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Long Term Hydrological Monitoring Program:

Amchitka, Alaska
1997

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ABSTRACT

Surface water samples were collected on the island of Amchitka, Alaska during the month of June 1997 as part of the Environmental Protection Agency's Long Term Hydrological Monitoring Program. The samples were scanned for the presence of gamma-ray emitting radionuclides and analyzed to determine tritium concentrations. Both conventional and enrichment methods were used. No man made gamma-ray emitters were detected and results of the tritium analyses are consistent with historical values. Trends in decreasing concentration appear to be due to radioactive decay and to dilution.

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ACRONYMS AND ABBREVIATIONS

DOE	Department of Energy
RSL	Radiation Sciences Laboratory
EMSL	Environmental Monitoring Systems Laboratory
EPA	Environmental Protection Agency
IAG	Interagency Agreement
LTHMP	Long-Term Hydrological Monitoring Program
MDA	minimum detectable activity
pCi/L	picocuries per liter = 10^{-12} curies per liter = 1/1,000,000,000,000 curies per liter
R&IE	Radiation and Indoor Environments National Laboratory
GZ	ground zero
SGZ	surface ground zero
SOP	standard operating procedure
USGS	U.S. Geological Survey

ACKNOWLEDGMENTS

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Site Background

Amchitka island is the southernmost member of the Rat Island group of the Aleutian Chain, Alaska (see Figures 1 and 2). It is approximately 42 miles long, varies from two to four miles in width, and lies between longitudes 178° 21' and 179° 29' east and latitudes 51° 21' and 51° 39' north. It is bounded by the Bering Sea to the north and the Pacific Ocean to the south.

Three high-yield underground nuclear tests were conducted by the Atomic Energy Commission on Amchitka between 1965 and 1971. They were:

- Project Long Shot, an 80 kiloton yield test on October 29, 1965 to improve the capability to detect, locate, and identify nuclear explosions.
- Project Milrow, a 1 megaton yield test on October 2, 1969 to determine the island's suitability to be the site of the larger test to follow (Cannikin).
- Project Cannikin, a 5 megaton yield test on November 6, 1971, to test the Spartan Anti- Ballistic Missile warhead.

General area maps of these sites are shown in Figures 3 and 4.

Surface Contamination

Several weeks following the Long Shot test in 1965, tritium was detected near the surface ground zero (SGZ) area in the water of sump ponds used for drilling mud and in associated drainage ditches. In 1971, several shallow wells were drilled in the area to determine the distribution of the tritium. Samples indicate that the region of maximum contamination lies between 200 and 300 feet, and in the immediate area of the SGZ. No radioactive strontium or cesium was detected in the samples. Periodic sampling, as part of the Amchitka Long Term Hydrological Monitoring Program (LTHMP), indicates that the tritium concentrations are decreasing faster than would be expected from radioactive decay alone, indicating that dilution is also taking place.

Drillback operations were conducted only at the Cannikin site on Amchitka. After core samples were taken, water used for decontamination of equipment was injected into the collapse chimney. Contaminated drilling tools were abandoned in the reentry hole, which was sealed at the termination of the program. Other items, such as valves and pipes that contained tritium, were cut into pieces and buried beneath cement in the Cannikin reentry well cellar.

