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Manager
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Nuclear Oversight

10 CFR 50, Appx. I

May 12, 2020

ATTN: Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Subject: **Docket Nos. 50-206, 50-361, 50-362 and 72-41**
2019 Annual Radiological Environmental Operating Report
San Onofre Nuclear Generating Station (SONGS), Units 1, 2 and 3 and Independent Spent Fuel Storage Installation

In accordance with the San Onofre Nuclear Generating Station (SONGS) Unit 1 Permanently Defueled Technical Specification (TS) Section D6.9.1.3 and SONGS Units 2 and 3 Permanently Defueled TS Section 5.7.1.2, "Annual Radiological Environmental Operating Report," Southern California Edison (SCE) is submitting the 2019 Annual Radiological Environmental Operating Report (AREOR) for SONGS Units 1, 2 and 3. The AREOR covers the operation of SONGS during January 1, 2019 through December 31, 2019 and includes summaries, interpretations, and analyses of trends of the results of the Radiological Environmental Monitoring Program (REMP).

In addition, the AREOR includes the results for direct radiation monitoring near the Independent Spent Fuel Storage Installation.

There are no commitments in this letter or the enclosure.

If you have any questions, please contact me at (949) 368-6945.

Sincerely,

Enclosure: 2019 San Onofre Nuclear Generating Station Annual Radiological Environmental Operating Report

cc: S. Morris, Regional Administrator, NRC Region IV
A. M. Snyder, NRC Project Manager, SONGS Units 1, 2 and 3
W. C. Allen, NRC Project Manager, SONGS ISFSI
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ENCLOSURE

2019 San Onofre Nuclear Generating Station
Annual Radiological Environmental Operating Report

San Onofre Nuclear Generating Station

2019

Annual Radiological Environmental Operating Report

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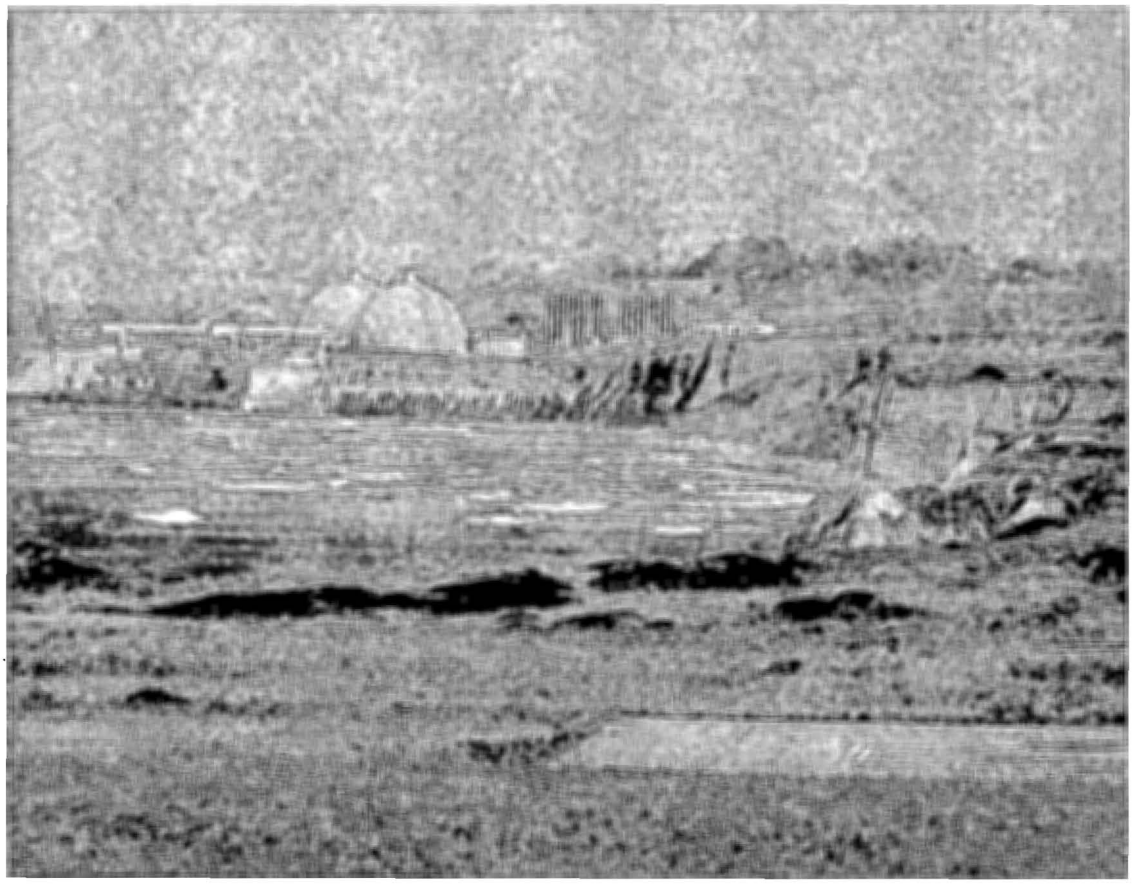
License Numbers:
DPR-13, NPF-10, NPF-15



This 2019 Annual Radiological Environmental Operating Report (AREOR) for the San Onofre Nuclear Generating Station (SONGS) fulfills the requirements of Technical Specifications (TS) Section §D6.9.1.3 of SONGS Unit 1 License DPR-13, Section §5.7.1.2 of the permanently defueled SONGS Units 2 and 3 Licenses NPF-10 and NPF-15, respectively, and the Independent Spent Fuel Storage Installation (ISFSI) facility. The 2019 AREOR covers the results of the environmental monitoring performed around SONGS during the time period January 1, 2019 through December 31, 2019.

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FIGURES

Acronyms

AREOR	Annual Radiological Environmental Operating Report
CAB	Controlled Area Boundary
CDPH	California Department of Public Health
CEAL	Contracted Environmental Analysis Laboratory
DOE	Department of Energy
EAB	Exclusion Area Boundary
EPA	U.S. Environmental Protection Agency
ISFSI	Independent Spent Fuel Storage Installation
LLD	Lower Limit of Detection
LUC	Land Use Census
MDC	Minimum Detectable Concentration
MDD	Minimum Differential Dose
ND	Not Detectable
NEI	Nuclear Energy Institute
NRC	U.S. Nuclear Regulatory Commission
ODCM	Offsite Dose Calculation Manual
QA	Quality Assurance
QC	Quality Control
REMP	Radiological Environmental Monitoring Program
SAB	Site Area Boundary
TLD	Thermoluminescent Dosimeter

1 Executive Summary

On June 12, 2013, Southern California Edison notified the Nuclear Regulatory Commission (NRC) that it had permanently ceased operation for both Units 2 and 3 on June 7, 2013. While all power operations have ceased, spent fuel remains stored on site. San Onofre Nuclear Generating Station (hereafter referred to as San Onofre or SONGS) continues to fulfill its regulatory commitment to monitor the environment and potential exposure pathways. The Radiological Environmental Monitoring Program (REMP) supports the conclusion that San Onofre has had an inconsequential radiological impact on the environment and that it is well within applicable state and federal regulations.

The REMP includes the sampling of environmental media and measuring radiation levels in the environment surrounding SONGS. Its purpose is to identify any levels of radioactivity or radiation associated with SONGS that have a potential exposure to a member of the general public. This is accomplished through the measurement of direct radiation and by the sampling and analyses of various environmental media, including:

- soil
- shoreline sediment (beach sand)
- air (particulate & iodine)
- local crops
- non-migratory marine species
- kelp
- drinking water
- ocean water
- ocean bottom sediments

Samples are analyzed for both naturally occurring and SONGS plant related radionuclides. A detailed description of the 2019 sampling locations and location maps are included in Appendix A of this report.

The California Department of Public Health (CDPH) Drinking Water and Sanitation Laboratory participated in an inter-laboratory split sampling program with SONGS, including ocean water tritium samples and gamma isotopic samples from various environmental media. The results are discussed in Appendix C. The CDPH also conducted a direct radiation (TLD) monitoring program in conjunction with SONGS. Refer to Appendix H.

This report describes the REMP as conducted at SONGS during the period from January 1, 2019 through December 31, 2019. The REMP produces scientifically defensible data indicating SONGS had no significant radiological environmental impact in 2019. This report fulfills applicable license commitments, as described in License Nos. DPR-13, NPF-10, NPF-15, and the Offsite Dose Calculation Manual (ODCM).

Beyond the immediate area of the ISFSI, the REMP data collected during 2019, as in previous years, continues to be representative of background levels. The data is summarized in the Statistical Summary of REMP Data found in Appendix B. As in previous years, cesium-137 (Cs-137) was identified in soil and is attributable to fallout from nuclear weapons testing and sources external to SONGS such as the Chernobyl accident. Though not measurable in 2019, I-131 has historically been detected in kelp due to the sewage discharge of medically administered I-131 and to the high biomagnification factor for iodine in kelp. In 2019, Cs-137 in fish was detected above the minimum detectable concentration (MDC) in one indicator sample. The Cs-137 in fish is consistent with concentrations detected in other west coast marine species

and may be attributable to the legacy Pacific Ocean discharges from Fukushima. These isotopes have been detected at indicator locations, as well as at control locations, in past years. Naturally occurring radionuclides, including beryllium-7 (Be-7), potassium-40 (K-40), thorium-228 (Th-228) and thorium-230 (Th-230) were detected in both control and indicator locations at similar concentrations and are not related to SONGS. Refer to Appendix B for a more detailed discussion.

There is a natural and manmade radiation background. Natural background is comprised of the terrestrial and cosmic radiation sources while manmade background results from past weapons testing fallout and routine medical applications. Prior to the construction of SONGS, environmental samples and measurements were collected and analyzed to determine the baseline natural radiation levels. The results from the indicator stations are compared to this pre-operational data, as well as control samples, to evaluate if changes in any radiation levels can be attributed to SONGS or other causes such as natural variations in the environment or manmade contributions external to SONGS.

In summary, the environmental monitoring data collected during 2019 supports a conclusion of no adverse effect on the population or the environment from SONGS. The radiation exposures to people living in the surrounding area from SONGS remains less than the detection level of the radiation exposures in the environment from the natural background from terrestrial and cosmic radiation.

2 Radiological Environmental Monitoring Program

Program Overview

The purpose of the REMP is to characterize the radiological environment outside of the power block and to detect potential radiological impacts resulting from activities at SONGS Units 2 and 3. The REMP monitors credible pathways of exposure to the public and fulfills the radiological environmental monitoring requirements of the ODCM.

Exposure pathways are the different routes by which people can potentially be exposed to radiation or radioactive materials. The pathways may be characterized into four general types, shown below along with a brief description of the monitoring as performed at SONGS:

- **AIRBORNE**. The airborne pathway represents the inhalation intake of airborne radioactive materials. This pathway is sampled in areas around SONGS by continuously drawing air through specialized filters and charcoal cartridges 24 hours a day, 7 days a week. Although both units at SONGS have been shut down since January 2012, these air samples continue to be collected on a weekly basis.
- **WATERBORNE**. The waterborne pathways include the exposure to radioactive materials accumulated in aquatic biota (fish, shellfish) and in shoreline sediments. These pathways are assessed through the collection of fish and shellfish samples in the environment around the plant. Sediment samples are also collected to evaluate any long-term buildup in the environment.
- **INGESTION**. The ingestion pathway includes broadleaf vegetation, agricultural products, and food products. Atmospheric releases from the plant can deposit on these food products, representing an intake exposure pathway through the consumption of these food products. Samples of crops (e.g., tomato, lettuce, sorrel) are collected from the local area around the plant to evaluate any impact on this pathway.

- **DIRECT RADIATION**. The direct radiation pathway represents the external exposure from sources on the plant site and directly from any radioactive effluents released to the air or water. This direct environmental radiation dose is measured through the use of direct measurement dosimeters, such as thermoluminescent dosimeters (TLDs) that are placed around the plant site and in the local environment.

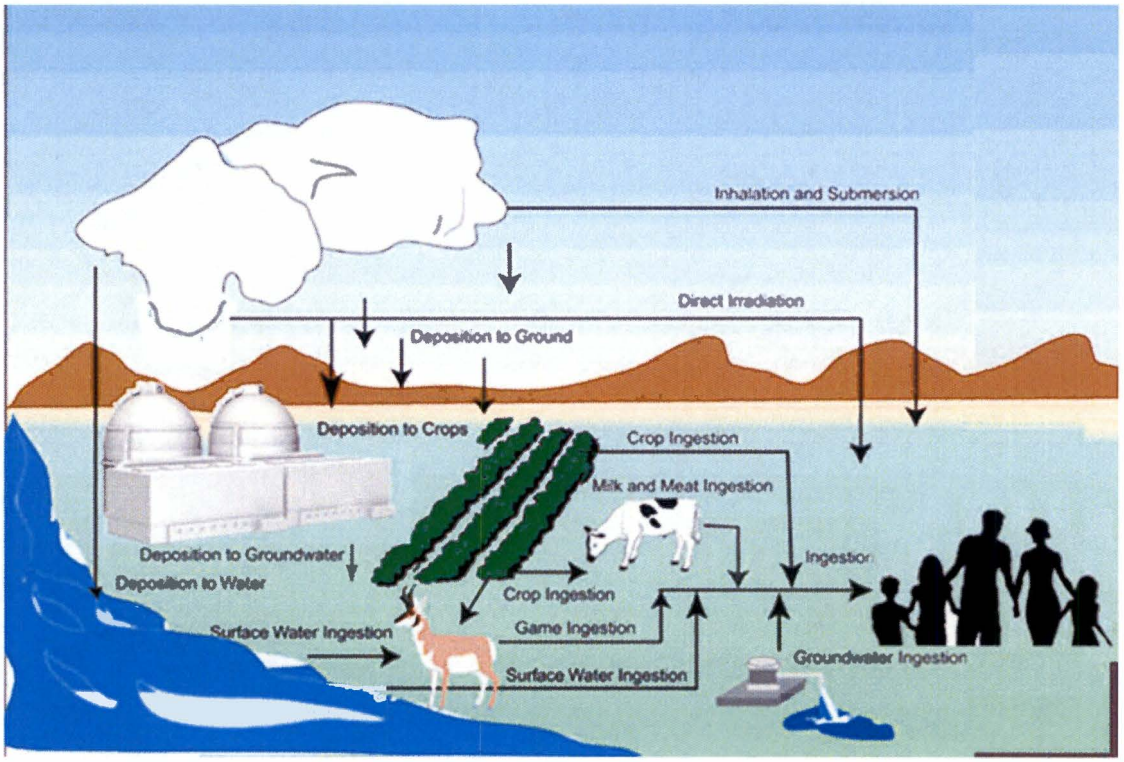


Figure 1 - Examples of Exposure Pathways

Site Area and Description

San Onofre Nuclear Generating Station is located next to San Onofre State Beach, adjoining Camp Pendleton Marine Corps Base, in San Diego County, 64 miles south of Los Angeles, California. At this time there are no operating reactors, but in the past, there were three operating pressurized water reactors with a total rated capacity of 2664 net megawatts electrical.

Figure 2 - SONGS 45 mile REMP Radius

Unit 1, rated at 410 net megawatts electrical, was supplied by Westinghouse Electric Company. Unit 1 began commercial operation on January 1, 1968. The unit was permanently shut down on November 30, 1992, and has been decommissioned. By August 31, 2004, all fuel was transferred to the Independent Spent Fuel Storage Installation (ISFSI). By November 29, 2006, all remaining monitored effluent pathways were permanently removed from service or routed to Unit 2 discharge to the outfall. Unit 1 is owned by Southern California Edison (80%) and San Diego Gas and Electric (20%).

Unit 2 and Unit 3 were supplied by Combustion Engineering, Inc., with turbine generators supplied by G.E.C. Turbine Generators, Ltd., of England. The units began commercial operation on August 18, 1983, and April 1, 1984, respectively, and were rated at 1127 net megawatts electrical each. The twin units are owned by Southern California Edison (78.21%), San Diego Gas and Electric (20%), and the City of Riverside (1.79%).

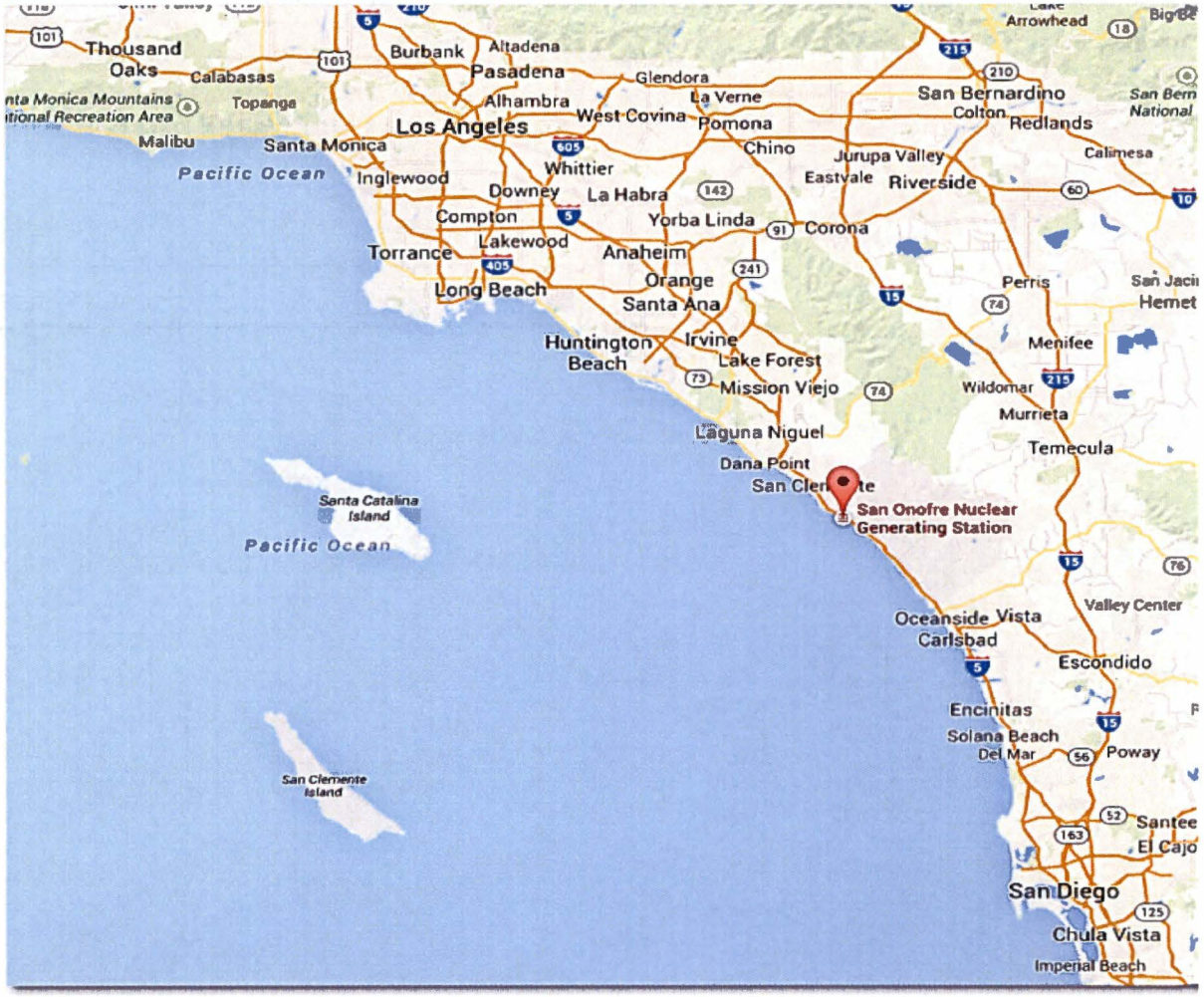


Figure 3 - SONGS Location

Effective December 29, 2006, the City of Anaheim transferred its ownership interests in San Onofre Units 2 and 3 and the entitlement to the Units 2 and 3 output to Southern California Edison Company, except that it retains its ownership interests in its spent nuclear fuel and Units 2 and 3's independent spent fuel storage installation located on the facility's site. In addition, the City of Anaheim retains financial responsibility for its spent fuel and for a portion of the Units 2 and 3 decommissioning costs. The City of Anaheim remains a licensee for purposes of its retained interests and liabilities. Southern California Edison notified the Nuclear Regulatory Commission (NRC) on June 12, 2013, that it had permanently ceased operation of Units 2 and 3 on June 7, 2013. The NRC notification, called a Certification of Permanent Cessation of Power Operations, sets the stage for SCE to begin preparations for decommissioning.

Sample Collection and Analyses

Samples of environmental media were obtained in accordance with the requirements of the ODCM to meet the regulatory requirements. Refer to Appendix A for a complete list of REMP sample locations as described in Table 5-4 of the ODCM.

Indicator samples close to SONGS are compared to control samples located in areas that are beyond the measurable influence of San Onofre. The control sample results are considered representative of background levels with no potential for contribution from releases and sources at SONGS. The control stations also serve as indicators of radioactive sources unrelated to activities at SONGS, such as sewage plant discharges of nuclear medicine applications or nuclear fallout attributable to external sources (legacy fallout from nuclear weapons, the nuclear accident at Chernobyl, and the nuclear accident at Fukushima). The indicator location samples are used to detect environmental radioactivity attributable to SONGS. Indicator sample locations can be located either onsite or offsite.

As described in Section 4, below, the SONGS REMP is conducted in accordance with a Quality Assurance Program, meeting the requirements of NRC Regulatory Guide 4.15, Rev. 1. Samples are collected using approved methods; radiochemical analyses of these samples are performed using standardized analytical methods. The Contracted Environmental Analysis Laboratory (CEAL) participates in an inter-laboratory comparison program in partial fulfillment of the quality assurance requirements for environmental monitoring. The CEAL participated in cross check programs which meet the intent of Reg. Guide 4.15. See Appendix C for additional details.

Detection Limit Terminology

The United States Nuclear Regulatory Commission (NRC) requires that equipment and analytical methods used for radiological monitoring must be able to detect specified minimum limits for the type sample and the radionuclide of the analysis. The *a priori* detection capability for the analytical system used for the measurement is referred to as the Lower Limit of Detection (LLD). This LLD ensures that radiation measurements are sufficiently sensitive to detect any levels of concern and small changes in the environment. Samples with no detectable radiation levels are typically referred to as less than the Minimum Detectable Concentration (MDC). The MDC is evaluated for each sample and is used to ensure that the specific analysis has sufficient sensitivity to detect levels consistent with the requirements for analysis by the system LLD. For a more thorough discussion, refer to NUREG/CR-4007.

- **Lower Limit of Detection (LLD)** - The LLD is the *a priori* (before the fact) lower limit of detection for the method used for the analysis. It is a measure of the detection capability for the analytical method and not for any single sample analysis. This value is calculated for each isotope and every matrix based on typical or expected values of decay time, sample size, counter efficiency, etc. The LLD values are listed in the ODCM and represent the detection capability that the analytical methods must meet for each the specified sample media.

- **Minimum Detectable Concentration (MDC)** - The MDC is the *a posteriori* (after the fact) lower limit of detection based on actual decay time, measured sample size, and counting efficiency for an individual sample analysis. The MDC is compared to the LLD to verify that the measurement met the ODCM requirements for the maximum value of the LLD for the listed radionuclides. Values flagged by the CEAL as being confirmed above the MDC are presumed to detected levels of radioactivity.

- **No Detectable (ND)** - The term ND refers to Thermoluminescent Dosimeter (TLD) data analyzed per ANSI N13.37-2014 (Environmental Dosimetry-Criteria for System Design and Implementation) that is less than the ANSI calculated detection limit above a specific location's baseline. A baseline is calculated per ANSI methods for each specific location because the direct radiation signal is a strong function of very local conditions. If the TLD data for a specific location is less than that specific location's baseline plus the ANSI calculated detection limit then the value is ND for that specific measurement.

The sampling and analyses for the REMP are conducted in accordance with the ODCM and the applicable regulatory requirements.

Regulations and Guidance

- **10 CFR 20**

10 CFR 20.1101 establishes the requirement for radiation protection programs. Within these programs, it exerts requirements for engineering controls and procedures to achieve occupational doses and doses to members of the public that are as low as reasonably achievable. 10 CFR 20.1301 establishes dose limits for individual members of the public. Specifically, it states total effective dose to individual members of the public does not exceed 100 mrem in a year, and in unrestricted areas, does not exceed 2 mrem in any one hour.

- **10 CFR 50, Appendix I**

10 CFR 50, Appendix I establishes limits on releases of radioactivity to the environment and the resulting dose to the public. The limits are:

Source	NRC Limits for SONGS
Liquid Effluent	Less than or equal to 3 mrem/yr to whole body from all pathways of exposure Less than or equal to 10 mrem/yr to any organ from all pathways of exposure
Gaseous Effluents – Noble Gases	Less than or equal to 10 mrad/yr gamma air dose Less than 20 mrad/yr, beta air dose Less than 5 mrem/yr, total body dose to an offsite exposed individual of the public
Iodine-131, tritium and particulates with half-life greater than 8 days	Less than or equal to 15 mrem to any organ for an offsite individual from all pathways of exposure

- **40 CFR 190**

The Environmental Protection Agency (EPA) has established environmental radiation protection standards in 40 CFR 190 for the uranium fuel cycle that includes nuclear power plants. These limits are applicable to the sum of liquid effluent, gaseous effluents and direct radiation.

The dose limits from all applicable pathways to any offsite individual are:

- 25 mrem/year to the whole body
- 75 mrem/year to the thyroid
- 25 mrem to any other organ

As discussed in the 2019 SONGS Annual Radioactive Effluent Release Report, the calculated dose to a member of the public as a result of SONGS is a small fraction of the dose standard established by the EPA. This conclusion is supported by the results of the REMP, as reflected by the absence of measurable levels of radiation or radioactive materials in the offsite environment attributable to SONGS.

