NRC Docket No: 50-295
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72-1037

ZION NUCLEAR POWER STATION
UNITS 1 and 2

Annual Radiological
Environmental Operating Report

1 January Through 31 December 2015

Prepared By

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Environmental Services

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Zion Nuclear Power Station
Zion, IL 60099

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Appendices

Licensee Personnel," and/or Part 95, "Facility Security Clearance and Safeguarding of National Security Information and Restricted Data."

8. Other Nuclear Regulatory Issues

a. Price-Anderson Indemnity and Nuclear Insurance

Solutions requests that NRC amend the Price-Anderson indemnity agreement for the LACBWR to add Solutions upon the NRC consent to the proposed transfer of the License. Dairyland will continue to maintain the existing onsite property damage insurance coverage and the existing offsite nuclear liability coverage in accordance with the exemptions to 10 CFR 50.54(w) and 10 CFR 140.11 issued by the NRC in a letter dated June 26, 1986. In addition, the NRC's June 26, 1986 letter provides that participation in the secondary insurance pool is not required based on the permanently defueled status of LACBWR.

b. Standard Contract for Disposal of Spent Nuclear Fuel

Dairyland will retain ownership of the spent nuclear fuel and will keep in effect its Standard Contract for Disposal of Spent Nuclear Fuel and/or High Level Waste with the DOE for the disposal of spent nuclear fuel to be performed by the DOE ("Standard Contract") and will retain all rights and obligations under that contract. This Standard Contract, No. DE-CR01-83NE44377, dated June 15, 1983, was entered into by Dairyland and the United States of America, represented by the DOE, to govern spent nuclear fuel generated at LACBWR. Dairyland will maintain possession of the LACBWR spent nuclear fuel and will be responsible for maintenance and security of ISFSI Site under the Company Services Agreement with Solutions, subject to oversight by Solutions. Solutions will have exclusive responsibility under the NRC License for the possession, maintenance and decommissioning of the LACBWR Site, which includes responsibility to NRC for the maintenance and security of the ISFSI Site.

Dairyland also will retain its Standard Contract rights and title to the LACBWR spent nuclear fuel, consistent with the terms of Section 302(b)(4) of the Nuclear Waste Policy Act, which contemplates that Standard Contract rights flow with "title to the spent nuclear fuel or high level waste involved." 42 U.S.C. § 10222(b)(4).

Dairyland will remain an owner licensee for purposes of its owning spent nuclear fuel at the ISFSI Site. Even it were not specifically licensed, Dairyland's continued ownership of the LACBWR spent nuclear fuel and retention of title would be authorized under general licenses granted for the ownership, but not possession, of spent fuel pursuant to 10 CFR 72.6(b) and the general licenses for byproduct, source and special nuclear material granted pursuant to 10 CFR 31.9, 40.21, 70.20, respectively.

Neither operation of the reactor nor loading of fuel is authorized under the LACBWR Possession Only License. Therefore, Solutions does not need to have a Standard Contract.

c. Exclusion Area Control

Upon approval of the transfer, Solutions will have control over the LACBWR exclusion area and will have authority to determine all activities within the exclusion area to the extent required by 10 CFR Part 100. Dairyland will act as a service provider to Solutions to provide operations, maintenance, access control, and security services for the ISFSI Site, subject to the requirements

I. Summary and Conclusions

This report on the Radiological Environmental Monitoring Program conducted for the Zion Nuclear Power Station (ZNPS) by Zion*Solutions* (ZS) covers the period 1 January 2015 through 31 December 2015. During that time period, 603 analyses were performed on 523 samples. In assessing all the data gathered for this report and comparing these results with preoperational data, it was concluded that the decommissioning of ZNPS had no adverse radiological impact on the environment.

Public water samples were analyzed for concentrations of gross beta, tritium and gamma emitting nuclides. No fission or activation products were detected. Gross beta activities detected were consistent with those detected in previous years.

Fish (commercially and recreationally important species) and sediment samples were analyzed for concentrations of gamma emitting nuclides. No Cs-137 activity was detected in fish or sediment samples. No plant produced fission or activation products were found in fish or sediment.

Air particulate samples were analyzed for concentrations of gross beta and gamma emitting nuclides. No fission or activation products were detected.

Environmental gamma radiation measurements were performed quarterly using thermoluminescent dosimeters.

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II. Introduction

The Zion Nuclear Power Station (ZNPS), consisted of two 1,100 MWt pressurized water reactors was owned and operated by Exelon Corporation, is located in Zion, Illinois adjacent to Lake Michigan. Unit No. 1 went critical in December 1973. Unit No. 2 went critical in September 1974. The plant permanently ceased operation in January of 1998 and has been permanently defueled. The plant is in an advanced state of decommissioning. The site is located in northeast Illinois on the western shore of Lake Michigan, approximately 50 miles north of Chicago, Illinois.

This report covers those analyses performed by Teledyne Brown Engineering (TBE), Mirion Technologies and Environmental Inc. (Midwest Labs) on samples collected during the period 1 January 2015 through 31 December 2015.

A. Objective of the REMP

The objectives of the REMP are to:

1. Provide data on measurable levels of radiation and radioactive materials in the site environs.

2. Evaluate the relationship between quantities of radioactive material released from the plant and resultant radiation doses to individuals from principal pathways of exposure.

B. Implementation of the Objectives

The implementation of the objectives is accomplished by:

1. Identifying significant exposure pathways.

2. Establishing baseline radiological data of media within those pathways.

3. Continuously monitoring those media before, during and after Station operation to assess Station radiological effects (if any) on man and the environment.

III. Program Description

A. Sample Collection

Samples for the ZNPS REMP were collected for ZS by Environmental Inc. (Midwest Labs). This section describes the general collection methods

used by Environmental Inc. (Midwest Labs) to obtain environmental samples for the ZNPS REMP in 2015. Sample locations and descriptions can be found in Table B–1 and Figures B–1 and B–2, Appendix B. The sampling methods used by Environmental Inc. (Midwest Labs) are listed in Table B-2.

Aquatic Environment

The aquatic environment was evaluated by performing radiological analyses on samples of public water, fish and sediment. Two gallon water samples were collected monthly from four public water locations (Z-14, Z-15, Z-16 and Z-18). Control locations were Z-14 and Z-18. All samples were collected in new unused plastic bottles, which were rinsed at least twice with source water prior to collection. Fish samples comprising the flesh of common carp, lake trout, burbot, smallmouth bass and largemouth bass were collected semiannually at two locations, Z-26 and Z-27. Sediment samples composed of recently deposited substrate were collected at one location semiannually, Z-25.

Atmospheric Environment

The atmospheric environment was evaluated by performing radiological analyses on samples of air particulates. Airborne particulate samples were collected and analyzed weekly at four locations (Z-01, Z-02, Z-03, and Z-13). The control location was Z-13. Airborne particulate samples were obtained at each location, using a vacuum pump with glass fiber filters attached. The pumps were run continuously and sampled air at the rate of approximately one cubic foot per minute. The filters were replaced weekly and sent to the laboratory for analysis.

Terrestrial Environment

The terrestrial environment was evaluated by performing radiological analyses on food product samples. Food products were collected annually in September at three locations (Z-Control, Z-Quad 3 and Z-Quad 4). The control location was Z-Control. Various types of samples were collected and placed in new unused plastic bags and sent to the laboratory for analysis.

Ambient Gamma Radiation

Direct radiation measurements were made using 2 CaF 200 and 2 LiF 100 LiF 4-chip Harshaw thermoluminescent dosimeters (TLD). Each location consisted of 2 TLD sets. The TLD locations were placed on and around the ZNPS site at the following locations:

Inner Ring: Z-101, Z-102, Z-103, Z-104, Z-105, Z-106, Z-107, Z-108, Z-109, Z-112, Z-113, Z-114, Z-115, Z-121, Z-124, Z-125, Z-129, Z-130, Z-131

Other: Z-01, Z-02, Z-03

Outer Ring: Z-209, Z-211, Z-212, Z-213, Z-214, Z-215, Z-216

Control: Z-13

The specific TLD locations were determined by the following criteria:

1. The presence of relatively dense population;

2. Site meteorological data taking into account distance and elevation for each of the sixteen–22 1/2 degree sectors around the site, where estimated annual dose from ZNPS, if any, would be most significant;

3. On hills free from local obstructions and within sight of the vents (where practical);

4. And near the closest dwelling to the vents in the prevailing downwind direction.

(Two TLDs – each comprised of two CaF_2 200 and 2 LiF 100 LiF 4-chip thermoluminescent phosphors enclosed in plastic – were placed at each location approximately four to eight feet above ground level. The TLDs were exchanged quarterly and sent to Mirion Technologies for analysis.

B. Sample Analysis

This section describes the general analytical methodologies used by TBE and Environmental Inc. (Midwest Labs) to analyze the environmental samples for radioactivity for the ZNPS REMP in 2015. The analytical procedures used by the laboratories are listed in Table B-2.

In order to achieve the stated objectives, the current program includes the following analyses:

1. Concentrations of beta emitters in public water and air particulates.

2. Concentrations of gamma emitters in public water, air particulates, fish, and sediment.

3. Concentrations of tritium in public water.

4. Ambient gamma radiation levels at various site environs.

C. Data Interpretation

The radiological and direct radiation data collected prior to Zion Nuclear Power Station becoming operational were used as a baseline with which these operational data were compared. For the purpose of this report, Zion Nuclear Power Station was considered operational at initial criticality. In addition, data was compared to previous years' operational data for consistency and trending. Several factors were important in the interpretation of the data:

1. Lower Limit of Detection and Minimum Detectable Concentration

The lower limit of detection (LLD) is defined as the smallest concentration of radioactive material in a sample that would yield a net count (above background) that would be detected with only a 5% probability of falsely concluding that a blank observation represents a "real" signal. The LLD is intended as a before the fact estimate of a system (including instrumentation, procedure and sample type) and not as an after the fact criteria for the presence of activity. All analyses were designed to achieve the required ZNPS detection capabilities for environmental sample analysis.

The minimum detectable concentration (MDC) is defined above with the exception that the measurement is an after the fact estimate of the presence of activity.

2. Net Activity Calculation and Reporting of Results

Net activity for a sample was calculated by subtracting background activity from the sample activity. Since the REMP measures extremely small changes in radioactivity in the environment, background variations may result in sample activity being lower than the background activity affecting a negative number. An MDC was reported in all cases where positive activity was not detected.

Gamma spectroscopy results for each type of sample were grouped as follows:

For public water, sediment and air particulates 11 nuclides, Mn-54, Co-58, Fe-59, Co-60, Zn-65, Nb-95, Zr-95, Cs-134, Cs-137, Ba-140, and La-140 were reported.

Means and standard deviations of the results were calculated. The standard deviations represent the variability of measured results for different samples rather than single analysis uncertainty.

D. Program Exceptions

For 2015 the ZNPS REMP had a sample recovery rate in excess of 98%. Sample anomalies and missed samples are listed in the tables below:

Table D-1 LISTING OF SAMPLE ANOMALIES

Sample Type	Location Code	Collection Date	Reason
PW	Z-16	01/07/15 - 01/28/15	Pump not operating; sample taken from "raw" water settling tank.
PW	Z-16	02/04/15	Pump not operating sample taken from "raw" water settling tank. NOTE: Pump repaired before 02-10-15 collection.
AP	Z-03	09/30/15	No apparent reason for low reading for 159.0 hours
AP	Z-03	10/07/15	No apparent reason for low reading for 152.7 hours; pump replaced.

Table D-2 LISTING OF MISSED SAMPLES

Sample Type	Location Code	Collection Date	Reason
AP	Z-01, Z-02 Z-03, Z-13	01/28/15	NCR 15-06 Air particulate filters inadvertently disposed of by lab personnel

Table D-2 LISTING OF MISSED SAMPLES (continued)

Sample Type	Location Code	Collection Date	Reason
TLD	Z-102	09/30/15	TLDs not provided to Environmental sample collector; Zion station personnel changed out the TLDs at this location due to decommissioning activities taking place such that this location was not continuously accessible to personnel for safety reasons
AP	Z-03	10/21/15	Wasp nest in air sampler; could not approach air sampler safely. The air sampler continued to run and collect air sample. The extended run time was accounted for by TBE during analysis the following week.

Each program exception was reviewed to understand the causes of the program exception. Sampling and maintenance errors were reviewed with the personnel involved to prevent recurrence. Occasional equipment breakdowns and power outages were unavoidable.

The overall sample recovery rate indicates that the appropriate procedures and equipment are in place to assure reliable program implementation.

E. Program Changes

A new REMP map was created to better illustrate TLD and air sample locations after removal of the meteorological tower. Some TLDs previously identified as ISFSI were removed from the REMP program (Z-110, Z-111, Z-122, and Z-123) and the remainder will remain in the REMP program but are listed under inner ring TLDs. Four additional control TLDs were hung at location Z-13 to improve the statistical sample of the background control measurements. The meteorological tower was removed because there is no longer a credible accident scenario involving a large quantity of radioactive release to the public, thus real-time monitoring of environmental conditions is no longer required. The air sample location Z-03 that was located at the meteorological tower was moved to the location indicated on the map in the NNE sector.

IV. Results and Discussion

A. Aquatic Environment

1. Public Water

Samples were taken weekly and composited monthly at four locations (Z-14, Z-15, Z-16 and Z-18). The following analyses were performed.

Gross Beta

Samples from all locations were analyzed for concentrations of gross beta (Table C–I.1, Appendix C). Gross beta was detected in 11 of 48 samples. The values ranged from 2.0 pCi/l to 3.5 pCi/l. Concentrations detected were consistent with those detected in previous years (Figures C–1 and C–2, Appendix C).

Tritium

Quarterly composites of weekly collections were analyzed for tritium activity (Table C–I.2, Appendix C). No tritium was detected and the LLD was met (Figures C–3 and C–4, Appendix C).

Gamma Spectrometry

Samples from both locations were analyzed for gamma emitting nuclides (Table C–I.3, Appendix C). No nuclides were detected and all required LLDs were met.

2. Fish

Fish samples comprised of common carp, lake trout, burbot, smallmouth bass and largemouth bass were collected at two locations (Z-26 and Z-27) semiannually. The following analysis was performed:

Gamma Spectrometry

The edible portion of fish samples from both locations was analyzed for gamma emitting nuclides (Table C–II.1, Appendix C). No nuclides were detected and all required LLDs were met.

3. Sediment

Aquatic sediment samples were collected at one location (Z-25) semiannually. The following analysis was performed:

Gamma Spectrometry

Sediment samples from Z-25 were analyzed for gamma emitting nuclides (Table C–III.1, Appendix C). No nuclides were detected and all required LLDs were met.

B. Atmospheric Environment

1. Airborne

a. Air Particulates

Continuous air particulate samples were collected from three locations on a weekly basis. The three locations were within the ZNPS site boundary (Z-01, Z-02 and Z-03). The following analyses were performed:

Gross Beta

Weekly samples were analyzed for concentrations of beta emitters (Table C–IV.1 and C–IV.2, Appendix C). Detectable gross beta activity was observed at all locations. Comparison of results among the three groups aid in determining the effects, if any, resulting from the operation of ZNPS. The results from the On-Site locations ranged from 5 E-3 pCi/m^3 to 37 E–3 pCi/m^3 with a mean of 15 E–3 pCi/m^3. The results from the Control location ranged from 7 E-3 pCi/m^3 to 37 E–3 pCi/m^3 with a mean of 16 E–3 pCi/m^3. Comparison of the 2015 air particulate data with previous years data indicate no effects from the operation of ZNPS. Concentrations detected were consistent with those detected in previous years.

Gamma Spectrometry

Weekly samples were composited quarterly and analyzed for gamma emitting nuclides (Table C–IV.3, Appendix C). No nuclides were detected and all required LLDs were met.

C. Terrestrial Environment

2. Food Product

Food product samples were collected at three locations (Z-Control, Z-Quad 3 and Z-Quad 4) when available. The following analysis was performed:

Gamma Spectrometry

Samples from all locations were analyzed for gamma emitting nuclides (Table C–V.1, Appendix C). No nuclides were detected and all required LLDs were met.

D. Ambient Gamma Radiation

Ambient gamma radiation levels were measured utilizing Harshaw (CaF and LiF) thermoluminescent dosimeters. Sixty-four TLD locations were established around the site. Results of TLD measurements are listed in Tables C–VI.1 to C–VI.3, Appendix C.

Most TLD measurements were below 25 mR/quarter, with a range of 16 mR/quarter to 56 mR/quarter.

E. Land Use Survey

A Land Use Census conducted during August 2015 around the Zion Nuclear Power Station (ZNPS) was performed by Zion Station Personnel for ZS to comply with Chapter 3 of the Zion Offsite Dose Calculation Manual. The purpose of the survey was to document the nearest resident, milk producing animal and garden of greater than 500 ft_2 in each of the sixteen 22 ½ degree sectors around the site. The results of this survey are summarized below.

Distance in Miles from ZS			
Sector	Residence Miles	Garden Miles	Milk Farm Miles
N	2.5	3.4	>10
NNE	-	-	-
NE	-	-	-
ENE	-	-	-
E	-	-	-
ESE	-	-	-
SE	-	-	-
SSE	-	-	-
S	-	-	-
SSW	1.9	>10	>10
SW	1.1	4.8	>10
WSW	1.0	3.0	>10
W	1.1	2.9	>10
WNW	1.0	2.7	>10
NW	1.0	3.2	>10
NNW	1.3	3.5	>10

Source: Ill. Department of agriculture and USGS recommended using google maps to locate garden areas due to gardens and milk animals are voluntary declarations, also aerial photographs on ARCGIS layers updated by government sources are 5-10 years old.

Garden's located using Google Maps to narrow down areas that appeared to have been ploughed by aerial photographs, then visually verified by visiting locations.

Milk producing animal located by internet search for dairies advertising selling milk for public consumption.

F. Errata Data

There is no errata data for 2015.

G. Summary of Results – Inter-Laboratory Comparison Program

The primary and secondary laboratories analyzed Performance Evaluation (PE) samples of air particulate, air iodine, milk, soil, vegetation and water matrices for (Appendix D). The PE samples, supplied by Analytics Inc., Environmental Resource Associates (ERA) and DOE's Mixed Analyte Performance Evaluation Program (MAPEP), were evaluated against the following pre-set acceptance criteria:

1. Analytics Evaluation Criteria

   Analytics' evaluation report provides a ratio of laboratory results and Analytics' known value. Since flag values are not assigned by Analytics, TBE-ES evaluates the reported ratios based on internal QC requirements, which are based on the DOE MAPEP criteria.

2. ERA Evaluation Criteria

   ERA's evaluation report provides an acceptance range for control and warning limits with associated flag values. ERA's acceptance limits are established per the USEPA, National Environmental Laboratory Accreditation Conference (NELAC), state specific performance testing (PT) program requirements or ERA's SOP for the Generation of Performance Acceptance Limits, as applicable. The acceptance limits are either determined by a regression equation specific to each analyte or a fixed percentage limit promulgated under the appropriate regulatory document.

3. DOE Evaluation Criteria

   MAPEP's evaluation report provides an acceptance range with associated flag values.

   The MAPEP defines three levels of performance: Acceptable (flag = "A"), Acceptable with Warning (flag = "W"), and Not Acceptable (flag = "N"). Performance is considered acceptable when a mean result for the specified analyte is ± 20% of the reference value. Performance is acceptable with warning when a mean result falls in the range from ±20% to ±30% of the reference value (i.e., 20% < bias < 30%). If the bias is greater than 30%, the results are deemed not acceptable.

For the TBE laboratory, 129 out of 139 analyses performed met the specified acceptance criteria. Ten analyses (AP - Cr-51, U-234/233, Gr A, Sr-90; Soil Sr-90; Water - Ni-63, Sr-89, Sr-90, U natural; Vegetation Sr-90 samples) did not meet the specified acceptance criteria for the following reasons and were addressed through the TBE Corrective Action Program:

Note: The Department of Energy (DOE) Mixed Analyte Performance Evaluation Program (MAPEP) samples are created to mimic conditions found at DOE sites which do not resemble typical environmental samples obtained at commercial nuclear power facilities.

1. Teledyne Brown Engineering's Analytics' June 2015 air particulate Cr-51 result of 323 ± 45.5 pCi was higher than the known value of

233 pCi with a ratio of 1.39. The upper ratio of 1.30 (acceptable with warning) was exceeded. The air particulate sample is counted at a distance above the surface of the detector to avoid detector summing which could alter the results. Chromium-51 has the shortest half-life (27.7 days) and the lowest gamma energy (320.08 keV) of this mixed nuclide sample. Additionally, Cr-51 has only one gamma energy and also has a low intensity (9.38 gamma photons produced per 100 disintegrations). This geometry produces a larger error for the Cr-51 and other gamma emitters as any distance from the detector decreases the counting rate and the probability of accurately detecting the nuclide energy. Taking into consideration the uncertainty, the activity of Cr-51 overlaps with the known value at a ratio of 1.19, which would statistically be considered acceptable. NCR 15-18

2. Teledyne Brown Engineering's MAPEP March 2015 soil Sr-90 result of 286 Total Bq/kg was lower than the known value of 653 Bq/kg, exceeding the lower acceptance range of 487 Bq/kg. The failure was due to incomplete digestion of the sample. Incomplete digestion of samples causes some of the sample to be left behind and is not present in the digested sample utilized for analysis. The procedure has been updated to include a more robust digestion using stirring during the heating phase. The MAPEP September 2014 soil Sr-90 series prior to this study was evaluated as acceptable with a result of 694 and an acceptance range of 601 – 1115 Bq/kg. The MAPEP September 2015 series soil Sr-90 after this study was evaluated as acceptable with a result of 429 and an acceptance range of 298 – 553 Bq/kg. We feel the issue is specific to the March 2015 MAPEP sample. NCR 15-13

3. Teledyne Brown Engineering's MAPEP March 2015 air particulate U-234/233 result of 0.0211 ± 0.0120 Bq/sample was higher than the known value of 0.0155 Bq/sample, exceeding the upper acceptance range of 0.0202 Bq/sample. Although evaluated as a failure, taking into consideration the uncertainty, TBE's result would overlap with the known value, which is statistically considered acceptable. MAPEP spiked the sample with significantly more U-238 activity (a found to known ratio of 0.96) than the normal U-234/233. Due to the extremely low activity, it was difficult to quantify the U-234/233. NCR 15-13

4. Teledyne Brown Engineering's MAPEP March 2015 air particulate gross alpha result of 0.448 Bq/sample was lower than the known value of 1.77 Bq/sample, exceeding the lower acceptance range of 0.53 Bq/sample. The instrument efficiency used for gross alpha is

determined using a non-attenuated alpha standard. The MAPEP filter has the alphas embedded in the filter, requiring an attenuated efficiency. When samples contain alpha particles that are embedded in the sample media, due to the size of the alpha particle, some of the alpha particles are absorbed by the media and cannot escape to be counted. When the sample media absorbs the alpha particles this is known as self-absorption or attenuation. The calibration must include a similar configuration/media to correct for the attenuation. In order to correct the low bias, TBE will create an attenuated efficiency for MAPEP air particulate filters. The MAPEP September series air particulate gross alpha result of 0.47 Bq/sample was evaluated as acceptable with a range of 0.24 – 1.53 Bq/sample. Unlike the MAPEP samples, air particulate Gross alpha analyses for power plants are not evaluated as a direct count sample. Power plant air particulate filters for gross alpha go through an acid digestion process prior to counting and the digested material is analyzed. NCR 15-13

5. Teledyne Brown Engineering's MAPEP September water Ni-63 result of 11.8 ± 10.8 Bq/L was higher than the known value of 8.55 Bq/L, exceeding the upper acceptance range of 11.12 Bq/L. The Ni-63 half-life is approximately 100 years. Nickel-63 is considered to be a "soft" or low energy beta emitter, which means that the beta energy is very low. The maximum beta energy for Ni-63 is approximately 65 keV, much lower than other more common nuclides such as Co-60 (maximum beta energy of 1549 keV). The original sample was run with a 10 mL aliquot which was not sufficient for the low level of Ni-63 in the sample. The rerun aliquot of 30 mL produced an acceptable result of 8.81 Bq/L. NCR 15-21

6. Teledyne Brown Engineering's MAPEP September air particulate Sr-90 result of 1.48 Bq/sample was lower than the known value of 2.18 Bq/sample, exceeding the lower acceptance range of 1.53 Bq/sample. In the past, MAPEP has added substances (unusual compounds found in DOE complexes) to various matrices that have resulted in incomplete removal of the isotope of interest for the laboratories analyzing the cross checks. TBE suspects that this may be the cause of this error. Many compounds, if not properly accounted for or removed in the sample matrix, can cause interferences to either indicate lower activity or higher activity. TBE will no longer analyze the air particulate Sr-90 through MAPEP but will participate in the Analytics cross check program to perform both Sr-89 and Sr-90 in the air particulate matrix. NCR 15-21

7. Teledyne Brown Engineering's MAPEP September vegetation Sr-90 result of 0.386 Bq/sample was lower than the known value of 1.30 Bq/sample, exceeding the lower acceptance range of 0.91 Bq/sample. In the past, MAPEP has added substances (unusual compounds found in DOE complexes) to various matrices that have resulted in incomplete removal of the isotope of interest for the laboratories analyzing the cross checks. TBE suspects that this maybe the cause of this error. Many compounds, if not properly accounted for or removed in the sample matrix, can cause interferences to either indicate lower activity or higher activity. Results from previous performance evaluations were reviewed and shown to be acceptable. NCR 15-21

8. & 9. Teledyne Brown Engineering's ERA May water Sr-89/90 results of 45.2 and 28.0 pCi/L, respectively were lower than the known values of 63.2 and 41.9 pCi/L, respectively, exceeding the lower acceptance limits of 51.1 and 30.8 pCi/L, respectively. The yields were on the high side of the TBE acceptance range, which indicates the present of excess calcium contributed to the yield, resulting in low results. NCR 15-09

10. Teledyne Brown Engineering's ERA November water Uranium natural result of 146.9 pCi/L was higher than the known value of 56.2 pCi/L, exceeding the upper acceptance limit of 62.4 pCi/L. The technician failed to dilute the original sample, but used the entire 12 mL sample. When the results were recalculated without the dilution and using the 12 mL aliquot, the result of 57.16 agreed with the assigned value of 56.2. NCR 15-19

For the EIML laboratory, 90 of 94 analyses met the specified acceptance criteria. Four analyses (Water – Co-57, Fe-55; AP – Co-57; Soil – Sr-90) did not meet the specified acceptance criteria for the following reasons:

1. Environmental Inc., Midwest Laboratory's MAPEP February 2015 water Co-57 result of 10.2 Bq/L was lower than the known value of 29.9 Bq/L, exceeding the lower control limit of 20.9 Bq/L. The reported value should have been 27.84, which would have been evaluated as acceptable. A data entry error resulted in a non-acceptable result.

2. The Environmental Inc., Midwest Laboratory's MAPEP February 2015 AP Co-57 result of 0.04 Bq/sample was lower than the known value of 1.51 Bq/ sample, exceeding the lower control limit of 1.06 Bq/sample. The reported value should have been 1.58 Bq/sample, which would have been evaluated as acceptable. A data entry error resulted in a non-acceptable result.

3. The Environmental Inc., Midwest Laboratory's MAPEP August 2015 soil Sr-90 result of 231 Bq/kg was lower than the known value of 425 Bq/kg, exceeding the lower control limit of 298 Bq/kg. The incomplete separation of calcium from strontium caused a failed low result. The reanalysis result of 352 Bq/kg fell within acceptance criteria.

4. The Environmental Inc., Midwest Laboratory's MAPEP August 2015 water Fe-55 result of 4.2 Bq/L was lower than the known value of 13.1 Bq/L, exceeding the lower control limit of 9.2 Bq/L. The known activity was below the routine laboratory detection limits for the available aliquot fraction.

The Inter-Laboratory Comparison Program provides evidence of "in control" counting systems and methods, and that the laboratories are producing accurate and reliable data.

