AMBIENT RADIATION MONITORING

INTRODUCTION

The principal or primary method for the SSES REMP's measurement of ambient radiation levels is the use of thermoluminescent dosimeters (TLDs). The TLDs are crystals (calcium sulfate) capable of detecting and measuring low levels of radiation by absorbing a portion of the radiation's energy that is incident upon them and storing the captured energy until the TLDs are processed (read). Processing involves heating the TLDs to release their stored energy in the form of light and measuring the intensity of the light that they emit. The intensity of the emitted light is proportional to the amount of radiation to which they were exposed. Calibration of the TLD processors permits a reliable relationship to be established between the light emitted and the amount of radiation dose received by the TLDs; the result permits accurate measurements of the ambient radiation in the environment.

Environmental TLDs are continually exposed to natural radiation from the ground (terrestrial radiation) and from the sky (cosmic) radiation. In addition, they also may be exposed to man-made radiation. Most of the environmental TLD's natural radiation exposure comes from sources in the ground. These terrestrial sources vary naturally with time due to changes in soil moisture, snow cover, etc. The natural-radiation picture is complicated because these factors affecting radiation reaching the TLDs from the ground vary differently with time from one location to another due to locational differences in such factors as soil characteristics (amounts of organic matter, particle size, etc.), drainage opportunities, and exposure to sunlight. Environmental TLDs can also be affected by direct radiation (shine) from the SSES turbine buildings during operation, radwaste transfer and storage, and radioactive gaseous effluents from the SSES.

Unfortunately, TLDs do not have any inherent ability to indicate the source of the radiation to which they are exposed. The placement of numerous TLDs in the environment can facilitate decision-making about the possible radiation sources to which TLDs are exposed. However, a method for evaluating TLD data is still required. The SSES REMP relies on a statistically based approach to simultaneously compare indicator TLD data with control TLD data and operational TLD data with preoperational TLD data. This approach permits the flagging of environmental TLD doses that might have been produced by both man-made sources of radiation, as well as natural radiation sources. It also provides a means for attributing a portion of the total TLD dose to SSES operation if appropriate. Appendix E, pages E-6 through E-10, provides a description of the process for evaluating the results of TLD measurements.

Scope

TLDs

The area around the SSES was divided for monitoring purposes into sixteen sectors radiating outwards from the plant site, each encompassing an area described by an arc of 22.5 degrees. TLDs were placed in all 16 sectors at varying distances from the plant. Monitoring locations were chosen according to the criteria presented in the NRC Branch Technical Position on Radiological Monitoring (Revision 1, November, 1979).(17) The locations for the TLDs were selected by considering factors such as local meteorological, topographical, and population distribution characteristics.

During 2002, the SSES REMP had 76 indicator TLD locations and eight control TLD locations. This level of monitoring exceeds that which is required by the Nuclear Regulatory Commission. The indicator TLDs nearest the SSES are positioned at the security or perimeter fences surrounding the site. This is the closest that a member of the public would be able to approach the station. The control TLDs are the most distant from the SSES, ranging from 10 to 20 miles from the site.

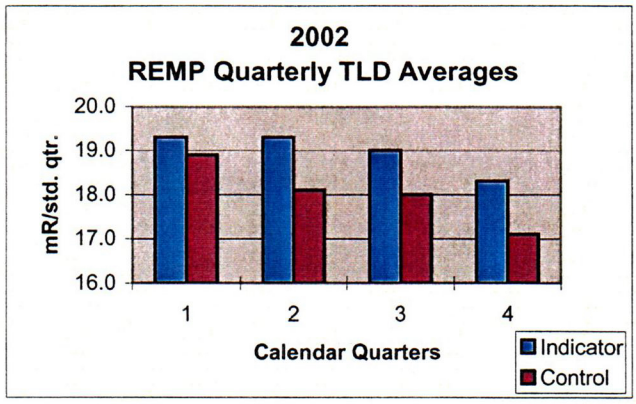
Monitoring Results

TLDs

TLDs were retrieved and processed quarterly in 2002. Average ambient radiation levels measured by environmental TLDs generally decreased each successive quarter throughout 2002, as shown in the bar graph on the following page. Refer to Figure 8 which trends both indicator and control data quarterly from 1973 through 2002.

The 2002 annual average exposures for indicator and control locations were 19.0 mR/std. qtr. and 18.1 mR/std. qtr., respectively. These are 1.0 mR/std. qtr. and 1.1 mR/std. qtr., respectively, below the corresponding 2001 annual averages. The 2002 exposures are within the ranges of annual averages for the prior operational periods at each type of monitoring location. Refer to Figure 8 at the end of this section which trends quarterly TLD results for both preoperational and operational periods at the SSES. Refer to Appendix H, Table H 1, page H 3 for a comparison of the 2002 mean indicator and control TLD results with the means for the preoperational and prior operational periods at the SSES.

Indicator environmental TLD results for 2002 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 suggested during 2002 at the following **onsite** locations: 1S2, 6S4, 6S9, 7S6, 8S2, 9S2, 10S2, 11S3, 12S4, 13S2, 13S4, 13S5, 16S1 and 16S2. Thus, there were 14 monitored locations in 2002 where a SSES dose contribution is considered to have been discernible. Refer to Appendix E, page E-6, for a discussion of "TLD Data Interpretation." TLD results for all locations for each quarter of 2002 may be found in Appendix I, Table I-1, beginning at page I-2.



The estimated quarterly exposure contributions were summed by location for the entire year. The largest dose suggested was approximately 0.0299 mrem at an onsite monitoring location, 9S2, 0.2 mile south of the SSES. This dose was used for determining compliance with SSES Technical Requirement Limit 3.11.3 for annual effluent reporting purposes. This dose amounts to only 0.12% of the 25 mrem whole-body dose limit of SSES Technical Requirement 3.11.3.

