SUMMARY OF U.S. NUCLEAR REGULATORY COMMISSION (NRC)-
U.S. DEPARTMENT OF ENERGY (DOE) MEETING ON
THE CALICO HILLS RISK/BENEFIT ANALYSIS
AND THE ESF ALTERNATIVES STUDY

January 29-31, 1991
Bethesda, Maryland

Agenda: See Attachment 1.

List of Attendees: See Attachment 2.

Summary:

The purposes of the meeting were for the NRC staff and DOE to discuss the results of DOE's Calico Hills Risk/Benefit Analysis (CHRBA), DOE's response to the NRC staff's Objection #2 to DOE's Consultative Draft of the Site Characterization Plan (CDSCP) relating to penetration into the Calico Hills unit, and results of the Exploratory Shaft Facility (ESF) Alternatives Study (ESF-AS). DOE was to explain what has been done in the CHRBA and the ESF-AS, including: (1) regulatory considerations that have been identified and incorporated into the two studies; (2) processes that have been used in carrying out the studies; and (3) results of the studies. The NRC staff intended to listen to DOE's presentations: (1) to learn the status of DOE's program in the area of ESF design, including options for penetrating into and drifting within the Calico Hills unit; (2) to gain an understanding of what has been done in the CHRBA and the ESF-AS; and (3) to provide preliminary feedback on whether DOE appears to have identified the pertinent regulatory considerations, to have considered them in the processes used in the studies, and to have demonstrated in the results that they have been appropriately addressed. However, prior to the meeting it had been determined that NRC staff final positions on whether the regulatory considerations have been appropriately considered and addressed were not to be forthcoming at this meeting and can only be taken after the NRC staff has reviewed DOE's submittals of the two subject documents. All NRC staff and DOE presentation materials are included as part of this meeting summary as Attachments 3-24.

The NRC staff opened the discussion on the CDSCP Objection #2 by restating the objection and its basis, and delineating four matters that need to be included in any proposal for penetration of and drifting within the Calico Hills unit, namely: (1) need for the data; (2) description of the proposed data collection methods and alternatives; (3) impacts of data collection on the site; and (4) based upon the foregoing information, a demonstration that data collection methods have been selected that will limit adverse impacts on the waste isolation capability of the site to the extent practical (Attachment 3). DOE's presentation related to CDSCP Objection #2 explained that the CHRBA was intended to address the NRC staff concerns raised in CDSCP Objection #2 and indicated that the four matters NRC had identified as needing to be included in such an analysis are contained within the CHRBA (Attachment 4).

DOE next proceeded with a series of presentations (Attachments 5-12) on various aspects of the CHRBA, which (like the ESF-AS discussed later in the meeting) was conducted under a fully qualified Subpart G quality assurance (QA) program. After overview presentations, DOE explained the Value of Information (VOI)

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Part 1

technique that was used to evaluate testing alternatives to characterize the Calico Hills unit. The objective of the VOI was to compare benefits of testing (measured by the improvement in decision-making due to increased understanding of site performance) to the potential for adverse impacts on site performance as a result of testing. DOE discussed the geotechnical inputs to the VOI (Attachment 7) and the mechanics of the VOI model (Attachment 8) before concluding with the VOI model results that testing will have no benefits in terms of improving decision-making with respect to the site's performance capability.

The NRC staff inquired why DOE chose to employ a VOI technique and other complicated decision-aiding methodologies instead of doing a performance assessment using currently available data. DOE responded that currently available performance assessment models are not mature enough, nor were they structured in such a way, to permit detailed calculations that would result in a recommendation for a specific testing strategy. DOE wanted a structured, formally correct, defensible, and documentable way to combine subjective expert judgments and support the ultimate recommendation on how to characterize the Calico Hills unit. DOE pointed out that performance assessments that have already been done utilizing available data were provided to the expert panels involved in the VOI. In addition, one of the CHRBA recommendations is that formal performance assessment exercises (particularly with respect to impacts on waste isolation) be conducted throughout design and site characterization.

With respect to the expected value of "R", the weighted cumulative radionuclide release, which was used as a measure of site performance in the VOI model, the NRC staff sought to determine what uncertainties were considered by the expert panels in assembling the distributions of R values. In particular, the NRC staff was interested in whether and how the conceptual model, parameter, data, and source term uncertainties were being considered. DOE maintained that all such uncertainties were factored into the R distributions by the experts and that the tails of the R distributions, where problems (should any exist) with site performance would be located, received emphasis.

The NRC staff also asked a number of other questions pertaining to uncertainties considered in the VOI. DOE stated that all uncertainties related to the aqueous release pathways are included but that certain scenarios (e.g., gaseous releases, human intrusion, and volcanism) are not included because testing of the Calico Hills unit will not provide more information on such scenarios.

The NRC staff asked why DOE chose to exclude gaseous release and direct release pathways from its VOI analyses. DOE responded that the purpose of the CHRBA was to recommend a test strategy for the Calico Hills unit. Because the Calico Hills unit is not considered a barrier to gaseous or direct releases no tests will be conducted in the unit to address those performance issues. Questions about performance issues related to aqueous releases will be the dominant basis for decisions on characterizing the Calico Hills unit.

The NRC staff sought clarification on the significance of the "no benefit to testing" outcome of the VOI. DOE emphasized that the VOI only evaluated the benefits of testing with respect to whether such testing would likely change decisions that are based on the site's performance capability. However, because there are other values associated with testing, DOE is committed to testing in the Calico Hills unit during site characterization. DOE indicated that those other values include increased scientific confidence and reasonable assurance with respect to predictions of site performance.

The next topic of discussion related to the CHRBA was the Multiattribute Utility Analysis (MUA) that was done subsequent to the VOI. DOE discussed the geotechnical inputs to the MUA (Attachment 9) and described the mechanics and results of the MUA (Attachment 10). DOE explained that the MUA was done because while the more narrowly focused VOI analysis found no value of information in any of the testing strategies, there was a clear preference for testing, indicating that there is a value to testing that was not captured effectively by the VOI model. An alternate explanation for the VOI results, that decision makers place high value on high confidence, even at extremely low levels of releases, was tested by sensitivity studies that have been presented in previous meetings. Given that there is value to testing, the MUA was initiated to evaluate test strategies in terms of performance measures such as release risk, cost, scientific confidence, delay, and phasing potential.

The MUA considered eight conceptual testing strategies representing a range of possibilities for characterizing the Calico Hills unit. The strategies utilize varying amounts and locations of the major types of test methods, namely drilling, underground drifting/exploration, and analog site studies. All of the strategies capture to a certain extent the data needs DOE has laid out, and the MUA was relied upon to rank the strategies. Based on the results of the MUA, testing strategies involving extensive underground exploration within the repository block were preferred. DOE stated that the full amount of drifting included in the preferred testing strategies may not be necessary, and can be adjusted if so indicated by a more complete future understanding of impacts to waste isolation or of the sufficiency of data needed for site characterization.

Having followed DOE's presentations on both the VOI and the MUA, the NRC staff continued to ask questions regarding the confidence of DOE in its estimates of site performance, which suggest that the site is extremely unlikely to violate the EPA standard under the scenarios and alternative conceptual models considered. The NRC staff questions highlighted the various sources of uncertainty in the estimates of site performance, including the uncertainties introduced by the use of expert judgment. DOE considered that its methodologies are defensible and take into account a conservative range of uncertainty.

DOE next presented the reasoning, design information, and analyses used in assessing the potential hydrologic impact of characterizing the Calico Hills unit via underground openings (Attachment 11). This information provided tools for the expert panels as they evaluated impacts in the VOI and MUA. The presentation included the types of impacts considered, design measures for mitigating the impacts, and quantitative measures of impacts. The approach used to estimate impacts from underground openings is based upon potential changes in flow and travel time through the Calico Hills unit. The impact measure was intended to represent the increase in flow over ambient conditions as a result of the presence of the openings. For the scenarios analyzed, DOE found the impacts to be insignificant, and stated that they can be mitigated by engineering measures if necessary. DOE's conclusion from these analyses is that potential impacts from characterization on postclosure aqueous releases from the total system are expected to be low and do not preclude extensive underground exploration in the Calico Hills unit below the proposed repository.

The next meeting topic was the ESF-AS, which DOE discussed in several presentations (Attachments 13-23). The goals of the ESF-AS were: to provide a comparative evaluation of ESF alternatives, to identify favorable features, and to address the concerns and recommendations of the NRC staff, the Nuclear Waste Technical Review Board, and the State of Nevada. The ESF-AS, conducted under a fully qualified 10 CFR Part 60 Subpart G QA program, consisted of six steps: (1) identify various ESF/repository configurations and associated construction methods (options); (2) identify all requirements and concerns applicable to the ESF and the repository; (3) use decision-aiding methodology to comparatively evaluate the options to account for discriminating requirements and concerns; (4) provide an overall rank ordering of options; (5) identify potentially favorable design features; and (6) document the findings of the study.

With respect to the decision-aiding methodology used in the ESF-AS, the NRC staff inquired as to why the subsystem requirements in 10 CFR 60.113 were not included as possible discriminators among options. DOE replied that the panel on postclosure performance decided that discrimination between ESF/repository options could not be provided by consideration of the subsystem requirements, and hence they were not used as measures for quantifying end consequences.

The NRC staff asked why direct release pathways were not considered in the analysis. DOE said that these were not included because they would not provide any discrimination among options in terms of postclosure performance. In that regard, DOE stated that it was the opinion of the expert panel that no option would have an advantage over the others in terms of avoiding disruptions by volcanism or human intrusion.

The NRC staff asked if DOE had made comparisons between expected releases and probabilities of releases estimated in the CHRBA and the ESF-AS as an internal check for consistency in results. DOE responded that the probability estimates were similar, but not directly comparable, because of different assumptions used by the two groups. However, DOE considered that the results of each study were defensible and that such a comparison, while potentially interesting, was unnecessary for the credibility of either.

Concerning the evaluation of major design features that are potentially important to waste isolation, the NRC staff asked why DOE had not considered it necessary to evaluate ESF/repository options which included all eight strategies in the CHRBA inasmuch as the Calico Hills excavations are potentially important to waste isolation. DOE responded that it considered only the recommended option from the CHRBA in the ESF-AS because the CHRBA factored the impacts on waste isolation into its eventual recommendation of an option and hence it would have been redundant for the ESF-AS to consider combinations of ESF/repository options involving the non-preferred CHRBA options.

The NRC staff also sought to understand how to extract the impacts on waste isolation of individual major design features from the multidimensional evaluation that involved several items (e.g., characterization testing;

programmatic viability) besides postclosure performance. DOE preferred not to evaluate the impacts of design features individually because their impacts may not be independent of one another and because the total effect of a number of features combined into an option may be quite different than the sum of individual impacts.

Due to time constraints, the NRC staff was unable to pursue all the aspects of the ESF-AS to the extent it considered necessary during the meeting. The NRC staff indicated that it might transmit further questions to DOE on the CHRBA or the ESF-AS via a letter shortly after the meeting.

<u>NRC Observations</u>

1. The NRC staff considered that the presentations and discussions at this meeting will make possible a more focused and insightful review of the CHRBA by the NRC staff. Although the ESF-AS will not be transmitted to the NRC staff for review for several months, and is not completed at this time, the meeting was useful in providing DOE's current thinking and approaches in the document under development.

2. The presentations and discussions established that DOE has made a substantial effort to consider and address regulatory requirements and other considerations in the two studies. No NRC staff final positions on whether the regulatory requirements have been appropriately addressed can be taken until completion of the NRC staff's reviews of DOE's submittals of the CHRBA and the ESF-AS.

3. NRC recognizes that the way in which DOE has considered regulatory requirements in the two studies, that is, incorporating the requirements with numerous other factors in decision-aiding methodologies, has been done because of the variety of inputs DOE must consider. However, the material pertinent to consideration of the requirements should still be clearly distinguishable and readily separable such that it can be reviewed as a distinct aspect of the subject studies. This would be most easily accomplished if the regulatory considerations were discussed in one place in the subject documents.

4. The NRC staff raised numerous questions during the meeting regarding whether the consideration of such items as alternative conceptual models, scenarios, radionuclides, pathways, and parameters in the two studies has been sufficiently conservative and comprehensive. In addition, similar questions were raised in connection with the treatment of uncertainties involved in the extensive use of expert judgment. DOE's responses indicated that such questions had been considered by the participants in the studies. Nevertheless, the NRC staff will independently evaluate these matters in the two reports.

5. DOE made numerous efforts to clarify the role that the VOI ultimately played in its overall analyses for the CHRBA and was particularly clear in stating that despite the "no benefit to testing" result, DOE management is committed to testing in the Calico Hills unit. However, in light of that clarification and, in addition, a suggestion by DOE that the outcome of the VOI not be focused upon by NRC during its review, the NRC staff is

unclear about what contribution DOE considers the VOI to make to the CHRBA.

6. Based upon the presentations at this meeting, the NRC staff has preliminary concerns about the expert panels and how they were utilized in the VOI and the MUA's. However, these concerns may be addressed in the CHRBA and the ESF-AS. In addition, DOE indicated that transcripts of the expert panels deliberations could be made available if needed by the NRC staff to complete its reviews.

7. DOE's analysis of the potential impacts of characterizing the Calico Hills unit via underground openings may not have considered all the potentially significant factors relevant to this determination. For example, there was no consideration of a possible increase in gaseous releases from the site as a result of the excavations.

8. With respect to the ESF-AS, it is the NRC staff's understanding, based upon the discussions at this meeting, that for the NRC staff to evaluate whether all applicable 10 CFR Part 60 regulations have been appropriately and explicitly considered, it may be necessary to review certain supporting packages of material (e.g., subsystem design requirements for the ESF) that will not be part of the ESF-AS itself. DOE indicated that those materials, which are voluminous, will be provided to the NRC staff at the same time as the ESF-AS.

9. DOE specifically addressed 10 CFR 60.21(c)(1)(ii)(D), which refers to the need for a comparative evaluation of alternatives to the major design features that are important to waste isolation. The NRC staff notes that the last part of that regulation states "...with particular attention to the alternatives that would provide longer radionuclide containment and waste isolation." In its analysis of alternatives in the ESF-AS, DOE should be conscious of the need to specifically address the containment requirement as well as the waste isolation requirement.

10. DOE mentioned the possibility that a reconfigured ESF/repository design, possibly comprising some of the most desirable features of the preferred ESF/repository design options, might be the final ESF/repository design option chosen. DOE indicated that in that case, the ESF/repository design option finally selected might not be included in the ESF-AS. If it is not included, the NRC staff considers that, depending upon the completeness of the ESF-AS and supporting materials, it will probably still be able to conduct a substantive review of the materials provided. However, it may not be able to take a final position on whether the ESF/repository design option finally selected appropriately addresses the regulatory requirements until it has the opportunity to review that option.

11. DOE discussed the possibility of adopting a phased approach to the characterization of the Calico Hills unit, including reevaluations of the extent of lateral drifting needed, diameter of drifts, etc. The NRC staff considers that this conservative approach may help to limit any adverse impacts on the waste isolation capability of the site, especially if iterative performance assessments and other quantitative evaluations of effects on containment and waste isolation based on the newly acquired information are conducted at various stages of characterization.

12. In some of DOE's analyses of the waste isolation impacts of drifting in the Calico Hills unit, it was not clear how much DOE was relying on the efficacy of backfilling and sealing the drifts. Unless DOE can establish that seals and backfills are likely to retain their integrity for 10,000 years, it would be prudent and conservative to assume ineffective seals and backfills in analyses of impacts of the drifting in the Calico Hills unit on waste isolation.

13. As required in 10 CFR 60.17(c), DOE presented a conceptual design for the repository in a supporting reference to the SCP. This conceptual design is based upon the ESF/repository design option contained in the SCP. After DOE has selected its ESF/repository design option, it will be necessary for DOE to revisit the previously submitted conceptual design for the repository. The revised repository design will need to be developed to a level which can demonstrate appropriate coordination between the ESF and the repository.

DOE Observations

1. In the various presentations, DOE distinguished among the values considered by the two DOE CHRBA models, VOI and MUA. Certain NRC staff appeared concerned that the two models gave incompatible results and were unsure how the VOI results contributed to the CHRBA. Presenters pointed out that the VOI was a more narrowly-focused analysis which looked at a limited set of values, and that the results of the two models needed to be looked at together to reach valid conclusions.

2. The relationship between risk-based, decision-aiding methodologies used in the models and performance assessment was discussed. NRC expressed high expectations of the role of performance assessment in supporting the recommendations which resulted from the CHRBA. While neither the ESF-AS nor the CHRBA were intended to be full performance assessments, those performance assessments that have already been done utilizing available data were factored into those studies. Currently available performance assessment models do not provide a basis for recommending a specific testing strategy. Each performance assessment model places demands on the test program through selection of information needs (input parameters) required by the model. However, the models do not prescribe how the information is to be collected (e.g., drilling, underground mining, or other means) and therefore, cannot uniquely determine the test program.

3. DOE is concerned that the emphasis placed by some NRC staff on the direct use of performance assessment in defining testing programs, and in determining site suitability, fails to recognize that other key considerations are at least as critical to the decision-making process. Specifically, contrary to the staff's implication that performance assessment results should be the major, if not the sole, determinant of test program design and, ultimately, of site suitability, DOE must observe that scientific judgment relative to perceived data needs, and constraints placed on the program by available testing methods, are at least as important as performance at the current level of program maturity. While performance assessment is a useful input and data analysis tool, it cannot be presumed to be adequate to dictate the entire testing program. An

approach to test need and technology definition that overemphasizes reliance on performance assessment, at its present state of maturity, is inherently high-risk, and could prove to be nonconservative, in terms of the ultimate availability of data to support determination of site suitability and licensing needs. In sum, performance assessment is important but is not the sole driver of the site characterization program.

4. For the purposes of conducting its consideration of the results of the DOE studies, NRC was interested in correlating the requirements of 10 CFR 60 and CDSCP Objection 2 as well as evaluating how each Part 60 requirement was considered. During the discussion, it was pointed out that comparison among alternatives focused on requirements that proved to be discriminators because the extent of meeting a particular requirement may be different from one option to another. Also, all of the alternatives considered for the ESF and Calico Hills studies were judged, by the expert panels, to meet the requirements. It should be noted that Part 60 was only one of the many considerations that DOE needed to factor into these studies. Therefore, DOE needed to combine many factors to perform a comprehensive evaluation.

5. It is DOE's opinion that the CHRBA Record of Memorandum, which the NRC staff had not had a chance to consider prior to this meeting, will provide answers to NRC questions and concerns.

6. The CHRBA was designed to respond specifically and directly to the NRC CDSCP objection. DOE provided at the meeting a comparison between the information requests in the objection, and the contents of the CHRBA. The CHRBA was not initiated independently with an analysis of 10 CFR 60. The 10 CFR 60 analysis was included in the ESF-AS in which the CHRBA was a contributor to the overall evaluation. The CHRBA itself focused specifically on the CDSCP objection, not on "all regulatory requirements."

7. To support the evaluations conducted in the ESF-AS, DOE has developed preliminary conceptual repository design information at a level of detail sufficient to support the comparative evaluation in this study. That information will be available as part of the supporting documentation in the records package for the study.

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AGENDA

DOE-NRC MEETING ON CALICO HILLS RISK BENEFIT ANALYSIS AND ESF ALTERNATIVES STUDY

January 29-31, 1991
(The meeting will begin at 8:30 AM on January 29th)

Holiday Inn Bethesda
8120 Wisconsin Avenue
Bethesda, Maryland

PURPOSE: To discuss the results of the Calico Hills Risk/Benefit Analysis (CHRBA) and DOE's response to NRC's Objection #2 to the Consultative Draft of the Site Characterization Plan (CDSCP) relating to penetration into the Calico Hills. In addition, results of the Exploratory Shaft Facility (ESF) Alternatives Study will be discussed.

SCOPE: This meeting will present (1) a review of the CHRBA in its entirety, including final recommendations and (2) a review of the ESF Alternatives Study and status of the Executive Report. The focus of presentations and discussion will be on regulatory considerations in the DOE reports.

Agenda Topics	Discussion Leader
Opening remarks	DOE, NRC, State
NRC Objection #2 (CDSCP)	
o Discussion of NRC position	NRC
o DOE response to Objection #2	DOE
Calico Hills Risk/Benefit Analysis	
o Introduction and summary of results	DOE
Discussion	All
o Value-of-information model overview	DOE
Discussion	All
o Multi-attribute utility analysis description and results - examples	DOE
Discussion	All

DOE-NRC MEETING ON CALICO HILLS RISK BENEFIT
ANALYSIS AND ESF ALTERNATIVES STUDY
(continued)

Agenda Topic	Discussion Leader
o Geotechnical inputs overview - rationale - models - pertinent geotechnical inputs	DOE
Discussion	All
o Impact evaluation	DOE
o Recommendations and closure	DOE
Discussion	All
ESF Alternatives Study	
o Overview	DOE
o Requirements - basis for evaluation	DOE
Discussion	All
o Options evaluated	DOE
Discussion	All
o Results of evaluation	DOE
Discussion	All
o Sensitivity information	DOE
Discussion	All
o Status of Executive Report	DOE
Discussion	All
o Review and acceptance process	DOE
Discussion	All
o Interface with repository design	DOE
Discussion	All

DOE-NRC MEETING ON CALICO HILLS RISK BENEFIT ANALYSIS AND ESF ALTERNATIVES STUDY (continued)

Agenda Topic	Discussion Leader
Concluding discussion and final remarks	DOE, NRC, State
Adjourn	

NOTE: It is expected there will be a 15 minute break each morning and afternoon with a lunch break from 12:00 - 1:00 PM.

1/29/91

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Stephan Brocoum	DOE	202 586-4262

NRC / DOE MEETING
1/31/91

Mark Delligatti	NRC	(301) 492-0430
Bakr Ibrahim	NRC	301-492-0523
Keith McConnell	NRC	301-492-0532
Priscilla Bunton	DOE	(202) 586-9896
V. Lewis Killpack	Weston/UBC	202 646 6644
Ray Wallace	USGS	202 586-1244
Dinesh Gupta	NRC	FTS 492-0547
Larry Costin	Sandia	505 846-0488
A. W. Dennis	Sandia Labs	505 844-7820
King Stablein	NRC	(301)-492-0446
Jerry King	SAIC	702-794-7648
Bob Waters	DOE	702-794-7833
David Rasmussen	Weston/DOE	(202) 646-6648
Bob Gamble	Weston	(202) 646-6656
Mike Lugo	SAIC	(702) 794-7830
Linda Desell	DOE	(202) 586-1462
Errol Gardiner	SAIC	(702)-794-7786
Simon Hsiung	CNWRA	(512) 522-5209
Derrick Wagg	SAIC	(702) 794 7788
Mikko Ahola	CNWRA	(512) 522-5799
Paula Austin	SAIC	703-827-4826
Phillip Becove	ADA	415-854-7101
Charlotte Abrams	NRC	301 492 8371
Ernest Hardin	SAIC	702/794-7617
Tom Blejwas	Sandia Nat. Labs	505-844-9160
Aldred L Stevens	"	505-844-1849
John Lathrop	Strategic Insights	415-941-4950

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NRC DOE meeting

Russ McFarland	NWTRB	703/235-4473
James Thompson	Thompson Engineering	713-462-6250
Bill Kennedy	RSN	702-794-7977
David Brooks	NRC	301 492 3457
R.L. Bullock	RSN	702/794-7014
N.A. Eisenberg	NRC	301-492-0324
John Peshel	NRC	301 492 0537
Maxwell Blanchard	DOE	702 794 7939
Stephan Brocoum	DOE	202 586-4267

NRC'S CDSCP OBJECTION #2

PRESENTED BY

KING STABLEIN

U.S. NUCLEAR REGULATORY COMMISSION

Attachment 3

DOE PROPOSAL IN THE CDSCP

- EXTEND EXPLORATORY SHAFT 1 (ES-1) 400 FEET BELOW THE PROPOSED REPOSITORY HORIZON INTO THE ZEOLITIC ZONE OF THE CALICO HILLS UNIT
- DRIFT WITHIN THE CALICO HILLS UNIT

CDSCP OBJECTION #2

PROPOSED PENETRATION OF AND DRIFTING WITHIN THE CALICO HILLS UNIT MAY HAVE SIGNIFICANT ADVERSE IMPACTS ON THE WASTE ISOLATION CAPABILITY OF THE SITE

REGULATORY BASIS FOR CDSCP OBJECTION #2: 10 CFR 60.15(c)(1)

INVESTIGATIONS TO OBTAIN THE REQUIRED INFORMATION SHALL BE CONDUCTED IN SUCH A MANNER AS TO LIMIT ADVERSE EFFECTS ON THE LONG-TERM PERFORMANCE OF THE GEOLOGIC REPOSITORY TO THE EXTENT PRACTICAL.

STATUS OF CDSCP OBJECTION #2: CLOSED

- IN THE SCP, DOE PROPOSED NO PENETRATION OF AND DRIFTING WITHIN THE CALICO HILLS UNIT
- DOE DEFERRED ITS DECISION ON PENETRATION OF AND DRIFTING WITHIN THE CALICO HILLS UNIT PENDING COMPLETION OF ANALYSES ON THE NEED FOR SUCH METHODS AND THEIR ADVERSE IMPACTS ON THE WASTE ISOLATION CAPABILITY OF THE SITE

ANY PROPOSAL FOR PENETRATION OF AND DRIFTING WITHIN THE CALICO HILLS UNIT SHOULD INCLUDE:

- NEED FOR THE DATA
- DESCRIPTION OF THE PROPOSED DATA COLLECTION METHODS AND ALTERNATIVES
- IMPACTS OF DATA COLLECTION ON THE SITE
- BASED UPON THE ABOVE INFORMATION, DEMONSTRATION THAT DATA COLLECTION METHODS HAVE BEEN SELECTED THAT WILL LIMIT ADVERSE IMPACTS ON THE WASTE ISOLATION CAPABILITY OF THE SITE TO THE EXTENT PRACTICAL

U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

DOE RESPONSE TO NRC OBJECTION #2 (CDSCP)

PRESENTED AT

DOE/NRC MEETING ON CALICO HILLS RISK/BENEFIT ANALYSIS AND ESF ALTERNATIVES STUDY

PRESENTED BY

DR. DAVID C. DOBSON
ACTING DIRECTOR - REGULATORY AND SITE EVALUATION DIVISION
YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

JANUARY 29-31, 1991

Attachment 4

RATIONALE FOR THE CHRBA

SUMMARY OF NRC OBJECTION #2 TO THE SCP/CD

- THE NEED HAS NOT BEEN ESTABLISHED TO EXTEND OR TO DRIFT HORIZONTALLY FROM ES-1 INTO THE CALICO HILLS

- POTENTIAL ADVERSE IMPACTS ON WASTE ISOLATION AS A RESULT OF PENETRATING THE CALICO HILLS HAVE NOT BEEN DEMONSTRATED

RATIONALE FOR THE CHRBA

(CONTINUED)

NRC RECOMMENDATION

- CONSIDER CHARACTERIZING THE CALICO HILLS WITHOUT PENETRATING THE BARRIER BETWEEN THE REPOSITORY HORIZON AND THE WATER TABLE
- A DETAILED DISCUSSION IS NEEDED BY DOE TO SHOW WHY THE BENEFITS OUTWEIGH THE POTENTIAL ADVERSE IMPACTS OF PENETRATING THE CALICO HILLS RATHER THAN OBTAINING THE NECESSARY INFORMATION BY ALTERNATE MEANS
- IF ALTERNATE MEANS CANNOT BE DEVELOPED, THEN JUSTIFY DESTRUCTIVE TESTING OF CALICO HILLS; INCLUDE THE CONSEQUENCES OF CONNECTING PATHWAYS FOR RADIONUCLIDES FROM WASTE EMPLACEMENT AREAS TO THE WATER TABLE

RATIONALE FOR THE CHRBA

(CONTINUED)

- THE FINAL SCP (SECTION 8.4.2.1.6.1) CONTAINED A COMMITMENT TO CONDUCT A RISK/BENEFIT ANALYSIS TO DETERMINE THE APPROPRIATE METHODS TO CHARACTERIZE THE CALICO HILLS UNIT. THE ANALYSIS WAS TO CONSIDER:

  - NEEDED DATA
  - ALTERNATE MEANS OF OBTAINING DATA
  - BENEFITS OF OBTAINING THE DATA
  - RISKS TO SITE PERFORMANCE BY OBTAINING DATA

- THE DOE ALSO COMMITTED TO CONSULT WITH NRC PRIOR TO TAKING ACTION

U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

CALICO HILLS RISK/BENEFIT ANALYSIS
OPENING REMARKS

PRESENTED AT

DOE/NRC MEETING ON CALICO HILLS RISK/BENEFIT ANALYSIS AND ESF ALTERNATIVES STUDY

PRESENTED BY

DR. DAVID C. DOBSON

ACTING DIRECTOR - REGULATORY AND SITE EVALUATION DIVISION
YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

JANUARY 29-31, 1991

Attachment 5

RATIONALE FOR STUDIES

10 CFR 60.16 STATES:

"BEFORE PROCEEDING TO SINK SHAFTS...
DOE SHALL SUBMIT TO THE DIRECTOR (NRC),
A SITE CHARACTERIZATION PLAN...DOE SHALL
DEFER THE SINKING OF SUCH SHAFTS UNTIL...
COMMISSION COMMENTS...HAVE BEEN SOLICITED
AND CONSIDERED."

RATIONALE FOR STUDIES
(CONTINUED)

THE NRC SITE CHARACTERIZATION ANALYSIS (NUREG 1347) IDENTIFIED CONCERNS WITH THE SITE CHARACTERIZATION PROGRAM, AND SPECIFICALLY WITH THE ESF. THE SCA CONTAINS THREE CATEGORIES OF CONCERNS:

"AN OBJECTION...IS A MATTER OF SUCH SERIOUSNESS... THAT NRC WOULD RECOMMEND DOE NOT START WORK IN THAT AREA UNTIL IT IS SATISFACTORILY RESOLVED"

"A COMMENT...IS A CONCERN...THAT WOULD RESULT IN A SIGNIFICANT ADVERSE AFFECT ON LICENSING IF NOT RESOLVED..."

"A QUESTION...IS A CONCERN WITH THE PRESENTATION OF THE PROGRAM IN THE SCP

RATIONALE FOR STUDIES

(CONTINUED)

- DOE HAS CONDUCTED THE STUDIES DESCRIBED HERE (CHRBA, ESF AS) TO ADDRESS AND CONSIDER CONCERNS IDENTIFIED BY NRC (AND OTHERS) WITH RESPECT TO THE ESF, CONSISTENT WITH THE REQUIREMENTS OF 10 CFR 60.16
- DOE WILL CONTINUE TO SOLICIT AND CONSIDER NRC COMMENTS AS THE ESF DESIGN EVOLVES, AND AS THE FACILITY IS CONSTRUCTED
- THIS NRC/DOE MEETING IS BEING CONDUCTED SO THAT THE DOE CAN REPORT THE RESULTS OF THE STUDIES TO NRC, AND SO THAT NRC CAN PROVIDE INPUT TO DOE AND THE DIRECTOR, OCRWM, REGARDING THE IMPORTANT DECISIONS ABOUT ESF DESIGN THAT WILL BE MADE IN THE NEAR FUTURE

U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

CALICO HILLS RISK/BENEFIT ANALYSIS
INTRODUCTION AND SUMMARY OF RESULTS

PRESENTED AT

DOE/NRC MEETING ON CALICO HILLS RISK/BENEFIT ANALYSIS AND ESF ALTERNATIVES STUDY

PRESENTED BY

DR. DAVID C. DOBSON

ACTING DIRECTOR - REGULATORY AND SITE EVALUATION DIVISION
YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

JANUARY 29-31, 1991

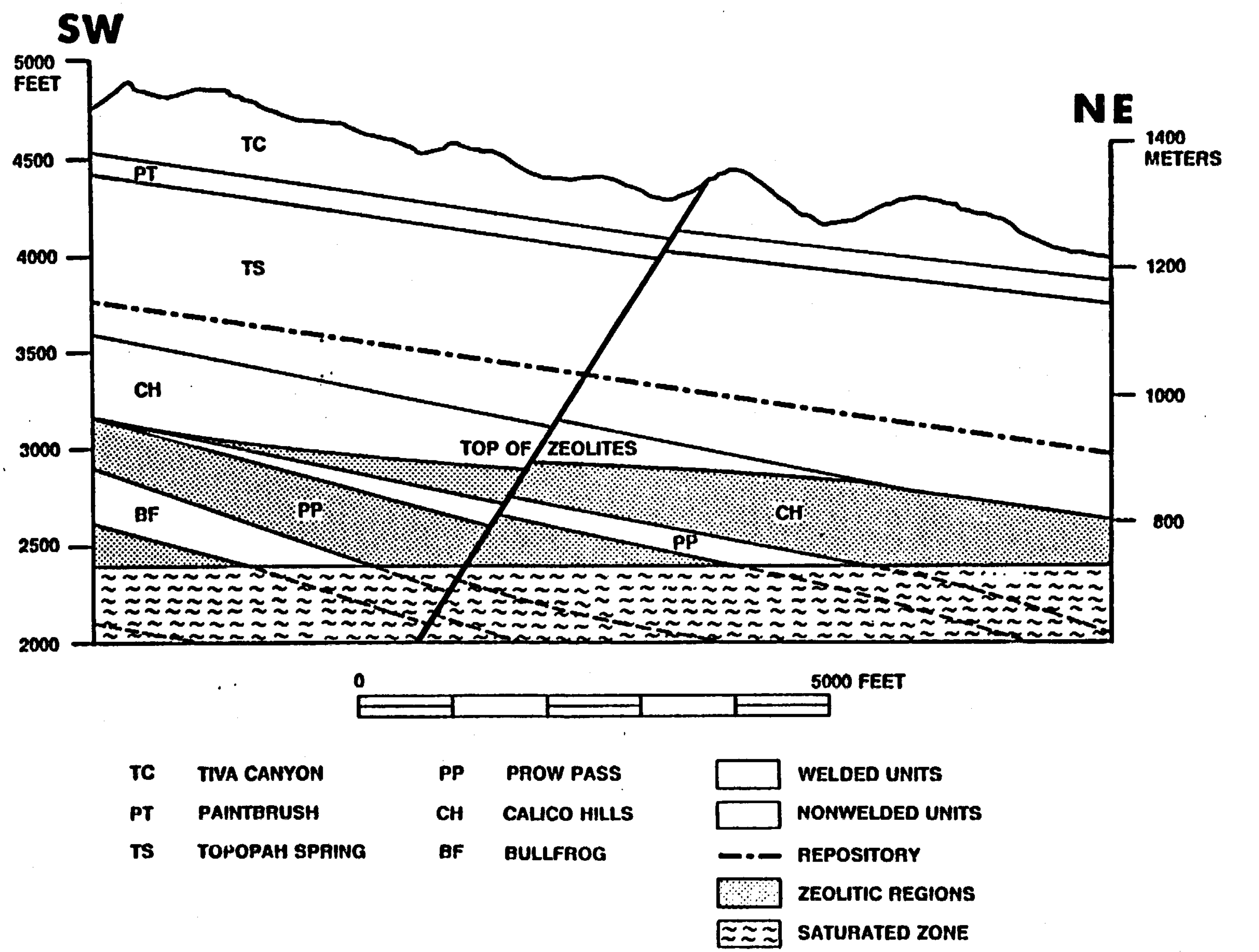
Attachment 6

CALICO HILLS RISK/BENEFIT ANALYSIS
AGENDA

• INTRODUCTION AND SUMMARY OF RESULTS	D. DOBSON, DOE
• VALUE-OF-INFORMATION MODEL OVERVIEW	
- GEOTECHNICAL INPUTS TO VOI STUDY	E. HARDIN, SAIC
- METHODOLOGY AND RESULTS	H. CALL, ADA
• MULTIATTRIBUTE UTILITY ANALYSIS	
- GEOTECHNICAL INPUTS TO MUA	E. HARDIN, SAIC
- DESCRIPTION AND RESULTS	J. LATHROP, STRATEGIC INSIGHTS
• IMPACT EVALUATION	C. VOSS, GOLDER & ASSOCIATES
• RECOMMENDATIONS AND CLOSURE	D. DOBSON,DOE

GEOLOGIC ORIENTATION:

CROSS SECTION SHOWING CHn AT YUCCA MOUNTAIN



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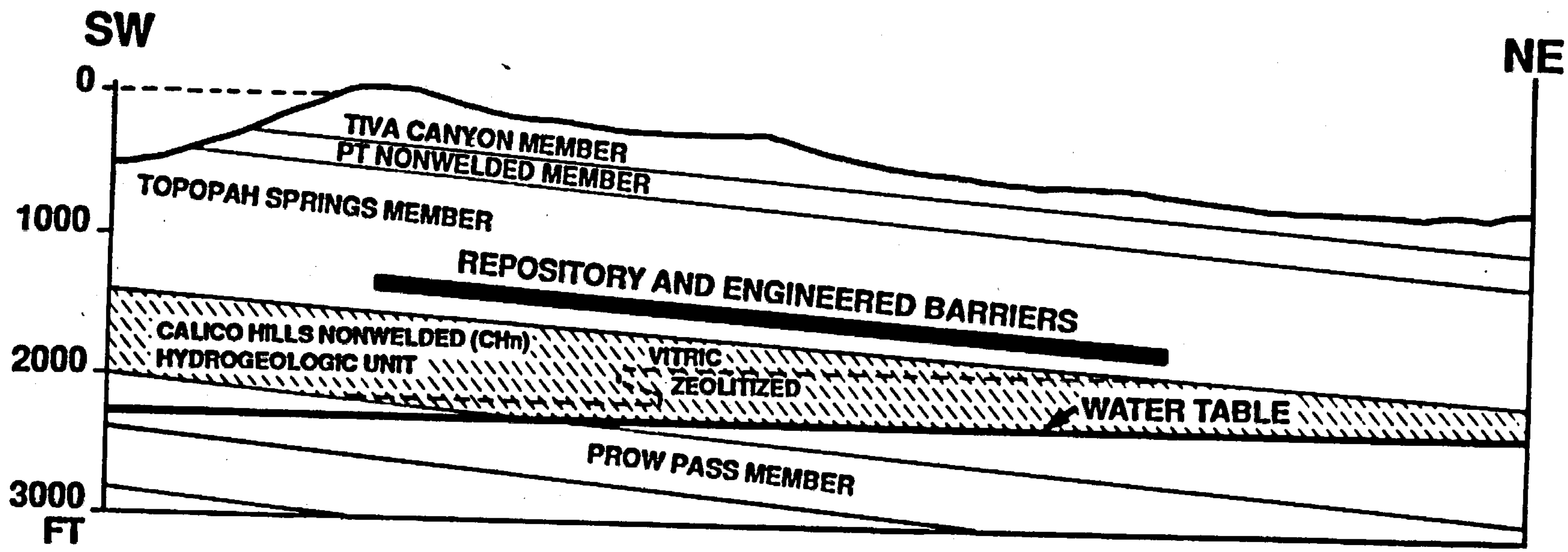
CROSS SECTION SHOWING CHn AT YUCCA MOUNTAIN



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OBJECTIVES AND METHODS

- THIS STUDY WAS CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS OF THE YMP QA PROGRAM

- THE DOE DECIDED TO CONDUCT THE STUDY IN ACCORDANCE WITH THE PRINCIPLES OF DECISION ANALYSIS, IN ORDER TO ENSURE THE BASIS FOR THE DECISION WAS CLEAR

- TWO DECISION-AIDING METHODOLOGIES WERE UTILIZED
  - A VALUE OF INFORMATION (VOI) TECHNIQUE
  - A MULTIATTRIBUTE UTILITY ANALYSIS (MUA)

- THE TASK GROUP WAS INSTRUCTED TO BASE THE EVALUATION PRIMARILY ON THE CRITERIA IDENTIFIED IN THE NRC OBJECTION
  - BENEFIT FROM TESTING
  - RISK TO PERFORMANCE

COMPOSITION OF THE TASK FORCE

- THE CHRBA TASK GROUP WAS COMPOSED OF SCIENTISTS, ENGINEERS, AND REGULATORY STAFF REPRESENTING THE MAJOR DISCIPLINES IN THE PROGRAM (e.g., HYDROLOGY, GEOLOGY, GEOCHEMISTRY, PERFORMANCE ASSESSMENT, ENGINEERING)

- THE TASK FORCE WAS NOT DESIGNED TO INCLUDE ALL POSSIBLE FIELDS OF EXPERTISE, BUT WAS EMPOWERED TO OBTAIN ADDITIONAL EXPERT INPUT WHERE REQUIRED

  - FOR EXAMPLE, THE TASK GROUP DID RECEIVE INPUT FROM PROJECT EXPERTS FOR THE ASSESSMENTS OF GEOCHEMICAL RETARDATION AND PERFORMANCE IMPACTS

TECHNICAL PARTICIPANTS

EARNEST L. HARDIN	SAIC	TASK LEADER
ELISABETH BROWNE	ADA	DECISION ANALYST
HOLLIS CALL	ADA	DECISION ANALYST
BRUCE CROWE	LANL	GEOLOGIST
DAVID C. DOBSON	DOE/YMP	REGULATORY/GEOLOGIST
LAWRENCE GALLANT	ADA	DECISION ANALYST
ERROL GARDINER	SAIC	MINING ENGINEER
CHARLES C. HERRINGTON	SAIC	REGULATORY SPECIALIST
JERRY L. KING	SAIC	REGULATORY SPECIALIST
JOHN LATHROP	STRATEGIC INSIGHTS	PRINCIPAL DECISION ANALYST
RICHARD C. LEE	SAIC	GEOPHYSICIST
BARNEY LEWIS	USGS	HYDROLOGIST/HYDROGEOLOGIST
ROBERT C. MURRAY	SAIC	GEOLOGIST
RUSSEL A. PAIGE	HARZA	GEOLOGIST
MARTHA W. PENDLETON	SAIC	REGULATORY/GEOLOGIST
JOHN B. ROBERTSON	HYDROGEOLOGIC, INC.	HYDROGEOLOGIST
VICTOR ROHRER	WESTINGHOUSE	COST & SCHEDULING
BRUCE SCHEPENS	REECo	MINING ENGINEER/COST & SCHED.
SCOTT SINNOCK	SNL	PERFORMANCE ASSESSMENT
MICHAEL D. VOEGELE	SAIC	REGULATORY SPECIALIST
CHARLIE VOSS	GOLDER ASSOCIATES	GEOTECHNICAL ENGINEER
WILLIAM E. WILSON	USGS	HYDROLOGIST/HYDROGEOLOGIST
DAVID WONDERLY	REECo	DRILLING ENGINEER

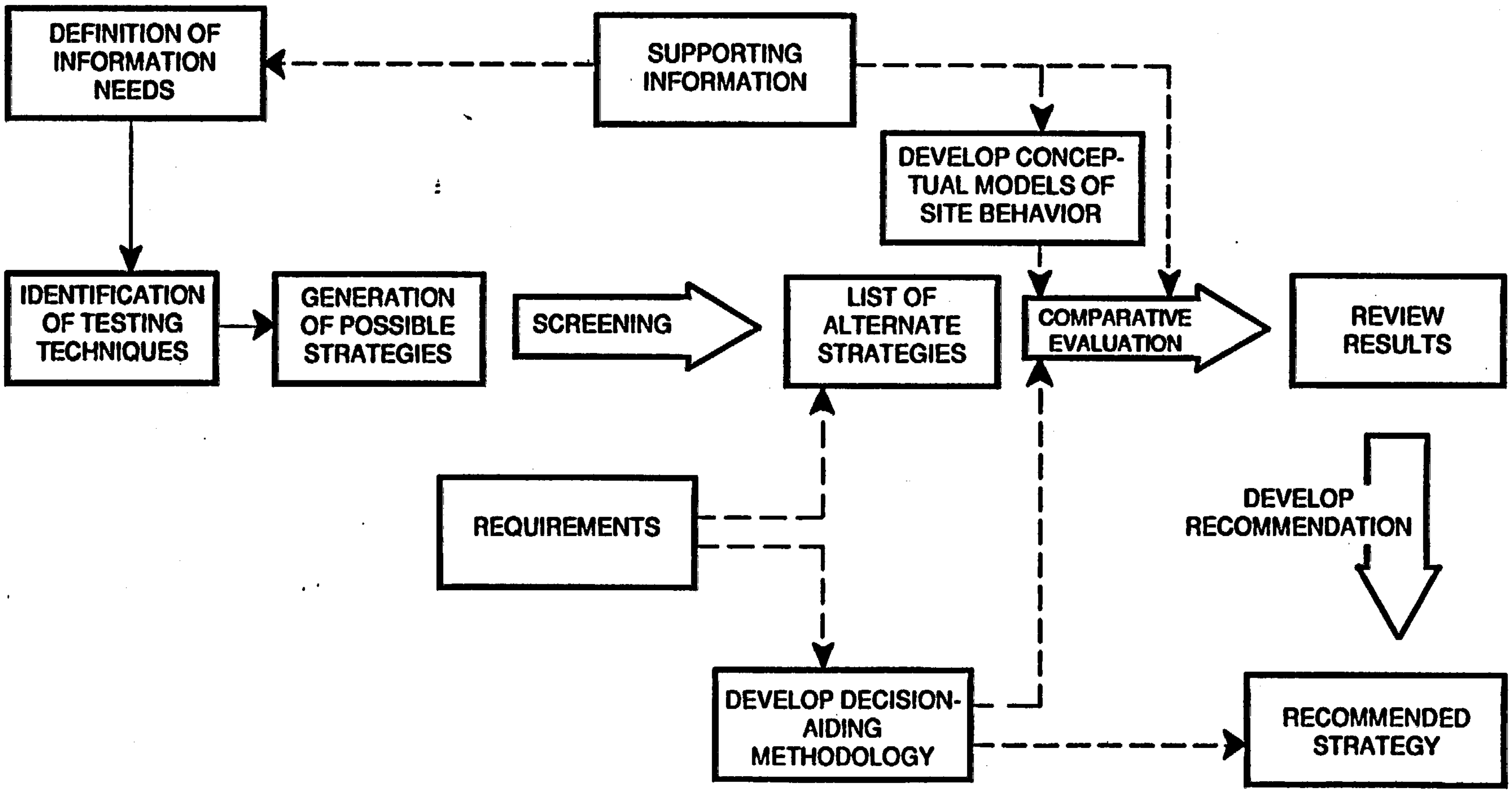
MANAGEMENT PARTICIPANTS

DAVID C. DOBSON	DOE/YMP
MAXWELL B. BLANCHARD	DOE/YMP
JEFFREY KIMBALL	DOE/HQ
STEPHAN BROCOUM	DOE/HQ
ARDYTH M. SIMMONS	DOE/YMP
JERRY L. KING	SAIC
MARTHA M. PENDLETON	SAIC
WILLIAM HASLEBACHER	WESTON

