FINAL VAPOR INTRUSION MITIGATION SYSTEM DIAGNOSTIC TESTING WORK PLAN
MCB CAMP LEJEUNE NC
1/1/2011
CH2M HILL

Final

Vapor Intrusion Mitigation System Diagnostic Testing Work Plan

Marine Corps Base Camp Lejeune
Jacksonville, North Carolina

Contract Task Order 92

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Contents

Abbreviations and Acronyms

AC	air conditioning
AS	air sparge
AST	aboveground storage tank
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CamLej	Camp Lejeune
CERCLA	Comprehensive Environmental Restoration, Compensation, and Liability Act
CSM	conceptual site model
CFM	cubic feet per minute
DoN	Department of the Navy
FFA	Federal Facilities Agreement
GWSL	Groundwater Screening Level
HEPA	High Efficiency Particulate Air
HFPP	Hadnot Point Fuel Farm
Hg	mercury
HVAC	heating, ventilating, and air conditioning
IA	indoor air
IASL	indoor air screening level
ID	identification
IR	Installation Restoration
IMC	International Mechanical Code
ITRC	Interstate Technology & Regulatory Council
L	liter
LNAPL	light nonaqueous phase liquid
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
mL/min	milliliters per minute
NCDENR	North Carolina Department of Environment and Natural Resources
NPL	National Priorities List
O&M	operation and maintenance
PCE	tetrachloroethene
PFE	pressure field extension
PMO	Project Management Office
QA/QC	quality assurance/quality control

RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RSL	Regional Screening Level
ROICC	Resident Officer in Charge of Construction
SG	soil gas
SGSL	soil gas screening level
SMACNA	Sheet Metal and Air Conditioning Contractors' National Association
SVE	soil vapor extraction
SSD	subslab depressurization system
3-D	three-dimensional
TCE	trichloroethene
USEPA	United States Environmental Protection Agency
UST	underground storage tank
VI	vapor intrusion
VIMS	vapor intrusion mitigation system
VOC	volatile organic compound

SECTION 1

Introduction

Marine Corps Base Camp Lejeune (MCB CamLej), located in Jacksonville, North Carolina, is home to an active duty, dependent, retiree, and civilian population of approximately 150,000 (**Figure 1-1**). Thousands of structures are located on the base, which covers approximately 236 square miles.

In October 2007, MCB CamLej initiated a base-wide vapor intrusion (VI) screening evaluation to address the subsurface to indoor air VI exposure pathway. Six investigation areas were identified for evaluation within MCB CamLej (**Figure 1-2**): Mainside; Hadnot Point; Marine Corps Air Station (MCAS), New River; Courthouse Bay; Camp Geiger; and Tarawa Terrace. Within each of the six areas, multiple volatile organic compound (VOC) subsurface releases, some of which are being actively remediated, have been documented. The investigation and cleanup of these releases are being managed under several programs, including the Installation Restoration (IR), Resource Conservation and Recovery Act (RCRA), and Underground Storage Tank (UST) Programs.

Three phases of VI investigation have been conducted to date. The results of the Phase I and II investigations are documented in the *Final Vapor Intrusion Evaluation Report, Marine Corps Base Camp Lejeune, Jacksonville, North Carolina* (AGVIQ-CH2M HILL, 2009) and the Phase III results are documented in the *Draft Vapor Intrusion Evaluation Report, Marine Corps Base Camp Lejeune, Jacksonville, North Carolina* (CH2M HILL, 2010).

As a result of these investigations, MCB CamLej identified seven buildings where VI mitigation pilot studies were to be performed: four buildings within Mainside (Buildings 3, 3B, 37, and 43) and three buildings within Hadnot Point (Building 902, 1005, and 1115). The proposed VI mitigation for Buildings 3, 3B, 37, 43, 902, and 1115 includes installation of a VI mitigation system (VIMS) using subslab depressurization techniques. The VIMS are expected to use vacuum to depressurize the buildings' subslab, thus mitigating the potential for intrusion of vapors into the buildings. At Building 1005, it appears that the current heating, ventilating, and air conditioning (HVAC) system has sufficient fresh-air intake that creating new set-points for the system can induce a positive pressure within the building compared to the subslab and outdoor pressures, thus mitigating the potential for intrusion of vapors into the building.

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Legend
- Installation Area
- Limited Access Higwhay
- Highway
- Local Roads
- Cities

N

0 10,000 20,000 40,000 Feet

1 inch = 20,000 feet

Figure 1-1
Base Location Map
MCB CamLej
North Carolina

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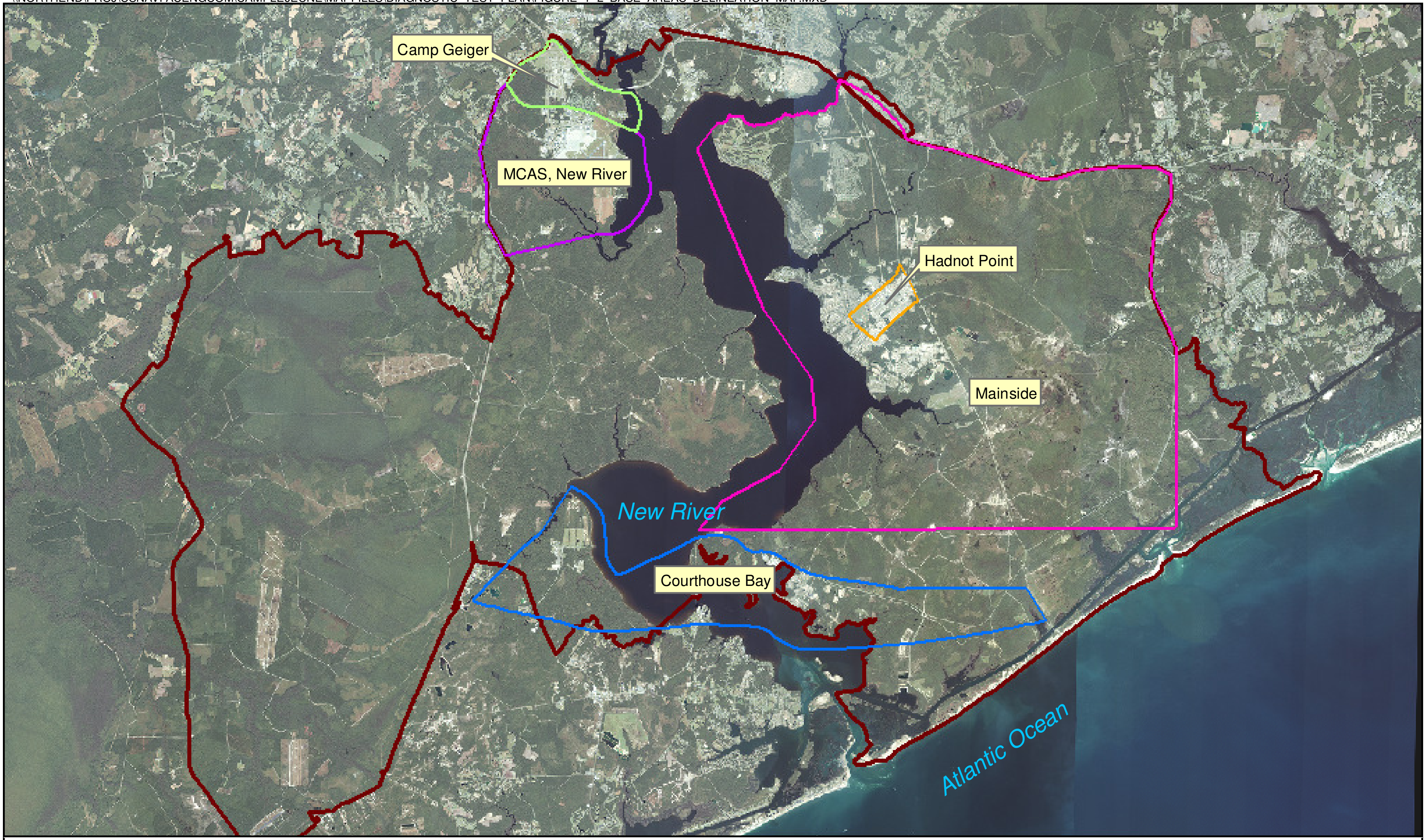

Legend

- MCAS, New River
- Camp Geiger
- Courthouse Bay
- Hadnot Point
- Mainside
- Installation Boundary

N

0 7,500 15,000 30,000 Feet

1 inch = 15,000 feet

Figure 1-2
Delineation of Base Areas
MCB CamLej
North Carolina

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SECTION 2

Site History

2.1 Mainside

Mainside is the main area of MCB CamLej and is located east of the New River (**Figure 1-2**). Hadnot Point, the industrial area, is located within Mainside. Mainside is home to the II Marine Expeditionary Force, 2nd Marine Division, three other major Marine commands, and a Naval hospital. There are barracks, residential housing, schools, and commercial areas in Mainside.

Mainside was evaluated as part of the base-wide VI evaluation at MCB CamLej. As a result of the investigation, the Base elected to conduct VI mitigation at four buildings within IR Site 88 (Buildings 3, 3B, 37, and 43). The following sections provide information on the conclusions of the VI evaluation for these buildings.

Site 88, Former Base Dry Cleaning Facility, operated beginning in the 1940s. Five 750-gallon USTs were installed on the north side of the building to store dry cleaning fluids. The remedial action performed at Site 88 in 2005 treated approximately 7,050 cubic yards of impacted soil with dual phase extraction and shallow soil mixing with clay/zero-valent iron. As a result, tetrachloroethene (PCE) concentrations in the soil were reduced by more than 99 percent. However, residual dissolved phase groundwater VOC contamination remains over a large portion of the surrounding and down-gradient areas. The Final Amended Remedial Investigation (RI) Report (CH2M HILL, 2008a), submitted in March 2008, identified a former leaking sanitary sewer line as a secondary source of chlorinated VOCs at Site 88.

Buildings 3, 3B, 37, and 43 are located in the southeastern portion of Site 88 (**Figure 2-1**). The groundwater flow direction in the shallow aquifer is complex, partially because of mounding created by the clay mixing. The subsurface at Site 88 consists primarily of sand. Depth to groundwater in shallow monitoring wells, measured during the August 2007 sampling event, ranged from approximately 7 to 15 feet below ground surface (bgs) (CH2M HILL, 2008a).

2.1.1 Building 3

Building 3 was classified as a large industrial building during the VI evaluation. It is used as the Project Management Office (PMO) Headquarters and primarily contains office space. Building 3 is located approximately 300 feet west and upgradient (based on radial shallow groundwater flow) of Building 25, the former dry cleaning facility. An industrial sewer extended northwest from Building 25 in the general direction of Building 3, and came within 75 feet of the northeast portion of Building 3 (**Figure 2-1).** This sewer was determined to be an additional PCE source during the Site 88 Amended RI.

Building 3 Characteristics

Building 3 is a two-story, C-shaped brick and mortar building approximately 175 feet long by 75 feet wide (based on the figure scale). The building underwent extensive reconstruction in 2008 and 2009. Currently, the building has approximately 7 doors, 1 double door, and 56 (approximately 2 feet by 4 feet) windows evenly placed around the building. The building is constructed of cinderblock walls with a brick exterior, on a concrete slab that is elevated approximately 1 foot above the ground surface, with fill material located beneath the slab. The concrete slab is approximately 8 inches thick. The hallways have vinyl tile floor covering, the office floors are covered with carpet, and the restrooms have ceramic tile floors. Floor drains are present in the restrooms. The building is serviced by multiple HVAC zones and units. Doors and windows are typically kept closed. Approximately 50 workers occupy the building during working hours, which are from7AM to 3PM on weekdays.

The foundation for Building 3 was constructed in the 1940s. According to drawing # 228877 (**Attachment A**), the subslab of the building was built from 1 to 2 feet above present grade and the approximately 4-inch thick concrete slab floors (unless otherwise noted) were reinforced with a 6 x 6-inch wire mesh and the concrete was poured over a sand asphalt base. The slab thickness was measured in the field to be approximately 8 inches, suggesting that the slab was built up from the original 1940s thickness of 4 inches. The exterior foundation walls (14 inches thick) extend a minimum of 10 inches below grade; the footings range from 18 to 30 inches in thickness and extend to a total depth of 18 inches below grade. The interior foundation walls (ranging from 8 to 14 inches in thickness) extend a minimum of 10 inches below grade; the footings range from 12 to 32.5 inches in thickness and extend to a total depth of 18 inches below grade. The foundation plans include the construction of a sump; however, the exact location of the sump was not noted on the building surveys completed during the VI investigation.

The present floor plan and foundation outline are shown on **Figure 2-2**.

VI Evaluation Results

Groundwater, exterior soil gas, subslab soil gas, and/or indoor air samples were collected during Phase I and Phase III VI evaluations at Building 3. A three-dimensional (3-D) conceptual site model (CSM) was created and refined based on the information collected throughout the investigations (**Figure 2-3**). The Phase I and III sample locations and results for VOCs with previous or current screening level exceedances for Building 3 are shown on **Figures 2-2 and 2-3**).

Groundwater and soil gas data suggested that VI could be significant at Building 3. However, the Phase III results for indoor air did not indicate that the building is currently being impacted by the VI pathway (CH2M HILL, 2010). There is uncertainty as to whether the VI pathway could be significant in the future at Building 3 based on the proximity of the building to the source area, exceedances of the base-specific soil gas screening levels (SGSLs) in both exterior soil gas and subslab soil gas, and the layout of the building, which is not conducive to enhanced outdoor air exchange. Due to this uncertainty, the Base has elected to conduct a VIMS pilot study at Building 3. The VIMS is expected to depressurize the building subslab, thus mitigating potential intrusion of vapors into the building.

2.1.2 Building 3B

Building 3B was classified as a small industrial building during the VI evaluation. The eastern half of the building is used as an office for PMO operations, specifically traffic control and public safety. The western half of the building is used as office space and storage.

Building 3B is located approximately 350 feet northwest of Building 25, the former dry cleaning facility. An industrial sewer extended northwest from Building 25 in the general direction of Building 3B, coming within 60 feet of the building (**Figure 2-1**). This sewer was determined to be an additional PCE source during the Site 88 Amended RI.

Building Characteristics

Building 3B is a one-story concrete block and mortar building approximately 75 feet long by 25 feet wide (based on the figure scale) by 8 feet high. The building is divided in half by a complete concrete block wall. The western side of the building exterior is brick and the eastern side of the exterior is vinyl siding. The entire floor surface is covered with vinyl tile. There are approximately five workers occupying the building during working hours, which are from 7AM to 3PM on weekdays and weekends.

The building likely has perimeter wall footings, and additional footings underneath the pillars were observed within the building. The concrete slab is level with the exterior ground surface; it is approximately 6 inches thick and contains wire mesh. There are no expansion joints in the building, but floor drains/sumps are present. Building 3B has an HVAC unit with one evaporator/condenser unit located on the east end of the building and a second evaporator/condenser unit located on the west end. The building has eight windows and three doors that typically remain closed. No foundation plans are available for this building; therefore, a better description of the foundation will be compiled during the diagnostic test.

The present floor plan is shown on **Figure 2-4**.

VI Evaluation Results

Groundwater, exterior soil gas, subslab soil gas, and/or indoor air samples were collected during Phase I, Phase II, and Phase III VI evaluations at Building 3B. A 3-D CSM was created and refined based on the information collected throughout the investigations (**Figure 2-5**). The Phase I, II, and III sample locations and results for VOCs with previous or current screening level exceedances for Building 3B are shown **Figures 2-4 and 2-5**.

The results of the phased VI evaluation for Building 3B indicate that the VI pathway is significant at Building 3B and could result in risks exceeding the target risk range of 1E-06 to 1E-04 (CH2M HILL, 2010). Therefore, the Base has elected to install a VIMS at Building 3B. The VIMS will be installed to depressurize the building subslab, thus mitigating potential intrusion of vapors into the building.

2.1.3 Building 37

Building 37 is used as office and classroom space and was classified as a large industrial building during the VI evaluation. Building 37 is located approximately 150 feet north of former Building 25 and 400 feet east of the industrial sewer identified as a source of PCE contamination. Shallow groundwater in the vicinity of Building 37 is radial.

Building Characteristics

Building 37 is a one-story brick and mortar building. The building is approximately 175 feet long by 50 feet wide (based on the figure scale) by 8 feet high. The interior walls are constructed of cinderblock. There are multiple offices, a kitchen, a classroom, and separate male and female restrooms within the building. The concrete slab is covered with ceramic tile in the restrooms, vinyl tile in the hallways, and carpet in the office spaces. Floor drains were observed in the restrooms and kitchen area. Windows and doors are typically kept closed, although one door on the south side of the building was propped open during the Phase III survey. Building 37 has two HVAC units (with evaporator/condenser units), which are located on the south side of the building. The building has approximately 35 windows and 6 doors that typically remain closed. The number of workers who occupy the building during working hours, from 7AM to 3PM on weekdays, is approximately 25.

The foundation for Building 37 was constructed in the 1940s. According to drawing # 267600 (**Attachment A**), the subslab of the building is approximately 4 inches thick and reinforced with 6 x 6-inch wire mesh. The slab thickness was measured in the field to be approximately 6 inches, suggesting that the slab was built up from the original 1940s thickness of 4 inches. The exterior foundation walls (14 to 16 inches thick) extend a minimum of 8 inches below grade; the footings are approximately 10 inches in thickness and extend to a minimal total depth of 18 inches below grade. The interior foundation walls (4 to 8 inches in thickness) extend below grade and the footings are approximately 14 inches thick. The foundation plans include the construction of a mechanical pit which extends greater than 8 feet below the slab surface; however, the exact location of the sump was not noted on the building surveys completed during the VI investigation.

The present floor plan and foundation outline are shown on **Figure 2-6**.

VI Evaluation Results

Groundwater, exterior soil gas, subslab soil gas, and/or indoor air samples were collected during Phase I, Phase II, and Phase III VI evaluations at Building 37. A 3-D CSM was created and refined based on the information collected throughout the investigations (**Figure 2-7**). The Phase I, II, and III sample locations and results for VOCs with previous or current screening level exceedances for Building 37 are shown **Figures 2-6 and 2-7**.

Groundwater and soil gas data suggested that VI could be significant at Building 37. However, the Phase III results for indoor air did not indicate that the building is currently being impacted by the VI pathway (CH2M HILL, 2010)**.** There is uncertainty as to whether the VI pathway could be significant in the future at Building 37 based on the proximity of the building to the source area, exceedances of the base-specific SGSL in both exterior soil gas and subslab soil gas, and the layout of the building, which is not conducive to enhanced outdoor air exchange. Due to this uncertainty, the Base has elected to conduct a VIMS pilot study at Building 37. The VIMS is expected to depressurize the building subslab, thus mitigating potential intrusion of vapors into the building.

