Susquehanna Steam Electric Station

Units 1 & 2

2012 ANNUAL REPORT

Annual Radiological Environmental Operating Report

ppl

PPL Susquehanna, LLC
Berwick, PA
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SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 and 2

Annual Radiological
Environmental Operating Report

2012

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Annual Radiological Environmental Operating Report for PPL Susquehanna, LLC Units 1 and 2

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SUMMARY AND CONCLUSIONS

Radiological Dose Impact

This report on the Radiological Environmental Monitoring Program covers the year 2012.

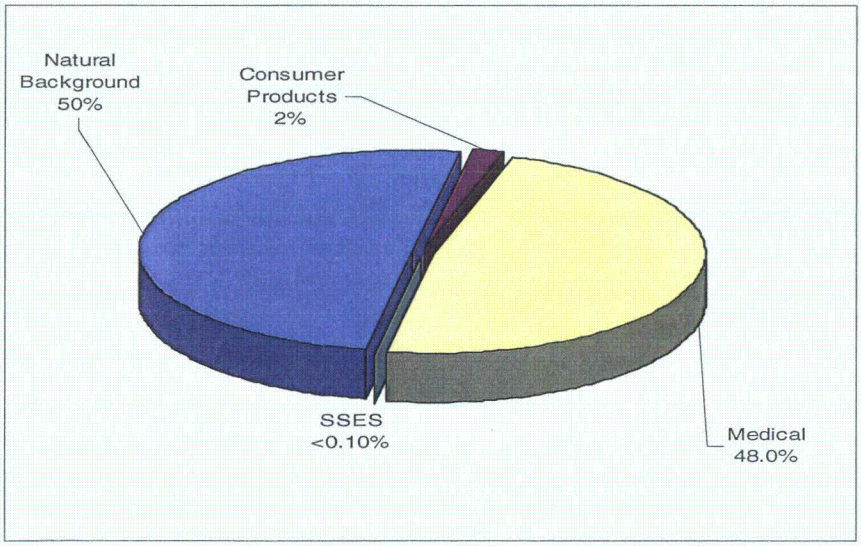
During that period, 1084 samples were collected at 57 sampling locations. Additionally, 228 optically stimulated luminescence dosimeters (OSLD) direct radiation measurements were performed at 57 locations around the site.

In assessing all the data gathered and comparing with SSES pre-operational data, it was concluded that the operation of SSES had no adverse radiological impact on the health and safety of the public or the environment.

The total whole body dose from both ingested radionuclides and direct radiation from SSES operations is negligible compared to the public's 620 millirem/year exposure from natural background radiation, medical irradiation, and radiation from consumer products.

The following graph compares public dose from SSES operation to that from other sources of radioactivity and radiation.

COMPARISON OF PERCENT OF AVERAGE ANNUAL PUBLIC EFFECTIVE DOSE-EQUIVALENT FROM OTHER SOURCES WITH WHOLE-BODY DOSE FROM THE SSES (NCRP REPORT NO. 160-2009)



Ambient Gamma Radiation

Environmental direct radiation measurements were performed quarterly on and around the SSES site using OSLDs.

The maximum direct radiation dose from SSES operation to a member of the public was approximately 7.21E-01 mrem for all of 2012. This dose represents approximately 2.88% of the 25-mrem whole-body SSES Technical Requirements (TRO 3.11.3) limit for all SSES sources of radioactivity and radiation.

Aquatic Environment

Surface water samples were analyzed for concentrations of tritium, and gamma emitting nuclides. Drinking water samples were analyzed for concentrations of gross beta, tritium and gamma emitting nuclides. Gross beta activities detected in drinking water were consistent with those reported in previous years.

Tritium activity attributable to SSES operation was detected in the aquatic pathway to man. The maximum dose from the ingestion of tritium was estimated at the nearest downriver municipal water supplier via the drinking water pathway and near the outfall of the SSES discharge to the Susquehanna River via the fish pathway. The maximum whole body and organ dose due to tritium identified via REMP samples is approximately 1.32E-03 mrem/year. This dose is less than one-tenth of one percent of the dose guidelines stated in 10 CFR 50, Appendix I.

Fish samples were analyzed for concentrations of gamma emitting nuclides. Concentrations of naturally occurring K-40 were consistent with those detected in previous years. No fission or activation products were detected in fish.

Sediment samples were analyzed for concentrations of gamma emitting nuclides. Concentrations of naturally occurring K-40, radium-226, and actinium-thorium-228 were found consistent with those detected in previous years. Cesium-137 was detected in sediment and determined to be residual fallout from atmospheric nuclear weapons testing in the 1940s through the 1970s and was not attributable to station operations. No fission or reactor byproducts were detected in sediment.

Atmospheric Environment

Air particulate samples were analyzed for concentrations of gross beta and gamma emitting nuclides. Cosmogenic Be-7 was detected at levels consistent with those detected in previous years.

Air iodine samples were analyzed for concentrations of iodine-131. All results were less than the MDC.

Terrestrial Environment

Soil samples were analyzed for concentrations of gamma emitting nuclides. Cesium-137 was observed in 1 of 4 soil samples and attributed to non-SSES sources (residual fallout from atmospheric weapons testing). Concentrations of naturally occurring

K-40 were consistent with those detected in previous years. Concentrations of naturally occurring actinium-thorium-228 and radium-226 were consistent with those of previous years.

Cow milk samples were analyzed for concentrations of iodine-131 as well as other gamma emitting nuclides. All iodine results were less than the MDC. Concentrations of naturally occurring K-40, and thorium-228 were consistent with those detected in previous years. No fission or activation products were detected.

Potatoes and field corn which were irrigated with Susquehanna River water downstream of the SSES were sampled. These food products were sampled during the harvest season and analyzed for concentrations of gamma emitting nuclides. The concentration of naturally occurring K-40 was found consistent with those in previous years. No fission or activation products were detected.

Ground Water

Ground water samples were analyzed for concentrations of tritium and gamma emitting nuclides. Tritium was observed in 9 of 60 samples slightly above analysis MDC's in 2012. The source of the tritium is due to recaptured tritium from routine airborne effluent releases from Susquehanna operations and subsequent precipitation washout and infiltration into groundwater. This tritiated precipitation makes its way into surface water and soil where it eventually seeps into shallow ground water. No fission or activation products were detected.

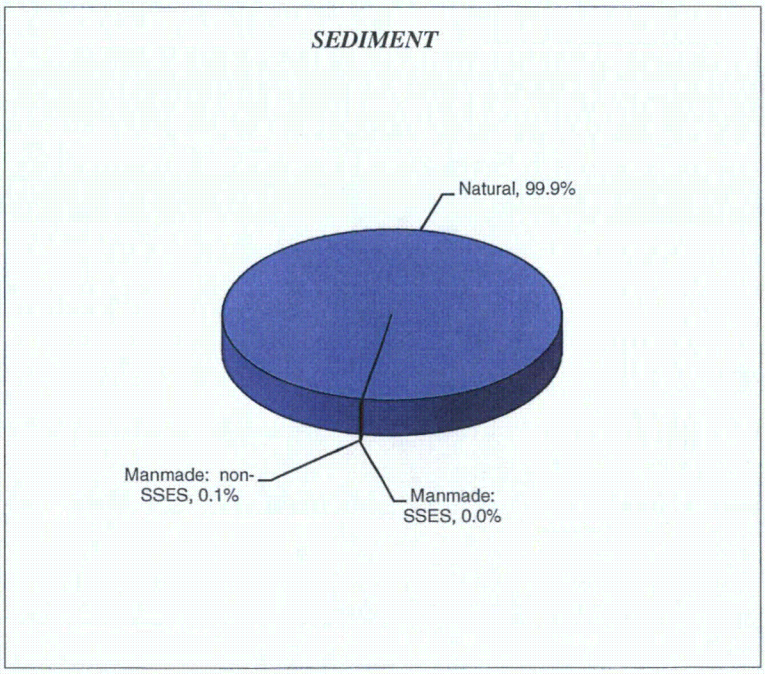
Relative Radionuclide Activity Levels in Selected Media

Some media monitored in the environment are significant for the numbers of gamma-emitting radionuclides routinely measured at levels exceeding analysis MDCs. Sediment in the aquatic pathway and soil in the terrestrial pathway are two such media.

The following graphs show the relative activity contributions for the types of gamma-emitting radionuclides reported at levels above the analysis MDCs in sediment and soil at indicator locations during 2012.

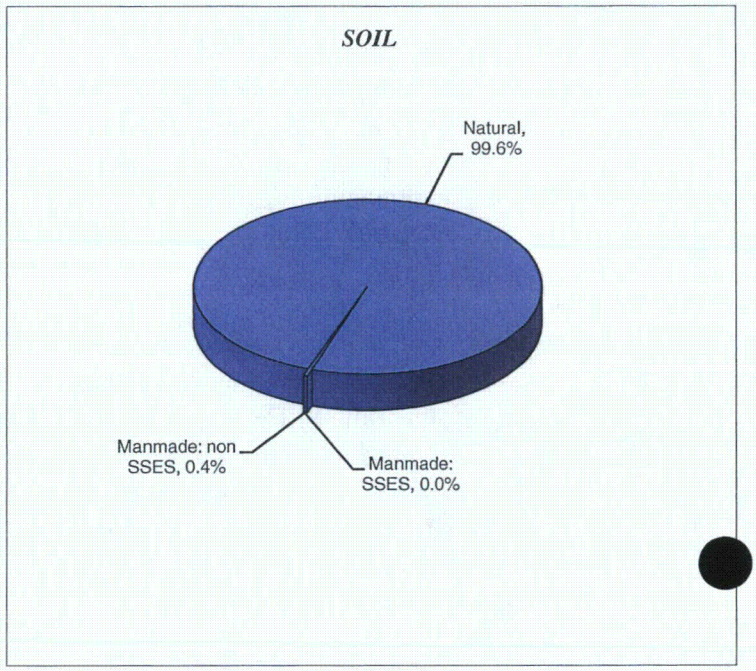
AQUATIC PATHWAY

PERCENT TOTAL GAMMA ACTIVITY



TERRESTRIAL PATHWAY

PERCENT TOTAL GAMMA ACTIVITY



Naturally occurring radionuclides accounted for over 99% of the gamma-emitting activity in both sediment and soil in 2012. Man-made radionuclides of SSES origin accounted for 0.0% of the gamma-emitting activity in sediment and soil during 2012.

Radionuclides Contributing to Dose from SSES Operation

Of the two man-made radionuclides detected in the environment by the SSES REMP (H-3 and Cs-137), tritium is the only radionuclide attributable to SSES operation.

The whole body and organ dose to members of the public attributable to tritium identified in REMP blowdown samples was 1.32E-03 mrem.

Tritium was included in the dose calculation because it was identified in the REMP samples of water being discharged to the river. The concentration of tritium in the water and the volume of water discharged were used to determine the amount of tritium released. The presumed exposure pathways to the public from this radionuclide were drinking water taken from the Susquehanna River at Danville, PA, and eating fish caught near the SSES discharge to the river. Dose from ground plane deposition (shoreline exposure) is not applicable because tritium does not emit gamma radiation and the beta radiation emitted by tritium is not sufficiently penetrating to reach an individual on the shore.

INTRODUCTION

Radiological Environmental Monitoring Program (REMP)

The SSES is located on approximately an 1500-acre tract along the Susquehanna River, five miles northeast of Berwick in Salem Township, Luzerne County, Pennsylvania. The area around the site is primarily rural, consisting predominately of forest and agricultural lands. (More specific information on the demography, hydrology, meteorology, and land use characteristics of the area in the vicinity of the SSES can be found in the Environmental Report (Reference 1), the Final Safety Analysis Report (Reference 2), and the Final Environmental Statement (Reference 3) for the SSES.)

The SSES implements the REMP in accordance with Technical Specifications, Technical Requirements Manual and the Offsite Dose Calculation Manual, which are based on the design objectives in 10CFR Part 50 Appendix I, Sections IV.B.2, IV.B.3, and IV.C.
The REMP supplements the results of the radioactive effluent-monitoring program by verifying that the measurable concentrations of radioactive materials and levels of radiation in the environment are not higher than expected on the basis of the effluent measurements and modeling of the environment in the vicinity of the SSES.

Key objectives of the SSES REMP are as follows:

- Document compliance with SSES REMP Technical Requirements radiological environmental surveillances
- Verify proper implementation of SSES radiological effluent controls
- Identify, measure, and evaluate trends of radionuclide concentrations in environmental pathways near SSES
- Assess impact of SSES Effluents on the environment and the public

PPL has maintained a Radiological Environmental Monitoring Program (REMP) in the vicinity of the Susquehanna Steam Electric Station Units 1 and 2 since April, 1972, prior to construction of both units and ten years prior to the initial operation of Unit 1 in September, 1982. The purpose of the preoperational REMP (April, 1972 to September, 1982) was to establish a baseline for radioactivity in the local environment that could be compared with the radioactivity levels observed in various environmental media throughout the operational lifetime of the SSES. This comparison facilitates assessments of the radiological impact of the SSES operation.

Potential Exposure Pathways

The three pathways through which radioactive material may reach the public from nuclear power plants are the atmospheric, terrestrial, and aquatic pathways. (Figure 1 depicts these pathways for the intake of radioactive materials.)

Mechanisms by which people may be exposed to radioactivity and radiation in the environment vary with the pathway. Three mechanisms by which a member of the public has the potential to be exposed to radioactivity or radiation from nuclear power plants such as the SSES are as follows:

- inhalation (breathing)
- ingestion (eating and drinking), and
- whole body irradiation directly from the deposition of nuclides on the ground or from immersion in the radioactive effluents.

REMP Scope

The scope of the SSES REMP was developed based on the NRC's Radiological Assessment Branch Technical Position on radiological environmental monitoring, as described in Revision 1, November 1979 (Reference 4). However, the REMP conducted by PPL for the SSES exceeds some of the monitoring suggested by the NRC's branch technical position, in terms of the number of monitoring locations, the frequency of certain monitoring, the types of analyses required for the samples, and the achievable analysis sensitivities.

