APPENDIX E

PROJECT QUALITY ASSURANCE QUALITY CONTROL PLAN

SECTION 11: PROCEDURE FOR VERIFICATIION OF ATTAINMENT OF THE OPTION 2 CRITERION FOR STABILIZED SLUDGE RADIOACTIVITY LEVELS

REVISED 5/23/97

11.0 PROCEDURE FOR VERIFICATION OF ATTAINMENT OF THE OPTION 2 CRITERION FOR STABILIZED SLUDGE AND SOIL RADIOACTIVITY LEVELS

11.1 INTRODUCTION

Stabilized sludges and soil containing chemical and radiological contamination from the Deepwell, Celite, V-1, and Burn Ponds are to be disposed of in onsite closure cells that meet U.S. EPA RCRA requirements. The contaminated soils will be excavated, transferred and then placed and compacted in the cells. The sludges will be blended in the ponds, excavated, transferred to an onsite processing plant and mixed with stabilizing agents. Subsequent processing will depend on the physical state of the stabilized sludge. Stabilized sludge that has is fluid-like will be pumped, conveyed or hauled by truck directly into the closure cell where it will be cast in place. Stabilized sludge that is soil-like will be stockpiled on staging pads for sampling. After sampling confirms compliance with applicable criteria, the stabilized sludge will be transferred into the closure cell by conveyor or truck where it will be placed and compacted in the cells.

The purpose of this procedure is to establish that the average radioactivity concentration of the stabilized sludge and soil placed into the closure cells meets the concentration limits for insoluble[1] depleted uranium (DU) as established for Option 2 in the U.S. Nuclear Regulatory Commission's (NRC's) Branch Technical Position (SECY 81-576) entitled, *"Disposal of Onsite Storage of Residual Thorium or Uranium (Either as Natural Ores or Without Daughters Present),"* dated October 5, 1981.

11.1.1 Criteria

The criterion established by Option 2 in SECY 81-576 for insoluble[1] uranium is that the average concentration of DU in the material (stabilized sludge and soil) placed into the closure cells does not exceed 300 pCi/g. This is referred to as the average guideline value.

The confirmation that the stabilized sludges and soil placed in the cells meet this criterion will be done in accordance with NUREG/CR-5849 *"Manual for Conducting Radiological Surveys in Support of License Termination"*. Because NUREG/CR-5849 does not specifically address stabilized sludge, this plan will consider the stabilized sludge using the criteria for soil. This is appropriate because the stabilized sludge will have a soil-like consistency (either immediately after stabilization or after cast-in-place

[1] The results of simulated lung fluid solubility testing performed on samples of waste from the BPCI project by an independent laboratory indicate that the material is insoluble and confirm the applicability of the 300 pCi/g criterion. The report entitled *"Lung Fluid Solubility Analysis Report"* was submitted to NRC on December 10, 1995. It was acknowledged without comment by NRC on December 21, 1995, and subsequently used by NRC in preparing the *Environmental Assessment* and *Safety Evaluation Report* in conjunction with the May 8, 1996 issuance of License Amendment 9.

materials solidify). NUREG/CR-5849 requires that soil activity at any location cannot exceed three times the average guideline value. For DU, the maximum activity concentration is not allowed to exceed 900 pCi/g. It also requires that areas of elevated activity between one and three times the average guideline value (i.e. between 300 pCi/g and 900 pCi/g) be less than $(100/A)^{0.5}$ times the guideline value, where A is the area of elevated activity in m^2 and is less than 100 m^2. For areas 100 m^2 (10 m X 10 m) and larger, the average guideline value of 300 pCi/g must be maintained.

11.1.2 Project-Specific Considerations

The following were considered while formulating the methodology to be used to meet the above stated criterion.

11.1.2.1 Existing DU Concentration

Data regarding the concentration of DU in the unstabilized sludges are presented in the BPCI report entitled, *"Summary of Radioactivity of Sludges, Mixed Waste Pond Closure Project, BP Chemicals, Inc., Lima, Ohio."* This report was included as Exhibit B with the May 25, 1994, response to comments document submitted to the NRC.

11.1.2.2 Current Conditions

No additional DU has been placed in the ponds since the referenced study (see Section 11.1.2.1) was conducted. Mechanical blending has taken place in two of the ponds (North Deepwell Pond and South Deepwell Pond) since the study was completed. Therefore, standard deviation and 95% confidence level concentrations of DU in these sludges are likely to be different than those reported in the referenced study. (Average concentrations should remain constant.)

11.1.2.3 Process Homogenization

The sludge within each individual pond has been or will be blended prior to excavation for processing. This will result in homogenization of each sludge. Excavation, which will take material from a variety of depths at any given location, will contribute to further homogenization of the sludge. The sludge removed from the ponds will be transported to the processing area via piping, a conveyor system or trucks. Pumping, which results in a high degree of homogenization, will be used where possible to transfer sludges because it is quicker and less likely to release contaminants to the air. Excavated material which is too dry for pumping will be transferred to the stabilization system by conveyor or truck. This will also further homogenize the material.

11.1.2.4 Processing Considerations

Sludge processing will involve mixing with stabilization additives which will reduce the concentration of DU. The sludge stabilization process is schematically depicted on Figure 11-1. Sludge removed from the ponds will be placed in a batch mixing tank where it will be mixed with Celite clay. Samples of the feedstock sludge will be taken to

guide stabilization process control. Batch mixing is needed to modify the sludge consistency to the specifications required to make an acceptable product. The processing of the sludge through the batch mixing tank will further homogenize it and reduce the concentration of DU. The sludge-clay mixture will be removed from the batch mixing tank, loaded onto a conveyor and transferred to a pug mill mixing device. Additional stabilization reagents will be combined with the sludge-clay mixture in the pug mill. The addition of reagents will create a structurally stable material and will also further reduce the concentration of DU. The stabilized sludge will be transported from the pug mill to a staging pad for storage until analysis is completed. From there it will then be moved to the disposal cells via truck, conveyor or pipeline.

No stabilization of soil is anticipated.

11.1.2.5 Material Handling and Placing Methods

The stabilized sludges and soil will be placed in the cells in batches. Stabilized sludge will be placed in Cell #1. After all sludge is placed, any available capacity remaining in Cell #1 will be used for soil disposal. Cell #2 will be used to dispose of the remainder of the soil. To guide the placement, the available surface of the cells will be divided into rows and columns. The spacing of the rows and columns will be such that each row and column will define a square which will allow one batch of stabilized material to be placed in lifts ranging from eight to twelve inches in thickness. Batches will be placed across one row at a time. For sludge, the batch size will be approximately 33 cubic meters or about one-third of a survey unit. For soil, the batch size will be determined by the contractor's equipment. The largest haul vehicle envisioned for operation will have a capacity of 7.5 m^3 (10 cubic yards). Therefore, a batch size will be approximately 7.5 m^3. For a one foot thick lift, this will result in a row and column spacing of about 5 meters.

11.1.2.6 Quality Control Sampling and Documentation

There will be a quality control contractor on site to oversee sample collection and analysis. An on-site laboratory will be provided to analyze materials. The key to successful process control will be the ability to quickly analyze process control samples. Cast-in-place stabilized sludge will be sampled as it leaves the processing plant. All samples will be labeled and archived. Samples at predetermined intervals will be analyzed. The archived samples will be saved in the event more detailed analyses are required for some portions of the stabilized sludge. Soil-like stabilized sludge will be stockpiled on the stabilization pad until analysis confirms conformance to the specifications. Based on analysis, it the will be either transferred into the cell for placement or returned to the processing plant. Soil to be placed in the cell will be sampled and analyzed in conjunction with efforts to demonstrate that the soils left in place are in compliance with the requirements for release. Additional soil sampling will be conducted on each batch delivered to the disposal cells. The level, row and column for each batch of stabilized sludge and soil placed in the disposal cells will be recorded by the quality control contractor.

11.2 METHODOLOGY

11.2.1 Approach

The approach to confirming conformance to the criteria of Section 11.1.1 varies for cast-in-place stabilized sludge, soil-like stabilized sludge and soil.

11.2.1.1 Cast-in-Place Stabilized Sludge

The approach to confirming that the material placed in the closure cells conforms to the criteria discussed in Section 11.1.1 will be to:

(a) Sample each batch of stabilized sludge during transfer to the cell. Analyze selected batches and calculate the concentration of DU in each batch. (See Section 11.3.)

(b) Map the location of each batch placed in the closure cell. If materials placed exhibit DU concentrations in excess of 300 pCi/g, additional sample analysis and calculations will be performed to verify that the average concentration in the area of elevated activity does not exceed the $(100/A)^{0.5}$ criterion.

(c) Excavate and return any placed batch of material which exceeds the criterion to the stabilization process system.

