

MAROS Optimization Case Studies

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Groundwater Services, Inc.

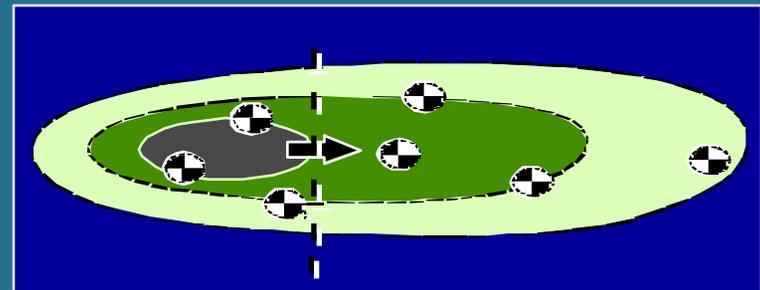


LTMO

Monitoring And Remediation Optimization Software

- Conceptual Model

- Site Characterization and Remedial Decision complete
- Distinct Source and Tail
- 2-Dimensional
- Groundwater flow in one direction
- >4-6 Sample events



MAROS

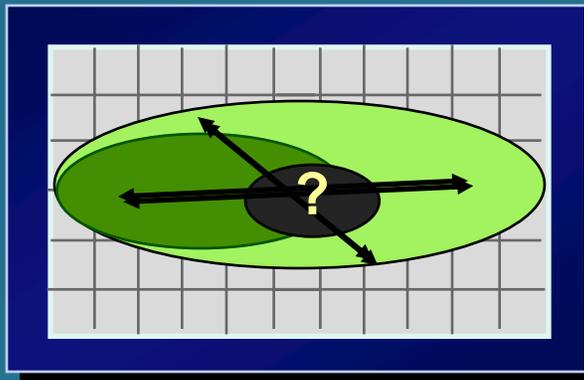
- **General Objectives**

- Determine overall plume stability
- Evaluate concentration trends
- Remove redundant wells without information loss
- Add new wells where uncertainty is high
- Sampling frequency recommendations
- Compare with current monitoring status

Case Studies

- Tinker AFB

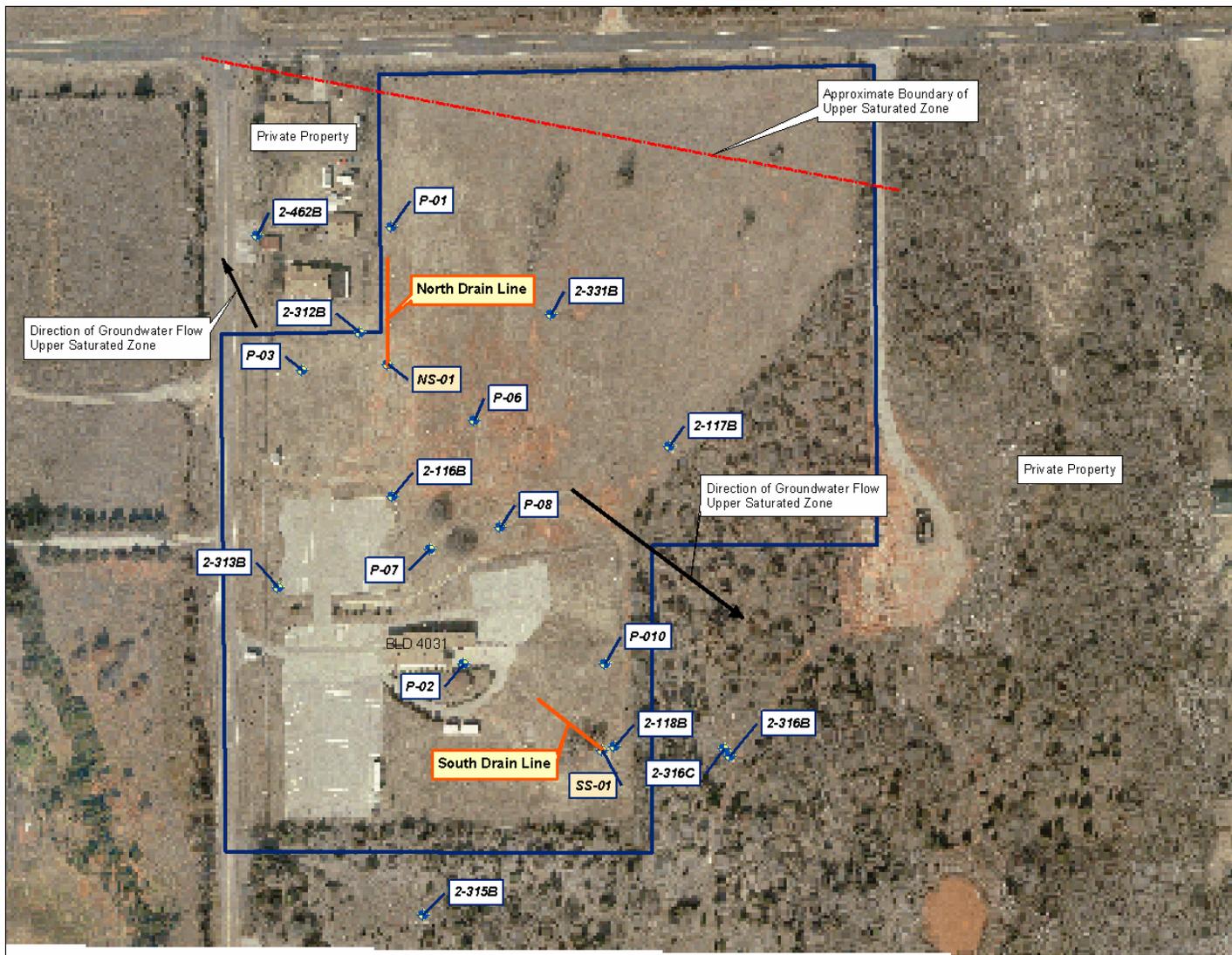
- No Definite Source
- Radial Groundwater flow
- Multiple units
- Short monitoring history
- Model shows more 'characterization' needed



