U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: TEST PRIORITIZATION TASK - RECOMMENDED EARLY ACTIVITIES TO DETECT POTENTIALLY UNSUITABLE SITE CONDITIONS

AUTHORS:
STEVEN R. MATTSON
BRUCE R. JUDD
SCOTT R. SINNOCK
DWIGHT T. HOXIE

DENVER, COLORADO
MARCH 6-7, 1991

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PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: INTRODUCTION TO THE TEST PRIORITIZATION TASK

PRESENTER: DR. J. RUSSELL DYER

PRESENTER'S TITLE AND ORGANIZATION: REGULATORY AND SITE EVALUATION DIVISION
YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
U.S. DEPARTMENT OF ENERGY

PRESENTER'S TELEPHONE NUMBER: (702) 794-7586

DENVER, COLORADO
MARCH 6-7, 1991

Test Prioritization Task
— Agenda —

- **Introduction to the test prioritization task** — *J. Russell Dyer, DOE*
  - Objectives of the TPT
  - Phased approach
  - Scope of phase I

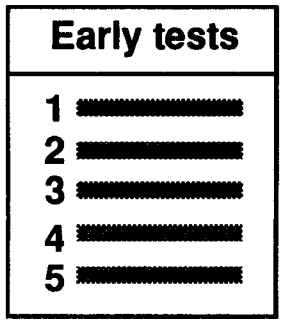
- **Phase I analysis and results** — *Bruce Judd, DAC*
  - Analytic approach
  - Importance of "potential concerns"
  - Test priorities

- **Future activities** — *Bruce Judd, DAC*
  - Phase II analysis
  - Ties to site-suitability evaluation

DOE has two primary objectives for this task

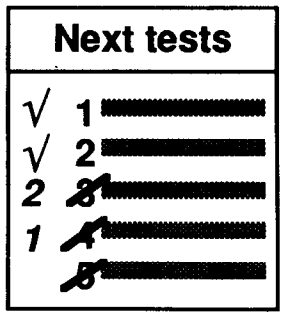
Objectives

- **Develop a decision-aiding method to prioritize tests that could be conducted early to detect potentially unsuitable site conditions**



- **Recommend methods to re-prioritize testing at any point during site characterization**

  Include a method for deciding when to stop testing



The method should provide a management tool for test prioritization that is consistent with site-suitability evaluation methods

The scope was originally limited to surface-based testing, but was expanded in the Fall of 1990

January 1990	"Prioritization of Surface-based Testing" task established under QA program. Original task included responsibility for making recommendations on possible site-suitability methodology
August 1990	Letter report on site-suitability (Letter from Shaler to Distribution August 9, 1990)
October 1990	Task scope modified • New site-suitability task created • Name changed to "Testing Prioritization Task" • Two-phased approach developed (Letter report October 1, 1990) • All testing to be considered

A two-phased approach has been developed to assist calendar-year 1991 and 1992 test prioritizations

Phases	Target Dates
I. **"Spreadsheet" application** ***Based on available information and assessed expert judgments on test benefits and impacts***	March 1991
II. **"Simple TSP model" application** ***Based on Phase I analytic approach with expanded scope, simplified "total-system-performance model" calculations, and assessments by a larger sampling of the experts***	Xxxxxx 1992

A five-step analytic approach has been developed for Phase I prioritization

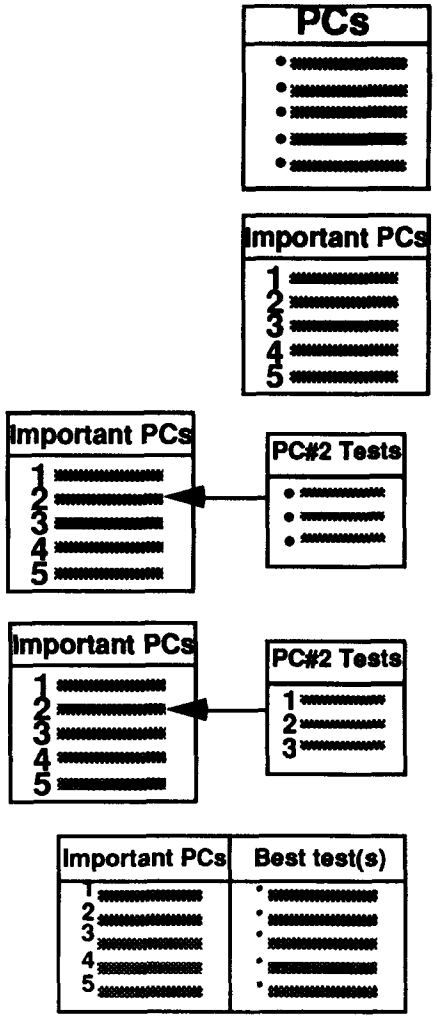
1. Compile a list of potential concerns (PCs)

2. Assess and rank the importance of each PC to waste isolation (measured in curies released)

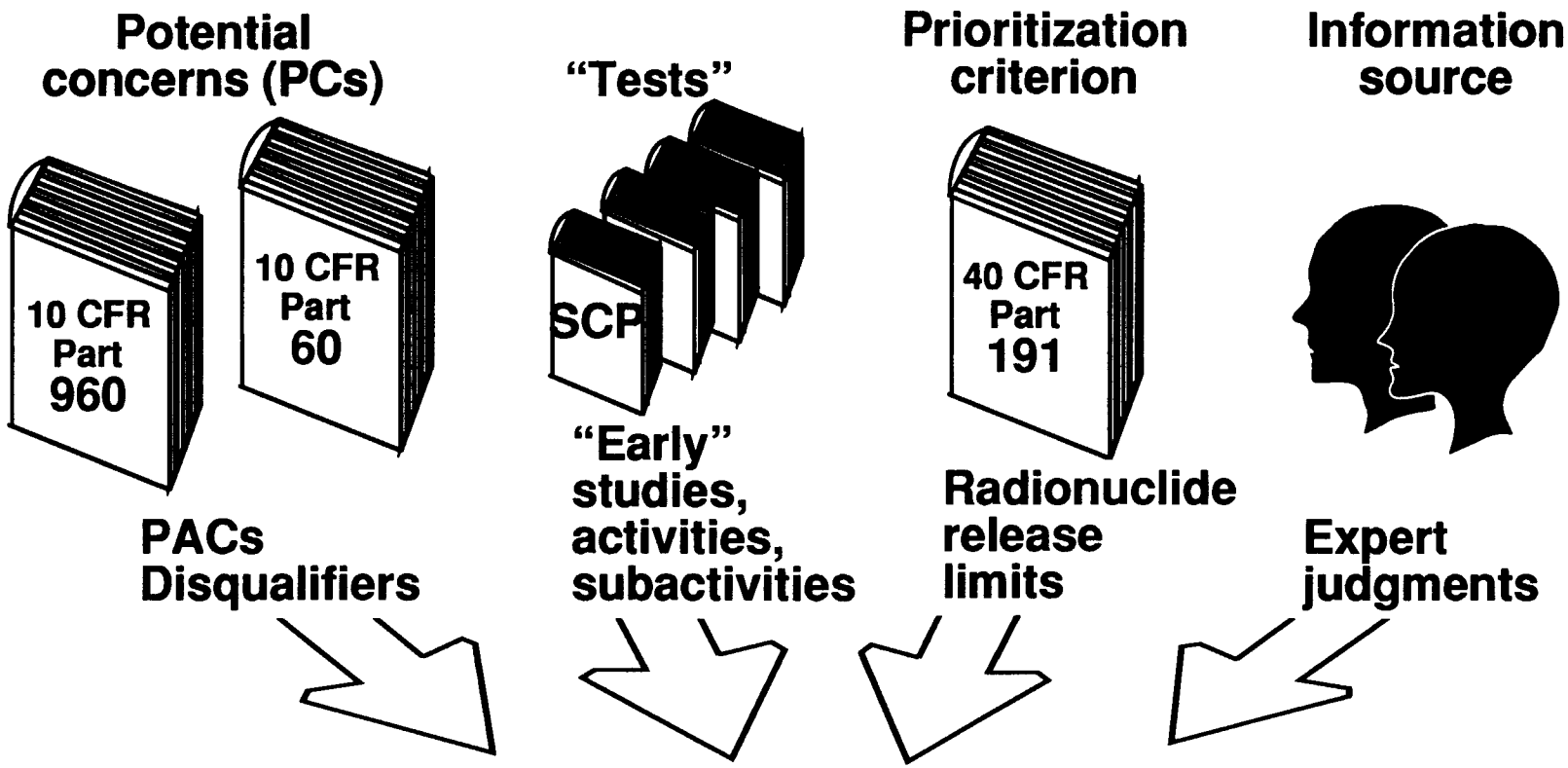
3. Compile a list of studies/tests addressing important PCs

