RADIOLOGICAL STATUS SURVEY OF THE V-1 POND SITE

MIXED WASTE POND CLOSURE PROJECT

BP CHEMICALS, INC.

LIMA, OHIO

NRC LICENSE NO. SUB-908
DOCKET NO. 040-07604

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1.0 BACKGROUND INFORMATION

As a part of its site-wide decontamination and decommissioning program, BP Chemicals, Inc., is conducting a mixed waste pond closure project at its acrylonitrile production facility in Lima, Ohio. Operating under the U.S. Nuclear Regulatory Commission (NRC) License SUB-908, Docket No. 40-7604, and the Ohio Environmental Protection Agency (OEPA) approved project Closure Plan, BP Chemicals has temporarily relocated mixed chemical and radioactive waste sludge and soils to holding areas on-site, and intends to construct RCRA-designed closure cells, stabilize/solidify the mixed wastes from the holding areas on-site, and place the wastes into the closure cells for permanent disposal.

The mixed waste pond closure project involves four existing surface impoundments, hereinafter called ponds, that contain sludges classified as radioactive and hazardous mixed wastes under the Atomic Energy Act of 1957, as amended, and the Resource Conservation and Recovery Act (RCRA), respectively. The project Closure Plan was developed in accordance with Federal Regulations, Title 10 CFR Part 20.302 and Title 40 CFR Part 265.112, which address closure of radioactive and hazardous waste facilities, and Section 3745-66-12 of the Ohio Administrative Code (OAC), which addresses closure of hazardous waste facilities. The Closure Plan was approved by the OEPA on September 20, 1993.

In accordance with the approved Closure Plan and NRC license SUB-908, one of the four ponds (known as V-1 Pond) has been cleaned of all RCRA and radioactive contamination in preparation for construction of a closure cell. The purpose of this report is to demonstrate that soils remaining in place following excavation at the V-1 Pond site are "clean" when compared to the NRC radioactive material contamination guideline of 35 pCi/g of depleted uranium identified in the NRC Branch Technical Position (Ref. 8). Radiological status of other locations on-site will be addressed in subsequent reports as the closure project continues.

A separate report was prepared to demonstrate the chemical clean-up at the V-1 Pond site. That report was submitted to OEPA, who subsequently released the V-1 Pond site for cell construction on November 29, 1993.

2.0 SITE INFORMATION

2.1 SITE DESCRIPTION

The V-1 Pond is one of four waste ponds on-site that received waste streams from the manufacture of acrylonitrile. An illustration of the site layout is provided in Figure 1, Appendix A. Until 1971, the acrylonitrile manufacturing process also used a catalyst manufactured from depleted uranium. This catalyst is the source of radioactivity in the ponds. The uranium, in the form of uranium oxide, is virtually insoluble.

The four ponds were permitted under the interim status provisions of RCRA and were listed on BP Chemicals 1980 Part A permit application. The ponds were also included in the NRC license granted to BP Chemicals and its predecessor companies for the possession of depleted uranium for use in the catalyst. The ponds, their waste characteristics and site geology and hydrogeology are discussed in detail in the NRC license amendment application submitted by BP Chemicals on February 28, 1992.

2.2 SITE CONDITIONS AT TIME OF FINAL SURVEY

The site of the V-1 Pond has been designated as the location of the first closure cell to be constructed at the plant site.

In order to proceed with the cell construction, the following events, evaluated in the Safety Analysis Report submitted to the NRC on July 10, 1991 (Ref. 1), have been executed:

- The pond water from the V-1 Pond and the Celite Pond was filtered, treated and disposed of in accordance with the conditions of Amendment #6 to the BP Chemicals NRC license SUB-908, dated September 9, 1992;

- Contaminated sludge from the V-1 Pond and the Celite Pond was transferred to the Deepwell Pond on site; and

- Contaminated soil from the V-1 Pond bottom and sidewalls was excavated and temporarily placed in the Celite Pond.

In order to remove the RCRA contamination, soil was excavated to a depth of approximately 12 feet below the pond bottom. The pond contour following this excavation is illustrated in Figure 2, Appendix A.

For this report, the V-1 Pond site subsequent to the contaminated soil excavation, is referred to as the V-1 Pond Survey Unit 1. In accordance with the NRC-approved project soil sampling plan, a comprehensive radiological status survey was performed over the excavation bottom to ensure that no radioactively contaminated material remained in the excavation site. This survey, its results and evaluation are discussed in this report.

Following BP Chemicals' evaluation of the radiological survey of the V-1 Pond Survey Unit 1, a test fill pad was constructed within a portion of Survey Unit 1. The purpose was to demonstrate to the OEPA that the proposed construction methods and in-situ materials would provide the required permeability and compressive strength. Since the OEPA had not yet released the pond bottom, RCRA requirements precluded moving the soil to another area, so the test fill pad had to be constructed within the V-1 Pond excavation.

Initially, soil was excavated from the pond bottom to a depth of approximately 40 inches over an area 80 feet wide by 100 feet long, and the excavated soil was stockpiled within the excavation site. A non-woven geofabric was installed to provide a drainage boundary for the in-situ permeability testing. The test fill pad was then constructed from the stockpiled soil, beginning with a six-inch cushion layer placed immediately above the geofabric, followed by six lifts of soil placed and compacted in six-inch layers over the cushion layer. The construction resulted in a test fill pad approximately 42 inches in height with sloped sides and a top surface area 50 feet wide by 75 feet long.

Because the V-1 Pond had not been released by the NRC prior to undertaking construction of the test fill pad, a supplemental radiological survey was conducted during and after construction of the test fill pad. For this report, the portion of the site upon which the test fill pad was installed including the test fill pad is referred to as the V-1 Pond Survey Unit 2. Eight walk-over surveys to detect gamma radiation exposure within 5 cm of the ground surface and at one meter from the ground surface were performed; after the excavation of the test fill pad site and prior to placing the geonet, after laying the soil cushion layer and after each of the six soil lifts. Soil samples were collected from exposed surfaces and at depths to 48 inches, upon completion of construction of the test fill pad. The V-1 Pond Survey Unit 2 surveys, results and evaluation are discussed in this report.

2.3 IDENTITY OF POTENTIAL CONTAMINANTS AND RELEASE GUIDELINES

Based on the knowledge of site operations and the results of the preliminary assessment and characterization survey the significant radiological contaminants were determined to be depleted uranium. The uranium is depleted in U-234 and U-235, below naturally occurring levels, such that the uranium isotope of concern is U-238, without long-lived daughter products.

In a Branch Technical Position on Disposal of Residual Thorium and Uranium (Ref. 8) the NRC established two guidelines applicable to the release of the V-1 Pond excavation site.

- a maximum soil contamination concentration of 35 pCi/g above background for depleted uranium under Option 1 of the on-site disposal criteria.
- soil contamination should be sufficiently low so that no individual may receive an external dose in excess of 10 microroentgen per hour (μR/hr) above background.

The NRC stated that at this concentration and dose rate level, no further restrictions on land use are needed to meet NRC dose guidelines (Ref. 8).

3.0 FINAL STATUS SURVEY OVERVIEW

Survey planning and procedures were in accordance with the Draft Manual for Conducting Radiological Surveys in Support of License Termination, NUREG/CR-5849 (Ref. 9).

3.1 SURVEY OBJECTIVES

The purpose of the final status survey was to demonstrate that the radiological conditions at the V-1 Pond excavation site satisfy the NRC guidelines and that the pond site can be released from licensing restrictions without controls due to concern for radioactive materials remaining in the ground. Under the NRC license amendment application, this excavation site will become the location of one of the permanent closure cells for the disposal of the site's mixed wastes, so that the area evaluated in this report will be underneath the closure cell designed, installed and maintained to meet regulations of the OEPA.

The specific objectives of the survey were to demonstrate at a 95% minimum confidence level that the following NRC release criteria were achieved:

- Average depleted uranium concentrations in soil are at or below guideline value of 35 pCi/g above background (For land areas, averaging is based on a 100 m^2 (10 m x 10 m) grid area).

- Radionuclide concentrations are sufficiently low so that the external exposure rate does not exceed 10 μR/hr above background, when measured at one meter from the ground surface.

Statistical methods detailed in NUREG/CR-5849 (Ref. 9) will be used to demonstrate that the above conditions have been met.

3.2 ORGANIZATION AND RESPONSIBILITIES

The radiological surveys and sampling were performed by a team composed of personnel from Halliburton NUS Corporation with Dames & Moore providing oversight of the work on behalf of BP Chemicals. Halliburton NUS is currently providing the site remediation construction services and support. Samples were analyzed at the NUS Laboratory in Pittsburgh, PA. Confirmatory analysis of selected samples was performed by ENSECO Labs of Arvada, Colorado and PACE, Inc., Laboratory of Golden, Colorado. Analytical results were reviewed and interpreted for this report by Dames & Moore.

3.3 RADIOLOGICAL SAMPLING PLAN

Procedures for the radiological surveys and soil sampling are briefly described below; further detail on procedures is presented in the NRC-approved project Soil Sampling Plan (Ref. 4).

3.3.1 Plan Overview

The Soil Sampling Plan was comprised of three phases of radiological investigation:

1) Phase I Radiological sampling consisted of a walkover gamma survey to identify areas with readings elevated above background; (elevated areas or "hot spots" are small, isolated locations where radioactivity or radiation is higher than the guideline level).

2) Phase II Radiological sampling involved sampling and analysis of "hot spots", identified in Phase I; and

3) Phase III Radiological sampling consisted of systematic measurement of radiation exposure and collection of surface soil from five locations within each 10 m x 10 m grid of the excavation site, and excavation and resampling where appropriate. Within each grid, four positions were located midway between the grid center and each of the four corners, while the fifth position was at the center of each grid. (See Figure 3, Appendix A).

Phase III sampling was completed when sample results passed the statistical test of significance as outlined in NUREG/CR-5849.

3.3.2 Area Classification

For purposes of establishing the sampling and measurement frequency and pattern, the V-1 Pond excavation site was categorized into affected and/or unaffected areas, using the definitions provided in NUREG/CR-5849 (Ref. 9). The bases for these classifications are:

- Affected Areas. Areas that have potential radioactive contamination (based on plant operating history) or known radioactive contamination (based on past or preliminary radiological surveillance); and

- Unaffected Areas: All areas not classified as affected. These areas are not expected to contain residual radioactivity, based on a knowledge of site history and previous survey information.

For this report the V-1 Pond excavation site was considered an affected area. No areas within the V-1 Pond excavation site were identified as unaffected.

3.3.3 Reference Grids

Grids were established for the purpose of referencing locations of samples and measurements, relative to buildings and other site features. There were no structures or inside surfaces within the V-1 Pond excavation site. Affected outside areas were gridded at 10 m intervals. The grid system is illustrated on Figures 1 and 2 in Appendix A. This grid system is identical to the one used during the characterization survey and the remedial action activities; where necessary the earlier grid was reestablished, expanded, or subdivided.

The facility was divided into "survey units" having common history, contamination potential, or that are naturally distinguishable from other site areas.

For this report, the V-1 Pond excavation site will be discussed as two survey units:

V-1 Pond Survey Unit 1 - this survey unit is comprised of the total excavation site, including side walls and bottom. This area of approximately 60 meters by 100 meters was surveyed, sampled and evaluated upon completion of soil removal and prior to construction of the test fill pad.

V-1 Pond Survey Unit 2 - this survey unit is comprised of the portion of the excavation site upon which the test fill pad was constructed. This area of approximately 80 feet by 100 feet was surveyed and evaluated during the test fill pad construction and was surveyed, sampled and evaluated upon completion of the test fill pad.

The positions of the grid, the sampling locations, and the location of Survey Unit 2 relative to Survey Unit 1 are shown on Figure 3, Appendix A.

3.3.4 Contamination Control During Soil Sample Collection

Proper decontamination practices were employed to prevent cross contamination of samples (e.g., sampling gloves were disposed of after collection of each sample). All sampling equipment was decontaminated prior to use at each radiological sample location and at the conclusion of the sampling program in accordance with the procedures specified in Section 2.0 of the Quality Assurance Project Plan (QAPjP). This section of the QAPjP was revised in July 1993 and is included in Appendix E of this report.

3.4 RADIOLOGICAL SAMPLING AND SURVEYING IN SURVEY UNIT 1

3.4.1 Phase I Radiological Surveying in Survey Unit 1

Upon completion of the chemical sampling program, the Phase I walkover gamma survey of the V-1 Pond bottom was started on July 23, 1993 and was completed on July [illegible], 1993. An Eberline Model ASP-1 (SN 2520) with a SPA-3 probe (2" x 2", sodium iodide detector) was used. The survey consisted of measurements taken within 5 cm (2 in) of the surface during a walkover of the site, covering the total area of the pond excavation (See Figure 4, Appendix A). Measured exposure rates were recorded along each path when there was a change in the observed exposure rate or when the surveyor changed direction. A total of 472 measurements were recorded and no hot spots or regions of unusual radiation exposure were observed.

3.4.2 Phase II Radiological Surveys and Sampling in Survey Unit 1

According to the project Soil Sampling Plan, the collection of Phase II soil samples for U-238 analysis and remedial excavation would have been necessary if hot spots had been identified during the Phase I gamma survey. Since no elevated readings or hot spots were identified, the

Phase III final clearance samples were collected immediately following the analysis of the Phase I radiological survey.

3.4.3 Phase III Systematic Radiological Surveying in Survey Unit 1

Phase III includes a measurement of gamma exposure rate at one meter from the ground surface and a soil sample collection at five positions per grid block. The gamma exposure rate survey was conducted by Halliburton NUS personnel using a Ludlum Survey Meter Model 19 (SN 44610). Measurements were obtained at five positions per 10 m x 10 m grid (as shown on Figure 3, Appendix A) on July 23, 1993 through July 26, 1993. This survey was to assure compliance with the criteria specified in the NRC Branch Technical Position, (Ref. 8) such that concentrations of the remaining radioactive materials are such that no individual may receive an external dose in excess of 10 μR/hr above background.

The collection of the Phase III soil samples started on July 24, 1993 and was completed on July 26, 1993. Halliburton NUS personnel collected 300 radiological samples, five per grid, from the V-1 Pond excavation site. A 1-foot long by 1-inch wide stainless steel chisel was used to excavate to a depth of approximately 6 inches and approximately 1 kg (2.54 pounds) of the excavated material was placed into an appropriately labeled plastic bag at each sampling location within the grid block.

3.5 RADIOLOGICAL SAMPLING AND SURVEYING IN SURVEY UNIT 2

Upon completion and evaluation of the radiological survey of the V-1 Pond Survey Unit 1, the construction of the soil test pad commenced in the excavation site. Surveys were performed in phases as described below, in sequence with the test fill pad construction.

3.5.1 Phase I Radiological Surveying in Survey Unit 2

Eight (8) walkover surveys (Phase I) were performed; one after the excavation; one after laying the cushion layer; and one after each of the six soil lifts, commencing on October 7, 1993, and culminating on October 27, 1993, upon completion of the soil test pad construction.

For the eight (8) Phase I surveys, an Eberline Model ASP-1 (SN 2520) with a SPA-3 probe (2' x 2", sodium iodide detector) was used to measure within 5 cm (2 in) of the surface during a walkover covering the total area of the test fill pad excavation. External gamma radiation exposure rates were recorded along each path when the exposure rate changed or when the surveyor changed direction. Each walkover consisted of 17 to 20 east-west traverses of the site, with 80 to 100 exposure rate observations recorded per survey. Results of each of the walkover surveys are tabulated in Appendix D. No hot spots or regions of unusual radiation exposure were observed.

3.5.2 Phase II Radiological Surveys and Sampling in Survey Unit 2

No hot spots or elevated exposures were observed, so Phase II soil sampling for U-238 analysis and subsequent remediation was omitted.

3.5.3 Phase III Systematic Radiological Surveying in Survey Unit 2

Eight Phase III systematic exposure rate measurement surveys were performed; one after the excavation; one after laying the cushion layer; and one after each of the six soil lifts, during the period October 7 - October 27, 1993.

The eight (8) Phase III systematic radiation surveys were performed by Halliburton NUS personnel using a Ludlum survey meter Model 19 (SN 44610). External dose was measured at one meter above the ground surface level at five locations within each grid, at the center and on each diagonal, between the center and each corner of the grid. These surveys were performed during the test fill pad construction, October 7 to October 27, 1993. Results of each of these systematic exposure rate surveys are tabulated in Appendix D.

For the Phase III systematic exposure rate surveys, the V-1 Pond Survey Unit 2 was re-gridded into 12 grids for ease of data recording and analysis. Eight of the grids were 25 ft x 25 ft (8 m x 8 m), while along the north edge of the test site, the grid size was 25 ft x 30 ft (8 m x 9 m). Drawings indicating the measurement positions and survey grids are provided with the tabulated survey results in Appendix D.

3.5.4 Phase III Systematic Radiological Soil Sampling in Survey Unit 2

Phase III soil sample collection was omitted during construction of the test fill pad, since soil sample collection would have compromised the compaction test.

Upon completion of the test fill pad evaluation, an auger and split spoon were used to obtain samples from the layers of compacted soil. For consistency with the sampling of Survey Unit 1 and to facilitate comparison of results, the boreholes were placed at the positions of the original 10 m x 10 m grid samples of Survey Unit 1, not the 8 m x 8 m grids used for the walkover surveys. At the 26 positions of the original grid residing within the test area, boreholes were extended to a depth of up to 48 inches beneath the elevation of the test fill pad surface, at each of the sampled positions in order to reach the depth of undisturbed soil below the test fill pad.

At each position, samples were obtained from the 40" - 48" depth which represents the undisturbed base upon which the test fill pad was constructed. At each position samples were obtained from the exposed surface layer (at most positions of Survey Unit 2 this was the 0"-6" depth, but on sloping sides of the pad the exposed "surface" was below the top elevation of the pad surface). A random number generator was used to collect samples from intermediate depth soil layers across the test area. Duplicate soil samples were collected from one in every twenty soil samples. These samples were collected by extending the sampling interval to approximately 12 inches, mixing the sample, splitting the sample in half and placing each half into a separate plastic sample bag. A total of 78 soil samples were collected from the 26 bore holes during the period December 10-11, 1993. The locations and depths sampled are identified in Table C-2, Appendix C.

3.6 BACKGROUND LEVEL DETERMINATIONS

3.6.1 Exposure Rate

An evaluation of ambient radiation exposure is performed at the Lima, Ohio site approximately three times per week as part of the Halliburton NUS Health and Safety Plan. Using a Ludlum "micro-R" Survey Meter Model 19, with a 1" x 1" sodium iodide scintillator, measurements of exposure rate are recorded at 40 to 50 sites around the perimeter and outside of radiologically controlled areas. Through two years of site operations, it has been shown that nominal background exposure rate is 2 μR/hr.

3.6.2 Soil Radioactivity

An evaluation of ambient levels of radioactivity in the soil in the vicinity of the BP Chemical Plant in Lima, Ohio was performed on May 5, 1993 from three borings located on BP Refinery property, approximately 1-mile south of the Mixed Waste Pond Closure Project site. This area was accepted by the OEPA as representative of the matrix of interest, i.e., soil similar to that in the vicinity of the Mixed Waste Pond Closure site, yet far enough removed from the site so as to be unaffected by contaminant migration. In each borehole four (4) samples were collected representing soil from depths of 0-9 inches, 18-27 inches, 42-51 inches and 60-66 inches.

The twelve soil samples were analyzed for U-238 by gamma spectroscopy by the NUS Laboratory in Pittsburgh, PA. Results of the analysis indicated that the soil activity of U-238 ranged from 1.7 +/- 1.6 pCi/g to 3.9 +/- 0.9 pCi/g (reported by the laboratory with the "two sigma" uncertainty) with a mean value of 2.6 pCi/g and a standard deviation of 0.7 pCi/g. This activity is considerably less than the NRC clean-up guideline of 35 pCi/g of depleted uranium and is comparable to the naturally occurring uranium concentration in igneous rock (1.3 pCi/g), identified by the NRC in the Branch Technical Position (Ref. 9). The background soil sample results are tabulated in Table C-6, Appendix C.

3.7 SAMPLE ANALYSIS

The 378 soil samples collected for the Phase III surveys in both Survey Units 1 and 2 were prepared in accordance with Section 5 of the Laboratory Procedures Manual for the ORAU Environmental Survey and Site Assessment Program, and were analyzed by NUS Laboratory for U-238 using gamma spectroscopy per Section 16 of the ORAU procedures. Results of the analysis were reported by the laboratory in units of pCi/g of U-238 to facilitate comparison to the guideline.

Paragraph 7.2 of NUREG/CR-5849 (Ref.9) states that analytical methods should be capable of measuring levels below the established release guidelines, and detection sensitivities of 10 to 25% of the guideline should be the target.

- For Survey Unit 1, the laboratory analysis was performed to achieve a minimum detectable activity (MDA) for U-238 in soil of 9 pCi/g (25% of 35 pCi/g), to follow the guidance in NUREG/CR-5849.

- For Survey Unit 2, the laboratory analysis was adjusted to achieve an even lower MDA of 3 pCi/g, based on the low activities observed in the analysis of Survey Unit 1 samples.

Six soil samples containing detectable amounts of U-238 above the MDA were further analyzed for isotopic uranium content by alpha spectroscopy, in order to establish the ratios of U-234, U-235 and U-238. These results would allow the distinction between naturally occurring uranium and depleted uranium contaminant.

Soil samples were also submitted to other laboratories in compliance with the Project's Quality Assurance Project Plan. Thirty of the 300 soil samples (10%) from Survey Unit 1 were sent to an independent laboratory (ENSECO, Inc.) for confirmatory U-238 analysis by gamma spectroscopy. Three of the six isotopic analysis samples (50%) were sent to an independent laboratory (PACE, Inc.) for confirmatory isotopic analysis by alpha spectroscopy.

3.8 DATA INTERPRETATION

Data conversions and evaluations were performed, following the guidance in Chapter 8, NUREG/CR-5849 (Ref. 9). Calculation equations from NUREG/CR-5849 used in the interpretation of the V-1 Pond data are provided in Appendix B of this report. Measurement data are reported in units of pCi/g (soil activity concentrations) or μR/hr (dose rate) for comparison with guidelines.

- Soil radionuclide concentration levels in individual grids were compared with "elevated area" criteria. (In accordance with NUREG/CR-5849 (Ref 9), areas of residual activity exceeding the guideline value, known as elevated areas, may be acceptable, provided they do not exceed the guideline value by greater than a factor of $(100/A)^{1/2}$, where A is the area of residual activity in m^2, and provided the activity level at any location does not exceed three times the guideline value.)

- Average values of dose rate or soil activity for survey units were determined and compared with guideline levels.

- Data for each survey unit were tested to demonstrate that at the 95% confidence level the dose rate or the activity concentration meets the appropriate cleanup guideline.

3.9 RECORDS

All sample analysis results and original survey data have been archived at the BP Chemicals offices and will be held until such time as authorized by the NRC for disposal.

4.0 SURVEY FINDINGS, RESULTS AND EVALUATIONS

Results of the laboratory analysis of soil samples are provided in Tables in Appendix C. Data interpretations and comparisons with guidelines and survey objectives are discussed below.

4.1 RADIOLOGICAL SAMPLING IN V-1 POND SURVEY UNIT 1

4.1.1 Phase I Radiological Soil Survey

During the walkover survey of the V-1 Pond excavation site, 472 measurements within 5 cm (2 in) of the ground surface were recorded at locations when the exposure rate changed or when the surveyor changed directions of walking (See Figure 4, Appendix A). Observed measurements fluctuated from 2800 cpm to 6400 cpm (or 3 μR/hr to 7 μR/hr using the instrument calibration factor of 92000 cpm = 100 μR/hr). These are instrument response indications uncorrected for the background response of 1800 cpm (2 μR/hr) recorded outside the perimeter of the worksite in an unrestricted area. No elevated areas were observed during the Phase I walkover survey.

4.1.2 Phase II Radiological Soil Sampling, Analysis and Excavation

Since no elevated readings, i.e., hot spots, were identified in the Phase I survey, no analysis of soil hot spots was necessary.

4.1.3 Phase III Systematic Exposure Rate Survey

Radiation exposure rates were measured at five positions per grid across the entire survey unit. Observed exposure rates fluctuated from 2 μR/hr to 6 μR/hr at locations in the excavation site. The five exposure rate observations in each grid were averaged to obtain the mean exposure rate for the grid and then the sixty grid averages were averaged to obtain an average exposure rate for the survey unit as a whole. This resulted in an average exposure rate at one meter from the surface of 4.3 μR/hr and a standard deviation of 1.1 μR/hr for Survey Unit 1. The 95% confidence parameter was calculated using the average activities of the sixty grid blocks, as listed in Table C-1, and the methods of Sections 8.5.4 and 8.5.5, NUREG/CR-5849, yielding a theoretical upper bound of 4.38 μR/hr on the exposure rate. These are instrument response indications uncorrected for the background response of 2 μR/hr recorded outside the perimeter of the worksite in an unrestricted area.

No elevated areas of radiation exposure were observed during the Phase III exposure rate survey. At no location did the exposure rate exceed the NRC guideline level of 10 μR/hr above background.

Exposure rate measurements were performed as planned, except that the readings at four locations along a steep embankment at the deepest portion of the excavation were not measured (6+7, K+L C; 6+7, K+L SE; 7+8, K+L SW; and 7+8, K+L SE). At these positions the slope was so steep that when the radiation detector was placed one meter vertically from the surface, it was less than two feet horizontally from the sloped surface, so that the readings would not have been comparable to those at other positions in the survey unit. Subsequent analysis of Phase III surface soil samples at these four locations indicated no unusual radioactivity (see Table C-1).

The statistical analysis of the Phase III exposure rate survey indicates:

number of measurements	=	296
max exposure rate (gross)	=	6 μR/hr
min exposure rate (gross)	=	2 μR/hr
mean exposure rate (gross)	=	4.3 μR/hr
standard deviation	=	1.1 μR/hr
95% upper bound (theory)	=	4.38 μR/hr
background exposure rate	=	2 μR/hr
NRC clearance guideline	=	10 μR/hr, above background

The guideline from the NRC Branch Technical Position (Ref. 8) states that external exposure measured at one meter from the surface shall not exceed 10 μR/hr above background. The statistical analysis performed here demonstrates that at a 95 % confidence level, the true average exposure rate for Survey Unit 1 is 4.38 μR/hr, or 2.38 μR/hr above background. Thus, the exposure rate guideline has been met at the 95% confidence level.

4.1.4 Phase III Systematic Surface Soil Sampling

The systematic soil sampling consisted of 300 separate soil samples (60 grids with 5 samples per grid). The results tabulated in Table C-1, Appendix C, indicate that only 16 samples had a positive detection of uranium, while 284 samples (95%) were reported as less than the minimum detectable activity of the analytical procedure. Three of the 300 samples (1%) were reported by NUS Laboratory with an MDA that exceeded the requested sensitivity level of 9 pCi/g (25% of the 35 pCi/g guideline).

The guideline of NUREG/CR-5849 states that additional remediation must be conducted in any area when the sample result is greater than three times the clean-up guideline. No sample in this survey exceeded this value, thus no subsequent remediation was performed.

The guideline of NUREG/CR-5849 states that when the concentration result exceeds the guideline, but is less than three times the guideline, the area-weighted average of elevated activity must be considered when calculating the grid average concentration. No sample in this survey exceeded the guideline, thus the area-weighted average technique was not considered.

The activity of the five soil samples from each grid were averaged to obtain a group mean activity. The group mean activity was calculated using reported activities and reported MDA values as if they were actual observed values. The group mean activities and uncertainties are shown in Table C-1 for each of the sixty 10 m x 10 m grids. The average U-238 activity in the soil for the survey unit was 6.8 pCi/g with a standard deviation of 0.63 pCi/g. The 95% confidence level parameter was calculated using the average activities of the sixty grid blocks, as listed in Table C-1, and the methods of Sections 8.5.4 and 8.5.5, NUREG/CR-5849, yielding an upper bound of 6.84 pCi/g on the soil activity concentration. This value is uncorrected for the site background activity due to naturally occurring uranium, which is 2.6 pCi/g with a standard deviation of 0.7 pCi/g, paragraph 3.5, above.

The statistical analysis of the Phase III radiological soil sampling indicates:

number of measurements	=	300
max concentration (gross)	=	< 10 pCi/g
min concentration (gross)	=	3.3 pCi/g
mean concentration (gross)	=	6.8 pCi/g
standard deviation	=	0.63 pCi/g
95% upper bound (theory)	=	6.9 pCi/g

background concentration = 2.6 pCi/g

NRC clearance guideline = 35 pCi/g, above background

The survey unit average soil activity data was interpreted using the methods of Section 8.5.5, NUREG/CR-5849, in order to test the data against the NRC guideline value of 35 pCi/g above background. The statistical analysis performed here demonstrates the 95% upper bound on the average activity of U-238 was found to be 6.9 pCi/g, or 4.3 pCi/g above background. Thus the contaminant level guideline has been met at the 95% confidence level.

4.2 RADIOLOGICAL SAMPLING IN V-1 POND SURVEY UNIT 2

4.2.1 Phase I Radiological Soil Exposure Rate Surveys

During eight walkover surveys performed during the test fill pad construction, 595 measurements within 5 cm (2 in) of the ground surface were recorded at locations when the observed exposure rate changed or when the surveyor changed direction of walking (See tabulated results in Appendix D). Observed measurements fluctuated from 4800 cpm to 7300 cpm (5.3 μR/hr to 8.1 μR/hr using the instrument calibration factor of 92000 cpm = 100 μR/hr). These are instrument response indications uncorrected for the background response of 1900 cpm (2 μR/hr) recorded outside the perimeter of the worksite in an unrestricted area. No hot spots or regions of unusually elevated radiation exposure were observed during the Phase I walkover surveys.

4.2.2 Phase II Radiological Soil Sampling, Analysis and Excavation

Since no elevated readings were identified in the Phase I survey, no analysis of elevated areas was necessary.

4.2.3 Phase III Systematic Exposure Rate Surveys

In each of eight systematic exposure rate surveys, the radiation exposure rate was measured at one meter from the ground surface at 60 locations across the test fill pad. (See tabulated results in Appendix D). Observed exposure rates were consistent in each of the surveys, fluctuating only between 6 μR/hr and 7 μR/hr. These are instrument response indications uncorrected for the background response of 2 μR/hr recorded outside the perimeter of the worksite in an unrestricted area.

At no location did the exposure rate exceed the NRC guideline level of 10 μR/hr above background.

4.2.4 Phase III Systematic Soil Sampling

The systematic soil sampling in Survey Unit 2 consisted of 78 separate soil samples, collected at 26 grid locations and three depths per location (from the surface, from the depth of undisturbed soil below the test fill pad, and at an intermediate depth). The results of the analysis, listed in Table C-2, Appendix C, indicate the presence of a very small radioactivity (U-238) concentration. The observed radioactivity (U-238) concentration in the soil ranged from 1.4 ± 1.1 pCi/g to 3.0 ± 1.6 pCi/g. At each of the 26 locations sampled, the soil radioactivity (U-238) concentration following the soil pad test was equal to or less than the activity observed before the soil was disrupted by the soil pad test. At none of the locations sampled was any activity observed that would negate the analysis and conclusions of the Survey Unit 1 analysis.

The guideline of NUREG/CR-5849 states that additional remediation must be conducted in any area when the sample result is greater than three times the clean-up guideline. No sample in this survey exceeded this value, thus no subsequent remediation was performed.

