Presenting:

A Structured Process for Developing a Performance Confirmation Plan for the Yucca Mountain Project

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A Structured Process for Developing a Performance Confirmation Plan for the Yucca Mountain Project

Decision Analysis Affinity Group

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Presentation Overview

- **Yucca Mountain and the Performance Confirmation (PC) Program**
- **Role of Decision Analysis in Developing the PC Program**
- **Details of DA Approach**
  - Multi-Attribute Utility Analysis
  - The "Portfolio Problem"
    - Phase 1 – Parameter Evaluation
    - Phase 2 – Portfolio Evaluation & Selection

Proposed Yucca Mountain Nuclear Waste Repository

- 100 miles NW of Las Vegas
- Expected capacity is ~77,000 tons

- 1978 – DOE begins studying YM, among other sites
- 1987-Congress directs DOE to study only YM
- 2002-Bush signs House Joint Resolution 87 approving site recommendation
- Currently - DOE is developing License Application to NRC

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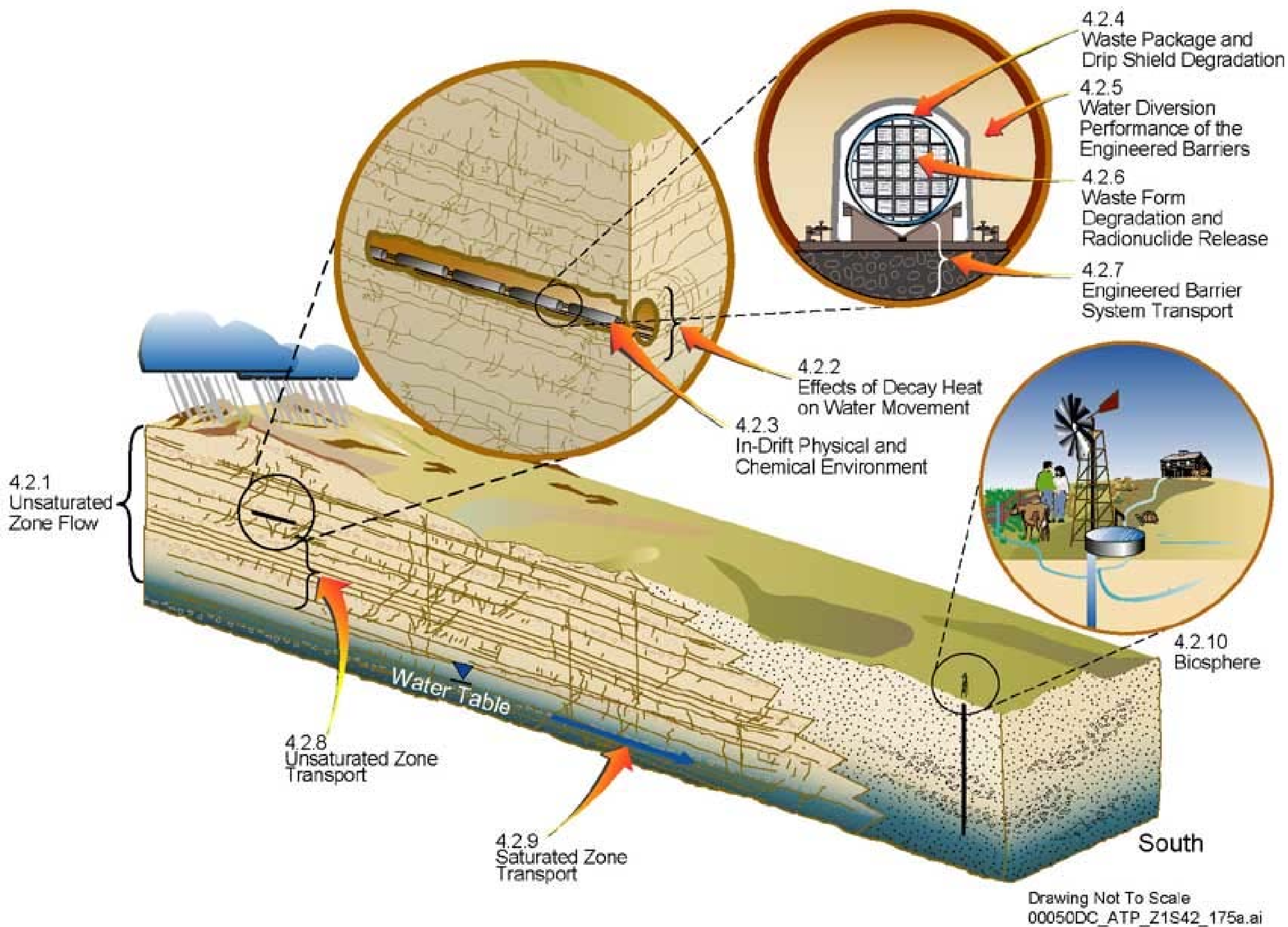
Repository Schematic