During the operational period of the SSES, two different categories of monitoring locations, called control and indicator locations, were established to further assist in assessing the impact of station operation. Control locations are located at sites where it is considered unlikely that radiation or radioactive material from normal station operation would be detected. Indicator locations are sited where it is expected that radiation and radioactive material that might originate from the station would be most readily detectable.

Control locations for the atmospheric and terrestrial pathways are more than 10 miles from the station. Preferably, the controls also are in directions from the station less likely to be exposed to wind blowing from the station than are the indicator locations. Control locations for the aquatic pathway, the Susquehanna River, are upstream of the station's discharge to the river.

Indicator locations are selected primarily on the basis of proximity to the station, although factors such as meteorology, topography, and sampling practicality also are considered. Indicator locations for the atmospheric and terrestrial pathways are typically less than 10 miles from the station. Most often, they are within 5 miles of the station. Indicator locations in the Susquehanna River are downstream of the station's discharge. Monitoring results from indicator locations are compared with results from control locations. These comparisons are made to discern any differences in the levels and/or types of radioactive material and/or radiation that might exist between indicators and controls and that could be attributable to the station.

In 2012, the SSES REMP collected 1084 samples at 57 locations. In addition, the REMP monitors ambient radiation levels using optically stimulated luminescence dosimeters (OSLDs) at 57 indicator and control locations, resulting in 228 radiation level measurements in 2012. The media monitored and analyses performed are summarized in the table below. Figures 2 through 7 display the REMP OSLD and sampling locations in the vicinity of the SSES. Appendix C provides directions, distances, and a brief description of each of the locations in Figures 2 through 7.

REMP Monitoring Sensitivity

Detection of radiation and radioactive material from the SSES in the environment is complicated by the presence of naturally occurring radiation and radioactive materials from both terrestrial and cosmic sources. Man-made radiation and radioactive material from non-SSES sources, such as fallout from previous nuclear weapons tests and medical wastes, also make differentiation between SSES radiation and naturally occurring radioactive material difficult. This effort is further complicated by the natural variations that typically occur from both monitoring locations and with time at the same locations.

The naturally occurring radionuclides potassium-40, beryllium-7, actinium-228, thorium-228, and tritium are routinely observed in certain environmental media. Potassium-40 has been observed in all monitored media and is routinely seen at readily detectable levels in such media as milk, fish, fruits and vegetables. Seasonal variations in beryllium-7 in air samples are regularly observed. Man-made radionuclides, such as cesium-137 left over from nuclear weapons testing are often observed as well. In addition, the radionuclide tritium, produced by both cosmic radiation interactions in the upper atmosphere as well as man-made (nuclear weapons), is another radionuclide typically observed.

SSES REMP	
Type of Monitoring	**Media Monitored**
Gross Beta Activity	Drinking Water and Air Particulates
Gamma-Emitting Radionuclide Activities	All Media
Tritium Activity	All Waters
Iodine-131 Activity (by Isotopic Analysis except Milk by Low Level Analysis)	All Media
Gamma Radiation Exposure (by OSLD)	Ambient Radiation Levels

Radioactivity levels in environmental media are usually so low that their measurements, even with state-of-the-art measurement methods, typically have significant degrees of uncertainty associated with them (Reference 5). As a result, expressions are often used when referring to these measurements that convey information about the levels being measured relative to the measurement sensitivities. Terms such as "minimum detectable concentration" (MDC) are used for this purpose. The MDC is an "a priori" estimate of the capability for detecting an activity concentration by a given measurement system, procedure, and type of sample. Counting statistics of the appropriate instrument background are used to compute the MDC for each specific analysis. The formulas used to calculate MDCs may be found in procedures referenced in Appendix A.

The methods of measurement for sample radioactivity levels used by PPL's contracted REMP radioanalytical laboratories are capable of meeting the analysis sensitivity requirements found in the SSES Technical Requirements.

