CATEGORY 1

REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

ACCESSION NBR:9904290292 DOC.DATE: ~~99/12/31~~ NOTARIZED: NO DOCKET #
FACIL:STN-50-528 Palo Verde Nuclear Station, Unit 1, Arizona Publi 05000528
STN-50-529 Palo Verde Nuclear Station, Unit 2, Arizona Publi 05000529
STN-50-530 Palo Verde Nuclear Station, Unit 3, Arizona Publi 05000530
AUTH.NAME AUTHOR AFFILIATION
KRAINIK,A.K. Arizona Public Service Co. (formerly Arizona Nuclear Power
RECIP.NAME RECIPIENT AFFILIATION

See Enviro Rpt.

SUBJECT: "Palo Verde Nuclear Generating Station Annual Radiological Environ Operating Rept for 1998." With 990421 ltr.

DISTRIBUTION CODE: C001D COPIES RECEIVED:LTR 1 ENCL 1 SIZE: 66
TITLE: Licensing Submittal: Environmental Rept Amdt & Related Correspondence

NOTES:STANDARDIZED PLANT 05000528
Standardized plant. 05000529
Standardized plant. 05000530

	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL
	FIELDS,M	1	1			
INTERNAL:	ACRS	1	1	FILE CENTER 01	1	1
	LA	1	1	NUDOCS-ABSTRACT	1	1
	OGC/HDS2	1	0	RGN4 DRS/RSB	1	1
EXTERNAL:	NOAC	1	1	NRC PDR	1	1

C A T E G O R Y 1 D O C U M E N T

MICROFILMED

NOTE TO ALL "RIDS" RECIPIENTS:
PLEASE HELP US TO REDUCE WASTE. TO HAVE YOUR NAME OR ORGANIZATION REMOVED FROM DISTRIBUTION LISTS OR REDUCE THE NUMBER OF COPIES RECEIVED BY YOU OR YOUR ORGANIZATION, CONTACT THE DOCUMENT CONTROL DESK (DCD) ON EXTENSION 415-2083

TOTAL NUMBER OF COPIES REQUIRED: LTTR 9 ENCL 8

Angela K. Krainik
Department Leader
Regulatory Affairs
Palo Verde Nuclear
Generating Station

Tel: 602/393-5421
Fax: 602/393-5442

Mail Station 7636
P.O. Box 52034
Phoenix, AZ 85072-2034

102-04275-AKK/SAB/CJJ
April 21, 1999

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Station P1-37
Washington, DC 20555-0001

Dear Sirs:

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2, & 3
Docket Nos. STN 50-528/529/530
Annual Radiological Environmental Operating Report for 1998

Enclosed please find a copy of the Annual Radiological Environmental Operating Report for 1998. This report covers operation of PVNGS Units 1, 2, and 3 during 1998, and is being submitted pursuant to PVNGS Technical Specification 5.6.2. No commitments are being made to the NRC in this letter.

Should you have any questions, please contact Scott A. Bauer at (602) 393-5978.

Sincerely,

Angela K. Krainik

AKK/SAB/CJJ

Enclosure

cc: E. W. Merschoff
M. B. Fields
J. H. Moorman
A. V. Godwin (ARRA)

9904290292 981231
PDR ADOCK 05000528
R PDR

ENCLOSURE

ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT 1998

FOR

PALO VERDE NUCLEAR GENERATING STATION

PALO VERDE

NUCLEAR GENERATING STATION

ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT
1998

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The Radiological Environmental Monitoring Program (REMP) is an ongoing program conducted by Arizona Public Service Company (APS) for the Palo Verde Nuclear Generating Station (PVNGS). Various types of environmental samples are collected near PVNGS and analyzed for radionuclide concentrations.

During 1998, the following categories of samples were collected by APS:

- Broad leaf vegetation
- Groundwater
- Drinking water
- Surface water
- Airborne particulate and radioiodine
- Sludge and sediment
- Soil

Thermoluminescent dosimeters (TLDs) were used to measure environmental gamma radiation. The Environmental TLD program is also conducted by APS.

APS reviews analysis results for trends and anomalies for inclusion in this report.

The Arizona Radiation Regulatory Agency (ARRA) performs radiochemistry analyses on various duplicate samples provided to them by APS. Samples analyzed by ARRA include: Reservoir, Evaporation Ponds 1 and 2, Sheppard well, well 27ddc, and well 34abb. Additionally, ARRA performs air sampling at seven locations identical to APS sampling. ARRA reports the results of their comparisons in a separate report.

Assessment of pre-operational and operational data revealed no changes to environmental radiation levels. There were no observed radiological impacts on the environment due to PVNGS operations in 1998.

(NOTE: Reference to APS throughout this report refers to PVNGS personnel)

OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

1. Introduction

This report presents the results of the operational environmental radiological monitoring program conducted by Arizona Public Service Company (APS). The Radiological Environmental Monitoring Program (REMP) was established for the Palo Verde Nuclear Generating Station (PVNGS) by APS in 1979. The REMP is performed in accordance with the federal requirements to provide a complete environmental monitoring program for nuclear reactors, and with concern for maintaining the quality of the local environment. The program complies with the requirements of 10 CFR50, Appendix I, PVNGS Technical Specifications, and with the guidance provided by the US Nuclear Regulatory Commission (USNRC) in their Radiological Assessment Branch Technical Position, Revision 1, November 1979.

This report contains the measurements and findings for 1998. All references are specifically identified in Section 12.

The objectives of the REMP are as follows: 1) to determine baseline radiation levels in the environs prior to plant operation and to compare the findings with measurements obtained during reactor operations; 2) to monitor potential critical pathways of radio-effluent to man; and 3) to determine radiological impacts on the environment caused by the operation of PVNGS.

Results from the REMP help to evaluate sources of elevated levels of radiation in the environment, (e.g., atmospheric nuclear detonations or abnormal plant releases).

Results of the PVNGS pre-operational environmental monitoring program are presented in Reference 1.

The initial criticality of Unit 1 occurred May 25, 1985. Initial criticality for Units 2 and 3 were April 18, 1986, and October 25, 1987, respectively. PVNGS operational findings (historical) are presented in Reference 2.

2. Description of the Monitoring Program

The pre-operational radiological environmental monitoring program, which began in 1979, was performed by APS and vendor organizations. APS and vendors continued the program into the operational phase of PVNGS.

2.1. 1998 PVNGS Radiological Environmental Monitoring Program

The assessment program consists of routine measurements of background gamma radiation and of radionuclide concentrations in media such as air, groundwater, drinking water, surface water, vegetation, sludge, sediment, and soil.

Samples were collected by APS at the monitoring sites shown in Figures 2.1 and 2.2. The specific sample types, sampling locations, and sampling frequencies, as set forth in the PVNGS Offsite Dose Calculation Manual (ODCM), Reference 4, are presented in Tables 2.1, 2.2 and 9.1. Additional onsite sampling (outside the scope of the ODCM) is performed to supplement the REMP. All results are included in this report. Sample analyses were performed by APS at the PVNGS Central Chemistry Laboratory.

Background gamma radiation measurements are performed by APS using TLDs at forty-nine locations near PVNGS.

In addition to the monitoring of environmental media, a land use census is performed annually to identify the nearest milk animals, residents, gardens, and/or changes thereto, near PVNGS. This information is used to evaluate the potential dose to members of the public for those exposure pathways that are indicated.

2.2. Radiological Environmental Monitoring Program Changes for 1998

REMP changes occurred as a result of the 1998 Land Use Census. Vegetation sample locations were changed to meet the requirements of the ODCM. Refer to Table 2.1 for a list of current sample locations. Refer to Table 10.1 for a summary of land use census results.

Table 2.1 SAMPLE COLLECTION LOCATIONS

SAMPLE SITE #	SAMPLE TYPE	LOCATION (a)	LOCATION DESCRIPTION
4	air	E16	APS Office
6A*	air	SSE13	Old US 80
7A	air	SE8	Arlington School
14A	air	NNE2	371st Ave. and Buckeye-Salome Rd.
15	air	NE2	NE Site Boundary
17A	air	E4	351st Ave
21	air	S3	S Site Boundary
29	air	W1	W Site Boundary
35	air	NNW8	Fire Station
40	air	N3	Transmission Rd
46	drinking water	NW9	McArthur Residence
47	vegetation	ENE3	Steele Residence
48	drinking water	SSW4	Sheppard Farm
49	drinking water	N2	Chowanec Residence
52	vegetation	ESE4 (b)	Hallman Residence
55	drinking water (supplemental)	SW3	Gavette Residence
57	groundwater	ONSITE	Well 27ddc
58	groundwater	ONSITE	Well 34abb
59	surface water	ONSITE	Evaporation Pond #1
60	surface water	ONSITE	Reservoir
62*	vegetation	E35	Rousseau Farming Co.
63	surface water	ONSITE	Evaporation Pond #2
64	vegetation (supplemental)	NNE2 (b)	Payne Residence

NOTES:

* Designates a control site

(a) Distances and direction are from the center-line of Unit 2 containment and rounded to the nearest mile
(b) Denotes a change in location from 1997

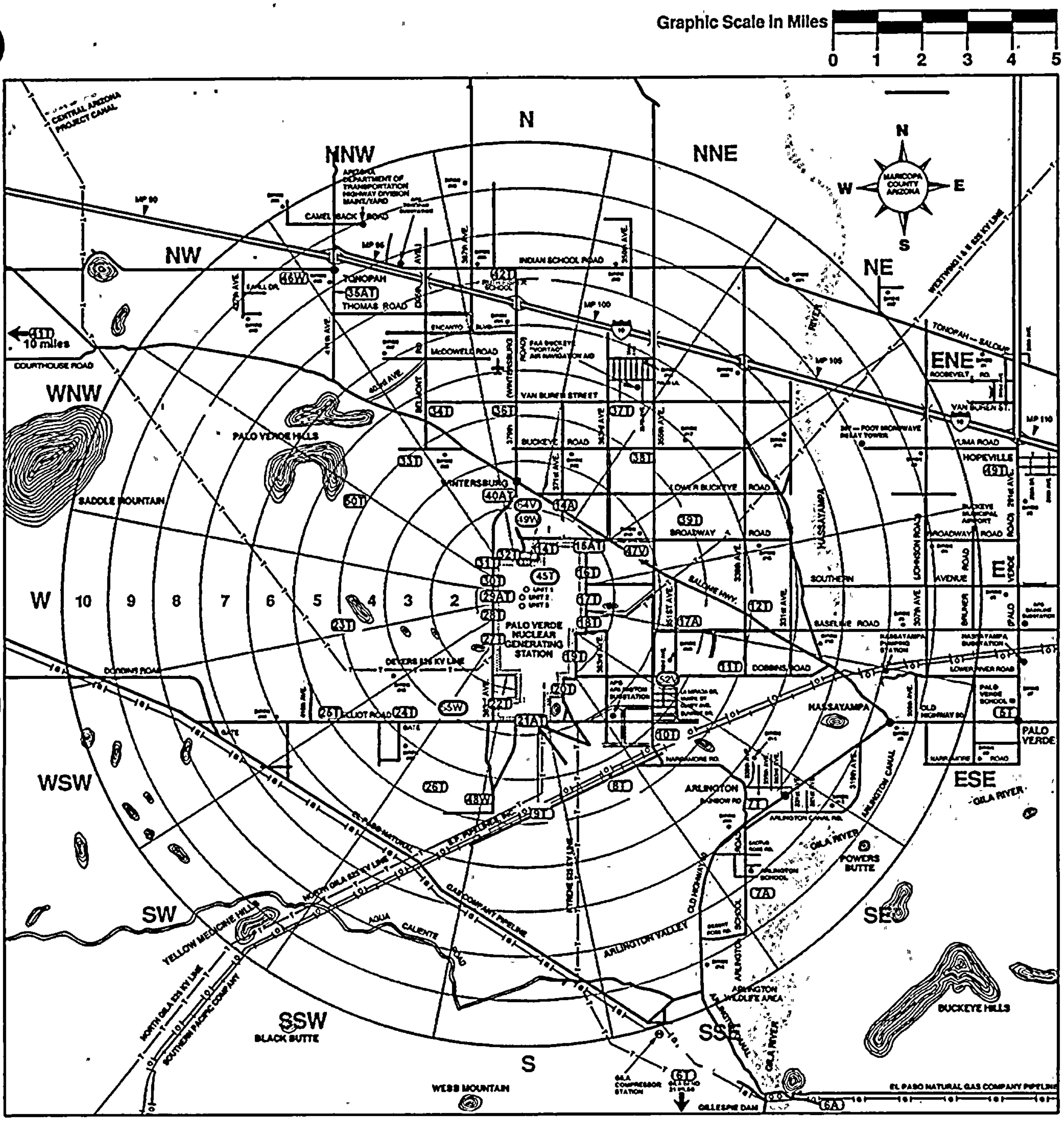
Air sample sites designated with the letter 'A' are sites which have the same site number as a TLD location, but are not in the same location (e.g. site #6 TLD location is different from site #6A air sample location; site #4 TLD location is the same as site #4 air sample location)

Table 2.2 SAMPLE COLLECTION SCHEDULE

SAMPLE SITE #	*AIR PARTICULATE*	*AIRBORNE RADIOIODINE*	*VEGETATION*	*GROUND WATER*	*DRINKING WATER*	*SURFACE WATER*
4	W	W				
6A	W	W				
7A	W	W				
14A	W	W				
15	W	W				
17A	W	W				
21	W	W				
29	W	W				
35	W	W				
40	W	W				
46					W	
47			M/AA			
48					W	
49					W	
52			M/AA			
55					W	
57				Q		
58				Q		
59						W
60						W
62			M/AA			
63						W
64			M/AA			

W = WEEKLY M/AA = MONTHLY AS AVAILABLE Q = QUARTERLY

FIGURE 2.1
REMP SAMPLE SITES
(0-10 MILES)



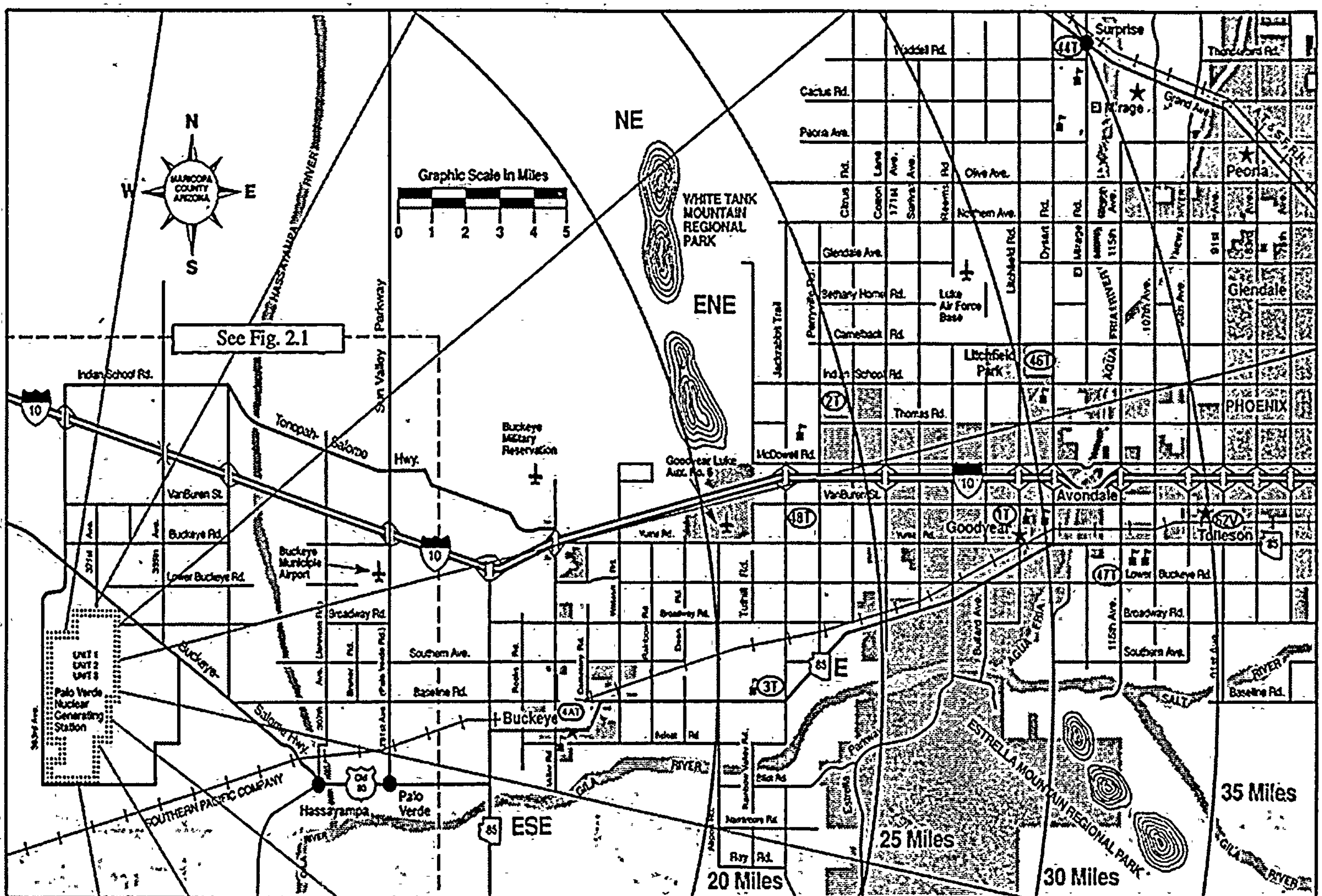
KEY TO MAP

- Paved Road
- Unpaved Road
- 4WD Road
- Gas Pipeline
- Oil Pipeline
- Power Line
- Railroad
- Airstrip
- School
- Siren
- MP Milepost
- Palo Verde Nuclear Generating Station Boundary
- T Thermoluminescent Dosimeters (TLD)
- A Air Sample
- V Vegetation Sample
- W Water Sample
- Sample Sites

Palo Verde Nuclear Generating Station

Radiological Environmental Monitoring Program Sample Sites

0 – 10 Miles



KEY TO MAP

- Railroad
- Airstrip/Airport
- Schools Located Near Sample Sites
- Municipal Buildings
- Palo Verde Nuclear Generating Station Boundary
- T Thermoluminescent Dosimeters (TLD)
- A Air Sample
- (1) Sample Sites
- V Vegetation

Palo Verde Nuclear Generating Station

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SAMPLE SITES

0–35 Miles

FIGURE 2.2
REMP SAMPLE SITES
(0-35 MILES)

3. Sample Collection Program

3.1. Water

Water samples were collected by APS using PVNGS procedures.

