IDENTIFICATION OF RADIOLOGICAL CONSTITUENTS IN WASTE SLUDGE

Submitted to:

MAGNESIUM ELEKTRON, INC.
500 Point Breeze Road
Flemington, New Jersey 08822

January 13, 1994
Report No. IT/NS-93-116

INTERNATIONAL
TECHNOLOGY
CORPORATION

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EXECUTIVE SUMMARY

Magnesium Elektron, Inc. (MEI) separates zirconium chemicals from zircon sand by chemical processing at its facility in Flemington, New Jersey. The sands contain uranium and thorium in very low concentrations. Processing of the sands coincidentally results in a siliceous hygroscopic sludge which contains the major portion of uranium and thorium from the sands. The sludge is stored (contained) in on-site, lined lagoons.

Two inspections performed by the U. S. Nuclear Regulatory Commission (USNRC) resulted in conflicting opinions as to whether a USNRC license to possess radioactive materials, pursuant to Title 10 Code of Federal Regulations, Part 40 (NRC, 1992) was necessary for the materials contained in the ponds.[1] To resolve this issue, a comprehensive sludge sampling program was implemented in order to characterize the radiological constituents and determine the need for USNRC licensing.

The approach and direction for achieving the program's objectives are described in a work plan that was approved for implementation by the USNRC on August 15, 1993 (IT, 1993). The sampling effort began on September 10, 1993, samples were collected and field screened on October 4 through 8, 1993, and radiological analyses were completed on November 5, 1993. The following is a summary of the findings from the program with respect to source material concentrations:

Location	Mean Source Material Concentration (ppm ± σ)
Pond 1-East	314 ± 67
Pond 6-Upper	222 ± 49
Pond 6-Lower	243 ± 44
Pond 7 (not sludge)	201 ± 36

These results demonstrate that the mean concentration of uranium and thorium, by weight, in the ponds are below the 0.05% licensing criterion (500 ppm), and are thus exempt from USNRC licensing. The results also demonstrate that the radionuclides in the ponds are distributed uniformly throughout the volume of the ponds. No sample had a measured concentration above the licensing criteria. Finally, with conservative assumptions regarding likely exposure scenarios, it is clear that the radiological impact of the ponds on members of the general public and intruders is trivial.

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[1] A license may be required for possession of "source material" under Title 10, Code of Federal Regulations, Part 40 if the combined mass of uranium and thorium in the material exceeds 0.05% of the total mass (e.g., greater than 500 parts per million of thorium and uranium).

INTRODUCTION AND OBJECTIVE

Magnesium Elektron, Inc. (MEI) separates zirconium chemicals from zircon sand by chemical processing at its facility in Flemington, New Jersey. The sands contain uranium and thorium in very low concentrations. Processing of the sands coincidentally results in a siliceous sludge which contains the major portion of uranium and thorium from the sands. The sludge is stored (contained) in on-site, lined lagoons.

On June 30, 1981, the U. S. Nuclear Regulatory Commission (USNRC) performed a survey and inspection of the MEI site. In that survey report, it was noted that:

> "The inspector obtained samples from the wells, stream, settling pond, discharge to salt pond, silica storage and sludge storage areas during the tour of the facility. These samples were analyzed at the Region I Office Laboratory. The results of the analyses are included in Attachment I and indicate that the licensee does not possess licensable concentrations of radioactive material in the wastes from the zirconium operation." (NRC, 1981).

On January 18, 1989, however, the USNRC performed another inspection of the site. That inspection report indicated that a radioactive materials license, pursuant to Title 10, Code of Federal Regulations (CFR), Part 40 (NRC, 1992) appeared necessary for possession of the materials contained in the ponds.[2]

As a result of these conflicting opinions, and because the extent of the sampling and analyses performed by the agency during the two inspections was limited in scope, it was MEI's opinion that it was not possible to confirm whether a radioactive materials license is required for the materials contained in the sludge ponds, nor to determine the extent of radiological controls needed to support an application for materials license if necessary. The USNRC concurred with this opinion.

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[2] A license may be required for possession of "source material" under Title 10, Code of Federal Regulations, Part 40 if the combined mass of uranium and thorium in the material exceeds 0.05% of the total mass (e.g., greater than 500 parts per million of thorium and uranium).

To resolve this issue, a more comprehensive sludge sampling program was implemented to characterize the radiological constituents. The objectives of this program were to collect sufficient data to:

- Determine whether the waste materials contained in the ponds contain greater than 0.05% of source material (uranium and thorium) pursuant to 10 CFR 40.13;
- Evaluate the level of hazard to workers, the public, and the environment caused by the uranium and thorium contained in the waste materials;
- Determine the scope of a radiological control program for control of these hazards, if licensing is required; and
- Guide decisions on disposition of the sludge.

The approach and direction for achieving the objectives were contained in the work plan for this effort (IT, 1993). After review and resolution of a number of comments, the work plan was approved for implementation by the USNRC on August 15, 1993. The field sampling effort began on September 10, 1993, samples were collected on October 4 through 8, 1993, and analyses were completed on November 5, 1993. Only one exception to the work plan was taken during its implementation.[3]

This report describes the MEI site, the sampling conducted to identify radiological constituents in the waste sludge, and the field and analytical methodologies. It also presents the data and an evaluation of the radionuclide concentrations in the sludge (parts per million) with respect to the 10 CFR 40.13 criteria for licensing. This evaluation shows that the radionuclide concentrations are below exempt levels.

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[3] Samples were not collected from Pond 1-West as required in the work plan because there was no sludge in that pond at the time of sampling.

CURRENT STATUS OF THE FLEMINGTON SITE

Site Description

The MEI facility is located on Point Breeze Road, approximately six miles west of Flemington, New Jersey. **Figure 1** is a site location map. On-going MEI operations include refining zircon sands with soda ash, hydrochloric acid, and sulfuric acid. The spent acids are neutralized with sodium carbonate and discharged into surface impoundments to permit settlement of particulates.[4] At the facility, there are a number of concrete-lined impoundments (ponds) currently in service and one inactive impoundment.

Waste water from plant operations is partially recycled through the ponds and back to a scrubber and neutralization system. The water goes to a lined desalinization feed pond, which provides surge capacity for the effluent feed to an existing desalinization system. The reject water from the desalinization system is discharged into the storage ponds, which serve as surge capacity for discharge to state surface waters. This discharge system is regulated by New Jersey Pollutant Discharge Elimination System (NJDES) permit Number NJ0027537. (O'Brien, 1990).

Location and Identification of Contaminants of Potential Concern

Table 1 contains a listing and a general description of the contents of all the storage ponds. **Figure 2** is a map of each pond's location with respect to their environs. Approximately 1.7 x 10^5 m^3 of waste water are generated per year from MEI operations. There are approximately 2.0 x 10^4 m^3 of sludge currently stored on site. Sludges which contain thorium and uranium in various concentrations are stored in Ponds 1-East, 1-West, Pond 6-Upper, and Pond 6-Lower.

The sludge contained in the ponds is a wet solid consisting principally of hydrated zirconium and silica values. The balance of the solids is made up of the impurity hydrates such as those of aluminum, iron, titanium, uranium, and thorium. Consequently, the sludge is

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[4] The feed material for the process is zircon sand, which contains uranium and thorium in low concentrations. Each lot of zircon sand delivered to the site is accompanied by a certificate of analysis demonstrating that the concentration of radioactive materials is less than the 0.05% criteria for licensing pursuant to 10 CFR 40. The active inventory is approximately 150,000 pounds.

naturally hygroscopic and exhibits a mean moisture content in excess of 75 percent in its current state. In fact, even if the sludge is formed into a filter press cake, the mean moisture content of the material still exceeds 50% (Jaeger, 1994).

Pond 7 contains soil that was removed from the bottom of Pond 2 after the sludge had bee removed to Pond 6 Upper and Pond 6 Lower. This soil is visibly distinguishable from the sludge, and was segregated accordingly.

SUMMARY OF FIELD SAMPLING

Field sampling pursuant to the work plan (IT, 1993) was implemented for Pond 1-East, Pond 6-Upper, Pond 6-Lower and Pond 7. The first step was to establish a grid as specified in the work plan and determine the sample collection locations. The second step was to collect the sludge/soil using appropriate equipment and tools. These two steps are described below for each of the ponds.

Pond 1-East

The dimensions of Pond 1-East are approximately 17 meters by 40 meters (See **Figure 2**). To obtain a uniform sampling coverage, a systematic approach using an aligned 7 by 10 meter grid was employed. **Figure 3** shows the four horizontal grid lines (Rows 1, 2, 3, and 4) and the two vertical grid lines (Lines 1-A and 1-B) established in this grid system. A total of six biased grid intersections were selected as sample collection locations. Because the discharge outlet is located at the north end of the pond, a greater number of sludge samples were intentionally collected from that end. Location 1-A-3 was randomly selected for a sample to be split with the USNRC.

Since Pond 1-East was water-filled, a boat was used to access the sample locations. Because this pond contained silty sludge less than two inches in depth at the time of sampling, it was not feasible to use a coring tube or a dredge for sample collection. Consequently, the sludge in this pond was pumped, mixed with water, and piped directly into sample containers at each collection location (see **Photo 1**). The total sample volume collected at each location, with the exception of 1-A-3, was approximately eight liters (including the water). Two eight-liter samples were collected at 1-A-3, one of which was provided to the USNRC for analysis.

Pond 6-Upper and 6-Lower

The dimensions of Pond 6-Upper and Pond 6-Lower are approximately 60 by 68 meters (see **Figure 2**). An aligned 10 by 10 meter grid resulted in 30 grid intersections within each pond. These grid intersections were used as sample collection locations. **Figure 4** shows the five horizontal grid lines (Rows 8 to 12 for Pond 6-Upper and Rows 1 to 5 for Pond 6-Lower) and six vertical lines (Lines 6-A to 6-F) in the grid system for both Ponds 6-Upper and 6-Lower. Seven randomly selected sample locations (three from Pond 6-Upper and four from Pond 6-Lower) produced samples that were split with the USNRC.

Sampling team members accessed the Pond 6-Upper and Pond 6-Lower collection locations by boat because both ponds were filled with water. For these ponds, a 2.4 meter PVC tube was used as a core sampler. The top end of the tube was connected to a flapper valve for suction and to a handle for maneuvering (see **Figure 5**). Clear Lexan tubes 2.4 meters in length and five centimeters in diameter were inserted into the core sampler as liners (see **Photo 2**). Sludge was collected directly into the liners. The bit of the sampler was attached to a sharp plastic nosepiece which held the liner in place and facilitated driving the sampler into the sludge (**Figure 5**). Since the sludge was soft, the sampler was easily pushed to the bottom of the pond by hand. To assist in retaining the soft sludge in the core, each Lexan tube incorporated a core catcher, or "eggshell", at the bottom opening. This device allowed the sludge to enter but not escape when the sampler was withdrawn from the sludge (**Figure 5**). Samples for the USNRC were obtained by splitting equally the sludge collected from the designated locations. The sludge was mixed before the sample volume was split.

Pond 7

Pond 7 was divided into four quadrants of equal proportion. One sample was collected from the center of each quadrant (see **Figure 6**). This pond contained soil that was removed from the bottom of Pond 2 (closed) after the sludge had been removed to Pond 6-Upper and Pond 6-Lower. However, 0.6 to 1.8 meters of accumulated rainwater covered three of the quadrants in Pond 7. The soil in the northwestern quadrant was dry and relatively elevated. This was the only walk-on area that permitted collection of a dry sample. The other three quadrants were accessed by boat.

Soil samples from Pond 7 were also collected using a coring device (see **Figure 5** and **Photo 3**). This sampler consisted of a 0.6 meter stainless steel cylinder, a flapper valve, and a maneuvering handle. A 1.2 meter extension rod was attached to the device in order to reach the soil under the rainwater. A 0.6 meter Lexan tube that was two inches in diameter was placed on the inside of the stainless steel cylinder as a liner. Soil was collected directly into the liner.

For the dry (northwest) quadrant, two samples of the top 0.15 meters of surface soil were collected adjacent to each other at the center of the quadrant. One of the two samples was collected by USNRC personnel and was used as a split sample. For each of the wet quadrants, a sample from the top 0.6 meters of soil/sludge was obtained.

Visual Inspection Findings

Pond 1-East contained off-white sludge that was fine and silty. Strata were not observed and the sludge appeared visually homogeneous. The sludge depth was less than five centimeters, and the predominant constituent seemed to be silica (SiO_2).

For Ponds 6-Upper and 6-Lower, some stratification of sludge deposits could be seen in the cores, although the analytical results later revealed uniform distribution of the radionuclides. The various lengths of sediment in the cores (60 to 120 cm) indicated that the accumulated sludge depth varied across the ponds.

Pond 6-Upper included grid Rows 8 through 12 (see **Figure 4**). For cores in Rows 10, 11 and 12, strata were not observed (see **Photo 4**). Strata of sludge from Rows 8 and 9 were observable in the upper half of the cores (see **Photo 5**).

Pond 6-Lower included grid Rows 1 through 5 (**Figure 4**). For cores in Rows 1, 2, 3, and 4, the depth profile from zero to approximately 46 centimeters showed relatively homogeneous, grayish, silty sludge. From about 0.5 to 1.2 meters of depth, the sludge contained thin strata (see **Photos 6 and 7**) in varying colors. Beyond 1.2 meters in depth, the type of sludge observed in the top 0.5 meters reappeared. The six cores in Row 5, however, did not show the thin strata observed in the middle of the cores in the other rows (see **Photo 8**).

The dry soil in the northwestern quadrant of Pond 7 was tightly packed and contained numerous small pieces of rock (see **Photo 3**). The wet soil/sludge collected from the other three quadrants was a composite of black and brown matters.