APPENDIX A

RADIOLOGICAL ENVIRONMENTAL MONITORING REPORT SUMMARY

TABLE A-1 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM ANNUAL SUMMARY FOR THE ZION NUCLEAR POWER STATION, 2015

Name of Facility: ZION **DOCKET NUMBER: 50-295 & 50-304**

Location of Facility: ZION IL **REPORTING PERIOD: ANNUAL 2015**

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	TYPES OF ANALYSIS PERFORMED	NUMBER OF ANALYSIS PERFORMED	REQUIRED LOWER LIMIT OF DETECTION (LLD)	INDICATOR LOCATIONS MEAN (M) (F) RANGE	CONTROL LOCATION MEAN (M) (F) RANGE	LOCATION WITH HIGHEST ANNUAL MEAN (M) MEAN (M) (F) RANGE	STATION # NAME DISTANCE AND DIRECTION	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
PUBLIC WATER (PCI/LITER)	GR-B	48	4	2.7 (16/36) (2.1/3.5)	2.5 (5/12) (2.0/3.1)	2.8 (4/12) (2.3/3.4)	Z-14 INDICATOR KENOSHA WATER WORKS 10.0 MILES N OF SITE	0
	H-3	16	200	<LLD	<LLD	-		0
	GAMMA	48						
	MN-54		15	<LLD	<LLD	-		0
	CO-58		15	<LLD	<LLD	-		0
	FE-59		30	<LLD	<LLD	-		0
	CO-60		15	<LLD	<LLD	-		0
	ZN-65		30	<LLD	<LLD	-		0

* THE MEAN AND 2 STANDARD DEVIATION VALUES ARE CALCULATED USING THE POSITIVE VALUES
FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F)

TABLE A-1 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM ANNUAL SUMMARY FOR THE ZION NUCLEAR POWER STATION, 2015

Name of Facility: ZION **DOCKET NUMBER: 50-295 & 50-304**

Location of Facility: ZION IL **REPORTING PERIOD: ANNUAL 2015**

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	TYPES OF ANALYSIS PERFORMED	NUMBER OF ANALYSIS PERFORMED	REQUIRED LOWER LIMIT OF DETECTION (LLD)	INDICATOR LOCATIONS MEAN (M) (F) RANGE	CONTROL LOCATION MEAN (M) (F) RANGE	LOCATION WITH HIGHEST ANNUAL MEAN (M) MEAN (M) (F) RANGE	STATION # NAME DISTANCE AND DIRECTION	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
PUBLIC WATER (PCI/LITER)	NB-95		15	<LLD	<LLD	-		0
	ZR-95		15	<LLD	<LLD	-		0
	CS-134		15	<LLD	<LLD	-		0
	CS-137		18	<LLD	<LLD	-		0
	BA-140		NA	<LLD	<LLD	-		0
	LA-140		NA	<LLD	<LLD	-		0
FISH (PCI/KG WET)	GAMMA	8						
	MN-54		130	<LLD	NA	-		0

* THE MEAN AND 2 STANDARD DEVIATION VALUES ARE CALCULATED USING THE POSITIVE VALUES
FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F)

TABLE A-1 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM ANNUAL SUMMARY FOR THE ZION NUCLEAR POWER STATION, 2015

Name of Facility: ZION **DOCKET NUMBER: 50-295 & 50-304**

Location of Facility: ZION IL **REPORTING PERIOD: ANNUAL 2015**

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	TYPES OF ANALYSIS PERFORMED	NUMBER OF ANALYSIS PERFORMED	REQUIRED LOWER LIMIT OF DETECTION (LLD)	INDICATOR LOCATIONS MEAN (M) (F) RANGE	CONTROL LOCATION MEAN (M) (F) RANGE	LOCATION WITH HIGHEST ANNUAL MEAN (M) MEAN (M) (F) RANGE	STATION # NAME DISTANCE AND DIRECTION	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
FISH (PCI/KG WET)	CO-58		130	<LLD	NA	-		0
	FE-59		260	<LLD	NA	-		0
	CO-60		130	<LLD	NA	-		0
	ZN-65		260	<LLD	NA	-		0
	NB-95		NA	<LLD	NA	-		0
	ZR-95		NA	<LLD	NA	-		0
	CS-134		100	<LLD	NA	-		0

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FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F)

TABLE A-1 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM ANNUAL SUMMARY FOR THE ZION NUCLEAR POWER STATION, 2015

Name of Facility: ZION **DOCKET NUMBER: 50-295 & 50-304**

Location of Facility: ZION IL **REPORTING PERIOD: ANNUAL 2015**

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	TYPES OF ANALYSIS PERFORMED	NUMBER OF ANALYSIS PERFORMED	REQUIRED LOWER LIMIT OF DETECTION (LLD)	INDICATOR LOCATIONS MEAN (M) (F) RANGE	CONTROL LOCATION MEAN (M) (F) RANGE	LOCATION WITH HIGHEST ANNUAL MEAN (M) MEAN (M) (F) RANGE	STATION # NAME DISTANCE AND DIRECTION	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
FISH (PCI/KG WET)	CS-137		100	<LLD	NA	-		0
	BA-140		NA	<LLD	NA	-		0
	LA-140		NA	<LLD	NA	-		0
SEDIMENT (PCI/KG DRY)	GAMMA	2						
	MN-54		NA	<LLD	NA	-		0
	CO-58		NA	<LLD	NA	-		0
	FE-59		NA	<LLD	NA	-		0
	CO-60		NA	<LLD	NA	-		0

* THE MEAN AND 2 STANDARD DEVIATION VALUES ARE CALCULATED USING THE POSITIVE VALUES
FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F)

TABLE A-1 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM ANNUAL SUMMARY FOR THE ZION NUCLEAR POWER STATION, 2015

Name of Facility: ZION **DOCKET NUMBER: 50-295 & 50-304**

Location of Facility: ZION IL **REPORTING PERIOD: ANNUAL 2015**

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	TYPES OF ANALYSIS PERFORMED	NUMBER OF ANALYSIS PERFORMED	REQUIRED LOWER LIMIT OF DETECTION (LLD)	INDICATOR LOCATIONS MEAN (M) (F) RANGE	CONTROL LOCATION MEAN (M) (F) RANGE	LOCATION WITH HIGHEST ANNUAL MEAN (M) MEAN (M) (F) RANGE	STATION # NAME DISTANCE AND DIRECTION	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
SEDIMENT (PCI/KG DRY)	ZN-65		NA	<LLD	NA	-		0
	NB-95		NA	<LLD	NA	-		0
	ZR-95		NA	<LLD	NA	-		0
	CS-134		150	<LLD	NA	-		0
	CS-137		180	<LLD	NA	-		0
	BA-140		NA	<LLD	NA	-		0
	LA-140		NA	<LLD	NA	-		0

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FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F)

TABLE A-1 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM ANNUAL SUMMARY FOR THE ZION NUCLEAR POWER STATION, 2015

Name of Facility: ZION **DOCKET NUMBER: 50-295 & 50-304**

Location of Facility: ZION IL **REPORTING PERIOD: ANNUAL 2015**

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	TYPES OF ANALYSIS PERFORMED	NUMBER OF ANALYSIS PERFORMED	REQUIRED LOWER LIMIT OF DETECTION (LLD)	INDICATOR LOCATIONS MEAN (M) (F) RANGE	CONTROL LOCATION MEAN (M) (F) RANGE	LOCATION WITH HIGHEST ANNUAL MEAN (M) MEAN (M) (F) RANGE	STATION # NAME DISTANCE AND DIRECTION	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
AIR PARTICULATE (E-3 PCI/CU.METER)	GR-B	203	10	15 (152/152) (5/37)	16 (51/51) (7/35)	16 (51/51) (7/37)	Z-01 INDICATOR ONSITE 1 0.3 MILES S OF SITE	0
	GAMMA	16						
	MN-54		NA	<LLD	<LLD	-		0
	CO-58		NA	<LLD	<LLD	-		0
	FE-59		NA	<LLD	<LLD	-		0
	CO-60		NA	<LLD	<LLD	-		0
	ZN-65		NA	<LLD	<LLD	-		0
	NB-95		NA	<LLD	<LLD	-		0

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FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F)

TABLE A-1 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM ANNUAL SUMMARY FOR THE ZION NUCLEAR POWER STATION, 2015

Name of Facility: ZION **DOCKET NUMBER: 50-295 & 50-304**

Location of Facility: ZION IL **REPORTING PERIOD: ANNUAL 2015**

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	TYPES OF ANALYSIS PERFORMED	NUMBER OF ANALYSIS PERFORMED	REQUIRED LOWER LIMIT OF DETECTION (LLD)	INDICATOR LOCATIONS MEAN (M) (F) RANGE	CONTROL LOCATION MEAN (M) (F) RANGE	LOCATION WITH HIGHEST ANNUAL MEAN (M) MEAN (M) (F) RANGE	STATION # NAME DISTANCE AND DIRECTION	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
AIR PARTICULATE (E-3 PCI/CU.METER)	ZR-95		NA	<LLD	<LLD	-		0
	CS-134		10	<LLD	<LLD	-		0
	CS-137		10	<LLD	<LLD	-		0
	BA-140		NA	<LLD	<LLD	-		0
	LA-140		NA	<LLD	<LLD	-		0
VEGETATION (PCI/KG WET)	GAMMA	6						
	MN-54		NA	<LLD	<LLD	-		0
	CO-58		NA	<LLD	<LLD	-		0

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FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F)

TABLE A-1 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM ANNUAL SUMMARY FOR THE ZION NUCLEAR POWER STATION, 2015

Name of Facility: ZION **DOCKET NUMBER: 50-295 & 50-304**

Location of Facility: ZION IL **REPORTING PERIOD: ANNUAL 2015**

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	TYPES OF ANALYSIS PERFORMED	NUMBER OF ANALYSIS PERFORMED	REQUIRED LOWER LIMIT OF DETECTION (LLD)	INDICATOR LOCATIONS MEAN (M) (F) RANGE	CONTROL LOCATION MEAN (M) (F) RANGE	LOCATION WITH HIGHEST ANNUAL MEAN (M) MEAN (M) (F) RANGE	STATION # NAME DISTANCE AND DIRECTION	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
VEGETATION (PCI/KG WET)	FE-59		NA	<LLD	<LLD	-		0
	CO-60		NA	<LLD	<LLD	-		0
	ZN-65		NA	<LLD	<LLD	-		0
	NB-95		NA	<LLD	<LLD	-		0
	ZR-95		NA	<LLD	<LLD	-		0
	CS-134		60	<LLD	<LLD	-		0
	CS-137		80	<LLD	<LLD	-		0

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TABLE A-1 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM ANNUAL SUMMARY FOR THE ZION NUCLEAR POWER STATION, 2015

Name of Facility: ZION **DOCKET NUMBER: 50-295 & 50-304**

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MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	TYPES OF ANALYSIS PERFORMED	NUMBER OF ANALYSIS PERFORMED	REQUIRED LOWER LIMIT OF DETECTION (LLD)	INDICATOR LOCATIONS MEAN (M) (F) RANGE	CONTROL LOCATION MEAN (M) (F) RANGE	LOCATION WITH HIGHEST ANNUAL MEAN (M) MEAN (M) (F) RANGE	STATION # NAME DISTANCE AND DIRECTION	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
VEGETATION (PCI/KG WET)	BA-140		NA	<LLD	<LLD	-		0
	LA-140		NA	<LLD	<LLD	-		0
DIRECT RADIATION (MILLI-ROENTGEN/QTR.)	TLD-QUARTERLY	256	NA	22.6 (232/232) (16/56)	20.5 (24/24) (18/24)	53.0 (4/4) (51/56)	Z-131-1 INDICATOR 0.2 MIES WSW	0

* THE MEAN AND 2 STANDARD DEVIATION VALUES ARE CALCULATED USING THE POSITIVE VALUES
FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F)

APPENDIX B

LOCATION DESIGNATION, DISTANCE & DIRECTION, AND SAMPLE COLLECTION & ANALYTICAL METHODS

TABLE B-1: Radiological Environmental Monitoring Program - Sampling Locations, Distance and Direction, Zion Nuclear Power Station, 2015

Location	Location Description	Distance & Direction From Site
A. Public Water		
Z-14	Kenosha Water Works (control)	10.0 miles N
Z-15	Lake County Water Works (indicator)	1.4 miles NNW
Z-16	Waukegan Water Works (indicator)	6.1 miles S
Z-18	Lake Forest Water Works (control)	12.9 miles S
B. Air Particulates		
Z-01	Onsite 1 (indicator)	0.3 miles S
Z-02	Onsite 2 (indicator)	0.2 miles W
Z-03	Onsite 3 (indicator)	0.2 miles NNW
Z-13	Offsite Control	10 miles NW
C. Fish		
Z-26	Lake Michigan Nearsite (indicator)	At station
Z-27	Lake Michigan Farsite (indicator)	10.1 miles N
D. Sediment		
Z-25	Lake Michigan, Illinois Beach State Park (indicator)	0.2 miles S
E. Environmental Dosimetry - TLD		
Inner Ring		
Z-101-1 and -2		0.2 miles N
Z-102-1 and -2		0.2 miles NNE
Z-103-1 and -2		0.15 miles NE
Z-104-1 and -2		0.13 miles ENE
Z-105-1 and -2		0.1 miles E
Z-106-1 and -2		0.1 miles ESE
Z-107-1 and -2		0.1 miles SE
Z-108-1 and -2		0.13 miles SSE
Z-109-1 and -2		0.2 miles SSE
Z-112-1 and -2		0.7 miles WSW
Z-113-1 and -2		0.6 miles W
Z-114-1 and -2		0.6 miles WNW
Z-115-1 and -2		0.4 miles NW
Z-121-1 and -2		0.2 miles NNW
Z-124-1 and -2		0.5 miles SW
Z-125-1 and -2		0.4 miles SSW
Z-129-1 and -2		0.2 miles NW
Z-130-1 and -2		0.2 miles WNW
Z-131-1 and -2		0.2 miles WNW
Other		
Z-01-1 and -2	Onsite 1 (indicator)	0.2 miles S
Z-02-1 and -2	Onsite 2 (indicator)	0.2 miles E
Z-03-1 and -2	Onsite 3 (indicator)	0.2 miles NNE

TABLE B-1: Radiological Environmental Monitoring Program - Sampling Locations, Distance and Direction, Zion Nuclear Power Station, 2015

Location	Location Description	Distance & Direction From Site
E. Environmental Dosimetry – TLD (continued)		
Outer Ring		
Z-209-1 and -2		5.1 miles S
Z-211-1 and -2		4.7 miles SW
Z-212-1 and -2		5.1 miles WSW
Z-213-1 and -2		5.1 miles W
Z-214-1 and -2		4.6 miles WNW
Z-215-1 and -2		4.0 miles NW
Z-216-1 and -2		3.0 miles NNW
Control		
Z-13-1 and -2		10 miles NW
Z-13-3 and -4		10 miles NW
Z-13-5 and -6		10 miles NW

TABLE B-2: Radiological Environmental Monitoring Program – Summary of Sample Collection and Analytical Methods, Zion Nuclear Power Station, 2015

Sample Medium	Analysis	Sampling Method	Analytical Procedure Number
Public Water	Gamma Spectroscopy	Monthly composite from weekly grab samples.	TBE, TBE-2007 Gamma emitting radioisotope analysis Env. Inc., GS-01 Determination of gamma emitters by gamma spectroscopy
Public Water	Gross Beta	Monthly composite from weekly grab samples.	TBE, TBE-2008 Gross Alpha and/or gross beta activity in various matrices Env. Inc., W(DS)-01 Determination of gross alpha and/or gross beta in water (dissolved solids or total residue)
Public Water	Tritium	Quarterly composite from weekly grab samples.	TBE, TBE-2011 Tritium analysis in drinking water by liquid scintillation Env. Inc., T-02 Determination of tritium in water (direct method)
Fish	Gamma Spectroscopy	Semi-annual samples collected via electroshocking or other techniques	TBE-2007 Gamma emitting radioisotope analysis Env. Inc., GS-01 Determination of gamma emitters by gamma spectroscopy
Sediment	Gamma Spectroscopy	Semi-annual grab samples	TBE, TBE-2007 Gamma emitting radioisotope analysis Env. Inc., GS-01 Determination of gamma emitters by gamma spectroscopy
Air Particulates	Gross Beta	One-week composite of continuous air sampling through glass fiber filter paper	TBE, TBE-2008 Gross Alpha and/or gross beta activity in various matrices Env. Inc., AP-02 Determination of gross alpha and/or gross beta in air particulate filters
Air Particulates	Gamma Spectroscopy	Quarterly composite of each station	TBE, TBE-2007 Gamma emitting radioisotope analysis Env. Inc., GS-01 Determination of gamma emitters by gamma spectroscopy
TLD	Thermoluminescence Dosimetry	Quarterly TLDs comprised of two CaF 200 and two LiF 100 LiF 4-chip Harshaw elements.	Mirion Technologies

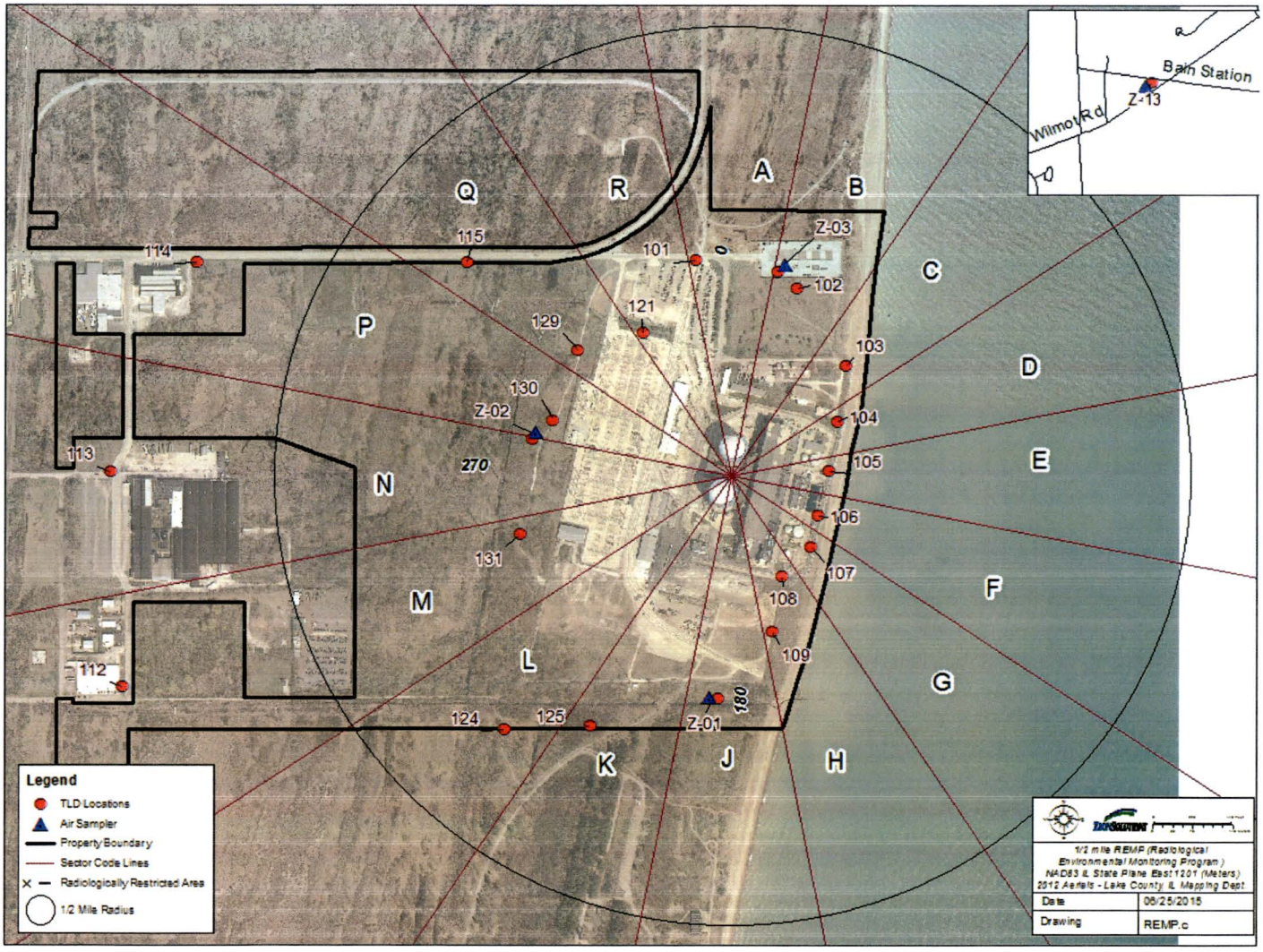


Figure B-1
Inner Ring TLD and Fixed Air Sampler Locations of the Zion Nuclear Power Station, 2015

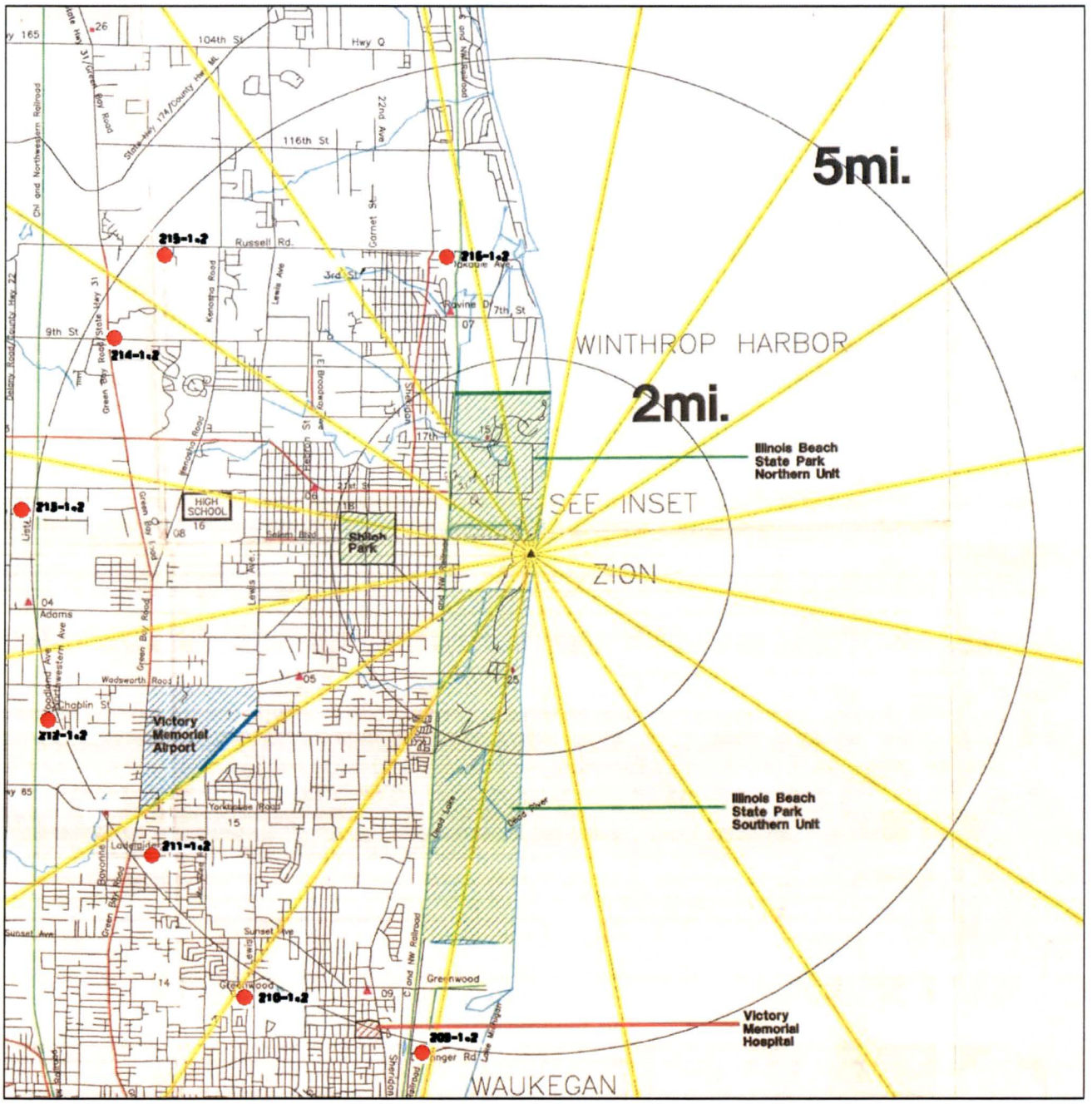


Figure B-2
Outer Ring TLD and Fixed Air Sampler Locations of the Zion Nuclear Power Station, 2015

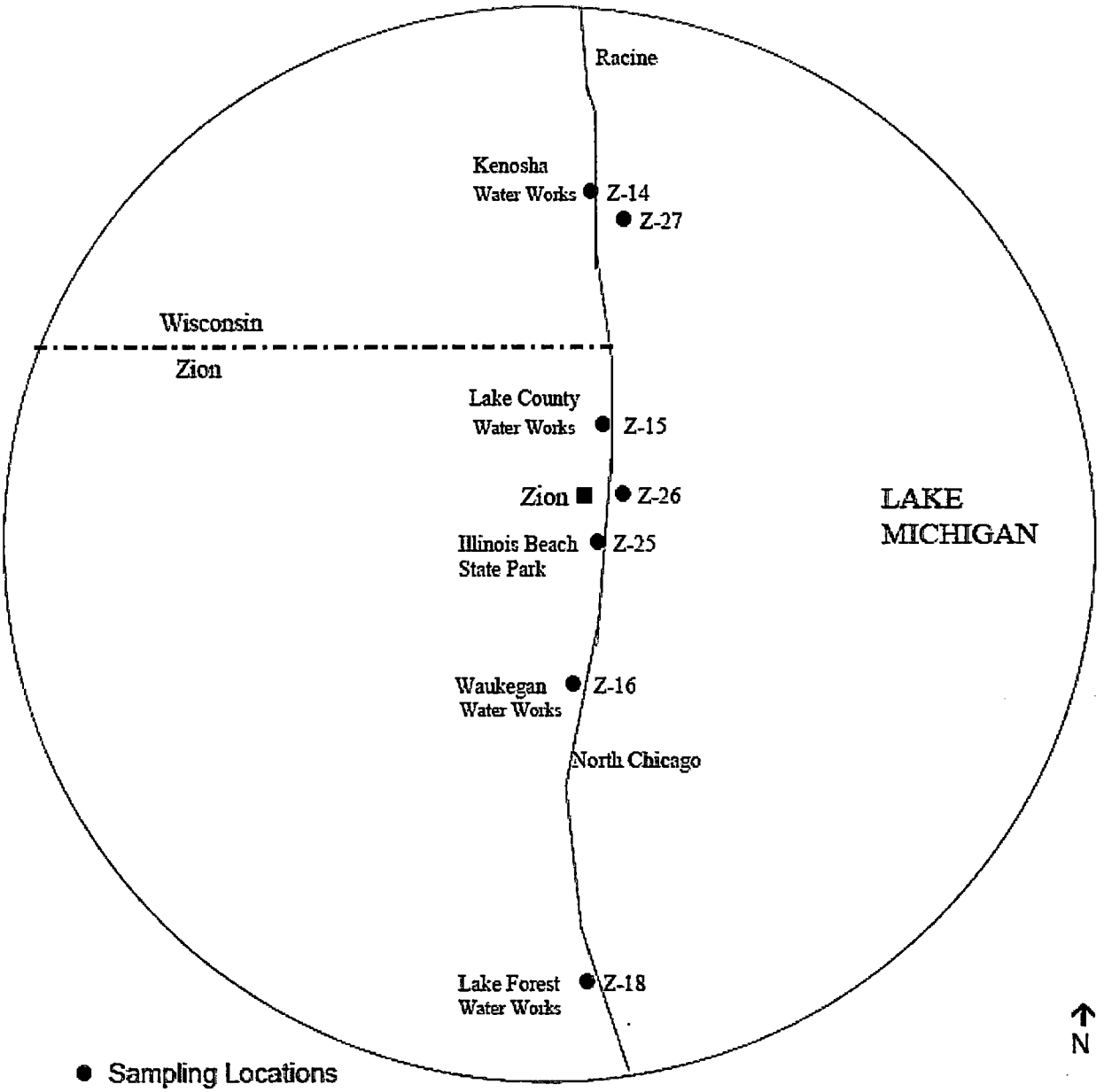


Figure B-3
Fish, Water and Sediment Sampling Locations of the Zion Nuclear Power Station, 2015

APPENDIX C

DATA TABLES AND FIGURES
PRIMARY LABORATORY

Table C-I.1 **Concentrations of Gross Beta in Public Water Samples Collected in the Vicinity of Zion Nuclear Power Station, 2015**

Results in Units of pCi/liter ± 2 Sigma

COLLECTION PERIOD	Z-14	Z-15	Z-16	Z-18
01/07/15 - 01/28/15	< 1.8	2.1 ± 1.3	3.1 ± 1.4	3.0 ± 1.4
02/04/15 - 02/25/15	< 2.2	< 1.9	< 2.2	< 2.3
03/04/15 - 03/25/15	< 2.2	3.3 ± 1.6	< 2.2	< 2.2
04/01/15 - 04/29/15	2.3 ± 1.3	3.1 ± 1.4	2.1 ± 1.3	2.0 ± 1.3
05/06/15 - 05/27/15	3.0 ± 1.7	< 2.4	< 2.4	< 2.3
06/03/15 - 06/24/15	3.4 ± 1.6	2.2 ± 1.5	< 2.2	3.1 ± 1.6
07/01/15 - 07/29/15	< 2.3	< 2.2	< 2.3	< 2.4
08/05/15 - 08/26/15	< 2.2	< 2.2	2.5 ± 1.5	2.3 ± 1.5
09/02/15 - 09/30/15	2.5 ± 1.4	3.5 ± 1.6	2.7 ± 1.5	< 2.0
10/07/15 - 10/28/15	< 2.2	2.7 ± 1.6	< 2.2	< 2.3
11/04/15 - 11/25/15	< 2.2	2.2 ± 1.5	< 2.1	< 2.2
12/02/15 - 12/30/15	< 2.1	< 2.1	2.8 ± 1.5	2.2 ± 1.5
MEAN	2.8 ± 0.9	2.7 ± 1.1	2.6 ± 0.8	2.5 ± 1.0

Table C-I.2 **Concentrations of Tritium in Public Water Samples Collected in the Vicinity of Zion Nuclear Power Station, 2015**

Results in Units of pCi/liter ± 2 Sigma

COLLECTION PERIOD	Z-14	Z-15	Z-16	Z-18
01/07/15 - 03/25/15	< 182	< 185	< 180	< 185
04/01/15 - 06/24/15	< 183	< 184	< 184	< 183
07/01/15 - 09/30/15	< 190	< 190	< 191	< 190
10/07/15 - 12/30/15	< 189	< 192	< 193	< 191
MEAN	-	-	-	-