4. Assess and rank the tests addressing important PCs

5. Evaluate testing priorities (Phase I)



Phase I sets priorities for a subset of "early" tests to detect potentially unsuitable site conditions



Important PCs	Best test(s)
1	•
2	•
3	•
4	•
5	•

The five-step approach screens the number of PCs to be analyzed in each step

		Number considered
1. List potential concerns (PCs)	PCs	>100 PCs
2. Assess and rank PCs	Important PCs 1 2 3 4 5	32 PCs
3. List tests	Important PCs 1 2 3 4 5 ← PC#2 Tests	15 test packages for 10 important PCs
4. Assess and rank tests	Important PCs 1 2 3 4 5 ← PC#2 Tests 1 2 3	15 test packages for 10 important PCs
5. Evaluate test priorities	Important PCs / Best test(s) 1 2 3 4 5	3 test-priority groups

Phase I prioritizes tests to detect potential concerns, but there are other important reasons for testing

Possible *Other Reasons* for Testing

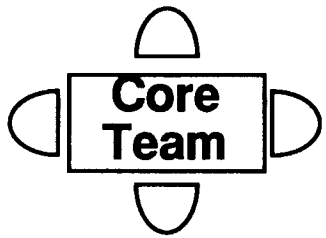
1. Evaluating preclosure health and safety concerns
2. Gathering information for design or construction
3. Providing other information required for licensing
4. Initiating long-duration performance-confirmation tests
5. Facilitating other tests (e.g., drilling boreholes)
6. Building scientific consensus and public confidence
7. ...

Priorities may need to be revised based on these considerations

The TPT core team guided the analysis and made recommendations to management

Steven R. Mattson
SAIC, team lead

Dwight T. Hoxie
USGS



Scott R. Sinnock
Sandia

Bruce R. Judd
Decision Analysis Co.

J. Russell Dyer
DOE/YMP oversight and management

We will now summarize our Phase I analysis and test prioritization results

- Introduction to the test prioritization task — *J. Russell Dyer, DOE*
  - Objectives of the TPT
  - Phased approach
  - Scope of phase I

- Phase I analysis and results — *Bruce Judd, DAC*
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OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: TEST PRIORITIZATION TASK - ANALYSIS AND TEST PRIORITIES

PRESENTER: DR. BRUCE R. JUDD

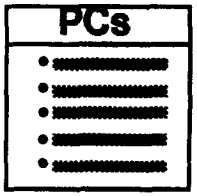
PRESENTER'S TITLE AND ORGANIZATION: PRESIDENT
DECISION ANALYSIS COMPANY

PRESENTER'S TELEPHONE NUMBER: (415) 851-3007

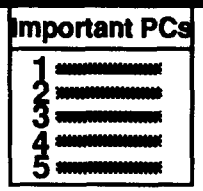
DENVER, COLORADO
MARCH 6-7, 1991

The core team and workshop participants developed a list of 32 potential concerns for Phase I analysis

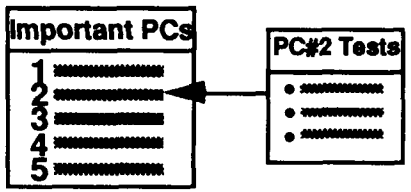
1. Compile a list of potential concerns (PCs)



2. Assess and rank the importance of each PC to waste isolation (measured in curies released)



3. Compile a list of studies/tests addressing important PCs



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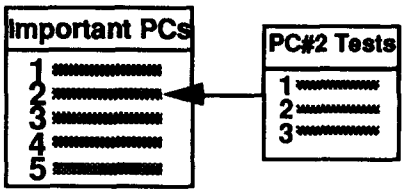
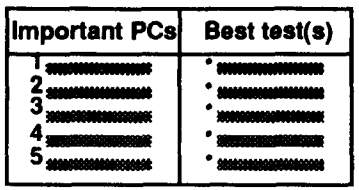


5. Evaluate testing priorities (Phase I)



Step 1 The list of potential concerns (PCs) was compiled from several sources

Sources

10 CFR Parts 60 and 960

- Potentially adverse conditions (PACs)
- Disqualifying conditions

Other concerns suggested by:

- EEI / EPRI
- NRC
- State of Nevada
- Workshop participants

Potential concern

(partial list)

- Gas flow radionuclide
- Reactive GW chemistry
- GW travel time < 1000y
- Usable water in controlled area
- ...
- ...

Definitions

Measures

Assessment thresholds

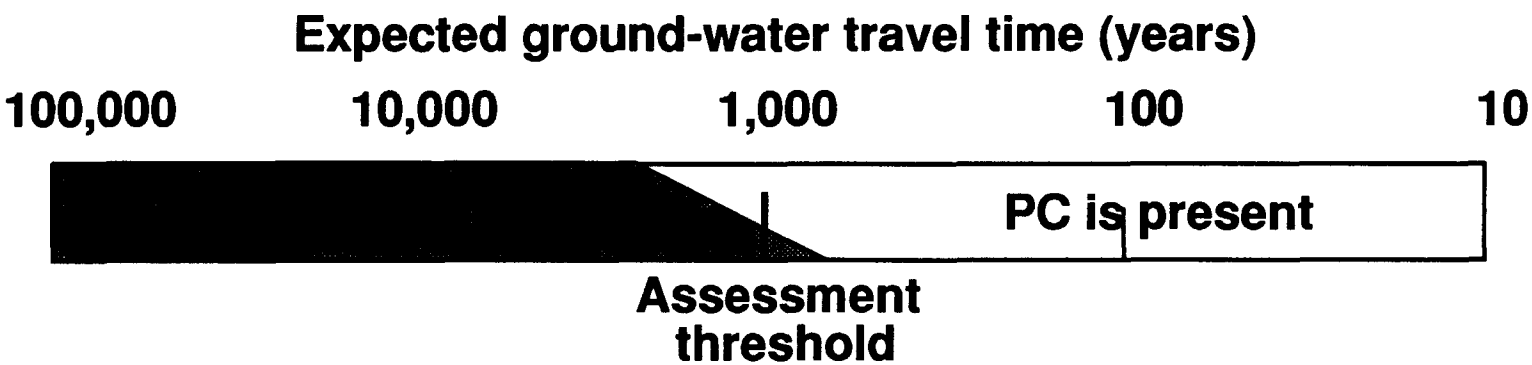
The list was condensed to 32 PCs that were assessed and analyzed quantitatively

Step 1 Measures were specified for each PC along with a threshold for assessing whether the PC is present

Potential concern: Ground-water travel time (GWTT)

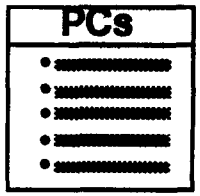
Measure: Expected GWTT in years

Assessment threshold: 1000 years



The 32 potential concerns were assessed and ranked by panelists in two Importance Assessment workshops

1. Compile a list of potential concerns (PCs)



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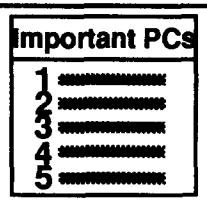
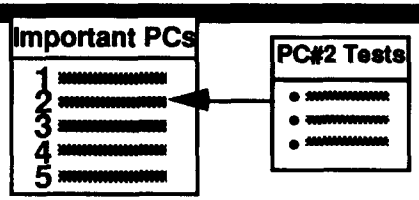


3. Compile a list of studies/tests addressing important PCs



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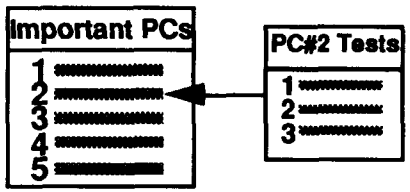
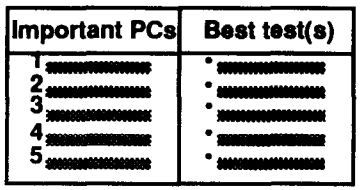


