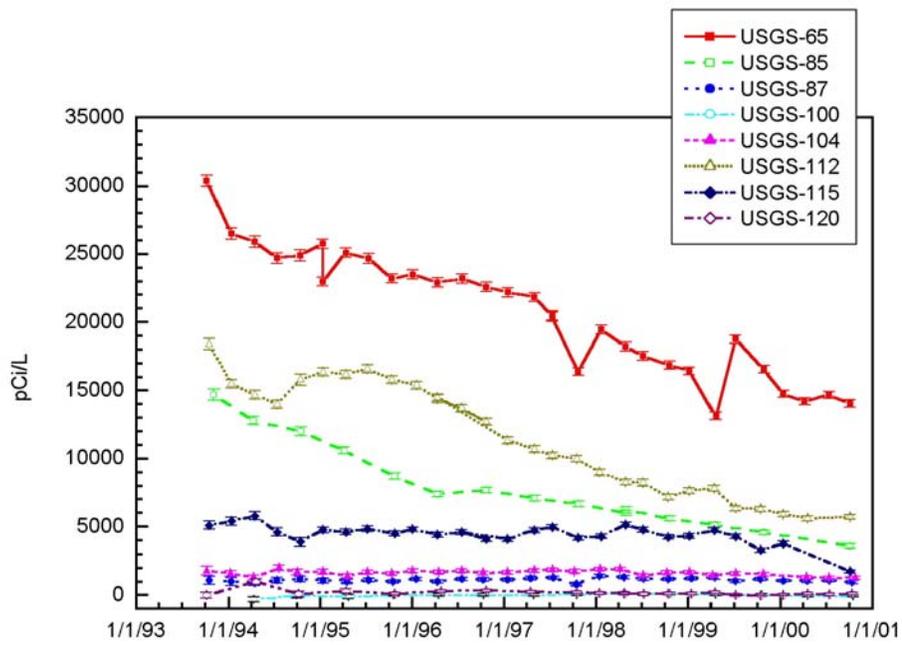


Figure 87 Tritium, south-central INEEL water monitoring sites.

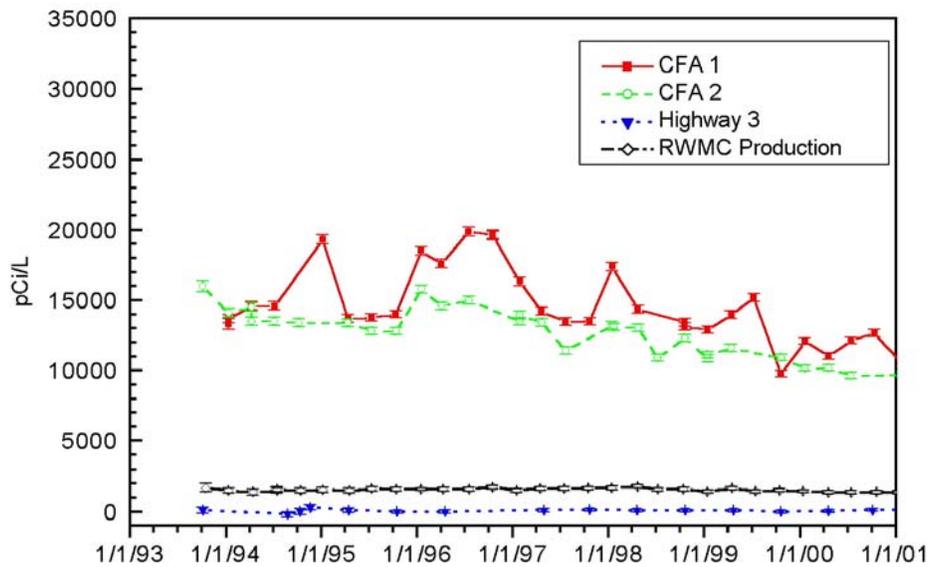


Figure 88 Tritium, INEEL drinking water monitoring sites.