The guideline of NUREG/CR-5849 states that when the sample activity concentration exceeds the guideline, but is less than three times the guideline, the area-weighted average of elevated activity must be considered. No sample in this survey exceeded the guideline, thus the area-weighted average technique was not considered.

Survey Unit 2 consisted of an approximately 80 ft x 100 ft area that overlapped portions of nine of the 10 m x 10 m grids in the V-1 Pond excavation site (See Figure 3, Appendix A). For consistency with the sampling of Survey Unit 1 and to facilitate comparison of results, the samples were collected at the positions of the original 10 m x 10 m grid sampling positions of Survey Unit 1. Thus not all grids had the same number of samples collected; sample locations ranged from one to five per grid. This enhanced the ability to compare samples location by location between the two sampling surveys, but it rendered the results in Survey Unit 2 inconsistent with performing the grid-based statistical analysis on the results that was performed in Survey Unit 1. Instead, the soil samples in Survey Unit 2 were analyzed by considering the samples from the same depth as a group for statistical comparison.

For the 26 soil samples collected from the surface layer, the average activity of U-238 was found to be 2.1 pCi/g, with a standard deviation of 0.55 pCi/g. The 95% confidence level upper bound was calculated using the methods of Section 8.5.4 and 8.5.5, NUREG/CR-5849, yielding an upper bound of 2.55 pCi/g on the soil activity concentration. This value is uncorrected for the site background activity due to naturally occurring uranium, which is 2.6 pCi/g with a standard deviation of 0.7 pCi/g, paragraph 3.5, above.

For the 26 soil samples collected from the depth undisturbed by excavation (42-48 inches), the average activity was found to be 2.1 pCi/g, with a standard deviation of 0.53 pCi/g. The 95% confidence level upper bound was calculated, yielding an upper bound of 2.54 pCi/g on the soil activity concentration. This value is uncorrected for site background activity due to naturally occurring uranium, which is 2.6 pCi/g with a standard deviation of 0.7 pCi/g, paragraph 3.5, above.

These statistical analyses demonstrate that at a 95% confidence level, the soil activity is less than or equal to the background soil activity due to natural uranium. This is considerably below the NRC guideline of 35 pCi/g above background, so that the contaminant level guideline has been met at the 95% confidence level.

4.3 SPECIAL ANALYSIS

Six soil samples from the Phase III survey of Survey Unit 1 were subjected to additional analysis by alpha spectroscopy, in an attempt to identify isotopic ratios of uranium in the soil. The results of the analysis are provided in Table C-3. The uranium activity in the soil was very small, yet the approximately equal activities of U-238 and U-234 indicated that the activity observed is naturally occurring uranium, rather than residual depleted uranium from licensed activities.

4.4 INTER-LABORATORY COMPARISONS

Selected soil samples from the Phase III sampling of Survey Unit 1 were sent to two separate, independent laboratories for comparative analysis as a quality check on the primary analysis laboratory.

Thirty soil samples were submitted to ENSECO-Rocky Mountain Analytical Laboratory, Arvada, CO. These samples were analyzed by gamma spectroscopy for U-238 activity and results were reported in units of pCi/g (Ref. 5). The analysis results from the ENSECO and NUS laboratories are summarized in Table C-4. The tabulated activities are as reported by the laboratories and have not been corrected for site background. A comparison of the two laboratories' reported sample activities at each position indicates consistent low activity levels reported by each laboratory, although ENSECO used a longer analysis procedure resulting in a lower MDA.

Three of the six samples discussed in paragraph 4.3, above, were submitted to PACE, Inc., Golden, CO. These samples were analyzed for isotopic uranium identification by alpha spectroscopy and results were reported in units of pCi/g (Ref. 7). The analysis results reported by the NUS and PACE laboratories are summarized in Table C-5. The tabulated activities are as reported by the laboratories and have not been corrected for site background. A comparison of the reported isotopic activities indicates consistent isotopic ratios by each laboratory supporting the conclusion that observed U-238 is in equilibrium with U-234 (i.e., naturally occurring uranium in equilibrium with long-lived decay products) and not due to residual depleted uranium from licensed activities. This isotopic analysis indicates that the observed activity was natural uranium and not depleted uranium. Thus, it is not appropriate to identify the observed activity as a "contaminant level".

5.0 SUMMARY

The final radiological status survey of the V-1 Pond Excavation Site demonstrates that the decontamination efforts have been effective in reducing residual activity, and that the site meets the NRC limits for release for unrestricted use, in compliance with the guidelines of Option 1 of the NRC Branch Technical Position on the disposal of uranium and thorium (Ref. 8).

6.0 REFERENCES

1. Dames & Moore, Inc. "Safety Analysis Report: Inter-pond Sludge and Contaminated Soil Mobilization, Mixed Waste Pond Closure Project, BP Chemicals, Lima, Ohio," July, 1991.

2. Dames & Moore, Inc. "Closure Plan: Mixed Waste Pond Closure Project, BP Chemicals, Lima, Ohio," January 1992.

3. Dames & Moore, Inc. "Work Plan, Background Soil Survey, Mixed Waste Pond Closure Project, BP Chemicals, Lima, Ohio," April, 1993.

4. Dames & Moore, Inc. "Soil Sampling Plan. Mixed Waste Pond Closure Project, BP Chemicals, Lima, Ohio," July, 1993.

5. ENSECO-Rocky Mountain Analytical Laboratory. "Analytical Results for BP Chemicals, ENSECO-RMAL No. 031242," September 24, 1993.

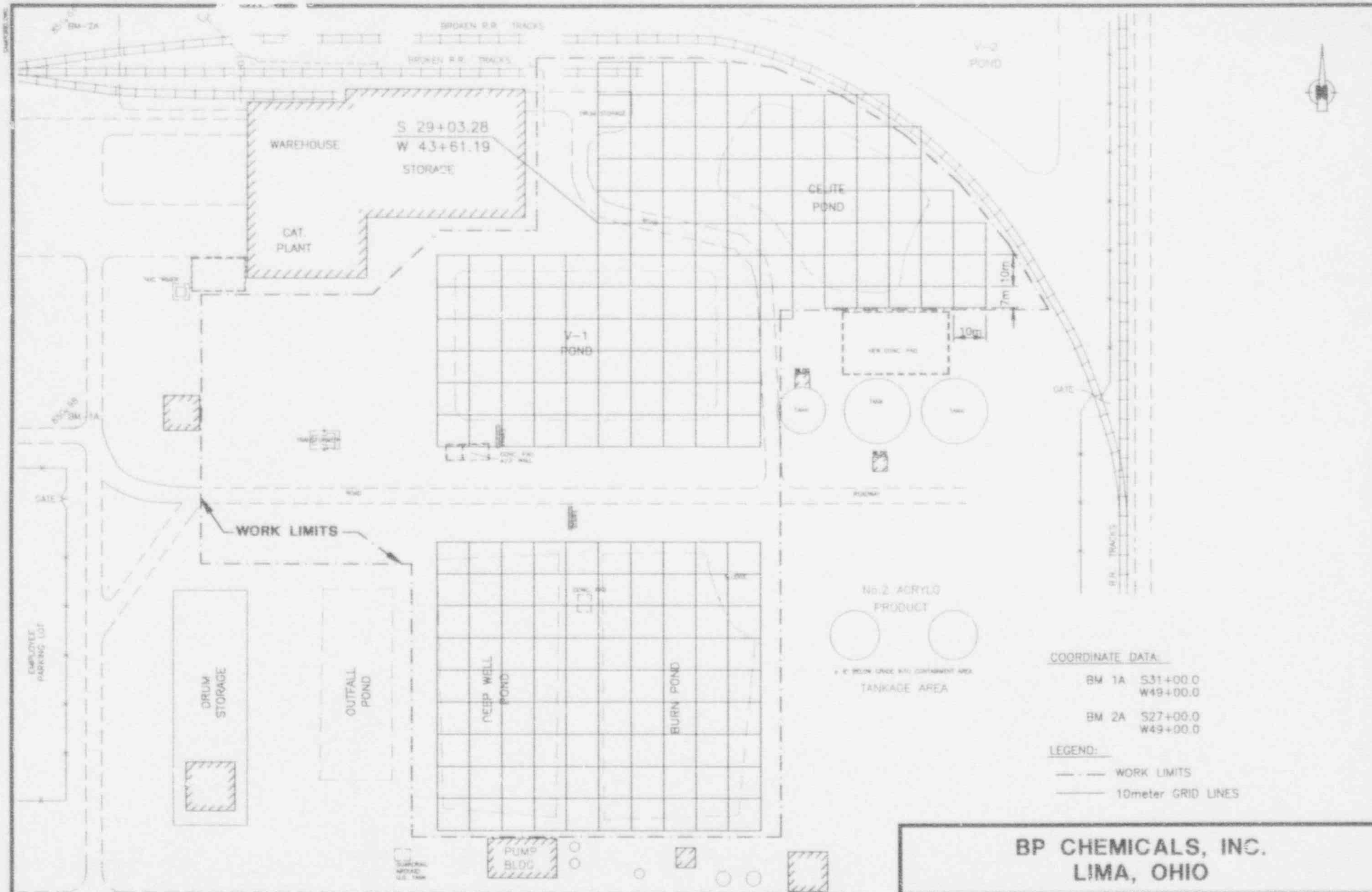
6. Halliburton NUS Corporation, NUS Laboratory. "Analytical Results for Radio Chemistry, V-1 Pond Closure Event," September 2, 1993.

7. Pace, Inc. "Pace Project No. D30812.502, RADCHEM ANALYSIS," September 29, 1993.

8. U.S. Nuclear Regulatory Commission. "Branch Technical Position on the Disposal of Residual Thorium or Uranium (46 Fed Reg 52061)," October, 1981.

9. U.S. Nuclear Regulatory Commission. "Manual for Conducting Radiological Surveys in Support of License Termination (NUREG/CR-5849)," June, 1992.

APPENDIX A
Drawings



NOTES:

1. TYPICAL GRID SPACING IS 10 SQ. METERS UNLESS OTHER WISE NOTED.
2. SAMPLING GRID IN THE AREA OF THE DEEP WELL & BURN POND NOT ESTABLISHED AS OF 7/92.

0 30 60 120 180 FT
GRAPHIC SCALE

BP CHEMICALS, INC.
LIMA, OHIO

FIGURE 1

POND AREAS SHOWING 10 METER SAMPLING GRID

DAMES & MOORE

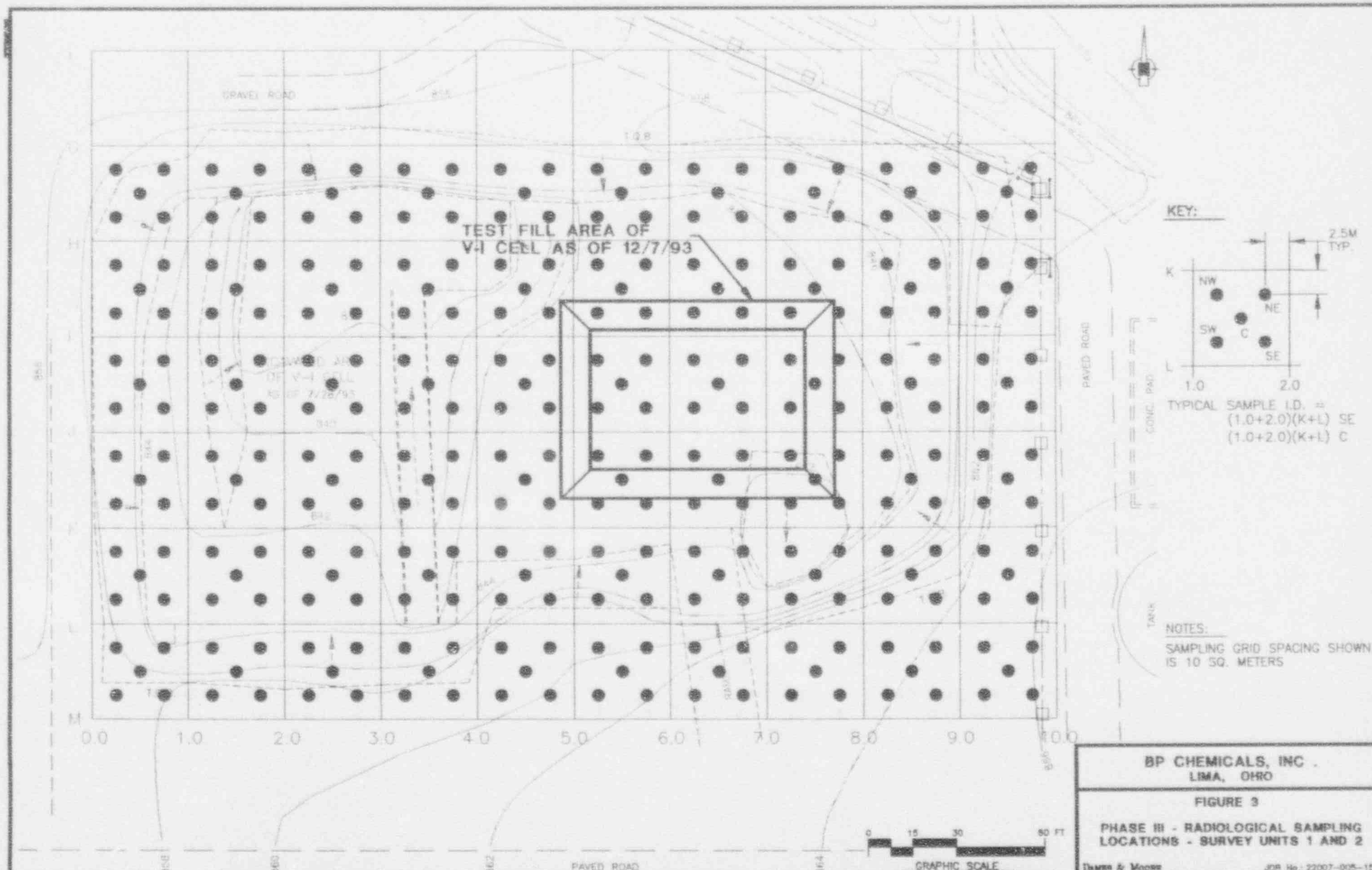
JOB No.: 22007-005-152

BP CHEMICALS, INC .
LIMA, OHIO

FIGURE 2
V-I POND EXCAVATION SITE
AS OF JULY 23, 1993
SURVEY UNIT 1

Dames & Moore

JOB No.: 22007-005-132



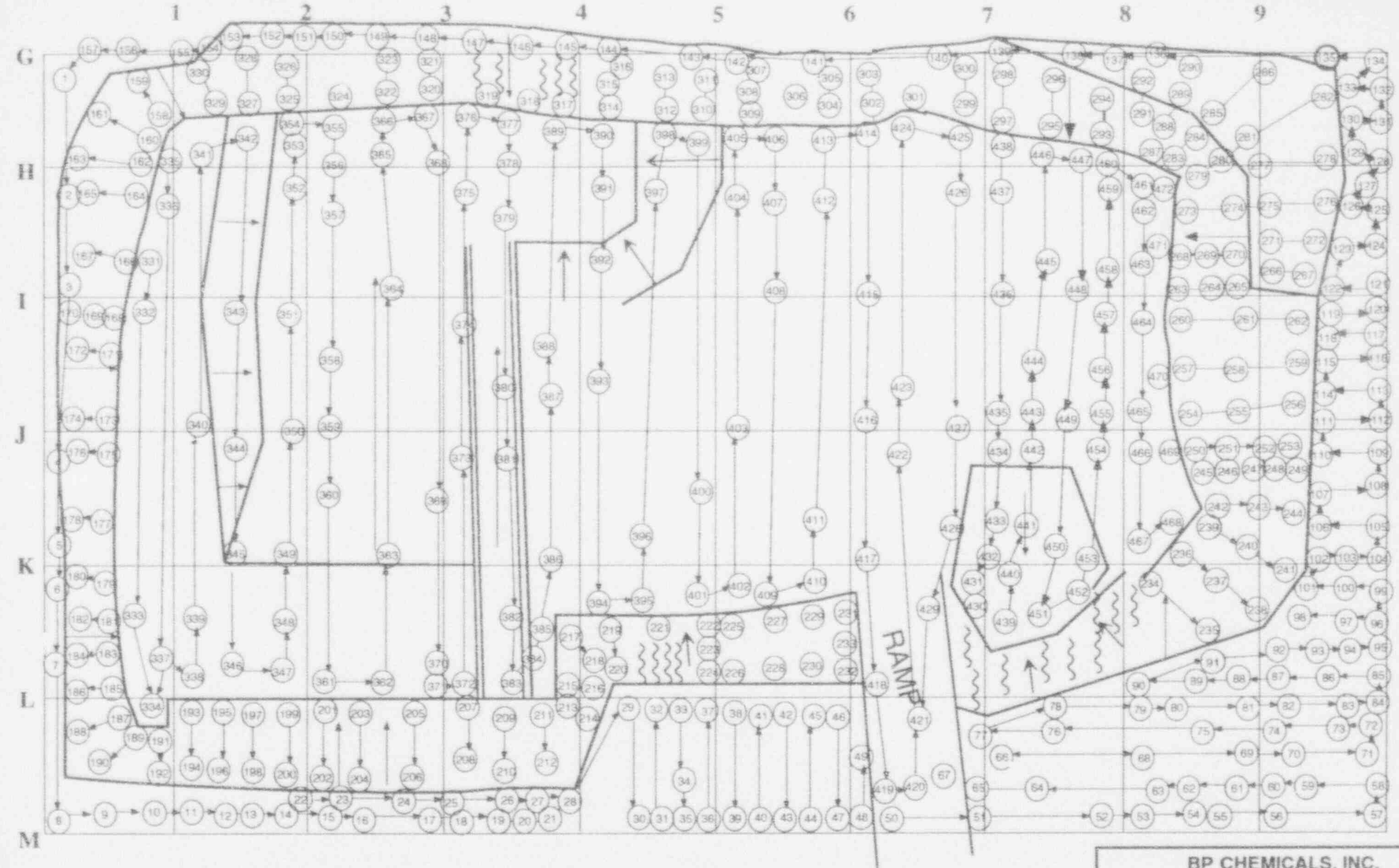
BP CHEMICALS, INC.
LIMA, OHIO

FIGURE 3

PHASE III - RADIOLOGICAL SAMPLING LOCATIONS - SURVEY UNITS 1 AND 2

DAMES & MOORE

JOB No.: 22007-005-152



0 15 30 60 ft

Graphic Scale

BP CHEMICALS, INC.
LIMA, OHIO

FIGURE 4

TRACE OF PHASE I RADIOLOGICAL SURVEY
SURVEY UNIT 1
V-1 POND EXCAVATION SITE

Dames & Moore

JOB No. 22007-005-152

APPENDIX B
Calculation Equations

APPENDIX B

CALCULATION EQUATIONS

The mean activity concentration (x_g) is calculated for each grid area using the number (n) of readings for each grid (x_{gi}) and equation 8-11 from NUREG/CR 5849:

$$\overline{x_g} = \frac{1}{n} \sum_{i=1}^{n} x_{gi}$$

The mean activity concentration for the survey unit (X) is calculated using the same equation by summing the grid means (x_g) over the number (N) of separate grid area elements.

$$X = \frac{1}{N} \sum_{g=1}^{N} \overline{x_g}$$

Uncertainties are calculated for each group and for the mean activity of all the groups to allow comparison with guideline values and conditions. NUREG/CR 5849 equation 8-12 is used to calculate the grid area standard deviation (sd_g) and the survey unit standard deviation (SD).

$$sd_g = \sqrt{\frac{\sum_{i=1}^{n} (\overline{x_g} - x_{gi})^2}{n-1}} \quad ; \quad SD = \sqrt{\frac{\sum_{g=1}^{N} (X - x_g)^2}{N-1}}$$

Equation 8-13 is used to determine a 95% confidence level upper bound on the mean activity of either the grid area group or the overall survey unit activity upper bound.

$$\mu_\alpha = X + t_{1-\alpha,df} \frac{SD}{\sqrt{N}}$$

Where:

$$t_{1-\alpha,\, df}$$

is the 95% confidence level coefficient obtained from NUREG/CR 5849 Appendix B.

and

$$t_{1-\alpha,df} \frac{sd_g}{\sqrt{n}}$$

is the 95% cofidence level parameter for each grid shown in Table C-1.

APPENDIX C
Tables of Data Results

Table C-1

Results of Gamma Spectroscopy Analysis of Phase III Systematic Soil Samples in Survey Unit 1 (Page 1 of 13)

NUS Sample Number	Sample Location in Grid	U-238 Concentration in pCi/g			Mean Activity pCi/g	Standard Deviation pCi/g
		Activity	Uncertainty*	MDA*		
P0243433	0+1, G+H C	<MDA	NA	8		
P0243691	0+1, G+H NE	<MDA	NA	8		
P0243292	0+1, G+H NW	<MDA	NA	5		
P0243616	0+1, G+H SE	<MDA	NA	8		
P0243635	0+1, G+H SW	<MDA	NA	8	7.4	1.3
P0243682	0+1, H+I C	<MDA	NA	7		
P0243639	0+1, H+I NE	<MDA	NA	8		
P0243617	0+1, H+I NW	<MDA	NA	7		
P0243261	0+1, H+I SE	<MDA	NA	8		
P0243721	0+1, H+I SW	<MDA	NA	5	7.0	1.2
P0243720	0+1, I+J C	<MDA	NA	7		
P0243677	0+1, I+J NE	<MDA	NA	8		
P0243270	0+1, I+J NW	<MDA	NA	8		
P0243722	0+1, I+J SE	<MDA	NA	6		
P0243345	0+1, I+J SW	<MDA	NA	5	6.8	1.3
P0243679	0+1, J+K C	<MDA	NA	7		
P0243262	0+1, J+K NE	<MDA	NA	5		
P0243279	0+1, J+K NW	<MDA	NA	5		
P0243614	0+1, J+K SE	<MDA	NA	7		
P0243675	0+1, J+K SW	<MDA	NA	8	6.4	1.3
P0243300	0+1, K+L C	<MDA	NA	6		
P0243275	0+1, K+L NE	<MDA	NA	6		
P0243647	0+1, K+L NW	<MDA	NA	7		
P0243406	0+1, K+L SE	<MDA	NA	6		
P0243297	0+1, K+L SW	<MDA	NA	6	6.2	0.4

* Note: Laboratories did not report an MDA when a positive activity was reported. The reported uncertainties are the "2 sigma" counting statistic uncertainties.

Table C-1

Results of Gamma Spectroscopy Analysis of Phase III Systematic Soil Samples in Survey Unit 1
(Page 2 of 13)

NUS Sample Number	Sample Location in Grid	U-238 Concentration in pCi/g			Mean Activity pCi/g	Standard Deviation pCi/g
		Activity	Uncertainty*	MDA*		
P0243674	0+1, L+M C	<MDA	NA	7		
P0243393	0+1, L+M NE	<MDA	NA	7		
P0243672	0+1, L+M NW	<MDA	NA	9		
P0243284	0+1, L+M SE	<MDA	NA	8		
P0243662	0+1, L+M SW	<MDA	NA	7	7.6	0.9
P0243460	1+2, G+H C	<MDA	NA	8		
P0243649	1+2, G+H NE	<MDA	NA	6		
P0243363	1+2, G+H NW	<MDA	NA	8		
P0243615	1+2, G+H SE	<MDA	NA	7		
P0243272	1+2, G+H SW	<MDA	NA	7	7.2	0.8
P0243405	1+2, H+I C	<MDA	NA	7		
P0243663	1+2, H+I NE	<MDA	NA	6		
P0243642	1+2, H+I NW	<MDA	NA	6		
P0243354	1+2, H+I SE	<MDA	NA	6		
P0243317	1+2, H+I SW	<MDA	NA	6	6.2	0.4
P0243404	1+2, I+J C	<MDA	NA	6		
PO243341	1+2, I+J NE	<MDA	NA	7		
P0243371	1+2, I+J NW	<MDA	NA	6		
P0243666	1+2, I+J SE	<MDA	NA	10		
P0243718	1+2, I+J SW	<MDA	NA	6	7.0	1.7
P0243403	1+2, J+K C	<MDA	NA	8		
P0243386	1+2, J+K NE	<MDA	NA	8		
P0243314	1+2, J+K NW	<MDA	NA	5		
P0243311	1+2, J+K SE	<MDA	NA	8		
P0243402	1+2, J+K SW	<MDA	NA	6	7.0	1.4

* Note: Laboratories did not report an MDA when a positive activity was reported. The reported uncertainties are the "2 sigma" counting statistic uncertainties.

Table C-1

Results of Gamma Spectroscopy Analysis of Phase III Systematic Soil Samples in Survey Unit 1

NUS Sample Number	Sample Location in Grid	U-238 Concentration in pCi/g			Mean Activity pCi/g	Standard Deviation pCi/g
		Activity	Uncertainty*	MDA*		
P0243664	1+2, K+L C	<MDA	NA	9		
P0243661	1+2, K+L NE	<MDA	NA	7		
P0243308	1+2, K+L NW	<MDA	NA	6		
P0243394	1+2, K+L SE	<MDA	NA	7		
P0243305	1+2, K+L SW	<MDA	NA	8	7.4	1.1
P0243309	1+2, L+M C	<MDA	NA	7		
P0243619	1+2, L+M NE	<MDA	NA	7		
P0243287	1+2, L+M NW	<MDA	NA	7		
P0243304	1+2, L+M SE	<MDA	NA	6		
P0243313	1+2, L+M SW	<MDA	NA	8	7.0	0.7
P0243336	2+3, G+H C	<MDA	NA	9		
P0243337	2+3, G+H NE	<MDA	NA	6		
P0243338	2+3, G+H NW	<MDA	NA	9		
P0243277	2+3, G+H SE	<MDA	NA	6		
P0243283	2+3, G+H SW	<MDA	NA	7	7.4	1.4
P0243628	2+3, H+I C	<MDA	NA	7		
P0243446	2+3, H+I NE	<MDA	NA	7		
P0243671	2+3, H+I NW	<MDA	NA	8		
P0243725	2+3, H+I SE	<MDA	NA	6		
P0243349	2+3, H+I SW	<MDA	NA	6	6.8	0.8
P0243621	2+3, I+J C	<MDA	NA	9		
P0243362	2+3, I+J NE	<MDA	NA	8		
P0243343	2+3, I+J NW	<MDA	NA	6		
P0243360	2+3, I+J SE	<MDA	NA	7		
P0243723	2+3, I+J SW	<MDA	NA	6	7.2	1.2

* Note: Laboratories did not report an MDA when a positive activity was reported. The reported uncertainties are the "2 sigma" counting statistic uncertainties.

Table C-1

Results of Gamma Spectroscopy Analysis of Phase III Systematic Soil Samples in Survey Unit 1 (Page 4 of 13)

NUS Sample Number	Sample Location in Grid	U-238 Concentration in pCi/g			Mean Activity pCi/g	Standard Deviation pCi/g
		Activity	Uncertainty*	MDA*		
P0243717	2+3, J+K C	<MDA	NA	7		
P0243355	2+3, J+K NE	<MDA	NA	7		
P0243331	2+3, J+K NW	<MDA	NA	8		
P0243339	2+3, J+K SE	<MDA	NA	9		
P0243432	2+3, J+K SW	<MDA	NA	7	7.6	0.9
P0243303	2+3, K+L C	<MDA	NA	6		
P0243350	2+3, K+L NE	<MDA	NA	8		
P0243651	2+3, K+L NW	<MDA	NA	9		
P0243329	2+3, K+L SE	<MDA	NA	8		
P0243316	2+3, K+L SW	<MDA	NA	7	7.6	1.1
P0243348	2+3, L+M C	<MDA	NA	7		
P0243342	2+3, L+M NE	<MDA	NA	6		
P0243431	2+3, L+M NW	<MDA	NA	6		
P0243714	2+3, L+M SE	<MDA	NA	7		
P0243356	2+3, L+M SW	<MDA	NA	9	7.0	1.2
P0243347	3+4, G+H C	<MDA	NA	7		
P0243344	3+4, G+H SE	<MDA	NA	7		
P0243390	3+4, G+H NE	<MDA	NA	5		
P0243622	3+4, G+H NW	<MDA	NA	6		
P0243330	3+4, G+H SW	<MDA	NA	8	6.6	1.1
P0243266	3+4, H+I C	<MDA	NA	6		
P0243366	3+4, H+I NE	<MDA	NA	5		
P0243364	3+4, H+I NW	<MDA	NA	6		
P0243624	3+4, H+I SE	<MDA	NA	7		
P0243263	3+4, H+I SW	<MDA	NA	7	6.2	0.8

* Note: Laboratories did not report an MDA when a positive activity was reported.
The reported uncertainties are the "2 sigma" counting statistic uncertainties.

Table C-1

Results of Gamma Spectroscopy Analysis of Phase III Systematic Soil Samples in Survey Unit 1
(Page 5 of 13)

NUS Sample Number	Sample Location in Grid	U-238 Concentration in pCi/g			Mean Activity pCi/g	Standard Deviation pCi/g
		Activity	Uncertainty*	MDA*		
P0243346	3+4, I+J C	<MDA	NA	5		
P0243291	3+4, I+J NE	<MDA	NA	8		
P0243357	3+4, I+J NW	5.2	2.8*			
P0243643	3+4, I+J SE	<MDA	NA	8		
P0243319	3+4, I+J SW	<MDA	NA	10	7.2	2.0
P0243687	3+4, J+K C	<MDA	NA	8		
P0243253	3+4, J+K NE	<MDA	NA	8		
P0243320	3+4, J+K NW	<MDA	NA	6		
P0243458	3+4, J+K SE	<MDA	NA	6		
P0243372	3+4, J+K SW	<MDA	NA	8	7.2	1.0
P0243335	3+4, K+L C	<MDA	NA	6		
P0243454	3+4, K+L NE	<MDA	NA	5		
P0243269	3+4, K+L NW	<MDA	NA	6		
P0243443	3+4, K+L SE	<MDA	NA	7		
P0243358	3+4, K+L SW	<MDA	NA	7	6.2	0.8
P0243293	3+4, L+M C	<MDA	NA	7		
P0243636	3+4, L+M NE	<MDA	NA	9		
P0243456	3+4, L+M NW	<MDA	NA	6		
P0243353	3+4, L+M SE	<MDA	NA	8		
P0243398	3+4, L+M SW	<MDA	NA	8	7.6	1.1
P0243285	4+5, G+H NW	4	2.1*			
P0243656	4+5, G+H C	<MDA	NA	6		
P0243422	4+5, G+H NE	<MDA	NA	7		
P0243424*	4+5, G+H SE	3.6	2.3*			
P0243429	4+5, G+H SW	<MDA	NA	8	5.0	2.0

* Note: Laboratories did not report an MDA when a positive activity was reported. The reported uncertainties are the "2 sigma" counting statistic uncertainties.

