Duke Energy®

Bryan J. Dolan
VP, Nuclear Plant Development

Duke Energy
EC09D/ 526 South Church Street
Charlotte, NC 28201-1006

Mailing Address:
P.O. Box 1006 – EC09D
Charlotte, NC 28201-1006

704-382-0605

Bryan.Dolan@duke-energy.com

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Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: Duke Energy Carolinas, LLC
William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019
AP1000 Combined License Application for the
William States Lee III Nuclear Station Units 1 and 2
Transmittal of Post-Demolition Field and Laboratory Basemat Test Results, Lee Nuclear Station Unit 1 Concrete Basemat Evaluation
Ltr# WL12009.07-03

Reference: Letter from Bryan J. Dolan (Duke Energy) to Document Control Desk (U.S. Nuclear Regulatory Commission), Transmittal of Concrete Basemat Evaluation, dated April 2, 2008 (ML080990522)

In the referenced letter, Duke Energy submitted a summary report describing the concrete basemat testing performed on the reactor building foundation of the former Cherokee Nuclear Station (Cherokee) Unit 1. This foundation will remain in place as concrete fill for the proposed William States Lee III Nuclear Station (Lee Nuclear Station) Unit 1. The summary report reflected the conditions of the existing basemat (structural) concrete, concrete fill, and foundation rock prior to the demolition of the partially constructed Cherokee Unit 1 reactor building. The purpose of basemat concrete testing was to characterize the properties of the existing basemat (structural) concrete, concrete fill, and foundation rock beneath the accessible areas of the partially constructed Cherokee Unit 1 reactor building structure.

The partially constructed Cherokee Unit 1 reactor building has since been demolished, leaving the concrete basemat that will remain under the proposed Lee Nuclear Station Unit 1. As committed in the referenced letter, and described in Final Safety Analysis Report (FSAR) Subsection 2.5.4.5.3.1, "Nuclear Island Foundation Materials," Revision 1, Duke Energy has performed an additional post-demolition test program that confirms the pre-demolition test results, and verifies that demolition activities did not impair the structural integrity of the existing foundation. Enclosure 2 provides the summary of the Post-Demolition Field and Laboratory Basemat Test Results, Unit 1 Concrete Basemat Evaluation.

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The post-demolition test program was developed to evaluate if demolition of the Cherokee Unit 1 superstructures adversely impacted the competence of the existing concrete basemat and underlying rock, and to ensure that the post-demolition concrete meets the strength requirements for concrete in the AP1000 Design Control Document (DCD), Revision 17, Subsection 2.5.4.1.3 and the foundation uniformity requirements in the AP1000 DCD, Revision 17, Subsection 2.5.4.5.3. The enclosed summary includes a description of the post-demolition field and laboratory testing program, sample collection, and test procedures with reported test results for the post-demolition test program, verifying that the AP1000 DCD requirements are met. The summary also compares the results of the post-demolition test program with the results of the pre-demolition test program to demonstrate that there were no adverse effects resulting from demolition activities.

The referenced letter noted two locations (Boreholes C-4 and C-15) where pre-demolition fill concrete compressive strength test results were not typical of other locations. While these values were lower than other test results, the measured values exceeded the DCD interface requirement of 2,500 psi minimum compressive strength for fill concrete with significant margin. Post-demolition tests were conducted at locations adjacent to these boreholes to provide a better characterization. Near Borehole C-4, post-demolition testing produced results that were more characteristic of other locations. Post-demolition tests near Borehole C-15 confirmed that the fill concrete strength in this location is somewhat less than at other locations. The concrete strengths at all locations investigated in both the pre-demolition and post-demolition tests meet project requirements by significantly exceeding the DCD interface requirement of 2,500 psi minimum compressive strength for fill concrete. Based on the results of all the borings from the pre-demolition and post-demolition testing, Duke Energy concludes that the testing performed demonstrates the adequacy of the existing concrete, and concludes that no further investigations are required.

Based on field and laboratory data collected as part of the pre-demolition test program evaluation, and confirmed by this post-demolition test program evaluation, foundation materials at the Lee Nuclear Station site have been determined to be in good condition and of acceptable quality and strength. The concrete-rock interface is well bonded with no significant zones of weakness or weathering observed. Recovered rock core is consistent with observations from Lee Nuclear Station site characterization activities in support of the Lee Nuclear Station combined license application and historic records, developed originally for the Cherokee site.

The results of the Cherokee Unit 1 pre-demolition test program evaluation, and confirmed by this post-demolition test program evaluation, validate the assumptions and bounding values for structural concrete, fill concrete, and rock materials described in the Lee Nuclear Station FSAR. Therefore, no changes to the Lee Nuclear Station FSAR

are required based on the pre-demolition and post-demolition test program evaluation results. This includes static and dynamic material properties as well as foundation support considerations relative to existing structural and fill concrete as described in FSAR Subsection 2.5.4.2.4, "Material Properties;" FSAR Subsection 2.5.4.3, "Foundation Interfaces;" FSAR Subsection 2.5.4.5, "Excavations and Backfill;" FSAR Subsection 2.5.4.7, "Response of Soil and Rock to Dynamic Loading;" and FSAR Subsection 2.5.4.10, "Static Stability."

However, since the pre-demolition test program and post-demolition test program evaluations are now complete, and the assumptions and bounding values for structural concrete, fill concrete, and rock materials described in the Lee Nuclear Station FSAR have been validated, FSAR Subsections 2.5.4.2.4.2, 2.5.4.5.3.1, and 2.5.4.13, are revised to delete descriptions of and references to these programs and to clarify the acceptability of the Cherokee Unit 1 concrete as meeting the applicable AP1000 DCD interface requirements. These changes are shown in Enclosure 1, and will be incorporated into a future revision of the Final Safety Analysis Report.

If you have any questions or need any additional information, please contact Peter S. Hastings, Nuclear Plant Development Licensing Manager, at 980-373-7820.

Bryan J. Dolan
Vice President
Nuclear Plant Development

Enclosures:

1) Revised FSAR Subsections 2.5.4.2.4.2, 2.5.4.5.3.1, and 2.5.4.13
2) Summary of Post-Demolition Field and Laboratory Basemat Test Results, Unit 1 Concrete Basemat Evaluation, Revision 0

AFFIDAVIT OF BRYAN J. DOLAN

Bryan J. Dolan, being duly sworn, states that he is Vice President, Nuclear Plant Development, Duke Energy Carolinas, LLC, that he is authorized on the part of said Company to sign and file with the U. S. Nuclear Regulatory Commission this supplement to the combined license application for the William States Lee III Nuclear Station and that all the matter and facts set forth herein are true and correct to the best of his knowledge.

Bryan J. Dolan

Bryan J. Dolan

Subscribed and sworn to me on July 17, 2009

Phoebe P. Elliott

Notary Public

My commission expires: June 26, 2011

SEAL

xc (w/o enclosures):

Loren Plisco, Deputy Regional Administrator, Region II
Stephanie Coffin, Branch Chief, DNRL

xc (w/ enclosures):

Brian Hughes, Senior Project Manager, DNRL

COLA Part 2, FSAR, Chapter 2, Subsection 2.5.4.2.4.2, third paragraph, is revised as follows:

Portions of the Cherokee Nuclear Station concrete that will remain under Lee Nuclear Station Unit 1 are described in Subsection 2.5.4.5. ~~Field and laboratory test results for existing concrete and underlying rock materials for the former Cherokee Nuclear Station Unit 1 reactor building foundation is described in a supplemental technical report (Reference 222). The results of the Cherokee Nuclear Station Unit 1 pre-demolition evaluation validates the assumptions and provisional values for structural and fill concrete and rock materials described in the application. The pre-demolition testing verifies that~~ The existing Cherokee Nuclear Station concrete ~~conforms to~~meets the strength requirements for ~~plain structural~~ concrete in DCD Subsection 2.5.4.~~6~~1.3.

COLA Part 2, FSAR, Chapter 2, Subsection 2.5.4.5.3.1, fifth and sixth paragraphs, are deleted as follows:

~~Following removal of the Cherokee Nuclear Station Unit 1 structures to the top of the foundation mat and excavation to the foundation subgrade at Unit 1, the concrete fill materials and reactor building basemat slab remaining from the Cherokee Nuclear Station are evaluated to verify that these materials have suitable properties for support of the Lee Nuclear Station nuclear island foundation. As described in Subsection 2.5.4.2.4.2, an additional exploration and laboratory testing program evaluates these remaining concrete materials. This evaluation of the concrete materials includes:~~

- ~~Coring of the concrete slab and fill concrete materials for visual observation of the concrete condition.~~
- ~~Shear and compression wave velocity measurement to evaluate the concrete fill or concrete slab.~~
- ~~Surface geophysical measurements to evaluate the condition of the concrete fill or concrete slab.~~
- ~~Laboratory testing of the concrete materials to include strength, shear wave velocity, petrographic analysis, and degradation due to chloride or sulfate reaction.~~

~~The exploration of the Unit 1 materials remaining from Cherokee Nuclear Station construction evaluates the rock materials immediately below the foundation concrete or fill concrete. The evaluation of the rock materials includes:~~

- ~~Coring of the concrete to rock contact for visual observation of the rock and the condition of the rock materials below the concrete fill or concrete slab~~
- ~~Shear and compression wave velocity measurement which characterizes the concrete and the rock materials below the concrete fill or concrete slab~~
- ~~Downhole logging using either televiewer or an impression packer device to evaluate the concrete to rock interface.~~

COLA Part 2, FSAR, Chapter 2, Subsection 2.5.4.13, Reference 222, is deleted as follows:

~~222. Bryan J. Dolan to Document Control Desk, U.S. Nuclear Regulatory Commission, Transmittal of Concrete Basemat Information, dated April 2, 2008 (ML080990522).~~

Enclosure No. 2

Rev. 0

For

WILLIAM STATES LEE III NUCLEAR STATION

COMBINED CONSTRUCTION PERMIT AND OPERATING LICENSE COL PROJECT

SUMMARY OF POST-DEMOLITION FIELD AND LABORATORY BASEMAT TEST RESULTS, UNIT 1

CONCRETE BASEMAT EVALUATION

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1.0 INTRODUCTION

This summary report summarizes the post-demolition field and laboratory test results on existing concrete and underlying rock materials collected at the former Cherokee Nuclear Station (CNS) Unit 1 reactor building foundation. Field work was performed by Duke Energy Carolinas LLC qualified subcontractors as part of site investigations for the proposed Duke Energy William States Lee III Nuclear Station (WLS).

A post-demolition test program is described in Final Safety Analysis Report (FSAR) Subsection 2.5.4.5.3.1 Nuclear Island Foundation Materials (Dolan, 2009). A pre-demolition test program was accomplished and the results are reported in Enclosure No. 1, Summary of Pre-Demolition Field and Laboratory Basemat Test Results, Unit 1 Concrete Basemat Evaluation (Dolan, 2008). The testing program is designed to comply with the post-demolition testing program outlined in Dolan (2008).

The post-demolition testing program was developed to evaluate if demolition of the CNS Unit 1 superstructures adversely impacted the competence of the existing concrete basemat and underlying rock and to ensure that the post-demolition concrete meets the strength requirements for concrete in Subsection 2.5.4.1.3 and foundation uniformity requirements in Subsection 2.5.4.5.3 of the AP1000 DCD Rev. 17. The results described in this project report summarize the post-demolition field and laboratory exploration, sample collection, and test procedures with reported test results. The post-demolition test results are then compared to pre-demolition results to evaluate the effects, if any, of demolition activities.

This summary report is organized into the following twelve sections:

1.0 Introduction
2.0 Background
3.0 Evaluation Objectives
4.0 Field Exploration, Laboratory Testing, and Methodology
5.0 Summary of Results
6.0 Comparison of Post-Demolition Results to Pre-Demolition Results
7.0 Conclusions
8.0 Quality Assurance
9.0 References
10.0 Tables
11.0 Figures
12.0 Appendices

All work was performed under an approved Quality Assurance Program meeting 10 CFR 50, Appendix B requirements.

2.0 BACKGROUND

As proposed, WLS will consist of twin AP1000 power plants located at the site of the former partially constructed CNS in Gaffney, South Carolina. The new AP1000 Unit 1 will reoccupy the former Unit 1 footprint and is planned to overlie portions of the existing fill and structural concrete of the former Unit 1; the new AP1000 Unit 2 will occupy the former CNS Unit 3 footprint area. Both plants under this configuration are located within the existing CNS excavation and some minor additional excavation will be required (Figure 1).

Construction at the CNS site was initiated in the mid-1970s and was halted in the early 1980s with the former CNS Units 1 and 2 excavations completed to foundation grade (continuous rock, defined as rock with a minimum RQD of 65 (Duke Power Company, 1974)) and the former CNS Unit 3 area partially excavated to top of rock. As a result of project cancellation, the CNS excavation including Unit 1 basemat structures below about elevation 579±5 ft. were submerged until WLS site investigation preparation in early 2006. The excavation is currently dewatered to maintain accessibility. Post-construction dewatering will not be required as the foundation basemat and below grade walls will be waterproofed during construction and are designed for hydrostatic pressure. Approximately 40% of the existing CNS Unit 1 reactor building and adjacent structures, including the reactor building basemat and lower structural walls, was completed prior to project termination. Demolition of all or parts of the partially completed former CNS Unit 1 structures was completed by Duke Energy contractors in March 2008. Demolition included removal of the concrete superstructure and portions of the auxiliary building basemat foundation. Beneath the proposed WLS Unit 1 powerblock, the existing CNS Unit 1 basemat foundation and portions of the reactor building walls are planned to remain. The demolition activities used to remove the CNS Unit 1 superstructure are described below.

The demolition program outlined the removal of the CNS Unit 1 reactor, turbine, auxiliary, and service buildings. The exterior walls of these buildings were removed using a 75-ton class excavator equipped with a hydraulic concrete breaker. The lower sections of the walls were removed to foundation surfaces using a 50-ton class excavator with a hydraulic concrete breaker. Within the reactor building, the steel sphere bottom of the reactor dome was removed in sections leaving only the concrete base. The internal and external reactor building walls were broken down to 3 in. to 6 in. above the basemat surface with any protruding rebar cut flush to the basemat surface.

Demolition work was completed deliberately to prevent damage to the basemat slab. At the conclusion of demolition activities, the basemat was cleaned, visually inspected, and found to be in sound visual condition.

The existing concrete foundation for the former CNS Unit 1 reactor building structure is a 214 ft. diameter steel reinforced circular basemat approximately 4 ft. thick with a nominal top elevation of 545 ft., corresponding to CNS plant elevation 55+0 ft. The existing basemat is underlain by fill concrete of variable thickness which in turn is underlain by continuous (sound) rock as defined in the Cherokee Preliminary Safety Analysis Report (PSAR) (Duke Power Company, 1974) and confirmed by the WLS COL investigation by coring through the existing basemat and fill concrete and into the rock. The foundation for the new Unit 1 nuclear island will be underlain by varying thickness of existing CNS concrete and new WLS fill concrete as required to an elevation of 550.5 ft, which corresponds to CNS and WLS plant elevation of 60+6 ft., to support the entire new WLS nuclear island for Unit 1 on the underlying rock.

The pre-demolition basemat testing program was developed to evaluate the condition of the existing CNS concrete, confirm it meets the strength and foundation uniformity requirements for concrete in subsection 2.5.4.1.3 and subsection 2.5.4.5.3, respectively, of the AP1000 DCD Rev. 17, and to use as a baseline for comparison to the post-demolition basemat testing results. The pre-demolition program consisted of 14 borings, static and dynamic laboratory testing, and field testing methods including crosshole and spectral analysis of surface waves (SASW) testing. The confined access field conditions inside the CNS reactor building structure limited drilling and sampling equipment options. A minimum of two borings were drilled within each of the reactor building foundation quadrants. Additional sample and test locations were positioned in the southeast reactor building quadrant. Post-demolition test results described in this

summary report were replicated at selected pre-demolition locations for the post-demolition testing program. The co-located post- and pre-demolition test locations allow for a direct comparison of the material properties and test results between the test events.

3.0 EVALUATION OBJECTIVES

The purpose of the post-demolition concrete basemat testing program was to collect sufficient representative samples to characterize the post-demolition properties of the existing basemat (structural) concrete, concrete fill, and underlying foundation rock beneath the CNS Unit 1 reactor. The sampling and testing program developed for the post-demolition basemat program represents a subset of previously performed pre-demolition testing described in Dolan (2008) and fulfills the commitment described in the WLS Combined License Application (COLA)(Dolan, 2009).

The post-demolition test program is described in FSAR Subsection 2.5.4.5.3.1 Nuclear Island Foundation Materials. The objectives of the post-demolition program include the following goals:

1) Collect and evaluate additional samples at selected pre-demolition test locations,

2) Confirm that CNS concrete materials meet the requirements for strength of concrete and foundation uniformity criteria described in AP1000 DCD Rev. 17 Subsections 2.5.4.1.3 and 2.5.4.5.3, respectively, and

3) Confirm that demolition activities did not substantially impair the structural qualities of basemat concrete material properties obtained during WLS COLA pre-demolition investigation.

The post-demolition testing program includes coring, collection of representative concrete and rock material samples, and field and laboratory testing at nine locations across the CNS basemat slab. Confirmatory testing included discrete test locations within each of the reactor building foundation quadrants (four locations) with additional testing at certain pre-demolition test locations to evaluate non-typical test results. These were at C-4 and C-15 (two locations). An assessment of the non-typical test results are described in subsection 6.4 of this summary report. The program to evaluate concrete, rock and the concrete-rock interface is described below.

Concrete testing program

- Visual inspection of basemat slab for evidence of significant surface cracking attributed to demolition.
- Coring of the structural and fill concrete materials for visual observation of concrete condition, using single and/or double-tube diamond coring methods.
- Field compression and shear wave velocity measurements at selected locations of pre-demolition tests (e.g. vicinity of C-1 through C-5) using the crosshole method.
- Field compression and shear wave velocity measurements at two locations using SASW test methods.
- Laboratory compression and shear wave velocity measurements on selected structural and fill concrete core samples using the unconfined, free-free, resonant column method.
- Laboratory testing of the concrete core samples to include unit weight, strength, compression and petrographic analysis, and degradation due to chloride or sulfate reaction.

Rock testing program

- Coring through the concrete into rock for visual observation of the rock and the condition of the rock materials below the concrete fill or concrete slab. Coring extended into rock up to 120 ft., averaging 65 ft., to obtain borehole geophysical measurements.
- Field compression and shear wave velocity measurements using crosshole and P-S suspension test methods.
- Field compression and shear wave velocity measurements at two locations using SASW test methods.
- Acoustic and optical televiewer imaging of boring walls to identify fractures, and determine dip and azimuth of these features.

Concrete-rock interface testing program

- Visual evaluation of the concrete-rock interface in recovered core for any separation, fracturing, or weathering.
- Televiewer logging at four locations (one in each basemat quadrant) to observe the in-situ concrete-rock contact for any separation, fracturing, or weathering.
- Field compression and shear wave velocity measurements using inclined crosshole wave paths.

The test-specific data (e.g., field and laboratory) results of the post-demolition testing are compiled and presented herein. This report also provides a pre- and post-demolition data comparison of the structural quality of CNS basemat materials and commentary regarding CNS concrete foundation materials uniformity and conformance to the strength requirements for concrete in DCD Subsections 2.5.4.5.3 and 2.5.4.1.3, respectively.

4.0 FIELD EXPLORATION, LABORATORY TESTING, AND METHODOLOGY

Field and laboratory evaluations were completed on rock and the two types of existing CNS concrete that serve as part of the WLS Unit 1 foundation: the surface leveling concrete referred to as "fill concrete" and overlying steel reinforced basemat referred to as "structural concrete."

The concrete and rock were cored and logged with samples selected for in-depth analysis including field and laboratory testing. The laboratory and in situ characteristics of the cored samples were determined from representative samples obtained from the existing CNS Unit 1 basemat.

Field activities including sample collection and testing at WLS Unit 1 were initiated on July 28, 2008 and continued through August 22, 2008. All test locations from pre- and post-demolition field programs were surveyed on September 8 and 9, 2008.

The distribution of borings across the reactor building basemat is intended to define the range of expected conditions and assess the post-demolition material properties. The boring and field test locations were all performed from the surface of the existing basemat which is at CNS plant elevation 55+0 ft., which corresponds to an elevation of 545 ft. North American Vertical Datum of 1988 (NAVD 88).

The site exploration program exploration is shown in Figure 2. The laboratory and field testing program is summarized in Table 1. The testing performed at each location including depth and thickness of concrete materials and rock are summarized in Table 2.

4.1 Test Methods

The procedures and testing methods utilized to obtain the data within this report used guidance provided in Regulatory Guide 1.132 - "Site Investigations for Foundations of Nuclear Power Plants." Concrete and rock borings completed for this study utilized the drilling procedures, sampling techniques, and core storage and transport techniques in accordance with the project approved geotechnical work plan and quality assurance plan.

4.1.1 Drilling Methods

Nine borings were completed at the existing CNS Unit 1 basemat. Electrically and hydraulically operated concrete coring equipment was used during this work. Each borehole was advanced to 4 ft. using a 4-inch diameter single tube thin-wall core barrel system to reach the structural/fill concrete interface. Once through the structural concrete, each boring was then advanced to target depths using a CME-550X or a Diedrich 120 geotechnical core drilling rig using double tube rotary HQ diamond-core methods (Figure 3). Drill runs were typically 5 ft. to obtain optimum recovery and minimal disturbance to core samples.

4.1.2 Boring Logs

Recovered concrete and rock core was collected, logged, and placed in a labeled sample box. The concrete core logs identify concrete as either "structural" or "fill" and are associated with construction of the former CNS Unit 1 foundation. Fill concrete was placed over continuous rock during construction to provide a level surface for construction of the structural foundation slab and lacks steel reinforcement. The structural concrete is similar to the fill concrete but reinforced with steel rebar. Figure 4 illustrates typical concrete and rock core samples. Selected structural and fill concrete core samples were tested to characterize the physical and chemical durability/strength of the existing concrete. The rock was identified and examined for strength and weathering properties with particular emphasis focused on the concrete and rock interface. All recovered core samples were logged, transported to and stored in the on-site sample storage facility, and selected samples were then packaged and shipped to the testing laboratory. Boring logs are presented in Appendix A.

4.2 Static Laboratory Testing

Selected core samples were prepared for testing to identify physical and chemical properties and characteristics. Sample preparation and testing was completed according to the ASTM procedures and guidelines for each test. All of the tested concrete cores had a cylindrical shape. Structural concrete samples had a nominal diameter of 3.7 in. and fill concrete samples had a nominal diameter of 2.5 in. Length of each sample varied from about 5 in. to 8.4 in. A sample testing summary by test type and sample interval is presented in Table 3. The following analyses and characterizations were carried out on core samples:

4.2.1 Physical & Mechanical Tests

The cores were photographed and visually inspected for the following characteristics:

- Maximum size aggregate
- Gradation of aggregates

- Condition of paste (characterization of surface defects, i.e. scaling)
- Presence or absence of reinforcing steel
- Measurement of the length and diameter of the cores

Laboratory testing to evaluate physical and strength properties was performed in accordance with the standard procedures listed below.

- Density, Absorption, and Voids in Hardened Concrete, ASTM C642
- Compressive Strength of Concrete Cores, ASTM C42
- Modulus of Elasticity of Concrete Cores, ASTM C469
- Splitting Tensile Strength of Concrete Cores, ASTM C496
- Petrographic Examination of Hardened Concrete, ASTM C856

Additional testing was performed to evaluate mix durability and additional concrete properties. The test purpose and applicable standard method is described below.

4.2.2 Mix Durability Tests

The following two test procedures were used to evaluate concrete mix durability.

- Permeability of concrete to chloride ions using Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration, ASTM C1202. Determination of the rapid chloride permeability was performed using a two-inch thick section of core placed into a chamber with a sodium chloride solution on one side and a sodium hydroxide solution on the other side. Sixty volts is placed across the concrete specimen. The current passed across the specimen is measured over six hours. The result of the testing provides an indication of the overall durability of the mix.

- Petrographic examination of multiple thin sections was conducted according to ASTM C856 to determine the following:
    - Performance of aggregates including types of aggregates, and presence of alkali-silica reactions.
    - Cementitious matrix including estimation of water/cement ratio, presence of pozzolans, microcracking, and degree of hydration.

4.2.3 Current Condition of Concrete Tests

The following test procedures were used to evaluate additional concrete properties:

- Chloride Content using Standard Test Method for Water-Soluble Chloride in Mortar and Concrete, ASTM C1218. Testing for chloride content was performed at both the exterior and interior (middle point) locations. Small sections of core were pulverized to pass a #50 sieve and then digested in acid to dissolve cement paste.
- Alkali-Silica Reactivity (ASR) using ASTM C856. In the Strategic Highway Research Program uranyl acetate test, concrete is treated with a uranyl acetate solution, which is then rinsed off. This process leaves uranyl (UO_2^{+2}) absorbed to the negatively charge ASR gel which fluoresces with yellow-green glow under UV light. It is this glow that is attributed to the

presence of ASR gel. The presence of gel is an indication of possible expansion products produced by highly reactive aggregate.

- Carbonation Depth Measurements, ASTM C856. Depth of carbonation was determined by an application of Rainbow Indicator (manufactured by Germann Instruments) on freshly cut cross sections of concrete core samples. These test results provide an overall indication of the current condition of concrete.

4.3 Dynamic Laboratory Testing – Unconfined Free-Free Resonant Column (URC)

A total of 12 intact concrete cores (six cores each for structural and fill concrete) from the existing CNS Unit 1 basemat materials were tested. All cores were recovered from six different boreholes: C-1P, C-3P, C-4P, C-9AP, C-11P, and C-16P over the depth range from about 0.55 ft. to 7.16 ft. Two samples, representing structural and fill concrete material, were obtained at different depths from each borehole and shipped to the University of Texas at Austin (UT) for unconfined free-free resonant column (URC) testing (Figure 5).

The objective of these tests was to measure the small-strain dynamic properties of the intact concrete cores that were recovered from the CNS Unit 1 reactor building foundation. All measurements were performed in the Soil and Rock Dynamics Laboratory at UT. Technique and calibrations procedures were developed and documented by UT and results were compared with industry standard published values. A proprietary procedure developed by UT was used for the unconfined, free-free, resonant column testing.

4.4 Field Geophysical Methods

Borehole and surface geophysical investigations were completed in the field. These include 3 types of borehole geophysical testing and 1 type of surface geophysical testing:

- P-S Suspension Logging
- Acoustic and Optical Televiewer Logging
- Crosshole Seismic Testing
- SASW testing

P-S Suspension surveys were completed in borings C-1P and C-9AP. Acoustic and optical televiewer data was collected in four borings, C-1P, C-9AP, C-11P, and C-15P. Borehole verticality surveys were completed for all post-demolition borings with the exception of C-16P. For this boring, a verticality survey was not deemed necessary due to its shallow depth. Crosshole testing was completed in borings C-1P through C-5P. Crosshole testing included both inclined and horizontal travel path evaluation. SASW surveys were performed in the vicinity of borings C-1P through C-5P and near borings C-15P and C-16P.

4.4.1 P-S Suspension Logging

P-S logging was completed for the post-demolition basemat evaluation to acquire compressional wave velocities (V_p) and shear wave velocities (V_S) as a function of depth in two borings, C-1P and C-9AP, and is used to supplement other geophysical testing.

Seismic velocity data was collected using the P-S suspension technique as shown in Figure 6. This technique directly determines the average velocity of a 3.3-ft. segment of the material surrounding the borehole by measuring the elapsed time between arrivals of a wave propagating upward from the source to the two receivers through the surrounding material

column. The separation of the two receivers is known to be 3.3 ft., allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in these surveys is 19 ft., with the center point of the receiver pair 12.1 ft. above the bottom end of the probe. The receivers that detect the wave and the source that generates the wave are moved as a unit to the bottom of the boring producing relatively constant amplitude signals at all depths. Measurements were taken every 1.6 ft. At each depth, V_p, V_s, and Poisson's ratio (ν) were calculated. Velocity measurements using the P-S suspension logger are confined to portions of fill concrete and the rock section only due to the length and configuration of the probe instrument.

4.4.2 Acoustic and Optical Televiewer Logging

Optical and acoustic televiewers were used to image the boring wall in four boreholes – C-1P, C-9AP, C-11P, and C-15P – to evaluate the concrete-rock interface and identify fractures and their orientations. Additionally, the acoustic televiewer was also used to complete borehole verticality surveys in all borings except for C-16P.

The acoustic televiewer probe is 7.58 ft. long, and 1.9 in. in diameter, and is fitted with upper and lower four-band centralizers to maintain contact with the borehole wall. The system produces images of the boring wall based upon the amplitude and travel time of an ultrasonic beam reflected from the formation wall. The beam is generated by a piezoelectric transducer at a frequency of 1.4 MHz which emits a periodic acoustic energy wave. The wave travels through the boring fluid until it reaches the interface between the boring fluid and the boring wall. Here a portion of the energy is reflected back to the transducer, the remainder continuing on into the formation. The travel time of the energy wave is the period between transmission of the source energy pulse and the return of the reflected wave measured at the point of maximum wave amplitude.

The optical televiewer probe is 8.2 ft. long and 2.1 in. in diameter, and is fitted with upper and lower four-band centralizers to maintain contact with the borehole wall. This system produces images of the boring based upon periodic annular scans of the boring wall, providing an equivalent horizontal pixel size of approximately 0.02 inches on the boring wall.

Each televiewer probe contains a fluxgate magnetometer to monitor magnetic north. All raw televiewer data is referenced to magnetic north. The processed data is referenced to true north, using a declination of 6.5 degrees west for this site and date, obtained from the NOAA declination website (http://www.ngdc.noaa.gov/geomagmodels/struts/calcDeclination). Also, a three axis accelerometer is enclosed in the probe allowing boring deviation data recorded during the logging runs to permit correction of apparent dip angles to true dip angles.

Deviations from vertical were measured in each borehole as stated above in an orthogonal plane perpendicular to the borehole axis at 0.04 ft. intervals using the acoustic televiewer. The use of the acoustic televiewer to measure borehole vertically is appropriate and in accordance with ASTM D4428 "Standard Test Methods for Crosshole Seismic Testing."

4.4.3 Crosshole Seismic Testing – Horizontal and Inclined Travel Paths

Crosshole testing was performed in the basemat structural concrete, fill concrete, and underlying rock. Two sets of crosshole tests – positioned orthogonally in a north-south and west-east orientation to form an "L" pattern – were preformed with borings C-1P, C-2P and C-3P (north to south) comprising one set and borings C-1P, C-4P and C-5P (west to east) comprising

the second set of the "L" pattern. Each test was arranged in a linear array and the center-to-center spacing between the boreholes was measured on the concrete surface before testing (Figure 7). The three boreholes in each leg contained one source and two receivers. Figure 8 presents the typical post-demolition concrete basemat crosshole field test configuration.

The same basic field procedure was used to obtain horizontal and inclined travel path measurements between each set of three boreholes. For horizontal travel path testing, the source and receivers were positioned at equal elevations (Figure 9). For inclined travel path testing, the receivers were positioned at equal elevations while the source was placed at a different elevation (Figure 10). Horizontal travel paths were tested to provide a direct measurement of each material. Inclined travel paths were tested to evaluate structural concrete-fill concrete and fill concrete-rock interfaces. The procedure involved starting seismic testing at the shallowest depth (1 ft.) and progressing in 1-ft. depth intervals to the final depth (34 ft.). Crosshole seismic analyses were performed in accordance with ASTM D 4428, "Standard Test Methods for Crosshole Seismic Testing." Verticality measurements for the boreholes were completed using the acoustic televiewer as described in Subsection 4.4.1. The inter-borehole distances developed from the deviation survey logs were used to calculate crosshole V_p and V_S.

4.4.4 SASW Testing

The SASW test method is a nondestructive and non-intrusive seismic method. The method utilizes the dispersive nature of Rayleigh-type surface waves propagating through a layered material to determine the shear wave velocity profile of the material (Figure 11). The SASW testing technique provides the average V_p and V_s to various depths in the existing concrete and of the underlying rock at the existing CNS Unit 1 reactor building structure. Post-demolition SASW testing was used to develop V_p and V_s profiles to a depth of about 27 ft.

Two SASW test arrays – S-1515 and S-1516 – were performed from the surface of the existing CNS Unit 1 basemat. The arrays were set-up in the general configuration shown in Figure 12 with various spacing of receivers. Receiver #1 was located at or near the centerline of each test array. Six receiver spacings ranging from 1 to 32 ft. were used. As different spacings were used, receiver #2 and the source were moved. Tests were performed in both the forward and reverse directions using a sledgehammer for an impact source for large spacings and a rock hammer for small spacings. The typical post-demolition SASW survey field setup is depicted in Figure 13. Regardless of the spacing between receivers, at no point in the data analysis were wavelengths considered that were longer than twice the distance between the source and first receiver in the receiver pair. This array geometry results in minimizing near-field effects while simultaneously recording long wavelengths. The largest receiver spacing was based on the space available for testing. This number and progression of receiver spacings resulted in significant overlapping of the individual dispersion curves used to develop the composite field curve, thereby enhancing the test reliability and confirming global lateral uniformity over the test array. A proprietary procedure developed by UT was used for the SASW field-testing.

5.0 SUMMARY OF RESULTS

The results for analyses performed on the concrete samples and field tests are presented in Tables 4 through 12 and are summarized below. As previously described boring logs are presented in Appendix A. Boring summary sheets for selected borings with results of field geophysical testing for SASW, Crosshole, and P-S Suspension surveys, and results of laboratory testing for unconfined compressive strength and Young's Modulus (static) tests are presented in Appendix B.

5.1 Visual-Logging

Visual descriptions of the rock and concrete indicated both were of good quality. Qualitative descriptions of the weathering and rock strength characteristics for recovered rock materials were completed according to project approved standards. Concrete is described in more detail in subsections 5.2 through 5.3. Visual analysis identified the weathering stage and strength characteristics of rock materials and is summarized in Table 4. The rock is described as meta-granodiorite to meta-diorite, strong to very strong (R4 to R5) and fresh/unweathered. The rock strength and weathering is consistent both at the interface with fill concrete and at depth. In Boring C-11P, rock at the contact zone is medium strong to very strong (R3 to R5) and rock below the contact zone contains incipient fractures. In Boring C-9AP, the rock below the contact zone contains healed fractures. In Borings C-15P and C-16P, rock below the contact zone shows evidence of localized weathering zones and is medium strong to very strong (R3 to R5). The observed described above are consistent with observations developed during the other COLA investigations in this area (Dolan, 2009 and Dolan, 2008).

No significant surface cracking of the structural slab was noted during the field investigation of the post-demolition testing program. These observations are based on visual inspection of the basemat.

5.2 Static Laboratory Testing

Selected core samples were prepared for testing to identify physical and chemical properties and characteristics. Sample preparation and testing was completed according to the ASTM procedures and guidelines for each test. The results for the tested samples are presented in Table 5 and summarized below.

5.2.1 Unit Weight, Density, Absorption, and Voids in Hardened Concrete

Structural concrete unit weight/density ranges from 151.7 to 143.7 pounds per cubic foot (pcf). Fill concrete ranges in unit weight/density from 147.8 to 144.8 pcf. The volume of permeable pore space varied between core samples, ranging from 1% to 8%. Figure 14 presents lapped longitudinal cross sections with representative void content of structural and fill concrete.

