

Headquarters U.S. Air Force

Integrity - Service - Excellence

Overview of Air Force Long-Term Monitoring Optimization Programs and Case Studies



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AFCEE/BCE
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Overview

- Opportunities
- AFCEE optimization tools
- Process
- Resource requirements
- Case studies
- Outreach & training



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Why Optimize?

- Air-Force wide network is about 35,000 Wells
- Corporately expensive to monitor
 - 35,000 wells x \$1500 per event = \$52.5M
 - Some installation O&M programs >\$2M per year
- Most data is not used for decision support
- Data redundancy
 - Number of wells
 - Frequency of sampling events
- Need *formal* mechanism to reduce redundancy and identify essential data



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Opportunities

- Reduction in monitoring 20 – 60%
- Reduces redundancy in data capture
- Provides *independent* analysis
- Supports & justifies O&M budget
- Reasonable costs to accomplish
- Proposal for stakeholders to improve sampling

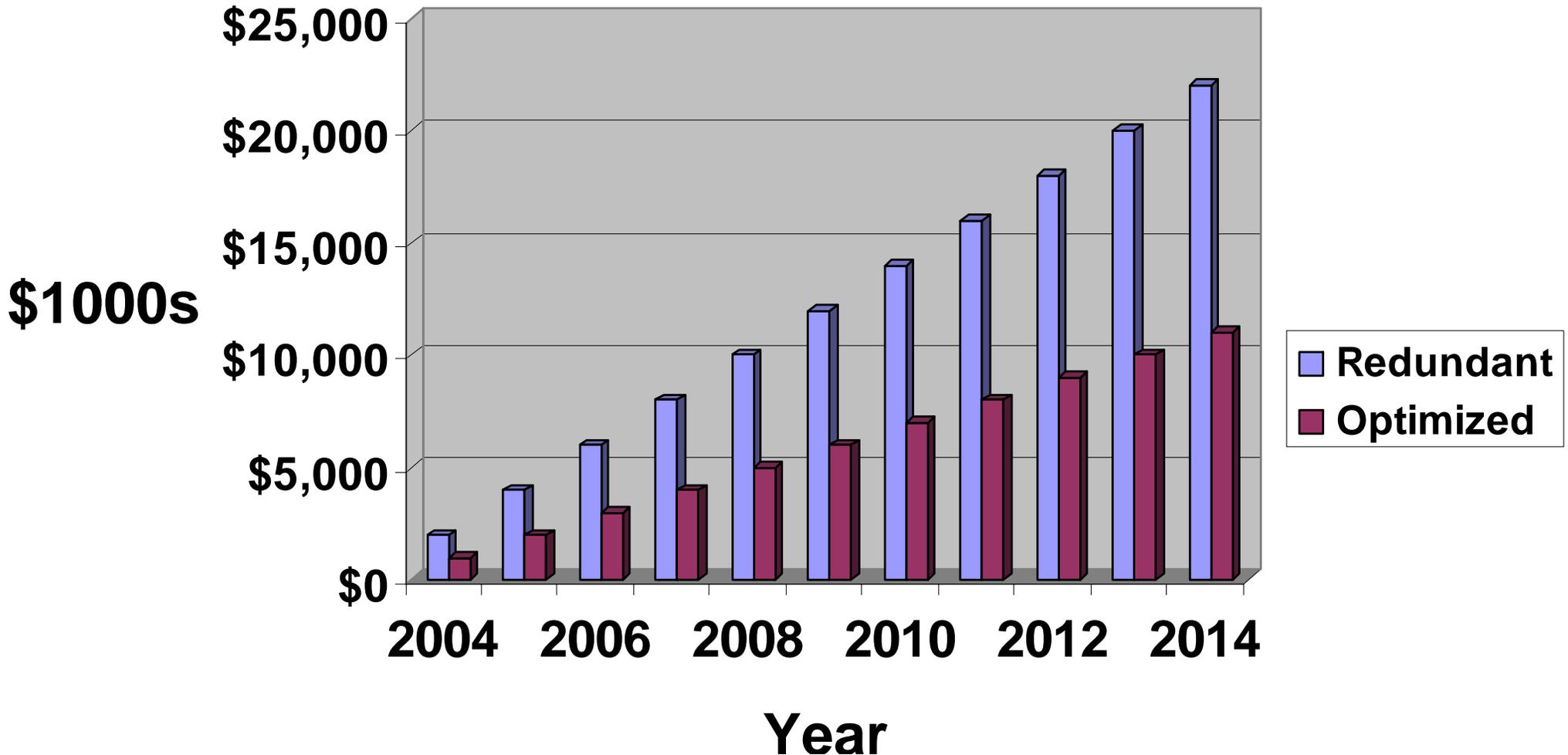


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Cumulative Monitoring Costs

\$2M Annual Program Optimized to \$1M

Air Force Base X





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LTM Monitoring Goals

- **Protect human health & the environment**
- **Sufficient data; avoid “*nice to have*” data**
- ***More than* adequate decision support**
- ***Tolerable* level of *uncertainty* in decision-making without significant information loss**



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LTM Optimization

AF Game Plan

- Develop *robust*, broad-application tools
- Rank & *prioritize* candidate facilities and sites
- *Implement* optimization process across AF
- Develop methods for post-optimization evaluation & *validation*
- Standardize reporting and output----*keep it simple*
- Refine *exit* strategies