Approach

- Tinker AFB

- Analyze USZ and LSZ separately
- Assume highest [C] is source
- Assume characterization is done
- Take weight of evidence



N

Legend

- ◆ TinkerUSZWells
- CG040Boundary
- Drain Lines for the USZ
- SS-01 Sump Wells

Map Source: NAD83
State Plane Oklahoma North 3501

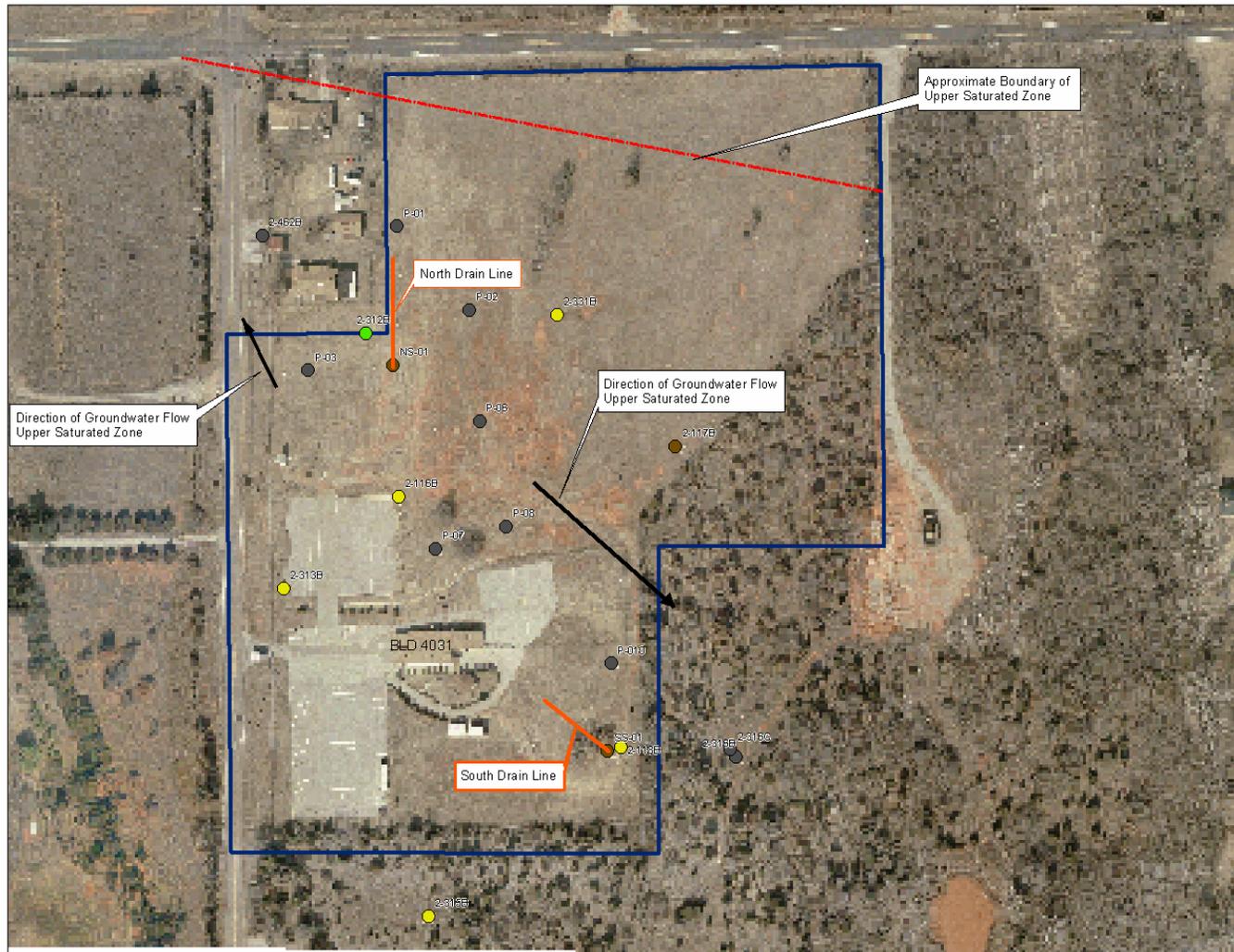
DRAFT

Scale (ft)

0 50 100

GROUNDWATER MONITORING NETWORK
Upper Saturated Zone
Tinker Air Force Base, CG040
Oklahoma City, Oklahoma

CGI/Map No: G-2336-11	Drawn By: M/V
Issued: 10/07/2004	Checked By: M/V
Revised: ---	Approved By: CJN
Scale: As Shown	FIGURE 1a



Legend

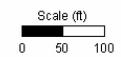
CG040 Boundary

MannKendall

- I
- PI
- S
- PD
- D
- NT
- N/A

Map Source: NAD83
State Plane Oklahoma North 3501

PRELIMINARY DRAFT



TCE MANN-KENDALL TREND RESULTS Upper Saturated Zone Tinker Air Force Base, CG040 Oklahoma City, Oklahoma

OS/ISS No: G-2338-11	Drawn By: M/V
Issue: 09/30/2004	Checked By: M/V
Revised: —	Approved By: CJN
Title: As Shown	FIGURE 5a

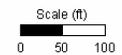


Legend

- CG040 Boundary
- First Moments (Annual Center of Mass)

