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EVALUATION OF POTENTIAL SOURCES OF PERFLUORINATED COMPOUNDS NAWC
WARMINSTER PA
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TETRA TECH

**Evaluation of Potential Sources
of
Perfluorinated Compounds**

**Former Naval Air Warfare Center
Warminster
Warminster, Pennsylvania**



**Naval Facilities Engineering Command
Mid-Atlantic**

**Contract Number N62470-08-D-1001
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**EVALUATION OF POTENTIAL SOURCES
OF
PERFLUORINATED COMPOUNDS**

**FORMER NAVAL WARFARE CENTER
WARMINSTER
WARMINSTER, PENNSYLVANIA**

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ACRONYMS

AFFF	Aqueous Film Forming Foam
bgs	Below Ground Surface
BRAC	Base Realignment and Closure
DCNR	Department of Conservation and Natural Resources
EPA	Environmental Protection Agency
ft	Feet
NADC	Naval Air Development Center
NAWC	Naval Air Warfare Center
OW	Office of Water
PA	Preliminary Assessment
PFCs	perfluorinated compound
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PHA	Provisional Health Advisory
Tetra Tech	Tetra Tech, Inc.
WMA	Warminster Municipal Authority

1.0 INTRODUCTION

This preliminary assessment (PA) report of potential sources has been prepared by Tetra Tech, Inc. (Tetra Tech) for the Department of the Navy under Contract N62470-08-D-1001, CTO WE23. The purpose of this report is to provide a summary of the locations where activities related to perfluorinated compound (PFC) use may have been conducted at or near Former Naval Air Warfare Center (NAWC) Warminster located in Warminster, Pennsylvania (Figures 1 and 2).

On June 4 and 26, 2013, groundwater samples were collected from Warminster Municipal Authority (WMA) well number 13 (WMA-13) and analyzed for perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), both of which are PFCs. Both samples had trace-level detections for each constituent. The maximum detection of PFOA (0.1 µg/l) was less than the Environmental Protection Agency's (EPA) Provisional Health Advisory (PHA) concentration of 0.4 µg/l. PFOS was detected at a concentration equal to the EPA PHA of 0.2 µg/l on June 4. PFOS was detected at a concentration of 0.18 µg/l on June 26. Since then, PFOA and PFOS have also been detected in municipal wells WMA-10 and WMA-26. As a result of those detections, this PA is being generated to determine potential sources of PFCs that could result in on- or off-site releases.

In completing this report, a review of available Navy site files and other published documents was conducted to identify where PFCs could have been used at the former NAWC Warminster and nearby. Information about PFCs was found on various online sources. In an effort to identify potential receptors in the area, an internet search was conducted of relevant websites including but not limited to the Pennsylvania Department of Conservation and Natural Resources (DCNR), Pennsylvania Department of Environmental Protection, WMA, Delaware River Basin Commission, Warminster Township, Ivyland Township, Northampton Township, and Bucks County (Appendix A).

2.0 SITE BACKGROUND

2.1 SITE LOCATION

The former NAWC Warminster was an 824-acre facility in Warminster Township and Ivyland Borough, Bucks County, Pennsylvania, located in a populated suburban area surrounded by private homes, various commercial and industrial activities, and a golf course. A number of commercial businesses currently operate on and near the former base. The north-central portion of the former base has been developed as a residential area and retirement community, the eastern portion developed as a park, and the western portion of the former base is an industrial park.

2.2 SITE USE HISTORY

The facility was originally the location of Brewster Aeronautical Corporation, a manufacturer of military aircraft. The Navy took over the site in 1944 as the Naval Air Modification Unit, which had the assigned mission to convert and modify newly produced aircraft prior to the delivery to the Naval fleet (EA, 1995). In 1949 the facility was designated as a Naval Air Development Center (NADC) and its main mission became research, development, testing and evaluation of Navy aircraft systems, components, coatings, electronics, and control devices (Tetra Tech, 2011). In 1992 the base was re-designated as NAWC Warminster, and in 1996 it was closed under the Base Realignment and Closure (BRAC) Program, which was implemented in 1997. Historically, wastes were generated during aircraft maintenance and repair, pest control, firefighting training, machine and plating shop operations, spray painting and other activities. These wastes included paint, solvent, waste oils and sludge that were disposed of in several pits, trenches and landfills. None of these sites are currently used for waste disposal. Previous environmental investigations have sub-divided the base into four areas (Areas A, B, C, and D) with eight sites (Sites 1 through 8).

2.3 ENVIRONMENTAL SETTING

The underlying geology at this location is the middle arkose member of the Stockton Formation. The middle member of the Stockton Formation consists of beds of fine to medium grained arkosic sandstone with interbedded layers of shale, siltstone, and fine-grained sandstone. The beds of the Stockton Formation in the area generally strike to the east-northeast and dip seven to nine degrees to the northwest, and the local strike and dip of the bedrock in the vicinity of Area C was measured at north 70° east and 9° to the northwest (Halliburton NUS, 1994). Most groundwater movement through the bedrock occurs through interconnected networks of fractures, with the sandstone units typically having higher water transmitting capacities and the finer grained mudstone units acting as aquitards limiting the vertical movement of groundwater across bedding. Groundwater recharge is primarily through infiltration of

precipitation, and an average local recharge rate of 11 inches per year (0.5 million gallons per day per square mile) has been estimated by the USGS (Sloto and Davis, 1983).

Wells WMA-10, WMA-13, and WMA-26 are municipal water supply wells for Warminster Township that are located in the general vicinity of the former NAWC. Information regarding the well construction and usage is provided below.

Well WMA-10 is located approximately 1 mile north of the western portion of the former NAWC. The well has a total depth of 528 feet and an open interval from 57 – 528 feet. Historic pumping information indicates that WMA-10 had been pumped at an average rate of approximately 400,000 gallons per day [278 gallons per minute (gpm)] over an extended (1974 – 1983) timeframe (Halliburton NUS, 1995), while recent pumping information for this well from WMA indicates that this well is currently pumped at a rate of approximately 350 gpm for 12 hours per day. Groundwater flow in the northwestern area of the former NAWC Warminster is generally to the north-northwest based on historic groundwater investigations at the former base (Figures 3, 4 and 5), in the general direction of WMA-10. A small stream that originates near the northern edge of Area A at the former NAWC and drains north to Little Neshaminy Creek is located near WMA-10. In addition, another small drainage that originates near Area C and drains north towards Little Neshaminy Creek passes by WMA-10.

Well WMA-13 is located north of Area C. The well was drilled to a total depth of 601 feet below ground surface (ft bgs), with an open interval from 50 – 600 ft bgs (Halliburton NUS, 1995). Historic pumping information indicates that WMA-13 had been pumped at an average rate of approximately 88,000 gallons per day [61 gallons per minute (gpm)] over an extended (1974 – 1983) timeframe (Halliburton NUS, 1995) and a 2012 WMA groundwater withdrawal application to the DRBC lists the well with a pump capacity of 108 gpm. Recent pumping information from WMA indicates that the well is currently pumped at approximately 175 gpm for 7 hours per day. Groundwater flow on the north side of the former NAWC Warminster where well WMA-13 is located is generally to the north-northwest based on historic groundwater investigations at the former base (Figures 3, 4 and 5). Surface water flow is also to the northwest in the area of WMA-13 (Figure 6).

Well WMA-26 is located approximately 1/2 mile north of the western portion of the former NAWC. The well has a total depth of 250 feet and an open interval from 70 – 250 feet. Historic pumping information indicates that WMA-26 had been pumped at an average rate of approximately 270,000 gallons per day [187 gallons per minute (gpm)] over an extended (1974 – 1983) timeframe (Halliburton NUS, 1995), while recent pumping information for this well from WMA indicates that this well is currently pumped at a rate of approximately 200 gpm for 24 hours per day. Groundwater flow in the northwestern area of the former NAWC Warminster is generally to the north-northwest based on historic groundwater investigations at the

former base (Figures 3, 4 and 5), in the general direction of WMA-26. A small stream that originates near the northern edge of Area A at the former NAWC and drains north to Little Neshaminy Creek is located near WMA-26.

2.4 2014 BASELINE PFC SAMPLING AT THE FORMER NAWC

In 2014, the Navy performed a round of sampling of monitoring and extraction wells in Areas A, C, and D to develop a baseline data set of concentrations of PFOA and PFOS. The Areas A and D sampling event was performed in May 2014, and PFOA and PFOS were detected in 22 of 23 wells sampled (Table 1).

Concentrations of both PFOA and PFOS exceeded the PHA levels in all Area D wells except EW-D8, while only detections of PFOS exceeded the PHA in Area A. Highest PFOA and PFOS detections were from wells located within Area D. Both Areas A and D are located in the general upgradient direction from municipal water supply wells WMA-26 and WMA-10.

The Area C baseline sampling event was performed in January 2014. PFOA and PFOS were detected in all nine wells sampled (Table 2). In addition to the well samples, the influents to the treatment plant from Area A and Area C were sampled, and PFOA and PFOS were detected in both influent water streams. The Navy had also previously performed some limited groundwater sampling for PFCs within Area C in 2011-2012 (sampling results are summarized on Figure 7). Concentrations of both PFOA and PFOS exceeded the PHA levels in all Area C wells, with maximum detected concentrations of PFOA and PFOS found in well OB-11, which is located adjacent to and north of Site 8. The Area C wells are located in a general upgradient (southerly) direction from municipal water supply well WMA-13.

2.5 AREA GROUNDWATER USERS

Within 1 mile of Site 8 (which was the initial focus of the study) are 125 wells (Figure 8) that were identified using the Pennsylvania DCNR online groundwater records. Data for water wells in Ivyland Borough, Northampton Township, and Warminster Township were downloaded from the PA DCNR site and plotted using GIS software. Duplicated listings were located based on local well number, which is a unique well identifier. The wells within 1 mile of Site 8 were numbered in this report from west to east to help identify the wells and well owners. Many of the wells listed are environmental monitoring wells for the former NAWC and nearby facilities. These wells, summarized in Table 3, have listed uses of domestic withdrawal, commercial withdrawal, industrial withdrawal, irrigation, and public supply. It should be noted that the PA DCNR well database contains information from various sources, but most of the records are from well drillers, beginning in 1969. Records for many wells are not in the database, as many well completion reports were never submitted. In addition, the location accuracy is variable, depending on the information provided to PA DCNR.

EPA, in support of the Navy's ongoing work to address PFC-related environmental issues related to the former NAWC, initiated a private well sampling program in the area surrounding the former NAWC in the summer of 2014. PFCs have been detected in a number of private wells in the nearby area, with the highest concentrations generally found north of the former base.

2.6 PFC BACKGROUND INFORMATION

PFCs are man-made compounds with chemical properties similar to fluorocarbons. Due to the strength of multiple carbon-fluorine bonds, PFCs breakdown very slowly in industrial use and in the environment, and are an emerging class of persistent environmental contaminants.

PFCs are used to make a wide range of products including oil-, stain- heat-, and water-resistant materials such as clothing, carpeting, furniture, food packaging, floors, non-stick cooking ware, stain/water resistant paint, and roofing materials. PFCs exist or were formerly present in 3M's Scotchgard, GORE-TEX, Stainmaster and DuPont's Teflon products. PFC's are also found in solvents in products such as electronic etching baths and photographic film. They are also used or were used as surfactants in metal plating baths, shampoos, moisturizers, shaving cream, oil well surfactants, aqueous film forming foam (AFFF), and semiconductor baths. There are other uses for PFCs including being used in rust inhibitors, starting materials for polymers, herbicides/pesticides, acid mist suppressants, aviation hydraulic fluids, and adhesives.

It is not documented whether PFCs were specifically used at Warminster, but operations or activities commonly associated with PFCs did take place on site. The two PFCs being investigated at Warminster are PFOA and PFOS, in accordance with DOD Instruction 4715.18 regarding emerging contaminants (DOD, 2009). Both PFOA and PFOS began to be produced by 3M in the late 1940s and were present in products used at Warminster. Groundwater samples collected from on-site and off-site wells in 2012 and 2013 contained low concentrations of PFOA and PFOS. In 2009, the EPA Office of Water (OW) developed PHAs for PFOA and PFOS to protect against potential risk from exposure to these chemicals through drinking water. PHAs serve as informal technical guidance to assist Federal, State and local officials in response to an urgent or rapidly developing drinking water contamination. They reflect reasonable, health-based hazard concentrations above which action should be taken to reduce exposure to these contaminants in drinking water. The PHA values are 0.4 µg/L for PFOA and 0.2 µg/L for PFOS. Provisional Health Advisories are not to be construed as legally enforceable federal standards and are subject to change as new information becomes available. Due to environmental concerns, the manufacture and use of PFOA and PFOS have been largely phased out globally.