Weekly samples were collected from the Reservoir, Evaporation Pond #1, Evaporation Pond #2, and four (4) residence wells. Samples were collected in one-gallon cubitainers and 500 ml glass bottles. One liter of each weekly one-gallon sample was added to a monthly composite, which is preserved with nitric acid (HNO_3). The composite samples are then analyzed for gamma emitters. Residence wells were also analyzed for gross beta activity. Weekly grab samples in glass bottles were composited quarterly and analyzed for tritium.

Quarterly grab samples were collected from onsite wells 34abb and 27ddc. Samples were collected in one-gallon cubitainers and 500 ml glass bottles. Samples were analyzed for gamma emitters and tritium.

Treated sewage effluent from the City of Phoenix is sampled as a weekly composite at the onsite Water Reclamation Facility and analyzed for gamma emitters. A monthly composite is analyzed for tritium.

3.2. Vegetation

Vegetation samples were collected by APS using PVNGS procedures.

Vegetation samples are scheduled to be collected monthly, as available, and were analyzed for gamma emitters.

3.3. Milk

Milk sampling was performed from 1979-1995 and discontinued in 1995. This was justified since there were no sample locations within 5 miles of PVNGS. The control location sample is also not taken since there would be no valid 'indicator' locations with which to compare results. If milk animals are located because of the annual land use census, an evaluation will be initiated to consider re-establishing a milk sample program.

3.4. Air

Air samples were collected by APS using PVNGS procedures.

Air particulate filters and charcoal canisters were exchanged at ten (10) sites on a weekly basis. Particulate filters were analyzed for gross beta. Charcoal canisters were analyzed for I-131. Particulate filters were composited quarterly, by location, and analyzed for gamma emitters.

3.5. Sludge and Sediment

Sludge and sediment samples were collected by APS using PVNGS procedures.

Sludge samples were obtained from the Water Reclamation Facility (WRF) centrifuge and analyzed for gamma emitters. Samples were collected using 1000 ml plastic bottles.

No cooling tower sludge was disposed of in the onsite landfill during in 1998. Therefore, no sample results are contained in this report.

Bottom sediment/sludge samples were obtained from Evaporation Pond #1 and #2 and analyzed for gamma emitters. Samples were collected from a boat at various locations using a bucket to preserve the integrity of the pond liners.

Sediment samples were collected from Sedimentation Basin #2 and analyzed for gamma emitters. Samples were collected using 1000 ml plastic bottles.

3.6. Soil

Soil samples were collected onsite during the fourth quarter by APS using PVNGS procedures. Sixteen (16) samples were obtained, one in each of the 16 meteorological sectors, at the site boundary.

All samples were collected in plastic bags, sieved, weighed, and analyzed for gamma emitters.

4. Analytical Procedures

The procedures described in this report are those used by APS to routinely analyze samples.

4.1. Air Particulate

4.1.1. Gross Beta

A glass fiber filter sample is placed in a 50-mm stainless steel planchet and counted for gross beta activity utilizing a low-background gas flow, proportional counter.

4.1.2. Gamma Spectroscopy

The glass fiber filters are placed in a standard geometry container and counted on a multichannel analyzer equipped with an intrinsic Ge or Ge (Li) detector. The resulting spectrum is analyzed by computer and specific nuclides, if present, are identified and quantified.

4.2. Airborne Radioiodine

The charcoal canister is counted on a multichannel analyzer equipped with an intrinsic Ge or Ge (Li) detector. The resulting spectrum is analyzed by computer and I-131, if present, is identified and quantified.

4.3. Vegetation

4.3.1. Gamma Spectroscopy

The sample is pureed in a food processor, placed in a one-liter plastic marinelli beaker, weighed, and counted on a multichannel analyzer equipped with an intrinsic Ge or Ge (Li) detector. The resulting spectrum is analyzed by computer and specific nuclides, if present, are identified and quantified.

4.4. Sludge/Sediment

4.4.1. Gamma Spectroscopy

The wet/dry sample is placed in a one-liter plastic marinelli beaker, weighed, and counted on a multichannel analyzer equipped with an intrinsic Ge or Ge (Li) detector. The resulting spectrum is analyzed by computer and specific nuclides, if present, are identified and quantified.

4.5. Water

4.5.1. Gamma Spectroscopy

The sample is measured, placed in a one-liter plastic marinelli beaker, and counted on a multichannel analyzer equipped with an intrinsic Ge or Ge (Li) detector. The resulting spectrum is analyzed by computer and specific nuclides if present, are identified and quantified.

4.5.2. Tritium

The sample is evaluated to determine the appropriate method of preparation prior to counting. If the sample contains suspended solids or is turbid, it may be filtered, distilled, and/or de-ionized, as appropriate. Eight (8) milliliters of sample are

mixed with fifteen (15) milliliters of liquid scintillation cocktail. The mixture is dark adapted and counted using a liquid scintillation counting system.

4.5.3. Gross Beta

A 200-250 milliliter sample is placed in a beaker. Five (5) milliliters of concentrated nitric (HNO_3) acid is added and the sample is evaporated down to about twenty (20) milliliters. The remaining sample is quantitatively transferred to a stainless steel planchet. The sample is heated to dryness and counted for gross beta in a gas flow, proportional counter.

4.6. Soil

4.6.1. Gamma Spectroscopy

The samples are sieved, placed in a one-liter plastic marinelli beaker, and weighed. The samples are then counted on a multichannel analyzer equipped with an intrinsic Ge or Ge (Li) detector. The resulting spectrum is analyzed by computer and specific nuclides if present, are identified and quantified.

5. Nuclear Instrumentation

5.1. Canberra Gamma Spectrometer

The Gamma Spectrometer consists of a Canberra System equipped with two intrinsic detectors having resolutions of 1.81 keV and 1.88 keV (as determined by full width half max with an energy of 0.5 keV per channel) and respective efficiencies of 16.3% and 38.4% (as determined by the manufacturer with Co-60). The Canberra System is used for all gamma counting. The system uses Canberra developed software (automatic radionuclide analysis) to search and identify, as well as quantify, the peaks of interest.

5.2. Beckman Liquid Scintillation Spectrometer

A Beckman LS-3801 Liquid Scintillation Counter is used for tritium determinations. The system background averages approximately 20 cpm with a counting efficiency of about 40% using a quenched standard.

5.3. Tennelec LB5100 Low Background Counting System

The LB5100 is a low background, gas flow proportional counter. The system contains an automatic sample changer capable of counting 50 samples in succession. Average beta background count rate is about 1-2 cpm with a beta efficiency of about 30% (Cs-137).

6. Isotopic Detection Limits and Reporting Criteria

6.1. Lower Limits of Detection

The lower limits of detection (LLD) and the method for calculation are specified in the PVNGS ODCM, Reference 4. ODCM required *a priori* LLDs are presented in Table 6.1. For reference, *a priori* LLDs are indicated at the top of data tables for samples having required LLD values.

6.2. Data Reporting Criteria

All results that are greater than the Minimum Detectable Activity (MDA) (a posteriori LLD) are reported as positive activity with its associated 2σ counting error.
All results that are less than MDA are reported as less than values at the associated MDA. For example, if the MDA is 12 pCi/liter, the value is reported as <12.

Typical MDA values are presented in Table 6.3.

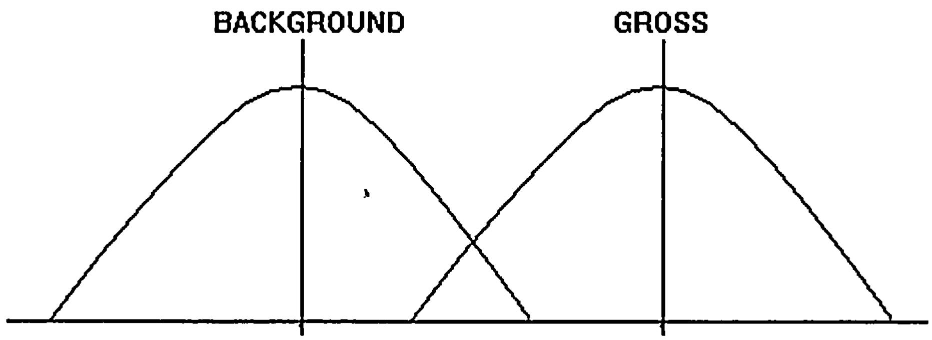
Occasionally the PVNGS ODCM *a priori* LLDs may not be achieved as a result of:

- Background fluctuations
- Unavoidably small sample sizes
- The presence of interfering nuclides
- Self absorption corrections
- Decay corrections for short half-life radionuclides
- Other uncontrollable circumstances

In these instances, the contributing factors will be noted in the table where the data are presented.

6.3. LLD and Reporting Criteria Overview

Making a reasonable estimate of the limits of detection for a counting procedure or a radiochemical method is usually complicated by the presence of significant background. It must be considered that the background or blank is not a fixed value but that a series of replicates would be normally distributed. The desired net activity is thus the difference between the gross and background activity distributions. The interpretation of this difference becomes a problem if the two distributions intersect as indicated in the diagram.



If a sufficient number of replicate analyses are run, it is to be expected that the results would fall in a normal Gaussian Distribution. Standard statistics allow an estimate of the probability of any particular deviation from the mean value. It is common practice to report the mean ± one or two standard deviations as the result. In routine analysis, such replication is not carried out, and it is not possible to report a Gaussian standard deviation. With counting procedures, however, it is possible to estimate a Poisson standard deviation directly from the count. Data is commonly reported as the measured value ± one or two Poisson standard deviations. The reported values are then considered to give some indication of the range in which the true value might be expected to occur.

The simplest possible case to consider would be one where the background is negligible and the sample activity is zero. It is sometimes not realized that if a series of counts is taken on such a system, half of the net values should be less than zero. Negative counts are not possible, of course. However, when there is an appreciable background, the entire scale is raised. The resulting situation: half of the sample counts on a zero activity sample would be less than background. The negative net counts occur frequently in low-level measurements, causing considerable concern. Actually, such results are to be expected.

A LLD is the smallest amount of sample activity that will yield a net count for which there is confidence at a predetermined level that activity is present. LLDs are calculated values for individual nuclides based on a number of different factors including sample size, counting efficiency and background count rate of the instrument, the background and sample counting time, the decay time, and the chemical recovery of the analytical procedures. A minimum detectable activity value (MDA) is the smallest amount of activity that can be detected in an actual sample and uses the values obtained from the instrument and outcome of the analytical process. Therefore, the MDA values may differ from the calculated LLD values if the sample size and chemical recovery, decay values, or the instrument efficiency, background, or count time differed from those used in the LLD calculation.

The factors governing the calculation of the LLD and MDA values are discussed below:

1. Sample Size

2. Counting Efficiency

The fundamental quantity in the measurement of a radioactive substance is the number of disintegrations per unit time. As with most physical measurements in analytical chemistry, it is seldom possible to make an absolute measurement of the disintegration rate, but rather it is necessary to compare the sample with one or more standards. The standards determine the counter efficiency that may then be used to convert sample counts per minute (cpm) to disintegrations per minute (dpm).

3. Background Count Rate

Any counter will show a certain counting rate without a sample in position. This background counting rate comes from several sources: 1) natural environmental radiation from the surroundings, 2) cosmic radiation, and 3) the natural radioactivity in the counter material itself. The background counting rate will depend on the amounts of these types of radiation and the sensitivity of the counter to the radiation.

4. Background and Sample Counting Time

The amount of time devoted to the counting of the background depends on the level of activity being measured. In general, with low-level samples, this time should be about equal to that devoted to counting a sample.

5. Time Interval between Sample Collection and Counting

Decay measurements are useful in identifying certain short-lived isotopes. The disintegration constant is one of the basic characteristics of a specific radionuclide and is readily determined, if the half-life is sufficiently short. In order to ensure the required LLDs are achieved, conservative values are used in decay correction to allow for transit time and sample processing.

6. Chemical Recovery of the Analytical Procedures

Most radiochemical analyses are carried out in such a way that losses occur during the separations. These losses occur due to the large number of contaminants that may be present and interfere during chemical separations. Thus, it is necessary to include a technique for estimating these losses in the development of the analytical procedure.

Table 6.1 ODCM REQUIRED LOWER LIMITS OF DETECTION (*a priori*)

ANALYSIS/ NUCLIDE	WATER (pCi/liter)	AIRBORNE PARTICULATE or GAS (pCi/m^3)	MILK (pCi/liter)	VEGETATION (pCi/kg, wet)
gross beta	4	0.01		
tritium	2000*			
Mn-54	15			
Fe-59	30			
Co-58, 60	15			
Zn-65	30			
Zr-95	30			
Nb-95	15			
I-131	1**	0.07	1	60
Cs-134	15	0.05	15	60
Cs-137	18	0.06	18	80
Ba-140	60		60	
La-140	15		15	

NOTES:

* If no drinking water pathway exists, a value of 3000 pCi/liter may be used.
** If no drinking water pathway exists, a value of 15 pCi/liter may be used.

This list does not mean that only these nuclides are to be detected and reported. Other peaks that are measurable and identifiable, together with the above nuclides, shall also be identified and reported.

Milk sampling was not performed in 1998 since no milk animals have been located within 5 miles of PVNGS.

Table 6.2 ODCM REQUIRED REPORTING LEVELS

ANALYSIS/ NUCLIDE	WATER (pCi/liter)	AIRBORNE PARTICULATE or GAS (pCi/m^3)	MILK (pCi/liter)	VEGETATION (pCi/kg, wet)
tritium	20,000*			
Mn-54	1,000			
Fe-59	400			
Co-58	1,000			
Co-60	300			
Zn-65	300			
Zr/Nb-95	400			
I-131	2**	0.9	3	100
Cs-134	30	10	60	1,000
Cs-137	50	20	70	2,000
Ba/La-140	200		300	

NOTES:

* For drinking water samples. This is a 40CFR141 value. If no drinking water pathway exists, a value of 30,000 pCi/liter may be used.

** If no drinking water pathway exists, a reporting level of 20 pCi/liter may be used.

Milk sampling was not performed in 1998 since no milk animals have been located within 5 miles of PVNGS.

Table 6.3 TYPICAL MDA VALUES

ANALYSIS/ NUCLIDE	WATER (pCi/liter)	AIRBORNE PARTICULATE or GAS (pCi/m^3)	VEGETATION (pCi/kg, wet)
gross beta	3	0.008	
tritium	300		
Mn-54	11		
Fe-59	20		
Co-58	10		
Co-60	10		
Zn-65	24		
Zr-95	18		
Nb-95	10		
I-131	12 [a]	0.03 [b]	20
Cs-134	12	0.02 [b]	20
Cs-137	13	0.02 [b]	25
Ba-140	38		
La-140	11		

NOTES:

a - low level I-131 is not required since there is no drinking water pathway
b - based on 433 m^3 volume

Milk sampling was not performed in 1998 since no milk animals have been located within 5 miles of PVNGS.

7. Interlaboratory Comparison Program

7.1. Quality Control Program

APS maintains an extensive QA/QC Program that provides certainty that samples are collected, handled, tracked, and analyzed to specified requirements. This program includes appropriate elements of USNRC Regulatory Guide 4.15, Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment, Rev. 1. Included in the program are procedures for sample collection, preparation and tracking, sample analysis, equipment calibration and checks, and ongoing participation in an interlaboratory comparison program. Duplicate/replicate samples are analyzed routinely to verify analytical precision and sample methodology. Comprehensive data reviews are performed including trending of data where appropriate.

During 1998, APS analyzed the following sample types under the interlaboratory comparison program;

- Beta/Gamma/ in Air Filter
- I-131 in Air
- Beta in Water
- Gamma in Water
- Tritium in Water

7.2. Intercomparison Results

APS participates in a crosscheck program using vendor supplied blind radionuclide samples and/or EPA supplied samples. All interlaboratory results in 1998 were acceptable. Results for the interlaboratory comparison program are presented in Table 7.1.

TABLE 7.1 INTERLABORATORY COMPARISON RESULTS

(All results in pCi/l unless otherwise annotated)

Type/Date	Nuclide/ Analysis	EPA Known Value	APS Value	Normalized Deviation of Known	Accept/Reject (a)
Iodine in Water (2-6-98)	I-131	104.9	110.3	0.90	Accept
Gamma in Water (6-5-98)	Co-60	12.0	14.7	0.92	Accept
	Zn-65	104.0	109.7	0.98	Accept
	Cs-134	31.0	32.3	0.46	Accept
	Cs-137	35.0	39.0	1.39	Accept
	Ba-133	40.0	37.0	-1.04	Accept
Blind Water (4-21-98)	gross beta	94.7	87.4	-1.26	Accept
	Cs-134	22.0	21.0	-0.35	Accept
	Cs-137	10.0	10.7	0.23	Accept
	Co-60	50.0	51.3	0.46	Accept
Water (1-30-98 and 7-24-98)	gross beta	12.8	10.9	-0.66	Accept
	gross beta	3.9	7.2	1.13	Accept
Tritium in Water (3-13-98)	tritium	2155.0	1945	-1.05	Accept

Notes:

(a) Acceptance criteria is $-3.0 \leq N \leq 3.0$ (where N is the Normalized Deviation of Known)

TABLE 7.1 INTERLABORATORY COMPARISON RESULTS

(All results in pCi/l unless otherwise annotated)

Type	Nuclide/ Analysis	Known Value	APS Value	Uncertainty (1 sigma)	Resolution (APS)	Ratio (APS/ Known)	Accept/Reject
Air Filter (pCi/filter)	Ce-141	71	68	2	34	0.96	Accept
	Cr-51	205	190	16	12	0.93	Accept
	Cs-134	86	71	3	24	0.83	Accept
	Cs-137	164	164	3	55	1.00	Accept
	Mn-54	138	142	3	47	1.03	Accept
	Fe-59	97	114	6	19	1.18	Accept
	Zn-65	145	160	6	27	1.10	Accept
	Co-60	87	88	3	29	1.01	Accept
Air (pCi/filter)	gross beta	75	62	2	31	0.83	Accept
Air (pCi/canister)	I-131	79	91	10	9	1.15	Accept

NRC Acceptance Criteria (a)

Resolution	Ratio
4-7	0.5-2.0
8-15	0.6-1.66
16-50	0.75-1.33
51-200	0.80-1.25
>200	0.85-1.18

(a) From NRC Inspection Manual, procedure #84750, "Radioactive Waste Systems; Water Chemistry; Confirmatory Measurements and Radiological Environmental Monitoring"

8. Data Interpretations and Conclusions

Associated with the analytical process are potential random and systematic errors. Systematic errors can be caused by instrument malfunctions, incomplete precipitation, and back scattering and self-absorption. Random errors are beyond the control of the analyst and are caused by the random nature of radioactive decay.

