GTS Case Studies

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GTS Introduction

- Development begun in 1998 under AFCEE sponsorship
  - Original goal: enable physical optimization of GW programs at wide variety of AF sites
- 9 AF and DOE sites analyzed using GTS
  - Basewide optimization under way at Tinker AFB
- Stand-alone GTS software under development

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GTS Basics

- Statistical & geostatistical algorithm
  - Not meant to supplant hydrogeological expertise
  - Decision-logic framework
- Optimization algorithm looks at two areas:
  - Monitoring network locations
  - Sampling frequencies in network
- Focus on statistical redundancy

GTS Philosophy

- Must balance cost-accuracy tradeoff
  - Optimal system = minor information loss but large gain in resource savings
  - Remove redundancy in practical, statistically defensible ways

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Note on Redundancy

- Practical definition: What happens when data removed from current system?
- Temporal
  - Can trends be re-constructed?
  - Do consecutive sampling events become uncorrelated?
- Spatial
  - Can surface map be re-constructed?
    - Plume extent and intensity

GTS Algorithm

- Uses geostatistical and trend optimization methods
  - Variogram = correlation measure
  - Locally-Weighted Quadratic Regression (LWQR)
    - Time series fitting
  - Multiple Indicator Local Regression (MILR)
    - Spatial regression

Case Studies

- 3 AF sites with varied geology
  - Pease AFB, New Hampshire
    - Site 49, TCE plume from underground storage tank
    - Fractured bedrock; varied overlying geology
    - 67 wells used as baseline

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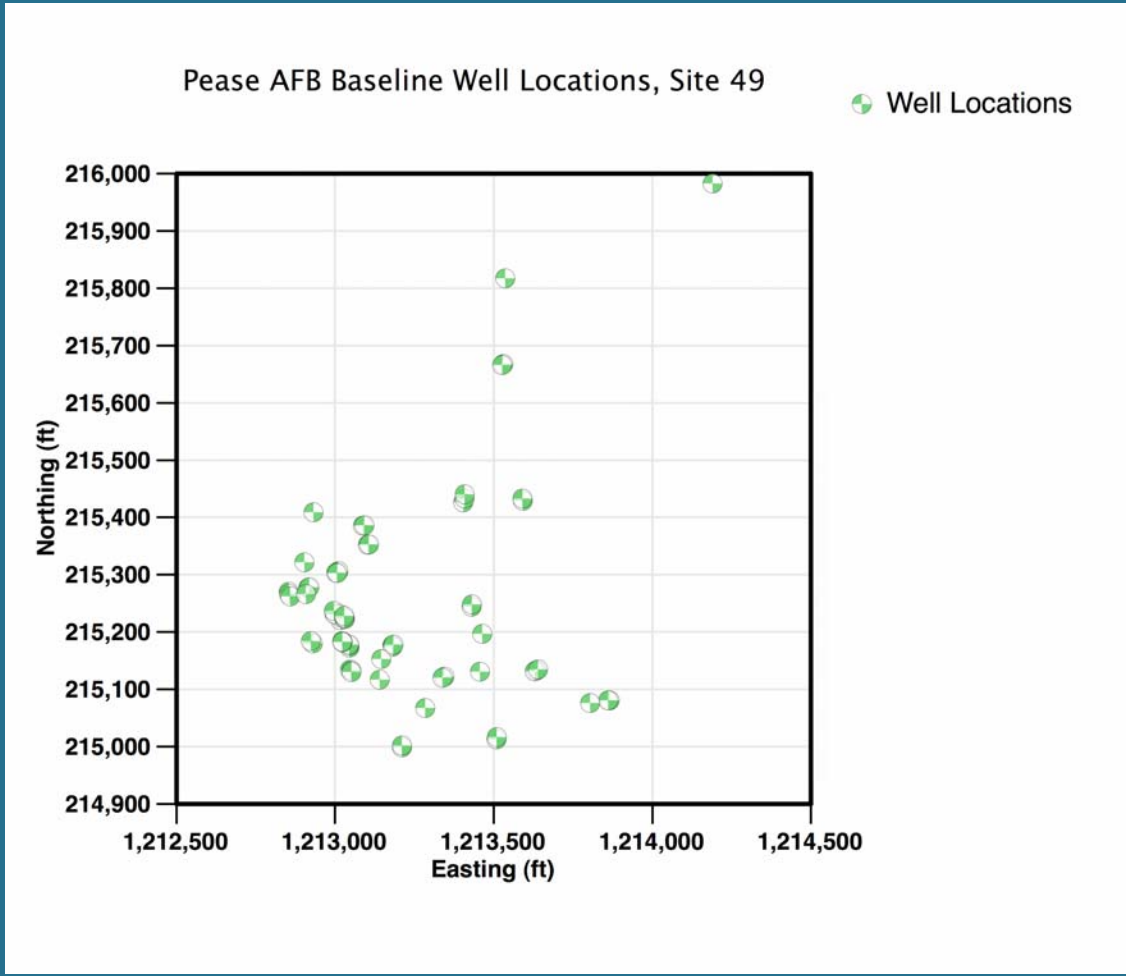
Pease AFB Site 49 Plan View



Case Studies (cont.)

- Loring AFB, Maine
  - Site OU-12, 30 contaminant sources, including BTEX, TCE
  - Lightly to heavily-fractured bedrock; 3 distinct overburden units
  - 115 wells used as baseline

