Federal Remediation Technologies Roundtable General Meeting

Case Study: NDMA Treatment at NASA White Sands Test Facility

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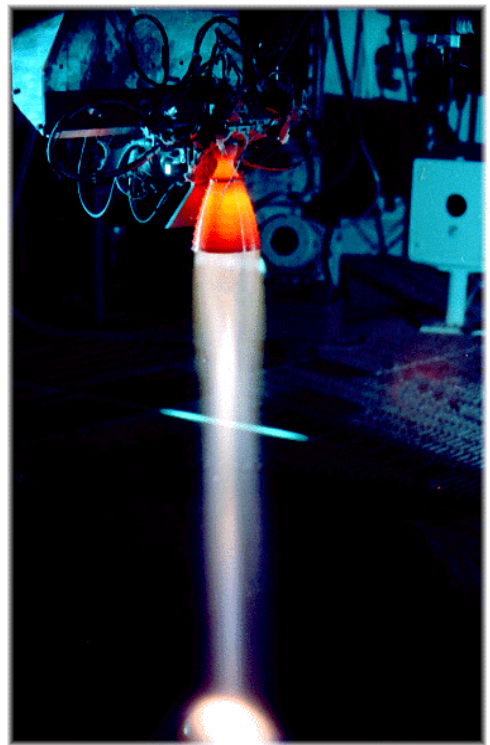
Outline

- History of groundwater contamination at WSTF
- Health risk of NDMA
- Analytical methods for NDMA
- Treatment standards
- Description of plume
- WSTF pump-and-treat system
- NDMA treatment results
- Future Plans

Introduction

- WSTF groundwater has been contaminated as a result of historical rocket engine testing operations.
- Contaminants of concern:
  - N-Nitrosodimethylamine (NDMA)
  - N- Nitrodimethylamine (DMN)
  - Trichloroethene (TCE)
  - Tetrachloroethene (PCE)
  - Several Freon compounds



Origins of NDMA Contamination

- Rocket fuels used at WSTF included Aerozine-50 (A-50)
  - Blend of 50% hydrazine, 50% unsymmetrical dimethyl hydrazine (UDMH).
- Treatment of Aerozine-50, followed by discharge to grade.
- Discharges occurred from the 1960s to the early 1970s.

Origins of NDMA Contamination

- Sources of waste A-50:
  - Purging of fuel lines
  - Decon water
  - Off-spec fuel

- Unreacted NDMA from synthesis of UDMH
- Waste A-50 was diluted with water, treated with calcium hypochlorite, then discharged to grade.

Initial Discovery of NDMA at WSTF

- WSTF initially screened groundwater samples with RCRA Appendix IX analytical Method 8270
- Method 8270: NDMA detection limit = 10,000 ppt
- In 1987, ~ 15,000 ppt NDMA was detected in two WSTF monitoring wells

Modified Method 607 NDMA Analysis

- WSTF worked with Southwest Research Institute (SwRI) to improve the detection limit of Method 607.
- SwRI modified Method 607 by using a GC with mass spectrometer as a detector.
- This modification is allowed by the Method 607 procedure.
- WSTF uses this method for known high concentration NDMA in groundwater and treatment system influent.

SwRI Low-Level NDMA Analysis

- At NASA's request, SwRI developed a low-level analytical method using:
  - High resolution gas chromatograph
  - High resolution mass spectrometer
  - Deuterated internal standards
- This method has been approved for use in California by the California Department of Health Services (CalDHS).
- NMED has approved of our use of CalDHS's criteria for selecting an alternative NDMA analytical method.
- WSTF uses this method for treatment system effluent.

Comparison of NDMA Analysis Methods

Method	Technology	MDL (ppt)
8270	GC/MS	10,000
8070	GC-NPD	150
607	GC-NPD	150
607 modified	GC/MS	5
NDMA-LL	HRGC/HRMS	0.2
521	SX/GC/MS/MS	0.28

Cancer Risk of NDMA

- EPA classifies NDMA as a probable human carcinogen.
- NDMA Oral Slope Factor = 51 $(mg/kg/day)^{-1}$

  ~ 100 times greater than TCE & PCE
- Using EPA exposure assumptions, 1.7 ppt NDMA = 1 x 10^{-6} cancer risk.
- NMED health risk guidance uses a 6-yr child exposure, followed by 24-yr adult exposure. Using this guidance, 1.3 ppt NDMA = 1 x 10^{-6} cancer risk.

