PRS-276 Analysis
Mound Site Miamisburg, Ohio

The BWX-OEPA-DOE-CAB Team

May15th-18th, 2000

Objectives

- Use PRS-276 as a training set for class exercise to learn the SmartSampling process
- Use SmartSampling to generate maps to answer:
  - Where to remediate (as a function of remediati reliability)?
  - What are costs of various remediation designs
  - Where to locate additional samples to reduce uncertainty in remediation design?

PRS-276 Background

- **For purposes of the class exercise, mode of contamination is unknown**
  - **Reality: dumptruck loads of contaminated soil from another location**
- **Soil contaminated with Th-232, Pu-238, Co-60, etc.**
  - **Class exercise examines Th-232 contamination**

Problem Setup

There are two Th-232 action levels being considered for PRS-276:

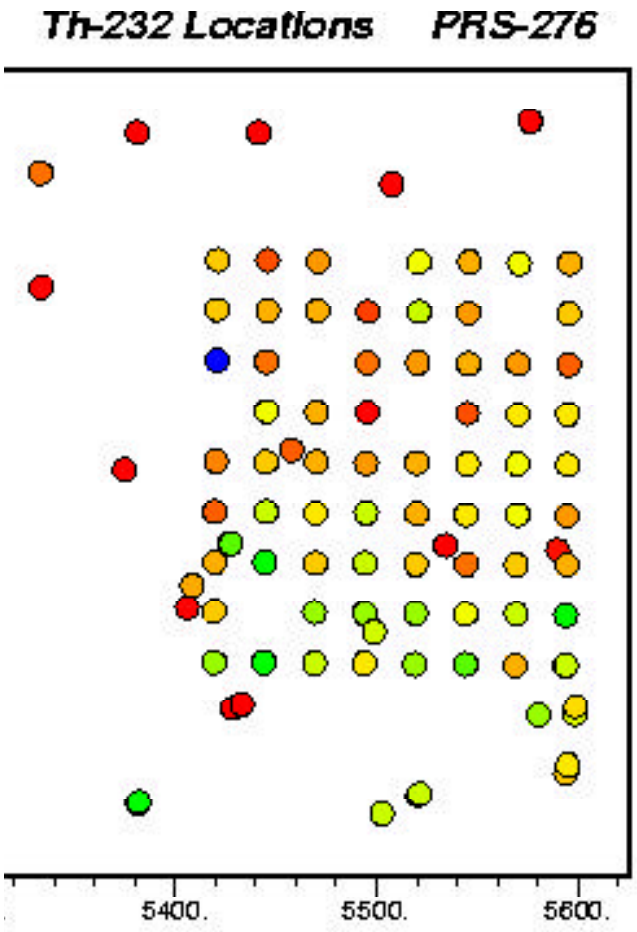
- 0.8 pCi/g
- 1.6 pCi/g

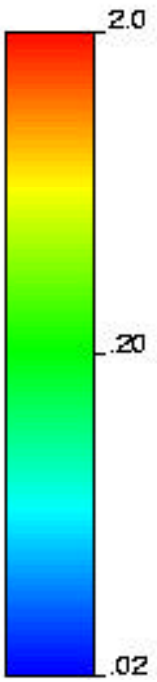
Remediation decisions will be made on 5x foot panels (nominal size of backhoe buck

Activity is contained within top six inches soil

Remediation cost is $300/yd^3

PRS-276





Th-232 sampled a
100 locations

Sampling plan wa
regular grid with s
random samples

Site is roughly 325
400 feet

Color legend is log-scaled (0.02 to 2.0) pCi/g

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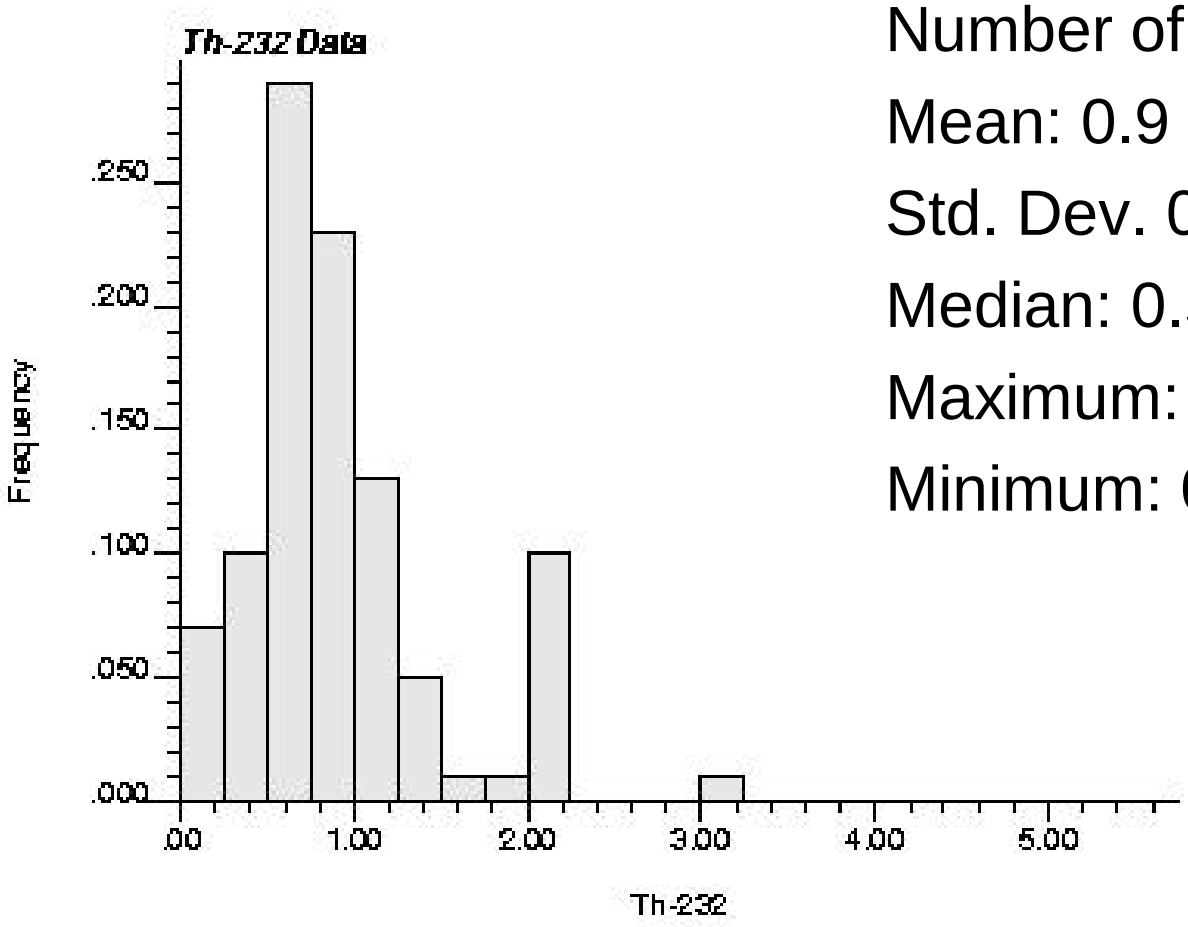
Th-232 Distribution (Histogram