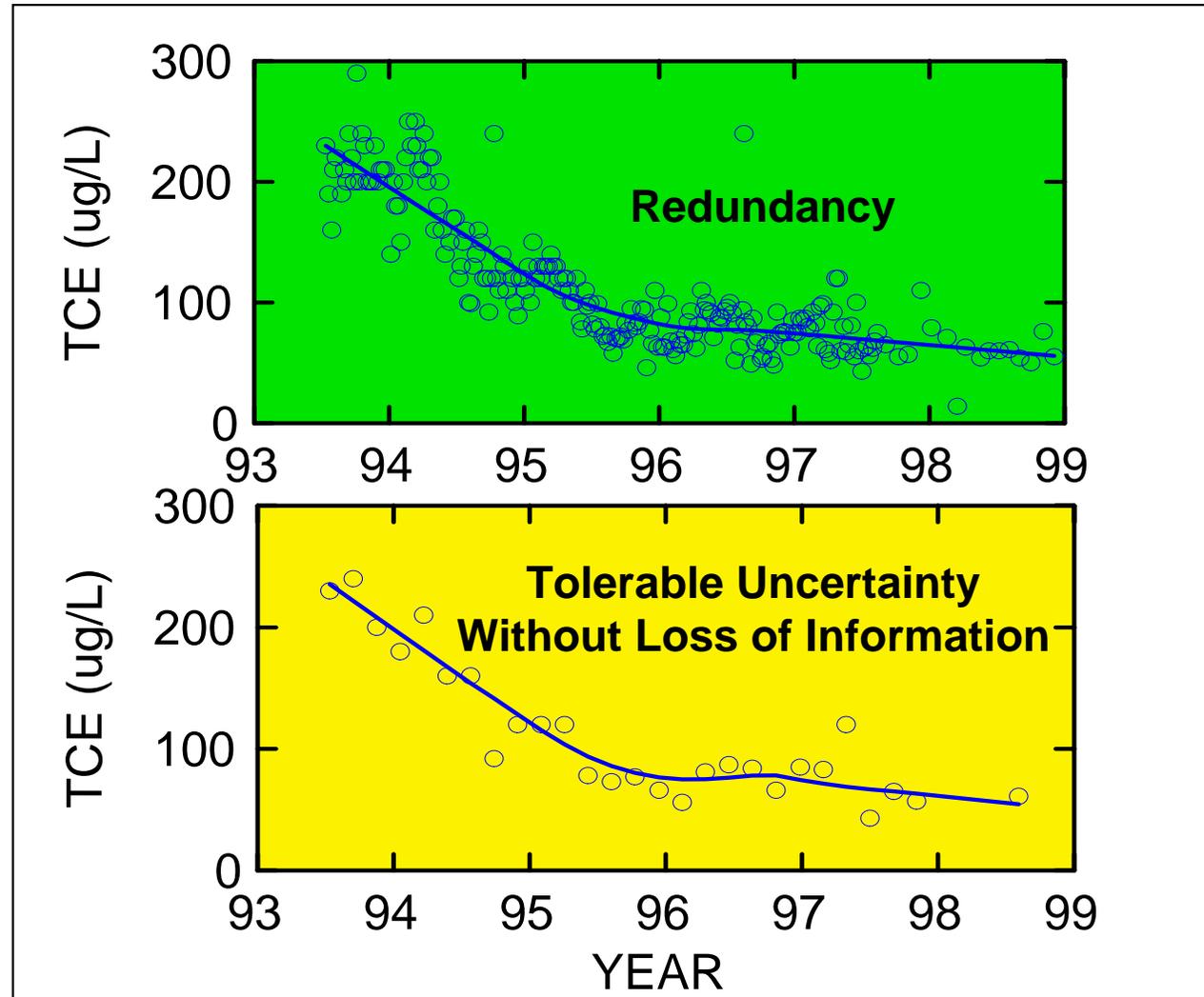


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Optimization Identifies Sampling Redundancy & Essential Data