3.0 POTENTIAL SOURCES OF PFCS

Through a review of the various information sources identified in Section 1, the following is a summary of potential sources for PFCS in the former NAWC area, along with an initial evaluation of the likelihood of each potential source being associated with the PFCS found within Area C and at WMA-13.

3.1 NAVY-RELATED POTENTIAL PFC SOURCES

Due to PFCS being used in a wide range of products related to former NAWC Warminster activities (i.e., metal plating, fire-fighting, non-stick paints) while it was operational, it is likely that some PFCS were present while the site was operational. Based on a review of available documents, some sites at the former NAWC Warminster were identified as having hosted PFC-related activities. Table 4 presents a summary of significant sites at and near NAWC Warminster, including the site's activities and whether there is a reason for concern for each site regarding PFCS, and if the site could have contributed to PFC contamination of water supply wells WMA-10, WMA-13, and/or WMA-26.

The following is a summary of sites where PFCS were potentially used/present (Figure 9):

- Buildings 1 and 2 – This area of NAWC Warminster was composed mostly of industrial and office buildings with parking lots and paved roads. These two buildings in Area D housed several laboratories and shops that supported research and development activities including a plating laboratory that was located in Building 1 (EA, 1995). Originally these facilities, including the metal plating shop, were used by Brewster Aeronautical Corporation for aircraft manufacturing. The metal plating shop was in use from 1942 to 1994. Any PFCS associated with the metal plating shop would have been from the chromium and other various baths used in the plating process since PFCS have been used in these types of operations to suppress toxic fumes that would go into the atmosphere. There were no documented sources of releases of materials containing PFCS; however, potential releases could have occurred during removal and replacement of metal bath water. Other historic operations of note in these buildings include an elastomer compounding and testing lab, electrical labs, an operational chemical and polymer research lab, and a photo lab (Tetra Tech NUS, 1998a). Both buildings also had chemical and waste storage areas. Based on the location and groundwater flow direction, it is highly unlikely that PFCS found within Area C and WMA-13 could originate from this area; however, the PFC detections in Area A/D wells and in municipal water supply wells WMA-10 and WMA-26 could be related to potential historic releases from these buildings.

- Impoundment Area - This site is located in Area A south of Site 1, and was composed of eight lagoons which held industrial wastewater sludge. Each lagoon was 60 feet by 75 feet long with depths around 10 feet deep. These impoundments were unlined and in operation from 1940 to 1973. PFCs potentially could have come from the liquids generated from the metal treatment baths from metal plating activities, if used in these processes (Tetra Tech, 2011). Based on the location and groundwater flow direction, it is highly unlikely that PFCs found within Area C and WMA-13 could originate from this area; however, the PFC detections in Area A/D wells and in municipal water supply wells WMA-10 and WMA-26 could be related to potential historic releases from this site.
- Sites 1 and 2 - Located near the northwestern corner of Area A, Site 1 was initially reported to be a burn pit used within an eroded ravine from approximately 1948 to 1950 (Halliburton NUS, 1993). Wastes reportedly disposed at Site 1 included inorganics, solvents, acids, bases, and firing range wastes (Tetra Tech, 2011). Historic aerial photographs revealed a pit, trench and disturbed ground in a period from the late 1940s to the early 1970s. After use of Site 1 was discontinued, the area was reportedly covered with soil from an on-base source. Site 2 was located adjacent to Site 1 and was reportedly a trench used for disposal of wastewater sludge. Soils at these two sites were excavated during a Removal Action performed by the Navy in 1998 – 1999. Based on the location and groundwater flow direction, it is highly unlikely that PFCs found within Area C and WMA-13 could originate from this area; however, the PFC detections in Area A/D wells and in municipal water supply wells WMA-10 and WMA-26 could be related to potential historic releases from these sites.
- Site 3 - Site 3 was reportedly used as a burn pit for solvents, paints, roofing materials, and other unspecified chemicals (Halliburton NUS, 1993). No evidence of a pit or open burning was identified by an aerial photo analysis. However, disturbed ground and open storage were noted in the area from 1958 to 1973. Residue from the pit was occasionally removed and deposited at an unknown area at NAWC Warminster (Halliburton NUS, 1993). Upon closure, Site 3 was reportedly backfilled with on-base soil and regraded. Based on the location and groundwater flow direction, it is highly unlikely that PFCs found within Area C and WMA-13 could originate from this area; however, the PFC detections in Area A/D wells and in municipal water supply wells WMA-10 and WMA-26 could be related to potential historic releases from this site.
- Site 4 - Located in the north-central part of the NAWC facility, north of the runway, and south of Kirk Road this site was used as a landfill that was composed of several trenches. Site 4 is the largest known waste disposal location at NAWC Warminster, and it is less than 100 feet from the facility boundary. The materials disposed in these trenches were non-industrial solid waste, paints, waste oils, waste metals, construction debris, solvents, and sewage sludge. This site was in use from 1966 to 1973, and the landfill was excavated and all wastes removed in 1996 (Tetra Tech, 2011). The

source of possible PFCs from this site would have been discarded AFFF or paints that possibly contained surface/stain protectors. While not specifically cited in historic files, it is possible that discarded AFFF could also have been disposed at Site 4 and subsequently excavated in 1996. Some drainage near Site 4 intersects an unnamed tributary of Little Neshaminy Creek, off site to the north of Kirk and Newtown Roads, near Munro Park (Tetra Tech NUS, 2000). This area is located generally upgradient of WMA-13 and could be a source of the PFCs detected in this well if they were released during historic activities at this site. Past groundwater monitoring at the site showed minimal, if any, impacts to groundwater; however, PFCs were not analyzed for. Based on location, it is considered unlikely that this site could be responsible for the PFCs found in municipal water supply wells WMA-10 and WMA-26; however, it is possible that an intermittent drainage that originates near Area C and flows north towards WMA-10 could be a secondary migration pathway for PFCs from Area C to potentially have some impact on WMA-10.

- Site 5 - This location is in Area B which is in the SE section of the NAWC facility. The area is composed of 8 trenches that were used for disposal of demo wastes, paint, solvents, scrap metal, aircraft paints, cans, and asphalt. These trenches were used from 1955 to 1970. Sources of PFCs at Site 5 would have come from the paints and aircraft paints as PFCs could be in certain paints such as paints with “surface protectors” containing Teflon (Tetra Tech, 2011). Based on the groundwater flow direction to the south, it is unlikely that PFCs found in wells within Areas A, C, and D and in municipal water supply wells WMA-10, WMA-13, and WMA-26 could originate from this area.
- Sites 6 and 7 - Located immediately north of Site 5, this area consisted of a number of pits that were dug by backhoe and then filled with waste paints, solvents, oil, flammable wastes, grease trap waste, and demo debris (Tetra Tech NUS, 1998b). The pits were later covered by two feet of soil (Tetra Tech NUS, 1999a). Site 6 was in use from 1960 to 1980 (Tetra Tech, 2011). Sources of PFCs at Site 6 would have come from the paints and aircraft paints as PFCs could be in certain paints such as paints with “surface protectors” using Teflon. Based on the groundwater flow direction to the south, it is unlikely that PFCs found in wells within Areas A, C, and D and in municipal water supply wells WMA-10, WMA-13, and WMA-26 could originate from this area.
- Site 8 - Site 8 was the location of a fire-fighting training area in Area C located directly north of the main airstrip (Halliburton NUS, 1994). This training area was composed of a section of runway approximately 75 feet by 75 feet, which was surrounded on three sides by a double berm. The site was used from 1961 to 1988 for fire-fighting training exercises which included a variety of flammable materials that were ignited on the run-way and then extinguished. Residents that lived along a tributary north of the training area complained about white foam floating in the tributary after the fire-fighting training exercises (Tetra Tech NUS, 1999b). This white foam may have been AFFF, as AFFF

is commonly used to suppress jet fuel fires. AFFF often contains PFCs, and may account for PFCs leaving the site. Given the surface drainage pathways, the run-off would migrate in the general direction of well WMA-13 (Figures 1-6 and 2-1) and site groundwater could be within the capture zone of WMA-13 under some potential operating (pumping) conditions, and there is a possibility that some groundwater from this site could also reach water supply wells WMA-10 and/or WMA-26. The limited groundwater sampling for PFCs that was performed by the Navy in 2011-2014 detected PFCs in wells in the vicinity of Site 8. However, there were also some detections of PFCs in wells located upgradient or cross gradient of Site 8 (Figure 1-8). There is a plume of tetrachloroethylene (PCE) associated with an unidentified source east of Site 8 (Tetra Tech 2007). Groundwater extraction and treatment was the selected remedy for Area C to address the PCE contamination. Extraction wells EW-C16 and EW-C17 were previously shut down after performance monitoring data showed that operation of these wells was not necessary to capture the PCE plume, but the wells are located downgradient of Site 8. Pumping operations in these two wells resumed in January 2014 to potentially intercept the PFCs detected near Site 8.

- Structure S-1 - In a section of runway located south of the fire-fighting training area there was an area used to test fire resistance of aviation suits. This testing was performed in a metal building and the aviation suits were passed through flames to test the suits' durability. Since PFCs can be found in some fire retardant/resistant clothing there could have been a potential for release as the suits were being extinguished after testing. It is not known what happened to the suits after they were tested. (Tetra Tech, 2011). Similar to Site 8, this area is located generally upgradient of WMA-13 and could be a source of PFCs if they were released during historic activities at this site, and there is a possibility that some groundwater from this site could also reach water supply wells WMA-10 and/or WMA-26.
- A-4C Crash – On July 23, 1974, a Navy A-4C crashed at the eastern end of the runway across Bristol Road and through the NAWC facility fence. The fuel was reportedly consumed in a fireball (EA, 1995). No other information was available on post-crash response; however, it is possible that AFFF could have been used to address the resulting fire. Based on the location, groundwater flow direction, and capture zone projections, it is unlikely that PFCs found within Areas A, C, or D and water supply wells WMA-10, WMA-13 and WMA-26 could originate from this area.
- Building 134 – Building 134 was the fire station that served the former NAWC. A “water surfactant,” possibly AFFF, was present in the building (EA 1995). Building 134 is currently the Bucks County Emergency Response Facility. PFCs are associated with AFFF products used by fire stations. It is possible that spills may have led to a release of PFC-containing AFFF. The facility is positioned

between Areas A, C, and D and could be a source of PFCs to all three areas and to water supply wells WMA-10, WMA-13 and WMA-26 if they were released during activities at this site.

- Building 90 – Building 90 was the former Crash House/Lab, located south of Building 134 near Jacksonville Road. It was reportedly used for emergency response prior to the construction of Building 134. The building housed a storage room/laboratory, boiler room, and offices, and storage of paints, lubricants, and degreasers was reported (EA, 1995). As an emergency response facility, it is expected that some fire control equipment was housed there for a period of time. The building is positioned between Areas A, C, and D and could be a source of PFCs to all three areas and to water supply wells WMA-10, WMA-13 and WMA-26 if they were used/released during activities at this site.
- Wastewater/Groundwater Treatment Plant Discharge – A wastewater treatment plant for the former NAWC was located within Area A. The plant is no longer active; however, the treatment plant for the Navy's groundwater extraction and treatment activities is located in the same area and has been in operation since the late 1990s. The discharge line from these treatment facilities runs northward before eventually discharging to a tributary of Little Neshaminy Creek. Leaks from the discharge line could potentially have resulted in releases of PFCs (if present) to shallow groundwater near the line, and could potentially have impacted water supply wells WMA-10 and/or WMA-26.