2.1.4 Building 43

Building 43 is used for military police operations and as the military police motor pool and was classified as a small industrial building for the VI evaluation. Building 43 is approximately 85 feet northeast of former Building 25 and approximately 200 feet east of the industrial sewer identified as a PCE source. The depth to groundwater in the vicinity of Building 43 is approximately 10 feet bgs. Shallow groundwater flows to the southwest in the vicinity of Building 43.

Building Characteristics

Building 43 is a one-story brick and mortar building. The building is approximately 40 feet long by 75 feet wide (based on the figure scale) by 8 feet high. The building is divided into two separate work areas. The entire floor is covered with linoleum tile. The southeast portion includes an open work space with three work areas, a restroom, and an office. The northeast section of the building contains a small office area with a closet and a small side room. Building 43 has an HVAC unit with one condenser/evaporator unit on the south side of the building. The building has 3 doors and 14 windows which are typically kept closed. Building 43 is typically occupied by approximately 10 workers during business hours, which are from 7AM to 3PM on weekdays.

The foundation for Building 43 was constructed in the 1940s. According to drawing # 228589 (**Attachment A**), the subslab of the building is approximately 4 inch and reinforced with a 6 x 6-inch wire mesh. The slab thickness was measured in the field to be approximately 6 inches, suggesting that the slab was built up from the original 1940s thickness of 4 inches. The exterior foundation walls (9.5 inches thick) extend a minimum of 6 inches below grade; the footings are 21.5 inches thick and extend to a minimal total depth of 18 inches below grade. The interior foundation walls (approximately 4.5 to 5 inches in thickness) extend below grade and the footings are approximately 6 inches thick. The foundation plans include the construction of a sump; however, the exact location of the sump was not noted on the building surveys completed during the VI investigation.

The present floor plan and foundation outline are shown on **Figure 2-8**.

VI Evaluation Results

Groundwater, exterior soil gas, subslab soil gas, and/or indoor air samples were collected during Phase I, Phase II, and Phase III VI evaluations at Building 43. A 3-D CSM was created and refined based on the information collected throughout the investigations (**Figure 2-9**). The Phase I, II, and III sample locations and results for VOCs with previous or current screening level exceedances for Building 43 are shown on **Figures 2-8 and 2-9**.

Groundwater and soil gas data suggested that VI could be significant at Building 43. However, the Phase III results for indoor air did not indicate that the building is currently being impacted by the VI pathway (CH2M HILL, 2010). There is uncertainty as to whether the VI pathway could be significant in the future at Building 43 based on the proximity of the building to the source area, exceedances of the base-specific SGSL in both exterior soil gas and subslab soil gas, and the layout of the building, which is not conducive to enhanced outdoor air exchange (**Figure 2-9**). Due to this uncertainty, the Base has elected to conduct a VIMS pilot study at Building 43. The VIMS is expected to depressurize the building subslab, thus mitigating potential intrusion of vapors into the building.

2.2 Hadnot Point

Hadnot Point is one of the oldest parts of MCB CamLej and is an industrial area containing numerous buildings. The buildings are primarily used as warehouses and maintenance facilities. Hadnot Point is located east of the New River, within Mainside (**Figure 1-2**).

Hadnot Point was evaluated as part of the basewide VI evaluation at MCB CamLej. As a result of the investigation, the Base elected to conduct VI mitigation at one building within the boundary of IR Site 78 (Building 902) and two buildings at the Hadnot Point Fuel Farm (HPFF) (Buildings 1005 and 1115). The following sections provide information on the conclusions of the VI evaluation for these buildings.

Site 78 consists of maintenance shops, warehouses, painting shops, printing shops, auto body shops, and other small industrial facilities. Many spills and leaks have occurred over the years. Groundwater has been impacted by chlorinated solvents (e.g., trichloroethene [TCE]) and low levels of fuel-related contamination (e.g., benzene, toluene, ethylbenzene, and xylene [BTEX]). Building 902 is located within the northern portion of Site 78. The subsurface at Site 78 consists primarily of sand. Groundwater flow is predominantly to the southwest. Depth to groundwater in shallow monitoring wells, measured during the August 2007 sampling event, ranged from approximately 8 to 9 feet bgs (CH2M HILL, 2008a).

The former HPFF area and the location of the former USTs associated with Building 1115 are between Site 78 North and Site 78 South. Free product has been observed and dissolved phase contamination has migrated from the source areas.

Air sparge/soil vapor extraction (AS/SVE) systems were installed in conjunction with a bio-pulse well field to remediate the environmental impacts caused by the HPFF and the former Building 1115 USTs. These systems are located in an area which extends approximately 400 feet north of Holcomb Boulevard and is bounded by Michael Road to the south, Dogwood Street to the west, and the Vehicle Ready fuel storage facility and Temporary Fuel Farm, off Michael Road to the east. Building 1005 is located within 100 feet of the extent of the bio-pulse system impact area. The bio-pulse well configuration is shown in Figure 2-40 of the Work Plan (CH2M HILL, 2008b).

2.2.1 Building 902

Building 902 is used as an equipment storage warehouse and includes several small office spaces. It was classified as a large industrial building during the VI evaluation. Building 902 is located up-gradient of monitoring wells where groundwater exceedances of the site-specific GWSLs for large industrial buildings have been recorded; however, the full extent of groundwater impacts beneath and to the north and east of Building 902 is unknown. Building 902 is located within the northern portion of Site 78 (**Figure 2-10**).

Building Characteristics

Building 902 is a one-story brick and mortar building with a half-story attic. It is approximately 360 feet long by 200 feet wide (based on the figure scale) by 35 feet high. The building is divided into three separate sections by concrete block walls; the northern section is an auto repair shop, the center section is used for tent storage, and the southern section is a storage area that is not often accessed. There are several small office spaces in the northern and center sections of the building (equaling approximately one-tenth the entire building area). During the Phase III building survey, it was noted that the southern section of the building was being used to teach combat scenarios.

The office portions of the building have raised wooden floors with carpet. The warehouse areas have exposed concrete floors. There are floor drains in both the bathrooms and the auto repair side of the building. During the Phase III building survey it was also noted that the sealant on the concrete slab is degrading.

Multiple air conditioning (AC) zones are present in the office areas of Building 902; however, the warehouse portions do not have AC or HVAC systems. There are approximately five workers occupying this building during working hours, which are from 7AM to 3PM on weekdays. Two to three of these workers spend most of their time in the office area.

The building foundation was constructed in the 1940s and is a pile type formation (drawing #387332, **Attachment A**) over a concrete slab, which is level with the exterior ground surface. The concrete slab is approximately 7 inches thick and contains wire mesh. The slab thickness was confirmed when measured in the field. The piling plan indicates that the footings are approximately 26 inches thick and are installed a minimum of 56 inches below the slab surface. Interior columns are spaced approximately 40 feet from one another except along the perimeter and central portions of the building.

The present floor plan and foundation outline are shown on **Figure 2-11**.

VI Evaluation Results

Groundwater, exterior soil gas, subslab soil gas, and/or indoor air samples were collected during Phase I, Phase II, and Phase III VI evaluations at Building 902. A 3-D CSM was created and refined based on the information collected throughout the investigations. The Phase I, II, and III sample locations and results for VOCs with previous or current screening level exceedances for Building 902 are shown on the **Figures 2-11 and 2-12**.

Groundwater and soil gas data suggested that VI is not significant at Building 902. However, there is uncertainty as to whether the VI pathway could be significant in the future at Building 902 based on the proximity of the suspected vadose VOC contamination underneath the southeastern portion of the building (**Figure 2-12**). To be conservative, the Base has elected to conduct a VIMS pilot study at Building 902 (CH2M HILL, 2010). The VIMS is expected to depressurize the building subslab, thus mitigating potential intrusion of vapors into the building.

2.2.2 Building 1005

Building 1005 is located in the HPFF area (**Figure 2-13**). Building 1005 is utilized for the Public Works and Resident Officer in Charge of Construction (ROICC) offices and is classified as a large industrial building for the VI evaluation. Building 1005 is located within 100 feet of the extent of the bio-pulse system impact area.

Building Characteristics

Building 1005 is a one-story E-shaped concrete block and mortar building, approximately 300 feet long by 200 feet wide (based on the figure scale) The building's use is classified as administrative and the building contains several offices, conference rooms, break rooms, and restrooms. The building has approximately 10 exterior doors and 70 windows. The restrooms contain floor drains. A large portion of the building floor is covered with vinyl tile, carpet, or ceramic tile. Building 1005 has a multi-zone heating/cooling system. Doors and windows typically remain closed at all times. The ceiling is an 8-foot drop-style construction. Approximately 100 workers occupy this building during business hours, which are from 7AM to 3PM on weekdays.

The building likely has perimeter wall footings, and additional footings underneath the pillars were observed within the building. Several additions and renovations have been conducted at the building since the original construction (**Figure 2-14**). The concrete slab is level with the exterior ground surface on the eastern portion of the building and elevated approximately 8 inches above grade toward the western portion of the building; the elevation change is gradual from east to west. The slab is approximately 6 inches thick and contains wire mesh. No expansion joints or sumps were observed within the building. No foundation plans are available for this building; therefore, a better description of the foundation will be compiled during the diagnostic test.

VI Evaluation Results

Subslab soil gas and indoor air samples were collected during Phase I, Phase II, and Phase III VI evaluations at Building 1005. A 3-D CSM was created and refined based on the information collected throughout the investigations. The Phase I, II, and III sample locations and results for VOCs with previous or current screening level exceedances for Building 1005 are shown **Figures 2-14 and 2-15**. A mitigation pilot study is proposed for Building 1005 by the Base, given the building's close proximity to the bio-pulse remediation system (**Figure 2-15**). Due to the construction of the building and the configuration of the current HVAC system, mitigation may be conducted by making adjustments to the HVAC system to evaluate the ventilation rate and create a positive internal pressure compared to the external and subslab pressure. The internal positive pressure environment created by the HVAC system should mitigate potential intrusion of vapors into the building.

2.2.3 Building 1115

Building 1115 is located in the HPFF area (**Figure 2-16**). This building is a warehouse for storage of recreational equipment and was classified as a small industrial building during the VI evaluation. Building 1115 is located within 100 feet of the Northwest AS/SVE system, and is within the bio-pulse system impact area. A former UST basin was located on the southwest side of Building 1115. Free product (light nonaqueous phase liquid (LNAPL) was observed in the UST basin when the tanks were removed in 1993.

Building Characteristics

Building 1115 is a one-story concrete block and mortar building, used for recreational equipment rentals and storage of gas-powered tree trimmers, lawn movers, grills, and coolers. The building is 87 feet long by 38 feet wide (based on the figure scale) with 12-foot high ceilings. Building 1115 is divided into three spaces by two dividing walls. There are openings in both dividing walls, which do not have doors. The dividing wall on the eastern end of the building has one large opening approximately 10 feet wide by 8 feet high. The dividing wall on the western end of the building has a 3.5-feet wide by 8-feet high opening. The building has 2 single doors, 1 warehouse double door, and 10 windows. The doors remain open during business hours, which are from 7AM to 3PM on weekdays. The number of workers varies seasonally. During the warmer months, approximately two workers are in the building between the hours of 7AM to 3PM on weekdays. Building 1115 does not have a central heating or cooling system. There are three window AC units which operate, in addition to the doors being left open during warmer months.

At the time of the Phase III building survey, it was noted that repair work should be performed on expansion joints. The expansion joints in need of repair may present a preferential pathway for vapor intrusion therefore, the expansion joints will be sealed with polyurethane caulk in a color that matched the current floor color. The caulk that will be used is a durable, flexible sealant that is designed for moving joints such as expansion and control joints, precast concrete panel joints, etc.

The building likely has perimeter wall footings, and additional footings underneath the pillars were observed within the building. The concrete slab of the main floor is level with the exterior ground surface. The slab is approximately 6 inches thick and contains wire mesh. No foundation plans are available for this building; therefore, a better description of the foundation will be compiled during the diagnostic test.

The present floor plan is shown on **Figure 2-17**.

VI Evaluation Results

Subslab soil gas and/or indoor air samples were collected during Phase I, Phase II, and Phase III VI evaluations at Building 1115. A 3-D CSM was created and refined based on the information collected throughout the investigations. The Phase I, II, and III sample locations and results for VOCs with previous or current screening level exceedances for Building 1115 are shown on **Figures 2-17 and 2-18**.

Groundwater and soil gas data suggested that VI could be significant at Building 1115. However, the Phase III results for indoor air did not indicate that the building is currently being impacted by the VI pathway (CH2M HILL, 2010). There is uncertainty as to whether the VI pathway could become significant in the future at Building 1115 based on exceedances of the base-specific SGSLs in subslab soil gas, the presence of benzene, ethylbenzene, chloroform, and m&p-xylenes in indoor air above indoor air screening levels (IASLs), and the results of the pressure monitoring, which suggest that the building is operating under neutral pressure, indicating a potential, intermittent driver for VI. Due to this uncertainty, the Base has elected to conduct a VIMS pilot study at Building 1115. The VIMS is expected to depressurize the building subslab, thus mitigating potential intrusion of vapors into the building.

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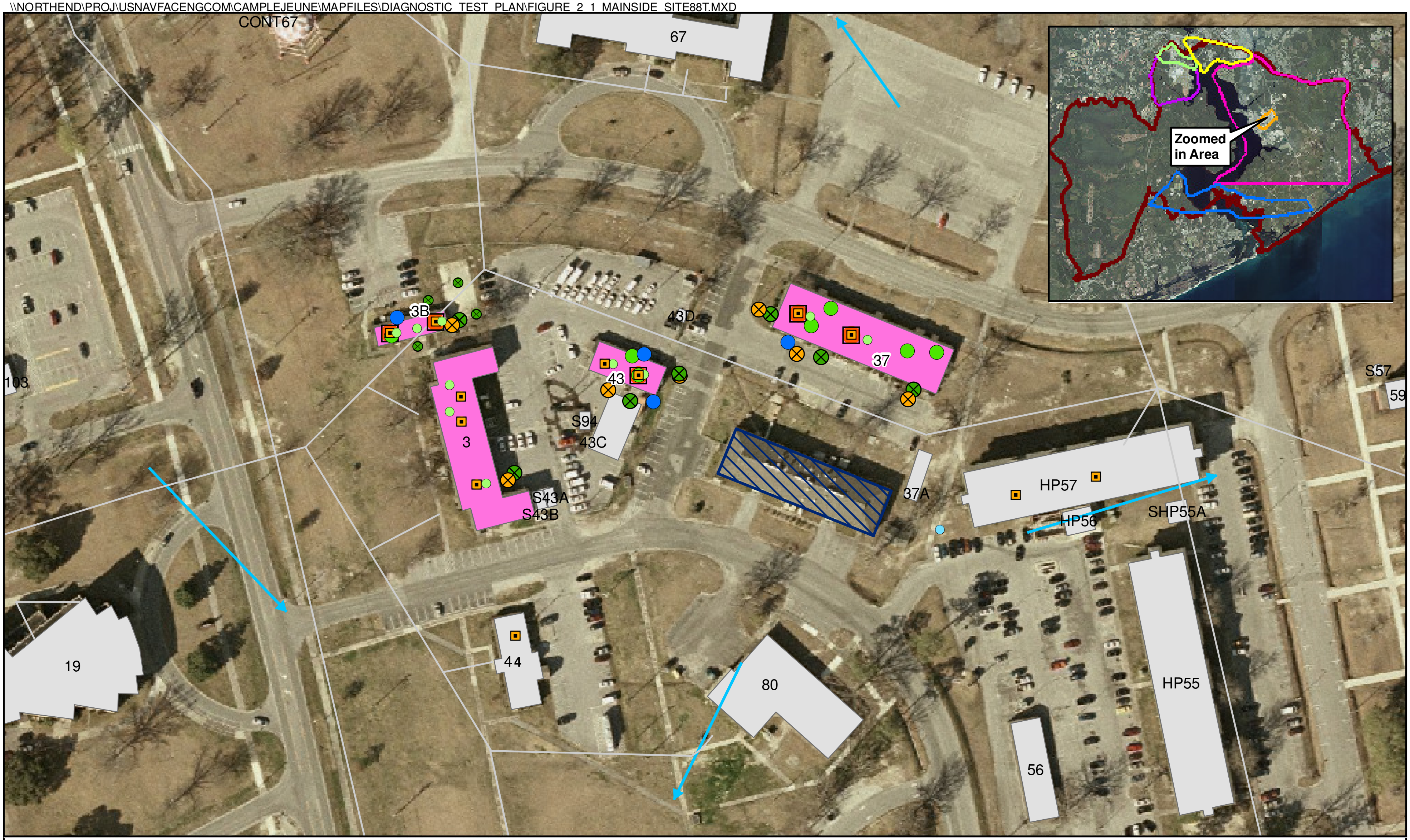


Legend

- Phase I - Groundwater Sample Location
- Phase I - Soil Vapor Sample Location
- Phase II - Indoor Air Sample Location
- Phase II - Outdoor Air Sample Location
- Phase II - Soil Gas Sample Location
- Phase III - Indoor Air Sample Location
- Phase III - Outdoor Air Sample Location
- Phase III - Groundwater Grab Sample Location
- Phase III - Soil Gas Sample Location
- Shallow Groundwater Flow
- Sanitary Sewer - March 2000
- Buildings of Interest
- Former Building 25
- Mainside
- Installation Boundary