C09

FIGURE 8 - AMBIENT RADIATION LEVELS BASED ON TLD DATA

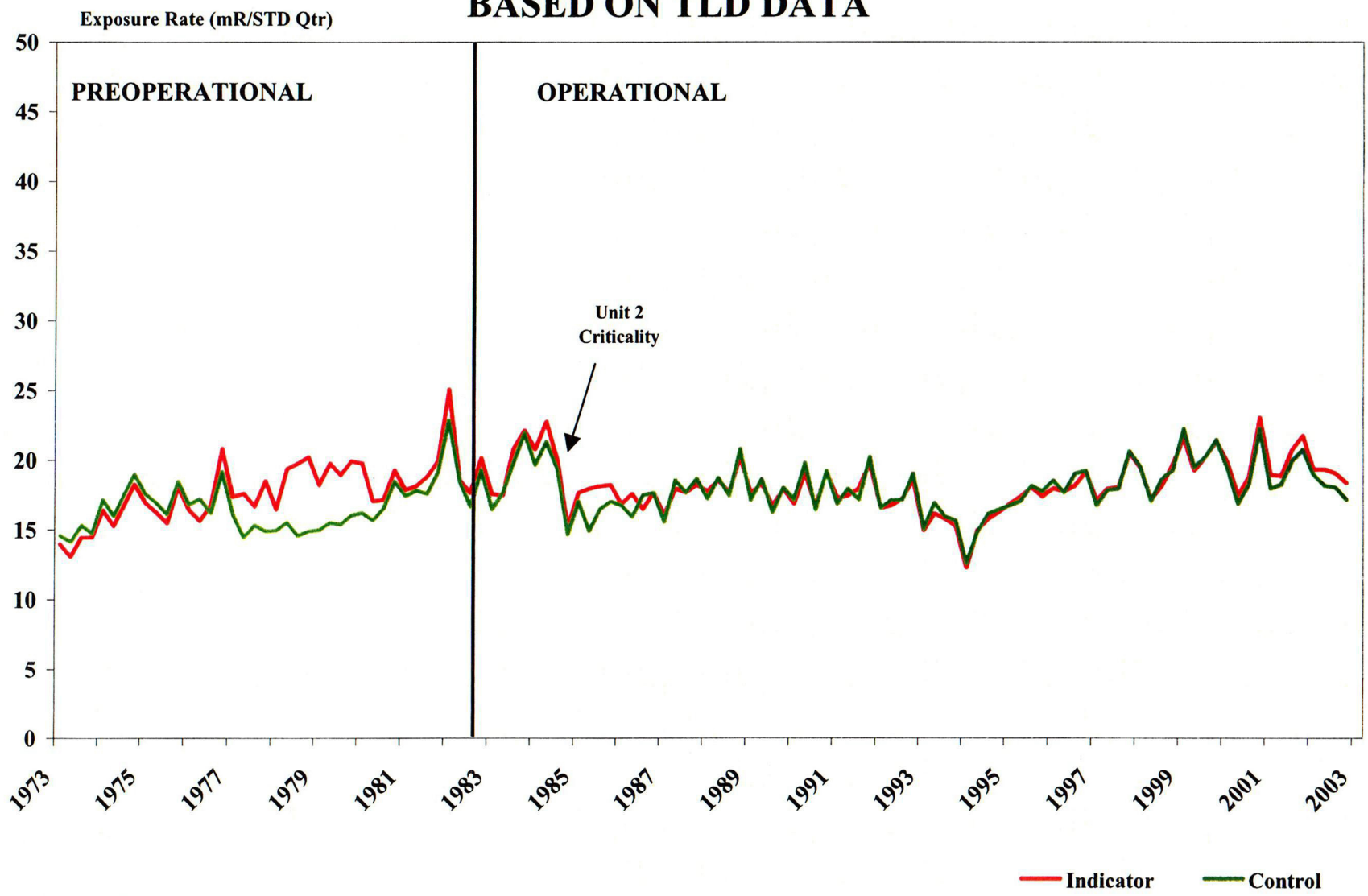


FIG. 8 - H\REMPFIG02.xls

AQUATIC PATHWAY MONITORING

INTRODUCTION

The following media were monitored in 2002 by the SSES REMP in the aquatic pathway: surface water, drinking water, fish, and sediment. 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 more clear than that which could be obtained if one or more were not included in the REMP.

Fruits or vegetables that are grown in fields irrigated with surface water would also be in the aquatic pathway. The land use census (Reference 73) conducted in 2002 looked at farms within 10 miles downstream of the SSES. Two farms were found to have been irrigated during the 2002 growing season.

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 occasional 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 potentially 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 can receive storm runoff from the SSES. 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.

Scope

Surface Water

Surface water was routinely sampled from the Susquehanna River at one indicator location (6S5) and one control location (6S6) at the SSES River Water Intake during 2002. Sampling also took

place at the following additional indicator locations: the SSES discharge line to the river (2S7/6S7) and Lake Took-A-While (LTAW).

Drinking Water

Drinking water samples were collected at location 12H2, the Danville Municipal Water Authority's treatment facility on the Susquehanna River, in 2002. 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 locations would be suitable for comparison.

Fish

Fish were sampled from the Susquehanna River in the spring and fall of 2002 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 the fish caught there would spend any time below the SSES discharge. In addition, fish were also sampled 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. In addition, sediment was also obtained from location LTAW.

Sampling

Surface Water

Weekly grab sampling was performed at the indicator location 6S5. Weekly grab samples were composited both monthly and biweekly at this location. Location 6S5 was considered a backup for locations 2S7 and 6S7 in the event that water could not be obtained from the automatic samplers at these locations. Nevertheless, 6S5 was sampled routinely throughout 2002, since it is the closest downstream sampling point to the SSES discharge.

Indicator locations 2S7 and 6S7, the SSES Cooling Tower Blowdown Discharge (CTBD) line, and control location 6S6, the SSES River Water Intake structure, were sampled time proportionally 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 either biweekly or monthly compositing.

The other surface water monitoring location, LTAW, was grab sampled once each month.

Drinking Water

Treated water was sampled time proportionally 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 either biweekly or 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 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.

Sample Preservation and Analysis

Surface and Drinking Water

Surface and drinking water samples were analyzed monthly for beta activities, the activities of gamma-emitting radionuclides, and tritium activities. Iodine-131 was analyzed biweekly for composite samples and monthly for the grab samples. In addition, drinking water samples were analyzed for gross alpha activity.

To optimize the accuracy of these sample analyses, preservatives were added to the samples as soon after collection as practical. Nitric acid was added to sample aliquots destined for gross alpha and beta activity analysis and the analysis of gamma-emitting radionuclide activity analysis. Sufficient acid was added to reduce the pH of these sample aliquots to nearly two in order to reduce the potential for radionuclides leaving the water and depositing on the sides of the sample containers.

Sodium bisulfite was added to sample aliquots destined for iodine-131 analysis in amounts equivalent to one gram per each gallon of water. This amount was recommended by the radioanalytical laboratory (Teledyne Brown Engineering) analyzing the samples. The purpose for sodium bisulfite addition is to reduce the potential for volatilization and loss of iodine from samples by maintaining it in a chemically reduced form.

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

Results from specific sample analyses of surface water may be found in Tables I-2 and I-3 of Appendix I. A summary of the 2002 surface water data may be located in Table G of Appendix G. Comparisons of 2002 monitoring results with those of past years may be found in Tables H 2 through H 4 of Appendix H.

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 to the NRC annually. Data from the following three surface water

monitoring locations were averaged together as indicators for reporting purposes: one 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).

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, it currently is required that the water that is discharged to the Susquehanna River through the CTBD line from the SSES be 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. Nevertheless, 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 are limited to a maximum of 200 gpm. 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 by the returning noncontaminated 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 2002 was approximately 6,400,000 gpm. This is more than 1,300 times the required minimum flow rate through the CTBD for discharges to be permitted.

The amounts of radioactively contaminated water being discharged are small. Nevertheless, sensitive analyses of the water samples can often detect the low levels of certain types 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. Most radionuclides discharged from the SSES CTBD are at such low levels in the downstream river water that, even with the sensitive analyses performed, they cannot be detected.

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 2S7/6S7) results in the indicator data that is averaged.

The 2002 data for **gross beta activity** analyses of surface water are lower than those of 2001. The 2002 mean gross beta activity of 5.4 pCi/liter for indicator locations is less than the 2001 indicator mean gross beta activity of 6.5 pCi/liter. The 2002 indicator mean activity is within the range of the annual means for the previous operational period of the SSES. The 2002 mean gross beta activity of 2.9 pCi/liter for control locations is less than the 3.5 pCi/liter for the 2001 control mean gross beta activity. The 2002 control mean activity is within the range of the annual means for both the previous operational and preoperational periods. Refer to Figure 9 which trends gross beta activities separately for surface water indicator and control locations quarterly from 1975 through 2002.