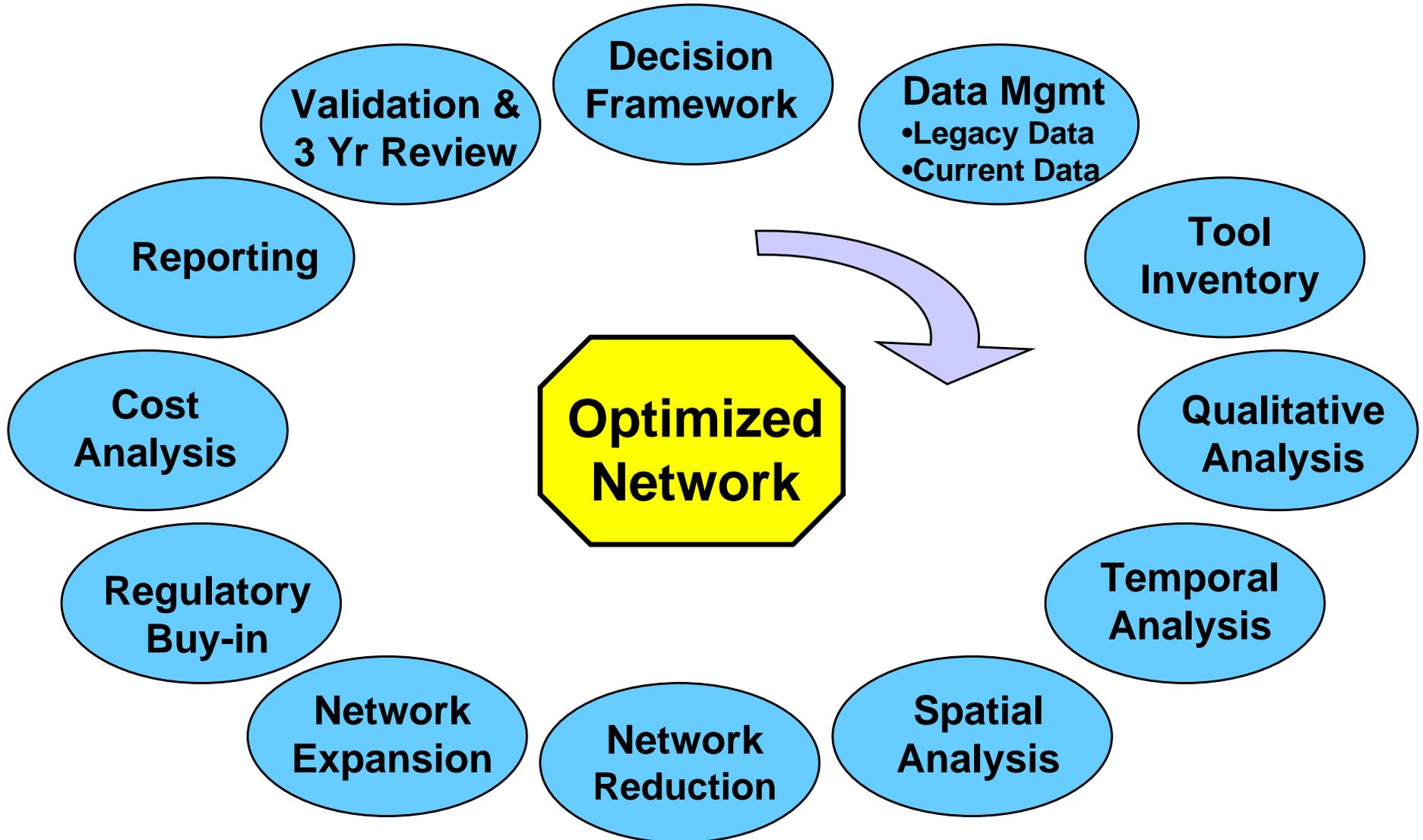
“Nice to have”
All Data
Samples = 240

“Essential”
90% Reduction
Samples = 27





Components and General Process

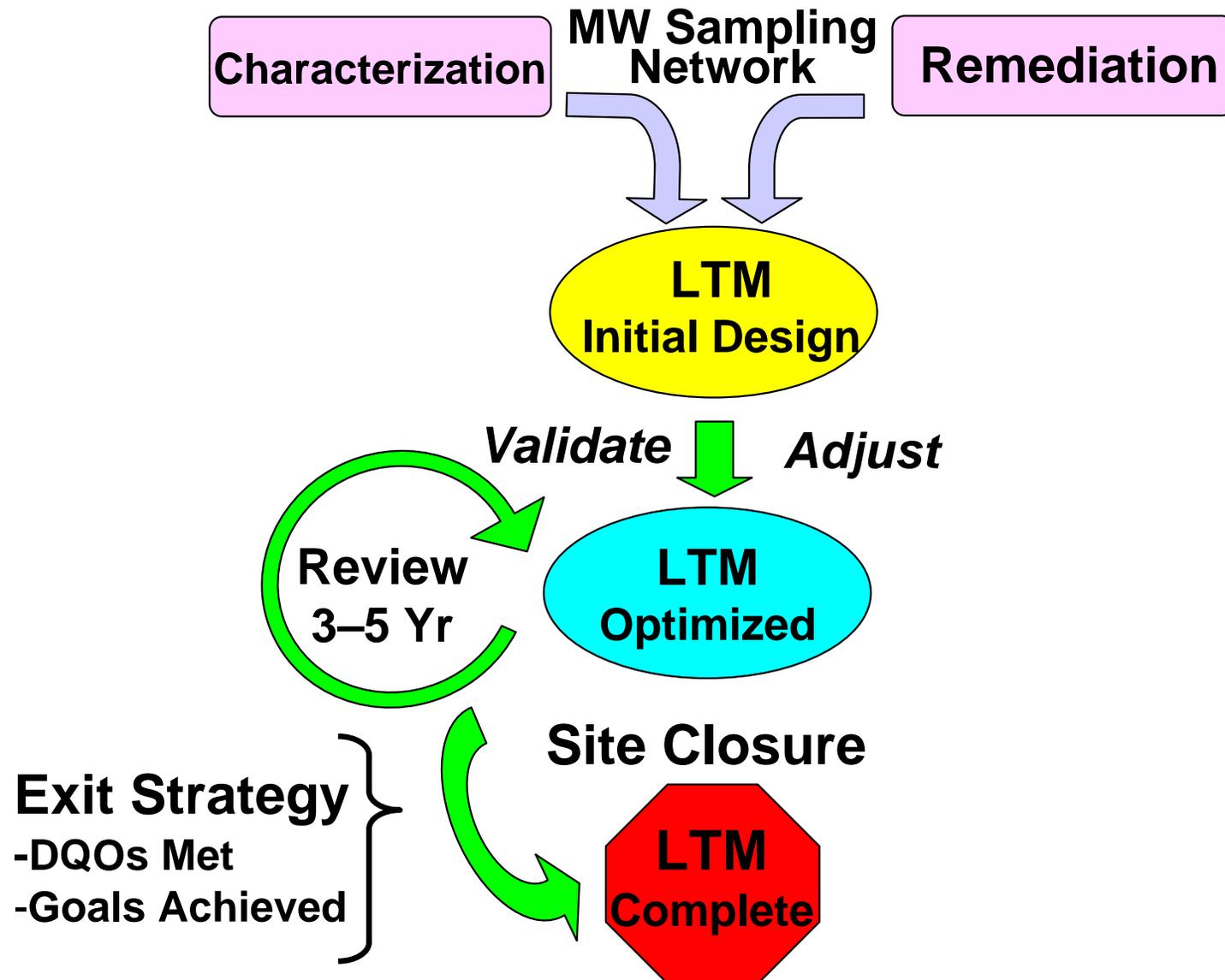




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LTM Optimization

Periodic Review, Adjustments, & Exit Strategy





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Process

- **RPO site visit; inventory of existing network**
- **Identify contaminants of concern (COCs)**
 - **Focus on 3 – 5 constituents**
 - **Need maximum coverage over time & space**
- **Regulatory framework**
 - **Permits**
 - **RODs**
- **Optimization tool selection**
- **GIS coverages**
- **Support from onsite contractors & web-enabled databases**



