Jacksonville Naval Air Station Hangar 1000

Nanoscale Zero Valent Iron—Monitored Natural Attenuation

Site Name: Jacksonville Naval Air Station Hangar 1000 (OU 6, PSC 52)
Site Location: Jacksonville, FL
Technology Used:

- Nanoscale Zero Valent Iron (NZVI)
- Monitored Natural Attenuation (MNA)

Regulatory Program: U.S. EPA Superfund NPL site
Remediation Scale: Full
Project Duration: 1991 to present

Site Information: The Jacksonville Naval Air Station (NAS) occupies approximately 3,900 acres on the western bank of the St. Johns River. Hangar 1000 is located within Operable Unit (OU) 6 and is part of a complex that services large aircraft (Figure 1). The Hangar 1000 regulated unit consisted of two former underground storage tanks (USTs), Tank A and Tank B, which were operated from the late 1960s until they were closed in 1994. Tank A was a 750-gallon capacity concrete tank used as an oil-water separator. Tank B was a 2000-gallon capacity steel UST that received oil overflow from Tank A and waste oils and solvents discharged from wash racks and floor drains located inside the Hangar's maintenance facilities. The tanks were interconnected with 2-, 4-, and 6-inch diameter metal piping.

The last known discharge of waste into the tanks occurred in November 1987. In 1994, the tanks and associated piping were excavated and removed. Some piping was cleaned and abandoned in place due to the presence of structures.

Contaminants: Volatile organic compounds (VOCs), primarily chlorinated solvents, are present in shallow groundwater of the surficial aquifer at concentrations that exceed Florida Department of Environmental Protection (FDEP) Groundwater Cleanup Target Levels (GCTLs). Semi-volatile organic compounds, polycyclic aromatic hydrocarbon, and target analyte list metal analyses indicated only one constituent—methylphenol—exceeding its respective FDEP GCTL at one location.

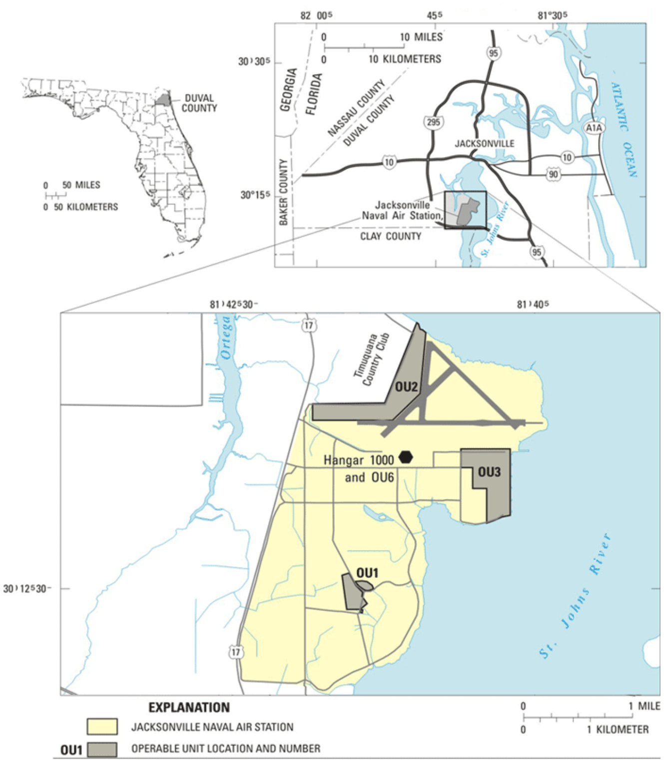

Figure 1: Jacksonville NAS and Hangar 1000 location

Nine VOCs exceed their respective FDEP GCTLs, including:

- Benzene
- 1,1-Dichloroethane (DCA)
- 1,1-Dichloroethene (DCE)
- 1,2-DCA
- 1,2-DCE
- 1,1,1-Trichloroethane (TCA)
- Trichloroethene (TCE)
- Tetrachloroethene (PCE)
- Vinyl chloride

The constituents with the most consistent detection were TCE, 1,1-DCE, and 1,2-DCE. TCE was the most commonly detected contaminant and was detected in 15 of the 27 wells above its GCTL of 3 µg/L. The maximum TCE concentration of 8,710 µg/L was detected in the source area well. The second highest TCE concentration of 1,610 µg/L was detected in a well located near the center of the plume. In general, the highest concentrations of VOCs were encountered in the shallow interval of the shallow aquifer unit. Groundwater collected from the intermediate aquifer contained no detectable constituents.

