Long-Term Stewardship
LLNL Livermore Site

2018 Long-Term Stewardship (LTS) Conference

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Lawrence Livermore National Laboratory Livermore Site

View of LLNL Livermore Site looking west toward San Francisco Bay

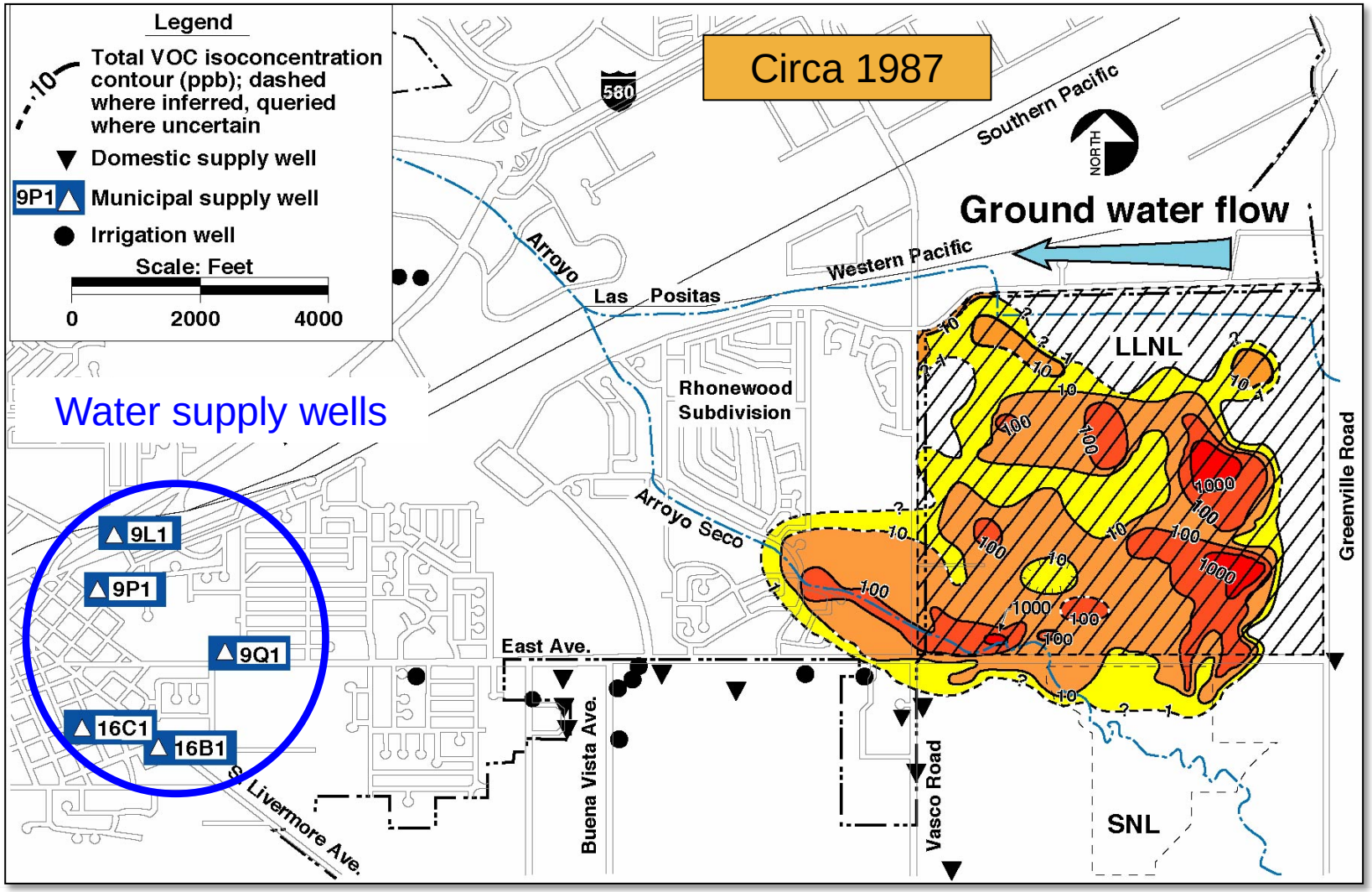
LLNL Livermore Site Background

- U.S. Navy operated NAS Livermore during WWII (1940s)
- LLNL established in 1952
- Ground water contamination first discovered in 1983
- Volatile organic compounds (VOCs), fuel hydrocarbons, metals (chromium), tritium
- Regulatory oversight by US EPA and State of California