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Resource Requirements

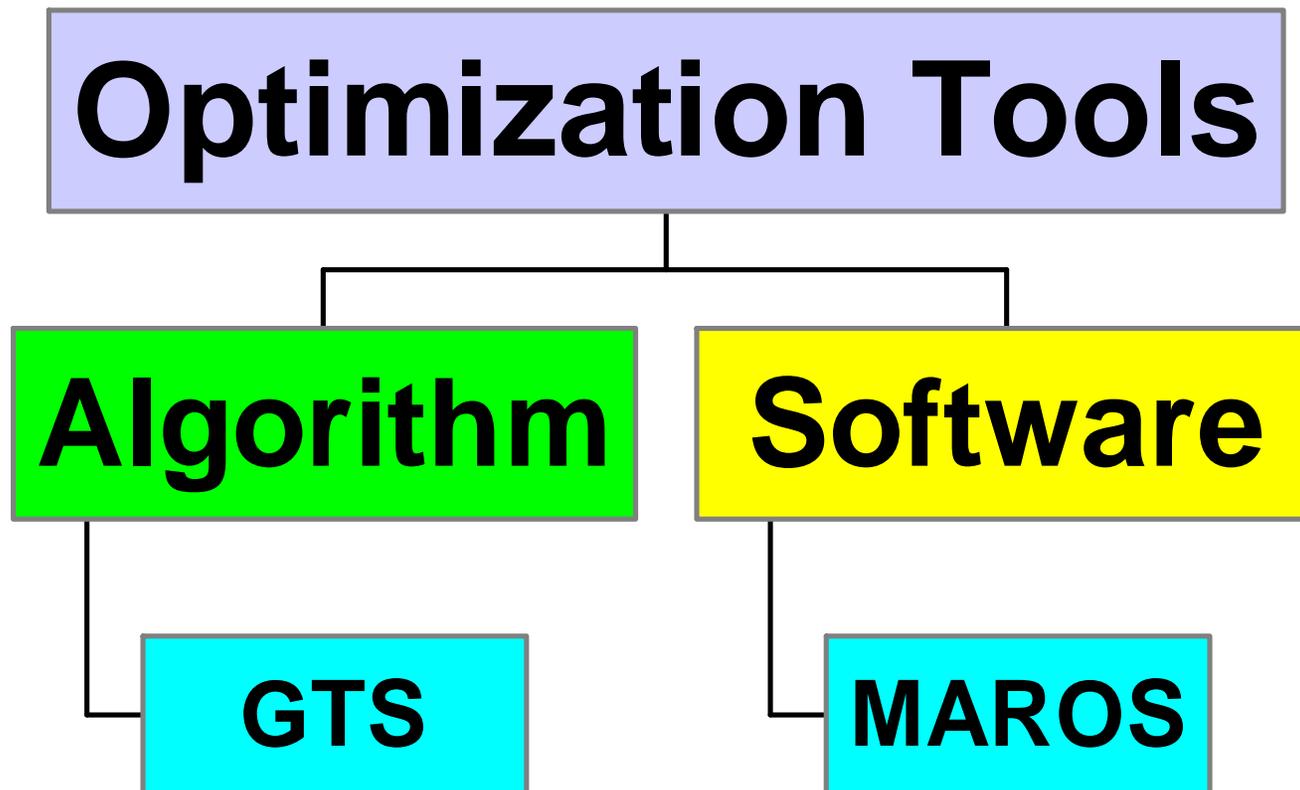
- **Electronic data**
- **Conceptual site model**
- **Contaminant hydrogeology**
- **Funding \$10-35K per site**
- **Entire installation can be > \$200K**
- **Typically < 15% annual O&M budget**



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Optimization Tools

AFCEE





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Other Approaches Are Important

- **Parson's Three-Tiered approach**
- **Intelligent search algorithms and artificial intelligence (AI)**
 - Genetic algorithms
 - Simulated annealing
 - Neural networks
- **AI more practical with increasing computational power**



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Optimization Tools

What Do They do?