The plume is relatively narrow, averaging approximately 100 ft across and 400 ft long. The plume trends to the southeast in the direction of groundwater flow (See Figure 2).

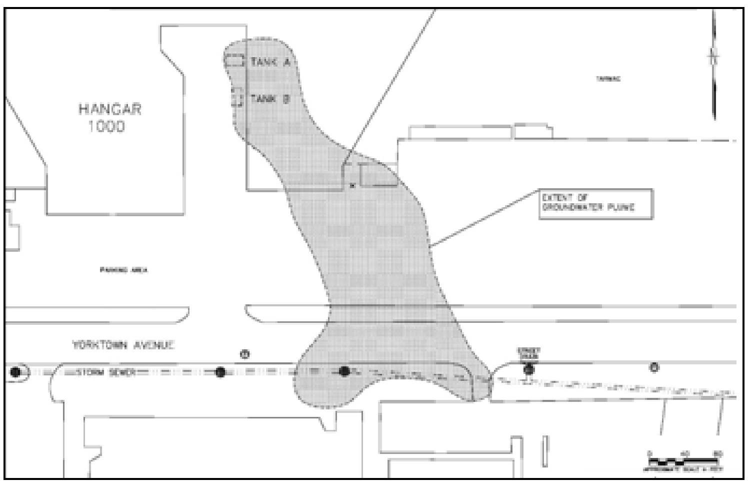

Figure 2: Location and Extent of Groundwater Plume at Hangar 1000

Source: U.S. EPA

Hydrogeology: The site geology is characterized by a fine to medium-grained unconsolidated sand near the ground surface, which grades vertically into a silty sand interval at approximately 15 ft below ground surface (bgs). This layer is followed by a sandy clay interval beginning at approximately 24 ft bgs. The shallow sand interval is heterogeneous in nature and contains silty clay and sandy clay stringers. The sandy clay interval transitions into a clay at approximately 28 to 30 ft bgs. The clay unit extends to approximately 50 ft bgs where a second sand unit is encountered.

The surficial aquifer at the site is located approximately 7 to 24 ft bgs. Shallow groundwater within the surficial aquifer flows to the southeast toward the drainage ditch located southeast of the site. Groundwater in the surficial aquifer is captured by a storm sewer located on the south side of Yorktown Avenue.

Project Goal(s): The following remedial action objectives were established for groundwater and surface water at Hangar 1000:

- Prevent unacceptable risks to human exposure to contaminants of concern (COCs) in groundwater
- Prevent contaminant migration in concentrations from groundwater to surface water above surface water preliminary remediation goals (PRGs) (Jacksonville NAS 2007) (See Table 1).

Cleanup Approach: Contaminated soils were delineated, excavated, and transported offsite for disposal in 1994. Tanks A and B were also excavated and removed at that time. Reviews of soil sample data indicated no exceedance of FDEP residential soil cleanup target levels. As a result, subsequent cleanup efforts at the site have been exclusively directed at groundwater, specifically at reducing concentrations of contaminants below residential risk-based target levels (Jacksonville NAS 2007).

In situ chemical oxidation (ISCO) was performed in the source area from 2000 to 2001 as an interim remedial action with dissolved phase rebound occurring after each application.

Injection of NZVI was implemented in January 2004, after the completion of the bench-scale treatability study. A total of 300 pounds of bimetallic nanoscale particles consisting of 99.9% iron and 0.1% palladium and polymer by weight were injected during two separate injection events. The specific locations were targeted based on the known presence of “hot spots” or elevated contaminant concentrations from site characterization efforts. NZVI was emplaced using two mechanisms: (1) strategic direct-injection into known hot spots using direct-push technology (DPT), and (2) a “closed-loop” recirculation process. Direct injection of the nanoscale iron using DPT was employed first at 10 "hot spot" locations. For injection via DPT, the iron suspension was diluted to 10 g/L and injected directly into the DPT boreholes using pumps from 7.5 to 23.0 ft bgs, equating to approximately 4.2 pounds of iron injected in each borehole (NFEC 2005).