Comparison of the 2002 indicator mean (5.4 pCi/l) to the 2002 control mean (2.9 pCi/l) suggests a contribution of beta activity from the SSES. The 2002 data is similar in this regard to the averages of annual means for indicator and control locations for the prior operational period. During the prior operational period, the average of annual indicator means exceeds the average of annual control means for gross beta activity.

The 2002 means for **iodine-131 activity** at indicator and control surface water monitoring locations were 0.61 pCi/liter and 0.43 pCi/liter, respectively. The 2002 indicator mean is greater than the 2001 indicator mean. The 2002 control mean is less than the 2001 control mean. Both the 2002 indicator and control mean activities are also greater than the averages of the annual means for both indicator and control locations for the prior operational and preoperational periods of the SSES.

Throughout the course of a year, iodine-131 is typically measured at levels in excess of analysis MDCs in some samples obtained from control surface water monitoring locations on the Susquehanna River upstream of the SSES as well as indicator locations downstream of the SSES. As determined by measurements of samples obtained by the SSES REMP, the mean iodine-131 activity level from the CTBD for all of 2002 was approximately 1.04 pCi/liter. This may be compared to the activity level of 0.43 pCi/liter for control surface water monitoring locations in 2002.

Iodine-131 from the discharge of medical wastes into the Susquehanna River upstream of the SSES is drawn into the SSES cooling tower basins through the SSES River Water Intake Structure. It is reasonable to assume that concentration of the already existing iodine-131 in the cooling tower

basins occurs as it does for other substances found in the river. For example, the SSES routinely assumes concentration factors in the basin for calcium of four to five times the concentrations in the river water entering the basins, based on past measurements. This concentrating effect occurs because of the evaporation of the water in the basins, leaving behind most dissolved and suspended materials in the unevaporated water remaining in the basins. If a concentration factor of four for iodine-131 were to be applied to the 2002 mean iodine-131 activity level for the control samples from the Susquehanna River, a mean concentration of 1.72 pCi/liter for iodine-131 in the basin water and the water being discharged from the basins would be expected. The actual 2002 mean of 1.04 pCi/liter for the CTBD iodine-131 activity level was less than this.

Because iodine-131 is radioactive, unlike the calcium that has been measured, iodine-131 is removed from the water while it is in the basins through the radioactive decay process. Thus, it might be expected that the net concentration factor for iodine-131 would be somewhat less than that for calcium, considering this additional removal process. The extent to which the iodine-131 concentration factor is less than that for calcium would depend on the mean residence time for the water in the basins compared to iodine-131's radioactive half-life - the greater the ratio of the mean residence time to the half-life, the smaller the concentration factor. A mean residence time for water in the basins is expected to be about two days. This is only about one-fourth of the approximately eight-day half-life of iodine-131. Thus, radioactive decay would not be expected to reduce the concentration factor for iodine-131 by a large amount. Therefore, the difference between the 2002 mean iodine-131 activity of about 1.04 pCi/liter in the CTBD and the 2002 mean iodine-131 activity for the control location of 0.43 pCi/liter should be the result of concentration in the basins. Iodine-131 was not reported to have been discharged with water released from the SSES to the Susquehanna River during 2002.

The 2002 mean tritium activity for indicator locations is more than the corresponding 2001 mean. The 2002 means for tritium activity at indicator and control locations were 1,363 pCi/liter and 36.1 pCi/liter, respectively. The 2002 indicator mean is greater than the annual average mean for prior operational and preoperational periods of the SSES. The control mean is within the range of the corresponding annual mean reported for the prior operational period of the SSES. Refer to Figure 10 which trends tritium activity levels separately for surface water indicator and control locations from 1972 through 2002.

The 2002 indicator mean tritium level for all surface water locations can be misleading for those interested in the mean tritium level in the Susquehanna River downstream of the SSES for 2002. The much higher levels of tritium observed in the CTBD line (location 2S7/6S7), 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 2002 was 49.6 pCi/liter, which is much closer to the mean tritium activity, 36.1 pCi/liter, for the control location, both of which represent actual river water levels.

In spite of the fact that the tritium activity levels reported for 2S7/6S7 are from the discharge line prior to dilution in the river, the highest quarterly average tritium activity reported at 2S7/6S7 during 2002 was approximately 6,955 pCi/liter for the second quarter, well below the NRC non-routine 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 2S7/6S7 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.

With the following exceptions, no gamma-emitting radionuclides were measured in surface water primary samples at an activity level exceeding an analysis MDC in 2002: potassium-40, iodine-131, radium-226, and thorium-228.

Drinking Water

Drinking water was monitored during 2002 at the Danville Water Company's facility 26 miles WSW of the SSES on the Susquehanna River. From 1977 (when drinking water samples were first collected) through 1984, drinking water samples were also obtained from the Berwick Water Company at location 12F3, 5.2 miles WSW of the SSES. The drinking water supply for the Berwick Water Company is not, however, water from the Susquehanna River; it is actually well water.

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.

Results from specific sample analyses of drinking water may be found in Table I-4 of Appendix I. A summary of the 2002 drinking water data may be located in Table G of Appendix G. Comparisons of 2002 monitoring results with those of past years may be found in Tables H 5 through H 7 of Appendix H.

Gross alpha activity has been monitored in drinking water since 1980. Gross alpha activity has been observed at levels above the analysis MDCs in a small minority of the samples during most years since 1980. The 2002 mean gross alpha activity level for drinking water was 0.24 pCi/liter. The 2002 mean alpha activity level is within the range of the corresponding annual means for the prior operational years. No gross alpha activity in drinking water during 2002 is attributed to liquid discharges from the SSES to the Susquehanna River.

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 2002 mean gross beta activity level for drinking water was 2.75 pCi/liter. The 2002 mean is above the 2001 mean gross beta activity level for drinking water but within the range of the corresponding annual means for both the prior operational and preoperational periods of the SSES. Refer to Figure 11 which trends gross beta activity levels separately for drinking water indicator and control locations from 1977 through 2002. No gross beta activity in drinking water during 2002 is attributed to liquid discharges from the SSES to the Susquehanna River.

Iodine-131 was measured in excess of analysis MDCs in 6 out of 26 drinking water samples in 2002. This compares with results from 17 samples for which analysis MDCs were exceeded in 2001. The 2002 mean iodine-131 activity level in drinking water samples was 0.22 pCi/liter. This is less than the 2001 mean drinking water activity level of 0.35 pCi/liter. Also, it is less than the 2002 mean of 0.43 pCi/liter for the surface water control location. No iodine-131 activity in drinking water during 2002 is attributed to liquid discharges from the SSES to the Susquehanna River.

Tritium was measured in excess of analysis MDCs twice in 2002 in drinking water. The 2002 mean tritium activity level for drinking water was 55.7 pCi/liter. The 2002 mean is below the averages of the corresponding annual means for both the prior operational and preoperational periods of the SSES. The low 2002 mean tritium activity level for drinking water is higher than the 2002 mean tritium activity level for the surface water control location. Tritium activity in drinking water can be attributed to liquid discharges from the SSES to the Susquehanna River.

