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Appendix A5

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Appendix A1

Preliminary Geotechnical Report May 25, 2007

GEI Consultants





Geotechnical Environmental and Water Resources Engineering

Geotechnical Report

National Synchrotron Light Source II

Advanced Concept Design Phase Brookhaven National Laboratory Upton, New York

Submitted to:

HDR Architecture, Inc. 1101 King Street, Suite 400 Alexandria, VA 22314

Submitted by:

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May 25, 2007 Project 062152-*-1000





Nathan L. Whetten, P.E., C.G. Senior Project Manager

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1. Introduction

1.1 Introduction

Previously, we conducted subsurface explorations and geotechnical engineering evaluations for Conceptual Design, and prepared a summary report dated November 9, 2006. The proposed building location was subsequently shifted about 500 feet to the west. In April and May 2007, we conducted supplemental explorations and engineering evaluations within the western portion of the site, to update our conceptual design recommendations for the current building configuration.

This report summarizes the results of previous (conceptual design) and recent (advanced conceptual design) subsurface explorations, and our geotechnical design and construction recommendations for conceptual design of the proposed National Synchrotron Light Source II (NSLS II). This report supersedes our conceptual design phase geotechnical report dated November 9, 2006.

1.2 Summary

The subsurface explorations encountered up to about 9 feet of fill overlying a sand deposit that extends to more than 100 feet below ground surface (bgs). We recommend that foundations be designed as spread footing foundations with slab-on-grade floors. The existing fill should be removed within the building limits and replaced with compacted Structural Fill.

1.3 Scope of Work

GEI performed the following conceptual design tasks in 2006:

- 1. Engaged subsurface exploration contractors to conduct test borings and cone penetrometer tests.
- 2. Provided a full-time field representative to observe the explorations, and classify the soil samples in the borings.
- 3. Engaged a materials testing laboratory to perform mechanical gradation analyses on representatives soil samples from the borings.
- 4. Evaluated the subsurface conditions encountered in the conceptual design explorations and prepared a summary report dated November 9, 2006.



GEI performed the following advanced conceptual design tasks in 2007:

- 1. Engaged subsurface exploration contractors to conduct supplemental test borings and cone penetrometer tests.
- 2. Provided a full-time field representative to observe the explorations, and classify the soil samples in the borings.
- 3. Engaged a materials testing laboratory to perform mechanical gradation analyses on representatives soil samples from the borings.
- 4. Evaluated the subsurface conditions encountered in the conceptual design and advanced conceptual design explorations and prepared this summary report.

1.4 Project Personnel

The following personnel performed services for this project:

Steven Hawkins	Field Engineer
Nathan Whetten, P.E.	Senior Project Manger
Michael Paster, P.E.	Technical Review

1.5 Authorization

The 2006 work was completed in accordance with our agreement dated June 26, 2006. The 2007 Advanced Concept Design phase work was completed in accordance with our agreement dated April 6, 2007.

1.6 Project Vertical Datum

Elevations in this report are in feet. The vertical coordinate system is Brookhaven National Laboratory (BNL) '94. We understand that BNL '94 is substantially equivalent to National Geodetic Vertical Datum of 1929 (NGVD-29).



2. Site and Project Description

2.1 Site Description

The approximately 50-acre site is bounded by Brookhaven Avenue to the north, Grove Street to the west, Fifth Street to the east, and a former landfill to the southeast. Seventh Street runs through the middle of the site in a north-south direction, and divides the site roughly in half.

The eastern portion of the site is generally a lawn area or is wooded. The western portion is occupied by several buildings, adjacent parking areas, access roads with asphalt, concrete, or gravel pavement, concrete loading docks, at-grade concrete pads, two railroad tracks, and chain link fences. Existing site features are shown on Figure 2.

The ground surface slopes gently downward from east to west. Ground surface elevations range from about El. 83 along Fifth Street to about El. 63 along Grove Street.

2.2 Project Description

Brookhaven Science Associates is planning to replace the existing National Synchrotron Light Source with a new facility, referred to as NSLS II. The new facility will be located within the BNL, south and east of the existing NSLS building (Figure 1). NSLS II will be located south of Brookhaven Avenue and east of Grove Street. The proposed facility layout is shown in plan on Figure 2.

NSLS II will be a state-of-the-art research facility. The facility will include a Ring Building, Operations Center Building, lab/office buildings, and service buildings, totaling about 382,000 square feet. The facility will also include an approximately 50,000 square foot Joint Photon Science Institute (JPSI) building.

We understand that the lowest level floors will generally be at existing site grades, and no basement levels are planned. Proposed floor elevations for the various facility components, provided by HDR Architecture, Inc. (HDR), are indicated in the table below.



	Proposed	
Structure	Floor El.	Ground Surface Elevation
Experimental Floor	El. 70	El. 68 (SW) to El. 77 (E)
Storage Ring Floor	El. 71.33	El. 68 (SW) to El. 77 (E)
Booster Ring	El. 71.33	El. 73
Lab/Office Buildings (LOB)	El. 70	El. 73 to 74 (N LOB)
		El. 73 to 77 (NE LOB)
		El. 70 to 77 (SE LOB)
		El. 66 to 68 (SW LOB)
		El. 68 to 73 (W LOB)
Operations Center Lower Floor	El. 71.33	El. 73
Service Buildings Lower Floor	El. 70	El. 73 (N Svc Bldg)
		El. 74 to 75 (NE Svc Bldg)
		El. 72 to 75 (SE Svc Bldg)
		El. 70 to 71 (SW Svc Bldg)
Joint Photon Science Institute	El. 70	El. 73 to 75

Comparing the proposed floor grades with the existing site grades, up to about 9 feet of excavation and up to 4 feet of fill will be required below floors.

We understand that the floor slab for the experimental hall will be 18 inches thick, and the adjacent tunnel ring slab will be 36 inches thick. These elements will be constructed as a monolithic slab. The design live load for the floor in these areas is 250 pounds per square foot (psf).



3. Subsurface Conditions

3.1 **Previous Subsurface Explorations**

1977 Explorations – In 1977, Stone & Webster conducted subsurface explorations for the existing NSLS facility. The explorations included six soil borings and four test pits. The borings were drilled to depths of 100 to 102 feet and the test pits were excavated to a depth of about 12 feet. Approximate exploration locations are shown on Figure 2, and logs of the test pits and borings are presented in Appendix A.

2003 Explorations – In 2003, we conducted eleven test borings for the nearby Center for Functional Nanomaterials (CFN) building. The test borings were advanced to depths of 7 to 62 feet bgs. Drilling activities were monitored by a GEI field technician. Test boring locations are shown on Figure 2, and boring logs prepared by the driller are provided in Appendix B.

3.2 Recent Subsurface Explorations

During the periods July 19 to 21, August 16, 2006, and April 23 to 26, 2007, we conducted ten test borings, (B101-B104 and B201-B206) and fifteen cone penetrometer soundings (CPT-1 to CPT-6, CPT-8, CPT-10 to CPT-14, and CPT-201 to CPT-203). Shear wave velocity measurements were made in CPT-3, -5A, -6, -12, -202, and -203 at 10-foot intervals within the sand. Explorations were monitored by a GEI engineer.

Test borings B101, B102, and B201-B204 were drilled to depths of 47 to 62 bgs. These borings were drilled using 3-inch-diameter driven casing, and Standard Penetration Tests were conducted at 5-foot intervals. Borings B101A and B102A were drilled a few feet away from borings B101 and B102, respectively, with continuous samples taken to a depth of 10 feet. Borings B103 and B104B were drilled to a depth of 32 feet using hollow-stem augers. B104 and B104A were terminated after encountering shallow refusals. Most of the borings included continuous or semi-continuous sampling within the upper 12 to 14 feet. Logs are presented in Appendix C.

The CPT soundings penetrated to depths typically ranging from 53 to 100 feet, and were terminated at refusal or at a maximum depth of 100 feet. Shallow refusals at depths less than 10 feet were encountered in CPT-5, -7, -13, and -13A. A second sounding (CPT-5A) was completed near CPT-5 to a depth of 83 feet; a second sounding (CPT-13A) near CPT-13 encountered shallow refusal and was terminated. CPT-9 was deleted from the exploration program. Logs of CPT soundings are presented in Appendix D.



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GEOTECHNICAL REPORT - ADVANCED CONCEPT DESIGN PHASE
NATIONAL SYNCHROTRON LIGHT SOURCE II
BROOKHAVEN NATIONAL LABORATORY
MAY 25, 2007
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3.3 Laboratory Testing

GeoTesting Express, of Boxborough, Massachusetts, performed 21 mechanical gradation analyses on soil samples recovered from the test borings. Sixteen gradation analyses were conducted on samples from borings B101 and B102, and five were conducted on samples from borings B202, B203, B204 and B206. Results are presented in Appendix E.

3.4 Subsurface Soil Conditions

Fill

Topsoil ranging in thickness from 2 to 12 inches was encountered in test borings that were drilled in landscaped areas. Topsoil was not encountered in B103, B104, B202, and B206, which were drilled in developed areas. Bituminous concrete approximately 4 inches thick was encountered in B202, which was drilled in an existing parking lot.

Each of the borings encountered fill typically described as silty sand (SM) or widely-graded sand (SW), and the thickness ranged from 2 to 9 feet. SPT N-Values ranged from 4 to 21 blows per foot (bpf), indicating the fill is loose to medium dense. Fill was also detected within the upper 1 to 10 feet in CPT soundings made near existing buildings and roadways. Explorations B104, B104A, CPT-13, and CPT-13A, located within the southern portion of the ring building, encountered refusals believed to represent buried objects, cobbles, or boulders within the fill.

Sand

A thick layer of stratified sand, sand with silt, and sand with gravel was encountered below the fill in all of the explorations. Subsurface explorations were terminated within the sand at maximum depths of about 100 feet. The sand is light brown to brown. SPT N-values ranged from about 15 bpf (medium dense) to greater than 50 bpf (very dense). The average corrected SPT N-value calculated from the CPTs within the upper 50 feet was about 30 bpf, The CPTs detected some localized zones with equivalent N-values between 10 and 20, 40 and 50, and over 50 bpf.

Shear wave velocity measurements made in CPT-3, -5A, -6, -12, -202, -203 indicate a uniform to slightly increasing shear wave velocity with depth. Velocities varied from 660 feet per second (fps) to 1,180 fps and typically ranged from 850 fps to 1,100 fps. The average of 54 shear wave velocity tests in these six CPTs was 946 fps.



A 1999 report on the stratigraphy and hydrogeologic conditions at the lab prepared by the United States Geologic Survey¹ refers to the sand as the "Upper Glacial Aquifer," and the thickness at BNL appears to be about 185 feet. Confining clay units and additional sand and gravel aquifers overlie bedrock, which reportedly occurs at a depth of about 1,500 feet.

3.5 Groundwater Conditions

Depths to groundwater range from about 21.5 (CPT-203) to 36.5 feet (B102) bgs, and vary with location at the site. Depths were measured in temporary wells and boreholes, and using a pore pressure transducer mounted on the cone probe. At the end of the cone probes, the excess pore water pressure was allowed to dissipate to measure the static water pressure. Groundwater level measurements represent conditions at the times and locations the measurements were made. Significantly different groundwater levels may occur at other times and locations.

^{1 &}quot;Stratigraphy and Hydrogeologic Conditions at the Brookhaven National Laboratory and Vicinity, Suffolk County, New York 1994-1997," prepared by the United States Geologic Survey, dated 1999.



4. Preliminary Foundation Recommendations

4.1 Foundation Design

We recommend that the proposed buildings be supported on spread footings bearing directly on the sand deposit, or on compacted structural fill placed after removal of existing fill. We recommend that footings be designed for a maximum allowable bearing pressure of 2.5 tons psf, and that footings be at least 3-feet wide.

Exterior footings should bear at least 4 feet below the adjacent finished grade for frost protection. Interior footings should be founded at least 18 inches below the bottom of the floor slab. The top of all footings should be at least 6 inches below the bottom of the overlying floor slab.

4.2 Floor Slab Design

Based on a comparison of proposed floor levels with existing site grades, the lowest level floors will range from 9 feet below to 4 feet above existing site grades. The lowest level floor may be designed as a slab-on-grade.

The existing fill is not considered suitable for support of floor slabs due to the low tolerance for settlement. Therefore, we recommend that all existing fill be removed from within the building limits, and replaced with compacted structural fill. A minimum of 6 inches of compacted structural fill should be placed below all floors.

Floors are above groundwater levels encountered in the explorations. Underslab drainage will not be required.

4.3 Settlement

Column and Wall Settlement

We estimate that total settlement of spread footings will be less than 1 inch, and differential settlements will be less than 0.75 inch. Settlement will occur as loads are applied. We understand that this settlement is acceptable for column and wall footings.



Floor Settlement

We understand that the floor slab within the experimental hall will support highly sensitive scientific equipment, and that settlement of the floor slab after the equipment has been installed and calibrated must be small. Based on discussions with HDR, we understand that post-construction total and differential settlement may need to be less than about 0.25 inch.

Soils beneath the floor slab will settle in response to dead and live loads. We anticipate that settlement will be complete within about one to two weeks after load application.

Settlement resulting from floor slab dead loads and fill required beneath the floor slab is expected to occur during construction, and therefore will not contribute to post-construction settlement. However, the 250 psf live load could cause minor post-construction settlement. We calculate the total and differential post-construction settlement from the live load to be less than 0.25 inch. Differential settlement will be less than the total settlement. For sensitive equipment, it may be desirable to allow a two to three week waiting period between installation and final calibration.

4.4 Seismic Design

The soil beneath the proposed buildings has an average shear wave velocity of 946 feet per second and is classified as a stiff soil profile for earthquake design purposes as defined by the New York State Building Code. The corresponding site class is D. The soil is not considered to be susceptible to liquefaction.

4.5 Reuse of Existing Fill

Based on the results of sieve analyses conducted on soil samples recovered from borings B101 and B102, we anticipate that the natural sand deposit will be suitable for reuse as compacted structural fill below building foundations. The existing fill has a relatively high percentage of fines (silt and clay size particles) and is not suitable for reuse as structural fill. The existing fill is suitable for reuse as common fill outside the building limits.

4.6 Subsurface Explorations for Final Design

Subsurface explorations conducted for the 2006 conceptual design and 2007 advanced concept design studies included a relatively small number of widely-spaced explorations. Most of these explorations penetrated to depths of 50 to 100 feet, to evaluate general subsurface conditions in the area of the facility.

We recommend that subsurface explorations for final design include additional test borings with continuous SPT sampling, to further evaluate the nature and thickness of fill materials.



Shallow refusals were encountered in B104, B104A, CPT-13 and -13A, and may indicate buried foundations or other objects within the fill. We recommend that test pits be excavated at locations where shallow refusal was encountered within the fill.



5. Final Design Services and Limitations

5.1 Final Design Engineering Services

We recommend that GEI be engaged during final design to:

- Conduct subsurface explorations, prepare a final geotechnical engineering report, and provide geotechnical consultation to the design team.
- Review plans and specifications to confirm that our recommendations have been interpreted and implemented as intended.

5.2 Limitations

This report was prepared for the exclusive use of HDR Architecture, Brookhaven Science Associates, and the NSLS II design team. Our recommendations are based on the project information provided to us at the time of this report and may require modification if there are any changes in the nature, design, or location of the proposed structure. We cannot accept responsibility for designs based on our recommendations unless we are engaged to review the final plans and specifications to determine whether any changes in the project affect the validity of our recommendations and whether our recommendations have been properly implemented in the design.

The recommendations in this report are based in part on the data obtained from the subsurface explorations. The nature and extent of variations between explorations may not become evident until construction. If variations from the anticipated conditions are encountered, it may be necessary to revise the recommendations in this report.

Our professional services for this project have been performed in accordance with generally accepted engineering practices. No warranty, express or implied, is made.



Figures





BROOKHAVEN NL\062150\BROOKHAVEN LOCATION MAP.CDR



APPROXIMATE LOCATION OF CONE PENETROMETER TEST MADE IN APRIL 2007

APPROXIMATE LOCATION OF TEST BORING DRILLED IN APRIL 2007

2006 EXPLORATIONS:

APPROXIMATE LOCATION OF TEST BORING DRILLED IN JULY AND AUGUST 2006

APPROXIMATE LOCATION OF CONE PENETROMETER TEST MADE IN JULY 2006

PREVIOUS EXPLORATIONS:

APPROXIMATE LOCATION OF TEST BORING INSTALLED IN 1977

APPROXIMATE LOCATION OF TEST PIT INSTALLED IN 1977

APPROXIMATE LOCATION OF TEST BORING INSTALLED IN 2003

- 1. PLAN BASED ON MAP TITLED **TOPOGRAPHIC SURVEY, PROPOSED** NSLS II SITE, SITUATED AT BNL, UPTON, NEW YORK, PREPARED BY MUNICIPAL LAND SURVEY P.C., 10 SYLVIA LANE, MIDDLE ISLAND, NEW YORK, 11953.
- 2. APPROXIMATE LOCATIONS OF 2006 AND 2007 EXPLORATIONS WERE PROVIDED BY BNL, AND WERE DETERMINED BY PACING FROM SITE FEATURES. LOCATIONS OF PREVIOUS EXPLORATIONS WERE ESTIMATED BASED ON RECORD DRAWINGS.
- 3. THE HORIZONTAL COORDINATE SYSTEM IS IN THE STATE PLANE COORDINATE SYSTEM, NEW YORK LONG ISLAND ZONE 3104, NAD '83, EXPRESSED IN US SURVEY FEET AS DEFINED BY BNL POINT COSMO
- 4. THE VERTICAL COORDINATE SYSTEM IS BNL '94 WHICH IS SUBSTANTIALLY EQUIVALENT TO THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 1929), EXPRESSED IN US SURVEY FEET AS DEFINED BY BNL POINT COSMO RM3.
- 5. PROPOSED BUILDING LAYOUT REVISED BASED ON MAP PROVIDED BY HDR ARCHITECTURE, INC.

ADC EXPLORATION LOCATIONS

May 2007

Figure 2

Appendix A

1977 Test Boring and Test Pit Logs



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1,19			3		KAPILISTIC FINES, LIGHT TELLOWISH CANT.				я :-	58 17	SP	SAND, NORES, CHARED, LESS THAN IN STRANGULAR GRAVEL, TO G.S. HULTION, CONSE TO THIS SAND, MOSTLY REDUCK TO THE: LESS HOMPLASTIC FINES, YELLOWIST GRAT.
		11	51	57-58	SAUDE UNBFORME, MEDICA TO FINE, MOSTLY FINE, 5-85 MARTINETIC				8	\$5 " 18	\$ 7	CRATTLY SAMD, NORLY BRADED, 15-305 BOREDED GRAVEL TO 0.5 HARDNAR, COLZEL TO FTMR 3450, NORTH COLRES AND FINE, LESS THAN 35 MORISTIC FIRES, JELLONISH CALY.
		30	- 41 -	3P	Sana, Uniform, Gadina to Pine, North Fine, Less Tain 35: Morflastic files, Light Thilduist Gany, Shall moveling Oraniz Footists of Silte Same.		90		11	36. 19	514514	SARD, FORLY GRADED, COLRES, TO FIRE, MISTLY MEDICAL AND FIR S-GE ROMFLASTIC FIRES, ITELDATISH CHAT, SOME MEDICINE AND AND A FEY PLACES OF CRAVEL TO 0.23 LIGH MAXIMUM.
- 26 -		39	33	à7	CHATCLIN SIMO, FOORAY GRADED, 13-155 SUBMOUNDED GRADET, TO. 0.35 INCE MAILBOOK, CONSE TO FIRE, NOSTLY MEDION AND FIRE, 1-35 ROMPLASTIC FIRE, TELLOSISH GRAF, SMALL LATER OF REOVERSE-GRAF FIRE FIRE SILLY SAMO.		35		80.	33	S₽	Sinth, BOOMLY CHARGE, 1223 THEM 54 NOTIFIED GRAVES, TO 9.5 TH HOLTHOR, COLNER TO FING SAND, MOSTLY MOLIFIE AND PENE, LESS THAN 55 MORTASTER FUNC, VELOCION CRAY.
- 30		×	1 7	·32,	CHAVELIX SIND, FOORLT GALDED, 20-25% SUMMOUNDER TO REGISTED GRAVEL TO 1.0 INCR RAIDERL COARSE TO FIRE, HOSTLY MEDIAN AND FIRE, LESS THAN 5% HOMPLAYIG FIRE, TELEVISI GART.		1500-		16C	12. 12.	5746H (S.1.00. FOORLY CHARGE, 5-85 STRADARDED CHARTY TO 0.79. INC. " COLESE TO FINE SAME, HOSTLY FIRE, 5-65 HOMPLASTIC FIRM, 1
35		104	. 33. 18	<u>,</u> 5×	<u>Stitt sand</u> , antipare, modum to fine, mattix pine, 15-406 morplastic RUNSS, BROM,					Į		. END OF BOREDIG AT 102.5 FT
ú		я	33	ડોમ્પ્ટલમ	SAND, NOGELY CAMPED, 1 FIDER OF SUMMOUNDED GRAVES 1.0 INTE MAINING. CORREL TO FIRE, MISTLY MEDIUM AND FIDER, 5-68 MUNTLASTIC FINES,							
43		57	10 51	57	CHATCHING GRAT. CHATCHING SAND, ROORLT GRAUGED, 10-155 BURGED GRATER TO 0:25 INCH MARLING, CONSE TO, FIRE, NOSTLY HERITOR AND FIRE, LESS THEN 35							
, R		33	35	: S7	NORTLASTIC FINES, TELLOUISH GRAF.							
- 35			55		SALTANA, CALEGA-TU FIRA JARO, NOTILA MENUWA, LESS TREE 53 MANELASTIC VIRES, TELLONISE GALL.				ļ		:	,
ĺ.			13		COLRESE TO FINE, NOSTLE NEDICH, LESS THIRS'S NUMPLASTIC FINES, TELLONISE CHAT.				ŀ			
. 60		4		;SP	SAME, SINCLAR TO 35 FIZ EXCEPT HOSTLY MEDICH AND FIRE SLMD.			1 1 1 1				
65		, %	55 14	ŝ₽	SATD, DOORT GRADED, LESS THUR IS STRANGULAR GRAVEL OF 0.25 INCH WALDING, COARSE TO FIRE, MOSTLE: MEDIUM, LESS THUR DE MORFLASTIC FINES, TELLORISM GRAZ.							
70	1	114	2.0	31	CANFLLT, JUND, DORLETORADED, 12-158 SUDROUNCED TO NONNEED CRAFTE, TO 0.97 INCH MAEHMM, COARSE TO TIME SAND, MOSTLY FEDIAN AND FIRE,						ļ.	
NES) SAM LA H OD : RLS :	THE BLOW OF A PLE DENOTE T MOLEA FALLIN SAMPLE SPOON SHOWN OPPOSI	ECOVEN HE KUN G 30" 1 12" Of DE NOCI	COL IXA DI IXA DI IXA DI IXA IXA IXA IXA IXA IXA IXA IXA IXA IX	JHN OPP BLOWS REJ TO DISTAN LJ DIGTO	OSITE OF 4 ACTUE TE SNOWN.	1. FI SQI 150	TURES LI LL SAMPI J LB HAD 2" GO SI	E DEAN OR AN DE DENOTE TH OUR FALLING URPLE SPOON	GOVEN B HUN 30" 1 12" 01	COL BEN O REQUI	LING OPF BLOWS REG TO DISTAN	osite :07 a JRIVE GE SKOWN.
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È M PE U TE O	ftoril sz Borins Ak (29 IV 97 BO	NCHEOTHON 411 SS AUGUST 22, Rinne	LIC 305		jusodina Dritel 1	514 <u>1</u> en <u>1</u> 40. No1.3011.100 BORING Han <u>1</u> . 100 BV <u>4. 12005</u> 100 BV <u>4. 12005</u> 1006666 BV <u>7006</u> (1	SITE TVPE = Date (Summa)	NATEONAL POGRAG DRILLED RY OF BU	SDICHIOTIKAL I SS AUGUST 22, AUGUST 22,	.1687 5 LOC	DURCE	nkoorg (Mile.)	SH 2 HO SH 2 HO LO KG 1001,10 BORHAS NA 3 AVEN NATIONAL LINCATORY OROUND CLEV. 72.1 LES BY T. ADUR LOSSES BY 100
FEET	DEPTH FEET	ROD	BLOWE SY	14PC 5	G R.M.HKC LDG	SOIL OR ROCK DESCRIPTION	ELEN FEET	DEPTH FEET	ROO	ALONE R	ele Tris	GRAPHIC LOG	SOL OF ROCK DESCRIPTION
 -	it in a		34 30	51- 51- 17- 17- 12- 12- 12- 12- 12- 12- 12- 12- 12- 12	58 57	TOP SOLLS STLITE SAME, WIDELT GRAND, 15-DOS AND THE GRANDE TO 0.7 THEM MAI, COMMENT OFFICE, MOSTING WITHER SAME, 15-205 SILUTINI FRASTIC FINES, TAKE SHOW MOTTLED WITH LIGHT MOME, SONG GRANDE MITERIAL SAME, FOORLI GRANDE, TRAGT OF 0.4 INCH GRANDE, CORRECT STORE, HOSTLE HETPILM SAME, TRAGT OF 0.4 INCH GRANDE, CORRECT STORE, HOSTLE HETPILM SAME, TRAGT OF 0.4 INCH GRANDE, CORRECT STORE, CORVEL TO SAME, MORE CRITER, LIGHT MOMENTAL TO STRATTER CRAVELY SAME, MODELI CRITER, AD-455 STMEMETAR TO STRATTER CRAVELY SAME, MAL CORRECT TO THE MINISTRA TO STRATTER CRAVELY SAME, LIGHT BOOM				2	23 16 17	57,-54	AND, FOORLY CRIMEN, 3-55 CRIVER, MA 0,5 DECH MAY, CARRAGE TO. THE, MOSTLY MEDICAL TO FIRE Same, 5-48 MANFLATTIC FIRES, CHATLER ANNO, SINILAR TO SMOTH
•	a s s s		- 4 - 7 - 1	- 131- 	sp-ak	SAND, TOORA'S GRADED,)-85 GRAVEZ TO 0.5 INCH MAX. COARSE TO FIDE, HUSTAL KROTON SAND, S-85 KONTLASTO FINES, CRAITER BOOM CRAVELT SAND, FOORLI GRADED, 18-405 STRADBORDED TO STRANGUEAR CRAVEL TO 0.7 MMR MATTERN GUARSE TO FIDE, "STEP MEDICA SAND, S-85 KONTLASTIC FINES, GRATISE BRAN				45	s sa sa	SÎ SI	CHAVELY SAED, SDAILAR TO FIRE
		20 	1 2 2 1 2 1	4	47 47	THE CONSTRAINT OF THE ANALY STATE THE SAME CANTEL OF C. THE CONSTRAINT AND		190 -	- Trinctile year	7	N	37	CHANNELLY AND, POSELY CHENTER, 10-155 STREAMENT CHEATEL TO Q.4 IN HAS. COLLEGE TO FINE, MOSTLE MEDILING SAME, 455 FINES, CHATTER MEDI AND, OWIFCOM, MERINA TO FINE, THACE OF DOLMAR SAME, 475 FILES, NEDILM BROW EARD OF BOLLER AT 101.5 FC
			2 2 2	12 F	35 35 35 35 35	SAME, FOORLY, CHAMER, 3-35 GRAVEL TO 0.4 INCH MAY., GOARSE TO FIRE, MUSILY PINE (THEY LITTLE CORRECT, SAME, CSS THESE, GRAVING GRAVELLY SAME, FOORLY GRADED, 33-355 STREOMONDOD GRAVEL TO 0.7 DATE MAY. COMPSE TO FIRE, MOSTLY KORTON SAME, CSS FEDER, GRATINE BRAVE CRAVELLY SAME, SDRUGAE TO ABOVE							
	8 8 8 8 8			31	57	CHATCHIT SAND, STRULAR TO AROTE, ELCEPT 25-335 GRAVEL CHATCHIT SAND, FRONT GRADED, 23-435 STRUCTURE TO SECTION FROM GRAVEL TO 0.6 DECH MAX, COARSE TO FIRE HOSTLY MEDICAN SAND, <35 FIRE, CRAFTSH BROWN							
	70		69 45	53 14 33 15	SP SPica	CHAINLY SIND, FORLY CRADED, 25-JDK SUMMOUTAN TO SUBMOUNDED TO 0.7 ERCH MAR. COMMENT TO FIRE, MOSTLY MEDING SAND, CS FIRES, CHAINES BROWN							
	GUNZS IN 16. SALOPI 24. OB SA 24. OB SA GUNES SH 100261	I HLOW OR R P. DANOTE T NER FALLIN NPLE SPOON OM OFFORM TO FCORE TS LOCATION ES LOCATION ES LOCATION STER STER NEXT TO SYN ES LOCATION QUALITY DU STER ST	ICOVER NE NUP A 30° NE NUP NE NUP NE OF S NEOL I NE OF S NEOL I NE OF S NEOL I	Y COL MEA O REQUI & THE R.CON RED. WOIST FLIT- AMPLI VOICA ATURA SIGN.	THE OPE THE OPE THE OPE DISTANCES DERU SPOOT S NG ATTE THE SAN L. ORO'N RL COAL	NOSITE I OF A ORAYE ICE SHOLM. ICE SHOLM. ANDLE. ANDLE. B BROGHAVEN SATIONAL LANDATONE B ROGHAVEN SATIONAL LANDATONE ANDLE. B ROGHAVEN SATIONAL LANDATONE ANDLE. ANDLE. B ROGHAVEN SATIONAL SECTOR ENGINEERING ANDLE. B ROGHAVEN SATIONAL SECTOR ENGINEERING ANDLE. B ROGHAVEN ANDLE. B ROGHAVEN SATIONAL SECTOR ENGINEERING ANDLE. B ROGHAVEN SATIONAL SECTOR ENGINEERING ANDLE.	1. P 1. A 2. S 3. 4. 5. 4. 5. 5. 5. 5. 5. 5. 5. 5. 5. 5. 5. 5. 5.	IGORES. 1 OIL SAM VO LB M. 27 OD: 1GURES 14 PERCI 2 (MOIC) 12 (MOIC) 17 MOIC) 10 MOIC 10 MOIC) 2 ASUE 30. + ROU 1 MOIC) ATUM IS	N BLOW OR I LE DENOTE 1 HOURE FALLIN RANDE SPOOL HOUR OPPOSI INTON OPPOSI INTON OPPOSI INTES LOCATIC TES LOCATIC O RECOVERY. NEXT TO SI INTES LOCATIC R QUALITY I INTES OFFICIA	LECOVE SHE AU G 10" I 12" SE AO AECOV IN OF IN OF IN OF IN OF IN OF	RY COI RUER (ALQUI DR THI CR COI ERED MOISI SPLIT SAUPLI INDICI HATURA ATION ATION	HAR OP HE BLOW MED TO LES DEN TABED SPOON NG ATT TES SA L GROY	POSITE S OF A JORYW NCE SHOWN OTS SAFELE BADE BROODDAYDS NATIONAL LIGHT SOURCE BROODDAYDS NATIONAL SUNCE BROODDAYDS NATIONAL SUNCE

HTE NATE DE	NTONAL J NORING DILLED . Y OF BO	ANGCOT 25, 2	(CHT 5 , LOC 1977	01668 A710	0HA	341 472.	SITE _ TYPE C DATE	HATION F BORIN DRILLE(121. 5715 195731 6. 52 	0 11000 s LOČA 1977	ALEBICE TION	1 	JO. NO. 1 TALLE BONING NO. 21
ELEV. FEET	DEPTH FEET	OVERALL WCATHERING AND RQD S SE NO TO YOU I L I I	BLOWS COV	1716	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION	FEET	DGPTH FEET	AND ROD to to co To use	BLOWE BLOWE	LE L	GRAPHIC LOG	SOIL OR ROCK DESCRIPTION
	, , , , , , , , , , , , , , , , , , ,		27 227	4.1 H.	54 - 	THE MOLE, SILTY TANT, SILTLY TABLE, 10-137 SCHARDLER GRAFFIL TO THE NEW WINCH, SOLRES TO FIRE CARD, MOSTLY FUNC, A-JOS MARLASTE TYPE, SHARE, JOHE BRIEF TATTING, PAR MOLE, LARD FRAMERIES FILL SALL, SYSTEM FIRE, LIGT WAY IN TRANSPORTATION, LIGHT GRAFTER THELE.		71		86 2	-	<u>,</u>	AND, SCHEDER SEET N AN. 196
	2 1 1 1 1 1 1 1 1 1		1	55 55	SP SP-SM	SATE, UNITED HERDEN TO FIGE, HOLTLY FIRE, HAS WEREASTE PIRES. TELIDOUSA CNAT.		11 -	*		7 3	S P .	CARTIN TARS, PROBLY GRADED, 10-1-X CREWEL TO 0.4 INVELNATION, CLADE TO FINE SAND, MOSTLY VERTH AND FIRE, ITAGE OF COARGE) LEDI THAN 58 NORPLASTIC FINES, INLOUTEN CRAY.
	20 -		17:	4.8	Sr-sh	NCEPLASTIC FIVES, TRELIDATEN GAT, JOH DURAS AN ACLINA, SAR SHITY SAND, CALAVILLY FART, FOCALY MODEL, L'-INF CARADOVERD CANES TO J,O DER RAAMVE, CALSE TO FILT 245, NOSTLY PEDINA AND THE, 10-155 DEEPLASTIC FIVES, RADIALOS CAY,		90 T		2 4 4 5 3	3 12 3	ir Ir	EAC: "SHENGE MELTUM AND FFC. (THAT OF CHAVEL TO 0.25 INCH) TOTAL FUE, IESS THAT "I SCUPIA THE PIPE, CARY. CANELLY SLYD, FOORLY GRADED 14-205 SUBROWNED TO ROUNDED GRAVEL T D. 4 DOCH MALERM, COURSE TO THE SAMD, MESTLY MEDIUM AND FIG. LESS THAT "SA SURFACTO FINIS, CARY.
	₩_		12	55	59	CHATTERING, POORLY GRADES, 12-115 ROUNDED CRATEL TO 0.5 INCH ANTICON: CLAIME TO FING, TOSTLY METION AND FING, 1555 THAN 95 HOTFLUSTIC FINES, GRAT.		8 8 1 1 1 1 1		74 55	 0 ^{si}	e.t	CRAVELLY SLAD, POCALY GRADED, 13-305 SUBDUMBED GRAVEL, COARSE TO FILS, RESTLY MEDICAN, LESS THAN 18 HORPLASTIC MIRES, TELEONISH GRAY.
	2 1 1 2 1 2 1 2 1 2 1 1 2 1 1 2 1 1 2 1	:	4 7	5 T	-sp 2P-sm	SALL, UNIVERY MALINE TO FISH (TRACE OF COARSE), LOS HOR SS NUCLASTIC FIRES, CAAT, 5 PINES OF ELAVEL TO 0.35 HOR HORISON, IMATELLY SACE, MORLY GRAPUS, 14-185 SUBROUNDED GRAPEL TO 1.0 INCR 		11111	TREAMATED	1177 53	1. 51	•	GAUD, UNITOUGH HEDIUH AND FIRT, (TRACE OF URAVEL TO 0.25 INCH), ISES THAN 55 WORFLASTIC FIRES, CRAF. ERD OF DOWING AT 101.5 FT
		-	- - 	14 T	SÞ	ACUELLETID FIRES, YELLETISK CRAY HOPPLEL JITH BARK GAY.							•
	\$ \$		14	10	5.9	ACTIVITY 2003, POORLY CRAFFO, POORLY & SUTANCOLLE TO SURGENDES TACTUE TO LT THEM RATEP ", CORRES TO YUR, MOTTER SOLDN AND FING LLUT TOWN 'S MEMFLATTIC FINES. YELLAISH DRAY.							
	* 1		93	11	57	TAUFUR: CORTA TO FIT: A CHIEFET ON AND FIRT THE LITTLE - 26-11, USL "WAY IF YORKLATE FIRE, TELEVISE ONE, 		1 1 1 1					
	1111 2 1 1 1	î	27		я	ALLETT JUT, MORET CANTEL, LOJET TOTOLED CRATEL TO D., INCH		11111					
	·		•. •		29 . J4	TACTICE LAST. PORTER TRATEL 2"- TO CUMATING CRIVEL TO P. 9 2000 TATION CONT. TO FIRE, MICTO PERTY REFITTE, 4-5 NUMPLASTIC TO TATION. DAT. OTTO DOC BROAD CTAINING.		1-1-1-1					
1. FIGU SOLL 140 A 2* FIGU THE	RES IN SAMPLE LB HAMM OD SAM RES 3MG PERCENT	BLOW ON ARC DENOTE THE MER FALLING MPLE SPOOR 1 2000 OPPOSITE OF COAR AR	COAEI 30.4 1 30.4 1 24 00 25 00	ER OL BER O NEQUS R THE COR	JIST OPP F BLOWS RED TO JISTAN SS OFRO	DSITE OF A DRIVE E SHOW,	1. FIGI S011 140 A 2' FIGU THE	RES IN SAMPLI LB HAND OD SAU RES SHI	BLOW OR REC E DENOTE THE GAL FALLING QUE SPOOD 1 DWN OPPOSITE T OF COMP OF	OVERY CO S NUMBER 10" REQU 12" ON TH S ROCK CO	ULINE OF I DIRES NE SI DRES	N OPPO BLOWS 3 TO C STANC DERUT	
=21 	NDICATE NDICATE NDICATE ITN RO CRIPT R ER. NOLCATE AULE. NOLCATE	LOCATION US LOCATION AECOTERY, RECT TO STHE S LOCATION	OF SI OF SI OF SI OF SI	IDIST PLIT+ INPLI IDICA IDICA	78320 S Spoon S Ng Atte Tes Jan L Groyn	HAPLE	2. 821 761 071 3005 8005 8005	NDICATI NDICATI NDICATI UTH NO CAIPT J ER. NDICATI ABLE.	IS LOCATION IS LOCATION IS LOCATION RECOVERY. HEAT TO SYNC IS LOCATION	OF UNDER OF SPLIT OF SAMPS IOL INDIC OF BATU	STURE P-SPO LING CATES RAG. C	BED. SA Don Sa Atten 5 Sand Gìno'mid	UNPLE. MOTE: MOTE: MATERIAL SINCHARTAGE LICHT SOURCE BROODIGVER RATIONAL LABORATORT D WATERIA
5. 11 11 6. DAT 70	NICĂTE N'IS	S OFFTH & L	ERGT		AX COAL		5. DAT	- AOCK NUIGATI M IS	QUALITY DES	ICKATIO INGTA O	F. 7 KK	0941	

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4						22 به من المراجع به من المراجع المراجع به من المراجع المراجع به من المراجع المراحع المراجع المراحي المر		37 49 57 57 57 57 57 57 57 57 57 57 57 57 57	PARE 2014 101 011 0445 11 4033 400 115	<pre>172. Marting file in way file. Marks File. A data File. < 1 South Life. 173. Marting file in way file. A data File. < 1 South Life. 174. South States file. The second state in the second state. 175. Marting file. The second state in the second state. 175. Marting file. The second state in the second state. 175. Marting file. The second state. 175. Marting file. 175. Marting file. The second state. 175. Marting file. 175. Marting file.</pre>	ANCE CRAFTEL TO 1.5 RECOLLETIC FIRES, TO 5.25 INCR TO 5.2
	IN RPLY SAND CATES CATES ATES CATES CATES	BLOT DEN VILE MOI O S LO S LO S LO S LO S LO S LO S LO S	W GR IDTE SPO COM CAT: CAT: CAT: TO : CAT: TO : CAT:	REC. THE ING ING ING ING ING ING ING ING ING ING	NUR NUR IO - O NOCI IP - O NOCI IP - O NOCI IP - SI I I - SI II II II II II II II II II II II II I	Y CO DER ALQUATHA (CO DED. SLIT NPL DICI TUTU 10H.	LING OF 1 I RES E JIRES STURES STURES ALL G RE	COALM	SIT OF MELT SES MPL MPL PT LE VAN	SITE STE STE STA RETE ESSOUR. SHOLA. SH	T SOURCE ATOM

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ATIONAL STACHEOT	RON LIGHT SOONCE	10. No. 12011.01 BORING No. 6		NATION			VIDOT	5.HR
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A HI RQI		BOIL OR ROCK DESCRIPTION	ELEN FEET	DEPTH	RQD a to bo to the	BLOW!	GRAPHIC GRAPHIC	SOIL OR ROCK DESCRIPTION
9 -			·		· · ·	Ì		T
5 1 7 7 7 7	14 ⁴⁴ 14	STLTY SAND, WEIFORM MEDIUM TO FIRE, MOSTELY FIRE, 12-195. HWFLASTIG		, a , 1	-	132	i5 15 SP-30	3448, ROORLY GRADED, 8-125 GRAVEL TO 0.5 INCH MAIL, COARGE TO FILSE, MOSTLY HERICH TO FINE SLUE, 5-85 HOMPLESTIZ FINES, SARY MONT
ب ب ب	94 25 SH	SIGTT AND, VIDELT GRADED, 18-235 SUBJUSTICAR GRAVEL TO 0.) INCR MAI. CONNER TO PIET, HOSTLT MEDION TO PIME'SRUD, 18-238 NON2LASTIC PINES, SHOWN				190/ 9	38 16 37-39	SAND, SDYLLAB TO ANDVE
2 1 1 1	55 50 3 31	SAND, FOORLY CRADED, 10-155 SUMMINITAR CHATTE TO 0.6 INCR.NUT. COARSE TO FIRE, MISTLY NEITUR TO FIRE SAND, 755 FIRES, MANY		2111		2 06	55 17 58-58	-CANVELLY SAME, FOORLY GRADED, 10-155 SUBAHURLAR GRAVEL TO 0.5 INST MALL COARSE. TO FILS, MOSTLY ASIM TO FIRE SAME, 3-45 WHENSTIP FIRES, RAYLING ROAD
≈ ┨ ; ; ; 1	35)27 2 0P	SANSY DRAVES, ROOKEY CRAMED, SUBARGUAR TO 0.4 THEE MAIL 43-675 CURRER TO FILTE, MUSTLY MEDION TO FERE SAND, 3-55 FILTES, GRATISE SALUF		* *		90	53 16 57-59	SAND, UNITONN, HODION TO FINE, THACE OF 0.4 INCH GRAVEL, 5-65 WORFLACTIC PINES, CRAVISH BROWN
23	126 5 5P	GRAVELLE SAVO, POORLY CRADED, LO-ASS SUPARCOLLAR TO SUBMOUNDED TO 0.7 INCH WAI. COLRSE TO FINE, MOSTLY VEDUCK SAND, 455 FIRES, GRAVIST BROAM		, 1 1		124	4 83 19 . 57	CANTELLT SAND, FOORLT CRADED, 15-305 SURANGULAR GRAVEL TO 0.6 INCH MAI, COLRES TO 7125, MOSTLE NEOLIM TO FLIE SAND, 255 FIRESS, CRAVISM BROWN
78	33 127 6 37	CRAVELLY, GAND, FOORLY GRADED, 20-255 SUBAMOULAR GRAVEL TO C.B INCH MAX, COLASE TO FORE, NOSTLY NEEDED TO FIRE SAND, \$5 FIRES, CAATING DROWN		3911	, INVERTO	137	33 20 37	SAND, FOORLT GRACHD, 4-125 GRAVEL TO 0.5 INCH MAL. COARGE TO P HOSTLY MARTIN RAND, 435 FINES, GLAIXSW RACH DOD OF RORING AY 102 FT
»	123 7 14	CRAVELLE CLUD, DORLT GRADED, 60-L55 JUMPOUTAR GRAVE, TO 0,7 INCK - HATE COMPANY CONTRACTOR CONTRACTOR OF THE SAND, 735 FIRES, CRAVESH BROWN		111	,			
	53 83 8 37	CRAYELLY SLIND, FOORLY GALARD, 12-JAX SUBSCORED CRAYEL TO 0.5 INCH NAT. CORREST TO FLOR, MOSTLY MODILIN TO PINE-GAND, «35 FIRST, CRAYESH BROWN		ولمانينا				
5	55 59 5 59	CHAVELLY SLUED, SIDELLAR TO ABOVE, RECEIPT 10-1555 CHAVEL			•			
» – -	128 35 128 10 59	CHANNELET SLEED, SIDHLAR TO ABOVE, MICEPT 15-255 GRAVEL TO 0.6 INCH MAIL			-			
	112 11 37-5	SAND. FORMET WANNIN, 5-85 GRATEL TO 0.4 INCR MAI, COMPLET TO FILE, MINISTLY VALUER TO FIRE SALD, 5-85 EWFLASTIC FIXES, GRATIST SERVE						
% 	40 12 3P-2	H SAND, SENSILA TO ABOVE						
*	72 13 5F-51	N SARD, SDULIN TO ANOTE				ŀ.		
ALS IN BLOW OF	57 14 SP-SP	R GAND, UNIFORM, ACOUNT TO FINE, THATE OF D. 4 INCH GRATEL, 5-85						
SANDLE DENOT LA MANNER FAL OD SAMPLE SM MES SHOWN OPM PENCENT OF COI MOICENTES LOCH	E THE NUMBER OF BLO LING 30" ABQUIRED TO JOH 12" ON THE JIST DISTE ROCK CORES DES US RECOVERED.		1. FIG 1. Jug A 2' FIG	URES IN L SAUPL LB MAR * OD SAU URES SH PENCEN	E DENOTE THE E DENOTE THE MER FALLING MPLE SPOON 1 DWI OFFOSITE COT CORE AR	UVERY (E NUMBEL 30" REG (2" OR 1 E ROCX (COVERE:	ULTHE OF LOF BLOW STRED TO INE JUSTA DARS JER L	rostre S op a Datye RCE skow, VER
HOICATES LOCAT	TON OF SPLIT-SPOON	SAMPLE.		INDICAT INDICAT	IS LOCATION IS LOCATION	OF SPLI	ST'MBED T-SFOON -	SAMPLE:



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- Will Remoto, Lieht Yer Fear-Ser Droming Dim
 - ALC: N
- HUNGH, HADRUN SAUD, SILTY, FILE, ULITERAL CH. 0- 10" FIL, SAURT TOTOR. FO-3-3" FIL, SAURY 3-356" SAUD, SILTY, FIG. U
- JU, FIAN WELL S.C.-R.O. AAUD, CALLE, URDING FING, UN ROUTING LIGHT TALLON CRAN BREITING DUPPING AW 20"

41 731 100,320 -6 74.4 100320 · 100.240

12 2

ACCREDAL.