11.2.1.2 Soil-Like Stabilized Sludge

The approach to confirming that the material placed in the closure cells conforms to the criteria discussed in Section 11.1.1 will be to:

(a) Sample and analyze the stabilized sludge and calculate the concentration of DU in the stockpiled material. (See Section 11.3.)

(b) Return to the stabilization process system any stockpiled material which exceeds the criteria.

(c) Place and compact in the closure cell all stockpiled material which conforms to the criteria.

11.2.1.3 Soil

The approach to confirming that the material placed in the closure cells conforms to the criteria discussed in Section 11.1.1 will be to:

(a) Sample each batch and analyze random batches of soil during placement. Calculate the concentration of DU in the random batches analyzed.

(b) Map the location of each batch placed in the closure cell. If random batches tested exhibit DU concentrations in excess of 300 pCi/g, analyze appropriate additional batches from archived samples. Calculate to verify that the average

concentration in the area of elevated activity does not exceed the $(100/A)^{0.5}$ criterion.

(c) Excavate any placed batch of material which exceeds the criterion and remove for processing in the stabilization process system.

The feasibility of this approach is addressed in the remainder of Section 11.2 of this plan. In Section 11.3, the protocols and procedures for implementing the plan are presented.

11.2.2 Homogeneity Demonstration

In conjunction with starting the stabilization system, a sludge homogeneity demonstration will be performed. The demonstration will include two elements. One element will be an evaluation of the homogeneity of each pond sludge after blending and before the start of pilot testing. The second element will be the verification that the DU concentration of each stabilized sludge behaves as statistically predicted after actual processing through the stabilization system. The second element of the demonstration will be undertaken at the conclusion of pilot testing and before starting actual stabilization and waste placement.

There is no demonstration of soil homogeneity proposed. Soil to be placed in the cell will be sampled and analyzed in conjunction with efforts to demonstrate that the soils left in place are in compliance with the requirements for release. In addition, all batches will be sampled prior to placement in the cell. The details of the process are described in Section 11.2.1.3.

11.2.2.1 Demonstration of Homogeneity of Sludge Characteristics within Each Pond

To minimize the potential need for removing and reprocessing stabilized sludge, a sampling and analysis program will be conducted after sludge blending and before any sludge is removed from the pond for pilot testing. Each pond shall be sampled to verify that the sludge is sufficiently homogeneous to assure the success of the stabilization program to a reasonable degree of confidence. This will be achieved by establishing that (a) the average DU values are within acceptable ranges relevant to meeting regulatory criteria for the stabilized sludge and (b) the variation of those average values within the pond as determined by sampling and statistical evaluation of sample results indicates that very few of the batches or survey units will fall outside the criteria.

Prior to sampling each pond, BPCI's contractor shall complete all planned mechanical blending of pond sludge to "homogenize" the sludge for pilot testing. This is necessary to assure that the sludge removed from each pond for pilot testing is representative of the entire pond contents. Otherwise, pilot test results may not accurately predict full-scale results. The homogeneity demonstration will be conducted for each pond individually.

The contractor shall meet the following performance criteria: blend each sludge and then obtain a sufficient number of samples to demonstrate with 80% confidence that, at most, 5% of the sludge in the pond might fail to meet DU concentration criteria. This alone will assure a high degree of conformance to criteria before treatment and confirmation sampling ever occur. In addition, the sampling results (as adjusted based on stabilization formulas established through bench-scale testing) should indicated that the upper 95% confidence level of the mean DU concentration of the stabilized material will be less than the criterion of 300 pCi/g.

Upon completion of blending operations for each pond, the contractor shall establish a sampling grid coordinate system across the pond for his use in documenting sampling locations. The contractor shall then collect either random or systematic grab samples from the pond using the coordinate system to document sampling locations.. All samples shall be analyzed for DU concentration using the contractor's onsite laboratory. At least one sample per pond shall subsequently be forwarded to an offsite laboratory for quality control duplicate analysis. The contractor shall follow all applicable requirements of Sections 2 and 10 of this Quality Assurance / Quality Control Plan in sample collection and analysis.

To make this demonstration, it will be assumed that the distribution of sample results will be *Normal*. The physical blending process and the statistical *Central Limit Theorem* provide theoretical support for this assumption. The objective of the blending and sampling will be to demonstrate from the sample results with at least 80% confidence that at least 95% of the sludge will meet the DU concentration criteria. The 95% controls the amount of blending and the 80% figure determines the frequency of sampling. The choice of locations, the use of random or systematic sampling, and number of samples collected for analysis shall be chosen by the contractor based on meeting these objectives.

The demonstration shall be accomplished by constructing 95% coverage, 80% confidence tolerance intervals based on the sample mean, sample standard deviation, and tabulated values from a standard statistical reference. (For this demonstration, the reference used shall be Hahn, B. and Meeker, W., *Statistical Intervals*, Tables A10 through A12.) Tolerance intervals should lie entirely within the range of acceptable criteria. The intervals will take into account changes in DU concentration expected as a result of the stabilization process.

The acquired DU data and an evaluation of the DU results achieved shall be reported to NRC at the conclusion of the demonstration for each pond.

11.2.2.2 Demonstration of Effect of Sludge Stabilization on DU Concentration

This demonstration is designed to verify that the DU concentration of each stabilized sludge behaves as statistically predictable after actual processing through the stabilization system. This demonstration will be undertaken at the conclusion of pilot testing but before starting actual production stabilization for waste placement.

At the conclusion of pilot testing for each sludge, a final, confirming batch of unstabilized sludge will be processed through the stabilization system. Sludge and

reagent feed rates and operational settings established by pilot testing will be used for this final, confirming run. The batch size for the final run shall be at least one-third of a survey unit (at least 33 cubic meters).

Ten (10) one liter grab samples of the unstabilized sludge shall be collected over equal time intervals while the batch mixing tank is being charged with sludge. The timing for collection of individual sludge samples shall be such that each sample is representative of 10% of the fill cycle time or volume. Ten (10) one liter grab samples of Celite clay shall also be collected. These clay samples shall be collected either over time as the clay is added (similar to sludge sample collection) or, if the clay charging rate is not uniform, from individual bucket loads as the batch mixing tank is charged. One sample of each of the purchased reagents shall be collected and analyzed in advance during loading of the silos. Ten (10) samples of the stabilized sludge shall be collected over equal time intervals as the material is discharged from the stabilization system. The timing for collection of individual stabilized sludge samples shall be such that each sample represents 10% of the batch processing time through the system.

All samples shall be analyzed and the data used to calculate the mean, standard deviation and 95% confidence level concentrations of DU in the raw sludge, the Celite clay, the other stabilization additives and the stabilized sludge. If the data indicate that project specifications have been met with the test run and are likely to be achieved in full-scale operation, the full-scale operation shall commence per Section 11.3.

11.3 DEMONSTRATION OF COMPLIANCE

The statistical evaluation presented in Section 8.5, "Comparison with Guideline Values," in NUREG/CR 5849 will be used to compare data generated from samples of the stabilized sludge and soil to the 300 pCi/g average activity criterion for DU. The statistical evaluation in Section 8.5 of NUREG/CR-5849 calculates the upper 95% confidence level value for the mean (average) concentration by computing the mean and standard deviation of the data population and then using these parameters in a "Student's t test." The value obtained for the upper 95% confidence level from this test is then compared to the criterion of 300 pCi/g and if it is at or below this value, the criterion is met. If the upper level exceeds 300 pCi/g then the criterion has not been met.

This evaluation also includes a limit or peak value of three times the average guideline value for soil activity at any location. Therefore, stabilized sludge or soil represented by a sample activity greater than 900 pCi/g will not meet the criterion even if the resultant average level is at or below 300 pCi/g for that sample population. This evaluation also includes a limit of $(100/A)^{0.5}$ times the guideline value for samples representing areas smaller than 100 m^2 which contain elevated activity between one and three times the average guideline value (i.e. between 300 and 900 pCi/g).

Three types of materials containing elevated DU activity are to be placed in the disposal cells: cast-in-place stabilized sludge, soil-like stabilized sludge and

contaminated soil. Since soil-like stabilized sludge will be sampled and analyzed prior to placement as described in Section 11.2.1, only cast-in-place stabilized sludge and soil will have any possible chance of being placed in the cell with DU activities exceeding the NUREG/CR 5849 guideline limits. Cast-in-place stabilized sludge and soil samples will be analyzed as each is placed in the cell with random samples analyzed during placement and other samples archived for possible future analysis.

