DRAFT
SEISMIC VIBRATION MONITORING PLAN
Site 1 – Former Drum Marshalling Area
Naval Weapons Industrial Reserve Plant
Bethpage, New York

Contract Number: N62470-16-D-9004
Contract Task Order: F6147

Document Control Number: APTIM-9004-F6147-011

March 2019

Submitted to:

NAVFAC Mid-Atlantic
9324 Virginia Avenue, Building Z140
Norfolk, VA 23511

Submitted by:
APTIM Federal Services LLC
150 Boush Street, Suite 701
Norfolk, Virginia 23510

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Prepared by:___________________________ Date: ______________
Bill Squire, P.G.
Program Quality Control Manager

Approved by:___________________________ Date: ______________
Monica Smeal, E.I.T.
Project Manager

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Acronyms and Abbreviations

APTIM	Aptim Federal Services LLC
ft	feet
in	inch
KFM	KFM Geoscience
LF	linear feet
m	meter
NAVFAC	Naval Facilities Engineering Command
Navy	U.S. Department of the Navy
NWIRP	Naval Weapons Industrial Reserve Plant
OU4	Operable Unit 4
PPV	Peak Particle Velocity
PSS	Paulus, Sokolowski and Sartor Engineering, PC
RIT	Royal Institute of Technology
ROD	Record of Decision
sec	second
TT	Tetra Tech
USBM	U.S. Bureau of Mines

1.0 INTRODUCTION

This Seismic Monitoring Plan presents the specific tasks and procedures that will be implemented by Aptim Federal Services, LLC (APTIM) during the remedial action for Site 1 at Naval Weapons Industrial Reserve Plant (NWIRP) Bethpage in Bethpage, New York. The remedial action is being performed for the U.S. Department of the Navy (Navy) Naval Facilities Engineering Command (NAVFAC) Mid-Atlantic, under Contract No. N62470-16-D-9004, Contract Task Order N4008518F6147.

The work at Site 1 will be executed in accordance with the *Performance Work Statement for Site 1 – Former Drum Marshalling Area Remedial Action for Contaminated Soil* (NAVFAC, 2018) and the *Specifications for Site 1 – Former Drum Marshalling Area* (Tetra Tech, 2018). The objective of this remedial action is to fulfill the requirements of the Operable Unit 4 (OU4) Record of Decision ([ROD] Navy, 2018). The 2018 OU4 ROD (draft) selected remedy includes excavation and either on-site reuse or off-site disposal of polychlorinated biphenyl-contaminated soils and installation of a reduced permeability cover.

To aid the excavation activities, sheet piling will be installed around the Dry Well 20-08 excavation area and along the western boundary of the main excavation area. Figure 1 shows the locations where the sheet piling will be installed.

The driving of sheet piles for temporary excavation support into the subsurface, as well as related construction activities, will create noise and vibration at and adjacent to the drive location. During the start of sheet pile driving, there tends to be a momentary peak in the noise level and then the noise is reduced as the sheet is driven further into the ground, typically increasing ground-borne vibration.

This Plan describes the various monitoring and mitigation measures to address potential vibration impacts to the immediate area as a result of steel sheet pile driving and related sheet pile installation activities at the Site.

1.1 Vibration Basics

Peak Particle Velocity (PPV) represents the maximum instantaneous positive or negative peak of a vibration signal. The PPV is an appropriate measure for evaluating impulsive vibration associated with vibration sources such as blasting or pile driving, and the potential resulting stresses that may damage buildings. The U.S. Bureau of Mines (USBM) criteria and methodology are applicable to this type of vibration measurement (USBM 1980).

Excessive vibration levels from construction activities, although temporary in duration, may create a nuisance condition for nearby receptors. Ground vibrations from construction activities very rarely reach the levels that can damage structures. Impact pile driving is one of the types of construction activities that typically generate the greatest vibrations. Sheet pile driving with a vibratory hammer, as proposed for use at this Site, typically generates less vibration compared to pile driving using an impact hammer

(Paulus, Sokolowski and Sartor Engineering [PSS] 2008).