Table 1: Groundwater and Surface Water PRGs

Contaminant of Concern	Groundwater PRG (μg/L)	Surface Water PRG (μg/L)
Chlorinated VOCs		
1,2-DCA	3	37
1,1-DCE	7	3.2
1,2-DCE (total)	70	7000
1,1,1-TCA	200	270
1,1,2-TCA	5	16
TCE	3	80.7
PCE	3	8.85
Vinyl Chloride	1	2.4
Petroleum Compounds		
Benzene	1	71.28
SVOCs		
3-Methylphenol	35	450
4-Methylphenol	3.5	70
Naphthalene	14	26

Source: U.S. EPA (Jacksonville NAS 2007)

A recirculation system was used to distribute the NZVI in the rest of the suspected source zone. The design of the recirculation system consisted of the two existing injection wells that had been previously used for ISCO, four new injection wells, and three extraction wells. Because the viscosity of the NZVI suspension is similar to groundwater (due to low iron concentrations) the water was introduced into the aquifer via gravity flow only. Injection pipes contained drilled slots to allow discharge of the iron into targeted depth intervals with elevated contaminant concentrations (NFEC 2005).

During the first recirculation event, water was recirculated via gravity into both of the existing injection wells that were used for ISCO and the four new injection wells. The recirculation system was operated continuously for an approximate total of 23 hours. Based on results of the bench-scale treatability study, the initial iron concentration applied was 2 g/L. It was later increased to 4.5 g/L based upon field observations that indicated the iron was being accepted by the aquifer without clogging or backing up in the wells. During the second recirculation event, water was only recirculated into the four new injection wells for approximately 21.5 hours. The applied iron concentration remained at 4.5 g/L. The ISCO injection wells were not used due to sediment buildup encountered during the first recirculation event (NFEC 2005).

Natural attenuation is expected to reduce remaining contaminant levels over time to below applicable cleanup goals through biological and other natural processes. Monitoring will consist of collecting and analyzing groundwater samples from within the contaminant plume for contaminant breakdown products to assess the effectiveness of this attenuation process after the implemented NZVI treatment.

Project Results: Results of samples collected 22 weeks after injection indicated that the iron recirculation process fostered favorable mass transfer from the sorbed and potential immiscible phases into the dissolved-phase. This increase was followed by rapid reductions ranging from 65 to 99% of concentrations of parent VOCs in many wells within five weeks (NFEC 2005).

The iron began to passivate after 6 to 9 months, as demonstrated by a loss of apparent reactivity, which suggested that nanoscale zero valent iron was effective in creating abiotic conditions for that approximate time period (Jacksonville NAS 2007). The NZVI injected did not create the strongly reducing conditions (oxidation-reduction potential of −400 mV or lower) necessary to generate substantial degradation of TCE. One suggested possibility for this outcome was that the NZVI was passivated before injection when it was mixed with oxygenated water. Another suggested possibility was that insufficient iron may have been injected; therefore, iron mass should to be determined based on iron-to-groundwater (or iron-to-soil) ratio, rather than iron-to-contaminant ratio (NFEC 2005).

Research conducted subsequent to the Jacksonville injections, indicates that nanoscale ZVI has a relatively short life in the subsurface and should not be expected to act as a long-term reductant (ITRC 2011).

However, favorable conditions remained for biological anaerobic reductive dechlorination. This was suggested by the increase in concentrations of other degradation parameters (e.g., methane and carbon dioxide), which were indicative of the presence of reducing conditions and biological respiration. Soil and groundwater data collected post-remediation indicated that contaminant mass had been reduced between 16 and 62 percent. Based on this result, it was concluded that the treatability study goal of contaminant mass reduction between 40 and 50 percent was achieved at the completion of the NZVI treatment in 2004 (Jacksonville NAS 2007).

The clean-up remedy selected for Hangar 1000 was scheduled to be evaluated after five years of monitoring to determine progress toward meeting remedial action objectives. In addition to the five-year data evaluation, the Jacksonville NAS was required to receive a statutory five-year review, which was completed in May 2011.

The estimated costs of remedy implementation and operation and maintenance are $598,000 over an 18-year span (Jacksonville NAS 2007).

Sources:

Final Record of Decision OU 6 Jacksonville Naval Air Station (NAS). EPA ID FL6170024412, 75 pp., March 21, 2007. http://www.epa.gov/superfund/sites/rods/fulltext/r2007040001532.pdf.

ITRC. 2011. Permeable Reactive Barrier: Technology Update. http://www.itrcweb.org/guidancedocument.asp?TID=5

Naval Facilities Engineering Command (NFEC). 2005. Cost and Performance Report for Nanoscale Zero-Valent Iron Technologies for Source Remediation. http://www.clu-in.org/download/remed/cr-05-007-env.pdf.

NFEC. 2011. Five-Year Review Operable Units 1, 2, 3, 4, 5, 6, 7, and 8 Naval Air Station Jacksonville, Jacksonville, Florida. http://www.epa.gov/superfund/sites/fiveyear/f2011040004182.pdf

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