Exposure Pathways to Humans

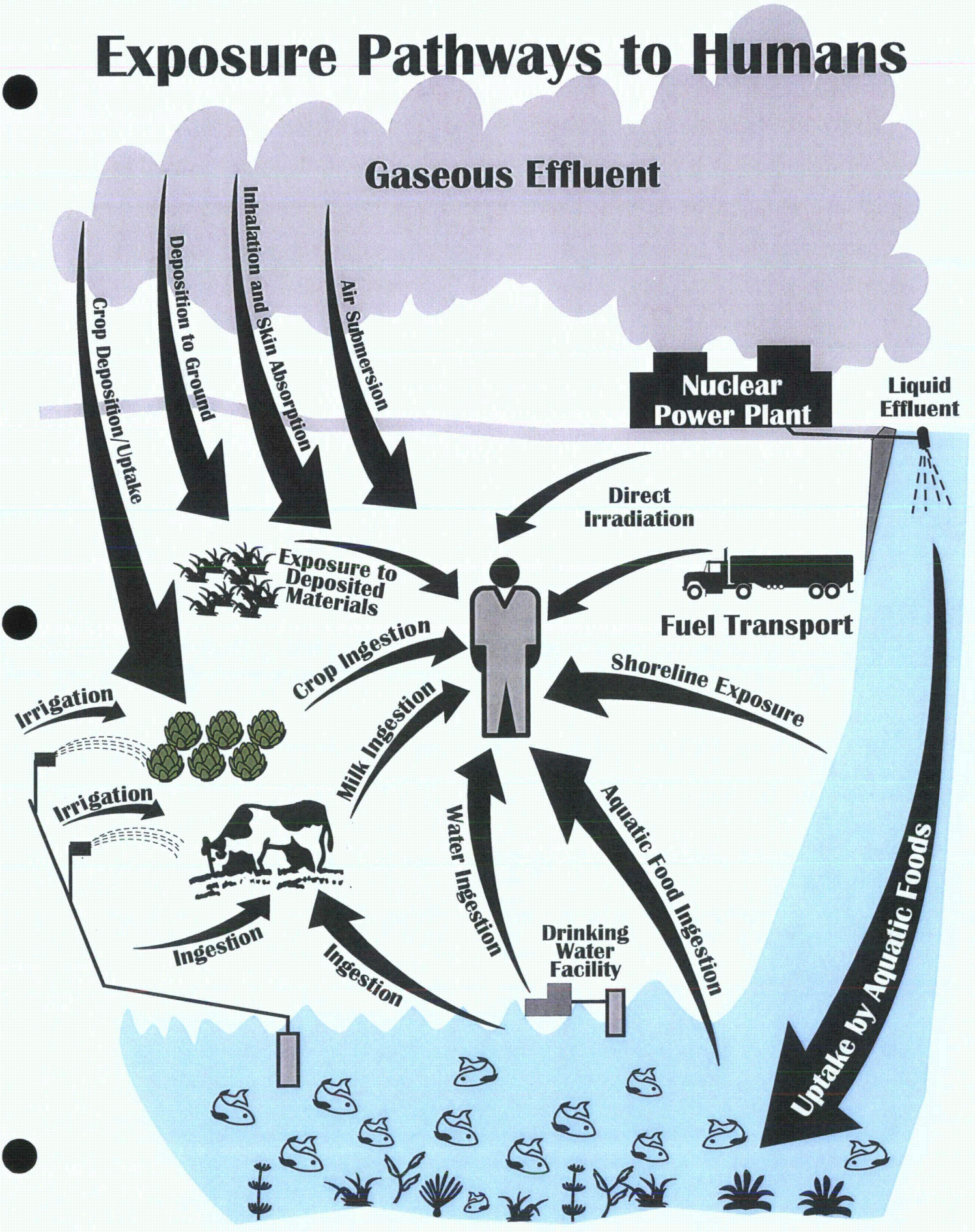


Figure 1

FIGURE 2
2012 DIRECT RADIATION MONITORING LOCATIONS WITHIN ONE MILE

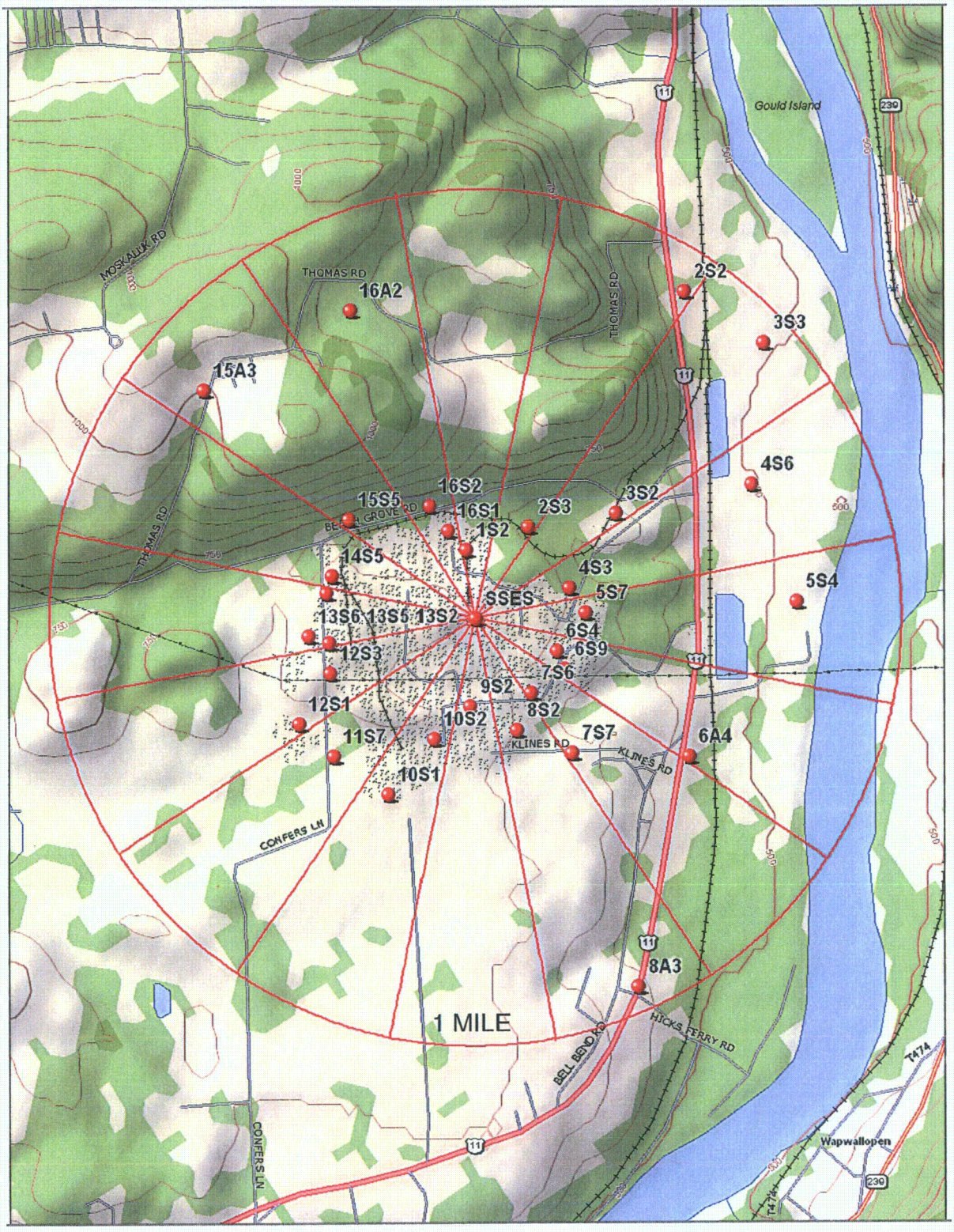


FIGURE 3
2012 DIRECT RADIATION MONITORING LOCATIONS
FROM ONE TO FIVE MILES

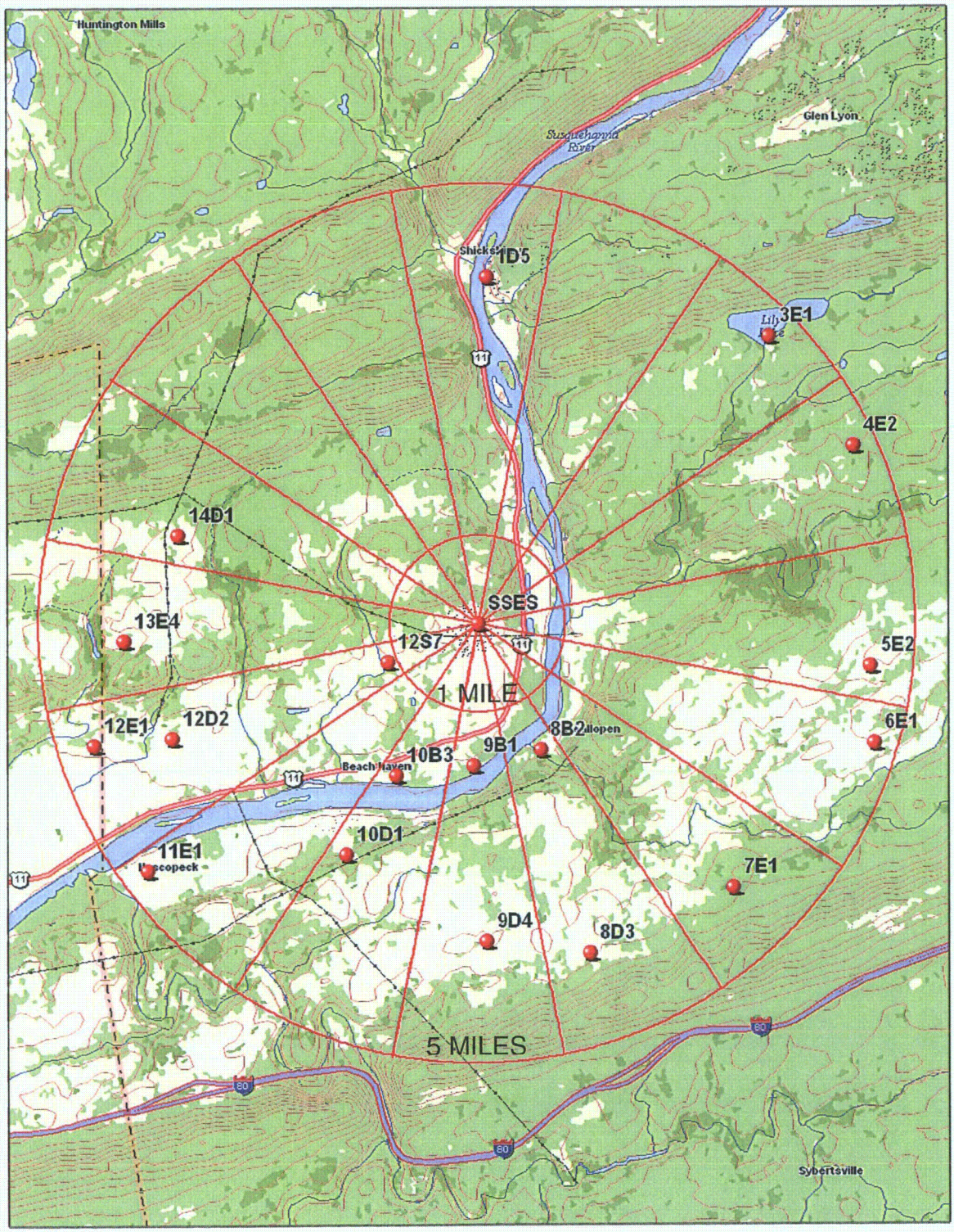


FIGURE 4
2012 DIRECT RADIATION MONITORING LOCATIONS
GREATER THAN FIVE MILES

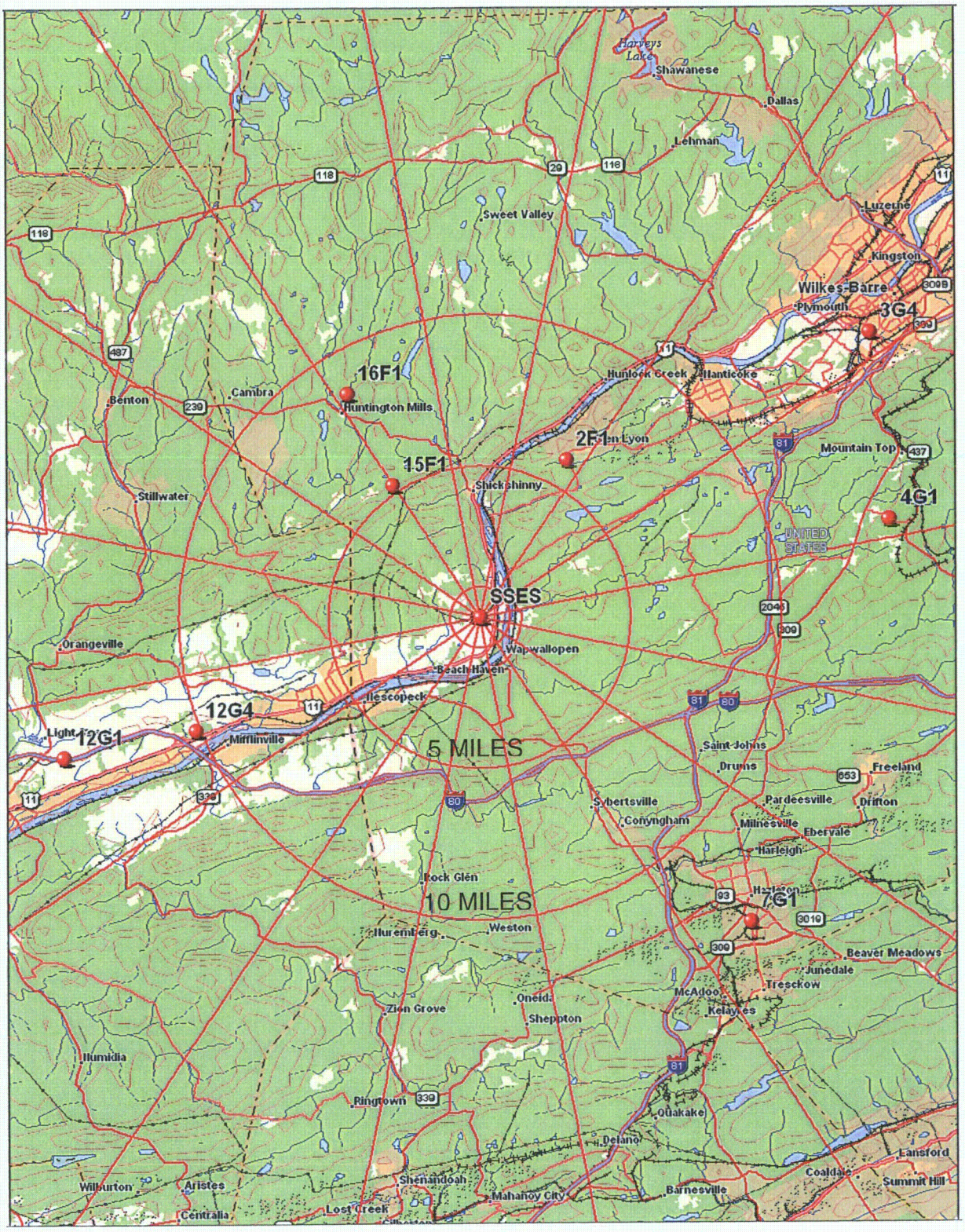


FIGURE 5
2012 ENVIRONMENTAL SAMPLING LOCATIONS WITHIN ONE MILE

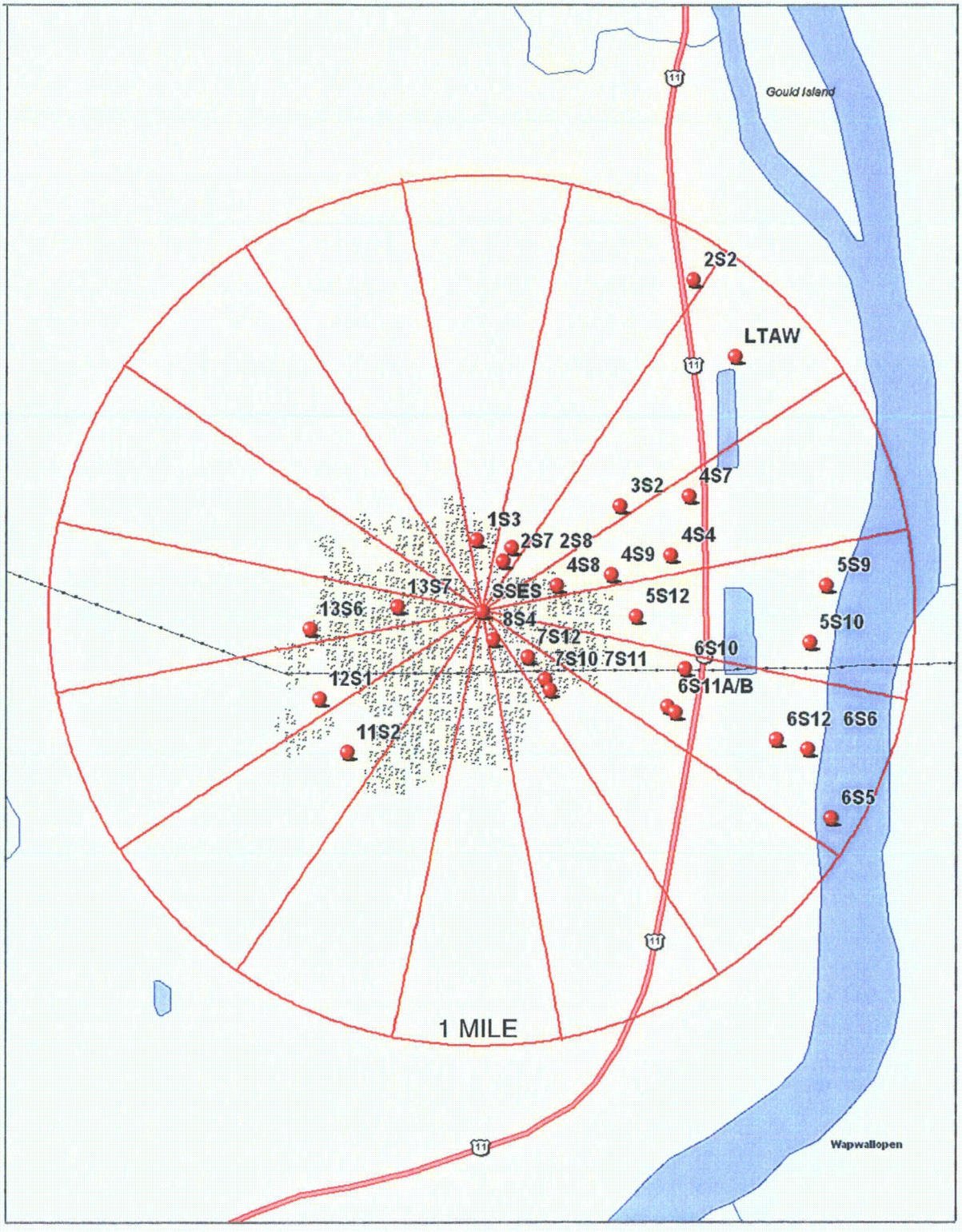


FIGURE 6
2012 ENVIRONMENTAL SAMPLING LOCATIONS
FROM ONE TO FIVE MILES

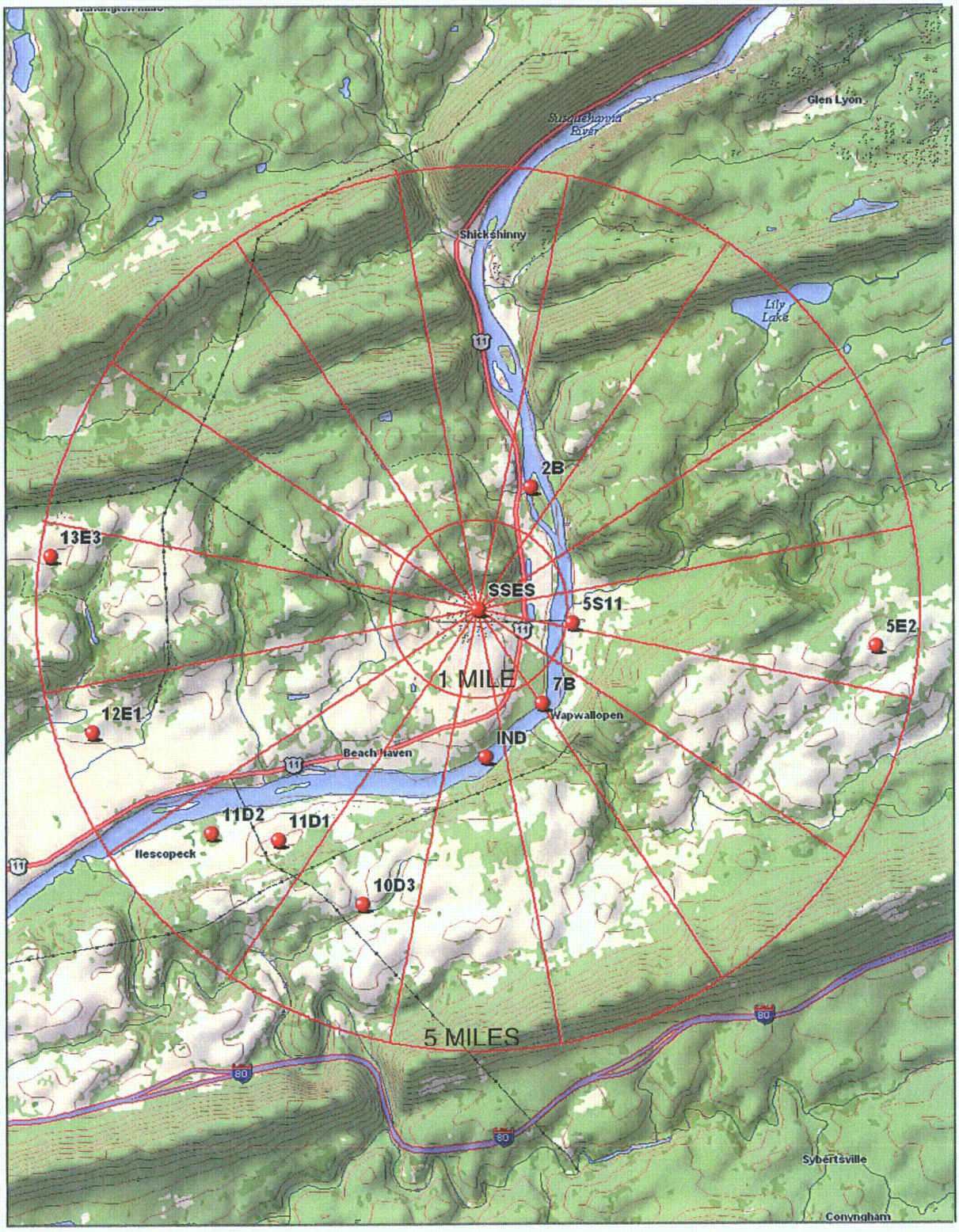
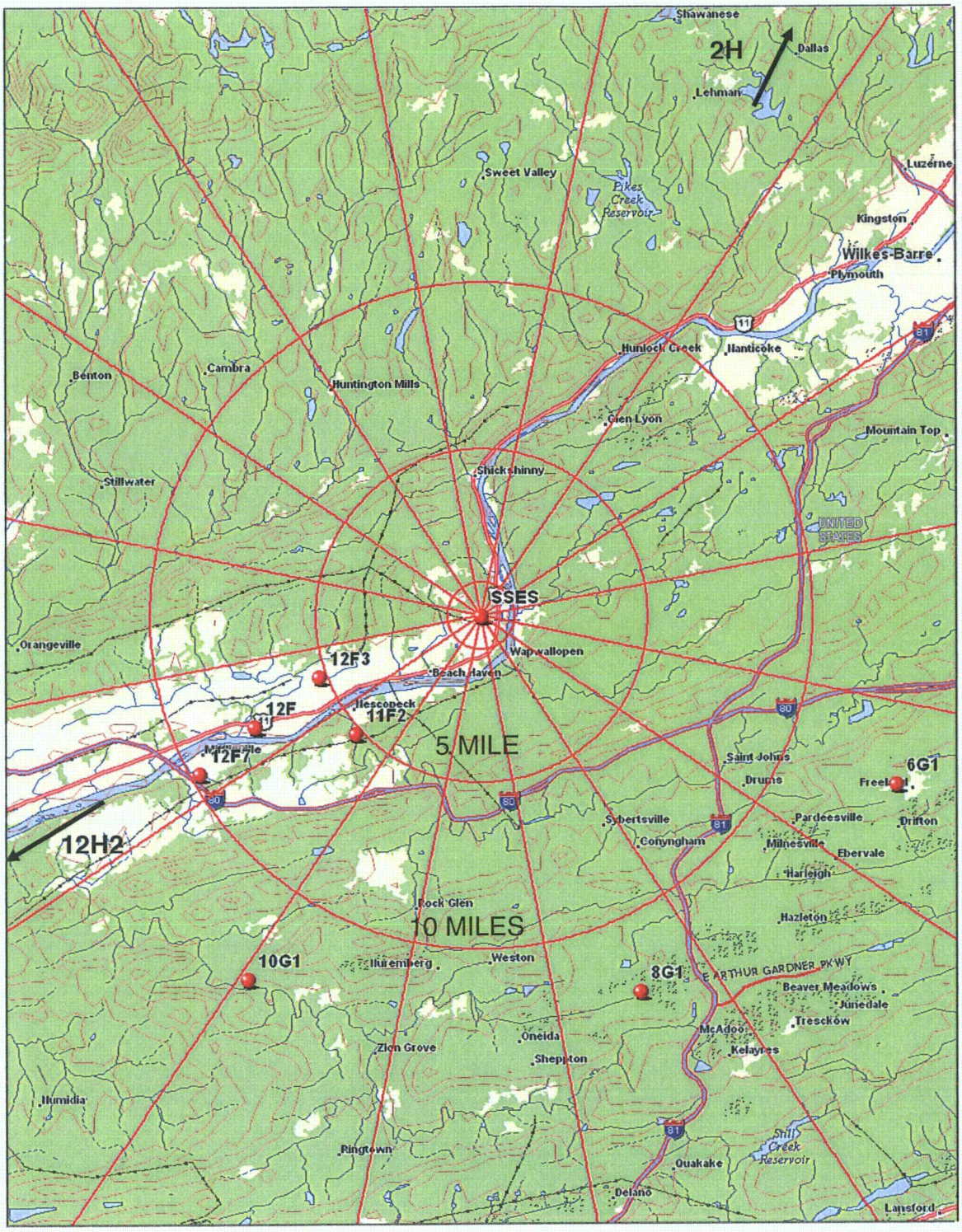