Table C-1

Results of Gamma Spectroscopy Analysis of Phase III Systematic Soil Samples in Survey Unit 1 (Page 6 of 13)

NUS Sample Number	Sample Location in Grid	U-238 Concentration in pCi/g			Mean Activity pCi/g	Standard Deviation pCi/g
		Activity	Uncertainty*	MDA*		
P0243425	4+5, H+I C	<MDA	NA	6		
P0243421	4+5, H+I NE	<MDA	NA	6		
P0243426	4+5, H+I NW	<MDA	NA	7		
P0243430	4+5, H+I SE	<MDA	NA	7		
P0243420	4+5, H+I SW	<MDA	NA	5	6.2	0.8
P0243427	4+5, I+J C	<MDA	NA	7		
P0243716	4+5, I+J NE	<MDA	NA	6		
P0243323	4+5, I+J NW	<MDA	NA	7		
P0243724	4+5, I+J SE	<MDA	NA	6		
P0243631	4+5, I+J SW	<MDA	NA	6	6.4	0.5
P0243660	4+5, J+K C	<MDA	NA	7		
P0243324	4+5, J+K NE	<MDA	NA	9		
P0243264	4+5, J+K NW	<MDA	NA	8		
P0243367	4+5, J+K SE	<MDA	NA	6		
P0243250	4+5, J+K SW	<MDA	NA	8	7.6	1.1
P0243251	4+5, K+L C	<MDA	NA	6		
P0243333	4+5, K+L NE	<MDA	NA	7		
P0243352	4+5, K+L NW	<MDA	NA	7		
P0243332	4+5, K+L SE	<MDA	NA	6		
P0243644	4+5, K+L SW	<MDA	NA	7	6.6	0.5
P0243368	4+5, L+M C	<MDA	NA	7		
P0243288	4+5, L+M NE	4	2.1*			
P0243257	4+5, L+M NW	<MDA	NA	6		
P0243289	4+5, L+M SE	<MDA	NA	6		
P0243267	4+5, L+M SW	<MDA	NA	7	6.0	1.2

* Note: Laboratories did not report an MDA when a positive activity was reported.
The reported uncertainties are the "2 sigma" counting statistic uncertainties.

Table C-1

Results of Gamma Spectroscopy Analysis of Phase III Systematic Soil Samples in Survey Unit 1
(Page 7 of 13)

NUS Sample Number	Sample Location in Grid	U-238 Concentration in pCi/g			Mean Activity pCi/g	Standard Deviation pCi/g
		Activity	Uncertainty*	MDA*		
P0243665	5+6, G+H C	<MDA	NA	6		
P0243625	5+6, G+H NE	<MDA	NA	8		
P0243653	5+6, G+H NW	<MDA	NA	9		
P0243650	5+6, G+H SE	<MDA	NA	7		
P0243669	5+6, G+H SW	<MDA	NA	8	7.6	1.1
P0243654	5+6, H+I C	<MDA	NA	7		
P0243634	5+6, H+I NE	<MDA	NA	7		
P0243668	5+6, H+I NW	<MDA	NA	6		
P0243641	5+6, H+I SE	<MDA	NA	7		
P0243715	5+6, H+I SW	<MDA	NA	8	7.0	0.7
P0243627	5+6, I+J C	<MDA	NA	9		
P0243659	5+6, I+J NE	<MDA	NA	7		
P0243626	5+6, I+J NW	<MDA	NA	5		
P0243652	5+6, I+J SE	<MDA	NA	9		
P0243685	5+6, I+J SW	4.1	2.6*		6.8	2.5
P0243259	5+6, J+K C	<MDA	NA	7		
P0243295	5+6, J+K NE	<MDA	NA	5		
P0243629	5+6, J+K NW	<MDA	NA	8		
P0243310	5+6, J+K SE	<MDA	NA	5		
P0243655	5+6, J+K SW	<MDA	NA	8	6.6	1.5
P0243658	5+6, K+L C	<MDA	NA	6		
P0243633	5+6, K+L NE	<MDA	NA	7		
P0243630	5+6, K+L NW	<MDA	NA	6		
P0243623	5+6, K+L SE	<MDA	NA	5		
P0243620	5+6, K+L SW	<MDA	NA	8	6.4	1.1

* Note: Laboratories did not report an MDA when a positive activity was reported.
The reported uncertainties are the "2 sigma" counting statistic uncertainties.

Table C-1

Results of Gamma Spectroscopy Analysis of Phase III Systematic Soil Samples in Survey Unit 1
(Page 8 of 13)

NUS Sample Number	Sample Location in Grid	U-238 Concentration in pCi/g			Mean Activity pCi/g	Standard Deviation pCi/g
		Activity	Uncertainty*	MDA*		
P0243396	5+6, L+M C	<MDA	NA	7		
P0243286	5+6, L+M NE	<MDA	NA	5		
PO243340	5+6, L+M NW	<MDA	NA	7		
P0243298	5+6, L+M SE	<MDA	NA	9		
P0243673	5+6, L+M SW	4.7	2.1*		6.5	2.0
P0243648	6+7, G+H C	<MDA	NA	7		
P0243401	6+7, G+H NE	<MDA	NA	5		
P0243418	6+7, G+H NW	<MDA	NA	6		
P0243678	6+7, G+H SE	<MDA	NA	5		
P0243435	6+7, G+H SW	<MDA	NA	6	5.8	0.8
P0243670	6+7, H+I C	<MDA	NA	6		
P0243676	6+7, H+I NE	<MDA	NA	7		
P0243271	6+7, H+I NW	<MDA	NA	7		
P0243711	6+7, H+I SE	<MDA	NA	8		
P0243646	6+7, H+I SW	<MDA	NA	7	7.0	0.7
P0243400	6+7, I+J C	<MDA	NA	6		
P0243408	6+7, I+J NE	<MDA	NA	8		
P0243640	6+7, I+J NW	<MDA	NA	7		
P0243686	6+7, I+J SE	<MDA	NA	6		
P0243445	6+7, I+J SW	<MDA	NA	6	6.6	0.9
P0243681	6+7, J+K C	<MDA	NA	9		
P0243459	6+7, J+K NE	<MDA	NA	8		
P0243417	6+7, J+K NW	<MDA	NA	9		
P0243690	6+7, J+K SE	<MDA	NA	7		
P0243265	6+7, J+K SW	<MDA	NA	8	8.2	0.8

* Note: Laboratories did not report an MDA when a positive activity was reported. The reported uncertainties are the "2 sigma" counting statistic uncertainties.

Table C-1

Results of Gamma Spectroscopy Analysis of Phase III Systematic Soil Samples in Survey Unit 1

NUS Sample Number	Sample Location in Grid	U-238 Concentration in pCi/g			Mean Activity pCi/g	Standard Deviation pCi/g
		Activity	Uncertainty*	MDA*		
P0243638	6+7, K+L C	<MDA	NA	8		
P0243689	6+7, K+L NE	<MDA	NA	8		
P0243612	6+7, K+L NW	<MDA	NA	6		
P0243645	6+7, K+L SE	<MDA	NA	6		
P0243688	6+7, K+L SW	<MDA	NA	7	7.0	1.0
P0243683	6+7, L+M C	<MDA	NA	7		
P0243461	6+7, L+M NE	<MDA	NA	8		
P0243373	6+7, L+M NW	<MDA	NA	7		
P0243692	6+7, L+M SE	<MDA	NA	6		
P0243359	6+7, L+M SW	<MDA	NA	7	7.0	0.7
P0243383	7+8, G+H C	<MDA	NA	6		
P0243376	7+8, G+H NE	<MDA	NA	7		
P0243385	7+8, G+H NW	<MDA	NA	6		
P0243375	7+8, G+H SE	<MDA	NA	5		
P0243370	7+8, G+H SW	<MDA	NA	8	6.4	1.1
P0243290	7+8, H+I C	<MDA	NA	4		
P0243321	7+8, H+I NE	4.7	2.6*			
P0243326	7+8, H+I NW	<MDA	NA	6		
P0243382	7+8, H+I SE	<MDA	NA	7		
P0243436	7+8, H+I SW	<MDA	NA	6	5.5	1.1
P0243384	7+8, I+J C	<MDA	NA	6		
P0243369	7+8, I+J NE	<MDA	NA	9		
P0243419	7+8, I+J NW	<MDA	NA	6		
P0243381	7+8, I+J SE	<MDA	NA	6		
P0243391	7+8, I+J SW	3.4	2.4*		6.1	2.0

* Note: Laboratories did not report an MDA when a positive activity was reported.
The reported uncertainties are the "2 sigma" counting statistic uncertainties.

Table C-1

Results of Gamma Spectroscopy Analysis of Phase III Systematic Soil Samples in Survey Unit 1

NUS Sample Number	Sample Location in Grid	U-238 Concentration in pCi/g			Mean Activity pCi/g	Standard Deviation pCi/g
		Activity	Uncertainty*	MDA*		
P0243378	7+8, J+K C	<MDA	NA	8		
P0243379	7+8, J+K NE	<MDA	NA	7		
P0243392	7+8, J+K NW	<MDA	NA	10		
P0243632	7+8, J+K SE	<MDA	NA	8		
P0243428	7+8, J+K SW	<MDA	NA	8	8.2	1.1
P0243327	7+8, K+L C	<MDA	NA	6		
P0243613	7+8, K+L NE	<MDA	NA	6		
P0243441	7+8, K+L NW	<MDA	NA	7		
P0243334	7+8, K+L SE	<MDA	NA	6		
P0243302	7+8, K+L SW	<MDA	NA	7	6.4	0.5
P0243301	7+8, L+M C	<MDA	NA	7		
P0243312	7+8, L+M NE	<MDA	NA	8		
P0243252	7+8, L+M NW	<MDA	NA	5		
P0243684	7+8, L+M SE	4.1	2.8*			
P0243680	7+8, L+M SW	<MDA	NA	8	6.4	1.8
P0243322	8+9, G+H C	<MDA	NA	7		
P0243255	8+9, G+H NE	<MDA	NA	5		
P0243414	8+9, G+H NW	<MDA	NA	5		
P0243374	8+9, G+H SE	<MDA	NA	8		
P0243377	8+9, G+H SW	<MDA	NA	8	6.6	1.5
P0243410	8+9, H+I C	<MDA	NA	7		
P0243444	8+9, H+I NE	<MDA	NA	5		
P0243380	8+9, H+I NW	<MDA	NA	7		
P0243713	8+9, H+I SE	<MDA	NA	6		
P0243268	8+9, H+I SW	3.3	2.3*		5.7	1.5

* Note: Laboratories did not report an MDA when a positive activity was reported. The reported uncertainties are the "2 sigma" counting statistic uncertainties.

Table C-1

Results of Gamma Spectroscopy Analysis of Phase III Systematic Soil Samples in Survey Unit 1 (Page 11 of 13)

NUS Sample Number	Sample Location in Grid	U-238 Concentration in pCi/g			Mean Activity pCi/g	Standard Deviation pCi/g
		Activity	Uncertainty*	MDA*		
P0243315	8+9, I+J C	<MDA	NA	9		
P0243438	8+9, I+J NE	<MDA	NA	9		
P0243281	8+9, I+J NW	<MDA	NA	5		
P0243294	8+9, I+J SE	<MDA	NA	8		
P0243307	8+9, I+J SW	<MDA	NA	6	7.4	1.8
P0243637	8+9, J+K C	<MDA	NA	6		
P0243719	8+9, J+K NE	<MDA	NA	7		
P0243407	8+9, J+K NW	3.8	2.2*			
P0243416	8+9, J+K SE	<MDA	NA	6		
P0243395	8+9, J+K SW	<MDA	NA	5	5.6	1.2
P0243351	8+9, K+L C	<MDA	NA	7		
P0243451	8+9, K+L NE	<MDA	NA	7		
P0243452	8+9, K+L NW	<MDA	NA	8		
P0243318	8+9, K+L SE	<MDA	NA	6		
P0243439	8+9, K+L SW	<MDA	NA	6	6.8	0.8
P0243448	8+9, L+M C	<MDA	NA	6		
P0243361	8+9, L+M NW	<MDA	NA	8		
P0243453	8+9, L+M SE	<MDA	NA	7		
P0243276	8+9, L+M NE	<MDA	NA	8		
P0243325	8+9, L+M SW	7.7	3.2*		7.3	0.8
P0243657	9+10, G+H C	<MDA	NA	8		
P0243386	9+10, G+H NE	<MDA	NA	5		
P0243712	9+10, G+H NW	<MDA	NA	9		
P0243387	9+10, G+H SE	<MDA	NA	6		
P0243388	9+10, G+H SW	<MDA	NA	5	6.6	1.8

* Note: Laboratories did not report an MDA when a positive activity was reported. The reported uncertainties are the "2 sigma" counting statistic uncertainties.

Table C-1

Results of Gamma Spectroscopy Analysis of Phase III Systematic Soil Samples in Survey Unit 1
(Page 12 of 13)

NUS Sample Number	Sample Location in Grid	U-238 Concentration in pCi/g			Mean Activity pCi/g	Standard Deviation pCi/g
		Activity	Uncertainty*	MDA*		
P0243273	9+10, H+I C	<MDA	NA	6		
P0243299	9+10, H+I NE	<MDA	NA	8		
P0243667	9+10, H+I NW	<MDA	NA	7		
P0243399	9+10, H+I SE	<MDA	NA	6		
P0243447	9+10, H+I SW	<MDA	NA	8	7.0	1.0
P0243389	9+10, I+J C	<MDA	NA	6		
P0243411	9+10, I+J NE	7.5	2.5*			
P0243618	9+10, I+J NW	<MDA	NA	8		
P0243397	9+10, I+J SE	<MDA	NA	7		
P0243260	9+10, I+J SW	<MDA	NA	6	6.9	0.9
P0243296	9+10, J+K C	4.2	2.4*			
P0243412	9+10, J+K NE	<MDA	NA	6		
P0243415	9+10, J+K NW	<MDA	NA	8		
P0243409	9+10, J+K SE	8.5	3.2*			
P0243413	9+10, J+K SW	<MDA	NA	6	6.5	1.7
P0243455	9+10, K+L C	<MDA	NA	6		
P0243365	9+10, K+L NE	6.2	2.4*			
P0243326	9+10, K+L SE	<MDA	NA	7		
P0243442	9+10, K+L NW	<MDA	NA	8		
P0243434	9+10, K+L SW	<MDA	NA	6	6.6	0.9

* Note: Laboratories did not report an MDA when a positive activity was reported. The reported uncertainties are the "2 sigma" counting statistic uncertainties.

Table C-1

Results of Gamma Spectroscopy Analysis of Phase III Systematic Soil Samples in Survey Unit 1

NUS Sample Number	Sample Location in Grid	U-238 Concentration in pCi/g			Mean Activity pCi/g	Standard Deviation pCi/g
		Activity	Uncertainty*	MDA*		
P0243449	9+10, L+M C	<MDA	NA	6		
P0243450	9+10, L+M NE	<MDA	NA	8		
P0243440	9+10, L+M NW	<MDA	NA	6		
P0243423	9+10, L+M SE	<MDA	NA	8		
P0243437	9+10, L+M SW	<MDA	NA	7	7.0	1.0

Data Summary:		
	Maximum Grid Upper Bound Activity pCi/g (Highest grid Average plus its 95% confidence parameter)	12.1
	Survey Unit Mean Activity, pCi/g:	6.8
	Survey Unit Standard Deviation, pCi/g:	0.63
	Survey Unit 95% confidence parameter, pCi/g:	0.1

* Note: Laboratories did not report an MDA when a positive activity was reported. The reported uncertainties are the "2 sigma" counting statistic uncertainties.

Table C-2

Results of Gamma Spectroscopy Analysis for U-238 (pCi/g)
Phase III Systematic Soil Sampling in Survey Unit 2
(Page 1 of 3)

Grid Location	Soil Depth Sampled							
	0"-6"	6"-12"	12"-18"	18"-24"	24"-30"	30"-36"	36"-42"	42"-48"
5+6, H+I, SW				1.7 ±1.1 (e)			2.1 ±1.2	1.6 ±1.5
5+6, H+I, SE				1.9 ±1.2 (e)	1.7 ± 1.5 (d)			1.9 ±1.2
6+7, H+I, SW				1.4 ±1.1 (e)		<3		2.0 ±1.2
6+7, H+I, SE				<3 (e)		1.6 ±1.2		2.3 ±1.2(a)
7+8, H+I, SW	1.9 ±1.6						2.2 ±1.6	<3
5+6, I+J, NW	1.6 ±1.1						1.9 ±1.6	2.1 ±1.1
5+6, I+J, NE	1.9 ±1.6		2.1 ±1.2 (c)					<3
5+6, I+J, C	1.8 ±1.6		1.8 ±1.2					2.3 ±1.6
5+6, I+J, SW	<3						2.3 ±1.4	<3
5+6, I+J, SE	2.3 ±1.2		<3					1.9 ±1.1
6+7, I+J, NW	2.4 ±1.6	<3						1.8 ±1.5

(a) Sample depth = 42"-45"
(b) Actually 0-12" sample, split for QA/QC purposes
(c) Actually 9-21" sample, split for QA/QC purposes
(d) Actually 24-36" sample, split for QA/QC purposes
(e) This is a surface layer sample, collected along the sloping side of the excavation site, where the ground surface level differed from the level of the Test Fill Pad surface
(f) Actually 6-18" sample, split for QA/QC purposes

Table C-2

Results of Gamma Spectroscopy Analysis for U-238 (pCi/g)
Phase III Systematic Soil Sampling in Survey Unit 2
(Page 2 of 3)

Grid Location	Soil Depth Sampled							
	0"-6"	6"-12"	12"-18"	18"-24"	24"-30"	30"-36"	36"-42"	42"-48"
6+7, I+J, NE	1.6 ±1.1		<3					1.9 ±1.2
6+7, I+J, C	3.0 ±1.6 (b)		1.4 ±1.2					2.2 ±1.6
6+7, I+J, SW	2.1 ±1.1 (b)						1.8 ±1.4	<3
6+7, I+J, SE	2.0 ±1.1	<3 (f)						1.9 ±1.1
7+8, I+J, NW	1.4 ±1.1			1.9 ±1.5				1.9 ±1.6
7+8, I+J, C	2.2 ±1.5				2.1 ±1.2			1.3 ±1.2
7+8, I+J, SW	1.9 ±1.2		1.7 ±1.1					1.5 ±1.1
5+6, J+K, NW	1.6 ±1.5					1.3 ±1.1		1.4 ±1.2
5+6, J+K, NE	<3	2.1 ±1.1 (f)						2.2 ±1.6(a)
5+6, J+K, C	<3				2.0 ±1.6			1.5 ±1.2
6+7, J+K, NW	1.5 ±1.4		1.8 ±1.1					2.5 ±1.5

(a) Sample depth = 42"-45"
(b) Actually 0-12" sample, split for QA/QC purposes
(c) Actually 9-21" sample, split for QA/QC purposes
(d) Actually 24-36" sample, split for QA/QC purposes
(e) This is a surface layer sample, collected along the sloping side of the excavation site, where the ground surface level differed from the level of the Test Fill Pad surface
(f) Actually 6-18" sample, split for QA/QC purposes

Table C-2

Results of Gamma Spectroscopy Analysis for U-238 (pCi/g)
Phase III Systematic Soil Sampling in Survey Unit 2
(Page 3 of 3)

Grid Location	Soil Depth Sampled							
	0"-6"	6"-12"	12"-18"	18"-24"	24"-30"	30"-36"	36"-42"	42"-48"
6+7, J+K, NE	2.3 ±1.1						<3	1.7 ±1.1
6+7, J+K, C		1.9±1.5 (c)					1.9 ±1.5	2.6 ±1.1
7+8, J+K, NW	1.8 ±1.3			2.4 ±1.8				2.2 ±1.1
7+8, J+K, C	<3						1.6 ±1.1	<3

(a) Sample depth = 42"-45"
(b) Actually 0-12" sample, split for QA/QC purposes
(c) Actually 9-21" sample, split for QA/QC purposes
(d) Actually 24-36" sample, split for QA/QC purposes
(e) This is a surface layer sample, collected along the sloping side of the excavation site, where the ground surface level differed from the level of the Test Fill Pad surface
(f) Actually 6-18" sample, split for QA/QC purposes

Table C-3

Results of Isotopic Uranium Analysis for Selected Soil Samples
Phase III Systematic Soil Sampling in Survey Unit 1

NUS Sample No.	Grid Location Sample ID	Gamma Spect U-238 pCi/g	Isotopic Uranium Alpha Spectroscopy		
			U-238 pCi/g	U-235 pCi/g	U-233/234 pCi/g
PO243268	9+5, H+I SW	3.3 +/- 2.3	0.6 +/- 0.1	0.05 +/- 0.03	0.6 +/- 0.3
PO243285	4+5, G+H NW	4.0 +/- 2.1	0.7 +/- 0.1	0.06 +/- 0.03	0.6 +/- 0.1
PO243288	4+5, L+M NE	4.0 +/- 2.1	0.6 +/- 0.1	<0.07	0.4 +/- 0.1
PO243357	3+4, I+J NW	5.2 +/- 2.8	1.2 +/- 0.2	0.02 +/- 0.01	0.9 +/- 0.2
PO243391	7+8, I+J SW	3.4 +/- 2.4	0.5 +/- 0.1	<0.07	0.3 +/- 0.1
PO243409	9+10, J+K SE	8.5 +/- 3.2	1.4 +/- 0.2	0.07 +/- 0.04	0.5 +/- 0.1

Table C-4

Results of Comparison of Gamma Spectroscopy Analysis for Selected Soil Samples Phase III Systematic Soil Sampling in Survey Unit 1

Grid Location Sample ID	NUS Sample No.	U-238 Activity pCi/g			ENSECO Sample No.	U-238 Activity pCi/g		
		Activity	Uncert	MDA		Activity	Uncert	MDA
0+1, J+K NE	P0243262	<MDA	NA	5	0001	1.76	0.81	*
1+2, G+H SW	P0243272	<MDA	NA	7	0002	1.87	0.68	
5+6, L+M NE	P0243286	<MDA	NA	5	0003	2.3	1.2	
9+10, J+K C	P0243296	4.2	2.4		0004	3.96	0.86	
1+2, J+K NE	P0243306	<MDA	NA	5	0005	2.6	1.1	
2+3, K+L SW	P0243316	<MDA	NA	7	0006	1.87	0.74	
7+8, H+I NW	P0243326	<MDA	NA	6	0007	1.9	1.0	
2+3, G+H C	P0243336	<MDA	NA	9	0008	2.4	1.2	
3+4, I+J C	P0243346	<MDA	NA	5	0009	1.94	0.8	
2+3, L+M SW	P0243356	<MDA	NA	9	0010	3.2	1.6	
3+4, H+I NE	P0243366	<MDA	NA	5	0011	1.28	0.98	
7+8, G+H NE	P0243376	<MDA	NA	7	0012	1.7	1.1	
9+10, G+H NE	P0243386	<MDA	NA	5	0013	2.1	1.0	
5+6, L+M C	P0243396	<MDA	NA	7	0014	3.1	1.4	
0+1, K+L SE	P0243406	<MDA	NA	6	0015	1.9	1.5	
8+9, J+K SE	P0243416	<MDA	NA	6	0016	1.8	0.95	
4+5, H+I NW	P0243426	<MDA	NA	7	0017	1.25	0.54	
7+8, H+I SW	P0243436	<MDA	NA	6	0018	1.46	0.8	
2+3, H+I NE	P0243446	<MDA	NA	7	0019	2.0	1.0	
3+4, L+M NW	P0243456	<MDA	NA	6	0020	3	1.2	
0+1, H+I NW	P0243617	<MDA	NA	7	0021	1.22	0.8	
5+6, I+J C	P0243627	<MDA	NA	9	0022	2.27	0.97	
8+9, J+K C	P0243637	<MDA	NA	6	0023	1.8	1.1	
0+1, K+L NW	P0243647	<MDA	NA	7	0024	1.14	0.73	
9+10, G+H C	P0243657	<MDA	NA	8	0025	2.1	1	
9+10, H+I NW	P0243667	<MDA	NA	7	0026	2.4	1.5	
0+1, I+J NE	P0243677	<MDA	NA	8	0027	3.3	1.5	
3+4, J+K C	P0243687	<MDA	NA	8	0028	2.6	1.2	
5+6, H+I SW	P0243715	<MDA	NA	8	0029	1.7	1	
2+3, H+I SE	P0243725	<MDA	NA	6	0030	3.2	1.3	

* NOTE: Laboratories did not report an MDA when a positive activity was reported.
The reported uncertainties are the "2 sigma" counting statistic uncertainties.

Table C-5

Results of Comparison of Isotopic Uranium Analysis for Selected Soil Samples
Phase III Systematic Soil Sampling in Survey Unit 1

Laboratory	Sample No.	Grid Location Sample ID	Isotopic Uranium		
			U-238 pCi/g	U-235 pCi/g	U-233/234 pCi/g
NUS	PO243268	9+5, H+I SW	0.6 +/- 0.1	0.05 +/- 0.03	0.6 +/- 0.3
PACE	650036847	9+5, H+I SW	1.6 +/- 0.28	0.05 +/- 0.06	1.5 +/- 0.27
NUS	PO243285	4+5, G+H NW	0.7 +/- 0.1	0.06 +/- 0.03	0.6 +/- 0.1
PACE	650036863	4+5, G+H NW	1.6 +/- 0.30	0.18 +/- 0.10	1.9 +/- 0.32
NUS	PO243288	4+5, L+M NE	0.6 +/- 0.1	<0.07	0.4 +/- 0.1
PACE	650036880	4+5, L+M NE	1.5 +/- 0.26	0.07 +/- 0.07	1.6 +/- 0.27

Table C-6

Results of Gamma Spectroscopy Analysis of Background Soil Samples
BP Chemicals, Lima, OH, May 5, 1993

Sample No.	U-238 (pCi/g)	
	U-238 Activity	Activity Uncert
SS1-R 0-9"	3.9	0.9
SS1-R 18-27"	2.8	0.9
SS1-R 42-51"	3.2	0.8
SS1-R 60-66"	1.7	1.6
SS2-R 0-9"	3.3	0.9
SS2-R 18-27"	2.5	1.7
SS2-R 42-51"	1.7	1.6
SS2-R 60-66"	3.1	0.9
SS3-R 0-9"	2.2	1.8
SS3-R 18-27"	1.8	1.7
SS3-R 42-51"	2.5	1.8
SS3-R 60-66"	2.6	1.7
Mean	2.61	0.69
95% upper bound (theory)	2.72	

APPENDIX D
Tabulated Results of Gamma Exposure Rate Surveys

HALLIBURTON NUS
Environmental Corporation

Environmental Technologies Group
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January 13, 1994

William M. Rupert
Technical Specialist - Environmental
BRITISH PETROLEUM CHEMICALS, INC.
Post Office Box 628
Lima, Ohio 45802

Ref: Site Transmittal #**HNUS 01.748**
Gamma Walkover Surveys

Dear Mr. Rupert,

Attached are two (2) copies of the radiation survey's that HALLIBURTON NUS performed at and on the Clay Test Fill Pad. One is for your use and information and the other one (without staples) is to be added to Dames & Moores report to the NRC.

The following table list the date the surveys were made and on what lift of the pad.

Survey No.	Date Taken	Lift
595	10/07/93	Excavated Area
596	10/07/93	Excavated Area
602	10/12/93	Top of 6" subgrade
603	10/12/93	Top of 6" subgrade
607	10/13/93	1st Lift
608	10/13/93	1st Lift
612	10/15/93	2nd Lift
613	10/15/93	2nd Lift
618	10/18/93	3rd Lift
619	10/18/93	3rd Lift
629	10/22/93	4th Lift
630	10/22/93	4th Lift
639	10/26/93	5th Lift
640	10/26/93	5th Lift
646	10/27/93	6th and Last Lift
647	10/27/93	6th and Last Lift

If you have any questions or concerns regarding this matter please contact me.