Number of Data: 100

Mean: 0.9

Std. Dev. 0.5

Median: 0.5

Maximum: 3.1

Minimum: 0.0

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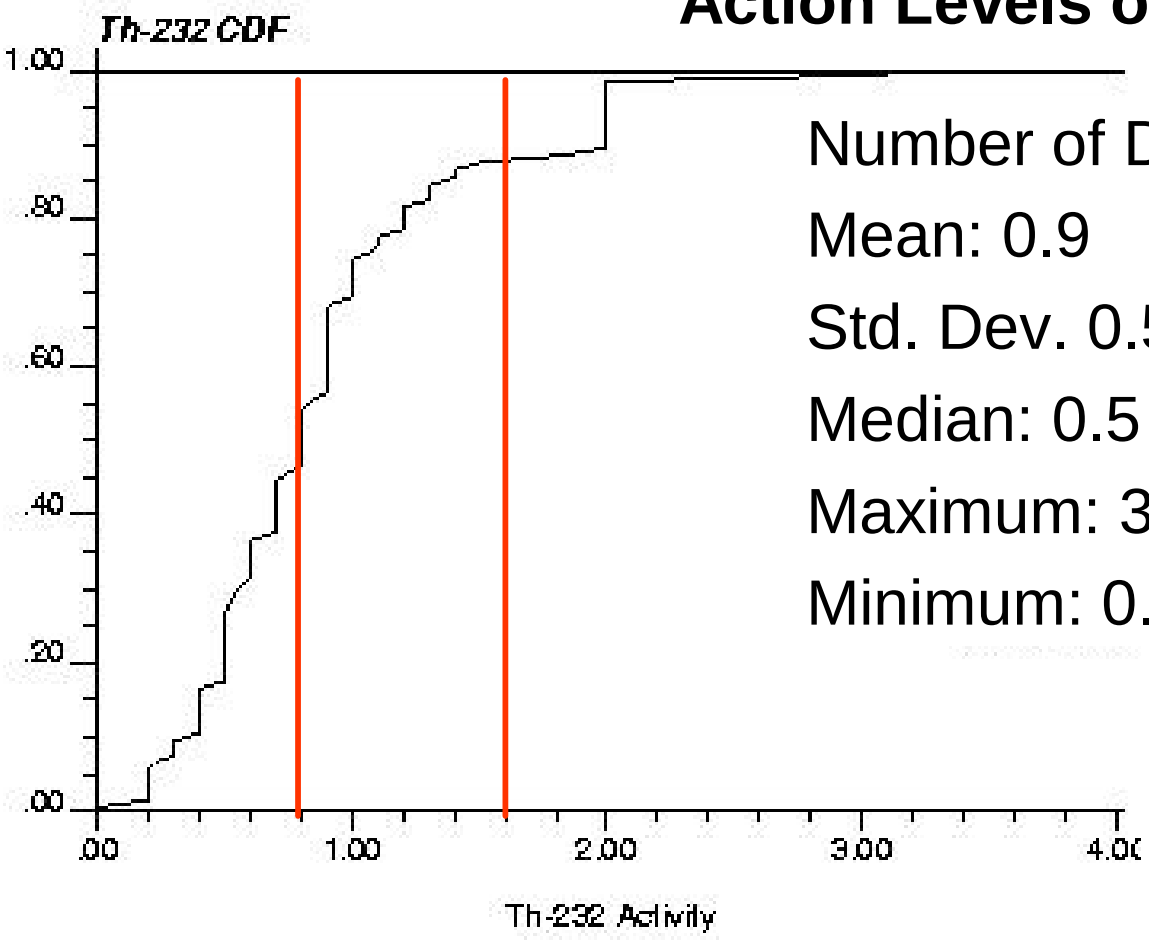
Th-232 Distribution (Cumulativ

Action Levels of 0.8 and 1.6



Number of Data: 100

Mean: 0.9

Std. Dev. 0.5

Median: 0.5

Maximum: 3.1

Minimum: 0.0

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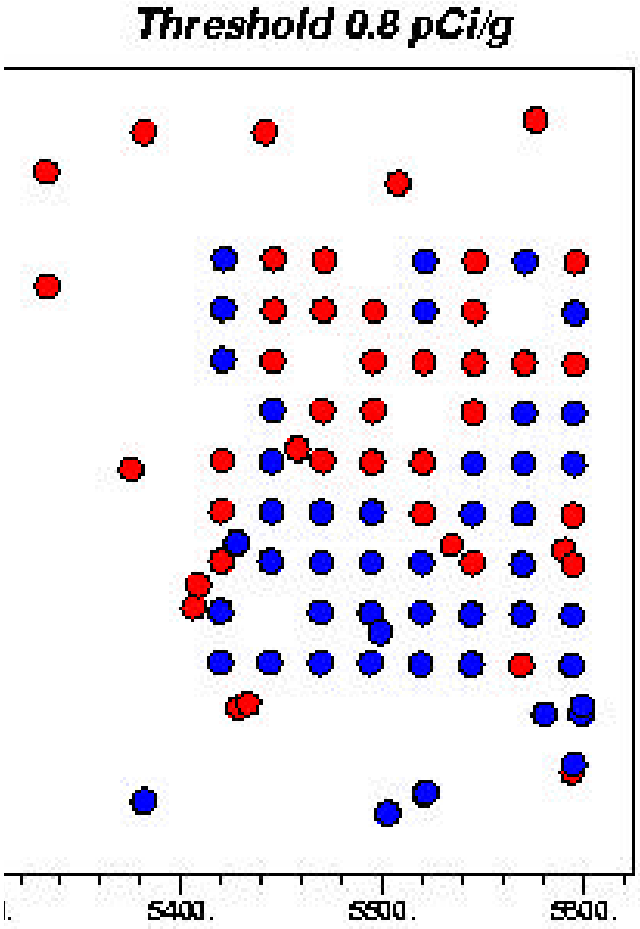
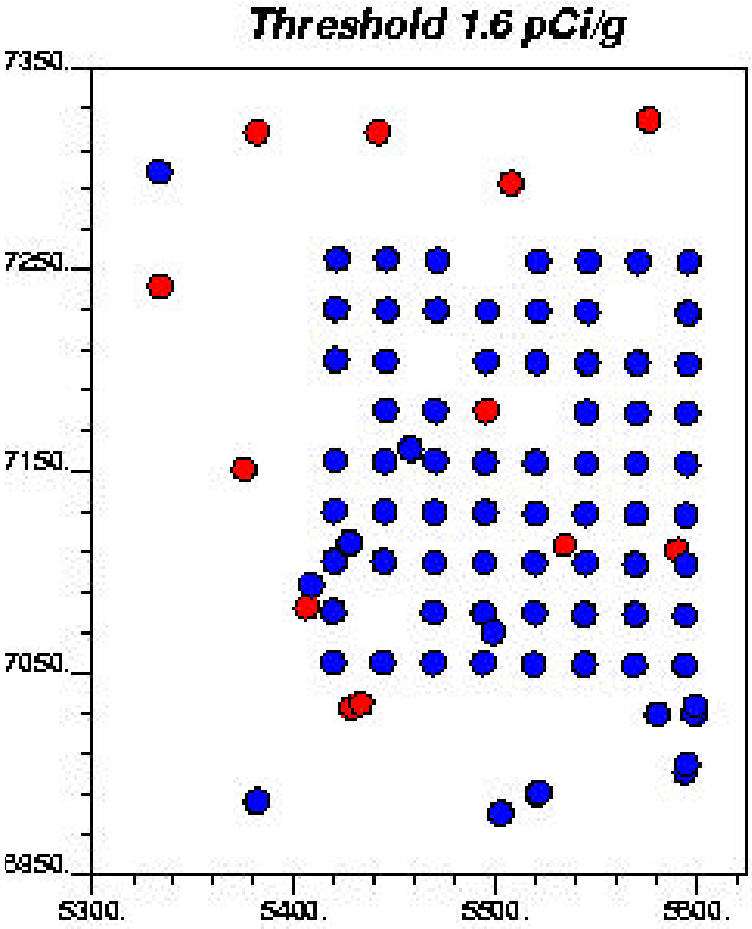
Threshold Classification of Samples