Research conducted by the Royal Institute of Technology (RIT) in Stockholm, Sweden has shown that most of the vibration loss occurs in the near field: 90-99 percent of the sheet pile vibration magnitude was dispersed within 0.5 meters (m) (1.6 feet [ft]) from the driven sheet pile. Moreover, the sheet pile – soil vibration transfer efficiency was reduced for higher sheet pile acceleration levels and higher frequencies (RIT 2013). Furthermore, it has been shown that even large magnitudes in the horizontal direction attenuate rather quickly to values below 5 millimeters/second (0.20 inches/second [in/sec]) at a distance of about 8 m (26 ft) from the source (RIT 2012).

Peak Particle Velocity values greater than 0.035 in/sec may be perceived by people. Annoyance from vibration often occurs when vibration levels exceed this threshold. These criteria are an order of magnitude below the damage threshold for normal buildings and are well below vibration levels (0.50 in/sec PPV) at which damage might be expected to occur. In other words, a person may be able to feel or perceive vibration at levels that are much lower than levels that could cause damage. It should be noted that the occurrence of PPV values greater than the USBM threshold value (0.50 in/sec PPV) does not imply that cosmetic cracking will occur, but that it could occur. The criteria for Structural Category III in Table 1 below can be considered applicable to “typical residential structures”. For this project, the PPV values of 0.20 in/sec and 0.12 in/sec (at the Site boundary), listed for Structural Categories III and IV, respectively, will be applied.

Table 1 - Construction Vibration Damage Criteria

Structural Category	Definition		PPV (in/sec)
I	Foundation	Competent	0.50
	Framing: Interior	Reinforced Concrete	
	Finish:	No plaster	
	Examples:	Industrial buildings, Bridges, masts, concrete retaining walls, unburied pipelines, underground structures such as cavern tunnels and lined or unlined galleries	
II	Foundation	Concrete or competent masonry	0.30
	Framing: Interior	Any framing, except as described for Category III below	
	Finish:	No plaster	
	Examples:	Engineered concrete and masonry buildings, masonry retaining walls, and buried pipelines	
III	Foundation	Less competent masonry	0.20
	Framing: Interior	Horizontal timber framing supported on masonry walls	
	Finish:	Any finish, including plaster "Non-engineered" buildings	
	Examples:	"Non-engineered" buildings	
IV	Buildings that are extremely susceptible to damage from vibration, such as all historic structures		0.12

Source: PSS 2008

1.2 Pile Driving Basics

The installation of piles is fairly common in modern construction projects. Piles are used to support parking structures, bridges, overpasses, many types of buildings and also are used as retaining structures/walls or barriers. Piles often form the backbone of structures that can serve as framework to support great weight and pressure of concrete loads. They can be used as walls or barriers that confine ground pressures and prevent unwanted movement. Installing piles into the ground, as with other construction activities, cannot be done without generating both noise and vibration. These activities can raise concern with regard to the potential for off-site impacts to nearby receptors. Pile driving is, however, a necessary construction activity (PSS 2008).

Sheet pile driving consists of inserting a long sheet, usually steel, into the ground. A common approach to accomplish this is with a vibratory hammer. This method makes less noise than using an impact hammer. An impact hammer is a heavy weight hammer that pounds on the pile creating sharp bang noises from the impact of the hammer on the pile. The vibratory hammer does away with the sharp bang noise, as it “shakes” or vibrates the pile into the ground. As such, it is considered to be quieter than an impact hammer (PSS 2008).

2.0 PROJECT DESCRIPTION

2.1 Site Description

The former NWIRP Bethpage is located in east-central Nassau County, Long Island, New York, approximately 30 miles east of New York City. NWIRP Bethpage is bordered on the north, west, and south by property owned, or formerly owned, by Northrop Grumman that covered approximately 500 acres, and, on the east, by a residential neighborhood.

Site 1 is situated along the eastern boundary of the former NWIRP Bethpage and is a relatively flat area with a four-ft vegetated windrow located along the eastern side of the Site. The Site is enclosed by a facility perimeter fence along the north, east, and south and an interior facility fence along the west. The area bounded by this fence is lightly vegetated and the remainder of Site 1 is covered with concrete or gravel. The Dry Well 20-08 excavation area is located on the northwest corner of the main excavation area, outside of the fence (Figure 1).

The land surrounding the nine-acre Bethpage facility in all directions is primarily industrial and residential (Figure 2).

2.2 Community Nearby Receptors

Nearby receptors include residential properties located to the east of the Site along 11th Street. As shown on Figure 2, the residential properties are more than 300 ft from the location of the sheet pile wall in the excavation area. Vibration monitoring activities will be conducted along the eastern side of the Site or in public areas near potentially affected receptors.