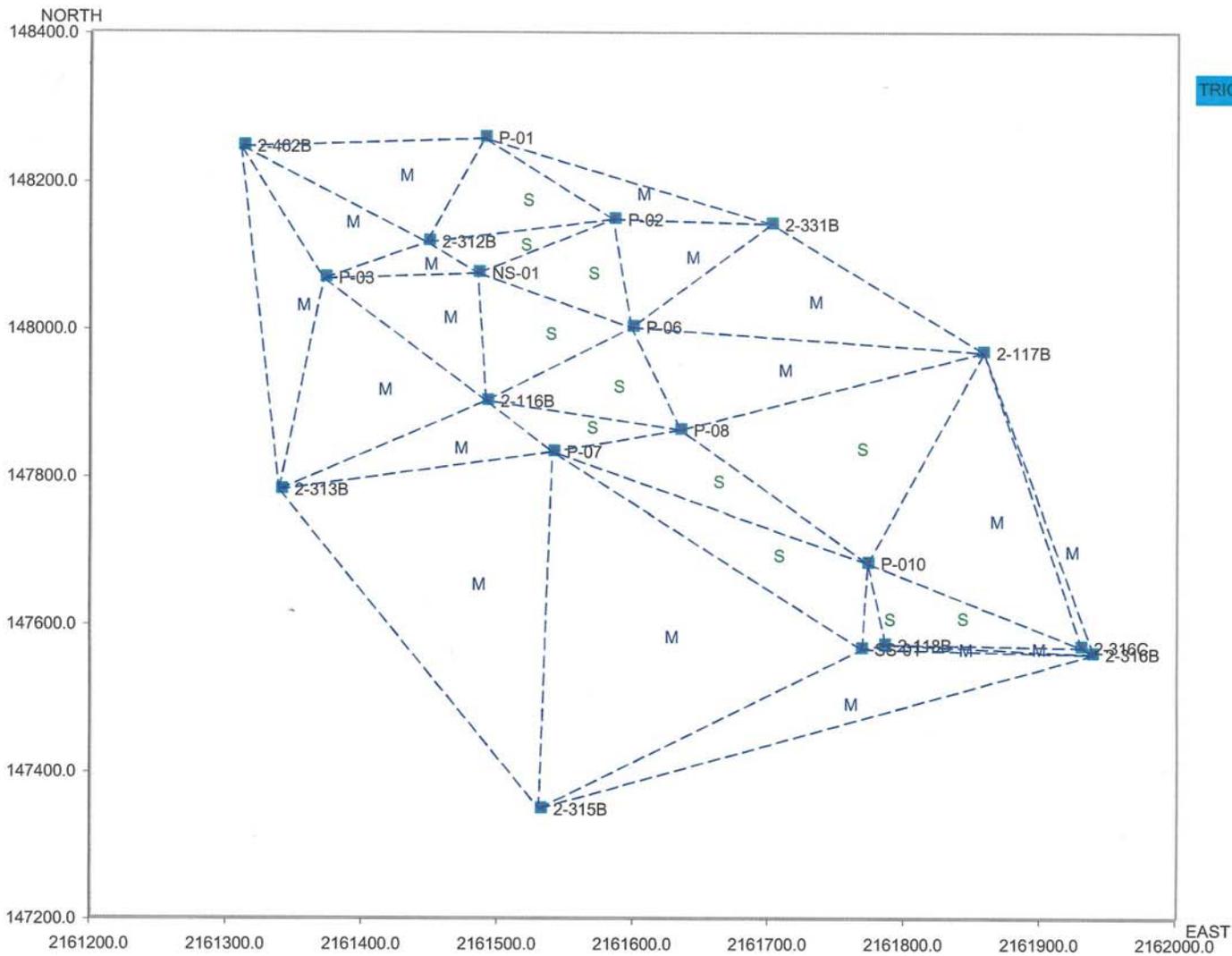
Map Source: NAD83
State Plane Oklahoma North 3501

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TCE FIRST MOMENTS 1999-2003
Upper Saturated Zone
Tinker Air Force Base, CG040
Oklahoma City, Oklahoma

OSLAB#:	G-2336-11	Drawn By:	M/V
Issued:	10/07/2004	Checked By:	M/V
Revised:	---	Approved By:	CJN
Scale:	As Shown	FIGURE 7a	



New Location
Analysis for
TRICHLOROETHYLENE (TCE)

Existing
Locations

Potential areas for
new locations are
indicated by triangles
with a high SF level.

Estimated SF Level:
S - Small
M - Moderate
L - Large
E - Extremely large

High SF -> high
estimation error ->
possible need for
new locations

Low SF -> low
estimation error ->
no need for new
locations

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Results

- Upper Saturated Zone

- Wells with sufficient data mostly Stable to Decreasing concentration trends
- First Moment Stable
- Spread Stable/No Trend
- Two piezometers redundant
- No additional wells
- Annual sampling

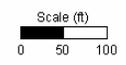


Legend

-  TinkerLSZWells
-  CG040 Boundary
-  LSZ Extraction Well

Map Source: NAD83
State Plane Oklahoma North 3501

DRAFT



GROUNDWATER MONITORING NETWORK
Lower Saturated Zone
Tinker Air Force Base, CS 040
Oklahoma City, Oklahoma

OSLASH: G-2336-11	Drawn By: MMV
Issued: 10/07/2004	Checked By: MMV
Revised: _____	Approved By: CJN
Scale: As Shown	FIGURE 1b

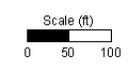


Legend

- CG040 Boundary
- Linear Regression Trend**
- I
- PI
- S
- PD
- D
- NT
- N/A

Map Source: NAD83
State Plane Oklahoma North 3501

DRAFT



**TCE LINEAR REGRESSION TREND RESULTS
Lower Saturated Zone**

Tinker Air Force Base, CG040
Oklahoma City, Oklahoma

CG040 No:	G-2336-11	Drawn By:	MM
Issued:	10/07/2004	Checked By:	MM
Revised:	---	Approved By:	CJN
Title:	As Shown	FIGURE 6B	



Legend

- CG040 Boundary
- First Moments LSZ (Annual Center of Mass)