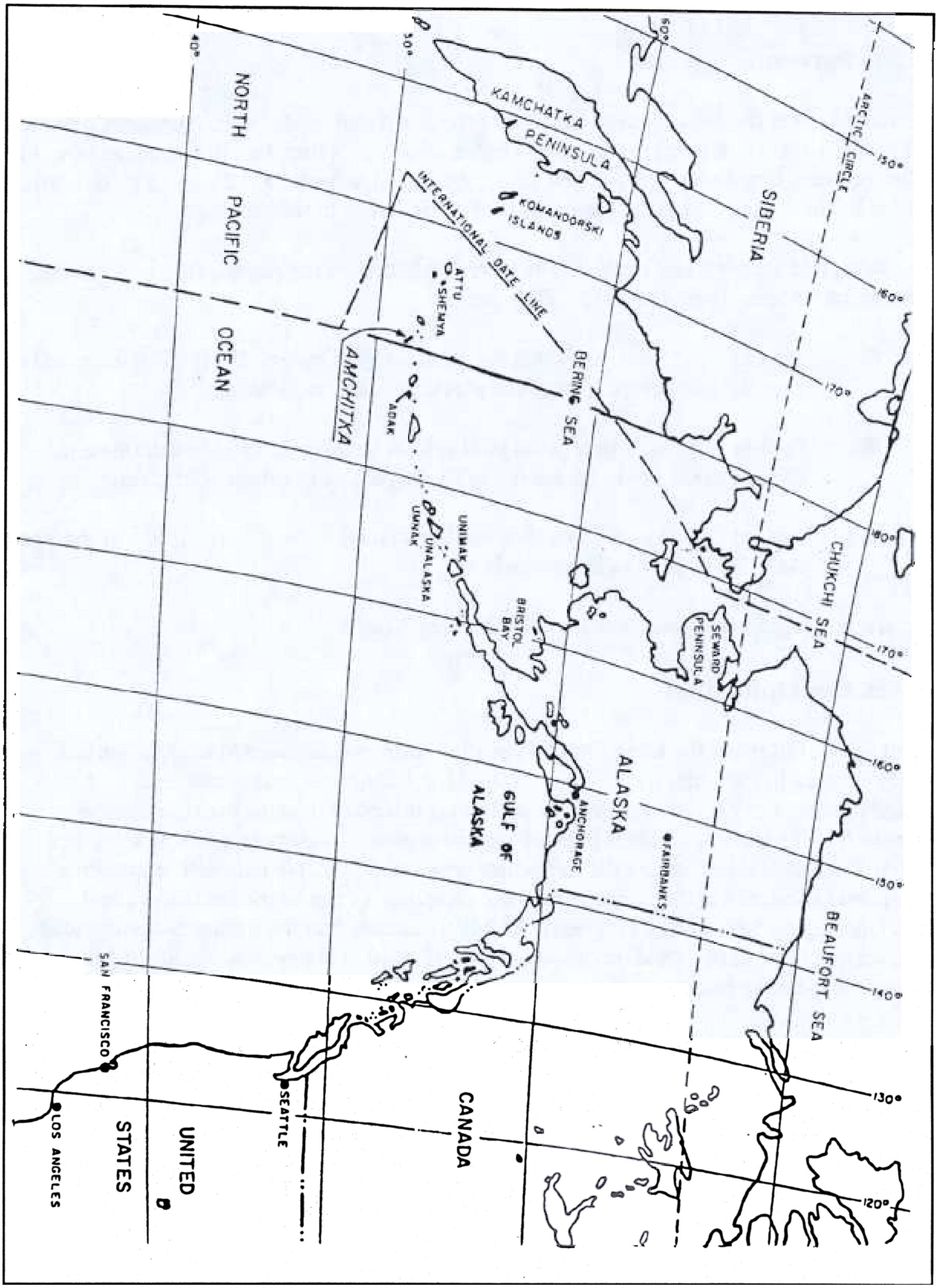


Figure 1 Location of Amchitka Island, Alaska

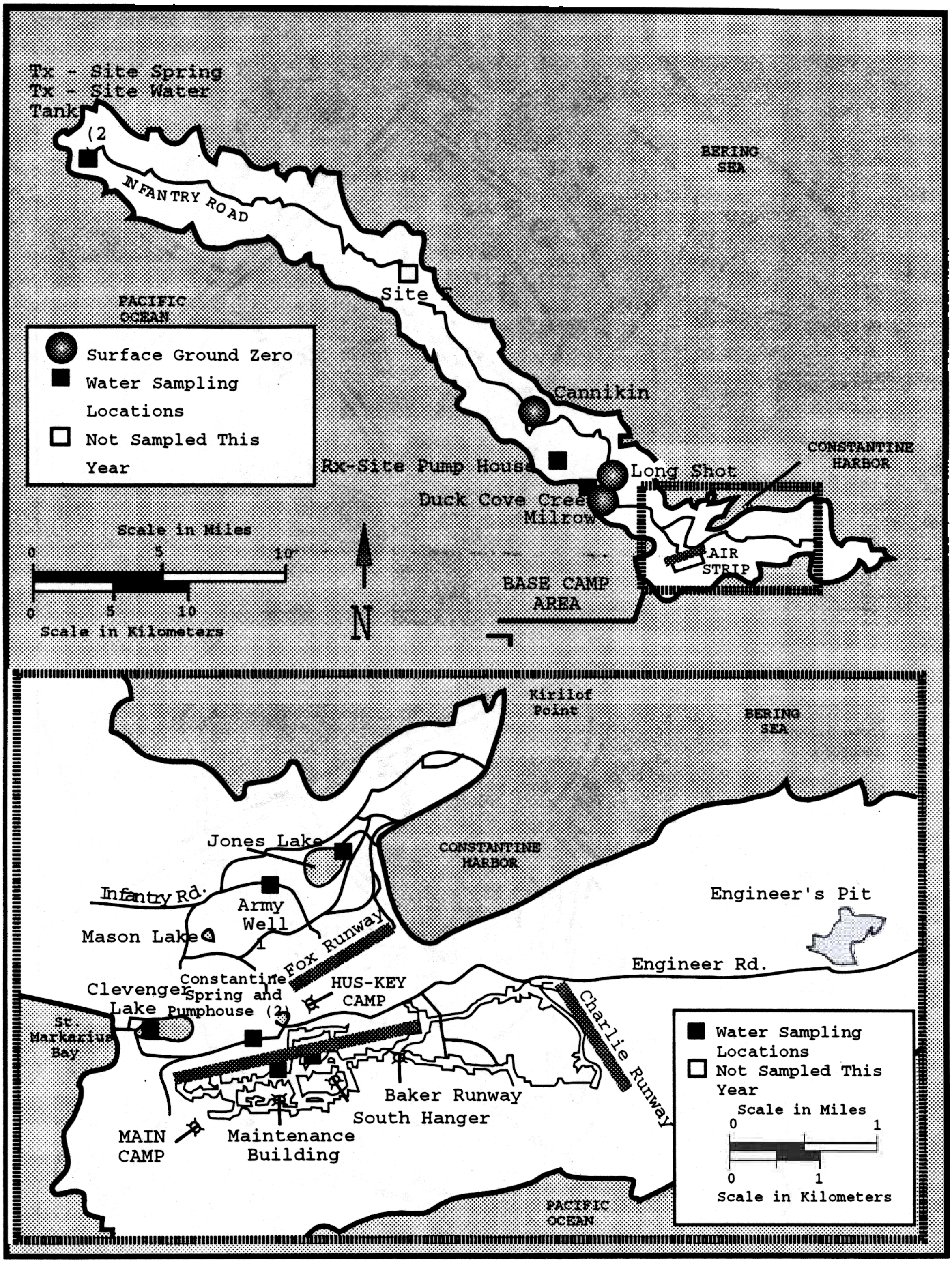


Figure 2. Amchitka Island and Camp Area

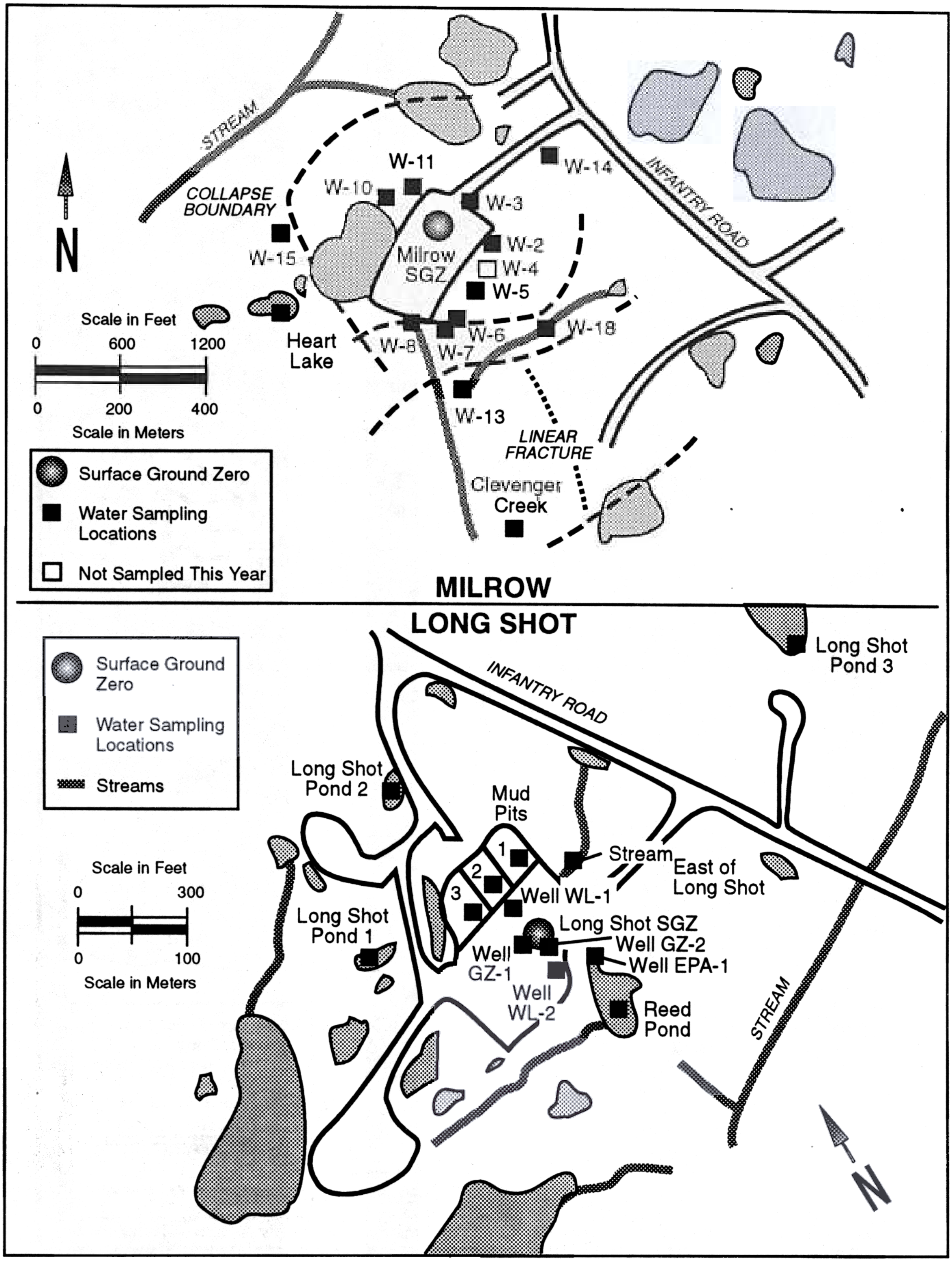


Figure 3. Long Shot/Milrow Surface Ground Zero Area

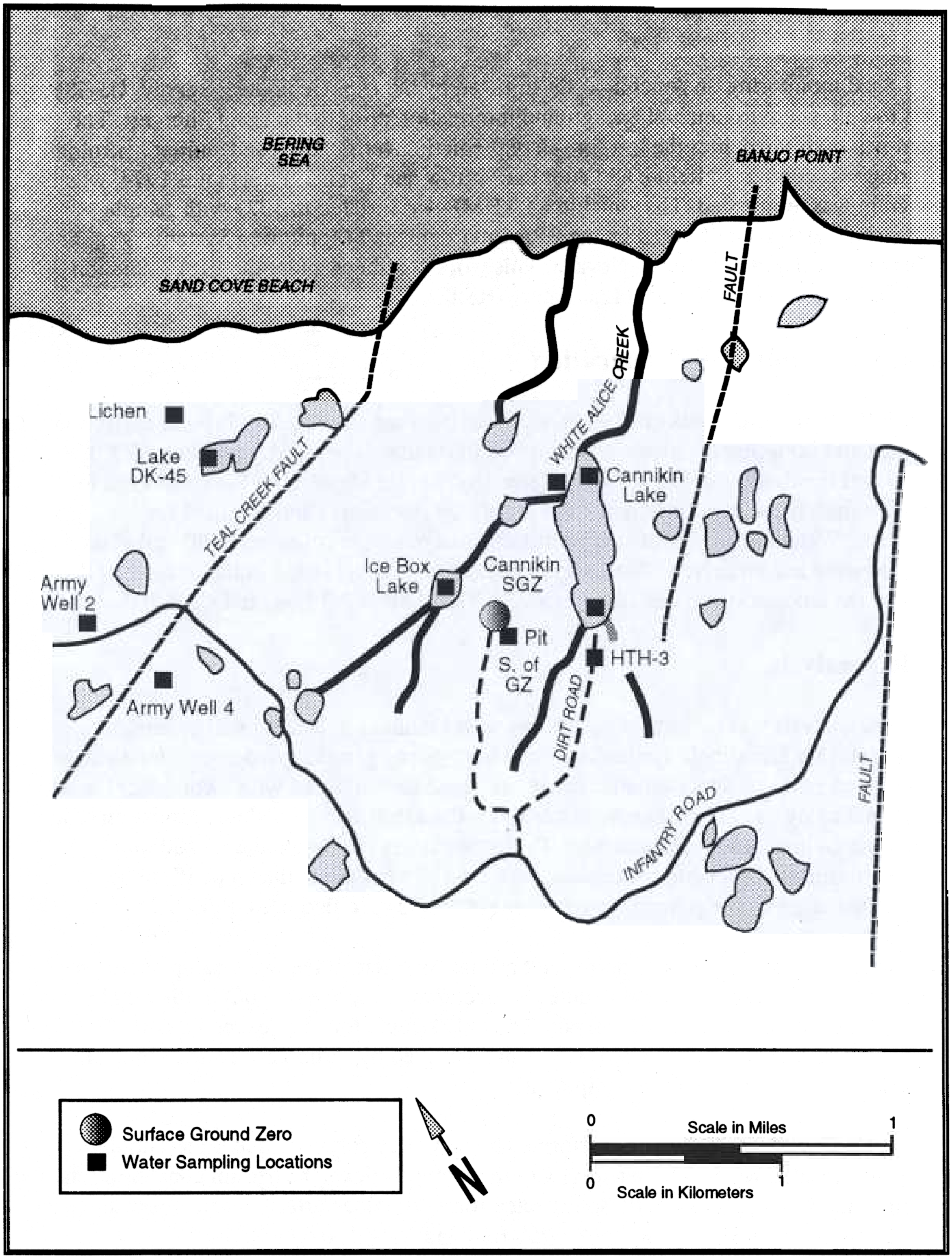


Figure 4. Cannikin Surface Ground Zero Area

Monitoring History

Hydrological monitoring on Amchitka was initiated by the U.S. Geological Survey (USGS) in 1963 to collect environmental background information prior to the Long Shot test. The program was continued after the test for safety prediction verification, and similar hydrologic monitoring was conducted before and after the Milrow and Cannikin tests until 1974, when the program was terminated. The Amchitka LTHMP was instated in 1977 with sample collection and analysis performed by the EPA Environmental Monitoring Systems Laboratory (EMSL) in Las Vegas, Nevada. This work continues under the EPA Radiation and Indoor Environments National Laboratory (R&IE).

Sample Collection and Preparation

Sample collection on Amchitka in 1997 took place between June 3 and 17. Field collection procedures and sampling locations are described in standard operating procedure (SOP) *CER-203* and the *Amchitka, Alaska Long Term Hydrologic Monitoring Plan.* Samples for gamma-ray analysis were collected in 3500 ml plastic cubitainers and acidified for preservation. Water samples collected for tritium analysis were collected in 500 ml glass bottles and were not preserved. The chain of custody procedures used in the transfer of the samples to the laboratory are described in *SOP's NRA 3.50, NRO 1.04,* and *CER-203.*

Sample Analysis

Gamma-ray analysis was performed by placing water samples in a calibrated geometric configuration (3.5 L marinelli beaker) and on a high-purity germanium detector for a known data collection periods. Spectrometric data were saved and analyzed with a computer based multichannel analyzer. The technique is useful for the identification and quantification of a large number of man-made radionuclides. Collection times of approximately 100 min allowed a minimum detectable concentration of Cs-137 of no more than 5 pCi/L to be obtained. Operation of the gamma-ray detector systems is specified in SOP *NRA 2. 17.*

Conventional tritium analysis was performed primarily to screen the water samples for gross contamination. The process is used to detect concentrations above 400 pCi/L directly by distillation and liquid scintillation analysis. The only sample found to exceed this concentration, Longshot Well GZ No. 1, was not analyzed by tritium enrichment to avoid any possible contamination of the equipment.

Tritium analysis by enrichment was performed by slow electrolysis which preferentially concentrates tritiated water. The sensitivity of the method allows the tritium concentrations to be determined to levels below those expected for worldwide surface waters. Procedures for both methods are described in SOP's *NRA 1.*14 and *NRA 1. 07.*

Sample Results

No manmade gamma-ray emitting radionuclides were detected in the samples within the scan periods used in the gamma-ray spectrometric analysis. Tritium values for the samples are given in Tables 1, 2, 3, and 4. For each sample collected in the 1997 project, a graph of all sample data for that location since the inception of the LTHMP is given in the Appendix. Moderate weather on the island precluded the collection of rain water during this sampling project.

Discussion and Conclusion

Tritium concentrations on Amchitka Island, Alaska follow a decreasing trend established from prior LTHMP sampling. At locations around the Longshot SGZ where contamination is known to exist, concentrations continue to decrease faster than would be expected from tritium decay alone indicating that dilution is also an important factor.

Table 1. Sampling Locations Established at the Long Shot Site (Figure 3).

Wells	pCi/L		
	Tritium	2-sigma	MDA
WL-1	12	3	5
WL-2	41	4	5
GZ-1	938	152	223
GZ-2	48	4	5
EPA-1	12	4	6
Surface Locations			
Reed Pond	15	4	6
Mud Pit No. 1	83	4	5
Mud Pit No. 2	113	5	5
Mud Pit No. 3	157	5	5
Stream East of Long Shot	110	5	5
Long Shot Pond No. 1	13	3	5
Long Shot Pond No. 2	13	3	5
Long Shot Pond No. 3	19	3	5

Table 2. Sampling Locations Established at the Milrow Site (Figure 3).

Tundra Holes	pCi/L		
	Tritium	2-sigma	MDA
W-2	8	136	223*
W-3	0	4	6
W-4	18	4	6
W-5	Not Sampled - well dry		
W-6	Not Sampled - well dry		
W-7	12	3	5
W-8	0.5	3.5	5.8
W-9	Not Sampled - well head under water		
W-10	0.3	3.5	5.8
W-11	5.1	3.5	5.6
W-12	Not Sampled - well head under water		
W-13	20	4	6
W-14	13	3	5
W-15	2.3	3.5	5.6
W-16	13	4	6
W-17	Not Sampled - well head under water		
W-18	21	4	6
W-19	Not Sampled - well head under water		
Surface Locations			
Heart Lake	0.0	4.8	7.9
Duck Cove Creek	5.4	3.5	5.6
Clevenger Creek	23	4	6

* Insufficient sample for enrichment, conventional screening only.

Table 3. Sampling Locations Established at the Cannikin Site (Figure 4).

Wells	pCi/L		
	Tritium	2-sigma	MDA
HTH-3	19	3	5
Surface Locations			
Cannikin Lake, north end	15	3	5
Cannikin Lake, south end	13	3	5
Ice Box Lake	16	4	6
Pit south of Cannikin GZ	9.1	3.4	5.3
DK-45 Lake	14	4	6
White Alice Creek	13	4	6

Table 4. Sampling Locations Established to Provide Background Data.

Wells	pCi/L		
	Tritium	2-sigma	MDA
Army Well No. 1	15	5	8
Army Well No. 2	9	3.2	5
Army Well No. 3	Not Collected - well blocked		
Army Well No. 4	9.4	2.5	3.8
Exploratory Hole D	Not Collected - well blocked		
Exploratory Hole E	Not Collected - well blocked		
Surface Locations			
Jones Lake	12	3	5
Constantine Spring	32	5	7
Clevenger Lake	19	4	5
TX Site Spring	13	3	5
Precipitation	None Collected		

REFERENCES

U.S. Atomic Energy Commission. *Project (Cannikin.* May, 1971 (internal document)

U.S. Department of Energy, Nevada Operations Office, Health Physics Division, Environmental Branch. *Long-Term Hydrologic Monitoring Program - Amchitka Island, Alaska.* Las Vegas, NV: U.S. Department of Energy, Nevada Operations Office; NVO-242; 1982.

