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# USE OF A SCENARIO-DEVELOPMENT PROCEDURE TO IDENTIFY POTENTIALLY DISRUPTIVE SCENARIOS, GREATER CONFINEMENT DISPOSAL FACILITY, AREA 5, NEVADA TEST SITE

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## ABSTRACT

The Greater Confinement Disposal (GCD) facility includes four boreholes that contain transuranic (TRU) waste. Presence of the TRU waste means that this facility must comply with the U.S. Environmental Protection Agency's Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Waste--Final Rule 40 CFR Part 191. To comply with the Containment Requirements of this rule, all potentially disruptive events and processes, and by implication all potentially disruptive combinations of events and processes (scenarios), must be identified for possible inclusion in performance assessments.

A scenario-development procedure was adopted that identifies individual potentially disruptive events and processes and combines these events and processes to form scenarios. This procedure consists of five steps. Step 1 either creates, adopts, or adapts an initial list of events and processes. Step 2 classifies the events and processes using any of a variety of schemes for organizational purposes. This step may already be included in an adopted list. Step 3 screens the events and processes using well-defined criteria based on regulatory guidance to identify those events and processes that can be eliminated from scenario development without affecting the performance measure. Step 4 constructs all possible combinations of the events and processes surviving the screening process through the use of a logic diagram. Step 5 screens the scenarios using well-defined criteria to identify those scenarios that can be excluded from full-scale performance assessments without affecting the performance measure.

In using this procedure to identify potentially disruptive scenarios for the GCD facility, some modifications were made to the original procedure. To address the completeness issue of the list of events and processes to be screened, lists from 11 sources were combined and consolidated by eliminating duplications. The result was an initial list of 205 features, events, and processes (FEPs). Because of the diverse nature of the FEPs, additional screening criteria were developed.

Screening of the FEPs identified four events for scenario development: exploratory drilling for natural resources, drilling withdrawal wells, irrigation, and subsidence. Recent environmental-isotope analyses of the vadose zone suggest that radionuclide transport from the boreholes to the water table by infiltration is not a feasible transport mechanism within the time frame of regulatory concern. For this reason, the event of drilling withdrawal wells was merged with exploratory drilling for resources. The descriptions of the remaining three events were modified slightly to aid in estimation of event probabilities and consequence analyses. The three events are: exploratory drilling for resources penetrates a TRU borehole, irrigation occurs at the Radioactive Waste Management Site (RWMS), and subsidence occurs at the RWMS.

Use of a logic diagram with these three events resulted in the construction of eight scenarios, including base-case (undisturbed) conditions. Screening these scenarios at this stage of scenario development was beyond the scope of this task. Based on the implementation assumptions, this scenario-development procedure produced a comprehensive set of mutually exclusive scenarios that are reproducible and auditable for use in GCD performance assessments.

## DISPOSAL-SYSTEM DESCRIPTION

The Greater Confinement Disposal (GCD) facility consists of 13 boreholes (including GCD Test) augered into basin-fill deposits in Area 5 of the Nevada Test Site (Fig. 1). All of the boreholes are within the boundaries of the Radioactive Waste Management Site (RWMS) (Fig. 2), which is being used for the disposal of low-level waste. Each of the GCD boreholes is approximately 37 meters deep, and all but two

boreholes are 3 meters in diameter. The remaining two boreholes are 3.7 meters in diameter (1). Four of the boreholes (Nos. 1, 2, 3, 4; Fig. 2) contain nuclear-weapons accident residue that consists of waste contaminated with transuranic (TRU) radionuclides (2). The TRU waste was placed in the bottom 15.2 meters of each borehole with probertite, in which the boron acts as a neutron absorber, used as backfill for this interval. The remainder of each borehole was filled with sifted, native material that had been removed during augering.

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Basin-fill deposits at the GCD location are approximately 506 meters thick, and the depth to the water table is approximately 244 meters. Total yearly precipitation at the GCD location ranges from 10 to 13 centimeters. Recent studies of environmental tracers in the unsaturated zone suggest that recharge is negligible to nonexistent at this location (3).