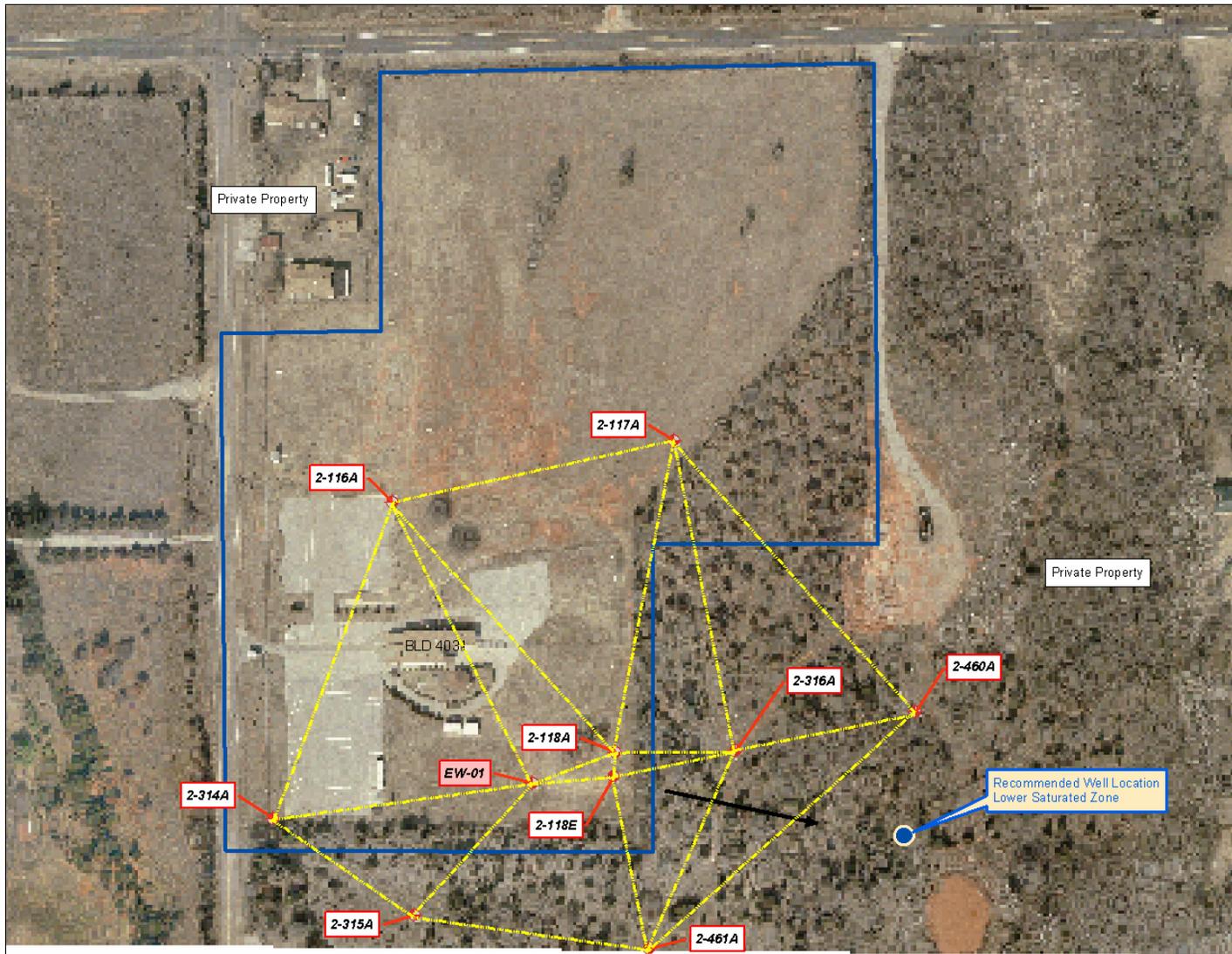
Map Source: NAD83
State Plane Oklahoma North 3501

DRAFT

Scale (ft)
0 50 100

**TCE FIRST MOMENTS 1999-2003
Lower Saturated Zone**
Tinker Air Force Base, CG040
Oklahoma City, Oklahoma

CLAIM No:	G-2336-11	Drawn By:	MV
Date:	10/07/2004	Checked By:	MV
Drawn:	---	Approved By:	CJN
Title:	As Shown	FIGURE 7b	

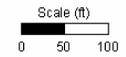


Legend

- TinkerLSZWells
- CG040Boundary
- LSZ Extraction Well
- Tinker Well Network
- Proposed New Well Location

Map Source: NAD83
State Plane Oklahoma North 3501

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RECOMMENDED NEW WELL LOCATION
Lower Saturated Zone
Tinker Air Force Base, CG040
Oklahoma City, Oklahoma

CSLabs No: G-2336-11	Date By: M/V
Issued: 10/07/2004	Drawn By: M/V
Revised: _____	Approved: CJN
Scale: As Shown	FIGURE 8

Results

- Lower Saturated Zone

- Wells mostly Decreasing except *one downgradient well*
- First Moment No Trend (two centers)
- Spread No Trend
- All wells retained
- New downgradient well
- Annual sampling

Case Studies

- **Wurtsmith AFB**

- Landfill source (many sources)
- Short plume discharging to a lake
- YMCA campground
- Many new wells
- Aesthetic issues
- Stakeholder issues
- Extensive Remediation

Approach

- Wurtsmith AFB

- Rank COCs

- Benzene for toxicity and prevalence
- VC for mobility, TCE just because

- Source is a line

- Evaluate geochemically similar compounds

- 65 ft Saturated thickness treated as one unit

MAROS COC Assessment

Project: Wurtsmith AFB

User Name: MV

Location: Oscoda

State: Michigan

Toxicity:

Contaminant of Concern	Representative Concentration (mg/L)	PRG (mg/L)	Percent Above PRG
BENZENE	2.7E-02	3.9E-04	6784.4%
TRICHLOROETHYLENE (TCE)	2.3E-02	5.0E-03	356.6%
VINYL CHLORIDE	3.4E-03	2.0E-03	71.2%

Note: Top COCs by toxicity were determined by examining a representative concentration for each compound over the entire site. The compound representative concentrations are then compared with the chosen PRG for that compound, with the percentage exceedence from the PRG determining the compound's toxicity. All compounds above exceed the PRG.