Field Screening Findings

The purpose of the field screening was to guide sampling and compositing of sludge collected from Pond 6-Upper and Pond 6-Lower. The variation in count rate along the depth at a given sample location was used to determine whether sludge collected from different depths could be composited for analysis. The horizontal variation across a pond was used to determine whether the sampling frequency for the pond was sufficient.[5]

For the field screening, the outside of the filled Lexan tubes were cleaned, and visual stratifications were noted and recorded. The length of the sludge column was documented and its mid-point was marked. The upper segment was then surveyed using a collimated Eberline SPA-3 detector.[6] In order to obtain a thorough scan of the sludge in the core, a spiral survey pattern was used. The tube was steadily rotated while the detector probe scanned down along each segment at a constant speed of approximately 2.5 to 4.5 centimeters per second (see **Photo 9**). A segment-specific count time was established to ensure that a statistically-sufficient number of counts were collected.

A statistically significant increase or decrease in counts along the lower segment for a count time equal to that used for the upper segment was determined by:

$$C_1-(3\times\sqrt{C_1}) \leq C_2 \leq C_1+(3\times\sqrt{C_1})$$

where C_1 = total counts from the upper segment over a count time, t, and C_2 = total counts from the lower segment over a count time, t. Cores in which total counts for the lower segments fell outside of the calculated range for the upper segments were separated into two segments and the entire sludge column from each segment was submitted for analysis. Cores in which total counts for the lower segments did not fall outside of the calculated range for the upper segments were composited and a single sample was collected and submitted for analysis.

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[5] Since the homogeneity of Pond 1-East and Pond 7 was not of concern, field screening was not performed for these two ponds.

[6] The SPA-3 detector contains a 2-inch by 2-inch crystal of sodium iodide, or NaI(Tl).

A total of four randomly selected cores (two each from Pond 6-Upper and Pond 6-Lower, as shown in **Figure 4**) were separated into two segments of equal length, regardless of the field screening results. The sludge from each length was analyzed separately in order to evaluate the equilibrium status of the two series radionuclides.

The field screening results for each core from Ponds 6-Upper and 6-Lower are contained in **Appendix A**. Approximately 50% of the cores collected from Pond 6-Upper showed sufficient variation in count rate along the cores to warrant separation into segments for analysis under the fairly rigorous screening method. For Pond 6-Lower, 90% of the cores were separated for analysis. **Table 2** shows the average count rate associated with each core for both Pond 6-Upper and Pond 6-Lower.

SUMMARY OF RADIONUCLIDE ANALYSES

Program Description

Samples received from the field by the analytical laboratory[7] were examined for damage and compared to the chain-of-custody and request-for-analysis forms. Each sample was weighed to the nearest gram, then logged into a laboratory information management system (LIMS). The samples were allowed to settle for 10 days. At that time, the supernatant (free liquid) was withdrawn, and the samples were weighed again. A third and final weight was recorded after normal sample preparation (drying, grinding, etc.) was complete. The second and third weights were used to determine the percent moisture in each aliquot that was analyzed.

To confirm the equilibrium status between the parent radionuclides of interest (e.g., thorium and uranium) and their daughter radionuclides, four randomly-selected cores collected from ponds 6-Upper and 6-Lower received gamma spectral analysis, isotopic uranium determination, isotopic thorium determination, radium-226 analysis and radium-228 analysis.[8]

Pursuant to the work plan, approximately 50% of the total number of samples collected from each pond were analyzed. Since the standard deviation in the mean of those results permits adequate characterization of the source material content (e.g., 95% confidence), the remainder of the samples were archived without analysis. These, as well as all other samples will be returned to MEI for disposal at the termination of this project.

Analytical Findings

Appendix B contains a listing of the converted analytical results for all samples analyzed by the method of gamma spectroscopy with all results listed as "ppm". **Table 3** contains the results of the uranium and thorium isotopic analyses from the four randomly-selected cores. When the isotopic results are evaluated, it is clear that the parents of the uranium and thorium decay series are in equilibrium with their daughter radionuclides. Therefore, no

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[7] IT Corporation, Analytical Services, 13715 Rider Tail North, Earth City, Missouri, 63045, (314) 298-8566.

[8] If the isotopic ratios from these samples were sufficiently similar to confirm the equilibrium status, the remainder of the samples collected from each pond would be analyzed by gamma spectroscopy only.

further correction to the gamma spectral results were made. The activity concentrations of radium-228 and thorium-234 from the gamma spectral analyses were taken to be equivalent to the activity concentrations of thorium-232 and uranium-238, respectively. All other thorium and uranium isotopes in the samples from the four cores were measured directly by this methodology.

EVALUATION OF RADIONUCLIDE CONCENTRATIONS IN SLUDGE

Test for Distribution

The method of D'Agostino was used to test for the distribution (normal, lognormal, or other) of concentrations in each of the ponds (D'Agostino 1971). For this method, all analytical results from each pond were ordered from smallest to largest to obtain the sample order statistics by:

$$x_{[1]} \leq x_{[2]} \leq \ldots \leq x_{[n]}$$

The D-statistic was computed by:

$$D = \frac{\sum_{i=1}^{n} [i - \frac{1}{2}(n+1)] x_{[i]}}{n^2 s}$$

where

$$s = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (x_i - \bar{x})^2}$$

The D-statistic was transformed to the statistic Y by computing:

$$Y = \frac{D - 0.28209479}{\frac{0.02998590}{\sqrt{n}}}$$

If *n* is large and the data are drawn from a normal distribution, then the expected value of Y is zero. For distributions that are not normal, Y will tend to be either less than or greater than zero, depending on the particular distribution. The null hypothesis of a normal distribution is rejected at the α significance level if the D'Agostino test statistic, Y, is less than $Y_{\alpha/2}$ or greater than $Y_{1-\alpha/2}$.[9] The value for α is chosen to be 0.05 for this report.

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[9] The Y statistic was also used to test the null hypothesis of a lognormal population by using $y_i = \ln x_i$ in place of x_i in the calculations.

Figure 7 shows that the radionuclide concentration across all ponds appears to be distributed normally. From the D'Agostino method, the results of which are shown in **Table 4**, it is clear that the radionuclide concentrations in Pond 1-East are, in fact, normally distributed. This finding is expected since significant mixing occurs as materials enter this pond.

The radionuclide concentrations in Ponds 6-Upper and 6-Lower, however, are neither clearly normally-distributed nor clearly lognormally-distributed. However, a normal distribution is the better approximation because the Y-statistic is closer to "zero" for that null hypothesis. A normal distribution was therefore selected as the basis for calculating mean concentrations. This was a conservative selection because the log-normal (geometric) mean is lower than the normal (arithmetic) mean.

Calculation of Average Radionuclide Concentration

Because the sludge in the ponds is a hygroscopic material (i.e., it is always in a wet physical form), "wet weight" represents the form of the radioactive material possessed and thus is used to determine source material concentrations, as specified in the work plan and USNRC letter of March 5, 1993 (Faraz, 1993). The mean concentration of each radionuclide in each pond was determined by:

$$C_{ave,j} = \frac{\sum_{i=1}^{N} C_{i,j}}{N}$$

where $C_{ave,j}$ = the average concentration (wet weight) of an individual radionuclide in pond "j", $C_{i,j}$ = the concentration (wet weight) of that radionuclide in an individual sample collected from that pond, and N = the total number of samples collected from that pond. **Table 5** contains a summary of the arithmetic mean concentrations of source material contained in each of the ponds at the MEI site.

These results show that the mean concentration of source material in the sludge ranges from 222 ppm (Pond 6-Upper) to 314 ppm (Pond 1-East). The standard deviation in values ranged from 36 to 67 ppm, which indicates homogeneous distribution of radionuclides within the samples. The maximum measured concentration in any sample is 388 ppm, which is still well-below the exempt level. The mean moisture content of the sludge samples, after freestanding water was removed, is 77 ± 6 per cent. The mean moisture content of the materials contained in Pond 7 is 56 ± 15 percent.

HAZARD EVALUATION

To assess the radiological impact of the ponds on members of the general population, two exposure scenarios were deemed pertinent. The first of these is the "intruder" scenario, wherein a hypothetical member of the general public gains access to the MEI site and remains in the immediate vicinity of the ponds (e.g., directly over the ponds) for an unspecified period of time. For this scenario, the pertinent pathways are direct radiation exposure and ingestion of sludge. From computer modeling of the radiation dose to an intruder from the radiological constituents in the sludge ponds, it is estimated that the maximum possible dose rate from all pathways would be 0.02 millirem per hour. Appendix C contains a summary of this assessment.

The second scenario of interest is the exposure of the nearest off-site resident. For this scenario, the pathways of interest include inhalation of airborne radioactivity, ingestion of contaminated foods and water, and direct radiation from surface deposition of dispersed material. The results of this assessment indicate a maximum possible annual dose rate of 0.1 millirem to the nearest off-site resident. The location of this resident is approximately 225 meters north-northwest of the sludge ponds (O'Brien, 1990). Appendix D contains a summary of this evaluation.

To put these findings into perspective, during any given year of life, every individual in the United States receives a radiation dose of approximately 360 millirem from normal background radiation sources, the majority of which include cosmic, terrestrial, and gaseous radiations which occur naturally (NCRP, 1987). When the 0.1 millirem per year reasonable maximum dose to the nearest off-site resident is compared to the radiation dose received by all humans by virtue of their being alive, the radiological impact of the sludge ponds is trivial.

SUMMARY AND CONCLUSIONS

A sampling program was implemented to characterize the radiological constituents in three on-site lined ponds at the MEI facility in Flemington, New Jersey. Samples were collected and analyzed as described in a work plan that was approved in advance by the USNRC (IT, 1993). The results of this effort, shown in Table 5, indicate that both the mean and the maximum concentration of uranium and thorium, by weight, in the ponds are below the 0.05% licensing criterion (500 ppm).

In summary, it is clear from implementation of the work plan, that the materials contained in the MEI sludge ponds are exempt from USNRC licensing, and that the radiological impact of the ponds on members of the general public and intruders is trivial. From the assumptions made regarding exposure conditions, it is clear that no radiation exposures in excess of what is considered safe by international standards groups (ICRP, 1976) and regulatory agencies (NRC, 1991).

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TABLES

TABLE 1
Contents of the Storage Ponds

Pond Number	General Description of Contents	Sludge Depth (ft)	Maximum Annual Water Depth (ft)**
1-East	Initial discharge point for neutralized effluent - Emptied on a quarterly basis	<1	4
1-West	Initial discharge point for neutralized effluent - Emptied on a quarterly basis	<1	4
Pond 2 (Closed)	Pond dredged and closed in July, 1991. Contents (sludge and soil) transferred to Ponds 7 and 6.	--	--
Pond 3	Inactive impoundment containing only rainwater. Does not contain radioactive materials in excess of background.	--	--
Pond 4 (Closed)	Does not contain radioactive materials in excess of background.	--	--
Pond 5 (Closed)	Does not contain radioactive materials in excess of background.	--	--
Pond 6-Lower	Contains discharge from 1-East and 1-West, and sludge from Ponds 2 and 7.	<8	1
Pond 6-Upper	Contains discharge from 1-East and 1-West, and sludge from Ponds 2 and 7.	<8	1
Pond 7	Contains soil removed from the bottom of former Pond 2 after the Pond 2 sludge had been transferred to Pond 6.	--	--
Pond 8	Contains process water that is shipped off-site. Does not contain radioactive materials in excess of background.	--	--
Pond 9	Contains process water that provides surge capacity for the effluent feed to the desalinization system. Does not contain radioactive materials in excess of background.	--	--

**Excluding sludge layer.

TABLE 2
Field Screening Count Rates

Examination of Horizontal Homogeneity in Pond 6-Upper and Pond 6-Lower

Pond 6-Upper

Field Screening Results

Core ID	Count Time (sec)	Upper Sgmnt	Lower Sgmnt	Average Counts	Ave. Count Rate (1/sec)
6-A12	NA	NA	NA	NA	NA
6-B12	25	2330	2590	2460	98.4
6-C12	15	1370	1500	1435	95.7
6-D12	15	1450	1500	1475	98.3
6-E12	15	1550	1570	1560	104.0
6-F12	15	1470	1540	1505	100.3
6-A11	25	2510	2660	2585	103.4
6-B11	25	2355	2640	2497.5	99.9
6-C11	25	2260	2750	2505	100.2
6-D11	25	2290	2640	2465	98.6
6-E11	25	2570	2590	2580	103.2
6-F11	25	2940	2510	2725	109.0
6-A10	25	2390	2530	2460	98.4
6-B10	25	2680	2780	2730	109.2
6-C10	25	2680	2830	2755	110.2
6-D10	25	2420	2930	2675	107.0
6-E10	15	1730	1720	1725	115.0
6-F10	25	3020	2280	2650	106.0
6-A09	25	1820	2370	2095	83.8
6-B09	25	2250	2420	2335	93.4
6-C09	25	2100	2450	2275	91.0
6-D09	25	2450	2490	2470	98.8
6-E09	25	2510	2850	2680	107.2
6-F09	25	2480	NA	2480	99.2
6-A08	25	2140	2850	2495	99.8
6-B08	25	2930	2900	2915	116.6
6-C08	25	2510	2880	2695	107.8
6-D08	25	2870	2850	2860	114.4
6-E08	25	3210	2780	2995	119.8
6-F08	25	2880	2790	2835	113.4

Average=	103.5
Std Dev.=	8.1

Pond 6-Lower

Field Screening Results

Core ID	Count Time (sec)	Upper Sgmnt	Lower Sgmnt	Average Counts	Ave. Count Rate (1/sec)
6-A05	25	3530	3530	3530	141.2
6-B05	25	2800	3820	3310	132.4
6-C05	25	3390	3990	3690	147.6
6-D05	25	3900	4290	4095	163.8
6-E05	25	3910	4530	4220	168.8
6-F05	25	4720	4570	4645	185.8
6-A04	25	4610	5390	5000	200.0
6-B04	25	3745	4200	3972.5	158.9
6-C04	25	3770	4990	4380	175.2
6-D04	25	4100	4680	4390	175.6
6-E04	25	4500	4670	4585	183.4
6-F04	25	5160	4890	5025	201.0
6-A03	25	4310	4760	4535	181.4
6-B03	25	4220	5080	4650	186.0
6-C03	25	3400	5560	4480	179.2
6-D03	25	3870	5050	4460	178.4
6-E03	25	4100	4600	4350	174.0
6-F03	25	4120	4900	4510	180.4
6-A02	25	3800	4260	4030	161.2
6-B02	25	3710	4070	3890	155.6
6-C02	25	3370	4080	3725	149.0
6-D02	25	3410	4280	3845	153.8
6-E02	25	3800	4190	3995	159.8
6-F02	25	3960	4570	4265	170.6
6-A01	25	3280	4130	3705	148.2
6-B01	25	3360	3920	3640	145.6
6-C01	25	3560	4170	3865	154.6
6-D01	25	3400	3970	3685	147.4
6-E01	25	3660	4020	3840	153.6
6-F01	25	3560	4070	3815	152.6

Average=	166.3
Std Dev.=	17.1

TABLE 3
Results of Isotopic Analyses for Four Randomly-selected Cores

Collection Location	Isotopic Concentration (pCi/gram)[10]				
	U-238	U-234	Th-230	Th-232	Th-228
6B-11-1	409	417	516	98.5	90.3
6B-11-2	255	249	275	58.9	60.5
6E-10-1	305	301	371	77.1	73.0
6E-10-2	200	188	238	48.4	48.0
6C-4-1	124	127	229	36.6	37.3
6C-4-2	138	142	206	40.2	42.0
6E-2-1	347	479	373	72.9	62.0
6E-2-2	171	177	212	42.4	42.2

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[10] Activity concentrations reflect dry weights after all water is driven off for sample preparation. No corrections for natural moisture content are shown.