71.7

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Test Pri "F" 0-252 Test 3-5-00 4u

- UD. SILTY, FAIL, UNIVERSA (Lint) ins
- ORA FURM BOUND Council Manual an P-P-P-P Sup, CLEAN, LA ni Ytayin
- A Ferrier Banand ALL TUN PIT N THADETH OF Dirpous Sty At No. 20 Dirpous SY At No. 20 Loris Dacarticus Trause Su Gast Fr. Free Susses
 - L-Tuesday
 - Ar. Fun. thi Tet Provident
- ierit Cinence Maninu 19 Azama Litzinul Int. Uniterni Finn Bay Gast Syont Fertifict Exerite any also Lister Taux 5.T-12.0' SA
- DIPPING WAY Nave Brend Telica Coppies Teat Pry In Kaat West Direction, Davide, Dista 6'-2"

- เซาร์ปเซี ธันเจ.ถึนรารที่มีไฟฟัติพ.ดีพรุสตา Manuid Baand, ฟรุสทสรเอ กันตุสำนาที่สว ค.เชาะเชช รั้นนุณ์ประที่มีสารที่รัฐมาให้สารที่ วินเน Bandi โมลเซี ชั้นเนอา สัมร์ รักเขตรี Patride Baconu Districton WeW A7 201 1647-812 D. 0-1-0 . 109 10-4-10 540





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Appendix B

2003 Test Boring Logs



CLIENT: GEI NEW ENGLAND BORING CONTRACTORS OF CT., INC. BORING No. B-1														
CLIEN	IT: GEI							129 KRIEGER I ANE	SUEET		G No. B-1			
PROJ	ECT NAME: B:	rookh	aven					GLASTONBURY, CT 06033	ADOL		T			
LOCA	TION: Long	Isla	nd, 1	ids IY				FAX (860) 657-8046	ENGIN	EER				
DRILL	ER: T. Roe	2			F				FILE NO	O. GEI-	LongIsland			
INSPE	CTOR: A. S	mart				TYP	Ē	Casing Sampler Core Barrel	SURFA					
DATE	START: 10/	28/03	1			SIZE	E I.D.	3-1/4" 1-3/8"		OTATION				
DATE	FINISH 10/	28/03	1			НАМ	MER FALL	30"	OFFORT					
		SA	, MPLE				CASING		OFFSE	T7				
	DEPTH		BLOWS	PER 6	•		BLOWS/ CORING	FIELD CLASSIFICATION AND REMARKS		Well	Installation			
No.	IN FEET	0-6	6-12	12-18	18-24	REC.	TIMES			Cons.	Details			
01	ר י <u>ח</u>	1	· · · ·	<u> </u>	4	011	CENT.							
51	0-2	'	1	2	1	8"		8" Dark Brown Topsoil	,6					
								Gray Brown Fine Sand, Some Silt, Trace of Ro Fill	oots -					
S2	5'-7'	5	6	8	9	1 <i>4</i> "		Light Brown Fine Sond Stratified	2.5					
			ũ	U	Ū	1.4								
S3	10'-12'	7	7	9	12	24"		Light Brown Fine Sand Same Silk Shullford						
								Light Drown Fine Sand, Some Sik, Strauned						
									ł					
S4	15'-17'	5	12	14	13	20"		Light Brown Fine Sand Little Gravet Stratified						
								Cobble @ 19'-19'6"						
S5	20'-22'	5	7	7	9	24"		Brown Fine-Med, Sand, Trace of Gravel, Stratif	īeđ					
								,,,,,,,,						
S6	25'-27'	5	6	10	11	24"								
07														
57	30'-32'	9	11	13	17	20"		Brown MedCrs. Sand, Little Fine Sand						
								End of Boring @ 32'	32.0					
								Water @ 31'						
							Í							
							Ì							
NOTES:	1) The stratification	ines repre	sent the	2) Water	lovel readin	ngs have bee	en made	REMARKS:						
	approximate bou types, Transitlo	indary betwe ns may be g	ion soil radual,	in the condit Fluctu	drill holes al lons stated o ations in th	t times and on the boring e level of o	under 1 logs. round-				l.			
				water than ti ureme	may occur d tose presen nts were ma	Ne to factors it at the time ide,	other meas-							
						· · · · · · · · · · · · · · · · · · ·								

r					F	NIENAL		ID DODING CONTRACTORS OF ST ING		-				
CLIEN	NT: GEI					NEW		ID BORING CONTRACTORS OF CT., INC.		BORING	G No. B-2			
PROJ	ECT NAME: B:	rookh	aven					129 KRIEGER LANE GLASTONBURY, CT 06033	SHEET	1 OF	1			
LOCA	TION: Long	ation Isla	hal, L	abs IY				(860) 633-4649 — (413) 733-1232 FAX (860) 657-8046	ARCHI ENGINI	TECT/ EER				
DRILL	ER: T. Roe	3						· · · · · · · · · · · · · · · · · · ·	FILE NO	0. GEI-	LongIsland.			
INSPE	ECTOR: A. S	mart				TYP	Έ	Casing Sampler Core Barrel HSA SS	SURFA					
DATE	START: 10/	28/03	3			SIZI HAN	E I.D. MER WT.	3-1/4" 1-3/8" 140	LINE & STATION					
DATE	FINISH 10/	28/03	ı			HAN	MER FALL	30"						
		SA	MPLE	_	I		CASING		OFFSE	. I I				
	DEPTH		BLOWS	PER 6"	_		BLOWS/ CORING	FIELD CLASSIFICATION AND REMARKS		Well	Installation			
No.	IN FEET	0-6	6-12	12-18	18-24	REC.	TIMES			Cons.	Details			
01	01 21	5				0.011	1 447 1 1 1							
	0-2	2	2	2	2	20		5" Dark brown Sandy Topsoil	.4					
								Brown Fine Sand, Little Silt, Trace of Roots - Fil	ll 3.0					
S2	5'-7'	4	7	10	13	18"		Light Brown Fine Sand						
			•	, 0	10	.0		Trace of Silt @ S6, Stratified						
								little silt @ s7						
S3	10'-12'	3	5	5	7	18"								
		_	-	-	·									
									1					
S4	15'-17'	3	4	5	5	16"								
Į.														
S5	20'-22'	5	5	6	8	18"								
			-	-	-									
							1				-			
S6	25'-27'	6	8	10	10	20"								
S7	30'-32'	7	9	10	9	18"								
									32.0					
								End of Boring @ 32' Water @ 29'						
								Water @ 28' Overnight						
						Ì								
						Í								
							[
											1			
											-			
NOTES:	1) The stratification	n lines repre	sent the	2) Water	level readin	ngs have bee	en made	REMARKS: Note: Moved Hole IN West Due to	<u>Ouget</u>	and Par	rchao			
	approximate bou types. Transitio	ndary betwe n≄ may be g	en soil radual	in the condition Flucture	drill holes al ons stated o tions in th	times and in the boring e level of m	under glogs, round-	The second	overn	icuu Drai	107150			
				water i than th	nay occur d ose presen	ue to factors A at the time	neas-							
				uremer	aa were ma	ue,								

		<u> `</u>	- <u>-</u>			<u> </u>					
CUEN	T: GEI					NCW	ENGLAN	ID BORING CONTRACTORS OF CI., INC.		BORIN	G No. B-3
PROJE		rookh	aven					129 KRIEGER LANE GLASTONBURY, CT 04033	SHEE	T 1 OF	1
LOCAT	ION: Long	ation Isla	had, ^I	abs M		1000		(860) 633-4649 — (413) 733-1232 FAX (860) 667-8048	ARCHI	itect/ IEER	
ORILLE	R: T. Roe	2			- F					O. GEI-	LongIsland,
INSPE	CTOR: A. S	imart				TYP	E	Casing Sampler Core Barrel HSA SS	SURF	ACE ELEV.	
DATE	START: 10/	28/03	5			SIZ	E I.D. MER WT.	3-1/4" 1-3/8" 140		STATION	
DATE		20/05				HAN	MER FALL	- 30"			
DATE	-INISH: 107	28703 SA	MPLE			.	CASING		OFFSE		
	DEPTH		BLOWS	PER 6	4	<u> </u>	BLOWS/			Weil	Installation
No.	RANGE IN FEET	0-8	6-12	12-18	18-24	REC,	TIMES			Cons.	Details
					1.4.2.		PERFI.				· · · · · · · · · · · · · · · · · · ·
S1	0'-2'	3	3	1	1	14"		1" Asphalt - 2" Dark Brown Topsoil.	2		
		ļ						Brown Fine Sand, Trace of Silt, Possible Fill	75		
			•					Light Brown Fine Sand, Stratified	<u>6.</u> 2		
S2	5-7	3	6	8	10	20"					
			-	-	_	1.01]				
53	10'-12'	3	5	5	5	16					
			•								
54	15'-17'	3	2	3	4	24					
				-	-						
55	20'-22'	3	4	5	8	20"					
			•	-	•						
S6	25'-27'	4	6	6	9	24"					
			-	-							
S/	30'-32'	2	5	6	10	24.			32.0		
								End of Boring @ 32'			
								Water @ 31' Water @ 28' Overnight			
					1						
									I		
NOTES	1) The strailload	n ines repr	neod thu	2) wat	er level read	linge heve be	ner made	REMARKS:			
Í	types, Transit	ons may be	gradual.	cons Fluc	lions stated	on the bolt	ne laga, ground-				- `
Í				viiki kani Vron	n may accur Those press terks were m	ous to facto wi el the titt 12de.	с шедэ» С шедэ»				
L				4, UI							

CLIEN	IT: GEI					NEW	ENGLAN	ID BORING CONTRACTORS OF CT., INC.	BORING No. B-4			
PROJ	ECT NAME: B:	rookh	aven					129 KRIEGER LANE GLASTONBURY, CT 06033	SHEET 1 OF 2			
LOCA	TiON: Long	ation Isla	al L	abs IY				(860) 633-4649 — (413) 733-1232 FAX (860) 657-8046	ARCHITECT/ ENGINEER			
DRILL	ER: T. Roe	¢			⊢	~~~			FIEN			
INSPE	CTOR: A. S	mart				TYP	E	Casing Sampler Core Barrel	SURE		hongisiand,	
DATE	START: 10/	27/03	3			SIZI HAN	E I.D. AMER WT.	3" 1-3/8" 300 140	LINE			
DATE	FINISH: 10/	27/03	3			НАМ	MER FALL	. 24" 30"				
	T	SA		050.01		·				<u></u>		
No.	DEPTH RANGE		ON SA	MPLER		REC.	CORING	FIELD CLASSIFICATION AND REMARKS		Well Cons.	Installation Details	
	IN FEET	0-6	6-12	12-18	18-24	<u> </u>	PER FT.					
S1	0'-2'	1	2	2	3	20"		Dark Brown Sandy Topsoil				
		1						Gray Fine Sand, Little Silt, Trace of Roots - Fill	1.0			
S2	5'-7'	8	11	13	14	20"		Light Brown Fine-Med. Sand, Stratified	3.0			
		ľ		10	• 7							
S3	10'-12'	9	10	9	8	18"						
84	451 471			47	4.5							
54	10-17	11	14	17	19	16"		Light Brown Fine-Crs. Sand, Trace of Fine Gravel Stratified				
									ĺ		-	
S5	20'-22'	3	4	6	9	12"		Light Brown Fine Sand Some Med Cro. Sand				
								Trace of Fine-Crs. Gravel				
S6	25'-27'	14	16	26	28	12"						
S7	30'-32'	15	25	25	28	12"						
											:	
S8	35'-37'	9	12	15	22	14"						
<u>89</u>	40'-42'	13	25	34	36	10#						
	40 42	15	20	34	30	12						
S10	45'-47'	9	22	22	25	14"						
011		-										
511	50'-52'	9	15	16	14	12"						
S12	55'-57'	10	14	10	9	12"						
NOTES:	1) The stratification	n lines repre	sent the	2) Water	level readi	ings have bee	en made	REMARKS:				
	approximate boi types. Transitio	ns may be g	sen soli radual	in the conditi Fluctu	drill holes a ons stated ations in th	it limes and on the boring ne level of g	under 3 logs, round-					
				than th urement	niay occur i kose presei nts were ma	nt at the time ade.	meas-					
							· · · · · ·					

CLIENT: GEI PROJECT NAME: Brookhaven LOCATION: Long Island, NY	NEW	NEW ENGLAND BORING CONTRACTORS OF CT., INC. 129 KRIEGER LANE GLASTONBURY, CT 06033 (860) 633-4649 - (413) 733-1232 FAX (860) 657-8046				BORING No. B-4 SHEET 2 OF 2 ARCHITECT/ ENGINEER		
DRILLER: T. Roe INSPECTOR: A. Smart DATE START: 10/27/03 DATE FINISH: 10/27/03	Casing Sampler Core Barrel TYPE NW SS SIZE I.D. 3" 1-3/8" HAMMER WT. 300 140 HAMMER FALL 24" 30"				FILE NO. GEI-LongIsland, SURFACE ELEV. LINE & STATION			
SAMPLE DEPTH BLOWS PER 6" No. RANGE IN FEET 0-6 6-12 12-18 18-2	REC.	CASING BLOWS/ CORING TIMES PER FT.	FIELD CLASSIFICATION AND REMARKS		Well Cons.	Installation Details		
S13 60'-62' 8 13 17 18	12"		End of Boring @ 62' Water @ 18' Overnight Water @ 23' After 60 Hours +/-	62.0				

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CLIEN	T: GEI		· _ · · ·			NEW I	ENGLAN	D BORING CONTRACTORS OF CT., INC.	BORING No. B-5			
PROJE	CT NAME: B1	rookh	aven					129 KRIEGER LANE GLASTONBURY, CT 06033	SHEE	T 1 OF	1	
LOCAT	10N: Long	tion Islai	al, ¹ 8	bs Y				(860) 633-4649 — (413) 733-1232 FAX (860) 657-8046	ARCH	ITECT/ IEER		
DRILLE	R: T. Roe	I			- F			· · · · · · · · · · · · · · · · · · ·	FILE N	IO. GEI-	LongIsland,	
INSPE	CTOR: A. S	mart				түр	E	Casing Sampler Core Barrel HSA SS	SURF/	ACE ELEV.	- •	
DATE	START: 10/3	80/03				SIZE Han	E I.D. AMER WT.	3-1/4" 1-3/8" 140	LINE 8	STATION		
DATE	-INISH: 10/3	30/03				HAN	IMER FALL	30"	OFFSE	ET		
		SAN	APLE BLOW/S	PER 6"			CASING BLOWS/					
No.	RANGE		ON SA	MPLER		REC.	CORING TIMES	FIELD CLASSIFICATION AND REMARKS		Well Cons.	Installation Details	
		0-6	6-12	12-18	18-24		PER FT.					
S1	0'-2'	2	2	2	1	18"		6" Dark Brown Topsoil	5			
								Brown Fine Sand, Little Silt - Fill	3.0			
S2	5'-7'	5	8	9	13	20"		Light Brown Fine Sand, Stratified				
		-	-	•								
S3	10'-12'	4	5	6	7	24"						
54	15' 17'		4		0	20"						
- 54	13-17	4	4	4	Ö	20						
S5	20'-22'	4	7	9	11	24"						
								Brown Fine Sand, Little Silt, Stratified				
		_										
S6	25'-27'	6	10	12	16	18"		Light Brown Fine Sand, Little Fine Gravel, Strat	tified			
S7	30'-32'	5	4	9	8	15"		Light Brown Fine-Med Sand Some Gravel St	ratified			
								End of Boring @ 32'	32.0			
								Water @ 28' Overnight				
						1			1			
NOTES:	1) The stratification approximate how	i fines repres	sent the	2) Water	level readi	ngs have be	en made under	REMARKS:		·		
types, Transitions may be gradual, conditions state Fluctuations in Water may occur							g logs, round- s other					
				than li ureme	ndse preser nts were ma	nt at the time ude.	1 R625-					

CLIENT: GEI						NEW		ID BORING CONTRACTORS OF CT., INC.	BORING No. B-6			
PROJE	ECT NAME: BI	rookh	aven					129 KRIEGER LANE GLASTONBURY, CT 06033	SHEET 1 OF 1			
LOCA	FION: Long	ition Isla	$\frac{a1}{nd}, \frac{1}{N}$	ibs IY			WILL PARTY	(860) 633-4649 (413) 733-1232 FAX (860) 657-8046	ARCHITECT/ ENGINEER			
DRILL	ER: T. Roe	•			F					FILE NO. GEI-LongIsland,		
INSPE	CTOR: A. S	mart				TYP	Casing Sampler Core Barrel TYPE HSA SS SIZE I.D. 3-1/4" 1-3/8" HAMMER WT. 140			NY SURFACE ELEV. LINE & STATION		
DATE	START: 10/2	29/03				HAN						
DATE	FINISH: 10/2	29/03						30-	OFFSE	т		
	DEPTH	SAI	MPLE BLOWS	PER 6"			CASING BLOWS/			Wall	la stallatio -	
No.	RANGE IN FEET	0-6	ON SA	MPLER	18-24	REC.	CORING TIMES	FIELD CLASSIFICATION AND REMARKS		Cons.	Details	
	01.01		-7				PERFT.					
51	0'-2'	2		4	2	24"		4" Dark Brown Topsoil - Fine Sand, Some Silt, Roots	Little			
								Brown Fine Sand, Some Silt, Stratified - Fill	.3			
S2	5'-7'	9	11	12	19	20"		Light Brown Fine Sand Stratified	5.5			
								Light brown Fine Sand, Straulied				
	101 101							Trace of Gravel @ S3				
53	10-12	9	10	12	15	24"						
S4	15'-17'	4	9	6	7	24"						
					3							
S5	20'-22'	8	18	18	21	24"		Light Brown Fine Sand, Trace of MedCrs. Sar	nd,			
								Stamen				
S6	25'-27'	10	21	25	30	24"						
S7	30'-32'	16	27	25	22	24"			22.0			
		-						End of Boring @ 32'	<u> </u>			
		-										
NOTES	1) The stratification	lines repre	sent the	2) Water	level read	nge bave h-	en mada	REMARKS				
	2/ Water level readings have b approximate boundary between soil types. Transitions may be gradual, but of thit hates at times and conditions stated on the board of Fluctuations to be level of											
				water than ti ureme	may occur o nose preser nts were ma	tue to factor nt at the time ide.	s other meas-					

CLIENT' GET						NEW	ENGLAN	ID BORING CONTRACTORS OF CT., INC.	BORING No. B-7				
PROJE	ECT NAME: BI	rookh	aven			129 KRIEGER LANE GLASTONBURY, CT 06033 (860) 633-4649 - (413) 733-1232 EAX (860) 657-8046				SHEET 1 OF 1			
1004	CION: Long	tipn		abs						ARCHITECT/			
DDILL		1914	na, r	AT.	L			FAX (860) 657-8046	ENGINEER				
	ert: T. Koe							Casing Sampler Core Barrel	FILE N	O. GEI-	LongIsland,		
INSPE	CTOR: A. S	mart				TYF SIZI	°E E I.D.	SA SS 4" 1-3/8"	SURF/	ACE ÈLEV.			
DATE	START: 10/2	29/03	3			HAN HAN	MMER WT.	140 30"	LINE 8	STATION			
DATE	FINISH: 10/2	29/03	3						OFFSE	T			
	перты	SAI	MPLE BLOWS	PER 6			CASING BLOWS/		_				
No.	RANGE		ON SA	MPLER		REC,	CORING	FIELD CLASSIFICATION AND REMARKS		vveil Cons,	Installation Details		
 	INCEI	0-6	6-12	12-18	18-24		PER FT.						
S1	0'-2'	1	2	1	1	24"		Dark Brown Topsoil	1.0				
								Brown Fine Sand, Some Silt - Fill					
62	51 7)	E		40	40	0.01		Light Brown Fine Sand, Stratified	3.0				
52		5	0	10	12	24"			7.0				
								End of Boring @ 7'					
								IND WALCH					
											f.		
									ĺ				
					ļ								
							Ĩ						
					ļ								
NOTES:	1) The stratification approximate bou	Ines repre Indary betwe	sent the sen soil	2) Water In the	level readi drill holes a	ngs have be it times and	en made under	REMARKS:	ł_				
	rybes, transitor	na may pe d	F 원 010 왕),	conditi Fluctus water r	ons stated ations in the may occur o	on the borin ne level of g tue to factor	g logs. round- s ather						
				than th tremer	osa presei nts were ma	nt at the time ade.	meas-						
CLIEN	T: GEI					NEW		ID BORING CONTRACTORS OF CT., INC.		BORIN	G No. B-8		
--------	--	--	--------------------	-------------------------------	---	---	---	---	-----------------	----------------	-------------------------		
PROJ	ECT NAME: B	rookh	aven					129 KRIEGER LANE GLASTONBURY, CT 06033	SHEET	1 OF	1		
LOCA	TION: Long	ation Islai	nd, N	h)s M			Carlos and C	(860) 633-4649 (413) 733-1232 FAX (860) 657-8046	ARCHI ENGINI	TECT/ EER			
DRILL	ER: T. Roe	2			ŀ				FILE N	D. GEI-	LongIsland,		
INSPE	CTOR: A. S	smart				TYP	E	Casing Sampler Core Barrel SA SS	SURFA	CE ELEV.	- ,		
DATE	START: 10/2	29/03	•			SIZE	E I.D. IMER WT.	4" 1-3/8" 140	LINE &	STATION			
DATE	FINISH: 10/	29/03					AMER FALL	. 30"	OFFSE	т			
	DEPTH	SAI	MPLE BLOWS	PER 6	1		CASING BLOWS/				_		
No.	RANGE	0-6	ON SA	MPLER	18.24	REC.	CORING TIMES	FIELD CLASSIFICATION AND REMARKS		Vveit Cons.	Installation Details		
		0.0		12-10			PER FT.						
ST	0'-2'	3	2	3	2	18"		Brown Fine Sand, Little Silt - Fill					
									4.0				
S2	5'-7'	3	3	4	4	24"		Light Brown Fine Sand, Trace of Gravel, Strati	fied				
								End of Boring @ 7'	<u>7.</u> 0				
								No Water					
											1		
NOTES													
NOTES:	 The stratification approximate bou types. Transition 	n fines repres Indary betwe ns may be gr	en soil radual,	2) Water in the conditi	level readin dri# holes ai ons stated o	ngs have bee t times and on the boring	en made Under Jogs.	REMARKS:					
				Huctua water r than th	auons in th nay occur d lose presen	e level of gr lue to factors it at the time	ound- other meas-						
				adud	a dere nia								

						NEW	FNGLAN	D BORING CONTRACTORS OF CT. INC.	1		
CLIEN	NT: GEI							129 KRIEGER LANE		BORIN	G No. B-9
PROJ	ECT NAME: B:	rookh	aven	_				GLASTONBURY, CT 06033	SHEE	LOF	1
LOCA	TION: Long	ation Isla	nd, K	abs IY				(860) 633-4649 (413) 733-1232 FAX (860) 657-8046	ARCH ENGIN	ITECT/ IEER	
DRILL	ER: T. Roe	2			F			· · · · · · · · · · · · · · · · · · ·	FILF N	O. GET-	LongTeland
INSPE	ECTOR: A. S	mart				TYP	Æ	Casing Sampler Core Barrel	el IDE		Longisiand,
DATE	START 10/	29/03	1			SIZI	E I.D.	4" 1-3/8"			
DATE		20/03				HAN	MER FALL	30"	LINE 8	STATION	
	FINISH. LUT.	SA	MPLE				CASING		OFFSE	T	·····
	DEPTH		BLOWS	PER 6	1		BLOWS/	FIELD CLASSIFICATION AND DEMARKS		Weil	Installation
No.	RANGE IN FEET	0-6	6-12	12-18	18-24	REC.	TIMES	FIELD CLASSIFICATION AND REMARKS		Cons.	Details
							<u> </u>				
SI	0'-2'	1	6	6	5	20"		- 8" Dark Brown Topsoil	.6		
								Black Fine Sand, Trace of Roots, Ash, Brick			
\$2	5'-7'	1	2	1	1	24			.1		
			2	1	•	24		Brown Fine Sand, Some Silt - Fill	7.0		
								Light Brown Fine Sand			
S3	10'-12'	5	5	4	7	18"					
			Ū	•	•				12.0		
								End of Boring @ 12' No Water			
						:					
							ſ				
							ľ				
									1		
											<i>.</i>
					l						
NOTES:	1) The stratification approximate bou	lines repres ndary betwe	sent the sen soil	2) Water in the	level readin drið holes af	igs have bee times and	en made i under	REMARKS:	1		
	vypes. Transilio	ns may be g	radual.	condit Fluctu: water	ions stated o ations in th may occur d	in the boring e level of gi ue to factors	riogs. round- a other				
				than th ureme	iose presen nis were ma	t at the time de.	meas-				

CLIEN PROJI	IT: GEI ECT NAME: B:	rookh	aven al La	bs		NEW		ID BORING CONTRACTORS OF CT., INC. 129 KRIEGER LANE GLASTONBURY, CT 06033 (860) 633-4649 - (413) 733-1232	SHEE	BORING	6 No. B-10 1
DRILL INSPE DATE	ER: T. Roe CTOR: A. S START: 10/:	mart 29/03	,			TYP Size Han Han	E E I.D. MER WT.	Casing Sampler Core Barrel SA SS 4" 1-3/8" 140 30"	FILE N SURF	IO. GEI- NY ACEELEV. STATION	LongIsland,
DATE	FINISH. IV/2	SAI	MPI F		<u> </u>		CASING		OFFS	ET	
	DEPTH		BLOWS	PER 6"		ŀ	BLOWS/			14/-11	
No.	RANGE IN FEET	0-6	ON SA	MPLER 12-18	18-24	REC.	CORING TIMES PER FT.	FIELD CLASSIFICATION AND REMARKS		Vveil Cons.	Installation Details
S1	0'-2'	1	4	3	3	24"		Dark Brown Topsoil Brown Fine Sand, Some Silt - Fill	1.0		
S2	5'-7'	2	4	6	5	24"		Light Brown Fine Sand, Trace of Gravel, Strati End of Boring @ 7' No Water	5.0 fied 7.0		
										ι.	
								,			
NOTES:	 The stratification approximate bou types. Transitio 	n lines repre: adary betwe ns may be g	sent the ren soil radual,	2) Water In the conditi Fluctus water than th uremen	level readin drill holes at ons stated o atlons in th may occur d ose preser ts were ma	ngs have been t times and on the boring to level of factors the to factors at the time tde.	en made under 3 logs. round- e other meas-	REMARKS:		·	

r						NIEWA		ID DODING CONTRACTORS OF AT UNA			
CLIEN	T: GEI					INEV		ID BORING CONTRACTORS OF CT., INC.	1	BORING	6 No. B-12
PROJ	ECT NAME: B:	rookh	aven					129 KRIEGER LANE GLASTONBURY, CT 06033	SHEET	г 1 оғ	1
LOCA	TION: Long	ation Isla	nd, 1	abs IY				(860) 633-4649 — (413) 733-1232 FAX (860) 657-8046	ARCHI ENGIN	TECT/ EER	
DRILL	ER: T. Roe	3			⊢				FILE N	O. GET-	LongIsland
INSPE	CTOR: A. S	Smart				TYP	Έ	Casing Sampler Core Barrel	SUDEA	NY	giorand,
DATE	START: 10/2	29/03	3			SIZI	E I.D.	3-1/4" 1-3/8"	LINE		
DATE		20/03	2			HAN	MMER FALL	- 30"	LINE &	STATION	
DATE	111011. 1077	SA	MPLE			•	CASING	I	OFFSE	T	
	DEPTH		BLOWS	PER 6"			BLOWS/	FIELD CLASSIFICATION AND REMARKS		Well	Installation
No.	IN FEET	0-6	6-12	12-18	18-24	REC.	TIMES			Cons.	Details
Q1	0' 2'	1	·			241					
31	0-2	1	2	3	2	24*		8" Dark Brown Topsoil	.6		
								Brown Fine Sand, Little Silt - Fill	4.0		
S2	5'-7'	2	5	8	8	24"		Brown Fine Sand, Stratified	4.0		
		-	•	•	Ŭ	47					
S3	10'-12'	5	9	9	11	24"					
S4	15'-17'	4	5	5	5	24"		Alternating 4"-10" Lavers of Brown Fine Sand a	nd		
								Brown Fine Sand, Little Silt			
S5	20'-22'	7	11	18	19	24"		Light Brown Fine-Med Sand Trace of Gravel			
								Stratified			1
S6	25'-27'	4	5	8	8	16"		Cobbles @ 22' to 24' Depth			
								Light Brown Med. Sand, Little Gravel, Stratified			
S7	30'-32'	9	12	14	18	20"					
								End of Boring @ 32'	32.0		
								Water @ 30' +/-			
							ĺ				i i
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NOTES	1) -	·	•								
NOTES;	 The stratification approximate bout types. Transition 	n änes repre: Indary betwe ns may be o	sent the sen soil radual.	2) Water In the conditi	level readin drill holes al ons slated 4	ngs have bee t times and on the boring	en made under 1 kogs.	REMARKS: Note: B-11 was Omitted			
		a		Fluctua water J Shan H	itions in th may occur d	e level of gi lue to factors at the time	ound- other meas-				
				wenter	ts were ma	de.					







						(G	R	A	IP	I	S	51	Ζ	Έ		D	K	S	T	R		B	U	T	-](0	N	1	Т	Έ	:<	3	Г	F	RE	F	2)I	R	Т	1							
		6 in,		3 in.	2 in.	1-1/2 in.		1 in,	3/4 in.	40 in		3/8 in.			1			610	2			#20			40		160				140		200																
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LΓ	%	5 + 3"	1	1			%	GR	A	/El	L,										31	<u>κ</u> %	SA		D		- n	<u>- 111</u>	1			Т				0	6 S	SIL.	т						9	6 C		Y	
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					<u>. </u>				0	.46	7				0.2	267	1		i	0.	.21	0 6				0.	<u>30</u> 11:	5					5					0		+			- <u>-</u> -					<u>-u</u>	
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o s	MATERIAL DESCRIPTION USCS AASHTO Silty SAND SM																																																
Pro Pro	ojec ojec	t No. t: C	0: ente	342 er fo	0 or F	un	ctic	C	lie 1 N	nt an	on	HI nat	DR eri	L A	.rc s, I	hit Bro	ect ook	ure ha	e, I	inc n l	Vai	tio	nal	L	abo	ora	tor	ry									Re O	m	arl	ks	:		<u>i</u>						
0 5	lou	rce: I	35								Sa	arr	ıpl	le	No	. :	SI						E	lev	v./I	De	pt	h:	0	to	2 :	ft																	
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Appendix C

2006-2007 Test Boring Logs



Boring		ation	_		FASTI	NG:		STATION	OFFSET [,]		BORING
IORIZ	ONTA	L DA	TUM: N	AD	83		ST,	ATION CENTERL	NE:		B-101
RTIC	CAL D TION: _	See I	/:: BNL Figure 2	94 !			GR	OUND SURFACE	ELEVATION (FT): 74.0	F	AGE 1 of 2
Drillin DATE S CONTRA EQUIPN AUGER HAMME WATER GENER	g Info TART / ACTOF /IENT: ID/OD: ER TYP LEVEI	Prmat PEND: Mobi : N/A E: S L DEP TES:	tion 7/20/2 ew Engla le Drill B / N/A afety Har THS (ft): Sample	006 nd l -53 nm	3 - 7/20/2 Boring Truck me er Dilected u	006 [[[] sing a 2-	DRILLER: rill Rig CASING II HAMMER	_Jeff Leavitt D/OD: <u>N/A / 3 in</u> WEIGHT (Ibs): <u>14</u> er split spoon	TOTAL DEPTH (FT): 52.0 LOGGED BY: Steve Hawkins BORING METHOD: Drive and CORE INFO:	t Wash	
ABBREV	VIATION	S: ID Of Pe Re	= inside 0) = Outsid n. = Pene c. = Reco	tiam e Dia tratic very	eter ameter on Length Length	bpf = f mpf = S = Sp DP = [Blows per F Minute per blit Spoon Direct Push	oot U = Undis Foot C = Rock V = Field Sample SC = Son	ubed Tube Sample WOR = Weight of Rods ore WOH = Weight of Hammer ane Shear RQD = Rock Quality Desig Core OVM = Organic Vapor Met	Q _v = Pock S _v = Pock nation F _v = Field er NA, NM =	et Penetrometer Strength et Torvane Shear Strength Vane Shear Strength Not Applicable, Not Measured
		Casing			SAMPL	E INFO	RMATIO	N g			
Elev. I (ft)	Depth (ft)	(bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	Sample Description & Classification	H ₂ C Dep	Remarks
+	- -		1	X	0 to 2	24/18	4-6-9-9		SILTY SAND (SM); fine to coarse sand, fines, 6% fine gravel, moist, dark brown, (TOPSOIL). Probable Fill, Silty Sand on auger cutting	32% silty roots	andaren er en
70	- 5 -		2	X	5 to 7	24/12	21-25- 27-30		WIDELY GRADED SAND WITH SILT (S fine to coarse sand, 12% silty fines, 3% f gravel, moist, light brown.	W-SM); ine	Strata change estimated at 3.5 feet
	- 10 -		3		10 to 12	24/10	4-8-8-9		WIDELY GRADED SAND (SW); fine to c sand, 8% fine gravel, 1% silty fines, wet, brown.	oarse light	
_	15		4	X	15 to 17	24/10	13-15- 17-17		WIDELY GRADED SAND (SW); fine to c sand, 6% fine gravel, 3% silty fines, wet, brown.	oarse light	
	- 20		5		20 to 22	24/12	20-25- 32-41		WIDELY GRADED SAND (SW); fine to c sand, 5% fine gravel, 4% silty fines, wet, brown.	oarse light	
Stratification boundary gradual, V at times a Fluctuation other factor measuren	ion lines between Nater lev Ind under Ins of gro ors than nents we	represe soil typ el readi conditi undwat those pr re made	nt approxines, transitings have to ons stated er may occurresent at the stated sectors and the stated sectors at the stated sectors at the stated sectors at the stated sectors and sectors at the sector	nate ions ieen cur d ne tir	may be made fue to me	CLIENT: PROJEC CITY/ST GEI PRO	HDR A	rchitecture, Inc. NSLS II Geoted oton, New York UMBER: 062150	GEI	GEI 455 Glas 860.	Consultants, Inc. Winding Brook Dr tonbury, CT 06033 368.5408

Borin		ation	<u>)</u>		EASTI			QTAT	<u></u>	OFFRET.		В	ORING
HORI	ZONTA	LDA	TUM: N	AD	83	NG:	ST	ATION CEN	UN: TERI	OFFSET:		В	-101
VERT			M: BNL	94			GF	ROUND SUR	FAC	E ELEVATION (FT): 74.0		PAG	GE 2 of 2
		Cooling			SAMDI				0	<u></u>			······
Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	GRAPHIC LOC	Sample Description & Classification		H ₂ 0 Depth	Remarks
-	25		6	M	25 to 27	24/12	25-27- 29-31		0 0 <td>WIDELY GRADED SAND WITH GRAV fine to coarse sand, 25% fine gravel, 5% fines, wet, light brown.</td> <td>EL (SW); 6 silty</td> <td></td> <td></td>	WIDELY GRADED SAND WITH GRAV fine to coarse sand, 25% fine gravel, 5% fines, wet, light brown.	EL (SW); 6 silty		
45	- - - -		7		30 to 32	24/10	18-22- 24-29			WIDELY GRADED SAND WITH GRAV fine to coarse sand, ~30% fine gravel, < fines, wet, light brown.	EL (SW); 5% silty		
40	35		8	M	35 to 37	24/6	14-16- 20-22			WIDELY GRADED SAND WITH GRAV fine to coarse sand, 27% fine to coarse 5% silty fines, wet, light brown.	EL (SW); gravel,		
35	40		9	X	40 to 42	24/8	15-16- 20-22			WIDELY GRADED SAND WITH GRAV fine to coarse sand, ~30% fine gravel, < fines, wet, light brown.	EL (SW); 5% silty		
30	- 45		10	X	45 to 47	24/8	20-26- 35-47			WIDELY GRADED SAND WITH SILT (fine to coarse sand, 8% silty fines, 1% fi gravel, wet, light brown.	SW-SM); ne		
25-	50		11	X	50 to 52	24/12	29-30- 31-28			WIDELY GRADED SAND WITH SILT (fine to coarse sand, ~10% silty fines, ~1 gravel, wet, brown.	SW-SM); 0% fine		
20													
Stratific bounda gradual at times Fluctua other fa measur	ation lines ry betwee . Water les and unde tions of gr ctors than ements w	represe n soil typ vel readi r conditi oundwat those p ere mad	ent approxi bes, transiti ings have t ions stated ter may occ resent at th e.	mate ions been cur c he tii	may be may be made File	CLIENT: PROJEC CITY/ST GEI PRO	<u>HDR A</u> T NAMI ATE: <u>U</u> DJECT N	Architecture, E: NSLS II G pton, New Y IUMBER: 06	Inc. Geote Ork 2150	chnical Investigation D-*-1000	Onsultants	GEI Co 455 Wi Glasto 860.36	onsultants, Inc. inding Brook Dr nbury, CT 06033 8.5408