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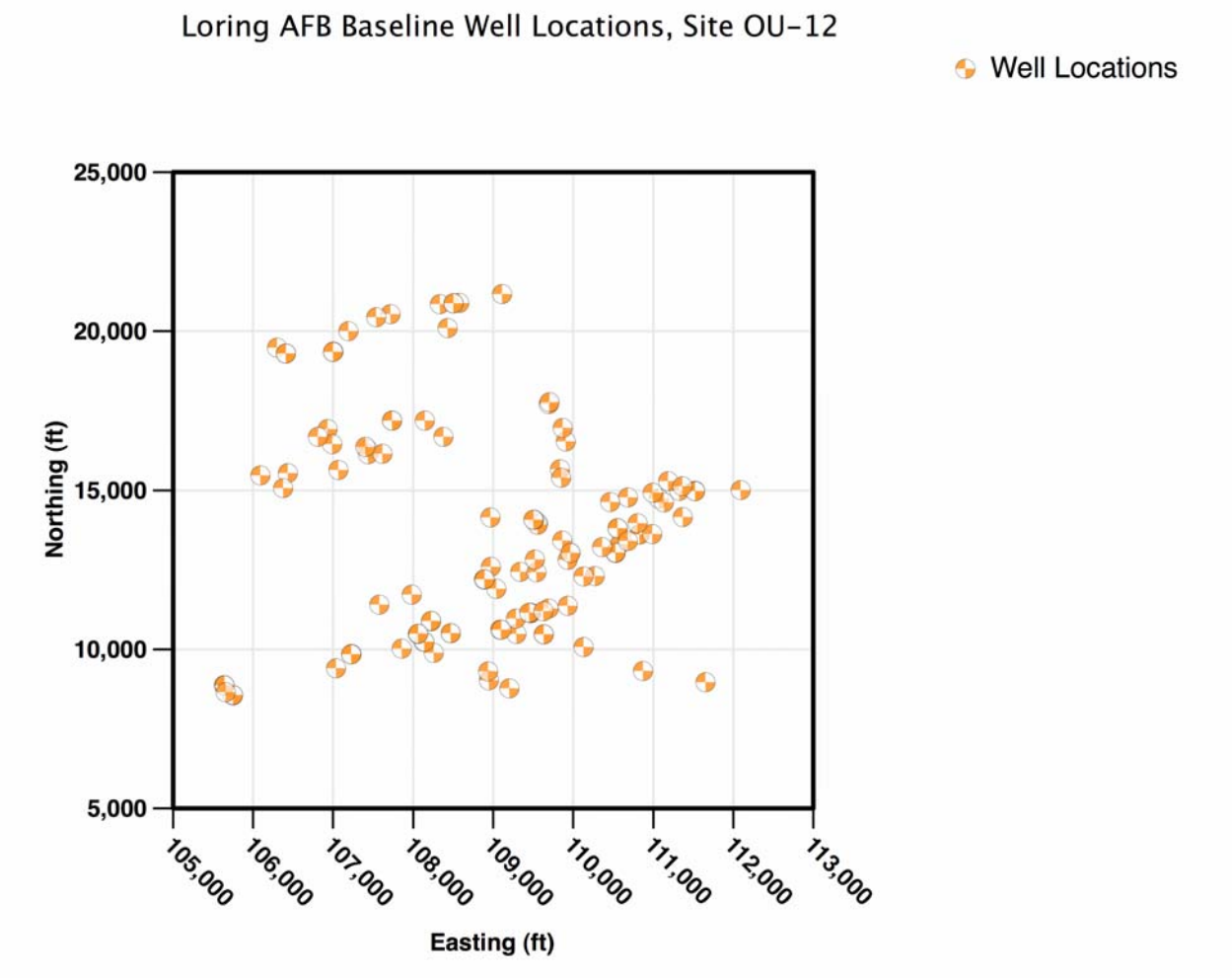
Loring AFB OU-12 Plan View



Case Studies (cont.)

- Edwards AFB, California
  - Sites 133, 37; Contamination due to storage & waste disposal practices
  - Fractured crystalline bedrock; weathered bedrock overlay
  - 140 wells used as baseline
- Question: how would GTS adapt to these situations?

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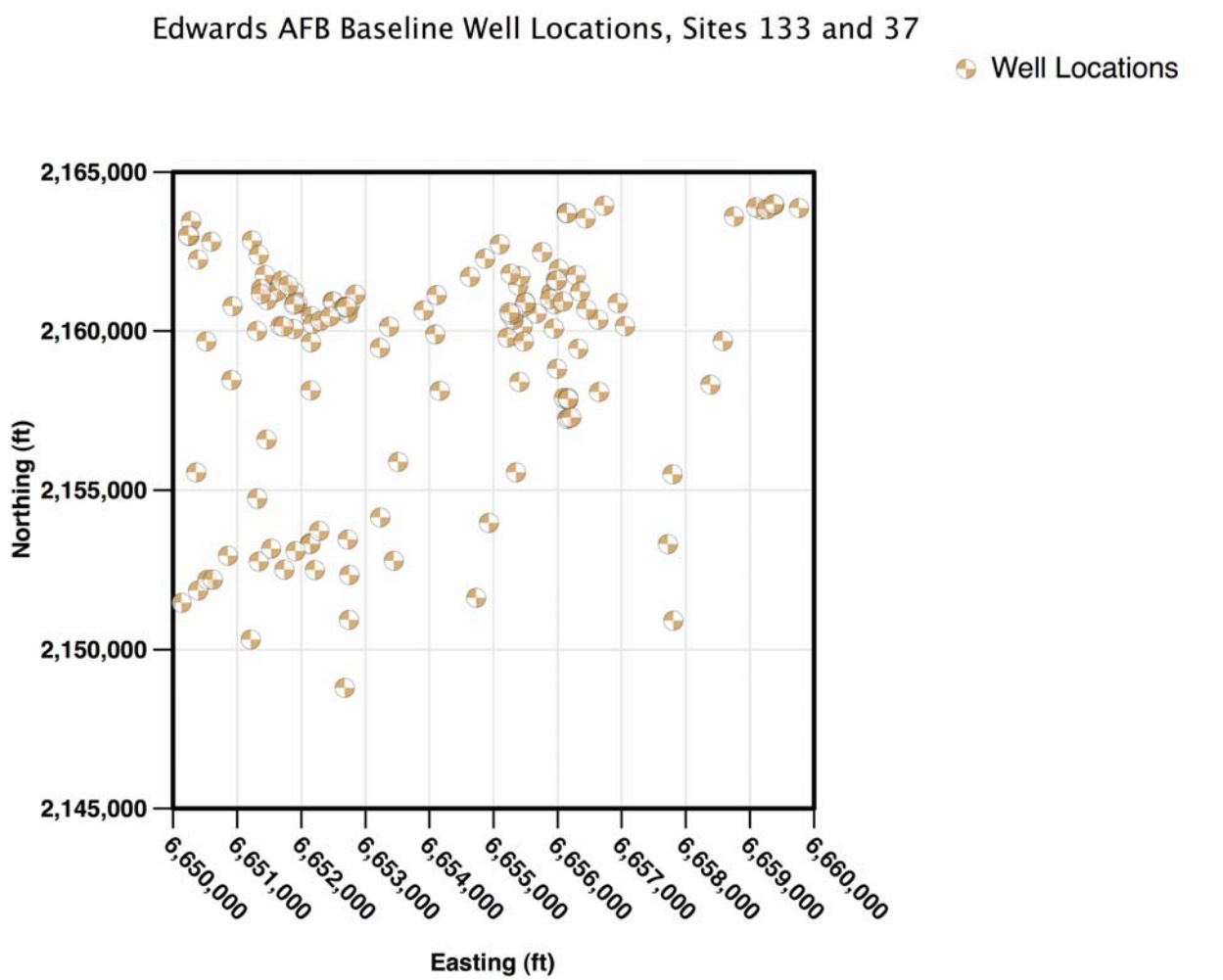
Edwards Site 133 Plan View



Temporal Optimization

- Two approaches
  - Temporal variogram to estimate average correlation between sampling events
  - Iterative “thinning” of individual wells to adjust well-specific sampling frequencies