SUMMARY OF THE RISK/BENEFIT ANALYSIS

- OVERALL STRUCTURE
- VOI MODEL
- MUA

STRUCTURE OF THE CALICO HILLS RISK/BENEFIT ANALYSIS



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VOI ANALYSIS

- A VALUE OF INFORMATION TECHNIQUE WAS EMPLOYED FOR SEVERAL REASONS

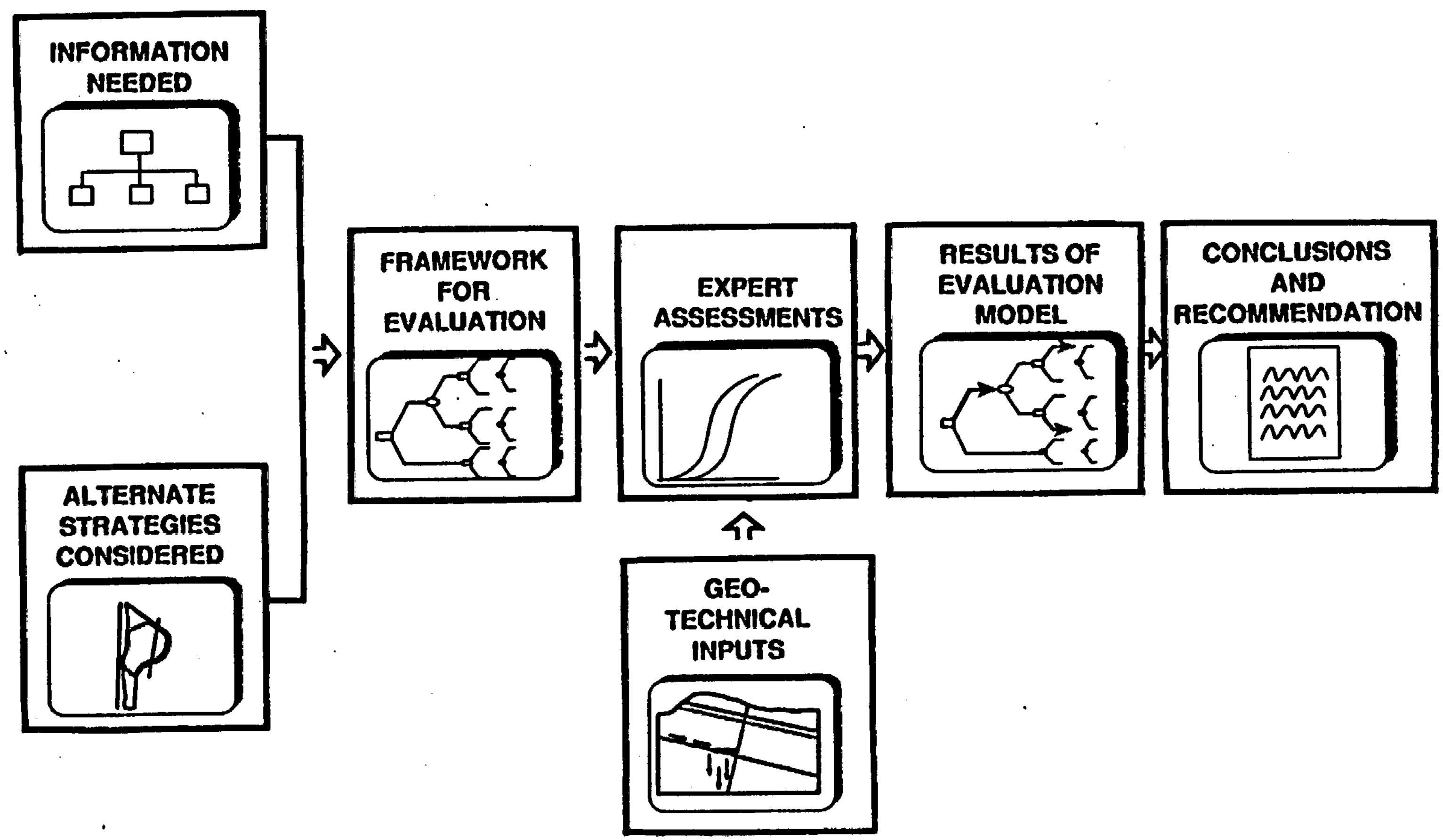
  - THE DECISION REQUIRED CONSIDERATION OF AVAILABLE QUANTITATIVE DATA AND MODEL RESULTS COMBINED WITH EXPERT JUDGEMENT

  - THE OBJECTIVE WAS TO COMPARE BENEFITS OF TESTING (MEASURED BY THE IMPROVEMENT IN DECISION MAKING DUE TO INCREASED UNDERSTANDING OF SITE PERFORMANCE) TO THE POTENTIAL FOR ADVERSE IMPACTS ON SITE PERFORMANCE AS A RESULT OF TESTING

VOI ANALYSIS

(CONTINUED)

COMPONENTS OF THE CALICO HILLS RISK/BENEFIT ANALYSIS: VOI MODEL



MULTIATTRIBUTE UTILITY ANALYSIS

A MULTIATTRIBUTE UTILITY ANALYSIS (MUA) WAS CONSIDERED BECAUSE THE VOI ANALYSIS FOUND NO VOI IN ANY OF THE TESTING STRATEGIES. THIS RESULT SUGGESTED THAT:

- DECISION MAKERS PLACE HIGH VALUE ON HIGH CONFIDENCE, EVEN AT EXTREMELY LOW LEVELS OF RELEASES; OR

- THERE IS A VALUE TO TESTING THAT WAS NOT CAPTURED WELL BY THE VOI MODEL

THE MUA WAS INITIATED TO EVALUATE TEST STRATEGIES IN TERMS OF SEVERAL PERFORMANCE MEASURES: RELEASE RISK, COST, SCIENTIFIC CONFIDENCE, DELAY, AND PHASING POTENTIAL

MULTIATTRIBUTE UTILITY ANALYSIS

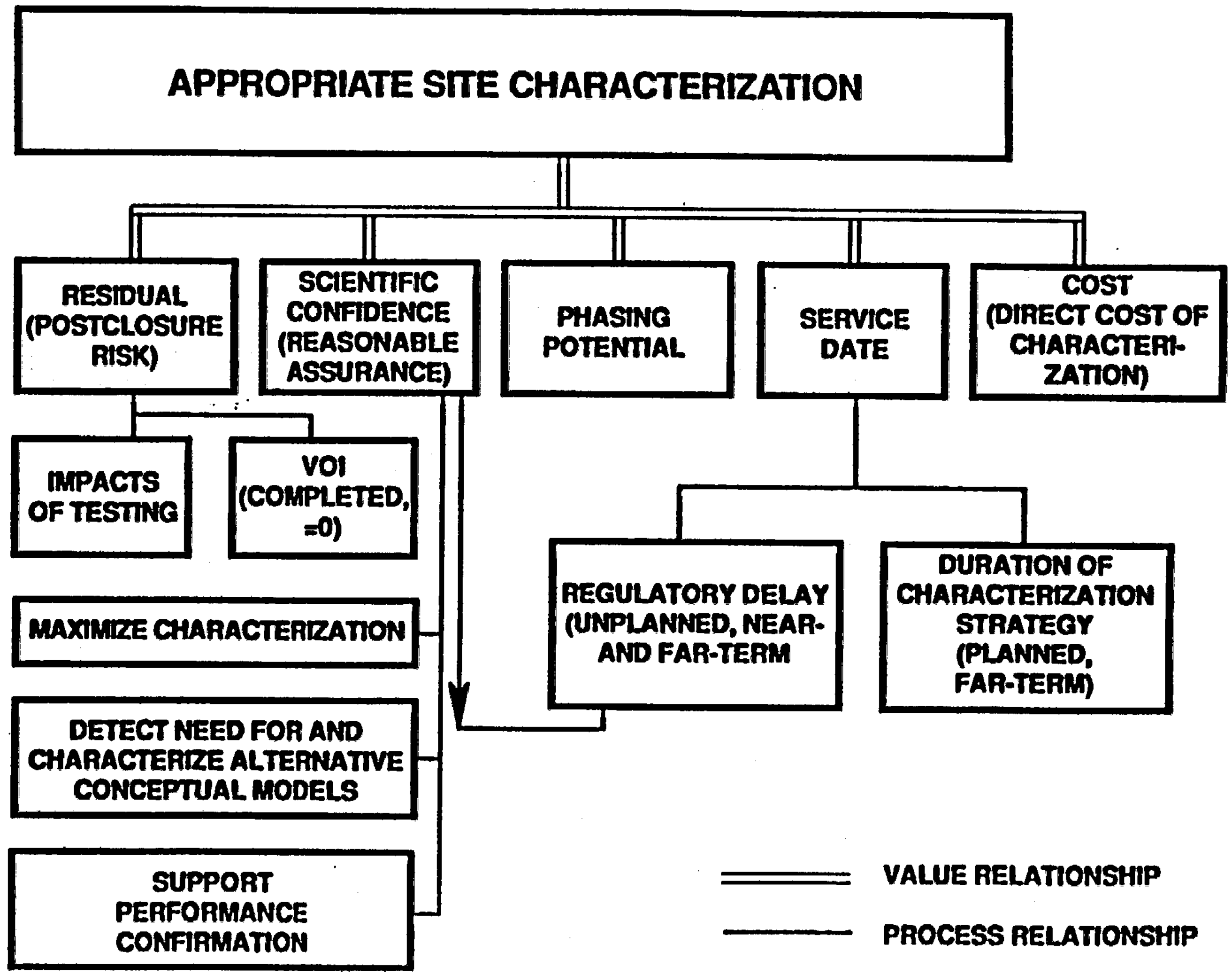
(CONTINUED)

- THE MUA TECHNIQUE WAS CONSIDERED APPROPRIATE BECAUSE THE NET BENEFIT OF TEST STRATEGIES VARIED FOR DIFFERENT PERFORMANCE MEASURES

- THE MUA METHOD PROVIDED A STRUCTURED, FORMALLY CORRECT AND DEFENSIBLE WAY TO COMBINE SUBJECTIVE EXPERT JUDGMENTS, AND ARRIVE AT A RECOMMENDATION

MULTI-ATTRIBUTE UTILITY ANALYSIS
(CONTINUED)

ISSUES/OBJECTIVES/MODEL HIERARCHY FOR THE MUA



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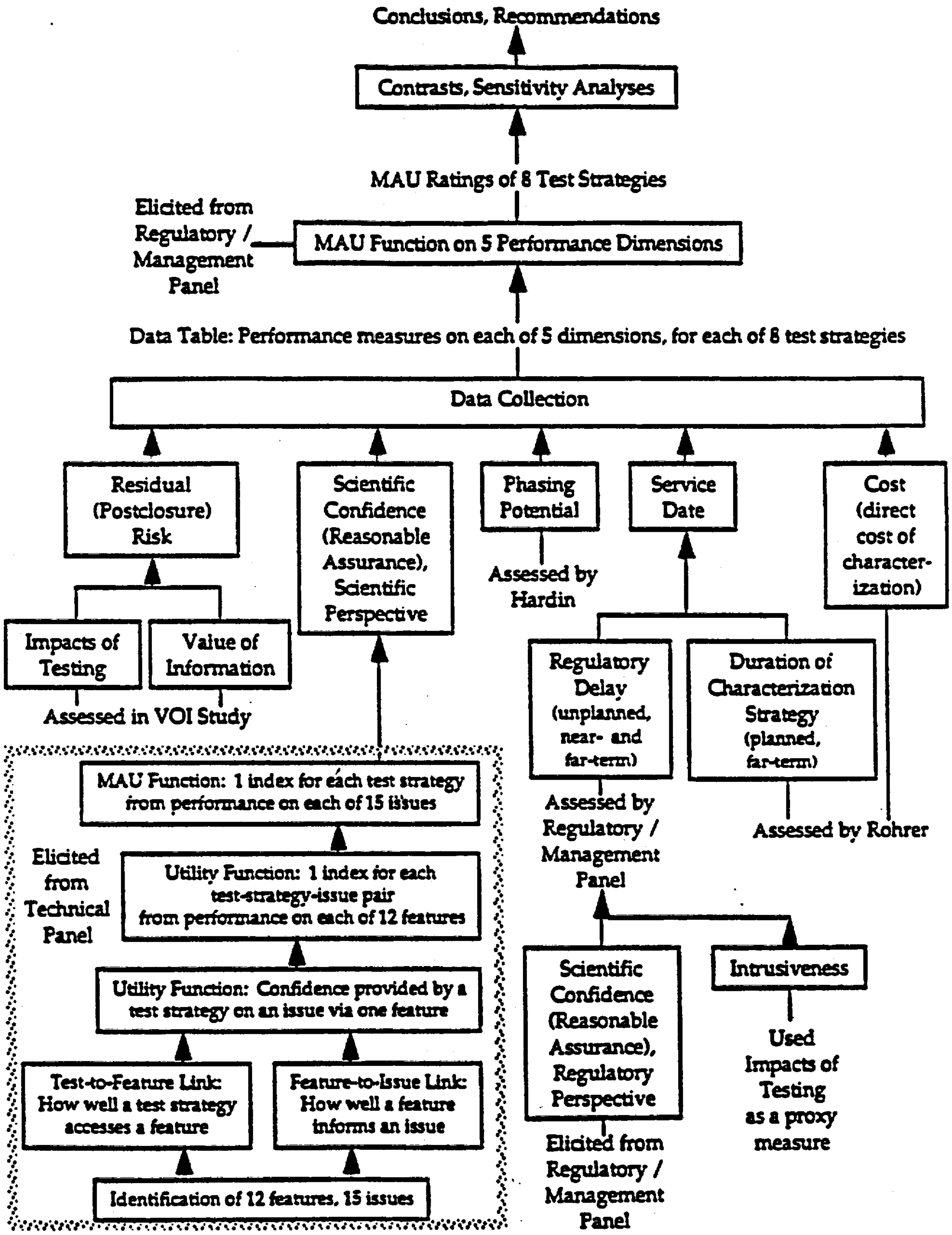
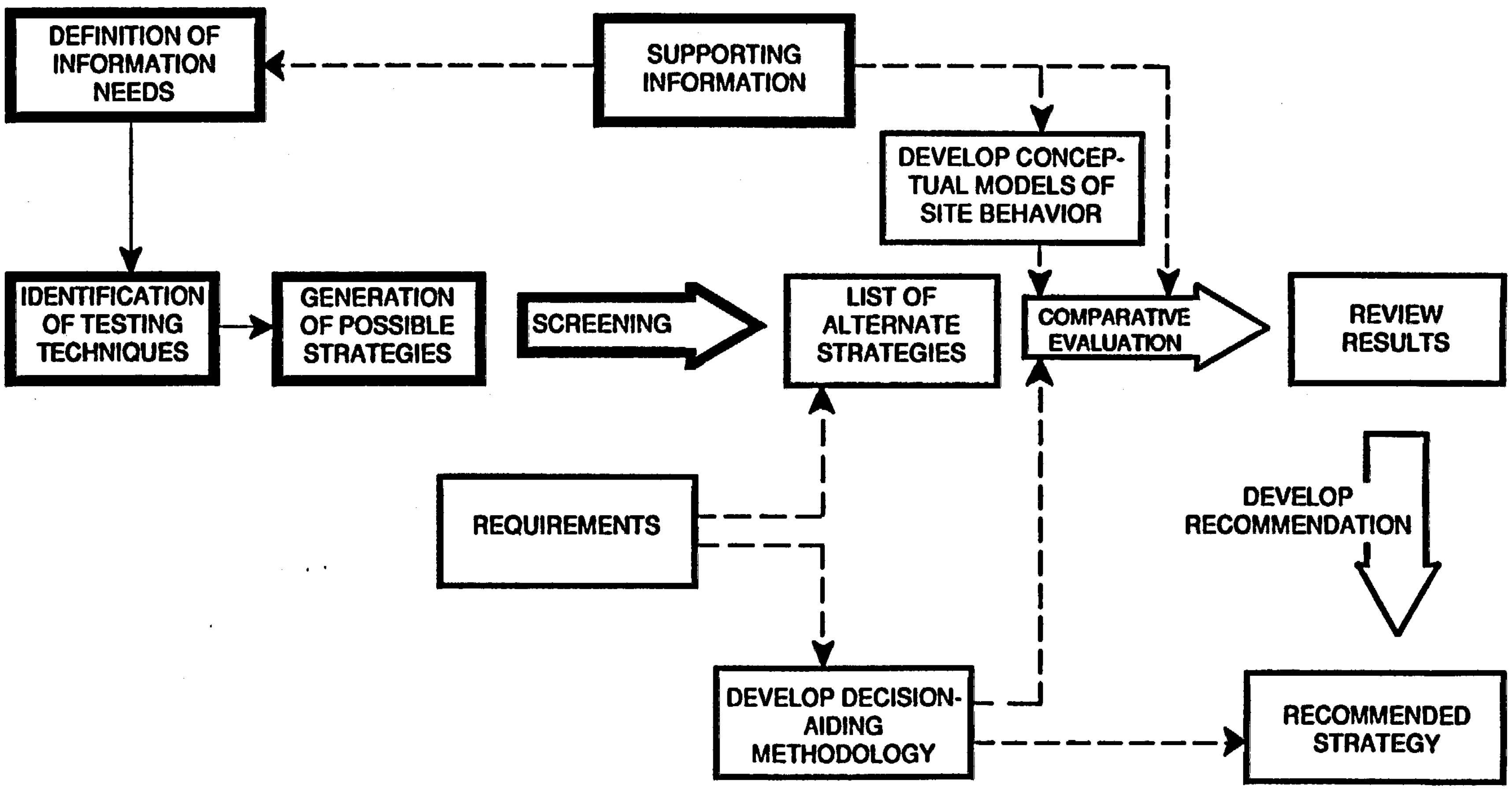
FLOWCHART OF THE COMPLETE MUA ANALYSIS



STRUCTURE OF THE ANALYSIS



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DEFINITION OF INFORMATION NEEDS

- A SUBPANEL OF THE TASK GROUP WAS FORMED TO DEFINE INFORMATION NEEDS FROM THE CALICO HILLS NONWELDED (CHn) HYDROGEOLOGIC UNIT CONSIDERING:
  - TYPES OF INFORMATION NEEDS (PARAMETERS)
  - LOCATIONS OF INFORMATION NEEDS (MATRIX vs FAULT ZONES)
  - SPATIAL CORRELATION OF INFORMATION NEEDS

EVALUATION OF TESTING TECHNIQUES

- THE FULL CHRBA TASK GROUP THEN CONSIDERED HOW WELL VARIOUS TESTING TECHNIQUES COULD PROVIDE THE NEEDED INFORMATION

  - TECHNIQUES INCLUDED BOTH SURFACE-BASED AND UNDERGROUND METHODS

  - TECHNIQUES INCLUDED BOTH INVASIVE (e.g., DRILLING AND UNDERGROUND EXCAVATION) AND NON-INVASIVE (e.g., GEOPHYSICS AND ANALOG STUDIES) METHODS

  - TECHNIQUES WERE QUALITATIVELY RANKED AS A BASIS FOR COMPOSING STRATEGIES

DEVELOPMENT OF ALTERNATE STRATEGIES

- GIVEN THE DEFINITION OF INFORMATION NEEDS AND THE EVALUATION OF THE TECHNIQUES, A SET OF TESTING OPTIONS WERE DEVELOPED TO COMPOSE DIFFERENT CONCEPTUAL TESTING STRATEGIES

- THE EIGHT STRATEGIES REPRESENT AN APPROPRIATE RANGE OF POSSIBILITIES IN TERMS OF THE VARIABLES DEFINED

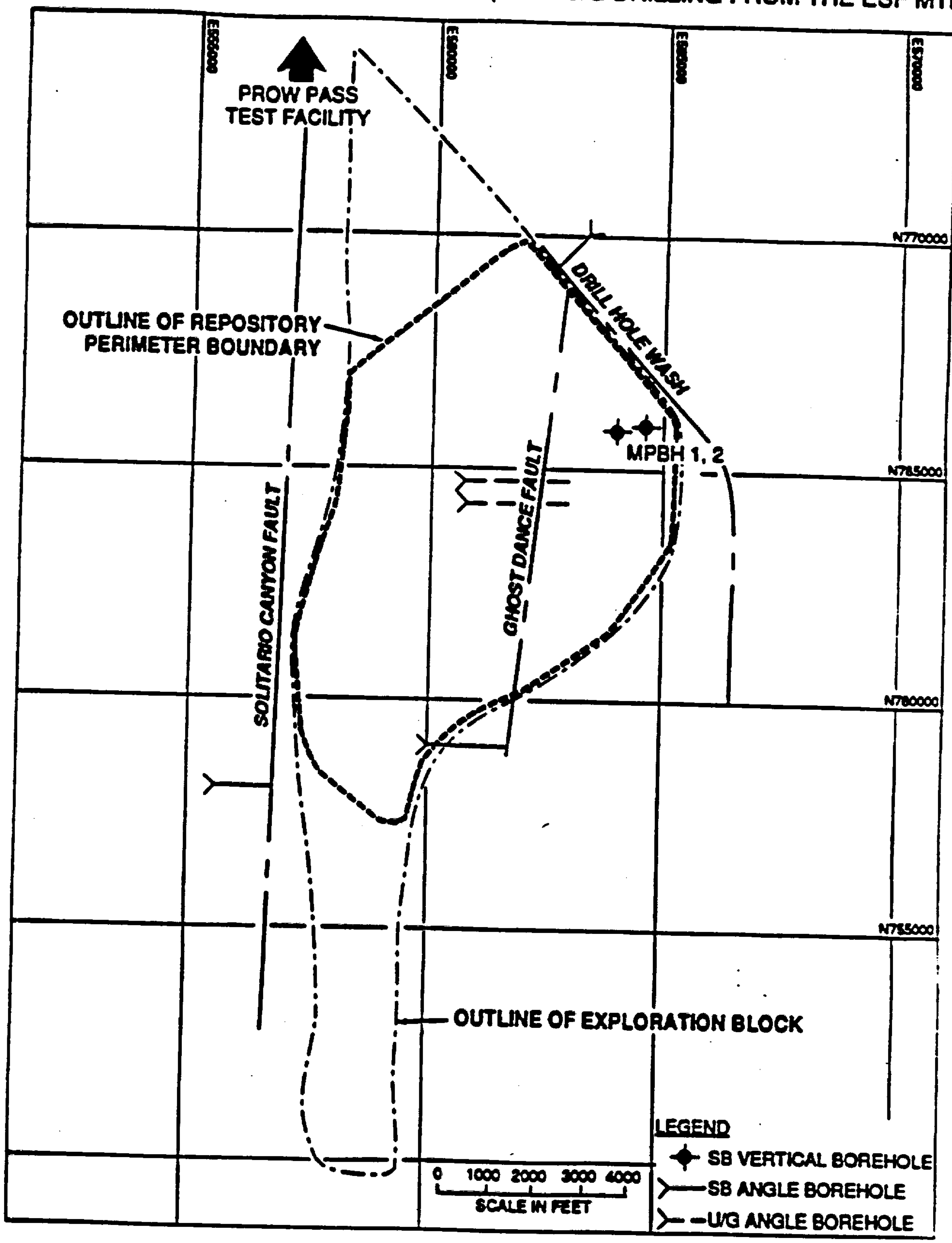
  - THE STRATEGIES UTILIZE VARYING AMOUNTS AND LOCATIONS OF EACH OF THE MAJOR TYPES OF TEST METHODS:
    - DRILLING
    - UNDERGROUND DRIFTING/EXPLORATION
    - ANALOG SITE STUDIES

DEVELOPMENT OF ALTERNATE STUDIES

- THE EIGHT STRATEGIES WERE NOT INTENDED TO REPRESENT FINAL DESIGN CONFIGURATIONS
- THE CHRBA TASK GROUP EXPECTS THAT STRATEGIES WILL BE MODIFIED DURING DESIGN
- THE CHRBA TASK GROUP DID NOT EXPLICITLY ADDRESS MEANS OF ACCESS TO THE CHn, BUT FOCUSED ON CHARACTERIZATION WITHIN THE UNIT
  - EVALUATIONS OF ALTERNATE MEANS OF ACCESS WERE PERFORMED BY THE ESF AS, WITH INPUT FROM (AND COORDINATION WITH THE CHRBA GROUP

DESCRIPTION OF THE STRATEGIES

STRATEGY NO. 6
ADDITIONAL SURFACE-BASED TESTING (WITH U/G DRILLING FROM THE ESF MTL)



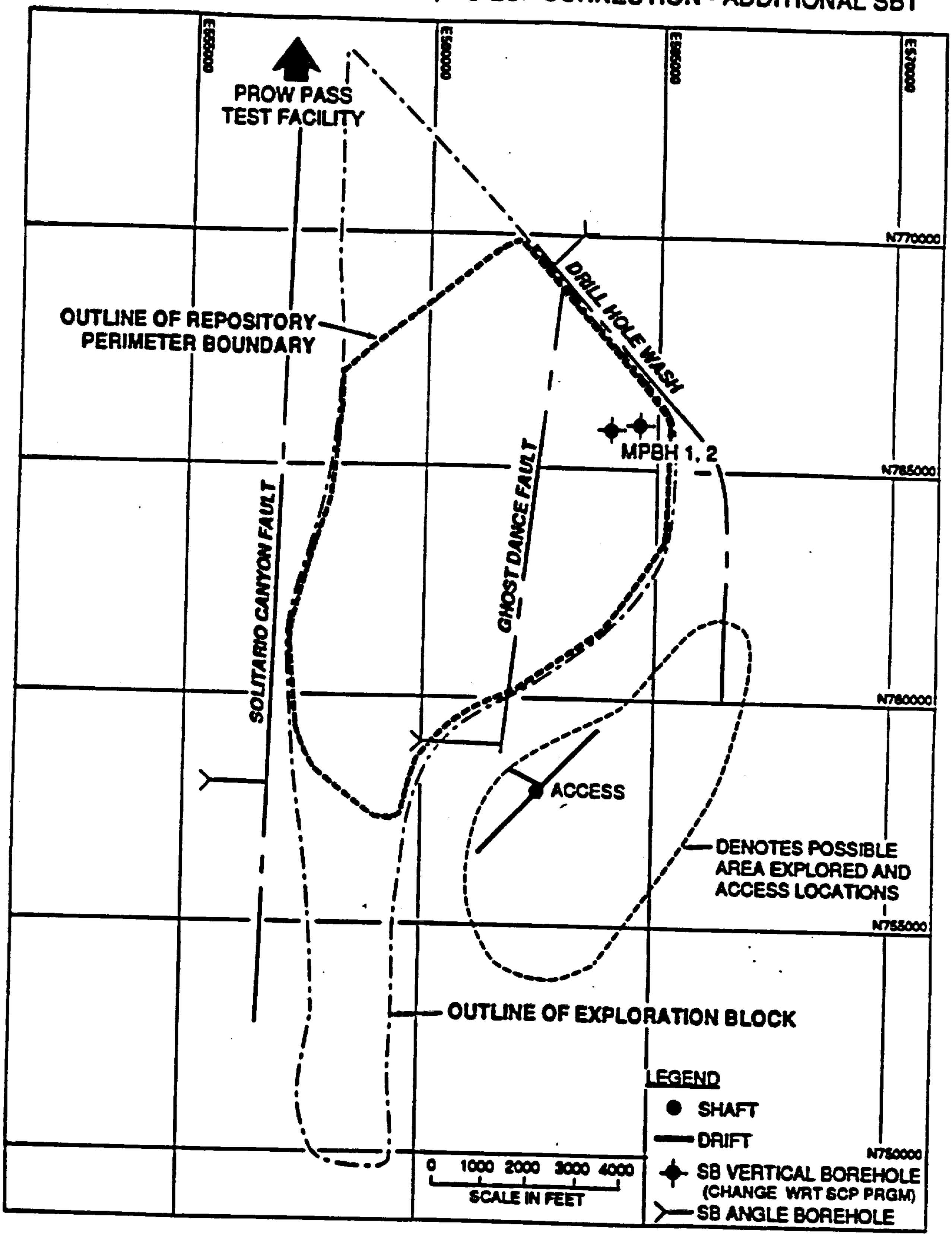
CALICO HILLS STRATEGIES

STRATEGY #6

- ACTIVITIES LIMITED TO DRILLING FROM THE SURFACE AND FROM THE ESF MAIN TEST LEVEL
- ANGLED DRILLHOLES (UP TO 35 DEGREES FROM VERTICAL) FOR FAULT EXPLORATION
- PROW PASS TEST FACILITY ADDED TO PERMIT DIRECT INVESTIGATION OF FAULTING IN ZEOLITIC FACIES AND TRANSPORT TESTING
- GEOPHYSICS TO BE INCLUDED, AS APPROPRIATE

STRATEGY NO. 8

OUTSIDE; SE; LIMITED FACILITY; NO ESF CONNECTION - ADDITIONAL SBT



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CALICO HILLS STRATEGIES

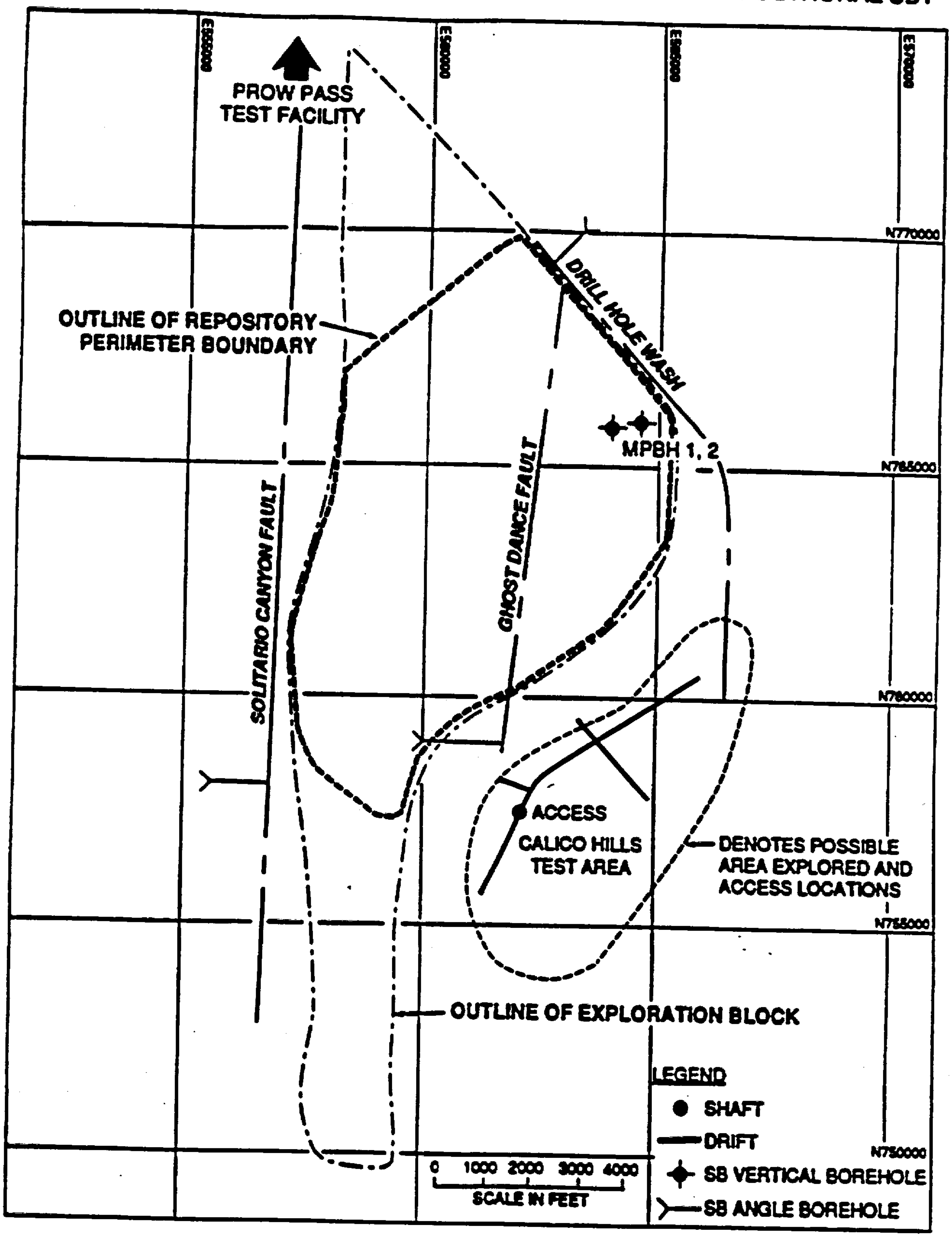
(CONTINUED)

STRATEGY #8

- ATTEMPT TO USE EXCAVATION TO COLLECT DATA WHILE MINIMIZING POSSIBLE IMPACTS TO WASTE ISOLATION
- DRIFTS WOULD EXPLORE THE SOUTHERN EXTENSION OF THE GHOST DANCE FAULT (OR RELATED FAULTS)
- INCLUDE ADDITIONAL SBT (IN ADDITION TO SCP) TO MAXIMIZE INFORMATION WITHOUT EXCAVATION INSIDE THE BLOCK

STRATEGY NO. 7

OUTSIDE; SE; EXTENDED DRIFTING; NO ESF CONNECTION - ADDITIONAL SBT



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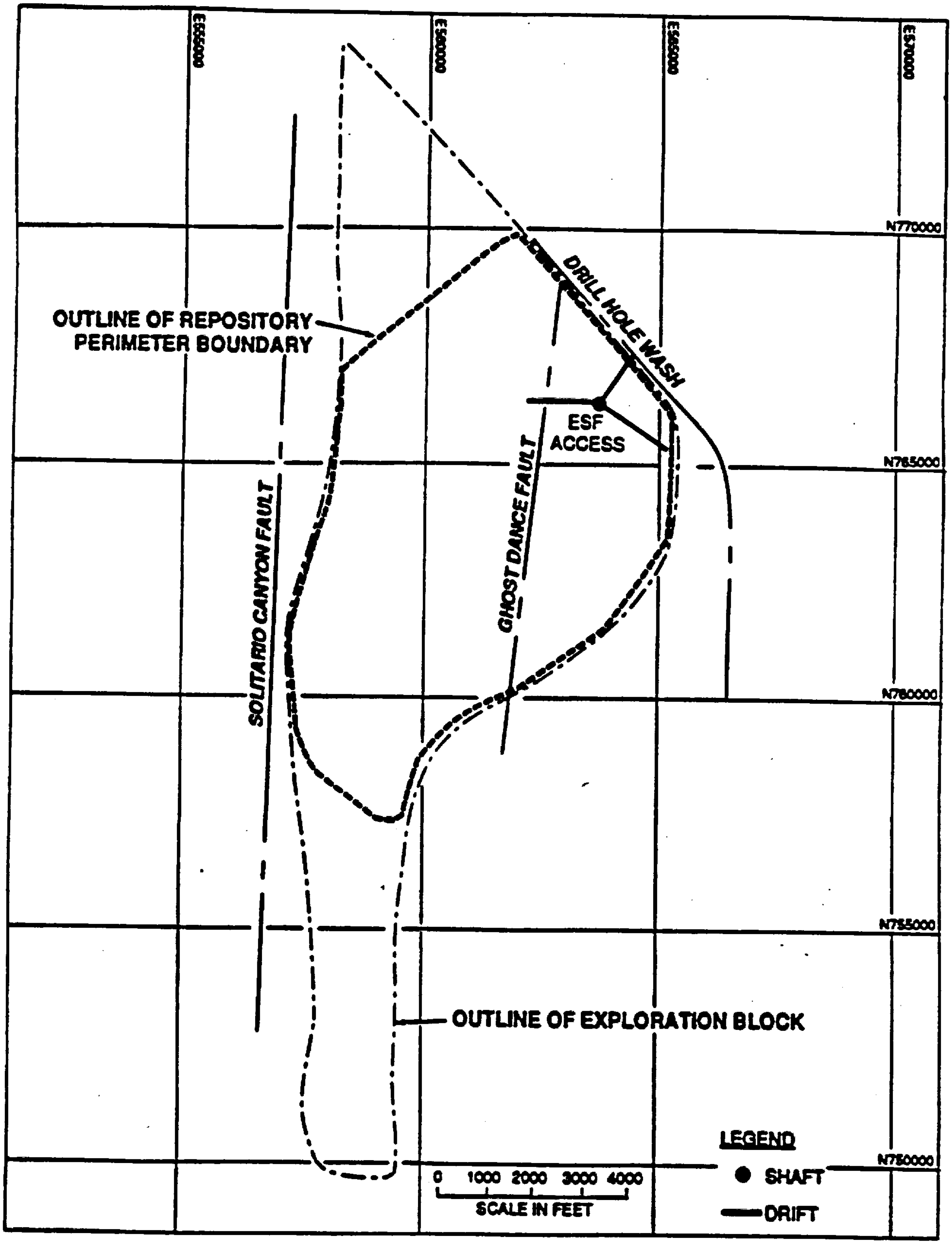
CALICO HILLS STRATEGIES
(CONTINUED)

STRATEGY #7

- ATTEMPT TO MAXIMIZE TEST ACCURACY WITHOUT EXCAVATION INSIDE THE REPOSITORY BLOCK
- SIMILAR TO #8, BUT WITH EXPANDED EXCAVATION OUTSIDE THE BLOCK TO THE SOUTHEAST
- EXTENSIVE EXCAVATION OUTSIDE THE BLOCK EXPLORES FACIES TRANSITION AND THE SOUTHERN EXTENSION OF THE GHOST DANCE FAULT OR RELATED FAULTS)
- INCLUDE ADDITIONAL SBT (IN ADDITION TO SCP) TO MAXIMIZE INFORMATION WITHOUT EXCAVATION INSIDE THE BLOCK

STRATEGY NO. 3
INSIDE; NE; LIMITED FACILITY; INTEGRATED WITH ESF



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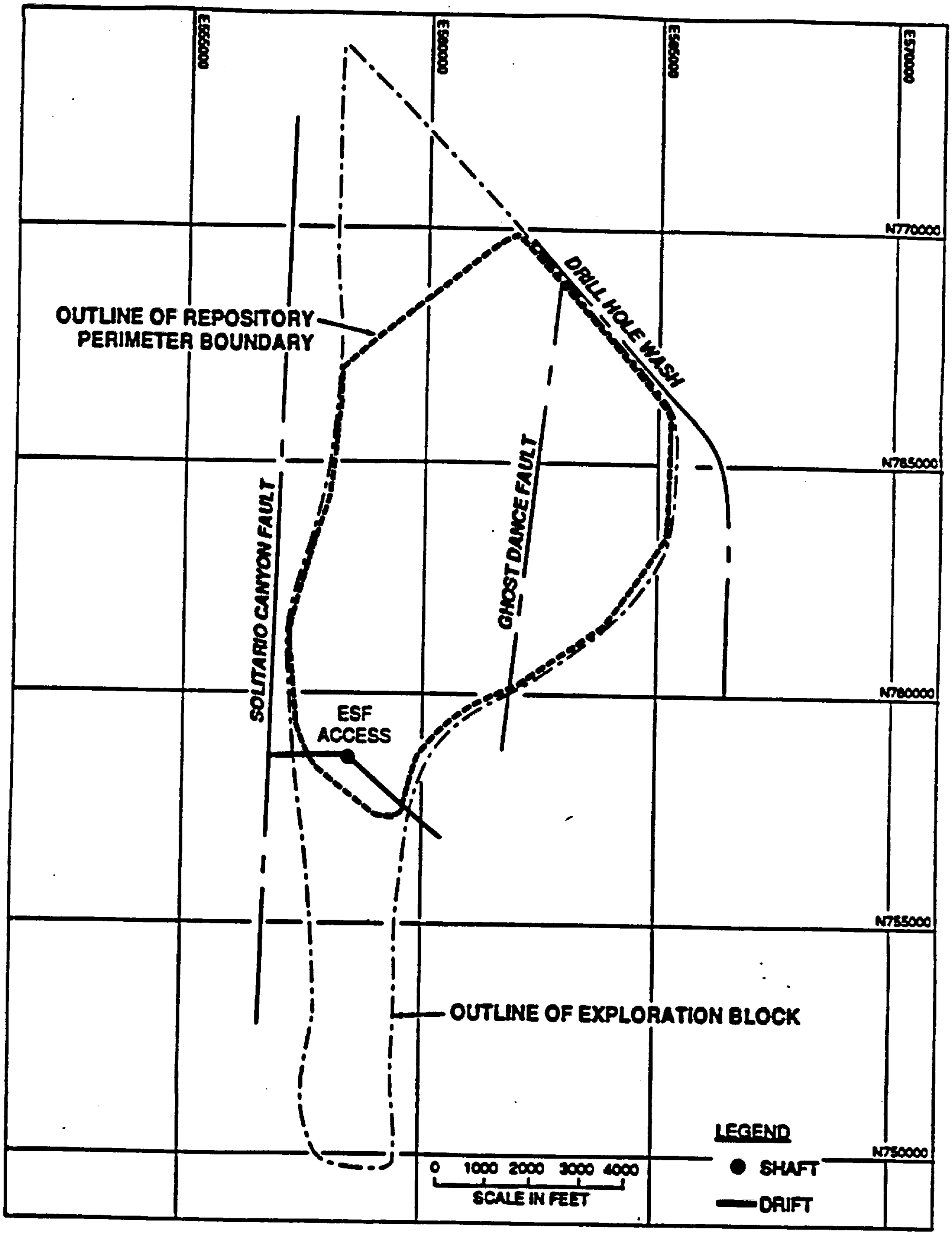
CALICO HILLS STRATEGIES
(CONTINUED)

STRATEGY #3

- BASELINE STRATEGY, SIMILAR TO THE ORIGINAL CALICO HILLS ACTIVITY IN THE CONSULTATION DRAFT SCP
- LOCATION PERMITS ACCESS TO GHOST DANCE FAULT, DRILLHOLE WASH, AND FAULTING TO THE EAST, WITH LIMITED DRIFTING (5,000 FT)

STRATEGY NO. 4
INSIDE; S; LIMITED FACILITY; INTEGRATED WITH ESF



CALICO HILLS STRATEGIES

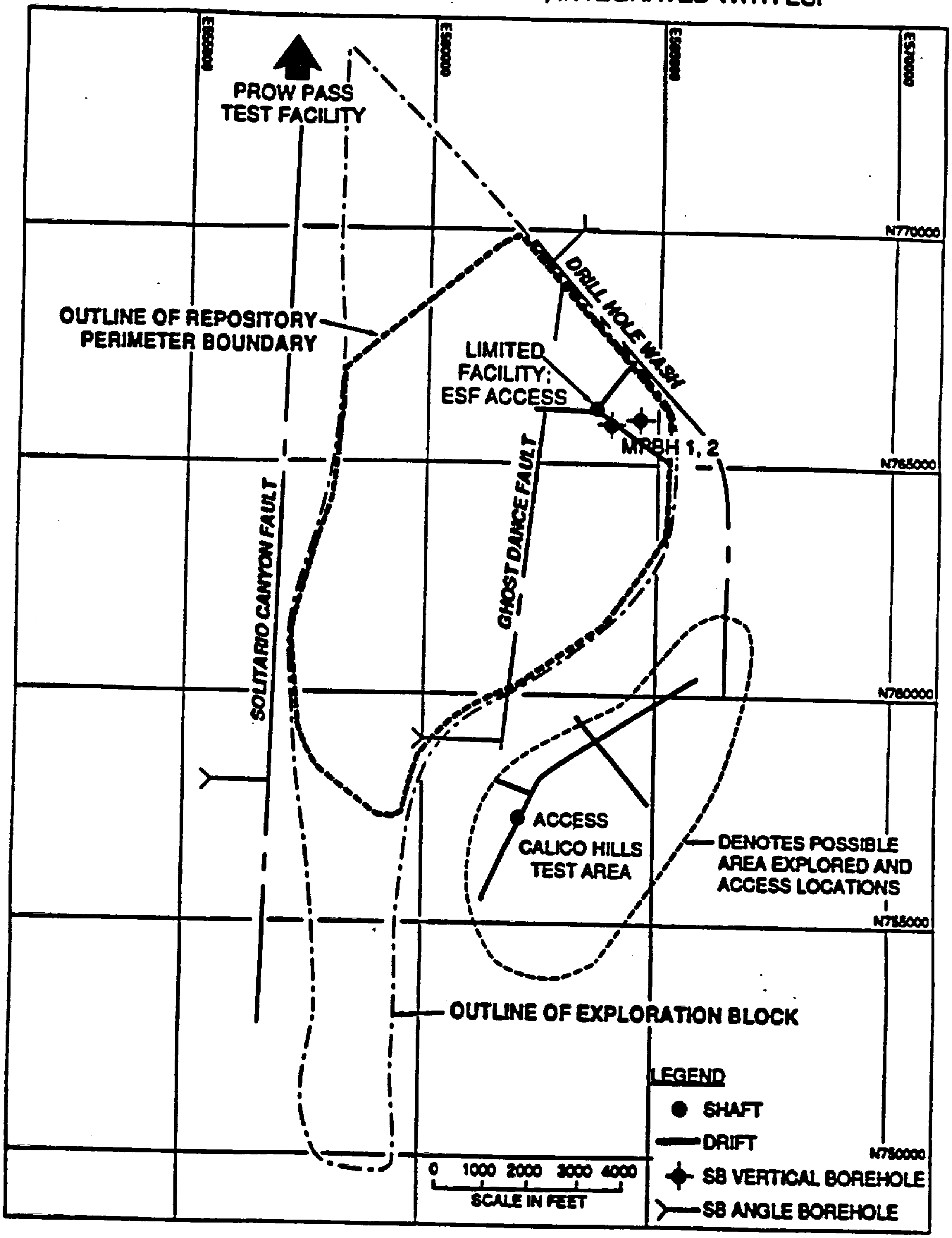
(CONTINUED)

STRATEGY #4

- SIMILAR TO BASELINE STRATEGY (#3), BUT LOCATED IN THE SOUTH WHERE THE CHn IS THICKER AND VITRIC
- PERFORMANCE IMPACTS MAY BE LESS THAN FOR BASELINE
- ACCESS TO FAULTS IS REDUCED RELATIVE TO BASELINE

STRATEGY NO. 1

OUTSIDE; SE; EXTENDED DRIFTING; NO ESF CONNECTION - ADDITIONAL SBT - WITH INSIDE, NE, LIMITED FACILITY; INTEGRATED WITH ESF



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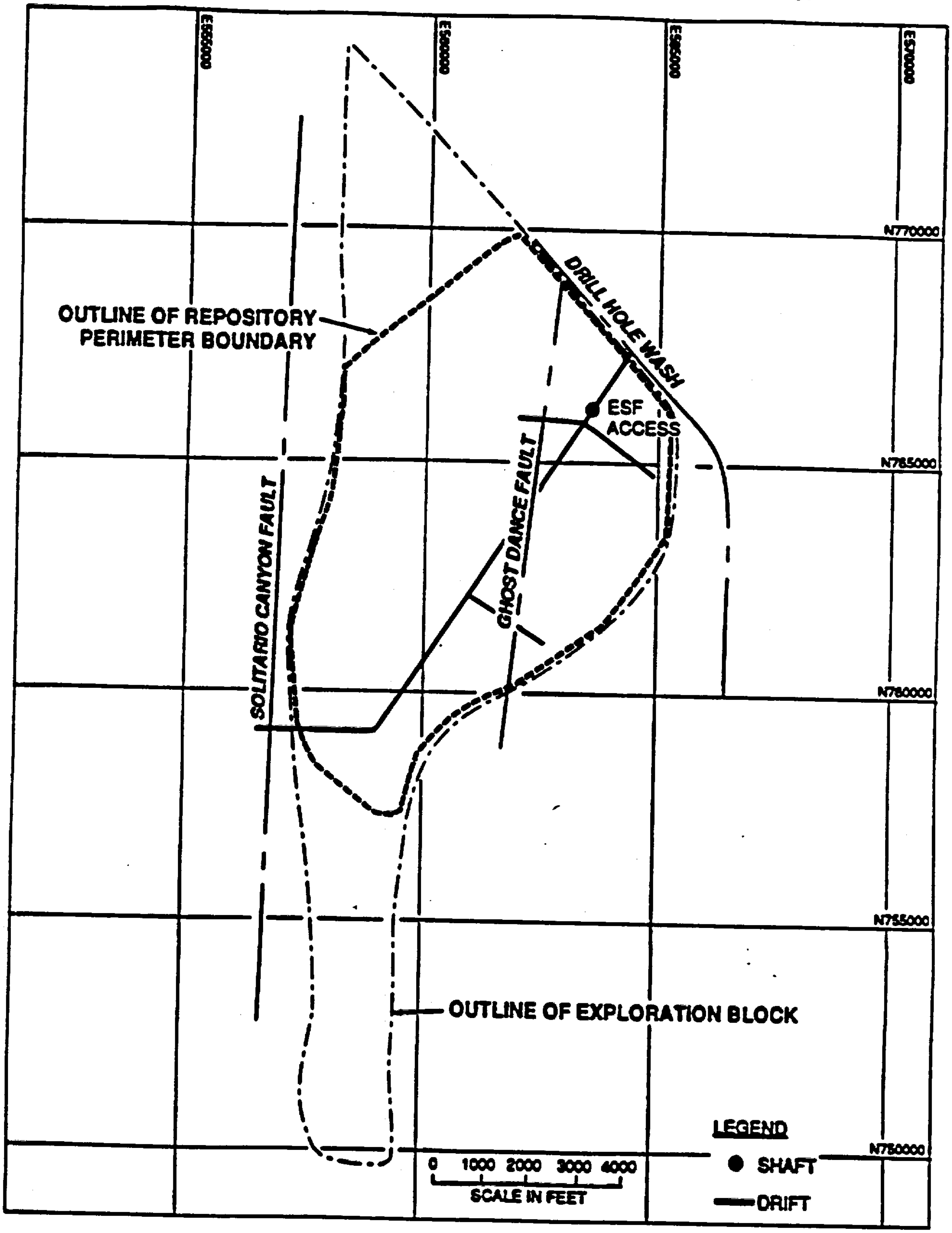
CALICO HILLS STRATEGIES

STRATEGY #1

- ATTEMPT TO ACHIEVE HIGH TEST ACCURACY WHILE LIMITING EXCAVATION WITHIN THE BLOCK
- SIMILAR TO #7, WITH THE ADDITION OF LIMITED EXCAVATION INSIDE THE NORTHEAST PART OF THE BLOCK
- EXTENSIVE EXCAVATION OUTSIDE THE BLOCK EXPLORES FAULTING AND FACIES TRANSITION
- LIMITED EXCAVATION INSIDE THE BLOCK EXPLORES GHOST DANCE FAULT, DRILLHOLE WASH, AND OTHER FEATURES IN THE ZEOLITIC FACIES
- INCLUDE ADDITIONAL SBT (IN ADDITION TO SCP) TO MAXIMIZE INFORMATION WHILE LIMITING EXCAVATION INSIDE THE BLOCK