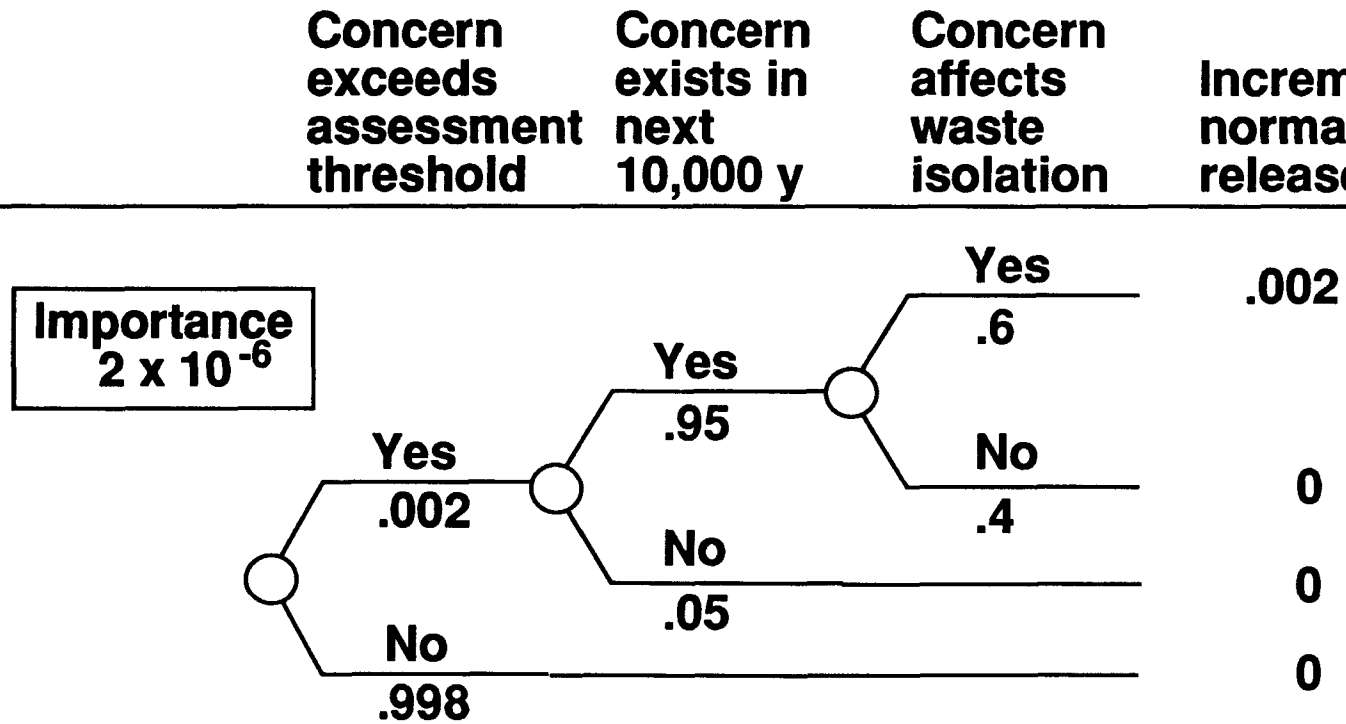
5. Evaluate testing priorities (Phase I)



Step 2

A probability tree illustrates the assessments and importance calculation

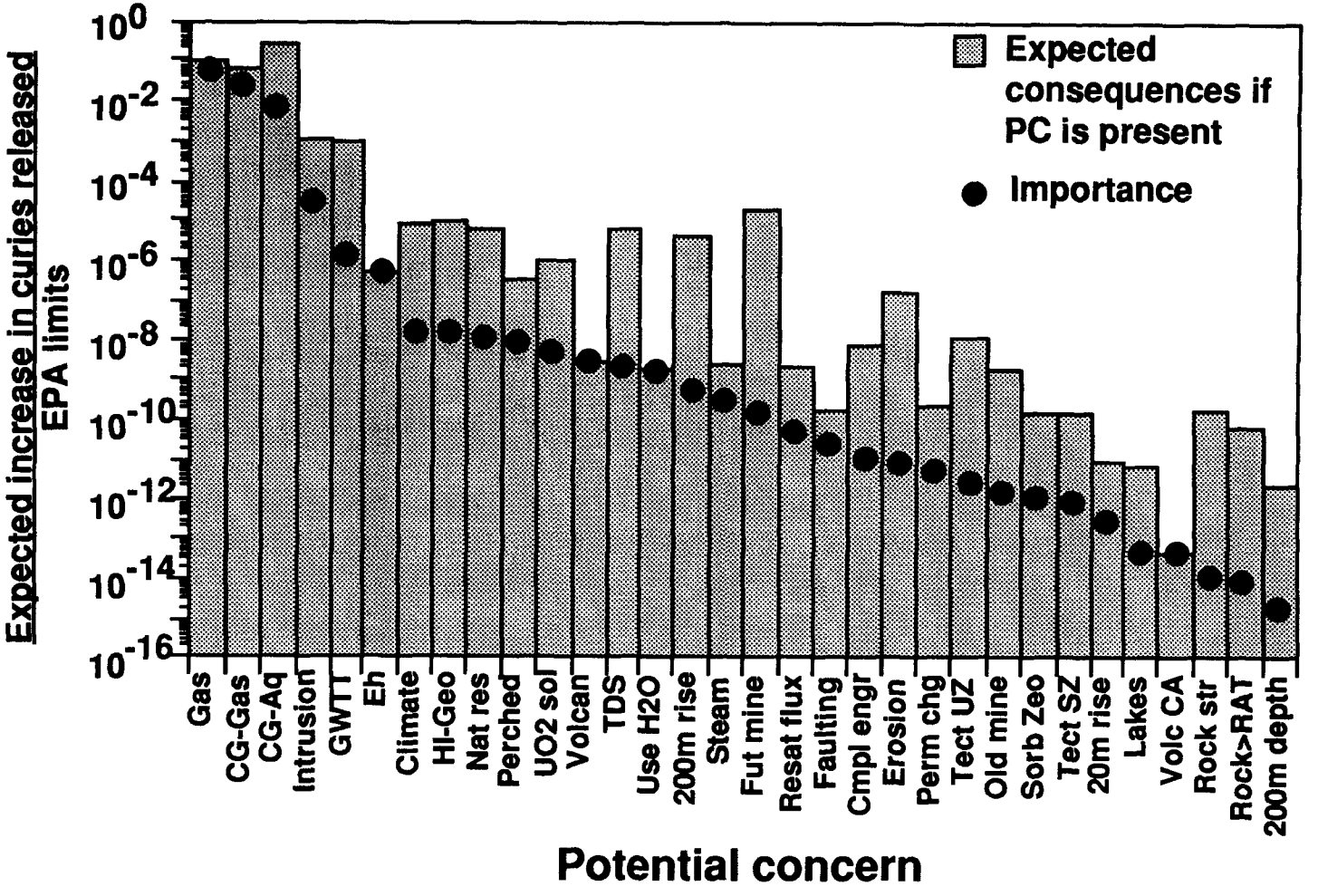
Potential concern:
expected ground-water travel time less than 1,000 years



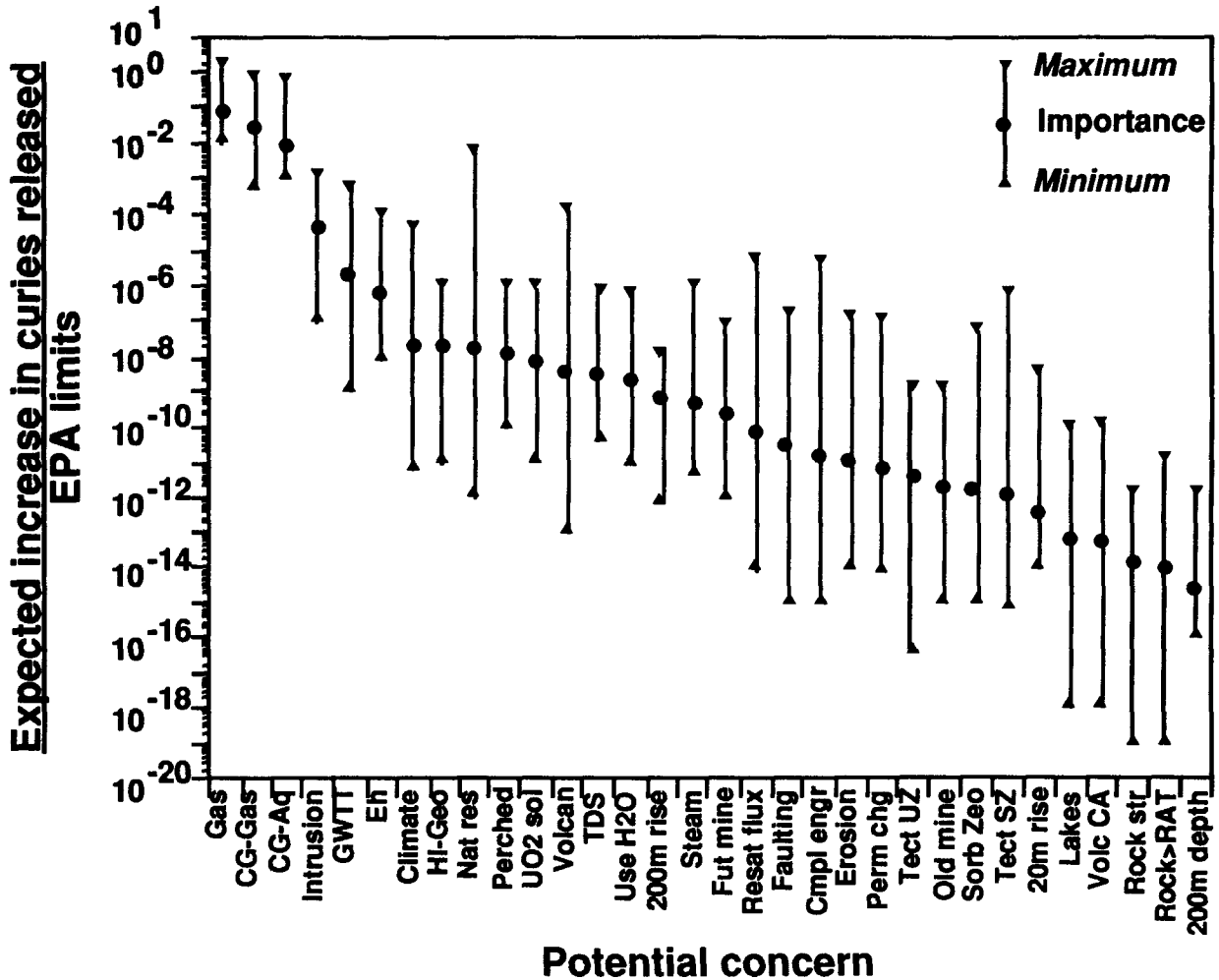
Expected value (importance): $.002 \cdot .95 \cdot .6 \cdot .002 = .000002$