U.S. Environmental Protection Agency, Office of Radiation and Indoor Air. *Amchitka, Alaska Long Term Hydrologic Monitoring Plan.* Las Vegas, NV: U.S. Environmental Protection Agency, Radiation and Indoor Environments National Laboratory. Submitted to U.S. Department of Energy April, 1997.

GLOSSARY OF TERMS

Background Radiation

The radiation in man's environment, including cosmic rays and radiation from naturally-occurring and man-made radioactive elements, both outside and inside the bodies of humans and animals. The usually quoted average individual exposure from background radiation is 125 millirem per year in mid-latitudes at sea level.

Curie (Ci)

The basic unit used to describe the rate of radioactive disintegration. The curie is equal to 37 billion disintegrations per second, which is the equivalent of 1 gram of radium. Named for Marie and Pierre Curie who discovered radium in 1898. One microcurie (μCi) is 0.000001 Ci.

Isotope

Atoms of the same element with different numbers of neutrons in the nuclei. Thus ^{12}C, ^{13}C, and ^{14}C are isotopes of the element carbon, the numbers denoting the approximate atomic weights. Isotopes have very nearly the same chemical properties, but have different physical properties (for example ^{12}C and ^{13}C are stable, ^{14}C is radioactive).

Enrichment Method

A method of electrolytic concentration that increases the sensitivity of the analysis of tritium in water. This method is used if the tritium concentration is less than 400 pCi/L.

Minimum Detectable Concentration (MDC)

The smallest amount of radioactivity that can be reliably detected with a probability of Type I and Type II errors at 5 percent each (DOE 1981).

Offsite

Areas exclusive of the immediate RIO BLANCO Test Site Area.

Type I Error

The statistical error of accepting the presence of radioactivity when none is present. Sometimes called alpha error.

Type II Error

The statistical error of failing to recognize the presence of radioactivity when it is present. Sometimes called beta error.

APPENDIX A

Summary of Analytical Procedures

Type of Analysis	Analytical Equipment	Counting Period (Min)	Analytical Procedures	Sample Size	Approximate Detection Limit[a]
HpGe Gamma[b]	HpGe detector calibrated at 0.5 keV/ channel (0.04 to 2 MeV range) individual detector Efficiencies ranging from 15 to 35%.	100	Radionuclide concentration quantified from gamma spectral data by online computer program.	3.5L	Varies with radionuclides.
^{3}H	Automatic liquid scintillation counter	300	Sample prepared by distillation.	5 to 10 mL	300 to 700 pCi/L
3H+ Enrichment (LTHMP samples)	Automatic liquid scintillation counter	300	Sample concentrated by electrolysis followed by distillation.	250 mL	5 pCi/L

[a] The detection limit is defined as the smallest amount of radioactivity that can be reliably detected, i.e., probability of Type I and Type II error at 5 percent each (DOE 1981).
[b] Gamma spectrometry using a high purity intrinsic germanium (HpGe) detector.

Typical MDA Values for Gamma Spectroscopy (100 minute count time)

Geometry*	Marinelli	Model	430G
Matrix	Water	Density	1.0 g/ml
Volume	3.5 liter	Units	pCi/L
		Ru-106	4.76E+01
Be-7	4.56E+01	Sn-113	8.32E+00
K-40	4.92E+01	Sb-125	1.65E+01
Cr-51	5.88E+01	I-131	8.28E+00
Mn-54	4.55E+01	Ba-133	9.16E+00
Co-57	9.65E+00	Cs-134	6.12E+00
Co-58	4.71E+00	Cs-137	6.43E+00
Fe-59	1.07E+01	Ce-144	7.59E+01
Co-60	5.38E+00	Eu-152	2.86E+01
Zn-65	1.24E+01	Ra-226	1.58E+01
Nb-95	5.64E+00	U-235	1.01E+02
Zr-95	9.06E+00	Am-241	6.60E+01

Disclaimer

The MDA's provided are for background matrix samples presumed to contain no known analytes and no decay time. All MDA's provided here are for one specific *Germanium detector and the geometry of interest. The MDA's in no way should be used as a source of reference for determing MDA's for any other type of detector. All gamma spectroscopy MDA's will vary with different types of shielding, geometries, counting times and decay time of sample.

APPENDIX B
Historic LTHMP Tritium Concentrations

Long Shot Site

A1	WL-1
A2	WL-2
A3	GZ -1
A4	GZ -2
A5	EPA-1
A6	Reed Pond
A7	Mud Pit No.1
A8	Mud Pit No.2
A9	Mud Pit No.3
A10	Stream East of Long Shot
A11	Long Shot Pond No.1
A12	Long Shot Pond No.2
A13	Long Shot Pond No.3

Milrow Site

A14	W-2
A15	W-3
A16	W-4
A17	W-7
A18	W-8
A19	W-10
A20	W-11
A21	W-13
A22	W-14
A23	W-15
A24	W-16
A25	W-18
A26	Heart Lake
A27	Duck Cove Creek
A28	Clevenger Creek

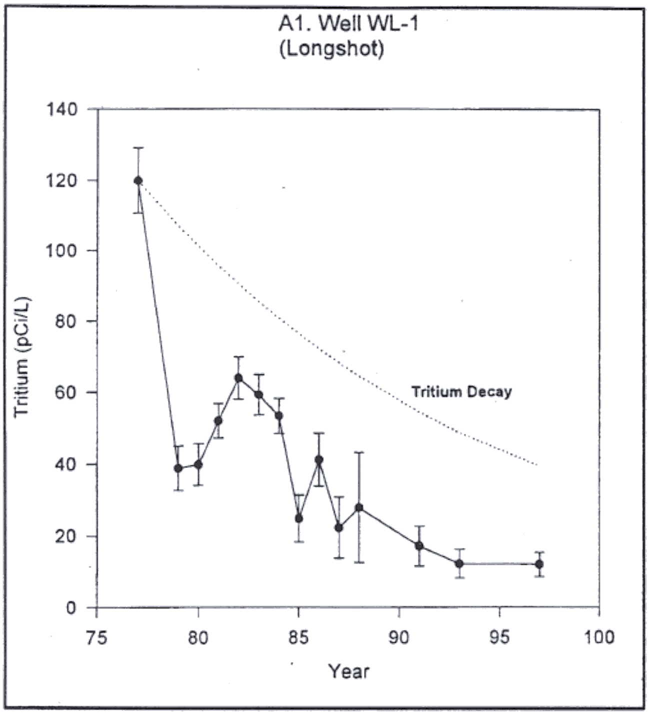
Cannikin Site

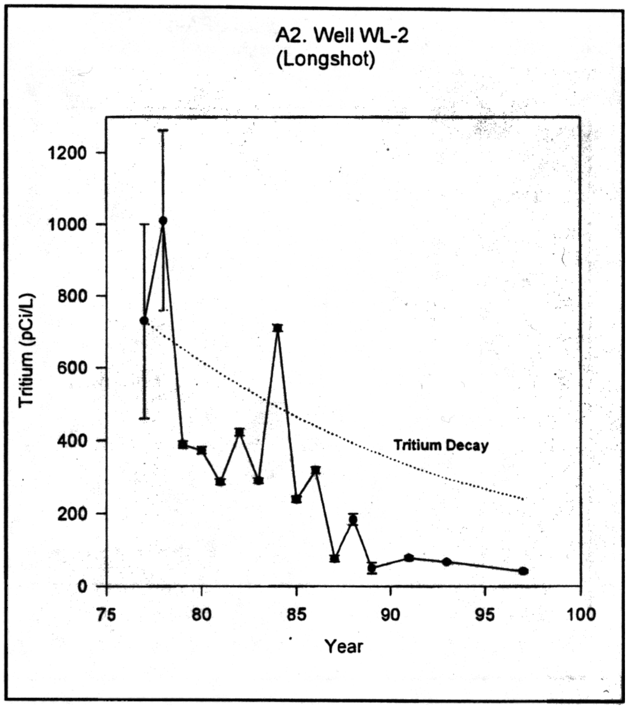
A29	HTH-3
A30	Cannikin Lake, north end
A31	Cannikin Lake, south end
A32	Ice Box Lake
A33	Pit south of Cannikin GZ
A34	DK-45 Lake
A35	White Alice Creek

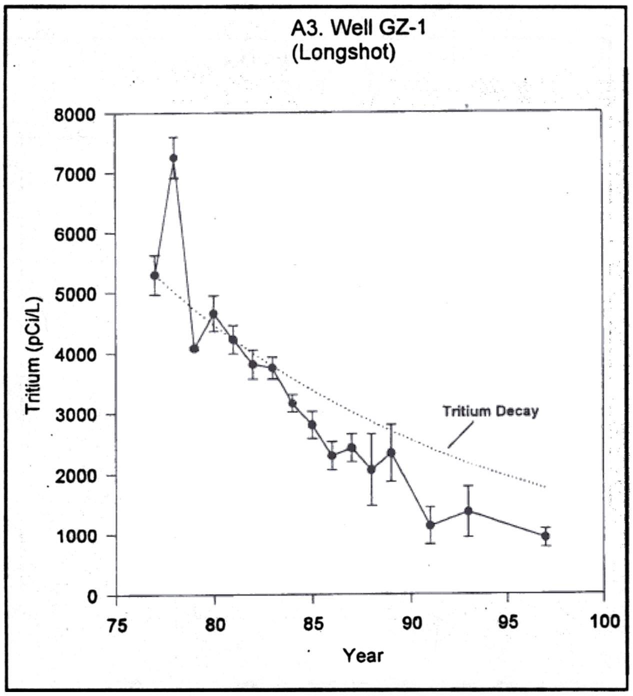
Background

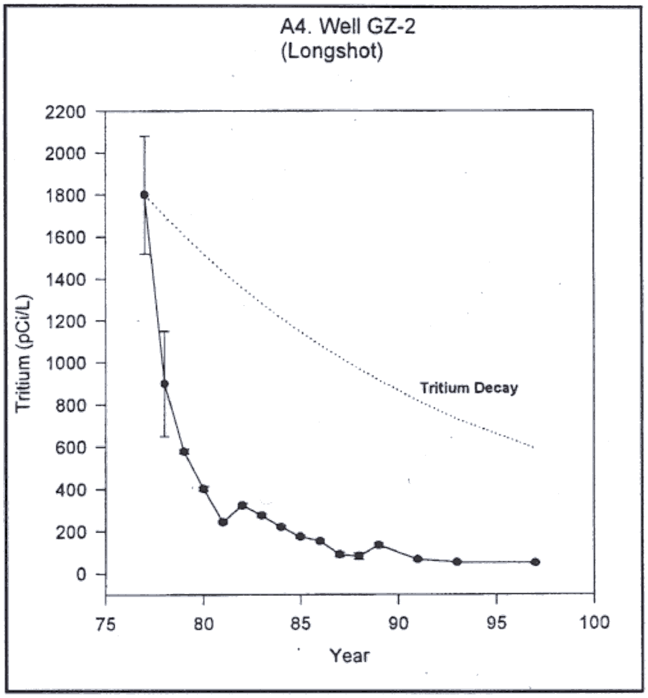
A36	Army Well No.1
A37	Army Well No.2
A38	Army Well No.4
A39	Jones Lake
A40	Constantine Spring
A41	Clevenger Lake
A42	TX Site Spring

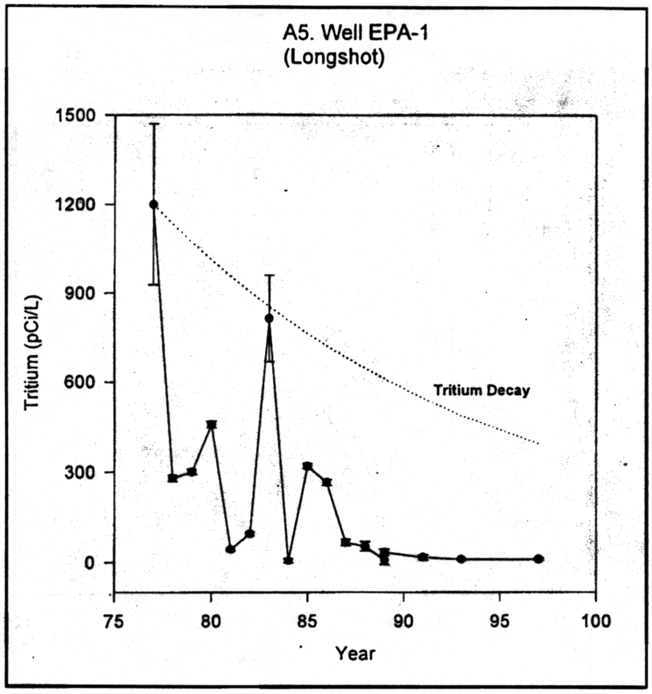
Note: The following graphs depict the variation of tritium concentrations at Amchitka sites since sample collection was begun as part of the Long Term Hydrological Monitoring Program. The error bars of each point represent a two-sigma uncertainty level. The lines connecting the points have been added for ease of visual tracking. They are not intended to imply that seasonal or other fluctuations do not occur. The dashed line represents the rate of decay for the first measured concentration at each site ($T_{1/2}$ = 12.3 years).