Role and requirements for performance confirmation

"Performance confirmation means the program of tests, experiments, and analyses that is conducted to evaluate the adequacy of the information used to demonstrate compliance with the performance objectives …"
(10 CFR 63.2)

- **The Nuclear Regulatory Commission requires a Performance Confirmation Plan as part of a License Application for the Yucca Mountain repository**
- **There are four subparts to the requirements for Performance Confirmation (Subpart F)**
  - General requirements
    - Provide data that indicate, where practicable, whether the repository system is functioning as intended and anticipated
  - Confirmation of geotechnical and design parameters
  - Design testing
  - Monitoring and testing waste packages

Process for revising the performance confirmation program

- **DOE is restructuring the PC Program to:**
  - Contain activities that are designed to evaluate the technical basis for the licensing decision
  - Be driven by requirements in 10CFR63 and YMRP expectations
  - Provide confidence and be risk-informed
  - Test an operational facility
- **There are a very large number of parameters and data acquisition methods that could potentially be included**
- **A structured decision analysis approach was used to:**
  - Develop a scope of activity commensurate with a risk-informed evaluation of contribution to performance and uncertainty
  - Provide a defensible and traceable approach for determining which parameters should be included

The approach separates parameter from portfolio evaluation

- **The Performance Confirmation Program consists of a "portfolio" of activities**
  - An activity is a combination of a performance confirmation parameter and a data acquisition method
- **The best portfolio does not necessarily result from simply including the top ranked activities**
  - There may be objectives or goals for a performance confirmation program that are unrelated to the specific activities included
  - There can be interactions among activities that make it more or less desirable to include two specific activities together
- **However, the value of the portfolio depends at least in part on the value of the specific components of that portfolio.**
- ***Evaluating the individual activities is a prerequisite to evaluation of portfolios***

Phase 1: Evaluating candidate activities

Develop evaluation criteria

- Barrier capability & system performance sensitivity to the parameter
- Confidence in the current representation of the parameter
- Accuracy with which the proposed activity measures or estimates the parameter

Technical value
- Sensitivity
- Confidence
- Accuracy

Evaluate activities (technical judgments against criteria)

Assign management value judgments to criteria

Define and describe candidate activities

Barrier 7
Barrier 5,6
Barrier 2,3,4
Barrier 1

Combine technical and management judgments to get overall utility for candidate activities