No increase in activity can occur once stabilized sludge and contaminated soil are placed. Therefore, the testing of soil-like stabilized sludge prior to placement and the testing of cast-in-place stabilized sludge and contaminated soil during placement shall be conducted so as to provide a demonstration of compliance. This demonstration will be sufficient to constitute a "final survey" and therefore will be subject to the requirements of NUREG/CR 5849.

Each of the three stabilized sludges and the contaminated soil will be evaluated against the criteria independently as each is placed into the cells. For this project the survey unit size will be 100 cubic meters.

11.3.1 Verification Sample Collection

11.3.1.1 Cast-in-Place Stabilized Sludge

Sampling will be by survey unit. One sample will be collected for each 10 cubic meters of stabilized sludge produced by the stabilization system so that ten samples will be collected per survey unit. Sample collection will be spaced over constant time intervals to approximate the production of 10 cubic meter volumes between samples, assuming a constant production rate. All samples will be labeled. Labeling shall be by survey unit identification number followed by sample sequential number (1 through 10 for each survey unit).

At least three of the ten individual samples from each survey unit will be analyzed. As many additional samples will be tested per survey unit as the onsite laboratory is capable of processing while keeping up with stabilization production. The remaining samples will be archived for future testing. For each survey unit, individual samples will be tested according to the following table:

Number of Samples Tested per Survey Unit	Individual Sample Numbers to be Tested
3	1, 5 and 10
4	1, 4, 7 and 10
5	1, 3, 6, 8 and 10
6	1, 2, 4, 7, 9 and 10

The analysis frequency may be altered if the evaluation discussed in Section 11.3.2 warrant it, regardless of production rate requirements. On the basis that three samples per survey unit will be analyzed and evaluated, the following total number of samples are expected to be analyzed for the entire project:

Pond	Stabilized Volume (cubic meters)	Number of Samples (at 3 per Survey Unit)
North Deepwell	7,200	216
South Deepwell	10,600	318
Burn	18,000	540

The samples will be collected using trowels, spoons or shallow cores and placed into plastic bags. The sampling equipment will be decontaminated between samples consistent with the methodology in Section 2.5.3, "Equipment Decontamination Procedures," of this Quality Assurance Quality Control Plan. Samples will be labeled to show the survey unit number, sample number, date and time. As was indicated previously, the lift, row and column where each survey unit is placed in the closure cell will also be recorded.

11.3.1.2 Soil-Like Stabilized Sludge

Confirmation samples will be based on individual survey units. Samples will be obtained at the discharge of the stabilization system prior to sludge transfer to the staging piles. Staging piles will be used to contain the stabilized sludge until analysis confirms that it is acceptable for permanent placement in the cell. The staging piles will be identifiable in the field as discrete separated piles, as piles separated by barriers, or as larger aggregate piles subdivided by visible markers. Each pile shall be completed to a volume equivalent to about one-third of a survey unit (about 33 cubic meters of stabilized material).

Grab samples will be collected using trowels, spoons or shallow cores and placed into plastic bags. The sampling equipment will be decontaminated between samples consistent with the methodology in Section 2.5.3, "Equipment Decontamination Procedures", of this *Quality Assurance Quality Control Plan*. Samples will be labeled to show the survey unit number, sample number, date and time. As was indicated previously, the lift, row and column where each survey unit is placed in the closure cell will also be recorded.

One sample will be collected for each 10 cubic meters of stabilized sludge produced by the stabilization system so that ten samples will be collected per survey unit. All samples will be labeled. Labeling shall be by survey unit identification number followed by sample sequential number (1 through 10 for each survey unit). For each survey unit, three staging piles will be made. The first third of the survey unit, represented by samples 1, 2 and 3, will be placed in pile A. The second third of the survey unit, represented by samples 4, 5, 6 and 7, will be placed in pile B. The remaining third of the survey unit, represented by samples 8, 9 and 10 will be placed in pile C.

At least three of the ten individual samples from each survey unit will be analyzed. The remaining samples will be archived for future testing. For each survey unit, the individual samples analyzed will follow the table in Section 11.3.1.1. Therefore, with a minimum of three samples analyzed per survey unit, one sample will be from each of the three staging piles. With six samples analyzed per survey unit, two samples will be from each of the three staging piles.

The minimum testing frequency shall be three samples per survey unit. As many additional samples will be tested per survey unit as the onsite laboratory is capable of processing while keeping up with stabilization production. The analysis frequency may be altered if the evaluation discussed in Section 11.3.2 warrant it, regardless of production rate requirements. (See table in Section 11.3.1.2 for an estimate of the total number of samples to be analyzed.)

11.3.1.3 Contaminated Soil

Grab samples of soil will be obtained from each load of the contractor's haul vehicles as batch quantities of soil are delivered for placement in the cells. Each batch (load) of soil will be approximately 7.5 m^3 (10 cubic yards). Each batch (load) will be sampled prior to or during placement in the cell.

Grab samples will be collected using trowels, spoons or shallow cores and placed into plastic bags. The sampling equipment will be decontaminated between samples consistent with the methodology in Section 2.5.3, "Equipment Decontamination Procedures", of this *Quality Assurance Quality Control Plan*. Samples will be labeled to show the batch number, date and time. As was indicated previously, the lift, row and column where each batch is placed in the closure cell will also be recorded.

For each 7.5 cubic meter batch, three grab samples will be obtained at locations within the vehicle bed chosen by the contractor to represent typical characteristics of material within the batch. Equal portions of each grab sample will be mixed until homogeneous to create a single composite sample which will represent the batch. The composite sample of every fifth batch will be analyzed for DU analysis as described in Section 11.3.2 below. The remaining samples will be labeled and archived for possible future analysis. Individual grab samples will not be archived.

11.3.2 Sample Evaluation

Samples will be evaluated in an onsite laboratory using gamma spectroscopy in accordance with the methods contained in EPA Standard Methods 901.1 (provided as Attachment A to this section). Sample evaluation will incorporate all applicable elements of the QA/QC Plan approved by NRC as a part of License Amendment 9, approved May 8, 1996 including the use of a second laboratory to confirm results. The laboratory QA/QC program is specified in Section 10 of this QA/QC Plan.

QA/QC cross checks of the on-site laboratory will be performed per the requirements of Section 10 of this QA/QC Plan. QA/QC cross check samples will be sent after analysis by the on-site laboratory to an offsite commercial laboratory for verification testing. The offsite commercial laboratory shall be licensed by the NRC to accept the

samples for analysis by gamma spectroscopy using procedures specified in Section 10 of this QA/QC Plan.

11.3.3 Comparison to Criterion

The method of comparing the actual sample results obtained after stabilization to the criteria in NUREG/CR-5849 is material specific. The method for each material is explained below. In addition, a running overall summary of the upper 95% confidence level for the mean will be maintained for each individual material placed and for each overall closure cell. The final summary results for each material and each cell will form the demonstration of compliance with NUREG/CR-5849 and will be submitted to NRC.

11.3.3.1 Cast-in-Place Stabilized Sludge

All results will be statistically compared to the 300 pCi/g criterion. If the measured activities of all analyzed samples are found to statistically conform to the criterion of 300 pCi/g for a given survey unit, then the survey unit shall be considered as permanently placed provided all criteria of Specification 03330 are met.

If a sample result reveals a level above 900 pCi/g, all non-analyzed archived samples between the sample in question and the last analyzed sample which met the criteria will be analyzed to determine the extent of the elevated levels. Stabilized sludge associated with the elevated sample results will be removed from the cell. The removed material will be returned to the stabilization feedstock for further treatment.

If a sample result reveals a level between 300 pCi/g and 900 pCi/g, all non-analyzed archived samples for the survey unit will be analyzed. The results will be evaluated to determine the extent of elevated activity within the survey unit. Where necessary, material with elevated activity will be removed for additional processing. Where results between 300 and 900 pCi/g are encountered, the data will be evaluated to assure that the material possessing the elevated concentration of DU conforms with NUREG/CR-5849. The criterion of $(100/A)^{0.5}$ times the guideline value will be used to make this evaluation. To apply this criterion to the survey unit, the symbol A will be used to denote the volume (in cubic meters) of elevated activity (smaller than 100 m^3) which is located within the survey unit.

If a sample result reveals a level between 300 pCi/g and 900 pCi/g, all non-analyzed archived samples for the survey unit will be analyzed. The results will be evaluated to determine the extent of elevated activity within the survey unit. Where necessary, material with elevated activity will be removed for additional processing. Where results between 300 and 900 pCi/g are encountered, the data will be evaluated to assure that the material possessing the elevated concentration of DU conforms with NUREG/CR-5849. The criterion of $(100/A)^{0.5}$ times the guideline value will be used to make this evaluation. To apply this criterion to the survey unit, the symbol A will be used to denote the volume (in cubic meters) of elevated activity (smaller than 100 m^3) which is located within the survey unit.