5.2.2 Compressive Strength of Drilled Concrete Cores

Unconfined compressive strength (UCS) of the structural concrete ranges from 9,610 to 7,320 pounds per square inch (psi) and the fill concrete ranges from 8,150 to 4,010 psi.

5.2.3 Static Elastic Modulus and Poisson's Ratio (ν)

The elastic modulus of the structural concrete ranges from 4,630 thousand pounds per square inch (ksi) to 3,510 ksi with a ν between 0.21 and 0.16. The fill concrete elastic modulus ranges from 2,970 ksi to 3,820 ksi with a ν between 0.27 and 0.17.

5.2.4 Splitting Tensile Strength of Cylindrical Concrete Specimens

Splitting tensile strength of the structural concrete ranges from 700 psi to 1,015 psi and the fill concrete ranges from 615 psi to 1,235 psi.

5.2.5 Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

The potential for rapid chloride penetrability was found to be "high" in the structural concrete with one exception; C-3P was found to be in the "low" range. Fill concrete specimens all fell in the "high" range. "High" indicates a passed charge greater than 4,000 Coulombs and "low" ranges from 1,000 to 2,000 Coulombs as described in ASTM C1202.

5.2.6 Petrographic Examination

Observations made during petrographic examination indicated the concrete represented by both the structural segments and the fill segments is judged to be of good condition. This conclusion was based on observations relating to the composition, paste properties, chemical reactivity and physical condition, all of which indicate the concrete was stable and of good quality.

Both the structural and the fill concrete consist of siliceous coarse and fine aggregates distributed in a hardened Portland cement paste. Nominal aggregate top size is one inch. Paste properties vary somewhat among the structural segments compared to the fill segments. Overall, paste properties are somewhat better in the structural segments compared to the fill segments. The concrete exhibits an advanced degree of cement hydration and secondary deposits are abundant (Figures 15 and 16). These observations are consistent with the age of the structure and the submerged condition reported.

No significant cracking was observed within the structural or fill core segments.

5.2.7 Water Soluble Chloride Analysis

The weight percent of concrete (fill and structural) considered soluble was very low. Chloride content within the core samples was consistently less than 0.001% by weight.

5.2.8 Alkali-Silica Reaction Analysis

Evidence of alkali-silica reaction (ASR) is observed in each of the core segments examined. ASR is occurring in chert fine aggregate particles that comprise a very small proportion of the total aggregate (Figure 17). However, no significant deterioration associated with the ASR is observed on account of the small size of the reacting particles and their relative scarcity within the concrete. Further, considering the age and previous exposure conditions of the concrete, it is probable that no additional ASR will occur in the future.

5.2.9 Carbonation Depth Analysis

Paste carbonation along the top surfaces of the structural concrete segments was shallow, generally up to 0.1 in. depth, with a few cores up to 0.3 in. The fill segments exhibited paste carbonation ranging from 0.1 to 0.2 inches in depth, with few cores exhibiting carbonation as deep as 0.4 inches. The extent of carbonation was also confirmed during petrographic examination (Figure 18).

5.3 Dynamic URC Free-Free Analysis

The URC Free-Free testing of the 12 concrete cores was performed without difficulties and the data quality is good. The dynamic response curves and waveforms that were measured were typical of competent, intact concrete. The results of the URC Free-Free testing are presented in Table 6. The measured values of total unit weight, wave velocities, moduli, and ν of the 12 cores were compared to values reported in the literature for plain and medium to high strength concrete (Table 7). The values of total unit weight, wave velocities, moduli, and ν of the cores equaled or exceeded values reported in the literature for 11 of the 12 cores. Values of the

twelfth core (specimen FrF6) were near or less than values reported in the literature, as described below.
Comparison of the averaged measured values of the 12 concrete cores presented in Table 6 to industry literature values yields the following assessment:

- The total unit weight of all cores except fill concrete samples WLS 7, 8, and 12 (specimen FrF2, FrF4, and FrF12) from Borings C-1P, C-3P, and C-16P, respectively, are within the range reported in the literature. Sample WLS 7 (specimen FrF2) exhibits a unit weight about 1.9% lower, than the others, Sample WLS 8 (specimen FrF4) exhibits a unit weight about 0.7% lower. Sample WLS 8 (specimen FrF12) exhibits a unit weight 1.8% lower.
- The wave velocities and moduli of all cores exceed values reported for normal weight concrete. The values of Sample WLS 9 (specimen FrF6, boring C-4P) are within the range or slightly below the lower values reported in the literature.
- The ν of all samples are within the range of literature values.
- The material damping ratios in shear and unconstrained compression are in the range of 0.35 to 0.67% (11 out of 12 cores), which, are typical of competent concrete. Sample WLS 12 (specimen FrF12, boring C-16P) exhibits slightly higher value in the shear mode (1.25%)

5.4 Field Geophysical Method Results

The concrete-rock interface and dynamic material properties were evaluated using multiple methods including velocity measurements obtained using televiewer logging (acoustic and optical), P-S suspension, crosshole, and SASW testing methods.

5.4.1 Acoustic/Optical Televiewer

Acoustic and optical televiewers were used to image the boring wall in four boreholes (C-1P, C-9AP, C-11P and C-15P) with fracture dips and dip azimuths identified. The concrete-rock interface imaged by the televiewer for these four borings is presented in Figures 19 thru 22. The image results show that the concrete-rock interface is highly irregular, very tight, with the absence of major fracturing or separation, and no significant weathering. In Borings C-9AP and C-11P, the rock below the contact zone exhibits very slight to slightly moderate fracturing with slight to moderate weathering in C-11P.

5.4.2 P-S Suspension

The seismic wave velocities measured and the calculated ν from the P-S suspension survey are summarized in Tables 8 and 9. P-S suspension measurements are confined to fill concrete and rock on account of instrument length and geometry.

5.4.2.1 Fill Concrete

Fill concrete averaged a V_s of 7,769 feet per second (fps) and a V_p of 15,218 fps at C-1P. At C-9AP, fill concrete averaged a V_s and a V_p of 9,776 fps and 17,568 fps, respectively.

P-S suspension velocities are slightly higher than crosshole velocities. This is inherent in the P-S suspension method due to the lower volume of material that is being tested as compared to crosshole methods. The measured fill concrete velocities are considered to represent very good concrete as shown by the average wave velocities.

The values of ν for the fill fall into the typical range or are slightly higher for plain concrete (0.20 to 0.30).

5.4.2.2 Rock

The rock is stiffer than concrete in C-1P and slightly less stiff in C-9AP. Rock averaged a V_s of 9,426 fps and a V_p of 17,572 fps at C-1P. At C-9AP, rock averaged a V_s and a V_p of 9,064 fps and 17,074 fps, respectively. The underlying rock is stiff as shown by the average wave velocities. Variation in rock velocities can be attributed to the presence of natural discontinuities and man-made discontinuities associated with standard excavation methods (e.g. blasting) used to reach suitable CNS foundation subgrade.

The values of ν for the rock fall into the typical range for many types of rock (0.25 to 0.35).

5.4.3 Crosshole

The average wave velocities for structural concrete, fill concrete and rock determined from crosshole analysis are summarized in Tables 10 and 11. In these calculations, horizontal travel paths were used to allow direct measurement as the source and receivers were in the same material. For the purpose of this evaluation, transition zones represent the irregular interface between CNS fill concrete and underlying rock where horizontal travel paths travel through multiple materials. No velocities were considered at these intervals. Also, only independent measurements (direct ray paths) were used; that is, measurements along the C-1P through C-2P and C-2P through C-3P travel paths were used between Boreholes C-1P, C-2P, and C-3P because the C-1P through C-3P travel path represents an averaging of the other two travel paths. Likewise, only the C-1P through C-4P and C-4P through C-5P travel paths were used between Boreholes C-1P, C-4P, and C-5P.

5.4.3.1 Structural Concrete

Structural concrete measurements between Boreholes C-1P, C-2P, and C-3P averaged 6,520 fps for V_s and 15,270 fps for V_p. V_s and V_p between Boreholes C-1P, C-4P, and C-5P averaged 7,190 fps and 15,010 fps, respectively. Average V_s for all structural concrete was calculated to be 6,855 fps. Both V_s and V_p are very similar between the two sets. Structural concrete is very stiff as shown by the average velocities.

5.4.3.2 Fill Concrete

Fill concrete averaged a V_s of 7,450 fps and a V_p of 15,530 fps between Boreholes C-1P, C-2P, and C-3P. Between Boreholes C-1P, C-4P, and C-5P fill concrete average V_s and V_p were calculated to be 7,270 fps and 14,740 fps, respectively. Average V_s for all fill concrete was calculated to be 7,360 fps.

Velocities between Boreholes C-1P, C-2P, and C-3P are slightly higher (about 6%) than between Boreholes C-1P, C-4P, and C-5P. However, all values show the fill concrete to be only slightly less stiff than the structural concrete. The stiffness of fill concrete is considered to represent very good concrete as shown by the average wave velocities.

Collectively the crosshole technique measured an average V_s of 7,110 fps for concrete (structural and fill).

5.4.3.3 Rock

Rock averaged a V_s of 8,040 fps and a V_p of 20,270 fps between Boreholes C-1P, C-2P, and C-3P. Between Boreholes C-1P, C-4P, and C-5P rock average V_s and V_p were calculated to be

7,490 fps and 19,990 fps, respectively. The rock is slightly stiffer between Boreholes C-1P, C-2P, and C-3P than between Boreholes C-1P, C-4P, and C-5P. The average V_s for all rock was determined to be 7,765 fps. In each case, the V_s and V_p velocities values of rock are above the structural and fill concrete. The underlying rock is stiff as shown by the average wave velocities.

The values of ν for rock, 0.41 and 0.42, are somewhat above the typical range for many types of rock (0.25 to 0.35). The reason or reasons are unknown but anisotropy in the rock due to fractures (both natural and blasting-derived) is possibly a contributor.

The variation in rock velocities is attributed to the presence of natural discontinuities and likely development of discontinuities associated with standard excavation methods (e.g. blasting) used to obtain CNS foundation subgrade. The concrete thickness and the concrete-rock interface transition are illustrated in Figure 9. Figure 9a shows relatively uniform concrete thickness and depth to the rock interface along the C-1P through C-3P direction. Figure 9b shows a relatively steep fill concrete-rock interface along the C-1P through C-5P direction. This condition results from the proximity of boring C-5P to the wall for the lower room 18 ft below the basemat slab grade (CNS plant elevation 37+0 ft.).

5.4.3.4 Inclined Travel Path Crosshole Testing

The inclined travel path crosshole testing was completed to evaluate the concrete-concrete and concrete-rock interfaces. The inclined tests yield comparable velocities to the horizontal travel path velocities indicating a tight and solid contact at each of the interfaces.

5.4.4 SASW

Two SASW velocity tests conducted for the post-demolition evaluation of the CNS Unit 1 basemat. SASW S-1515 (UT Site 1) is in the immediate vicinity of the crosshole test locations and SASW S-1516 (UT Site 2) is located approximately 60 ft. southwest of S-1515 (Figure 2). The post-demolition SASW results are presented in Table 12.

Velocity data from SASW S-1515 and SASW S-1516 exhibits slightly lower velocities than crosshole, and downhole data. All velocity data from downhole, crosshole and SASW measurements is shown in Figure 23. The SASW velocity data falls within the range of V_s values measured between Boreholes C-1P, C-2P and C-3P and above the values measured between Boreholes C-1P, C-4P and C-5P. SASW V_s is higher in structural concrete and slightly lower in fill concrete than downhole and crosshole V_s. SASW testing yields rock V_s slightly lower than rock crosshole velocities. The SASW profile also exhibits V_s values slightly lower than the test results from the concrete cores. Ultimately, comparisons between rock V_s profiles measured by SASW testing during this study and by independent crosshole and downhole seismic tests performed during previous WLS COL investigations exhibit good correlation across the site.

6.0 COMPARISON OF POST-DEMOLITION RESULTS TO PRE-DEMOLITION RESULTS

The objectives of the post-demolition test program include the following goals:

1) Collect and evaluate additional samples at selected pre-demolition test locations,

2) Confirm that CNS concrete materials meet the requirements for strength of concrete and foundation uniformity criteria described in AP1000 DCD Rev. 17 Subsections 2.5.4.1.3 and 2.5.4.5.3, respectively, and

3) Confirm that demolition activities did not substantially impair the structural qualities of basemat concrete material properties obtained during WLS COLA pre-demolition investigation.

The first two objectives were satisfied by the testing completed for the post-demolition test program as described in sections 4.0 and 5.0. This section compares the post-demolition test results to the pre-demolition test results to satisfy the third objective of the post-demolition test program. The pre-demolition test results are described in pre-demolition summary report (Dolan, 2008) and summarized in the following subsections.

6.1 Comparison of Physical and Mechanical Laboratory Testing Results

Pre- and post-demolition physical and mechanical laboratory testing consisted of five ASTM tests:

- C-642 - Standard Test Method for Density, Adsorption, and Voids in Hardened Concrete,
- C-42 - Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete,
- C-469 - Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression,
- C-496 - Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens, and
- C-1202 - Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.

The comparison of test results by borehole is presented in Table 13. The averages and standard deviations of pre-demolition and post-demolition testing are also presented in the table and discussed below.

6.1.1 Unit Weight/Density

Pre-demolition structural concrete averaged a unit weight/density of 147.6 pcf (standard deviation (σ) 1.9 pcf). Pre-demolition fill concrete averaged a unit weight/density of 146.4 pcf (σ 1.8 pcf). Post-demolition structural concrete averaged a unit weight/density of 147.8 pcf (σ 2.7 pcf). Post-demolition fill concrete averaged a unit weight/density of 146.5 pcf (σ 1.1 pcf).

The results show a 0.2% difference in structural concrete and a 0.1% difference in fill concrete. The observed difference is within the expected range of variability.

6.1.2 Compressive Strength of Drilled Concrete Cores

Pre-demolition structural concrete averaged an UCS of 8,980 psi (σ 1,254 psi). Pre-demolition fill concrete averaged an UCS of 6,279 psi (σ 1,365 psi). Post-demolition structural concrete averaged an UCS of 8,543 psi (σ 620 psi). Post-demolition fill concrete averaged an UCS of 6,036 psi (σ 1,336 psi).

These results equate to a difference in UCS of 5% in structural concrete and 4% in fill concrete. The observed difference is within the expected range of variability.

6.1.3 Static Elastic Modulus and Poisson's Ratio (ν)

Pre-demolition structural concrete averaged an elastic modulus of 3,745 ksi (σ 334 ksi) and a ν average of 0.19 (σ 0.01). Pre-demolition fill concrete averaged an elastic modulus of 3,109 ksi (σ 563 ksi) and a ν average of 0.18 (σ 0.03). Post-demolition structural concrete averaged an elastic modulus of 3,985 ksi (σ 413 ksi) and a ν average of 0.19 (σ 0.02). Post-demolition fill concrete averaged an elastic modulus of 3,283 ksi (σ 1,269 ksi) and a ν average of 0.21 (σ 0.08).

The elastic modulus shows a 6% difference from pre-demolition to post-demolition testing for both structural and fill concrete. Poisson's Ratio is unchanged for structural concrete and shows a 12% difference in fill concrete. The observed differences are within the expected range of variability.

6.1.4 Splitting Tensile Strength of Cylindrical Concrete Specimens

Pre-demolition structural concrete averaged a splitting tensile strength of 608 psi (σ 77 psi). Pre-demolition fill concrete averaged a splitting tensile strength of 528 psi (σ 62 psi). Post-demolition structural concrete averaged a splitting tensile strength of 843 psi (σ 106 psi). Post-demolition fill concrete averaged a splitting tensile strength of 1,038 psi (σ 217 psi).

The post-demolition results represent a 39% difference in structural concrete tensile strength and a 97% difference in fill concrete tensile strength.

The apparent increase in tensile strength can be attributed to the reduced diameter of the concrete cores tested of the post-demolition tested cores. The pre-demolition concrete cores were 6 in. in diameter while the post-demolition cores were 4 in. in diameter. It is assumed that the 4-inch cores resulted in the higher tensile strength exhibited in the post-demolition test results.

6.1.5 Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

Pre-demolition structural concrete chloride penetrability ranged from "moderate" to a "high" with an overall "high" trend. Pre-demolition fill concrete chloride penetrability was "high".

Post-demolition structural concrete chloride penetrability was "high" with the exception of C-3P. Core sample C-3P was found to be in the "low" range. Post-demolition fill concrete chloride penetrability was "high".

"High" indicates a passed charge greater than 4,000 Coulombs and "low" ranges from 1,000 to 2,000 Coulombs (designations by ASTM C1202-05).

As expected, the pre- and post-demolition concrete exhibits very similar chloride ion penetrability.

6.2 Dynamic URC Free-Free Analysis

Pre- and post-demolition dynamic laboratory testing measured the total unit weight, wave velocities, moduli, and ν of the basemat concrete cores. The comparison of these test results is presented in Table 14. Lab velocity data is graphically compared to field velocity data in Figures 24 and 25. The dynamic testing shows comparable results between pre- and post-demolition tests. The largest differences (≥10%) are seen in results for the shear and compression material

damping ratios. The ratios are used to calculate ν, and as such, the percent differences in ν in turn vary between 15% and 20%. Dynamic laboratory testing velocities compared with static laboratory testing UCS is shown in Figure 26. The results show that the existing CNS Unit 1 basemat concrete conforms to the strength requirements for concrete and foundation conformity criteria outlined in Subsections 2.5.4.1.3 and 2.5.4.5.3, respectively, of the AP1000 DCD Rev. 17.

6.3 Comparison of Field Seismic Velocity Measurements

The pre- and post-demolition field geophysical methods consisted of comparable crosshole and SASW testing. P-S suspension was not possible in the pre-demolition testing program due to the confined working space of the CNS Unit 1 reactor building. The post-demolition P-S Suspension velocity data is slightly higher than the other methods and pre-demolition velocities. This is attributed to the amount of material that is being tested with this technique as compared to the others as discussed in Subsection 5.4.2.1. The comparison of pre- and post-demolition field seismic velocity measurements, including P-S suspension data, is presented in Table 15 and in Figures 24 and 25.

6.3.1 Crosshole Geophysical Testing

Post-demolition crosshole borings were located in the immediate vicinity of the pre-demolition tests. Pre-demolition and post-demolition crosshole V_S and V_P data is tabulated and averaged by material in Table 15.

Pre-demolition V_S for structural concrete, fill concrete, and rock averaged 6,990 fps, 7,525 fps, and 6,625 fps, respectively. Measured velocities were lower between boreholes C-1 to C-5 than C-1 to C-3. Also, data between C-4 and C-5 was sparse due to the depth of fill concrete in C-5. Post-demolition V_S for structural concrete, fill concrete, and rock averaged 6,855 fps, 7,360 fps, and 7,765 fps, respectively. Measured velocities were lower between boreholes C-1 to C-5 than C-1 to C-3 with the exception of structural concrete.

The post-demolition velocities are very slightly lower than pre-demolition velocities with the exception of rock, exhibiting good correlation with pre-demolition results.

6.3.2 SASW Testing

Pre-demolition and post-demolition SASW survey velocities are presented in Table 15. Pre-demolition SASW survey velocities exhibit good correlation to pre-demolition crosshole testing. Post-demolition SASW survey velocities are generally lower than post-demolition crosshole and P-S suspension velocities, as well as pre-demolition SASW velocities.

The reasons for this observed trend are not readily apparent. The SASW method is a global tool measuring material properties over a large lateral extent as opposed to borehole-specific methods that measure a much smaller volume of material. This method assumes a 2-D layered model, and lateral variability in shear wave properties and material thicknesses across the receiver array may contribute to the lower results when compared directly to borehole methods in the same locality. The SASW results show uniform properties and consistent trends between post-demolition and pre-demolition surveys, indicating no appreciable change in concrete quality following removal of the CNS Unit 1 superstructure. The SASW test results are viewed

as supplemental to the borehole tests. When considered as a whole, the velocity measurements for all borehole-derived measurements show good correlations and consistent results for all materials across the site.

6.4 Evaluation of Selected Post-Demolition and Pre-Demolition Fill Concrete Samples

A component of the post-demolition analysis included re-evaluating two pre-demolition locations initially characterized as anomalous. Characterization of pre-demolition fill concrete samples, C-4 and C-15, as anomalous was not intended to imply that the test results did not conform to the project requirements, but was intended to describe the samples as outliers or non-typical when compared to the pre-demolition dataset (Dolan, 2008). The evaluation included testing fill concrete samples from post-demolition borings C-4P and C-15P that were co-located adjacent to their respective pre-demolition borings. The UCS and laboratory-derived V_s test results are described below.

- Boring C-4P fill concrete UCS and laboratory-derived V_s results show similar values to both pre- and post-demolition samples (refer to Figure 26), whereas the UCS results increased by over 60 percent. The UCS and V_s results for the post-demolition and pre-demolition testing are 6,780 psi and 7,644 fps, and 4,130 and 4,120 psi and 7,311 fps, respectively.
- Boring C-15P fill concrete UCS result when compared to the pre-demolition test results is essentially unchanged. The UCS results for the post-demolition and pre-demolition testing are 4,110 and 4,010 psi, and 4,060 psi, respectively.

The post-demolition test results for these two non-typical areas demonstrate that the fill concrete at these locations conform to the project requirements.

7.0 CONCLUSIONS

Based on field and laboratory data collected as part of the post-demolition evaluation on existing CNS Unit 1 concrete and rock materials, the WLS Site is determined to be in good condition, of acceptable quality and strength. The concrete-rock interface is bonded with no significant zones of weakness or weathering observed. Recovered rock core is consistent with observations from WLS COL and evaluations associated with historic CNS investigations.

Post-demolition testing indicates that existing CNS concrete conforms to the strength requirements for structural concrete and foundation conformity critera in AP1000 DCD Rev. 17 Subsections 2.5.4.1.3 and 2.5.4.5.3, respectively. Concrete represented by both the structural and fill segments is judged to be of good quality and is in good condition. The concrete exhibits an advanced degree of cement hydration and secondary deposits are abundant. These observations are consistent with the age of the concrete and the long-term submerged conditions. Considering the age and previous exposure conditions of the concrete it is likely that no additional ASRs will occur. No significant cracking was observed in structural or fill concrete.

By comparison to the pre-demolition test results, the post-demolition CNS basemat has not been adversely affected by demolition activities. Physical and chemical laboratory testing reveals similar results between pre- and post-demolition samples. The higher tensile strength values of post-demolition samples are attributed to differences in core sample diameter. The results of field testing show comparable results between post- and pre-demolition evaluation.

The results of the CNS Unit 1 post-demolition evaluation validates the assumptions and provisional values for structural and fill concrete and rock materials described in the FSAR.

Static and dynamic material properties as well as foundation support considerations relative to existing CNS structural and fill concrete are described in the following FSAR Rev. 1 Subsections:

- 2.5.4.2.4 Material Properties,
- 2.5.4.3 Foundation Interfaces,
- 2.5.4.5 Excavations and Backfills,
- 2.5.4.7 Response to Soil and Rock to Dynamic Loading, and
- 2.5.4.10 Static Stability.

Based on the testing and evaluation described in this report, the CNS Unit 1 concrete basemat remaining in place and the underlying foundation rock conforms to the requirements for strength of concrete and foundation uniformity criteria described in AP1000 DCD Rev. 17 Subsections 2.5.4.1.3 and 2.5.4.5.3, respectively.

8.0 QUALITY ASSURANCE

Quality related activities performed by Duke Energy Carolinas, LLC subcontractor organizations that provided equipment and personnel during the completion of this COL project were in accordance with the project approved Quality Assurance (QA) program. The project approved QA program complies with the requirements of 10 CFR 50 Appendix B.

9.0 REFERENCES

ASTM C 42, 2004, "Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete."

ASTM C 469, 2002, "Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression."

ASTM C 496, 2004, "Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens."

ASTM C 642, 2006, "Standard Test Method for Density, Adsorption, and Voids in Hardened Concrete."

ASTM C 856, 2004, "Standard Practice for Petrographic Examination of Hardened Concrete."

ASTM C1202, 2005, "Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration."

ASTM C 1218, 2008, "Standard Test Method for Water-Soluble Chloride in Mortar and Concrete."

ASTM D 4428, 2000, "Standard Test Methods for Crosshole Seismic Testing."

ASTM D 5753, 2005, "Standard Guide for Planning and Conducting Borehole Geophysical Logging."

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10.0 TABLES

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Laboratory and Field Testing: Types and Methods	Laboratory and Field Testing Quantities
Concrete and Rock Borings, Rock Coring	9
Static Modulus of Elasticity and Poisson's Ratio for Concrete in Compression, ASTM C 469	12
Compressive Strength of Drilled Concrete Cores ASTM C 42	23
Splitting Tensile Strength of Cylindrical Concrete Specimens, ASTM C 469	18
Density, Absorption, and Voids in Hardened Concrete, ASTM C 642	18
Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration, ASTM C 1202	18
Petrographic Examination of Hardened Concrete, ASTM C 856	18
Water-Soluble Chloride Analysis, ASTM C 1218	18
Unconfined, Free-Free, Resonant Column Test, Proprietary Procedure - University of Texas at Austin	12
Crosshole Seismic Analysis, ASTM D 4428	2 sets (3 boreholes in each set)
Spectral Analysis of Surface Waves (SASW) Survey, Proprietary Procedure - University of Texas at Austin	2 SASW Surveys
P-S Suspension Logging, ASTM D 5753	2 Suspension Surveys

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Summary of Post-Demolition Geotechnical Exploration Field and Laboratory Testing Program

TABLE 1 Rev 0

Facility (1)	CNS Basemat Slab Plant Elevation(1) (ft.)	Boring Number	Elevation(2) (ft.)	Northing(2)	Easting(2)	Depth into Rock Below Existing Basemat/Fill Concrete (ft.)	Material Type and Max. Depth(3) (Measured from top of slab)			Material Type Elevation(3)				Physical and Chemical Concrete Static Tests (4)							Field and Laboratory Dynamic Testing(4)					
				(SC State Plane NAD 83)			Structural Concrete	Fill Concrete	Rock	Top Structural Concrete	Top Fill Concrete	Top of Rock	Bottom of Hole	Static Modulus	Poisson's Ratio	UCS	Tensile strength	Petro-graphy	Unit Weight	Chloride Penetra-bility	Crosshole Inclined	Crosshole horizontal	SASW	P-S Suspension	Televiewer	Unconfined Free-Free Resonant Column
WLS Unit 1 (Basemat Elevation 550.5 ft. MSL)	55+0	C-1P	544.3	1165949	1846399	111.7	4.0	8.8	121.0	544.3	540.3	535.5	423.8	X	X	X	X	X	X	X	X	X	X	X	X	X
	55+0	C-2P	544.2	1165942	1846400	28.2	3.9	6.7	34.9	544.2	540.3	537.5	509.3	--	--	X	X	X	X	X	X	X	X	--	X	--
	55+0	C-3P	544.3	1165935	1846400	29.8	4.0	6.2	36.0	544.3	540.3	538.1	508.3	X	X	X	X	X	X	X	X	X	X	--	X	X
	55+0	C-4P	544.3	1165950	1846407	26.0	4.0	9.3	35.3	544.3	540.3	535.0	509.0	X	X	X	X	X	X	X	X	X	X	--	X	X
	55+0	C-5P	544.2	1165950	1846414	34.9	4.0	25.1	60.0	544.2	540.3	519.1	484.2	--	--	X	X	X	X	X	X	X	X	--	X	--
	55+0	C-9AP	544.2	1166028	1846357	111.5	3.9	8.4	119.9	544.2	540.3	535.8	424.3	X	X	X	X	X	X	X	--	--	--	X	X	X
	55+0	C-11P	544.3	1165969	1846321	58.9	3.9	11.3	70.2	544.3	540.4	533.0	474.1	X	X	X	X	X	X	X	--	--	--	--	X	X
	55+0	C-15P	544.4	1165890	1846316	61.4	3.9	9.3	70.7	544.4	540.4	535.1	473.7	--	--	X	X	X	X	X	--	--	X	--	X	--
	55+0	C-16P	544.5	1165885	1846364	28.2	4.0	6.9	35.1	544.5	540.5	537.6	509.4	X	X	X	X	X	X	X	--	--	X	--	--	X

Notes:

1. Sample locations and plant grade elevations based on Duke Power Company Project 81, Auxiliary Building Plan EL 55+0, Reactor Building Plan EL 55+0, General Arrangment, Drawing No. P81-1040-2; and Longitudinal Section General Arrangement, Drawing No. P81-1040-10.
2. As-built survey locations.
3. Depths and elevations taken from post-demolition boring logs (Appendix A).
4. Tests completed in accordance with Lee COL Geotechincal Data Collection Plan, Rev. 5, 2008.
5. Boring notes from field exploration:
   - -- Indicates no test completed or attempted
   - X Indicates tested

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Summary of Completed Post-Demolition Geotechnical Borings and Tests for Basemat Concrete
TABLE 2 Rev 0

Core/ Boring ID	Completed Testing and Designated Core Segment Test Intervals (depths indicated in feet)						
	ASTM C856 Petrography	ASTM C1218 Water-soluble Chloride	ASTM C469 Modulus of Elasticity	ASTM C42 Compressive Strength	ASTM C496 Splitting Tensile Strength	ASTM C642 Density, Absorption and Voids	ASTM C1202 Rapid Chloride Penetration
C-1P	1S 0 - 0.95		*4S 2.27 -2.94	2S 0.95-1.6	3S 1.6-2.27	6S 3.25 -3.96	S 2.94 – 3.25
	7F 3.96 - 4.50		*9F 6.45 -7.16	10F 7.16-7.70	8F 4.50-5.0	12F 8.17 -8.65	F 7.70 – 8.17
C-2P	1S 0.00 - 1.08		- -	3S 2.17 -2.84	2S 1.08-1.74	5S 3.27 -3.94	S 2.84 – 3.27
	6F 3.94 - 4.57			7F 4.57 -5.00	8F 5.0 -5.42	10F 6.0 -6.7	F 5.42 – 6.00
C-3P	1S 0.00 - 0.55		– *2S 0.55 -1.21	3S 1.21-1.78	6S 2.80 -3.48	8S 3.72 -4.00	S 3.48 – 3.72
				4S 1.90 -2.23			
				5S 2.30 -2.70			
	9F 4.00 - 4.47		*10F 4.47 -4.90	11F 4.90 -5.32	12F 5.32 -5.74	14F 6.00 -6.27	F 5.74 – 6.00
C-4P	1S 0.00 - 1.0		*2S 1.0 -1.67	3S 1.67 -2.33	4S 2.33 -3.0	6S 3.33 -4.0	S 3.00 – 3.33
	7F 4.0 - 4.71		*8F 4.71-5.13	9F 5.20 -5.61	10F 5.61 -6.03	12F 6.50 -7.0	F 6.03 – 6.50
C-5P	1S 0.00 -1.0		- -	2S 1.0 -1.67	4S 2.33 -3.0	6S 3.35 -3.92	S 3.00 – 3.35
				3S 1.67 -2.33			
	7F/S 3.92 - 4.68			8F/S 5.85 - 6.5	9F/S 6.50 -7.05	11F/S 7.5-8.0	F 7.05 – 7.50
C-9AP	1S 0.00 -1.0		*2S 1.0 -1.67	3S 1.67 -2.33	4S 2.33 -3.0	6S 3.36 -3.92	S 3.00 – 3.36
	7F 3.92 - 4.56		*8F 4.56 -5.24	10F 5.77 -6.20	9F 5.24 -5.72	12F 6.60 -7.0	F 6.20 – 6.60
C-11P	1S 0.00 1.0		*2S 1.0 -1.67	3S 1.67 -2.33	4S 2.33 -3.0	6S 3.5 -3.92	S 3.00 – 3.50
	7F 3.92 - 4.75		12F 6.50 -6.91+	9F 5.18 -5.60	10F 5.67 -6.09	*8F 4.75 -5.18+	F 6.09 – 6.50
C-15P	1S 0.00 - 1.0		- -	2S 1.0 -1.67	4S 2.33 -3.0	6S 3.45 -3.92	S 3.00 – 3.45
				3S 1.67 -2.33			
	7F 3.92 - 4.56			8F 4.56 -4.97	10F 5.60 -6.0	11F 6.0 -6.25	F 6.25 – 6.83
				9F 4.97 -5.39			
C-16P	1S 0.0 - 1.0		*3S 1.67 -2.33	4S 2.33 -3.0	2S 1.0 -1.67	6S 3.42 -4.0	S 3.00 – 3.42
	7F 4.0 - 4.58		*8F 4.58 -5.01	9F 5.01 -5.42	10F 5.42 -5.83	12F 6.26 -6.67	F 5.83 – 6.26

Notes:

* Indicates core segments shipped by University of Texas at Austin following completion of Free-Free URC testing

\+ Core segment C-11P 8F 4.75-5.18', intended for C469, was slightly shorter than the ideal length of 5 in. The end portion of the fill concrete for C-11P, which included segment 12F 6.50-6.91', intended for C642, had extra material and could provide 5 in. of suitable core length. Therefore, segment 12F 6.50-6.91' was substituted for the C469 testing, and segment 8F 4.75-5.18' was used for C642.

- - No tests designated

Sample designation — Sample depth interval

4S 2.33 -3.0

S - Designates structural slab

F - Designates fill concrete

F/S - Dual symbol identifying the condition at the previous boring C-5 in which a layer of steel reinforcement was encountered at approximately 21.5 ft. depth, but below approximately 17.5 ft. of fill concrete.

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Summary of Post-Demolition Physical and Chemical Tests for Concrete

TABLE 3 Rev 0

	Rock at Fill Concrete Interface			Rock Below Contact with Fill Concrete		
Boring	Weathering	Strength	Notes	Weathering	Strength	Notes
C-1P	Fresh	R4 - Strong	- -	Fresh	R4 - R5 Strong - Very Strong	- -
C-2P	Fresh	R4 - Strong	- -	Fresh	R4 - Strong	- -
C-3P	Fresh	R4 - Strong	minor shear fabric	Fresh	R4 - Strong	minor shear fabric
C-4P	Fresh	R4 - Strong	- -	Fresh	R4 - Strong	- -
C-5P	Fresh	R4 - Strong	- -	Fresh	R4 - Strong	moderate shear fabric
C-9AP	Fresh	R4 - Strong	- -	Fresh	R4 - R5 Strong - Very Strong	fractured
C-11P	Slightly to Moderately Weathered	R3-R4 Medium Strong - Strong	minor to moderate shear fabric	Fresh	R4 - R5 Strong - Very Strong	fractured
C-15P	Fresh	R4 - R5 Strong - Very Strong	- -	Fresh to Slightly Weathered	R3 - R5 Medium Strong - Very Strong	localized weathering zones
C-16P	Fresh	R4 - Strong	minor shear fabric	Fresh to Moderately Weathered	R3 - R5 Medium Strong - Very Strong	minor to moderate shear fabric

Explanation

- - No notable features

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Summary of Post-Demolition Visual Observations from Boring Logs

TABLE 4 Rev 0

Concrete Type and Core/ Boring ID	Test Type and Method					
	ASTM C469		ASTM C42	ASTM C496	ASTM C642	ASTM C1202
	Modulus of Elasticity (ksi)	Poisson's Ratio	Compressive Strength (psi)	Tensile Strength (psi)	Unit Weight (pcf)	Chloride Penetrability [1]
Structural						
C-1P	4,310	0.19	8,760	840	147.9	high
C-2P	--	--	8,720	925	150.2	high
C-3P	4,630	0.21	9,610 9,000 8,440	1,015	151.7	low
C-4P	3,690	0.16	8,300	720	150.0	high
C-5P	--	--	7,960 8,190	880	146.1	high
C-9AP	3,900	0.18	8,510	760	149.0	high
C-11P	3,510	0.19	7,320	700	146.4	high
C-15P	--	--	8,340 9,580	940	143.7	high
C-16P	3,870	0.19	8,330	810	145.1	high
Fill						
C-1P	3,130	0.17	7,070	1,180	147.8	high
C-2P	--	--	6,530	1,080	146.0	high
C-3P	3,270	0.27	6,770	1,220	147.4	high
C-4P	3,350	0.20	6,780	975	146.4	high
C-5P	--	--	4,870	615	144.8	high
C-9AP	3,820	0.19	8,150	1,235	147.7	high
C-11P	2,970	0.20	6,080	1,115	147.1	high
C-15P	--	--	4,110 4,010	760	145.4	high high
C-16P	3,160	0.02	5,990	1,165	145.9	high

Notes:

-- Indicates that no segment was tested.