3.2 NON-NAVY RELATED POTENTIAL PFC SOURCES

Due to the variety of products that PFCs are associated with, there are several potential sources of PFCs in the area near the former NAWC Warminster. The following list summarizes the known potential nearby sources identified through this data review, although other sources may exist:

- PPC Lubricants – This facility, located at 1020 Louis Drive approximately 0.3 mile north of Area A, is currently active in the manufacture of lubricants, oils and greases. PFCs could be associated with the products they manufacture. Based on its location, any releases of PFCs could have impacted water supply wells WMA-10 and/or WMA-26; however, this location is not upgradient of the identified PFC contamination associated with Area C/WMA-13.
- Crown Marking Equip Co. – This facility engraves, marks and plates various metals such as chrome, and also manufactures marking and engraving devices. PFCs are associated with etching and plating baths. Located at 301 Ivyland Road approximately 0.4 mile north of Area A, any releases of PFCs could have impacted water supply wells WMA-10 and/or WMA-26; however, this location is not upgradient of the identified PFC contamination associated with Area C/WMA-13.

- Double H Plastics, Inc./Former Hurst Shifter Plant – The Double H Plastics facility, located at 50 West Street Road near the southern edge of Area D, manufactures plastic containers, lids, and plastic cores for paper, foil and film. They also manufacture containers for major commercial companies such as Breyer's ice cream. PFCs are associated with plastic polymers and the coatings of food containers. This is the same location as the former Hurst Shifter Plant, which reportedly performed chrome plating operations onsite. PFCs can be associated with metal plating operations (including chrome plating) as PFCs have been used in these types of operations to suppress toxic fumes that would go into the atmosphere. Any releases of PFCs from this location could have impacted water supply wells WMA-10 and/or WMA-26; however, this location is not upgradient of the identified PFC contamination associated with Area C/WMA-13.
- General Rivet Company – General Rivet, formerly located northwest of former NAWC Warminster, manufactured and electroplated metal rivets. General Rivet was fined for illegal dumping of waste, and after the business closed, over 400 drums of hazardous materials were found on site along with piles of coal ash on the property. The site is believed to have been effectively cleaned (EA, 1995). Formerly located on Ivyland Road approximately 0.5 mile north of Area A, any releases of PFCs could have impacted water supply wells WMA-10 and/or WMA-26; however, this location is not upgradient of the identified PFC contamination associated with Area C/WMA-13.
- Greif Packaging LLC – This facility manufactures rigid industrial containers (drums), flexible intermediate bulk containers, plastic bags, geotextiles, and paper packaging. PFCs could be associated with the raw materials used to make their products, and from the coatings of the plastic products to make them resistant to oil and water. Located at 695 Louis Drive approximately 0.2 mile west of Area D, any releases of PFCs could have impacted water supply wells WMA-10 and/or WMA-26; however, this location is not upgradient of the identified PFC contamination associated with Area C/WMA-13.
- Castrol Industrial – Castrol, located at 775 Louis Drive west of the former base, manufactures lubricants at this facility. Of particular note, a high-performance lubricant (Braycote 601 EF) is manufactured at the facility and is derived from a perfluorinated polyether chemical. Located approximately 0.2 mile northwest of Area D, any releases of PFCs could have impacted water supply wells WMA-10 and/or WMA-26; however, this location is not upgradient of the identified PFC contamination associated with Area C/WMA-13.
- CRC Industries - This facility, located at 885 Louis Drive approximately 0.1 mile northwest of Area A, is currently active in the manufacture/handling of a wide range of lubricants, adhesives, oils, greases, protectants, cleaners/degreasers, protectants/coatings, and fabric care products. PFCs could

potentially be associated with some of the products they manufacture; however, this location is not upgradient of the identified PFC contamination associated with Area C/WMA-13.

- Abraxis, LLC – Abraxis was awarded a small business grant by the U.S. Government in 2006 for research related to improving methods for analyzing/detecting PFOA in various matrices, including food, water, soil, etc. Abraxis LLC is located at 54 Steam Whistle Drive in Warminster, PA, is approximately 1.5 miles north of WMA-13 and is not considered a potential source of PFCs to any of the NAWC wells, nor is it considered a potential source for supply wells WMA-10, WMA-13, or WMA-26.
- Ivyland Fire Company Station 62 – PFCs are associated with AFFF products used by fire stations. It is possible that spills may have led to a release of PFC-containing AFFF. Located approximately 0.3 mile northeast of Area A and 0.45 mile west of WMA-13, any releases of PFCs at this location could have impacted water supply wells WMA-10 and/or WMA-26. The station is not upgradient of the identified PFC contamination associated with Area C/WMA-13; however, it is located roughly along bedrock strike with WMA-13 and could potentially have impacted the water supply well.
- Madison Avenue Warminster Fire Company Station - PFCs are associated with AFFF products used by fire stations. It is possible that spills may have led to a release of PFC-containing AFFF. The station is located approximately 0.7 mile southwest of Area D, and is on the southern edge of the topographic divide that runs roughly east-west along the former runway. It is expected that surface water and groundwater in this area generally drains southward towards Pennypack Creek; however, it is possible that any releases of PFCs at this location could have impacted water supply wells WMA-10 and/or WMA-26. Due to its location approximately 1.5 miles west-southwest of Area C/WMA-13, any PFC releases from this fire station would not have impacted Area C/WMA-13.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations were developed based on the information generated through this evaluation.

4.1 CONCLUSIONS

PFCs have been detected in groundwater in Areas A, C, and D at the former NAWC as well as in groundwater in nearby off-base wells (both private and public water supply). West of Jacksonville Road, highest PFC levels were found in Area D wells, while east of Jacksonville Road, the highest PFC levels were detected in wells near Site 8.

Due to the general northward groundwater flow directions within and extending out from Areas A and D at the former NAWC, historic releases of PFCs from these areas could have impacted water supply wells WMA-10 and/or WMA-26, and groundwater sampling results from Areas A and D confirm the presence of PFCs in these areas. Buildings 134 and 90 are also potential sources for the PFCs found in this general area, and by extension, could have impacted WMA-10 and/or WMA-26. In addition, a number of potential non-Navy PFC sources were identified in the area, primarily along Louis Drive and Ivyland Road, that could have impacted WMA-10 and/or WMA-26. It is considered highly unlikely that releases of PFCs to groundwater from Area C sites would directly impact these wells; however, an intermittent stream that originates near the northern edge of Area C may have provided a secondary route of transport for PFCs to reach the general vicinity of WMA-10. Any potential releases of PFCs from Area B/Sites 5, 6, and 7 would not impact WMA-10 and/or WMA-26 based on the groundwater flow direction to the south within Area B and Area B's location at the far end of the former NAWC from these water supply wells and from Areas A and D.

Due to the groundwater flow direction on the northwestern side of the former NAWC Warminster (west of Jacksonville Road) being to the north-northwest, it is unlikely that the contamination in WMA-13 is the result of any activities that occurred in Area A, Area D, or as a result of any of the identified non-Navy potential sources. It is also considered unlikely that the PFC contamination in WMA-13 could be originating from Area B/Sites 5, 6, and 7, based on the groundwater flow direction to the south in that area.

Given the historical uses of Area C and its position in a general upgradient direction from WMA-13, Site 4 or Site 8 (including structure S-1) are the most likely possible sources of PFCs to well WMA-13 that have been identified, and are discussed below. The 1974 plane crash site and the former fire house are also possible, but unlikely, sources for the PFCs as they both are somewhat cross-gradient to the groundwater

flow direction and are well outside the projected capture zone for WMA-13. The following information was considered in reaching these conclusions:

- The airplane crash was a one-time event that happened almost 40 years ago, and it is not certain that AFFF was used in response to the crash. Therefore, it is considered unlikely that the fire department's response to the air plane crash is responsible for the PFC contamination at WMA-13. Also, the location of the crash is not directly upgradient of well WMA-13, although it is possible water may have been pulled across gradient to the well due to withdrawal from this well. At most, a very small percentage of the water pumped by WMA-13 would be from this area. At this time, the crash site is not considered a high priority for further investigation.
- Site 4 was the largest waste disposal location at NAWC Warminster, and it is located directly upgradient of WMA-13. However, a removal action was conducted in 1996 during which over 22,000 tons of soil and other debris was excavated from Site 4 and transported to an off-base landfill (Tetra Tech NUS, 2000). Confirmation samples verified that sufficient excavation had been performed, and Site 4 was backfilled with clean material. Due to this removal action, Site 4 is not the primary location suspected to be responsible for the PFCs at WMA-13; however, it cannot be discounted at this time as PFCs were not sampled for in past groundwater monitoring of the site.
- The fire-fighting training activities that occurred at Site 8 are the most likely source of PFCs at WMA-13. The reports of white fire-fighting foam flowing in the creek toward WMA-13, along with the site groundwater being upgradient of WMA-13 support this conclusion. Firefighting foam (AFFF) contains PFCs, and the creek provided a pathway for the foam to get closer to WMA-13 where it could infiltrate to groundwater. Since WMA-13 is a water supply well, the pumping of that well could result in the draw-down of PFC contaminated water. For these reasons, Site 8 should be considered the most likely source of PFCs to well WMA-13. Building 134 should be considered an additional possible source. It should also be noted, however, that some wells within Area C with PFC detections are not downgradient or in the near vicinity of Site 8 (most notable HN-23A and HN-28S) – the PFC detections in these wells suggest that Site 8 is not the sole source of PFCs in groundwater in this area. These wells are located between Sites 4 and 8, and are downgradient of the Anns Choice retirement community complex.

4.2 RECOMMENDATIONS

Based on the findings and conclusions presented in this report, the following recommendations are made:

- The potential Navy source areas for PFCs should be further investigated as necessary to either confirm or rule them out as likely sources, and to identify specific sources areas to the extent

reasonably possible. Any additional groundwater investigation work should target shallow groundwater and/or depth horizons where the most significant VOC impacts were noted in prior investigations.

- The Navy has already submitted a draft sampling and analysis plan (SAP) to EPA and PADEP to conduct a remedial investigation (RI) at Area C. The Navy plans to amend this with a SAP to expand the RI to include Areas A and D.

- Information regarding potential non-Navy sources should be considered along with data for the former NAWC sites in developing an overall strategy for addressing PFC impacts to groundwater in the area.

- The results of the RI and the private well sampling, along with a reevaluation of previous investigations of other potential sources should be completed as part of the RI to determine if additional sources of PFCs could be present outside the footprint of the former NAWC.

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TABLES

TABLE 1

AREAS A AND D BASELINE GROUNDWATER SAMPLING FOR PFCS
MAY 2014 ANALYTICAL RESULTS
FORMER NAWC, WARMINSTER, PENNSYLVANIA

Location ID	Sample ID	Date Sampled	PFOA, µg/L	PFOS, µg/L
EPA Office of Water Provisional Health Advisory (PHA) (2009) (µg/L)			0.4	0.2
Area A Samples				
EW-A1	EW-A1	5/21/14	0.102	0.258
EW-A2	EW-A2	5/21/14	0.128	0.445
DUP-1 (EW-A2)	DUP-1	5/21/14	0.133	0.441
EW-A3	EW-A3	5/21/14	0.208	0.665
EW-A4	EW-A4	5/21/14	0.274	0.641
EW-A5	EW-A5	5/21/14	0.381	0.523
EW-A6	EW-A6	5/21/14	0.288	0.506
EW-A7	EW-A7	5/21/14	0.289	0.432
EW-A8	EW-A8	5/21/14	0.0978	0.191
EW-A9	EW-A9	5/21/14	0.374	0.707
EW-A10	EW-A10	5/21/14	0.296	0.532
EW-A11	EW-A11	5/21/14	0.160	0.153
EW-A12	EW-A12	5/21/14	0.232	0.299
EW-A13	EW-A13	5/21/14	0.223	0.344
EW-A15	EW-A15	5/21/14	0.280	0.450 E
EW-A19	EW-A19	5/21/14	0.157	0.491
DUP-2 (EW-A19)	DUP-2	5/21/14	0.147	0.528
Area D Samples				
EW-D1	EW-D1	5/20/14	1.19	1.51
EW-D2	EW-D2	5/20/14	1.49	2.10
EW-D3	EW-D3	5/21/14	1.17	1.19
EW-D4	EW-D4	5/21/14	1.56	2.22
DUP-3 (EW-D4)	DUP-3	5/21/14	1.62	2.41
EW-D5	EW-D5	5/21/14	1.18	1.65
EW-D6	EW-D6	5/22/14	0.926	1.48
EW-D7	EW-D7	5/21/14	0.669	1.15
EW-D8	EW-D8	5/21/14	0.016 U	0.016 U

Notes:

All samples analyzed for PFOA/PFOS by EPA Method 537 Modified.

Bold indicates detected analyte. Gray highlight indicates a detected value exceeding the PHA.