Very truly yours,

HALLIBURTON NUS CORPORATION

Sidney A. Rasnick

Sidney A. Rasnick
Project Manager

cc: Dave Dougherty
Bruce Dykes
Roland Chretien
project file 1.1.1

RADIATION SURVEY

JOB # - 4075	B.P. CHEMICALS, LIMA, OHIO MIXED WASTE POND CLOSURE PROJECT BY HALLIBURTON NUS CORPORATION	Survey# 595 RWP# 036 Date 10/07/93 Time 0800 Page 1 of 4

Location: V-1 Pond Test Pad Area

Job Description: Gamma walkover survey; 0.1 mR/hr 92000cpm & 0.1 mR/hr 100 mr/hr

Radiation Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Background
ASP-1 w/SPA-3	2520	11/28/93	1800 cpm
N/A	N/A	N/A	N/A

Contamination Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Eff. %	Background
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
1	N/A	N/A	6.74	* See survey map. (page 4)
2	N/A	N/A	6.52	* The circles represent the change in
3	N/A	N/A	6.96	reading with the arrow indicating the
4	N/A	N/A	6.74	direction of movement to the next change,
5	N/A	N/A	5.87	and readings along the path of the arrow
6	N/A	N/A	5.65	are equal to the last change.
7	N/A	N/A	5.65	* See conversion factor regarding mR/hr.
8	N/A	N/A	6.52	* Three significant numbers were given
9	N/A	N/A	6.74	for mR/hr readings in order to convert
10	N/A	N/A	6.52	to cpm accurately.
11	N/A	N/A	6.30	
12	N/A	N/A	6.74	
13	N/A	N/A	6.52	
14	N/A	N/A	5.87	
15	N/A	N/A	6.52	
16	N/A	N/A	5.87	
17	N/A	N/A	5.87	
18	[illegible]	N/A	5.87	
19	N/A	N/A	5.87	
20	N/A	N/A	6.30	

Reviewed by: ______________________

RADIATION SURVEY

JOB # - 4075

Survey#	595
RWP#	036
Date	10/07/93
Time	0800
Page	2 of 4

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
21	N/A	N/A	6.52	N/A
22	N/A	N/A	6.30	N/A
23	N/A	N/A	6.52	N/A
24	N/A	N/A	6.52	N/A
25	N/A	N/A	5.87	N/A
26	N/A	N/A	6.52	N/A
27	N/A	N/A	6.30	N/A
28	N/A	N/A	5.87	N/A
29	N/A	N/A	6.52	N/A
30	N/A	N/A	6.30	N/A
31	N/A	N/A	6.96	N/A
32	N/A	N/A	6.30	N/A
33	N/A	N/A	6.52	N/A
34	N/A	N/A	6.52	N/A
35	N/A	N/A	6.30	N/A
36	N/A	N/A	6.52	N/A
37	N/A	N/A	6.09	N/A
38	N/A	N/A	6.30	N/A
39	N/A	N/A	6.30	N/A
40	N/A	N/A	5.65	N/A
41	N/A	N/A	6.30	N/A
42	N/A	N/A	6.09	N/A
43	N/A	N/A	6.09	N/A
44	N/A	N/A	6.30	N/A
45	N/A	N/A	6.52	N/A
46	N/A	N/A	6.09	N/A
47	N/A	N/A	6.09	N/A
48	N/A	N/A	6.09	N/A
49	N/A	N/A	6.30	N/A
50	N/A	N/A	6.09	N/A
51	N/A	N/A	6.52	N/A
52	N/A	N/A	6.52	N/A
53	N/A	N/A	6.52	N/A
54	N/A	N/A	6.09	N/A
55	N/A	N/A	6.09	N/A
56	N/A	N/A	6.09	N/A
57	N/A	N/A	5.87	N/A
58	N/A	N/A	6.09	N/A
59	N/A	N/A	6.30	N/A
60	N/A	N/A	6.30	N/A
61	N/A	N/A	6.30	N/A
62	N/A	N/A	6.52	N/A
63	N/A	N/A	6.09	N/A
64	N/A	N/A	6.30	N/A

RADIATION SURVEY

JOB # – 4075

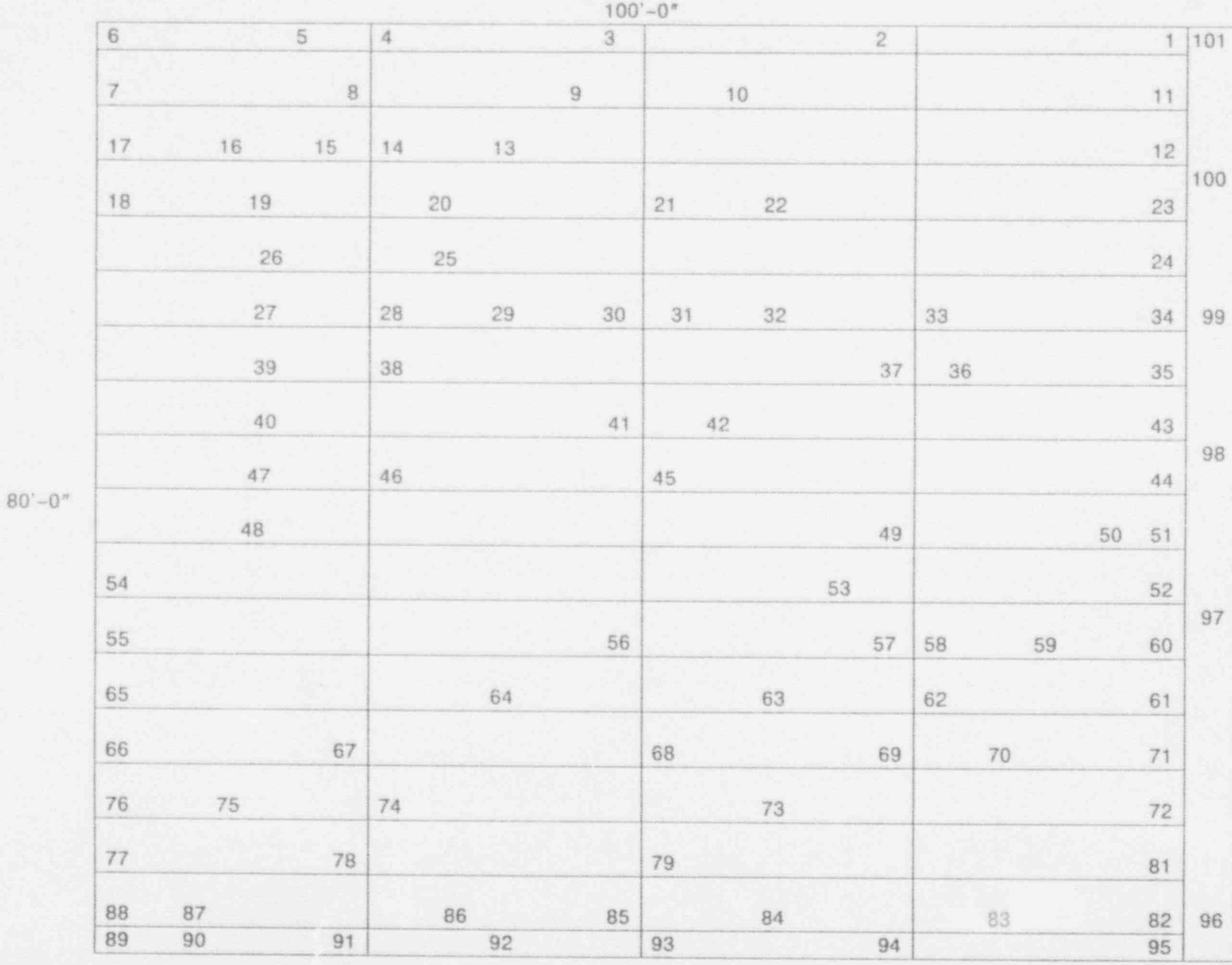
Survey#	595
RWP#	036
Date	10/07/93
Time	0800
Page	3 of 4

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
65	N/A	N/A	6.30	N/A
66	N/A	N/A	6.30	N/A
67	N/A	N/A	5.87	N/A
68	N/A	N/A	6.09	N/A
69	N/A	N/A	6.30	N/A
70	N/A	N/A	6.52	N/A
71	N/A	N/A	6.30	N/A
72	N/A	N/A	6.52	N/A
73	N/A	N/A	6.09	N/A
74	N/A	N/A	6.52	N/A
75	N/A	N/A	6.30	N/A
76	N/A	N/A	6.52	N/A
77	N/A	N/A	6.30	N/A
78	N/A	N/A	6.30	N/A
79	N/A	N/A	6.09	N/A
80	N/A	N/A	6.74	N/A
81	N/A	N/A	6.30	N/A
82	N/A	N/A	6.30	N/A
83	N/A	N/A	6.52	N/A
84	N/A	N/A	6.52	N/A
85	N/A	N/A	6.09	N/A
86	N/A	N/A	6.30	N/A
87	N/A	N/A	6.09	N/A
88	N/A	N/A	6.30	N/A
89	N/A	N/A	6.09	N/A
90	N/A	N/A	6.74	N/A
91	N/A	N/A	6.96	N/A
92	N/A	N/A	6.52	N/A
93	N/A	N/A	6.74	N/A
94	N/A	N/A	7.12	N/A
95	N/A	N/A	7.89	N/A
96	N/A	N/A	7.12	N/A
97	N/A	N/A	6.96	N/A
98	N/A	N/A	6.74	N/A
99	N/A	N/A	7.12	N/A
100	N/A	N/A	7.12	N/A
101	N/A	N/A	7.12	N/A

B.P. CHE CALS, INC.
LIMA, O
MIXED WASTE POND CLOSURE

JOB# 4075 SURVEY # 5
DATE: 10-07-93 RWP #0

GAMMA WALKOVER SURVEY
By
HALLIBURTON NUS CORPORATION



RADIATION SURVEY

JOB # - 4075	B.P. CHEMICALS, LIMA, OHIO MIXED WASTE POND CLOSURE PROJECT BY HALLIBURTON NUS CORPORATION	Survey# 596 RWP# 036 Date 10/07/93 Time 1040 Page 1 of 3

Location: V-1 Pond Test Pad Area

Job Description: Gamma survey of area.

Radiation Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Background
Ludlum Model 19	44510	03/02/94	2 mR/hr
N/A	N/A	N/A	N/A

Contamination Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Eff. %	Background
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
1	N/A	N/A	6	* See survey map. (page 3)
2	N/A	N/A	6	* Smear location actually indicates
3	N/A	N/A	6	location of reading.
4	N/A	N/A	6	
5	N/A	N/A	6	
6	N/A	N/A	6	
7	N/A	N/A	6	
8	N/A	N/A	6	
9	N/A	N/A	7	
10	N/A	N/A	6	
11	N/A	N/A	6	
12	N/A	N/A	7	
13	N/A	N/A	6	
14	N/A	N/A	6	
15	N/A	N/A	6	
16	N/A	N/A	7	
17	N/A	N/A	7	
18	N/A	N/A	6	
19	N/A	N/A	6	
20	N/A	N/A	6	

Reviewed by: ____________________

RADIATION SURVEY

JOB # - 4075

Survey#	596
RWP#	036
Date	10/07/93
Time	1040
Page	2 of 3

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	Remarks
21	N/A	N/A	6	N/A
22	N/A	N/A	6	N/A
23	N/A	N/A	6	N/A
24	N/A	N/A	7	N/A
25	N/A	N/A	7	N/A
26	N/A	N/A	6	N/A
27	N/A	N/A	6	N/A
28	N/A	N/A	7	N/A
29	N/A	N/A	7	N/A
30	N/A	N/A	7	N/A
31	N/A	N/A	7	N/A
32	N/A	N/A	6	N/A
33	N/A	N/A	6	N/A
34	N/A	N/A	6	N/A
35	N/A	N/A	6	N/A
36	N/A	N/A	6	N/A
37	N/A	N/A	6	N/A
38	N/A	N/A	6	N/A
39	N/A	N/A	6	N/A
40	N/A	N/A	7	N/A
41	N/A	N/A	7	N/A
42	N/A	N/A	6	N/A
43	N/A	N/A	6	N/A
44	N/A	N/A	6	N/A
45	N/A	N/A	6	N/A
46	N/A	N/A	6	N/A
47	N/A	N/A	5	N/A
48	N/A	N/A	6	N/A
49	N/A	N/A	6	N/A
50	N/A	N/A	7	N/A
51	N/A	N/A	6	N/A
52	N/A	N/A	6	N/A
53	N/A	N/A	6	N/A
54	N/A	N/A	7	N/A
55	N/A	N/A	6	N/A
56	N/A	N/A	7	N/A
57	N/A	N/A	7	N/A
58	N/A	N/A	7	N/A
59	N/A	N/A	6	N/A

B.P. CH CALS, INC.
LIMA, O
MIXED WASTE POND CLOSURE

JOB # 4075 SURVEY # 5
DATE: 10-07-93 RWP #03

GAMMA SURVEY
By
HALLIBURTON NUS CORPORATION

RADIATION SURVEY

JOB # - 4075	B.P. CHEMICALS, LIMA, OHIO MIXED WASTE POND CLOSURE PROJECT BY HALLIBURTON NUS CORPORATION	Survey# 602 RWP# 036 Date 10/12/93 Time 0815 Page 1 of 4

Location: V-1 Pond Test Pad Area

Job Description: Gamma walkover survey; 0.1 mR/hr 92000cpm & 0.1 mR/hr 100 mr/hr

Radiation Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Background
ASP-1 w/SPA-3	2520	11/28/93	1800 cpm
N/A	N/A	N/A	N/A

Contamination Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Eff. %	Background
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
1	N/A	N/A	6.96	* See survey map. (page 4)
2	N/A	N/A	6.52	* The circles represent the change in
3	N/A	N/A	6.09	reading with the arrow indicating the
4	N/A	N/A	5.43	direction of movement to the next change,
5	N/A	N/A	5.43	and readings along the path of the arrow
6	N/A	N/A	5.87	are equal to the last change.
7	N/A	N/A	6.09	* See conversion factor regarding mR/hr.
8	N/A	N/A	6.52	* Three significant numbers were given
9	N/A	N/A	6.74	for mR/hr readings in order to convert
10	N/A	N/A	6.52	to cpm accurately.
11	N/A	N/A	5.87	
12	N/A	N/A	5.87	
13	N/A	N/A	5.43	
14	N/A	N/A	5.43	
15	N/A	N/A	6.09	
16	N/A	N/A	5.87	
17	N/A	N/A	6.30	
18	N/A	N/A	6.09	
19	N/A	N/A	5.87	
20	N/A	N/A	6.09	

Reviewed by: ______________________

RADIATION SURVEY

JOB # – 4075

Survey#	602
RWP#	036
Date	10/12/93
Time	0815
Page	2 of 4

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
21	N/A	N/A	5.87	N/A
22	N/A	N/A	5.65	N/A
23	N/A	N/A	5.87	N/A
24	N/A	N/A	5.65	N/A
25	N/A	N/A	6.09	N/A
26	N/A	N/A	5.87	N/A
27	N/A	N/A	5.87	N/A
28	N/A	N/A	6.09	N/A
29	N/A	N/A	5.87	N/A
30	N/A	N/A	5.65	N/A
31	N/A	N/A	5.43	N/A
32	N/A	N/A	5.65	N/A
33	N/A	N/A	5.87	N/A
34	N/A	N/A	5.43	N/A
35	N/A	N/A	6.09	N/A
36	N/A	N/A	6.09	N/A
37	N/A	N/A	5.65	N/A
38	N/A	N/A	5.87	N/A
39	N/A	N/A	5.87	N/A
40	N/A	N/A	5.43	N/A
41	N/A	N/A	5.65	N/A
42	N/A	N/A	5.43	N/A
43	N/A	N/A	5.65	N/A
44	N/A	N/A	5.65	N/A
45	N/A	N/A	5.65	N/A
46	N/A	N/A	5.87	N/A
47	N/A	N/A	6.09	N/A
48	N/A	N/A	5.87	N/A
49	N/A	N/A	5.65	N/A
50	N/A	N/A	5.65	N/A
51	N/A	N/A	6.09	N/A
52	N/A	N/A	5.65	N/A
53	N/A	N/A	5.43	N/A
54	N/A	N/A	6.09	N/A
55	N/A	N/A	5.87	N/A
56	N/A	N/A	5.87	N/A
57	N/A	N/A	6.09	N/A
58	N/A	N/A	6.30	N/A
59	N/A	N/A	6.09	N/A
60	N/A	N/A	5.43	N/A
61	N/A	N/A	5.65	N/A
62	N/A	N/A	5.87	N/A
63	N/A	N/A	6.09	N/A
64	N/A	N/A	5.87	N/A

RADIATION SURVEY

JOB # - 4075

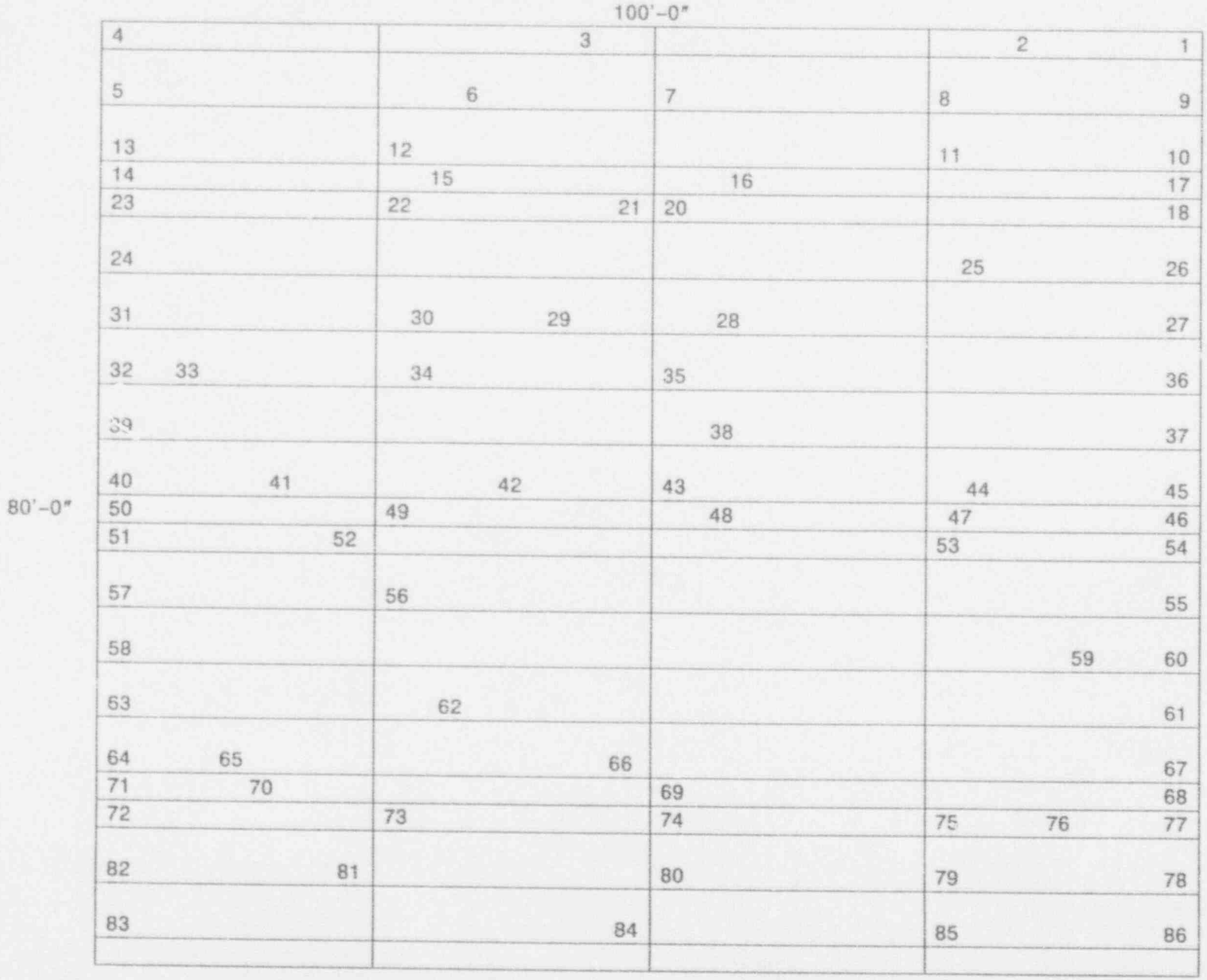
Survey#	602
RWP#	036
Date	10/12/93
Time	0815
Page	3 of 4

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*	
65	N/A	N/A	6.09	N/A	
66	N/A	N/A	5.43	N/A	
67	N/A	N/A	5.87	N/A	
68	N/A	N/A	6.09	N/A	
69	N/A	N/A	5.65	N/A	
70	N/A	N/A	6.09	N/A	
71	N/A	N/A	6.30	N/A	
72	N/A	N/A	5.87	N/A	
73	N/A	N/A	5.65	N/A	
74	N/A	N/A	5.43	N/A	
75	N/A	N/A	6.09	N/A	
76	N/A	N/A	5.87	N/A	
77	N/A	N/A	6.09	N/A	
78	N/A	N/A	6.09	N/A	
79	N/A	N/A	5.87	N/A	
80	N/A	N/A	6.09	N/A	
81	N/A	N/A	5.87	N/A	
82	N/A	N/A	6.09	N/A	
83	N/A	N/A	6.09	N/A	
84	N/A	N/A	5.87	N/A	
85	N/A	N/A	6.09	N/A	
86	N/A	N/A	6.09	N/A	
87	N/A	N/A	6.09	N/A	
88	N/A	N/A	6.09	N/A	

B.P. CHEMICALS, INC.
LIMA, OH
MIXED WASTE POND CLOSURE

JOB # 4075 SURVEY # 602
DATE: 10-12-93 RWP # 036

GAMMA WALKOVER SURVEY
By
HALLIBURTON NUS CORPORATION



RADIATION SURVEY

JOB # - 4075	B.P. CHEMICALS, LIMA, OHIO MIXED WASTE POND CLOSURE PROJECT BY HALLIBURTON NUS CORPORATION	Survey# 603 RWP# 036 Date 10/12/93 Time 0815 Page 1 of 3

Location: V-1 Pond Test Pad Area

Job Description: Gamma survey of area.

Radiation Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Background
Ludlum Model 19	44610	03/02/94	2 mR/hr
N/A	N/A	N/A	N/A

Contamination Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Eff. %	Background
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
1	N/A	N/A	7	* See survey map. (page 3)
2	N/A	N/A	7	* Smear location actually indicates
3	N/A	N/A	7	location of reading.
4	N/A	N/A	7	
5	N/A	N/A	7	
6	N/A	N/A	7	
7	N/A	N/A	7	
8	N/A	N/A	7	
9	N/A	N/A	7	
10	N/A	N/A	7	
11	N/A	N/A	7	
12	N/A	N/A	7	
13	N/A	N/A	7	
14	N/A	N/A	7	
15	N/A	N/A	7	
16	N/A	N/A	6	
17	N/A	N/A	6	
18	N/A	N/A	6	
19	N/A	N/A	7	
20	N/A	N/A	7	

Reviewed by: ____________________

RADIATION SURVEY

JOB # – 4075

Survey#	603
RWP#	036
Date	10/12/93
Time	0815
Page	2 of 3

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
21	N/A	N/A	7	N/A
22	N/A	N/A	6	N/A
23	N/A	N/A	6	N/A
24	N/A	N/A	6	N/A
25	N/A	N/A	6	N/A
26	N/A	N/A	7	N/A
27	N/A	N/A	7	N/A
28	N/A	N/A	7	N/A
29	N/A	N/A	7	N/A
30	N/A	N/A	6	N/A
31	N/A	N/A	7	N/A
32	N/A	N/A	7	N/A
33	N/A	N/A	7	N/A
34	N/A	N/A	7	N/A
35	N/A	N/A	7	N/A
36	N/A	N/A	7	N/A
37	N/A	N/A	7	N/A
38	N/A	N/A	7	N/A
39	N/A	N/A	7	N/A
40	N/A	N/A	7	N/A
41	N/A	N/A	7	N/A
42	N/A	N/A	7	N/A
43	N/A	N/A	7	N/A
44	N/A	N/A	7	N/A
45	N/A	N/A	7	N/A
46	N/A	N/A	7	N/A
47	N/A	N/A	7	N/A
48	N/A	N/A	7	N/A
49	N/A	N/A	7	N/A
50	N/A	N/A	7	N/A
51	N/A	N/A	7	N/A
52	N/A	N/A	7	N/A
53	N/A	N/A	7	N/A
54	N/A	N/A	7	N/A
55	N/A	N/A	6	N/A
56	N/A	N/A	7	N/A
57	N/A	N/A	7	N/A
58	N/A	N/A	7	N/A
59	N/A	N/A	7	N/A
60	N/A	N/A	7	N/A

B.P. CHEMIC S, INC.
LIMA, OHIO
MIXED WASTE POND CLOSURE

JOB # 4075
DATE: 10-12-93

SUR # 603
RWP 036

GAMMA SURVEY
By
HALLIBURTON NUS CORPORATION

RADIATION SURVEY

JOB # - 4075	B.P. CHEMICALS, LIMA, OHIO MIXED WASTE POND CLOSURE PROJECT BY HALLIBURTON NUS CORPORATION	Survey# 607 RWP# 036 Date 10/13/93 Time 1245 Page 1 of 4

Location: V-1 Pond Test Pad Area

Job Description: Gamma walkover survey; 0.1 mR/hr 92000cpm & 0.1 mR/hr 100 mr/hr

Radiation Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Background
ASP-1 w/SPA-3	2520	11/28/93	1800 cpm
N/A	N/A	N/A	N/A

Contamination Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Eff. %	Background
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
1	N/A	N/A	6.09	* See survey map. (page 4)
2	N/A	N/A	5.65	* The circles represent the change in
3	N/A	N/A	5.43	reading with the arrow indicating the
4	N/A	N/A	5.43	direction of movement to the next change,
5	N/A	N/A	5.87	and readings along the path of the arrow
6	N/A	N/A	6.09	are equal to the last change.
7	N/A	N/A	6.30	* See conversion factor regarding mR/hr.
8	N/A	N/A	5.65	* Three significant numbers were given
9	N/A	N/A	5.43	for mR/hr readings in order to convert
10	N/A	N/A	5.87	to cpm accurately.
11	N/A	N/A	5.43	
12	N/A	N/A	5.43	
13	N/A	N/A	5.43	
14	N/A	N/A	5.65	
15	N/A	N/A	5.65	
16	N/A	N/A	5.65	
17	N/A	N/A	5.87	
18	N/A	N/A	5.43	
19	N/A	N/A	5.65	
20	N/A	N/A	5.43	

Reviewed by: ______________________

RADIATION SURVEY

JOB # - 4075

Survey#	607
RWP#	036
Date	10/13/93
Time	1245
Page	2 of 4

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
21	N/A	N/A	5.65	N/A
22	N/A	N/A	5.43	N/A
23	N/A	N/A	5.65	N/A
24	N/A	N/A	5.87	N/A
25	N/A	N/A	5.87	N/A
26	N/A	N/A	5.65	N/A
27	N/A	N/A	5.43	N/A
28	N/A	N/A	5.65	N/A
29	N/A	N/A	5.43	N/A
30	N/A	N/A	5.65	N/A
31	N/A	N/A	5.43	N/A
32	N/A	N/A	5.87	N/A
33	N/A	N/A	5.87	N/A
34	N/A	N/A	5.87	N/A
35	N/A	N/A	5.65	N/A
36	N/A	N/A	5.43	N/A
37	N/A	N/A	5.43	N/A
38	N/A	N/A	5.65	N/A
39	N/A	N/A	5.43	N/A
40	N/A	N/A	5.65	N/A
41	N/A	N/A	5.43	N/A
42	N/A	N/A	5.87	N/A
43	N/A	N/A	5.65	N/A
44	N/A	N/A	5.87	N/A
45	N/A	N/A	5.43	N/A
46	N/A	N/A	5.65	N/A
47	N/A	N/A	5.43	N/A
48	N/A	N/A	5.65	N/A
49	N/A	N/A	5.65	N/A
50	N/A	N/A	5.87	N/A
51	N/A	N/A	5.65	N/A
52	N/A	N/A	5.87	N/A
53	N/A	N/A	5.87	N/A
54	N/A	N/A	5.43	N/A
55	N/A	N/A	5.65	N/A
56	N/A	N/A	5.65	N/A
57	N/A	N/A	5.43	N/A
58	N/A	N/A	5.65	N/A
59	N/A	N/A	5.87	N/A
60	N/A	N/A	6.09	N/A
61	N/A	N/A	6.09	N/A
62	N/A	N/A	5.87	N/A
63	N/A	N/A	5.65	N/A
64	N/A	N/A	5.43	N/A

RADIATION SURVEY

JOB # - 4075

Survey#	607
RWP#	036
Date	10/13/93
Time	1245
Page	3 of 4

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
65	N/A	N/A	5.43	N/A
66	N/A	N/A	5.65	N/A
67	N/A	N/A	5.43	N/A
68	N/A	N/A	5.65	N/A
69	N/A	N/A	5.87	N/A
70	N/A	N/A	6.09	N/A
71	N/A	N/A	6.09	N/A
72	N/A	N/A	5.87	N/A
73	N/A	N/A	6.09	N/A
74	N/A	N/A	5.65	N/A
75	N/A	N/A	5.65	N/A
76	N/A	N/A	5.65	N/A
77	N/A	N/A	5.43	N/A
78	N/A	N/A	5.87	N/A
79	N/A	N/A	5.87	N/A
80	N/A	N/A	5.87	N/A
81	N/A	N/A	6.09	N/A
82	N/A	N/A	5.43	N/A
83	N/A	N/A	5.43	N/A
84	N/A	N/A	6.09	N/A
85	N/A	N/A	5.87	N/A
86	N/A	N/A	5.65	N/A
87	N/A	N/A	6.09	N/A
88	N/A	N/A	6.09	N/A
89	N/A	N/A	5.43	N/A
90	N/A	N/A	5.87	N/A
91	N/A	N/A	6.30	N/A
92	N/A	N/A	5.87	N/A

B.P. CHEMICALS, INC.
LIMA, OHIO
MIXED WASTE POND CLOSURE

JOB # 4075 SURVEY # 607
DATE: 10-13-93 RWP # 036

GAMMA WALKOVER SURVEY
By
HALLIBURTON NUS CORPORATION

100'-0"

80'-0"

3 2			1
4 5			6
12 11	10 9		8 7
13			14 15
20 19	18 17		16
21 22	23		24
28	27	26	25
29		30	31 32
37 36		35 34	33
38 39		40	41 42 43
48 47	46	45	44
49 50	51		52
55		54	53
56	57	58	59 60
65	64	63 62	61
66	67	68	69 70
75	74	73	72 71
76	77	78	79
83	82	81	80
84 85	86		87
92	91 90		89 88

RADIATION SURVEY

JOB # - 4075	B.P. CHEMICALS, LIMA, OHIO MIXED WASTE POND CLOSURE PROJECT BY HALLIBURTON NUS CORPORATION	Survey# 608 RWP# 036 Date 10/13/93 Time 1415 Page 1 of 3

Location: V-1 Pond Test Pad Area

Job Description: Gamma survey of area.