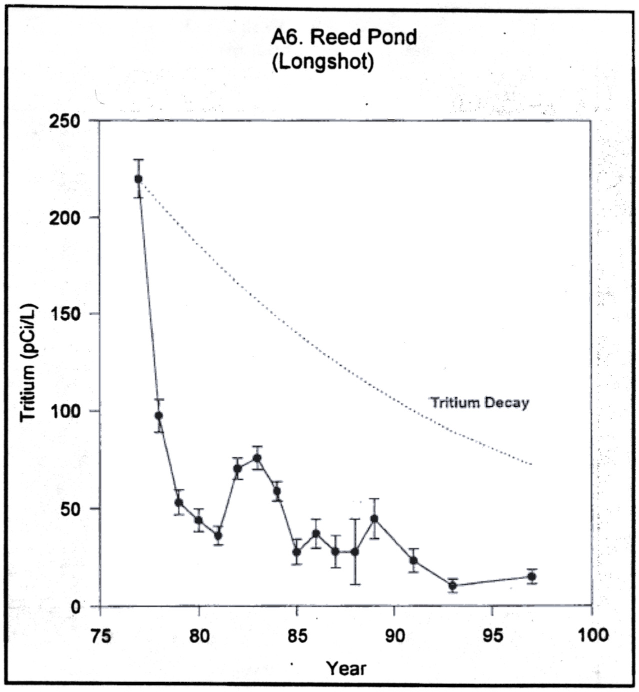

A1. Well WL-1
(Longshot)
Tritium (pCi/L)
Tritium Decay
Year
140
120
100
80
60
40
20
0
75
80
85
90
95
100

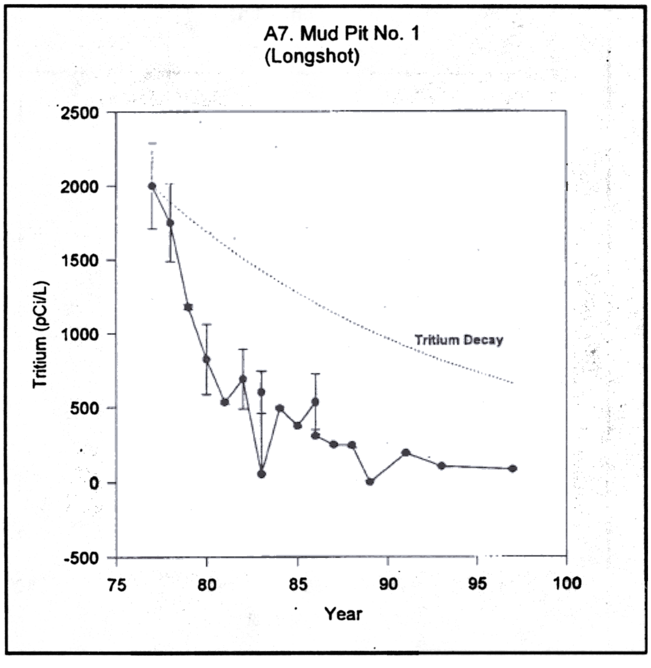

A2. Well WL-2
(Longshot)
Tritium (pCi/L)
Tritium Decay
Year
1200
1000
800
600
400
200
0
75
80
85
90
95
100

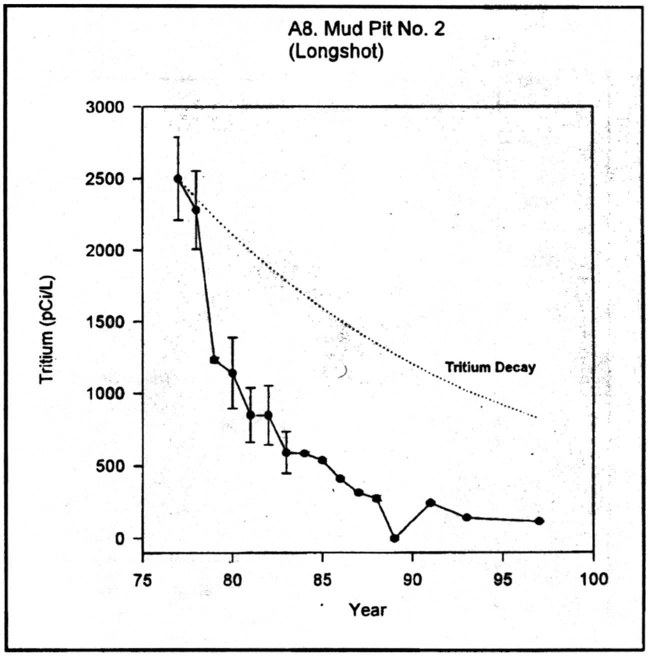

A3. Well GZ-1
(Longshot)
Tritium (pCi/L)
Tritium Decay
Year
8000
7000
6000
5000
4000
3000
2000
1000
0
75
80
85
90
95
100

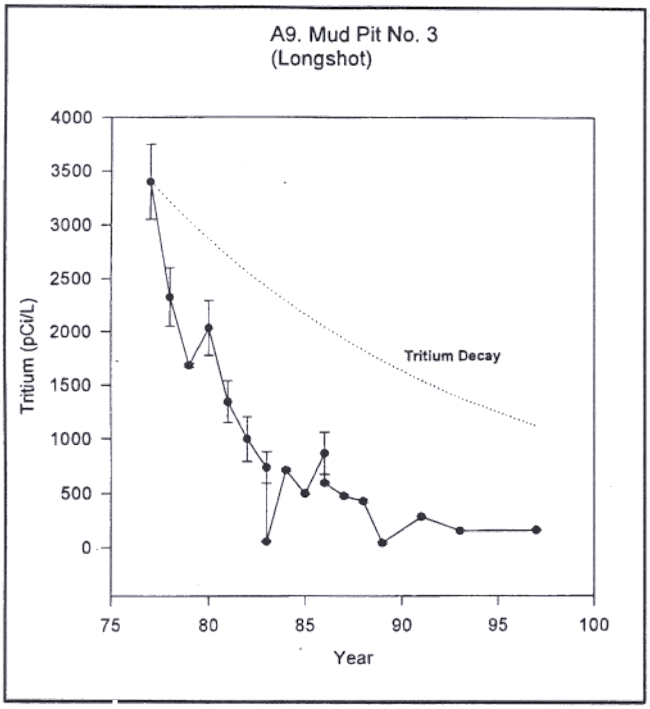

A4. Well GZ-2
(Longshot)
Tritium (pCi/L)
Tritium Decay
Year
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
75
80
85
90
95
100


A5. Well EPA-1
(Longshot)
Tritium (pCi/L)
Year
Tritium Decay

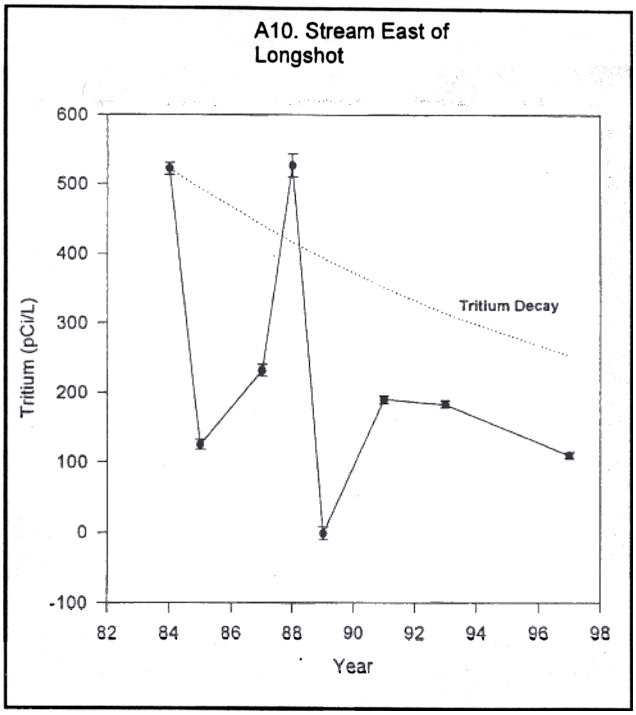

A6. Reed Pond
(Longshot)
Tritium (pCi/L)
Year
Tritium Decay


A7. Mud Pit No. 1
(Longshot)
Tritium (pCi/L)
Year
Tritium Decay

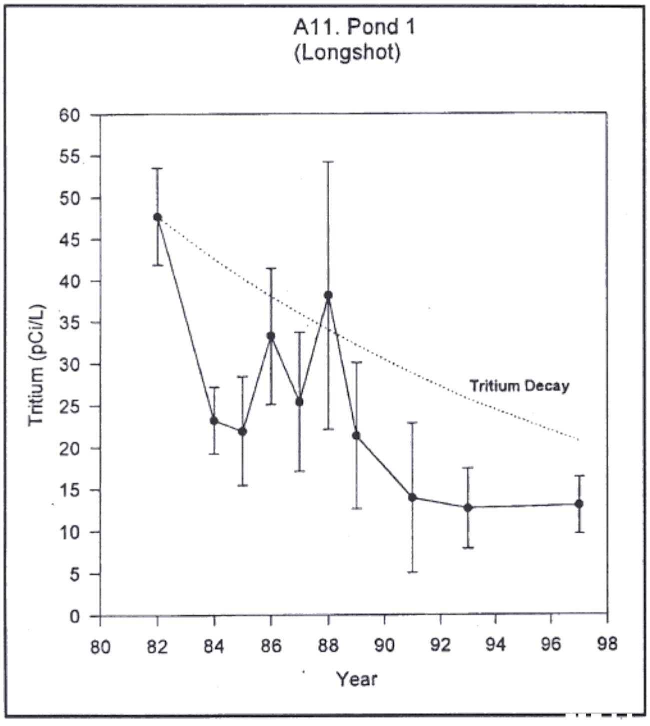

A8. Mud Pit No. 2
(Longshot)
Tritium (pCi/L)
Year
Tritium Decay



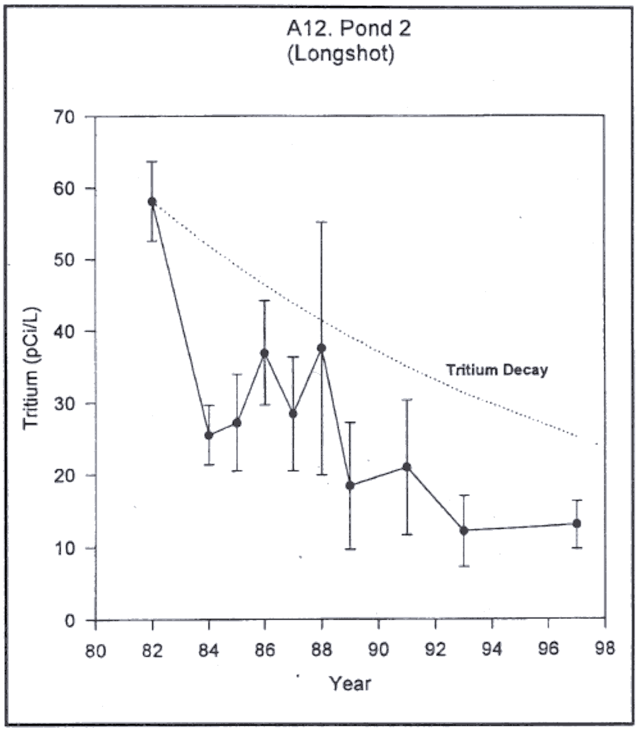
A9. Mud Pit No. 3
(Longshot)
Tritium (pCi/L)
Tritium Decay
Year