Parameter evaluation criteria

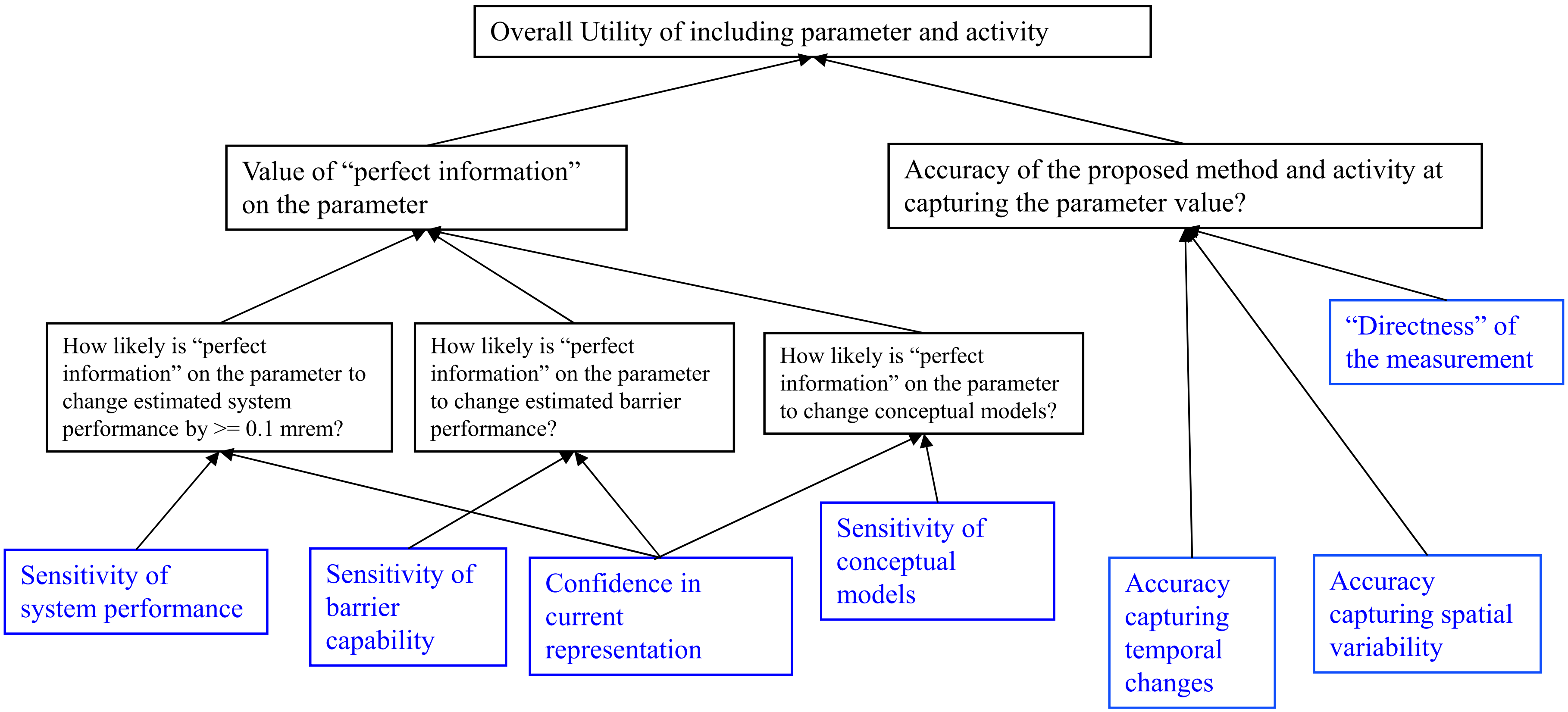
- **At an initial Workshop (Aug 26, 2002), an expanded core team developed three criteria to be used in developing technical judgments of the potential impact of a performance confirmation activity on the performance confirmation program:**
  - Barrier capability & system performance sensitivity to the parameter
  - Confidence in the current representation of the parameter
  - Accuracy with which the proposed activity measures or estimates the parameter

- **Workshop participants included**
  - Technical investigators with various areas of expertise
  - Performance assessment analysts and managers
  - DOE staff

A detailed set of questions was developed around each of the criteria

- **The purpose of the questionnaire was to elicit technical judgments on how well proposed parameters and activities meet the three criteria**
  - Detailed questions and "scales" are also necessary to allow managerial value judgments to be applied consistently to the technical judgments
- **Another goal of the questionnaire was improve consistency across model areas**
  - Technical judgments about sensitivity, confidence, and accuracy must be made by the relevant technical experts most familiar with the model areas
  - Unaided or ad hoc evaluation of parameters by different individuals typically result in vastly different interpretations of the criteria
  - A single consistent set of questions reduces inter-individual variations in interpretation

Technical judgments: use of the questionnaire



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Technical judgments: use of the questionnaire

Overall Utility of including parameter and activity

How likel… informatio… change es… performan…

Sensitivity o… system perf…

…ess" of …urement

…spatial

Question 1.2.a: Ass… the parameter is fo… outside it's current… modeled range: W… likelihood that the … estimate of 10,000 … combined mean annual dose will change by more than 0.1 mrem?