Prevalence:

Contaminant of Concern	Class	Total Wells	Total Excedences	Percent Excedences	Total detects
BENZENE	ORG	51	30	58.8%	35
VINYL CHLORIDE	ORG	51	18	35.3%	35
TRICHLOROETHYLENE (TCE)	ORG	51	6	11.8%	21

Note: Top COCs by prevalence were determined by examining a representative concentration for each well location at the site. The total exceedences (values above the chosen PRGs) are compared to the total number of wells to determine the prevalence of the compound.

Mobility:

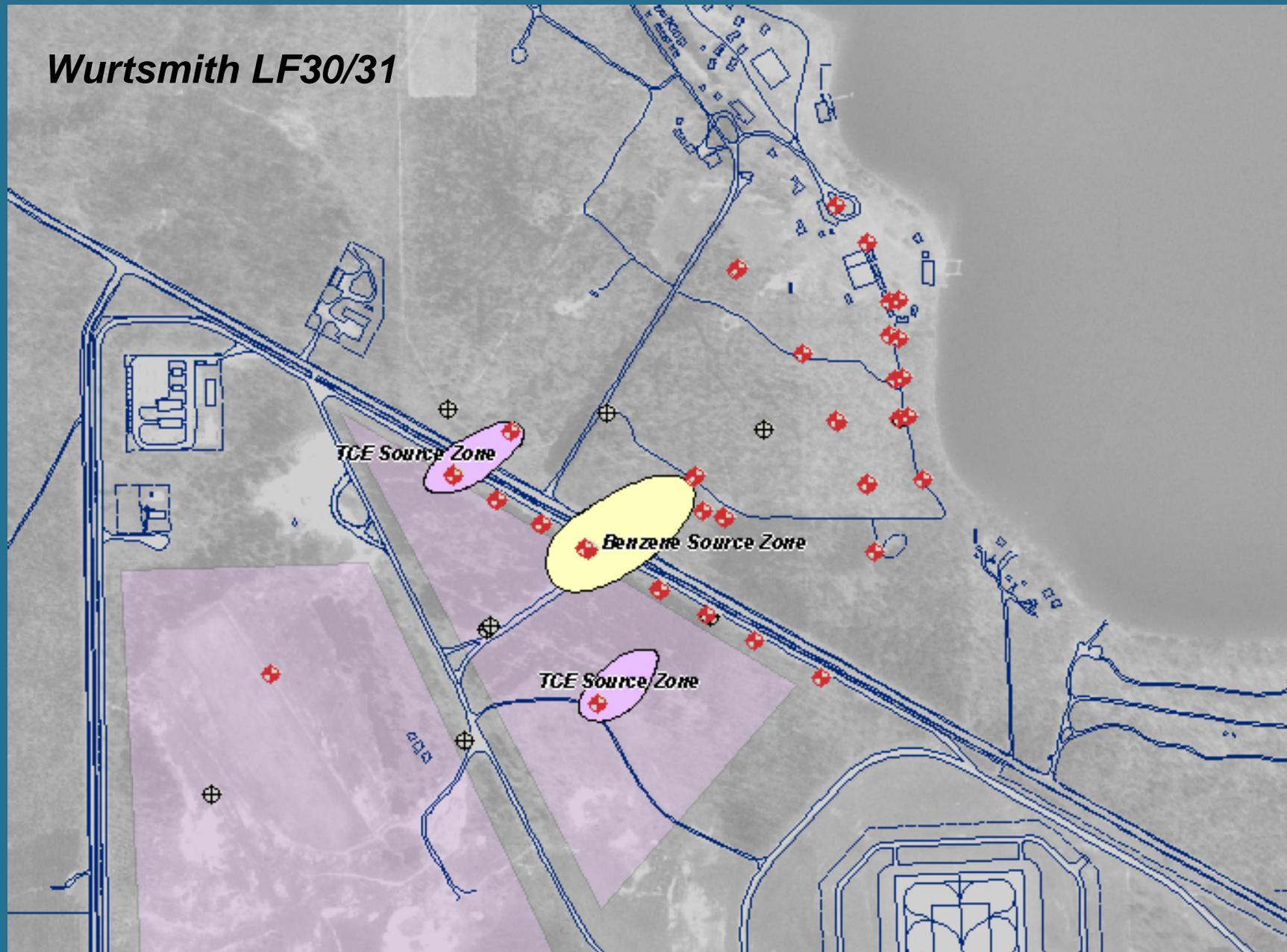
Contaminant of Concern	Kd
VINYL CHLORIDE	0.042
BENZENE	0.0984
TRICHLOROETHYLENE (TCE)	0.297

Note: Top COCs by mobility were determined by examining each detected compound in the dataset and comparing their mobilities (Koc's for organics, assume foc = 0.001, and Kd's for metals).