The following regulatory and industry guidance has been identified as applicable to the SONGS REMP with application as may be required.

- US NRC Regulatory Guide 4.1, Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants, 1975
- US NRC Regulatory Guide 4.2, Preparation of Environmental Reports for Nuclear Power Stations, 1976
- NUREG-0133, Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants
- US NRC Regulatory Guide 1.109, Calculation of Annual Doses to Man from Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I, 1977
- NUREG-1301, Offsite Dose Calculations Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors, Generic Letter 89-01, Supplement No. 1, 1991
- SNRC Regulatory Guide 4.13, Revision 2, June 2019, Environmental Dosimetry Performance Specifications, Testing, and Data Analysis
- ANSI/HPS N13.37, "Environmental Dosimetry – Criteria for System Design and Implementation", 2014
- US NRC Regulatory Guide 4.15, Rev. 1, Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment, 1979
- NUREG-1576, Multi-agency Radiological Laboratory Analytical Protocols
- NUREG/CR-4007, Lower Limit of Detection: Definition and Elaboration of a Proposed Position for Radiological Effluent and Environmental Measurements, 1984

NRC Reporting Limits

The NRC has established required reporting levels that represent thresholds above which an investigation is needed to evaluate and ensure compliance with radiation safety standards for the public. Licensed nuclear facilities must prepare a special report if any environmental sample value exceeds the corresponding reporting limit. SONGS did not submit any special reports to the NRC in 2019, as no reporting limits were exceeded.

Summary of Analysis of Results and Trends

The 2019 SONGS REMP was conducted in accordance with 10 CFR 50, Appendix I, 10 CFR §50.36a, and Section 5.0 of the SONGS ODCM. The REMP sample data have been summarized in the format specified in NUREG-1301. Data have been evaluated to identify the levels of any plant related environmental radioactivity above background levels (i.e., plant related contributions that are distinguishable from background). For data distinguishable from background, a comparison has been made between current environmental monitoring results and preoperational or previous operational data as appropriate, for trending environmental radioactivity resulting from plant operation.

To conform with 10 CFR Part 50, Appendix I, Section IV B.2, data on measurable levels of radiation and radioactive materials in the environment are provided to allow for a comparison to the predicted (calculated) values in the environment from radioactive material released in effluents.

The tabulated means, ranges, and standard deviations are presented in Appendix B. Comparisons with background and pre-operational baseline data are presented in Appendix D.

The REMP data are reviewed for accuracy and are compared against NRC reporting levels. Measurements exceeding the administrative levels (10% of the NRC reporting levels) are flagged. Analyses are performed using instrumentation and methods that provide analytical results with a level of detection as required by the ODCM. The *a posteriori* Minimum Detectable Concentration (MDC) is compared to the maximum value for the *a priori* Lower Limit of Detection (LLD) specified in the ODCM. This ensures that regulatory limits for the maximum LLD are met.

Analysis	Water (pCi/L)	Airborne Particulate or Gases (pCi/m^3)	Marine Animals (pCi/kg, wet)	Local Crops (pCi/kg, wet)	Sediment (pCi/kg, dry)
Gross beta	4	1E-02			
H-3	2000				
Mn-54	15		130		
Fe-59	30		260		
Co-58, 60	15		130		
Zn-65	30		260		
Zr-95, Nb-95	15				
I-131	1	7E-02		60	
Cs-134	15	5E-02	130	60	150
Cs-137	18	6E-02	150	80	180
Ba-140, La-140	15				

Table 1 - Maximum LLDs as Specified in SONGS ODCM

The impact of SONGS on the surrounding environment is assessed through a series of analyses. These analyses include: comparisons of indicator to control locations (Appendix B); comparison of operational to preoperational environmental data (Appendix D); summary of deviations from sampling requirements and corrective actions taken (Appendix E); and the results of the 2019 Land Use Census (Appendix F).

A detailed discussion of the 2019 analytical results is presented in this report. Analytical values from offsite indicator sample stations continue to trend with the control stations. The data indicate that SONGS had no significant radiological impact on the environment during 2019. In addition, dose to members of the public attributable to SONGS related radiological activities remain well below regulatory limit of 100 mrem per year, as specified in 10 CFR 20.1301 and in keeping with the philosophy of "as low as is reasonably achievable" (ALARA), as specified in 10 CFR 20.1101(b).

The data are summarized in the Statistical Summary of REMP Data found in Appendix B. Cesium-137 (Cs-137) is routinely identified in some soil samples. However, the level of Cs-137 found in control and indicator samples or soil is consistent with historical and expected Cs-137 concentrations from nuclear weapons testing. Cs-137 was detected (greater than the MDC and less than the LLD) in one indicator sheephead marine species sample, refer to Appendix B. Naturally occurring radionuclides, including beryllium-7 (Be-7), potassium-40 (K-40), thorium-228 (Th-228) and thorium-230 (Th-230) were detected in both control and indicator locations at similar concentrations and are not related to SONGS. Refer to Appendix B for a more detailed discussion.

3 Land Use Census

In accordance with 10 CFR Part 50, Appendix I, Section IV.B.3, each year a Land Use Census is performed to identify any changes in the use of areas at and beyond the site boundary. Modifications to the monitoring program are made if required by the results of this census to reflect new or changes in locations for pathways of exposure around the plant. Appendix F of the report identifies changes to the census in 2019. The 2019 Land Use Census (LUC) identified two existing locations with higher occupancy for the year. No changes to the sampling media or sample locations were required.

4 Quality Assurance

A portion of REMP sampling activity is devoted to quality assurance. All REMP activities, including support contractors, are assessed as defined in Regulatory Guide 4.15, Rev. 1. The quality assurance program's main aspects include process quality control, instrument quality control, comprehensive data reviews, cross-check analyses, and audits. Routine REMP assessments ensure that the program, procedures and personnel are performing satisfactorily. Samples are collected using approved methods; radiochemical analyses of these samples are performed using standardized analytical methods. Quality audits and independent technical reviews help determine areas that need attention. These areas are addressed in accordance with the station's Corrective Action Program.

The California Department of Public Health (CDPH) participates in a split sampling program in accordance with the site's REMP procedures. Duplicate radiological split sampling is performed by SONGS to demonstrate repeatability of the sample collection, preparation, and analysis process. Split sample analysis is performed for the evaluation of the precision and bias trends of the method of analysis without the added variables introduced by sampling. The 2019 CDPH data resulted in similar conclusions to the 2019 SONGS REMP data.

GEL Laboratories, LLC (GEL) performs the radiochemistry analysis of samples noted within this report. GEL performs the requested analysis under its Quality Assurance Program, which meets the requirements of Title 10 Code of Federal Regulations Appendix B Part 50, ASME NQA-1 and Regulatory Guide 4.15 Revision 1. The measurement capabilities of the radiological laboratory are demonstrated by participating in an inter-laboratory measurement assurance program and performing duplicate and split sample analyses. Approximately 10% of the analyses performed are quality control samples, consisting of inter-laboratory measurement assurance program samples, duplicate samples, and split samples. The inter-laboratory measurement assurance program provides samples that are similar in matrix and size to those sampled and measured by the REMP. This program assures that equipment calibrations and sample preparation methods accurately measure radioactive material in samples. See Appendix C for detailed QA measurement data.

Stanford Dosimetry performs the environmental TLD analyses noted in this report. Stanford Dosimetry performs the requested analyses under its quality assurance program which meets the requirement of Title 10 Code of Federal Regulations Part 50, Appendix B, ASME NQA-1, Regulatory Guide 4.15 Revision 1 and Regulatory Guide 4.13 Revision 2 (Environmental Dosimetry – Performance Standards, Testing and Data Analysis).

5 Program Deviations

Any deviation in the conduct of the program as required, either in terms of sample collection or analysis, requires an investigation as to the cause and identification of measures to prevent recurrence. Deviations from the sampling program or sensitivity requirements are acknowledged and explained in Appendix E to this report.

6 Conclusion

Radiological environmental data collected throughout 2019 have been evaluated to determine any impact that San Onofre operations has on the surrounding environment. To accomplish this, several methods of evaluation were employed, namely:

1. Compilation and verification of all data, as well as a determination of those data considered to be greater than background levels.

2. Correlation of effluent concentrations to concentrations in the environment. Refer to Appendix B.

3. Examination of time dependent variations of pertinent radioisotopes in selected environmental media throughout the year at both indicator and control locations.

4. Comparison of radioactivity in various media in 2019 against the levels observed in preoperational years.

5. Historical trending of radionuclides in various media during operational years.

This evaluation identified one indicator non-migratory marine species Sheephead sample with Cs-137 detected above the MDC. It is concluded that activities at SONGS in 2019 had no significant radiological environmental impact.

7 References

1. SONGS Offsite Dose Calculation Manual (ODCM), Section 5.0.

2. SONGS Radiological Monitoring (RM) Procedures established for the following:

   a. Radiological Environmental Monitoring Program

   b. Review, Analysis and Reporting of Radiological Environmental Monitoring Program (REMP) Data

   c. Radiation Monitoring and Exposure Controls

3. NUREG/CR-4007, "Lower Limit of Detection: Definition and Elaboration of a Proposed Position for Radiological Effluent and Environmental Measurements," August 1984.

APPENDIX A. SAMPLE TYPE AND SAMPLING LOCATIONS

Table 2 - Direct Radiation Measuring Locations

DIRECT RADIATION MEASURING LOCATION		DISTANCE[a] (miles)	DIRECTION[a] (Sector)
1	City of San Clemente (Former SDG&E Offices) (Control)	5.7	NW
2	Camp San Mateo – (MCB, Camp Pendleton)	3.6	N
3	Camp San Onofre – (MCB, Camp Pendleton)	2.8	NE
4	Camp Horno – (MCB, Camp Pendleton)	4.4	E
6	Old El Camino Real (AKA Old Highway 101)	3.0	ESE
8	Noncommissioned Officers' Beach Club	1.4	NW
10	Bluff	0.7	WNW
11	Former Visitors' Center	0.4[b]	NW
12	South Edge of Switchyard	0.2[b]	E
13	Southeast Site Boundary (Bluff)	0.4[b]	ESE
15	Southeast Site Boundary (Office Building)	0.1[b]	SSE
16	East Southeast Site Boundary	0.4[b]	ESE
19	San Clemente Highlands	4.9	NNW
22	Former US Coast Guard Station - San Mateo Point	2.7	WNW
23	SDG&E Service Center Yard (Control)	8.1	NW
31	Aurora Park - Mission Viejo (Control)	18.6	NNW
33	Camp Talega – (MCB, Camp Pendleton) (Control)	5.9	N
34	San Onofre School – (MCB, Camp Pendleton)	1.9	NW
35	Range 312 – (MCB, Camp Pendleton)	4.8	NNE
36	Range 208C – (MCB, Camp Pendleton)	4.1	NE
38	San Onofre State Beach Park	3.4	SE
40	SCE Training Center - Mesa	0.7	NNW
41	Old Route 101 – East	0.3[b]	E
44	Fallbrook Fire Station (Control)	17.7	E
46	San Onofre State Beach Park	1.0	SE
47	Camp Las Flores – (MCB, Camp Pendleton) (Control)	8.6	SE
49	Camp Chappo – MCB (Control)	12.9	ESE
50	Oceanside Fire Station (Control)	15.6	SE
53	San Diego County Operations Center (Control)	44.2	SE
54	Escondido Fire Station (Control)	31.8	ESE
55	San Onofre State Beach (U1 West)	0.2[b]	WNW
56	San Onofre State Beach (U1 West)	0.2[b]	W

DIRECT RADIATION MEASURING LOCATION		DISTANCE[a] (miles)	DIRECTION[a] (Sector)
57	San Onofre State Beach (Unit 2)	0.1[b]	SW
58	San Onofre State Beach (Unit 3)	0.1[b]	S
59	SONGS Meteorological Tower	0.3[b]	WNW
61	Mesa - East Boundary	0.7	N
62	MCB - Camp Pendleton	0.7	NNE
63	MCB - Camp Pendleton	0.6	NE
64	MCB - Camp Pendleton	0.6	ENE
65	MCB - Camp Pendleton	0.7	E
66	San Onofre State Beach	0.6	ESE
67	Former SONGS Evaporation Pond	0.6	NW
68	Range 210C – (MCB, Camp Pendleton)	4.4	ENE
73	South Yard Facility	0.4[b]	ESE
74	Oceanside City Hall (Backup Control)	15.6	SE
75	Gate 25 MCB	4.6	SE
76	Former El Camino Real Mobil Station	4.6	NW
77	Area 62 Heavy Lift Pad	4.2	N
78	Horno Canyon (AKA Sheep Valley)	4.4	ESE

Table 3 – Airborne Radioactivity Sampling Locations

AIRBORNE SAMPLING LOCATION		DISTANCE[a] (miles)	DIRECTION[a] (Sector)
1	City of San Clemente (City Hall)	5.1	NW
7	AWS Roof	0.18[b]	NW
9	State Beach Park	0.6	ESE
10	Bluff	0.7	WNW
11	Mesa EOF	0.7	NNW
12	Former SONGS Evaporation Pond	0.6	NW
13	Marine Corp Base (Camp Pendleton East)	0.7	E
16	San Luis Rey Substation (Control)	16.7	SE

Table 4 – Soil Sampling Locations

SOIL SAMPLING LOCATION[c]		DISTANCE[a] (miles)	DIRECTION[a] (Sector)
1	Camp San Onofre	2.8	NE
2	Old Route 101 – (East Southeast)	3.0	ESE
3	Basilone Road / I-5 Freeway Off ramp	2.0	NW
5	Former Visitors Center	0.4[b]	NW
7	Prince of Peace Abbey – Oceanside (Control)	15	SE

Table 5 – Ocean Water Radioactivity Sampling Locations

OCEAN WATER SAMPLING LOCATION		DISTANCE[a] (miles)	DIRECTION[a] (Sector)
A	Station Discharge Outfall - Unit 1	0.6	SW
B	Outfall - Unit 2	1.5	SW
C	Outfall - Unit 3	1.2	SSW
D	Newport Beach (Control)	30.0	NW
51	Unit 2 Conduit (not listed in the ODCM)	0.1	SW
52	Unit 3 Conduit (not listed in the ODCM)	0.1	SSW

Table 6 – Drinking Water Radioactivity Sampling Locations

DRINKING WATER SAMPLING LOCATION		DISTANCE[a] (miles)	DIRECTION[a] (Sector)
4	Camp Pendleton Drinking Water Reservoir	2.0	NW
5	Oceanside City Hall (Control)	15.6	SE

Table 7 – Shoreline Sediment Radioactivity Sampling Locations

SHORELINE SEDIMENT SAMPLING LOCATION		DISTANCE[a] (miles)	DIRECTION[a] (Sector)
1	San Onofre State Beach (Southeast)	0.6	SE
2	San Onofre Surfing Beach	0.8	WNW
3	San Onofre State Beach (Southeast)	3.5	SE
4	Newport Beach North End (Control)	29.2	NW

Table 8 – Local Crops Sampling Locations

LOCAL CROPS SAMPLING LOCATION		DISTANCE[a] (miles)	DIRECTION[a] (Sector)
2	Oceanside (Control)	15 to 25	SE to ESE
6	SONGS Garden Mesa EOF	0.7	NNW

Table 9 – Non-Migratory Marine Animal Sampling Locations

MARINE ANIMAL SAMPLING LOCATION		DISTANCE[a] (miles)	DIRECTION[a] (Sector)
A	Unit 1 Outfall	0.9	WSW
B	Units 2/3 Outfall	1.5	SSW
C	Laguna Beach (Control)	20 to 25	WNW to NW

Table 10 – Kelp Sampling Locations

KELP SAMPLING LOCATION[d]		DISTANCE[a] (miles)	DIRECTION[a] (Sector)
A	San Onofre Kelp Bed	1.5	S
B	San Mateo Kelp Bed	3.8	WNW
C	Barn Kelp Bed	6.3	SSE to SE
E	Salt Creek (Control)	11 to 13	WNW to NW

Table 11 – Backup Kelp Sampling Locations

Backup KELP SAMPLING LOCATION[d, e]		DISTANCE[a] (miles)	DIRECTION[a] (Sector)
G	Capistrano Beach Reef (not listed in the ODCM)	8.9 to 9.1	NW
H	San Clemente Pier (not listed in the ODCM)	5.7 to 5.8	NW
I	Wheeler North Artificial Reef (not listed in the ODCM)	5.3	WNW

Table 12 – Ocean Bottom Sediment Sampling Locations

OCEAN BOTTOM SAMPLING LOCATION		DISTANCE[a] (miles)	DIRECTION[a] (Sector)
B	Unit 1 Outfall	0.8	SSW
C	Unit 2 Outfall	1.6	SW
D	Unit 3 Outfall	1.2	SSW
E	Laguna Beach (Control)	20-25	NW
F	SONGS Up-coast	0.9	WSW
51	Unit 2 Conduit (not listed in the ODCM)	0.1	SW
52	Unit 3 Conduit (not listed in the ODCM)	0.1	SSW

NOTES:

a Distance (miles) and Direction (sector) are measured relative to Units 2/3 midpoint as described in the ODCM. Direction determined from degrees true north.

b Distances are within the Units 2/3 SAB/EAB (Site Area Boundary/Exclusion Area Boundary)

c Soil samples are not required by Technical Specifications.

d Kelp samples are not required by Technical Specifications.

e Backup kelp sampling locations are only used if needed. In 2019, a sample was obtained from Wheeler North backup kelp sample location.

MCB = Marine Corps Base (Camp Pendleton)

Table 13 - Sector and Direction Designations

DEGREES TRUE NORTH FROM SONGS 2 AND 3 MIDPOINT			NOMENCLATURE	
Sector Limit	**Center Line**	**Sector Limit**	**22.5^0 Sector**	**Direction**
348.75	0 & 360	11.25	A	N
11.25	22.5	33.75	B	NNE
33.75	45.0	56.25	C	NE
56.25	67.5	78.75	D	ENE
78.75	90.0	101.25	E	E
101.25	112.0	123.75	F	ESE
123.75	135.0	146.25	G	SE
146.25	157.0	168.75	H	SSE
168.75	180.0	191.25	J	S
191.25	202.5	213.75	K	SSW
213.75	225.0	236.25	L	SW
236.25	247.5	258.75	M	WSW
258.75	270.0	281.25	N	W
281.25	292.5	303.75	P	WNW
303.75	315.0	326.25	Q	NW
326.25	337.5	348.75	R	NNW