	Borir NOR1	ng Loc THING:	atior	1		EASTI	NG:		STAT	ION:		OFFSET:			E	ORING
	HORI	ZONTA	LDA	TUM: N	AD	83		ST	ATION CEN	ITER					В	-101a
	VERT LOCA	ICAL E	See	M: <u>BNL</u> Figure 2	94			GR		RFAC	E ELEVAI	'ION (FT) <u>:</u> 74.0)		PA	GE 1 of 1
┝	Drilli	ng Infe	orma	tion				·······								·····
	DATE	START	/ END:	8/16/2	006	- 8/16/2	006				~	TOTAL DEPTH	(FT): <u>10.0</u>			
	EQUIP	MENT:	R: <u>N</u> Mob	ew Englai ile Drill B-	<u>nd t</u> .53	truck mo	unted dri	DRILLER: II rig.	Jeff Leavit	t		LOGGED BY: BORING METH	Steven Hawkin IOD: Hollow S	ns Stem Auger		
	AUGE	r id/od	4.2	25 in / N/A			(CASING I	D/OD: N/A	/ N/A		CORE INFO:				
ļ	HAMM		'E: <u>9</u>	afety Har	nme	er	I	AMMER	WEIGHT (Ibs	s): <u>1</u>	40	HAMMER DRO	P (inch): 30			
	GENE	RAL NO	TES:	Sample:	s cc	lected u	ising a 2-	inch diam	eter split spoo					····		a and the state of
Ī	ABBR	VIATION	1 S: ID	= Inside D	iam Dia	ətər	bpf = I	Blows per F	oot U	= Und	istrubed Tube	Sample WOR =	Weight of Rods	Q, =	Pocket	Penetrometer Strength
			Pe Re	en. = Penet ec. = Recov	ratic /ery	n Length Length	S = S DP = I	ilit Spoon Direct Push	Sample S	'= Field C = So	l Vane Shear nic Core	RQD = 1 OVM = 1	Rock Quality Desig Organic Vapor Met	r s _v = µnation F _v ≓ ter NA,	Field Va	orvane Snear Strength ne Shear Strength ot Applicable, Not Measured
ſ			Casing Pen.		;	SAMPL	E INFO	RMATIO	N	00						
	Elev.	Depth	(bpf) or	Sample	ø	Denth	Pen./	Blows	Field	HICI		Sam Descrip	ple tion &		H ₂ 0 Deoth	Remarks
	(11)	(11)	Core Rate (mpf)	No.	Å	(ft)	Rec. (in)	or	Test Data	RAP		Classifi	cation			
┢			(S-1	\mathbf{H}	0	24/14	3-3-4-4		***	SILTY S	AND (SM); fine to	o coarse sand,	~25%		
	-	***			X	to 2					silty fines	, ~5% fine grave <u>4 inches of tops</u>	el, dry, brown, ~ soil	-10%		
	-	-		S-2	Ĥ	2	24/20	4-9-9-			SILTY S	ND (SM): fine to	o coarse sand	~25%		
	_	_			IXI.	to 4		10			silty fines	, ~5% fine grave	el, dry, brown, E	Sottom 5		
	70	-			Ш								obarde dana. I	<u>16</u> C.	1	Strata change
		_		S-3	M	4 to	24/12	9-10- 10-12			WIDELY fine to co	GRADED SANE arse sand, ~10%	0 WITH SILT (S 6 siltv fines. ~5	W-SM); % fine		feet
	-	5			\mathbb{N}	6					gravel, di	y, brown.	3 ,			
		-		S-4	H	6	24/12	13-16-			WIDELY	GRADED SANE) (SW); fine to a	coarse		
	_	-			X	10 8		10-15			sand, ~5 dry, brow	% silty fines, ~5% n.	% fine to coarse	e gravel,		
	_	-		S-5	Н	8	24/18	12-13-) (SMA: fina ta (202700		
24/06	65 —	_			١¥١	to		13-15			sand, ~5	% silty fines, ~5%	% fine gravel, d	ry,		
DT 8/	-	- 10			Λ	10					DIQWN.	<u></u>				
TE.G		_									End of B Fill with c	oring at 10 feet outtings upon cor	npletion			
MPLA																
TA TE	-	-														
EIDA	-	-														
20	60 —	-														
GS.GI	_	- 15														
1910	-	-														
BORIN																
IN	_	_														
DIG	er															
SILA	55-	~														
LNSL	-	— 20														
2 BN	-	-														
90	-	-														
SING	-	-														
	Stroff -	tion line		Dt anner 1												
INICA	stratifica boundan gradual	uon iines / betweer Water iev	represe soil typ el readi	nt approxim es, transitio ngs have by	nate Dris r Ben -	nay be C			rchitechture	Inc.				N		onsultants, Inc.
TECH	at times Fluctuati	and unde ons of gro	r conditi undwat	ons stated. er may occi	ur da	ue to C	RUJEC	ATE: Ut	ton, New Y	seote ork	cnnical Inv	estigation		y (+∋∋ vv Glasto	nding Brook Dr nbury, CT 06033
	other fac neasure	tors than ments we	those pr re made	esent at the	ə tim	ie G	EI PRO	JECT N	UMBER: 00	52150)-*-1000			nsultants {	360.36	8.5408

	Borin NORT	ng Loc THING:	ation	1		EAST	NG:		STATI	ON-	OFESET.		B	ORING
	HORI	ZONTA	LDA	TUM: N	IAD	83		ST	ATION CEN	TERL			B	-102
	VERT	ICAL E	See	M: <u>BNL</u> Figure 2	<u>94</u>			GR	OUND SUR	FACE	ELEVATION (FT): 81.0		PA	GE 1 of 3
┢				tion										<u></u>
	DATE	START	/ END:	7/19/2	006	- 7/20/2	006				TOTAL DEPTH (FT): 62.0			
	CONTI	RACTO	R: <u>N</u>	ew Engla	ind I	Boring		ORILLER:	Jeff Leavitt		LOGGED BY: Steve Hawkin	s		
	EQUIP		Mob	ile Drill B	-53	Truck m	ounted D	rill Rig		9 in	BORING METHOD: Drive an	id Wash		
	HAMM	ER TYP	E: S	afety Ha	mm	er	— ` •	ASING	WEIGHT (ibs)	<u>3 m</u> 14	D HAMMER DROP (inch): 30			
	WATE	R LEVE	L DEP	THS (ft):	¥	36.50	/20/2006	9:20 am	¥ 36.50 7/20)/2006	1:55 pm			······
┝			TES:	Sample	S CC	eler	bof = F	in diamete	er split spoon	= 1 India	trubert Tube Sample WOP - Weight of Pode	0.	- Dankat I	lanatsamataa Ciraa alb
			OI Pe	D = Outsid an. = Pene	e Dia tratic	ameter on Length	mpf = S = Sp	Minute per blit Spoon	Foot C :	= Rock = Field	Core WOH = Weight of Hamme Vane Shear ROD = Rock Quality Desi	r S _v ⊧ onation F.≠	= Pocket 1 = Field Va	orvane Shear Strength
			Re	ec. ≖ Reco	very	Length	DP = [Direct Push	Sample SC	: = Son	c Core OVM = Organic Vapor Me	ter NA	NM = No	t Applicable, Not Measured
			Casing Pen.		тт	SAMPL	E INFO	RMATIO	N	LOG	Sample			
	Elev. (ft)	Depth (ft)	(opr) or Core	Sample	, g	Depth	Pen./	Blows	Field	문	Description &		H₂0 Depth	Remarks
	, ,	.,	Rate (mpf)	No.	ř	(ft)	(in)	or RQD	Data	BRAF	Classification			
ŀ				1	\mathbf{t}	0	24/8	3-13-5-		<u></u>	SILTY SAND (SM); fine to coarse sand,	27% silty		
	80 —	-			X	to 2		4			tines, 11% tine gravel, dry, brown, Cont roots, TOPSOIL	ains	ſ	
	-	-			А						Probable Fill, Silty Sand on auger cuttin	gs.		
	-	-								\bigotimes				
										\bigotimes				
		-												
	-	- 5		2	Н	5	24/12	8-14-		\sim	WIDELY GRADED SAND (SW); fine to	coarse	-	Strata change
	75 —	-			X	to 7		15-16			sand, 13% fine gravel, 5% silty fines, me brown.	oist, light		estimated at 5.0
	_	_			Щ									
		-												
	-	-												
		- 10		3	Н	10	24/10	8-10-			WIDELY GRADED SAND (SW): fine to	coarse		
24/06	70	-			M	to		13-13			sand, 9% fine gravel, 3% silty fines, mo	st, light		
18					\mathbb{N}	12					biowit.			
B]				Π									
PLAT	+	-												
TEM	-	-												
ATA	_	- 15			Ц		0.4440							
E E	65 _			4	М	15 to	24/12	4-9-18- 18			fine to coarse sand, 7% fine gravel, 7%	SW-SM); silty		
a	05	-			Μ	17					fines, moist, light brown.	-		
S	-				Н									
л У	-	-												
BORI	-	-											-	
ارت ال	_													
ž		20		5	M	20 to	24/12	12-18- 24-22			WIDELY GRADED SAND WITH SILT (S	SW-SM); fine		
23 19	60 -	-			١Ň	22					gravel, moist, light brown.		*****	
ğ	-	-			H									
S)	4	-								••••				
E B				Ļ										
NCA	Stratifica boundary graduct	tion lines y betweer Water les	represe soit typ	nt approxir es, transiti	nate ions	may be	LIENT:	HDR A	rchitecture, I	nc.		``` `	GEI Co	onsultants, Inc.
핍	at times : Fluctuation	and unde	r condition	ons stated. er may occ	cur d	ue to	KUJEC	INAME ATE: U	: <u>NSLS II G</u> oton. New ⊻∕	eotec ork	nnical Investigation		405 VV Glasto	naing Brook Dr nbury, CT 06033
ю Ю	other fac measure	tors than ments we	those pr re made	resent at th e.	ne tin	^{ne} C	EI PRO	JECT N	UMBER: 06	2150	*-1000 UEL a	insultants	860.36	8.5408

Bori	ng Loc	ation	L									BORING
NOR	THING:				EASTI	NG:			ION:	OFFSET:		D 400
			TUM: <u>N</u>	AD QA	0.83		ST/ 		TERL			<u>B-102</u>
LOC	ATION:	Seel	Figure 2	2	· · · ·							PAGE 2 of 3
	T	Casino			SAMPI		RMATIO	N	JO			
Elev. (ft)	Depth (ft)	Pen, (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	GRAPHIC LO	Sample Description & Classification		H ₂ 0 Depth Remarks
55-	25		6		25 to 27	24/12	27-36- 46-45			WIDELY GRADED SAND WITH SILT (S fine to medium sand, 10% silty fines, 3% gravel, moist, light brown.	SW-SM); 6 fine	Begins washing out ahead of casing advancement. Material too dense to drive
50 -	30		7		30 to 32	24/10	37-45- 47-61			WIDELY GRADED SAND (SW); fine to sand, ~10% fine gravel, ~5% silty fines, brown.	coarse wet, light	casing.
45-	35		8		35 to 37	24/10	31-47- 61-73			WIDELY GRADED SAND WITH SILT (5 fine to coarse sand, 7% silty fines, 5% fi gravel, wet, light brown.	SW-SM); ne	¥
40 -	40		9	X	40 to 41.5	18/10	39-62- 100			WIDELY GRADED SAND (SW); fine to sand, ~5% fine gravel, ~5% silty fines, w brown.	coarse vet,	
35 -			10	X	45 to 47	24/12	31-42- 49-55			WIDELY GRADED SAND WITH SILT (S fine to coarse sand, 9% fine gravel, 8% fines, wet, brown.	SW-SM); silty	
			11		50 to 52	24/14	29-37- 40-46			WIDELY GRADED SAND WITH GRAVI fine to coarse sand, ~20% fine gravel, ~ fines, wet, light brown.	EL (SW); 5% silty	
Stratific bounda gradua at time Fluctua other fa	I cation lines ary between I. Water lev s and under ations of gr actors than rements we	I represe n soil typ vel readi er conditi oundwat those p ere mad	I ent approximations transitions have to lons stated ter may occurre to the resent at the	mate ions been l. cur o ne ti	e (s may be (n made due to (me (LIENT: PROJEC CITY/ST GEI PRO	HDR A	L Architecture, E: NSLS II (pton, New Y IUMBER: 06	Inc. Geote Ork 52150	chnical Investigation -*-1000		GEI Consultants, Inc. 455 Winding Brook Dr Glastonbury, CT 06033 860.368.5408

ſ	Borin	ig Loc	ation	<u> </u>		FACTU			OT A TI	<u></u>	0550°T.			B	ORING
	HORI	HING: ZONTA	L DA	TUM: N		EASTI 83	NG:	ST		UN: TERI	OFFSET:	-		R	-102
1	VERT		ATU	M: BNL	94			GR		FACI	E ELEVATION (FT): 81.0		<u>. </u>		
	LOCA	TION:	See	Figure 2	2				, 1					FAU	3E 3 0I 3
	Elev. (ft)	Depth (ft)	Casing Pen, (bpf) or Core Rate (mof)	Sample No.	Type	SAMPL Depth (ft)	E INFO Pen./ Rec. (in)	RMATIO Blows Count or BOD	Field Test Data	SRAPHIC LOG	Sample Description & Classification			H₂0 Depth	Remarks
	25			12	X	55 to 57	24/14	27-32- 39-48			WIDELY GRADED SAND WITH G fine to coarse sand, ~20% fine grav fines, wet, light brown.	RAVE vel, ~5	L (SW); i% silty		
	- - 20—	- 60		13	$\overline{\mathbb{N}}$	60 to 62	24/10	30-36- 39-45			WIDELY GRADED SAND WITH G fine to coarse sand, ~20% fine grav fines, wet, light brown.	RAVE	L (SW); i% silty		
ATA TEMPLATE.GDT 8/24/06		- 65 - 70 - 70 - 75									End of Boring at 62 feet				
BORING LOG 02 BNL NSLSIJ BORING LOGS GPJ GEI D.		- 80 - 80 													
GEOTECHNICAL	Stratifica boundar gradual. at times Fluctuat other far measure	ation lines y between Water lev and unde ions of gro ctors than ements we	represe n soil typ vel readi r conditi oundwat those p are mad	ent approximates transitions have be ings have be ions stated ter may occur resent at the e.	mate ions beer cur o ne ti	e may be n made p may be due to me ()	CLIENT: PROJEC CITY/ST GEI PRO	HDR A T NAMI ATE: U DJECT N	Architecture, I E: NSLS II G pton, New Yo IUMBER: 06	Inc. ieote ork 2150	chnical Investigation GE		O nsuitants	GEI C 455 W Glasto 860.36	onsultants, Inc. inding Brook Dr nbury, CT 06033 i8.5408

	orin ORT	g Loc HING:	atior	1		EASTI	NG:		STAT		OFFSFT		BORING
н	ORIZ	ONTA	L DA		AD	83		ST/	ATION CEN	TER	_INE:	— —	B-102a
	CA	CAL E	See	M: <u>BNL</u> Figure 2	94			GR		FAC	E ELEVATION (FT): 81.0	_	PAGE 1 of 1
DI D/ CC EC AL H/ W	rillir ATE S DNTF QUIPI JGEF AMMI ATEF ENEF	IG INFO START RACTOI MENT: R ID/OD ER TYP R LEVE R LEVE	orma / END:	tion 8/16/2 ew Engla ile Drill B 5 in / N/P Gafety Hau THS (ft): Sample	006 nd E -53 (mme s co	- 8/16/2 Borings truck mo er er	006 E C H using a 2-	DRILLER: Il rig. CASING II IAMMER inch diam	_Jeff Leavitt D/OD: _N/A / WEIGHT (Ibs eter split spoo	N/A): _14 n.	TOTAL DEPTH (FT): <u>10</u> LOGGED BY: <u>Steven Ha</u> BORING METHOD: <u>Holl</u> CORE INFO: <u>10</u> HAMMER DROP (inch): _	0 awkins ow Stem Auger 30	· · · · · · · · · · · · · · · · · · ·
Ai	BBRE	VIATION	IS: ID O Pe Re	= Inside D D = Outsid en. = Pene ec. = Reco	liame e Dia tratio very	eter ameter in Length Length	bpf = 6 mpf = S = Sp DP = 0	Blows per F Minute per blit Spoon Direct Push	cot U Foot C V Sample St	= Undi = Rock = Field C = So	strubed Tube Sample WOR ≠ Weight of Ro core WOH ≠ Weight of Ha Vane Shear RQD ≠ Rock Quality nic Core OVM = Organic Vapo	ds Q _v = mmer S _v = Designation F _v = r Meter NA,	Pocket Penetrometer Strength Pocket Torvane Shear Strength Field Vane Shear Strength NM = Not Applicable, Not Measured
			Casing Pen.		;	SAMPL	E INFO	RMATIO	N	8 S			
(1	ev. ft)	Depth (ft)	(bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	GRAPHIC	Sample Description & Classification		H ₂ 0 Depth Remarks
8	30-	-		S-1	M	0 to 2	24/24	4-3-2-2			SILTY SAND (SM); fine to coarse sa silty fines, ~10% fine to coarse grav brown, Organics, 4 inches of Topsoi	and, ~20% el, dry, l.	
	+	-		S-2	M	2 to 4	24/12	3-3-3-4			SILTY SAND (SM); fine to coarse sa silty fines, ~5% fine to coarse grave FILL.	and, ~15% , dry, brown,	
		- 5		S-3	M	4 to 6	24/12	4-5-6-6			WIDELY GRADED SAND WITH SIL fine to coarse sand, ~10% silty fines gravel, dry, light brown.	T (SW-SM); , ~5% fine	Strata change estimated at 4 feet
7	′5	-		S-4	K	6 to 8	24/13	8-10- 11-6			WIDELY GRADED SAND WITH SIL fine to coarse sand, ~10% silty fines gravel, dry, light brown.	.T (SW-SM); , ~5% fine	
T 8/24/06	+	-		S-5	$\left \right\rangle$	8 to 10	24/17	8-12- 12-14			WIDELY GRADED SAND WITH SIL fine to coarse sand, ~10% silty fines gravel, dry, light brown.	.T (SW-SM); , ~5% fine	
TEMPLATE.GC	'0	-									End of Boring at 10 feet Fill with cuttings upon completion		
J GEI DATA		-											
IG LOGS.GP		— 15 -											
ONAL BORIN		-											
SLSI ADDIT		- 20											
BNL N	io	-											
BORING LOC	**	~											
Stra bot	atificat undary	lion lines betweer	represe soil typ	ent approxi bes, transiti	nate ons r	may be C	LIENT:		rchitechture	, Inc.			GEI Consultants, Inc.
fgra Gatt Elu	dual. imes a cluativ	Water lev and unde ons of arr	rei readi r condit	ings have b ions stated ter may acc	ieen ;ur di	made F ue to C	ROJEC		E: NSLS II C		chnical Investigation		155 Winding Brook Dr Glastonbury, CT 06033
COEO me	er fac asure	tors than ments we	those p are mad	resent at the	ie tin		SEI PRO	JECT N	UMBER: 06	52150	<u>-*-1000</u>	Consultants (360.368.5408

Borin	ng Loc rHING:	atior	<u>1</u>		EASTIN	NG:		STAT	ION:	OFFSET:		BORING			
HORI	ZONTA	L DA	TUM: N	AD	83		ST	ATION CEN	TERL	.INE:		B-103			
			M: BNL	94		····	GF	OUND SUR	RFACE	ELEVATION (FT): 73.0		PAGE 1 of 2			
		366	rigule z	,								·····			
Drilli DATE	ng Info START	orma / END:	tion 8/16/2	006	<u>- 8/16/20</u>	006				TOTAL DEPTH (FT): 32.0	·····				
	RACTO	Nob Mob	ew Englai ile Drill B	.53	Borings truck moi	L unted dri	IRILLER:	Jeff Leavitt	[BORING METHOD: Hollow S	ns Stem Auger	•			
AUGE	R ID/OD	: 4.2	25 in / N/A			(CASING I	D/OD:	N/A	CORE INFO:					
	IER TYP	E: <u>S</u>	Safety Har	nm V	er	łł		WEIGHT (Ibs	s): <u>14</u>	0 HAMMER DROP (inch): 30					
GENE	RAL NO	TES:	Sample:	<u>-×</u> s co	llected u	sing a 2-	inch diam	eter split spoo	พา.						
ABBR	EVIATION	I S: ID OI	= Inside D D = Outside	iam e Di	eter ameter	bpf = l mpf =	Blows per F Minute per	oot U Foot C	= Undis = Rock	trubed Tube Sample WOR = Weight of Rods Core WOH = Weight of Hamme	Q _v = r S _v =	Pocket Penetrometer Strength Pocket Torvane Shear Strength			
	Casing Pen. SAMPLE INFORMATION Pen. O O Flev Denth (bpf) Denth Blows To the strength Sector and the strength SC = Sonic Core Sample Rec. = Recovery Length DP = Direct Push Sample SC = Sonic Core OVM = Organic Vapor Meter NA, NM = Not Applicable, Not Measured														
		Casing Pen.		т т	SAMPLI	e info	RMATIC	N	. 09 - 10	Onemale					
Elev. (ft)	Depth (ft)	(bpf) or Core Rate	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or	Field Test Data	RAPHIC	Sample Description & Classification		H ₂ 0 Depth Remarks			
<u> </u>		(inpi)	S-1		0	24/12	4-7-8-8		34	WIDELY GRADED SAND WITH SILT (S	SW-SM);	d			
-	S-1 0 24/12 4-7-6-8 WIDELY GRADED SAND WITH SLLT (SW-SM); ine to coarse sand, ~10% silty fines, ~5% fine gravel, dry, light brown, roots, topsoil, FILL S-2 2 24/12 7-4-5-9 SILTY SAND (SM); fine to coarse sand, ~20%														
70-			S-2	M	2 to	24/12	7-4-5-9			SILTY SAND (SM); fine to coarse sand, silty fines, ~5% fine gravel, moist, brown	~20% I, FILL				
-	70														
-	- 5		S-3	М	5	24/24	5-9-25- 46		××	in S-2, FILL. WIDELY GRADED SAND WITH SILT (S	SW-SM); 0% fine	Strata change			
				\mathbb{A}	7					gravel, moist, brown.	070 11116	feet			
65-	-		S-4	\mathbb{N}	7 to 9	24/18	16-29- 30-35			SILTY SAND (SM); fine to coarse sand, silty fines, ~5% fine gravel, moist, reddis	~15% sh brown.				
	- 10	3	0.5		10	04/00	10.10			9-10 ft: Soil cuttings similar to material of in S-4.	observed				
) 	-		3-0	X	to 12	24/20	16-17			fine to coarse sand, ~10% silty fines, ~5 gravel, dry, brown.	% fine				
60 —	+		S-6	X	12 to 14	24/14	17-19- 19-20			WIDELY GRADED SAND WITH SILT (S fine to coarse sand, ~15% fine to coarse ~10% silty fines, dry, brown.	SW-SM); e gravel,				
-	- 15		97		15	24/15	4560								
				X	to 17	24/10	4-0-0-0			sand, ~5% silty fines, ~5% fine gravel, d	ry, tan.				
55	 - -														
- - 50	- 20		S-8		20 to 22	24/15	7-9-13- 13			WIDELY GRADED SAND (SW); fine to sand, ~10% fine to coarse gravel, ~5% s moist, tan.	coarse silty fines,				
Stratifics	ation lines	represe	nt approxin	nate	, ,					". <u> </u>		CEL Consultanta Ira			
boundar gradual at times Fluctuat	water lev and under ions of gro	r soil type rel readi r condition undwat	ings have b ions stated. ter may occ	een	may be C made P lue to C	ROJEC	HDR A T NAMI ATE:_U	rchitechture E: NSLS II C pton, New Y	, Inc. Geotec 'ork	chnical Investigation		GEI Consultants, Inc. 455 Winding Brook Dr Glastonbury, CT 06033			
measure	ements we	ere mad	n caernal (1 6,	.ड (('' [©] G	EI PRC	JECT N	UMBER: 06	62150		onsultants	860.368.5408			

GEOTECHNICAL BORING LOG 02 BNL NSLSII ADDITONAL BORING LOGS GPJ GEI DATA TEMPLATE GDT 8/24/06

Borir		ation			EAST	NG		STAT	ONIC	OEESET		BORING
HOR	ZONTA	L DA'	TUM: N	IAD	83	NG	ST.	ATION CEN	TERL	OFF3E1	-	B-103
VERT		ATUR	N: BNL	94			GR		FACI	ELEVATION (FT): 73.0	-	PAGE 2 of 2
	A HON:	See	rigure 2	2							-	
Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	E INFO Pen./ Rec. (in)	RMATIO Blows Count or RQD	N Field Test Data	GRAPHIC LOG	Sample Description & Classification		H ₂ 0 Depth Remarks
-	25		5-9		25 to 27	24/15	9-12- 16-17			WIDELY GRADED SAND (SW); fine sand, ~5% silty fines, ~5% fine grave	to coarse I, moist, tar	ı.
45 —	30		S-10		30 to 32	24/18	13-16- 19-39			WIDELY GRADED SAND (SW); fine sand, ~5% silty fines, wet, brown.	to coarse	∑ .
40-	- 35									End of Boring at 32 feet Fill with cuttings upon completion		
35-	- - - - 40											
30-												
25-	- 50											
20-	ation lines	represe	ent approxi	imat	e		HDR 4	Architechture	Inc			GEI Consultants, Inc.
gradual gradual at times Fluctua other fa measur	ey betwee I. Water le Is and under tions of gr ictors than rements w	n soil typ vel readi tr conditi oundwat those p are mad	bes, transi Ings have ions stated ter may oc resent at t e.	tions beer d. cur the ti	a may be n made due to ime	PROJEC CITY/ST GEI PRO	T NAMI	E: NSLS II G pton, New Y IUMBER: 06	eote ork 2150	chnical Investigation GE	Consultants	455 Winding Brook Dr Glastonbury, CT 06033 860.368.5408

ſ	Borin NORT	ig Loc HING:	ation	<u> </u>		EASTI	NG:	·	STAT	ION:	OFFSET:		BORING
	HORIZ		L DA		AD	83		ST	ATION CEN	TER	_INE;		B-104
	LOCA	TION:	See	Figure 2	<u>94</u> ?			GF	COND SUR	FAC	ELEVATION (F1): 76.0		PAGE 1 of 1
╞	Drilli	na Info	orma	tion									
	DATE	START	END:	8/16/2	006	- 8/16/2	006				TOTAL DEPTH (FT):	7.0	
	CONTI	RACTO	R: <u>N</u>	ew Engla	nd I	Boring] // // // // // // // // // // // // //	RILLER:	Jeff_Leavit		LOGGED BY: Steve	Hawkins	
	AUGE	R ID/OD	1VIOD : 4.2	116 Drill B 15 in / N/A	- <u>33</u> \	(reck mo	unteo on (II 119. CASING I	D/OD: N/A /	N/A	BORING METHOD: CORE INFO:	Hollow Stem Auger	
	HAMM	ER TYP	E: _S	afety Har	nm	er	ŀ	AMMER	WEIGHT (Ibs): 14	0 HAMMER DROP (inch	ı): <u>30</u>	
	WATE		L DEP	THS (ft): Sample	- ~ ~	Macted u	eina a 2-	inch diam	eter split spoo		···	<u></u>	
ł	ABBRE	VIATION	IS: ID	= Inside D)iam	eter	bpf = E	Blows per F	oot U	= Undi	strubed Tube Sample WOR = Weight o	of Rods Q, =	Pocket Penetrometer Strength
			OI Pe Re	D = Outside an. = Penel ac. = Recov	e Dia tratio very	ameter on Length Length	mpf = S = Sp DP = I	Minute per Nit Spoon Direct Push	Foot C V Sample S	= Roci = Field C = So	Core WOH = Weight o Vane Shear RQD = Rock Qua nic Core OVM = Organic V	of Hammer $S_v =$ ality Designation $F_v = 1$ Vapor Meter NA, I	Pocket Torvane Shear Strength Field Vane Shear Strength NM = Not Applicable, Not Measured
			Casing Pen.			SAMPL	E INFO	RMATIC	N	Ö			
	Elev.	Depth	(bpf) or	Sample		Donth	Pen./	Blows	Field	1 E E	Sample Description &		H ₂ 0 Depth Remarks
	(11)	(11)	Core Rate	No.	1 ²	(ft)	Rec. (in)	or	Test Data	RAPI	Classification		
┟			(mpt)	S-1		0	24/12	RQD			SILTY SAND (SM): fine to coars	a sand ~25%	
	75				M	to			l		silty fines, slight petroleum-like o	odor, moist, dark	
					\square	-					brown, organica, ritt.		
				S-2	М	2 to	24/15	3-4-6- 16			SILTY SAND (SM); fine to coars silty fines, ~10% fine gravel, moi	e sand, ~30% ist. brown. FiLL.	
	-	-			Ŵ	4				\otimes			
	-	-			Н						4-5 ft: Soil cuttings similar to ma	aterial observed	
		5		S-3	Н	5	24/10	16-19-		\otimes	in S-2, FILL. SILTY SAND (SM): fine to coars	e sand ~15%	
	70	_			M	to	2.0.10	30-30			silty fines, ~5% fine gravel, dry, t	brown, Probable	
					Μ	'				\otimes	FILL.		
											Auger refusal encountered ~7-fe Fill with cuttings upon completion	eet bgs. n	
g	-	-											
8/24/0	-	-											
<u>E</u>	-	- 10											
Ψ	65 —												
ENE	-	_											
TAT													
2 11	-	-											
입	-	-											
GS.G	-	- 15											
<u>ig Po</u>	60 —	_											
ORIN													
AL B													
<u>j</u>	-												
II ADI	-	-											
NSLS	-	— 20				1							
BNL	55-	_											
8	_												
<u>ا</u> د	٦												
JORIN	-	~											
ł	Stratifica	ition lines	represe	I Int approxim	nate	, , , , , , , , , , , , , , , , , , ,			L Architechture	l Inc	<u> </u>		El Consultants. Inc.
ÎN HO	gradual. at times	Water lev and unde	el readi r conditi	ngs have b	een	made F	ROJEC	TNAM	E: NSLS II (Geote	chnical Investigation		55 Winding Brook Dr
10 1E	Fluctuati other fac	ons of gro tors than	oundwat those p	er may occ resent at th	cur d 1e tir	tue to			pton, New Y	ork	<u> </u>	E Consultante	Blastonbury, CT 06033
۵Ľ	measure	ments we	re mad	Θ.		C.		NECI N	UNDER: 0	2150			00.000.0400

Boring Location NORTHING: EAST HORIZONTAL DATUM: NAD 83 VERTICAL DATUM: BNL 94 LOCATION: ~5 feet North of B-104	ING:STATION: STATION CENTERLINE: GROUND SURFACE ELEVAT ; See Figure 2	OFFSET: ION (FT) <u>: 76.0</u>	BORING B-104a PAGE 1 of 1
Drilling Information DATE START / END: <u>8/16/2006 - 8/16/</u> CONTRACTOR: <u>New England Boring</u> EQUIPMENT: <u>Mobile Drill B-63 truck m</u> AUGER ID/OD: <u>4.25 in / N/A</u> HAMMER TYPE: <u>Safety Hammer</u> WATER LEVEL DEPTHS (ft): <u>GENERAL NOTES: Samples collected</u> ABBREVIATIONS: ID = Inside Diameter OD = Outside Diameter Pen. = Penetration Lengti Rec. = Recovery Length	2006 DRILLER: Jeff Leavitt Jounted drill rig. CASING ID/OD: N/A / N/A HAMMER WEIGHT (Ibs): 140 using a 2-inch diameter split spoon. bpf = Blows per Foot U = Undistrubed Tube mpf = Minute per Foot C = Rock Core N = S = Split Spoon N = Split Spoon D = Direct Push Sample	TOTAL DEPTH (FT): <u>3.0</u> LOGGED BY: <u>Steve Hawkins</u> BORING METHOD: <u>Hollow Stem Aug</u> CORE INFO: HAMMER DROP (inch): <u>30</u> Sample WOR = Weight of Rods Q WOH = Weight of Hammer S, RQD = Rock Quality Designation F, OVM = Organic Vapor Meter N	,= Pocket Penetrometer Strength = Pocket Torvane Shear Strength = Field Vane Shear Strength A, NM = Not Applicable, Not Measured
Elev. Depth (ft) (ft) (ft) (ft) (ft) (ft) (ft) (ft)	LE INFORMATION 50 Pen./ Blows Field Count Test 0 (in) RQD Data 20	Sample Description & Classification	H ₂ 0 Depth Remarks
75	Electrical at Fill with c	wire encountered ~3-feet bgs. Auger ~3 feet bgs. uttings upon completion	
Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made.	CLIENT: HDR Architechture, Inc. PROJECT NAME: NSLS II Geotechnical Inv CITY/STATE: Upton, New York GEI PROJECT NUMBER: 062150-*-1000	estigation GEI Consultants	GEI Consultants, Inc. 455 Winding Brook Dr Glastonbury, CT 06033 860.368.5408

Bor	ring		ation	<u> </u>		EASTI	NG			TION	OFESET		B	ORING
HOF	RIZO	ONTA	L DA	TUM: N	AD	83		\$т	ATION CE	NTER	OFF3ET		B	-104b
	ТТ С С А Т			M: BNL	94 of	P 104a	· Soo Ei	GF	ROUND SU	RFAC	E ELEVATION (FT): 76.0	[PA	GE 1 of 2
			~5 16			D-104a	, See ri	guie z			· · · · · · · · · · · · · · · · · · ·	<u> </u>		
	llin E S	g Info TART	FND:	8/16/2	006	- 8/16/2	006					32.0		
CON	NTR/	ACTO	R: <u>N</u>	ew Engla	nd E	Borings	[RILLER	: _Jeff Leav	itt	LOGGED BY: Steve	en Hawkins		
EQU	JIPN		Mob	ile Drill B-	53	truck mo	ounted dri	ll rig.		1.61/.0	BORING METHOD:	Hollow Stem Auger		
HAN	JER MME	RTYP	: <u>4.2</u> E: S	afety Har	nme	 er	\ 	ASING	R WEIGHT (IL	<u>(/N/A</u>)s): 1	IO HAMMER DROP (incl	h): 30		
WAT	TER	LEVE	L DEP	THS (ft):	₽	31.00	8/16/200	6 12:57 p	m		, ,			······
GEN		AL NO	TES:	Samples = loside D	iame	illected L	using a 2-	inch diam Nows per F	ieter split spo Foot	00n.	strubed Tube Sample MOR = Weight	of Rods 0 =	Pocket	Penetrometer Strength
			Ol Pe Re	D = Outside en. = Penet ec. = Recov	e Dia ratio /ery	ameter In Length Length	mpf = S = Sg DP = 1	Minute per lit Spoon Direct Push	Foot Sample	C = Roc V = Fiel SC = Sc	Core WOH = Weight Vane Shear RQD = Rock Qu nic Core OVM = Organic	of Hammer $S_v = 1$ uality Designation $F_v = 1$ vapor Meter NA, 1	Pocket 1 Field Va NM = No	orvane Shear Strength ne Shear Strength t Applicable, Not Measured
			Casing		;	SAMPL	E INFO	RMATIC	N	_ 0				
Elev	<i>ı</i> . I	Depth	(bpf) or	Sample		Donth	Pen./	Blows	Field	- 1 	Sample Description &		H₂0 Depth	Remarks
(n)		(11)	Core Rate	No.	Ţ	(ft)	Rec.		Test Data	RAPI	Classification	1	- opui	
	+		(mpt)		H		<u> </u>	RUD			See boring log R-104a for same	de information		
75	+				$\left \right $						and description of material from	1 0 to 7-feet bgs.		
	T													
	+													
	+	- 5												
70	-													
	+					_		:						
				S-1	M	7 to	24/6	15-22- 27-39			SILTY SAND (SM); fine to coars silty fines, ~5% fine gravel, dry,	se sand, ~15% brown.		
g	T				M	9								
8/24	Ť				Π						9-10: Soil cuttings similar to ma	aterial observed in		
100	+	- 10		S-2	Ħ	10	24/19	9-17-			SILTY SAND (SM); fine to coars	se sand, ~15%		
변동 65					X	to 12		19-15			silty fines, ~5% fine gravel, mois	st, brown.		
EMP	+			6.2	Ц	10	24/20	12 14						
ATA				3-3	M	to	24/20	16-16			sand, ~5% silty fines, ~5% fine (gravel, moist,		
GELC					\mathbb{N}	14					drown,			
GPJ	Ť				П									
068.0	+	- 15		S-4	Н	15	24/12	3-4-8-7		••••	WIDELY GRADED SAND (SW)); fine to coarse		
- 9 8 60	+				X	to 17					sand, ~10% fine to coarse grave dry, tan.	el, ~5% silty fines,		
BORI	+				Ц						· ·			
ONAL	\downarrow													
)TIOO														
SILA	Ť													
INSI	+	- 20		S-5	Ħ	20	24/18	6-9-12-			WIDELY GRADED SAND (SW)); fine to coarse		
8 55·	+				XI.	to 22		10			sand, ~10% fine to coarse grave dry, tan.	el, ~5% silty fines,		
0 90	+				Ц					••••				
DN NG														
BOR														
Stratif	, fication dary I	on lines betweer	represe soil typ	nt approxin es, transiti	nate ons i	may be	LIENT:	HDR A	Architechtur	re, Inc			SEI C	onsultants, Inc.
fr gradu	ial. W ies ar	Vater lev	el readi r conditi	ngs have b ons stated.	een	made F	ROJEC		E: NSLS II	Geote	chnical Investigation		55 W	inding Brook Dr
O other	facto facto	ns or gro prs than pents we	those pi tre made	er may occ resent at th e.	ur di e tim		GEI PRO	JECT N	NUMBER: (101K 06215	<u>-*-1000</u> G	Consultants 8	60.36	8.5408
	411											-		

Borir	ng Loc FHING:	ation	<u> </u>		EASTI	NG:		STAT	ON:	OFFSET:		В	ORING
HORI	ZONTA	L DA	TUM: N	AD	83		ST	ATION CEN	TERI	_INE:		B	-104b
	ICAL E	ATUI ~5 fe	W: <u>BNL</u> et West	<u>94</u> t of	B-104a	: See Fi	GF aure 2	OUND SUR	FAC	E ELEVATION (FT): 76.0	—	PA	GE 2 of 2
	[Casino			SAMPI	F INFO	RMATIO	N	0	······································			
Elev. (ft)	Depth (ft)	Peri, (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	GRAPHIC LO	Sample Description & Classification		H₂0 Depth	Remarks
- 50 — -	- 25		S-6	M	25 to 27	24/12	10-15- 19-17			WIDELY GRADED SAND WITH GRAV fine to coarse sand, ~15% fine to coarse ~5% silty fines, dry, tan.	EL (SW); e gravel,		
45-	30		S-7		30 to 32	24/16	7-11- 11-10			WIDELY GRADED SAND (SW); fine to sand, ~10% fine to coarse gravel, ~5% moist, tan.	coarse silty fines,	Ţ	
	- - - - - -								<u>a</u> <u>a</u>	End of Boring at 32 feet Fill with cuttings upon completion			
35	- 40 -												
30	45												
25	- 50												
Stratifica boundar gradual at times Fluctuat other fa measure	ation lines ry between Water lev and unde tions of gro ctors than ements we	represe soil typ ret readi r conditi pundwat those p those p	ent approximation approxim approximation approximation approxim approximation approximation approximatio approximation approximation approximatio	mate ions been cur c ne ti	e maybe nmade Jueto me	CLIENT: PROJEC CITY/ST GEI PRO	HDR A	Architechture E: NSLS II G pton, New Yo IUMBER: 06	Inc. ieote ork 2150	chnical Investigation *-1000		GEI Co 455 W Glasto 860.36	o nsultants, Inc. inding Brook Dr nbury, CT 06033 i8.5408

Bori	ng Loc	ation	_									В	ORING		
NOR	THING:				EASTI	NG:	ST			OFFSET:		D	201		
VERT	TICAL D	ATUN	1: BNL	94	03 01		GF	OUND SUI	RFAC	E ELEVATION (FT): 73.0			-201		
LOCA	ATION:	See I	Plan									PA	GE 1 of 2		
Drilli	ing Info	ormat	tion												
DATE	START	END:	4/23/20	007	' - 4/23/2	007				TOTAL DEPTH (FT): 47.0					
CONT	RACTOR	R: <u>Ne</u>	ew Englar	nd	Borings	[DRILLER:	Jeff Leavi	tt	LOGGED BY: Steven Haw	kins				
AUGE	ER ID/OD	: N/A	x / N/A			(CASING I	D/OD: 3 in	/ 3.25 i	n CORE INFO:	and wash				
HAM	MER TYP	E: _S	afety Har	nm	er	ŀ	AMMER	WEIGHT (Ib	s): _14	HAMMER DROP (inch): _30)				
WATE	ER LEVE	L DEP	THS (ft):	7	27.30 4	/24/2007	7:26 am								
ABBR	EVIATION	S: ID	= Inside D	iam	eter	bpf = E	Blows per F	oot l	J = Undi	strubed Tube Sample WOR = Weight of Rods	Q., :	= Pocket I	Penetrometer Strength		
		OL Pe Re) = Outside n. = Penet c. = Recov	e Di rati very	ameter on Length Length	mpf = S = Sp DP = [Minute per blit Spoon Direct Push	Foot (Sample S	C = Rock / = Field SC = Sol	Core WOH = Weight of Ham Vane Shear RQD = Rock Quality De nic Core OVM = Organic Vapor 1	ner S _v = signation F _v = Neter NA	= Pocket 1 = Field Va , NM = No	Forvane Shear Strength ne Shear Strength ot Applicable, Not Measured		
		Casing			SAMPL	E INFO	RMATIC	N	OG						
Elev.	Image: Instruction of the construction of the construct														
(ft)	(ft)	Core Rate	No.	Type	(ft)	Rec.	or	Test	SAPH	Classification		Doput			
	(mpf) RQD Data Io S-1 0 24/15 6-4-4-4 SILTY SAND (SM); ~75% sand, ~20% fines, ~5% gravel; moist, brown, F-M sand, roots, F S-2 2 24/16 11-13- *5** WIDELY GRADED SAND (SW); ~90% sand,														
	70 X-2 2 24/16 11-13- 27-30 2-5% gravel, moist, brown, F-M sand, roots, F 70 X-2 2 24/16 11-13- 27-30 2-5% gravel, moist, brown, F-M sand, roots, F														
-	No.														
70-	70 S-2 2 24/16 11-13- 27-30 WIDELY GRADED SAND (SW); ~90% sand, ~5% gravel, ~5% fines; fine to medium, dry, yellowish brown, F-C gravel max. 1in.														
	70 to 27-30 ~5% gravel, ~5% fines; fine to medium, dry, yellowish brown, F-C gravel max. 1in. S-3 4 24/19 21-21- WIDELY GRADED SAND (SW); ~85% sand,														
	70 4 27-30 ~5% gravel, ~5% tines; tine to medium, dry, yellowish brown, F-C gravel max. 1in. S-3 4 24/19 21-21- to 31-36 ~10% gravel, ~5% fines; fine to medium, dry, yellowish brown, F-C gravel max. 1in.														
	- 5			Ň	6				••••	light brown, F-C gravel max. 1in.	5 8 3				
	+		S-4	H	6	24/17	41-57-		••••	WIDELY GRADED SAND (SW); ~909	sand,				
	+			Ŋ	to		65-70			~5% gravel, ~5% fines; fine to medium	n, dry, light				
05				M	0				••••	brown, 1-6 graver max. This					
65-			S-5	M	8 to	24/19	22-27-			WIDELY GRADED SAND WITH SILT	(SW-SM); fine to	1			
	+			Ň	10		01-07			medium, moist, brown, F-C gravel ma	x. 1in.				
· .	- 10		S-6	H	10	24/14	40-41-			WIDELY GRADED SAND WITH SILT	(SW-SM)				
	1			Ŋ	to	2011	42-40			~85% sand, ~10% fines, ~5% gravel;	fine to				
5				\mathbb{N}	12					medium, moist, brown, F-C gravel ma	x, 3/4 III.				
	T			Π											
60-	+														
	+								••••			1			
	15														
	13		S-7	M	15 to	24/9	14-10-	ē.		WIDELY GRADED SAND (SW); ~909 ~5% gravel ~5% fines: fine to coarse	sand, fine				
	Ť			Ň	17					gravel, wet, light brown.					
	+			A					•••••						
55-									••••						
									•••••						
	T								••••						
-	- 20		S-8		20	24/10	19-17-		••••	WIDELY GRADED SAND (SW); ~90%	6 sand,				
	+			X	to 22		22-34		••••	~5% gravel, ~5% fines; fine to coarse gravel, wet, light brown	fine				
	1			\square	_				••••						
									••••						
50-	Ť								•••• ••••						
Stratific	l cation lines	represe	nt approxir	nat	• . <i>(</i>			Architechtur	e Inc			GELC	onsultants. Inc.		
gradual	I. Water level and under	n soil typ rel readi	es, transiti ngs have b	ons	may be made	ROJEC	CT NAM	E: NSLS II	- ACD			455 W	/inding Brook Dr		
Fluctua other fa	ations of gro	those p	er may occ resent at #	cur o ne ti	due to (CITY/ST	ATE: U	pton, New	York	GFI		Glasto	onbury, CT 06033		
measur	rements we	ere made	э			JEI PRO	DJECT N	UMBER: (062152		Consultants	860.36	00.0300		