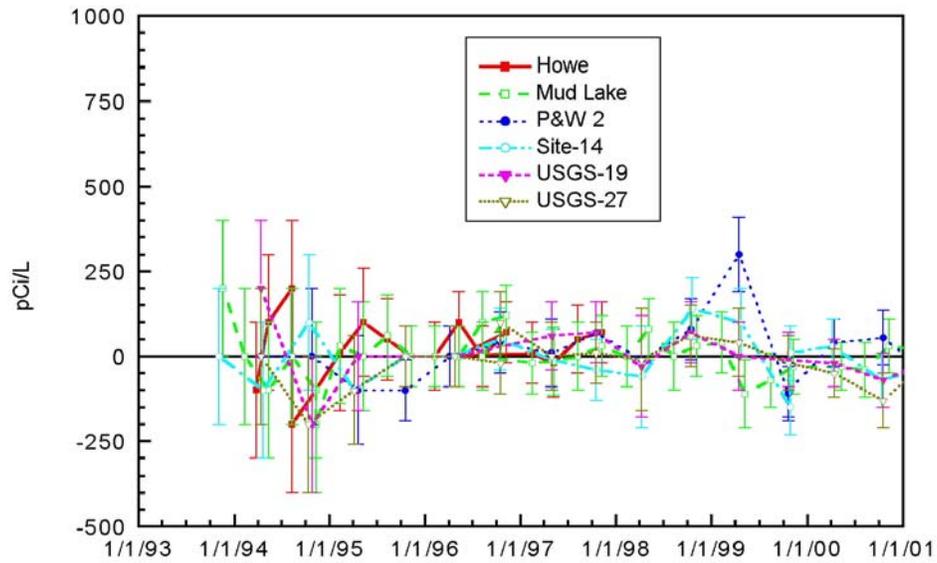


Figure 89 Tritium, upgradient INEEL water monitoring sites.

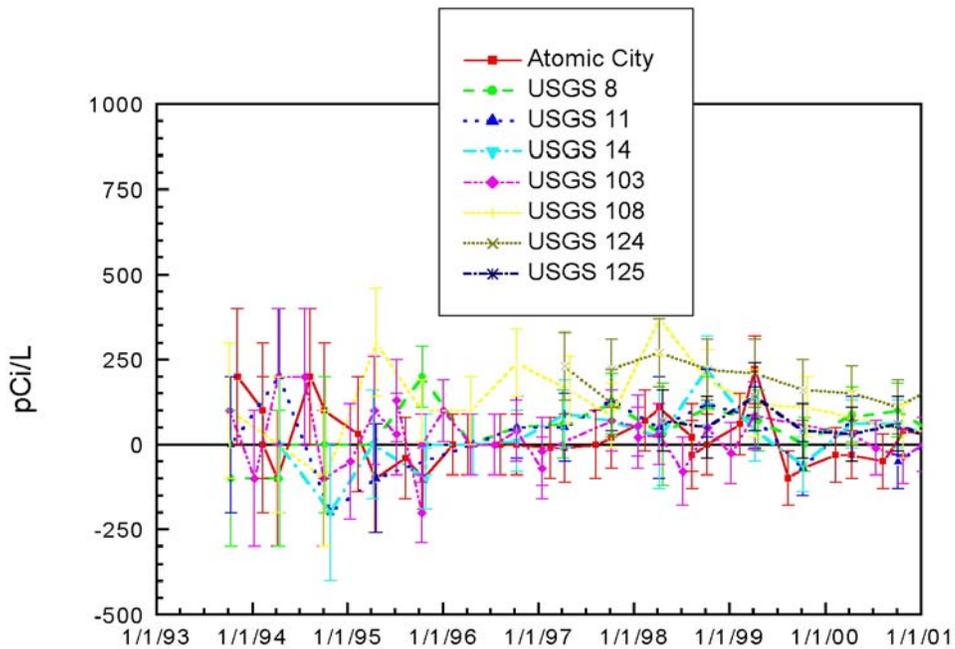


Figure 90 Tritium, INEEL southern boundary water monitoring sites.