Step 2

This graph shows the wide range of consequences and importance of potential concerns



Step 2 Sensitivity analysis shows the range of effects of individual participants' judgments



Essentially all workshop participants agreed on the importance of "gas flow radionuclide" and "complex geology (CG)"

Step 2

Step 2 generated significant insights and conclusions about the importance of PCs

Conclusions from the Importance Assessment

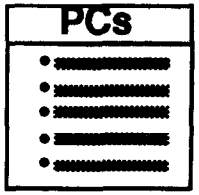
- There is substantial variation in the "importance" of PCs and, therefore, in the value of testing for unsuitable conditions

- "Gas flow" and "complex geology" are more "important" than other PCs by at least a factor of 200

- Screening in Step 2 identified 14 PCs that were carried forward to test-accuracy assessment
  (4 PCs were later eliminated or combined with others)

Step 3 identified 15 test packages that address 10 high-ranking PCs

1. Compile a list of potential concerns (PCs)



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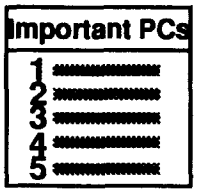

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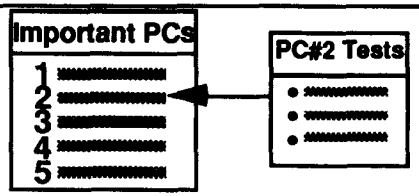

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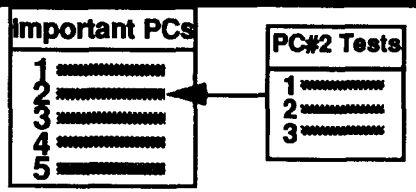
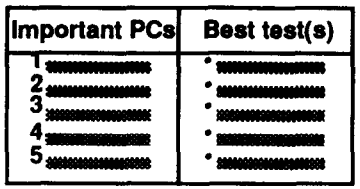


5. Evaluate testing priorities (Phase I)



Step 3 The Site Characterization Plan, PARATRAC, and panelists provided lists of potential of tests

- "Tests" are actually "test packages," which include SCP investigations, studies, activities, or sub-activities

- Tests are not prioritized *within* packages

- "Levels" of tests were compiled for 4 PCs

  Example: testing levels for ground-water travel time:
  - Level 1 No new boreholes; available data and non-surface-disturbing work
  - Level 2 Limited surface-based drilling + Level 1 data
  - Level 3 Data from Exploratory Shaft testing + Levels 1 & 2 data

Step 3 For example, 10 SCP activities were identified for investigating complex geology* with boreholes

Potential concern #2: Complex geology—aqueous

Tests for Complex Geology: Level 1—Borehole studies (2-6 total boreholes)

SCP Activity #	Title
8.3.1.2.2.3.2	Site vertical boreholes - 1 to 3 feature based boreholes
8.3.1.2.2.3.3	Solitario Canyon horizontal borehole study - 1 horizontal borehole
8.3.1.2.3.1.1	Solitario Canyon fault study - 2 boreholes
8.3.1.2.3.1.2	Site potentiometric-level evaluation - Those portions that target the steep gradient investigations - 2 boreholes
8.3.1.4.2.2.3	Bore hole evaluations of faults and fractures
8.3.1.4.3.1.1	Systematic drilling program - 1 to 3 exclusive of the features
8.3.1.2.2.3.1	Matrix hydrologic properties testing
8.3.1.4.2.1.3	Borehole geophysical surveys
8.3.1.4.2.1.1	Surface and subsurface stratigraphic studies of the host rock and surrounding units - Focusing on study of bedded tuff, this allows determination of the extent of such hydrologic properties such as moisture content
8.3.1.4.2.2.1	Geologic mapping of zonal features in the Paintbrush Tuff

* Investigate three site features—Solitario Canyon fault, Ghost Dance fault, and steep gradient zone—plus baseline data from 1–3 feature-independent boreholes

The 15 test packages were assessed and ranked by panelists in three Testing Assessment workshops

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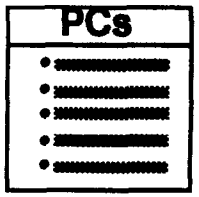

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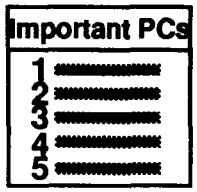

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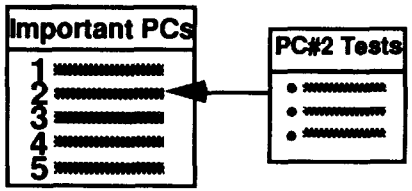

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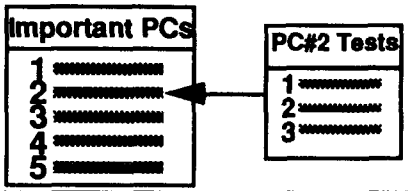
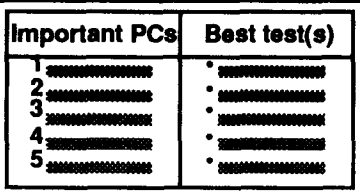


5. Evaluate testing priorities (Phase I)

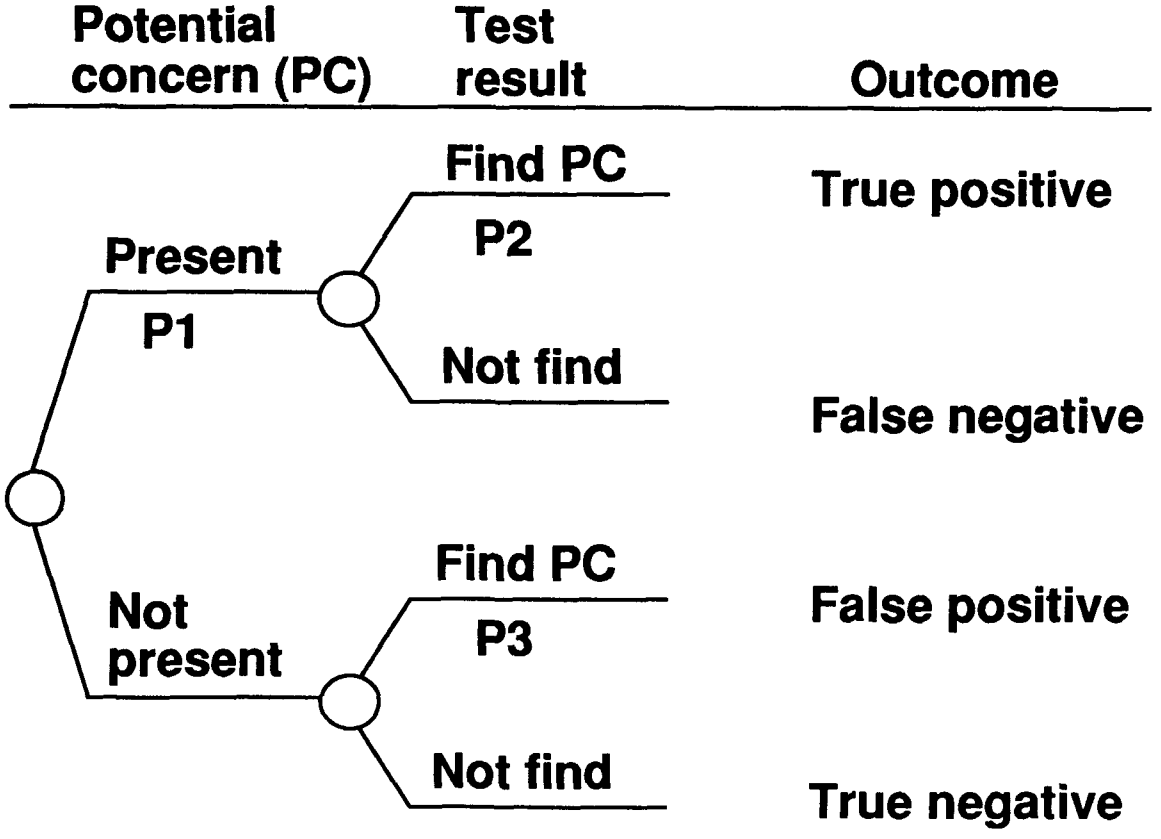


Step 4 Test accuracy was quantified using conditional probabilities of "true-" and "false-positive" results