Borin		ation	<u> </u>		EASTI	NG		QTATI		OFESET.		В	ORING
HORI	ZONTA	LDA	TUM: N	AC	83 CT	NG	ST	ATION CEN	TERI		-	B	8-201
LOCA	ATION:	See	VI: <u>BNL</u> Plan	94			GR	OUND SUR	FAC	E ELEVATION (FT): 73.0	-	PA	GE 2 of 2
		Casing		ł	SAMPL	E INFO	RMATIO	N	OG	8 - 25			
Elev. (ft)	Depth (ft)	(bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	GRAPHIC L	Sample Description & Classification		H₂0 Depth	Remarks
	- 25		S-9	X	25 to 27	24/11	20-21- 37-29			WIDELY GRADED GRAVEL WITH S ~60% gravel, ~35% sand, ~5% fines; coarse, rounded, wet, light brown.	AND (GW); fine to	Ā	
	- 30 		S-10	X	30 to 32	24/10	20-25- 30-35			WIDELY GRADED SAND (SW); ~95 ~5% fines, ~0% gravel; fine to mediu brown.	% sand, m, wet, light		
	- 35 		S-11	X	35 to 37	24/8	21-22- 22-23			WIDELY GRADED SAND (SW); ~95 ~5% fines, ~0% gravel; fine to mediu brown.	% sand, m, wet, light		
- - - 30 —	40		S-12	X	40 to 42	24/8	17-21- 25-39			WIDELY GRADED SAND (SW); ~90 ~5% gravel, ~5% fines; fine to mediu gravel, wet, light brown.	% sand, m, coarse		
	45 		S-13	X	45 to 47	24/2	11-12- 13-17			WIDELY GRADED SAND (SW); ~70 ~25% gravel, ~5% fines; fine to coars coarse gravel, wet, brown.	% sand, se, fine to	Arrest and a second sec	Drill Chatter Running sands, rewash out casing.
25-	50									End of Boring at 47 feet			
20-										8			
Stratific bounda gradual at times Fluctua other fa measur	ation lines ry betwee . Water let and under tions of gr ctors than ements we	represe n soil typ vel readi er conditio oundwat those p ere mad	ent approxi bes, transitions have to ons stated her may occur resent at the e.	mations beer I. cur (he ti	e s may be n made due to me	CLIENT PROJEC CITY/ST GEI PRO	HDR A T NAMI ATE: U	Architechture E: NSLS II - pton, New Y IUMBER: 06	, Inc. ACD ork 2152	GEI	Consultants	GEI C 455 W Glasto 860.36	onsultants, Inc. /inding Brook Dr nbury, CT 06033 58.5300

Borin		ation	<u> </u>		EASTU			9TA	TION		OFFRET			В	ORING
HOR	ZONTA	L DA	TUM: N	AD	83 CT	vG:	ST	ATION CE	NTERL	LINE:	_ OFFSET: _			B	8-202
VERT	TICAL D	ATUI See	VI: BNL Plan	94	:		GF	ROUND SU	RFAC	EELEVAT	ON (FT): 73.5			PA	GE 1 of 2
Drilli	ng Info	orma	tion												
DATE CONT	START	END: R: Ne	4/25/20 ew Englar	007 nd	' - 4/25/20 Borings	007 [ORILLER:	Jeff Leav	itt		TOTAL DEPTH LOGGED BY:	(FT): 47.0 Steven Hawkir	IS		
EQUIF		Truc	k V NVA	_					12 25 1		BORING METH	OD: Drive and	d Wash		
HAMN	IER TYP	E: _S	afety Har	nm	er	i	AMMER	WEIGHT (Ib	os): 14	0	HAMMER DRO	P (inch): _30			
GENE	R LEVE	_ DEP TES:	THS (ft):	<u> </u>	31.30 4	/25/2007	' 10:14 an	n							
ABBRI	EVIATION	S: ID OI Pe Re	= Inside D D = Outside n. = Penet ec. = Recov	iam 9 Di ratio /ery	eter ameter on Length Length	bpf = E mpf = S = Sp DP = [Blows per F Minute per blit Spoon Direct Push	oot Foot Sample	U = Undis C = Rock V = Field SC = Son	strubed Tube S Core Vane Shear hic Core	ample WOR = WOH = RQD = F OVM = 0	Weight of Rods Weight of Hammer Rock Quality Desig Drganic Vapor Met	Q _v = S _v = nation F _v = er NA,	Pocket Pocket T Pocket T Field Va NM = No	Penetrometer Strength Forvane Shear Strength ne Shear Strength ot Applicable, Not Measured
		Casing			SAMPL		RMATIO	N	g						
Elev. (ft)	Depth (ft)	(bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	GRAPHIC L		Samı Descripi Classific	ble tion & cation		H₂0 Depth	Remarks
-	S-1 1 24/14 3-2-2-2 SILTY SAND (SM); ~57% sand, ~35% fines, 9% <td< td=""></td<>														
-	S-1 1 24/14 3-2-2-2 SILTY SAND (SM); ~57% sand, ~35% fines, ~8% gravel; rounded, fine to coarse gravel, moist, dark brown to brown, FILL. 70 S-2 3 18/11 3-3-3 SILTY SAND (SM); ~65% sand, ~30% fines,														
70-			S-2	X	3 to 4.5	18/11	3-3-3			SILTY SA ~5% grave moist, bro	ND (SM); ~65% el; rounded, fine wn, FILL.	sand, ~30% fi to coarse grav	nes, vel,		
-	- 5		S-3	X	5 to 7	24/21	8-13- 21-28			SILTY SA ∼5% grav ∖ moist, bro	ND (SM); ~55% əl; rounded, fine wn, FILL.	sand, ~40% fi to coarse grav	nes, /el,/		Drilled through cobble. Move rig north ~2ft. in order to get
-	-		S-4	X	7 to 9	24/13	27-28- 30-33			WIDELY (~5% grave gravel, mo WIDELY (GRADED SAND al, ~5% fines; fir bist, light brown. GRADED SAND	(SW); ~90% s ne to medium, f	and, ine W-SM);		casing past.
65	- - - - - -		S-5	X	9 to 11	24/16	25-30- 31-23			~85% san medium, f WIDELY (~10% gra fine to coa	d, ~10% fines, ~ ine gravel, mois GRADED SAND vel, ~5% fines; f irse gravel, dry,	~5% gravel; fine t, light brown. (SW); ~85% s ine to coarse, r light brown.	e to / and, rounded,		
- 60 — -	15		S-6		15	24/11	17-20-			WIDELY	GRADED SAND	(SW); ~90% s	and,		
- - 55 —	-			X	to 17		20-21			~5% grave	el, ~5% fines; fir Irse gravel, dry,	ie to coarse, ro light brown.	unded,		
	- 20		S-7	X	20 to 22	24/12	14-12- 12-16			WIDELY (~10% grave	GRADED SAND vel, ~5% fines; f l, dry, light brow	(SW); ~85% s ine to coarse, r n.	and, ounded,		
Stratifica boundar	ation lines ry between	represe soil typ	nt approxin es, transitio	nate	may be	LIENT:	HDR A	rchitechtur	re, Inc.			T.		GEI Co	onsultants, Inc.
gradual. at times Fluctuat other fac	. Water lev and under tions of gro ctors than	el readi conditi undwat hose pr	ngs have b ons stated. er may occ resent at th	een ur d e tir	made P lue to C ne C	ROJEC		E: NSLS II pton, New	- ACD York			GEI		455 W Glasto 360 36	inding Brook Dr nbury, CT 06033 38 5300
measure	ements we	re made	э.				JOLOT N		02102				,		

GEOTECHNICAL BORING LOG 02 ACD BORING LOGS GPJ GEI DATA TEMPLATE GDT 5/21/07

Borin		ation	<u> </u>		EAST	NG		STATI	0.11.	OFESET.		В	ORING
HOR	ZONTA	L DA	TUM: N	AD	83 CT	NG:	ST	ATION CEN	TERI	OFFSET:		B	-202
VERT		ATU	M: BNL	94			GR	OUND SUR	FAC	E ELEVATION (FT): 73.5	1	PA	GE 2 of 2
LOCA	ATION:	See	Plan	_									022012
Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	SAMPL Depth (ft)	E INFO Pen./ Rec. (in)	RMATIO Blows Count or ROD	N Field Test Data	SRAPHIC LOG	Sample Description & Classification		H₂0 Depth	Remarks
	- 25 - 25 		S-8	X	25 to 27	24/10	20-21- 17-17			WIDELY GRADED SAND (SW); ~80% ~15% gravel, ~5% fines; fine to coarse fine gravel, dry, light brown.	sand, , rounded,		
45	- - - - - - - - - - -		S-9	X	30 to 32	24/14	17-16- 12-16			WIDELY GRADED SAND (SW); ~75% ~20% gravel, ~5% fines; fine to coarse fine to coarse gravel, dry, light brown.	sand, , rounded,	¥	
40	- - - - - -		S-10	X	35 to 37	24/10	20-20- 21-23			WIDELY GRADED SAND (SW); ~90% ~5% gravel, ~5% fines; fine to coarse, fine gravel, dry, light brown.	sand, rounded,		
35	- - - - - - - -		S-11	X	40 to 42	24/9	17-14- 19-25			WIDELY GRADED SAND (SW); ~90% ~5% gravel, ~5% fines; fine to coarse, fine gravel, dry, light brown.	sand, rounded,		
30	- - - 45 -		S-12	X	45 to 47	24/0	17-20- 21-26			No recovery.			
25 -	- - - - - - - -												
20-	- - - - - - -												
Stratific bounda gradual at times Fluctua other fa measur	Auton lines ry betweet . Water lev and under tions of gr ctors than ements we	represe n soil typ vel readi or condition those p are mad	ent approxi bes, transit ings have t ions stated ter may occur resent at the e.	ions beer I. cur (he ti	may be name of the second seco	CLIENT PROJEC CITY/ST GEI PRO	: HDR A CT NAME ATE: U DJECT N	Architechture E: NSLS II - pton, New Y IUMBER: 06	, Inc. ACD ork 2152	GEI	Consultants	GEI C 455 W Glasto 860.36	onsultants, Inc. /inding Brook Dr nbury, CT 06033 88.5300

Borin	ng Loc	ation	<u> </u>					074				В	ORING
HORI	THING: ZONTA	L DA	TUM: N	AD	EASTII 83 CT	NG:	ST	ATION CE	ENTERI	OFFSET:		B	-203
VERT		ATU	M: BNL	94			GF	ROUND SU	JRFACI	ELEVATION (FT): 71.0		PA	GE 1 of 2
LOCA	ATION:	566	Plan	_								01 34.54	
Drilli	NG INFO	ormation / END:	4/25/2	007	- 4/25/20	007				TOTAL DEPTH (FT): 47.0			
CONT	RACTOR	R: <u>N</u>	ew Engla	nd E	Borings	C	RILLER	: Jeff Leav	vitt	LOGGED BY: Steven Hawki	ns		
AUGE	PMENT: R ID/OD	Truc : N/A	k A / N/A			C	CASING I	D/OD: 3 in	n / 3.25 ii	BORING METHOD: Drive an CORE INFO:	d Wash	_	
HAMN	IER TYP	E: _S	afety Har	nme	ər	F	AMMER	WEIGHT (I	bs): 14	0 HAMMER DROP (inch): 30			
GENE	R LEVE	L DEP TES:	THS (ft):	<u>¥</u>	28.00 4	/25/2007	2:07 pm	2					
ABBR	EVIATION	IS: ID OI Pe	= Inside D D = Outside m. = Penet	iame e Dia ratio	eter ameter in Length	bpf = E mpf = S = Sp	Blows per F Minute per blit Spoon	Foot Foot	U = Undis C = Rock V = Field	trubed Tube Sample WOR = Weight of Rods Core WOH = Weight of Hamme Vane Shear RQD = Rock Quality Desig	Q _v = r S _v = gnation F _v =	= Pocket I = Pocket 1 = Field Va	Penetrometer Strength Forvane Shear Strength The Shear Strength
		Re	ec. = Recov	very	Length		Direct Push	Sample	SC = Sor	ic Core OVM = Organic Vapor Me	ter NA,	, NM = No	t Applicable, Not Measured
	Denth	Casing Pen. (bof)		Π	SAMPL	E INFO	RIOWS		- 0	Sample		но	
(ft)	(ft)	or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Count or RQD	Field Test Data	GRAPHIC	Description & Classification		Depth	Remarks
70-	_		S-1	M	0 to 2	24/14	7-8-15- 11			WIDELY GRADED SAND (SW); ~70% s ~20% gravel, ~10% fines; fine to coarse gravel, roots, moist, dark brown to gray,	sand, , coarse Top 8"		
			S-2	X	2 to	6/0	6			No recovery.			Grind through
					2.5								cobble/debris
-	- 5		S-3	M	4 to 6	24/12	8-12- 14-16			WIDELY GRADED SAND WITH SILT (S ~78% sand, ~13% fines, ~9% gravel; fin coarse, rounded, fine to coarse gravel, o brown.	SW-SM); ie to dry, light		
65 —			S-4	X	6 to 8	24/16	12-16- 21-28		0 0 0	SILTY SAND (SM); ~80% sand, ~15% f ~5% gravel; fine to coarse, rounded, fine dry, light brown.	ines, e gravel,		
	_		S-5	M	8 to 10	24/12	8-9-10- 10			WIDELY GRADED SAND (SW); ~90% s ~5% gravel, ~5% fines; fine to coarse, ro fine to coarse gravel, dry, light brown.	sand, ounded,		
- 60 –	— 10 —		S-6	$\left \right\rangle$	10 to 12	24/17	10-8-8- 11			WIDELY GRADED SAND (SW); ~90% s ~5% gravel, ~5% fines; fine to coarse, re fine gravel, dry, light brown.	sand, ounded,		
IEMPLATE.GDI 5/21/	- - - 15		S-7		15	24/10	11-12-			WIDELY GRADED SAND (SW); ~90% s	sand,		
10 LUGS.GPJ GEI DAIA	-			X	to 17		13-14			~5% gravel, ~5% fines; fine to coarse, r fine gravel, moist, light brown.	ounded,		
	20		S-8	X	20 to 22	24/10	23-25- 26-31			WIDELY GRADED SAND (SW); ~90% s ~5% gravel, ~5% fines; fine to coarse, re fine gravel, moist, light brown.	sand, ounded,		
HON .													Drill chatter
Stratific bounda gradual at times Fluctua other fa measur	ation lines ry betweer . Water lev and unde tions of gro ctors than ements we	represe n soil typ vel readi or condition oundwal those p are mad	ent approxim bes, transiti ngs have to cons stated ter may occorresent at the e.	mate ons been cur d ne tin	may be made ue to ne	CLIENT: PROJEC CITY/ST GEI PRO	HDR / T NAM ATE: U	Architechtu E: NSLS I Ipton, New NUMBER:	ure, Inc. II - ACD / York 062152	GEI		GEI C 455 W Glasto 860.36	onsultants, Inc. /inding Brook Dr nbury, CT 06033 88.5300

Bori	ng Loc	ation	L		FACTI			OTAT		OFFORT.	a		В	ORING
HOR	ZONTA	LDA	TUM: N	AD	83 CT	NG:	STA	ATION CEN	TERI	LINE:			B	-203
VER		See	M: BNL	94			GR	OUND SUR	FAC	E ELEVATION (FT): 71.0			PA	GE 2 of 2
		Casing			SAMPI	E INEO	RMATION	N	Ø					
Elev. (ft)	Depth (ft)	Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	GRAPHIC LO	Sample Descriptio Classifica	e in & tion		H₂0 Depth	Remarks
45-	25		S-9	X	25 to 27	24/8	24-36- 37-43			WIDELY GRADED SAND (~5% gravel, ~5% fines; fine fine gravel, moist, light brow	SW); ~90% s to coarse, ro /n.	and, ounded,		
40-	30		S-10	X	30 to 32	24/11	16-14- 12-10			WIDELY GRADED SAND (~5% gravel, ~5% fines; fine fine gravel, moist, light brow	SW); ~90% s to coarse, ro /n.	and, bunded,	<u>×</u>	
35 —	35		S-11	X	35 to 37	24/8	16-16- 16-20			WIDELY GRADED SAND (~5% gravel, ~5% fines; fine fine gravel, moist, light brow	SW); ~90% s to coarse, ro /n.	and, bunded,		Dia abattar
30-	40		S-12	X	40 to 42	24/7	11-10- 9-9			WIDELY GRADED SAND (~20% gravel, ~5% fines; fin fine to coarse gravel, moist,	SW); ~75% s e to coarse, light brown.	and, rounded,	5	Rig chatter
25 –	45		S-13	X	45 to 47	24/0	11-15- 12-14			No recovery.			0	
20-	50				÷									
Stratific	ation lines	represe	ent approxi	mate	may be		HDR A	rchitechture	, Inc.				GELC	onsultants, Inc.
gradua at times	I. Water le and under	vel read	ings have t ions stated	beer l.	made	PROJEC	CT NAME	NSLS II -	ACD		~(455 W	inding Brook Dr
Fluctua other fa	tions of gr actors than	oundwa those p	ter may oci resent at th	cur d he ti	due to	CITY/ST	ATE: Up	oton, New Y	ork		GEI.		Glasto	nbury, CT 06033
measu	ements w	ere mad	е.			GEI PR	JJECT N	UMBER: 00	52152	<u> </u>		insurrants (500.36	0.0000

Boring Location		OFESET	BORING								
HORIZONTAL DATUM: NAD83 CT	STATION CENTER	RLINE:	B-204								
VERTICAL DATUM: BNL 94 LOCATION: See Plan	GROUND SURFAC	CE ELEVATION (FT): 68.0	PAGE 1 of 2								
Drilling Information											
DATE START / END: 4/25/2007 - 4/26/2007 TOTAL DEPTH (FT): 47.0											
EQUIPMENT: Truck DRILLER: Jeil Leavitt LOGGED BY: Steven Hawkins BORING METHOD: Drive and Wash											
AUGER ID/OD: N/A / N/A CASING ID/OD: 3 in / 3.25 in CORE INFO: HAMMER TYPE: Safety Hammer HAMMER WEIGHT (lbs): 140 HAMMER DROP (inch): 30											
WATER LEVEL DEPTHS (ft): ¥ 26.00 4/26/2007 8:31 am											
GENERAL NOTES:	bof = Blows per Foot II = Up	distruted Tube Sample WOR = Weight of Rods	0 = Pocket Penetrometer Strength								
OD = Outside Diameter Pen. = Penetration Leng Rec. = Recovery Length	mpf = Minute per Foot C = Ro th S = Split Spoon V = Fie DP = Direct Push Sample SC = S	ck Core WOH = Weight of Hammer Id Vane Shear RQD = Rock Quality Designa onic Core OVM = Organic Vapor Meter	S _v = Pocket Torvane Shear Strength tion F _v = Field Vane Shear Strength NA, NM = Not Applicable, Not Measured								
Casing SAMF Pen.	PLE INFORMATION										
Elev. Depth (ft) (ft) (ft) (ft) (ft) (ft) (ft) (ft)	n Pen./ Blows Count Field OH Rec. or Data 22 (in) RQD Data 22	Sample Description & Classification	H ₂ 0 Depth Remarks								
- S-1 0 to 2	24/19 2-3-5-7	WIDELY GRADED SAND WITH SILT (SM ~83% sand, ~13% fines, ~4% gravel; fine t coarse, fine gravel, moist, dark brown to br Top 8" topsoil, FILL.); io own,								
65 - S-2 2 to 4	24/16 7-5-2-4	SILTY SAND (SM); ~70% sand, ~25% fine ~5% gravel; fine to coarse, fine gravel, dry brown, FILL.	is, ,								
$\begin{array}{ c c c c } & - & & & \\ \hline & - & 5 & \\ \hline & - & 5 & \\ \hline & & & &$	24/20 7-9-11- 12	 WIDELY GRADED SAND (SW); ~90% sar ~5% gravel, ~5% fines; fine to coarse, fine gravel, dry, grayish brown, FILL. 	nd,								
S-4 6 to 8	24/18 15-25- 37-41	WIDELY GRADED SAND WITH SILT (SW ~80% sand, ~10% gravel, ~10% fines; fine coarse, fine to coarse gravel, moist, grayis	/-SM); e to h								
60 - S-5 8 to 10	24/20 37-39- 49-50	WIDELY GRADED SAND WITH SILT (SW ~71% sand, ~15% gravel, ~14% fines; fine medium, fine gravel, moist, grayish brown.	/-SM); to								
- 10 - S-6 10 to 12	24/20 17-21- 28-27	WIDELY GRADED SAND WITH SILT (SW ~85% sand, ~10% fines, ~5% gravel; fine t medium, fine gravel, moist, grayish brown.	/-SM); to								
		 WIDELY GRADED SAND (SW); ~90% sar ~5% gravel, ~5% fines; fine to coarse, fine gravel, dry, light brown. 	id,								
	24/14 27-35- 34-27	WIDELY GRADED SAND (SW); ~80% sar ~15% gravel, ~5% fines; fine to coarse, subrounded, fine to coarse gravel, dry, ligh brown.	nd, It								
	24/13 20-22-	WIDELY GRADED SAND (SWA): ~85% sar	nd.								
	24-20	~10% gravel, ~5% fines; fine to coarse, subrounded, fine gravel, dry, light brown.									
Stratification lines represent approximate boundary between soil types, transitions may be gradual. Water level readings have been made at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time measurements were made. CLIENT: HDR Architechture, Inc. PROJECT NAME: NSLS II - ACD CITY/STATE: Upton, New York GEI PROJECT NUMBER: 062152 GEI Consultants 655 Winding Brd 455 Winding Brd Glastonbury, CT 860.368.5300											

Borin		ation	<u> </u>		EASTI	NG		STAT		OFESET		E	BORING	
HOR	ZONTA	L DA	TUM: N	AD	83 CT	NG	ST		ITERI	OFF3ET		B-204		
VERT	TICAL E	See	VI:<u>BNL</u> Plan	94			GR	OUND SUF	RFAC	E ELEVATION (FT): 68.0	- -	PA	GE 2 of 2	
		Casing			SAMPI	E INFO	RMATIO	N	U					
Elev. (ft)	Depth (ft)	Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Pen./ Rec. (in)	Blows Count or RQD	Field Test Data	GRAPHIC LO	Sample Description & Classification		H₂0 Depth	Remarks	
-	— 25 —		S-9	X	25 to 26.5	18/10	19-29- 40			WIDELY GRADED SAND (SW); ~90 ~5% gravel, ~5% fines; fine to coars subrounded, fine gravel, dry, light br	9% sand, e, own.	¥	Running sands	
40	- - - - -		S-10	\mathbb{X}	30 to 32	24/12	14-14- 14-11			WIDELY GRADED SAND (SW); ~90 ~5% gravel, ~5% fines; fine to coars subrounded, fine gravel, dry, light br	9% sand, e, own.			
	- 35		S-11	X	35 to 37	24/7	9-9-7- 13			WIDELY GRADED SAND (SW); ~90 ~5% gravel, ~5% fines; fine to coars subrounded, fine to coarse gravel, d brown.	9% sand, e, ry, light			
	- 40 		S-12	X	40 to 42	24/7	14-18- 18-26			WIDELY GRADED SAND (SW); ~90 ~5% gravel, ~5% fines; fine to mediu subrounded, coarse gravel, dry, light)% sand, im, : brown.		-	
	- - 45		S-13	X	45 to 47	24/12	20-29- 35-37			WIDELY GRADED SAND (SW); ~90 ~5% gravel, ~5% fines; fine to mediu subrounded, fine gravel, dry, light br)% sand, ım, own.			
20-	50									End of Boring at 47 feet				
15-														
Stratific bounda gradual at times Fluctual other fa measur	ation lines ry between . Water leve and under tions of gro ctors than ements we	represe n soil typ vel readi r conditi pundwat those p are made	ent approxim bes, transitions have to ions stated ter may occur resent at the e.	mate ions beer cur o ne ti	e may be n made due to me	CLIENT: HDR Architechture, Inc. PROJECT NAME: NSLS II - ACD CITY/STATE: Upton, New York GEI PROJECT NUMBER: 062152 GEI PROJECT NUMBER: 062152						GEI C 455 W Glasto 860.3	onsultants, Inc. /inding Brook Dr onbury, CT 06033 68.5300	

VERTICAL DATUM: NADOS CT STATION CENTERLINE: B-2 VERTICAL DATUM: BNL 94 GROUND SURFACE ELEVATION (FT): 77.0 PAGE LOCATION: See Plan PAGE	205 E 1 of 2										
Drilling Information											
Drilling Information DATE START / END: 4/24/2007 - 4/24/2007											
CONTRACTOR: New England Borings DRILLER: Jeff Leavitt LOGGED BY: Steven Hawkins EQUIPMENT: Truck BORING METHOD: Drive and Wash											
AUGER ID/OD: N/A / N/A CASING ID/OD: 3 in / 3.25 in CORE INFO: HAMMER TYPE: Safety Hammer HAMMER WEIGHT (lbs): 140 HAMMER DROP (inch): 30											
WATER LEVEL DEPTHS (ft):											
ABBREVIATIONS: ID = Inside Diameter OD = Outside Diameter Pen. = Penetration Length Rec. = Recovery Length bpf = Blows per Foot mpf = Minute per Foot S = Split Spoon DP = Direct Push Sample U = Undistrubed Tube Sample C = Rock Core V = Field Vane Shear SC = Sonic Core WOR = Weight of Rods WOH = Weight of Hammer RQD = Rock Quality Designation OVM = Organic Vapor Meter Q _v = Pocket Penetrometer Strength S _v = Pocket Torvane Shear Strength NA, NM = Not Applicable, Not Measu											
Casing SAMPLE INFORMATION 0											
Elev. (ft)Depth (ft)(bpf) or Core Rate (mpf)Sample u FDepth (ft)Pen./ Rec. (in)Blows Count or RQDField Test DataD U Count Count Test DataD U Count Count Test DataH-0 D Test Count Count Count Test DataD U Count Count Count Test DataH-0 D Test Count Count Count Count 	Remarks										
S-1 0 24/19 3-3-4-4 SILTY SAND (SM); ~75% sand, ~20% fines, ~5% gravel; roots, moist, dark brown, Top 8" topsoil, FILL.											
75- S-2 2 24/17 9-11- 15-26 15-26 SILTY SAND (SM); ~80% sand, ~15% fines, ~5% gravel; fine to coarse gravel, dry, grayish brown.											
S-3 4 24/20 21-41- to 6 40-29 WIDELY GRADED SAND (SW); ~90% sand, ~5% gravel, ~5% fines; fine to medium, fine to coarse gravel, dry, brown.											
70 S-4 6 to 8 24/15 21-22- 25-21 WIDELY GRADED SAND (SW); ~90% sand, ~5% gravel, ~5% fines; fine to medium, fine to coarse gravel, dry, brown.											
S-5 8 24/16 6-7-10- 10 WIDELY GRADED SAND (SW); ~90% sand, ~10% gravel, ~0% fines; fine to medium, rounded, fine to coarse gravel, dry, light brown.											
S-6 10 24/14 12-10- 11-10 WIDELY GRADED SAND (SW); ~90% sand, ~10% gravel, ~0% fines; medium to coarse, rounded, fine to coarse gravel, dry, light brown.											
15 S-7 15 24/8 12-15- 60 17 17 17-21 WIDELY GRADED SAND (SW); ~90% sand, 60 17 17-21 ***											
S-8 22 24/10 15-17- 24-21 WIDELY GRADED SAND WITH GRAVEL (SW); ~70% sand, ~25% gravel, ~5% fines; fine to coarse, rounded, fine to coarse gravel, wet, light brown.											
Intradification lines represent approximate Inc Inc	nsultants. Inc.										
at times and under conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the time masser made to the made tothet to the made	ding Brook Dr bury, CT 06033 .5300										

Boring Location								OTAT.		OFFRET.		В	ORING
HORIZONTAL DATUM: NAD83 CT STATION CENTERLINE:										B	-205		
VERT		ATU	I: BNL	94			GR	OUND SUR	FAC	E ELEVATION (FT): 77.0	GE 2 of 2		
LOCA	ATION:	See	Plan						1				
Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	Depth (ft)	E INFO Pen./ Rec. (in)	RMATIO Blows Count or RQD	N Field Test Data	GRAPHIC LOG	Sample Description & Classification		H₂0 Depth	Remarks
- 50 —	25		S-9	X	25 to 27	24/9	36-25- 22-34			WIDELY GRADED SAND WITH GRAV ~65% sand, ~30% gravel, ~5% fines; fi coarse, rounded, fine gravel, wet, light l	EL (SW); ne to prown.		
45-	- 30 		S-10	X	30 to 32	24/6	15-12- 8-10			WIDELY GRADED SAND WITH GRAV ~65% sand, ~30% gravel, ~5% fines; fii coarse, rounded, fine gravel, wet, light l	EL (SW); ne to prown.	¥	
40-	35		S-11	X	35 to 37	24/9	16-20- 21-25			WIDELY GRADED SAND (SW); ~85% ~10% gravel, ~5% fines; fine to coarse, fine gravel, wet, light brown.	sand, rounded,		
35 —	40		S-12	X	40 to 42	24/9	20-21- 20-30			WIDELY GRADED SAND (SW); ~85% ~10% gravel, ~5% fines; fine to coarse, fine gravel, wet, light brown.	sand, rounded,		
30-	45		S-13	X	45 to 47	24/10	17-20- 24-30			WIDELY GRADED SAND (SW); ~95% ~5% fines, ~0% gravel; fine to coarse, v brown.	sand, wet,		
	50												
25-													
Stratific bounda gradual at times Fluctua other fa measur	ation lines ry betwee . Water les and under tions of gr actors than rements w	represe soil typ readi r conditi oundwat those p are mad	ent approxi bes, transit ngs have t ons stated er may oc resent at t e.	mations beer 1. cur (he ti	e may be made due to me	CLIENT: HDR Architechture, Inc. PROJECT NAME: NSLS II - ACD CITY/STATE: Upton, New York GEI PROJECT NUMBER: 062152						GEI C 455 W Glasto 860.36	onsultants, Inc. inding Brook Dr nbury, CT 06033 88.5300

Borin		ation	<u>1</u>		EASTI			OT A			OFFORT.			E	BORING	
HOR	ZONTA	L DA	TUM: N	IAD	083 CT	STATION: OFFSET:						B-206				
VER1	FICAL E	ATUI See	M: <u>BNL</u> Plan	94	·		GF	ROUND SU	RFAC	E ELEVA1	ION (FT): 73.5		8	PAGE 1 of 2		
Drilli	Drilling Information															
DATE	DATE START / END: 4/24/2007 - 4/24/2007 TOTAL DEPTH (FT): 47.0															
CONT	RACTO		ew Engla k	Ind	Borings	[ORILLER:	Jeff Leavi	tt		LOGGED BY: BORING METH	Steven Hawkin	IS 1 Wash			
AUGE	AUGER ID/OD: N/A / N/A CASING ID/OD: 3 in / 3.25 in CORE INFO:															
HAMN	HAMMER TYPE: Safety Hammer HAMMER WEIGHT (ibs): 140 HAMMER DROP (inch): 30 WATER LEVEL DEPTHS (ft): ¥ 35.00 4/24/2007 4:06 pm HAMMER DROP (inch): 30															
GENE	GENERAL NOTES:															
ABBR	EVIATION	IS: ID OI Pe	= Inside D D = Outside en. = Penel	Diarr le Di trati	neter iameter on Length	bpf = 1 mpf = S = Sp	Blows per F Minute per olit Spoon	Foot (U = Undi C = Rock V = Field	strubed Tube Core Vane Shear	Sample WOR = ' WOH = ' RQD = F	Weight of Rods Weight of Hammer Rock Quality Desig	Q _v = S _v = nation F _v =	Pocket Pocket Field Va	Penetrometer Strength Torvane Shear Strength ine Shear Strength	
		Casing	ec. = Reco	very	SAMPI			Sample 3	sc = soi	nic Core	0VM = (Organic Vapor Met	er NA,			
Elev.	Depth	Pen. (bpf)			O/ WII E	Den /	Blows	Field	C LO		Sam	ole		H,0	-	
(ft)	(ft)	or Core Rate (mpf)	Sample No.	Type	Depth (ft)	Rec. (in)	Count or RQD	Test Data	GRAPHI		Classific	cation &		Depth	Remarks	
	-		S-1	M	0 to	24/20	6-5-5-5			SILTY S	AND (SM); ~65%	sand, ~30% fi	nes,			
	-			Ň	2					-076 grav	i, coal, ury, uai	K DIOWII, FILL.				
2-	-		S-2	\square	2	24/3	7-11-			SILTY S	AND (SM); ~80%	sand, ~15% fi	nes,			
70-	-			X	to 4		21-26			~5% grav	/el; roots, dry, da	rk brown, FILL	<u>.</u>			
10	-		S-3	\mathbb{H}	4	24/18	15-21-			WIDELY	GRADED SAND	(SW); ~85% s	and,			
	- 5			X	to 6		28-39			~10% gra rounded,	avel, ~5% fines; f fine gravel, dry,	ine to medium, light brown, FII	-L.			
	-		S-4	\mathbb{A}	6	24/14	26-29-			SILTY S	AND (SM): ~64%	sand. ~26% fi	nes			
	-		100 000	X	to 8		31-33			~10% gra FILL.	avel; fine to coars	se, rounded, dr	y, brown,			
	-		S-5	$\left(\right)$	8	24/23	12-13-			SILTY S	AND (SM): ~75%	sand ~20% fi	nes			
65-	-			X	to 10		13-16			~5% grav	vel; fine to coarse	e, rounded, dry	brown,			
	- 10		S-6	$\left(\right)$	10	24/14	15-12-		• • • • • • • • • • • • •	WIDELY ~5% grav	GRADED SAND /el, ~5% fines; m	edium to coars	and, e, fine	1.		
-	-			X	to 12		12-15		••••	gravel, m WIDELY	oist, light brown. GRADED SAND	(SW); ~90% s	and,			
-	-			\square					• • • • • • • • • • • • • • • • • • • •	~5% grav gravel, di	/el, ~5% fines; fir ′y, white.	ne to medium, f	îne			
-	-								••••							
60-									••••							
-	- 15								***							
-	- 13		S-7	M	15 to	24/9	9-10- 11-15		• • • • • • • • • • • •	WIDELY ~5% grav	GRADED SAND /el, ~5% fines; fir	(SW); ~90% s ne to coarse, fir	and, ne			
	-			M	17					gravel, di	y, light brown.					
-	-															
55-	-								°°°° °°°°							
-	-															
-	- 20		S-8		20	24/14	14-18-			WIDELY	GRADED SAND	(SW); ~90% s	and,			
	-			X	to 22		20-25		••••	~5% grav gravel, di	/el, ~5% fines; fir y, light brown.	ne to coarse, fir	10			
	-			H					••••							
50-	-															
Stratific	ation lines	represe	nt approxir	mate	• 6	I IENT.		rchitochtur	• o Inc			-		GELC	onsultante Inc	
gradual at times	ry betweer . Water lev and unde	n soil typ el readi r conditi	pes, transiti ngs have b ions stated	ions beer	may be rade rade	ROJEC	T NAME	E: NSLS II	- ACD					455 W	/inding Brook Dr	
Fluctual other fa	tions of gro	undwat those p	ter may occ resent at th	cur d ne ti	due to Come	STY/ST		pton, New Y	York)		GEL	sultants S	Glasto	onbury, CT 06033 58.5300	
measur	ements we	e mad	θ.	_					52152			2010 000				

Borin	ng Loo THING:	ation	<u>ı</u>		EASTI	NG:		STATI	ON:	OFFSET:		B	ORING
HORI	ZONTA		TUM: <u>N</u> M: BNL	AD 94	83 CT		STA GR	ATION CEN	FAC	LINE: E ELEVATION (FT): 73.5		E	3-206
LOC	ATION:	See	Plan									PA	GE 2 of 2
Elev. (ft)	Depth (ft)	Casing Pen. (bpf) or Core Rate (mpf)	Sample No.	Type	SAMPL Depth (ft)	E INFO Pen./ Rec. (in)	RMATIOI Blows Count or RQD	Field Test Data	GRAPHIC LOG	Sample Description & Classification		H₂0 Depth	Remarks
	- 25		S-9	X	25 to 27	24/12	26-25- 25-25			WIDELY GRADED SAND (SW); ~90% ~5% gravel, ~5% fines; fine to coarse, o gravel, dry, light brown, Max. gravel size	sand, coarse e 1.5".		
45	- - - - - - - - - - - -		S-10	X	30 to 32	24/11	16-11- 10-10	12		WIDELY GRADED SAND WITH GRAV ~80% sand, ~15% gravel, ~5% fines; fir coarse, fine gravel, dry, light brown, Ma size 1.5".	EL (SW); ne to x. gravel		Rig chatter
40-	- - - - - - - - -		S-11	X	35 to 37	24/8	17-23- 23-26			WIDELY GRADED SAND WITH SILT (~80% sand, ~10% gravel, ~10% fines; i coarse, fine gravel, dry, light brown, Ma size 1.5".	SW-SM); îne to x. gravel	Ţ	
35 -	- - - - - - - - - - - -		S-12	X	40 to 42	24/6	15-16- 20-23			WIDELY GRADED SAND WITH SILT (~80% sand, ~10% gravel, ~10% fines; coarse, fine gravel, dry, light brown, Ma size 1.5".	SW-SM); îne to x. gravel		
GEI DATA TEMPLATE.GDT 5/2	- - - - - - - -		S-13	X	45 to 47	24/4	26-29- 37-39			WIDELY GRADED SAND WITH SILT (~80% sand, ~10% gravel, ~10% fines; i medium, fine gravel, dry, brown, Max. g 1.5". End of Boring at 47 feet	SW-SM); ine to ravel size		
100 02 ACU BOKING LUGS IGT	- - - - - - - - - - - - - -												
Stratific bounda at times Fluctua other fa measur	ation lines ry betwee . Water le and under tions of gr ictors than ements w	s represe n soil typ vel readi er condit roundwal n those p ere mad	ent approxi bes, transit ings have t ions stated ter may oc resent at th e.	mate ions peen cur c he ti	may be made fue to ne C	CLIENT: PROJEC CITY/ST GEI PRO	HDR A T NAME ATE: Up	rchitechture : NSLS II - oton, New Yo UMBER: 06	Inc. ACD ork 2152	GEI	onsultants	GEI C 455 W Glasto 860.36	onsultants, Inc. Inding Brook Dr nbury, CT 06033 58.5300

Appendix D

2006-2007 Cone Penetrometer Test (CPT) Logs




TABLE 1 - SUMMARY OF CPTU SOUNDINGS

Job No.: Location: Client: Date:	06-773 Brookhaven National GEI Consultants July 19, 20, 21, 2006	Labs			
Date	CPTU Sounding	File Name	CPT Total Depth (ft)	Shear wave Velocity Tests	Comments
19-Jul-06	CPT-1	773cp01.cor	94.32		refusal
19-Jul-06	CPT-2	773cp02.cor	100.06		
20-Jul-06	CPT-3	773cp03.cor	86.12	9	refusal
19-Jul-06	CPT-4	773cp04.cor	95.14		refusal
20-Jul-06	CPT-5	773cp05.cor	7.87		refusal
20-Jul-06	CPT-SA	773cp05a.cor	82.68	9	refusal
20-Jul-06	CPT-6	773cp06.cor	100.06	10	
21-Jul-06	CPT-7	773cp07.cor	6.40		refusal
20-Jul-06	CPT-8	773cp08.cor	52.98		refusal
21-Jul-06	CPT-10	773cp10.cor	61.02		
21-Jul-06	CPT-11	773cp11.cor	73.49		
20-Jul-06	CPT-12	773cp12.cor	100.06	10	
20-Jul-06	CPT-13	773cp13.cor	6.73	6 6	refusal
20-Jul-06	CPT-13A	773cp13a.cor	5.58		refusal
21-Jul-06	CPT-14	773cp14.cor	95.80		refusal
Job Totals:		15	968.31	38	











Job No	06-773
Client	GEI Consultants
Project Title	National Labs
Hole	CPT-3
Site	Brookhaven, New York
Date	7/20/2006
Seismic Sou	rce: Beam

Seismic Source:	Beam	
Source Offset:	1.97	(ft)
Source Depth:	0.00	(ft)
Geophone Offset:	0.66	(ft)

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Depth Interval (ft)	Time Interval (ms)	Mid-layer Depth (ft)	Vs Interval Velocity (ft/s)
10.01	9.35	9.56				
20.01	19.35	19.45	9.89	10.84	14.35	913
30.02	29.36	29.43	9.98	10.57	24.36	944
40.03	39.37	39.42	9.99	10.93	34.37	914
50.03	49.37	49.41	9.99	10.57	44.37	945
60.04	59.38	59.42	10.00	10.20	54.38	981
70.05	69.39	69.42	10.01	10.20	64.39	981
80.05	79.39	79.42	10.00	9.75	74.39	1025
86.12	85.46	85.49	6.07	5.15	82.43	1178









(ji) djqad







Job No	06-773
Client	GEI Consultants
Project Title	National Labs
Hole	CPT-5A
Site	Brookhaven, New York
Date	7/20/2006
Oniomia Cau	Beers
Seismic Sou	rce: Beam

Seisifiic Source.	Deam	
Source Offset:	1.97	(ft)
Source Depth:	0.00	(ft)
Geophone Offset:	0.66	(ft)

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Depth Interval (ft)	Time Interval (ms)	Mid-layer Depth (ft)	Vs Interval Velocity (ft/s)
10.01	9.35	9.56				
20.01	19.35	19.45	9.89	10.05	14.35	985
30.02	29.36	29.43	9.98	10.52	24.36	948
40.03	39.37	39.42	9.99	10.83	34.37	923
50.03	49.37	49.41	9.99	10.28	44.37	972
60.04	59.38	59.42	10.00	10.36	54.38	966
70.05	69.39	69.42	10.01	10.83	64.39	924
80.05	79.39	79.42	10.00	10.44	74.39	958
82.68	82.02	82.05	2.63	2.43	80.71	1082