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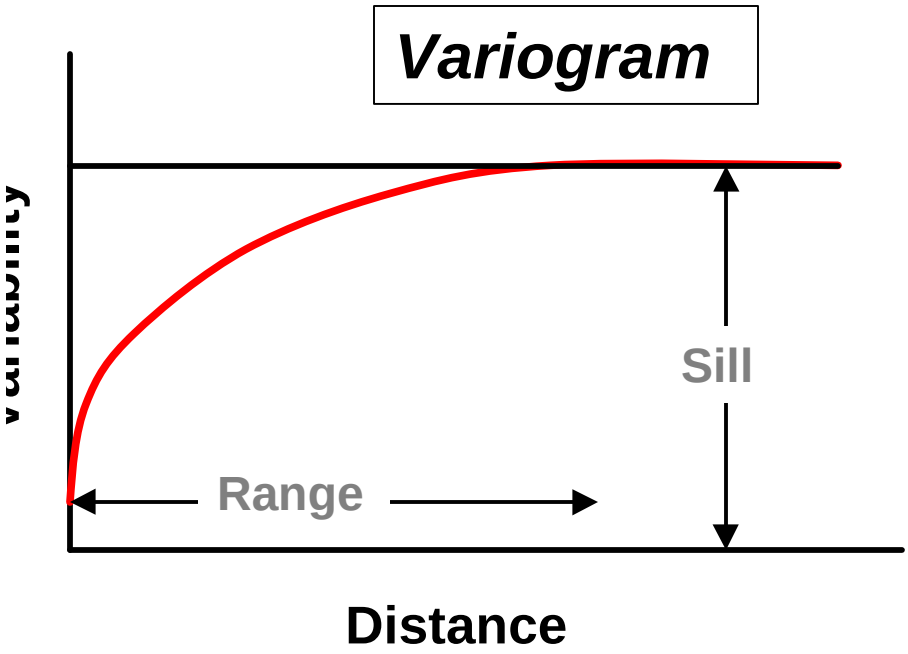
Data Exploitation

- 100 samples provide data
- Need to derive information from these samples to make remediation and sampling decisions
- Have locations and univariate distribution (histogram)
- Next step is to examine spatial correlation

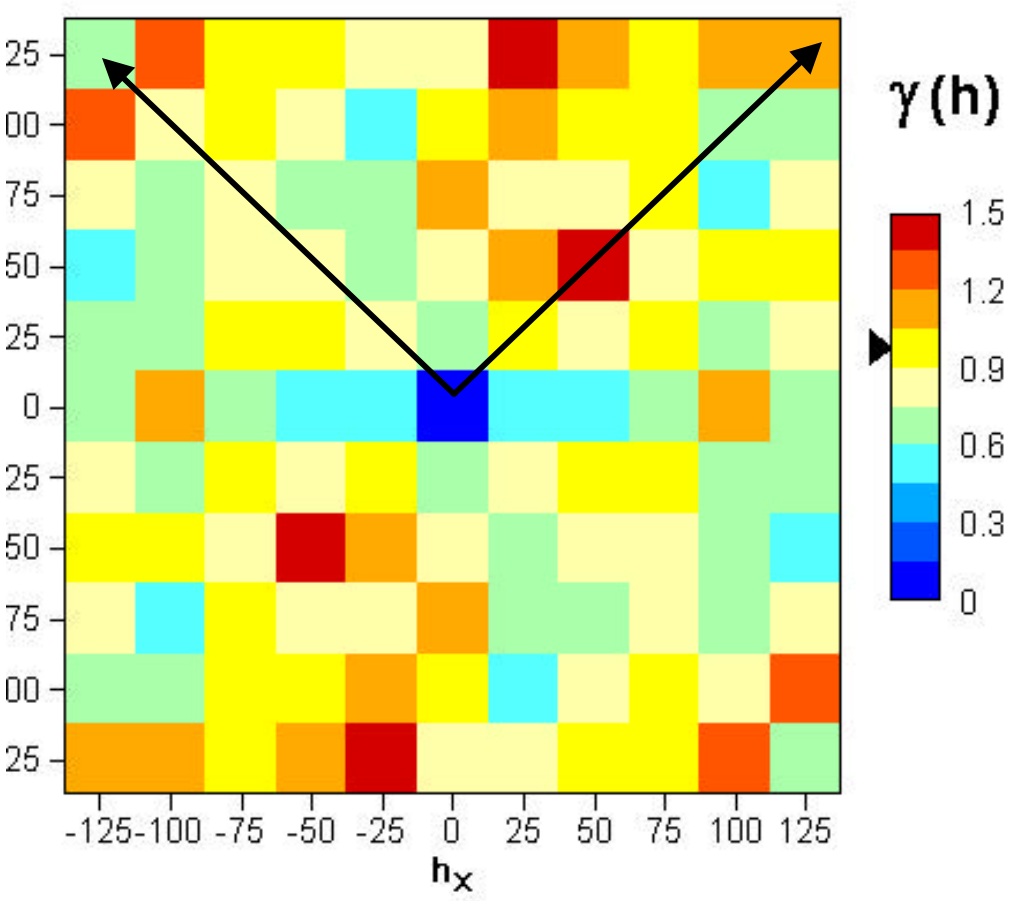
Spatial Correlation/Variation

Variation between two samples is proportional to the distance between them



Applicable to earth science, environmental financial, epidemiologic agricultural, etc., data