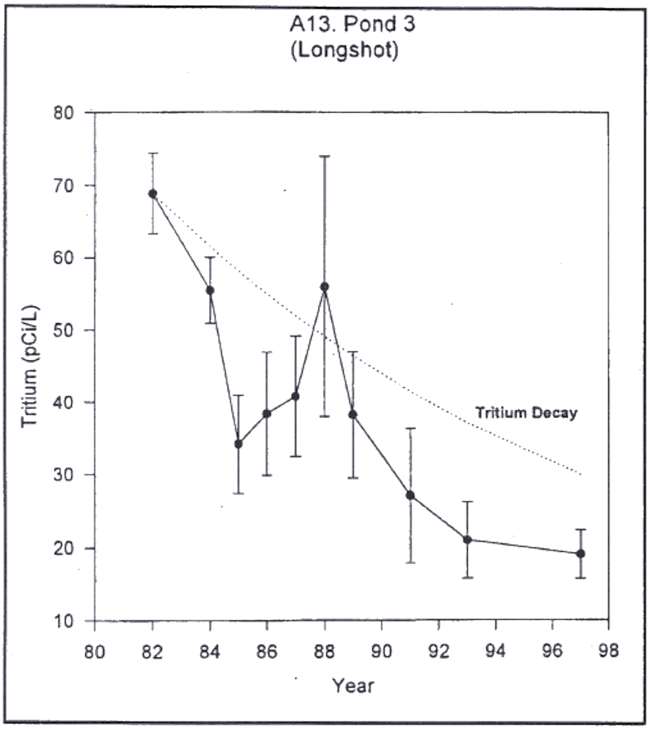
A10. Stream East of
Longshot
Tritium (pCi/L)
Tritium Decay
Year

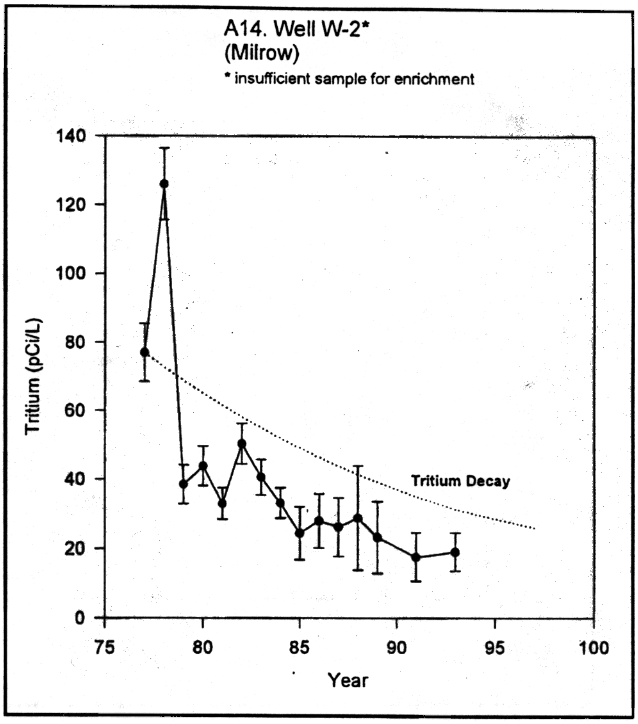


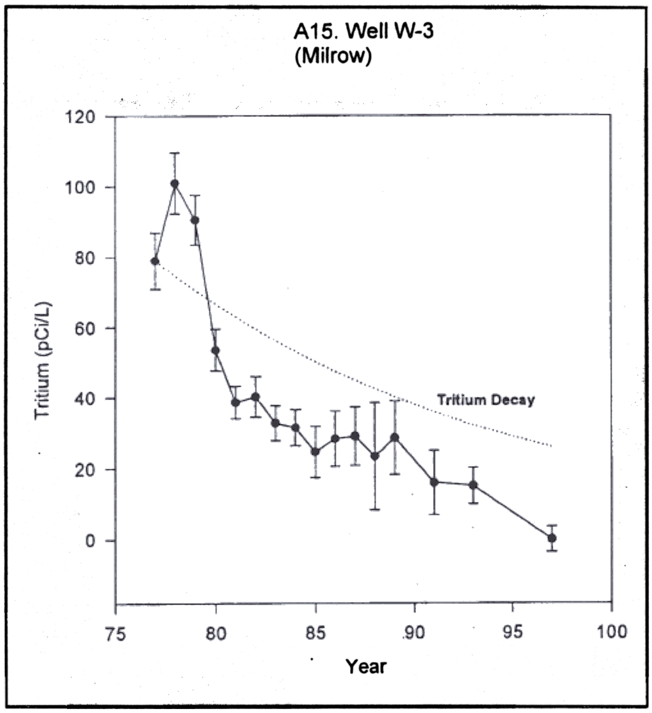
A11. Pond 1
(Longshot)
Tritium (pCi/L)
Tritium Decay
Year

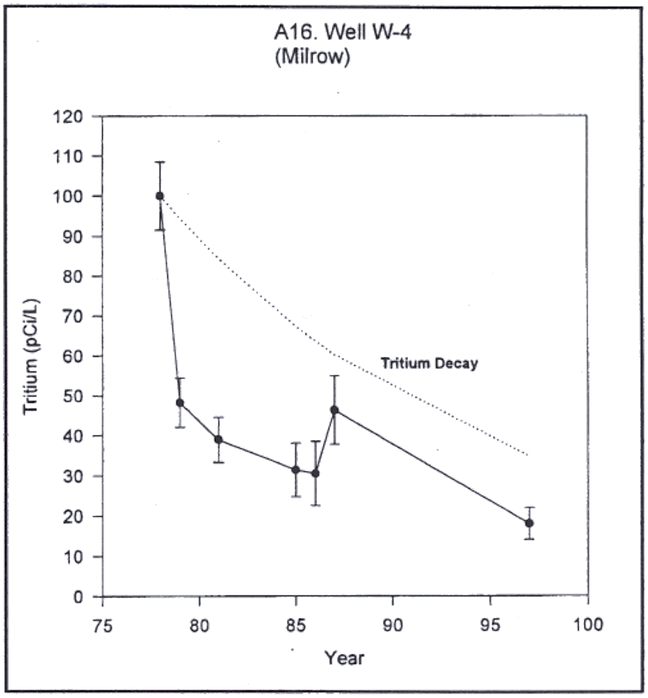


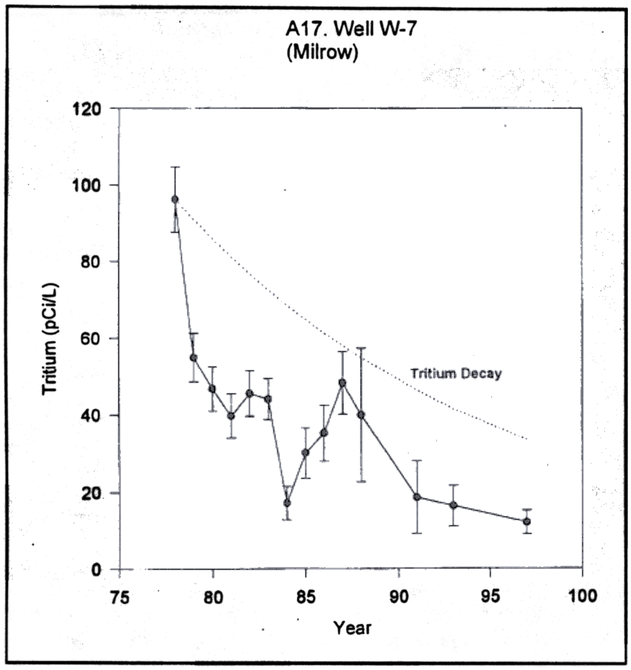
A12. Pond 2
(Longshot)
Tritium (pCi/L)
Tritium Decay
Year

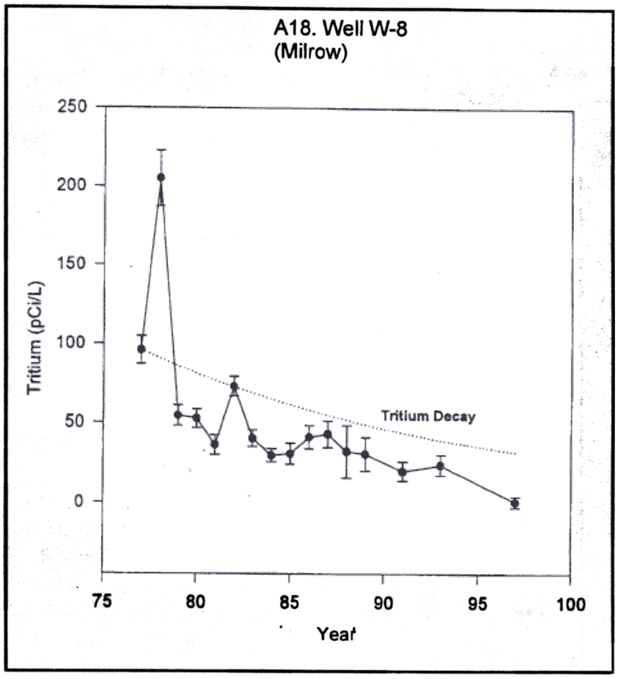

A13. Pond 3
(Longshot)
Tritium (pCi/L)
Year
Tritium Decay
80
70
60
50
40
30
20
10
80
82
84
86
88
90
92
94
96
98

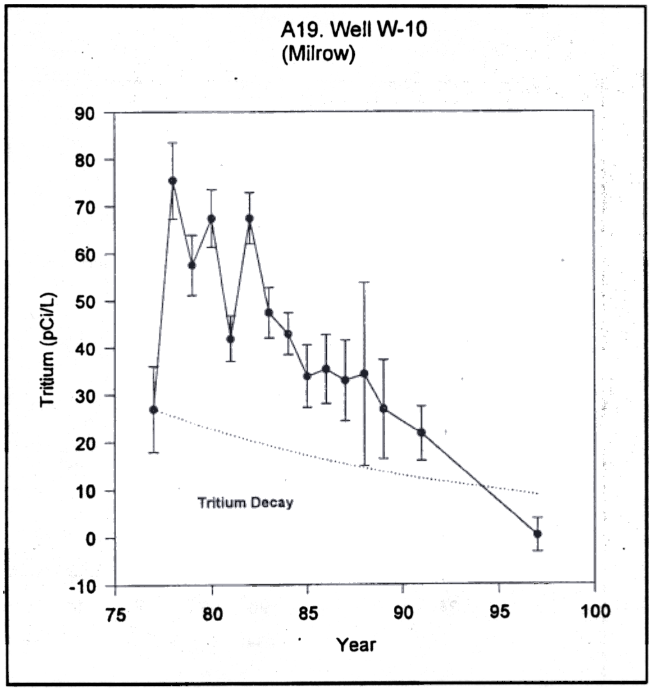

A14. Well W-2*
(Milrow)
* insufficient sample for enrichment
Tritium (pCi/L)
Year
Tritium Decay
140
120
100
80
60
40
20
0
75
80
85
90
95
100