Radiation Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Background
Ludlum Model 19	44610	03/02/94	2 mR/hr
N/A	N/A	N/A	N/A

Contamination Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Eff. %	Background
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
1	N/A	N/A	7	* See survey map. (page 3)
2	N/A	N/A	6	* Smear location actually indicates
3	N/A	N/A	6	location of reading at 1 meter above
4	N/A	N/A	6	surface.
5	N/A	N/A	6	
6	N/A	N/A	6	
7	N/A	N/A	6	
8	N/A	N/A	7	
9	N/A	N/A	6	
10	N/A	N/A	7	
11	N/A	N/A	7	
12	N/A	N/A	7	
13	N/A	N/A	7	
14	N/A	N/A	6	
15	N/A	N/A	6	
16	N/A	N/A	7	
17	N/A	N/A	7	
18	N/A	N/A	7	
19	N/A	N/A	7	
20	N/A	N/A	6	

Reviewed by: ______________________

RADIATION SURVEY

JOB # - 4075

Survey#	608
RWP#	036
Date	10/13/93
Time	1415
Page	2 of 3

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	Remarks
21	N/A	N/A	6	N/A
22	N/A	N/A	7	N/A
23	N/A	N/A	7	N/A
24	N/A	N/A	7	N/A
25	N/A	N/A	7	N/A
26	N/A	N/A	6	N/A
27	N/A	N/A	6	N/A
28	N/A	N/A	7	N/A
29	N/A	N/A	6	N/A
30	N/A	N/A	6	N/A
31	N/A	N/A	7	N/A
32	N/A	N/A	6	N/A
33	N/A	N/A	6	N/A
34	N/A	N/A	6	N/A
35	N/A	N/A	6	N/A
36	N/A	N/A	6	N/A
37	N/A	N/A	6	N/A
38	N/A	N/A	6	N/A
39	N/A	N/A	6	N/A
40	N/A	N/A	6	N/A
41	N/A	N/A	6	N/A
42	N/A	N/A	6	N/A
43	N/A	N/A	6	N/A
44	N/A	N/A	6	N/A
45	N/A	N/A	6	N/A
46	N/A	N/A	6	N/A
47	N/A	N/A	6	N/A
48	N/A	N/A	6	N/A
49	N/A	N/A	6	N/A
50	N/A	N/A	6	N/A
51	N/A	N/A	6	N/A
52	N/A	N/A	6	N/A
53	N/A	N/A	7	N/A
54	N/A	N/A	7	N/A
55	N/A	N/A	6	N/A
56	N/A	N/A	6	N/A
57	N/A	N/A	6	N/A
58	N/A	N/A	6	N/A
59	N/A	N/A	6	N/A
60	N/A	N/A	6	N/A

B.P. CHEMICALS, INC.
LIMA, OHIO
MIXED WASTE POND CLOSURE

JOB # 4075
DATE: 10-13-93

SURVEY # 608
RWP # 636

GAMMA SURVEY
By
HALLIBURTON NUS CORPORATION

RADIATION SURVEY

JOB # - 4075	B.P. CHEMICALS, LIMA, OHIO MIXED WASTE POND CLOSURE PROJECT BY HALLIBURTON NUS CORPORATION	Survey# 612 RWP# 036 Date 10/15/93 Time 1200 Page 1 of 4

Location: V-1 Pond Test Pad Area

Job Description: Gamma walkover survey; 0.1 mR/hr 92000cpm & 0.1 mR/hr 100 mr/hr

Radiation Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Background
ASP-1 w/SPA-3	2520	11/28/93	1800 cpm
N/A	N/A	N/A	N/A

Contamination Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Eff. %	Background
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
1	N/A	N/A	6.09	* See survey map. (page 4)
2	N/A	N/A	5.65	* The circles represent the change in
3	N/A	N/A	5.87	reading with the arrow indicating the
4	N/A	N/A	5.65	direction of movement to the next change,
5	N/A	N/A	5.87	and readings along the path of the arrow
6	N/A	N/A	6.09	are equal to the last change.
7	N/A	N/A	6.52	* See conversion factor regarding mR/hr.
8	N/A	N/A	6.09	* Three significant numbers were given
9	N/A	N/A	5.65	for mR/hr readings in order to convert
10	N/A	N/A	5.87	to cpm accurately.
11	N/A	N/A	5.87	
12	N/A	N/A	6.09	
13	N/A	N/A	6.30	
14	N/A	N/A	6.30	
15	N/A	N/A	6.09	
16	N/A	N/A	5.87	
17	N/A	N/A	5.43	
18	N/A	N/A	5.65	
19	N/A	N/A	5.87	
20	N/A	N/A	5.65	

Reviewed by: ____________________

RADIATION SURVEY

JOB # - 4075

Survey#	612
RWP#	036
Date	10/15/93
Time	1200
Page	2 of 4

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
21	N/A	N/A	6.52	N/A
22	N/A	N/A	6.30	N/A
23	N/A	N/A	6.09	N/A
24	N/A	N/A	5.87	N/A
25	N/A	N/A	5.65	N/A
26	N/A	N/A	5.65	N/A
27	N/A	N/A	5.87	N/A
28	N/A	N/A	6.09	N/A
29	N/A	N/A	6.09	N/A
30	N/A	N/A	5.87	N/A
31	N/A	N/A	5.65	N/A
32	N/A	N/A	6.09	N/A
33	N/A	N/A	5.65	N/A
34	N/A	N/A	5.65	N/A
35	N/A	N/A	5.87	N/A
36	N/A	N/A	5.65	N/A
37	N/A	N/A	5.87	N/A
38	N/A	N/A	5.65	N/A
39	N/A	N/A	5.87	N/A
40	N/A	N/A	6.09	N/A
41	N/A	N/A	5.87	N/A
42	N/A	N/A	5.87	N/A
43	N/A	N/A	5.87	N/A
44	N/A	N/A	5.65	N/A
45	N/A	N/A	5.87	N/A
46	N/A	N/A	5.43	N/A
47	N/A	N/A	6.09	N/A
48	N/A	N/A	5.87	N/A
49	N/A	N/A	5.87	N/A
50	N/A	N/A	6.30	N/A
51	N/A	N/A	5.87	N/A
52	N/A	N/A	6.09	N/A
53	N/A	N/A	5.65	N/A
54	N/A	N/A	5.65	N/A
55	N/A	N/A	5.87	N/A
56	N/A	N/A	5.65	N/A
57	N/A	N/A	6.30	N/A
58	N/A	N/A	6.30	N/A
59	N/A	N/A	6.09	N/A
60	N/A	N/A	5.87	N/A
61	N/A	N/A	5.65	N/A
62	N/A	N/A	5.87	N/A
63	N/A	N/A	5.87	N/A
64	N/A	N/A	6.09	N/A

RADIATION SURVEY

JOB # - 4075

Survey#	612
RWP#	036
Date	10/15/93
Time	1200
Page	3 of 4

Smear Location	ccpm/smear	dpm/smear	uR/hr	Remarks
65	N/A	N/A	5.65	N/A
66	N/A	N/A	5.87	N/A
67	N/A	N/A	6.09	N/A
68	N/A	N/A	5.87	N/A
69	N/A	N/A	6.52	N/A
70	N/A	N/A	6.09	N/A
71	N/A	N/A	5.87	N/A
72	N/A	N/A	6.09	N/A
73	N/A	N/A	5.87	N/A
74	N/A	N/A	6.09	N/A
75	N/A	N/A	5.65	N/A
76	N/A	N/A	5.65	N/A
77	N/A	N/A	5.43	N/A
78	N/A	N/A	5.87	N/A
79	N/A	N/A	5.43	N/A
80	N/A	N/A	6.09	N/A
81	N/A	N/A	6.30	N/A
82	N/A	N/A	6.52	N/A
83	N/A	N/A	6.52	N/A
84	N/A	N/A	6.09	N/A
85	N/A	N/A	5.87	N/A
86	N/A	N/A	5.87	N/A
87	N/A	N/A	5.87	N/A
88	N/A	N/A	6.09	N/A
89	N/A	N/A	6.52	N/A

CHEMICALS, INC.
LIMA, OHIO
MIXED WASTE POND CLOSURE

GAMMA WALKOVER SURVEY
By
HALLIBURTON NUS CORPORATION

JOB # 4075
DATE: 10-15-93

SURVEY [illegible]2
RWP # 036

100'-0"

80'-0"

*3 2			1
4	5	6	7
10	9		8
11			12 13
17	16		15 14
18		19 20	21
25	24	23	22
26	27		28
34 33	32	31 30	29
35 36		37	38 39
42	41		40
43	44 45	46 47	48
54 53	52	51	50 49
55		56	57
62	61 60	59	58
63 64 65	66	67	68
76 75	74 73 72	71	70 69
77 78	79 80	81	82
86 85			84 83
87		88	89

RADIATION SURVEY

JOB # - 4075	B.P. CHEMICALS, LIMA, OHIO MIXED WASTE POND CLOSURE PROJECT BY HALLIBURTON NUS CORPORATION	Survey# 613 RWP# 036 Date 10/15/93 Time 1400 Page 1 of 3

Location: V-1 Pond Test Pad Area

Job Description: Gamma survey of area.

Radiation Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Background
Ludlum Model 19	44610	03/02/94	2 mR/hr
N/A	N/A	N/A	N/A

Contamination Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Eff. %	Background
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
1	N/A	N/A	6	* See survey map. (page 3)
2	N/A	N/A	7	* Smear location actually indicates
3	N/A	N/A	7	location of reading.
4	N/A	N/A	6	
5	N/A	N/A	6	
6	N/A	N/A	6	
7	N/A	N/A	6	
8	N/A	N/A	6	
9	N/A	N/A	6	
10	N/A	N/A	6	
11	N/A	N/A	6	
12	N/A	N/A	6	
13	N/A	N/A	7	
14	N/A	N/A	6	
15	N/A	N/A	6	
16	N/A	N/A	6	
17	N/A	N/A	6	
18	N/A	N/A	6	
19	N/A	N/A	6	
20	N/A	N/A	6	

Reviewed by: ____________________

RADIATION SURVEY

JOB # - 4075

Survey#	613
RWP#	036
Date	10/15/93
Time	1400
Page	2 of 3

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
21	N/A	N/A	6	N/A
22	N/A	N/A	6	N/A
23	N/A	N/A	6	N/A
24	N/A	N/A	6	N/A
25	N/A	N/A	6	N/A
26	N/A	N/A	6	N/A
27	N/A	N/A	6	N/A
28	N/A	N/A	7	N/A
29	N/A	N/A	6	N/A
30	N/A	N/A	6	N/A
31	N/A	N/A	6	N/A
32	N/A	N/A	6	N/A
33	N/A	N/A	7	N/A
34	N/A	N/A	6	N/A
35	N/A	N/A	6	N/A
36	N/A	N/A	6	N/A
37	N/A	N/A	6	N/A
38	N/A	N/A	6	N/A
39	N/A	N/A	6	N/A
40	N/A	N/A	6	N/A
41	N/A	N/A	6	N/A
42	N/A	N/A	6	N/A
43	N/A	N/A	6	N/A
44	N/A	N/A	6	N/A
45	N/A	N/A	6	N/A
46	N/A	N/A	6	N/A
47	N/A	N/A	6	N/A
48	N/A	N/A	7	N/A
49	N/A	N/A	6	N/A
50	N/A	N/A	6	N/A
51	N/A	N/A	6	N/A
52	N/A	N/A	6	N/A
53	N/A	N/A	6	N/A
54	N/A	N/A	6	N/A
55	N/A	N/A	6	N/A
56	N/A	N/A	6	N/A
57	N/A	N/A	6	N/A
58	N/A	N/A	7	N/A
59	N/A	N/A	7	N/A
60	N/A	N/A	6	N/A

B.P. CHEMICALS, INC.
LIMA, OHIO
MIXED WASTE POND CLOSURE

JOB # 4075
DATE: 10-15-93

SURVEY # 613
RWP # 036

GAMMA SURVEY
By
HALLIBURTON NUS CORPORATION

RADIATION SURVEY

JOB # - 4075	B.P. CHEMICALS, LIMA, OHIO MIXED WASTE POND CLOSURE PROJECT BY HALLIBURTON NUS CORPORATION	Survey# 618 RWP# 036 Date 10/18/93 Time 1455 Page 1 of 4

Location: V-1 Pond Test Pad Area

Job Description: Gamma walkover survey; 0.1 mR/hr 92000cpm & 0.1 mR/hr 100 mr/hr

Radiation Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Background
ASP-1 w/SPA-3	2520	11/28/93	1800 cpm
N/A	N/A	N/A	N/A

Contamination Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Eff. %	Background
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
1	N/A	N/A	5.87	* See survey map. (page 4)
2	N/A	N/A	5.65	* The circles represent the change in
3	N/A	N/A	6.09	reading with the arrow indicating the
4	N/A	N/A	5.87	direction of movement to the next change,
5	N/A	N/A	5.65	and readings along the path of the arrow
6	N/A	N/A	5.65	are equal to the last change.
7	N/A	N/A	5.65	* See conversion factor regarding mR/hr.
8	N/A	N/A	5.43	* Three significant numbers were given
9	N/A	N/A	5.43	for mR/hr readings in order to convert
10	N/A	N/A	5.65	to cpm accurately.
11	N/A	N/A	5.65	
12	N/A	N/A	5.65	
13	N/A	N/A	5.65	
14	N/A	N/A	5.65	
15	N/A	N/A	5.87	
16	N/A	N/A	5.87	
17	N/A	N/A	5.87	
18	N/A	N/A	5.65	
19	N/A	N/A	5 87	
20	N/A	N/A	5.65	

Reviewed by: ______________________

RADIATION SURVEY

JOB # - 4075

Survey#	618
RWP#	036
Date	10/18/93
Time	1455
Page	2 of 4

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
21	N/A	N/A	5.43	N/A
22	N/A	N/A	5.87	N/A
23	N/A	N/A	5.65	N/A
24	N/A	N/A	6.09	N/A
25	N/A	N/A	5.65	N/A
26	N/A	N/A	5.43	N/A
27	N/A	N/A	5.65	N/A
28	N/A	N/A	6.09	N/A
29	N/A	N/A	5.87	N/A
30	N/A	N/A	5.65	N/A
31	N/A	N/A	5.87	N/A
32	N/A	N/A	5.87	N/A
33	N/A	N/A	5.65	N/A
34	N/A	N/A	6.09	N/A
35	N/A	N/A	5.43	N/A
36	N/A	N/A	5.43	N/A
37	N/A	N/A	5.43	N/A
38	N/A	N/A	5.65	N/A
39	N/A	N/A	5.87	N/A
40	N/A	N/A	5.87	N/A
41	N/A	N/A	5.87	N/A
42	N/A	N/A	5.65	N/A
43	N/A	N/A	6.09	N/A
44	N/A	N/A	5.65	N/A
45	N/A	N/A	5.65	N/A
46	N/A	N/A	5.43	N/A
47	N/A	N/A	5.65	N/A
48	N/A	N/A	5.87	N/A
49	N/A	N/A	5.87	N/A
50	N/A	N/A	5.87	N/A
51	N/A	N/A	5.65	N/A
52	N/A	N/A	5.43	N/A
53	N/A	N/A	5.65	N/A
54	N/A	N/A	5.65	N/A
55	N/A	N/A	6.09	N/A
56	N/A	N/A	6.09	N/A
57	N/A	N/A	6.09	N/A
58	N/A	N/A	5.87	N/A
59	N/A	N/A	5.43	N/A
60	N/A	N/A	5.87	N/A
61	N/A	N/A	5.43	N/A
62	N/A	N/A	5.43	N/A
63	N/A	N/A	5.43	N/A
64	N/A	N/A	5.65	N/A

RADIATION SURVEY

JOB # - 4075

Survey#	618
RWP#	036
Date	10/18/93
Time	1455
Page	3 of 4

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
65	N/A	N/A	5.87	N/A
66	N/A	N/A	5.65	N/A
67	N/A	N/A	5.87	N/A
68	N/A	N/A	5.87	N/A
69	N/A	N/A	5.65	N/A
70	N/A	N/A	5.43	N/A
71	N/A	N/A	5.65	N/A
72	N/A	N/A	5.65	N/A
73	N/A	N/A	5.87	N/A
74	N/A	N/A	5.43	N/A
75	N/A	N/A	5.87	N/A
76	N/A	N/A	5.87	N/A
77	N/A	N/A	5.87	N/A
78	N/A	N/A	5.65	N/A
79	N/A	N/A	5.87	N/A
80	N/A	N/A	5.65	N/A
81	N/A	N/A	5.87	N/A

B.P. CHEMICALS, INC.
LIMA, OHIO
MIXED WASTE POND CLOSURE

JOB #4075 SURVEY # 618
DATE: 10-18-93 RWP # 036

GAMMA WALKOVER SURVEY
BY
HALLIBURTON NUS CORPORATION

RADIATION SURVEY

JOB # - 4075	B.P. CHEMICALS, LIMA, OHIO MIXED WASTE POND CLOSURE PROJECT BY HALLIBURTON NUS CORPORATION	Survey# 619 RWP# 036 Date 10/18/93 Time 1600 Page 1 of 3

Location: V-1 Pond Test Pad Area

Job Description: Gamma survey of area; each reading was taken at 1 meter from surface.

Radiation Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Background
Ludlum Model 19	44610	03/02/94	2 mR/hr
N/A	N/A	N/A	N/A

Contamination Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Eff. %	Background
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
1	N/A	N/A	6	* See survey map. (page 3)
2	N/A	N/A	6	* Smear location actually indicates
3	N/A	N/A	6	location of reading.
4	N/A	N/A	6	
5	N/A	N/A	6	
6	N/A	N/A	6	
7	N/A	N/A	6	
8	N/A	N/A	6	
9	N/A	N/A	6	
10	N/A	N/A	6	
11	N/A	N/A	6	
12	N/A	N/A	6	
13	N/A	N/A	6	
14	N/A	N/A	6	
15	N/A	N/A	6	
16	N/A	N/A	6	
17	N/A	N/A	6	
18	N/A	N/A	6	
19	N/A	N/A	6	
20	N/A	N/A	6	

Reviewed by: ______________________

RADIATION SURVEY

JOB # - 4075

Survey#	619
RWP#	036
Date	10/18/93
Time	1600
Page	2 of 3

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
21	N/A	N/A	6	N/A
22	N/A	N/A	6	N/A
23	N/A	N/A	6	N/A
24	N/A	N/A	6	N/A
25	N/A	N/A	6	N/A
26	N/A	N/A	6	N/A
27	N/A	N/A	6	N/A
28	N/A	N/A	6	N/A
29	N/A	N/A	6	N/A
30	N/A	N/A	6	N/A
31	N/A	N/A	6	N/A
32	N/A	N/A	6	N/A
33	N/A	N/A	6	N/A
34	N/A	N/A	6	N/A
35	N/A	N/A	6	N/A
36	N/A	N/A	6	N/A
37	N/A	N/A	6	N/A
38	N/A	N/A	6	N/A
39	N/A	N/A	6	N/A
40	N/A	N/A	6	N/A
41	N/A	N/A	6	N/A
42	N/A	N/A	6	N/A
43	N/A	N/A	6	N/A
44	N/A	N/A	6	N/A
45	N/A	N/A	6	N/A
46	N/A	N/A	6	N/A
47	N/A	N/A	6	N/A
48	N/A	N/A	6	N/A
49	N/A	N/A	6	N/A
50	N/A	N/A	6	N/A
51	N/A	N/A	6	N/A
52	N/A	N/A	6	N/A
53	N/A	N/A	6	N/A
54	N/A	N/A	6	N/A
55	N/A	N/A	6	N/A
56	N/A	N/A	6	N/A
57	N/A	N/A	6	N/A
58	N/A	N/A	6	N/A
59	N/A	N/A	6	N/A
60	N/A	N/A	6	N/A

B.P. CHEMICALS, INC.
LIMA, OHIO
MIXED WASTE POND CLOSURE

JOB # 4075
DATE: 10-18-93

SURV[illegible]# 619
RWP [illegible]6

GAMMA SURVEY
By
HALLIBURTON NUS CORPORATION

RADIATION SURVEY

JOB # - 4075	B.P. CHEMICALS, LIMA, OHIO MIXED WASTE POND CLOSURE PROJECT BY HALLIBURTON NUS CORPORATION	Survey# 629 RWP# 036 Date 10/22/93 Time 1615 Page 1 of 4

Location: V-1 Pond Test Pad Area

Job Description: Gamma walkover survey; 0.1 mR/hr 92000cpm & 0.1 mR/hr 100 mr/hr

Radiation Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Background
ASP-1 w/SPA-3	2520	11/28/93	2000 cpm
N/A	N/A	N/A	N/A

Contamination Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Eff. %	Background
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
1	N/A	N/A	5.65	* See survey map. (page 4)
2	N/A	N/A	5.87	* The circles represent the change in
3	N/A	N/A	5.43	reading with the arrow indicating the
4	N/A	N/A	5.65	direction of movement to the next change,
5	N/A	N/A	5.43	and readings along the path of the arrow
6	N/A	N/A	5.65	are equal to the last change.
7	N/A	N/A	5.43	* See conversion factor regarding mR/hr.
8	N/A	N/A	5.65	* Three significant numbers were given
9	N/A	N/A	5.43	for mR/hr readings in order to convert
10	N/A	N/A	5.87	to cpm accurately.
11	N/A	N/A	5.43	
12	N/A	N/A	5.43	
13	N/A	N/A	5.43	
14	N/A	N/A	5.65	
15	N/A	N/A	5.65	
16	N/A	N/A	5.43	
17	N/A	N/A	5.43	
18	N/A	N/A	5.43	
19	N/A	N/A	5.65	
20	N/A	N/A	5.43	

Reviewed by: ______________________

RADIATION SURVEY

JOB # – 4075

Survey#	629
RWP#	036
Date	10/22/93
Time	1615
Page	2 of 4

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	Remarks
21	N/A	N/A	5.43	N/A
22	N/A	N/A	5.43	N/A
23	N/A	N/A	5.65	N/A
24	N/A	N/A	5.43	N/A
25	N/A	N/A	5.65	N/A
26	N/A	N/A	5.43	N/A
27	N/A	N/A	5.43	N/A
28	N/A	N/A	5.65	N/A
29	N/A	N/A	5.43	N/A
30	N/A	N/A	5.43	N/A
31	N/A	N/A	5.43	N/A
32	N/A	N/A	5.65	N/A
33	N/A	N/A	5.43	N/A
34	N/A	N/A	5.43	N/A
35	N/A	N/A	5.65	N/A
36	N/A	N/A	5.43	N/A
37	N/A	N/A	5.65	N/A
38	N/A	N/A	5.43	N/A
39	N/A	N/A	5.43	N/A
40	N/A	N/A	5.65	N/A
41	N/A	N/A	5.43	N/A
42	N/A	N/A	5.65	N/A
43	N/A	N/A	5.43	N/A
44	N/A	N/A	5.43	N/A
45	N/A	N/A	5.65	N/A
46	N/A	N/A	5.43	N/A
47	N/A	N/A	5.65	N/A
48	N/A	N/A	5.43	N/A
49	N/A	N/A	5.43	N/A
50	N/A	N/A	5.43	N/A
51	N/A	N/A	5.65	N/A
52	N/A	N/A	5.65	N/A
53	N/A	N/A	5.43	N/A
54	N/A	N/A	5.65	N/A
55	N/A	N/A	5.43	N/A
56	N/A	N/A	5.22	N/A
57	N/A	N/A	5.43	N/A
58	N/A	N/A	5.22	N/A
59	N/A	N/A	5.43	N/A
60	N/A	N/A	5.65	N/A
61	N/A	N/A	5.43	N/A
62	N/A	N/A	5.65	N/A
63	N/A	N/A	5.87	N/A
64	N/A	N/A	5.65	N/A

RADIATION SURVEY

JOB # – 4075

Survey#	629
RWP#	036
Date	10/22/93
Time	1615
Page	3 of 4

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
65	N/A	N/A	5.87	N/A
66	N/A	N/A	5.43	N/A
67	N/A	N/A	5.43	N/A
68	N/A	N/A	5.43	N/A
69	N/A	N/A	5.65	N/A
70	N/A	N/A	5.43	N/A
71	N/A	N/A	5.87	N/A
72	N/A	N/A	5.87	N/A
73	N/A	N/A	5.87	N/A
74	N/A	N/A	5.65	N/A
75	N/A	N/A	5.43	N/A
76	N/A	N/A	5.65	N/A
77	N/A	N/A	5.43	N/A
78	N/A	N/A	5.43	N/A
79	N/A	N/A	5.43	N/A
80	N/A	N/A	5.65	N/A
81	N/A	N/A	5.87	N/A
82	N/A	N/A	5.65	N/A
83	N/A	N/A	5.87	N/A
84	N/A	N/A	5.87	N/A
85	N/A	N/A	5.65	N/A
86	N/A	N/A	5.87	N/A
87	N/A	N/A	5.65	N/A
88	N/A	N/A	5.43	N/A
89	N/A	N/A	5.65	N/A
90	N/A	N/A	5.43	N/A

B.P. CHEMICALS, INC.
LIMA, O
MIXED WASTE POND CLOSURE

JOB # 4075 SURVEY # 6
DATE: 10-22-93 RWP # 0

GAMMA WALKOVER SURVEY
By
HALLIBURTON NUS CORPORATION

100'-0"

80'-0"

6 5	4	3	2 1
7	8 9	10 11	12
17	16	15	14 13
18		19	21
26 25	24	23	22
27	28	29	30
34		33 32	31
35 36 37	38	39	40
45	44	43	42 41
46 47	48 49		50
57 56	55 54	53	52 51
58 59	60 61	62 63	64
68		67	66 65
69	70	71 72	73
79	78	77 76	75 74
80	81 82	83	84
90	89	88 87	86 85

RADIATION SURVEY

JOB # - 4075	B.P. CHEMICALS, LIMA, OHIO MIXED WASTE POND CLOSURE PROJECT BY HALLIBURTON NUS CORPORATION	Survey# 630 RWP# 036 Date 10/22/93 Time 1715 Page 1 of 3

Location: V-1 Pond Test Pad Area

Job Description: Gamma survey of area; each reading was taken at 1 meter from surface.

Radiation Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Background
Ludlum Model 19	44610	03/02/94	2 mR/hr
N/A	N/A	N/A	N/A

Contamination Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Eff. %	Background
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
1	N/A	N/A	7	* See survey map. (page 3)
2	N/A	N/A	6	* Smear location actually indicates
3	N/A	N/A	6	location of reading.
4	N/A	N/A	7	
5	N/A	N/A	7	
6	N/A	N/A	6	
7	N/A	N/A	6	
8	N/A	N/A	6	
9	N/A	N/A	6	
10	N/A	N/A	6	
11	N/A	N/A	6	
12	N/A	N/A	6	
13	N/A	N/A	6	
14	N/A	N/A	6	
15	N/A	N/A	6	
16	N/A	N/A	6	
17	N/A	N/A	6	
18	N/A	N/A	6	
19	N/A	N/A	6	
20	N/A	N/A	6	

Reviewed by: ____________________

RADIATION SURVEY

JOB # – 4075

Survey#	630
RWP#	036
Date	10/22/93
Time	1715
Page	2 of 3

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
21	N/A	N/A	6	N/A
22	N/A	N/A	[illegible]	N/A
23	N/A	N/A	6	N/A
24	N/A	N/A	6	N/A
25	N/A	N/A	6	N/A
26	N/A	N/A	6	N/A
27	N/A	N/A	6	N/A
28	N/A	N/A	6	N/A
29	N/A	N/A	6	N/A
30	N/A	N/A	6	N/A
31	N/A	N/A	6	N/A
32	N/A	N/A	6	N/A
33	N/A	N/A	6	N/A
34	N/A	N/A	7	N/A
35	N/A	N/A	7	N/A
36	N/A	N/A	6	N/A
37	N/A	N/A	6	N/A
38	N/A	N/A	6	N/A
39	N/A	N/A	6	N/A
40	N/A	N/A	7	N/A
41	N/A	N/A	7	N/A
42	N/A	N/A	6	N/A
43	N/A	N/A	6	N/A
44	N/A	N/A	6	N/A
45	N/A	N/A	6	N/A
46	N/A	N/A	7	N/A
47	N/A	N/A	7	N/A
48	N/A	N/A	6	N/A
49	N/A	N/A	6	N/A
50	N/A	N/A	6	N/A
51	N/A	N/A	6	N/A
52	N/A	N/A	6	N/A
53	N/A	N/A	7	N/A
54	N/A	N/A	6	N/A
55	N/A	N/A	6	N/A
56	N/A	N/A	6	N/A
57	N/A	N/A	6	N/A
58	N/A	N/A	6	N/A
59	N/A	N/A	6	N/A
60	N/A	N/A	6	N/A

B.P. CHEMICALS, INC.
LIMA, OHIO
MIXED WASTE POND CLOSURE

JOB # 4075
DATE: 10-22-93

SURVEY # 630
RWP [illegible]36

GAMMA SURVEY
By
HALLIBURTON NUS CORPORATION

RADIATION SURVEY

JOB # - 4075	B.P. CHEMICALS, LIMA, OHIO MIXED WASTE POND CLOSURE PROJECT BY HALLIBURTON NUS CORPORATION	Survey# 639 RWP# 036 Date 10/26/93 Time 0800 Page 1 of 4

Location: V-1 Pond Test Pad Area

Job Description: Gamma walkover survey; 0.1 mR/hr 92000cpm & 0.1 mR/hr 100 mr/hr

Radiation Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Background
ASP-1 w/SPA-3	2520	11/28/93	1800 cpm
N/A	N/A	N/A	N/A

Contamination Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Eff. %	Background
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
1	N/A	N/A	5.87	* See survey map. (page 4)
2	N/A	N/A	5.43	* The circles represent the change in
3	N/A	N/A	5.87	reading with the arrow indicating the
4	N/A	N/A	5.65	direction of movement to the next change,
5	N/A	N/A	5.65	and readings along the path of the arrow
6	N/A	N/A	5.65	are equal to the last change.
7	N/A	N/A	5.87	* See conversion factor regarding mR/hr.
8	N/A	N/A	5.65	* Three significant numbers were given
9	N/A	N/A	5.87	for mR/hr readings in order to convert
10	N/A	N/A	5.87	to cpm accurately.
11	N/A	N/A	5.87	
12	N/A	N/A	5.65	
13	N/A	N/A	5.87	
14	N/A	N/A	5.65	
15	N/A	N/A	5.43	
16	N/A	N/A	5.43	
17	N/A	N/A	5.43	
18	N/A	N/A	5.65	
19	N/A	N/A	5.43	
20	N/A	N/A	5.65	

Reviewed by: ______________________

RADIATION SURVEY

JOB # – 4075

Survey#	639
RWP#	036
Date	10/26/93
Time	0800
Page	2 of 4

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
21	N/A	N/A	5.65	N/A
22	N/A	N/A	5.87	N/A
23	N/A	N/A	5.65	N/A
24	N/A	N/A	5.87	N/A
25	N/A	N/A	5.43	N/A
26	N/A	N/A	5.65	N/A
27	N/A	N/A	5.43	N/A
28	N/A	N/A	5.65	N/A
29	N/A	N/A	5.43	N/A
30	N/A	N/A	5.87	N/A
31	N/A	N/A	5.65	N/A
32	N/A	N/A	5.87	N/A
33	N/A	N/A	5.65	N/A
34	N/A	N/A	5.43	N/A
35	N/A	N/A	5.65	N/A
36	N/A	N/A	5.65	N/A
37	N/A	N/A	5.65	N/A
38	N/A	N/A	5.87	N/A
39	N/A	N/A	6.09	N/A
40	N/A	N/A	5.65	N/A
41	N/A	N/A	5.87	N/A
42	N/A	N/A	5.87	N/A
43	N/A	N/A	5.65	N/A
44	N/A	N/A	5.87	N/A
45	N/A	N/A	5.65	N/A
46	N/A	N/A	5.65	N/A
47	N/A	N/A	5.65	N/A
48	N/A	N/A	5.87	N/A
49	N/A	N/A	5.65	N/A
50	N/A	N/A	5.87	N/A
51	N/A	N/A	5.65	N/A
52	N/A	N/A	5.87	N/A
53	N/A	N/A	5.65	N/A
54	N/A	N/A	5.43	N/A
55	N/A	N/A	5.87	N/A
56	N/A	N/A	5.65	N/A
57	N/A	N/A	5.65	N/A
58	N/A	N/A	5.65	N/A
59	N/A	N/A	5.43	N/A
60	N/A	N/A	5.87	N/A
61	N/A	N/A	6.09	N/A
62	N/A	N/A	6.09	N/A
63	N/A	N/A	5.87	N/A
64	N/A	N/A	5.65	N/A

RADIATION SURVEY

JOB # - 4075

Survey#	639
RWP#	036
Date	10/26/93
Time	0800
Page	3 of 4

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
65	N/A	N/A	5.87	N/A
66	N/A	N/A	5.65	N/A
67	N/A	N/A	5.43	N/A
68	N/A	N/A	5.87	N/A
69	N/A	N/A	5.65	N/A
70	N/A	N/A	5.87	N/A
71	N/A	N/A	5.87	N/A
72	N/A	N/A	6.09	N/A
73	N/A	N/A	5.65	N/A
74	N/A	N/A	5.87	N/A
75	N/A	N/A	5.65	N/A
76	N/A	N/A	5.65	N/A
77	N/A	N/A	5.65	N/A
78	N/A	N/A	5.87	N/A
79	N/A	N/A	5.87	N/A

B.P. CHEMICALS, INC.
LIMA, OHIO
MIXED WASTE POND CLOSURE

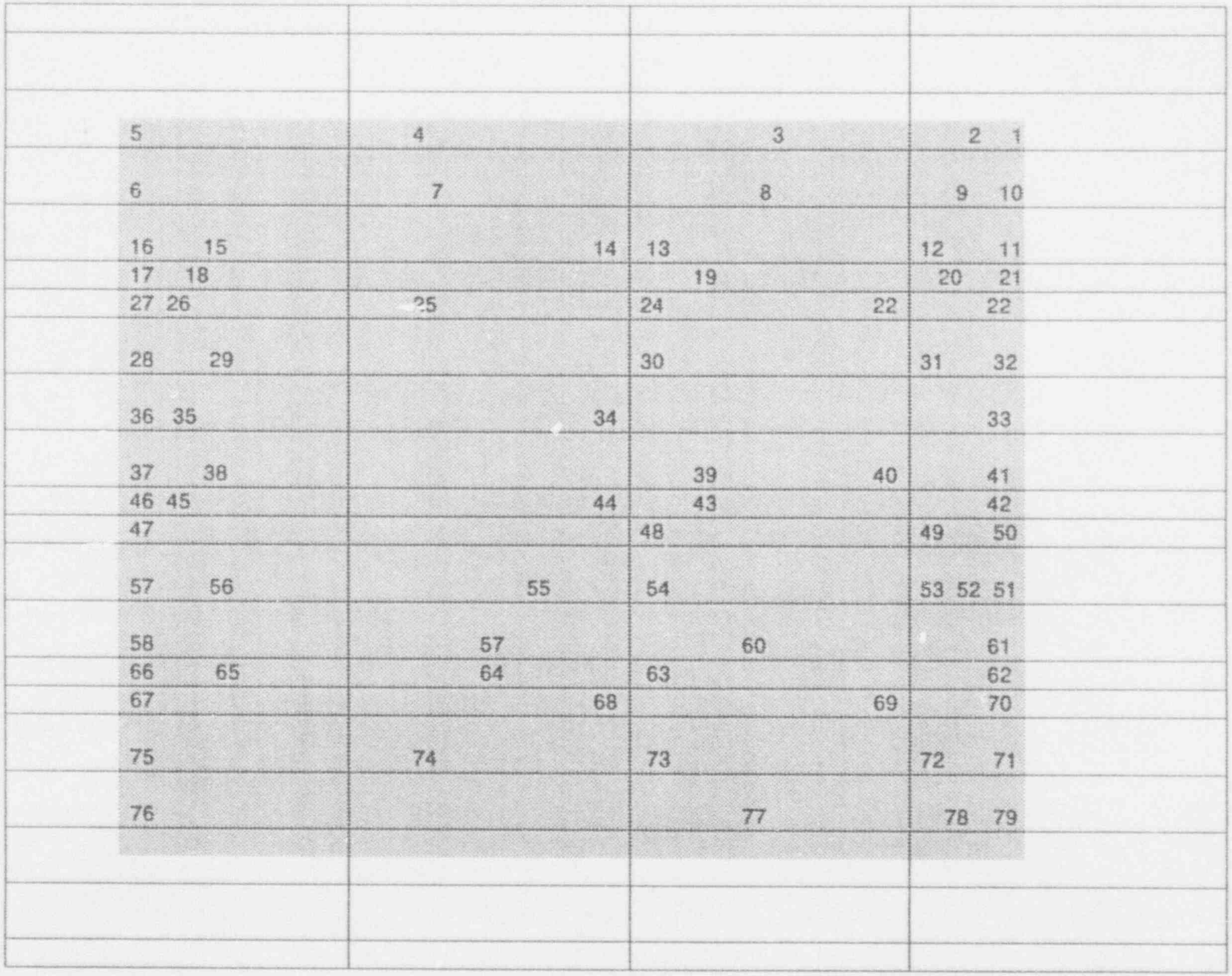
JOB # 4075 SURVEY # 63
DATE: 10-26-93 RWP # 036

GAMMA WALKOVER SURVEY
By
HALLIBURTON NUS CORPORATION

(Lift is within center of shaded area)

100'-0"

80'-0"



RADIATION SURVEY

JOB # - 4075	B.P. CHEMICALS, LIMA, OHIO MIXED WASTE POND CLOSURE PROJECT BY HALLIBURTON NUS CORPORATION	Survey# 640 RWP# 036 Date 10/26/93 Time 0855 Page 1 of 3

Location: V-1 Pond Test Pad Area

Job Description: Gamma survey of area; each reading was taken at 1 meter from surface.