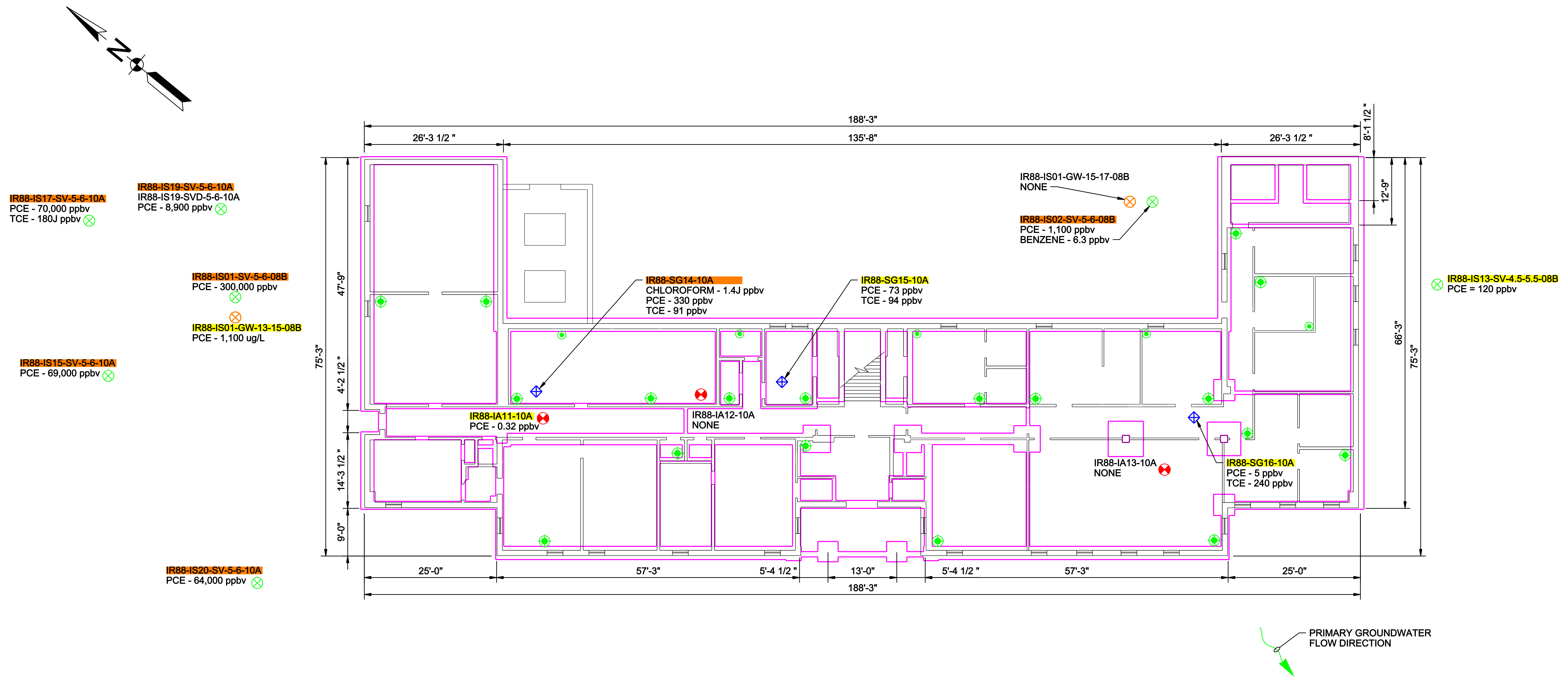
N

0 75 150 Feet

1 inch = 150 feet

Figure 2-1
Mainside Site 88
MCB CamLej
North Carolina

CH2MHILL

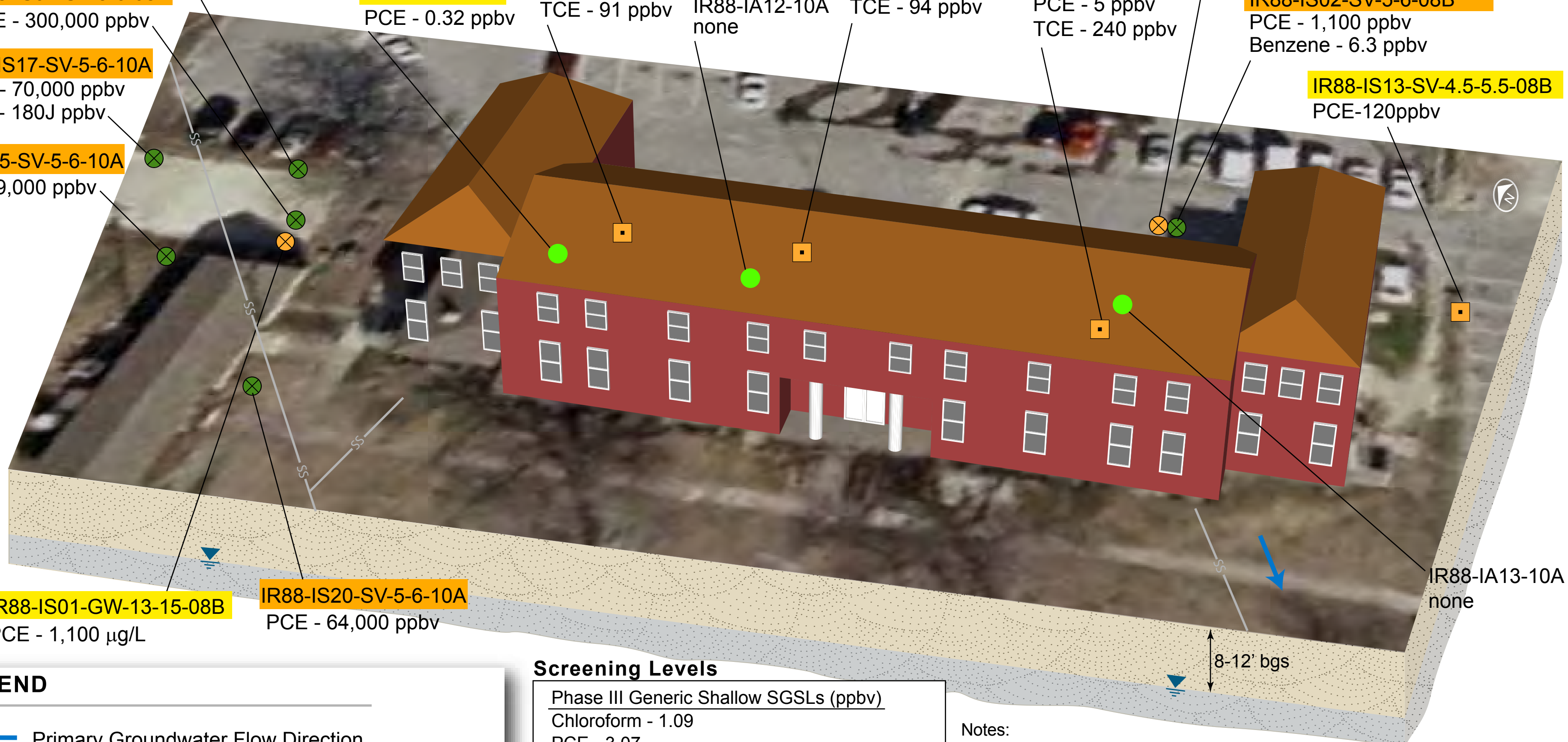


LEGEND

- FOUNDATION FOOTING
- FLOOR PLAN
- SOIL GAS SAMPLE LOCATION
- INDOOR AIR SAMPLE LOCATION
- SOIL VAPOR SAMPLE LOCATION
- GROUNDWATER SAMPLE LOCATION
- SAMPLE WITH ONE OR MORE EXCEEDING CONSTITUENTS
- SAMPLE WITH ONE OR MORE EXCEEDING CONSTITUENTS OF BASE SPECIFIC SGSLs
- PROPOSED LOCATION FOR TEST HOLE
- PROPOSED LOCATION FOR SUCTION HOLE

Figure 2-2
Building 3 Floor and Foundation Plan
with Sample Locations
MCB CamLej
North Carolina

CH2MHILL



LEGEND

- Primary Groundwater Flow Direction
- Water Table
- Mix of sand and sandy clay with areas of clay
- Sample with one or more exceeding constituents
- Sample with one or more exceeding constituents of Base-specific SGSLs
- Soil Gas Sample Location
- Indoor Air Sample Location
- Groundwater Sample Location
- Soil Vapor Sample Location
- SS Sanitary Sewer

Screening Levels

Phase III Generic Shallow SGSLs (ppbv)
Chloroform - 1.09
PCE - 3.07
TCE - 11.4

Phase III Base-Specific Shallow SGSLs (ppbv)
PCE - 307

Phase III Industrial Air RSLs (ppbv)
PCE - 0.307

Phase I Generic GWSL (ug/L)
PCE - 2.79

Phase I Generic Shallow SGSL (ppbv)
PCE - 3.1
Benzene - 5.01

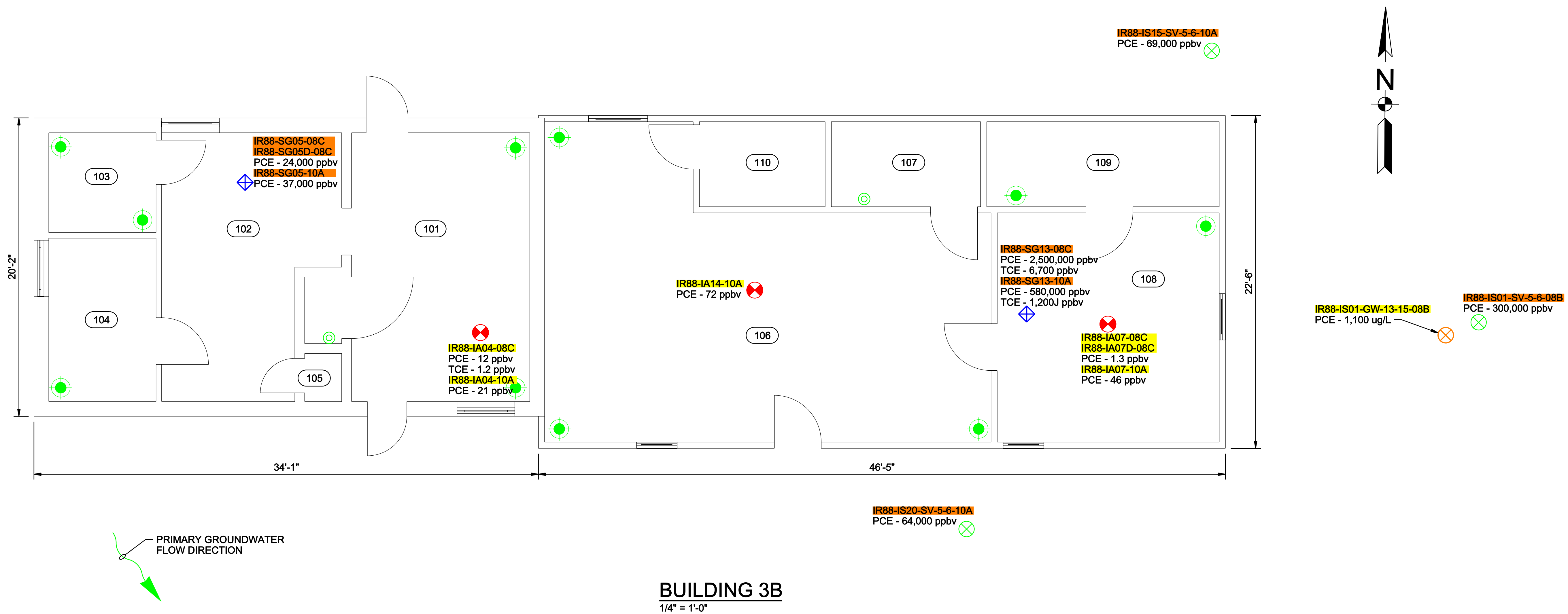
Phase I Base-Specific Shallow SGSL (ppbv)
PCE - 310
Benzene - 501

Notes:
J - Analyte present. Value may or may not be accurate or precise
ppbv - Parts per billion volume
SL - screening level
ft bgs – feet below ground surface
µg/L - micrograms/Liter

Figure 2-3
Building 3 CSM
MCB CamLej
North Carolina

CH2MHILL

ES040710032706KNV Mainside_Bldg3_VaporIntrusionCSM_v9_9/7/10_lk

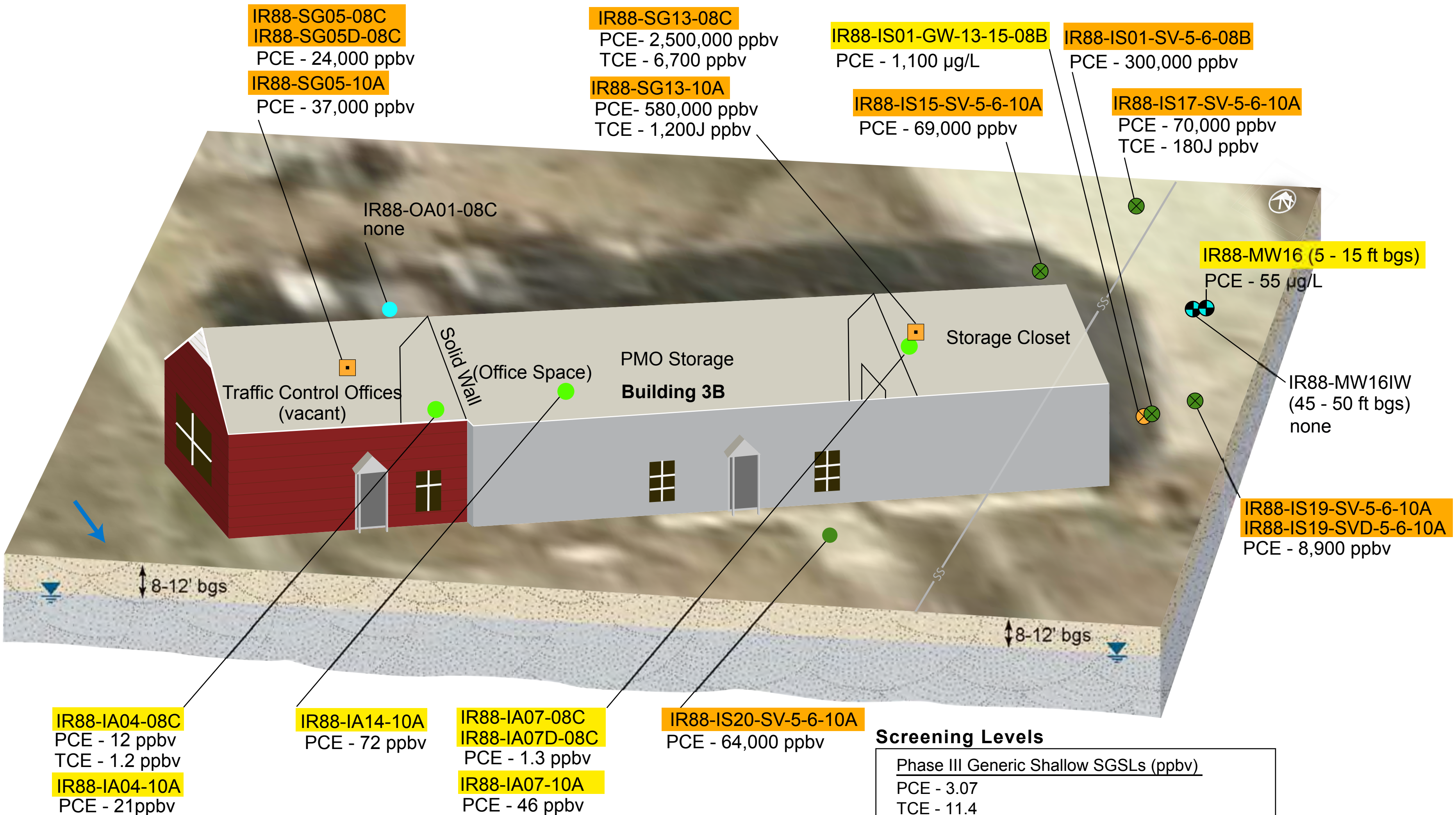


LEGEND

- FLOOR PLAN
- SOIL GAS SAMPLE LOCATION
- SHALLOW MONITORING WELL LOCATION (SAMPLED BETWEEN 2002 AND 2007)
- OUTDOOR AIR SAMPLE LOCATION
- INDOOR AIR SAMPLE LOCATION
- SOIL VAPOR SAMPLE LOCATION
- GROUNDWATER SAMPLE LOCATION
- SAMPLE WITH ONE OR MORE EXCEEDING CONSTITUENTS
- SAMPLE WITH ONE OR MORE EXCEEDING CONSTITUENTS OF BASE SPECIFIC SGSLs
- 101 ROOM NUMBER
- PROPOSED LOCATION FOR TEST HOLE
- PROPOSED LOCATION FOR SUCTION HOLE

Figure 2-4
Building 3B Floor with Sample Locations
MCB CamLej
North Carolina

CH2MHILL.



Screening Levels

Phase III Generic Shallow SGSLs (ppbv)
PCE - 3.07
TCE - 11.4

Phase III Base-Specific Shallow SGSLs (ppbv)
PCE - 307
TCE - 1,140

Phase III Industrial Air RSLs (ppbv)
PCE - 0.307

LEGEND

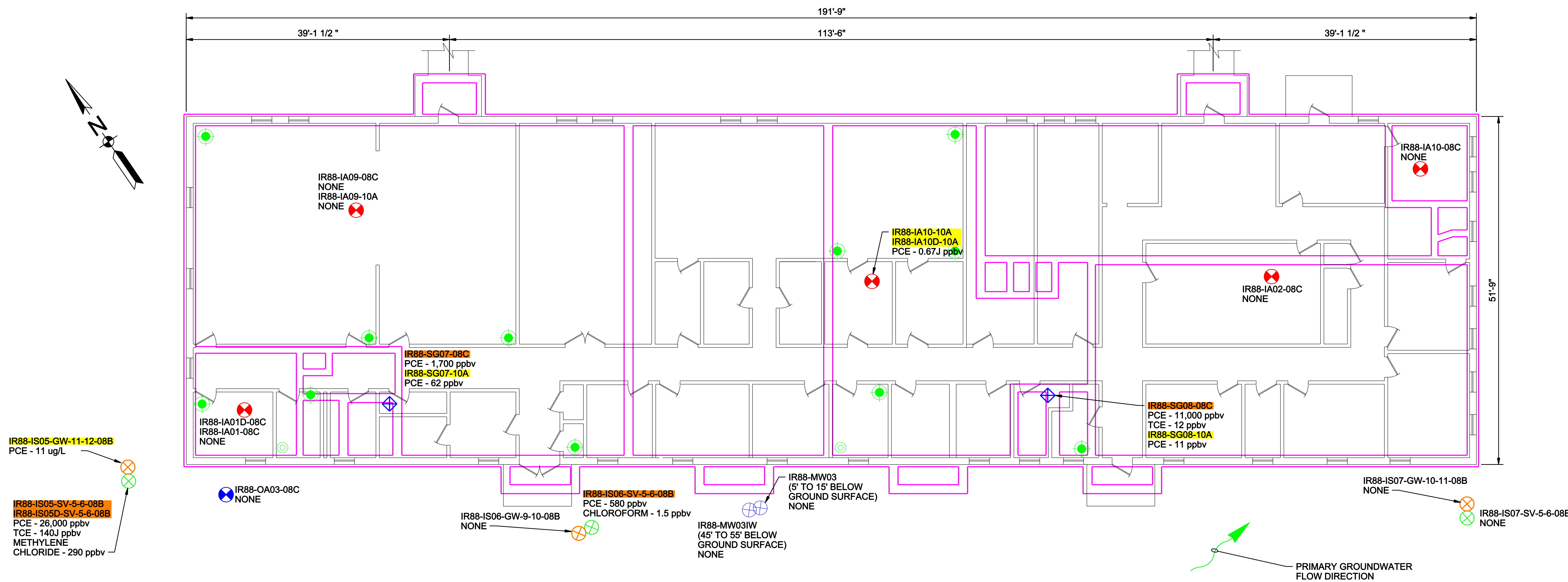
- Primary Groundwater Flow Direction
- Water Table
- Mix of sand and sandy clay with areas of clay
- Sample with one or more exceeding constituents
- Sample with one or more exceeding constituents of Base-specific SGSLs
- Soil Gas Sample Location
- Indoor Air Sample Location
- Outdoor Air Sample Location
- Shallow Monitoring Well (Sampled between 2002 and 2007)
- Groundwater Sample Location
- Soil Vapor Sample Location
- SS Sanitary Sewer

Notes:
J - Analyte present. Value may or may not be accurate or precise
ppbv - Parts per billion volume
SL - screening level
ft bgs – feet below ground surface
µg/L - micrograms/Liter

Figure 2-5
Building 3B CSM
MCB CamLej
North Carolina

CH2MHILL.