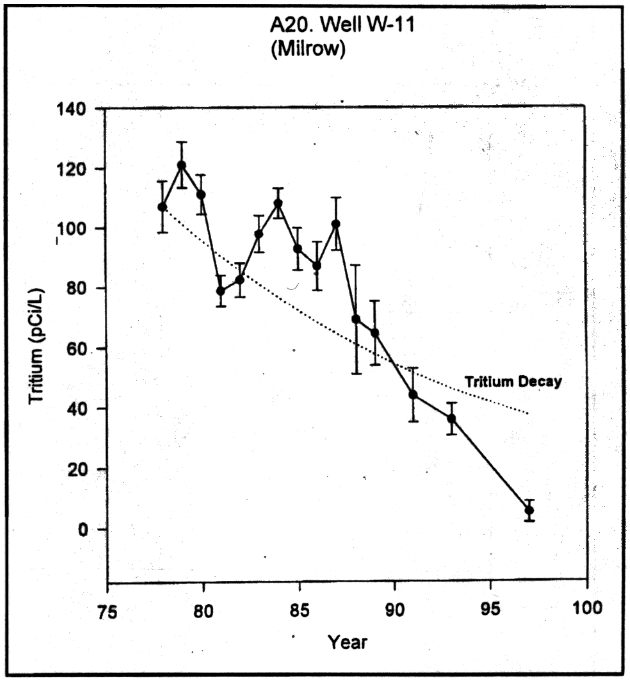

A15. Well W-3
(Milrow)
Tritium (pCi/L)
Year
Tritium Decay
120
100
80
60
40
20
0
75
80
85
90
95
100


A16. Well W-4
(Milrow)
Tritium (pCi/L)
Year
Tritium Decay
120
110
100
90
80
70
60
50
40
30
20
10
0
75
80
85
90
95
100

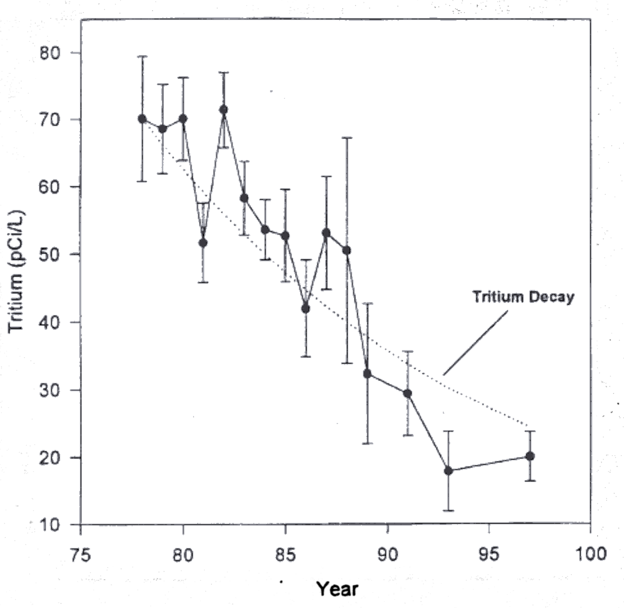

A17. Well W-7
(Milrow)
Tritium (pCi/L)
Year
Tritium Decay
120
100
80
60
40
20
0
75
80
85
90
95
100


A18. Well W-8
(Milrow)
Tritium (pCi/L)
Year
Tritium Decay
250
200
150
100
50
0
75
80
85
90
95
100

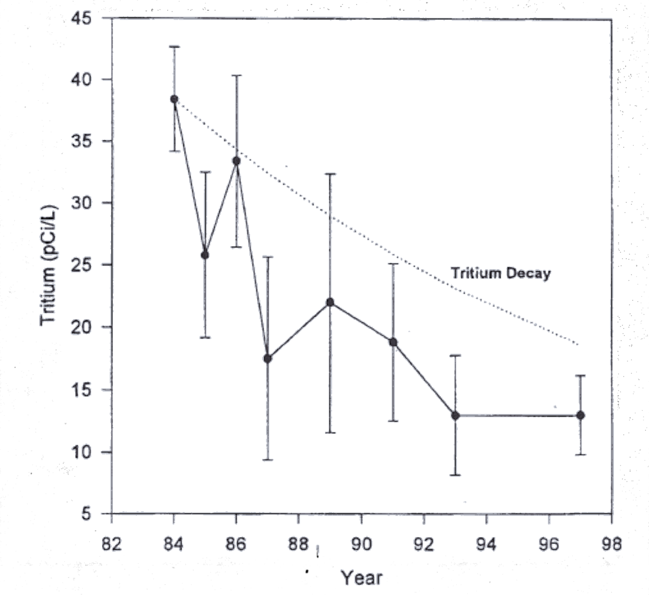

A19. Well W-10
(Milrow)
Tritium (pCi/L)
Year
Tritium Decay
90
80
70
60
50
40
30
20
10
0
-10
75
80
85
90
95
100


A20. Well W-11
(Milrow)
Tritium (pCi/L)
Year
Tritium Decay
140
120
100
80
60
40
20
0
75
80
85
90
95
100

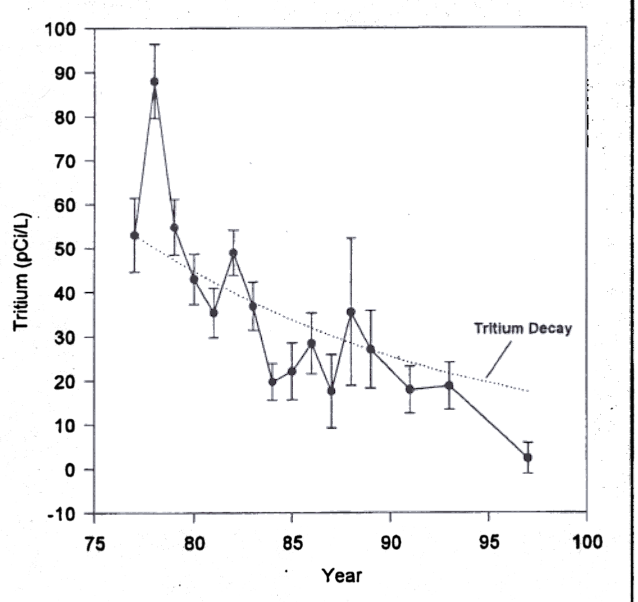
A21. Well W-13
(Milrow)



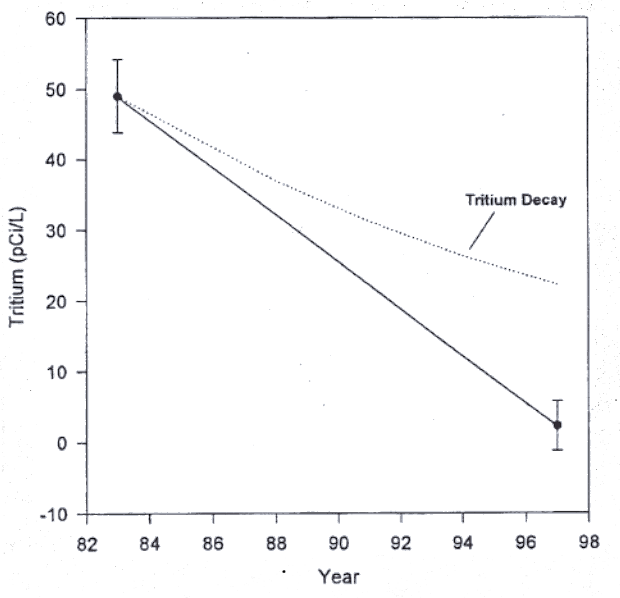
A22. Well W-14
(Milrow)

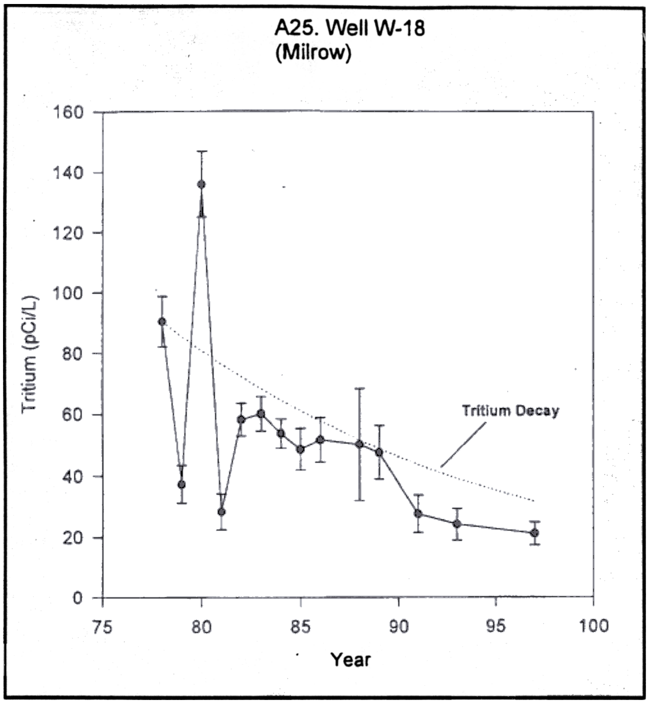


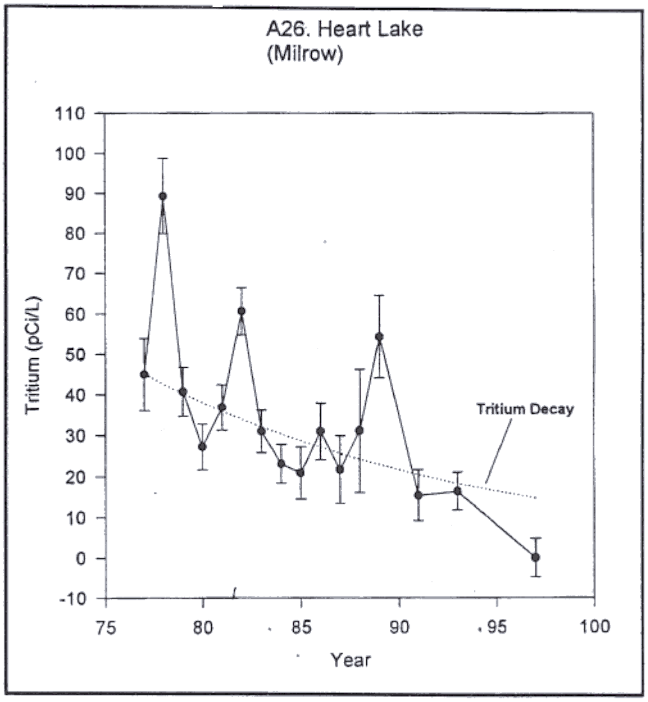
A23. Well W-15
(Milrow)

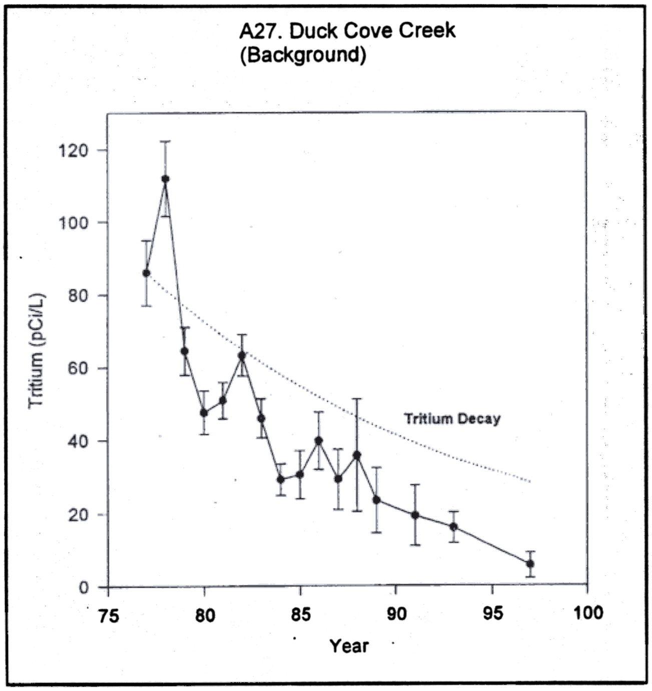


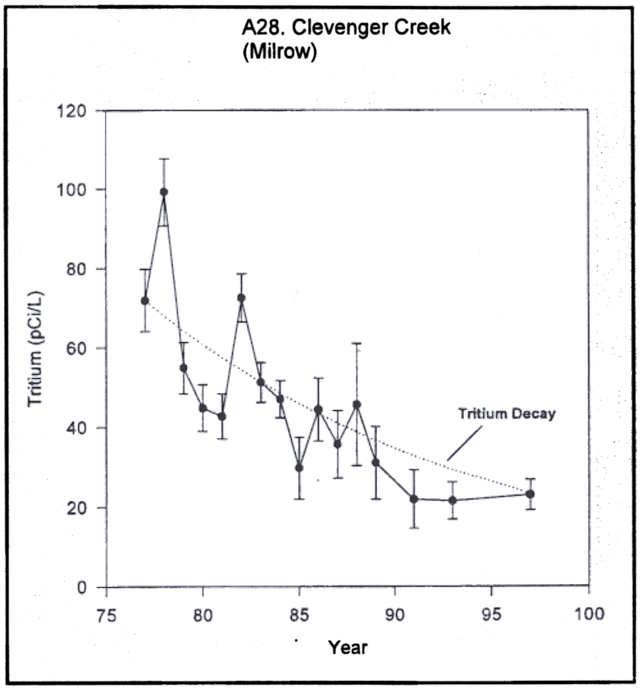
A24. Well W-16
(Milrow)