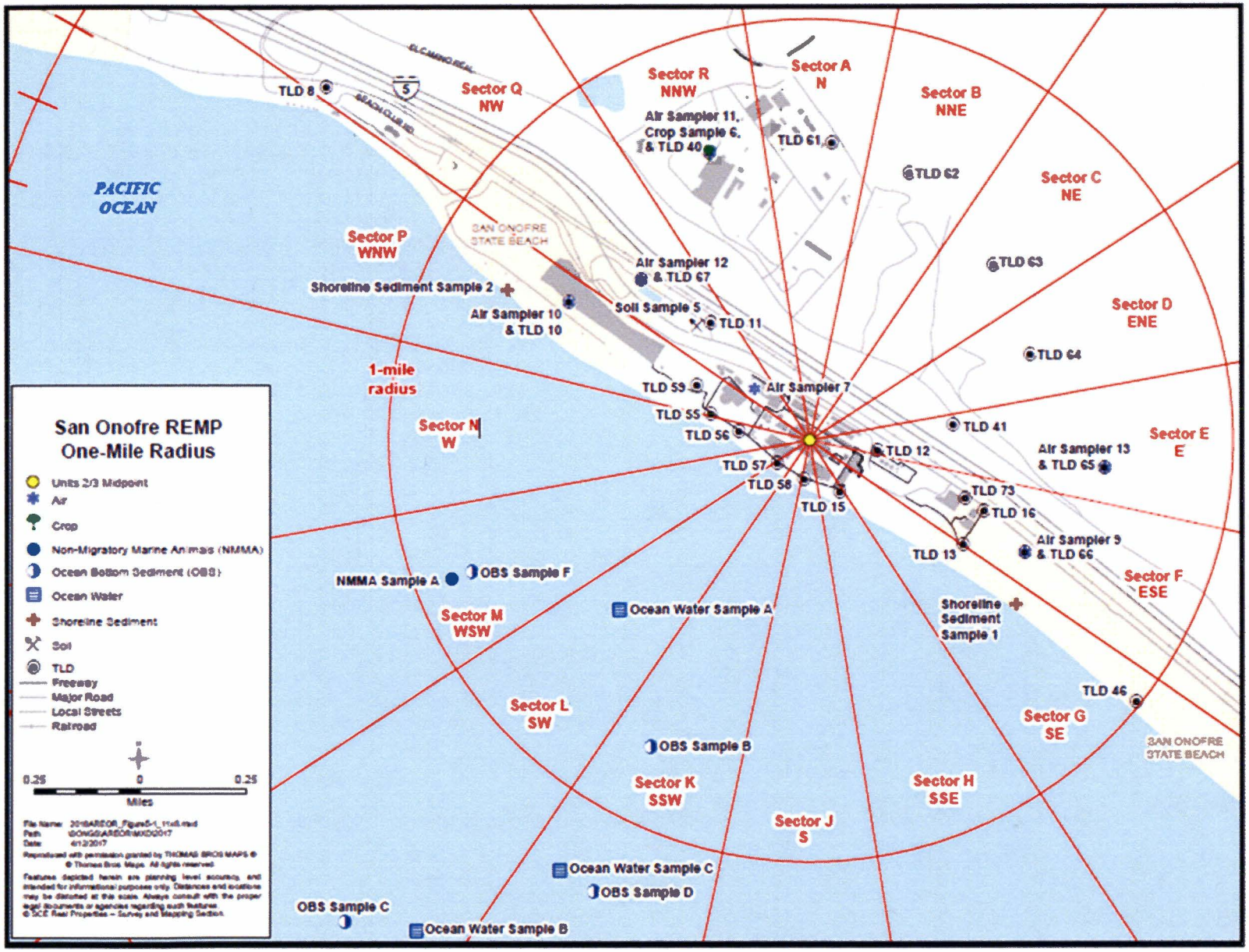


Figure 4 - SONGS REMP One Mile Radius

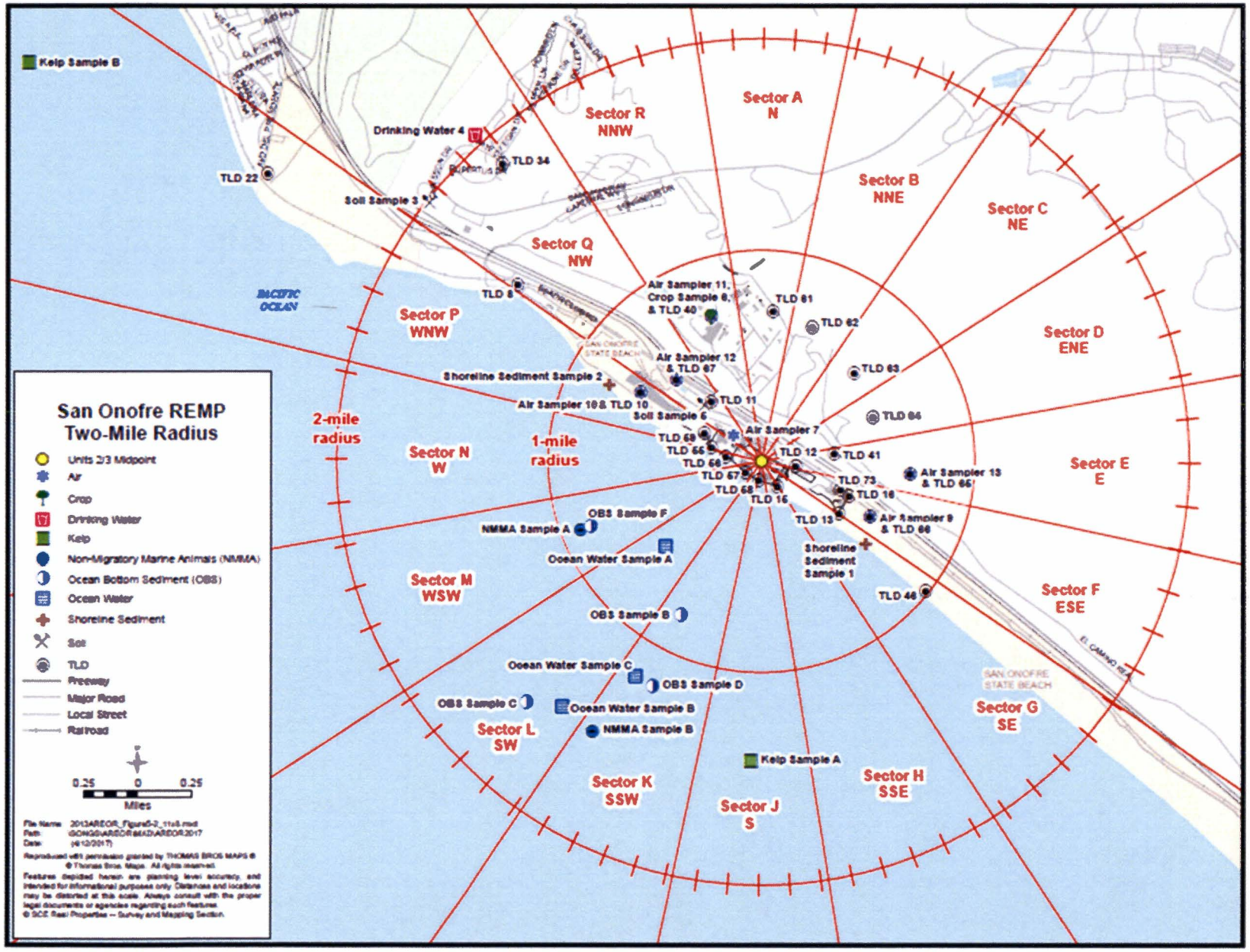


Figure 5 - SONGS REMP Two Mile Radius

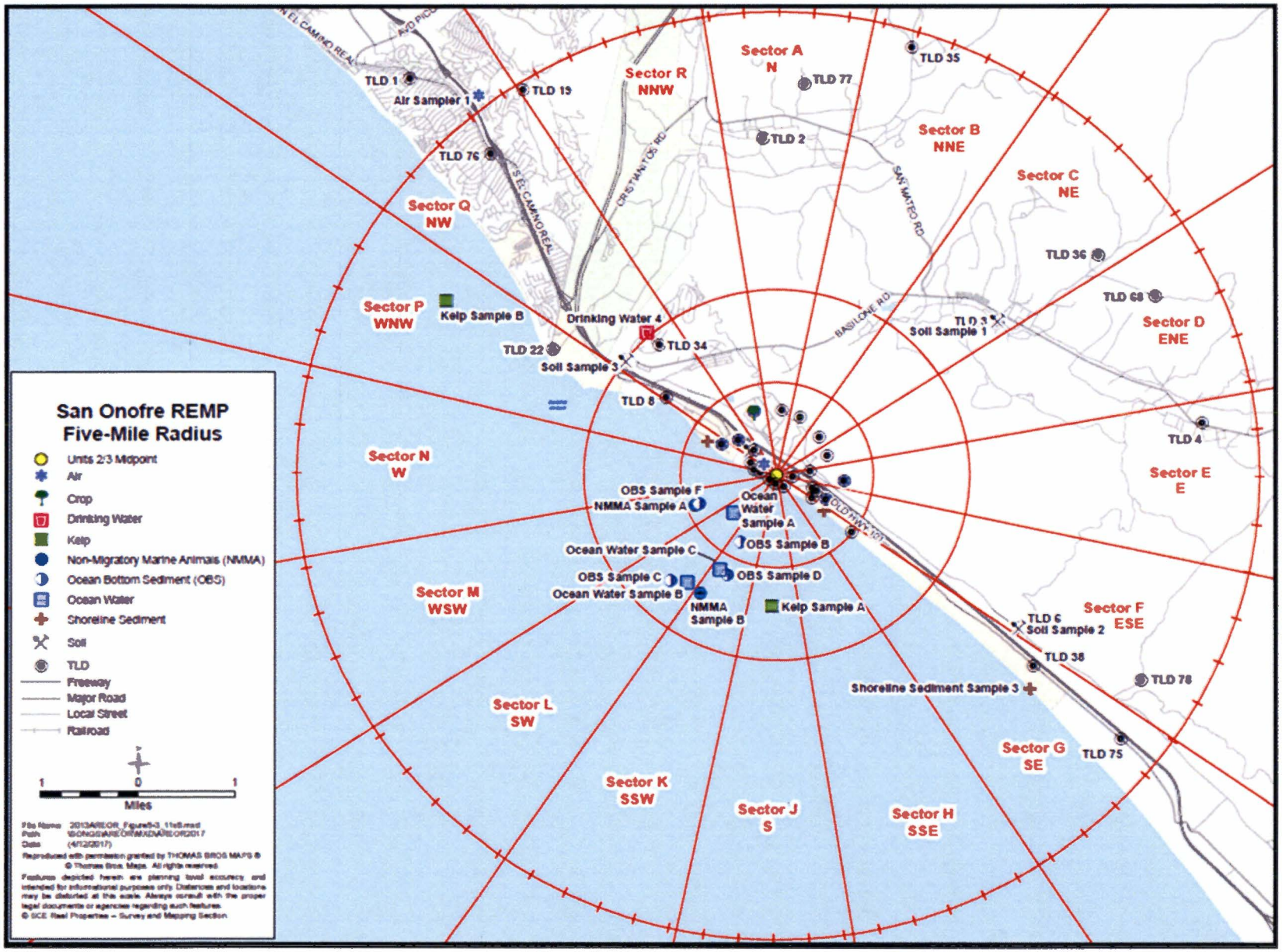


Figure 6 - SONGS REMP Five Mile Radius

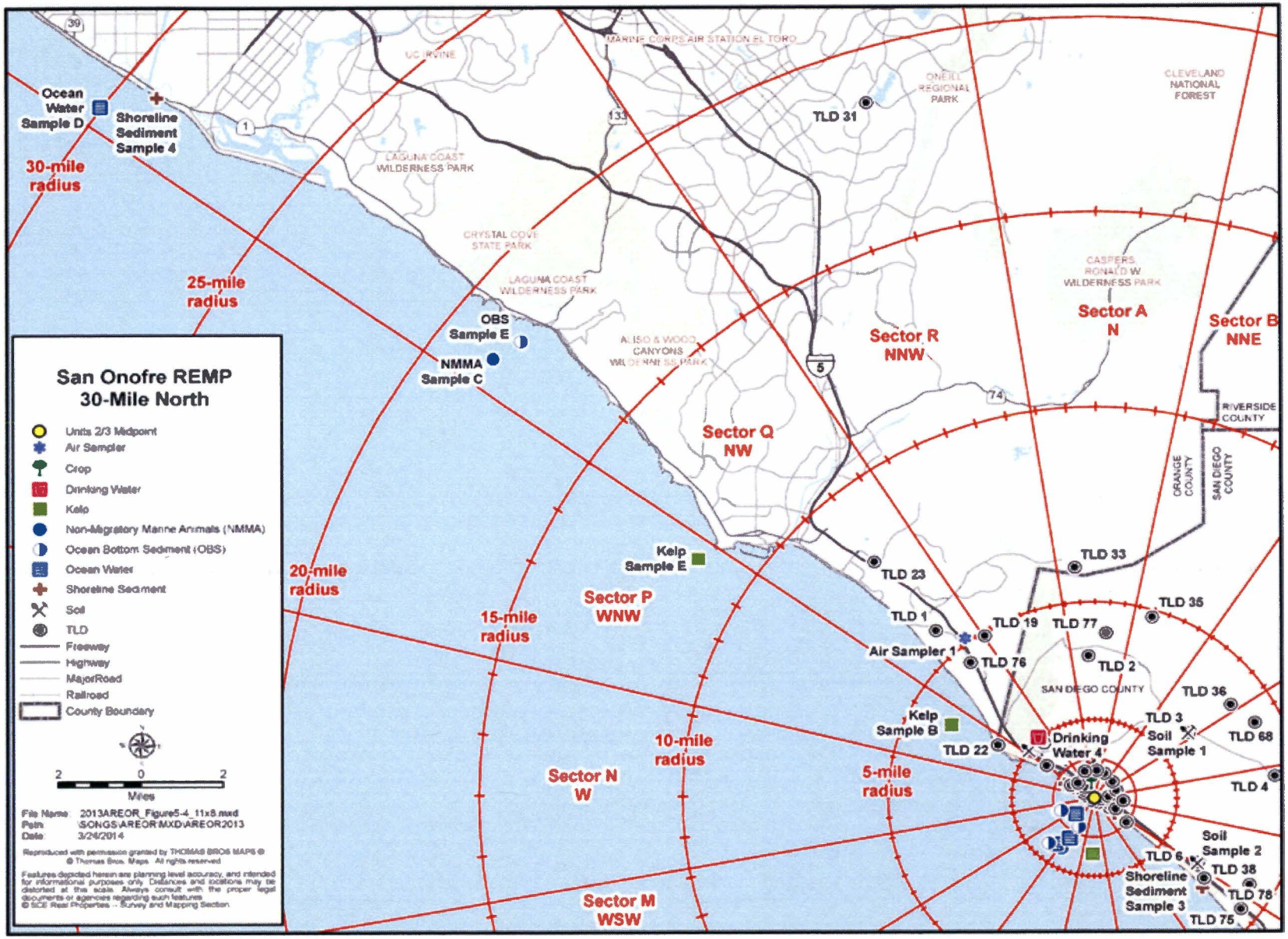


Figure 7 - SONGS REMP 30-mile Radius North

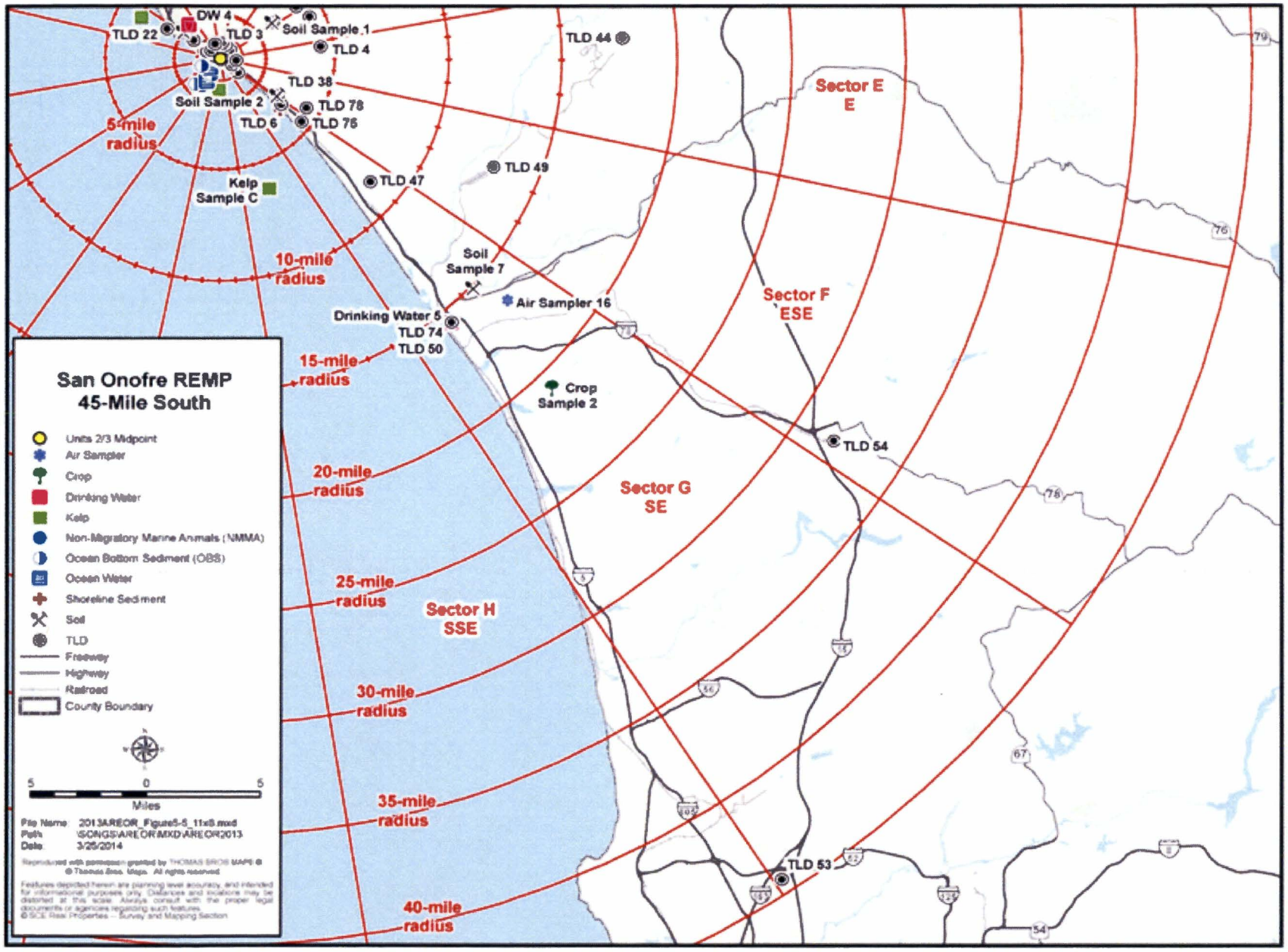


Figure 8 - SONGS REMP 45-mile Radius South

APPENDIX B. RESULTS AND DISCUSSIONS OF 2019 ENVIRONMENTAL DATA

Summary

A summary of the type and number of REMP samples obtained in 2019 appears in Table 14.

The analysis results, as presented below, support the conclusion that all measured levels of radioactivity can be attributable to sources external to SONGS (fallout and ongoing liquid discharges to the Pacific Ocean from the nuclear accident at the Fukushima Daiichi Nuclear Power Station, Chernobyl, residual fallout from legacy atmospheric nuclear weapons testing, and discharge of medically administered I-131 from the San Juan Sewage Plant outfall). Cs-137 has been intermittently detected in the indicator and in the control soil samples in past years and no correlation between Cs-137 level in soil and proximity to the plant has been observed.

Table 14 - REMP Sample Analysis Summary for 2019

Medium	Analysis Type	Sampling Frequency	# of ODCM Locations	Total # of Analyses in 2019[a]
Direct Radiation	Dosimetry	Quarterly	49	195[b]
Airborne Particulates	Gross Beta I-131	Weekly	8 8	416 416
	Gamma	Quarterly	8	32
Ocean Water	Gamma H-3	Monthly	4 4	52[a] 52[a]
	H-3	Quarterly	4	16
Drinking Water, Unfiltered	Gamma, H-3 Gross Beta	Monthly	2 2 2	24 24 24
Shoreline Sediment	Gamma	Semi-Annually	4	8
Ocean Bottom Sediment	Gamma	Semi-Annually	5	14[a]
Marine Species, Flesh	Gamma	Semi-Annually	3	24
Local Crops	Gamma	Semi-Annually	2	8
Kelp	Gamma	Semi-Annually	4	3[c]
Soil	Gamma	Annually	5	5

NOTES:

a. The total number of analyses includes environmental samples that were taken at additional locations to the ODCM required sample point.

b. Environmental dosimeters used for ISFSI monitoring not included in this total. REMP TLD 11 was not available for the second quarter 2019. See Appendix E.

c. The kelp canopy was absent at two locations in April 2019. A kelp sample was taken at an alternate control location (Wheeler North Reef) in April 2019. The Kelp canopy was completely absent at all locations in October 2019. See Appendix E.

Results and Discussions of 2019 Environmental Data

Direct Radiation

Direct gamma radiation is monitored in the environment by calcium sulfate ($CaSO_4$) Thermoluminescent Dosimeters (TLDs) placed at 49 locations and analyzed quarterly per the methodology described in Regulatory Guide 4.13 Revision 2 (based on ANSI/HPS N13.37-2014, "Environmental Dosimetry – Criteria for System Design and Implementation"). The Annual Public Dose, as referenced in Table 15, is based on the potential member of the public exposure at the listed locations. For onsite locations, at or near the EAB/CAB, the occupancy factor is determined per site procedure for Direct Radiation Exposure Controls and Monitoring. The hypothetical maximum associated exposure to a member of the general public, adjusted for occupancy, is less than the minimum detectable dose as calculated using the ANSI method.

The 2019 quarterly dose measurements (accounting for background) at all TLD locations outside the SONGS Exclusion Area Boundary (EAB) were ND (not detectable). The criteria for establishing a detectable dose, in accordance with USNRC Reg. Guide 4.13, is 5 mrem per quarter and 10 mrem per year. Dose measurements less than these values are reported as ND (not detectable). In accordance with ANSI N13.37, the annual facility dose is calculated using the sum of the four quarterly dose measurements and subtracting the annual baseline. Annual dose measurements less than 10 mrem are reported as ND (not detectable). Refer to Table 15 for a summary of all 2019 SONGS REMP TLD data. The data for offsite locations indicate no significant change since 2018.

The 2019 REMP quarterly dose measurements within the EAB were detectable at TLD 13 and at TLD 55. REMP TLD 13, Southeast Site Boundary (Bluff) is within the EAB at the southwest corner of SONGS facility footprint and has been used for radioactive equipment and materials storage for a number of years; TLD location 13 is not readily accessible to the public. REMP TLD 55, (located on the beach walkway between the ISFSI and the ocean), is readily accessible to the general public and had a detectable quarterly dose measurement during the first quarter of 2019. The REMP TLD 55 data includes any detected neutron dose in 2019. In 2019, the measurable doses at REMP TLD 55 are attributable to the operation of the SONGS ISFSI located in the near vicinity.

The annual dose measurements at TLD 13, TLD 55, TLD 56, TLD 59, and TLD 73 were also detectable. The detectable dose measurement at TLD 73 (located close to TLD 13) is also attributable to the storage and transport of radioactive materials at SONGS. The detectable annual dose measurements at TLDs 56 and 59 (located close to 55) are also attributable to the operation of the ISFSI.

Separate TLDs are used to compensate for transit dose and a fade TLD is used to evaluate for the time and temperature dependent "fade" that may affect dosimeter data. After the samples were analyzed, the measured doses were corrected for pre and post field exposure times.

A neutron dosimeter package was co-located with REMP TLD 55 and at selected TLD locations around the ISFSI. Any detected neutron dose was added to the gamma dose to report a total dose for each station with a neutron package. The maximum quarterly neutron dose for the ISFSI TLD locations was 2.2 mrem. This was due to the increased movement and storage of spent fuel that was added to the SONGS ISFSI.

Direct Radiation baseline evaluation and estimation of natural background

An in-depth analysis of the environmental radiation results for the period of 2001 through 2010 was completed for all the REMP TLD monitoring locations. It can be inferred that if the standard deviation was low and no additional exposure above background was identified at a particular station, the average of that station's radiation exposure results should be equal to natural background (baseline) at that location. The baseline results for REMP TLDs have been summarized with the annual and quarterly values in Table 15.

Natural background radiation is variable and a minor shift in location can yield a measurable change in background radiation. Therefore, if a TLD is moved, the baseline (background) for that location may be affected. The natural direct gamma radiation varies according to location because of differences in the natural radioactive materials in the soil, soil moisture content, buildings, and other factors.

The baseline environmental exposure analysis of 2001 through 2010 environmental TLD results included an assessment of the standard deviation of the quarterly results and annual totals at each location. This is an appropriate methodology to determine the ability to detect radiation exposure above background, described in ANSI/HPS N13.37-2014. The quarterly and annual results expressed in Table 15 are positive exposures if they exceed either 5 mrem above the baseline quarterly or 10 mrem above the baseline annually. If not, the measurement is noted as "ND" for "Not Detectable."

In 1980 the Department of Energy (DOE) conducted an Aerial Radiological Survey of SONGS and the surrounding area. The baseline/background value of 15.8 mrem per standard quarter within the SONGS EAB is consistent with the 1980 gamma exposure rates reported by the DOE for the areas immediately north and south of SONGS, taking into account the reduction in environmental radioactivity and background dose rates caused by the decay of atmospheric nuclear weapons testing fallout since 1980.

An empirical determination of the background baseline for stations within the Exclusion Area Boundary (EAB) is not possible due to the known plant related radiological activities (e.g., storage and transport of radioactive materials) that occurred during the baseline calculation study period. The average of nearby proxy locations outside the EAB was used to estimate the baseline within the EAB. A value of 15.8 mrem per quarter was selected as the baseline for the REMP stations located within the EAB.

Table 15 - SONGS REMP TLD Data

TLD (SCE-##)	Location	Distance (miles)	Qtr. Baseline (mrem)	2019 Quarterly Results (mrem)				Baseline Adjusted Quarterly Results (mrem)				Ann. Baseline (mrem)	Annual Total (mrem)	Annual Facility Dose (mrem)	Annual Public Dose (mrem)
				1	2	3	4	1	2	3	4				
1	City of San Clemente	5.7	18.4	19.6	17.4	16.7	19.1	ND	ND	ND	ND	73.6	72.9	ND	ND
2	Camp San Mateo – MCB	3.6	19.6	19.1	18.3	18.3	19.0	ND	ND	ND	ND	78.2	74.7	ND	ND
3	Camp San Onofre – MCB	2.8	17.2	17.8	15.7	15.7	17.2	ND	ND	ND	ND	69.0	66.4	ND	ND
4	Camp Horno – MCB	4.4	19.0	18.3	18.2	16.9	17.9	ND	ND	ND	ND	76.1	71.3	ND	ND
6	Old Route 101 (ESE)	3.0	12.0	11.8	10.6	10.5	11.3	ND	ND	ND	ND	47.9	44.3	ND	ND
8	Noncommissioned Officers' Beach Club	1.4	16.2	15.7	14.5	15.7	15.8	ND	ND	ND	ND	64.8	61.7	ND	ND
10	Bluff	0.7	17.2	18.1	16.6	15.9	16.3	ND	ND	ND	ND	69.0	66.9	ND	ND
19	San Clemente Highlands	4.9	18.7	19.7	17.3	18.7	19.8	ND	ND	ND	ND	74.8	75.6	ND	ND
22	Former US Coast Guard Station	2.7	18.8	18.8	17.7	18.6	19.2	ND	N/A	ND	ND	75.3	74.3	N/A	N/A
23	SDG&E Service Center Yard (Control)	8.1	16.6	16.7	15.2	15.6	15.8	ND	ND	ND	ND	66.4	63.3	ND	ND
31	Aurora Park - Mission Viejo (Control)	18.6	19.4	19.8	18.9	19.7	20.3	ND	ND	ND	ND	77.8	78.6	ND	ND
33	Camp Talega – MCB (Control)	5.9	19.9	18.9	19.0	18.2	19.2	ND	ND	ND	ND	79.5	75.3	ND	ND
34	San Onofre School – MCB	1.9	17.0	17.8	16.5	14.9	17.7	ND	ND	ND	ND	68.1	66.9	ND	ND
35	Range 312 – MCB	4.8	17.8	16.4	15.5	14.8	15.9	ND	ND	ND	ND	71.1	62.6	ND	ND
36	Range 208C – MCB	4.1	20.5	19.5	19.3	19.0	20.4	ND	ND	ND	ND	82.0	78.2	ND	ND
38	San Onofre State Beach Park	3.4	15.0	14.1	12.9	13.3	14.0	ND	ND	ND	ND	60.1	54.2	ND	ND
40	SCE Training Center – Mesa	0.7	18.0	19.3	17.4	17.3	17.8	ND	ND	ND	ND	71.9	71.8	ND	ND
44	Fallbrook Fire Station (Control)	17.7	14.7	16.0	15.7	14.1	15.9	ND	ND	ND	ND	58.9	61.7	ND	ND
46	San Onofre State Beach Park	1.0	12.8	15.0	12.1	13.0	14.3	ND	ND	ND	ND	51.3	54.4	ND	ND
47	Camp Las Flores – MCB (Control)	8.6	14.0	17.5	14.2	15.2	16.2	ND	ND	ND	ND	55.9	63.1	ND	ND
49	Camp Chappo – MCB (Control)	12.9	14.9	16.8	14.2	15.5	16.0	ND	ND	ND	ND	59.7	62.5	ND	ND
50	Oceanside Fire Station (Control)	15.6	17.4	19.3	17.1	15.7	17.7	ND	ND	ND	ND	69.8	69.8	ND	ND
53	San Diego County Operations Center (Control)	44.2	19.1	20.8	19.8	18.3	20.3	ND	ND	ND	ND	76.5	79.2	ND	ND
54	Escondido Fire Station (Control)	31.8	16.9	17.7	18.2	17.2	19.0	ND	ND	ND	ND	67.7	72.1	ND	ND
61	Mesa - East Boundary	0.7	16.2	15.5	15.6	15.7	15.6	ND	ND	ND	ND	64.8	62.3	ND	ND
62	Camp Pendleton	0.7	13.9	13.6	12.8	13.5	12.7	ND	ND	ND	ND	55.5	52.5	ND	ND
63	Camp Pendleton	0.6	14.6	14.4	14.1	14.5	14.4	ND	ND	ND	ND	58.4	57.4	ND	ND
64	Camp Pendleton	0.6	15.8	16.3	15.3	15.7	15.2	ND	ND	ND	ND	63.1	62.6	ND	ND

TLD (SCE-##)	Location	Distance (miles)	Qtr. Baseline (mrem)	2019 Quarterly Results (mrem)				Baseline Adjusted Quarterly Results (mrem)				Ann. Baseline (mrem)	Annual Total (mrem)	Annual Facility Dose (mrem)	Annual Public[e] Dose (mrem)
				1	2	3	4	1	2	3	4				
65	Camp Pendleton	0.7	14.1	14.4	13.4	13.3	13.2	ND	ND	ND	ND	56.3	54.3	ND	ND
66	San Onofre State Beach	0.6	14.7	14.8	14.6	15.1	13.5	ND	ND	ND	ND	58.9	58.0	ND	ND
67	Former SONGS Evaporation Pond	0.6	17.8	17.4	17.6	18.4	17.2	ND	ND	ND	ND	71.1	70.7	ND	ND
68	Range 210C – MCB	4.4	15.8	16.8	15.7	16.1	15.6	ND	ND	ND	ND	63.1	64.2	ND	ND
74	Oceanside City Hall (Backup Control)	15.6	14.0	15.0	13.6	13.8	14.5	ND	ND	ND	ND	55.9	57.0	ND	ND
75	Gate 25 MCB	4.6	16.7	16.0	15.4	16.8	16.9	ND	ND	ND	ND	66.9	65.0	ND	ND
76	El Camino Real Mobil Station	4.6	18.2	19.2	19.3	17.7	18.8	ND	ND	ND	ND	72.7	75.0	ND	ND
77	Area 62 Heavy Lift Pad	4.2	20.2	18.6	18.6	19.4	19.1	ND	ND	ND	ND	80.7	75.7	ND	ND
78	Horno Canyon	4.4	11.7	11.9	11.7	12.4	11.9	ND	ND	ND	ND	46.7	47.9	ND	ND
11[b]	Former Visitors' Center[a]	0.4*	15.8	16.8	N/A	16.8	16.4	ND	N/A	ND	ND	63.1	N/A	N/A	N/A
12	South Edge of Switchyard[a]	0.2*	15.8	19.2	17.1	17.7	17.5	ND	ND	ND	ND	63.1	71.5	ND	ND
13	Southeast Site Boundary (Bluff)[a]	0.4*	15.8	23.7	21.7	21.5	22.8	7.9	5.9	5.7	7.0	63.1	89.7	26.6	ND
15[c]	Southeast Site Boundary (Office Bldg)[a]	0.1*	15.8	18.8	16.7	17.1	17.6	ND	ND	ND	ND	63.1	70.1	ND	ND
16	East Southeast Site Boundary[a]	0.4*	15.8	17.6	16.5	15.8	16.7	ND	ND	ND	ND	63.1	66.5	ND	ND
41	Old Route 101 – East[a]	0.3*	15.8	16.9	15.3	15.5	15.9	ND	ND	ND	ND	63.1	63.6	ND	ND
55	San Onofre State Beach (U1 West)[a, d]	0.2*	15.8	21.5	19.5	19.9	20.4	5.7	ND	ND	ND	63.1	81.3	18.2	ND
56	San Onofre State Beach (U1 West)[a]	0.2*	15.8	19.7	18.6	18.3	19.2	ND	ND	ND	ND	63.1	75.8	12.7	ND
57	San Onofre State Beach (Unit 2)[a]	0.1*	15.8	18.0	16.8	17.8	17.8	ND	ND	ND	ND	63.1	70.5	ND	ND
58	San Onofre State Beach (Unit 3)[a]	0.1*	15.8	18.0	17.3	17.6	18.1	ND	ND	ND	ND	63.1	71.0	ND	ND
59	SONGS Meteorological Tower[a]	0.3*	15.8	20.6	19.7	20.2	19.9	ND	ND	ND	ND	63.1	80.4	17.3	ND
73	South Yard Facility[a]	0.4*	15.8	19.5	18.6	18.1	18.2	ND	ND	ND	ND	63.1	74.5	11.5	ND

* Indicates that the station is within the EAB (Exclusion Area Boundary). The baseline has been estimated to be 15.8 mrem per standard 91-day quarter within the EAB.

a Indicates on site location. The dose to members of the public is based on a default non-office area annual occupancy time of 300 hours per year.

b SCE-11 TLD was lost during second quarter. Since empirical TLD data is only available for three quarters, the annual dose for TLD 11 is not available. However, based on the quarters data from quarters that were available, the annual dose at TLD 11 appears to be consistent with prior years, with no dose to members of the general public.

c TLD 15 was moved during the second quarter of 2018 to avoid construction damage.

d A neutron TLD package was collocated at location 55 during each quarter. The estimated neutron dose was added to the gamma dose in 2019.

e Adjusted for occupancy in accordance with Radiation Monitoring and Exposure Controls procedure.