With the exception of I-131, no gamma-emitting radionuclides were measured above the analysis MDCs for gamma spectroscopic analyses of drinking water samples during 2002.

Fish

Results from specific sample analyses of fish may be found in Table I 5 of Appendix I. A summary of the 2002 fish data may be located in Table G of Appendix G. A comparison of 2002 monitoring results with those of past years may be found in Table H 8 of Appendix H.

Three species of fish were sampled at each of one indicator location and one control location on the Susquehanna River in April 2002 and again in October 2002. The species included the following: smallmouth bass, channel catfish, and shorthead redhorse. In addition, one largemouth bass was sampled from PPL's LTAW. A total of 15 fish were collected and analyzed.

The only gamma-emitting radionuclide reported in excess of analysis MDCs in fish during 2002 was naturally occurring potassium-40. The 2002 indicator and control means for the activity levels of potassium-40 in fish were 3.61 pCi/gram and 3.78 pCi/gram, respectively. The 2002 indicator and control means were slightly greater than the 2001 means. Both the 2002

indicator and control means are within the ranges of their corresponding annual means for prior operational and preoperational years. Naturally occurring potassium-40 in fish is not attributable to the liquid discharges from the SSES to the Susquehanna River.

Sediment

Shoreline sediment was sampled in April 2002 and again in October 2002. Results from specific sample analyses of sediment may be found in Table I-6 of Appendix I. A summary of the 2002 sediment data is located in Table G of Appendix G. Comparisons of 2002 monitoring results with those of past years may be found in Tables H 9 through H 12 of Appendix H.

Naturally occurring potassium-40, radium-226, and thorium-228 were measured at activity levels above analysis MDCs in all shoreline sediment samples in 2002 with two exceptions. Thorium-228 did not exceed the MDC in a sample from April and October.

The 2002 indicator and control means for potassium-40 activity levels in shoreline sediment were 12.8 pCi/gram and 10.4 pCi/gram, respectively. The 2002 indicator and control means for potassium-40 activity are less than their corresponding 2001 means. The 2002 indicator and control means were within the ranges of corresponding annual means for all prior operational and preoperational years.

The 2002 indicator and control means for radium-226 activity levels in shoreline sediment were 2.02 pCi/gram and 2.4 pCi/gram, respectively. The 2002 indicator and control mean radium-226 activities are higher than the corresponding 2001 means. These 2002 radium-226 means were above the ranges of the corresponding annual means for all prior operational years.

The 2002 indicator and control means for thorium-228 activity levels in shoreline sediment were 1.7 and 2.11 pCi/gram, respectively. The 2002 indicator mean is the same as the 2001 indicator mean. The 2002 control mean is greater than the corresponding 2001 control mean. The 2002 control mean is greater than the range of corresponding means for prior operational years. The 2002 indicator mean is within the range of corresponding means for prior operational years. The naturally occurring radionuclides in sediment discussed above are not attributable to the liquid discharges from the SSES to the Susquehanna River.

Cesium-137 was measured at activity levels in shoreline sediment exceeding analysis MDCs in 4 of 6 analyses during 2002. The 2002 indicator and control means for cesium-137 activity levels in sediment were 0.055 pCi/gram and 0.13 pCi/gram, respectively. The 2002 indicator mean is less than the corresponding 2001 mean. The 2002 control mean is greater than the corresponding 2001 mean. The 2002 indicator mean is less than the average of corresponding annual means for both prior operational as well as preoperational years. The 2002 control mean is greater than the averages of corresponding annual means for both prior operational as well as preoperational years. This cesium-137 in the sediment is attributed to residual

fallout from past atmospheric nuclear weapons tests.

Dose from the Aquatic Pathway

Tritium was the only radionuclide identified in 2002 by the SSES REMP in the aquatic pathway that was attributable to SSES operation and also included in the pathway to man.

The total tritium activity released from the SSES for the year was estimated based on REMP monitoring results for use in projecting maximum doses to the public. This estimate assumed that the tritium was present continuously in the CTBD line throughout 2002 at a level equivalent to the annual mean activity level of tritium. It was also assumed that the annual average activity level of tritium being contributed to the Susquehanna River water could be represented by the difference between the annual mean activity levels of tritium in the CTBD line (without correction for cooling tower basin reconcentration) and in the river upstream of the SSES.

The annual mean activity level of tritium in the CTBD line (monitoring location 2S7\6S7) for 2002 was 3,885 pCi/l. The annual mean activity level for the river upstream of the SSES (monitoring location 6S6) was approximately 36 pCi/l. Thus, the difference in the mean activity levels for these two locations was about 3,849 pCi/l. The annual mean flow rate for the CTBD line was 7,839 gpm. Using the proper unit conversions and multiplying 7,839 gpm times 3,849 pCi/l yields a value of 58.4 curies for the estimate of tritium released during 2002 based on the results of radiological environmental monitoring. This estimate is 7 curies less than the amount of tritium determined by effluent monitoring to have been released to the river by the SSES in 2002. This agreement between the estimate based on environmental monitoring and the amount reported by effluent monitoring is consistent with previous years comparisons.

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 dose obtained 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 doses were each estimated to be approximately 0.0014 mrem.