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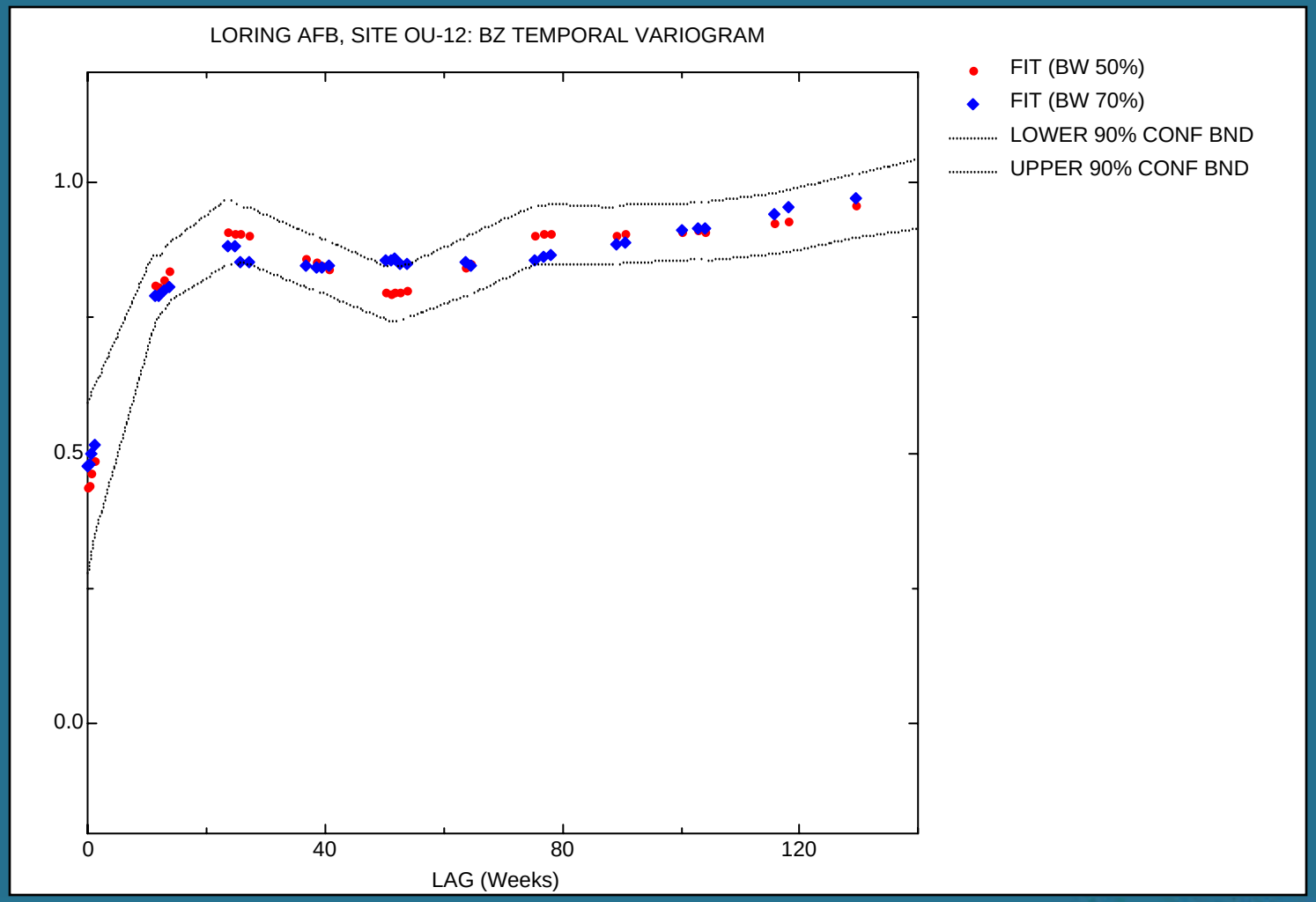
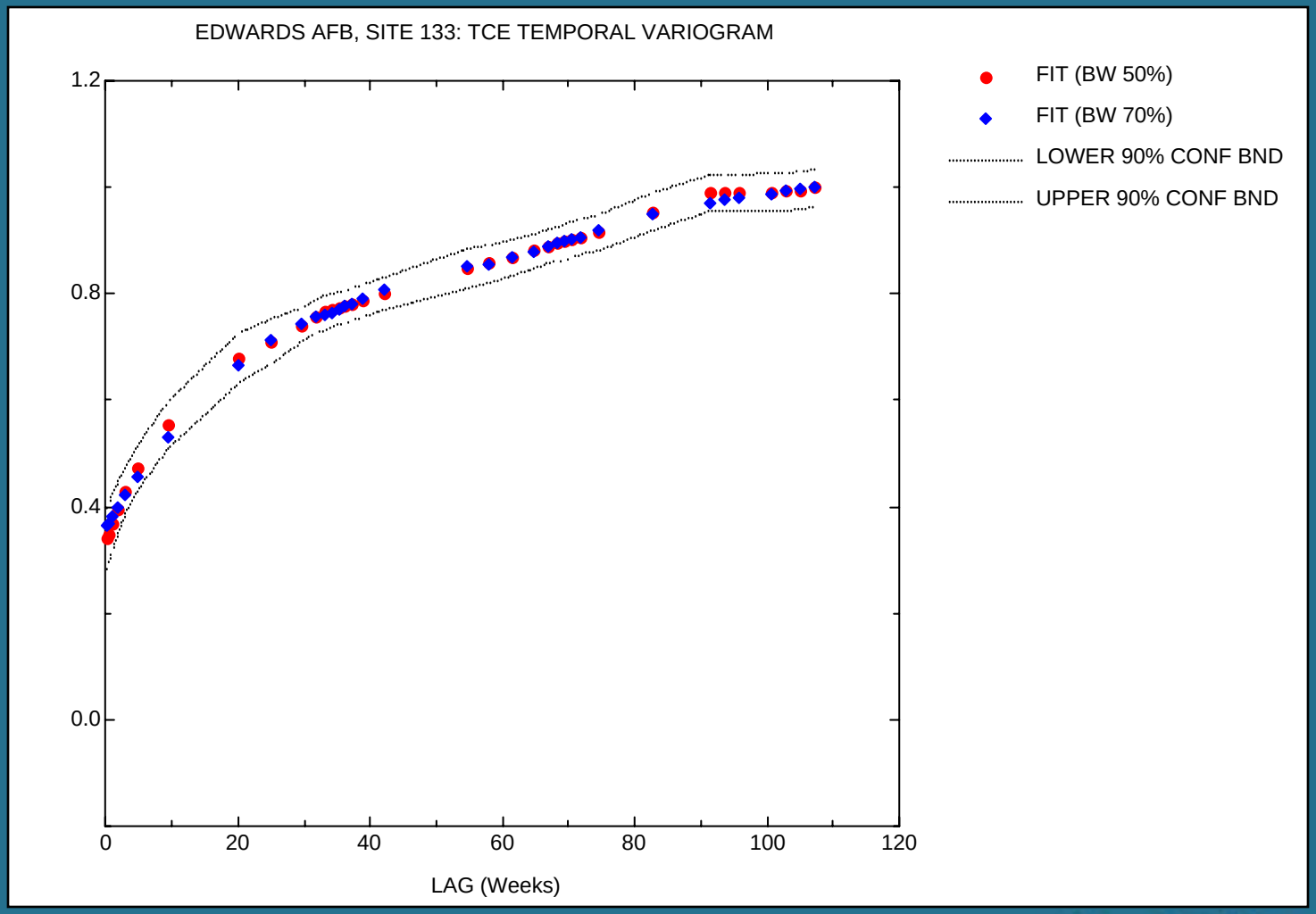
Temporal Approaches

- Advantages of variogram
  - Useful with irregularly spaced data
  - Data from multiple wells can be included
  - Single graph shows optimal global sampling interval
- Advantages of iterative thinning
  - Complex trends, seasonal patterns OK
    - LWQR fits non-linear trends
  - Each well optimized uniquely
    - Not dependent on average correlation like temporal variogram
  - Operational target interval = median of individual well sampling intervals