Efforts are made to eliminate both systematic and random errors in the data reported. Systematic errors are eliminated by performing reviews throughout the analysis. For example, instruments are checked routinely with radioactive sources and recovery and self-absorption factors based on individual sample analyses are incorporated into the calculation equations where necessary. Random errors are reduced by comparing all data to historical data for the same site and performing cross comparisons between analytical results when available. In addition, when data do not appear to match historical results, analyses may be rerun on a separate aliquot of the sample to verify the presence of the activity. The acceptance of data is dependent upon the results of quality control samples and is part of the data review process for all analytical results.

The "plus or minus value" reported with each analytical result represents the counting error associated with the result and gives the 95% confidence (2σ) interval around the data.

Most samples contain radioactivity associated with natural background/cosmic radioactivity (e.g. K-40, Th-234, and Be-7). Gross beta results for drinking water and air are due to natural background. **Gamma emitting radionuclides, which can be attributed to natural background sources, are not indicated in this report**.

Results and interpretation of the data for all of the samples analyzed during 1998 are presented in the following sections. Assessment of pre-operational and operational data revealed no changes to environmental radiation levels. There were no observed radiological impacts on the environment due to PVNGS operations in 1998.

8.1. Air Particulates

Weekly gross beta results, in quarterly format, are presented in Tables 8.1 and 8.2 and depicted in graphs in Figures 8.1 and 8.2. Gross beta activity ranged from 0.007 to 0.055 pCi/m^3. The associated counting error ranged from 0.001 to 0.004 pCi/m^3. Mean quarterly activities are calculated using all weekly activities except those marked invalid. Also presented in the tables are the weekly mean values of all the sites as well as the relative standard deviation (RSD) of the data. The findings are consistent with pre-operational baseline and previous operational results. Figure 8.2 shows the results of the gross beta in air from the pre-operational phase compared to the 1991-1998 gross beta in air results. As can be seen, the indicator sites trend consistently with the control site. Table 8.3 displays the results of gamma spectroscopy on the quarterly composites. The results are summarized in Table 11.1. No Cs-134 or Cs-137 was observed.

8.2. Airborne Radioiodine

Tables 8.4 through 8.5 present the quarterly radioiodine results. No radioiodine was detected in any of the samples.

8.3. Vegetation

Table 8.6 presents gamma isotopic data for the vegetation samples. No gamma emitting nuclides were observed in any of the samples.

8.4. Drinking Water

Samples were analyzed for gross beta, tritium, and gamma emitting nuclides. Results of these analyses are presented in Table 8.7. No tritium or gamma-emitting nuclides were detected in any samples. Gross beta activity ranged from less than detectable, to a high of 10.0 ± 2.5 pCi/l (Sheppard farm, November composite).

8.5. Groundwater

Groundwater samples were analyzed for tritium and gamma emitting nuclides. Results obtained from the analysis of the samples are presented in Table 8.8.

No tritium or gamma emitting nuclides were observed in any of the samples.

8.6. Surface Water

Surface water samples from the Reservoir and Evaporation Ponds were analyzed for tritium and gamma emitting nuclides. The Reservoir contains processed sewage water from the City of Phoenix and is approximately 80 acres in size. The two Evaporation Ponds receive mostly circulating water from main turbine condenser cooling and are about 250 acres each. Results are presented in Table 8.9. Cs-137 was observed in Evaporation Pond # 2 in four of twelve monthly composite samples. The concentrations were 9 - 23 pCi/l.

Tritium was routinely observed in Evaporation Ponds 1 and 2. The highest concentration in Evaporation Pond #1 was 1527 ± 194 pCi/l and the highest concentration in Evaporation Pond #2 was 1137 ± 186 pCi/l. The tritium has been attributed to plant gaseous effluent releases.

Water Reclamation Facility (WRF) influent (Phoenix sewage effluent) samples collected by the WRF were analyzed for gamma emitting nuclides and tritium. The results, presented in Table 8.9, demonstrate that I-131 was observed routinely. The highest I-131 concentration was 71 ± 16 pCi/l (week of February 10). The results are consistent with assays from the previous years. None of the samples analyzed indicated the presence of tritium.

Table 8.9 also presents gamma spectroscopy and tritium measurements of samples collected from Sedimentation Basin #2. This basin collects rain waters from site runoff and was dry for most of the year. No gamma emitting nuclides were detected in these samples. Tritium was detected in ten of eighteen samples ranging from 328 to 3044 pCi/liter. The tritium in this basin has been attributed to plant gaseous effluent releases.

8.7. Sludge and Sediment

8.7.1. WRF Centrifuge waste sludge

Sludge samples were obtained from the Water Reclamation Facility (WRF) centrifuge and analyzed by gamma spectroscopy. The I-131 in the WRF waste centrifuge sludge is consistent with historical values and, as previously discussed, is due to radiopharmaceuticals in the WRF influent. I-131 was present in all forty-nine samples ranging from 588 to 3891 pCi/kg.

In-111 was also identified in the sludge on occasion. The highest In-111 concentration was 191 ± 20 pCi/l (week of March 17). It was previously established that In-111 is in use in the Phoenix area as a radiopharmaceutical. Results for WRF centrifuge waste sludge can be found in Table 8.10.

8.7.2. Sedimentation Basin #2 sediment

Sedimentation Basin #2 sediment samples were analyzed by gamma spectroscopy. No gamma emitting nuclides were observed in any of the samples. Sample results can be found in Table 8.10.

8.7.3. Evaporation Ponds #1 and #2 sediment

No gamma emitting nuclides were observed in any of the samples from Evaporation Pond #1. Evaporation Pond #2 samples indicated low levels of Cs-137 and Co-60. These radionuclides are evidently due to previous primary-to-secondary leaks that resulted in their transport to the onsite ponds and are consistent with previous results. Sample results can be found in Table 8.10.

8.7.4. Cooling Tower sludge

No cooling tower sludge was disposed of in the onsite landfill in 1998.

8.8. Soil

Soil samples were collected at sixteen locations at the site boundary and analyzed by gamma spectroscopy. Thirteen of sixteen samples contained Cs-137. All results were within the range of Cs-137 identified in pre-operational soil studies. See Table 8.11 for results.

8.9. Summary of Results

Sample data are presented in graphic form in Figures 8.1-8.6. When practical, comparisons to pre-operational data are displayed. A summary of the sample results is presented in Table 11.1 (ODCM required samples only).

TABLE 8.1 PARTICULATE GROSS BETA IN AIR 1st - 2nd QUARTER

ODCM required samples denoted by *

units are pCi/m^3

1st Quarter

Week #	START DATE	STOP DATE	Site 4 (control)	Site 6A*	Site 7A	Site 14A*	Site 15*	Site 17A	Site 21	Site 29*	Site 35	Site 40*	Mean	RSD (%)
1	29-Dec-97	5-Jan-98	0.034	0.034	0.038	0.035	0.035	0.037	0.039	0.041	0.038	0.038	0.037	6.3
2	5-Jan-98	13-Jan-98	0.032	0.033	0.039	0.030	0.034	0.032	0.034	0.033	0.030	0.031	0.033	8.0
3	13-Jan-98	20-Jan-98	0.039	0.041	0.045	0.036	0.035	0.036	0.038	0.037	0.032	0.036	0.038	9.5
4	20-Jan-98	28-Jan-98	0.034	0.042	0.039	0.032	0.033	0.032	0.037	0.032	0.030	0.033	0.034	10.9
5	28-Jan-98	3-Feb-98	0.040	0.039	0.043	0.039	0.040	0.039	0.040	0.042	0.039	0.042	0.040	3.7
6	3-Feb-98	10-Feb-98	0.012	0.011	0.009	0.010	0.012	0.009	0.009	0.009	0.011	0.011	0.010	12.2
7	10-Feb-98	18-Feb-98	0.023	0.023	0.023	0.022	0.020	0.023	0.020	invalid (a)	0.022	0.021	0.022	5.8
8	18-Feb-98	23-Feb-98	0.018	0.019	0.020	0.020	0.018	0.020	0.021	0.019	0.017	0.018	0.019	6.6
9	23-Feb-98	2-Mar-98	0.020	0.022	0.018	0.018	0.018	0.021	0.021	0.021	0.020	0.019	0.020	7.5
10	2-Mar-98	9-Mar-98	0.027	0.027	0.026	0.024	0.026	0.028	0.027	0.022	0.028	0.026	0.026	7.1
11	9-Mar-98	16-Mar-98	0.033	0.038	0.035	0.032	0.029	0.032	0.034	0.036	0.033	0.037	0.034	7.9
12	16-Mar-98	24-Mar-98	0.032	0.030	0.034	0.031	0.031	0.029	0.031	0.026	0.025	0.023	0.029	11.8
13	24-Mar-98	30-Mar-98	0.010	0.008	0.010	0.007	0.009	0.008	0.010	0.011	0.011	0.010	0.009	14.4
	Mean		0.027	0.028	0.029	0.026	0.026	0.027	0.028	0.027	0.026	0.027	0.027	4.0

2nd Quarter

Week #	START DATE	STOP DATE	Site 4 (control)	Site 6A*	Site 7A	Site 14A*	Site 15*	Site 17A	Site 21	Site 29*	Site 35	Site 40*	Mean	RSD (%)
14	30-Mar-98	6-Apr-98	0.013	0.011	0.011	0.013	0.012	0.007	0.014	0.013	0.014	0.010	0.012	18.2
15	6-Apr-98	14-Apr-98	0.020	0.019	0.023	0.017	0.020	0.017	0.020	0.020	0.020	0.021	0.020	9.0
16	14-Apr-98	21-Apr-98	0.021	0.023	0.025	0.022	0.023	0.022	0.024	0.026	0.024	0.025	0.024	6.7
17	21-Apr-98	28-Apr-98	0.028	0.032	0.027	0.029	0.030	0.028	0.029	0.032	0.030	0.030	0.030	5.6
18	28-Apr-98	4-May-98	0.037	0.036	0.040	0.036	0.038	0.036	0.042	0.033	0.037	0.038	0.037	6.6
19	4-May-98	11-May-98	0.016	0.012	0.011	0.012	0.012	0.013	0.011	0.014	0.015	0.014	0.013	13.1
20	11-May-98	18-May-98	0.021	0.021	0.019	0.015	0.019	0.017	0.020	0.019	0.017	0.014	0.018	13.2
21	18-May-98	26-May-98	0.026	0.029	0.030	0.028	0.027	0.031	0.028	0.028	0.030	0.031	0.029	5.9
22	26-May-98	1-Jun-98	0.020	0.016	0.016	0.017	0.017	0.018	0.019	0.017	0.016	0.018	0.017	7.8
23	1-Jun-98	8-Jun-98	0.018	0.017	0.023	0.018	0.021	0.021	0.024	0.022	0.024	0.019	0.021	12.5
24	8-Jun-98	16-Jun-98	0.024	0.026	0.026	0.025	0.027	0.022	0.027	0.027	0.026	0.026	0.026	6.2
25	16-Jun-98	22-Jun-98	0.020	0.016	0.020	0.017	0.017	0.015	0.013	0.011	0.024	0.014	0.017	22.9
26	22-Jun-98	29-Jun-98	0.027	0.027	0.024	0.025	0.023	0.023	0.027	0.022	0.025	0.023	0.025	7.7
	Mean		0.022	0.022	0.023	0.021	0.022	0.021	0.023	0.022	0.023	0.022	0.022	3.5

(a) sample invalidated due to sample equipment problems resulting in abnormal 'as found' flow rate

TABLE 8.2 PARTICULATE GROSS BETA IN AIR 3rd - 4th QUARTER

ODCM required samples denoted by *

units are pCi/m^3

3rd Quarter

Week #	START DATE	STOP DATE	Site 4	(control) Site 6A*	Site 7A	Site 14A*	Site 15*	Site 17A	Site 21	Site 29*	Site 35	Site 40*	Mean	RSD (%)
27	29-Jun-98	6-Jul-98	0.028	0.021	0.024	0.023	0.021	0.014	0.022	0.020	0.022	0.017	0.021	17.9
28	6-Jul-98	13-Jul-98	0.030	0.026	0.026	0.024	0.023	0.023	0.026	0.025	0.025	0.029	0.026	9.0
29	13-Jul-98	20-Jul-98	0.030	invalid (a)	0.030	0.037	0.035	0.032	0.030	0.034	0.034	0.036	0.033	8.2
30	20-Jul-98	27-Jul-98	0.034	0.028	0.023	0.027	0.026	0.021	0.027	0.018	0.023	0.029	0.026	17.7
31	27-Jul-98	4-Aug-98	0.034	0.028	0.035	0.029	0.035	0.030	0.031	0.031	0.031	0.034	0.032	8.0
32	4-Aug-98	10-Aug-98	0.036	0.034	0.036	0.035	0.035	0.032	0.037	0.031	0.036	0.036	0.035	5.6
33	10-Aug-98	17-Aug-98	0.037	0.030	0.028	0.024	0.033	0.030	0.026	0.030	0.025	0.028	0.029	13.3
34	17-Aug-98	24-Aug-98	0.040	0.031	0.029	0.035	0.036	0.037	0.036	0.033	0.039	0.034	0.035	9.7
35	24-Aug-98	31-Aug-98	0.038	0.040	0.039	0.037	0.038	0.034	0.036	0.039	0.040	0.039	0.038	5.0
36	31-Aug-98	8-Sep-98	0.038	invalid (a)	0.021	0.031	0.032	0.028	0.030	0.028	0.029	0.027	0.029	15.4
37	8-Sep-98	14-Sep-98	0.037	invalid (a)	0.025	invalid (a)	0.038	0.034	0.028	0.035	0.027	0.030	0.032	15.4
38	14-Sep-98	21-Sep-98	0.038	invalid (a)	0.028	0.026	0.029	0.029	0.030	0.020	0.039	0.034	0.030	19.6
39	21-Sep-98	28-Sep-98	0.029	0.025	0.033	0.027	0.031	0.029	0.029	0.033	0.031	0.026	0.029	9.4
	Mean		0.035	0.029	0.029	0.030	0.032	0.029	0.030	0.029	0.031	0.031	0.030	5.8

4th Quarter

Week #	START DATE	STOP DATE	Site 4	Site 6A*	Site 7A	Site 14A*	Site 15*	Site 17A	Site 21	Site 29*	Site 35	Site 40*	Mean	RSD (%)
40	28-Sep-98	5-Oct-98	0.032	0.023	0.020	0.026	0.036	0.022	0.028	0.026	0.037	0.032	0.028	20.8
41	5-Oct-98	12-Oct-98	0.033	0.025	0.037	0.033	0.034	0.026	0.036	0.031	0.031	0.028	0.031	12.8
42	12-Oct-98	19-Oct-98	0.035	0.032	0.029	0.022	0.027	0.021	0.022	0.029	0.032	0.033	0.028	17.9
43	19-Oct-98	26-Oct-98	0.027	0.024	0.022	0.021	0.026	0.023	0.024	0.026	0.031	0.024	0.025	11.5
44	26-Oct-98	2-Nov-98	0.030	0.030	0.035	0.029	0.033	0.027	0.034	0.033	0.033	0.033	0.032	8.0
45	2-Nov-98	9-Nov-98	0.038	0.038	0.042	0.037	0.028	0.035	0.041	0.040	0.043	0.035	0.038	11.6
46	9-Nov-98	16-Nov-98	0.034	0.037	0.032	0.032	0.030	0.029	0.035	0.029	0.025	0.024	0.031	13.6
47	16-Nov-98	23-Nov-98	0.039	0.054	0.053	0.043	0.046	0.040	0.050	0.049	0.047	0.045	0.047	10.9
48	23-Nov-98	30-Nov-98	0.047	0.049	0.039	0.036	0.037	0.033	0.050	0.038	0.033	0.040	0.040	15.7
49	30-Nov-98	7-Dec-98	0.028	0.026	0.026	0.023	0.025	0.024	0.028	0.025	0.026	0.021	0.025	8.5
50	7-Dec-98	14-Dec-98	0.039	0.033	0.028	0.030	0.033	0.024	0.039	0.036	0.027	0.028	0.032	16.3
51	14-Dec-98	21-Dec-98	0.041	0.038	0.041	0.040	0.035	0.035	0.038	0.039	0.037	0.032	0.038	7.7
52	21-Dec-98	28-Dec-98	0.051	0.051	0.055	0.046	0.044	0.041	0.049	0.047	0.032	0.039	0.046	14.9
	Mean		0.036	0.035	0.035	0.032	0.033	0.029	0.036	0.034	0.033	0.032	0.034	6.8
	(a) sample invalid due to power outage													
	Annual Average		0.030	0.029	0.029	0.027	0.028	0.026	0.029	0.028	0.028	0.028	0.028	3.8

