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FY2015 Saltstone Core-Drilling Mock-Up Summary

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EXECUTIVE SUMMARY

Mock-up testing with respect to the core-drilling of simulant saltstone was conducted to support the future retrieval of field-emplaced saltstone samples from Saltstone Disposal Unit (SDU) Cell 2A. The primary objectives of extracting samples from SDU Cell 2A are to enable measurement of field-emplaced samples with respect to properties that influence long-term performance, such as saturated hydraulic conductivity, and to compare the measured properties for field-emplaced samples with simulated samples prepared in the laboratory.

Initial mock-up activities (Phases 1 and 2) were conducted in Fiscal Years (FY) 2013 and 2014 in order to demonstrate the viability of standard wet core-drilling techniques that are typically employed for sampling concrete structures. The primary requirement for the core-drilling technique was that it minimize physical or chemical change to the samples that would artificially degrade key properties. The mock-ups were aimed at optimizing the techniques for core-drilling through approximately 3 feet of grout to reach the target sample using a set-up that mimicked, to the extent practical, both the physical characteristics, and operational complexities, of core-drilling saltstone from the roof of the SDU. These intial phases also served to demonstrate an in-house designed extraction tool that could be inserted into the core hole to retrieve the core-drilled samples.

A third phase of mock-up testing was required in FY2015 in order to demonstrate that the preferred wet core drilling technique was applicable to drilling through 6 feet of grout and that the 6-foot core length could subsequently be retrieved. The required drilling depth increased from 3 to 6 feet due to an increase in the allowable SDU fill height from 18.5 to 21.5 feet. The target sample is located at the 16-foot elevation in the SDU. The ability to core-drill and extract 6-foot samples was successfully demonstrated on multiple samples. The strategy utilized initially involved drilling to a depth of 6 feet from the grout surface followed by two sample extraction steps. Core-drilling to the 6-foot depth required that drilling be halted twice to insert additional drill (core barrel) sections in order to reach the target sample depth. Once cored the samples were retrieved in 2 steps; the first involved extraction of the top 4 feet of sample (that will ultimately be placed back into the SDU) followed by the separate extraction of 2 feet of sample that will be transported to Savannah River National Laboratory (SRNL) for physical and chemical analysis. A transport container that could be inerted to prevent oxidation of redox sensitive constituents, most notably technetium (^{99}Tc), was also developed as part of the FY2015 mock-up testing. Upon receipt at SRNL the containers will be transferred to a purpose-built inerting chamber in which the cores will be stored and prepared for analysis. Analysis will include measurement of density, porosity, moisture content, saturated hydraulic conductivity (SHC), key radionuclide concentrations, contaminant transport behavior, and ^{99}Tc oxidation state.

Based on the lessons learned during the three phases of mock-up testing and the subsequent optimization of the core-drilling and core-extraction processes the intent is to core-drill and extract six samples from SDU Cell 2A in Spring 2015.

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ACRONYMS AND ABBREVIATIONS

BFS	Blast Furnace Slag
ES	Energy*Solutions*
FA	Fly Ash
FY	Fiscal Year
GPM	Gallons per Minute
HEPA	High-Efficiency Particulate Air
MCU	Modular Caustic Side Solvent Extraction Unit
PA	Performance Assessment
RCO	Radiological Control Operations
RPM	Revolutions per Minute
SDF	Saltstone Disposal Facility
SDU	Saltstone Disposal Unit
SHC	Saturated Hydraulic Conductivity
SPF	Saltstone Production Facility
SRNL	Savannah River National Laboratory
SRR	Savannah River Remediation LLC
TSR	Technical Safety Requirements
TTR	Technical Task Request

1.0 BACKGROUND AND OBJECTIVE

This report documents the Saltstone Disposal Unit (SDU) core-drilling mock-up tests conducted during Fiscal Year (FY) 2015 to support the planned FY2015 retrieval of field-emplaced saltstone samples from SDU Cell 2A. The primary objectives of sampling SDU Cell 2A are:

1. To enable measurement of field-emplaced saltstone samples with respect to saturated hydraulic conductivity (SHC) and contaminant (most notably technetium (^{99}Tc)) leaching behavior, both of which serve as key inputs to the time-dependent contaminant transport models utilized in the Saltstone Disposal Facility (SDF) Performance Assessment (PA) [1].
2. To establish a correlation of the aforementioned properties for field-emplaced samples and laboratory-prepared simulant samples, which would validate the past and future use of data derived using saltstone simulant processed and cured in the laboratory.

Preliminary mock-up activities for core-drilling simulated saltstone were initiated in FY2013, and details of this testing are provided in SRR-SPT-2013-00044, *Update of Fiscal Year 2013 Activities Related to SDU Sampling and Analyses* [2], and SRR-SPT-2013-00056, *Physical Comparison of Core-Drilled and Cast Saltstone Simulant* [3]. Lessons learned, and any observed core-drilling issues requiring resolution, were subsequently addressed in extended mock-up activities conducted in FY2014. The FY2014 mock-up also served to demonstrate the performance of an in-house designed sample extraction tool for removing core samples from the drill hole. SRR-CWDA-2014-00059, *FY2014 Saltstone Core-Drilling Mock-Up Summary* [4], provides comprehensive details with respect to the scope and findings of the FY2014 core-drilling mock-up. Table 1 summarizes the key objectives and findings for the FY2014 core-drilling mock-up:

Table 1: FY2014 mock-up objectives and summary of findings.

	OBJECTIVE		FINDINGS
1	Demonstrate ability to core-drill 3.5 feet of saltstone.		Wet coring to a grout depth of 3.5 feet was successfully demonstrated. The preferred coring technique involved drilling to a certain depth, adding core barrels (also referred to as drill string), and continued drilling to the desired depth.
2	Demonstrate ability to extract 3.5 feet of drilled cores.		An in-house designed retrieval tool was successfully demonstrated with respect to retrieving a 3.5-foot core comprising smaller samples due to through-diameter cracking. Cracking was predominantly associated with cold joints in the monolith.

	OBJECTIVE		FINDINGS
3	Investigate engineering or operational techniques to reduce drill string and scoring of sample material.		A purpose-designed mounting plate generally enhanced stability of the core-drilling equipment, but induced secondary wobbling in the drill motor stand. Secondary wobble was reduced when using newly procured drill string sections which had not been deformed by multiple coupling, coring, and uncoupling operations.
4	Demonstrate use of camera to monitor coring operation at surface of grout.		Camera and video display were installed and successfully utilized by operators to facilitate core-drilling and core retrieval.
5	Demonstrate ability to core two different samples from a single 11-inch camera (access) port.		The slotted design of the mounting plate enabled operators to translate the core-drilling machine across a single access port. Cores were drilled at two separate locations within a single access port with minimal effort with respect to repositioning of the drill.
6	Demonstrate ability to remove, handle, and prepare core material for shipment.		Core material was removed from the grout using the extraction tool in both single (3.5 feet) and multiple (1 foot) drill increments. All core material was removed and packaged for transportation.
7	Determine optimal flow rate for cooling water during core-drilling.		Flow rates > 1 GPM were necessary to prevent sample binding in the drill string. A flow rate of 0.5 GPM was used as an indicator that water flow was becoming sufficiently impeded, and to prompt operators to temporarily halt drill advancement.
8	Familiarize operators and Radiological Control Operations (RCO) with drill operations.		Two operators and two RCO observed core drilling operations, and two operators practiced proficiency on both drilling and retrieving core material; operations were conducted under the supervision of industry expert Mr. Barry Copeland of Atlanta Coring, Atlanta, GA.
9	Solicit input of industry expert during dry run phase of the mock-up.		Copeland provided comments on drilling technique, grout consistency, and equipment limitations for both engineering and operations.

	OBJECTIVE		FINDINGS
10	Determine extent of water ingress into samples during wet core-drilling.		Characterization of the water content for samples wet or dry core-drilled indicate no significant difference in water content.

Based on the findings of the FY2014 mock-up activities additional development was considered necessary with respect to the following aspects of the core-drilling and sample extraction processes:

1. The grout monolith utilized for mock-up activities in FY2013 and FY2014 was approximately 3.5 feet deep. This depth was based on a maximum SDU fill height limit for radioactive grout of 18.5 feet as defined in Rev. 10 of S-TSR-Z-00002, *Saltstone Facility Technical Safety Requirements (TSR)* [5], which would require drilling through 2-3 feet of overlying grout to retrieve the approximately 3-inch long sample of interest located at an SDU elevation of 16 feet. However, per Revision 11 of the TSR (issued January 2014) the SDU fill height limit was increased to 21.5 feet (Figure 1) which subsequently requires drilling through approximately 6 feet of grout to retrieve the sample at the 16-foot elevation. It is anticipated that retrieving a sample from a grout depth of 6-foot may result in additional complexities with respect to both drilling and sample extraction. Hence, a subsequent phase of testing should utilize a container filled with grout to a depth of 6 feet or greater. Testing should also assess changes that might be required with respect to water flow and drilling equipment capacity.

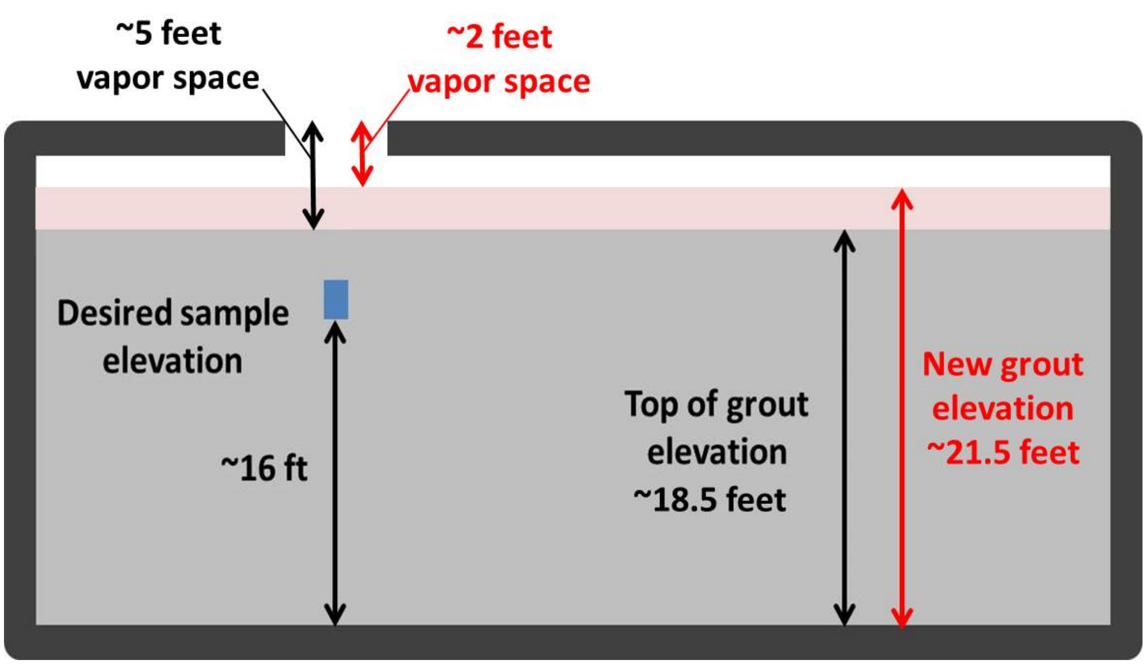


Figure 1: Schematic illustrating increased grout elevation in SDU Cell 2A.

2. Once the samples have been extracted from SDU Cell 2A they will be transported to the Savannah River National Laboratory (SRNL) for storage and eventual analysis. SRNL personnel have indicated that a core length sample of 3 feet (preferably less) would significantly reduce the handling complexity of the samples after receipt at the laboratory. Thus, the advantages and disadvantages of coring a 6-foot core length and extraction of the entire length compared to coring two or more reduced length sections, and retrieving separately, should be determined.
3. Develop and test a modified tool, or strategy, to ensure that the core sample is fully inserted, or sufficiently retained, in the retrieval tool to prevent drop out during lifting out of the SDU.
4. Demonstrate the ability to drill and retrieve cores using artificial lighting in conjunction with a camera/video system. Drilling and extraction will be conducted through 11-inch camera ports atop the SDU though these will be shielded to the extent practicable to reduce worker dose. As such operators must rely on video images of the artificially illuminated SDU interior to perform the entire drilling and extraction process.
5. Finalize design for anchoring the drilling equipment atop the SDU. It is critical that the mounting plate enable the drilling equipment to be securely attached to the SDU in order to reduce equipment vibration, drill string wobble, and potential mechanical damage of the cored samples.
6. Develop and test containment for transporting cores to SRNL that can be purged with an inert atmosphere. The samples will also require some form of secondary containment for transport to SRNL.
7. Procure long handled “grabber” tool to remove core material that may fall out of the drill string during retraction from the SDU. In the FY2014 mock-up some core pieces were initially retained in the drill string but subsequently fell from the drill string (back to the grout surface) as it was lifted above the drill hole. A simple tool is needed to retrieve these samples.
8. Drain pooled water from the monolith surface during future mock-up testing. The size of the monolith and the number of practice cores drilled and extracted during mock-up activities results in the accumulation of large amounts of water (drill bit coolant) on the surface of the monolith; this can inhibit vision of the drilling and extraction process. It is anticipated that when drilling in the actual SDU the drilling water will be rapidly dispersed to surrounding areas of the SDU and will not accumulate at the drill location. Hence, in order to mimic conditions in the SDU water pooling on the surface of the mock-up monolith should be removed throughout the drilling process.
9. Develop and test a piece of equipment that is secured to the drilling access port and serves to reduce worker dose and mitigate potential contamination from wet coring operations. If possible, the equipment should also wipe/clean the drill string as it is lifted from the SDU.
10. Tape drill string threaded connections to preclude water spray from the drill string during operation.

11. Optimize operations involving drill string addition to reduce the movement and potential damage of core samples, and to reduce time and labor intensity. Drilling to retrieve samples from a depth of 6 feet will require the addition of one or more drill string sections during the coring process.

Subsequent sections of this report will provide details on how the above items were addressed in the FY2015 core-drilling mock-up.

2.0 MATERIALS AND EQUIPMENT

2.1 Grout Monolith Preparation

The grout monolith for the FY2015 mock-up studies was produced by Energy*Solutions* (ES) at their Barnwell Facility in South Carolina. ES utilized a 40-inch diameter Sonotube® Commercial Concrete Form to prepare a monolith 6 feet in depth. The Sonotube® form was positioned in an ES designed transport frame prior to filling as illustrated in Figure 2.

Figure 2: Sonotube® concrete form in ES designed transport frame.

For earlier mock-up activities (FY2013 and FY2014) a non-radioactive saltstone was processed utilizing a Tank 50 salt solution simulant containing primary salt components that included nitrates, nitrites, hydroxides, phosphates, oxalates, sulfates, and aluminates. To prepare a monolith 6-foot in depth it was determined that a simpler salt solution, a 6 wt% (1.6 M) sodium hydroxide (NaOH) solution, could be utilized to simulate saltstone. Saltstone which contains fly ash (FA), blast furnace slag (BFS), and cement at 45, 45, and 10 wt%, respectively, relies on the hydration of cement and the alkali-activation of the BFS (and to a lesser extent FA) to form the gel components responsible for binding the cementitious matrix together, and reducing the amount and size distribution of the post-cured porosity. Alkali activation in saltstone is predominantly achieved via the reaction of BFS with the hydroxide contained in the Tank 50 salt solution. The aforementioned concentration of 1.6 M NaOH represents the average alkalinity of the Modular Caustic Side Solvent Extraction Unit (MCU) waste stream [1]. Grout produced using this solution has also been studied for use as saltstone clean cap [6].

Additional changes in producing the 6-foot Sonotube® monolith in comparison to the B25 monolith included the lift heights incorporated into the 6-foot monolith. When filling the B25 container daily lifts of 8-9 inches were utilized to achieve a total height of approximately 42 inches. The intent for pouring in lifts for the original monolith was to simulate potential “cold joints” between lifts of grout emplaced in the SDU, and to subsequently determine if coring and extraction resulted in a through-diameter fracture of the cores at the cold joints. As detailed in the FY2013 report [2] cores were observed to fracture predominantly at the cold joints. For the 6-foot monolith the intent was to more accurately simulate the lift heights associated with each daily pour that occurred to emplace the upper 6 feet of grout in SDU Cell 2A. The daily lift heights were determined using PI Process data from the Saltstone Production Facility (SPF) process computers regarding the gallon amount of grout poured on a given day, and the cross-sectional area of the SDU (with an approximate diameter of 150 feet). Table 2 indicates the pour dates and times, and the associated volume and lift height for each daily pour. A total of 17 saltstone additions were made to SDU Cell 2A from 8/9/2013 to 6/11/2014; at a current height of 21.25 feet no further saltstone additions are anticipated. Individual lift heights during the indicated time period ranged from 2.3 to 6.1 inches and totaled 6 feet. The lift dated 8/12/13 represents the material targeted for sampling.

Table 2: Daily lift heights utilized for preparing the FY2015 monolith.

Date	Process Start Time	Process Finish Time	Process Time (h)	Process Time (min)	Avg Grout Production Rate (GPM)	Total Grout (gal)	Total Grout (in^3)	Lift Height (in)
8/9/13	9:12 AM	4:11 PM	6.98	419	147	6.16E+04	1.42E+07	5.6
8/10/13	8:27 AM	4:06 PM	7.65	459	147	6.75E+04	1.56E+07	6.1
8/11/13	8:44 AM	4:22 PM	7.63	458	147	6.73E+04	1.56E+07	6.1
8/12/13	**11:20 AM**	**3:40 PM**	**4.33**	**260**	**147**	**3.82E+04**	**8.83E+06**	**3.5**
8/14/13	8:50 AM	4:18 PM	7.47	448	147	6.59E+04	1.52E+07	6.0
12/11/13	10:00 AM	2:45 PM	4.75	285	133	3.79E+04	8.76E+06	3.4
12/16/13	9:00 AM	12:35 PM	3.58	215	147	3.16E+04	7.30E+06	2.9
5/19/14	10:15 AM	2:32 PM	4.28	257	147	3.78E+04	8.73E+06	3.4
5/20/14	9:05 AM	2:31 PM	5.43	326	133	4.34E+04	1.00E+07	3.9
5/21/14	9:40 AM	12:45 PM	3.08	185	147	2.72E+04	6.28E+06	2.5
5/28/14	8:47 AM	2:33 PM	5.77	346	147	5.09E+04	1.17E+07	4.6
5/29/14	9:02 AM	2:30 PM	5.47	328	147	4.82E+04	1.11E+07	4.4
6/3/14	9:46 AM	2:31 PM	4.75	285	147	4.19E+04	9.68E+06	3.8
6/5/14	9:03 AM	2:32 PM	5.48	329	133	4.38E+04	1.01E+07	4.0
6/9/14	8:46 AM	2:33 PM	5.78	347	147	5.10E+04	1.18E+07	4.6
6/10/14	9:00 AM	2:34 PM	5.57	334	147	4.91E+04	1.13E+07	4.5
6/11/14	8:40 AM	11:52 AM	3.20	192	133	2.55E+04	5.90E+06	2.3
							Total Lift (ft)	**6.0**
SDU Diameter (ft)	**SDU X-Sectional Area (ft^2)**	**SDU X-Sectional Area (in^2)**	Lift height is estimated by dividing the grout volume poured on a specific day by the cross-sectional area of the SDU.					
150	1.767E+04	2.545E+06						

<u>**Note**</u>: For the Sonotube® monolith prepared by ES the lift heights indicated in Table 2 were adjusted to the nearest ¼ inch, and poured over a period of approximately 4 weeks.

Figure 3 indicates the 1st and 14th lifts added to the Sonotube® immediately after each pour was complete and also after curing overnight.

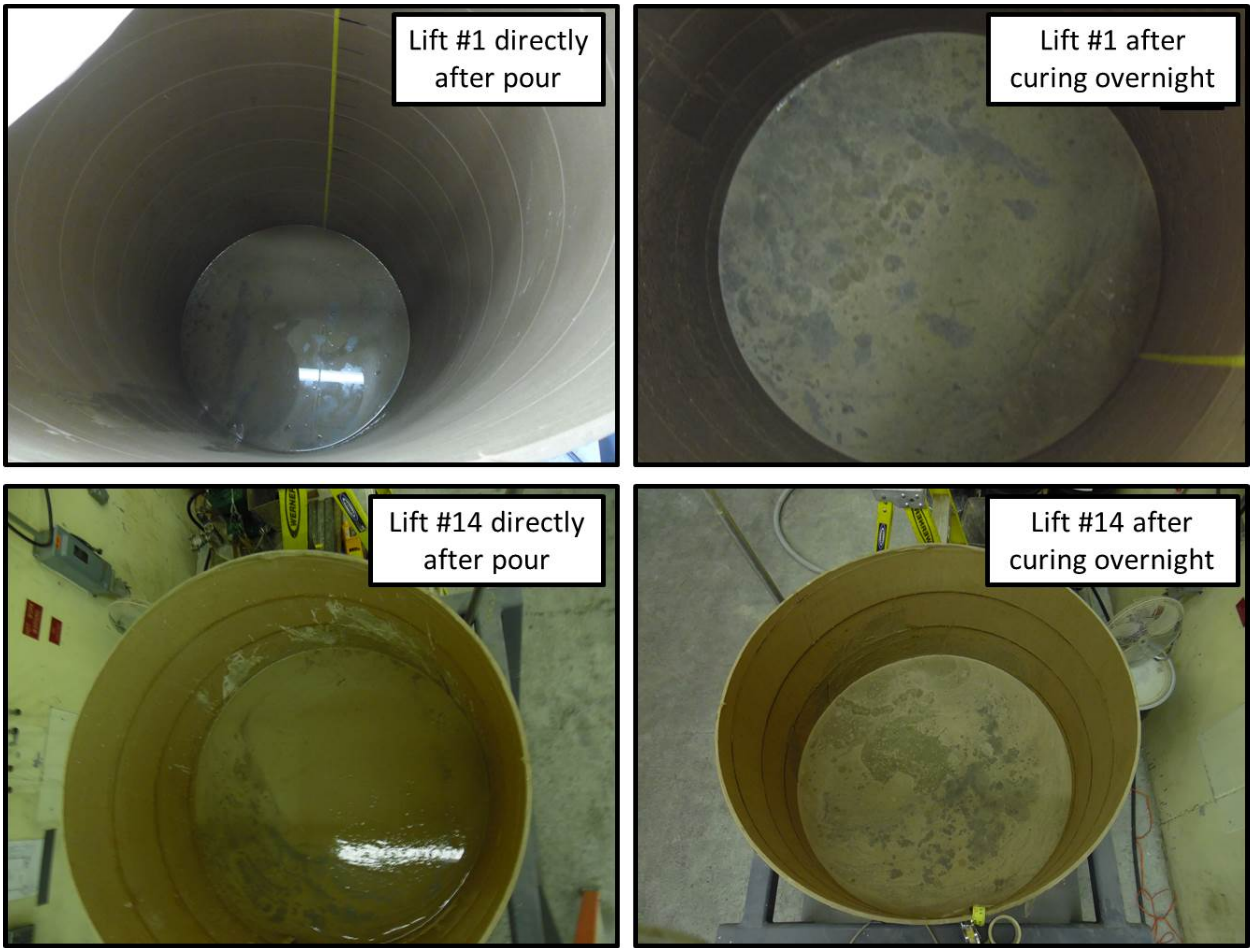


Figure 3: Photos of 1st and 14th lifts added to the Sonotube®.

The incorporation of 17 lifts also provided operators the ability to practice the extraction of a 6-foot core length that may be broken into at least 17 pieces (due to fractures at the aforementioned cold joints). Figure 4 illustrates the potential complexity of this process due to the fact that each 2-inch diameter sample may be differently aligned in the 2.5 inch core hole. The drill bit is a double kerf design with an outside diameter of 2.5 inches which facilitates the formation of a 2.5 inch diameter core hole required for insertion of the extraction tool (see Figure 5). Operators will be required to manipulate the extraction tool to align each sample as the tool is advanced down into the core hole.