Quality Control Duplicate Direct Radiation Samples

Duplicate Quality Control (QC) TLDs were installed adjacent to TLD 66 and TLD 67. The duplicate TLDs agreed closely with the indicator TLDs, see Appendix C for results. These TLDs were not required by the ODCM and are not included in the Statistical Summary of REMP Data.

ISFSI Direct Radiation Samples

Independent Spent Fuel Storage Installation (ISFSI) TLDs were placed in the vicinity of the ISFSI. Data from these TLDs have not been included in the statistical summary of REMP data because they are not included in the ODCM. The ISFSI data are listed and discussed in Appendix I.

Airborne Particulate, Iodine, and Composite Isotopic Analyses

Air particulate samples were collected on a weekly basis from seven indicator locations and from one control location. The samples were analyzed for gross beta activity, I-131, and composited quarterly for gamma isotopic analysis. Sample locations were selected according to the requirements of the ODCM.

Gross beta analysis is a measure of total radioactivity of beta-emitting radionuclides in a sample. Beta radiation is emitted by many radionuclides. Gross beta measurements are used to identify samples with elevated levels of radioactivity for further analysis. The gross beta analysis does not identify specific radionuclides.

All weekly gross beta activity analysis results were above the MDC. The concentration of gross beta activity in the samples collected from the indicator locations ranged from 0.010 pCi/m^3 to 0.111 pCi/m^3, averaging 0.029 pCi/m^3 of air. The concentrations of gross beta activity in the samples from the control location ranged from 0.015 to 0.141 pCi/m^3, averaging 0.036 pCi/m^3 of air. There is seasonal variability to the gross beta results for air samplers, and the results in 2019 are not significantly different from what has been seen in previous years. The seasonal variability is evident in both control and indicator locations and shows that this is attributable to a factor external to SONGS.

Per the requirements of the ODCM, Section 5, Table 5-1, an assessment was performed to determine whether the gross beta activity of the indicators exceeded 10 times the background (control location #16). The results showed that the indicator location maximum gross beta activity in air in 2019 was 0.111 pCi/m^3 which is less than 10 times the average background measured at the control location (0.036 pCi/m^3). No further action is required by the ODCM.

Indicator samples analyzed for I-131 were all identified below the MDC. No action was required by the ODCM.

No SONGS related radionuclides were detected in any of the quarterly air particulate composite samples.

Ocean Water

Monthly ocean water samples were collected from three indicator locations near each station discharge and from the control location at Newport Beach. Two additional locations were sampled semiannually near the outfall conduit at Unit 2 and Unit 3. The samples were analyzed for naturally occurring and SONGS related gamma-emitting radionuclides, including tritium. Quarterly composite ocean water samples were analyzed for tritium according to ODCM requirements.

Throughout 2019, only naturally occurring radionuclides were detected in the monthly gamma spectral analyses of ocean water. Monthly ocean water samples were also analyzed for tritium, consistent with the State of California Department of Public Health (CDPH) split sample program. During 2019, all the SONGS REMP and the duplicate CPDH tritium in ocean water sample results were less than detectable.

The data indicate that SONGS had no measurable impact on the environment as measured by ocean water.

Drinking Water

In 2019, monthly drinking water samples were collected from one indicator location and from the Oceanside control location. Samples were analyzed for tritium, gross beta, naturally occurring and SONGS related gamma emitting radionuclides. There is no drinking water pathway for liquid effluent at SONGS.

No station related radionuclides were detected in drinking water outside of SONGS during 2019. Gross beta activity was identified in some samples, but gamma spectroscopy identified only natural radionuclides. SONGS had no impact on the environment as measured by drinking water.

Shoreline Sediment (Beach Sand)

Beach sand was collected semiannually in 2019 from three indicator locations and from a control location situated in Newport Beach. After collection, the samples were analyzed for plant related and naturally occurring radionuclides. Only naturally occurring radionuclides were detected in all samples. No plant related radionuclides were reported above the MDC. SONGS had no impact on the environment as measured in beach sand.

Ocean Bottom Sediments

Ocean bottom sediments were collected from three indicator locations and the Laguna Beach control location. The samples were analyzed by gamma spectral analysis for naturally occurring and station related radionuclides. Only naturally occurring radionuclides were detected in ocean bottom sediment samples collected during 2019.

Four non-ODCM ocean bottom sediment samples were obtained from two locations, Unit 2 outfall conduit and Unit 3 outfall conduit. The conduit samples were collected to measure the radiological environmental effect potentially resulting from the minor conduit leakage. During 2019, all conduit sample analysis results were below the MDC for station related radionuclides. SONGS had no impact on the environment as measured by ocean bottom sediments.

Marine Species (Flesh)

Species of adult fish, crustacean and mollusks were collected on a semi-annual basis at the SONGS Unit 1 outfall, the SONGS Units 2/3 outfall and from Laguna Beach control location. The edible portion of each sample type was analyzed for gamma-emitting station related and naturally occurring radionuclides. The results were subsequently reported to SONGS in terms of wet sample weights. Because results based on a wet sample weight are most useful for calculating doses, the results of sample analyses are summarized in terms of "as received" wet weights. Cs-137 was detected above the MDC and below the LLD in one indicator Sheephead sample in 2019. The reported result (0.0150 +/- 0.0117) pCi/g had a count specific MDC of 0.0098 pCi/g and a method specific LLD of 0.150 pCi/g. This sample was split with the California Department of Public Health (CDPH). The Cs-137 result (greater than the MDC but less than the LLD) is consistent with results from other marine species samples collected at other west coast locations. Publicly available research from scientific organizations indicates that the presence of Cs-137 in Pacific Ocean sea creatures is attributable to the legacy radioactive discharges from Fukushima, Japan. Naturally occurring radionuclides, such as K-40, were also detected in marine species samples collected during 2019. (Refer to Table 30 for comparison results.) SONGS had no significant impact on the environment as measured by this sample medium.

Local Crops

Fleshy and leafy crops were collected semiannually in 2019 from the SONGS garden and from the control location 21 miles SE from SONGS Units 2/3 midpoint. Tomato, cabbage, lettuce, sorrel and squash were sampled in 2019, and only naturally occurring radionuclides were identified. No plant related radioactivity was detected. It is concluded that in 2019 SONGS had no measurable impact on local crops.

Soil

To determine if there is evidence of a build-up of radionuclides in the land near SONGS, indicator soil samples were collected from Camp San Onofre, Old Route 101, Basilone Road and the East Site Boundary (Former Visitors Center). A control sample was obtained from Prince of Peace Abbey in Oceanside. Surface soil was collected from all indicator and control locations at the depth of 3 inches. The sampling protocol is consistent with the procedure described in HASL-300. Soil sampling is not required by the ODCM.

Soil samples were analyzed for naturally occurring and SONGS related gamma-emitting radionuclides using gamma spectral analysis. The 2019 soil samples showed measurable levels of naturally occurring radionuclides. Cs-137 was detected in one indicator sample (0.068 pCi/g) and the control sample (0.079 pCi/g). Cs-137 in soil samples at these levels is attributable to factors external to SONGS (e.g., residual nuclear weapons testing fallout and the Chernobyl accident).

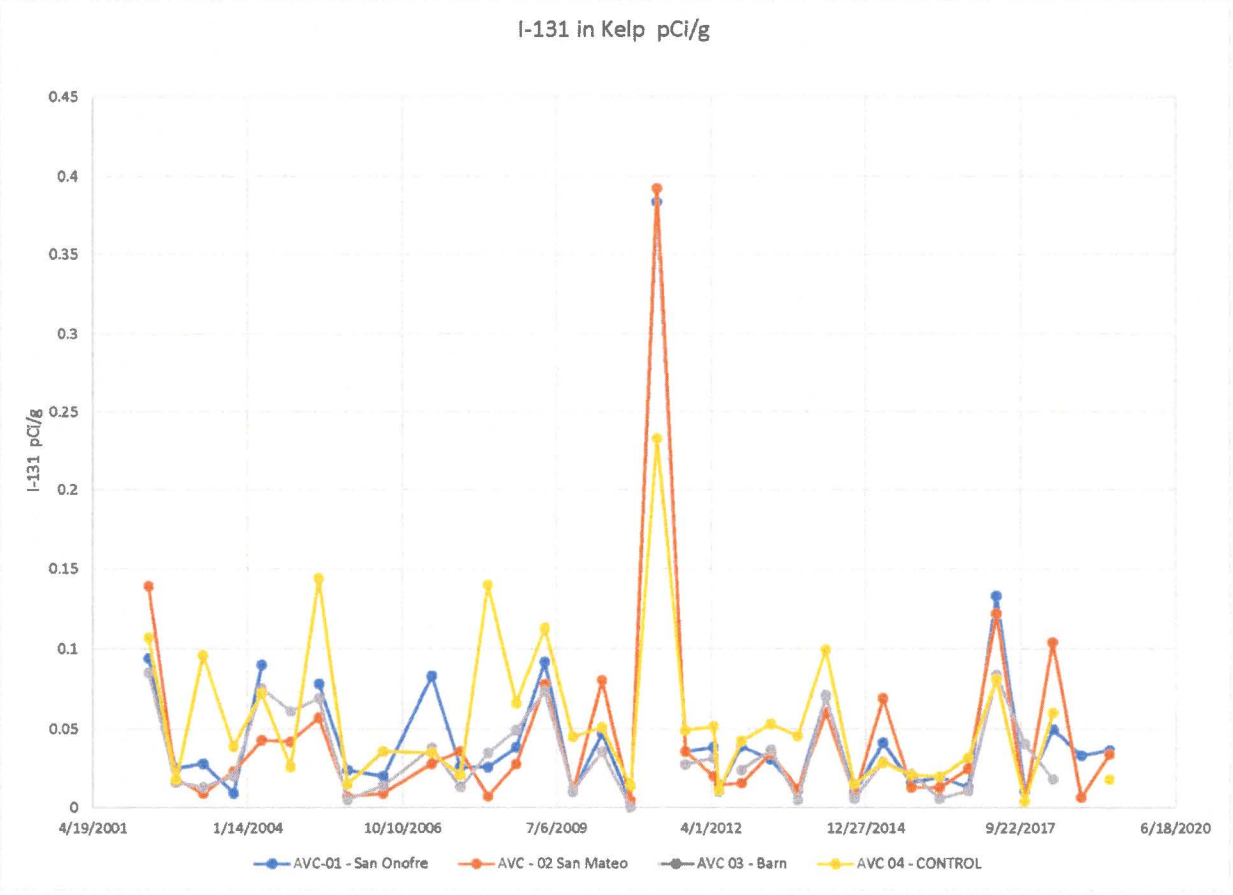
Cs-137 and strontium-90 (Sr-90) were detected in soil profile analyses conducted in previous years. These radionuclides are attributable to the nuclear weapons testing fallout depositing on soil and retention of these radionuclides due to their long half-lives. The presence of Cs-137 in the indicator and in the control locations at similar levels supports the conclusion that the source of this radionuclide to a factor external to SONGS (fallout deposition). During 2019, SONGS did not have a detectable effect on the environment as measured by soil samples.

Kelp

Kelp was collected at three locations in April 2019 (the San Onofre kelp bed, San Mateo kelp bed, and the Wheeler North alternate control kelp bed). The samples were analyzed by gamma-spectral analysis for naturally occurring and station related radionuclides. Naturally occurring K-40 was detected in all three kelp samples collected in 2019. Iodine-131 (half-life of 8 days) was not detected in any kelp sample collected during 2019. Kelp was not available in October 2019because no kelp canopy was present at any of the locations in October 2019.SONGS is permanently shut down and the nuclear fuel is not in the reactor vessel. Therefore, Iodine-131 is not being generated at SONGS. The iodine-131 detected in kelp in previous years is attributable to sewage plant discharges of medically administered iodine-131.

I-131 has been detected at indicator and control locations in previous years. I-131 data in ocean water samples near SONGS have been consistently indistinguishable radiologically from background. The northern control locations are too far away and in the predominantly upstream current direction for the I-131 activity to be attributable to SONGS. The Salt Creek control kelp sample station near the San Juan Sewage Plant outfall has consistently yielded the highest I-131 activity measured in kelp and has consistently yielded I-131 above radiological background. Figure 9 shows a relatively close correlation between indicator and control locations over an extended period, further supporting the assessment that the likely source for this radionuclide is external to SONGS. (Note: Figure 9 includes all I-131 results, including those that are below the MDC.)

Figure 9 - I-131 in Aquatic Kelp



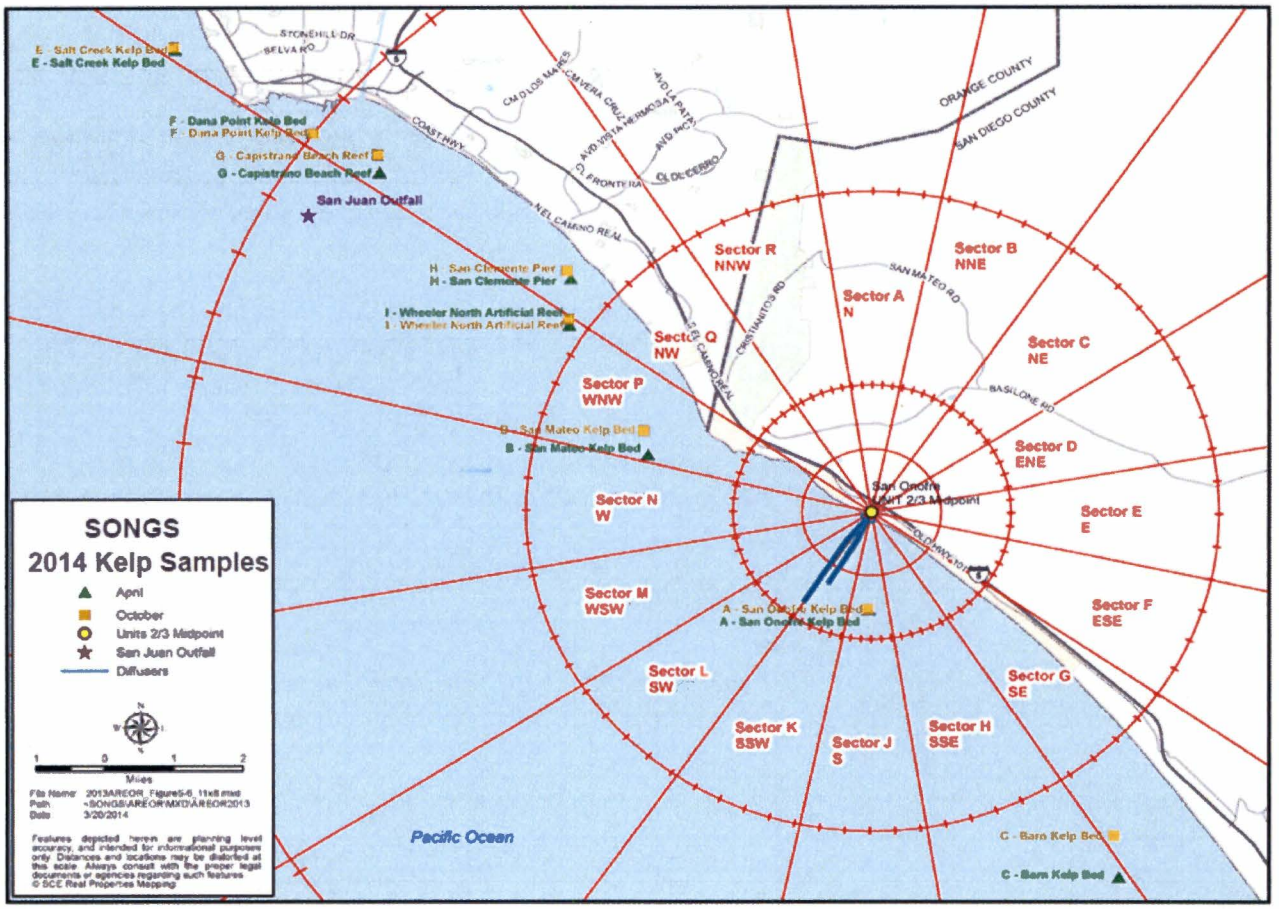


Figure 10 - Kelp Sampling Locations

Refer to Figure 10 for the relative location of the kelp beds, the San Juan Sewage Plant outfall, and the SONGS outfalls. The data strongly support the conclusion that the I-131 detected in kelp is attributable to medically administered I-131 discharged through the San Juan Sewage Plant outfall and not to SONGS.

Correlation of Effluent Concentration to Concentrations in the Environment

In accordance with 10 CFR 50 Appendix I, Section IV, B.2, data on measurable levels of radiation and radioactive materials in the environment have been evaluated to determine the relationship between quantities of radioactive material released in effluents and resultant radiation doses to individuals from principal pathways of exposure.

REMP samples, both terrestrial and marine, indicated no accumulation of plant related radioactivity in the environs. Samples with detectable activity were not statistically different from control samples. Plant related radionuclides detected during 2019 were attributed to sources external to SONGS (past nuclear weapons fallout, Chernobyl, Fukushima, and medical iodine releases in sewage). The regulatory requirement to evaluate the relationship between quantities of radioactive materials released in effluents and the resultant radiation doses to individuals may be summarized by the following conclusion:

Effluent program releases are evaluated annually to determine the receptor(s) with the highest hypothetical dose. The 2019 REMP sample data indicated no accumulation of plant related radioactive materials in the offsite environment, thereby lending confirmation to the adequacy of the in-plant effluent controls program and dose assessments.

Statistical Summary of REMP Data for 2019

For the tables below, the numbers in parentheses next to the mean value indicate number of samples with positive results compared to the total number of samples. The smaller font numbers in parentheses indicate the range of results.

Table 16 – Weekly Airborne Particulates Gross Beta

Pathway (Measurement Unit)	Type and Number of Analysis Performed	Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
				Name, Distance and Direction	Mean (Range)		
Air Filter Inhalation (pCi/m³)	Gross Beta 416	0.01	0.029 (364/364) (0.010 – 0.111)	San Luis Rey Substation 16.7 Mi. SE	0.036 (52/52) (0.015 – 0.141)	0.036 (52/52) (0.015 – 0.141)	0

Table 17 – Weekly Radioiodine I-131 Activity

Pathway [a] (Measurement Unit)	Type and Number of Analysis Performed	Lower Limit of Detection (LLD) [b]	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
				Name, Distance and Direction	Mean (Range)		
Activated Charcoal Inhalation (pCi/m³)	I-131 416	0.07	< MDC[c]	All locations	< MDC	< MDC (0/52)	0

NOTES:

a This table summarizes the weekly air iodine-131 cartridge data above the MDC. Iodine-131 has an 8-day half-life. With reactor shutdown, it is no longer a radionuclide attributable to SONGS.

b LLD is the a priori limit as prescribed by the ODCM.

c The Term <MDC as used means that results had no detectable activity above the minimum detectable.

Table 18 – Quarterly Composite Airborne Particulate Gamma Activity

Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Air Filter Inhalation (pCi/m^3)	Be-7[a]	32	N/A	0.118 (28/28) (0.066 – 0.192)	San Luis Rey Substation 16.7 Mi. SE	0.129 (4/4) (0.100 – 0.192)	0.129 (4/4) (0.100 – 0.192)	0
	Cs-134	32	0.05	< MDC	< MDC	< MDC	< MDC	0
	Cs-137	32	0.06	< MDC	< MDC	< MDC	< MDC	0

NOTES:

a As expected natural occurring Be-7 was detected in all quarterly composite air particulate samples. Other naturally occurring radionuclides (such as K-40 and Th-234) were observed in some 2019 quarterly composite air samples.

Table 19 - Monthly Ocean Water Activity

Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Ocean Water (pCi/L)	K-40[a]	52	N/A	348 (40/40) (301 – 397)	Conduit Unit 2 0.2 Mi. SSW	367 (2/2) (348 – 385)	343 (12/12) (293 – 390)	4
	Ba-140	52	15	< MDC	< MDC	< MDC	< MDC	4
	Cs-134	52	15	< MDC	< MDC	< MDC	< MDC	4
	Cs-137	52	18	< MDC	< MDC	< MDC	< MDC	4
	Co-58	52	15	< MDC	< MDC	< MDC	< MDC	4
	Co-60	52	15	< MDC	< MDC	< MDC	< MDC	4
	I-131	52	15	< MDC	< MDC	< MDC	< MDC	4
	Fe-59	52	30	< MDC	< MDC	< MDC	< MDC	4
	La-140	52	15	< MDC	< MDC	< MDC	< MDC	4
	Mn-54	52	15	< MDC	< MDC	< MDC	< MDC	4
	Nb-95	52	15	< MDC	< MDC	< MDC	< MDC	4
	Tritium	52	2000	< MDC	< MDC	< MDC	< MDC	4
	Zn-65	52	30	< MDC	< MDC	< MDC	< MDC	4
	Zr-95	52	15	< MDC	< MDC	< MDC	< MDC	4

NOTES:

a Natural occurring K-40 was observed in all 2019 ocean water samples.

Table 20 - Quarterly Ocean Water Tritium

Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Ocean Water (pCi/L)	Tritium	16	2000	< MDC	< MDC	< MDC	< MDC	0

Table 21 – Monthly Drinking Water Activity

Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Drinking Water (pCi/L)	Gross Beta	24	4	2.63 (1/12) (2.63 – 2.63)	Oceanside City Hall 15.6 Mi. SE	4.19 (6/12) (3.25 – 5.34)	4.19 (6/12) (3.25 – 5.34)	0
	Ba-140	24	15	< MDC	< MDC	< MDC	< MDC	0
	Cs-134	24	15	< MDC	< MDC	< MDC	< MDC	0
	Cs-137	24	18	< MDC	< MDC	< MDC	< MDC	0
	Co-58	24	15	< MDC	< MDC	< MDC	< MDC	0
	Co-60	24	15	< MDC	< MDC	< MDC	< MDC	0
	I-131	24	15	< MDC	< MDC	< MDC	< MDC	0
	Fe-59	24	30	< MDC	< MDC	< MDC	< MDC	0
	La-140	24	15	< MDC	< MDC	< MDC	< MDC	0
	Mn-54	24	15	< MDC	< MDC	< MDC	< MDC	0
	Nb-95	24	15	< MDC	< MDC	< MDC	< MDC	0
	Tritium	24	2000	< MDC	< MDC	< MDC	< MDC	0
	Zn-65	24	30	< MDC	< MDC	< MDC	< MDC	0
	Zr-95	24	15	< MDC	< MDC	< MDC	< MDC	0

Table 22 – Semi-annual Shoreline Sediment Gamma Activity (pCi/g)

Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Beach Sand Direct Exposure (pCi/g)	K-40[a]	8	N/A	14.3 (6/6) (8.5 – 20.8)	Newport Beach 29.2 Mi NW	23.6 (2/2) (23.5 – 23.8)	23.6 (2/2) (23.5 – 23.8)	0
	Cs-134	8	0.150	< MDC	< MDC	< MDC	< MDC	0
	Cs-137	8	0.180	< MDC	< MDC	< MDC	< MDC	0

NOTES:
a Natural occurring radionuclides such as K-40 were detected in the 2019 shoreline sediment samples.