TABLE 4
Results of the D'Agostino Test

Pond	Distribution (Null Hypothesis)	Y-Statistic	Range of Significance ($\alpha = 0.05$)
1-East	Normal	-0.16181	-2.757 to 1.038
1-East	Lognormal	-23.0123	-2.757 to 1.038
6-Upper	Normal	-9.45779	-2.757 to 1.038
6-Upper	Lognormal	-50.5779	-2.757 to 1.038
6-Lower	Normal	-4.46726	-2.757 to 1.038
6-Lower	Lognormal	-51.4344	-2.757 to 1.038
All Ponds	Normal	-5.91323	-2.652 to 1.176
All Ponds	Lognormal	-75.7127	-2.652 to 1.176

TABLE 5
Mean Concentration of Source Materials at MEI's Flemington Site

Location	Mean Source Material Concentration (ppm ± σ)[11]
Pond 1-East	314 ± 67
Pond 6-Upper	222 ± 49
Pond 6-Lower	243 ± 44
Pond 7	201 ± 36

---

[11] A USNRC license is required if the concentration of source material exceeds 500 parts per million (ppm)

FIGURES

FIGURE 1
Site Location Map

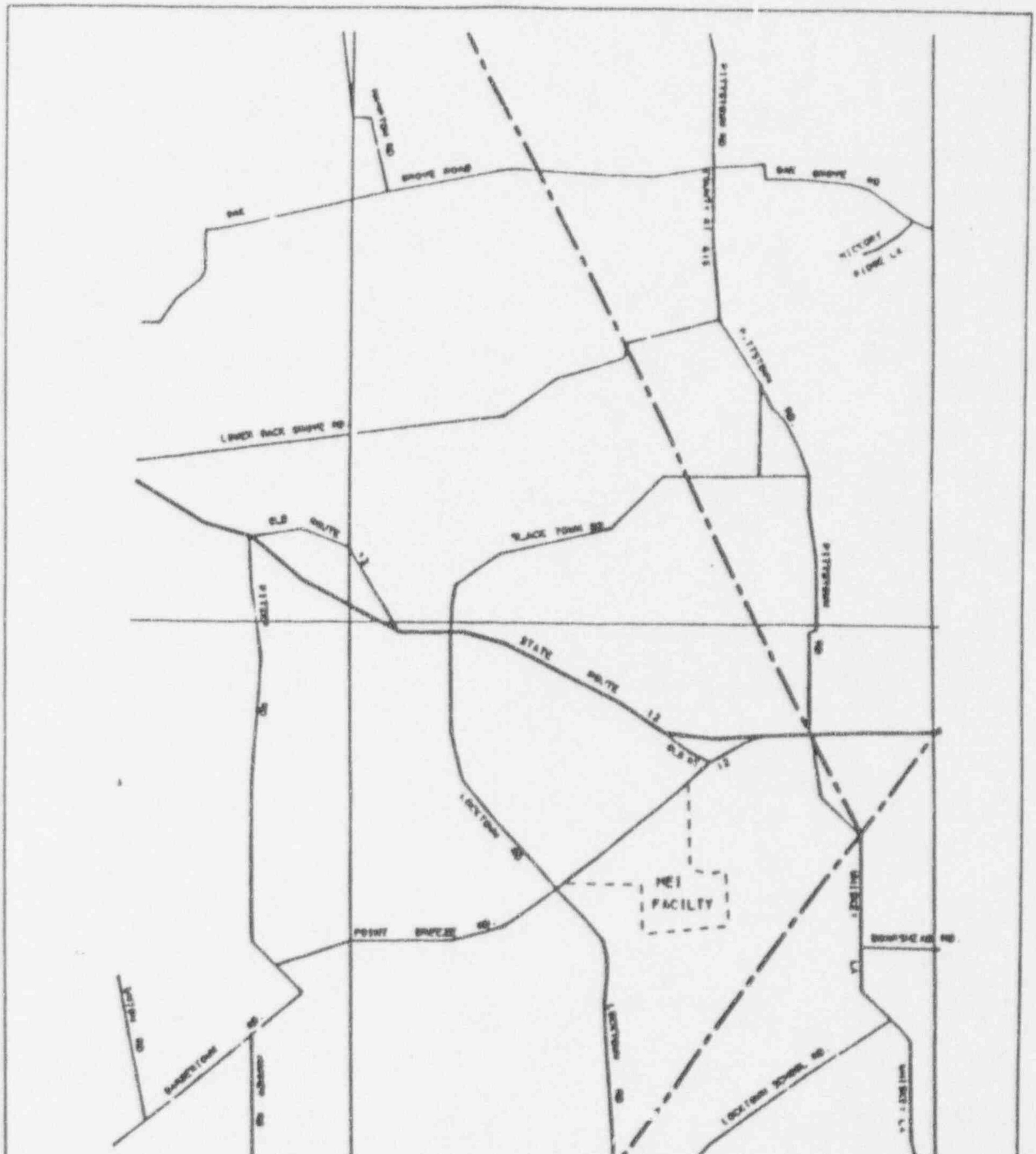


FIGURE 2
Map of Pond Locations

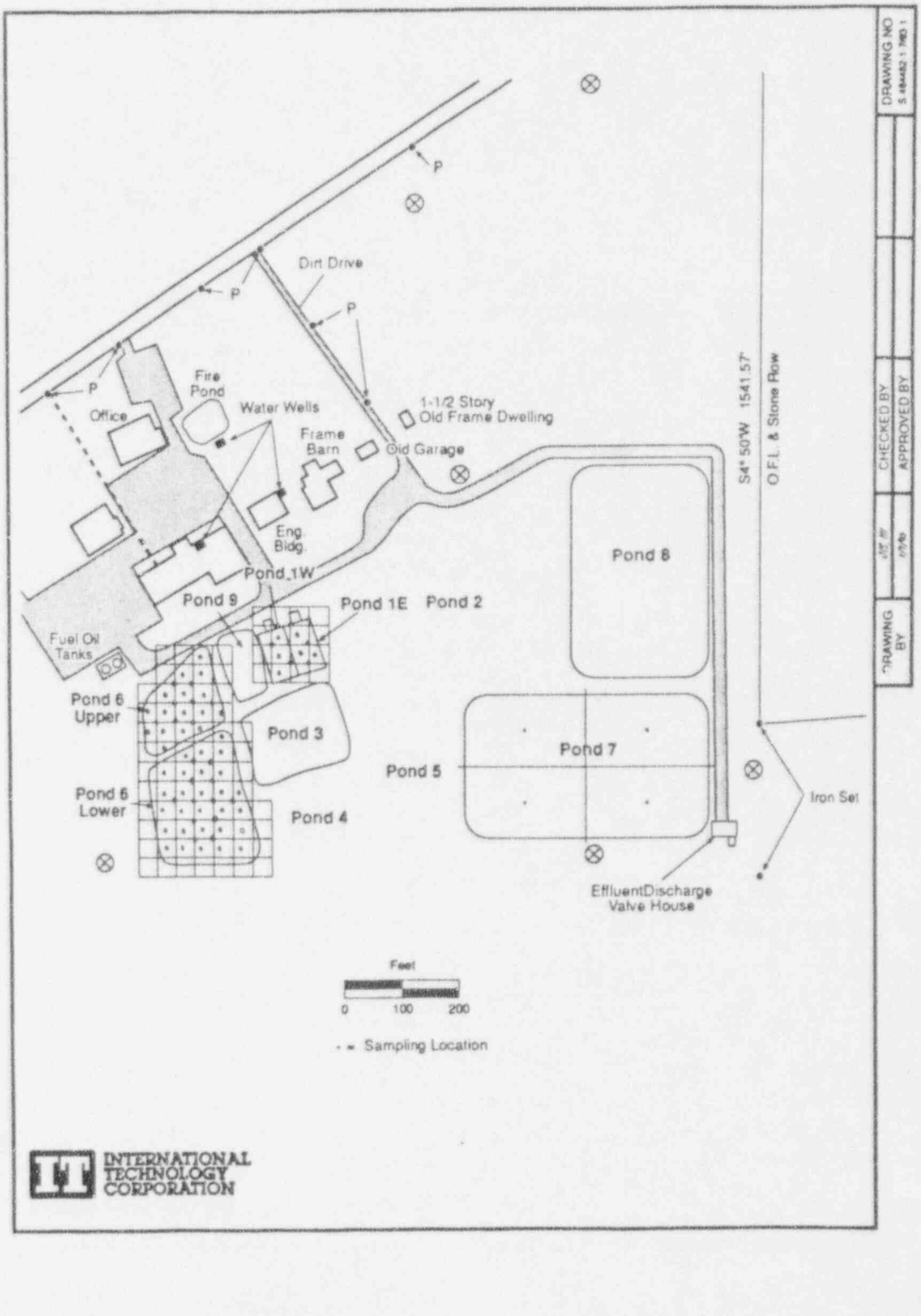
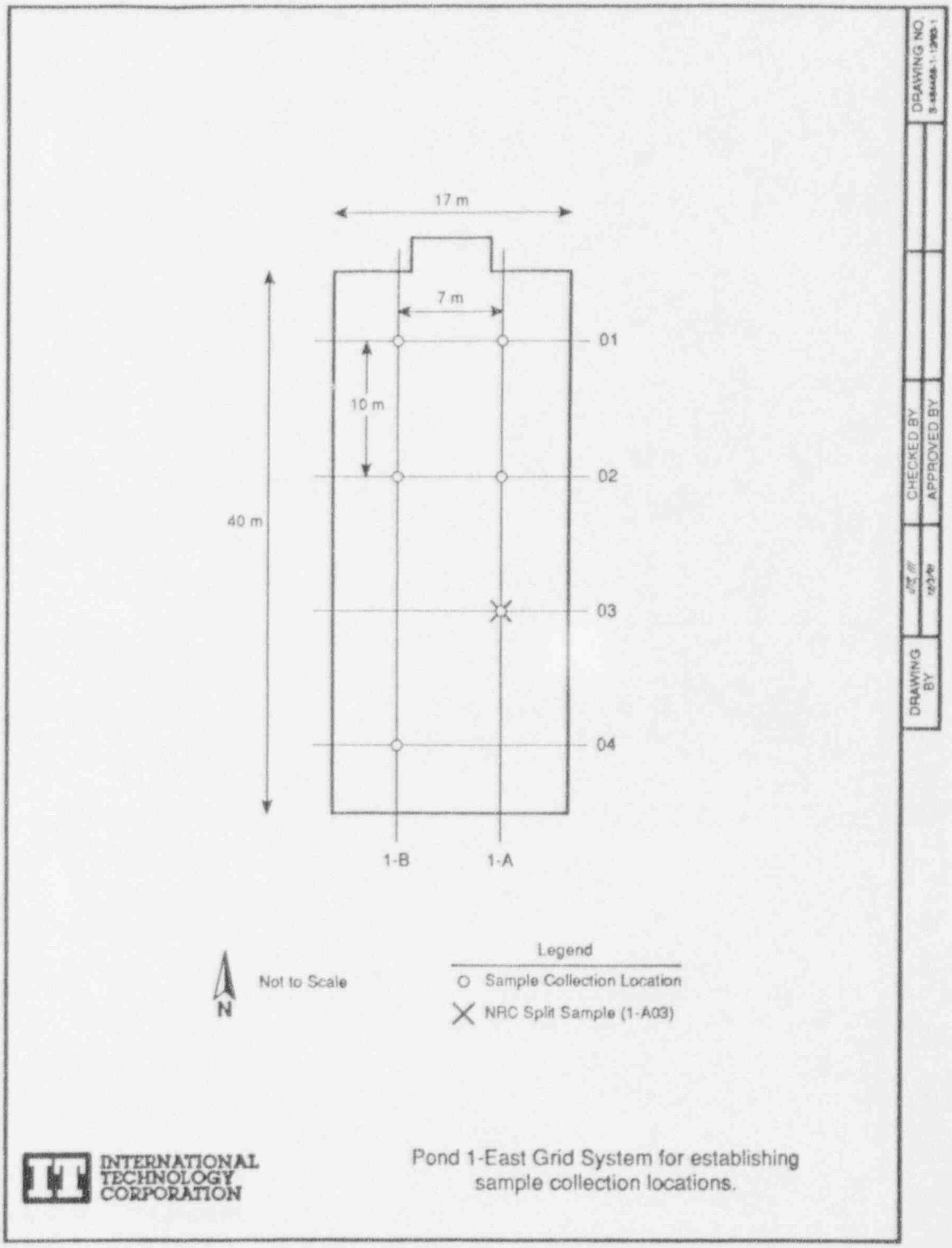