TABLE 8.3 GAMMA IN AIR FILTER COMPOSITES

ODCM required samples denoted by *
units are pCi/m^3

QUARTER ENDPOINT	NUCLIDE	Site 4	(control) Site 6A*	Site 7A	Site 14A*	Site 15*	Site 17A	Site 21	Site 29*	Site 35	Site 40*
30-Mar-98	Cs-134	<0.0023	<0.0017	<0.0020	<0.0010	<0.0024	<0.0016	<0.0021	<0.0019	<0.0021	<0.0023
	Cs-137	<0.0013	<0.0013	<0.0017	<0.0020	<0.0021	<0.0018	<0.0021	<0.0022	<0.0015	<0.0020
29-Jun-98	Cs-134	<0.0019	<0.0018	<0.0017	<0.0020	<0.0018	<0.0016	<0.0013	<0.0018	<0.0024	<0.0021
	Cs-137	<0.0014	<0.0014	<0.0019	<0.0017	<0.0017	<0.0016	<0.0012	<0.0016	<0.0019	<0.0018
28-Sep-98	Cs-134	<0.0016	<0.0029	<0.0023	<0.0019	<0.0017	<0.0016	<0.0019	<0.0020	<0.0019	<0.0020
	Cs-137	<0.0019	<0.0029	<0.0014	<0.0011	<0.0012	<0.0019	<0.0016	<0.0016	<0.0019	<0.0016
28-Dec-98	Cs-134	<0.0023	<0.0018	<0.0019	<0.0015	<0.0019	<0.0017	<0.0016	<0.0023	<0.0017	<0.0019
	Cs-137	<0.0019	<0.0017	<0.0018	<0.0019	<0.0020	<0.0015	<0.0019	<0.0016	<0.0018	<0.0017

TABLE 8.4 RADIOIODINE IN AIR 1st - 2nd QUARTER

ODCM required samples denoted by *

units are pCi/m^3

1st Quarter

Week #	START DATE	STOP DATE	Site 4	(control) Site 6A*	Site 7A	Site 14A*	Site 15*	Site 17A	Site 21	Site 29*	Site 35	Site 40*
						required LLD <0.070						
1	29-Dec-97	5-Jan-98	<0.026	<0.022	<0.025	<0.025	<0.025	<0.021	<0.017	<0.027	<0.025	<0.021
2	5-Jan-98	13-Jan-98	<0.012	<0.023	<0.019	<0.011	<0.021	<0.012	<0.023	<0.010	<0.020	<0.012
3	13-Jan-98	20-Jan-98	<0.027	<0.009	<0.021	<0.013	<0.026	<0.012	<0.021	<0.024	<0.008	<0.026
4	20-Jan-98	28-Jan-98	<0.022	<0.011	<0.022	<0.013	<0.021	<0.021	<0.012	<0.025	<0.026	<0.013
5	28-Jan-98	3-Feb-98	<0.029	<0.030	<0.026	<0.028	<0.013	<0.027	<0.012	<0.027	<0.013	<0.029
6	3-Feb-98	10-Feb-98	<0.020	<0.014	<0.019	<0.023	<0.024	<0.011	<0.023	<0.010	<0.013	<0.022
7	10-Feb-98	18-Feb-98	<0.010	<0.009	<0.021	<0.010	<0.011	<0.020	<0.024	invalid (a)	<0.034	<0.016
8	18-Feb-98	23-Feb-98	<0.030	<0.018	<0.030	<0.016	<0.025	<0.027	<0.029	<0.014	<0.025	<0.015
9	23-Feb-98	2-Mar-98	<0.017	<0.012	<0.024	<0.022	<0.018	<0.020	<0.024	<0.008	<0.023	<0.022
10	2-Mar-98	9-Mar-98	<0.024	<0.023	<0.012	<0.033	<0.011	<0.027	<0.028	<0.017	<0.029	<0.014
11	9-Mar-98	16-Mar-98	<0.012	<0.024	<0.010	<0.021	<0.012	<0.025	<0.027	<0.029	<0.011	<0.025
12	16-Mar-98	24-Mar-98	<0.010	<0.018	<0.010	<0.023	<0.008	<0.021	<0.011	<0.025	<0.019	<0.010
13	24-Mar-98	30-Mar-98	<0.034	<0.028	<0.026	<0.025	<0.028	<0.036	<0.026	<0.033	<0.025	<0.032

2nd Quarter

Week #	START DATE	STOP DATE	Site 4	(control) Site 6A*	Site 7A	Site 14A*	Site 15*	Site 17A	Site 21	Site 29*	Site 35	Site 40*
						required LLD <0.070						
14	30-Mar-98	6-Apr-98	<0.027	<0.011	<0.024	<0.014	<0.019	<0.014	<0.017	<0.013	<0.028	<0.012
15	6-Apr-98	14-Apr-98	<0.025	<0.016	<0.013	<0.019	<0.013	<0.024	<0.014	<0.027	<0.015	<0.023
16	14-Apr-98	21-Apr-98	<0.026	<0.014	<0.026	<0.014	<0.019	<0.014	<0.024	<0.015	<0.026	<0.016
17	21-Apr-98	28-Apr-98	<0.030	<0.032	<0.026	<0.021	<0.022	<0.031	<0.031	<0.025	<0.027	<0.030
18	28-Apr-98	4-May-98	<0.029	<0.031	<0.027	<0.030	<0.030	<0.022	<0.029	<0.017	<0.030	<0.018
19	4-May-98	11-May-98	<0.021	<0.012	<0.018	<0.014	<0.025	<0.015	<0.024	<0.014	<0.014	<0.022
20	11-May-98	18-May-98	<0.026	<0.015	<0.029	<0.017	<0.031	<0.021	<0.018	<0.016	<0.018	<0.026
21	18-May-98	26-May-98	<0.017	<0.023	<0.028	<0.013	<0.023	<0.015	<0.014	<0.024	<0.025	<0.015
22	26-May-98	1-Jun-98	<0.028	<0.030	<0.015	<0.027	<0.015	<0.022	<0.015	<0.025	<0.017	<0.024
23	1-Jun-98	8-Jun-98	<0.025	<0.013	<0.019	<0.014	<0.026	<0.018	<0.020	<0.013	<0.023	<0.013
24	8-Jun-98	16-Jun-98	<0.021	<0.014	<0.021	<0.015	<0.018	<0.012	<0.013	<0.014	<0.012	<0.022
25	16-Jun-98	22-Jun-98	<0.030	<0.021	<0.027	<0.021	<0.015	<0.019	<0.028	<0.014	<0.022	<0.019
26	22-Jun-98	29-Jun-98	<0.014	<0.025	<0.015	<0.026	<0.015	<0.032	<0.017	<0.015	<0.031	<0.016

(a) sample invalidated due to sample equipment problems resulting in abnormal 'as found' flow rate

TABLE 8.5 RADIOIODINE IN AIR 3rd - 4th QUARTER

ODCM required samples denoted by *
units are pCi/m^3

Week #	START DATE	STOP DATE	Site 4	Site 6A* (control)	Site 7A	Site 14A*	Site 15*	Site 17A	Site 21	Site 29*	Site 35	Site 40*
3rd Quarter					required LLD <0.070							
27	29-Jun-98	6-Jul-98	<0.023	<0.024	<0.015	<0.025	<0.014	<0.021	<0.016	<0.020	<0.028	<0.016
28	6-Jul-98	13-Jul-98	<0.021	<0.015	<0.024	<0.015	<0.023	<0.015	<0.022	<0.014	<0.023	<0.016
29	13-Jul-98	20-Jul-98	<0.023	invalid (a)	<0.023	<0.017	<0.032	<0.016	<0.017	<0.021	<0.031	<0.018
30	20-Jul-98	27-Jul-98	<0.015	<0.024	<0.016	<0.025	<0.020	<0.021	<0.016	<0.014	<0.029	<0.014
31	27-Jul-98	4-Aug-98	<0.017	<0.013	<0.014	<0.012	<0.013	<0.020	<0.011	<0.019	<0.013	<0.017
32	4-Aug-98	10-Aug-98	<0.033	<0.017	<0.025	<0.017	<0.024	<0.017	<0.028	<0.014	<0.029	<0.034
33	10-Aug-98	17-Aug-98	<0.023	<0.014	<0.022	<0.015	<0.019	<0.014	<0.024	<0.015	<0.015	<0.026
34	17-Aug-98	24-Aug-98	<0.022	<0.012	<0.023	<0.013	<0.027	<0.013	<0.022	<0.015	<0.025	<0.016
35	24-Aug-98	31-Aug-98	<0.024	<0.025	<0.016	<0.024	<0.021	<0.016	<0.024	<0.015	<0.014	<0.024
36	31-Aug-98	8-Sep-98	<0.014	invalid (a)	<0.019	<0.015	<0.019	<0.015	<0.023	<0.014	<0.025	<0.014
37	8-Sep-98	14-Sep-98	<0.028	invalid (a)	<0.014	invalid (a)	<0.019	<0.016	<0.026	<0.018	<0.031	<0.017
38	14-Sep-98	21-Sep-98	<0.018	invalid (a)	<0.013	<0.020	<0.012	<0.025	<0.015	<0.024	<0.014	<0.015
39	21-Sep-98	28-Sep-98	<0.021	<0.023	<0.025	<0.017	<0.027	<0.022	<0.019	<0.030	<0.022	<0.026
4th Quarter					required LLD <0.070							
Week #	START DATE	STOP DATE	Site 4	Site 6A* (control)	Site 7A	Site 14A*	Site 15*	Site 17A	Site 21	Site 29*	Site 35	Site 40*
40	28-Sep-98	5-Oct-98	<0.026	<0.021	<0.015	<0.021	<0.015	<0.024	<0.013	<0.028	<0.014	<0.024
41	5-Oct-98	12-Oct-98	<0.017	<0.022	<0.017	<0.027	<0.015	<0.022	<0.016	<0.029	<0.027	<0.016
42	12-Oct-98	19-Oct-98	<0.015	<0.017	<0.022	<0.014	<0.023	<0.014	<0.013	<0.026	<0.023	<0.015
43	19-Oct-98	26-Oct-98	<0.014	<0.024	<0.021	<0.025	<0.018	<0.023	<0.014	<0.017	<0.012	<0.024
44	26-Oct-98	2-Nov-98	<0.025	<0.012	<0.014	<0.024	<0.021	<0.013	<0.024	<0.014	<0.026	<0.013
45	2-Nov-98	9-Nov-98	<0.017	<0.014	<0.021	<0.015	<0.026	<0.015	<0.021	<0.013	<0.028	<0.014
46	9-Nov-98	16-Nov-98	<0.025	<0.014	<0.022	<0.014	<0.020	<0.014	<0.020	<0.015	<0.014	<0.025
47	16-Nov-98	23-Nov-98	<0.021	<0.014	<0.025	<0.014	<0.018	<0.015	<0.015	<0.014	<0.015	<0.027
48	23-Nov-98	30-Nov-98	<0.022	<0.016	<0.027	<0.016	<0.024	<0.014	<0.026	<0.018	<0.026	<0.017
49	30-Nov-98	7-Dec-98	<0.023	<0.024	<0.014	<0.016	<0.020	<0.014	<0.027	<0.016	<0.013	<0.026
50	7-Dec-98	14-Dec-98	<0.012	<0.022	<0.014	<0.020	<0.014	<0.024	<0.015	<0.023	<0.019	<0.022
51	14-Dec-98	21-Dec-98	<0.031	<0.014	<0.026	<0.014	<0.011	<0.016	<0.014	<0.024	<0.014	<0.022
52	21-Dec-98	28-Dec-98	<0.023	<0.017	<0.030	<0.020	<0.029	<0.020	<0.037	<0.018	<0.028	<0.034

(a) sample invalidated due to power outage

TABLE 8.6 VEGETATION

ODCM required samples denoted by *
units are pCi/kg, wet

			<60	<60	<80
LOCATION	**TYPE**	**DATE COLLECTED**	**I-131**	**Cs-134**	**Cs-137**
STEELE RESIDENCE (SITE #47)*	Lettuce	10-Apr-98	<16	<17	<17
PAYNE RESIDENCE (SITE #64)	Collards	10-Apr-98	<18	<19	<19
ROUSSEAU FARMS (SITE #62)*	Cabbage	9-Jan-98	<12	<16	<15
	Cabbage	4-Feb-98	<32	<43	<32
	Napa	4-Feb-98	<27	<36	<22
	Bok Choy	4-Feb-98	<31	<34	<26
	Cabbage	4-Mar-98	<16	<18	<19
	Lettuce	4-Mar-98	<22	<22	<31
	Spinach	4-Mar-98	<19	<20	<15
	Cabbage	10-Apr-98	<11	<15	<14
	Cabbage	8-May-98	<22	<24	<24
	Collard Greens	18-Nov-98	<19	<19	<19
	Cabbage	18-Nov-98	<18	<24	<21
	Spinach	11-Dec-98	<32	<53	<43
	Collard Greens	11-Dec-98	<17	<24	<18
	Kale	11-Dec-98	<28	<41	<30
HOMMEL RESIDENCE (SITE #65)	Mustard greens	8-May-98	<36	<55	<46
HALLMAN RESIDENCE (SITE #52)*	Lettuce	5-Jun-98	<16	<20	<14

TABLE 8.7 DRINKING WATER

ODCM required samples denoted by *
units are pCi/liter

SAMPLE LOCATION	MONTH ENDPOINT	<15 Mn-54	<15 Co-58	<30 Fe-59	<15 Co-60	<30 Zn-65	<15 Nb-95	<30 Zr-95	<15 I-131	<15 Cs-134	<18 Cs-137	<60 Ba-140	<15 La-140	<2000 QTRLY Tritium	<4.0 Gross Beta
McARTHUR RESIDENCE (SITE #46) *	27-Jan-98	<7	<8	<13	<6	<16	<8	<14	<15	<8	<7	<38	<13		<2.6
	23-Feb-98	<9	<9	<19	<7	<18	<9	<15	<9	<10	<9	<29	<10		2.7 ± 1.6
	30-Mar-98	<7	<9	<14	<9	<20	<9	<16	<10	<9	<9	<32	<8	<287	4.2 ± 1.6
	28-Apr-98	<11	<11	<21	<14	<24	<12	<19	<12	<14	<11	<42	<10		3.0 ± 1.6
	26-May-98	<8	<7	<13	<8	<16	<8	<11	<10	<9	<8	<28	<8		<2.6
	29-Jun-98	<9	<9	<18	<10	<23	<11	<17	<10	<12	<10	<35	<9	<292	<2.7
	27-Jul-98	<10	<10	<19	<11	<26	<12	<18	<11	<14	<11	<40	<10		3.3 ± 1.8
	31-Aug-98	<12	<11	<20	<14	<25	<12	<17	<11	<13	<12	<42	<9		<2.6
	28-Sep-98	<10	<10	<18	<11	<22	<12	<19	<12	<13	<11	<37	<10	<293	3.8 ± 1.8
	26-Oct-98	<9	<9	<22	<10	<21	<12	<18	<13	<12	<11	<42	<13		4.5 ± 1.7
	30-Nov-98	<10	<10	<17	<9	<24	<12	<19	<11	<11	<10	<39	<10		5.0 ± 1.7
	28-Dec-98	<11	<13	<24	<10	<19	<15	<21	<12	<12	<13	<46	<11	<278	<2.9
GAVETTE RESIDENCE (SITE #55)	27-Jan-98	<8	<8	<19	<8	<20	<10	<14	<13	<9	<9	<38	<15		2.6 ± 1.6
	23-Feb-98	<9	<9	<15	<9	<19	<10	<15	<10	<9	<7	<33	<11		<2.5
	30-Mar-98	<9	<8	<14	<8	<19	<10	<13	<11	<9	<9	<29	<11	<288	4.8 ± 1.6
	28-Apr-98	<11	<10	<21	<10	<28	<11	<19	<10	<13	<12	<41	<10		<2.4
	26-May-98	<11	<10	<22	<9	<22	<10	<18	<11	<11	<11	<40	<10		3.2 ± 1.7
	29-Jun-98	<11	<10	<21	<12	<27	<10	<19	<11	<11	<10	<38	<14	<290	<2.7
	27-Jul-98	<11	<11	<25	<10	<25	<13	<18	<12	<13	<12	<40	<12		<2.8
	31-Aug-98	<12	<11	<20	<12	<21	<10	<17	<11	<11	<13	<40	<10		3.0 ± 1.7
	28-Sep-98	<11	<10	<19	<12	<21	<11	<19	<11	<11	<11	<36	<9	<291	<2.8
	26-Oct-98	<8	<9	<21	<13	<20	<10	<19	<12	<11	<9	<39	<12		3.0 ± 1.7
	30-Nov-98	<10	<10	<16	<10	<26	<12	<18	<12	<12	<11	<34	<11		5.3 ± 1.8
	28-Dec-98	<10	<12	<17	<10	<20	<12	<14	<11	<12	<11	<35	<10	<276	<2.8

TABLE 8.7 DRINKING WATER

ODCM required samples denoted by *
units are pCi/liter

SAMPLE LOCATION	MONTH ENDPOINT	<15 Mn-54	<15 Co-58	<30 Fe-59	<15 Co-60	<30 Zn-65	<15 Nb-95	<30 Zr-95	<15 I-131	<15 Cs-134	<18 Cs-137	<60 Ba-140	<15 La-140	<2000 QTRLY Tritium	<4.0 Gross Beta
	27-Jan-98	<8	<9	<18	<9	<13	<11	<15	<11	<8	<11	<42	<12		6.8 ± 2.3
	23-Feb-98	<12	<13	<23	<12	<23	<11	<22	<11	<13	<13	<41	<11		4.5 ± 2.1
	30-Mar-98	<8	<9	<19	<9	<19	<9	<14	<10	<10	<8	<35	<10	<289	7.8 ± 2.1
	28-Apr-98	<8	<11	<15	<12	<24	<9	<19	<10	<12	<12	<37	<8		6.1 ± 2.1
SHEPPARD	26-May-98	<13	<13	<25	<14	<26	<12	<20	<13	<14	<12	<45	<13		5.1 ± 2.2
RESIDENCE	29-Jun-98	<9	<9	<20	<10	<20	<9	<17	<11	<12	<11	<37	<10	<289	<3.5
(SITE #48) *	27-Jul-98	<10	<10	<20	<10	<21	<12	<15	<10	<10	<11	<36	<8		<3.3
	31-Aug-98	<11	<8	<25	<11	<21	<9	<17	<11	<12	<11	<37	<9		<3.4
	28-Sep-98	<11	<10	<22	<11	<28	<10	<22	<12	<13	<11	<38	<10	<291	<4.6 (a)
	26-Oct-98	<12	<12	<24	<10	<26	<11	<18	<13	<13	<13	<44	<11		6.3 ± 2.2
	30-Nov-98	<11	<9	<21	<11	<26	<9	<18	<10	<11	<10	<35	<14		10 ± 2.5
	28-Dec-98	<11	<11	<25	<11	<23	<13	<20	<11	<13	<13	<38	<12	<295	<4.4 (a)
	27-Jan-98	<8	<10	<15	<5	<24	<9	<12	<13	<9	<8	<38	<9		<2.1
	23-Feb-98	<12	<10	<25	<11	<26	<11	<22	<13	<15	<13	<45	<14		2.7 ± 1.5
	30-Mar-98	<8	<8	<20	<10	<18	<8	<15	<10	<9	<10	<34	<12	<289	<2.2
	28-Apr-98	<6	<6	<12	<6	<14	<6	<11	<7	<8	<7	<23	<6		<2.4
CHOWANEC	26-May-98	<10	<11	<22	<8	<22	<11	<19	<13	<12	<10	<41	<11		<2.6
RESIDENCE	29-Jun-98	<9	<10	<19	<9	<22	<11	<13	<10	<12	<12	<41	<11	<290	<2.6
(SITE #49) *	27-Jul-98	<9	<9	<19	<12	<22	<11	<17	<10	<10	<12	<34	<12		<2.6
	31-Aug-98 (b)	<11	<10	<18	<8	<20	<10	<14	<11	<12	<11	<37	<12		<2.2
	28-Sep-98	<9	<11	<18	<12	<18	<11	<18	<11	<11	<11	<36	<14	<293 (b)	<2.6
	26-Oct-98	<10	<9	<15	<10	<23	<12	<17	<13	<10	<10	<43	<12		<2.4
	30-Nov-98	<12	<10	<19	<12	<22	<12	<17	<11	<13	<11	<37	<10		<2.4
	28-Dec-98	<11	<10	<23	<10	<20	<11	<18	<12	<13	<10	<35	<9	<299	<2.7