FIGURE 7
2012 ENVIRONMENTAL SAMPLING LOCATIONS
GREATER THAN FIVE MILES



AMBIENT RADIATION MONITORING

INTRODUCTION

The SSES changed from using thermoluminescence dosimeters (TLDs) to optically stimulated luminescence dosimeters (OSLDs) in 2012 for measurement of ambient radiation levels in the environment. The OSL technology uses a detector material made of aluminum oxide crystals that measures direct radiation levels in the environment.

Interpretation of environmental OSLD results is described in PPL Nuclear Engineering Study, EC-ENVR-1012 (Revision 2, January 2013), per reference 12.

Scope

Direct radiation measurements were made using OSLDs. During 2012, the SSES REMP had 46 indicator, 6 special interest and 5 control OSLD locations. Refer to Table C1 and C2 for OSLD measurement locations. The OSLD locations are placed on and around the SSES site as follows:

A site boundary ring (i.e. an inner ring) with at least 1 OSLD in each of the 16 meteorological sectors, in the general area of the site boundary. Currently there are 30 locations. They are: (1S2, 2S2, 2S3, 3S2, 3S3, 4S3, 4S6, 5S4, 5S7, 6S4, 6S9, 7S6, 7S7, 8S2, 8A3, 9S2, 9B1, 10S1, 10S2, 11S7, 12S1, 12S3, 12S7, 13S2, 13S5, 13S6, 14S5, 15S5, 16S1 and 16S2) near and within the site perimeter representing fence post doses from a SSES release.

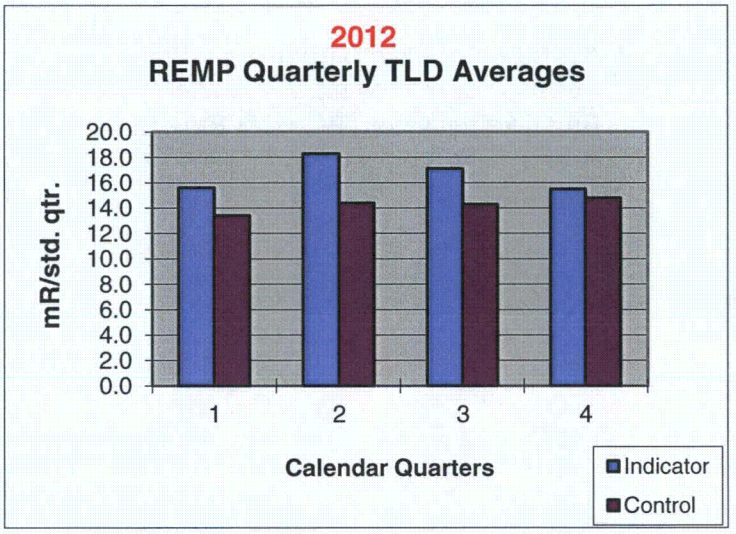
An outer distance ring with at least 1 OSLD in each of the 16 meteorological sectors, in the 3 to 9 mile range from the site. Currently there are 16 locations. They are: (1D5, 2F1, 3E1, 4E2, 5E2, 6E1, 7E1, 8D3, 9D4, 10D1, 11E1, 12D2, 13E4, 14D1, 15F1 and 16F1). These OSLDs are located to measure possible exposure to close-in population.

The balance of OSLD locations represent special interest areas such as population centers, schools, residences and control locations. Currently there are six special interest locations (6A4, 15A3, 16A2, 8B2, 10B3 and 12E1) and 5 control locations (3G4, 4G1, 7G1, 12G1 and 12G4).

The specific locations were determined according to the criteria presented in the NRC Branch Technical Position on Radiological Monitoring (Revision 1, November 1979).

Monitoring Results

The OSLDs are exchanged quarterly by SSES Health Physics and processed by Landauer Dosimetry Lab in Glenwood, IL. Average quarterly ambient gamma radiation levels measured by environmental OSLDs are shown in the bar graph below.



The annual mean of all indicator locations in 2012 was 16.6 +/- 10.1 mrem per standardized quarter. The annual mean of the control locations in 2012 was 14.2 +/- 4.8 mrem per standardized quarter.

Indicator environmental OSLD results for 2012 were examined quarterly on an individual location basis and compared with both current control location results and preoperational data. Very small SSES exposure contributions were identified during 2012 at nineteen onsite locations as follows: 1S2, 2S3, 4S3, 5S7, 6S4, 6S9, 7S6, 8S2, 9S2,

10S1, 10S2, 12S1, 12S3, 13S2, 13S5, 13S6, 15S5, 16S1, 16S2.

The highest, estimated, gamma radiation dose of 7.21E-01 mrem for 2012 was at location 9S2. It is assumed that the occupancy time for a member of the public is no more than twenty hours each calendar quarter at location 9S2. This dose is approximately 2.88 % of the 25 mrem whole-body SSES Technical Requirements (TRO 3.11.3) limit for all SSES sources of radioactivity and radiation.

Refer to the following for results of OSLD measurements for 2012:

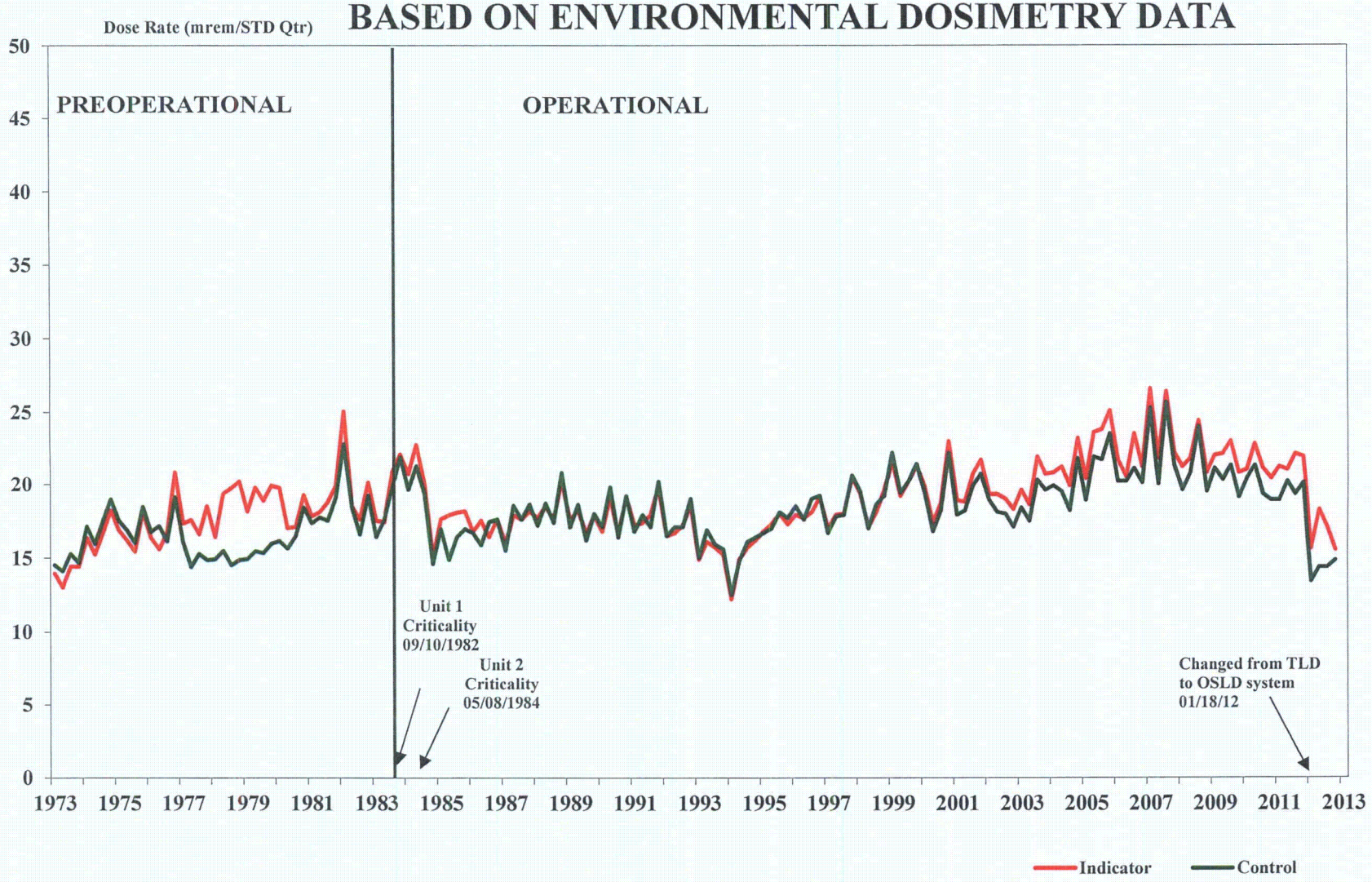
- Figure 8, trends quarterly direct radiation monitoring results for both preoperational and operational periods

- Appendix G, Table G Summary of Data Table, shows the averages for OSLD indicator and control locations for the entire year.

- Appendix H, Table H1, shows a comparison of the 2012 mean indicator and control OSLD results with the means for the preoperational and operational periods at the SSES.

- Appendix I, Table I-1, shows OSLD results for all locations for each quarter of 2012.

FIGURE 8 - AMBIENT RADIATION LEVELS BASED ON ENVIRONMENTAL DOSIMETRY DATA



AQUATIC PATHWAY MONITORING

INTRODUCTION

In 2012 the SSES REMP monitored the following media in the aquatic pathway: surface water, drinking water, fish, sediment, fruits and vegetables. Some of the media (e.g., drinking water and fish) provide information that can be especially useful to the estimation of possible dose to the public from potentially ingested radioactivity, if detected. Other media, such as sediment, can be useful for trending radioactivity levels in the aquatic pathway, primarily because of their tendency to assimilate certain materials that might enter the surface water to which they are exposed. The results from monitoring all of these media provide a picture of the aquatic pathway that is clearer than that which could be obtained if one or more were not included in the REMP.

SSES Technical Requirements only require that fruit and vegetables be sampled at locations irrigated by Susquehanna River water from points downstream of the SSES discharge to the River. The land use census (Reference 11) conducted in 2012 identified two farms within 10 miles downriver of PPL Susquehanna that used Susquehanna River water for irrigation: Zehner Farm (location 11D1, 3.3 miles SW) irrigated cabbage, pumpkins and soy beans and Lupini Farm – Mifflinville Field (location 12F7, 8.3 miles WSW) irrigated potatoes and field corn.

No other fields within 10 miles downriver of Susquehanna SES were irrigated in 2012.

The aquatic pathway in the vicinity of the SSES is the Susquehanna River. Monitoring of all of the aquatic media, except drinking water, is conducted both downstream and upstream of the location from which periodically permitted SSES low-level radioactive discharges enter the river. The upstream monitoring locations serve as controls to provide data for comparison with downstream monitoring results. The potential exists for radioactive material that might be present in SSES airborne releases to enter the Susquehanna River upstream of the plant through either direct deposition (e.g., settling or washout) or by way of runoff from deposition on land adjacent to the river. However, direct deposition and runoff are considered to be insignificant as means of entry for SSES radioactivity into the Susquehanna River when compared to liquid discharges under normal conditions.

Lake Took-a-While (LTAW), which is located in PPL's Riverlands Recreation Area adjacent to the Susquehanna River, is also considered to be part of the aquatic pathway for monitoring purposes. Although it is not in a position to receive water discharged to the river from the SSES, it does receive storm runoff from the SSES. The C-1 Pond (5S12) and the S-2 Pond (7S12) are sedimentation ponds which also receive storm runoff from the site.