1 Rating per Table 1 in ASTM C1202-05.

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Summary of Post-Demolition Physical and Chemical Tests and Results for Concrete

TABLE 5 Rev 0

WLS Sample No.	Free-Free Spec. No .	UT Sample ID	Borehole	Concrete Type	Depth (ft.)	Total Unit Weight (pcf)	V_c (fps)	E_{max} (psf)	Dc (%)	V_s (fps)	G_{max} (psf)	D_s (%)	V_p (fps)	M_{max} (psf)	Poisson's Ratio (ν)		
															(MG)(1)	(ME)(2)	(EG)(3)
1	FrF1	UTA-64-1	C-1P	Structural	2.27 - 2.94	140.9	**13,114**	7.52E+08	0.40	**8,456**	3.13E+08	0.34	**13,666**	8.17E+08	**0.19**	**0.18**	**0.20**
2	FrF3	UTA-64-3	C-3P	Structural	0.55 - 1.21	140.4	**13,773**	8.27E+08	0.35	**8,773**	3.36E+08	0.32	**14,517**	9.19E+08	**0.21**	**0.20**	**0.23**
3	FrF5	UTA-64-5	C-4P	Structural	1.0 - 1.67	142.8	**12,521**	6.95E+08	0.37	**8,044**	2.87E+08	0.32	**13,190**	7.71E+08	**0.20**	**0.20**	**0.21**
4	FrF7	UTA-64-7	C-9AP	Structural	1.0 - 1.67	142.1	**12,798**	7.23E+08	0.36	**8,255**	3.01E+08	0.36	**13,291**	7.79E+08	**0.19**	**0.17**	**0.20**
5	FrF9	UTA-64-9	C-11P	Structural	1.0 - 1.67	142.2	**11,880**	6.23E+08	0.36	**7,837**	2.71E+08	0.38	**12,355**	6.74E+08	**0.16**	**0.18**	**0.15**
6	FrF11	UTA-64-11	C-16P	Structural	1.67 - 2.33	142.3	**12,583**	7.00E+08	0.37	**8,127**	2.92E+08	0.36	**13,314**	7.83E+08	**0.20**	**0.21**	**0.20**
7	FrF2	UTA-64-2	C-1P	Fill	6.45 - 7.16	137.4	**12,464**	6.63E+08	0.47	**8,079**	2.79E+08	0.63	**12,969**	7.18E+08	**0.18**	**0.18**	**0.19**
8	FrF4	UTA-64-4	C-3P	Fill	4.47 - 4.90	139.0	**12,325**	6.56E+08	0.62	**7,846**	2.66E+08	0.51	**12,757**	7.03E+08	**0.20**	**0.17**	**0.23**
9	FrF6	UTA-64-6	C-4P	Fill	4.71 - 5.13	141.1	**11,701**	6.00E+08	0.67	**7,644**	2.56E+08	0.50	**12,146**	6.47E+08	**0.17**	**0.17**	**0.17**
10	FrF8	UTA-64-8	C-9AP	Fill	4.56 - 5.24	143.5	**12,667**	7.15E+08	0.37	**8,242**	3.03E+08	0.56	**13,074**	7.62E+08	**0.17**	**0.16**	**0.18**
11	FrF10	UTA-64-10	C-11P	Fill	4.75 - 5.18	141.4	**12,242**	6.58E+08	0.66	**7,919**	2.75E+08	0.59	**12,810**	7.20E+08	**0.19**	**0.19**	**0.19**
12	FrF12	UTA-64-12	C-16P	Fill	4.58 - 5.01	137.5	**12,377**	6.54E+08	0.56	**7,962**	2.71E+08	1.25	**12,932**	7.14E+08	**0.19**	**0.19**	**0.21**

1) Poisson's Ratio derived from: $$\nu_{MG} = \frac{M_{max} - 2G_{max}}{2\,(M_{max} - G_{max})}$$

2) Poisson's Ratio derived from: $$\nu_{ME} = \frac{1}{4M_{max}}\left(-M_{max} + E_{max} + \sqrt{9M_{max}^2 - 10M_{max}E_{max} + E_{max}^2}\right)$$

3) Poisson's Ratio derived from: $$\nu_{EG} = \frac{E_{max} - 2G_{max}}{2G_{max}}$$

Notes:

- V_c Unconstrained Compression Wave Velocity
- E_{max} Young's Modulus
- Dc Material Damping Ratio in Compression
- V_s Shear Wave Velocity
- G_{max} Shear Modulus
- D_s Material Damping Ratio in Shear
- V_p Constrained Compression Wave Velocity
- M_{max} Constrained Compression Modulus

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Summary of Post-Demolition
Free-Free Resonant Column and
Direct-Arrival Test for Concrete

TABLE 6 Rev 0

Parameter	Unit	Unconfined Resonant Column (URC) Measurements			Values in Reference[1]
		Average	Minimum	Maximum	
γ_t	lb/ft^3	140.9	137.4	143.5	140 - 150 for plain concrete (PC)
V_C	ft/sec	12,537	11,701	13,773	11996 for PC with high strength
E_{max}	lb/ft^2	6.89E+08	6.00E+08	8.27E+08	6.50E+08 for PC with high strength
D_C	%	0.46	0.35	0.67	n/a
V_S	ft/sec	8,099	7,644	8,773	7743 to 8088 for PC with high strength
G_{max}	lb/ft^2	2.87E+08	2.56E+08	3.36E+08	2.7E+08 to 2.9E+08 for PC with high strength
D_S	%	0.51	0.32	1.25	n/a
V_P	ft/sec	13,085	12,146	14,517	12131 to 12645 for PC with high strength
M_{max}	lb/ft^2	7.51E+08	6.47E+08	9.19E+08	6.6E+08 to 7.2E+08 for PC with high strength
ν	(MG)[2]	0.19	0.16	0.21	0.1 to 0.3 for plain normal concrete
	(ME)[3]	0.18	0.16	0.21	
	(EG)[4]	0.2	0.15	0.23	

Notes:

1) Roy R. Craig, Mechanics of Material, John Wiley & Sons, Inc., New York, NY, 2000; V.M. Malhotra and N.J. Carino, Handbook on Nondestructive Testing of Concrete, CRC Press, Inc., Boca Raton, Florida, 1991.

2) Poisson's Ratio derived from: $\nu_{MG} = \dfrac{M_{max} - 2G_{max}}{2\,(M_{max} - G_{max})}$

3) Poisson's Ratio derived from: $\nu_{ME} = \dfrac{1}{4M_{max}}\left(-M_{max} + E_{max} + \sqrt{9M_{max}^2 - 10M_{max}E_{max} + E_{max}^2}\right)$

4) Poisson's Ratio derived from: $\nu_{EG} = \dfrac{E_{max} - 2G_{max}}{2G_{max}}$

Explanation

γ_t Total unit weight
V_c Unconstrained Compression Wave Velocity
E_{max} Young's Modulus
Dc Material Damping Ratio in Compression
V_s Shear Wave Velocity
G_{max} Shear Modulus
D_s Material Damping Ratio in Shear
V_p Constrained Compression Wave Velocity
M_{max} Constrained Compression Modulus

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Summary of Post-Demolition Laboratory and Field Average Dynamic Analysis Results Compared to Published Values

TABLE 7 Rev 0

Depth at Midpoint between Receivers (ft.)	Velocity V_s (ft/s)	Velocity V_p (ft/s)	Poisson's Ratio
4.9	7660	16260	0.36
6.6	8770	15500	0.26
8.2	6870	13890	0.34
9.8	6630	13610	0.34
11.5	8550	18020	0.35
13.1	9730	17540	0.28
14.8	10340	17090	0.21
16.4	7490	14490	0.32
18.0	5950	14810	0.40
19.7	6060	13890	0.38
21.3	6470	15150	0.39
23.0	7170	15150	0.36
24.6	7250	15870	0.37
26.3	8550	15500	0.28
27.9	8600	16670	0.32
29.5	9660	16670	0.25
31.2	9390	17540	0.30
32.8	9730	16670	0.24
34.5	10670	18020	0.23
36.1	8280	18020	0.37
37.7	9260	17540	0.31
39.4	9590	16670	0.25
41.0	8770	16260	0.29
42.7	9730	16670	0.24
44.3	9880	18520	0.30
45.9	9520	17540	0.29
47.6	10260	18520	0.28
49.2	10100	18520	0.29
50.9	8490	19050	0.38
52.5	8130	16670	0.34
54.1	11020	19050	0.25
55.8	9260	19050	0.35
57.4	9800	19050	0.32
59.1	10100	17540	0.25
60.7	11110	18520	0.22
62.3	9660	18020	0.30
64.0	10260	16260	0.17
65.6	9320	16670	0.27
67.3	9950	17090	0.24
68.9	9390	17540	0.30
70.5	8180	17090	0.35
72.2	9320	18020	0.32
73.8	10030	18520	0.29
75.5	9460	19050	0.34
77.1	9590	18020	0.30
79.1	9320	18520	0.33
80.4	9070	18020	0.33
82.0	9660	18520	0.31
84.0	10840	20200	0.30
85.3	10580	19050	0.28
86.9	10260	18520	0.28
88.6	9880	18520	0.30
90.2	10100	18520	0.29
91.9	10100	17540	0.25
93.5	9950	18520	0.30
95.1	9950	17090	0.24
96.8	10030	17540	0.26
98.4	9950	18520	0.30
100.1	10260	19050	0.30
101.7	10500	17540	0.22
103.4	10580	18020	0.24
105.0	10030	18020	0.28
106.6	11020	18520	0.23

Note: - - Signifies no data available at that particular depth interval.

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Summary of Post-Demolition P-S
Suspension Survey Data - Borehole C-1P

TABLE 8 Rev 0

Depth at Midpoint between Receivers	Velocity		Poisson's Ratio	Depth at Midpoint between Receivers	Velocity		Poisson's Ratio
	V_s	V_p			V_s	V_p	
(ft.)	(ft/s)	(ft/s)		(ft.)	(ft/s)	(ft/s)	
4.9	9010	18020	0.33	65.6	8130	16670	0.34
6.6	10930	18020	0.21	67.3	8600	18520	0.36
8.2	9390	16670	0.27	68.9	9010	18520	0.34
9.8	9730	17540	0.28	70.5	9520	18020	0.31
11.5	9200	17540	0.31	72.2	10100	17090	0.23
13.1	11110	17090	0.13	73.8	8600	17090	0.33
14.8	10260	17090	0.22	75.5	9390	18520	0.33
16.4	7290	14810	0.34	77.1	10030	17090	0.24
18.0	7580	15500	0.34	78.7	9590	16260	0.23
19.7	7170	17540	0.40	80.4	9070	19610	0.36
21.3	3920	13070	0.45	82.0	9460	19050	0.34
23.0	9260	15500	0.22	83.7	10340	17090	0.21
24.6	6500	16260	0.40	85.3	10420	17540	0.23
26.3	5600	16670	0.44	86.9	10420	19050	0.29
27.9	9390	16670	0.27	88.6	10420	18520	0.27
29.5	8390	18020	0.36	90.2	10260	18020	0.26
31.2	7370	13610	0.29	91.9	10100	18020	0.27
32.8	8600	15150	0.26	93.5	10180	17090	0.23
34.5	8280	17090	0.35	95.1	10260	18020	0.26
36.1	9520	17540	0.29	96.8	10100	18520	0.29
37.7	9130	16260	0.27	98.4	10100	18020	0.27
39.4	8230	16260	0.33	100.1	10420	18020	0.25
41.0	7210	15870	0.37	101.7	10420	18520	0.27
42.7	9730	17540	0.28	103.4	10340	18520	0.27
44.3	9320	17090	0.29	105.0	10420	18020	0.25
45.9	8130	14810	0.28	106.6	10260	18520	0.28
47.6	8180	15500	0.31				
49.2	10420	17540	0.23				
50.9	9520	17540	0.29				
52.5	10840	18520	0.24				
54.1	9390	16670	0.27				
55.8	9070	16670	0.29				
57.4	8180	15150	0.29				
59.1	8440	17090	0.34				
60.7	8330	17090	0.34				
62.3	8440	15150	0.28				
64.0	6870	15500	0.38				

Note: - - Signifies no data available at that particular depth interval.

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Summary of Post-Demolition P-S
Suspension Survey Data - Borehole C-9AP

TABLE 9 Rev 0

Summary of Post-Demolition Shear-Wave Velocities by Crosshole Set (Horiztonal Wave Paths)

C-1P to C-2P		C-2P to C-3P		C-1P to C-2P and C-2P to C-3P	C-4P to C-1P		C-5P to C-4P		C-5P to C-4P and C-4P to C-1P	Average Post-Demolition Velocities[2]
Velocity[1]	Average Velocity[2]	Velocity[1]	Average Velocity[2]	Average Velocity[2]	Velocity[1]	Average Velocity[2]	Velocity[1]	Average Velocity[2]	Average Velocity[2]	
fps	fps	fps	fps	fps	fps	fps	fps	fps	fps	fps
6360		6570			8040		7050			Strucutral Concrete
6420	6610	6250	6430	6520	7280	7560	6710	6810	7190	
7120		6460			7020		6710			6855
6530		- -	- -		7890		6770			
7410		6940			6780		6900			
7330	7520	7800	7370	7450	7170	7320	7040	7210	7270	Fill Concrete
7820		- -	- -		7240		6970			7360
- -	- -	- -	- -		8090		7640			
7330		7970			- -		7480			
7990		8140			7260		- -			
7330		7010			6940		- -			
7810		9120			7140		- -			
8670		9350			7420		- -			
8890		9120			7640		- -			
9000		9350			6600		- -			
8670		8910			7030		- -			
8080		8510			7660		- -			Rock
8460	7900	8330	8170	8040	7820	7300	- -	7670	7490	
7890		8610			6680		- -			7765
5780		6420			5620		- -			
6340		6890			6020		- -			
6960		6480			7340		- -			
8160		7730			7950		7600			
8060		8140			7730		7450			
8870		8700			8310		7540			
- -[3]		- -[3]			8890		8060			
- -[3]		- -[3]			- -		- -			

Notes:

1. Measured velocity from field crosshole testing
2. Average velocities calculated by material type.
3. Shear travel velocities could not be inteptreted from downward impact at depths of 32 and 34 ft.

- - No data (wave path through different materials)

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Summary of Post-Demolition
Crosshole Shear-Wave Velocities (V_s)

TABLE 10 Rev 0

Average Post-Demolition Compressional-Wave Velocities by Crosshole Set (Horiztonal Wave Paths)

C-1P to C-2P		C-2P to C-3P		C-1P to C-2P and C-2P to C-3P	C-5P to C-4P		C-4P to C-1P		C-5P to C-4P and C-4P to C-1P	Average Post-Demolition Velocities[2]
Velocity[1]	Average Velocity[2]	Velocity[1]	Average Velocity[2]	Average Velocity[2]	Velocity[1]	Average Velocity[2]	Velocity[1]	Average Velocity[2]	Average Velocity[2]	
fps	fps	fps	fps	fps	fps	fps	fps	fps	fps	fps
14700		14000			13960		15280			
16390	15790	15120	14750	15270	14520	14630	15290	15380	15010	Strucutral Concrete 15140
15660		15120			15810		15610			
16380		--	--		14230		15310			
14390		14540			14220		15030			
16750	15570	16440	15490	15530	13670	14350	15040	15130	14740	Fill Concrete 15135
18000[3]		--	--		14510		15670			
--	--	--	--		14210		14770			
20040	20680	19920			15120		--			
21240		19920			-		18770			
21240		19920			-		17510			
18970		19930			-		20290			
21890		20470			-		21430			
21230		20470			-		20320			
21230		19930			-		20330			
21880		19420			-		20350			
21220		20470			-		19840			
21230		20480	19860	20270	-	20170	20930	19810	19990	Rock 20130
21880		21050			-		19870			
21220		20480			-		18920			
20600		19430			-		18500			
20010		19940			-		18980			
20590		20480			19830		19480			
18940		18930			19860		20010			
20010		19410			21060		20560			
20000		19400			19930		20580			
19460		17190			-		-			

Notes:
1. Measured velocity from field crosshole testing
2. Average velocities calculated by material type.
3. Possibly a refracted wave and deleted from the calculation of average wave velocity

-- = No data (travel path through different materials)

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Summary of Post-Demolition Crosshole Compressional-Wave Velocities (V_P)

TABLE 11 Rev 0

Post-Demolition SASW Testing on Basemat Slab (CNS Plant Elevation 55+0)

Site #1 (S-1515) - Profile Parameters Used to Develop Theoretical Dispersion Curve

Layer No .	Thickness, ft	Depth to Top of Layer, ft	P-Wave Velocity, ft/s	S-Wave Velocity , ft/s	Assumed Poisson' s Ratio	Assumed Total Unit Weight, pcf
1	0.18	0	15715	8400	0.3	140
2	0.32	0.18	14966	8000	0.3	140
3	0.5	0.5	14405	7700	0.3	140
4	1	1	13844	7400	0.3	140
5	2	2	13282	7100	0.3	140
6	6	4	11786	6300	0.3	140
7	10	10	12490	6000	0.35	135
8	Half Space*	20	16028.8	7700	0.35	135

*Layer below maximum depth of the Vs Profile

Site #2 (S-1516) - Profile Parameters Used to Develop Theoretical Dispersion Curve

Layer No .	Thickness, ft	Depth to Top of Layer, ft	P-Wave Velocity, ft/s	S-Wave Velocity, ft/s	Assumed Poisson' s Ratio	Assumed Total Unit Weight, pcf
1	0.1	0	15715	8400	0.3	140
2	0.4	0.1	15340	8200	0.3	140
3	1.5	0.5	14779	7900	0.3	140
4	2	2	13657	7300	0.3	140
5	1	4	13095	7000	0.3	140
6	5	5	11224	6000	0.3	140
7	29*	10	12073	5800	0.35	135
8	Half Space*	39	13530	6500	0.35	135

*Layer below maximum depth of the Vs Profile

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Summary of Post-Demolition Profile Parameters for Theoretical Dispersion Curves - SASW
TABLE 12 Rev 0

	Test Type and Concrete Parameter		C-1[1]	C-1P[2]	C-2[1]	C-2P[2]	C-3[1]	C-3P[2]	C-4[1]	C-4P[2]	C-5[1]	C-5P[2]
STRUCTURAL CONCRETE	ASTM C469	Modulus (ksi)	4,060	4,310	3,570	- -	3,870	4,630	3,790	3,690	3,500	- -
		Poisson's Ratio (ν)	0.19	0.19	0.18	- -	0.20	0.21	0.19	0.16	0.18	- -
	ASTM C42	Compressive Strength (psi)	7,700	8,760	8,960	8,720	9,320	9,610 9,000 8,440	9,870	8,300	8,720	7,960 8,190
	ASTM C496	Tensile Strength (psi)	620	840	650	925	600	1,015	630	720	690	880
	ASTM C642	Unit Weight (pcf)	148.7	147.9	147.8	150.2	147	151.7	146.3	150.0	149.1	146.1
	ASTM C1202	Chloride Penetrability	high	high	moderate	high	moderate	low	high	high	high	high
FILL CONCRETE	ASTM C469	Modulus (ksi)	3,590	3,130	3,370	- -	3,510	3,270	2,410 2,010	3,350	2,550	- -
		ν	0.17	0.17	0.18	- -	0.19	0.27	0.15 0.22	0.20	0.22	- -
	ASTM C42	Compressive Strength (psi)	7,520	7,070	7,250	6,530	7,360	6,770	4,130 4,120	6,780	6,760	4,870
	ASTM C496	Tensile Strength (psi)	580	1,180	560	1,080	540	1,220	390 - -	975	480	615
	ASTM C642	Unit Weight (pcf)	146.2	147.8	147.1	146.0	146.7	147.4	144.2 143.4	146.4	143.8	144.8
	ASTM C1202	Chloride Penetrability	high	high	high	high	high	high	high	high	high	high

Notes:
1. Source data for pre-demolition borings from Enclosure No. 1 (Duke Energy, Carolinas LLC, 2008).
2. Source data for post-demolition borings from this investigation.
3. Percent difference is the ratio of the difference between post- and pre-demolition value to pre-demolition value.
4. - - = No test completed

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Comparison of Pre- and
Post-Demolition Physical and Chemical
Test Results (Sheet 1 of 3)

TABLE 13 Rev 0

	Test Type and Concrete Parameter		C-9A[1]	C-9AP[2]	C-11[1]	C-11P[2]	C-12[1]	C-15[1]	C-15P[2]
STRUCTURAL CONCRETE	ASTM C469	Modulus (ksi)	3,970	3,900	3,650	3,510	3,170	3,900	- -
		ν	0.19	0.18	0.18	0.19	0.17	0.20	- -
	ASTM C42	Compressive Strength (psi)	9,060	8,510	6,310	7,320	6,950	8,690	8,340 9,580
	ASTM C496	Tensile Strength (psi)	400	760	- -	700	520	620	940
	ASTM C642	Unit Weight (pcf)	146.8	149.0	147.7	146.4	145.8	147.1	143.7
	ASTM C1202	Chloride Penetrability	high	high	high	high	high	moderate	high
FILL CONCRETE	ASTM C469	Modulus (ksi)	3,710	3,820	3,600	2,970	3,260	2,720	- -
		ν	0.17	0.19	0.16	0.20	0.18	0.17	- -
	ASTM C42	Compressive Strength (psi)	7,750	8,150	5,480	6,080	6,410	4,060	4,110 4,010
	ASTM C496	Tensile Strength (psi)	580	1,235	560	1,115	570	460	760
	ASTM C642	Unit Weight (pcf)	149.3	147.7	147.3	147.1	147.2	144.4	145.4
	ASTM C1202	Chloride Penetrability	high	high	high	high	high	high	high

Notes:
1. Source data for pre-demolition borings from Enclosure No. 1 (Duke Energy, Carolinas LLC, 2008).
2. Source data for post-demolition borings from this investigation.
3. Percent difference is the ratio of the difference between post- and pre-demolition value to pre-demolition value.
4. - - = No test completed

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Comparison of Pre- and Post-Demolition
Physical and Chemical Test Results
(Sheet 2 of 3)
TABLE 13 Rev 0

	Test Type and Concrete Parameter		C-16[1]	C-16P[2]	C-18[1]	C-19A[1]	C-20[1]	C-21[1]	Pre-Demolition		Post-Demolition		% Difference
									Average	Standard Deviation	Average	Standard Deviation	
STRUCTURAL CONCRETE	ASTM C469	Modulus (ksi)	3,820	3,870	4,350	4,070	3,510	3,200	3,745	334	3,985	413	6%
		ν	0.18	0.19	0.19	0.21	0.19	0.18	0.19	0.01	0.19	0.02	-1%
	ASTM C42	Compressive Strength (psi)	9,230	8,330	10,000	10,030	10,550	10,330	8,980	1,254	8,543	620	-5%
	ASTM C496	Tensile Strength (psi)	590	810	630	650	610	700	608	77	843	106	39%
	ASTM C642	Unit Weight (pcf)	144.6	145.1	151.2	149	149.9	144.8	147.6	1.9	147.8	2.7	0.2%
	ASTM C1202	Chloride Penetrability	moderate	high	high	high	high	high	high	N/A	high	N/A	N/A
FILL CONCRETE	ASTM C469	Modulus (ksi)	3,330	3,160	3,420	3,620	- -	2,430	3,109	563	3,283	1,269	6%
		ν	0.16	0.20	0.16	0.19	- -	0.24	0.18	0.03	0.21	0.08	12%
	ASTM C42	Compressive Strength (psi)	7,240	5,990	6,650	6,900	- -	- -	6,279	1,365	6,036	1,336	-4%
	ASTM C496	Tensile Strength (psi)	—	1,165	580	510	- -	- -	528	62	1,038	217	97%
	ASTM C642	Unit Weight (pcf)	148.5	145.9	146.3	147.7	146.8	- -	146.4	1.8	146.5	1.1	0.1%
	ASTM C1202	Chloride Penetrability	high	high	high	high	high	- -	high	N/A	high	N/A	N/A

Notes:
1. Source data for pre-demolition borings from Enclosure No. 1 (Duke Energy, Carolinas LLC, 2008).
2. Source data for post-demolition borings from this investigation.
3. Percent difference is the ratio of the difference between post- and pre-demolition value to pre-demolition value.
4. - - = No test completed

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Comparison of Pre- and Post-Demolition
Physical and Chemical Test Results
(Sheet 3 of 3)
TABLE 13 Rev 0

Parameter	Unit	Pre-Demolition Results			Post-Demolition Results		
		Average	Minimum	Maximum	Average	Minimum	Maximum
γ_t	lb/ft^3	141.1	135.9	142.8	140.9	137.4	143.5
V_C	ft/sec	12915	11491	13229	12537	11701	13773
E_{max}	lb/ft^2	7.32E+08	5.57E+08	7.76E+08	6.89E+08	6.00E+08	8.27E+08
D_C	%	0.35	0.32	0.40	0.46	0.35	0.67
V_S	ft/sec	8191	7311	8423	8099	7644	8773
G_{max}	lb/ft^2	2.95E+08	2.26E+08	3.14E+08	2.87E+08	2.56E+08	3.36E+08
D_S	%	0.34	0.31	0.38	0.51	0.32	1.25
V_P	ft/sec	13702	12413	14118	13085	12146	14517
M_{max}	lb/ft^2	8.24E+08	6.50E+08	8.81E+08	7.51E+08	6.47E+08	9.19E+08
ν	(MG)[1]	0.22	0.20	0.24	0.19	0.16	0.21
	(ME)[2]	0.21	0.18	0.23	0.18	0.16	0.21
	(EG)[3]	0.24	0.23	0.27	0.20	0.15	0.23

1) Poisson's Ratio derived from: $\nu_{MG} = \dfrac{M_{max} - 2G_{max}}{2\,(M_{max} - G_{max})}$

2) Poisson's Ratio derived from: $\nu_{ME} = \dfrac{1}{4M_{max}}\left(-M_{max} + E_{max} + \sqrt{9M_{max}^2 - 10M_{max}E_{max} + E_{max}^2}\right)$

3) Poisson's Ratio derived from: $\nu_{EG} = \dfrac{E_{max} - 2G_{max}}{2G_{max}}$

Explanation

- γ_t Total unit weight
- V_c Unconstrained Compression Wave Velocity
- E_{max} Young's Modulus
- Dc Material Damping Ratio in Compression
- V_s Shear Wave Velocity
- G_{max} Shear Modulus
- D_s Material Damping Ratio in Shear
- V_p Constrained Compression Wave Velocity
- M_{max} Constrained Compression Modulus

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Comparison of Pre- and Post-Demolition Free-Free Resonant Column and Direct-Arrival Test for Concrete
TABLE 14 Rev 0

Material Type	Pre-Demolition Average Seismic Velocities (1)				Post-Demolition Average Seismic Velocities (2)					
	Crosshole		SASW		Crosshole (2)		P-S Suspension		SASW	
	Vs	Vp	Vs	Vp	Vs	Vp	Vs	Vp	Vs	Vp
Structural Concrete	6,990	14,975	7,900	14,780	6,855	15,140	- -	- -	7,835	14,660
Fill Concrete	7,525	14,080	7,100	13,280	7,360	15,135	8,770	16,390	6,400	11,970
Rock	6,625	18,360	7,350	15,300	7,765	20,130	9,245	17,320	6,500	13,530

Notes:
1. Pre-demolition results from Enclosure No. 1, Rev. 0 (Duke Energy Carolinas LLC, 2008).
2. Pre-demolition results from this investigation.
3. All values are in fps.
4. - - = No data.

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NUCLEAR STATION UNITS 1 & 2

Summary of Pre- and Post-Demolition
Average Field Seismic Velocities

TABLE 15 Rev 0

11.0 FIGURES

Figure 1 Site Features of Lee Nuclear Station Unit 1 & 2 Area

Figure 2 Completed Post-Demolition Test Locations Unit 1 Concrete Basemat

Figure 3 Typical Post-Demolition Basemat Rock Coring Setup

Figure 4 Typical Post-Demolition Concrete Basemat and Rock Core Samples

Figure 5 General Test Setup Configuration for Unconfined, Free-Free, Resonant Column Testing

Figure 6 Typical Post-Demolition P-S Suspension Logging System and Field Setup

Figure 7 Borehole Configuration Used in Post-Demolition Crosshole Testing

Figure 8 Typical Post-Demolition Crosshole Test Configuration

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Figure 10 Inclined Travel Paths Used in Post-Demolition Crosshole Testing Between Boreholes C-1P, C-2P, and C-3P

Figure 11 Illustration of Surface Waves with Different Wavelengths Sampling Different Materials in a Layered System

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Figure 13 Typical Post-Demolition SASW Survey Field Testing Set-Up

Figure 14 Representative Void Content Identification For Structural and Fill Concrete, Borings C-1P and C-15P

Figure 15 Representative Thin-Section Photomicrographs of Paste and Core Petrography for Structural Concrete, Boring C-2P

Figure 16 Representative Thin-Section Photomicrographs of Paste and Core Petrography for Fill Concrete, Boring C-11P

Figure 17 Representative ASR-Reactive Chert Aggregate Particles in Structural and Fill Concrete, Borings C-15P and C-11P

Figure 18 Representative Thin-Section Photomicrographs of Carbonate and Core Petrography for Structural Concrete, Boring C-2P

Figure 19 Post-Demolition Optical and Acoustic Televiewer Logs – C-1P

Figure 20 Post-Demolition Optical and Acoustic Televiewer Logs – C-9AP

Figure 21 Post-Demolition Optical and Acoustic Televiewer Logs – C-11P

Figure 22 Post-Demolition Optical and Acoustic Televiewer Logs – C-15P

Figure 23 Comparison of Post-Demolition Shear-Wave Velocity (V_S) Profiles for Concrete and Rock, Crosshole, P-S Suspension, and SASW Testing

Figure 24 Pre- and Post-Demolition Crosshole, SASW, P-S Suspension, and Free-Free Lab Data Velocities - C-1P to C-3P

Figure 25 Pre- and Post-Demolition Crosshole, SASW, P-S Suspension, and Free-Free Lab Data Velocities - C-1P to C-5P

Figure 26 Summary of Laboratory Shear Wave Velocity (V_S) Measured Using Free-Free URC Versus Compressive Strength for Concrete

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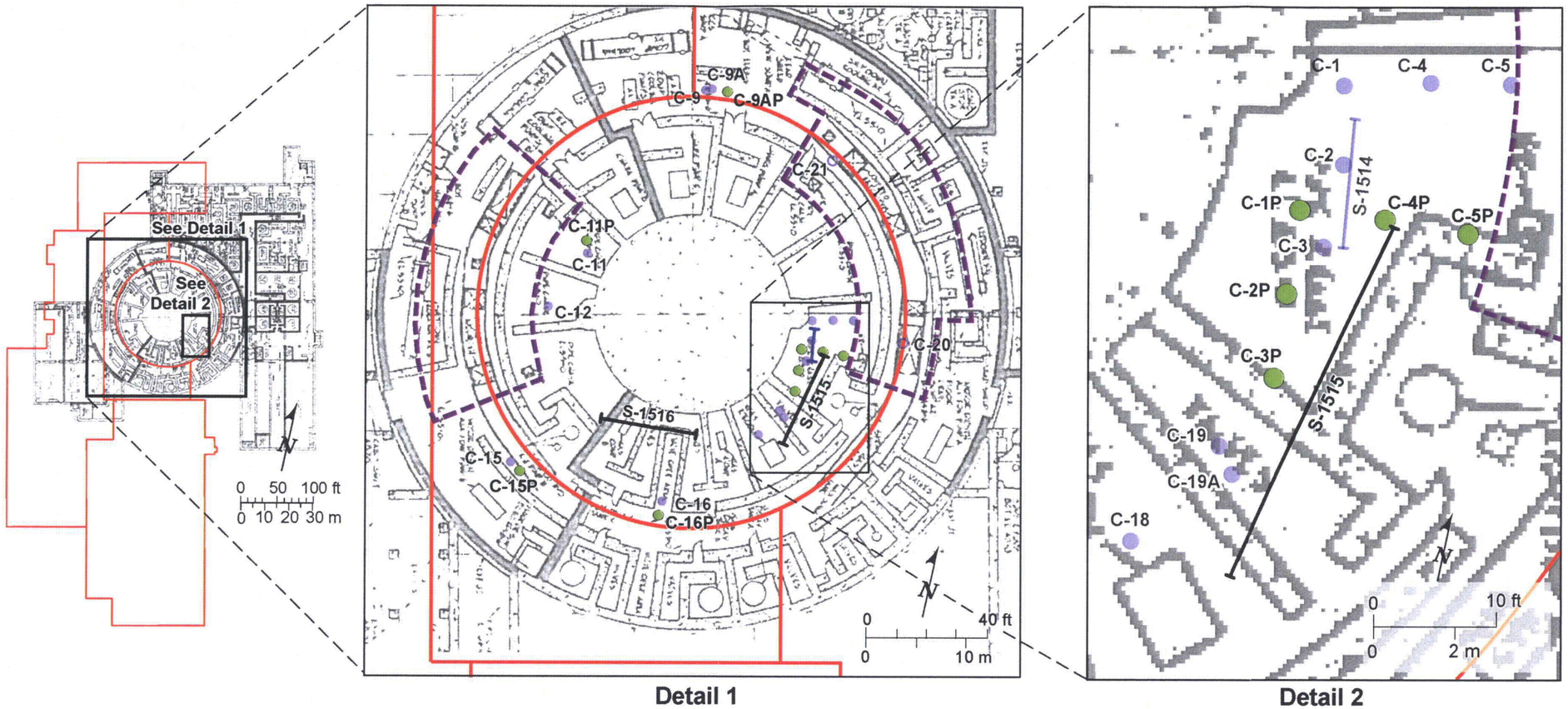
NUCLEAR STATION UNITS 1 & 2

Site Features of Lee Nuclear
Station Units 1 & 2 Area

FIGURE 1 Rev 0



Detail 1

Detail 2

Explanation

C-1P	Post-demolition core location (CNS plant elev. 55 + 0)
C-20	Pre-demolition core location (CNS plant elev. 37 + 0)
C-9	Pre-demolition core location (CNS plant elev. 55 + 0)
S-1514	Pre-demolition SASW array
S-1516	Post-demolition SASW array
	Lower room (CNS plant elevation 37 + 0)
	AP1000 power block footprint

Sources:
1. PSAR Figure 2.4.13-1, Reactor and Auxiliary Buildings, Ground Water Control, Cherokee Nuclear Station, Duke Power Company, 1974.
2. AP1000 Site and Facility Layout, 124029-CVL-SP.dwg, Shaw Stone & Webster, Inc., September, 2007.