(a) Required LLD not met due to high solids content of sample

(b) monthly and quarterly composite did not include sample from 8-24-98 since well was out of service

TABLE 8.8 GROUNDWATER

ODCM required samples denoted by *
units are pCi/liter

SAMPLE LOCATION	DATE COLLECTED	<15 Mn-54	<15 Co-58	<30 Fe-59	<15 Co-60	<30 Zn-65	<15 Nb-95	<30 Zr-95	<15 I-131	<15 Cs-134	<18 Cs-137	<60 Ba-140	<15 La-140	<2000 Tritium
WELL 27ddc (Site #57)*	27-Jan-98	<11	<10	<22	<11	<22	<12	<18	<12	<12	<10	<39	<12	<286
	28-Apr-98	<9	<9	<19	<10	<22	<13	<17	<12	<11	<12	<36	<11	<288
	30-Jul-98	<12	<10	<25	<12	<27	<13	<22	<12	<14	<13	<41	<15	<287
	8-Sep-98	<12	<11	<23	<13	<28	<13	<19	<11	<13	<12	<38	<13	<280
	7-Dec-98	<13	<11	<26	<12	<24	<15	<20	<14	<11	<12	<46	<10	<295
WELL 34abb (Site #58)*	27-Jan-98	<7	<7	<14	<6	<14	<8	<11	<14	<7	<6	<33	<13	<289
	28-Apr-98	<10	<10	<18	<9	<22	<12	<16	<11	<11	<9	<34	<11	<288
	30-Jul-98	<10	<9	<19	<10	<19	<12	<16	<10	<12	<10	<34	<11	<287
	8-Sep-98	<9	<9	<21	<10	<21	<12	<18	<11	<11	<10	<36	<12	<283
	7-Dec-98	<9	<12	<25	<11	<25	<14	<18	<12	<12	<11	<40	<11	<292

TABLE 8.9 SURFACE WATER

ODCM required samples denoted by *
units are pCi/liter

SAMPLE LOCATION	MONTH ENDPOINT	<15 Mn-54	<15 Co-58	<30 Fe-59	<15 Co-60	<30 Zn-65	<15 Nb-95	<30 Zr-95	<15 I-131	<15 Cs-134	<18 Cs-137	<60 Ba-140	<15 La-140	<3000 Tritium
RESERVOIR (Site #60) *	27-Jan-98	<9	<8	<21	<8	<22	<9	<14	<14	<10	<9	<41	<11	
	23-Feb-98	<13	<11	<24	<10	<20	<10	<22	<15	<12	<13	<43	<12	
	30-Mar-98	<8	<7	<19	<10	<19	<9	<15	<11	<10	<8	<33	<9	<292
	28-Apr-98	<10	<9	<24	<13	<23	<11	<21	<13	<11	<11	<45	<11	
	26-May-98	<13	<11	<23	<12	<29	<11	<20	<13	<13	<12	<44	<11	
	29-Jun-98	<11	<11	<23	<8	<21	<11	<19	<11	<11	<12	<37	<12	<292
	27-Jul-98	<10	<10	<21	<13	<26	<11	<18	<12	<11	<10	<39	<12	
	31-Aug-98	<10	<11	<21	<10	<25	<11	<17	<13	<12	<10	<38	<8	
	28-Sep-98	<11	<9	<19	<9	<22	<12	<15	<12	<12	<9	<36	<8	<291
	26-Oct-98	<9	<11	<23	<10	<26	<11	<24	<14	<10	<12	<43	<17	
	30-Nov-98	<11	<10	<24	<10	<24	<11	<18	<11	<11	<10	<37	<12	
	28-Dec-98	<11	<8	<20	<10	<20	<11	<18	<11	<11	<10	<36	<7	<295
EVAP POND 1 (Site #59) *	27-Jan-98	<11	<12	<26	<13	<28	<12	<19	<12	<12	<13	<37	<10	
	23-Feb-98	<9	<9	<20	<7	<23	<11	<17	<10	<11	<11	<30	<8	
	30-Mar-98	<13	<12	<24	<12	<28	<13	<21	<12	<14	<13	<44	<13	1527 ± 194
	28-Apr-98	<11	<11	<22	<12	<25	<13	<18	<13	<12	<12	<41	<12	
	26-May-98	<11	<11	<22	<12	<29	<12	<19	<13	<11	<14	<41	<12	
	29-Jun-98	<10	<10	<22	<9	<26	<11	<16	<11	<12	<12	<40	<10	1050 ± 194
	27-Jul-98	<12	<10	<21	<10	<23	<10	<15	<12	<11	<11	<36	<9	
	31-Aug-98	<11	<10	<20	<12	<25	<9	<16	<12	<12	<10	<39	<10	
	28-Sep-98	<10	<11	<22	<12	<23	<12	<19	<11	<11	<11	<36	<12	929 ± 184
	26-Oct-98	<11	<10	<20	<12	<26	<11	<19	<13	<10	<12	<40	<11	
	30-Nov-98	<10	<11	<24	<10	<25	<10	<19	<11	<10	<11	<36	<12	
	28-Dec-98	<13	<12	<26	<12	<17	<12	<21	<13	<14	<14	<42	<10	738 ± 153
EVAP POND 2 (Site #63) *	27-Jan-98	<10	<10	<23	<9	<22	<11	<17	<15	<11	9 ± 8	<32	<13	
	23-Feb-98	<7	<7	<13	<7	<15	<7	<12	<8	<8	9 ± 6	<23	<7	
	30-Mar-98	<9	<9	<18	<8	<21	<11	<14	<10	<12	15 ± 8	<31	<11	1137 ± 186
	28-Apr-98	<13	<13	<29	<10	<26	<12	<25	<14	<15	<16	<50	<11	
	26-May-98	<7	<8	<16	<9	<19	<7	<12	<10	<9	<10	<31	<8	
	29-Jun-98	<9	<10	<21	<9	<23	<11	<18	<11	<12	<14	<35	<12	713 ± 188
	27-Jul-98	<11	<9	<22	<11	<26	<10	<19	<11	<13	<14	<36	<9	
	31-Aug-98	<11	<10	<23	<9	<25	<11	<21	<12	<13	<14	<35	<11	
	28-Sep-98	<11	<10	<21	<13	<24	<10	<19	<12	<12	<14	<34	<11	1059 ± 185
	26-Oct-98	<11	<12	<23	<8	<25	<12	<17	<13	<13	23 ± 10	<41	<12	
	30-Nov-98	<12	<10	<20	<11	<27	<12	<18	<11	<13	<14	<39	<9	
	28-Dec-98	<10	<9	<21	<11	<25	<11	<19	<11	<14	<6	<37	<12	845 ± 153

TABLE 8.9 SURFACE WATER

ODCM required samples denoted by *
units are pCi/liter

SAMPLE LOCATION	DATE COLLECTED	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	I-131	Cs-134	Cs-137	Ba-140	La-140	Tritium
WRF INFLUENT	6-Jan-98	<5	<5	<10	<6	<10	<6	<10	9 ± 7	<6	<5	<25	<8	
	13-Jan-98	<11	<12	<23	<10	<23	<10	<19	15 ± 8	<12	<11	<38	<13	
	20-Jan-98	<5	<5	<12	<6	<11	<5	<9	17 ± 7	<7	<6	<19	<6	
	27-Jan-98	<12	<11	<20	<13	<17	<11	<18	20 ± 17	<12	<11	<44	<14	<297
	3-Feb-98	<12	<12	<24	<12	<29	<13	<22	48 ± 13	<14	<13	<63	<17	
	10-Feb-98	<11	<12	<22	<13	<24	<14	<18	71 ± 16	<12	<13	<44	<13	
	17-Feb-98	<12	<11	<22	<22	<23	<11	<21	31 ± 12	<14	<14	<40	<13	
	24-Feb-98	<8	<8	<18	<9	<15	<8	<14	17 ± 10	<11	<8	<28	<10	<307
	3-Mar-98	<7	<6	<14	<8	<15	<8	<13	18 ± 10	<9	<9	<32	<9	
	17-Mar-98	<12	<13	<22	<13	<23	<12	<20	21 ± 10	<14	<12	<42	<11	
	24-Mar-98	<7	<9	<17	<9	<18	<9	<14	31 ± 8	<9	<9	<27	<8	<297
	7-Apr-98	<10	<12	<23	<13	<25	<12	<19	14 ± 6	<13	<13	<47	<13	
	14-Apr-98	<10	<9	<19	<12	<24	<10	<19	10 ± 8	<12	<10	<37	<10	
	24-Apr-98	<10	<9	<21	<10	<23	<10	<17	34 ± 10	<11	<11	<35	<11	
	28-Apr-98	<11	<9	<22	<14	<26	<12	<20	28 ± 11	<11	<10	<43	<12	
	5-May-98	<12	<11	<25	<9	<29	<11	<19	30 ± 11	<14	<14	<42	<12	
	12-May-98	<11	<10	<19	<8	<21	<10	<18	16 ± 7	<13	<11	<31	<8	
	19-May-98	<13	<13	<26	<10	<25	<14	<21	<15	<13	<12	<43	<11	
	26-May-98	<11	<11	<21	<13	<27	<11	<17	18 ± 11	<13	<11	<44	<16	<300
	2-Jun-98	<10	<11	<18	<8	<21	<11	<15	<11	<12	<11	<30	<11	
	9-Jun-98	<10	<10	<18	<10	<22	<10	<20	<11	<11	<11	<27	<9	
	16-Jun-98	<9	<10	<18	<7	<22	<11	<14	30 ± 8	<11	<11	<35	<8	
	23-Jun-98	<12	<11	<20	<11	<25	<11	<19	13 ± 9	<13	<11	<38	<9	
	30-Jun-98	<11	<12	<21	<10	<26	<10	<17	18 ± 11	<13	<13	<35	<6	<302
	7-Jul-98	<10	<10	<19	<11	<18	<9	<17	16 ± 8	<13	<10	<35	<10	
	14-Jul-98	<9	<10	<21	<8	<22	<10	<17	<13	<13	<10	<38	<11	
	21-Jul-98	<10	<10	<24	<10	<26	<10	<18	23 ± 12	<13	<12	<40	<9	
	28-Jul-98	<9	<10	<18	<11	<16	<9	<18	20 ± 9	<10	<11	<33	<7	<303
	4-Aug-98	<11	<10	<22	<12	<26	<11	<18	20 ± 10	<12	<10	<35	<11	
	10-Aug-98	<9	<9	<19	<10	<19	<10	<18	<13	<13	<10	<35	<10	
	18-Aug-98	<10	<10	<22	<11	<22	<9	<15	<12	<10	<8	<37	<10	

TABLE 8.9 SURFACE WATER

ODCM required samples denoted by *
units are pCi/liter

SAMPLE LOCATION	DATE COLLECTED	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	I-131	Cs-134	Cs-137	Ba-140	La-140	Tritium
WRF INFLUENT (continued)	25-Aug-98	<11	<10	<20	<11	<22	<10	<16	31 ± 10	<11	<9	<32	<13	<287
	2-Sep-98	<10	<11	<25	<11	<23	<10	<22	<13	<15	<10	<37	<13	
	8-Sep-98	<11	<10	<20	<11	<24	<10	<16	18 ± 10	<11	<10	<36	<9	
	16-Sep-98	<10	<8	<17	<9	<20	<9	<14	22 ± 11	<12	<11	<30	<11	
	22-Sep-98	<10	<10	<17	<11	<23	<11	<17	29 ± 10	<10	<12	<33	<12	<296
	7-Oct-98	<10	<13	<24	<9	<24	<13	<20	<18	<13	<12	<51	<14	
	14-Oct-98	<12	<12	<20	<10	<20	<11	<19	<8	<13	<13	<40	<11	
	21-Oct-98	<8	<9	<21	<9	<23	<11	<18	31 ± 12	<10	<10	<28	<14	
	28-Oct-98	<10	<10	<19	<10	<19	<10	<16	47 ± 12	<11	<9	<34	<9	<294
	4-Nov-98	<10	<8	<17	<10	<21	<10	<17	18 ± 12	<10	<11	<31	<10	
	11-Nov-98	<9	<10	<19	<11	<21	<11	<16	<12	<12	<10	<33	<9	
	18-Nov-98	<10	<11	<21	<13	<25	<10	<17	18 ± 11	<14	<13	<36	<8	
	25-Nov-98	<10	<11	<20	<8	<22	<10	<16	21 ± 8	<11	<11	<31	<7	<287
	2-Dec-98	<10	<10	<19	<12	<24	<11	<16	13 ± 11	<12	<10	<34	<9	
	23-Dec-98	<10	<11	<18	<13	<15	<10	<16	22 ± 12	<11	<12	<38	<11	
	29-Dec-98	<11	<9	<16	<11	<20	<11	<18	47 ± 13	<12	<11	<40	<11	
SEDIMENT. BASIN #2	5-Jan-98	<8	<8	<20	<8	<17	<13	<16	<57	<8	<7	<86	<31	1295 ± 193
	13-Jan-98	<8	<9	<18	<8	<16	<9	<15	<12	<9	<8	<35	<7	3044 ± 216
	10-Feb-98	<6	<5	<8	<5	<13	<6	<9	<6	<7	<6	<18	<6	<314
	17-Feb-98	<11	<11	<21	<13	<24	<10	<23	<13	<13	<12	<45	<11	328 ± 177
	23-Feb-98	<11	<11	<23	<12	<26	<12	<21	<14	<14	<13	<41	<14	474 ± 180
	2-Mar-98	<8	<9	<15	<7	<17	<9	<13	<8	<10	<9	<31	<8	1078 ± 198
	9-Mar-98	<10	<8	<15	<9	<20	<8	<14	<10	<12	<11	<30	<12	585 ± 194
	16-Mar-98	<9	<9	<16	<6	<21	<10	<13	<9	<11	<9	<33	<11	519 ± 186
	24-Mar-98	<5	<6	<12	<5	<12	<6	<10	<9	<6	<6	<27	<9	512 ± 187
	30-Mar-98	<8	<9	<15	<10	<20	<8	<15	<9	<11	<10	<28	<6	460 ± 183
	6-Apr-98	<9	<9	<15	<8	<14	<9	<15	<9	<10	<9	<31	<11	<304
	14-Apr-98	<10	<9	<19	<10	<19	<9	<18	<9	<13	<11	<38	<9	<282
	21-Apr-98	<10	<9	<18	<11	<20	<10	<19	<9	<12	<9	<36	<8	<308
	28-Apr-98	<12	<12	<25	<13	<28	<11	<20	<11	<13	<11	<40	<10	<299
	4-May-98	<10	<9	<21	<9	<22	<10	<17	<11	<12	<10	<37	<8	<294
	4-Aug-98	<11	<10	<21	<10	<24	<10	<18	<10	<11	<11	<38	<7	<285
	17-Aug-98	<9	<10	<20	<10	<16	<9	<16	<10	<11	<10	<36	<9	848 ± 181
	14-Sep-98	<10	<11	<17	<10	<22	<10	<17	<10	<10	<10	<37	<9	<310