## REGULATORY BASIS FOR SCENARIOS

Because of the presence of the TRU waste in four of the GCD boreholes, this facility will have to comply with the U.S. Environmental Protection Agency's Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Waste--Final Rule 40 CFR Part 191 (the Standard) (4). Performance assessments (PAs) are required to address the Containment Requirements (§191.13) of this regulation. By definition in the regulation (§191.12(q)), a PA includes the identification of processes and events that may affect disposal-system performance and estimates these effects. By implication, combinations of processes and events also must be included in the analyses in order to assure that no important disruptions of the disposal system are omitted from the analyses. These combinations of processes and events are referred to as scenarios.

## DESCRIPTION OF THE SCENARIO-DEVELOPMENT PROCEDURE

If all combinations of all events and processes that might occur at a disposal site are constructed, the result is a larger number of scenarios than can possibly be analyzed (i.e., $2^n$, where n equals the number of events and processes). An alternative to identifying all scenarios is to only identify those scenarios that may have a significant impact on the release of radionuclides from the engineered facility and/or the transport of radionuclides from the engineered facility to the accessible environment (i.e., the land surface and the geologic system more than 5 km from the repository boundary). A scenario-development procedure (5) that accomplishes this goal was developed as one component of the performance-assessment methodology (6,7) adopted by the PA Task of the GCD Project. Several assumptions are made in implementing this procedure:

- only postclosure conditions are considered
- only events and processes compromising the performance of the engineered facility and/or affecting radionuclide transport to the accessible environment are considered
- regulatory guidance limits the severity of human-intrusion events that need to be considered
- regulatory guidance limits the probability of occurrence of events and processes that need to be considered
- the time frame for the scenarios is 10,000 years after disposal-system closure.
- events and processes within a scenario are independent or dependence can be addressed during modeling
- the sum of the probabilities of the scenarios developed by the procedure is equal to 1

These assumptions are incorporated into the scenario-development procedure as screening criteria and into the method of scenario construction.

The scenario-development procedure (5) contains five steps. In the first step, a list of events and processes that potentially can affect disposal-system performance is either created, adopted, or adapted. Cranwell et al. (5) contains a generic list of 27 events and processes that were considered to be a starting point in compiling a site-specific or geologic-medium-specific list of potentially disruptive events and processes.

The second step of the procedure classifies the events and processes using any of several schemes for organizational purposes and to help assure that no important events and processes have been omitted. One of the more useful classification schemes is to distinguish between naturally occurring, human-induced, and repository/waste-induced events and processes. Subdivisions within each category also may be useful. In an adopted or an adapted list, this step may already be incorporated in the list.

The third step of the procedure screens the events and processes using specific criteria based on guidance provided to the Standard to identify those events and processes that can be eliminated from scenario development without effecting the performance measure as determined in PAs. Three screening criteria were proposed: probability of occurrence, consequence, and physical reasonableness. Guidance to the Standard states that events and processes that have a probability of less than one chance in 10,000 of occurring in 10,000 years can be eliminated from consideration no matter what the potential magnitude of the consequence may be. The rationale behind the consequence criterion is that the elimination from analyses of any event or process that does not have the potential to affect radionuclide escape or transport simplifies scenario development by producing fewer scenarios and will not affect the calculated radionuclide releases in PAs. Screening out an event or process because of a lack of physical reasonableness is essentially the same as low probability, only the decision is based on logical arguments rather than a calculated (or elicited) numerical value.

Scenarios are constructed in the fourth step of the procedure by developing all possible combinations of the events and processes that survived the screening in Step 3. Combinations are developed through the use of a logic diagram. In the logic diagram, a decision is made at each branch as to whether the corresponding event across the top of the diagram occurs or does not occur in each path through the diagram (each path is a scenario). The sequence of events and processes within a scenario is not relevant to the definition of the scenario. Temporal relationships among events and processes may be addressed during modeling. As a result, each scenario is composed of a unique combination of occurring and nonoccurring events and processes. If none of the events and processes occur (the topmost branch in the diagram), the disposal system is undisturbed (base-case scenario). An example of a logic diagram is included in the section below demonstrating the use of this procedure for the GCD facility.

The final step of the procedure uses two screening criteria to identify which scenarios should be included in performance-assessment analyses. Probability of occurrence is one criterion, using the same numerical constraints used to screen the events and processes. The other criterion is consequence, in the form of radionuclide releases to the accessible environment.