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Completed Post-Demolition Test Locations - Unit 1 Concrete Basemat

FIGURE 2 Rev 0

A) Typical Diedrich 120 rig setup for HQ drilling (Boring C-16P).

B) Typical CME-550X setup and drilling (Boring C-9AP).

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NUCLEAR STATION UNITS 1 & 2

Typical Post-Demolition Basemat
Rock Coring Setup

FIGURE 3 Rev 0

A) Typical concrete core, Boring C-11P.

B) Typical Rock Core, Boring C-3P.

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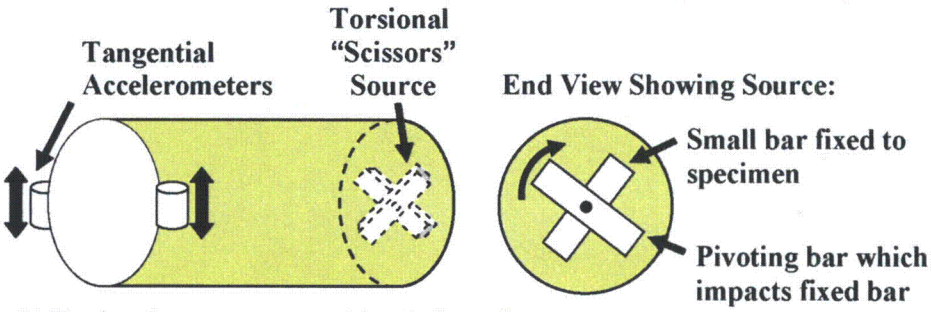
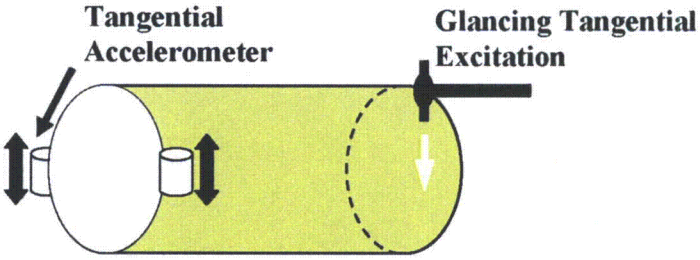
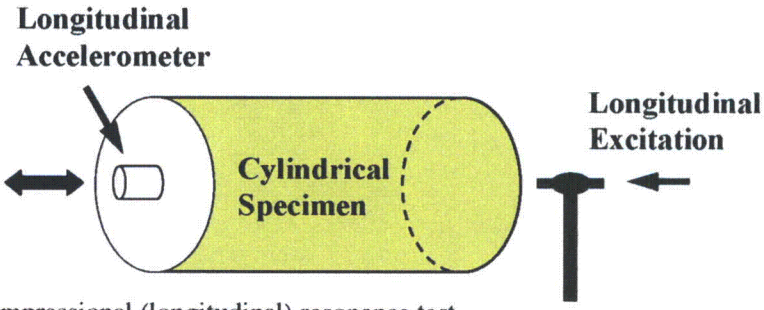
Typical Post-Demolition Concrete Basemat and Rock Core Samples	
FIGURE 4	Rev 0



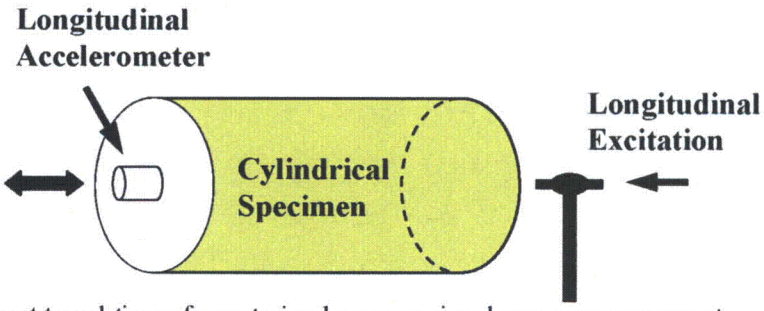
A) Torsional resonance test with a "scissors" source



B) Torsional resonance test with a tangential impact



C) Compressional (longitudinal) resonance test



D) Direct travel-time of constrained compressional waves measurement

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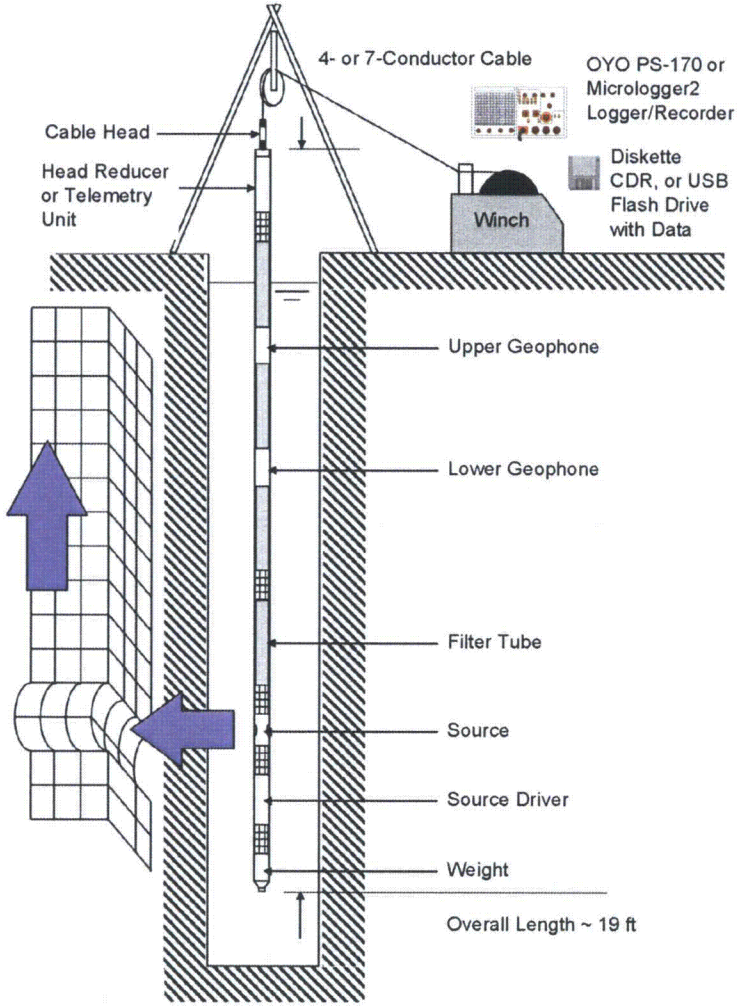
NUCLEAR STATION UNITS 1 & 2

General Test Setup Configuration
for Unconfined, Free-Free,
Resonant Column Testing
FIGURE 5 Rev 0



A) Post-demolition P-S Suspension Logging System.

B) P-S suspension field setup with instrument lowered into borehole for testing. Top of cable head visible at concrete surface.

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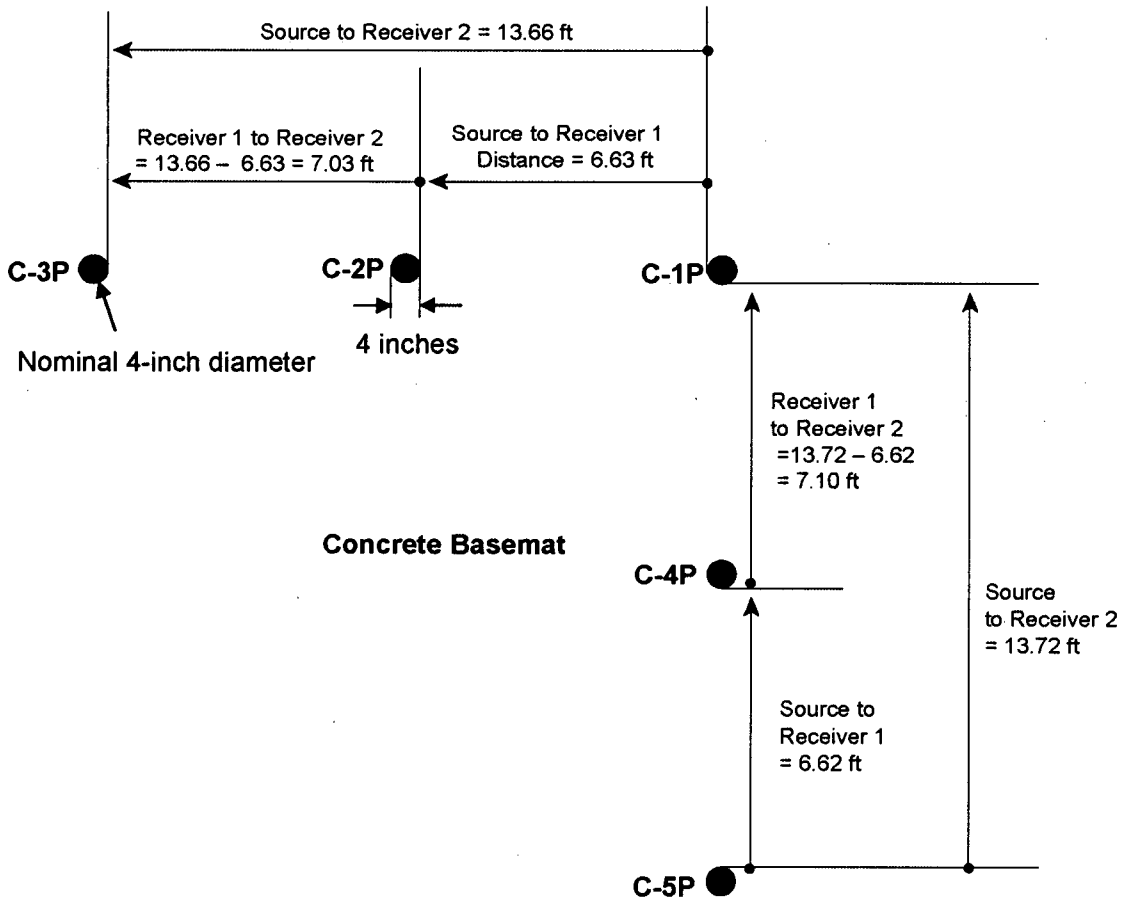
NUCLEAR STATION UNITS 1 & 2

Typical Post-Demolition P-S Suspension Logging System and Field Setup

FIGURE 6 Rev 0



Test setup	Source	Receiver 1	Receiver 2
Test 1	C-1P	C-2P	C-3P
Test 2	C-5P	C-4P	C-1P

Distances indicated measured at surface prior to testing.
Survey and deviation data was used in final calculations.

Drawing not to scale

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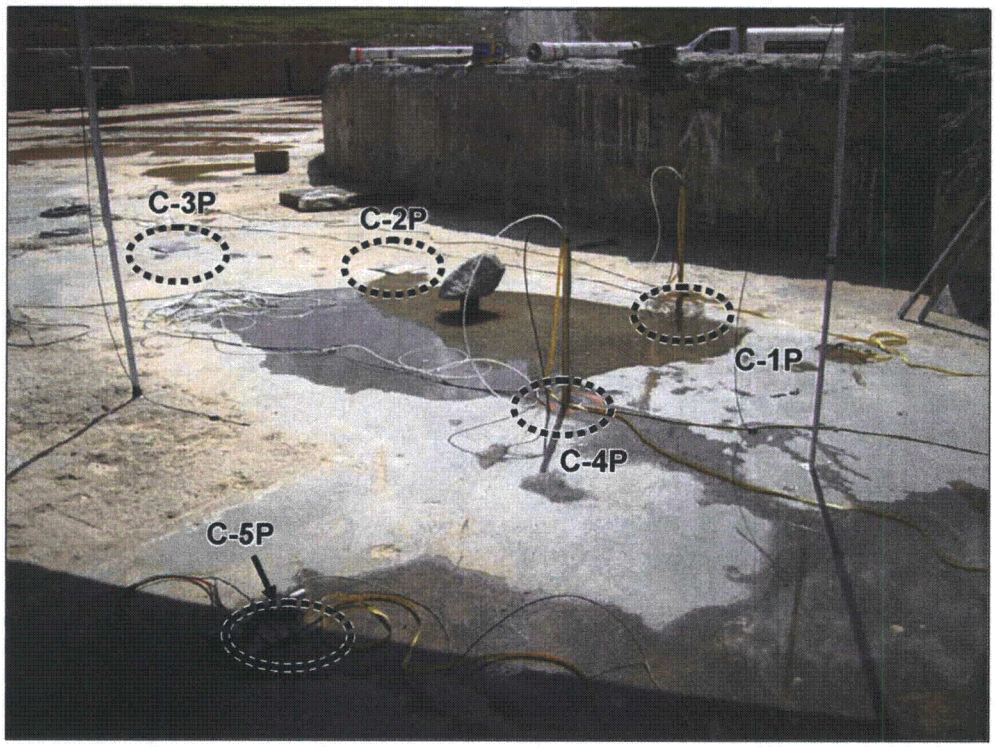
Borehole Configuration Used in Post-Demolition Crosshole Testing

FIGURE 7 Rev 0



Typical crosshole configuration for basemat testing in boreholes C-1P, C-4P, and C-5P. Seismic source is located in borehole C-5P with seismic receivers located in boreholes C-1P and C-4P.

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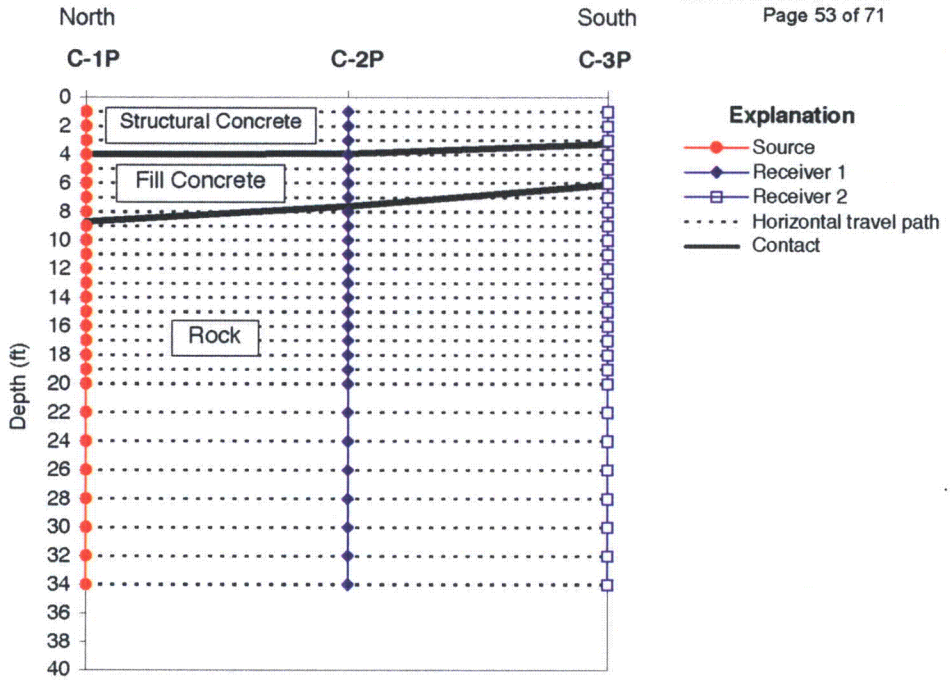
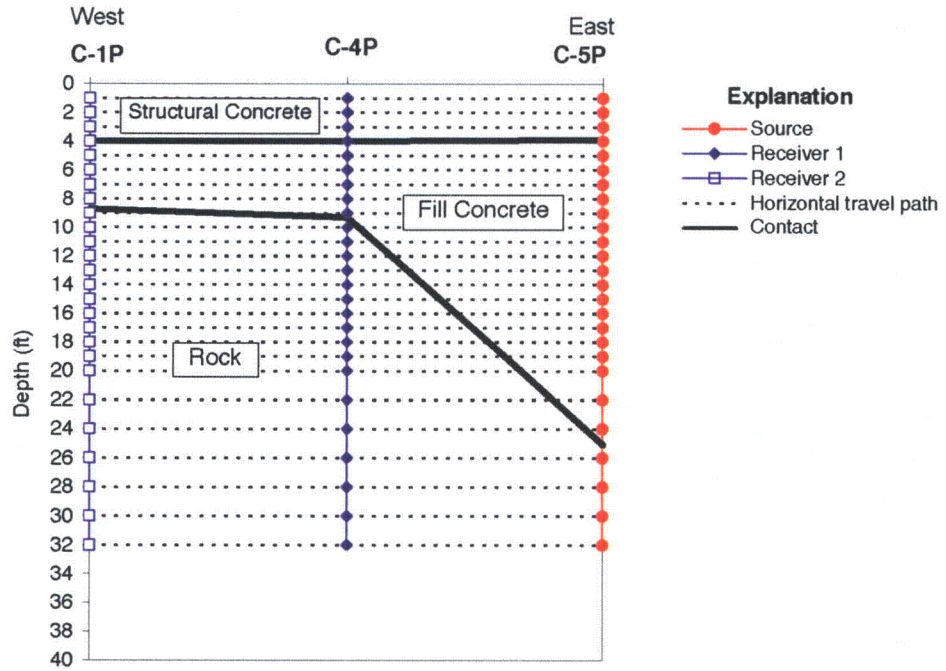
NUCLEAR STATION UNITS 1 & 2

Typical Post-Demolition Crosshole
Test Configuration

FIGURE 8 Rev 0



A) All horizontal travel paths used in crosshole testing between boreholes C-1P, C-2P, and C-3P.



B) All horizontal travel paths used in crosshole testing between boreholes C-1P, C-4P, and C-5P.

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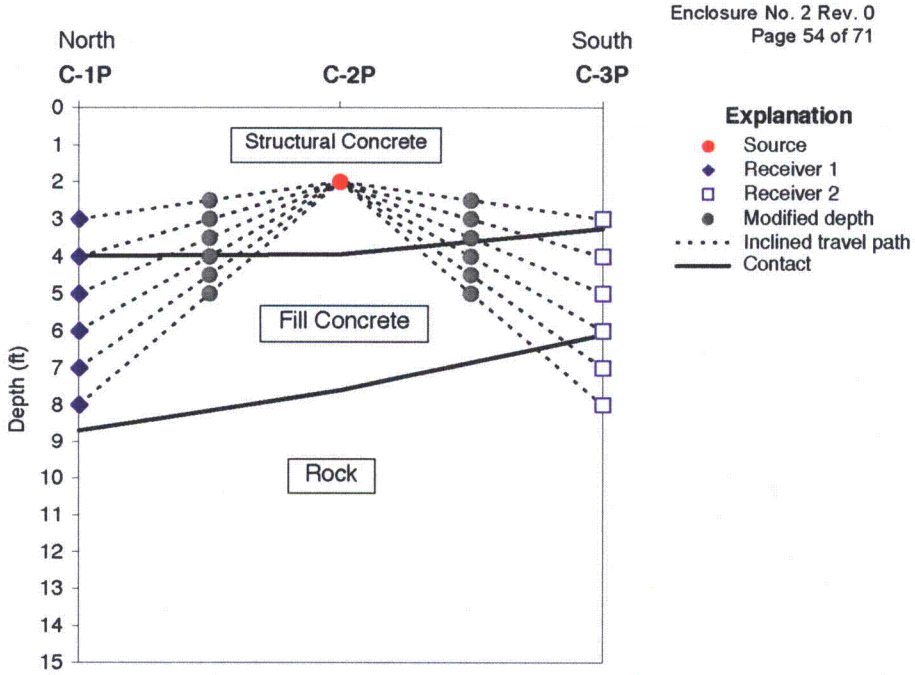
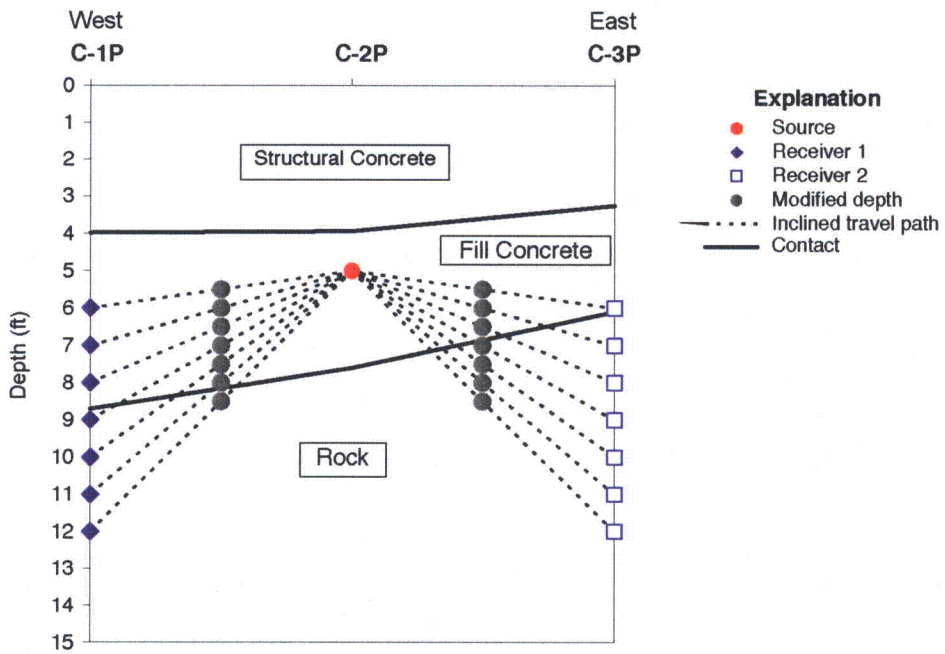
NUCLEAR STATION UNITS 1 & 2

Horizontal Travel Paths Used in
Post-Demolition Crosshole Testing between
Boreholes C-1P through C-5P

FIGURE 9 Rev 0



A) Inclined travel paths used in crosshole testing between boreholes C-1P, C-2P, and C-3P: source fixed at a depth of 2 ft. in borehole C-2P; receiver 1 at depths from 3 to 8 ft. in borehole C-2P and receiver 2 at depths from 3 to 8 ft. in borehole C-3P.



B) Inclined travel paths used in crosshole testing between boreholes C-1P, C-2P, and C-3P: source fixed at a depth of 5 ft. in borehole C-2P; receiver 1 at depths from 6 to 12 ft. in borehole C-2P and receiver 2 at depths from 6 to 12 ft. in borehole C-3P.

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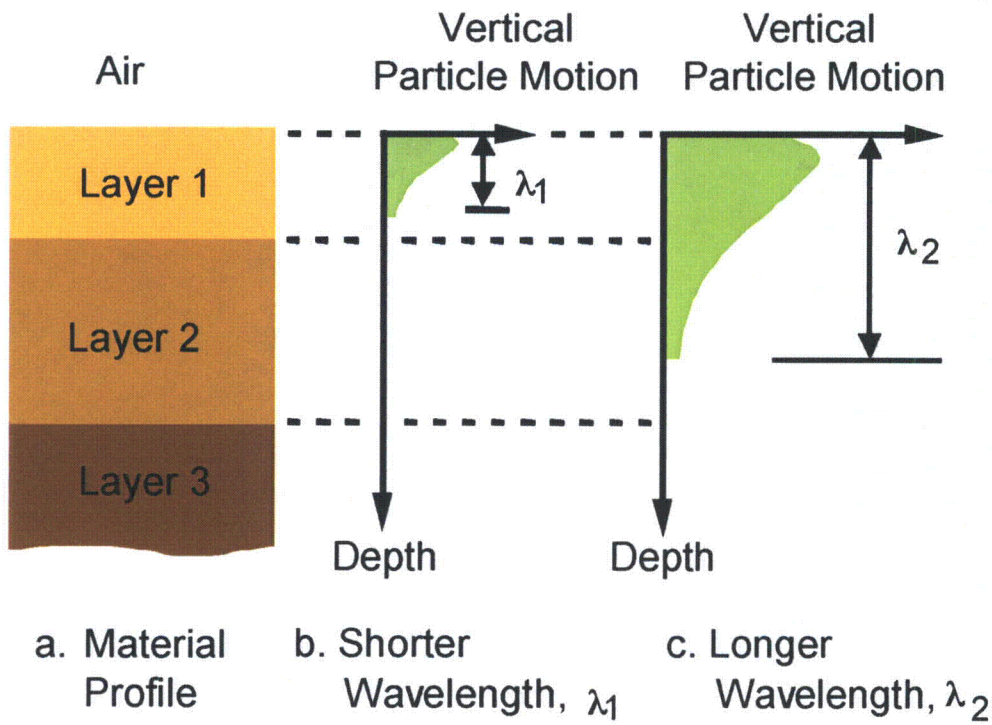
NUCLEAR STATION UNITS 1 & 2

Inclined Travel Paths Used in Post-Demolition Crosshole Testing between Boreholes C-1P, C-2P, and C-3P

FIGURE 10 Rev 0



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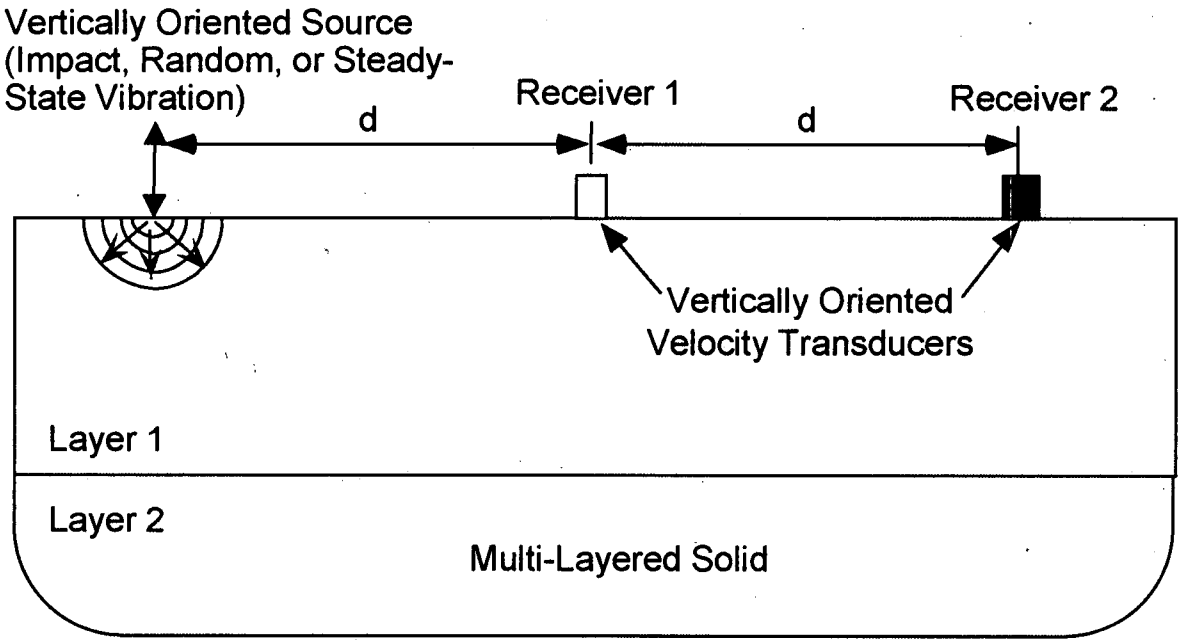
NUCLEAR STATION UNITS 1 & 2

Illustration of Surface Waves with Different Wavelengths Sampling Different Materials in a Layered System

FIGURE 11 Rev 0



Post-Demolition SASW S-1515 Source to Reciever Distances

Set-Up Number	Source to Receiver #1 (ft.)	Receiver #1 to Receiver #2 (units as shown)
1	1.0	11.75 in.
2*	1.0	11.75 in.
3*	2.0	23.5 in.
4	2.0	23.5 in.
5	4.0	4.0 ft.
6*	4.0	4.0 ft.
7*	8.0	7 ft - 11.75 in.
8	8.0	7 ft - 11.75 in.
9	16.0	16.0 ft.
10*	16.0	16.0 ft.
11*	32.0	32.0 ft.
12	32.0	32.0 ft.
13	32.0	32.0 ft.

* Test conducted in reverse direction

Post-Demolition SASW S-1516 Source to Reciever Distances

Set-Up Number	Source to Receiver #1 (ft.)	Receiver #1 to Receiver #2 (ft.)
1	1.0	1.0
2*	1.0	1.0
3*	2.0	2.0
4	2.0	2.0
5	4.0	4.0
6*	4.0	4.0
7*	8.0	8.0
8	8.0	8.0
9	16.0	16.0
10*	16.0	16.0
11*		32.0

* Test conducted in reverse direction

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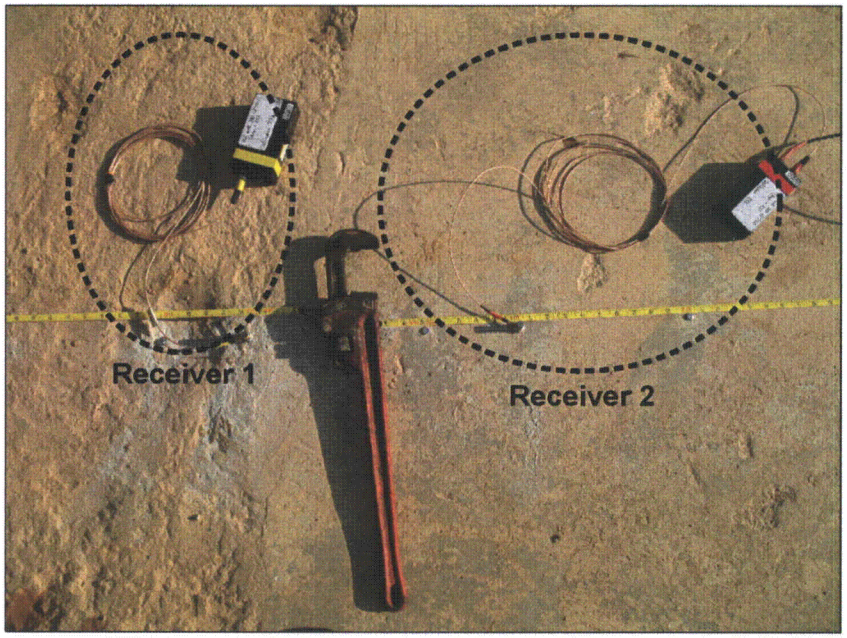
NUCLEAR STATION UNITS 1 & 2

Schematic Diagram of SASW Survey Arrangement and Post-Demolition Source-Receiver Spacings
FIGURE 12 Rev 0



A) Example of field setup for SASW survey with two receivers - close spacing (SASW S-1515).

B) Hammer source for close spacing SASW tests. Larger hammers were used as distance from source to receiver spacings increased.

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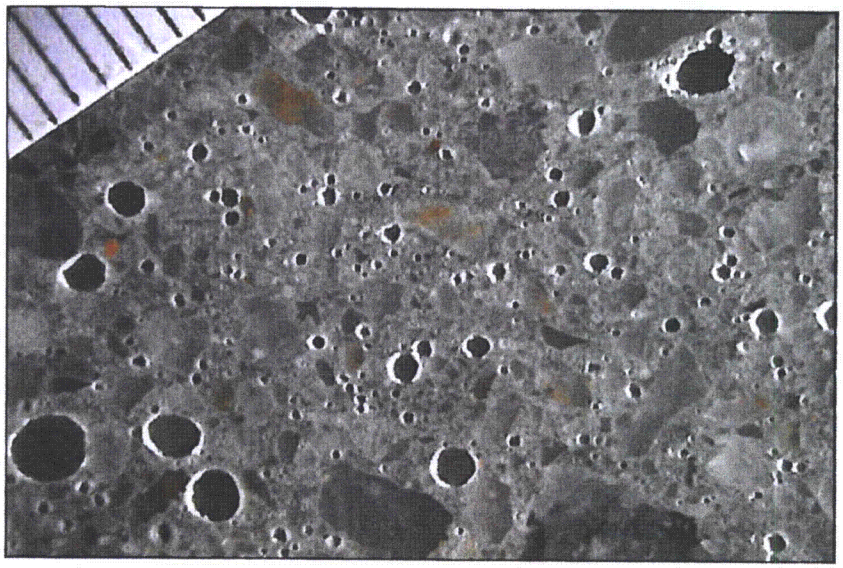
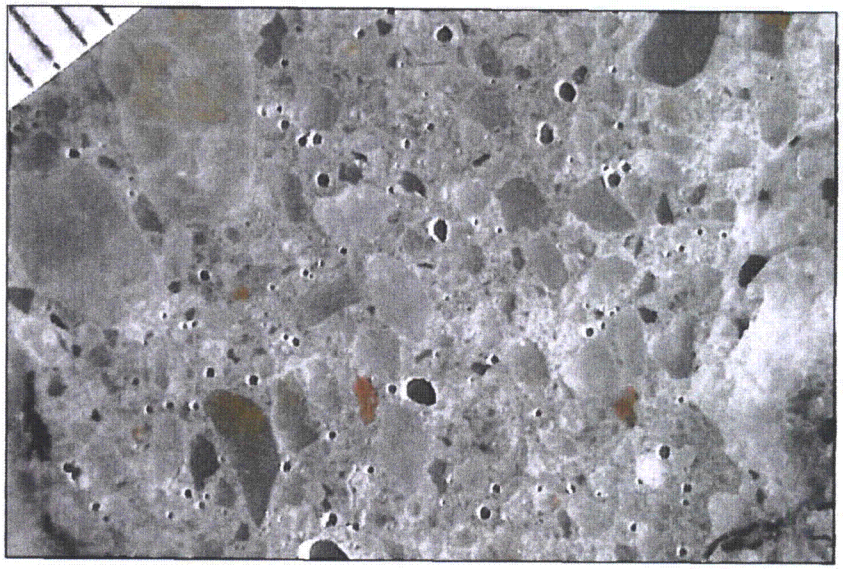
Typical Post-Demolition SASW
Survey Field Testing Setup

FIGURE 13 Rev 0



A) Lapped longitudinal cross section of structural concrete core C-15P. Air content in core segment is estimated at 5 to 7%. Scale marks represent 0.5 mm (0.02 in.).



B) Lapped longitudinal cross section of fill concrete core C-1P. Air content in core segment is estimated at 2 to 4%. Scale marks represent 0.5 mm (0.02 in.).