THE MEAN AND 2 STANDARD DEVIATION ARE CALCULATED USING THE POSITIVE VALUES

Table C-I.3 **Concentrations of Gamma Emitters in Public Water Samples Collected in the Vicinity of Zion Nuclear Power Station, 2015**

Results in Units of pCi/liter ± 2 Sigma

SITE	COLLECTION PERIOD	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	Cs-134	Cs-137	Ba-140	La-140
Z-14	01/07/15 - 01/28/15	< 4	< 5	< 10	< 6	< 9	< 6	< 7	< 4	< 5	< 34	< 12
	02/04/15 - 02/25/15	< 5	< 6	< 15	< 5	< 9	< 7	< 11	< 5	< 5	< 71	< 17
	03/04/15 - 03/25/15	< 6	< 7	< 13	< 5	< 11	< 7	< 12	< 5	< 6	< 61	< 18
	04/01/15 - 04/29/15	< 2	< 3	< 6	< 2	< 5	< 3	< 5	< 2	< 2	< 28	< 9
	05/06/15 - 05/27/15	< 5	< 6	< 17	< 5	< 12	< 7	< 12	< 5	< 6	< 61	< 25
	06/03/15 - 06/24/15	< 4	< 4	< 9	< 3	< 7	< 4	< 7	< 4	< 4	< 28	< 9
	07/01/15 - 07/29/15	< 6	< 7	< 13	< 6	< 10	< 5	< 11	< 6	< 5	< 52	< 21
	08/05/15 - 08/26/15	< 3	< 4	< 10	< 4	< 8	< 4	< 8	< 3	< 4	< 26	< 8
	09/02/15 - 09/30/15	< 7	< 7	< 17	< 8	< 14	< 8	< 14	< 8	< 7	< 40	< 13
	10/07/15 - 10/28/15	< 6	< 6	< 17	< 4	< 15	< 7	< 10	< 5	< 5	< 54	< 17
	11/04/15 - 11/25/15	< 6	< 7	< 15	< 6	< 14	< 7	< 14	< 7	< 7	< 47	< 14
	12/02/15 - 12/30/15	< 5	< 4	< 11	< 4	< 11	< 5	< 9	< 6	< 5	< 48	< 14
	MEAN	-	-	-	-	-	-	-	-	-	-	-
Z-15	01/07/15 - 01/28/15	< 6	< 6	< 16	< 9	< 13	< 7	< 13	< 6	< 9	< 50	< 14
	02/04/15 - 02/25/15	< 4	< 6	< 12	< 4	< 9	< 5	< 10	< 5	< 3	< 72	< 18
	03/04/15 - 03/25/15	< 4	< 5	< 10	< 4	< 8	< 5	< 9	< 4	< 4	< 57	< 17
	04/01/15 - 04/29/15	< 3	< 3	< 7	< 2	< 5	< 3	< 5	< 2	< 3	< 29	< 10
	05/06/15 - 05/27/15	< 6	< 7	< 15	< 5	< 11	< 6	< 12	< 5	< 5	< 59	< 21
	06/03/15 - 06/24/15	< 6	< 6	< 12	< 5	< 13	< 6	< 10	< 5	< 6	< 39	< 12
	07/01/15 - 07/29/15	< 6	< 7	< 13	< 4	< 12	< 8	< 14	< 7	< 6	< 87	< 30
	08/05/15 - 08/26/15	< 5	< 6	< 12	< 6	< 10	< 6	< 10	< 5	< 5	< 34	< 15
	09/02/15 - 09/30/15	< 7	< 7	< 16	< 8	< 13	< 7	< 14	< 7	< 8	< 38	< 14
	10/07/15 - 10/28/15	< 4	< 6	< 11	< 3	< 12	< 7	< 9	< 5	< 5	< 52	< 15
	11/04/15 - 11/25/15	< 5	< 5	< 13	< 6	< 11	< 6	< 10	< 5	< 5	< 38	< 10
	12/02/15 - 12/30/15	< 6	< 6	< 11	< 6	< 12	< 6	< 11	< 6	< 6	< 49	< 13
	MEAN	-	-	-	-	-	-	-	-	-	-	-

(1) SEE PROGRAM EXCEPTIONS SECTION FOR EXPLANATION

Table C-I.3 **Concentrations of Gamma Emitters in Public Water Samples Collected in the Vicinity of Zion Nuclear Power Station, 2015**

Results in Units of pCi/liter ± 2 Sigma

SITE	COLLECTION PERIOD	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	Cs-134	Cs-137	Ba-140	La-140
Z-16	01/07/15 - 01/28/15	< 6	< 6	< 13	< 4	< 13	< 7	< 12	< 6	< 7	< 48	< 14
	02/04/15 - 02/25/15	< 4	< 6	< 12	< 4	< 9	< 6	< 11	< 5	< 5	< 61	< 17
	03/04/15 - 03/25/15	< 6	< 8	< 14	< 8	< 13	< 7	< 15	< 6	< 6	< 89	< 23
	04/01/15 - 04/29/15	< 2	< 2	< 6	< 2	< 4	< 3	< 4	< 2	< 2	< 25	< 7
	05/06/15 - 05/27/15	< 6	< 6	< 18	< 6	< 13	< 8	< 12	< 5	< 6	< 96	< 35
	06/03/15 - 06/24/15	< 5	< 5	< 11	< 3	< 10	< 5	< 9	< 4	< 5	< 32	< 9
	07/01/15 - 07/29/15	< 7	< 7	< 20	< 7	< 11	< 9	< 14	< 7	< 7	< 51	< 17
	08/05/15 - 08/26/15	< 5	< 5	< 10	< 4	< 9	< 5	< 10	< 5	< 5	< 36	< 12
	09/02/15 - 09/30/15	< 7	< 7	< 16	< 9	< 12	< 8	< 14	< 8	< 8	< 37	< 10
	10/07/15 - 10/28/15	< 7	< 7	< 15	< 5	< 15	< 7	< 12	< 6	< 6	< 57	< 14
	11/04/15 - 11/25/15	< 8	< 9	< 17	< 8	< 18	< 11	< 14	< 7	< 8	< 55	< 17
	12/02/15 - 12/30/15	< 6	< 5	< 16	< 6	< 15	< 6	< 9	< 6	< 6	< 46	< 15
	MEAN	-	-	-	-	-	-	-	-	-	-	-
Z-18	01/07/15 - 01/28/15	< 7	< 7	< 16	< 6	< 17	< 8	< 12	< 6	< 7	< 52	< 17
	02/04/15 - 02/25/15	< 6	< 7	< 21	< 6	< 13	< 9	< 12	< 5	< 6	< 84	< 27
	03/04/15 - 03/25/15	< 5	< 6	< 11	< 5	< 11	< 7	< 12	< 5	< 5	< 75	< 21
	04/01/15 - 04/29/15	< 6	< 6	< 17	< 7	< 7	< 7	< 12	< 5	< 6	< 75	< 32
	05/06/15 - 05/27/15	< 8	< 7	< 15	< 6	< 12	< 8	< 14	< 7	< 5	< 82	< 19
	06/03/15 - 06/24/15	< 4	< 6	< 11	< 5	< 10	< 6	< 10	< 5	< 5	< 37	< 14
	07/01/15 - 07/29/15	< 5	< 6	< 12	< 5	< 13	< 6	< 13	< 5	< 7	< 69	< 22
	08/05/15 - 08/26/15	< 3	< 4	< 8	< 3	< 7	< 4	< 6	< 3	< 3	< 24	< 8
	09/02/15 - 09/30/15	< 7	< 8	< 17	< 8	< 12	< 6	< 12	< 6	< 7	< 29	< 10
	10/07/15 - 10/28/15	< 7	< 7	< 17	< 7	< 18	< 7	< 15	< 7	< 7	< 59	< 22
	11/04/15 - 11/25/15	< 8	< 7	< 18	< 10	< 14	< 9	< 15	< 8	< 8	< 61	< 12
	12/02/15 - 12/30/15	< 7	< 8	< 16	< 8	< 19	< 9	< 13	< 7	< 6	< 54	< 18
	MEAN	-	-	-	-	-	-	-	-	-	-	-

Table C-II.1

Concentrations of Gamma Emitters in Fish Samples Collected in the Vicinity of Zion Nuclear Power Station, 2015

Results in Units of pCi/kg Wet ± 2 sigma

SITE	COLLECTION PERIOD	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	Cs-134	Cs-137	Ba-140	La-140
Z-26												
Common Carp	05/01/15	< 47	< 70	< 122	< 65	< 84	< 63	< 108	< 64	< 63	< 323	< 128
Largemouth Bass	05/01/15	< 79	< 85	< 180	< 67	< 163	< 80	< 124	< 68	< 73	< 431	< 80
Common Carp	10/23/15	< 77	< 87	< 181	< 80	< 163	< 84	< 151	< 74	< 81	< 566	< 179
Smallmouth Bass	10/23/15	< 45	< 58	< 107	< 46	< 69	< 33	< 54	< 26	< 53	< 270	< 96
	MEAN	-	-	-	-	-	-	-	-	-	-	-
Z-27												
Burbot	05/12/15	< 45	< 77	< 131	< 65	< 105	< 76	< 133	< 52	< 56	< 744	< 317
Lake Trout	05/12/15	< 31	< 55	< 175	< 52	< 116	< 75	< 85	< 50	< 71	< 825	< 232
Burbot	10/14/15	< 53	< 107	< 180	< 83	< 67	< 106	< 142	< 54	< 86	< 744	< 82
Lake Trout	10/14/15	< 56	< 64	< 129	< 55	< 119	< 70	< 113	< 67	< 79	< 606	< 134
	MEAN	-	-	-	-	-	-	-	-	-	-	-

Table C-III.1 **Concentrations of Gamma Emitters in Sediment Samples Collected in the Vicinity of Zion Nuclear Power Station, 2015**

Results in Units of pCi/kg Dry ± 2 sigma

SITE	COLLECTION PERIOD	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	Cs-134	Cs-137	Ba-140	La-140
Z-25	05/12/15	< 36	< 37	< 96	< 33	< 80	< 47	< 69	< 33	< 39	< 228	< 74
	10/07/15	< 43	< 44	< 97	< 54	< 122	< 36	< 100	< 38	< 50	< 182	< 47
	MEAN	-	-	-	-	-	-	-	-	-	-	-

Table C-IV.1 **Concentrations of Gross Beta in Air Particulate Samples Collected in the Vicinity of Zion Nuclear Power Station, 2015**

Results in Units of E-3 pCi/cu meter ± 2 Sigma

COLLECTION PERIOD	GROUP I			GROUP II
	Z-01	Z-02	Z-03	Z-13
12/31/14 - 01/07/15	25 ± 5	23 ± 5	23 ± 5	27 ± 5
01/07/15 - 01/14/15	20 ± 4	12 ± 4	19 ± 4	22 ± 4
01/14/15 - 01/21/15	18 ± 4	11 ± 4	16 ± 4	16 ± 4
01/21/15 01/28/15	(1)	(1)	(1)	(1)
01/28/15 - 02/04/15	12 ± 4	12 ± 4	16 ± 4	16 ± 4
02/04/15 - 02/10/15	19 ± 5	17 ± 5	24 ± 5	26 ± 5
02/10/15 - 02/18/15	19 ± 4	21 ± 4	24 ± 4	20 ± 4
02/18/15 - 02/25/15	37 ± 5	35 ± 5	30 ± 5	35 ± 5
02/25/15 - 03/04/15	18 ± 4	14 ± 4	12 ± 4	11 ± 4
03/04/15 - 03/11/15	19 ± 4	15 ± 4	15 ± 4	19 ± 4
03/11/15 - 03/18/15	16 ± 4	10 ± 3	12 ± 4	13 ± 4
03/18/15 - 03/25/15	15 ± 4	12 ± 4	13 ± 4	18 ± 4
03/25/15 - 04/01/15	9 ± 3	9 ± 4	11 ± 4	8 ± 3
04/01/15 - 04/08/15	22 ± 5	9 ± 4	11 ± 4	14 ± 4
04/08/15 - 04/15/15	14 ± 4	11 ± 4	8 ± 4	12 ± 4
04/15/15 - 04/22/15	11 ± 4	7 ± 3	7 ± 3	7 ± 3
04/22/15 - 04/29/15	10 ± 3	11 ± 3	10 ± 3	11 ± 3
04/29/15 - 05/06/15	10 ± 4	10 ± 4	12 ± 4	14 ± 4
05/06/15 - 05/12/15	7 ± 3	6 ± 2	9 ± 3	7 ± 2
05/12/15 - 05/20/15	8 ± 3	9 ± 3	6 ± 3	10 ± 3
05/20/15 - 05/27/15	16 ± 4	13 ± 4	11 ± 4	16 ± 4
05/27/15 - 06/03/15	10 ± 4	7 ± 4	8 ± 4	9 ± 4
06/03/15 - 06/10/15	14 ± 4	10 ± 3	13 ± 4	15 ± 4
06/10/15 - 06/17/15	8 ± 3	6 ± 3	8 ± 3	8 ± 3
06/17/15 - 06/24/15	9 ± 3	5 ± 3	11 ± 4	10 ± 3
06/24/15 - 07/01/15	10 ± 3	10 ± 4	10 ± 4	9 ± 3
07/01/15 - 07/08/15	14 ± 4	13 ± 4	12 ± 4	14 ± 4
07/08/15 - 07/16/15	10 ± 3	8 ± 3	11 ± 3	10 ± 3
07/16/15 - 07/22/15	16 ± 5	9 ± 4	12 ± 5	10 ± 4
07/22/15 - 07/29/15	18 ± 4	15 ± 4	20 ± 4	19 ± 4
07/29/15 - 08/05/15	17 ± 4	10 ± 4	15 ± 4	14 ± 4
08/05/15 - 08/12/15	15 ± 4	9 ± 3	13 ± 4	14 ± 4
08/12/15 - 08/19/15	19 ± 4	17 ± 4	16 ± 4	17 ± 4
08/19/15 - 08/26/15	15 ± 4	7 ± 3	12 ± 4	12 ± 4
08/26/15 - 09/02/15	27 ± 5	22 ± 5	25 ± 5	27 ± 5
09/02/15 - 09/09/15	29 ± 5	24 ± 5	36 ± 5	30 ± 5
09/09/15 - 09/16/15	17 ± 4	11 ± 4	20 ± 4	15 ± 4
09/16/15 - 09/23/15	15 ± 4	9 ± 3	13 ± 4	14 ± 4
09/23/15 - 09/30/15	18 ± 4	18 ± 4	22 ± 4	18 ± 4
09/30/15 - 10/07/15	7 ± 3	6 ± 3	9 ± 4	7 ± 3
10/07/15 - 10/14/15	21 ± 5	15 ± 4	18 ± 4	19 ± 4
10/14/15 - 10/21/15	22 ± 4	15 ± 4	(1)	19 ± 4
10/21/15 - 10/28/15	23 ± 5	19 ± 4	20 ± 3	21 ± 4
10/28/15 - 11/04/15	16 ± 4	13 ± 4	15 ± 4	14 ± 4
11/04/15 - 11/11/15	20 ± 4	15 ± 4	18 ± 4	20 ± 4
11/11/15 - 11/18/15	20 ± 5	19 ± 4	22 ± 5	22 ± 5
11/18/15 - 11/25/15	12 ± 4	10 ± 4	13 ± 4	12 ± 4
11/25/15 - 12/02/15	15 ± 4	13 ± 4	16 ± 4	16 ± 4
12/02/15 - 12/09/15	25 ± 5	27 ± 5	26 ± 5	23 ± 5
12/09/15 - 12/16/15	14 ± 4	14 ± 4	18 ± 4	14 ± 4
12/16/15 - 12/23/15	23 ± 4	20 ± 4	21 ± 4	21 ± 4
12/23/15 - 12/30/15	20 ± 4	19 ± 4	16 ± 4	18 ± 4
MEAN	16 ± 12	13 ± 12	15 ± 12	16 ± 12

(1) SEE PROGRAM EXCEPTIONS SECTION FOR EXPLANATION

Table C-IV.2 **Monthly and Yearly Mean Values of Gross Beta Concentrations in Air Particulate Samples Collected in the Vicinity of Zion Nuclear Power Station, 2015**

Results in Units of E-3 pCi/cu meter ± 2 Sigma

GROUP I - ONSITE LOCATIONS				GROUP II - OFFSITE CONTROL LOCATION			
COLLECTION PERIOD	MIN	MAX	MEAN ± 2SD	COLLECTION PERIOD	MIN	MAX	MEAN ± 2SD
12/31/14 - 12/30/15	11	25	18 ± 9	12/31/14 - 12/30/15	16	27.4	21 ± 10
01/28/15 - 02/25/15	12	37	22 ± 16	01/28/15 - 02/25/15	16	35	24 ± 16
02/25/15 - 04/01/15	9	19	13 ± 6	02/25/15 - 04/01/15	8	18.8	14 ± 9.1
04/01/15 - 04/29/15	7	22	11 ± 8	04/01/15 - 04/29/15	7	14	11 ± 6
04/29/15 - 06/03/15	6	16	9 ± 6	04/29/15 - 06/03/15	7	16	11 ± 8
06/03/15 - 07/01/15	5	14	10 ± 5	06/03/15 - 07/01/15	8	15	10 ± 6
07/01/15 - 07/29/15	8	20	13 ± 7	07/01/15 - 07/29/15	10	19	13 ± 9
07/29/15 - 09/02/15	7	27	16 ± 11	07/29/15 - 09/02/15	12	27	17 ± 12
09/02/15 - 09/30/15	9	36	19 ± 15	09/02/15 - 09/30/15	14	30	19 ± 14
09/30/15 - 10/28/15	6	23	16 ± 12	09/30/15 - 10/28/15	7	21	16 ± 13
10/28/15 - 12/02/15	10	22	16 ± 7	10/28/15 - 12/02/15	12	22	17 ± 8
12/02/15 - 12/23/15	14	27	21 ± 9	12/02/15 - 12/23/15	14	23	20 ± 9
12/31/14 - 12/30/15	5	37	15 ± 12	12/31/14 - 12/30/15	7	35	16 ± 12

Table C-IV.3 **Concentrations of Gamma Emitters in Air Particulate Samples Collected in the Vicinity of Zion Nuclear Power Station, 2015**

Results in Units of E-3 pCi/cu meter ± 2 Sigma

SITE	COLLECTION PERIOD	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	Cs-134	Cs-137	Ba-140	La-140
Z-01	12/31/14 - 04/01/15	< 2	< 3	< 12	< 4	< 7	< 5	< 5	< 2	< 3	< 90	< 58
	04/01/15 - 07/01/15	< 2	< 3	< 7	< 1	< 6	< 4	< 6	< 2	< 2	< 99	< 49
	07/01/15 - 09/30/15	< 2	< 3	< 9	< 3	< 5	< 3	< 7	< 3	< 2	< 83	< 44
	09/30/15 - 12/30/15	< 3	< 3	< 7	< 3	< 8	< 4	< 7	< 3	< 3	< 52	< 19
	MEAN	-	-	-	-	-	-	-	-	-	-	-
Z-02	12/31/14 - 04/01/15	< 6	< 7	< 18	< 4	< 14	< 8	< 14	< 5	< 4	< 232	< 84
	04/01/15 - 07/01/15	< 4	< 7	< 16	< 5	< 11	< 7	< 7	< 4	< 4	< 165	< 50
	07/01/15 - 09/30/15	< 1	< 3	< 10	< 2	< 3	< 2	< 6	< 2	< 2	< 117	< 27
	09/30/15 - 12/30/15	< 2	< 3	< 5	< 3	< 5	< 2	< 4	< 2	< 2	< 36	< 7
	MEAN	-	-	-	-	-	-	-	-	-	-	-
Z-03	12/31/14 - 04/01/15	< 2	< 6	< 12	< 4	< 9	< 5	< 9	< 3	< 3	< 133	< 51
	04/01/15 - 07/01/15	< 2	< 2	< 12	< 2	< 6	< 3	< 6	< 2	< 2	< 113	< 19
	07/01/15 - 09/30/15	< 2	< 3	< 9	< 3	< 5	< 3	< 6	< 2	< 2	< 116	< 47
	09/30/15 - 12/30/15	< 4	< 6	< 10	< 5	< 5	< 5	< 8	< 4	< 3	< 81	< 42
	MEAN	-	-	-	-	-	-	-	-	-	-	-
Z-13	12/31/14 - 04/01/15	< 4	< 4	< 12	< 3	< 8	< 5	< 6	< 3	< 3	< 132	< 57
	04/01/15 - 07/01/15	< 3	< 5	< 11	< 3	< 7	< 5	< 9	< 4	< 3	< 138	< 51
	07/01/15 - 09/30/15	< 2	< 2	< 6	< 2	< 5	< 3	< 6	< 2	< 2	< 101	< 25
	09/30/15 - 12/30/15	< 2	< 2	< 5	< 2	< 6	< 2	< 6	< 2	< 2	< 46	< 16
	MEAN	-	-	-	-	-	-	-	-	-	-	-

Table C-V.1 **CONCENTRATIONS OF GAMMA EMITTERS IN VEGETATION SAMPLES COLLECTED IN THE VICINITY OF ZION NUCLEAR POWER STATION, 2015**

RESULTS IN UNITS OF PC/KG WET ± 2 SIGMA

SITE	COLLECTION PERIOD	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	Cs-134	Cs-137	Ba-140	La-140
Z-CONTROL												
Cabbage	09/09/15	< 24	< 27	< 53	< 20	< 50	< 21	< 39	< 21	< 25	< 90	< 36
Carrots	09/09/15	< 19	< 20	< 40	< 16	< 47	< 19	< 37	< 17	< 22	< 86	< 19
	MEAN	-	-	-	-	-	-	-	-	-	-	-
Z-QUAD 3												
Kale	09/09/15	< 18	< 17	< 36	< 16	< 50	< 17	< 27	< 18	< 19	< 91	< 19
Potatoes	09/09/15	< 23	< 22	< 54	< 15	< 53	< 24	< 52	< 25	< 25	< 126	< 38
	MEAN	-	-	-	-	-	-	-	-	-	-	-
Z-QUAD 4												
Cabbage	09/09/15	< 36	< 25	< 44	< 26	< 84	< 22	< 61	< 29	< 38	< 112	< 35
Carrots	09/09/15	< 17	< 17	< 38	< 19	< 36	< 21	< 30	< 19	< 20	< 66	< 19
	MEAN	-	-	-	-	-	-	-	-	-	-	-

Table C-VI.1 Quarterly TLD Results for Zion Nuclear Power Station, 2015

Results in Units of Milli-Roentgen/Quarter ± 2 Standard Deviations

STATION CODE	MEAN ± 2 S.D.	JAN - MAR	APR - JUN	JUL - SEP	OCT - DEC
Z-01-1	33 ± 10	27	37	37	30
Z-01-2	32 ± 4	30	34	31	34
Z-02-1	19 ± 3	20	20	18	17
Z-02-2	18 ± 3	19	20	18	16
Z-03-1	19 ± 3	19	20	17	18
Z-03-2	19 ± 2	20	18	19	18
Z-13-1	21 ± 4	24	22	20	19
Z-13-2	20 ± 3	21	21	18	20
Z-13-3	21 ± 3	21	23	20	19
Z-13-4	21 ± 3	21	23	20	20
Z-13-5	20 ± 4	22	21	19	18
Z-13-6	20 ± 3	22	21	19	19
Z-101-1	18 ± 3	20	19	17	17
Z-101-2	18 ± 3	20	19	17	17
Z-102-1	20 ± 2	20	21	19	19
Z-102-2	21 ± 4	23	22	19	19
Z-103-1	20 ± 2	20	21	20	19
Z-103-2	19 ± 3	21	20	18	18
Z-104-1	19 ± 3	20	20	19	17
Z-104-2	19 ± 5	22	19	17	16
Z-105-1	19 ± 3	19	20	19	16
Z-105-2	18 ± 4	20	20	17	16
Z-106-1	19 ± 4	20	20	19	16
Z-106-2	20 ± 4	20	22	19	17
Z-107-1	20 ± 4	22	22	19	18
Z-107-2	20 ± 3	20	21	19	18
Z-108-1	23 ± 6	27	23	21	21
Z-108-2	22 ± 2	23	23	22	21
Z-109-1	38 ± 9	32	39	40	42
Z-109-2	43 ± 12	35	43	48	47
Z-112-1	20 ± 5	21	23	18	18
Z-112-2	21 ± 6	25	20	20	18
Z-113-1	19 ± 5	22	20	17	17
Z-113-2	18 ± 4	19	20	17	16
Z-114-1	20 ± 4	20	22	18	18
Z-114-2	20 ± 3	21	21	18	21
Z-115-1	20 ± 3	21	21	18	18
Z-115-2	19 ± 3	21	20	18	18
Z-121-1	19 ± 3	20	20	17	17
Z-121-2	20 ± 3	21	21	19	18
Z-124-1	19 ± 3	19	21	18	19
Z-124-2	21 ± 4	21	24	20	20
Z-125-1	22 ± 6	25	23	20	19
Z-125-2	21 ± 3	22	23	21	19
Z-129-1	19 ± 4	20	21	18	16
Z-129-2	19 ± 3	20	19	19	16
Z-130-1	26 ± 14	36	25	22	21
Z-130-2	26 ± 13	35	25	22	20
Z-131-1	53 ± 5	56	51	51	54

Table C-VI.1 Quarterly TLD Results for Zion Nuclear Power Station, 2015

Results in Units of Milli-Roentgen/Quarter ± 2 Standard Deviations

STATION CODE	MEAN ± 2 S.D.	JAN - MAR	APR - JUN	JUL - SEP	OCT - DEC
Z-131-2	50 ± 11	54	53	50	42
Z-209-1	20 ± 5	23	19	18	18
Z-209-2	19 ± 5	21	21	17	17
Z-211-1	22 ± 2	23	23	21	21
Z-211-2	23 ± 7	24	27	21	19
Z-212-1	23 ± 4	24	25	22	21
Z-212-2	24 ± 5	23	27	22	22
Z-213-1	25 ± 4	27	26	25	22
Z-213-2	24 ± 3	24	26	22	23
Z-214-1	23 ± 6	20	26	26	21
Z-214-2	22 ± 3	21	24	21	21
Z-215-1	24 ± 4	26	25	22	22
Z-215-2	23 ± 2	22	24	23	23
Z-216-1	19 ± 2	20	20	18	19
Z-216-2	19 ± 2	20	20	18	18

(1) SEE PROGRAM EXCEPTIONS SECTION FOR EXPLANATION

Table C-VI.2 Mean Quarterly TLD Results for Inner Ring, ISFSI Inner Ring, Other, Outer Ring, and Control Locations For Zion Nuclear Power Station, 2015

Results in Units of Milli-Roentgen/Quarter ± 2 Standard Deviation of the Station Data

COLLECTION PERIOD	INNER RING ± 2 S.D.	OUTER RING	OTHER	CONTROL
JAN-MAR	24 ± 17	23 ± 4	23 ± 10	22 ± 2
APR-JUN	24 ± 16	24 ± 6	25 ± 17	22 ± 2
JUL-SEP	22 ± 18	21 ± 5	23 ± 17	19 ± 2
OCT-DEC	21 ± 18	21 ± 4	22 ± 16	19 ± 2

Table C-VI.3 Summary of the Ambient Dosimetry Program for Zion Nuclear Power Station, 2015

Results in Units of Milli-Roentgen/Quarter

LOCATION	SAMPLES ANALYZED	PERIOD MINIMUM	PERIOD MAXIMUM	PERIOD MEAN ± 2 S.D.
INNER RING	152	16	56	23 ± 18
OUTER RING	56	17	27	22 ± 5
OTHER	24	16	37	23 ± 14
CONTROL	24	18	24	21 ± 3

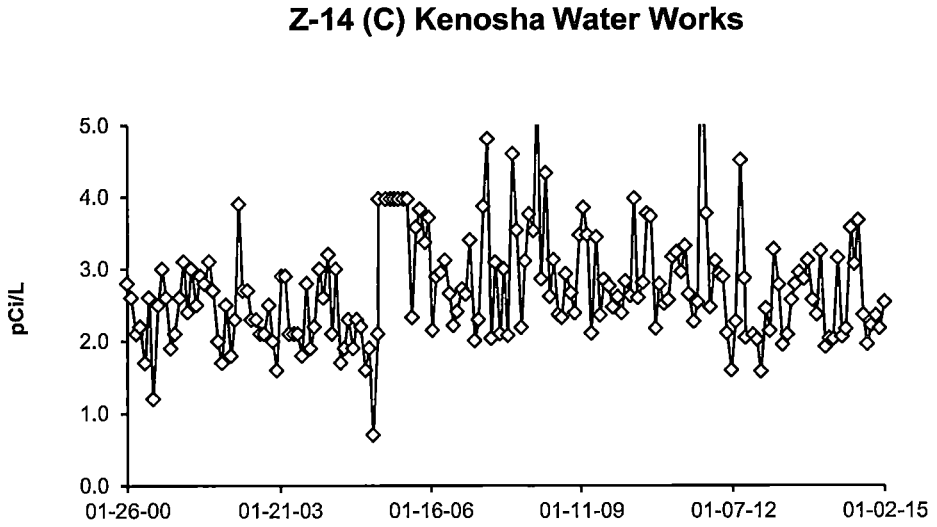
INNER RING STATIONS - Z-101-1, Z-101-2, Z-102-1, Z-102-2, Z-103-1, Z-103-2, Z-104-1, Z-104-2, Z-105-1, Z-105-2, Z-106-1, Z-106-2, Z-107-1, Z-107-2, Z-108-1, Z-108-2, Z-109-1, Z-109-2, Z-112-1, Z-112-2, Z-113-1, Z-113-2, Z-114-1, Z-114-2, Z-115-1, Z-115-2, Z-121-1, Z-121-2, Z-124-1, Z-124-2, Z-125-1, Z-125-2, Z129-1, Z-129-2, Z-130-1, Z-130-2, Z-131-1, Z-131-2