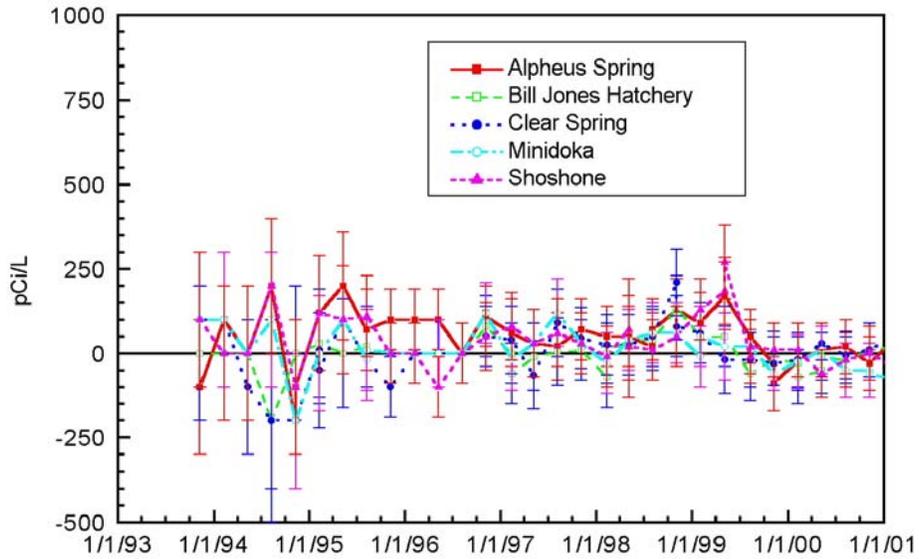


Figure 91 Tritium, distant water monitoring sites.

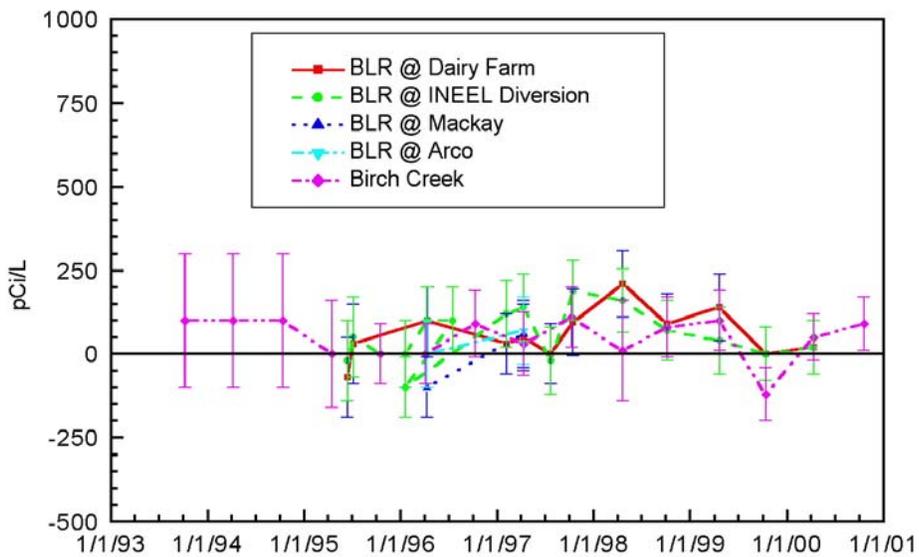


Figure 92 Tritium, surface water monitoring sites.

Enhanced tritium

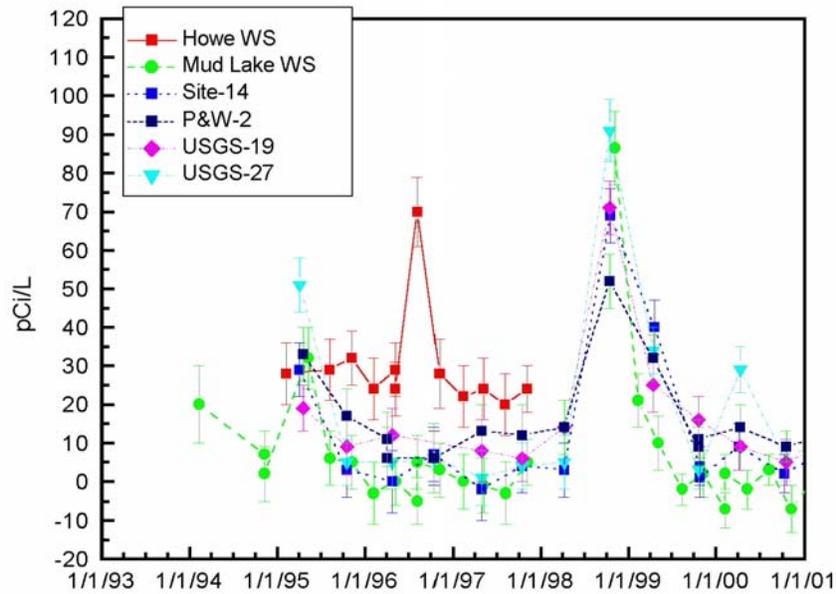


Figure 93 Enhanced tritium, upgradient INEEL water monitoring sites.