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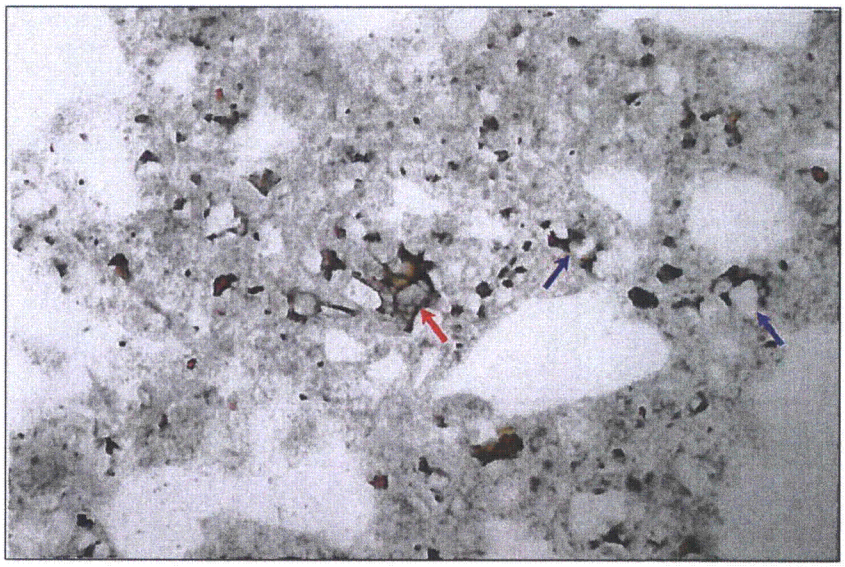
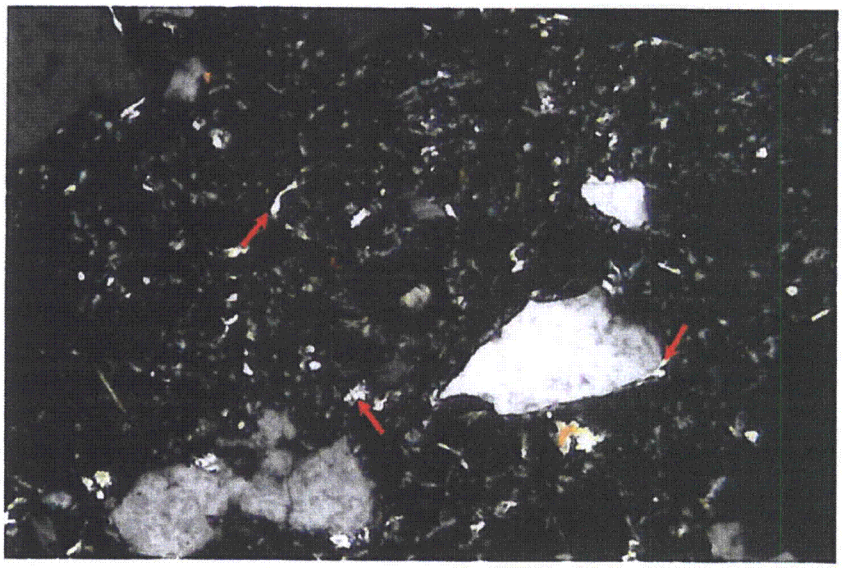
NUCLEAR STATION UNITS 1 & 2

Representative Void Content Identification for Structural and Fill Concrete, Borings C-1P and C-15P

FIGURE 14 Rev 0



A) Plane-polarized light. Red arrow designates unhydrated portland cement clinker particle while blue arrows designate relics of in-situ



B) Cross-polarized light. Red arrow indicate abundant bright calcium hydroxide within paste matrix and along periphery of aggregates.

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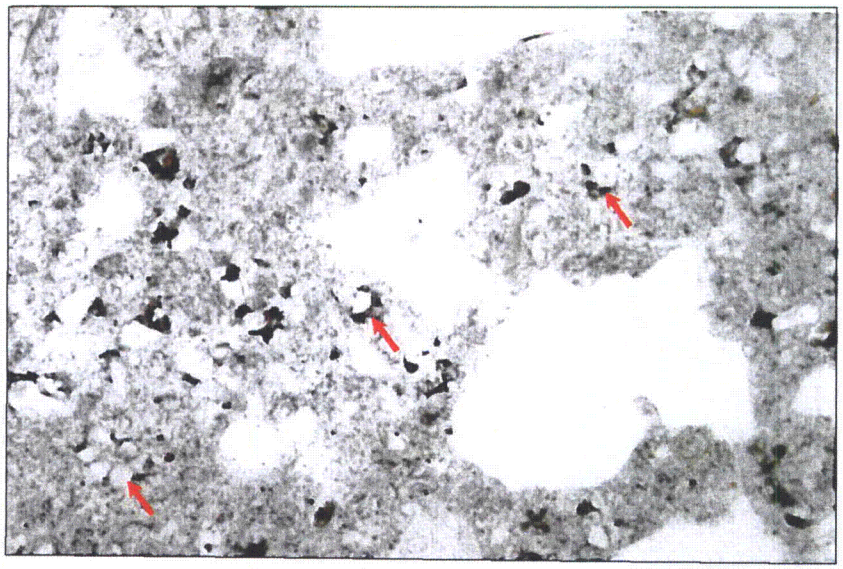
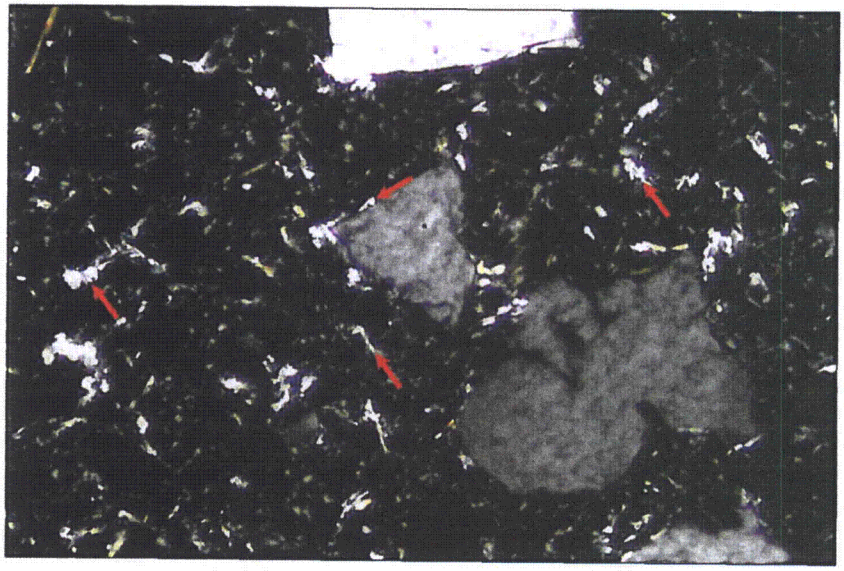
NUCLEAR STATION UNITS 1 & 2

Representative Thin-Section Photomicrographs of Paste and Core Petrography for Structural Concrete, Boring C-2P

FIGURE15 Rev 0



A) Plane-polarized light. Red arrows designate relics of in-situ hydrated clinker.



B) Cross-polarized light. Red arrows indicate abundant bright calcium hydroxide within paste matrix and along periphery of aggregates.

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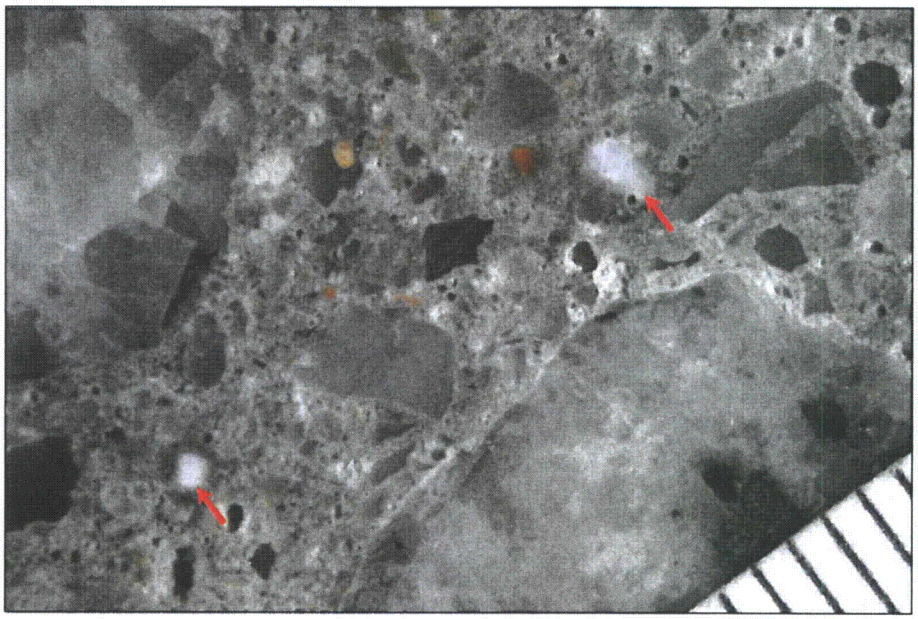
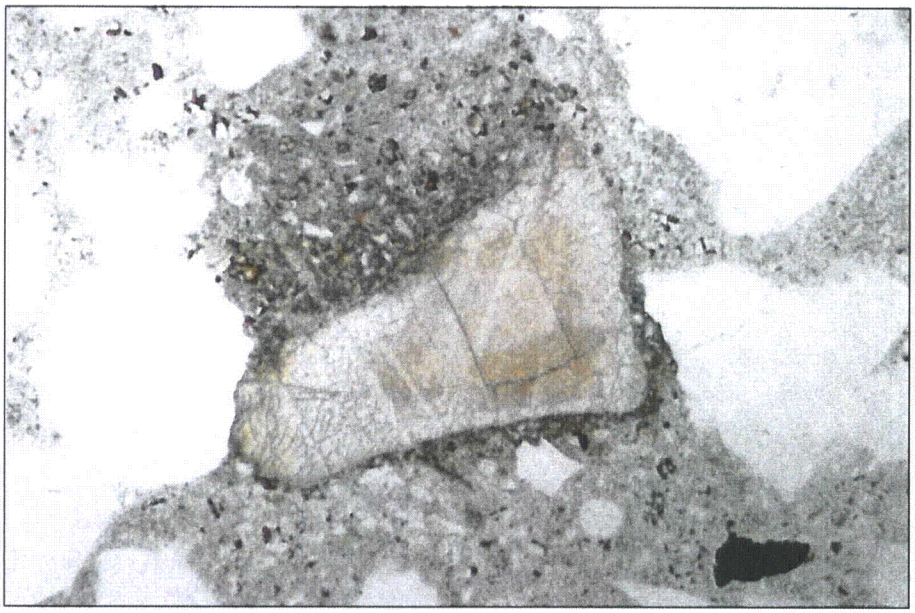
NUCLEAR STATION UNITS 1 & 2

Representative Thin-Section Photomicrographs of Paste and Core Petrography for Fill Concrete, Boring C-11P

FIGURE 16 Rev 0



A) Lapped longitudinal cross section of Core C-15P-1 structural concrete. Arrows indicate chert fine aggregate particles. Note darkened appearance of paste surrounding particles and internal microcracks in upper particle. Scale marks represent 0.5 mm (0.02 in.)



B) Plane polarized light thin-section photomicrographs of Core C-11P-7 fill concrete, showing internally cracked and ASR-reactive chert fine aggregate particles. Field of view approximately 0.75 mm (0.03 in.) across.

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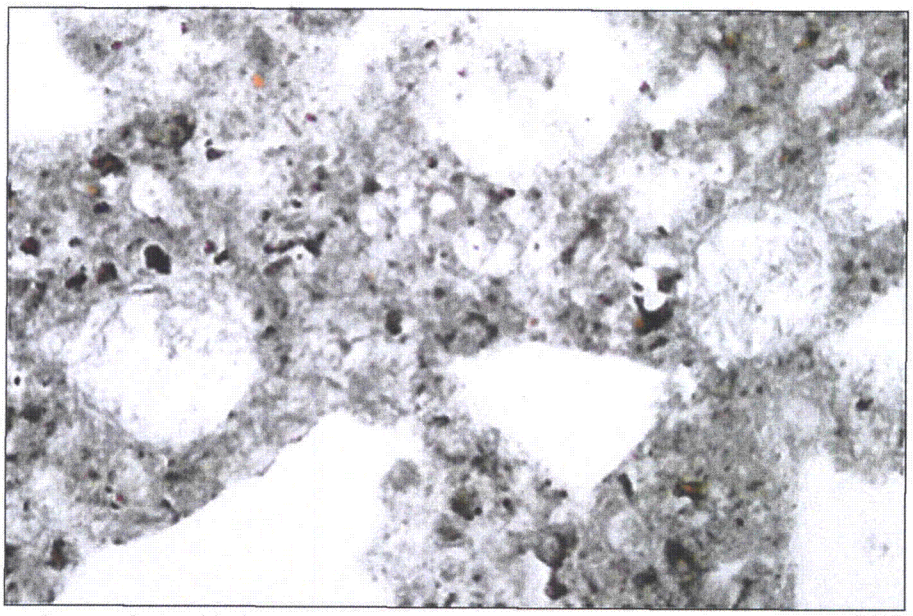
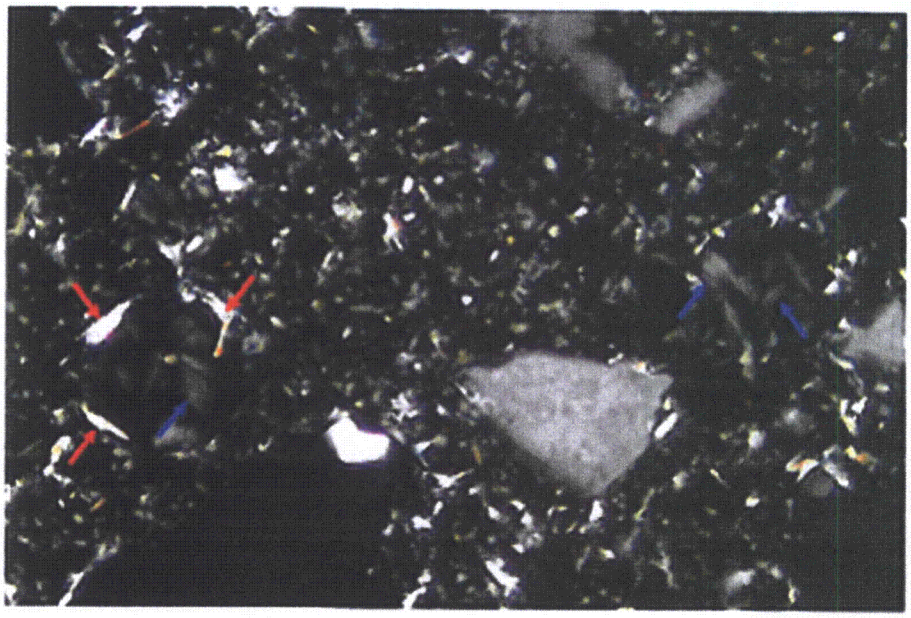
NUCLEAR STATION UNITS 1 & 2

Representative ASR-Reactive Chert Aggregate Particles in Structure and Fill Concrete Boring C-15P and C-11P

FIGURE 17 Rev 0



A) Plane-polarized light (same sample as below), structural concrete Boring C-2P. Field of view approximately 0.6 mm (0.024 in.) across.



B) Cross-polarized light. Red arrows indicate bright calcium hydroxide, while blue arrows designate gray, somewhat feathery, ettringite, structural concrete Boring C-2P. Field of view approximately 0.6 mm (0.024 in.) across.

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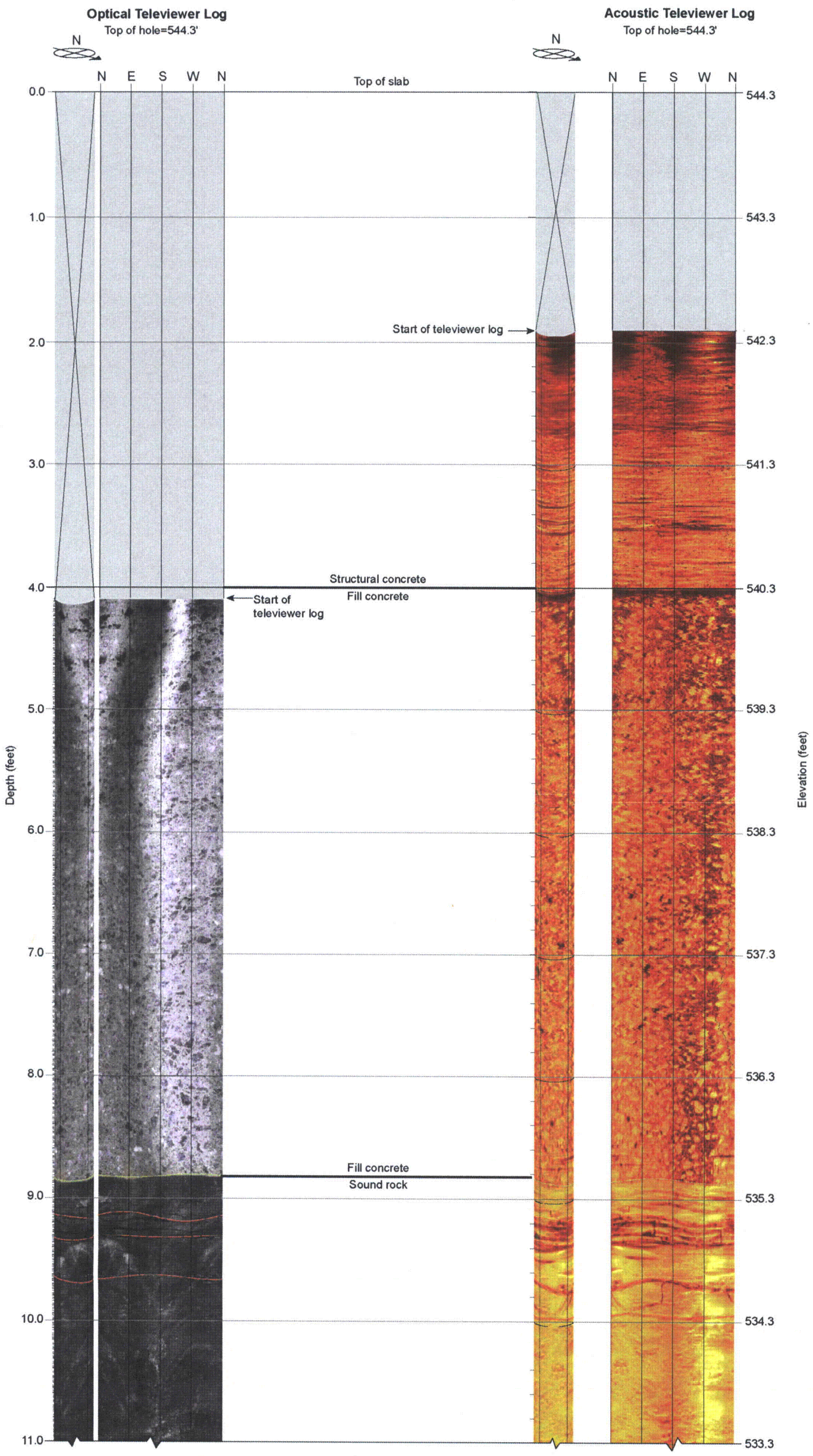
NUCLEAR STATION UNITS 1 & 2

Representative Thin-Section Photomicrographs of Carbonate and Core Petrography Structural Concrete, Boring C-2P

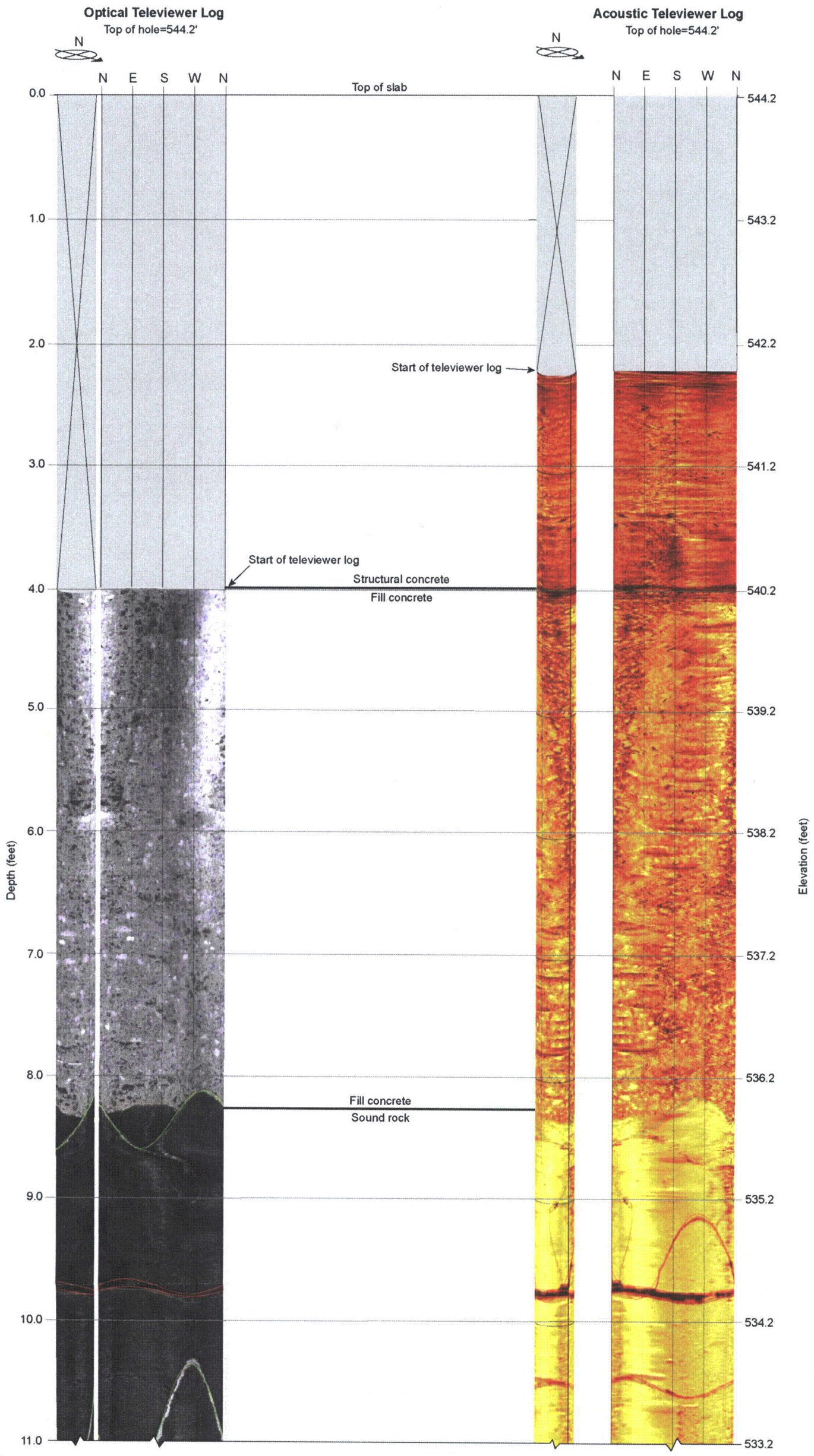
FIGURE 18 Rev 0



WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Post-Demolition Optical and Acoustic Televiewer Logs C-1P

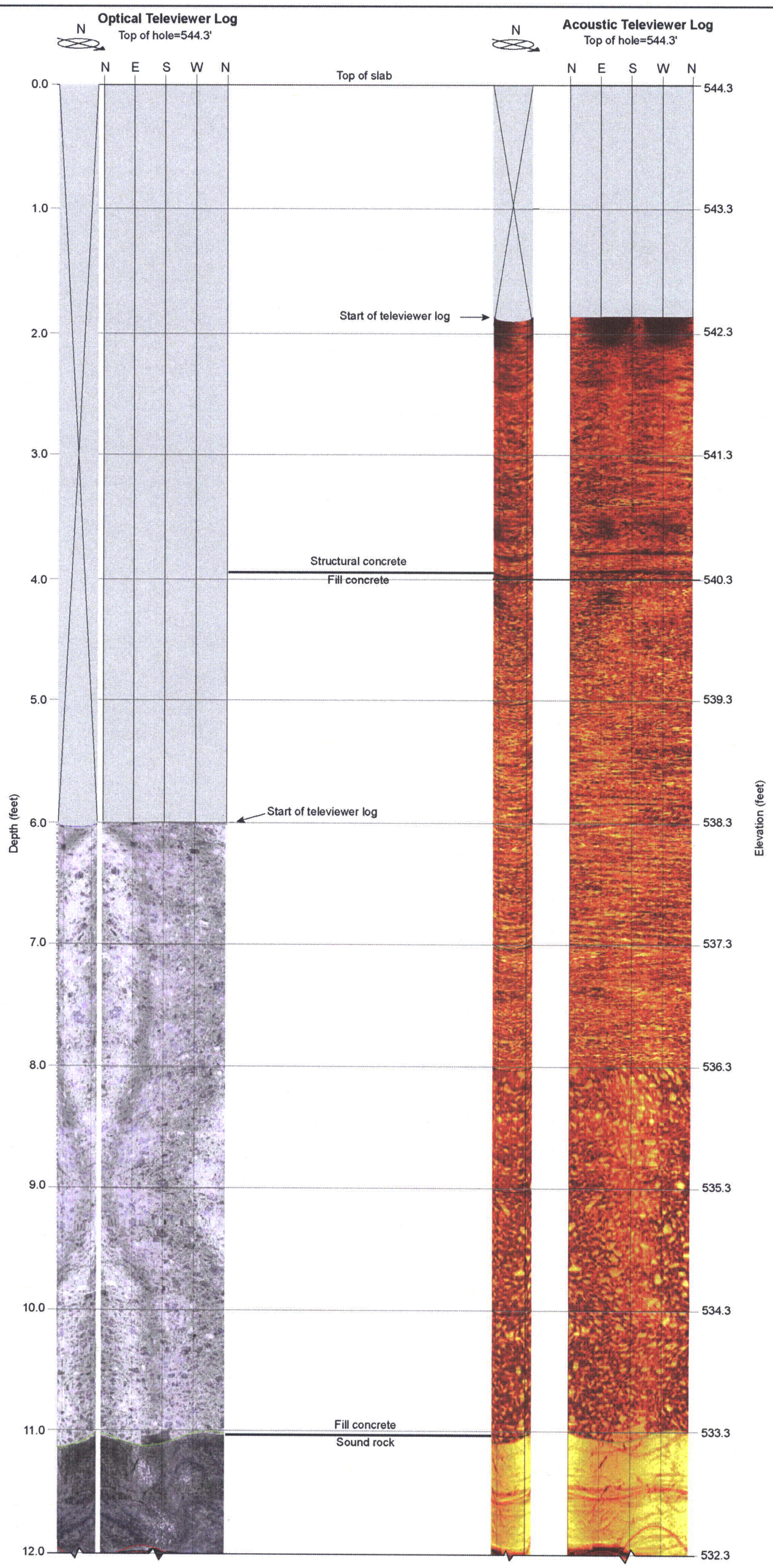
FIGURE 19 Rev 0



WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Post-Demolition Optical and Acoustic Televiewer Logs C-9AP

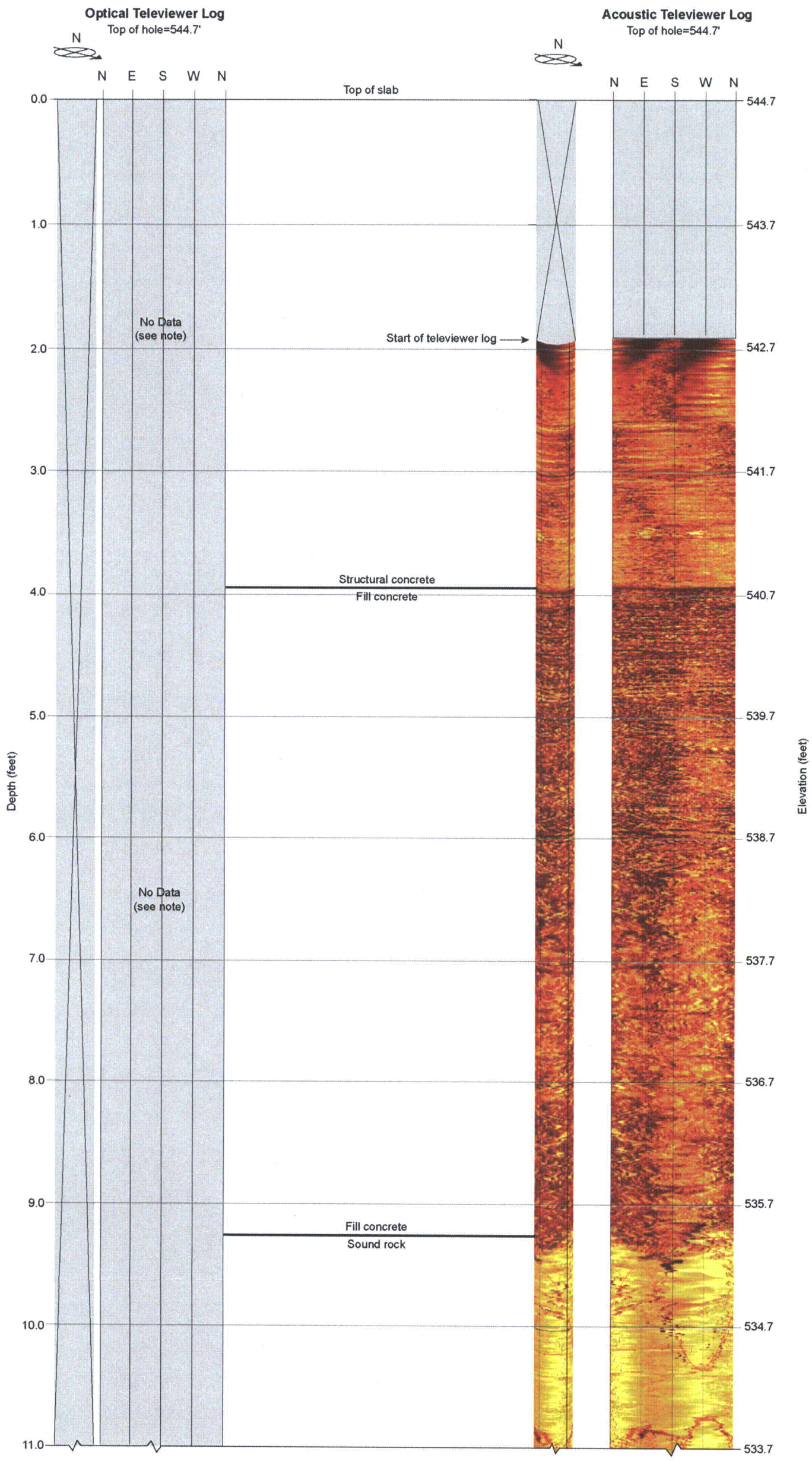
FIGURE 20 Rev 0



WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Post-Demolition Optical and Acoustic Televiewer Logs C-11P

FIGURE 21 Rev 0



Note: Optical Televiewer logging was obscured by turbid water conditions in borehole.

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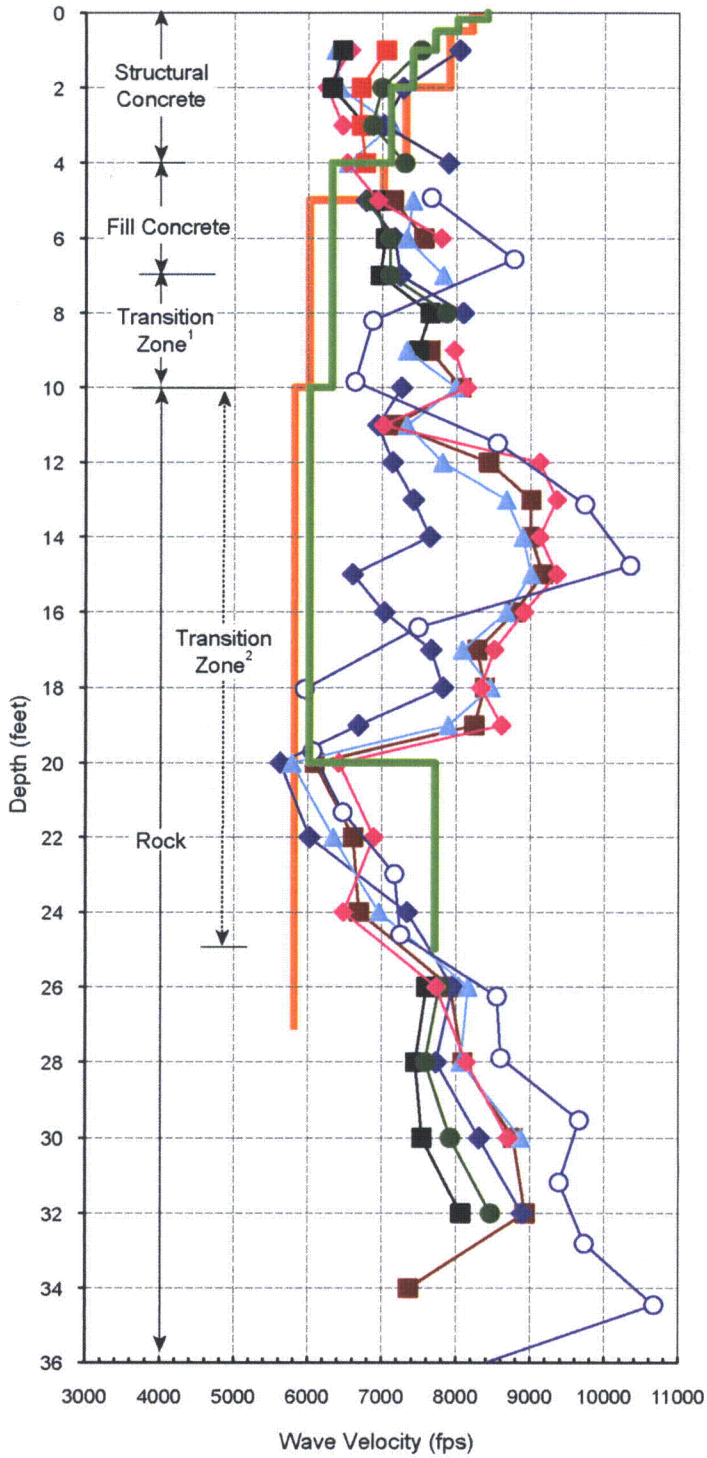
NUCLEAR STATION UNITS 1 & 2

Post-Demolition Optical and Acoustic Televiewer Logs C-15P

FIGURE 22 Rev 0



Explanation

Shear Wave Velocities (fps)

- Vs - Crosshole (C-1P to C-2P)
- Vs - Crosshole (C-2P to C-3P)
- Vs - Crosshole (C-1P to C-3P)
- Vs - Crosshole (C-1P to C-4P)
- Vs - Crosshole (C-4P to C-5P)
- Vs - Crosshole (C-1P to C-5P)
- Vs - SASW Site #1 (S-1515)
- Vs - SASW Site #2 (S-1516)
- Vs - P-S Suspension (C-1P)

Notes:
1. Transition zone is from 7 to 9 ft. between C-1P and C-3P and 8 to 9 ft. between C-1P and C-4P.
2. Transition zone is from 10 to 25 ft. between C-4P and C-5P.
3. Transition zone is interpreted as an irregular interface between CNS fill concrete and underlying competent foundation rock.