## SCENARIO DEVELOPMENT FOR THE GCD FACILITY

One of the major concerns in scenario development is the possibility that events and processes that could have a significant impact on disposal-system performance are omitted from the original list of events and processes, thereby excluding these events and processes from scenario construction. To address this concern about completeness, scenario-development for the GCD facility (8) merged 11 lists from various sources. The sources for these 11 lists can be divided into four categories: generic lists from U.S. programs, site-specific lists from U.S. Programs, generic lists from international programs, and lists from other national programs. The composite list contains 761 features, events, processes, and miscellaneous other listings, which for convenience are referred to as FEPs (Features, Events, and Processes). Consolidation of this master list by eliminating duplications and redundancies produced a revised list of 205 FEPs.

The motivation in the development of the events and processes list in Cranwell et al. (5) was to identify possible disruptions to the disposal system. Several of the merged lists were compiled with other objectives in mind (e.g., listing all conceivable FEPs, identifying pathways to man, etc.). Because of the diverse nature of these FEPs when compared to the Cranwell et al. (5) list, additional screening criteria were developed (Table I) to focus scenario development on identifying potential disruptions of the disposal system in order to address the Containment Requirements in the Standard.

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Screening of the 205 FEPs in the revised list identified three events for scenario development: exploratory drilling for resources, irrigation, and subsidence over the LLW trenches and/or the TRU boreholes. Exploratory drilling is a concern to disposal-system performance, because this event could result in the release of radionuclides directly to the surface if the borehole penetrates the waste in the boreholes or the diffusion halo surrounding the TRU boreholes. Both irrigation through the addition of water and subsidence through ponding of runoff are possible mechanisms for increasing the soil moisture in the vicinity of the TRU boreholes, thereby increasing the rooting depth of either crops or native vegetation. Using probability of occurrence or consequence modeling to screen these three events was beyond the scope of preliminary scenario development. The definitions of these events were modified slightly to be more specific on where the events occur for later use in probability estimation and consequence analyses. The revised wording results in the following three events: exploratory drilling penetrates a TRU borehole, irrigation occurs at the RWMS, and subsidence occurs at the RWMS. An event of drilling withdrawal wells originally survived screening, but the elimination of the transport pathway of radionuclides reaching the water table (9) eliminates concerns of withdrawal wells bringing contaminated water to the surface. The potential releases of radionuclides to the surface resulting from withdrawal wells being drilled into TRU boreholes were included by considering these boreholes to be exploratory drilling for water and therefore combined with the more generic event of exploratory drilling for resources penetrates a TRU borehole. If analyses of irrigation and subsidence indicate that the increased infiltration associated with either of these events can result in radionuclide transport to the water table, the event of drilling withdrawal wells will be reconsidered as a mechanism for radionuclide transport to the accessible environment.

The three events can be combined with the use of a logic diagram to form eight scenarios (Fig. 3). In this preliminary scenario development (8), no attempt was made to screen the constructed scenarios. Both probability estimation of and consequence analyses for the individual events in the scenarios are ongoing activities. Preliminary estimation of scenario probabilities (10) suggests that from the probability point of view, disposal-system performance is dominated by the base-case scenario (i.e., undisturbed conditions) and subsidence exclusive of the occurrence of the other two events. From the consequence point of view, no single scenario or small number of scenarios has been identified at this time through consequence analyses as dominating disposal-system performance. The dominant mechanisms of radionuclide transport to the accessible environment are human intrusion by drilling and radionuclide uptake by plants. One or both mechanisms may be present in each scenario. Although the scenarios containing more than one of these transport mechanisms may seem more likely to result in greater consequences than scenarios with single mechanisms, the duration of occurrence of each mechanism in each scenario within the time period of regulatory concern may result in different conclusions.

PLACE FIG. 3 HERE

## CONCLUSIONS

Based on certain implementing assumptions, the use of a structured scenario-development procedure has produced a comprehensive set of mutually exclusive scenarios that are reproducible and auditable for use in PAs. Comprehensive refers to the fact that all possible scenarios are constructed from those events that survived screening. Mutually exclusive means that each scenario consists of a unique combination of events, which is essential when associating scenario consequences with scenario probabilities. The scenarios are reproducible in that an identical set of events will always produce the same scenarios. These scenarios are auditable in that the steps of the procedure are well defined, and the decisions made in implementing the procedure are documented.