Normal-Score Variogram Map



LagX = lagY =

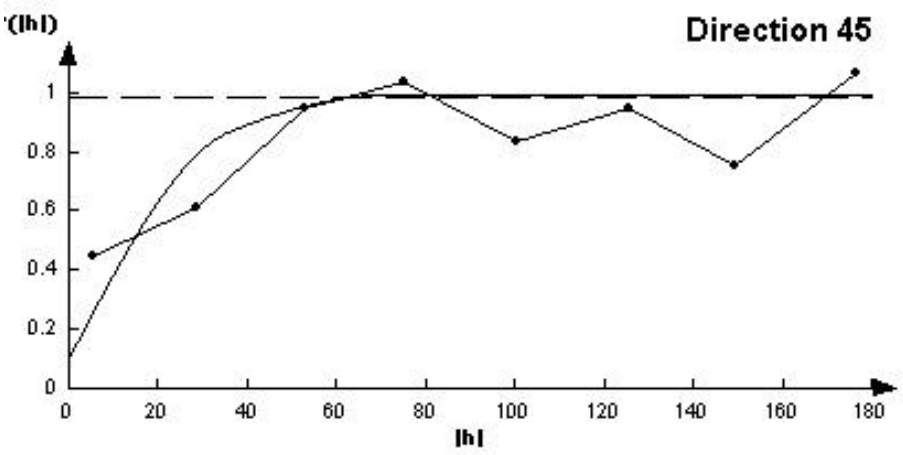
5 lags in X and

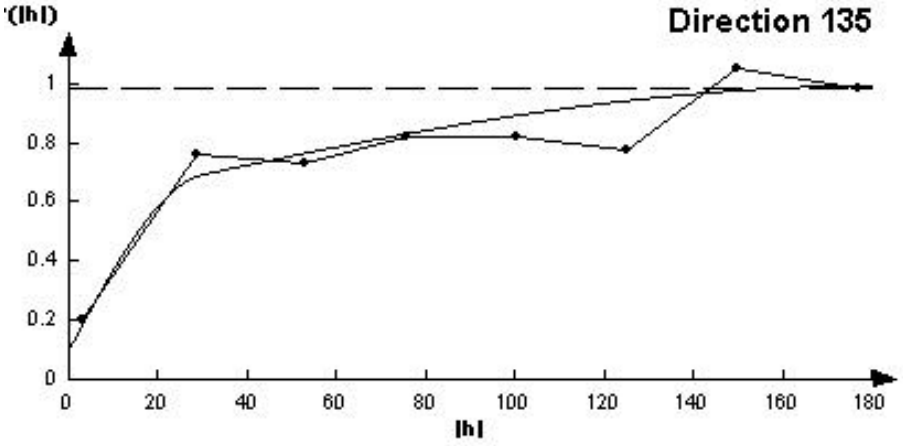
Complex Anisotropy:

Nearly Isotropic at sh ranges

NW-SE appears as longest range

Directional Variograms





Nugget = 0.10

NE-SW (45 deg)

sph1: 36.0 0.50

sph2: 72.0 0.40

NW-SE (135 deg

sph1: 30.0 0.5(

sph2: 180.0 0.4(

Modeled the 135 direc
with *anis* of 1.2 and 0.

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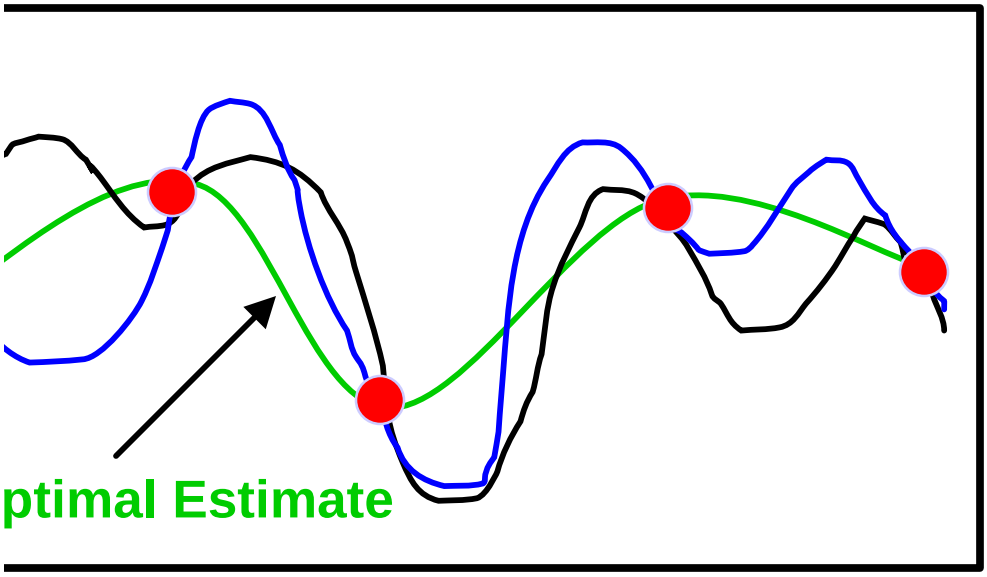
Jtility of Spatial Correlation

- **Correlated data provide information on unsampled locations**
- **Exploit this information to better estimate the concentration values at unsampled locations**
- **How?**
  - **Geostatistical estimation (kriging)**
  - **Geostatistical simulation**

Simulation vs. Estimation

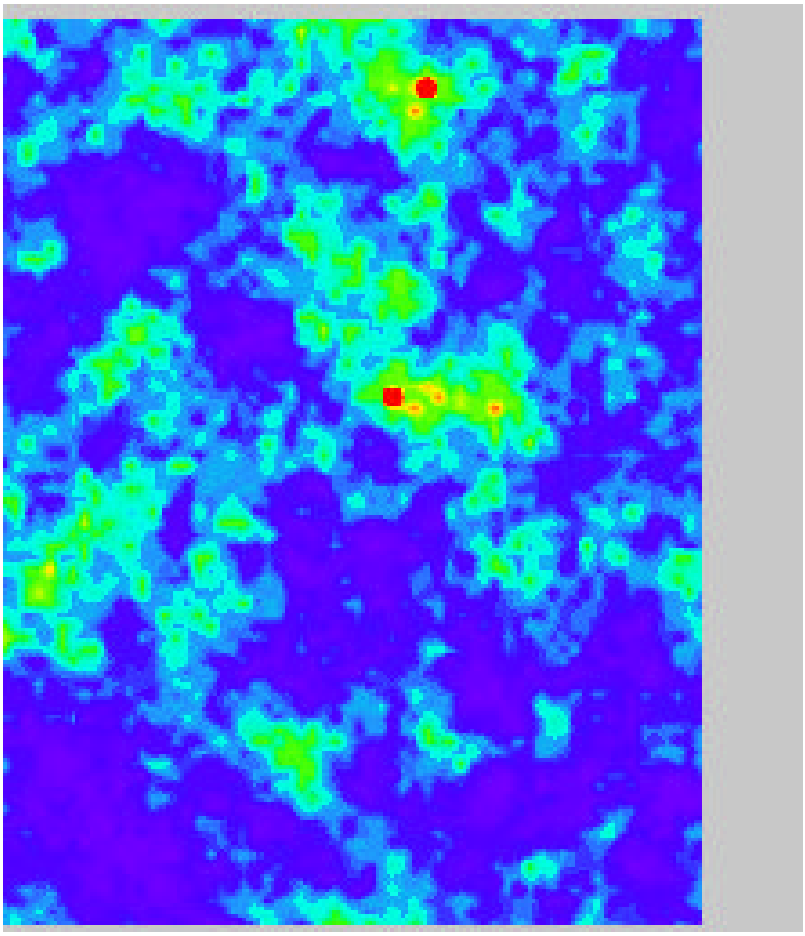


Distance

Estimation (*krigi*
is a geostatistica
process that retu
best guess (optir
value) at each
location.

imulation is a geostatistical process that creates
he full distribution of possible values at each
ocation and then randomly chooses one of them as
epresentative

Geostatistical Simulation



Monte Carlo process that create multiple images of activity at the site.