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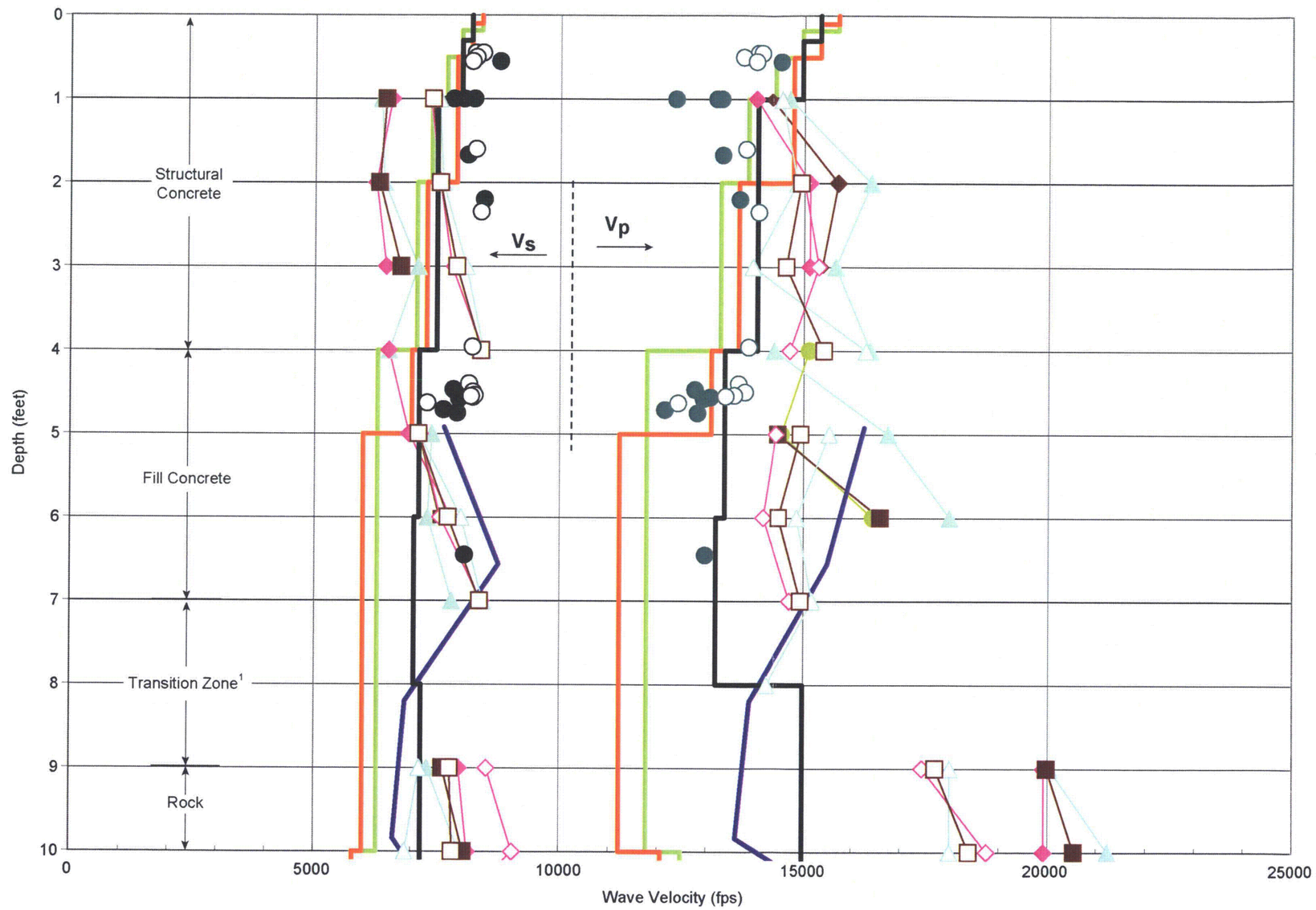
NUCLEAR STATION UNITS 1 & 2

Comparison of Post-Demolition Shear Wave Velocity (Vs) Profiles for Concrete and Rock Crosshole, P-S Suspension, and SASW Testing
FIGURE 23 Rev 0



Explanation

Post-Demolition

Shear Wave Velocities (fps)

- Vs - Crosshole (C-1P to C-2P)
- Vs - Crosshole (C-2P to C-3P)
- Vs - Crosshole (C-1P to C-3P)
- Vs - SASW Site #1 (S-1515)
- Vs - SASW Site #2 (S-1516)
- Vs - Free-Free Lab Data
- Vs - P-S Suspension (C-1P)

Compression Wave Velocities (fps)

- Vp - Crosshole (C-1P to C-2P)
- Vp - Crosshole (C-2P to C-3P)
- Vp - Crosshole (C-1P to C-3P)
- Vp - SASW Site #1 (S-1515)
- Vp - SASW Site #2 (S-1516)
- Vp - Free-Free Lab Data
- Vp - P-S Suspension (C-1P)

Pre-Demolition

Shear Wave Velocity (fps)

- Vs - Crosshole (C-1 to C-2)
- Vs - Crosshole (C-2 to C-3)
- Vs - Crosshole (C-1 to C-3)
- Vs - SASW Site #1 (S-1514)
- Vs - Free-Free Lab Data (2007)

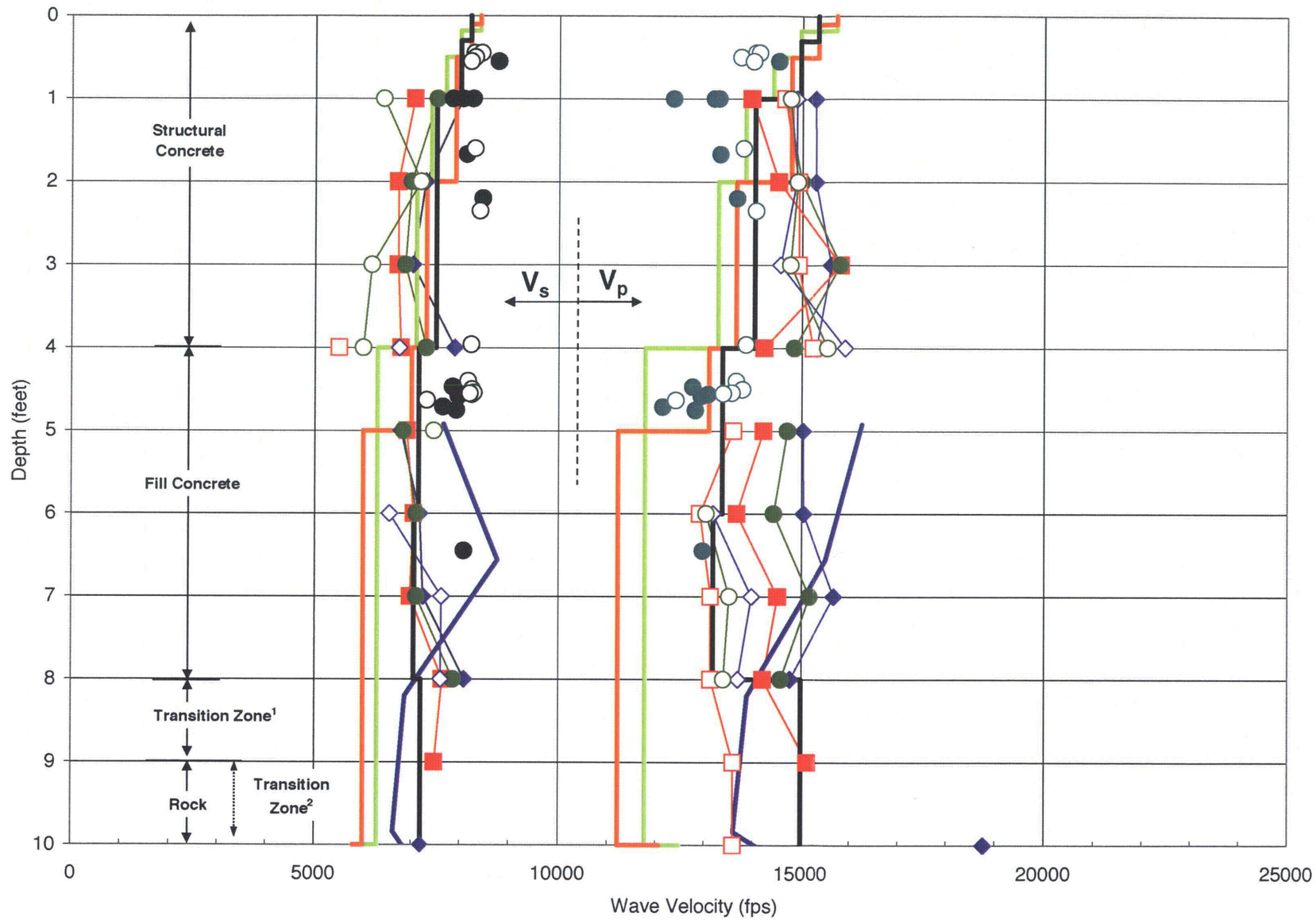
Compression Wave Velocity (fps)

- Vp - Crosshole (C-1 to C-2)
- Vp - Crosshole (C-2 to C-3)
- Vp - Crosshole (C-1 to C-3)
- Vp - SASW Site #1 (S-1514)
- Vp - Free-Free Lab Data (2007)

Notes:
1. Transition zone is from 7 to 9 ft. between C-1P and C-3P.
2. Transition zone is interpreted as an irregular interface between CNS fill concrete and underlying competent foundation rock.

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Pre- and Post-Demolition Crosshole, SASW, P-S Suspension, and Free-Free Lab Data
Concrete Velocities - C-1P to C-3P
FIGURE 24 Rev 0



Explanation

Post-Demolition

Shear Wave Velocities (fps)

- Vs - Crosshole (C-1P to C-4P)
- Vs - Crosshole (C-4P to C-5P)
- Vs - Crosshole (C-1P to C-5P)
- Vs - SASW Site #1 (S-1515)
- Vs - SASW Site #2 (S-1516)
- Vs - Free-Free Lab Data
- Vs - P-S Suspension (C-1P)

Compression Wave Velocities (fps)

- Vp - Crosshole (C-1P to C-4P)
- Vp - Crosshole (C-4P to C-5P)
- Vp - Crosshole (C-1P to C-5P)
- Vp - SASW Site #1 (S-1515)
- Vp - SASW Site #2 (S-1516)
- Vp - Free-Free Lab Data
- Vp - P-S Suspension (C-1P)

Pre-Demolition

Shear Wave Velocity (fps)

- Vs - Crosshole (C-1 to C-4)
- Vs - Crosshole (C-4 to C-5)
- Vs - Crosshole (C-1 to C-5)
- Vs - SASW Site #1 (S-1514)
- Vs - Free-Free Lab Data (2007)

Compression Wave Velocity (fps)

- Vp - Crosshole (C-1 to C-4)
- Vp - Crosshole (C-4 to C-5)
- Vp - Crosshole (C-1 to C-5)
- Vp - SASW Site #1 (S-1514)
- Vp - Free-Free Lab Data (2007)

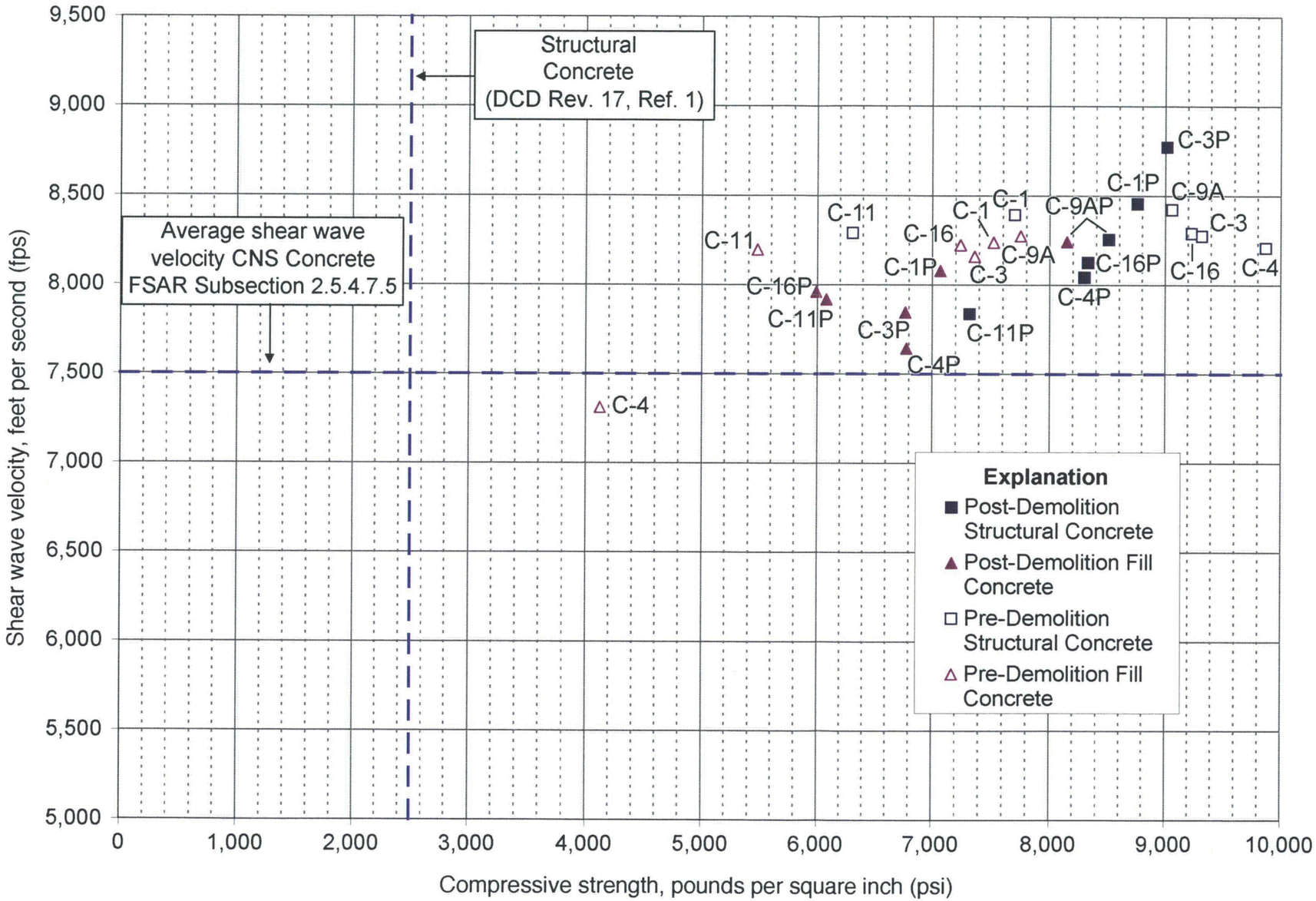
Notes:
1. Transition zone is from 8 to 9 ft. between C-1P and C-4P.
2. Transition zone is from 10 to 25 ft. between C-4P and C-5P.
2. Transition zone is interpreted as an irregular interface between CNS fill concrete and underlying competent foundation rock.

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Pre- and Post-Demolition Crosshole, SASW, Free-Free Lab Data, and P-S Suspension Velocities - C-1P through C-5P

FIGURE 25 Rev 0

Laboratory Mean Shear Wave Velocities (V_s) and Compressive Strengths



Post-Demolition Tests

Structural Concrete:
Compressive Strength
8,444 ± 525 psi
Shear Wave Velocity
8,249 ± 330 fps

Fill Concrete:
Compressive Strength
6,256 ± 1,210 psi
Shear Wave Velocity
7,949 ± 204 fps

Pre-Demolition Tests

Structural Concrete:
Compressive Strength
8,980 ± 1,254 psi
Shear Wave Velocity
8,314 ± 80 fps

Fill Concrete:
Compressive Strength
6,459 ± 1,255 psi
Shear Wave Velocity
8,067 ± 373 fps

All Data
Mean Compressive Strength
7,625 ± 1,647 psi
Mean Shear Wave Velocity
8,145 ± 293 fps

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Summary of Laboratory Shear Wave Velocity (Vs) Measured Using Free-Free URC Versus Compressive Strength for Concrete

FIGURE 26 Rev 0

12.0 APPENDICES

Appendix A Post-Demolition Basemat Boring Logs

Appendix B Post-Demolition Boring Summary Sheets

Appendix A – Post-Demolition Basemat Boring Logs

CONCRETE LOG CHEROKEE10-10-07.GPJ WLA9-8-06.GDT 5/15/09

Project Name and Job Number Lee Nuclear Station COL 6234-06-3389	MACTEC / WLA William Lettis & Associates, Inc.	CONCRETE LOG - Boring No. C-1P	
Type and Diameter of Boring Concrete core / 4 inch	Boring Location East Side of CNS Unit 1 N 1165949 E 1846399		Total Depth 121.0 feet
Drilling Contractor and Rig Concrete Coring and Saw / MACTEC ATL / CME 550 X	Elevation and Datum 544.3 feet MSL	Ground Water Depth N/A	Depth to Bedrock 8.9 feet
Casing Size and Depth N/A	Length of Core Barrel and Bit 8.5 feet	No. of Core Boxes 9	Date Started 8/2/08
	Borehole Inclination -90	Logged by G. Van Etten/M. Buga	Date Completed 8/6/08

Reviewed by / Date M. BUGA 5/15/09
Reviewed by / Date MGG 5/15/09

Run No.	Recovery / Cut	% RQD	Weathering	Strength	In-Situ Testing	Lithology	Remarks
1	4.0/4.0					STRUCTURAL CONCRETE One reinforcing bar from 0.32' to 0.42'	One No. 11 rebar encountered at 0.32' to 0.42' Start HQ coring at 10:30 am
2	5.0/5.0			R3 R4		FILL CONCRETE; light olive brown (2.5Y 5/3), granodiorite and diorite aggregate clasts <0.1' wide, subangular, matrix supported 0.2' wide granodiorite clast in concrete Sharp contact at 8.9'	Top of fill concrete at 3.96'
3	4.9/5.0	98	F	R4		META-GRANODIORITE; very dark bluish gray (GLEY 2 7/1), massive, fine grained with <0.02' wide, quartz vein very steeply dipping (>80°), ~60% pyroxene and hornblende, ~30% quartz, ~5% plagioclase, ~5% micas, trace pyrite and actinolite in veins CONTINUOUS ROCK	
4	0.6/1.0	60	F	R4			
5	4.4/5.0	88	F	R4			
6	5.0/5.0	92	F	R4		Many very thin cross-cutting quartz veins Sharp contact at 24.1'	
7	5.2/5.0	100	F	R4		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), massive with abundant quartz veins, <0.02' thick, dipping 30°-60°; fine to coarse grained, ~50% quartz, ~30% pyroxene hornblende, ~10% plagioclase, 5% micas, trace to ~5% pyrite and actinolite 24.1' to 24.5', white to pink quartz vein Several 0.1' wide mafic inclusions	
8	4.3/4.0	100	F	R4			
9	2.6/2.2	100	F	R4		35.1' to 35.6', 0.07' wide quartz vein	Rig replaced with CME 550 X due to mechanical failure. Run 9 cut short to get on 5' stroke.
10	4.9/5.0	92	F	R4		36.3' to 37.8', quartz rich with several 0.1' thick quartz veins	

Depth (feet): 0–40. Elevation (feet): 544–505.

CONCRETE LOG CHEROKEE10-10-07.GPJ WLA9-8-06.GDT 5/15/09

Project Name and Job Number
Lee Nuclear Station COL
6234-06-3389

MACTEC WLA William Lettis & Associates, Inc.

CONCRETE LOG - Boring No. C-1P

Run No.	Recovery / Cut	% RQD	Weathering	Strength	In-Situ Testing	Lithology	Remarks
						META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), massive with many quartz veins, <0.02' thick, dipping 30-60°; fine to coarse grained, ~50% quartz, ~30% pyroxene and hornblende, ~10% plagioclase, ~10% micas, trace pyrite and orthoclase	41.2' Start of drilling on 8/4/08 at 8:20 am
11	5.2/5.0	94	F	R4			Moderate, gray water return
12	5.0/5.0	100	F	R4		47.7' to 48.7', 0.5' wide quartz vein with pyroxene, dips ~70°	
13	3.0/3.6	83	F	R4		53.2' to 53.6', 0.1' wide quartz vein	9:30 am new MACTEC driller arrived on site; Robert Banks Driller placed industrial quartz sand down hole, tripped out rods and replaced bit
14	1.7/2.0	85	F	R4			
15	4.6/5.0	92	F	R4			
16	2.5/2.0	100	F	R4		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), massive with occasional quartz veins, <0.02' thick, medium grained, ~50% quartz, ~30% pyroxene and hornblende, ~10% plagioclase, 10% micas, trace orthoclase and pyrite, several small mafic inclusions	Moderate, gray water return
17	2.7/3.0	70	F	R4		64.5' to 64.8', 0.05' wide quartz vein dipping ~60°	
18	5.0/5.0	86	F	R4		69.5' to 70.5', joint, tight, healed with quartz, pyroxene, and chlorite Grades to fine and medium grained meta-granodiorite	
19	4.9/5.0	32	F	R4		74.3' to 75.0', 0.05' wide quartz vein with mafic inclusions	Moderate, gray water return
20	5.2/4.0	90	F	R4			

Depth (feet): 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80

Elevation (feet): 504, 503, 502, 501, 500, 499, 498, 497, 496, 495, 494, 493, 492, 491, 490, 489, 488, 487, 486, 485, 484, 483, 482, 481, 480, 479, 478, 477, 476, 475, 474, 473, 472, 471, 470, 469, 468, 467, 466, 465

CONCRETE LOG CHEROKEE10-10-07.GPJ WLA9-8-06.GDT 5/15/09

Project Name and Job Number
Lee Nuclear Station COL
6234-06-3389

MACTEC WLA William Lettis & Associates, Inc.

CONCRETE LOG - Boring No. C-1P

Depth (feet)	Run No.	Recovery / Cut	% RQD	Weathering	Strength	In-Situ Testing	Lithology	Remarks	Elevation (feet)
80									464
81									463
82	21	3.3/3.3	100	F	R4 to R5		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1); massive with occasional quartz veins <0.02' thick, medium grained, ~50% quartz, ~30% pyroxene and hornblende, ~10% plagioclase, 10% micas, trace orthoclase and pyrite, several small mafic inclusions Sharp contact, dips 30°	12:30 pm 8/5/08 New rig setup over C-1P Randy Parker completes safety check. M. Buga begins logging Run 21.	462
83									461
84								1:22 pm Drillers replace bit	460
85									459
86	22	5.0/5.0	100	F	R4 to R5		META-DIORITE; very dark bluish gray (GLEY 2 3/1), fine grained, almost dacite, all pyroxene and hornblende, occasional quartz veins, mostly near contact, abundant incipient and healed fractures, weak to moderately foliated	1:40 pm Resume drilling	458
87									457
88							85.6' to 86.0', 55° dipping shear zone with quartz and pyroxene, trace pyrite		456
89							Abundant quartz veining, moderately foliated 88.2' to 89.0', 60° dipping foliation/shear 89.1', sharp contact, dips 65°, quartz vein, 0.05' thick		455
90									454
91	23	5.0/5.0	100	F	R4 to R5		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fine to medium grained, weakly foliated, 45% quartz, 35% pyroxene and hornblende, 10% plagioclase, 5% potassium feldspar, 5% mica, abundant incipient and healed fractures, up to 0.1' xenoliths of meta-diorite, 0.03' to 0.05' thick, subvertical quartz vein from 92.3' to 93.5'	0.8' of core from Run 21 not recovered Drill 1.0' to pick it up	453
92									452
93									451
94									450
95									449
96	24	5.0/5.0	94	F	R4 to R5		96.4' to 97.6', large quartz vein, 0.03' to 0.05' thick, dipping 70°		448
97									447
98									446
99									445
100									444
101	25	5.0/5.0	94	F	R4 to R5				443
102									442
103									441
104									440
105									439
106	26	5.0/5.0	100	F	R4 to R5		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fine to medium grained, ~50% quartz, 30% pyroxene and hornblende, 15% plagioclase, 5% potassium feldspar, mafic xenoliths, weakly foliated		438
107									437
108							107.2', abundant incipient and healed fractures		436
109									435
110							Prominent vertical shear/healed fracture in top 0.5' of Run 27	End of day	434
111								8/6/08 8:00 am, began drilling	433
112	27	5.0/5.0	96	F	R4 to R5		111.8', 0.15' thick zone of shear, dipping 70°-75°, contains quartz, plagioclase, potassium feldspar, mica, pyrite, possible oxidation on some quartz crystals	Run 27 first foot hard drilling resharpen bit	432
113									431
114							Transition into highly deformed zone		430
115								Drillers pull rods to replace bit	429
116	28	5.0/5.0	100	F	R4 to R5		META-DIORITE to META-GRANODIORITE; dark bluish gray to very dark bluish gray (GLEY 2 4/1-3/1), fine to medium grained, abundant quartz vein and healed fractures, oxidized zone from 117.0' to 118.0', 45-55% quartz, 35-45% pyroxene and hornblende, 10% plagioclase, less than 5% mica and potassium feldspar	After drilling 0.4' of Run 28, sharpen bit	428
117									427
118									426
119									425
120		2.0							

CONCRETE LOG CHEROKEE10-10-07.GPJ WLA9-8-06.GDT 5/15/09

Project Name and Job Number
Lee Nuclear Station COL
6234-06-3389

MACTEC WLA William Lettis & Associates, Inc.

CONCRETE LOG - Boring No. C-1P

Depth (feet)	Lithology	Run No.	Recovery / Cut	% RQD	Weathering	Strength	In-Situ Testing	Lithology	Remarks	Elevation (feet)
120		29	1.9	100	F	R4 to R5		META-DIORITE/META-GRANODIORITE; dark bluish gray to very dark bluish gray (GLEY 2 4/1-3/1), fine to medium grained, highly sheared and foliated, highly abundant plagioclase and quartz veins		424
121										423
122										422
123										421
124								Total Depth 121 ft. Groundwater encountered at 0 feet		420
125										419
126										418
127										417
128										416
129										415
130										414
131										413
132										412
133										411
134										410
135										409
136										408
137										407
138										406
139										405
140										404
141										403
142										402
143										401
144										400
145										399
146										398
147										397
148										396
149										395
150										394
151										393
152										392
153										391
154										390
155										389
156										388
157										387
158										386
159										385
160										

CONCRETE LOG CHEROKEE10-10-07.GPJ WLA9-8-06.GDT 5/15/09

Project Name and Job Number Lee Nuclear Station COL 6234-06-3389	MACTEC / WLA William Lettis & Associates, Inc.	CONCRETE LOG - Boring No. C-2P	
Type and Diameter of Boring Concrete core / HQ core / 4 inch	Boring Location East Side of CNS Unit 1 N 1165942 E 1846400		Total Depth 34.9 feet
Drilling Contractor and Rig Concrete Coring and Saw / King Drilling / D 120	Elevation and Datum 544.2 feet MSL	Ground Water Depth N/A	Depth to Bedrock 6.7 feet
Casing Size and Depth N/A	Length of Core Barrel and Bit 8.5 feet	No. of Core Boxes 4	Date Started 8/1/08
	Borehole Inclination -90	Logged by G. Van Etten	Date Completed 8/2/08

Reviewed by / Date M.Buga 5/15/09
Reviewed by / Date MGG 5/15/09

Run No.	Recovery / Cut	% RQD	Weathering	Strength	In-Situ Testing	Lithology	Remarks
1	1.1 / 1.1					STRUCTURAL CONCRETE Two reinforcing bars from 0.27' to 0.37'	Two No. 11 rebar, perpendicular
2	2.9 / 2.9					Two reinforcing bars from 3.25' to 3.45'	Two No. 11 rebar, perpendicular
3	4.8 / 5.0	96		R3		FILL CONCRETE; light olive brown (2.5Y 5/5), medium strong, granodiorite aggregate clasts <0.1' wide, subangular, cement matrix supported, occasional vugs, 0.01'-0.02' wide with most <0.01'	3.94' top of fill concrete Start HQ drilling at 2:15 pm 8/1/2008
			F	R4		META-DIORITE; very dark bluish gray (GLEY 2 3/1), massive with <0.05' wide quartz veins, most dipping 30°-60°, fine grained, ~60% pyroxenes and hornblende, ~30% quartz, ~5% plagioclase, ~5% micas, trace actinolite and pyrite, some shearing along healed joints, 7.0'-7.2' is a 0.05' wide quartz and actinolite (chlorite?) vein dipping ~35°	
4	4.9 / 5.0	98	F	R4		CONTINUOUS ROCK 11.3' to 11.9' vein 0.04' wide quartz and chlorite?	Run 3 core has drill spin on most of the core.
5	5.0 / 5.0	100	F	R4		META-DIORITE; very dark bluish gray (GLEY 2 3/1), massive with two subparallel 0.03' wide quartz veins, dipping 30°-60°, fine grained, ~60% pyroxenes and hornblende, ~30% quartz, ~5% plagioclase, ~5% micas, actinolite, and pyrite, some ductile shearing along healed joints	good, gray water return several 0.02' wide quartz veins dipping ~80°
6	4.9 / 5.0	98	F	R4		22.0' to 22.4' META-GRANODIORITE xenolith bounded by healed joints, pyrite in quartz-rich boundaries	
7	5.0 / 5.0	100	F	R4		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), massive with abundant quartz veins <0.06' wide, fine to medium grained, ~50% quartz,~30% pyroxenes and hornblende, ~10% plagioclase, 10% micas, trace actionolite and pyrite, some minor offset in joints Healed joint at 26.9', offsets 0.06' wide quartz vein by 0.2', apparent reverse fault motion	
8	5.0 / 5.0	100	F	R4		META-GRANODIORITE; dark bluish gray (GLEY 2 6/1), massive with occasional quartz veins <0.04' wide, fine to medium grained, ~50% quartz, ~30% pyroxene and hornblende, ~10% plagioclase, 10% micas, trace actinolite and pyrite	good, gray water return 30.1' start drilling on 8/2/2008 at 7:45 am 32.9' changed bit to series 10
9	0.7 / 1.0	70	F	R4			
						Total Depth 34.9 ft. Groundwater encountered at 0 feet	

Depth (feet): 0–40. Elevation (feet): 544–505.

CONCRETE LOG CHEROKEE10-10-07.GPJ WLA9-8-06.GDT 5/15/09

Project Name and Job Number Lee Nuclear Station COL 6234-06-3389	MACTEC / WLA William Lettis & Associates, Inc.	CONCRETE LOG - Boring No. C-3P	
Type and Diameter of Boring Concrete core / HQ core / 4 inch	Boring Location East Side of CNS Unit 1 N 1165935 E 1846400		Total Depth 36.0 feet
Drilling Contractor and Rig Concrete Coring and Saw / King Drilling / D 120	Elevation and Datum 544.3 feet MSL	Ground Water Depth N/A	Depth to Bedrock 6.2 feet
Casing Size and Depth N/A	Length of Core Barrel and Bit 8.5 feet	No. of Core Boxes 4	Date Started 8/1/08
	Borehole Inclination -90	Logged by G. Van Etten	Date Completed 8/1/08

Reviewed by / Date M. Bugh 5/15/09
Reviewed by / Date MGG 5/15/09

Depth (feet)	Run No.	Recovery / Cut	% RQD	Weathering	Strength	In-Situ Testing	Lithology	Remarks	Elevation (feet)
0–1	1	1.8/1.8					STRUCTURAL CONCRETE Two reinforcing bars from 0.4' to 0.5' Welded Wire Fabric at 1.35' and 1.41' Cold Joint in Concrete between Runs 1 and 2 Rubber waterstop between Runs 2 and 3 Reinforcing bars from 3.75' to 3.78'	Two No. 11 rebars Two mats of welded wire fabric	544–543
1–3	2, 3	0.5, 0.5							542
3–4	4	0.5							541
4–5	5	0.5, 1.2, 1.2	86		R3		FILL CONCRETE; light olive brown (2.5Y 5/3), medium strong, meta-granodiorite aggregate clasts <0.1' wide, subangular, matrix supported, occasional vugs 0.01' - 0.02', most less than 0.01'	No. 9 rebar Started HQ drilling at 9:30 am 8/1/08 Good, light gray water return Sharp contact, 5°-10°	540–538
5–7	5	5.0/5.0	86	F	R4		META-DIORITE; very dark bluish gray (GLEY 2 3/1), massive with <0.2' wide quartz veins dipping ~60°, fine grained, ~60% pyroxenes and hornblende, ~30% quartz, ~5% plagioclase, ~5% micas, minor shear fabric along veins and joints 10.8' to 11.0', 0.04' wide quartz and actinolite vein dipping ~35° CONTINUOUS ROCK	Quartz veins intersect and occasionally offset slightly	537–535
7–9	5	5.0/5.0	100	F	R4				534–531
9–12	6	5.0/5.0	100	F	R4		META-DIORITE; very dark bluish gray (GLEY 2 3/1), massive with <0.02' wide quartz veins dipping ~10°, fine grained, ~60% pyroxenes and hornblende, ~30% quartz, ~5% plagioclase, ~5% micas, actinolite, and pyrite, some shear fabric along veins and joints	Good, gray water return	530–526
12–15	7	5.0/5.0	94	F	R4			Quartz vein, vertical with oxidized contact.	525–521
15–18	8	5.0/5.0	100	F	R4		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), massive with numerous quartz veins <0.02' thick most dipping ~60°, fine to medium grained, 50% quartz, 30% pyroxenes and hornblende, 15% plagioclase, 5% micas, trace actinolite and pyrite, some shear fabric along healed veins and joints	Sharp contact	520–518
18–21	9	5.0/5.0	88	F	R4			Rig stopped due to mechanical problems 29.4' to 29.7', 0.05' thick quartz vein Good, gray water return	517–513
21–23	10	2.0/2.0	100	F	R4				512–509
23–36							Total Depth 36 ft. Groundwater encountered at 0 feet		508–505

CONCRETE LOG CHEROKEE10-10-07.GPJ WLA9-8-06.GDT 5/15/09

Project Name and Job Number Lee Nuclear Station COL 6234-06-3389	MACTEC / WLA William Lettes & Associates, Inc.	CONCRETE LOG - Boring No. C-4P	
Type and Diameter of Boring Concrete core / HQ core / 4 inch	Boring Location East Side of CNS Unit 1 N 1165950 E 1846407		Total Depth 35.3 feet
Drilling Contractor and Rig Concrete Coring and Saw / MACTEC ATL / CME 550 X	Elevation and Datum 544.3 feet MSL	Ground Water Depth N/A	Depth to Bedrock 9.3 feet
Casing Size and Depth N/A	Length of Core Barrel and Bit 8.6 feet	No. of Core Boxes 4	Date Started 8/1/08
	Borehole Inclination -90	Logged by M. Buga	Date Completed 8/1/08