8





Vs (ft/s)



(ff) dfgad





Job No	06-773		
Client	GEI Consultants		
Project Title	National Labs		
Hole	CPT-6		
Site	Brookhave	en, New York	
Date	7/20/2006		
Seismic Sou	rce:	Beam	
Source Offse	et:	1.97	

Seisifiic Source.	Dedill	
Source Offset:	1.97	(ft)
Source Depth:	0.00	(ft)
Geophone Offset:	0.66	(ft)

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Depth Interval (ft)	Time Interval (ms)	Mid-layer Depth (ft)	Vs Interval Velocity (ft/s)
10.01	9.35	9.56				
20.01	19.35	19.45	9.89	11.00	14.35	900
30.02	29.36	29.43	9.98	10.02	24.36	996
40.03	39.37	39.42	9.99	10.20	34.37	980
50.03	49.37	49.41	9.99	9.30	44.37	1074
60.04	59.38	59.42	10.00	8.94	54.38	1119
70.05	69.39	69.42	10.01	9.21	64.39	1086
80.05	79.39	79.42	10.00	10.02	74.39	998
90.06	89.40	89.43	10.01	10.02	84.40	999
100.07	99.41	99.43	10.01	9.57	94.41	1046

9







(j]) djqeQ





(11) AlqsD





(11) Afged





Job No	06-773		
Client	GEI Consultants		
Project Title	National Labs		
Hole	CPT-12		
Site	Brookhaven, New York		
Date	7/20/2006		
Seismic Sou	rce: Beam		
Source Offse	et: 1.97		

Seismic Source.	Beam	
Source Offset:	1.97	(ft)
Source Depth:	0.00	(ft)
Geophone Offset:	0.66	(ft)

Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Depth Interval (ft)	Time Interval (ms)	Mid-layer Depth (ft)	Vs Interval Velocity (ft/s)
10.01	9.35	9.56				
20.01	19.35	19.45	9.89	11.44	14.35	865
30.02	29.36	29.43	9.98	11.24	24.36	888
40.03	39.37	39.42	9.99	11.64	34.37	859
50.03	49.37	49.41	9.99	11.24	44.37	889
60.04	59.38	59.42	10.00	10.15	54.38	986
70.05	69.39	69.42	10.01	11.34	64.39	882
80.05	79.39	79.42	10.00	10.74	74.39	931
90.06	89.40	89.43	10.01	10.45	84.40	958
100.07	99.41	99.43	10.01	9.95	94.41	1006

9



GEI Consultants National Labs July 20, 2006



Vs (ft/s)







⁽⁺³⁾



(jì) diqaQ





GEI Consultants Project: Brookhaven National Laboratory, Upton, NY Sounding: CPT-202 April 23, 2007

Beam

2.00

0.00

0.66

Seismic Source: Source Offset (ft): Source Depth (ft): Geophone Offset (ft):

Client:

Date:

SEISMIC - Vs								
			•					
Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Depth Interval (ft)	Time Interval (ms)	Vs (ft/s)	Mid Layer (ft)		
6.56	5.90	6.23						
16.40	15.74	15.87	9.64	14.24	677	10.82		
26.25	25.59	25.66	9.79	10.82	905	20.67		
36.09	35.43	35.49	9.82	11.41	861	30.51		
45.93	45.27	45.32	9.83	11.35	866	40.35		
55.77	55.11	55.15	9.83	10.80	911	50.19		
65.62	64.96	64.99	9.84	10.39	947	60.04		
75.46	74.80	74.83	9.84	10.49	938	69.88		
85.30	84.64	84.67	9.84	10.93	900	79.72		
95.14	94.48	94.51	9.84	11.08	888	89.56		
100.07	99.41	99.43	4.92	5.63	874	96.94		



Client: GEI Consultants Location: Brookhaven National Laboratory, Upton, NY CPT Sounding: CPT-202 Date: April 23, 2007







GEI Consultants Brookhaven National Laboratory, Upton, NY CPT-203 April 23, 2007

Beam

2.00

0.00

0.66

Seismic Source: Source Offset (ft): Source Depth (ft): Geophone Offset (ft):

Client:

Date:

Project: Sounding:

SEISMIC - Vs								
Tip Depth (ft)	Geophone Depth (ft)	Ray Path (ft)	Depth Interval (ft)	Time Interval (ms)	Vs (ft/s)	Mid Layer (ft)		
6.56	5.90	6.23				-		
16.40	15.74	15.87	9.64	14.63	659	10.82		
26.25	25.59	25.66	9.79	9.68	1011	20.67		
36.09	35.43	35.49	9.82	12.03	816	30.51		
45.93	45.27	45.32	9.83	10.17	967	40.35		
55.77	55.11	55.15	9.83	10.53	934	50.19		
65.62	64.96	64.99	9.84	9.91	993	60.04		
75.46	74.80	74.83	9.84	10.79	912	69.88		
85.30	84.64	84.67	9.84	10.55	933	79.72		
95.14	94.48	94.51	9.84	10.44	943	89.56		
100.07	99.41	99.43	4.92	4.81	1024	96.94		



Client: GEI Consultants Location: Brookhaven National Laboratory, Upton, NY CPT Sounding: CPT-203 Date: April 23, 2007



GEOTECHNICAL REPORT - ADVANCED CONCEPT DESIGN PHASE NATIONAL SYNCHROTRON LIGHT SOURCE II BROOKHAVEN NATIONAL LABORATORY

Appendix E

Laboratory Test Results




Client:	GEI Consu	iltants				
Project:	Brookhave	en National Lab	oratory			
Location:	Upton, NY				Project No:	GTX-6864
Boring ID:	B-101		Sample Type:	jar	Tested By:	pcs
Sample ID:	:S-1		Test Date:	08/04/06	Checked By:	jdt
Depth :	0-2 ft		Test Id:	94474		
Test Comm	ient:	sieve stack 6				
Sample De	scription:	Moist, yellowis	sh brown silty s	and		
Sample Co	mment:	***				



GeoTesting express a subsidiary of Grocomp Corporation

Client:	GEI Consu	Itants				
Project:	Brookhave	n National Lab	oratory			
Location:	Upton, NY				Project No:	GTX-6864
Boring ID:	B-101		Sample Type:	jar	Tested By:	pcs
Sample ID:	S-2		Test Date:	08/04/06	Checked By:	jdt
Depth :	5-7 ft		Test Id:	94475	*)	
Test Comm	ent:	sieve stack 6				
Sample Des	scription:	Moist, light gra	ay silty sand			
Sample Cor	mment:					



Sieve Hame	mm	Percent Piller	spec. Percent	complies
3/8 inch	9.51	100		
#4	4.75	97		
#10	2.00	91		
#20	0.84	81		
#40	0.42	56		
#60	0.25	33		
#100	0.15	20		
#200	0.075	12		

Coe	officients				
D ₈₅ =1.1429 mm	D ₃₀ =0.2189 mm				
D ₆₀ =0.4753 mm	D ₁₅ =0.0949 mm				
D ₅₀ =0.3706 mm	D ₁₀ =0.0622 mm				
Cu =7.641	Cc =1.621				
Clas	sification				
<u>ASTM</u> N/A					
AASHTO Silty Gravel	and Sand (A-2-4 (0))				
Sample/Test Description Sand/Gravel Particle Shape : ANGULAR					
Sandy Graver Hardness					



Client:	GEI Consu	Itants				
Project:	Brookhave	n National Lab	oratory			
Location:	Upton, NY				Project No:	GTX-6864
Boring ID:	B-101		Sample Type:	jar	Tested By:	pcs
Sample ID:	S-3		Test Date:	08/04/06	Checked By:	jdt
Depth :	10-12 ft		Test Id:	94476	с.	5
Test Comm	ent:	sieve stack 6				
Sample Des	scription:	Moist, light gr	ay sand			
Sample Con	nment:					



Sample/Test Description Sand/Gravel Particle Shape : ANGULAR Sand/Gravel Hardness : HARD



Client:	GEI Consu	Itants				
Project:	Brookhave	en National Lab	oratory			
Location:	Upton, NY				Project No:	GTX-6864
Boring ID:	B-101		Sample Type:	jar	Tested By:	pcs
Sample ID	:S-4		Test Date:	08/04/06	Checked By:	jdt
Depth :	15-17 ft		Test Id:	94477		
Test Comn	nent:	sieve stack 1				
Sample De	escription:	Moist, light gr	ay sand			
Sample Co	mment:					





Client:	GEI Consu	Iltants				
Project:	Brookhave	en National Lab	oratory			
Location:	Upton, NY				Project No:	GTX-6864
Boring ID:	B-101	_	Sample Type:	jar	Tested By:	pcs
Sample ID	:S-5		Test Date:	08/02/06	Checked By:	jdt
Depth :	20-22 ft		Test Id:	94478		5
Test Comm	nent:	sieve stack 6				
Sample De	scription:	Moist, white s	and			
Sample Co	mment:					



<u>Classification</u> ASTM Poorly graded sand (SP)

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description Sand/Gravel Particle Shape : ANGULAR Sand/Gravel Hardness : HARD

#40

₹60

#100

#200

0.42

0.25

0.15

0.075

48

15

7

4

GeoTesting express a substriliary of Geocomp Corporation

Client:	GEI Consu	ultants				
Project:	Brookhave	en National Lab	oratory			
Location:	Upton, NY				Project No:	GTX-6864
Boring ID:	B-101		Sample Type:	jar	Tested By:	pcs
Sample ID	:S-6		Test Date:	08/02/06	Checked By:	jdt
Depth :	25-27 ft		Test Id:	94479		
Test Comn	nent:	sieve stack 1				
Sample De	escription:	Moist, very pa	ale brown sand	with silt and	d gravel	
Sample Co	mment:					



1/2 1101	12.70	92		
3/8 inch	9.51	85		
#4	4.75	75		
#10	2.00	67		
#20	0.84	59	_	
#40	0.42	35		
#60	0.25	17		
#100	0.15	10		
\$200	0.074	5		

Co	efficients
D ₈₅ =9.6327 mm	D ₃₀ =0.3633 mm
D ₆₀ = 0.9539 mm	D ₁₅ =0.2209 mm
D ₅₀ =0.6500 mm	D ₁₀ =0.1520 mm
C _u =6.276	Cc =0.910
Clas	sification
ASTM N/A	
AASHTO Stone Frag	mente Gravel and Sand
AADITO Stone Hay	ments, Graver and Sand
(A-1-b (0))	
(A-1-b (0)) Sample/1	rest Description
(A-1-b (0)) Sand/Gravel Particle	<u>Shape : ROUNDED</u>
(A-1-b (0)) Sample/1 Sand/Gravel Particle Sand/Gravel Hardnes	Cest Description Shape : ROUNDED s : HARD
(A-1-b (0)) Sample/1 Sand/Gravel Particle Sand/Gravel Hardnes	Shape : ROUNDED
(A-1-b (0)) Sand/Gravel Particle Sand/Gravel Hardnes	Test Description Shape : ROUNDED s : HARD



Client:	GEI Const	ultants				
Project:	Brookhave	en National Lab	oratory			
Location:	Upton, NY	•			Project No:	GTX-6864
Boring ID:	B-101		Sample Type:	jar	Tested By:	pcs
Sample ID	:S-8		Test Date:	08/04/06	Checked By:	idt
Depth :	35-37 ft		Test Id:	94480		
Test Comm	nent:	sieve stack 1				
Sample Description: Moist, pale b		own sand with	gravel			
Sample Co	mment:					





Client:	GEI Consu	iltants				
Project:	Brookhave	en National Lab	oratory			
Location:	Upton, NY				Project No:	GTX-6864
Boring ID:	B-101		Sample Type:	jar	Tested By:	pcs
Sample ID	:S-10		Test Date:	08/04/06	Checked By:	jdt
Depth :	45-47 ft		Test Id:	94481		
Test Comn	nent:	sieve stack 1				
Sample Description: Moist, light		Moist, light ye	llowish brown s	and with si	ilt	
Sample Co	mment:					



Sieve Maine	mm	Percent Piner	Spec. Percent	complies
3/8 Inch	9.51	100		
#4	4.75	99		
#10	2.00	99		
#20	0.84	98		
#40	0.42	90		
#60	0.25	70		
#100	0.15	34		
≠ 200	0.074	8		
and the second se				

Coeffi	icients			
D ₈₅ =0.3666 mm	D ₃₀ =0.1332 mm			
D ₆₀ =0.2172 mm	D ₁₅ =0.0888 mm			
D ₅₀ =0.1877 mm	D ₁₀ =0.0775 mm			
C ₄ =2.803	Cc =1.054			
Classif	ication			
ASTM N/A	isación -			
AASHTO Fine Sand (A-3 (0))				
Sand/Gravel Particle Sha	t Description			
Sandy Graver Particle Sha	ipe ,			
Sand/Gravel Hardness :				



Client:	GEI Consu	iltants				
Project:	Brookhave	en National Lab	oratory			
Location:	Upton, NY				Project No:	GTX-6864
Boring ID:	B-102		Sample Type:	jar	Tested By:	pcs
Sample ID	:S-1		Test Date:	08/04/06	Checked By:	jdt
Depth :	0-2 ft		Test Id:	94482		
Test Comm	nent:	sieve stack 1				
Sample De	scription:	Moist, Dark ye	ellowish brown	silty sand		
Sample Co	mment:					



1/2 inch	12.70	89		
3/8 inch	9.51	89		
#4	4,75	89	-	
#10	2.00	86		
\$20	0.84	79		
#40	0.42	59		
#60	0.25	42		-
#100	0.15	32		
#200	0.074	27		

Coeffic	Coefficients						
D ₈₅ =1.8592 mm	D ₃₀ =0.1121 mm						
D ₆₀ =0.4377 mm	D15=N/A						
D ₅₀ =0.3177 mm	D ₁₀ = N/A						
Cu =N/A	Cc =N/A						
Classifi	ication						
ASTM N/A	cation						
AASHTO Silty Gravel and Sand (A-2-4 (0))							
Sample/Test	Description ANGULAR						
Sundy Graver Particle Sinaj	pe : moount						
Sand/Gravel Hardness : HARD							
era protectionen en Caldo Madadada dato	All a growing a						



Client: G	EI Consultants				
Project: Br	rookhaven National L	aboratory			
Location: U	pton, NY			Project No:	GTX-6864
Boring ID: B-1	102	Sample Type:	jar	Tested By:	pcs
Sample ID:S-	2	Test Date:	08/04/06	Checked By:	jdt
Depth : 5-3	7 ft	Test Id:	94483		
Test Commen	t: sieve stack	6			
Sample Descr	iption: Moist, light	olive brown sand			
Sample Comm	nent:				



Client: **GEI** Consultants Project: GeoTesting Brookhaven National Laboratory Location: Upton, NY Project No: GTX-6864 express Boring ID: B-102 Sample Type: jar Tested By: pcs a subsidiary of Geocomp Corporation Sample ID:S-3 Test Date: 08/04/06 Checked By: jdt Depth : 10-12 ft Test Id: 94484 Test Comment: sieve stack 6 Sample Description: Moist, light yellowish brown sand Sample Comment: ---



SHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description Sand/Gravel Particle Shape : Sand/Gravel Hardness :



Client:	GEI Consu	ltants				
Project:	Brookhave	n National Lab	oratory			
Location:	Upton, NY				Project No:	GTX-6864
Boring ID:	3-102		Sample Type:	jar	Tested By:	pcs
Sample ID:	S-4		Test Date:	08/02/06	Checked By:	jdt
Depth :	15-17 ft		Test Id:	94485		
Test Comme	ent:	sieve stack 1			10 C	and the second second second second
Sample Des	cription:	Moist, brown	sand with silt			
Sample Con	nment:					



Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1/2 inch	12.70	100		
3/8 inch	9.51	97		
#4	4.75	93		
<i>‡</i> 10	2.00	83		
#20	0.84	71		
#40	0.42	48		
#60	0.25	27		
#100	0.15	12		
#200	0.074	7		

	Coe	fficients	
D ₈₅ =2.42	.68 mm	D ₃₀ =0.2707 mm	
D60=0.60	58 mm	D ₁₅ =0.1657 mm	
D ₅₀ =0.44	64 mm	D ₁₀ =0.1157 mm	
Cu = 5.23	6	Cc =1.045	
ASTM	N/A Clas	<u>sification</u>	
AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))			
Sand/Gra Sand/Gra	Sample/T vel Particle S vel Hardness	est Description ihape : ANGULAR : : HARD	



Client:	GEI Consul	tants				
Project:	Brookhave	n National Labo	oratory			
Location:	Upton, NY	_			Project No:	GTX-6864
Boring ID:	B-102		Sample Type:	jar	Tested By:	pcs
Sample ID:	S-5		Test Date:	08/02/06	Checked By:	jdt
Depth :	20-22 ft		Test Id:	94486		
Test Comm	ent:	sieve stack 6				
Sample Des	scription:	Moist, light bro	own sand with	silt		
Sample Cor	nment:					



3/8 inch	9.51	100	
#4	4.75	99	 and the second second
#10	2.00	98	
#20	0.84	92	
#40	0.42	78	
#60	0.25	47	
#100	0.15	15	
#200	0.075	6	

	Coe	fficients	
D ₈₅ =0.61	.13 mm	D ₃₀ =0.1901 mm	
D60=0.31	.48 mm	D ₁₅ =0.1455 mm	
D50=0.26	53 mm	D ₁₀ =0.1005 mm	
$C_u = 3.13$	2	Cc =1.142	
<u>ASTM</u>	N/A Clas	<u>sification</u>	
AASHTO Fine Sand (A-3 (0))			
Sand/Gra Sand/Gra	Sample/To vel Particle S vel Hardness	est Description hape :	



Client:	GEI Const	ultants				
Project:	Brookhav	en National Lat	oratory			
Location:	Upton, NY	·			Project No:	GTX-6864
Boring ID:	B-102		Sample Type:	jar	Tested By:	pcs
Sample ID	:5-6	5	Test Date:	08/04/06	Checked By:	jdt
Depth :	25-27 ft		Test Id:	94487		_
Test Comn	nent:	sieve stack 1				
Sample De	escription:	Moist, light ye	ellowish brown s	and with s	ilt	
Sample Co	mment:					



	mm			
3/8 inch	9.51	100		
#4	4.75	97		
\$10	2.00	94		
#20	0.84	89	-	and the second second second
#40	0.42	79		
#60	0.25	55		
#100	0.15	22		
#200	0.074	10		

$D_{30} = 0.1681 \text{ mm}$ $D_{15} = 0.0992 \text{ mm}$ $D_{10} = 0.0756 \text{ mm}$ $C_c = 1.339$ fication
$D_{15} = 0.0992 \text{ mm}$ $D_{10} = 0.0756 \text{ mm}$ $C_c = 1.339$ fication
D ₁₀ =0.0756 mm C _c =1.339 fication
C _c =1.339 fication
fication
3 (0))
t Description ape :



Client:	GEI Conse	ultants					
Project:	Brookhav	en National Lab	oratory				
Location:	Upton, NY	·			Project No:	GTX-6864	
Boring ID:	B-102		Sample Type:	jar	Tested By:	pcs	
Sample ID	:S-8		Test Date:	08/04/06	Checked By:	jdt	
Depth :	35-37 ft		Test Id:	94488			27
Test Comn	nent:	sieve stack 1					
Sample De	escription:	Moist, pale br	own sand with	silt			
Sample Co	mment:						



Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1/2 inch	12.70	100		
3/8 inch	9.51	97		
#4	4.75	95		
#10	2.00	91		A to be the other states of the
#20	0.84	85		
#40	0.42	<u>59</u>		
#60	0.25	30		ALC: NO. CO.
#100	0.15	14		
#200	0.074	7		

	Coefficients			
0 ₈₅ =0.8377 mm	D ₃₀ = 0.2499 mm			
0 ₆₀ =0.4304 mm	D ₁₅ =0.1533 mm			
0 ₅₀ =0.3572 mm	D ₁₀ =0.0988 mm			
Cu =4.356	C _c =1.469			
	Classification			
<u>N/A</u>				
ASHTO Fine S	and (A-3 (0))			
Samı Sand/Gravel Par	ble/Test Description ticle Shape : ANGULAR			
Sand/Gravel Hardness : HARD				

GeoTesting express

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Client:	GEI Consu	Iltants				
Project:	Brookhave	en National Lab				
Location:	Upton, NY				Project No:	GTX-6864
Boring ID:	B-102		Sample Type:	jar	Tested By:	pcs
Sample ID:	:S-10		Test Date:	08/04/06	Checked By:	jdt
Depth :	45-47 ft		Test Id:	94489		
Test Comm	ient:	sieve stack 6				
Sample Description: Moist, light o		ive brown sand	with silt			
Sample Co	mment:					



1/2 inch	12.70	100	
3/8 inch	9.51	94	
#4	4.75	91	
#10	2.00	88	
#20	0.84	78	
\$40	0.42	51	
<i>‡</i> 60	0.25	25	
\$100	0.15	13	
#200	0.075	7	

<u>AASHTO</u>	Fine Sand (A-3 (0))
	Sample/Test Description
Sand/Gra	vel Particle Shape : ANGULAR
Sand/Gra	vel Hardness : HARD

Classification

ASTM

N/A

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Clienti - Gel Co	nsultants		· ·	· · ·	
Project: Brookh	aven National L	aboratory			
Location: Upton,	NY			Project No:	GTX-6864
Boring ID: B-202		Sample Type	: bag	Tested By:	mll
Sample ID:S-1		Test Date:	05/14/07	Checked By:	jdt
Depth: 1-3 ft		Test Id:	111381		
Test Comment:	P				
Sample Description	: Moist, light	olive brown clay	vey sand		
Sample Comment:					



Sieve Manie	mm	Percent riller	shec secent	Complies
1/2 Inch	12.70	100		
3/8 Inch	9.51	96		
#4	4.75	92		
#10	2.00	89		
#20	0.64	82		
#40	0.42	65		
#60	0.25	49		
#100	0.15	40		
#200	0.075	35		

	·· · · · ·							
Coeff	icients							
D ₈₅ =1.1764 mm	D ₃₀ == N/A							
D ₆₀ =0.3555 mm	D15 = N/A							
D ₅₀ =0.2544 mm	$D_{10} = N/A$							
$C_u = N/A$	Cc =N/A							
Classif	lication							
ASTM N/A								
AASHTO Silty Solis (A-4 (0))								
Sample/Tes	t Description							
Sand/Gravel Particle Sha	ape : ROUNDED							
Sand/Gravel Hardness :	HARD							
ł								

GeoTesting express a subsidiary of Geocomp Corporation Boring ID: B Sample ID:S

Client: GEI Con	sultants	and the second second			
Project: Brookha	ven National La	aboratory			
Location: Upton, N	IY			Project No:	GTX-6864
Boring ID: B-203		Sample Type	e: bag	Tested By:	mll
Sample ID:S-3		Test Date:	05/14/07	Checked By:	jdt
Depth: 4-6 ft		Test Id:	111382		
Test Comment:					
Sample Description:	Moist, light y	ellowish brown	silty sand		
Sample Comment:					



Siève Name	Sieve Size, mm	Percent Finer	Spec. Percent Complies
1/2 Inch	12.70	100	
3/8 Inch	9.51	96	
#4	4.75	91	
#10	2.00	86	
#20	0.84	78	
#40	0.42	62	
#60	0.25	42	
#100	0.15	25	
#200	0.074	13	

Coefficients									
D ₈₅ =1.8062 mm	D ₃₀ =0.1753 mm								
D ₆₀ =0.4064 mm	D15=0.0822 mm								
D ₅₀ =0.3087 mm	D ₁₀ =0.0601 mm								
$C_u = N/A$	Cc =N/A								
Class	sification								
ASTM N/A									
AASHTO Silty Gravel and Sand (A-2-4 (0))									
Sand/Gravel Particle S	Sample/Test Description								
Sand/Gravel Hardness	: HARD								

:

GeoTesting e x p r e s s a subsidiary of Geocomp Corporation

Client:	GEI Cons	ultants				
Project:	Brookhav	en National La	boratory			
Location:	Upton, NY	(Project No:	GTX-6864
Boring ID:	B-204		Sample Type	: bag	Tested By:	mll
Sample ID	:S-1		Test Date:	05/14/07	Checked By:	jdt
Depth :	0-2 ft		Test Id:	111383		
Test Comn	nent:	P##				
Sample De	scription:	Moist, olive b	prown silty sand	t		
Sample Co	mment:					
	Client: Project; Location: Boring ID: Sample ID Depth : Test Comm Sample De Sample Co	Client: GEI Const Project: Brookhav Location: Upton, N Boring ID: B-204 Sample ID:S-1 Depth : 0-2 ft Test Comment: Sample Description: Sample Comment:	Client: GEI Consultants Project: Brookhaven National La Location: Upton, NY Boring ID: B-204 Sample ID:S-1 Depth: 0-2 ft Test Comment: Sample Description: Moist, olive to Sample Comment:	Client: GEI Consultants Project: Brookhaven National Laboratory Location: Upton, NY Boring ID: B-204 Sample Type Sample ID:S-1 Test Date: Depth: 0-2 ft Test Id: Test Comment: Sample Description: Moist, olive brown silty sand Sample Comment:	Client: GEI Consultants Project: Brookhaven National Laboratory Location: Upton, NY Boring ID: B-204 Sample Type: bag Sample ID:S-1 Test Date: 05/14/07 Depth: 0-2 ft Test Id: 111383 Test Comment: Sample Description: Molst, olive brown silty sand Sample Comment:	Client: GEI Consultants Project: Brookhaven National Laboratory Location: Upton, NY Project No: Boring ID: B-204 Sample Type: bag Tested By: Sample ID:S-1 Test Date: 05/14/07 Checked By: Depth: 0-2 ft Test Id: 111383 Test Comment: Sample Description: Moist, olive brown silty sand Sample Comment:



Siéve Name	Sieve Size, mm	Percent Finer	Spec. Percent Complies
1/2 Inch	12.70	100	
3/8 Inch	9,51	99	
#4	4.75	96	
#10	2.00	91	
#20	0.84	83	
#40	0.42	55	
#60	0,25	32	
#100	0,15	20	
#200	0.074	13	

	C	oefficients							
	D ₈₅ =1.0741 mm	D ₃₀ ==0.2279 mm							
	D ₆₀ =0.4772 mm	D15=0.0912 mm							
	D ₅₀ =0.3755 mm	D ₁₀ =0.0544 mm							
	$C_u = N/A$	Cc =N/A							
1	Cl	assification							
	ASTM N/A								
	AASHTO Silty Gravel and Sand (A-2-4 (0))								
	Sample,	Test Description							
	Sanuy Gravel Paruci	e shape , Roonded							
	Sand/Gravel Hardness : HARD								

Client: GEI Consultants Project: Brookhaven National Laboratory GeoTesting Location: Upton, NY Project No: GTX-6864 express Boring ID: B-206 Sample Type: bag Tested By: mll a subsidiary of Geocomp Corporation Sample ID:S-4 Test Date: 05/15/07 Checked By: jdt 111385 Depth : 6-8 ft Test Id: Test Comment: Moist, reddish brown silty sand Sample Description:

Sample Comment:

Particle Size Analysis - ASTM D 422-63 (reapproved 2002) 1/2 inch 3/8 inch /4 Inch #100 #200 99 # #40 #10 100 90 80 70 60 Percent Finer 50 40 30 20 ŝ, 10 0 0.001 100 10 0.1 0.01 1000 1 Grain Size (mm) % Silt & Clay Size %Gravel % Cobble %Sand 10.6 63.8 25.6 ____ Ciave Name | Store Street | Descent Elver | Spac Descent | Complet

Sleve Maille	mm	Pei Leine I III ei	Speci reitent	r.comhuica
3/4 Inch	19.00	100		
1/2 inch	12,70	96		
3/8 Inch	9,51	93		
#4	4.75	69		
#10	2.00	85		
#20	0.84	81		
#40	0.42	70		
#60	0,25	56		
#100	0,15	39		
#200	0.074	26		

	Coefficients										
	D ₈₅ =1.8829 mm	D ₃₀ =0.0928 mm									
	D ₆₀ =0.2898 mm	D15 = N/A									
	D ₅₀ =0.2083 mm	$D_{1.0} = N/A$									
	Cu =N/A	$C_c = N/A$									
	Clas	sification									
	ASTM N/A	<u>911001011</u>									
	AASHTO Silty Gravel and Sand (A-2-4 (0))										
Ì	Sample/T	est Description									
	Sand/Gravel Particle Shape : ROUNDED										
	Sand/Gravel Hardness : HARD										

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	Client:	- GEI Cons	ultants			-	
ng	Location:	Upton, N	en National L '	aboratory		Project No:	GTX-6864
	Boring ID:	B-204		Sample Type	e: bag	Tested By:	mli
oration	Sample ID	:S-5		Test Date:	05/14/07	Checked By:	jdt
	Depth :	8-10 ft		Test Id:	111384	•	-
	Test Comm	nent:				r	
	Sample De	scription:	Molst, light	olive brown silty	/ sand with g	jravel	
	Sample Co	mment:		,	-	-	

Particle Size Analysis - ASTM D 422-63 (reapproved 2002)



AASHTO Silty Gravel and Sand (A-2-4 (0))

<u>Sample/Test Description</u> Sand/Gravel Particle Shape : ROUNDED Sand/Gravel Hardness : HARD

0.25

0.15

0.075

37

23

14

#6D

#100

#200

Appendix A2

Preliminary Vibration and Acoustic Report September 15, 2006

Colin Gordon & Associates, Inc.

NSLS II Vibration and Acoustic Criteria

Vibration – Experiment Hall

The vibration limits of the experiment hall are those associated with the user-supplied research instruments, which are not well defined at this time. It may only be possible to represent the vibration requirements of this space using generic vibration criteria. The vibration needs of the vast majority of research equipment available today would be satisfied by a floor meeting vibration criterion VC-E or NIST-A.¹ At frequencies less than 20 Hz, the NIST-A criterion is more stringent than VC-E.

Vibration – Storage Ring

The vibration requirements for the storage ring have been provided in a much different manner. The RMS amplitude², R, is to be less than 20 to 30 nm, where R is defined as

$$R = \sqrt{\sum_{f=50}^{f=4} \Delta(f) \times \delta f}$$

where $\Delta(f)$ is the displacement power spectral density spectrum (in units such as m²/Hz, where the frequency term in the denominator is the measurement bandwidth) and δf is the frequency resolution of the spectrum. The lower and upper bounds of the summation are 4 and 50 Hz, respectively. Frequency components outside this range may be neglected. The vibrations associated with fluid flow should meet the condition R < 20.

Acoustic Noise

The facility will have two primary groups of noise sources: (1) the facility's mechanical systems, such as air handlers, and (2) the user-provided research equipment. The noise control associated with the first group is within the purview of the NSLS II design team, but the ability to mitigate noise associated with the second group is somewhat limited. It can be anticipated via passive room noise control measures incorporated into the design, but it cannot be controlled via mechanical constraints such as airflow velocities, fan selection, or silencers, concepts typically employed for the first group.

Studies carried out during the design of the Advanced Photon Source determined that final operational room noise in the Experiment Hall would be a mix of sound from both groups of sources, and that NC-60 to NC-65 would be achievable from a combination of

¹ Vibration criteria VC-E and NIST-A are defined in **H. Amick**, M. Gendreau, T. Busch, and C. Gordon, "Evolving criteria for research facilities: vibration," *Proceedings of SPIE Conference 5933: Buildings for Nanoscale Research and Beyond*, San Diego, CA. Criterion VC-E has a one-third octave band rms velocity amplitude of 125 microinches/sec at frequencies between 1 and 100 Hz. Criterion NIST-A has a one-third octave band rms displacement amplitude of 1 microinch at frequencies between 1 and 20 Hz and a onethird octave band rms velocity amplitude of 125 microinches/sec at frequencies between 20 and 100 Hz. ² Simply stated, *R* is the area under the displacement PSD spectrum (m²/Hz) between a lower and upper bound frequency.

mechanical system noise control measures on the proposed air handling system and room absorption made part of walls and ceiling.³ This is the noise range found in many industrial cleanrooms. In the absence of absorptive material, the noise at APS was predicted to be on the order of NC-70. In order to achieve this, the recommended noise goal of the mechanical systems alone is NC-50 to NC-55.

³ The results of the study were reported in "Acoustical Evaluation of Experiment Hall: Argonne National Laboratory", A. M. Yazdanniyaz & S. K. Bui, Acentech Report No. 56, January 1991. The noise from the experimental equipment was included in the model via sound power estimates based on measurements made at NSLS in 1989 by Acentech Incorporated as part of the APS design effort, reported in "Measurement of Noise and Vibration: National Synchrotron Light Source, Brookhaven National Laboratory", Hal Amick & Colin G. Gordon, Acentech Report No. 11, June 1989.

Site Vibration Study

Figure 1 shows an aerial photograph of the portion of the BNL complex containing the NSLS II site. Nearby are the site of the Center for Functional Nanomaterials (CFN), now under construction, and the existing NSLS. Vibrations were measured at all of these locations, as well as at Location 'A' and at a remote location to the north east of the indicated portion of the BNL campus.

Figure 2 shows a plan view of the proposed NSLS II, indicating Locations 1-6 at which ambient vibration measurements were made on the afternoon of 14 June 2006.¹ Vibrations were measured at each of these locations in each of three principal directions (vertical, north-south, and east-west). Each measurement lasted approximately two minutes, and produced an energy-averaged constant-bandwidth (FFT) rms velocity spectrum with 400 data points, 0-100 Hz frequency range, Hanning windowing, and 90% overlapping. The sensor, a seismic accelerometer, was supported on a 12" steel stake with a flat top, driven into the ground such that the flat top was flush with the ground.

The data were analyzed "live" and saved as spectra to the internal memory of the portable analyzer. The spectra were downloaded to a laptop computer and subsequently post-processed to obtain one-third octave band velocity spectra and 400-line displacement power spectral density (PSD) spectra. The PSD spectra, in turn, were processed to calculate RMS displacement amplitudes using numerical summing between a lower-frequency cutoff (CO) and 50 Hz. Nominally, the lower cutoff was 4 Hz for consistency with the particle ring criterion.

As noted previously, the nominal lower cutoff was 4 Hz for consistency with the particle ring criterion. However, in some cases the spectra below 6-7 Hz was contaminated by instrumentation noise floor. As a result, all of the RMS amplitudes are reported with low-frequency cutoff of 4, 6 and 8 Hz.

Figure 2(a) and (b) show a statistical representation of the vertical and horizontal vibrations, respectively, at the NSLS II site, in terms of one-third octave band rms velocity. These measurements were made during the mid-afternoon. Shown for reference are the VC-E and NIST-A criteria.

It should be noted in Figure 2 that the vibrations easily meet VC-E, but do not meet the NIST-A requirement. A similar observation was made at the time of the CFN vibration survey, and an additional study (using measurements at Location 'A') demonstrated that the low-frequency component which exceeds NIST-A disappears at night, and is thought to be due to traffic, probably on the Long Island Expressway.

The daytime and nighttime measurements at Location 'A' are represented in Figure 4 by open and closed triangles, respectively. At frequencies of 20 Hz and greater, the

¹ At the suggestion of BNL personnel, vibrations were not measured in the wooded areas, in order to avoid ticks.

difference is visible though not as significant as that observed at frequencies near 4 Hz. The log mean of the vertical vibrations at the NSLS II site, represented in Figure 4 using diamond symbols, lies between the two Location 'A' spectra at frequencies of 10 Hz and less.

The data from the NSLS II measurement locations, as well as from Location 'A', were taken with the sensor supported on a steel stake. It is known that a "free-field" measurement made in this manner produces a spectrum with a higher amplitude at most frequencies than one made on a slab of significant size or inside a building.² Discussions of this effect in the context of the NSLS II measurements suggested the desirability of carrying out vibrations inside a building with a similar thick slab, at night when the vibrations were at their least. The vertical spectrum obtained in this manner in the partially-completed microscopy suite in CFN is shown with circle symbols, and is thought to be representative of the performance of the eventual nighttime performance of the Experiment Hall slab in NSLS II.

The constant-bandwidth FFT velocity spectra saved to the portable analyzer and downloaded to a spreadsheet on a laptop were transformed to rms displacement spectra by dividing each point in a spectrum by 2π times the frequency of that point. The rms displacement spectra were then transformed to displacement PSD spectra by squaring the amplitude and dividing each squared amplitude by the measurement bandwidth (0.375 Hz). The statistical displacement PSD spectra are shown in Figure 5(a) and (b), for vertical and horizontal vibration, respectively. The log mean (the heavier red line) will be used for comparative purposes in a discussion that will follow.

As noted previously, the vibration criterion for the ring is defined in terms of *R*, the area beneath the PSD spectrum $\Delta(f)$ between cutoff frequencies f_1 and f_2 , defined as 4 and 50 Hz, respectively. For the discrete spectra being used in this study, this may be defined as

$$R = \sqrt{\sum_{f_2=50}^{f_1=4} \Delta(f) \times \delta f}$$

where δf is the frequency resolution of 0.25 Hz. However, it was observed during postprocessing that some of the spectra were contaminated by system noise at low frequencies (found after the fact to be due to connection noise in a cable), so values of *R* were calculated using additional f_1 frequencies of 6 and 8 Hz. The *R* values are summarized for the NSLS II site in Table 1. When the lower cutoff frequency f_1 is set to 4 Hz, the RMS quantities do not meet the criterion of 30 nm specified by BNL, but when f_1 is increased to 6 Hz, the quantity is within the prescribed limits. As noted previously, the PSD content at frequencies below 6 or 7 Hz is thought to be due to system noise, not actual vibration.

² H. Amick, T. Xu, and M. Gendreau, "The Role of Buildings and Slabs-on-Grade in the Suppression of Low-Amplitude Ambient Ground Vibrations," *Proc.* 11th Intl. Conf. on Soil Dyn. & Earthquake Engng. (11th ICSDEE) & the 3rd Intl. Conf. on Earthquake Geotech. Engng. (3rd ICEGE), 7-9 January, 2004, Berkeley, CA.

Supplemental measurements were carried out on 31 Aug 2006 and 1 Sept 2006. The results of those measurements, along with some taken at Location 'A' for the CFN site study, are summarized in Table 2. The most important data are likely those taken in the microscopy lab at CFN, where the RMS amplitudes at both measurement times are 20 nm or less, in any direction. (The amplitudes calculated using 6 Hz and 8 Hz cutoff frequencies are shown for interest, but the CFN space meets the most stringent interpretation of the NSLS II criterion. This demonstrates that the building effect impacts the RMS amplitude, as well as the one-third octave band spectrum (shown in Figure 4).

Vibrations were measured on the floor at Beam Line X1 in NSLS, around midnight, to provide a comparison with the vibrations measured in CFN. These results are also shown in Table 2, as Location 9. The difference between the two is quite dramatic, 71 nm for NSLS compared to 20 nm in CFN. (The same low-noise setup was used in both cases.)

BNL provided collected PSD spectra measured at several other light source facilities. The log mean PSD for the NSLS II site are shown superimposed on these data in Figure 6. The arrow indicates the NSLS II spectrum. It should be noted that the data from other facilities represent several different quantities of data points (the present data containing 200 points between 0 and 50 Hz) and quantity of averages. Either a smaller number of data points or a greater number of averages (or both) will produce a smoother spectrum. (For example, the vertical PSD spectrum from ESRF (shown in red) contains a very large number of data points, but most likely resulted from less than five spectra being averaged.) However, it is the fundamental nature of PSD spectra that spectral amplitude of stationary random vibration is roughly independent of bandwidth.

The data in Figure 6 initially suggest a rather unfavorable comparison between the NSLS II site and the other light sources. This was one of the reasons that nighttime data were subsequently measured in NSLS and CFN, such that the presence of a building could be taken into consideration, and at a remote location on the BNL property, so that proximity to the campus energy sources could be removed from consideration.

Data measured at the following locations were used for comparison:

- Microscopy suite of CFN, under construction
- Foundation of a light standard near CFN, prior to installation of the pole; this may be considered a "free-field" location, unstiffened by the presence of the building
- The floor of NSLS, directly beneath Beam Line X1 in the Experiment Hall
- A remote location near the northeast corner of BNL campus, on a hard surface at the center of a fire access road

Figure 7 shows the vertical Log Mean of site vibrations at NSLS II site (red curve marked by red arrow), expressed as PSD, compared with similar data from ALS, ESRF and SPRING-8 (using data provided by BNL). Shown also are PSD spectra measured at NSLS Beam Line X1 just after midnight, the "free-field" location near CFN, and the microscopy suite at CFN (identified by the black arrow). The vertical red dashed line

indicates 4 Hz. The legend indicates the RMS amplitude using summation between 4 and 50 Hz, except for the NSLS II log mean, which is summed with a 6 Hz lower cutoff.

The vibrations near Beam Line X1 lie well above all the others, particularly at frequencies associated with rotating mechanical equipment, such as 18 Hz and 30 Hz. The data from the CFN microscopy suite lies below all the other BNL locations and ties with ALS for the -lowest RMS amplitude, at 20 nm.

Figure 8 compares the "best" BNL location—the CFN microscopy suite—with Location 'A' measured night using a stake and with the remote location simply measured on a road surface at noon. In this comparison, the remote location lies somewhat higher than the CFN spectrum at frequencies less than 8 Hz, but lies well below it at frequencies between 10 and 25 Hz. Recall from Figure 4 that there was a reduction factor of 3 to 5 times (in terms of amplitude) at frequencies below 8 Hz. In terms of power (i.e., PSD) this reduction factor becomes 9 to 25 times, which would suggest that the *surface* nighttime vibration at the remote location. Even though vibrations were not measured at night at the remote location, it is suggested that there is a cultural effect in the diurnal vibrations on the BNL campus, and that a remote site farther from the utility plant and the expressway might be worthy of consideration as design progresses.

The vibration study indicates that following the installation of the ring structure and experiment hall, which will significantly stiffen the site, the vibration environment will be comparable to that of other light source facilities. Additional modeling studies are recommended as the design progresses to examine the building and slab effect in greater detail, as much of the published experience deals with rectangular buildings, rather than toroidal. The dynamics are likely to differ to some extent.

Greater insight would be gained from carrying out a continuous vibration survey of 24 hours or more, in order to better document the diurnal variation of vibration at the site. This could be done at the ring site, using simultaneous multiple recording locations distributed around the ring. With data taken simultaneously, it may be possible to glean additional insight into the mechanism(s) and source(s) involved in the vibrations between 1 and 10 Hz.