- Identify essential sampling locations
- Determine an optimal sampling frequency
- Assess relative importance of individual wells
- But, there is no *purely objective* solution or answer



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Tool Selection

■ GTS

- Minimum no. wells > 30
- Multiple sites and OUs, or individual sites
- Need a geostatistician

■ MAROS

- Site modeled as a distinct plume
 - ◆ Source area known
 - ◆ Plume delineation
 - ◆ Well categories respective of plume
- Handles large sites or networks < 40 wells



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Information

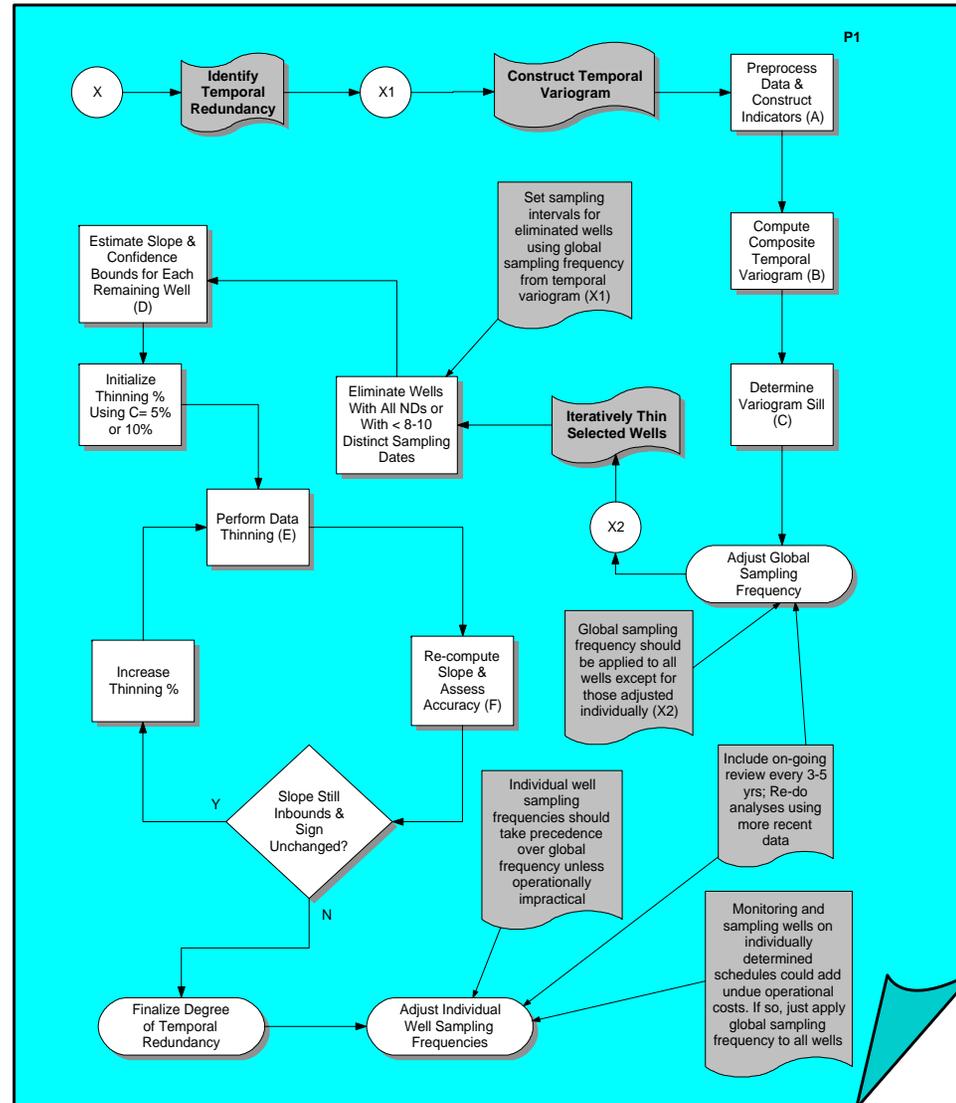
- GTS and MAROS (Vers 2.0 downloads)
- <http://www.afcee.brooks.af.mil/er/rpo.htm>
- Cameron & Hunter, 2002, Using Spatial Models to Optimize Long-Term Monitoring Networks, *Environmetrics*, Vol. 13
- Aziz, Julia et. al., 2003, MAROS: A Decision Support System for Optimizing Monitoring Plans, *Ground Water*, Vol. 41, No.3



GTS Optimization Algorithm

(translated to software, Dec 2004)

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GTS

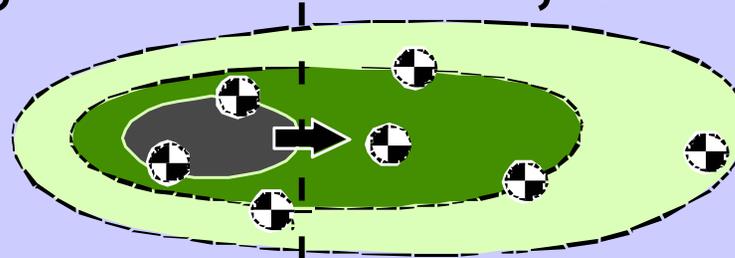
Technical Update

- **Locally weighted quadratic regression (LWQR) replaces Kriging algorithm**
- **LWQR**
 - **Smoothing technique, not an interpolator**
 - **Robust; does not assume or require a spatial covariance model (variogram)**
 - **Can estimate complex seasonal trends and nonlinear data**
 - **Handles multiple values in time and space**
 - **A less complex and flexible alternative for software development**
- **GTS 2.0 coming July 2004**
- **GTS Software December 2004**

MAROS Flow Chart

Enter Data, Reduce Data, Select Wells

1



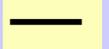
Source Zone | Tail Zone

2

Identify Site Constituents of Concern (COCs).