2.3 Construction Activities and Equipment (Vibration Sources)

As discussed in the Remedial Action Work Plans (APTIM 2019 and Agviq 2019), approximately 430 linear ft (LF) of interlocking AZ26 sheet piling will be installed to 48ft depth around the Dry Well 20-08 excavation area. Approximately 270 LF of interlocking SZ-14.5RU steel sheet piling will be installed to 50ft depth along the western boundary of the main excavation area. Sheet piling will be constructed in accordance with Section 31 41 16 of the Project Specifications and the subcontractor's approved Shoring Plan. Figure 1 shows the locations where the sheet piling will be installed. Other equipment to be used in support of the sheet piling installation includes: Manitowoc EPIC 222 Crawler Crane, ICE Model 416 Vibratory Hammer, Caterpillar 322CL Excavator, and Trojan 1700 Rubber Tire Loader. Installation of sheet piles for the various alignments is anticipated to start in April 2019 and continue intermittently for three months.

3.0 ANTICIPATED VIBRATION

Table 2 lists typical vibration levels for various pieces of construction equipment.

Table 2 - Vibration Levels for Construction Equipment		
Equipment		**PPV at 25 ft (in/sec)**
Pile Driver (impact)	upper range	1.518
	typical	0.644
Pile Driver (vibratory)	upper range	0.734
	typical	0.170
Clam shovel drop (slurry wall)		0.202
Hydromill (slurry wall)	in soil	0.008
	in rock	0.017
Vibratory Roller		0.210
Hoe Ram		0.089
Large bulldozer		0.089
Caisson drilling		0.089
Loaded trucks		0.076
Jackhammer		0.035
Small bulldozer		0.003

Source: John A Volpe National Transportation Systems Center 2018

Assuming that subsurface soil conditions are consistent across the Site, the following equation can be used to calculate the PPV at a given distance from a source:

$$PPVequip = PPVref\ x\ \left(\frac{25}{D}\right)^{1.5}$$

where: PPV (equip) is the peak particle velocity in in/sec of the equipment adjusted for distance
PPV (ref) is the reference vibration level in in/sec at 25 ft from Table 2
D is the distance from the equipment to the receiver.

Using the upper range (i.e. extreme) value for vibratory pile driving, 0.734 in/sec (Table 2), the estimated PPV resulting from the pile driving for residents at approximately 300 ft from the work area (see Figure 2) would be:

$$PPV_{equip} = PPV_{ref}\ x\ \left(\frac{25}{D}\right)^{1.5}$$

$$= 0.734\ x\ \left(\frac{25}{300}\right)^{1.5}$$

$$= 0.734\ x\ (0.083)^{1.5}$$

$$= 0.734\ x\ (0.024)$$

$$= 0.017 \text{ in/sec}$$

As stated in Section 1.1, the PPV values of 0.20 in/sec and 0.12 in/sec at the Site boundary, are applicable for this project. The estimated PPV calculated above, 0.017 in/sec, is well below the applicable project limits.

Vibration from pile driving can vary in intensity and duration depending on the specific driving activities and depth of the sheet in the ground.

4.0 MONITORING PLAN

Vibration monitoring will be performed to assess potential community impacts and to establish a data record for implementing mitigation measures. Monitoring will be performed for vibration caused by sheet pile driving. The placement of monitors along the Site boundary or in other public areas will provide necessary data on vibration in the areas closest to nearby residents and will provide data for comparing the vibration levels with their respective action levels.

4.1 Vibration Action Levels

Two vibration "action level" threshold values will be used to assess the potential vibration at the perimeter of the Site. Table 3 identifies the vibration action level thresholds and prescribed actions.

Although a criterion of 0.50 in/sec PPV has been established by the USBM as the threshold above which damage to interior plaster walls may occur, a conservative vibration criterion of 0.20 in/sec PPV is proposed as the applicable action threshold criteria for ground vibration measurement during the proposed remedial construction activities.

Table 3
VIBRATION ACTION LEVELS

Action	Vibration Threshold Values PPV (in/sec)	Remarks
Warning	0.12	The vibration "warning" threshold level is 0.12 inches per second PPV. If this level is exceeded then the situation will be reviewed to identify the potential cause.
Temporary Halt	0.20	The vibration "stop work" threshold is 0.20 inches per second PPV. The potential causes of such vibration will be reviewed and possible mitigation methods investigated.