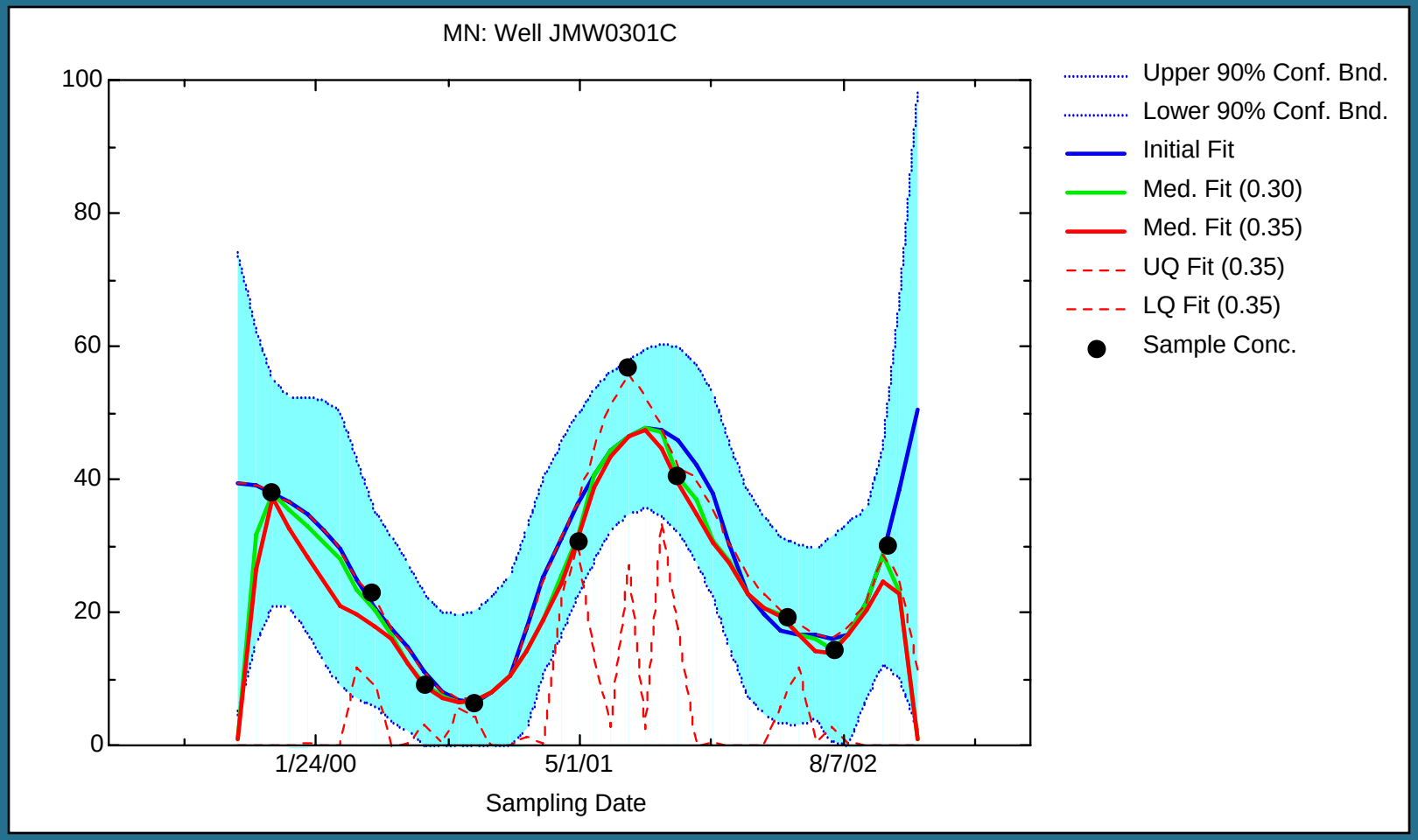
BZ Temporal Variogram



TCE Temporal Variogram



Iterative Thinning: Loring



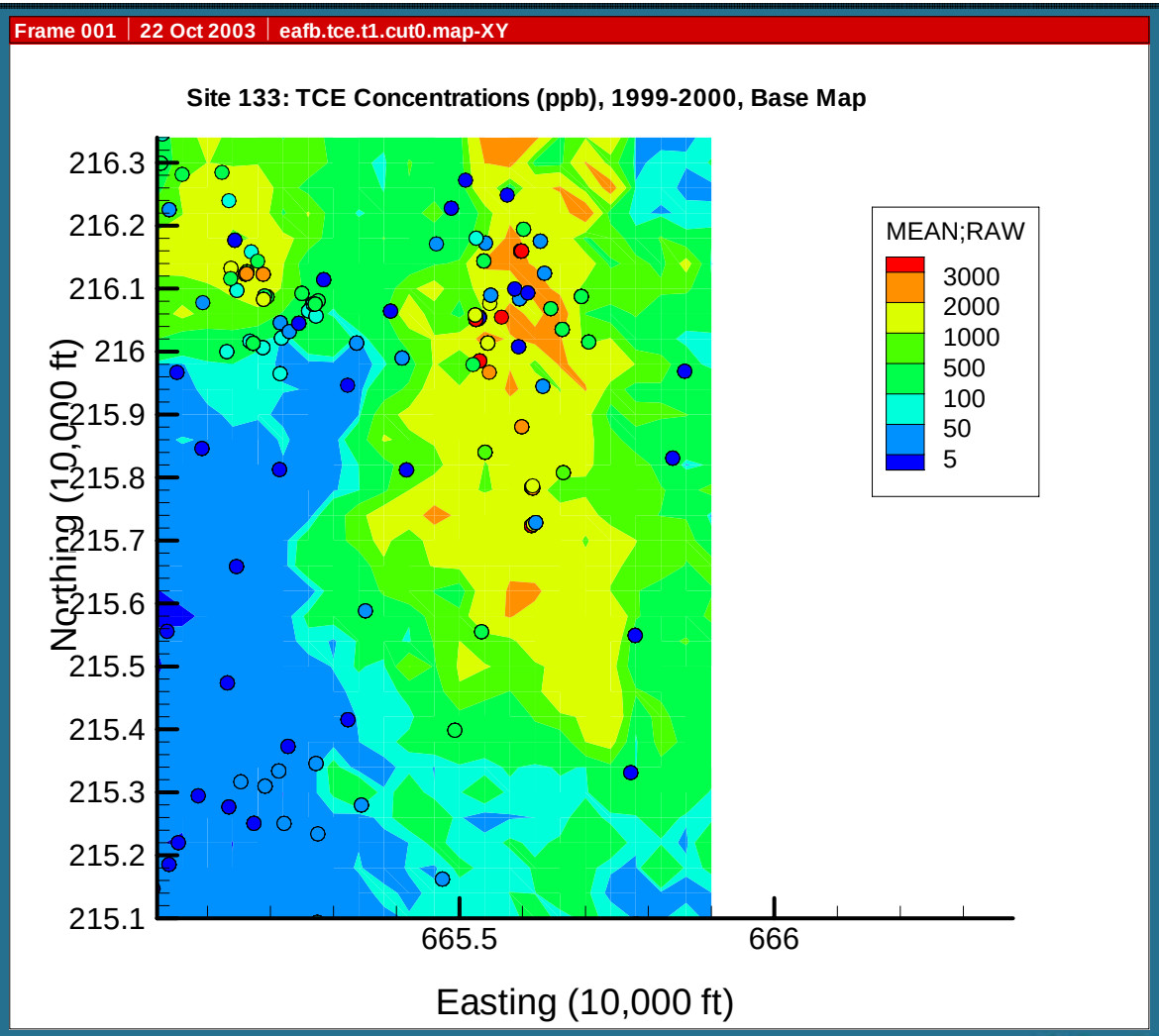
Basic Spatial Approach

- Create base map using all available data
- Iteratively remove least influential wells; re-estimate map
  - Influence measured by loss of map quality/accuracy compared to baseline
- Create cost/accuracy tradeoff curves
  - Pick off optimal degree of data removal