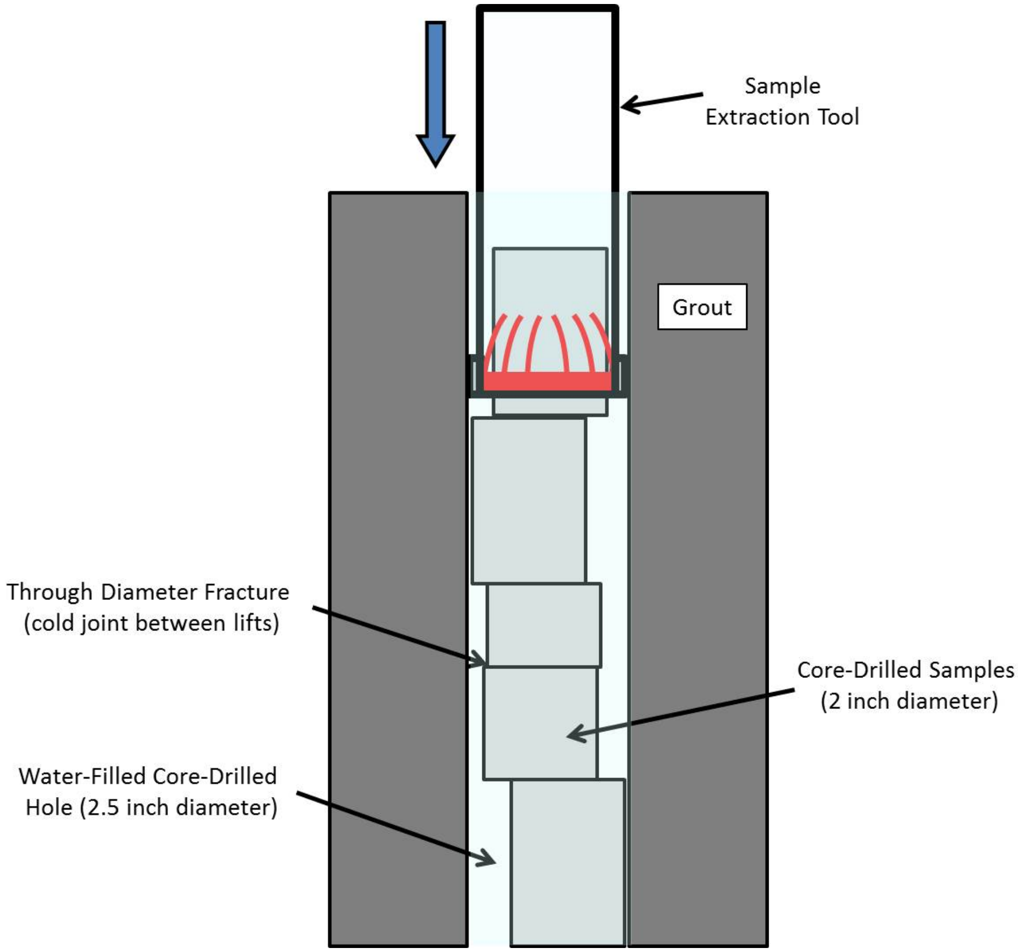


Figure 4: Potential misalignment of 2-inch diameter samples in 2.5-inch diameter core hole.

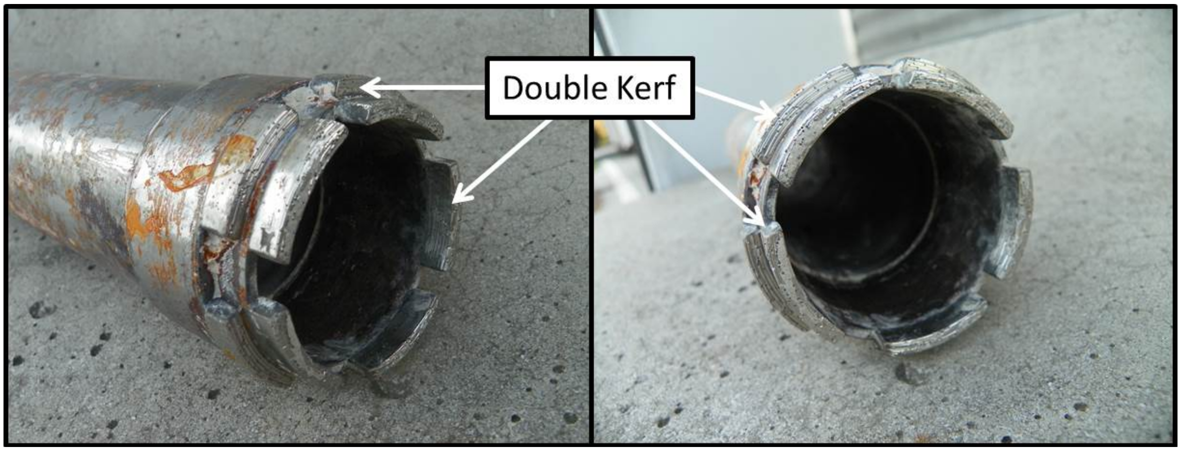


Figure 5: 2-inch internal diameter core-drill diamond bit with double kerf to produce a 2.5-inch diameter core hole.

The sample of primary interest in SDU Cell 2A (indicated by red text in Table 2), that will ultimately be extracted and analyzed, was poured on 8/12/2013. This date coincides with the day on which fresh grout samples were also retrieved from the outlet of the SPF grout hopper. Per SRR-SPT-2012-00049, *Saltstone Sampling and Analyses Plan* [7], the intent is to compare specific physical and chemical properties of samples prepared and cured in the laboratory (using non-radioactive salt simulant) with radioactive samples core-drilled from the SDU. If anomalies arise between laboratory and field emplaced saltstone samples additional testing of radioactive samples retrieved from the SPF, but cured in a laboratory environment, may be required. The analyses to be conducted on the samples was detailed originally in Reference 7 but has been more recently updated and formalized in a Technical Task Request (TTR) [8]. The intended analysis comprises the following:

1. Bulk density, porosity, and water content.
2. Compositional analyses to determine total ^{99}Tc, ^{90}Sr, ^{79}Se, ^{129}I, and ^{226}Ra content.
3. Determination of distribution coefficient (Kd) for ^{99}Tc, ^{90}Sr, ^{79}Se, ^{129}I, and ^{226}Ra.
4. Determination of Tc(VII) / Tc(total) ratio utilizing established leaching technique.
5. Saturated hydraulic conductivity (SHC).

At a height of 3.5 inches the sample poured on 8/12/2014 (red text in Table 2) will be utilized for measuring SHC (assuming it possesses sufficient physical integrity). It is anticipated that samples from grout poured on the prior day (8/11/2013), or following processing day (8/14/2013), will be utilized for the remaining analyses. Samples poured on those dates are expected to have been processed with virtually identical Tank 50 salt solution to the 8/12/2013 sample, and cured according to a virtually identical temperature regime.

2.2 Saltstone Coring Mock-Up Test Stand

In order to provide representative field conditions to support mock-up testing, a dedicated test stand (Figure 6) was fabricated to simulate the physical characteristics, and operational complexities, of core-drilling saltstone atop the roof of the SDU. The test stand is located at the TNX facility. The test stand was originally constructed to allow the placement of a B25 container (with a 3.5-foot high grout monolith) underneath a working platform. The height of the test stand was increased to accommodate the 6-foot monolith, and the working platform was placed approximately 2-3 feet above the grout surface to represent the approximate anticipated distance between the SDU roof and the grout surface in SDU Cell 2A.

The drill stand was secured to the test stand platform utilizing a mounting bracket that has been specifically designed to mount to the SDU roof and support the mounting plate. The bracket is illustrated in Figure 7 and incorporates slots to enable translation across the camera port to facilitate the drilling two cores per camera port. Attachment 1 provides details of the mounting plate designed for anchoring the drilling equipment to the roof of the SDU.

Figure 6: Photos illustrating increased test stand height to accommodate the 6-foot monolith.

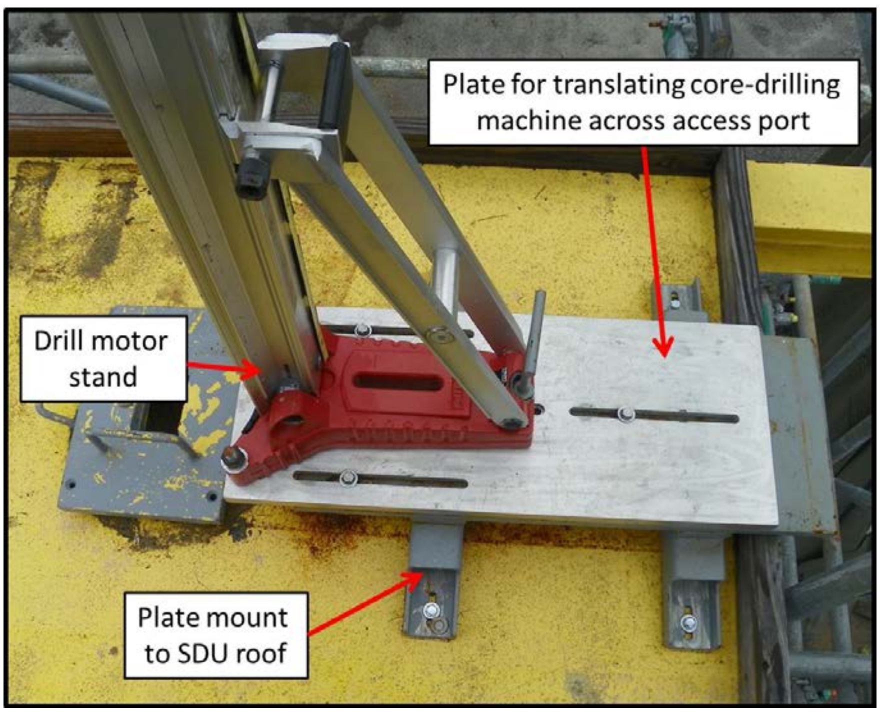


Figure 7: Photo of bracket to be utilized for securing the drill stand to the SDU roof.

2.3 Core Drilling and Extraction Equipment

The following drilling equipment was utilized for the FY2014 mock-up activities (additional details are provided in Reference 4):

- Hilti Model No. DD 200 Diamond Coring System
- 2-inch internal diameter threaded diamond core bits modified to cut a wider 2.5 inch kerf to enable insertion of core retrieval tools
- 2 ¼-inch internal diameter threaded core extension barrels (drill string).

For the FY2015 studies the only change to the above equipment included the use of a higher power motor (Hilti Model No. DD 350 Diamond Coring system). The required motor power was anticipated to be greater for coring through 6 feet of grout in comparison to the 3-foot depth previously drilled. Ultimately, both the DD 200 and DD 350 drills were successfully utilized in the FY2015 mock-up.

The basic design of the retrieval tool was unchanged with respect to that utilized for the FY2014 mock-up activities except that two tools of specific lengths will be used. An approximately 4 ft. extraction tool will be used to remove the upper cores first, then a 2.5 ft. extraction tool will be used to remove the remaining core material for transport to the laboratory. Photographs of the device are shown in Figure 8. The retrieval tool is also designed to serve as the inner container for transport of the core samples from the SDU to the laboratory for storage and analysis. Following retrieval of the cores, the tool can be placed directly into a transport container thereby eliminating the need for operators to directly handle the samples.

Figure 8: Photos illustrating the core retrieval tool.

3.0 TEST RESULTS

FY2015 core-drilling mock-up activities were conducted over a 2-week period during which six cores were drilled and retrieved. A discussion of each objective including lessons learned and open items is presented in the subsequent text. Operational log sheets documenting the tests conducted during this mock-up are provided in Attachment 2.

A number of the development activities that were established after completion of the FY2014 mock-up (and listed in Section 1.0) do not require significant elaboration, and are briefly discussed below. More significant development activities including demonstrating the ability to core and extract samples from a 6-foot grout depth, development of secondary containment, and inerting the sample environment for transporting are discussed in greater detail in Section 3.1.

The complete list of development activities proposed for the FY2015 studies are:

1. Demonstrate the ability to consistently core-drill and extract grout samples from a 6-foot depth without, to the extent possible, imparting physical or chemical changes that would adversely affect desired sample analysis (analysis detailed in Section 2.1). Testing should also assess changes that might be required with respect to water flow and drilling equipment capacity.

   See Section 3.1 for details.

2. Once the samples have been extracted from SDU Cell 2A they will be transported to SRNL for storage and eventual analysis. SRNL personnel have indicated that a core length sample of 3 feet (preferably less) would significantly reduce the handling complexity of the samples after receipt at the laboratory. Thus, the advantages and disadvantages of coring a 6-foot core length and extraction of the entire length compared to coring two or more reduced length sections, and retrieving separately, should be determined.

   See Section 3.1 for details.

3. Develop and test a modified tool, or strategy, to ensure that the core sample is fully inserted, or sufficiently retained, in the retrieval tool to prevent drop out during lifting out of the SDU.

   In the course of the mock-up it was determined that the extraction tool possessed sufficient strength to retain a 4-foot sample during lifting from the grout surface to the SDU roof even if the sample wasn't fully inserted into the extraction tube. Four feet is the maximum sample length that will be extracted in a single step; as such it was decided that modification of the extraction tool was not needed.

4. Demonstrate the ability to drill and retrieve cores using artificial lighting in conjunction with a camera/video system. Drilling and extraction will be conducted through 11-inch camera ports atop the SDU though these will be shielded to the extent practicable to reduce worker dose. As such operators must rely on video images of the artificially illuminated SDU interior to perform the entire drilling and extraction process.

   The entire drilling and sample extraction process was successfully demonstrated utilizing artificial light and a video display for two six-foot core lengths. The top of the

Sonotube® was surrounded with cardboard to prevent the entry of natural light from the side of the container to the drilling area and operators relied on an artificial light source and camera with video feed to a monitor atop the mock-up platform to perform all drilling and extraction activities. Two cores were successfully drilled and extracted under these conditions.

5. Finalize design for anchoring the drilling equipment atop the SDU. It is critical that the mounting plate utilized enables the drilling equipment to be securely attached to the SDU in order to reduce equipment vibration, drill string wobble, and potential mechanical damage of the cored samples.

   The mounting plate was successfully demonstrated during drilling operations. Attachment 1 provides details with respect to the design of the mounting plate for attachment to the roof of the SDU. The mounting plate is also depicted in Figure 7.

6. Develop and test containment for transporting cores to SRNL that can be purged with an inert atmosphere. The samples will also require some form of secondary containment for transport to SRNL.

   Options considered for sample inerting after extraction from the SDU are discussed in Section 3.1. With respect to a secondary transport container, Figure 9 indicates a cooler (Rubbermaid 150 quart) that will be used to transport samples (two samples per container) from the roof of the SDU to SRNL for storage and subsequent analysis. The cooler contains a foam material with cut-outs for secure placement of the samples in order to prevent excessive movement during transport.

Figure 9: Transport container for transferring samples from SDU to SRNL.

7. Procure long handled “grabber” tool to remove core material that may fall out of the drill string during retraction from the SDU. In the FY2014 mock-up some core pieces were initially retained in the drill string but subsequently fell from the drill string (back to the grout surface) as it was lifted above the drill hole. A simple tool is needed to retrieve these samples.

   Figure 10 illustrates a commercially available “grabber” tool that was successfully employed during the mock-up to retrieve samples that had been retained in the drill string as it was withdrawn from the core hole, but subsequently fell out of the drill string onto the grout surface.

Figure 10: Commercial “grabber” tool for retrieving samples that have fallen from the drill string or extraction tool back onto the grout surface in the SDU.

8. Drain pooled water from the monolith surface during future mock-up testing. The size of the monolith and the number of practice cores drilled and extracted during mock-up activities results in the accumulation of large amounts of water (drill bit coolant) on the surface of the monolith; this can inhibit vision of the drilling and extraction process. It is anticipated that when drilling in the actual SDU the drilling water will be rapidly dispersed to surrounding areas of the SDU and will not accumulate at the drill location. Hence, in order to mimic conditions in the SDU water pooling on the surface of the mock-up monolith should be removed throughout the drilling process.

   A simple pump and tubing set up was utilized to periodically and effectively remove excess water from the surface of the monolith during core-drill operation.

9. Develop and test a piece of equipment that is secured to the drilling access port and serves to reduce worker dose and mitigate potential contamination from wet coring operation. If possible, the equipment should also wipe/clean the drill string as it is lifted from the SDU.

Figure 11 shows some simple shield split plates in place during mock-up drilling to reduce worker dose. Splashing from below the test platform to the platform surface was not observed during FY2015 testing. In addition, upon retraction of the drill string no significant smearing of wet cutting fines was observed other than at the cutting edge of the drill bit. Radiological Control Operations (RCO) personnel indicated that, if necessary, the drill bit cutting edge could be held just below the port and sprayed using a low pressure water lance to remove cutting fines. As such equipment to wipe/clean the drill string upon retraction from the SDU was not considered necessary.

Figure 11: Temporary shielding plates to reduce worker dose and potential contamination from within the SDU.

10. Tape drill string threaded connections to preclude water spray from the drill string during operation.

    During the FY2014 mock-up water was observed to leak (sometimes spray during drill string rotation) from the threaded joints between drill strings due to some deformation of the drill strings after decoupling with wrenches. The concern relates to the potential spread of contamination outside the SDU. In an effort to minimize this phenomenon, a self-fusing silicone tape was applied to the male threads of each drill string section (see Figure 12). This tape served to significantly reduce water leakage but did not totally eliminate it. It is important to note, however, that new, non-deformed drill strings will be used for drilling each 6-foot core and thus the joints between drill string sections would be expected to exhibit significantly less leakage.

Figure 12: Self-fusing silicon tape applied to drill string threads to reduce joint leakage.

11. Optimize operations involving drill string section addition to reduce the movement and potential damage of core samples, and to reduce time and labor intensity. Drilling to retrieve samples from a depth of 6 feet will require the addition of one or more drill string sections during the coring process.

    See Section 3.1 for details.

3.1 Demonstrate Ability to Core-Drill 6 Feet of Saltstone Simulant and Extract Sample

Prior to initiating the FY2015 mock-up a preferred drilling and extraction strategy was identified. The strategy attempts to minimize the duration and complexity of operations as well as worker dose while ensuring that the samples of interest are retrieved with minimal damage. In FY2014 testing, the method in which cores were drilled and retrieved in multiple steps was found to be too labor intensive since the drill string had to be removed from the core hole prior to retrieval of each drilled section. Subsequently, the majority of testing for the FY2014 mock-up was performed using the less complex approach. Continuous drilling is performed with drill string being added as needed to reach the required depth. After the drilling is complete the entire drilled core is removed in a single retrieval step. Using this technique it was possible to drill and retrieve two cores (each 3.5 feet in length) in approximately 40 minutes.

Due to limitations on receivable sample size at SRNL, the strategy was modified for FY2015 tests to include core-drilling through approximately 6 feet of grout in a single step (with drilling operations halted to insert two additional sections of drill string) followed by two separate extraction steps. After retraction of the drill string, an initial sample length of 4-foot length was extracted from the core hole. The intent is that this core length will ultimately be returned to the SDU after all drilling and extraction activities for a particular access port are complete. The second extraction step involves the removal of the remaining 2-foot core length containing the target sample material. Specific details on the drilling and extraction steps are provided in the

subsequent sections. Attachment 3 provides the latest revision of the operations procedure (incorporating lessons learned during FY2015 testing) that will be utilized by operators when drilling and extracting actual cores from SDU Cell 2A.

3.1.1 Core-Drilling Operations

Core-drilling entails a number of key processes that will be discussed with respect to the FY2015 testing in the subsequent text.

(1) Seating the Drill Bit

Correct seating of the drill bit on the grout surface is essential to ensure that drilling occurs along the drill motor axis. This minimizes lateral stresses on the drill strings which may subsequently be imparted to the sample. The potential effect of drill bit skidding across the surface prior to engaging the grout is depicted (though exaggerated) in Figure 13. As the drill bit moves further into the grout its misalignment with the drill motor axis increases thereby imparting increased stresses on the drill string and the samples contained within the drill strings.

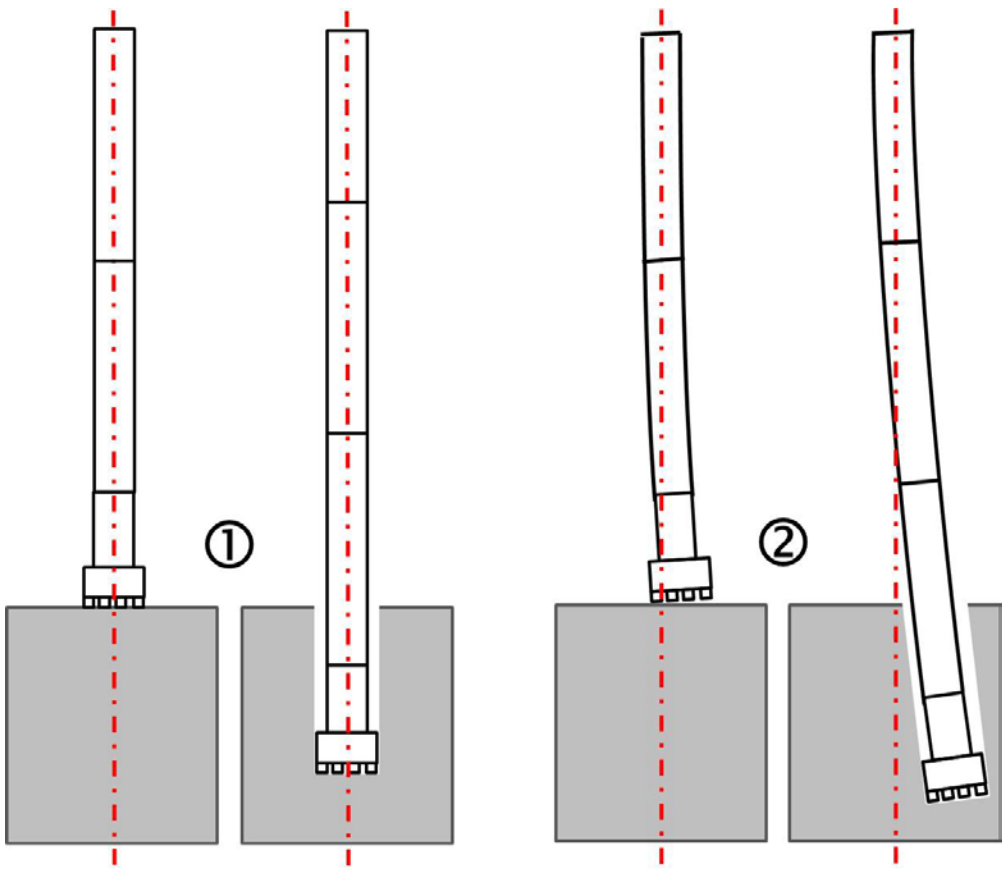


Figure 13: Schematic illustrating (1) correct seating and drill alignment and (2) effect of poor drill bit seating on the grout surface due to surface skidding.

For preliminary FY2015 core-drilling skidding of the drill bit was observed across the grout surface. However, sample seating was readily improved by utilizing the “starting mode” feature available on HILTI DD350 which enables the drill bit to revolve at a low RPM until the drill bit is seated correctly. The lower power HILTI DD200 motor does not have the starting mode but adequate seating can be achieved by initially contacting the drill bit with the grout surface and applying light pressure while rapidly cycling the motor on and off until the drill bit adequately engages the grout.

(2) Advancing the Drill into the Grout

For the FY2014 tests it was determined that the speed at which the drill could be advanced was a function of how rapidly fines could be removed from the cutting face which is dependent on the cutting speed and the flow rate of water to the drilling face. Insufficient removal of fines can result in sample binding and complete loss of water flow. For coring to a depth of approximately 3.5 feet in the B25 monolith maintaining a minimal flow rate of 0.5 GPM was required for preventing excessive build-up of fines and subsequent sample binding. When the flow rate decreased below 0.5 GPM advancement (but not the revolution) of the drill was halted until the fines had been cleared and the water flow rate had returned to the desired 0.5 GPM or greater.

For the FY2015 tests maintaining a flow rate of 0.5 GPM was also determined to minimize sample binding when drilling through 6 feet of grout. However, on a number of occasions during the initial tests the drop in flow rate below 0.5 GPM occurred so rapidly (and unexpectedly based on operator experience during the FY2014 tests) that the operator was unable to react in time to prevent sample binding. Due to the occurrence of rapid binding an initial thought was that as the water flow decreased below 0.5 GPM rather than just halting advancement of the drill it should actually be retracted slightly to better facilitate the removal of fines from the cutting face. While this proved successful in allowing the fines to be removed, it was found that after coring was complete and the drill retracted, cores were bound in the drill string sections. Consultation with Mr. Barry Copeland (Atlanta Coring, Atlanta, GA) indicated that retraction of the drill bit was undesirable since if the drill was retracted past a fractured cold joint then the sample could move within the core hole and subsequently be crushed upon re-lowering the drill bit as schematically illustrated in Figure 14. The presence of sample fragments and additional fines could subsequently cause binding of the cores inside the drill string. Copeland indicated that the procedure employed previously of merely halting the advancement of the drill bit was the recommended technique for preventing sample binding, and he iterated the need to carefully monitor the water flow rate such that the reduced flow could be detected early and sample binding subsequently avoided. In order to avoid future occurrences of sample binding within the drill more attention was paid to the flow rate by the operators and advancement of the drill was thereafter halted in time to minimize sample binding.