Initial Ground Water Contaminants from Navy Aircraft Maintenance Operations (WWII)

WWII Plane Assembly

Municipal supply wells within 3 miles of the plume placed LLNL on EPA's Superfund National Priority List



LLNL ground water cleanup to date

- Pump-and-Treat initiated in 1989
- Constructed 37 treatment facilities:
  - 28 ground water facilities
  - 9 soil vapor treatment facilities
- Treatment to date:
  - 6 billion gallons of ground water
  - 850 million cubic feet of soil vapor
  - 3,300 kg (3.6 tons) of VOCs have been removed from the subsurface
- Fuel (gasoline) release site remediation completed in 1996
- Tritium primarily below drinking water cleanup standard

Current Status and Next Steps

Optimization:

- Pump-and-treat facility build-out complete
- Leveraging technology for efficient operation
- Evaluating alternative cleanup techniques

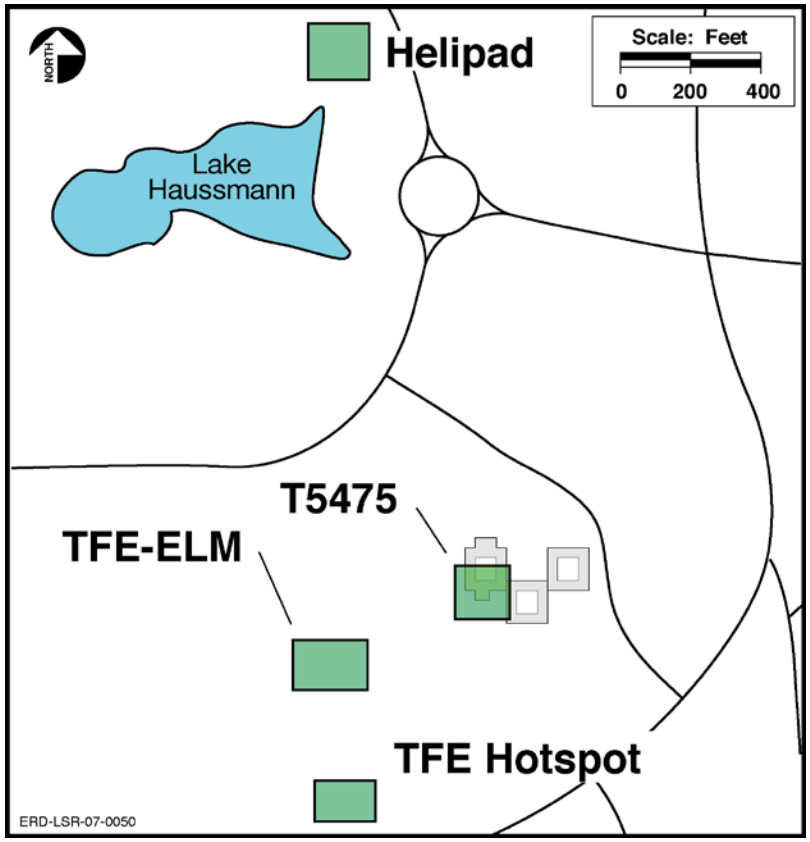
Goal:

- Reduce life-cycle cost by reducing time to cleanup/closure

Livermore Site Environmental Restoration

- Primary VOCs:
  - Trichloroethylene (TCE; C_2HCl_3)
  - Perchloroethylene (PCE; C_2Cl_4)
    - aka Tetrachloroethylene
- Although tritium in site groundwater predominately less than the MCL, it poses difficulties when implementing the approved pump-and-treat remedy.
- Aqueous- and vapor-phase granular activated carbon (GAC) used to remove VOCs from groundwater and soil vapor may be designated as mixed waste in areas of comingled VOC and tritium plumes.