STRATEGY NO. 5

INSIDE; NE; EXTENDED DRIFTING; INTEGRATED WITH ESF



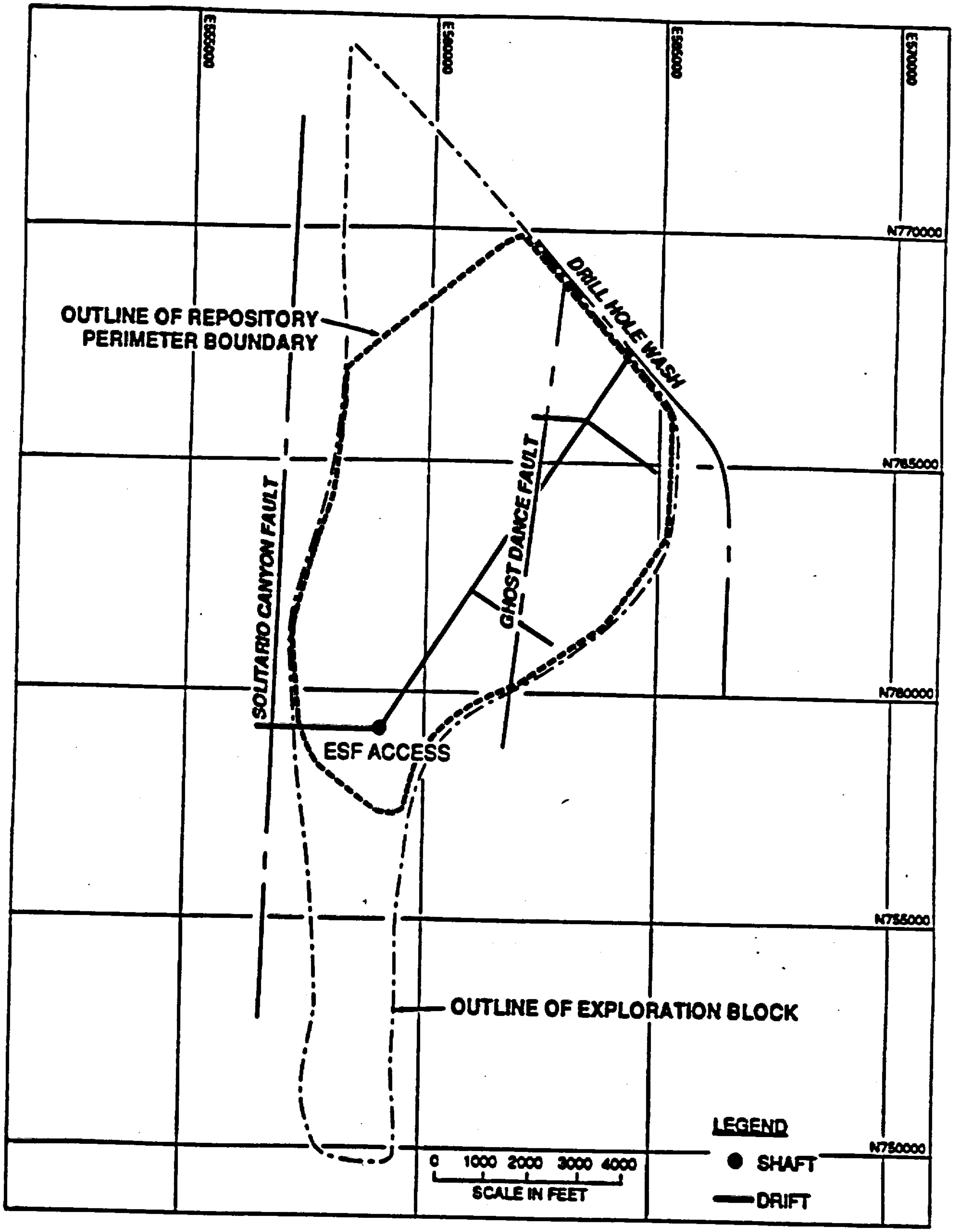
CALICO HILLS STRATEGIES
(CONTINUED)

STRATEGY #5

- SIMILAR TO STRATEGY #2, EXCEPT ACCESSES WOULD BE LOCATED IN THE SOUTH, WHERE THE CHn IS THICKER AND VITRIC
- PERFORMANCE IMPACTS MAY BE LESS THAN FOR STRATEGY #2
- USE OF BOTH #2 AND #5 ASSURES THAT AT LEAST ONE STRATEGY WITH HIGH TEST ACCURACY CAN BE INTEGRATED WITH ANY OPTION CONSIDERED IN THE ESF STUDY

STRATEGY NO. 2

INSIDE; S; EXTENDED DRIFTING; INTEGRATED WITH ESF



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CALICO HILLS STRATEGIES

(CONTINUED)

STRATEGY #2

- ATTEMPT TO MAXIMIZE TEST ACCURACY BY PROVIDING EXTENSIVE, REPRESENTATIVE DATA
- LARGEST EXTENT OF EXCAVATION CONSIDERED INSIDE THE BLOCK
- AS MUCH AS 19,000 FT OF DRIFTING EXPLORES:
  - GHOST DANCE FAULT
  - SOLITARIO CANYON FAULT
  - DRILLHOLE WASH
  - FAULTING TO THE EAST
  - FACIES TRANSITION

CONCLUSIONS AND RECOMMENDATIONS

- THE RECORD MEMORANDUM OF THE CHRBA CONTAINS SEVEN CONCLUSIONS AND FIVE RECOMMENDATIONS

CONCLUSIONS OF THE CHRBA

1. POTENTIAL IMPACTS FROM CHARACTERIZATION ON POSTCLOSURE AQUEOUS RELEASES FROM THE TOTAL SYSTEM ARE EXPECTED TO BE LOW AND DO NOT PRECLUDE EXTENSIVE UNDERGROUND EXPLORATION IN THE CHn BELOW THE PROPOSED REPOSITORY

2. TESTING STRATEGIES 1,2,5, AND 7 INCLUDE EXTENSIVE UNDERGROUND EXPLORATION WITHIN OR NEAR THE REPOSITORY BLOCK AND PROVIDE A SIGNIFICANT IMPROVEMENT IN SCIENTIFIC CONFIDENCE RELATIVE TO STRATEGIES 3,4,6, AND 8

CONCLUSIONS OF THE CHRBA

(CONTINUED)

3. WHEN ALL OBJECTIVES (CONFIDENCE, RISK, COST, DELAY, AND PHASING POTENTIAL) ARE CONSIDERED, STRATEGIES 2 AND 5 ARE PREFERRED TO STRATEGY 1 BY A SMALL MARGIN

4. MODIFICATIONS OF 2 AND 5 WHICH ARE CONSISTENT WITH THEIR DEFINITION WOULD PROVIDE GREATER SCIENTIFIC CONFIDENCE THAN STRATEGY 1

CONCLUSIONS OF THE CHRBA

(CONTINUED)

5. EACH OF THE 12 KEY FEATURES OF THE SITE WOULD BE INVESTIGATED BY STRATEGY 2 OR 5. THE BENEFIT OF EARLY ACCESS TO THE CHn WOULD BE DIRECTLY RELATED TO THE NUMBER OF THESE FEATURES THAT ARE INTERCEPTED EARLY

6. A RAMP FROM THE EAST OF THE REPOSITORY BLOCK COULD PROVIDE SIGNIFICANT INFORMATION WHICH COULD POTENTIALLY BE USED TO AID IN CHARACTERIZATION OF THE CALICO HILLS UNIT

CONCLUSIONS OF THE CHRBA

(CONTINUED)

7. THE RELATIVE IMPORTANCE OF THE CHn UNIT AS A BARRIER DEPENDS ON THE IMPORTANCE OF THE OTHER BARRIERS, BOTH NATURAL AND ENGINEERED

   FOR THE CHRBA, ESTIMATED PERFORMANCE OF THE ENGINEERED BARRIERS AND THE HOST ROCK WERE CONSERVATIVE, WHEREAS ESTIMATES OF THE PERFORMANCE OF THE SATURATED ZONE WERE INTENDED TO BE REALISTIC, BUT NOT NECESSARILY CONSERVATIVE

RECOMMENDATIONS

1. THE CHRBA WORKING GROUP RECOMMENDS USING EXTENSIVE DRIFTING WITHIN THE BLOCK, AN APPROACH SIMILAR TO STRATEGIES 2 AND 5 (STRATEGIES 2 AND 5 ARE VERY SIMILAR AND WERE RATED ABOUT THE SAME BY THE CHRBA)

   IT ALSO RECOMMENDS THAT THESE STRATEGIES BE MODIFIED TO INCLUDE A DRIFT TO EXPLORE THE ABANDONED WASH FAULT AND AN UNDERGROUND ACCESS OUTSIDE THE REPOSITORY BLOCK FOR AGGRESIVE TESTING

RECOMMENDATIONS

(CONTINUED)

- THE MODIFICATIONS WOULD PROVIDE A MORE ROBUST DECISION

- THE RECOMMENDATION COULD BE DEPENDENT ON THE SENSITIVITY TO THE DIFFERENCE IN RISK (IMPACTS ON WASTE ISOLATION) BETWEEN TESTING INSIDE AND OUTSIDE THE BLOCK

- A FINAL COMMITMENT TO FULL EXCAVATION OF STRATEGY 2 OR 5 IS NOT CURRENTLY REQUIRED BECAUSE FUTURE UNDERSTANDING OF IMPACTS TO WASTE ISOLATION OR THE SUFFICIENCY OF DATA REQUIRED FOR SITE CHARACTERIZATION MAY INDICATE THAT THE FULL AMOUNT OF DRIFTING IS NOT NECESSARY

RECOMMENDATIONS

(CONTINUED)

2. PLANNING FOR CHn UNIT EXPLORATION FACILITIES SHOULD FOCUS ON PROVIDING ACCESS TO THE 12 GEOLOGIC FEATURES (SEE TABLE 2.5.2.5-1) IDENTIFIED IN THE MUA AS EARLY AS PRACTICABLE

3. REVIEW OF EXISTING DATA AND COLLECTION OF OBSERVATIONAL DATA AT RAINIER MESA SHOULD BE UNDERTAKEN

4. WASTE ISOLATION IMPACTS SHOULD BE ADDRESSED IN TITLE II DESIGN TO FURTHER EXAMINE THE ASSUMPTIONS AND ASSESSMENTS MADE BY THE CHRBA

5. CERTAIN ASSUMPTIONS AND CRITERIA (SUCH AS THE WATER-TABLE STANDOFF DISTANCE AND THE DEFINITIONS OF INSIDE/OUTSIDE THE BLOCK) FROM THE CHRBA MAY BE IMPORTANT WITH RESPECT TO CONTROL OF INPUT TO THE ESF DESIGN

U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

CALICO HILLS RISK/BENEFIT ANALYSIS
VALUE-OF-INFORMATION (VOI) MODEL OVERVIEW - GEOTECHNICAL INPUTS TO VOI STUDY

PRESENTED AT

DOE/NRC MEETING ON
CALICO HILLS RISK/BENEFIT ANALYSIS
AND ESF ALTERNATIVES STUDY

PRESENTED BY

ERNEST L. HARDIN
STAFF SCIENTIST - TECHNICAL SUPPORT
TECHNICAL & MANAGEMENT SUPPORT SERVICES/SAIC

DEPARTMENT OF ENERGY
UNITED STATES OF AMERICA

JANUARY 29-31, 1991

Attachment 7

OVERVIEW OF GEOTECHNICAL INPUTS

VOI STUDY:

- CONCEPTUAL MODELS
- 6 CATEGORIES OF GEOTECHNICAL ASSESSMENTS

MUA ANALYSIS:

- SCIENTIFIC CONFIDENCE
  - FEATURE, ISSUE DEFINITIONS
  - SCORING STRATEGIES ON FEATURES
  - SCORING OF FEATURES ON ISSUES
  - RANKING/WEIGHTING ISSUES
- USE RISK ASSESSMENT FROM VOI STUDY

AGENDA INCLUDES MORE DETAILED DISCUSSION OF POTENTIAL IMPACTS TO WASTE ISOLATION

PREPARED FOR POSSIBLE DETAILED DISCUSSION OF OTHER TOPICS

GEOTECHNICAL INPUTS
GENERAL APPROACH

- DECISION AIDING METHODOLOGY, NOT PA
- DOCUMENTATION OF RATIONALE AND STATE OF KNOWLEDGE OF THE TECHNICAL PANEL
- FOR RISK ANALYSIS:

  TO ESTIMATE IMPACTS TO WASTE ISOLATION, MUST ALSO ESTIMATE SYSTEM PERFORMANCE

- CALCULATIONS SUPPLEMENT EXPERT JUDGMENT, BUT JUDGMENT MUST BE RELIED UPON TO:
  - CHARACTERIZE UNCERTAINTY OF COMPLEX MEASURES (e.g., R)
  - ASSESS COMPLEX EFFECTS
    * TRANSPORT PROCESSES
    * PATHWAY EFFECTS
    * INSIDE VS. OUTSIDE

IMPACT/RISK DEFINITIONS

- ABSOLUTE RISK
  - RESIDUAL RISK (PERF. MEASURE) R
  - RESIDUAL RISK, WITH IMPACT R'

INCREMENTAL RISK FROM IMPACT

$$R' - R = \Delta R$$

- RELATIVE RISK
  - RELATIVE IMPACT (%) $\frac{\Delta R}{R}$

- DIFFERENTIAL RISK

DIFFERENTIAL RISK

$$\Delta R - (\Delta R)_{MIN}$$

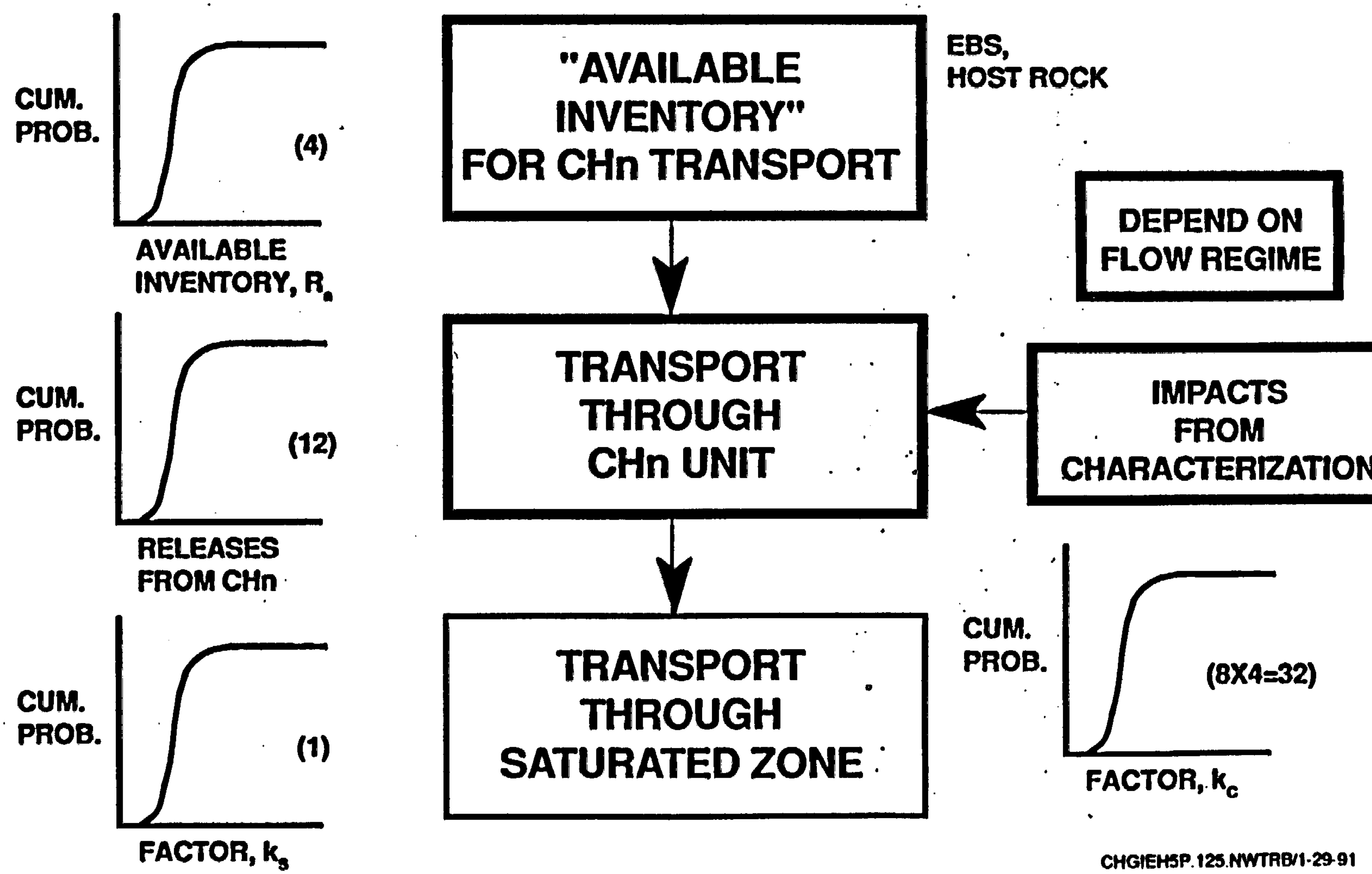
CONCEPTUAL MODELS USED FOR TECHNICAL INPUTS

- LINEAR PROBABILISTIC MODEL FOR SYSTEM PERFORMANCE
- PERFORMANCE MEASURE R
  - ASSUMED "MIX" OF RADIONUCLIDES IN RELEASED INVENTORY
- FLOW REGIMES
  - SLOW MATRIX, SM
  - FAST MATRIX, FM
  - CONCENTRATED FRACTURE, CF
  - DISTRIBUTED FRACTURE, DF

DEVELOPED ORIGINALLY FOR VOI STUDY,
USED ALSO IN MUA

CONCEPTUAL MODELS

LINEAR PROBABILISTIC MODEL FOR AQUEOUS RELEASE FROM TOTAL SYSTEM



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CONCEPTUAL MODELS

PERFORMANCE MEASURE, R

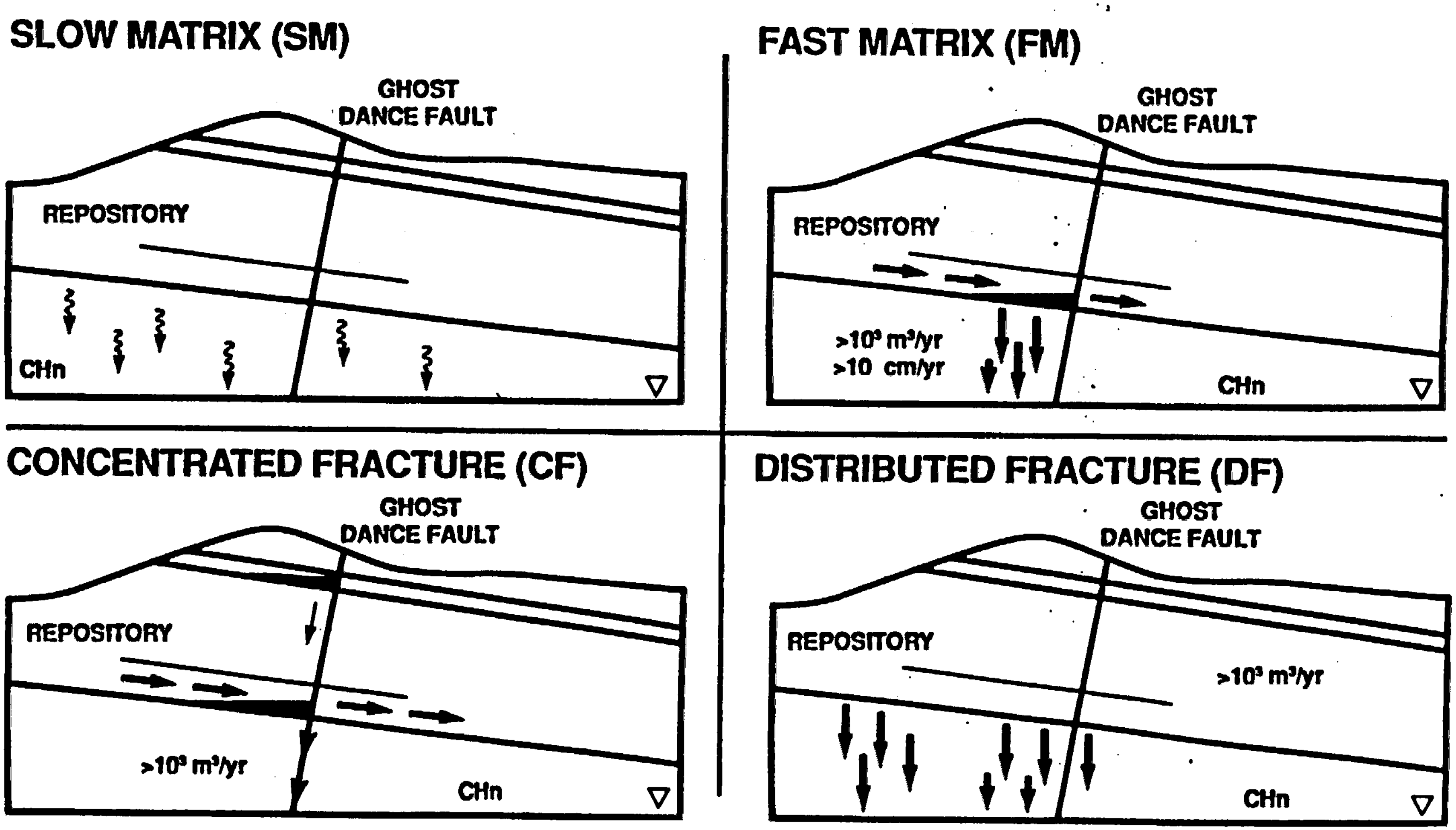
- **TOTAL SYSTEM PERFORMANCE (40 CFR 191, APP. A)**

$$R = \sum \frac{R_i}{A_i}$$

R ASSESSED DIRECTLY BY THE TECHNICAL PANEL

- **ASSUMED "MIX" OF RADIONUCLIDES IN RELEASED INVENTORY:**
  - **ACTINIDES APPROX. BY VOLUME FRACTION**
  - **MOBILE SPECIES (e.g., Tc-99) ENRICHED TO THE LEVEL OF THE MOST ABUNDANT ACTINIDE ISOTOPE**

CONCEPTUAL MODELS
FLOW REGIMES



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GEOTECHNICAL INPUTS TO VOI STUDY

- PRIOR PROBABILITIES OF FLOW REGIMES
- TEST LIKELIHOOD FUNCTIONS
- AVAILABLE INVENTORY ("SOURCE")
- CHn UNIT TRANSPORT
- SATURATED ZONE TRANSPORT
- CHARACTERIZATION IMPACT TO CHn UNIT PERFORMANCE

COMBINE ALL 6 IN A PROBABILISTIC MODEL, TO ESTIMATE THE INCREMENT IN RISK FROM CHn UNIT CHARACTERIZATION

TECHNICAL INPUTS

PROBABILITIES OF FLOW REGIMES

ASSESS PROBABILITY THAT EACH FLOW REGIME WILL PREVAIL OVER 10,000 YR

MAJOR INFLUENCE	DETAILS CONSIDERED
TOTAL FLUX	RETURN TO PLUVIAL CONDITIONS
CAPILLARY/PERMEABILITY BARRIERS	E.G. TSw – CHn CONTACT CHn FACIES TRANSITIONS
FLUX CONCENTRATING MECHANISM	DISTRIBUTION OF FLUX PRODUCED BY OVERLYING UNITS AND PROCESSES
MATRIX HYDRAULIC PROPERTIES	CHn FACIES DISTRIBUTION

PROBABILITIES FOR FLOW CONDITIONS:

SM	FM	CF	DF
.69	.06	.11	.14

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TECHNICAL INPUTS

TEST LIKELIHOOD FUNCTIONS

PANELISTS ASSESSED HOW LIKELY THEY WOULD BE TO CONCLUDE EACH FLOW REGIME WILL PREVAIL:

- GIVEN ONE FLOW REGIME IS THE CORRECT RESULT
- GIVEN RESULTS FROM EACH STRATEGY

MAJOR INFLUENCE	DETAILS CONSIDERED
TOTAL FLUX	UNCERTAINTY OF FUTURE CHANGES IN FLUX AFFECTS ALL LIKELIHOODS
FLUX CONCENTRATING MECHANISM	TEST STRATEGY LOCATION
FRACTURE HYDRAULIC PROPERTIES	EXTENT OF UNDERGROUND EXPLORATION OF TARGETED FAULTS/FEATURES
	EXTENT OF EXPOSURE OF FRACTURE MINERALIZATION

TECHNICAL INPUTS

SUMMARY OF TEST LIKELIHOOD FUNCTION

- UNDERGROUND EXCAVATION STRATEGIES ARE MORE LIKELY TO CORRECTLY IDENTIFY FLOW REGIMES
- RESULTS FROM A PROW PASS (OUTCROP) TEST FACILITY WOULD HAVE LIMITED REPRESENTATIVENESS
- A SINGLE, SMALL U/G FACILITY IN THE SOUTH (#4) OR SOUTHEAST (#8) HAS LOW LIKELIHOOD OF CORRECTLY IDENTIFYING FLOW REGIMES, WHETHER IT IS INSIDE OR OUTSIDE THE BLOCK
- AN EXTENSIVE FACILITY SOUTHEAST OF THE BLOCK (#7) IS COMPARABLE TO A SMALL FACILITY INSIDE THE NORTHEAST PART OF THE BLOCK (#3)
- STRATEGIES 2 AND 5 HAVE SIGNIFICANTLY HIGHER LIKELIHOOD OF CORRECTLY IDENTIFYING FLOW REGIMES

TECHNICAL INPUTS

AVAILABLE INVENTORY FOR CHn TRANSPORT

ASSESSED AQUEOUS RELEASES AVAILABLE AT THE TOP OF THE CHn OVER 10,000 YR FOR EACH FLOW REGIME

MAJOR INFLUENCE	DETAILS CONSIDERED
TOTAL FLUX	FLUX ASSOCIATED WITH FLOW REGIMES
WATER CONTACTING WASTE PACKAGE	DISTRIBUTION OF FLUX PRODUCED BY OVERLYING UNITS AND PROCESSES
WASTE FORM RELEASE	DEGREE OF CONSERVATISM FOR RELEASE FROM "FAILED" WASTE PACKAGES
RETARDATION IN EBS	EXTENT OF CONTAMINATED WATER FLOW THROUGH ENGINEERED MATERIALS

TECHNICAL INPUTS

RELEASES FROM THE CHn UNIT

GIVEN AN INVENTORY OF RADIONUCLIDES TRANSPORTED TO THE CHn UNIT (REPRESENTED BY A VALUE FOR R), WHAT INVENTORY IS TRANSPORTED TO THE WATER TABLE IN 10,000 YR?

MAJOR INFLUENCE	DETAILS CONSIDERED
MINERALOGY/HYDRAULIC/ SORPTIVE PROPERTIES	CHn FACIES DISTRIBUTION
FRACTURE–MATRIX DISTRIBUTION OF FLOW	FAULT ZONES MAY HAVE "TIGHT" ZONES WHERE MATRIX FLOW OCCURS
GEOHYDROLOGIC FRAMEWORK	FLOW PATHS WILL BE EXTENDED BY LATERAL DIVERSION AND HETEROGENEOUS DISTRIBUTION FOR MATRIX PROPERTIES
	VARIATION OF CHn THICKNESS
MATRIX DIFFUSION EFFECTS	DEGREE OF CONSERVATISM FOR RETARDATION OF MOBILE SPECIES, PARTICULARLY FOR FRACTURE FLOW

TECHNICAL INPUTS
SATURATED ZONE TRANSPORT

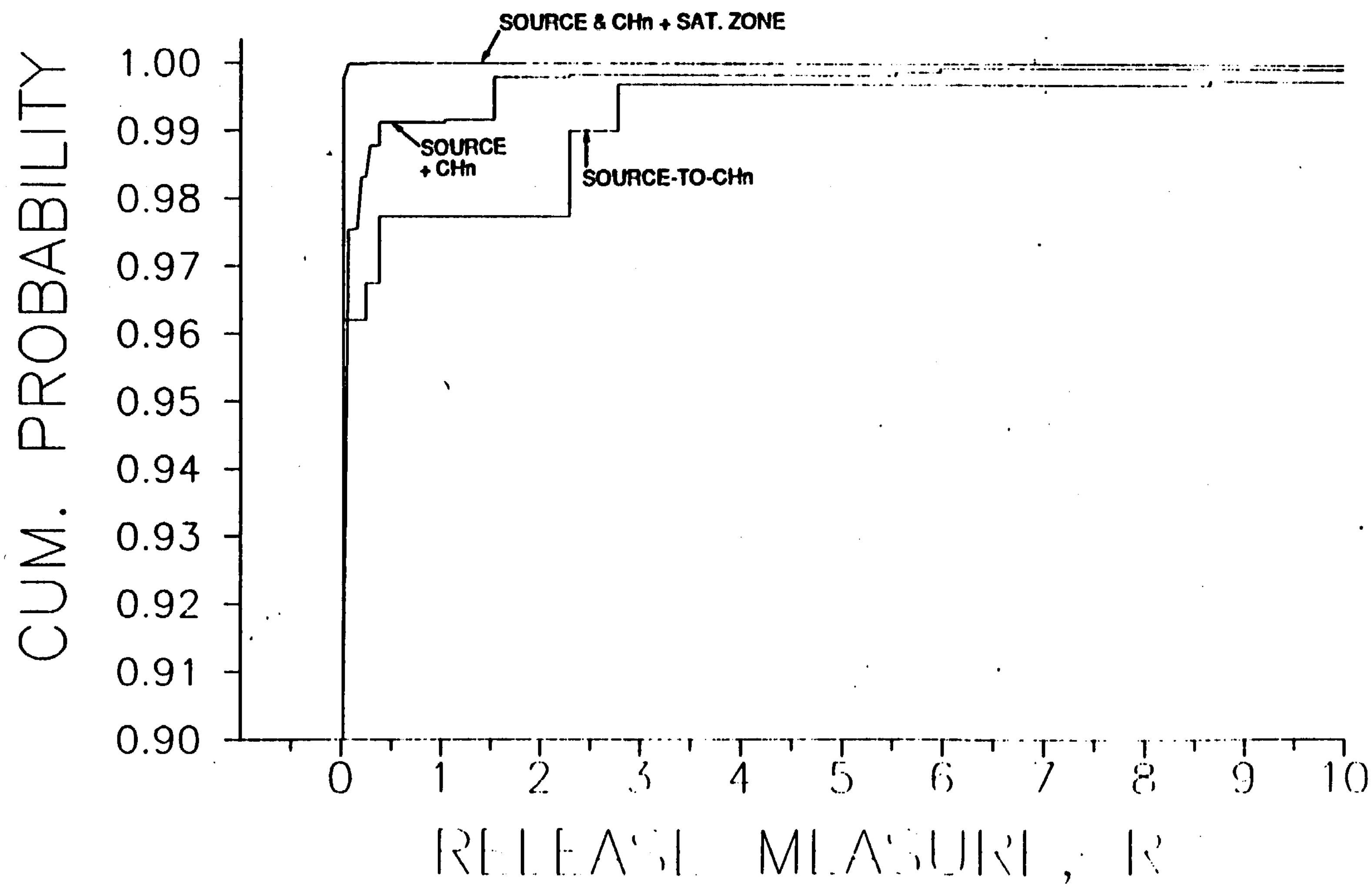
ASSESS RELEASE REDUCTION FACTOR FOR TRANSPORT THROUGH THE SZ FROM THE REPOSITORY TO THE ACCESSIBLE ENVIRONMENT

- ANY LEVEL OF RELEASED INVENTORY
- ANY FLOW REGIME

MAJOR INFLUENCE	DETAILS CONSIDERED
GEOHYDROLOGIC FRAMEWORK	CHANGE IN AQUIFER TRANSMISSIVITY WITH WATER TABLE RISE
	UPWARD FLOW POTENTIAL GRADIENT IN TUFF/CARBONATE AQUIFER SYSTEM
EFFECTIVE POROSITY	SCP POROSITY VALUES ARE CONSERVATIVE
RETARDATION IN SZ	MORE EXTENSIVE EXPERIENCE WITH SATURATED vs UNSATURATED CONDITIONS
MATRIX DIFFUSION	5 KM PATHWAY IS LONG ENOUGH TO PRESENT OPPORTUNITIES FOR MATRIX DIFFUSION

CDF'S FOR RELEASES FROM DIFFERENT COMPONENTS OF THE TOTAL SYSTEM

AGGREGATED OVER ALL FLOW REGIMES



TECHNICAL INPUTS

WASTE ISOLATION IMPACTS

ASSESS RELEASE–IMPACT FACTOR FOR EACH STRATEGY AND EACH FLOW REGIME; THE FACTOR IS A MULTIPLIER ON RELEASES FROM THE CHn UNIT

MAJOR INFLUENCE	DETAILS CONSIDERED
FLUX IN UZ BETWEEN REPOSITORY AND WATER TABLE	SIGNIFICANT TRANSPORT ALONG BACKFILLED/SEALED OPENINGS REQUIRES WATER FLUX ALONG OPENINGS
PERCHED WATER BELOW REPOSITORY	NATURAL CONCENTRATING MECHANISM NEEDED FOR THE GREATEST POTENTIAL FLUX ALONG OPENINGS
GROUNDWATER FLOW TIME	UNSEALED, "LOST" BOREHOLE INTERSECTING PERCHED WATER MAY BE THE LARGEST IMPACT
GEOHYDROLOGIC FRAMEWORK	PLAN AREA AND SIZE OF OPENINGS ARE SMALL COMPARED TO CORRESPONDING DIMENSIONS OF THE SITE AND CHn UNIT

TECHNICAL INPUTS

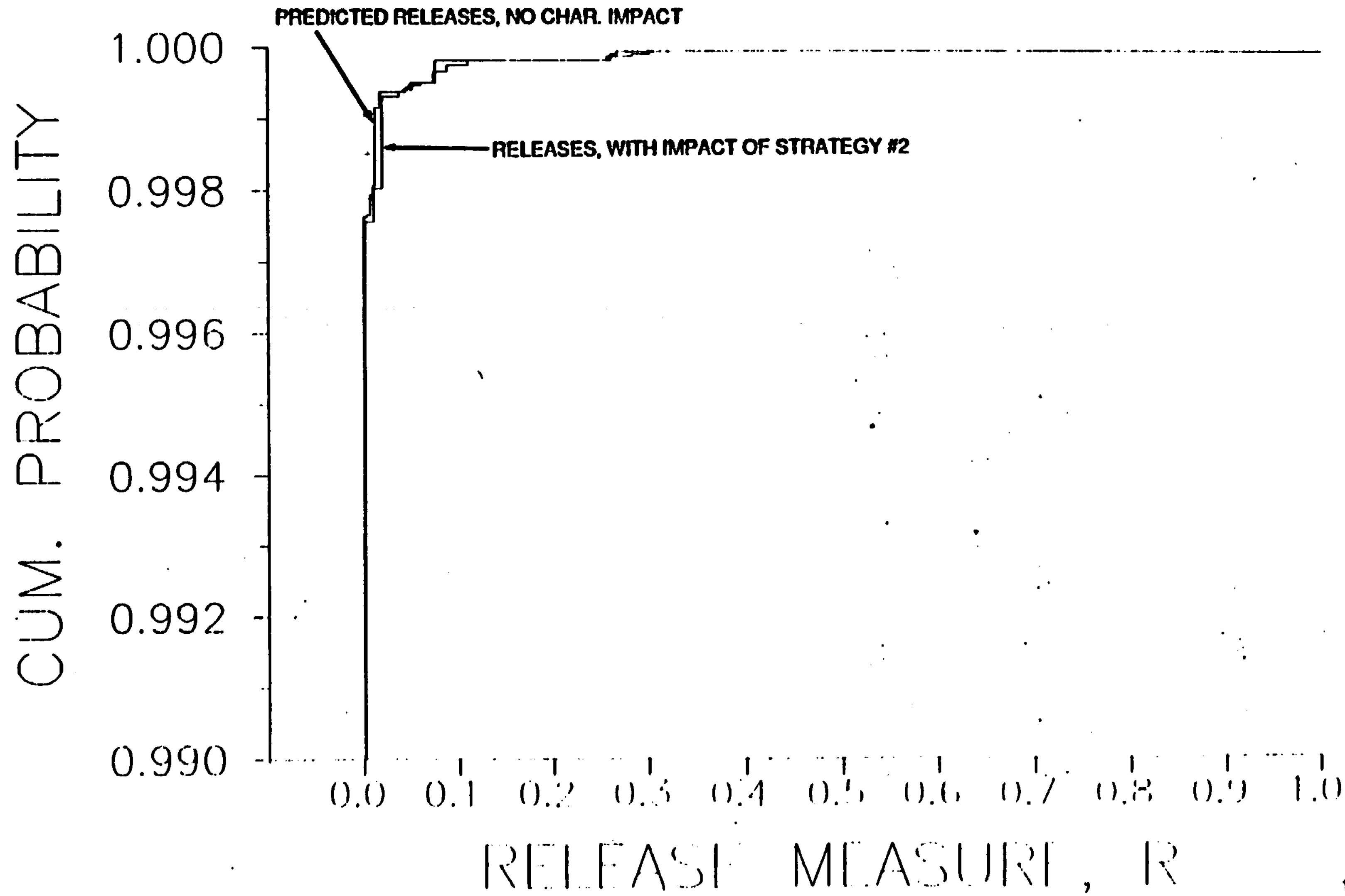
WASTE ISOLATION IMPACTS

(CONTINUED)

MAJOR INFLUENCE	DETAILS CONSIDERED
FRACTURE–MATRIX DISTRIBUTION OF FLOW	DIVERSION OF GROUNDWATER FROM NATURAL PATHWAYS INTO ENGINEERED MATERIALS MAY IMPROVE PERFORMANCE
MOISTURE CONTENT	WATER USED IN CONSTRUCTION AND TESTING WILL DIFFUSE AND REMAIN NEAR OPENINGS IN NONWELDED TUFF
	VENTILATION OF DRIFTS WILL REMOVE SIGNIFICANT AMOUNTS OF WATER FROM THE WALL ROCK
PRECIPITATION, COLLOID EFFECTS, AND SORPTION COEFFICIENTS	FLUIDS/MATERIALS IMPORTED BY CONSTRUCTION/TESTING ARE LIKELY TO REMAIN NEAR THE UNDERGROUND OPENINGS

CDF'S FOR RELEASES FROM THE TOTAL SYSTEM

WITH AND WITHOUT IMPACT FROM STRATEGY #2



TECHNICAL INPUTS

EXPECTED TOTAL SYSTEM RELEASES AND WASTE ISOLATION IMPACTS

EXPECTED RELEASES, $R = 1.5 \times 10^{-4}$ (NO CHn UNIT CHARACTERIZATION IMPACT)

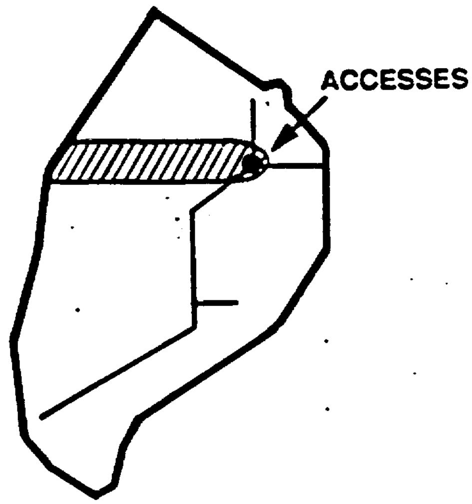
STRATEGY #	DESCRIPTION	CALC. ΔR	$\frac{\Delta R}{R}$
2 (OR 5)	EXTENSIVE, INSIDE	2.0×10^{-5}	13%
1	EXTENSIVE, OUTSIDE SE, + LIMITED, INSIDE NE, + SBT	4.7×10^{-6}	3%
3	LIMITED, INSIDE NE	4.2×10^{-6}	3%
4	LIMITED, INSIDE S	3.5×10^{-6}	2%
6	SBT	3.0×10^{-6}	2%
7	EXTENSIVE, OUTSIDE SE, + SBT	1.6×10^{-7}	<1%
8	LIMITED, OUTSIDE SE, + SBT	1.3×10^{-7}	<1%

IMPACT ESTIMATES SUPPLEMENTAL CALCULATIONS

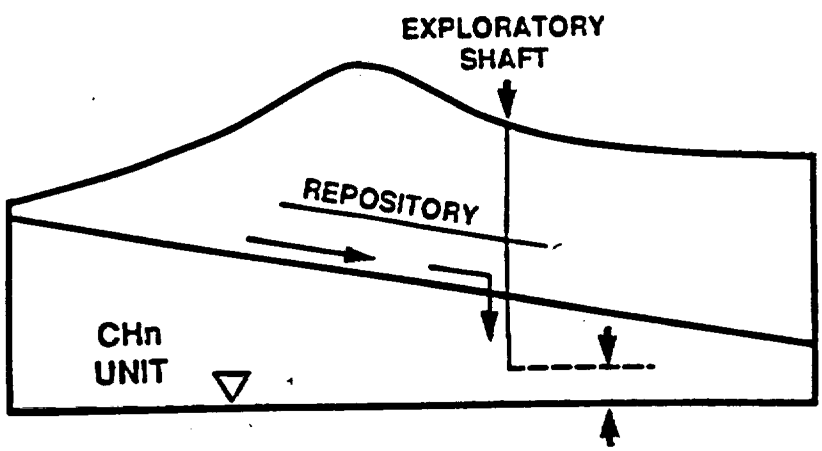
ASSUMPTIONS

- PROCESS UNIFORMITY
  - AVERAGE REPOSITORY FLUX: TEMPORAL, SPATIAL AVERAGE
  - RATIO OF FLOW ALONG BACKFILLED OPENINGS TO FLOW THROUGH THE BLOCK, SURROGATE FOR RATIO OF RELEASES
- MODIFIED PERMEABILITY ZONE
  - AFTER CASE & KELSALL (1987)
- SEALING
  - EFFECTIVE SEALING ASSUMED, INCLUDING LOW-CONDUCTIVITY BACKFILL AS APPROPRIATE ($K_{SAT} = 10^{-8}$ M/SEC)

SCHEMATIC OF IMPACT MEASURE FOR CONCENTRATED FLOW



$$\text{FLOW RATIO} = \frac{\text{MAX. FLOW THROUGH OPENINGS}}{\text{TOTAL REPOSITORY AREA X AVERAGE FLUX}} \leq 5\% \text{ (SEE TEXT)}$$



$$\text{TRAVEL TIME RATIO} = \frac{\left(\dfrac{\text{UNIT THICKNESS}}{\text{ROCK } k_{SAT}}\right)}{\left(\dfrac{\text{UNDISTURBED THICKNESS}}{\text{ROCK } k_{SAT}} + \dfrac{\text{DISTURBED THICKNESS}}{\text{EFFECTIVE OPENING } k_{SAT}}\right)} \approx 0.1 - 3.0$$

DEPENDING ON OPENING TYPE; RAMP < SHAFT

IMPACT MEASURE FOR CONCENTRATED FLOW =
(FLOW RATIO) (TRAVEL TIME RATIO) + 1 < 1.11

IMPACT ANALYSIS SUPPLEMENTAL CALCULATIONS OVERVIEW

- GREATEST IMPACT ASSOCIATED ONLY WITH CERTAIN FLOW CONDITIONS:
  - NATURAL FLUX CONCENTRATION MECHANISM
  - INCREASED RECHARGE
- CONCENTRATED FLOW CONDITIONS COULD PRODUCE GREATER POTENTIAL RELATIVE IMPACT THAN DISTRIBUTED FLOW
- HOWEVER, RELATIVE IMPACT IS LIMITED BY THE FLOW CAPACITY OF BACKFILLED, SEALED OPENINGS, AND IS INVERSELY RELATED TO AVERAGE TOTAL FLUX
- SUPPLEMENTAL CALCULATIONS SUPPORT THE ASSESSMENTS BY THE TECHNICAL PANEL AND SHOW THAT THE CALCULATED EXPECTATION OF RELATIVE IMPACT IS CONSERVATIVE
- THE CONCENTRATED FLOW CASE INDICATES THAT THE GREATEST RELATIVE IMPACT MAY BE SMALLER FOR A RAMP THAN A SHAFT

IMPACT ESTIMATES
SUPPLEMENTAL CALCULATIONS

COMPARISON TO JUDGMENTS ELICITED FROM TECHNICAL PANEL

SUPPLEMENTAL CALCULATIONS	PANEL JUDGMENT
(TABLES 2.6.1.6-1 AND 2.6.1.6-5)	(TABLE 2.6.1.6-11)
ESTIMATED RELATIVE IMPACT:	EXPECTED VALUE OF RELATIVE IMPACT:
2% (DISTRIBUTED) 11% (CONCENTRATED)	3 TO 13% (INSIDE) < 1% (OUTSIDE)
BASED ON CONSERVATIVE ASSUMPTIONS	EXPECTATION LEVEL > 90TH PERCENTILE

EXPECTED RELATIVE IMPACT FROM JUDGEMENT-BASED INPUTS IS COMPARABLE TO A CONSERVATIVE ANALYTICAL APPROACH.

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YUCCA MOUNTAIN
SITE CHARACTERIZATION
PROJECT

CALICO HILLS RISK/BENEFIT ANALYSIS
VALUE-OF-INFORMATION MODEL OVERVIEW

PRESENTED AT

DOE/NRC MEETING ON
CALICO HILLS RISK/BENEFIT ANALYSIS
AND ESF ALTERNATIVES STUDY

PRESENTED BY

HOLLIS CALL
PRINCIPAL DECISION ANALYST
APPLIED DECISION ANALYSIS, INC.