FIGURE 3
Sampling Locations, Pond 1-East



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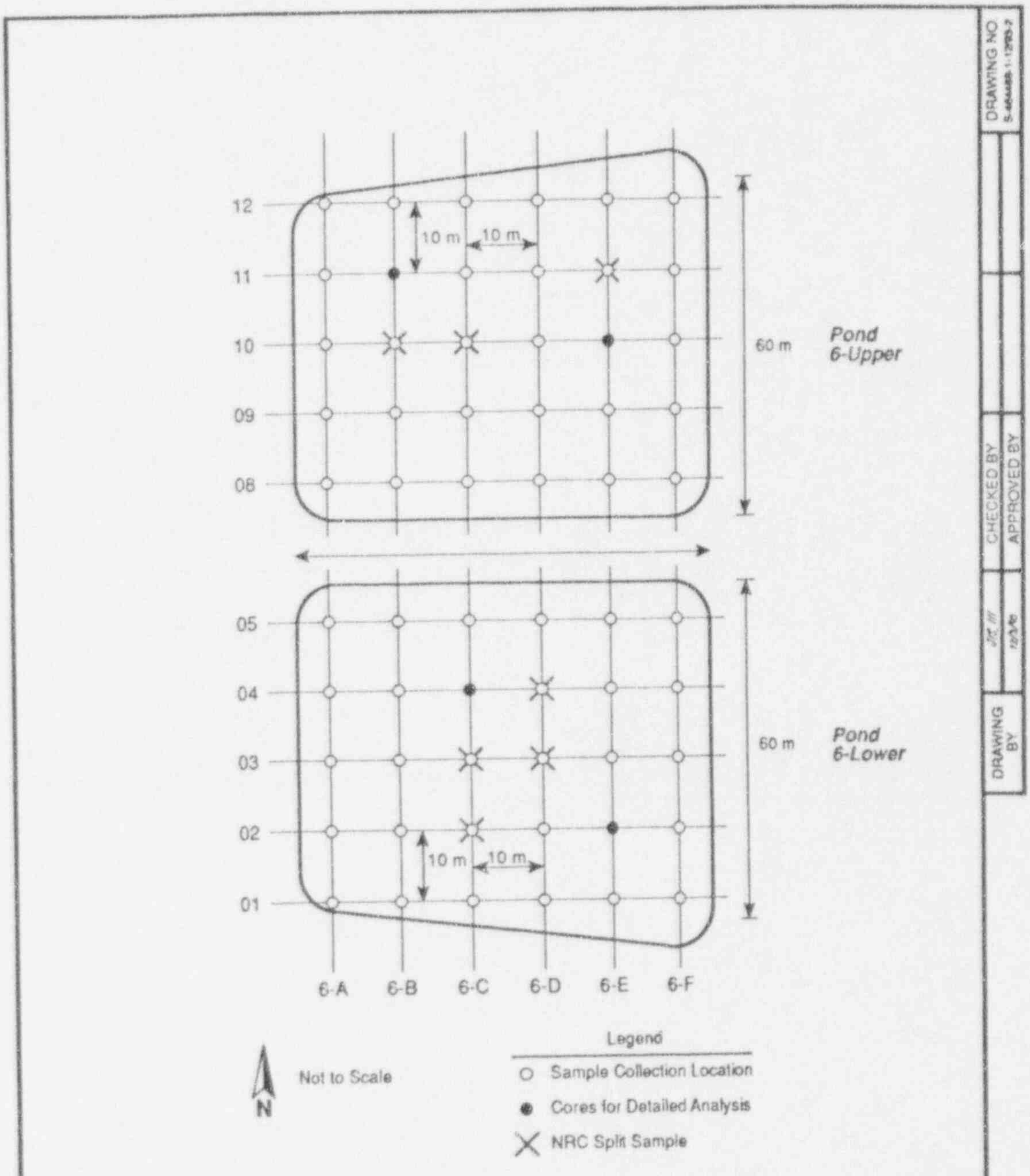
Pond 1-East Grid System for establishing sample collection locations.

FIGURE 4
Sampling Locations, Ponds 6-Upper and 6-Lower



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Ponds 6-Upper and 6-Lower Grid System for establishing sample collection locations.

FIGURE 5
Core Extraction Device

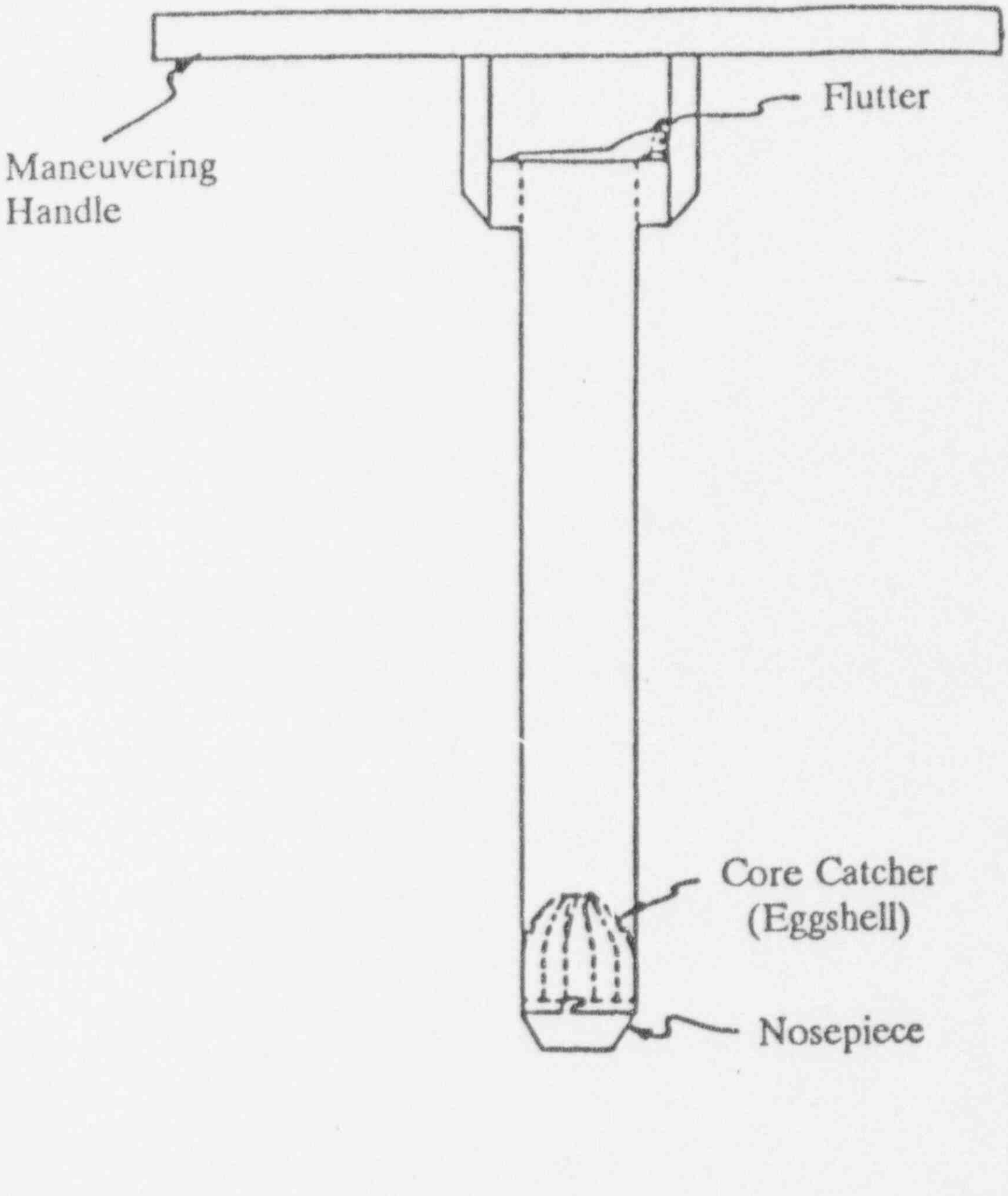
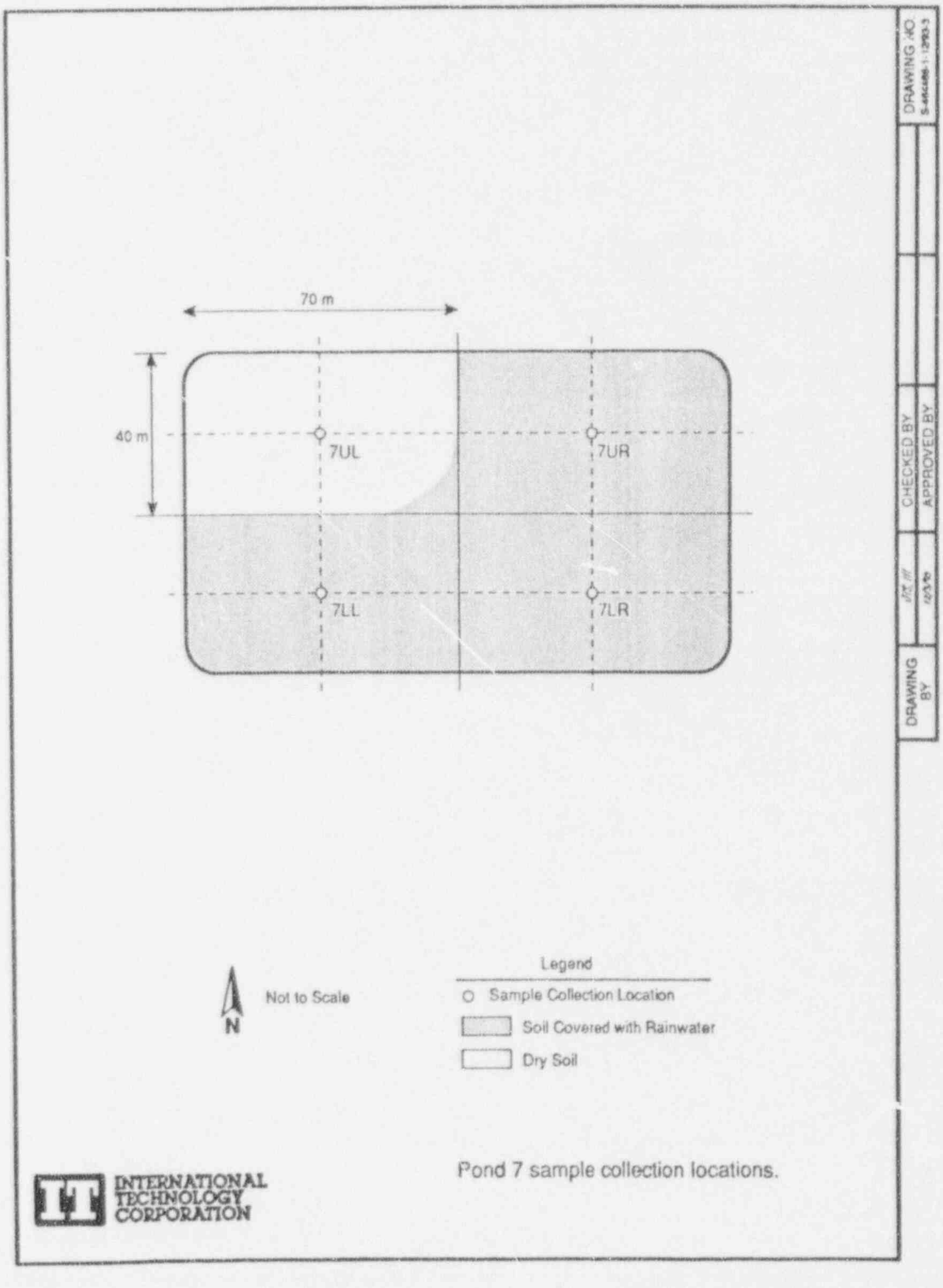
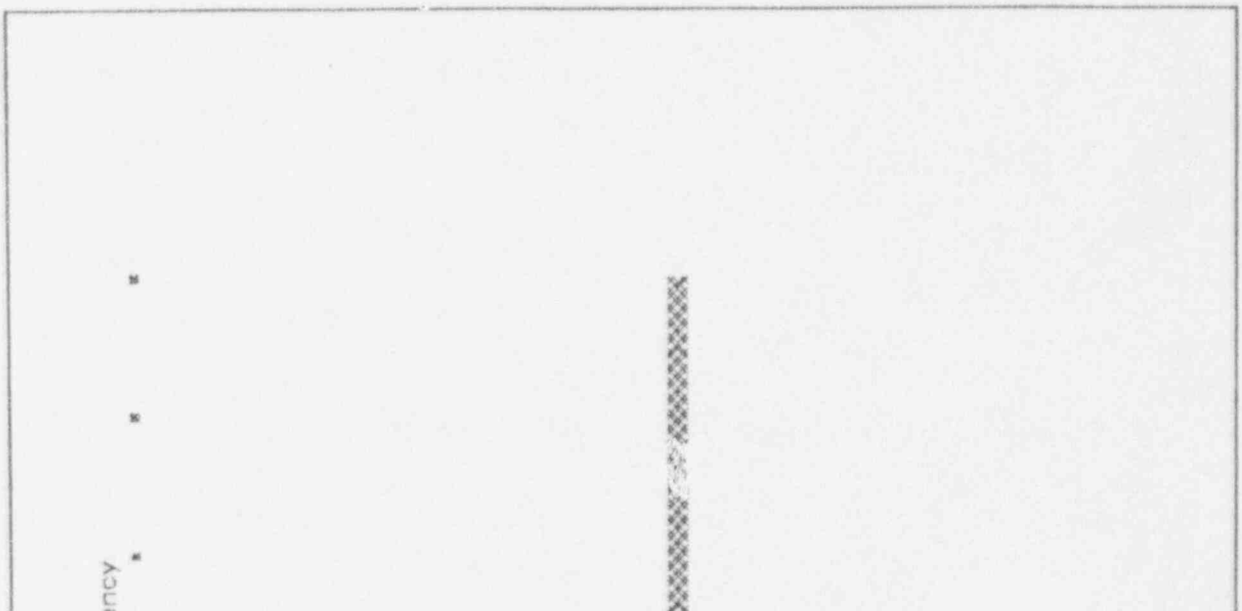


FIGURE 6
Sampling Locations, Pond 7



Pond 7 sample collection locations.