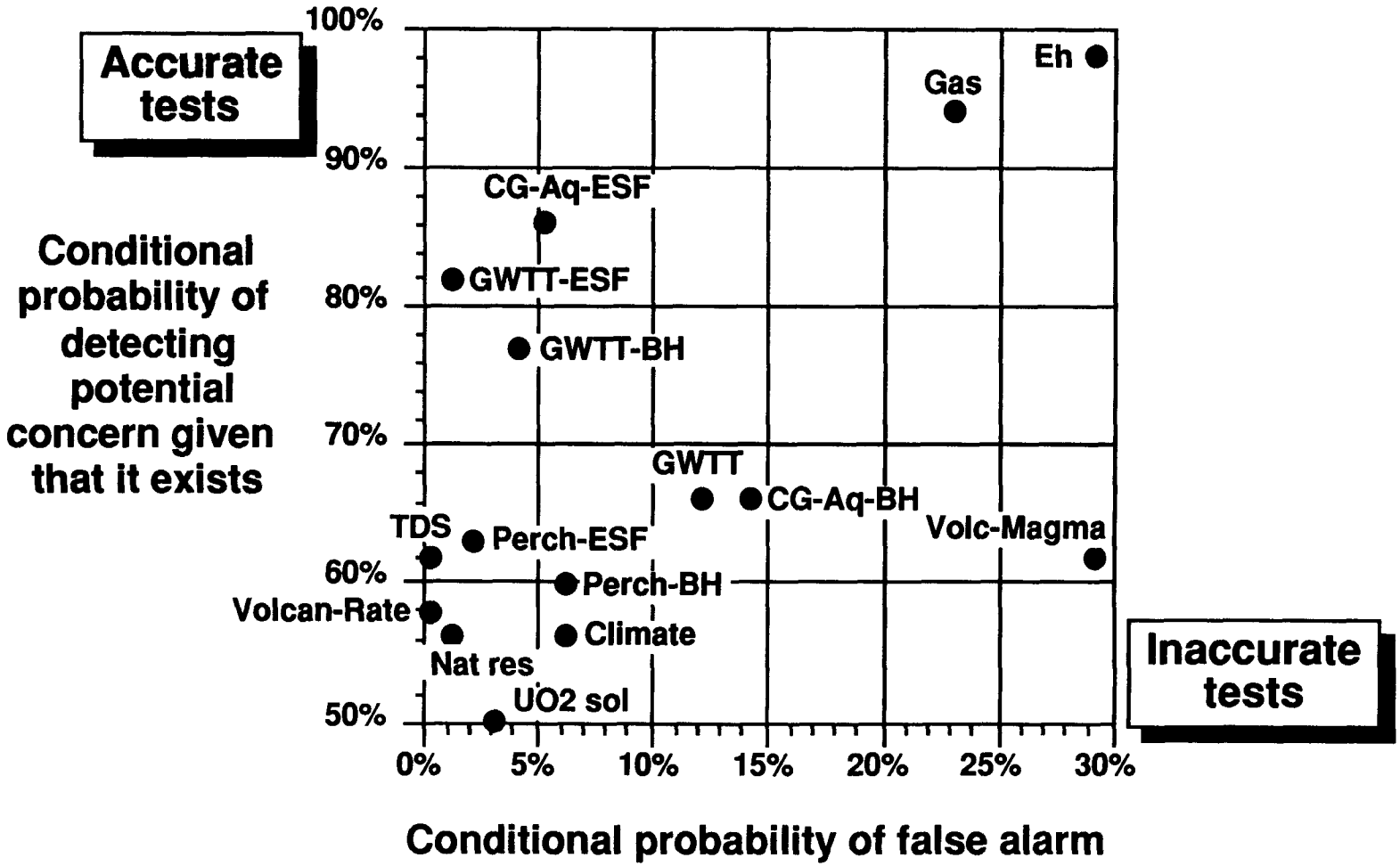
Typical Test Accuracy Assessment Questions

P2: P(True positive): Probability test will accurately detect the PC, given that it is present

P3: P(False positive): Probability test will falsely "detect" the PC, given that it is *not* present



Step 4 Panelists quantified test accuracy for 15 combinations of PCs and tests



This chart identifies the relative accuracy of tests for the PCs, but accuracy alone is not a good basis for test priorities; once should also consider probabilities and consequences of the PCs

Step 5 identified three test-priority groups

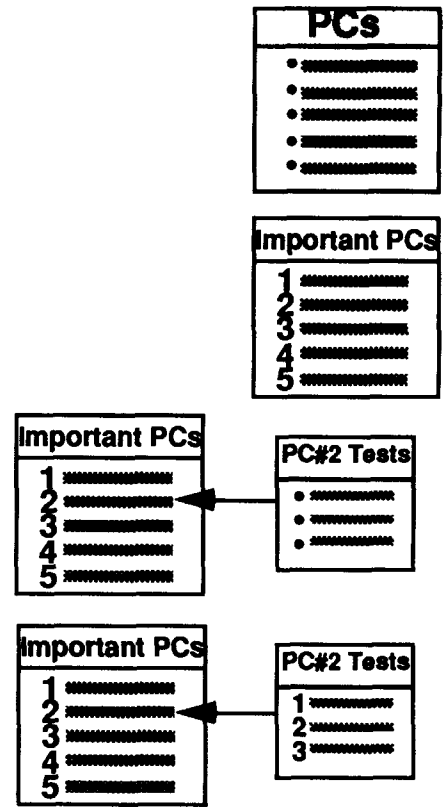
1. Compile a list of potential concerns (PCs)

2. Assess and rank the importance of each PC to waste isolation (measured in curies released)

3. Compile a list of studies/tests addressing important PCs

4. Assess and rank the tests addressing important PCs

5. Evaluate testing priorities (Phase I)



Important PCs	Best test(s)
1	
2	
3	
4	
5	

Step 5 Testing benefits are quantified assuming action will be taken if a potential concern is detected

- Possible actions range from "mitigate consequences" to "abandon the site" *(but these were not assessed specifically)*
- The same action will be taken whether the detection is a true positive or "false alarm" (the decision maker can't distinguish)
- The action (e.g., mitigate or abandon) is assumed *to prevent* any incremental releases associated with the PC
- The benefits of the action are assumed to be *proportional to* the expected increase in curies released if the PC is present, relative to baseline releases

Step 5 "Detection benefits" measure the maximum value of a test in detecting a PC