ACKNOWLEDGMENT

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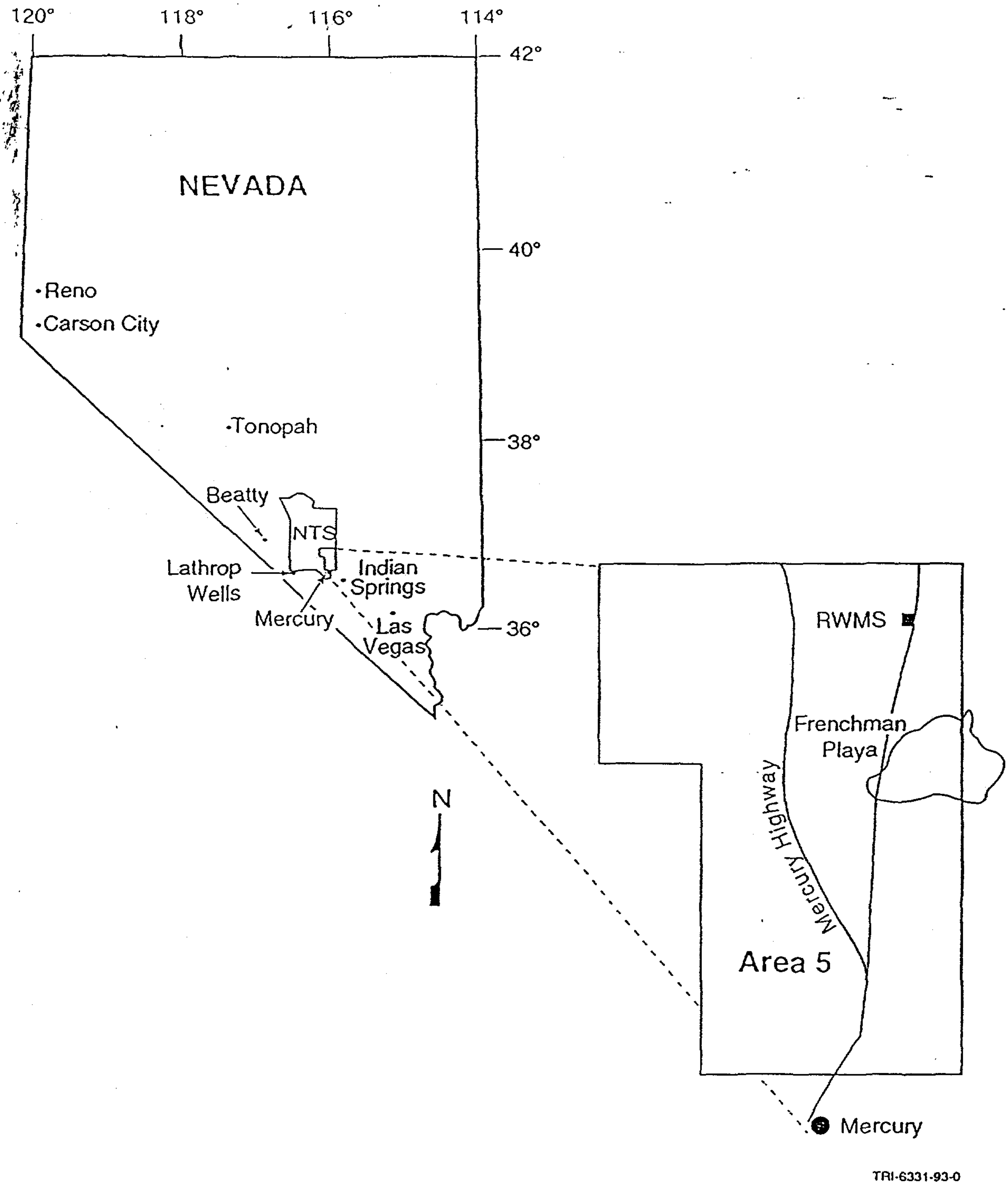



Figure ~~2-~~1. Location of Radioactive Waste Management Site (RWMS) at Area 5 of Nevada Test Site, Nevada (8)