Radiation Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Background
Ludlum Model 19	44610	03/02/94	2 mR/hr
N/A	N/A	N/A	N/A

Contamination Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Eff. %	Background
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
1	N/A	N/A	7	* See survey map. (page 3)
2	N/A	N/A	7	* Smear location actually indicates
3	N/A	N/A	7	location of reading .
4	N/A	N/A	7	
5	N/A	N/A	7	
6	N/A	N/A	7	
7	N/A	N/A	7	
8	N/A	N/A	6	
9	N/A	N/A	7	
10	N/A	N/A	7	
11	N/A	N/A	7	
12	N/A	N/A	7	
13	N/A	N/A	7	
14	N/A	N/A	7	
15	N/A	N/A	7	
16	N/A	N/A	7	
17	N/A	N/A	7	
18	N/A	N/A	7	
19	N/A	N/A	7	
20	N/A	N/A	7	

Reviewed by: ______________________

RADIATION SURVEY

JOB # - 4075

Survey#	640
RWP#	036
Date	10/26/93
Time	0855
Page	2 of 3

Survey Results:

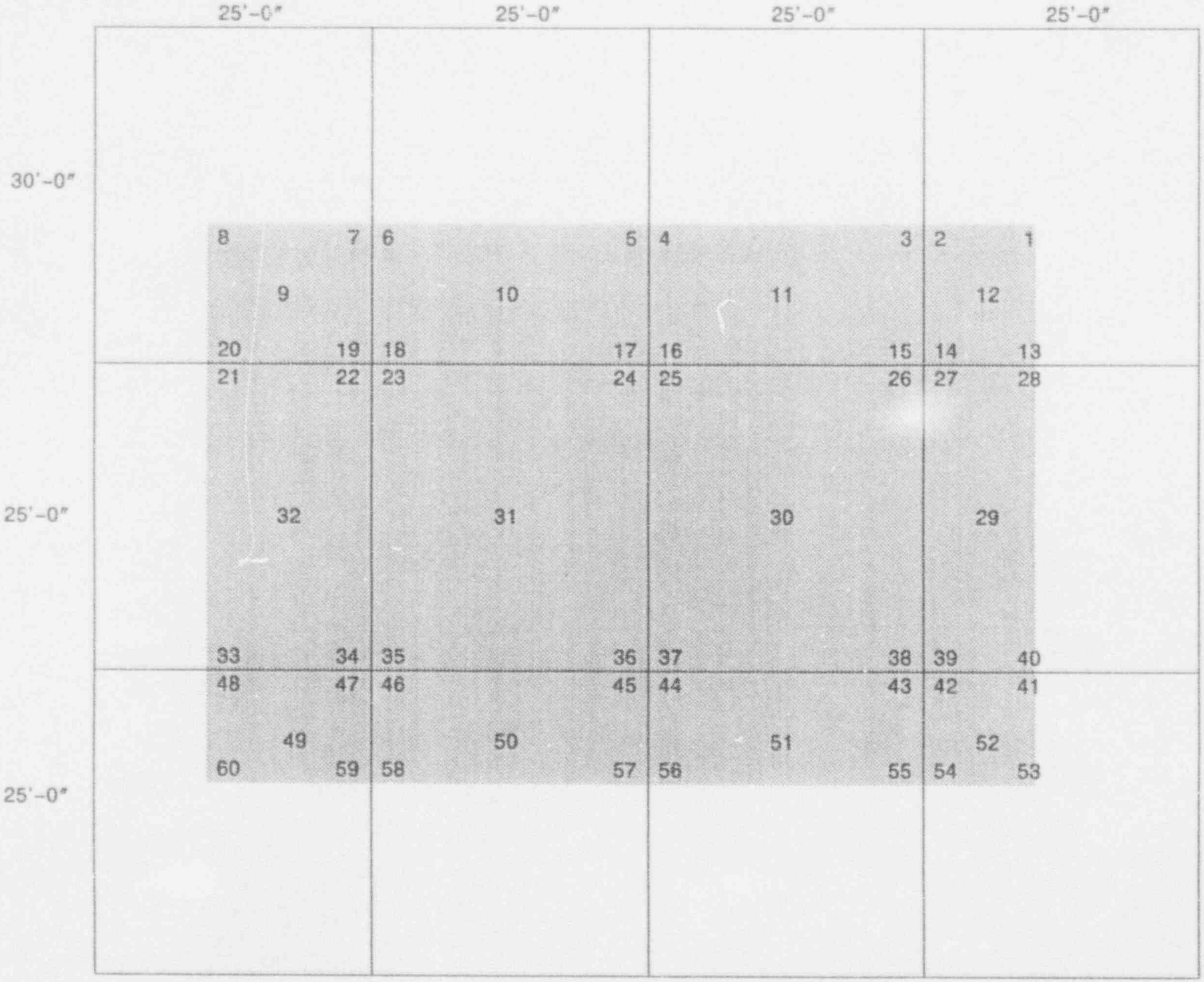
Smear Location	ccpm/smear	dpm/smear	uR/hr	Remarks
21	N/A	N/A	7	N/A
22	N/A	N/A	7	N/A
23	N/A	N/A	7	N/A
24	N/A	N/A	7	N/A
25	N/A	N/A	7	N/A
26	N/A	N/A	7	N/A
27	N/A	N/A	7	N/A
28	N/A	N/A	7	N/A
29	N/A	N/A	7	N/A
30	N/A	N/A	7	N/A
31	N/A	N/A	7	N/A
32	N/A	N/A	7	N/A
33	N/A	N/A	7	N/A
34	N/A	N/A	7	N/A
35	N/A	N/A	7	N/A
36	N/A	N/A	6	N/A
37	N/A	N/A	7	N/A
38	N/A	N/A	7	N/A
39	N/A	N/A	7	N/A
40	N/A	N/A	7	N/A
41	N/A	N/A	7	N/A
42	N/A	N/A	7	N/A
43	N/A	N/A	7	N/A
44	N/A	N/A	7	N/A
45	N/A	N/A	6	N/A
46	N/A	N/A	7	N/A
47	N/A	N/A	7	N/A
48	N/A	N/A	7	N/A
49	N/A	N/A	7	N/A
50	N/A	N/A	7	N/A
51	N/A	N/A	7	N/A
52	N/A	N/A	7	N/A
53	N/A	N/A	7	N/A
54	N/A	N/A	7	N/A
55	N/A	N/A	7	N/A
56	N/A	N/A	7	N/A
57	N/A	N/A	7	N/A
58	N/A	N/A	7	N/A
59	N/A	N/A	7	N/A
60	N/A	N/A	6	N/A

B.P. CHEMICALS, INC.
LIMA, OH
MIXED WASTE POND CLOSURE

JOB # 4075
DATE: 10-26-93

SURVEY # 640
RWP # 036

GAMMA SURVEY
By
HALLIBURTON NUS CORPORATION



RADIATION SURVEY

JOB # - 4075	B.P. CHEMICALS, LIMA, OHIO MIXED WASTE POND CLOSURE PROJECT BY HALLIBURTON NUS CORPORATION	Survey# 646 RWP# 036 Date 10/27/93 Time 1430 Page 1 of 3

Location: V-1 Pond Test Pad Area

Job Description: Gamma walkover survey; 0.1 mR/hr 92000cpm & 0.1 mR/hr 100 mr/hr

Radiation Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Background
ASP-1 w/SPA-3	2520	11/28/93	1800 cpm
N/A	N/A	N/A	N/A

Contamination Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Eff. %	Background
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
1	N/A	N/A	5.65	* See survey map. (page 3)
2	N/A	N/A	5.43	* The circles represent the change in
3	N/A	N/A	5.43	reading with the arrow indicating the
4	N/A	N/A	5.22	direction of movement to the next change,
5	N/A	N/A	5.43	and readings along the path of the arrow
6	N/A	N/A	5.22	are equal to the last change.
7	N/A	N/A	5.43	* See conversion factor regarding pR/hr.
8	N/A	N/A	5.65	* Three significant numbers were given
9	N/A	N/A	5.43	for pR/hr readings in order to convert
10	N/A	N/A	5.43	to cpm accurately.
11	N/A	N/A	5.43	
12	N/A	N/A	5.43	
13	N/A	N/A	5.43	
14	N/A	N/A	5.65	
15	N/A	N/A	5.43	
16	N/A	N/A	5.22	
17	N/A	N/A	5.65	
18	N/A	N/A	5.87	
19	N/A	N/A	5.65	
20	N/A	N/A	5.65	

Reviewed by: ____________________

RADIATION SURVEY

JOB # – 4075

Survey#	646
RWP#	036
Date	10/27/93
Time	1430
Page	2 of 3

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
21	N/A	N/A	5.43	N/A
22	N/A	N/A	5.65	N/A
23	N/A	N/A	5.22	N/A
24	N/A	N/A	5.43	N/A
25	N/A	N/A	5.43	N/A
26	N/A	N/A	5.43	N/A
27	N/A	N/A	5.65	N/A
28	N/A	N/A	5.65	N/A
29	N/A	N/A	5.87	N/A
30	N/A	N/A	5.43	N/A
31	N/A	N/A	5.43	N/A
32	N/A	N/A	5.43	N/A
33	N/A	N/A	5.22	N/A
34	N/A	N/A	5.43	N/A
35	N/A	N/A	5.65	N/A
36	N/A	N/A	5.43	N/A
37	N/A	N/A	5.22	N/A
38	N/A	N/A	5.43	N/A
39	N/A	N/A	5.65	N/A
40	N/A	N/A	5.43	N/A
41	N/A	N/A	5.22	N/A
42	N/A	N/A	5.65	N/A
43	N/A	N/A	5.87	N/A
44	N/A	N/A	5.65	N/A
45	N/A	N/A	5.65	N/A
46	N/A	N/A	5.87	N/A
47	N/A	N/A	5.43	N/A
48	N/A	N/A	5.65	N/A
49	N/A	N/A	5.43	N/A
50	N/A	N/A	5.22	N/A
51	N/A	N/A	5.43	N/A
52	N/A	N/A	5.65	N/A
53	N/A	N/A	5.43	N/A
54	N/A	N/A	5.65	N/A
55	N/A	N/A	5.43	N/A

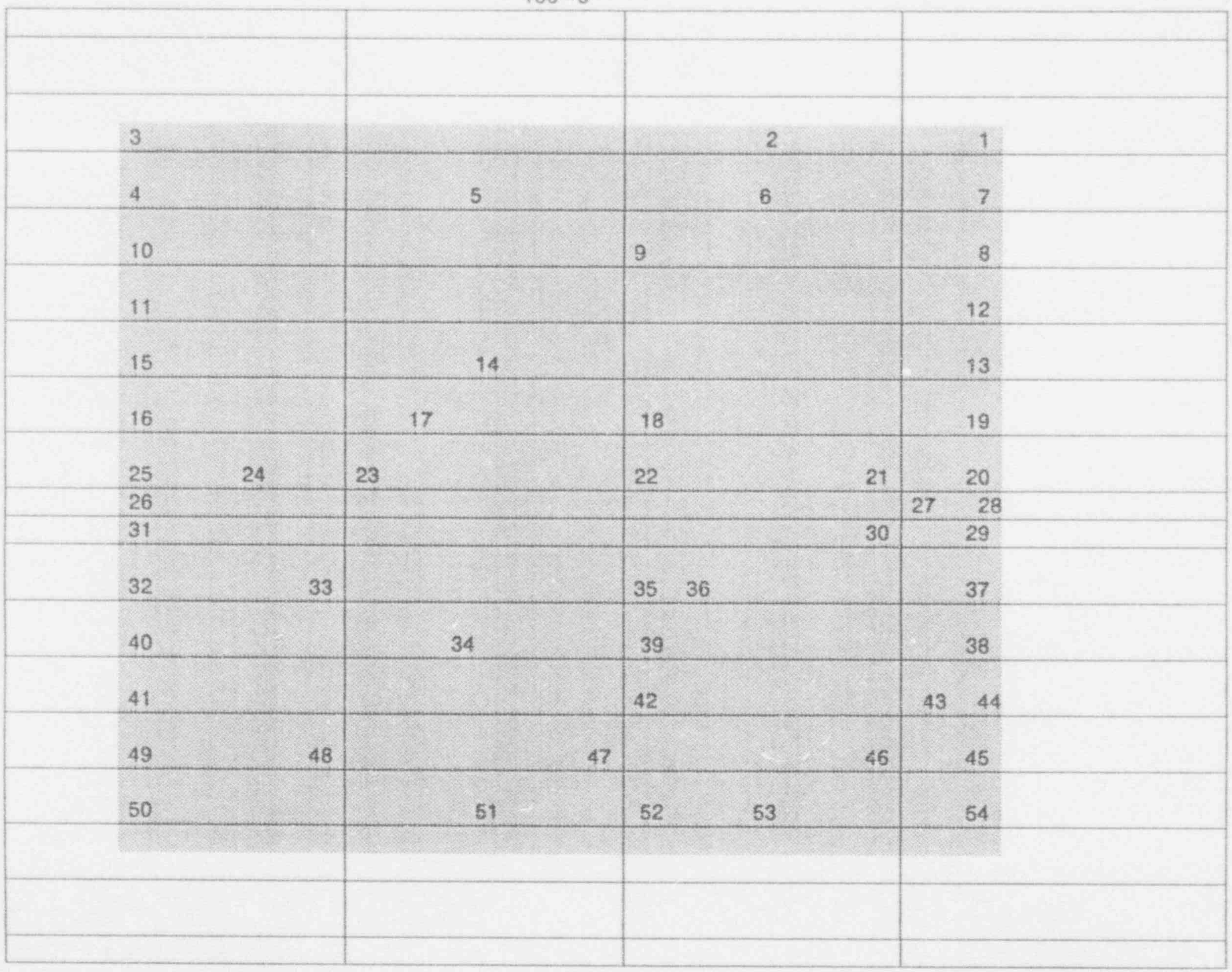
B.P. CHE[illegible]CALS, INC.
LIMA, O[illegible]
MIXED WASTE POND CLOSURE

JOB # 4075 SURVEY # 646
DATE: 10-27-93 RWP # 036

GAMMA WALKOVER S[illegible]EY
By
HALLIBURTON NUS CORPORATION

100'-0"

80'-0"



RADIATION SURVEY

JOB # - 4075	B.P. CHEMICALS, LIMA, OHIO MIXED WASTE POND CLOSURE PROJECT BY HALLIBURTON NUS CORPORATION	Survey# 647 RWP# 036 Date 10/27/93 Time 1515 Page 1 of 3

Location: V-1 Pond Test Pad Area

Job Description: Gamma survey of area; each reading was taken at 1 meter from surface

Radiation Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Background
Ludlum Model 19	44610	03/02/94	2 uR/hr
N/A	N/A	N/A	N/A

Contamination Survey Instruments:

Instrument Type	S/N #	Cal. Due Date	Eff. %	Background
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
1			7	* See survey map . (page 3)
2			7	* Smear location actually indicates location
3			7	of reading.
4			6	
5			6	
6			7	
7			7	
8			6	
9			6	
10			6	
11			7	
12			7	
13			7	
14			7	
15			7	
16			7	
17			7	
18			7	
19			7	
20			6	

Reviewed by: ______________________

RADIATION SURVEY

JOB # – 4075

Survey#	647
RWP#	036
Date	10/27/93
Time	1515
Page	2 of 3

Survey Results:

Smear Location	ccpm/smear	dpm/smear	uR/hr	*Remarks*
21	N/A	N/A	6	N/A
22	N/A	N/A	7	N/A
23	N/A	N/A	7	N/A
24	N/A	N/A	7	N/A
25	N/A	N/A	7	N/A
26	N/A	N/A	7	N/A
27	N/A	N/A	7	N/A
28	N/A	N/A	7	N/A
29	N/A	N/A	7	N/A
30	N/A	N/A	7	N/A
31	N/A	N/A	6	N/A
32	N/A	N/A	6	N/A
33	N/A	N/A	6	N/A
34	N/A	N/A	6	N/A
35	N/A	N/A	6	N/A
36	N/A	N/A	6	N/A
37	N/A	N/A	6	N/A
38	N/A	N/A	6	N/A
39	N/A	N/A	6	N/A
40	N/A	N/A	7	N/A
41	N/A	N/A	7	N/A
42	N/A	N/A	6	N/A
43	N/A	N/A	6	N/A
44	N/A	N/A	6	N/A
45	N/A	N/A	6	N/A
46	N/A	N/A	6	N/A
47	N/A	N/A	6	N/A
48	N/A	N/A	6	N/A
49	N/A	N/A	7	N/A
50	N/A	N/A	7	N/A
51	N/A	N/A	7	N/A
52	N/A	N/A	7	N/A
53	N/A	N/A	7	N/A
54	N/A	N/A	6	N/A
55	N/A	N/A	6	N/A
56	N/A	N/A	6	N/A
57	N/A	N/A	6	N/A
58	N/A	N/A	6	N/A
59	N/A	N/A	6	N/A
60	N/A	N/A	7	N/A

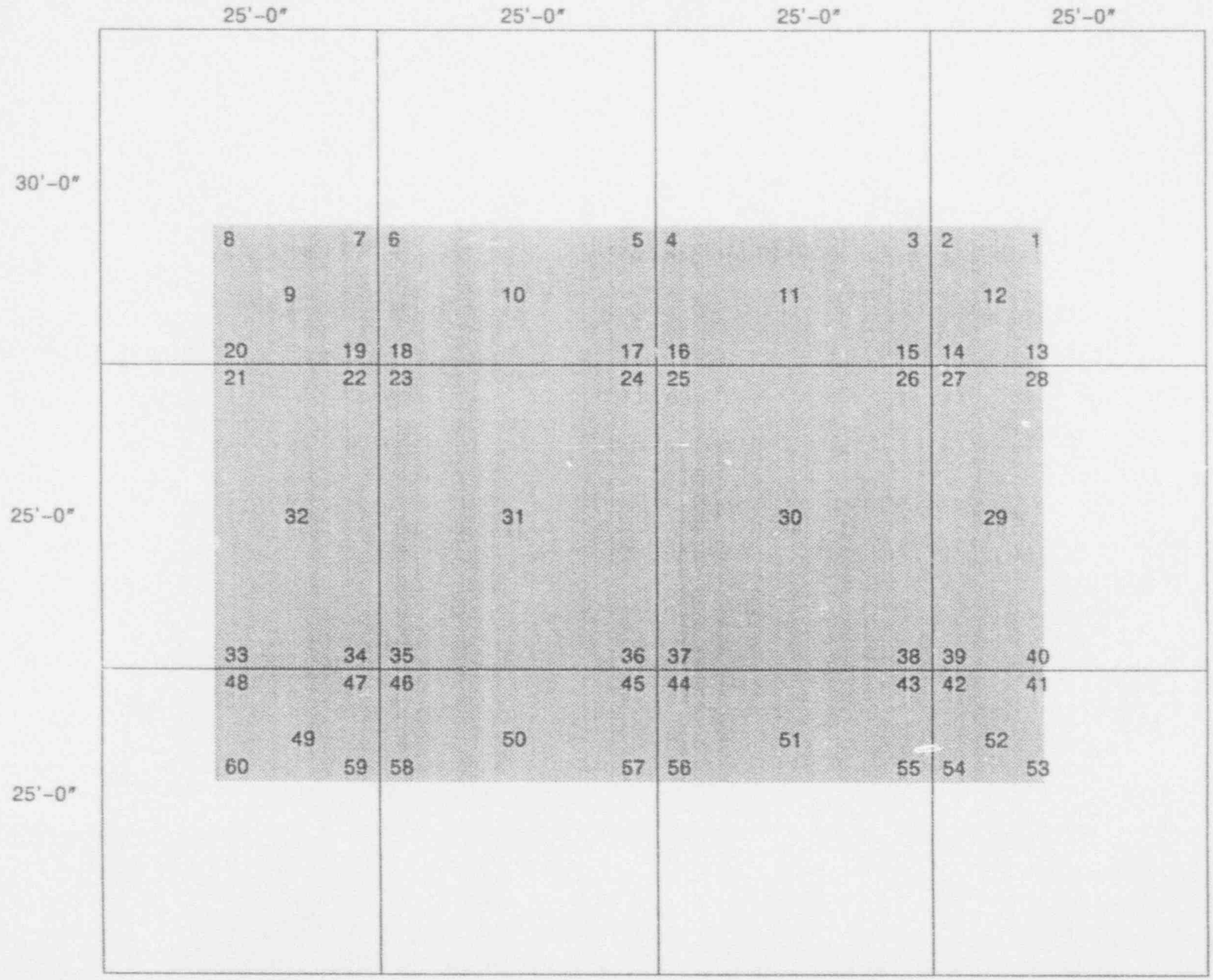
B.P. CHEMICALS, INC.
LIMA, OH
MIXED WASTE POND CLOSURE

JOB # 4075
DATE: 10-27-93

SURVEY # 647
RWP # 036

GAMMA SURVEY
By
HALLIBURTON NUS CORPORATION

(Shaded area represents the top of the Fill Pad)



APPENDIX E
Section 2 of the Quality Assurance Project Plan

2.0 QUALITY ASSURANCE PROJECT PLAN

SOIL SAMPLING

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

2.0 SOIL SAMPLING QUALITY ASSURANCE PROJECT PLAN

2.1 INTRODUCTION

This Quality Assurance Project Plan (QAPjP) presents the policies, organization, objectives, functional activities, and specific quality assurance (QA) and quality control (QC) activities to ensure that data of known quality is generated in the conduct of soil sampling and analyses for the Mixed Waste Pond Closure Project at the BP Chemical, Inc. Lima, Ohio facility. The QAPjP is intended to ensure that all technical data generated are sufficiently accurate, precise and representative to support the intended use of the data.

QC consists of a system of checks on field sampling and laboratory analysis (through the use of field blanks, duplicates, documentation of all sample movement, chain of custody records, etc.) to provide supporting information on the quality of the methods employed and on the data. QA consists of overview checking to certify that the QC procedures have been properly implemented to produce accurate data. QA is in general a supervisory function. All QA/QC procedures will accord with applicable technical standards, government regulations and guidelines, and specific project goals and requirements. This QAPjP is prepared in accordance with all OEPA and USEPA guidance documents and incorporates relevant provisions of HASL-300.

The QAPjP presents QA/QC provisions applicable to the following activities:

- Sample collection, control, chain-of-custody, and analysis;
- Document control;
- General laboratory instrumentation, analysis, and control; and
- Review of project reports.

Specific laboratory QA, instrumentation and control protocols are found in the Laboratory's Quality Assurance Project Plan (LQAPjP) which is incorporated into this document by reference.

2.2 PROJECT DESCRIPTION

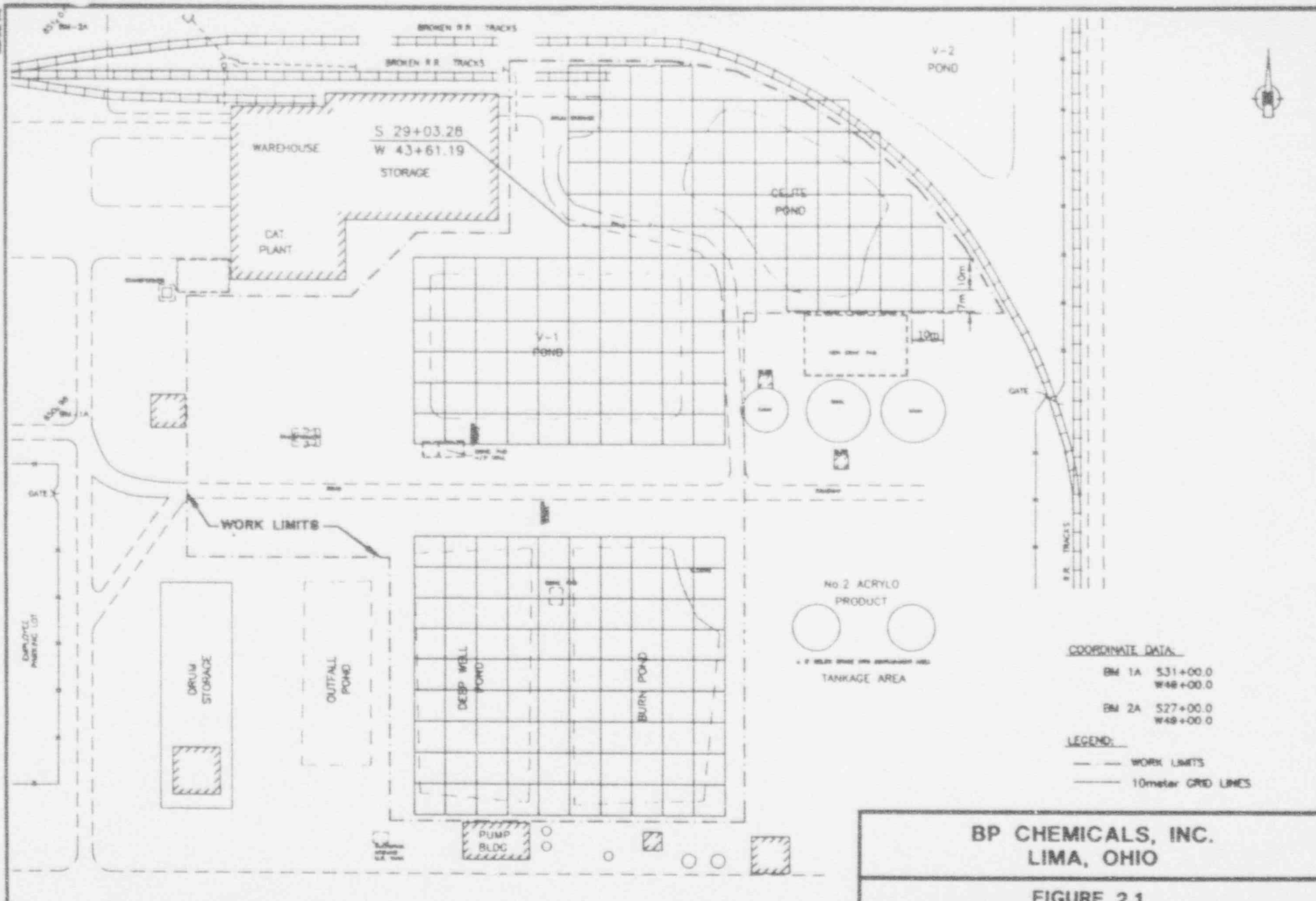
Soil sampling will be conducted as part of a mixed waste pond closure project at BP Chemical, Inc.'s Lima facility. Four surface impoundments at the facility -- Burn, Deepwell, Celite and V-1 impoundments-- will be closed. Specific closure activities are described in detail in BP Chemical's "Closure Plan, Mixed Waste Pond Closure Project, BP Chemicals, Inc., Lima, Ohio, June 12, 1991."

2.2.1 SITE DESCRIPTION

The four surface impoundments to be closed are located on BP Chemical property in Lima, Ohio and are shown on Figure 2-1. Descriptions of the impoundments can be found in the Closure Plan referenced above.

2.2.2 SITE BACKGROUND

Until mid-1988, the Burn, Deepwell, and Celite Ponds managed acrylonitrile, acetonitrile and catalyst-process waste waters which resulted in pond sludges containing the EPA-listed wastes K011, K013, and K014, as well as low levels of depleted uranium. The V-1 Pond was used to manage caustic waste waters and was found to contain low levels of depleted uranium. The sludges in all four ponds are classified as radioactive mixed waste.



NOTES:

1. TYPICAL GRID SPACING IS 10 SQ. METERS UNLESS OTHER WISE NOTED.
2. SAMPLING GRID IN THE AREA OF THE DEEP WELL & BURN POND NOT ESTABLISHED AS OF 7/92.

BP CHEMICALS, INC.
LIMA, OHIO

FIGURE 2.1

POND AREAS SHOWING
10 METER SAMPLING GRID

DAMES & MOORE

JOB No: 22007-001-152

As described in the Closure Plan, the sludges in the four surface impoundments will be excavated and treated, and the underlying soils will be sampled and analyzed for target parameters (discussed in Section 2.2.3). In order to minimize the post-closure footprint of the ponds, the sludges and contaminated soils from the four ponds will be consolidated into two ponds.

The closure cells will be located in the area now occupied by the Celite and V-1 ponds. Excavation of the soil in the Celite and V-1 ponds will be conducted until contaminated soil is removed. If this is not practical, a risk assessment will be performed to determine if constituents in the soil may be safely left in place. A risk assessment will determine if leaving the soils in place represents a potential threat to human health and the environment. The risk assessment will be performed in accordance with OEPA's "Closure Plan Review Guidance." The excavation will be kept open until such time as OEPA has reviewed the findings of the risk assessment. Due to the possible presence of radioactive constituents in the soil, Oak Ridge Associated Universities must conduct a survey of the pond bottoms to determine if they are suitable for license termination and unrestricted release.

The Deepwell and Burn ponds will be clean closed, if clean closure is found to be technically feasible. Feasibility will be determined after sludge removal, when it is possible to sample the underlying soil. The objective of clean closure of the Burn and Deepwell ponds is to remove contaminated soils until the concentrations of all of the hazardous constituents in the ponds are below acceptable "clean levels" (i.e. either background levels or method detection limits as defined in the Closure Plan). Similar to the Celite and V-1 ponds, Oak Ridge Associated Universities must conduct a survey of the pond bottoms to determine if they are suitable for license termination and unrestricted release.