Question 1.2.a: Assume the parameter value is found to lie outside it's currently modeled range. Use the scale below to estimate the likelihood that the new estimate of 10,000-year combined (nominal plus disruptive) mean annual dose changes more than 0.1 mrem.

A	More than 1 chance in 10
B	Between 1 chance in 100 and 1 chance in 10
C	Between 1 chance in 1000 and 1 chance in 100
D	Between 1 chance in 10,000 and 1 chance in 1000
E	Between 1 chance in 100,000 and 1 chance in 10,000
F	Less than 1 chance in 100,000

Technical inputs

- **Workshops were held in September 2002 with each group of technical experts**
  - Explain the process, identify candidate parameters and data acquisition methods
  - Test the questionnaire on real activities
  - Technical investigators and TSPA modelers familiar with each barrier, with total system evaluations, and with disruptive events analyses

Technical inputs

Parameter	Activity	Barrier (B)
Perforated fraction of Cladding at closure	Stay abreast of literature	Cladding
Waste Form dissolved concentration limits Tc dissolv. conc. limits/ Tc	Lab tests	WF
Composition and physical characteristics of the invert (incl mineralogy)	Testing On-site, prior to WP emplacement	Invert
Composition and physical charact.of the invert (incl mineralogy)	Off-footprint activities (lab tests)	Invert
Temperature/RH of Waste Package	Temp/RH of exit air at exits to regular drifts	WP
Temperature/RH of Waste Package	Using instruments within regular emplacement drifts	WP
Temperature/RH of Waste Package	Using instruments within an accelerated thermal drift	WP
Temperature/RH of Waste Package	Using an ROV to take periodic measurements within an accelerated thermal drift	WP
Temperature/RH of Waste Package	Using an ROV to take periodic measurements within regular emplacement drifts	WP
Temperature/RH of Waste Package	Temp/RH of exit air at an accelerated thermal drift	WP
Hydrologic Properties of Fractures, TSw (porosity, permeability)	Air-permeability testing in different repository areas, gas tracer testing in a few locations, liquid release tests in different locations above drifts, laboratory testing of moisture retention, testing after drift construction, but before emplacement	UZ Above, UZ Below

Technical inputs

- **After the workshops, technical experts evaluated candidate activities**
  - A subset of the core team specified their technical judgments on each proposed activity across all model areas, to provide a consistency check
  - Differences in the technical judgments by the two groups were identified and then reconciled

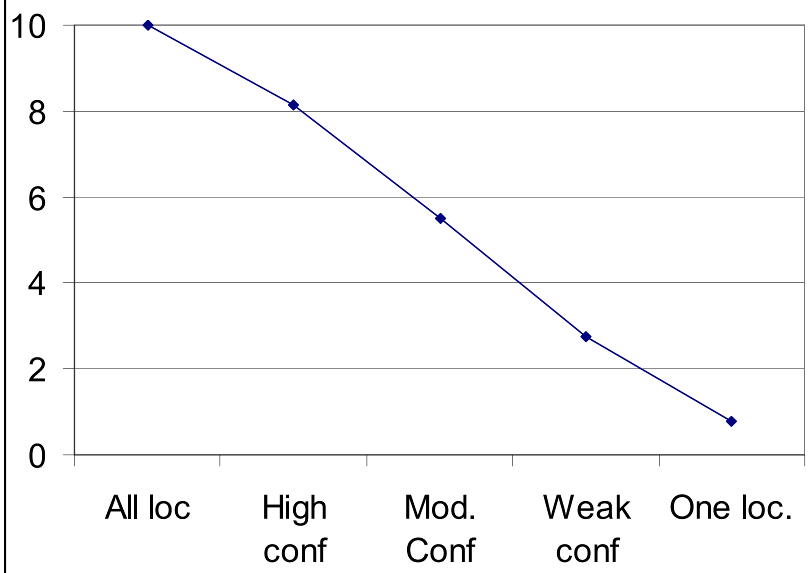
Performance Assessment managers provided the necessary management value judgments