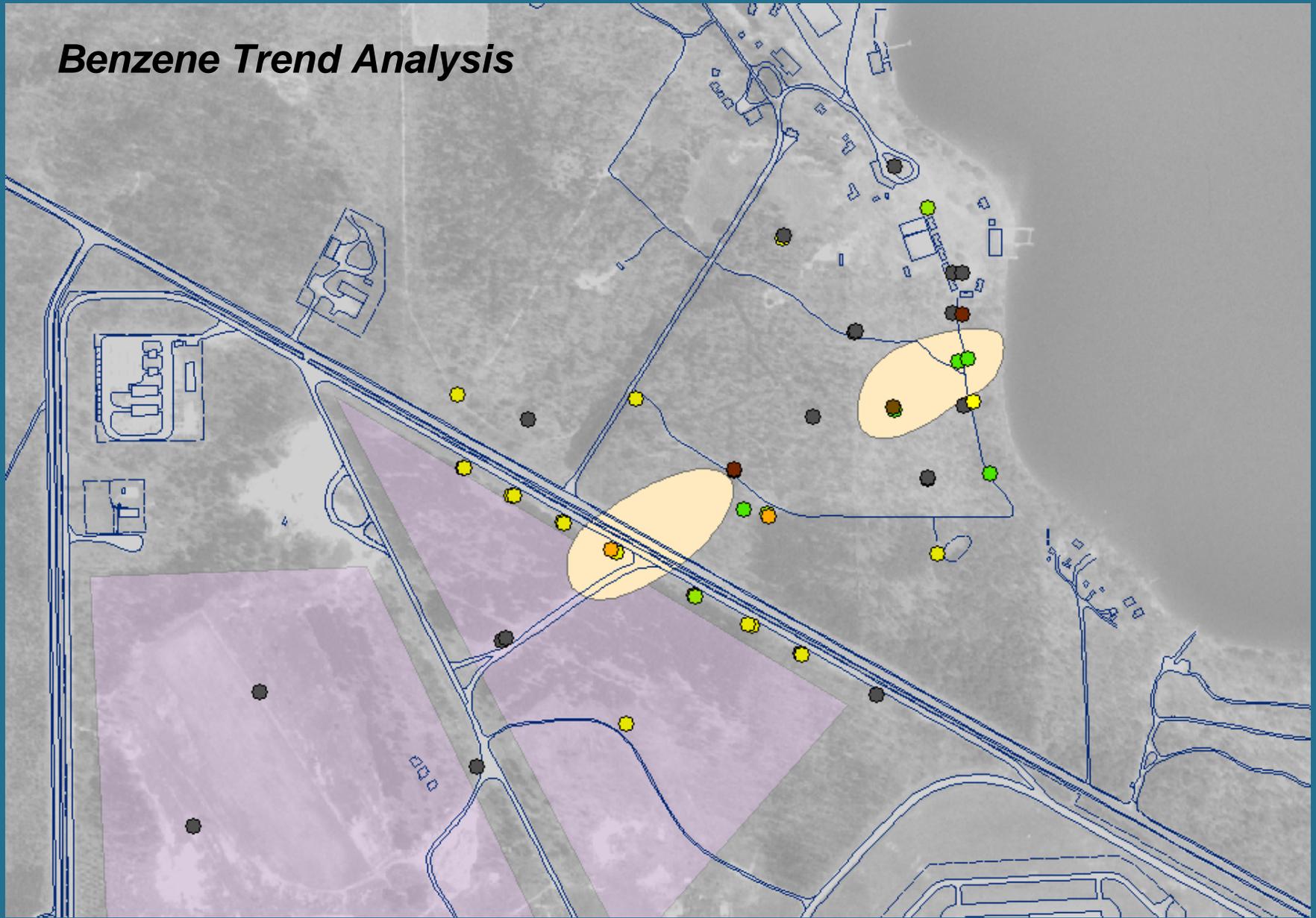
Contaminants of Concern (COC's)