The researchers may also benefit from a statistical representation of the temporal variation of vibration.³

³ This is discussed at length in H. Amick, M. Gendreau, & N. Wongprasert, "Centile spectra, measurement times, and statistics of ground vibration," *Proceedings of the Second International Symposium on Environmental Vibrations: Prediction, Monitoring, Mitigation and Evaluation (ISEV2005)*, Okayama University, Okayama, Japan (20 to 22 September 2005)

Location	Desition		Vertical		North-South			East-West			
Location	rosition	f_1 :	4 Hz	6 Hz	8 Hz	4 Hz	6 Hz	8 Hz	4 Hz	6 Hz	8 Hz
1	8 o'clock		69	29	23	45	23	19	35	24	21
2	10 o'clock		52	29	24	37	25	22	42	28	25
3	11 o'clock		43	26	20	30	20	17	29	19	16
4	1 o'clock		44	30	26	34	25	21	33	25	21
5	2 o'clock		36	26	22	30	23	21	46	36	33
6	7 o'clock		30	21	18	26	16	12	26	13	10

 Table 1. Summary of RMS amplitudes at NSLS II site, mid-afternoon

Table 2. Summary of RMS amplitudes at supplemental locations, various times

Location	Description	Time		Vertical			North-South			East-West		
Location	Description	1 mie	f_1 :	4 Hz	6 Hz	8 Hz	4 Hz	6 Hz	8 Hz	4 Hz	6 Hz	8 Hz
7	Microscopy Lab in CEN	730pm		20	15	14	12	8	7	19	9	7
/	Microscopy Lab III CFN	1120pm		20	14	13	11	6	5	13	7	6
8	Free-Field, Foundation of Light Standard at CFN	1140pm		24	19	17	41	37	35	38	35	34
9	Beam Line X1 at NSLS	Midnight		71	48	42	12	9	8	13	9	7
10	Remote Site, on Wellhead	Noon		24	12	8	27	16	15	33	15	10
11	Remote Site, on Road	Noon		21	9	6	25	14	12	26	12	9
12	Location "A"	315pm		80	53	46						
	Location A	1030pm		35	29	27						



Figure 1. Aerial photograph of a portion of BNL showing approximate location for NSLS II and other relevant locations



Figure 2. Site plan showing approximate location of NSLS II and the measurement locations used in this study



Figure 3. Statistical representation of daytime ambient site vibrations at Locations 1-6, NSLS II site



Figure 4. Comparison of one-third octave band vibrations at the NSLS II site, Location 'A', and at night in the CFN microscopy suite.



Figure 5. Statistical representation of daytime ambient site vibrations at Locations 1-6, NSLS II site, in terms of displacement power spectral density (PSD), 1-100 Hz





Figure 6. Log Mean of site vibrations at NSLS II site, expressed as PSD, compared with other sites (data for other sites provided by BNL)



Figure 7. Log Mean of site vibrations at NSLS II site, expressed as PSD, compared with other sites (data for other sites provided by BNL) and with NSLS Beam Line X1, Free-Field at CFN, and the microscopy suite at CFN.

PSD - Vertical Ground Motion


Figure 8. Comparison of PSD vibrations at three alternate reference locations, including Location 'A' and CFN Microscopy, both at night, and the remote location at noon.

PSD - Vertical Ground Motion

Vibration and Acoustic Design Issues

Utility Distribution

Two utility concepts were examined during the course of this review. One was a distributed system along the lines of that used for APS, where the air handlers are placed at locations around the ring, perhaps along the outside of the experiment hall as at APS. The other concept was a centralized system, where the air handlers are placed at a central location and air distribution is via ducting. Each approach offers arguments pro and con, but examination of the issues specific to BNL philosophy and the proposed NSLS II layout led toward the centralized system.

From a vibration perspective, the difference between the two concepts lies in the amount of energy present in a concentrated area. (The distributed system works with a larger quantity of smaller air handlers, thus the maximum horsepower at any location near the ring is less, so there is a lower risk in placing the units closer to the ring.) However, a centralized system offers maintenance benefits, and the primary vibration control design issues become those of distance and conservative vibration isolation. It is important to maximize the distance between the air handlers themselves and the ring, though this will affect energy efficiency. A careful study of tradeoff between these two variables is recommended as design progresses.

A preference has been expressed to avoid vibration isolation on piping and ducting as much as possible. An important reason for this is that isolation works on the concept of exploiting a low resonance frequency of a sprung mass (the duct or pipe on a spring) and the random vibration energy in the duct or pipe is shifted to very low frequencies. Because the ring is sensitive to displacement, particularly at low frequencies, this is not a desirable feature. The alternatives for vibration control include low duct and pipe velocities (i.e., larger diameters) and long straight runs of mains. Both of these concepts can easily be incorporated as the design progresses.

Isolation of the Experiment Hall floor from the Ring tunnel floor

The outer corridor of the Experiment Hall will be separated from the floor slab of the Experiment Hall by means of a joint in the slab, following the APS model. This decouples the public corridor, which has pedestrian activities and deliveries, from the more vibration-sensitive Experiment Hall area.

Concerns have been expressed regarding the connectivity of the Tunnel and the floor of the Experiment Hall. This is not as simple a decision as that to decouple the outer corridor. The argument in favor of a joint is similar: it is desirable to mitigate "humming" and other vibration that might be generated by the equipment associated with the ring. The argument against a joint is that it introduces the risk of differential settlement between the Tunnel and Experiment Hall, which could cause a small, though quasi-static, beam misalignment.

The thick concrete slab of the Experiment Hall and Tunnel together will offer some improvement of the ground surface that might not be as dramatic if it is actually two ring slabs, one inside the other. This is an issue that can be addressed analytically as the design progresses.

An option worthy of consideration is the use of a damping admixture in the concrete beneath the ring. It would help to dissipate the high-frequency "humming" vibration. It could be placed as a topping on the concrete, as done in mechanical corridors at CFN. An unknown that would require evaluation is the severity of the radiation and how the polymer would respond to that radiation.

Acoustics of Experiment Hall

The Experiment Hall is a large open area which will have a vast quantity of user-supplied noise sources. A noise study was carried out in 1989 as part of the APS design effort, in part to develop a "typical" source sound power spectrum for design of the APS Experiment Hall.¹ At that time, the average noise level was found to be 69 dBA, though noise levels as high as 80 dBA were measured. It was assumed that the experiments themselves were not adversely affected (as noise protection could be built into the hutches), but the noise environment in the hall was a detriment to speech communication and contributed to researcher fatigue.

It might be worthwhile for BNL to consider imposing a limit on the allowable sound power associated with user-supplied equipment. However, the most proactive move is probably to use acoustically absorbent materials on walls and ceiling. The latter is relatively straightforward, by means of an acoustically absorbent roof deck. There are number of manufacturers of the product. Essentially it is a corrugated decking in which the grooves (as seen from above) are perforated and filled with acoustical material. The high spots are surfaces for supporting roofing or sheeting that supports concrete roof system. You can get very good performance from these systems. A facility with this kind of decking is the Experiment Hall at the Center for Advanced Microstructures and Devices (CAMD) at Louisiana State University. Some of the vendors of this product are Versa-Dek, United Steel Deck, and Vulcraft. A noise study should be carried out as the design progresses to the point that the mechanical system noise can be combined with the sound power for the research equipment.² That study can develop specific recommendations regarding the NRC of the decking and wall coverings and the optimal percentage of wall covering.

¹ Amick, H., and C. G. Gordon, "Measurement of Noise and Vibration, National Synchrotron Light Source, Brookhaven National Laboratory", Acentech Report 11 (June 1989).

² Sound power data for typical NSLS equipment were reported in "Acoustical Evaluation of Experiment Hall: Argonne National Laboratory", A. M. Yazdanniyaz & S. K. Bui, Acentech Report No. 56, January 1991. The noise from the experimental equipment was included in their noise model via sound power estimates based on measurements made at NSLS in 1989, see Acentech Report 11.

Appendix A3

Preliminary EMI/RFI Site Assessment Study Report September 1, 2006

VitaTech Engineering, LLC

VitaTech Engineering, LLC

EMF Measurements, Surveys & Risk Assessment EMF Mitigation - Shielding & Cancellation E-mail: lvitale@vitatech.net Homepage: www.vitatech.net

September 1, 2006

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Tel: (402) 399-4908

Subject: Future NSLS-II Brookhaven Labs EMI/RFI Site Assessment Study

Dear Mr. Jamison:

VitaTech Engineering was engaged by HDR to perform an EMI/RFI Site Assessment Study for the future NLSL-II building site located at Brookhaven Labs in Long Island, New York. The EMI/RFI data contained in this report was recorded on 14 June 2006 by the author of this report and Mr. Eric Friedlein of VitaTech Engineering. The proposed NSLS-II site has underground distribution circuits traveling east-west along Brookhaven Avenue and other electrical feeders west of Seventh Avenue running north-south. VitaTech must return in late September to record additional RF data from the NEXRAD Dopper Radar 2200 ft. from the site.

AC ELF Electromagnetic Interference (EMI)

Electron microscopes (SEMs, TEMs, STEMs), Focus Ion Beam (FIB) writers and E-Beam Writers are very susceptible to AC ELF (extremely low frequency) 3 Hz to 3000 Hz magnetic fields emanating from various electrical power sources outside of the NLSL-II building and within. VitaTech recommends a maximum of 1 mG Br (resultant) RMS AC ELF magnetic flux density emissions for NMRs and MRIs, 0.3 mG Br (resultant) RMS AC ELF magnetic flux density emissions for Cleanrooms and 0.1 mG Br (resultant) RMS AC ELF magnetic flux density emissions for SEMs, TEMs, STEMs, FIBs and E-Beam Writers as shown in the Chart #1 below:



Chart #1, Recommended EMI AC & DC Magnetic Performance Specs

Electromagnetic induction occurs when time-varying AC magnetic fields couple with any conductive object including wires, electronic equipment and people,

thereby inducing circulating currents and voltages. In unshielded (susceptible) electronic equipment (computers monitors, video projectors, computers, televisions, LANs, diagnostic instruments, magnetic media, etc.) and signal cables (audio, video, telephone & data), electromagnetic induction generates electromagnetic interference (EMI), which is manifested as visible screen jitter in displays, hum in analog telephone/audio equipment, lost sync in video equipment and data errors in magnetic media or digital signal cables.

Placement of each scientific tool and instrument depends on the actual EMI susceptibility under defined thresholds, which are often not easy to ascertain from the manufacturer's performance criteria. Magnetic flux density susceptibility can be specified in magnetic field strength (A/m) or in milligauss (mG) using one of three magnetic flux density terms: Brms, Bpeak-to-peak(Bp-p) and Bpeak (Bp) according to the following conversion formula below.

$$B_{rms} = \frac{Bp - p}{2\sqrt{2}} = \frac{Bp}{\sqrt{2}}$$

To convert magnetic field strength to units of milligauss (mG), simply multiple the magnetic field strength by 4π . For example, 3 A/m is equal to 37.7 mG (3 x 12.57 = 37.7 mG). Using simulated emission profiles and the correct conversion formula, it is possible to identify the appropriate levels acceptable for each tool *if the correct EMI susceptibility figure can be ascertained from the manufacturer's specifications. Therein, lies the real EMI challenge.*

Generally, for AC ELF sources the minimum EMI threshold is 10 mG in unshielded electronic equipment, especially 14" to 17" CRT color computer monitors and analog signal cables; however, the AC ELF EMI threshold for high-resolution 17" to 21" CRT color monitors is only 5 mG. *Analog audio/video equipment and cables are susceptible to EMI noise less than 5 mG including diagnostic medical instruments such as EEGs, EKGs, EMGs, ECGs, and other electrode contract devices.*

The semiconductor industry has specified AC EMI threshold performance requirements in SEMI E33-94, Specification For Semiconductor Manufacturing Facility Electromagnetic Compatibility, as shown below in Chart #2 - The AC ELF EMI Threshold Charts:

Chart #2 – AC ELF EMI Threshold Chart



AC ELF EMI Recorded Data & Assessment

On 14 June 2006 VitaTech recorded lateral AC extremely low frequency (ELF) magnetic flux density levels at 1-meter above grade with a survey wheel and the FieldStar 1000 gaussmeter (see Test Instruments for details) within the proposed NLSL-II building site. The following is an AC ELF magnetic flux density assessment of the RMS recorded data:

Figure #1 shows five lateral Hatch Plots recorded across the proposed NLSL-II building site. Each lateral data path has four color hatch marks (0.1 mG, 0.25 mG, 1.0 mG and 5.0 mG) representing the threshold level recorded at each one-foot interval (no hatch marks indicate levels less the 0.1 mG). Figure #2 presents five Profile Plots of the Figure #1 Hatch Plots with resultant Br (black) levels and three Bx (red), By (green) and Bz (blue) components shown as a function of distance.

The three north-south laterals (records #1 - #3) in Figures #1 and #2 shows the recorded magnetic fields emanating from the east-west underground distribution lines on Brookhaven Avenue (peaks 1.5 to 3.4 mG). The three north-south laterals rapidly decay to less than 0.1 mG 75 to 100 feet from the Brookhaven Avenue south curb. The levels were also very low along the east-west lateral in the center of the field rapidly decaying to 0.00 mG between Seventh and Fifth Streets except within 75 feet south of Brookhaven Avenue. The proposed NLSL-II site has very low AC ELF magnetic flux density levels 75 feet south of Brookhaven Avenue, ranging from 0.1 mG to 0.00 mG as shown in the five Figure #2 Lateral Profile Plots.

Figure #3 shows the timed wideband 3 Hz to 3,000 Hz AC ELF magnetic flux density field levels at the proposed NLSL-II site recorded with the MultiWave System II three axis fluxgate magnetometer sampled at 15 second intervals for 42 minutes. The timed Br resultant peak was 0.192 mG with an average 0.18 mG over the 42 minute period: this is the noise floor of the MultiWave System II where the actual levels are below the recording range. Therefore, the actual timed levels are 0.0 mG at this distance (200 - 250 ft) south of Brookhaven Ave.

Conclusions: The recorded AC ELF magnetic flux density emissions were very low ranging from 0.1 mG at 75 to 100 feet south of Brookhaven Avenue rapidly decay to 0.00 mG at 100 feet all the way to the other side of the site including the wooded areas. The NSLS-II site complies with all four of the following AC ELF magnetic flux density performance requirements 100 feet south of Brookhaven Avenue between Seventh and Fifths Streets:

- 0.01 to 0.1 mG EMI threshold for ultrahigh resolution STEMs;
- 0.1 to 0.3 mG EMI threshold for scientific tools (i.e., SEMs, TEMs, FIB, E-Beam Writers, etc.);
- 0.25 mG Level A SEMI E33-94 AC ELF EMF Standard; and,
- 10 mG long-term human exposures threshold recommended by the Swiss Bunderstat and NCRP Draft Report (see AC ELF Magnetic Field Health Issues, Standards & Guidelines)

Ground/Net Current Issues

Ground and net currents are due to N.E.C. violations (i.e., grounded neutrals, wiring errors, etc.) in the electrical service, distribution and grounding systems of a building and N.E.S.C. violations (i.e., grounding problems, etc.) on distribution and transmission lines. Unbalanced phases on medium voltage distribution lines and 480V/208V low-voltage feeders generate zero-sequence currents, which return on the neutrals and grounding conductors. Most utilities maintain 5% and less unbalanced phases on high voltage transmission lines and 10-15% unbalanced phases on distribution lines (power quality issues) except in local neighborhoods where unbalanced phases may exceed 20%. A percentage of the zero-sequence neutral currents on distribution lines travel along other electrically conductive paths (i.e., underground water pipes, earth channels, grounded guy wires, building neutrals/grounding systems, etc.) back to the substation. If all the zero-sequence currents were to return via the multi-ground neutral system (MGN) wire mounted on the pole under the three phase conductors (sum of all phase and neutral currents are zero), then the magnetic fields would decay at the normal inverse square rate $(1/r^2 \text{ in meters})$ from the single-circuit distribution line (same for transmission lines and low-voltage feeders). However, if only a fraction of the zero-sequence current returns on the MGN system or low-voltage neutral conductor, then there is a net current missing (amount of current returning via other paths) – this net current emanates a magnetic field similar to a ground current (electrical current of low voltage returning on a ground wire, water pipe or other conductive path) that decays at a linear 1/r (in meters) rate based upon the following formula:

$B_{mG} = 2(I)/r$ where I is amps and r meters

Magnetic fields from ground and net (zero-sequence) currents decay at a slow, linear rate illustrated below, using a 5 amp ground/net current source: 10 mG is 1 m away, 1 mG is 10 m away, 0.5 mG is 20 m away and 0.1 m is 100 m away:



Since there is a proportional relationship between current load and magnetic flux density levels, the above chart can be used to predict the emission levels based upon ground/net current loads. Using 2.5 amps of ground/net current, the levels above the selected decay distance are calculated by dividing by 2, which is 50% of 5 amps. The ground/net current decay chart is indispensable in ascertaining the acceptable operating distance from ground and net (zero sequence) currents based upon a specified instrument performance criteria (i.e., 1 mG, 0.1 mG or 0.01 mG).

Ground and net current magnetic field emissions are difficult to shield using flat or L-shaped ferromagnetic and conductive shields -- the most effective shielding method for AC ELF ground/net current emissions requires a six-sided, seam welded aluminum plate shielding system with a waveguide entrance. *Finally, low ambient magnetic field levels can be achieved inside a research laboratory and imaging suite* by adhering to the N.E.C. and good wiring practices. However, these low levels can only be achieved under the most pristine conditions and without any circulating ground/net currents present on the primary electrical distribution system outside of the building, low-voltage 480/208V distribution feeders and branch circuits inside the building systems and the grounding system.

DC Electromagnetic Interference (EMI)

Large and small ferromagnetic masses in motion such as elevators, cars, trucks, trains, subways and metal doors produce geomagnetic field perturbations in the sub-extremely low frequency (SELF) 0 - 3 Hz band that radiate (similar to throwing a pebble in a pond) from the source generating DC electromagnetic interference (EMI) in sensitive scientific tools and instruments. The magnitude of the geomagnetic field perturbation and radiated distance from the source depends on the size, mass and speed of the moving ferromagnetic object. Theoretically, DC magnetic emission sources (i.e., ferromagnetic objects, magnets, etc.) decay according to the inverse cube law, in practice the decay rates are not ideal. Other problematic DC EMI sources include traction currents from underground/surface electric DC trolleys/subways, electromagnetic pulse (EMP) devices with high-voltage discharge, and finally unshielded NMRs and MRIs.

Electron microscopes (SEMs, TEMs, STEMs), Focus Ion Beam (FIB) writers and E-Beam Writers are very susceptible to DC EMI emissions and require clean DC environments. VitaTech recommends a maximum of 1 mG dB/dt Br (resultant) RMS DC EMI for NMRs and MRIs, 0.3 mG dB/dt Br (resultant) RMS DC EMI for Cleanrooms and 0.1 mG dB/dt Br (resultant) RMS DC EMI for SEMs, TEMs, STEMs, FIBs and E-Beam Writers as shown in the Chart #1 below:

> EMI AC & DC Magnetic Field Performance Specs NMR Maximum Requirement: 1 mG Br RMS (2.83 mG p-p) Instrument & Quite Labs Maximum Requirement: 0.1 mG Br RMS (0.3 mG p-p) Cleanrooms Maximum Requirement: 0.3 mG Br RMS (0.1 mG p-p)

Chart #1, Recommended EMI AC & DC Magnetic Performance Specs

Placement of scientific tools depends on the actual DC EMI susceptibility under defined thresholds, which are often not easy to ascertain from the manufacturer's performance criteria. Electron microscopes are sensitive at 1 mG Brms from DC disturbances while SEMs and TEMs such as the TEM JOEL 2010 have 0.4 mG horizontal and 0.2 mG vertical performance requirements while next generation EM tools are less than 0.1 mG Brms and Super STEMs (also known as ultra-high resolution STEMs) have a 0.01 mG DC EMI threshold. DC susceptibility in typical 1.5 to 4 Tesla MRIs can range from 1 mG to over 0.5 Gauss depending on the

magnetic field strength, resolution and type (open vs. closed, active shielding, etc.). Furthermore, to ensure a safe working environment around MRIs and NMRs, adequate signage must be posted at 5 and 10 Gauss lines to warn staff and visitors with implantable devices and to minimize inadvertent data corruption (coercivity) of credit cards and other valuable magnetic media. Below is a list of DC EMI Thresholds in Gauss that will impact CRT displays, electronic instruments and magnetic media:

Chart #3 – DC EMI Threshold Chart

DC EMI Thresholds - CRT screen shift, noise & coercivity (data errors) 0.001 Gauss & Less SEMs, TEMs E-Beam/FIB Writers 0.75 Gauss CRT Monitors & Electronic Instruments 5 Gauss Cardiac Pacemakers & Implantable Devices Warning Sign 10 Gauss Credit Cards & Magnetic Media Warning Sign 300 Gauss Low Coercivity Mag-Stripe Cards 700 Gauss High Coercivity Mag-Sripe Cards & Video Tapes 1000 milligauss (mG) = 1 Gauss (G) & 1 mG = 0.001 G = 0.1 uT (microtesla)

According to the National Geophysical Data Center (NGDC), the average Br resultant DC magnetic flux density level at Brookhaven National Labs is 528.5 mG at 0 ft. elevation. Depending on the location and distance from ferromagnetic materials (pipes, steel beams, rebar, cars, etc.), the recorded average time DC Br resultant RMS levels at the site was 536.9 mG (see Figure #3), which is only a 8.4 mG differential.

Moving Vehicle DC EMI Emission Profiles & Impact

As discussed the DC EMI emissions from moving vehicles (cars, SUVs, VANs, trucks and busses), and trains can compromise sensitive research tools. Normally, VitaTech recommends adequate spacing between the proposed building site, roads with heavy traffic, parking garages, trains, subways and other DC EMI emission sources to minimize potential EMI problems with sensitive instruments and tools.

Figure #4 shows the timed (15 second interval) resultant (Br) and component (Bx, By and Bz) RMS DC data recorded with the MultiWave System II three-axis fluxgate magnetometer more than 200 feet from Brookhaven Avenue. The only noticeable DC dB/dt EMI data was generated from an SUV that drove up to our location (200 - 250 feet south of Brookhaven Avenue) within 10 feet of the fluxgate probe. The Br resultant chart shows a 4 mG dB/dt square pulse from the SUV vehicle as it approached the fluxgate probe.

VitaTech recorded timed DC EMI data from moving vehicles at the University of Florida several years ago as shown in Figure #5. Calculated car and bus vehicle profiles were generated by applying the decay data to Curve Fitting software – this data was overlaid on the NSLS-II site plan. Similarly, the vehicle decay chart should be used to evaluate the DC EMI impact from cars driving on Brookhaven Avenue and Seventh/Fifth Streets adjacent to the proposed site. It should be noted that in practice the magnetic fields decay more rapidly after 30 meters than the calculated levels indicate (see recorded data). Nevertheless, the calculated DC

differential dB/dt emissions from a moving bus at 40 meters would be 0.2 mG while in practice the actual bus levels will be less than 0.1 mG.

Conclusions: Standard resolution imaging tools with dB/dt differential DC EMI resultant RMS thresholds of 1 mG to 0.1 mG can be located between 12 meters (40 ft) to 40 m (131.2 ft) south of Brookhaven Avenue assuming cars and busses are moving east and west. High resolution imaging tools with differential dB/dt DC EMI resultant RMS thresholds of 0.1 to 0.01 mG can be located from 40 m (131.2 ft) to 60 m (197 ft.), which is the predicted 0.01 mG isoline) south of Brookhaven Avenue. Similar separation distances are required from the north-south Seventh and Fifth streets to ensure adequate DC EMI immunity for moving vehicles of similar mass.

Radiofrequency Interference (RFI)

The Federal Communications Commission (FCC), not the local municipal zoning authorities or law enforcement, has legal jurisdiction over radiofrequency Simply stated RF devices (intentional and unintentional interference (RFI). emitters) are not permitted to cause RFI with other radio services, electronic equipment and systems. At present, there are no mandated radiofrequency interference (RFI) susceptibility government standards in the United States. The only equipment susceptibility standards that exist are unique to equipment (quality control) internal standards written by equipment manufacturers based on radiated emission standards for intentional radiators set forth by the FCC. In other words, an equipment manufacturer in United States must design the equipment to function properly within a radiated emission field level from intentional radiators set forth by the FCC, Part 15. Like any other communications facility, wireless broadband facilities must comply with these FCC limits. The following FCC parts apply to electromagnetic interference (EMI) and radio frequency interference (RFI) conducted and radiated emissions (see below):

Radio Frequency Devices - Part 15 Multipoint Distribution Service - Part 21, subpart K Paging and Radiotelephone Service - Part 22, subpart E Cellular Radiotelephone Service - Part 22, subpart H Personal Communications Services - Part 24 Satellite Communications - Part 25 General Wireless Communications Service - Part 26 Wireless Communications Service - Part 27 Radio Broadcast Services - Part 73 Experimental, auxiliary, and special broadcast and other program distributional services - Part 74 Experimental Radio Service - Part 5 Stations in the Maritime Service - Part 80 Private Land Mobile, Paging Operations - Part 90 Private Land Mobile, "Covered" Specialized Mobile Radio - Part 90 Amateur Radio Service - Part 97 Local Multipoint Distribution Service - Part 101, subpart L

Mobile and portable devices used as follows: Cellular Radio Service Personal Communications Service Satellite Communications Branch General Wireless Communications Service Wireless Communications Service Maritime Service "Covered" Specialized Mobile Radio Service

In Europe, there are susceptibility (radiated immunity) standards, such as the EN 61000-6-1, that states 3 V/m level for residential electronic equipment, while 10 V/m is standard for industrial electronic equipment in the EN 61000-6-2. Engineers in the United States utilize the European susceptibility standards as a guideline. The SEMI E33-94 EMC Standard is 10 V/m and 3 V/m depending on frequency (see below):

 $Chart\,\#4-RFI\ Threshold\ Chart$



RFI Electric Field Strength Site Assessments & Conclusions Timed Wideband 100 kHz – 18 GHz RF Electric Field Strength Data

VitaTech recorded timed RF electric field strength data in volts-per-meter (V/m) was recorded at 1-meter above grade from 100 kHz to 3 GHz and 3 MHz to 18 GHz at 0.4 second intervals for two 10 minute periods on 14 June 2006 as shown in Figures #6 and #7. A summary of the 14 June 2006 recorded RF electric field strength levels are presented in Tables #1 and #2 below:

Table #1: 100KHz - 3GHz RF Data 14 June 2006

Max

(V/m)

0.31

Site

NSLS-II

Table #2: 3MHz - 18GHz RF Data 14 June 2006

-				II UUI		
	Min	Average		Max	Min	Average
	(V/m)	(V/m)	Site	(V/m)	(V/m)	(V/m)
	0.00	0.12	NSLS-II	0.25	0.0	0.12

Tables #1 and #2 present 20 minutes of recorded RF electric field strength at the NSLS-II site as shown in Figure #6. These are very low RF electric field strength levels considering the NEXRAD Doppler Weather Radar is only 2200 ft. away from the site, therefore the radar was not operational or under low power during data collection. Figure #7 shows the maximum electric field strength thresholds recorded during two ten minute sampling periods. Again, very low maximum peak

threshold levels were recorded from 100 kHz to 3 GHz and from 3 MHz to 18 GHz indicating the radar was not operational or under low power during the testing.

The NEXRAD Doppler Radar transmitter frequency range is 2.7 to 3.0 GHz with a peak output power of 750 kW (pulse width - short at 1.57 microsecond and 4.5 microsecond wide) from an S-Band center-feed parabolic dish (28 ft. outsidediameter) with a 0.95 degree pencil beam, 6 RPM azimuth rate and -1 to +20 degree elevation. VitaTech will return in late September 2006 with our new spectrum analyzer, the Narda SRM-3000 Selective Radiation Meter, to record the electric field strength and FCC Bulletin 65 (MPE) maximum permissible exposure levels at the proposed NSLS-II site with the NEXRAD Doppler Radar at maximum power (must be scheduled with the NEXRAD engineers and operators).

VitaTech previously recorded electric field strength levels for the Center for Functional Nanomaterials on the roof of the existing LightSpeed building. The RF emission levels around scientific tools such as the E-Beam Writers, NMRs, and Mass Spectrometers should be 20 mV/m or less. Based upon the previously recorded RF emission levels at that site, RF shielding was recommended on the façade of the Center for Functional Nanomaterials, but budgetary issues deleted the RF shielding. Nevertheless, the existing LightSource building had RFI problems from the NEXRAD Dopper Radar, and RF shielding was installed around selected laboratory and research areas to reduce the RFI problems.

<u>Center for Functional Nanomaterials RF Shielding Assessment/Mitigation Options</u> The following section was extracted from the Center For Functional Nanomaterials report on RFI shielding options. It should be noted that the estimated prices are not accurate and should be increased by 30% for budgetary reasons:

The nearby NEXTRAD Doppler Radar operates between the 2.7 to 3 GHz frequency range with up to 750 kW of effective radiated power (ERP) depending resolution and weather conditions. Building materials will provide natural shielding attenuation based upon frequency and distance from the facade facing the RF emission source. At 3 GHz the aluminum metal building façade (0.04 inches thick) would provide 50 dB to 60 dB of attenuation due to the high reflection and absorption characteristics of the exterior interlocking aluminum siding/roofing. The second floor heavy gage steel floor pans (0.034 inches thick) would add another 50 dB to 60 dB of attenuation (i.e., reflection and absorption) to the roof figures for a total of 100 to 120 dB attenuation in the vertical plane. If the east facade windows and walls were not shielded the natural horizontal attenuation factor would be 25 dB at 5 meters inside the exterior wall, over 35 dB at 10 meters, and over 60 dB at 20 meters deep inside the building. Although the east facade exterior wall is covered with aluminum panels providing at least 50 to 60 dB of attenuation, the large unshielded windows provide an open portal allowing the Doppler RF energy to penetrate deep into the building. Therefore, RF shielding the windows is necessary to minimize potential RFI problems in the adjacent ground floor laboratories.

VitaTech presents two RF window shielding options: transparent conductive RF film that can be applied to the windows when needed and conductive RF shielded glass with conductive gaskets and aluminum window frames. The best conductive RF film available is from 3M and sold under the Scotchtint trademark providing from 26 to 36 dB of attenuation depending on the type of film purchased (i.e., tint, conductivity, UV block and other parameters). When installed by professionals, the 3M Scotchtint has a 10 year warranty. It is supplied in 100 ft. by 5 ft. wide rolls costing from \$1,200 to \$1,500 per roll (not including installation) depending on the tint, shielding performance and energy rating. VitaTech provided samples of the P-18AR High Performance Silver (26 dB at 2.5 GHz) and RE35AMARL (36 dB at 2.5 GHz) to HDR several week ago. *It would cost \$40,000 - \$60,000 to install 3M RF film on 2,380 sq. ft. of windows including labor, expenses and profit.*

The other option is to use recently developed RF shielded glass "DATASTOP" sold by Pilkington and Tempest Security Systems, Inc. of Troy, OH. Shielding performance of the sealed double glazed DATASTOP windows ranged from 62 dB for the D50 with neutral tint up to 78 dB for the D60 with gold tint as shown below:



The DATASTOP double glazed windows are typically two layers of $\frac{1}{4}$ -inch thick glass separated by a $\frac{1}{2}$ -inch air gap mounted with conductive gaskets in an aluminum window frame shown below:



The basic no tint double glazed DATASTOP window costs \$60 per square foot (not including installation). It has a 10 year warranty and would provide an average of 60 dB of attenuation, which is similar in attenuation to the exterior aluminum façade and aluminum roof. RF energy may penetrate into the building interior through various holes, openings, and mechanical seams in the aluminum exterior east façade wall: any space more than a $1/2\lambda$ of 3 GHz, which is 1.95 inches in diameter (see mesh section for formula). Since the DATASTOP aluminum window frames will not be conductively bonded and/or RF sealed to the exterior east aluminum wall panels, RF penetration through any 2 inch and large space will occur around the windows, doors and other separation joints between the conductive and metallic surfaces. It would cost \$290,000 - \$325,000 to install 2,380 sq. ft. of DATASTOP D50 double glazed windows with no tint, fames and conductive gaskets including labor, expenses and profit.

Shielding the east building façade with wire mesh behind the aluminum exterior panels would significantly attenuate any RF energy leakage into thorough holes and penetrations the research laboratories while providing an extra layer of RF protection. First, the wavelength of 3 GHz must be calculated using $C = \lambda f$ where C is the speed of light (2.997 x 10⁸ m/s) and f is frequency of attenuation (3.0 x 10⁹ in cycles per second). The wavelength λ of 3 GHz is 0.0999 meters (99.9 mm or 3.9 inches) while any wavelength greater than 1/2 λ (1.95 inches) is attenuated (i.g., lower the frequency the longer the wavelength).

Next, the ideal shielding effectiveness (SE) in decibels for wire mesh is calculated where λ (lamda) is the wavelength of the incident Doppler microwave in meters and g is the airgap in meters: (SE)_{dB} = 20 log₁₀ (0.5 λ /g)

Assuming 60 dB of attenuation is the objective, than the calculated wire mesh spacing (airgap g) is 0.04995 mm (0.002 inches), which is equivalent to a 270 mesh. Only stainless steel fine mesh wire cloth is available in a 270 mesh size and is not used in RF shielding because of the difficulty in seam bonding and grounding. There are two other reasonable alternatives: 100 Mesh copper or aluminum screening. The calculated SE for 100 Mesh (0.0045 copper) with a 0.14 mm airgap is 51 dB while the measured SE is 47 dB as shown in the diagram below:



The 100 Mesh copper comes in 100 ft. rolls, 48 inches wide, and costs \$1.30 to \$1.50 per square foot (F.O.B). Aluminum 100 Mesh of the same length and width is a custom weave (must be an alloy with lower conductivity because of the needed tensile strength during the weaving process) costs \$1.50 to \$1.75 per square foot (F.O.B). The 100 Mesh copper and aluminum screens are easy to apply (staples, screws and adhesives) to the outside wall, can be mechanically bonded to the aluminum window frames using screws, and seam bonded (overlap edges and soldered) and grounded. Therefore, 47 dB of attenuation is available using the 100 Mesh copper and 40 dB using 100 Mesh aluminum alloy RF screening. It would cost \$55,000 - \$80,000 to install 5,660 sq. ft. of aluminum 100 Mesh on the exterior walls beneath the aluminum panels and mechanically bonded to the aluminum window frames including labor, expenses and profit.

VitaTech does not recommend applying copper and aluminum tapes with conductive adhesive backings over wire mesh seams, on window frames or other conductive structures because overall shielding performance will seriously degrade over time due to weathering and temperature variations. If wire mesh RF shielding is used on the east façade wall behind the exterior aluminum panels, it must be mechanically bonded to the window frames and all other metallic surfaces to ensure long-term performance with minimal failure (warning to avoid galvanic reactions only aluminum can be mechanically bonded to aluminum window/door frames).

RF Shielding Options & Estimated Costs

VitaTech presents the following RF shielding options with costs to minimize RFI interference from the nearby Doppler radar inside the new Center for Functional Nanomaterials building laboratories and offices:

Option 1: Additional RF shielding is not installed because the aluminum exterior east wall and roof building surfaces will provide at least 50 to 60 dB of attenuation coupled with the interior attenuation characteristics of the building. It should be noted that the east side 1st floor windows will provide open portals to the Doppler RF energy with only the office doors and walls to absorb and reflect the microwave energy. If RFI problems are identified and

measured in specific laboratories, localized RF shielding should be applied to the area of concern to mitigate the problem, where practical. However, two alternative RF solutions are offered below with Option 1 where improved RF shielding is required:

Alternative #1: apply 3M conductive film to 1st floor windows for additional 36 dB of attenuation for an estimated cost of \$40,000 - \$60,000 including labor, expenses and profit. Shielding performance will be marginal because the edge between the conductive window film and window frame is difficult to bond (ground). Therefore, RF leakage around the inside glass window frames will present a serious problem.

Alternative #2: to reduce RF leakage through holes and seams along windows, doors and other openings apply 5,600 sq. ft. of aluminum 100 Mesh for an estimated costs of \$55,000 - \$80,000 including labor, expenses and profit. Special Note: aluminum 100 Mesh can not be applied after exterior aluminum wall panels are installed.

Option 2: Install DATASTOP RF shielded windows, conductive gaskets and frames in ground and 2nd floor east wall façade (2,380 sq. ft. area) as shown in Figure #11. Assume conductivity with aluminum exterior wall and roof to provide a reasonable RF shielding system of 60 dB and higher. Estimated cost: \$290,000 - \$325,000 for windows, frames, gaskets including labor, expenses and profit. Additional RF shielding is required to minimize RF leakage and improve overall shielding performance:

Alternative #3: seams with minimal electrical conductivity between DATASTOP aluminum window frames and exterior east aluminum walls will cause RF leakage penetrating into the interior building laboratories – install 100 Mesh aluminum screen to ground and 2^{nd} floor walls behind aluminum panels and mechanically couple to the DATASTOP window frames RF sealing the east side of the building. Estimated cost: \$55,000 - \$80,000 for 5,660 sq. ft. of aluminum 100 Mesh includes labor, expense and profit.

VitaTech recommends shielding the east exterior wall with the DATASTOP windows and 100 Mesh aluminum screen presented in Option 2 and Alternative #3 to provide the maximum RF shielding attenuation especially with close proximity to the ground floor research labs just several feet from the east side offices. Unfortunately, the Option 1 RF shielding solutions with Alternatives #1 and #2 will be marginally effective.

Conclusions: The four ambient timed recorded 100 kHz to 18 GHz electric field strength average and maximum peak data does not reflect the actual conditions since the Doppler Radar was probably not operational or at very low power. VitaTech will return in late September 2006 to record additional RF data with a spectrum analyzer (coordinate with engineers).

AC ELF, DC & RF Test Instruments

FieldStar 1000 Gaussmeter - AC ELF Magnetic Flux Density

VitaTech recorded the AC ELF magnetic flux density data using a FieldStar 1000 gaussmeter with a NIST traceable calibration certificate manufactured by Dexsil Corporation. The FieldStar 1000 has a resolution of 0.04 mG in the 0 - 10 mG range, 1% full-scale accuracy to 1000 mG and a frequency response of 60 Hz (55 - 65 Hz @ 3dB). Three orthogonal powdered-iron core coils are oriented to reduce interference to less than 0.25% over the full dynamic range. The three coils are arranged inside the unit holding horizontal with the display forward: Bx horizontal coil points forward, By horizontal coil points to the right side, and Bz vertical coil points upward. The microprocessor instantly converts the magnetic field to true RMS magnetic flux density (milligauss) readings of each axis (Bx, By, Bz) and simultaneously calculates the resultant R_{rms} (root-means-square) vector according to the following formula:

$$R_{rms} = \sqrt{Bx^2 + By^2 + Bz^2}$$

When collecting contour path data, a nonmetallic survey wheel is attached to the FieldStar 1000 gaussmeter and the unit is programmed to record mapped magnetic flux density data at selected (1-ft., 5-ft., 10-ft. etc.) intervals. The FieldStar 1000 is exactly 39.37 inches (1 meter) above the ground with the survey wheel attached. Along each path the distance is logged by the survey wheel and the relative direction (turns) entered on the keyboard. Up to 22,000 spot, mapped and timed data points can be stored, each containing three components (Bx, By & Bz), event markers and turn information. After completing the path surveys, magnetic flux density data is uploaded and processed. All plots display a title, time/date stamp, ID path number, and the following statistical data (in milligauss) defined below:

Peak - maximum magnetic field (flux) value measured in group. **Mean** - arithmetic average of all magnetic field (flux) values collected.

The following is a quick description of the Hatch, Profile and 3-D Contour plots presented in the figures of this report:

Hatch Plot - data is represented by four difference hatch marks (0.1 mG, 0.25 mG, 0.5 mG and 1.0 mG thresholds) based on width and color as a function of distance along the survey path that shows 90 and 45 degree turns. Note: the site drawing and all Hatch Plots were scaled in feet to verify actual recorded distances and correct survey locations.

Profile Plot - data shows each recorded component (Bx, By, Bz) axis and the resultant (Br) levels as a function of distance: Bx (red) is the horizontal component parallel to the survey path, By (green) is the horizontal component normal (perpendicular) to the survey path, and Bz (blue) is the vertical component with the computed Br resultant RMS (root-means-square) summation of the three components.

EMR-300 RF Meter - Electric Field Strength Data 100 kHz - 18 GHz

The EMR-300 is an radiofrequency (RF) electric field strength meter for broadband measuring and monitoring from 100 kHz to 18 GHz. The isotropic non-directional field probe with high sensitivity records average, maximum, peak and timed data in electric fields strength volts-per-meter (V/m), magnetic field strength amps-per-meter (A/m) and power levels. Ten minute timed data was sampled at 0.4 seconds intervals from 100 kHz – 3 GHz with a Probe 18 (range 0.2 V/m to 320 V/m) and from 3 MHz to 18 GHz with Probe 9C (range 0.5 V/m to 1000 V/m) at each location.

<u>MultiWave System II – Magnetic Flux Density 0 Hz – 3000 Hz</u>

Geomagnetic and static DC magnetic emission measurements were recorded with a fluxgate triple-axis MultiWave System II magnetometer (serial #1045). The MultiWave System II consists of a hand-held LCD display and keyboard controller unit, wideband 10 Gauss (G) peak (DC - 3 kHz) tri-axial fluxgate magnetometer, data acquisition and processing unit with 3.5" floppy disk drive unit and 0 to 10 Gauss range, 1% accuracy, 0.1 mG resolution.

AC ELF Magnetic Field Health Issues, Standards & Guidelines

Currently, there are no Federal standards for AC ELF electric and magnetic field levels. The National Energy Policy Act of 1992 authorized the Secretary of the Department of Energy (DOE) to establish a five-year, \$65 million EMF Research and Public Information Dissemination (RAPID) Program to ascertain the affects of ELF EMF on human health, develop magnetic field mitigation technologies, and provide information to the public. In May 1999, the NIEHS Director Kenneth Olden, Ph.D. delivered his final report, *Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields*, to Congress that stated the following in the Cover Letter and Executive Summary below:

The scientific evidence suggesting that ELF-EMF exposures pose any health risk is weak. The strongest evidence for health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and chronic lymphocytic leukemia in occupationally exposed adults... The NIEHS concludes that ELF-EMI exposure cannot be recognized at this time as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard.

U.S. & International Organizational AC ELF EMF Standards

The International Commission on Non-Ionizing Radiation Protection (IRPA/INIRC) have established 833 mG maximum human exposure limit over 24 hours for the general public and 4,167 mG for occupational workers. Whereas The American Conference of Governmental Industrial Hygienists (ACGIH) recommends a 10,000 mG (10 Gauss) exposure limit over 24 hours for occupational workers, but specifies only 1,000 mG (1 Gauss) as a maximum exposure for workers with cardiac pacemakers.