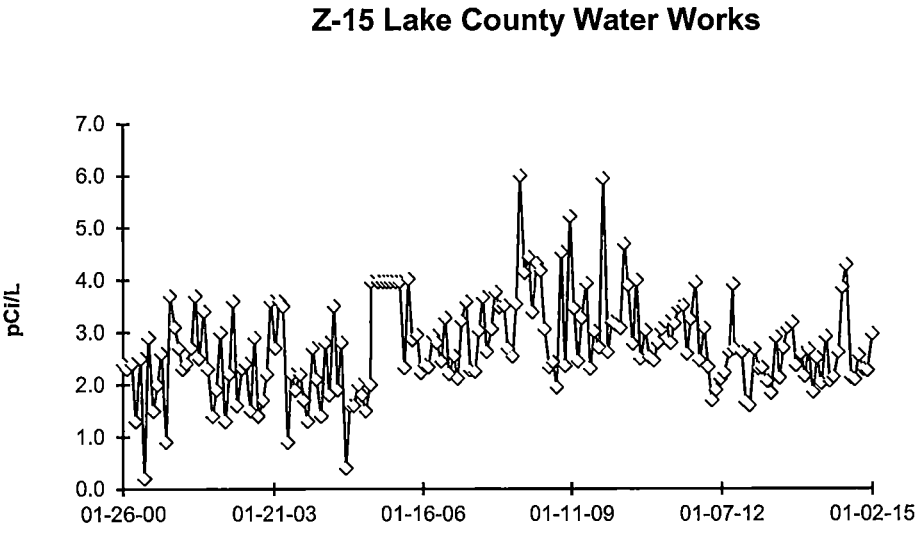
OUTER RING STATIONS - Z-209-1, Z-209-2, Z-211-1, Z-211-2, Z-212-1, Z-212-2, Z-213-1, Z-213-2, Z-214-1, Z-214-2, Z-215-1, Z-215-2, Z-216-1, Z-216-2

OTHER STATIONS - Z-01-1, Z-01-2, Z-02-1, Z-02-2, Z-03-1, Z-03-2

CONTROL STATIONS - Z-13-1, Z-13-2, Z-13-3, Z-13-4, Z-13-5, Z-13-6

FIGURE C-1
PUBLIC WATER - GROSS BETA - STATIONS Z-14 AND Z-15 COLLECTED IN THE VICINITY OF ZNPS, 2000 - 2015

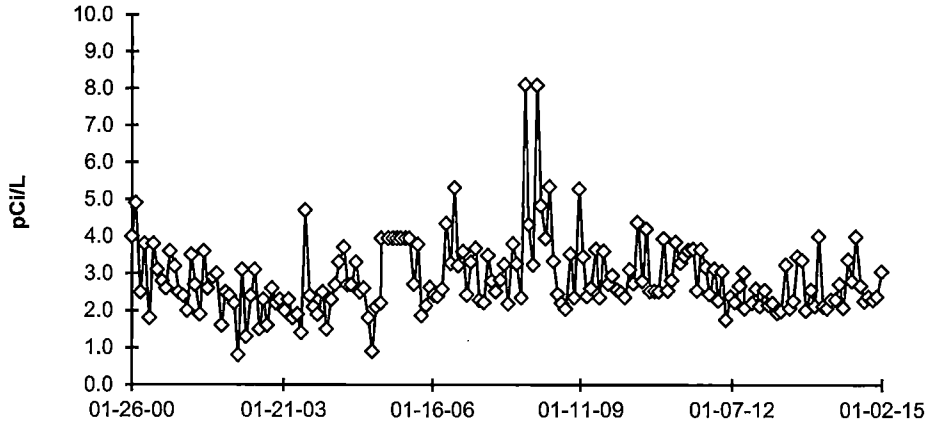




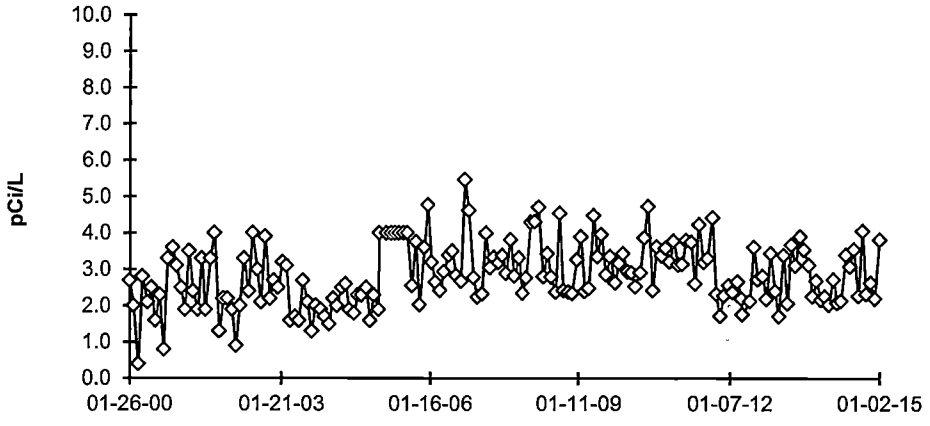
DUE TO VENDOR CHANGE IN 2005, < VALUES ARE LLD VALUES JANUARY THROUGH JUNE 2005 AND MDC VALUES AFTER JUNE 2005

FIGURE C-2
PUBLIC WATER - GROSS BETA - STATIONS Z-16 AND Z-18 COLLECTED IN THE VICINITY OF ZNPS, 2000 - 2015

Z-16 Waukegan Water Works



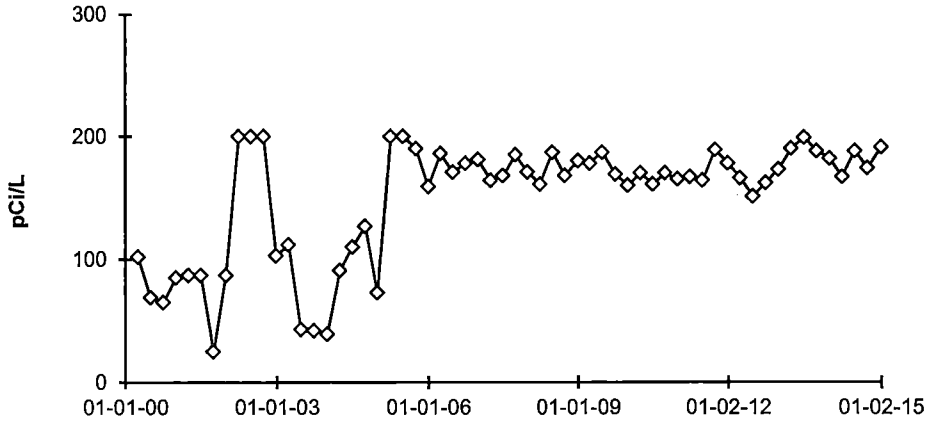
Z-18 (C) Lake Forest Water Works



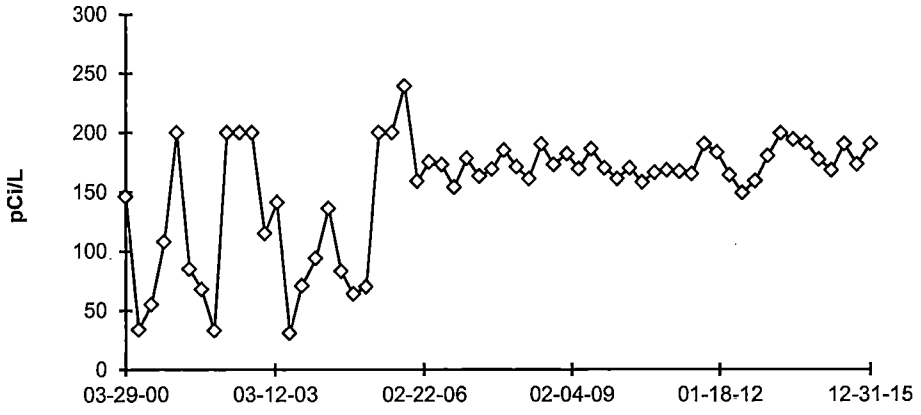
DUE TO VENDOR CHANGE IN 2005, < VALUES ARE LLD VALUES JANUARY THROUGH JUNE 2005 AND MDC VALUES AFTER JUNE 2005

FIGURE C-3
PUBLIC WATER - TRITIUM - STATION Z-14 AND Z-15 COLLECTED IN THE VICINITY OF ZNPS, 2000 - 2015

Z-14 (C) Kenosha Water Works



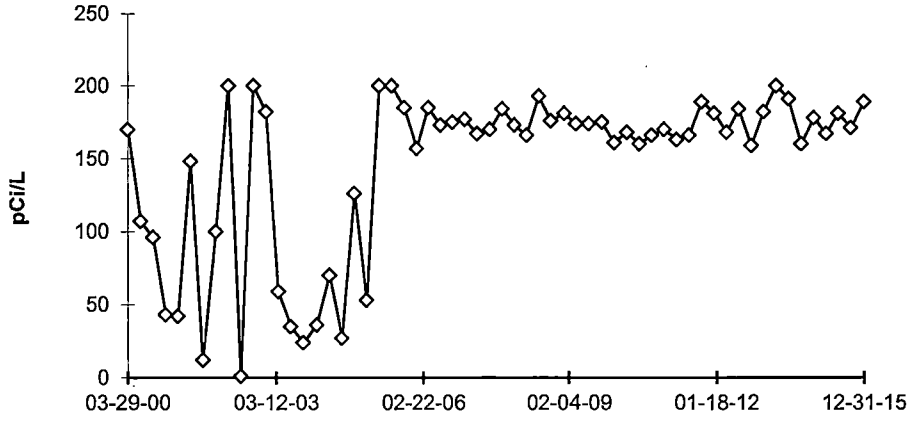
Z-15 Lake County Water Works



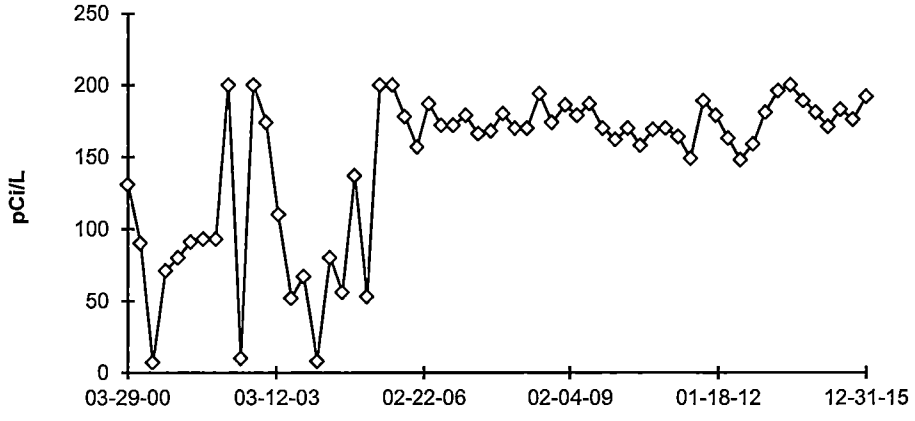
DUE TO VENDOR CHANGE IN 2005, < VALUES ARE LLD VALUES JANUARY THROUGH JUNE 2005 AND MDC VALUES AFTER JUNE 2005

FIGURE C-4
PUBLIC WATER - TRITIUM - STATION Z-16 AND Z-18 COLLECTED IN THE VICINITY OF ZNPS, 2000 - 2015

Z-16 Waukegan Water Works



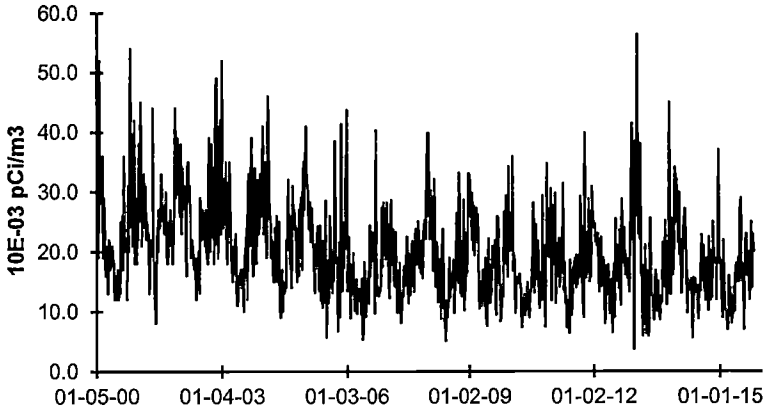
Z-18 (C) Lake Forest Water Works



DUE TO VENDOR CHANGE IN 2005, < VALUES ARE LLD VALUES JANUARY THROUGH JUNE 2005 AND MDC VALUES AFTER JUNE 2005

FIGURE C-5
AIR PARTICULATES - GROSS BETA - STATIONS Z-01 AND Z-02 COLLECTED IN THE VICINITY OF ZNPS, 2000 - 2015

Z-01 Onsite No. 1, Southside



Z-02 Onsite No. 2, Westside

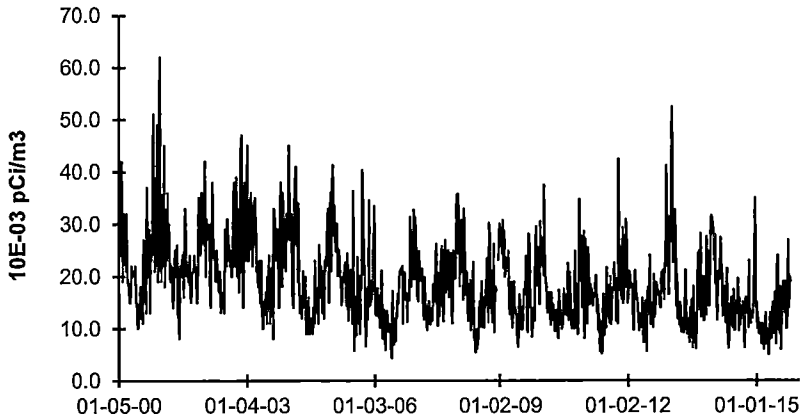
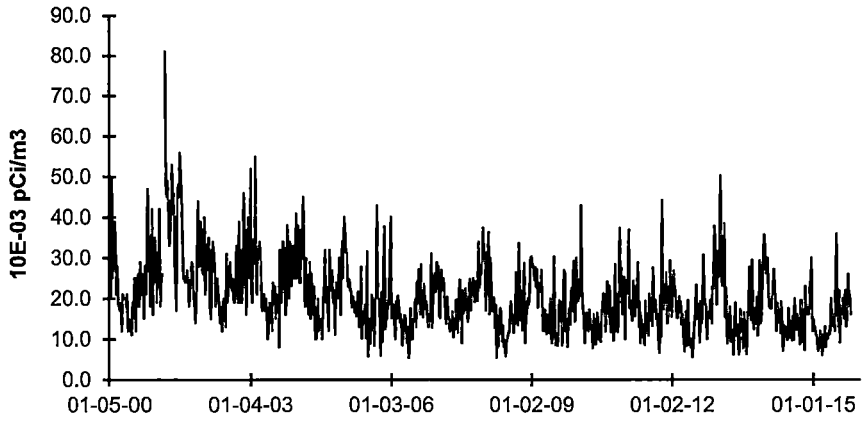
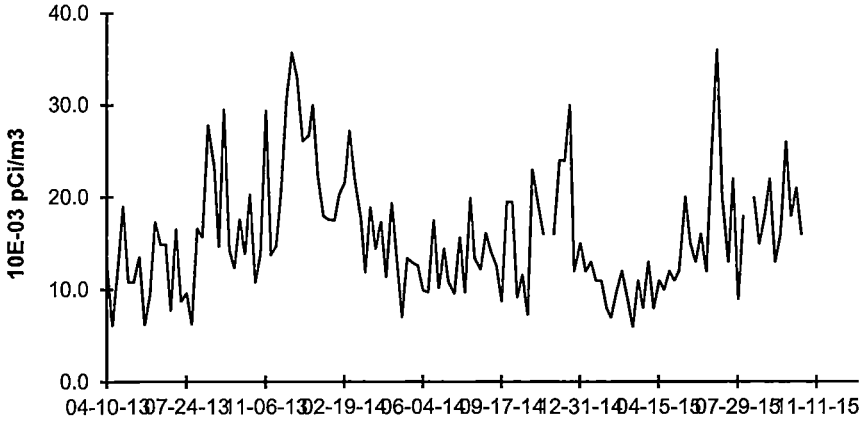


FIGURE C-6
AIR PARTICULATES - GROSS BETA - STATIONS Z-03 AND Z-13 COLLECTED IN THE VICINITY OF ZNPS, 2000 - 2015

Z-03 Onsite No. 3, Northside



Z-13 Offsite Control



APPENDIX D

INTER-LABORATORY COMPARISON PROGRAM

TABLE D-1 **ANALYTICS ENVIRONMENTAL RADIOACTIVITY CROSS CHECK PROGRAM**
TELEDYNE BROWN ENGINEERING, 2015
(PAGE 1 OF 3)

Month/Year	Identification Number	Matrix	Nuclide	Units	Reported Value (a)	Known Value (b)	Ratio (c) TBE/Analytics	Evaluation (d)
March 2015	E11181	Milk	Sr-89	pCi/L	88.9	97.2	0.91	A
			Sr-90	pCi/L	12.2	17.4	0.70	W
	E11182	Milk	I-131	pCi/L	61.3	65.1	0.94	A
			Ce-141	pCi/L	104	113	0.92	A
			Cr-51	pCi/L	265	276	0.96	A
			Cs-134	pCi/L	138	154	0.90	A
			Cs-137	pCi/L	205	207	0.99	A
			Co-58	pCi/L	178	183	0.97	A
			Mn-54	pCi/L	187	188	0.99	A
			Fe-59	pCi/L	182	177	1.03	A
			Zn-65	pCi/L	345	351	0.98	A
			Co-60	pCi/L	379	405	0.94	A
	E11184	AP	Ce-141	pCi	107	85.0	1.26	W
			Cr-51	pCi	261	224	1.17	A
			Cs-134	pCi	74.6	77.0	0.97	A
			Cs-137	pCi	99.6	102	0.98	A
			Co-58	pCi	99.8	110	0.91	A
			Mn-54	pCi	99.2	96.9	1.02	A
			Fe-59	pCi	109	119	0.92	A
			Zn-65	pCi	188	183	1.03	A
			Co-60	pCi	200	201	1.00	A
	E11183	Charcoal	I-131	pCi	82.9	85.4	0.97	A
	E11185	Water	Fe-55	pCi/L	1950	1900	1.03	A
June 2015	E11234	Milk	Sr-89	pCi/L	94.9	92.6	1.02	A
			Sr-90	pCi/L	14.3	12.7	1.13	A
	E11238	Milk	I-131	pCi/L	93.2	95.9	0.97	A
			Ce-141	pCi/L	Not provided for this study			
			Cr-51	pCi/L	349	276	1.26	W
			Cs-134	pCi/L	165	163	1.01	A
			Cs-137	pCi/L	143	125	1.14	A
			Co-58	pCi/L	82.0	68.4	1.20	A
			Mn-54	pCi/L	113	101	1.12	A
			Fe-59	pCi/L	184	151	1.22	W
			Zn-65	pCi/L	269	248	1.08	A
			Co-60	pCi/L	208	193	1.08	A
	E11237	AP	Ce-141	pCi	Not provided for this study			
			Cr-51	pCi	323	233	1.39	N (1)
			Cs-134	pCi	139	138	1.01	A
			Cs-137	pCi	111	106	1.05	A
			Co-58	pCi	54.0	57.8	0.93	A
			Mn-54	pCi	96.8	84.9	1.14	A
			Fe-59	pCi	162	128	1.27	W
			Zn-65	pCi	198	210	0.94	A
			Co-60	pCi	178	163	1.09	A
	E11236	Charcoal	I-131	pCi	93.9	80	1.17	A

TABLE D-1 ANALYTICS ENVIRONMENTAL RADIOACTIVITY CROSS CHECK PROGRAM
TELEDYNE BROWN ENGINEERING, 2015
(PAGE 2 OF 3)

Month/Year	Identification Number	Matrix	Nuclide	Units	Reported Value (a)	Known Value (b)	Ratio (c) TBE/Analytics	Evaluation (d)
June 2015	E11238	Water	Fe-55	pCi/L	1890	1790	1.06	A
September 2015	E11289	Milk	Sr-89	pCi/L	95.7	99.1	0.97	A
			Sr-90	pCi/L	15.4	16.4	0.94	A
	E11290	Milk	I-131	pCi/L	94.9	99.9	0.95	A
			Ce-141	pCi/L	228	213	1.07	A
			Cr-51	pCi/L	499	538	0.93	A
			Cs-134	pCi/L	208	212	0.98	A
			Cs-137	pCi/L	270	255	1.06	A
			Co-58	pCi/L	275	263	1.05	A
			Mn-54	pCi/L	320	290	1.10	A
			Fe-59	pCi/L	255	226	1.13	A
			Zn-65	pCi/L	392	353	1.11	A
			Co-60	pCi/L	350	330	1.06	A
	E11292	AP	Ce-141	pCi	104	85.1	1.22	W
			Cr-51	pCi	262	215	1.22	W
			Cs-134	pCi	86.1	84.6	1.02	A
			Cs-137	pCi	93	102	0.91	A
			Co-58	pCi	106	105	1.01	A
			Mn-54	pCi	117	116	1.01	A
			Fe-59	pCi	94.8	90.2	1.05	A
			Zn-65	pCi	160	141	1.13	A
			Co-60	pCi	146	132	1.11	A
	E11291	Charcoal	I-131	pCi	85.9	81.7	1.05	A
	E11293	Water	Fe-55	pCi/L	2090	1800	1.16	A
	E11294	Soil	Ce-141	pCi/kg	209	222	0.94	A
			Cr-51	pCi/kg	463	560	0.83	A
			Cs-134	pCi/kg	231	221	1.05	A
			Cs-137	pCi/kg	311	344	0.90	A
			Co-58	pCi/kg	245	274	0.89	A
			Mn-54	pCi/kg	297	302	0.98	A
			Fe-59	pCi/kg	248	235	1.06	A
			Zn-65	pCi/kg	347	368	0.94	A
			Co-60	pCi/kg	328	344	0.95	A
December 2015	E11354	Milk	Sr-89	pCi/L	96.2	86.8	1.11	A
			Sr-90	pCi/L	14.8	12.5	1.18	A
	E11355	Milk	I-131	pCi/L	95.1	91.2	1.04	A
			Ce-141	pCi/L	117	129	0.91	A
			Cr-51	pCi/L	265	281	0.94	A
			Cs-134	pCi/L	153	160	0.96	A
			Cs-137	pCi/L	119	115	1.03	A
			Co-58	pCi/L	107	110	0.97	A
			Mn-54	pCi/L	153	145	1.06	A
			Fe-59	pCi/L	117	108	1.08	A
			Zn-65	pCi/L	261	248	1.05	A
			Co-60	pCi/L	212	213	1.00	A

TABLE D-1 ANALYTICS ENVIRONMENTAL RADIOACTIVITY CROSS CHECK PROGRAM
TELEDYNE BROWN ENGINEERING, 2015
(PAGE 3 OF 3)

Month/Year	Identification Number	Matrix	Nuclide	Units	Reported Value (a)	Known Value (b)	Ratio (c) TBE/Analytics	Evaluation (d)
December 2015	E11357	AP	Ce-141	pCi	89.9	84.0	1.07	A
			Cr-51	pCi	215	184	1.17	A
			Cs-134	pCi	103	105	0.98	A
			Cs-137	pCi	76.6	74.8	1.02	A
			Co-58	pCi	76.2	71.9	1.06	A
			Mn-54	pCi	91.4	94.4	0.97	A
			Fe-59	pCi	78.6	70.3	1.12	A
			Zn-65	pCi	173	162	1.07	A
			Co-60	pCi	138	139	0.99	A
	E11422	AP	Sr-89	pCi	98.0	96.9	1.01	A
			Sr-90	pCi	10.0	14.0	0.71	W
	E11356	Charcoal	I-131	pCi	74.9	75.2	1.00	A
	E11358	Water	Fe-55	pCi/L	2160	1710	1.26	W
	E11353	Soil	Ce-141	pCi/kg	252	222	1.14	A
			Cr-51	pCi/kg	485	485	1.00	A
			Cs-134	pCi/kg	319	277	1.15	A
			Cs-137	pCi/kg	292	276	1.06	A
			Co-58	pCi/kg	193	190	1.02	A
			Mn-54	pCi/kg	258	250	1.03	A
			Fe-59	pCi/kg	218	186	1.17	A
			Zn-65	pCi/kg	457	429	1.07	A
			Co-60	pCi/kg	381	368	1.04	A

(1) AP Cr-51 - Cr-51 has the shortest half-life and the weakest gamma energy of the mixed nuclide sample, which produces a large error. Taking into account the error, the lowest value would be 119% of the reference value, which would be considered acceptable. NCR 15-18

(a) Teledyne Brown Engineering reported result.

(b) The Analytics known value is equal to 100% of the parameter present in the standard as determined by gravimetric and/or volumetric measurements made during standard preparation.

(c) Ratio of Teledyne Brown Engineering to Analytics results.

(d) Analytics evaluation based on TBE internal QC limits: A= Acceptable, reported result falls within ratio limits of 0.80-1.20. W-Acceptable with warning, reported result falls within 0.70-0.80 or 1.20-1.30. N = Not Acceptable, reported result falls outside the ratio limits of < 0.70 and > 1.30.

TABLE D-2 DOE'S MIXED ANALYTE PERFORMANCE EVALUATION PROGRAM (MAPEP)
TELEDYNE BROWN ENGINEERING, 2015
(PAGE 1 OF 1)

Month/Year	Identification Number	Media	Nuclide*	Units	Reported Value (a)	Known Value (b)	Acceptance Range	Evaluation (c)
March 2015	15-MaW32	Water	Am-241	Bq/L	0.632	0.654	0.458 - 0.850	A
			Ni-63	Bq/L	2.5		(1)	A
			Pu-238	Bq/L	0.0204	0.0089	(2)	A
			Pu-239/240	Bq/L	0.9	0.8	0.582 - 1.082	A
	15-MaS32	Soil	Ni-63	Bq/kg	392	448.0	314 - 582	A
			Sr-90	Bq/kg	286	653	487 - 849	N (3)
	15-RdF32	AP	Sr-90	Bq/sample	-0.0991		(1)	A
			U-234/233	Bq/sample	0.0211	0.0155	0.0109 - 0.0202	N (3)
			U-238	Bq/sample	0.095	0.099	0.069 - 0.129	A
	15-GrF32	AP	Gr-A	Bq/sample	0.448	1.77	0.53 - 3.01	N (3)
			Gr-B	Bq/sample	0.7580	0.75	0.38 - 1.13	A
	15-RdV32	Vegetation	Cs-134	Bq/sample	8.08	7.32	5.12 - 9.52	A
			Cs-137	Bq/sample	11.6	9.18	6.43 - 11.93	W
			Co-57	Bq/sample	-0.0096		(1)	A
			Co-60	Bq/sample	6.53	5.55	3.89 - 7.22	A
			Mn-54	Bq/sample	0.0058		(1)	A
			Sr-90	Bq/sample	0.999	1.08	0.76 - 1.40	A
			Zn-65	Bq/sample	-0.108		(1)	A
September 2015	15-MaW33	Water	Am-241	Bq/L	1.012	1.055	0.739 - 1.372	A
			Ni-63	Bq/L	11.8	8.55	5.99 - 11.12	N (4)
			Pu-238	Bq/L	0.727	0.681	0.477 - 0.885	A
			Pu-239/240	Bq/L	0.830	0.900	0.630 - 1.170	A
	15-MaS33	Soil	Ni-63	Bq/kg	635	682	477 - 887	A
			Sr-90	Bq/kg	429	425	298 - 553	A
	15-RdF33	AP	Sr-90	Bq/sample	1.48	2.18	1.53 - 2.83	N (4)
			U-234/233	Bq/sample	0.143	0.143	0.100 - 0.186	A
			U-238	Bq/sample	0.149	0.148	0.104 - 0.192	A
	15-GrF33	AP	Gr-A	Bq/sample	0.497	0.90	0.27 - 1.53	A
			Gr-B	Bq/sample	1.34	1.56	0.78 - 2.34	A
	15-RdV33	Vegetation	Cs-134	Bq/sample	6.10	5.80	4.06 - 7.54	A
			Cs-137	Bq/sample	0.0002		(1)	A
			Co-57	Bq/sample	8.01	6.62	4.63 - 8.61	W
			Co-60	Bq/sample	4.97	4.56	3.19 - 5.93	A
			Mn-54	Bq/sample	8.33	7.68	5.38 - 9.98	A
			Sr-90	Bq/sample	0.386	1.30	0.91 - 1.69	N (4)
			Zn-65	Bq/sample	6.07	5.46	3.82 - 7.10	A

(1) False positive test.

(2) Sensitivity evaluation.

(3) Soil Sr-90 - incomplete digestion of the sample resulted in low results; AP U-234/233 - extremely low activity was difficult to quantify AP Gr-A - the MAPEP filter has the activity embedded in the filter. To corrected the low bias, TBE will create an attenuated efficiency for MAPEP samples. NCR 15-13

(4) Water Ni-63 extremely low activity was difficult to quantify; AP & Vegetation Sr-90 was lost during separation, possible from substance added by MAPEP NCR 15-21.