Table 23 – Semi-annual Ocean Bottom Sediment Gamma Activity (pCi/g)

Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Waterborne Ocean Bottom Sediment (pCi/g)	K-40[a]	14	N/A	18.5 (12/12) (15.4 – 22.3)	Laguna Beach 20 - 25 Mi NW	22.3 (2/2) (20.3 – 24.2)	22.3 (2/2) (20.3 – 24.2)	4
	Cs-134	14	0.150	< MDC	< MDC	< MDC	< MDC	4
	Cs-137	14	0.180	< MDC	< MDC	< MDC	< MDC	4

NOTES:
a Natural occurring radionuclides such as K-40 were detected in the 2019 ocean bottom sediment samples.

Table 24 – Semi-annual Marine Animal Gamma Activity (pCi/g)

Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Non-Migratory Marine Animals (pCi/g)	K-40[a]		N/A	3.24 (16/16) (1.83 – 4.04)	Unit 1 Outfall 0.9 Mi. WSW	3.25 (8/8) (1.88 – 4.04)	2.87 (8/8) (0.887 – 3.94)	0
	Cs-134	24	0.130	< MDC	< MDC	< MDC	< MDC	0
	Cs-137[b]	24	0.150	0.0069 (16/16) (-0.0017 – 0.0150)	Laguna Beach 20 - 25 Mi NW	0.0099 (8/8) (0.0005 – 0.0204)	0.0099 (8/8) (0.0005 – 0.0204)	0
	Co-58	24	0.130	< MDC	< MDC	< MDC	< MDC	0
	Co-60	24	0.130	< MDC	< MDC	< MDC	< MDC	0
	Fe-59	24	0.260	< MDC	< MDC	< MDC	< MDC	0
	Mn-54	24	0.130	< MDC	< MDC	< MDC	< MDC	0
	Zn-65	24	0.260	< MDC	< MDC	< MDC	< MDC	0

NOTES:

a Natural occurring radionuclides (K-40 and others) were detected in the 2019 non-migratory marine animal samples.

b Cs-137 data includes all data for 2019, including values less than the MDC, for the non-migratory marine animals.

Table 25 – Semi-annual Local Crops Gamma Activity (pCi/g)

Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Local Crops ingestion (pCi/g)	K-40[a]	9	N/A	4.89 (4/4) (2.41 – 7.87)	SONGS Garden 0.7 Mi. NNW	4.89 (4/4) (2.41 – 7.87)	2.55 (4/4) (2.26 – 2.78)	0
	Cs-134	9	0.06	< MDC	< MDC	< MDC	< MDC	0
	Cs-137	9	0.08	< MDC	< MDC	< MDC	< MDC	0
	I-131	9	0.06	< MDC	< MDC	< MDC	< MDC	0

NOTES:

a Natural occurring radionuclides (K-40 and others) were observed in the 2019 local crop samples.

Table 26 –Annual Soil Gamma Activity, 3" Depth (pCi/g)

Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Soil Direct Exposure (pCi/g)	K-40[a]	5	N/A	15.5 (4/4) (6.9 – 22.2)	Camp San Onofre 2.8 Mi. NE	22.2 (1/1) (22.2 – 22.2)	2.64 (1/1) (2.64 – 2.64)	0
	Cs-134	5	0.150	< MDC	< MDC	< MDC	< MDC	0
	Cs-137[b]	5	0.180	0.068 (1/4) (0.068 – 0.068)	Prince of Peace Abbey 15.0 Mi. SE	0.079 (1/1) (0.079 – 0.079)	0.079 (1/1) (0.079 – 0.079)	0

NOTES:
a K-40 and other radionuclides were detected in the 2019 REMP soil samples.
b The Cs-137 detected in the control and in one indicator sample at the same level (approximately 0.1 pCi/g) are due to factors external to SONGS (legacy fallout from nuclear weapons testing and Chernobyl) and are not attributable to SONGS.

Table 27 –Semi-Annual Kelp Gamma Activity (pCi/g)

Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Range)	Location with Highest Annual Mean		Control Locations Mean (Range)	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Kelp Ingestion (pCi/g)	K-40[b]	3	N/A	11.16 (2/2) (10.34 – 11.97)	Wheeler North Kelp Bed Alternate control 4 to 7 Mi. WNW-NW	12.06 (1/1) (12.06 – 12.06)	12.06 (1/1) (12.06 – 12.06)	0
	I-131[a]	3	0.06	< MDC	< MDC	< MDC	< MDC	0

NOTES:
a I-131 in kelp was not detected above the MDC during 2019.
b Naturally occurring K-40 was detected in all 2019 kelp samples.

APPENDIX C. SUMMARY OF QUALITY CONTROL PROGRAMS

Summary

All REMP samples are collected, shipped, and analyzed in accordance with NRC Regulatory Guide 4.15. Marine radiological environmental samples are collected by a vendor, MBC Environmental, per the vendor's Quality Assurance manual. REMP sample analysis is performed by the Contracted Environmental Analysis Laboratory (CEAL) in accordance with the Laboratory Quality Assurance Plan. The CEAL for REMP TLDs was Stanford Dosimetry. The raw data was reported as milli-Roentgen/standard quarter and converted to milli-Rem per standard quarter using conversion factors in ANSI N13.37.

Quarterly Duplicate TLDs

SONGS deployed a duplicate TLD package, TLD 200, in the same canister as TLD 66. The quarterly dose measured by the duplicate TLD package was statistically equivalent.

Table 28 - 2019 Quarterly Duplicate TLD Data Comparison

TLD #	1ST QUARTER (mrem) +/- 1 sigma	2ND QUARTER (mrem) +/- 1 sigma	3RD QUARTER (mrem) +/- 1 sigma	4TH QUARTER (mrem) +/- 1 sigma
TLD 66	14.80 ± 0.68[a]	14.60 ± 0.64	15.10 ± 0.76	13.50 ± 0.84
TLD 200	15.06 ± 0.90	14.01 ± 0.61	14.17 ± 0.50	13.66 ± 0.60

NOTES:
a Data is reported as mrem per standard quarter ± 1 sigma

Annual Duplicate TLDs

SONGS deployed an annual duplicate TLD package, TLD 201, in the same location and canister as REMP TLD 67. The sum of four quarterly TLD 67 exposure results is statistically equal to the annual TLD 201 results for the period spanning July 2018 to June 2019.

Table 29 - 2019 Annual Duplicate TLD Data compared to data from the same canister

TLD #	July 2018 to June 2019 4 quarters (mrem/91 days +/- 1 sigma)
TLD 67	70.7 ± 4.2
TLD 201	69.7 ± 1.7

Calibration of Air Sampler Volume Meters

All REMP air sampler volume meters are calibrated annually using standards referenced to National Institute of Standard and Technology. Calibration of all REMP air samplers is verified quarterly to ensure the volume meters remain within limits. Meters are removed from service if they fail the quarterly test. This is an *a posteriori* review of the volume meter performance to evaluate method bias and to identify possible outlier analysis results. A bias was not detected in 2019. A review of the air particulate beta results over the course of the year did not indicate a particular bias for any particular sampler. The trends in the beta results over the course of the year were consistent, within the limitations of the gross beta method of analysis.

Interlaboratory Cross-Check Program

The State of California Department of Public health (CDPH) participates in a comprehensive radiological environmental split sampling program in conjunction with SONGS. In 2019, the CDPH acquired split samples, collected by an independent third party, from the following SONGS media: atmospheric radioactivity, non-migratory marine animals, kelp, ocean bottom sediments, ocean water gamma emitters, and ocean water tritium. (The CDPH also conducts a parallel terrestrial direct radiation (TLD) measurement effort at SONGS. Refer to Appendix H for a discussion of the CDPH TLD data.)

CDPH Atmospheric Radioactivity Gross Beta, I-131 and quarterly gamma analysis results were substantially similar to the SONGS results for the same media. As expected, both the CDPH DWRL (Drinking Water and Radiation Laboratory) and the SONGS contracted GEL found a gross beta signal above the detection limit. Both labs detected naturally occurring Be-7 in the quarterly composite gamma particulate media samples. Both labs did not detect anthropogenic radionuclides in the split samples with the exception of non-migratory marine animals.

Since ocean water tritium and non-migratory marine animals have the potential for human consumption, their raw data are tabulated below. Fourteen split sample analyses for marine species were conducted. Analysis methodologies are different in that the SONGS contract laboratory reported a wet weight result, where the CDPH lab reported a dry weight result. SONGS lab detected Cs-137 above the MDC in one Unit 2 Outfall sample (8-Apr-2019 10:00) which is consistent with the CDPH lab report. CDPH lab reported Cs-137 above the MDC in other samples, including two from the Control Location in Laguna Beach and three from SONGS environs. SONGS contract laboratory did not detect Cs-137 activity above MDC for other locations. The variability in positive results is due to differences in sample processing, the uncertainty of isotope detection and detection limits at low concentrations. (For a discussion on the presence of Cs-137 in fish, refer to Appendix B.)

Table 30 - Non-migratory marine animals analysis results

SPLIT SAMPLE LOCATION		Sample Date / Time	SONGS data (wet weight)		CDPH data (dry weight)	
			gamma result +/- 2 sigma (pCi/g)	MDC	Gamma result +/- uncertainty (pCi/g)	MDC
A	Station Discharge Outfall - Unit 1	24-Apr-19 / 0800	K-40 4.04 +/- 0.377	1.17E-1	17.5 +/- 0.972 Dry / wet ratio 0.219	4.59E-1
		24-Apr-19 / 0800	Cs-137(UI) 9.97E-3 +/- 9.94E-3	9.77E-3	5.58E-2 +/-1.12E-2 Dry / wet ratio 0.219	2.2E-2
		8-Oct-19 / 1035	K-40 1.88 +/- 0.223	7.27E-2	11.2 +/- 0.658 Dry / wet ratio 0.197	5.30E-1
		8-Oct-19 / 1035	Cs-137 -1.71E-3 +/- 4.38E-3	7.15E-3	6.01E-3 +/- 7.39E-3 Dry / wet ratio 0.197	1.76E-2
B	Outfall - Unit 2	8-Apr-19 / 0920	K-40 1.83 +/- 0.211	9.28E-2	10.9 +/- 0.675 Dry / wet ratio 0.156	7.61E-1
		8-Apr-19 / 0920	Cs-137 2.56E-3 +/- 4.27E-3	7.70E-3	7.42E-3 +/- 8.62E-3 Dry / wet ratio 0.156	2.05E-2
		8-Apr-19 / 0950	K-40 3.42 +/- 0.276	8.73E-2	13.3 +/- 0.730 Dry / wet ratio 0.261	3.23E-1
		8-Apr-19 / 0950	Cs-137 5.36E-3 +/- 4.60E-3	8.62E-3	1.55E-2 +/- 6.87E-3 Dry / wet ratio 0.261	1.51E-2
		8-Apr-19 / 1000	K-40 3.94 +/- 0.35	8.19E-2	18.4 +/- 0.990 Dry / wet ratio 0.236	4.55E-1

SPLIT SAMPLE LOCATION		Sample Date / Time	SONGS data (wet weight)		CDPH data (dry weight)	
			gamma result +/- 2 sigma (pCi/g)	MDC	Gamma result +/- uncertainty (pCi/g)	MDC
		8-Apr-19 / 1000	Cs-137 (> MDC) 1.50E-2 +/- 1.17E-2	9.83E-3	3.46E-2 +/- 8.40E-3 Dry / wet ratio 0.236	1.71E-2
		8-Oct-19 / 0910	K-40 3.67 +/- 0.312	6.31E-2	17.3 +/- 0.930 Dry / wet ratio 0.236	7.05E-1
		8-Oct-19 / 0910	Cs-137 (UI) 1.04E-2 +/- 6.19E-3	8.52E-3	4.65E-2 +/-1.16E-2 Dry / wet ratio 0.236	2.42E-2
		8-Oct-19 / 0955	K-40 3.70 +/- 0.287	6.37E-2	14.5 +/- 1.21 Dry / wet ratio 0.268	3.79E-1
		8-Oct-19 / 0955	Cs-137 (UI) 1.01E-2 +/- 5.91E-3	6.76E-3	1.21E-2 +/- 6.95E-3 Dry / wet ratio 0.268	1.56E-2
		8-Oct-19 / 1000	K-40 3.70 +/- 0.324	7.76E-2	18.9 +/- 0.834 Dry / wet ratio 0.245	4.44E-1
		8-Oct-19 / 1000	Cs-137 (UI) 1.24E-2 +/- 8.28E-3	9.83E-3	3.66E-2 +/-9.33E-3 Dry / wet ratio 0.245	1.96E-2
C	Laguna Beach - Control	23-Apr-19 / 1015	K-40 0.997 +/- 0.212	9.39E-2	4.36 +/- 0.344 Dry / wet ratio 0.124	5.09E-1
		23-Apr-19 / 1015	Cs-137 5.95E-3 +/- 6.59E-3	6.12E-3	2.26E-3 +/- 5.77E-3 Dry / wet ratio 0.124	1.35E-2
		23-Apr-19 / 1030	K-40 3.43 +/- 0.304	6.06E-2	16.8 +/- 0.808 Dry / wet ratio 0.230	4.52E-1
		23-Apr-19 / 1030	Cs-137 6.20E-3 +/- 5.83E-3	1.10E-2	3.17E-2 +/-8.81E-3 Dry / wet ratio 0.230	1.85E-2
		23-Apr-19 / 1205	K-40 3.75 +/- 0.283	7.17E-2	15.6 +/- 0.879 Dry / wet ratio 0.252	4.41E-1
		23-Apr-19 / 1205	Cs-137 6.12E-3 +/- 6.55E-3	6.14E-3	9.34E-3 +/- 6.57E-3 Dry / wet ratio 0.252	1.60E-2
		3-Oct-19 / 0940	K-40 0.887 +/- 0.155	5.87E-2	8.27 +/- 0.571 Dry / wet ratio 0.147	6.37E-1
		3-Oct-19 / 0940	Cs-137 4.54E-4 +/- 4.59E-3	7.55E-3	1.28E-3 +/- 9.23E-3 Dry / wet ratio 0.147	2.12E-2
		3-Oct-19 / 1025	K-40 3.87 +/- 0.332	7.54E-2	15.8 +/- 0.712 Dry / wet ratio 0.245	4.14E-1
		3-Oct-19 / 1025	Cs-137 6.27E-4 +/- 1.04E-2	9.57E-3	1.28E-2 +/-7.92E-3 Dry / wet ratio 0.245	1.78E-2
		3-Oct-19 / 1055	K-40 3.22 +/- 0.255	8.40E-2	15.8 +/- 0.842 Dry / wet ratio 0.240	6.19E-1
		3-Oct-19 / 1055	Cs-137 (UI) 1.93E-2 +/- 7.76E-3	5.54E-3	3.41E-2 +/-1.01E-2 Dry / wet ratio 0.240	2.15E-2

UI - Uncertain identification for gamma spectroscopy

MDC - minimum detectable concentration (SONGS lab)

Table 31 below shows the results from ocean water tritium samples. All SONGS and CDPH results for 2019 tritium in ocean water were less than detectable.

NOTE: When sample results are analyzed to be lower in activity than the laboratory background result, the result is depicted as a negative value.

Table 31 - CDPH and SONGS split sample tritium in ocean water

SPLIT SAMPLE LOCATION		Sample Date	SONGS tritium data		CDPH tritium data	
			H-3 result +/- 2 sigma (pCi/L)	MDC	H-3 result +/- uncertainty (pCi/L)	MDC
A	Station Discharge Outfall - Unit 1	24-Jan-19	-97 +/- 346	595	-38.7 +/- 136	235
		19-Feb-19	92 +/- 326	531	14.6 +/- 140	240
		18-Mar-19	70 +/- 138	208	-72.8 +/- 138	240
		17-Apr-19	137 +/- 424	688	-89.2+/- 138	240
		15-May-19	21 +/- 115	192	72.1 +/- 133	225
		17-Jun-19	4 +/- 237	398	-35.3 +/- 122	213
		15-Jul-19	85 +/- 324	531	-26.5 +/- 123	213
		19-Aug-19	67 +/- 354	583	19.4 +/- 125	213
		16-Sep-19	-268 +/- 353	632	14.8 +/- 131	224
		15-Oct-19	37 +/- 142	227	107 +/- 133	224
		18-Nov-19	31 +/- 288	478	-93.0 +/- 125	219
		16-Dec-19	-294 +/- 318	571	78.5 +/- 182	307
B	Outfall - Unit 2	24-Jan-19	-32 +/- 352	596	-28.2 +/-.136	235
		19-Feb-19	-56 +/- 301	516	-94.7 +/- 137	240
		18-Mar-19	-138 +/- 91	210	-113 +/- 137	240
		17-Apr-19	-309 +/- 390	712	205 +/- 136	225
		15-May-19	-52 +/- 115	196	-77.7 +/- 129	225
		17-Jun-19	-297 +/- 193	398	-72.4 +/- 122	213
		15-Jul-19	-83 +/- 300	517	-98.8 +/- 121	213
		19-Aug-19	303 +/- 364	565	-54.7 +/- 123	213
		16-Sep-19	-50 +/- 370	628	154 +/- 134	224
		15-Oct-19	39 +/- 144	230	-29.6 +/- 129	224
		18-Nov-19	442 +/- 318	458	-98.3 +/- 125	219
		16-Dec-19	-260 +/- 328	585	-27.4 +/- 180	307
C	Outfall - Unit 3	24-Jan-19	-17 +/- 358	604	-106 +/- 134	235
		19-Feb-19	106 +/- 323	524	-71.0 +/- 138	240
		18-Mar-19	34 +/- 132	210	-147 +/- 176	240
		17-Apr-19	94 +/- 430	704	94.3 +/- 133	225
		15-May-19	-124 +/- 112	189	79.3 +/- 133	225
		17-Jun-19	-15 +/- 233	395	-74.1 +/- 122	213
		15-Jul-19	12 +/- 305	510	79.4 +/- 126	213
		19-Aug-19	69 +/- 345	568	-12.4 +/- 124	213
		16-Sep-19	150 +/- 387	628	44.4 +/- 131	224

SPLIT SAMPLE LOCATION		Sample Date	SONGS tritium data		CDPH tritium data	
			H-3 result +/- 2 sigma (pCi/L)	MDC	H-3 result +/- uncertainty (pCi/L)	MDC
		15-Oct-19	-3 +/- 135	227	25.9 +/- 131	224
		18-Nov-19	100 +/- 285	460	-177 +/- 123	219
		16-Dec-19	-360 +/- 324	592	31.0 +/- 181	307
D	Newport Beach (Control)	24-Jan-19	466 +/- 393	595	-28.2 +/- 136	235
		19-Feb-19	-73 +/- 303	522	-49.2 +/- 139	240
		18-Mar-19	32 +/- 131	209	-94.7 +/- 137	240
		17-Apr-19	208 +/- 439	700	49.9 +/- 132	225
		15-May-19	10 +/- 131	219	7.40 +/- 131	225
		17-Jun-19	-129 +/- 219	398	-37.1 +/- 123	213
		15-Jul-19	105 +/- 308	501	-122 +/- 121	213
		19-Aug-19	-142 +/- 315	553	-104 +/- 121	213
		16-Sep-19	-296 +/-340	615	37.0 +/- 131	224
		15-Oct-19	-151 +/-101	224	66.6 +/- 132	224
		18-Nov-19	177 +/-292	458	-132 +/- 124	219
		16-Dec-19	-188 +/-327	573	-1.83 +/- 180	307

Note that the EPA drinking water maximum permissible tritium activity is 20,000 pCi / liter.

Both labs only detected naturally occurring radionuclides in ocean bottom sediments and ocean water. No plant related radionuclides were reported above the MDC.

GEL participates in three independent cross check programs. GEL's QA programs consists of these testing vendors: Eckert & Ziegler Analytics, U.S. DOE MAPEP, and ERA's MARD Proficiency Testing Program. Non-agreement results were resolved in accordance with GEL's corrective action program.

In 2019, the environmental TLDs, routine quality control (QC) testing was performed for the types of dosimeters issued by the Environmental Dosimetry Company (EDC). During 2019, 100% (72/72) of individual dosimeters evaluated against the EDC internal performance acceptance criteria (high-energy photons only) met the criterion for accuracy and 100% (72/72) met the criterion for precision.

The GEL and Stanford Dosimetry performance meets the criteria described in Reg. Guide 4.15 and ANSI/HPS N13.37-2014.

APPENDIX D. COMPARISON OF OPERATIONAL TO PREOPERATIONAL DATA

Comparison of Operational to Preoperational Data and Analysis of Trends

Unit 1 achieved criticality on June 14, 1967 and was permanently retired from service on November 30, 1992. Unit 2 attained initial criticality on July 26, 1982 and Unit 3 on August 29, 1983.

A variety of environmental samples were analyzed and the analytical results (January 1, 1979 to July 31, 1982) were compared with the 2019 operational data obtained for SONGS Units 2/3.

The following media were evaluated and compared with the operational data of SONGS Units 1, 2 and 3:

- External Radiation
- Air Particulates
- Radioiodine
- Ocean Water
- Shoreline Sediment (Sand)
- Ocean Bottom Sediments
- Marine Species
- Local Crops
- Soil
- Kelp
- Drinking Water

The measurements obtained from the SONGS Unit 1 operational Radiological Environmental Monitoring Program (REMP) during the period from January 1979 to July 1982 are used as the preoperational baseline for SONGS Units 2/3. This is in accordance with San Onofre Units 2/3, Environmental Report, Operating License Stage, Appendix 6A, Pre-operational Radiological Environmental Monitoring, May 31, 1978. Comparisons of preoperational data to 2019 operational data are possible for each of the following exposure pathways: (1) direct radiation, (2) air particulates (inhalation), and (3) ocean water (marine pathway for ingestion). Comparisons can also be made between preoperational and operational data for ocean bottom sediment data to ascertain if there has been any significant increase in radioactivity in ocean bottom sediments near the SONGS Units 2/3 outfalls.

Currently the preoperational data are higher than the operational data. The decrease in radioactivity is due primarily to the cessation of atmospheric nuclear weapons testing and to the decay of fallout radionuclides. There is a close correlation between indicator and control data over several decades. There are no indications of adverse effects from SONGS on the environment.

Direct Radiation

The direct radiation measurements for the SONGS REMP were made by TLDs on a quarterly collection cycle at 49 locations in 2019. (See Appendix I for ISFSI TLD data.) The TLDs were located at inner and outer ring locations as specified by the ODCM. During the preoperational period from January 1979 to July 31, 1982, the indicator stations ranged from 16.1 to 46.6 mR. The preoperational indicator average was 25.3 mR. The preoperational control range was 19.3 to 30.1 and the control mean was 23.1 mR. During the 2019 operational year for Units 2/3, the SONGS REMP TLD data was processed in accordance with ANSI/HPS N13.37-2014. Accordingly, the data from individual REMP TLD locations are evaluated against the baseline for each location. The individual REMP TLD locations are not compared with distant control locations for evaluation per the current regulatory guidance, Regulatory Guide 4.13 Revision 2, 2019 (Environmental Dosimetry – Performance Specifications, Testing, and Data Analysis). Refer to Appendix B for a detailed discussion of the REMP TLD data evaluation process.

Factors such as meteorology, local geology, the fallout from atmospheric nuclear weapons testing, and seasonal fluctuations account for the variability in the data as observed during the preoperational period for each location. The decrease in radiation levels at all TLD sample locations is attributable to the curtailment of the atmospheric nuclear weapons testing, and the continued decay of the manmade background from fallout from past nuclear weapons tests.

Simultaneous variation in the radiation levels at both the control and indicator locations shows that the variations are due to factors external to SONGS. Outside the EAB there were no measurable levels of increased direct radiation associated with SONGS as measured by TLDs.

Airborne Particulates

From January 1979 through December 1982 (considered to be the preoperational period for SONGS Units 2/3), there was a noticeably higher gross beta activity in air at all sample locations. This period extends from the fourth quarter of 1980 through the fourth quarter of 1981. These higher activity levels were attributable to the Chinese atmospheric nuclear weapons test conducted on October 15, 1980.