JANUARY 29-31, 1991

Attachment 8

MAIN TOPICS

- INTRODUCTION
- VALUE-OF-INFORMATION, CONCEPTS AND TECHNIQUES
- OVERVIEW OF VOI MODEL FOR CHn ANALYSIS
- VOI MODEL RESULTS AND EXPLANATION

THE PURPOSE OF THE CHn ANALYSIS WAS TO EVALUATE TESTING ALTERNATIVES BASED ON "RISKS" AND "BENEFITS," DEFINED AS FOLLOWS IN THE VOI ANALYSIS

"RISKS": THE POSSIBILITY THAT TESTING COULD DIMINISH THE EFFECTIVENESS OF THE CHn UNIT AS A BARRIER TO TRANSPORT

"BENEFITS": THE *VALUE* OF THE UNCERTAINTY REDUCTION OF TESTING

MAIN TOPICS

- INTRODUCTION
- VALUE-OF-INFORMATION, CONCEPTS AND TECHNIQUES
- OVERVIEW OF VOI MODEL FOR CHn ANALYSIS
- VOI MODEL RESULTS AND EXPLANATION

THE FOLLOWING EXAMPLE IS

HYPOTHETICAL

FOR ILLUSTRATION ONLY

THERE ARE SEVERAL BASIC FEATURES OF DECISION ANALYSIS MODELS, DEMONSTRATED HERE IN A SIMPLE PROBLEM

CHOICES *OUTCOMES* *VALUE MEASURES* *PROBABILITES* *RESULTS*

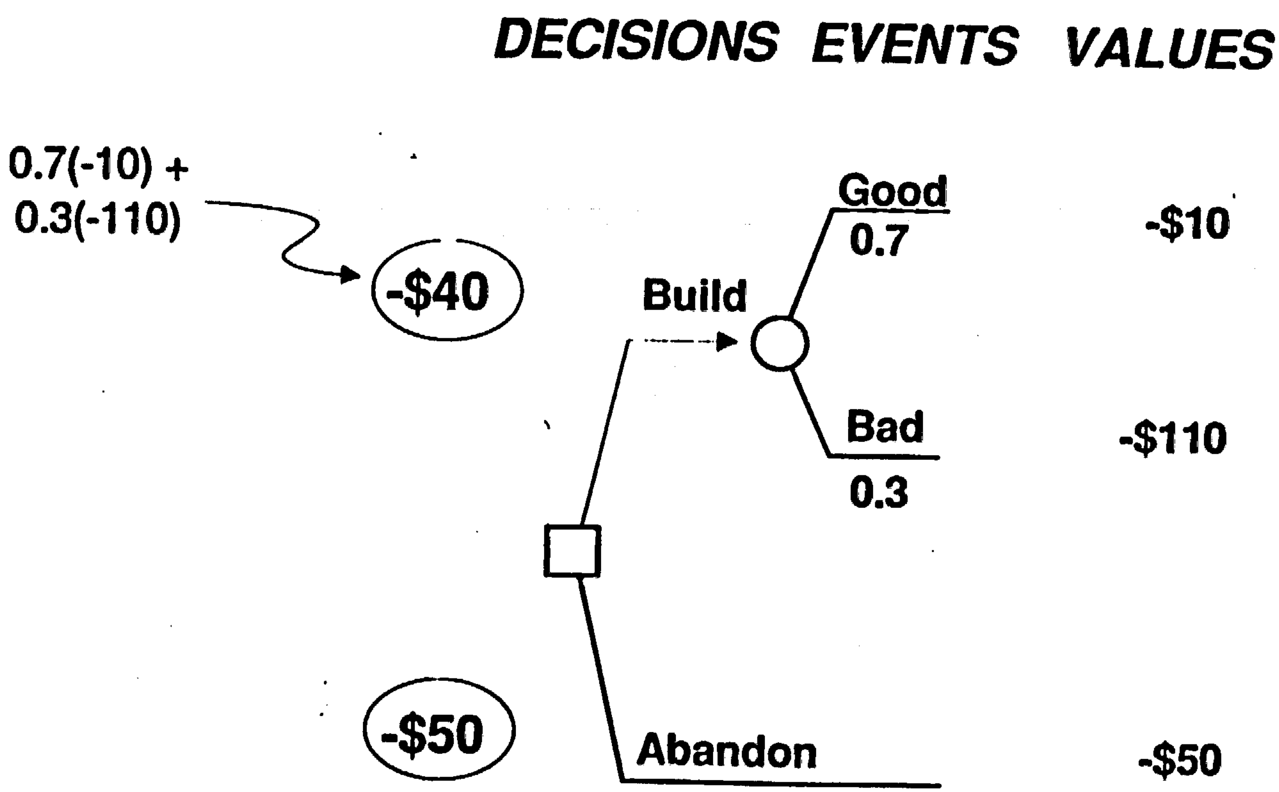
A SPREADSHEET MODEL FOR THE EXAMPLE PROBLEM

DECISIONS	*REPOS. PERFORM.*	*NET COST*	*PROBA-BILITIES*	*NET COST*
Build	Good	-\$10	0.70	0.7(-10) +
	Bad	-\$110	0.30	0.3(-110)
				EV= -\$40
Abandon	NA	-\$50	1.0	-\$50

ILLUSTRATIVE PROBLEM

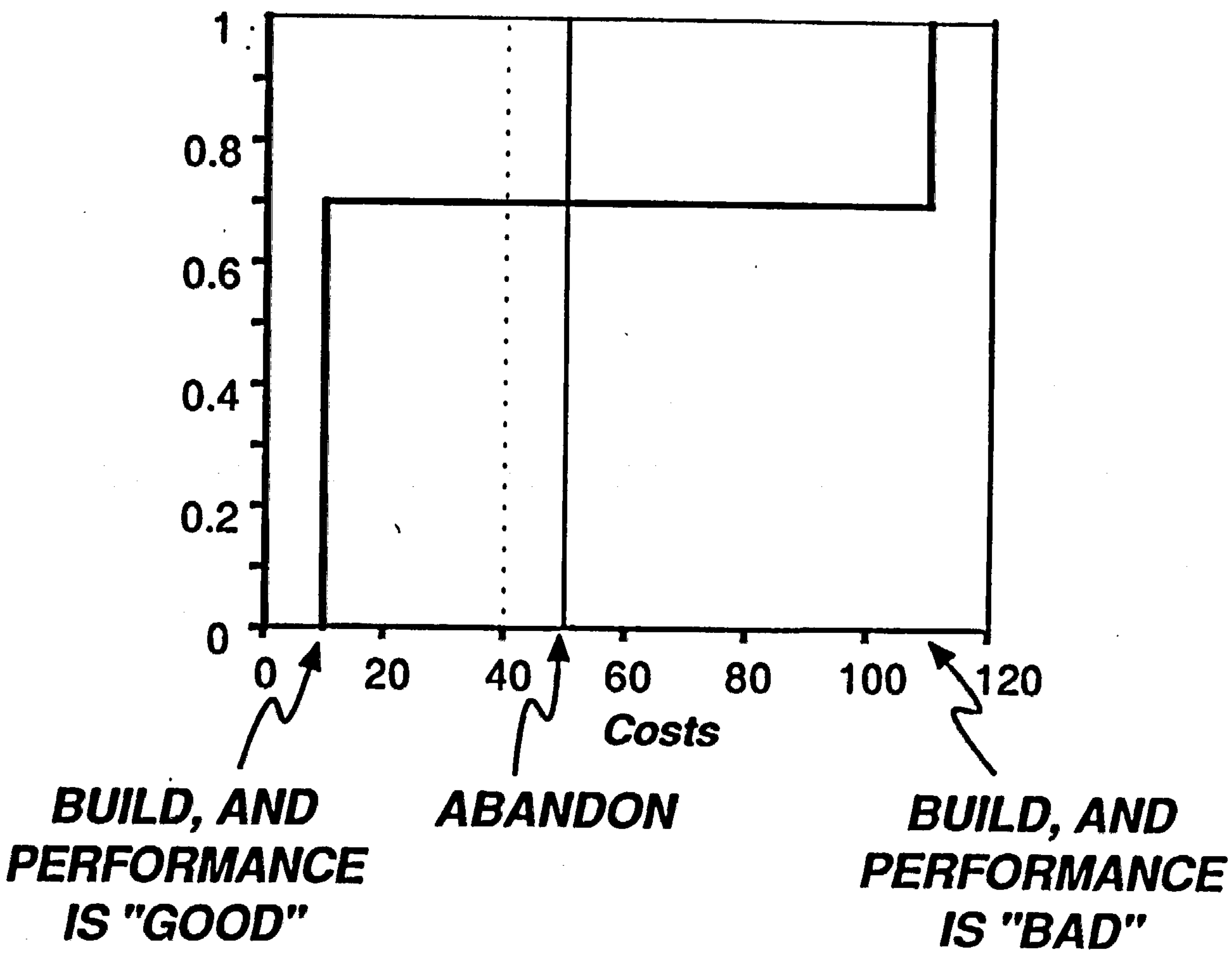
NRCHLLS5P.125/1-28-91

THE SAME INFORMATION CAN BE REPRESENTED IN A DECISION TREE



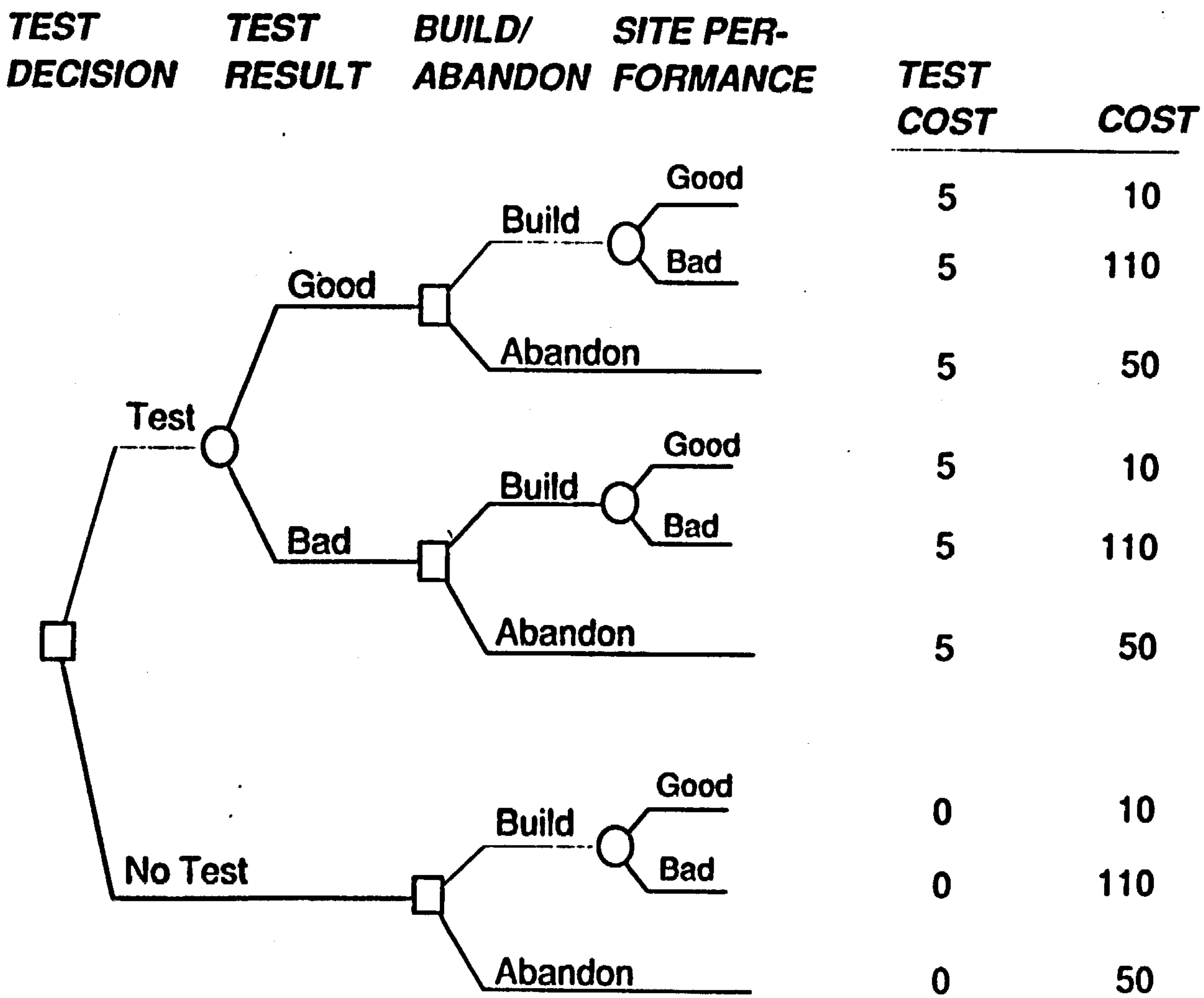
ILLUSTRATIVE PROBLEM

RESULTS OF THE EXAMPLE TREE SHOW HOW MORE INFORMATION MIGHT BE VALUABLE



ILLUSTRATIVE PROBLEM

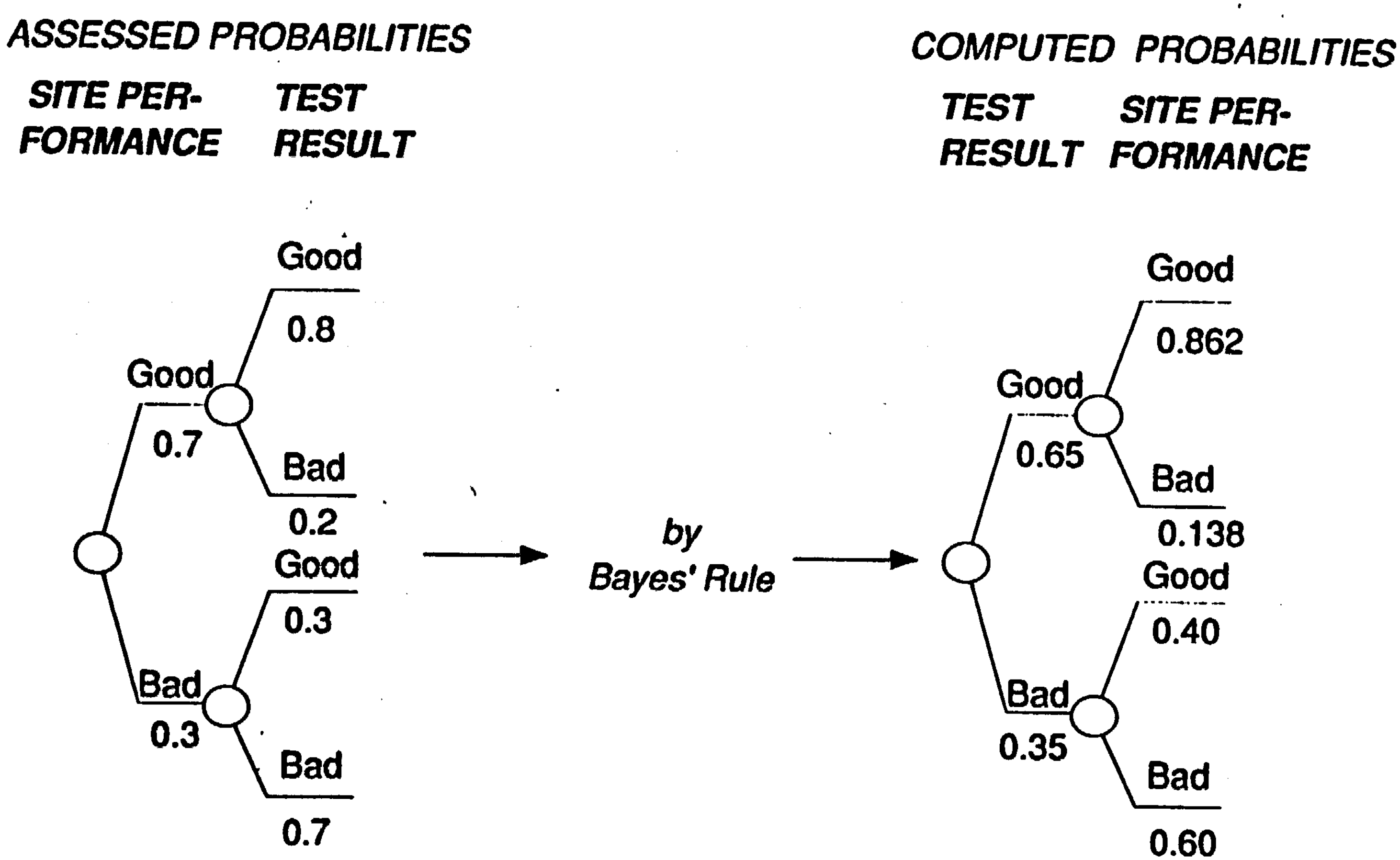
THE NEW MODEL STRUCTURE WITH A TESTING DECISION



ILLUSTRATIVE PROBLEM

NRCHLLS5P.125/1-28-91

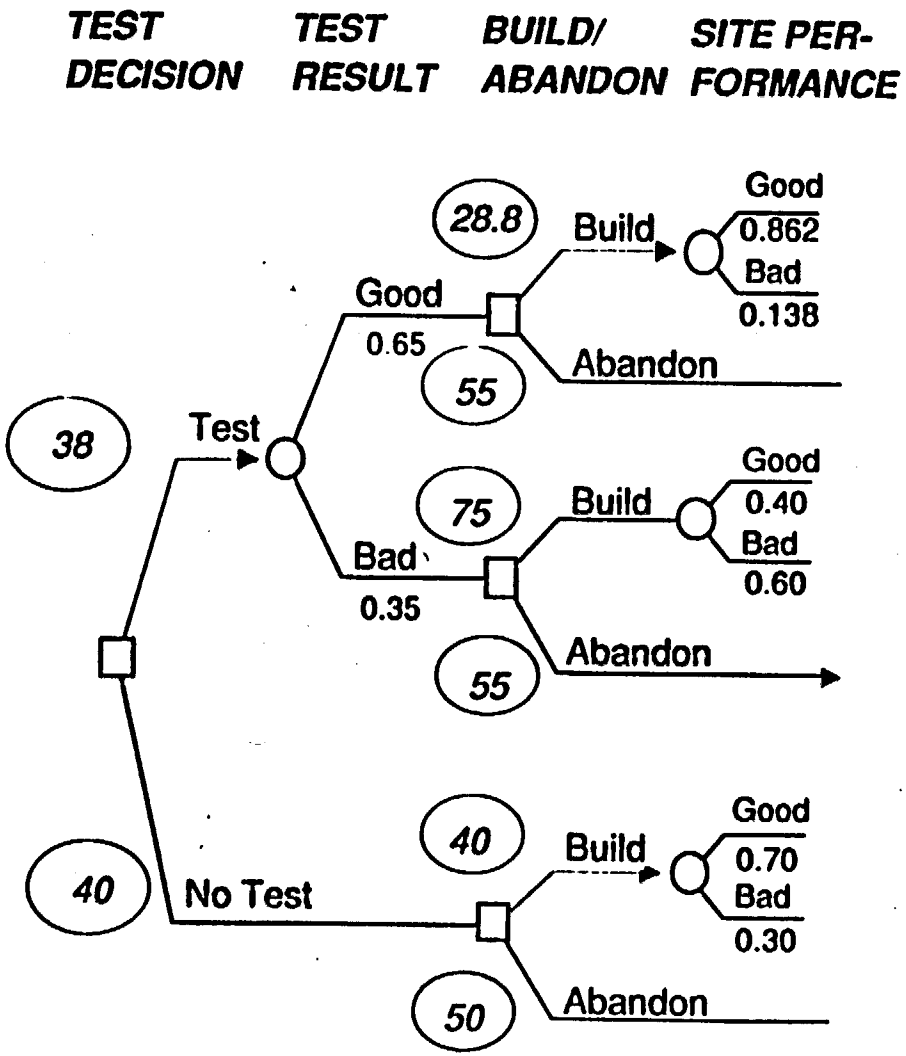
ASSESSMENTS AND COMPUTATIONS FOR MEASURING TEST "ACCURACY"



ILLUSTRATIVE PROBLEM

NRCHLLS5P 125/1 28 91

MODEL STRUCTURE, DATA, AND RESULTS FOR THE EXAMPLE PROBLEM

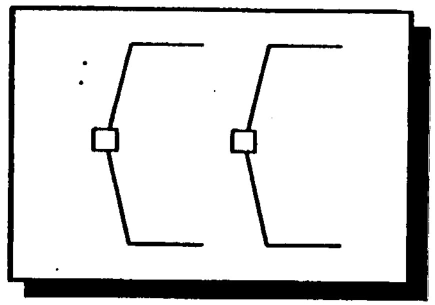


TEST COST	COST
5	10
5	110
5	50
5	10
5	110
5	50
0	10
0	110
0	50

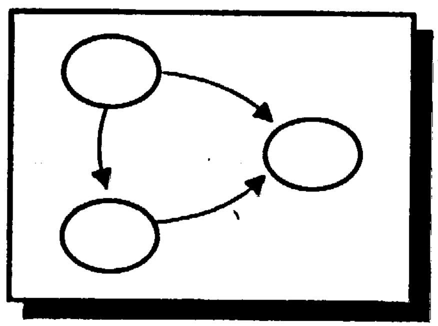
ILLUSTRATIVE PROBLEM

MAIN TOPICS

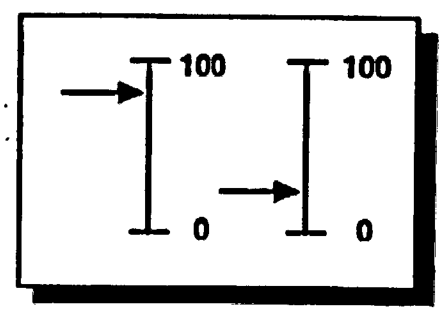
- INTRODUCTION
- VALUE-OF-INFORMATION, CONCEPTS AND TECHNIQUES
- OVERVIEW OF VOI MODEL FOR CHn ANALYSIS
- VOI MODEL RESULTS AND EXPLANATION



DECISIONS

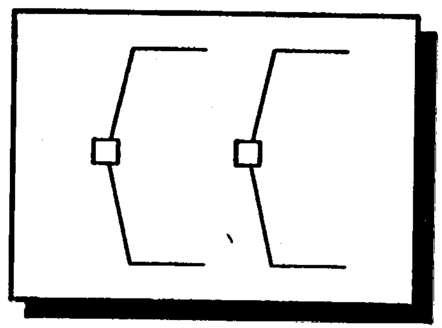


EVENTS



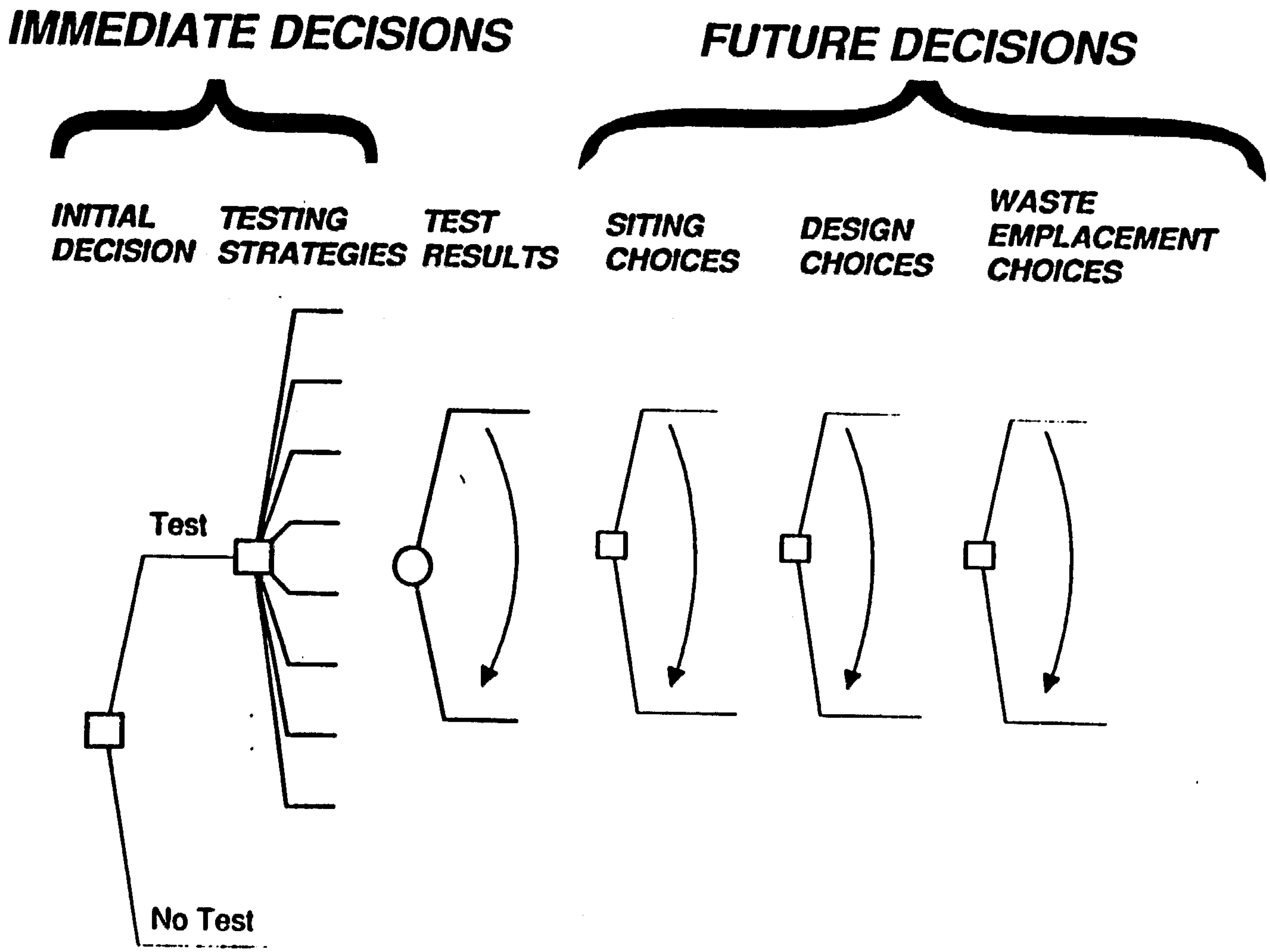
VALUES

NRCHLLS5P.125/1-28-91

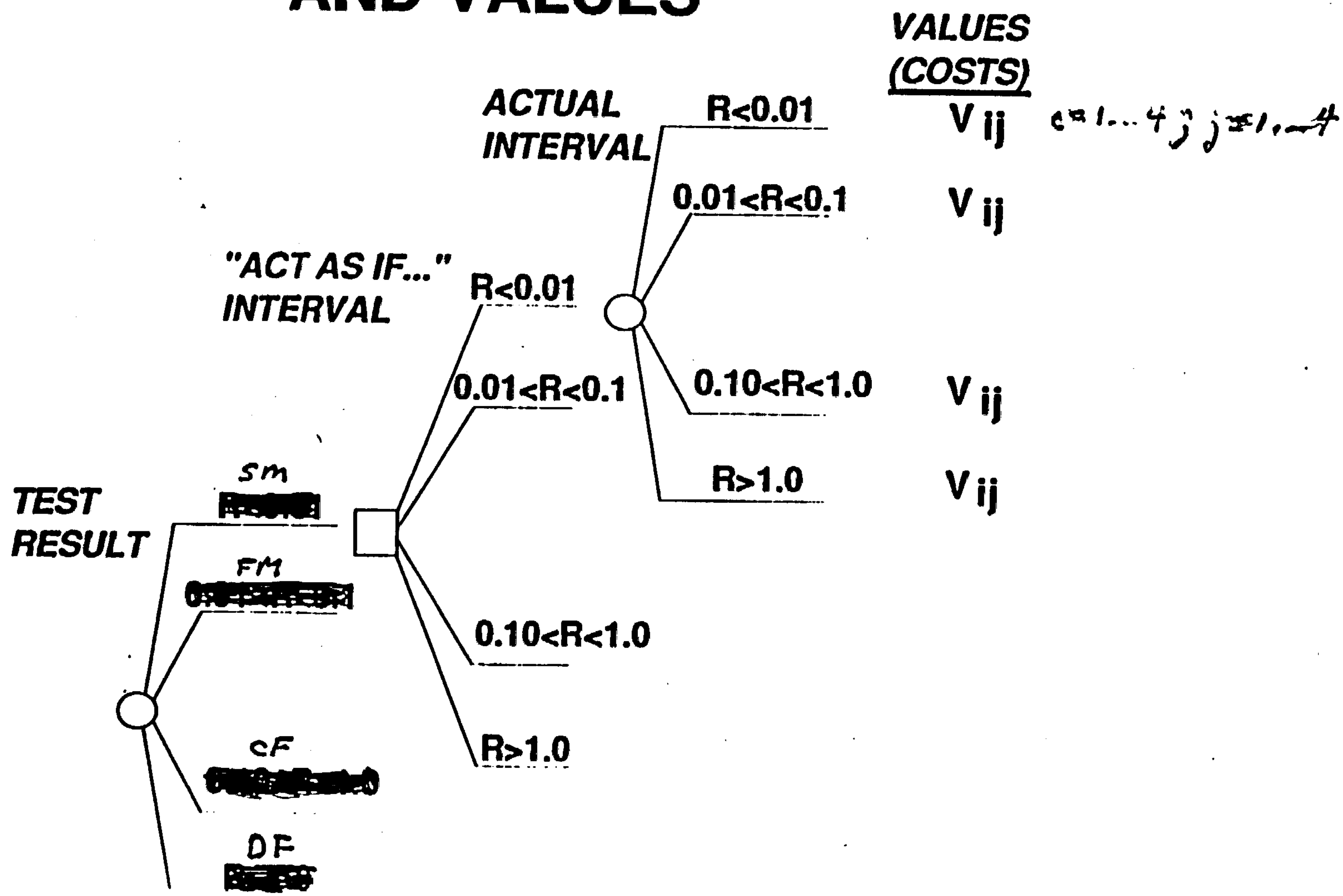


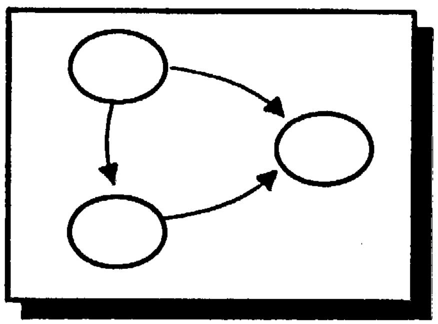
CHn DECISIONS

WE IDENTIFIED THE MAJOR TYPES OF DECISIONS AND ALTERNATIVES



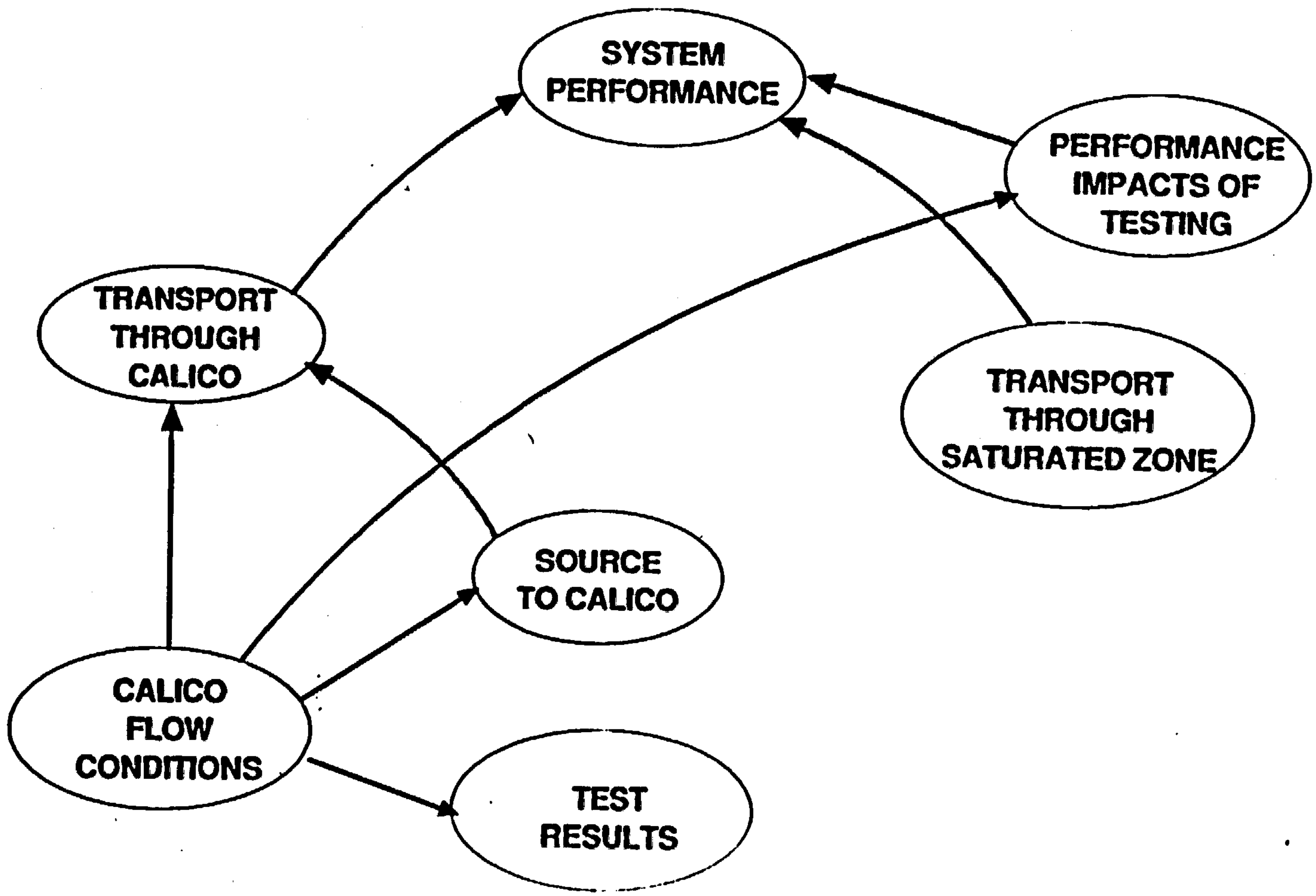
THE CHn VOI MODEL DECISIONS PROVIDE A LINK FROM TEST RESULTS TO OUTCOMES AND VALUES





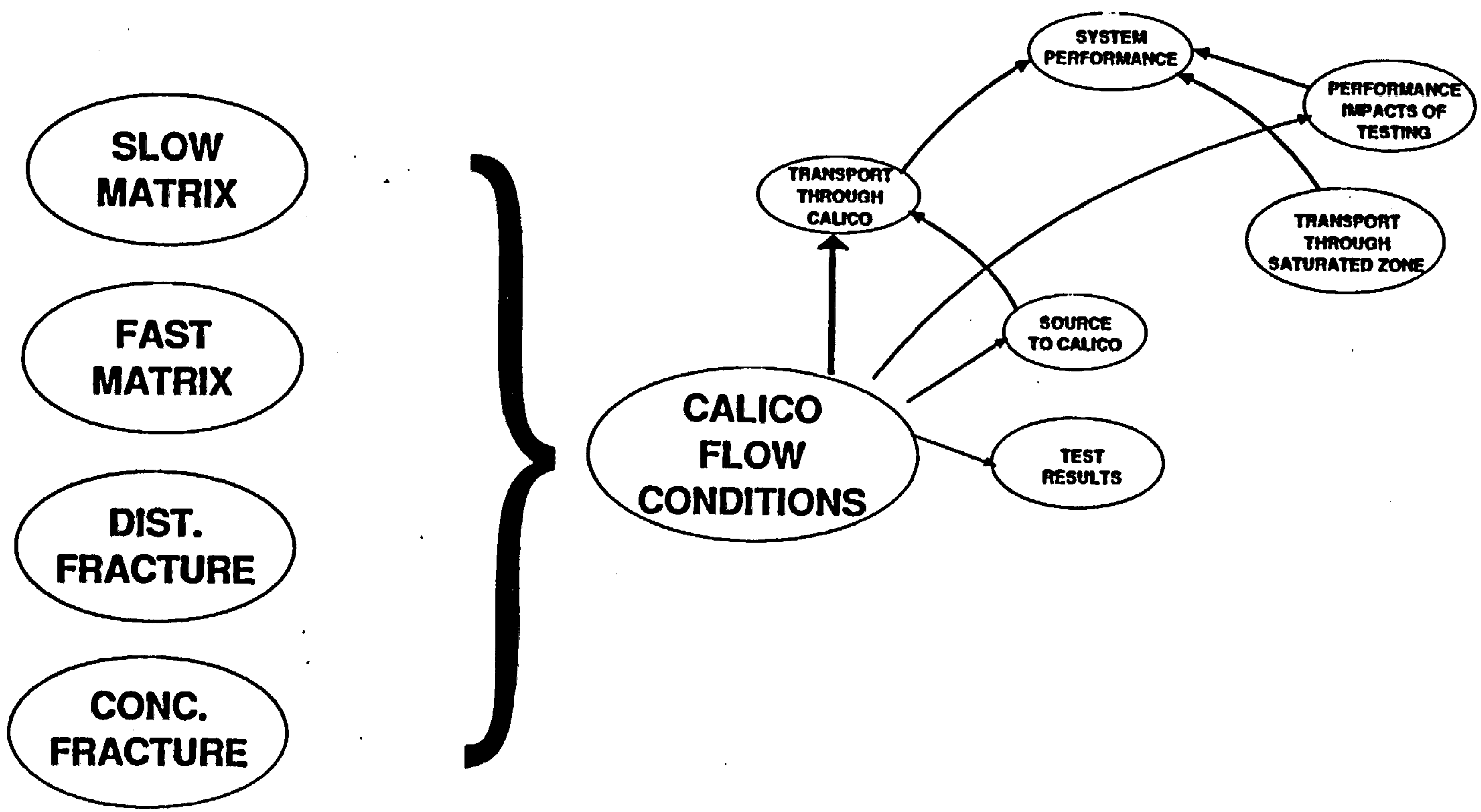
CHn UNCERTAINTIES AND PROBABILISTIC RELATIONSHIPS

KEY UNCERTAINTIES AND PROBABILISTIC RELATIONSHIPS

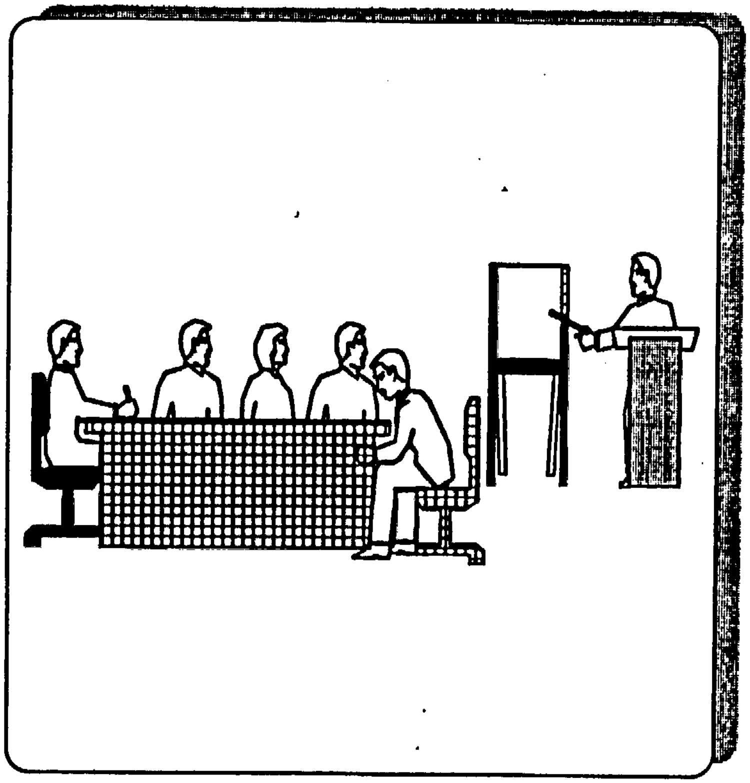


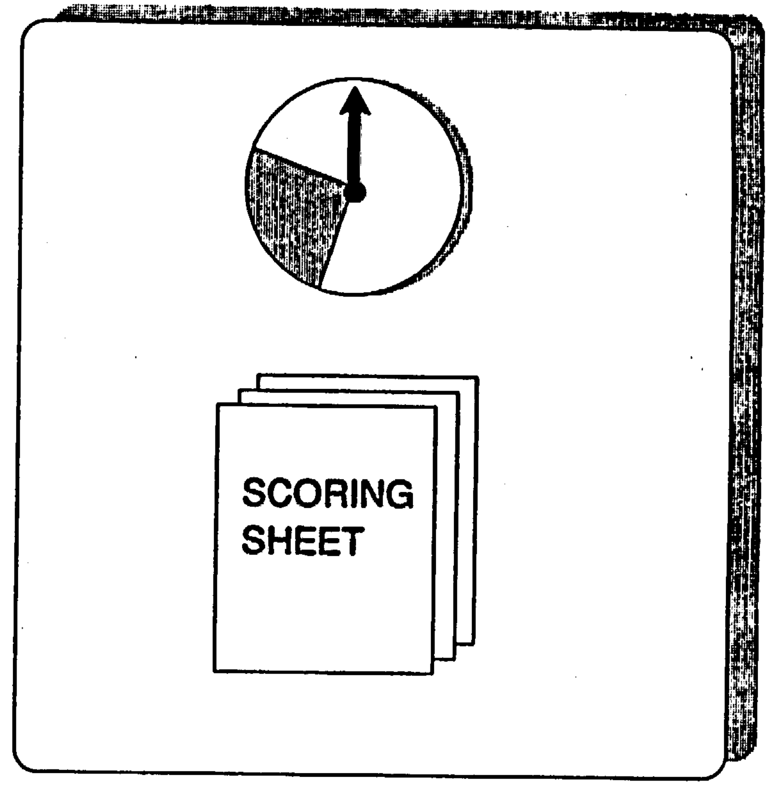
NRCHLLS5P 125/1 28-91

DETAILED CONCEPTUAL MODELS WERE DEVELOPED FOR KEY VARIABLES



PROBABILISTIC INPUTS WERE DEVELOPED BY THE PANEL OF TECHNICAL EXPERTS, USING STANDARD TECHNIQUES FOR ELICITATION OF EXPERT JUDGMENT

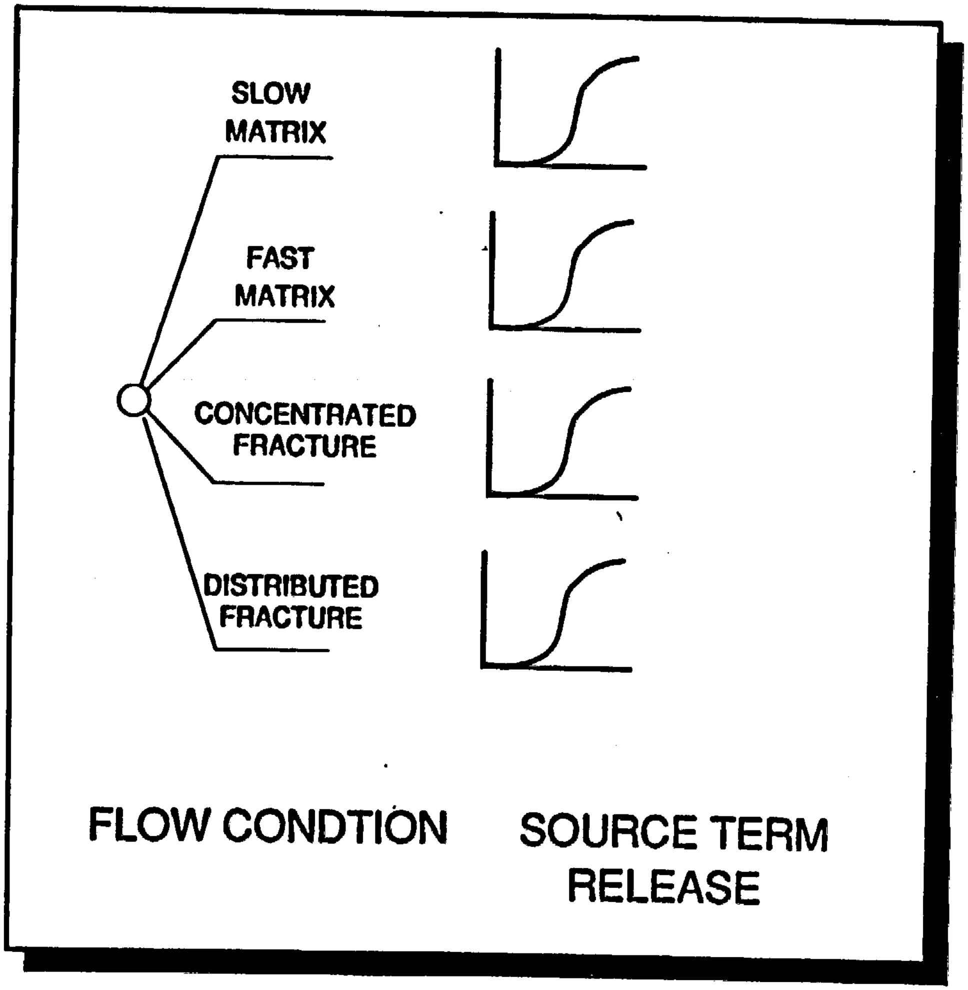


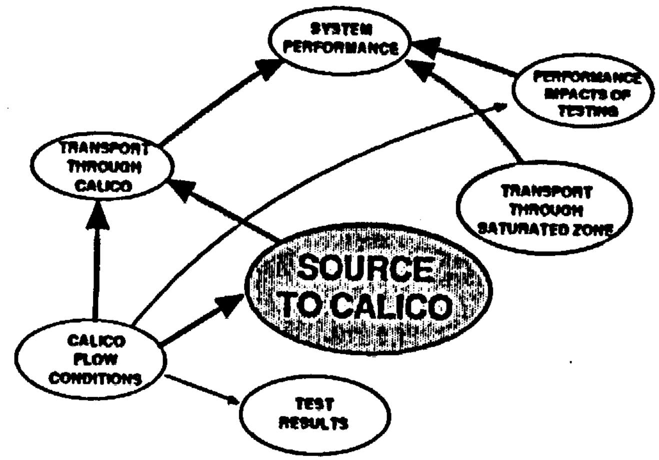


SAMPLE QUESTION:* *Given the true flow condition is concentrated fracture flow, what is the probability that you would conclude this using test strategy #2?