(a) Teledyne Brown Engineering reported result.

(b) The MAPEP known value is equal to 100% of the parameter present in the standard as determined by gravimetric and/or volumetric measurements made during standard preparation.

(c) DOE/MAPEP evaluation: A=acceptable, W=acceptable with warning, N=not acceptable.

TABLE D-3 **ERA ENVIRONMENTAL RADIOACTIVITY CROSS CHECK PROGRAM**
TELEDYNE BROWN ENGINEERING, 2015
(PAGE 1 OF 1)

Month/Year	Identification Number	Media	Nuclide	Units	Reported Value (a)	Known Value (b)	Acceptance Limits	Evaluation (c)
May 2015	RAD-101	Water	Sr-89	pCi/L	45.2	63.2	51.1 - 71.2	N (1)
			Sr-90	pCi/L	28.0	41.9	30.8 - 48.1	N (1)
			Ba-133	pCi/L	80.6	82.5	63.9 - 90.8	A
			Cs-134	pCi/L	71.7	75.7	61.8 - 83.3	A
			Cs-137	pCi/L	187	189	170 - 210	A
			Co-60	pCi/L	85.7	84.5	76.0 - 95.3	A
			Zn-65	pCi/L	197	203	183 - 238	A
			Gr-A	pCi/L	26.1	42.6	22.1 - 54.0	A
			Gr-B	pCi/L	28.8	32.9	21.3 - 40.6	A
			I-131	pCi/L	23.5	23.8	19.7 - 28.3	A
			U-Nat	pCi/L	6.19	6.59	4.99 - 7.83	A
			H-3	pCi/L	3145	3280	2770 - 3620	A
November 2015	RAD-103	Water	Sr-89	pCi/L	40.9	35.7	26.7 - 42.5	A
			Sr-90	pCi/L	29.3	31.1	22.7 - 36.1	A
			Ba-133	pCi/L	31.5	32.5	25.9 - 36.7	A
			Cs-134	pCi/L	59.65	62.3	50.6 - 68.5	A
			Cs-137	pCi/L	156	157	141 - 175	A
			Co-60	pCi/L	70.6	71.1	64.0 - 80.7	A
			Zn-65	pCi/L	145	126	113 - 149	A
			Gr-A	pCi/L	38.2	51.6	26.9 - 64.7	A
			Gr-B	pCi/L	42.0	36.6	24.1 - 44.2	A
			I-131	pCi/L	24.8	26.3	21.9 - 31.0	A
			U-Nat	pCi/L	146.90	56.2	45.7 - 62.4	N (2)
			H-3	pCi/L	21100	21300	18700 - 23400	A

(1) Yield on the high side of our acceptance range indicates possibility of calcium interference. NCR 15-09

(2) Technician failed to dilute original sample. If dilulted, the result would have been 57.1, which fell within the acceptance limits. NCR 15-19

(a) Teledyne Brown Engineering reported result.

(b) The ERA known value is equal to 100% of the parameter present in the standard as determined by gravimetric and/or volumetric measurements made during standard preparation.

(c) ERA evaluation: A=acceptable. Reported result falls within the Warning Limits. NA=not acceptable. Reported result falls outside of the Control Limits. CE=check for Error. Reported result falls within the Control Limits and outside of the Warning Limit.

TABLE D-4 **ERA (a) STATISTICAL SUMMARY PROFICIENCY TESTING PROGRAM[a]**
ENVIRONMENTAL, INC., 2015
(Page 1 of 1)

Lab Code	Date	Analysis	Concentration (pCi/L) Laboratory Result [b]	ERA Result [c]	Control Limits	Acceptance
ERW-1444	04/06/15	Sr-89	59.71 ± 5.44	63.20	51.10 - 71.20	Pass
ERW-1444	04/06/15	Sr-90	43.41 ± 2.43	41.90	30.80 - 48.10	Pass
ERW-1448	04/06/15	Ba-133	77.75 ± 4.69	82.50	69.30 - 90.80	Pass
ERW-1448	04/06/15	Cs-134	68.82 ± 3.08	75.70	61.80 - 83.30	Pass
ERW-1448	04/06/15	Cs-137	- 191.92 ± 5.9	189	- 170.00 - 210.0	Pass
ERW-1448	04/06/15	Co-60	85.05 ± 4.59	84.50	76.00 - 95.30	Pass
ERW-1448	04/06/15	Zn-65	- 195.97 ± 12.0	203	- 183.00 - 238.0	Pass
ERW-1450	04/06/15	Gr. Alpha	34.05 ± 1.90	42.60	22.10 - 54.00	Pass
ERW-1450	04/06/15	G. Beta	26.93 ± 1.12	32.90	21.30 - 40.60	Pass
ERW-1453	04/06/15	I-131	22.47 ± 0.83	23.80	19.70 - 28.30	Pass
ERW-1456	04/06/15	Uranium	5.98 ± 0.31	6.59	4.99 - 7.83	Pass
ERW-1461	04/06/15	H-3	3,254 ± 180	3280	2,770 - 3620	Pass
ERW-5528	10/05/15	Sr-89	34.76 ± 0.06	35.70	26.70 - 42.50	Pass
ERW-5528	10/05/15	Sr-90	29.23 ± 0.06	31.10	22.70 - 36.10	Pass
ERW-5531	10/05/15	Ba-133	30.91 ± 0.53	32.50	25.90 - 36.70	Pass
ERW-5531	10/05/15	Cs-134	57.40 ± 2.57	62.30	50.69 - 68.50	Pass
ERW-5531	10/05/15	Cs-137	- 163.12 ± 4.8	157	- 141.00 - 175.0	Pass
ERW-5531	10/05/15	Co-60	73.41 ± 1.72	71.10	64.00 - 80.70	Pass
ERW-5531	10/05/15	Zn-65	- 138.94 ± 5.7	126	- 113.00 - 149.0	Pass
ERW-5534	10/05/15	Gr. Alpha	29.99 ± 0.08	51.60	26.90 - 64.70	Pass
ERW-5534	10/05/15	G. Beta	27.52 ± 0.04	36.60	24.10 - 44.20	Pass
ERW-5537	10/05/15	I-131	25.54 ± 0.60	26.30	21.90 - 31.00	Pass
ERW-5540	10/05/15	Uranium	53.30 ± 0.55	56.20	45.70 - 62.40	Pass
ERW-5543	10/05/15	H-3	21,260 ± 351	21,300	18,700 - 23400.0	Pass

[a] Results obtained by Environmental, Inc., Midwest Laboratory as a participant in the crosscheck program for proficiency testing in drinking water conducted by Environmental Resources Associates (ERA).

[b] Unless otherwise indicated, the laboratory result is given as the mean ± standard deviation for three determinations.

[c] Results are presented as the known values, expected laboratory precision (1 sigma, 1 determination) and control limits as provided by ERA.

TABLE D-5 **DOE'S MIXED ANALYTE PERFORMANCE EVALUATION PROGRAM (MAPEP)**
ENVIRONMENTAL, INC., 2015
(Page 1 of 2)

			Concentration [a]			
Lab Code [b]	Date	Analysis	Laboratory result	Known Activity	Control Limits [c]	Acceptance
MASO-975	02/01/15	Ni-63	341 ± 18	448	314 - 582	Pass
MASO-975	02/01/15	Sr-90	523 ± 12	653	457 - 849	Pass
MASO-975	02/01/15	Cs-134	533 ± 6	678	475 - 881	Pass
MASO-975	02/01/15	Cs-137	0.8 ± 2.5	0.0	NA [c]	Pass
MASO-975	02/01/15	Co-57	0.5 ± 1	0.0	NA [c]	Pass
MASO-975	02/01/15	Co-60	741 ± 8	817	572 - 1062	Pass
MASO-975	02/01/15	Mn-54	1,153 ± 9	1,198	839 - 1557	Pass
MASO-975	02/01/15	Zn-65	892 ± 18	1064	745 - 1383	Pass
MAW-969	02/01/15	Am-241	0.650 ± 0.078	0.654	0.458 - 0.850	Pass
MAW-969	02/01/15	Cs-134	21.09 ± 0.25	23.5	16.5 - 30.6	Pass
MAW-969	02/01/15	Cs-137	19.63 ± 0.34	19.1	13.4 - 24.8	Pass
MAW-969 [d]	02/01/15	Co-57	10.2 ± 0.4	29.9	20.9 - 38.9	Fail
MAW-969	02/01/15	Co-60	0.02 ± 0.05	0.00	NA [c]	Pass
MAW-969	02/01/15	H-3	569 ± 13	563	394 - 732	Pass
MAW-969	02/01/15	Fe-55	6.00 ± 6.60	6.88	4.82 - 8.94	Pass
MAW-969	02/01/15	Mn-54	0.02 ± 0.07	0.00	NA [c]	Pass
MAW-969	02/01/15	Ni-63	2.9 ± 3	0.00	NA [c]	Pass
MAW-969	02/01/15	Zn-65	16.54 ± 0.85	18.3	12.8 - 23.8	Pass
MAW-969	02/01/15	Pu-238	0.02 ± 0.03	0.01	NA [e]	Pass
MAW-969	02/01/15	Pu-239/240	0.81 ± 0.10	0.83	0.58 - 1.08	Pass
MAW-969	02/01/15	Sr-90	9.40 ± 1.30	9.48	6.64 - 12.32	Pass
MAW-950	02/01/15	Gr. Alpha	0.66 ± 0.05	1.07	0.32 - 1.81	Pass
MAW-950	02/01/15	Gr. Beta	2.72 ± 0.06	2.79	1.40 - 4.19	Pass
MAAP-978	02/01/15	Cs-134	1.00 ± 0.04	1.15	0.81 - 1.50	Pass
MAAP-978	02/01/15	Cs-137	0.004 ± 0.023	0.00	NA [c]	Pass
MAAP-978 [e]	02/01/15	Co-57	0.04 ± 0.04	1.51	1.06 - 1.96	Fail
MAAP-978	02/01/15	Co-60	0.01 ± 0.02	0.00	NA [c]	Pass
MAAP-978	02/01/15	Mn-54	1.11 ± 0.08	1.02	0.71 - 1.33	Pass
MAAP-978	02/01/15	Zn-65	0.83 ± 0.10	0.83	0.58 - 1.08	Pass
MAAP-981	02/01/15	Sr-89	38.12 ± 1.01	47.5	33.3 - 61.8	Pass
MAAP-981	02/01/15	Sr-90	1.22 ± 0.13	1.06	0.74 - 1.38	Pass
MAAP-984	02/01/15	Gr. Alpha	0.59 ± 0.06	1.77	0.53 - 3.01	Pass
MAAP-984	02/01/15	Gr. Beta	0.95 ± 0.07	0.75	0.38 - 1.13	Pass
MAVE-972	02/01/15	Cs-134	6.98 ± 0.13	7.32	5.12 - 9.52	Pass
MAVE-972	02/01/15	Cs-137	9.73 ± 0.21	9.18	6.43 - 11.93	Pass
MAVE-972	02/01/15	Co-57	0.01 ± 0.04	0.00	NA [c]	Pass
MAVE-972	02/01/15	Co-60	3.89 ± 0.20	5.55	3.89 - 7.22	Pass
MAVE-972	02/01/15	Mn-54	0.04 ± 0.07	0.00	NA [c]	Pass
MAVE-972	02/01/15	Zn-65	0.09 ± 0.12	0.00	NA [c]	Pass

TABLE D-5 **DOE'S MIXED ANALYTE PERFORMANCE EVALUATION PROGRAM (MAPEP)**
ENVIRONMENTAL, INC., 2015

			Concentration [a]			
Lab Code [b]	Date	Analysis	Laboratory result	Known Activity	Control Limits [c]	Acceptance
MASO-4903	08/01/15	Ni-63	556 ± 18	682	477 - 887	Pass
MASO-4903 f	08/01/15	Sr-90	231 ± 7	425	298 - 553	Fail
MASO-4903 f	08/01/15	Sr-90	352 ± 10	425	298 - 553	Pass
MASO-4903	08/01/15	Cs-134	833 ± 10	1,010	707 - 1313	Pass
MASO-4903	08/01/15	Cs-137	808 ± 11	809.00	566 - 1052	Pass
MASO-4903	08/01/15	Co-57	1,052 ± 10	1,180	826 - 1534	Pass
MASO-4903	08/01/15	Co-60	2 ± 2	1.3	NA [e]	Pass
MASO-4903	08/01/15	Mn-54	1,331 ± 13	1,340	938 - 1742	Pass
MASO-4903	08/01/15	Zn-65	686 ± 15	662	463 - 861	Pass
MAW-5007	08/01/15	Cs-134	16.7 ± 0.4	23.1	16.2 - 30	Pass
MAW-5007	08/01/15	Cs-137	-0.36 ± 0.13	0	NA [c]	Pass
MAW-5007	08/01/15	Co-57	21.8 ± 0.4	20.8	14.6 - 27	Pass
MAW-5007	08/01/15	Co-60	17.3 ± 0.3	17.1	12 - 22.2	Pass
MAW-5007	08/01/15	H-3	227.5 ± 8.9	216	151 - 281	Pass
MAW-5007 g	08/01/15	Fe-55	4.2 ± 14.1	13.1	9.2 - 17	Fail
MAW-5007	08/01/15	Mn-54	16.6 ± 0.5	15.6	10.9 - 20.3	Pass
MAW-5007	08/01/15	Ni-63	9.1 ± 2.6	8.55	5.99 - 11.12	Pass
MAW-5007	08/01/15	Zn-65	15.5 ± 0.9	13.9	9.7 - 18.1	Pass
MAW-5007	08/01/15	Sr-90	4.80 ± 0.50	4.80	3.36 - 6.24	Pass
MAW-5007	08/01/15	Gr. Alpha	0.41 ± 0.04	0.43	0.13 - 0.73	Pass
MAW-5007	08/01/15	Gr. Beta	3.45 ± 0.07	3.52	1.76 - 5.28	Pass
MAAP-4911	08/01/15	Sr-89	3.55 ± 0.67	3.98	2.79 - 5.17	Pass
MAAP-4911	08/01/15	Sr-90	0.94 ± 0.16	1.05	0.74 - 1.37	Pass
MAAP-4907	08/01/15	Gr. Alpha	0.30 ± 0.04	0.90	0.27 - 1.53	Pass
MAAP-4907	08/01/15	Gr. Beta	1.85 ± 0.09	1.56	0.78 - 2.34	Pass
MAVE-4901	08/01/15	Cs-134	5.56 ± 0.16	5.80	4.06 - 7.54	Pass
MAVE-4901	08/01/15	Cs-137	-0.02 ± 0.06	0.00	NA [c]	Pass
MAVE-4901	08/01/15	Co-57	7.74 ± 0.18	6.62	4.63 - 8.61	Pass
MAVE-4901	08/01/15	Co-60	4.84 ± 0.15	4.56	3.19 - 5.93	Pass
MAVE-4901	08/01/15	Mn-54	8.25 ± 0.25	7.68	5.38 - 9.98	Pass
MAVE-4901	08/01/15	Zn-65	5.78 ± 0.29	5.46	3.82 - 7.10	Pass

[a] Results are reported in units of Bq/kg (soil), Bq/L (water) or Bq/total sample (filters, vegetation).

[b] Laboratory codes as follows: MAW (water), MAAP (air filter), MASO (soil), MAVE (vegetation).

[c] MAPEP results are presented as the known values and expected laboratory precision (1 sigma, 1 determination) and control limits as defined by the MAPEP. A known value of "zero" indicates an analysis was included in the testing series as a "false positive". MAPEP does not provide control limits.

[d] Lab result was 27.84. Data entry error resulted in a non-acceptable result.

[e] Lab result was 1.58. Data entry error resulted in a non-acceptable result.

f The incomplete separation of calcium from strontium caused a failed low result. The result of reanalysis acceptable.

g The known activity was below the routine laboratory detection limits for the available aliquot fraction.

APPENDIX E

EFFLUENT DATA

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INTRODUCTION

Units 1 and 2 of the Zion Station, located in Zion, Illinois adjacent to Lake Michigan, were 1100 MWe (3520 MWt) Westinghouse pressurized water reactors. The plant permanently ceased operation in February of 1998 and has been permanently defueled. The station is in an advanced state of decommissioning.

The station was designed to keep releases to the environment at levels below those specified in the regulations. Historical data has been established that Zion, as a fully operational facility, did not contribute appreciable doses to the surrounding public. Sampling results for 2015 showed minimal releases above background for a variety of monitored pathways, e.g. water, vegetation, air samples and TLIV.

Liquid effluents from Zion Station are released to Lake Michigan in controlled batches after radioassay of each batch and continuously through a monitored pathway. There are no routine noble gas releases. Due to decay, iodine is no longer present. The only noble gas that remained prior to January 2015 was Kr-85 captured in the spent fuel assemblies stored in the fuel pool in the fuel building. During January 2015, the last fuel assembly was removed from the fuel building and Kr-85 is no longer present in the fuel handling building. The results of effluent analyses are summarized on a monthly basis and reported to the Nuclear Regulatory Commission as required per Quality Assurance Project Plan which replaced the Technical Specifications after spent fuel was transferred to the ISFSI. Airborne concentrations of noble gases and particulate radioactivity in offsite areas are calculated using effluent and historical meteorological data.

Currently Zion Station is undergoing decommissioning. During the decommissioning process, containerized waste is temporarily maintained at designated locations onsite. The designated locations are located in a manner to minimize the direct radiation exposure to the public at or near the site boundary.

Environmental monitoring was conducted by sampling at indicator and control (background) locations in the vicinity of the Zion Station to measure changes in radiation or radioactivity levels that may be attributable to the station. If significant changes attributable to Zion Station are measured, these changes are correlated with effluent releases or direct radiation from containerized waste.

ISFSI operations were conducted in 2015 which attributed direct radiation dose in the form of gamma and neutron radiation to members of the public. The results of the calculated dose from direct radiation from the ISFSI have been calculated and included in this report. In addition to the dose contributed to members of the public, a special case exists for members of the public working

onsite in the switchyard area. Switchyard worker dose results are also included in this report.

SUMMARY

Gaseous, liquid and solid waste effluents for the period contributed to only a small fraction of the Station Technical Specification limits. Calculations of environmental concentrations based on effluent and historical meteorological data for the period indicate that consumption by the public of radionuclides attributable to the Zion Station does not exceed regulatory limits. Radiation exposure from direct radiation from the ISFSI and containerized waste at the site boundary represented the critical pathway for the period with a maximum individual total body dose estimated to be 1.94E+01 mrem for the year, where a factor to analyze exposure based on habits of the real individual of 3.38-01 was applied at the maximally exposed receptor. The assessment of radiation doses is performed in accordance with the Zion Station Offsite Dose Calculation Manual (ODCM). The results of analysis confirm that the station is operating in compliance with 10CFR50 Appendix I, 10CFR20, 10CFR72 and 40CFR190.

1.0 EFFLUENTS

1.1 Gaseous Effluents to the Atmosphere

Measured concentrations and isotopic composition of noble gases and particulate radioactivity released to the atmosphere were monitored during the year. A total of 0.00E+00 microcuries of fission and activation gases was released with a maximum average release rate of 0.00E+00 µCi/sec during any one quarter period.

A total of 9.41E-04 curies of beta-gamma emitters was released as airborne particulate matter with a maximum average quarterly release rate of 2.99E-05 µCi/sec. Alpha-emitting radionuclides were less than measurable detection limits. 0.00E+00 curies of tritium were released with a maximum average quarterly release rate of 0.00E+00 µCi/sec.

1.2 Liquids Released to Lake Michigan

A total of 1.54E+07 liters of liquid waste containing 2.82E-02 curies of fission and activation products, 1.06E+00 curies of tritium, and 1.87E-05 Ci of Alpha was discharged from the station via an approved pathway after dilution with a total of 9.96E+09 liters of water. These wastes were released at a maximum quarterly average concentration of 6.46E-08 µCi/ml. Monthly release estimates and principal radionuclides in liquid effluents are reported in the Zion Nuclear Power Station Radioactive Effluent Report for 2015.

2.0 SOLID RADIOACTIVE WASTE

There were 67 solid radioactive waste shipments in 2015. For more detail, refer to the Zion Station 2015 Annual Radioactive Effluent Release Report.

3.0 DOSE TO MAN

3.1 Gaseous Effluent Pathways

Table 3.1-1 summarizes the doses resulting from releases of airborne radioactivity via the different exposure pathways.

3.1.1 Gaseous Releases

3.1.1.1 Gamma Dose Rates

Offsite Gamma air and whole (total) body dose rates are shown in Table 3.1-1 and were calculated based on measured release rates, isotopic composition of the gases, and meteorological data for the period. Based on measured effluents and historical meteorological data, the maximum total body dose to an individual would be 2.94E-02 mrem (adult) for the year (Table 3.5-1), with an occupancy or shielding factor of 0.7 included. The maximum gamma air dose was 0.00E+00 mrad based on measured effluents and average historical meteorological data (Table 3.5-1).

3.1.1.2 Beta Air and Skin Dose Rates

The range of beta particles in air is relatively small (on the order of a few meters or less); consequently, plumes of gaseous effluents may be considered "infinite" for purpose of calculating the dose from beta radiation incident on the skin. However, the actual dose to sensitive skin tissues is difficult to calculate due to the effect of the beta particle energies, thickness of inert skin and clothing covering sensitive tissues. For purposes of this report the skin is taken to have a thickness of 7.0 mg/cm^2 and an occupancy factor of 1.0 is used. The skin dose from beta and gamma radiation for the year 0.00E+00 mrem based on measured effluents and historical meteorological data (Table 3.5-1).

The maximum offsite beta air dose for the year was 0.00E+00 mrad based on measured effluents and historical meteorological data (Table 3.5-1).

3.1.2 Radioactive Iodine

The human thyroid exhibits a significant capacity to concentrate ingested or inhaled iodine. The radioiodine, 1-131, released during routine operation of the station, may

be made available to man resulting in a dose to the thyroid. The principal pathway of interest for this radionuclide is ingestion of radioiodine in milk. As Zion Station is not operational and I-131 has decayed away, the maximum offsite concentration is estimated to be zero, as expected.

3.1.3 Dose to Thyroid

The hypothetical thyroid dose to a maximum exposed individual living near the station via ingestion of milk was calculated. As Zion Station is not operational and 1-131 has decayed away, the maximum offsite concentration is estimated to be zero, as expected.

3.2 Liquid Effluent Pathways

The three principal pathways through the aquatic environment for potential doses to man from liquid waste are ingestion of potable water, eating aquatic foods, and exposure while on the shoreline. Not all of these pathways are significant or applicable at a given time but a reasonable approximation of the dose can be made by adjusting the dose formula for season of the year or type and degree of use of the aquatic environment. NRC developed equations* were used to calculate the doses to the whole body, lower GI tracts, thyroid, bone, skin; specific parameters for use in the equations are given in the Zion Station Offsite Dose Calculation Manual. The maximum whole body dose (total body) for the year was 3.64E-03 mrem and no organ dose exceeded 1.00E-01 mrem (Table 3.2-1).

3.3 Direct Radiation

During the period January to December 2015, Zion Station during decommissioning has stored containerized radioactive waste combined with direct radiation from the ISFSI (including gamma plus neutron) that contributed a total of 1.94E+01 mrem to the whole body of a maximally exposed individual at site boundary taking into account the occupancy factor of 3.38E-01 calculated in Zion Station ES&H Technical Support Document (TSD) 13-009 "Member of the Public Dose from All Onsite Sources." The maximally exposed member of the public working in the switchyard onsite was calculated to receive 9.15E+01 mrem to the whole body at the south switchyard boundary. This value takes into account the occupancy factor of 2.38E-01 as described in ES&H TSD 13-009 referenced above.

3.4 Assessment of Dose to Member of Public

During the period January to December, 2015, Zion Station did not exceed the below limits as shown in Table 3.1-1 and Table 3.2-1 (based on yearly average meteorological data), and Table 3.3 (based on TLD results):

- The RETS limits on dose or dose commitment to an individual due to radioactive materials in liquid effluents from each reactor unit (3 mrem to the whole body or 10 mrem to any organ during any calendar year).

- The RETS limits on air dose in noble gases released in gaseous effluents to a member of the public from each reactor unit (10 mrads for gamma radiation or 20 mrad for beta radiation during any calendar year).

- The RETS limits on dose to a member of the public due to iodine-131, iodine-133, tritium, and radionuclides in particulate form 'with half-lives greater than eight days in gaseous effluents released from each reactor unit (15 mrem to any organ during any calendar year).

- The 10CFR20 limit on Total Effective Dose Equivalent to individual members of the public (100 mrem).

- The 10CFR72.104 limit on Total Effective Dose Equivalent to individual members of the public from combined effluents and radioactive material including ISFSI(25 mrem).

4.0 SITE METEOROLOGY

A summary of the site meteorological measurements taken during the period of operation of the meteorological tower is given in Appendix 11. After fuel was removed from the fuel building, the meteorological tower was no longer required and the tower was removed. A new historical average of the meteorological data was created to reflect current parameters and the data are presented as cumulative joint frequency which represents a time period from January 1 2009 to December 31 2014.

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*Nuclear Regulatory Commission, Regulatory Guide 1.109 (Rev. 1)
distributions of the wind direction for the 250' level and wind speed class by atmospheric stability class determined from the temperature difference between the 250' and 35' levels. Data recovery for these measurements was 99.6% during 2015 (Table 3.5-1).

APPENDIX E-1

DATA TABLES AND FIGURES

Table 3.1-1
Maximum Dose Resulting from Airborne Releases
Zion Station 2015

GASEOUS EFFLUENTS - SUMMATION OF ALL RELEASES
Unit 1 Vent Stack - GROUND RELEASES

REPORT FOR 2015	Units	QTR 1	QTR 2	QTR 3	QTR 4	YEAR
Fission and Activation Gases						
1. Total Release	Ci	<LLD	<LLD	<LLD	<LLD	<LLD
2. Avg. Release Rate	uCi/sec	<LLD	<LLD	<LLD	<LLD	<LLD
Iodine-131						
1. Total Release	Ci	<LLD	<LLD	<LLD	<LLD	<LLD
2. Avg. Release Rate	uCi/sec	<LLD	<LLD	<LLD	<LLD	<LLD
Particulates Half Life >= 8 days						
1. Total Release	Ci	0.00E+00	2.57E-06	9.04E-04	3.43E-05	9.41E-04
2. Avg. Release Rate	uCi/sec	0.00E+00	3.27E-07	1.15E-04	4.36E-06	2.99E-05
Tritium						
1. Total Release	Ci	<LLD	<LLD	<LLD	<LLD	<LLD
2. Avg. Release Rate	uCi/sec	<LLD	<LLD	<LLD	<LLD	<LLD
Gross Alpha Radioactivity						
1. Total Release	Ci	<LLD	<LLD	<LLD	<LLD	<LLD
2. Avg. Release Rate	uCi/sec	<LLD	<LLD	<LLD	<LLD	<LLD

GASEOUS EFFLUENTS - GROUND RELEASES - CONTINUOUS MODE

REPORT FOR 2015	Units	QTR 1	QTR 2	QTR 3	QTR 4	YEAR
Fission and Activation Gases		<LLD	<LLD	<LLD	<LLD	<LLD
Iodines		<LLD	<LLD	<LLD	<LLD	<LLD
Particulates Half Life >= 8 days						
CO-60	Ci	<LLD	0.00E+00	7.46E-04	2.62E-05	7.72E-04
CS-137	Ci	<LLD	2.57E-06	1.58E-04	8.12E-06	1.69E-04
Totals for Period...	Ci	<LLD	2.57E-06	9.04E-04	3.43E-05	9.41E-04
Tritium		<LLD	<LLD	<LLD	<LLD	<LLD
Gross Alpha Radioactivity		<LLD	<LLD	<LLD	<LLD	<LLD

GASEOUS EFFLUENTS - GROUND RELEASES - BATCH MODE

REPORT FOR 2015	Units	QTR 1	QTR 2	QTR 3	QTR 4	YEAR
No Batch Releases.						

Table 3.1-1(continued)
Maximum Dose Resulting from Airborne Releases
Zion Station 2015

GASEOUS EFFLUENTS - SUMMATION OF ALL RELEASES
Unit 2 Vent Stack - GROUND RELEASES

REPORT FOR 2015	Units	QTR 1	QTR 2	QTR 3	QTR 4	YEAR
Fission and Activation Gases						
1. Total Release	Ci	<LLD	<LLD	<LLD	<LLD	<LLD
2. Avg. Release Rate	uCi/sec	<LLD	<LLD	<LLD	<LLD	<LLD
Iodine-131						
1. Total Release	Ci	<LLD	<LLD	<LLD	<LLD	<LLD
2. Avg. Release Rate	uCi/sec	<LLD	<LLD	<LLD	<LLD	<LLD
Particulates Half Life >= 8 days						
1. Total Release	Ci	4.99E-06	2.72E-06	1.40E-05	3.40E-06	2.51E-05
2. Avg. Release Rate	uCi/sec	6.34E-07	3.46E-07	1.78E-06	4.32E-07	7.97E-07
Tritium						
1. Total Release	Ci	<LLD	<LLD	<LLD	<LLD	<LLD
2. Avg. Release Rate	uCi/sec	<LLD	<LLD	<LLD	<LLD	<LLD
Gross Alpha Radioactivity						
1. Total Release	Ci	<LLD	<LLD	<LLD	<LLD	<LLD
2. Avg. Release Rate	uCi/sec	<LLD	<LLD	<LLD	<LLD	<LLD

GASEOUS EFFLUENTS - GROUND RELEASES - CONTINUOUS MODE

REPORT FOR 2015	Units	QTR 1	QTR 2	QTR 3	QTR 4	YEAR
Fission and Activation Gases		<LLD	<LLD	<LLD	<LLD	<LLD
Iodines		<LLD	<LLD	<LLD	<LLD	<LLD
Particulates Half Life >= 8 days						
CO-60	Ci	3.28E-07	2.72E-06	7.89E-06	0.00E+00	1.09E-05
CS-137	Ci	4.66E-06	0.00E+00	6.07E-06	3.40E-06	1.41E-05
Totals for Period...	Ci	4.99E-06	2.72E-06	1.40E-05	3.40E-06	2.51E-05
Tritium		<LLD	<LLD	<LLD	<LLD	<LLD
Gross Alpha Radioactivity		<LLD	<LLD	<LLD	<LLD	<LLD

GASEOUS EFFLUENTS - GROUND RELEASES - BATCH MODE

REPORT FOR 2015	Units	QTR 1	QTR 2	QTR 3	QTR 4	YEAR
No Batch Releases.						