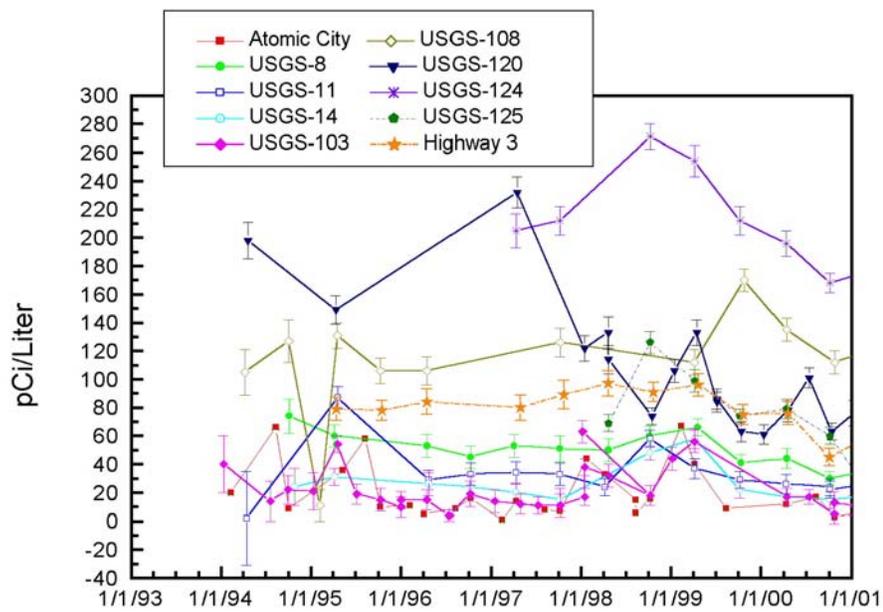


Figure 94 Enhanced tritium, southern boundary water monitoring sites.

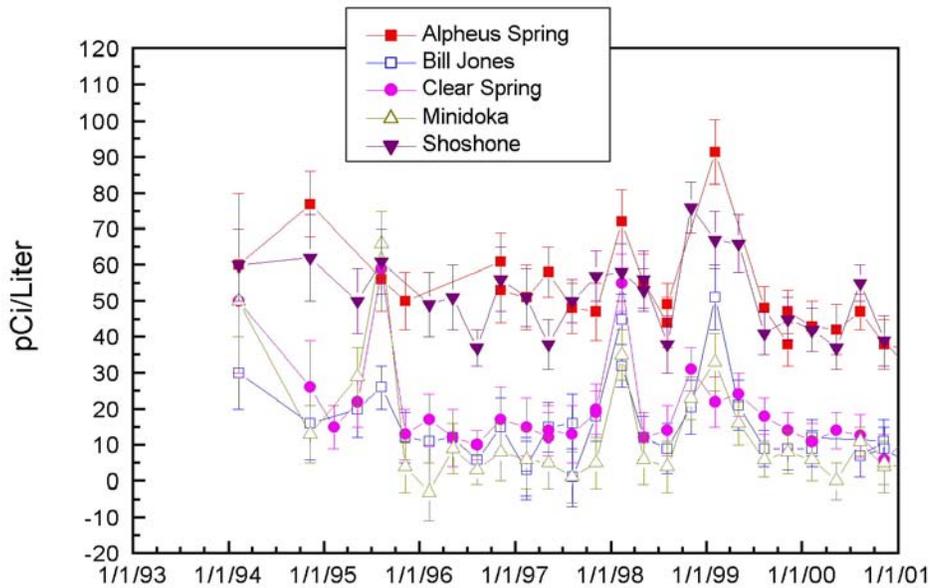


Figure 95 Enhanced tritium, distant water monitoring sites.