11.3.3.2 Soil-Like Stabilized Sludge

If the measured activities of all analyzed samples from staging piles are found to statistically conform to the criterion of 300 pCi/g for a given survey unit, then the staging piles shall be delivered to the cell.

If the measured activity of any staging pile exceeds 900 pCi/g, then that staging pile shall be returned to the stabilization system for additional treatment.

If the measured activities of all the staging piles contain elevated activities which cause the statistical exceedance of the criterion for a given survey unit, then all the staging piles will be returned to the stabilization system for additional treatment.

If the measured activity in one or more of the staging piles cause the statistical exceedance of the criterion for a given survey unit, but the measurements of samples from the other staging piles of the same survey unit meet the criterion, then either the staging pile(s) containing the elevated concentration of DU will be returned for reprocessing or further testing of archived samples of the staging piles containing the elevated concentration of DU will be conducted to confirm compliance with the criterion. (See Section 11.3.3.1 for application of the $(100/A)^{0.5}$ criterion to samples containing between 300 pCi/g and 900 pCi/g of DU activity.)

If the measured activity in one of the staging piles is between 300 pCi/g and 900 pCi/g, but the entire survey unit conforms statistically to the criteria, the staging piles which conform may be placed. The staging pile with the elevated DU concentration will be returned for reprocessing or further testing of archived samples will be conducted to confirm compliance with the criterion. (See Section 11.3.3.1 for application of the $(100/A)^{0.5}$ criterion to samples containing between 300 pCi/g and 900 pCi/g of DU activity.)

If one or more staging piles for a survey unit are returned for reprocessing, then they will be replaced using freshly processed sludge to restore the survey unit volume to 100 cubic meters. Samples collected from the replacement material will be labeled with the same sequence numbers as the material which was returned followed by a suffix character A through Z to denote the substitution. The replacement material shall be analyzed following the same procedure as the original material. The analytical results for the replacement staging pile(s) will be combined with the results of the conforming staging piles of the survey unit to determine overall conformance to the criterion for that survey unit.

11.3.3.3 Contaminated Soil

If a sample result reveals a level above 900 pCi/g, all non-analyzed archived samples between the sample in question and the last analyzed sample which met the criteria will be analyzed to determine the extent of the elevated levels. Affected soil associated with the elevated sample results will be removed from the cell. The removed soil will be moved to the stabilization feedstock for further treatment.

All sample results will be compared to the 300 pCi/g average and other criteria. In the event that a concentration higher than 300 pCi/g is encountered, the archived samples between the previously analyzed batch and the batch in question will be analyzed. The results will be evaluated to determine the extent of elevated activity Where necessary, material with elevated activity will be removed for additional processing. Where results between 300 and 900 pCi/g are encountered, the data will be evaluated to assure that the concentration of DU within the entire survey unit conforms to the criterion. (See Section 11.3.3.1 for application of the $(100/A)^{0.5}$ criterion to samples containing between 300 pCi/g and 900 pCi/g of DU activity.)

11.4 DOCUMENTATION

All sample collection activities will be documented as outlined in Section 2.0, "Soil Sampling," of this *Quality Assurance Quality Control Plan* for radiological sampling. All analysis results and subsequent evaluation of the results will be documented in a consistent format with results submitted to BP's onsite construction manager and copies will be kept in the onsite laboratory or site field office.

W.M. Rupert
5/23/97
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APPENDIX E

PROJECT QUALITY ASSURANCE QUALITY CONTROL PLAN

SECTION 11: PROCEDURE FOR VERIFICATIION OF ATTAINMENT OF THE OPTION 2 CRITERION FOR STABILIZED SLUDGE RADIOACTIVITY LEVELS

REVISED 5/23/97
AND
MODIFIED TO SHOW ALL TEXT OF ORIGINAL 10/17/95 VERSION

11.0 PROCEDURE FOR VERIFICATION OF ATTAINMENT OF THE OPTION 2 CRITERION FOR STABILIZED SLUDGE AND SOIL RADIOACTIVITY LEVELS

11.1 INTRODUCTION

Stabilized sludges and soil containing chemical and radiological contamination from the Deepwell, Celite, V-1, and Burn Ponds are to be ~~placed~~ **disposed of** in onsite closure cells that meet **U.S. EPA** RCRA requirements. The contaminated soils will be excavated, transferred and then placed and compacted in the cells. The sludges will be ~~removed by pumping or dredging, stabilized by mixing with reagents,~~ **blended in the ponds, excavated, transferred to an onsite processing plant and mixed with stabilizing agents. Subsequent processing will depend on the physical state of the stabilized sludge. Stabilized sludge that has is fluid-like will be pumped, conveyed or hauled by truck directly into the closure cell where it will be cast in place. Stabilized sludge that is soil-like will be stockpiled on staging pads for sampling. After sampling confirms compliance with applicable criteria, the stabilized sludge will be transferred into the closure cell by conveyor or truck where it will be** ~~and then~~ placed ~~into~~ **and compacted in** the cells.

The purpose of this procedure is to ~~define the methodology confirming~~ **establish** that the average **radioactivity** concentration of the stabilized sludge and soil placed into the closure cells ~~does not exceed~~ **meets** the concentration limits for insoluble[1] depleted uranium **(DU)** as established for Option 2 in the U.S. Nuclear Regulatory Commission's (NRC's) Branch Technical Position (SECY 81-576) entitled, *"Disposal of Onsite Storage of Residual Thorium or Uranium (Either as Natural Ores or Without Daughters Present),"* dated October 5, 1981. ~~The results of simulated lung fluid solubility testing indicate that the material is insoluble and confirm the applicability of the 300 pCi/g criterion.~~

11.1.1 CRITERIA

The criterion established by Option 2 in SECY 81-576 **for insoluble[1] uranium** is that the average concentration of ~~depleted uranium of~~ **DU in** the material ~~to be disposed of~~ (stabilized sludge and soil) placed into the closure cells does not exceed 300 pCi/g. This is referred to as the average guideline value.

The confirmation that the stabilized sludges and soil placed in the cells meet this criterion will be done in accordance with NUREG/CR-5849 *"Manual for Conducting Radiological Surveys in Support of License Termination"*. Because NUREG/CR-5849

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[1] The results of simulated lung fluid solubility testing performed on samples of waste from the BPCI project by an independent laboratory indicate that the material is insoluble and confirm the applicability of the 300 pCi/g criterion. The report entitled *"Lung Fluid Solubility Analysis Report"* was submitted to NRC on December 10, 1995. It was acknowledged without comment by NRC on December 21, 1995, and subsequently used by NRC in preparing the *Environmental Assessment* and *Safety Evaluation Report* in conjunction with the May 8, 1996 issuance of License Amendment 9.

does not specifically address stabilized sludge, this plan will consider the stabilized sludge using the criteria for soil. This is appropriate because the stabilized sludge will have a soil-like consistency **(either immediately after stabilization or after cast-in-place materials solidify).** NUREG/CR-5849 requires that soil activity at any location cannot exceed three times the average guideline value. **For DU, the maximum activity concentration is not allowed to exceed 900 pCi/g.** It also requires that areas of elevated activity between one and three times the average guideline value **(i.e. between 300 pCi/g and 900 pCi/g)** be less than $(100/A)^{0.5}$ times the guideline value, where A is the area of elevated activity in m^2 and is less than 100 m^2. **For areas 100 m^2 (10 m X 10 m) and larger, the average guideline value of 300 pCi/g must be maintained.**

11.1.2 PROJECT-SPECIFIC CONSIDERATIONS

The following were considered while formulating the methodology to be used to meet the above stated criterion.

11.1.2.1 Existing DU Concentration

Data regarding the concentration of DU in the unstabilized sludges are presented in the **BPCI** report entitled, *"Summary of Radioactivity of Sludges, Mixed Waste Pond Closure Project, BP Chemicals, Inc., Lima, Ohio."* This report was included as Exhibit B with the May 25, 1994, response to comments document submitted to the NRC.

11.1.2.2 Current Conditions

No additional DU has been placed in the ponds since the referenced study (see Section 11.1.2.1) was conducted. Mechanical blending has taken place in two of the ponds (North Deepwell Pond and South Deepwell Pond) since the study was completed. Therefore, standard deviation and 95% confidence level concentrations of DU in these sludges are likely to be different than those reported in the referenced study. (Average concentrations should remain constant.)