BENZENE
TRICHLOROETHYLENE (TCE)
VINYL CHLORIDE

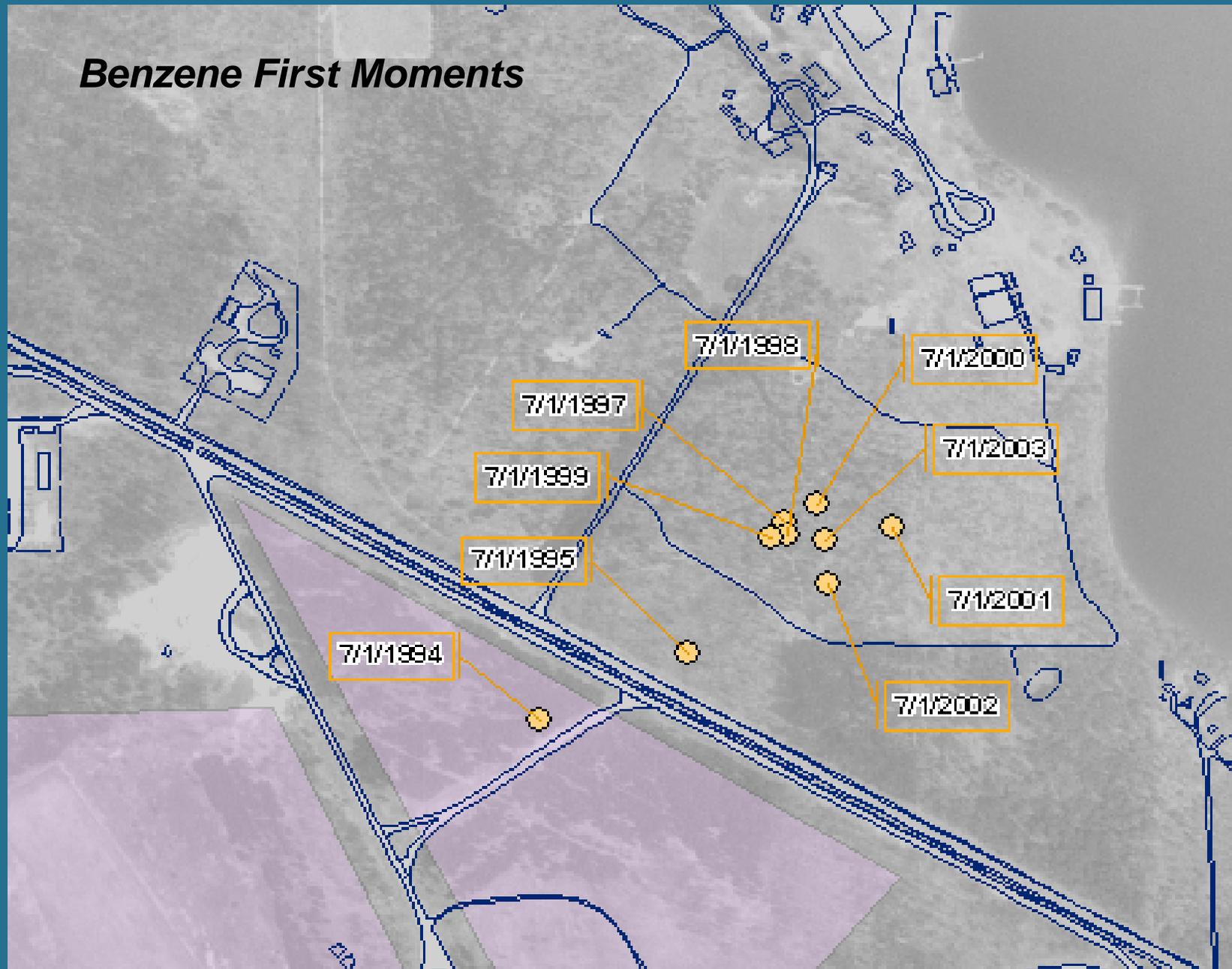
Wurtsmith LF30/31



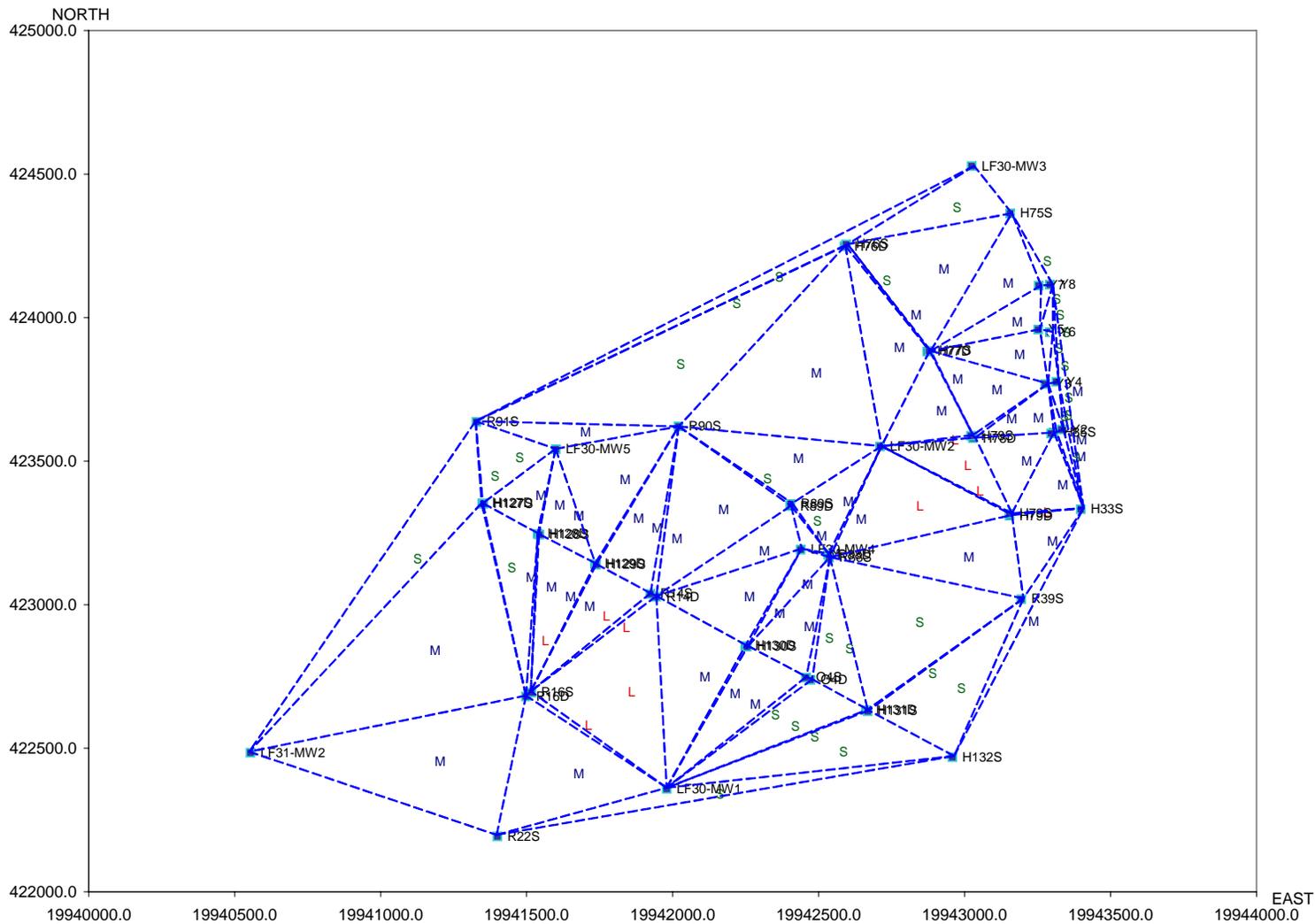
Benzene Trend Analysis



Benzene First Moments



Well Name	Benzene Recommended Frequency Result ⁽³⁾	Vinyl Chloride Recommended Frequency Result ⁽³⁾	TCE Recommended Frequency Result ⁽³⁾	Final Interpreted Result	Comment
H127D	Annual*	Annual*	Annual	Annual	TCE source area
H127S	Annual	Annual*	Annual	Annual	TCE source area
H128D	Biennial	Annual	Biennial	Biennial	
H128S	Biennial	Annual	Biennial	Biennial	
H129D	Biennial	Annual	Biennial	Biennial	
H129S	Annual	Annual	Biennial	Annual	
H130D	Biennial	Annual	Biennial	Biennial	
H130S	Annual	Annual	Biennial*	Annual	
H131D	*	*		Eliminate	
H131S	*	*	*	Eliminate	
H132S	*	*	*	Eliminate	
H33S	Biennial	Annual	Biennial	Annual	Monitoring for vinyl chloride
H35S	Annual	Quarterly	Annual	Annual	Decreasing trend for vinyl chloride
H75S	Annual	Annual	SemiAnnual	Annual	
H76D	Annual	SemiAnnual*	Annual*	Annual	Recommended for removal, kept as compliance point with reduce frequency
H76S	Annual*	SemiAnnual*	Annual*	Annual	Recommended for removal, kept as compliance point with reduce frequency
H77D	Annual	SemiAnnual	Annual*	Annual	Limited history, no TCE detections, benzene and vinyl chloride below MCLs
H77S	Annual	SemiAnnual	Annual*	Annual	Limited history, no TCE detections, benzene and vinyl chloride below MCLs