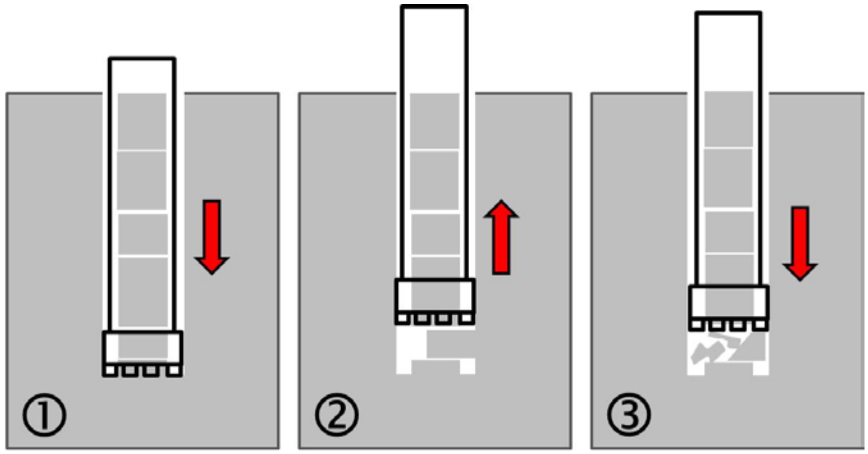


Figure 14: Potential effect of retracting the drill bit to facilitate the removal of fines.

(3) Drill String Addition

Drilling to retrieve samples from a depth of 6 feet below the grout surface will require the addition of one or more drill string sections during the coring process. Figure 15 depicts the addition of drill strings in order to retrieve the sample from the desired SDU elevation.

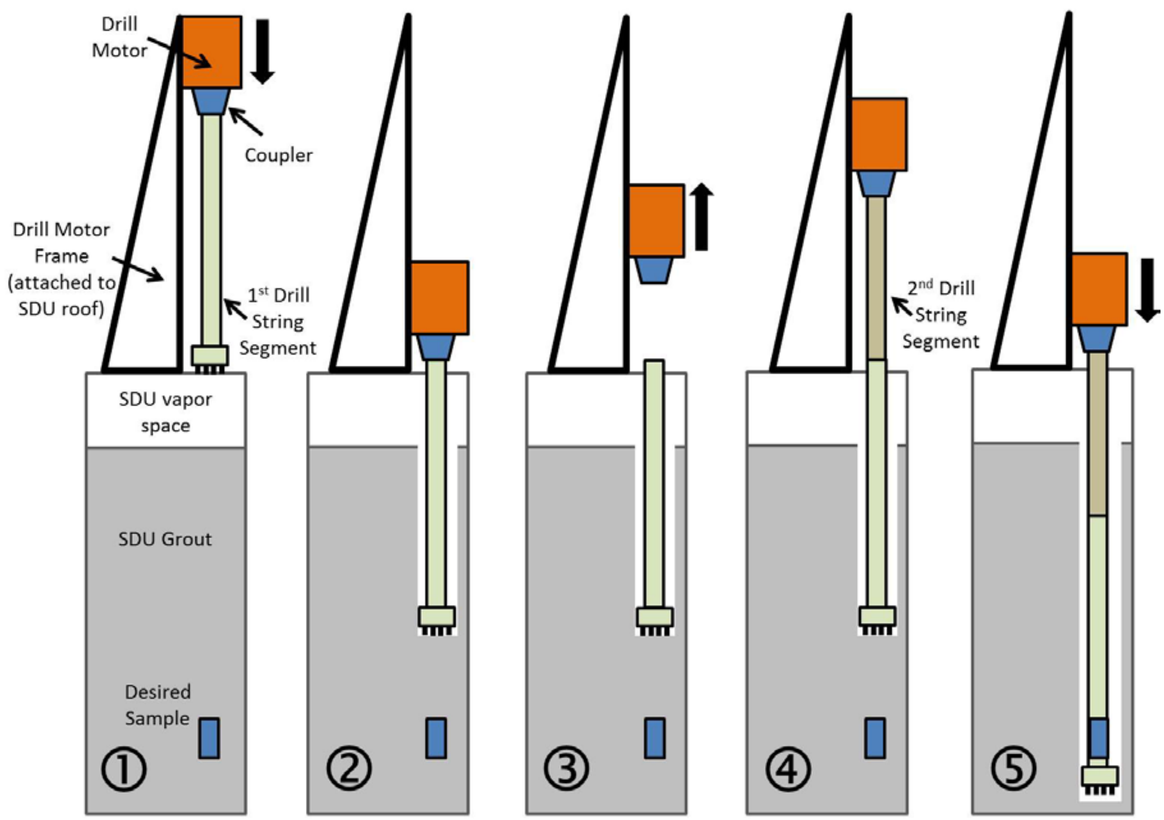


Figure 15: Process of adding drill strings to reach the desired sample depth.

The steps 1-5 indicated in Figure 15 are described as follows:

① The length of the drill string (including the diamond drill bit) is limited by the maximum height above the SDU roof that enables safe operation of the drill by the operators. During the FY2014 mock-up this was determined to be approximately 6 feet. The drill motor can be raised to this height and a drill string section with a length equal to distance between the drill motor coupling and the SDU roof surface can be attached.

② The drill bit is advanced through the SDU vapor space and into the grout until the drill motor coupling and drill string segment are still exposed above the surface of the SDU roof. At this stage the drilling depth is insufficient to retrieve the desired sample.

③ The drill motor and drill string are decoupled and the motor raised back up the drill stand. The first section of drill string remains in the core hole.

④ An additional section of drill string is coupled between the drill motor and first section of drill string. Operations ③ and ④ may need repeating until sufficient drill string length is available to reach the desired sample depth.

⑤ The drill bit is advanced further into the SDU grout until the elevation for retrieval of the desired sample is reached.

Figure 16 indicates the process of inserting additional drill sections as part of the FY2015 mock-up. The drill motor is stopped and decoupled from the initial drill string. The motor is then raised and the next section of drill string (2 feet in length) is inserted and coupled to the lower drill string and the drill motor.

Figure 16: Drill string addition during FY2015 core-drilling mock-up.

Figure 17 indicates the initial drill string / drill bit configuration prior to drilling, and the final configuration that was utilized in the mock-up to reach the sample at the desired height (equivalent to the 16-foot elevation measured from the floor of the SDU).

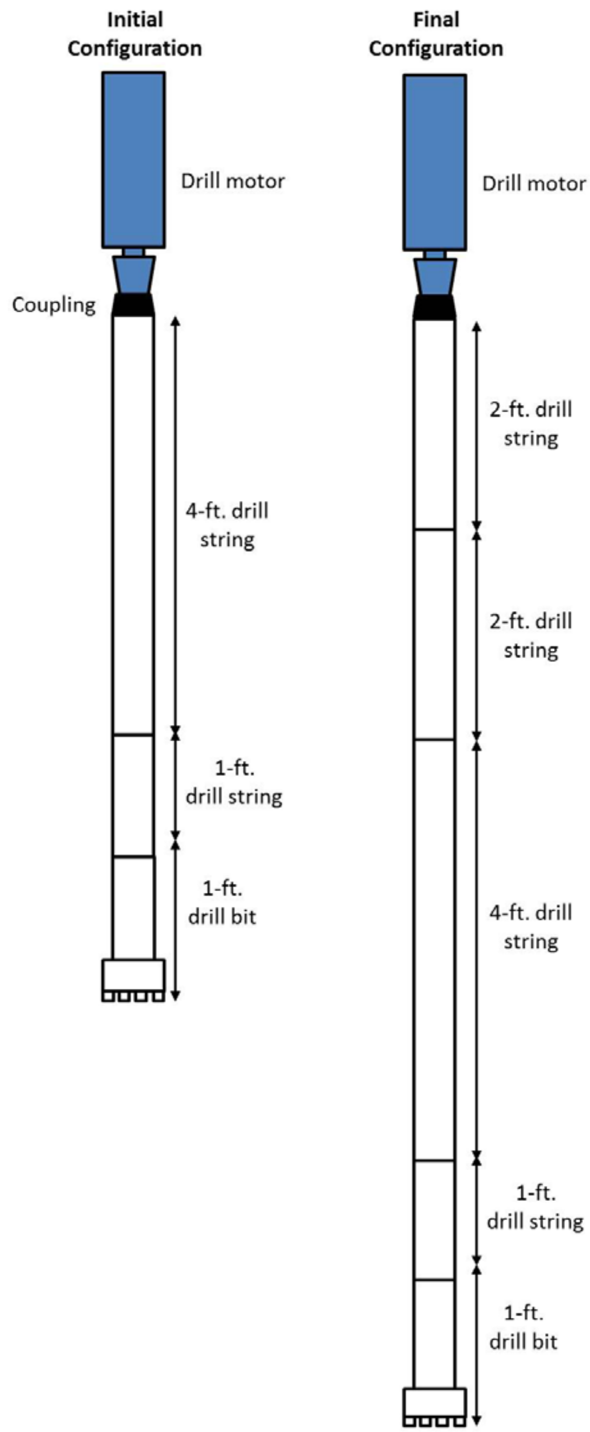


Figure 17: Initial and final configurations of drill string and drill bit.

One observed consequence of drill string addition in the FY2015 mock-up was increased vibration of the drill rig. In FY2013 testing drill vibration was observed but was attributed to inadequate restraint of the drill motor rig to a rigid base. This was remedied for FY2014 testing with the use of a purpose built plate that enabled more rigid mounting of the drill motor stand with the test stand platform. As stated above drill vibration was again observed during FY2015 testing and was most prominent upon insertion of the 2-foot segments of drill string. The vibration was reduced (but not eliminated) when alternate drill string sections were utilized. As such it was concluded that the vibration was likely the result of deformation of the drill string tubes that had occurred after multiple coupling, coring, and decoupling operations. As illustrated in Figure 16 the drill strings must be held tightly with a wrench to enable decoupling. Consultation with Copeland indicated that repeated decoupling operations would result in deformation of the drill string tubes causing them to become slightly non-circular in cross-section. Despite significant vibration the samples retrieved in the mock-up were still of sufficient integrity to perform the analyses that is intended for those samples extracted from SDU Cell 2A. In particular, samples 3 inches in length should be useable for SHC measurements. Figure 18 shows a photo of samples retrieved from the mock-up when significant drill vibration was observed. Additional photos for all cores drilled and extracted during the FY2015 mock-up are provided in Attachment 2.

A point of note, however, is that in the sample depicted in Figure 18 there are through-diameter fractures in excess of those that can be attributed to fracture along cold joints. It is possible that the additional sample fractures are the result of excessive vibration which would be expected to impart significant stress on the core samples. While through-diameter fractures are readily observed an additional concern exists with respect to damage that is not detectable by eye (e.g., micro-cracking) and which might result in artificially high SHCs. The recommendation for minimizing vibration (and potential sample damage) from Copeland was that new drill strings and drill bits should be used for each of the six cores to be drilled in the SDU.

Figure 18: Photo of samples illustrating sufficient sample integrity for subsequent analysis.

(4) Retracting the Drill String after Core-Drilling

The intent when retracting the drill string is to ensure that the entire core length remains in the core hole such that it can be retrieved as planned utilizing the extraction tool. If core segments are held up in the drill string they can either fall back onto the grout surface as the drill string is raised out of the SDU, or remain in the drill string. If material simply falls from the drill bit back into the cell the “grabber” tool (Figure 10) will be used to retrieve the samples from the grout surface. However, if this occurs there is a possibility that the sample integrity may have been compromised by the fall. If material remains lodged in the drill string, the retained samples would have to be removed on top of the SDU (resulting in increased worker dose) or alternatively shipped to SRNL for extraction. In order to minimize the hold up of samples in the drill string a pushrod can be employed by operators (Figure 19). After the required core depth is reached the drill motor is uncoupled from the drill string; one operator then raises the drill string while another inserts a pushrod into the drill string to detect sample binding. The operator can apply force to the pushrod in the event that sample binding is detected. While applying the force may damage the upper sample in direct contact with the pushrod, lower samples appear undamaged.

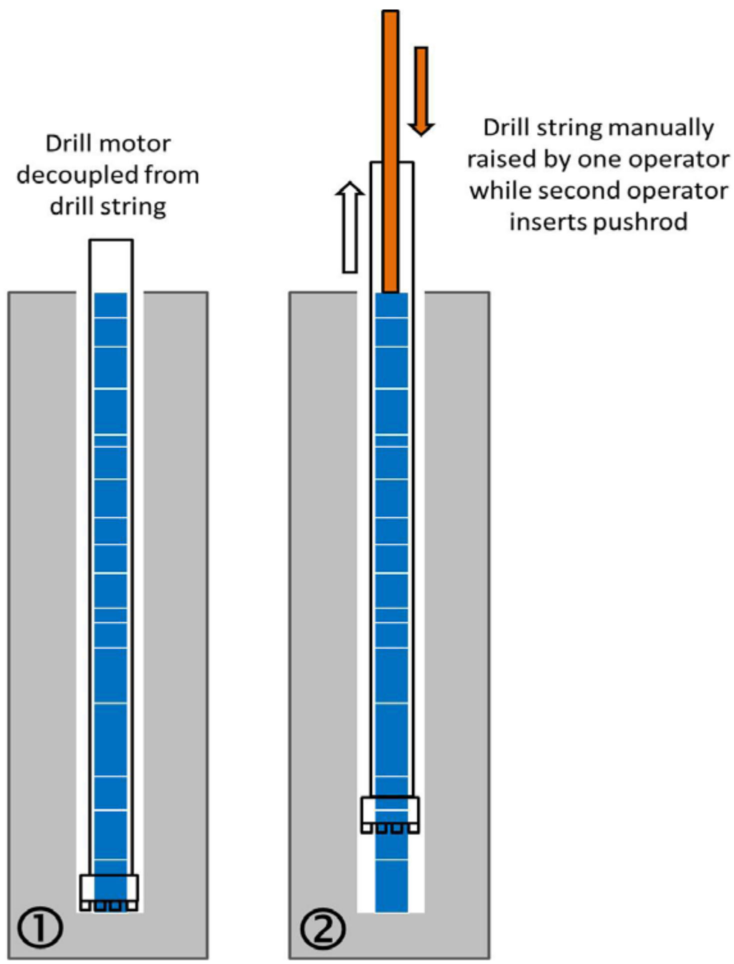


Figure 19: Use of pushrod to release bound samples from drill string.

(5) Core Extraction

As stated previously the length of core to be transported to SRNL for analysis should be less than 3 feet in length. The length of useful sample is limited to the lowest 2 feet of the core which would incorporate the sample associated with the 8/12/2013 pour plus samples associated with pours directly prior and after the 8/12/2013 pour. Figure 20 illustrates the core extraction process.

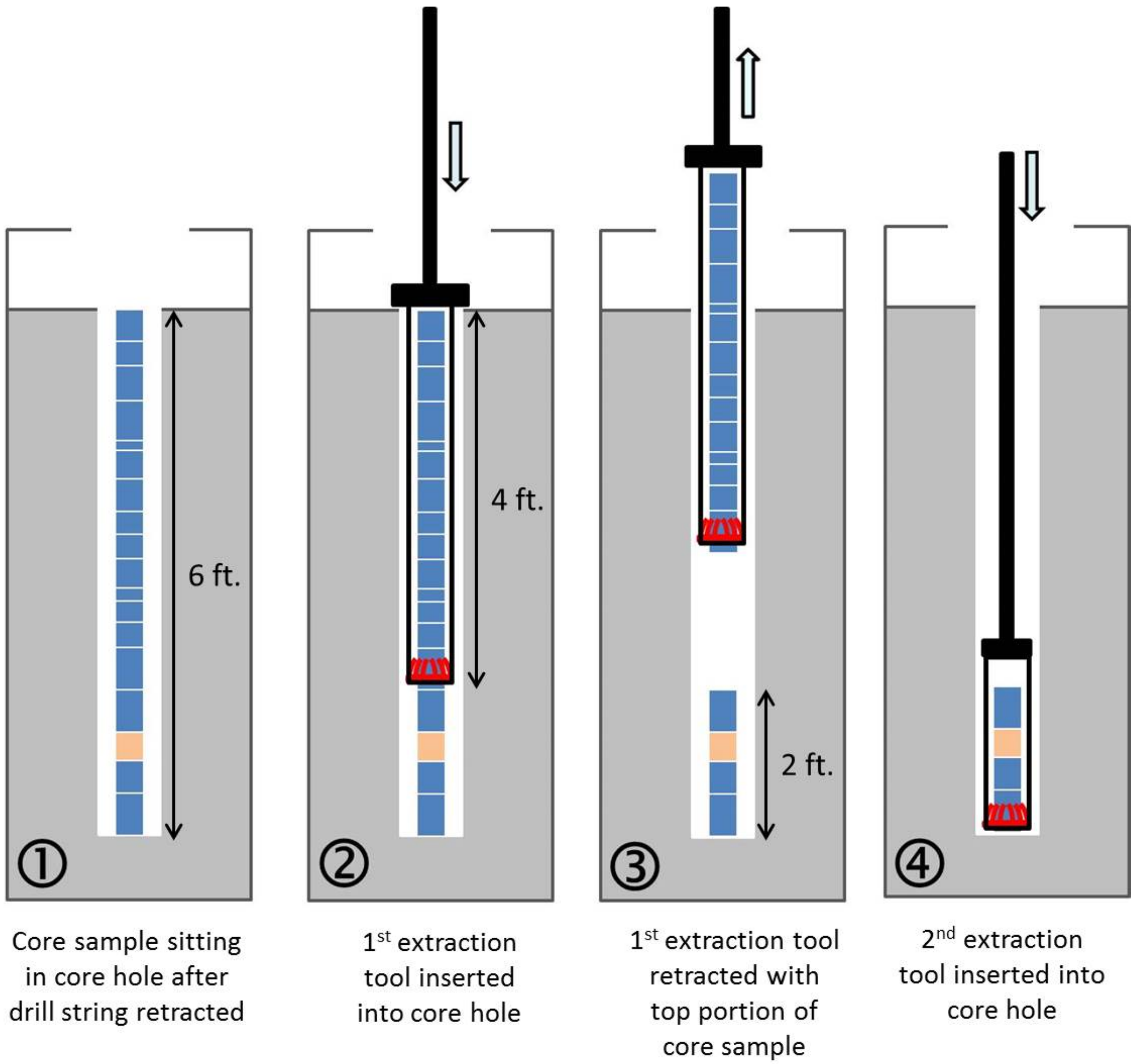


Figure 20: Schematic illustrating 2-step sample extraction.

The steps 1-4 indicated in Figure 20 are described as follows:

① Core-drilling is complete and the drill string has been retracted from the core hole.

② The extraction tool for retrieving the upper 4 feet of core is inserted into the core hole. This tool incorporates a coupling at the top of the tube with a larger diameter than the core hole. This acts as a "tool stop" to prevent more than 4 feet of core being extracted from the hole.

③ The 4-foot upper core section is retreived from the core hole and staged on top of the SDU. After all coring and extractions are complete for a particular access port, the 4-foot of core will be replaced into the SDU.

④ A second extraction tool is utilized to retrieve the lower 2 feet of core sample. This tool is approximately 2.5 feet long and capable of full insertion into the core hole.

Figure 21 illustrates the various extraction tool components.

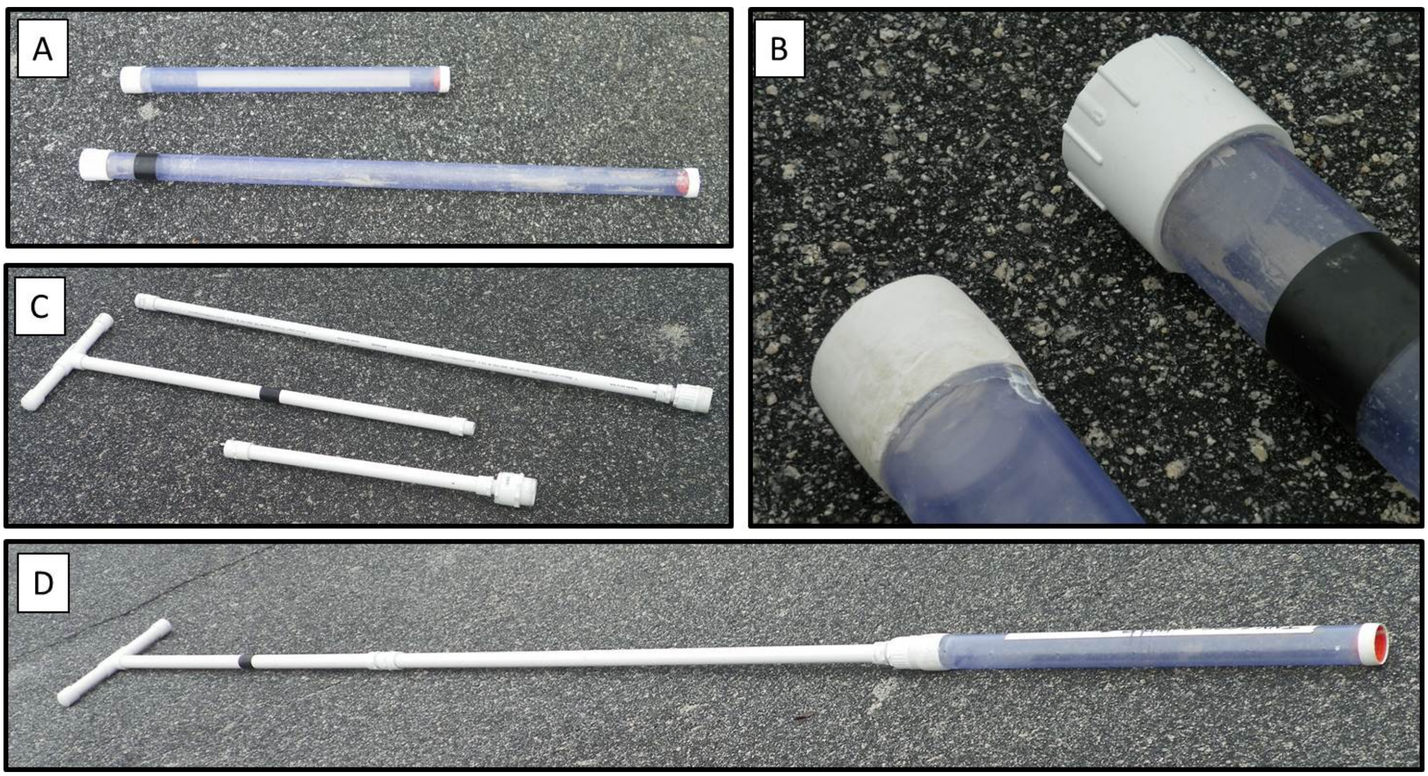


Figure 21: Core extraction tools: (A) 2 and 4-foot core extraction tools; (B) increased diameter on 4-foot extraction tool to limit insertion; (C) extension tools; (D) fully assembled tool to extract 2-foot core.

As anticipated, misalignment of multiple samples in the core hole (see Figure 4) did complicate extraction of the cores though ultimately operators were able to manipulate the tool to extract all samples. In order to improve the extraction process a modification was made to the extraction

tool that served to align samples as the tool was inserted into the core hole. Figure 22 shows a thinned lip section on the end of the extraction tool.

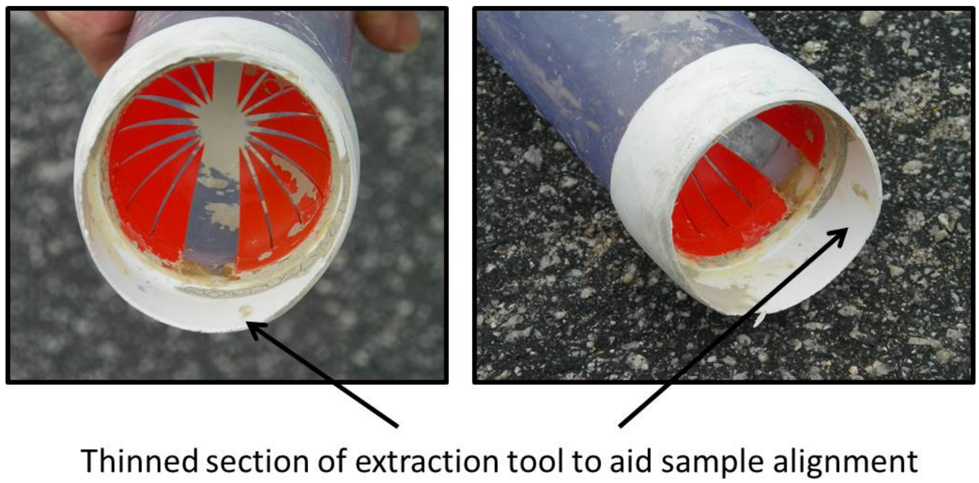


Figure 22: Reduced thickness lip on extraction tool to facilitate sample alignment in core hole.

Figure 23 depicts a schematic representation of operating the modified extraction tool to align samples.