TABLE 8.10 SLUDGE/SEDIMENT

ODCM required samples denoted by *
units are pCi/kg, wet

SAMPLE LOCATION	DATE COLLECTED	I-131	Cs-134	Cs-137	In-111
WRF CENTRIFUGE WASTE SLUDGE	6-Jan-98	1018 ± 35	<10	<8	
	13-Jan-98	1438 ± 39	<8	<6	
	20-Jan-98	1136 ± 24	<6	<5	36 ± 10
	27-Jan-98	1003 ± 39	<11	<11	47 ± 32
	3-Feb-98	1611 ± 42	<11	<11	
	10-Feb-98	1839 ± 44	<10	<9	
	17-Feb-98	2096 ± 44	<9	<9	
	24-Feb-98	1704 ± 40	<11	<11	88 ± 14
	3-Mar-98	1032 ± 34	<13	<10	13 ± 11
	17-Mar-98	1427 ± 38	<12	<10	191 ± 20
	24-Mar-98	897 ± 28	<10	<10	48 ± 12
	7-Apr-98	842 ± 26	<9	<9	
	14-Apr-98	865 ± 26	<9	<8	63 ± 10
	21-Apr-98	2257 ± 44	<12	<11	26 ± 10
	28-Apr-98	2458 ± 46	<11	<10	56 ± 14
	5-May-98	2597 ± 46	<9	<8	143 ± 15
	12-May-98	1631 ± 39	<11	<10	136 ± 14
	19-May-98	1164 ± 35	<11	<10	65 ± 12
	26-May-98	1206 ± 32	<10	<12	40 ± 9
	2-Jun-98	1673 ± 41	<13	<11	30 ± 11
	9-Jun-98	1359 ± 34	<10	<9	125 ± 12
	16-Jun-98	1500 ± 34	<9	<9	39 ± 10
	23-Jun-98	1085 ± 31	<9	<8	
	30-Jun-98	1133 ± 33	<11	<8	78 ± 14
	7-Jul-98	1615 ± 37	<10	<9	88 ± 12
	14-Jul-98	1340 ± 36	<10	<10	
	21-Jul-98	3891 ± 57	<9	<8	45 ± 16
	28-Jul-98	2311 ± 46	<10	<10	
	4-Aug-98	1713 ± 40	<9	<8	29 ± 13
	10-Aug-98	1418 ± 35	<10	<10	42 ± 14
	18-Aug-98	588 ± 22	<7	<8	10 ± 7
	25-Aug-98	1618 ± 37	<13	<8	66 ± 12
	1-Sep-98	1092 ± 31	<8	<8	86 ± 13
	8-Sep-98	1102 ± 32	<10	<8	79 ± 12
	16-Sep-98	1422 ± 89	<19	<24	
	22-Sep-98	1611 ± 107	<33	<22	
	7-Oct-98	609 ± 53	<13	<10	
	14-Oct-98	746 ± 66	<10	<21	
	21-Oct-98	627 ± 64	<25	<22	
	28-Oct-98	1432 ± 88	<27	<19	
	4-Nov-98	1219 ± 80	<30	<28	
	11-Nov-98	913 ± 73	<24	<29	
	18-Nov-98	852 ± 45	<17	<15	
	2-Dec-98	873 ± 68	<16	<19	
	9-Dec-98	1326 ± 60	<20	<18	
	16-Dec-98	1066 ± 77	<24	<23	
	23-Dec-98	761 ± 26	<10	<10	
	29-Dec-98	940 ± 77	<18	<19	

TABLE 8.10 SLUDGE/SEDIMENT

ODCM required samples denoted by *
units are pCi/kg, wet

SAMPLE LOCATION	DATE COLLECTED	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	I-131	Cs-134	Cs-137	Ba-140	La-140
Evap Pond 1 (N)	28-Oct-98	<21	<22	<37	<27	<43	<20	<35	<22	<24	<22	<63	<24
Evap Pond 1 (E)	28-Oct-98	<14	<14	<31	<23	<34	<14	<27	<16	<18	<19	<47	<13
Evap Pond 1 (S)	28-Oct-98	<30	<27	<65	<29	<49	<28	<53	<24	<27	<31	<109	0
Evap Pond 1 (W)	28-Oct-98	<15	<13	<25	<16	<34	<15	<27	<14	<15	<21	<50	<12
Evap Pond 1 (C)	28-Oct-98	<26	<18	<57	<35	<66	<22	<51	<20	<29	<30	<67	0
Evap Pond 2 (N)	29-Oct-98	<13	<15	<28	135 ± 30	<36	<15	<25	<16	<21	33 ± 14	<50	<12
Evap Pond 2 (E)	29-Oct-98	<24	<18	<59	61 ± 22	<52	<24	<38	<22	<22	<38	<74	<11
Evap Pond 2 (S)	29-Oct-98	<24	<22	<57	<45	<54	<23	<36	<18	<30	<30	<80	<23
Evap Pond 2 (W)	29-Oct-98	<18	<16	<29	71 ± 24	<37	<16	<26	<13	<21	41 ± 15	<47	<8
Evap Pond 2 (C)	29-Oct-98	<17	<15	<35	50 ± 18	<36	<14	<28	<14	<20	<14	<52	<16
SEDIMENTATION BASIN #2 (North)	3-Sep-98	<16	<16	<40	<20	<49	<18	<31	<14	<22	<18	<54	<14
SEDIMENTATION BASIN #2 (Center)	3-Sep-98	<46	<45	<87	<45	<107	<50	<71	<39	<57	<59	<147	<48

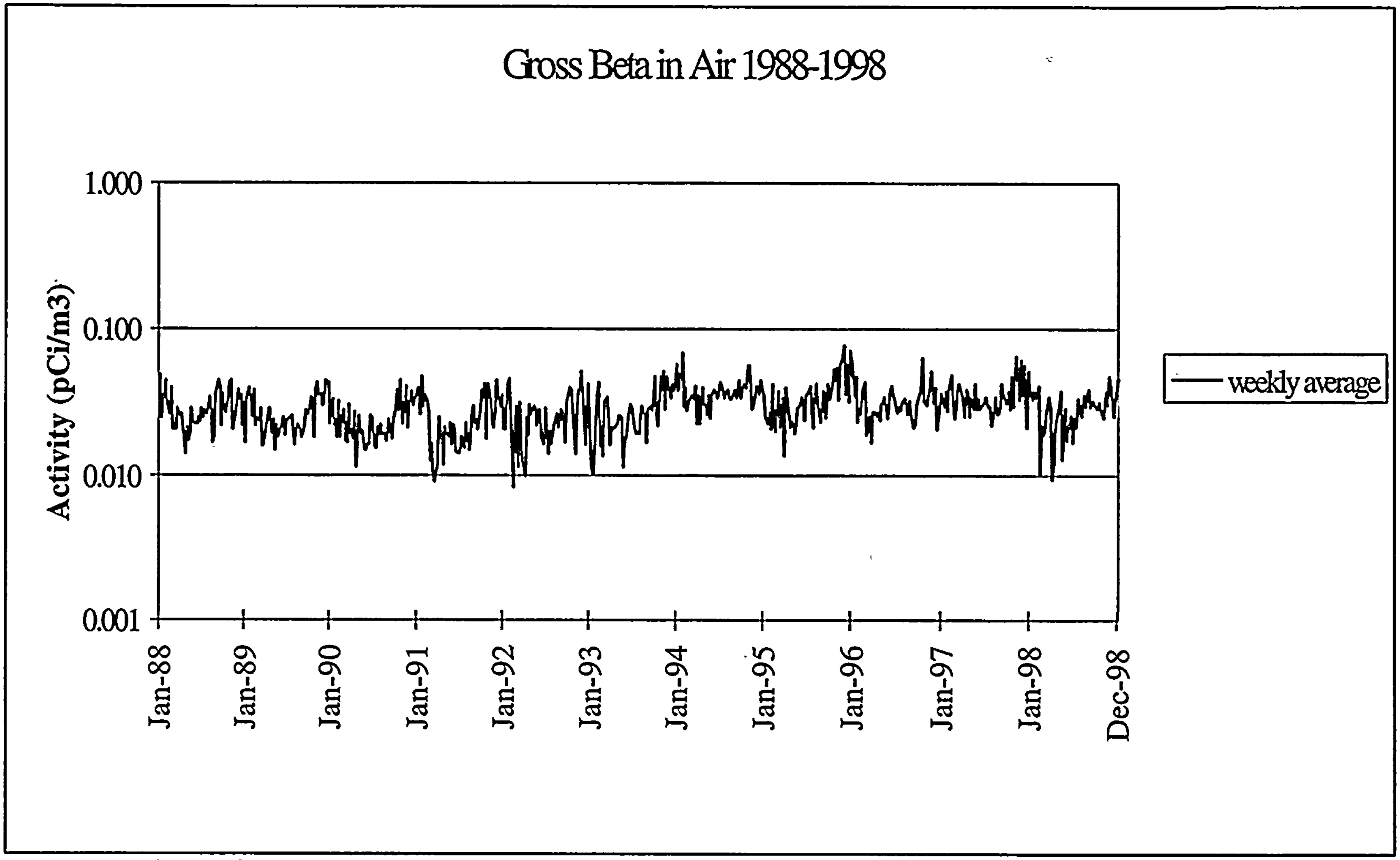
TABLE [illegible] SOIL

units are pCi/kg

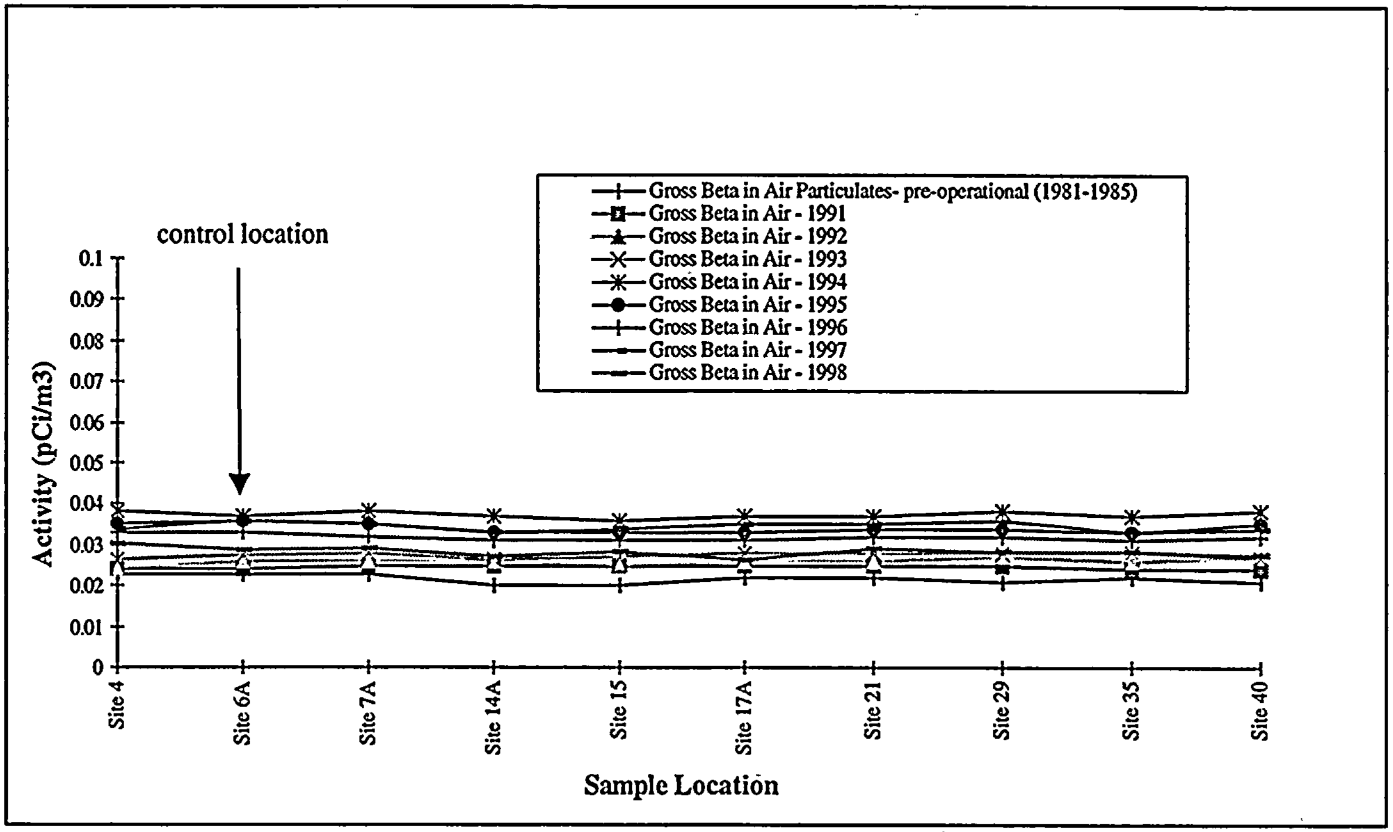
SAMPLE LOCATION (a)	DATE COLLECTED	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	I-131	Cs-134	Cs-137	Ba-140	La-140
Site #32	21-Oct-98	<24	<21	<48	<24	<54	<26	<39	<20	<30	453 ± 31	<73	<20
Site #13	21-Oct-98	<21	<18	<41	<21	<50	<22	<33	<17	<26	77 ± 28	<64	<15
Site #14	21-Oct-98	<22	<19	<43	<23	<52	<24	<34	<19	<27	296 ± 34	<67	<16
Site #15	13-Nov-98	<36	<33	<79	<40	<84	<39	<62	<29	<42	53 ± 24	<104	<31
Site #16	13-Nov-98	<23	<20	<54	<24	<55	<25	<39	<19	<31	<27	<69	<21
Site #17	13-Nov-98	<33	<26	<65	<28	<74	<33	<56	<26	<43	505 ± 56	<101	<29
Site #18	13-Nov-98	<23	<19	<47	<24	<58	<25	<38	<21	<30	239 ± 36	<68	<15
Site #19	13-Nov-98	<35	<39	<81	<41	<89	<42	<60	<32	<47	486 ± 60	<128	<35
Site #20	13-Nov-98	<23	<20	<52	<24	<55	<25	<39	<20	<29	202 ± 30	<70	<20
Site #21	11-Dec-98	<37	<33	<80	<39	<99	<37	<63	<29	<50	58 ± 38	<118	<31
Site #22	11-Dec-98	<38	<34	<88	<46	<97	<40	<70	<33	<51	157 ± 47	<118	<32
Site #27	11-Dec-98	<25	<22	<50	<27	<65	<27	<43	<21	<33	154 ± 29	<77	<18
Site #31	11-Dec-98	<24	<20	<53	<25	<59	<28	<40	<21	<29	90 ± 27	<68	<18
Site #28	11-Dec-98	<37	<35	<82	<38	<98	<40	<75	<33	<50	<47	<116	<35
Site #29	11-Dec-98	<23	<23	<53	<23	<70	<26	<43	<23	<36	71 ± 27	<77	<23
Site #30	15-Dec-98	<44	<36	<90	<47	<110	<44	<72	<32	<56	63 ± 40	<125	<26

(a) Sample locations are site boundary TLD locations. Soil samples were collected near these TLD sites.

FIGURE 8.1 HISTORICAL GROSS BETA IN 1988-1998 (WEEKLY SYSTEM AVERAGES)