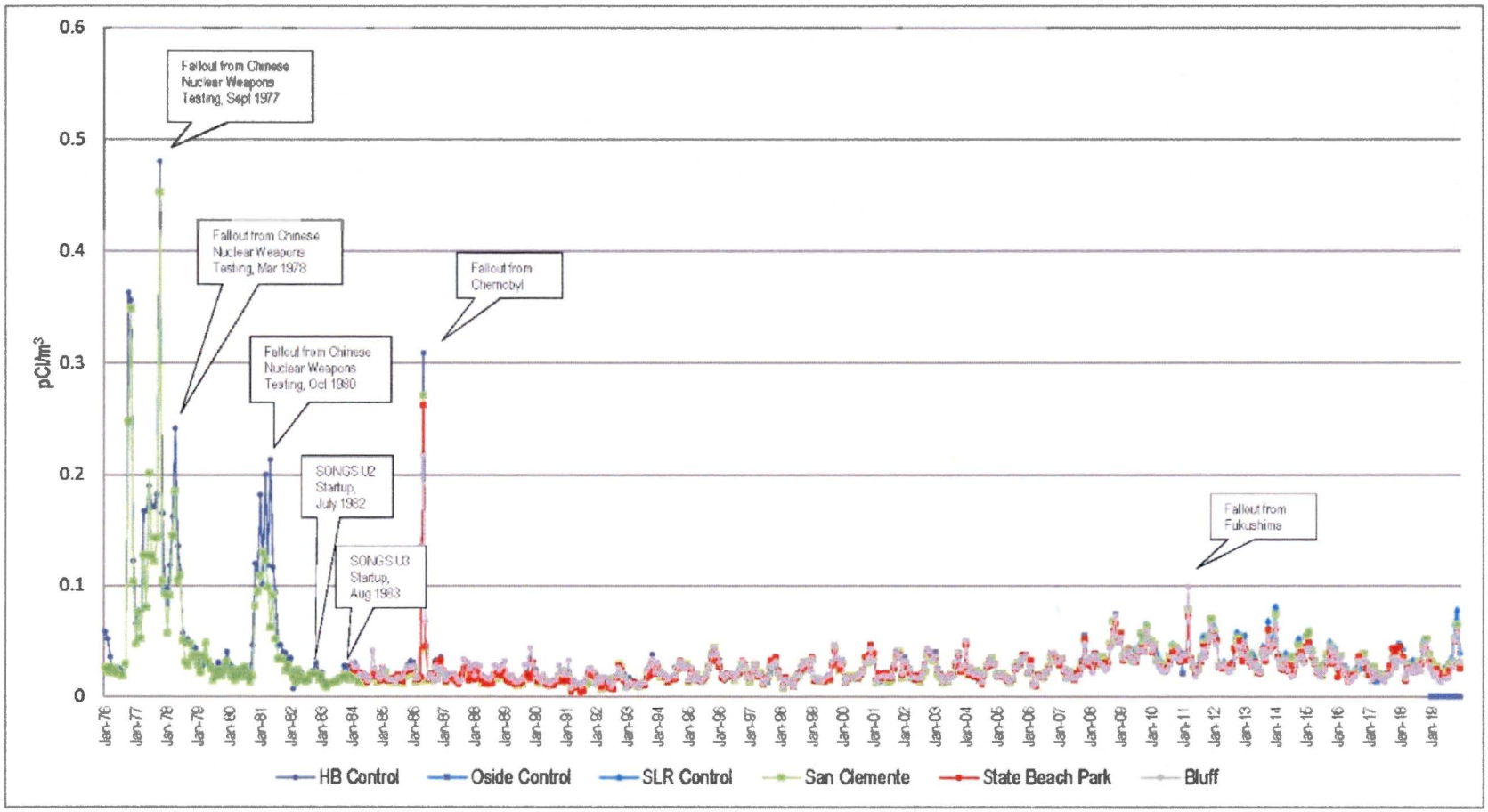


Figure 11 - Monthly Average Airborne Particulate Gross Beta Preoperational and Operational Data for Units 2 and 3, (1976 – 2019)

For 2019, the maximum monthly average airborne particulate gross beta result was approximately 0.036 pCi/m^3. This result is in line with both recent history and SONGS preoperational data.

Radioiodine

Most of the preoperational data for I-131 level was below the detection limit. All the 2019 operational I-131 data were below the detection limit. This is expected, as the shutdown and defueled SONGS is no longer producing I-131, and all previously produced I-131 has decayed away. SONGS had no effect on the environment as measured by the radioiodine cartridge data in 2019.

Ocean Water

Monthly ocean water samples were collected near each of the Station discharge outfalls, and from the Newport Beach control location. The ocean water samples are analyzed for naturally occurring and station-related gamma-emitting radionuclides. Samples were composited quarterly and analyzed for tritium.

During the preoperational period, naturally occurring potassium-40 was detected in each of the samples collected from both indicator and control locations. Other gamma-emitting radionuclides were detected in only one ocean water sample. In May 1980, Co-58, Co-60, Cs-134, and Cs-137 were detected in an ocean water sample collected from the SONGS Unit 1 outfall. Concentrations of the radionuclides in this sample were 11, 6, 380, and 430 pCi/l respectively. Tritium was also detected in two of the ocean water samples collected in May 1980 from the SONGS Unit 2 outfall and in and from the Newport Beach control location.

The data at all ocean water locations during the 2019 operational period support that no plant related radionuclides were detected. SONGS had no impact on the environment as measured by this exposure pathway in 2019.

Drinking Water

Due to its location near the beach, there is no drinking water pathway for SONGS. Nonetheless, drinking water samples from Oceanside and Camp Pendleton were collected and analyzed. No plant related radionuclides were detected during the 2019 operational period. Gross beta activity (from natural radionuclides) was detected during both the operational and preoperational periods at both the indicator and the control locations. No plant related radionuclides (including tritium) have been identified in 2019, and no trends have been noted. SONGS had no impact on the environment as measured by this exposure pathway.

Shoreline Sediments (Sand)

Beach sand is collected semiannually from three indicator locations and from a control location situated at Newport Beach. The samples are analyzed for naturally occurring and plant related radionuclides.

To assess the impact of SONGS operations on this environmental medium, preoperational data were compared to 2019 operational data (refer to Table 32). The radionuclide detected in shoreline sediment in the preoperational time frame was Cs-137 with a range of 0.012 to 0.022 pCi/g, averaging 0.019 in 5 sediment samples. One control sample with a Cs-137 activity of 0.032 pCi/g was observed in July 1979. The presence of Cs-137 in both control and indicator locations during the preoperational period leads to the conclusion that the root cause is external to SONGS and is most likely attributable to atmospheric nuclear weapons testing. No SONGS related radionuclides were detected in shoreline sediment during the 2019 operational period. SONGS had no impact on the environment as measured by this exposure pathway in 2019.

Table 32 - Shoreline Sediment Concentration

		INDICATOR		CONTROL	
Radionuclide	Period [a]	Range [b] (pCi/g, wet)	Average (pCi/g, wet)	Range (pCi/g, wet)	Average (pCi/g, wet)
Cs-137	PreOp Operational	0.012 - 0.022 < LLD	0.019 < LLD	< LLD - 0.032 < LLD	< LLD < LLD
All other SONGS radionuclides	PreOp Operational [c]	< LLD < LLD	< LLD < LLD	< LLD < LLD	< LLD < LLD

NOTES:
- a Preoperational period is January 1979 – July 1982. Operational period is January 2019 – December 2019
- b LLD for operational data are listed in Appendix B
- c During 2019, all station related radionuclides from all sample locations were < LLD

Ocean Bottom Sediments

During the preoperational and operational periods, representative samples of ocean bottom sediments were collected semiannually from each of the Station discharge outfalls and from a control station in Laguna Beach. The samples were analyzed for naturally occurring and SONGS related radionuclides.

Table 33 compares historical information versus 2019 sample results. During the preoperational period, manganese-54 (Mn-54) was detected in 5 of the 28 samples. Cobalt-58 (Co-58) was detected in nine samples. Cobalt-60 (Co-60) was measured in 15 of the 28 samples. Cs-137 was also detected in 16 of the 28 samples. The concentrations of Cs-137 in the samples ranged from 0.014 to 0.090 pCi/g, averaging 0.039 pCi/g. Cerium-144 (Ce-144) was found in two samples.

Results of the 2019 data indicate that there has not been a build-up of radionuclides with time in ocean bottom sediments near SONGS. The results also indicate notable decrease in the concentrations of plant related radionuclides in the ocean bottom sediment. Although Co-58, Co-60, and Cs-137 are normally associated with nuclear power operations, preoperational study reveals no accumulation trend for these radionuclides, and no increase in levels for these radionuclides was detected during the operational period.

The concentration of station related radionuclides in all ocean bottom sediment samples analyzed in 2019 was below the MDC, supporting the conclusion of no detectable impact on ocean bottom sediments from SONGS. SONGS had no impact on the environment as measured by this exposure pathway in 2019.

Table 33 - Ocean Bottom Sediment Concentration

		INDICATOR		CONTROL	
Radionuclide	Period [a]	Range[b] (pCi/g, wet)	Average[b] (pCi/g, wet)	Range (pCi/g, wet)	Average (pCi/g, wet)
Mn-54	PreOp 2019	0.015 - 0.49 < LLD	0.129 < LLD	< LLD < LLD	< LLD < LLD
Co-58	PreOp 2019	0.013 - 1.160 < LLD	0.199 < LLD	< LLD < LLD	< LLD < LLD
Co-60	PreOp 2019	0.014 - 8.100 < LLD	0.788 < LLD	< LLD < LLD	< LLD < LLD
Ag-110m	PreOp 2019	< LLD - 0.020 < LLD	< LLD < LLD	< LLD < LLD	< LLD < LLD
Cs-137	PreOp 2019	0.014 - 0.090 < LLD	0.039 < LLD	< LLD < LLD	< LLD < LLD
Ce-144	PreOp 2019	0.060 - 0.260 < LLD	0.160 < LLD	< LLD < LLD	< LLD < LLD
All other SONGS radionuclides	PreOp 2019	< LLD < LLD	< LLD < LLD	< LLD < LLD	< LLD < LLD

NOTES:

a Preoperational period is January 1979 – July 1982

b LLD for operational data are listed in Appendix B

Marine Species (Flesh)

Non-migratory marine species are collected semi-annually near SONGS. Non-migratory marine animals are collected near the SONGS outfalls and from Laguna Beach and analyzed for gamma-emitting radionuclides as specified in the ODCM. The results are subsequently reported as pCi/g, wet weight.

Results for several marine species for both the preoperational and 2019 operational periods for Units 2/3 are summarized in Table 34. The marine species used for purposes of comparison include: Sheephead (a fish), Black Perch (a fish), Bay Mussel (a mollusk), and Spiny Lobster (a crustacean). Radionuclides analyzed, but not included in Table 34, were below the lower limits of detection for both the preoperational and operational periods.

During 2019 one SONGS indicator sample had a Cs-137 activity > MDC and < LLD. This is consistent with other Pacific Ocean marine organism samples at other locations and is consistent with the levels of Cs-137 in marine samples that may be attributable to the ocean water discharges from Fukushima. The data indicate no accumulation trends attributable to SONGS. SONGS had an insignificant impact on the environment as measured by this exposure pathway in 2019.

Table 34 - Marine Species Concentration

		INDICATOR		CONTROL	
Radionuclide	Period [a]	Range (pCi/g, wet)	Average (pCi/g, wet)	Range (pCi/g, wet)	Average (pCi/g, wet)
Sheephead Flesh[d]					
Co-58	PreOp Operational[b]	0.016 - 0.030 < LLD	0.023 < LLD	< LLD < LLD	< LLD < LLD
Co-60	PreOp Operational	0.005 - 0.044 < LLD	0.017 < LLD	< LLD < LLD	< LLD < LLD
Ag-110m	PreOp Operational	< LLD - 0.004 < LLD	< LLD < LLD	< LLD < LLD	< LLD < LLD
Cs-137	PreOp Operational	0.004 - 0.018 < LLD	0.007 < LLD	0.005 - 0.012 < LLD	0.007 < LLD
All other SONGS radionuclides	PreOp Operational	< LLD < LLD	< LLD < LLD	< LLD < LLD	< LLD < LLD
Black Perch Flesh[d]					
Co-58	PreOp Operational	0.009-0.011 < LLD	0.010 < LLD	< LLD < LLD	< LLD < LLD
Co-60	PreOp Operational	0.004-0.045 < LLD	0.017 < LLD	< LLD < LLD	< LLD < LLD
Ag-110m	PreOp Operational	0.002-0.009 < LLD	0.006 < LLD	< LLD < LLD	< LLD < LLD
Cs-137	PreOp Operational	0.003-0.015 < LLD	0.008 < LLD	0.004-0.014 < LLD	0.009 < LLD
All other SONGS radionuclides	PreOp Operational	< LLD < LLD	< LLD < LLD	< LLD < LLD	< LLD < LLD
Mussel Flesh (Bay or California)[d]					
Mn-54	PreOp Operational	0.009 - 0.025 < LLD	0.017 < LLD	< LLD < LLD	< LLD < LLD
Co-58	PreOp Operational	0.008 - 0.080 < LLD	0.028 < LLD	-- < LLD	-- < LLD
Co-60	PreOp Operational	0.005 - 0.400 < LLD	0.077 < LLD	< LLD < LLD	< LLD < LLD
Cs-137	PreOp Operational	0.003 - 0.006 < LLD	0.004 < LLD	< LLD < LLD	< LLD < LLD
Ru-103	PreOp Operational	< LLD - 0.045 < LLD	< LLD < LLD	< LLD < LLD	< LLD < LLD
All other SONGS radionuclides	PreOp Operational[c]	< LLD < LLD	< LLD < LLD	< LLD < LLD	< LLD < LLD

Spiny Lobster Flesh (Bay or California)[d]					
Co-58	PreOp Operational	0.007 - 0.270 < LLD	0.086 < LLD	< LLD < LLD	< LLD < LLD
Co-60	PreOp Operational	0.014 - 0.210 < LLD	0.060 < LLD	< LLD < LLD	< LLD < LLD
Cs-137	PreOp Operational	0.005 - 0.011 < LLD	0.008 < LLD	0.040 - 0.015 < LLD	0.008 < LLD
All other SONGS radionuclides	PreOp Operational[c]	< LLD < LLD	< LLD < LLD	< LLD < LLD	< LLD < LLD

NOTES:

a Preoperational period is January 1979 – July 1982. Operational period is January 2019 – December 2019

b LLD for operational data are listed in Appendix B

c During 2019, all station related radionuclides from all sample locations were < LLD

d Samples collected in 2019 include crustaceae, mollusks, and two adult species of fish

Local Crops

In the preoperational period of January 1979 through July 1982, Sr-90 was detected in the control samples of kale, parsley, and squash. Naturally occurring K-40 was detected in cucumber, kale, and tomato samples from the indicator and control locations. Ce-144 and Zr-95 were detected in one sample of parsley at the control location at concentrations of 0.12 and 0.09 pCi/g, wet weight respectively.

During 2019, only natural radionuclides were identified in local crops, at both the indicator and control locations. SONGS had no impact on the environment as measured by this exposure pathway in 2019.

Soil

A comparison of operational and preoperational data does not reveal any accumulation pattern of SONGS related isotopes in soil (refer to Table 35). The intermittent detection of Cs-137 in both indicator and control locations is due to residual fallout from atmospheric nuclear weapons testing. SONGS had no impact on the environment as measured by this exposure pathway in 2019.

Table 35 - Soil Concentration

		Indicator		Control	
Radionuclide	Period	Range (pCi/g)	Average (pCi/g)	Range (pCi/g)	Average (pCi/g)
Sr-90	PreOp Operational	0.02 - 0.08 N/A	0.044 N/A	< LLD - 0.03 N/A	< LLD N/A
Cs-137	PreOp Operational	0.02 - 0.20 -0.01 – 0.07	0.096 0.03	< LLD - 0.06 0.08	< 0.10 0.08
All other SONGS radionuclides	PreOp Operational	< LLD < LLD	< LLD < LLD	< LLD < LLD	< LLD < LLD

Kelp

Kelp is collected semiannually from three indicator locations and from a control location situated at Salt Creek. The samples are analyzed by gamma-spectral analysis for naturally occurring and SONGS related radionuclides.

To assess the impact of SONGS operations on kelp, preoperational data were compared to 2019 operational data in Table 36. Radionuclides detected during the preoperational period for SONGS include Mn-54, Co-60, Zr-95, I-131, and Cs-137.

During the 2019 operational period, no SONGS related radionuclides were detected in kelp samples. There is correlation between indicator and control sample locations over an extended period of time.

Although I-131 activity has been detected in kelp since 1977, there is no evidence that the concentrations of I-131 are a result of operations at SONGS. The presence of I-131 in kelp is due to the sewer release of medical administrations of radioisotopes, since it has been detected consistently in control as well as indicator locations. Since 1988, the concentration of I-131, when detected, has typically been highest at the control locations.

Table 36 - Kelp Concentration

		Indicator		Control	
Radionuclide	Period	Range (pCi/g)	Average (pCi/g)	Range (pCi/g)	Average (pCi/g)
Mn-54	PreOp Operational	< LLD - 0.005 < LLD	< LLD < LLD	< LLD < LLD	< LLD < LLD
Co-60	PreOp Operational	0.006 - 0.009 < LLD	0.008 < LLD	< LLD < LLD	< LLD < LLD
Zr(Nb)-95	PreOp Operational	0.014 - 0.090 < LLD	0.046 < LLD	0.018 - 0.053 < LLD	0.036 < LLD
I-131	PreOp Operational	0.006 - 0.024 < LLD	0.013 < LLD	0.008 - 0.030 < LLD	0.014 < LLD
Cs-137	PreOp Operational	0.004 - 0.071 < LLD	0.027 < LLD	< LLD < LLD	< LLD < LLD
All other SONGS radionuclides	PreOp Operational	< LLD < LLD	< LLD < LLD	< LLD < LLD	< LLD < LLD

The Kelp I-131 results in 2019 were all < LLD. Only three kelp samples were available during 2019 because the kelp canopy was missing at all location for most of the year. Since there is no longer a viable production mechanism for I-131 at SONGS, it is reasonable to conclude that the detection of I-131 in kelp is due to factors external to SONGS. SONGS had no impact on the environment as measured by this exposure pathway in 2019.

APPENDIX E. DEVIATIONS FROM ODCM SAMPLING REQUIREMENTS IN 2019

DEVIATIONS FROM ODCM SAMPLING REQUIREMENTS

Deviations from the ODCM sampling requirements are identified below in accordance with section 5.0 of the ODCM. During 2019, the ODCM specified *a priori* LLD was achieved for all REMP samples. Deviations from the ODCM were associated with external factors not within the control of REMP personnel such as limited availability of marine samples at the locations specified in the ODCM, external power outages, and other unavoidable deviations. The 2019 ODCM deviations had no meaningful impact on the REMP data and does not compromise the validity of the reported conclusions.

Direct Radiation

Thermoluminescent Dosimeters (TLDs)

1. TLD 11 was discovered to be off station during the second quarter 2019 TLD collection effort. The TLD canister was found damaged and TLD 11 could not be located. Thus, no empirical TLD 11 data exists to report for this location during the second quarter 2019.

Air Sampling

At SONGS, the ODCM requires a total of 4 Indicator stations and 1 Control station.

Downtime for each air sampler in 2019 was due to weekly sample collection, quarterly calibrator flow comparison checks, scheduled air sampler motor assembly / calibrator change-outs, and preventative air sampler motor assembly change-outs which was conducted if a motor assembly was observed to show signs of degraded performance (excessive bearing noise, vane erosion, flow decline, etc.). During 2019, there were no avoidable deviations from the ODCM. The unavoidable ODCM deviations (routine planned air sampler maintenance and one unplanned external power outage) constituted less than 3 hours per air sampler during 2019.

Routine unavoidable air sampler down time (per sampler) includes the following:

Weekly sample collection events:	0.5 minutes (approx.) x 52 = 26 minutes
Quarterly calibrator comparison check:	5 minutes (approx.) x 4 = 20 minutes
Other air sampler maintenance:	10 minutes (approx.)

Downtimes in excess of 1 hour are addressed below for each ODCM required air sample.

1) Air Sampler #16 (San Luis Rey Substation (control)) was off for 88.2 hours experienced approximately 1.2 hours of down time during the sample collection period ending 3/19/2019. This was attributable to an external power outage.
2) Air Sampler #13 (Camp Pendleton East) was out of service for 6.7 hours on 5/21/2019 due to an external power outage.
3) Air Sampler #9 (State Beach Park) was out of service for 6.3 hours during the week ending 11/19/2019 because of a planned external power outage.

Ocean Water Sampling

No deviations were observed

Drinking Water

No deviations were observed

Shoreline Sediments

No deviations were observed

Ocean Bottom Sediments

No deviations were observed

Marine Species (Flesh)

No deviations were observed

Local Crops

No deviations were observed

Soil

No deviations were observed

Kelp

Kelp samples are not required by Section 5.1 of the ODCM. Normally, four kelp beds are collected twice a year for a total of eight kelp samples. Three samples were collected in April 2019. In October 2019, no kelp beds had sufficient canopy to provide a sample. There were a total of three kelp samples in 2019 instead of the normal eight samples. This did not constitute a deviation from the ODCM.

APPENDIX F. LAND USE CENSUS

Introduction

The regulatory basis for conducting a Land Use Census (LUC) is identified in 10 CFR 50, Appendix I, Section IV.B.3. The site specific regulatory position (NUREG 0490 Section 2.4.4) describes atmospheric dispersion and assumes a ground plane release. Therefore, the purpose of the LUC is to "identify the location of the nearest garden of greater than 500 square feet producing leafy vegetables, the nearest milk animals, and the nearest residence in each of the 16 meteorological sectors within a distance of five miles from SONGS Units 2 and 3." Using the procedurally described criteria will always identify the critical receptor in each sector for a ground plane release. This meets the NUREG 0490 requirement for a surveillance program "to identify changes in the use of unrestricted areas and to permit modifications in monitoring program for evaluating doses to individuals from principle pathways of exposure." In addition, Regulatory Guide 4.15, Rev. 1, Section C3 address that "written procedures should be prepared, reviewed, and approved for activities involved in carrying out the monitoring program." The 2019 LUC was conducted to comply with the surveillance requirement as defined in the Offsite Dose Calculation Manual (ODCM) Section 5.2. The current Radiological Environmental Monitoring Program Procedure, Land Use Census, establishes the method of documenting and verifying Land Use Census results in compliance with the ODCM.

Executive Summary

The land area around SONGS is not subject to significant change due to the nature of the land uses. The area around SONGS is divided into sixteen (16) geographical sectors. The Pacific Ocean and the SONGS seawall beach walkway (open to unrestricted use by members of the general public) comprise six sectors. The United States Marine Corps (USMC) Base Camp Pendleton and the San Onofre State Beach Campground comprise 7 of the 16 sectors surrounding SONGS. The City of San Clemente (a mature municipal area) and coastline comprise the remaining three sectors. Therefore, the characteristics of the local land area substantially inhibit significant land use changes.

Definition of Uses

Residence is defined as any structure (single-family house, apartment, mobile home, barracks or similar unit) that is occupied by an individual(s) or resident(s) for three months or longer in a given year.

Other Specified Use is defined as a location occupied by members of the general population as other than their primary residence. The use is divided into two categories: employment and non-employment related.

Employment use is defined as a location occupied by members of the general population engaged in normal work activities regardless of the length of time spent at the location, and regardless of its permanence, including concession stands, restaurants, campground hosts, markets and guard shacks.

Non-employment-related use is defined as a location occupied by members of the general population who are not engaged in normal work activities, including campgrounds, temporary housing, time-share condominiums, motels, hotels, schools and beaches.

Milk animals are cows, goats, and sheep whose milk is used in dairy products for human consumption.

Meat animals include, but are not limited to, deer, cattle, goats and sheep whose meat is used for human consumption.

Fresh, leafy vegetables include, but are not limited to, lettuce, cabbage and spinach.

Fleshy vegetables include, but are not limited to, tomatoes, cucumbers, cauliflower and sweet corn.

The Land Use Census Scope

The land area around SONGS includes both Orange and San Diego counties. The Orange County portion includes a portion of the city of San Clemente (official population as of July 2018 is 64,857 per the US Census statistical information website) and the San Clemente State Park. The San Diego County portion includes much of the (USMC) Base Camp Pendleton, San Onofre State Beach Park, the SONGS seawall beach walkway, and SONGS itself.

The LUC map is divided into 16 geographical sectors: A, B, C, D, E, F, G, H, J, K, L, M, N, P, Q and R. The ODCM surveillance requirement is performed by identifying the location of the nearest garden greater than 500 square feet, nearest milk animals, nearest residence, and other identified land uses in each of the sixteen (16) geographical sectors within a distance of five (5) miles from San Onofre Units 2 and 3. In addition, the Land Use Census aids in detecting changes in the presence of hazardous manufacturing and handling facilities within the five (5) mile radius. The methodology consists of reviewing data from the previous LUC reports and verifying if any information has changed. The LUC is conducted and updated at least once per 12 months between the dates of June 1st and October 1st. Other Specified Use locations, such as fire stations, surf camps, and other potential pathways of exposure to an individual, may be identified if these locations are closer to SONGS than the closest full time residence for all age groups. An Other Specified Use location is not identified if a higher occupancy Other Specified Use location in that sector is closer to SONGS.

Sectors A, B, C, D, E, and F include land within the boundaries of (USMC) Base Camp Pendleton. The study area in sector G includes the area along the coast south of SONGS. Sectors H, J, K, L, M, and N include the beach seawall walkway which may be open to the general public for non-employment usage. The non-employment use observed on this walkway is the recreational pedestrian transit between the beaches north and south of SONGS. Sectors P, Q, and R include a section of San Clemente, the San Onofre State Park, and part of Camp Pendleton.

Research Methodology

Completion of the 2019 SONGS Land Use Census required field research and communication with agencies, organizations, and individuals. The Radiological Effluent and Environmental Program (REMP) Specialist reviewed and verified the 2018 LUC and associated documentation. If changes occurred, then changes were reflected in the 2019 land use census. Information gathered by communication with the cognizant point of contact for the appropriate agency, organization, or military base. The following agencies and organizations were contacted. Information was also researched through the agency websites.

- California Highway Patrol
- State of California Department of Parks and Recreation, including San Onofre State Beach
- Orange County Agricultural Commissioner

- United States Border Patrol
- US Census Bureau
- Endless Summer Surf Camp
- San Onofre Recreation Beach (SORB) management
- Marine Corps Base Camp Pendleton (CPEN), Community Plans and Liaison office

As per the LUC procedure, if the existence of a garden greater than 500 square feet at a candidate location could not be determined from the street, then a garden greater than 500 square feet was presumed to exist at that location. Department of Homeland Security (Border Patrol) management personnel provided occupancy data for the Border Patrol check point. Communication provided by the points of contact from Camp Pendleton and State Parks was considered to be conclusive. Agency contact and documentation were completed in compliance with the Land Use Census procedure.

Field Research

During and after the completion of the preliminary research, field research was undertaken to confirm initial findings and obtain further information necessary to complete the Land Use Census. Field research was initiated in August 2019 and completed in October 2019.

Data and Methodology Summary

The closest candidate residence, garden, dairy within five miles of SONGS was identified for each of the 16 sectors. If there were Other Specified Uses (including both employment and non-employment related locations) closer than the closest residence, then these locations were also noted in the appropriate LUC map. The appropriate individual or organization was identified for each existing and new LUC location. The individual or organization was contacted to determine the use and occupancy for that location. For each LUC location, the appropriate individual was asked to provide an estimate of annual occupancy based on personal knowledge of the location. The information gathered is summarized in Table 37.