- The benefit of a test is assumed to be proportional to avoided releases

- Detection benefit =

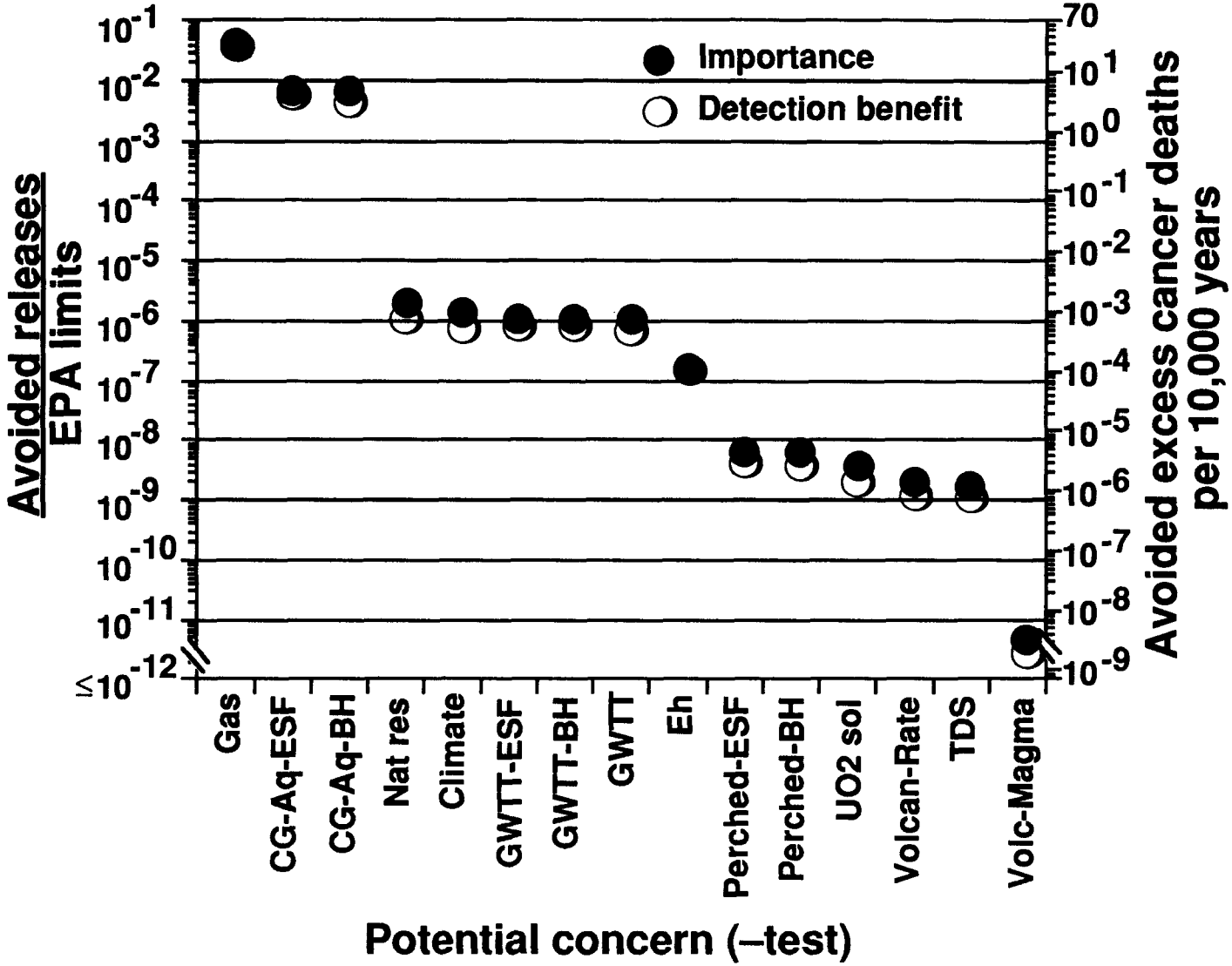
  P(PC present) • P(detect | PC present) • Expected curies avoided

- Units: $\frac{\text{Avoided releases}}{\text{EPA limits}}$

Detection benefits can be measured in avoided radionuclide releases or in avoided excess cancer deaths *(EPA limit x 1.0 = 700 excess cancer deaths)*

Step 5

This graph shows that detection benefits closely track the "importance" of each PC



Step 5 "False-alarm costs" reflect the impact of an erroneous detection of a PC

- These are the costs of action (e.g., to mitigate or abandon), that is taken unnecessarily

- The consequences of false-alarms are assumed to be *proportional to* the expected increase in curies released if the PC is present

- False-alarm cost =

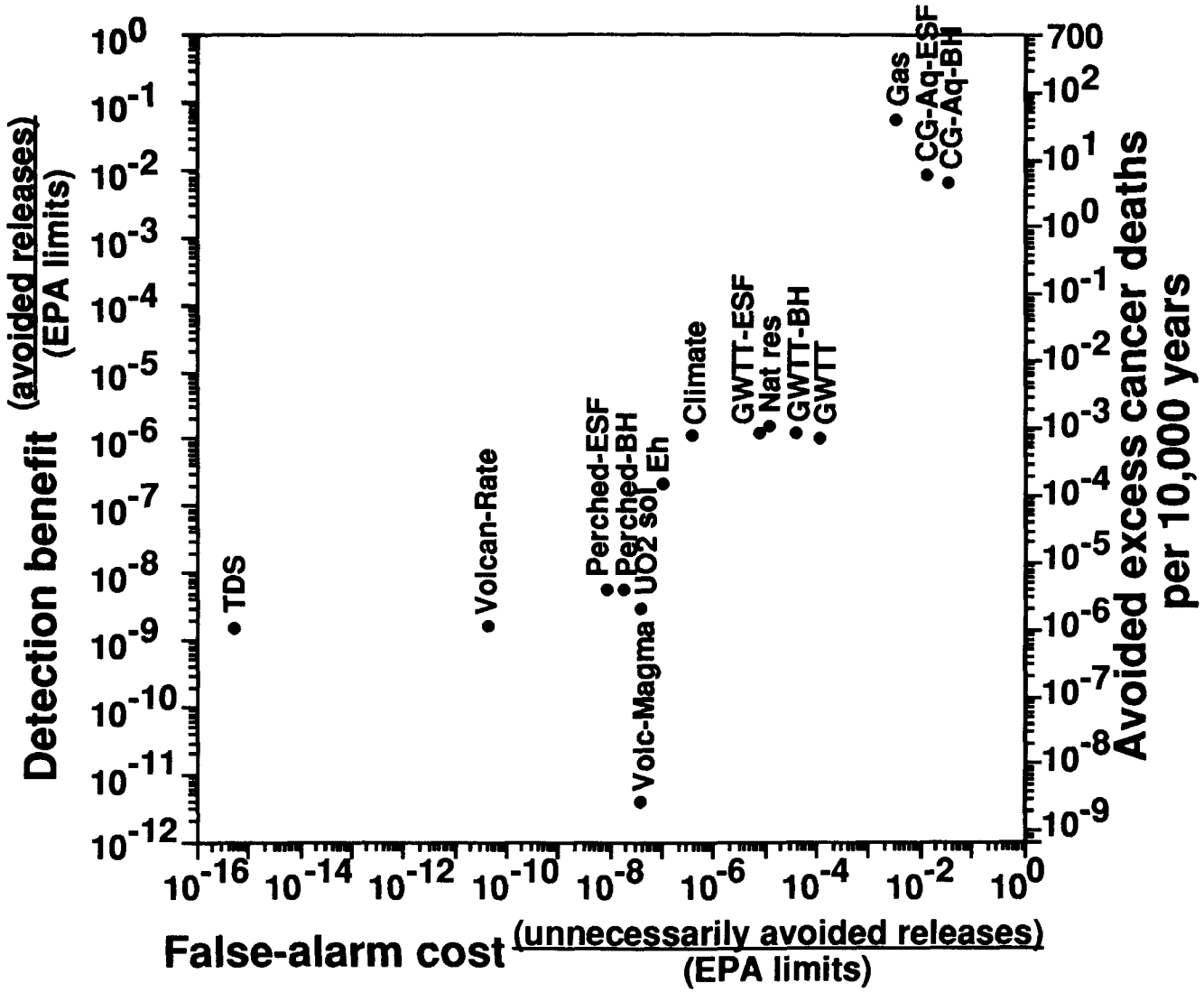
  P(PC *not* present) • P(detect | PC *not* present) • Expected curies "avoided"