3

Analyze Lines of Evidence (LOEs) for Plume Stability (by well and by COC)

- Increasing (I) 
- Probably Increasing (PI) 
- No Trend (NT) 
- Stable (S) 
- Probably Decreasing (PD) 
- Decreasing (D) 



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MAROS

Technical Update

- **Spatial moment analysis**
 - **Impacts total mass, center of mass, & spread of mass calculations**
 - **Estimation technique inaccurate in some cases**
 - **Programming fix is in process**
- **MAROS 2.1 coming August 2004**



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Products & Deliverables

- **Decision framework & methodology**
- **Essential monitoring locations**
- **Redundant monitoring locations**
- **Optimized sampling frequency**
- **Expanded network in areas of uncertainty**
- **Cost benefit analysis & return on investment**



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Web-Enabled Data Resources

Great Asset for Facilitating Optimization

Data Management Tools - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites Media Print

Address <http://tinker.saiceemg.com/default.asp> Go Links >>

Home Data Wiz **Download Files** Go Upload files Contacts

TINKER AFB DATA MANAGEMENT TOOLS

Click on the tool you you want to use.

 View environmental data on-line or export for analysis

Database Last Modified: 5/20/2004 (examples)

[Change Password] | Data Wiz |

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Internet



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Essential Wells

Ranking is Important to Network Design

Categories Based on:

- Semi-quantitative scheme
- Relative statistical importance
- Global regression weights or slope factors
- Temporal influence & coverage

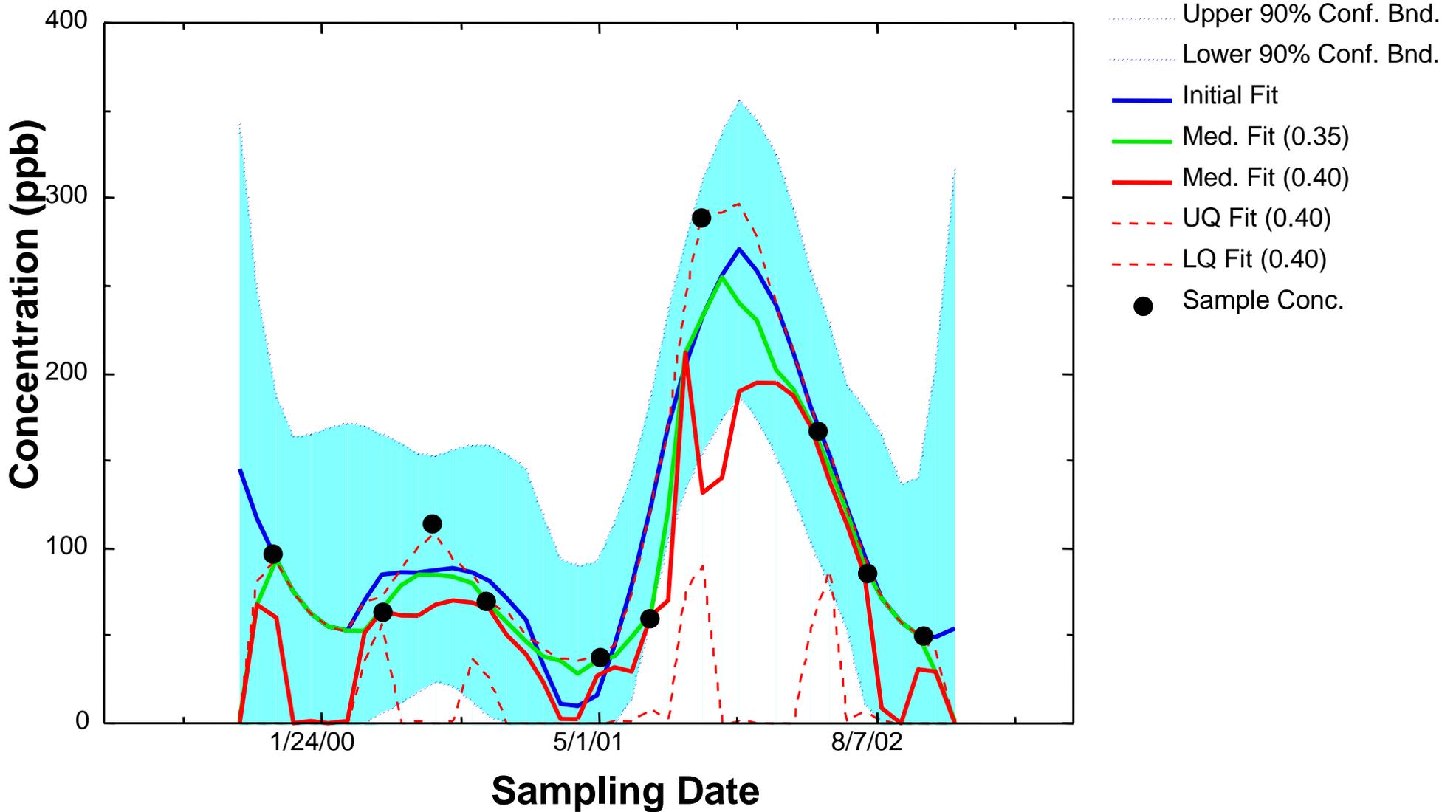
Well	Ranking
MW-01	High
MW-03	High
MW-08	Medium
MW-11	Medium
MW-05	Low
MW-13	Low