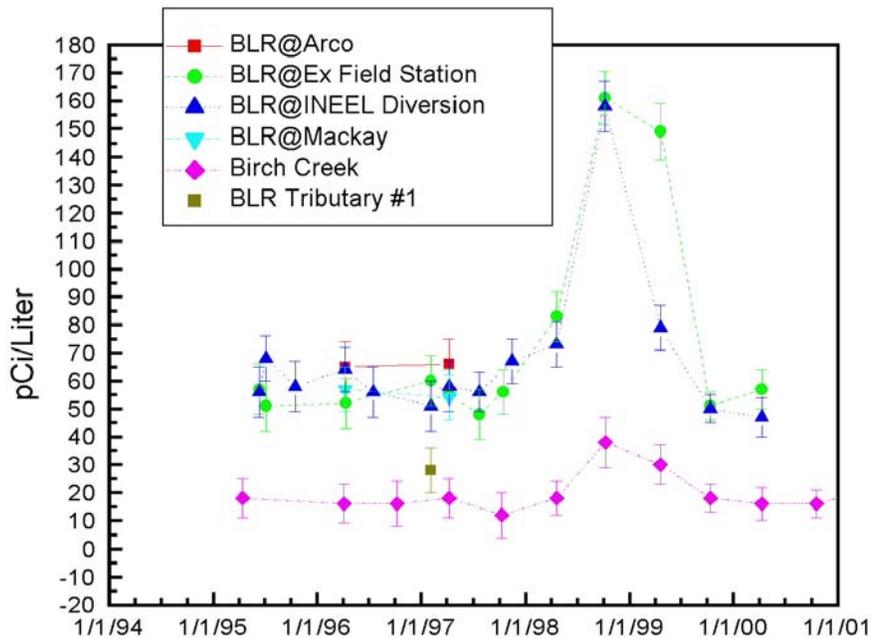


Figure 96 Enhanced tritium, Surface water monitoring sites.

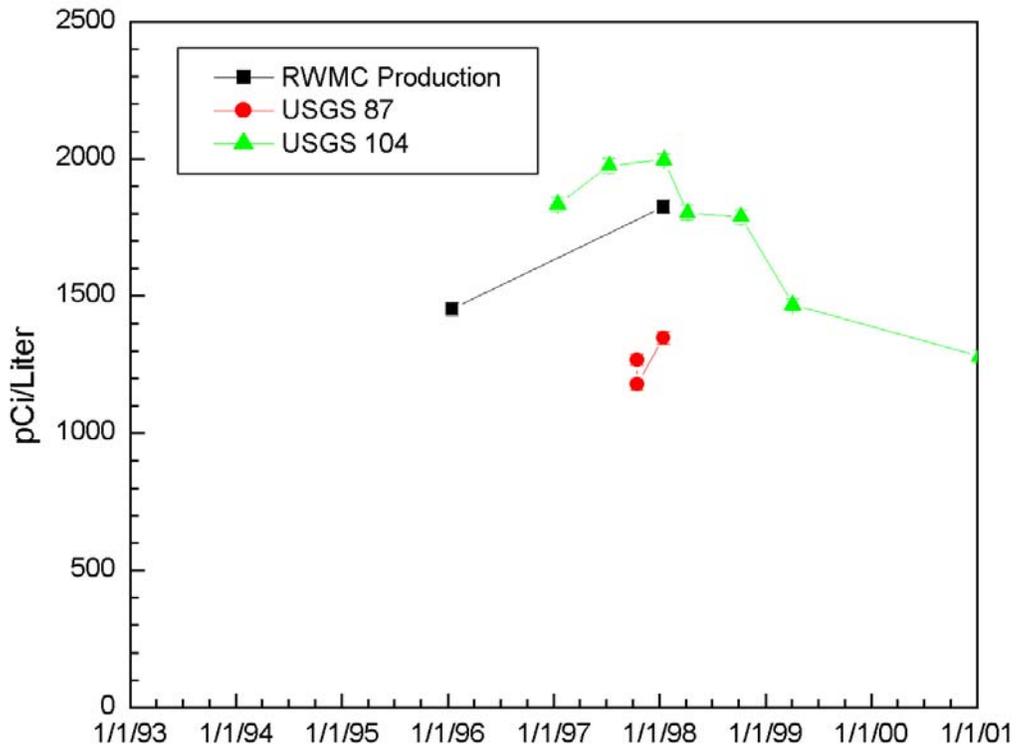


Figure 97 Enhanced tritium, INEEL water monitoring sites with lower tritium activity.