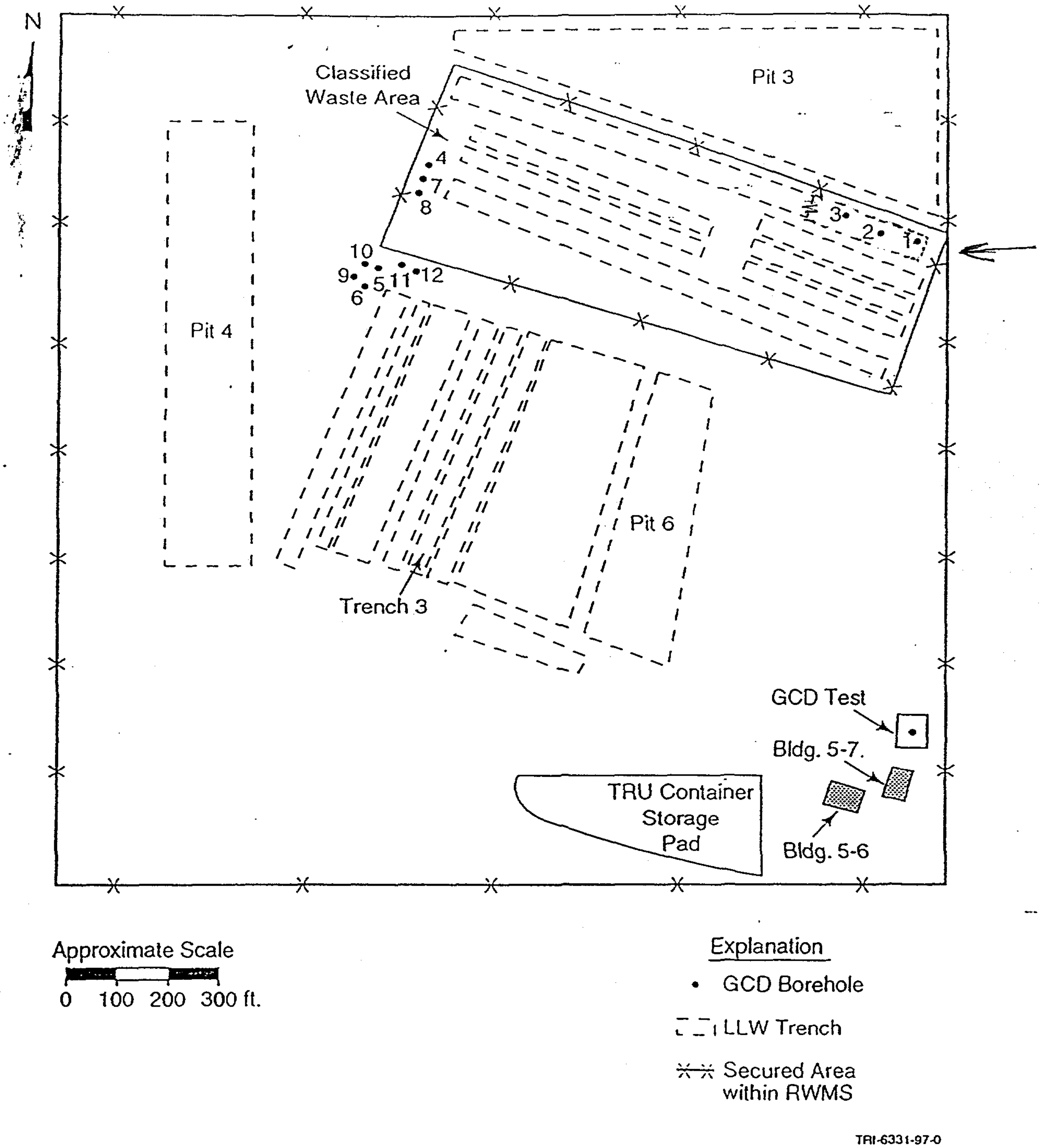



Figure 2-2. Schematic Representation of RWMS (after ~~Chu and Bernard, 1991~~ 3)

TABLE I. Criteria for Screening FEPs (after 8)

Original Screening Criteria in Cranwell et al. (5)