PFOA = Perfluorooctanoic Acid

PFOS = Perfluorooctanoic Sulfonate

PHA = Provisional Health Advisory

E = Value exceeds calibration range.

J = Estimated value

U = Not detected above the laboratory method detection limit (MDL). Value given is Limit of Detection (LOD).

NA = Not applicable

Results presented above are raw analytical results which have not yet been validated.

Data/Table source: H&S Environmental

TABLE 2

**AREA C BASELINE GROUNDWATER SAMPLING FOR PFCS
JANUARY 2014 ANALYTICAL RESULTS
FORMER NAWC, WARMINSTER, PENNSYLVANIA**

Location ID	Sample ID	Date Sampled	PFOA, µg/L	PFOS, µg/L
EPA Office of Water Provisional Health Advisory (PHA) (2009) (µg/L)			0.4	0.2
Area C Samples				
EW-C16	EW-C16-010614	1/9/14	1.8	3.2
EW-C17	EW-C17-010614	1/9/14	1.5	0.95
HN-24S	HN-24S-010614	1/9/14	1.3	1.4
HN-25S	HN-25S-010614	1/6/14	0.64	1.2
HN-25I	HN-25I-010614	1/6/14	0.72	1.0
OB-11	OB-11-010914	1/9/14	2.6	16 J
OB-11 (DUP-1)	DUP-1-010914	1/9/14	2.4	15
OB-13	OB-13-010814	1/8/14	2.0	6.5
R-9	R-9-010814	1/8/14	0.71	0.69
WMA-13	WMA-13-010914	1/9/14	0.093	0.21
GWTP Samples				
Area A Influent	AREA A INFLUENT-012014	1/20/14	0.23	0.66 J
Area C Influent	AREA C INFLUENT-010914	1/9/14	2.6	1.5
Combined Effluent	COMBINED EFFLUENT-010914	1/9/14	0.19	0.20 U

Notes:

Bold indicates detected analyte. Gray highlight indicates a detected value exceeding the PHA.

PFOA = Perfluorooctanoic Acid

PFOS = Perfluorooctanoic Sulfonate

PHA = Provisional Health Advisory

J = Estimated value

U = Not detected above the laboratory method detection limit (MDL). Value given is Limit of Detection (LOD).

GWTP = Groundwater Treatment Plant

NA = Not applicable

Results presented above are not validated

Data/Table source: H&S Environmental

TABLE 3

**WELLS WITHIN 1 MILE OF SITE 8
FORMER NAWC, WARMINSTER, PENNSYLVANIA
PAGE 1 OF 4**

Well Number	Date Drilled	Latitude DD	Longitude DD	Local Well #	Owner	Well Depth	Well Use	Water Use
1		40.20667	-75.08611	BK 1131		23.1	UNUSED	UNUSED
2	10/20/1978			BK 1067	WARMINSTER AUTH	400	UNUSED	UNUSED
3	9/5/1996	40.20083	-75.08472	BK 2859	NAVAL AIR WARFARE CENTER	204	TEST	UNUSED
4	2/7/1997	40.20028	-75.08472	BK 2886	NAVAL AIR WARFARE CENTER	0	TEST	OTHER
5	2/10/1997	40.2	-75.08472	BK 2887	NAVAL AIR WARFARE CENTER	0	TEST	OTHER
6	9/10/1996	40.20111	-75.08444	BK 2858	NAVAL AIR WARFARE CENTER	151	TEST	UNUSED
7	2/6/1997	40.20083	-75.08417	BK 2885	NAVAL AIR WARFARE CENTER	0	TEST	OTHER
8	9/11/1996	40.20167	-75.08389	BK 2857	NAVAL AIR WARFARE CENTER	151	TEST	UNUSED
9		40.2008	-75.0836		US NAVAL WARFARE CENTER	246	WITHDRAWAL	UNUSED
10		40.2008	-75.0836		US NAVAL WARFARE CENTER	247	WITHDRAWAL	UNUSED
11	3/28/1994	40.19889	-75.08333	BK 2611	NAVAL AIR WARFARE CENTER	96	OBSERVATION	UNUSED
12	3/28/1994	40.19889	-75.08333	BK 2612	NAVAL AIR WARFARE CENTER	0	OBSERVATION	UNUSED
13	3/25/1994	40.19889	-75.08333	BK 2613	NAVAL AIR WARFARE CENTER	0	OBSERVATION	UNUSED
14	3/25/1994	40.20028	-75.08278	BK 2614	NAVAL AIR WARFARE CENTER	69	OBSERVATION	UNUSED
15	8/29/1996	40.2025	-75.08278	BK 2855	NAWC	201	TEST	OTHER
16	3/15/1994	40.20139	-75.0825	BK 2616	NAVAL AIR WARFARE CENTER	66	OBSERVATION	UNUSED
17	3/14/1994	40.20139	-75.0825	BK 2617	NAVAL AIR WARFARE CENTER	144	OBSERVATION	UNUSED
18	8/27/1996	40.2025	-75.0825	BK 2856	NAVAL AIR WARFARE CENTER	153	TEST	UNUSED
19	8/1/1941	40.20167	-75.0825	BK 374	U S NADC	250	WITHDRAWAL	UNUSED
20	3/25/1994	40.20056	-75.08194	BK 2615	NAVAL AIR WARFARE CENTER	84	OBSERVATION	UNUSED
21		40.21028	-75.08167	BK 1050	HABERMEHL C	0		
22	3/11/1994	40.20278	-75.08167	BK 2605	NAVAL AIR WARFARE CENTER	287	OBSERVATION	UNUSED
23		40.21194	-75.08167	BK 1051	STOVER R	0		
24		40.1989	-75.0808		US NAVAL WARFARE CENTER	584	WITHDRAWAL	UNUSED
25		40.1989	-75.0808		US NAVAL WARFARE CENTER	600	WITHDRAWAL	UNUSED
26	4/15/2011	40.20556	-75.08057		CRC INDUSTRIES WARMINSTER	67	OBSERVATION	UNUSED
27	4/1/1942	40.19917	-75.08056	BK 375	U S NADC	600	WITHDRAWAL	UNUSED
28	4/18/1994	40.20167	-75.08028	BK 2606	NAVAL AIR WARFARE CENTER	172.5	OBSERVATION	UNUSED
29	4/1/1994	40.20167	-75.08028	BK 2607	NAVAL AIR WARFARE CENTER	0	OBSERVATION	UNUSED
30	9/16/1996	40.20528	-75.08028	BK 2860	NAVAL AIR WARFARE CENTER	300	TEST	UNUSED
31	4/1/1942	40.19944	-75.08028	BK 376	U S NADC	592	WITHDRAWAL	DOMESTIC
32	12/6/1977			BK 1059	WARMINSTER AUTH	400	WITHDRAWAL	PUBLIC SUPPLY
33	4/15/2011	40.20572	-75.08009		CRC INDUSTRIES WARMINSTER	56	OBSERVATION	UNUSED
34	8/19/1996	40.20222	-75.08	BK 2851	NAVAL AIR WARFARE CENTER	57	TEST	UNUSED
35		40.1958	-75.08		US NAVAL WARFARE CENTER	400	WITHDRAWAL	UNUSED
36	8/19/1996	40.2025	-75.07972	BK 2852	NAVAL AIR WARFARE CENTER	157	TEST	UNUSED

TABLE 3

**WELLS WITHIN 1 MILE OF SITE 8
FORMER NAWC, WARMINSTER, PENNSYLVANIA
PAGE 2 OF 4**

Well Number	Date Drilled	Latitude DD	Longitude DD	Local Well #	Owner	Well Depth	Well Use	Water Use
37	1/1/1967	40.19556	-75.07944	BK 962	U S NADC	400	WITHDRAWAL	UNUSED
38	8/19/1996	40.20222	-75.07917	BK 2853	NAVAL AIR WARFARE CENTER	142	TEST	UNUSED
39	10/1/1980	40.20417	-75.07917	BK 1831	US NAVAL AIR DEV CENTER	298	OBSERVATION	UNUSED
40	8/16/1996	40.20028	-75.07806	BK 2847	NAWC	84	TEST	OTHER
41	5/18/1972			BK 959	WARMINSTER AUTH	250	WITHDRAWAL	UNUSED
42	8/16/1996	40.20056	-75.0775	BK 2848	NAVAL AIR WARFARE CENTER	143	TEST	UNUSED
43		40.205	-75.07694	BK 1285	JN WAGNER & SONS INC	0	WITHDRAWAL	INDUSTRIAL
44		40.205	-75.07694	BK 1286	JN WAGNER & SONS INC	0	WITHDRAWAL	INDUSTRIAL
45	3/30/1994	40.19889	-75.07611	BK 2579	NAVAL AIR WARFARE CENTER	50	OBSERVATION	UNUSED
46	3/30/1994	40.19889	-75.07611	BK 2580	NAVAL AIR WARFARE CENTER	95	OBSERVATION	UNUSED
47	3/29/1994	40.19889	-75.07611	BK 2581	NAVAL AIR WARFARE CENTER	300	OBSERVATION	UNUSED
48	8/15/1996	40.2025	-75.07556	BK 2849	NAVAL AIR WARFARE CENTER	43	TEST	UNUSED
49	8/15/1996	40.20278	-75.07528	BK 2850	NAVAL AIR WARFARE CENTER	112	TEST	UNUSED
50	1/1/1965			BK 951	WARMINSTER AUTH	528	WITHDRAWAL	PUBLIC SUPPLY
51	10/1/1980	40.20028	-75.07444	5331N	SMC MARTIN ASSOC.	300		INDUSTRIAL
52		40.205	-75.07417	BK 1053	SMITH	20.5	WITHDRAWAL	DOMESTIC
53	10/1/1980	40.19861	-75.07389	5330N	SMC MARTIN ASSOC.	60		INDUSTRIAL
54	3/17/1994	40.20417	-75.07361	BK 2582	NAVAL AIR WARFARE CENTER	151	OBSERVATION	OTHER
55	3/17/1994	40.20417	-75.07361	BK 2583	NAVAL AIR WARFARE CENTER	152	OBSERVATION	OTHER
56	9/1/1996	40.20667	-75.07361	BK 2871	NAVAL AIR WARFARE CENTER	496	TEST	UNUSED
57	1/1/1948	40.20444	-75.07361	BK 377	U S NADC	352	WITHDRAWAL	UNUSED
58	7/12/1994	40.20941	-75.0729		DRYDEN OIL	25		INDUSTRIAL
59	7/12/1994	40.20941	-75.07274		DRYDEN OIL	22		INDUSTRIAL
60	2/22/1994	40.2	-75.07194	BK 2592	NAVAL AIR WARFARE CENTER	53	OBSERVATION	UNUSED
61	2/17/1994	40.2	-75.07194	BK 2593	NAVAL AIR WARFARE CENTER	201	OBSERVATION	UNUSED
62	12/1/1988	40.21583	-75.07139	BK 2730	HUNSINGER JEFF	100	WITHDRAWAL	DOMESTIC
63	12/1/1988	40.21583	-75.07139	BK 2730	JACKSON MARY ELLEN	100	WITHDRAWAL	DOMESTIC
64	5/6/1970	40.20583	-75.07111	BK 997	BEARN ROBERT	110	WITHDRAWAL	DOMESTIC
65		40.1925	-75.07111	BK 1043	KING JOHN	44	WITHDRAWAL	DOMESTIC
66	10/23/1973	40.21556	-75.07111	BK 1054	RADELBACK HERBERT	85	WITHDRAWAL	
67	1/1/1963	40.19361	-75.07083	BK 1060	PASSMORE BARRY	115	WITHDRAWAL	DOMESTIC
68	1/1/1973	40.215	-75.07083	X 2491	RADELBACK HERB	85	WITHDRAWAL	DOMESTIC
69	1/1/1970	40.205	-75.07	X 1616	BEARN STEWERT	110	WITHDRAWAL	DOMESTIC
70	2/22/1994	40.20111	-75.06972	BK 2586	NAVAL AIR WARFARE CENTER	73	OBSERVATION	UNUSED
71	2/17/1994	40.20111	-75.06972	BK 2587	NAVAL AIR WARFARE CENTER	151	OBSERVATION	UNUSED
72	2/16/1994	40.20333	-75.06972	BK 2602	NAVAL AIR WARFARE CENTER	103	OBSERVATION	UNUSED