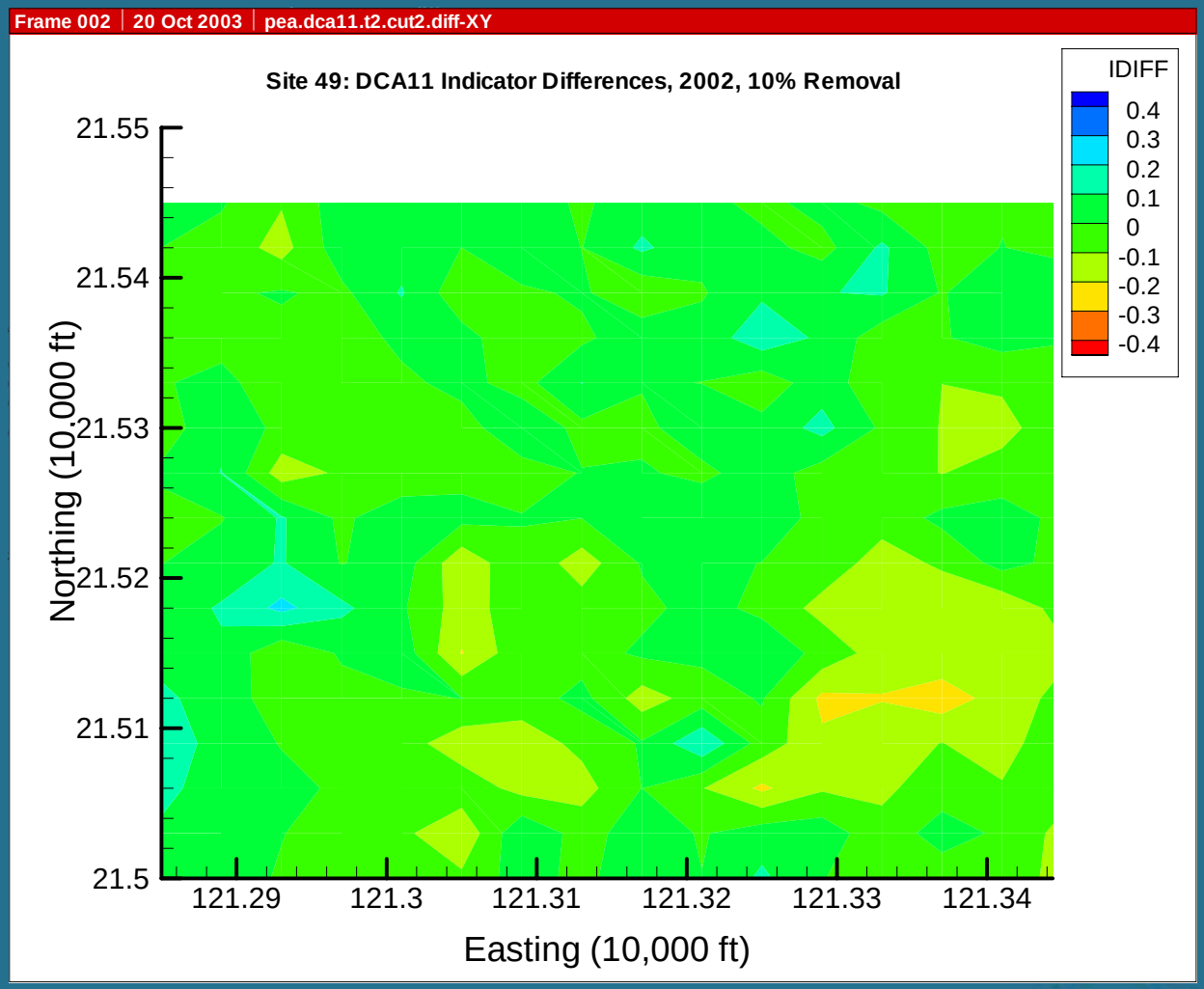
Spatial Advantages

- Advantages to MILR approach
  - A priori spatial model not required
  - Smoother, not an interpolator
  - Quasi-nonparametric
- Can build site maps either in:
  - 3-D space
  - Separately by depth horizon or geologic unit
  - Separately by regulatory or geographic unit
    - As long as enough data available per unit