4.2 Vibration Monitoring

Vibration monitoring will be conducted one day prior to the start of pile driving to record baseline conditions and then during all sheet pile driving as part of the planned remedial construction activities. A monitoring array, consisting of four vibration detectors (geophones) and a recording device (seismograph), will be deployed along the perimeter of the excavation area and potentially at varying distances from the sheet pile driving activities and/or near structures in close proximity to the sheet pile driving activity. The number and locations of monitoring points may be adjusted as work progresses to obtain the most representative data based on the specific location of the sheet pile installation (Figure 3). Re-location of monitoring equipment will also depend upon field logistics.

Triaxial geophones and a portable seismograph (Blastmate III or equivalent) will be used to detect and record the movement of the ground surface in the longitudinal, transverse, and vertical direction caused by the sheet pile driving operations. The seismograph instrument provides continuous recording of PPV data.

4.3 Monitoring Guidelines

Placement of the geophone and coupling it with the ground surface are the two most important factors to ensure accurate ground motion data collection.

a) The geophone monitoring array shall be placed along the fence line as close as possible to the perpendicular line connecting the center of the array and the sheet pile driving activity. The geophone array will extend a total of 30 ft, with geophones placed at 5 ft and 15 ft on either side of the centerline. Consequently, the monitoring array may need to be repositioned during the day as the sheet pile driving activity advances along the alignment.

b) The geophone shall be placed on level ground following removal of any sod/debris to expose native competent soil. Placement on driveways, walkways, and slabs must be avoided due to potential vibration amplification or diminution effects (Tetra Tech/KFM Geoscience [TT/KFM] 2008).

c) The density of the soil under the geophone should be greater than or equal to the geophone density. Uncompacted fill material, loose sand, unconsolidated soils, mulch or other unusual media shall be avoided as they may have an adverse influence on the recording accuracy (TT/KFM 2008).

d) The geophone shall be oriented in the direction towards the sheet pile driving activity according to the manufacturer's recommendations. Typically, an arrow or longitudinal channel needs to be oriented directly at the vibration source to collect correct directional ground motion data (TT/KFM 2008).

e) For measured accelerations less than 1g (gravitational acceleration g = 32.17 ft/sec^2), the geophones shall be coupled with the ground surface using sand bagging and spiking. Spiking entails firmly pressing the sensor with the attached tapered spike(s) into the prepared level ground surface. Sand bagging consists of placing the sensor on the exposed native competent soil with a sand bag(s) over top. Sand bags shall be sufficiently large to be loosely filled with about 10 pounds of sand. When placed over the sensor the sand bag profile should be as low and wide as possible with a maximum amount of firm contact with the ground (TT/KFM 2008).

f) All cables shall be secured to prevent geophone movement from the wind or other extraneous sources (TT/KFM 2008).

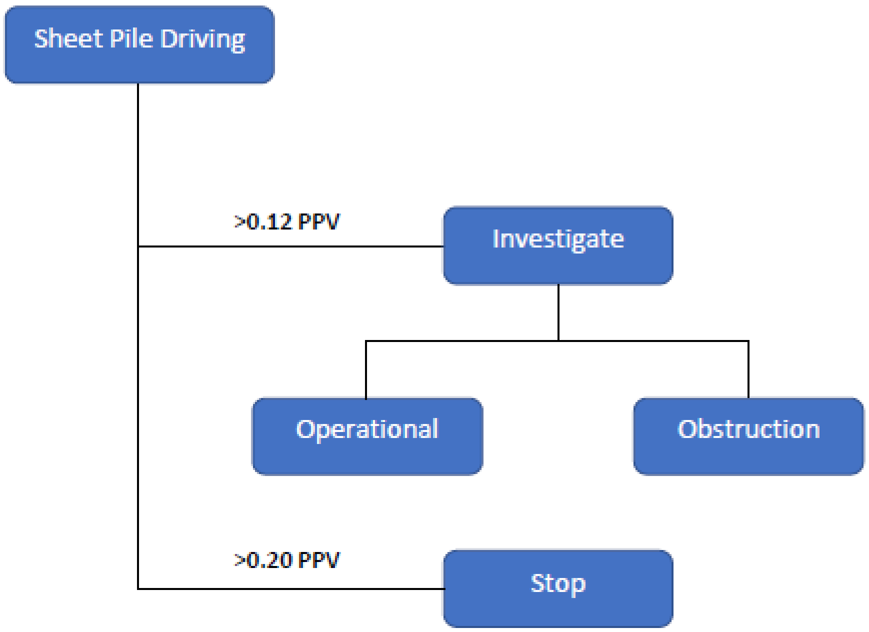
Collected vibration monitoring results will be compared to the vibration criteria in Table 3 and work activities will proceed accordingly. The results will also be tabulated and reviewed on a weekly basis to assess trends and formulate the basis for mitigation measures, if required.

