PRESENTATION TO
THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: FLOWDOWN OF REGULATORY REQUIREMENTS TO THE PERFORMANCE ASSESSMENT PROGRAM

PRESENTER: DR. LARRY D. RICKERTSEN
PRESENTER’S TITLE AND ORGANIZATION: MANAGER, ISSUES RESOLUTION SECTION WESN TECHNICAL SUPPORT TEAM OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
PRESENTER’S TELEPHONE NUMBER: (202) 646-6760

MAY 16-17, 1989
U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

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SCOPE OF PRESENTATION

• RELATION OF PERFORMANCE ASSESSMENT STRATEGY TO ISSUES RESOLUTION STRATEGY

• MEASURES OF PERFORMANCE TO BE EVALUATED

• ELEMENTS OF THE PERFORMANCE ASSESSMENT STRATEGY THAT FOLLOWS FROM THE PERFORMANCE OBJECTIVES OF 10 CFR PART 60
PERFORMANCE ASSESSMENT PROCESS

SITE, ENGINEERED BARRIERS CHARACTERISTICS

PERFORMANCE MEASURES

DEVELOP PHYSICAL MODELS

DEVELOP CALCULATIONAL MODELS

CALCULATE PERFORMANCE MEASURES

ANALYZE SENSITIVITY AND UNCERTAINTY

RESULTS
ISSUE RESOLUTION STRATEGY

1a DEVELOP SYSTEM DESCRIPTION

1 IDENTIFY REGULATORY REQUIREMENTS

2 DEFINE ISSUES

3 SET LICENSING STRATEGY

4 IDENTIFY INFORMATION NEEDS

5 IDENTIFY PARAMETERS, SET TENTATIVE "GOALS", AND SET "INDICATIONS OF CONFIDENCE"

6 DEVELOP TESTING STRATEGY

7 CONDUCT INVESTIGATIONS

8 ANALYZE RESULTS

9 ESTABLISH THAT INFORMATION NEEDS ARE SATISFIED

10 USE INFORMATION TO RESOLVE ISSUES

11 DOCUMENT RESOLUTION
FLOWDOWN OF REGULATORY REQUIREMENTS TO SITE INVESTIGATIONS, DESIGN, AND PERFORMANCE ASSESSMENT

REGULATORY REQUIREMENTS

PERFORMANCE AND DESIGN ISSUES

PERFORMANCE MEASURES

PERFORMANCE ASSESSMENTS

SITE, ENGINEERED BARRIERS INFORMATION

YES

FURTHER ADDRESS UNCERTAINTIES?

ISSUE RESOLUTION

TESTING AND DESIGN STRATEGIES TO ADDRESS UNCERTAINTIES

PROGRAM OF INVESTIGATIONS AND DESIGN

PERFORMANCE ALLOCATION
PERFORMANCE ASSESSMENT PROCESS

SITE, ENGINEERED BARRIERS CHARACTERISTICS

DEVELOP PHYSICAL MODELS

DEVELOP CALCULATIONAL MODELS

CALCULATE PERFORMANCE MEASURES

ANALYZE SENSITIVITY AND UNCERTAINTY

RESULTS
PERFORMANCE ASSESSMENT OBJECTIVES DEFINE PERFORMANCE MEASURES

- Evaluate system and subsystem performance to demonstrate compliance with the technical criteria of 10 CFR Part 60 for the license application.

- Evaluate environmental impacts for the environmental impact statement.

- Assess sensitivities and uncertainties in the performance assessment.

- Guide design and testing activities.
DOSES TO REPOSITORY WORKERS AND MEMBERS OF THE GENERAL PUBLIC FROM ROUTINE OPERATIONS MUST MEET CRITERIA SPECIFIED IN 10 CFR PART 20 AND 40 CFR PART 191, SUBPART A

NO CRITERIA FOR DOSES FROM ACCIDENTS BUT CRITERION FOR SYSTEMS, COMPONENTS AND STRUCTURES IMPORTANT TO SAFETY
REQUIREMENTS FOR POSTCLOSURE PERFORMANCE
10 CFR 60.112
40 CFR PART 191, SUBPART B (CURRENTLY IN REMAND)

CONTAINMENT FOR SIGNIFICANT PROCESSES AND EVENTS

PROBABILITY OF 10,000-YEAR CUMULATIVE RELEASE TO ACCESSIBLE ENVIRONMENT SHALL BE LESS THAN ONE CHANCE IN TEN OF EXCEEDING SPECIFIED LIMITS AND LESS THAN ONE CHANCE IN 1000 OF EXCEEDING TEN TIMES THESE LIMITS