Objective Evidence File

Throughout the study, records of contacts, phone notes, meeting minutes, emails, and field survey notes were maintained in accordance with the Land Use Census Procedure. A documentation portfolio was prepared and retained in the plant retrievable record system.

2019 Land Use Census Observations and Changes

The following observations and changes were noted:

- The closest garden (greater than 500 square feet) in each sector was identified.
- In Sector P the closest garden is located at 4130 Calle Isabella (LUC #G-3).
- In Sector Q the closest garden is located at 130 Calle Pacifica (LUC #G-15).
- In Sector R the closest garden is located at 786 Avenida Salvador (LUC #G-19).

- The SONGS garden is also located in Sector R (LUC #G-10). However, the SONGS garden is a source of leafy and fleshy samples to satisfy the REMP local crop sampling requirement. The SONGS garden is not used for human consumption and is 0.7 miles from SONGS.
- LUC #R-P3 and R-Q5 are San Onofre Recreational Beach (SORB) camping areas that are closest to SONGS in sector P and sector Q respectively. In February 2019 the SORB initiated an "extended stay policy" for active duty personnel and their dependents. The new policy allows active duty personnel and their dependents to remain continuously at the SORB for two straight years. Thus R-P3 and R-Q5 are potential Full Time Residences (FTR) for all age groups in 2019. This is a change from the 2018 LUC.
- The occupancy for the Border Patrol Station remained 2000 hours per year based on information from the on-site management. The California Highway Patrol weigh station also remained 2000 hours an interview with the on-site management.
- LUC #R-G1 (San Onofre State Park campground host) occupied spaces 103 to 104 in 2019. No change
- Other Specified Use locations were included only if there were no Other Specified Use locations with a higher occupancy closer to SONGS in the same sector.

Milk Animals

No dairies or other facilities producing milk for human consumption were identified in 2019.

Meat Animals

No agricultural meat animals were identified during the 2019 LUC. The only known meat animal pathway land uses is recreational hunting. Deer graze year round on Camp Pendleton.

Growing Season for fleshy and leafy vegetables

Fleshy and leafy vegetables were available approximately eight months during 2019 at the SONGS garden.

Summary of Changes

1. For the period of July 1, 2018 to June 30, 2019, the Camp Pendleton deer hunting take data was updated and is reflected in Table 38. Per the USMC wildlife biologist, the exact location of a particular kill was not known. The reported take area should be interpreted as an estimate of approximate location. Thus, a deer reported taken in hunting area Alpha-2 may actually have been taken in an adjacent hunting area (such as Romeo-3 or Bravo-3). There were no changes to the estimated distances from SONGS to the nearest vegetation potentially consumed by deer from July 1, 2018 through June 30, 2019.

Distances to nearest vegetation typically consumed by deer:

Units 2/3 Sector	Distance from Units 2/3 (miles)
P	0.3
Q	0.3
R	0.2
A	0.1
B	0.1
C	0.1
D	0.1
E	0.2
F	0.3
G	0.1

Table 37 – SONGS 2019 Land Use Census[a]

Units 2/3 Sector	LUC #	Residence	Miles from U2/3	Estimated hours of Maximum Occupancy	LUC #	Gardens	Miles from U2/3	LUC #	Other Specified Uses	Miles from U2/3	Estimated hours of Maximum Occupancy
A	R-A1	Camp San Mateo	3.6	FTR[b]				O-8	Camp San Mateo Motor Pool	3.6	2,000
								22	SCE land uses	0.4	
B								O-9	USMC CP Sanitary Land Fill	2.1	816
C	R-C2	Camp San Onofre Fire Station #7 52 Area	2.4	FTR				O-10	Camp San Onofre (STP #11)	2.2	2,000
	R-C3	Camp San Onofre Barracks	2.6	FTR							
D	R-D1	Camp San Onofre Barracks	3.0	FTR							
E	R-E1	Camp Horno Barracks	4.1	FTR				O-5	Camp Horno Motor Pool	4.0	2,500
F								O-1	San Onofre State Beach Guard Shack	0.8	1,500
								31A	Border Patrol Checkpoint (NB)	1.9	2,000
G	R-G1	San Onofre State Park-Host sites # 103-104	2.9	FTR				O-2	San Onofre Beach Campground - all ages	1.8	720
								32	Hwy Patrol Weigh Station (SB)	2.1	2,000
								O-2A	Endless Summer Surf Camp sites 99-101 (see notes)	2.8	2,880
Sectors H, J, K, L, M, and N have only non-employment related other specified uses (recreational transit via the beach walkway). These sectors are primarily the Pacific Ocean and contain only a small portion of the plant site, and the beach walkway providing access for state beach park users north & south of SONGS.											
P	R-P3	San Onofre Rec Beach (SORB)	1	FTR[c]				O-6	Surf Beach (Lifeguard)	0.5	800
	R-P2	San Mateo Point housing	2.7	FTR	G-3	4130 Calle Isabella	2.8				
Q	R-Q5	SORB Recreational Beach	1.1	FTR[c]	G-15	130 Calle del Pacifico	4	O-3	State Park Office Trailer	0.6	2,000
	R-Q2	San Onofre III housing	1.4	FTR				5	Surf Beach Guard Shack	0.7	1,500
								1A	SORB Campground Check-in	1.3	2,000
R	R-R1	San Onofre III housing	1.3	FTR	G-10	SONGS Garden	0.7				
					G-19	786 Ave Salvador	4.9				

NOTE:
a Data as of 10-3-2019
b FTR - Full Time Residence
c Indicates a change from the 2018 LUC

NOTES FOR Table 37

RESIDENCES

LUC#	Description
R-A1	Camp San Mateo (Barracks) - This is an employment and an FTR land use location for person 17 and older.
R-C2	Camp San Onofre Fire Station - This is an employment and FTR land use location for persons 18 and older.
R-C3	Camp San Onofre Barracks - This is an employment and FTR land use location for persons 17 and older.
R-D1	Camp San Onofre Barracks - This is a Full time residence for persons 17 and older.
R-E1	Camp Horno Barracks - This is an employment and a FTR land use location for persons 17 and older.
R-G1	San Onofre State Park - (2) Camp Host Volunteers live FTR at campsites #103 - 104.
R-P2	San Mateo Point Housing - This is a FTR for all age groups.
R-R1	San Onofre III housing is located in sector Q and R.
R-Q2	This permanent housing development is a FTR for all ages.
R-P3 R-Q5	San Onofre Recreation Beach (SORB) - R-P3 and R-Q5 are temporary residences for military and other personnel eligible to use SORB facilities. In 2019 the SORB instituted an "Extended Stay Policy" for active duty military personnel, allowing active duty military personnel and their dependents to stay continuously a maximum of two years. Thus LUC R-P3 and R-Q5 are potential Full Time Residences for all age groups in 2019.

VEGETABLE GARDENS

Historically, several gardens have been identified on Avendia Salvador and documented in the Land Use Census. A drive by was conducted and the following was observed:

- The closest garden in Sector R is G-19 (786 Avendia Salvador).
- The closest garden in Sector Q is G-15 (130 Calle del Pacifico).
- The closest garden in Sector P is G-3 (4130 Calle Isabella).
- These are the same gardens identified in the 2018 LUC.
- No gardens were identified in the remaining 13 sectors within the study area.

/

OTHER LUC LOCATIONS CLOSER THAN THE CLOSEST RESIDENCE

LUC#	Description
O-1	San Onofre State Beach Guard Shack - this is an employment land use location for persons 18 and older.
O-2	San Onofre Beach Campground - This is a non-employment (recreational) and use location for all age groups. A camper may stay a maximum of 30 days (720 hours).
O-2A	Endless Summer Surf Camp/Campground Host - The Endless Summer Surf Camp is located in spaces 99 to 101. The maximum occupancy for persons age 18 and older is 2880 hours. The maximum occupancy for persons 17 and younger is 360 hours. This is both an employment and a non-employment land use location.
O-3	State Park Office Trailer - This is an employment land use location for persons 18 and older.
O-5	Camp Horno Motor Pool - This is an employment land use location for persons 17 and older.
O-6	Surf Beach (Lifeguard) - This is an employment land use location for persons 18 and older.
O-8	Camp San Mateo Motor Pool - This is an employment land use location for persons 17 and older.
O-9	USMC CP Sanitary Landfill - This is an employment land use location for persons 18 and older.
O-10	Camp San Onofre Waste Water Treatment Plant (STP #11) - This is an employment land use location for persons 18 and older.
R-C2	San Onofre Fire Station #7 52 Area - This is an employment land use location for persons 18 and older.
5	Surf Beach Guard Shack - This is an employment land use location for persons 18 and older.
22	SCE Land Uses-Are occupied by unmonitored SCE workers.
31A	Border Patrol Checkpoint - This is an employment land use location for persons 18 and older.
32	Southbound Highway Patrol Weigh Station - This is an employment land use location for persons 18 and older.

SONGS Beach Walkway - The beach walkway runs adjacent to the SONGS seawall and has been open to members of the general public for all of 2019. This is primarily a recreational land use but it is not associated with a specific fixed location. Measuring the beach walkway occupancy is not specifically required by procedure. However, the direct radiation exposure (as measured by REMP TLD data) along the walkway can be indicative of dose to a member of the general public. An occupancy value of 300 hours for the year was determined appropriate for the beach walkway occupancy.

Table 38 – Camp Pendleton Hunting Take Data. July 1, 2018 – June 30, 2019

Area		Deer Hunter Effort	Sm Game Hunter Effort	Deer	Coyote	Dove	Quail	Rabbit	Squirrel	Pigeon
		Hours	Hours							
Alpha-1	B(3),C(3.2)	120	135	2	3	14	4	0	60	0
Alpha-2	E(0.8),D(0.8),C(3)	176	100	5	1	0	3	0	0	0
Alpha-3	D(2.2)	144	39	1	0	2	0	0	67	0
Bravo-2	B(3.8), A(4.2)	144	42	2	0	2	5	2	1	0
Bravo-3	B(1.6),A(1.8),R(1.8)	16	10	0	0	0	1	0	0	0
Romeo-1	E(1)	144	41	2	0	0	5	0	0	0
Romeo-2	E(2.6)	272	88	7	0	4	1	0	0	0
Romeo-3	E(1.4), F(1.5)	168	0	4	0	0	0	0	0	0
Papa-2 & Tango	F(5)	352	75	9	0	10	0	2	35	0
Totals		1536	530	32	4	32	19	4	163	0

1. The total hunting hours includes time attributable to multiple individuals. This value bounds the maximally exposed individual.

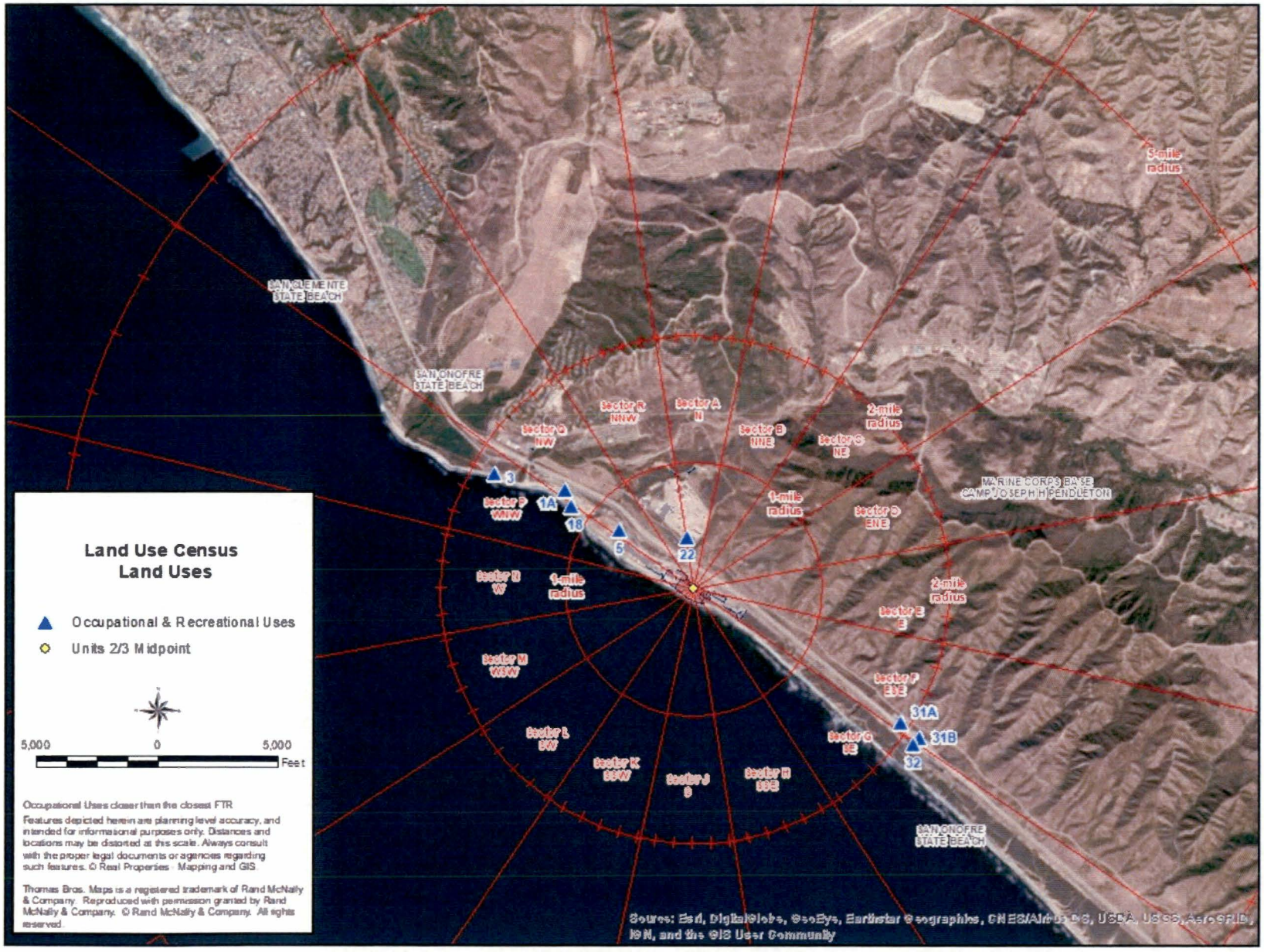


Figure 12 - Land Use Census: Land Uses

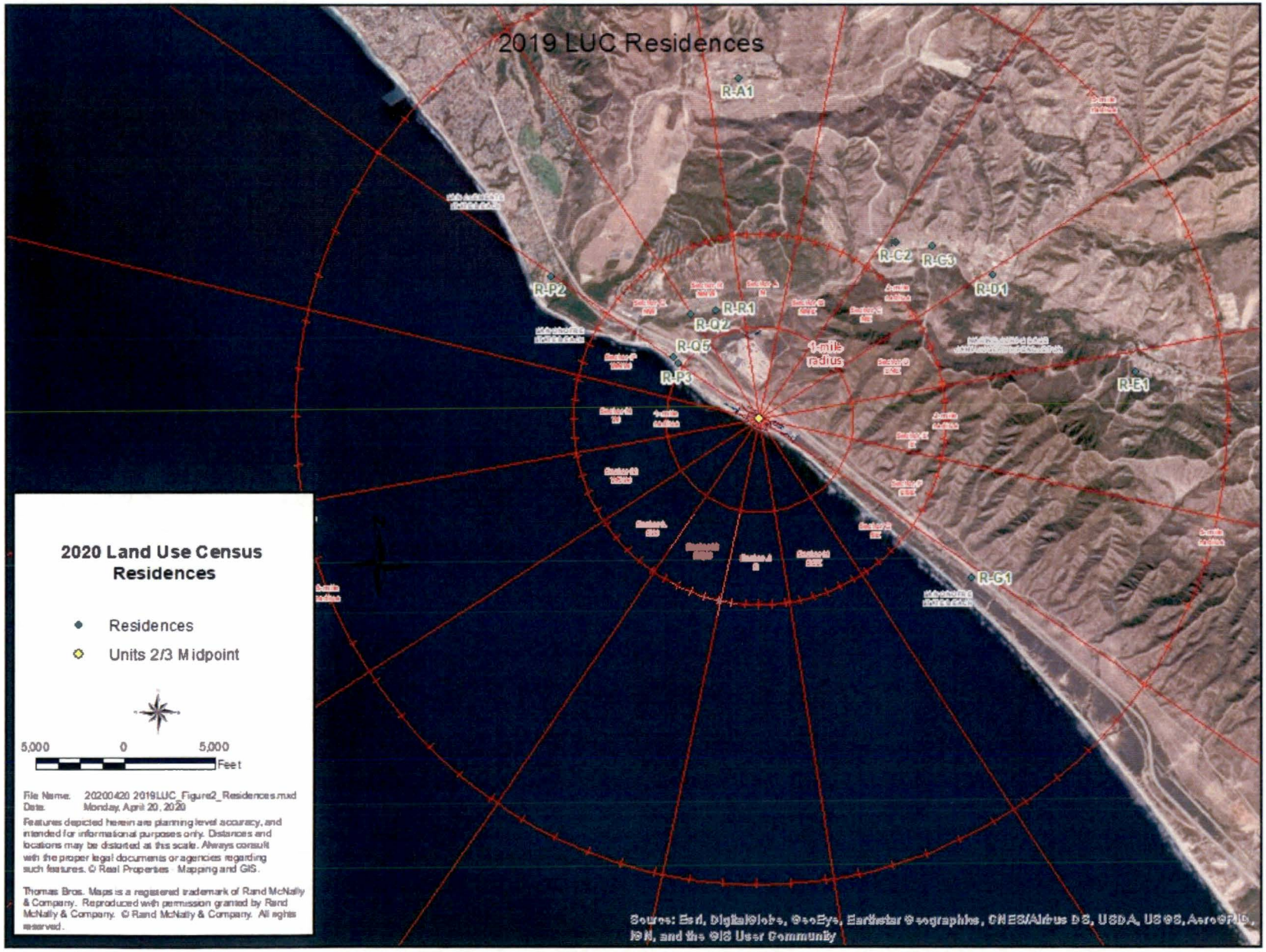


Figure 13 - Land Use Census: Residences

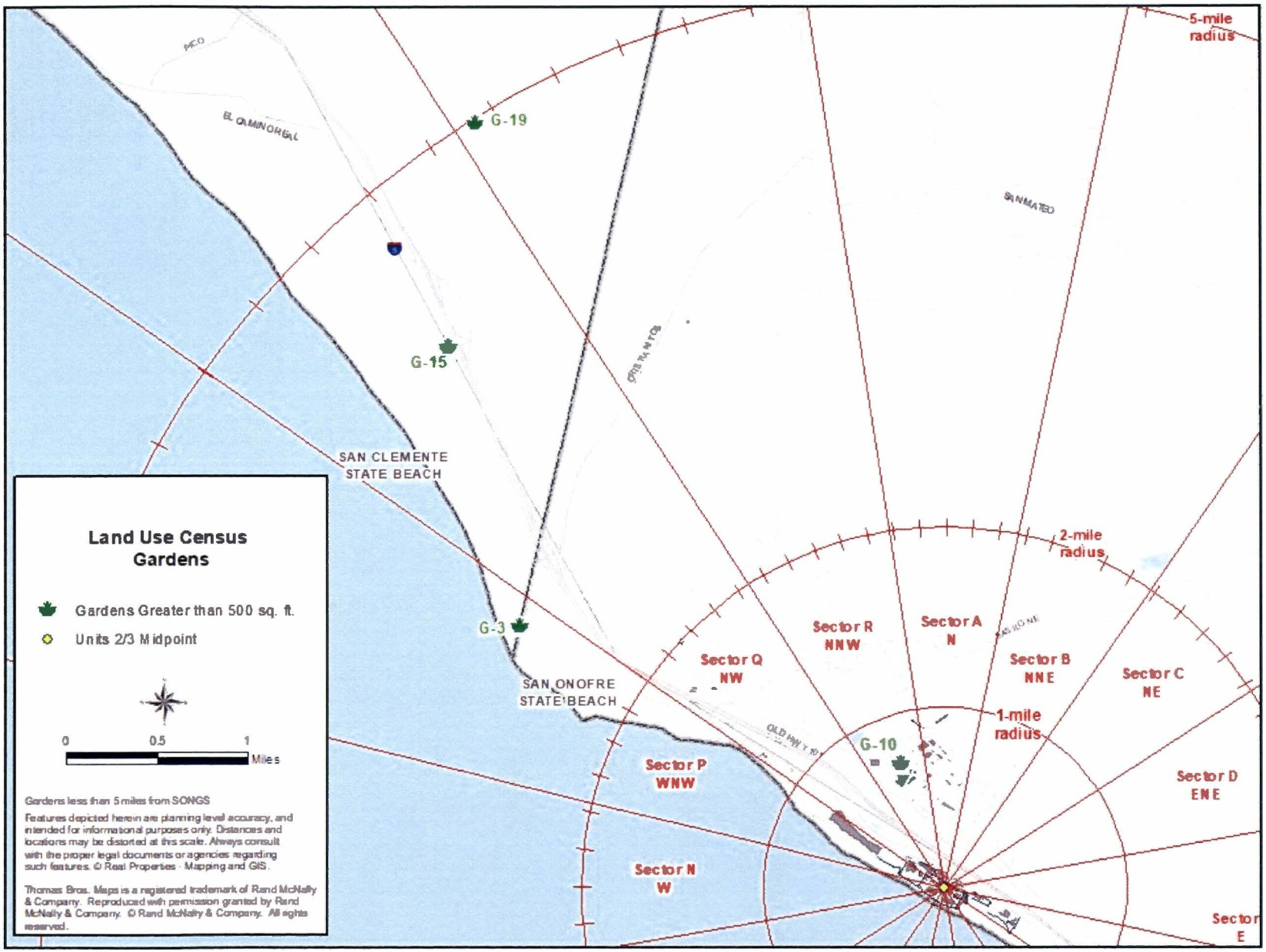


Figure 14 - Land Use Census: Gardens

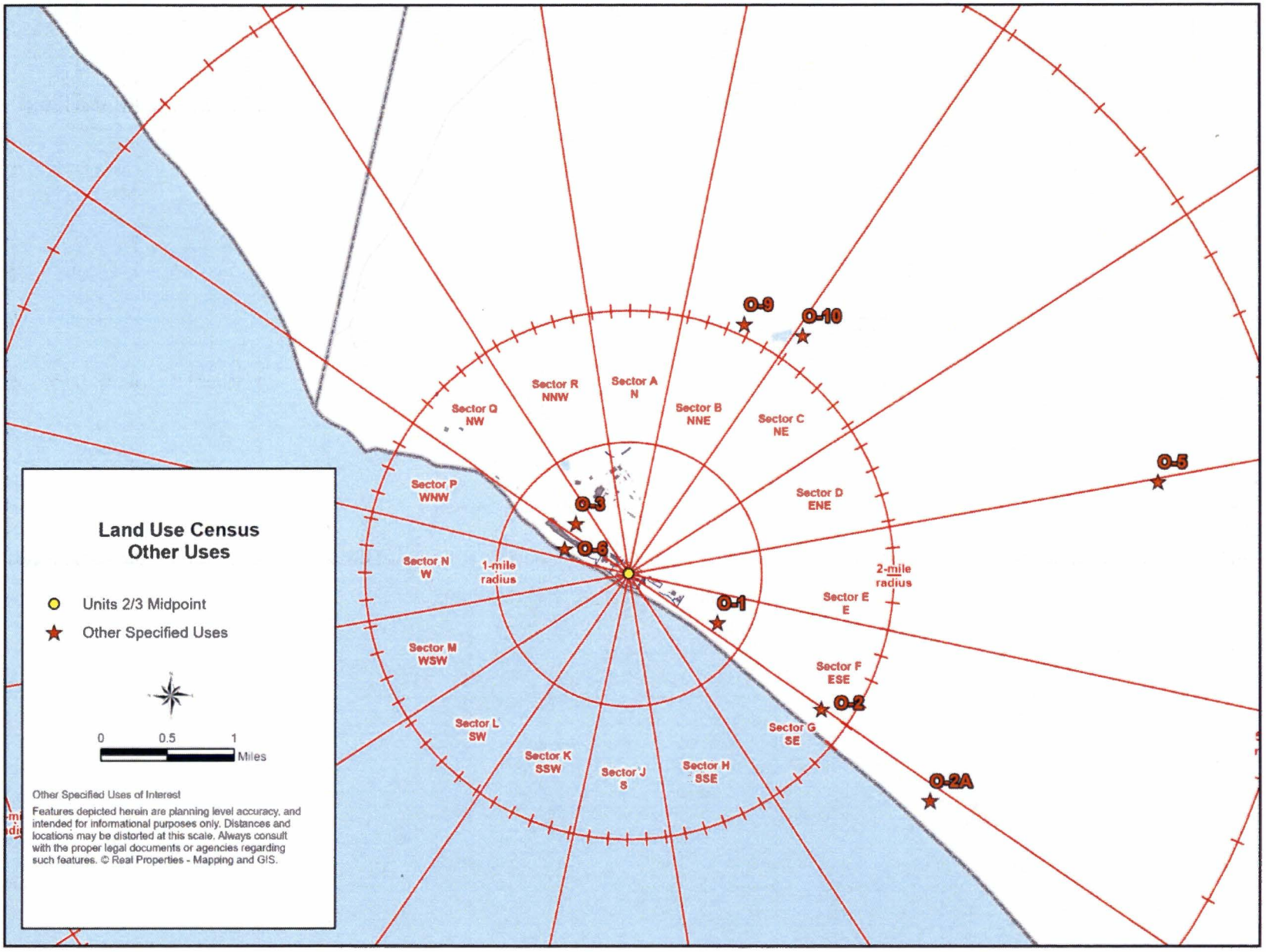


Figure 15 - Land Use Census: Other Uses

APPENDIX G. ERRATA TO PREVIOUS AREORs

The 2018 AREOR reported numerical results for the LLD in units of pCi/kg in the statistical summary of REMP data (Appendix B) for Table 7 (Shoreline Sediment), Table 12 (Ocean Bottom Sediment), Table 9 (Non-migratory Marine Animals), and Table 8 (Local Crops). However, the column heading was inappropriately labeled pCi/g.