Cancer Risk of NDMA at Various MDLs

Method	Detection Limit (ppt)	30-Year Adult Cancer Risk	6-Year Child, 24-Year Adult Cancer Risk
8270	10,000	5.9×10^{-3}	7.6×10^{-3}
8070	150	9.0×10^{-5}	1.1×10^{-4}
607	150	9.0×10^{-5}	1.1×10^{-4}
Mod. 607	5	3.0×10^{-6}	3.8×10^{-6}
NDMA-LL	0.2	1.2×10^{-7}	1.5×10^{-7}

Treatment Standards

- NMED set treatment standards for NDMA & DMN at 10 ppt (using Method 607).
- NMED also has a cumulative cancer risk standard of 1×10^{-5}
  - NDMA, DMN, TCE, and PCE contribute to cumulative cancer risk.
  - This forces WSTF to treat NDMA to much less than 10 ppt.

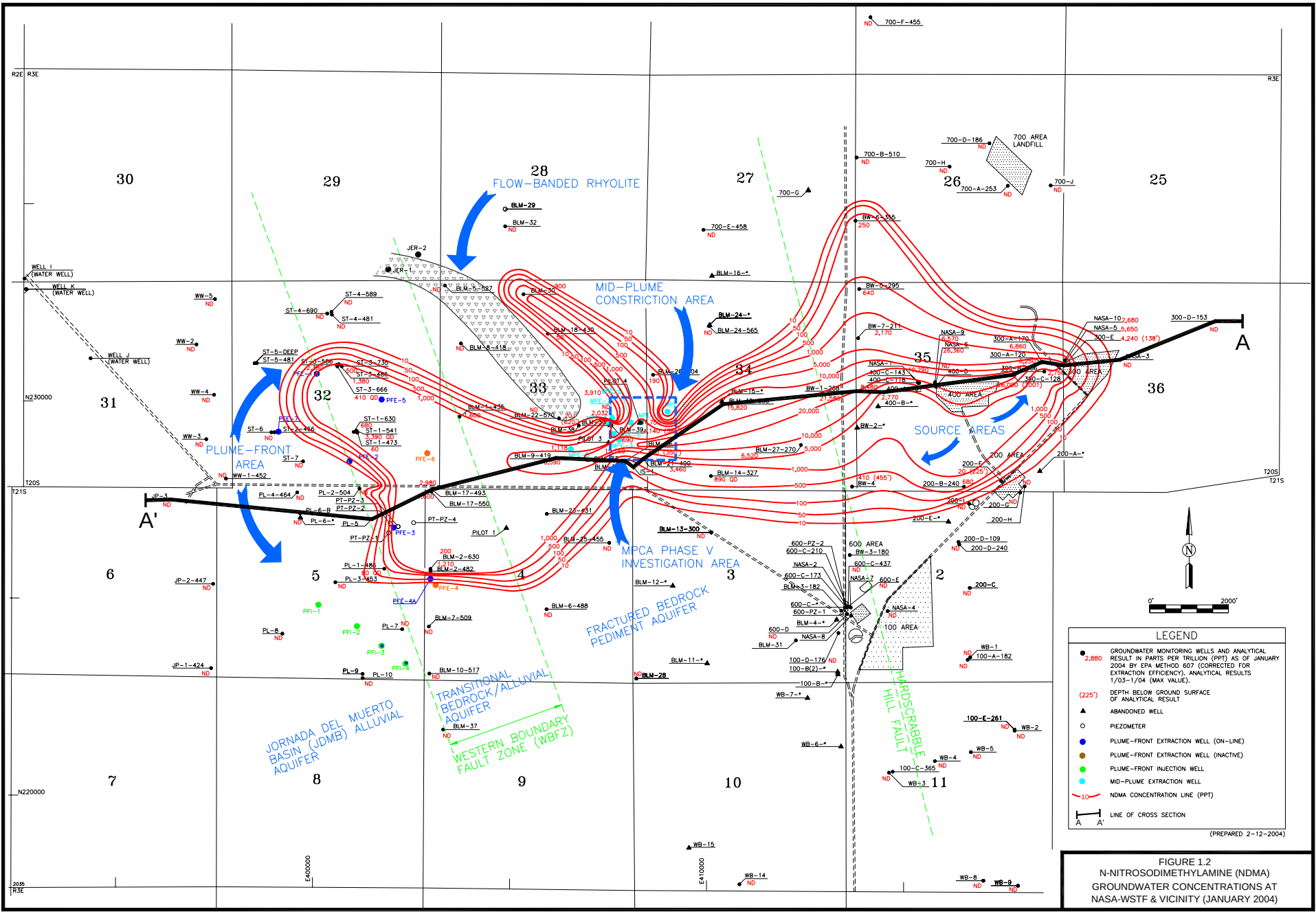


FIGURE 1.2
N-NITROSODIMETHYLAMINE (NDMA)
GROUNDWATER CONCENTRATIONS AT
NASA-WSTF & VICINITY (JANUARY 2004)