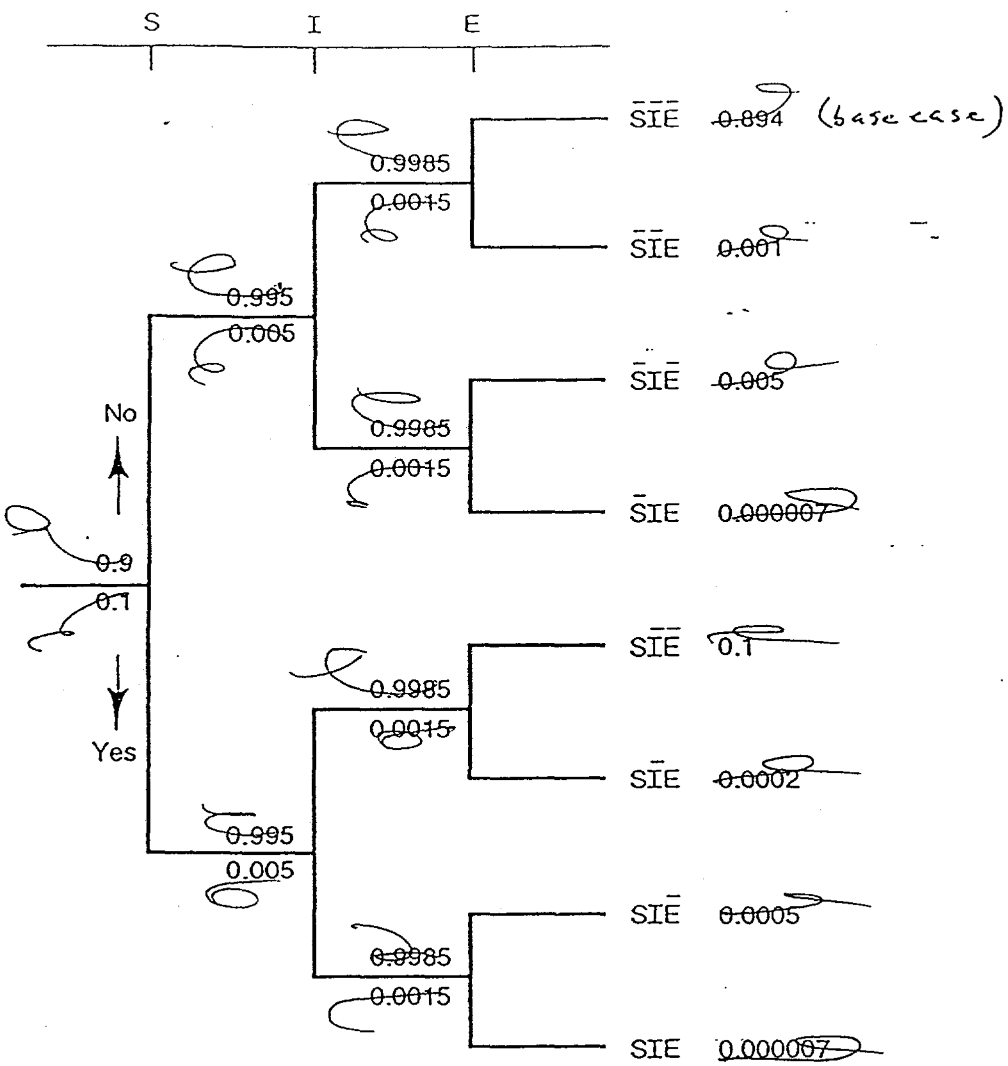
- probability of occurrence
- consequence
- physical reasonableness

Implied Screening Criteria in Cranwell et al. (5)

- regulatory restrictions for performance assessments
  - only postclosure conditions
  - only inadvertent human intrusion
  - limits severity of human-intrusion events at the site
  - eliminates surface transport and biological pathways to humans
- base-case condition

Additional Screening Criteria for GCD Analysis

- part of conceptual model
- response of the disposal system to an event or process
- applicability to
  - geologic setting
  - disposal facility
  - type of waste/waste form
  - analysis
- "event" or "process" not adequately defined




Explanation

S - Subsidence Occurs at RWMS
I - Irrigation Occurs at RWMS
E - Exploratory Drilling Penetrates TRU Borehole

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Figure ~~6-1~~ 3: Preliminary Calculation of Scenario Probabilities through the Use of a Logic Diagram. (A bar over a letter indicates an event that does not occur in that scenario). (after 10)