The vibration monitoring and surveillance equipment will be operated, maintained and calibrated in accordance with the manufacturer's instructions and the established quality assurance procedures. Seismic monitoring equipment will be checked daily for proper operation. Field validation logs will be maintained on-site.

5.0 VIBRATION MITIGATION APPROACH

Mitigation measures will follow the steps as shown in Chart 1

Chart 1 – Vibration Mitigation Action Flow Chart



Should PPV levels reach 0.12 in/sec, the potential cause will be investigated, however work may continue. Causes may be due to operational factors such as mis-aligned sheets or a subsurface obstruction such as a boulder or soil layer of greater density. Should PPV levels reach 0.20 in/sec, work will stop and the causes will be investigated and remedies put in place before work continues.

Mitigation measures can include:

Re-alignment of sheets: Subsurface resistance may cause difficulties with sheet piling alignment and contribute to additional vibration, resulting in the need to retract and re-drive the sheet(s) to adjust alignment. Retracting, re-aligning, and re-driving sheet piles can add to the duration of vibration from the sheet pile driving process.

Reduction of Vibratory Hammer Load: Reducing the load on a vibratory hammer, both normal and high-frequency, has proven beneficial at similar remediation sites and is an effective method of reducing both noise and vibration. Reducing load, in combination with the use of a high-frequency vibratory hammer, has shown to decrease pile-driving related noise and vibration.

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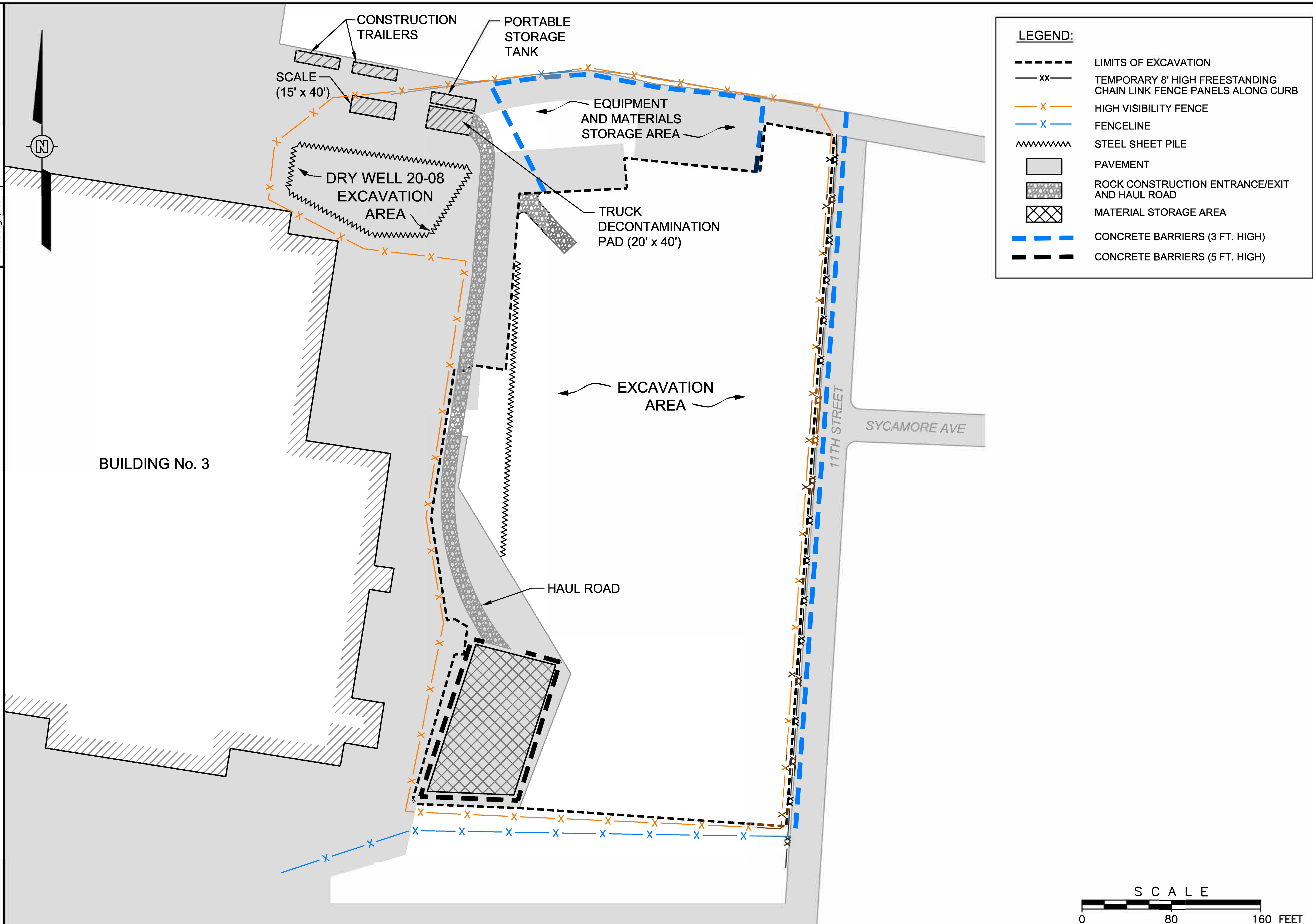
Figures