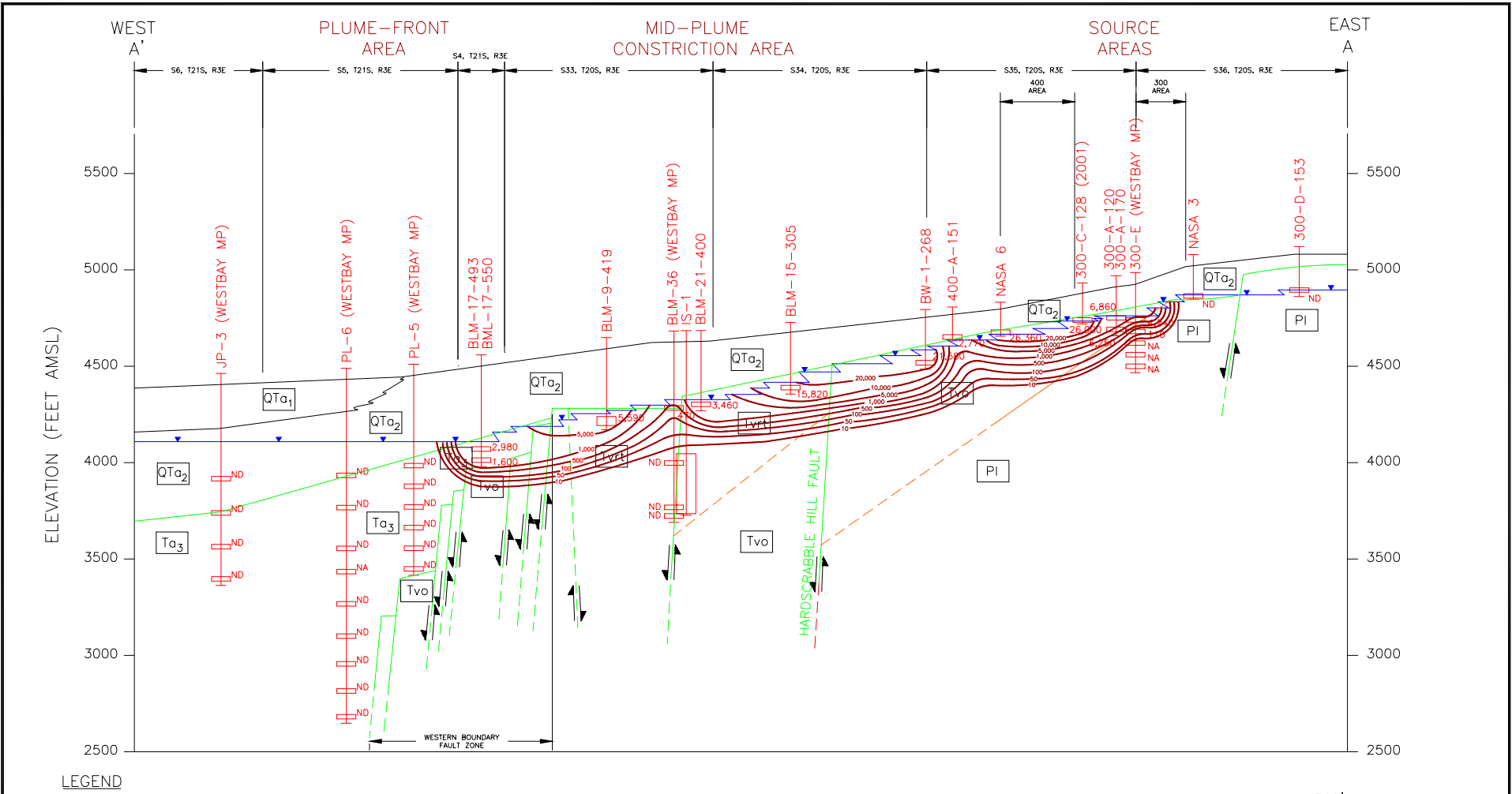


FIGURE 1.3
HYDROGEOLOGIC CROSS-SECTION A-A' SHOWING WELL CONFIGURATIONS & NMDA CONCENTRATIONS

Plume-Front Treatment System

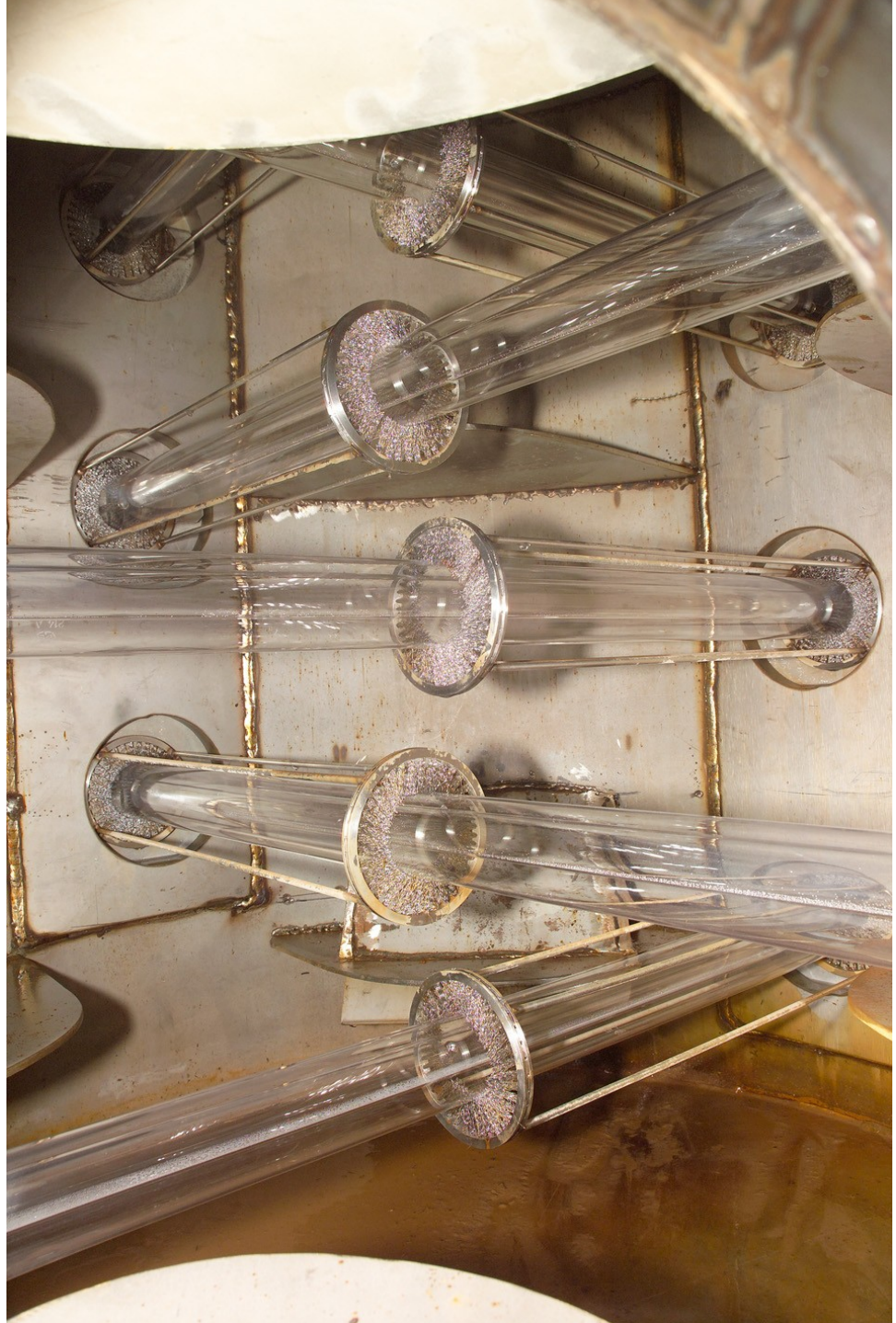
- Six extraction wells, with total design flowrate of 1,076 gpm
- Dual-wall HDPE pipeline (untreated water)
- Treatment facility
  - Two sieve tray air strippers in parallel
  - Filtration to remove particulate / turbidity > 1 µm
  - One UV oxidation reactor

Plume-Front Treatment System

- Single-wall HDPE pipeline (treated water)
- Four injection wells
- System designed for unattended operation
  - SCADA system monitors flowrate at each well, operation of treatment equipment, leak detection cable in dual-wall pipe
  - Alarm or system shutdown if problem is detected