FIGURE 7
Frequency Distribution of Source Material in Ponds



PHOTOGRAPHS

Photo 1 Sludge Pumping from Pond 1-East.
The pump was placed near sampling team members on the left. One end of the pump was connected to a tube several feet long that extended to the bottom of the pond. The team member on the right held the tube for stability. A sample container was linked to the other end of the pump and was held by the team member on the left. The sludge was pumped directly into the container.

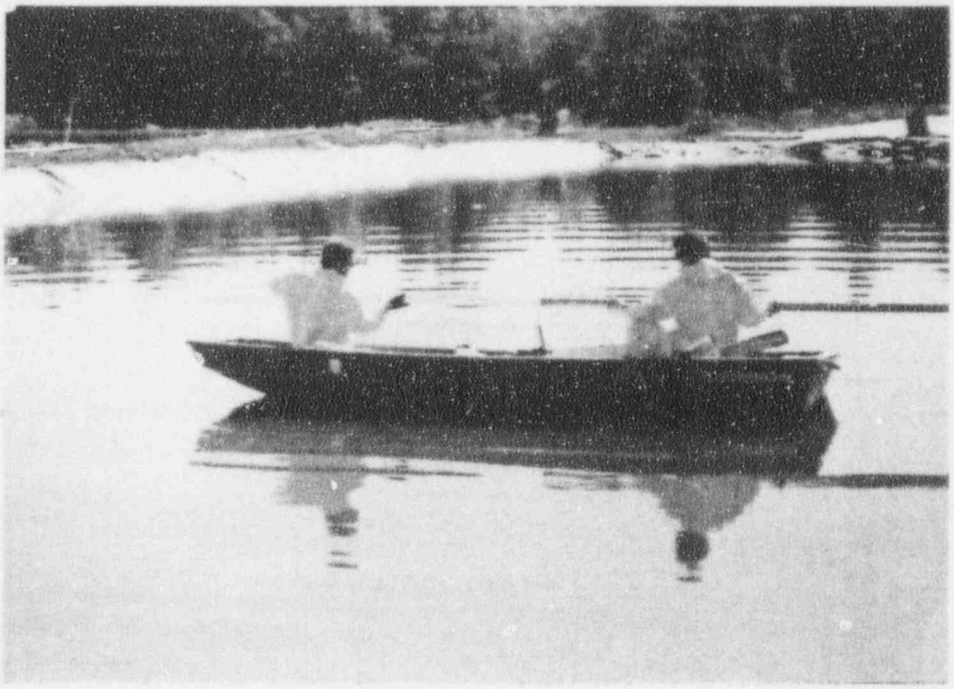


Photo 2 Liners Using Clear Lexan tubes.
A clear Lexan tube (on the left) was inserted into the core sampler (on the right) as a liner for sludge collection at Ponds 6-Upper and 6-Lower.

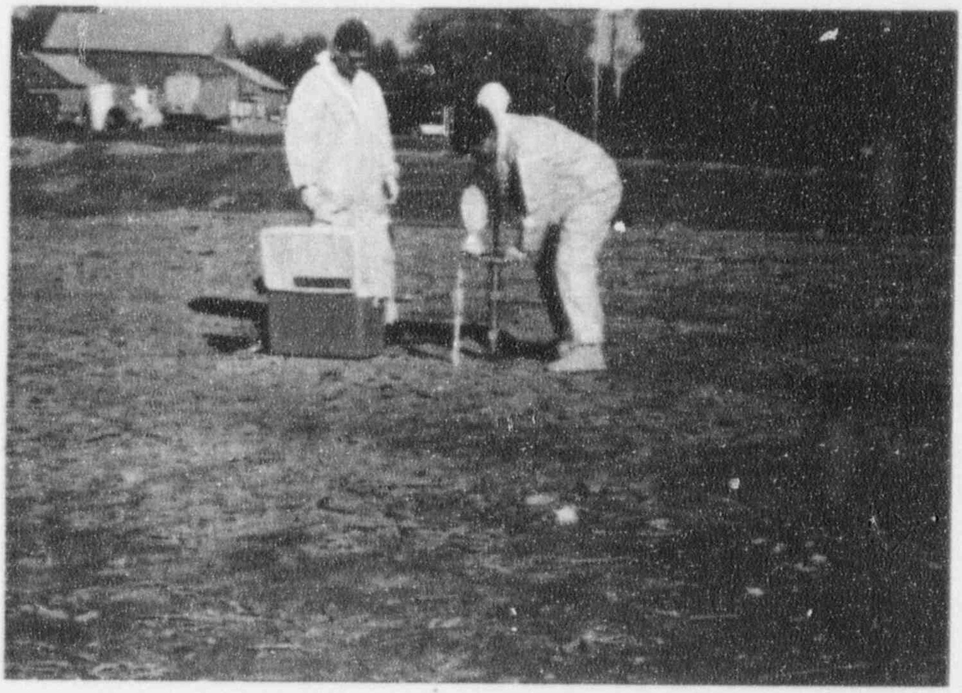


Photo 3 Coring Device for Pond 7.
This device consisted of a 2-foot long stainless steel cylinder, a flapper valve, and a maneuvering handle. The dry ground shown in this photo was from the northwestern quadrant where soil was tightly packed and contained numerous small pieces of rock. In order to reach the soil under the rainwater in the other quadrants, a 4-foot extension rod was attached to the device. A 2 foot-long Lexan tube with 2-inch diameter was placed on the inside of the cylinder as a liner (not shown). Soil was collected directly into the liner.

Photo 4 Several Sludge Cores Collected from Rows 11 and 12 of Pond 6-Upper.
Strata of sludge in cores collected from Rows 10 (not shown), 11, and 12 were not obvious. Different types of sludge in various colors mixed in the cores.

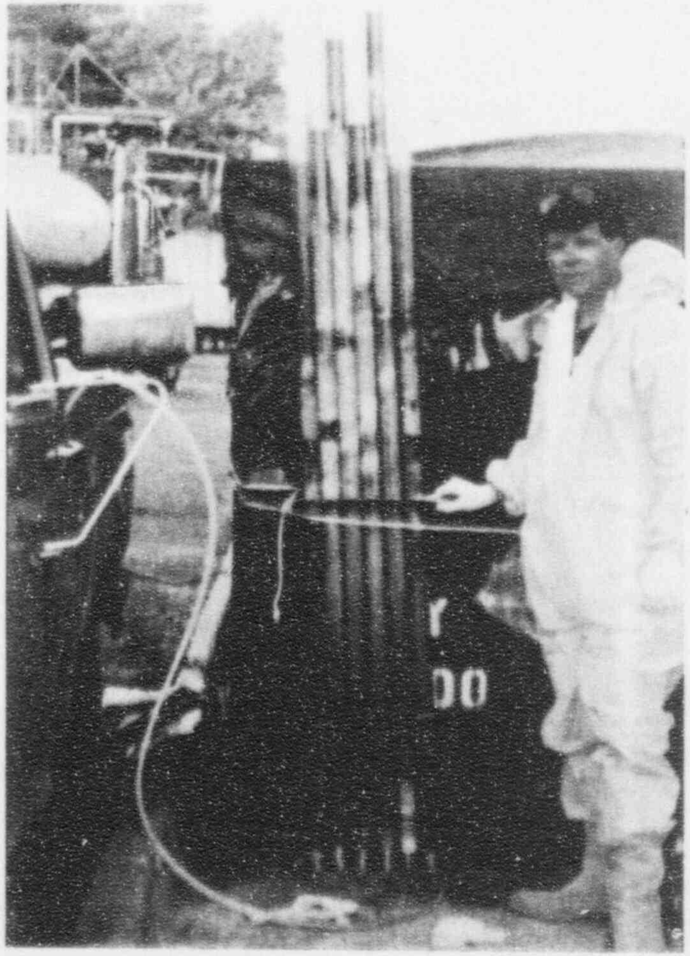


Photo 5 Cores of Row 08 from Pond 6-Upper (from L to R: Cores 6-A08, 6-B08, 6-C08, 6-D08, 6-E08, and 6-F08).
In Rows 8 and 9 (not shown), sludge strata appeared in the upper half of the cores. The lower half of the cores contained primarily black sludge and small amounts of white sludge.

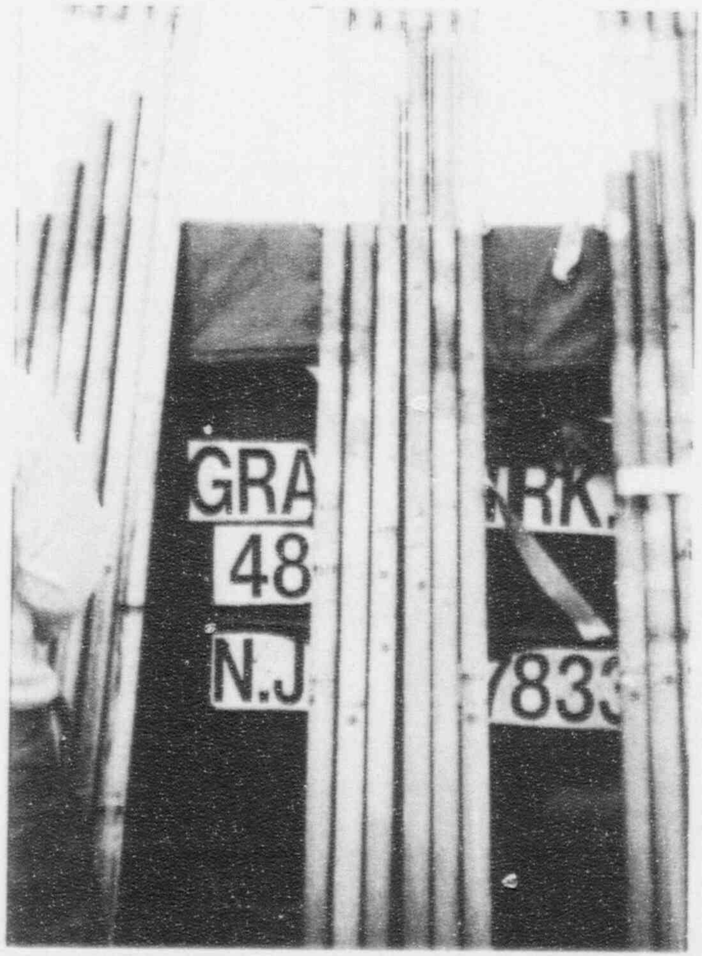


Photo 6 (Middle) Row 04 from Pond 6-Lower (from L to R: Cores 6-A04, 6-B04, 6-C04, 6-D04, 6-E04, and 6-F04).

0 - 1.5 ft:	grayish and relatively homogeneous sludge
1.5 - 4 ft:	many different thin sludge strata in various colors
4 ft down:	sludge appeared to be similar to that in 0 - 1.5 ft.

Photo 7 (From L to R) Rows 03, 02, and 01 from Pond 6-Lower (For each row, from L to R: Cores 6-A0i, 6-B0i, 6-C0i, 6-D0i, 6-E0i, and 6 F-0i, where i=3, 2, and 1).

0 - 1.5 ft:	grayish and relatively homogeneous sludge
1.5 - 4 ft:	many different thin sludge strata in various colors
4 ft down:	sludge appeared to be similar to that in 0 - 1.5 ft.

Photo 8 (Middle) Row 05 from Pond 6-Lower (from L to R: Cores 6-A05, 6-B05, 6-C05, 6-D05, 6-E05, and 6-F05). Small multiple tiers of sludge were not observed. The cores contained basically mixed black and white sludge.

Photo 9 Spiral Survey Pattern for Field Screening
The team member on the left steadily rotated the core and the team member on the right scanned along the segment downward in a constant speed (≈2.5 - 4.5 cm/sec).