New York State Public Service Commission AC ELF EMF Standards

Effective September 1990, the State of New York Public Service Commission (PSC) "began a process looking toward the adoption of an interim magnetic field standard for future major electric transmission facilities". The Commission concludes that a prudent approach should be taken that will avoid unnecessary increases in existing levels of magnetic field exposure. Therefore, future transmission circuits shall be designed, constructed and operated such that magnetic fields at the edges of their rights-of-way will not exceed 200 mG when the circuit phase currents are equal to the winter-normal conductor rating. They also established an electric field strength interim standard of 1.6 kV/m electric transmission facilities.

IARC June 2002 Report

In June 2002, the International Agency for Research on Cancer (IARC) issued a 400+ page report formally classifying extremely low frequency magnetic fields as **possibly carcinogenic to humans** based on studies of EMF and childhood leukemia. This is the first time that a recognized public health organization has formally classified EMF as a possible cause of human cancer. IARC found that, while selection bias in the childhood leukemia studies could not be ruled out, pooled analyses of data from a number of well-conducted studies show a fairly consistent statistical association between childhood leukemia and power-frequency residential magnetic fields above 4 milliGauss (mG), with an approximately two-fold increase in risk that is unlikely to be due to chance.

IARC is a branch of the World Health Organization. The IARC classification of EMF was made by a panel of scientists from the U.S. National Institute of Environmental Health Sciences, the U.S. Environmental Protection Agency, the U.K. National Radiological Protection Board, the California Department of Health Services, EPRI, and other institutions around the world.

Switzerland's February 2000 AC ELF Standard

The Swiss Bundersrat in February 2000 set by law an emission control limit of 10 mG from overhead and underground transmission lines, substations, transformer vaults and all electrical power sources.

VitaTech's & NCRP Draft Recommended 10 mG Standard

Section 8.4.1.3 option 3 in the National Council of Radiation Protection and Measurements (NCRP) draft report published in the July/August 1995 issue of *Microwave News* (visit the Microwave News Homepage <www.microwavenews.com> for the entire draft report) recommended the following:

8.4.1.3 Option 3: An exposure guideline of $1 \ \mu T$ (10 mG) and 100 V/m: A considerable body of observations has documented bioeffects of fields at these strengths across the gamut from isolated cells to animals, and in man. Although the majority of these reported effects do not fall directly in the category of hazards, many may be regarded as potentially hazardous. Since epidemiological studies point to increased cancer risks at even lower levels, a case can be made for recommending $1 \ \mu T$ (10 mG) and 100 V/m as levels not

to be exceeded in prolonged human exposures. Most homes and occupational environments are within these values, but it would be prudent to assume that higher levels may constitute a health risk. In the short term, a safety guideline set at this level would have significant consequences, particularly in occupational settings and close to high voltage transmission and distribution systems, but it is unlikely to disrupt the present pattern of electricity usage. These levels may be exceeded in homes close to transmission lines, distribution lines and transformer substations, in some occupational environments, and for users of devices that operate close to the body, such as hair dryers and electric blankets. From a different perspective, adoption of such a guideline would serve a dual purpose: first, as a vehicle for public instruction on potential health hazards of existing systems that generate fields above these levels, as a basis for "prudent avoidance"; and second, as a point of departure in planning for acceptable field levels in future developments in housing, schooling, and the workplace, and in transportation systems, both public and private, that will be increasingly dependent on electric propulsion.

RF Human Exposure Standards

Presently, four major RF standards are used in the United States: IEEE, ACGIH (American Conference of Governmental Industrial Hygienists), NCRP (National Council on Radiation Protection and Measurements) and the ICNIRP (International Commissions of Non-Ionizing Radiation Protection). In 1991, the IEEE released a revised RF human exposure standard IEEE C95.1-1991, Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHZ. However, in August 1997 the Federal Communications Commission (FCC) Office of Engineering & Technology (OTE) released Bulletin 65 Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields, which became the defacto RF exposure standard in the United States. Both standards are very similar for Occupational/Controlled and General Population/Uncontrolled maximum permissible exposure (MPE), except for some minor differences -- the FCC standard is more restrictive and used in RF Safety & Exposure Testing.

The FCC's Bulletin 65 specifies separate maximum permissible exposure (MPE) limits for Occupational/Controlled and General Population/Uncontrolled exposure over a 0.3 MHz to 100 GHz bandwidth as shown below:

LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency	Electric Field	Magnetic Field	Power Density	Averaging Time
Range	Strength (E)	Strength (H)	(S)	E ² , H ² or S
(MHz)	(V/m)	(A/m)	(mW/cm ²)	(minutes)
0.3-3.0	614	1.63	(100)*	6

(A) Limits for Occupational/Controlled Exposure

3.0-30	1842/f	4.89/f	(900/f ²)*	6
30-300	61.4	0.163	1.0	6
300-1500			f/300	6
1500-100,000			5	6

Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm ²)	Averaging Time E ² , H ² or S (minutes)
0 3-1 34	614	1 63	(100)*	30
1.34-30	824/f	2.19/f	$(180/f^2)^*$	30
30-300	27.5	0.073	0.2	30
300-1500			f/1500	30
1500-100,000			1.0	30

(B) Limits for General Population/Uncontrolled Exposure

f = frequency in MHz *Plane-wave equivalent power density

General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

Specific Absorption Rate (SAR) is the basis of most safety standards, when applied in the far-field, plane-wave conditions. It is the rate of energy absorption per unit of body mass. When the human body is exposed to the RF field, the SAR experienced is proportional to the squared value of the electric field strength induced in the body. At an absorption level of 4 W/kg, reversible behavioral disruption is noted. Levels above 5 W/kg can result in permanent adverse affects. Therefore, most standards have been based on SAR's of 0.4 W/kg to conservatively limit exposures to 1/10th of the levels to account for biological uncertainty and to add an additional safety factor.

Unfortunately, the Occupational Safety & Health Administration (OSHA) has not revised the standard since 1978 (see OSHA Regulations Standards - 29 CFR, Nonionizing Radiation - 1910.97), but has already cited and fined organizations for exceeding the new standards. OSHA has the right to enforce based on consensus of scientifically-based standards under its general duty clause. Nevertheless, OSHA uses 10 mW/cm² as the maximum SAR exposure over an averaged period of 6 minutes from continuous or intermittent RF sources between 10 MHz and 100 GHz. Figure 1, below presents the FCC Limits for Maximum Permissible Exposure (MPE) in units of Power Density (mW/cm²):



Figure 1. FCC Limits for Maximum Permissible Exposure (MPE)

This completes the Future NSLS-II Brookhaven Labs EMI/RFI Site Assessment Study.

Best regards,

Louis S. Vitale, Jr. President & Chief Engineer

Attachments: Figures #1 - #7.



	AC ELF Magnetic Field Human Exposure Standards
netic	NYS Public Service Commission 200 mG @ 1-meter on Edge -ROW or 50 ft. from 69 kV poles
pecs ement: G p-p)	IRPA/INIRC 833 mG over 24 hours General Public Exposure
.abs lient: G p-p)	ACGIH 1000 mG general public & workers with cardia pacemakers
nent: G p-p)	Swiss Bunderstat NCRP Draft Report 10 mG from overhead/underground transmission/distribution lines, substations, etc.

All magnetic flux density data recorded with a FieldStar 1000 gaussmeter and survey wheel.

AC ELF EMI Thresholds (screen jitter & noise)

10 mG for 12-15 inch CRT computer monitors & audio/video equipment 5 mG for 17-21 inch CRT monitors & medical (i.e., EEGs, ECGs, EMGs,. etc.). 1.0 mG for standard scientific tools (STEMs, TEMs, FIB, I-Beam, etc.) 0.1-0.3 mG for high resolution Nanotech scientific tools 0.01 mG for optimum superhigh resolution STEM tools

SEMI E33-94 AC ELF EMC Standards

- Level A less than 0.25 mG
- Level B less than 0.50 mG
- Level C less than 1.00 mG
- Level D less than 2.00 mG
- Level E 2.0 mG and greater

Figure #2, NSLS-II Brookhaven National Labs Proposed Site



Figure #3, NSLS-II Brookhaven National Labs Proposed Site Timed AC ELF (0.3 Hz - 3,000 Hz) Magnetic Flux Density Levels @ 1-meter Upton, Long Island, New York **AC ELF Magnetic Field**

Field (uG)

m









Figure #4, NSLS-II Brookhaven National Labs Proposed Site Timed DC (0 Hz - 0.3 Hz) Magnetic Flux Density Levels @ 1-meter Upton, Long Island, New York





Figure #6, NSLS-II Brookhaven National Labs Proposed Site 100 kHz to 18 GHz Timed RF Electric Field Strength Data Upton, Long Island, New York





Electric field strength RF levels were recorded in volts-per-meter (V/m) for 10 minutes sampled at 0.04-second intervals with a Narda ERM-300 electric field meter using a Probe 18 from 100 kHz to 3 Ghz (range of 0.2 to 320 V/m) and Probe 9C from 3 MHz to 18 GHz (range of 0.5 to 1000 V/m). The objective is to investigate sources of radio-frequency interference (RFI) over a wide bandwidth. It should be noted that 3 V/m is the industry standard RFI threshold and 1 V/m the medical/scientific instrument RFI threshold.

VitaTech Engineering, LLC (540) 286-1984 Fredericksburg, Va

Figure #7, NSLS-II Brookhaven National Labs Proposed Site 100 kHz to 18 GHz Timed RF Maximum Electric Field Strength Data Upton, Long Island, New York



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Electric field strength RF levels were recorded in volts-per-meter (V/m) with a Narda SRM-3000 Selective Radiation Meter. It should be noted that 3 V/m is the industry standard RFI threshold and 1 V/m the medical/scientific instrument RFI threshold.

8.201 nW/cm²

88.000 MHz

2900.000 MHz

Total

Total 175.8 mV/m 88.000 MHz 2900.000 Figure #2A - FCC Spectrum 75 MHz - 3 GHz @ 1-me NSLS-II Brookhaven National Labs Proposed Site

32.68 mV/m

120.8 mV/m

1850.000 MHz

2700.000 MHz

PCS Broadband

Others

NEXTRAD Dopple 60.55 mV/m

E E E E E E E E E E E E E E E E E E E	Store Mode MAN Date 09/19/2006
00 MHz 202.4 mV/m 32 MHz 120.5 mV/m 0 MHz 97.07 mV/m 7 MHz 73.45 mV/m	Minimum Frequency [Hz] 75 MHz Maximum Frequency [Hz] 3 GHz Resolution Bandwidth [Hz] 5 MHz Measurement Range [V/m] 2.5 V/m Unit V/m
MHz 39.49 mV/m MHz 35.32 mV/m MHz 33.77 mV/m	Result Type MAX Number of Averages 64 Average Flag OK Overdrive Flag OK
2 MHz 33.09 mV/m MHz 32.23 mV/m MHz 27.72 mV/m	Threshold [V/m] 25 µV/m Y-Scale Reference [V/m] 28 V/m Y-Scale Range [dB]100
3 MHz 25.48 mV/m 3 MHz 24.84 mV/m 2 MHz 23.77 mV/m	Standard Name ICNIRP GP CommentG4 Device Serial No. J-0016
5 MHz 23.77 mV/m 5 MHz 21.93 mV/m 1 MHz 21.88 mV/m	Device Calibration Date 05/15/2006 Device Firmware Version V1.4.10 Cable Name
09 MHz21.26 mV/m04 MHz20.85 mV/m16 MHz20.76 mV/m	Cable Serial No. Cable Calibration Date Antenna Name 3AX 75M-3G Antenna Serial No. G-0147
43 MHz 20.65 mV/m 11 MHz 20.62 mV/m	Antenna Calibration Date 05/18/2006 VitaTech Engineering, LLC
RF Data Recorded 9/19/2006	(540) 286-1984 Fredericksburg, Va
y Band	Dataset Type TAB Store Mode MAN
y Band Upper Frequency 108.000 MHz 159.000 MHz 216.000 MHz 806.000 MHz	Dataset Type TAB Store Mode MAN Date 09/19/2006 Time 10:06:25 Minimum Frequency [Hz] 88 MHz Maximum Frequency [Hz] 2.9 GHz Measurement Range [V/m] 2.5 V/m Unit V/m
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y Band Upper Frequency 108.000 MHz 159.000 MHz 216.000 MHz 806.000 MHz 821.000 MHz 824.000 MHz 849.000 MHz 899.000 MHz 896.000 MHz 901.000 MHz 902.000 MHz 930.000 MHz	Dataset Type TAB Store Mode MAN Date 09/19/2006 Time 10:06:25 Minimum Frequency [Hz] 88 MHz Maximum Frequency [Hz] 2.9 GHz Measurement Range [V/m] 2.5 V/m Unit V/m Result Type MAX Number of Averages 4 Average Flag OK Overdrive Flag OK Overdrive Flag OK Threshold [V/m] 25 µV/m Display DETAIL Axis RSS Standard Name ICNIRP GP Service Table Name FCC STD CommentG5 Device Serial No. L0016
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y Band Upper Frequency 108.000 MHz 159.000 MHz 216.000 MHz 806.000 MHz 821.000 MHz 824.000 MHz 824.000 MHz 894.000 MHz 894.000 MHz 901.000 MHz 901.000 MHz 930.000 MHz 931.000 MHz 932.000 MHz 932.000 MHz 932.000 MHz 930.000 MHz 930.000 MHz 930.000 MHz 941.000 MHz 990.000 MHz	Dataset Type TAB Store Mode MAN Date 09/19/2006 Time 10:06:25 Minimum Frequency [Hz] 88 MHz Maximum Frequency [Hz] 2.9 GHz Measurement Range [V/m] 2.5 V/m Unit V/m Result Type MAX Number of Averages 4 Average Flag OK Overdrive Flag OK Threshold [V/m] 25 µV/m Display DETAIL Axis RSS Standard Name ICNIRP GP Service Table Name FCC STD Comment G5 Device Serial No. J-0016 Device Calibration Date 05/15/2006 Device Firmware Version V1.4.10 Cable Name Cable Serial No. Cable Calibration Date Antenna Name 3AX 75M-3G Antenna Calibration Date 05/18/2006
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Figure #1 - RF Spectrum 2.7 - 3 GHz NEXTRAD Doppler Radar @ 1-meter NSLS-II Brookhaven National Labs Proposed Site

RF Dat 9/1



Level	Dataset Type SPEC Store Mode MAN Date 09/19/2006 Time 09:52:16
721.4 mV/m 698.0 mV/m 146.6 mV/m	Minimum Frequency [Hz] 2.705 GHz Maximum Frequency [Hz] 3 GHz
29.03 mV/m 13.30 mV/m	Measurement Range [V/m] 2.5 V/m Unit V/m
12.80 mV/m 11.95 mV/m	Result Type MAX Number of Averages 64 Average Flag OK
11.78 mV/m 11.62 mV/m 11.37 mV/m	Overdrive Flag OK Threshold [V/m] 25 µV/m Y-Scale Reference [V/m] 28 V/m
11.36 mV/m 11.29 mV/m	Axis RSS Standard Name ICNIRP GP
11.14 mV/m 11.05 mV/m 11.03 mV/m 10.96 mV/m	Device Serial No. J-0016 Device Calibration Date 05/15/2006 Device Firmware Version V1.4.10 Cable Name
10.72 mV/m 10.69 mV/m 10.68 mV/m	Cable Serial No. Cable Calibration Date Antenna Name 3AX 75M-3G Antenna Serial No. G-0147
10.66 mV/m	Antenna Calibration Date 05/18/2006
a Recorded 19/2006	VitaTech Engineering, LLC (540) 286-1984 Fredericksburg, Va
quency & Level	Dataset Type SPEC
Level	Dataset Type SPEC Store Mode MAN Date 09/19/2006
Level 202.4 mV/m 76.24 mV/m	Dataset Type SPEC Store Mode MAN Date 09/19/2006 Time 10:00:21 Minimum Frequency [Hz] 75 MHz
Level 202.4 mV/m 76.24 mV/m 73.45 mV/m	Dataset Type SPEC Store Mode MAN Date 09/19/2006 Time 10:00:21 Minimum Frequency [Hz] 75 MHz Maximum Frequency [Hz] 3 GHz Resolution Bandwidth [Hz] 5 MHz
uency & Level Level 202.4 mV/m 76.24 mV/m 73.45 mV/m 39.06 mV/m	Dataset Type SPEC Store Mode MAN Date 09/19/2006 Time 10:00:21 Minimum Frequency [Hz] 75 MHz Maximum Frequency [Hz] 3 GHz Resolution Bandwidth [Hz] 5 MHz Measurement Range [V/m] 2.5 V/m
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Level 202.4 mV/m 76.24 mV/m 73.45 mV/m 39.06 mV/m 33.71 mV/m 33.43 mV/m 33.09 mV/m 31.85 mV/m	Dataset TypeSPECStore ModeMANDate09/19/2006Time10:00:21Minimum Frequency [Hz]75 MHzMaximum Frequency [Hz]3 GHzResolution Bandwidth [Hz]5 MHzMeasurement Range [V/m]2.5 V/mUnitV/mResult TypeMAXNumber of Averages64Average FlagOKOverdrive FlagOK
Level 202.4 mV/m 76.24 mV/m 73.45 mV/m 39.06 mV/m 33.71 mV/m 33.43 mV/m 33.09 mV/m 31.85 mV/m 27.17 mV/m	Dataset TypeSPECStore ModeMANDate09/19/2006Time10:00:21Minimum Frequency [Hz]75 MHzMaximum Frequency [Hz]3 GHzResolution Bandwidth [Hz]5 MHzMeasurement Range [V/m]2.5 V/mUnitV/mResult TypeMAXNumber of Averages64Average FlagOKOverdrive FlagOKThreshold [V/m]25 µV/mY-Scale Reference [V/m]28 V/m
Level Level 202.4 mV/m 76.24 mV/m 73.45 mV/m 39.06 mV/m 33.71 mV/m 33.43 mV/m 33.09 mV/m 31.85 mV/m 27.17 mV/m 24.80 mV/m	Dataset TypeSPECStore ModeMANDate09/19/2006Time10:00:21Minimum Frequency [Hz]75 MHzMaximum Frequency [Hz]3 GHzResolution Bandwidth [Hz]5 MHzMeasurement Range [V/m]2.5 V/mUnitV/mResult TypeMAXNumber of Averages64Average FlagOKOkOverdrive FlagOKThreshold [V/m]Y-Scale Reference [V/m]28 V/mY-Scale Range [dB]100Axia
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Level 202.4 mV/m 76.24 mV/m 73.45 mV/m 39.06 mV/m 33.71 mV/m 33.43 mV/m 33.09 mV/m 31.85 mV/m 27.17 mV/m 24.80 mV/m 23.81 mV/m 23.81 mV/m 21.94 mV/m 21.94 mV/m 21.94 mV/m 21.88 mV/m 20.77 mV/m 20.65 mV/m 20.65 mV/m 20.56 mV/m	Dataset Type SPEC Store Mode MAN Date 09/19/2006 Time 10:00:21 Minimum Frequency [Hz] 75 MHz Maximum Frequency [Hz] 3 GHz Resolution Bandwidth [Hz] 5 MHz Measurement Range [V/m] 2.5 V/m Unit V/m Result Type MAX Number of Averages 64 Average Flag OK Overdrive Flag OK Threshold [V/m] 25 µV/m Y-Scale Reference [V/m] 28 V/m Y-Scale Reference [V/m] 28 V/m Y-Scale Range [dB]100 Axis RSS Standard Name Comment Device Serial No. J-0016 Device Calibration Date 05/15/2006 Device Firmware Version V1.4.10 Cable Name Cable Serial No. Cable Calibration Date 05/15/2006 MitaTech Engineering LLC
Level 202.4 mV/m 76.24 mV/m 73.45 mV/m 39.06 mV/m 33.71 mV/m 33.71 mV/m 33.43 mV/m 33.09 mV/m 31.85 mV/m 27.17 mV/m 24.80 mV/m 23.81 mV/m 23.81 mV/m 23.81 mV/m 21.94 mV/m 21.94 mV/m 21.94 mV/m 21.94 mV/m 21.95 mV/m 20.76 mV/m 20.65 mV/m 20.56 mV/m 20.52 mV/m	Dataset Type SPEC Store Mode MAN Date 09/19/2006 Time 10:00:21 Minimum Frequency [Hz] 75 MHz Maximum Frequency [Hz] 3 GHz Resolution Bandwidth [Hz] 5 MHz Measurement Range [V/m] 2.5 V/m Unit V/m Result Type MAX Number of Averages 64 Average Flag OK Overdrive Flag OK Threshold [V/m] 25 µV/m Y-Scale Reference [V/m] 28 V/m Y-Scale Range [dB]100 Axis RSS Standard Name Comment Device Serial No. J-0016 Device Calibration Date 05/15/2006 Device Firmware Version V1.4.10 Cable Name Cable Serial No. Cable Calibration Date Antenna Name 3AX 75M-3G Antenna Serial No. G-0147 Antenna Calibration Date 05/18/2006 VitaTech Engineering, LLC (540) 286-1984
Level 202.4 mV/m 76.24 mV/m 73.45 mV/m 39.06 mV/m 33.71 mV/m 33.43 mV/m 33.09 mV/m 31.85 mV/m 27.17 mV/m 24.80 mV/m 23.81 mV/m 23.81 mV/m 23.81 mV/m 21.94 mV/m 21.94 mV/m 21.94 mV/m 21.94 mV/m 21.95 mV/m 20.76 mV/m 20.65 mV/m 20.56 mV/m 20.52 mV/m 20.52 mV/m	Dataset Type SPEC Store Mode MAN Date 09/19/2006 Time 10:00:21 Minimum Frequency [Hz] 75 MHz Maximum Frequency [Hz] 3 GHz Resolution Bandwidth [Hz] 5 MHz Measurement Range [V/m] 2.5 V/m Unit V/m Result Type MAX Number of Averages 64 Average Flag OK Overdrive Flag OK Threshold [V/m] 25 µV/m Y-Scale Reference [V/m] 28 V/m Y-Scale Range [dB]100 Axis RSS Standard Name Comment Device Serial No. J-0016 Device Calibration Date 05/15/2006 Device Firmware Version V1.4.10 Cable Name Cable Serial No. G-0147 Antenna Name 3AX 75M-3G Antenna Serial No. G-0147 Antenna Calibration Date 05/18/2006 VitaTech Engineering, LLC (540) 286-1984 Fredericksburg, Va



quency & Level	Dataset Type SPEC
Level	Store Mode MAN
799.3 mV/m	Time 10:41:34
29.75 mV/m	Minimum Frequency [Hz] 2.7 GHz
25 45 mV/m	Maximum Frequency [Hz] 3 GHz
24.74 m\//m	Resolution Bandwidth [HZ] 5 MHZ
24.10 m\//m	Unit V/m
27.10 mV/m	Result Type MAX
23.30 mV/m	Number of Averages 64
23.33 IIIV/III	Average Flag OK Overdrive Flag OK
23.32 IIIV/III	Threshold [V/m] 25 µV/m
23.30 mV/m	Y-Scale Reference [V/m] 28 V/m
23.07 mV/m	Y-Scale Range [dB]100
22.96 mV/m	AXIS RSS Standard Name
22.96 mV/m	Comment
22.82 mV/m	Device Serial No. J-0016
22.82 mV/m	Device Calibration Date 05/15/2006
22.79 mV/m	Cable Name
22.69 mV/m	Cable Serial No.
22.65 mV/m	Cable Calibration Date
22.51 mV/m	Antenna Name 3AX 75M-3G
21.96 mV/m	Antenna Calibration Date 05/18/2006
21.96 mV/m	
a Decorded	VitaTech Engineering LLC
a Recorded	
herry-Picker	(340) 200-1904
19/2006	Fredericksburg, va
quency & Level	Dataset Type SPEC
quency & Level Level	Dataset Type SPEC Store Mode MAN Date 09/19/2006
quency & Level Level 227.0 mV/m	Dataset Type SPEC Store Mode MAN Date 09/19/2006 Time 10:46:07
quency & Level Level 2 227.0 mV/m 130.6 mV/m	Dataset Type SPEC Store Mode MAN Date 09/19/2006 Time 10:46:07 Minimum Frequency [Hz] 75 MHz
quency & Level Level 227.0 mV/m 130.6 mV/m 129.3 mV/m 83.46 mV/m	Dataset Type SPEC Store Mode MAN Date 09/19/2006 Time 10:46:07 Minimum Frequency [Hz] 75 MHz Maximum Frequency [Hz] 3 GHz Resolution Bandwidth [Hz] 5 MHz
quency & Level Level 227.0 mV/m 130.6 mV/m 129.3 mV/m 83.46 mV/m 73 53 mV/m	Dataset Type SPEC Store Mode MAN Date 09/19/2006 Time 10:46:07 Minimum Frequency [Hz] 75 MHz Maximum Frequency [Hz] 3 GHz Resolution Bandwidth [Hz] 5 MHz Measurement Range [V/m] 2.5 V/m
quency & Level Level 2 227.0 mV/m 130.6 mV/m 129.3 mV/m 83.46 mV/m 73.53 mV/m 67 70 mV/m	Dataset Type SPEC Store Mode MAN Date 09/19/2006 Time 10:46:07 Minimum Frequency [Hz] 75 MHz Maximum Frequency [Hz] 3 GHz Resolution Bandwidth [Hz] 5 MHz Measurement Range [V/m] 2.5 V/m Unit V/m Result Type MAX
quency & Level Level 227.0 mV/m 130.6 mV/m 129.3 mV/m 83.46 mV/m 73.53 mV/m 67.70 mV/m 64.39 mV/m	Dataset TypeSPECStore ModeMANDate09/19/2006Time10:46:07Minimum Frequency [Hz]75 MHzMaximum Frequency [Hz]3 GHzResolution Bandwidth [Hz]5 MHzMeasurement Range [V/m]2.5 V/mUnitV/mResult TypeMAXNumber of Averages64
quency & Level Level 227.0 mV/m 130.6 mV/m 129.3 mV/m 83.46 mV/m 73.53 mV/m 67.70 mV/m 64.39 mV/m	Dataset TypeSPECStore ModeMANDate09/19/2006Time10:46:07Minimum Frequency [Hz]75 MHzMaximum Frequency [Hz]3 GHzResolution Bandwidth [Hz]5 MHzMeasurement Range [V/m]2.5 V/mUnitV/mResult TypeMAXNumber of Averages64Average FlagOK
quency & Level Level 2 227.0 mV/m 130.6 mV/m 129.3 mV/m 83.46 mV/m 73.53 mV/m 67.70 mV/m 64.39 mV/m 47.85 mV/m 42.70 mV/m	Dataset TypeSPECStore ModeMANDate09/19/2006Time10:46:07Minimum Frequency [Hz]75 MHzMaximum Frequency [Hz]3 GHzResolution Bandwidth [Hz]5 MHzMeasurement Range [V/m]2.5 V/mUnitV/mResult TypeMAXNumber of Averages64Average FlagOKOverdrive FlagOKThreshold [V/m]25 µV/m
quency & Level Level 227.0 mV/m 130.6 mV/m 129.3 mV/m 83.46 mV/m 73.53 mV/m 67.70 mV/m 64.39 mV/m 47.85 mV/m 42.70 mV/m 37.88 mV/m	Dataset TypeSPECStore ModeMANDate09/19/2006Time10:46:07Minimum Frequency [Hz]75 MHzMaximum Frequency [Hz]3 GHzResolution Bandwidth [Hz]5 MHzMeasurement Range [V/m]2.5 V/mUnitV/mResult TypeMAXNumber of Averages64Average FlagOKOverdrive FlagOKThreshold [V/m]25 μV/mY-Scale Reference [V/m]28 V/m
cuency & Level Level 227.0 mV/m 130.6 mV/m 129.3 mV/m 83.46 mV/m 73.53 mV/m 67.70 mV/m 64.39 mV/m 47.85 mV/m 47.85 mV/m 37.88 mV/m 37.86 mV/m	Dataset TypeSPECStore ModeMANDate09/19/2006Time10:46:07Minimum Frequency [Hz]75 MHzMaximum Frequency [Hz]3 GHzResolution Bandwidth [Hz]5 MHzMeasurement Range [V/m]2.5 V/mUnitV/mResult TypeMAXNumber of Averages64Average FlagOKOkThreshold [V/m]25 μV/mY-Scale Reference [V/m]28 V/mY-Scale Range [dB]100A
cuency & Level Level 227.0 mV/m 130.6 mV/m 129.3 mV/m 83.46 mV/m 73.53 mV/m 67.70 mV/m 64.39 mV/m 47.85 mV/m 47.85 mV/m 37.88 mV/m 37.86 mV/m 32.78 mV/m	Dataset TypeSPECStore ModeMANDate09/19/2006Time10:46:07Minimum Frequency [Hz]75 MHzMaximum Frequency [Hz]3 GHzResolution Bandwidth [Hz]5 MHzMeasurement Range [V/m]2.5 V/mUnitV/mResult TypeMAXNumber of Averages64Average FlagOKOkOverdrive FlagVrnshold [V/m]25 μV/mY-Scale Reference [V/m]28 V/mY-Scale Range [dB]100AxisAxisRSSStandard Name
cuency & Level Level 227.0 mV/m 130.6 mV/m 129.3 mV/m 83.46 mV/m 73.53 mV/m 67.70 mV/m 64.39 mV/m 47.85 mV/m 47.85 mV/m 37.88 mV/m 37.86 mV/m 2.72 mV/m	Dataset TypeSPECStore ModeMANDate09/19/2006Time10:46:07Minimum Frequency [Hz]75 MHzMaximum Frequency [Hz]3 GHzResolution Bandwidth [Hz]5 MHzMeasurement Range [V/m]2.5 V/mUnitV/mResult TypeMAXNumber of Averages64Average FlagOKOverdrive FlagOKThreshold [V/m]25 μV/mY-Scale Reference [V/m]28 V/mY-Scale Range [dB]100AxisAxisRSSStandard NameComment
quency & Level Level 227.0 mV/m 130.6 mV/m 129.3 mV/m 83.46 mV/m 73.53 mV/m 67.70 mV/m 64.39 mV/m 47.85 mV/m 42.70 mV/m 37.88 mV/m 237.86 mV/m 29.72 mV/m 29.29 mV/m	Dataset TypeSPECStore ModeMANDate09/19/2006Time10:46:07Minimum Frequency [Hz]75 MHzMaximum Frequency [Hz]3 GHzResolution Bandwidth [Hz]5 MHzMeasurement Range [V/m]2.5 V/mUnitV/mResult TypeMAXNumber of Averages64Average FlagOKOkerdrive FlagOKThreshold [V/m]25 μV/mY-Scale Reference [V/m]28 V/mY-Scale Range [dB]100AxisAxisRSSStandard NameCommentDevice Serial No.J-0016
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quency & Level Level 227.0 mV/m 130.6 mV/m 129.3 mV/m 83.46 mV/m 73.53 mV/m 67.70 mV/m 64.39 mV/m 47.85 mV/m 47.85 mV/m 237.86 mV/m 29.72 mV/m 29.72 mV/m 29.29 mV/m 26.91 mV/m 24.93 mV/m	Dataset TypeSPECStore ModeMANDate09/19/2006Time10:46:07Minimum Frequency [Hz]75 MHzMaximum Frequency [Hz]3 GHzResolution Bandwidth [Hz]5 MHzMeasurement Range [V/m]2.5 V/mUnitV/mResult TypeMAXNumber of Averages64Average FlagOKOverdrive FlagOKThreshold [V/m]25 μV/mY-Scale Reference [V/m]28 V/mY-Scale Range [dB]100AxisAxisRSSStandard Name05/15/2006Device Serial No.J-0016Device Calibration Date05/15/2006Device Firmware VersionV1.4.10Cable Name05/15/2006
quency & Level Level 227.0 mV/m 130.6 mV/m 129.3 mV/m 83.46 mV/m 73.53 mV/m 67.70 mV/m 64.39 mV/m 47.85 mV/m 42.70 mV/m 237.88 mV/m 237.86 mV/m 29.72 mV/m 29.29 mV/m 26.91 mV/m 24.34 mV/m	Dataset TypeSPECStore ModeMANDate09/19/2006Time10:46:07Minimum Frequency [Hz]75 MHzMaximum Frequency [Hz]3 GHzResolution Bandwidth [Hz]5 MHzMeasurement Range [V/m]2.5 V/mUnitV/mResult TypeMAXNumber of Averages64Average FlagOKOkOverdrive FlagV-Scale Reference [V/m]28 V/mY-Scale Range [dB]100AxisRSSStandard Name05/15/2006Device Serial No.J-0016Device Calibration Date05/15/2006Device Firmware VersionV1.4.10Cable NameCable Serial No.Cable Serial No.Cable Serial No.
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quency & Level Level 227.0 mV/m 130.6 mV/m 129.3 mV/m 83.46 mV/m 73.53 mV/m 67.70 mV/m 64.39 mV/m 47.85 mV/m 47.85 mV/m 237.88 mV/m 237.86 mV/m 29.72 mV/m 29.72 mV/m 29.29 mV/m 24.93 mV/m 24.34 mV/m 23.81 mV/m 23.73 mV/m	Dataset TypeSPECStore ModeMANDate09/19/2006Time10:46:07Minimum Frequency [Hz]75 MHzMaximum Frequency [Hz]3 GHzResolution Bandwidth [Hz]5 MHzMeasurement Range [V/m]2.5 V/mUnitV/mResult TypeMAXNumber of Averages64Average FlagOKOkerdrive FlagOKThreshold [V/m]25 μV/mY-Scale Reference [V/m]28 V/mY-Scale Range [dB]100AxisAxisRSSStandard Name05/15/2006Device Serial No.J-0016Device Calibration Date05/15/2006Device Firmware VersionV1.4.10Cable Serial No.Cable Serial No.Cable Serial No.G-0147
cuency & Level 227.0 mV/m 130.6 mV/m 129.3 mV/m 83.46 mV/m 73.53 mV/m 67.70 mV/m 64.39 mV/m 47.85 mV/m 237.88 mV/m 237.86 mV/m 29.72 mV/m 29.72 mV/m 29.72 mV/m 29.72 mV/m 29.73 mV/m 23.73 mV/m 24.93 mV/m 23.73 mV/m 23.73 mV/m 23.73 mV/m	Dataset Type SPEC Store Mode MAN Date 09/19/2006 Time 10:46:07 Minimum Frequency [Hz] 75 MHz Maximum Frequency [Hz] 3 GHz Resolution Bandwidth [Hz] 5 MHz Measurement Range [V/m] 2.5 V/m Unit V/m Result Type MAX Number of Averages 64 Average Flag OK Overdrive Flag OK Threshold [V/m] 25 µV/m Y-Scale Reference [V/m] 28 V/m Y-Scale Reference [V/m] 28 V/m Y-Scale Range [dB]100 Axis RSS Standard Name Comment Device Serial No. J-0016 Device Calibration Date 05/15/2006 Device Firmware Version V1.4.10 Cable Name Cable Serial No. Cable Calibration Date 3AX 75M-3G Antenna Name 3AX 75M-3G Antenna Serial No. G-0147 Antenna Calibration Date 05/18/2006
quency & Level 227.0 mV/m 130.6 mV/m 129.3 mV/m 83.46 mV/m 73.53 mV/m 67.70 mV/m 64.39 mV/m 47.85 mV/m 47.85 mV/m 237.86 mV/m 237.86 mV/m 23.78 mV/m 23.78 mV/m 23.73 mV/m 23.73 mV/m 24.34 mV/m 23.73 mV/m	Dataset TypeSPECStore ModeMANDate09/19/2006Time10:46:07Minimum Frequency [Hz]75 MHzMaximum Frequency [Hz]3 GHzResolution Bandwidth [Hz]5 MHzMeasurement Range [V/m]2.5 V/mUnitV/mResult TypeMAXNumber of Averages64Average FlagOKOverdrive FlagOKOverdrive FlagOKThreshold [V/m]25 μV/mY-Scale Reference [V/m]28 V/mY-Scale Range [dB]100AxisAxisRSSStandard Name05/15/2006Device Serial No.J-0016Device Serial No.05/15/2006Device Firmware VersionV1.4.10Cable Name3AX 75M-3GAntenna Name3AX 75M-3GAntenna Serial No.G-0147Antenna Calibration Date05/18/2006
quency & Level 227.0 mV/m 130.6 mV/m 129.3 mV/m 83.46 mV/m 73.53 mV/m 67.70 mV/m 64.39 mV/m 47.85 mV/m 47.85 mV/m 237.88 mV/m 237.86 mV/m 29.72 mV/m 29.72 mV/m 29.72 mV/m 23.73 mV/m 24.93 mV/m 23.73 mV/m 23.73 mV/m 23.73 mV/m 23.73 mV/m 24.94 mV/m 23.75 mV/m 24.93 mV/m 24.94 mV/m 23.75 mV/m	Dataset Type SPEC Store Mode MAN Date 09/19/2006 Time 10:46:07 Minimum Frequency [Hz] 75 MHz Maximum Frequency [Hz] 3 GHz Resolution Bandwidth [Hz] 5 MHz Measurement Range [V/m] 2.5 V/m Unit V/m Result Type MAX Number of Averages 64 Average Flag OK Overdrive Flag OK Overdrive Flag OK Threshold [V/m] 25 µV/m Y-Scale Reference [V/m] 28 V/m Y-Scale Range [dB]100 Axis RSS Standard Name Comment Device Serial No. J-0016 Device Calibration Date 05/15/2006 Device Firmware Version V1.4.10 Cable Name Cable Serial No. Cable Calibration Date Antenna Name 3AX 75M-3G Antenna Serial No. G-0147 Antenna Calibration Date 05/18/2006 VitaTech Engineering, LLC (540) 286-1084
quency & Level 227.0 mV/m 130.6 mV/m 129.3 mV/m 83.46 mV/m 73.53 mV/m 67.70 mV/m 64.39 mV/m 47.85 mV/m 47.85 mV/m 237.88 mV/m 237.86 mV/m 29.72 mV/m 29.72 mV/m 29.72 mV/m 23.73 mV/m 24.93 mV/m 23.73 mV/m 23.73 mV/m 23.73 mV/m 23.73 mV/m 24.34 mV/m 23.73 mV/m 24.34 mV/m 23.73 mV/m 24.34 mV/m 23.73 mV/m	Dataset Type SPEC Store Mode MAN Date 09/19/2006 Time 10:46:07 Minimum Frequency [Hz] 75 MHz Maximum Frequency [Hz] 3 GHz Resolution Bandwidth [Hz] 5 MHz Measurement Range [V/m] 2.5 V/m Unit V/m Result Type MAX Number of Averages 64 Average Flag OK Overdrive Flag OK Threshold [V/m] 25 µV/m Y-Scale Reference [V/m] 28 V/m Y-Scale Range [dB]100 Axis RSS Standard Name Comment Device Serial No. J-0016 Device Calibration Date 05/15/2006 Device Firmware Version V1.4.10 Cable Name Cable Serial No. Cable Serial No. Cable Calibration Date 05/15/2006 Device Firmware Version V1.4.10 Cable Name Cable Serial No. Cable Calibration Date 05/18/2006 VitaTech Engineering, LLC (540) 286-1984 Erodorick burg V/g

Appendix A4

HVAC Calculations Accelerator Ring Tunnel – one pentant Experimental Hall – one pentant

HVAC

CALCULATIONS

HVAC Load Calculations for:

- One Accelerator Ring Tunnel Pentant AHU-101
- One Experimental Hall Pentant AHU 201A and AHU-201B
| HDR MECHANICAL SECTION | | | HEATING/COOLING LOAD CALCULATIONS | | | | |
|---|--|--------------------|---|-------------------------------|--|--|--|
| | | ROOM DAT | 1.000 1.000 A | ROOM TYPES
CFM | | | |
| PROJECT: BNL
DATE: 05-Sep-0 | 7 | | UNIT:
ENGINEER: | AHU-101
ATIENZA | | | |
| ROOM NO:
ROOM NAME:
AREA (SQFT):
HEIGHT (FT):
DESIGN AC:
RM TEMP (DEG F):
PEOPLE SENS (BTUH):
PEOPLE LAT (BTUH): | T1
TUNNEL 1
6393
9
6
78
450
450 | 78 | PEOPLE (NO EA):
LIGHTS (WATTS):
MISC SENS (BTUH):
MISC LAT (BTUH):
RA=0/EA=1
CFM/SQFT:
PRESS (CFM):
NO OF RMS: | 15
1.5
216000
0
1 | | | |
| WALL ARE
(SQF | EA WINE
T) | DOW AREA
(SQFT) | | | | | |
| N:
E:
S:
W: | 0
0
0
0 | 0
0
0 | | | | | |
| ROOF AREA (SQFT):
WALL BELOW GRADE (SQ
SLAB ON GRADE (SQFT): | FT): | 6841
6393 | | | | | |

HDR MECHANICAL SECTION	EATING/COOLI				
	ROOM	1 DATA	1.	0 CFM	
PROJECT: BNL DATE: 05-Sep-07			UI ENGINEER:	NIT: AHU-201-A ATIENZA	
ROOM NO: ROOM NAME: AREA (SQFT): HEIGHT (FT): DESIGN AC: RM TEMP (DEG F): PEOPLE SENS (BTUH): PEOPLE LAT (BTUH):	P1A PENTANT 1A 19762 12 6 75 450 450	75	PEOPLE (NO EA): LIGHTS (WATTS): MISC SENS (BTUH MISC LAT (BTUH RA=0/EA=1 CFM/SQFT: PRESS (CFM): NO OF RMS:	38 2.0 118000 1): 0 0 1	
WALL AREA (SQFT)	WINDOW A	AREA QFT)			
N: 6411 E: 0 S: 6295 W: 0) 5)	1188 0 0 0			
ROOF AREA (SQFT): WALL BELOW GRADE (SQF SLAB ON GRADE (SQFT):	1 T): = ===================================	19762 19762 ====: =======			

HDR MECHANICAL SECTION		HEATING/COOLING LOAD CALCULATIONS				
					1.000 RC	DOM TYPES
		R	DOM DATA		0 CF	۳M
					ιινίτ· Δι	411-201-R
DATE:	05-Sep-07			ENGINEER:	AT	TENZA
ROOM NO:		P1B		PEOPLE (NO EA)):	38
ROOM NAME:		PENTANT 1B		LIGHTS (WATTS):	2.8
AREA (SOET)		19762		MISC SENS (BTU). ()Н).	118000
HEIGHT (ET)		12		MISCIAT (BTI	UH)	110000
DESIGN AC:		6		RA=0/FA=1	<i>Q</i> (1).	0
RM TEMP (DEG	F):	75	75	CEM/SOFT:		Ŭ
PEOPLE SENS (BTUH):	450	, .	PRESS (CEM):		0
PEOPLE LAT (B	TUH):	450		NO OF RMS:		1
	WALL AREA	WINDO	W AREA			
	(SQFT)		(SQFT)			
N:	6411		1188			
E:	0		0			
S:	6295		0			
W:	0		0			
ROOF AREA (SO WALL BELOW G	QFT): GRADE (SQF ⁻	Г):	19762			
SLAB ON GRAD	E (SQFT):	· 	19762		=====: =:	