Storm runoff from the SSES site should not normally contain any measurable radioactivity from the plant. However, the SSES REMP, consistent with other aspects of aquatic monitoring and the REMP, in general, goes beyond its requirements by monitoring LTAW, C-1 Pond (5S12) and S-2 Pond (7S12).

Scope

Surface Water

Surface water was routinely sampled from the Susquehanna River at one indicator location (6S5/Outfall Area) and one control location (6S6/River Water Intake Line) during 2012. Sampling also took place at the following additional indicator locations: the SSES discharge line to the river (2S7), Lake Took-A-While (LTAW), Peach Stand Pond (4S7), C-1 Pond (5S12) and S-2 Pond (7S12).

Drinking Water

Drinking water samples were collected at location 12H2, the Danville Municipal Water Authority's treatment facility on the Susquehanna River, in 2012. Treated water is collected from the end of the processing flowpath, representing finished water that is suitable for drinking. This is the nearest point downstream of the SSES discharge to the River at which drinking water is obtained. No drinking water control location is sampled. For all intents and purposes, control surface water sampling location (6S6) would be suitable for comparison.

Fish

Fish were sampled from the Susquehanna River in the spring and fall of 2012, at one indicator location, IND, downstream of the SSES liquid discharge to the River and one control location, 2H, sufficiently upstream to essentially preclude the likelihood that fish caught there would spend any time below the SSES discharge. In addition, fish were also sampled in the fall from PPL's Lake Took-a-While, location LTAW. This location is not downstream of the SSES discharge. It is sampled because of its potential for receiving runoff from the SSES. LTAW is considered an indicator location.

Sediment

Sediment sampling was performed in the spring and fall at indicator locations 7B and 12F and control location 2B on the Susquehanna River.

Fruits and Vegetables

In 2012, potatoes and field corn were irrigated with Susquehanna River water at indicator location 12F7. Cabbage, pumpkins, and soy beans were also irrigated with Susquehanna River water at indicator location 11D1.

Sampling

Surface Water

Weekly water samples were collected at indicator location 6S5 for both biweekly and monthly compositing. Location 6S5 was considered a backup for location 2S7 in the event that water could not be obtained from the automatic sampler at this location.

Routine samples for 6S5 were collected from a boat, unless river conditions prohibited boating. When this occurs, samples are collected from an alternate shoreline site located below the Susquehanna SES discharge diffuser. The shoreline samples are collected approximately 100-150 yards down river from the 6S5 site.

Indicator location 2S7, the SSES Cooling Tower Blowdown Discharge (CTBD) line, and control location 6S6, the SSES River Water Intake structure, were time -proportionally sampled using automatic continuous samplers. The samplers were typically set to obtain 30-60 ml aliquots every 20-25 minutes. Weekly, the water obtained by these samplers was retrieved for both biweekly and monthly compositing.

The other surface water monitoring locations, LTAW, Peach Stand Pond (4S7), C-1 Pond (5S12) and S-2 Pond (7S12) were grab sampled once each quarter.

Drinking Water

Treated water was time-proportionally sampled by an automatic sampler. The sampler was typically set to obtain three 12-ml aliquots every twenty minutes. Weekly, the water obtained by this sampler was retrieved for monthly compositing.

Fish

Fish were obtained by electrofishing. Electrofishing stuns the fish and allows them to float to the surface so that those of the desired species and sufficient size can be sampled. Sampled fish include recreationally important species, such as largemouth bass, smallmouth bass, and also channel catfish and shorthead redhorse. The fish are filleted and the edible portions are kept for analysis.

Sediment

Shoreline sediment was collected to depths of four feet of water.

Fruits and Vegetables

Potatoes and field corn grown at indicator location 12F7 were sampled since they were irrigated with Susquehanna river water. Cabbage, pumpkins and soy beans were also irrigated with Susquehanna River water at indicator location 11D1 but were not sampled at the wishes of the farm owner.

Sample Preservation and Analysis

Surface and Drinking Water

Surface water samples were analyzed monthly for gamma-emitting radionuclides and tritium. Drinking water samples were analyzed monthly for gross beta, gamma-emitting radionuclides, and tritium.

Sediment and Fish

Fish are frozen until shipment. All samples are analyzed by gamma spectroscopy for the activities of any gamma emitting radionuclides that may be present.

Monitoring Results

Surface Water

Refer to the following for results of surface water analyses for 2012:

- Appendix G, Table G, shows a summary of the 2012 surface water data.
- Appendix H, Table H 4, shows comparisons of tritium monitoring results against past years data.
- Appendix I, Table I-2 shows specific results for tritium and gamma spectroscopic analyses of surface water samples.

The Nuclear Regulatory Commission (NRC) requires that averages of the activity levels for indicator environmental monitoring locations and for control environmental monitoring locations of surface water, as well as other monitored media, be reported annually. Data from the following six surface water monitoring locations were averaged together as indicators for reporting purposes: location (6S5) on the Susquehanna River downstream of the SSES, Lake-Took-a While (LTAW) adjacent to the river, and the SSES cooling tower blowdown discharge (CTBD) line to the river (2S7), and the Peach Stand Pond (4S7), C-1 Pond (5S12) and S-2 Pond (7S12).

Technically, the CTBD line is not part of the environment. The CTBD line is a below ground pipe to which the public has no access, contrary to the other environmental monitoring locations on the Susquehanna River to which the public does have access. However, currently there is no automatic composite sampling of an indicator location on the Susquehanna River, so the CTBD line from the SSES is included as an indicator monitoring location in the radiological environmental monitoring program.

Most of the water entering the Susquehanna River through the SSES CTBD line is simply water that was taken from the river upstream of the SSES, used for cooling purposes without being radioactively contaminated by SSES operation, and returned to the river. Batch discharges of relatively small volumes of slightly radioactively contaminated water are made to the river through the SSES CTBD at times throughout each year. The water is released from tanks of radioactively contaminated water on site to the CTBD and mixes with the noncontaminated water already present in the CTBD. Flow rates from the tanks containing radioactively contaminated water being discharged to the CTBD vary based on the radioactivity level of the batch release. In addition, the minimum flow rate for the returning water in the CTBD is maintained at a flow rate of 5,000 gpm or higher. These requirements are in place to ensure adequate dilution of radioactively contaminated water in the CTBD prior to entering the river.

At the point that CTBD water enters the river, additional, rapid dilution of the discharged water by the river is promoted by releasing it through a diffuser. The diffuser is a large pipe with numerous holes in it that is positioned near the bottom of the river.

CTBD discharges exit the diffuser through the many holes, enhancing the mixing of the discharge and river waters. The concentrations of contaminants are reduced significantly as the discharged water mixes with the much larger flow of river water. The mean flow rate of the Susquehanna River in 2012 was approximately 4,920,000 gpm. The CTBD average flow during 2012 was 11,382 gpm. Based on the average river flow and the average CTBD flow during 2012, liquid discharges from the SSES blowdown line were diluted by approximately a factor of 432 after entering the river. The amount of radioactively contaminated water being discharged is small. Nevertheless, sensitive analyses of the water samples can often detect low levels of radioactivity in the CTBD water following dilution. Though the levels of radioactivity measured in the CTBD water are generally quite low, they tend to be higher than those in the river downstream of the SSES.

When the radioactivity levels from the CTBD samples throughout the year are averaged with those obtained from actual downstream monitoring locations, the result is an overall indicator location average that is too high to be representative of the actual average radioactivity levels of the downstream river water. As the following discussions are reviewed, consideration should be given to this inflation of average radioactivity levels from the inclusion of CTBD (location 2S7) results in the indicator data.

Surface Water Tritium

Quarterly samples from all surface water locations were analyzed for concentrations of tritium activity (Table I-2 and Table G). Tritium was detected in the indicator location above MDC. The 2012 indicator values ranged from -19.6 to 12,400 pCi/l compared to -98.9 to 8,500 for 2011. Comparison of the 2012 mean tritium activity of 1,090 pCi/l for all indicator locations to the average of the annual preoperational control mean of 171 pCi/l indicates a contribution of tritium activity from the SSES.

Refer to Figure 10 which trends tritium activity levels separately for surface water indicator and control locations from 1972 through 2012.

The much higher levels of tritium observed in the CTBD line (location 2S7), when averaged with the low levels from the downstream location 6S5 sample analysis results distort the real environmental picture. The mean tritium activity level from indicator location 6S5 for 2012 was 89.18 pCi/liter, which is slightly greater than the mean tritium activity of 52.8 pCi/l for the control location and is below the annual preoperational control mean of 171 pCi/l.

Tritium activity levels reported for 2S7 are from the discharge line prior to dilution in the river. The highest quarterly average tritium activity reported at 2S7 during 2012 was approximately 5,501 pCi/liter for the second quarter. This is well below the NRC Reporting Levels for quarterly average activity levels of

20,000 pCi/liter when a drinking water pathway exists or 30,000 pCi/liter when no drinking water pathway exists.

The tritium activity reported in the CTBD line from location 2S7 is attributable to the SSES. Refer to the "Dose from the Aquatic Pathway" discussion at the end of this section for additional information on the projected dose to the population from tritium and other radionuclides in the aquatic pathway attributable to the SSES.

No gamma-emitting radionuclides were detected in surface water samples above MDC, with the exception of naturally occurring K-40, Ra-226 and Th-228.

Drinking Water

Drinking water was monitored during 2012 at the Danville Water Company's facility 26 miles WSW of the SSES on the Susquehanna River at location 12H2.

There are no known drinking water supplies in Pennsylvania on the Susquehanna River upstream of the SSES and therefore no drinking water control monitoring locations. Danville drinking water analysis results may be compared to the results for surface water control monitoring locations.

Refer to the following for results of surface water analyses for 2012:

- Figure 11 trends gross beta activity levels for drinking water location 12H2 from 1977 through 2012.
- Appendix G, Table G, shows a summary of the 2012 drinking water data.
- Appendix H, Table H 6 and H 7, show comparisons of gross beta and tritium activity in drinking water for 2012 against past years' data.
- Appendix I, Table I-4 shows specific results of gross beta, tritium and gamma spectroscopic analyses of drinking water

Drinking Water Gross Beta

Monthly samples from the 12H2 drinking water location were analyzed for concentrations of gross beta activity (Table I-4). Beta activity was detected in samples from the 12H2 location above MDC for 2012. The 2012 values ranged from -.07 to 3.81 pCi/l compared to -.06 to 7.98 for 2011.

Gross beta activity has been monitored in drinking water since 1977. Gross beta activity is typically measured at levels exceeding the MDCs in drinking water samples. The 2012 mean gross beta activity of 1.9 pCi/l is slightly below the mean gross beta activity of 2.26 for 2011 and below the preoperational (1977-81) values of 2.2 to 3.2 pC/l.

Drinking Water Tritium

Monthly samples from the 12H2 drinking water location were analyzed for concentrations of tritium activity (Table I-4). Tritium activity was not detected above MDC in any of the 12 drinking water samples in 2012. The 2012 values ranged from 36.3 to 138 pCi/l compared to -32.5 to 104 for 2011.

The 2012 mean tritium activity of 69.6 pCi/l for drinking water was higher than the mean tritium activity of 15.6 pCi/l

for 2011 and is less than the preoperational (1977-81) values of 101 to 194 pCi/l.

Drinking Water Gamma Spectroscopic

No gamma-emitting radionuclides attributable to SSES were detected in drinking water samples above the MDC.

Fish

Refer to the following for results of fish analyses for 2012:

- Table G shows a summary of the 2012 fish data.
- Table H 8 shows comparisons of potassium-40 monitoring results against past years' data.
- Table I-5 shows specific results of gamma spectroscopic analyses of fish.

Fish Gamma Spectroscopic

Semi-annual samples from the indicator (IND) and control (2H) fish locations were analyzed for concentrations of gamma activity (Table I-5).

Four species of fish were sampled at each of one indicator location and one control location on the Susquehanna River in spring 2012 and again in fall 2012. The species included the following: smallmouth bass, channel catfish and shorthead redhorse.
In addition, one largemouth bass and a rainbow trout were sampled from PPL's LTAW in October 2012. A total of 14 fish were collected and analyzed.

The only gamma-emitting radionuclide reported in excess of analysis MDCs in fish during 2012 was naturally occurring potassium-40. The 2012 indicator values ranged from 3,605 to 5,299 pCi/kg compared to 3,080 to 4,370 for 2011. The 2012 indicator and control means for the activity levels of potassium-40 in fish were 4,348 pCi/kg and 4,184 pCi/kg, respectively. Naturally occurring potassium-40 in fish is not attributable to the liquid discharges from the SSES to the Susquehanna River.

Sediment

Refer to the following for results of sediment analyses for 2012:

- Appendix G, Table G, shows a summary of the 2012 sediment data.
- Appendix H, Tables H 9, 10, 11 and 12, shows comparisons of potassium-40, radium-226, thorium-228, and cesium-137 monitoring results against past years' data.
- Appendix I, Table I-6 shows specific results of gamma spectroscopic analyses of sediment samples.

Sediment Gamma Spectroscopic

Semi-annual samples from all sediment locations were analyzed for concentrations of gamma activity (Table I-6).
Naturally occurring Potassium-40, Radium-226, Actinium228, Thorium-228, and Beryllium-7 were measured at activity levels above MDCs in some shoreline sediment samples in 2012.

The naturally occurring radionuclides in sediment are not attributable to the liquid discharges from the SSES to the Susquehanna River.

Cesium-137 was measured at activity levels slightly above MDCs in 3 of 6 shoreline sample analyses in 2012. The 2012 indicator and control means for cesium-137 activity in sediment were 45.9 pCi/kg and 117 pCi/kg, respectively. The 2012 indicator and control means are comparable to 46 pCi/kg and 61.1 pCi/kg for 2011 values. These samples are within the annual mean for all preoperational years of station operation. Cesium-137 has been observed in previous operational years in the 80 to 170 pCi/kg range, and is determined to be fallout from atmospheric nuclear weapons testing in the 1940s through 1970s. No cesium-137 was reported as being released in liquid effluents in 2012. The highest cesium-137 concentration of 157 pCi/kg was detected in the 2B control location (at 95% confidence level), during the fourth quarter of 2012.