Table 3.1-1(continued)
Maximum Dose Resulting from Airborne Releases
Zion Station 2015

40CFR190 URANIUM FUEL CYCLE DOSE REPORT

GAS ANNUAL DOSE SUMMARY

Year.....: 2015
From Unit.....: 1
To Unit.....: 2
Coefficient Type.....: Historical
Gas Receptor.....: 5 Composite Crit. Receptor - IP
Distance (meters).....: 0.00
Compass Point.....: NA

=== MAXIMUM PERIOD DOSE TO LIMIT (Any Organ) ===

Dose Period	Age Group	Organ	Dose (mrem)	Limit Period	Admin Limit	Admin % of Limit	T.Spec Limit	T.Spec % of Limit
Quarter 1	INFANT	LIVER	2.46E-03	Quarter	5.63E+00	4.38E-02	7.50E+00	3.28E-02
Quarter 2	INFANT	LIVER	1.48E-03	Quarter	5.63E+00	2.64E-02	7.50E+00	1.98E-02
Quarter 3	INFANT	LIVER	1.24E-01	Quarter	5.63E+00	2.20E+00	7.50E+00	1.65E+00
Quarter 4	INFANT	LIVER	7.42E-03	Quarter	5.63E+00	1.32E-01	7.50E+00	9.90E-02
Annual	INFANT	LIVER	1.35E-01	Annual	1.13E+01	1.20E+00	1.50E+01	9.01E-01

=== MAXIMUM PERIOD DOSE TO LIMIT (Tot Body)) ===

Dose Period	Age Group	Organ	Dose (mrem)	Limit Period	Admin Limit	Admin % of Limit	T.Spec Limit	T.Spec % of Limit
Quarter 1	ADULT	TBODY	4.95E-04	Quarter	5.25E+00	9.43E-03	7.50E+00	6.60E-03
Quarter 2	ADULT	TBODY	4.02E-04	Quarter	5.25E+00	7.66E-03	7.50E+00	5.37E-03
Quarter 3	ADULT	TBODY	5.52E-02	Quarter	5.25E+00	1.05E+00	7.50E+00	7.37E-01
Quarter 4	ADULT	TBODY	2.59E-03	Quarter	5.25E+00	4.93E-02	7.50E+00	3.45E-02
Annual	ADULT	TBODY	5.87E-02	Annual	1.05E+01	5.59E-01	1.50E+01	3.92E-01

Table 3.1-1(continued)
Maximum Dose Resulting from Airborne Releases
Zion Station 2015

GASEOUS RELEASE AND DOSE SUMMARY REPORT
(Composite Critical Receptor - Limited Analysis)

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Release ID.....: 1  All Gas Releases
Period Start Date....: 01/01/2015 00:00
Period End Date......: 01/01/2016 00:00
Period Duration (min): 5.256E+05
Coefficient Type.....: Historical
From Unit............:  0
To Unit..............:  2
Receptor.............: 5   Composite Crit. Receptor - IP
Distance (meters)....: 0.0
Compass Point........: 0.0
```

=== MAXIMUM PERIOD DOSE TO LIMIT (Any Organ) ===

Dose Period	Age Group	Organ	Dose (mrem)	Limit Period	Admin Limit	Admin % of Limit	T.Spec Limit	T.Spec % of Limit
Strt->End	INFANT	LIVER	1.35E-01	31-day	2.25E-01	6.00E+01	3.00E-01	4.50E+01
				Quarter	5.63E+00	2.40E+00	7.50E+00	1.80E+00
				Annual	1.13E+01	1.20E+00	1.50E+01	9.01E-01

```
Critical Pathway........: 3  Grs/Goat/Milk (GMILK)
Major Contributors......: 0.0  % or greater to total
```

Nuclide	Percentage
MN-56	5.48E-02
CO-60	2.89E+01
CS-137	7.10E+01

=== MAXIMUM PERIOD DOSE TO LIMIT (Tot Body)) ===

Dose Period	Age Group	Organ	Dose (mrem)	Limit Period	Admin Limit	Admin % of Limit	T.Spec Limit	T.Spec % of Limit
Strt->End	ADULT	TBODY	5.87E-02	31-day	1.50E-01	3.92E+01	2.00E-01	2.94E+01
				Quarter	5.25E+00	1.12E+00	7.50E+00	7.83E-01
				Annual	1.05E+01	5.59E-01	1.50E+01	3.92E-01