11.1.2.3 Process Homogenization

The sludge within each individual pond has been or will be blended prior to excavation for processing. ~~Sludge will be removed from the ponds by pumping and dredging simultaneously from at least two points~~. This will result in homogenization of ~~the~~ **each** sludge. ~~Dredging~~ **Excavation**, which will take material from a variety of depths at any given location, will ~~also result in considerable~~ **contribute to further** homogenization of the sludge. The sludge removed from the ponds will be transported to the processing area via piping, a conveyor system or trucks. Pumping, which results in a high degree of homogenization, will be used where possible **to transfer sludges** because it is quicker and less likely to release contaminants to the air. ~~Dredged~~ **Excavated** material which is too dry for ~~processing may be returned to the pond from which it was taken to increase its moisture content~~ **pumping will be transferred to**

the stabilization system by conveyor or truck. This will **also** further homogenize the material.

11.1.2.4 Processing Considerations

Sludge processing will involve mixing with ~~the~~ stabilization additives **which** will reduce the concentration of **DU**. The sludge ~~solidification~~ **stabilization** process is schematically depicted on Figure 11-1. Sludge removed from the ponds will be placed in a ~~conditioning tank~~ **batch mixing tank where it will be mixed with Celite clay**. Samples of the feedstock **sludge** will be taken to guide ~~pre-solidification~~ **stabilization** process control. ~~The conditioning~~ **Batch mixing** ~~tank~~ is needed to modify the sludge consistency to the specifications required to make an acceptable product. ~~This might include the addition or removal of water, the removal and breaking up of large particles etc. Conditioning chemicals will also be added as required.~~ The ~~passing~~ **processing** of the sludge through the ~~conditioning~~ **batch mixing** tank will ~~also~~ **further** homogenize it **and reduce the concentration of DU**. **The sludge-clay mixture will be removed from the batch mixing tank, loaded onto a conveyor and transferred to a pug mill mixing device**. ~~The~~ **Additional stabilization** reagents will be combined with the sludge**-clay mixture** in ~~a mixing device~~ **the pug mill**. ~~For reference design purposes this is considered to be a pug mill mixer~~. The addition of reagents ~~to~~ **will** create a structurally stable material **and** will also **further** reduce the concentration of ~~depleted uranium~~ **DU**. The **stabilized** sludge will be transported from the pug mill to a staging pad for storage until analysis is completed. ~~The material~~ **From there it** will then be moved to the disposal cells via truck, **conveyor or pipeline**.

No stabilization of soil is anticipated.

11.1.2.5 Material Handling and Placing Methods

The stabilized sludges and soil will be placed in the cells in batches[4]. Stabilized sludge will be placed in Cell #1. After all sludge is placed, any available capacity remaining in Cell #1 will be used for soil disposal. Cell #2 will be used to dispose of the remainder of the soil. To guide the placement, the available surface of the cells will be divided into rows and columns. The spacing of the rows and columns will be such that each row and column will define a square which will allow one batch of stabilized material to be placed in lifts ranging from ~~one to three feet~~ **eight to twelve inches** in thickness. Batches will be placed across one row at a time. **For sludge, the batch size will be approximately 33 cubic meters or about one-third of a survey unit**. **For soil, the** ~~The~~ batch size will be determined by the contractor's equipment. The largest haul vehicle envisioned for operation will have a capacity of 7.5 m^3 (10 cubic yards). **Therefore, a batch size will be approximately 7.5 m^3**. For a one foot thick lift, this will result in a row and column spacing of **about** 5 meters.

~~[4] In this document the term batch refers to a single filling of the haul vehicle which will be used to transport stabilized sludge from the stabilization plant to the disposal cells. The same batch size is assumed for the vehicle which transports feedstock to the conditioning tank. Continuous processes are assumed to be subdivided into discrete batches for analysis purposes.~~

11.1.2.6 Quality Control Sampling and Documentation

There will be a quality control contractor **on site to oversee sample collection and analysis. An** ~~with an~~ on-site laboratory ~~who will sample and~~ **will be provided to** analyze materials. The key to successful process control will be the ability to quickly analyze process control samples. ~~The~~ **Cast-in-place** stabilized sludge will be sampled as it leaves the ~~batch~~ **processing** plant. All samples will be labeled and archived. Samples at predetermined intervals will be analyzed. The archived samples will be saved in the event more detailed analyses are required for some portions of the stabilized sludge. **Soil-like stabilized sludge will be stockpiled on the stabilization pad until analysis confirms conformance to the specifications. Based on analysis, it the will be either transferred into the cell for placement or returned to the processing plant.** Soil to be placed in the cell will be sampled and analyzed in conjunction with efforts to demonstrate that the soils left in place are in compliance with the requirements for release. **Additional soil sampling will be conducted on each batch delivered to the disposal cells.** The level, row and column for each batch of stabilized sludge and soil **placed in the disposal cells** will be recorded by the quality control contractor.

11.2 METHODOLOGY

11.2.1 APPROACH

The approach to confirming conformance to the criteria of Section 11.1.1 varies for cast-in-place stabilized sludge, soil-like stabilized sludge and soil.

11.2.1.1 Cast-in-Place Stabilized Sludge

The approach to confirming that the material placed in the closure cells conforms to the criteria discussed in ~~the previous section~~ **Section 11.1.1** will be to:

(a) Sample ~~and analyze the soil and~~ **each batch of** stabilized sludge **during transfer to the cell**. ~~and~~ **Analyze selected batches and** calculate the concentration of DU in ~~the as placed material~~ **each batch**. **(See Section 11.3.)**

(b) Map the location of each batch placed in the closure cell. If materials placed exhibit DU concentrations in excess of 300 pCi/g, **additional sample analysis and** calculations will be performed to verify that the average concentration in the area of elevated activity does not exceed the $(100/A)^{0.5}$ criterion.

(c) **Excavate and** return any ~~mixed or~~ placed batch of material which exceeds the criterion to the stabilization process system. ~~Based on data obtained from sampling the ponds and a simulation of the processing system discussed in Section 11.2.2, this is considered to have a probability of occurrence of less than one in 10 million.~~

11.2.1.2 Soil-Like Stabilized Sludge

The approach to confirming that the material placed in the closure cells conforms to the criteria discussed in Section 11.1.1 will be to:

(a) Sample and analyze the stabilized sludge and calculate the concentration of DU in the stockpiled material. (See Section 11.3.)

(b) Return to the stabilization process system any stockpiled material which exceeds the criteria.

(c) Place and compact in the closure cell all stockpiled material which conforms to the criteria.

11.2.1.3 Soil

The approach to confirming that the material placed in the closure cells conforms to the criteria discussed in Section 11.1.1 will be to:

(a) Sample each batch and analyze random batches of soil during placement. Calculate the concentration of DU in the random batches analyzed.

(b) Map the location of each batch placed in the closure cell. If random batches tested exhibit DU concentrations in excess of 300 pCi/g, analyze appropriate additional batches from archived samples. Calculate to verify that the average concentration in the area of elevated activity does not exceed the $(100/A)^{0.5}$ criterion.

(c) Excavate any placed batch of material which exceeds the criterion and remove for processing in the stabilization process system.

The feasibility of this approach is addressed in the ~~next section~~ remainder of Section 11.2 of this plan. In Section 11.3, the protocols and procedures for implementing the plan are presented.

~~11.2.2 EVALUATION~~

~~Samples were taken of the unstabilized sludge in each of the ponds and analyzed for depleted uranium activity. The results of these analyses were presented in the report entitled, "Summary of Radioactivity of Sludges, Mixed Waste Pond Closure Project, BP Chemicals, Inc., Lima, Ohio." The data were statistically analyzed using the procedures presented in NUREG/CR 5849, Section 8.5. Using the 1994 data, the mean, the standard deviation and the upper 95% confidence limit were calculated. The results of these analyses are summarized on Table 11-1 below:~~

Table 11-1
Summary Statistics of Unstabilized Sludges

SOURCE SLUDGE	MEAN DU ACTIVITY OF UNSTABILIZED SLUDGE (pCi/g)	STANDARD DEVIATION (pCi/g)	UPPER 95% CONFIDENCE LIMIT (pCi/g)
Burn	410	261	486
V-1	100	78	122
Deepwell & Celite	208	111	246

As can be seen from these analyses, the upper 95% confidence limit for the unstabilized sludges from the V-1, Deepwell and Celite ponds is less than 300 pCi/g. Sampling and analysis will be performed on the sludges from all of the ponds after stabilization. However, since it is the only pond from which raw sludge in excess of the 300 pCi/g criterion is anticipated, only the Burn Pond sludge is evaluated further in this section.

To evaluate the technical feasibility of the proposed sampling and analysis approach, a numerical simulation of the sludge processing operation was performed. The calculations for this evaluation are presented in Appendix 11-A. In this evaluation, the sludge was assumed to be added to a 20,000 gallon (99 cubic yard) conditioning tank. Total homogenization was assumed. The activity in each batch was generated randomly from the normal distribution defined by the statistics presented in Table 11-1 The results of the analysis are presented as a cumulative distribution on Figure 11-2. As can be seen from these figures, none of the solidified batches are expected to exceed the 300 pCi/g maximum criterion.