FIGURE 9 - GROSS BETA ACTIVITY IN SURFACE WATER

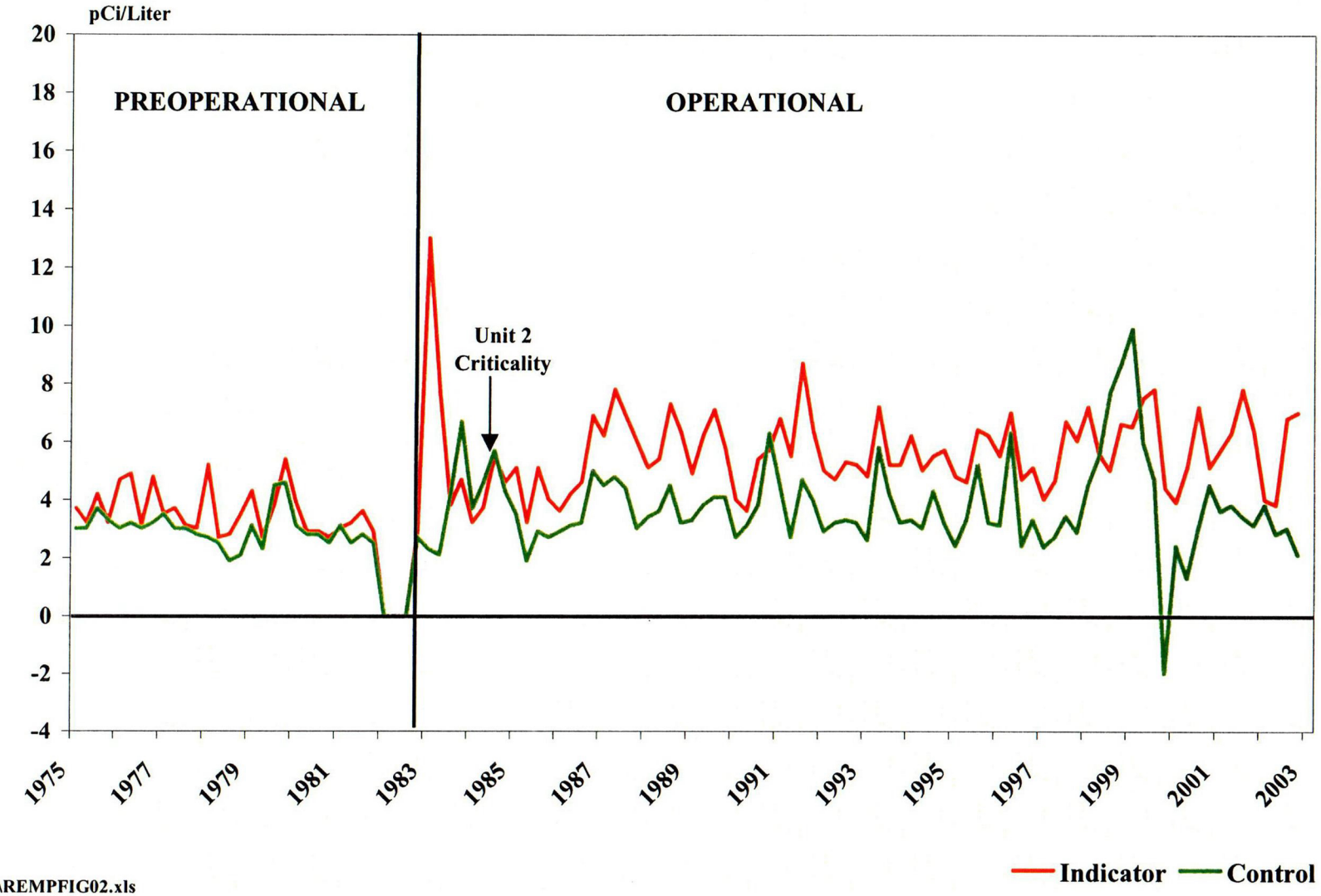


FIG. 9 - H\REMPFIG02.xls

FIGURE 10 - TRITIUM ACTIVITY IN SURFACE WATER

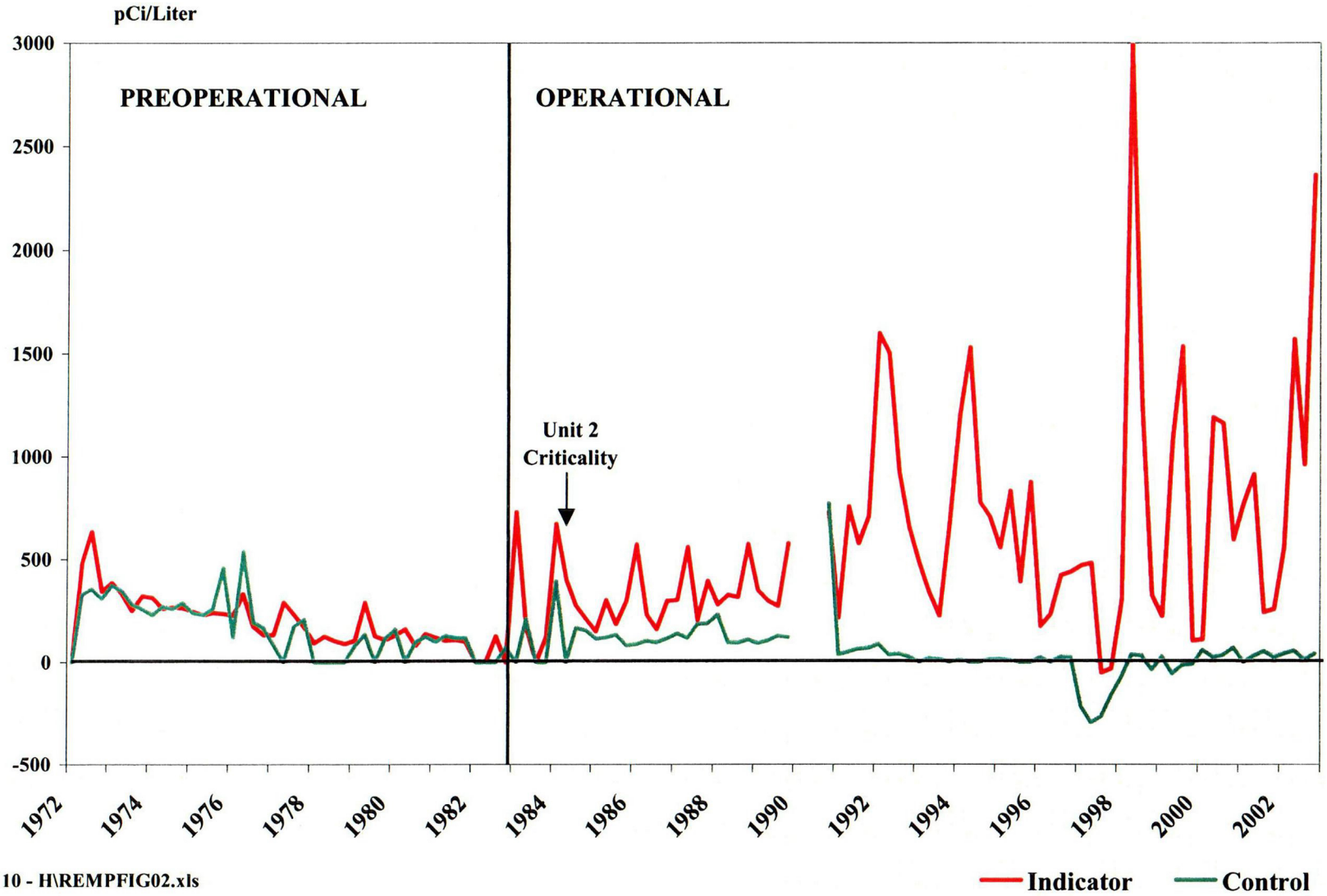


FIG. 10 - H\REMPFIG02.xls

FIGURE 11 - GROSS BETA ACTIVITY IN DRINKING WATER

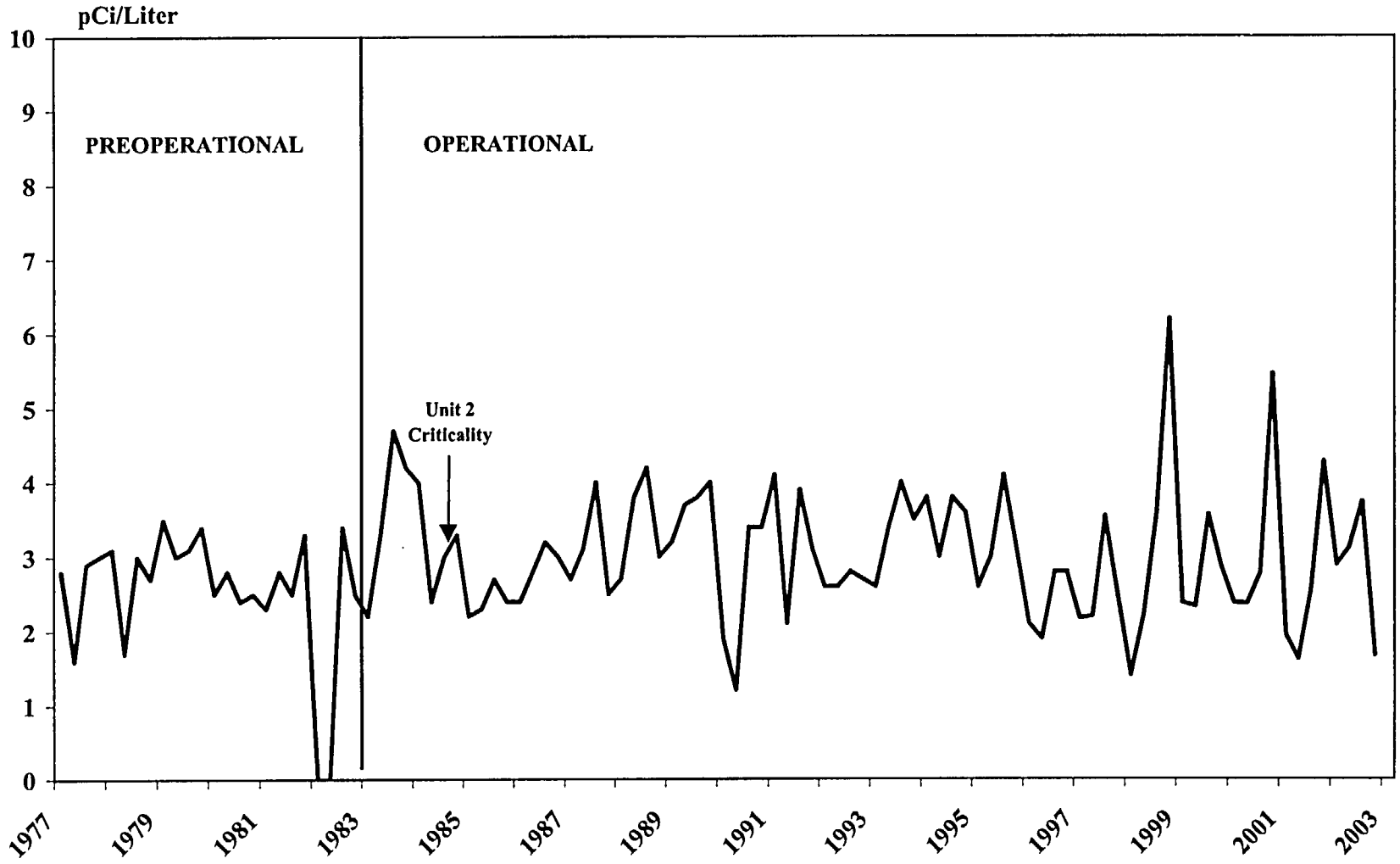


FIG . 11 - H\REMPFIG02.XLS

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 2002. 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. Monitoring must be performed at the community in the vicinity of the SSES with the greatest predicted sensitivity. A control location that is expected to be unaffected by any routine SSES releases must be monitored.

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

Gross beta activity is always 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. Figure 12 trends the quarterly mean gross beta activities for the indicator and control locations separately from 1974 through 2002. 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.

Particulate gross beta activity levels for each monitoring location and monitoring period in 2002 are presented in Table I-8 of Appendix I. Comparisons of 2002 gross beta analysis results with those of previous years may be found in Table H 13 of Appendix H. For 2002, the annual means for the beta activities of the indicator and control locations are 16.0E-3 pCi/m^3 and 14.0E-3 pCi/m^3, respectively. These are near the low end of the corresponding ranges of previous operational yearly averages. They are significantly below the corresponding lower ends of their preoperational yearly averages. A contribution of radioactivity from the SSES may be suggested from the 2002 airborne gross beta data based on the higher mean activity reported for indicator location.

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

Beryllium-7 was measured above analysis MDCs for all quarterly composite samples in 2002. The 2002 indicator and control means for beryllium-7 activity were 137E-3 pCi/m^3, and 94E-3 pCi/m^3, respectively. The 2002 means are higher than the corresponding 2001 means. The 2002 indicator and control means were higher than the averages of the corresponding annual means for the prior operational and preoperational periods. Beryllium-7 activity levels for each 2002 calendar quarter at each monitoring location are presented in Table I-9 of Appendix I. Comparisons of 2002 beryllium-7 analysis results with previous years may be found in Table H 14 of Appendix H.

Mn-54 was identified in the fourth quarter composite sample from monitoring location 12S1.

No other gamma-emitting radionuclides were reported for air in 2002. Beryllium-7 and potassium-40 are not attributable to SSES operation. Mn-54 was identified on SSES effluent air

samples and thus can be attributable to SSES operations.

Air Iodine

Iodine-131 has been detected infrequently from 1976, when it was first monitored, through 2002. 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. No iodine-131 was reported for the 2002 air monitoring results.