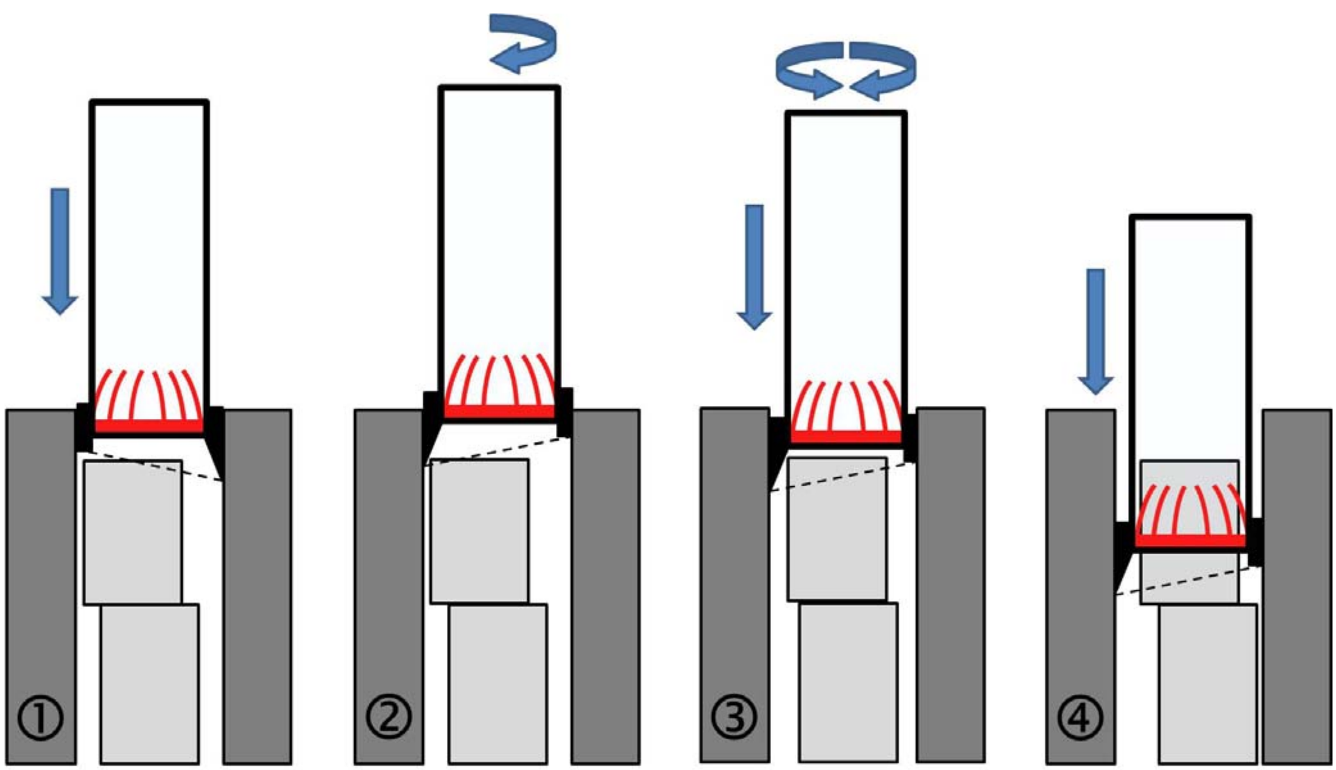


Figure 23: Schematic of extraction tool operation to aid core alignment.

The steps depicted in Figure 23 are described as follows:

① The extraction tool is advanced down into the core hole until resistance is felt against the core samples.

② The extraction tool is rotated until the thinned section captures the edge of the misaligned sample.

③ The extraction tool is rotated back and forth to move the core to the center of the core hole.

④ Once centered the extraction tool can be further advanced to capture the core.

(6) Core Packaging and Transport

As stated previously the lower 2 to 2.5 feet of core material will be packaged and transferred to SRNL for storage and eventual analysis while the upper 4 feet of core sample will be placed back into the SDU once core-drilling activities at a particular camera port have been completed. The 2-foot core sample will remain in the core extraction tube for transfer. The tube will be placed into an inerting container from which oxygen can be removed. This is necessary in order to ensure the chemical state of the samples is not compromised. In particular, it is important that the redox sensitive species, such as Tc(IV), are not exposed to oxygen during transport to SRNL. When the samples are received at SRNL they will be transferred to an inerted chamber for storage and preparation for analysis. It is understood that samples will be exposed to oxygen during the drilling and extraction processes but it is anticipated that saturation of the samples with water from the core-drilling process will significantly reduce the sample interaction with gaseous oxygen.

There are a number of ways to remove the oxygen from the container holding the core samples; these are (1) evacuation, (2) oxygen adsorption, or (3) flushing with an inert gas such as N_2. It is worth noting that any technique that is utilized for removing oxygen from the transport container must be amenable to execution on the SDU roof and should limit the spread of radiological contamination.

Evacuating the container will protect the sample from exposure to atmospheric oxygen, but was not a preferred option since the samples will be wet, and water would begin to evaporate under the reduced pressure environment potentially making it difficult to confirm the degree of evacuation. The use of oxygen adsorbers was assessed by inserting oxygen absorber packets (Multisorb Technologies, FreshPax) which are capable of reducing and maintaining the oxygen content in a sealed container to below 1%. Wet core samples were sealed in plastic rad material bags with 2, 8, 15, and 25 packs of FreshPax oxygen adsorbers (each capable of adsorbing 300 cc of oxygen) (see Figure 24). An oxygen sensor (Vernier O_2 Gas Sensor, Model O2-BTA) was also placed into the bags to characterize the time-dependent change in oxygen content; this data is provided in Figure 25.

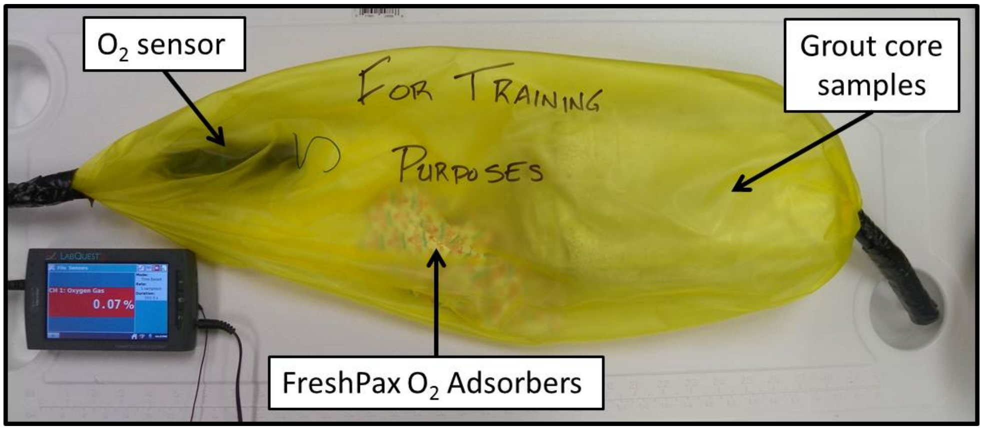


Figure 24: Testing time-dependent O_2 adsorption.

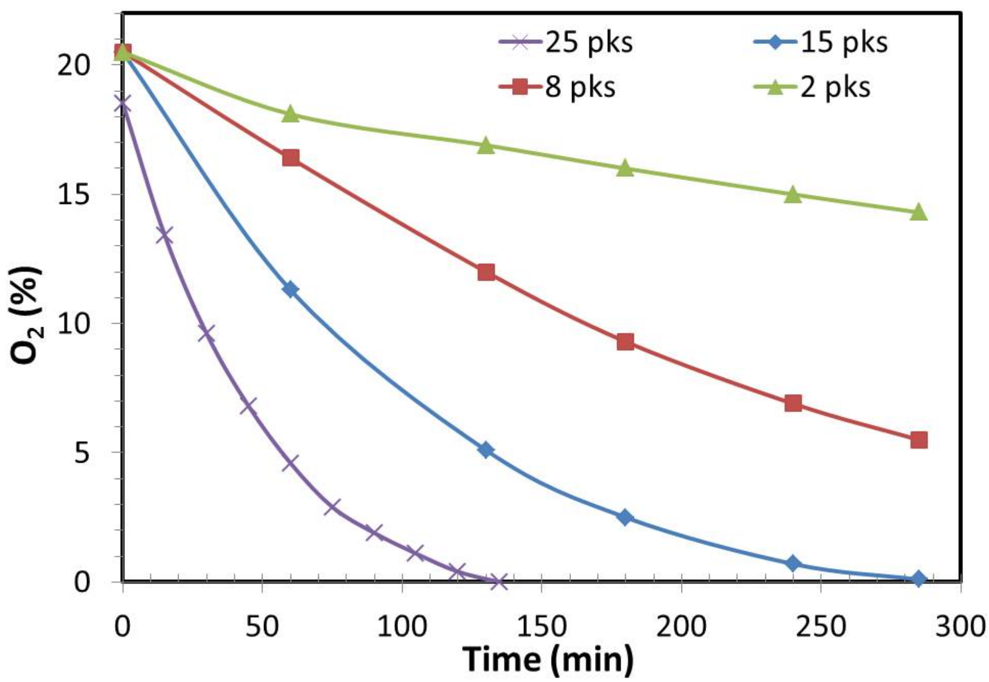


Figure 25: Time-dependent O_2 adsorption for FreshPax O_2 adsorber packets.

While Figure 25 illustrates the ability of the FreshPax O_2 adsorbers to reduce the oxygen level to <1%, the time to achieve this exceeds 2 hours even when using 25 FreshPax adsorbers. The time response of the oxygen adsorbers was too slow to ensure that unacceptable oxidation did not occur and was discarded as a primary option.

The final option considered involves displacing the air around the core sample with an inert gas, such as N_2. Figure 26 indicates a simple design for an inerting container.

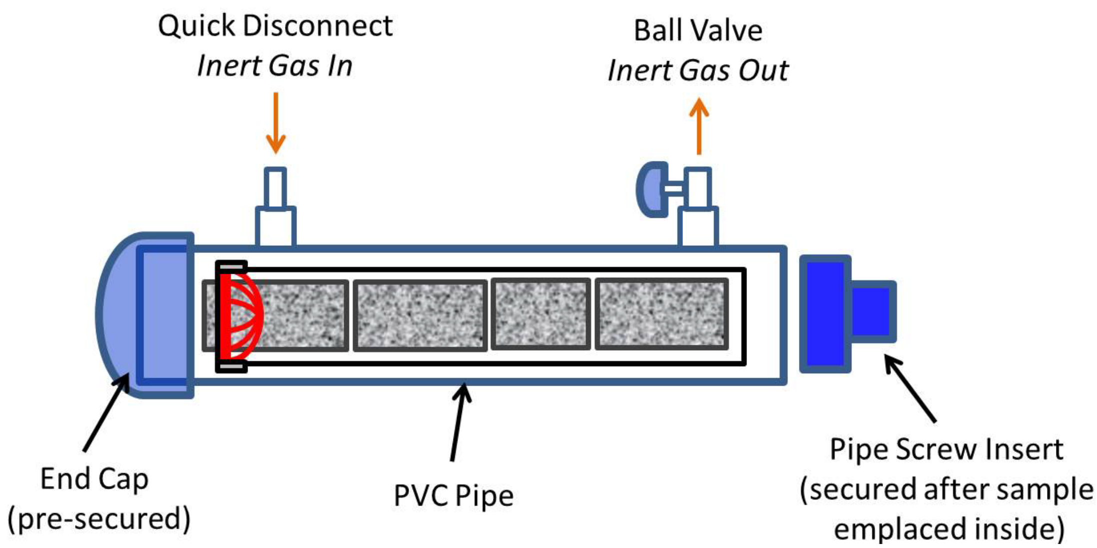


Figure 26: Schematic of inerting container for sample transport.

A preliminary mock-up of the inerting container is depicted in Figure 27. It is constructed from readily available PVC plumbing components and incorporates a quick disconnect valve for introducing the inert gas and a manual ball valve that can be opened during purging and subsequently closed once the container is inerted.

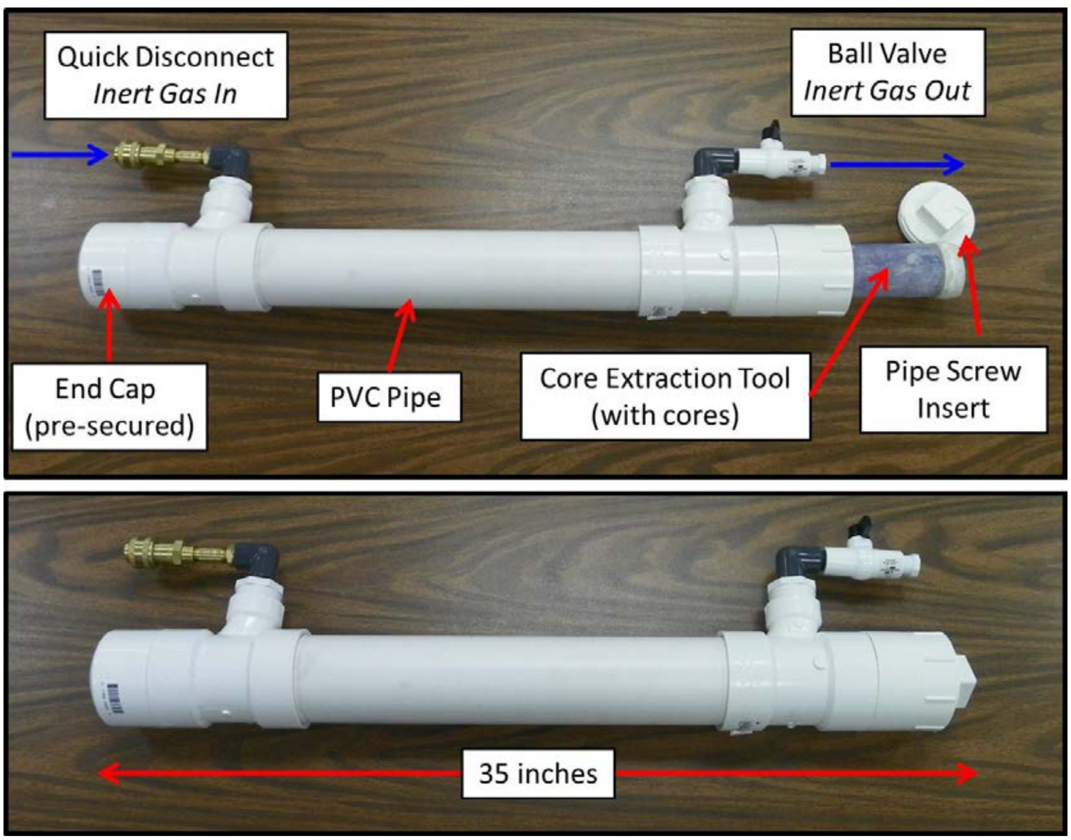


Figure 27: Assembled inerting chamber.

Figure 28 illustrates an inerting container that was fabricated to determine the required N_2 flush time. It incorporates a Vernier O_2 Gas Sensor and a 2 cubic feet per minute (CFM) high-efficiency particulate air (HEPA) filter on the outlet pipe. The HEPA filter is required to prevent the spread of radioactive contamination during the inerting process and limits the N_2 flush rate to 2 CFM maximum.

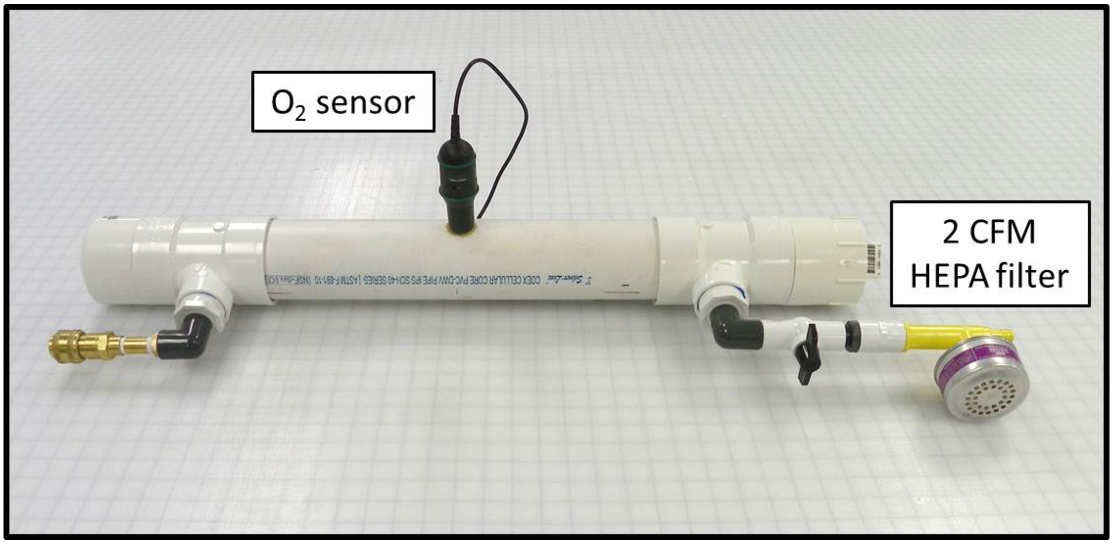


Figure 28: Inerting container assembled for testing.

Testing of the container was conducted to determine (1) the N_2 flushing time required to achieve an O_2 content of <1%, and (2) the length of time for which the purged O_2 environment was maintained. The following steps were included in the full inerting process:

1. Flush the open container (without the sample and with the screw insert removed) with air and calibrate the O_2 sensor to ~20.9% O_2.
2. Add two FreshPax O_2 adsorber packets to the container and attach the screw insert. The O_2 adsorber packets are added as an additional protective measure against oxygen exposure to the sample.
3. Open the outlet valve (with the HEPA filter attached), attach the N_2 delivery tube from the N_2 source (99.99% purity), and flush the container with N_2 at 1 CFM for 5 minutes.
4. Shut off N_2 flow to the container, close the outlet valve, and allow the container to sit overnight while automatically monitoring the O_2 content. Note that the outlet valve is only closed once N_2 flow has ceased in order to avoid pressurizing the container.

   Actions 1-4 are to simulate pre-flushing of the container the day before core-drilling of samples from the SDU.

5. Remove the screw insert from the container and allow the container to sit open for 2 minutes.

6. Insert the 2-foot simulant saltstone sample (contained within extraction tube) into the container, add five FreshPax O_2 adsorber packets to the container, and attach the screw insert.

   Actions 5 and 6 are to simulate the length of the time the pre-flushed container may be open while operators insert the sample and attach the screw insert.

7. Open the outlet valve (with the HEPA filter attached), attach the N_2 delivery tube from the N_2 source (99.99% purity), and flush the container with N_2 at 1 CFM for 5 minutes.
8. Shut off N_2 flow to the container, close the outlet valve and allow the container to sit for 24 hours while automatically monitoring the O_2 content.

   Actions 7 and 8 are to simulate purging of the container and to determine the length of time for which the purged O_2 environment was maintained.

Figure 29 provides the O_2 content data for the inerting container. The shaded area from approximately 0 to 18 hours is associated with the 5 minute N_2 pre-flush of the empty container. Prior to N_2 pre-flushing the container was flushed with air. Upon pre-flushing with N_2 the O_2 content fell from 20.9% to less than 1% in approximately 1.5 minutes. Pre-flushing continued for a total pre-flush time of 5 minutes after which the container was closed and allowed to sit overnight. After approximately 18 hours the O_2 content had increased to 3.5%. The source of the O_2 is unclear though a potential pathway for air ingress is at the seal between the O_2 sensor and the PVC pipe (note that a leak was observed at the seal between the oxygen sensor and the pipe when the container was pressurized to 3 psi with air and tested with a liquid leak testing solution).

The unshaded portion of the graph pertains to the process of opening the container, inserting the sample, and flushing with N_2 at 1 CFM for 5 minutes. While the container was kept open for 2 minutes (to simulate the time it might take for the operators to insert the sample and close the container), the O_2 content increased to 13.9%. Upon flushing with N_2 at 1 CFM the O_2 content dropped to less than 1% in approximately 1 minute. After a total N_2 flushing time of 5 minutes the outlet valve on the container was closed and the O_2 content monitored for 24 hours. After 24 hours the O_2 content was recorded at 3.3%. Further development and testing will be conducted in an effort to improve the leak tightness of the containers though it is not expected that a 3% O_2 content within the inerting container will result in oxidation of redox sensitive contaminants. Of particular relevance with respect to this assertion are: (1) only the sample interior rather than sample surface (that may have been exposed to air) will be used for analysis involving redox sensitive components, and (2) the saltstone samples will be saturated with water and the diffusivity of oxygen in water is four orders of magnitude smaller than that observed in air (diffusion coefficient of oxygen in water at 25 °C ~ 2.4E-05 cm^2/sec [9]).

It should be noted that given the fact that the container can be purged to an oxygen content of less than 1% in approximately 1 minute the pre-flushing procedure conducted the day prior to coring (shaded area in Figure 29) may not be necessary.

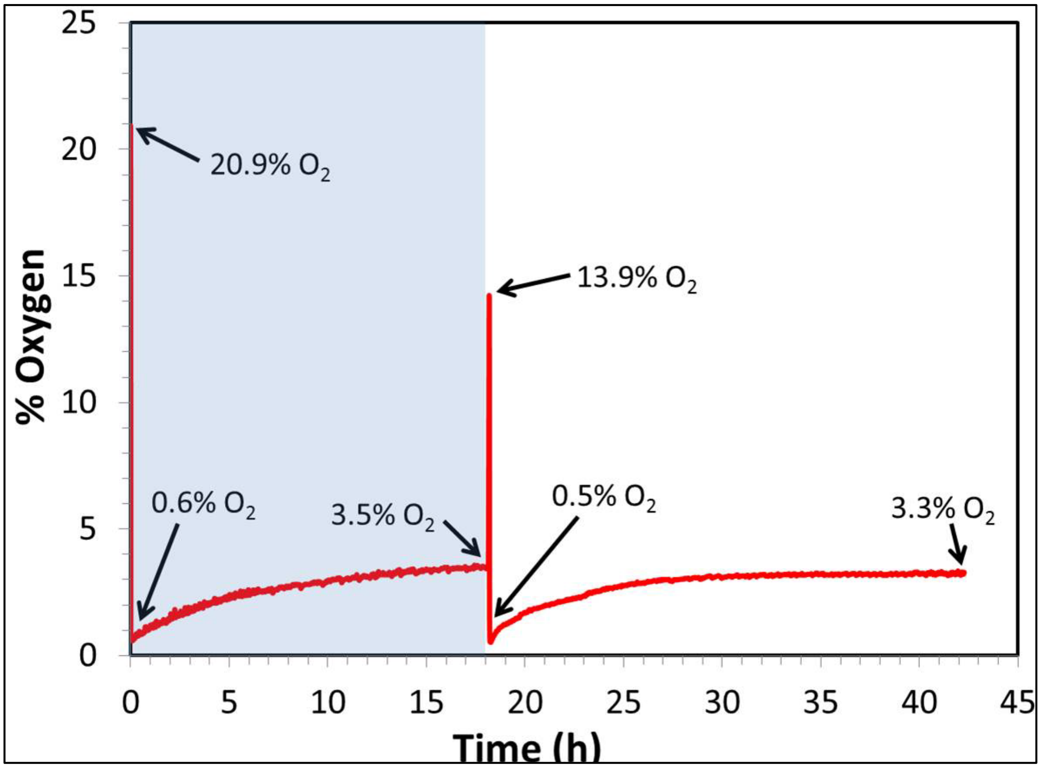


Figure 29: Test data for inerting procedure

4.0 CONCLUSIONS

The ability to wet core-drill saltstone simulant to a depth of 6 feet, and subsequently extract the samples has been successfully demonstrated on multiple samples as part of the FY2015 mock-up testing. The main objectives and findings of the FY2015 testing are detailed in Table 3.

Table 3: FY2015 mock-up objectives and summary of findings.

	OBJECTIVE		FINDINGS
1	Demonstrate ability to core-drill through 6-foot of saltstone simulant.		Wet coring to a grout depth of 6 feet was successfully demonstrated. Two additions of 2-foot length drill string sections were required to achieve the desired sample depth.
2	Demonstrate ability to extract 6 feet of drilled core, and define strategy to retrieve lowest 2-foot section of sample to send to SRNL for analysis. Demonstrate ability of extraction tool to retain longer sample lengths		An in-house designed retrieval tool was successfully demonstrated with respect to retrieving a 6-foot core comprising multiple smaller (3-6 inch) samples due to through-diameter cracking along cold joints. The extraction process was divided into 2 steps and involved the initial retrieval of the top 4 feet of core, which will be ultimately placed back in the SDU

	OBJECTIVE		FINDINGS
	(and mass) than demonstrated during FY2014 mock-up.		followed by the retrieval of the lower 2 feet of core which will be sent to SRNL for analysis.
3	Develop equipment to anchor drilling equipment to SDU roof.		A purpose designed mounting plate was fabricated, and successfully demonstrated. The mounting plate incorporated a plate that can be translated across the access port to allow retrieval of two samples per access port.
4	Demonstrate the ability to drill and retrieve cores using artificial lighting in conjunction with a camera/video system.		Drilling and extraction of cores utilizing artificial lighting and camera/video display was successfully demonstrated on two full-length cores.
5	Develop inerting container and secondary transport container.		An inerting container and procedure for inerting have been developed and deemed satisfactory for ensuring that redox sensitive contaminants within the sample interior are not subject to oxidation during transport.
6	Demonstrate "grabber" tool that can be utilized to retrieve samples that have fallen back onto the grout surface during retraction of the drill string or the extraction tool.		A commercially available tool was procured and successfully demonstrated for sample retrieval.