GTS Time Series Output with Confidence Bands

Manganese in Well JBW7317

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TCE Spatial Comparison

All Wells vs Reduced Network

All Wells

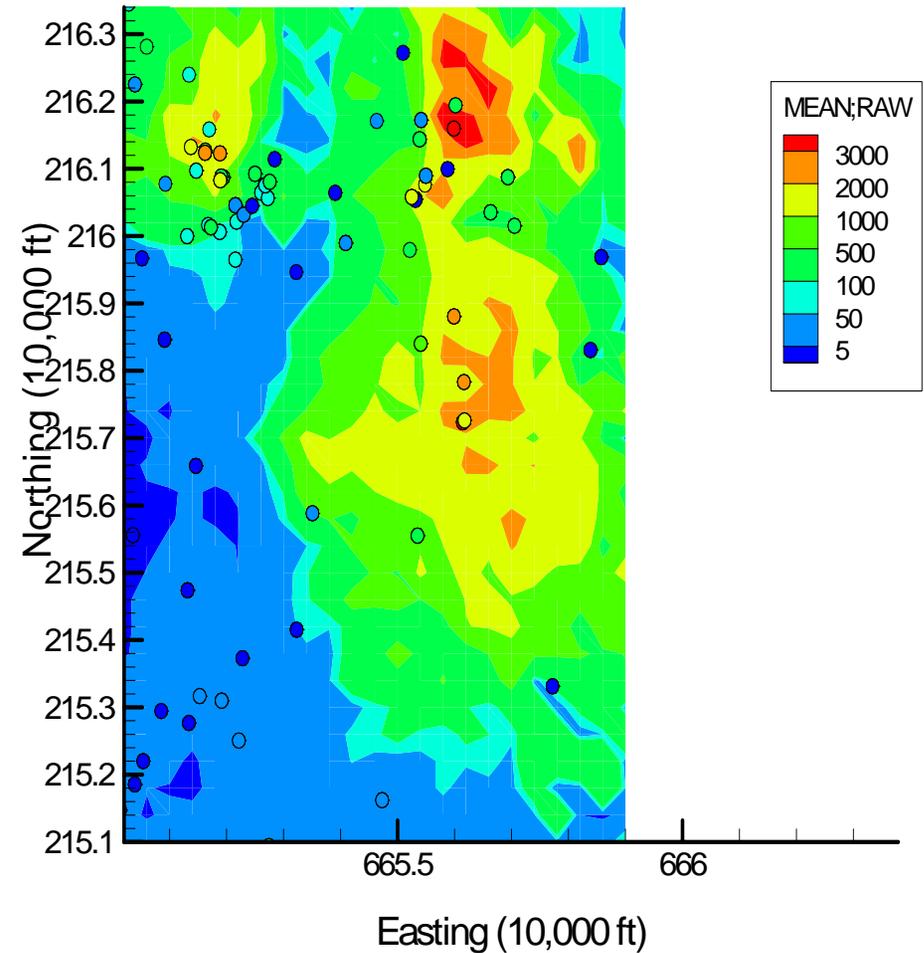
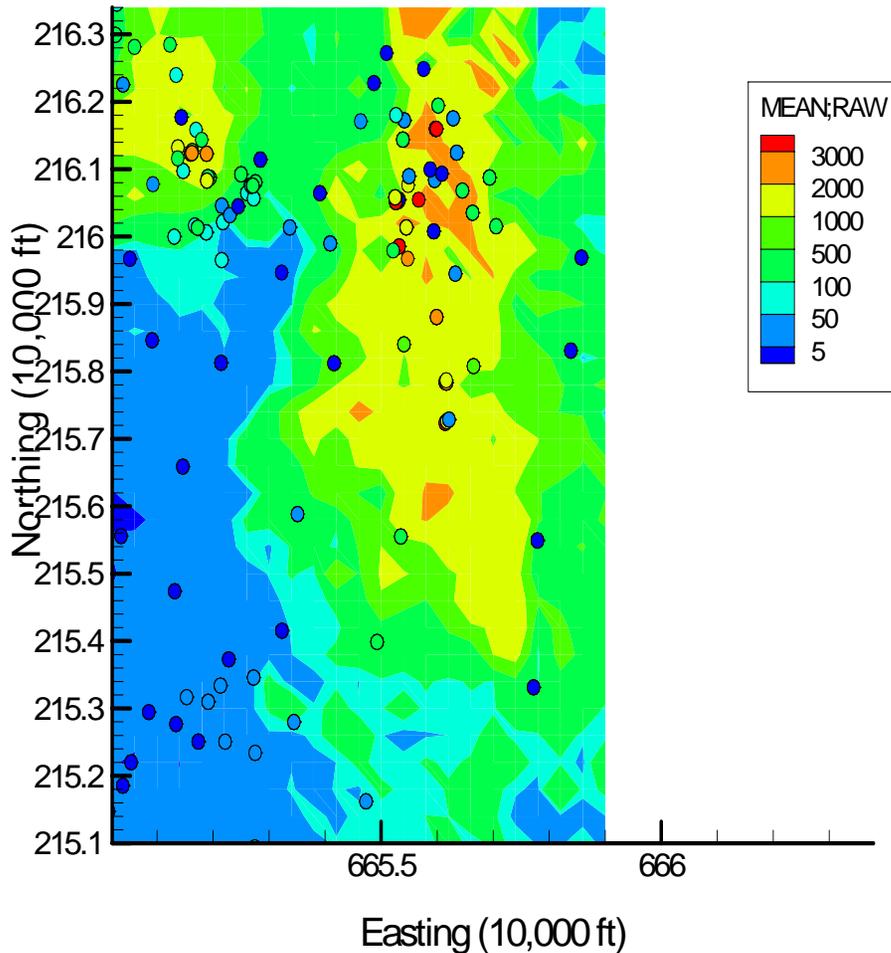
Well Reduction 40%