FIGURE 12 - GROSS BETA ACTIVITY IN AIR PARTICULATES

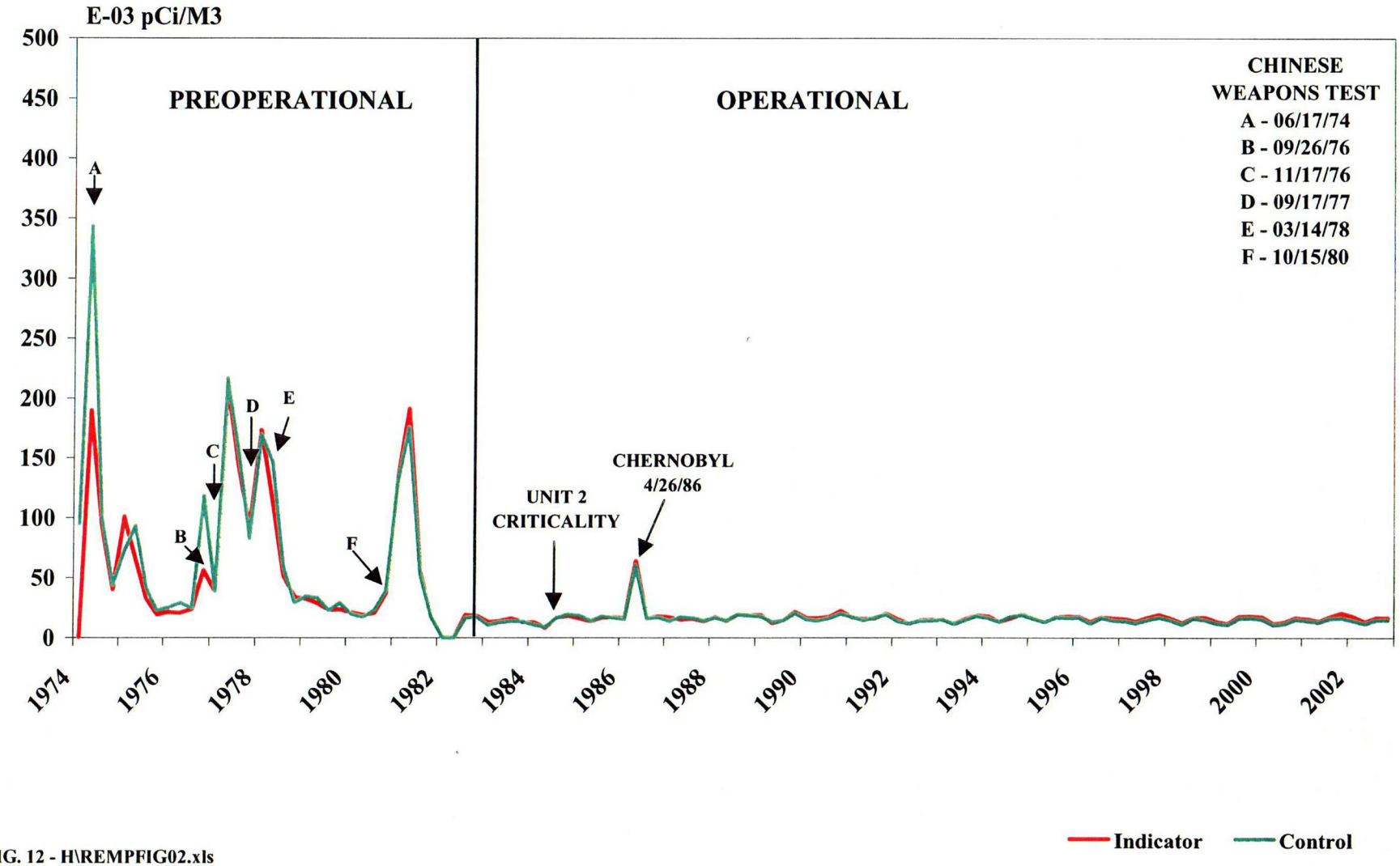


FIG. 12 - H\REMPFIG02.xls

TERRESTRIAL PATHWAY MONITORING

INTRODUCTION

The following media were monitored in the Terrestrial Pathway in 2002: soil, milk, fruits and vegetables.

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 highly 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 four 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 and fruit and vegetable samples were obtained at 3 locations in 2002. 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. Additional milk sampling was performed from April through June in conjunction with a new dairy farm replacing an existing dairy farm. SSES Technical Requirements only require that fruit and vegetables be sampled at locations irrigated by Susquehanna River from points downstream of the SSES discharge to the River. There are only three locations within 10 miles downstream of the SSES that have been known to irrigate with water from the Susquehanna River during unusually dry periods. These locations do not irrigate every year. Irrigation was performed at the Zehner Brothers Farm (11D1) and the Lupini Farm (12F7) during 2002 as identified by the 2002 Land Use Census (Reference 73).

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 certain fruit and vegetables 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 2002 in accordance with its scheduled annual sampling frequency, at the following four REMP air sampling locations, 3S2, 12S1, 13S6, and 8G1. Location 8G1 was a control sampling location; the remaining sampling sites were indicator locations.

Twelve 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 four monitoring locations, a total of 8 soil samples were analyzed in 2002.

Milk

Milk was sampled at least monthly at the following four locations through June of 2002: 10D1, 10D2, 10D3, and 10G1. Location 12B2 was added in April 2002.

Milk was sampled semi-monthly from April through October when cows were more likely to be on pasture. As of July 1, 2002 12B2 replaced 10D3 due to location 12B2 believed to be a more sensitive indicator site than 10D3. Locations 10D1, 10D2, 10D3, and 12B2 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. A total of 76 milk samples from both indicator and control locations were analyzed in 2002.

Fruits and Vegetables

Pumpkins, green beans, and potatoes were sampled during the harvest season at 3 locations surrounding the SSES. A total of 5 samples were collected from locations 11D1, 12F7, and 13G2. Location 13G2 was the control location.

Both locations were identified as having irrigated with Susquehanna River water from downstream of the SSES during 2002. There are often years with adequate rainfall when no irrigation is performed.

Sample Preservation and Analysis

The only sample medium monitored in the terrestrial pathway in which preservatives were used is milk. Sodium bisulfite was added to milk samples at the rate of 40 grams per gallon. This both helps maintain iodine in a reduced form and reduces the spoilage rate.

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

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 now 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 which might suggest the SSES as the source.

Cesium-137 normally has been measured in excess of analysis MDCs in most soil samples. Although game is not currently being monitored, cesium-137 has also been seen often at levels above the MDCs in game in the past.

Certain naturally occurring radionuclides are also routinely found above analysis MDCs in terrestrial pathway media. 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 are thorium-228 and radium-226 in soil, and beryllium-7 in fruits and vegetables.

The results of the 2002 terrestrial pathway monitoring resemble those of the past. Results for specific sample analyses of terrestrial pathway media may be found in Tables I-10 through I-12 of Appendix I. A summary of the 2002 terrestrial monitoring data may be located in Appendix G. Comparisons of 2002 monitoring results with those of past years may be found in Tables H 15 through H 20 of Appendix H.

Soil

The following gamma-emitting radionuclides are routinely measured in soil at levels exceeding analysis MDCs: naturally occurring potassium-40, radium-226, and thorium-228 and man-made cesium-137. The 2002 analysis results were similar to those for previous years. No other gamma-emitting radionuclides were reported at levels above analysis MDCs.

The 2002 means for indicator and control location sample potassium-40 activity were 13.3 pCi/gram and 8.32 pCi/gram, respectively. The indicator and control means are within the range of corresponding means for both prior operational and preoperational years. This is not the result of SSES operation because the potassium-40 is naturally occurring. The 2002 indicator mean for potassium-40 was below its corresponding 2001 mean.

All soil samples in 2002 were not analyzed for radium-226. The vendor lab performing the soil sample analysis normally does not analyze for

radium - 226 in soil. Radium-226 to be added to the soil sample analysis spectrum for 2003 soil samples.. Radium-226 is not the result of SSES operation because it is naturally occurring.

The 2002 means for indicator and control location sample thorium-228 activity were 0.8 pCi/gram and 0.7 pCi/gram, respectively. The 2002 indicator and control means for thorium-228 are lower than the corresponding 2001 means. The indicator and control means are within the ranges of the corresponding means for both the previous operational and preoperational periods, as applicable, of the SSES. Thorium-228 in soil is not the result of SSES operation because it is naturally occurring.

The 2002 means for indicator and control location sample cesium-137 activity were 0.02 pCi/g and 0.09 pCi/g, respectively. The 2002 indicator mean is below the range of the corresponding annual mean for prior operational years and preoperational years. The 2002 control mean is below the ranges of the corresponding annual means for both prior operational and preoperational years. Cesium-137 levels in soil samples typically vary widely from sample to sample. Levels of cesium-137 activity in 2002 samples varied by nearly a factor of ten over the entire range. Cesium-137 in soil, although man-made, is not from the operation of the SSES. It is residual fallout from previous atmospheric nuclear weapons testing.

Milk

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 separately from 1977 through 2002. Typically, iodine-131 is not reported at levels exceeding the MDCs for the analyses in any milk samples during a monitored year. The 2002 monitoring year was no exception; no iodine-131 above the analysis MDCs was observed in either indicator or control samples.

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 2002. The 2002 means for indicator and control location sample potassium-40 activity were 1403 pCi/liter and 1338 pCi/liter, respectively. The 2002 indicator and control means are higher than the 2001 means. The 2002 indicator and control means for potassium-40 activity are within the corresponding ranges of annual means for previous operational and preoperational years. The potassium-40 activity in milk is not attributable to the SSES operation because it is naturally occurring.