In Table 24 of the 2018 AREOR the reported LLDs for soil were 80 and 60. The correct LLDs and units for soil were 0.150 pCi/g and 0.180 pCi/g.

These two errors do not change the conclusion of the 2018 AREOR.

APPENDIX H. CDPH CO-LOCATED TLDs

DATA FROM THE CDPH TLDs CO-LOCATED WITH SONGS REMP TLDs DURING 2019

California Department of Public Health (CDPH) maintains a TLD program in the environs of SONGS. Per CDPH request, the 2019 exposure results from the CDPH dosimeters are reported in the table below. The Location Numbers refer to the current SDS (SONGS Decommissioning Solutions) alphanumeric location identifier and the current CDPH location number.

Table 39 - 2019 State of California Data from the CDPH TLD program (mR/standard quarter)

Location Numbers	Location Name	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
SDS-1, CDPH #2	City of San Clemente	8	8	15	12
SDS-22, CDPH #4	Former US Coast Guard Station – San Mateo Point	6	3	12	12
SDS-34, CDPH #5	San Onofre Elementary School	M	M	15	14
SDS-10, CDPH #6	Bluff (Adjacent to PIC #1) (San Onofre Surfing Beach)	8	9	16	16
SDS-16, CDPH #7	East Southeast Site Boundary	6	4	11	9
SDS-2, CDPH #8	Camp San Mateo	15	3	18	16
SDS-3, CDPH #9	Camp San Onofre	9	5	15	14
SDS-6, CDPH #10	Old El Camino Real (Old Highway 101) (ESE)	-1	3	7	7
SDS-50, CDPH #13	Oceanside Fire Station	7	5	16	14

M=CDPH RHB data is not available from CDPH location #5 for the 1st and 2nd quarter 2019. The TLD was missing during collection.

The CDPH TLD program does not conform to the same environmental dosimeter standard USNRC Regulatory Guide 4.13 (ANSI N13.37-2014) used to generate direct radiation data for the SONGS REMP TLD program. CDPH lab reports results in different units of measurement and is therefore not technically equivalent to the SONGS TLD data set. The different methodologies and the different units of measurement make it unsuitable to directly compare individual REMP data to the corresponding individual CDPH TLD data. However, the CDPH results are consistent with conclusion that, beyond the EAB, there is no detectable direct radiation signal attributable to SONGS.

APPENDIX I. ISFSI TLD DATA

Summary

Per 10 CFR 72.126, SONGS implemented an area monitoring TLD program in the vicinity of the ISFSI.

An evaluation of the entire REMP TLD database yielded an estimated background exposure rate of approximately 15.8 mrem/std. quarter (91 days). However, some local variability within the CAB / EAB is to be attributable to factors external to SONGS. Therefore, a comparison of pre-operational data and operational data needs to be considered in conjunction with a comparison of ISFSI TLD data and the estimated baseline background exposure rate within the EAB.

Environmental exposure rates are variable and small changes in TLD location can measurably change the data. SONGS REMP TLD data show an environmental seasonal variability that are not related to any activities at SONGS. The ISFSI TLD data gathered to date follow a similar seasonal variability (Figure 17).

In addition to environmental factors, some non-ISFSI work activities at Unit 1 have elevated the pre-operational measured ISFSI TLD exposure. The storage and transport of radioactive materials and waste near the location of the ISFSI foundation area in 2001 and 2002 have elevated the exposure rates of TLDs 306 to 315. TLD 306 was retired in 2018 to accommodate work in preparation for the Unit 1 reactor vessel transport. In addition, the movement of the Unit 1 reactor vessel in October 2002 caused a noticeable increase in the measured exposure for TLDs 301 to 315. The measured exposure rate for the ISFSI TLDs close to the ISFSI is consistent with the exposure rate expected from known radiological work activities. The elevated exposure rate from TLDs 301, 302, 303, 304, 323, 324, 325, 326, 327 and 328 in 2019 is primarily due to the movement and storage of used fuel at the ISFSI during the year.

In the second quarter of 2011 additional TLDs 327 and 328 were placed along the fence on the southwest side of the ISFSI. These TLDs routinely have the highest measured doses, as they did in 2019. These locations are not accessible to members of the public and were retired in 2019.

Publicly accessible REMP TLD locations SCE-55 (San Onofre State Beach U1West) and SCE-56 (located next to SCE-55) recorded measurable annual facility doses at approximately 18.2 and 12.7 mrem/year respectively, including the estimated neutron exposure. This correlates to an occupancy adjusted annual dose to a member of the general public of 1 mrem/year. TLDs 55 and 56 are the REMP TLDs locations closest to the ISFSI and this is the most conservative place available to measure dose to a member of the general public attributable to SONGS.

Starting in the fourth quarter 2010 neutron dosimeters were placed in ISFSI TLD canisters 311, 324, 325, and 326. In the second quarter 2011 neutron dosimeters were also placed adjacent to TLDs 327 and 328. Beginning in the 4th quarter of 2016, neutron TLDs were co-located with locations SCE-339 through SCE-343. The neutron TLDs were added to obtain neutron information prior to the off load of spent fuel from Units 2 and 3.

The 2019 neutron TLDs identified measurable levels of neutron radiation from spent fuel in dry storage. A dose equivalent conversion factor for the TLD neutron signal based on a similar ISFSI facility at another site was adopted to estimate the neutron dose rate at SONGS. It is being applied to the SONGS TLD results only to provide an estimate of the neutron dose equivalent being measured. The neutron dose has been included in the quarterly results for these locations in Table 40. The results from all locations at the fence around the ISFSI pad show that a member of the public, when adjusted for occupancy is less than the minimum detectable dose.

Table 40 - 2019 ISFSI TLD Data

TLD (SCE-##)	Location[a]	Qtr. Baseline (mrem)	2019 Quarterly Results (mrem)[f]				Baseline Adjusted Quarterly Results (mrem)				Annual Dose (mrem)	Annual Facility Dose (mrem)	Annual Public Dose[b] (mrem)
			1	2	3	4	1	2	3	4			
301		15.8	18.9	17.2	18.2	18.7	ND	ND	ND	ND	73.1	10.0	ND
302		15.8	21.8	20.2	22.9	24.1	6.0	ND	7.1	8.3	89.0	25.9	ND
303		15.8	22.0	21.1	21.5	22.3	6.2	5.3	5.8	6.5	86.9	23.8	ND
304		15.8	21.0	19.2	20.0	20.7	5.2	ND	ND	ND	80.9	17.8	ND
307		15.8	21.1	20.2	20.8	21.1	5.3	ND	5.0	5.3	83.1	20.0	ND
308		15.8	19.9	18.8	19.7	19.7	ND	ND	ND	ND	78.2	15.1	ND
309		15.8	20.5	18.8	20.6	19.2	ND	ND	ND	ND	79.1	16.0	ND
310		15.8	21.1	20.2	20.9	20.0	5.4	ND	5.1	ND	82.2	19.2	ND
311	ISFSI-01[c]	15.8	20.8	19.1	21.4	19.7	ND	ND	5.6	ND	81.0	17.9	ND
312		15.8	15.8	14.9	16.6	15.3	ND	ND	ND	ND	62.5	ND	ND
314		15.8	20.9	19.3	19.9	20.4	5.2	ND	ND	ND	80.5	17.4	ND
315		15.8	20.2	18.8	19.4	19.3	ND	ND	ND	ND	77.7	14.6	ND
316		15.8	16.0	15.4	15.7	16.7	ND	ND	ND	ND	63.9	ND	ND
317		15.8	18.0	16.3	17.0	17.4	ND	ND	ND	ND	68.7	ND	ND
318[e]		15.8	20.4	18.4	19.4	19.2	ND	ND	ND	ND	77.4	14.3	ND
319[e]		15.8	19.1	18.6	18.8	18.8	ND	ND	ND	ND	75.2	12.2	ND
320[e]		15.8	19.5	18.7	19.3	18.6	ND	ND	ND	ND	76.1	13.0	ND
321[e]		15.8	19.8	18.1	19.4	19.8	ND	ND	ND	ND	77.0	13.9	ND
322		15.8	18.6	17.7	---	---	ND	ND	N/A	N/A	36.2	N/A	N/A
323		15.8	20.5	20.5	---	---	ND	ND	N/A	N/A	41.0	N/A	N/A
324	ISFSI-04[c]	15.8	26.8	26.7	---	---	11.0	10.9	N/A	N/A	53.5	N/A	N/A
325	ISFSI-03[c]	15.8	26.4	25.7	---	---	10.7	9.9	N/A	N/A	52.1	N/A	N/A
326	ISFSI-02[c]	15.8	21.6	21.4	23.7	25.1	5.9	5.6	7.9	9.3	91.8	28.7	ND
327	ISFSI-05[c]	15.8	51.1	49.2	---	---	35.3	33.4	N/A	N/A	100.3	N/A	N/A
328	ISFSI-06[c]	15.8	44.0	36.1	---	---	28.3	20.3	N/A	N/A	80.1	N/A	N/A
339	ISFSI-08[c]	15.8	21.3	19.8	25.1	25.4	5.6	ND	9.3	9.7	91.7	28.6	ND
340	ISFSI-09[c]	15.8	20.5	18.1	21.9	22.7	ND	ND	6.2	7.0	83.2	20.2	ND
341	ISFSI-10[c]	15.8	23.2	21.1	22.1	22.5	7.4	5.3	6.3	6.7	88.8	25.7	ND
342	ISFSI-11[c]	15.8	24.4	24.1	25.2	25.8	8.6	8.3	9.5	10.0	99.5	36.4	ND

TLD (SCE-##)	Location[a]	Qtr. Baseline (mrem)	2019 Quarterly Results (mrem)[f]				Baseline Adjusted Quarterly Results (mrem)				Annual Dose (mrem)	Annual Facility Dose (mrem)	Annual Public Dose[b] (mrem)
			1	2	3	4	1	2	3	4			
343	ISFSI-12[c]	15.8	21.4	21.3	21.5	23.0	5.7	5.5	5.7	7.2	87.2	24.2	ND
344		15.8	20.6	19.4	20.6	20.2	ND	ND	ND	ND	80.9	17.8	ND
55[d, e]	San Onofre State Beach (U1 West) ISFSI-07[c]	15.8	21.5	19.5	19.9	20.4	5.7	ND	ND	ND	81.3	18.2	ND
56[d]	San Onofre State Beach (U1 West)	15.8	19.7	18.6	18.3	19.2	ND	ND	ND	ND	75.8	12.7	ND
57[d)]	San Onofre State Beach (Unit 2)	15.8	18.0	16.8	17.8	17.8	ND	ND	ND	ND	70.5	ND	ND
59	SONGS Meteorological Tower	15.8	20.6	19.7	20.2	19.9	ND	ND	ND	ND	80.4	17.3	ND

Notes:

a ISFSI TLDs are placed around the ISFSI pad, and not in locations accessible to the general public.

b Public dose is based on the individual location occupancy as specified.

c Station has a collocated neutron dosimeter package. The neutron dose is estimated using a neutron signal conversion factor measured at a similar ISFSI installation (HPSTID 08-015).

d These TLDs are publicly accessible.

e For TLD 55 the estimated neutron dose contributed to the total measured dose in 2019.

f For locations with a collocated neutron dosimetry package the measured neutron dose (if any) is included in the reported dose.

Figure 16 - SONGS ISFSI and Selected REMP TLD Locations

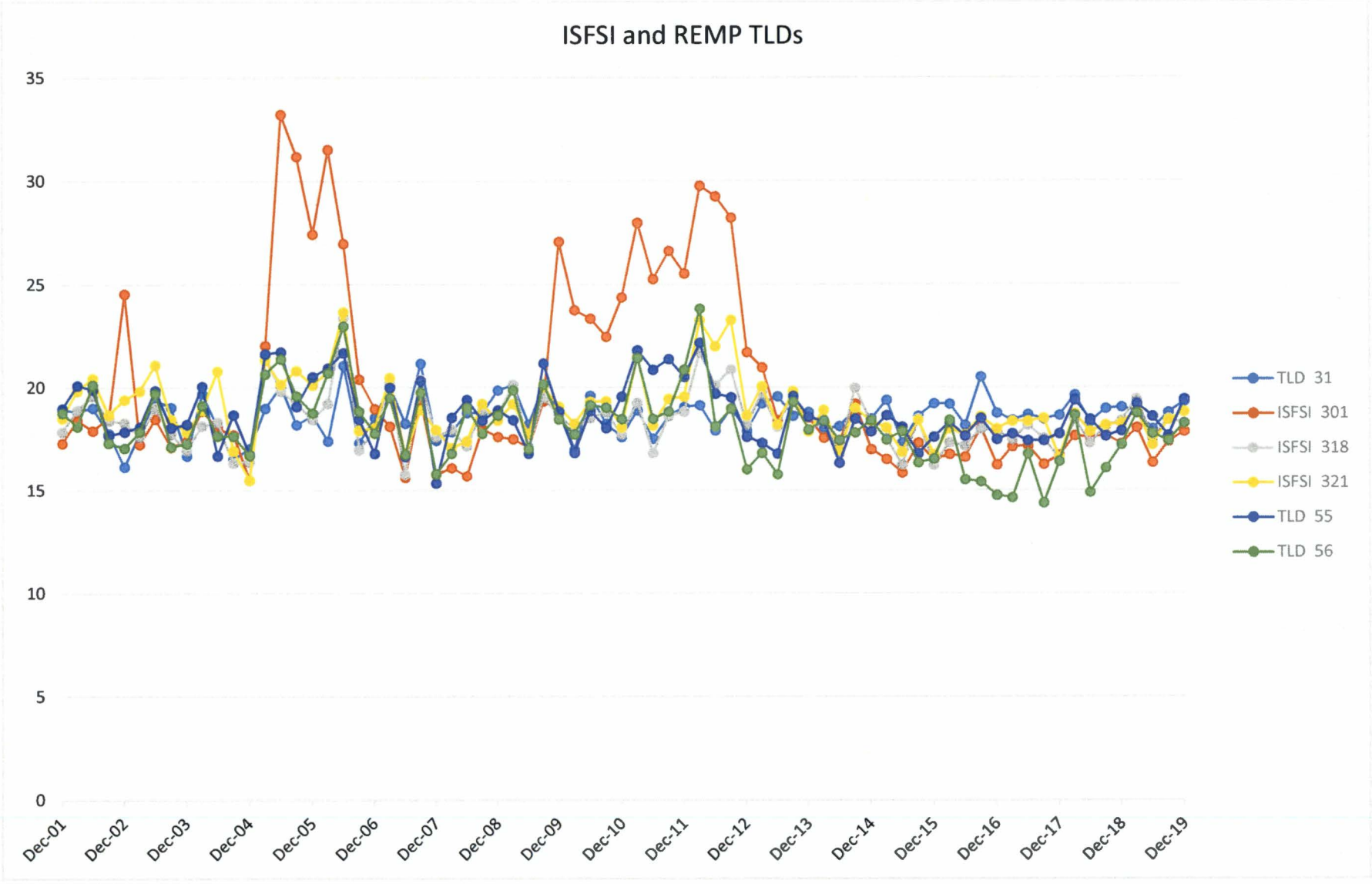


Figure 17 - ISFSI and REMP TLDs

APPENDIX J. OFFSITE GROUND WATER SAMPLING

Offsite Drinking Water

All investigations have shown that there are no drinking water pathways at SONGS.

Figure 18 below illustrates groundwater well locations along with the flow of the groundwater. SONGS had no impact on drinking water wells in the vicinity of SONGS.

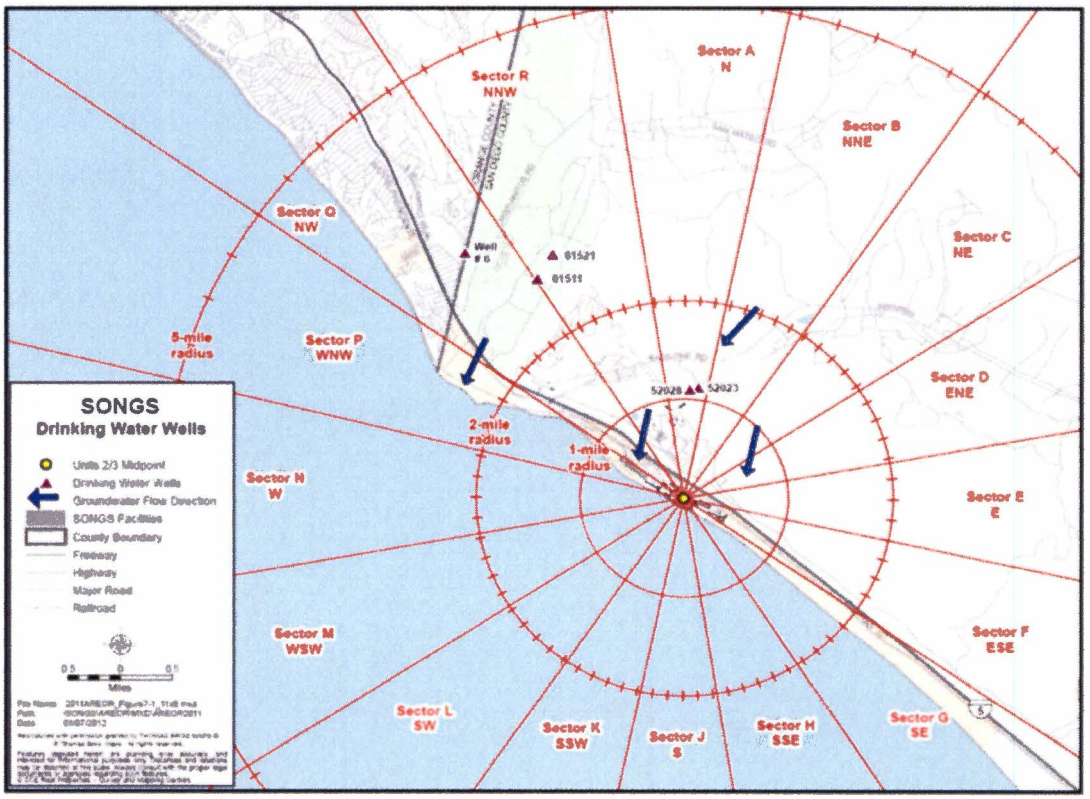


Figure 18 - Closest Drinking Water Wells

Glossary

a posteriori After the fact

a priori Before the fact

ALARA As Low As is Reasonably Achievable means making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.

Cosmogenic nuclides Radionuclides (or isotopes) created when a high-energy cosmic ray interacts with the nucleus of an atom. These isotopes are produced within Earth materials such as rocks or soil, in Earth's atmosphere, and in extraterrestrial items such as meteorites. Radioactive isotopes beryllium-7 and beryllium-10 fall into this series of three light elements (lithium, beryllium, boron) formed mostly by cosmic ray spallation nucleosynthesis, both of these nuclides have half-lives too short for them to have been formed before the formation of the Solar System, and thus they cannot be primordial nuclides. Since the cosmic ray spallation route is the only possible source of beryllium-7 and beryllium-10 occurrence naturally in the environment, they are therefore cosmogenic.

Below is a list of radioisotopes formed by the action of cosmic rays in the atmosphere; the list also contains the production mode of the isotope.

Isotope	Mode of formation	Isotope	Mode of formation
^{3}H (tritium)	^{14}N (n, $^{12}C)^{3}H$	^{32}P	Spallation (Ar)
^{7}Be	Spallation (N and O)	^{34m}Cl	Spallation (Ar)
^{10}Be	Spallation (N and O)	^{35}S	Spallation (Ar)
^{11}C	Spallation (N and O)	^{36}Cl	^{35}Cl (n, γ)^{36}Cl
^{14}C	^{14}N (n, p) ^{14}C	^{37}Ar	^{37}Cl (p, n)^{37}Ar
^{18}F	^{18}O (p, n)^{18}F and Spallation (Ar)	^{38}Cl	Spallation (Ar)
^{22}Na	Spallation (Ar)	^{39}Ar	^{38}Ar (n, γ)^{39}Ar
^{24}Na	Spallation (Ar)	^{39}Cl	^{40}Ar (n, np)^{39}Cl & spallation (Ar)
^{28}Mg	Spallation (Ar)	^{41}Ar	^{40}Ar (n, γ)^{41}Ar
^{31}Si	Spallation (Ar)	^{81}Kr	^{80}Kr (n, γ) ^{81}Kr
^{32}Si	Spallation (Ar)		

Decay Series	There are three naturally occurring decay series of heavy elements that transform into a series of various radioactive elements by releasing energy in the form of particles, (such as alpha or beta), and/or gamma rays to end in a stable form of non-radioactive Lead. All three decay series start with extremely long lived radioactive, heavy elements that can be measured in geologic time units. They are Uranium-238 with an approximate half-life of 4.5 billion years, Uranium -235 with a half-life of about 700 million years, and Thorium- 232 with a half-life of 14 billion years. All three series contain some more well-known radioactive species, Radium and Radon.
Distinguishable from background	Detectable concentration of a radionuclide that is statistically different from the background concentration of that radionuclide at that location.
Dose	The amount of radiation that is absorbed by a person's body. In the radiation field the term dose is sometimes used interchangeably with dose equivalent.
Half-life	A measure of how fast half the mass of a radioactive element will transform itself into another element. Each radioactive element has its own unique rate of transformation. Consequently, if a radioactive element, such as Iodine-131 has a half-life of 8 days, then in 8 days half of the original amount of Iodine-131 will be gone; in another 8 days half of that half will be left and so on.
Gamma Spectroscopy	A scientific method used to analyze gamma rays emanating from radioactive elements. The analytical system determines the gamma ray energy which acts as a "fingerprint" for specific radioactive materials. For example, Potassium-40 (K-40) has a very, distinctive gamma energy at 1460 keV. This uniqueness allows the instrument to positively identify the K-40 1460 energy as its own unique fingerprint. A keV is an abbreviation for kilo electron volt, which is a measure of energy at the atomic level. A kilo is a scientific prefix for the multiplier 1,000.
Gross Beta	A screening technique employed to measure the total number of beta particles emanating from a radioactive sample, without isotopic identification. At SONGS samples with an elevated gross beta are analyzed by gamma spectroscopy to identify the specific radionuclides causing the elevated gross beta signal. A beta particle is a negatively charged particle a mass equal to that of an orbiting electron.
Liquid Scintillation	The analytical technique by which tritium activity is measured in water. A sample is placed in a glass vial containing scintillation cocktail. The mixture is sealed and homogenized. When the tritium decays it emits a very low energy beta particle. The beta interacts with the scintillating medium and produces a light pulse that is counted by the instrument.
Millirem (mrem)	one thousandth (1/1000) of a rem.
milliRoentgen (mR)	one thousandth (1/1000) of a Roentgen

pCi/kg	an acronym for a pico-curie per kilogram, which is a concentration unit that defines how much radioactivity is present in a unit mass, such as a kilogram. A "pico" is a scientific prefix for an exponential term that is equivalent to one trillionth (1/1,000,000,000,000).
pCi/l	an acronym for a pico-curie per liter, which is a concentration unit that defines how much radioactivity is present in a unit volume, such as a liter.
Rem	an acronym for roentgen equivalent man. It is a conventional unit of dose equivalent that is based on how much of the radiation energy is absorbed by the body multiplied by a quality factor, which is a measure of the relative hazard of energy transfer by different particles, (alpha, beta, neutrons, protons, etc.), gamma rays or x-rays. In comparison the average natural background radiation dose equivalent to the United States population is estimated to be 292 millirems per year, or 0.8 millirem per day, with 68 % of that dose coming from radon. A millirem is one thousandth, (1/1000), of a rem.
Roentgen	a special unit of exposure named after the discoverer of X-Rays, Wilhelm Roentgen. It is a measure of how much ionization is produced in the air when it is bombarded with X-Rays or Gamma Rays. Ionization is described as the removal of an orbital electron from an atom.
Skyshine	is radiation from a radioactive source that bounces off air molecules in the sky, much like a cue ball does off the banking of a billiard table, and is scattered/redirected back down to the earth.
Thermolumines cent Dosimeters (TLD)	very small plastic-like phosphors or crystals that are placed in a small plastic cage and mounted on trees, posts, etc. to absorb any radiation that impinges on the material. Special readers are then used to heat the plastic to release the energy that was stored when the radiation was absorbed by the plastic. The energy released is in the form of light and that light is counted by the TLD reader. The intensity of the light emitted from the crystals is directly proportional to the amount of radiation that the TLD phosphor was exposed to.
Site Area Boundary (SAB)	SONGS SAB is defined as that line beyond which the land is not owned, leased, or otherwise controlled by the licensee; from ODCM definition.
Tritium (Hydrogen-3 or H-3)	H-3 is the naturally occurring radioactive form of Hydrogen. All radioactive elements are represented as a combination of their chemical symbol and their mass number. Therefore, Tritium, which is a heavy form of the Hydrogen molecule with one proton and two neutrons in the nucleus of its atom, is abbreviated and represented by its chemical symbol, H-3, for Hydrogen and 3 for the number of particles in its nucleus, or mass number. Similarly, other radioactive elements, such as Potassium-40, can be represented and abbreviated as K-40, and so on.