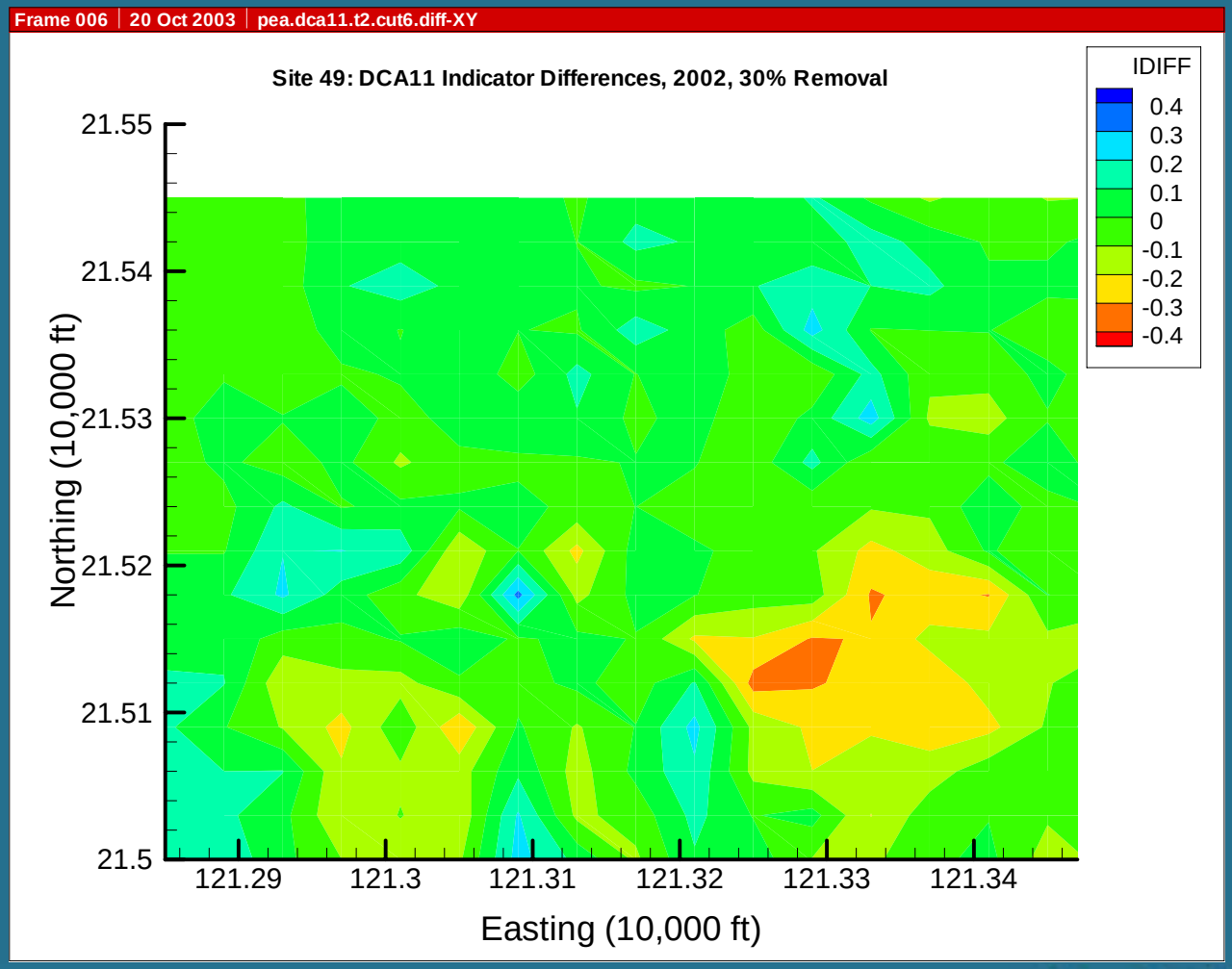
Edwards AFB: Base Map



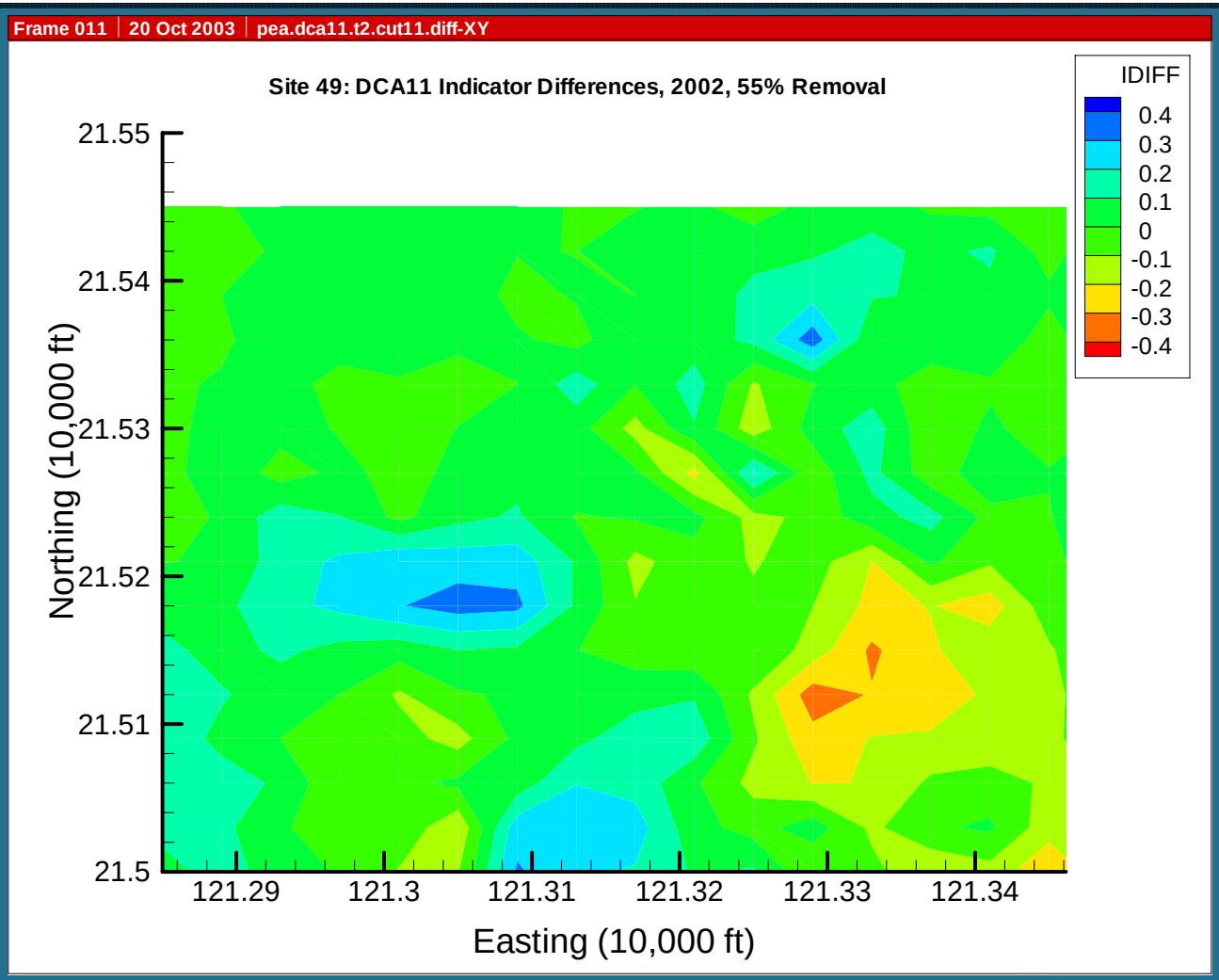
Pease: 10% Removal



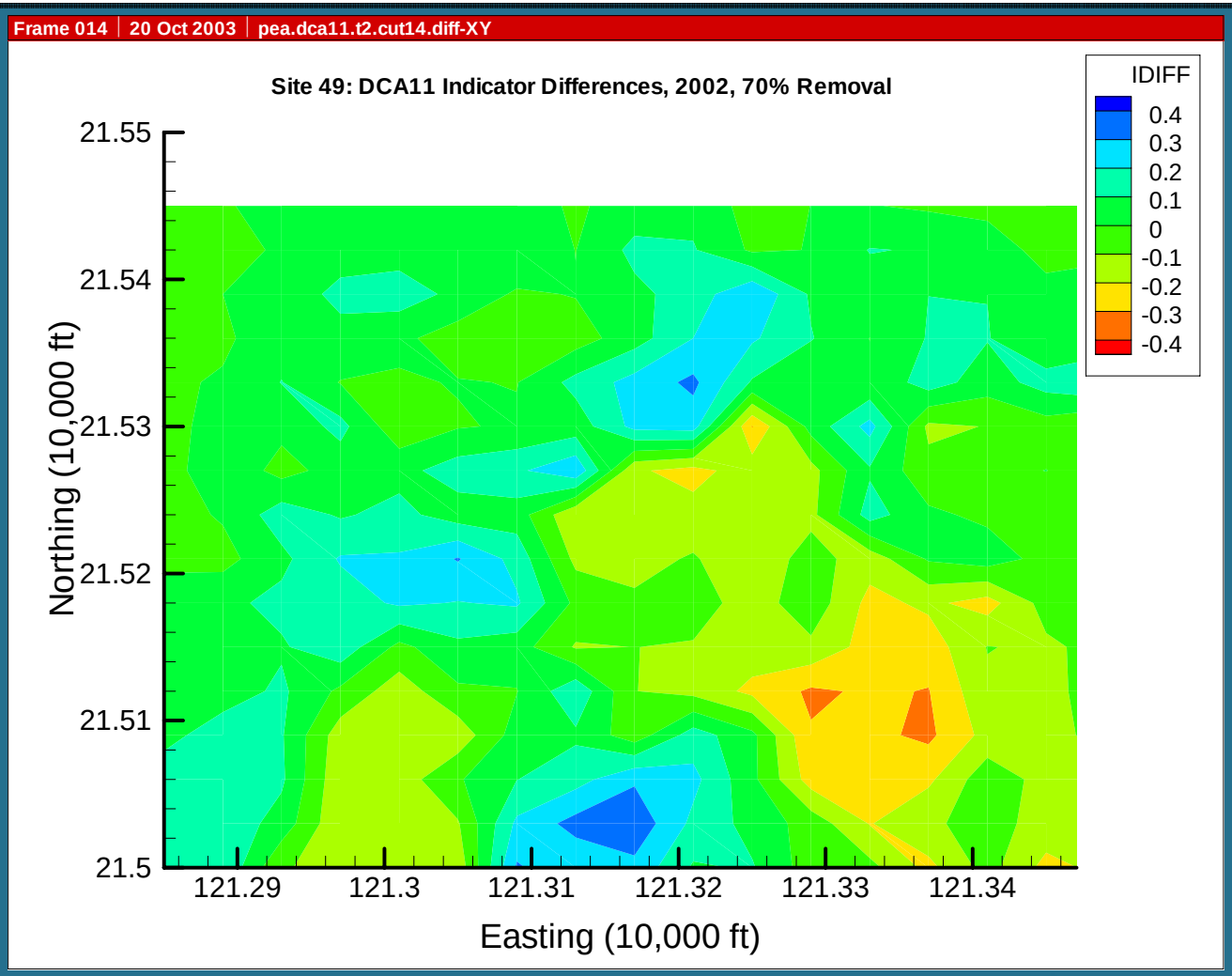
Pease: 30% Removal



Pease: 55% Removal



Pease: 70% Removal



Case Study Results

	Edwards	Loring	Pease
Original Interval	Annual	Qtrly	Annual
Optimized Interval	Every 7 Qtrs	Every 2-3 Qtrs	Biennial
Redundant Wells	20-34%	20-30%	10-36%
Cost Reduction	54-62%	33-39%	49-52%
Annual Cost Savings	$230 K-$266 K	$306 K-$358 K	$85 K-$89 K