Fruits and Vegetables

Naturally occurring potassium-40 was the only gamma-emitting radionuclide measured in fruits and vegetables at an activity level in excess of analysis MDC during 2002.

The 2002 means for indicator and control location sample potassium-40 activity were 2.5 pCi/gram and 3.0 pCi/gram, respectively. The 2002 indicator mean is the same as its corresponding 2001 mean. The 2002 control mean is slightly below its corresponding 2001 mean. The 2002 indicator and control means are within the range of the corresponding annual means for pre-operational and prior operational years. Potassium-40 in fruits and vegetables is not attributable to SSES operation because it is a naturally occurring radionuclide.

FIGURE 13 - IODINE-131 ACTIVITY IN MILK

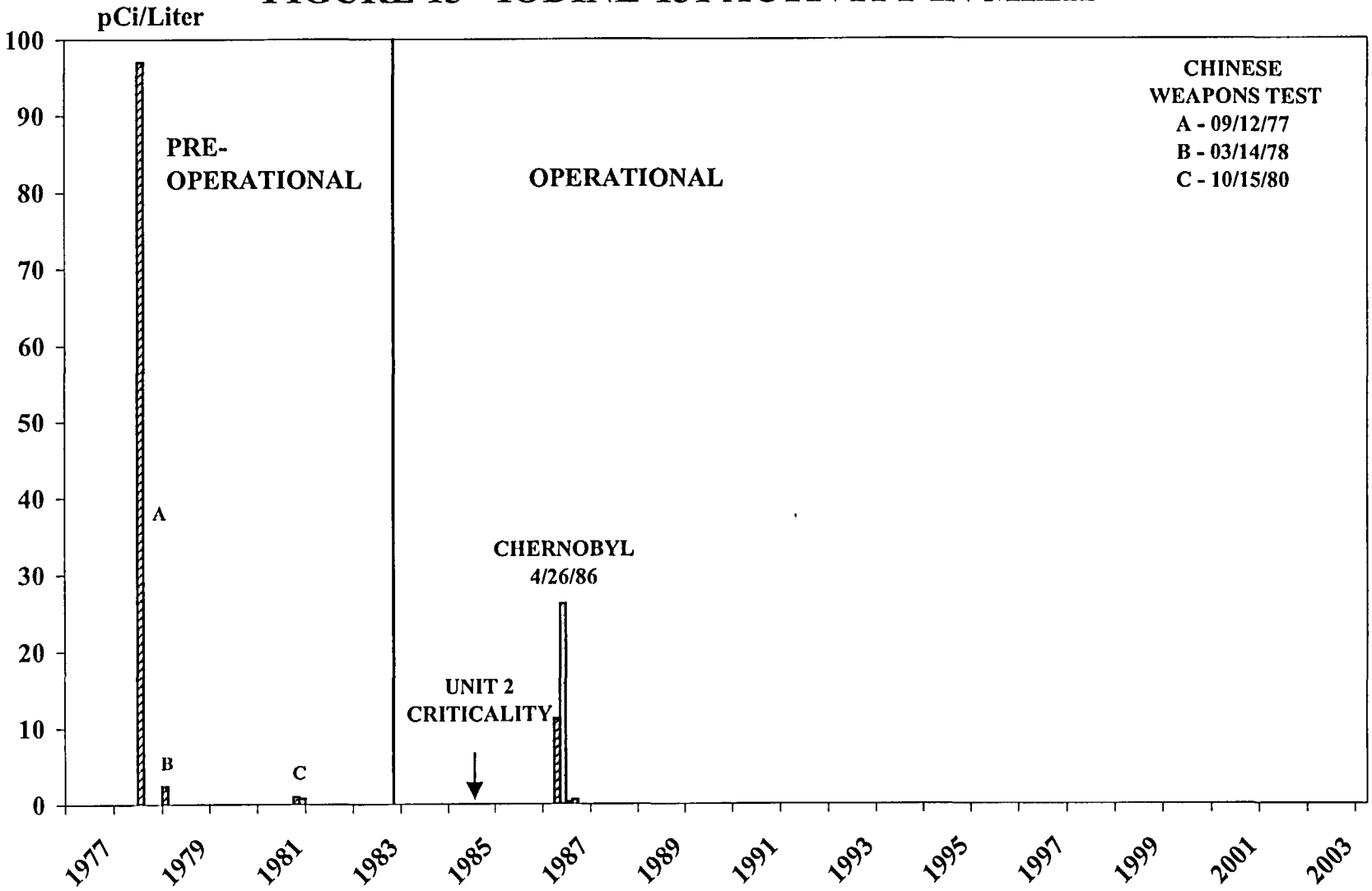


FIG. 13 - H\REMPFIG02.XLS

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.

Because routine SSES operation releases primarily tritium and, to a lesser extent, isotopes of xenon and krypton to the air, no radionuclides attributable to SSES operation are expected to be observed in ground water. Iodine and particulate releases to the air are negligible. Gaseous xenon and krypton tend to remain airborne; deposition or washout of these would be expected to be very minimal. Tritium would be the most likely radionuclide to reach the ground with precipitation and, if not lost to streams (surface water) by runoff, move readily through the soil to the ground water.

Scope

Ground water in the SSES vicinity was sampled monthly at 2 indicator locations (2S2 and 4S4) and one control location (12F3) during 2002.

With the exception of location 4S4, 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 Training Center, well water actually is obtained from on-site and piped to the Training Center after treatment. This sampling is performed as a check to ensure that water has not been radioactively contaminated. Sampling is performed at the Training Center to facilitate the sample collection process.

Sample Preservation & Analysis

All samples (except the aliquots assigned for tritium analyses) were preserved with nitric acid, as described in Aquatic Pathway Monitoring.

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

Monitoring Results

Tritium activity levels in ground water have typically been observed to be lower than in surface water. A noticeable decline occurred between 1992 and 1993. Fewer measurements were above the analysis sensitivities in 1993 than in 1992.

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 and thorium-228 have been measured above their MDCs occasionally in ground water. Potassium-40 was reported in 1979, 1981, 1985, 1991, 1992, 1993, and 1997. 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.

The results of the 2002 REMP ground water surveillance resemble those of the past. Results for specific ground water sample analyses may be found in Table I-7 of Appendix I. A summary of the 2002 ground water monitoring data may be located in Appendix G. Comparisons of 2002 monitoring results for tritium with those of past years may be found in Table H 21 of Appendix H.

During 2002, tritium was measured in excess of analysis MDCs on 1 occasion. The 2002 mean tritium activity levels for indicator and control monitoring locations were 78 pCi/liter and 63 pCi/liter, respectively. The indicator and control means are higher than those for 2001. Both the 2002 indicator and control mean tritium activity levels are within the range of corresponding averages of annual means for prior operational and preoperational years.

Naturally occurring potassium-40 was measured in excess of analysis MDCs for some ground water samples during 2002. No man-made gamma-emitting radionuclides were determined to be at levels in excess of analysis MDCs. No radioactivity contributions to ground water from the SSES were identifiable in 2002.

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