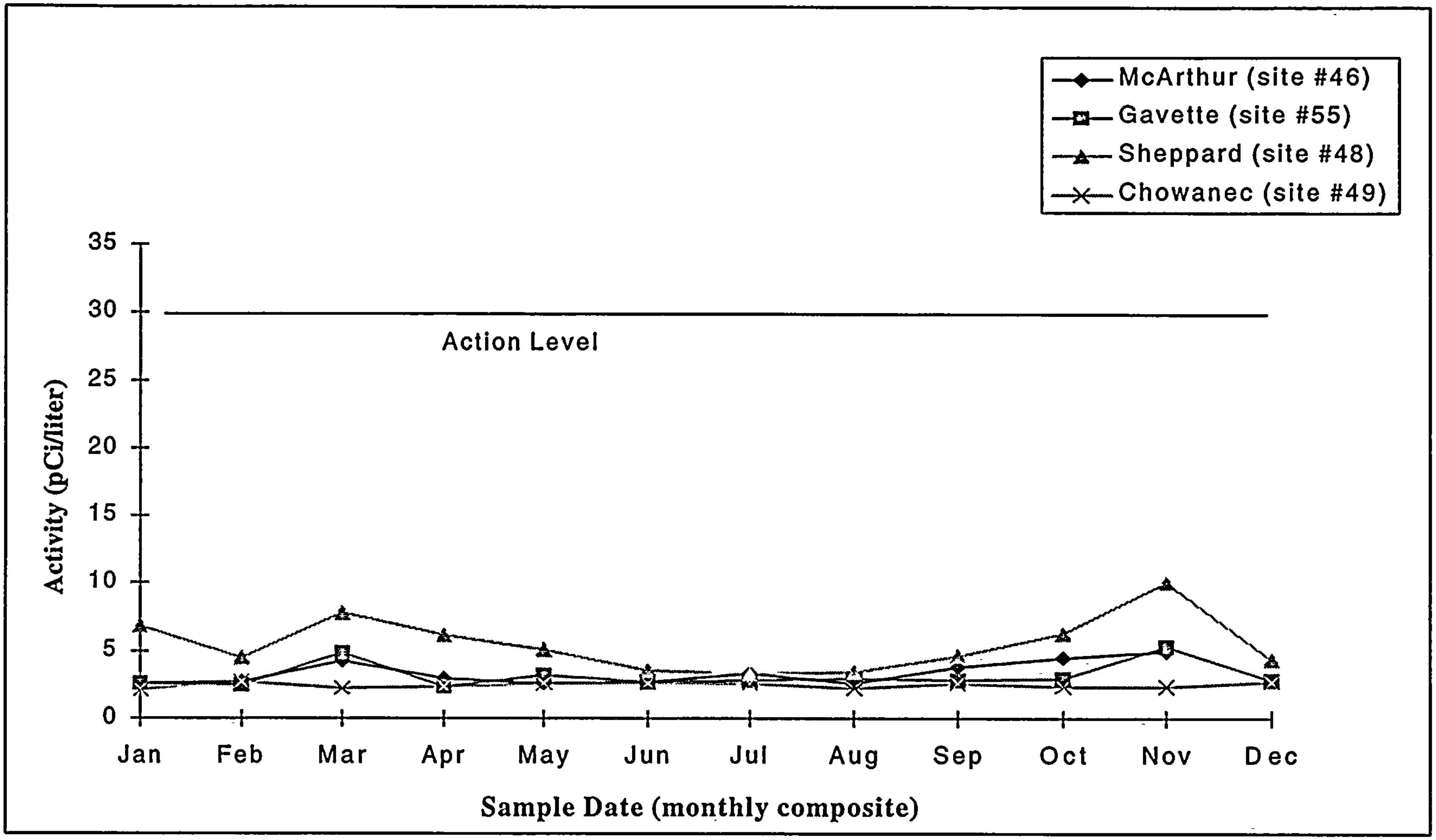


URE 8.2 HISTORICAL GROSS BETA IN AIR (ANNU ITE TO SITE COMPARISONS) COMPARED TO PRE



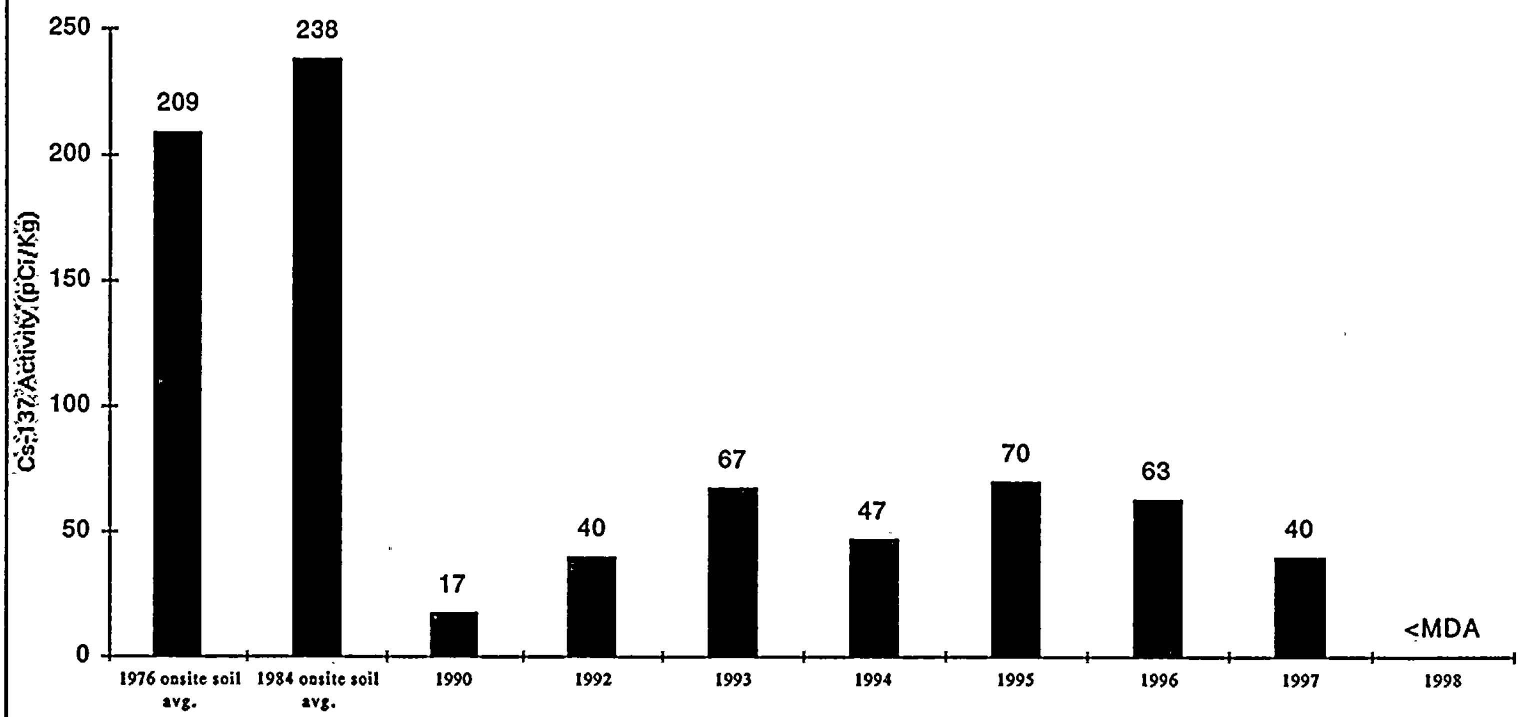
The 1994-1998 data trend higher. This is evidently the result of changing to the onsite central chemistry laboratory as our analyzing laboratory in 1994, which has shown a consistently high bias. The indicator locations trended well with the control location. Additionally, the central laboratory showed satisfactory results for interlaboratory comparison samples. No action is warranted since gross beta in air is trended and compared to action levels on an ongoing basis.

FIGURE 8.3 GROSS BE[illegible]N DRINKING WATER



NOTES: MDA values plotted as activity (e.g. <2.3 is plotted as 2.3)
Sheppard well routinely contains visible suspended solids

FIGURE 8.4 SOIL Cs-137 COMPARED TO ONSITE SEDIMENT BASIN #2



(Sedimentation Basin #2 accepts site storm runoff, no other gamma emitters present)

FIGURE 8.5 EVAPORATION POND TRITIUM ACTIVITY

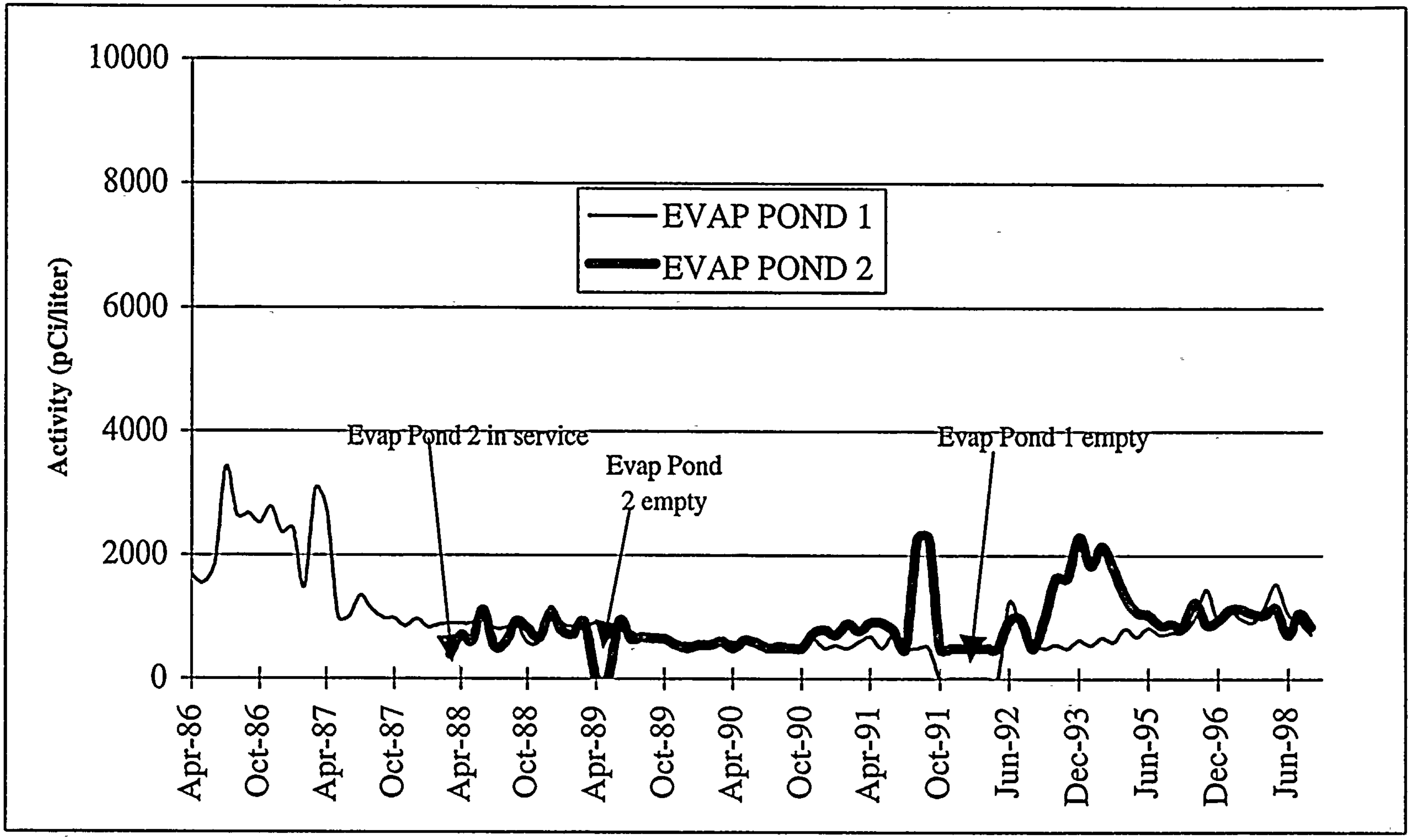
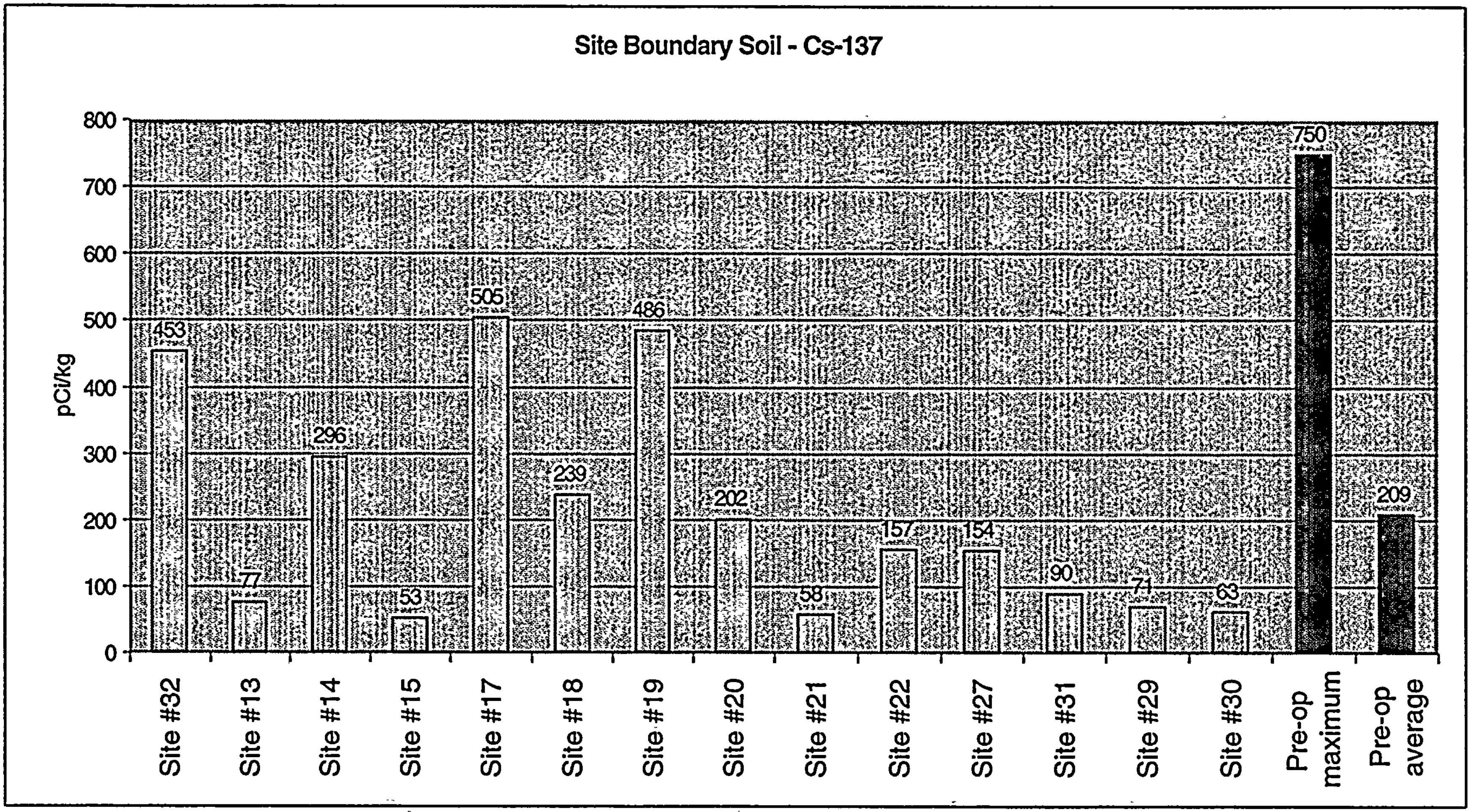


FIGURE 8.6 ON-SITE SOIL CS-137

No other gamma emitters (other than natural background) were detected in soil samples obtained at the site boundary.



9. Thermoluminescent Dosimeter (TLD) Results and Data

The environmental TLD used at PVNGS is the Panasonic Model 812 Dosimeter. The Model 812 is a multi-element dosimeter combining two elements of lithium borate and two elements of calcium sulfate under various filters.

Thermoluminescent dosimeters were placed in forty-nine locations from one to thirty-five miles from the PVNGS. TLD locations are shown in Figures 2.1 and 2.2. TLD locations are described in Table 9.1. TLD results for 1998 are presented in Table 9.2. TLD results for 1985 through 1998 are presented in graphical form on Figure 9.1 (excluding transit control TLD #45).

Technical Specification 5.6.2 requires that TLD results representing collocated dosimeters in relation to the NRC TLD program and the exposure period associated with each result be reported in the AREOR. The NRC TLD program was deleted as of 12-31-97. Therefore, no such results are included in this report.

Figure 9.2 depicts the environmental TLD results from 1998 as compared to the pre-operational TLD results (excluding indicator location #43 that was deleted and #46-50 due to no pre-op TLD at these locations for comparison). As can be seen, the site to site comparisons indicate a direct correlation with respect to pre-operational results. It is evident that the offsite dose, as measured by TLDs, has not changed since Palo Verde became operational.

TABLE 9.1 TLD SITE LOCATIONS

(distances and directions are relative to Unit 2 in miles)

TLD SITE	LOCATION	LOCATION DESCRIPTION
1	E30	APS Western Division Office
2	ENE24	Scott-Libby School
3	E21	Liberty School
4	E16	APS Buckeye Office
5	ESE11	Palo Verde School
6	SSE31	APS Gila Bend substation
7	SE7	Arlington School
8	SSE5	Southern Pacific Pipeline Rd.
9	S5	Southern Pacific Pipeline Rd.
10	SE5	355th Ave. and Elliot Rd.
11	ESE5	339th Ave. and Dobbins Rd.
12	E5	339th Ave. and Buckeye-Salome Rd.
13	N1	N site boundary
14	NNE2	NNE site boundary
15	NE2	NE site boundary
16	ENE2	ENE site boundary
17	E2	E site boundary
18	ESE2	ESE site boundary
19	SE2	SE site boundary
20	SSE2	SSE site boundary
21	S3	S site boundary
22	SSW3	SSW site boundary
23	W5	Elliot Rd
24	SW4	Elliot Rd
25	WSW5	Elliot Rd
26	SSW5	Sheppard farm
27	SW1	SW site boundary
28	WSW1	WSW site boundary
29	W1	W site boundary
30	WNW1	WNW site boundary
31	NW1	NW site boundary
32	NNW1	NNW site boundary
33	NW4	Buckeye Rd
34	NNW5	395th Ave. and Van Buren St.
35	NNW8	Fire Station
36	N5	Wintersburg Rd. and Van Buren St.
37	NNE5	363rd Ave. and Van Buren St.
38	NE5	355th Ave. and Buckeye Rd.
39	ENE5	343rd Ave
40	N3	Transmission Rd
41	WNW20	Harquahala Valley School
42	N8	Ruth Fisher School

TABLE 9.1 TLD SITE LOCATIONS

(distances and directions are relative to Unit 2 in miles)

TLD SITE	LOCATION	LOCATION DESCRIPTION
44*	ENE35	APS El Mirage Office
45**	Onsite	Central Laboratory (lead pig)
46	ENE30	Litchfield Park School
47	E35	Littleton School
48	E24	Jackrabbit Trail south of I-10
49	ENE11	Palo Verde Rd south of I-10
50	WNW5	west of Wintersburg Rd., south of Buckeye-Salome Rd.

* Site #6 and site #44 are the control locations.

** Site #45 is the transit control TLD (stored in lead pig).

TABLE 9.2 1998 ENVIRONMENTAL TLD RESULTS

units are mrem/std qtr

TLD Site #	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Average
1	21.3	22.9	22.3	23.8	22.6
2	19.8	21.2	21.0	19.4	20.4
3	21.8	21.7	22.0	21.1	21.7
4	20.9	21.7	22.8	20.9	21.6
5	20.2	21.2	21.3	22.8	21.4
6 (control)	26.1	24.6	25.2	24.2	25.0
7	23.8	25.2	23.1	22.7	23.7
8	23.7	21.4	21.4	20.8	21.8
9	29.1	28.6	26.1	27.2	27.8
10	20.3	22.3	21.6	20.4	21.2
11	24.9	24.8	24.3	23.9	24.5
12	23.3	21.3	20.9	21.8	21.8
13	22.5	23.2	23.3	22.2	22.8
14	24.0	23.4	22.2	22.3	23.0
15	21.1	23.7	21.4	23.0	22.3
16	19.4	19.9	20.9	19.4	19.9
17	23.1	24.9	24.6	24.2	24.2
18	22.4	22.0	24.1	20.1	22.2
19	22.6	23.6	24.9	21.6	23.2
20	23.9	23.4	24.3	23.4	23.8
21	24.4	27.2	25.3	23.7	25.2
22	26.6	27.7	27.3	23.8	26.4
23	20.5	21.2	20.4	22.6	21.2
24	20.6	20.4	21.6	21.3	21.0
25	20.9	21.7	20.5	21.0	21.0
26	23.7	25.6	27.9	26.4	25.9
27	25.7	26.7	24.6	26.6	25.9
28	26.6	24.4	26.5	24.3	25.5
29	24.8	24.3	24.9	25.2	24.8
30	25.1	26.1	25.1	24.4	25.2
31	22.1	22.1	20.2	20.6	21.3
32	23.0	23.2	24.7	25.8	24.2
33	23.7	24.2	23.7	23.7	23.8
34	27.0	27.6	27.1	23.4	26.3
35	29.8	28.0	29.9	28.5	29.1
36	22.9	23.5	22.2	24.3	23.2
37	23.4	23.1	22.2	20.9	22.4
38	27.0	25.5	25.5	24.3	25.6
39	23.1	22.3	21.1	22.1	22.2
40	22.0	23.3	24.8	21.9	23.0
41	25.2	26.3	24.7	25.6	25.5
42	23.1	24.3	23.6	23.4	23.6
44 (control)	17.9	19.7	18.6	18.6	18.7
45 (transit control)	5.1	5.7	4.7	5.2	5.2
46	25.2	25.2	24.1	25.0	24.9
47	21.9	23.5	23.7	20.9	22.5
48	22.3	21.8	21.8	20.4	21.6
49	20.0	22.8	19.5	19.6	20.5
50	17.3	18.8	17.0	17.3	17.6