TABLE 3

**WELLS WITHIN 1 MILE OF SITE 8
FORMER NAWC, WARMINSTER, PENNSYLVANIA
PAGE 3 OF 4**

Well Number	Date Drilled	Latitude DD	Longitude DD	Local Well #	Owner	Well Depth	Well Use	Water Use
73	2/21/1994	40.2025	-75.06944	BK 2594	NAVAL AIR WARFARE CENTER	103	OBSERVATION	UNUSED
74	2/15/1994	40.2025	-75.06944	BK 2595	NAVAL AIR WARFARE CENTER	158	OBSERVATION	UNUSED
75	6/6/1972			BK 1087	WARMINSTER AUTH	400	UNUSED	UNUSED
76	10/1/1949	40.1975	-75.06917	BK 378	U S NADC	278	WITHDRAWAL	UNUSED
77	2/12/1980			BK 1130	WARMINSTER AUTH	400	TEST	UNUSED
78	2/1/1980			5333N	WARMINSTER AUTHORITY	400	TEST	UNUSED
79	3/1/1994	40.20306	-75.06861	BK 2588	NAVAL AIR WARFARE CENTER	122.5	OBSERVATION	UNUSED
80	2/18/1994	40.20306	-75.06861	BK 2589	NAVAL AIR WARFARE CENTER	202	OBSERVATION	UNUSED
81	2/22/1994	40.20111	-75.06833	BK 2596	NAVAL AIR WARFARE CENTER	81.5	OBSERVATION	UNUSED
82	2/16/1994	40.20111	-75.06833	BK 2597	NAVAL AIR WARFARE CENTER	172	OBSERVATION	UNUSED
83	3/2/1994	40.20472	-75.06806	BK 2591	NAVAL AIR WARFARE CENTER	142	OBSERVATION	UNUSED
84		40.20278	-75.0675	BK 702	U S NADC	202	WITHDRAWAL	UNUSED
85	12/9/1970	40.20806	-75.0675	BK 998	VARNEY JOSEPH	135	WITHDRAWAL	DOMESTIC
86	12/9/1971	40.20806	-75.0675	5340N	VARNEY J	0	WITHDRAWAL	DOMESTIC
87	8/1/1941	40.20083	-75.06694	BK 373	U S NADC	250	WITHDRAWAL	UNUSED
88		40.2025	-75.06667	BK 1034	ANDRE	70	WITHDRAWAL	DOMESTIC
89	2/10/1994	40.19944	-75.06611	BK 2601	NAVAL AIR WARFARE CENTER	100	OBSERVATION	UNUSED
90		40.20194	-75.06556	BK 1035	MUNRO CRAIG	0		
91	3/7/1994	40.20139	-75.065	BK 2599	NAVAL AIR WARFARE CENTER	61.5	OBSERVATION	UNUSED
92	1/1/1966			BK 953	WARMINSTER AUTH	601	WITHDRAWAL	PUBLIC SUPPLY
93		40.19	-75.06444	BK 1032	SINKLER EARL	152	WITHDRAWAL	DOMESTIC
94		40.21194	-75.06361	BK 960	GOLF FARM	400	WITHDRAWAL	IRRIGATION
95		40.19083	-75.06306	BK 1033	SINKLER EARL	30	UNUSED	UNUSED
96	8/1/1965			BK 952	WARMINSTER AUTH	623	WITHDRAWAL	PUBLIC SUPPLY
97	11/17/1993	40.19778	-75.06278	BK 2539	NAVAL AIR WARFARE CENTER	120	OBSERVATION	UNUSED
98	11/24/1993	40.19778	-75.06278	BK 2540	NAVAL AIR WARFARE CENTER	70	OBSERVATION	UNUSED
99	12/2/1993	40.19778	-75.06278	BK 2541	NAVAL AIR WARFARE CENTER	35	OBSERVATION	UNUSED
100		40.19778	-75.06278	BK 703	U S NADC	0	WITHDRAWAL	UNUSED
101	11/15/1993	40.19528	-75.06139	BK 2557	NAVAL AIR WARFARE CENTER	252	OBSERVATION	UNUSED
102	12/14/1993	40.19528	-75.06139	BK 2559	NAVAL AIR WARFARE CENTER	38	OBSERVATION	UNUSED
103	11/9/1993	40.19917	-75.05944	BK 2530	NAVAL AIR WARFARE CENTER	127	OBSERVATION	UNUSED
104	11/11/1993	40.19917	-75.05944	BK 2531	NAVAL AIR WARFARE CENTER	90	OBSERVATION	UNUSED
105		40.21222	-75.05917	BK 1073	GOLF FARM	400	UNUSED	UNUSED
106		40.1925	-75.05861	BK 1028	HOY H	20	UNUSED	UNUSED
107	11/10/1993	40.19694	-75.05861	BK 2533	NAVAL AIR WARFARE CENTER	135	OBSERVATION	UNUSED
108	11/23/1993	40.19694	-75.05861	BK 2534	NAVAL AIR WARFARE CENTER	97	OBSERVATION	UNUSED

TABLE 3

WELLS WITHIN 1 MILE OF SITE 8
 FORMER NAWC, WARMINSTER, PENNSYLVANIA
 PAGE 4 OF 4

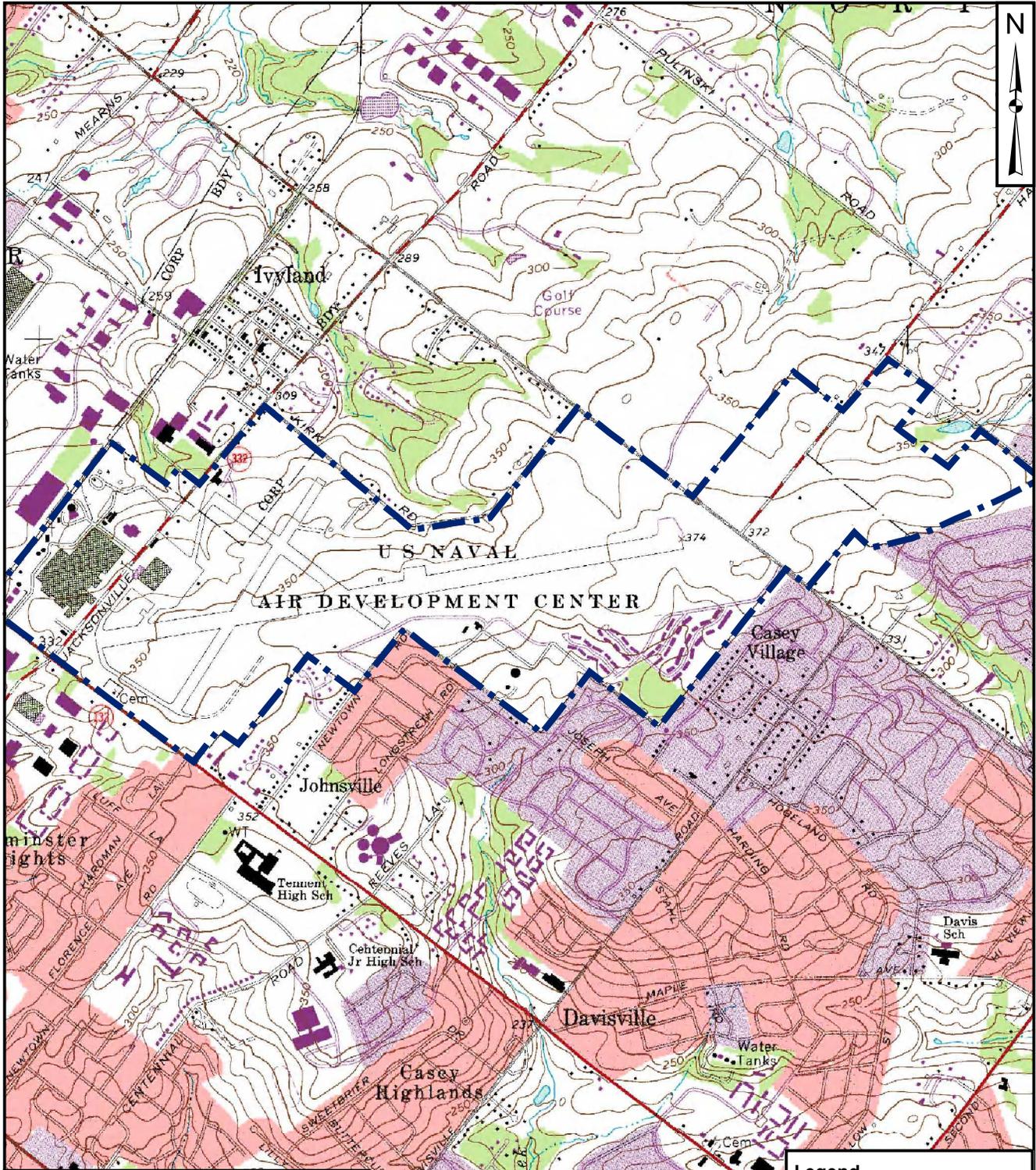
Well Number	Date Drilled	Latitude DD	Longitude DD	Local Well #	Owner	Well Depth	Well Use	Water Use
109	11/6/1990	40.19694	-75.05861	BK 2535	U S NAVAL AIR WARFARE CNTR	33	OBSERVATION	UNUSED
110	1/1/1966	40.21111	-75.05833	BK 1072	GOLF FARM	458	WITHDRAWAL	COMMERCIAL
111		40.19278	-75.05833	BK 1027	HOY H	70		
112		40.20556	-75.05833	BK 1036	MCKELVIE JAMES	0	WITHDRAWAL	DOMESTIC
113		40.20583	-75.05806	BK 1037	MCKELVIE W	0		
114	11/23/1993	40.19583	-75.05778	BK 2536	NAVAL AIR WARFARE CENTER	135	OBSERVATION	UNUSED
115	11/24/1993	40.19583	-75.05778	BK 2537	NAVAL AIR WARFARE CENTER	95	OBSERVATION	UNUSED
116	11/6/1990	40.19583	-75.05778	BK 2538	U S NAVAL AIR WARFARE CNTR	32	OBSERVATION	UNUSED
117	1/1/1967	40.20333	-75.05556	BK 1019	U S NADC	385	WITHDRAWAL	UNUSED
118	11/8/1993	40.19611	-75.05472	BK 2542	NAVAL AIR WARFARE CENTER	85	OBSERVATION	UNUSED
119	11/18/1993	40.19611	-75.05472	BK 2543	NAVAL AIR WARFARE CENTER	200	OBSERVATION	UNUSED
120	11/24/1993	40.19611	-75.05472	BK 2544	NAVAL AIR WARFARE CENTER	50	OBSERVATION	UNUSED
121	11/2/1993	40.19722	-75.05333	BK 2551	NAVAL AIR WARFARE CENTER	178	OBSERVATION	UNUSED
122	11/17/1993	40.19722	-75.05333	BK 2552	NAVAL AIR WARFARE CENTER	75	OBSERVATION	UNUSED
123	11/17/1993	40.19722	-75.05333	BK 2553	NAVAL AIR WARFARE CENTER	45	OBSERVATION	UNUSED
124	4/12/1968	40.19861	-75.05194	BK 1020	U. S. NADC	395	UNUSED	UNUSED
125		40.19333	-75.07083	BK 1061	PASSMORE BARRY	0		