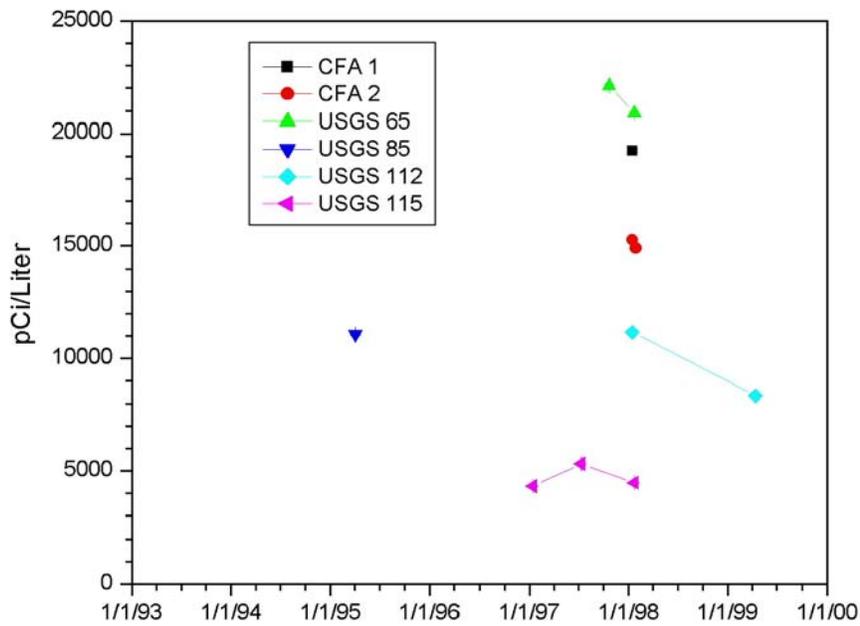


Figure 98 Enhanced tritium, INEEL water monitoring sites with higher tritium activity.