```
Critical Pathway........: 0  Ground Plane Deposition (GPD)
Major Contributors......: 0.0  % or greater to total
```

Nuclide	Percentage
MN-56	1.26E-01
CO-60	6.79E+01
CS-137	3.20E+01

Table 3.2-1
Maximum Dose Resulting from Liquid Effluents
Zion Station 2015

LIQUID EFFLUENTS - SUMMATION OF ALL RELEASES (Unit 1 & Unit 2 combined)

REPORT FOR 2015	Units	QTR 1	QTR 2	QTR 3	QTR 4	YEAR
Fission and Activation Products						
AG-108M	Ci	0.00E+00	0.00E+00	1.04E-05	2.51E-06	1.29E-05
C-14	Ci	4.41E-06	3.85E-04	3.50E-04	1.86E-04	9.25E-04
CO-60	Ci	1.00E-05	8.09E-04	7.82E-04	4.15E-04	2.02E-03
CS-137	Ci	0.00E+00	1.28E-05	9.54E-06	1.30E-05	3.54E-05
FE-55	Ci	1.57E-06	1.13E-04	1.08E-04	5.73E-05	2.79E-04
NI-59	Ci	3.01E-06	2.11E-04	1.06E-04	5.65E-05	3.77E-04
NI-63	Ci	1.31E-04	1.08E-02	8.83E-03	4.69E-03	2.45E-02
PU-241	Ci	1.03E-07	9.00E-06	8.75E-06	4.65E-06	2.25E-05
SR-90	Ci	1.69E-06	9.47E-05	4.31E-06	2.29E-06	1.03E-04
Totals for Period...	Ci	1.52E-04	1.24E-02	1.02E-02	5.43E-03	2.82E-02
Tritium						
H-3	Ci	6.64E-03	2.57E-01	2.57E-01	5.43E-01	1.06E+00
Totals for Period...	Ci	6.64E-03	2.57E-01	2.57E-01	5.43E-01	1.06E+00
Dissolved and Entrained Gases						
1. Total Release	Ci	<LLD	<LLD	<LLD	<LLD	<LLD
Gross Alpha Radioactivity						
ALPHA	Ci	0.00E+00	7.22E-06	4.90E-06	6.55E-06	1.87E-05
Totals for Period...	Ci	0.00E+00	7.22E-06	4.90E-06	6.55E-06	1.87E-05
Volume of liquid waste	liters	1.27E+06	1.82E+06	2.23E+06	1.01E+07	1.54E+07
Volume of dil. water	liters	1.23E+09	1.24E+09	2.48E+09	5.01E+09	9.96E+09

LIQUID EFFLUENTS - CONTINUOUS MODE (Unit 1 & Unit 2 combined)

REPORT FOR 2015	Units	QTR 1	QTR 2	QTR 3	QTR 4	YEAR
Fission and Activation Products		<LLD	<LLD	<LLD	<LLD	<LLD
Tritium		<LLD	<LLD	<LLD	<LLD	<LLD
Dissolved and Entrained Gases		<LLD	<LLD	<LLD	<LLD	<LLD
Gross Alpha Radioactivity		<LLD	<LLD	<LLD	<LLD	<LLD

Table 3.2-1 (continued)
Maximum Dose Resulting from Liquid Effluents
Zion Station 2015

LIQUID EFFLUENTS - BATCH MODE (Unit 1 & Unit 2 combined)

REPORT FOR 2015	Units	QTR 1	QTR 2	QTR 3	QTR 4	YEAR
Fission and Activation Products						
AG-108M	Ci	0.00E+00	0.00E+00	1.04E-05	2.51E-06	1.29E-05
C-14	Ci	4.41E-06	3.85E-04	3.50E-04	1.86E-04	9.25E-04
CO-60	Ci	1.00E-05	8.09E-04	7.82E-04	4.15E-04	2.02E-03
CS-137	Ci	0.00E+00	1.28E-05	9.54E-06	1.30E-05	3.54E-05
FE-55	Ci	1.57E-06	1.13E-04	1.08E-04	5.73E-05	2.79E-04
NI-59	Ci	3.01E-06	2.11E-04	1.06E-04	5.65E-05	3.77E-04
NI-63	Ci	1.31E-04	1.08E-02	8.83E-03	4.69E-03	2.45E-02
PU-241	Ci	1.03E-07	9.00E-06	8.75E-06	4.65E-06	2.25E-05
SR-90	Ci	1.69E-06	9.47E-05	4.31E-06	2.29E-06	1.03E-04
Totals for Period...	Ci	1.52E-04	1.24E-02	1.02E-02	5.43E-03	2.82E-02
Tritium						
H-3	Ci	6.64E-03	2.57E-01	2.57E-01	5.43E-01	1.06E+00
Totals for Period...	Ci	6.64E-03	2.57E-01	2.57E-01	5.43E-01	1.06E+00
Dissolved and Entrained Gases	N/A	<LLD	<LLD	<LLD	<LLD	
Gross Alpha Radioactivity						
ALPHA	Ci	0.00E+00	7.22E-06	4.90E-06	6.55E-06	1.87E-05
Totals for Period...	Ci	0.00E+00	7.22E-06	4.90E-06	6.55E-06	1.87E-05

SUPPLEMENTAL INFORMATION
LIQUID EFFLUENTS - BATCH MODE

REPORT FOR 2015	Units	QTR 1	QTR 2	QTR 3	QTR 4	YEAR
Number of releases		1	16	17	33	67
Total release time	minutes	2.57E+03	7.87E+04	4.93E+04	1.01E+05	2.32E+05
Maximum release time	minutes	2.57E+03	1.13E+04	9.22E+03	4.32E+03	1.13E+04
Average release time	minutes	2.57E+03	4.92E+03	2.90E+03	3.08E+03	3.46E+03
Minimum release time	minutes	2.57E+03	1.19E+03	6.17E+02	1.92E+03	6.17E+02
Permit dilution vol	ltr	2.58E+07	9.92E+08	1.62E+09	3.84E+09	6.48E+09
Permit dilution flow	gpm	2.65E+03	3.33E+03	8.68E+03	1.00E+04	7.38E+03
Permit max total diluted concentration (no H-3)	uCi/ml	5.89E-09	6.46E-08	2.17E-08	5.17E-09	6.46E-08
Period dilution vol	ltr	1.23E+09	1.24E+09	2.48E+09	5.01E+09	9.96E+09
Period dilution flow	gpm	2.51E+03	2.50E+03	4.95E+03	9.99E+03	5.01E+03

Table 3.2-1 (continued)
Maximum Dose Resulting from Liquid Effluents
Zion Station 2015

40CFR190 URANIUM FUEL CYCLE DOSE REPORT

LIQUID ANNUAL DOSE SUMMARY

Year.....: 2015
From Unit.....: 1
To Unit.....: 2
Liquid Receptor.....: 0 Liquid Receptor

=== MAXIMUM PERIOD DOSE TO LIMIT (Any Organ) ===

Dose Period	Age Group	Organ	Dose (mrem)	Limit Period	Admin Limit	Admin % of Limit	T.Spec Limit	T.Spec % of Limit
Quarter 1	CHILD	BONE	1.19E-03	Quarter	2.50E+00	4.76E-02	2.50E+00	4.76E-02
Quarter 2	CHILD	BONE	9.40E-02	Quarter	2.50E+00	3.76E+00	2.50E+00	3.76E+00
Quarter 3	CHILD	BONE	3.46E-02	Quarter	2.50E+00	1.38E+00	2.50E+00	1.38E+00
Quarter 4	CHILD	BONE	9.27E-03	Quarter	2.50E+00	3.71E-01	2.50E+00	3.71E-01
Annual	CHILD	BONE	1.00E-01	Annual	5.00E+00	2.00E+00	5.00E+00	2.00E+00

=== MAXIMUM PERIOD DOSE TO LIMIT (Tot Body)) ===

Dose Period	Age Group	Organ	Dose (mrem)	Limit Period	Admin Limit	Admin % of Limit	T.Spec Limit	T.Spec % of Limit
Quarter 1	CHILD	TBODY	3.93E-05	Quarter	1.50E+00	2.62E-03	1.50E+00	2.62E-03
Quarter 2	CHILD	TBODY	3.28E-03	Quarter	1.50E+00	2.18E-01	1.50E+00	2.18E-01
Quarter 3	CHILD	TBODY	1.27E-03	Quarter	1.50E+00	8.48E-02	1.50E+00	8.48E-02
Quarter 4	ADULT	TBODY	4.31E-04	Quarter	1.50E+00	2.87E-02	1.50E+00	2.87E-02
Annual	CHILD	TBODY	3.64E-03	Annual	3.00E+00	1.21E-01	3.00E+00	1.21E-01

Table 3.2-1 (continued)
Maximum Dose Resulting from Liquid Effluents
Zion Station 2015

LIQUID RELEASE AND DOSE SUMMARY REPORT
---------- (PERIOD BASIS) ----------

Release ID.....: 1 All Liquid Release Types
Period Start Date.....: 01/01/2015 00:00
Period End Date.....: 01/01/2016 00:00
Period Duration (mins): 5.256E+05
Receptor.....: 0 Liquid Receptor

=== MAXIMUM PERIOD DOSE TO LIMIT (Any Organ) ==========

Dose Period	Age Group	Organ	Dose (mrem)	Limit Period	Admin Limit	Admin % of Limit	T.Spec Limit	T.Spec % of Limit
Strt->End	CHILD	BONE	1.23E-01	31-day	5.00E+00	2.45E+00	5.00E+00	2.45E+00
				Quarter	2.50E+00	4.91E+00	2.50E+00	4.91E+00
				Annual	5.00E+00	2.45E+00	5.00E+00	2.45E+00

Critical Pathway.....: 1 Fresh Water Fish - Sport (FFSP)
Major Contributors.....: 0.0 % or greater to total

Nuclide	Percentage
H-3	0.00E+00
FE-55	2.32E-02
CO-60	0.00E+00
NI-63	9.37E+01
SR-90	4.89E+00
CS-137	1.30E+00

=== MAXIMUM PERIOD DOSE TO LIMIT (Tot Body)) ==========

Dose Period	Age Group	Organ	Dose (mrem)	Limit Period	Admin Limit	Admin % of Limit	T.Spec Limit	T.Spec % of Limit
Strt->End	CHILD	TBODY	4.44E-03	31-day	3.00E+00	1.48E-01	3.00E+00	1.48E-01
				Quarter	1.50E+00	2.96E-01	1.50E+00	2.96E-01
				Annual	3.00E+00	1.48E-01	3.00E+00	1.48E-01

Critical Pathway.....: 1 Fresh Water Fish - Sport (FFSP)
Major Contributors.....: 0.0 % or greater to total

Nuclide	Percentage
H-3	6.78E-01
FE-55	1.05E-01
CO-60	3.20E+00
NI-63	8.81E+01
SR-90	2.73E+00
CS-137	5.09E+00

Table 3.3-1
Maximum Dose Resulting from Direct Radiation
Zion Station 2015

Maximally exposed sector: J (25mrem/year limit)

Unit	Qtr 1 (mrem)	Qtr 2 (mrem)	Qtr 3 (mrem)	Qtr 4 (mrem)	2015 (mrem)
Unit 1	8.25E-01	1.57E+00	1.83E+00	1.57E+00	5.80E+00
Unit 2	8.25E-01	1.57E+00	1.83E+00	1.57E+00	5.80E+00
ISFSI – gamma	8.25E-01	1.57E+00	1.83E+00	1.57E+00	5.80E+00
ISFSI – neutron	3.00E-01	4.70E-01	7.15E-01	4.20E-01	1.91E+00
Sum:	2.78E+00	5.18E+00	6.21E+00	5.13E+00	1.93E+01

Maximally exposed switchyard: Switchyard South (100mrem/year limit)

Switchyard	Qtr 1 (mrem)	Qtr 2 (mrem)	Qtr 3 (mrem)	Qtr 4 (mrem)	2015 (mrem)
Gamma	2.61E+01	1.81E+01	2.23E+01	1.58E+01	8.23E+01
Neutron	3.10E+00	1.80E+00	2.90E+00	1.40E+00	9.20E+00
Sum	2.92E+01	1.99E+01	2.52E+01	1.72E+01	9.15E+01

Table 3.4-1
ZION STATION
2015
Unit 1
10CFR20 Compliance Assessment

1. 10CFR 20.1301 (a) (1) Compliance

Total Effective Dose Equivalent	**5.83E+00 mrem/year**
10 CFR 20.1301 (a) (1) limit	100 mrem/year
% of the limit	**5.83E+00 %**

2. Compliance Summary 10CFR20

	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr	% of Limit
TEDE	**8.25E-01**	**1.57E+00**	**1.86E+00**	**1.57E+00**	**5.83E+00%**

Table 3.4-1 (continued)
ZION STATION
2015
Unit 2
10CFR20 Compliance Assessment

1. 10CFR 20.1301 (a) (1) Compliance

Total Effective Dose Equivalent	**5.83E+00 mrem/year**
10 CFR 20.1301 (a) (1) limit	100 mrem/year
% of the limit	**5.83E+00 %**

2. Compliance Summary 10CFR20

	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr	% of Limit
TEDE	**8.25E-01**	**1.57E+00**	**1.86E+00**	**1.57E+00**	**5.83E+00%**

Table 3.4-1 (continued)
ZION STATION
2015
Switchyard
10CFR20 Compliance Assessment

1. 10CFR 20.1301 (a) (1) Compliance

Total Effective Dose Equivalent	**9.15E+01 mrem/year**
10 CFR 20.1301 (a) (1) limit	100 mrem/year
% of the limit	**9.15E+01%**

2. Compliance Summary 10CFR20

	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr	% of Limit
TEDE	**2.92E+01**	**1.99E+01**	**2.52E+01**	**1.72E+01**	**9.15E+01%**

Table 3.4-1 (continued)
ZION STATION
2015
ISFSI
10CFR72.104 Compliance Assessment

1. 10CFR72.104 (a) (2) Compliance

Total Effective Dose Equivalent	**7.71E+00 mrem/year**
10 CFR 72.104 (a) limit	25 mrem/year
% of the limit	**3.08E+01%**

2. Compliance Summary 10CFR20

	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr	% of Limit
TEDE	**1.13E+00**	**2.04E+00**	**2.55+00**	**1.99E+00**	**3.08E+01%**

Table 3.5-1

Doses Resulting from Airborne Releases

The following are the maximum annual calculated cumulative offsite doses resulting from Zion Station airborne releases.

Unit 1:

Dose	*Maximum Value*	*Sector Affected*
gamma air [1]	0.00E+00 mrad	
beta air [2]	0.00E+00 mrad	
whole body [3]	2.94E-02 mrem	East
skin [4]	0.00E+00 mrem	East
organ [5] (infant liver)	6.75E-02 mrem	East

Unit 2:

Dose	*Maximum Value*	*Sector Affected*
gamma air [1]	0.00E+00 mrad	
beta air [2]	0.00E+00 mrad	
whole body [3]	2.94E-02 mrem	East
skin [4]	0.00E+00 mrem	East
organ [5] (infant liver)	6.75E-02 mrem	East

All values based on historical values of atmospheric dispersion coefficients and XOQDOQ values reflecting the time period from Jan. 1, 2009 to Dec. 31 2014. Meteorological Tower was removed March 2015.

Data recovery: 98.71%

(1) Gamma Air Dose – GASPAR II, NUREG-0597
(2) Beta Air Dose – GASPAR II, NUREG-0597
(3) Whole Body Dose – GASPAR II, NUREG-0597
(4) Skin Dose – GASPAR II, NUREG-0597
(5) Inhalation and Food Pathways Dose – GASPAR II, NUREG-0597

APPENDIX F

METEOROLOGICAL DATA

1. Introduction

The purpose of the meteorological program conducted at Zion Station site was to provide information sufficient to assess the local weather conditions and was used to determine the degree of atmospheric dispersion of airborne radioactive effluent from the station.

During the first quarter of 2015, all fuel had been removed to the ISFSI location and continuous meteorological monitoring was no longer required. The previous 6 years of data from Jan. 1, 2009 to Dec. 31, 2014 was queried to generate the historic average wind rose and atmospheric dispersion parameters for future airborne effluents from Zion Station.

The method of dose calculation that will be used going forward is ground level release and relevant information that is applicable to this method of effluent dose calculation has been included in this report.

The meteorological tower that was used in calculation of these historical averages was 250 ft. in elevation and was instrumented at two levels. Wind speed and direction measured at 35 ft. and 250 ft. Ambient temperature was measured at 35 ft. Differential temperature, referenced to 35 ft. was measured at 250 ft. Dew point temperature was measured approximately ten feet from the tower at an elevation of 5 ft. Precipitation was measured by a rain gauge located on the roof of the meteorological shelter building.

Joint frequency stability wind rose tables of wind direction, wind speed, and stability were routinely tabulated from hourly measurements during the six year period of this historical average. The six year historical average data tables are included in this report.

2. Summary

Zion Station meteorological monitoring program produced 51,918 total hours valid for the instruments used in generating the historical average out of a possible 52596 total hours in the 6 year monitoring period from Jan. 1, 2009 to Dec. 31, 2014. (365.25 days X 6 years X 24 hours/day). 678 total hours of data were lost representing a 98.71% data recovery rate.

The stability wind rose tables included in this report have been generated using the 35 ft. wind data with the 250-35 ft. differential temperature data.

3. Data Acquisition

Information regarding Data Acquisition, Data Analysis and instruments used can be found in the meteorological monitoring sections of prior Zion Stations Annual Radioactive Environmental Monitoring Reports from 2009 to 2014.

Table 1

Wind Direction Classes

Wind Direction Class	Compass Direction the Wind is Coming From		
N	348.75^0	< WD ≤	11.25^0
NNE	11.25^0	< WD ≤	11.25^0
NE	33.75^0	< WD ≤	33.75^0
ENE	56.25^0	< WD ≤	56.25^0
E	78.75^0	< WD ≤	78.75^0
ESE	101.25^0	< WD ≤	101.25^0
SE	123.75^0	< WD ≤	123.75^0
SSE	146.25^0	< WD ≤	146.25^0
S	168.75^0	< WD ≤	168.75^0
SSW	191.25^0	< WD ≤	191.25^0
SW	213.75^0	< WD ≤	213.75^0
WSW	236.25^0	< WD ≤	236.25^0
W	258.75^0	< WD ≤	258.75^0
WNW	281.25^0	< WD ≤	281.25^0
NW	303.75^0	< WD ≤	303.75^0
NNW	326.25^0	< WD ≤	348.75^0

Table 2

Wind Speed Classes

Wind Speed Class	Wind Speeds are in miles per hour (mph)		
1	0.0	< WS ≤	0.7
2	0.7	< WS ≤	3.5
3	3.5	< WS ≤	7.5
4	7.5	< WS ≤	12.5
5	12.5	< WS ≤	18.5
6	18.5	< WS ≤	24.5
7	24.5	< WS	

Table 3

Atmospheric Stability Classes

Class	Differential Temperature Interval (in $^{o}C/100m$)[1]	Differential Temperature Interval (in ^{o}F over the 250-35 ft. interval)[2]
A – Extremely Unstable	$\Delta T \leq -1.9$	$\Delta T \leq -2.3$
B – Moderately Unstable	$-1.9 < \Delta T \leq -1.7$	$-2.3 < \Delta T \leq -2.1$
C – Slightly Unstable	$-1.7 < \Delta T \leq -1.5$	$-2.1 < \Delta T \leq -1.8$
D – Neutral	$-1.5 < \Delta T \leq -0.5$	$-1.8 < \Delta T \leq -0.6$
E – Slightly Stable	$-0.5 < \Delta T \leq 1.5$	$-0.6 < \Delta T \leq 1.7$
F – Moderately Stable	$1.5 < \Delta T \leq 4.0$	$1.7 < \Delta T \leq 4.7$
G – Extremely Stable	$4.0 < \Delta T$	$4.7 < \Delta T$

(1) From ANSI/ANS 2.5

(2) ANSI/ANS 2.5 intervals scaled for instrument heights on the Zion meteorological tower.

4. The following two programs were used to calculate doses resulting from radioactive releases:

    a. XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations (NUREG/CR-2919)

The program is based on the theory that material released to the atmosphere will be normally distributed (Gaussian) about the plume centerline. A straight-line trajectory is assumed between the point of release and all receptors.

The program implements the assumptions outlined in Section C of NRC Regulatory Guide 1.111. In evaluating routine releases from nuclear power plants, it primarily is designed to calculate annual relative effluent concentrations, X/Q values and annual average relative deposition, D/Q values.

The historical average output from the XOQDOQ program from 2009-2014 was used to develop the input to the RETDAS program.

    b. RETDAS: Radiological Effluent Tracking and Dose Assessment Software.

RETDAS is a program written for the evaluation of radiological impacts due to the release of radioactive material to the environment during normal operation of reactors. The RETDAS code implements the radiological impact models of NRC Regulatory Guide 1.109 Rev. 1, for atmospheric releases. The program is used to estimate the maximum individual doses at the maximally exposed location in the vicinity of the plant.

5. Detailed information regarding the meteorological maintenance and calibration information of the meteorological tower and instruments used during the historical average evaluation time period can be found in prior Zion Station Annual Radioactive Environmental Operating Reports from 2009 to 2014.

6. Stability Wind Rose Data

   The historical stability wind roses are given in Tables 4 through 8. For the year, winds measured at 35ft. most frequently came from the West (10.86%) and fell into the 3.6 to 7.5 mph wind speed class (34.94%). Calms (wind speeds at or below 1mph were measured at 0.16% of the time and speeds greater than 24.5 mph were measured 0.09% of the time.

   Stability based on the 250-35 ft. differential temperature most frequently fell into the neutral classification(39.58%)

Table 4

Percent of time at each Wind Speed and Direction

Period of Record: Jan. 1, 2009 to Dec. 31, 2014

Stability Class: A - Extremely Unstable

Elevation: Ground Level Release

Wind Direction	Wind Speed (mph) at 10m Level							
	<1	1 - 3.5	3.6 - 7.5	7.6 - 12.5	12.6 - 18.5	18.6 - 24.5	>24.5	Total:
N	0	0	0.031	0.156	0.254	0.04	0.002	0.48
NNE	0	0	0.176	0.98	0.287	0.006	0	1.45
NE	0	0.002	0.391	0.559	0.075	0.004	0	1.03
ENE	0	0.002	0.368	0.22	0.019	0.002	0	0.61
E	0	0.004	0.412	0.133	0.023	0	0	0.57
ESE	0	0.002	0.379	0.141	0	0	0	0.52
SE	0	0	0.272	0.219	0.01	0	0	0.5
SSE	0	0	0.05	0.249	0.035	0	0	0.33
S	0	0	0.01	0.046	0.019	0	0	0.08
SSW	0	0.002	0.015	0.068	0.144	0.01	0	0.24
SW	0	0.002	0.041	0.319	0.331	0.015	0.006	0.71
WSW	0	0	0.133	0.516	0.366	0.021	0.004	1.04
W	0	0	0.12	0.577	0.401	0.01	0	1.11
WNW	0	0	0.089	0.492	0.187	0.002	0	0.77
NW	0	0.006	0.068	0.404	0.112	0	0	0.59
NNW	0	0	0.039	0.058	0.037	0	0	0.13
Total:	0	0.019	2.591	5.137	2.3	0.11	0.012	10.17

Percent of time at each Wind Speed and Direction

Period of Record: Jan. 1, 2009 to Dec. 31, 2014

Stability Class: B - Moderately Unstable

Elevation: Ground Level Release

	Wind Speed (mph) at 10m Level							
Wind Direction	<1	1 - 3.5	3.6 - 7.5	7.6 - 12.5	12.6 - 18.5	18.6 - 24.5	>24.5	Total:
N	0	0	0.039	0.102	0.119	0.015	0	0.28
NNE	0	0	0.112	0.196	0.058	0.004	0.002	0.37
NE	0	0.012	0.108	0.052	0.014	0.004	0	0.19
ENE	0	0.012	0.068	0.029	0.014	0	0	0.12
E	0	0.004	0.077	0.025	0.002	0	0	0.11
ESE	0	0.008	0.066	0.045	0	0	0	0.12
SE	0	0	0.097	0.041	0	0	0	0.14
SSE	0	0	0.06	0.164	0.025	0	0	0.25
S	0	0	0.01	0.052	0.008	0.002	0	0.07
SSW	0	0	0.013	0.058	0.098	0.008	0.002	0.18
SW	0	0.002	0.033	0.149	0.158	0.013	0.002	0.36
WSW	0	0	0.062	0.193	0.089	0.012	0.002	0.36
W	0	0.002	0.068	0.211	0.129	0.004	0	0.41
WNW	0	0	0.06	0.179	0.081	0.004	0	0.32
NW	0	0.004	0.049	0.191	0.052	0	0	0.29
NNW	0	0.002	0.021	0.054	0.027	0.002	0	0.11
Total:	0	0.044	0.938	1.739	0.872	0.067	0.008	3.67

Percent of time at each Wind Speed and Direction

Period of Record: Jan. 1, 2009 to Dec. 31, 2014

Stability Class: C - Slightly Unstable

Elevation: Ground Level Release

	Wind Speed (mph) at 10m Level							
Wind Direction	<1	1 - 3.5	3.6 - 7.5	7.6 - 12.5	12.6 - 18.5	18.6 - 24.5	>24.5	Total:
N	0	0.004	0.086	0.243	0.177	0.013	0.008	0.53
NNE	0	0.01	0.183	0.31	0.079	0.004	0	0.59
NE	0	0.023	0.15	0.102	0.031	0.01	0.006	0.32
ENE	0	0.023	0.1	0.044	0.021	0.012	0.002	0.2
E	0	0.01	0.146	0.025	0.018	0	0	0.2
ESE	0	0.019	0.115	0.037	0.014	0	0	0.18
SE	0	0.006	0.181	0.054	0.016	0	0	0.26
SSE	0	0.006	0.106	0.351	0.11	0.01	0	0.58
S	0	0.004	0.066	0.101	0.021	0	0	0.19
SSW	0	0.002	0.041	0.119	0.154	0.017	0.004	0.34
SW	0	0	0.094	0.244	0.189	0.023	0.006	0.56
WSW	0	0.004	0.11	0.252	0.139	0.01	0.002	0.52
W	0	0.008	0.133	0.277	0.165	0.008	0	0.59
WNW	0	0.008	0.127	0.308	0.079	0	0	0.52
NW	0	0.01	0.096	0.206	0.096	0	0	0.41
NNW	0	0.01	0.033	0.133	0.045	0.004	0	0.22
Total:	0	0.145	1.768	2.806	1.352	0.11	0.027	6.21

Percent of time at each Wind Speed and Direction

Period of Record: Jan. 1, 2009 to Dec. 31, 2014

Stability Class: D - Neutral

Elevation: Ground Level Release

	Wind Speed (mph) at 10m Level							
Wind Direction	<1	1 - 3.5	3.6 - 7.5	7.6 - 12.5	12.6 - 18.5	18.6 - 24.5	>24.5	Total:
N	0	0.102	0.597	1.392	1.05	0.21	0.06	3.41
NNE	0	0.142	0.758	1.123	0.769	0.042	0.031	2.87
NE	0	0.161	0.528	0.57	0.405	0.046	0.025	1.74
ENE	0.001	0.137	0.348	0.346	0.347	0.092	0.008	1.28
E	0	0.121	0.392	0.303	0.353	0.094	0.013	1.28
ESE	0	0.148	0.489	0.289	0.163	0.035	0.002	1.13
SE	0	0.127	0.567	0.378	0.149	0.008	0	1.23
SSE	0	0.075	0.523	1.258	0.944	0.168	0.054	3.02
S	0	0.106	0.686	0.805	0.314	0.015	0	1.93
SSW	0	0.128	0.641	0.994	0.774	0.087	0.008	2.63
SW	0	0.152	0.612	1.443	1.003	0.108	0.015	3.33
WSW	0.001	0.138	0.849	1.327	0.659	0.042	0.002	3.02
W	0	0.146	1.1	1.766	0.961	0.029	0.002	4
WNW	0	0.169	1.139	1.402	0.52	0.012	0	3.24
NW	0	0.164	1	1.404	0.489	0.021	0	3.08
NNW	0	0.098	0.655	1.21	0.387	0.039	0.006	2.39
Total:	0.006	2.117	10.886	16.01	9.286	1.048	0.225	39.58

Percent of time at each Wind Speed and Direction

Period of Record: Jan. 1, 2009 to Dec. 31, 2014

Stability Class: E - Slightly Stable

Elevation: Ground Level Release

	Wind Speed (mph) at 10m Level							
Wind Direction	<1	1 - 3.5	3.6 - 7.5	7.6 - 12.5	12.6 - 18.5	18.6 - 24.5	>24.5	Total:
N	0.005	0.302	0.672	0.53	0.173	0.021	0.012	1.72
NNE	0.004	0.245	0.564	0.447	0.058	0.013	0	1.33
NE	0.004	0.204	0.314	0.167	0.075	0.002	0	0.77
ENE	0.003	0.154	0.212	0.092	0.071	0.01	0	0.54
E	0.003	0.148	0.212	0.082	0.11	0.054	0.008	0.62
ESE	0.002	0.129	0.233	0.091	0.052	0.017	0	0.52
SE	0.003	0.163	0.456	0.273	0.079	0.004	0	0.98
SSE	0.004	0.192	0.452	0.84	0.291	0.029	0.019	1.83
S	0.005	0.292	1.375	0.839	0.166	0.004	0	2.68
SSW	0.005	0.441	1.19	0.661	0.154	0.015	0	2.47
SW	0.006	0.324	0.855	0.607	0.183	0.013	0	1.99
WSW	0.004	0.277	1.008	0.503	0.069	0.002	0	1.86
W	0.005	0.353	1.349	0.649	0.117	0.006	0.002	2.48
WNW	0.005	0.38	1.136	0.599	0.05	0.002	0	2.17
NW	0.005	0.319	1.069	0.48	0.073	0	0	1.95
NNW	0.004	0.252	0.593	0.203	0.058	0	0	1.11
Total:	0.065	4.178	11.692	7.063	1.779	0.193	0.04	25.01

Percent of time at each Wind Speed and Direction

Period of Record: Jan. 1, 2009 to Dec. 31, 2014

Stability Class: F - Moderately Stable

Elevation: Ground Level Release

	Wind Speed (mph) at 10m Level							
Wind Direction	<1	1 - 3.5	3.6 - 7.5	7.6 - 12.5	12.6 - 18.5	18.6 - 24.5	>24.5	Total:
N	0.002	0.151	0.162	0.043	0	0	0	0.36
NNE	0.001	0.094	0.106	0.019	0	0	0	0.22
NE	0.001	0.083	0.086	0.025	0	0	0	0.2
ENE	0.001	0.076	0.064	0.024	0.014	0.002	0	0.18
E	0.001	0.079	0.077	0.027	0.01	0	0	0.19
ESE	0.001	0.077	0.111	0.045	0.016	0	0	0.25
SE	0.001	0.072	0.156	0.07	0.006	0	0	0.3
SSE	0.001	0.068	0.154	0.351	0.118	0.013	0	0.7
S	0.003	0.24	0.714	0.368	0.08	0.002	0	1.41
SSW	0.004	0.472	0.51	0.031	0.004	0	0	1.02
SW	0.005	0.454	0.334	0.023	0.002	0	0	0.82
WSW	0.005	0.495	0.368	0.015	0	0	0	0.88
W	0.005	0.416	0.637	0.015	0	0	0	1.07
WNW	0.003	0.307	0.458	0.008	0	0	0	0.78
NW	0.004	0.333	0.466	0.012	0	0	0	0.82
NNW	0.003	0.202	0.165	0.002	0.002	0	0	0.37
Total:	0.042	3.618	4.571	1.075	0.251	0.017	0	9.57

Percent of time at each Wind Speed and Direction

Period of Record: Jan. 1, 2009 to Dec. 31, 2014

Stability Class: G - Extremely Stable

Elevation: Ground Level Release

Wind Speed (mph) at 10m Level

Wind Direction	<1	1 - 3.5	3.6 - 7.5	7.6 - 12.5	12.6 - 18.5	18.6 - 24.5	>24.5	Total:
N	0.001	0.058	0.025	0	0	0	0	0.08
NNE	0.001	0.034	0.028	0	0	0	0	0.06
NE	0.001	0.03	0.01	0.008	0.002	0	0	0.05
ENE	0.001	0.029	0.018	0.008	0.012	0	0	0.07
E	0.001	0.033	0.029	0.02	0.008	0	0	0.09
ESE	0.001	0.039	0.058	0.021	0.004	0	0	0.12
SE	0.001	0.034	0.066	0.029	0.002	0	0	0.13
SSE	0.001	0.052	0.095	0.167	0.054	0	0	0.37
S	0.002	0.116	0.424	0.316	0.057	0	0	0.91
SSW	0.005	0.256	0.11	0.006	0	0	0	0.38
SW	0.005	0.258	0.189	0	0	0	0	0.45
WSW	0.006	0.481	0.316	0	0	0	0	0.8
W	0.008	0.586	0.609	0	0	0	0	1.2
WNW	0.007	0.353	0.401	0	0	0	0	0.76
NW	0.003	0.104	0.108	0	0	0	0	0.22
NNW	0.003	0.071	0.016	0	0	0	0	0.09
Total:	0.048	2.534	2.498	0.574	0.139	0	0	5.79

Table 5
Percent Wind Direction by Stability Class

Wind Direction	Stability Class							
	A	B	C	D	E	F	G	Total
N	0.48	0.28	0.53	3.4	1.72	0.36	0.08	6.86
NNE	1.45	0.37	0.59	2.9	1.33	0.22	0.06	6.89
NE	1.03	0.19	0.32	1.7	0.77	0.2	0.05	4.3
ENE	0.61	0.12	0.2	1.3	0.54	0.18	0.07	3
E	0.57	0.11	0.2	1.3	0.62	0.19	0.09	3.06
ESE	0.52	0.12	0.18	1.1	0.52	0.25	0.12	2.84
SE	0.5	0.14	0.26	1.2	0.98	0.3	0.13	3.54
SSE	0.33	0.25	0.58	3.0	1.83	0.7	0.37	7.08
S	0.08	0.07	0.19	1.9	2.68	1.41	0.91	7.27
SSW	0.24	0.18	0.34	2.6	2.47	1.02	0.38	7.26
SW	0.71	0.36	0.56	3.3	1.99	0.82	0.45	8.22
WSW	1.04	0.36	0.52	3.02	1.86	0.88	0.8	8.48
W	1.11	0.41	0.59	4	2.48	1.07	1.2	10.86
WNW	0.77	0.32	0.52	3.24	2.17	0.78	0.76	8.56
NW	0.59	0.29	0.41	3.08	1.95	0.82	0.22	7.36
NNW	0.13	0.11	0.22	2.39	1.11	0.37	0.09	4.42
TOTAL	10.17	3.67	6.21	39.58	25.01	9.57	5.79	100

Table 6

Percent Wind Direction by Wind Speed

Wind Direction	Wind Speed in mph							
	<1	1 - 3.5	3.6 - 7.5	7.6 - 12.5	12.6 - 18.5	18.6 - 24.5	>24.5	Total:
N	0.008	0.617	1.612	2.466	1.773	0.299	0.082	6.86
NNE	0.006	0.525	1.927	3.075	1.251	0.069	0.033	6.89
NE	0.006	0.515	1.587	1.483	0.602	0.066	0.031	4.3
ENE	0.006	0.433	1.178	0.763	0.498	0.118	0.01	3
E	0.005	0.399	1.345	0.615	0.524	0.148	0.021	3.06
ESE	0.004	0.422	1.451	0.669	0.249	0.052	0.002	2.84
SE	0.005	0.402	1.795	1.064	0.262	0.012	0	3.54
SSE	0.006	0.393	1.44	3.38	1.577	0.22	0.073	7.08
S	0.01	0.758	3.285	2.527	0.665	0.023	0	7.27
SSW	0.014	1.301	2.52	1.937	1.328	0.137	0.014	7.26
SW	0.016	1.192	2.158	2.785	1.866	0.172	0.029	8.22
WSW	0.016	1.395	2.846	2.806	1.322	0.087	0.01	8.48
W	0.018	1.511	4.016	3.495	1.773	0.057	0.004	10.86
WNW	0.015	1.217	3.41	2.988	0.917	0.02	0	8.56
NW	0.012	0.94	2.856	2.697	0.822	0.021	0	7.36
NNW	0.01	0.635	1.522	1.66	0.556	0.045	0.006	4.42
Total	0.161	12.655	34.944	34.404	15.979	1.545	0.312	100

Table 7
Percent Speed by Stability Class

Speed (mph)	Stability Class							
	A	B	C	D	E	F	G	Total
<1	0	0	0	0.006	0.065	0.042	0.048	0.161
1 - 3.5	0.227	0.177	0.524	4.22	6.601	4.625	3.303	19.677
3.6 - 7.5	2.591	0.938	1.768	10.886	11.692	4.571	2.498	34.944
7.6 - 12.5	5.137	1.739	2.806	16.01	7.063	1.075	0.574	34.404
12.6 - 18.5	2.3	0.872	1.352	9.286	1.779	0.251	0.139	15.979
18.6 - 24.5	0.11	0.067	0.11	1.048	0.193	0.017	0	1.545
>24.5	0.012	0.008	0.027	0.225	0.04	0	0	0.312
Total:	10.17	3.67	6.21	39.58	25.01	9.57	5.79	100

APPENDIX G

ANNUAL RADIOLOGICAL GROUNDWATER PROTECTION PROGRAM REPORT (ARGPPR)

Docket No: 50-295
50-304

ZION NUCLEAR POWER STATION
UNITS 1 and 2

Annual Radiological
Groundwater Protection Program Report

1 January Through 31 December 2015

Prepared By

Teledyne Brown Engineering
Environmental Services

ZIONSOLUTIONS LLC
An EnergySolutions Company

Zion Nuclear Power Station
Zion, IL 60099

May 2016

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Appendices

I. Summary and Conclusions

In 2006, Exelon instituted a comprehensive program to evaluate the impact of station operations on groundwater and surface water in the vicinity of Zion Nuclear Power Station. This is the ninth in a series of annual reports on the status of the Radiological Groundwater Protection Program (RGPP) conducted at Zion Nuclear Power Station. This report covers both groundwater and surface water samples, collected from the environment, on station property in 2015. During that time period, 501 analyses were performed on 51 samples from 12 locations. Phase 1 of the monitoring was part of a comprehensive study initiated by Exelon to determine whether groundwater or surface water at and in the vicinity of Zion Nuclear Power Station had been adversely impacted by any releases of radionuclides. Phase 1 was conducted by Conestoga Rovers and Associates (CRA) and the conclusions were made available to state and federal regulators as well as the public in station specific reports.

Phase 2 of the RGPP was conducted by Zion*Solutions* (Exelon was responsible for the program up to 8/31/2010; Zion*Solutions* became the licensee on 9/1/2010, thus assuming responsibility for the RGPP) personnel to initiate follow up of Phase 1 and begin long-term monitoring at groundwater and surface water locations selected during Phase 1. All analytical results from Phase 2 monitoring are reported herein.

In assessing all the data gathered for this report, it was concluded that the operation of Zion Nuclear Power Station had no adverse radiological impact on the environment, and there are no known active releases into the groundwater at Zion Nuclear Power Station.

Naturally occurring K-40 was detected in two groundwater samples. No other gamma-emitting radionuclides were detected at concentrations greater than their respective Lower Limits of Detection (LLDs) as specified in the Offsite Dose Calculation Manual (ODCM) in any of the groundwater or surface water samples. Strontium-90 was not detected in any of the samples analyzed in 2015.

Tritium was not detected in any groundwater or surface water samples analyzed in 2015. In the case of tritium, Zion*Solutions* specified that its laboratories achieve a lower limit of detection 10 times lower than that required by federal regulation.

Gross Alpha and Gross Beta analyses in the dissolved and suspended fractions were performed on surface water samples during all four quarters of sampling in 2015. Gross Alpha (dissolved) and Gross Alpha (suspended) was not detected in any of the surface water locations. Gross Beta (dissolved) was detected in four samples at one surface water location. The concentrations ranged from 2.3 to 7.3 pCi/L. Gross Beta (suspended) was not detected in any of the surface

water locations. Dissolved Gross Alpha and Dissolved Gross Beta are detectable in samples due to the presence of naturally occurring isotopes. Iron-55, Ni-59, and Nickel-63 analyses were performed in 2015 on 50 samples from 11 groundwater and one surface water location. All results were less than their respective LLDs.

II. Introduction

The Zion Nuclear Power Station (ZNPS), consisting of two 1,100 MWt pressurized water reactor was owned and operated by Exelon Corporation, is located in Zion, Illinois adjacent to Lake Michigan. Unit No. 1 went critical in December 1973. Unit No. 2 went critical in September 1974. The plant permanently ceased operation in January of 1998 and has been permanently defueled. The site is located in northeast Illinois on the western shore of Lake Michigan, approximately 50 miles north of Chicago, Illinois.

This report covers those analyses performed by Teledyne Brown Engineering (TBE) and Environmental Inc. (Midwest Labs) on samples collected in 2015.

A. Objective of the RGPP

The long-term objectives of the RGPP are as follows:

1. Identify suitable locations to monitor and evaluate potential impacts from station operations before significant radiological impact to the environment and potential drinking water sources.

2. Understand the local hydrogeologic regime in the vicinity of the station and maintain up-to-date knowledge of flow patterns on the surface and shallow subsurface.