- Managers reviewed the overall process and endorsed the specific criteria being used to evaluate parameters and methods
- Managers answered a series of tradeoff questions, designed around the technical questions used in the questionnaire, to establish management value judgments about the relative importance of the criteria
- Management value judgments used in conjunction with the technical judgments to establish the overall utility for each activity

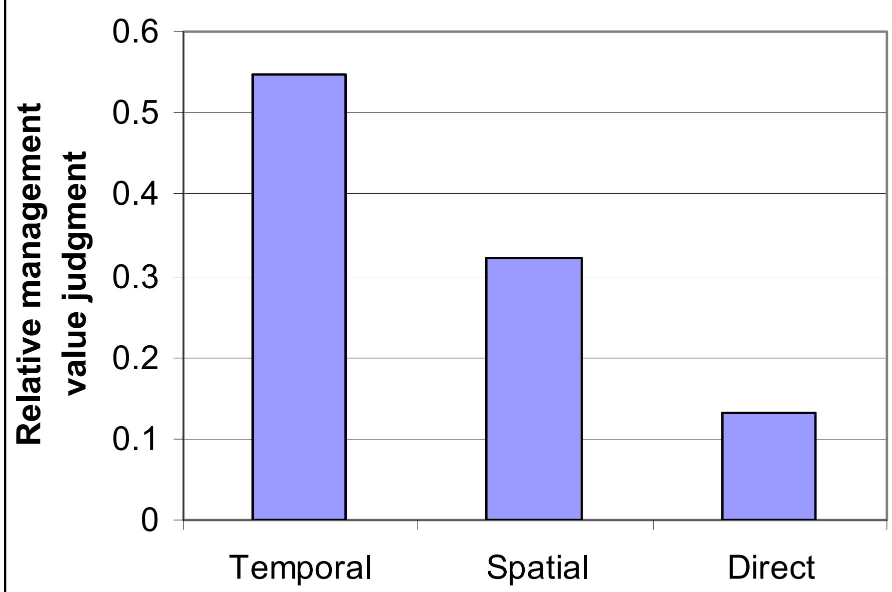
Example management value judgments

- **Several types of management value judgments were required**

- **Judgments about the relative value of changes in “scores” within a single criterion: spatial representativeness**



- **Judgments about the relative value of different criteria: components of accuracy metric**



Costs for each activity

- **Understanding both the benefits and the costs of a candidate activity is an essential component of the decision making process**
  - Including activities based solely on maximizing “benefit” may result in a highly cost-ineffective PC Plan
  - Including activities based solely on minimizing costs may also result in a highly cost-ineffective PC Plan
- **Very rough cost estimates were derived from the answers to three of the questions on the questionnaire**
  - How difficult will it be to take the proposed measurements?
  - How long will a single test or measurement take?
  - How long will the testing or monitoring program continue?
- **The core team and cost experts reviewed the rough cost estimates and made some modifications based on their experience**

Summary of activity evaluation

- **Started with 237 parameters and a total of 360 activities**
- **After discussion and evaluation, 204 parameters and 287 total activities remained**
- **Utility and Cost estimates for the 287**
- **A review meeting was held with representatives of the technical experts who provided input**
  - Technical experts indicated where they thought the results did not reflect their technical opinions, and comments were carried forward to the portfolio development phase

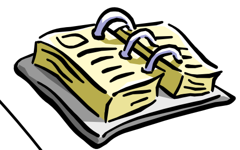
Phase 2: Developing and evaluating alternative portfolios