INDIVIDUAL PROTECTION FOR UNDISTURBED PERFORMANCE

ANNUAL DOSE TO INDIVIDUALS LESS THAN SPECIFIED LIMITS FOR 1000 YEARS AFTER DISPOSAL

GROUND-WATER PROTECTION FOR UNDISTURBED PERFORMANCE

CONCENTRATIONS IN SPECIAL SOURCES OF GROUND WATER LESS THAN SPECIFIED LIMITS FOR 1000 YEARS AFTER DISPOSAL
REQUIREMENTS FOR NATURAL AND ENGINEERED BARIERS
10 CFR 60.113

CONTAINMENT OF HLW WITHIN WASTE PACKAGES WILL BE SUBSTANTIALLY COMPLETE FOR A PERIOD BETWEEN 300 AND 1000 YEARS AFTER PERMANENT CLOSURE FOR ANTICIPATED PROCESSES AND EVENTS

ANNUAL RELEASE OF ANY RADIONUCLIDE FROM THE EBS FOR ANTICIPATED PROCESSES AND EVENTS SHALL BE LESS THAN SPECIFIED LIMIT

PRE-WASTE-EMPLACEMENT GROUND-WATER TRAVEL TIME ALONG FASTEST PATH OF LIKELY RADIONUCLIDE TRAVEL FROM DISTURBED ZONE TO ACCESSIBLE ENVIRONMENT SHALL BE AT LEAST 1000 YEARS
REQUIREMENTS FOR FAVORABLE AND POTENTIALLY ADVERSE CONDITIONS
10 CFR 60.122

MUST EVALUATE EFFECT ON WASTE ISOLATION OF POTENTIALLY ADVERSE CONDITIONS THAT MAY BE PRESENT:

(1) POTENTIAL FOR FLOODING OF UNDERGROUND FACILITY
(2) FORESEEABLE HUMAN ACTIVITY THAT COULD AFFECT GROUND-WATER FLOW SYSTEM
(3) LARGE SURFACE WATER IMPOUNDMENTS THAT MAY BE ADVERSE
(4) STRUCTURAL DEFORMATION THAT MAY AFFECT REGIONAL GROUND-WATER SYSTEM
(5) CHANGES TO HYDROLOGIC CONDITIONS THAT COULD AFFECT RADIONUCLIDE MIGRATION
(6) CHANGES TO HYDROLOGIC CONDITIONS THAT COULD AFFECT EBS
(7) GEOCHEMICAL PROCESSES THAT COULD ADVERSELY AFFECT THE EBS
REQUIREMENTS FOR FAVORABLE AND POTENTIALLY ADVERSE CONDITIONS
10 CFR 60.122
(CONTINUED)

(8) GEOCHEMICAL PROCESSES THAT COULD ADVERSELY AFFECT WASTE ISOLATION
(9) GROUND-WATER CONDITIONS THAT ARE NOT REDUCING
(10) EVIDENCE OF DISSOLUTIONING
(11) STRUCTURAL DEFORMATION DURING QUATERNARY PERIOD
(12) EARTHQUAKES THAT COULD AFFECT THE SITE SIGNIFICANTLY
(13) INDICATION THAT FREQUENCY OR MAGNITUDE OF EARTHQUAKES MAY INCREASE
(14) MORE FREQUENT OCCURRENCE OF EARTHQUAKES AT SITE THAN IN REGION
(15) IGNEOUS ACTIVITY SINCE THE START OF THE QUATERNARY PERIOD
(16) EXTREME EROSION DURING QUATERNARY PERIOD
REQUIREMENTS FOR FAVORABLE AND POTENTIALLY ADVERSE CONDITIONS
10 CFR 60.122
(CONTINUED)

(17) PRESENCE OF NATURAL RESOURCES
(18) SUBSURFACE MINING AT THE SITE
(19) DRILLING AT THE SITE
(20) ROCK OR GROUND-WATER CONDITIONS REQUIRING COMPLEX ENGINEERING
(21) GEOCHEMICAL CONDITIONS THAT DO NOT PERMIT STABLE OPENINGS
(22) POTENTIAL FOR WATER TABLE RISE TO SATURATE THE UNDERGROUND FACILITY
(23) PERCHED WATER BODIES THAT MAY BE ADVERSE
(24) MOVEMENT OF GASEOUS RADIONUCLIDES THROUGH AIR-FILLED PORE SPACES
DESIGN CRITERIA
10 CFR 60.130-135

GENERAL DESIGN CRITERIA (60.131)

- LIMITS SPECIFIED IN 10 CFR PART 20 (10 CFR 60.111)
- STRUCTURES, SYSTEMS, COMPONENTS IMPORTANT TO SAFETY

ADDITIONAL DESIGN CRITERIA FOR SURFACE FACILITIES (60.132)

- REQUIREMENTS OF 10 CFR 60.111

ADDITIONAL DESIGN CRITERIA FOR THE UNDERGROUND FACILITY (60.133)