Fruits and Vegetables

Refer to the following for results of fruits and vegetables for SSES:

- Appendix G, Table G, shows a summary of the 2012 fruits and vegetables.

- Appendix I, Table I-12 shows specific gamma spectroscopic analysis of fruit/vegetable samples.

Fruit /Vegetable Gamma Spectroscopic

Potato and field corn samples were collected in 2012 from location 12F7. Cabbage, pumpkin and soybeans were grown and irrigated using Susquehanna river water at location 11D1,but were not collected due to wishes of the Zehner Farm not to participate in the REMP program.
However, the potato and field corn samples were collected and analyzed for concentrations of gamma emitting nuclide activity (Table I-12). Potassium-40 was the only gamma-emitting radionuclide measured in fruits and vegetables at an activity level above MDC during 2012. The average potassium-40 concentration for the indicator sample was 4,000 pCi/kg compared to 2,760 pCi/kg for 2011.

Potassium-40 in fruits and vegetables is not attributable to SSES operation because it is a naturally occurring radionuclide.

Dose from the Aquatic Pathway

Tritium was the only radionuclide identified in 2012 by the SSES REMP in the aquatic pathway that was attributable to SSES operation and also included in the pathway to man. The identified cesium-137 in sediment is determined to be residual fallout from atmospheric weapons testing in the 1940s through 1970s.

The total tritium activity released from the SSES for the year was estimated based on REMP monitoring results and used in projecting maximum doses to the public. The annual mean activity level of tritium in the CTBD line (monitoring location 2S7) for 2012 was 3,366 pCi/l. The annual mean activity of tritium for control location 6S6 was 52.8 pCi/l. For the purpose of performing the dose calculation, tritium

was assumed to be present continuously in the CTBD line throughout 2012 at a level equivalent to the annual mean activity of 3,366 pCi/l. The annual mean flow rate for the CTBD line was 11,382 gpm.
Using the proper unit conversions and multiplying 11,382 gpm times 3,366 pCi/l yields a value of 76.4 curies for the estimate of tritium released from SSES during 2012. This estimate is 1.8 curies more than the 74.6 curies of tritium determined by effluent monitoring that was released to the river by the SSES in 2012.

Given the total tritium activity released, the maximum whole-body and organ doses to hypothetical exposed individuals in four age groups (adult, teenager, child, and infant) were determined according to the methodology of the Offsite Dose Calculation Manual using the RETDAS computer program. This is in accordance with SSES Technical Requirement 3.11.4.1.3.

The maximum offsite dose from the aquatic pathway of exposure was calculated using annual average values for Susquehanna River flow, cooling tower blowdown flow and the annual mean tritium concentration in the cooling tower blowdown line. The maximum whole body and organ dose from the aquatic pathway were each calculated as 1.32E-3 mrem.

FIGURE 10 - TRITIUM ACTIVITY IN SURFACE WATER

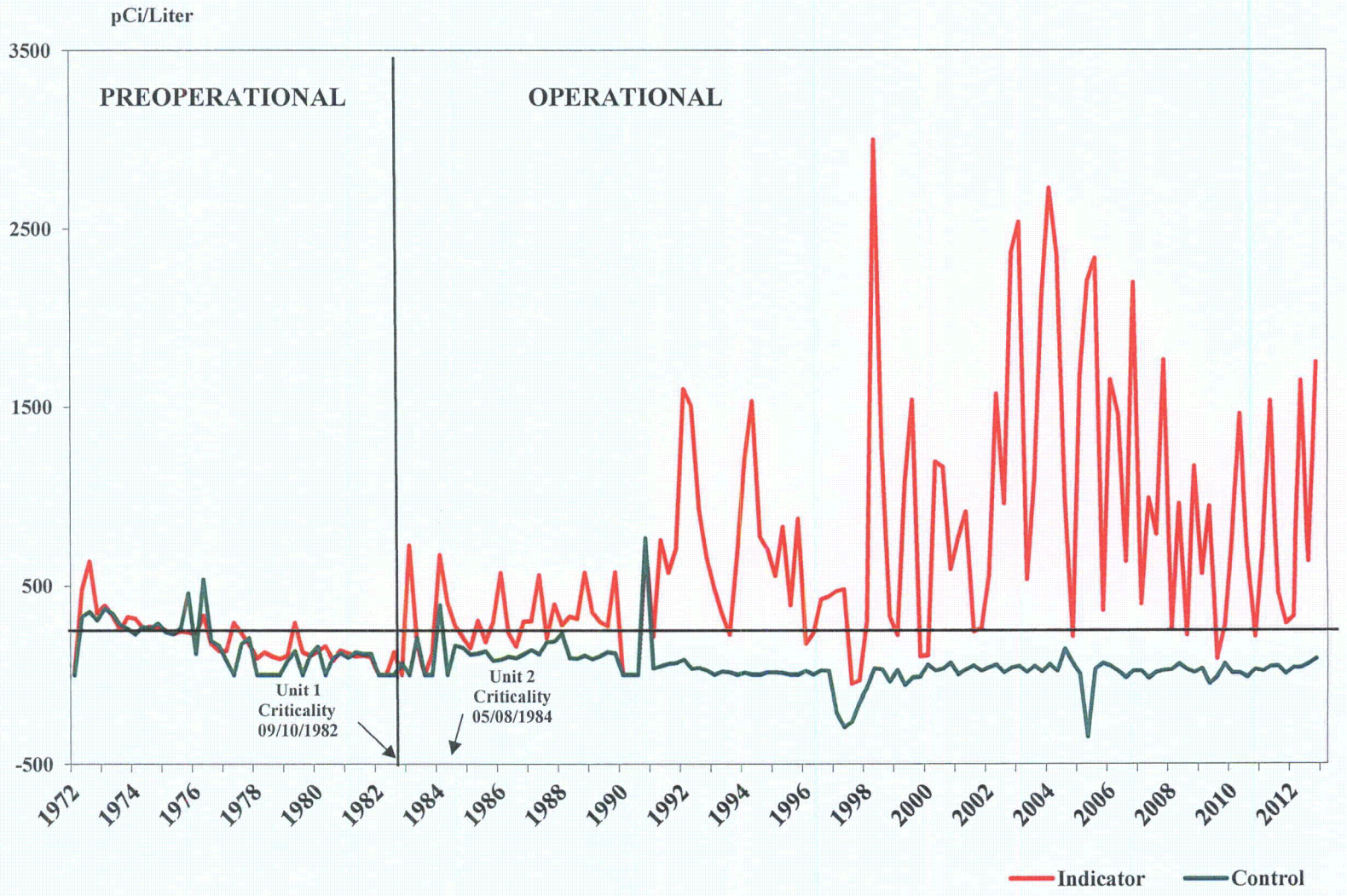
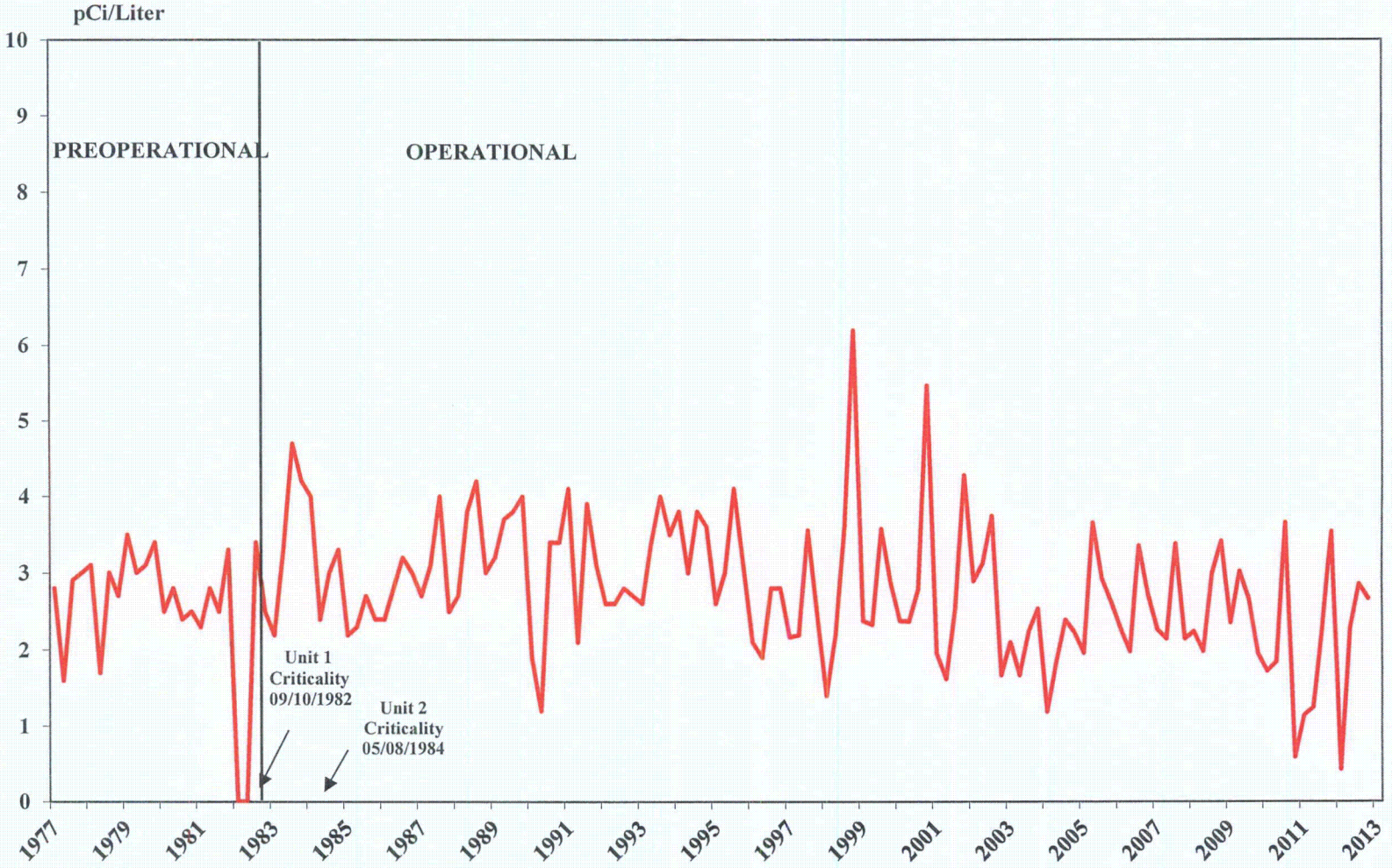


FIGURE 11 - GROSS BETA ACTIVITY IN DRINKING WATER



ATMOSPHERIC PATHWAY MONITORING

INTRODUCTION

Atmospheric monitoring by the SSES REMP involves the sampling and analysis of air. Because the air is the first medium that SSES vent releases enter in the pathway to man, it is fundamental that it be monitored. Mechanisms do exist for the transport of airborne contaminants to other media and their concentration in them. For example, airborne contaminants may move to the terrestrial environment and concentrate in milk. Concentrations of radionuclides can make the sampling and analysis of media like milk more sensitive approaches for the detection of radionuclides, such as iodine-131, in the pathway to man than the monitoring of air directly. (PPL also samples milk; refer to the Terrestrial Pathway Monitoring section of this report.) Nevertheless, the sensitivity of air monitoring can be optimized by the proper selection of sampling techniques and the choice of the proper types of analyses for the collected samples.

Scope

Air samples were collected on particulate filters and charcoal cartridges at indicator locations 3S2, 12S1, 13S6 and 12E1, and control locations 6G1 and 8G1.

Sampling and Analysis

Air

The SSES REMP monitored the air at four indicator locations and two control locations during 2012. The SSES Technical Requirements require monitoring at only a total of five sites. Monitoring is required at three locations at the SSES site boundary in different sectors with the greatest predicted sensitivities for the detection of SSES releases (3S2, 12S1, 13S6). Monitoring must be performed at the community in the vicinity of the SSES with the greatest predicted sensitivity (12E1). A control location that is expected to be unaffected by any routine SSES releases must be monitored (6G1, 8G1).

Airborne particulates were collected on glass fiber filters using low volume (typically 2.0 to 2.5 cfm sampling rates) air samplers that run continuously. Air iodine samples were collected on charcoal cartridges, placed downstream of the particulate filters.

Particulate filters and charcoal cartridges were exchanged weekly at the air monitoring sites. Sampling times were recorded on elapsed-time meters. Air sample volumes for particulate filters and charcoal cartridges were measured with dry-gas meters.

Air filters were analyzed weekly for gross beta activity, then composited quarterly and analyzed for the activities of gamma-emitting radionuclides. The charcoal cartridges were analyzed weekly for iodine-131.

Monitoring Results

Air Particulates

Refer to the following for results of air particulate analyses for 2012:

- Figure 12 trends gross beta activities separately for air particulate indicator and control locations from 1974 through 2012.
- Appendix G, Table G shows a summary of the 2012 air particulate data.
- Appendix H, Tables H 13 and 14 show comparisons of gross beta and Beryllium-7 monitoring results against past years' data.
- Appendix I, Table I-8, shows specific sample results of gross beta analyses for air particulate filters.

Air Particulate Gross Beta

Weekly samples from all air particulate filter locations were analyzed for concentrations of gross beta activity (Table I-8). Gross beta activity was observed at the majority of locations above MDC for 2012. The 2012 indicator values ranged from 4.41E-3 to 26.6E-3 pCi/m^3, compared to 4.39E-3 to 29.3E-3 pCi/m^3 for 2011. The 2012 mean gross beta activity of 14.5E-3 pCi/m^3 for all indicator locations compared to the average of the annual preoperational control mean of 62E-3 pCi/m^3 indicates activity detected below the preoperational control. In addition, a comparison of the 2012 indicator mean of 14.5E-3 pCi/m^3 with the 2012 control locations mean of 13.6E-3 pCi/m^3 indicates no appreciable effects from the operation of SSES.

Gross beta activity is normally measured at levels in excess of the analysis MDCs on the fiber filters. The highest gross beta activity levels that have been measured during the operational period of the SSES were obtained in 1986 following the Chernobyl accident in the former Soviet Union and 2011 Dai-ichi plant incident in Fukushima Japan.