The intent is to core-drill "actual" saltstone samples from SDU Cell 2A around the April 2015 timeframe. Operators will undergo hands-on refresher training utilizing the equipment and monolith detailed in this report. SRNL is currently developing protocols for receipt, storage, and analysis of the samples. With respect to storage a purpose built anaerobic chamber with the ability to inert with nitrogen is being fabricated to store and prepare samples for analysis. This chamber will maintain the oxygen-free environment required to prevent oxidation of redox sensitive components, most notably ^{99}Tc.

5.0 REFERENCES

1. *Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site*, SRR-CWDA-2009-00017, Rev. 0, October 2009.
2. *Update of Fiscal Year 2013 Activities Releated to SDU Sampling and Analyses*, SRR-SPT-2013-00044, Rev. 0, September 2013.
3. *Physical Property Comparison of Core-Drilled and Cast Simulant Saltstone*, SRR-SPT-2013-00056, Rev. 0, March 2014.

4. *FY2014 Saltstone Core-Drilling Mock-Up Summary,* SRR-CWDA-2014-00059, Rev. 0, June 2014.
5. *Technical Safety Requirements Savannah River Site: Saltstone Facility*, S-TSR-Z-00003.
6. *Saltstone Clean Cap Assessment*, VSL-14R3330-1, Rev. 0, March 2014.
7. *Saltstone Sampling and Analyses Plan*, SRR-SPT-2012-00049, Rev. 1, May 2013.
8. *Liquid Waste (LW) Technical Task Request: SRNL Support for Saltstone Sampling and Analysis*, G-TTR-Z-00008, Rev. 2, January 2015.
9. *Handbook of Chemistry and Physics Online (95th Edition)*, 2014- 2015.

6.0 ATTACHMENTS

ATTACHMENT 1: Engineering Drawing of SDU Mounting Plate

ATTACHMENT 2: FY2014 Core-Drilling Mock-Up Operations Log

ATTACHMENT 3: SDU Core Sampling – Operation Manual Procedure

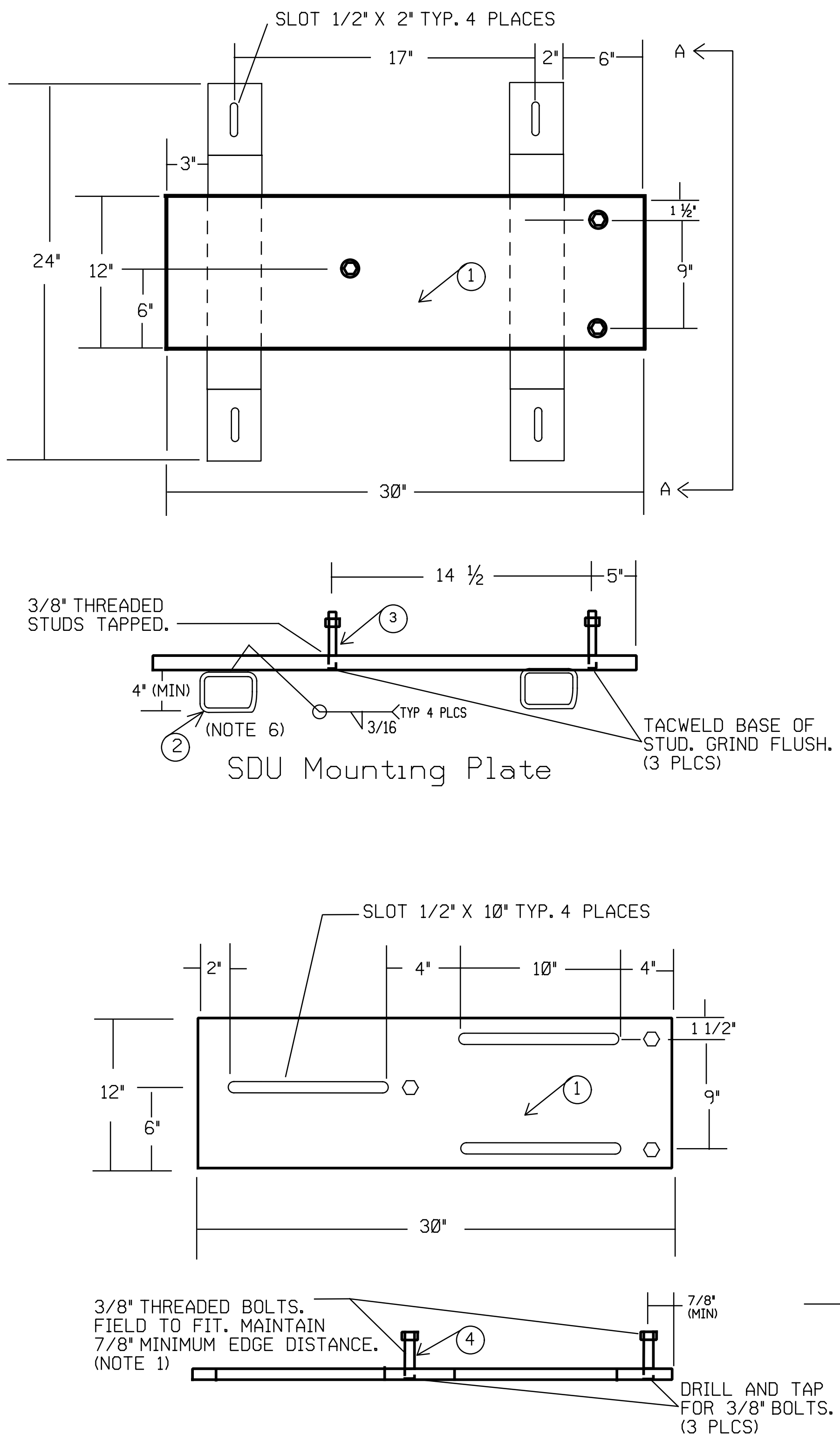
ATTACHMENT 1

BILL OF MATERIALS				
ITEM	QUAN.	UNITS	DESCRIPTION	P-CODE
1	2	EA	1/2" (MIN)X12"X30" A36 CARBON STEEL PLATE, OR APPROVED EQ.	
2	AS REQ'D	LF	4"X4" TUBE STEEL, WALL THICKNESS 1/4", OR APPROVED EQ. (NOTE 6)	
3	AS REQ'D	LF	3/8" THREADED ROD	
4	3	EA	3/8" BOLTS. LENGTH BY FIELD.	
5	4	EA	3/8" HILTI QUICK BOLTS (KB-TZ), A36	
6	AS REQ'D	EA	SIKA SIKADUR 31 HI-MOD GEL, OR APPROVED EQ.	

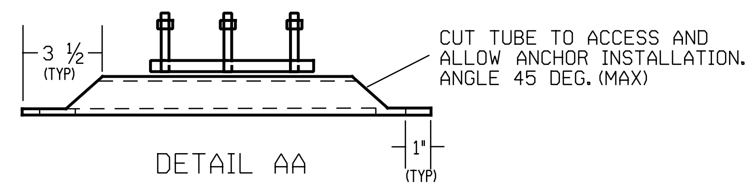
NOTES

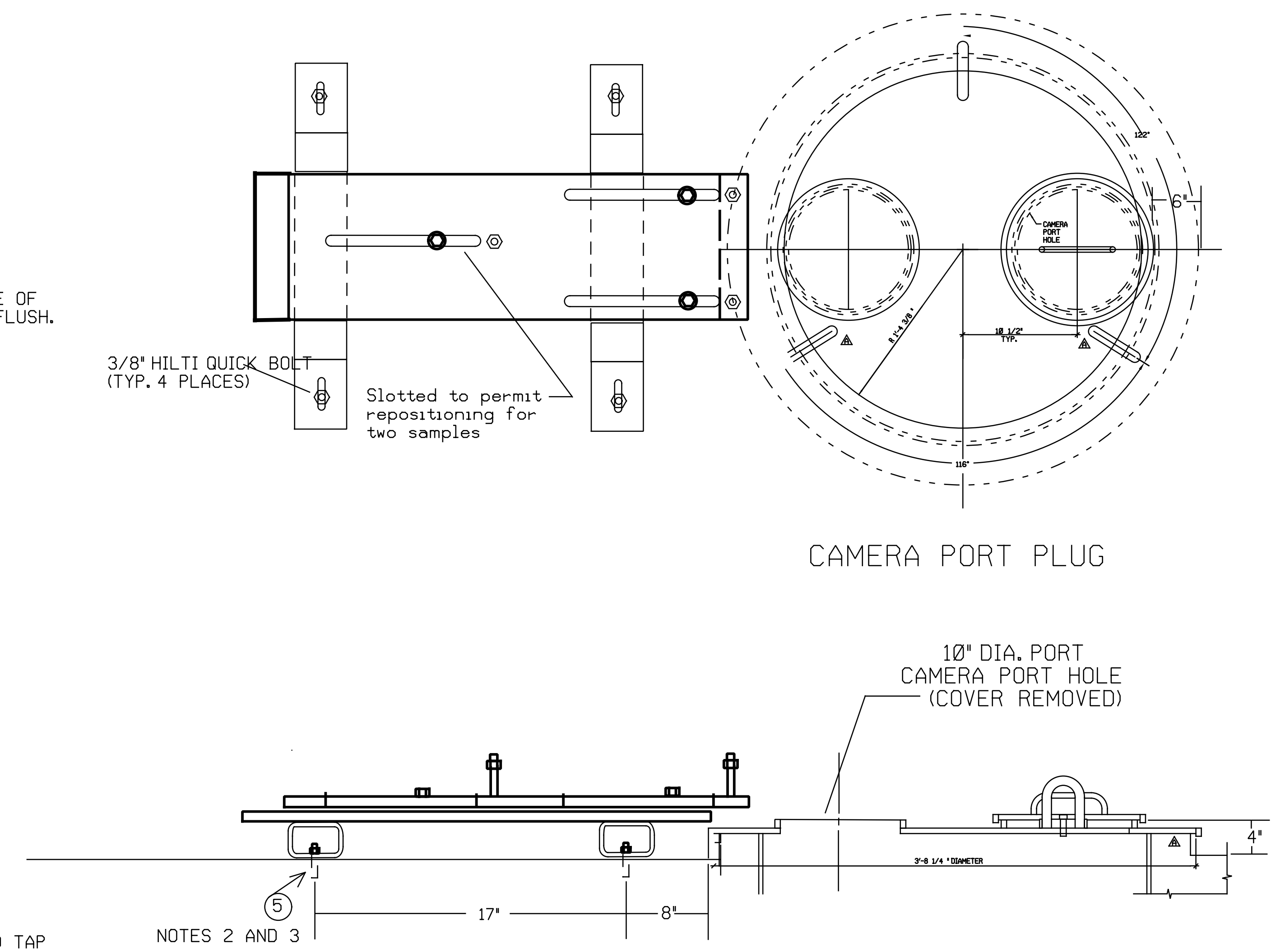
NOTES:

LEGEND



FABRICATION DETAILS





INSTALLATION DETAILS

U FS Z 00001 LATEST REVISION A

THIS DRAWING HAS BEEN FURNISHED BY THE SAVANNAH RIVER SITE. THE INFORMATION AND KNOW HOW THEREON MAY NOT BE USED NOR THE DRAWING REPRODUCED WITHOUT WRITTEN PERMISSION OF THE PRIME CONTRACTOR. ALL REPRODUCTIONS IN WHOLE OR IN PART, INCLUDING VENDOR'S SHOP DRAWINGS, SHALL BEAR OR REFER TO THIS STAMP.

REFERENCE DRAWINGS	
WB00001-004	2.9 - MG SALTSTONE TANKS 2A & 2B

REFERENCE STANDARDS

PROJ.	REV. NO.	REVISION	PRP'D	LEAD ENG	CHK'D/VERIF'D	APRV'D	APRV'D	APRV'D
SDU6	0	ISSUED FOR CONSTRUCTION	APPROVALS MAINTAINED IN DCR/EDWS					

UNITED STATES DEPARTMENT OF ENERGY

SAVANNAH RIVER SITE

BLDG. NO.	SITE CLEARANCE NO.	DESIGN AREA NO.	DESIGN GROUP
451-002Z	TBD	Z-451	DA

TITLE

Z AREA
SALSTONE DISPOSAL SITE

SDU 2A CORE DRILL
SDU AND DRILL STAND
MOUNTING PLATES SKETCH
FABRICATION AND INSTALLATION DETAILS

SCALE	SRP DRAWING NO.	SHEET NO.	LATEST REVISION
NONE	N/A	1 OF 1	A

PSC= PLOT DATE DRAWN BY (ORIG): TIME LAST CADD REV. BY: DATE:

Scale shown on this drawing is only applicable when plotted at 30"x42" (actual drawing size)

ATTACHMENT 2

Date: 12/4/14

Purpose: Perform initial testing to support core sampling at the desired 6.5 ft elevation. Testing will be performed without Ops in order to verify the following to ensure acceptability of equipment:

- DD 350 operation (core drilling equipment)
- Mounting plate design and operability
- Retrieval Tool (upper and lower tool)
- Ability to core 6ft and Retrieve samples

Completed setup of drilling equipment and water supply. No deficiencies identified as part of setup.

Prepared for Initial Core Sampling. Core Hole #1

Initial Core Barrel configuration and additions will be performed as follows:

- Initial Configuration - (1) 4ft section with adapter, (1) 1ft section + (1) 1.5ft core bit
- Coring will be performed in 3 segments of 2ft based on 6ft height of Grout
- 2ft core barrels will be added each segment

There will not be any recorded durations as part of initial sampling attempt.

SW 24.6-SPU 2 section 5.6 DRAFT D marked up to support 6ft coring will be used.

Initiated Procedure.

* Failed to obtain greater than 1.0 gpm water flow on flow meter. Water was visible at core bit. Inspected flow meter and determined installed backwards. Decided to proceed and will address for subsequent testing.

* Denotes Issue or Opportunity

Date: 12/14/14 (Cont.)

Core Hole #1 (cont.)

* Initial operating height of drill motor may be an issue. Will evaluate core barrel lengths following initial test of Core Hole #1

- Initiated core drilling.

- Completed core drilling initial 2ft.

  * Encountered some difficulty seating core bit. Will evaluate options and consider using "starting mode" available on HILTI DD 350.

  * Vibrations encountered during coring. Appears to be in drill stand and not mounting plate

- Added 2ft section of core barrel. No Issues.

- Resumed core drilling.

- Completed second segment. Approximately 4ft depth reached.

  Vibrations continued. Mounting plate does not appear to be issue.

  Progressed slowly based on no flow indication.

- Added final section of 2ft core barrel. No Issues.

- Resumed core drilling

- Completed third and final segment

  Measuring tape provided accurate indication that had reached bottom of sono tube

  Vibrations consistent with previous segments.

* Denotes Issue or Opportunity

Date: 12/4/14 (Cont.)

Core Hole #1 (Cont.)

- Proceeded with Removal of Core Barrels to allow sample recovery. 2nd Core Hole will not be performed at this time.
- Removed Upper 4 ft Section of Core Barrels. Consisted of 2 X 2 ft core barrels.

  No Issues encountered. However some water was trapped in core barrels, but appeared to drain.
- Proceeded with Removal of Lower section of core Barrels. (Length 6.5 ft)
- Completed Removal of Lower Section of Core Barrels.

✱ Inspection of Lower Section identified a portion of Samples were trapped in the upper portion of the 4 ft core barrel.

  Removed trapped core samples from 4 ft Section of core barrel. Removed samples relatively easily. Sections of core were approximately 1 ft in length.

  Remainder of samples remained in core hole.
- Proceeded with removal of Remaining Samples
- Inserted 4.5 ft Retrieval Tool into core hole. Based on 6.0 ft lift Retrieval Tool was marked at 4 ft.
- Removed upper portion of core samples. Samples measured approx. 3 ft indicating upper portion of core samples removed.
- Cores removed of 4.5 ft Retrieval Tool and aligned with cores previously removed from 4 ft core Barrel.

✱ Denotes Issue or Opportunity

Date: 12/4/14 (Cont.)

Core Hole #1 (Cont.)

- Upper Portion of Core Samples measured at ≃ 50 inches.

- Proceeded with removal of Lower Portion of Core Samples using the the 2.5ft Retrieval Tool.

  Removed approx. 16-18" of core samples, initially Second attempt allowed recovery of additional Core Sample. Samples removed from Tool and measured.

  Lower Portion of Core Samples measured ≃ 22".

- Total Length of Recovered Samples ≃ 72" which Corresponds very closely with the measured lift in the Sonotube.

Summary: Successfully demonstrated ability to core 6ft and Retrieve desired samples using both Retrieval Tools

Observations / Issues.

- Initial operating height of drill motor needs evaluation for acceptability with OPs. Future Testing to be performed.

- Difficulty seating core bit

  An option is to use the "drill Starting mode" available on DD350. By depressing ON switch twice, the Starting speed of drill motor is reduced.

- Vibration of drill stand.

  Inspection of drill motor mounting bolt on the drill stand identified it was not tightened adequately. Monitor to see if vibration improves.

Date: 12/4/14 (cont.)

Observations / Issues (cont.)

- No flow indication

  Flow gage reinstalled in correct flow direction. Water supplied and flow indication verified.

- Plugging of core barrel.

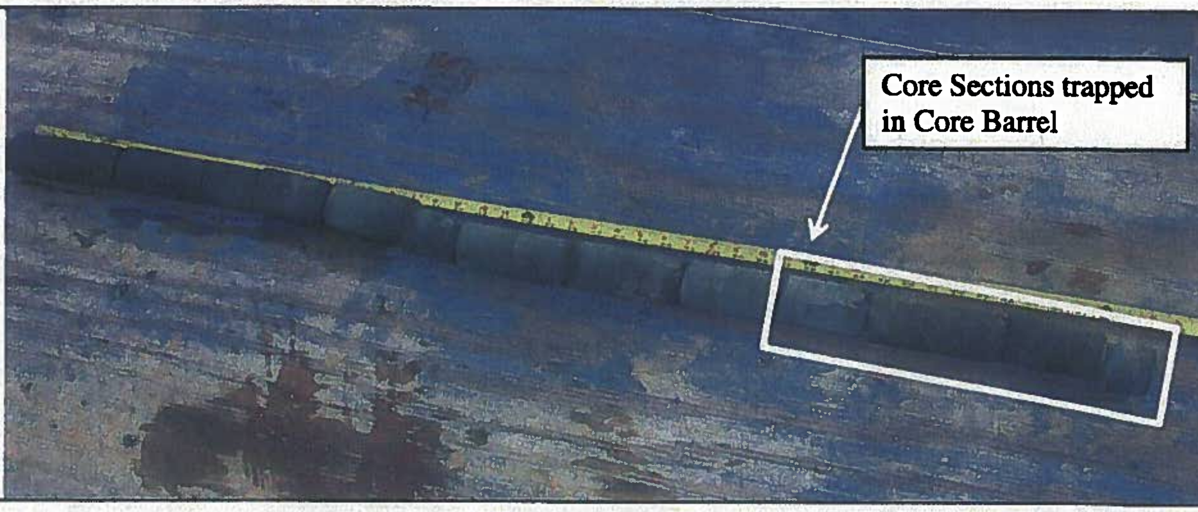
  Continue to monitor on future testing. May have been caused by inability to monitor water flow. However, previous plugging appeared to be from inability to remove fines.

  Consider performing core drilling by attempting to maximize water flow.

G.B. [signature] 12/4/14

TNX Core Drilling Mock Up Test Log (Page 6 of 7)

Date:

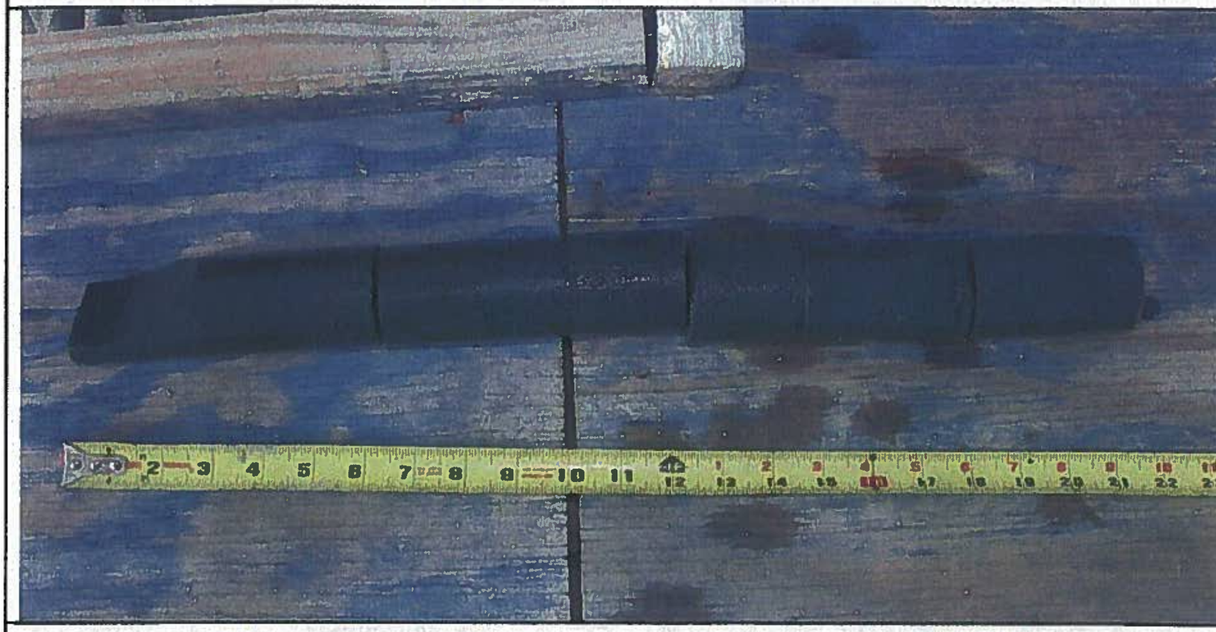


Photograph 1: Upper Section of Core Samples

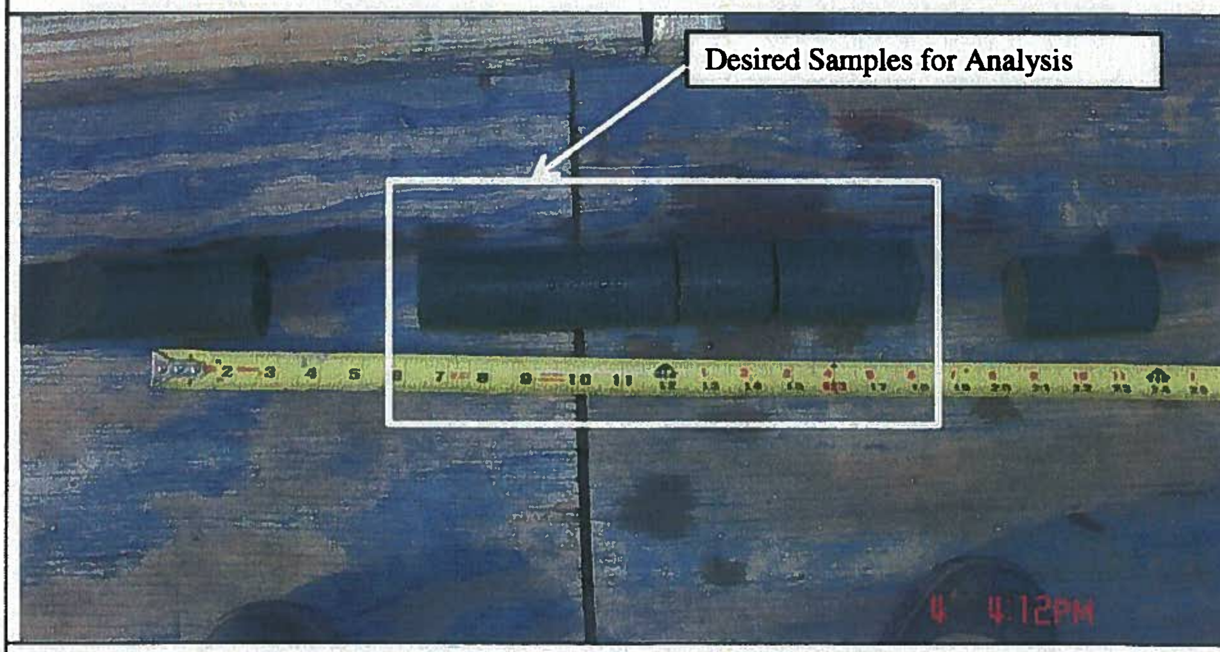
Photograph 2: Upper Section of Core Samples

TNX Core Drilling Mock Up Test Log (Page 7 of 7)

Date:



Photograph 3: Lower Section of Core Samples



Photograph 4: Lower Section of Core Samples

Date: 12/~~10~~ 9/14

Purpose: Perform additional testing to support OPs and ensure readiness for there participation scheduled for Wed. 12/10/14. The following are objectives for the day:
- Ensure flow gage operates satisfactorily.
- Finalize technique for seating core bit.
- Ensure vibration issue resolved.
- Finalize Technique for coring to minimize potential for plugging core barrels. Initial core will be obtained maximizing flow rate 7 1.7 gpm.
- Evaluate operating heights using 1 ft core bit

Core Hole #2

Coring will be performed attempting to maximize water flow 7 1.7 gpm. This will address Open Item 3.7.2.1 in FY14 Mockup Test Report.