Frame 001 | 22 Oct 2003 | eafb.tce.t1.cut0.map-XY

Frame 001 | 7 Jun 2004 | eafb.tce.t1.cut6.map-XY

Site 133: TCE Concentrations (ppb), 1999-2000, Base Map

Site 133: TCE Concentrations (ppb), 1999-2000, 40% Removal



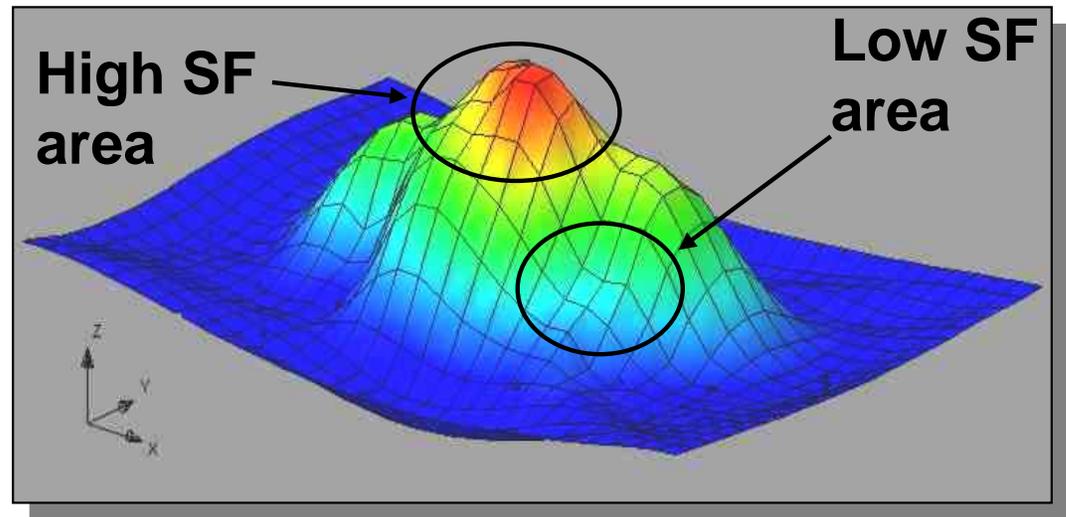


MAROS Well Sufficiency Analysis

(from Aziz, 2003)

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**Estimation
Uncertainty plot
based on Slope
Factor (SF) values**



High SF areas → High estimation error → Possible need for new locations

Low SF areas → Low estimation error → No need for new locations



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“Smart” Sampling Scheme

Random Well Groups & Staggered Events Help Future Analysis

Optimized Semiannual Sampling

		Group 1		Group 2		
	Year 1	MW-1, MW-2, MW-3	MW-4, MW-5, MW-6			
	Year 2	MW-2, MW-5, MW-6	MW-1, MW-3, MW-4			
	Year 3	MW-3, MW-4, MW-5	MW-1, MW-2, MW-6			
Year 1	Jan	Feb	Mar	Apr	May	Jun
Year 1	Jul	Aug	Sep	Oct	Nov	Dec
Year 2	Jan	Feb	Mar	Apr	May	Jun
Year 2	Jul	Aug	Sep	Oct	Nov	Dec
Year 3	Jan	Feb	Mar	Apr	May	Jun
Year 3	Jul	Aug	Sep	Oct	Nov	Dec

Sampling events in color



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Estimating Cost Savings

Baselined Against Current Monitoring

•Inputs

- List of wells monitored
- Annual samples collected (including QC samples)
- Analytical costs (analyte and method used)
- Materials and equipment costs (rentals & expendable items)
- Shipping costs
- Labor costs for ...
 - Field sample collection and field measurements
 - Chemistry data management
 - Meetings and preparing reports
 - Updating/revising documents/databases
 - Professional site visits and QA/QC audits
 - Project management and administration

•Cost of performing optimization



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Case Studies

■ GTS

- MMR, FS-12 and Eastern Briarwood Plumes
- AFP6
- Loring, Pease, & Edwards AFBs
- **Tinker AFB** (in process)

■ MAROS

- **Tinker AFB, ST-40**
- **Wurtsmith AFB, LF30-31**
- **MMR, Ashumet Valley Plume**
- **Homestead AFB, SS-2A (proposed)**
- **McLellan, Vandenberg, Dover, Edwards, Fort Lewis, Long Prairie Superfund Site (early studies)**



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GTS Case Study Results

Potential Savings at AF Installations

	Edwards	Loring	Pease
Original Frequency	Annual	Quarterly	Annual
Optimized Interval	Every 7 Qtrs	Every 2-3 Qtrs	Every 8 Qtrs
Redundant Wells	20-34%	20-30%	10-36%
Cost Reduction	54-62%	33-39%	49-52%
Annual Cost Savings	\$230 K-\$270 K	\$300 K- \$360 K	\$85 K- \$90 K



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Training

- **GTS & MAROS**
- **Brooks City-Base**
- **Before Dec 2004**



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LTM Optimization Summary

- **AF optimization tools are available**
- **Significant cost savings can be realized**
- **Case studies have matured technology**
- **Implementation should focus on priority sites**
- **Training to take place at AFCEE**



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Thanks



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