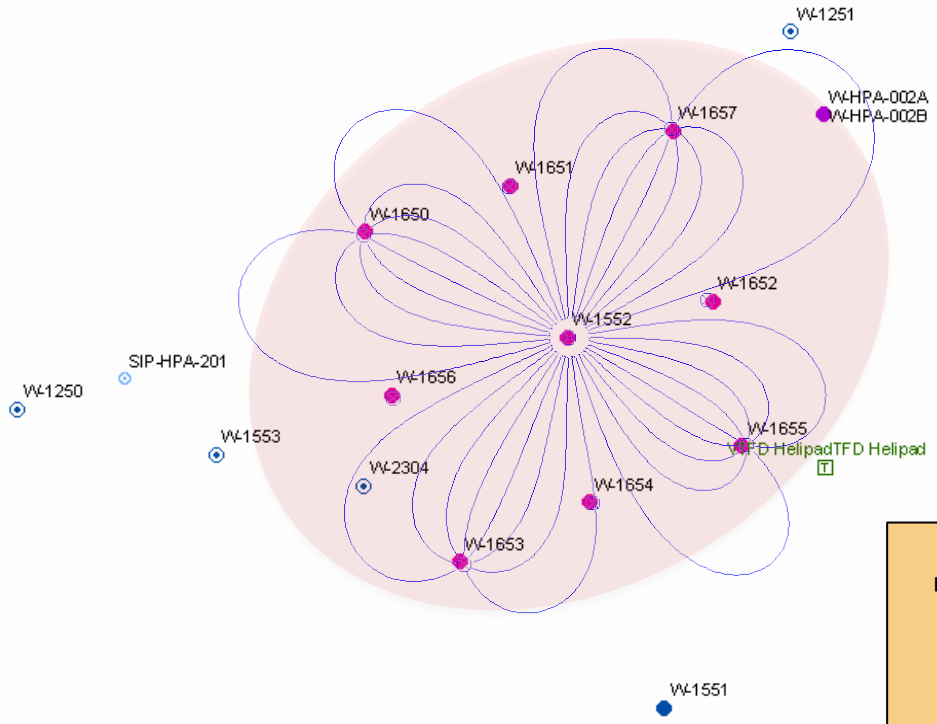
Enhanced Source Area Remediation (ESAR) test sites



- **Helipad:** *in situ* bioremediation test
- **TFE-ELM:** thermally-enhanced ground water and soil vapor remediation
- **TFE Hotspot:** pneumatic fracturing to increase subsurface permeability
- **T5475:** tritium & VOCs in ground water
- **TFC:** Zero-Valent Iron (ZVI) emplacement