APPENDIX A: FIELD SCREENING RESULTS

MAGNESIUM ELEKTRON, INC.
"Identification of Radiological Constituents in Waste Slag"
January 13, 1994, Page 41

RADIOLOGICAL SURVEY LOG

Survey Description: Field Screening for Homogeneity of Sludge from Pond 6-Upper

Project Name: MEI

Page 1 of 5

Drawing Attached: Yes____ No x

Survey Date: 10/6/93

Instrument Model: Eberline SPA-3 / Eberline ESP-1

Surveyed by: Show-Hua Fong, 10/19/93
Signature Date

Calibration Date: 5/4/93

Print name: Show-Hua Fong / Tom Breen

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Homogeneity Test			Sample Collection
							Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Number
							$UL1=C1+3\sqrt{C1}=$ 1481 $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-C12	168		1	84	C1= 1370	15 Sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-C12-1
			2	84	C2= 1500	15 Sec				6-C12-2
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ 1585 $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-F12	113		1	56	C1= 1470	15 sec	Homogeneous? (Is LL1<C2<UL1?) [✓ Y] N	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-F12-12
			2	57	C2= 1540	15 sec				
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ 1668 $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-E12	133		1	66	C1= 1550	15 Sec	Homogeneous? (Is LL1<C2<UL1?) [✓ Y] N	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-E12-12
			2	67	C2= 1570	15 Sec				
			3		C3=					

Date: 10/6/93

RADIOLOGICAL SURVEY LOG
CONTINUATION SHEET

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							Homogeneity Test			Sample Collection
Core Number	Total 0 Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Number
							UL1=C1+3$\sqrt{C1}$= LL1=C1-3$\sqrt{C1}$=	1,564	UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$=	6-D12-12
6-D12	173		1	86	C1= 1450	15 sec	Homogeneous? (Is LL1<C2<UL1?) [✓ Y] N	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	
			2	87	C2= 1500	15 sec				
			3		C3=					

										Sample Collection
Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Number
							UL1=C1+3$\sqrt{C1}$= LL1=C1-3$\sqrt{C1}$=		UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$=	6-A12-12
6-A12	Dry Kiln waste piled on the corners of Pond 6-Upper. NOT the sludge!		1	N/A	C1= N/A		Homogeneous? NA (Is LL1<C2<UL1?) Y N	Homogeneous? (Is LL1<C3<UL1?) Y N	NA Homogeneous? (Is LL2<C3<UL2?) Y N	
			2		C2=					
			3		C3=					

										Sample Collection
Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Number
							UL1=C1+3$\sqrt{C1}$= LL1=C1-3$\sqrt{C1}$=	2475	UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$=	
6-B12	216		1	108	C1= 2330	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-B12-1
			2	108	C2= 2590	25 sec				6-B12-2
			3		C3=					

										Sample Collection
Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Number
							UL1=C1+3$\sqrt{C1}$= LL1=C1-3$\sqrt{C1}$=	2537	UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$=	6-A10-12
6-A10	127		1	63	C1= 2340	25 sec	Homogeneous? (Is LL1<C2<UL1?) [✓ Y] N	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	
			2	64	C2= 2530	25 sec				
			3		C3=					

RADIOLOGICAL SURVEY LOG
CONTINUATION SHEET

Date: 10/6/93

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Core Number	Total 0 Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Homogeneity Test: Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection: Sample Number
6-B10 Split samples w/ NRC	204		1	102	C1= 2680	25 sec	UL1=C1+3$\sqrt{C1}$= 2835 LL1=C1-3$\sqrt{C1}$= Homogeneous? (Is LL1<C2<UL1?) [✓ Y] N	Homogeneous? (Is LL1<C3<UL1?) Y N	UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$= Homogeneous? (Is LL2<C3<UL2?) Y N	6-B10-1 (6-B10-1s)
			2	102	C2= 2780	25 sec				6-B10-2 (6-B10-2s)
			3		C3=					

Despite the homogeneity found in the test, [illegible] samples from both segments were collected. This was a error.

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection: Sample Number
6-C10 split sample w/ NRC	201		1	100	C1= 2680	25 sec	UL1=C1+3$\sqrt{C1}$= 2835 LL1=C1-3$\sqrt{C1}$= Homogeneous? (Is LL1<C2<UL1?) [✓ Y] N	Homogeneous? (Is LL1<C3<UL1?) Y N	UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$= Homogeneous? (Is LL2<C3<UL2?) Y N	6-C10-12
			2	101	C2= 2830	25 sec				(6-C10-12s)
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection: Sample Number
6-D10	193		1	96	C1= 2420	25 sec	UL1=C1+3$\sqrt{C1}$= 2568 LL1=C1-3$\sqrt{C1}$= Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$= Homogeneous? (Is LL2<C3<UL2?) Y N	6-D10-1
			2	97	C2= 2930	25 sec				6-D10-2
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection: Sample Number
6-E10 Detailed Analysis	137		1	68	C1= 1730	15 sec	UL1=C1+3$\sqrt{C1}$= LL1=C1-3$\sqrt{C1}$= 1605 Homogeneous? (Is LL1<C2<UL1?) [✓ Y] N	Homogeneous? (Is LL1<C3<UL1?) Y N	UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$= Homogeneour? (Is LL2<C3<UL2?) Y N	6-E10-1
			2	69	C2= 1720	15 sec				6-E10-2
			3		C3=					

Samples from both segments were collected because of detailed analysis for this core.

Date: 12/6/93

RADIOLOGICAL SURVEY LOG
CONTINUATION SHEET

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Core Number	Total 0 Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Homogeneity Test Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ $LL1=C1-3\sqrt{C1}=$ 2855		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-F10	135		1	67	C1= 3020	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-F10-1
			2	68	C2= 2280	25 sec				6-F10-2
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ 2,660 $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-A11	142		1	71	C1= 2,510	25 sec	Homogeneous? (Is LL1<C2<UL1?) [✓ Y] N	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-A11-12
			2	71	C2= 2660	25 sec				
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ 2,501 $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-B11 Detailed Analysis	188		1	94	C1= 2,355	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-B11-1
			2	94	C2= 2640	25 sec				6-B11-2
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ 2403 $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-C11	221		1	110	C1= 2260	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-C11-1
			2	111	C2= 2750	25 sec				6-C11-2
			3		C3=					

Date: 10/6/93

RADIOLOGICAL SURVEY LOG
CONTINUATION SHEET

Page 5 of 5

Core Number	Total 0 Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Homogeneity Test Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ 2434 $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-D11	203		1	101	C1= 2290	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-D11-1
			2	102	C2= 2640	25 sec				6-D11-2
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ 2722 $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-E11 split sample w/ NRC	201		1	100	C1= 2570	25 sec	Homogeneous? (Is LL1<C2<UL1?) [✓ Y] N	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-E11-12
			2	101	C2= 2590	25 sec				(6-E11-12$_2$)
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ $LL1=C1-3\sqrt{C1}=$ 2777		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-F11	142		1	71	C1= 2940	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-F11-1
			2	71	C2= 2510	25 sec				6-F11-2
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
			1		C1=		Homogeneous? (Is LL1<C2<UL1?) Y N	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	
			2		C2=					
			3		C3=					

RADIOLOGICAL SURVEY LOG

Survey Description: Field Screening for Homogeneity of Sludge from Pond 6-Upper

Project Name: MEI

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Drawing Attached: Yes ____ No X

Survey Date: 10/7/93

Instrument Model: Eberline SPA-3 / Eberline ESP-1

Surveyed by: Shaw-Hwa Fong , 10/19/93
Signature Date

Calibration Date: 5/4/93

Print name: Shaw-Hwa Fong / Tom Breen

							Homogeneity Test			Sample Collection
Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Number
							UL1=C1+3$\sqrt{C1}$= 2,598 LL1=C1-3$\sqrt{C1}$=		UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$=	
6-D09	203		1	101	C1= 2,450	25 Sec	Homogeneous?	Homogeneous?	Homogeneous?	6-D09-12
			2	102	C2= 2,490	25 Sec	(Is LL1<C2<UL1?)	(Is LL1<C3<UL1?)	(Is LL2<C3<UL2?)	
			3		C3=		[✓ Y] N	Y N	Y N	

							Homogeneity Test			Sample Collection
Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Number
							UL1=C1+3$\sqrt{C1}$= 1,948 LL1=C1-3$\sqrt{C1}$=		UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$=	
6-A09	206		1	103	C1= 1,820	25 Sec	Homogeneous?	Homogeneous?	Homogeneous?	6-A09-1
			2	103	C2= 2,370	25 Sec	(Is LL1<C2<UL1?)	(Is LL1<C3<UL1?)	(Is LL2<C3<UL2?)	6-A09-2
			3		C3=		Y [✓ N]	Y N	Y N	

							Homogeneity Test			Sample Collection
Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Number
							UL1=C1+3$\sqrt{C1}$= 2660 LL1=C1-3$\sqrt{C1}$=		UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$=	
6-E09	143		1	71	C1= 2510	25 Sec	Homogeneous?	Homogeneous?	Homogeneous?	6-E09-1
			2	72	C2= 2850	25 Sec	(Is LL1<C2<UL1?)	(Is LL1<C3<UL1?)	(Is LL2<C3<UL2?)	6-E09-2
			3		C3=		Y [✓ N]	Y N	Y N	

Date: 10/7/93

RADIOLOGICAL SURVEY LOG
CONTINUATION SHEET

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Core Number	Total 0 Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Homogeneity Test: Sgmnts 1 & 2 UL1=C1+3$\sqrt{C1}$= 2237 LL1=C1-3$\sqrt{C1}$=	Sgmnts 1 & 3	Sgmnts 2 & 3 UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$=	Sample Collection Sample Number
6-C09	215		1	107	C1= 2100	25 Sec	Homogeneous?	Homogeneous?	Homogeneous?	6-C09-1
			2	108	C2= 2,450	25 Sec	(Is LL1<C2<UL1?)	(Is LL1<C3<UL1?)	(Is LL2<C3<UL2?)	6-C09-2
			3		C3=		Y [✓ N]	Y N	Y N	

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2 UL1=C1+3$\sqrt{C1}$= 2392 LL1=C1-3$\sqrt{C1}$=	Sgmnts 1 & 3	Sgmnts 2 & 3 UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$=	Sample Collection Sample Number
6-B09	224		1	112	C1= 2250	25 Sec	Homogeneous?	Homogeneous?	Homogeneous?	6-B09-1
			2	112	C2= 2,420	25 Sec	(Is LL1<C2<UL1?)	(Is LL1<C3<UL1?)	(Is LL2<C3<UL2?)	6-B09-2
			3		C3=		Y [✓ N]	Y N	Y N	

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2 UL1=C1+3$\sqrt{C1}$= NA LL1=C1-3$\sqrt{C1}$=	Sgmnts 1 & 3	Sgmnts 2 & 3 UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$=	Sample Collection Sample Number
6-F09	91		1	91	C1= 2,480	25 Sec	Homogeneous? N/A	Homogeneous?	Homogeneous?	6-F09-12
			2	↑ One segment	C2=		(Is LL1<C2<UL1?)	(Is LL1<C3<UL1?)	(Is LL2<C3<UL2?)	
			3	only	C3=		Y N	Y N	Y N	

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2 UL1=C1+3$\sqrt{C1}$= 2279 LL1=C1-3$\sqrt{C1}$=	Sgmnts 1 & 3	Sgmnts 2 & 3 UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$=	Sample Collection Sample Number
6-A08	168		1	84	C1= 2140	25 sec	Homogeneous?	Homogeneous?	Homogeneous?	6-A08-1
			2	84	C2= 2850	25 sec	(Is LL1<C2<UL1?)	(Is LL1<C3<UL1?)	(Is LL2<C3<UL2?)	6-A08-2
			3		C3=		Y [✓ N]	Y N	Y N	

Date: 12/7/93

RADIOLOGICAL SURVEY LOG
CONTINUATION SHEET

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Core Number	Total 0 Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Homogeneity Test: Sgmnts 1 & 2	Homogeneity Test: Sgmnts 1 & 3	Homogeneity Test: Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ $LL1=C1-3\sqrt{C1}=$	 2768	$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-B08	196		1	98	C1= 2,930	25 sec	Homogeneous?	Homogeneous?	Homogeneous?	6-B08-12
			2	98	C2= 2900	25 sec	(Is LL1<C2<UL1?)	(Is LL1<C3<UL1?)	(Is LL2<C3<UL2?)	
			3		C3=		[✓ Y] N	Y N	Y N	

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ $LL1=C1-3\sqrt{C1}=$	2660 	$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-C08	218		1	109	C1= 2510	25 sec	Homogeneous?	Homogeneous?	Homogeneous?	6-C08-1
			2	109	C2= 2880	25 sec	(Is LL1<C2<UL1?)	(Is LL1<C3<UL1?)	(Is LL2<C3<UL2?)	6-C08-2
			3		C3=		Y [✓ N]	Y N	Y N	

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ $LL1=C1-3\sqrt{C1}=$	 2709	$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-D08	196		1	98	C1= 2870	25 sec	Homogeneous?	Homogeneous?	Homogeneous?	6-D08-12
			2	98	C2= 2850	25 sec	(Is LL1<C2<UL1?)	(Is LL1<C3<UL1?)	(Is LL2<C3<UL2?)	
			3		C3=		[✓ Y] N	Y N	Y N	

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ $LL1=C1-3\sqrt{C1}=$	 3,040	$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-E08	226		1	113	C1= 3,210	25 sec	Homogeneous?	Homogeneous?	Homogeneous?	6-E08-1
			2	113	C2= 2,780	25 sec	(Is LL1<C2<UL1?)	(Is LL1<C3<UL1?)	(Is LL2<C3<UL2?)	6-E08-2
			3		C3=		Y [✓ N]	Y N	Y N	

RADIOLOGICAL SURVEY LOG
CONTINUATION SHEET

Date: 10/7/93

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Core Number	Total 0 Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Homogeneity Test Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ $LL1=C1-3\sqrt{C1}=$ 2,719		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-F08	157		1	78	C1= 2,880	25 sec	Homogeneous? (Is LL1<C2<UL1?) [✓ Y] N	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-F08-12
			2	79	C2= 2,790	25 sec				
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
			1		C1=		Homogeneous? (Is LL1<C2<UL1?) Y N	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	
			2		C2=					
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
			1		C1=		Homogeneous? (Is LL1<C2<UL1?) Y N	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	
			2		C2=					
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
			1		C1=		Homogeneous? (Is LL1<C2<UL1?) Y N	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	
			2		C2=					
			3		C3=					

RADIOLOGICAL SURVEY LOG

Survey Description: Field Screening for Homogeneity of Sludge from Pond 6-Lower

Drawing Attached: Yes_____ No X

Instrument Model: Eberline SPA-3/ Eberline ESP-1

Calibration Date: 5/4/93

Project Name: MEI

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Survey Date: 10/8/93

Surveyed by: Show-Hua Fong, 10/19/93
Signature Date

Print name: Show-Hua Fong/ Tom Breen

							Homogeneity Test			Sample Collection
Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Number
6-A05	140		1	70	C1= 3530	25 sec	$UL1=C1+3\sqrt{C1}=$	3708	$UL2=C2+3\sqrt{C2}=$	6-A05-12
			2	70	C2= 3530	25 sec	$LL1=C1-3\sqrt{C1}=$		$LL2=C2-3\sqrt{C2}=$	
			3		C3=		Homogeneous? (Is LL1<C2<UL1?) [✓ Y] N	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	

							Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection
Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	$UL1=C1+3\sqrt{C1}=$	2959	$UL2=C2+3\sqrt{C2}=$	Sample Number
							$LL1=C1-3\sqrt{C1}=$		$LL2=C2-3\sqrt{C2}=$	
6-B05	204		1	102	C1= 2800	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-B05-1
			2	102	C2= 3820	25 sec				6-B05-2
			3		C3=					

							Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection
Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	$UL1=C1+3\sqrt{C1}=$	3565	$UL2=C2+3\sqrt{C2}=$	Sample Number
							$LL1=C1-3\sqrt{C1}=$		$LL2=C2-3\sqrt{C2}=$	
6-C05	216		1	108	C1= 3390	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-C05-1
			2	108	C2= 3990	25 sec				6-C05-2
			3		C3=					

Date: 10/8/93

RADIOLOGICAL SURVEY LOG
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Core Number	Total 0 Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Homogeneity Test Sgmnts 1 & 2	 Sgmnts 1 & 3	 Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ 4087 $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-D05	221		1	110	C1= 3400	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-D05-1
			2	111	C2= 4290	25 sec				6-D05-2
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ 4098 $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-E05	239		1	119	C1= 3910	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-E05-1
			2	120	C2= 4530	25 sec				6-E05-2
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ $LL1=C1-3\sqrt{C1}=$ 4514		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-F05	151		1	75	C1= 4720	25 sec	Homogeneous? (Is LL1<C2<UL1?) [✓ Y] N	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-F05-12
			2	76	C2= 4570	25 sec				
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ 4814 $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-A04	198		1	99	C1= 4610	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-A04-1
			2	99	C2= 5390	25 sec				6-A04-2
			3		C3=					

Date: 10/8/93

RADIOLOGICAL SURVEY LOG
CONTINUATION SHEET

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								Homogeneity Test			
Core Number	Total 0 Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts		Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection
								UL1=C1+3$\sqrt{C1}$= LL1=C1-3$\sqrt{C1}$=	3929	UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$=	Sample Number
6-B04	189		1	94	C1=	3745	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-B04-1
			2	45	C2=	4200	25 sec				6-B04-2
			3		C3=						

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts		Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection
								UL1=C1+3$\sqrt{C1}$= LL1=C1-3$\sqrt{C1}$=	3454	UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$=	Sample Number
6-C04 Detailed Analysis	224		1	112	C1=	3770	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-C04-1
			2	112	C2=	4990	25 sec				6-C04-2
			3		C3=						

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts		Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection
								UL1=C1+3$\sqrt{C1}$= LL1=C1-3$\sqrt{C1}$=	4292	UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$=	Sample Number
6-D04 split sample w/NRC	239		1	119	C1=	4100	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-D04-1(6-D04-1a)
			2	120	C2=	4680	25 sec				6-D04-2(6-D04-2a
			3		C3=						

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts		Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection
								UL1=C1+3$\sqrt{C1}$= LL1=C1-3$\sqrt{C1}$=	4701	UL2=C2+3$\sqrt{C2}$= LL2=C2-3$\sqrt{C2}$=	Sample Number
6-E04	234		1	117	C1=	4500	25 sec	Homogeneous? (Is LL1<C2<UL1?) [✓ Y] N	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-E04-12
			2	117	C2=	4670	25 sec				
			3		C3=						

RADIOLOGICAL SURVEY LOG
CONTINUATION SHEET

Date: 10/8/93

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Core Number	Total 0 Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts		Count Time	Homogeneity Test Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
								UL1=C1+3$\sqrt{C1}$=		UL2=C2+3$\sqrt{C2}$=	
								LL1=C1-3$\sqrt{C1}$=	4444	LL2=C2-3$\sqrt{C2}$=	
6-F04	193		1	96	C1=	5160	25 sec	Homogeneous?	Homogeneous?	Homogeneous?	6-F04-1
			2	97	C2=	4890	25 sec	(Is LL1<C2<UL1?)	(Is LL1<C3<UL1?)	(Is LL2<C3<UL2?)	6-F04-2
			3		C3=			Y [✓ N]	Y N	Y N	

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts		Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
								UL1=C1+3$\sqrt{C1}$=	4507	UL2=C2+3$\sqrt{C2}$=	
								LL1=C1-3$\sqrt{C1}$=		LL2=C2-3$\sqrt{C2}$=	
6-A03	203		1	101	C1=	4310	25 sec	Homogeneous?	Homogeneous?	Homogeneous?	6-A03-1
			2	102	C2=	4760	25 sec	(Is LL1<C2<UL1?)	(Is LL1<C3<UL1?)	(Is LL2<C3<UL2?)	6-A03-2
			3		C3=			Y [✓ N]	Y N	Y N	

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts		Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
								UL1=C1+3$\sqrt{C1}$=	4415	UL2=C2+3$\sqrt{C2}$=	
								LL1=C1-3$\sqrt{C1}$=		LL2=C2-3$\sqrt{C2}$=	
6B03	208		1	104	C1=	4220	25 sec	Homogeneous?	Homogeneous?	Homogeneous?	6-B03-1
			2	104	C2=	5080	25 sec	(Is LL1<C2<UL1?)	(Is LL1<C3<UL1?)	(Is LL2<C3<UL2?)	6-B03-2
			3		C3=			Y [✓ N]	Y N	Y N	

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts		Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
								UL1=C1+3$\sqrt{C1}$=	3575	UL2=C2+3$\sqrt{C2}$=	
								LL1=C1-3$\sqrt{C1}$=		LL2=C2-3$\sqrt{C2}$=	
6-C03	221		1	110	C1=	3400	25 sec	Homogeneous?	Homogeneous?	Homogeneous?	6-C03-1 (6-C03-1$_s$)
split samples w/NRC			2	111	C2=	5560	25 sec	(Is LL1<C2<UL1?)	(Is LL1<C3<UL1?)	(Is LL2<C3<UL2?)	6-C03-2 (6-C03-2$_s$
			3		C3=			Y [✓ N]	Y N	Y N	

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Core Number	Total 0 Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Homogeneity Test			Sample Collection
							Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Number
							$UL1=C1+3\sqrt{C1}=$ 4057 $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-D03 split samples w/NRC	234		1	117	C1= 3870	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-D03-1 (6-D03-1s)
			2	117	C2= 5050	25 sec				6-D03-2 (6-D03-2s
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ 4292 $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-E03	231		1	115	C1= 4100	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-E03-1
			2	116	C2= 4600	25 sec				6-E03-2
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ 4313 $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-F03	216		1	108	C1= 4120	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-F03-1
			2	108	C2= 4900	25 sec				6-F03-2
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection Sample Number
							$UL1=C1+3\sqrt{C1}=$ 3985 $LL1=C1-3\sqrt{C1}=$		$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	
6-A02	160		1	80	C1= 3800	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-A02-1
			2	80	C2= 4260	25 sec				6-A02-2
			3		C3=					

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Core Number	Total 0 Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Homogeneity Test: Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection: Sample Number
6-B02	163		1	81	C1= 3710	25 sec	$UL1=C1+3\sqrt{C1}=$	3893	$UL2=C2+3\sqrt{C2}=$	6-B02-1
			2	82	C2= 4070	25 sec	$LL1=C1-3\sqrt{C1}=$		$LL2=C2-3\sqrt{C2}=$	6-B02-2
			3		C3=		Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection: Sample Number
6-C02 split samples w/ NRC	201		1	100	C1= 3370	25 sec	$UL1=C1+3\sqrt{C1}=$	3544	$UL2=C2+3\sqrt{C2}=$	6-C02-1 (6-C02-1
			2	101	C2= 4080	25 sec	$LL1=C1-3\sqrt{C1}=$		$LL2=C2-3\sqrt{C2}=$	6-C02-2 (6-C02-2
			3		C3=		Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection: Sample Number
6-D02	201		1	100	C1= 3410	25 sec	$UL1=C1+3\sqrt{C1}=$	3585	$UL2=C2+3\sqrt{C2}=$	6-D02-1
			2	101	C2= 4280	25 sec	$LL1=C1-3\sqrt{C1}=$		$LL2=C2-3\sqrt{C2}=$	6-D02-2
			3		C3=		Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection: Sample Number
6-E02 Detailed Analysis	213		1	106	C1= 3800	25 sec	$UL1=C1+3\sqrt{C1}=$	3985	$UL2=C2+3\sqrt{C2}=$	6-E02-1
			2	107	C2= 4190	25 sec	$LL1=C1-3\sqrt{C1}=$		$LL2=C2-3\sqrt{C2}=$	6-E02-2
			3		C3=		Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	

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Core Number	Total 0 Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Homogeneity Test: Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection
							$UL1=C1+3\sqrt{C1}=$ $LL1=C1-3\sqrt{C1}=$	4149	$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	Sample Number
6-F02	221		1	110	C1= 3960	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-F02-1
			2	111	C2= 4570	25 sec				6-F02-2
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection
							$UL1=C1+3\sqrt{C1}=$ $LL1=C1-3\sqrt{C1}=$	3452	$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	Sample Number
6-A01	159		1	79	C1= 3280	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-A01-1
			2	80	C2= 4130	25 sec				6-A01-2
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection
							$UL1=C1+3\sqrt{C1}=$ $LL1=C1-3\sqrt{C1}=$	3534	$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	Sample Number
6-B01	216		1	108	C1= 3360	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-B01-1
			2	108	C2= 3920	25 sec				6-B01-2
			3		C3=					

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sgmnts 1 & 2	Sgmnts 1 & 3	Sgmnts 2 & 3	Sample Collection
							$UL1=C1+3\sqrt{C1}=$ $LL1=C1-3\sqrt{C1}=$	3734	$UL2=C2+3\sqrt{C2}=$ $LL2=C2-3\sqrt{C2}=$	Sample Number
6-C01	208		1	104	C1= 3560	25 sec	Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]	Homogeneous? (Is LL1<C3<UL1?) Y N	Homogeneous? (Is LL2<C3<UL2?) Y N	6-C01-1
			2	104	C2= 4170	25 sec				6-C01-2
			3		C3=					

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Core Number	Total 0 Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sample Number
6-D01	231		1	115	C1= 3,400	25 sec	6-D01-1
			2	116	C2= 3,970	25 sec	6-D01-2
			3		C3=		

Homogeneity Test

Sgmnts 1 & 2 / Sgmnts 1 & 3: UL1=C1+3√C1= 3575
LL1=C1-3√C1=
Sgmnts 2 & 3: UL2=C2+3√C2=
LL2=C2-3√C2=

Sgmnts 1 & 2: Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]
Sgmnts 1 & 3: Homogeneous? (Is LL1<C3<UL1?) Y N
Sgmnts 2 & 3: Homogeneous? (Is LL2<C3<UL2?) Y N

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sample Number
6-E01	234		1	117	C1= 3660	25 sec	6-E01-1
			2	117	C2= 4020	25 sec	6-E01-2
			3		C3=		

Sgmnts 1 & 2 / Sgmnts 1 & 3: UL1=C1+3√C1= 3,841
LL1=C1-3√C1=
Sgmnts 2 & 3: UL2=C2+3√C2=
LL2=C2-3√C2=

Sgmnts 1 & 2: Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]
Sgmnts 1 & 3: Homogeneous? (Is LL1<C3<UL1?) Y N
Sgmnts 2 & 3: Homogeneous? (Is LL2<C3<UL2?) Y N

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sample Number
6-F01	229		1	114	C1= 3,560	25 sec	6-F01-1
			2	115	C2= 4070	25 sec	6-F01-2
			3		C3=		

Sgmnts 1 & 2 / Sgmnts 1 & 3: UL1=C1+3√C1= 3739
LL1=C1-3√C1=
Sgmnts 2 & 3: UL2=C2+3√C2=
LL2=C2-3√C2=

Sgmnts 1 & 2: Homogeneous? (Is LL1<C2<UL1?) Y [✓ N]
Sgmnts 1 & 3: Homogeneous? (Is LL1<C3<UL1?) Y N
Sgmnts 2 & 3: Homogeneous? (Is LL2<C3<UL2?) Y N

Core Number	Total Sludge Length(cm)	Visual Strata Observ.	Sgmnt	Sludge Sgmnt Length(cm)	Total Counts	Count Time	Sample Number
			1		C1=		
			2		C2=		
			3		C3=		

Sgmnts 1 & 2 / Sgmnts 1 & 3: UL1=C1+3√C1=
LL1=C1-3√C1=
Sgmnts 2 & 3: UL2=C2+3√C2=
LL2=C2-3√C2=

Sgmnts 1 & 2: Homogeneous? (Is LL1<C2<UL1?) Y N
Sgmnts 1 & 3: Homogeneous? (Is LL1<C3<UL1?) Y N
Sgmnts 2 & 3: Homogeneous? (Is LL2<C3<UL2?) Y N