ES040710032706KNV Mainside_Bldg3B_VaporIntrusionCSM_v10_9/8/10_lk



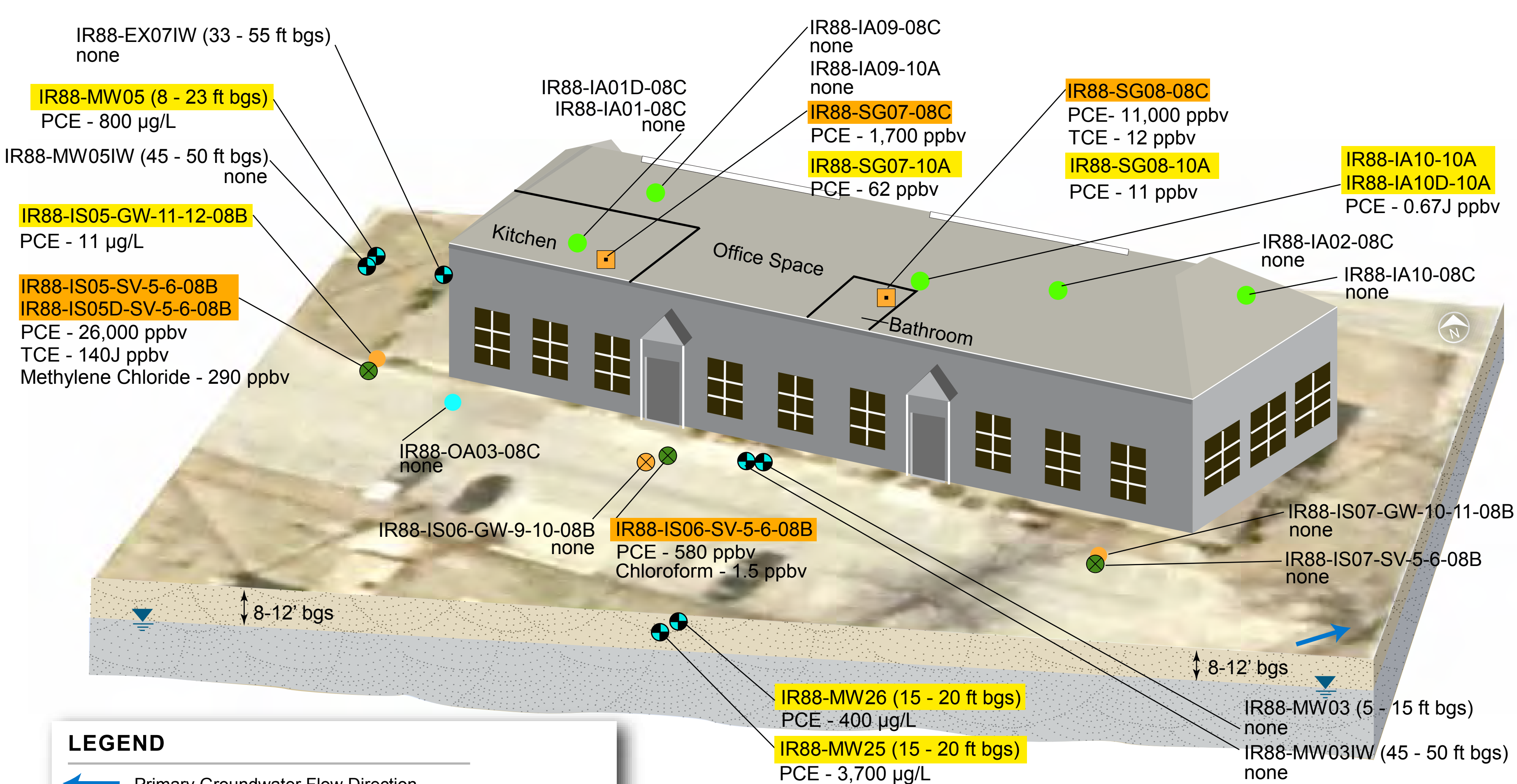
LEGEND

- FOUNDATION FOOTING
- FLOOR PLAN
- SOIL GAS SAMPLE LOCATION
- SHALLOW MONITORING WELL LOCATION (SAMPLED BETWEEN 2002 AND 2007)
- OUTDOOR AIR SAMPLE LOCATION
- INDOOR AIR SAMPLE LOCATION
- SOIL VAPOR SAMPLE LOCATION
- GROUNDWATER SAMPLE LOCATION
- SAMPLE WITH ONE OR MORE EXCEEDING CONSTITUENTS
- SAMPLE WITH ONE OR MORE EXCEEDING CONSTITUENTS OF BASE SPECIFIC SGSLs
- PROPOSED LOCATION FOR TEST HOLE
- PROPOSED LOCATION FOR SUCTION HOLE

BUILDING 37
1/8" = 1'-0"

Figure 2-6
Building 37 Floor and Foundation Plan
with Sample Locations
MCB CamLej
North Carolina

CH2MHILL.



LEGEND

- Primary Groundwater Flow Direction
- Water Table
- Mix of sand and sandy clay with areas of clay
- Sample with one or more exceeding constituents
- Sample with one or more exceeding constituents of Base-specific SGSLs
- Soil Gas Sample Location
- Indoor Air Sample Location
- Outdoor Air Sample Location
- Shallow Monitoring Well (Sampled between 2002 and 2007)
- Groundwater Sample Location
- Soil Vapor Sample Location

Screening Levels

Phase III Generic Shallow SGSLs (ppbv) PCE - 3.07	Site Specific GWSLs (µg/L) PCE - 5.49
Phase III Industrial Air RSLs (ppbv) PCE - 0.307	Generic GWSLs (µg/L) PCE - 3.04

Notes:

J - Analyte present. Value may or may not be accurate or precise

ppbv - Parts per billion volume

SL - screening level

µg/L - microgram/Liter

ft bgs - feet below ground surface

Figure 2-7
Building 37 CSM
MCB CamLej
North Carolina

CH2MHILL

Es040710032706KNV Mainside_Bldg37_VaporIntrusionCSM_v8_7/27/10_lk

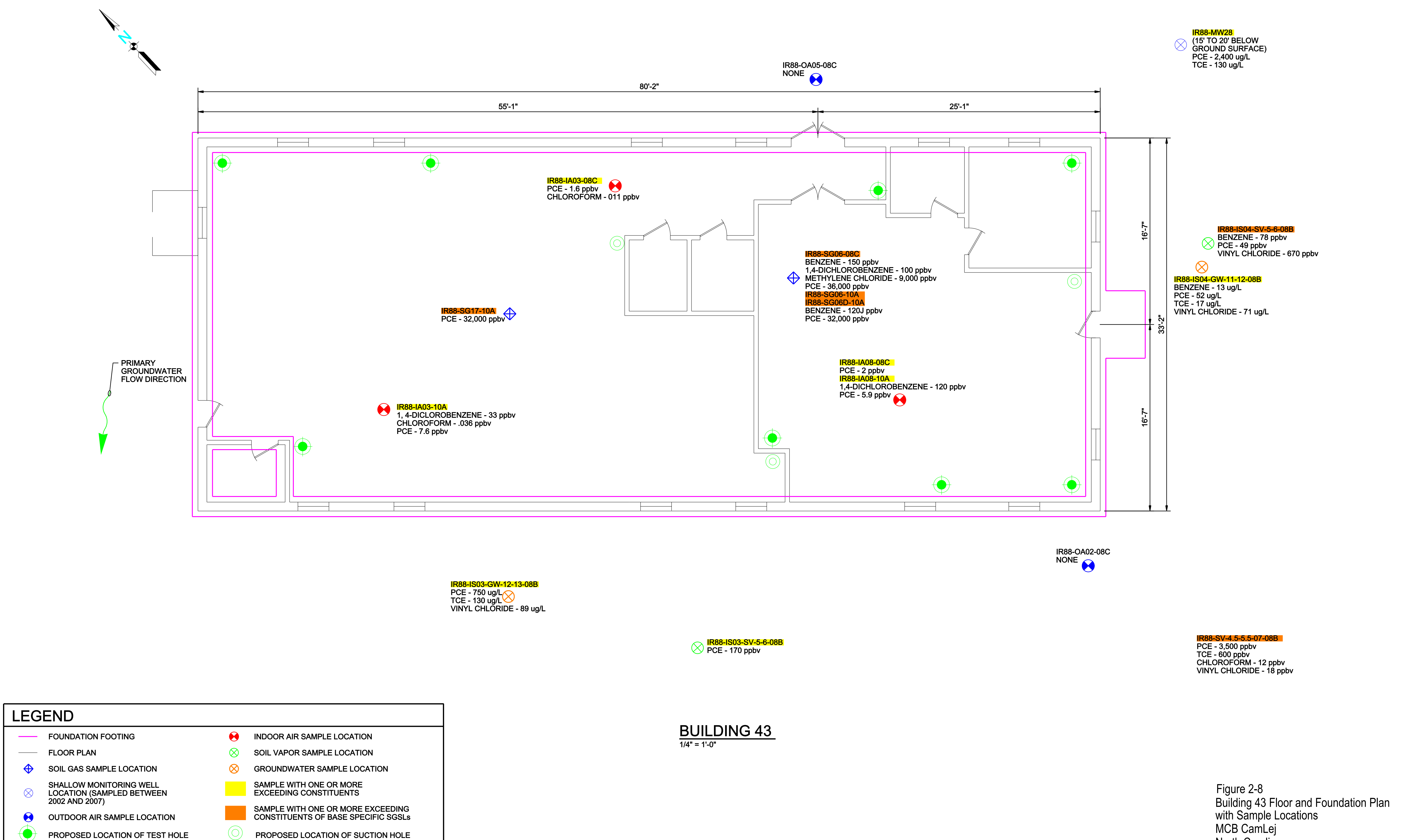
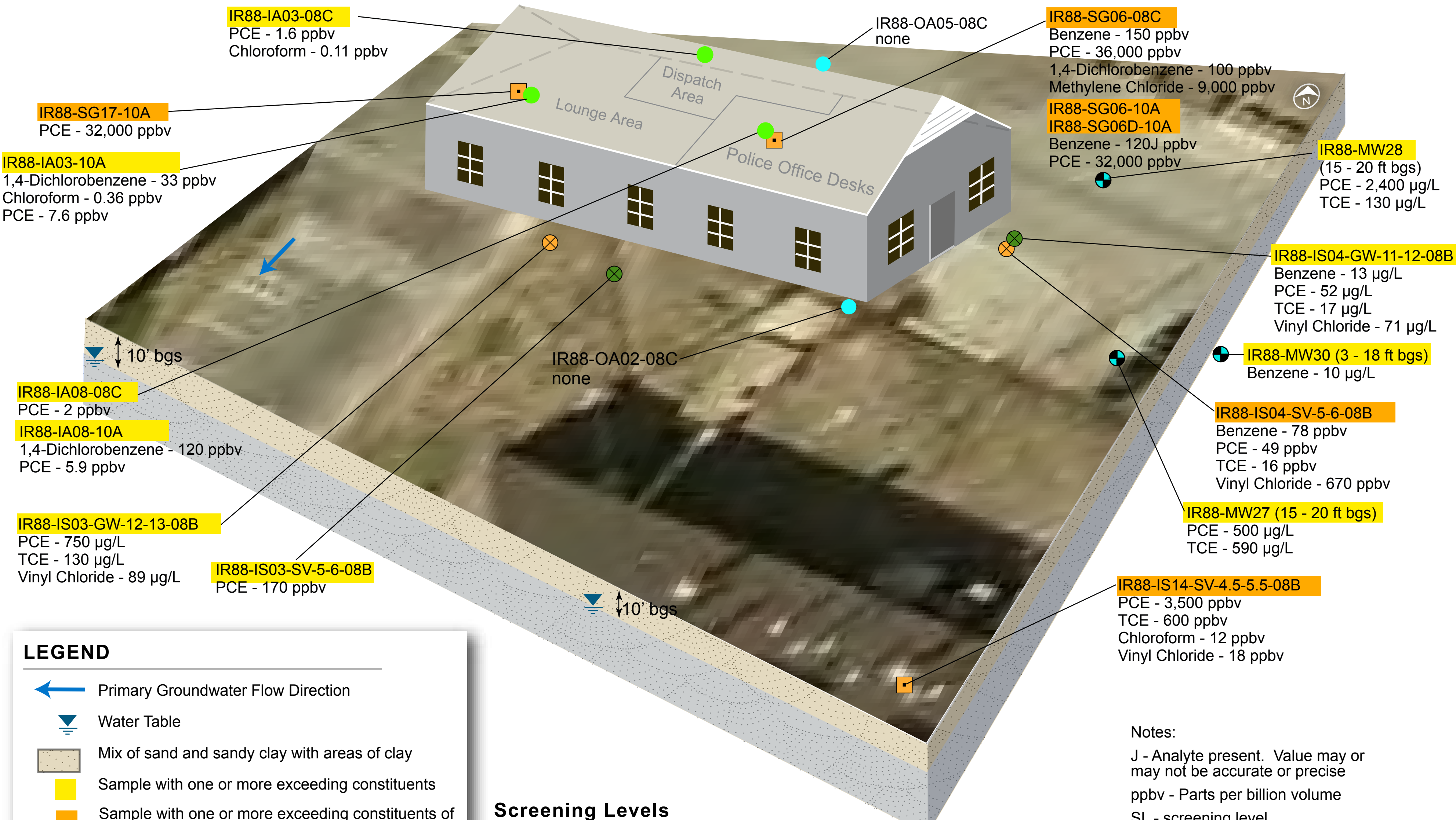


Figure 2-8
Building 43 Floor and Foundation Plan
with Sample Locations
MCB CamLej
North Carolina

CH2MHILL.



LEGEND

- Primary Groundwater Flow Direction
- Water Table
- Mix of sand and sandy clay with areas of clay
- Sample with one or more exceeding constituents
- Sample with one or more exceeding constituents of Base-specific SGSLs
- Soil Gas Sample Location
- Indoor Air Sample Location
- Outdoor Air Sample Location
- Monitoring Well With Exceedances
- Groundwater Sample Location
- Soil Vapor Sample Location

Screening Levels

Phase III Generic Shallow SGSLs (ppbv)	Site-Specific GWSLs (µg/L)
Benzene - 4.91	Benzene - 8.65
PCE - 3.07	PCE - 4.17
Phase III Base-Specific Shallow SGSLs (ppbv)	TCE - 20.0
PCE - 307	**Generic GWSLs (µg/L)**
Phase III Industrial Air RSLs (ppbv)	Benzene - 7.67
1,4-DCB - 0.185	PCE - 3.04
Chloroform - 0.109	TCE - 16.56
PCE - 0.307	Vinyl Chloride - 2.52

Notes:

J - Analyte present. Value may or may not be accurate or precise

ppbv - Parts per billion volume

SL - screening level

µg/L - microgram/Liter

ft bgs - feet below ground surface

Figure 2-9
Building 43 CSM
MCB CamLej
North Carolina

CH2MHILL.

\\NORTHEND\PROJ\USNAVFACENGCOM\CAMPLEJEUNE\MAPFILES\DIAGNOSTIC_TEST_PLAN\FIGURE_2_10_HADNOT_POINT_SITE_78_N.MXD

Legend

- Phase I - Groundwater Sample Location
- Phase II - Soil Gas Sample Location
- Phase III - Indoor Air Sample Location
- Phase III - Outdoor Air Sample Location
- Phase III - Groundwater Grab Sample Location
- Phase III - Soil Gas Sample Location
- Shallow Groundwater Flow
- Buildings of Interest
- Hadnot Point
- Installation Boundary