Develop portfolio philosophies

Define activities included in each portfolio

Evaluate portfolios

Phase 1 Results



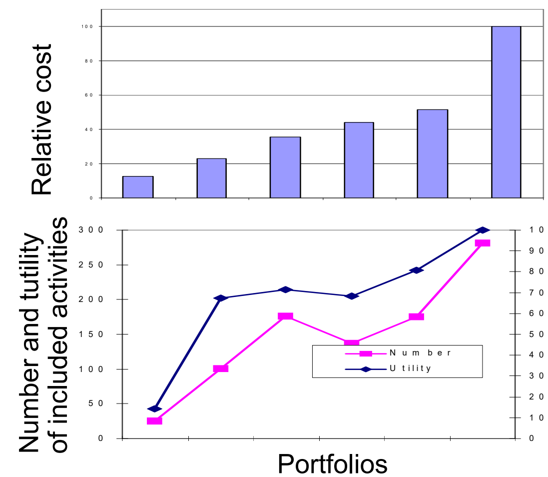
– Basic requirement: any portfolio must meet the requirements of 10CFR63

– Beyond the basic requirement, consider portfolios defined around:

- –Cost-effectiveness
- –Testing specific hypotheses
- –Maximizing regulatory robustness and coverage
- –Maximizing use of high-capital-cost items
- –Maximizing off-footprint activities
- –etc

Portfolio A
Activity 1
Activity 2
. . .

Portfolio B
Activity A
Activity B
Activity C
Activity D
…



Use management judgment to select and refine a final portfolio

Philosophy for portfolio development

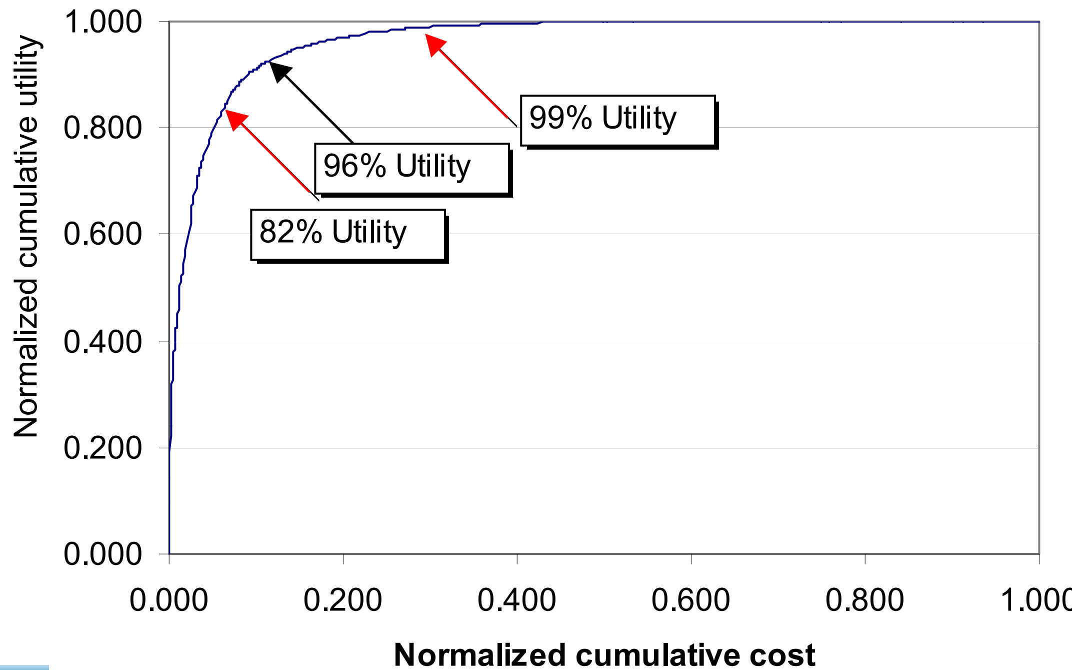
- **Each portfolio addresses the performance confirmation requirements of 10 CFR 63**
- **Eleven portfolios were developed**
  - Spanned a range of scope, costs, and robustness
  - Included portfolios that emphasized cost-benefit and hypothesis testing philosophies
  - Included portfolios that emphasized off-site work or on-site work
- **One portfolio will be selected for the License Application**
  - The selected portfolio will be a modification of one of the eleven portfolios
  - The selected portfolio may evolve before emplacement of waste