Initial Core Barrel Configuration will be as follows
- (1) ~~#~~ 1 ft core barrel (top), (1) 4 ft core barrel, and (1) 1 ft core bit.

Two foot core barrels will be added each segment

SW 24.6 - SDU2 section 5.6 DRAFT E will be used with exception of flow rate requirements will Attempt maintain 7 1.7 gpm. or max possible.

Completed setup for coring Hole #2.
Operating height improved with removal 1.5ft core bit.

- Initiated water flow. Max flow rate ≃ 2.0 gpm No issues w/ flow gage.
- Initiated core drilling.
- Completed Coring Segment 1
- Coring first 2ft was performed maximizing water flow. This was acheived by coring slowing and raising drill frequently to reestablish flow rate. Able to maintain ≃ 1.7 gpm. Very slow progress. with this method.

Date: 12/9/14

Core Hole #2 (Cont.)

- Vibration improved from Core Hole #1
- Added 2ft Section of Core barrel for Segment 2
  Resumed coring and attempt to maintain higher flow rate.
- Completed segment 2
  Vibration increased in Segment 2. Overall still improved from previous coring Hole #1
- Water flow maintained ≃ 1.7 gpm during Segment 2
- Added 2ft core barrel for 3rd segment
- Completed 3rd Segment
  Vibration still increased, but still improved from previous coring.
- Waterflow maintained ≃ 1.7gpm during Segment 3.
  Required very slow progress and raising drill frequently to reestablish flow.
- Removed upper section of 2ft core barrel.
  No Issues
- * Removed intermediate 2ft section of core barrel.
  Water observed at the top of the lower section of core barrels indicating possible pluggage.
- Proceeded with removal of lower sections core barrels to identify area of pluggage. Total length lower Section 6ft.
- Lower section of core barrels at core bit clear
  Plug appears to be located in the 4ft core barrel
- Raised core barrels out of test to further inspect on platform.

* Denotes Issue / Opportunity

Date: 12/9/14 (cont.)

Core Hole #2 (cont.)

- Broke lower section of core barrels at core bit and 4ft section.
- Cores visible about halfway in 4ft core barrels indicating lower section ~~of~~ of cores are in hole
- Cores removed from 4ft core barrel with retrieval tool extention.

* - Plug appeared to be result of cores fragmenting and binding up other cores.

- Proceeded with 4.5 ft retrieval in order to attempt removal of remaining upper section of cores.

* Difficulty in getting the cores to enter the tool

- Successful in removing approximately 1.5ft of cores. Cores smaller and fragmented.
- Proceeded with 2.5 ft retrieval tool in order to attempt removal of lower section of cores.
- Lower 2ft section of cores removed.

* Extremely difficult to get tool to bottom of sono tube. Cores appeared to have difficulty entering tool.

Inspection of cores showed considerable damage. ~~Sig~~ Cores damaged and fragmented to extent could not account for over a foot of samples.

Observations

- Maintaining water flow at higher rates appeared to have adverse affect on cores.
- Cores were found solid, but were damaged and fragmented.
- This type of plugging has not been experienced. Previous plugging was a result of ~~accum~~ accumulation of fines.

* Denotes Issue / Opportunity

Date: 12/9/14 (cont.)

Suspended testing to discuss results of Core Hole #2 and determine pathforward.

* After further discussion with Malcolm and consideration of technique used to core, the possible cause for damage to the cores could have been the result of raising and lowering core barrels.

The core bit may have caused the damage during raising and lowering to maintain flow.

* The method for which the sonotube was filled (using 3 in lifts) may also be a factor. These were smaller lifts than those poured in the B-25. The smaller lifts may make raising the core bit a problem since may damage the cores if raised above a 3" lift.

* Denotes Issue / Opportunity

Date: 12-9-14

Core Hole #3

Based results of Core Hole #2, core hole #3 will use steps in procedure with exception of raising and lowering core barrels to maintain flow.
Flow will be maintained ≥ .5 gpm, but process to maintain flow will be to pause and allow only water to flush. core barrels will not be raised.

- Completed setup of drill equipment and core barrels Configuration of core barrels consistent with Core Hole #2

- Initiated coring segment #1

- Completed coring segment #1
No issues. Water flow maintained ≈ .8 gpm

- Addede 2ft core barrel for Segment 2
Care taken to minimize raising of lower section of core barrels.

- Initiated coring segment #2

- Completed coring Segment #2
Water flow reduced but maintained ≥ .5 gpm
Pausing briefly was successful in reastablishing water flow.

- Added 2ft core barrel for Segment 3
- Initiated Coring Segment #3

- Completed Coring Segment 3
Water flow successfully maintained ≥ .5 gpm
Vibration was noticeable and increased from Segment 1 but manageable.

Date: 12-9-14

Core Hole # 3 (cont.)

- Removed upper 4ft section of core barrels. Care taken raising the core barrels to minimize potential damage to cores.

- Removed lower section of core barrels. No pluggage found in any section of core barrels.

- Setup for removal of upper 4ft of cores.

- Successfully Removed upper section of cores with 4.5 ft retrieval tool. No Issues. Upper Section was ≈ 4ft.

- Prepared for removal of lower 2ft Section of cores

- Removed lower section of cores. No Issues. Lower section measured ≈ 2ft.

- Cores ~~placed~~ removed from retrieval tools and assembled for measurement.

* Upper Section measurement ≈ 4ft
Some additional breaks observed at the top but generally samples in good condition

* Lower Section measurement ≈ 20 in.
Cores observed to be in very good condition
May not have been able to retrieve lower 4 in section.

Date: 12-9-14

Issues / Opportunities

- Core Hole #2 again encountered plugging of core barrels with samples.
  The techniques of core drilling core Hole #2 involved the following:
  - maximizing water flow
  - raising and lowering core barrels to maximize water flow.

  Observations following Core Hole #2 noted that this type plugging has not been encountered before.
  Plugging of core samples in barrel appears to be related to samples fragmenting and binding samples in core barrels.

- Core Hole #3 appeared to eliminate potential of plugging

  Core Hole #3 was performed as in previous coring operations by maintaining water flow ≥0.5gpm with the exception of raising and lowering core barrels to reestablish flow.

  Flow was reestablished by pausing at current height.

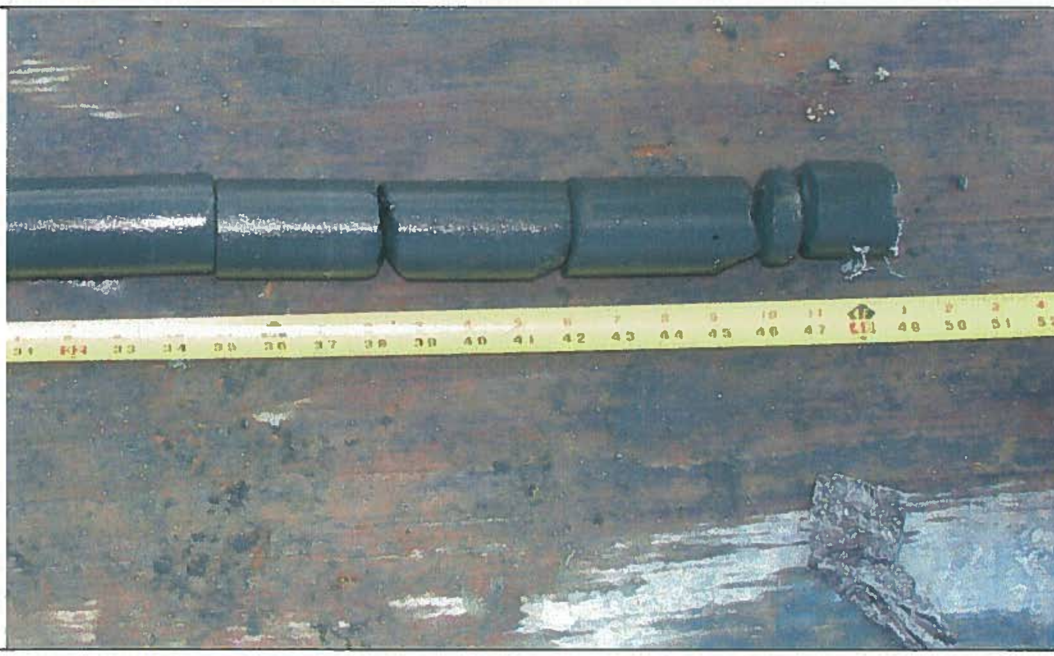
  Pathforward for future testing will be to only pause/stop if flow is reduced ≤0.5gpm.

G.B. [signature] 12-9-14

TNX Core Drilling Mock Up Test Log (Page 8 of 9)

Date: 12-9-14

Photograph 5: Core Hole #3 Upper Section of Core Samples

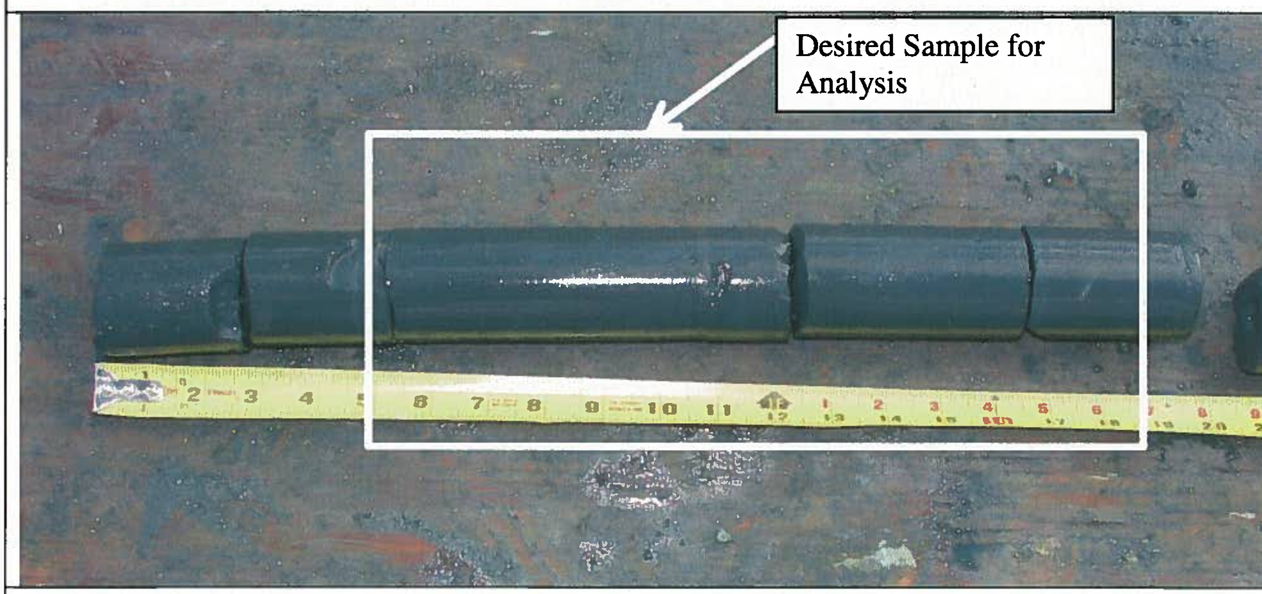


Photograph 6: Core Hole #3 Upper Section of Core Samples

TNX Core Drilling Mock Up Test Log (Page 9 of 9)

Date: 12-9-14

Photograph 7: Core Hole #3 Lower Section of Core Samples



Photograph 8: Core Hole #3 Lower Section of Core Samples

Date: 12/10/14

Purpose: Operations will participate in Mockup Testing today. The goal will be to familiarize operations with changes to procedure to achieve deeper coring and core removal.

- Briefed OPs on changes in mockup and procedure based on increased drilling height.

- Provided overview of the larger DD 350 and operation. Operators had already read operating manual and were relatively familiar.

- Performed walk through of procedure DRAFT E. Operators were familiar with DRAFT D. Explained change in DRAFT E supported coring additional length based on 6ft core depth. Also revised steps for removal and addition of core barrels based on depth.

- Operators received concurrence from First Line to perform core drilling and sampling per steps outlined in DRAFT E.

Core Hole #4

- Initiated Procedure SW 24.6-SDU2 5.6 DRAFT E
- Initiated Coring Segment #1
- Paused Stopped Coring Segment ~~#~~ #1
  Lost Flow approximately 4"-6" following start

  Explained to Operator that really do not have to apply a large amount of pressure. Just need to proceed slowly and let drill do the work.

Date: 12/10/14 (cont.)

Core Hole #4 (cont.)

- Raised core barrels and removed plug. Plug was small and easily removed.
- Re installed core barrels and moved cradle to allow starting a clean hole.
- Restarted procedure and Initiated Coring Segment #1
- Completed coring Segment #1

Operator was much smoother with drill operation. and proceeded slowly.

* Did note operator raise and lower core barrels to re-establish flow. Carryover from previous core testing. Discussed results from previous coring and emphasized the need to just pause/stop to re-establish flow.

- Added 2ft core barrel for coring Segment #2 Operations comfortable with sequence of procedure to this point
- Initiated coring Segment #2
- Completed Coring Segment #2 Operator maintained water flow ≥ 0.5 gpm by pausing to re-establish flow.
- Added 2ft Core barrel for coring Segment #3 No Issues
- Initiated Coring Segment #3
- Completed Coring Segment #3 Operator maintained waterflow ≥ 0.5 gpm. Becoming more comfortable with drill operation and pressure required during coring.

* Denotes Issue / opportunity

Date: 12/10/14 (cont.)

Core Hole #4 (cont.)

- Will not perform coring of second hole at this time.
- Initiated removal of core barrels for sampling.
- Raised upper 4ft section of core barrels. (2 x 2ft sections)
- Removed upper 4ft section of core barrels.

* Attempted to use pipe (friction) clamp received from Construction. Clamp very cumbersome to use based on design. Requires the tightening of at least 2 bolts to secure. Operator held lower section to allow removal of upper section of core barrels.

* During removal of upper section of core barrels water was present and cores visible in the top portion of the lower section of core barrels.

- Proceeded with removal of lower section of core barrels.
- Inspection of core barrels revealed majority of cores remained in the core hole.
- Successfully removed plugged cores from lower section of core barrels. Cores measured ≈ 2ft.

  * Need to explore options to ensure core samples remain in core hole.

- Operations comfortable with managing lower 6ft section of core barrels.
- Proceeded with removal of Remaining core samples

* Denotes Issue/Opportunity

Date: 12/10/14 (Cont.)

Core Hole # 4 (cont.)

- Removed remaining upper section of core samples using 4.5ft tool.

  Ops measured cores, cores measured ≈ 2.5ft. Provided good indication upper section of core removed.

  Ops noted very difficult in manipulating tool into core hole. Explained this has been case on previous core holes since some of the core samples have been small.

- Proceeded with removal of lower section of core samples with 2.5ft tool.

- Lower section of cores removed.

  Cores measured to be approximately ≈1.5ft in tool

  Again ops had difficulty manipulating the tool past core samples for them to enter the retrieval tool.

* Need to evaluate improvements to the tool head to allow the samples to more easily enter the tool.

- Assembled the upper and lower section of core samples.

  Upper Section measured ≈ 46 in long.
  Lower Section measured ≈ 18 in long.

  May not have been able to recover bottom section of sample.

* Denotes Issue/opportunity

Date: 12/10/14 (cont.)

Issues / opportunities

- Ensure procedure is revised to remove allowance to raise core barrels to re-establish flow. Indications are this may increase potential to damage cores
- Pipe (Friction) Clamp.
  Operations believes clamp is beneficial but need to be simplified for use.

  Continue to work with Construction to improve design
- Need to evaluate means to ensure cores remain in hole. Will evaluate options.
- Need to evaluate improvements to tool head to ~~aid~~ allow samples to enter tool easier.
- Operations noted that it would be better to core 1st hole with mounting plate in extended position. This will simplify sequence to allow for sample recovery.
  This will be incorporated into procedure.

G.B. [signature] 12/10/14

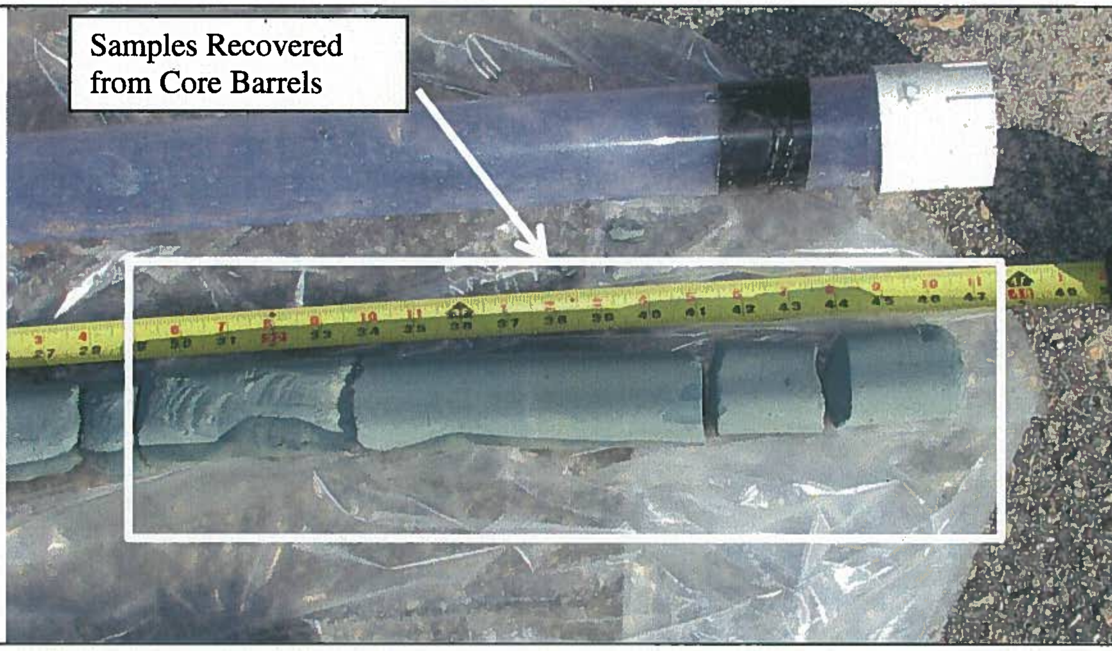
TNX Core Drilling Mock Up Test Log (Page 6 of 7)

Date: 12-10-14

Photograph 9: **Core Hole #4 Upper Section of Core Samples**

TNX Core Drilling Mock Up Test Log (Page 7 of 7)

Date: 12-10-14	



Photograph 10: Core Hole #4 Upper Section of Core Samples

Photograph 11: Core Hole #4 Lower Section of Core Samples

Date: 12/11/14

Purpose: Barry Copeland w/ Atlanta Coring will participate in Mockup Testing today in order to provide his input with our current Coring approach at increased grout height.

- Briefed Barry on our current progress and approach with coring.
- Performed walkdown of mockup with current configuration which includes the new 6 ft monolith, new mounting plate design and availability of the Hilti DD 350. Also discussed the method in which the grout monolith was poured in 3" lifts.
- Performed safety Briefing with Barry and discussed Hazards and required PPE.
- Started setup of coring equipment.
- During setup of coring equipment identified water supplies had frozen, as well as, water buffalo supply pump. Notified operations of delay.
- Successfully thawed supply lines and supply pump. No damage to lines equipment identified.
- Operations notified and informed would not be available til after 12.
- Decided to proceed with Coring with support of Barry to allow him to get experience with new mockup arrangement.

Date: 12/11/14 (cont.)

Core Hole #5

- Barry Copeland will perform coring to ensure we get as much insight from his expertise as possible.

- After application of water to drill ~~~~, GFCI tripped when drill started and could not be reset.

- The colder than anticipated temperatures appear to have caused water within the HILTI DD 350 cooling jacket to freeze and likely resulted in the internal cooling jacket cracking.

- Replaced HILTI DD350 w/ DD200.

- Initiated Coring Core Hole #5

- Completed coring Segment #1
  No Issues
  Water flow maintained 20.5 gpm
  Barry reiterated the need to let the drill do the work. No need to apply excessive pressure.

- Added 2ft core barrel.

- Initiated Coring Segment #2

- Completed Coring Segment #2
  Water flow maintained 20.5 gpm
  Barry concurred with steps to prevent raising the drill to re-establish. Also felt that stopping the drill is acceptable.

  Barry also noted the higher vibrations after addition of core barrel. Could be result of bent/egg shaped barrel.

- Added 2ft core barrel

Date: 12/11/14 (cont.)

Core Hole #5 (cont)

- Initiated coring segment #3
- Completed coring segment #3

  No Issues
  Vibration did not increase further during segment 3
- Initiated core barrel removal to support sample recovery.
- Removed upper 4ft section of core barrels

  No Issues during removal
  No cores observed stuck in core barrels.
- Removed lower section of core barrels.
  No Issues during removal
  No cores were stuck in barrels.
- Proceeded with removal of upper 4ft section of cores.
  Cores successfully removed.
  Continue to experience manipulating tool past core segments.
- Proceeded with removal of lower 2ft section of cores.
- Cores removed from tools, measured and photograph.
  Had to use personal phone. Quality may be questionable
- Lower 2ft section of cores measured ≅ 24"

Date: 12/11/14 (cont.)

Summary of Barry Copeland's Observations.

- Sequence of steps with regards to coring are acceptable. Addition of 2ft barrels maintains good operating heights.

- DD 200 appears adequate for coring 7ft depth based on the material used for the mockup.

- Very Important to let the "drill" do the work. Applying too much pressure increases likelihood of plugging. Need to allow time to flush fines from area between core bit and core hole.

- Concerned with anticipated conditions of 3" lifts. Agreed with our thoughts concerning raising the core barrels during coring and the potential to damage a smaller core sample with the core bit. Based on experience with core hole #5 simply pausing / stopping should be adequate to maintain flow provided minimal pressure applied during coring.

- Vibrations encountered during coring ~~were~~ was acceptable from the standpoint of drill operation. However, the vibrations could be impacting the quality of samples.
  Barry felt the use of new core barrels and the ability to securely anchor the mounting plate to tank top with anchors would decrease vibration to some degree.
  Vibration is to be expected based on length of core barrels required.

G.B. Chandler 12/11/14

TNX Core Drilling Mock Up Test Log (Page 5 of 5)

Date: 12/11/4

Photograph 12: Core Hole # 5 Core Samples

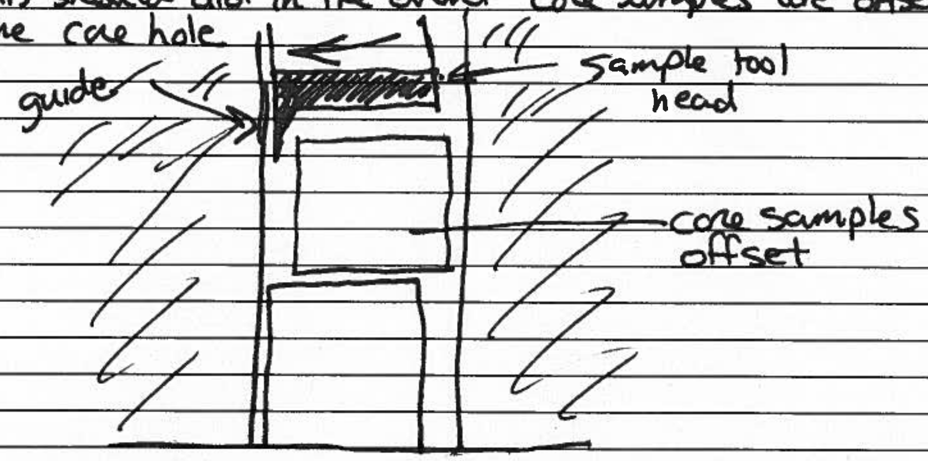
Photograph 13: Core Hole # 5 Lower Section of Core Samples

Date: 12-15-14

Purpose: Continue to develop Operator profency with coring and sample recovery, to support Management observation on Wed 12-17. Goal today will be to do dry runs with sleaving material.