N

0 100 200 400 Feet

1 inch = 200 feet

Figure 2-10
Hadnot Point Site 78 North
MCB CamLej
North Carolina

CH2MHILL

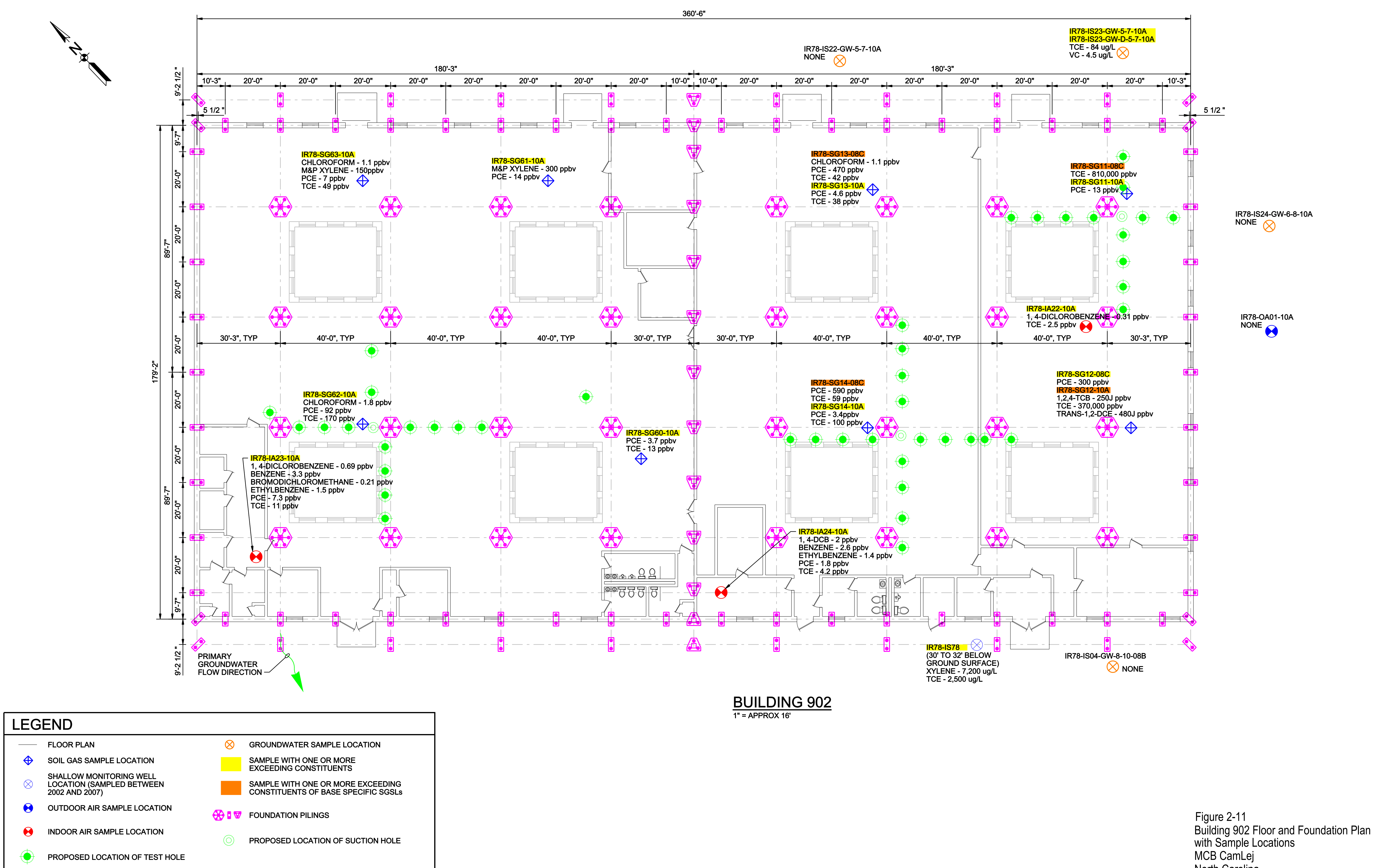
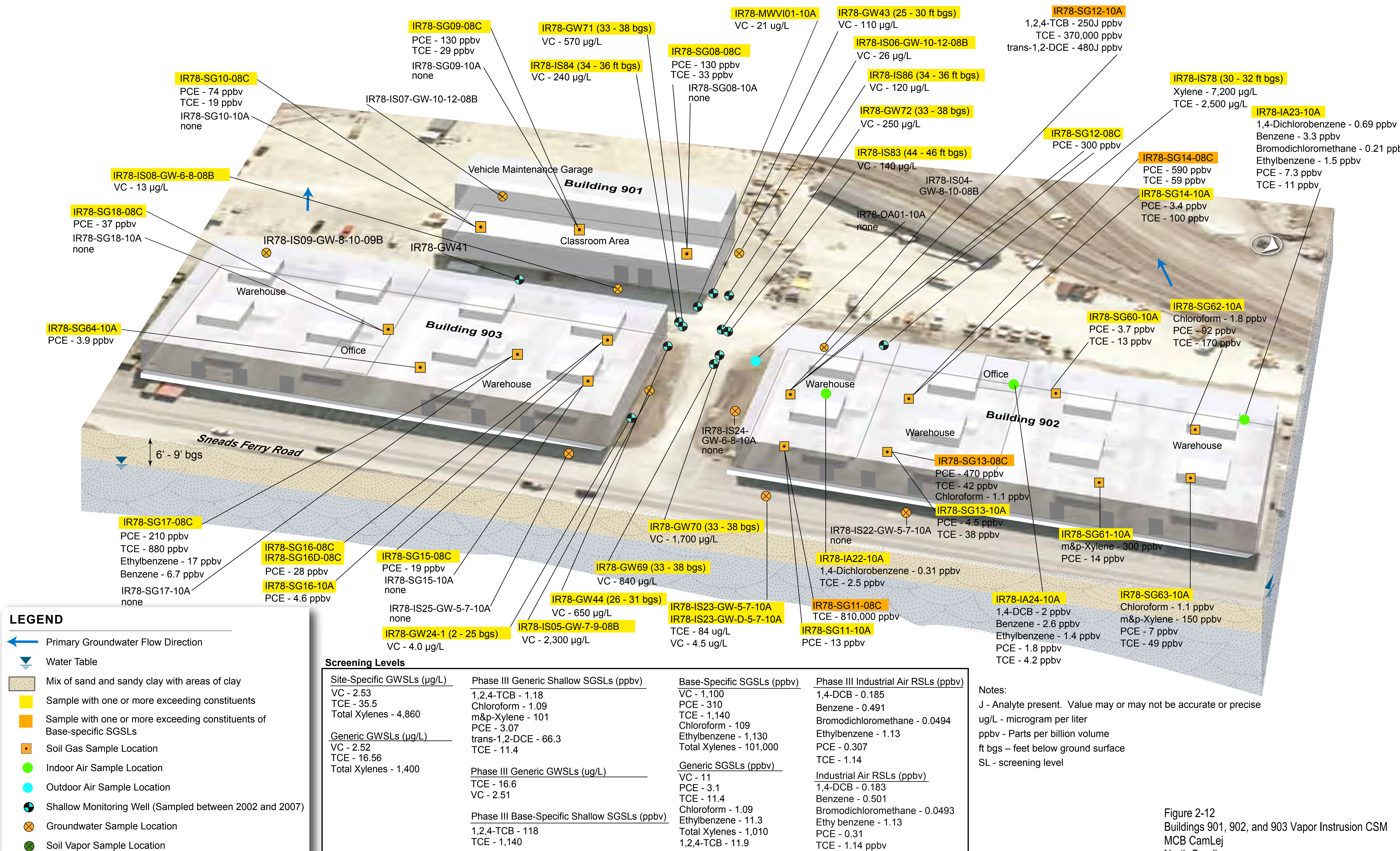


Figure 2-11
Building 902 Floor and Foundation Plan
with Sample Locations
MCB CamLej
North Carolina

CH2MHILL.



Screening Levels

Site-Specific GWSLs (µg/L)	Phase III Generic Shallow SGSLs (ppbv)	Base-Specific SGSLs (ppbv)	Phase III Industrial Air RSLs (ppbv)
VC - 2.53 TCE - 35.5 Total Xylenes - 4,860	1,2,4-TCB - 1.18 Chloroform - 1.09 m&p-Xylene - 101 PCE - 3.07 trans-1,2-DCE - 66.3 TCE - 11.4	VC - 1,100 PCE - 310 TCE - 1,140 Chloroform - 109 Ethylbenzene - 1,130 Total Xylenes - 101,000	1,4-DCB - 0.185 Benzene - 0.491 Bromodichloromethane - 0.0494 Ethylbenzene - 1.13 PCE - 0.307 TCE - 1.14
Generic GWSLs (µg/L)	**Phase III Generic GWSLs (ug/L)**	**Generic SGSLs (ppbv)**	**Industrial Air RSLs (ppbv)**
VC - 2.52 TCE - 16.56 Total Xylenes - 1,400	TCE - 16.6 VC - 2.51	VC - 11 PCE - 3.1 TCE - 11.4 Chloroform - 1.09 Ethylbenzene - 11.3 Total Xylenes - 1,010 1,2,4-TCB - 11.9	1,4-DCB - 0.183 Benzene - 0.501 Bromodichloromethane - 0.0493 Ethy benzene - 1.13 PCE - 0.31 TCE - 1.14 ppbv
	Phase III Base-Specific Shallow SGSLs (ppbv)		
	1,2,4-TCB - 118 TCE - 1,140		

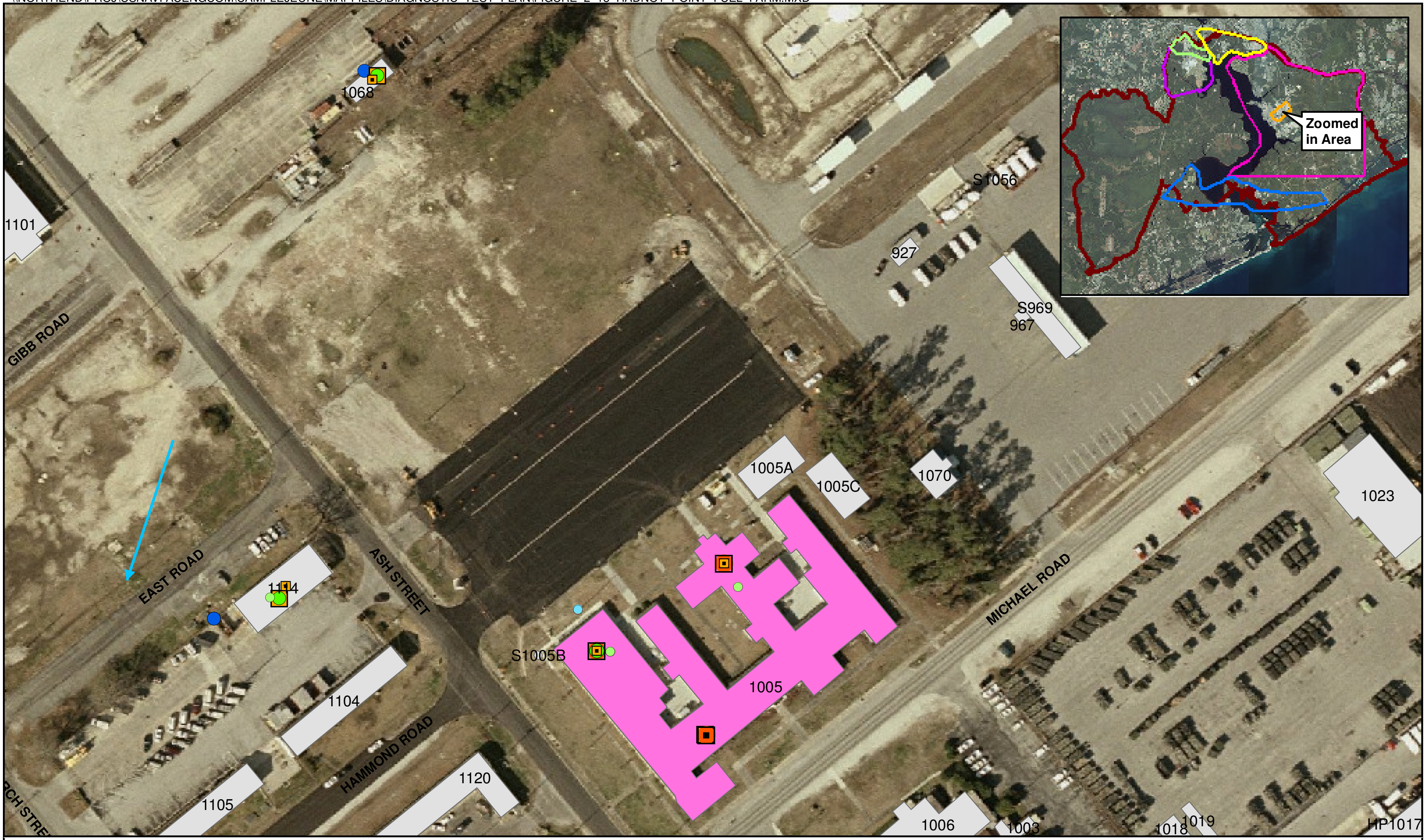
Notes:
J - Analyte present. Value may or may not be accurate or precise
ug/L - microgram per liter
ppbv - Parts per billion volume
ft bgs – feet below ground surface
SL - screening level

Figure 2-12
Buildings 901, 902, and 903 Vapor Instrusion CSM
MCB CamLej
North Carolina

CH2MHILL.

ES040710032706KNV HadnotPoint_Site78North_Bldg910_902_903_VaporIntrusionCSM_v6_9/23/10_lk

\\NORTHEND\PROJ\USNAVFACENGCOM\CAMPLEJEUNE\MAPFILES\DIAGNOSTIC_TEST_PLAN\FIGURE_2_13_HADNOT_POINT_FUEL_FARM.MXD



Legend

- Indoor Air Sample Location
- Outdoor Air Sample Location
- Soil Gas Sample Location
- Phase II - Indoor Air Sample Location
- Phase II - Soil Gas Sample Location
- Phase III - Indoor Air Sample Location
- Phase III - Outdoor Air Sample Location
- Phase III - Soil Gas Sample Location
- Shallow Groundwater Flow
- Hadnot Point
- Buildings of Interest
- Installation Boundary

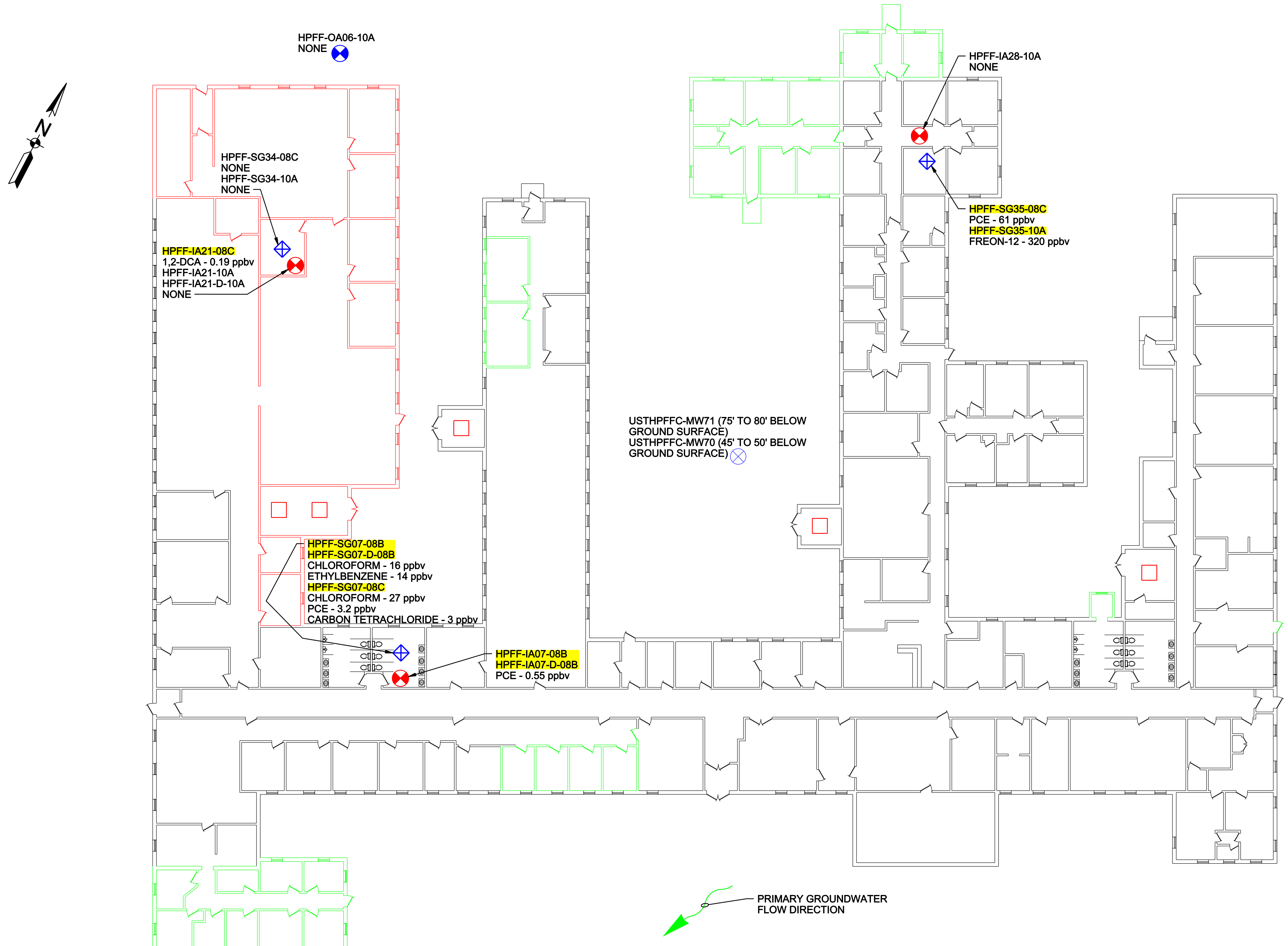
N

0 75 150 300 Feet

1 inch = 150 feet

Figure 2-13
Hadnot Point Fuel Farm
MCB CamLej
North Carolina

CH2MHILL



BUILDING 1005

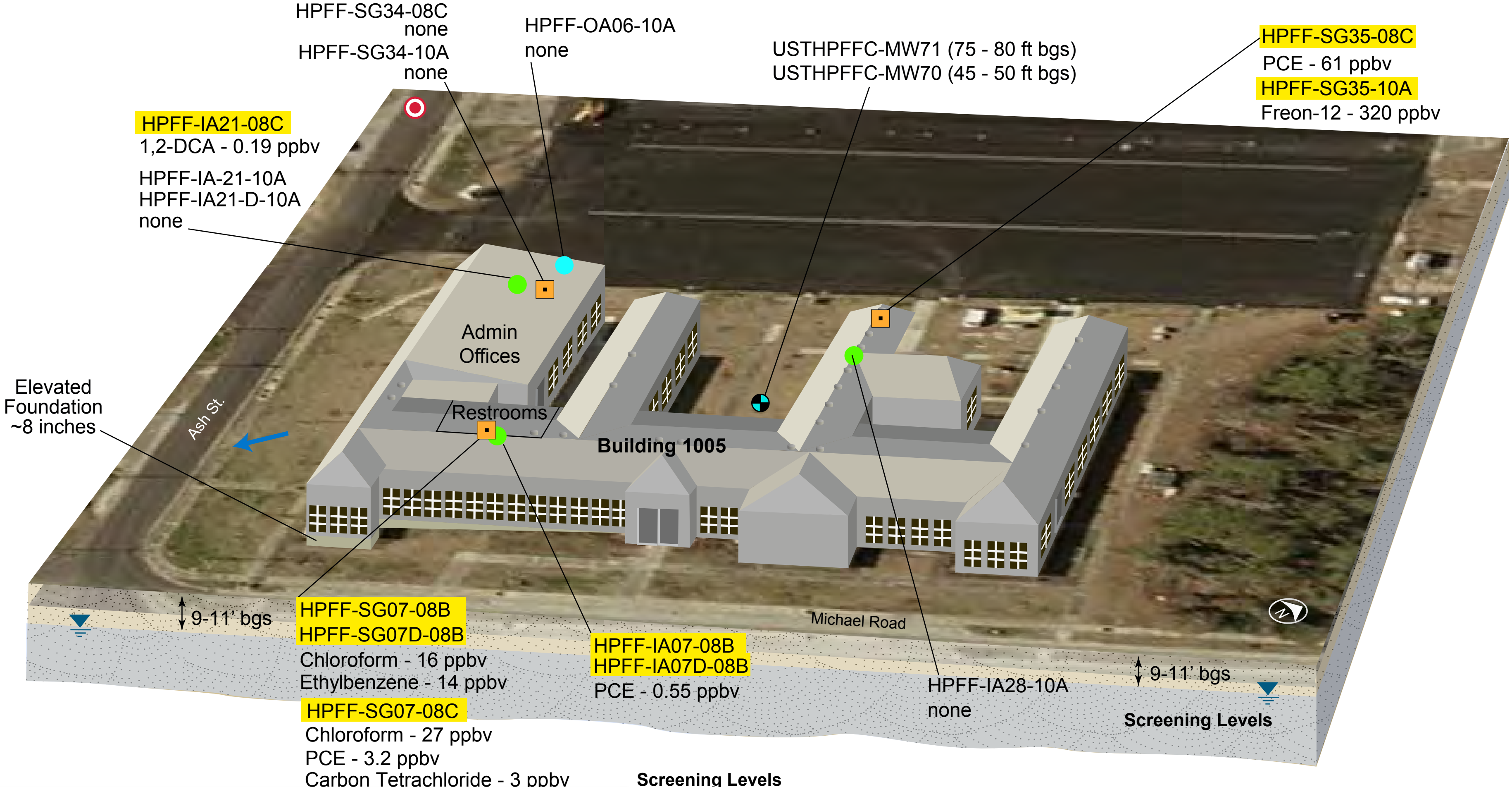
1" = APPROX 16'

LEGEND

FLOOR PLAN (PRIOR TO 2001)	OUTDOOR AIR SAMPLE LOCATION
FLOOR PLAN (ADDITION / RENOVATION 2002)	INDOOR AIR SAMPLE LOCATION
FLOOR PLAN (ADDITION / RENOVATION 2007)	SAMPLE WITH ONE OR MORE EXCEEDING CONSTITUENTS
SOIL GAS SAMPLE LOCATION	SAMPLE WITH ONE OR MORE EXCEEDING CONSTITUENTS OF BASE SPECIFIC SGSLs
SHALLOW MONITORING WELL LOCATION (SAMPLED BETWEEN 2002 AND 2007)	HVAC LOCATION

Figure 2-14
Building 1005 Floor Plan with
Sample Locations
MCB CamLej
North Carolina

CH2MHILL.