Two bounding portfolios were developed

- **Most extensive portfolio**
  - Includes all activities identified by the technical experts and evaluated as having positive benefit (ignoring costs)
- **Minimum portfolio**
  - Least-cost set of activities that addresses the performance confirmation requirements of 10 CFR 63
  - The degree of activity for each 10 CFR 63 requirement is small, to achieve minimum cost
- **These bounding portfolios were evaluated in detail**

Cost-benefit portfolios

- **Three portfolios were developed**
  - All activities were ranked by utility-to-cost ratio
  - "Threshold" utility-to-cost ratios were set for alternative portfolios
  - Activities that met the threshold were included in the portfolio
  - Reviewed for cost synergies among activities
- **Portfolios capturing 99% and 82% of the total potential utility were evaluated in detail**



Hypothesis testing portfolios

- **Two portfolios were defined using the concept of "hypothesis testing"**
  - A set of performance "hypotheses" was developed at the barrier and total system level
  - Activities were identified as
    - Testing a technical "bottom line" of the hypothesis
    - Testing "inputs" to the hypothesis
  - Example:
    - The surficial barrier will limit infiltration to less than nn% of precipitation, averaged over the footprint and one year
- **The first hypothesis testing portfolio included both direct and indirect tests of the hypotheses**
- **A second hypothesis testing portfolio was developed with fewer activities**
- **Both portfolios were evaluated in detail**

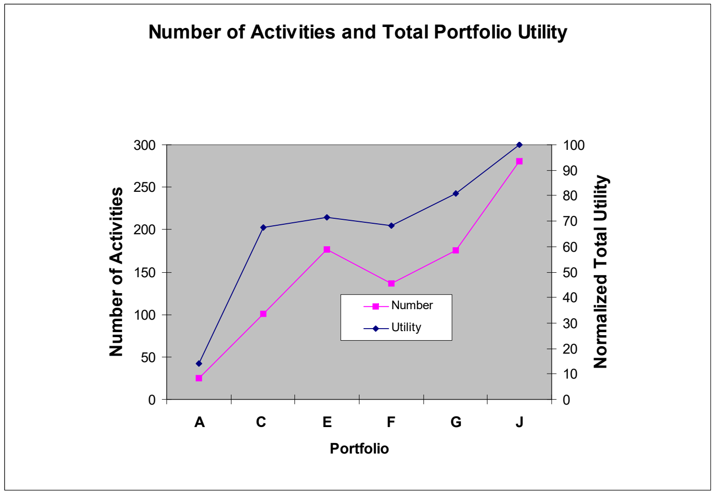
Location-dependent portfolios

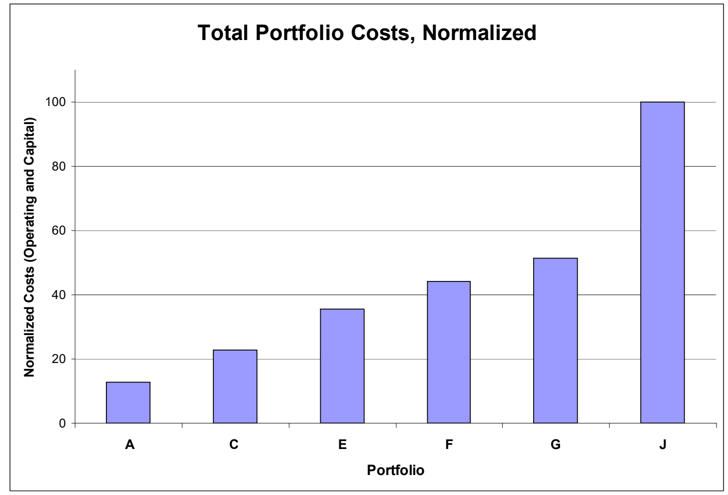
- **Two portfolios were developed that focus on the location of performance confirmation activities**
  - Maximize use of a thermally-accelerated drift
    - Assumes an accelerated drift will be included in the program; includes primarily activities making use of that drift
  - Maximize use of off-footprint testing
    - Designed to keep worker risks as low as possible, and minimize interference of the program with activities in the Geologic Repository Operations Area
- **Neither location-dependent portfolio was evaluated in detail**
  - Did not provide significant additional benefit over other portfolios