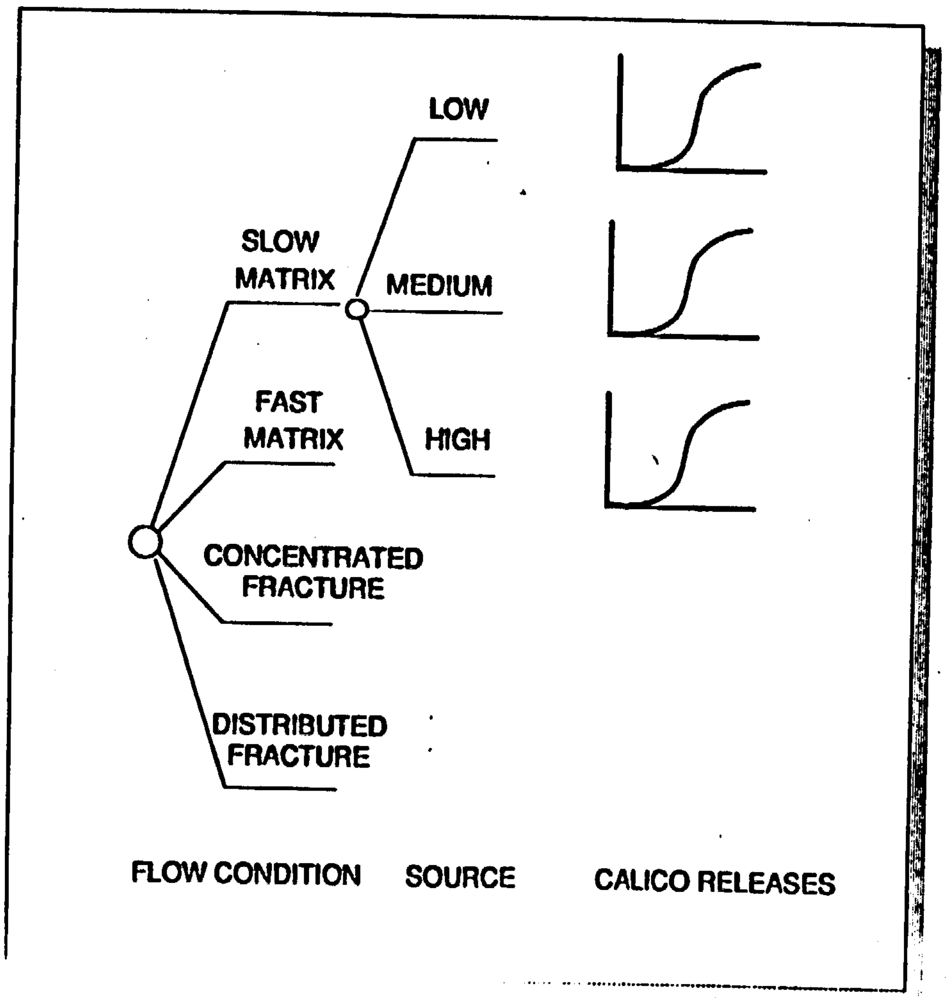
NRCHLLS5P.125/1-28-91

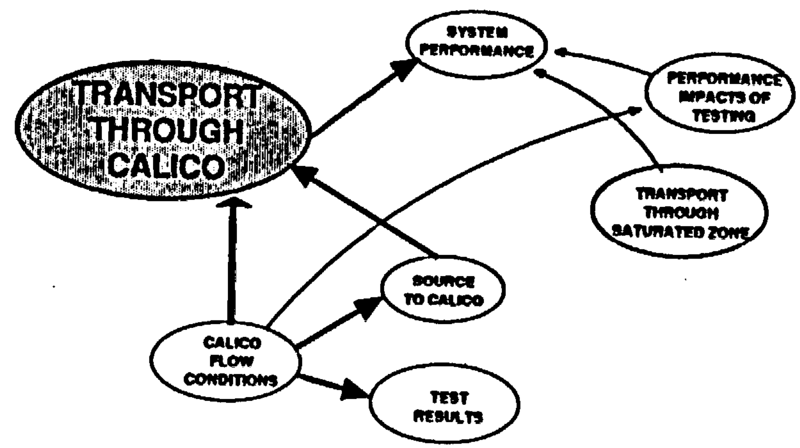
RELEASE FROM THE "SOURCE" WAS ASSESSED AS DEPENDENT ON CALICO FLOW CONDITIONS





RELEASES FROM THE CALICO WERE ASSESSED AS CONDITIONAL ON THE FLOW MODE AND THE SOURCE TERM





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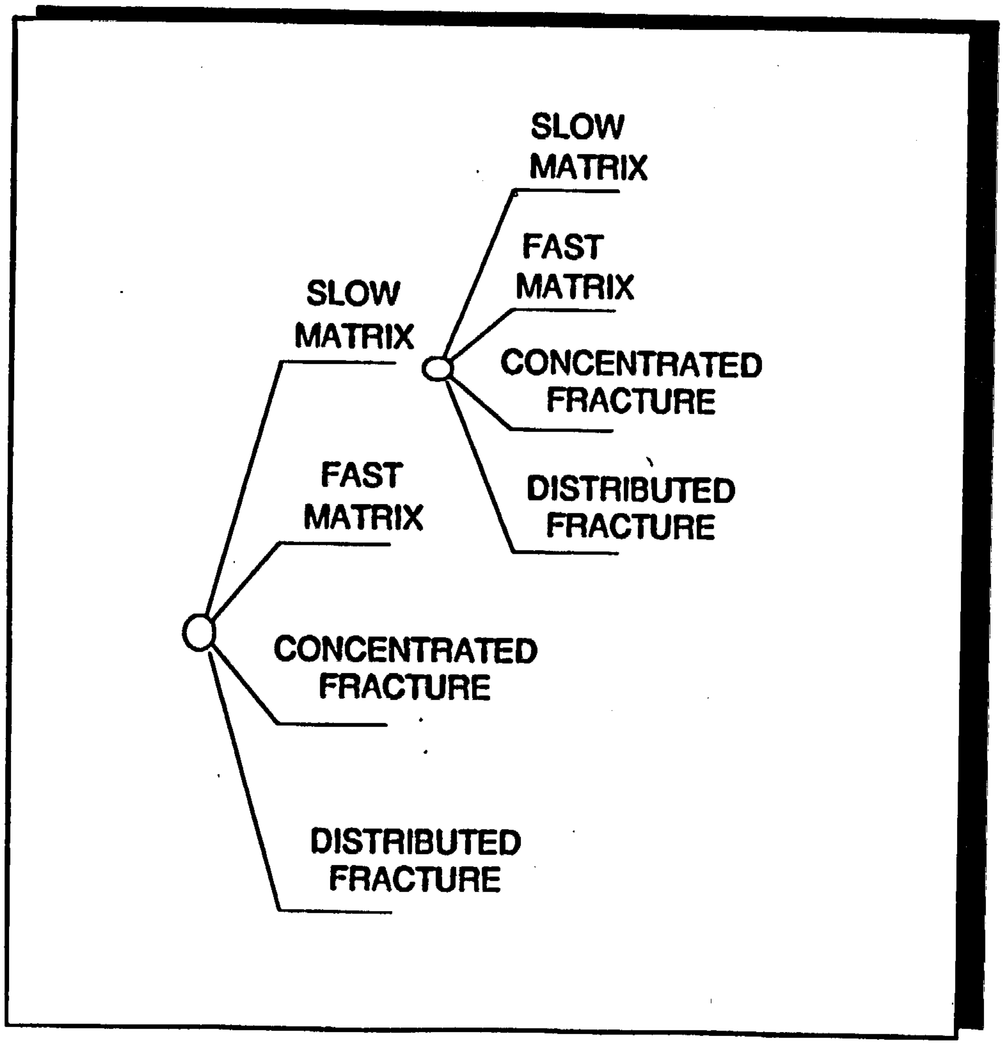
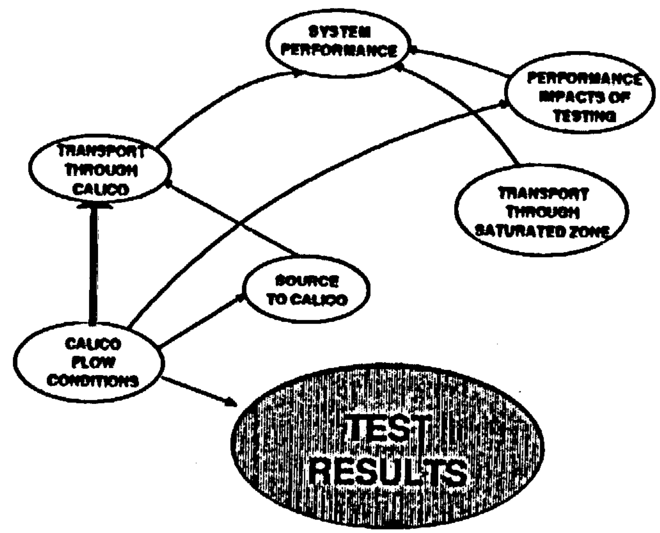
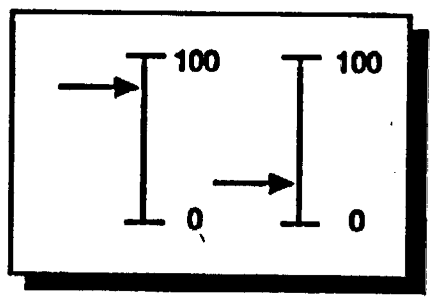
THE LIKELIHOOD OF EACH TEST RESULT WAS ASSESSED AS DEPENDENT ON CALICO FLOW CONDITIONS

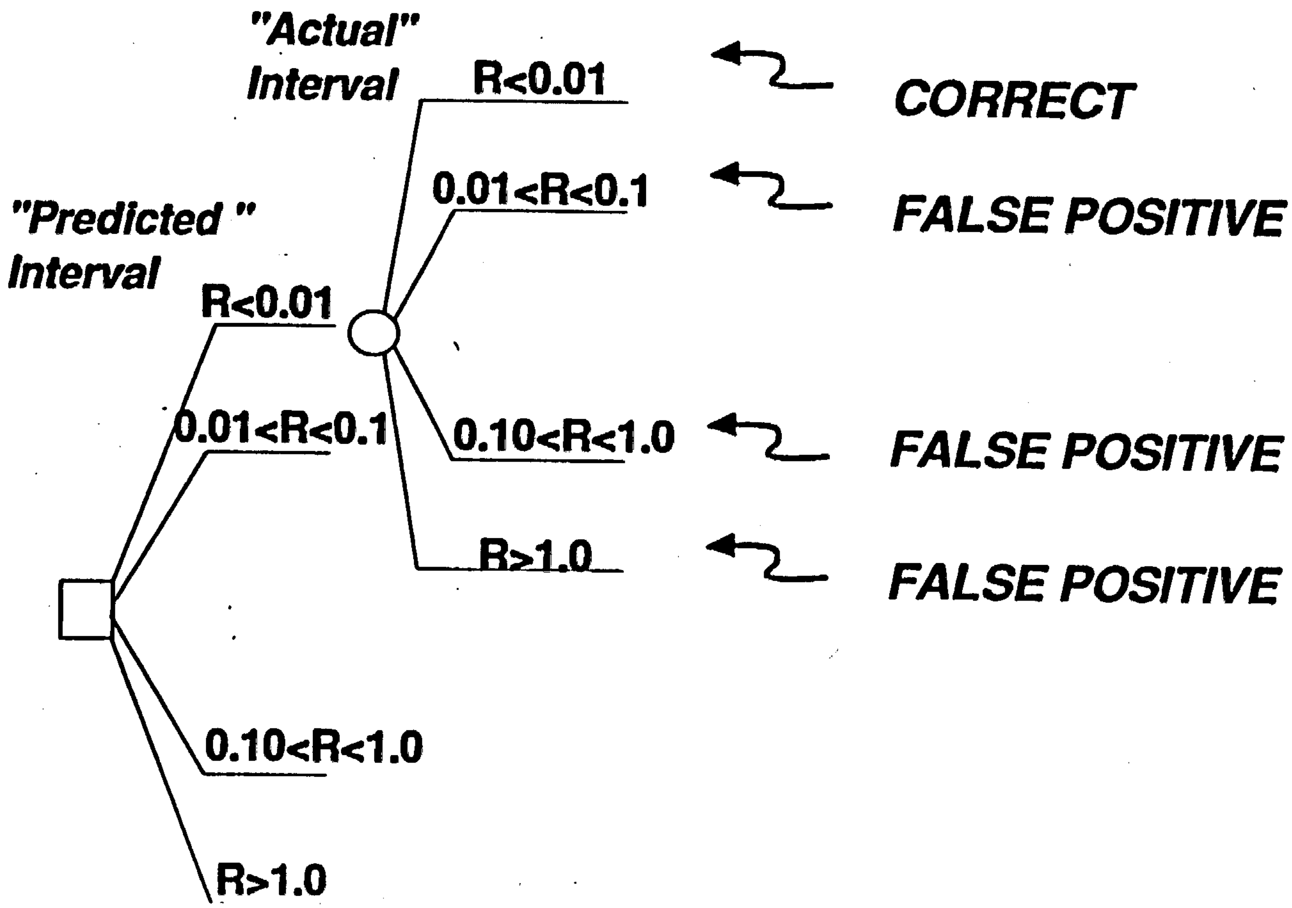






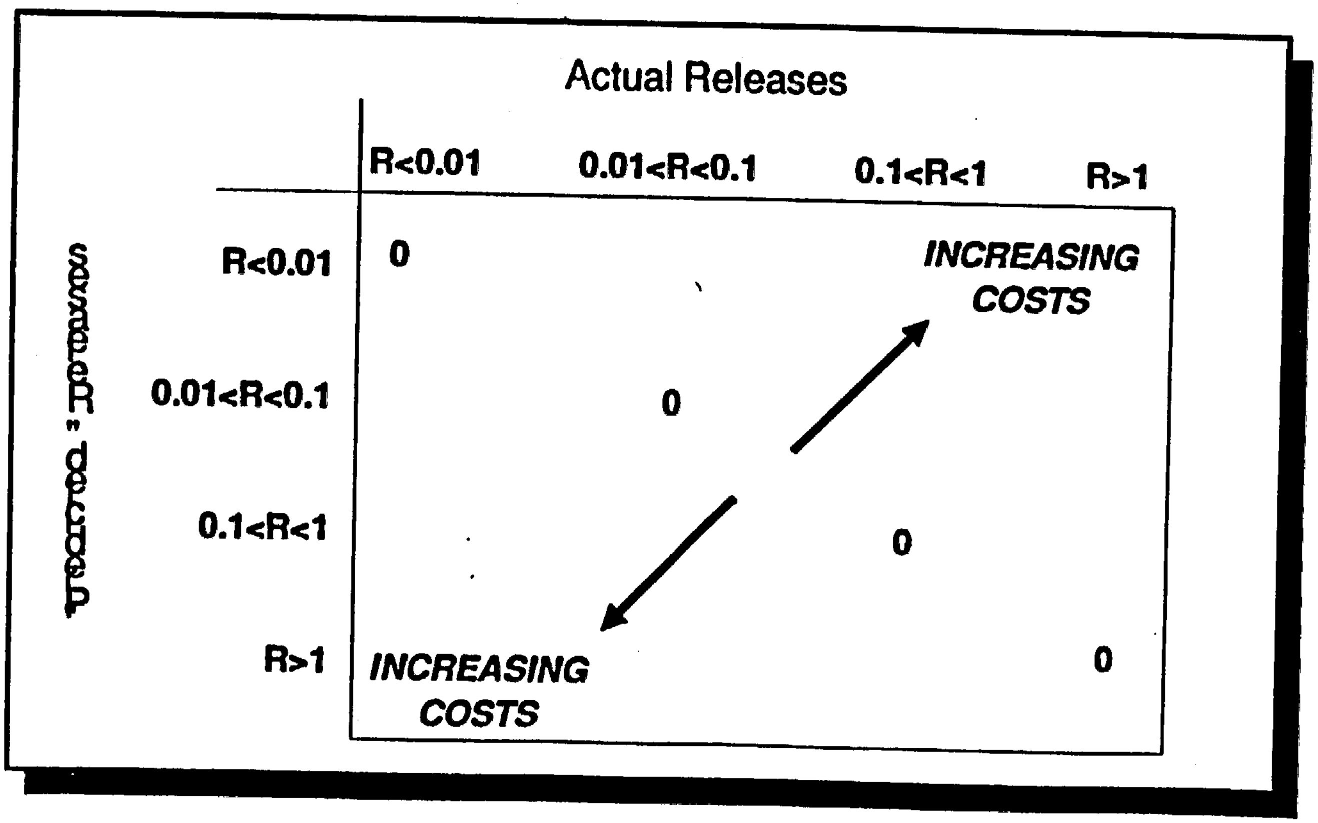
VALUES

VALUES WERE MEASURED AS THE COSTS OF EACH COMBINATION OF "ACT AS IF..." AND ACTUAL RELEASE INTERVAL



NRCHLLS5P.125/1-28-91

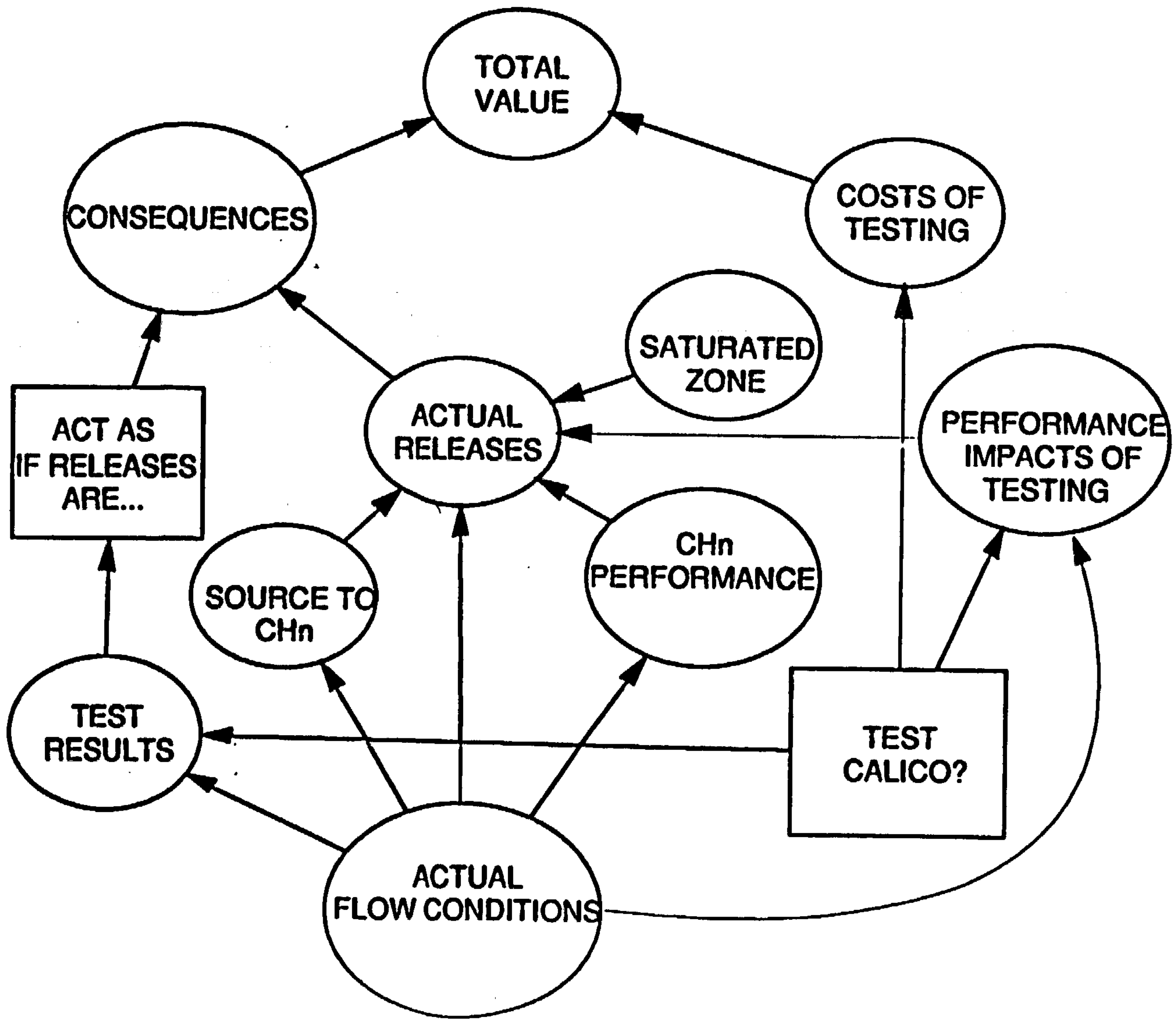
OUR VALUE ASSESSMENT MEASURED THE VALUE OF OVER-PREDICTING, UNDER-PREDICTING, AND BEING "RIGHT" ABOUT RELEASES



The release intervals imply that decisions and events are sensitive to changes from one interval to another.

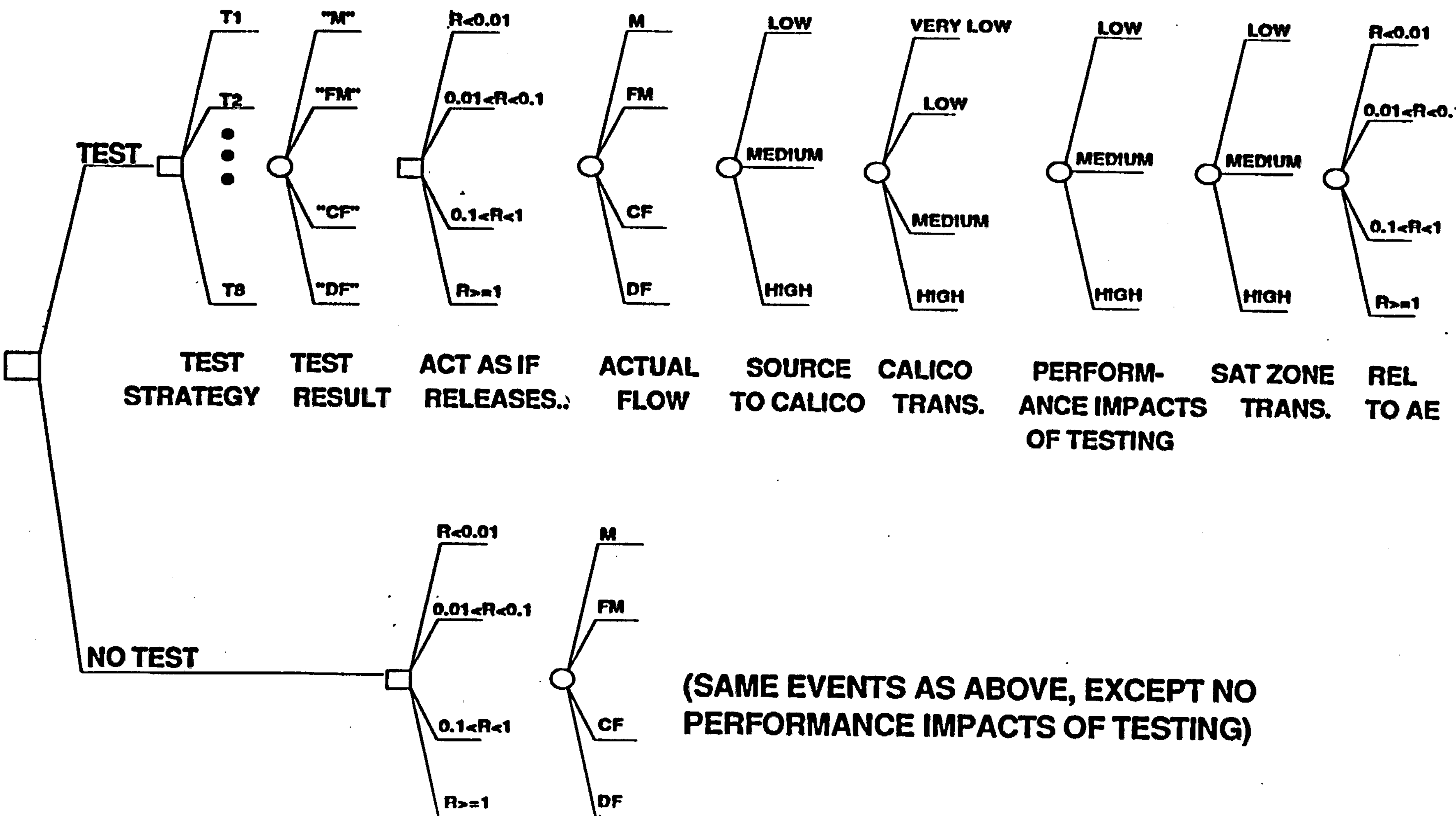
NRCHLLS5P.125/1-28-91

AN INFLUENCE DIAGRAM FOR THE CHn VOI MODEL



NRCHLLS5P.125/1-28-91

A SCHEMATIC DECISION TREE FOR THE CHn VOI MODEL

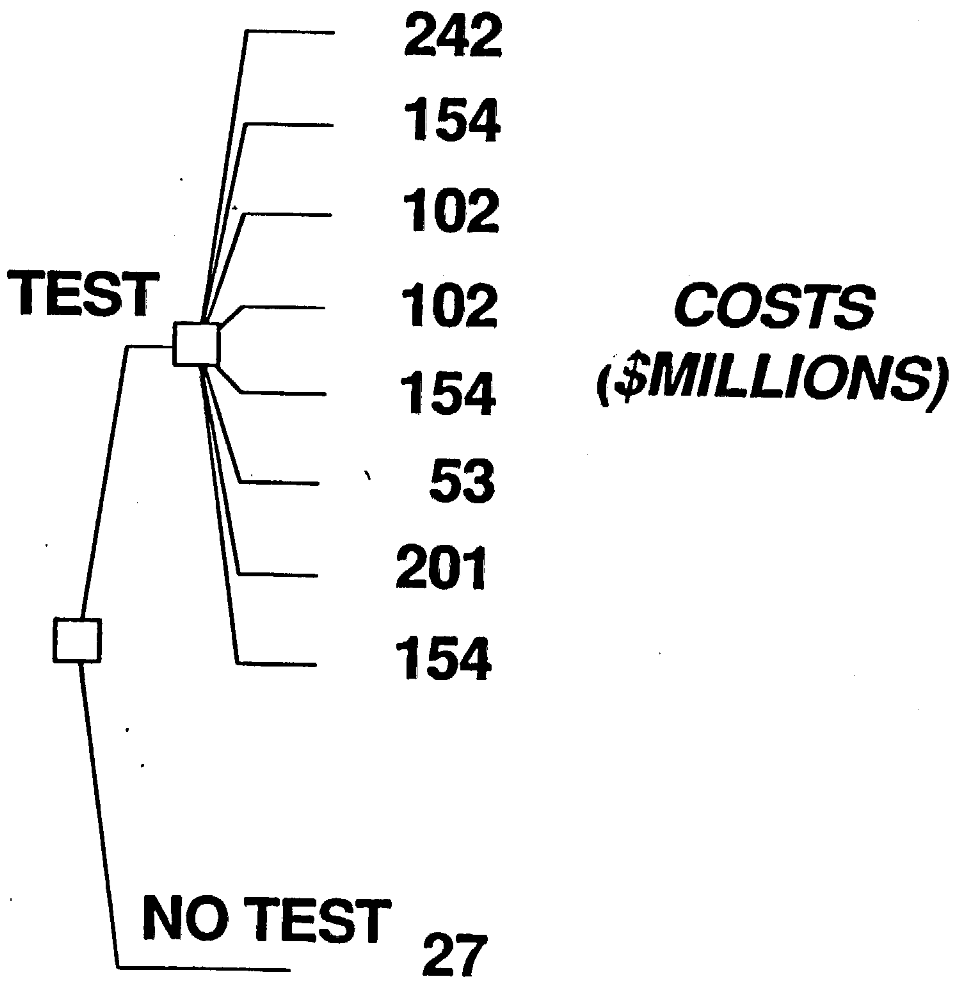


(SAME EVENTS AS ABOVE, EXCEPT NO PERFORMANCE IMPACTS OF TESTING)

MAIN TOPICS

- INTRODUCTION
- VALUE-OF-INFORMATION, CONCEPTS AND TECHNIQUES
- OVERVIEW OF VOI MODEL FOR CHn ANALYSIS
- VOI MODEL RESULTS AND EXPLANATION

EXPECTED VALUE OF TESTING STRATEGIES



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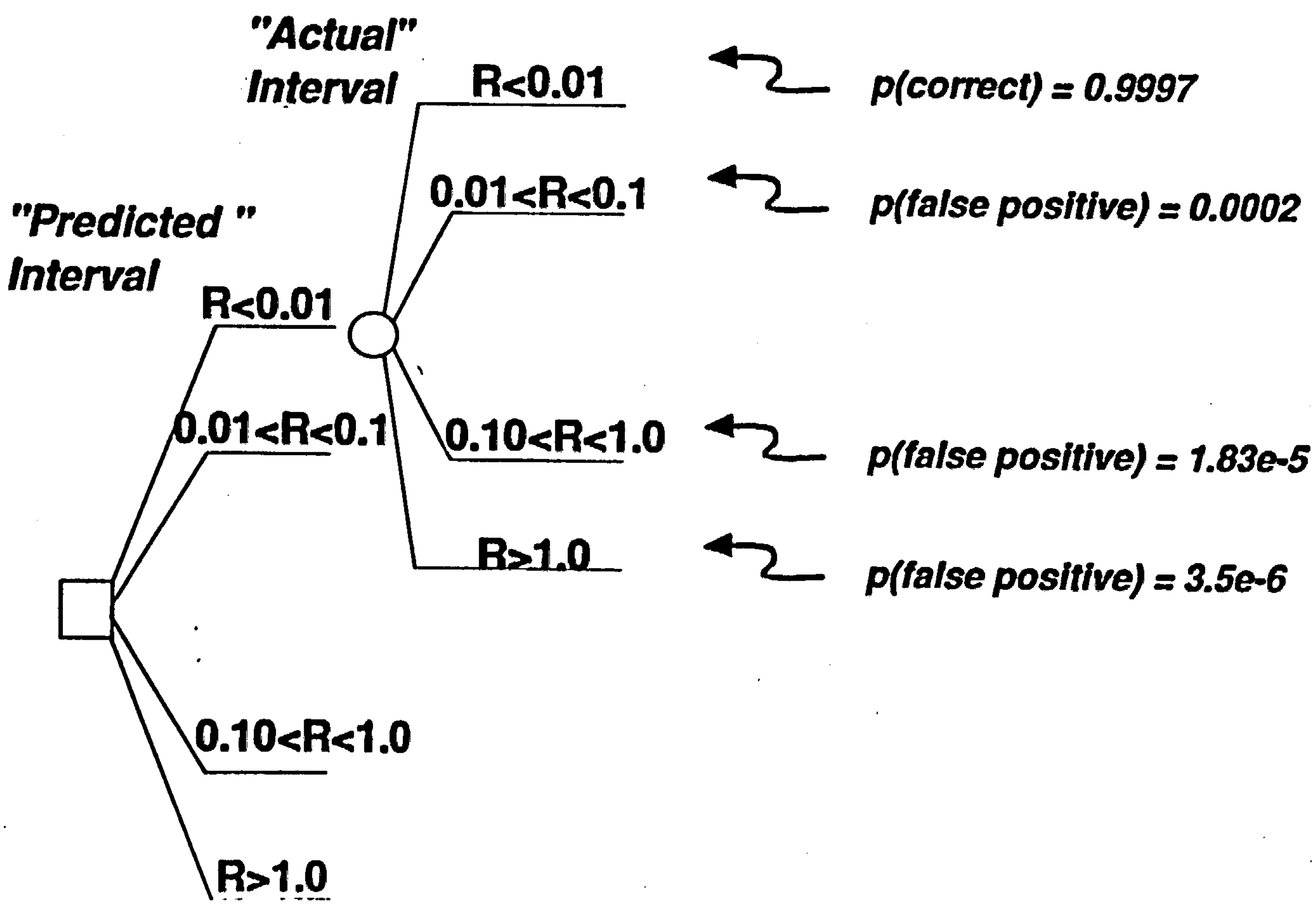
IF THE BEST POLICY IS TO "ACT AS IF" RELEASES WILL BE IN THE LOWEST INTERVAL, BAD OUTCOMES (e.g., FALSE POSITIVES) HAVE A LOW PROBABILITY OF OCCURING



NRCHLLS5P.125/1-28-91

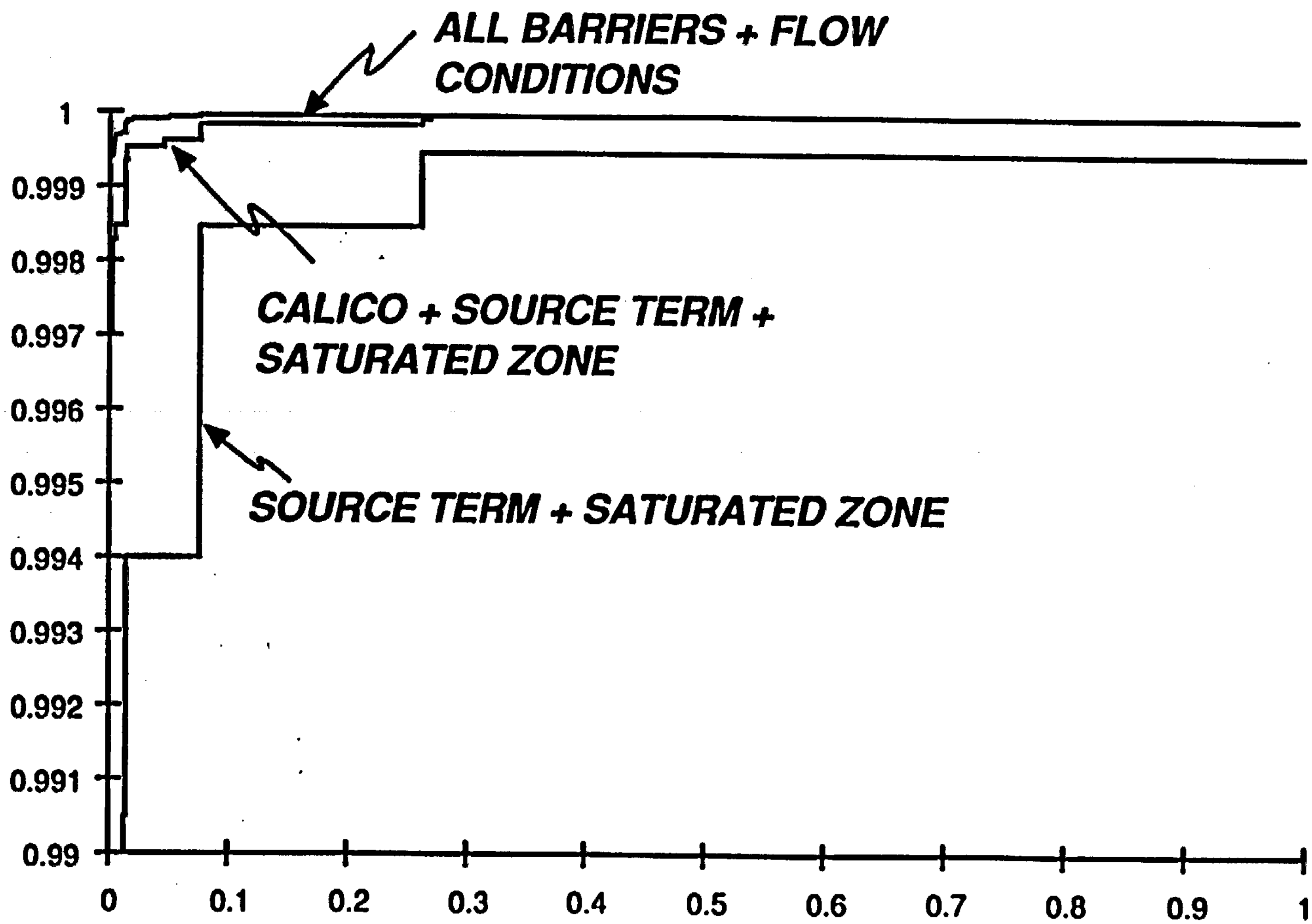
SENSITIVITY ANALYSIS ON INPUTS TO RELEASE MODEL

SCENARIO	VARIABLES				RESULTS			
	Source	Flow Condition	Calico Releases	Saturated Zone	Single Variable		Cumulative	
					E(R)	p(R<=1)	E(R)	p(R<=1)
"Worst Case"	*High*	*Dist. Fracture*	*High*	*None*	*32**	*NA*	*32**	*NA*
Include Saturated Zone Performance	High	Dist. Fracture	High	~	0.11	0.95	0.10820	0.9500
Include Source Term Performance	~	Dist. Fracture	High	None	0.47	0.90	0.00158	0.9998
Include Calico Performance	High	Dist. Fracture	~	None	2.18	0.85	0.00089	0.9999
Include Flow Conditions	High	~	High	None	5.50	0.70	0.00002	0.9999

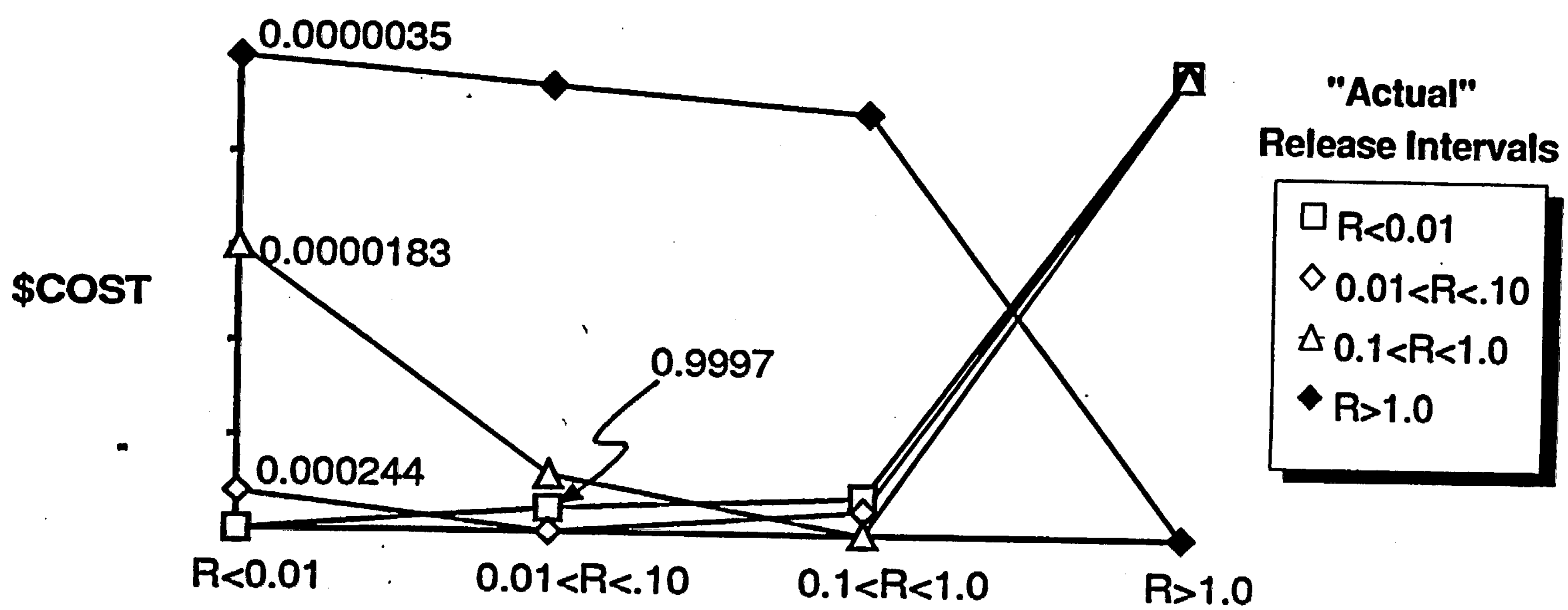
~ Indicates variable treated as uncertain.

* Deterministic point value.

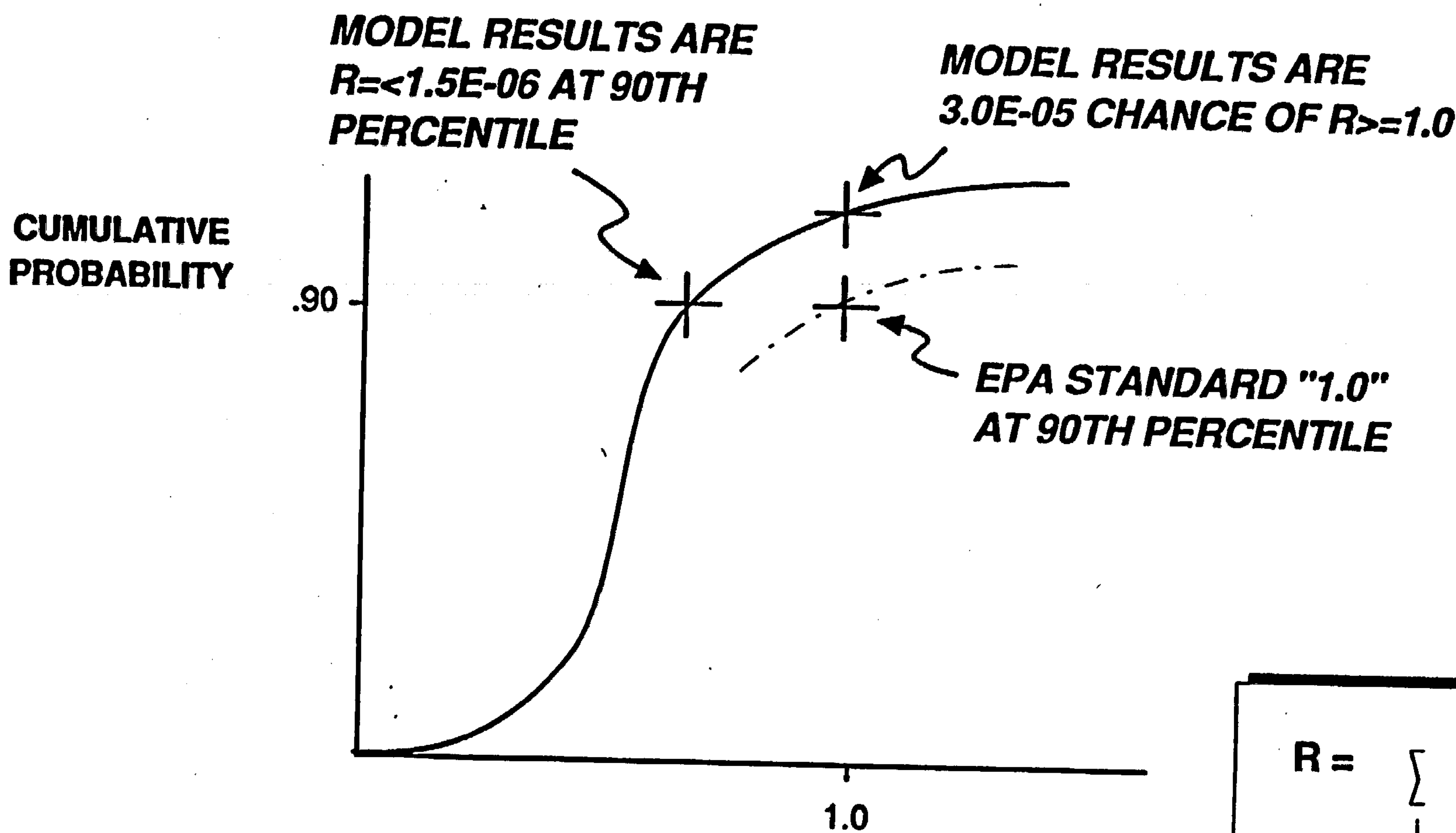
MULTIPLE BARRIER PERFORMANCE



VALUE FUNCTIONS FOR "PREDICTED" vs. "ACTUAL" RELEASES



HOW DOES OUR ESTIMATED "R" COMPARE TO THE EPA STANDARD?



$$R = \sum_{i} \frac{R_i}{AR_i}$$

WHY NO TESTING?
SUMMARY INTERPRETATION OF RESULTS

- ❑ EXPECTED RELEASES ARE VERY LOW (ORDERS OF MAGNITUDE BELOW THE EPA STANDARD), AND TEST RESULTS ARE NOT LIKELY TO CHANGE THAT VIEW.

- ❑ TEST COSTS ARE RELATIVELY HIGH; CHEAPER, INCREMENTAL OR PHASED TESTS MIGHT FARE BETTER.

A PREFERENCE FOR TESTING SUGGESTS ONE OR BOTH OF THE FOLLOWING:

- ❑ DECISION MAKERS PLACE HIGH VALUE ON CONFIDENCE, EVEN AT EXTREMELY LOW LEVELS OF RELEASES (1.0E-8). WE DID NOT OBSERVE THIS LEVEL OF SENSITIVITY IN OUR ASSESSMENT.

- ❑ TESTING HAS VALUEIN THIS PROBLEM BEYOND ITS ABILITY TO HELP MAKE BETTER DECISIONS.

U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

YUCCA MOUNTAIN

CALICO HILLS RISK/BENEFIT ANALYSIS
GEOTECHNICAL INPUTS TO MUA

PRESENTED AT

DOE/NRC MEETING ON CALICO HILLS RISK/BENEFIT ANALYSIS AND ESF ALTERNATIVES STUDY

PRESENTED BY

ERNEST L. HARDIN

STAFF SCIENTIST - TECHNICAL SUPPORT

TECHNICAL & MANAGEMENT SUPPORT SERVICES/SAIC

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

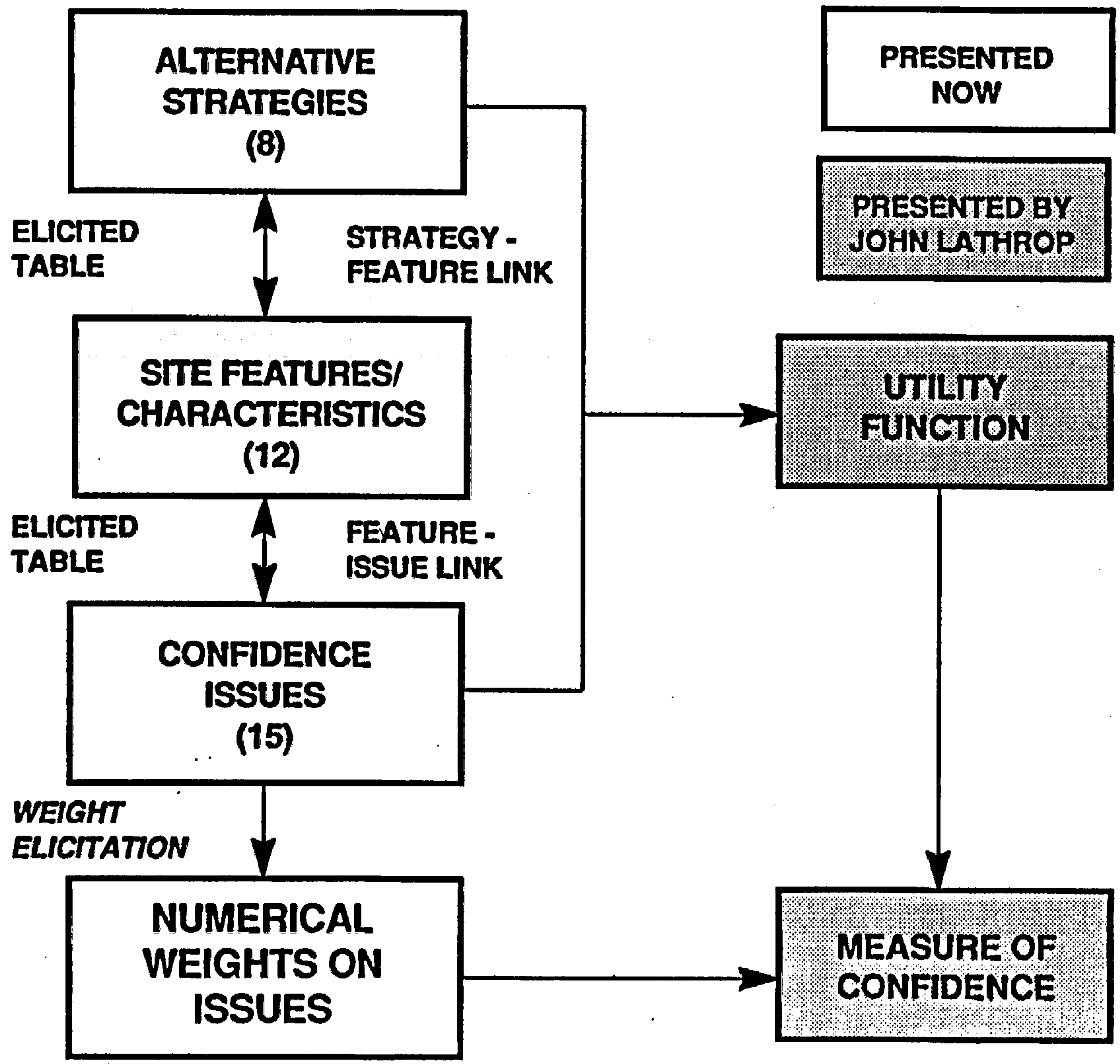
JANUARY 29-31, 1991

Attachment 9

MUA GEOTECHNICAL INPUTS

- SCIENTIFIC CONFIDENCE
  - FEATURE, ISSUE DEFINITIONS
  - SCORING STRATEGIES ON FEATURES
  - SCORING OF FEATURES ON ISSUES
  - RANKING/WEIGHTING ISSUES
- USE RISK ASSESSMENT FROM VOI STUDY

MUA TECHNICAL INPUTS
SCIENTIFIC CONFIDENCE



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MUA TECHNICAL INPUTS

FEATURE-ISSUE DEFINITIONS

"FEATURE" = OPPORTUNITY TO LEARN SOMETHING ABOUT THE SITE AT A PHYSICAL LOCATION

- BOUNDING/STRUCTURAL FEATURES
- FACIES
- UNKNOWN FEATURES
- PERMEABILITY CONTRASTS
- HYDROCHEMISTRY
- ACCESS OUTSIDE THE REPOSITORY BLOCK

"ISSUE" = CATEGORIES OF CONCERN FOR CHARACTERIZATION DECISION

- MAXIMIZE CHARACTERIZATION
- ALTERNATIVE CONCEPTUAL MODELS
- PERFORMANCE CONFIRMATION

MUA TECHNICAL INPUTS
FEATURES

A. GHOST DANCE FAULT

B. DRILL HOLE WASH

C. SOLITARIO CANYON FAULT

D. ABANDONED WASH FAULT

E. IMBRICATE NORMAL FAULT ZONE (EAST)

F. UNKNOWN FEATURES (INCL. PERCHED WATER, DIKES, ETC.)

G. VITRIC FACIES

H. ZEOLITIC FACIES

I. CHn FACIES TRANSITION

J. PERMEABILITY CONTRASTS/CAPILLARY BARRIERS

K. SITE HYDROCHEMISTRY

L. SIMILAR CONDITIONS OUTSIDE THE BLOCK

MUA TECHNICAL INPUTS
SCORING STRATEGIES ON FEATURES

- STRATEGIES 1 THRU 8 (TABLE 2.6.2.2.1-1)
- 4-POINT SCALE:

  0 = NO ACCESS; NO BENEFIT RELATIVE TO SCP BASELINE PROGRAM

  1 = LIMITED ACCESS BY ANALOGY OR LIMITED MEANS

  2 = ACCESSED DIRECTLY, BUT TO A LIMITED EXTENT

  3 = ACCESSED DIRECTLY, TO THE MAXIMUM EXTENT REASONABLE

STRATEGY - FEATURE LINK

EXCERPTED FROM TABLE 2.6.2.2.1-1

	FEATURE	STRATEGY #1	STRATEGY #2
A	GHOST DANCE FAULT	2	3
B	DRILL HOLE WASH	2	2
C	SOLITARIO CANYON FAULT	1	2
D	ABANDONED WASH FAULT	3	0
E	IMBRICATE NORMAL FAULT ZONE (EAST)	3	2
F	UNKNOWN FEATURES (PW, DIKES, etc.)	2	3
G	VITRIC FACIES	2	3
H	ZEOLITIC FACIES	3	3
I	CHn FACIES TRANSITION	2	3
J	PERMEABILITY CONTRAST/CAPILLARY BARRIERS	1	3
K	HYDROCHEMISTRY	2	3
L	SIMILAR ROCK OUTSIDE THE BLOCK	3	0

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MUA TECHNICAL INPUTS: ISSUES

MC-1	STATISTICAL CHARACTERIZATION
MC-2	FLEXIBILITY
MC-3	ACCESS FOR IN SITU TRANSPORT TESTING
MC-4	BOUNDARIES OF CHn BARRIER

ACM-1	DETECT/CHARACTERIZE NONSYSTEMATIC SPATIAL VARIABILITY
ACM-2	FRACTURE/MATRIX SYSTEM RESPONSE
ACM-3	DETECT/CHARACTERIZE RESPONSE OF FAULTS AND FRACTURES DIRECTLY INFLUENCED BY THEM
ACM-4	DETECT/CHARACTERIZE FEATURES THAT COULD CAUSE LATERAL DIVERSION
ACM-5	DETECT/CHARACTERIZE FEATURES OR PROCESSES THAT COULD LIMIT RETARDATION
ACM-6	QUATERNARY WATER TABLE INSTABILITY
ACM-7	IMPERMANENT ROCK CHARACTERISTICS FROM NATURAL CAUSES
ACM-8	POTENTIAL CHANGES IN ROCK CHARACTERISTICS FROM CHARACTERIZATION OR REPOSITORY