LEGEND

- Primary Groundwater Flow Direction
- Water Table
- Mix of sand and sandy clay with areas of clay
- Soil Gas Sample Location
- Indoor Air Sample Location
- Outdoor Air Sample Location
- Shallow Monitoring Well (Sampled between 2002 and 2007)
- Sample with one or more exceeding constituents
- Bio-pulse sparge well location

Screening Levels

Phase III Generic Shallow SGSLs (ppbv)
Freon-12 - 177

Generic Shallow SGSLs (ppbv)
PCE - 3.1
Chloroform - 1.09
Ethylbenzene - 11.3
Carbon Tetrachloride - 1.3

Indoor Air Generic SLs (ppbv)
Chloroform - 0.109
PCE - 0.31
Carbon Tetrachloride - 0.31
1,2-DCA - 0.116

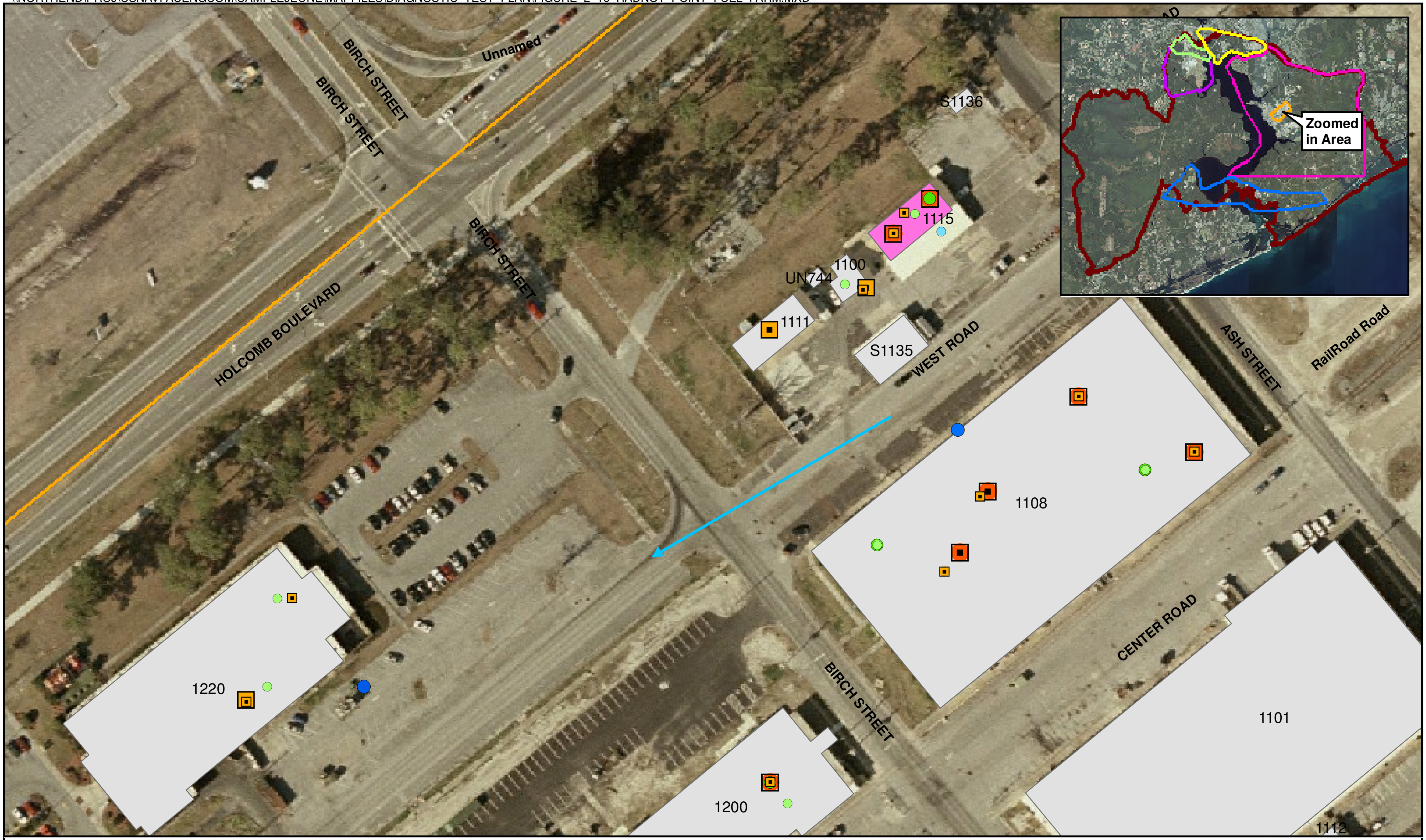
Base-Specific Shallow SGSLs (ppbv)
PCE - 310
Chloroform - 109
Ethylbenzene - 1,130
Carbon Tetrachloride - 130

Notes:
ppbv - Parts per billion volume
SL - screening level
ft bgs – feet below ground surface

Figure 2-15
Building 1005 Vapor Intrusion CSM
MCB CamLej
North Carolina

CH2MHILL

\\NORTHEND\PROJ\USNAVFACENGCOM\CAMPLEJEUNE\MAPFILES\DIAGNOSTIC_TEST_PLAN\FIGURE_2_16_HADNOT_POINT_FUEL_FARM.MXD



Legend

- Indoor Air Sample Location
- Outdoor Air Sample Location
- Soil Gas Sample Location
- Phase II - Indoor Air Sample Location
- Phase II - Outdoor Air Sample Location
- Phase II - Soil Gas Sample Location
- Phase III - Indoor Air Sample Location
- Phase III - Outdoor Air Sample Location
- Phase III - Soil Gas Sample Location
- Shallow Groundwater Flow
- Hadnot Point
- Buildings of Interest
- Installation Boundary

N

0 62.5 125 250 Feet

1 inch = 125 feet

Figure 2-16
Hadnot Point Fuel Farm
MCB CamLej
North Carolina

CH2MHILL

BUILDING 1115

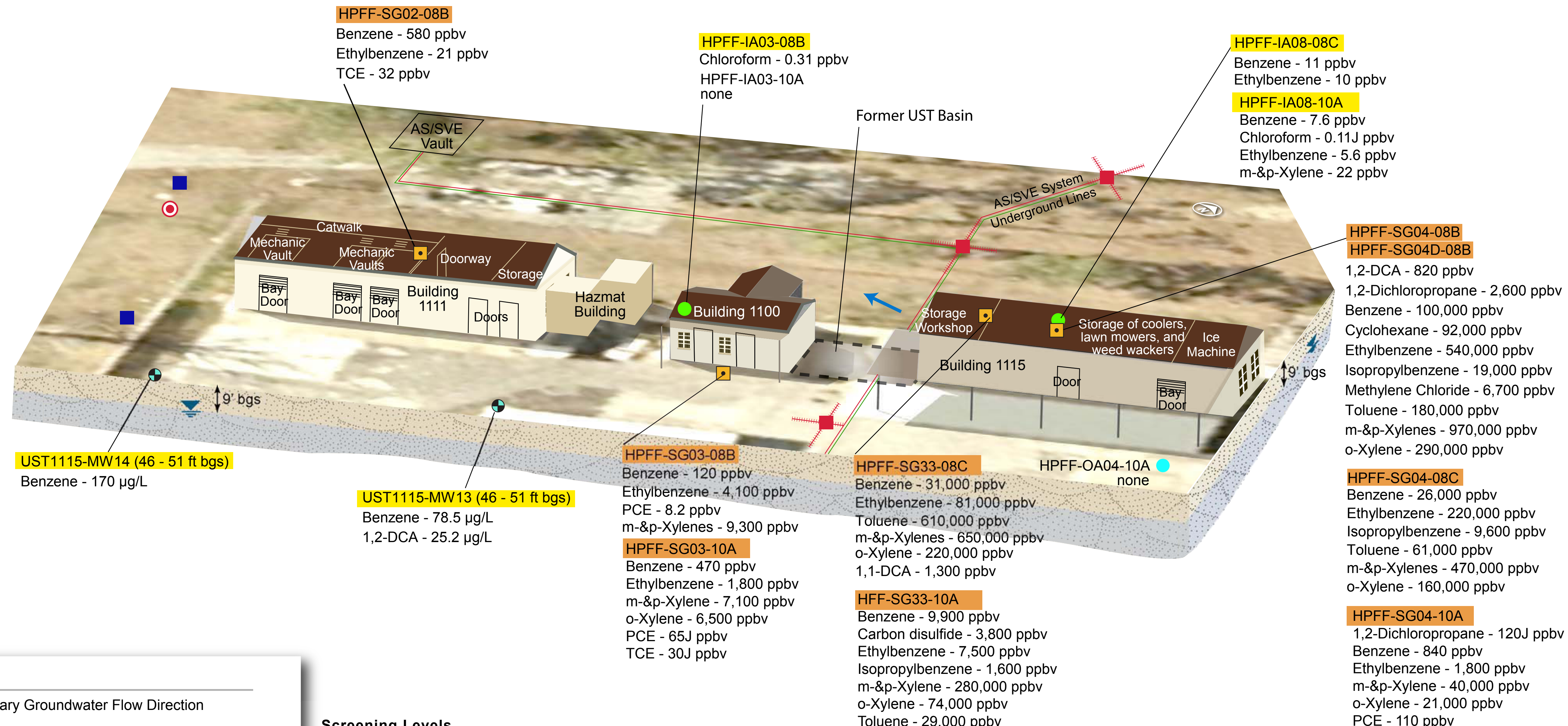
1" = APPROX 4'

LEGEND

- FLOOR PLAN
- SOIL GAS SAMPLE LOCATION
- OUTDOOR AIR SAMPLE LOCATION
- INDOOR AIR SAMPLE LOCATION
- SAMPLE WITH ONE OR MORE EXCEEDING CONSTITUENTS
- SAMPLE WITH ONE OR MORE EXCEEDING CONSTITUENTS OF BASE SPECIFIC SGSLs
- PROPOSED LOCATION OF TEST HOLE
- PROPOSED LOCATION OF SUCTION HOLE

Figure 2-17
Building 1115 Floor Plan
with Sample Locations
MCB CamLej
North Carolina

CH2MHILL.



LEGEND

- Primary Groundwater Flow Direction
- Water Table
- Mix of sand and sandy clay with areas of clay
- Soil Gas Sample Location
- Indoor Air Sample Location
- Outdoor Air Sample Location
- Shallow Monitoring Well (Sampled between 2002 and 2007)
- Sample with one or more exceeding constituents
- Sample with one or more exceeding consitituents of Base-specific SGSLs
- Biosparge well location
- Bio-pulse sparge well location
- Airsparge/SVE well location
- Former UST Basin

Screening Levels

Site-Specific GWSLs (µg/L)
- Benzene - 9.96
- 1,2-DCA - 14.6

Generic SGSLs (ppbv)
- TCE - 11.4
- PCE - 3.1
- 1,2-DCA - 1.16
- 1,1-DCA - 19
- 1,2-Dichloropropane - 2.6
- Methylene Chloride - 74.8
- Benzene - 5.01
- Ethylbenzene - 11.3
- Toluene - 58,400
- m-&p-Xylenes - 1,010
- o-Xylene - 7,140
- Isopropylbenzene - 3,660
- Cyclohexane - 75,500

Base-Specific SGSLs (ppbv)
- TCE - 1,140
- PCE - 310
- 1,2-DCA - 116
- 1,1-DCA - 1,900
- 1,2-Dichloropropane - 260
- Methylene Chloride - 7,480
- Benzene - 501
- Ethylbenzene - 1,130
- Toluene - 5,840,000
- m-&p-Xylenes - 101,000
- o-Xylene - 714,000
- Isopropylbenzene - 366,000
- Cyclohexane - 7,550,000

Phase III Base-Specific Shallow SGSLs (ppbv)
- Benzene - 491
- Ethylbenzene - 1,130
- m-&p-Xylene - 10,100
- o-xylene - 70,700

Phase III Generic Shallow SGSLs (ppbv)
- 1,2-DCP - 2.66
- Benzene - 4.91
- Carbon disulfide - 986
- Ethylbenzene - 11.3
- Isopropylbenzene - 356
- m-&p-Xylene - 101
- o-Xylene - 707
- PCE - 3.07
- Tolulene - 5,810
- TCE - 11.4

Phase III Generic Indoor Air SLs (ppbv)
- Benzene - 0.491
- Chloroform - 0.109
- Ethylbenzene - 1.13
- m-&p-Xylene - 10.1

Industrial Air RSLs (ppbv)
- Benzene - 0.501
- Ethylbenzene - 1.13
- Chloroform - 0.109

Notes:
J - Analyte present. Value may or may not be accurate or precise
ppbv - Parts per billion volume
SL - screening level
µg/L - microgram/Liter
ft bgs - feet below ground surface

Figure 2-18
HPFF Building 1111, 1100, & 1115 Vapor Intrusion CSM
MCB CamLej
North Carolina

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SECTION 3

Diagnostic Testing

Sub-surface contaminants can enter a building through the portions of the structure that are in contact with the ground surface. The potential contaminant entry is a result of three primary variables: the source strength of the contaminant below the building; entry routes into the building; and the process by which the building draws contaminants from the soil into the building. Quantifying and understanding the relationships among these three variables and the effect the variables have on the final indoor air contaminant concentrations is the key to developing an effective mitigation plan. Proper diagnostics (described in this section) will provide the design engineers with the information necessary to manipulate the influencing factors and mitigate potential VI.

The primary goal of mitigation is to prevent VOC vapors in the subsurface from entering structures at levels that would cause indoor air concentrations to exceed acceptable risk-based concentrations.

3.1 Testing Procedures

Two types of tests are proposed in this work plan. Buildings 3, 3B, 37, 43, 902, and 1115 will be subject to subslab pressure field extension (PFE) potential tests to determine the radius of influence that can be achieved beneath the floor slabs. These data will be used to design subslab depressurization systems (SSDs). The existing HVAC systems at Building 1005 will be evaluated and manipulated as needed to create and maintain positive pressure in the building interior relative to the subslab pressure and to determine the ventilation rate. The HVAC system will be returned to its pre-existing operating condition following the test. Both tests are described in the following sections.

3.1.1 Subslab Pressure Field Extension Potential Test

It is difficult to design a VIMS in an industrial/commercial building without first measuring the subslab negative PFE potential. Commercial buildings can present significant challenges to achieving subslab depressurization. This is due to the size of the buildings, the compacted fill that underlies the slab, and the soil type below the fill. In addition, if there may be limited air flow through subslab fill material, small leakages through the slab at cracks or utility penetrations can result in vacuum loss that significantly reduces the negative PFE. In other cases, there are very high system air flow requirements beneath the slab because of either high soil porosity or a combination of porous fill and slab leakage. In order to accurately determine how many negative pressure points are necessary to successfully create a negative pressure environment in the subslab of a building, a subslab communication test must be performed. This communication test will be repeated in all sections of the building that appear to have a unique foundation, barriers to subslab communication, or significantly different features such as slab leakage, subslab material, or underlying soil types. In general, it is recommended that a minimum negative pressure of -0.008 inch of water column be maintained under the slab to minimize or prevent soil gas intrusion into the building. However, subslab pressure readings as low as – 0.004 inch of water column have been shown to be effective.

Utility Location

Prior to entering the building, the building representative will be contacted to provide access to all areas of the building. Building plans will be reviewed with the building representative and locations proposed for suction and test holes confirmed. Once the final locations have been agreed to, a third party utility locator will clear utilities at each proposed drilling location. The purpose of the utility locating service is to identify utilities that may be in conflict with the proposed holes that will be made through the floor. Suction and test holes will be relocated if necessary to avoid damaging the subsurface utilities.

Structural Details Evaluation

The available structural details of each building were reviewed prior to proposing suction and test hole locations. As-built drawings, building surveys, and information gathered from the Base and building representatives were evaluated to place the suction and test holes in the most appropriate locations to best perform the diagnostic testing. **Table 3-1** presents the number and locations of suction holes test holes proposed for the various buildings. The specific locations and number of suction and test holes will likely need to be adjusted based on any new data gathered before installation of the holes and the location of subsurface utilities.

Suction and Test Hole Installation

Suction and test holes will be installed using a wet core drill to cut through the slab and an auger to excavate the subslab material. The suction holes will be 2.5-inch in diameter and will be installed through the slab. Two 5/16-inch diameter test holes will then be drilled through the floor slab at a distance of approximately 12 inches from the 2.5 inch-diameter suction holes and will be used to measure vacuum during the test. Test holes (5/16-inch diameter) will be drilled through the slab at varying distances from the suction hole. During drilling, a shop vacuum with a High Efficiency Particulate Air (HEPA) filter will be used to minimize the release of dust into the building and to clean the dust out from the suction and test holes.

The actual number of holes will be determined based on the building survey results, construction details, the interior layout, tenant occupancy, any access agreement requirements, the best-fit locations given CH2M HILL's experience at similar-size structures, and consultations in the field with the subcontractor.

Negative Pressure Field Communication Testing

Communication testing will include multiple subslab vacuum test locations at varying distances from the vacuum suction hole. A 6.5-horsepower shop vacuum equipped with a HEPA and carbon filter will be utilized to determine the PFE from the measurements taken at the suction holes. By varying the amount of air being drawn out of the subslab while carefully measuring the airflow and pressure changes, a profile can be determined that defines the subslab resistance. These measurements define what size piping is used, how many suction points are necessary, what size fan should be used, and how many suction points can be attached to each fan. This allows exact sizing of the required system. Airflow will be monitored and regulated using a pitot tube.