TABLE 4

PFC POTENTIAL SOURCE SUMMARY TABLE
FORMER NAWC, WARMINSTER, PENNSYLVANIA

	Site Activities	Potential PFC Use	Reason for Concern	Potential Source of WMA-10/26 PFCs	Potential Source of WMA-13 PFCs
On-Site					
A-4C Crash	1974 plane crash, may have received AFFF.	Y	AFFF may have been used to fight crash fire.	N	Y
Building 1	Numerous laboratories, and storage.	Y	Plating operations may have used PFCs	Y	N
Building 2	Numerous laboratories, and storage.	Y	High potential for PFC containing materials	Y	N
Impoundment Area	Lagoons holding wastewater sludge.	Y	N/A	Y	N
Building 134	Fire Station	Y	AFFF used in fire-fighting	Y	Y
Site 1	Burn pit and waste disposal from 1940s to 1970s.	Y	Wastes may have contained PFCs	Y	N
Site 2	Trench used for disposal of wastewater sludge.	Y	Wastes may have contained PFCs	Y	N
Site 3	Burn pit for solvents, paint, and other chemicals.	Y	Wastes may have contained PFCs	Y	N
Site 4	Landfill used for disposal of oil, paint, and solvents from 1966 to 1973.	Y	Wastes may have contained PFCs	N	Y
Site 5	Trenches used for disposal of solvents, paint, and other waste from 1955 to 1970.	Y	Wastes may have contained PFCs	N	N
Site 6	Disposal of waste paint, solvents, oil, flammable waste and other item from 1960 to 1980.	Y	Wastes may have contained PFCs	N	N
Site 7	Trenchs used for disposal of wastewater sludge.	N	N/A	N	N
Site 8	Fire-fighting training area.	Y	AFFF may have been used as in training	N	Y
Structure S-1	Testing of fire resistant aviation suits.	Y	PFCs in suits	N	Y
Building 90	Emergency response/lab	Y	Possible handling of fire control equipment	Y	Y
Treatment Plant Discharge Line	Convey water discharge from treatment plants	Y	Water may contain PFCs; possible leaks in line	Y	N
Off-Site					
CRC Industries	Manufacturing/handling of lubricants, adhesives, protectants/coatings, degreasers	Y	PFCs may be used in some products and in plating operations	Y	N
Castrol Industrial	Manufacturing/handling of lubricants	Y	PFCs may be used in some lubricants	Y	N
Crown Marking	Facility engraves, marks and plates various metals.	Y	PFCs used in etching and engraving	Y	N
Double H Plastics/Hurst Plant	Manufacture of plastic containers, lids and plastics, pla	Y	Plastics contain PFCs	Y	N
General Rivet Co.	Manufacture and electroplating of metal rivets.	Y	PFCs used in plating process	Y	N
Abraxis LLC	Research into PFOA analysis methods	Y	PFOA may have been handled	N	N
Greif Packaging	Manufactures drums, plastic bags, and paper packagi	Y	Plastics contain PFCs	Y	N
Ivyland Fire Company St. 62	AFFF could be used or stored here.	Y	AFFF contains PFCs	Y	Y?
Warminster Fire Station	AFFF could be used or stored here.	Y	AFFF contains PFCs	Y	N
PPC Lubricants	Manufacture of lubricants, oils and greases.	Y	Possible PFC presence	Y	N

FIGURES



Legend

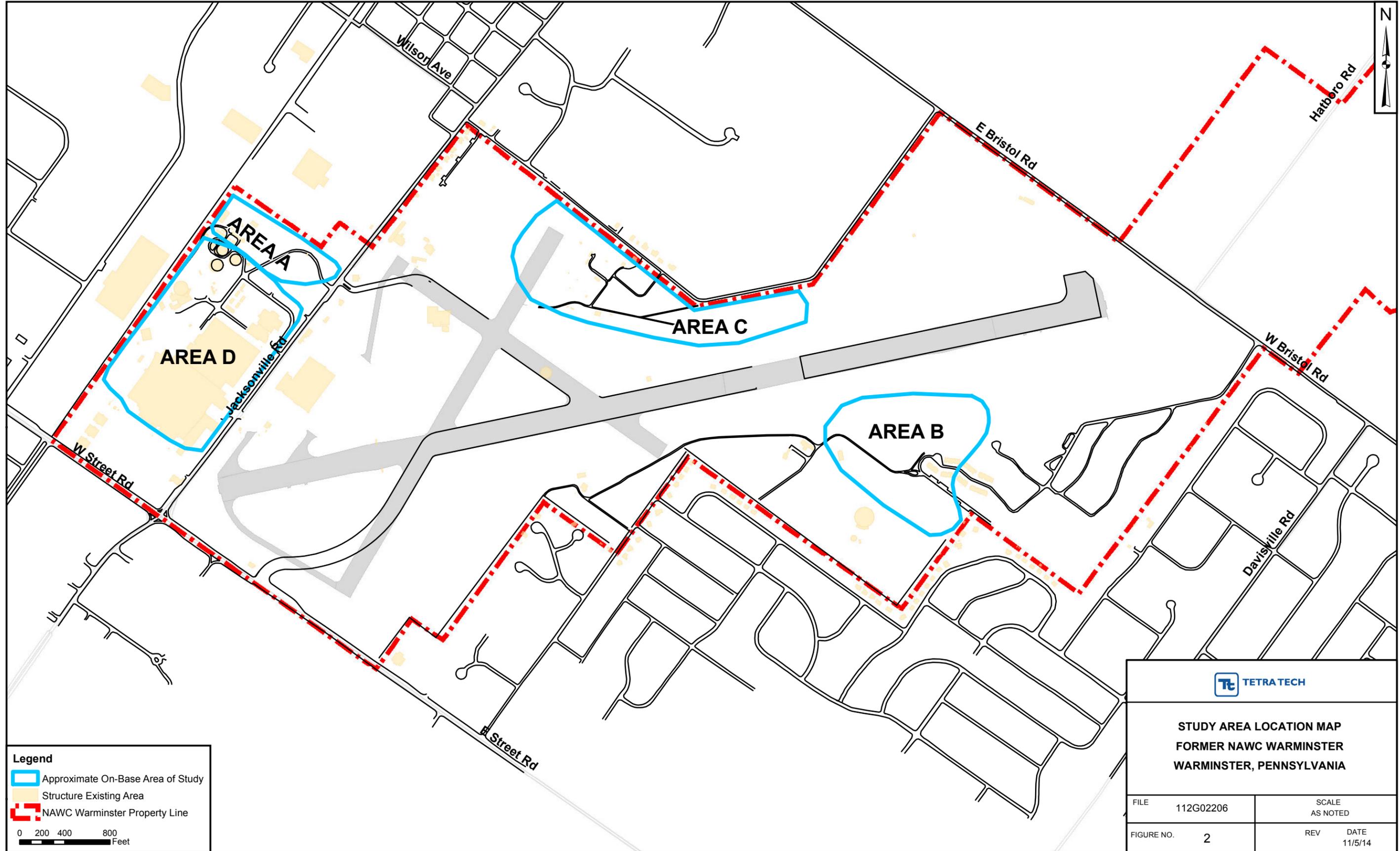
 NAVY PROPERTY LINE

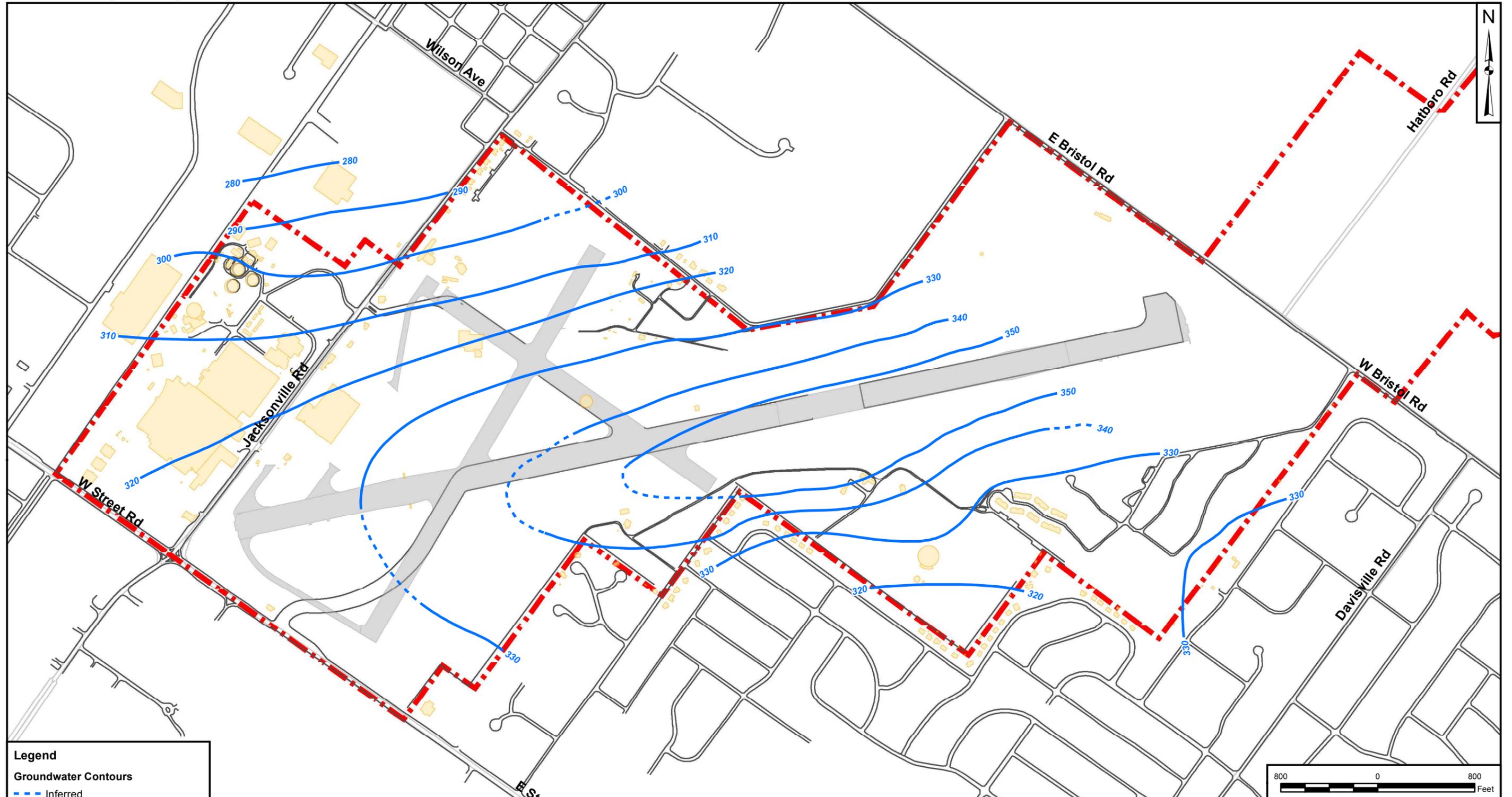
DRAWN BY	DATE
D. COUCH	04/14/14
CHECKED BY	DATE
J. ORIENT	04/16/14
REVISED BY	DATE
SCALE	AS NOTED

TETRA TECH

SITE LOCATION MAP
FORMER NAVAL AIR WARFARE CENTER (NAWC)
WARMINSTER, PENNSYLVANIA

CONTRACT NUMBER	CTO NUMBER
2206	---
APPROVED BY	DATE
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APPROVED BY	DATE
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FIGURE NO.	REV
1	0

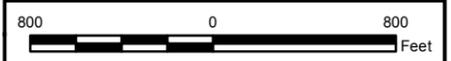




Legend

Groundwater Contours

- - - Inferred
- Regular
- Structure Existing Area
- Airfield Surface Area
- Roads
- NAWC Warminster Property Line
- Local Road