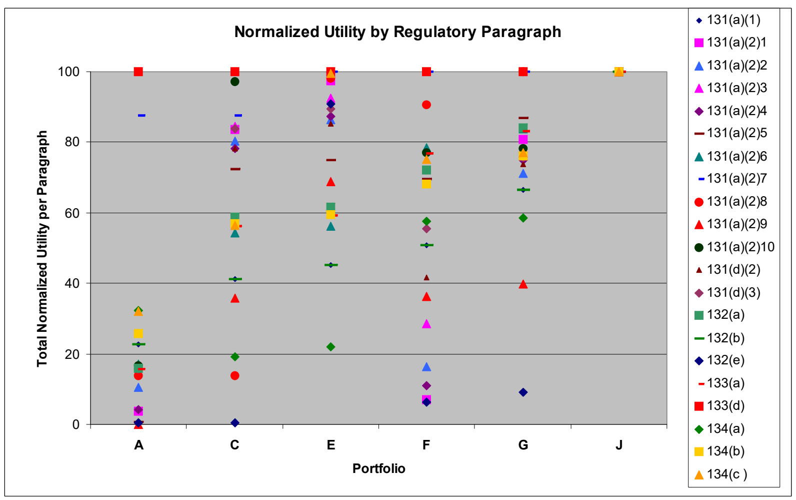
Portfolio evaluation criteria

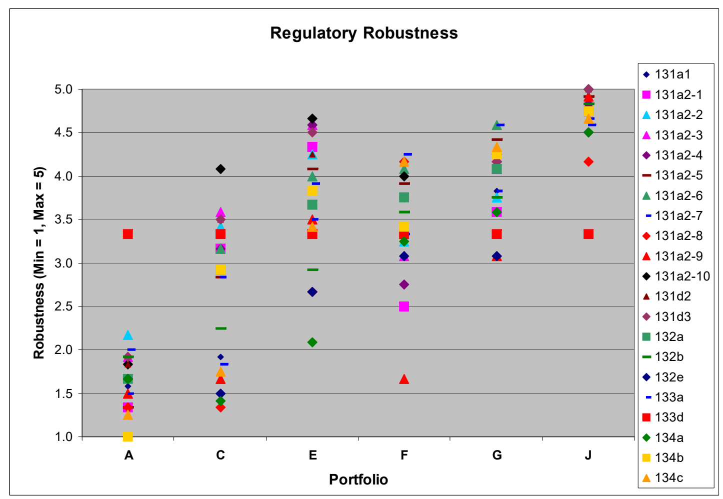
- **Activities were mapped to the regulatory requirements in 10 CFR 63 Subpart F**
  - Some activities support multiple requirements
- **Attributes were totaled across the activities in each portfolio**
  - Activity count
  - Total utility
  - Total operating plus capital cost
- **Activity utilities were summed for each regulatory requirement in 10 CFR 63 Subpart F, within each portfolio**
- **A subjective assessment was made against each regulatory requirement in 10 CFR 63 Subpart F, for each portfolio**
  - This added "coverage" as a subjective sub-criterion

Portfolio evaluation criteria









Portfolio selection

- The core team (seven people) supported by the two decision analysts evaluated the portfolios using the criteria
- The BSC Project Oversight Board reviewed the evaluation and selected a portfolio to send to DOE

Current Status

- BSC is developing a recommendation to the DOE Office of Repository Development
- The DOE will consider the BSC recommendation and select a portfolio for the Performance Confirmation Program for the license application