SPC-1	ACCESS TO FEATURES FOR LONG-TERM TESTING
SPC-2	BASELINE DATA WHERE CHANGES ARE LIKELY
SPC-3	ACCESS TO FEATURES WHERE TESTING MAY BE REQUIRED BY OTHER PARTIES

MUA TECHNICAL INPUTS
ALTERNATIVE CONCEPTUAL MODELS

USE OF SCP HYDROLOGY ACM TABLE

- **(ACM-1) NONSYSTEMATIC VARIABILITY**
  - CHn DESCRIPTION AS A COHERENT UNIT
- **(ACM-2) FRACTURE/MATRIX SYSTEM RESPONSE**
  - FRACTURE FLOW AT LOW MATRIX SATURATION
  - LOCAL THERMODYNAMIC EQUILIBRIUM
  - FRACTURE MINERALIZATION
- **(ACM-3) FAULT/FAULT ZONE RESPONSE**
  - RESPONSE TO EPISODIC RECHARGE
  - RESPONSE OF FRACTURES DIRECTLY INFLUENCED BY FAULTS

MUA TECHNICAL INPUTS
ALTERNATIVE CONCEPTUAL MODELS

USE OF SCP HYDROLOGY ACM TABLE,
(CONTNUED)

- (ACM-4) FEATURES THAT COULD CAUSE LATERAL DIVERSION
  - PERMEABILITY CONTRASTS/CAPILLARY BARRIERS
- (ACM-6) QUATERNARY WATER TABLE INSTABILITY
  - DEFINITION OF WATER TABLE, CAPILLARY FRINGE
- (ACM-7) IMPERMANENT ROCK CHARACTERISTICS
  - STORAGE, TRANSMISSIVITY
  - TECTONIC, VOLCANIC EFFECTS
  - COUPLING WITH SATURATED ZONE

MUA TECHNICAL INPUTS
ALTERNATIVE CONCEPTUAL MODELS

USE OF SCP GEOCHEMISTRY ACM TABLE

- (ACM-5) FEATURES OR PROCESSES THAT COULD LIMIT RETARDATION
  - FLOW FIELD, FRACTURE FLOW
  - COLLOIDAL, PSEUDO-COLLOIDAL, MICROBIAL PROCESSES
  - PRECIPITATION EFFECTS
  - RESTRICTION OF MATRIX DIFFUSION
  - LOCAL THERMODYNAMIC NON-EQUILIBRIUM
- (ACM-2) FRACTURE/MATRIX SYSTEM RESPONSE
- FAULT/FAULT ZONE RESPONSE (ACM-3)
- (ACM-4) FEATURES THAT COULD CAUSE LATERAL DIVERSION
- (ACM-8) POTENTIAL CHANGES IN CHN ROCK CHARACTERISTICS CAUSED BY SITE CHARACTERIZATION OR THE REPOSITORY

MUA TECHNICAL INPUTS
ALTERNATIVE CONCEPTUAL MODELS

USE OF SCP ROCK CHARACTERISTICS ACM TABLE

- (ACM-5) FEATURES OR PROCESSES THAT COULD LIMIT RETARDATION
  - FRACTURE COATING MINERALS LIMIT CHEMICAL OR PHYSICAL RETARDATION
- (ACM-1) NONSYSTEMATIC VARIABILITY
  - VOLCANIC/VOLCANOCLASTIC PROCESSES
  - COMPLEXITY OF MINERAL ALTERATION
- (ACM-7) IMPERMANENT ROCK CHARACTERISTICS
  - TECTONIC CHANGE IN FRACTURE/FAULT ZONE TRANSMISSIVITY
  - RESPONSE TO EXCAVATION- OR THERMALLY-INDUCED STRESS Δ

MUA TECHNICAL INPUTS

DEFINITION OF ISSUES INVOLVING LONG-TERM TESTING/MONITORING

	NATURAL	MAN-CAUSED
ACTIVE TESTING	SPC-1	SPC-1
PASSIVE MONITORING	SPC-1	SPC-2 (IN CHn)

MUA TECHNICAL INPUTS
SCORING OF FEATURES ON ISSUES

- **ISSUES**

  MC-1 THRU MC-4 (TABLE 2.6.2.2.1-2)
  ACM-1 THRU ACM-8 (TABLE 2.6.2.2.1-3)
  SPC-1 THRU SPC-3 (TABLE 2.6.2.2.1-4)

- **3-POINT SCALE:**

  0 = WEAK; NEGLIBLE CONTRIBUTION TO SCIENTIFIC CONFIDENCE RELATIVE TO SCP BASELINE PROGRAM

  1 = INTERMEDIATE; INVESTIGATING THIS FEATURE PROVIDES SOME INCREASE IN SCIENTIFIC CONFIDENCE

  2 = STRONG; INVESTIGATING THIS FEATURE SIGNIFICANTLY INCREASES CONFIDENCE

FEATURE - ISSUE LINK

EXCERPTED FROM TABLES 2.6.2.2.1-2 THRU -4

ISSUE		FEATURE											
		A	B	C	D	E	F	G	H	I	J	K	L
ACM-3	FLOW: DETECT/CHARACTERIZE FAULT SYSTEM RESPONSE, INCLUDING FRACTURES DIRECTLY AFFECTED BY FAULTS	2	1	2	2	2	1	0	0	0	1	2	1
ACM-2	FLOW: DETECT/CHARACTERIZE FRACTURE/MATRIX SYSTEM RESPONSE	1	1	1	1	1	1	2	2	2	2	2	2
MC-1	FLEXIBILITY: ACCESS TO FEATURES FOR COLLECTING DATA IN REACTION TO OBSERVATIONS	2	1	1	1	1	2	2	2	2	2	2	1

MUA TECHNICAL INPUTS

ISSUE WEIGHTS FOR SCIENTIFIC CONFIDENCE, TECHNICAL PANEL (RE: TABLE 2.6.2.2.2-1)

ISSUE	AVG. WEIGHT	
ACM-3	0.16	DETECT/CHARACTERIZE RESPONSE OF FAULTS, AND FRACTURES DIRECTLY INFLUENCED BY THEM
ACM-2	0.15	FRACTURE/MATRIX SYSTEM RESPONSE
MC-1	0.14	STATISTICAL CHARACTERIZATION
ACM-1	0.09	DETECT/CHARACTERIZE NONSYSTEMATIC SPATIAL VARIABILITY
MC-2	0.09	FLEXIBILITY
ACM-4	0.07	DETECT/CHARACTERIZE FEATURES THAT COULD CAUSE LATERAL DIVERSION
MC-3	0.07	ACCESS FOR IN SITU TRANSPORT TESTING
MC-4	0.05	BOUNDARIES OF CHn BARRIER
ACM-5	0.04	DETECT/CHARACTERIZE FEATURES OR PROCESSES THAT COULD LIMIT RETARDATION

OTHER PERMANENCE ISSUES, PERFORMANCE CONFIRMATION ISSUES, AND WATER TABLE INSTABILITY WERE WEIGHTED $\leq$ 0.03

MUA TECHNICAL INPUTS
RANKING/WEIGHTING 15 ISSUES

- EMPHASIS ON HYDROLOGIC ACM'S

TECHNICAL PANEL IS SENSITIVE TO THE FUNDAMENTAL CORRECTNESS/CONSISTENCY OF UNDERSTANDING OF SITE PROCESSES

- HYDROLOGY ACM-ISSUES HIGHLY RANKED:
  - FAULT/FRACTURE RESPONSE (ACM-3)
  - FRACTURE/MATRIX SYSTEM RESPONSE (ACM-2)
- SOME ISSUES ARE ALREADY ADDRESSED BY THE SCP BASELINE PROGRAM. EXAMPLES ARE:
  - STATISTICAL CHARACTERIZATION (MC-1)
  - QUATERNARY INSTABILITY OF WATER TABLE (ACM-6)
- OTHER IMPORTANT ISSUES:
  - FLEXIBILITY
  - LONG-TERM MONITORING
  - IN SITU TRANSPORT TESTING
  - BOUNDARIES OF CHn BARRIER

SUMMARY OF GEO TECHNICAL INPUTS
VOI STUDY AND MUA

- AQUEOUS RELEASES LIKELY TO BE << EPA LIMITS (EXPECTED R $\approx 1.5 \times 10^{-4}$)
- RELATIVE IMPACT ($\Delta R/R$) FROM TESTING IS LIKELY TO BE A SMALL FRACTION OF TOTAL RELEASES
- THEREFORE, MAXIMUM INCREMENTAL RISK IS SMALL IN ABSOLUTE TERMS (EXPECTED $\Delta R \leq 2 \times 10^{-5}$)
- MULTIPLE BARRIERS CONTRIBUTE SIMILAR PERFORMANCE
- SCIENTIFIC CONFIDENCE CAN BE ACHIEVED WITH LESS THAN THE MAXIMUM REASONABLE "LOOK"
- CONFIDENCE ACCUMULATES AS MORE FEATURES ARE EXPLORED
- COMPARING TEST LIKELIHOOD (VOI) AND SCIENTIFIC CONFIDENCE (MUA):

TEST ACCURACY ASSESSMENT COMBINED SCIENTIFIC CONFIDENCE + SUCCESS IN CONVEYING THIS IN THE PUBLIC ARENA; WHEREAS THE MUA TREATED THESE SEPARATELY

U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

YUCCA MOUNTAIN
SITE CHARACTERIZATION
PROJECT

CALICO HILLS RISK/BENEFIT ANALYSIS
MULTIATTRIBUTE UTILITY ANALYSIS - DESCRIPTION AND RESULTS

PRESENTED AT

DOE/NRC MEETING ON
CALICO HILLS RISK/BENEFIT ANALYSIS
AND ESF ALTERNATIVES STUDY

PRESENTED BY

DR. JOHN LATHROP
DIRECTOR,
STRATEGIC INSIGHTS

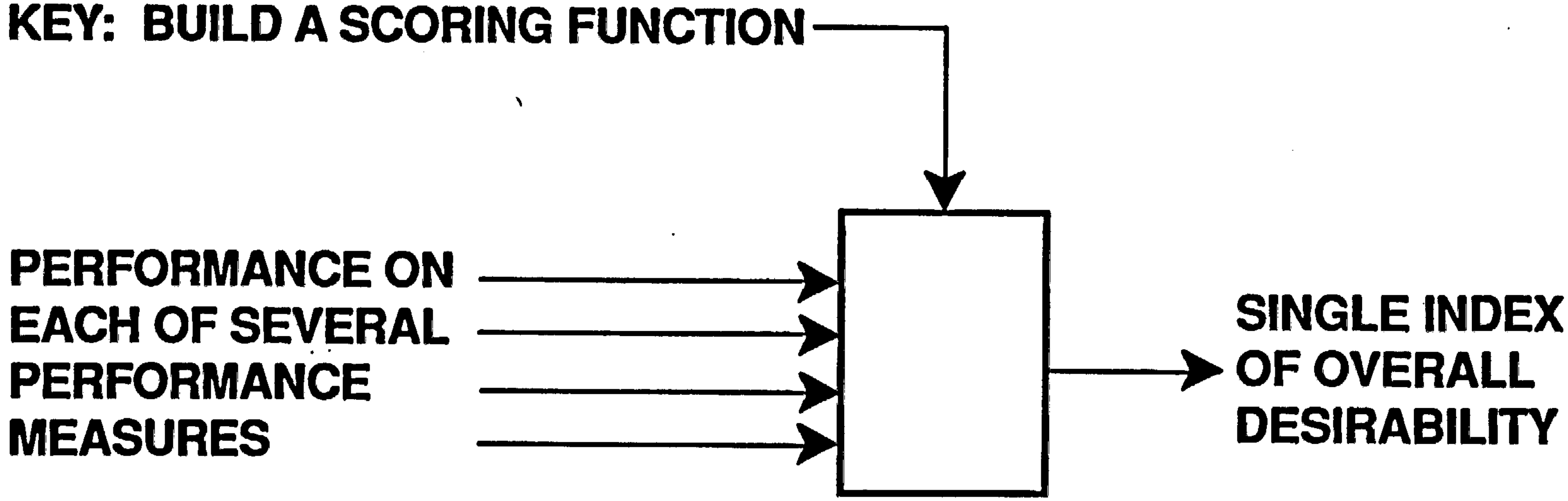
JANUARY 29-31, 1991

Attachment 10

WHAT IS MULTIATTRIBUTE UTILITY ANALYSIS ?

IT IS A METHODOLOGY TO EVALUATE ALTERNATIVE ACTIONS BY HOW WELL EACH ACTION SATISFIES EACH OF SEVERAL OBJECTIVES, AS INDICATED BY SEVERAL PERFORMANCE MEASURES

KEY: BUILD A SCORING FUNCTION



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SEVEN STEPS TO A MULTIATTRIBUTE UTILITY ANALYSIS

1. DEFINE OBJECTIVES, PERFORMANCE MEASURES
2. IDENTIFY PEOPLE WHOSE OPINIONS ARE TO BE INCORPORATED INTO THE EVALUATION
3. ASK VALUE ELICITATION QUESTIONS
4. FIT A SCORING FUNCTION TO THE ANSWERS
5. APPLY SCORING FUNCTION TO DATA SET
6. CONDUCT SENSITIVITY ANALYSES
7. INTERPRET RESULTS

KEY FEATURES OF MULTIATTRIBUTE UTILITY ANALYSIS (MUA)

- CAN USE SUBJECTIVE PERFORMANCE MEASURES
- CAN USE SUBJECTIVE EVALUATION ALONG EACH MEASURE
- CAN USE SUBJECTIVE EVALUATION TRADEOFFS BETWEEN MEASURES
- STRUCTURES EXPERT JUDGMENT, INCLUDING SUBJECTIVE EXPERT JUDGMENT, INTO A FORMALLY CORRECT, DEFENSIBLE ANALYSIS

WHY USE MUA HERE?

- TEST STRATEGIES VARY ON SEVERAL DIFFERENT PERFORMANCE MEASURES
- EVALUATION ALONG EACH OF THE MEASURES INVOLVES EXPERT SUBJECTIVE JUDGMENT
- EVALUATION TRADEOFFS AMONG THE MEASURES INVOLVES EXPERT SUBJECTIVE JUDGMENT

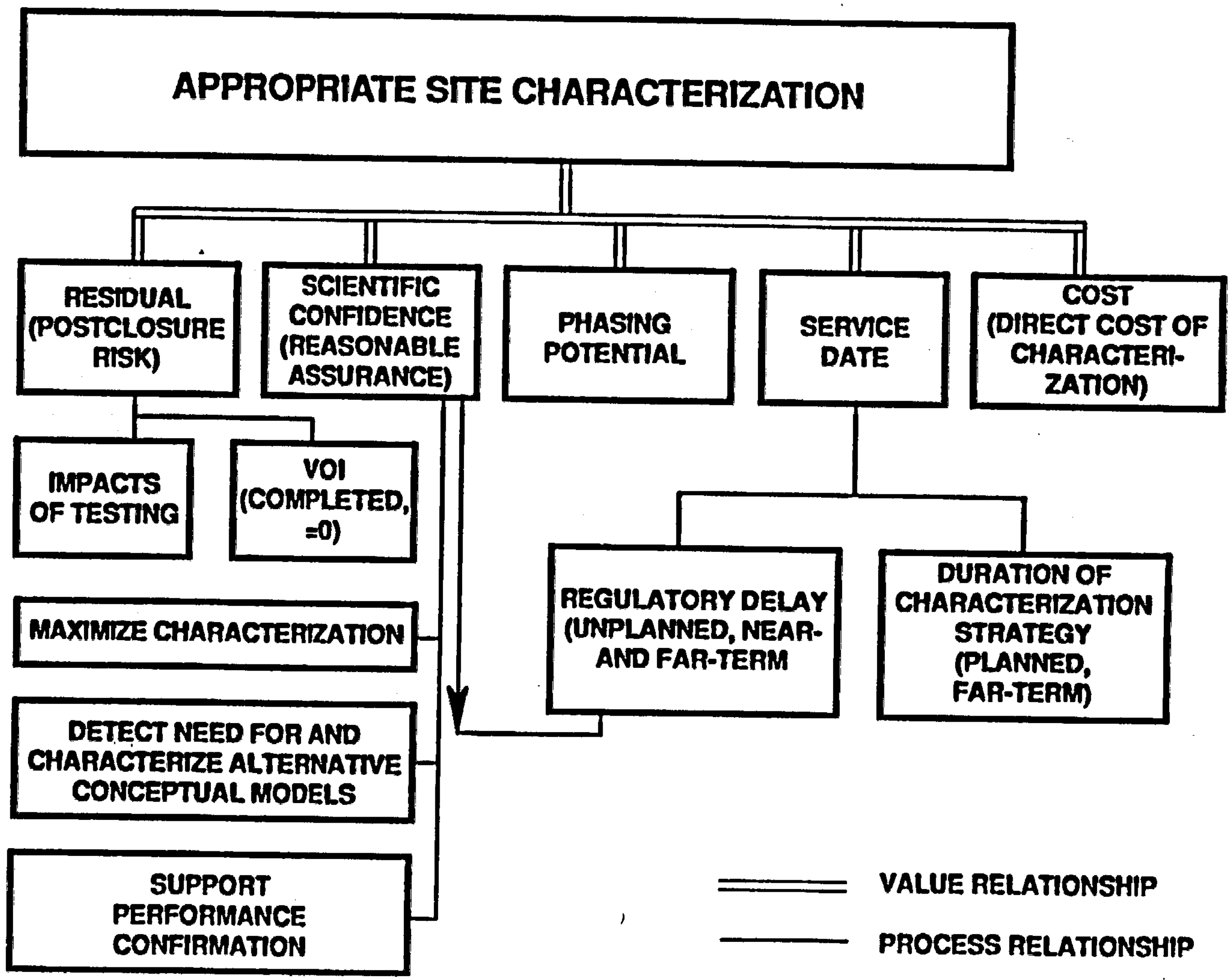
MUA VERSUS VOI

- THE TWO ANALYSES MEASURE DIFFERENT ASPECTS OF THE STRATEGIES
- VOI EVALUATES TEST STRATEGIES IN TERMS OF HOW TEST DATA WOULD AFFECT PERFORMANCE (RELEASE RISK, COSTS) BY AFFECTING MANAGEMENT/ DESIGN DECISIONS, i.e., HOW TEST DATA WOULD HELP THE DOE MAKE BETTER DECISIONS
- MUA EVALUATES TEST STRATEGIES IN TERMS OF SEVERAL PERFORMANCE MEASURES (RELEASE RISK, COST, SCIENTIFIC CONFIDENCE, DELAY, PHASING POTENTIAL), IN A WAY NOT TIED TO HOW THE DATA AFFECTS SPECIFIC DECISIONS

MUA VERSUS VOI
(CONTINUED)

- THE VOI ANALYSIS FOUND NO VOI IN ANY STRATEGY (SINCE NO DATA WOULD AFFECT ANY DECISION)
- THE MUA FOUND DIFFERENCES IN NET BENEFIT AMONG THE STRATEGIES
- THESE FINDINGS ARE <u>NOT</u> IN CONFLICT

ISSUES/OBJECTIVES/MODEL HIERARCHY



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ELEMENTS OF A MULTIATTRIBUTE UTILITY FUNCTION

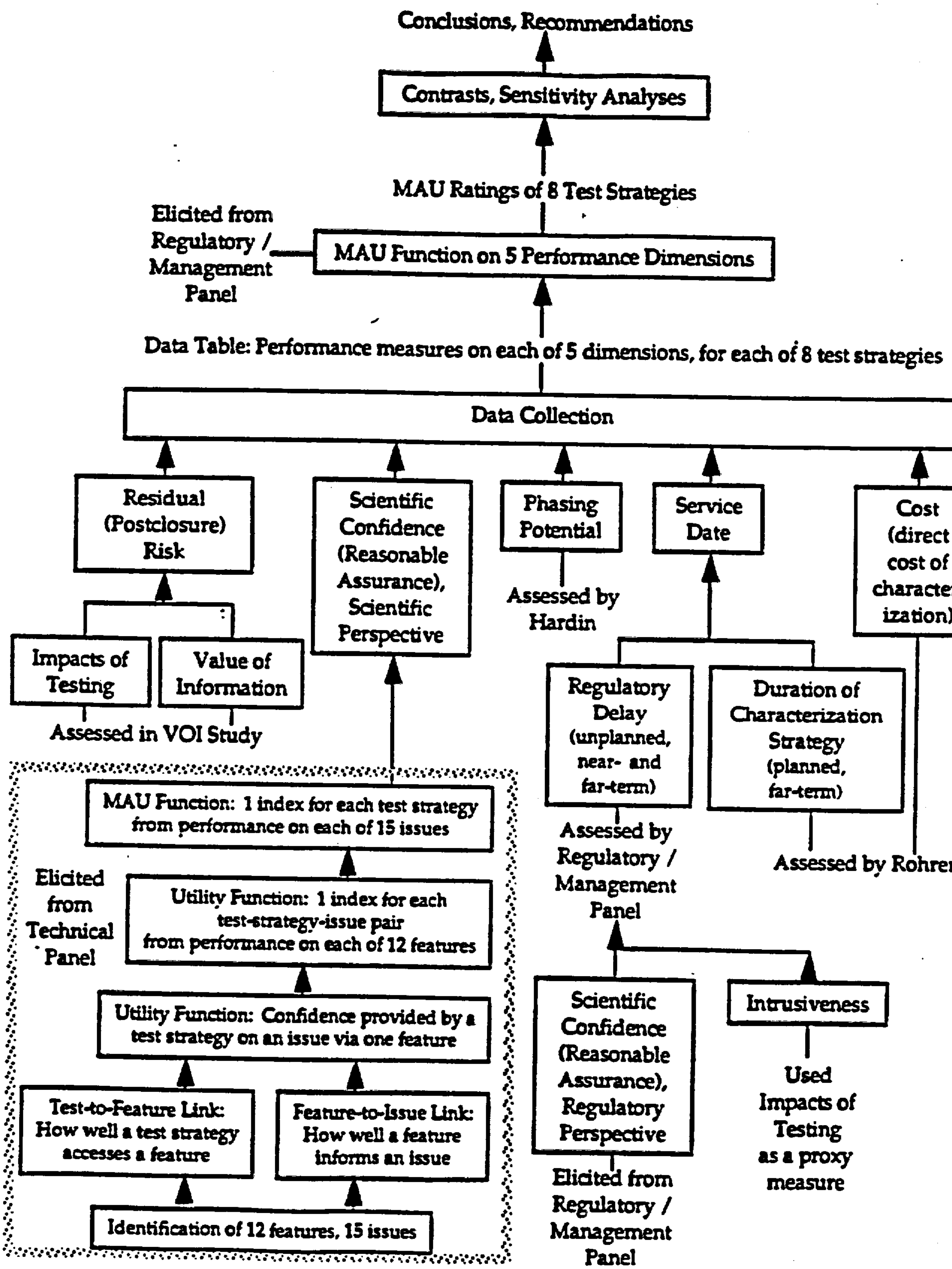
$$U(\text{ALTERNATIVE}) = k_1u_1(x_1) + k_2u_2(x_2) + k_3u_3(x_3) + \text{etc.} +, \text{ PERHAPS, INTERACTION TERMS}$$

x_i = PERFORMANCE ON iTH DIMENSION

u_i = UTILITY FUNCTION, REPRESENTING CHANGING MARGINAL UTILITY, ATTITUDE TOWARD RISK

k_i = IMPORTANCE WEIGHT, REPRESENTING RELATIVE VALUE TRADEOFFS

FLOWCHART OF THE COMPLETE MUA ANALYSIS



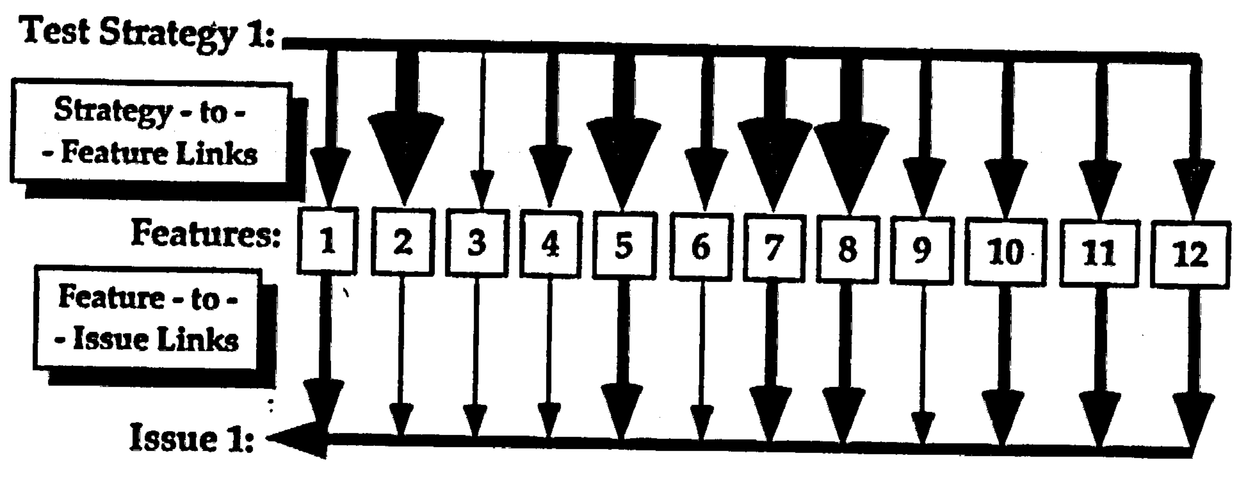
DEFINITIONS OF SCIENTIFIC CONFIDENCE

- DEGREE TO WHICH CCDF APT TO REMAIN UNCHANGED IN RESPONSE TO FUTURE DATA, OTHER THAN EXPECTED RESOLUTION OF UNCERTAINTY
- DEMONSTRATED ABILITY TO PREDICT BEHAVIOR OF THE SYSTEM
- UNDERSTANDING: ABILITY TO INTERPRET DATA WITHIN A CONSISTENT CONCEPTUAL FRAMEWORK
- UNDERSTANDING: ABILITY TO ANSWER QUESTIONS THAT MAY BE RAISED IN LICENSING
- INVOLVEMENT OF RECOGNIZED EXPERTISE
- REASONABLE ASSURANCE

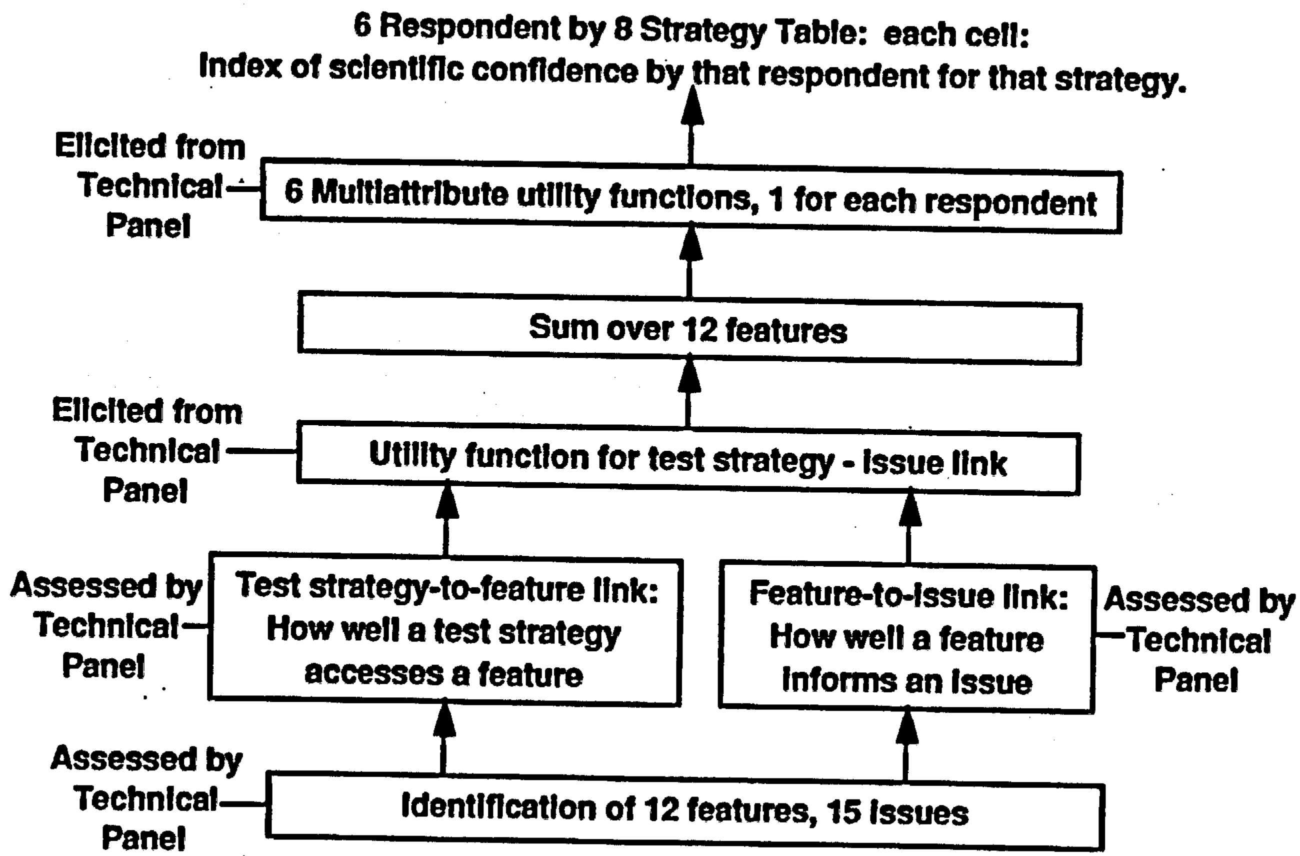
OUR OPERATIONAL DEFINITION OF SCIENTIFIC CONFIDENCE:

- SCIENTIFIC CONFIDENCE IS INCREASED BY DATA COLLECTION
- NOT JUST ANY DATA, BUT DATA THAT ADDRESSES ANY OF FIFTEEN SPECIFIC ISSUES

RELATIONSHIP BETWEEN TEST STRATEGIES, FEATURES, AND ISSUES



FLOWCHART OF SCIENTIFIC CONFIDENCE MUA



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UTILITY FUNCTION FOR TEST-ISSUE LINK

Feature-Issue Link:	Test-Feature Link: 0	1	2	3
0	0	0	0	0
1	0	0.5	0.7	0.8
2	0	0.7	0.8	1

TEST STRATEGY 1 U
(SCIENTIFIC CONFIDENCE)

Feature: / Issue	1 A	2 B	3 C	4 D	5 E	6 F	7 G	8 H	9 I	10 J	11 K	12 L	Sum
MC-1	.8	.7	.5	.8	.8	.8	.8	1.0	.8	.7	.8	.8	9.3
MC-2	.8	.8	.7	1.0	1.0	.8	.8	1.0	.8	.7	.8	.8	10.0
MC-3	.8	.7	.5	.8	.8	.8	.8	1.0	.8	.7	.8	1.0	9.5
MC-4	.8	.8	.7	1.0	1.0	.7	.7	.8	.7	.7	.7	.8	9.4
ACM-1	.8	.7	.5	.8	.8	.8	.8	1.0	.8	.7	.8	.8	9.3
ACM-2	.7	.7	.5	.8	.8	.7	.8	1.0	.8	.7	.8	1.0	9.3
ACM-3	.8	.7	.7	1.0	1.0	.7	.0	.0	.0	.5	.8	.8	7.0
ACM-4	.7	.0	.5	.8	.8	.7	.7	.8	.8	.7	.7	.8	8.0
ACM-5	.8	.7	.5	.8	.8	.7	.8	1.0	.8	.7	.8	1.0	9.4
ACM-6	.7	.0	.5	.8	.8	.7	.8	1.0	.8	.0	.8	.8	7.7
ACM-7	.7	.7	.7	.8	1.0	.7	.7	.8	.7	.5	.7	.8	8.8
ACM-8	.7	.0	.0	.0	.8	.7	.7	.8	.7	.5	.7	.8	6.4
SPC-1	.8	.7	.5	.8	1.0	.7	.8	1.0	.8	.7	.7	1.0	9.5
SPC-2	.7	.7	.0	.0	.8	.7	.7	.8	.7	.5	.7	.0	6.3
SPC-3	.7	.7	.5	.8	.8	.7	.7	.8	.7	.5	.7	.8	8.4

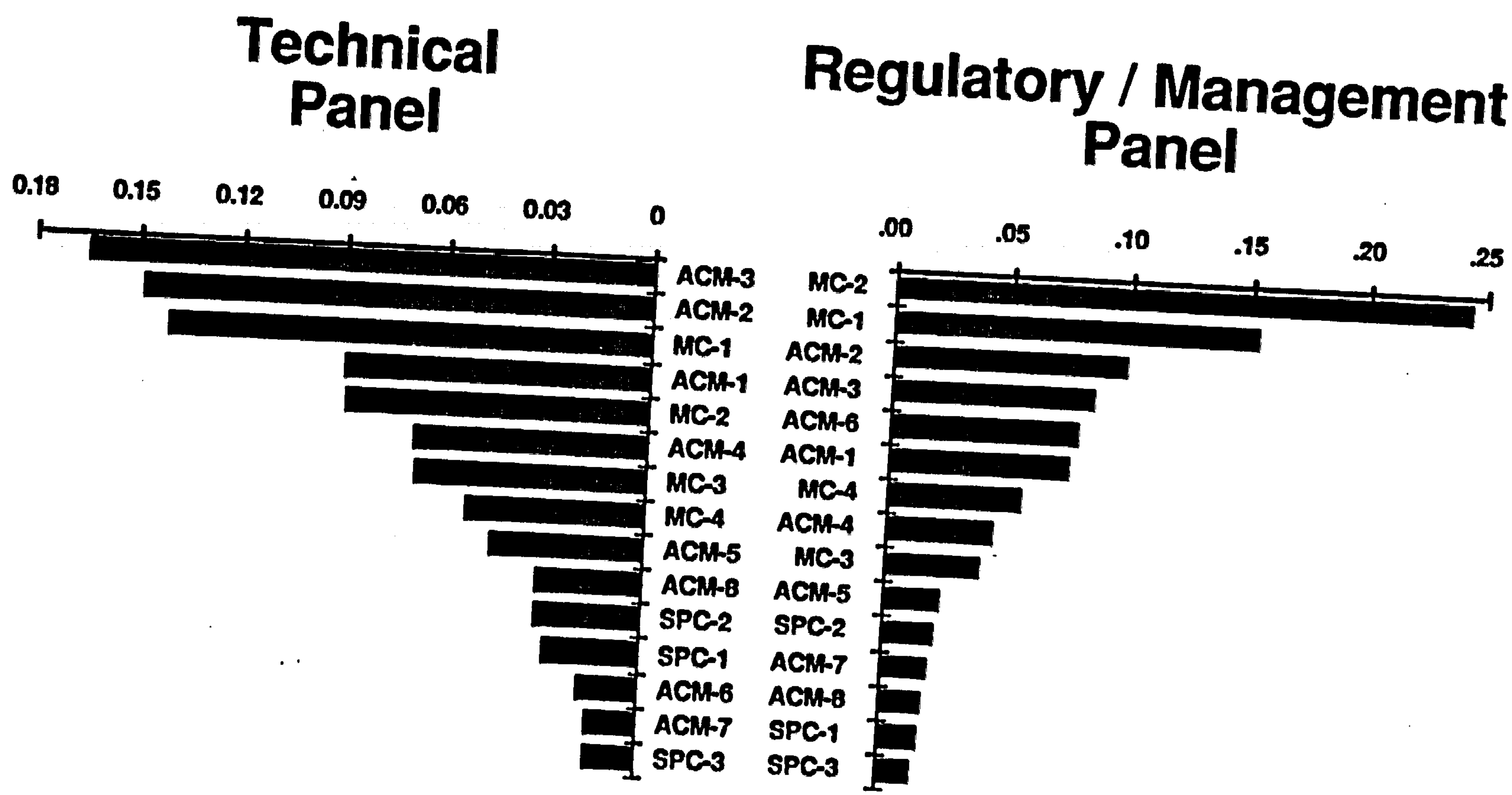
TEST STRATEGY 2 U
(SCIENTIFIC CONFIDENCE)

Feature: / Issue	1 A	2 B	3 C	4 D	5 E	6 F	7 G	8 H	9 I	10 J	11 K	12 L	Sum
MC-1	1.0	.7	.7	.0	.7	1.0	1.0	1.0	1.0	1.0	1.0	.0	9.1
MC-2	1.0	.8	.8	.0	.8	1.0	1.0	1.0	1.0	1.0	1.0	.0	9.4
MC-3	1.0	.7	.7	.0	.7	1.0	1.0	1.0	1.0	1.0	1.0	.0	9.1
MC-4	1.0	.8	.8	.0	.8	.8	.8	.8	.8	1.0	.8	.0	8.4
ACM-1	1.0	.7	.7	.0	.7	1.0	1.0	1.0	1.0	1.0	1.0	.0	9.1
ACM-2	.8	.7	.7	.0	.7	.8	1.0	1.0	1.0	1.0	1.0	.0	8.7
ACM-3	1.0	.7	.8	.0	.8	.8	.0	.0	.0	.8	1.0	.0	5.9
ACM-4	.8	.0	.7	.0	.7	.8	.8	.8	1.0	1.0	.8	.0	7.4
ACM-5	1.0	.7	.7	.0	.7	.8	1.0	1.0	1.0	1.0	1.0	.0	8.9
ACM-6	.8	.0	.7	.0	.7	.8	1.0	1.0	1.0	.0	1.0	.0	7.0
ACM-7	.8	.7	.8	.0	.8	.8	.8	.8	.8	.8	.8	.0	7.9
ACM-8	.8	.0	.0	.0	.7	.8	.8	.8	.8	.8	.8	.0	6.3
SPC-1	1.0	.7	.7	.0	.8	.8	1.0	1.0	1.0	1.0	.8	.0	8.8
SPC-2	.8	.7	.0	.0	.7	.8	.8	.8	.8	.8	.8	.0	7.0
SPC-3	.8	.7	.7	.0	.7	.8	.8	.8	.8	.8	.8	.0	7.7

ISSUE WEIGHTS FOR SCIENTIFIC CONFIDENCE

Technical Panel			Regulatory / Management Panel		
Short Name	Av'g Wt.	Issue	Issue	Av'g Wt.	Short Name
Fault System	.16	ACM-3	MC-2	.24	Flexibility
Fracture / Matrix System	.15	ACM-2	MC-1	.15	Statistical Characterization
Statistical Characterization	.14	MC-1	ACM-2	.10	Fracture / Matrix System
Spatial Variability	.09	ACM-1	ACM-3	.09	Fault System
Flexibility	.09	MC-2	ACM-6	.08	Water Table Instability
Lateral Flow	.07	ACM-4	ACM-1	.08	Spatial Variability
In Situ Active Testing	.07	MC-3	MC-4	.06	Boundary Conditions
Boundary Conditions	.05	MC-4	ACM-4	.05	Lateral Flow
Retardation	.04	ACM-5	MC-3	.04	In Situ Active Testing
Man-Caused Rock Changes	.03	ACM-8	ACM-5	.02	Retardation
Passive Mon'g: Man-Caused Eff's	.03	SPC-2	SPC-2	.02	Passive Mon'g: Man-Caused Eff's
Long-Term Active Monitoring	.03	SPC-1	ACM-7	.02	Natural-Cause Rock Changes
Water Table Instability	.02	ACM-6	ACM-8	.02	Man-Caused Rock Changes
Natural-Cause Rock Changes	.01	ACM-7	SPC-1	.02	Long-Term Active Monitoring
Accomodate Other's Requests	.01	SPC-3	SPC-3	.02	Accomodate Other's Requests

ISSUE WEIGHTS FOR SCIENTIFIC CONFIDENCE



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UTILITY TRANSFORM OF TABLE 2.6.2.2.1-7
UTILITY OF RESPONDENT A

ISSUE	TEST STRATEGY: 1	2	3	4	5	6	7	8	A WT.
MC-1	1.06	1.02	.24	.06	1.02	.34	.92	.58	.05
MC-2	1.00	.89	.16	.00	.89	.29	.87	.55	.01
MC-3	1.10	1.02	.24	.06	1.02	.38	.96	.60	.15
MC-4	1.05	.93	.55	.00	.93	.58	.97	.76	.05
ACM-1	1.06	1.02	.24	.06	1.02	.34	.92	.58	.20
ACM-2	1.03	.97	.50	.06	.97	.63	.94	.73	.05
ACM-3	1.00	.73	.28	.08	.73	.15	.88	.60	.19
ACM-4	1.00	.90	.41	.33	.90	.45	.90	.62	.15
ACM-5	1.08	.98	.20	.02	.98	.38	.94	.56	.03
ACM-6	.95	.82	.15	.12	.82	.35	.84	.51	.02
ACM-7	1.05	.89	.32	.06	.89	.33	.89	.57	.01
ACM-8	.93	.92	.62	.10	.92	.57	.86	.66	.03
SPC-1	1.10	.96	.20	-.02	.96	.34	.94	.54	.03
SPC-2	.92	1.00	.71	.10	1.00	.59	.83	.64	.03
SPC-3	.98	.86	.30	.03	.86	.30	.84	.53	.01
									1.00
MAU =	1.04	.927	.317	.098	.927	.365	.913	.607	
ULE =	8.49	7.92	4.75	3.81	7.92	4.96	7.84	6.24	

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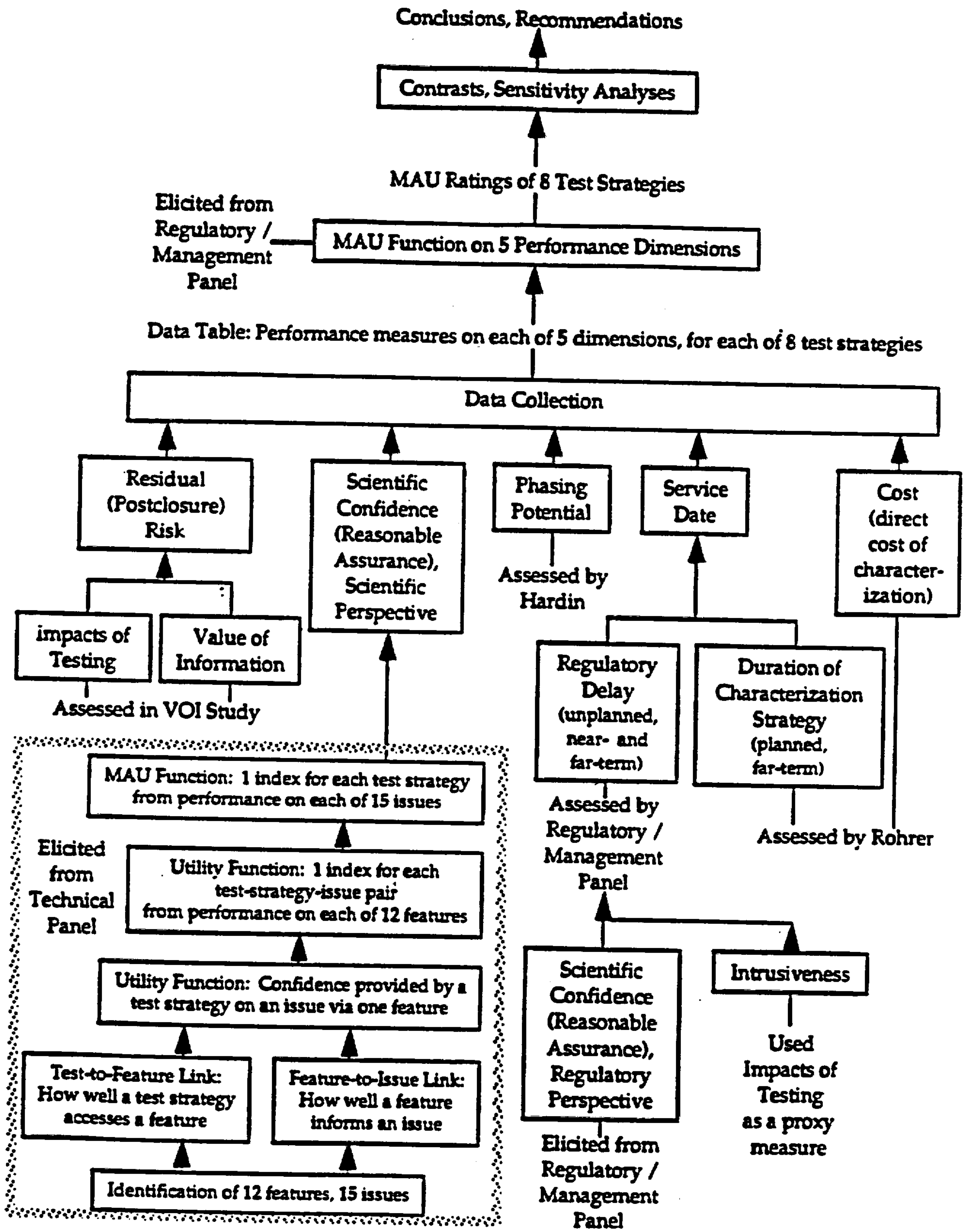
SCIENTIFIC CONFIDENCE RESULTS

Equivalent Number of Maximum-Strong Looks at Every One of the 15 Issues								Root Sum Squared Difference From:	
Strategy: / Respondent	1	2,5	3	4	6	7	8	Average	D
A	8.5	7.9	4.8	3.8	5.0	7.8	6.2	.31	1.65
B	8.7	8.3	4.8	3.8	5.1	8.0	6.2	.32	2.17
C	9.2	8.7	5.0	3.9	5.5	8.5	6.7	1.32	3.24
D	7.9	7.0	4.7	3.9	4.7	7.3	5.9	1.93	.00
E	9.2	8.7	5.0	3.9	5.4	8.5	6.7	1.26	3.18
F	8.4	7.7	4.7	3.8	4.9	7.8	6.2	.59	1.38
Average:	8.6	8.0	4.8	3.9	5.1	8.0	6.3	.95	1.94

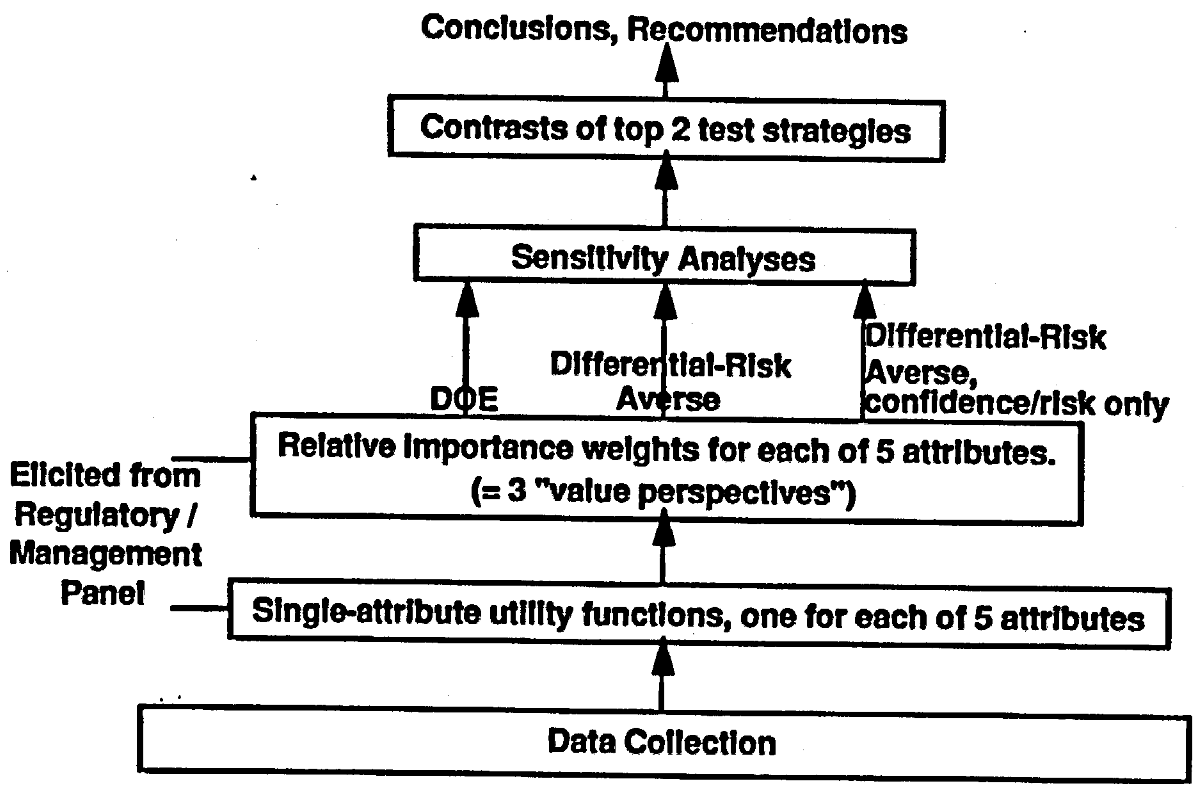
SCIENTIFIC CONFIDENCE RESULTS: RANK ORDERS

Strategy: / Respondent	1	2,5	3	4	6	7	8
A	1	2	6	7	5	3	4
B	1	2	6	7	5	3	4
C	1	2	6	7	5	3	4
D	1	3	6	7	5	2	4
E	1	2	6	7	5	3	4
F	1	3	6	7	5	2	4
Average:	1	2	6	7	5	3	4

FLOWCHART OF THE COMPLETE MUA ANALYSIS



FLOWCHART OF FIVE-ATTRIBUTE MUA



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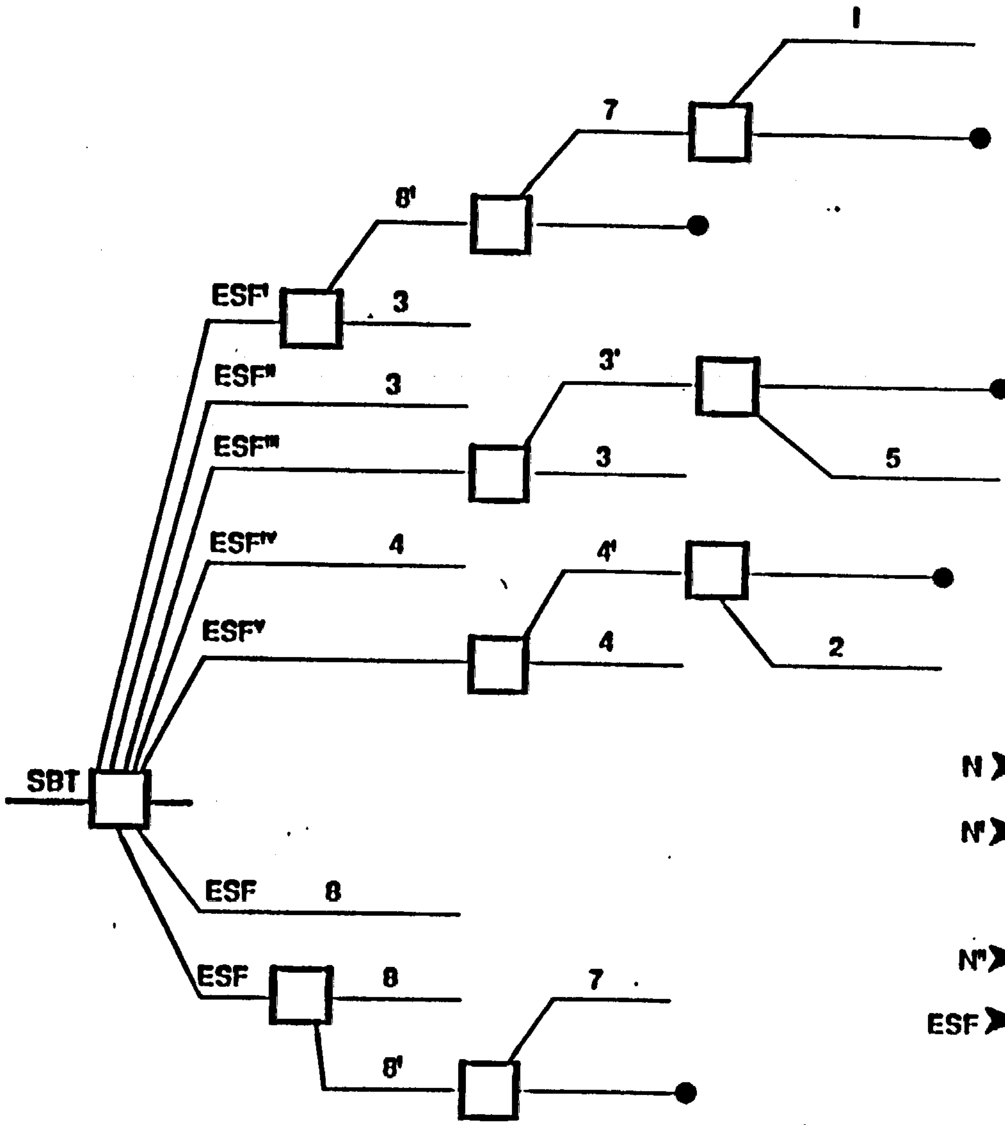
PHASING DIAGRAM WITH INITIAL SBT



N ➤ CHSTRATEGY N

N' ➤ UNIQUE IMPLEMENTATION OF ESF OR STRATEGY N W/ CAPABILITY FOR SPECIFIC ADDITIONAL ACTIVITIES

N'' ➤ ANOTHER UNIQUE IMPLEMENTATION....