3. Perform routine water sampling and radiological analysis of water from selected locations.

4. Report new leaks, spills, or other detections with potential radiological significance to stakeholders in a timely manner.

5. Regularly assess analytical results to identify adverse trends.

6. Take necessary corrective actions to protect groundwater resources.

7. The RGPP supports implementation of License Termination Plan (LTP) related requirements for groundwater characterization and ultimately groundwater compliance under the LTP for site release.

B. Implementation of the Objectives

The objectives identified have been implemented at Zion Nuclear Power Station as discussed below:

1. Exelon and its consultant identified locations as described in the

Phase 1 study. Phase 1 studies were conducted by Conestoga Rovers and Associates (CRA) and the results and conclusions were made available to state and federal regulators as well as the public in station specific reports.

2. The Zion Nuclear Power Station reports describe the local hydrogeologic regime. Periodically, the flow patterns on the surface and shallow subsurface are updated based on ongoing measurements.

3. Zion Nuclear Power Station will continue to perform routine sampling and radiological analysis of water from selected locations.

4. Zion Nuclear Power Station has continued using established procedures to identify and report new leaks, spills, or other detections with potential radiological significance in a timely manner.

5. Zion Nuclear Power Station staff and consulting hydrogeologist assess analytical results on an ongoing basis to identify adverse trends.

C. Program Description

1. Sample Collection

Sample locations can be found in Table A–1 and Figures A–1, Appendix A.

Groundwater and Surface Water

Samples of water are collected, managed, transported and analyzed in accordance with approved procedures following EPA methods. Groundwater samples were collected. Sample locations, sample collection frequencies and analytical frequencies are controlled in accordance with approved station procedures. Contractor and/or station personnel are trained in the collection, preservation management, and shipment of samples, as well as in documentation of sampling events. Analytical laboratories are subject to internal quality assurance programs, industry cross-check programs, as well as nuclear industry audits. Station personnel review and evaluate all analytical data deliverables as data are received.

Analytical data results are reviewed by both station personnel and an independent hydrogeologist for adverse trends or changes to hydrogeologic conditions.

D. Characteristics of Tritium (H-3)

Tritium (chemical symbol H-3) is a radioactive isotope of hydrogen. The most common form of tritium is tritium oxide, which is also called "tritiated water". The chemical properties of tritium are essentially those of ordinary hydrogen.

Tritiated water behaves the same as ordinary water in both the environment and the body. Tritium can be taken into the body by drinking water, breathing air, eating food, or absorption through skin. Once tritium enters the body, it disperses quickly and is uniformly distributed throughout the body. Tritium is excreted primarily through urine with a clearance rate characterized by an effective biological half-life of about 14 days. Within one month or so after ingestion, essentially all tritium is cleared. Organically bound tritium (tritium that is incorporated in organic compounds) can remain in the body for a longer period.

Tritium is produced naturally in the upper atmosphere when cosmic rays strike air molecules. Tritium is also produced during nuclear weapons explosions, as a by-product in reactors producing electricity, and in special production reactors, where the isotopes lithium-7 and/or boron-10 are activated to produce tritium. Like normal water, tritiated water is colorless and odorless. Tritiated water behaves chemically and physically like non-tritiated water in the subsurface, and therefore tritiated water will travel at the same velocity as the average groundwater velocity.

Tritium has a half-life of approximately 12.3 years. It decays spontaneously to helium-3 (He-3). This radioactive decay releases a beta particle (low-energy electron). The radioactive decay of tritium is the source of the health risk from exposure to tritium. Tritium is one of the least dangerous radionuclides because it emits very weak radiation and leaves the body relatively quickly. Since tritium is almost always found as water, it goes directly into soft tissues and organs. The associated dose to these tissues is generally uniform and is dependent on the water content of the specific tissue.

III. Program Description

A. Sample Analysis

This section describes the general analytical methodologies used by TBE to analyze the environmental samples for radioactivity for the Zion Nuclear Power Station RGPP in 2015.

In order to achieve the stated objectives, the current program includes the following analyses:

1. Concentrations of gamma emitters in groundwater and surface water.

2. Concentrations of strontium in groundwater and surface water.

3. Concentrations of tritium in groundwater and surface water.

4. Concentration of gross alpha and gross beta in groundwater and surface water.

5. Concentrations of Iron-55 in groundwater and surface water.

6. Concentrations of Nickel-59 and Nickel-63 in groundwater and surface water.

B. Data Interpretation

The radiological data collected prior to Zion Nuclear Power Station becoming operational were used as a baseline with which these operational data were compared. For the purpose of this report, Zion Nuclear Power Station was considered operational at initial criticality. Several factors were important in the interpretation of the data:

1. <u>Lower Limit of Detection and Minimum Detectable Concentration</u>

   The lower limit of detection (LLD) is specified by federal regulation as a minimum sensitivity value that must be achieved routinely by the analytical parameter.

2. <u>Laboratory Measurements Uncertainty</u>

   The estimated uncertainty in measurement of tritium in environmental samples is frequently on the order of 50% of the measurement value.

Statistically, the exact value of a measurement is expressed as a range with a stated level of confidence. The convention is to report results with a 95% level of confidence. The uncertainty comes from calibration standards, sample volume or weight measurements, sampling uncertainty and other factors. Zion*Solutions* reports the uncertainty of a measurement created by statistical process (counting error) as well as all sources of error (Total Propagated Uncertainty or TPU). Each result has two values calculated. Zion*Solutions* reports the TPU by following the result with plus or minus ± the estimated sample standard deviation, as TPU, that is obtained by propagating all sources of analytical uncertainty in measurements.

Analytical uncertainties are reported at the 95% confidence level in this report for reporting consistency with the AREOR.

C. Background Analysis

A pre-operational Radiological Environmental Monitoring Program (pre-operational REMP) was conducted to establish background radioactivity levels prior to operation of the Station. The environmental media sampled and analyzed during the pre-operational REMP were atmospheric radiation, fall-out, domestic water, surface water, marine life, and foodstuffs. The results of the monitoring were detailed in the report entitled, Environmental Radiological Monitoring for Zion Nuclear Power Station, Commonwealth Edison Company, Annual Report 1973, issued May 1974.

The pre-operational REMP contained analytical results from samples collected from the surface water and groundwater.

Tritium levels in Lake Michigan water were studied in the vicinity of Zion Station throughout 1970. The concentration of tritium in the surface water samples from the Lake at Zion ranged from approximately 311 ± 20 pCi/L to 374 ± 34 pCi/L and averaged 340 pCi/L. There was no statistical difference in average tritium concentrations among the stations (eight stations from Kenosha to Waukegan).

Prior to 1998, surface water samples were collected at the following six locations along Lake Michigan:

- Kenosha, Wisconsin (intake located 10 miles north of the station)
- Lake County Public Water District (intake located 1.1 miles north of the Station)

- Waukegan, Illinois (intake located 6 miles south of the Station)
- North Chicago, Illinois (intake located 10 miles south of the Station)
- Great Lakes NTS (intake located 13 miles south of the Station)
- Lake Forest, Illinois (intake located 16.5 miles south of the Station)

After 1998, surface water samples were collected at the following four locations along Lake Michigan:

- Kenosha, Wisconsin (intake located 10 miles north of the station)
- Lake County Public Water District (intake located 1.1 miles north of the Station)
- Waukegan, Illinois (intake located 6 miles south of the Station)
- Lake Forest, Illinois (intake located 16.5 miles south of the Station)

Lake Michigan surface water data are collected as part of the REMP. Tritium concentrations in surface water samples from Lake Michigan taken between 1973 and 2012 have ranged from non-detect to 660 pCi/L.

Groundwater was collected from one off-site well on a quarterly basis. Gamma isotopic, Iron-55, Nickel-59, Nickel-63, Strontium-90 and tritium analyses were performed on all samples. Fe-55, Ni-59, Ni-63, Sr-90, tritium and gamma emitters were below their respective LLDs.

1. Background Concentrations of Tritium

   The purpose of the following discussion is to summarize background measurements of tritium in various media performed by others. Additional detail may be found by consulting references (CRA 2006).

   a. Tritium Production

      Tritium is created in the environment from naturally occurring processes both cosmic and subterranean, as well as from anthropogenic (i.e., man-made) sources. In the upper atmosphere, "Cosmogenic" tritium is produced from the bombardment of stable nuclides and combines with oxygen to form tritiated water, which will then enter the hydrologic cycle. Below ground, "lithogenic" tritium is produced by the bombardment of natural lithium present in crystalline rocks by neutrons produced by the radioactive decay of naturally abundant uranium and thorium. Lithogenic production of tritium is usually negligible compared to other sources due to the limited abundance of lithium in rock. The lithogenic tritium is introduced directly to groundwater.

A major anthropogenic source of tritium and strontium-90 comes from the former atmospheric testing of thermonuclear weapons. Levels of tritium in precipitation increased significantly during the 1950s and early 1960s, and later with additional testing, resulting in the release of significant amounts of tritium to the atmosphere. The Canadian heavy water nuclear power reactors, other commercial power reactors, nuclear research and weapons production continue to influence tritium concentrations in the environment.

b. Precipitation Data

Precipitation samples are routinely collected at stations around the world for the analysis of tritium and other radionuclides. Two publicly available databases that provide tritium concentrations in precipitation are Global Network of Isotopes in Precipitation (GNIP) and USEPA's RadNet database. GNIP provides tritium precipitation concentration data for samples collected worldwide from 1960 to 2006. RadNet provides tritium precipitation concentration data for samples collected at stations throughout the U.S. from 1960 up to and including 2006. Based on GNIP data for sample stations located in the U.S. Midwest, tritium concentrations peaked around 1963. This peak, which approached 10,000 pCi/L for some stations, coincided with the atmospheric testing of thermonuclear weapons. Tritium concentrations in surface water showed a sharp decline up until 1975 followed by a gradual decline since that time. Tritium concentrations in Midwest precipitation have typically been below 100 pCi/L since around 1980. Tritium concentrations in wells may still be above the 200 pCi/L detection limit from the external causes described above. Water from previous years and decades is naturally captured in groundwater, so some well water sources today are affected by the surface water from the 1960s that were elevated in tritium.

c. Surface Water Data

Tritium concentrations are routinely measured in large surface water bodies, including Lake Michigan and the Mississippi River. Illinois surface water data were typically less than 100 pCi/L.

The USEPA RadNet surface water data typically has a reported 'Combined Standard Uncertainty' of 35 to 50 pCi/L.

According to USEPA, this corresponds to a ± 70 to 100 pCi/L 95% confidence bound on each given measurement. Therefore, the typical background data provided may be subject to measurement uncertainty of approximately ± 70 to 100 pCi/L.

The radio-analytical laboratory is counting tritium results to an Exelon specified LLD of 200 pCi/L. Typically, the lowest positive measurement will be reported within a range of 40 – 240 pCi/L or 140 ± 100 pCi/L. Clearly, these sample results cannot be distinguished as different from background at this concentration.

IV. Results and Discussion

A. Groundwater and Surface Water Results

Groundwater and Surface Water

Samples were collected from on-site wells throughout the year in accordance with the station radiological groundwater protection program. Analytical results and anomalies are discussed below.

Tritium

Samples from all locations were analyzed for tritium activity (Table B–I.1, Appendix B) (Table B–II.1, Appendix B). Tritium was not detected in any groundwater or surface water samples analyzed. Zion Nuclear Power Station does not have any off-site wells.

Strontium

Strontium-90 was not detected in any of the samples analyzed in 2015.

Iron

Iron-55 was not detected in any of the samples analyzed in 2015.

Nickel

Nickel-59 and Nickel-3 were not detected in any of the samples analyzed in 2015.

Gross Alpha and Gross Beta (Dissolved and Suspended)

Gross Alpha and Gross Beta analyses in the dissolved and suspended fractions were performed on groundwater samples during all four quarters of sampling in 2015. Gross Alpha (dissolved) was not detected at any of the groundwater location. Gross Alpha (suspended) was not detected at any of the groundwater locations. Gross Beta (dissolved) was detected at all forty-six groundwater samples. The concentrations ranged from 2.2 to 20.9 pCi/L. Gross Beta (suspended) was not detected in any of the groundwater locations.

Gross Alpha and Gross Beta analyses in the dissolved and suspended fractions were performed on surface water samples during all four quarters of sampling in 2015. Gross Alpha (dissolved) and Gross Alpha (suspended) was not detected in any of the surface water locations. Gross Beta (dissolved) was detected in four surface water samples at one surface water location. The concentrations ranged from 2.3 to 7.3 pCi/L. Gross Beta (suspended) was not detected in any of the surface water locations. Dissolved Gross Alpha and Dissolved Gross Beta are detectable in samples from background isotopes. A more detailed discussion on where these isotopes come from is explained later in this section. The concentration range of the isotopes can be found in (Table B–I.1, Appendix B) (Table B–II.1, Appendix B).

Gamma Emitters

Naturally occurring K-40 was detected in two of 46 samples analyzed. The concentration ranged from 88 to 98 pCi/L. All other gamma-emitting radionuclides were not detected in either groundwater or surface water samples analyzed (Table B–I.2, Appendix B) (Table B–II.1, Appendix B).

Other Naturally Occurring Isotopes

Gross Beta activity present in the environment may be detected from the following sources: Be-7 and H-3 produced in the upper atmosphere when galactic rays strike nitrogen atoms, which then may reach the ground during precipitation. Gross Beta may also be detected from Cs-137 from past atomic bomb testing as it is still detectable in the environment. K-40 is a naturally occurring radioactive isotope that occurs as a percentage of all stable isotopes of potassium. Gross alpha can occur as naturally occurring uranium in soil undergoes decay to form Radon gases

and in this decay chain, many isotopes of alpha emitting radionuclides are present.

B. Drinking Water Well Survey

A drinking water well survey was conducted during the summer 2006 by CRA (CRA 2006) around the Zion Nuclear Power Station.

C. Summary of Results – Inter-Laboratory Comparison Program

Inter-Laboratory Comparison Program results for TBE and Environmental Inc. (Midwest Labs) are presented in the AREOR.

D. Leaks, Spills, and Releases

On 11/25/2015 while down-ending a box containing a Unit 1 reactor vessel nozzle piece, approximately 3 gallons of water spilled from the lid of the box and onto the concrete pad beneath, some of the water flowed off the pad and onto soil. The water accumulation was suspected to have leaked into the box from recent ice/snow. The leakage is suspected to have been caused by ice formation creating an opening in the lid to box interface, allowing for water intrusion. The remaining nozzle boxes were covered to prevent reoccurrence and a recovery plan initiated to remove any residual water that may have intruded into the remaining boxes. Soil samples were taken at the point of the spill, and the area was marked for cleanup under the final status survey plan. Nearby downstream RGPP wells were sampled and found there was no intrusion of water from this spill into groundwater. The soil area was identified for mitigation for the final status survey plan. The levels of this spill were not of reportable quantity and groundwater results indicated less than the required lower limits of detection.

E. Trends

There are no previously identified plumes; therefore, there are no trends.

F. Investigations

There are currently no investigations at this time.

G. Actions Taken

1. Compensatory Actions

   There have been no station events requiring compensatory actions at the Zion Nuclear Power Station.

2. Installation of Monitoring Wells

   No new wells were required to be installed.

3. Actions to Recover/Reverse Plumes
   There have been no station events requiring actions to recover/reverse any plumes.

APPENDIX A

LOCATION & DIRECTION

TABLE A-1: Sampling Locations and Distance for the Radiological Groundwater Protection Program, Zion Station, 2015.

Site	Site Type	Temporary/Permanent	Distance
MW-ZN-01S	Monitoring Well	Permanent	On-Site
MW-ZN-02S	Monitoring Well	Permanent	On-Site
MW-ZN-03S	Monitoring Well	Permanent	On-Site
MW-ZN-04S	Monitoring Well	Permanent	On-Site
MW-ZN-05S	Monitoring Well	Permanent	On-Site
MW-ZN-06S	Monitoring Well	Permanent	On-Site
MW-ZN-07S	Monitoring Well	Permanent	On-Site
MW-ZN-08S	Monitoring Well	Permanent	On-Site
MW-ZN-09S	Monitoring Well	Permanent	On-Site
MW-ZN-10S	Monitoring Well	Permanent	On-Site
MW-ZN-11S	Monitoring Well	Permanent	On-Site
SW-ZN-01	Surface Water	Lake Michigan	On-Site

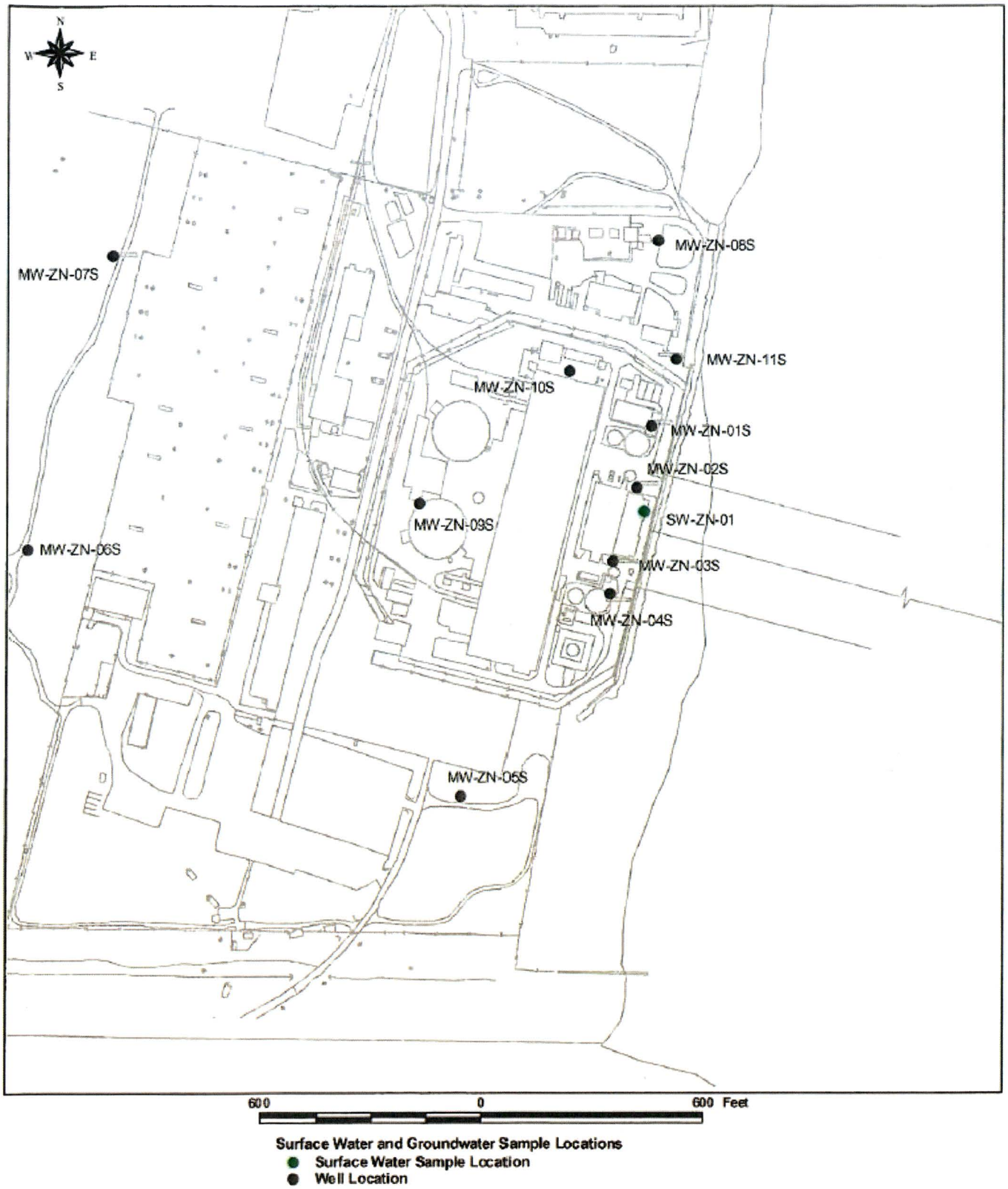

Figure A-1

Radiological Ground Water Protection Program
Groundwater and Surface Water Locations of the Zion Station, 2015

APPENDIX B

DATA TABLES

TABLE B-I.1 **CONCENTRATIONS OF TRITIUM, STRONTIUM, GROSS ALPHA AND GROSS BETA IN GROUNDWATER SAMPLES COLLECTED IN THE VICINITY OF ZION NUCLEAR POWER STATION, 2015**

RESULTS IN UNITS OF PCI/LITER ± 2 SIGMA

SITE	COLLECTION DATE	H-3	Sr-90	Gr-A (Dis)	Gr-A (Sus)	Gr-B (Dis)	Gr-B (Sus)
LIFT STATION	03/10/15	< 177					
MW-ZN-01S	03/11/15	< 178	< 0.7	< 1.8	< 0.5	9.5 ± 1.5	< 1.6
MW-ZN-01S	06/03/15	< 182	< 0.6	< 1.8	< 0.6	10.5 ± 1.5	< 1.1
MW-ZN-01S	08/04/15	< 192	< 0.9	< 1.0	< 0.9	7.9 ± 1.2	< 1.3
MW-ZN-01S	10/13/15	< 179	< 0.9	< 0.8	< 1.1	7.8 ± 1.2	< 1.6
MW-ZN-02S	03/10/15	< 179	< 0.7	< 1.3	< 0.5	11.3 ± 1.2	< 1.6
MW-ZN-02S	05/30/15	< 182	< 0.5	< 1.2	< 0.6	8.8 ± 1.0	< 1.1
MW-ZN-02S	08/04/15	< 187	< 0.8	< 1.1	< 0.9	12.4 ± 1.4	< 1.3
MW-ZN-02S	10/13/15	< 180	< 0.7	< 2.1	< 3.9	20.9 ± 3.1	< 2.1
MW-ZN-03S	03/10/15	< 176	< 0.6	< 1.7	< 0.5	9.9 ± 1.5	< 1.6
MW-ZN-03S	05/30/15	< 183	< 0.7	< 1.5	< 0.6	7.5 ± 1.2	< 1.1
MW-ZN-03S	08/04/15	< 186	< 0.8	< 0.9	< 0.9	7.1 ± 1.1	< 1.3
MW-ZN-03S	10/13/15	< 182	< 0.8	< 0.9	< 1.1	5.8 ± 1.2	< 1.6
MW-ZN-04S	03/10/15	< 180	< 0.7	< 1.9	< 0.5	11.6 ± 1.6	< 1.6
MW-ZN-04S	06/04/15	< 183	< 0.7	< 2.6	< 0.6	12.6 ± 2.3	< 1.1
MW-ZN-04S	08/04/15	< 192	< 0.9	< 1.1	< 0.9	11.4 ± 1.4	< 1.3
MW-ZN-04S	10/13/15	< 181	< 0.7	< 1.0	< 1.1	8.0 ± 1.3	< 1.6
MW-ZN-04S	12/03/15	< 188	< 0.7	< 1.9	< 0.6	14.2 ± 1.5	< 1.4
MW-ZN-05S	03/10/15	< 178	< 0.6	< 1.8	< 0.5	4.2 ± 1.3	< 1.6
MW-ZN-05S	06/04/15	< 182	< 0.5	< 1.5	< 0.6	5.2 ± 1.2	< 1.1
MW-ZN-05S	08/05/15	< 190	< 0.6	< 1.0	< 0.9	3.9 ± 1.0	< 1.3
MW-ZN-05S	10/14/15	< 182	< 0.6	< 0.8	< 1.1	3.6 ± 1.1	< 1.6
MW-ZN-05S	12/03/15	< 186	< 0.7	< 1.7	< 0.6	6.2 ± 1.2	< 1.4
MW-ZN-06S	03/09/15	< 177	< 0.6	< 2.1	< 0.5	5.8 ± 1.4	< 1.6
MW-ZN-06S	06/04/15	< 180	< 0.6	< 1.8	< 0.6	6.9 ± 1.4	< 1.1
MW-ZN-06S	08/03/15	< 187	< 0.7	< 1.1	< 0.9	4.4 ± 1.1	< 1.3
MW-ZN-06S	10/14/15	< 177	< 0.9	< 1.0	< 1.1	3.9 ± 1.1	< 1.6
MW-ZN-07S	03/09/15	< 174	< 0.6	< 1.3	< 0.5	6.4 ± 1.4	< 1.6
MW-ZN-07S	06/08/15	< 181	< 0.5	< 1.7	< 0.7	4.7 ± 1.3	< 1.6
MW-ZN-07S	08/03/15	< 186	< 0.8	< 1.6	< 0.9	2.2 ± 1.1	< 1.3
MW-ZN-07S	10/12/15	< 181	< 0.8	< 1.6	< 0.5	4.5 ± 1.1	< 1.8
MW-ZN-08S	03/09/15	< 179	< 0.6	< 1.1	< 0.5	7.4 ± 1.4	< 1.6
MW-ZN-08S	05/27/15	< 187	< 0.6	< 2.0	< 0.7	6.3 ± 2.6	< 1.6
MW-ZN-08S	08/03/15	< 185	< 0.7	< 0.9	< 0.9	6.7 ± 1.2	< 1.3
MW-ZN-08S	10/12/15	< 180	< 0.7	< 1.2	< 0.5	5.1 ± 1.1	< 1.8
MW-ZN-09S	03/20/15	< 176	< 0.7	< 0.8	< 0.5	14.6 ± 1.6	< 1.6
MW-ZN-09S	05/30/15	< 183	< 0.6	< 1.8	< 0.7	6.9 ± 1.6	< 1.6
MW-ZN-09S	08/04/15	< 189	< 0.6	< 0.8	< 1.0	6.4 ± 1.2	< 1.4
MW-ZN-09S	10/12/15	< 181	< 0.8	< 0.9	< 0.5	6.0 ± 0.9	< 1.8
MW-ZN-10S	03/20/15	< 177	< 0.6	< 0.9	< 0.5	13.4 ± 1.7	< 1.6
MW-ZN-10S	05/27/15	< 186	< 0.6	< 1.2	< 0.7	7.0 ± 1.3	< 1.6
MW-ZN-10S	08/03/15	< 192	< 0.7	< 2.9	< 0.9	7.2 ± 1.0	< 1.3
MW-ZN-10S	10/12/15	< 182	< 0.9	< 1.2	< 0.5	7.2 ± 1.2	< 1.8
MW-ZN-11S	03/09/15	< 180	< 0.7	< 0.8	< 0.5	8.4 ± 1.4	< 1.6
MW-ZN-11S	05/27/15	< 181	< 0.8	< 1.3	< 0.7	7.2 ± 1.4	< 1.6
MW-ZN-11S	08/03/15	< 189	< 0.6	< 3.0	< 0.9	6.7 ± 1.1	< 1.3
MW-ZN-11S	10/12/15	< 182	< 0.8	< 1.4	< 0.6	6.4 ± 1.2	< 1.9

TABLE B-I.2 **CONCENTRATIONS OF GAMMA EMITTERS IN GROUNDWATER SAMPLES COLLECTED IN THE VICINITY OF ZION NUCLEAR STATION, 2015**

Results in Units of pCi/liter ± 2 Sigma

SITE	COLLECTION DATE	Be-7	K-40	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	Cs-134	Cs-137	Ba-140	La-140
MW-ZN-01S	03/11/15	< 83	< 83	< 4	< 7	< 15	< 4	< 9	< 8	< 14	< 5	< 5	< 346	< 88
MW-ZN-01S	06/03/15	< 37	< 24	< 2	< 3	< 9	< 3	< 6	< 4	< 6	< 3	< 3	< 96	< 25
MW-ZN-01S	08/04/15	< 78	< 41	< 5	< 10	< 20	< 7	< 14	< 9	< 14	< 6	< 7	< 136	< 30
MW-ZN-01S	10/13/15	< 37	< 76	< 4	< 5	< 9	< 5	< 8	< 5	< 9	< 4	< 5	< 28	< 10
MW-ZN-02S	03/10/15	< 83	< 34	< 5	< 7	< 27	< 5	< 12	< 9	< 17	< 4	< 5	< 363	< 144
MW-ZN-02S	05/30/15	< 59	< 59	< 3	< 5	< 14	< 3	< 7	< 6	< 11	< 4	< 4	< 172	< 49
MW-ZN-02S	08/04/15	< 57	< 90	< 5	< 7	< 14	< 5	< 7	< 7	< 14	< 5	< 5	< 118	< 38
MW-ZN-02S	10/13/15	< 44	< 83	< 4	< 5	< 10	< 5	< 10	< 5	< 8	< 5	< 5	< 30	< 11
MW-ZN-03S	03/10/15	< 67	< 36	< 4	< 7	< 18	< 4	< 8	< 8	< 12	< 4	< 4	< 307	< 81
MW-ZN-03S	05/30/15	< 48	88 ± 41	< 3	< 5	< 12	< 3	< 7	< 5	< 8	< 3	< 3	< 144	< 51
MW-ZN-03S	08/04/15	< 64	< 45	< 5	< 7	< 18	< 5	< 11	< 7	< 13	< 5	< 5	< 132	< 34
MW-ZN-03S	10/13/15	< 42	< 80	< 4	< 4	< 9	< 5	< 9	< 5	< 8	< 4	< 4	< 26	< 8
MW-ZN-04S	03/10/15	< 87	< 44	< 5	< 6	< 19	< 4	< 9	< 7	< 10	< 4	< 5	< 366	< 90
MW-ZN-04S	06/04/15	< 25	< 32	< 2	< 3	< 8	< 2	< 4	< 3	< 5	< 2	< 2	< 73	< 25
MW-ZN-04S	08/04/15	< 85	< 59	< 6	< 8	< 22	< 6	< 15	< 10	< 14	< 7	< 6	< 153	< 51
MW-ZN-04S	10/13/15	< 57	< 49	< 6	< 6	< 13	< 6	< 12	< 6	< 11	< 5	< 6	< 39	< 15
MW-ZN-04S	12/03/15	< 45	< 48	< 5	< 5	< 12	< 4	< 12	< 5	< 10	< 5	< 5	< 31	< 9
MW-ZN-05S	03/10/15	< 83	< 42	< 6	< 8	< 25	< 5	< 11	< 8	< 15	< 5	< 5	< 362	< 114
MW-ZN-05S	06/04/15	< 49	< 71	< 3	< 5	< 12	< 3	< 7	< 5	< 10	< 3	< 3	< 127	< 45
MW-ZN-05S	08/05/15	< 67	< 101	< 6	< 8	< 14	< 6	< 14	< 8	< 12	< 5	< 5	< 126	< 44
MW-ZN-05S	10/14/15	< 45	< 35	< 4	< 4	< 12	< 4	< 9	< 5	< 7	< 4	< 4	< 31	< 10
MW-ZN-05S	12/03/15	< 45	< 49	< 5	< 6	< 13	< 5	< 11	< 5	< 10	< 5	< 6	< 36	< 9
MW-ZN-06S	03/09/15	< 61	< 29	< 4	< 6	< 18	< 4	< 8	< 7	< 12	< 4	< 4	< 303	< 105
MW-ZN-06S	06/04/15	< 34	< 48	< 2	< 3	< 8	< 2	< 4	< 4	< 6	< 2	< 2	< 82	< 25
MW-ZN-06S	08/03/15	< 69	< 34	< 5	< 7	< 15	< 5	< 12	< 7	< 12	< 5	< 5	< 119	< 41
MW-ZN-06S	10/14/15	< 45	< 41	< 4	< 5	< 10	< 5	< 10	< 5	< 8	< 4	< 5	< 36	< 8
MW-ZN-07S	03/09/15	< 81	< 80	< 6	< 8	< 21	< 5	< 10	< 8	< 14	< 4	< 3	< 421	< 115
MW-ZN-07S	06/08/15	< 49	< 38	< 4	< 5	< 14	< 4	< 8	< 5	< 10	< 4	< 4	< 108	< 33
MW-ZN-07S	08/03/15	< 71	< 21	< 6	< 6	< 12	< 5	< 11	< 6	< 11	< 5	< 6	< 135	< 34
MW-ZN-07S	10/12/15	< 40	< 37	< 4	< 4	< 8	< 4	< 8	< 5	< 8	< 4	< 5	< 32	< 14
MW-ZN-08S	03/09/15	< 72	98 ± 49	< 4	< 7	< 25	< 4	< 12	< 8	< 12	< 5	< 5	< 475	< 158
MW-ZN-08S	05/27/15	< 34	< 15	< 2	< 3	< 9	< 2	< 4	< 3	< 6	< 2	< 2	< 114	< 39
MW-ZN-08S	08/03/15	< 67	< 46	< 6	< 7	< 19	< 5	< 12	< 8	< 14	< 5	< 5	< 150	< 51
MW-ZN-08S	10/12/15	< 44	< 102	< 5	< 5	< 10	< 4	< 9	< 6	< 9	< 4	< 5	< 35	< 10
MW-ZN-09S	03/20/15	< 75	< 59	< 6	< 8	< 25	< 6	< 11	< 10	< 17	< 5	< 6	< 307	< 92
MW-ZN-09S	05/30/15	< 50	< 35	< 4	< 6	< 14	< 3	< 9	< 6	< 11	< 3	< 4	< 172	< 65
MW-ZN-09S	08/04/15	< 78	< 86	< 6	< 8	< 20	< 4	< 10	< 7	< 13	< 4	< 5	< 131	< 46
MW-ZN-09S	10/12/15	< 47	< 69	< 3	< 4	< 9	< 5	< 8	< 6	< 8	< 3	< 3	< 33	< 8

TABLE B-I.2 **CONCENTRATIONS OF GAMMA EMITTERS IN GROUNDWATER SAMPLES COLLECTED IN THE VICINITY OF ZION NUCLEAR STATION, 2015**

Results in Units of pCi/liter ± 2 Sigma

SITE	COLLECTION DATE	Be-7	K-40	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	Cs-134	Cs-137	Ba-140	La-140
MW-ZN-10S	03/20/15	< 78	< 77	< 5	< 8	< 22	< 5	< 9	< 8	< 14	< 5	< 5	< 262	< 88
MW-ZN-10S	05/27/15	< 41	< 27	< 3	< 4	< 11	< 3	< 6	< 5	< 7	< 2	< 3	< 146	< 44
MW-ZN-10S	08/03/15	< 55	< 42	< 4	< 6	< 14	< 4	< 9	< 6	< 11	< 4	< 4	< 108	< 36
MW-ZN-10S	10/12/15	< 50	< 43	< 6	< 5	< 12	< 6	< 11	< 5	< 11	< 5	< 5	< 38	< 13
MW-ZN-11S	03/09/15	< 57	< 70	< 3	< 5	< 16	< 3	< 7	< 6	< 10	< 3	< 3	< 374	< 112
MW-ZN-11S	05/27/15	< 42	< 24	< 3	< 4	< 11	< 3	< 6	< 5	< 8	< 3	< 3	< 142	< 52
MW-ZN-11S	08/03/15	< 49	< 74	< 4	< 5	< 13	< 3	< 8	< 5	< 9	< 4	< 4	< 105	< 30
MW-ZN-11S	10/12/15	< 35	< 38	< 4	< 4	< 8	< 3	< 7	< 4	< 7	< 3	< 4	< 27	< 9

TABLE B-I.3 CONCENTRATIONS OF IRON-55 AND NICKEL-63 IN GROUNDWATER SAMPLES COLLECTED IN THE VICINITY OF ZION NUCLEAR STATION, 2015

RESULTS IN UNITS OF PCI/LITER ± 2 SIGMA

SITE	COLLECTION DATE	Fe-55	Ni-59	Ni-63
MW-ZN-01S	03/11/15	< 164	< 173	< 4.2
MW-ZN-01S	06/03/15	< 178	< 21	< 4.3
MW-ZN-01S	08/04/15	< 164	< 59	< 4.8
MW-ZN-01S	10/13/15	< 97	< 64	< 3.4
MW-ZN-02S	03/10/15	< 187	< 59	< 4.0
MW-ZN-02S	05/30/15	< 178	< 71	< 3.0
MW-ZN-02S	08/04/15	< 108	< 104	< 4.9
MW-ZN-02S	10/13/15	< 109	< 62	< 3.4
MW-ZN-03S	03/10/15	< 174	< 180	< 4.1
MW-ZN-03S	05/30/15	< 177	< 82	< 3.7
MW-ZN-03S	08/04/15	< 135	< 72	< 4.8
MW-ZN-03S	10/13/15	< 136	< 73	< 3.4
MW-ZN-04S	03/10/15	< 170	< 50	< 4.3
MW-ZN-04S	06/04/15	< 184	< 39	< 4.3
MW-ZN-04S	08/04/15	< 103	< 77	< 4.4
MW-ZN-04S	10/13/15	< 93	< 19	< 3.4
MW-ZN-04S	12/03/15	< 178	< 48	< 4.5
MW-ZN-05S	03/10/15	< 119	< 190	< 4.4
MW-ZN-05S	06/04/15	< 183	< 83	< 4.6
MW-ZN-05S	08/05/15	< 116	< 83	< 4.1
MW-ZN-05S	10/14/15	< 74	< 94	< 4.0
MW-ZN-05S	12/03/15	< 167	< 60	< 4.5
MW-ZN-06S	03/09/15	< 180	< 85	< 4.5
MW-ZN-06S	06/04/15	< 144	< 82	< 4.5
MW-ZN-06S	08/03/15	< 114	< 74	< 5.0
MW-ZN-06S	10/14/15	< 69	< 83	< 4.4
MW-ZN-07S	03/09/15	< 90	< 166	< 4.5
MW-ZN-07S	06/08/15	< 127	< 77	< 4.4
MW-ZN-07S	08/03/15	< 98	< 97	< 4.5
MW-ZN-07S	10/12/15	< 88	< 61	< 4.7
MW-ZN-08S	03/09/15	< 162	< 89	< 4.1
MW-ZN-08S	05/27/15	< 183	< 84	< 4.1
MW-ZN-08S	08/03/15	< 166	< 67	< 4.4
MW-ZN-08S	10/12/15	< 101	< 58	< 2.8
MW-ZN-09S	03/20/15	< 158	< 91	< 4.3
MW-ZN-09S	05/30/15	< 167	< 71	< 3.1
MW-ZN-09S	08/04/15	< 103	< 43	< 3.8
MW-ZN-09S	10/12/15	< 112	< 53	< 3.6
MW-ZN-10S	03/20/15	< 163	< 181	< 4.3
MW-ZN-10S	05/27/15	< 175	< 79	< 3.5
MW-ZN-10S	08/03/15	< 89	< 70	< 3.0
MW-ZN-10S	10/12/15	< 67	< 82	< 3.5
MW-ZN-11S	03/09/15	< 126	< 105	< 4.6
MW-ZN-11S	05/27/15	< 197	< 42	< 3.3
MW-ZN-11S	08/03/15	< 121	< 61	< 3.0
MW-ZN-11S	10/12/15	< 158	< 67	< 3.6

TABLE B-II.1 **CONCENTRATIONS OF TRITIUM, STRONTIUM, GROSS ALPHA AND GROSS BETA IN SURFACE WATER SAMPLES COLLECTED IN THE VICINITY OF ZION NUCLEAR POWER STATION, 2015**

RESULTS IN UNITS OF PCI/LITER ± 2 SIGMA

SITE	COLLECTION DATE	H-3	Sr-90	Gr-A (Dis)	Gr-A (Sus)	Gr-B (Dis)	Gr-B (Sus)
SW-ZN-01	03/10/15	< 176	< 0.7	< 0.5	< 0.5	3.6 ± 0.8	< 1.6
SW-ZN-01	05/30/15	< 184	< 0.5	< 1.7	< 0.7	2.3 ± 1.4	< 1.6
SW-ZN-01	08/04/15	< 190	< 0.9	< 1.6	< 0.7	7.3 ± 0.9	< 2.4
SW-ZN-01	10/13/15	< 181	< 0.8	< 0.8	< 0.5	2.5 ± 0.8	< 1.8

TABLE B-II.2 CONCENTRATIONS OF GAMMA EMITTERS IN SURFACE WATER SAMPLES COLLECTED IN THE VICINITY OF ZION NUCLEAR STATION, 2015

Results in Units of pCi/liter ± 2 Sigma

SITE	COLLECTION DATE	Be-7	K-40	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	Cs-134	Cs-137	Ba-140	La-140
SW-ZN-01	03/10/15	< 55	< 64	< 3	< 6	< 17	< 4	< 7	< 6	< 11	< 3	< 3	< 330	< 106
SW-ZN-01	05/30/15	< 42	62 ± 35	< 3	< 4	< 11	< 3	< 6	< 4	< 7	< 3	< 3	< 115	< 40
SW-ZN-01	08/04/15	< 65	< 47	< 6	< 8	< 17	< 7	< 14	< 10	< 16	< 6	< 5	< 131	< 59
SW-ZN-01	10/13/15	< 36	< 31	< 4	< 4	< 8	< 4	< 8	< 5	< 7	< 4	< 4	< 27	< 8

TABLE B-II.3 **CONCENTRATIONS OF IRON-55 AND NICKEL-63 IN SURFACE WATER SAMPLES COLLECTED IN THE VICINITY OF ZION NUCLEAR STATION, 2015**

RESULTS IN UNITS OF PCI/LITER ± 2 SIGMA

SITE	COLLECTION DATE	Fe-55	Ni-59	Ni-63
SW-ZN-01	03/10/15	< 128	< 174	< 4.0
SW-ZN-01	05/30/15	< 143	< 87	< 3.8
SW-ZN-01	08/04/15	< 166	< 39	< 3.6
SW-ZN-01	10/13/15	< 115	< 65	< 3.5