This risk assessment will be prepared following receipt of the analytical results so that the potential risks associated with the constituents may be estimated individually and in combination. However, the framework for the assessment will be prepared in advance. This schedule will prevent delay of closure activities.

The excavated sludges will be stabilized with cement admixtures before being placed in the closure cells to provide stability and to bind up the contaminants. The stabilization will be done in a temporary processing plant constructed on-site and will be in accordance with laboratory-tested solidification agents-sludge mix design specifications.

Liquids removed from the ponds during closure operations will be disposed of as hazardous waste in accordance with currently permitted practices at the BP Chemicals, Inc. facility.

The closure cells will be constructed in accordance with the requirements of RCRA section 3004(o). The cells will have a dual liner system, a leachate collection system, and a leak detection system below the stabilized sludges and contaminated soil. The cells will be covered with a cap that conforms to RCRA requirements and includes drainage layers, a compacted clay barrier layer, and synthetic membrane liners. Storm water control will be provided during closure operations and the closure period.

Because depleted uranium (U^{238}) has a very long half-life, a pathway analysis was performed. The analysis assumed that institutional control of the site had ceased, the stability and recognizability of the waste form was lost, and all barriers constructed above and below the sludges had disintegrated. The results of this analysis indicated that the dose that would be received by the hypothetical maximally exposed individual, an intruder, would be a fraction of normal background exposure in the area.

After closure is completed, the closure cells will be monitored and maintained, as required, by BP Chemicals, Inc. The closure cell design is such that active maintenance will not be required. Post-closure monitoring will consist of groundwater monitoring, which has already been instituted for the area beneath and around the ponds. The groundwater monitoring program currently in place at BP consists of two upgradient wells and nine downgradient wells. The wells screen the uppermost aquifer in the bedrock and range in depth from 51.3 ft. to 72.1 ft. There will also be periodic inspections of various design features of the closed facility.

2.2.3 TESTING AND SAMPLING

In order to estimate the extent of the contamination in the soil in the four impoundment areas, soil sampling and analyses will be performed. Samples will be taken of the soil using split spoon samplers from each impoundment area after the sludges have been removed, and the underlying clay has been exposed. The excavated area will be surveyed for radiological contamination, and the samples will be screened in the field for organic contamination. The specific sequence and procedures followed are summarized in Section 2.5 "Sampling Procedures" below, and in detail in the Closure Plan.

Samples will be analyzed for the following parameters:

- Volatile organics - acetone, acetonitrile, acrylonitrile, trichloroethylene, 1,1-dichloroethane, vinyl chloride, 1,1-dichloroethylene, methyl ethyl ketone, tetrachloroethylene, 1,1,1-trichloroethane and bromomethane;

- Semi-volatile organics - methyl naphthalene and pyridine;

- RCRA total metals - arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver;

- Cyanide; and

- Radioactivity (U^{238}).

The analytical results of this effort will be compared to "clean" soil levels as specified in the project Closure Plan (concentration limits and/or as estimated through a health based risk assessment) . If the results indicate higher concentrations then those established for the clean levels then additional samples below the 2-foot interval will be taken in the respective areas. Additional samples will be obtained and analyzed in this manner until acceptable contaminant concentration levels are reached. Refer to Section 2.5.1 "Sampling Protocols" for more detailed information on the sampling procedures.

Numerous quality assurance checks will be performed on the sample analysis. They involve the preparation of field and laboratory blanks and duplicates. The specific frequency of blanks and duplicate sample analysis varies from one in ten, to one in twenty, depending on the parameter and method.

It is anticipated that the sampling and analytical work for this project will take from eight to sixteen weeks spread out over three to six months. This timing depends on the timing of the completion of the waste excavation effort preceding it.

2.2.4 PROJECT SCHEDULE

A detailed project schedule is included in the Closure Plan.

2.3 PROJECT ORGANIZATION AND RESPONSIBILITY

This QAPjP provides for designated QA personnel to review products and provide guidance on QA matters. This QAPjP also outlines the approach to be followed to ensure that products of sufficient quality are obtained. Figure 2-2 illustrates the QA program organization. This structure will provide for direct and constant operational responsibility, clear lines of authority, and the integration of QA activities. The various QA functions are explained below.

2.3.1 PROJECT DIRECTOR

The project director will have overall responsibility for ensuring that the project meets BP's objectives and quality standards. In addition, he will be responsible for technical quality control and project oversight, and will provide the project manager with access to BP management.

2.3.2 PROJECT MANAGER

The project manager will be responsible for implementing the project and will have the authority to commit the resources necessary to meet project objectives and requirements. The project manager's primary function is to ensure that technical, financial, and scheduling objectives are achieved successfully. The project manager will report directly to BP Project Director, and will provide the major point of contact and control for matters concerning the project. The project manager will:

- Define project objectives and develop a detailed work plan and schedule;
- Establish project policy and procedures to address the specific needs of the project as a whole, as well as the objectives of each task;
- Acquire and apply technical and corporate resources as needed to ensure performance schedule constraints;
- Orient all team leaders and support staff concerning the project's special considerations;
- Monitor and direct the team leaders;
- Develop and meet ongoing project and/or task staffing requirements, including mechanisms to review and evaluate each task product;
- Review the work performed on each task to ensure its quality, responsiveness, and timeliness;
- Review and analyze overall task performance with respect to planned requirements and authorizations;
- Approve all external reports (deliverables) before their submission to BP;
- Ultimately be responsible for the preparation and quality of interim and final reports; and
- Represent the project team at meetings and public hearings.

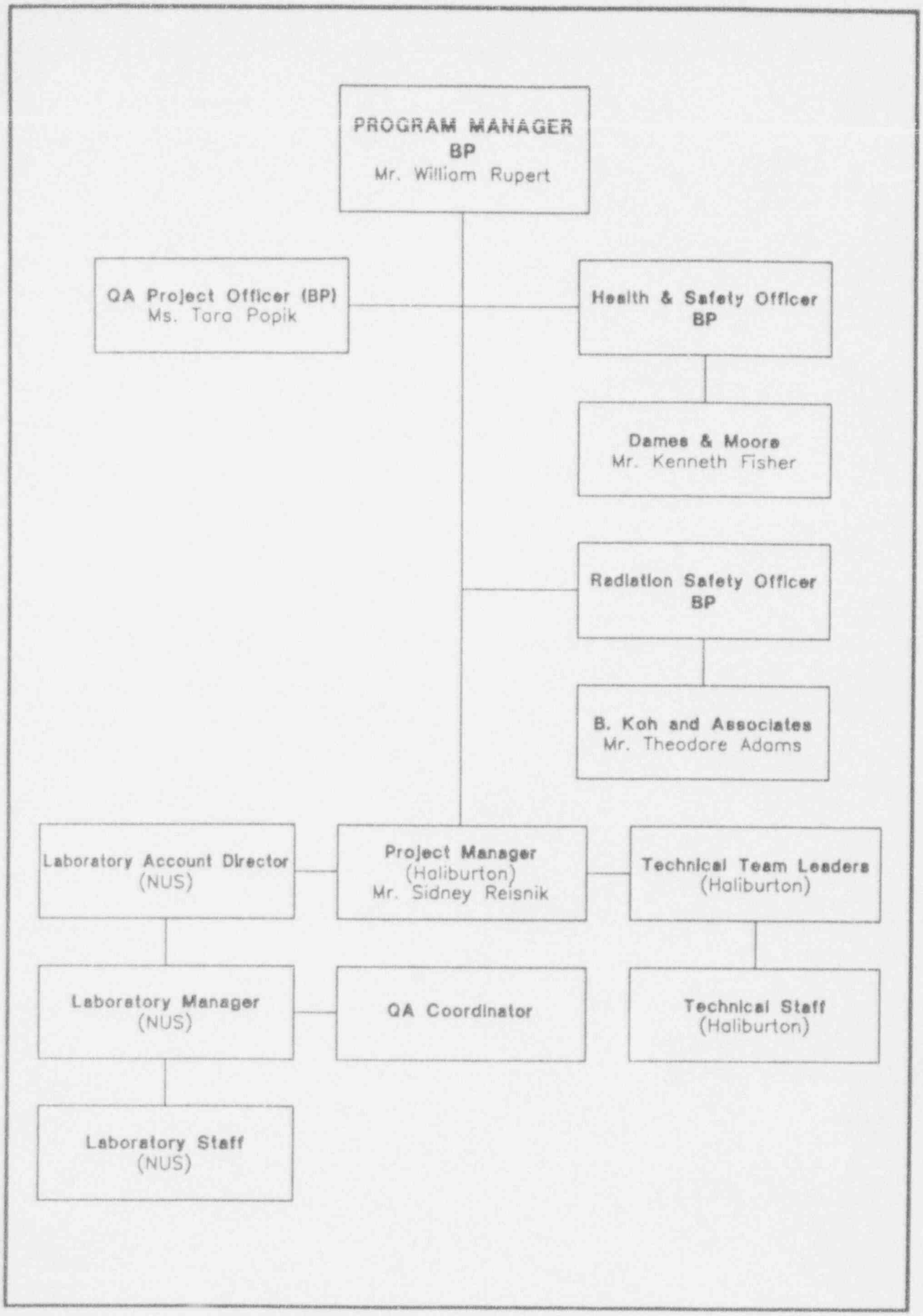


Figure 2-2 Quality Assurance Program Organization

2.3.3 TEAM LEADERS

The project manager will be supported by a team leader or leaders who will be responsible for leading and coordinating the day-to-day activities of the various resource specialists under their supervision. The team leader is a highly experienced environmental professional who will report directly to the project manager. Specific team leader responsibilities include:

- Provision of day-to-day coordination with the project manager on technical issues in specific areas of expertise;
- Development and implementation of team-related work plans, assurance of schedule compliance, and adherence to management-developed study requirements;
- Coordination and management of team staff;
- Implementation of QC for technical data provided by the team staff;
- Adherence to work schedules provided by the project manager;
- Authorship, review, and approval of text and graphics required for team efforts;
- Coordination of technical efforts of subcontractors assisting the team;
- Identification of problems at the team level, discussion of resolutions with the project manager, and provision of communication between team and upper management; and
- Participation in preparation of the final report.

2.3.4 TECHNICAL STAFF

The technical staff (team members) for this project will be drawn from corporate resources. The technical team staff will be utilized to gather and analyze data, and to prepare various task reports and support materials. All of the designated technical team members will be experienced professionals who possess the degree of specialization and technical competence required to effectively and efficiently perform the required work.

2.3.5 QA PROJECT OFFICER

The QA project officer will be responsible for maintaining QA for the BP pond closure project. Specific functions and duties include:

- Providing an external, and thereby independent, QA function;
- Coordinating with BP officers, the project manager, contractor laboratory management and staff to ensure that QA objectives appropriate to the project are set, and that personnel are aware of these objectives;
- Coordinating with laboratory management and personnel to ensure that QC procedures appropriate to demonstrating data validity and sufficient to meet QA objectives are developed and in place;

- Coordinating with laboratory QA personnel to ensure that QC procedures are followed and documented;

- Requiring and/or reviewing actions taken in the event of QC failures; and

- Reporting non-conformance with QC criteria or QA objectives, including an assessment of the impact on data quality or project objectives, to the project manager.

2.3.6 LABORATORY ACCOUNT EXECUTIVE

The laboratory director will be responsible for all analytical work and will work in conjunction with the QA unit. He will maintain liaison with the QA officer regarding QA and custody requirements. Specific duties include:

- Maintaining indexed master copies of all laboratory project records and final reports, listing for each project the equipment used, instrument methods, nature of project, date project was initiated, current status, name of sponsor, name of project manager, and status of final report;

- Maintaining copies of the methods and safety manual;

- Maintaining written status reports on the project, noting any problems, recommendations, and corrective actions taken; and

- Requiring that all final reports be reviewed for accuracy.

2.3.7 LABORATORY MANAGER

The laboratory manager will maintain liaison with the laboratory director regarding QA elements of specific sample analyses tasks. He will report to the laboratory director and work in conjunction with the QA unit. Specific duties include:

- Developing the project-specific protocols in coordination with the laboratory director;

- Ensuring that personnel clearly understand their required tasks;

- Ensuring that the study is carried out in accordance with the protocol;

- Ensuring that all project QA/QC methods are followed;

- Ensuring that all data generated during a project are accurately recorded and verified;

- Ensuring that any problems reported during the monitoring of a project by the QA unit are reported to the QA director and that corrective actions are taken and documented; and

- Ensuring that the study protocol, as well as the final report and all the supporting raw data, are transferred to suitable archives upon completion of the study.

2.3.8 QA COORDINATOR

The Laboratory QA officer will be responsible for overseeing the QA program within the laboratory and for maintaining all QC documentation. He will report directly to the laboratory director. Specific duties include:

- Conducting independent QA review of laboratory data;
- Reviewing all QC procedures, documentation, and corrective actions;
- Reporting QA/QC problems to laboratory and corporate management;
- Maintaining standard operating procedures and laboratory QA/QC manual; and
- Conducting internal laboratory performance audits.

2.3.9 LABORATORY STAFF

Each member of the laboratory staff will perform an assigned QA or analytical function that is pertinent to and within the scope of his or her knowledge, experience, training, and aptitude. An individual will be assigned the responsibility for checking, reviewing, or otherwise verifying that a sample analysis activity has been correctly performed.

2.3.10 LABORATORY FACILITIES

The laboratory will have capabilities to handle mixed waste and will be staffed by full-time scientists and technicians.

All laboratory work will be performed in accordance with applicable guidelines established by the NRC, OEPA, and USEPA. When approved protocols do not exist, the laboratory staff will develop and validate appropriate analytical methods. In addition, QA and QC programs will be maintained for the instruments and the analytical procedures used. Refer to the Project Laboratory QAPjP for a listing and description of these procedures.

The laboratory will be equipped with state-of-the-art instrumentation for the analyses of soil samples. There will be sufficient back-up instrumentation to prevent exceeding sample holding times in the event of instrumentation failure.

The laboratory will be fully equipped for analysis of all types of water and soil samples for chemical contaminants and general characterization. Proven and approved analytical techniques will be used, backed by a rigorous system of QC and QA checks to ensure reliable and defensible data.

Organic analysis will be accomplished by GC and/or GC/MS. For the extraction of samples, the laboratory will utilize separatory funnel and sonication methods routinely and Soxhlet and continuous extraction methods when necessary.

The laboratory may use two types of instruments for analysis of metals in various matrices: AAS and ICP. The various AAS techniques include application of flame, furnace, cold vapor, and hydride generation procedures. During sample preparation and analysis, laboratory staff should be especially careful to avoid the matrix interference effects to which the analysis of solid samples (soil, sediment, and sludge) for trace metals is particularly susceptible. Check standards (either USEPA-provided or National Technical Institute of Standards [NTIS]-traceable) will be used with each set of prepared samples.

Other instruments in the laboratory should include a total organic carbon analyzer, specific ion electrodes (fluoride, cyanide, nitrate, ammonia), spectrophotometers and basic items such as pH and conductivity meters. Other equipment necessary for analyses as required by this QAPjP will be available within the laboratory as applicable.

2.4 QA OBJECTIVES FOR MEASUREMENT DATA

The characteristics of major importance for the assessment of generated data are accuracy, precision, completeness, representativeness, and comparability. These characteristics are defined below.

2.4.1 ACCURACY

Accuracy is the degree of agreement of a measurement or average of measurements with an accepted reference or "true" value and is a measure of bias in the system.

Analytical accuracy may be expressed as the percent recovery of an analyte which has been added to the environmental sample at a known concentration before analysis. The equation used to calculate percent recovery is found in Section 2.13.1.1.

Accuracy of a particular analysis is measured by assessing its performance with "known" samples. These "knowns" can take the form of EPA or NTIS traceable standards (usually spiked into a pure water matrix), or laboratory prepared solutions of target analytes into a pure water or sample matrix; or (in the case of GC or GC/MS analyses) solutions of surrogate compounds which can be spiked into every sample and are designed to mimic the behavior of target analytes without interfering with their determination. In each case the recovery of the analyte is measured as a percentage, corrected for analytes known to be present in the original sample if necessary, as in the case of a matrix spike analysis. For EPA or NTIS supplied known solutions, this recovery is compared to the published data that accompany the solution. For prepared solutions and surrogate compounds, the recovery is compared to EPA-developed data or laboratory-specific control limits as available. Refer to the Laboratory QAPjP for procedures and data used in surrogate compound recovery comparisons.

If recoveries do not meet required criteria, then the analytical data for the batch (or, in the case of surrogate compounds, for the individual sample) are considered potentially inaccurate. The analyst or his supervisor must initiate an investigation of the cause of the problem and take corrective action. This can include re-calibration of the instrument, reanalysis of the QC sample, reanalysis of the samples in the batch, or flagging the data as suspect if the problems cannot be resolved. As a rule, analyses are not corrected for recovery of matrix spike or surrogate compounds.

The accuracy of simple, yet fundamental field analysis is difficult to assess quantitatively. Sampling accuracy can be maximized, however, by adoption and adherence to a strict QA program. Specifically, all procedures will be documented as standard protocol and all equipment and instrumentation will be properly calibrated and well maintained. Trip blanks, ambient condition blanks (field blanks) and equipment decontamination washes will be associated with all field samples in order to assess representativeness and potential cross contamination. In addition to equipment operation and standard operating procedures, a high level of accuracy will be maintained by thorough and frequent review of field procedures. In this manner, any deficiencies will be quickly documented and corrected.

2.4.2 PRECISION

Precision is defined as the degree of mutual agreement among multiple measures of the same condition under similar circumstances. However, one must differentiate between analytical precision and total system precision. Analytical precision may entail an examination of the agreement of multiple points in a calibration curve (linearity). This is measured either as a correlation coefficient and as percent relative standard deviation (%RSD). Specific acceptance criteria can be found in the Laboratory QAPjP under "Calibration".

Precision, as a measure of the reproducibility of an analytical result, is assessed through the use of duplicate sample analyses or matrix spike duplicate analyses. A relative percent difference (RPD) is calculated and the RPD must be less than a method specific value for the results to be considered precise. Specific acceptance criteria can be found in the Laboratory QAPjP.

Total system precision is assessed through the review of field duplicate data. RPDs are calculated and the results compared to the following control limits: for water samples RPD <50%, for solids samples RPD <100%. If these criteria are met the data are considered to be reasonably representative of actual field conditions.

2.4.3 COMPLETENESS

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount expected to be obtained under correct normal conditions. Completeness is expressed as the percentage of valid data obtained from a measurement system.

Field sampling conditions are often unpredictable and non-uniform. However, the objective of the field sampling program is to obtain samples for analyses required at each individual site, provide sufficient sample material to complete those analyses, and to produce QC samples that represent all possible contamination situations, i.e., contamination during sample collection, transportation and storage.

The overall data quality objective for completeness during this investigation is 95 percent because all data points are considered critical to this investigation.

2.4.4 REPRESENTATIVENESS

Representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.

The characteristic of representativeness is not quantifiable. Subjective factors to be taken into account are as follows:

- The degree of homogeneity of a site;

- The degree of homogeneity of a sample taken from one point in a site; and
- The available information on which a sampling plan is based.

To maximize representativeness of results, sampling techniques and sample locations will be carefully chosen so that they provide laboratory samples representative of the site and the specific area. Within the laboratory, precautions are taken to extract from the sample bottle an aliquot representative of the whole sample. This includes premixing the sample and discarding pebbles from soil samples.

2.4.5 COMPARABILITY

Comparability expresses the confidence with which one data set can be compared to another. Comparability is assured through the consistent use of sampling and analytical standard operating procedures and the consistent use of units of measure throughout the sampling and analysis program.

2.4.6 GOALS

The quality control samples that will be collected in the field are as follows: one duplicate sample per day or for every 20 samples for organic, uranium, pH and cyanide analysis (or for every 10 samples analyzed for metals), whichever is greater; one equipment blank per day and when moving from area of high contaminant concentration to an area of low concentration; one trip blank per day (for organics only); and one field (ambient) blank sample per day or for every 20 samples, whichever is greater. Numerical goals for QA objectives for the soil sampling program are listed in Table 2-1. Sample results will be reported on a dry weight basis, along with moisture content of the sample.

Target values for method detection limits are included in Section 2.8, Analytical Procedures. Note that tabulated values are not always attainable. Instances may arise where high sample concentrations, nonhomogeneity of samples, or matrix interferences preclude achievement of target detection limits or other quality control criteria. In such instances the contractor will report reasons for deviations from these detection limits or noncompliance with quality control criteria. If method detection limits need to be defined, they will be done so in accordance with Section 2.8.

2.5 SAMPLING PROCEDURES

Because mixed waste contaminants may be present, the soil in the four ponds will be sampled and analyzed for both radiological and chemical parameters. The Burn and Deepwell Ponds are planned for clean closure and are therefore subject to the clean closure standards for both radiological and chemical parameters. The soil in the Celite and V-1 Ponds must meet the criteria for clean closure for radiological parameters before liner systems are installed; however, chemical contaminants that exceed clean closure standards may be left in place providing that they would not affect groundwater quality.

The sequence of sampling events is tabulated below. Sampling for chemical contamination will precede the radiological sampling. However, as required by the Contractors Health, Safety and Radiation Control Plan, a gamma survey will be performed before and during the chemical sampling effort. Each event is described in detail in the following discussion.

TABLE 2-1

PROJECT PRECISION, ACCURACY AND COMPLETENESS GOALS

Method	Analyte	Precision (%RPD)	Accuracy (% LCS Rec)	Completeness (% Valid Data)
EPA 3050 and 6010/7000 series	Total Metals	25%	**	95%
SW-846, 8240/8030 8270	Volatile Organics: Semi-volatile Organics	30%	**	95%
ORAU Procedures; Section 16 (or equal)	Radioactivity	30%	**	95%
CLP SOW IMP 02.1	Total Cyanide	30%	**	95%

RPD = Relative percent difference
LCS Rec = Laboratory control standard recovery
** = 70 - 130% unless control limits specified in Table 1-9

SAMPLING EVENTS

SAMPLING EVENT	DESCRIPTION	EXCAVATION
Chemical Sampling	Two 2 ft. split-spoon samples collected from every other 10m x 10m grid intersection	14m radial area around identified chemical hot spot is excavated
Phase I Radiological	Walkover gamma survey	Areas with elevated readings are identified (i.e. above background). Phase II ceases when sampling shows levels lower than three times the guidance value of 35 pCi/g (105 pCi/g)
Phase II Radiological	Sampling (to depth of 6 in.) and analysis for U-238 at hot spots identified in Phase I	7m radial area around identified radiological hot spots are excavated
Phase III Radiological	Systematic sampling-5 samples (to a depth of 6 in.) collected from within each 10m x 10m grid etc.	Excavation in areas where appropriate; re-sampling,

2.5.1 SAMPLING PROTOCOLS

2.5.1.1 Chemical Soil Sampling

To identify and define the horizontal extent of the chemical contamination, the chemical sampling plan will be a systematic plan conducted on the 10m x 10m grid system. Sample locations will be on every other grid intersection or 20m apart. Samples will also be collected from all areas that a visual inspection of the pond bottom suggests may contain contamination.

Figure 2-1 shows the 10m x 10m grid overlay for each pond. It is estimated that the following number of samples will be collected from each pond:

Pond	Approximate Number of Samples
Burn Pond	15
Deepwell	15
Celite	18
V-1	15

To identify and define the vertical extent of the chemical contamination samples will initially be collected to a depth of 4 feet in 2-foot intervals using 2-inch or 3-inch diameter, stainless steel core sampler. Each 2-foot core sample will be separated into two 1-foot samples that will be placed in glass sample containers. The two 1-foot samples from the top 2 feet of soil will initially be sent to the laboratory for analysis. The remaining samples (samples collected at depths from 2 to 4 feet) will be properly labeled and preserved. It is anticipated that the surface where the sampling is conducted may be smeared with small amounts of waste sludge deposited by the wheels or tracks of equipment. Consequently, the top 1 inch of the surface will be scraped prior to sampling in order to prevent false positive test results. Smears and tracks will be identified visually and removed after the underlying soil is determined to be representative of target values.

To identify samples with high levels of contamination in the field, the first sample jar filled at a sample location will be screened with an on-site gas chromatograph. The results will be noted and recorded in the field log book.

The soil samples will be analyzed for the following indicator parameters: volatile organics, semi-volatile organics, total cyanide, RCRA total metals and radiological parameters (see Table 2-2). Holding times will be measured from the date of collection.

If laboratory analysis of the first set of samples (i.e. samples from 0-1 feet and 1-2 feet) show the concentrations of indicator parameters in excess of "clean levels," the results may be reevaluated using a health risk assessment model to determine whether the existing levels present a health risk. If the risk assessment model determines that there is no health risk posed by the levels of contaminants in place, clean closure activities will be considered complete. If the results of the risk assessment model determine that the levels of contaminants are unacceptable, the second set of samples (i.e., the 2-4 foot depth samples already collected) will be analyzed by the laboratory. The process (i.e., laboratory analysis and risk assessment) will be repeated for this second set of samples. If it is determined that levels of contaminants are unacceptable in the last set of samples, it will be necessary to excavate the hot spot(s) (described below) and to re-sample.

TABLE 2-2

METHODS, SAMPLES CONTAINERS, PRESERVATION METHODS AND HOLDING TIMES FOR RADIOLOGICAL AND CHEMICAL SOIL ANALYSIS

Analyte	Method[a]	Estimated Method Detection Limit (mg/kg)[b]	Preservation/ Holding Time	Container
total cyanide	9010	0.5	4°C/14 days	4 oz. plastic or glass jar
organics				
acetonitrile	8240B	0.1	4°C/14 days	4 oz. wide-mouth glass bottle, Teflon-lined cap
acrylonitrile	8030A	0.09		
1,1,1-trichloroethane	8240	5		
methyl ethyl ketone	8240	100		
acetone	8240	100		
1,1-dichloroethylene	8240	5		
pyridine	8270	5		
methyl naphthalene	8270	10		
trichloroethylene	8240	50		
bromomethane	8240	10		
tetrachloroethylene	8240	5		
1,1-dichlorethane	8240	5		
vinyl chloride	8240	10		
Total Metals	3050 and			
arsenic	7060A	2	4° C/6 months	8 oz. wide-mouth glass or plastic bottle
barium	6010A	40	4° C/6 months	
cadmium	6010A	1	4° C/6 months	
chromium	6010A	2	4° C/6 months	
lead	7421	1	4° C/6 months	
mercury	7470A	2	4° C/28 days	
selenium	7740	1	4° C/6 months	
silver	6010A	2	4° C/6 months	
Uranium-238; Radium-226;	ORAU Procedures Sections 5, 15 and 16	*[c]	none	1 kg plastic bottle

[a] Analysis methods (except those for radioactivity) are from U.S. EPA's SW-846, Test Methods of Evaluating Solid Waste, Third Edition, November 1990.
[b] Elevated detection limits may result from matrix interferences.
[c] Lower level detection limits are background levels and are site specific.

Soil removal will be done in the hot spot areas to the depths identified by the analysis of the first 4 feet of soil. The size of the hot spot is calculated according to EPA's "Methods for Evaluating the Attainment of Cleanup Standards - Volume 1: Soils and Sludges."

The hot spot calculations depend on three parameters. Two of the parameters are chosen and fixed and the third is determined by the choice of the first two factors. The three parameters are:

- grid pattern and spacing;
- hot spot shape and size; and
- false positive rate.

A 20m grid spacing (determined as described above) and a 5% false positive rate (i.e. chance of missing a hot spot if a hot spot is present) are the two fixed factors. If it is assumed that the hot spot is circular, the hot spot area is calculated to have a radius of 14m.

After the hot spot area(s) are excavated, another round of samples will be collected. This additional sampling will consist of one 2-foot split spoon collected at each sampling location. The sampling points will be located on the original 10m x 10m grid; however, the sample locations will be shifted 10m down and 10m over from the original locations (i.e. the samples will be taken diagonally across from the locations of the first two sets of samples).

Once the chemical sampling analysis results are below chemical clean level standards or the risk assessment model determines the levels to be safe, the area will be considered suitable for clean closure.

2.5.1.2 Radiological Soil Sampling

Sampling methods to be utilized are taken from Laboratory Procedures Manual for the Environmental Survey and Site Assessment Program, latest Edition, C.F. Weaver, M.J. Lauderman, and S. Shanmugan, for Oak Ridge Associated Universities, Oak Ridge, Tennessee (ORAU); and Manual for Conducting Radiological Surveys in Support of License Termination, J.D. Berger, 1992 (NUREG/CR-5849).

Radiologica' soil sampling will be carried out in three phases: Phase I will consist of a radiological soil survey and identific on of hot spot areas; Phase II will consist of soil sampling and radiological analysis for depleted uranium and excavation, as necessary; and Phase III will involve the collection of final clearance samples. The radiological sampling plan will be a systematic sampling plan conducted on a 10m x 10m grid system.

Phase I of the radiological sampling plan will consist of a walkover gamma survey (i.e. over the entire surface area). The gamma survey will be performed with an appropriately shielded, 2" x 2", sodium iodine (NaI) detector with an accompanying ratemeter (e.g., Eberline ESP-2 with SPA scintillation probe or equivalent) to locate elevated readings (i.e. readings above background). The results will be logged on a survey map containing the 10m x 10m grid lines so that exact locations of elevated readings can be properly documented. At this time, areas exhibiting elevated readings (i.e. "hot spots") will be identified.

Phase II will consist of selected surface soil sampling. Grab samples of approximately 1 kg (i.e. within 6 inches of the surface) will be collected from those areas that showed elevated readings identified during the Phase I radiological survey. In the absence of hot spots, one sample may be collected from within each grid area.

Results of these laboratory measurements will identify soil contaminated with greater than 35 pCi/gm of depleted uranium, the recommended maximum concentration for unrestricted release permitted under disposal option 1 (as defined in the Nuclear Regulatory Commission's document, "SECY 81-576").

A 7-meter radial area around these contaminated spots (i.e., hot spots) will be excavated before Phase III begins. The methodology to derive the 7-meter radial hot spot area is presented in the EPA publication, "Methods for Evaluating the Attainment of Clean-up Standards - Volume 1: Soils and Solid Media," (PB89-234959). Hot spot calculations depend on three parameters. Two of the parameters are chosen and fixed and the third is determined by the choice of the first two factors. The three parameters are:

- grid spacing (G);
- hot spot shape and size (L represents the radius for a circular hot spot); and
- false positive rate ($\propto$).

The two fixed factors are the grid spacing and the false positive rate (i.e., chance of missing a hot spot if a hot spot is present). Table A.11 (PB89 - 234959), provides a tabulation of false positive rates for elliptical shaped hot spots based on:

1. grid pattern (square or triangular).

2. L/G; the ratio of the longer diameter of the elliptical shaped hot spot (L) to the grid spacing (G).

3. ES; the elliptical shape factor, defined as S/L the ratio of the shorter diameter (S) to the longer diameter (L) of the elliptical shaped hot spot.

   Using:

   1. square grid pattern

   2. S = L for a circle, therefore ES=1.0

   3. a false positive rate of 5 % (0.05), when compared to the values for these rates given in the table it is very close to 0 % (0.00).

      Gives an estimated L/G ratio of 0.7, and since:

      G = 10 then
      L = 0.7 (10) = 7 meters

From Table A.11, using a false positive rate of 5 percent and a square grid pattern with 10-meter spacing result in a hot spot with a radius of 7 meters.