ESF ➤ EXPLORATORY SHAFT FACILITY

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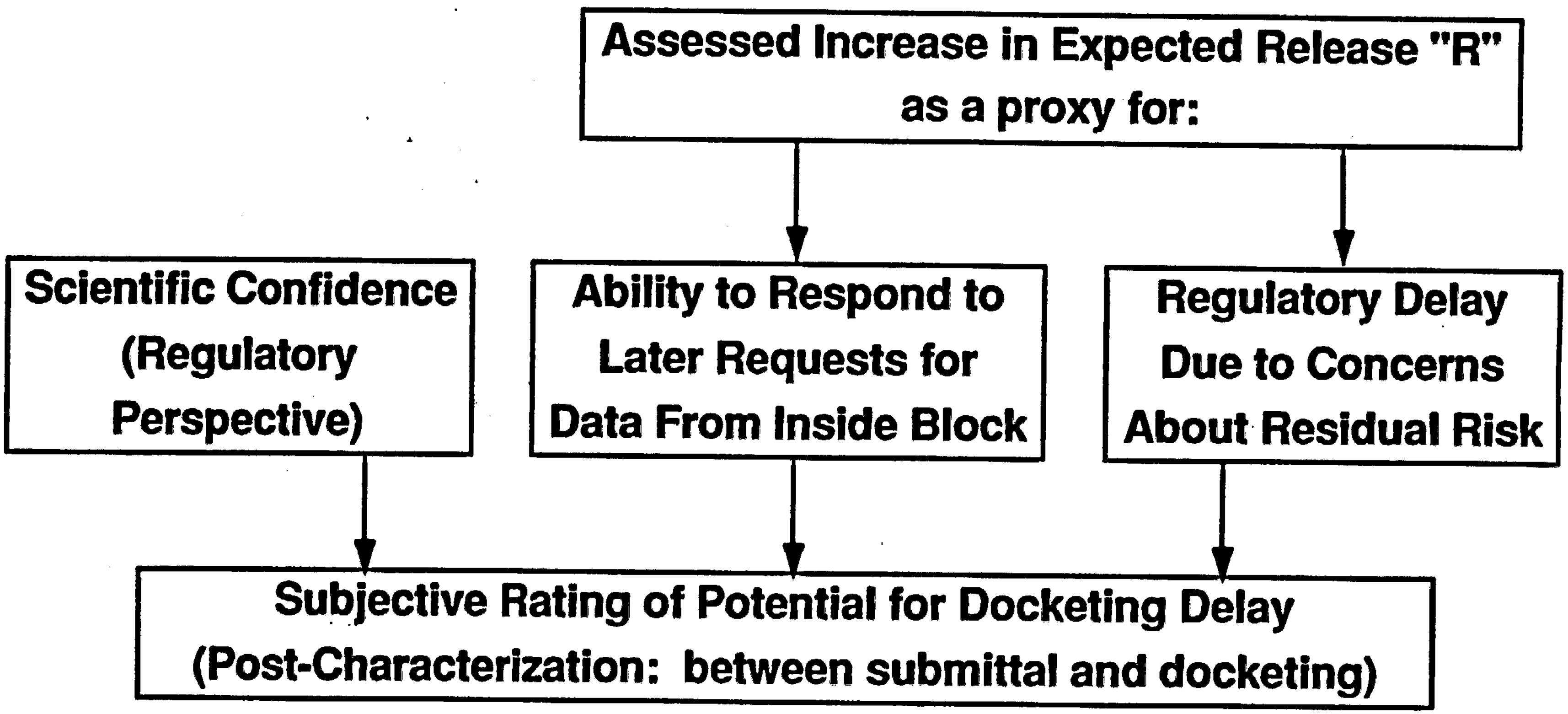
FLOWCHART FOR DELAY SCALE JUDGMENTS



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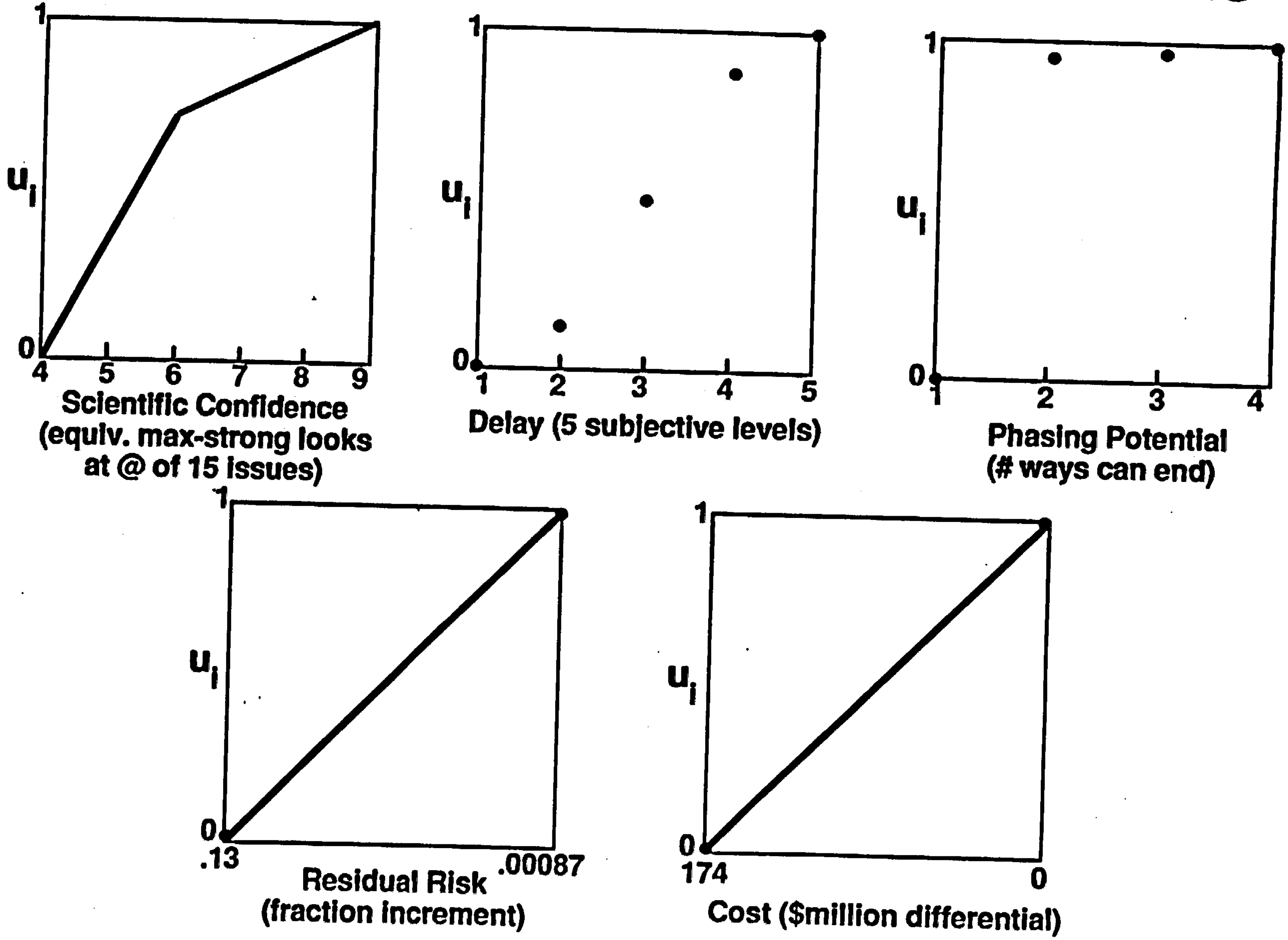
DELAY DATA, SCALE:

Delay Scale Level	Test Strategy	Scientific Confidence (Reg/Mgmt Perspect'v)	Two Minimum-Confidence Issues		Risk Concern and In-Block Flexibility (change in R as a proxy)	
5	2,5	8.4	5.9	6.3	2E-5	13%
4	1	8.9	6.3	6.4	5E-6	3%
3	3	4.8	3.5	3.8	4E-6	3%
3	7	8.2	5.5	5.8	2E-7	<1%
3	4	4.0	2.2	2.2	4E-6	2%
2	8	6.5	3.9	4.1	1E-7	<1%
1	6	5.3	3.5	3.5	3E-6	2%

DIRECT PERFORMANCE DATA

STRATEGY:	1	2,5	3	4	6	7	8	UNITS
SCI CONF'C:								
BASE CASE	8.6	8.0	4.8	3.9	5.1	8.0	6.3	EQUIVALENT NUMBER OF "MAXIMUM-STRONG LOOKS" AT EVERY ONE OF 15 ISSUES
SENS ANL 1	7.9	7.0	4.7	3.9	4.7	7.3	5.9	
SENS ANL 2	9.2	8.7	5.0	3.9	5.5	8.5	6.7	
RESID RISK	.031	.13	.028	.023	.020	.0011	.00087	FRACTION INCREMENT
DELAY	4	5	3	3	1	3	2	LEVELS DEFINED IN TEXT
COST	174	116	52	52	0	113	78	[redacted] $MM DIFFERENTIAL
PHASING	4	2	1	1	1	3	2	NUMBER OF OPTIONS

SINGLE-ATTRIBUTE UTILITY FUNCTIONS



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WEIGHTS ON THE FIVE ATTRIBUTES, FROM THREE PERSPECTIVES

DOE Perspective

Attribute	Respondent: A	B	C	D	E	F	G	Average
Confidence	.45	.47	.42	.61	.36	.35	.44	.44
Resid Risk	.05	.06	.10	.03	.05	.06	.06	.06
Delay	.22	.23	.19	.25	.29	.23	.28	.24
Cost	.19	.15	.19	.08	.23	.29	.15	.18
Phasing	.09	.08	.10	.04	.07	.07	.07	.07

Differential-Risk Averse Perspective

Attribute	Respondent: A	B	C	D	E	F	G	Average
Confidence	.50	.41	.37	.47	.41		.33	.42
Resid Risk	.35	.39	.37	.19	.28		.42	.33
Delay	.08	.13	.18	.22	.26		.15	.17
Cost	.04	.05	.04	.07	.04		.08	.05
Phasing	.04	.02	.03	.04	.01		.02	.03

Differential-Risk Averse Perspective, Confidence and Risk Only

Attribute	Respondent: A	B	C	D	E	F	G	Average
Confidence	.57	.51	.50	.58	.58		.46	.53
Resid Risk	.43	.49	.50	.42	.42		.54	.47

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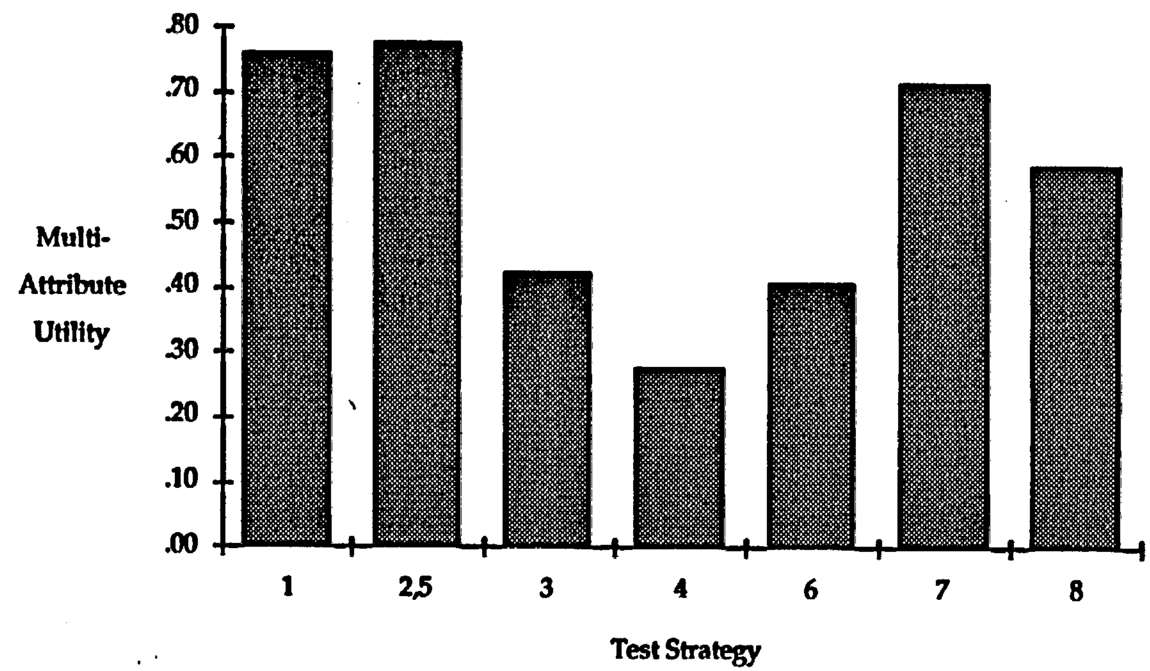
DOE PERSPECTIVE MULTIATTRIBUTE UTILITY



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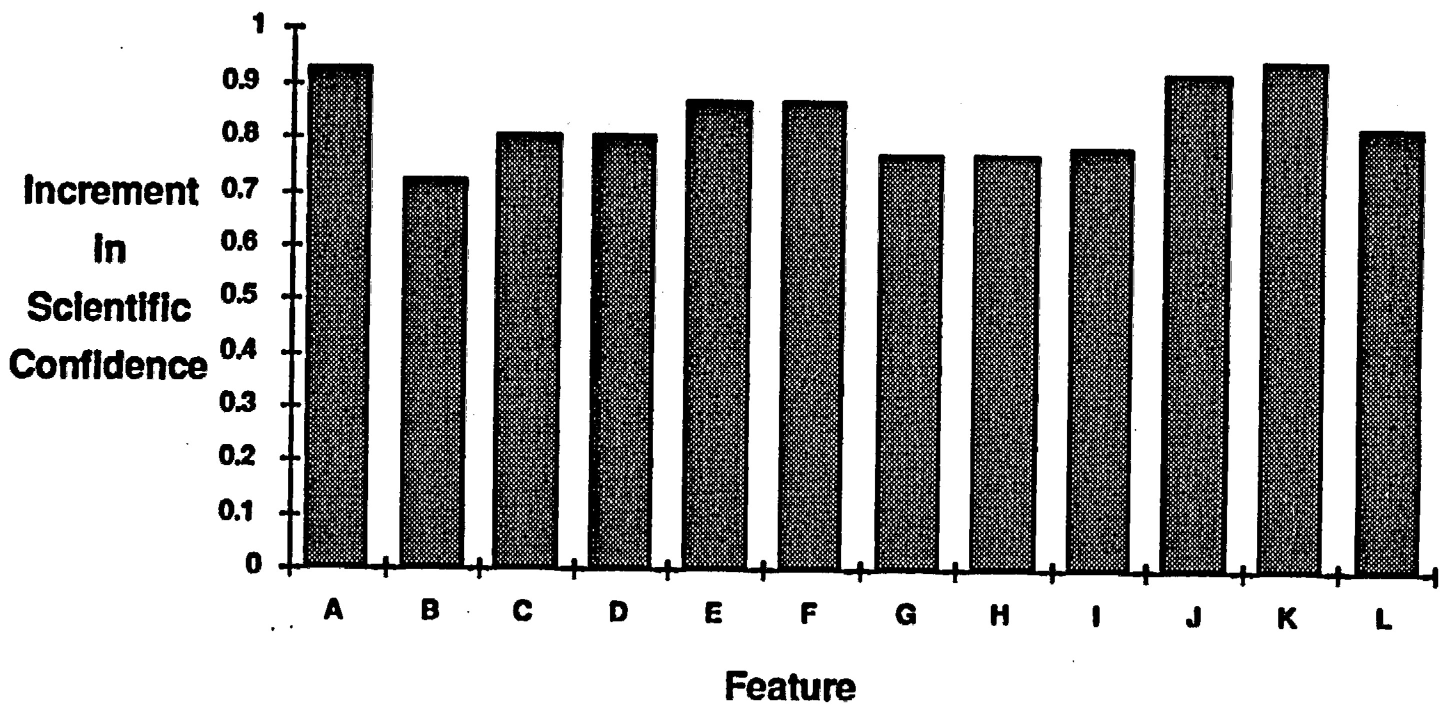
DOE PERSPECTIVE MAU RANK ORDERS, CONFIDENCE BASE CASE

STRATEGY:		1	2,5	3	4	6	7	8
RESP'T:	A	2	1	5	7	6	3	4
	B	2	1	5	7	6	3	4
	C	1	3	6	7	5	2	4
	D	1	2	5	7	6	3	4
	E	2	1	5	7	6	3	4
	F	3	1	6	7	5	2	4
	G	2	1	5	7	6	3	4
AVERAGE:		2	1	5	7	6	3	4

SCIENTIFIC CONFIDENCE PROVIDED BY EACH FEATURE



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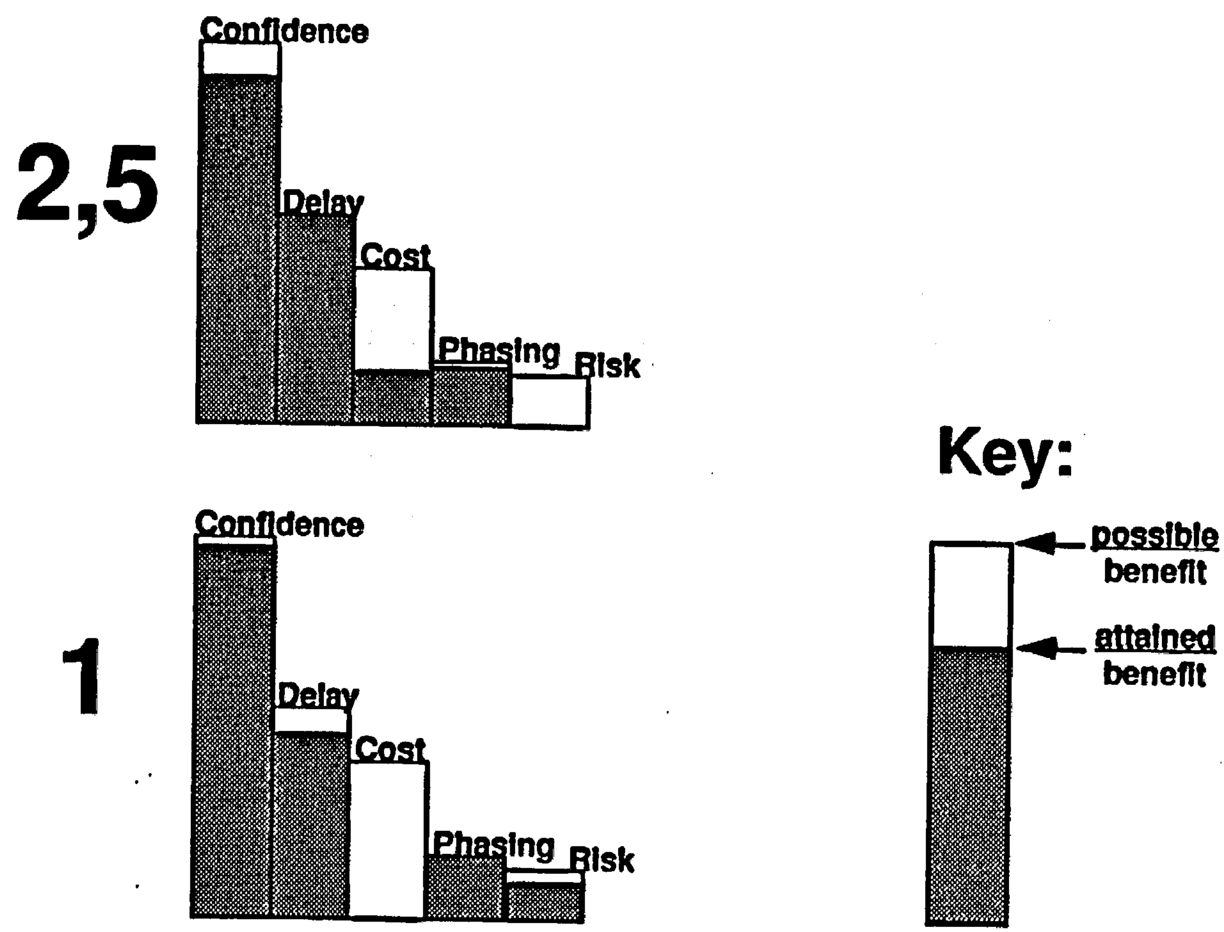
CONTRASTING TEST STRATEGIES 1 vs 2,5



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CONTRAST TABLE: STRATEGIES 2,5 vs 1

Attribute	Data 2,5	Data 1	Utility 2,5	Utility 1	Utility Diff'c	DOE Weight	Weight'd Differ'c
Confidence	8.0	8.6	.91	.97	-.05	.44	-.02
Delay	5	4	1.00	.88	.13	.24	.03
Cost	116	174	.33	.00	.33	.18	.06
Phasing	2	4	.95	1.00	-.05	.07	.00
Resid Risk	.13	.031	.00	.77	-.77	.06	-.05
						Sum=	.02

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DISCUSSION

GENERAL FINDINGS

- STRATEGY 2,5 IS THE MOST DESIRABLE OF THE EIGHT STRATEGIES CONSIDERED, BUT IT IS NOT MUCH MORE DESIRABLE THAN STRATEGY 1

- MORE GENERALLY, MORE EXCAVATION IN THE CALICO HILLS UNIT REPOSITORY BLOCK PROVIDES A NET BENEFIT COMPARED TO MINIMUM EXCAVATION THERE, CONSIDERING RISK, SCIENTIFIC CONFIDENCE, DELAY, COST AND PHASING POTENTIAL TOGETHER

- THE ROBUSTNESS OF THE RANKING OF STRATEGY 2,5 OVER STRATEGY 1 COULD BE INCREASED BY:
  - ADDING FEATURE ACCESSES TO STRATEGY 2,5
  - A MORE REFINED ELICITATION OF IMPORTANCE WEIGHTS

DISCUSSION

(CONTINUED)

QUALIFICATIONS TO FINDINGS

1) "DIFFERENTIAL-RISK-AVERSE PERSPECTIVE" RANKS STRATEGY 2,5 BELOW STRATEGIES 7, 1 AND 8

2) ADDING FEATURE ACCESSES TO STRATEGY 2,5 INCREASES THE ROBUSTNESS WITH WHICH IT IS RANKED OVER STRATEGY 1, THOUGH IT DOES NOT CHANGE THE DIFFERENTIAL-RISK-AVERSE PERSPECTIVE RANKING

3) THE RANKING RESULTS ARE ROBUST WITH RESPECT TO UNCERTAINTY IN SCIENTIFIC CONFIDENCE

DISCUSSION

(CONTINUED)

MORE GENERAL INSIGHTS

1. ACCESS TO EACH OF THE FEATURES PROVIDES A SIMILAR INCREMENT IN SCIENTIFIC CONFIDENCE, SO IN GENERAL, THE MORE FEATURES ACCESSED, THE BETTER

2. THE RELATIVE WEIGHT GIVEN TO RESIDUAL RISK AS ELICITED HERE (i.e., WITH A STRONG COMPONENT OF DIFFERENTIAL-RISK-AVERSION) IS CRITICAL TO THE RANKING OF ALTERNATIVE STRATEGIES, THOUGH A MORE REFINED ELICITATION WOULD PROBABLY REDUCE THAT SENSITIVITY

3. DELAY AND COST CONSIDERATIONS CAN BE JUST AS SIGNIFICANT AS RESIDUAL RISK AND SCIENTIFIC CONFIDENCE IN THE RANKING OF STRATEGIES, SO IT IS IMPORTANT TO CONSIDER AT LEAST THOSE FOUR ATTRIBUTES

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YUCCA MOUNTAIN

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

CALICO HILLS RISK/BENEFIT ANALYSIS IMPACT EVALUATION

PRESENTED AT

DOE/NRC MEETING ON CALICO HILLS RISK/BENEFIT ANALYSIS AND ESF ALTERNATIVES STUDY

PRESENTED BY

CHARLES F. VOSS

SENIOR ENGINEER

GOLDER ASSOCIATES, INC.

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

JANUARY 29-31, 1991

Attachment 11

INTRODUCTION

- THIS PRESENTATION WILL SUMMARIZE SOME OF THE REASONING, DESIGN INFORMATION, AND ANALYSES USED BY THE CHRBA IN ASSESSING THE POTENTIAL HYDROLOGIC IMPACT OF CHARACTERIZING THE CALICO HILLS UNIT VIA UNDERGROUND OPENINGS

- THESE INCLUDE:

  - TYPES OF IMPACTS CONSIDERED
  - DESIGN MEASURES FOR MITIGATING THE IMPACT
  - QUANTITATIVE MEASURES OF IMPACTS

APPROACH

- THE APPROACH USED TO ESTIMATE IMPACTS FROM UNDERGROUND OPENINGS IS BASED ON POTENTIAL CHANGES IN FLOW AND TRAVEL TIME THROUGH THE CHn

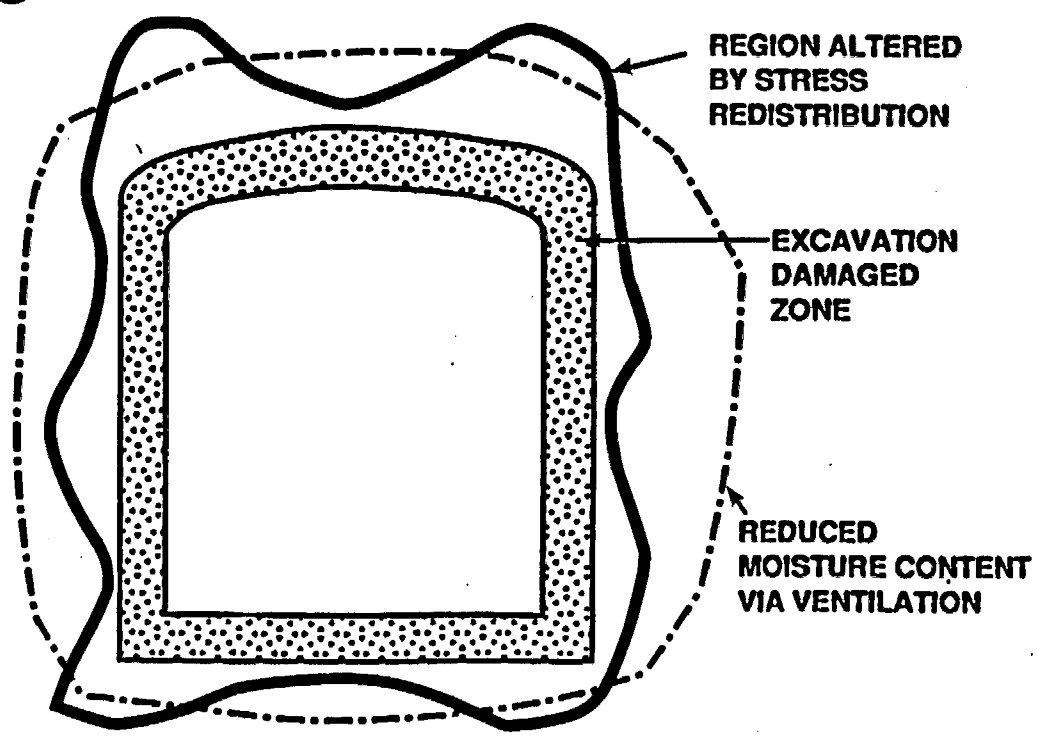
- THESE CHANGES MAY RESULT FROM:

  - ALTERED HYDROLOGIC CONDITIONS
  - CHANGES IN THE AMOUNT OR SPATIAL DISTRIBUTION OF FLUX
  - CREATION OF NEW PATHWAYS

ALTERED HYDROLOGIC CONDITIONS AND FLUX DISTRIBUTION

EXAMPLE:

THE EXCAVATION OF THE OPENINGS, STRESS REDISTRIBUTION, VENTILATION, ETC. WILL CHANGE THE HYDRAULIC PROPERTIES AND HYDROLOGIC CONDITIONS



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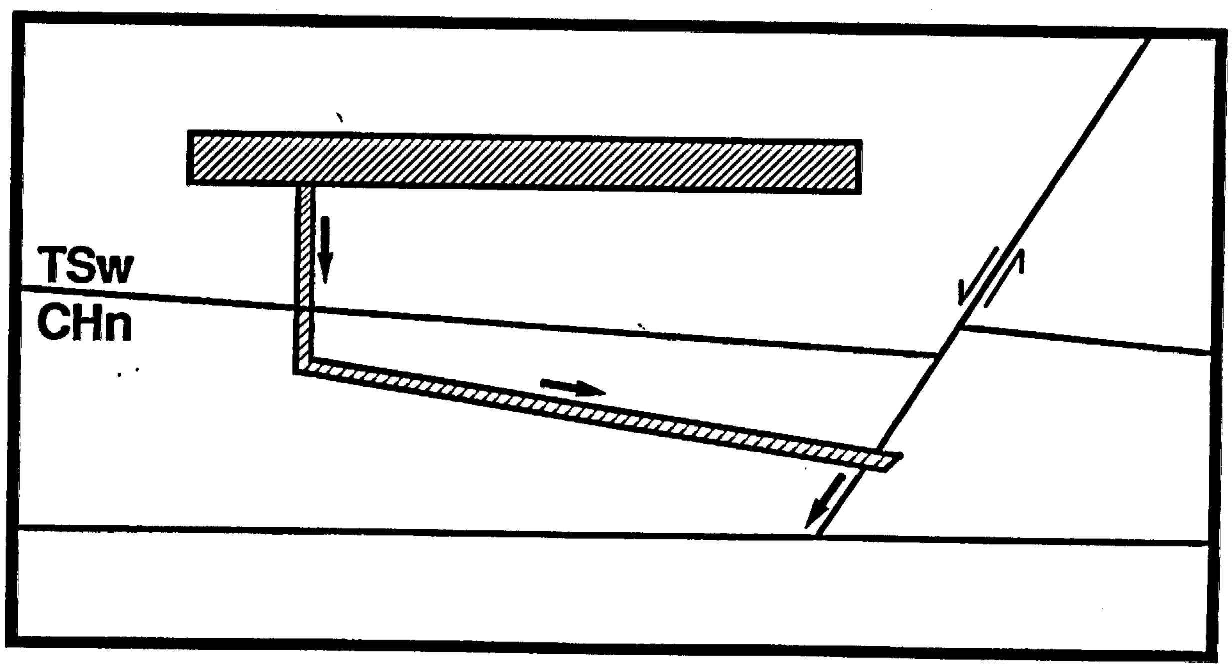
CREATION OF NEW PATHWAYS

EXAMPLE:

THE UNDERGROUND OPENINGS COULD BECOME PATHWAYS THROUGH SIGNIFICANT PORTIONS OF THE CALICO HILLS UNIT WITH FASTER TRAVEL TIMES THAN THE SURROUNDING ROCK

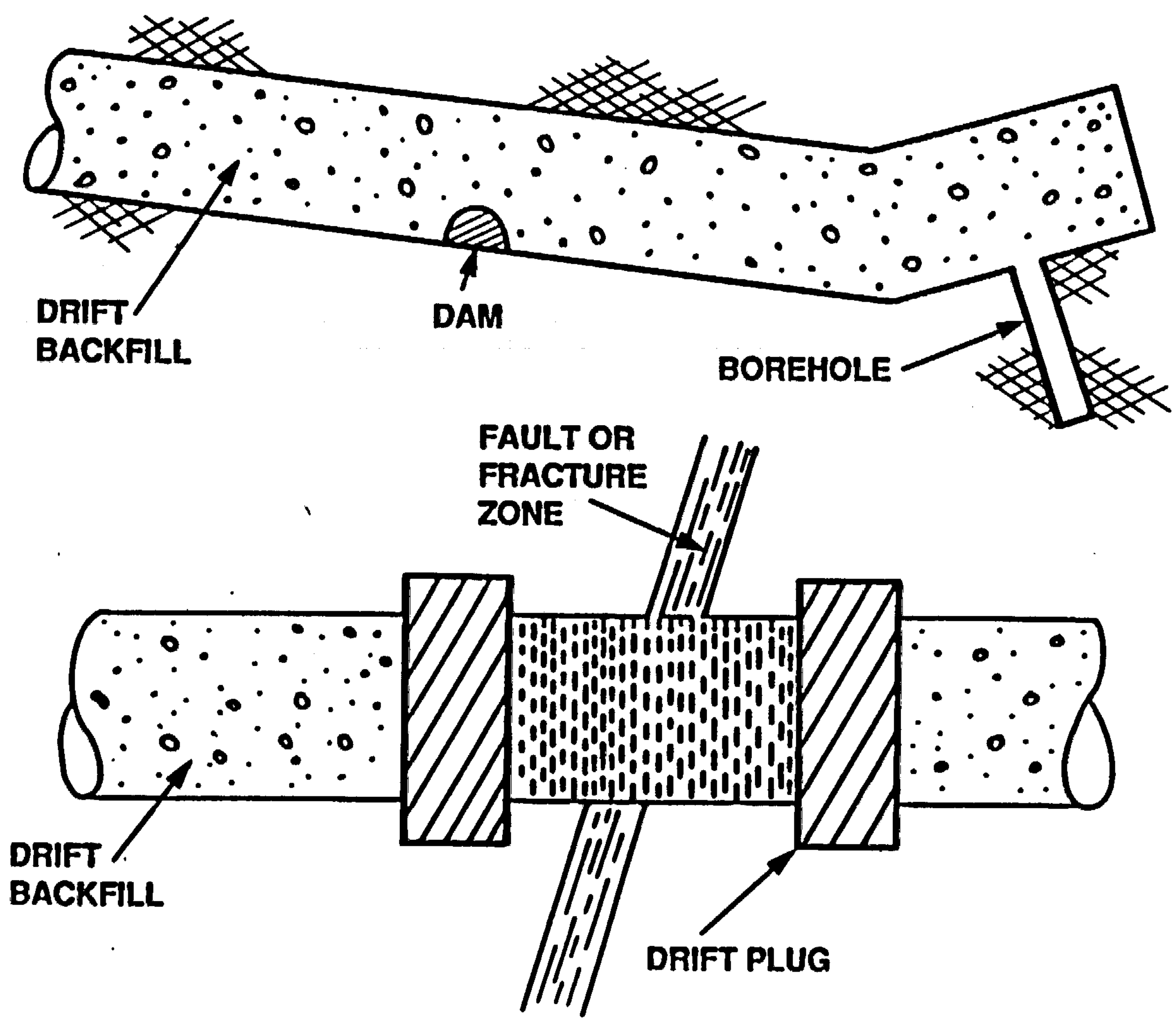


DESIGN MEASURES ARE AVAILABLE TO MITIGATE THE IMPACT

SOME EXAMPLES ARE:

- USE MECHANICAL METHODS TO EXCAVATE OPENINGS
- DESIGN OPENINGS TO MINIMIZE STRESSES
- EMPLOY STRUCTURES THAT MINIMIZE HYDRAULIC COMMUNICATION ALONG OPENING
- ISOLATE ADVERSE FEATURES

ENGINEERING MEASURES TO MITIGATE IMPACT



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QUANTITATIVE MEASURES OF IMPACT

- THE MEASURE OF IMPACT WAS BASED ON CHANGES IN FLOW AND TRAVEL THROUGH THE CHn UNIT BECAUSE OF THE EXCAVATIONS

- THE CALCULATIONS ARE BASED ON CONSERVATIVE ASSUMPTIONS FOR THE INFLUENCE OF EXCAVATIONS, BACKFILL CONDUCTIVITY, SEALING, FLOW PATHS, AND OPENING GEOMETRY

TWO CONCEPTUAL MODELS WERE CONSIDERED:

- DISTRIBUTED FLOW CONDITIONS

- CONCENTRATED FLOW CONDITIONS

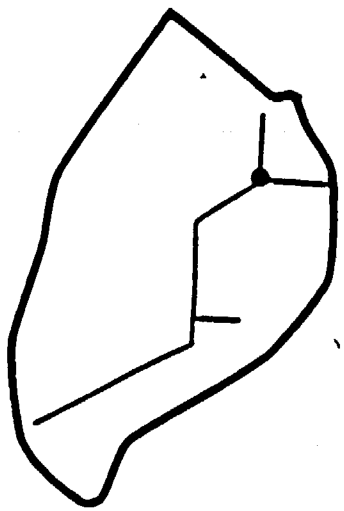
DISTRIBUTED FLOW CONDITIONS

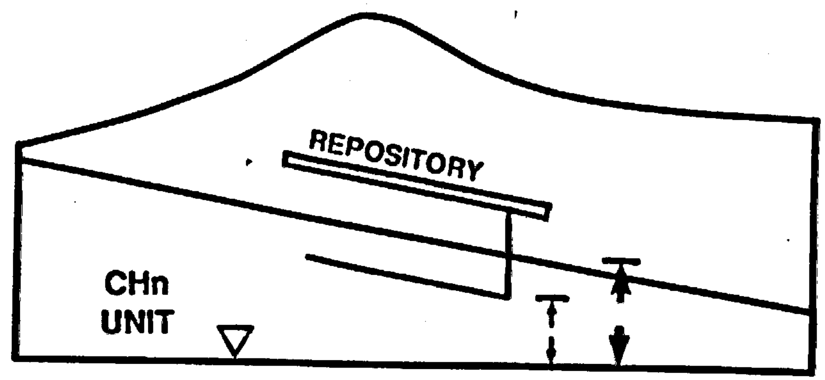
- PERTAINS TO SLOW MATRIX AND DISTRIBUTED FRACTURE FLOW REGIMES

- THE IMPACT MEASURE IS BASED ON GEOMETRIC CONSIDERATIONS AND REPRESENTS THE INCREASE IN FLOW OVER THE AMBIENT CONDITIONS

DISTRIBUTED FLOW CONDITIONS
(CONTINUED)

CONCEPTUAL MODEL





$$\text{AREA RATIO} = \frac{\text{AREA OF OPENINGS}}{\text{AREA OF REPOSITORY}}$$

$$\text{HEIGHT RATIO} = \frac{h_{\text{UNDISTURBED}}}{\text{UNIT THICKNESS}}$$

$$\text{MEASURE OF IMPACT} = \frac{\text{AREA RATIO}}{\text{HEIGHT RATIO}}$$

DISTRIBUTED FLOW CONDITIONS

(CONTINUED)

- **ASSUMPTIONS:**
  - CHn UNIT THICKNESS = 200M
    MINIMUM UNDISTURBED THICKNESS = 70M
  - EXTENT OF DRIFTING = 3,650M
    DRIFT DIAMETER = 5M
  - SHAFT DIAMETER = 5M
    RAMP LENGTH IN CHn UNIT = 1,500M
    RAMP DIAMETER = 6M
  - TWO–FOLD FLOW CONVERGENCE INTO RAMPS AND DRIFTS
  - NUMBER OF BOREHOLES: UPHOLE = DOWNHOLE = 36
    BOREHOLE DIAMETER = 0.15M
  - ALL WATER THAT ENTERS AN OPENING REMAINS IN THE OPENING AND EXITS AT THE LOWEST POINT

DISTRIBUTED FLOW CONDITIONS

IMPACT MEASURES FOR DISTRIBUTED FLOW CONDITIONS

OPENING TYPE	DISTURBED INTERVAL THICKNESS	COMPUTED IMPACT MEASURE
SHAFTS	130 M	<0.01 X IMPACT FOR OTHER TYPES OF OPENINGS
UPHOLES	65 M	<0.01 X IMPACT FOR OTHER TYPES OF OPENINGS
DOWNHOLES	135 M	<0.01 X IMPACT FOR OTHER TYPES OF OPENINGS
ACCESS RAMP	130 M	0.009
DRIFTS	65 M	0.009
TOTAL (RAMP/SHAFT)		APPROX. 0.02

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CONCENTRATED FLOW CONDITIONS

FLOW RATIO FOR OPENINGS AS A FUNCTION OF AVERAGE FLUX BENEATH THE REPOSITORY

AVERAGE FLUX mm/yr	3-m SHAFT	5-m SHAFT	6-m RAMP/ DRIFTS	(36) 0.25-m UPHOLES	(36) 0.25-m DOWNHOLES	TOTAL
1	9.3E-3	2.6E-2	5.5E-3	2.4E-3	2.4E-3	4.6E-2
3	3.1E-3	8.6E-3	1.8E-3	8.0E-4	8.0E-4	1.5E-2
10	9.3E-4	2.6E-2	5.5E-4	2.4E-4	2.4E-4	4.6E-3
30	3.1E-4	8.6E-4	1.8E-4	8.0E-5	8.0E-5	1.5E-3

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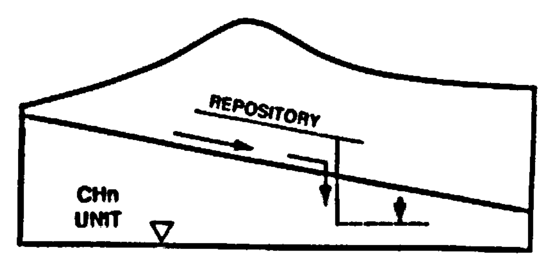
CONCENTRATED FLOW CONDITIONS
TRAVEL TIME RATIOS AND IMPACT MEASURES FOR CHn OPENINGS

	3-m SHAFT	5-m SHAFT	6-m RAMP/ DRIFTS	(36) 0.25-m UPHOLES	(36) 0.25-m DNHOLES	TOTAL
DISTURBED INTERVAL THICKNESS, m	130	130	130	65	135	
TRAVEL TIME RATIO	2.79	2.79	0.063	1.5	3.0	
IMPACT MEASURE FOR AVERAGE FLUX (mm/yr)						
1	2.6E-2	7.3E-2	3.5E-4	3.6E-3	7.2E-3	0.11
3	8.6E-3	2.4E-2	1.1E-4	1.2E-3	2.4E-3	0.036
10	2.6E-3	7.3E-3	3.5E-5	3.6E-4	7.2E-4	0.011
30	8.6E-4	2.4E-3	1.1E-5	1.2E-4	2.4E-4	0.0036

$$\text{FLOW RATIO} = \frac{\text{MAX FLOW THROUGH OPENINGS}}{\text{TOTAL REPOSITORY AREA x AVERAGE FLUX}}$$

$$\text{TRAVEL TIME RATIO} = \frac{\left(\dfrac{\text{UNIT THICKNESS}}{\text{ROCK } k_{SAT}}\right)}{\left(\dfrac{\text{UNDISTURBED THICKNESS}}{\text{ROCK } k_{SAT}} \quad \dfrac{\text{DISTURBED THICKNESS}}{\text{EFFECTIVE OPENING } k_{SAT}}\right)}$$



IMPACT MEASURE = (FLOW RATIO) (TRAVEL TIME RATIO)

CONCLUSIONS

- WITHOUT A NATURAL CONCENTRATING MECHANISM, OPENINGS IN THE CHn CONDUCT A SMALL PORTION OF THE TOTAL FLUX THROUGH THE REPOSITORY
- THE IMPACT IS LIMITED TO A SMALL FRACTION OF THE CHn UNIT
- FOR CONCENTRATED FLOW CONDITIONS, THE VERTICAL PENETRATIONS HAVE A GREATER IMPACT THAN THE HORIZONTAL ONES
- THE APPROACH USED FOR ESTIMATING IMPACTS IS BELIEVED TO BE CONSERVATIVE
- ENGINEERING MEASURES ARE AVAILABLE TO MITIGATE THE IMPACT OF THE OPENINGS

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CALICO HILLS RISK/BENEFIT ANALYSIS RECOMMENDATIONS AND CLOSURE

PRESENTED AT

DOE/NRC MEETING ON CALICO HILLS RISK/BENEFIT ANALYSIS AND ESF ALTERNATIVES STUDY

PRESENTED BY

DR. DAVID C. DOBSON

ACTING DIRECTOR - REGULATORY AND SITE EVALUATION DIVISION
YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

JANUARY 29-31, 1991

Attachment 12

CONCLUSIONS AND RECOMMENDATIONS

- THE RECORD MEMORANDUM OF THE CHRBA CONTAINS SEVEN CONCLUSIONS AND FIVE RECOMMENDATIONS

CONCLUSIONS OF THE CHRBA

1. POTENTIAL IMPACTS FROM CHARACTERIZATION ON POSTCLOSURE AQUEOUS RELEASES FROM THE TOTAL SYSTEM ARE EXPECTED TO BE LOW AND DO NOT PRECLUDE EXTENSIVE UNDERGROUND EXPLORATION IN THE CHn BELOW THE PROPOSED REPOSITORY