Every image honors:

Sample data

Histogram

Variogram

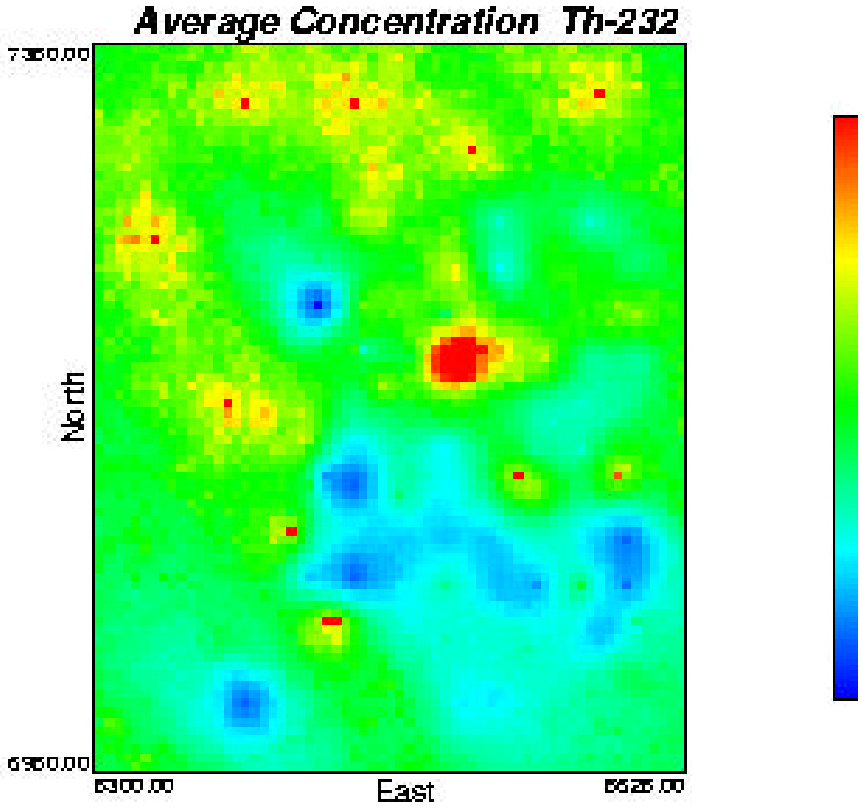
Given our knowledge of th site, *every image is a plausible depiction of the activity distribution.*

Jsing Simulations

e multiple simulations
n be processed to
ovide a number of
ferent maps.

e simple postprocessing
hnique is to determine
average simulated value
every location.

es the average, or
pectation, map help us
sign a remediation?



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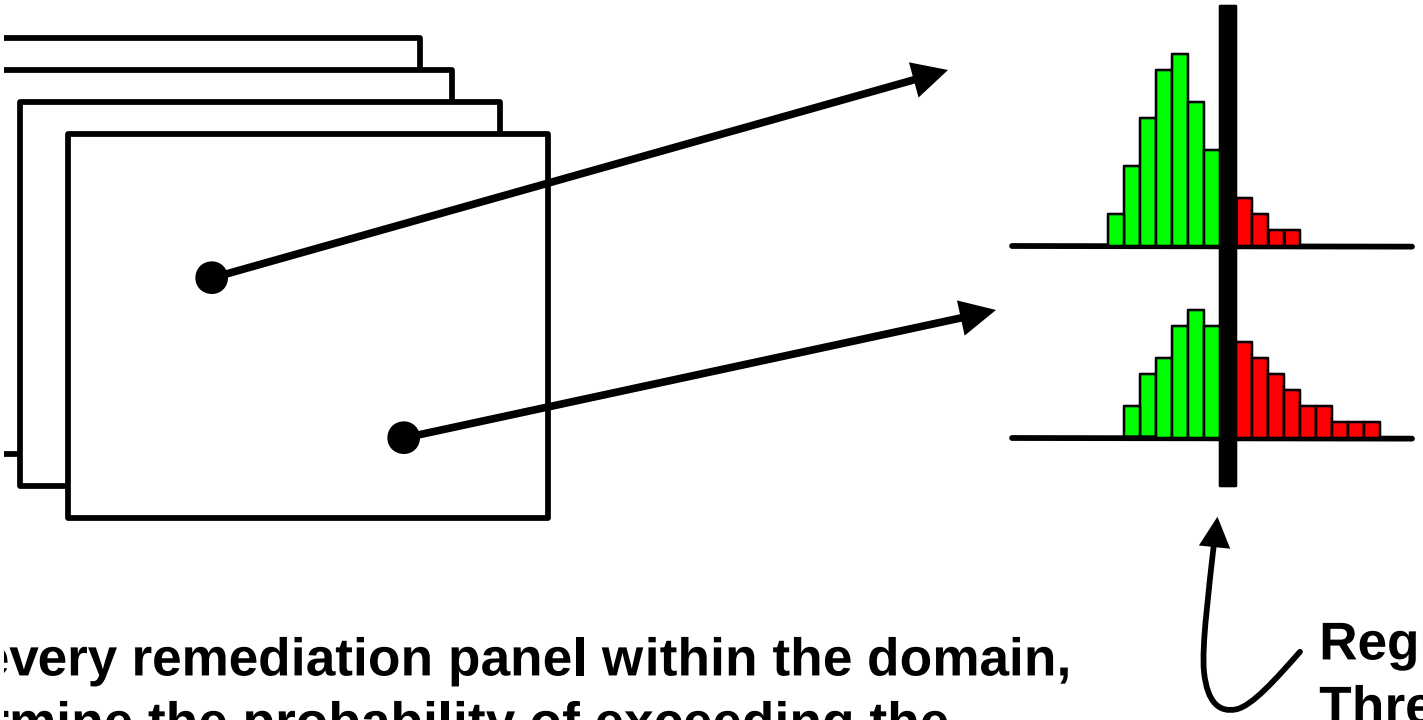
Probability Mapping

ow can we use the multiple contaminant maps
ealizations) to design a single remediation map?