- Units: $\frac{\text{Unnecessarily avoided releases}}{\text{EPA limits}}$

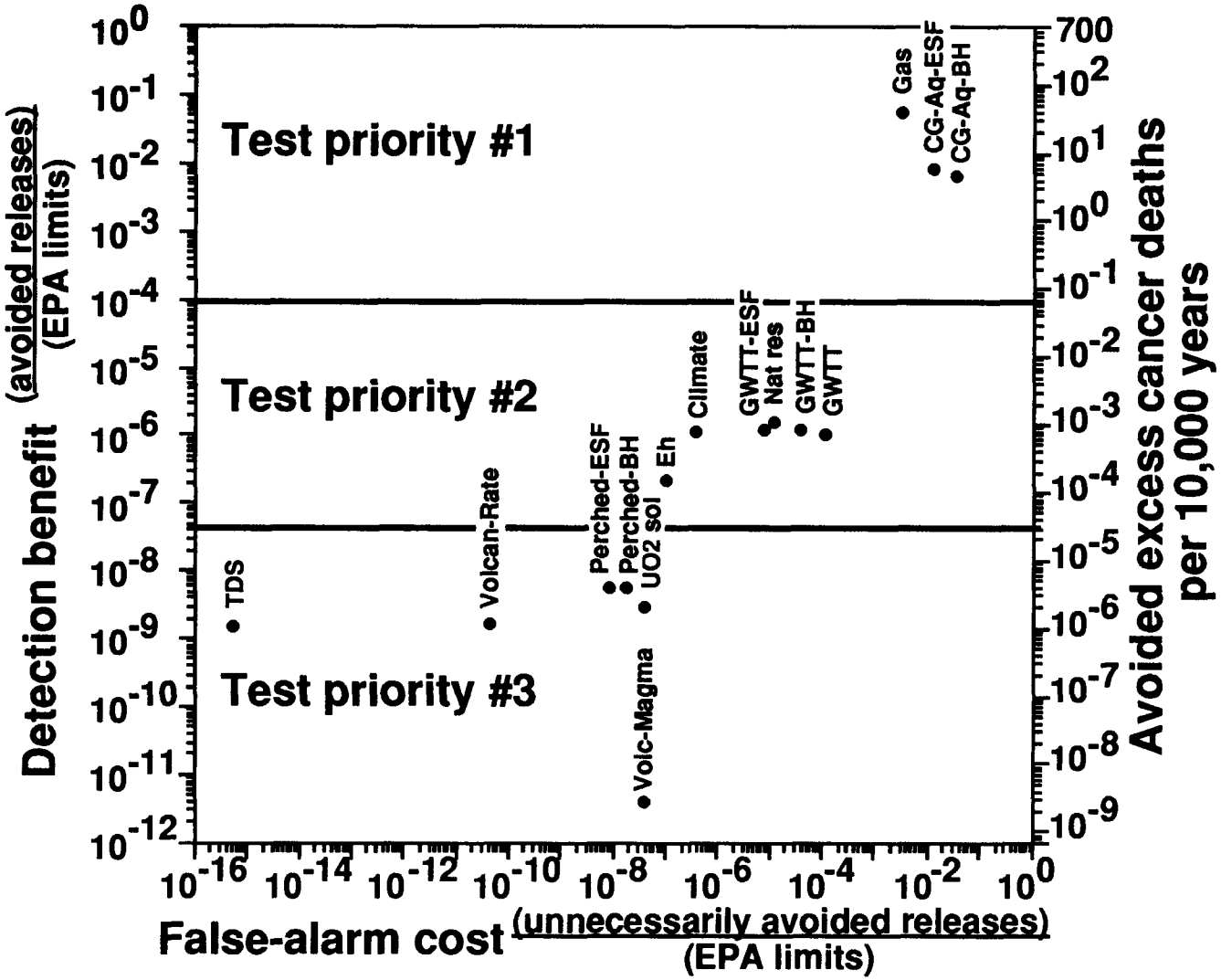
- *False-alarm costs may exceed detection benefits if the PC is unlikely and if the probability of a false-positive result is high*

Step 5

A scatter diagram illustrates the relative detection benefits and false-alarm costs of the tests

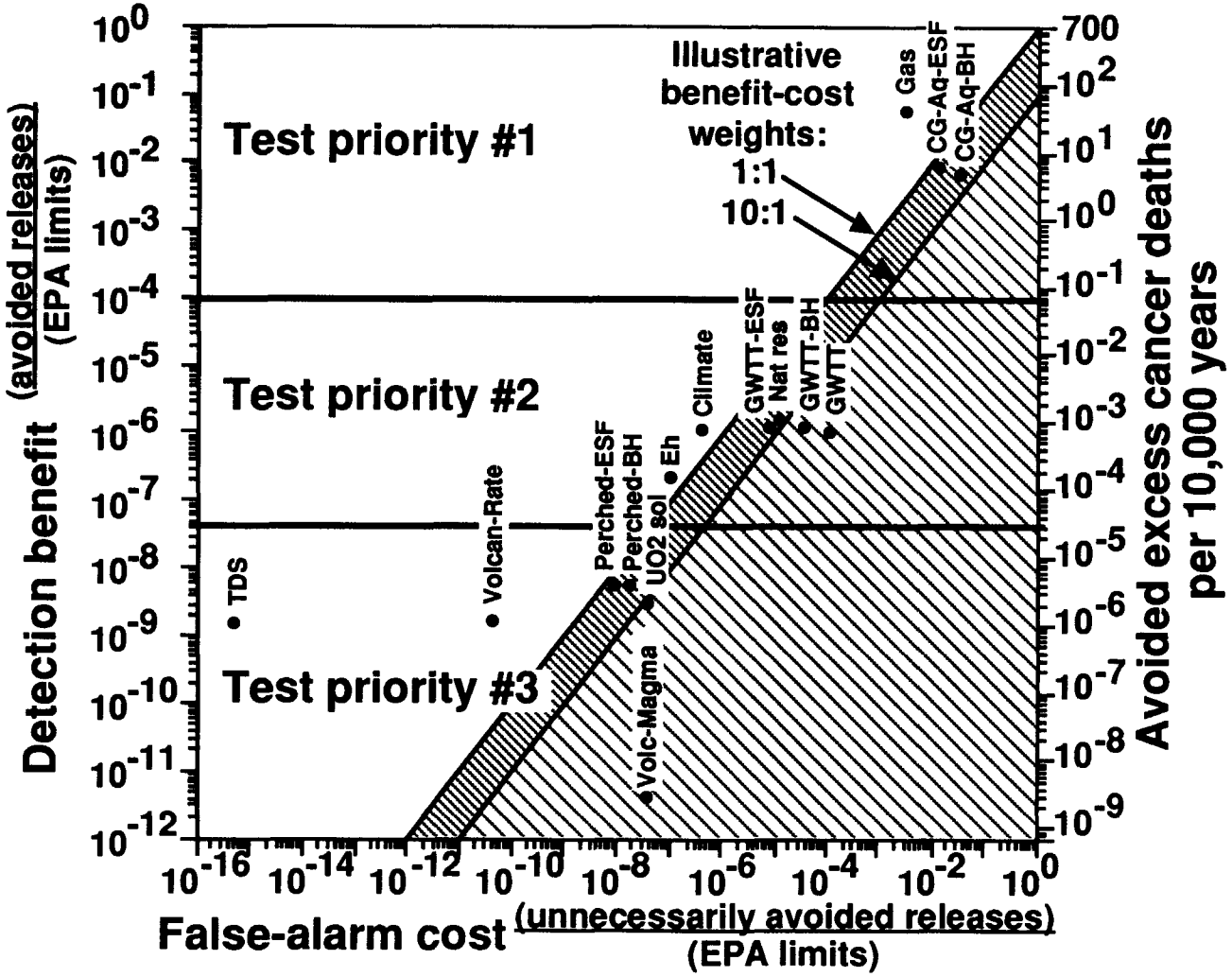


Step 5 Tests fall into one of three priority groups, based on detection benefits



Step 5

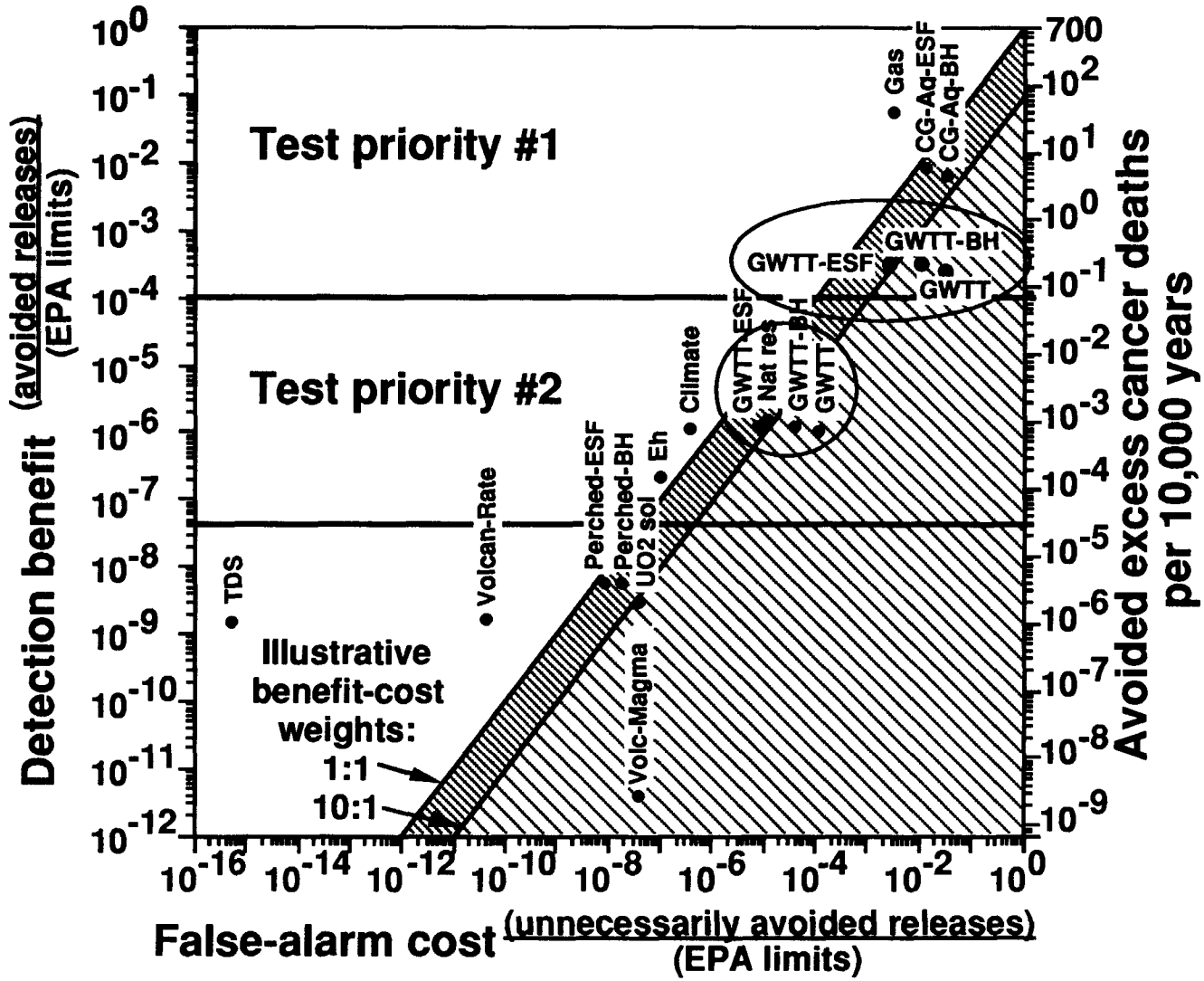
Within a priority group, one must trade off detection benefits with false-alarm costs