FIGURE 9.1 NETWORK ENVIRONMENTAL TLD EXPOSURE RATES

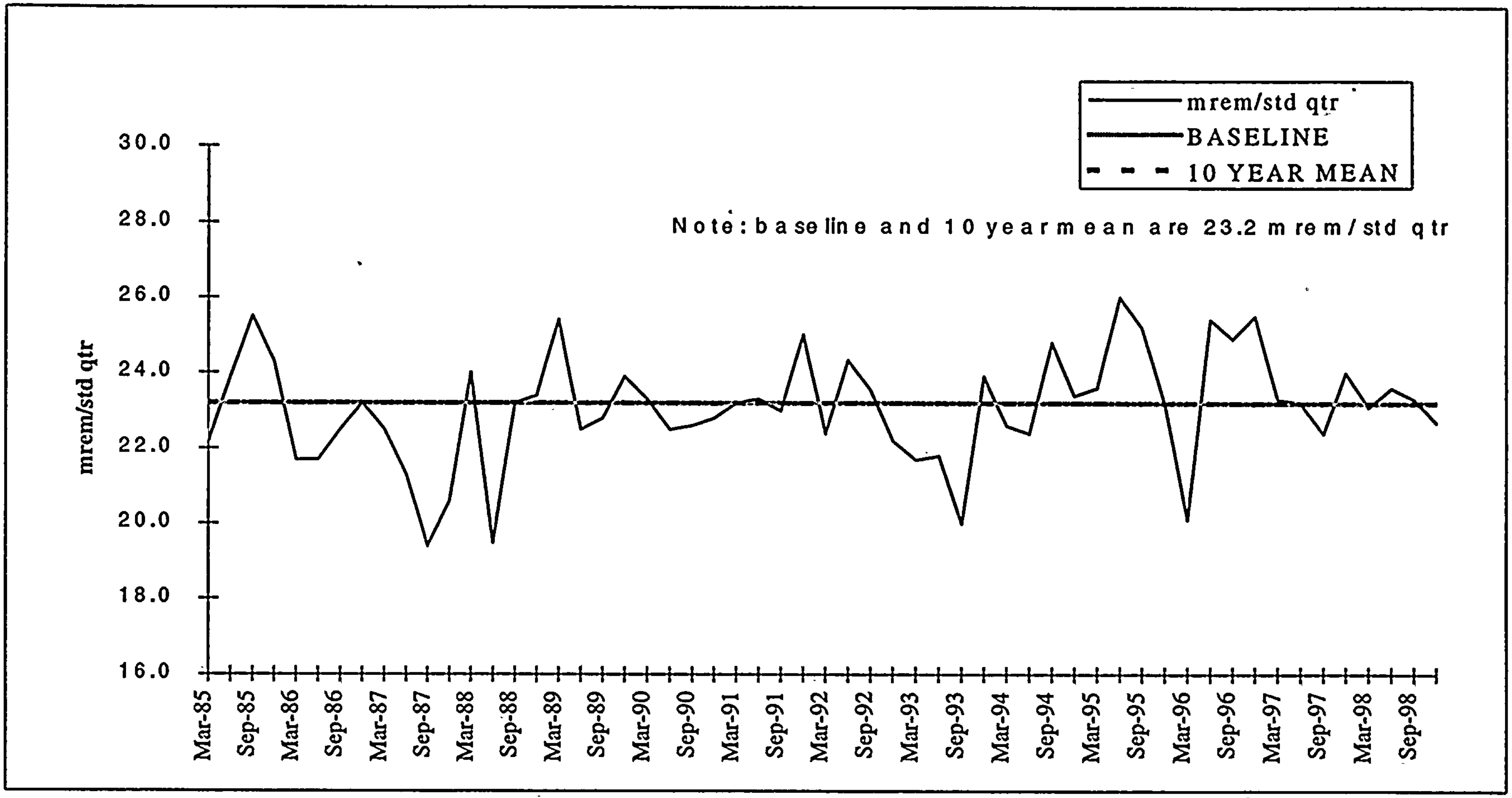
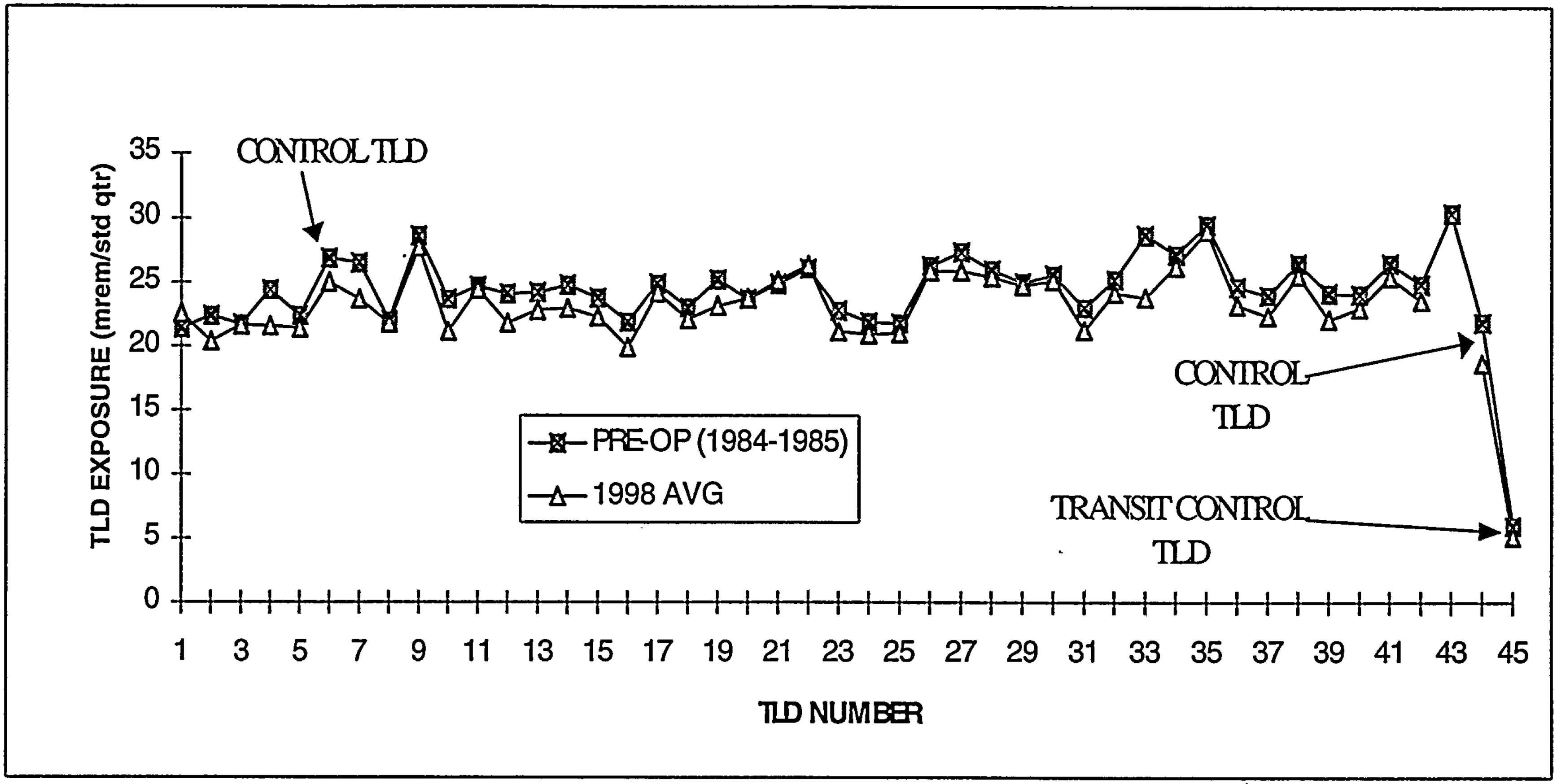


FIGURE 9.2 ENVIRONMENTAL TLD COMPARISON - PRE-OPERATIONAL VS 1998



TLD #43 monitoring location was deleted in 1994.
TLDs #46-50 are not included since they were not included in the pre-op monitoring program.

10. Land Use Census

10.1. Introduction

In accordance with the PVNGS ODCM, Section 6.2, the annual Land Use Census was performed within a five mile radius of the mid-line of Unit 2 containment in April/May, 1998.

Observations were made in each of the 16 meteorological sectors to determine the nearest milking animals, residences, and gardens of greater than 500 square feet. This census was completed by driving the roads and speaking with residents within a five-mile radius of PVNGS.

The results of the Land Use Census are presented in Table 10.1 and discussed below. The directions and distances listed are in sectors and miles from the Unit 2 containment.

10.2. Census Results

Nearest Resident

There were four (4) changes in nearest resident status. Locations changed in the WSW, W, NW, and NNW sectors.

Milking Animal

There were no milking animals located in the five-mile radius in the census.

Vegetable Gardens

There were three (3) changes in nearest garden status. New gardens were located in the ESE, SW, and NNW sectors.

Conclusion

See Table 10.1 for a summary of the specific results.

TABLE 10.1 1998 LAND USE CENSUS

(Distances and directions are relative to Unit 2 in miles)

SECTOR	NEAREST RESIDENT	NEAREST GARDEN	NEAREST MILK ANIMAL (COW/GOAT)	CALCULATED DOSE (mrem)	CHANGE FROM 1997
N	1.79	NONE	NONE	3.68E-02	NONE
NNE	1.66	2.10	NONE	9.44E-02 (resident) 2.67E-01 (garden)	NONE
NE	2.16	NONE	NONE	1.13E-01	NONE
ENE	2.77	2.87	NONE	5.80E-02 (resident) 2.77E-01 (garden)	NONE
E	2.86	NONE	NONE	7.02E-02	NONE
ESE	3.44	3.78	NONE	8.73E-02 (resident) 3.89E-01 (garden)	**GARDEN**
SE	4.18	NONE	NONE	9.69E-02	NONE
SSE	4.21	NONE	NONE	2.30E-01	NONE
S	4.67	NONE	NONE	2.90E-01	NONE
SSW	4.17	NONE	NONE	1.39E-01	NONE
SW	1.39	3.92	NONE	1.67E-01 (resident) 2.39E-01 (garden)	**GARDEN**
WSW	0.72	NONE	NONE	1.03E-01	**RESIDENT**
W	2.71	NONE	NONE	2.19E-02	**RESIDENT**
WNW	2.40	NONE	NONE	1.14E-02	NONE
NW	1.81	NONE	NONE	1.87E-02	**RESIDENT**
NNW	2.31	4.01	NONE	1.56E-02 (resident) 4.39E-02 (garden)	**RESIDENT GARDEN**

COMMENTS:

Dose calculations were performed using the GASPAR code and 1997 meteorological data and source term. Dose reported for each location is the total for all three PVNGS Units and is the highest individual dose identified (organ, bone, total body, or skin).

11. Summary and Conclusions

The conclusions are based on a review of the radioassay results and background gamma radiation measurements for the 1998 calendar year. The radioassay results and conclusions are based on observations of fission product and/or activation radionuclides and do not include observations of naturally occurring radionuclides, with the exception of gross beta in air and drinking water.

A summary of all sample results for 1998 is presented in Table 11.1. Note that this table does not contain data from sample locations that are not ODCM required. With the exception of onsite surface water and associated sludge, all sample assays presented in the report reveal no detectable man-made radioactivity that can be attributed to PVNGS.

I-131 concentrations identified on occasion in the Evaporation Ponds, WRF Influent, WRF Centrifuge sludge, and Reservoir are the result of offsite sources and appear in the effluent sewage from Phoenix. The levels of I-131 detected in these locations are consistent with levels identified in previous years.

Tritium concentrations identified in the Evaporation Ponds are the result of plant effluents which have already been accounted for as gaseous releases.

Natural background radiation is consistent with measurements reported in previous pre-operational and Operational Radiological Environmental annual reports, Reference 2.

TABLE 11.1

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM ANNUAL SUMMARY

Palo Verde Nuclear Generating Station
Maricopa County, Arizona

Docket Nos. STN 50-528/529/530
Calendar Year 1998

Medium or Pathway Sampled (Unit of Measurement)	Type and Total Number of Analyses Performed	Lower Limit of Detection (LLD) (from Table 6.1)	All Indicator Locations Mean (f)[a] Range	Location with Highest Annual Mean: Name Distance and Direction	Location with Highest Annual Mean: Mean (f)[a] Range	Control Locations Mean (f)[a] Range	Number of Nonroutine Reported Measurements
Direct Radiation (mrem/std. qtr.)	TLD - 196	NA	23.2 (184/184) 17.0 - 29.9	Site #35 8 miles 330°	29.1 (4/4) 28.0 - 29.9	21.9 (8/8) 17.9 - 26.1	0
Air Particulates (pCi/m³)	Gross Beta - 514	0.010	0.028 (466/466) 0.007 - 0.055	Site #4 16 miles 90°	0.030 (52/52) 0.010 - 0.051	0.029 (48/48) 0.008 - 0.054	0
	Gamma Spec. Composite- 40						
	Cs-134	0.05	<LLD	NA	<LLD	<LLD	0
	Cs-137	0.06	<LLD	NA	<LLD	<LLD	0
Air Radioiodine (pCi/m³)	Gamma Spec. - 514						
	I-131	0.07	<LLD	NA	<LLD	<LLD	0
Broadleaf Vegetation (pCi/Kg-wet)	Gamma Spec. - 18						
	I-131	60	<LLD	NA	<LLD	<LLD	0
	Cs-134	60	<LLD	NA	<LLD	<LLD	0
	Cs-137	80	<LLD	NA	<LLD	<LLD	0
Groundwater (pCi/l)	Tritium - 10	2000	<LLD	NA	<LLD	NA	0
	Gamma Spec. - 10						
	Mn-54	15	<LLD	NA	<LLD	NA	0
	Fe-59	30	<LLD	NA	<LLD	NA	0
	Co-58	15	<LLD	NA	<LLD	NA	0
	Co-60	15	<LLD	NA	<LLD	NA	0
	Zn-65	30	<LLD	NA	<LLD	NA	0
	Zr-95	30	<LLD	NA	<LLD	NA	0

TABLE 11.1

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM ANNUAL SUMMARY

Palo Verde Nuclear Generating Station
Maricopa County, Arizona

Docket Nos. STN 50-528/529/530
Calendar Year 1998

Medium or Pathway Sampled (Unit of Measurement)	Type and Total Number of Analyses Performed	Lower Limit of Detection (LLD) (from Table 6.1)	All Indicator Locations Mean (f)[a] Range	Location with Highest Annual Mean: Name Distance and Direction	Location with Highest Annual Mean: Mean (f)[a] Range	Control Locations Mean (f)[a] Range	Number of Nonroutine Reported Measurements
Groundwater (pCi/l) -continued-	Nb-95	15	<LLD	NA	<LLD	NA	0
	I-131	15	<LLD	NA	<LLD	NA	0
	Cs-134	15	<LLD	NA	<LLD	NA	0
	Cs-137	18	<LLD	NA	<LLD	NA	0
	Ba-140	60	<LLD	NA	<LLD	NA	0
	La-140	15	<LLD	NA	<LLD	NA	0
Drinking Water (pCi/l)	Gross Beta - 48	4.0	4.2 (21/48) 2.6 - 10.0	Site #48 5 miles 190°	6.7 (7/12) 4.5 - 10.0	NA	0
	Tritium - 16	2000	<LLD	NA	<LLD	NA	0
	Gamma Spec. - 48						
	Mn-54	15	<LLD	NA	<LLD	NA	0
	Fe-59	30	<LLD	NA	<LLD	NA	0
	Co-58	15	<LLD	NA	<LLD	NA	0
	Co-60	15	<LLD	NA	<LLD	NA	0
	Zn-65	30	<LLD	NA	<LLD	NA	0
	Zr-95	30	<LLD	NA	<LLD	NA	0
	Nb-95	15	<LLD	NA	<LLD	NA	0
	I-131	15	<LLD	NA	<LLD	NA	0
	Cs-134	15	<LLD	NA	<LLD	NA	0
	Cs-137	18	<LLD	NA	<LLD	NA	0
	Ba-140	60	<LLD	NA	<LLD	NA	0
	La-140	15	<LLD	NA	<LLD	NA	0

TABLE 11.1

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM ANNUAL SUMMARY

Palo Verde Nuclear Generating Station
Maricopa County, Arizona

Docket Nos. STN 50-528/529/530
Calendar Year 1998

Medium or Pathway Sampled (Unit of Measurement)	Type and Total Number of Analyses Performed	Lower Limit of Detection (LLD) (from Table 6.1)	All Indicator Locations Mean (f)[a] Range	Location with Highest Annual Mean: Name Distance and Direction	Location with Highest Annual Mean: Mean (f)[a] Range	Control Locations Mean (f)[a] Range	Number of Nonroutine Reported Measurements
Surface Water (pCi/l)	Gamma Spec. - 36						
	Mn-54	15	<LLD	NA	<LLD	NA	0
	Fe-59	30	<LLD	NA	<LLD	NA	0
	Co-58	15	<LLD	NA	<LLD	NA	0
	Co-60	15	<LLD	NA	<LLD	NA	0
	Zn-65	30	<LLD	NA	<LLD	NA	0
	Zr-95	30	<LLD	NA	<LLD	NA	0
	Nb-95	15	<LLD	NA	<LLD	NA	0
	I-131	15	<LLD	NA	<LLD	NA	0
	Cs-134	15	<LLD	NA	<LLD	NA	0
	Cs-137	18	14 (4/36) 9-23	Site #63 Onsite 180°	14 (4/12) 9-23	NA	0
	Ba-140	60	<LLD	NA	<LLD	NA	0
	La-140	15	<LLD	NA	<LLD	NA	0
	Tritium - 12	3000	1000 (8/12) 713 - 1527	Site #59 Onsite 180°	1061 (4/4) 738 - 1527	NA	0

(a) Mean and range based upon detectable measurements only. Fraction of detectable measurements at specified locations is indicated in parentheses. (f)

NOTE: Miscellaneous samples which are not listed on Tables 2.1 and 9.1 (not ODCM required) are not included on this table.

12. References

1. Pre-Operational Radiological Monitoring Program, Summary Report 1979-1985.
2. 1985-1997 Annual Radiological Environmental Operating Reports, Palo Verde Nuclear Generating Station.
3. Palo Verde Nuclear Generating Station Technical Specifications (Improved Technical Specifications (ITS) and the Technical Reference Manual (TRM)).
4. Offsite Dose Calculation Manual, PVNGS Units 1, 2, and 3.
5. Regulatory Guide 4.8, Environmental Technical Specifications for Nuclear Power Plants.
6. Branch Technical Position, Revision 1, November 1979.