very remediation panel within the domain,
mine the probability of exceeding the
latory threshold and display as a map

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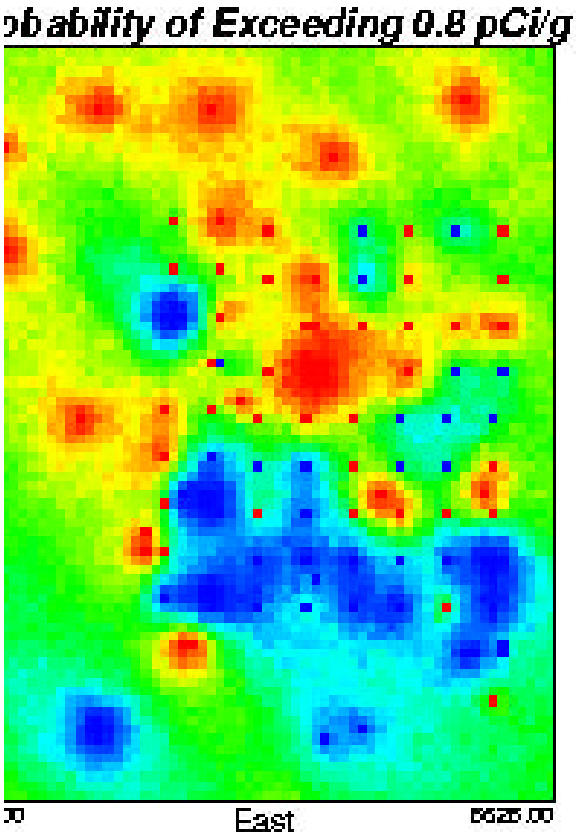
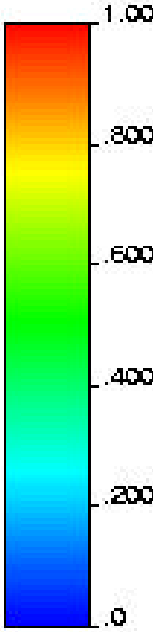
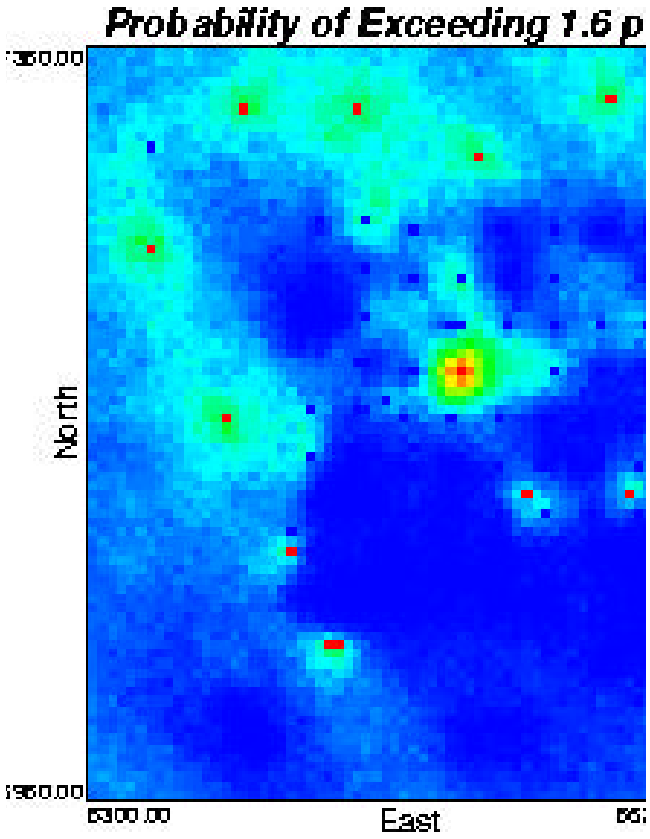
Probability Map Results