Strontium-90 and Tectenium-99

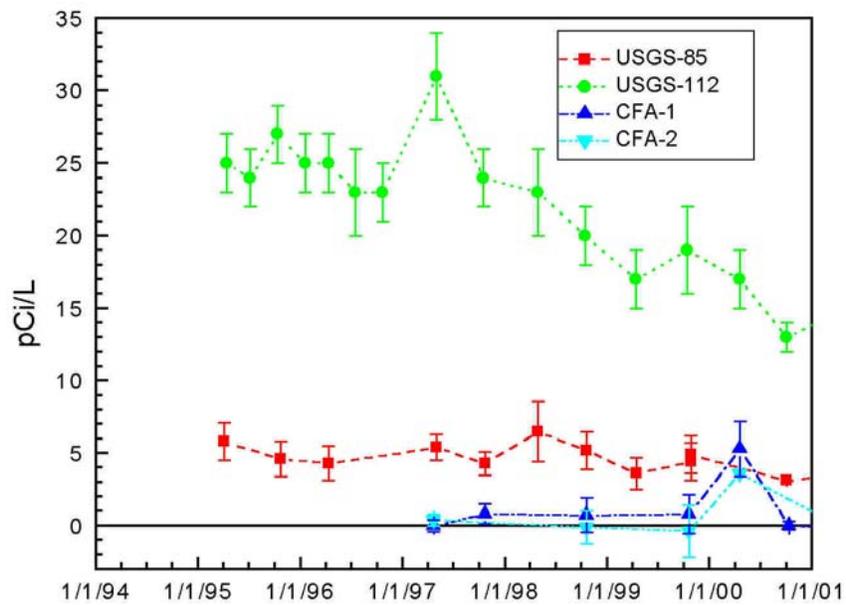


Figure 99 Strontium-90 for selected locations

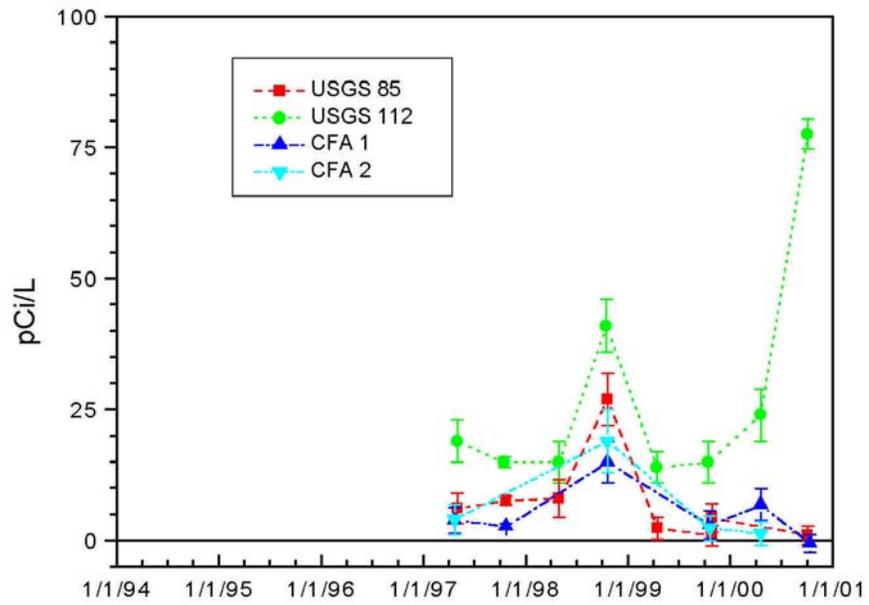


Figure 100 Technetium-99 for selected locations.

Radiological Blank samples

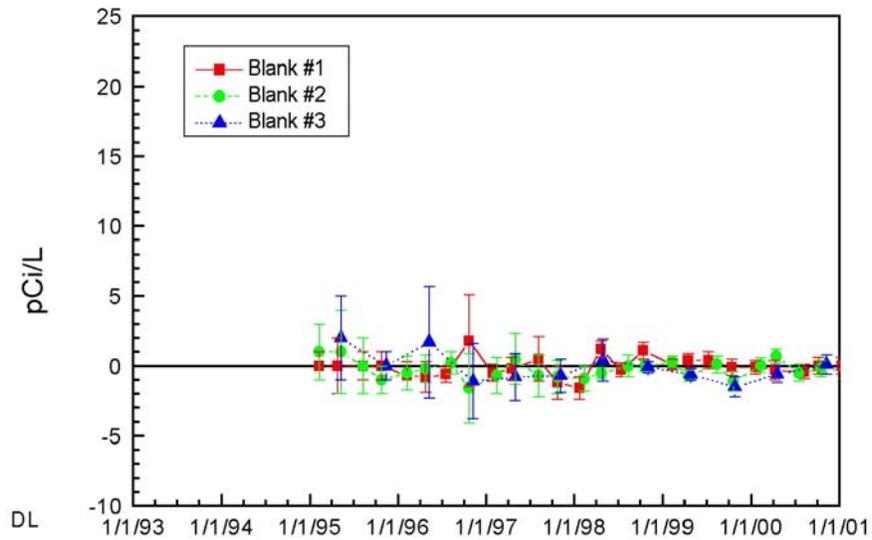


Figure 101 Gross alpha radioactivity for DI water submitted blind to ISU-EML.

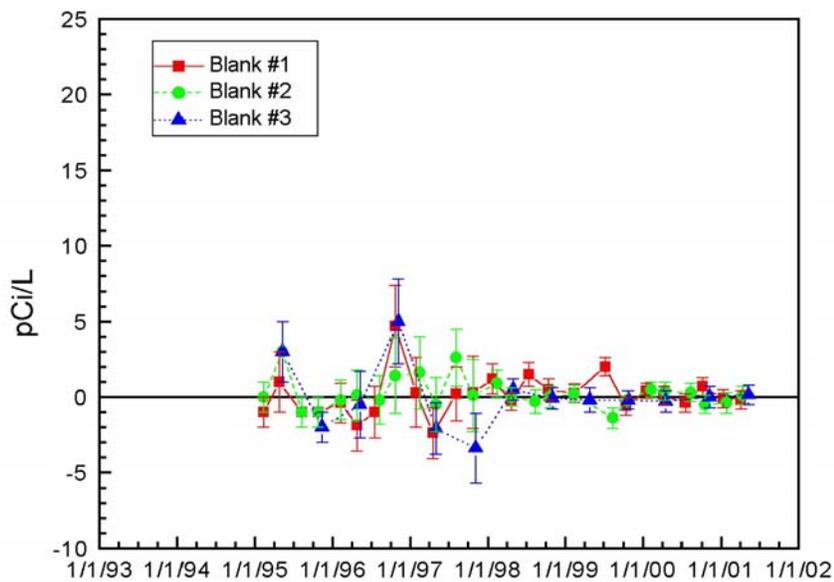


Figure 102 Gross beta radioactivity for DI water submitted blind to ISU-EML.