PROJECT:	BNL					UNIT:	AHU-101	
DATE:	05-Sep-07					PAGE:	1	
ROOM	ROOM	SA	RA	EA	SQFT	ES/SQFT	COOL	DT
NO	NAME	(CFM)	(CFM)	(CFM)		AC =======	AC	HTG =======
T1	TUNNEL 1	10280	10280	0	6393	6	11	4
		10280	10280	0	6393			

ROOM DATA SUMMARY

PROJECT: BNL DATE: 05-Sep-07

UNIT: AHU-101 PAGE: 2

COOLING (BTUH)

ROOM	ROOM	TOTAL	EXT	INTER	NAL SENS	IBLE	TOTAL	HTG	HTG
NO		SENS	SENS	LIGHTS	PEOPLE	MISC	LATENT	(BTUH)	(BTUH/FT)
========	=======================================	========	=======	=======	=======	==============	========	=======	==================
T1	TUNNEL 1	255354	0	32604	6750	216000	6750	39702	
=========	=======================================	=========	=======	=======	=======	========	========	=======	
		255354	0	32604	6750	216000	6750	39702	

AHU DATA SUMMARY

PROJECT:	BNL	UNIT: A	AHU-101
DATE:	05-Sep-07	PAGE:	3

		COOLING L	OAD SENSI	BLE (BTUH)					
BTUH	8	10	12	2	4	6	(BIUN)		
TOTAL SENSIBLE TOTAL LATENT GRAND TOTAL	255354 6750 262104	255354 6750 262104	255354 6750 262104	255354 6750 262104	255354 6750 262104	255354 6750 262104	39702 0		
AVG DT	23	23	23	23	23		AC CFM	SQFT CFM	HTG CFM
SA (CFM) RA (CFM) EA (CFM)	10280 10280 0	10280 10280 0	10280 10280 0	10280 10280 0	10280 10280 0	10280 10280 0	5754	0	106387
TOTAL SA (CFM) TOTAL RA (CFM) TOTAL EA (CFM)	10280 10280 0								
	0	0	0	0	0	0	0	0	
SENSIBLE COOLING	0 255354	0 255354	0 255354	0 255354	0 255354	0 255354	0 39702	0	
:	255354	255354	255354	255354	255354	255354	39702	0	0
LATENT COOLING	0 6750	0 6750	0 6750	0 6750	0 6750	0 6750	0 0	0	
	= === ================================	6750	6750	6750	6750	6750	0	========== 0	0
SUPPLY AIR	0 10280	0 10280	0 10280	0 10280	0 10280	0 10280	0 5754	0 0	106387
		======= 10280	10280	10280	10280	10280	5754	0	106387
RETURN AIR	0 10280	0 10280	0 10280	0 10280	0 10280	0 10280	0 5754	0 0	60193
	10280	======================================	10280	10280	10280	10280	5754	0	60193
EXHAUST AIR	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	51610
	•==== == ••••••••••••••••••••••••••••••	0	 0		0	0	0	0	51610 551610
9 10	9	9	9	9	9	9	9	9	9

GLOBAL DATA

PROJECT: DATE: ENGINEER:	BNL 05-Sep-07 ATIENZA				A PAGE:	HU-101 4.00	4.00
Uwall: Uwindow s: Uwindow w: Uroof: SHADE FC: WALL CONST: FLOOR CONST:	0.05 0.30 0.29 0.04 0.44 3.00 (3.00 (20.00 BELOW G BELOW G	RADE) RADE)	PEOPLE SI PEOPLE L/ OAT WINT SA TEMP (DT HTG (D	ENS (BTUH AT (BTUH): (DEG F): DEG F): EG F):	250.00 200.00 0.00 55.00 40.00	
Factors Correcte Time of Day	d for Latitude-N 08:00 AM	1onth 10:00 AM	12:00 PM	02:00 PM	04:00 PM	06:00 PM	
CLTDroof:	22	23	26.00	31.00	36.00	39.00	
CLTDwall: N: E: S: W:	TYPE B 9 13 12 17	8 13 10 15	7.64 16.77 10.13 13.45	8.47 19.26 10.96 12.62	9.30 21.75 13.45 13.45	23.00 32.00 43.00 43.00	
CLTDwindow:	3	7	12.00	16.00	17.00	12.00	
SHGF: N: E: S: W:	130 216 205 216	130 216 205 216	130 216 205 216	130 216 205 216	130 216 205 216	130 216 205 216	
CLFwindow: N: E: S: W:	0.65 0.80 0.23 0.11	0.80 0.62 0.58 0.15	0.89 0.27 0.83 0.17	0 0.86 0.22 0.68 0.53	0.75 0.17 0.35 0.82	0.70 0.16 0.33 0.67	

Time of Day 08:00 AM 10:00 AM 12:00 PM 02:00 PM 04:00 PM 06:00 PM

Raw Factors

CLTDroof	20	21.00	24.00	29.00	34.00	38.00
CLTDwall	TYPE E					
N:	4	6	9.00	13.00	17.00	20.00
E:	11	26	36.00	37.00	34.00	32.00
S:	3	5.00	13.00	24.00	32.00	33.00
W:	6	6.00	9.00	14.00	27.00	43.00
CLTD Correction	Factor (LM)					
Roof:	1					
Walls:						
N	3					
E	0					
S	10					
W	0					

PROJECT:	BNL					UNIT:	AHU-201-A	A
DATE:	05-Sep-07					PAGE:	1	
ROOM NO	ROOM NAME	SA (CFM)	RA (CFM)	EA (CFM)	SQFT)	ES/SQFT AC	COOL AC	DT HTG
P1A	PENTANT 1A	23710	23710	0	19762	6 =========	4	8
		23710	23710	0	19762			

ROOM DATA SUMMARY

PROJECT: BNL DATE: 05-Sep-07

UNIT: AHU-201-A PAGE: 2

COOLING (BTUH)

ROOM	ROOM	TOTAL	EXT	INTER	NAL SENS	IBLE	TOTAL	HTG	HTG
NO		SENS	SENS	LIGHTS	PEOPLE	MISC	LATENT	(BTUH)	(BTUH/FT)
==================	=================		==========	=======================================	========	=======		========	=============
P1A	PENTANT 1A	378408	108926	134382	17100	118000	17100	192059	
	=======================================	=======	=	=======================================	=======================================	=======	=======	=======	
		378408	108926	134382	17100	118000	17100	192059	

AHU DATA SUMMARY

PROJECT: BNL	UNIT: AHU-201-A
DATE: 05-Sep-07	PAGE: 3

		cc	OLING L	HTG (BTUH)						
BTUH	٤	3	10	12	2	4	6			
TOTAL SENSIBLE TOTAL LATENT GRAND TOTAL	344150 1710 361250		355770 17100 372870	365774 17100 382874	369640 17100 386740	367524 17100 384624	378408 17100 395508	192059 0		
AVG DT	2	0	Ź0	20	20	20		AC CFM	SQFT CFM	HTG CFM
SA (CFM) RA (CFM) EA (CFM)	1593 1593	3 3 0	16471 16471 0	16934 16934 0	17113 17113 0	17015 17015 0	17519 17519 0	23714	0	149622
TOTAL SA (CFM) TOTAL RA (CFM) TOTAL EA (CFM)	2371 2371	0 0 0								
		0	0	0	0	0	0	0	0	
SENSIBLE COOLING	3441	0 50	0 355770	0 365774	0 369640	0 367524	0 378408	0 192059	0	
	======== 3441:	== === 50	355770	365774	369640	367524	378408	192059	0	0
LATENT COOLING	171	0 00	0 17100	0 17100	0 17100	0 17100	0 17100	0 0	0	
	======== 171		17100	17100 <u>17</u> 100	17100	17100	17100	0	0	0
SUPPLY AIR	159	0 33	0 16471	0 16934	0 17113	0 17015	0 17519	0 23714	0 0	149622
	=== == 159	:=: == 33	16471	16934	17113	17015	17519	23714	0	149622
RETURN AIR	159	0 33	0 16471	0 16934	0 17113	0 17015	0 17519	0 23714	0 0	103427
	====== 159	33 33	16471	16934	17113	17015	17519	23714	0	103427
EXHAUST AIR		0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	51610
		0	0	0	0	0	0	0	0	51610
9	10	9	9	9	9	g) 9	9	9	9

GLOBAL DATA

PROJECT: DATE: ENGINEER:	BNL 05-Sep-07 ATIENZA				PAGE:	AHU-201-A 4.00	4.00
Uwall: Uwindow s: Uwindow w: Uroof: SHADE FC: WALL CONST: FLOOR CONST:	0.05 0.30 0.29 0.04 0.44 3.00 3.00	20.00 (BELOW 6 (BELOW 6	RADE) RADE)	PEOPLE SI PEOPLE L/ OAT WINT SA TEMP (DT HTG (D	ENS (BTUH AT (BTUH): (DEG F): DEG F): EG F):	250.00 200.00 0.00 55.00 40.00	
Factors Corrected Time of Day	d for Latitude-N 08:00 AM	Month 10:00 AM	12:00 PM	02:00 PM	04:00 PM	06:00 PM	
CLTDroof:	22	23	26.00	31.00	36.00	39.00	
CLTDwall: N: E: S: W:	TYPE B 9 13 12 17	8 13 10 15	7.64 16.77 10.13 13.45	8.47 19.26 10.96 12.62	9.30 21.75 13.45 13.45	23.00 32.00 43.00 43.00	
CLTDwindow:	3	7	12.00	16.00	17.00	12.00	
SHGF: N: E: S: W:	130 216 205 216	130 216 205 216	130 216 205 216	130 216 205 216	130 216 205 216	130 216 205 216	
CLFwindow: N: E: S: W:	0.65 0.80 0.23 0.11	0.80 0.62 0.58 0.15	0.89 0.27 0.83 0.17	0 0.86 0.22 0.68 0.53	0.75 0.17 0.35 0.82	0.70 0.16 0.33 0.67	

Time of Day 08:00 AM 10:00 AM 12:00 PM 02:00 PM 04:00 PM 06:00 PM

Raw Factors

CLTDroof	20	21.00	24.00	29.00	34.00	38.00
CLTDwall	TYPE E					
N:	4	6	9.00	13.00	17.00	20.00
E:	11	26	36.00	37.00	34.00	32.00
S:	3	5.00	13.00	24.00	32.00	33.00
W:	6	6.00	9.00	14.00	27.00	43.00
CLTD Correc	tion Factor (LM)					
Roof:	1					

Walls:	
N	3
E	0
S	10
W	0

PROJECT: DATE:	BNL 05-Sep-07					UNIT: / PAGE:	АНU-201-Е 1	\$
ROOM NO	ROOM NAME	SA (CFM)	RA (CFM)	EA (CFM)	SQFT)E	S/SQFT AC	COOL AC	DT HTG
P1B	PENTANT 1B	23710	23710	0	19762	6 	5 ========	8
		23710	23710	0	19762			

ROOM DATA SUMMARY

PROJECT: BNL DATE: 05-Sep-07

UNIT: AHU-201-B PAGE: 2

COOLING (BTUH)

ROOM NO	ROOM	TOTAL SENS	EXT SENS	INTER LIGHTS	NAL SENS PEOPLE	IBLE MISC	TOTAL LATENT	HTG (BTUH)	HTG (BTUH/FT)
=========	=======================================	=========		=======	=======	=======	=======	========	=================
P1B	PENTANT 1B	432161	108926	188134	17100	118000	17100	192059	
=========		========	=======================================			=======	=========	=========	
		432161	108926	188134	17100	118000	17100	192059	

AHU DATA SUMMARY

PROJECT: BNL	UNIT: AHU-201-B
DATE: 05-Sep-07	PAGE: 3

			HTG (BTUH)							
BTUH		8	10	12	2	4	6			
TOTAL SENSIBLE TOTAL LATENT GRAND TOTAL		397902 17100 415002	409523 17100 426623	419526 17100 436626	423393 17100 440493	421277 17100 438377	432161 17100 449261	192059 0		
AVG DT		20	20	20	20	20		AC CFM	SQFT CFM	HTG CFM
SA (CFM) RA (CFM) EA (CFM)		18421 18421 0	18959 18959 0	19423 19423 0	19602 19602 0	19504 19504 0	20007 20007 0	23714	0	113799
TOTAL SA (CFM) TOTAL RA (CFM) TOTAL EA (CFM)		23710 23710 0								
		0	0	0	0	0	0	0	0	
SENSIBLE COOLING		0 397902	0 409523	0 419526	0 423393	0 421277	0 432161	0 192059	0	
	==	397902	409523	419526	423393	421277	432161	192059	0	0
LATENT COOLING		0 17100	0 17100	0 17100	0 17100	0 17100	0 17100	0 0	0	
	=:	17100	17100	17100	17100	17100	17100	0	0	0
SUPPLY AIR		0 18421	0 18959	0 19423	0 19602	0 19504	0 20007	0 23714	0 0	113799
	=:	18421	18959	19423	19602	19504	20007	23714	0	113799
RETURN AIR		0 18421	0 18959	0 19423	0 19602	0 19504	0 20007	0 23714	0 0	67604
	=	18421	18959	19423	19602	19504	20007	23714	0	67604
EXHAUST AIR		0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	51610
		0	0	0	======= 0	0	0		0	51610
9	10	9	9	9	9	9	9	9	9	9

GLOBAL DATA

PROJECT: I DATE: ENGINEER: /	BNL 05-Sep-07 ATIENZA				PAGE:	AHU-201-B 4.00	4.00
Uwall: Uwindow s: Uwindow w: Uroof: SHADE FC: WALL CONST: FLOOR CONST:	0.05 0.30 0.29 0.04 0.44 3.00 (3.00	20.00 (BELOW G (BELOW G	RADE) RADE)	PEOPLE SI PEOPLE L/ OAT WINT SA TEMP (DT HTG (D	ENS (BTUH AT (BTUH): (DEG F): DEG F): EG F):	250.00 200.00 0.00 55.00 40.00	
Factors Corrected Time of Day	l for Latitude-N 08:00 AM	/onth 10:00 AM	12:00 PM	02:00 PM	04:00 PM	06:00 PM	
CLTDroof:	22	23	26.00	31.00	36.00	39.00	
CLTDwall: N: E: S: W:	TYPE B 9 13 12 17	8 13 10 15	7.64 16.77 10.13 13.45	8.47 19.26 10.96 12.62	9.30 21.75 13.45 13.45	23.00 32.00 43.00 43.00	
CLTDwindow:	3	7	12.00	16.00	17.00	12.00	
SHGF: N: E: S: W:	130 216 205 216	130 216 205 216	130 216 205 216	130 216 205 216	130 216 205 216	130 216 205 216	
CLFwindow: N: E: S: W:	0.65 0.80 0.23 0.11	0.80 0.62 0.58 0.15	0.89 0.27 0.83 0.17	0.86 0.22 0.68 0.53	0.75 0.17 0.35 0.82	5 0.70 7 0.16 5 0.33 2 0.67	

Time of Day 08:00 AM 10:00 AM 12:00 PM 02:00 PM 04:00 PM 06:00 PM

Raw Factors

CLTDroof	20	21.00	24.00	29.00	34.00	38.00
CLTDwall	TYPE E					
N:	4	6	9.00	13.00	17.00	20.00
F:	11	26	36.00	37.00	34.00	32.00
S [.]	3	5.00	13.00	24.00	32.00	33.00
W:	6	6.00	9.00	14.00	27.00	43.00
CLTD Correcti	on Eactor (LM)					

CLTD Correction Factor (LM) Roof: 1

Roof:	1
Walls:	
N	3
E	0
S	10
W	0

PROJECT: DATE:	BNI 08-AUG-0	- 7				UNIT: PAGE:	AHU-101 1			
ROOM NO	ROOM NAME	SA (CFM)	RA (CFM)	EA (CFM)	SQFT	DES/SQFT AC	COOL AC	DT HTG	0A	%OA
======== T1	TUNNEL 1	10280	10280		6393	6	11	4	540	5.25%
		10280	=== = === 10280		6393 6	=======================================			540	======================================
AIR FLOW W	DIVERSITY	10280	CFM					OA MAX OA BY %	540 540	CFM CFM
SF AIR FLOW	I Contraction of the second	11822	CFM					Y	5 25%	<<<<<<
RF AIR FLOW	1	11822	CFM					×	5.25%	
EA=SF-RF			CFM					Z	5.25%	
OA		540	CFM	5%						
OA CHECK			CFM							
RELIEF		540	CFM							

PROJECT: DATE:	BNL 08-AUG-07					UNIT:\H PAGE:	IU-201-A 1			
ROOM NO	ROOM NAME	SA (CFM)	RA (CFM)	EA (CFM)	SQFT	DES/SQFT AC	COOL AC	DT HTG	OA	%OA
====== Р1А	PENTANT 1A	23710	23710		19762	6	4	8	1368	5.77%
		23710	23710		19762	==========		******	1368	============ 5.77%
AIR FLOW W	/DIVERSITY	23714	CFM					OA MAX OA BY %	1368 1368	CFM CFM
SF AIR FLOV	V	27272	CFM					\checkmark	5 77%	<<<<<<<
RF AIR FLOV	V	27272	CFM					X Z	5.77%	
EA=SF-RF			CFM					<u> </u>	0.1175	
OA		1368	CFM	6%						
OA CHECK			CFM							
RELIEF		1368	CFM							

PROJECT:	BNL 08-AUG-07					UNIT:\ PAGE:	HU-201-B 1			
ROOM	ROOM NAME	SA (CFM)	RA (CFM)	EA (CFM)	SQFT	DES/SQFT AC	COOL AC	DT HTG	OA	%OA
P1B	PENTANT 1B	23710	23710		19762	6	5	8	1368	5.77%
==============================		23710	23710	========	======= 19762				1368	======================================
AIR FLOW W	DIVERSITY	20007	CFM					OA MAX OA BY %	1368 1368	CFM CFM
SF AIR FLOW	1	23009	CFM					Y	5.77%	<<<<<<
RF AIR FLOW	I	23009	CFM					×	5.77%	
EA=SF-RF			CFM					2	5.77%	
OA		1368	CFM	7%						
OA CHECK			CFM							
RELIEF		1368	CFM							

BNL NSLS II 05-Sep-07		AIR HANDLING CV	G UNIT PSYCH	ROMETRICS	
AHU-101	<<<<<<	ENGINEER:	ATIENZA	<<<<<<	
OUTSIDE DESIGN CO	ONDITIONS				
SU	MMER	WINTER	र		
OA DB OA WB OA ENT	95 DEG F <<<<<< 76 DEG F <<<<<<< 39.3 BTU/LB OF DRY AIR	<* () DEG F<<<<	<	
AIR FLOW	HEAT GA	NN		HEAT LOSS	
SA RA OA	11822 CFM<<<< SENSIBL 11282 CFM PLENUM 540 CFM<<<< LATENT	E 25535 100	4 BTUH<<<< 0 BTUH<<<< 0 BTUH<<<<	< 63839 BTUH<<<<· <<<	18776 W
FAN TOTAL PRESSU	JRE FAN TEM	IP RISE	FAN ENT R	ISE	
SUPPLY RETURN LIGHTS TO PLEN AHU LAT	4 IN WG <<<- 3 1.5 IN WG <<<- 1 IUM C	0.1 DEG F .4 DEG F 0.0 DEG F	0.74 0.39 0.09	4 BTU/LB OF DRY AIR 5 BTU/LB OF DRY AIR 0 BTU/LB OF DRY AIR	
LAT DB LAT WB LAT ENT	56 DEG F <<<<<< 53.0 DEG F 22.61 BTU/LB OF DRY AIF	<<< {			
ROOM CONDITIONS	3				
SRMTEMP DB SRMTEMP WB RMENT	78.0 DEG F<<<<< 60.0 DEG F 27.91 BTU/LB OF DRY AIF	WRMTEMP I	DB 6	8 DEG F	
RETURN AIR					
RA DB RA WB RA ENT	79.4 DEG F 60.4 DEG F 28.26 BTU/LB OF DRY All	R			
COOLING COIL					
EAT DB EAT WB EA ENT	80.2 DEG F 61.2 DEG F 28.76 BTU/LB OF DRY AI	R			
LAT DB LAT WB LA ENT	52.9 DEG F 52.8 DEG F 21.88 BTU/LB OF DRY AI	R			
CAPACITY	31 TONS				
PREHEAT COIL AT	NORMAL OPERATION	REHEAT C	DILS	HEAT LOSS	TOTAL HEATING
SA WINTER EAT DB	11822 CFM <<<<< 64.9 DEG F	<<<<	65 DEG F E/	AT.	
HTG CAP HTG CAP HTG CAP HTG CAP	0 BTUH 0 KW 0 LBS/HR STEAM	39	658 BTUH 12 KW 42 LBS/HR \$	63839 BTUH STEAM	103496 BTUH
HUMIDIFIER					
WRMTEMP DB REL HUM HUM RAT CAPACITY	68.0 DEG F 30 % <<<<< 30 GR/LB OF DRY AI 72 LBS/HR STEAM	<<<« R ECON MIN	0 I OA 4:	244 CFM 540 CFM	
PREHEAT COIL A	T 100% OA	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,			
EAT DB LAT DB HTG CAP HTG CAP HTG CAP	0 DEG F 52.9 DEG F 675757 BTUH 199 KW 711 LBS/HR STEAM				

BNL NSLS II 05-Sep-07			AIR HANDLIN VVR	G UNIT PSYC	HROMETRICS	
AHU-201-A	<<<<<<		ENGINEER:	ATIENZA	<<<<<<	
OUTSIDE DESIGN C	ONDITIONS					
SL	IMMER		WINTE	R		
OA DB OA WB OA ENT	95 DEG F 76 DEG F 39.3 BTU/LB OF	<<<<<<< <<<<<<<<< DRY AIR		0 DEG F<<<<	.<	
AIR FLOW		HEAT GAIN	1		HEAT LOSS	
SA RA OA	27272 CFM<<<< 25904 CFM 1368 CFM<<<<	SENSIBLE PLENUM LATENT	58906 100	6 BTUH<<<< 0 BTUH<<<< 0 BTUH<<<<	< 147266 BTUH<<<<· <<< <	43314 W
FAN TOTAL PRESS	JRE	FAN TEMP	RISE	FAN ENT F	RISE	
SUPPLY RETURN LIGHTS TO PLEN AHU LAT	6 IN WG <<< 1.5 IN WG <<< IUM	4.6 1.4 0.0	DEG F DEG F DEG F	1.1 0.3 0.0	1 BTU/LB OF DRY AIR 5 BTU/LB OF DRY AIR 0 BTU/LB OF DRY AIR	
LAT DB LAT WB LAT ENT	56 DEG F 53.0 DEG F 22.09 BTU/LB OF	<<<<<<				
ROOM CONDITION	S					
SRMTEMP DB SRMTEMP WB RMENT	75.0 DEG F<<< 60.0 DEG F 26.66 BTU/LB OI	 DRY AIR	WRMTEMPI	DB 6	88 DEG F<<<<<	
RETURN AIR						
RA DB RA WB RA ENT	76.4 DEG F 60.4 DEG F 27.01 BTU/LB O	F DRY AIR				
COOLING COIL						
EAT DB EAT WB EA ENT	77.4 DEG F 61.2 DEG F 27.62 BTU/LB O	F DRY AIR				
LAT DB LAT WB LA ENT	51.4 DEG F 51.3 DEG F 20.99 BTU/LB C	F DRY AIR				
CAPACITY	68 TONS					
PREHEAT COIL A	T NORMAL OPERAT	ION	REHEAT C	OILS	IEAT LOSS	HEATING
SA WINTER EAT DB	27272 CFM 64.6 DEG F	<<<<<<	<<	65 DEG F E	AT	
LAT DB HTG CAP	51.4 DEG F 0 BTUH		100	466 BTUH	147266 BTUH	247732 BTUH
HTG CAP HTG CAP	0 KW 0 LBS/HR S	втеам		30 KW 106 LBS/HR	STEAM	
HUMIDIFIER						
WRMTEMP DB	68.0 DEG F		~~~	0		
REL HUM HUM RAT CAPACITY	30 % 30 GR/LB O 154 LBS/HR	F DRY AIR STEAM	ECON	NOA 9	091 CFM	
PREHEAT COIL A	T 100% OA		MIN	NOA 1	368 CFM	
EAT DB	0 DEG F					
LAT DB HTG CAP	51.4 DEG F 1513618 BTUH					
HTG CAP HTG CAP	445 KW 1593 LBS/HR	STEAM				

BNL NSLS II 05-Sep-07		AIR HANDLING VVR	UNIT PSYCH	ROMETRICS	
AHU-201-B	<<<<<<	ENGINEER:	ATIENZA	<<<<<<	
OUTSIDE DESIGN C	ONDITIONS				
SL	IMMER	WINTER			
OA DB OA WB OA ENT	95 DEG F <<<<<< 76 DEG F <<<<<< 39.3 BTU/LB OF DRY AIR	< 0	DEG F<<<<	<	
AIR FLOW	HEAT GA	IN		HEAT LOSS	
SA RA OA	23009 CFM<<<< SENSIBLE 21641 CFM PLENUM 1368 CFM<<<< LATENT	E 496985 0 1000	BTUH<<<<< BTUH<<<<< BTUH<<<<<	< 124246 BTUH<<<< [,] <<< <	36543 W
FAN TOTAL PRESS	URE FAN TEM	P RISE	FAN ENT R	ISE	
SUPPLY RETURN LIGHTS TO PLEM AHU LAT	6 IN WG <<<· 4. 1.5 IN WG <<<· 1. NUM 0.	6 DEG F 4 DEG F 0 DEG F	1.11 0.35 0.00	1 BTU/LB OF DRY AIR 5 BTU/LB OF DRY AIR 1 BTU/LB OF DRY AIR	
LAT DB LAT WB LAT ENT	56 DEG F <<<<<< 53.0 DEG F 22.09 BTU/LB OF DRY AIR	<<			
ROOM CONDITION	S				
SRMTEMP DB SRMTEMP WB RMENT	75.0 DEG F<<<<< 60.0 DEG F 26.66 BTU/LB OF DRY AIR	WRMTEMP DE	3 6	8 DEG F<<<<<	
RETURN AIR					
RA DB RA WB RA ENT	76.4 DEG F 60.4 DEG F 27.01 BTU/LB OF DRY AIR	ł			
COOLING COIL					
EAT DB EAT WB EA ENT	77.5 DEG F 61.4 DEG F 27.74 BTU/LB OF DRY AIF	R			
LAT DB LAT WB LA ENT	51.4 DEG F 51.3 DEG F 20.99 BTU/LB OF DRY AIF	र			
CAPACITY	58 TONS				
PREHEAT COIL A	T NORMAL OPERATION	REHEAT CO	ILS	HEAT LOSS	TOTAL HEATING
SA WINTER EAT DB	23009 CFM <<<<<< 64.0 DEG F	<<< (64 DEG F EA	λŢ	
LAT DB HTG CAP HTG CAP HTG CAP	51.4 DEG F 0 BTUH 0 KW 0 LBS/HR STEAM	1004(: 1004(56 BTUH 30 KW 56 LBS/HR S	124246 BTUH STEAM	224712 BTUH
HUMIDIFIER					
WRMTEMP DB REL HUM HUM RAT	68.0 DEG F 30 % <<<<< 30 GR/LB OF DRY AIF	<<< }	0	370 CEM	
		MIN	DA 13	368 CFM	
EAT DB LAT DB	0 DEG F 51.4 DEG F 1277014 BTUH				

HTG CAP 376 KW HTG CAP 1344 LBS/HR STEAM

Appendix A5

Hourly Whole Building Energy Analysis September 10, 2007

EMO Energy Solutions



September 10th, 2007

BROOKHAVEN NSLS II – UPTON, NEW YORK: SCHEMATIC DESIGN ENERGY ANALYSIS HOURLY WHOLE BUILDING ENERGY ANALYSIS AND LEED®-NC v2.2 EA Cr.1 OPTIMIZATION



Purpose & Scope:

The United States Department of Energy (DOE) has contracted HDR Architecture, Inc. (HDR) and for the design and implementation of sustainable design strategies and features for the new Brookhaven National Laboratory – National Synchrotron Light Source II (NSLS II) in Upton, New York. This project is intended to incorporate environmentally sensitive materials and technologies along with the principals of sustainable design and the integrated whole building design approach. To this end, HDR has contracted EMO Energy Solutions, LLC (EMO) to perform a comprehensive whole building energy simulation, energy analysis, and general sustainable design and green engineering assistance.

This project will be applying for Leadership in Energy and Environmental Design, New Construction (LEED®-NC) version 2.2 with the goal of a "Gold" level of certification. As part of this certification process, EMO will simulate the annual energy use of the building as-designed / Design Energy Cost (DEC) model and the building as if it were designed to meet ASHRAE 90.1-2004 minimum specifications / Performance Rating Method (PRM) model. The difference in consumption between the two models is used to determine the final point total for Credit-1 of the LEED®-NC Energy and Atmosphere category.

Given this stage (Schematic) in design, this energy analysis report is intended to cover the following for the design team:

- Preliminary hourly building energy analysis
- Energy performance as compared to ASHRAE 90.1-2004 baseline (*initial performance* expected to change with more refined building)
- Provide the design team feedback with regards to energy cost savings expectations going forward into the Design Development phase
- Itemize some of the energy cost savings for different energy efficiency opportunities
- Highlight some key ASHRAE 90.1-2004 Appendix G requirements
- Provide the design team information regarding energy utilization in the proposed facility and how to improve LEED®-NC EA Cr.1 performance

For this "SD Level" energy analysis, EMO has incorporated the <u>estimated</u> envelope, building design, and HVAC system options for the SD phase as well as all other parameters and components as represented in the documents (dated 27 January 2007), the "Title I Preliminary Design Report – 50% Review Submittal" and conversations with HDR.

Methodology:

The standard sustainable design approach employed by EMO is based upon and optimized by the interactive design approach. Sustainable improvements are defined as modifications that will reduce the negative environmental impact of the building for future generations by minimizing the energy and water consumption, minimizing pollution emissions, and increasing the useful life of the building by improving the quality of the occupied spaces. This process incorporates four distinct, but fluid processes that work with the design team through the course of the design:

- <u>Generate the Baseline</u> Generate a DOE-2.2 energy model of the current design of the facility, of which include all proposed building systems including the ASHRAE 90.1 guidelines for new construction where applicable.
- <u>Evaluate the Baseline</u> Compare to ASHRAE or existing building code and PRM for LEED® ; determine energy goals and targets
- <u>Generate and Evaluate ECMs</u> Generate parametric runs for any and all applicable ECMs to account for any associated savings that would add any LEED® credits in the Energy & Atmosphere category of the LEED® Rating System
- <u>Final Design</u> Present the packaged ECMs, highlighting the energy savings, the overall Energy Usage Intensity (EUI-kBtu/sf) reduction, and the potential LEED® credits awarded.

The process of identifying energy efficiency and conservation measures relies on the following three step strategy. This strategy is applied to optimize and fully capitalize on the associated savings and emphasis on reduction of waste:

- <u>Minimize Building Loads</u> Improve the building envelope, reduce lighting power densities and usage, incorporate suitable day lighting techniques, reduce equipment power densities and usage, and reduce water consumption flow rates.
- <u>Improve System Effectiveness</u> Improve HVAC system design, increase motor efficiencies, utilize solar heating technologies, incorporate energy recovery technologies, and utilize applicable controls strategies.
- <u>Optimize Resource Delivery</u> Provide renewable energy generation, incorporate energy storage techniques, increase the efficiency of the plant, review utility rate options, and investigate district heating and cooling options.

The method of evaluation closely followed the guidelines stipulated by the US Green Building Council's LEED® design approach and the ASHRAE/IESNA 90.1-2004 interactive calculation method.

All project energy modeling used eQUEST 3.61e, a program that utilizes DOE-2.2 to simulate the hourly energy consumption and demand load shapes for a given facility. To develop a model, the user creates a graphic representation of the building, using floor plans, floor heights, and window configurations. Specifics of the central plant, air-handling units, and building envelope are included along with the operating parameters such as lighting power density, occupancy, building schedules, and airflow rates. The simulation uses 30-year average hourly weather data to accurately estimate the energy consumption of the building for each hour of the year.

Results Summary:

With the assumptions and strategies represented in the design drawings and implementation of all listed measures this project is expected to save ~\$492,908/yr (~21.8%) in total energy costs when compared to the ASHRAE baseline meeting EA Prerequisite 2 and equating to (3-4) LEED®-NC v2.2 E&A Credit 1 (New Construction) points.

It is important to note that the quoted performance will change once the design is developed further. However, it gives the project team an idea of the expectation following an aggressive design. [Review section "Energy Performance Issues"]

Brief Modeling Description:

The following is a list, in no particular order, of some of the major modeling parameters accounted for at this stage. A more detailed line-by-line description of the differences between the "As-designed (DEC)" and "Initial Baseline (PRM)" energy simulations is shown in Figure 1.

- DOE Energy Information Administration published blended utility rates for New York State (\$0.1543/kWh)
- Assumed a district steam rate of \$25.00/MMBtu-delivered
- Utilizing typical meteorological year TMY2 hourly weather file for New York City, NY
- Utilized Title 24 approved diversity schedules for lighting, occupancy, plugs, process, etc.
- All envelop parameters (layer-by-layer assemblies, vertical glazings, programming, etc.)
- All internal loads (lighting, equipment "plugs", domestic hot water, occupancy, etc.)
- All external loads (climate zone, infiltration, solar transmitted, ground conductance, etc.)
- Photocells, occupancy sensors, CO₂, etc. / where anticipated
- All HVAC components (Chillers ASHRAE 90.1, district steam, air-side equipment, controls, circulation loop infrastructure, settings, thermal zones, etc)
- Assumed on-site ASHRAE 90.1-2004 compliant chillers (per requirement for district system)
- All unknown parameters assumed to be ASHRAE 90.1-2004 Appendix G minimally compliant
- Water-cooled Synchrotron cooling neglected (i.e. ~2400 tons cooling, etc.); only energy uses
 of which can be controlled are included in addition to the LEED®-NC requirement for process
 energy
- Others...



Figure 1: 3-D Energy Model Renderings of the Design Energy Cost

Energy Performance Issues:

This section of the memo is intended to highlight some of the energy performance "<u>highlights</u>" and energy "<u>hogs</u>" of which will work either for or against optimizing total energy cost savings for LEED®-NC v2.2 Energy & Atmosphere Credit 1. The following, in no particular order, is a list of key parameters that are both improving and reducing our energy performance related to the ASHRAE 90.1-2004 Appendix G Performance Rating Method:

Improved Energy Cost Performance	Reduced Energy Cost Performance
 Having high process energy and tight indoor thermal requirements (i.e. 1°F) enables the project to do rather well when compared to ASHRAE 90.1-2004 compliance 	 Stringent requirement for Total Fan Power. Assumed ASHRAE 90.1-2004 Appendix G fan power (very important to confirm) – Designers should review the following:
- Long Island is one of the only areas in New York that doesn't require air-side economizers. Including economizers at a facility with high internal heat gains will pay huge dividends. If the site was located elsewhere the annual energy cost savings would be significantly less (see "Energy Efficiency Opportunities")	 Appendix G Table G3.1.2.9 Section G31.2.9 Appendix G User's Manual (Pgs G-28, G-29) District steam does not provide the opportunity to generate plant level heating savings given no site level heating source (Appendix G3.1.1.1)
 Outside air economizers (N.R. per ASHRAE climate zone 4a) 	 District chilled water does not provide the opportunity to generate plant level heating savings given no site level heating source (Appendix G3.1.3.7)
 Having tight thermal requirements for the Experimental Hall provides significant opportunity (more so than most projects) for energy cost savings with a significantly improved envelope 	 Constant volume AHUs for Laboratory spaces Other parameters are unknown and a judgment cannot be made either way as to their impact at this time
Centria® Formawall®: U-value = 0.045 (see "Appendix A")	
Metal Deck Roof: U-value = 0.054 (High Albedo white roof w/ low absorptance)	
High Performance Glazing: U-value = 0.311 SHGC = (BOD: Viracon VE 1-2M)	
 High efficiency lighting for Experimental Hall (0.8 W/sf), Offices (0.9 W/sf), and Laboratories (1.0 W/sf) 	
- Daylighting and photocell control for perimeter LOB offices (N.R. per ASHRAE 90.1)	

Energy Efficiency Opportunities:

<u>Variable Air Volume AHUs for Laboratories</u>: Currently, the proposed facility is utilizing constant volume AHUs for the laboratories. If this is the case then the project cannot claim the energy cost savings associated with the sensible heat recovery since it will be required per ASHRAE 90.1-2004 G3.1.2.10. If VAV AHUs are utilized then the savings for ventilation energy or heat recovery can be claimed. Table 1 illustrates the savings associated with VAV AHUs equipped with variable speed drives.

Table 1.	Savings	Summary	/ for	EEO-1
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EEO No.	Description	Electricity Savings (kWh)	Annual Steam Savings (MMBtu)	Annual Energy Cost Savings	Total % Cost Savings
1	VAV for Laboratories	129,777	-1	\$19,977	1.1%

<u>High Performance Glazings</u>: As mentioned earlier, having tight thermal conditions in a large space volume opens up the opportunity for significant energy cost savings with improvements in the building envelope. The Experimental Hall is required to be maintained at 75°F year round with a 1.0°F tolerance. Therefore, there will be a significant amount of off-peak heating required and as such improving the glazing will generate energy cost savings. The basis-of-design for the "As-Designed" glazing is Viracon VE 1-2M or equivalent with improved conduction and reduced solar heat gain coefficient compared to that required by ASHRAE 90.1-2004 Climate Zone 4a. Table 2 illustrates the savings associated with VAV AHUs equipped with variable speed drives.

Table 2. Savings Summary for EEO-2

EEO No.	Description	Electricity Savings (kWh)	Annual Steam Savings (MMBtu)	Annual Energy Cost Savings	Total % Cost Savings
2	High Performance Glazings	45,439	764	\$26,089	1.5%

Daylighting Control: Currently, the proposed design shows several photocells in the commons areas, laboratories, classrooms, and main stairwell. EMO has elected to itemize the energy cost savings associated with turning off electrical lighting for the perimeter LOB office space only where adequate natural light is sufficient in supporting the specific space's primary function. Table 3 illustrates the savings associated with a typical LOB perimeter office employing photocell control based on natural light.

Table 3. Brief Daylighting Statistics

Space	Percentage	Foot Candle	Peak Energy	Percentage
	Lighting	photocell	Reduction	Runtime Reduction
	controlled	setpoint	(Daylit hours)	(All hours)
LOB Perimeter Office	100%	50	79.0%	46.0%

Table 4 of this report illustrates the energy cost savings associated with this measure.

Table 4. Savings Summary for EEO-3

EEO No.	Description	Electricity Savings (kWh)	Annual Steam Savings (MMBtu)	Annual Energy Cost Savings	Total % Cost Savings
3	Daylighting (Perimeter Offices Only)	39,953	-37	\$5,232	0.3%

Improved Building Envelope: Similar to that of EEO-2 an improved envelope will generate substantial savings at this site. EMO has itemized the savings with the improved wall assembly, roof assembly, and roof absorptance proposed for this project to illustrate the importance of the measure. Table 5 of this report illustrates the energy cost savings associated with this measure.

Table 5. Savings Summary for EEO-4

EEO No.	Description	Electricity Savings (kWh)	Annual Steam Savings (MMBtu)	Annual Energy Cost Savings	Total % Cost Savings
4	Improved Building Envelope	99,318	1,757	\$59,231	3.2%

<u>Air-side Economizers</u>: Upton, New York is one of the only regions in New York State of which airside economizers are not required (Climate Zone 4a). The savings for this measure are much higher than in a typical building given the high internal heat gains, substantial exterior surface area, and only 75°F cooling requirement. Table 6 of this report illustrates the energy cost savings associated with this measure.

Table 6. Savings Summary for EEO-5

EEO No.	Description	Electricity Savings (kWh)	Annual Steam Savings (MMBtu)	Annual Energy Cost Savings	Total % Cost Savings
5	Air-side Economizer	1,826,471	-354	\$272,952	13.4%

Improved Lighting Efficiency: HDR is expecting to have low peak power densities for a significant portion of the building. The majority of the electrical lighting in this facility is that of the Experimental Hall. The ASHRAE Table 9.6.1 requirement for this Laboratory type space is a lighting power density (LPD-W/sf) of 1.40 W/sf. HDR has indicated that the Experimental Hall will be designed to an LPD of 0.80 W/sf (43% improvement). This will require an aggressive lighting design most likely including 5-lamp T5HO technology in lieu of HID or T8 lighting technologies. Furthermore, HDR is designing to 0.90 W/sf in the Offices and 1.00 W/sf in the LOB laboratories. Table 7 of this report illustrates the energy cost savings associated with improving the lighting as indicated.

Table 7. Savings Summary for EEO-6

EEO No.	Description	Electricity Savings (kWh)	Annual Steam Savings (MMBtu)	Annual Energy Cost Savings	Total % Cost Savings
6	Improved Lighting Efficiency	632,559	-871	\$75,810	4.1%



Figure 2 and Figure 3 provide energy and cost by building end-use for the "Initial PRM" and "All EEOs" simulations.

Figure 2: Energy End-Use Breakdown and Energy Usage Intensity



Figure 3: Energy Cost Breakdown by End-Use and Annual Utility Budgets



Figure 4: Annual Energy Cost and LEED-NC ver 2.2 Points

Appendix A: Centria® Formawall[™]







LEED® Quick Hits

- Significantly reduces thermal bridging from outside-to-inside and conduction for drastically improved envelope assembly (Total wall = R-22.2 | AHSRAE 90.1-2004 = R-8.1). [LEED®-NC EA Cr.1]
- Opportunity for earning LEED® Innovation Credit for utilizing a "Cradle-to-Cradle" certified building material
- Formawall[™] panels contain an average of at least **16% post-consumer and 6% post-industrial** recycled content. [LEED®-NC MR Cr 4.1 & 4.2]
- **Panels have a VOC content of 180 grams/liter**, which is less than the maximum limit of 250 grams/liter established by this regulation for architectural sealants. [LEED®-NC EQ Cr. 4.1]
- No VOC's are generated at the jobsite from field-painting operations. [LEED®-NC EQ Cr 4.2]