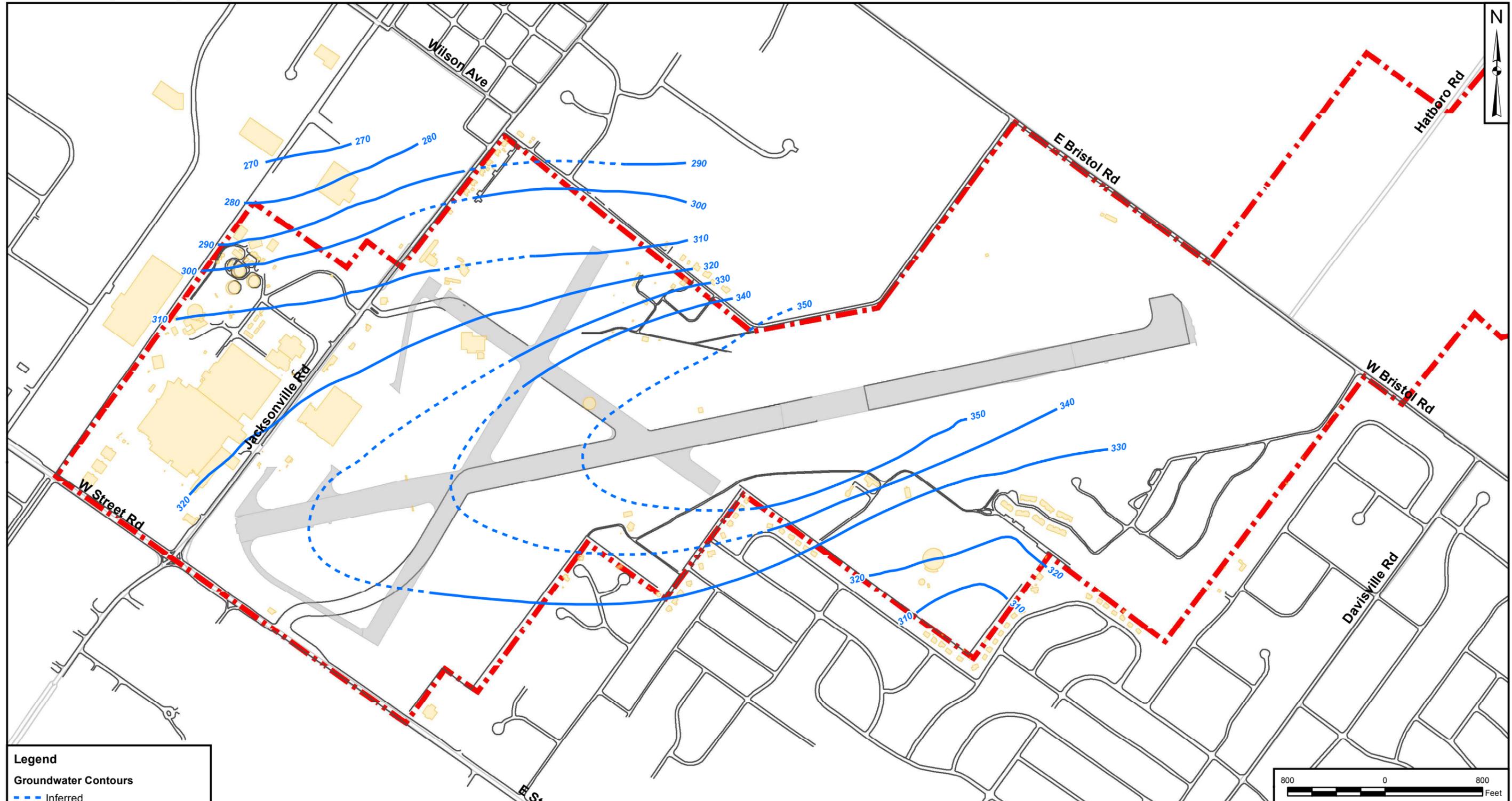


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J. ORIENT	04/16/14
REVISED BY	DATE
SCALE AS NOTED	



SHALLOW GROUNDWATER FLOW MAP
FORMER NAWC
WARMINSTER, PENNSYLVANIA

CONTRACT NUMBER	CTO NUMBER
2206	
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO.	REV
3	0



Legend

Groundwater Contours

- - - Inferred
- Regular
- Structure Existing Area
- Airfield Surface Area
- Roads
- NAWC Warminster Property Line
- Local Road

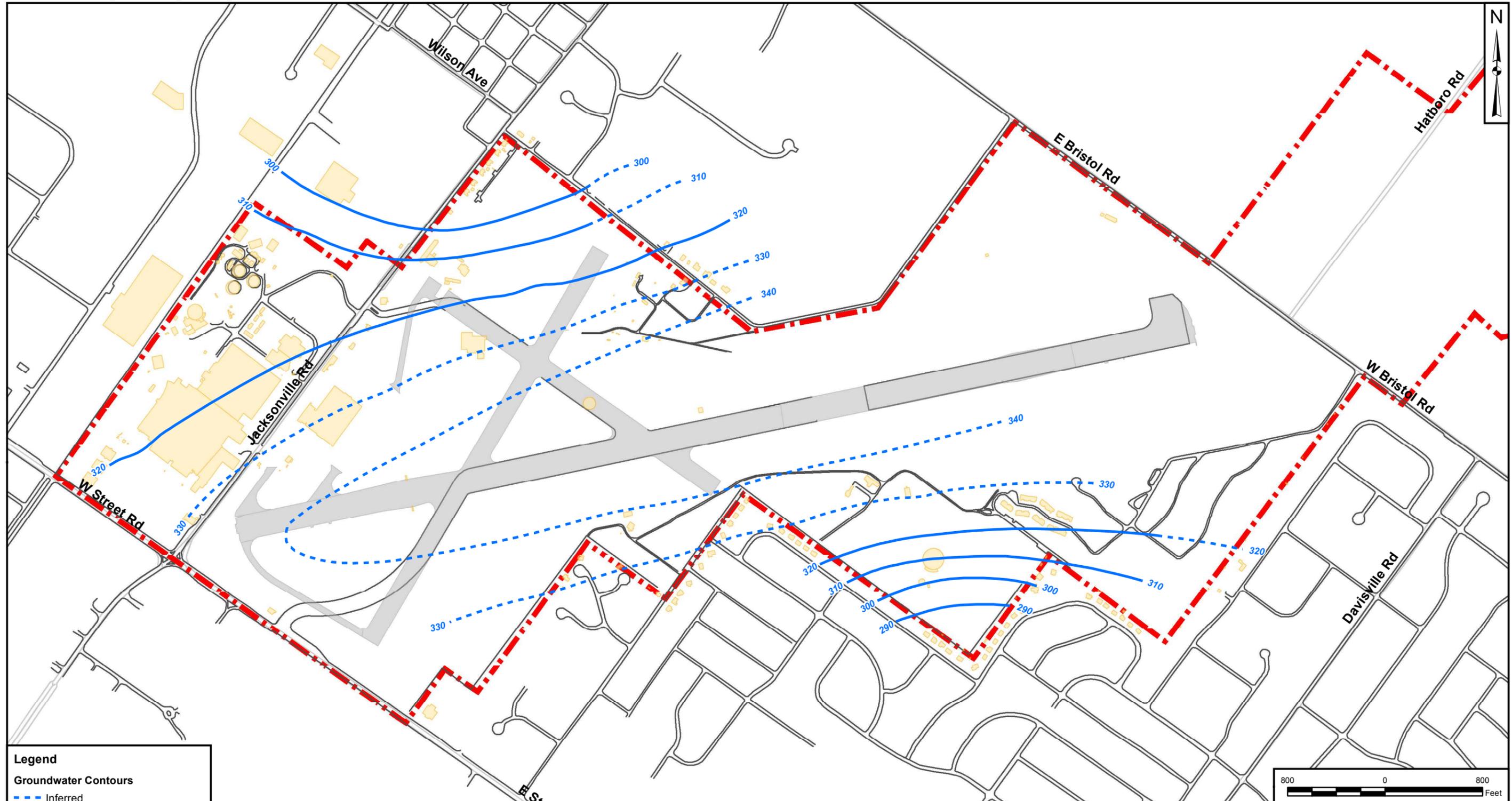


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J. ORIENT	04/16/14
REVISED BY	DATE
SCALE AS NOTED	



INTERMEDIATE GROUNDWATER FLOW MAP
FORMER NAWC
WARMINSTER, PENNSYLVANIA

CONTRACT NUMBER	CTO NUMBER
2206	
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO.	REV
4	0



Legend

Groundwater Contours

- - - Inferred
- Regular
- Structure Existing Area
- Airfield Surface Area
- Roads
- - - NAWC Warminster Property Line
- Local Road

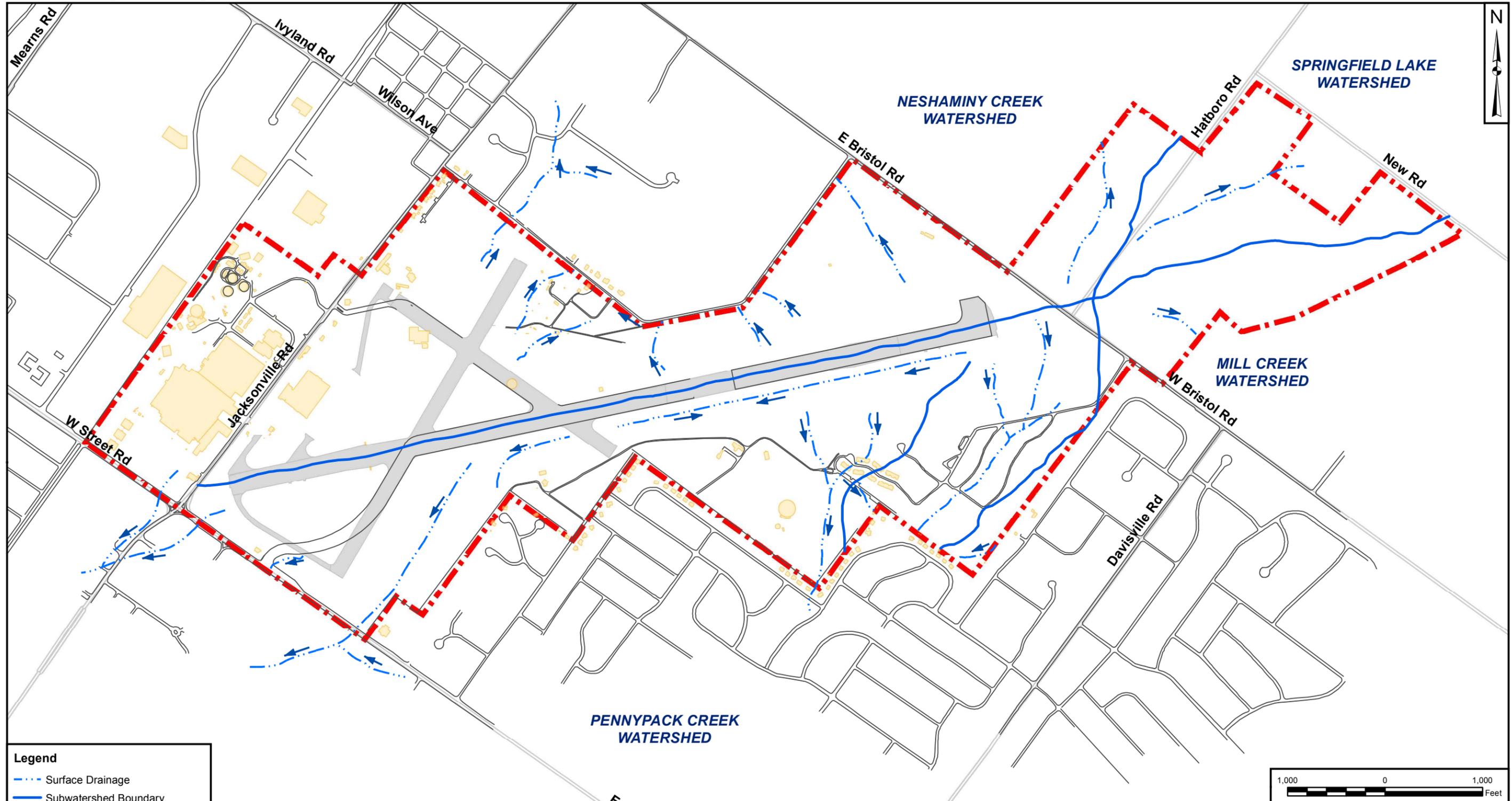


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J. ORIENT	04/15/14
REVISED BY	DATE
SCALE AS NOTED	



DEEP GROUNDWATER FLOW MAP
FORMER NAWC
WARMINSTER, PENNSYLVANIA

CONTRACT NUMBER	CTO NUMBER
2206	
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO.	REV
5	0



Legend	
	Surface Drainage
	Subwatershed Boundary
	Flow Arrow
	Road
	Structure Existing Area
	Airfield Surface Area
	NAWC Warminster Property Line
	Local Road