Note that prior to SSES operation, before 1982, the unusually high gross beta activities were generally attributable to fallout from atmospheric nuclear weapons tests. Typical gross beta activities measured on air particulate filters are the result of naturally occurring radionuclides associated with dust particles suspended in the sampled air. They are thus terrestrial in origin.

The SSES Technical Requirements Manual requires radionuclide analysis if any weekly gross beta result was greater than ten times the most recent years annual mean gross beta value for all air particulate sample control locations. This condition did not occur during 2012.

Air Particulate Gamma Spectroscopic

Quarterly gamma spectroscopic measurements of composited filters often show the naturally occurring radionuclide beryllium-7. Occasionally, other naturally occurring radionuclides, potassium-40, radium-226, actinium-228, and thorium-228 are also observed. Beryllium-7 is cosmogenic in origin, being produced by the interaction of cosmic radiation with the earth's atmosphere. The other four gamma-

emitting radionuclides originate from soil and rock.

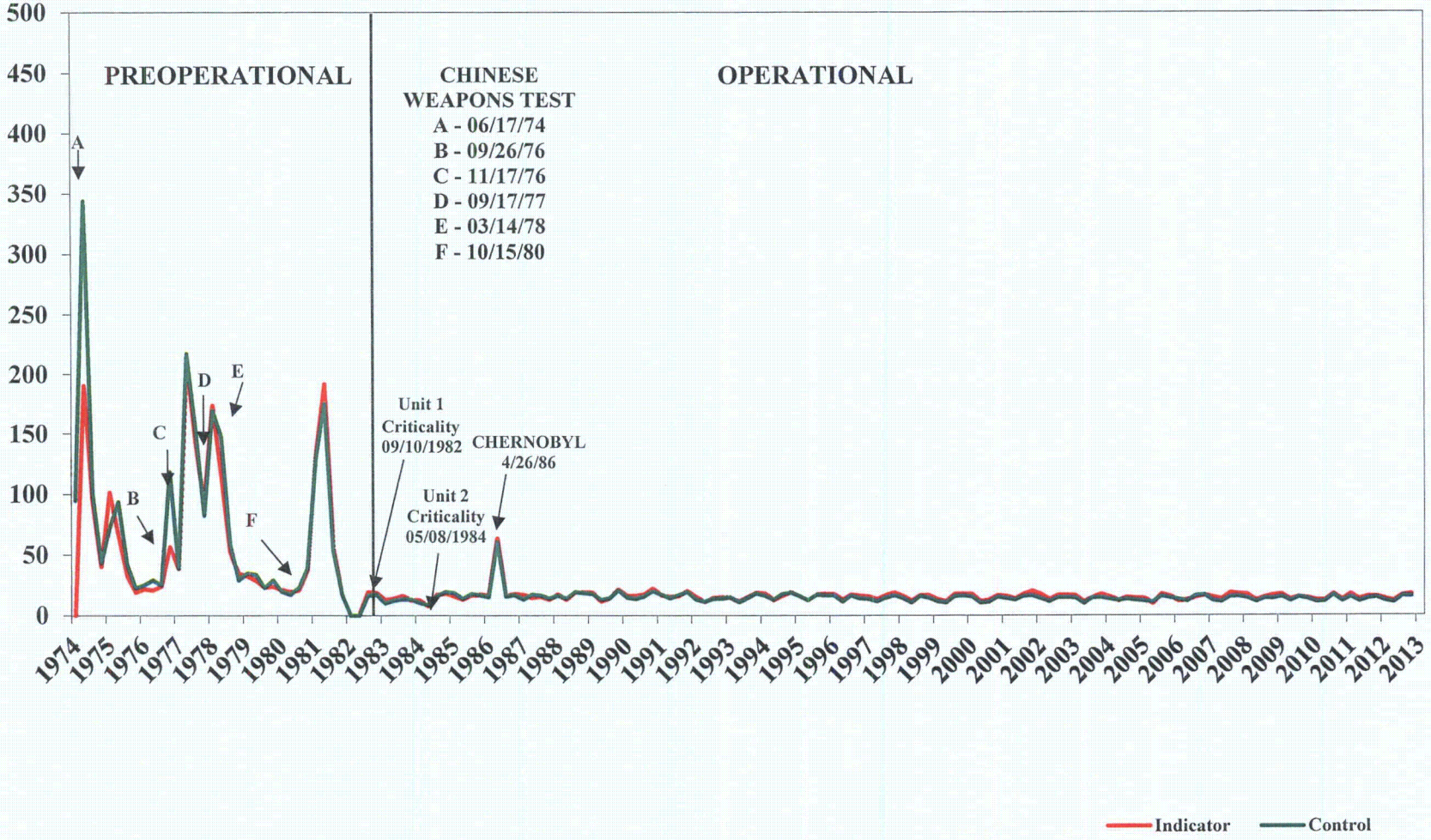
Beryllium-7 was measured above analysis MDCs for all quarterly composite samples in 2012. The 2012 indicator and control means for beryllium-7 activity were 104E-3 and 103E-3 pCi/m^3, respectively. Beryllium-7 activity levels for each 2012 calendar quarter at each monitoring location are presented in Table I-9 of Appendix I. Comparisons of 2012 beryllium-7 analysis results with previous years may be found in Table H 14 of Appendix H.

No other gamma-emitting radionuclides were reported for air in 2012. Beryllium-7 is not attributable to SSES operation.

Air Iodine

Iodine-131 has been detected infrequently from 1976, when it was first monitored, through 2012. Since operation of the SSES began in 1982, iodine-131 has only been positively detected in air samples in 1986 due to the Chernobyl accident and the 2011 Fukushima Dai-ichi plant incident in Japan. No iodine-131 was measured above analysis MDC's in any REMP air samples for 2012.

FIGURE 12 - GROSS BETA ACTIVITY (E-03 pCi/m^3) IN AIR PARTICULATES



TERRESTRIAL PATHWAY MONITORING

INTRODUCTION

Soil and milk were monitored in the Terrestrial Pathway in 2012.

Soil can be a great accumulator of man-made radionuclides that enter it. The extent of the accumulation in the soil depends of course on the amount of the radionuclides reaching it, but it also depends on the chemical nature of those radionuclides and the particular characteristics of the soil. For example, the element cesium, and, therefore, cesium-137 can be bound very tightly to clay in soils. The amount of clay in soil can vary greatly from one location to another. In clay soils, cesium-137 may move very slowly and also may be taken up very slowly in plants as they absorb soil moisture.

Any medium, such as soil, that tends to accumulate radioactive materials can also provide more sensitivity for radionuclide detection in the environment than those media that don't. Such a medium facilitates the early identification of radionuclides in the environment, as well as awareness of changes that subsequently may occur in the environmental levels of the identified radionuclides.

The SSES REMP samples soil near two of the six REMP air-sampling stations. The purpose for soil sampling near the air sampling sites is to make it easier to correlate air sampling results with soil sampling results if any SSES related radioactive material were found in either medium. Sampling is performed at different depths near the surface to help provide information on how recently certain radioactive materials may have entered the soil. Sampling at more than one depth also may help ensure the detection of materials that move relatively quickly through the soil. Such quick-moving materials may have already passed through the topmost layer of soil at the time of sampling.

Milk was sampled at four locations in 2012. SSES Technical Requirements require that the SSES REMP sample milk at the three most sensitive monitoring locations near the SSES and one control location distant from the SSES.

No requirement exists for the SSES REMP to monitor soil. All monitoring of the terrestrial pathway that is conducted by the SSES REMP in addition to milk (and broad leaf vegetation in certain cases when milk sampling not performed) is voluntary and reflects PPL's willingness to exceed regulatory requirements to ensure that the public and the environment are protected.

Scope

Soil

Soil was sampled in September 2012 in accordance with its scheduled annual sampling frequency, at the following two REMP air sampling locations: 12S1 (indicator) and 8G1 (control).

Several soil plugs were taken at selected spots at each monitoring location. The plugs were separated into "top" (0-2 inches) and "bottom" (2-6 inches) segments. Each set of top and bottom segments was composited to yield 2 soil samples from each location for analysis. Since there are two monitoring locations, a total of 4 soil samples were analyzed in 2012.

Milk

Milk was sampled at least monthly at the following locations in 2012: 5E2, 10D3, 13E3 and 10G1.

Milk was sampled bi-weekly from April through October when cows were more likely to be on pasture and monthly at other times. Locations 5E2, 10D3, and 13E3 are believed to be the most sensitive indicator sites available for the detection of radionuclides released from the SSES. Location 10G1 is the control location.

Sample Preservation and Analysis

All media in the terrestrial pathway are analyzed for the activities of gamma-emitting radionuclides using gamma spectroscopy. The other analysis that is routinely performed is the radiochemical analysis for iodine-131 in milk.

Monitoring Results

Refer to the following for results of the terrestrial pathway analyses for 2012:

- Figure 13 trends iodine-131 activities separately for milk
- Appendix G, Table G, shows a summary of the 2012 terrestrial monitoring results for milk and soil.
- Appendix H, Tables H-15 through H-19, shows comparisons of terrestrial pathway monitoring results against past years' data.
- Appendix I, Tables I-10 and I-11, shows results of specific sample analyses for terrestrial pathway media.

The only man-made radionuclides normally expected at levels in excess of analysis MDCs in the terrestrial pathway are strontium-90 and cesium-137. Both of these radionuclides are present in the environment as a residual from previous atmospheric nuclear weapons testing. Strontium-90 analyses are not routinely performed for any media samples in the terrestrial pathway. Strontium-90 activity would be expected to be found in milk. SSES Technical Requirements do not require that milk be analyzed for strontium-90. Strontium-90 analyses may be performed at any time if the results of other milk analyses would show detectable levels of fission product activity, such as I-131, which might suggest the SSES as the source.

Certain naturally occurring radionuclides are also routinely found above anaylsis MDCs. Potassium-40, a primordial and very long-lived radionuclide, which is terrestrial in origin, is observed in all terrestrial pathway media. Other naturally occurring radionuclides often observed in soil are thorium-228 and radium-226.

Soil

Annual samples from the 12S1 and 8G1 soil locations were analyzed for concentrations of gamma emitting nuclides (Table I-11). The following gamma-emitting radionuclides are routinely measured in soil at levels exceeding analysis MDCs: naturally occurring potassium-40, radium-226, actinium-228, thorium-228 and man-made cesium-137. The 2012 analysis results were similar to those for previous years. No other gamma-emitting radionuclides were reported at levels above analysis MDCs.

The 2012 means for indicator and control location potassium-40 activity were 13,120 pCi/kg and 9,033 pCi/kg, respectively. This is not the result of SSES operation because the potassium-40 is naturally occurring.

The 2012 means for indicator and control location radium-226 activity were 1,969 pCi/kg and 2,397 pCi/kg, respectively. Radium-226 in soil is not the result of SSES operation because it is naturally occurring.

The 2012 means for indicator and control actinium-228 activity were 939 pCi/kg and 795 pCi/kg, respectively.

The 2012 means for indicator and control location thorium-228 activity were 916 pCi/kg and 877 pCi/kg, respectively. Thorium-228 in soil is not the result of SSES operation because it is naturally occurring.

The 2012 means for indicator and control location cesium-137 activity were 64.8 pCi/kg and 89 pCi/kg, respectively. The 2012 indicator values ranged from 56 to 73.6 pCi/kg, compared to 92.3 to 124 pCi/kg for 2011. Cesium-137 was observed in preoperational control samples at 200 to 1200 pCi/kg as well as prior operational years in the 70 to 1200 pCi/kg range. The measured activities of cesium-137 were also detected in previous years at expected levels due to residual fall out from past atmospheric weapons testing and the Chernobyl event. As a general rule, it takes approximately ten half lives for a radionuclide to decay to non-detectable levels. Cesium-137 with its 30 year half life (300 years to decay to non-detectable) would still be present in samples in 2012. Cesium-137 in soil, although man-made, is not from Susquehanna station operations.

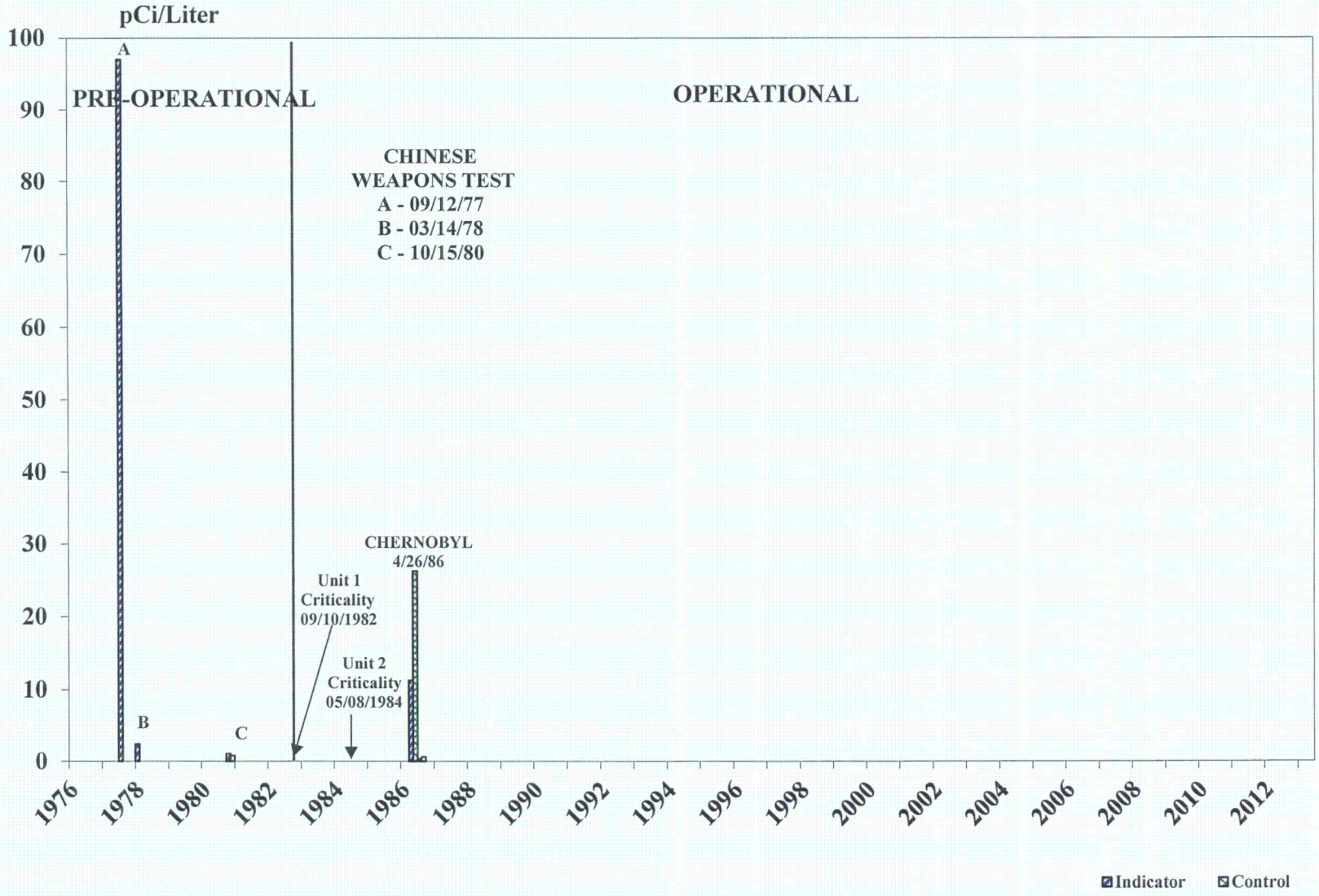
Milk

Semi-monthly or monthly samples from all milk locations were analyzed for concentrations of iodine-131 and other gamma-emitting nuclide activity (Table I-10). No detectable iodine-131 activity above MDC was observed at any location for 2012. The 2012 indicator values ranged from -.50 to .47 pCi/l, compared to -0.61 to 0.71 pCi/l for 2011. Iodine-131 has been chemically separated in milk samples and counted routinely since 1977. Refer to Figure 13 which trends iodine-131 activity in milk for indicator and control locations from 1977 through 2012.