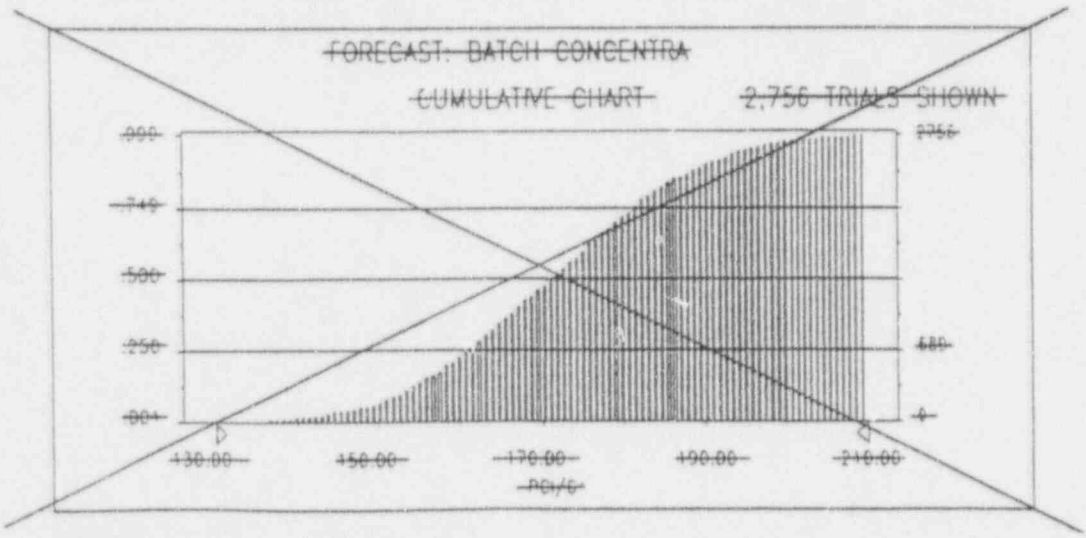

Figure 11-2 Cumulative distribution of sludge stabilization simulation results.

~~11.2.3~~ 11.2.2 Homogeneity Demonstration

~~When~~ In conjunction with starting the stabilization system ~~is started~~, a sludge homogeneity demonstration will be performed. The demonstration will include two elements. One element will be an evaluation of the homogeneity of each pond sludge after blending and before the start of pilot testing. The second element will be the verification that the DU concentration of each stabilized sludge behaves as statistically predicted after actual processing through the stabilization system. The second element of the demonstration will be undertaken at the conclusion of pilot testing and before starting actual stabilization and waste placement.

There is no demonstration of soil homogeneity proposed. Soil to be placed in the cell will be sampled and analyzed in conjunction with efforts to demonstrate that the soils left in place are in compliance with the requirements for release. In addition, all batches will be sampled prior to placement in the cell. The details of the process are described in Section 11.2.1.3.

11.2.2.1 Demonstration of Homogeneity of Sludge Characteristics within Each Pond

To minimize the potential need for removing and reprocessing stabilized sludge, a sampling and analysis program will be conducted after sludge blending and before any sludge is removed from the pond for pilot testing. Each pond shall be sampled to verify that the sludge is sufficiently homogeneous to assure the success of the stabilization program to a reasonable degree of confidence. This will be achieved by establishing that (a) the average DU values are within acceptable ranges relevant to meeting regulatory criteria for the stabilized sludge and (b) the variation of those average values within the pond as determined by sampling and statistical evaluation of sample results indicates that very few of the batches or survey units will fall outside the criteria.

Prior to sampling each pond, BPCI's contractor shall complete all planned mechanical blending of pond sludge to "homogenize" the sludge for pilot testing. This is necessary to assure that the sludge removed from each pond for pilot testing is representative of the entire pond contents. Otherwise, pilot test results may not accurately predict full-scale results. The homogeneity demonstration will be conducted for each pond individually.

The contractor shall meet the following performance criteria: blend each sludge and then obtain a sufficient number of samples to demonstrate with 80% confidence that, at most, 5% of the sludge in the pond might fail to meet DU concentration criteria. This alone will assure a high degree of conformance to criteria before treatment and confirmation sampling ever occur. In addition, the sampling results (as adjusted based on stabilization formulas established through bench-scale testing) should indicated that the upper 95% confidence

level of the mean DU concentration of the stabilized material will be less than the criterion of 300 pCi/g.

Upon completion of blending operations for each pond, the contractor shall establish a sampling grid coordinate system across the pond for his use in documenting sampling locations. The contractor shall then collect either random or systematic grab samples from the pond using the coordinate system to document sampling locations.. All samples shall be analyzed for DU concentration using the contractor's onsite laboratory. At least one sample per pond shall subsequently be forwarded to an offsite laboratory for quality control duplicate analysis. The contractor shall follow all applicable requirements of Sections 2 and 10 of this Quality Assurance / Quality Control Plan in sample collection and analysis.

To make this demonstration, it will be assumed that the distribution of sample results will be *Normal*. The physical blending process and the statistical *Central Limit Theorem* provide theoretical support for this assumption. The objective of the blending and sampling will be to demonstrate from the sample results with at least 80% confidence that at least 95% of the sludge will meet the DU concentration criteria. The 95% controls the amount of blending and the 80% figure determines the frequency of sampling. The choice of locations, the use of random or systematic sampling, and number of samples collected for analysis shall be chosen by the contractor based on meeting these objectives.

The demonstration shall be accomplished by constructing 95% coverage, 80% confidence tolerance intervals based on the sample mean, sample standard deviation, and tabulated values from a standard statistical reference. (For this demonstration, the reference used shall be Hahn, B. and Meeker, W., *Statistical Intervals*, Tables A10 through A12.) Tolerance intervals should lie entirely within the range of acceptable criteria. The intervals will take into account changes in DU concentration expected as a result of the stabilization process.

The acquired DU data and an evaluation of the DU results achieved shall be reported to NRC at the conclusion of the demonstration for each pond.

11.2.2.2 Demonstration of Effect of Sludge Stabilization on DU Concentration

This demonstration is designed to verify that the DU concentration of each stabilized sludge behaves as statistically predictable after actual processing through the stabilization system. This demonstration will be undertaken at the conclusion of pilot testing but before starting actual production stabilization for waste placement.

At the conclusion of pilot testing for each sludge, a final, confirming batch of unstabilized sludge will be processed through the stabilization system. Sludge and reagent feed rates and operational settings established by pilot testing will be used for this final, confirming run. The batch size for the final run shall be at least one-third of a survey unit (at least 33 cubic meters).

~~A total of one hundred and fifty cubic yards of sludge will be included in this demonstration. The demonstration will consist of sampling and analyzing each 5 cubic yard batch of sludge which is taken from the ponds and each 5 cubic yard batch of stabilized sludge from the solidification plant. The raw sludge for the experiment will be taken from two different parts of the Burn Pond. If possible, the sludges will be taken form the locations where the highest and lowest U-238 concentrations were encountered during the sampling program.~~ **Ten (10) one liter grab samples of the unstabilized sludge shall be collected over equal time intervals while the batch mixing tank is being charged with sludge. The timing for collection of individual sludge samples shall be such that each sample is representative of 10% of the fill cycle time or volume. Ten (10) one liter grab samples of Celite clay shall also be collected. These clay samples shall be collected either over time as the clay is added (similar to sludge sample collection) or, if the clay charging rate is not uniform, from individual bucket loads as the batch mixing tank is charged. One sample of each of the purchased reagents shall be collected and analyzed in advance during loading of the silos. Ten (10) samples of the stabilized sludge shall be collected over equal time intervals as the material is discharged from the stabilization system. The timing for collection of individual stabilized sludge samples shall be such that each sample represents 10% of the batch processing time through the system.**

All samples shall be analyzed and the data used to calculate the mean, standard deviation and 95% confidence level concentrations of DU in the raw sludge, the Celite clay, the other stabilization additives and the stabilized sludge. ~~The stabilized sludge data will be plotted in control chart form and compared to the theoretical control chart curve based on the mixing model which was discussed in the previous section.~~ **If the data indicate that project specifications have been met with the test run and are likely to be achieved in full-scale operation, the full-scale operation shall commence per Section 11.3.**