To confirm that the hot spot material was contained within and removed from the excavated area, a minimum of four soil samples will be collected from within the excavation. Typically, one sample will be taken from the location of the original sample (center of the hot spot), and three will be taken at a radius of 3 to 4-meters from the original location. The samples will also be located so as to be equidistant from each other (plus or minus 2-feet). For sufficiently large hot spots where the excavation area is larger than defined by a 7-meter radius circle, the confirmation samples will be taken at the nodes created from overlaying a 5 by 5-meter grid on the affected area.

Soil samples will be analyzed for depleted uranium using methods outlined in the Laboratory Procedures Manual for the ORAU Environmental Survey and Site Assessment Program, Latest Edition: Sections 5 and 16. Approximately 10% of the samples will be collected as quality assurance/quality control (QA/QC) samples. Several of these samples will also be submitted to an independent radiological laboratory to develop correlations between gamma spectroscopy analysis, laboratory gamma spectroscopy cross check results, and radiochemical isotopic uranium analysis.

Remediation of the hot spot areas will continue until all the soil sample results are less than three times the guidance value of 35 pCi/gm (105 pCi/gm). Once this has been achieved, then Phase III Radiological sampling activities will commence.

The results of the hot spot evaluation and remediation will be included in the report submitted to the Nuclear Regulatory Commission (NRC) outlining the results of the project sampling effort. The report will include sample locations, results, and quantities of material removed.

Phase III will consist of a systematic sampling design for surface soils at the site and will follow clearance sampling/analysis and excavation to remove any chemical contamination.

As specified in the NRC Technical Branch Position, SECY 81, Disposal or On-Site Storage of Thorium or Uranium Wastes from Past Operations, the concentrations of remaining materials shall be sufficiently low so that no individual may receive an external dose in excess of 10 micro-roentgens per hour (10 μR/hr). To assure that this criteria is satisfied, Phase III will include a gamma exposure rate survey which will be performed in each 10m x 10m grid. The gamma exposure rates will be measured at 1-meter above the ground surface using a portable rate meter with a gamma scintillation detector (NaI) cross-calibrated with a pressurized ionization chamber. Five measurements will be taken from within each 10m x 10m grid block.

Following a final walkover gamma survey, five surface soil samples of approximately 1 kg (2.54 pounds) each will be collected (within 0.15 m or 6" of the surface) from each 10m x 10m grid square. If no elevated readings are identified within a grid square during the walkover gamma surface survey, surface soil samples will be collected near the corners and the center of each grid. If elevated readings are detected, then a sample of the soil from the area of elevated reading will be collected as part of the five samples per grid area. Samples will be collected using trowels, spoons, or shallow cores (0.6") and placed into plastic bags that will be appropriately labeled. Proper decontamination practices will be employed to prevent cross contamination of samples (e.g., sampling gloves will be disposed of after the collection of each sample).

The areas of elevated activity used in the evaluation will be defined from four or more soil samples taken from locations surrounding the sample location which exhibited the elevated result. The samples will be taken from locations that are in a rectangular pattern, and will be at a distance no greater than $\frac{1}{2}\sqrt{A}$, where:

$$A = 100\left(\frac{\textit{elevated activity value}}{(35\ pCi/gm)^2}\right)^2$$

If the sample results for a grid fail the test of significance, (calculation 8-13 of Draft NUREG/CR-5849 described below), then further remediation sampling, and evaluation will occur in the area of elevated activity. If the sample results pass the test of significance, then remediation work in the area tested will stop.

2.5.1.3 Evaluation of Phase III Radiological Sample Results

Evaluation of the soil sampling program results will be performed in accordance with Draft NUREG/CR-5849 as follows:

- Section 8.5.2, Comparison with Guideline Values, Elevated Areas of Activity, Calculation 8-10
- Section 8.5.4, Calculating Average Levels, Calculation 8-11
- Section 8.5.5, Comparisons, Calculations 8-12 and 8-13

All of the soil sample results will be compared to the guideline value of 35 pCi/gm. Any sample results exceeding the guideline value by three times (105 pCi/gm) will be treated as a hot spot and result in further remediation sampling and evaluation. Once all of the sample results are below three times the guideline value, then the results of the soil samples collected from each 10m x 10m grid will be tested for statistical significance (per Chapter 8, Sections 8.5.2 and 8.5.5 of Draft NUREG/CR-5849) and compared to the guideline value of 35 pCi/gm.

2.5.2 SAMPLE HANDLING

The sample containers, preservation methods, and holding times required for the soil samples are listed in Table 2-2.

2.5.3 EQUIPMENT DECONTAMINATION PROCEDURES

Sampling equipment must be cleaned prior to reuse. The following is the accepted procedure for decontaminating sampling equipment used to collect samples to be evaluated for chemical contamination.

- scrub with tap water[1] and non-phosphate detergent;
- rinse with tap water;
- rinse with 10% HNO_3,

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[1] Tap water mav be used from any municipal water treatment system. The use of the untreated potable water supply is not an acceptable substitute unless it is known that the aquifer is not contaminated.

- rinse with deionized water;
- rinse with hexane;
- rinse with methanol;
- rinse with deionized water (demonstrated analyte-free water);
- air dry; and
- wrap in aluminum foil.

The following is the accepted procedure for decontaminating sampling equipment used to collect samples to be evaluated for Radiological Contamination:

- scrub with tap water and non-phosphate detergent;
- rinse with tap water;
- rinse with 10% HNO_3;
- rinse with deionized water;
- air dry; and
- wrap in aluminum foil.

2.6 SAMPLE CUSTODY FOR SOIL SAMPLES

2.6.1 FIELD OPERATIONS

This section describes standard operating procedures for sample identification and chain-of-custody to be utilized for all field activities. The purpose of these procedures is to ensure that the quality of the samples is maintained during their collection, transportation, storage and analysis. All chain-of-custody requirements comply with standard operating procedures indicated in USEPA sample-handling protocol.

Sample identification documents must be carefully prepared so that sample identification and chain-of-custody can be maintained and sample disposition controlled. Sample identification documents include:

- Daily logs;
- Sample label;
- Custody seals; and
- Chain-of-custody records.

2.6.1.1 Daily Logs

Daily logs and data forms are necessary to provide sufficient data and observations to enable participants to reconstruct events that occurred during the project. All daily logs will be kept in a bound notebook and consecutively numbered. All entries will be made in waterproof ink, dated, and signed. Sampling data will be recorded in the sampling record. Corrections will be made according to the procedures given at the end of this section.

The Site Log is the responsibility of the site team leader and will include a complete summary of the day's activities at the site.

The sampling record will include:

- Name of person making entry (signature).
- Names of samplers/title.
- Levels of personnel protection:
  - Level of protection originally used;
  - Changes in protection, if required; and
  - Reasons for changes.
- Documentation on samples taken, including:
  - Sampling location and depth station numbers;
  - Sampling date and time, sampling personnel;
  - Type of sample (grab, composite, etc.);
  - Sample matrix; and
  - Preservation.
- On-site measurement data.
- Field observations and remarks.
- Weather conditions, wind direction, etc.
- Unusual circumstances or difficulties.
- Initials of person recording the information.

2.6.1.2 Sample Identification

A field coding system will be used to identify each sample obtained during the sampling program. This coding system will provide a tracking record to allow retrieval of information about a particular sample and assure that each sample is properly identified.

Each sample is to be identified by a unique code which will indicate the sample number, sample type, sample point and sequence number. An example of the sample identification code is as follows:

Sample Identification Code
X-YY-(B'-C')-BB

where X is the first letter of the pond name, YY represents sample location as related to the grid system, (B'-C') is the depth below the surface, AAAA represents the analytical parameter, and BB represents sample type (where appropriate).

The pond names represented above by X may be one of the following:

B - Burn Pond
C - Celite Pond
V - V-1 Pond
D - Deepwell Pond

The sequence number YY is used in conjunction with the pond identifier to describe sample location according to the grid (e.g., 7L, 10H, etc).

The analytical parameter codes, AAAA, that may be used are as follows:

VOA - volatile organic analytes
SVOA - semi-volatile organic analytes
MET - metals
CYN - cyanide
U238 - uranium-238
R226 - radium-226

Sample type letter designations that may be used are as follows:

TB - trip blank
FB - field blank
EB - equipment blank
DUP - duplicate sample

Field duplicate samples will have their own sequential numbering system for the YY designator that does not correspond to the site grids (i.e., the first DUP will be 01, second 02, etc.). The corresponding sample member or I.D. will be recorded in the field log book, and this information will not be communicated to the laboratory.

2.6.1.3 <u>Sample Containerization and Labeling</u>

Each sample will be labeled, preserved (as required) and sealed immediately after collection. To minimize handling of sample containers, labels will be filled out prior to sample collection. The sample label will be filled out using waterproof ink and will be firmly affixed to the sample containers. The sample label will give the following information:

- Name of sampler,
- Date and time of collection,
- Sample number, and
- Analysis required.

2.6.1.4 Field Custody Procedures

The primary objective of the chain-of-custody procedures is to provide an accurate written or computerized record that can be used to trace the possession and handling of a sample from collection to completion of all required analyses. A sample is in custody if it is:

- In someone's physical possession;
- In someone's view;
- Locked up; or
- Kept in a secured area that is restricted to authorized personnel.

Appropriate field custody procedures include the following:

- As few persons as possible should handle samples.
- Sample bottles will be obtained precleaned by the laboratory or an approved retail source. Coolers or boxes containing cleaned bottles should be sealed with a custody tape seal during transport to the field or while in storage prior to use.
- The sample collector is personally responsible for the care and custody of samples collected until they are transferred to another person or dispatched properly under chain-of-custody rules.
- The sample collector will record sample data in the field log book.
- The site team leader will determine whether proper custody procedures were followed during the field work and decide if additional samples are required.

2.6.1.5 Custody Seals

Custody seals are pre-printed adhesive-backed seals with security slots designed to break if the seals are disturbed. Sample shipping containers (coolers, cardboard boxes, etc., as appropriate) are sealed in as many places as necessary to ensure security. Seals must be signed and dated before use.

2.6.1.6 Chain-of-Custody Record

The chain-of-custody record must be fully completed at least in duplicate by the field technician who has been designated by the project manager as responsible for sample shipment to the appropriate laboratory for analysis. In addition, if samples are known to require rapid turnaround in the laboratory because of project time constraints or analytical concerns (e.g., extraction time or sample retention period limitations, etc.), the person completing the chain-of-custody record should note these constraints in the "Remarks" section of the custody record.

2.6.1.7 Transfer of Custody and Shipment

- The coolers in which the samples are packed must be accompanied by a chain-of-custody record. When transferring samples, the individuals relinquishing and receiving them must sign, date, and note the time on the chain-of-custody record. This record documents sample custody transfer.

- Samples must be dispatched to the laboratory for analysis with a separate chain-of-custody record accompanying each shipment. Shipping containers must be sealed with custody seals for shipment to the laboratory. The method of shipment, name of courier, and other pertinent information a . entered in the "Remarks" section of the chain-of-custody record.

- All shipments must be accompanied by the chain-of-custody record identifying their contents. The original record accompanies the shipment. The other copies are distributed appropriately to the site team leader and project manager.

- If sent by mail, the package is registered with return rece[illegible] quested. If sent by common carrier, a bill of lading is used. Freight bills, Postal Service rece[illegible] d bills of lading are retained as part of the permanent documentation. Samples will not be ship[illegible] Friday to insure that there is no chance of samples being held in-route over a weekend.

2.6.1.8 Corrections to Documentation

Notebook:

As with any data logbooks, no pages will be removed for any reason. If corrections are necessary, these must be made by drawing a single line through the original entry (so that the original entry can still be read) and writing the corrected entry alongside. The correction must be initialed and dated. Most corrected errors will require a footnote explaining the correction.

Sampling Forms and Sampling Record:

As previously stated, all sample identification tags, chain-of-custody records, and other forms must be written in waterproof ink. None of these documents are to be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document.

If an error is made on a document assigned to one individual, that individual may make corrections simply by crossing a line through the error and entering the corrected information. The incorrect information should not be obliterated. Any subsequent error discovered on a document should be corrected by the person who made the entry. All corrections must be initialed and dated.

2.6.2 SAMPLE HANDLING, PACKAGING, AND SHIPPING

The transportation and handling of samples must be accomplished in a manner that not only protects the integrity of the sample, but also prevents any detrimental effects due to the possible hazardous nature of samples. Regulations for packaging, marking, labeling, and shipping hazardous materials are promulgated by the United States Department of Transportation (DOT) in 49 CFR 171 through 177.

All chain-of-custody requirements must comply with standard operating procedures in the USEPA sample handling protocol.

2.6.2.1 Sample Packaging

Samples must be packaged carefully to avoid breakage or contamination and must be shipped to the laboratory at proper temperatures. The following sample packaging requirements will be followed:

- Sample bottle lids must never be mixed. All sample lids must stay with the original containers.
- The sample volume level can be marked by placing the top of the label at the appropriate sample height, or with a grease pencil. This procedure will help the laboratory to determine if any leakage occurred during shipment. The label should not cover any bottle preparation QA/QC lot numbers.
- Shipping coolers must be partially filled with packing materials and ice when required, to prevent the bottles from moving during shipment.
- The sample bottles must be placed in the cooler in such a way as to ensure that they do not touch one another.
- When the environmental samples are to be cooled, the use of "blue ice" or some other artificial icing material is preferred. If necessary, ice may be used, provided that it is placed in plastic bags. Ice is not to be used as a substitute for packing materials.
- Any remaining space in the cooler should be filled with inert packing material. Under no circumstances should material such as sawdust, sand, etc., be used.
- A duplicate custody record must be placed in a plastic bag and taped to the bottom of the cooler lid. Custody seals are affixed to the sample cooler.

2.6.2.2 Shipping Containers

Environmental samples will be properly packaged and labeled for transport and dispatched to the laboratory. A separate chain-of-custody record must be prepared for each container. The following requirements for shipping containers will be followed.

Shipping containers are to be custody-sealed for shipment as appropriate. The container custody seal will consist of filament tape wrapped around the package at least twice and custody seals affixed in such a way that access to the container can be gained only by cutting the filament tape and breaking a seal.

Field personnel will make arrangements for transportation of samples to the laboratory. When custody is relinquished to a shipper, field personnel will telephone the laboratory custodian to inform him of the expected time of arrival of the sample shipment and to advise him of any time constraints on sample analysis. Samples will be retained by the laboratory for 30 days after the final report is submitted.

2.6.2.3 Marking and Labeling

- Use abbreviations only where specified.
- The words "This End Up" or "This Side Up" must be clearly printed on the top of the outer package. Upward pointing arrows should be placed on the sides of the package. The words "Laboratory Samples" should also be printed on the top of the package.
- After a sample container has been sealed, two chain-of-custody seals will be placed on the container, one on the front and one on the back. The seals are protected from accidental damage by placing strapping tape over them.
- In addition, the coolers must also be labeled and placarded in accordance with DOT regulations if the samples to be shipped represent a medium and high hazard.

2.6.3 LABORATORY OPERATIONS

A designated sample custodian accepts custody of the shipped samples and verifies that the sample identification number matches that on the chain-of-custody (c-o-c) record. Pertinent information as to shipment, pickup, and courier is entered in the "Remarks" section. The custodian then enters the sample identification number and other information into the laboratory sample tracking system. The custodian will then place each sample in the proper secure storage area. When samples are requested by a technician for sample preparation and/or analysis, the custodian will relinquish the samples to the technician using proper logging out procedures. Upon return of the samples, proper logging in procedures will be followed, and the custodian will return the samples to the proper secure storage area.

Upon receipt at the laboratory, the custodian must check that custody seals on boxes are intact. Strapping tape should be placed over the seals to ensure that seals are not accidentally broken during shipment.

2.7 CALIBRATION PROCEDURES AND FREQUENCY FOR INSTRUMENTATION

All instruments and equipment used during laboratory analysis will be operated, calibrated, and maintained according to the manufacturer's guidelines and recommendations as well as criteria set forth in the Laboratory QAPjP. Operation, calibration, and maintenance will be performed by personnel properly trained in these procedures. Documentation of all routine and special maintenance and calibration information will be maintained as outlined in the Laboratory QAPjP and will be available on request.

2.8 ANALYTICAL PROCEDURES

Analytical methods to be utilized for the sampling tasks are referenced in the USEPA document, Test Methods for Evaluating Solid Waste (Physical/Chemical Methods), SW-846, Revised November 1990.

The detection limits and quality control criteria for the analytical program are contained in the Laboratory QAPjP referenced above. Instances may arise where high sample concentrations, non-homogeneity of samples, or matrix interferences preclude achieving the detection limits of associated quality control criteria. In such instances, the reasons for deviations from these detection limits or noncompliance with quality control criteria will be reported, and the method detection limits must be established as specified by the procedures for each parameter (i.e. using a multiplier). If no specific method (or multiplier) is provided, then the laboratory is to submit to BP Chemical's QA project officer for review the lowest obtainable instrument detection limits (IDL's) which will be used as MDL's.

Methodology references contain specific QC criteria associated with the particular methods. These specific requirements include calibration, tuning, and QC samples and are described in detail within the methods. Daily performance tests and demonstration of precision and accuracy are required.

2.9 DATA REDUCTION, VALIDATION, AND REPORTING

QA/QC requirements will be strictly adhered to during sampling and analytical work. All data generated will be reviewed by comparing and interpreting results from chromatograms (responses, stability of retention times), accuracy (mean percent recovery of spiked samples), and precision (reproducibility of results). Refer to the Laboratory QAPjP for a detailed discussion of QA/QC protocol. Data will be reported on a dry weight basis, along with the moisture content of the sample.

All calculations and data manipulations will be included in the appropriate methodology references. Control charts and calibration curves will be used to review the data and identify outlying results. Prior to the submission of the report to the client, all data will be evaluated for precision, accuracy, and completeness. Sections 2.4, 2.8, and 2.13 of this document include some of the QC criteria to be utilized in the data validation process.

Data storage and documentation will be maintained using logbooks and data sheets that will be kept on file. Analytical and field QC will be documented and included in the report. The central file will be maintained for the sampling and analytical effort for a period of five years after the final report is issued.

Complete evaluation of the analytical data requires that the data be reported completely and correctly. An independent data review will be performed as outlined in the Laboratory QAPjP. The following information is required for complete evaluation of the analytical data and will be reported separately:

- Dates the samples were collected in the field;
- Extraction and analysis dates for all the samples;
- Applicable holding times for each analysis; and
- Analysis dates for laboratory QC samples.

Reports will be reviewed by the laboratory supervisor, the QA officer, laboratory manager and/or director, and the project manager. Analytical reports will contain a data table including results; supporting QC information will also be provided. Raw data will be available for later inspection, if required, and maintained in the control job file.

2.10 INTERNAL QUALITY CONTROL CHECKS

QC data are necessary to determine precision and accuracy and to demonstrate the absence of interferences and/or contamination of glassware and reagents. Laboratory-based QC will consist of calibration verifications, replicates, spikes, and blanks. Field duplicates and field blanks will be analyzed by the laboratory as samples and will not necessarily be identified to the laboratory as duplicates or blanks.

Calculations will be performed for recoveries and standard deviations along with review of retention times, response factors, chromatograms, calibration, tuning, and all other QC information generated. All QC data, including split samples, will be documented. QC records will be retained and results reported with sample data.

2.10.1 BLANK SAMPLES

Blank samples are analyzed in order to assess possible contamination from the field and/or laboratory so that corrective measures may be taken, if necessary. Blank samples are discussed in the following sub-sections: Field Blanks and Laboratory Blanks.

2.10.1.1 Field Blanks

Various types of blanks are used to check the cleanliness of field handling methods. The following types of blanks may be used: the trip blank, the routine field blank and the field equipment blank. They are analyzed in the laboratory as samples, and their purpose is to assess the sampling and transport procedures as possible sources of sample contamination. Field staff may add blanks if field circumstances are such that they consider normal procedures are not sufficient to prevent or control sample contamination, or at the direction of the project manager. Rigorous documentation of all blanks in the site logbooks is mandatory.

- Trip Blanks are similar to routine field blanks with the exception that they are not exposed to field conditions. Their analytical results give the overall level of contamination from everything except ambient field conditions. Each trip blank will be prepared by filling a 40-ml vial with deionized water prior to the sampling trip, transported to the site, handled like a sample, and returned to the laboratory for analysis without being opened in the field.

- Field Equipment Blanks are blank samples (sometimes called transfer blanks or equipment blanks) designed to demonstrate that sampling equipment has been properly prepared and cleaned before field use, and that cleaning procedures between samples are sufficient to minimize cross contamination.

2.10.1.2 Laboratory Blanks

In addition to field blank samples, three types of blanks routinely analyzed in the laboratory are calibration blanks, method blanks, and reagent blanks. Method blanks and reagent blanks are used to assess laboratory procedures as possible sources of sample contamination.

- Method Blanks are laboratory blanks that correspond to the first step in sample preparation and as such, provide a check on contamination resulting from sample preparation and measurement activities. Method blanks for water and soil samples consist of deionized water and are subjected to the entire sample procedure as appropriate for the analytical method being utilized.

- Reagent/Solvent Blanks are closely related to method blanks, but they do not incorporate all sample preparation materials and analytical reagents in one sample. When a method blank reveals significant contamination, one or more reagent blanks are prepared and analyzed to identify the source of contamination. These reagent blanks are then subjected to the entire sample procedure as appropriate for the analytical method being utilized.

- Calibration blanks are employed to verify that the instrument's zero setting has not drifted such that low levels of analytes might be subject to false positives or false negatives.

2.10.2 FIELD DUPLICATES

Field duplicate samples consist of a set of two samples collected independently at a sampling location during a single sampling event. In some instances the field duplicate can be a blind duplicate, i.e., indistinguishable from other analytical samples so that personnel performing the analyses are not able to determine which samples are field duplicates. Field duplicates are designed to assess the consistency of the overall sampling and analytical system.

2.10.3 LABORATORY REPLICATES

Laboratory replicate samples are aliquots of a single sample that are split on arrival at the laboratory or upon analysis. Laboratory replicate samples may be made if no field duplicate samples are provided by the field sampling team; however, their purposes are not always interchangeable. Significant differences between laboratory replicate samples are generally due to analytical technique, whereas significant differences in field duplicate samples may be due to a variety of reasons.

2.10.4 CALIBRATION STANDARDS

A calibration standard is prepared in the laboratory by dissolving a known amount of a pure compound in an appropriate matrix. The final concentration calculated from the known quantities is the true value of the standard. The results obtained from these standards are used to generate a standard curve and thereby quantitate the compound in the environmental sample. A minimum of three calibration standards will be used to generate a standard curve for all analyses.

2.10.5 CHECK STANDARD

A check standard can be prepared in the same manner as a calibration standard or it may be obtained from USEPA. The final concentration calculated from the known quantities is the "true" value of the standard. The important difference in a check standard is that it is not carried through the same process used for the environmental samples, but is analyzed without digestion or extraction. A check standard result is used to validate an existing concentration calibration standard file or calibration curve. The check standard can provide information on the accuracy of the instrumental analytical method independent of various sample matrices.

2.10.6 SPIKE SAMPLE

A sample spike is prepared by adding to an environmental sample (before extraction or digestion), a known amount of pure compound of the same type that is to be assayed for in the environmental sample. These spikes simulate the background and interferences found in the actual samples and the calculated percent recovery of the spike is taken as a measure of the accuracy of the total analytical method. When there is no change in volume due to the spike, it is calculated as follows:

$$\%R = \frac{100\ (O-X)}{T}$$

Where: %R = Percent recovery;
O = Measured value of analyte;
X = Measured value of analyte concentration in the sample before the spike is added; and
T = Quantity of added spike.

Tolerance limits for acceptable percent recovery are established in the methodology references and presented in Section 2.10 of this document.

2.10.7 INTERNAL STANDARD

An internal standard is prepared by adding a known amount of pure compound to the environmental sample; the compound selected is not one expected to be found in the sample, but is similar in nature to the compound of interest. Internal standards are added to the environmental sample just prior to analysis. (Note: Internal standards and surrogate spikes are different compounds. The internal standard is for quantification purposes using the relative response factor; surrogate spikes indicate the percent recovery and, therefore, the efficiency of the methodology.)

2.10.8 MATRIX SPIKE/DUPLICATE

Aliquots are made in the laboratory of the same sample and each aliquot is treated exactly the same throughout the analytical method. Spikes are added at approximately 10 times the method detection limit. The relative percent difference (RPD) between the values of the matrix spike and matrix spike duplicate, as calculated below, is taken as a measure of the precision of the analytical method:

$$RPD = \frac{(D_1 - D_2)}{(D_1 + D_2)\ /\ 2} \times 100$$

Where: RPD = Relative percent difference;
D_1 = First sample value; and
D_2 = Second sample value (duplicate).

In general, the tolerance limit for RPDs between laboratory duplicates should not exceed 20% for validation in homogeneous inorganic samples. Refer to Section 2.8 for criteria on RPDs.

2.10.9 QUALITY CONTROL CHECK SAMPLES

Inorganic and organic control check samples will be provided by BP and are to be used as a means of evaluating analytical techniques of the analyst.

2.10.10 LABORATORY CONTROL STANDARDS

Laboratory Control Standards (LCS) are aliquots of organic-free or deionized water to which known amounts of analyte have been added. They are subjected to the sample preparation extraction procedure and analyzed as samples. The stock solutions used for LCS are purchased or prepared independently of calibration standards. The LCS recovery tests the function of analytical methods or equipment and are described in more detail in the Laboratory QAPjP.

2.10.11 CONTROL LIMITS

Minimal control limits for each analytical method have been established by the U.S.EPA (SW-846, Third Edition). Refer to the Laboratory QAPjP for the internal quality control procedures for each analytical method to be used for this project.

2.11 PERFORMANCE AND SYSTEM AUDITS

The Project QA/QC Supervisor assigned to the project will conduct periodic audits of the operations at the site to ensure that work is being performed in accordance with the work plan and associated standard operating practice. A checklist appropriate to the activities scheduled during the audit will be used. The audit will cover, but not necessarily be limited to, such areas as:

- Conformance to standard operating procedures;
- Completeness and accuracy of documentation;
- Chain-of-custody procedures;
- Compliance with the Health and Safety Plan; and
- Construction specifications.

BP, or its appointed representative, may choose to audit the laboratory. These audits may take the form of Performance Evaluation samples or on-site inspections of the laboratory. Performance evaluation samples may be either blind samples or know to the laboratory. Reasonable notice will be provided if the audit is to include an on-site inspection of the laboratory.

2.12 PREVENTIVE MAINTENANCE

All laboratory and field instruments and equipment used for sample analysis will be maintained and serviced only by qualified personnel. All repairs, adjustments, and calibrations will be documented in an appropriate logbook or data sheet that will be kept on file.

A stock of spare parts and consumables for all analytical equipment will be maintained. In addition, a sufficient redundancy of equipment items to allow for a reasonable level of equipment failure should also be maintained.

2.13 PROCEDURES USED TO ASSESS DATA PRECISION, ACCURACY, AND COMPLETENESS

Performance of the following calculations will be documented and included in the QC section.

2.13.1 FORMULAS

2.13.1.1 Accuracy

Accuracy is the difference between an average value and the "true" value when the latter is known or assumed. The term "accuracy" is normally used interchangeably with "percent recovery," and describes either recovery of a known amount of analyte (spike) added to a sample of known value, or recovery of a synthetic standard of known value.

$$\%\ Recovery\ (spike) = \frac{SSR - SR}{SA} \times 100$$

Where: SSR = Spike sample results
SR = Sample result
SA = Spike added

$$\%\ Recovery\ (standard) = \frac{Observed\ Value}{True\ Value} \times 100$$

Note: The units for the concentrations of spikes, samples, and observed and true values vary based on the analysis. However, they are typically µg/L or mg/L for water samples and µg/kg or mg/kg for soil samples.

Average: The average (or arithmetic mean) of a set of "N" values is the sum of the values divided by "N":

$$X = \frac{\sum_{i=1}^{N} X_i}{N}$$

2.13.1.2 Precision

Relative to the data from a single test procedure, precision is the degree of mutual agreement among individual measurements made under prescribed conditions. An estimate of standard deviation is normally used to describe the precision of a method.

Standard Deviation Estimate: Standard deviation estimate is the most widely used measure to describe the dispersion of a set of data.

Normally, X + SD will include 68%, and X + 2SD will include about 95%, of the data from a study.

$$(SD) = \frac{\sum_{i=1}^{N} (\bar{X}_i - X)^2}{N - 1}$$

Relative Standard Deviation (RSD): The estimate of precision of a series of replicate measurements will usually be expressed as the relative standard deviation (RSD):

$$RSD = \frac{SD}{\bar{X}} \times 100$$

Relative Percent Difference (RPD): A measure of the difference between two samples assumed to be identical through dividing (splitting) an original sample, analyzing each portion, identifying the values of the first replicate (X_1) and that of the second replicate (X_2), and dividing the difference by the mean (X) of X_1 and X_2.

$$RPD = \frac{X_1 - X_2}{X} \times 100$$

2.13.1.3 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the total amount expected to be obtained under normal conditions. The goal of is to achieve 100% completeness, however, a 95% completeness figure is usually required for a particular analysis and overall project objective.

Completeness for each parameter is calculated as:

$$Completeness = \frac{Number\ of\ accepted\ analyses}{Number\ of\ requested\ analyses} \times 100$$

2.13.2 CONTROL LIMITS

Control limits are developed by the laboratory based on historical data. Refer to the Laboratory QAPjP for the project control limits.

2.14 CORRECTIVE ACTION

Corrective actions can be initiated as a result of performance and system audits, laboratory and inter-field comparison studies, data validation, and/or a QA program audit. They may also be required as a result of a request from BP. Success or failure of BP-requested corrective actions will be reported to BP with an estimate of the effect on data quality, if any.

Corrective actions may include altering procedures in the field, conducting subsequent audits, or modifying laboratory protocol. Time and type of corrective action, if needed, will depend on the severity of the problem and relative overall project importance. The project manager is responsible for initiating corrective action and the laboratory manager/director or the team leader is responsible for its implementation.

Precision and accuracy will be regularly tracked by the analytical staff to determine unacceptable results and to evaluate and implement corrective actions. Precision and accuracy criteria for all analyses are listed in Section 2.4 of this QAPjP. Laboratory supervisors and QA/QC staff will evaluate analytical data against the accompanying quality control data for validity. Corrective actions may include, but are not limited to, re-calibration of instruments using freshly prepared calibration standards; replacement of lots of solvent or other reagents that give unacceptable blank values; additional training of laboratory personnel; or reassignment, if necessary. Corrective actions in many cases may have to be defined as the need arises.

If substantial corrective action is required or if serious QA problems are encountered, BP will be notified by phone and in writing as soon as possible. All corrective action will be implemented and documented after notification of BP.

2.15 QUALITY ASSURANCE REPORTS

Upon completion of a project sampling effort, analytical and QC data will be included in a comprehensive report that summarizes the work and provides a data evaluation. A discussion of the validity of the results in the context of QA/QC procedures will be made, as well as a summation of all QA/QC activity.

Serious analytical problems will be reported to BP. Time and type of corrective action, if needed, will depend on the severity of the problem and relative overall project importance. Corrective actions may include altering procedures in the field, conducting an audit, or modifying laboratory protocol. All corrective action will be implemented after notification of BP.