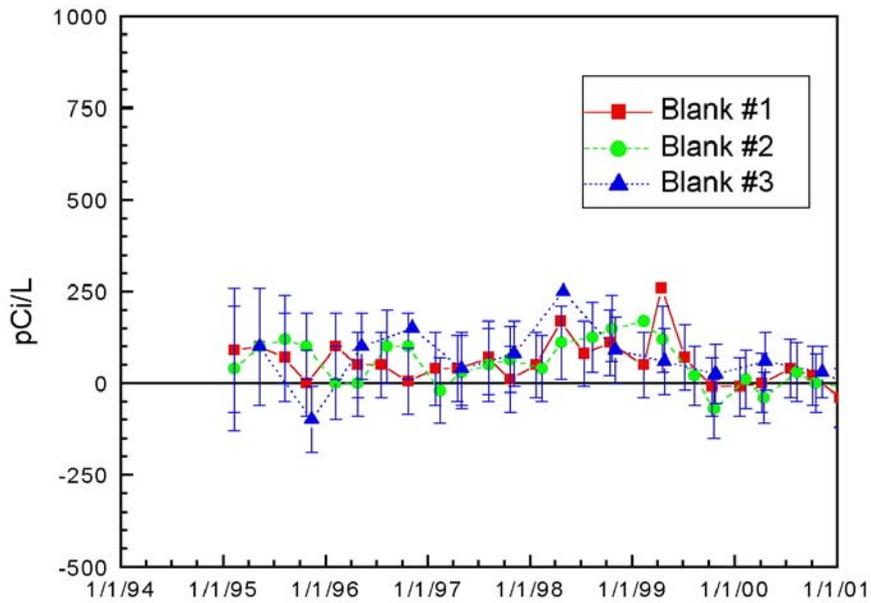


Figure 103 Tritium for DI water submitted blind to ISU-EML.

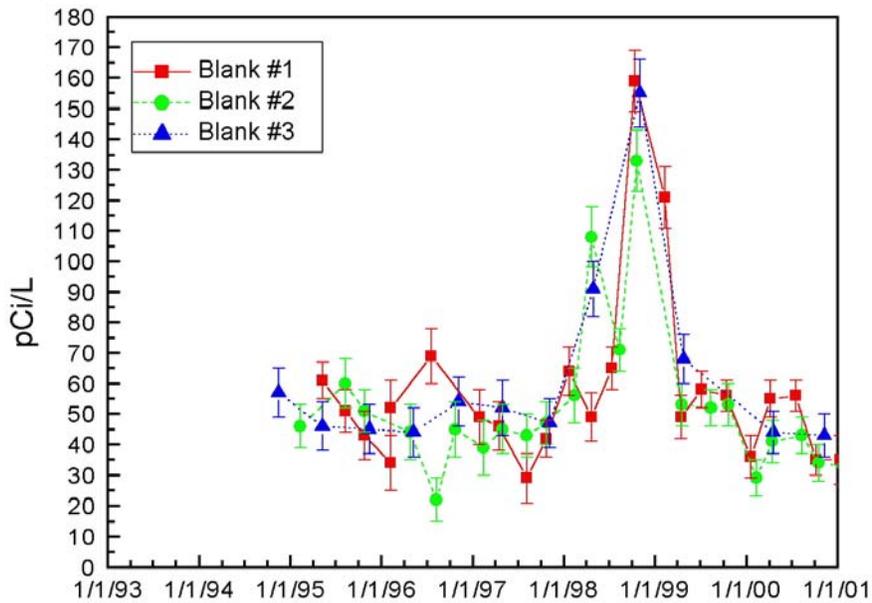


Figure 104 Enhanced tritium for DI water submitted blind to ISU-EML.