0.8 pCi/g



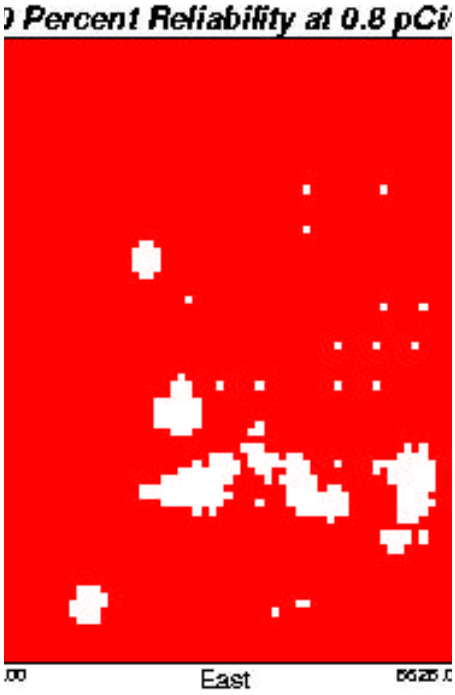


1.6 pCi/g

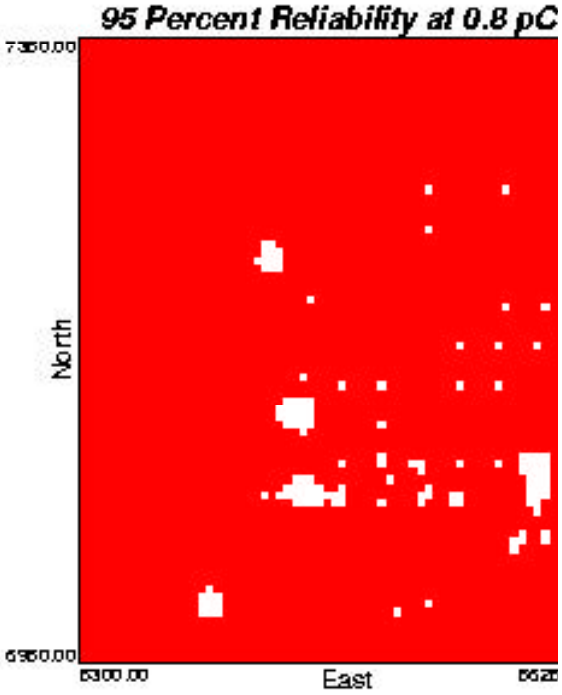


Remediation Maps 0.8 pCi/g

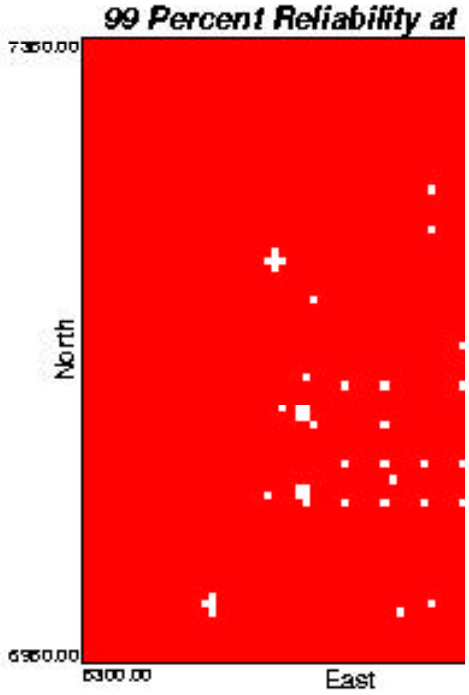
90 Percent



95 Percent



99 Perce



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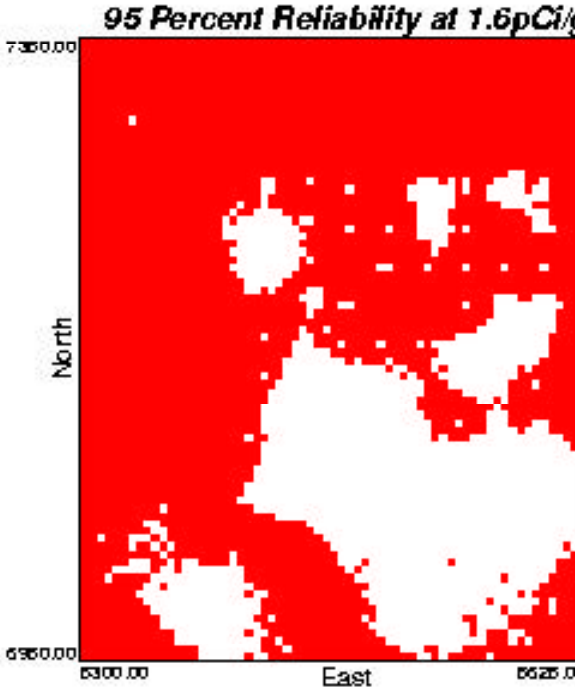
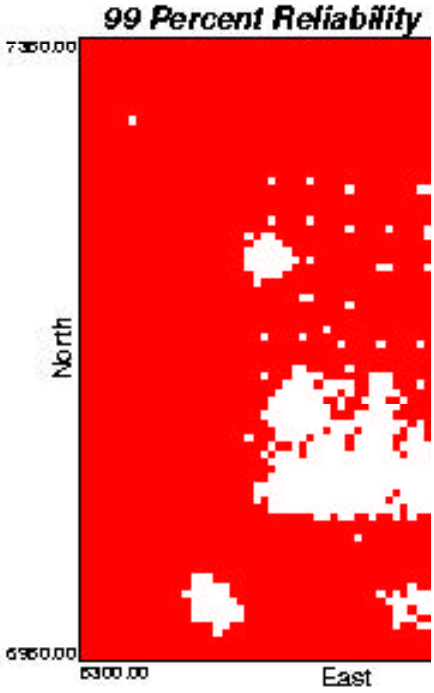
Remediation Maps 1.6 pCi/g

90 Percent

95 Percent



99 Perce



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Does this actually work?

cision results from SmartSampling application at cky Flats 903 Pad site. Decisions at 510 locations

anup Goal	Specified Reliability	Correct Decisions	False Negatives	False Positives
-241	0.99	335	4	171
-241	0.95	426	4	80
239	0.99	273	3	234
239	0.95	385	6	119
n of Ratios	0.99	235	11	264
n of Ratios	0.95	293	12	205

se Negative: not remediated, actually contaminated

se Positive: remediated, actually below action level

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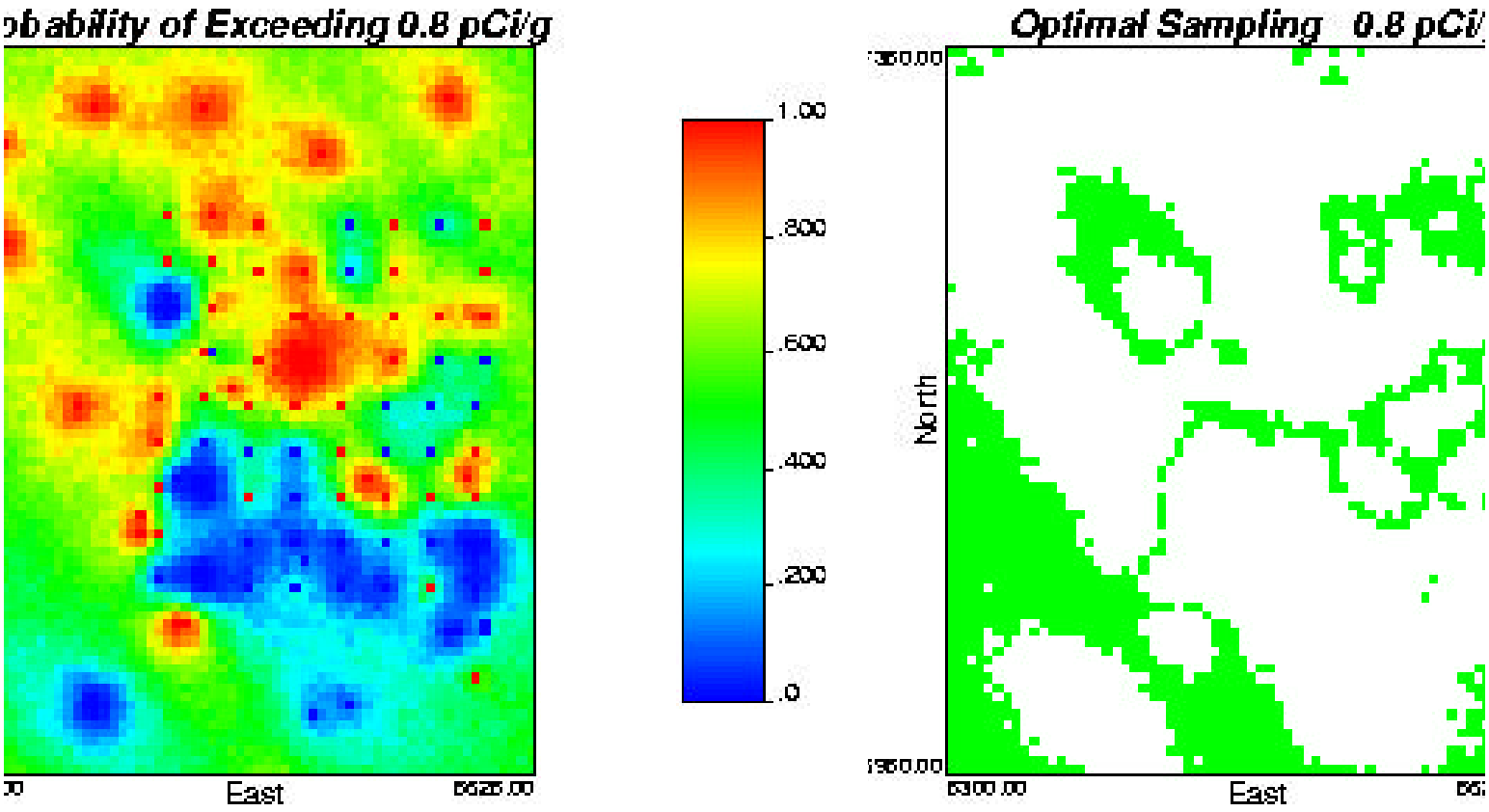
Additional Samples