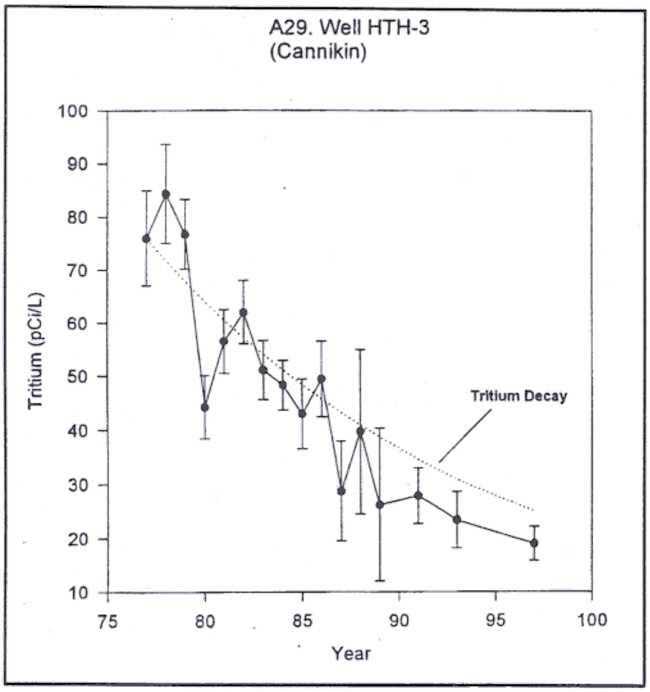


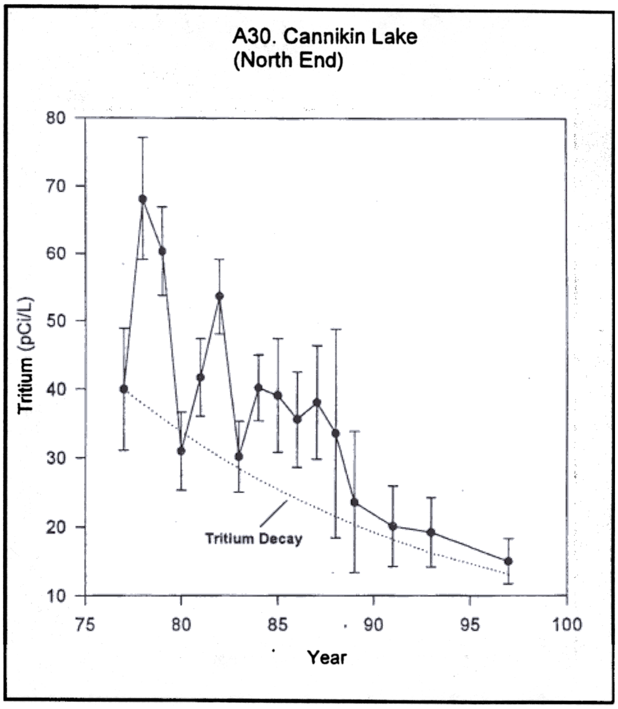

A25. Well W-18
(Milrow)
Tritium (pCi/L)
Year
Tritium Decay
0
20
40
60
80
100
120
140
160
75
80
85
90
95
100

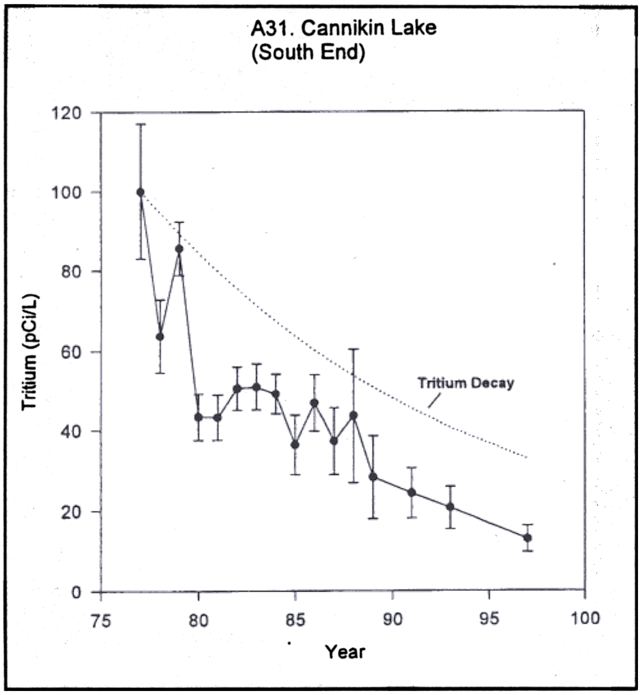

A26. Heart Lake
(Milrow)
Tritium (pCi/L)
Year
Tritium Decay
-10
0
10
20
30
40
50
60
70
80
90
100
110
75
80
85
90
95
100

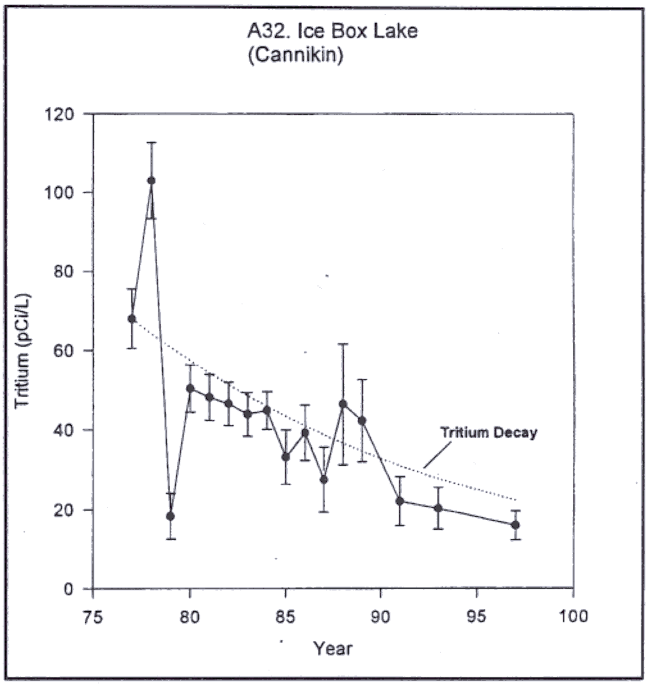

A27. Duck Cove Creek
(Background)
Tritium (pCi/L)
Year
Tritium Decay
0
20
40
60
80
100
120
75
80
85
90
95
100

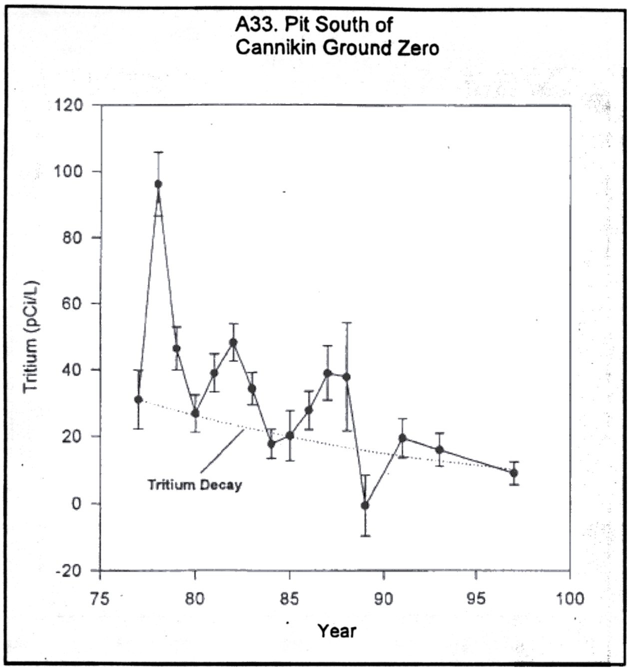

A28. Clevenger Creek
(Milrow)
Tritium (pCi/L)
Year
Tritium Decay
0
20
40
60
80
100
120
75
80
85
90
95
100

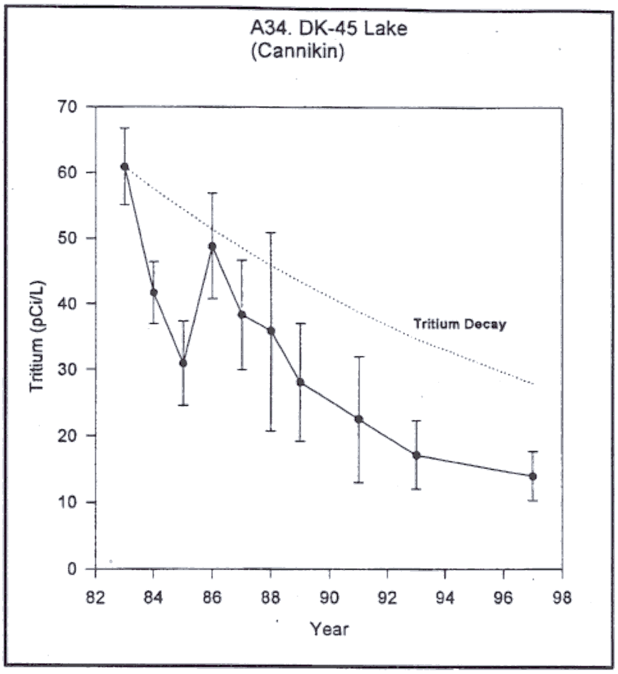

A29. Well HTH-3
(Cannikin)
Tritium (pCi/L)
Year
Tritium Decay
100
90
80
70
60
50
40
30
20
10
75
80
85
90
95
100

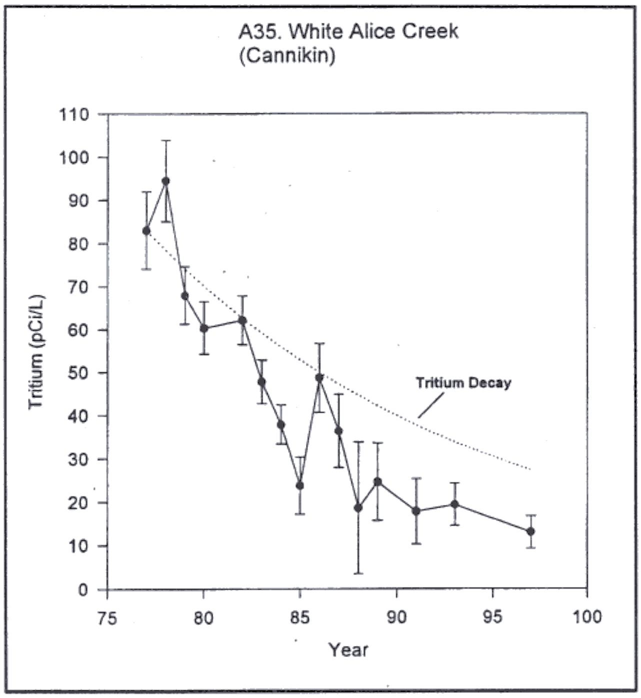

A30. Cannikin Lake
(North End)
Tritium (pCi/L)
Year
Tritium Decay
80
70
60
50
40
30
20
10
75
80
85
90
95
100