Once benefit-cost weights are assigned, the shaded area identifies tests with excessive false-alarm costs

Step 5

Ground-water travel time increases in priority if the 1000-year objective has consequences equal to EPA release limits

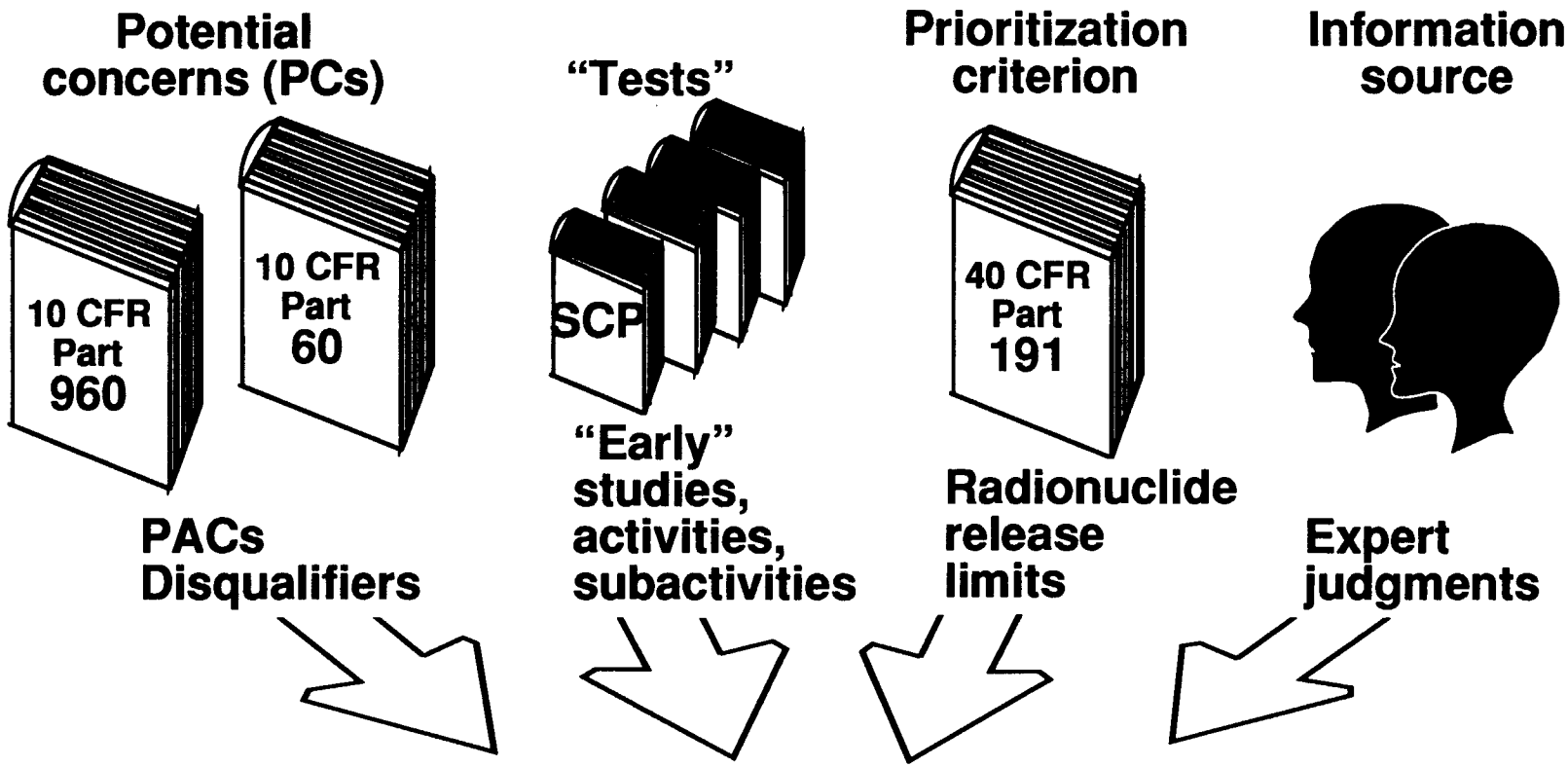


Phase I provides a tool to assist managers in setting test priorities

Products from Phase I

- Relative importance of potential concerns (PCs)
- Priority tests for early detection of PCs
- Areas where current program strategy needs to be reevaluated (carbon-14)
- Sensitivity of priorities to value judgments
- Insights into the significance of potential false alarms
- Implications of using total-system vs. subsystem performance criteria for prioritizing ground-water-travel-time tests
- A tool for revising priorities based on new information

Phase I has identified priorities for a subset of "early" tests to detect potentially unsuitable site conditions



Important PCs	Best test(s)
1	•
2	•
3	•
4	•
5	•

Phase I prioritizes tests to detect potential concerns, but there are other important reasons for testing

Possible *Other Reasons* for Testing

1 Evaluating preclosure health and safety concerns
2 Gathering information for design or construction
3 Providing other information required for licensing
4 Initiating long-duration performance-confirmation tests
5 Facilitating other tests (e.g., drilling boreholes)
6 Building scientific consensus and public confidence
7 ...

Priorities may need to be revised based on these considerations

We will now summarize our recommendations for use of Phase I results and progression to Phase II

- Introduction to the test prioritization task — *J. Russell Dyer, DOE*
  - Objectives of the TPT
  - Phased approach
  - Scope of phase I

- Phase I analysis and results — *Bruce Judd, DAC*
  - Analytic approach
  - Importance of "potential concerns"
  - Test priorities

- Future activities — *Bruce Judd, DAC*
  - Phase II analysis
  - Ties to site-suitability evaluation

The task force recommends the following actions

1. Develop a systematic method for assessing key management judgments

2. Set priorities for early tests
   - Reevaluate strategy for carbon-14
   - Consider tests for complex geology

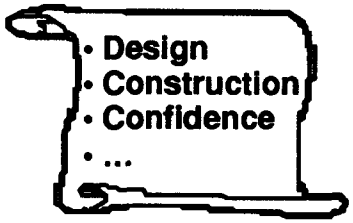
3. Consider incorporating cost and other criteria for test prioritization

4. Complete Phase II assessment and analysis

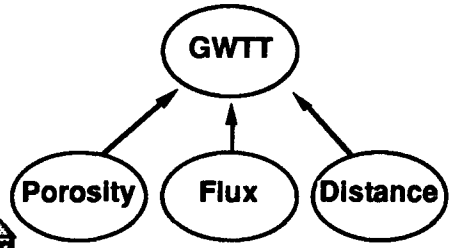
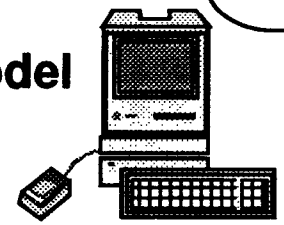
5. Provide results and insights to the Early Site-suitability Evaluation (ESSE) effort

6. Apply method when warranted to reprioritize tests during site characterization

Expanding the scope of the analysis in Phase II can enhance its usefulness as a management tool

- Expanded prioritization criteria
  - Cost of tests
  - "Other" reasons for testing 

- Expanded assessments and analysis
  - Broader range of experts

  - Disaggregated assessments 

  - Total-system-performance model