“go for the green”

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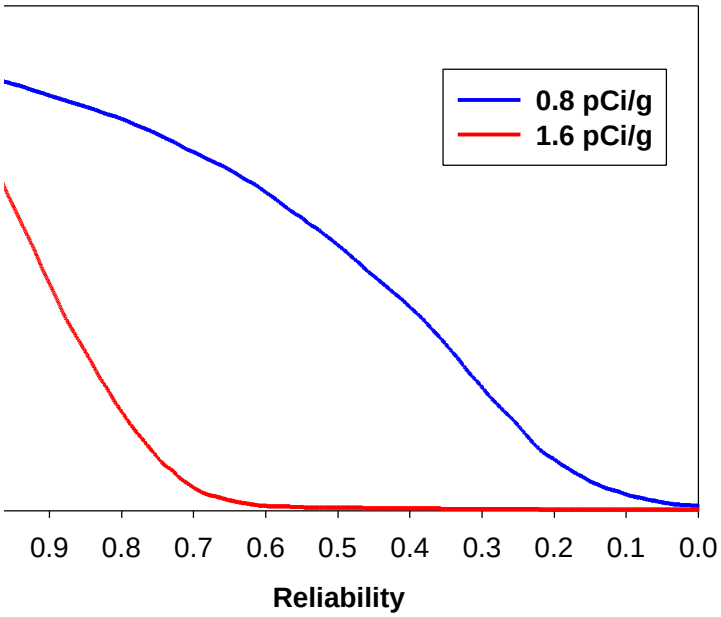
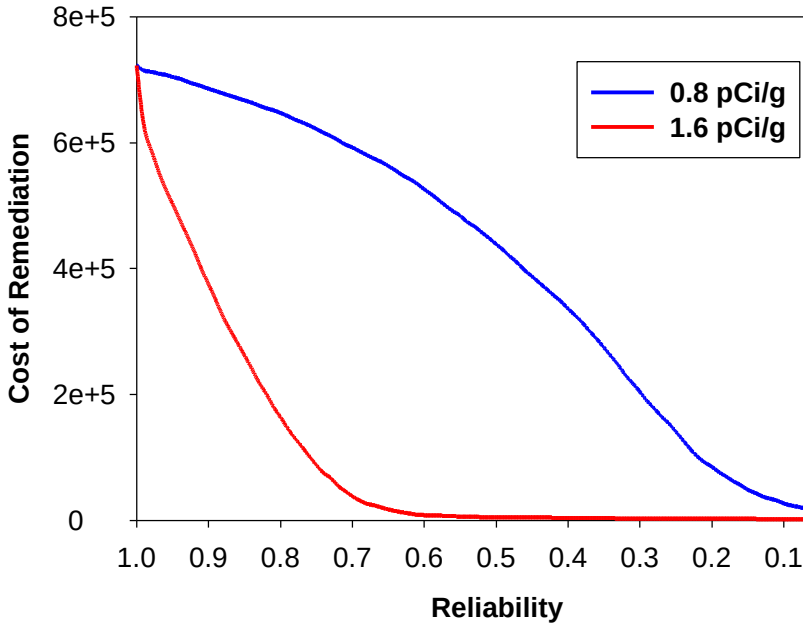
Remediation Reliability

Dirt Moved



Cost of Dirt Moved



t of remediation is $300/yd³. Each remediation panel is 5 x 5 x
(or 0.46 yd³ or $138.89)

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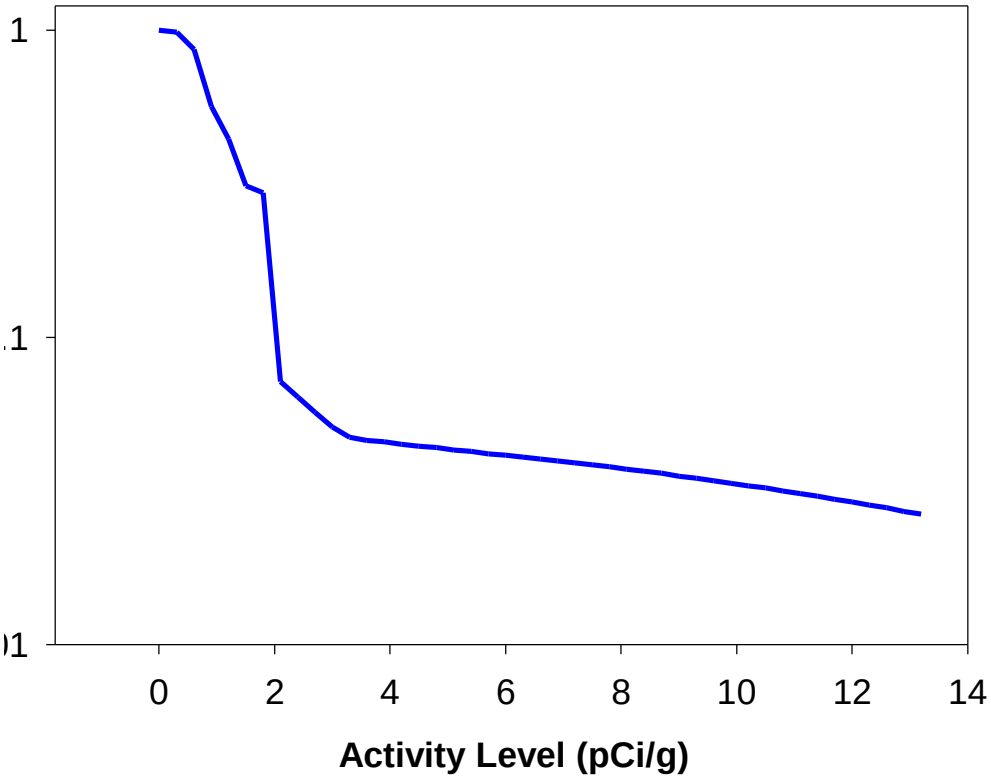
Activity Inventory



Across 200 simulati
the average number
curies on site is 0.0(

The majority of this
occurs in panels wit
activities <= 2.0 pCi/

big difference in the amount of inventory removed between an action level o
s 2.0. Real gains in inventory removal occur at action levels below 2.0. *Are*
vels really contamination or are they due to naturally occurring Th values?

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Summary

- Th-232 activity values at PRS-276 exhibit spatial correlation
- Geostatistical techniques exploit that correlation to define uncertainty in activity values at unsampled locations
- Probability maps provide remediation maps as a function of reliability and optimal locations for additional samples
- Other tools provide information on cost, reliability and total inventory

Summary

- Limited sampling means spatial uncertainty
- Spatial uncertainty leads to uncertainty in costs, sampling locations and remediatior plans
- SmartSampling provides a set of tools for practical decision making under uncertainty
  - "SmartSampling doesn't make decisions, People make decisions"