- Construction arrived with modified friction clamp. Clamp was modified with a hinge to allowed ability to open and close, and a single wing nut to allow tightening.

- Modified Retrieval Tool was completed over the weekend. The head of the tool was modified with the addition of a "guide" which should ~~allow~~ aid the tool to guide the samples into the tool while it is being simultaneously rotated and inserted into the core hole. This should aid in the event core samples are offset in the core hole.



- Completed setup of core drilling equipment

- Performed "Dry Run" of coring procedure to support only core barrel removal and sleeving.

TNX Core Drilling Mock Up Test Log (Page 2 of 2)

Date: 12-15-14

- Utilized modified friction clamp during removal of core barrels.

  Friction clamp worked well and was much easier to use.

  * May want consider having wing nut wired to clamp to prevent loss.

  Discussed the use of PVC rod which could be inserted into the core barrel during removal to ensure the cores remain in core hole. RadCon was receptive to the idea.

- Performed removal of upper 4ft core barrel section. Preferred sequence of steps as written worked well, with the addition of using the "PVC rod" during raising the core barrels.

  Rod length may need to be increased, but seemed to provide the ensurance we need to make sure cores stay in the hole.

  Use of pvc rod will be incorporated into the final revision of the procedure.

[signature]

ATTACHMENT 3

5.6 SDU CORE SAMPLING

5.6.1 Precautions / Limitations

A. Comply with radiological and contamination control requirements identified on the applicable Radiological Work Permit (RWP). Radiological Protection Department (RPD) will perform radiation and contamination surveys, as necessary, to assess changing conditions.

B. Any powered tool/equipment that will be used shall be connected to a Ground Fault Circuit Interrupter (GFCI) protected outlet.

C. Personnel performing this procedure are responsible for: (1) inspecting the required PPE prior to use and (2) the proper donning of the required PPE.

D. If discrepancies are encountered which can NOT be resolved within the scope of this procedure, then discontinue work, and notify Management for developing corrective actions.

E. ALARA principles must always be employed throughout the sampling evolution.

F. Entry into HRA requires initiation of Procedure 200-Z-2100, *Entry Into Access Controlled High Radiation Areas*.

G. Provide a portable self-contained eyewash with rinse wand (for each potentially exposed employee - pressure must be within 85 to 100 psi and inspection date must be current) at location for initial flush then proceed to the nearest available and functional Safety shower and eyewash station for required flushing of exposed areas.

H. Employees should be cognizant of and self-monitor for signs/symptoms of Heat Stress or Cold Stress. Personnel should be alert to slipping and tripping hazards and for possible animals / snakes / insects.

I. Use caution in placement of hands and fingers due to pinch points.

J. Comply with safe operation requirements per manufacturer labeling and all facility barricade posting requirements.

K. Tools are to be inspected prior to use for obvious defects.

5.6.1 Precautions / Limitations, Cont'd

L. Individuals should not attempt to lift more than 50 pounds. The weight limit for a single person lift is set at **no more than** 50 pounds. In the instances where an object weighs more than 50 pounds, multiple personnel must be used to not exceed this limit or a mechanical lifting device should be used. If it is felt that the use of two or more persons to perform a lift would create a greater hazard, the DWPF/SS Safety Professional must be contacted for concurrence. Personal capability is a factor below 50 pounds (i.e., some people are not capable of lifting up to 50 pounds & should not attempt to lift that much weight). In no case should an employee lift more than they can safely handle. Proper lifting techniques should be used. Loads should be lifted with the legs instead of the back, while twisting or bending at the waist should be avoided.
If equipment is hard or awkward to handle, mechanical means should be used and/or additional personnel should perform the task. R&HE assistance may be required when removing bundled waste.

M. Core Drilling involves mechanical rotating equipment which can cause serious injury to personnel. Core drill will be unplugged when drill is not in operation and during the addition/removal of drill barrels.

N. Core Drilling does have the potential to generate heat, leather gloves must be worn to ensure proper thermal insulation when handling the drill bit immediately after core drilling.

O. Portable remote camera support is preferred to support core drilling operations and during removal of core samples. (drilling operations may continue, if safe to do so, at the direction of the PIC)

P. Portable ventilation may be required. (e.g., coppus blower with hepa filter)

Q. Prior to surveying for contamination, items such as scissors, knives and shears, should be closed to prevent contact with sharp edge per Manual 5Q1.2, Procedure 133.

R. Sections and/or Steps may be marked N/A as directed by Manual 2S, Procedure 1.3.

S. If IH monitoring is required, respiratory protection may be necessary.
If breathing zone exceeds 0.008 milligrams per cubic meter of MERCURY, supplied air respiratory protection will be "required". If breathing zone exceeds 25 ppm of AMMONIA, or, 5 ppm TRIMETHYLAMINE, a full facepiece negative pressure respirator with Type M cartridge will be "required".

5.6.2 Tools, Material and Equipment

- Radioactive waste bag(s)
- Plastic sheeting
- Kraft paper
- Rubber gloves (Paired)
- Tape (Masking and/or Green and/or Black Plastic)
- Swipes and Absorbents
- Sample Labels
- NFPA Hazardous Communication Label (if required)
- Hilti Model number DD 200 or DD350 Diamond Coring System
- Threaded diamond core bit
- Threaded extension barrel(s)
- Water source (for wet core drilling - water buffalo)
- Flow meter installed as part of water supply line at drilling equipment
- Power supplied from welding receptacle, bang board, or generator, as appropriate
- B-25 and De-Characterized waste drum
- Leather gloves
- Hard Hat (if required per PIC direction)
- Safety glasses with side shields (not required with respirator)
- Sturdy work shoes
- Foam inserts for noise
  (when within barricades posted with hearing protection requirements)
- Knee protection (if kneeling is required)

5.6.2 **Tools, Material and Equipment**, Cont'd

- Portable Ventilation (e.g., coppus blower with hepa filter)
- Garden sprayer
- Pipe wrench(s)/clamp(s)
- Two (2) 4.0 feet upper core sample retrieval tools with handle (marked to indicate anticipated sample depth)
- Two (2) 2.5 feet lower core sample retrieval tools with handle (labeled according to coring position and marked to indicate anticipated sample depth) and threaded end cap
- Wrenches for drill mounting plate and drill stand
- Extended Reach (Grabber) tool
- Depth measuring tape attached to drill stand
- Core sample transport container (cooler)
- PVC Push Rod Assembly (used to ensure core samples remain in hole)
- Nitrogen cylinder
- Inerting container(s) (pre-labeled and pre-flushed with nitrogen)
- Non-Corrosive Gas Regulator
  (maximum inlet pressure 3,000 psi; maximum supply pressure 50 psi)
- Rotameter (maximum flow rate 2 to 5 CFM)
- Nitrogen supply tubing (with quick disconnect to attach to inerting container)
- Spare Caps (with Teflon tape or equivalent sealant/grease)
- Oxygen adsorber packets (sealed in vacuum pack)
- Scissors/Knife
- Thread seal tape
- Portable remote camera installed by I&M
- Portable radios and/or headsets

5.6.3 Prerequisites

Initials

1. **HAVE** Engineering "ENSURE" the following documents have been provided to the Person-In-Charge (PIC): ______

   - Structural Authority Approval of Loads
   - Core Sample Location map

Engineering: ______________________________ / ______________________________
Signature Print Name

Date: ______________ Time: ______________

2. **CONTACT** Industrial Hygiene (IH) to verify baseline data has been obtained for Mercury, Ammonia, Trimethylamine, and CLFL, **AND**

   RECORD the following:

IH person contacted	______________________ (printed name)
Date	_______/_______/_______
Time	_______________________ hours

______

3. **ENSURE** Waste Verifier and/or GCO have been notified of Core Sampling Evolution. ______

4. **ENSURE** LW Sample Group will be available to transport Core Samples. ______

5. **ENSURE** SRNL personnel will be available to receive Core Samples. ______

6. **ENSURE** Inspection and Monitoring (I&M) group is available to support in-cell camera monitoring during Core Sampling evolution. ______

5.6.3 Prerequisites, Cont'd

Initials

> **NOTE:** Only cementitious material (i.e., saltstone) may be permanently left within the cell. Tape, PPE, plastic or other non-saltstone material may NOT be placed in the cell for disposal purposes.

7. **IF** SRNL sample material from Vault 4, Cell E, is required to be placed in SDU 2A, **THEN**

ENSURE Vault 4, Cell E, sample material is appropriately staged so that it can be disposed of in SDU 2A after core drilling operation is complete. ______

8. **ENSURE** a Pre-Job briefing with all personnel involved with this procedure has been conducted per S4, OPS-SO-LWO.01. ______

9. **IF** required, **THEN**

ENSURE R&HE have staged crane and/or forklift. ______

10. **IF** the SDU area is a High Radiation Area, **THEN**

ENSURE all personnel involved with this procedure have completed procedure 200-Z-2100, *Entry into Access Controlled High Radiation Areas*. ______

11. **ENSURE** GCO has identified and prepared the required waste containers to support core sampling.
(Characterized and De-Characterized Waste) ______

12. **ENSURE** the appropriate number of portable self-contained eyewash(s) with rinse wand(s) is/have been installed / staged. ______

13. **ENSURE** B-25 and De-Characterized waste drum have been appropriately staged per PIC/RPD direction. ______

14. **VERIFY** drill stand guide has been equipped with depth measuring tape in order to monitor drill depth. ______

15. **ENSURE** retrieval tools are staged and pre-labeled for sample location. ______

5.6.3 Prerequisites, Cont'd

Initials

16. **ENSURE** Inerting Equipment is staged and prepared to receive samples. ______

17. **ENSURE** transport container (cooler) is staged and prepared to receive samples. ______

18. **VERIFY** weather conditions/forecast will permit Core Sampling evolution to be performed for the expected duration. ______

Prerequisites
Completed By: ______________________ / ______________________
Signature Print Name

Date: __________ Time: __________

PIC
Review By: ______________________ / ______________________
Signature Print Name

Date: __________ Time: __________

5.6.4 Core Sampling

Initials

1. **ENSURE** the area around the cell access port has been prepared. _______

NOTE: Step 2 performed concurrently with Steps 3 through 7.

*****RPD ACTION STEP*****

2. **HAVE** RPD "PERFORM" a contamination and radiation survey during cell access port removal to ensure levels do **NOT** exceed the levels listed in the table below: _______

Contamination (dpm/100 cm^2)		Probe (dpm/100 cm^2)		Dose Rate (mrem/hr)		Airborne	
200	α	N/A	α	300	Extremity	ND above background	DAC-hr
1,000	$\beta\gamma$	N/A	$\beta\gamma$	50	Skin		
				50	Whole Body		

AND

IF radiation or contamination levels <u>exceed</u> the limits above, **THEN**

a. **CONTACT** FLM/PIC <u>and</u> RPD FLM to determine path forward. _______

b. **RECORD** action taken: ________________________________

____ _______

c. PIC: ____________________ RPD FLM: ____________________
Signature Signature

5.6.4 Core Sampling, Cont'd

Initials

> **NOTE:** Step 3 and/or 4 will be performed during cell access port cover/cap removal (Step 5).

3. **HAVE** IH "PERFORM" survey for Mercury (Hg), Ammonia, Trimethylamine (TMA), and CLFL at the SDU access port opening to ensure levels do NOT exceed the following: _______

Mercury (Hg)	.008 mg/m3
Ammonia	25.0 ppm
Trimethylamine (TMA)	5.0 ppm
CLFL	less than 25%

AND

IF any levels exceed the limits above, **THEN**

a. **SUSPEND** work. _______

b. **CONTACT** the FLM/PIC to determine if portable ventilation will be required. _______

4. **IF** Portable Ventilation was required, **THEN**

PERFORM the following:

a. **ENSURE** portable ventilation has been initiated. _______

b. **HAVE** IH "PERFORM" survey for Mercury (Hg), Ammonia, and Trimethylamine (TMA) at the SDU access port opening to ensure levels do NOT exceed the following:

Mercury (Hg)	.008 mg/m3
Ammonia	25.0 ppm
Trimethylamine (TMA)	5.0 ppm
CLFL	less than 25%

____

5.6.4 Core Sampling, Cont'd

Initials

5. **REMOVE** and **BAG** cell access port cover/cap, **AND**

   HAVE RPD Tag and Store for re-installation. ______

6. **ENSURE** the Core Sampling drill has been installed and properly anchored. ______

7. **ENSURE** portable remote camera has been installed, secured to prevent adverse weather from dislodging, and is operational. ______

> **NOTE:** Remote camera monitoring of the core drill assembly is preferred while the core drill bit assembly is in the SDU, to verify water is not trapped in a clogged drill bit. Water flow to be maintained at 0.5 gpm or greater.

> **! WARNING !**
>
> **Core Drilling involves mechanical rotating equipment which can cause serious injury to personnel. Drill operator will ensure all personnel are clear of the area prior to energizing the core drill (plugging in the drill motor to the receptacle). Core drill will be de-energized (unplugged) when not needed.**

8. **OBTAIN** approval from PIC for the required personnel to initiate grout core sampling activities. ______

PIC
Approval: ______________________ / ______________________
Signature Print Name

Date: ____________ Time: ____________

5.6.4 Core Sampling, Cont'd

Initials

NOTE: Step 9 performed concurrently with Step 10.

*****RPD ACTION STEP*****

9. **HAVE** RPD "PERFORM" a contamination and radiation survey during grout core sampling evolution to ensure levels do **NOT** exceed the levels listed in the table below: ______

Contamination (dpm/100 cm^2)		Probe (dpm/100 cm^2)		Dose Rate (mrem/hr)		Airborne	
200	α	N/A	α	400	Extremity	ND above background	DAC-hr
10,000	βγ	N/A	βγ	50	Skin		
				50	Whole Body		

AND

IF radiation or contamination levels exceed the limits above, **THEN**

a. **SUSPEND** work. ______

b. **CONTACT** FLM/PIC and RPD FLM to determine path forward. ______

c. **RECORD** action taken: ________________________________

____ ______

d. PIC: ____________________ RPD FLM: ____________________
Signature Signature

10. **PERFORM** drilling for grout core sample(s) per Attachment 1, *Core Drilling*. ______

5.6.4 **Core Sampling**, Cont'd

Initials

> **NOTE:** Step 11 performed concurrently with Step 12.

*****RPD ACTION STEP*****

11. **HAVE** RPD "PERFORM" a contamination and radiation survey during removal of drill barrels to ensure levels do **NOT** exceed the levels listed in the table below: ______

Contamination (dpm/100 cm^2)		Probe (dpm/100 cm^2)		Dose Rate (mrem/hr)		Airborne	
200	α	N/A	α	400	Extremity	ND above background	DAC-hr
10,000	βγ	N/A	βγ	50	Skin		
				50	Whole Body		

AND

IF radiation or contamination levels exceed the limits above, **THEN**

a. **SUSPEND** work. ______

b. **CONTACT** FLM/PIC and RPD FLM to determine path forward. ______

c. **RECORD** action taken: ______________________________

______________________________ ______

d. PIC: ____________________ RPD FLM: ____________________
Signature Signature

12. **WHEN** Attachment 1, *Core Drilling*, is COMPLETE, **THEN**

a. If required, **DECON** the area, **AND**

PREPARE the area for Removal of Drill Barrels. ______

b. **PERFORM** removal of drill barrels per Attachment 2, *Removal of Drill Barrels*. ______

5.6.4 Core Sampling, Cont'd

Initials

NOTE: Step 13 performed concurrently with Steps 14 through 16.

*****RPD ACTION STEP*****

13. **HAVE** RPD "PERFORM" a contamination and radiation survey during removal of core sample(s) to ensure levels do **NOT** exceed the levels listed in the table below: ______

Contamination (dpm/100 cm^2)		Probe (dpm/100 cm^2)		Dose Rate (mrem/hr)		Airborne	
200	α	N/A	α	400	Extremity	ND above background	DAC-hr
10,000	$\beta\gamma$	N/A	$\beta\gamma$	50	Skin		
				50	Whole Body		

AND

IF radiation or contamination levels <u>exceed</u> the limits above, **THEN**

a. **SUSPEND** work. ______

b. **CONTACT** FLM/PIC <u>and</u> RPD FLM to determine path forward. ______

c. **RECORD** action taken: ______________________________

____ ______

d. PIC: ____________________ RPD FLM: ____________________
Signature Signature

14. **WHEN** Attachment 2, *Removal of Drill Barrels*, is COMPLETE, **THEN**

a. If required, **DECON** the area, **AND**

PREPARE the area for Core Sample Removal. ______

NOTE: Data will be recorded in Step 15 during the performance of Attachment 3.

b. **PERFORM** grout core sample removal per Attachment 3, *Core Sample Removal*. ______

5.6.4 Core Sampling, Cont'd

15. ENSURE the following for each sample obtained:

Core Hole #1 Sample Lengths	Sample Length	Initials
UPPER Core Sample Length	____________ inches	
Recovered UPPER Core Sample Length	____________ inches	
Recovered LOWER Core Sample Length	____________ inches	
LOWER Core Sample Length	____________ inches	

Core Hole #2 Sample Lengths	Sample Length	Initials
UPPER Core Sample Length	____________ inches	
Recovered UPPER Core Sample Length	____________ inches	
Recovered LOWER Core Sample Length	____________ inches	
LOWER Core Sample Length	____________ inches	

16. ENSURE the following:

Actions	**Initials** (Core Hole #1)	**Initials** (Core Hole #2)
Sample container SLEEVED	________ #1	________ #2
Sample container SEALED / TAPED	________ #1	________ #2
Sleeved Samples labeled per RPD with Radiation and Contamination Survey Data	________ #1	________ #2
PLACED in transport container for shipment	________ #1	________ #2

5.6.4 Core Sampling, Cont'd

Initials

> **NOTE:** Step 17 performed concurrently with Steps 18 and 19.

*****RPD ACTION STEP*****

17. **HAVE** RPD perform a contamination and radiation survey of the bagged sample container and sample carrier to verify levels do **NOT** exceed the levels listed in the table below: ______

Contamination (dpm/100cm^2)		Probe (dpm/100 cm^2)		Dose Rate (mrem/hr)		Airborne	
< 20	α	N/A	α	400	Extremity	N/A	DAC-hr
< 200	$\beta\gamma$	N/A	$\beta\gamma$	50	Skin		
				50	Whole Body		

AND

IF radiation or contamination levels <u>exceed</u> the limits above, **THEN**

a. **SUSPEND** work. ______

b. **CONTACT** FLM/PIC <u>and</u> RPD FLM to determine path forward. ______

c. **RECORD** action taken: ________________________________

____ ______

d. PIC: ____________________ RPD FLM: ____________________
Signature Signature

18. **ENSURE** RPD has labeled Transport Container with Radiation and Contamination Survey Data. ______

19. **STAGE** Transport Container as directed by PIC. ______

20. **REQUEST** PIC to initiate a Chain of Custody form for each Shipment. ______

> **NOTE:** Vault 4 Cell E material will be placed in SDU 2A during performance of Attachment 4, Disposal of Upper Core Samples.

21. **IF** required, **THEN**

PREPARE SRNL sample material from Vault 4, Cell E, for disposal into SDU 2A. ______

5.6.4 Core Sampling, Cont'd

Initials

NOTE: Step 22 performed concurrently with Steps 23 and 24.

*****RPD ACTION STEP*****

22. **HAVE** RPD "PERFORM" a contamination and radiation survey during disposal of core samples to ensure levels do **NOT** exceed the levels listed in the table below: ______

Contamination (dpm/100 cm^2)		Probe (dpm/100 cm^2)		Dose Rate (mrem/hr)		Airborne	
200	α	N/A	α	400	Extremity	ND above background	DAC-hr
10,000	βγ	N/A	βγ	50	Skin		
				50	Whole Body		

AND

IF radiation or contamination levels exceed the limits above, **THEN**

a. **SUSPEND** work. ______

b. **CONTACT** FLM/PIC and RPD FLM to determine path forward. ______

c. **RECORD** action taken: ________________________________

____ ______

d. PIC: ____________________ RPD FLM: ____________________
Signature Signature

23. **PERFORM** Disposal of Core Samples per Attachment 4, *Core Sample Disposal*. ______

24. **WHEN** Attachment 4, *Core Sample Disposal*, is COMPLETE, **THEN**

If required, **DECON** the area, **AND**

PREPARE the area for Removal of Core Drilling Equipment. ______

5.6.4 **Core Sampling**, Cont'd

Initials

> **NOTE:** Step 25 performed concurrently with Step 26.

*****RPD ACTION STEP*****

25. **HAVE** RPD "PERFORM" a contamination and radiation survey during removal of grout core sampling equipment to ensure levels do **NOT** exceed the levels listed in the table below: ______

Contamination (dpm/100cm^2)		Probe (dpm/100 cm^2)		Dose Rate (mrem/hr)		Airborne	
< 20	α	N/A	α	400	Extremity	N/A	DAC-hr
< 200	$\beta\gamma$	N/A	$\beta\gamma$	50	Skin		
				50	Whole Body		

AND

IF radiation or contamination levels <u>exceed</u> the limits above, **THEN**

a. **SUSPEND** work. ______

b. **CONTACT** FLM/PIC <u>and</u> RPD FLM to determine path forward. ______

c. **RECORD** action taken: ________________________________

____ ______

d. PIC: ____________________ RPD FLM: ____________________
Signature Signature

26. **REMOVE** and **BAG** grout core sampling equipment, **AND**

STAGE at the next core sampling location (if applicable) <u>OR</u> as directed per PIC. ______

5.6.4 **Core Sampling**, Cont'd

Initials

27. **IF** required, **THEN**

HAVE IH "PERFORM" survey for Mercury (Hg), Ammonia, and Trimethylamine (TMA) at the SDU access port opening to ensure levels do NOT exceed the following: ______

Mercury (Hg)	.008 mg/m3
Ammonia	25.0 ppm
Trimethylamine (TMA)	5.0 ppm

AND

IF any levels exceed the limits above, **THEN**

a. **SUSPEND** work. ______

b. **CONTACT** FLM/PIC and RPD FLM to determine path forward. ______

28. **IF** portable ventilation was required, **THEN**

STOP portable ventilation operation. ______

29. **PERFORM** the following:

- **REMOVE** paper and plastic around sample access port area
- **ABSORB** all free-standing liquid

AND

PLACE in Waste bag and seal. ______

5.6.4 Core Sampling, Cont'd

Initials

30. **REPLACE** the cell access port cover/cap. ______

31. **HAVE** RPD "SURVEY" the working area. ______

32. **IF** elevated contamination is detected, **THEN**

DECON area, **AND/OR**

CONTAIN contamination at the source per RPD instructions. ______

33. **PERFORM** housekeeping. ______

34. **DISPOSE** of all waste generated per GCO/Waste Verifier direction. ______

35. **NOTIFY** PIC that Core Sampling is complete. ______

Comments: ____

____

____

____

____

____

____

____

____

Completed By: ______________________ / ______________________
Signature Print Name

Date: ____________ Time: ____________

PIC
Review By: ______________________ / ______________________
Signature Print Name

Date: ____________ Time: ____________

5.6.5 Core Sample Completion

Initials

1. **ENSURE** PIC has completed a Chain of Custody form for each Shipment. ______

2. **ENSURE** LW Sample Group has obtained the sample carriers <u>and</u> a copy of the Radiation Survey Log Sheet (RSLS) for transport to SRNL per SW26.1-TRANSPORT, LW Transportation Manual. ______

Comments: ____

____

____

____

____

____

____

Completed By: ______________________________ / ______________________________
Signature Print Name

Date: ______________ Time: ______________

PIC
Review By: ______________________________ / ______________________________
Signature Print Name

Date: ______________ Time: ______________

Attachment 1, Core Drilling
(Page 1 of 8)

INSTRUCTIONS

1. A depth of 6.5 feet is required to achieve sample depth. Core drilling will be performed in 3 Segments based on limited travel of drill stand.

- Segment 1 will core the first 2 feet.
- Segment 2 will core an additional 2 feet.
- Segment 3 will core the final 2.5 feet.

2. Segment 1 drill barrel configuration consists of one 4 foot section with quick disconnect, one 1 foot section and a 1 foot section with core bit. Segment 2 will add one 2 foot section. Segment 3 will add one 2 foot section.

3. Depth measuring tape to be re-positioned to zero position each time a new core drilling elevation is established.

4. During the addition of drill barrels, thread seal tape should be applied to the male threads to minimize water spray during coring. Additional tape may be added around the drill barrel joints if water spray is visible.