The preoperational years 1976, 1978, and 1980 were exceptional years in the sense that iodine-131 activity was observed in excess of MDCs due to fallout from atmospheric nuclear weapons testing. Iodine-131 activity was also measured at levels exceeding MDCs in milk samples in 1986 in the vicinity of the SSES as a result of the Chernobyl incident.

With the exception of the naturally occurring potassium-40, no gamma-emitting radionuclides were measured in excess of analysis MDCs in 2012. The 2012 means for indicator and control location potassium-40 activity were 1,311 pCi/liter and 1,313 pCi/liter, respectively. The potassium-40 activity in milk is not attributable to SSES operation because it is naturally occurring.

FIGURE 13 - IODINE-131 ACTIVITY IN MILK



GROUND WATER MONITORING

INTRODUCTION

Normal operation of the SSES does not involve the release of radioactive material to ground water directly, or indirectly through the ground. As a result, there are no effluent monitoring data to compare with REMP ground water monitoring results. Ground water could conceivably become contaminated by leakage or spills from the plant or by the washout or deposition of radioactive material that might be airborne. If deposited on the ground, precipitation/soil moisture could aid in the movement of radioactive materials through the ground to water that could conceivably be pumped for drinking purposes. No use of ground water for irrigation near the SSES has been identified.

Primary release paths for recent groundwater contamination events at other nuclear facilities have been: 1) spent fuel pool leakage; 2) leaks from liquid radwaste discharge lines and; 3) leaks from cooling tower blowdown lines. The physical location of the spent fuel pools at Susquehanna and the fuel pool leakage collection system make it highly unlikely that the fuel pools would be a radiological contamination source for groundwater. Leaks from the liquid radwaste discharge line or the cooling tower blowdown line could impact ground water, but to date, there has been no indication of any radiological impacts on groundwater due to station operations.

Scope

Ground water in the SSES vicinity was sampled quarterly at 14 indicator locations (2S2, 4S4, 6S10, 11S2, 1S3, 4S8, 4S9, 8S4, 7S10, 13S7, 2S8, 6S11A/B, 6S12, and 7S11) and one control location (12F3) during 2012.

With the exception of locations 4S4 and 12F3, untreated ground water was sampled. Untreated means that the water has not undergone any processing such as filtration, chlorination, or softening. At location 4S4, the SSES Learning Center, well water actually is obtained from on-site and piped to the Learning Center after treatment. This treatment would not affect tritium analysis. This sampling is performed as a check to ensure that water has not been radioactively contaminated. Sampling is performed at the Learning Center to facilitate the sample collection process.

Sample Preservation & Analysis

Ground water samples were analyzed for gamma-emitting radionuclide and tritium activities. Gamma spectrometric analyses of ground water began in 1979 and tritium analyses in 1972, both prior to SSES operation.

Monitoring Results

Gamma-emitting radionuclides in excess of MDCs have been found in only a few samples in all the years that these analyses have been performed. The naturally occurring radionuclides potassium-40, thorium-228 and actinium-228 have been measured above their MDCs occasionally in ground water. Thorium-228 was found in 1985 and 1986. The man-made radionuclide cesium-137 has been detected only occasionally since 1979. Its presence has always been attributed to residual fallout from previous atmospheric nuclear weapons tests.

Results for the 2012 specific ground water sample analyses may be found in Table I-7 of Appendix I. A summary of the 2012 ground water monitoring data is in Appendix G.
Comparisons of 2012 monitoring results for tritium with those of past years may be found in Table H 20 of Appendix H.

In 2012 tritium was measured above MDC, in seven samples at indicator locations 1S3, 4S8, 8S4, 4S9, 7S10, 6S11A, and 13S7. The activities were slightly above the detection limit. The 2012 indicator values ranged from -93 to 259 pCi/l, compared to -117 to 246 pCi/l for 2011. The 2012 mean tritium activity levels for indicator and control monitoring locations were 58.4 and -5.87 pCi/l, respectively.

The source of the low level tritium monitored in groundwater is associated with the permitted discharge of tritiated water vapor or gases released from routine airborne effluent from Susquehanna operations and subsequent washout into precipitation and infiltration of tritium into groundwater.

Monitoring Wells and Precipitation

An expanded groundwater-monitoring network was initiated in 2006 for the Station as part of a site-wide hydrogeological investigation in accordance with the Nuclear Energy Institute (NEI) Groundwater Protection Initiative (GPI).

The additional groundwater monitoring wells are sampled as part of the Radiological Environmental Monitoring Program to regularly assess groundwater quality and provides early detection of any inadvertent leaks or spills of radioactive materials that could reach groundwater. Groundwater is sampled quarterly and analyzed for tritium and gamma activity. Additionally, precipitation sampling was initiated in 2007 and analyzed for tritium activity to assess the influence of station airborne tritium emissions on groundwater tritium activities.

Precipitation washout monitoring data is not used in dose calculations; however, the data does give a gross indication of tritium concentrations which makes its way into surface water and soil where it eventually seeps into shallow groundwater. The average annual tritium concentrations in precipitation, perimeter drain manholes, groundwater monitoring wells, and surface water results are summarized in Table GW 1 and graphically depicted in Figure 14.

Table GW 1 – 2008, 2009, 2010, 2011 and 2012 Annual Average Tritium Concentration (pCi/l) in Precipitation, Perimeter Drain, Monitoring Wells and LTAW Surface Water Data

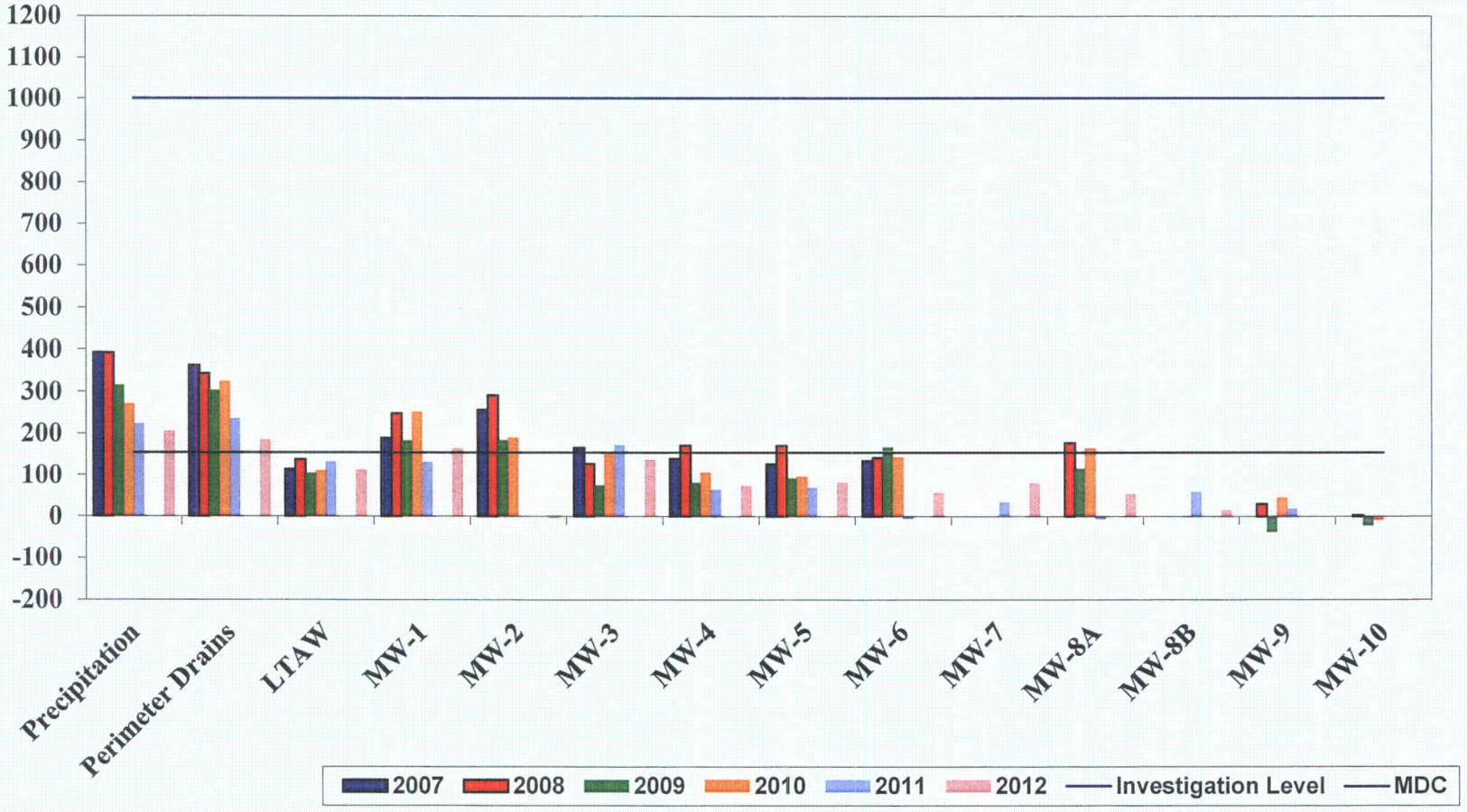
Site	2008	2009	2010	2011	2012
Precip Sites 3S2,12S1,8G1 (off-site, controls)	62*	49	40	38	82
Precip Sites 1 and 2 (on-site, East of Station Reactor Buildings)	370	230*	193	216	242
Precip Sites 3 and 4 (on-site, West of Station Reactor Buildings)	414	404*	350	233	169
Perimeter Drain manholes (below grade, 28')	344	304	325	236	185
1S3 – MW-1 (43')	248	150	252	131	164
4S8 – MW-2 (45')	292	154	190	173	137
4S9 – MW-3 (94')	127	54	150	64	80
8S4 – MW-4 (111')	172	66	105	68	81
7S10 – MW-5 (36')	171	69	96	-6	74
13S7 – MW-6 (16')	142	134	143	34	80
2S8 – MW-7 (not installed)	N/A (not installed)	N/A (not installed)	N/A (not installed)	22	54
6S11A – MW-8A (14')	177	82	165	58	15
MW-8B (19')	N/A (well dry)	N/A (well dry)	N/A (well dry)	N/A (well dry)	N/A (well dry)
6S12 – MW-9 (28')	30	-44	45	18	6
7S11 – MW-10 (132')	3	-27	-9	1	-1
12F3 – Groundwater Control (5.2 miles from Site)	26	-53	-2	5	-6
LTAW: Surface Water	179	104	110	132	132

* Revised values to reflect full scope of precipitation data.

Precipitation will invariably become groundwater via infiltration through soil and into groundwater. The highest average tritium concentration in precipitation on-site in 2012 was 242 pCi/l from Sites 1 and 2 located on the west side of the station reactor buildings. In 2012, the tritium concentration in rainwater samples ranged from 32 to 511 pCi/l compared to -11 to 1100 pCi/l in 2011. Liquid is not always present in the precipitation collection devices during dry months, thus quarterly and annual tritium averages are generally only representative of wetter months. The decreasing trend in tritium in the perimeter drain system parallels the decrease in tritium in precipitation seen in Figure 14.

The perimeter foundation drain system is below grade (approximately 28 feet) and serves to reduce hydrostatic pressure from groundwater on the building structures. Precipitation and storm water runoff may also enter these drains via infiltration. Groundwater results from the perimeter drains have tritium concentrations that are slightly above MDC. The source of the tritium at these locations can be attributed to precipitation washout of tritium from routine airborne effluent releases. It is evident that elevated tritium levels found within sub-surface groundwater in close proximity to the station is influenced by station airborne emissions and tritiated precipitation washout. The impact of the station tritium emissions on groundwater activities is dependent on the distance from the station, groundwater depth and general dispersion conditions around the station. The pre-operational groundwater background (12F3 control) from 1980-81 was approximately 120 pCi/l and is located 5.2 miles WSW of the Susquehanna site.

FIGURE 14 - ANNUAL AVERAGE TRITIUM ACTIVITY (pCi/l) IN PRECIPITATION, PERIMETER DRAIN, SURFACE WATER VERSUS GROUND WATER



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