Reviewed by / Date M.BUGA 5/15/09
Reviewed by / Date MGG 5/15/09

Run No.	Recovery / Cut	% RQD	Weathering	Strength	In-Situ Testing	Lithology	Remarks
1	1.0/1.0					STRUCTURAL CONCRETE One reinforcing bar from 0.42' to 0.52'	Concrete core broke at 1.0' in depth One No. 11 rebar encountered in top (0.42' to 0.52') and bottom (3.48' to 3.58') reinforcing mats
2	3.0/3.0					One reinforcing bar from 3.48' to 3.58'	
3	5.0/5.0			R4		FILL CONCRETE; ~45% 1" aggregate, ~50% fine aggregate and cement mixture, minor occasional air voids up to 0.01' in width	Begin coring at 8:40 am 8/1/2008 Water at surface 650 psi down feed pressure
4	5.0/5.0	100	F	R4		META-DIORITE; very dark bluish gray (GLEY 2 3/1), fine grained, weakly to moderately foliated, ~70% pyroxene and hornblende, ~15% plagioclase, ~10% quartz, 5% very fine mica, shear planes dipping 55-60°, healed fractures throughout (penetrate/cut foliation), vein with actinolite and quartz at 11.5', increase in hornblendes and micas below 12.4' CONTINUOUS ROCK	Sharp contact, dipping 10°
5	5.0/5.0	100	F	R4		META-DIORITE; dark bluish gray (GLEY 2 4/1), fine to medium grained, like above	
6	5.0/5.0	94	F	R4		META-GRANODIORITE to META-QUARTZ GRANODIORITE, dark bluish gray to bluish gray (GLEY 2 4/1 - 5/1), fine to medium grained, ~45% quartz, 45% pyroxene and hornblende, ~5-10% plagioclase, trace micas Below 18.8', quartz veins with actinolite, pyroxene, hornblende, mica, epidote, pyrite, predominantly quartz, groundmass significantly more quartz ~60-70%, large subvertical to vertical joint (healed but mechanically broken during drilling)	Run 5, core mechanically broken due to core/bit blockage Drillers pulled rods and retrieved broken core
7	5.0/5.0	92	F	R4		META-DIORITE; very dark bluish gray (GLEY 2 3/1), fine to medium grained, predominantly mafic minerals, pyroxene, hornblende, mica, ~10-15% quartz and plagioclase, weakly developed foliation	Pieces from Run 5 and fractured rock make Run 6 lengthy
8	5.0/5.0	76	F	R4			
9	1.3/1.3	100	F	R4		META-GRANODIORITE to META-QUARTZ GRANODIORITE; bluish gray (GLEY 2 5/1), fine to medium grained, well developed foliations, abundant incipient fractures, quartz veins generally dipping 60°, 50% quartz, 40% pyroxene and hornblende	Boring terminated at 3:00 pm

Total Depth 35.3 ft.
Groundwater encountered at 0 feet

Depth (feet): 0–40
Elevation (feet): 544–505

CONCRETE LOG CHEROKEE10-10-07.GPJ WLA9-8-06.GDT 5/15/09

Project Name and Job Number Lee Nuclear Station COL 6234-06-3389	MACTEC / WLA William Lettis & Associates, Inc.	CONCRETE LOG - Boring No. C-5P	
Type and Diameter of Boring Concrete core / HQ core / 4 inch	Boring Location East Side of CNS Unit 1 N 1165950 E 1846414		Total Depth 60.0 feet
Drilling Contractor and Rig Concrete Coring and Saw / MACTEC ATL / CME 550 X	Elevation and Datum 544.2 feet MSL	Ground Water Depth N/A	Depth to Bedrock 25.1 feet
Casing Size and Depth N/A	Length of Core Barrel and Bit 8.6 feet	No. of Core Boxes 6	Date Started 7/29/08
	Borehole Inclination -90	Logged by G. Van Etten	Date Completed 7/31/08

Reviewed by / Date M. Buga 5/15/09
Reviewed by / Date MGG 5/15/09

Depth (feet)	Run No.	Recovery / Cut	% RQD	Weathering	Strength	In-Situ Testing	Lithology	Remarks	Elevation (feet)
0–4	1	4.0/4.0					STRUCTURAL CONCRETE One No. 11 reinforcing bar from 3.38' to 3.48'	One No. 11 rebar encountered in bottom (3.38' to 3.48') mat Start HQ coring at 9:15 am 7/29/2008	544–541
4–9	2	5.0/5.0			R3		FILL CONCRETE; light olive brown (2.5Y 5/3), medium strong, meta-granodiorite to meta-diorite angular aggregate clasts <0.1' wide, subangular, occasional 0.02' wide air voids		540–536
9–14	3	5.0/5.0			R3		9.5', 0.01' thick tan lamination across core possible boundary between lifts.	Air voids in concrete smaller than 0.01' in diameter	535–531
14–19	4	5.0/5.0			R3		FILL CONCRETE; light olive brown (2.5Y 5/3), medium strong, granitic to meta-diorite aggregate clasts <0.1' wide, subangular, occasional 0.01' in diameter air voids 16.0', 0.01' thick tan lamination across core, possible boundary between concrete lifts	Light gray water return	530–526
19–24	5	5.0/5.0			R3		22.2' to 22.5', sand and cement mixture with sinuous lines across core 22.5', planar contact, joint in concrete	Brownish water return for 0.3'	525–521
24–25					R3				520
25–29	6	5.0/5.0	94	F	R4		META-DIORITE; dark bluish gray (GLEY 2 4/1), fine grained, highly metamorphosed and mafic, 70% pyroxenes and hornblendes, 20% quartz, 10% plagioclase and micas, fresh, strong, 0.01' thick quartz veins dipping 60° CONTINUOUS ROCK	Sharp contact at 25.1' Water return becomes dark gray	519–515
29–34	7	5.0/5.0	100	F	R4		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fresh, strong, fine to medium grained, highly sheared, healed with many 0.02' thick quartz veins dipping 60°, ~50% quartz, ~35% pyroxenes and hornblende, ~10% plagioclase, ~5% micas	Contact dipping 60°	514–510
34–39	8	5.0/5.0	100	F	R4		META-DIORITE; mafic, very dark bluish gray (GLEY 2 3/1), fresh, strong, fine grained with 0.01'-0.02' wide quartz veins dipping 60°, ~50% pyroxenes and hornblendes, ~30% quartz, ~10% plagioclase, ~10% micas and trace pyrite Phenocrysts have shear fabric along quartz veins indicating ductile deformation - lineated	High angle, ductile deformed quartz veins < 0.03' thick	509–505

CONCRETE LOG CHEROKEE10-10-07.GPJ WLA9-8-06.GDT 5/15/09

Project Name and Job Number
Lee Nuclear Station COL
6234-06-3389

MACTEC WLA William Lettis & Associates, Inc.

CONCRETE LOG - Boring No. C-5P

Depth (feet)	Run No.	Recovery / Cut	% RQD	Weathering	Strength	In-Situ Testing	Lithology	Remarks	Elevation (feet)
40–43	9	5.0/5.0	92	F	R4		META-DIORITE; mafic, very dark bluish gray (GLEY 2 3/1), fresh, strong, fine grained with 0.01'-0.02' wide quartz veins dipping 60°, ~50% pyroxenes and hornblendes, ~30% quartz, ~10% plagioclase, ~10% micas and trace pyrite	Sharp contact	504–501
44–48	10	5.0/5.0	100	F	R4		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fresh, strong, fine to medium grained, abundant 0.01' thick quartz veins and healed fractures, ~50% quartz, ~30% pyroxenes and hornblendes, ~10% plagioclase, ~10% micas, pyrite, actinolite among others 46.6' to 46.9', quartz vein with medium grained muscovite and chlorite		500–496
49–54	11	5.0/5.0	100	F	R4		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fresh, strong, fine to medium grained phenocrysts, several 0.02' thick quartz veins dipping ~50°, ~50% quartz, ~25% pyroxenes and hornblendes, ~15% plagioclase and potassium feldspar, ~10% micas, pyrite, and actinolite 50.7' to 51.0', shear fabric	50.5', no water return due to loose shoe, shoe tightened, drilling continued with good water return	495–491
55–59	12	5.0/5.0	100	F	R4		57.9' to 59.0', quartz vein and healed joint along entire length of core 59.0' to 59.3', 0.02' wide orthoclase vein		490–485
60	13	1.0/1.0	100	F	R4			59.3', replaced coring bit	484
61–80							Total Depth 60 ft. Groundwater encountered at 0 feet		483–465

CONCRETE LOG CHEROKEE10-10-07.GPJ WLA9-8-06.GDT 5/15/09

Project Name and Job Number Lee Nuclear Station COL 6234-06-3389	MACTEC / WLA William Lettis & Associates, Inc.	**CONCRETE LOG - Boring No. C-9AP**	
Type and Diameter of Boring Concrete core / HQ core / 4 inch	Boring Location North Side of CNS Unit 1 N 1166028 E 1846357		Total Depth 119.9 feet
Drilling Contractor and Rig Concrete Coring and Saw / MACTEC ATL / CME 550 X	Elevation and Datum 544.2 feet MSL	Ground Water Depth N/A	Depth to Bedrock 8.4 feet
Casing Size and Depth N/A	Length of Core Barrel and Bit 8.6 feet	No. of Core Boxes 10	Date Started 7/29/08
	Borehole Inclination -90	Logged by M. Buga	Date Completed 8/3/08

Reviewed by / Date M.BUGA 5/15/09
Reviewed by / Date MGG 5/15/09

Depth (feet)	Run No.	Recovery / Cut	% RQD	Weathering	Strength	In-Situ Testing	Lithology	Remarks	Elevation (feet)
0–3	1	3.9/3.9			R4		STRUCTURAL CONCRETE One reinforcing bar from 0.34' to 0.44' One reinforcing bar from 3.48' to 3.58'	One No. 11 rebar encountered in top (0.34' to 0.44') and bottom (3.48' to 3.58') mats	544–541
4–8	2	5.0/5.0	100		R4		FILL CONCRETE; average 0.5" aggregate, ~35-40% aggregate, 55-60% sand and cement mixture, <5% air voids Sharp, 15° dipping contact at 8.4'	Begin HQ coring at 3:30 pm 7/29/2008 Dark gray water return	540–536
9–10	3	3.0/3.0	100	F	R4		META-DIORITE; very dark bluish gray (GLEY 2 3/1), fine grained, ~15% plagioclase, ~5% mica, quartz vein dipping 60°, massive, 10% pyroxene, healed fractures, larger, high angle quartz veins below 6.5' up to 0.1' thick, quartz vein is within a long shear zone at 12.2' CONTINUOUS ROCK	Rig chatter at end of Run 3 Multiple attempts to recover unbroken core from Run 4	535–533
12–13	4	1.9/1.9	100	F	R4				532–531
14–17	5	5.0/5.3	100	F	R4		META-DIORITE; very dark bluish gray (GLEY 2 3/1), fine to medium grained, ~15% plagioclase, ~10% mica, pyroxene groundmass 14.5', large quartz vein ~0.1' to 0.12' thick, dipping 60°, rock is weakly foliated	Good water return	530–527
19–22	6	5.0/5.0	100	F	R4		20.1' to 20.6', 0.3' thick quartz vein with pyrite clasts Quartz filled, healed joints <0.01' thick	Start drilling 7/30/2008 Water at ground surface	526–522
24–27	7	5.0/5.0	94	F	R4		24.0' to 28.0', very weakly foliated Below 28.0', moderately foliated	600 psi down feed pressure	521–517
29–31							29.0', healed fractures/joints anastomosing, mostly high angle 29.5', metamorphic quartz vein		516–514
31–34	8	5.0/5.0	100	F	R4		META-GRANODIORITE; bluish gray (GLEY 2 5/1), massive, groundmass predominantly quartz (~75%), 20% pyroxene and hornblende, ~5% plagioclase and mica, weakly to moderately foliated, meta-diorite xenoliths up to 0.2' in size, incipient fractures throughout, shear fabric at 34.0', dipping 70°, 0.4' thick 34.0' to 38.7', abundant incipient joints, tightly healed	Stop drilling to refill water tank	513–510
35–39	9	5.0/5.0	100	F	R4		36.6' to 37.0', shear fabric, dips 50°-60°, ductile deformation, healed	800 psi down feed pressure	509–505
40									

CONCRETE LOG CHEROKEE10-10-07.GPJ WLA9-8-06.GDT 5/15/09

Project Name and Job Number
Lee Nuclear Station COL
6234-06-3389

MACTEC WLA William Lettis & Associates, Inc.

CONCRETE LOG - Boring No. C-9AP

Depth (feet)	Lithology	Run No.	Recovery / Cut	% RQD	Weathering	Strength	In-Situ Testing	Lithology	Remarks	Elevation (feet)
40		10	5.0/5.0	100	F	R4		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), massive, fine to medium grained, ~65% quartz, 25% pyroxene and hornblende, ~9% plagioclase, ~1% mica 40.2' to 42.5', large subvertical metamorphosed zone, quartz veins up to 0.1' thick associated with healed fractures, some pyrite Below 42.5' abundant incipient fractures, high angle, tight healed 44.0' to 45.0', heavily metamorphosed zone, abundant quartz, healed fractures 44.0' to 49.0', abundant incipient fractures and healed joints, anastomosing to blocky, large quartz vein from 45.6' to 46.2', fine to coarse grained pyrite throughout	Started drilling at 2:20 pm	504
41										503
42										502
43										501
44		11	5.0/5.0	100	F	R4				500
45										499
46										498
47									Steady, hard drilling	497
48										496
49										495
50		12	5.0/5.0	100	F	R4			Grading to higher percentage of micas, ~5%	494
51										493
52										492
53									600 psi down feed pressure ~100% water return	491
54		13	5.0/5.0	100	F	R4		Abundant fractures/joints, high angle and healed with quartz veins up to 0.5' thick		490
55										489
56										488
57								Below 58.0', heavily deformed, abundant quartz, plagioclase with meta-granodiorite fragments	Done drilling for 7/30/2008 Water at ground surface	487
58										486
59		14	4.9/5.0	98	F	R4		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fine to medium grained, ~40-50% quartz, 35% pyroxene and hornblende and mica, 25% plagioclase, abundant incipient and healed fractures, generally high angle 59.0' to 60.5', large quartz veins and zones of deformations including xenoliths 63.2' to 63.6', large quartz zone, 0.1' thick, mica lining along one side		485
60									8/1/2008 stop drilling, rig moved to C-9AP from C-4P at 3:00 pm	484
61										483
62										482
63										481
64		15	5.0/5.0	100	F	R4				480
65										479
66										478
67								66.7' to 71.0', abundant quartz veining and zones of accumulation "blebs", blebs up to 0.5' in length incipient fractures, micas near veins, xenolith inclusions (~0.5" in size)		477
68										476
69										475
70		16	5.0/5.0	100	F	R4				474
71								Below 71.0', return to meta-granodiorite, like above	8/1/2008 stop drilling for the day	473
72								71.9', quartz lens/bleb, ~0.1' thick 72.0' to 73.0', steep dipping (75°) mineralized fracture with minor healed shearing, quartz, pyroxene, hornblende, biotite, plagioclase, pyrite, 0.01' thick		472
73										471
74		17	5.0/5.0	100	F	R4 to R5		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fine to medium grained, ~50% quartz, 25% to 30% pyroxene and hornblende, 10% to 15% plagioclase, 5% mica, abundant incipient and healed fractures, anastomosing and blocky, occasional quartz veins 74.6' to 76.0', highly disturbed zone with abundant healed fractures, prominent fractures are up to 0.02' to 0.04' thick, high angle, and contains quartz, pyroxene,	Begin drilling at 7:45 am 8/2/2008 Water at ground surface	470
75										469
76										468
77										467
78										466
79										465
80										

CONCRETE LOG CHEROKEE10-10-07.GPJ WLA9-8-06.GDT 5/15/09

Project Name and Job Number
Lee Nuclear Station COL
6234-06-3389

MACTEC WLA William Lettis & Associates, Inc.

CONCRETE LOG - Boring No. C-9AP

Depth (feet)	Lithology	Run No.	Recovery / Cut	% RQD	Weathering	Strength	In-Situ Testing	Lithology	Remarks	Elevation (feet)
80								hornblende, pyrite, plagioclase		464
81		18	5.0/5.0	100	F	R4 to R5				463
82										462
83										461
84										460
85								86.0' to 88.5', prominent foliations, 0.3' thick, high angle (~60°), large quartz vein (post foliation), at least 3 events of deformation, foliation composed of fine grained feldspars and pyroxenes hornblende, some quartz	750-800 psi down feed pressure 100% water return	459
86		19	5.0/5.0	100	F	R4 to R5				458
87										457
88										456
89								META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fine to medium grained, weakly to moderately foliated, ~50-55% quartz, 25-30% pyroxene and hornblende, 20% feldspar, abundant incipient and healed fractures		455
90										454
91		20	5.0/5.0	100	F	R4 to R5		91.7' to 92.2', 0.02' thick foliation zone	Replace bit in middle of Run 20	453
92										452
93								93.0' to 95.5', highly disturbed zone - shears, healed fractures, xenoliths, mostly (meta-diorite) high angle fractures and veins, overall 5-10% more quartz		451
94									1,000 psi down feed pressure 100% water return	450
95										449
96		21	5.0/5.0	100	F	R4 to R5				448
97								96.5' to 100.6', meta-granodiorite, like above, abundant healed fractures		447
98										446
99										445
100										444
101		22	5.0/5.0	100	F	R4 to R5		100.6' to 102.2', highly fractured zone, predominantly quartz, fractures are healed anastomosing to blocky		443
102										442
103										441
104										440
105								META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fine to medium grained, 104.4' to 109.0' prominent vertical fracturing and quartz vein up to 0.15' thick, runs entire length of core, highly contact metamorphosed, abundant quartz, potassium feldspar and plagioclase, ~15-20% pyroxene and hornblende, trace pyrite and mica		439
106		23	5.0/5.0	100	F	R4 to R5				438
107									Driller having problems with rock core recovery, leaving pieces of core down hole	437
108										436
109								Below 109' becomes subvertical fracture out of core at 110.6'		435
110										434
111		24	5.0/5.0	94	F	R4 to R5				433
112										432
113								112.7' to 114.6', large 0.3' thick, quartz vein, dipping 70°		431
114										430
115								META-GRANODIORITE; same as previous description, abundant healed fractures	Bit/sampling barrel plugging up.	429
116		25	4.6/4.6	100	F	R4 to R5				428
117										427
118									Replace bit	426
119		26	1.3/1.3	100	F	R4 to R5		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fine to medium grained, 50% quartz, ~25-30% pyroxene and hornblende, ~15% plagioclase, ~5% mica	End 8/2/2008, water at ground surface Fixed rig and begin drilling	425
120										

CONCRETE LOG CHEROKEE10-10-07.GPJ WLA9-8-06.GDT 5/15/09

Project Name and Job Number
Lee Nuclear Station COL
6234-06-3389

MACTEC WLA William Lettis & Associates, Inc.

CONCRETE LOG - Boring No. C-9AP

Depth (feet)	Lithology	Run No.	Recovery / Cut	% RQD	Weathering	Strength	In-Situ Testing	Lithology	Remarks	Elevation (feet)
120									Run 25 rock core damaged at top of hole during recovery Boring terminated at 119.9'	424
121										423
122										422
123								Total Depth 119.9 ft. Groundwater encountered at 0 feet		421
124										420
125										419
126										418
127										417
128										416
129										415
130										414
131										413
132										412
133										411
134										410
135										409
136										408
137										407
138										406
139										405
140										404
141										403
142										402
143										401
144										400
145										399
146										398
147										397
148										396
149										395
150										394
151										393
152										392
153										391
154										390
155										389
156										388
157										387
158										386
159										385
160										

CONCRETE LOG CHEROKEE10-10-07.GPJ WLA9-8-06.GDT 5/15/09

Project Name and Job Number Lee Nuclear Station COL 6234-06-3389	MACTEC / WLA William Lettus & Associates, Inc.	CONCRETE LOG - Boring No. C-11P	
Type and Diameter of Boring Concrete core / HQ core / 4 inch	Boring Location West Side of CNS Unit 1 N 1165969 E 1846321		Total Depth 70.9 feet
Drilling Contractor and Rig Concrete Coring and Saw / King Drilling / D 120	Elevation and Datum 544.3 feet MSL	Ground Water Depth N/A	Depth to Bedrock 11.3 feet
Casing Size and Depth N/A	Length of Core Barrel and Bit 8.7 feet	No. of Core Boxes 6	Date Started 8/12/08
	Borehole Inclination -90	Logged by M. Buga	Date Completed 8/13/08

Reviewed by / Date M.BUGA 5/15/09
Reviewed by / Date MGG 5/15/09

Run No.	Recovery / Cut	% RQD	Weathering	Strength	In-Situ Testing	Lithology	Remarks
1	3.9/3.9					STRUCTURAL CONCRETE No. 11 reinforcing bar from 0.4' to 0.5' No. 11 reinforcing bar from 3.45' to 3.55'	One No. 11 rebar encountered in top (0.4' to 0.5') and bottom (3.45' to 3.55') mats
2	5.0/5.0			R4		FILL CONCRETE; ~50% 0.5" - 1" aggregate, ~50% sand and cement mixture, trace air voids	Begin HQ core 8/12/2008
3	5.0/5.0	100		R4			
3			MW to SW	R3 to R4		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fine to medium grained, weakly to moderately foliated locally otherwise well developed foliations, abundant incipient fractures, 50% quartz, 40-45% pyroxene and hornblende, 5-10% plagioclase, trace potassium feldspar, quartz veining CONTINUOUS ROCK	Sharp contact dipping 5°
4	5.0/5.0	100	SW to F	R4 to R5			
5	5.0/5.0	94	F	R4 to R5		META-GRANODIORITE; SAA, sparse to moderately abundant meta-diorite xenoliths, more potassium feldspar, 45% quartz, 35% pyroxenes and hornblende, 20% potassium feldspar, trace mica Below 23.0', trace potassium feldspar	Begin drilling 18.9' 8/13/2008 Rig chatter in first foot of run Pulled rods, lifting ring was stuck
6	5.0/5.0	100	SW to F	R4 to R5		25.0', potassium feldspar increases to ~20% 26.5', 0.05' thick band of potassium feldspar absent granodiorite	Rig chatter Sharpen bit 16 minutes into 4th foot of Run 6
7	5.0/5.0	100	F	R4 to R5		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fine to medium grained, weakly to moderately foliated, abundant incipient fractures, abundant diorite xenoliths, 45% to 50% quartz, 40% pyroxene and hornblende, 10-15% plagioclase, <5% potassium feldspar 32.4' to 32.9', shear/foliated zone	
8	5.0/5.0	96	F	R4 to R5		36.1' to 36.4', shear zone Below 36.4' to 38.4' prominent, subvertical quartz vein	
						Same as previous; abundant incipient/healed fractures	Driller stops 3" short of completing Run 8 to sharpen bit with sand

Depth (feet): 0–40. Elevation (feet): 544–505.

CONCRETE LOG CHEROKEE10-10-07.GPJ WLA9-8-06.GDT 5/15/09

Project Name and Job Number
Lee Nuclear Station COL
6234-06-3389

MACTEC WLA William Lettis & Associates, Inc.

CONCRETE LOG - Boring No. C-11P

Depth (feet)	Lithology	Run No.	Recovery / Cut	% RQD	Weathering	Strength	In-Situ Testing	Lithology	Remarks	Elevation (feet)
40										504
41		9	5.0/5.0	100	F	R4 to R5			Slow drilling	503
42								Below 42', subvertical quartz vein, smaller than previous one	800-850 psi down feed pressure	502
43									Trouble recovering core - lifting ring worn	501
44										500
45		10	4.0/5.0	80	F	R4 to R5		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fine to medium grained, moderately to locally heavily foliated, 45% quartz, 40% pyroxene and hornblende, 10% plagioclase, 5% potassium feldspar, abundant incipient fractures	Drill bit plugged up	499
46									Tripped out, recovered missing core except for 1.5'	498
47									Over drills to pick up unrecovered core	497
48										496
49									Drilled 5.0', no recovery	495
50								51.1', 45° dipping quartz vein		494
51		11	5.0/5.0	96	F	R4 to R5			Send barrel down hole	493
52									Recover 1' of core each time barrel is sent down hole	492
53									Can't retrieve last 1.2' of core	491
54										490
55								META-GRANODIORITE; like previous, well developed foliations, abundant high angle fractures/foliations		489
56		12	5.0/5.0	100	F	R4 to R5		At 55.0', large quartz vein and "bleb", sheared off	550 psi down feed pressure	488
57								56.3' to 57', steep dipping quartz vein, ~15% plagioclase, 10% potassium feldspar	100% water returning out of boring C-1	487
58										486
59								58.5' increase in potassium feldspar, up to 5%, locally 10%		485
60										484
61		13	5.0/5.0	100	F	R4 to R5		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fine to medium grained, well developed strong foliation, 45% quartz, 40% pyroxene and hornblende, 10% plagioclase, 5% potassium feldspar, diorite xenoliths, quartz veins at 63.1'	600 psi down feed pressure	483
62										482
63									Difficulty recovering core	481
64										480
65										479
66		14	5.0/5.0	100	F	R4 to R5				478
67										477
68								67.3'-69.1' large vertical-subvertical quartz vein	Driller stops at 67.0', removes rock cored to sharpen bit with coarse sand	476
69										475
70		15	1.3/2.0	65	F	R4 to R5			Drilled to 70.9' but only recovered 1.3'	474
71									Boring terminated at 6:24 pm on 8/13/2008	473
72										472
73								Total Depth 70.9 ft.		471
74								Groundwater encountered at 0 feet		470
75										469
76										468
77										467
78										466
79										465
80										

CONCRETE LOG CHEROKEE10-10-07.GPJ WLA9-8-06.GDT 5/15/09

Project Name and Job Number Lee Nuclear Station COL 6234-06-3389	MACTEC / WLA William Lettis & Associates, Inc.	**CONCRETE LOG - Boring No. C-15P**	
Type and Diameter of Boring Concrete core / HQ core / 4 inch	Boring Location West Side of CNS Unit 1 N 1165890 E 1846316		Total Depth 70.7 feet
Drilling Contractor and Rig Concrete Coring and Saw / King Drilling / D 120	Elevation and Datum 544.4 feet MSL	Ground Water Depth N/A	Depth to Bedrock 9.3 feet
Casing Size and Depth N/A	Length of Core Barrel and Bit 8.7 feet	No. of Core Boxes 6	Date Started 8/11/08
	Borehole Inclination -90	Logged by M. Buga	Date Completed 8/12/08

Reviewed by / Date M. Buga 5/15/09
Reviewed by / Date MGG 5/15/09

Depth (feet)	Lithology	Run No.	Recovery / Cut	% RQD	Weathering	Strength	In-Situ Testing	Lithology	Remarks	Elevation (feet)
0–4		1	3.9/4.0					STRUCTURAL CONCRETE One reinforcing bar from 3.45' to 3.55'	One No. 11 rebar encountered in bottom structural mat	544–541
4–9		2	4.9/4.9			R3 to R4		FILL CONCRETE; 60% 1" aggregate, ~40% sand and cement mixture, <1% air voids (<0.01' in diameter)	Begin HQ coring Water at ground surface	540–536
9–14		3	5.0/5.0	100	F	R4 to R5		META-GRANODIORITE; bluish gray to dark bluish gray (GLEY 2 5/1 - 4/1), fine to medium grained, weakly to moderately foliated, abundant healed fractures, quartz veining, calcite on fracture faces, 55% to 60% quartz, 35% pyroxene and hornblende, 5% to 10% plagioclase CONTINUOUS ROCK	100% water return	535–531
14–19		4	5.0/5.0	100	F	R4		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fine to medium grained, moderately foliated, abundant healed fractures, anastomosing to blocky, quartz veining	400 psi down feed pressure 100% water return	530–526
19–24		5	5.0/5.0	68	SW to F MW to SW F	R3 to R4 R3 R4		21.0' to 22.6', moderately to slightly weathered zone with closely to very closely spaced near horizontal fractures broken up by drilling		525–521
24–29		6	5.0/5.0	100	F	R4 to R5		Same as above, 50% quartz, 45% pyroxene and hornblende, 5% plagioclase		520–516
29–34		7	5.0/5.0	100	SW to F	R4 to R5		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fine to medium grained, weakly to moderately foliated, abundant hairline thick healed fractures, quartz infilling veins, shallow dipping, 45% to 50% quartz, 40% pyroxene and hornblende, 10% to 15% plagioclase, <1% mica, locally fresh to slightly weathered	Slow cutting	515–511
34–40		8	5.0/5.0	100	F	R4 to R5		Below 33.9', moderately to heavily foliated, highly abundant tighty healed fractures, subvertical pervasive quartz veins, sparse xenoliths (meta-diorite)	1,000 psi down feed pressure Rig chatter at 34.6' Barrel plugs up, circulation stops Stop Run 8 2.0' short of completion	510–505

CONCRETE LOG CHEROKEE10-10-07.GPJ WLA9-8-06.GDT 5/15/09

Project Name and Job Number
Lee Nuclear Station COL
6234-06-3389

MACTEC WLA William Lettis & Associates, Inc.

CONCRETE LOG - Boring No. C-15P

Run No.	Recovery / Cut	% RQD	Weathering	Strength	In-Situ Testing	Lithology	Remarks
9	5.0/5.0	100	F	R4 to R5		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fine to medium grained, weakly to moderately foliated, abundant hairline thick healed fractures, quartz infilling veins, shallow dipping, 45% to 50% quartz, 40% pyroxene and hornblende, 10% to 15% plagioclase, <1% mica, locally fresh to slightly weathered	Start coring at 7:30 am 8/12/2008 Water at ground surface Drillers change bits and finish Run 8 Water returning to surface via Boring C-1 during Run 9 coring
10	5.0/5.0	100	F	R4 to R5		META-DIORITE (META-DACITE); very dark bluish gray (GLEY 2 3/1), fine grained, moderate to well developed foliation, highly abundant healed tight fractures, incipient fractures, some quartz veins	Core from Run 9 stuck in shoe, mechanically broken to remove Replaced bit during Run 10 500 psi down pressure
11	5.0/5.0	96	F	R4 to R5		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fine to medium grained, moderate to well developed foliation, prominent quartz veins, abundant healed/incipient fractures	
12	5.0/5.0	100	F	R4 to R5		META-DIORITE (META-DACITE); very dark bluish gray (GLEY 2 3/1), fine grained, >90% pyroxene and hornblende, <1% quartz, healed fractures infilled with quartz [DIKE] META-GRANODIORITE; like previous from 50.6' to 52.5', healed fracture zone META-DIORITE; like previous dike from 52.5' to 54.1' META-GRANODIORITE; like previous from 50.6' to 52.5', lineated, foliated, quartz veins	Drillers sharpen bit
13	5.0/5.0	100	F	R4 to R5		META-GRANODIORITE to META-QUARTZ GRANODIORITE; dark bluish gray (GLEY 2 4/1), fine to medium grained, 45% to 50% quartz, 35% pyroxene and hornblende, 10% to 20% plagioclase, trace mica 61.2' to 61.7', steeply dipping vein	100% water return to surface from Boring C-1
14	5.0/5.0	100	F	R4 to R5		64.0' to 64.3', quartz vein with mica or oxides perpendicular to dip, abundant healed fractures Below 64.9', highly deformed, abundant healed fractures and incipient joints, highly lineated, locally strong foliation, abundant quartz veins, high angle	Difficult sample recovery Several attempts to recover remaining core
15	1.8/1.8	90	F	R4 to R5			

Total Depth 70.7 ft.
Groundwater encountered at 0 feet

Boring terminated at 3:36 pm 8/12/2008

Depth (feet): 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80

Elevation (feet): 504, 503, 502, 501, 500, 499, 498, 497, 496, 495, 494, 493, 492, 491, 490, 489, 488, 487, 486, 485, 484, 483, 482, 481, 480, 479, 478, 477, 476, 475, 474, 473, 472, 471, 470, 469, 468, 467, 466, 465

CONCRETE LOG CHEROKEE10-10-07.GPJ WLA9-8-06.GDT 5/15/09

Project Name and Job Number Lee Nuclear Station COL 6234-06-3389	MACTEC / WLA William Lettes & Associates, Inc.	CONCRETE LOG - Boring No. C-16P	
Type and Diameter of Boring Concrete core / HQ core / 4 inch	Boring Location South Side of CNS Unit 1 N 1165885 E 1846364		Total Depth 35.1 feet
Drilling Contractor and Rig MACTEC/Akins/212393 / D 120	Elevation and Datum 544.5 feet MSL	Ground Water Depth N/A	Depth to Bedrock 6.9 feet
Casing Size and Depth N/A	Length of Core Barrel and Bit 8.7 feet	No. of Core Boxes 4	Date Started 8/11/08
	Borehole Inclination -90	Logged by M. Buga	Date Completed 8/11/08

Reviewed by / Date M.BUGA 5/15/09
Reviewed by / Date MGG 5/15/09

Run No.	Recovery / Cut	% RQD	Weathering	Strength	In-Situ Testing	Lithology	Remarks
1	4.0/4.0					STRUCTURAL CONCRETE Two No. 11 reinforcing bars perpendicular from 0.29' to 0.49' Two No. 11 reinforcing bars perpendicular from 3.42' to 3.62'	Two perpendicular No. 11 rebars in top and bottom mats
2	4.8/4.8	100		R4 to R5		FILL CONCRETE; 60% 1" aggregate, 40% sand and cement mixture, minor (<2%) air voids	Begin coring at 9:30 am 8/11/2008 Water at ground surface
3	5.0/5.0	100	F	R4		META-GRANODIORITE; dark bluish gray (GLEY 2 4/1), fine to medium grained, weakly foliated, 50% pyroxene and hornblende, 40-45% quartz, 5-10% plagioclase, abundant incipient and healed fractures	Sharp contact, dipping 5° 100% water return
4	5.0/5.0	100	F	R4 to R5		META-DIORITE (META-DACITE); very dark bluish gray (GLEY 2 3/1), weakly to moderately foliated, fine to medium grained, 80% pyroxene and hornblende, 20% plagioclase, trace to no quartz 17.8' grades to ~40% plagioclase	Sharp contact, dipping 55° 350 psi down feed pressure 100% water return
5	5.0/5.0	98	F	R4		Below 19.0' strongly lineated, abundant healed fractures, subvertical-vertical quartz vein, vein has been deformed ductilely, meta-granodiorite xenoliths 21.0', 0.1' zone of very closely spaced fractures, 30-45° dip, stepped, tight, lacks infilling	
6	5.0/5.0	60	MW to SW	R3 to R4		23.4' to 25.8', very close to close, planar joints, near horizontal to 45°, disturbed by drilling, increasing potassium feldspar and mafics 26.0', continuing subvertical to vertical quartz vein	
			F	R4			
			MW to SW	R3 to R4		27.8' to 28.2', moderately to slightly weathered zone of planar joints, very close to close, near horizontal	
7	5.0/5.0	100	F	R4 to R5		META-DIORITE (META-DACITE); very dark bluish gray (GLEY 2 3/1), heavily foliated, fine to medium grained, abundant, healed fractures, subvertical quartz vein	
8	1.3/1.3	100	SW to F	R4		META-GRANODIORITE; bluish gray (GLEY 2 3/1), moderately to heavily foliated, fine to medium grained, 45% to 50% quartz, 35% to 40% pyroxenes and hornblende, 10% to 20% plagioclase	Boring terminated at 12:30 pm 8/11/2008

Total Depth 35.1 ft.
Groundwater encountered at 0 feet

Depth (feet): 0–40
Elevation (feet): 544–505

Appendix B – Post-Demolition Boring Summary Sheets

Explanation

Symbols

Lab test

RQD — Percent of recovery

0 — 100%

Rock Quality Designation (RQD) and percent of recovery

● 16,930 psi — Laboratory unconfined compression test result (psi)

(8,238,000 psi) — Laboratory (static) Young's Modulus (E, psi)

P — Petrographic analysis

UTA-54-A — Resonant column and torsional shear test

In situ test

3,200,000 psi
4,300,000 psi — Goodman Jack (True Young's Modulus, Et, psi)