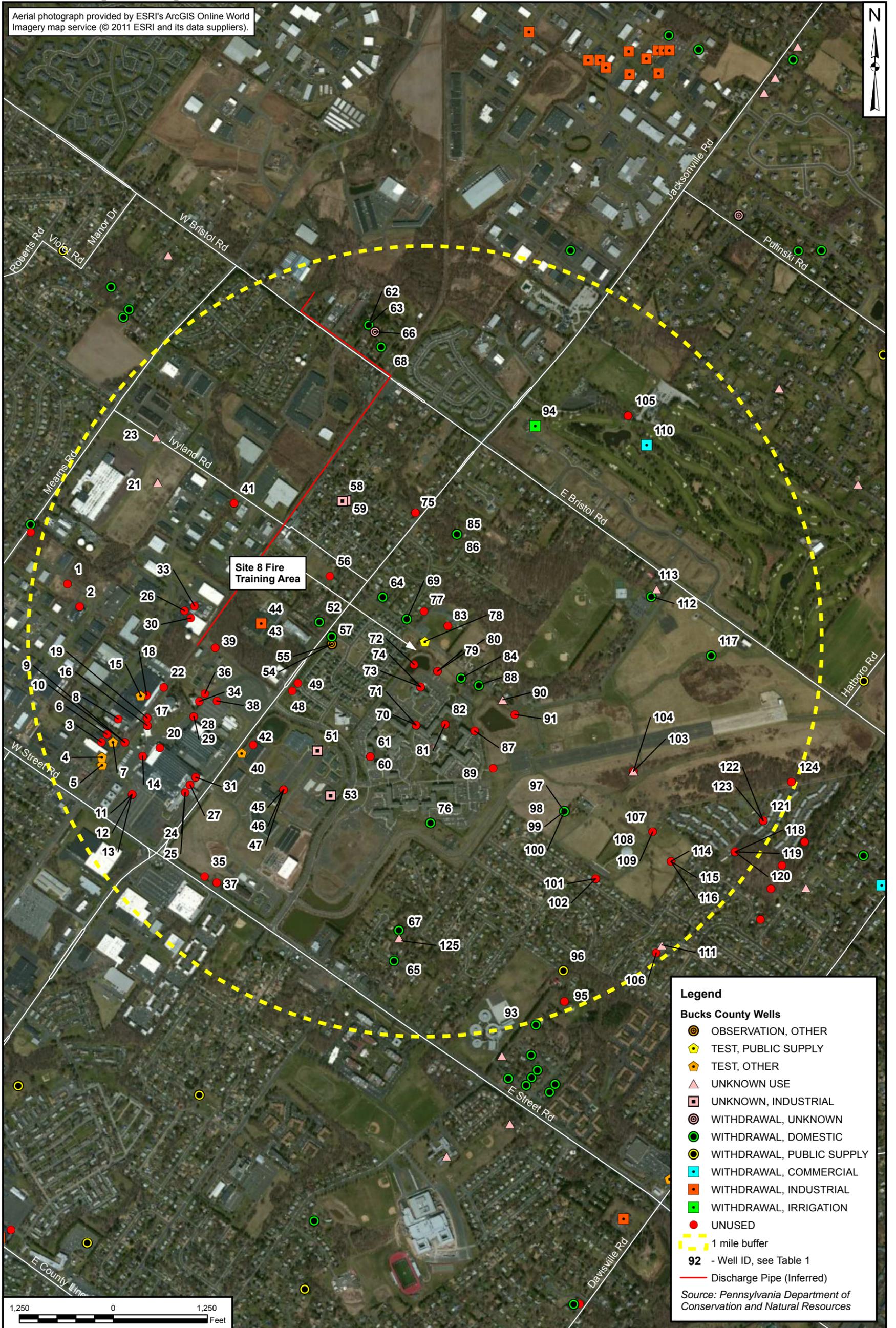
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D. COUCH	04/15/14
CHECKED BY	DATE
J. ORIENT	04/15/14
REVISD BY	DATE
SCALE	
AS NOTED	



SURFACE DRAINAGE
FORMER NAWC
WARMINSTER, PENNSYLVANIA

CONTRACT NUMBER	CTO NUMBER
2206	
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO.	REV
6	0

Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (© 2011 ESRI and its data suppliers).



Legend

Bucks County Wells

- ⊙ OBSERVATION, OTHER
- ⬡ TEST, PUBLIC SUPPLY
- ⬢ TEST, OTHER
- △ UNKNOWN USE
- ◻ UNKNOWN, INDUSTRIAL
- ⊖ WITHDRAWAL, UNKNOWN
- WITHDRAWAL, DOMESTIC
- ⊙ WITHDRAWAL, PUBLIC SUPPLY
- ◻ WITHDRAWAL, COMMERCIAL
- ◻ WITHDRAWAL, INDUSTRIAL
- ◻ WITHDRAWAL, IRRIGATION
- UNUSED

--- 1 mile buffer

92 - Well ID, see Table 1

— Discharge Pipe (Inferred)

Source: Pennsylvania Department of Conservation and Natural Resources

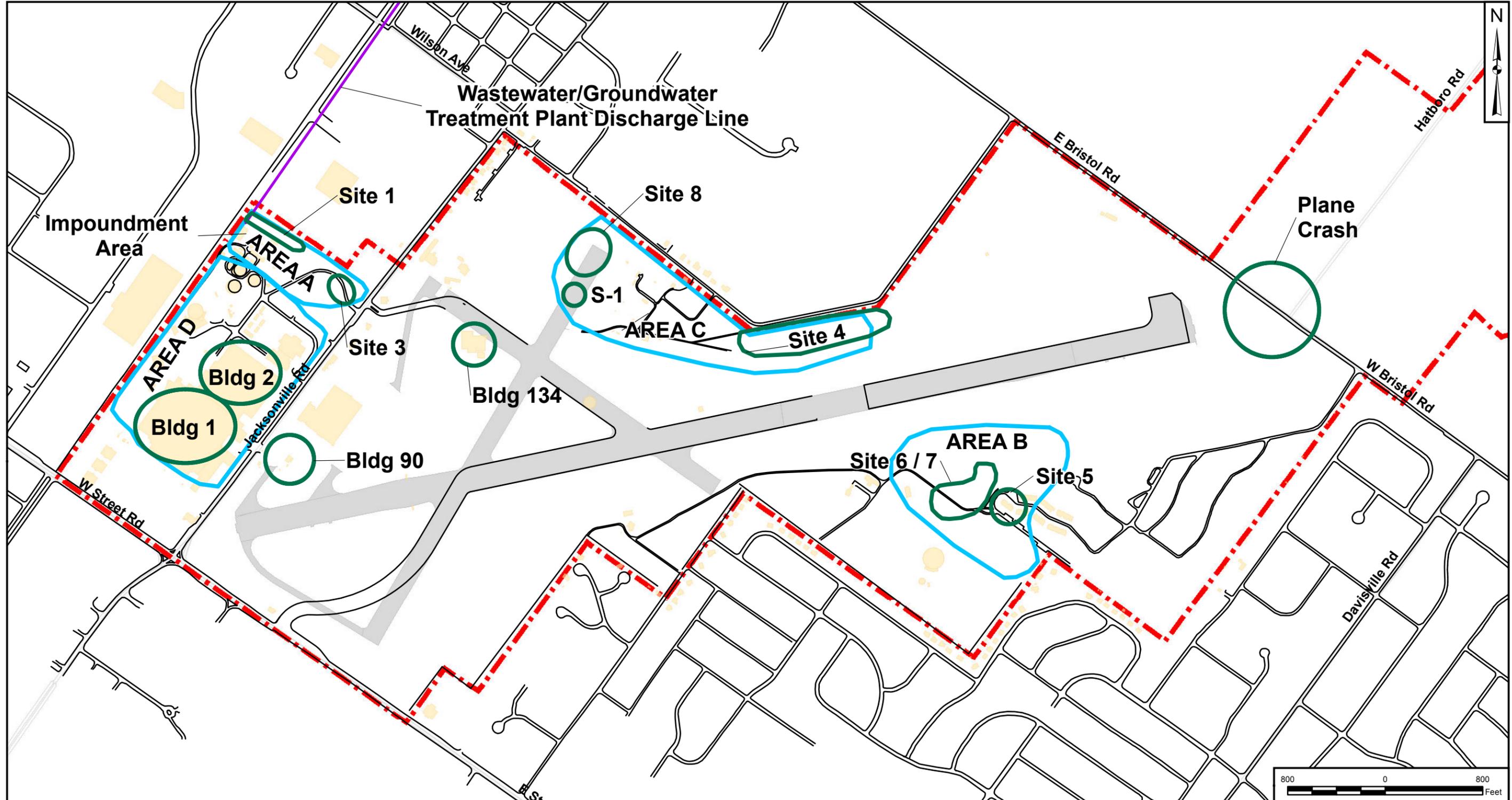


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J. ENGLISH	11/04/14
CHECKED BY	DATE
J. ORIENT	11/04/14
REVISED BY	DATE
SCALE	
AS NOTED	



WELLS WITHIN 1 MILE OF SITE 8
WMA-13
FORMER NAWC
WARMINSTER, PENNSYLVANIA

CONTRACT NUMBER	CTO NUMBER
2206	
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO.	REV
8	0



Legend	
	Approximate On-Base Area of Study
	Structure Existing Area
	NAWC Warminster Property Line

DRAWN BY	DATE
J. ENGLISH	04/14/14
CHECKED BY	DATE
J. ORIENT	11/06/14
REVISED BY	DATE
SCALE	
AS NOTED	



FORMER NAVY SITES WITH POTENTIAL PFC USE
FORMER NAWC
WARMINSTER, PENNSYLVANIA



CONTRACT NUMBER	CTO NUMBER
2206	
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO.	REV
9	0

APPENDIX A

ONLINE SOURCES OF INFORMATION

APPENDIX A

ONLINE SOURCES OF INFORMATION

Bucks County	
County Homepage	http://www.buckscounty.org/
Delaware River Basin Commision	
DRBC Homepage	http://www.state.nj.us/drbc/
PFC Presentation	http://www.state.nj.us/drbc/library/documents/toxics060513_post.pdf
DRBC Emerging Contaminants	http://www.state.nj.us/drbc/library/documents/EmergingContaminants-pres2011.pdf
Tidal DRBC Emerging Contaminants	http://www.state.nj.us/drbc/library/documents/contaminants-of-emerging-concernAug2013rev.pdf
Environmental Protection Agency	
EPA Homepage	http://www.epa.gov/
UCMR 3 Page	http://water.epa.gov/lawsregs/rulesregs/sdwa/ucmr/ucmr3/basicinformation.cfm
EPA Method 537 for PFCs	http://www.epa.gov/nerlcwww/documents/Method%20537_FINAL_rev1.1.pdf
Emerging Contaminant Brief	http://www.epa.gov/fedfac/pdf/ec_technical_fs_pfos_pfoa_march_2013.pdf
Toxicity of PFOS and PFOA	http://www.epa.gov/region4/water/documents/d_final_pfoa_pfos_rfd_memo_OSWER_10_28_09.pdf
Provisional Health Advisories	http://water.epa.gov/action/advisories/drinking/upload/2009_01_15_criteria_drinking_pha-PFOA_PFOS.pdf
Ivyland Borough	
Borough Homepage	http://www.ivylandborough.org/
Borough Stormwater Info	http://www.ivylandborough.org/Stormwater_Info.html
Northampton Township	
Township Homepage	http://www.northamptontownship.com/
Township Map	http://www.northamptontownship.com/inc/documents/1/map-1.pdf
Municipal Authority	http://www.nbcmatoday.org/
Annual Drinking Water Quality Report	http://www.nbcmatoday.org/PDFs/Consumer%20Confidence%20Report%202012.pdf
Pensylvania Department of Conservation and Natural Resources	
PA DNRC Homepage	http://www.dcnr.state.pa.us/
PaGWIS Water Well Records	http://www.dcnr.state.pa.us/topogeo/groundwater/pagwis/records/index.htm
Pennsylvania Department of Environmental Protection	
PA DEP Homepage	http://www.depweb.state.pa.us/
Pa DEP Water Programs	http://www.portal.state.pa.us/portal/server.pt/community/water/6008
Private Water Well Info	http://www.portal.state.pa.us/portal/server.pt/community/private_water_wells/21163
USGS	
USGS Homepage	http://www.usgs.gov/
Report of Warminster Groundwater	http://pa.water.usgs.gov/reports/ofr98-86.pdf
Sloto and Davis Paper	http://pubs.usgs.gov/wri/1982/4020/report.pdf
Area C Borehole Analysis Report	http://pubs.usgs.gov/of/2008/1207/pdf/ofr2008-1207.pdf
Geohydrology of Stockton Formation	http://pubs.usgs.gov/wri/1996/4047/report.pdf
Warminster Municipal Authority	
WMA Homepage	http://www.warminsterauthority.com/
Source Water Assessment	http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-64383/RW1090069001%20Warminster%20Mun%20Auth.pdf
Warminster Township	
Township Homepage	http://warminstertownship.org/
Township Engineering and Operations	http://warminstertownship.org/public-services/engineering-operations
Township Environmental Info	http://warminstertownship.org/public-information/environmental-information