11.3 DEMONSTRATION OF COMPLIANCE

The statistical evaluation presented in Section 8.5, "Comparison with Guideline Values," in ~~(draft)~~ NUREG/CR 5849 will be used to compare data generated from samples of the stabilized sludge and soil to the 300 pCi/g average activity ~~of depleted uranium~~ criterion **for DU. The statistical evaluation in Section 8.5 of NUREG/CR-5849 calculates the upper 95% confidence level value for the mean (average) concentration by computing the mean and standard deviation of the data population and then using these parameters in a "Student's t test." The value obtained for the upper 95% confidence level from this test is then compared to the criterion of 300 pCi/g and if it is at or below this value, the criterion is met. If the upper level exceeds 300 pCi/g then the criterion has not been met.** ~~This evaluation also includes a limit or peak value of three times the average guideline value for soil activity at any location. Therefore, stabilized sludge or soil represented by a sample activity greater than 900 pCi/g will not meet the criterion even if the resultant average level is at or below 300 pCi/g for that sample population.~~

~~The statistical evaluation in Section 8.5 of NUREG/CR-5849 calculates the upper 95% confidence level value for the mean (average) concentration by calculating the mean and standard deviation of the data population and then using these parameters in a "Student's t test." The value obtained for the upper 95% confidence level from this test is then compared to the criterion of 300 pCi/g and if it is at or below this value, the criteria are met. If the upper level exceeds 300 pCi/g then the criteria have not been met.~~

This evaluation also includes a limit or peak value of three times the average guideline value for soil activity at any location. Therefore, stabilized sludge or soil represented by a sample activity greater than 900 pCi/g will not meet the criterion even if the resultant average level is at or below 300 pCi/g for that sample population. This evaluation also includes a limit of $(100/A)^{0.5}$ times the guideline value for samples representing areas smaller than 100 m^2 which contain elevated activity between one and three times the average guideline value (i.e. between 300 and 900 pCi/g).

Three types of materials containing elevated DU activity are to be placed in the disposal cells: cast-in-place stabilized sludge, soil-like stabilized sludge and contaminated soil. Since soil-like stabilized sludge will be sampled and analyzed prior to placement as described in Section 11.2.1, only cast-in-place stabilized sludge and soil will have any possible chance of being placed in the cell with DU activities exceeding the NUREG/CR 5849 guideline limits. Cast-in-place stabilized sludge and soil samples will be analyzed as each is placed in the cell with random samples analyzed during placement and other samples archived for possible future analysis.

No increase in activity can occur once stabilized sludge and contaminated soil are placed. Therefore, the testing of soil-like stabilized sludge prior to placement and the testing of cast-in-place stabilized sludge and contaminated soil during placement shall be conducted so as to provide a demonstration of compliance. This demonstration will be sufficient to constitute a "final survey" and therefore will be subject to the requirements of NUREG/CR 5849.

~~The stabilized Burn Pond sludge~~ **Each of the three stabilized sludges** and the contaminated soil will be evaluated against the criteria independently as each is placed into the cells. **For this project the survey unit size will be 100 cubic meters.**

11.3.1 VERIFICATION SAMPLE COLLECTION

11.3.1.1 Cast-in-Place Stabilized Sludge

Sampling will be by survey unit. One sample will be collected **for each 10 cubic meters of stabilized sludge produced** ~~from each batch of stabilized sludge as it comes from the pug mill~~ **by the stabilization system so that ten samples will be collected per survey unit**. ~~All samples will be archived. During startup for the feedstock from each pond, the first eight batches will be analyzed to start a control~~

~~chart. After startup of the system, one sample for every 40 cubic yards of stabilized sludge will be analyzed. The results will be plotted on a control chart. The analysis frequency is based on having one analysis per 100 m^2 of material placed in one foot thick lifts~~. **Sample collection will be spaced over constant time intervals to approximate the production of 10 cubic meter volumes between samples, assuming a constant production rate. All samples will be labeled. Labeling shall be by survey unit identification number followed by sample sequential number (1 through 10 for each survey unit).** ~~The analysis frequency may be altered if the evaluation discussed in Section 11.3.2 warrant it.~~

At least three of the ten individual samples from each survey unit will be analyzed. As many additional samples will be tested per survey unit as the onsite laboratory is capable of processing while keeping up with stabilization production. The remaining samples will be archived for future testing. For each survey unit, individual samples will be tested according to the following table:

Number of Samples Tested per Survey Unit	Individual Sample Numbers to be Tested
3	1, 5 and 10
4	1, 4, 7 and 10
5	1, 3, 6, 8 and 10
6	1, 2, 4, 7, 9 and 10

The analysis frequency may be altered if the evaluation discussed in Section 11.3.2 warrant it, regardless of production rate requirements. On the basis that three samples per survey unit will be analyzed and evaluated, the following total number of samples are expected to be analyzed for the entire project:

Pond	Stabilized Volume (cubic meters)	Number of Samples (at 3 per Survey Unit)
North Deepwell	7,200	216
South Deepwell	10,600	318
Burn	18,000	540

The samples will be collected using trowels, spoons or shallow cores and placed into plastic bags. The sampling equipment will be decontaminated between samples consistent with the methodology in Section 2.5.3, "Equipment Decontamination Procedures," of this ~~QAPjP~~ **Quality Assurance Quality Control Plan**. Samples will be labeled to show the ~~batch~~ **survey unit number, sample** number, date and time. ~~Where the feedstock is sampled, records will be kept showing the approximate location in the pond where the material was taken from.~~ As was indicated previously, the lift, row and column where each ~~batch~~ **survey unit** is placed in the closure cell will also be recorded.

11.3.1.2 Soil-Like Stabilized Sludge

Confirmation samples will be based on individual survey units. Samples will be obtained at the discharge of the stabilization system prior to sludge transfer to the staging piles. Staging piles will be used to contain the stabilized sludge until analysis confirms that it is acceptable for permanent placement in the cell. The staging piles will be identifiable in the field as discrete separated piles, as piles separated by barriers, or as larger aggregate piles subdivided by visible markers. Each pile shall be completed to a volume equivalent to about one-third of a survey unit (about 33 cubic meters of stabilized material).

"Grab" samples will be collected using trowels, spoons or shallow cores and placed into plastic bags. The sampling equipment will be decontaminated between samples consistent with the methodology in Section 2.5.3, "Equipment Decontamination Procedures," of this Quality Assurance Quality Control Plan. Samples will be labeled to show the survey unit number, sample number, date and time. As was indicated previously, the lift, row and column where each survey unit is placed in the closure cell will also be recorded.

One sample will be collected for each 10 cubic meters of stabilized sludge produced by the stabilization system so that ten samples will be collected per survey unit. All samples will be labeled. Labeling shall be by survey unit identification number followed by sample sequential number (1 through 10 for each survey unit). For each survey unit, three staging piles will be made. The first third of the survey unit, represented by samples 1, 2 and 3, will be placed in pile A. The second third of the survey unit, represented by samples 4, 5, 6 and 7, will be placed in pile B. The remaining third of the survey unit, represented by samples 8, 9 and 10 will be placed in pile C.

At least three of the ten individual samples from each survey unit will be analyzed. The remaining samples will be archived for future testing. For each survey unit, the individual samples analyzed will follow the table in Section 11.3.1.1. Therefore, with a minimum of three samples analyzed per survey unit, one sample will be from each of the three staging piles. With six samples analyzed per survey unit, two samples will be from each of the three staging piles.

The minimum testing frequency shall be three samples per survey unit. As many additional samples will be tested per survey unit as the onsite laboratory is capable of processing while keeping up with stabilization production. The analysis frequency may be altered if the evaluation discussed in Section 11.3.2 warrant it, regardless of production rate requirements. (See table in Section 11.3.1.2 for an estimate of the total number of samples to be analyzed.)

11.3.1.3 Contaminated Soil

Grab samples of soil will be obtained from each load of the contractor's haul vehicles as batch quantities of soil are delivered for placement in the cells.

Each batch (load) of soil will be approximately 7.5 m^3 (10 cubic yards). Each batch (load) will be sampled prior to or during placement in the cell.

Grab samples will be collected using trowels, spoons or shallow cores and placed into plastic bags. The sampling equipment will be decontaminated between samples consistent with the methodology in Section 2.5.3, "Equipment Decontamination Procedures," of this Quality Assurance Quality Control Plan. Samples will be labeled to show the batch number, date and time. As was indicated previously, the lift, row and column where each batch is placed in the closure cell will also be recorded.

For each 7.5 cubic meter batch, three grab samples will be obtained at locations within the vehicle bed chosen by the contractor to represent typical characteristics of material within the batch. Equal portions of each grab sample will be mixed until homogeneous to create a single composite sample which will represent the batch. The composite sample of every fifth batch will be analyzed for DU analysis as described in Section 11.3.2 below. The remaining samples will be labeled and archived for possible future analysis. Individual grab samples will not be archived.