2. TESTING STRATEGIES 1,2,5, AND 7 INCLUDE EXTENSIVE UNDERGROUND EXPLORATION WITHIN OR NEAR THE REPOSITORY BLOCK AND PROVIDE A SIGNIFICANT IMPROVEMENT IN SCIENTIFIC CONFIDENCE RELATIVE TO STRATEGIES 3,4,6, AND 8

CONCLUSIONS OF THE CHRBA

(CONTINUED)

3. WHEN ALL OBJECTIVES (CONFIDENCE, RISK, COST, DELAY, AND PHASING POTENTIAL) ARE CONSIDERED, STRATEGIES 2 AND 5 ARE PREFERRED TO STRATEGY 1 BY A SMALL MARGIN

4. MODIFICATIONS OF 2 AND 5 WHICH ARE CONSISTENT WITH THEIR DEFINITION WOULD PROVIDE GREATER SCIENTIFIC CONFIDENCE THAN STRATEGY 1

CONCLUSIONS OF THE CHRBA

(CONTINUED)

5. EACH OF THE 12 KEY FEATURES OF THE SITE WOULD BE INVESTIGATED BY STRATEGY 2 OR 5. THE BENEFIT OF EARLY ACCESS TO THE CHn WOULD BE DIRECTLY RELATED TO THE NUMBER OF THESE FEATURES THAT ARE INTERCEPTED EARLY

6. A RAMP FROM THE EAST OF THE REPOSITORY BLOCK COULD PROVIDE SIGNIFICANT INFORMATION WHICH COULD POTENTIALLY BE USED TO AID IN CHARACTERIZATION OF THE CALICO HILLS UNIT

CONCLUSIONS OF THE CHRBA

(CONTINUED)

7. THE RELATIVE IMPORTANCE OF THE CHn UNIT AS A BARRIER DEPENDS ON THE IMPORTANCE OF THE OTHER BARRIERS, BOTH NATURAL AND ENGINEERED

   FOR THE CHRBA, ESTIMATED PERFORMANCE OF THE ENGINEERED BARRIERS AND THE HOST ROCK WERE CONSERVATIVE, WHEREAS ESTIMATES OF THE PERFORMANCE OF THE SATURATED ZONE WERE INTENDED TO BE REALISTIC, BUT NOT NECESSARILY CONSERVATIVE

RECOMMENDATIONS

1. THE CHRBA WORKING GROUP RECOMMENDS USING EXTENSIVE DRIFTING WITHIN THE BLOCK, AN APPROACH SIMILAR TO STRATEGIES 2 AND 5 (STRATEGIES 2 AND 5 ARE VERY SIMILAR AND WERE RATED ABOUT THE SAME BY THE CHRBA)

   IT ALSO RECOMMENDS THAT THESE STRATEGIES BE MODIFIED TO INCLUDE A DRIFT TO EXPLORE THE ABANDONED WASH FAULT AND AN UNDERGROUND ACCESS OUTSIDE THE REPOSITORY BLOCK FOR AGGRESIVE TESTING

RECOMMENDATIONS

(CONTINUED)

- THE MODIFICATIONS WOULD PROVIDE A MORE ROBUST DECISION

- THE RECOMMENDATION COULD BE DEPENDENT ON THE SENSITIVITY TO THE DIFFERENCE IN RISK (IMPACTS ON WASTE ISOLATION) BETWEEN TESTING INSIDE AND OUTSIDE THE BLOCK

- A FINAL COMMITMENT TO FULL EXCAVATION OF STRATEGY 2 OR 5 IS NOT CURRENTLY REQUIRED BECAUSE FUTURE UNDERSTANDING OF IMPACTS TO WASTE ISOLATION OR THE SUFFICIENCY OF DATA REQUIRED FOR SITE CHARACTERIZATION MAY INDICATE THAT THE FULL AMOUNT OF DRIFTING IS NOT NECESSARY

RECOMMENDATIONS

(CONTINUED)

2. PLANNING FOR CHn UNIT EXPLORATION FACILITIES SHOULD FOCUS ON PROVIDING ACCESS TO THE 12 GEOLOGIC FEATURES (SEE TABLE 2.5.2.5-1) IDENTIFIED IN THE MUA AS EARLY AS PRACTICABLE

3. REVIEW OF EXISTING DATA AND COLLECTION OF OBSERVATIONAL DATA AT RAINIER MESA SHOULD BE UNDERTAKEN

4. WASTE ISOLATION IMPACTS SHOULD BE ADDRESSED IN TITLE II DESIGN TO FURTHER EXAMINE THE ASSUMPTIONS AND ASSESSMENTS MADE BY THE CHRBA

5. CERTAIN ASSUMPTIONS AND CRITERIA (SUCH AS THE WATER-TABLE STANDOFF DISTANCE AND THE DEFINITIONS OF INSIDE/OUTSIDE THE BLOCK) FROM THE CHRBA MAY BE IMPORTANT WITH RESPECT TO CONTROL OF INPUT TO THE ESF DESIGN

FINAL OBSERVATIONS

- DOE CONSIDERS THAT THE CHRBA IS ADEQUAE TO MEET THE COMMITMENT MADE BY DOE IN RESPONSE TO OBJECTION # 2 (CDSCP) AND THAT THE ANALYSIS PROVIDES SUFFICIENT BASIS FOR DESIGN

- DOE CAUTIONS THAT NEITHER THE PRECISE TESTING CONFIGURATION NOR THE TREATMENT OR WASTE ISOLATION IMPACTS SHOULD BE CONSIDERED FINAL

  - IT IS EXPECTED THAT BOTH WILL CHANGE AS DATA IS ACQUIRED DURING SITE CHARACTERIZATION AND ENGINEERING TRADE STUDIES ARE PERFORMED

  - NRC WILL HAVE ADDITIONAL OPPORTUNITY TO COMMENT AS THE DESIGN EVOLVES

FINAL OBSERVATIONS

(CONTINUED)

- DOE BELIEVES THAT THE INTEGRATION BETWEEN THE CHRBA AND THE ESF AS HAS BEEN EFFECTIVE AND THAT THE CURRENT TOP-RANKED ESF OPTIONS WILL SUPPORT AN EFFECTIVE CHARACTERIZATION PROGRAM IN THE CALICO HILLS

  - ACCESS TO THE CALICO HILLS VIA RAMPS FROM THE EAST WILL PROVIDE MORE EXTENSIVE CHARACTERIZATION DATA THAN STRATEGY 2,5 ALONE

  - ACCESS VIA RAMPS FROM THE EAST WILL ELIMINATE ANY DIRECT VERTICAL PATHWAYS THAT COULD AFFECT FLUID FLOW, SO IMPACTS ON WASTE ISOLATION WILL LIKELY BE EVEN SMALLER THAN THOSE CALCULATED IN THIS STUDY

  - THE ROBUSTNESS OF THE RECOMMENDATION FOR STRATEGY 2,5 WOULD BE INCREASED BY A COMBINATION WITH RAMP ACCESSES FROM THE EAST

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ESF ALTERNATIVES STUDY INTRODUCTION

PRESENTED AT

DOE/NRC MEETING ON CALICO HILLS RISK/BENEFIT ANALYSIS AND ESF ALTERNATIVES STUDY

PRESENTED BY

EDGAR H. PETRIE
ACTING DIRECTOR-ENGINEERING & DEVELOPMENT DIVISION
YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

JANUARY 29-31, 1991

Attachment 13

ACTIVITIES LEADING TO THE NEED FOR AN ESF ALTERNATIVES STUDY

- DOE RECEIVED COMMENTS ON THE SCP FROM NRC AND OTHER PARTIES EXTERNAL TO DOE IN 1989

- NWTRB STRUCTURAL GEOLOGY AND GEOENGINEERING PANEL OFFERED SUGGESTIONS ON ESF CONSTRUCTION AND TESTING

- DOE EVALUATED THE NWTRB SUGGESTIONS DURING THE SUMMER OF 1989

- NWTRB PROVIDED ADDITIONAL ESF SUGGESTIONS IN AUGUST 1989

- BASED ON THE ABOVE CONCERNS, ON OCTOBER 30, 1989 DOE/HQ ISSUED GUIDANCE TO YMP FOR IMPLEMENTING A STUDY FOR EVALUATION OF ALTERNATIVES UNDER A 10 CFR 60 SUBPART G PROGRAM

IMPLEMENTATION PLAN

IMPLEMENTATION OF THE GUIDANCE WAS CARRIED OUT BY DOE AS FOLLOWS:

- YMP DIRECTED THE WORK THROUGH THE PROJECT OFFICE ENGINEERING AND DEVELOPMENT DIVISION
- SANDIA NATIONAL LABORATORIES WAS ASSIGNED THE LEAD TECHNICAL AND COORDINATION RESPONSIBILITIES
- PROJECT PARTICIPANTS PROVIDED MATRIX SUPPORT TO EACH TASK WITHIN THE STUDY AS REQUIRED

GOALS OF THE STUDY:

- TO PROVIDE A COMPARATIVE EVALUATION OF ESF ALTERNATIVES
- TO IDENTIFY FAVORABLE FEATURES
- TO ADDRESS NRC OBJECTIONS AND CONCERNS
- TO ADDRESS NWTRB RECOMMENDATIONS
- TO ADDRESS CONCERNS OF THE STATE OF NEVADA

SCOPE OF THE STUDY

- CONDUCT THE STUDY UNDER A FULLY QUALIFIED SUBPART G QA PROGRAM
- IDENTIFY VARIOUS ESF/REPOSITORY CONFIGURATIONS AND ASSOCIATED CONSTRUCTION METHODS (OPTIONS)
- IDENTIFY ALL REQUIREMENTS AND CONCERNS APPLICABLE TO THE ESF AND REPOSITORY
- USE DECISION - AIDING METHODOLOGY TO COMPARATIVELY EVALUATE THE OPTIONS TO ACCOUNT FOR DISCRIMINATING REQUIREMENTS AND CONCERNS
- PROVIDE AN OVERALL RANK ORDERING OF OPTIONS
- IDENTIFY POTENTIALLY FAVORABLE DESIGN FEATURES
- DOCUMENT THE FINDINGS OF THE STUDY

ACTIVITY AND SCHEDULE

KEY ACTIVITIES

<u>ACTIVITY</u>	<u>SCHEDULE</u>
SNL SUBMITTED ESFAS FINDINGS REPORT FOR PROJECT OFFICE ACCEPTANCE	DEC. 21, 1990
PROJECT OFFICE MANAGEMENT REVIEW COMPLETED	JAN. 5, 1991
REVISED ESFAS REPORT TO PROJECT OFFICE	JAN 9, 1991
REPORT TO RW-1	JAN. 14, 1991
RW-1 DETERMINES FUTURE COURSE OF ACTION FOR ESF	JAN. 31, 1991

ESF ALTERNATIVES STUDY
AGENDA

• INTRODUCTION	T. PETRIE	DOE
• OVERVIEW	A. STEVENS	SNL
• REQUIREMENTS - BASIS FOR EVALUATION	A. STEVENS	SNL
• OPTIONS EVALUATED	W. KENNEDY	RSN
• RESULTS OF EVALUATION	P. GNIRK	RE/SPEC
• SENSITIVITY INFORMATION	P. GNIRK	RE/SPEC
- EVALUATION OF FEATURES	L. COSTIN	SNL
• STATUS OF EXECUTIVE REPORT	T. PETRIE	DOE
• REVIEW AND ACCEPTANCE PROCESS	T. PETRIE	DOE
• INTERFACE WITH REPOSITORY DESIGN		
• STATUS OF SCA CONCERNS	J. KING	SAIC

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YUCCA MOUNTAIN

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ESF ALTERNATIVES STUDY OVERVIEW

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PRESENTED BY

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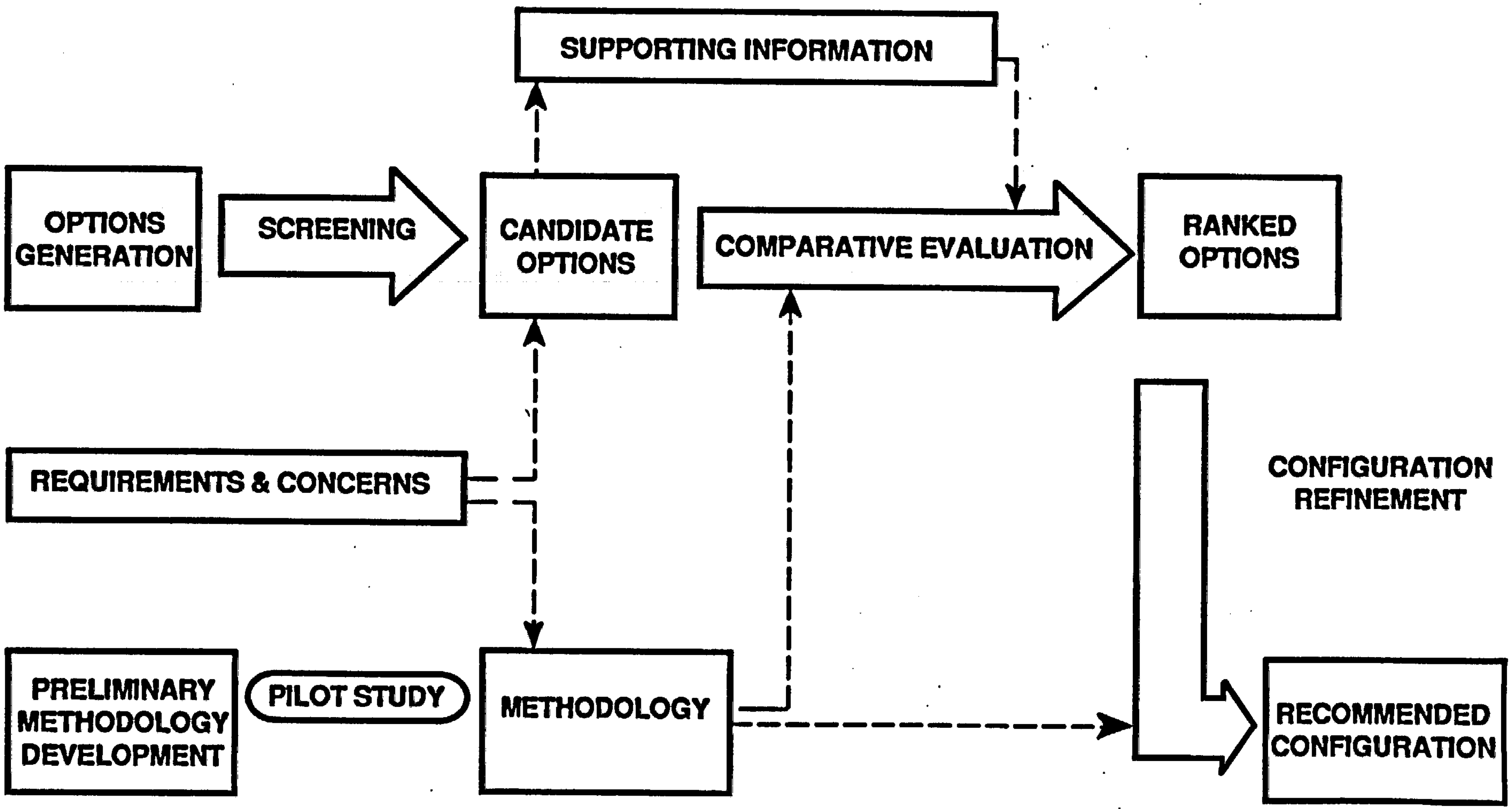
REPOSITORY ENGINEERING DIVISION
SANDIA NATIONAL LABORATORIES

DEPARTMENT OF ENERGY UNITED STATES OF AMERICA

JANUARY 29-31, 1991

Attachment 14

ESF ALTERNATIVES STUDY



HIGHEST-LEVEL OBJECTIVES FOR THE COMPARATIVE EVALUATION OF ESF ALTERNATIVES

RANK ORDER THE ALTERNATIVE ESF-REPOSITORY CONFIGURATIONS

- **MAXIMIZE PROGRAMMATIC VIABILITY**

  (MEANS OBJECTIVE)

  (REQUIRES ELICITATION OF ONE PROBABILITY FROM ONE EXPERT PANEL)

- **MAXIMIZE VALUE OF INFORMATION FROM CHARACTER-IZATION TESTING**

  (MEANS OBJECTIVE)

  (REQUIRES ELICITATION OF FIVE PROBABILITIES FROM TWO EXPERT PANELS)

- **MAXIMIZE COMPLIANCE WITH APPLICABLE REGULATIONS**

  (MEANS OBJECTIVE)

  (REQUIRES ELICITATION OF TWO PROBABILITIES FROM ONE EXPERT PANEL)

- **MINIMIZE ADVERSE IMPACTS ATTRIBUTABLE TO AN ESF-REPOSITORY CONFIGURATION**

  (FUNDAMENTAL OBJECTIVE)

  (REQUIRES SCORING OF ESF OPTIONS AGAINST 8 PERFORMANCE MEASURES BY SIX EXPERT PANELS PLUS DEVELOPMENT OF UTILITY FUNCTIONS AND SCALING (WEIGHTING) FACTORS BY MANAGEMENT PANEL)

REGULATORY REQUIREMENTS HAVE BEEN IDENTIFIED FOR USE IN EVALUATION OF OPTIONS

- APPROXIMATELY 2500 REQUIREMENTS WERE IDENTIFIED FROM 25 SOURCE DOCUMENTS
- APPROXIMATELY 250 REQUIREMENTS WERE DETERMINED TO BE POTENTIALLY DISCRIMINATORY TO THE SELECTION OF RECOMMENDED CONFIGURATION
- THESE REQUIREMENTS WERE CROSS-CORRELATED TO THE INFLUENCE DIAGRAMS

ADDITIONAL DOE GUIDANCE FOR THE ESF ALTERNATIVES STUDY

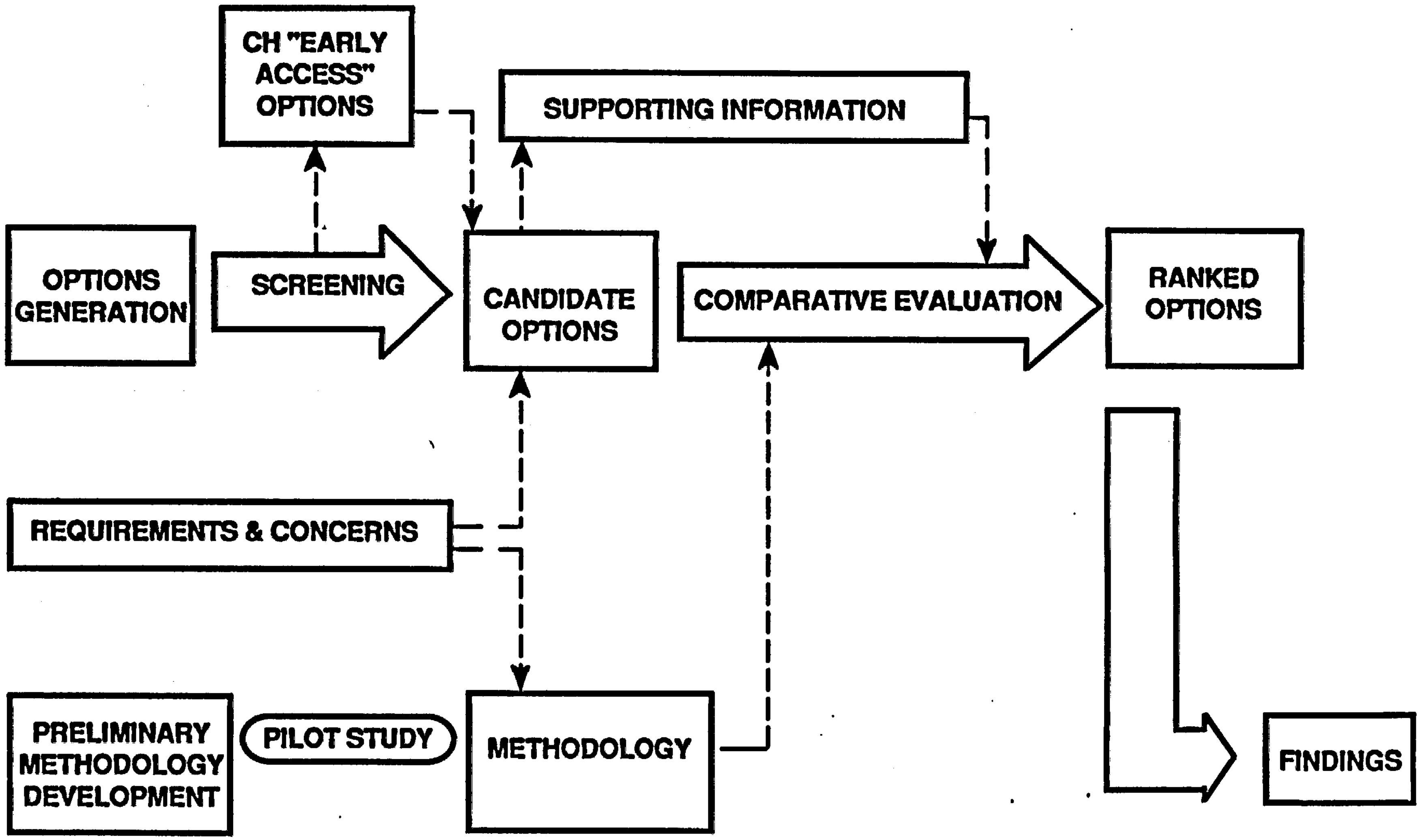
- **EXTENSIVE EXPLORATORY DRIFTING IN THE CALICO HILLS UNIT (CH)**
  - PRELIMINARY CONFIGURATIONS WERE PRESENTED AT THE JULY 25, 1990 NWTRB TECHNICAL EXCHANGE

- **IMPLEMENT AN EARLY TESTING STRATEGY TO IDENTIFY POTENTIAL EVIDENCES OF SITE UNSUITABILITY**

  THIS REQUIRED REVISIONS TO:

  - METHODOLOGY
  - OPTION CONFIGURATIONS AND SUPPORTING INFORMATION
  - SCHEDULE FOR EVALUATIONS BY EXPERT PANELS

ESF ALTERNATIVES STUDY



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OBJECTIVES OF TESTING STRATEGIES

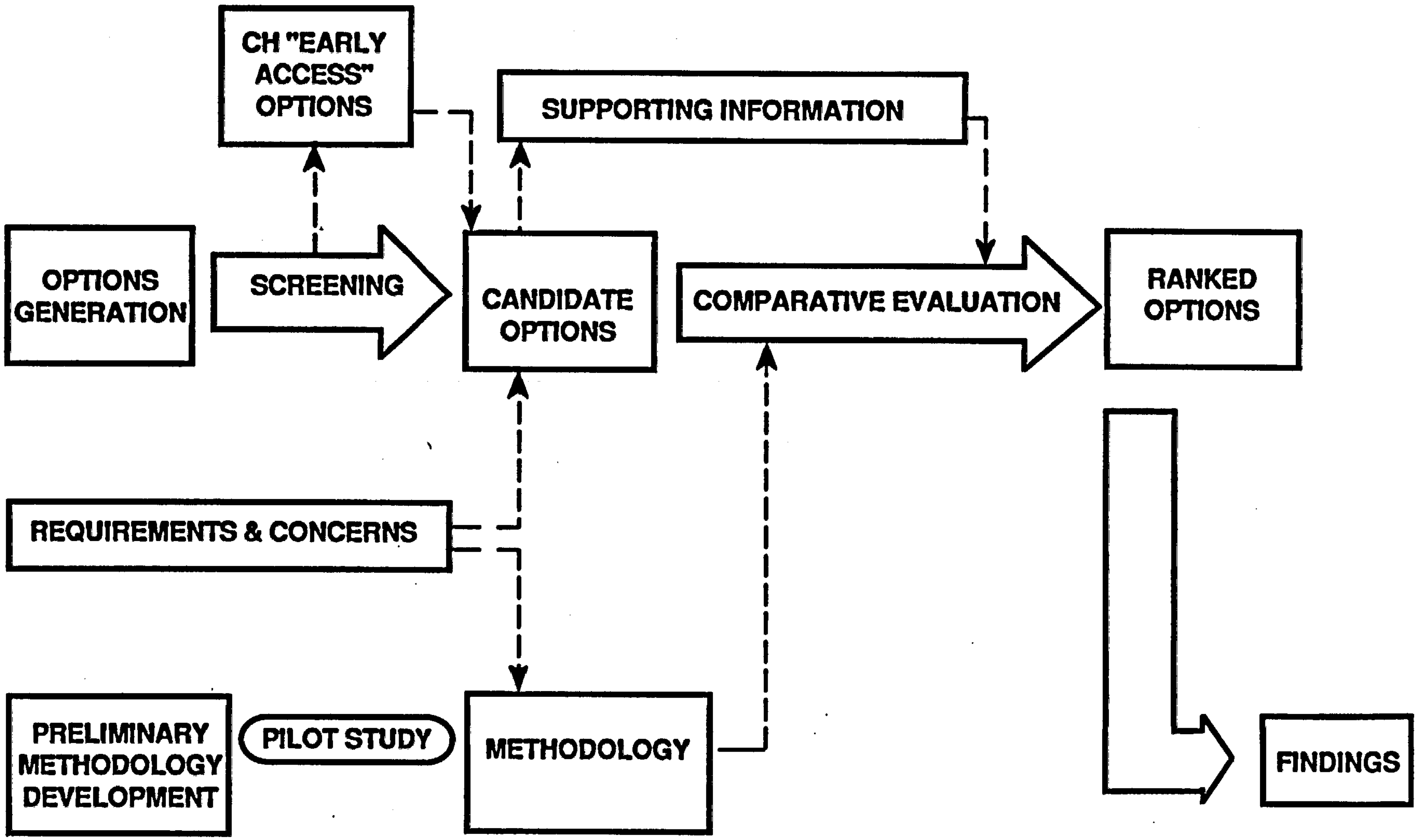
OPTIONS 1-17 (STRATEGY #1)	OBTAIN ALL DATA TO SUPPORT SCP DATA NEEDS USING SYSTEMATIC PROGRESSION FROM ACCESSES TO TOPOPAH SPRINGS TO CALICO HILLS
OPTIONS18-34 (STRATEGY #2)	PROCEED AS QUICKLY AS POSSIBLE TO CALICO HILLS TO IDENTIFY POTENTIAL EVIDENCE OF SITE UNSUITABILITY, DEFERRING TESTS IN ACCESSES, EXCEPT THOSE FOR WHICH DATA WOULD BE IRRETRIEVABLY LOST IF NOT ACQUIRED DURING ACCESS CONSTRUCTION

SUMMARY OF ESF/REPOSITORY OPTIONS

OPTION #			E.S.F.								REPOSITORY				
			ACCESS 1		ACCESS-2		MAIN TEST LEVEL				ACCESSES		CONSTRUCTION METHOD		
			SIZE	CONST. METHOD	SIZE	CONST. METHOD	LAYOUT	CONST. METHOD	LOCATION	ELEVATION	SHAFTS	RAMPS (TBM)	RAMPS & DRIFTS	EMPL. AREA	TOTAL ACCESSES
18	1	BASE CASE	12' SHAFT	DRILL & BLAST	12' SHAFT	DRILL & BLAST	TITLE II G.A.	DRILL & BLAST	NE	SAME AS REPOS.	2-20'	1-25' 1-25'	TBM	DRILL & BLAST	6
19	2	A1	16' SHAFT	"	25' RAMP	TBM	MODIFIED T II G.A.	"	"	"	2-25'	1-25' +ESF	"	"	5
20	3	A2	16' SHAFT	"	16' SHAFT	DRILL & BLAST	"	"	"	"	"	2-25'	"	"	6
21	4	A4 REV.1	16' SHAFT	"	12' SHAFT 25' RAMP	D&B TBM	"	"	"	"	1-25' ENLARGE ES-1 25'	1-25' +ESF	"	"	5
22	5	A5	16' SHAFT	"	25' RAMP	TBM	"	"	S	"	2-25'	"	"	"	5
23	6	A7	25' RAMP	TBM	25' RAMP	"	"	"	NE	"	"	IN ESF	"	"	4
24	7	B3, REV. 2-		SBM											
25	8	B3,REV.3-		V-MOLE											
26	9	B3,REV. 4-	16' SHAFT	BLIND BORE	"	"	"	MECH.	"	"	"	1-25' +ESF	"	TBM	5
27	10	B3,REV. 5-		RAISE BORE											
28	11	B3, REV. 6-		DRILL & BLAST											
29	12	B4	16' SHAFT	DRILL & BLAST	"	"	"	"	S	"	"	"	"	"	5
30	13	B7	25' RAMP	TBM	"	"	"	"	"	"	"	IN ESF	"	"	4
31	14	B8	16' SHAFT	DRILL & BLAST	"	"	"	"	"	"	1-25'	2-25' +ESF	"	"	5
32	15	C1	16' SHAFT	"	"	"	TWO LEVEL	"	NE	TWO LEVELS SAME AS REPOS.	2-25' ENLARGE ES-1-25'	1-25' +ESF	"	"	4
33	16	C4	16' SHAFT	"	"	"	"	"	S	"	2-25'	"	"	"	5
34	17	R11	12' SHAFT	"	12' SHAFT	DRILL & BLAST	TITLE II G.A.	DRILL & BLAST	NE	SAME AS REPOS.	2-25'	2-25'	"	"	6

ESFSUM6P.126/11-20-90

ESF ALTERNATIVES STUDY



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U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

ESF ALTERNATIVES STUDY
REQUIREMENTS - BASIS FOR EVALUATION

PRESENTED AT

DOE/NRC MEETING ON CALICO HILLS RISK/BENEFIT ANALYSIS AND ESF ALTERNATIVES STUDY

PRESENTED BY

DR. ALDRED L. STEVENS
DIVISION SUPERVISOR
REPOSITORY ENGINEERING DIVISION
SANDIA NATIONAL LABORATORIES

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

JANUARY 29-31, 1991

Attachment 15

DOCUMENTS REVIEWED UNDER ESF ALTERNATIVES STUDY

- 10 CFR 60, DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTE IN GEOLOGIC REPOSITORIES
- 10 CFR 960, GENERAL GUIDELINES FOR RECOMMENDATION OF SITES FOR NUCLEAR WASTE REPOSITORIES
- 40 CFR 191, ENVIRONMENTAL STANDARDS FOR THE MANAGEMENT AND DISPOSAL OF SPENT NUCLEAR FUEL, HIGH-LEVEL AND TRANSURANIC RADIOACTIVE WASTES
- NUCLEAR WASTE POLICY ACT (1982) AND AMENDMENTS (1987)
- 10 CFR 20, STANDARDS FOR PROTECTION AGAINST RADIATION
- 29 CFR 1910, OCCUPATIONAL SAFETY AND HEALTH STANDARDS (OSHA)
- CRITERIA FROM THE DESIGN ACCEPTABILITY ANALYSIS OF ESF TITLE I DESIGN
- TRANSCRIPT OF DOE BRIEFING TO NUCLEAR WASTE TECHNICAL REVIEW BOARD (STRUCTURAL GEOLOGY AND GEOENGINEERING PANEL), APRIL 11-12, 1989
- RECOMMENDATIONS FROM THE NWTRB REPORT TO CONGRESS AND DOE (3/90): RECOMMENDATIONS A, B, C, D, E, J

DOCUMENTS REVIEWED

(CONTINUED)

- NUREG 1347: NRC STAFF SITE CHARACTERIZATION ANALYSIS OF THE DEPARTMENT OF ENERGY'S SITE CHARACTERIZATION PLAN, YUCCA MOUNTAIN SITE, NEVADA
- GENERIC REQUIREMENTS DOC. (OGR/B-2)
- REPOSITORY DESIGN REQUIREMENTS (RDR, REV.D)
- ESF SUBSYSTEM DESIGN REQUIREMENTS DOCUMENT (SDRD, REV.1)
- CALIFORNIA ADMINISTRATIVE CODE TUNNEL (CTSO TITLE 8) AND MINE (CTSO TITLE 8) SAFETY ORDERS
- NEVADA MINE SAFETY AND HEALTH STANDARDS (NRS TITLE 46)
- 30 CFR CHAPTER I, MINE SAFETY AND HEALTH ADMINISTRATION (MSHA): 30 CFR 57, SAFETY AND HEALTH STANDARDS - UNDERGROUND METAL AND NONMETAL MINES
- STATE OF NEVADA COMMENTS ON CONSULTATION DRAFT OF SCP
- SITE CHARACTERIZATION PLAN (TESTING REQUIREMENTS)
- DOE ORDERS (VARIOUS ORDERS ADDRESSED. SEE ATTACHED LIST)

DOE ORDERS

6430.1A (GENERAL DESIGN CRITERIA)
4700.1 (PROJECT MANAGEMENT)
5400 SERIES (ENVIRONMENTAL)
5500 SERIES (EMERGENCY PLANNING)
1000 SERIES (MANAGEMENT & ADMINISTRATIVE)
1100 SERIES (ORGANIZATION, ETC.)
1200 SERIES (EXTERNAL RELATIONSHIPS)
1300 SERIES (MANAGEMENT SYSTEMS AND STANDARDS)
1500 SERIES (TRAVEL AND TRANSPORTATION)
2200 SERIES (ACCOUNTING)
4200 SERIES (PROCUREMENT)
5100 SERIES (PLANNING, PROGRAMMING, BUDGETING)
5300 SERIES (TELECOMMUNICATIONS)
5700 SERIES (ENERGY PROGRAMS AND POLICIES)
DOE/EP 0108 STANDARD FOR FIRE PROTECTION . . .
DOE/EP 0043 STANDARD ON FIRE PROTECTION . . .
DOE/00551/1 ELECTRICAL SAFETY CRITERIA . . .
DOE/EV 0132 ENVIRONMENTAL COMPLIANCE GUIDE
DOE/EV 06194-3 DOE EXPLOSIVE SAFETY MANUAL

10 CFR 60 REQUIREMENTS CONSIDERED FOR ESF

		CLASS
1	60.15 (b) . .IN SITU EXPLOR AT DEPTH OF WASTE EMPLACEMENT	3
2	60.15 (c) (1) . . LIMIT IMPACTS ON ISOLATION	1
	(2) . . LIMIT NUMBER BOREHOLES	1
	(3) . . BOREHOLES/SHAFTS IN PILLARS	1
	(4) . . .COORD DRILLING WITH GROA	1
3	60.16 . . .ISSUE SCP & RECEIVE COMMENTS ON SHAFT	3
*4	60.17 . . . SCP CONTENT	3
5	60.21 (c) (1) (ii) (D) . . .COMPARATIVE EVALUATION	2
6	60.21 (c) (1) (ii) (E) . . .ITEMS IMPORTANT TO SAFETY	2
7	60.21 (c) (11) . . .FEATURES TO FACILITATE CLOSURE	2
*8	60.24 (a) . . . UPDATE LA AND ER	3
9	60.72 (a) . . .MAINTAIN RECORDS	3
10	60.72 (b) . . .TYPES OF RECORDS	3
11	60.74 . . .NRC DEFINED TESTS	1
12	60.111 (a) . . .PART 20 COMPLIANCE	2
13	60.111 (b) (1) . . .PRESERVE THE OPTION OF WASTE RETRIEVAL	2
14	60.111 (b) (3) . . .RETRIEVAL SCHEDULE	3
15	60.112 . . .TOTAL SYSTEM PERFORMANCE	1

* SCA COMMENT 128

10 CFR 60 REQUIREMENTS CONSIDERED FOR ESF

(CONTINUED)

		CLASS
	16 60.113 (a) (1) (i) . . .SUB. COMP. CONT. & RELEASE RATE	1
	17 60.113 (a) (1) (ii) (A) . . .300 TO 1000 YR W. PACKAGE	1
	(a) (1) (ii) (B) . . .10^-5 RELEASE RATE	1
*	18 60.113 (a) (2) . . . PERF. PARTICULAR BARRIERS-GEO. SETTING	3
*	19 60.113 (b) (2) (3) AND (4) . . . PERF. PART. BARRIERS AFTER CLOSURE	3
*	20 60.122 . . . SITING CRITERIA	2
	21 60.130 . . .OTHER FEATURES TO MEET P.O.	2
*	22 60.131 (a) . . . GROA DES. CRIT. RAD. PROT.	3
	23 60.131 (b) (1) . .SS/C IMPORTANT SAFETY CONSIDER NATURAL FEATURES	3
	24 60.131 (b) (2) . . .SS/C IMPORTANT PROT. DYNAMIC	3
	25 60.131 (b) (3) . . .SS/C IMPORTANT SAFETY PROT. FIRE/EXPLOSION	3
	26 60.131 (b) (4) (i) . . . SS/C IMPORTANT SAFETY MAINTAIN CONTROL	3
*	27 60.131 (b) (4) (ii) . . .GROA DESIGN CRIT. EMERG. CAP.	3
	28 60.131 (b) (6) . . . SS/C IMPORTANT SAFETY INSPECT. TEST	3
*	29 60.131 (b) (8). . . GROA DESIGN CRIT. INST/CONT.	3
	30 60.131 (b) (9) . . . COMPLIANCE MINING REGULATIONS	3
*	31 60.131 (b) (10) . . . GROA DESIGN CRIT. SHAFT CONV.	3

* SCA COMMENT 128

10 CFR 60 REQUIREMENTS CONSIDERED FOR ESF

(CONTINUED)

			CLASS
32	60.133 (a)	(1) ...ORIENTATION CONTRIB. TO ISOLATION	1
		(2) ...DISRUPTIVE EVENTS NOT SPREAD	2
33	60.133 (b)	...UG FACILITY FLEXIBLE FOR SITE CONDITIONS	1
34	60.133 (c)	...RETRIEVAL OF WASTE	3
35	60.133 (d)	...CONTROL WATER AND GAS	3
36	60.133 (e) (1)	...RETRIEVABILITY	2
	60.133 (e) (2)	...DELETERIOUS MOVEMENT	1
37	60.133 (f)	...EXCAVATION EFFECTS	1
38	60.133 (g)	...VENTILATION	1
39	60.133 (h)	...EBS ASSIST GEOLOGICAL SETTING	1
40	60.133 (i)	...THERMAL/MECHANICAL LOADS	2
*41	60.134	... DESIGN OF SEALS	1
42	60.137	...PERFORMANCE CONFIRMATION	2
43	60.140 (b)	...START PERF. CON. DURING SITE CHARACTERIZATION	3
44	60.140 (c)	...APPROPRIATE MONITORING PGM	3
45	60.140 (d) (1)	...PGM NOT AFFECT NAT & ENG BAR MEET P.O.	3

* SCA COMMENT 128

10 CFR 60 REQUIREMENTS CONSIDERED FOR ESF

(CONTINUED)

		CLASS
	46 60.141 (a) . . .SURVEIL, MAPPING, TESTING	3
	47 60.141 (b) . . .MONITOR DESIGN	3
	48 60.141 (c) . . .REQUIRED MEASUREMENTS	3
	49 60.141 (d) . . .COMP. TO ORIGINAL DESIGN	3
	50 60.141 (e) . . .MONITOR THERM/MECH	3
	51 60.142 (a) . . .BOREHOLE/SHAFT SEALS	3
	52 60.142 (b) . . .INITIATED EARLY	3
	53 60.142 (c) . . .TEST BACKFILL EFFECT	3
	54 60.142 (d) . . .SEAL EFFECT	3
*	55 60.143 . . . MON. WASTE PACKAGE	3
	56 60.151 . . .QA PROGRAM APPLICABILITY	3
	57 60.152 . . .QA PROGRAM BASIS	3

* SCA COMMENT 128

BASIS FOR EVALUATION OF OPTIONS

- THE METHODOLOGY INCORPORATED REQUIREMENTS THROUGH THE INFLUENCE DIAGRAMS VIA SPECIFIC CATEGORIES (i.e., POSTCLOSURE PERFORMANCE, TESTING, RADIOLOGICAL SAFETY, etc.)
- REQUIREMENTS WERE CATEGORIZED ACCORDING TO INFLUENCE DIAGRAM CATEGORIES (SEE MATRIX)
- REQUIREMENTS WERE CLASSIFIED FOR IMPACT ON DISCRIMINATING BETWEEN OPTIONS

CLASSIFICATION OF REQUIREMENTS

DISCRIMINATION CLASS	IMPACT OF REQUIREMENT IN DISCRIMINATION BETWEEN OPTIONS
1	VALUE OF THE PERFORMANCE MEASURE (PM) FOR AN OPTION IS EXPECTED TO DEPEND STRONGLY ON THIS REQUIREMENT
2	VALUE OF THE PM FOR AN OPTION IS NOT EXPECTED TO DEPEND STRONGLY ON THIS REQUIREMENT
3	REQUIREMENT NOT EXPECTED TO DISCRIMINATE BETWEEN OPTIONS

NOTE: ALL REQUIREMENTS WILL BE INCLUDED IN DESIGN BASES FOR THE SELECTED OPTION

ESF DISCRIMINATORS 1 AND 2

INFLUENCE DIAGRAM NUMBERS*

10 CFR 60 REFERENCES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
60.15 (c) (1)				X						X		X	X	X	X	X	X	X	X	X		
60.15 (c) (2)				X			X			X	X	X	X	X	X	X	X	X	X	X		
60.15 (c) (3)				X			X			X	X	X	X	X	X	X	X	X	X	X		
60.15 (c) (4)				X			X			X		X	X	X	X	X	X	X	X	X		
60.21 (c) (1) (ii) (D)				X																		
60.21 (c) (1) (ii) (E)				X																		
60.21 (c) 11				X							X		X	X								
60.74 (a)			X	X	X	X						X	X	X	X	X	X	X	X	X		
60.74 (b)		X	X									X	X	X					X	X		
60.111 (a)					X	X																
60.111 (b) (1)																					X	
60.112	X	X	X	X																X		
60.113 (a) (1)			X																	X		
60.122 [(a) (2) and (b) (1)]		X		X														X	X			
60.130			X	X			X													X		
60.133 (a) (1)			X	X							X									X		
60.133 (a) (2)			X	X			X				X									X		
60.133 (b)				X																X		
60.133 (e) (1)				X								X								X	X	
60.133 (e) (2)				X			X				X	X			X	X	X	X	X	X		
60.133 (f)				X							X	X								X		
60.133 (g)				X			X				X	X								X		
60.133 (h)			X	X																X		
60.133 (i)		X		X																X		
60.134			X	X																		
60.137		X	X	X									X	X								

LEGEND

*The following titles relate to the "INFLUENCE DIAGRAM NUMBERS.

Postclosure Health and Safety
- 1 Health Effects Portion
- 2 Transport Through Natural Barriers Portion
- 3 Engineered Barrier System Portion
- 4 Scenario Portion

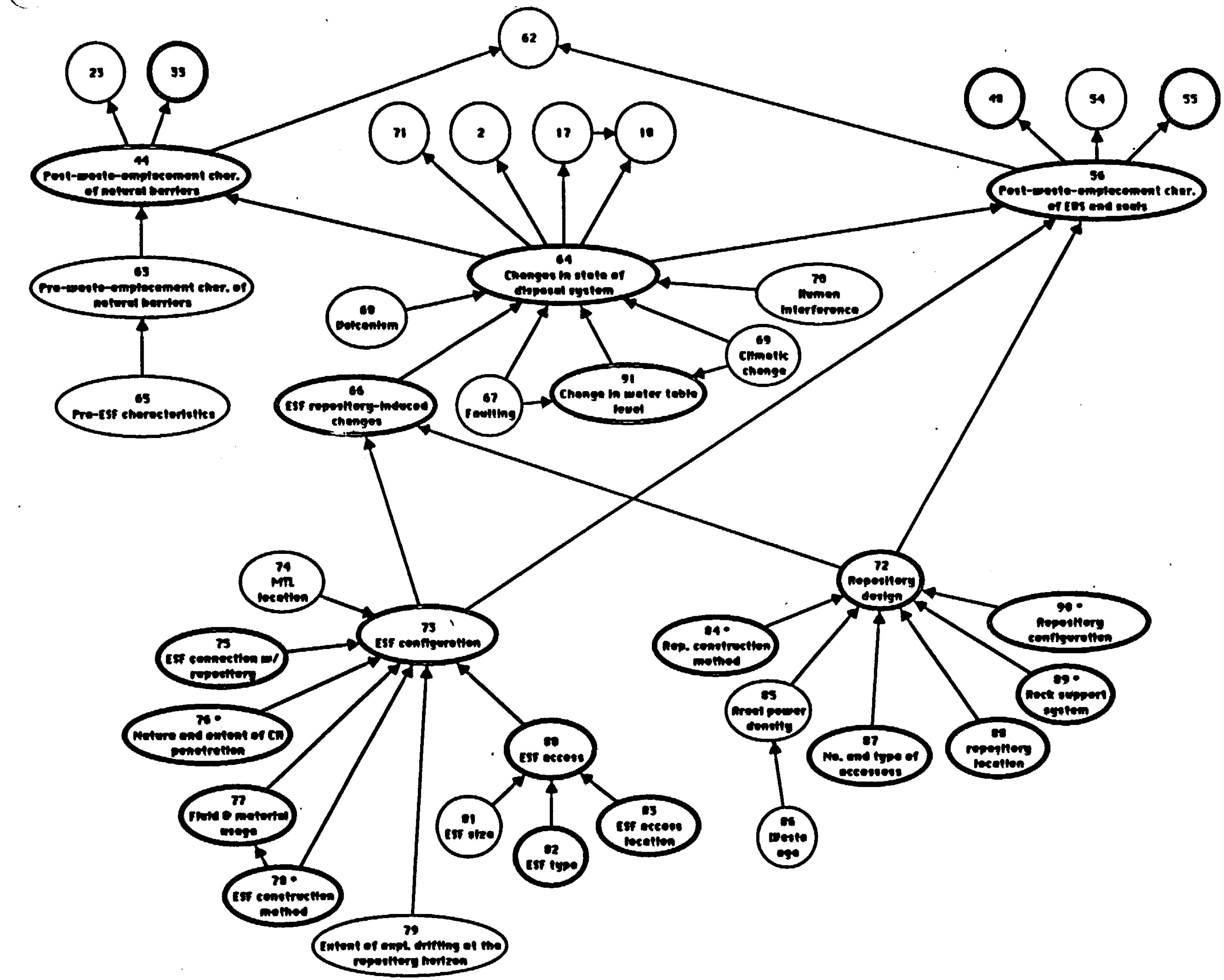
Preclosure Health and Safety
- 5 Radiological Worker Health
- 6 Radiological Public Health
- 7 Nonradiological Worker Safety

Environment
- 8 Aesthetics
- 9 Historical Properties

Cost
- 10 Total System Life Cycle Cost
- 11 Repository Life Cycle Cost
- 12 ESF Cost

Schedule
- 13 Schedule - Indirect Costs
- 14 Schedule

Probabilities
- 15 Probability of Early False Negative
- 16 Probability of Late False Negative (Page 1 of 2)
- 17 Probability of Late False Negative (Page 2 of 2)
- 18 Probability of Early False Positive
- 19 Probability of Late False Positive
- 20 Likelihood of Construction/Operation Approval
- 21 Likelihood of Retrieval
- 22 Probability of Programmatic Viability



Influence Diagram Draft 8 [9/5/90] - Scenario Portion (pg 4 of 4)

INFLUENCE DIAGRAM NAME/NO.	I. D. ELEMENT No.	I. D. ELEMENT STATEMENT	REQUIREMENT REFERENCE	REQUIREMENT STATEMENT (or NOTE)	RK
Schedule, Draft 8	14	Decom. and closure duration			
Repository LCC, Draft 5	18	Costs of closure and decommissioning			
Postclosure Health & Safety Scenario Portion, Draft 6	72	Repository design			
	73	ESF configuration			
	90	Repository configuration			
			60.74(a)	Tests. DOE shall perform, or permit the Commission to perform, such tests as the Commission deems appropriate or necessary for administration of the regulations of this par These may include tests of: (1) Radioactive (2) the geologic repository including its structures, systems, and components, (3) radi detection and monitoring instruments, and (4) equipment and devices used in connection with receipt, handling, or storage of radioactive	1
Schedule, Draft 8	20	Test requirements			
	23	Test plan			
	25	Add. req. for NWTRB/NRC/NV testing			
Postclosure Health & Safety Scenario Portion, Draft 6	64	Changes in state of disposal system			
	66	ESF repository induced changes			
	72	Repository design			
	73	ESF configuration			
	80	ESF access			
	85	Areal power density			
	86	Waste age			