Calgon UV Reactor in Bldg. 650

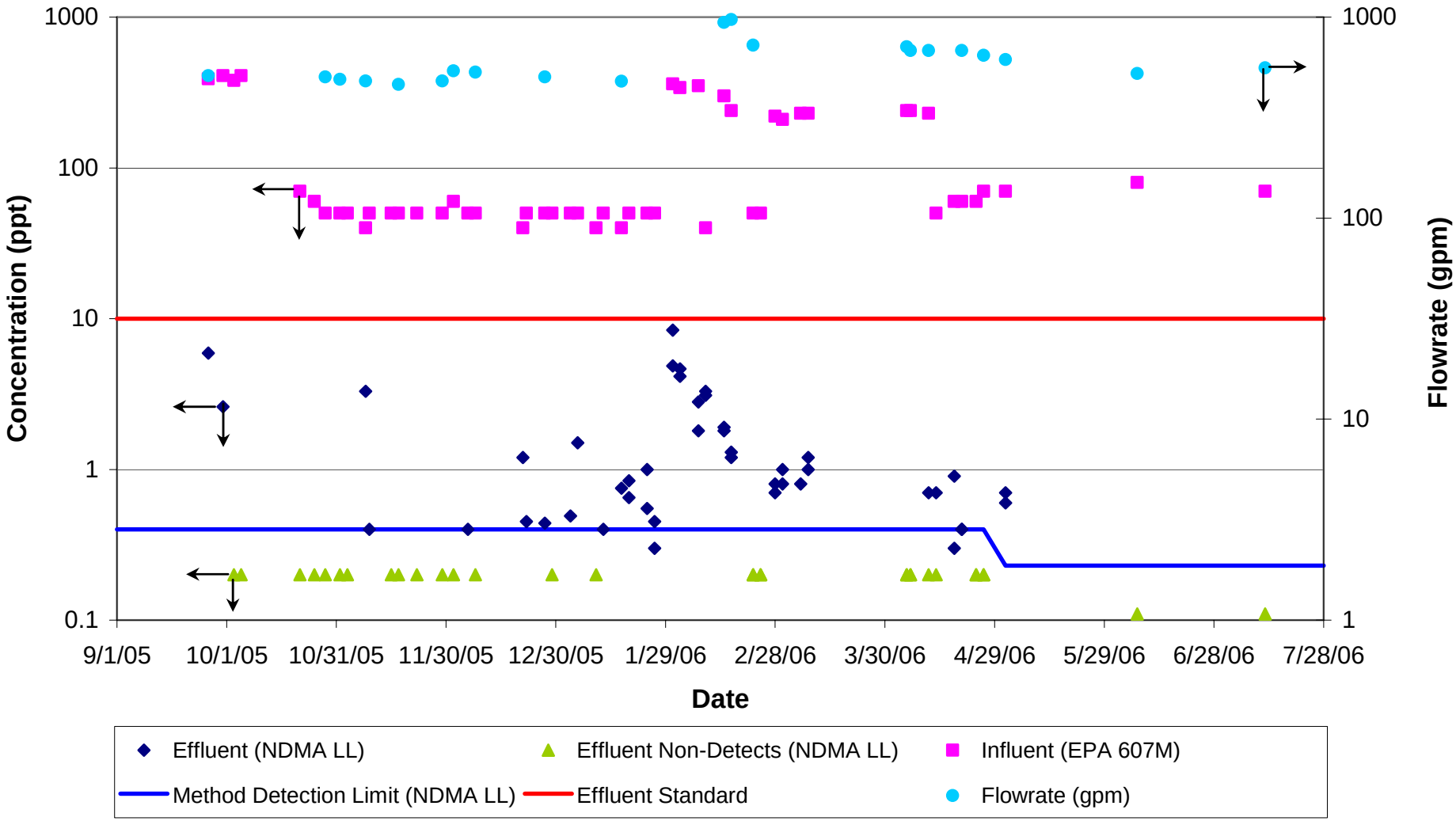
UV Reactor Internals



Current Status

- Total Design & Construction Cost: ~$9 M
- Injection well rehab & shakedown testing from Sept. 2004 thru Sept. 2005
- Operation from Sept. 2005 thru Aug. 2006
  - Currently shut down for injection well rehabilitation, and changes to injection piping

NDMA Concentrations and System Flowrate
September 2005 - July 2006



Cumulative Cancer Risk

	Influent	Effluent
May 2006	3.6×10^{-3}	8.7×10^{-6}
June 2006	3.5×10^{-3}	8.3×10^{-6}
July 2006	3.3×10^{-3}	8.3×10^{-6}

Future Plans

- Design & install treatment system for mid-plume area
- Continue investigation of source areas
- Follow developments in NDMA remediation and analytical technology

Conclusions

- Cancer risk of NDMA is the driving force behind remediation of WSTF's groundwater.
- Due to its chemical properties and cancer risk, NDMA is difficult and expensive to measure and treat.