OFFICE Pittsburgh, PA

DRAWING NUMBER 501164-A1

REVISIONS

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150 Boush Street, Suite 701
Norfolk, Virginia 23510

DESIGNED BY	DATE	CHECKED BY	DATE
M. Smith	8/6/18		
DRAWN BY	**DATE**	**APPROVED BY**	**DATE**
B. O'Connor	8/6/18		

NAVFAC Naval Facilities Engineering Command MID-ATLANTIC

NAVAL WEAPONS INDUSTRIAL RESERVE PLANT BETHPAGE, NEW YORK

SITE 1 - FORMER DRUM MARSHALLING AREA

SITE PLAN

SCALE: AS SHOWN | SIZE: B

DELIVERY ORDER NO. F6147

CONSTR. CONTRACT NO. N62470-16-D-9004

NAVFAC DRAWING NO. --

SHEET I.D. FIGURE 1

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Plotted By: bernadette.oconnor

LEGEND:

- - - -	LIMITS OF EXCAVATION
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—x— (orange)	HIGH VISIBILITY FENCE
—x— (blue)	FENCELINE
(red zigzag)	STEEL SHEET PILE
(grey box)	PAVEMENT
(stippled box)	ROCK CONSTRUCTION ENTRANCE/EXIT AND HAUL ROAD
(crosshatched box)	MATERIAL STORAGE AREA
(blue dashes)	CONCRETE BARRIERS (3 FT. HIGH)
(black dashes)	CONCRETE BARRIERS (5 FT. HIGH)

SCALE

0 80 160 FEET

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APTIM Federal Services, LLC
150 Boush Street, Suite 701
Norfolk, Virginia 23510

APTIM

DESIGNED BY	DATE	CHECKED BY	DATE
W. Squire	3/6/19		

DRAWN BY	DATE	APPROVED BY	DATE
B. O'Connor	3/6/19		

NAVFAC
Naval Facilities Engineering Command
MIDATLANTIC

NAVAL WEAPONS INDUSTRIAL RESERVE PLANT BETHPAGE, NEW YORK
SITE 1 - FORMER DRUM MARSHALLING AREA
SITE 1 AND SURROUNDING AREA