A shop vacuum will be used to draw air out of the suction hole. Putty will be used to create an air-tight seal at the slab suction and test holes. The shop vacuum would be expected to create a varying PFE through the subslab that would be measured at the test hole. The airflow out of the suction hole will be measured with a pitot tube or other airflow measuring instrument. These data will indicate the resistance of the soil and the force needed to extend the pressure field out from a single suction point. These data will then be matched up to an applicable fan curve to determine location, size, and number of fans required.

While the suction hole is under vacuum, changes in pressure will be monitored at the test hole using a very sensitive micro-monometer capable of reading pressure changes down to 0.001 inch of water column. Pressure changes will be recorded on the field data sheet (**Attachment B**). Depending on the vacuum measured at each test hole (less than or greater than -0.001 inch of water column), additional test holes may be drilled either closer to the suction hole, or further away to accurately determine the radius of influence.

The suction hole and test hole locations will be measured from the perimeter walls of the building and sketched on a field data sheet (**Attachment B**).

The proposed communication testing for each building is presented in **Table 3-1**.

TABLE 3-1
Proposed Diagnostic Testing Details

Building No.	No. Suction Locations	No. Test Locations	Comments
3	5	18	Building has multiple rooms and offices and carpeted areas that will limit the PFE test locations. These two buildings also have subslab foundation walls that sub-divide the subslab area and block the PFE from extending beyond the dividing foundation walls. See **Figure 2-2** for proposed test locations.
3B	2	10	Building has limited interior walls, which will allow adequate PFE measurements to be made. See **Figure 2-4** for proposed test locations.
37	2	10	Building has multiple rooms and offices and carpeted areas that will limit the PFE test locations. These two buildings also have subslab foundation walls that sub-divide the subslab area and block the PFE from extending beyond the dividing foundation walls. See **Figure 2-6** for proposed test locations.
43	3	8	Building has limited interior walls, which will allow adequate PFE measurements to be made. See **Figure 2-8** for proposed test locations.
902	3	44	Large industrial building; building floors consist of finished exposed concrete slab (allows thorough testing of the subslab PFE). See **Figure 2-11** for proposed test locations.
1115	2	5	Building floors consist of unfinished exposed concrete slabs. The exposed slab allows thorough testing of the subslab PFE. See **Figure 2-17** for proposed test locations.

Exhaust Sampling

While air is being extracted from the suction hole, exhaust sampling will be conducted on the shop vacuum. The off-gas samples will be submitted for analysis of VOCs by USEPA Method TO-15. The exhaust sample results will measure concentrations of VOCs being discharged to the atmosphere and the potential need for in-line treatment of vapors. The results of the exhaust sampling will be compared to the appropriate North Carolina and USEPA air regulations. Should the results of the VIMS exhaust sampling indicate that the VIMS exhaust exceeds one or more air regulation limits, VIMS exhaust treatment units will be included in the VIMS design. The initial subslab VOC concentrations are likely to be significantly greater than the operating VIMS exhaust VOC concentrations; this will be taken into taken into consideration regarding the need for exhaust treatment.

An exhaust sample will be collected for each building during the diagnostic test. Samples will be collected by attaching a 10-foot piece of Teflon tubing to each Summa™ canister and placing the tubing into the exhaust tubing of the shop vacuum during the diagnostic test. The samples will be collected in 1-liter (L) Summa™ canisters equipped with flow controllers to regulate the sample collection to 200 milliliters per minute (mL/min). The Summa™ canisters will be filled until the pressure gauge reads between -2 and -4 inches of mercury (Hg). Sampling field data sheets will be filled out during the sample collection (**Attachment C**).

Samples will be given identification numbers (IDs) using the site/building/sample type as indicated in the format shown below:

Site name –Building number- exhaust vent sample number- year/quarter

For example, a sample collected from Building 3 on December 10, 2010 would receive the following ID:

IR88-BLDG3-EV01-10D

The exhaust samples will be shipped overnight under standard chain-of-custody procedures to the laboratory for VOC analysis by Method TO-15. No quality control/quality assurance samples will be collected and no data validation/loading of data will be required.

Site Restoration

At the completion of the subslab PFE potential test, the drilled holes will be sealed with Portland cement. The work area will be restored to pre-drilling conditions. Field staff will replace any equipment or interior furnishings that were disturbed to access the test locations.

3.1.2 HVAC Testing

Negative pressure inside a building in comparison to the underlying soil is a primary driving force for VI into a building. Commercial buildings have a number of sources of interior negative pressure. For example, wind creates a complex pressure field around a building that can transfer negative pressure to the interior through intended openings (passive relief dampers) and un-intended openings. Temperature-driven airflow out of a building, often referred to as "stack effect," results in negative pressure at the slab level, pulling pollutants into the building from the subsurface through slab cracks or penetrations.

Stack effect is enhanced by the height of the building and greater interior to exterior temperature differences. Commercial buildings have varying numbers and sizes of exhaust fans, outdoor make-up air and passive relief dampers. Buildings that are designed to be under a positive pressure often have rooms on the lower level that are under a negative pressure in comparison to the subslab pressure. Mechanically induced transport also changes every time a building or the HVAC system is modified, cycles or is adjusted.

The International Mechanical Code (IMC) and American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standards have defined the amount of necessary ventilation for various building uses. In general, office building outdoor ventilation (i.e., makeup air added from outside the structure) is defined by cubic feet per minute (CFM) per person. In 1989, ASHRAE (Standard 62-89) recommends a minimum of 20 CFM per person for an office building during occupied hours.

Building 1005 has five separate air handlers to provide HVAC for the entire building (**Figure 2-15**). Outdoor air is supplied to each of the HVAC units. All of the HVAC outdoor air supplies have dampers that can be adjusted. The site visit, conducted in October 2010, indicated that one HVAC unit has an access panel adjacent to the outdoor air damper; the remaining HVAC units will require installation of access panels adjacent to the outdoor damper locations in the existing ductwork of these units. The outdoor damper that was visible was rusted and one of the damper wings was open, while the other was closed at the time of the site visit. All dampers for HVAC units servicing Building 1005 will be tested to determine whether the dampers are operating correctly; each of the control heads for each HVAC unit has a gauge that specifies the damper position.

The occupancy rate and the outdoor air presently being supplied to each of the five HVAC zones within Building 1005 will be measured by a qualified HVAC technician. It is recommended that the minimum amount of outdoor air being supplied to each of these zones matches the recommended current ASHRAE ventilation rate. If the existing system can achieve 20 CFM per building occupant, it will be assumed that the HVAC system can create a positive pressure compared to subslab pressure.

The following activities will be performed to determine if the existing HVAC system can provide positive pressurization to the occupied space relative to the subslab and the outdoors under the required operating conditions:

- Review and evaluate latest Test and Balance Report
- Review and evaluate odor complaints from Building 1005 occupants
- Measure the operating parameters of the air handling system (amount of total supply air, total return air, total exhaust air, and outside air) under varying conditions. The available controls and set points may be adjusted to determine the system air flow rates under a variety of expected operating conditions for the HVAC system. The Base civil engineer, the HVAC operation and maintenance (O&M) contractor, or a subcontractor will perform these tests under the supervision of CH2M HILL.
- Measure the airflow of all exhaust fans in the building and compare their performance to the original design airflow to determine if these fans need to be adjusted.

- Measure the relative pressure between the subslab and the occupied space using a micromanometer with the HVAC system under a variety of expected HVAC system operating conditions. Each existing subslab soil gas probe will be utilized to collect instantaneous pressure readings. Supporting data will be documented including, but not be limited to, wind speed, HVAC operation, and interior and exterior temperature.
- Measure the relative pressure between the outside atmosphere and the occupied space under a variety of expected operating conditions for the HVAC system.
- Test supply, return, exhaust, and outside air ductwork to estimate the amount of air leakage under the expected HVAC system operating conditions. Leakage will be measured for the expected Seal Class of the ductwork using the appropriate procedures detailed in the latest edition of the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) HVAC Duct Leakage Test Manual. This will be performed only if the existing system is not able to deliver sufficient outdoor air to the building.
- Adjust the settings of supply, return, exhaust, and outside air dampers as necessary to produce positive pressure in the occupied space, if the existing equipment had adequate capacity. The original settings of dampers will be marked to allow for the return of the system to its existing conditions once testing has concluded. Care will be taken to ensure that the HVAC system is able to adequately condition the supply air before providing it to the space.

After the system has been adjusted, the following activities will be conducted:

- Measure the relative pressure over a 2-week period between the subslab and the occupied space using a micromanometer with data logging capabilities. One probe will be installed near each of the four air handler zones to adequately capture the pressure data. Pressure will be recorded at each of the four probe locations simultaneously.

To determine the long-term capability of the system to provide positive pressure, nameplate data will be collected from the components of the HVAC system and compared to heating and cooling capabilities of existing equipment. This information will be used to evaluate the capabilities of the unit required to condition the amounts of outside air necessary for positive pressurization.

If required, CH2M HILL will make recommendations for changes to existing equipment or additional equipment necessary to positively pressurize the space relative to the subslab and the outside air under the required operating conditions.

SECTION 4

Diagnostic Testing Reporting

The data collected during the diagnostic testing will be documented in the VIMS pilot test design plan. The design plan will include the results of the utility locations, field notes, results of the diagnostic testing, and results of the exhaust sampling.

4.1 Diagnostic Data Interpretation

4.1.1 Buildings 3, 3B, 37, 43, 902, & 1115

The subslab communication diagnostic testing data, in combination with the structural details, will be used in the design of the structure-specific VIMS to be tested. The air flow rate, applied vacuum, and radius of vacuum distribution from the diagnostic suction points will be used to determine the following:

- The number of suction points required and their location within the structure. The number of suction points can be increased or decreased depending on the vacuum that can be applied at a given location using a given mitigation fan or blower. The number of suction points is also strongly influenced by the physical features of the structure that impact the vacuum radius of influence (e.g., a load-bearing footing for an interior wall may block air flow in the subsurface at that location, resulting in the need for suction points on either side).
- The size of the mitigation fan or blower. This equipment is sized to maintain the desired negative pressure, flow rate, and vacuum distribution beneath the structure.
- The size and location of the extraction piping. This is sized relative to the number and location of suction points, the number of mitigation fan(s) or blower(s), and the layout of the building.

The suction points, mitigation fans or blowers, and extraction piping will be selected using a tradeoff process whereby the goal is to achieve a VIMS that can meet the designed pressure differential across the slab while minimizing the physical impacts to the structure and occupants, minimizing the cost to construct, and minimizing long-term O&M, including utilities.

4.1.2 Building 1005

The HVAC assessment and pressure measurements, in combination with the structural details, will be used to achieve a minimum of 20 CFM per person (ASHRAE Standard 62-89) by performing necessary alterations to Building 1005's HVAC system. If after HVAC adjustments are made, indoor to subslab pressure remains negative and the minimum fresh air delivery of 20 CFM per person is not achieved, then the following will be evaluated for efficiency, effectiveness, and cost:

- Addition of makeup air to adjust the building pressure. This may add significant costs for increased cooling loads.
- Addition of a blower door where data can be collected for use in evaluating the adjustments needed to create positive pressure in the building. This may require the reconfiguration of the current HVAC system to meet the stated minimum fresh air delivery of 20 CFM per person, which could add significant costs.
- Installation of an SSD VIMS to create a negative pressure in the subslab compared to the interior of the building. This may add significant costs for the required diagnostic testing, based on the large square footage of the building and number of fans required.

4.2 Exhaust Sampling Interpretation

The results of the VIMS will be screened against the appropriate North Carolina and USEPA air regulations. Should the results of the VIMS exhaust sampling indicate that the VIMS exhaust exceeds one or more air regulation limits, VIMS exhaust treatment (using carbon units) may be required. Additionally, the results of the exhaust sampling will support cost-benefit analyses and implementation decisions for design and future installation of VIMS.

SECTION 5

References

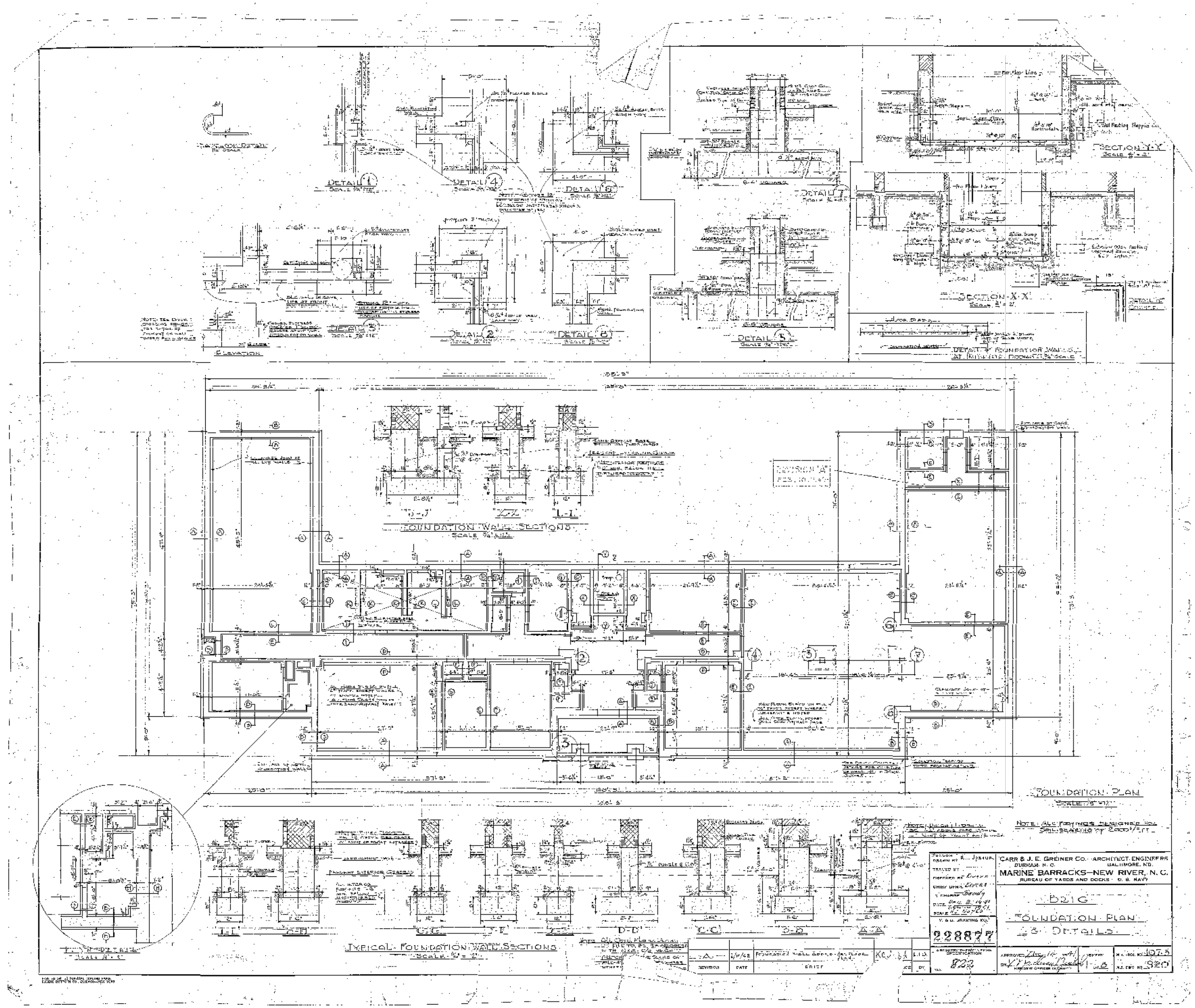
AGVIQ-CH2M HILL, 2009. *Final Vapor Intrusion Evaluation Report Volumes 1 through 6, Marine Corps Base Camp Lejeune, Jacksonville, North Carolina.* November.

CH2M HILL. 2008a. *Final Amended Remedial Investigation, Site 88, Marine Corps Base Camp Lejeune, Jacksonville, North Carolina.* March.

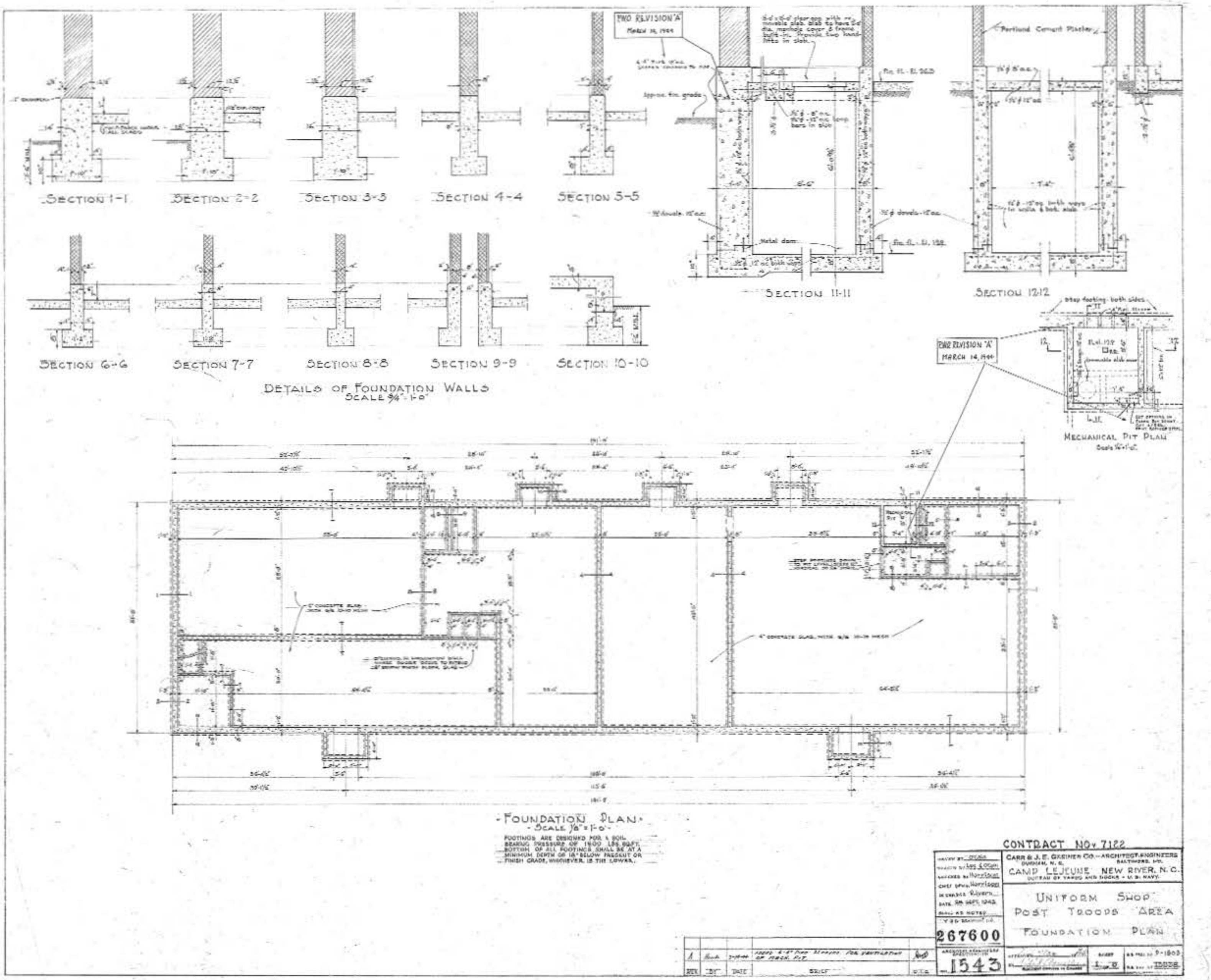
CH2M HILL. 2008b. *Final Vapor Intrusion Evaluation Work Plan*, Marine Corps Base Camp Lejeune, Jacksonville, North Carolina. June.