11.3.2 SAMPLE EVALUATION

~~The~~ Samples ~~collected~~ will be evaluated in an onsite laboratory using gamma spectroscopy in accordance with the methods contained in EPA Standard Methods 901.1 (provided as Attachment A to this section). Sample evaluation will incorporate all applicable elements of the QA/QC Plan approved by NRC as a part of License Amendment 9, approved May 8, 1996 including the use of a second laboratory to confirm results. The laboratory QA/QC program is specified in Section 10 of this QA/QC Plan.

~~Quick on-site laboratory turnaround time is feasible considering that the criterion is an average concentration of 300 pCi/g. Count times of approximately 15 minutes can be used to achieve appropriate detection limits. Quick turnaround of the stabilized batches will allow for corrective action to be taken prior to the curing of a batch of material in closure cell.~~

QA/QC cross checks of the on-site laboratory will be performed per the requirements of Section 10 of this QA/QC Plan. ~~One sample in 10~~ QA/QC cross check samples will ~~also~~ be sent after analysis by the on-site laboratory to an offsite commercial laboratory for verification testing. The offsite commercial laboratory shall be licensed by the NRC to accept the samples for analysis by gamma spectroscopy using procedures specified in Section ~~2.0, "Soil Sampling,"~~ 10 of this ~~QAPjP~~ QA/QC Plan. ~~These can also serve as confirmation samples.~~

~~The results from each analysis of stabilized Burn Pond sludge or contaminated soil will be added to the data base of the results from the same material type previously generated. A weekly evaluation will be made of the material placed (stabilized sludge~~

~~or contaminated soil) to verify that sufficient samples have been collected in consideration of a variance of the material which has been placed to date. This will be done in the form of a control chart which will track a running average standard deviation and control limits and variability.~~

11.3.3 COMPARISON TO CRITERIA

The method of comparing the actual sample results obtained after stabilization to the criteria in NUREG/CR-5849 is material specific. The method for each material is explained below. In addition, a running overall summary of the upper 95% confidence level for the mean will be maintained for each individual material placed and for each overall closure cell. The final summary results for each material and each cell will form the demonstration of compliance with NUREG/CR-5849 and will be submitted to NRC.

11.3.3.1 Cast-in-Place Stabilized Sludge

All results will be statistically compared to the 300 pCi/g criterion. If the measured activities of all analyzed samples are found to statistically conform to the criterion of 300 pCi/g for a given survey unit, then the survey unit shall be considered as permanently placed provided all criteria of Specification 03330 are met.

If a sample result reveals a level above 900 pCi/g, all non-analyzed archived samples between the sample in question and the last analyzed sample which met the criteria will be analyzed to determine the extent of the elevated levels. Stabilized sludge ~~or affected soil~~ associated with the elevated sample results will be removed from the cell. The removed material will be ~~conditioned and~~ returned to the stabilization feedstock for further treatment.

If a sample result reveals a level between 300 pCi/g and 900 pCi/g, all non-analyzed archived samples for the survey unit will be analyzed. ~~In the event that a concentration higher than 300 pCi/g is encountered, the archived samples between the previously analyzed batch and the batch in question will be analyzed.~~ The results will be evaluated to determine the extent of elevated activity **within the survey unit**. Where necessary, material with elevated activity will be removed for additional processing. Where results between 300 and 900 pCi/g are encountered, the data will be evaluated to **assure that the material possessing the elevated concentration of DU conforms with NUREG/CR-5849. The criterion of $(100/A)^{0.5}$ times the guideline value will be used to make this evaluation. To apply this criterion to the survey unit, the symbol A will be used to denote the volume (in cubic meters) of elevated activity (smaller than 100 m^3) which is located within the survey unit.**

If a sample result reveals a level between 300 pCi/g and 900 pCi/g, all non-analyzed archived samples for the survey unit will be analyzed. ~~On a daily basis, the sample results will be compared to the 300 pCi/g average and other criteria~~. **The**

results will be evaluated to determine the extent of elevated activity within the survey unit. Where necessary, material with elevated activity will be removed for additional processing. Where results between 300 and 900 pCi/g are encountered, the ~~plotted~~ data will be ~~analyzed~~ evaluated to assure that the material possessing the elevated concentration of DU conforms with NUREG/CR-5849. The criterion of $(100/A)^{0.5}$ times the guideline value will be used to make this evaluation. To apply this criterion to the survey unit, the symbol A will be used to denote the volume (in cubic meters) of elevated activity (smaller than 100 m^3) which is located within the survey unit. ~~and size of the area conform to the $(100/A)^{0.5}$ criterion. The allowable level will depend on the batch size, as follows:~~

~~Batch Size~~	~~Lift Area~~	~~Maximum Concentration~~
~~5.0 CY~~	~~12.5 m^2~~	~~847 pCi/g~~
~~7.5 CY~~	~~18.8 m^2~~	~~690 pCi/g~~
~~10.0 CY~~	~~25.1 m^2~~	~~598 pCi/g~~

~~All results generated from the sampling (except for the results that represent the elevated material that was removed) will be added to the sample database for the same type of material (stabilized sludge or contaminated soil) previously generated. The data generated to date for the stabilized sludge or contaminated soil will then be evaluated against the 300 pCi/g criterion and sample size requirement as defined above. In the event that a concentration higher than 300 pCi/g is encountered, the archived samples between the previously analyzed batch and the batch in question will be analyzed. The results will be evaluated to determine the extent of the area of elevated activity. This material will be removed and returned to the processing system for further treatment if the area exceeds the $(100/A)^{0.5}$ criteria.~~

11.3.3.2 Soil-Like Stabilized Sludge

If the measured activities of all analyzed samples from staging piles are found to statistically conform to the criterion of 300 pCi/g for a given survey unit, then the staging piles shall be delivered to the cell.

If the measured activity of any staging pile exceeds 900 pCi/g, , then that staging pile shall be returned to the stabilization system for additional treatment.

If the measured activities of all the staging piles contain elevated activities which cause the statistical exceedance of the criterion for a given survey unit, then all the staging piles will be returned to the stabilization system for additional treatment.

If the measured activity in one or more of the staging piles cause the statistical exceedance of the criterion for a given survey unit, but the measurements of samples from the other staging piles of the same survey unit meet the criteria,

then either the staging pile(s) containing the elevated concentration of DU will be returned for reprocessing or further testing of archived samples of the staging piles containing the elevated concentration of DU will be conducted to confirm compliance with the criterion. (See Section 11.3.3.1 for application of the $(100/A)^{0.5}$ criterion to samples containing between 300 pCi/g and 900 pCi/g of DU activity.)

If the measured activity in one of the staging piles is between 300 pCi/g and 900 pCi/g, but the entire survey unit conforms statistically to the criteria, the staging piles which conform may be placed. The staging pile with the elevated DU concentration will be returned for reprocessing or further testing of archived samples will be conducted to confirm compliance with the criterion. (See Section 11.3.3.1 for application of the $(100/A)^{0.5}$ criterion to samples containing between 300 pCi/g and 900 pCi/g of DU activity.)

If one or more staging piles for a survey unit are returned for reprocessing, then they will be replaced using freshly processed sludge to restore the survey unit volume to 100 cubic meters. Samples collected from the replacement material will be labeled with the same sequence numbers as the material which was returned followed by a suffix character A through Z to denote the substitution. The replacement material shall be analyzed following the same procedure as the original material. The analytical results for the replacement staging pile(s) will be combined with the results of the conforming staging piles of the survey unit to determine overall conformance to the criterion for that survey unit.

11.3.3.3 Contaminated Soil

If a sample result reveals a level above 900 pCi/g, all non-analyzed archived samples between the sample in question and the last analyzed sample which met the criteria will be analyzed to determine the extent of the elevated levels. Affected soil associated with the elevated sample results will be removed from the cell. The removed soil will be moved to the stabilization feedstock for further treatment.

All sample results will be compared to the 300 pCi/g average and other criteria. In the event that a concentration higher than 300 pCi/g is encountered, the archived samples between the previously analyzed batch and the batch in question will be analyzed. The results will be evaluated to determine the extent of elevated activity Where necessary, material with elevated activity will be removed for additional processing. Where results between 300 and 900 pCi/g are encountered, the data will be evaluated to assure that the concentration of DU within the entire survey unit conforms to the criterion. (See Section 11.3.3.1 for application of the $(100/A)^{0.5}$ criterion to samples containing between 300 pCi/g and 900 pCi/g of DU activity.)

11.4 DOCUMENTATION

All sample collection activities will be documented as outlined in Section 2.0, "Soil Sampling," of this ~~QAPjP~~ **Quality Assurance Quality Control Plan** for radiological sampling. All analysis results and subsequent evaluation of the results will be documented in a consistent format with results submitted to BP's onsite construction manager and copies will be kept in the onsite laboratory or site field office.

W.M. Rupert
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