In situ bioremediation test at former Helipad area

Ground Water circulation system



C_2HCl_3
TCE

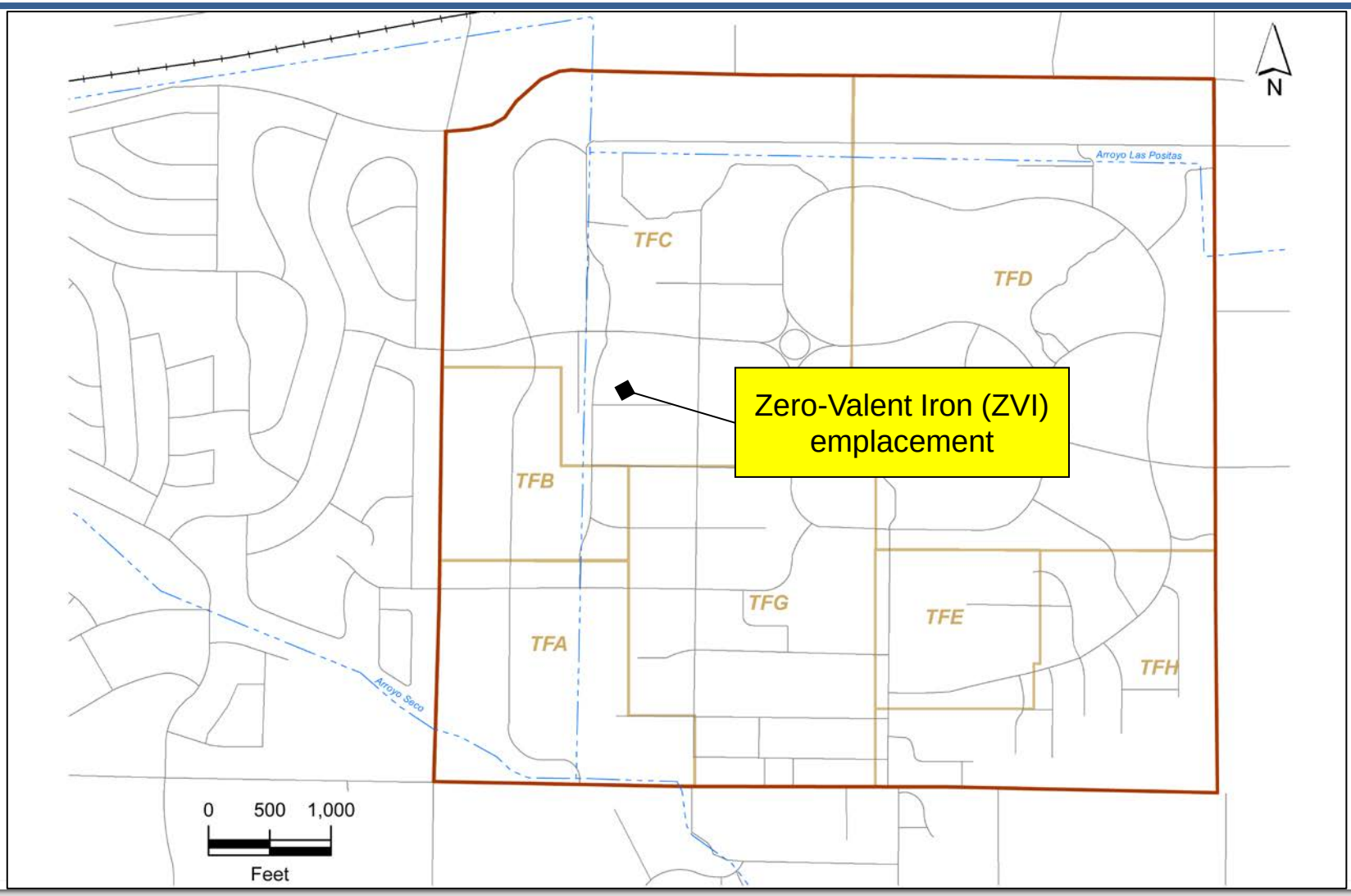
$C_2H_2Cl_2$
1,2-DCE

C_2H_3Cl
Vinyl Chloride

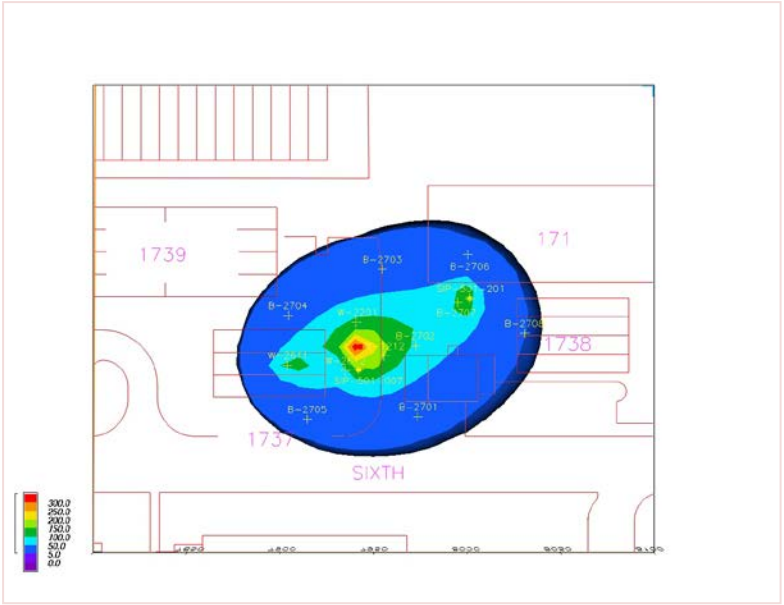
C_2H_4
Ethene

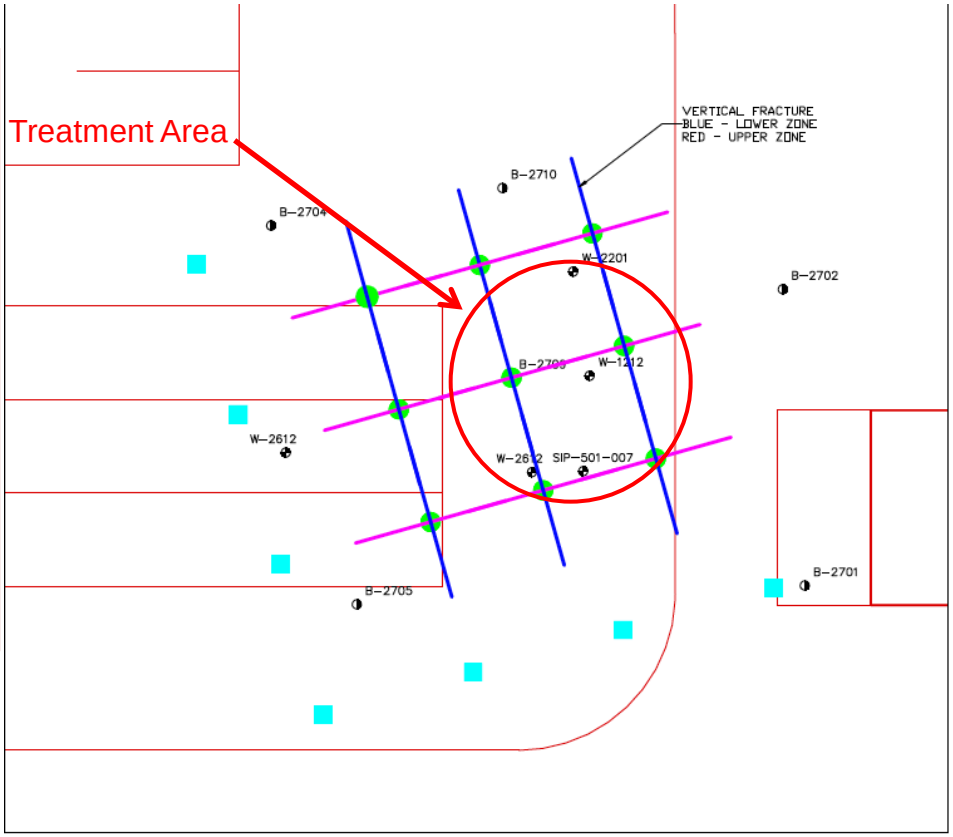
- Ground water extracted from four corner wells and re-injected into the center well
- Nutrients and microbes added to the re-injected ground water to destroy VOCs *in situ*