SCALE: AS SHOWN
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CONSTR. CONTRACT NO. N62470-16-D-9004
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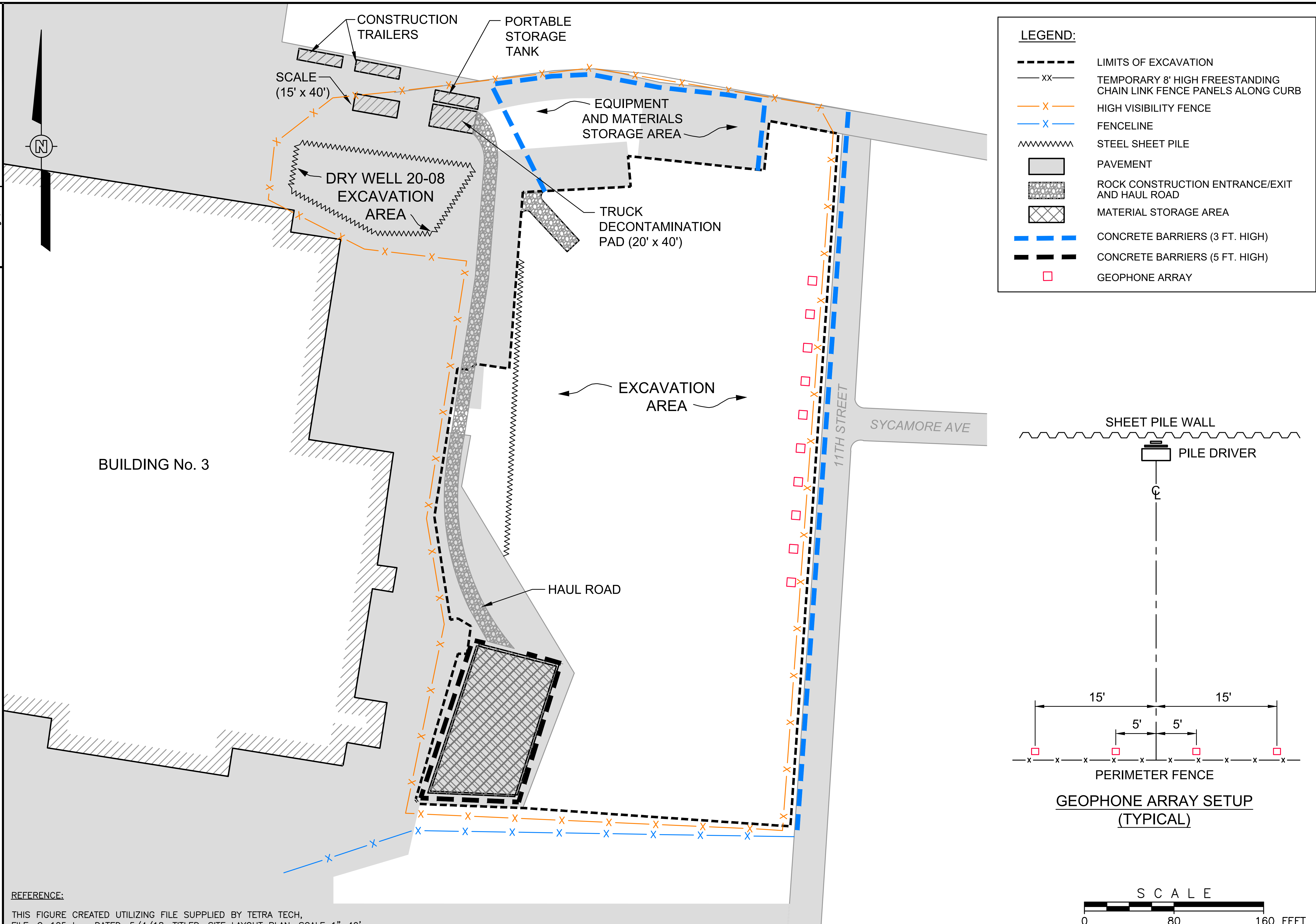
SHEET I.D.

FIGURE 2



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APTIM Federal Services, LLC
150 Boush Street, Suite 701
Norfolk, Virginia 23510

DESIGNED BY	DATE	CHECKED BY	DATE
M. Smith	8/6/18		

DRAWN BY	DATE	APPROVED BY	DATE
B. O'Connor	8/6/18		

NAVFAC Naval Facilities Engineering Command MID-ATLANTIC

NAVAL WEAPONS INDUSTRIAL RESERVE PLANT BETHPAGE, NEW YORK
SITE 1 - FORMER DRUM MARSHALLING AREA
POTENTIAL GEOPHONE LOCATIONS

SCALE: AS SHOWN
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DELIVERY ORDER NO. F6147
CONSTR. CONTRACT NO. N62470–16–D–9004
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SHEET I.D. FIGURE 3