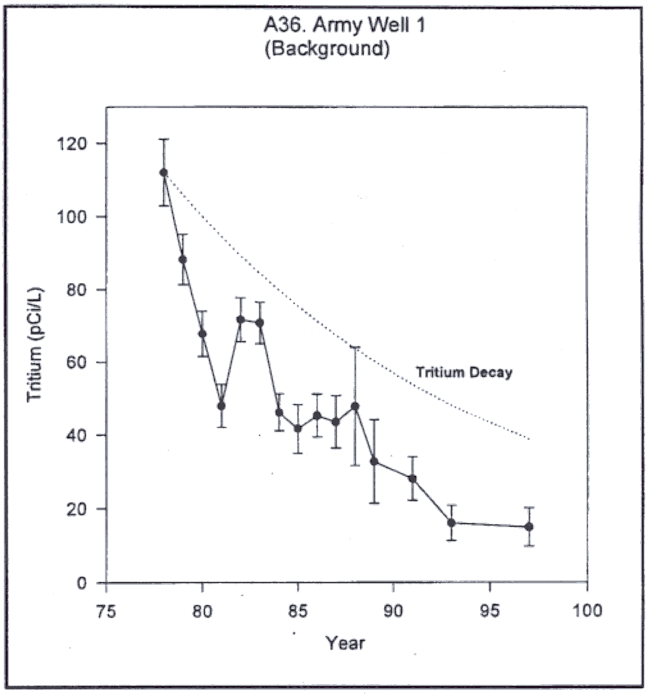

A31. Cannikin Lake
(South End)
Tritium (pCi/L)
Year
Tritium Decay
120
100
80
60
40
20
0
75
80
85
90
95
100

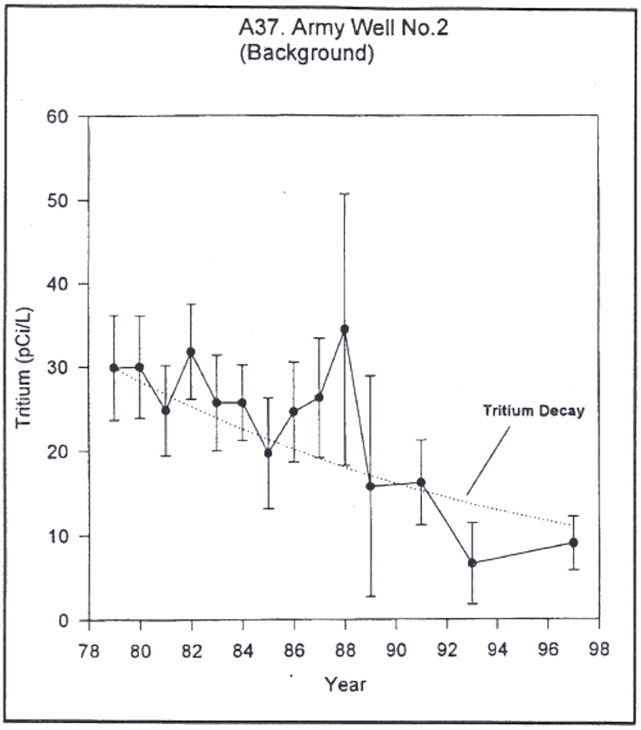

A32. Ice Box Lake
(Cannikin)
Tritium (pCi/L)
Year
Tritium Decay
120
100
80
60
40
20
0
75
80
85
90
95
100

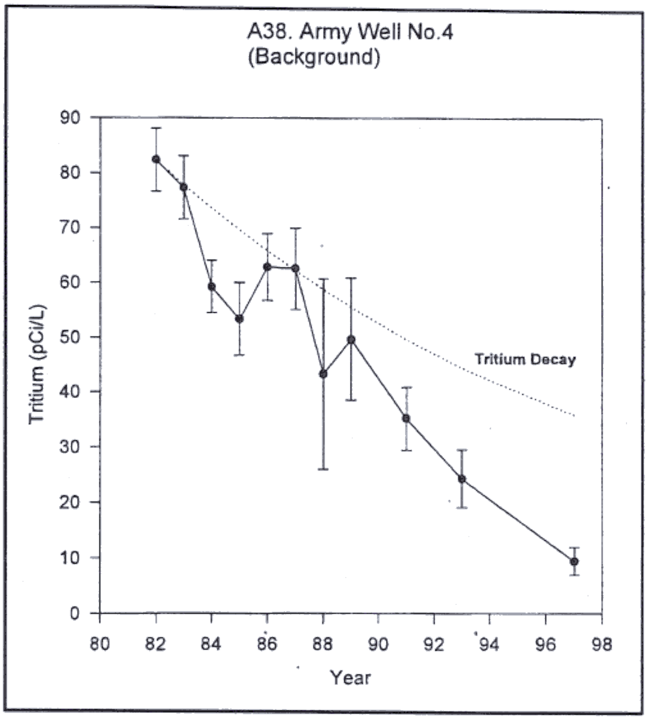

A33. Pit South of
Cannikin Ground Zero
Tritium (pCi/L)
Year
Tritium Decay
120
100
80
60
40
20
0
-20
75
80
85
90
95
100

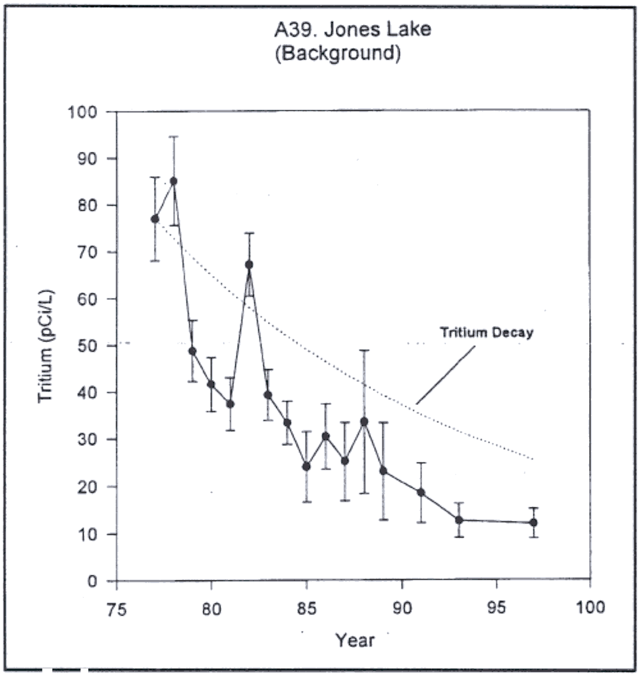

A34. DK-45 Lake
(Cannikin)
Tritium (pCi/L)
Year
Tritium Decay
70
60
50
40
30
20
10
0
82
84
86
88
90
92
94
96
98

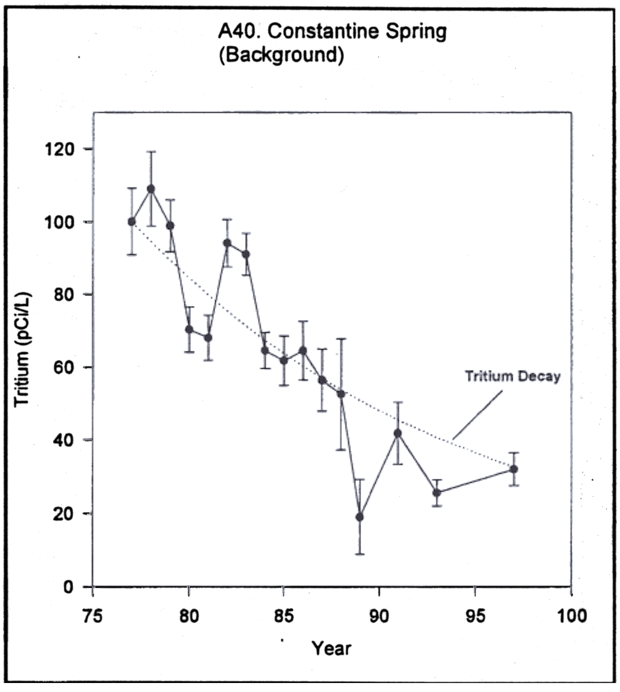

A35. White Alice Creek
(Cannikin)
Tritium (pCi/L)
Year
Tritium Decay
110
100
90
80
70
60
50
40
30
20
10
0
75
80
85
90
95
100

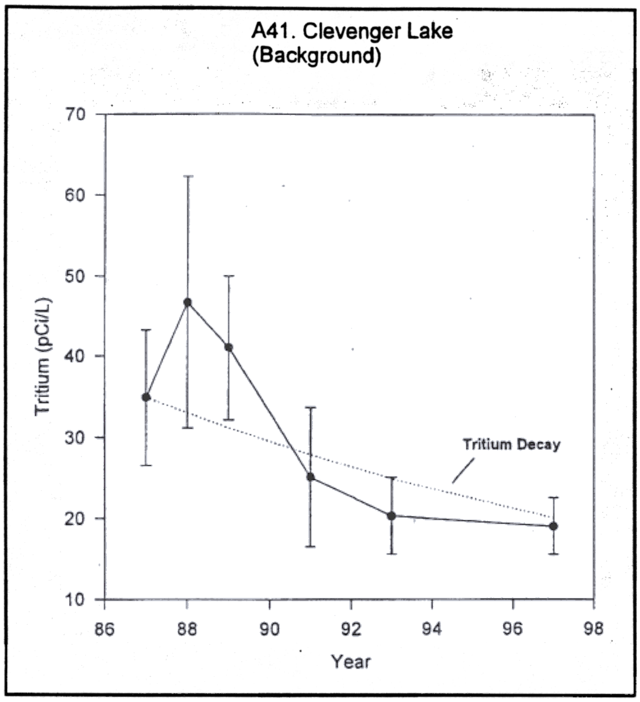

A36. Army Well 1
(Background)
Tritium (pCi/L)
Year
Tritium Decay
120
100
80
60
40
20
0
75
80
85
90
95
100


A37. Army Well No.2
(Background)
Tritium (pCi/L)
Tritium Decay
Year

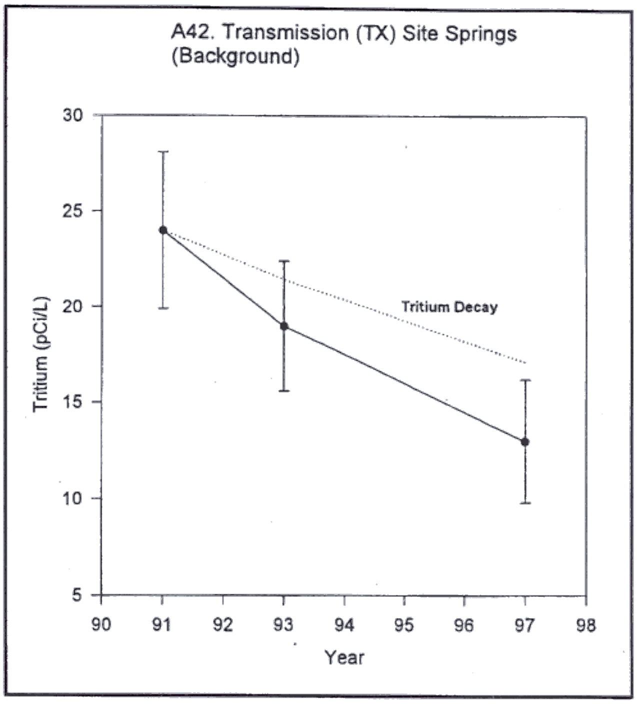

A38. Army Well No.4
(Background)
Tritium (pCi/L)
Tritium Decay
Year


A39. Jones Lake
(Background)
Tritium (pCi/L)
Tritium Decay
Year


A40. Constantine Spring
(Background)
Tritium (pCi/L)
Tritium Decay
Year



A41. Clevenger Lake
(Background)
Tritium (pCi/L)
70
60
50
40
30
20
10
Tritium Decay
86
88
90
92
94
96
98
Year



A42. Transmission (TX) Site Springs
(Background)
Tritium (pCi/L)
30
25
20
15
10
5
Tritium Decay
90
91
92
93
94
95
96
97
98
Year