Zero-Valent Iron (ZVI) Emplacement - 2014



ZVI Dual-Azimuth Emplacement at TFC Hotspot Source Area





LEGEND

- ZVI-PRB RESISTIVITY STRING LOCATION AND DESIGNATION (4 TOTAL)
- ZVI-PRB HYDRAULIC FRACTURE WELL LOCATION AND DESIGNATION (6 TOTAL)
- MULTI-AZIMUTH RESISTIVITY STRING LOCATION AND DESIGNATION (7 TOTAL)
- MULTI-AZIMUTH HYDRAULIC FRACTURE WELL LOCATION AND DESIGNATION (9 TOTAL)
- B-2705 PREVIOUSLY INSTALLED SOIL BORING
- W-1212 EXISTING MONITORING WELL

OPTION #2
CONCEPTUAL MULTI-AZIMUTH INSTALLATION LAYOUT

15' 0' 15'

Cross-Linked Gel with Suspended ZVI

ZVI Emplacement using injection wells

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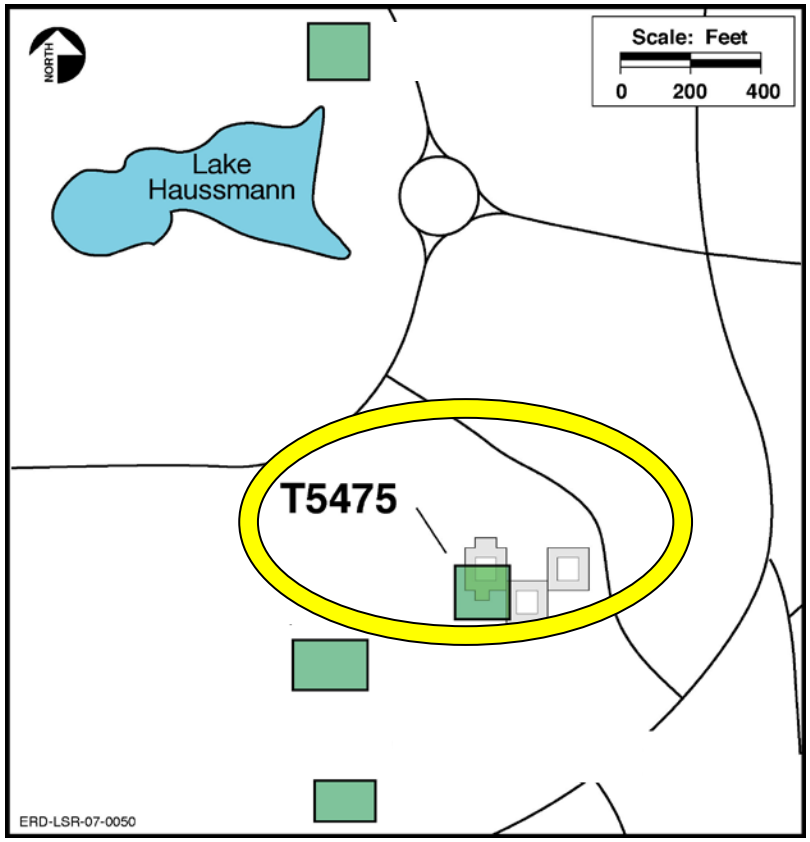

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