SEGMENT 1 - Core Drilling (first 2 feet)	
1.	**ENSURE** drill barrels are assembled to support coring Segment 1.
2.	**ATTACH** drill barrels to drill motor at quick disconnect for coring Segment 1.
3.	**ENSURE** Water Source and Power Source is ENERGIZED, **AND** **ENSURE** drill motor GFCI is reset.
4.	**ENSURE** depth measuring tape is attached to the drill stand, **AND** **ENSURE** camera monitor is operating and providing visual of coring location.
5.	**ENSURE** all seams on the drill barrel are taped, **THEN** **LOWER** barrel until it touches the surface of the grout, **AND** **ENSURE** the depth measuring tape is placed at the ZERO position.
6.	**BUMP** drill motor to verify power is available.

Attachment 1, Core Drilling
(Page 2 of 8)

7. **OPEN** the Drill Motor Water Isolation Valve, **AND**

VERIFY the following:

- Water is visible at bottom of drill barrels via camera monitor
- Water flow is greater than 1.0 gpm on water flow indicator

8. Using camera monitor, **ENSURE** the core bit is "seated" into the grout by bumping the drill motor on and off (depressing the "on" button twice for reduced operating speed if using the Hilti DD350) to allow the core bit to get started into the grout.

CAUTION

During the core drilling operation, it is important to minimize the raising of the drill barrels to the extent practical in order to prevent possible damage to the core samples.

9. **INITIATE** core drilling, **AND**

ENSURE the following:

- Core depth of 2 feet is reached via Depth Measuring Tape
- Maintain water flow greater than or equal to 0.5 gpm on water flow indicator

10. **IF** water flow indicator displays less than 0.5 gpm, **THEN**

PAUSE/STOP core drilling at current depth, **AND**

ALLOW water flow to increase to greater than 0.5 gpm.

11. **WHEN** a core depth of 2 feet is reached via Depth Measuring Tape, **THEN**

a. **STOP** the drill motor.

b. **VERIFY** water flow indication is greater than 0.5 gpm.

c. **CLOSE** the drill motor water isolation valve.

d. **VERIFY** water flow is indicating 0.0 gpm.

e. **DISCONNECT** power by unplugging the power supply cord.

Attachment 1, Core Drilling

SEGMENT 2 - Core Drilling (additional 2 feet)

NOTE: 2 Operators are required to remove and add sections of drill barrels.

CAUTION

During the core drilling operation, it is important to minimize the raising of the drill barrels to the extent practical in order to prevent possible damage to the core samples.

12. **DISCONNECT** drill barrel from drill motor at the quick disconnect (drill barrels to remain in core hole).

13. **RAISE** the drill motor, **AND**

    SECURE the drill motor in place.

14. **ADD** 2 foot section of drill barrel with thread seal tape applied to threads, **AND**

    TIGHTEN drill barrels.

15. **LOWER** drill motor, **AND**

    CONNECT drill motor to barrel at quick disconnect.

16. **IF** required, **REPOSITION** Depth Measuring Tape on core drill mounting rail to identify starting point for coring Segment 2.

17. **ENSURE** power cord is plugged into power source, **AND**

    ENSURE drill motor GFCI is reset.

18. **BUMP** drill motor to verify power is available.

19. **OPEN** the Drill Motor Water Isolation Valve, **AND**

    VERIFY water flow is greater than 0.5 gpm on water flow indicator.

20. **IF** water flow indicator displays less than 0.5 gpm, **THEN**

    ATTEMPT to restore water flow by bumping drill motor.

Attachment 1, Core Drilling
(Page 4 of 8)

CAUTION

During the core drilling operation, it is important to minimize the raising of the drill barrels to the extent practical in order to prevent possible damage to the core samples.

21. **INITIATE** core drilling, **AND**

    ENSURE the following:

    - Core depth of 2 feet reached via Depth Measuring Tape
    - Maintain water flow greater than or equal to 0.5 gpm on water flow indicator

22. **IF** water flow indicator displays less than 0.5 gpm, **THEN**

    PAUSE/STOP core drilling at current depth, **AND**

    ALLOW water flow to increase to greater than 0.5 gpm.

23. **WHEN** a core depth of 2 feet is reached via Depth Measuring Tape, **THEN**

    a. **STOP** the drill motor.

    b. **VERIFY** water flow indication is greater than 0.5 gpm.

    c. **CLOSE** the drill motor water isolation valve.

    d. **VERIFY** water flow is indicating 0.0 gpm.

    e. **DISCONNECT** power by unplugging the power supply cord.

Attachment 1, Core Drilling
(Page 5 of 8)

SEGMENT 3 - Core Drilling (final 2.5 feet)	
NOTE: 2 Operators are required to remove and add sections of drill barrels.	
CAUTION **During the core drilling operation, it is important to minimize the raising of the drill barrels to the extent practical in order to prevent possible damage to the core samples.**	
24.	**DISCONNECT** drill barrel from drill motor at the quick disconnect (drill barrels to remain in core hole).
25.	**RAISE** the drill motor, **AND** **SECURE** the drill motor in place.
26.	**ADD** 2 foot section of drill barrel with thread seal tape applied to threads, **AND** **TIGHTEN** drill barrels.
27.	**LOWER** drill motor, **AND** **CONNECT** drill motor to barrel at quick disconnect.
28.	**IF** required, **REPOSITION** Depth Measuring Tape on core drill mounting rail to identify starting point for coring Segment 3.
29.	**ENSURE** power cord is plugged into power source, **AND** **ENSURE** drill motor GFCI is reset.
30.	**BUMP** drill motor to verify power is available.
31.	**OPEN** the Drill Motor Water Isolation Valve, **AND** **VERIFY** water flow is greater than 0.5 gpm on water flow indicator.
32.	**IF** water flow indicator displays less than 0.5 gpm, **THEN** **ATTEMPT** to restore water flow by bumping drill motor.

Attachment 1, Core Drilling
(Page 6 of 8)

CAUTION

During the core drilling operation, it is important to minimize the raising of the drill barrels to the extent practical in order to prevent possible damage to the core samples.

33. **INITIATE** core drilling, **AND**

ENSURE the following:

- Core to a depth of 2.5 feet (minimum) is reached via Depth Measuring Tape
- Maintain water flow greater than or equal to 0.5 gpm on water flow indicator

34. **IF** water flow indicator displays less than 0.5 gpm, **THEN**

PAUSE/STOP core drilling at current depth, **AND**

ALLOW water flow to increase to greater than 0.5 gpm.

35. **WHEN** a core depth of 2.5 feet (minimum) is reached via Depth Measuring Tape, **THEN**

a. **STOP** the drill motor.

b. **VERIFY** water flow indication is greater than 0.5 gpm.

c. **CLOSE** the drill motor water isolation valve.

d. **VERIFY** water flow is indicating 0.0 gpm.

e. **DISCONNECT** power by unplugging the power supply cord.

36. **IF** the second core sample is complete, **THEN**

RETURN to Subsection 5.6.4, Step 10.

Attachment 1, Core Drilling
(Page 7 of 8)

Drill Barrel Removal to Support Coring Second Sample	
NOTE: Two core samples will be removed from each spare access port location. The core positions are labeled as Core Position #1 and Core Position #2.	
37.	**DISCONNECT** drill barrels from drill motor, **THEN** **RAISE** the drill motor, **AND** **SECURE** the drill motor in place.
38.	**LOOSEN** the three (3) mounting plate anchors.
39.	**RE-POSITION** the drill stand to Core Position #2 and Secure.

NOTE: Two (2) Operators are required to remove and add sections of drill barrels.	
Removal of Upper 4 Foot (2 x 2 ft drill barrels) Drill Barrel Section	
40.	**PREPARE** containment sleeve for removal of the upper section of 4 foot drill barrels. (2 x 2 ft drill barrels)
41.	**INSERT** PVC Push Rod Assembly into upper section.
42.	**Slowly RAISE** the drill barrels, **while** using the PVC Push Rod Assembly, **AND** **ENSURE** the core samples remain in the core hole.
43.	**RAISE** the upper 4 foot drill barrel section (2 x 2 ft drill barrels) until it is approximately 1 to 2 feet above the access port opening, **AND** **ATTACH** pipe (friction) clamp to lower section of drill barrels to secure during removal of upper 4 foot drill barrel section.
44.	**REMOVE** upper section of 4 foot drill barrels (2 x 2 ft drill barrels), **THEN** **BAG** the upper section of drill barrels, **AND** **STORE/DISPOSE** per PIC/RPD direction.

Attachment 1, Core Drilling
(Page 8 of 8)

Preparation for Core Drilling Sample #2	
45.	**INSERT** PVC Push Rod Assembly into lower section of drill barrels.
46.	**Slowly RAISE** the drill barrels with camera monitor assistance, **while** using the PVC Push Rod Assembly, **AND** **ENSURE** the core samples remain in the core hole.
47.	**RAISE** the lower section of drill barrels until core bit is visible above the grout surface.
48.	**POSITION** the lower section of drill barrels on top of grout surface to support.
49.	**Carefully LOWER** drill motor <u>and</u> manipulate drill barrels to allow connection to drill motor.
50.	Using camera monitor assistance, **ENSURE** the drill barrels are positioned with adequate distance from Core Hole # 1 to prevent overlapping core holes.
51.	**TIGHTEN** the three (3) mounting plate anchors.
52.	**IF** a coring second sample is required, **THEN** **REPEAT** Steps 1 through 35.
53.	**RETURN** to Subsection 5.6.4, Step 10.

Attachment 2, Removal of Drill Barrels

(Page 1 of 2)

<u>INSTRUCTIONS</u>

1. The drill barrels will be removed in <u>two</u> sections. The UPPER section consists of <u>two</u> 2 foot drill barrels. The LOWER section consists of <u>one</u> 4 foot drill barrel, <u>one</u> 1 foot section and <u>one</u> 1 foot core bit.

2. Two operators are required to remove sections of drill barrels.

1.	**PREPARE** containment sleeve for removal of the UPPER section of drill barrels.
2.	**DISCONNECT** drill barrels from drill motor at the quick disconnect.
3.	**RAISE** the Drill Motor, **THEN** **REMOVE** the Drill Motor from the Drill Stand, **AND** **STORE** per PIC/RPD direction.
4.	**INSERT** PVC Push Rod Assembly into upper section of drill barrels.
5.	**Slowly RAISE** the drill barrels, **while** using the PVC Push Rod Assembly, **AND** **ENSURE** the core samples remain in the core hole
6.	**RAISE** the upper 4 foot drill barrel section (2 x 2 ft drill barrels) until it is approximately 1 to 2 feet above the access port opening, **AND** **ATTACH** pipe (friction) clamp to lower section of drill barrels to secure during removal of upper 4 foot drill barrel section.
7.	**REMOVE** upper section of 4 foot drill barrels (2 x 2 ft drill barrels), **THEN** **PLACE** upper section of drill barrels in containment sleeve, **AND** **STORE/DISPOSE** per PIC/RPD direction.
8.	**PREPARE** containment sleeve for removal of the LOWER section of drill barrels.
9.	**INSERT** PVC Push Rod Assembly into lower section of drill barrels.

Attachment 2, Removal of Drill Barrels
(Page 2 of 2)

10.	Using garden sprayer to remove residual coring sludge/material, **Slowly RAISE** the drill barrels with camera monitor assistance, **while** using the PVC Push Rod Assembly, **AND** **ENSURE** the core samples remain in the core hole.
11.	**PLACE** lower section of drill barrels in containment sleeve, **AND** **STORE/DISPOSE** per PIC/RPD direction.
12.	**RETURN** to Subsection 5.6.4, Step 12.

Attachment 3, Core Sample Removal
(Page 1 of 7)

INSTRUCTIONS

1. Four (4) Core Sample Retrieval Tools are required to support sampling:

- Two (2) 4.0 foot Retrieval Tools for removal of the upper core samples which will be staged and returned to SDU 2A.
- Two (2) 2.5 foot Retrieval Tools for the removal of the lower core samples to be transported to SRNL.

2. Core Samples from Core Hole #1 will be removed first followed by Core Samples from Core Hole #2.

3. Core Sample Retrieval Tool should only be manipulated in the CLOCKWISE direction when retrieving core samples in order to prevent the Tool Handle from becoming detached from lower section of tool.

4. The Core Sample Retrieval Tool may be raised and lowered to re-position core samples for entry into retrieval tool.

RETRIEVAL OF UPPER CORE SAMPLES USING 4.0 FOOT RETRIEVAL TOOL	
1.	**ENSURE** 4.0 foot core sample retrieval tool is assembled with handle.
2.	Using the camera monitor (if available), **Carefully LOWER** and manipulate core sample retrieval tool over the core sample to be obtained.
3.	**Slowly INSERT** the core sample retrieval tool into the hole, **AND** **Continually TURN** handle in clockwise direction to allow sample to enter retrieval tool.
4.	Using camera (if available), **MONITOR** progress of retrieval tool until sample depth (approximately 4.0 feet) is reached. (achieved when the upper coupling of the retrieval tool contacts the grout surface)
5.	**WHEN** sample depth has been reached, **THEN** **Slowly RAISE** core sample retrieval tool, **AND** **TURN** handle in the clockwise direction (as needed) to aid in removal of retrieval tool.
6.	Using camera (if available), **MONITOR** retrieval tool as it exits the core sample hole.

Attachment 3, Core Sample Removal
(Page 2 of 7)

7.	**IF** lower portion of the core sample is visible below the bottom of the retrieval tool, **THEN** **Carefully USE** the top of the grout surface to push the core sample further into the retrieval tool.
8.	Using camera (if available), **VERIFY** core sample retrieval tool recovered approximately 4.0 feet of core sample.

9.	**IF** approximately 4.0 feet of core sample is NOT visible, **THEN**
	
	Slowly INSERT core sample retrieval tool into sample hole, **AND**
	
	REPEAT Steps 2 through 7 until approximately 4.0 feet of core sample is obtained
	
	<u>OR</u>
	
	IF directed by PIC, **THEN**
	
	GO TO Step 10.

10.	**IF** residual coring fines/material is present on the outside of the sample, **THEN** **USE** garden sprayer to remove residual coring sludge/material.
11.	**RAISE** retrieval tool above the access port to allow measurement of core samples.
12.	**MEASURE** as accurately as possible the length of core samples, **THEN** **RECORD** the Length in Section 5.6.4, Step 15, (Upper Core Sample Length).
13.	**RETURN** 4.0 foot core sample retrieval tool back into the SDU, **AND** **STAGE** in a location that does NOT impact collection of Core Hole Samples.
14.	**IF** a portion of the core sample is lost during removal of retrieval tool, **THEN** **Carefully USE** extended reach tool to recover the sample.
15.	**If** sample is recovered, **MEASURE** as accurately as possible the length of core samples, **AND** **RECORD** the Length in Section 5.6.4, Step 15, (Recovered Upper Core Sample Length), **THEN** **RETURN** recovered sample to SDU 2A.

Attachment 3, Core Sample Removal
(Page 3 of 7)

RETRIEVAL OF LOWER CORE SAMPLES FOR TRANSPORT TO SRNL	
16.	**PREPARE** containment sleeve for removal of Core Samples.
17.	**PREPARE** the Inerting Equipment for receipt of retrieval tool and samples (refer to Page 6 of Attachment 3, Core Sample Removal).
18.	**ENSURE** 2.5 foot core sample retrieval tool is assembled with handle, **AND** **LABELED** according to the Core Sample to be obtained.
19.	Using camera monitor (if available), **Carefully LOWER** and manipulate core sample retrieval tool over the core sample to be obtained.
20.	**Slowly INSERT** the core sample retrieval tool into the core hole, **AND** **TURN** handle in clockwise direction (as needed) to allow sample to enter retrieval tool.
21.	Using camera (if available), **MONITOR** progress of retrieval tool until anticipated sample depth is reached as indicated on retrieval tool handle.
22.	**WHEN** sample depth has been reached, **THEN** **Slowly RAISE** core sample retrieval tool, **AND** **TURN** handle in the clockwise direction (as needed) to aid in removal of retrieval tool.
23.	Using camera (if available), **MONITOR** retrieval tool as it exits the core sample hole.
24.	**IF** lower portion of the core sample is visible below the bottom of the retrieval tool, **THEN** **Carefully USE** the top of the grout surface to push the core sample further into the retrieval tool.

25.	**IF** approximately 2 to 2.5 feet of core sample is NOT visible, **THEN**
	
	Slowly INSERT core sample retrieval tool into sample hole, **AND**
	
	REPEAT Steps 19 through 24 until approximately 2 to 2.5 feet of core sample is obtained
	
	<u>OR</u>
	
	IF directed by PIC, **THEN**
	
	GO TO Step 26.

Attachment 3, Core Sample Removal
(Page 4 of 7)

26.	**IF** residual coring sludge/material is present on the outside of the sample, **THEN** **USE** garden sprayer to remove residual coring sludge/material, **AND** **STAGE** retrieval tool by resting on grout surface to allow drying and preparation for removal.
27.	**IF** a portion of the core sample is lost during removal of retrieval tool, **THEN** **a.** **PREPARE** containment bag/area for recovery of sample. **b.** **USE** extended reach tool to recover the sample. **c.** **MEASURE** as accurately as possible the length of Core Sample recovered, **AND** **RECORD** Length in Section 5.6.4, Step 15, (Recovered Lower Core Sample Length). **d.** **PLACE** recovered lower core sample into the containment bag/area as directed by RPD.
28.	**WHEN** directed by PIC/RPD, **THEN** **a.** **RAISE** retrieval tool. **b.** **REMOVE** the upper section of retrieval tool extension handle once it has cleared the access port opening. **c.** Continue to **RAISE** the retrieval tool with lower section of extension rod until the retrieval tool has cleared the access port. **d.** **IF** a portion of core sample was recovered, **THEN** **INSERT** the recovered core sample into the bottom of the retrieval tool with the assistance of RPD.
29.	**MEASURE**, as accurately as possible, the length of Core Samples recovered, **AND** **RECORD** Length in Section 5.6.4, Step 15, (Lower Core Sample Length).

Attachment 3, Core Sample Removal
(Page 5 of 7)

30. Using the retrieval tool extension rod, **PLACE** the retrieval tool into the Inerting chamber, **THEN**

REMOVE the 2 inch PVC reducer with extension rod from the retrieval tool, **AND**

REPLACE with threaded end cap and hand tighten (lightly).

31. **SEAL** the Inerting chamber with PVC plug cap.

32. **PREPARE** Inerting Equipment to allow Inerting of core samples as shown on Page 6 of Attachment 3, Core Sample Removal:

a. **PLACE** the inerting container in the vertical position with cap at top.

b. **REMOVE** the cap (cap to be discarded).

c. **PLACE** the sample (including extraction sleeve) into the inerting container.

d. **PLACE** five (5) Oxygen adsorber packets on top of sample.

e. **INSTALL** a new cap (pre-fitted with Teflon tape or equivalent sealant/grease), **AND**

ENSURE the new cap is secured to the inerting container.

f. **CONNECT** Nitrogen supply tubing with quick disconnect to the inerting container.

g. **Crack OPEN** (valve should NOT be fully open) outlet valve of inerting container.

h. **SET** Nitrogen flow to 1 CFM, **THEN**

Fully OPEN outlet valve of inerting container.

i. **FLUSH** inerting container for a minimum of 5 minutes while maintaining nitrogen flow at 1 CFM.

j. **WHEN** 5 minutes has elapsed, **THEN**

CLOSE Nitrogen supply regulator.

k. **WHEN** nitrogen supply regulator pressure indicates zero (0) psi, **THEN**

CLOSE the outlet valve of inerting container, **AND**

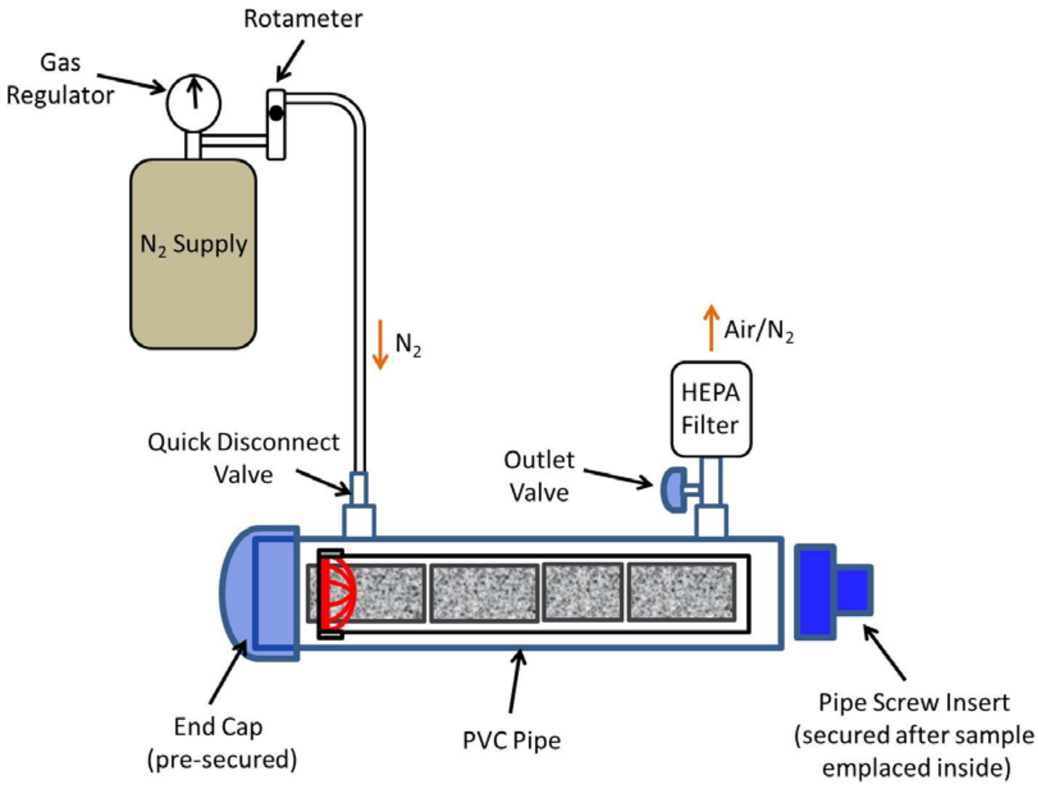
DISCONNECT Nitrogen supply tubing with quick disconnect.

Attachment 3, Core Sample Removal
(Page 6 of 7)

33.	**STAGE** inerting container per PIC/RPD direction for transport preparation.
34.	**IF** second sample is to be removed, **THEN** **REPEAT** Steps 1 through 34.
35.	**IF** second sample has been obtained, **THEN** **RETURN** to Subsection 5.6.4, Step 14.

Attachment 3, Core Sample Removal
(Page 7 of 7)

INERTING EQUIPMENT ARRANGEMENT



CHECKLIST

Verify Nitrogen cylinder contains sufficient amount for pre-flushing & flushing 2 inerting containers

Ensure operation of non-corrosive gas regulator

Ensure operation of rotameter

Verify inerting container has been pre-flushed and oxygen adsorbers added

Ensure Oxygen adsorber packets are maintained in sealed vacuum pack

Nitrogen supply pressure set at 2 psi - Rotameter valve to remain CLOSED

Attachment 4, Core Sample Disposal
(Page 1 of 1)

INSTRUCTIONS

1. The core samples which were retrieved using the 4.0 foot retrieval tool and Vault 4, Cell E, samples are to be disposed of in SDU 2A. It is acceptable to just "drop" the samples (cementitious material only) into SDU 2A through the open camera port.

1.	**PREPARE** containment bag(s)/sleeve(s) for removal of the 4.0 foot retrieval tools from SDU 2A.
2.	Using camera monitor (if available), **Carefully RAISE** 4.0 foot retrieval tool.
3.	**REMOVE** upper extension handle, **THEN** **PLACE** extension handle in containment bag/sleeve, **AND** **STORE/DISPOSE** per PIC/RPD direction.
4.	Continue to "RAISE" retrieval tool, **REMOVE** the 2 inch PVC reducer with lower extension rod, **THEN** **PLACE** in containment bag/sleeve, **AND** **STORE/DISPOSE** per PIC/RPD direction.
5.	**Carefully PLACE** open retrieval tool over SDU 2A camera port, **AND** **DISPOSE** of unwanted core samples.
6.	**PLACE** empty retrieval tool in containment sleeve/bag, **AND** **STORE/DISPOSE** per PIC/RPD direction.
7.	**IF** second sample is to be disposed, **THEN** **REPEAT** Steps 1 through 6.
8.	**IF** Vault 4 Cell E Samples are to be disposed of in SDU 2A, **THEN** **PREPARE** Samples for disposal per RPD direction.
9.	**DISPOSE** of Vault 4 Cell E Samples.
10.	**IF** core sample disposal is complete, **THEN** **RETURN** to Subsection 5.6.4, Step 23.