Monitoring and Site Characterization for In-Situ Bioremediation of Chlorinated Organic Compounds

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NCIBRD'S MISSION

Wurtsmith Air Force Base (WAFB) was decommissioned in June of 1993. Shortly thereafter, the United States Environmental Protection Agency (U.S. EPA), the Strategic Environmental Research and Development Program (SERDP) of the Department of Defense (DoD), the University of Michigan and the Michigan Department of Natural Resources joined resources to develop the National Center for Integrated Bioremediation Research and Development (NCIBRD). NCIBRD is a DoD National Environmental Technology Demonstration Program (DNETDP) Location for the development and evaluation of site characterization and remediation technologies. The mission of NCIBRD is to provide a well defined and controlled research and development platform for in-situ environmental cleanup technologies emphasizing bioremediation techniques applied to subsurface contamination problems. In-situ biological technologies which have the potential to remediate unsaturated zone and saturated zone organochlorine solvent contamination in subsurface systems are of particular interest. Numerous such sites exist at WAFB which are being monitored to detect spatial and temporal changes due to intrinsic bioremediation in preparation for more active bioremediation technology trials.

PHYSICAL SETTING

WAFB is located in Iosco County in northeast Michigan (MI) in the coastal zone of Lake Huron north of Oscoda, Michigan. Oscoda is accessible by rail, highway and commercial air routes north of Saginaw-Bay City, MI. It is under the authority of the Oscoda-Wurtsmith Airport Authority and the Wurtsmith Area Economic Adjustment

Commission. The U.S. Air Force Base Conversion Authority (BCA) is charged with remediation of sites of contamination to enable the transition of site facilities to civilian use. At present, five private or public concerns have leased sites on the base for operations involving an aircraft maintenance facility, a plastics manufacturer, educational institutions and recreational resources. The base occupies seven square miles bounded by the Au Sable River/Au-Sable River wetlands complex to the south, Lake Van Etten to the east and to the west by bluffs fronting a five-mile wide plain extending onto the base. Lake Huron receives the discharge from the associated ground-water flow system and the Au Sable River approximately one-half mile south of the base boundary. The altitude of the land surface ranges from 580 to 750 ft. above mean sea level.

Mean monthly temperatures range from 21°F (-6°C) in January to 68°F (20°C) in July. The lowest recorded temperature was -22°F (-30°C), the highest was 102°F (39°C). Average annual precipitation is 30 inches (76cm) and average snowfall is 44 inches (112cm). Surficial geologic materials are of quaternary glacio-fluvial origins made up largely of medium to fine sands and coarse sand and gravel deposits to depths of 60 to 90 ft. (18 to 27m). Below the glacial deposits a thick confining lacustrine clay layer (i.e. 125 to 250 ft. thick) separates the upper aquifer groundwater from lower more saline waters in bedrock units. In the eastern regions of the area, intermittent sand, sand/gravel, and clay layers of 1 to 3 ft. (< 0.3 to ~ 1m) thickness have been observed in the saturated zone. These features are site-specific. Depths to ground water in the upper aquifer range from < 10 to ~ 30 ft. (< 3 to 9m) in areas remote from pumping. Average ground water recharge rates range from 8 to 18"/yr. (20 to 46 cm/yr).

Hydraulic conductivities at the base range from 75 to 310 ft/day (23 to 95 m/day) based on selected pump tests and estimations from particle size distributions. These values are being refined for specific sites at the base as investigations continue.

Flow in the sand and gravel upper aquifer is generally eastward and south-southeast to surface water discharge areas at average rates of 0.8 to 0.3 ft/day (0.2 to 0.1 m/d), respectively. In general, vertical flow gradients are negligible except in zones of ground-water discharge to surface water bodies or near pumping centers.

CONTAMINANT PROFILE

Contaminant investigations at the base began in the late seventies. The Air Force and the U.S. Geological Survey had been involved in formal studies since 1979. A large number of known and potential contamination sites (i.e. > 50) have been identified at the base by their efforts and those of remedial investigation (RI) and feasibility study (FS) contractors under the DoD Installation Restoration program (IRP). Principal contaminants of concern at the base include: components of petroleum hydrocarbon fuels, oils, and lubricants (POL), organochlorine solvents (e.g. trichloroethylene, dichloroethylene), fire-fighting compounds, combustion products (e.g. naphthalene and phenanthrene) and chlorinated aromatic compounds (e.g. dichloro-benzenes). Soil, aquifer solids, sediments and groundwater are the major

environmental media involved. Of the 58 high priority sites at the base, 13 include chlorinated solvents or partial microbial degradation products as primary contaminants. Twelve of these thirteen sites identify perchloroethylene and trichloroethylene as primary contaminants in soil, aquifer solids and ground water and show evidence of reductive dechlorination processes (i.e. presence of cis-1,2 dichloroethylene, vinyl chloride monomer). These sites have abundant levels of non-chlorinated organic matter and exhibit reducing to suboxic redox conditions as evidenced by the results from Fire Training Area 2. The only site at which sparse evidence for microbial dechlorination of TCE exists is the Pierces Pt. Plume where oxic to transitional redox conditions exist in the dissolved plume. The extent of contamination of aquifer materials remains unknown.

ONGOING ACTIVITIES

The U.S. EPA (Region V), Michigan DNR and the BCA actively cooperate in the ongoing IRP activities as well as the efforts of NCIBRD. Currently, NCIBRD occupies seven buildings on the base in addition to 10,000 ft^2 of office and laboratory space in Ann Arbor. Facilities for offices, laboratories, storage, field operation, staging and decontamination have been developed to support activities at three sites of intensive investigations. Mobile laboratory and drilling vehicles provide additional support for in-field sampling and analysis as well as instructional offerings in contaminant hydrogeology and geochemistry. A basewide ground-water flow model has been developed and refined by estimates of hydraulic conductivity and mass water level measurements at more than 500 wells. A site-wide water balance and refined ground-water transport model for critical areas of the base are being developed as well.

At Fire-Training Area #2, the site of nearly forty years of fire-training exercises, an intensive investigation of in-situ natural bioremediation has been underway since 1993. More than 40 wells and nearly 500' of subsurface cores have been used to delineate the dissolved plume and solid-associated concentrations of fuel constituents, chlorinated aliphatic and aromatic compounds. Dissolved concentrations of the parent chlorinated compounds are a factor of five lower than those in the corresponding amount of aquifer solids. Metabolites of perchloroethylene and trichloroethylene have been identified at the site. The primary metabolites cis -1,2-DCE and vinyl chloride are principally in the ground water and show considerable spatial and temporal variability (i.e. of the order of a factor of 2 to 5 difference in ground water in successive quarters). Evaluation of the progress of natural microbial transformation processes at this site will continue through 1996.

Concentrations of TCE in the water at Pierce's Pt. appear to be decreasing over the past ten years, but this effect could be an artifact of the monitoring network design. These investigations continue in order to refine compound mass distributions and net changes with time. Specific sites for the evaluation of anaerobic dechlorination, bioventing and aerobic fuel metabolism are being evaluated in collaboration with experts in industrial, federal and university laboratories. Suitable sites for several of these demonstrations will be selected in 1995. As part of ongoing investigations, evaluations of soil gas monitoring techniques, monitoring well purging methods and

infield chemical analysis techniques have been conducted. These methodological and instrumental studies will continue in the 1995 and 1996 timelines.

NCIBRD staff and collaborators welcome the contributions and participation of interested groups in future investigations of promising site characterization and bioremediation cleanup technologies.