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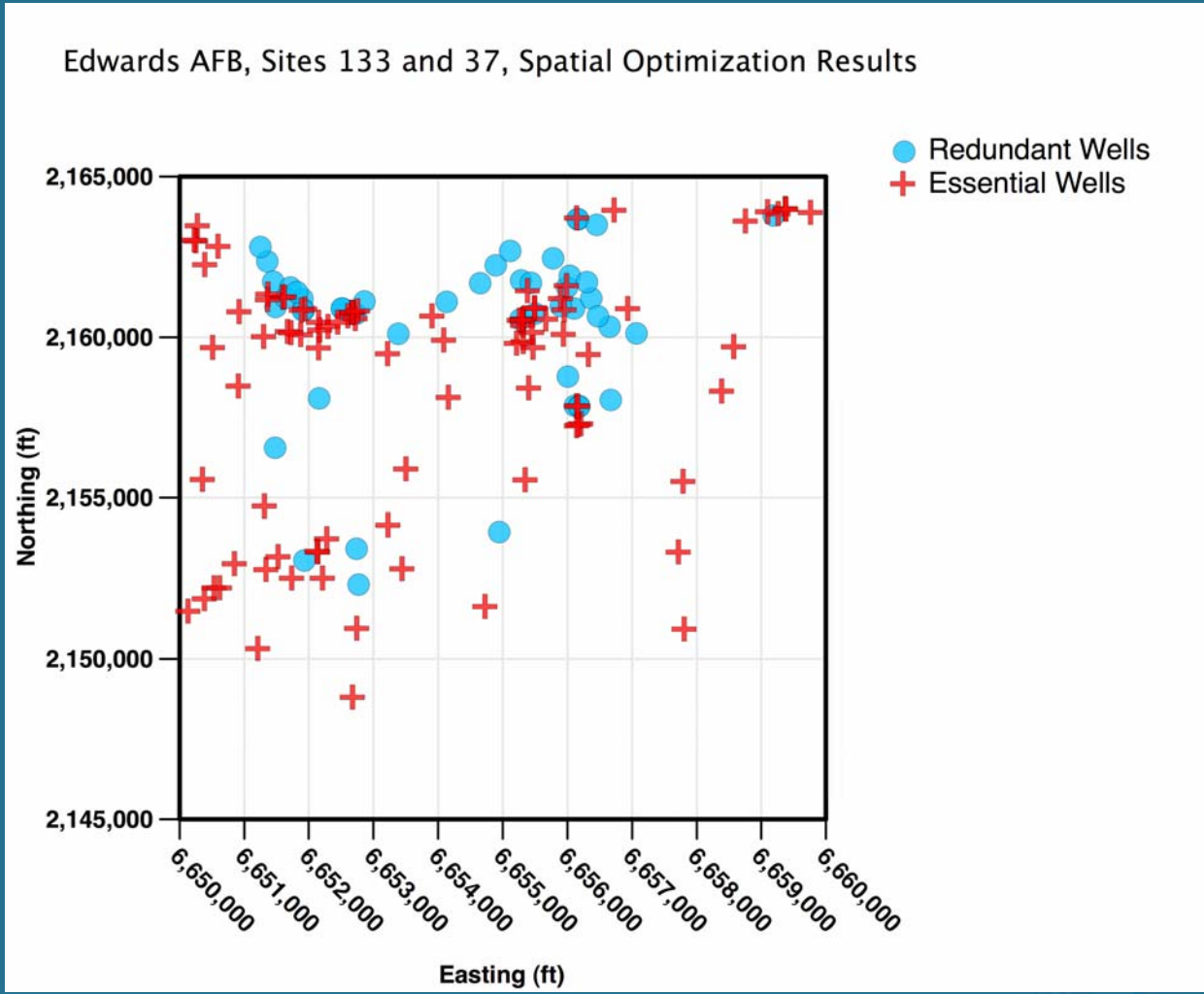
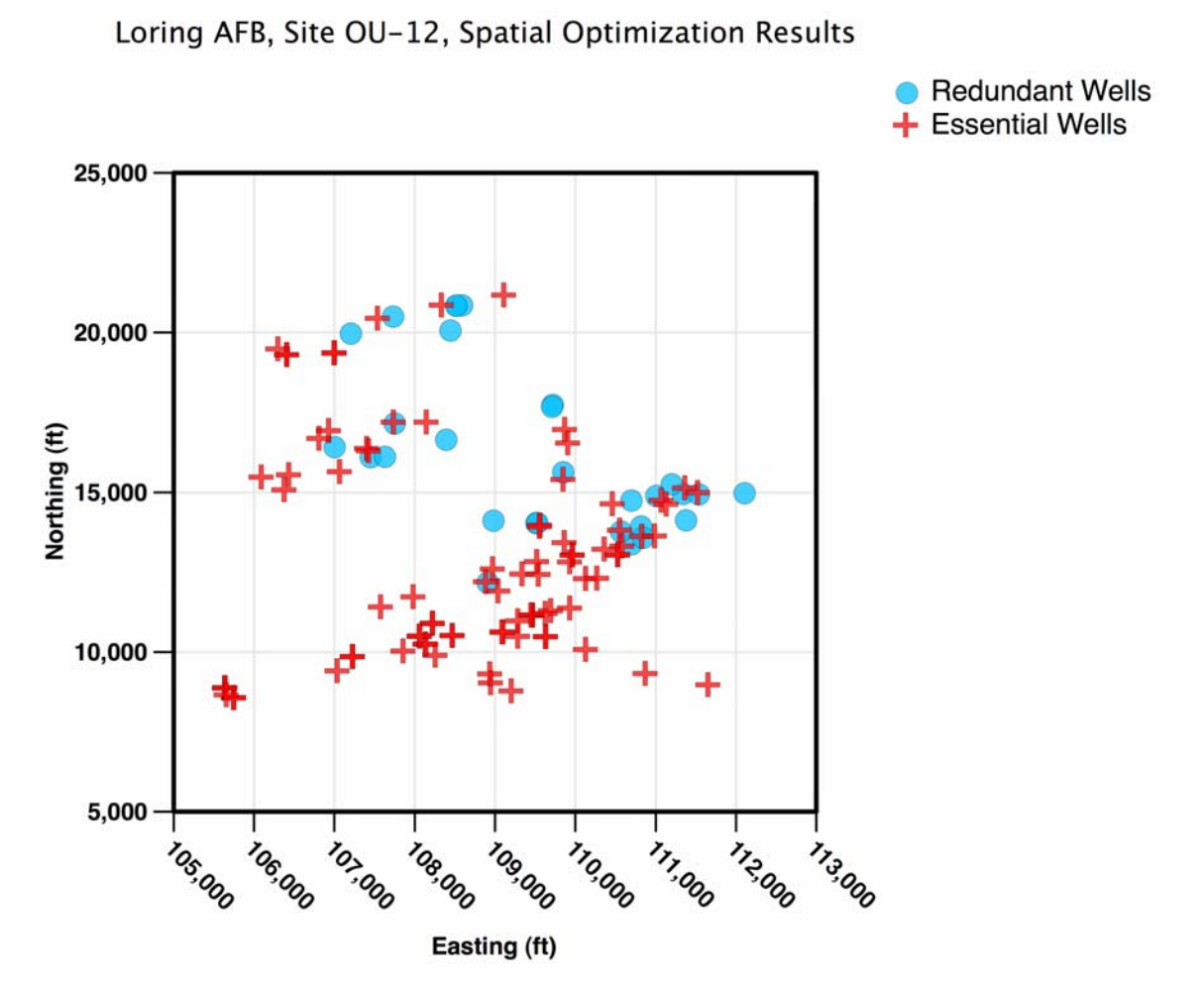
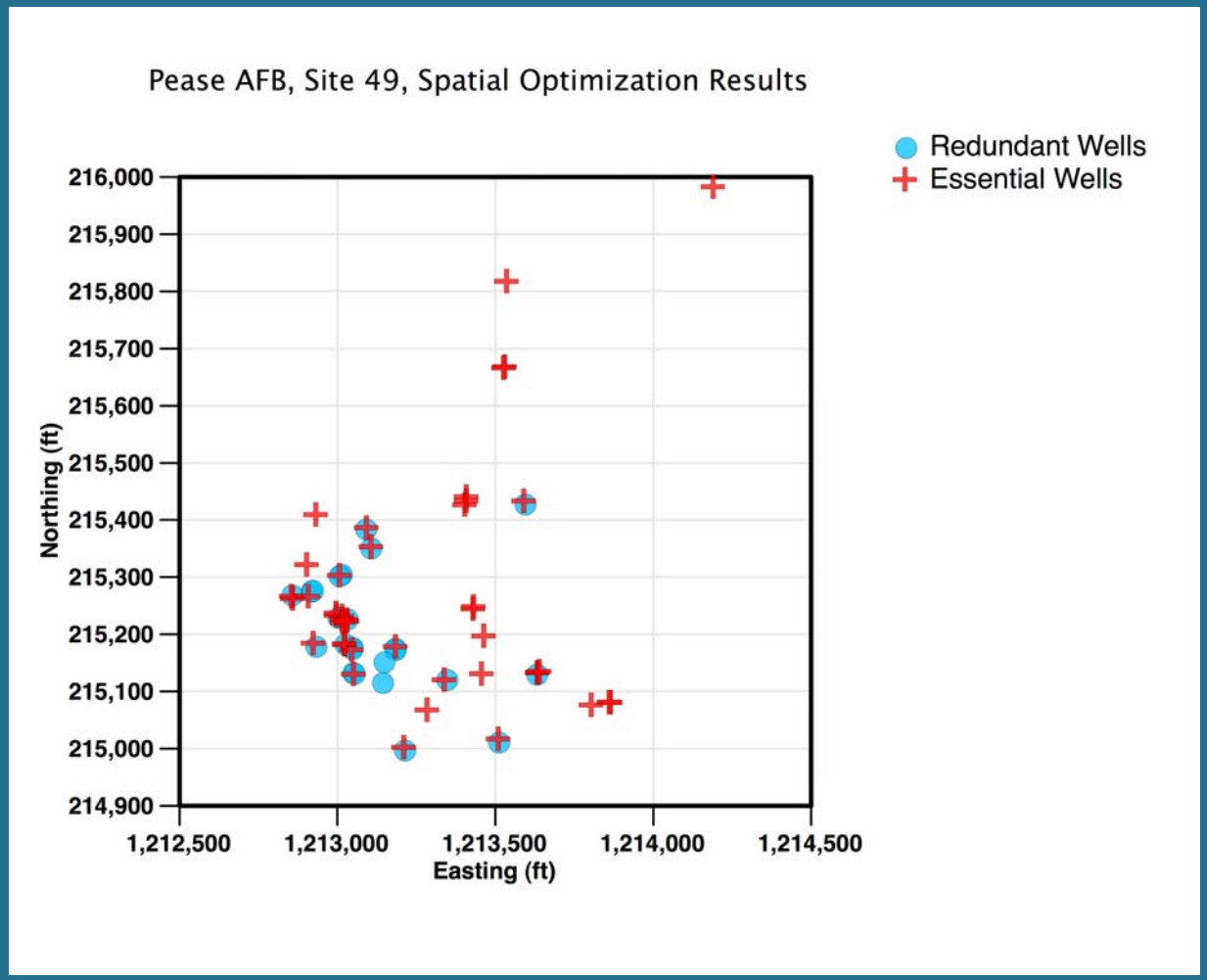
Edwards: Optimized Wells



Loring: Optimized Wells



Pease: Optimized Wells



GTS Summary

- Novel combination of geostatistical & statistical tools
  - Semi-objective optimization process
- "Plug-in" architecture, flexibility
  - Temporal, spatial, or both
- Recommendations can be combined with other optimization, sampling, or monitoring objectives

GTS Summary (cont.)

- Flexible, practical optimization
  - Edwards AFB
    - Not enough historical data for iterative thinning
    - Temporal variogram reduced sampling from annually to once every 7 quarters
  - Loring AFB
    - Iterative thinning & temporal variograms both suggested once per 2-3 quarters
- Emphasis on graphical/visual output
- Substantial cost savings