90,000 psi ◆ — Pressuremeter (Shear Modulus, G, psi)

Abbreviations

Res = Residuum
Sap = Saprolite
Col = Colluvium
PWR = Partially weathered rock
MW = Moderately weathered
SL-F = Slightly weathered to fresh rock
BOH = Bottom of hole

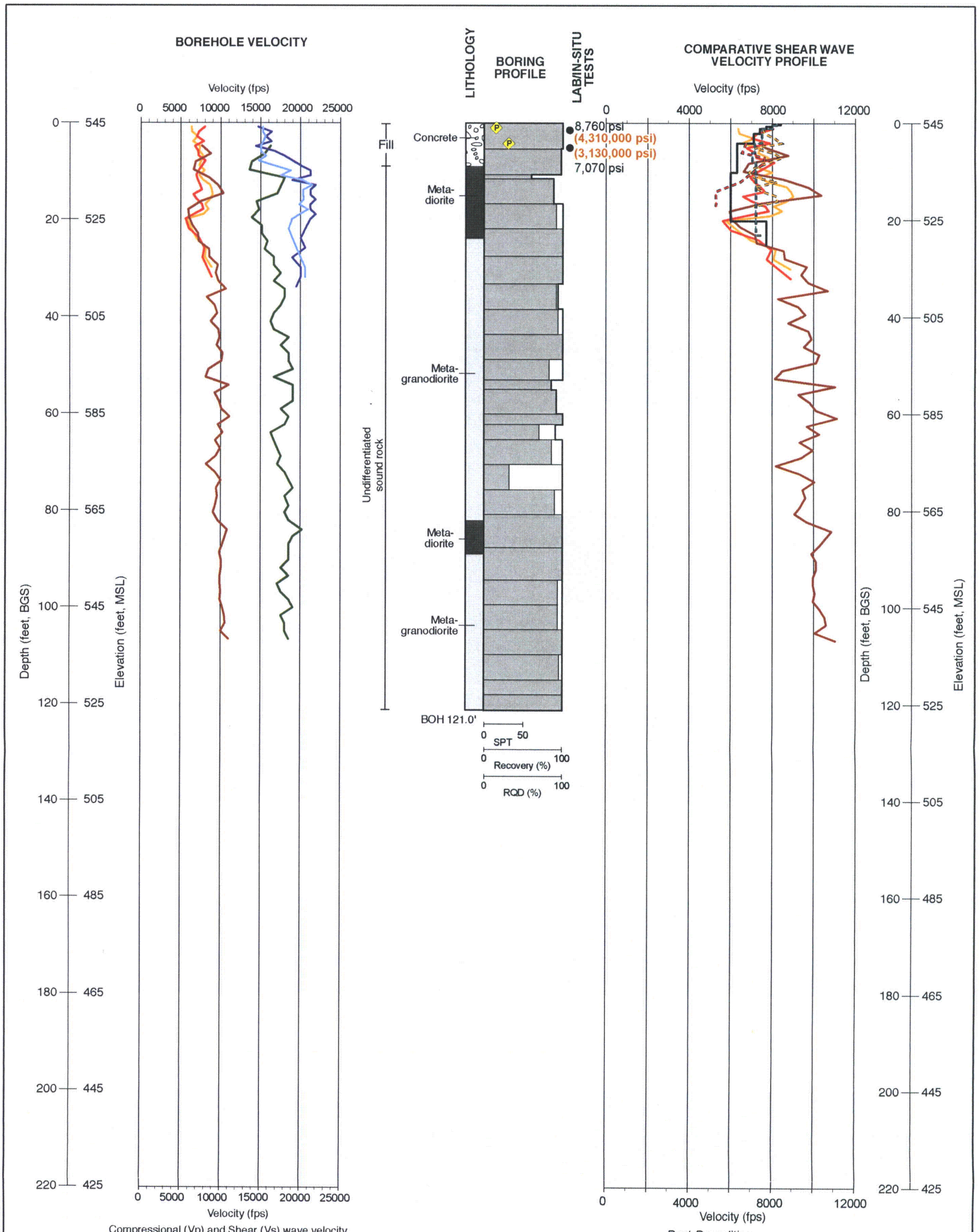
Lithology

- Concrete
- Silty sand (SM)
- Sandy silt (ML)
- Gravel
- Diabase
- Meta-granodiorite
- Meta-quartz Diorite
- Meta-diorite

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Boring Summary Sheet Explanation

FIGURE 1 Rev 0



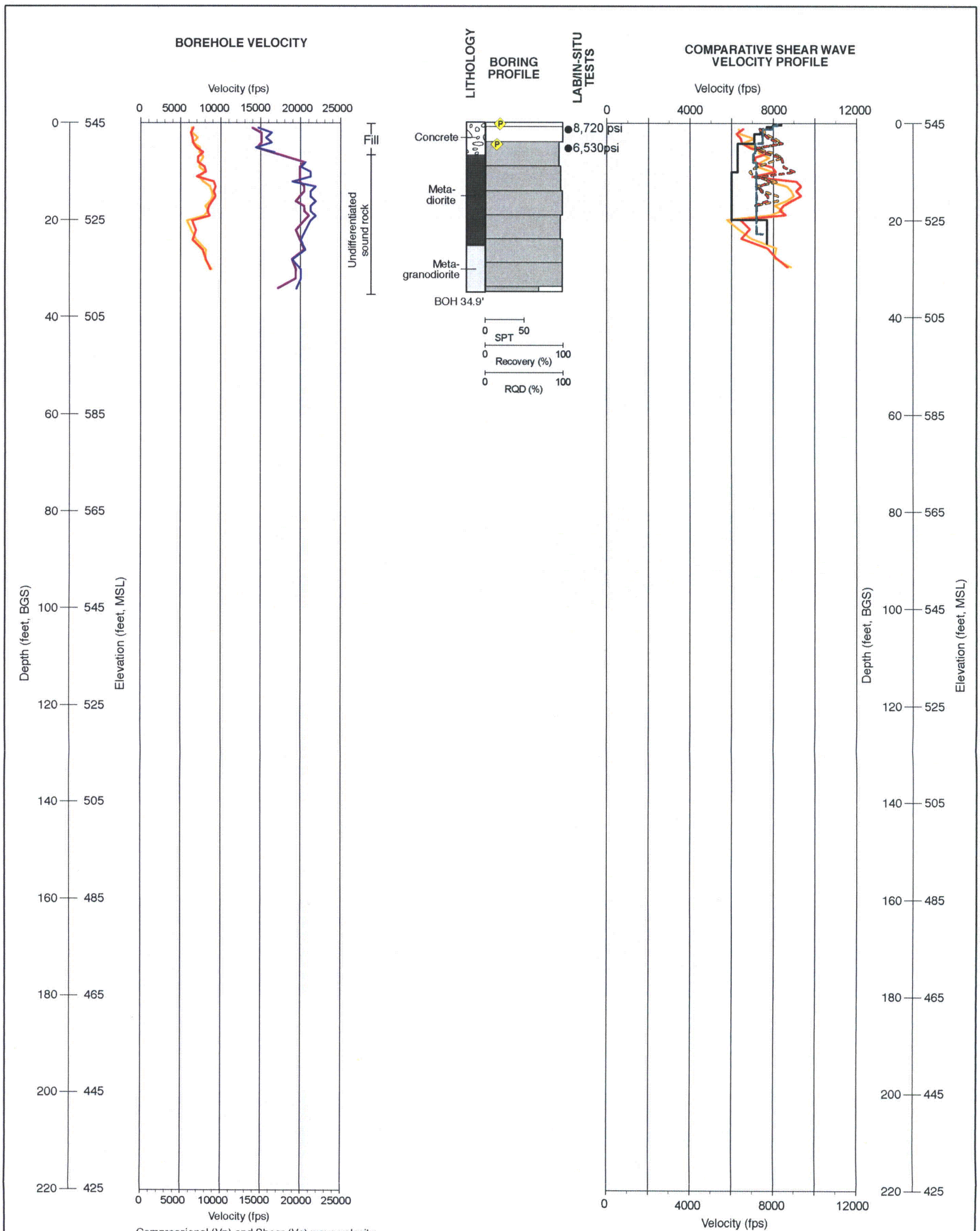
For explanation see FIGURE 1

Notes:
1. Borehole geophysics performed by GEOVision Geophysical Services.
2. Surface geophysics and crosshole logging performed by University of Texas at Austin.
3. SPT field blows determined with a 140-lb. hammer, 30-in. drop - uncorrected.
4. RQD (Rock Quality Designation) - a percentage of solid core segments larger than 0.33 feet relative to core run length, excluding mechanical breaks.

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Boring Summary Sheet, Boring C-1P

FIGURE 2 Rev 0



For explanation see FIGURE 1

Notes:
1. Borehole geophysics performed by GEOVision Geophysical Services.
2. Surface geophysics and crosshole logging performed by University of Texas at Austin.
3. SPT field blows determined with a 140-lb. hammer, 30-in. drop - uncorrected.
4. RQD (Rock Quality Designation) - a percentage of solid core segments larger than 0.33 feet relative to core run length, excluding mechanical breaks.

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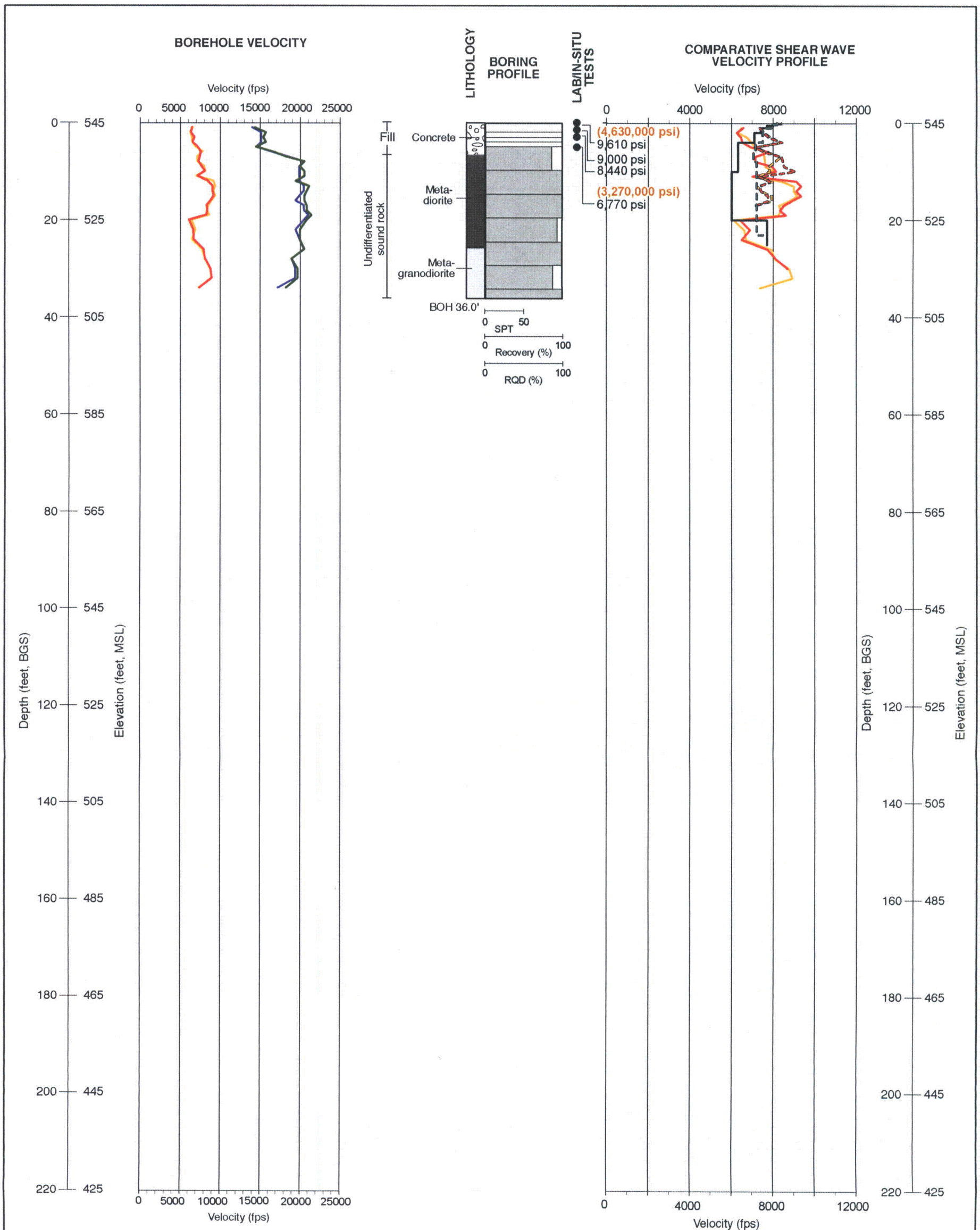
NUCLEAR STATION UNITS 1 & 2

Boring Summary Sheet, Boring C-2P

FIGURE 3 Rev 0



For explanation see FIGURE 1

Notes:
1. Borehole geophysics performed by GEOVision Geophysical Services.
2. Surface geophysics and crosshole logging performed by University of Texas at Austin.
3. SPT field blows determined with a 140-lb. hammer, 30-in. drop - uncorrected.
4. RQD (Rock Quality Designation) - a percentage of solid core segments larger than 0.33 feet relative to core run length, excluding mechanical breaks.

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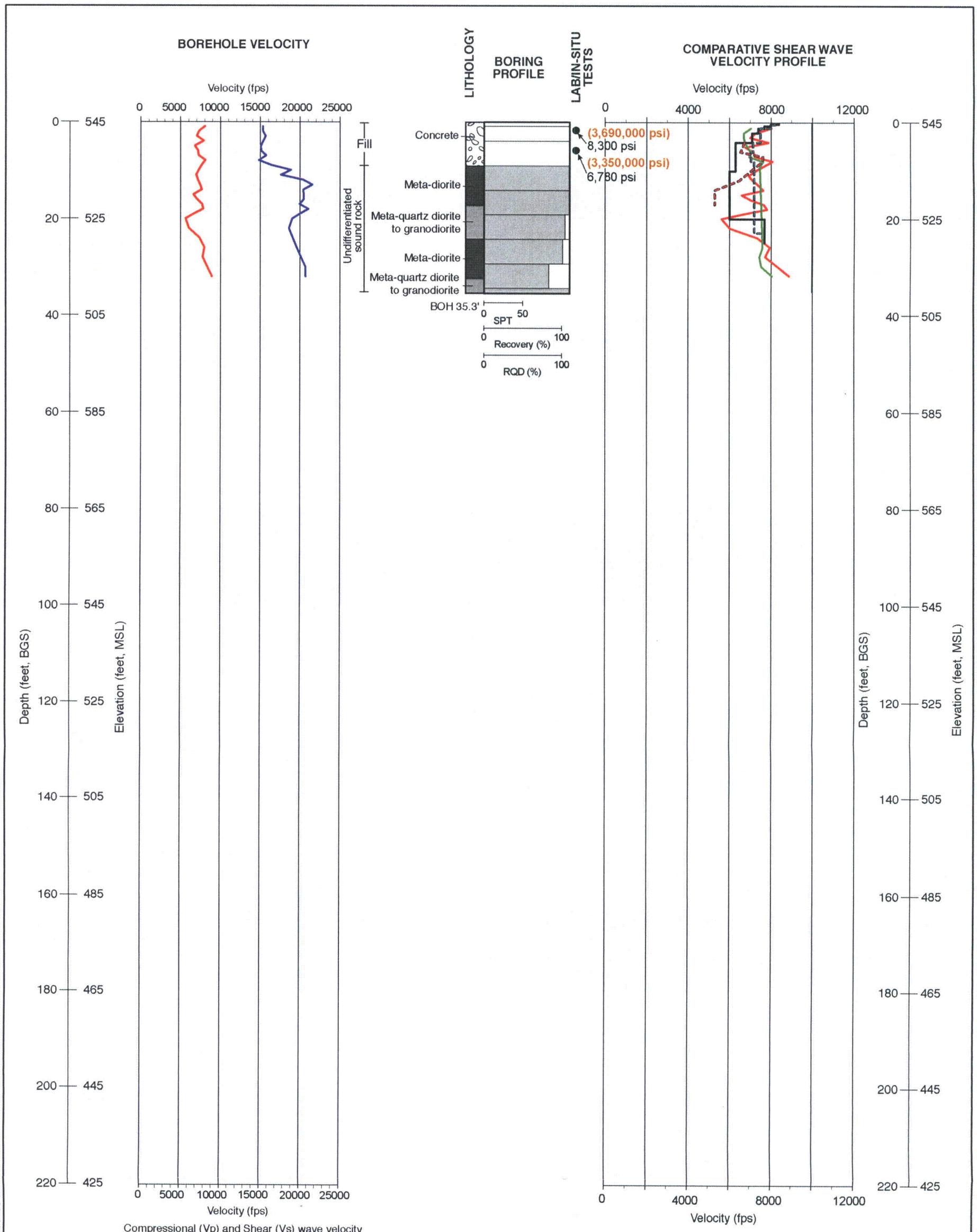
NUCLEAR STATION UNITS 1 & 2

Boring Summary Sheet, Boring C-3P

FIGURE 4 Rev 0



Compressional (Vp) and Shear (Vs) wave velocity (fps) from crosshole velocity survey (horizontal wave paths)

Post-Demolition

Vs - Crosshole (C-1P to C-4P)

Vp - Crosshole (C-1P to C-4P)

Post-Demolition

Vs - Crosshole (C-1P to C-4P)

Vs - Crosshole (C-4P to C-5P)

Vs - SASW (S-1515)

Pre-Demolition

Vs - Crosshole (C-1 to C-4)

Vs - SASW (S-1514)

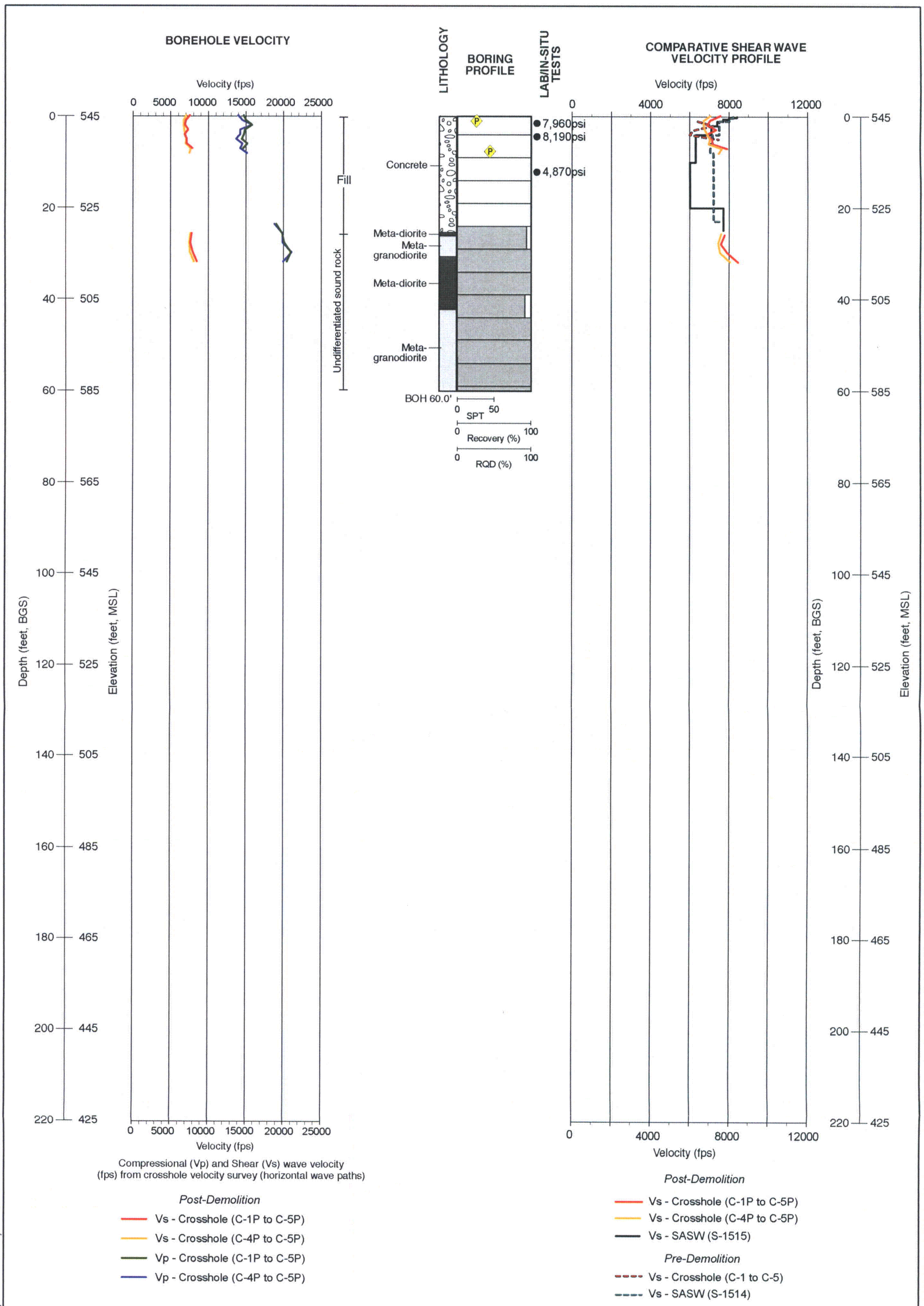
For explanation see FIGURE 1

Notes:
1. Borehole geophysics performed by GEOVision Geophysical Services.
2. Surface geophysics and crosshole logging performed by University of Texas at Austin.
3. SPT field blows determined with a 140-lb. hammer, 30-in. drop - uncorrected.
4. RQD (Rock Quality Designation) - a percentage of solid core segments larger than 0.33 feet relative to core run length, excluding mechanical breaks.

WILLIAM STATES LEE III NUCLEAR STATION UNITS 1 & 2

Boring Summary Sheet, Boring C-4P

FIGURE 5 Rev 0



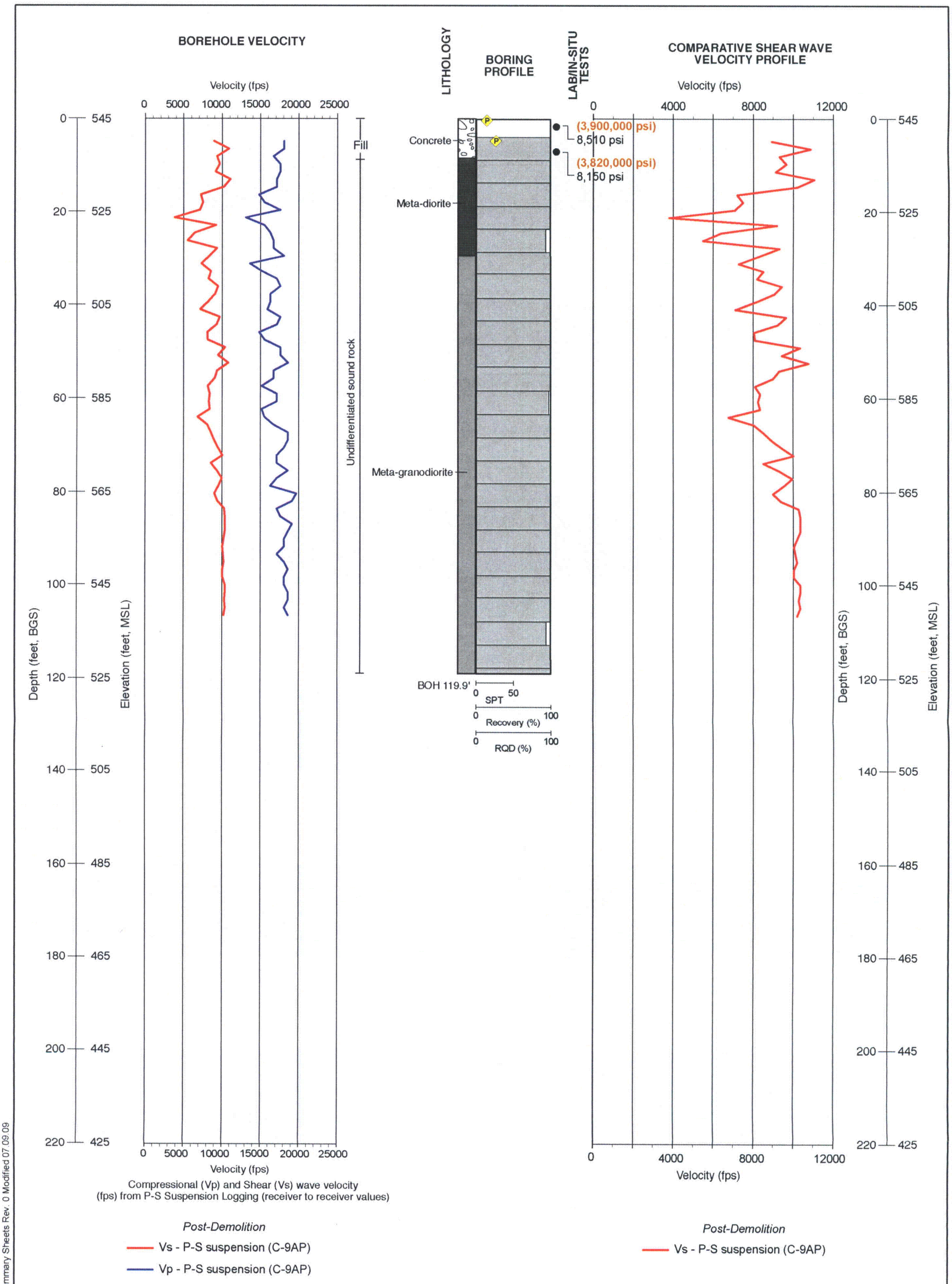
For explanation see FIGURE 1

Notes:
1. Borehole geophysics performed by GEOVision Geophysical Services.
2. Surface geophysics and crosshole logging performed by University of Texas at Austin.
3. SPT field blows determined with a 140-lb. hammer, 30-in. drop - uncorrected.
4. RQD (Rock Quality Designation) - a percentage of solid core segments larger than 0.33 feet relative to core run length, excluding mechanical breaks.

WILLIAM STATES LEE III NUCLEAR STATION UNITS 1 & 2

Boring Summary Sheet, Boring C-5P

FIGURE 6 Rev 0



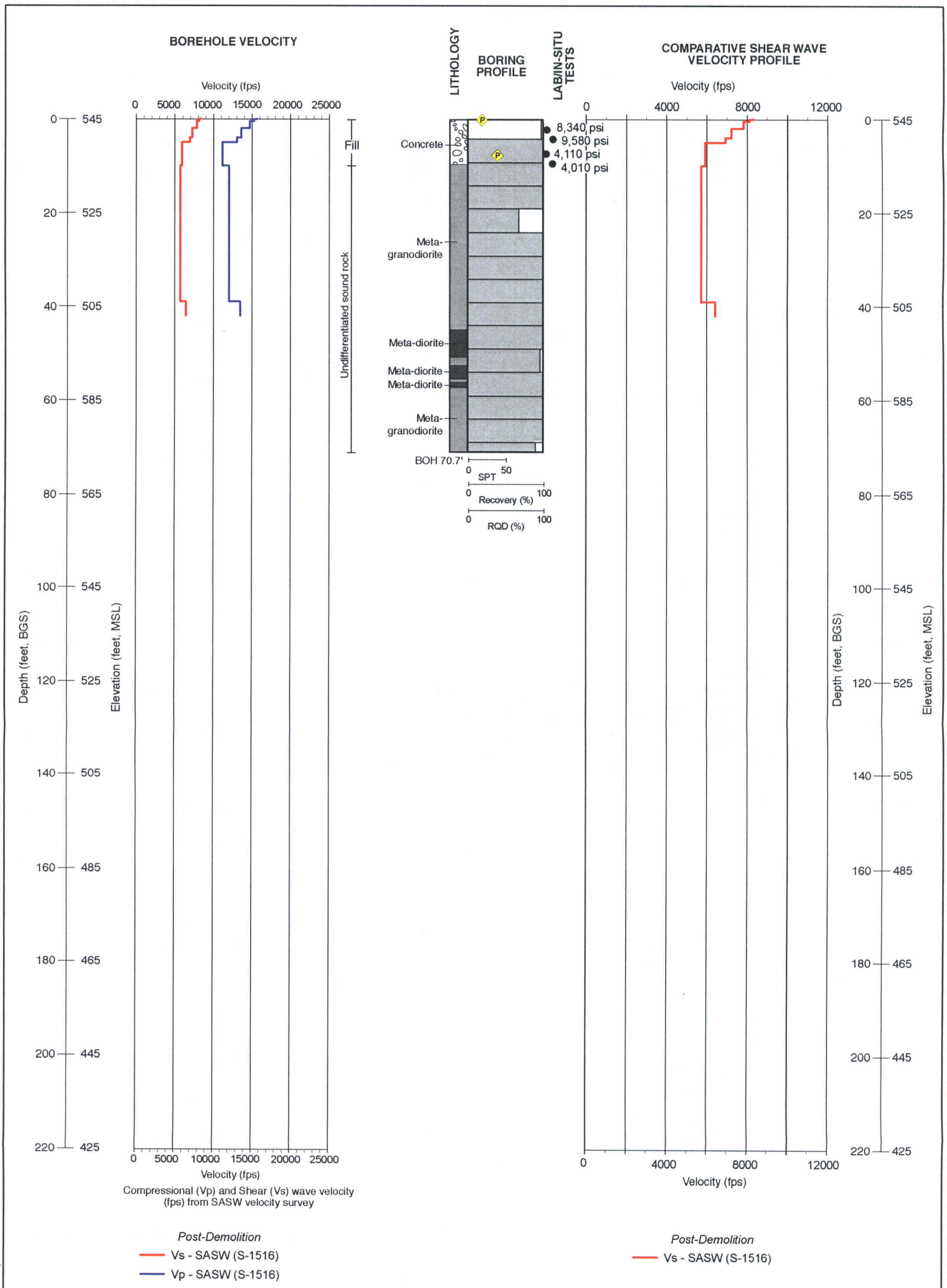
Notes:
1. Borehole geophysics performed by GEOVision Geophysical Services.
2. Surface geophysics and crosshole logging performed by University of Texas at Austin.
3. SPT field blows determined with a 140-lb. hammer, 30-in. drop - uncorrected.
4. RQD (Rock Quality Designation) - a percentage of solid core segments larger than 0.33 feet relative to core run length, excluding mechanical breaks.

For explanation see FIGURE 1

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Boring Summary Sheet, Boring C-9AP

FIGURE 7 Rev 0



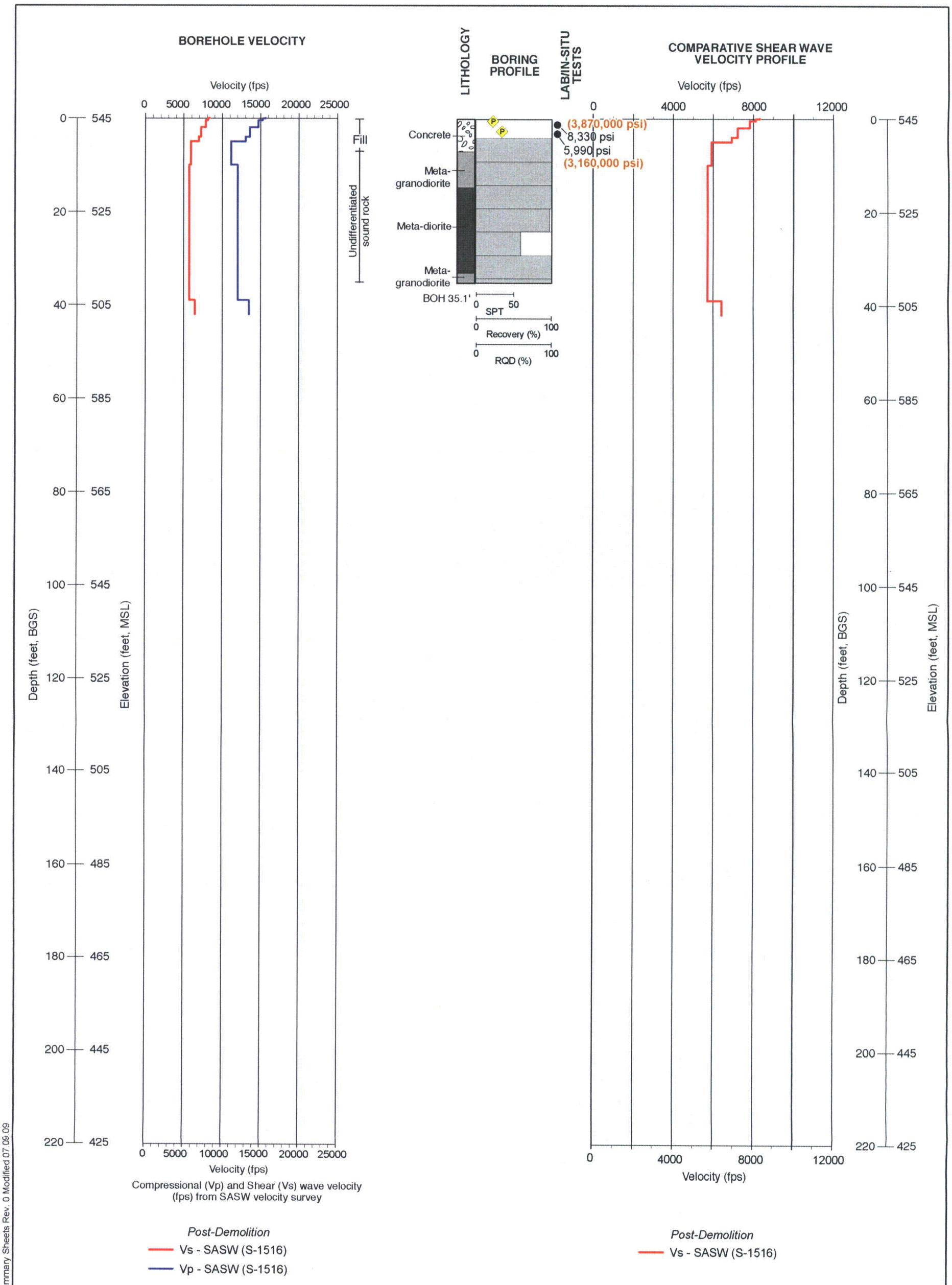
For explanation see FIGURE 1

Notes:
1. Borehole geophysics performed by GEOVision Geophysical Services.
2. Surface geophysics and crosshole logging performed by University of Texas at Austin.
3. SPT field blows determined with a 140-lb. hammer, 30-in. drop - uncorrected.
4. RQD (Rock Quality Designation) - a percentage of solid core segments larger than 0.33 feet relative to core run length, excluding mechanical breaks.

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Boring Summary Sheet, Boring C-15P

FIGURE 8 Rev 0



Notes:
1. Borehole geophysics performed by GEOVision Geophysical Services.
2. Surface geophysics and crosshole logging performed by University of Texas at Austin.
3. SPT field blows determined with a 140-lb. hammer, 30-in. drop - uncorrected.
4. RQD (Rock Quality Designation) - a percentage of solid core segments larger than 0.33 feet relative to core run length, excluding mechanical breaks.

For explanation see FIGURE 1

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Boring Summary Sheet, Boring C-16P

FIGURE 9 Rev 0