APPENDIX B: ANALYTICAL (GAMMA SPECTROSCOPY) RESULTS

Collection Location	Radionuclide Concentration (ppm, wet weight)						
	U-238	Th-234	U-234	Th-230	Th-232	Th-228	TOTAL
POND 1-EAST							
1-A-1	1.32E+02	1.92E-09	7.11E-03	2.20E-03	1.35E+02	1.80E-08	267
1-A-2	1.57E+02	2.28E-09	8.43E-03	2.61E-03	1.28E+02	1.71E-08	285
1-A-3	1.38E+02	2.00E-09	7.40E-03	2.29E-03	1.54E+02	2.05E-08	291
1-B-1	1.99E+02	2.88E-09	1.07E-02	3.30E-03	1.27E+02	1.70E-08	326
1-B-2	2.17E+02	3.14E-09	1.16E-02	3.60E-03	1.24E+02	1.66E-08	341
1-B-4	2.28E+02	3.30E-09	1.22E-02	3.79E-03	1.45E+02	1.93E-08	373
POND 6-LOWER							
6-A-2-1	8.02E+01	1.16E-09	4.31E-03	1.33E-03	9.14E+01	1.22E-08	172
6-A-2-2	8.88E+01	1.29E-09	4.77E-03	1.47E-03	1.25E+02	1.67E-08	214
6-A-4-1	9.60E+01	1.39E-09	5.15E-03	1.59E-03	1.35E+02	1.81E-08	231
6-A-4-2	1.06E+02	1.54E-09	5.70E-03	1.76E-03	1.24E+02	1.66E-08	230
6-B-1-1	6.82E+01	9.88E-10	3.66E-03	1.13E-03	1.06E+02	1.42E-08	175
6-B-1-2	1.07E+02	1.55E-09	5.73E-03	1.77E-03	1.32E+02	1.77E-08	239
6-B-5-1	7.28E+01	1.06E-09	3.91E-03	1.21E-03	8.09E+01	1.08E-08	154
6-B-5-2	1.05E+02	1.52E-09	5.64E-03	1.74E-03	1.27E+02	1.70E-08	233
6-C-2-1	6.77E+01	9.81E-10	3.64E-03	1.12E-03	8.59E+01	1.15E-08	154
6-C-2-2	1.11E+02	1.60E-09	5.94E-03	1.84E-03	1.30E+02	1.74E-08	241
6-C-3-1	7.79E+01	1.13E-09	4.18E-03	1.29E-03	9.54E+01	1.28E-08	173
6-C-3-2	1.21E+02	1.75E-09	6.49E-03	2.01E-03	1.32E+02	1.76E-08	253

Collection Location	Radionuclide Concentration (ppm, wet weight)						
	U-238	Th-234	U-234	Th-230	Th-232	Th-228	TOTAL
6-C-4-1	7.26E+01	1.05E-09	3.90E-03	1.21E-03	9.26E+01	1.24E-08	165
6-C-4-2	9.42E+01	1.36E-09	5.06E-03	1.56E-03	1.38E+02	1.84E-08	232
6-D-1-1	8.79E+01	1.27E-09	4.72E-03	1.46E-03	1.25E+02	1.67E-08	213
6-D-1-2	8.61E+01	1.25E-09	4.62E-03	1.43E-03	1.26E+02	1.68E-08	212
6-D-3-1	7.08E+01	1.03E-09	3.80E-03	1.18E-03	1.01E+02	1.35E-08	172
6-D-3-2	1.04E+02	1.50E-09	5.56E-03	1.72E-03	1.32E+02	1.76E-08	235
6-D-4-1	1.02E+02	1.47E-09	5.45E-03	1.69E-03	1.28E+02	1.71E-08	230
6-D-4-2	1.14E+02	1.65E-09	6.12E-03	1.89E-03	1.31E+02	1.76E-08	245
6-D-5-1	8.71E+01	1.26E-09	4.68E-03	1.45E-03	1.44E+02	1.92E-08	231
6-D-5-2	1.17E+02	1.70E-09	6.29E-03	1.95E-03	1.54E+02	2.06E-08	271
6-5-2-1	1.05E+02	1.52E-09	5.65E-03	1.75E-03	1.47E+02	1.97E-08	252
6-E-2-2	9.69E+01	1.40E-09	5.20E-03	1.61E-03	1.26E+02	1.69E-08	223
6-E-4-12	1.01E+02	1.46E-09	5.40E-03	1.67E-03	1.22E+02	1.63E-08	223
6-F-1-1	8.28E+01	1.20E-09	4.45E-03	1.37E-03	1.37E+02	1.84E-08	220
6-F-1-2	1.06E+02	1.54E-09	5.70E-03	1.76E-03	1.39E+02	1.86E-08	245
6-F-3-1	6.12E+01	8.87E-10	3.29E-03	1.02E-03	7.24E+01	9.68E-09	134
6-F-3-2	1.40E+02	2.03E-09	7.51E-03	2.32E-03	2.49E+02	3.32E-08	388
6-F-5-12	1.38E+02	2.00E-09	7.41E-03	2.29E-03	1.65E+02	2.20E-08	303
POND 6-UPPER							
6-A-11-12	1.14E+02	1.65E-09	6.11E-03	1.89E-03	1.24E+02	1.66E-08	238

Collection Location	Radionuclide Concentration (ppm, wet weight)						
	U-238	Th-234	U-234	Th-230	Th-232	Th-228	TOTAL
6-A-9-1	1.15E+02	1.67E-09	6.19E-03	1.91E-03	1.32E+02	1.77E-08	248
6-A-9-2	9.96E+01	1.44E-09	5.34E-03	1.65E-03	1.31E+02	1.75E-08	230
6-B-10-1	1.12E+02	1.62E-09	5.99E-03	1.85E-03	1.41E+02	1.88E-08	252
6-B-10-2	1.09E+02	1.58E-09	5.85E-03	1.81E-03	1.40E+02	1.83E-08	249
6-B-11-1	1.10E+02	1.60E-09	5.93E-03	1.83E-03	1.10E+02	1.47E-08	221
6-B-11-1	1.14E+02	1.65E-09	6.10E-03	1.89E-03	1.14E+02	1.52E-08	228
6-B-11-2	1.00E+02	1.46E-09	5.39E-03	1.67E-03	1.49E+02	1.99E-08	250
6-B-11-2	1.02E+02	1.47E-09	5.47E-03	1.69E-03	1.54E+02	2.06E-08	256
6-B-12-1	1.27E+02	1.77E-09	6.54E-03	2.02E-03	8.87E+01	1.19E-08	211
6-B-12-2	1.07E+02	1.55E-09	5.75E-03	1.78E-03	1.37E+02	1.83E-08	244
6-E-8-12	1.39E+02	2.02E-09	7.49E-03	2.31E-03	1.84E+02	2.45E-08	323
6-C-10-12	1.11E+02	1.61E-09	5.96E-03	1.84E-03	1.48E+02	1.98E-08	259
6-C-9-1	8.77E+01	1.27E-09	4.71E-03	1.46E-03	1.28E+02	1.71E-08	216
6-C-9-2	9.47E+01	1.37E-09	5.08E-03	1.57E-03	1.38E+02	1.84E-08	232
6-D-11-1	1.50E+02	2.17E-09	8.03E-03	2.48E-03	1.16E+02	1.55E-08	266
6-D-11-2	9.68E+01	1.40E-09	5.20E-03	1.61E-03	1.28E+02	1.71E-08	225
6-D-12-12	1.11E+02	1.61E-09	5.97E-03	1.85E-03	1.38E+02	1.84E-08	249
6-D-8-12	1.14E+02	1.65E-09	6.12E-03	1.89E-03	1.36E+02	1.82E-08	250
6-E-10-1	1.01E+02	1.47E-09	5.44E-03	1.68E-03	1.34E+02	1.79E-08	236
6-E-10-1	1.02E+02	1.48E-09	5.47E-03	1.69E-03	1.32E+02	1.76E-08	234

Collection Location	Radionuclide Concentration (ppm, wet weight)						
	U-238	Th-234	U-234	Th-230	Th-232	Th-228	TOTAL
6-E-10-2	1.11E+02	1.60E-09	5.94E-03	1.84E-03	1.12E+02	1.50E-08	223
6-E-10-2	9.88E+01	1.43E-09	5.30E-03	1.64E-03	1.12E+02	1.50E-08	211
6-E-11-12	1.14E+02	1.66E-09	6.15E-03	1.90E-03	1.26E+02	1.69E-08	241
6-E-9-1	1.24E+02	1.80[illegible]	6.67E-03	2.06E-03	1.30E+02	1.74E-08	255
6-E-9-2	1.42E+02	2.06E-09	7.62E-03	2.36E-03	1.90E+02	2.54E-08	332
6-F-10-2	4.39E+01	6.37E-10	2.36E-03	7.29E-04	3.38E+01	4.52E-09	78
6-F-12-12	1.15E+02	1.66E-09	6.16E-03	1.90E-03	1.29E+02	1.72E-08	243
6-F-8-12	1.32E+02	1.91E-09	7.07E-03	2.19E-03	2.06E+02	2.75E-08	338
POND 7							
7-LL	9.19E+01	1.33E-09	4.94E-03	1.53E-03	1.69E+02	2.26E-08	261
7-LR	7.24E+01	1.05E-09	3.89E-03	1.20E-03	1.00E+02	1.34E-08	173
7-UL	3.33E+01	4.82E-10	1.79E-03	5.52E-04	1.67E+02	2.24E-08	64
7-UR	8.26E+01	1.20E-09	4.43E-03	1.37E-03	8.95E+01	1.20E-08	172

APPENDIX C: DOSE RATE TO AN INTRUDER

The dose rates (internal and external) in the vicinity of the MEI sludge ponds were determined from computer modeling of the various exposure pathways based upon knowledge of the amount and distribution of the contaminants of concern in the waste sludge. For this effort, the methodologies contained in "A Manual for Implementing Residual Radioactive Material Guidelines" (ANL, 1989) were used. The computer code RESRAD (Version 4.1), developed at Argonne National Laboratory for the U. S. Department of Energy, was used to calculate radiation doses to an on-site intruder from radioactive contamination in soil. In this computer code, nine environmental pathways are considered, however only the following are applicable to intruders on the MEI property:

- Direct radiation from radionuclides in the sludge; and
- Ingestion of sludge.

To assess the radiation dose to an intruder, the following parameters were used as input to the RESRAD code:

- Ponds 1-East, 6-Upper and 6-Lower were modeled as a single impoundment with dimensions equal to 8,840 m^2.
- The thickness of contaminated material is evenly distributed over the entire impoundment at an average depth of 2.4 meters, which is approximately equal to the maximum depth of the sludge in the ponds during the October 4, 1993 sampling period.
- The radionuclides in the soil are evenly distributed throughout the entire impoundment at an average concentration of 35.99 pCi/g of ^{238}U and 14.23 pCi/g of ^{232}Th. These are the mean activity concentrations (wet weight) for all of the ponds combined. The radioactive daughters are assumed to be in equilibrium with the parent of the series.
- There is no cap or cover over the ponds

- Sludge ingestion rates for intruders is 50 mg per day (EPA, 1989). To ensure conservatism, this rate applies to children over six years of age, and includes the predicted incidence of "pica".[12]
- All other input parameters to the RESRAD code, including dose conversion factors, were selected from the RESRAD default values.

The maximum possible dose rate (TEDE) by all pathways for an intruder that remains directly over the sludge ponds at the MEI property is 0.02 millirem per hour. This dose rate drops rapidly as the intruder moves away from the ponds. The following are the individual doses from each pathway:

Exposure Pathway	Dose Rate (millirem per hour)
Direct	2.15×10^{-2}
Ingestion of Soil	2.34×10^{-4}
TOTAL - ALL PATHWAYS	2.18×10^{-2}

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[12] "Pica" is defined in the EPA Exposure Factors Handbook as "abnormally high soil ingestion rate" (EPA, 1989). Although abnormal soil ingestion is uncommon, it is included in this analysis in order to interject a measure of conservatism.

APPENDIX D: DOSE RATE TO THE NEAREST OFF-SITE RESIDENT

To determine the maximum possible dose rates for individuals that live in the vicinity of the MEI site, the CAP88-PC computer code was used. The CAP-88 (Clean Air Act Assessment Package-1988) model permits assessments of both collective population dose, and maximally exposed individual dose. CAP88-PC uses a modified Gaussian plume equation to estimate the average dispersion of radionuclides released from up to six sources, which may be either elevated stacks or uniform area sources (EPA, 1992).

The program computes radionuclide concentrations in air, rates of deposition on ground surfaces, concentrations in food, and intake rates by people from ingestion of food produced in the assessment area. Estimates of the radionuclide concentrations in produce, leafy vegetables, milk and meat consumed by humans are made by coupling the output of the atmospheric transport models with the USNRC Regulatory Guide 1.109 terrestrial food chain models. A library of meteorological data for most major cities is supplied with the code. The following assumptions were used as input to the CAP88-PC code for estimating dose rates at various distances away from the MEI sludge ponds:

- Meteorological data from Lakehurst, New Jersey (Lakehurst Airport) were deemed applicable to conditions at Flemington.
- A uniform area source configuration was assumed.
- The area of the three sources of emissions is equivalent to the dimensions of the three sludge ponds (e.g., 680 m^2 for Pond 1-East, and 4080 m^2 for each of Ponds 6-Upper and 6-Lower).
- A momentum plume rise was assumed.
- Agricultural usage fits an "Urban" scenario, meaning that 100% of all vegetables, milk and meat consumed by the off-site residents are produced at home.
- The uranium and thorium daughter concentrations in the release fractions are equal to the parent concentrations of 35.99 pCi/g and 14.23 pCi/g, respectively. These are the mean activity concentrations (wet weight) for all of the ponds combined.

- Assuming a maximum dust loading of 200 micrograms per cubic meter (NCRP, 1987),[13] a mixing height of 10 meters (Till, 1983), and an average annual wind speed of 10.7 miles per hour (Ruffner, 1986), the activity release rate from the site is 3.1×10^{-2} Ci of ^{238}U per year, and 1.2×10^{-2} Ci of ^{232}Th per year.

- The distance to the nearest off-site receptor is 225 meters to the north-northwest of the sludge ponds (O'Brien, 1990).

- Residents spend 24 hours per day, 365 days per year at the off-site location.

- All other input parameters to the CAP88-PC code, including dose conversion factors, were selected from default values.

The maximum possible dose rate calculated by the CAP88-PC code for all pathways is 0.10 millirem per year for the nearest off-site resident. The following are the individual doses from each pathway:

Exposure Pathway	Dose Rate (millirem per year)
Ingestion	1.33×10^{-3}
Inhalation	9.17×10^{-2}
Air Immersion	4.38×10^{-7}
Ground Surface	6.75×10^{-3}
TOTAL - ALL PATHWAYS	1.00×10^{-1}

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[13] This value is clearly conservative since this dust loading value is for dusty operations while the materials contained in the sludge ponds are always in a wet (gel-like) form.

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