New Location
Analysis for

BENZENE

Existing
Locations

**Potential areas for
new locations** are
indicated by triangle
with a high SF level

Estimated SF Level:

S - Small

M - Moderate

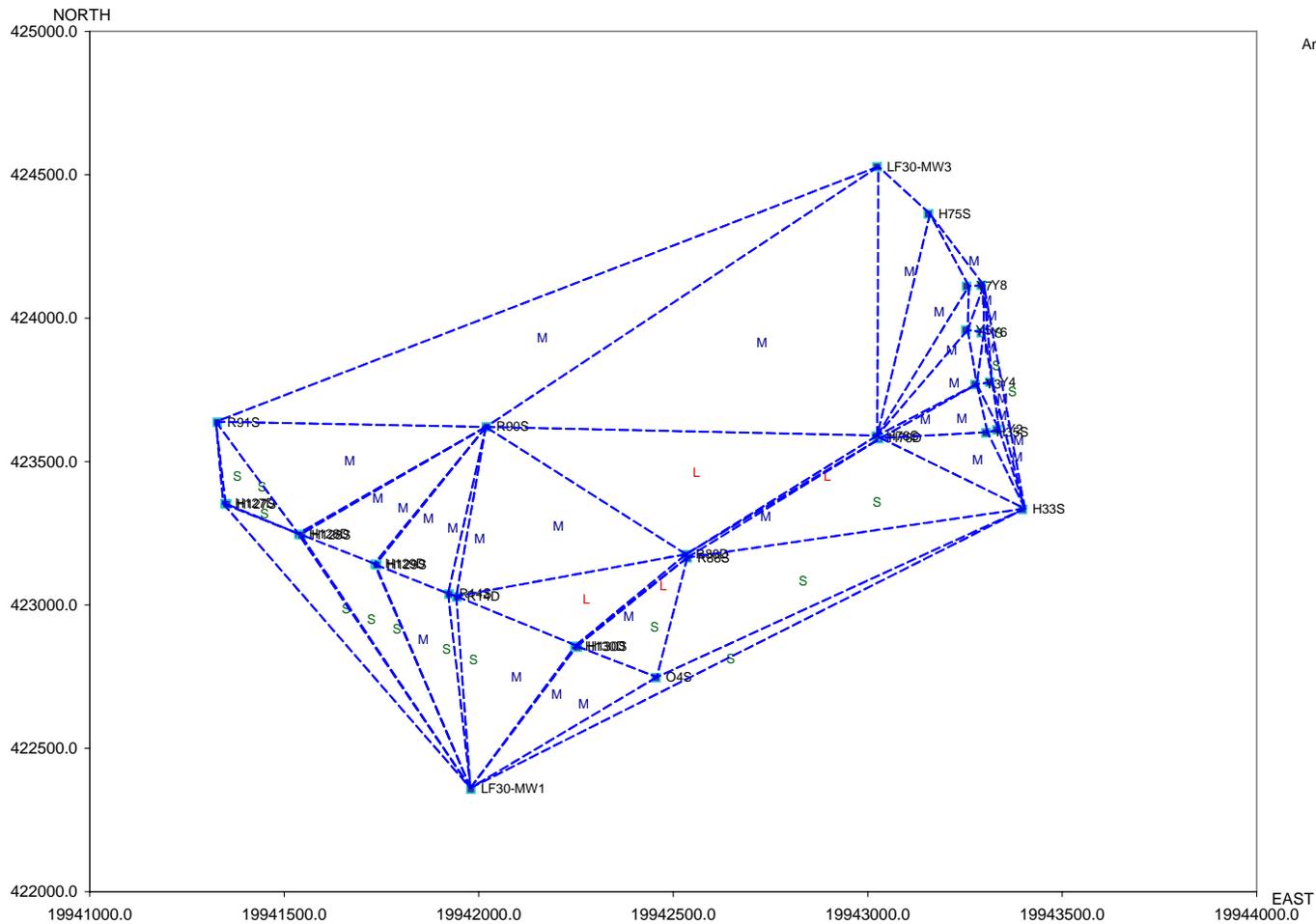
L - Large

E - Extremely large

High SF -> high
estimation error ->
possible need for
new locations

Low SF -> low
estimation error ->
no need for new
locations

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New Location
Analysis for Optimized Netwo

BENZENE

Existing
Locations

Potential areas for
new locations are
indicated by triangle
with a high SF level

Estimated SF Level:
S - Small
M - Moderate
L - Large
E - Extremely large

High SF -> high
estimation error ->
possible need for
new locations

Low SF -> low
estimation error ->
no need for new
locations

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Results

- Wurtsmith AFB

- 3 distinct COC plumes
- Trends mainly Stable to Decreasing
- First Moments Increasing before remediation, Stable to Decreasing after
- Increasing Second Moments (wider more dilute)
- Remove 8 wells from the program

Results

- Wurtsmith AFB

- Average of 41 samples annually
 - 7 Semi-annual
 - 24 Annual
 - 6 Biennial
- Original recommendation 94 sample annually
- Savings of \$53,000/yr

Summary

- The perfect site does not exist
- Weight of evidence approach
 - Concentration trends
 - Moment analysis
 - Mesh evaluation
 - Frequency evaluation
 - Statistical Power Analysis
- Balance temporal and spatial sampling