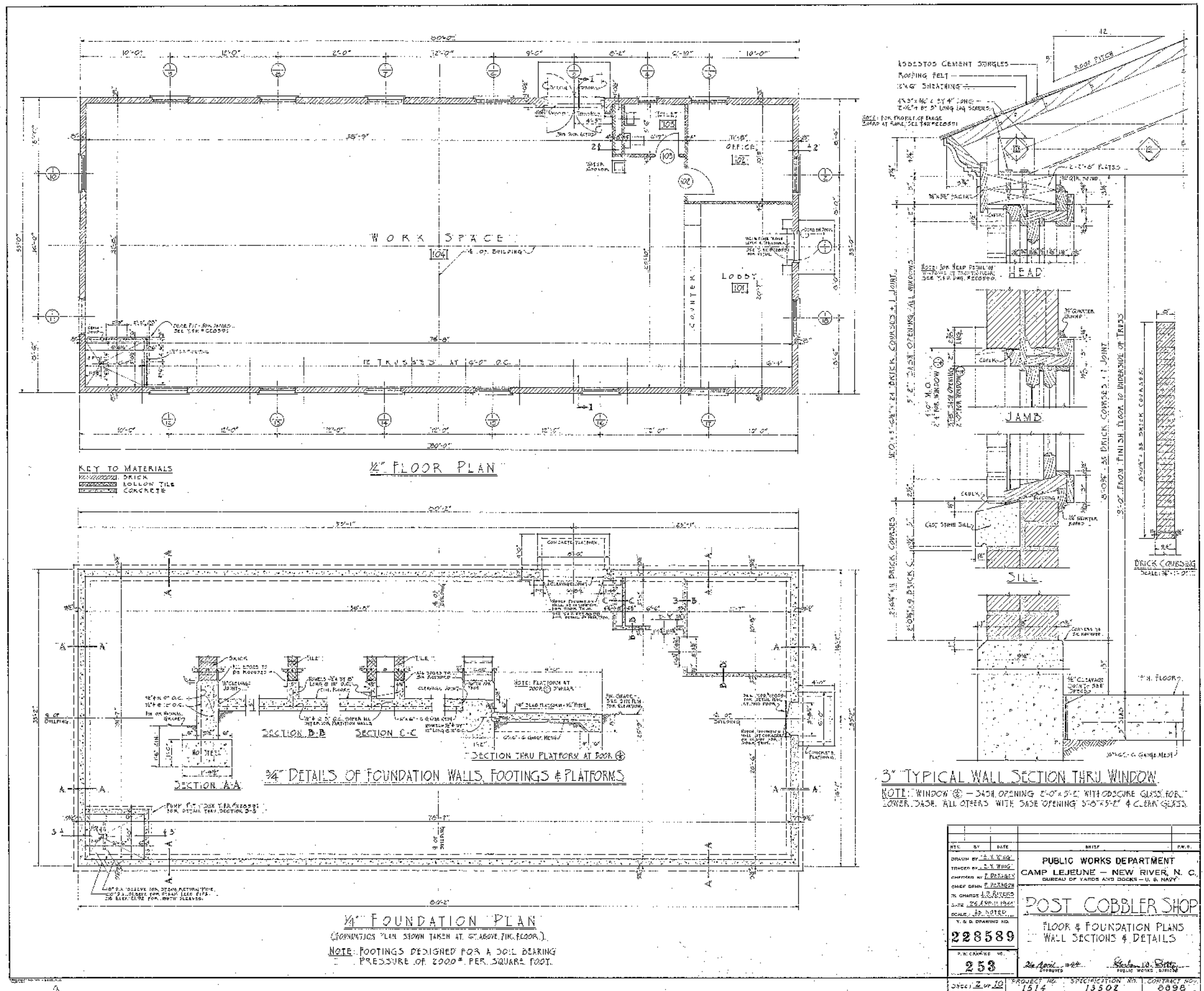
CH2M HILL. 2010. *Draft Vapor Intrusion Evaluation Report Volumes 1 through 5, Marine Corps Base Camp Lejeune, Jacksonville, North Carolina*. November.

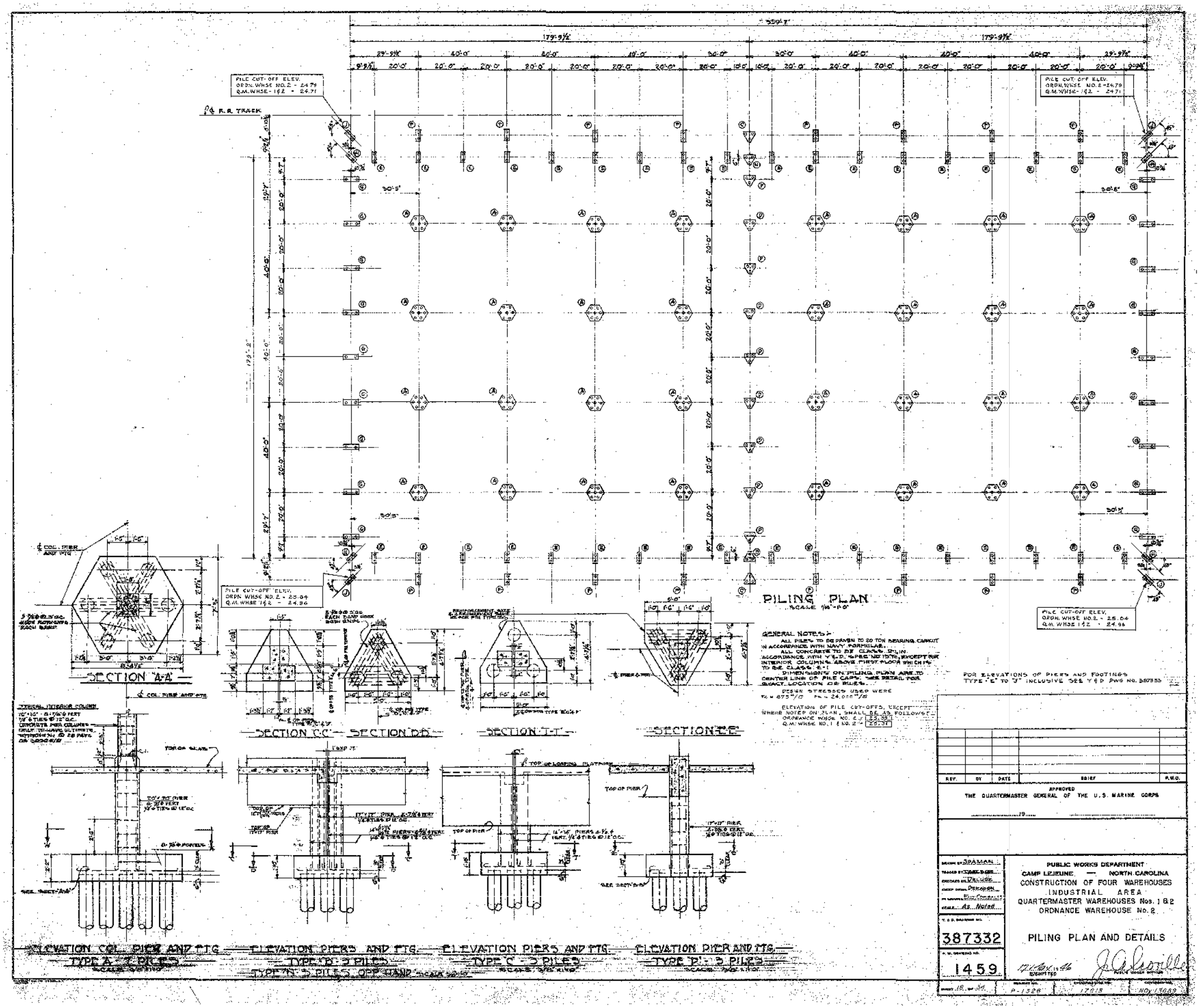
Attachment A
Buildings 3, 37, 43, and 902 Foundation Plans



DETAIL 4
DETAIL 6
DETAIL 7
SECTION Y-Y
DETAIL 2
DETAIL 8
DETAIL 5
SECTION X-X
ELEVATION
FOUNDATION WALL SECTIONS
FOUNDATION PLAN
NOTE: ALL FOOTINGS DESIGNED FOR SOIL BEARING OF 2000#/FT.
TYPICAL FOUNDATION WALL SECTIONS
CARR & J. E. GREINER CO. ARCHITECT-ENGINEERS
DURHAM, N. C.
BALTIMORE, MD.
MARINE BARRACKS—NEW RIVER, N. C.
BUREAU OF YARDS AND DOCKS · U. S. NAVY
BRIG
FOUNDATION PLAN
& DETAILS
Y. & D. DRAWING NO.
228877
SPECIFICATION
823
APPROVED
1075
920


Section 1-1
Section 2-2
Section 3-3
Section 4-4
Section 5-5
Section 6-6
Section 7-7
Section 8-8
Section 9-9
Section 10-10
Details of Foundation Walls
Scale 3/4" - 1'-0"
Section 11-11
Section 12-12
Portland Cement Plaster
Metal dam
Mechanical Pit Plan
Revision "A"
March 14, 1944
Foundation Plan
Scale 1/8" = 1'-0"
Footings are designed for a soil bearing pressure of 1500 lbs. sq. ft. Bottom of all footings shall be at a minimum depth of 18" below present or finish grade, whichever is the lower.
Contract No. 7122
Carr & J. E. Greiner Co. — Architect-Engineers
Durham, N. C.
Baltimore, Md.
Camp Lejeune New River, N. C.
Bureau of Yards and Docks - U. S. Navy
Uniform Shop
Post Troops Area
Foundation Plan
Date 28 Sept. 1942
Scale as noted
267600
1543
A
Added 6"-6" pipe sleeves for ventilation of mech. pit
Rev.
By
Date
Brief


1/4" FLOOR PLAN
WORK SPACE
104
OFFICE
102
LOBBY
101
TOILET
103
COUNTER
KEY TO MATERIALS
BRICK
HOLLOW TILE
CONCRETE
1/4" FOUNDATION PLAN
(FOUNDATION PLAN SHOWN TAKEN AT 6" ABOVE FIN. FLOOR.)
NOTE: FOOTINGS DESIGNED FOR A SOIL BEARING PRESSURE OF 2000# PER SQUARE FOOT.
3/4" DETAILS OF FOUNDATION WALLS, FOOTINGS & PLATFORMS
SECTION A-A
SECTION B-B
SECTION C-C
SECTION THRU PLATFORM AT DOOR
3" TYPICAL WALL SECTION THRU WINDOW
HEAD
JAMB
SILL
BRICK COURSING
NOTE: WINDOW – SASH OPENING 2'-0"x5'-2" WITH OBSCURE GLASS FOR LOWER SASH. ALL OTHERS WITH SASH OPENING 3'-0"x5'-2" & CLEAR GLASS.
PUBLIC WORKS DEPARTMENT
CAMP LEJEUNE – NEW RIVER, N. C.
BUREAU OF YARDS AND DOCKS – U. S. NAVY
POST COBBLER SHOP
FLOOR & FOUNDATION PLANS
WALL SECTIONS & DETAILS
Y. & D. DRAWING NO. 228589
P.W. DRAWING NO. 253
DATE 26 APRIL 1944
SCALE AS NOTED
SHEET 2 OF 10
PROJECT NO. 1514
SPECIFICATION NO. 13502
CONTRACT NO. 8898
PUBLIC WORKS OFFICER


PILING PLAN
SCALE 1/16"=1'-0"
PILE CUT-OFF ELEV.
ORDN. WHSE NO. 2 - 24.79
Q.M. WHSE - 1 & 2 - 24.71
PILE CUT-OFF ELEV.
ORDN. WHSE NO. 2 - 25.04
Q.M. WHSE 1 & 2 - 24.96
GENERAL NOTES:-
ALL PILES TO BE DRIVEN TO 20 TON BEARING CAPACITY IN ACCORDANCE WITH NAVY FORMULAE.
ALL CONCRETE TO BE CLASS "B" IN ACCORDANCE WITH Y&D. SPEC. NO 15Yc, EXCEPT FOR INTERIOR COLUMNS ABOVE FIRST FLOOR WHICH IS TO BE CLASS E-1
DIMENSIONS ON PILING PLAN ARE TO CENTER LINE OF PILE CAPS. SEE DETAIL FOR EXACT LOCATION OF PILES.
DESIGN STRESSES USED WERE
ELEVATION OF PILE CUT-OFFS, EXCEPT WHERE NOTED ON PLAN, SHALL BE AS FOLLOWS:
ORDNANCE WHSE. NO. 2 = 25.39
Q.M. WHSE NO. 1 & NO. 2 = 25.31
FOR ELEVATIONS OF PIERS AND FOOTINGS TYPE "E" TO "J" INCLUSIVE SEE Y & D DWG NO. 387333
SECTION "A-A"
SECTION C-C
SECTION D-D
SECTION "I-I"
SECTION "E-E"
ELEVATION COL. PIER AND FTG. TYPE "A" 7 PILES
ELEVATION PIERS AND FTG. TYPE "B" 3 PILES
TYPE "H" 3 PILES OPP. HAND
ELEVATION PIERS AND FTG. TYPE "C" 3 PILES
ELEVATION PIER AND FTG. TYPE "D" 3 PILES
REV. | BY | DATE | BRIEF | A.W.O.
APPROVED
THE QUARTERMASTER GENERAL OF THE U.S. MARINE CORPS
19
DRAWN BY SPAMAN
CHECKED BY DeLuca
SCALE As Noted
Y. & D. DRAWING NO.
387332
1459
PUBLIC WORKS DEPARTMENT
CAMP LEJEUNE — NORTH CAROLINA
CONSTRUCTION OF FOUR WAREHOUSES
INDUSTRIAL AREA
QUARTERMASTER WAREHOUSES Nos. 1 & 2
ORDNANCE WAREHOUSE No. 2
PILING PLAN AND DETAILS
SUBMITTED
PUBLIC WORKS OFFICER
SHEET 18 OF 34
P-1326
17215
NOy 13669

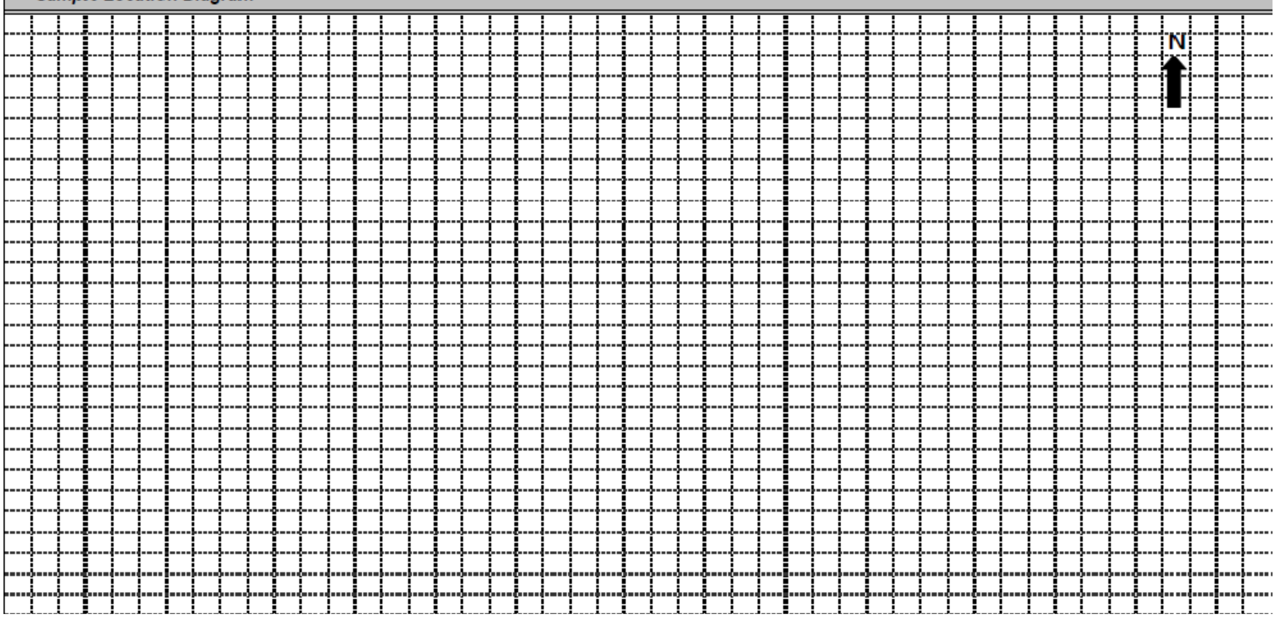
Attachment B
Diagnostic Test Data Forms

Diagnostic Test Field Log
Project Information
Project Name **Project #:**
By **Date:**

Sample Data Log: Building #: Suction Hole ID:

Test Hole Location (radius from Suction Hole)	ID	Initial Pressure	Start Time	Test Pressure	End Time	Pressure difference	Location Influence	Comments			

Sample Location Diagram



Other Observations and comments (note any unique circumstances):

Attachment C
Exhaust Vent Data Forms

CH2M HILL **Applied Sciences Laboratory**

Ambient Air, Outdoor Air & Crawl Space Air Sampling Log (Summa Canister)

Project Information

Project Name: ______________________ Project # : ______________

By: ______________ Date: ______________

Sampling Data Log

Sample Location	Field ID	Canister ID	Flow Controller ID	Initial Canister Pressure ("Hg)	Initial Flow Controller Rate (ml/min)	Start Date & Time	End Data & Time	Final Pressure ("Hg)	Final Flow Controller Rate (ml/min)

Sample Location Diagram

N

Note:
Draw in outline the structure's foundation and interior walls, identify rooms, and note other defining features. Show location of canister relative to physical objects, etc.

Other Observations and Comments (note any unique circumstances): ______________________