- CONTRIBUTE TO WASTE ISOLATION AND CONTAINMENT

DESIGN OF SEALS FOR SHAFTS AND BOREHOLES (60.134)

- DO NOT COMPROMISE ABILITY TO MEET PERFORMANCE OBJECTIVES
- DO NOT CREATE PREFERENTIAL PATHWAY

CRITERIA FOR THE WASTE PACKAGE (60.135)

- DO NOT COMPROMISE ABILITY TO MEET PERFORMANCE OBJECTIVES
ANALYSES REQUIRED FOR ENVIRONMENTAL IMPACT STATEMENT
CEQ GUIDELINES

• ANALYSES DEFINED DURING SCOPING

• ENVIRONMENTAL IMPACTS (E.G., DOSE OR HEALTH EFFECTS)

• ANALYSIS OF LONG-TERM PERFORMANCE

• ANALYSIS OF ACCIDENTS AND DISRUPTIONS
SITE SUITABILITY ANALYSIS AND
ANALYSES TO SUPPORT DESIGN AND
TESTING PROGRAMS

ANALYSES FOCUS ON PERFORMANCE
MEASURES OF 10 CFR PART 60
PERFORMANCE MEASURES

PRECLOSURE SAFETY

- DOSES TO WORKERS AND MEMBERS OF PUBLIC FROM ROUTINE OPERATIONS
- DOSES TO MEMBERS OF PUBLIC FROM ACCIDENTS

POSTCLOSURE TOTAL SYSTEM PERFORMANCE

- 10,000-YEAR CUMULATIVE RELEASE TO ACCESSIBLE ENVIRONMENT (CCDF)
- ANNUAL DOSE TO INDIVIDUALS
- CONCENTRATIONS IN SPECIAL SOURCES OF GROUND WATER

ENGINEERED BARRIERS PERFORMANCE

- TIME OF CONTAINMENT OF RADIOACTIVE MATERIAL IN WASTE PACKAGES
- RATE OF RELEASE OF FROM ENGINEERED BARRIER SYSTEM

NATURAL BARRIERS PERFORMANCE

- PRE-WASTE-EMPLACEMENT GROUND-WATER TRAVEL TIME ALONG FASTEST PATH OF LIKELY RADIONUCLIDE TRAVEL FROM DISTURBED ZONE TO ACCESSIBLE ENVIRONMENT
OTHER PERFORMANCE MEASURES

- SURROGATE PERFORMANCE MEASURES WHEN DATA ARE INCOMPLETE

- VARIABLES IMPORTANT TO THE PERFORMANCE MEASURES
PERFORMANCE ASSESSMENT PROCESS

SITE, ENGINEERED BARRIERS CHARACTERISTICS

DEVELOP PHYSICAL MODELS

DEVELOP CALCULATIONAL MODELS

CALCULATE PERFORMANCE MEASURES

ANALYZE SENSITIVITY AND UNCERTAINTY

RESULTS
PHYSICAL MODELS

SITE CONCEPTUAL MODELS

SCENARIOS

PROCESS AND CONSTITUTIVE MODELS
SOLITARIO CANYON YUCCA MOUNTAIN GHOST DANCE FAULT DRILL HOLE WASH

SOLITARIO CANYON FAULT

1500 - CANYON FAULT BOW RIDGE FAULT

QTc QTc QTc

M

1000-

REPOSITORY ENVELOPE

TOPPAH SPRING MEMBER TIVA CANYON MEMBER PROW PASS MEMBER BULLFROG MEMBER TRAM MEMBER HIGHLY FAULTED AND BRECCIATED ZONE

ALLUVIUM & COLLUVIUM BASAL VITROPHYRE

FLOW BRECCIA

BEDDED TUFF TUFFACEOUS BEDS OF CALICO HILLS

Tb

ELEVATION IN METERS

HORIZONTAL SCALE

0 1000 2000 FEET

0 500

Tb Tp Tp Tp Tp

FEET

Tb

Tb

Tb

Tb

Tb

HOT Springs

Tuffaceous Beds of Calico Hills

Tuff Breccia

Faults with minor dip-slip displacements

Positions known or concealed at surface

Faults with major dip-slip displacements

Positions known or concealed at surface

Unmapped & inferred faults

With small displacement

STRATIGRAPHY UNCERTAIN

WATER TABLE

ARROWS SHOW DIRECTION OF RELATIVE DISPLACEMENT

TIVA CANYON MEMBER

PROW PASS MEMBER

BULLFROG MEMBER

TRAM MEMBER

FLOW BRECCIA

BEDDED TUFF

TUFFACEOUS BEDS OF CALICO HILLS

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PERFORMANCE ASSESSMENT PROCESS

SITE, ENGINEERED BARRIERS CHARACTERISTICS

PERFORMANCE MEASURES

DEVELOP PHYSICAL MODELS

DEVELOP CALCULATIONAL MODELS

CALCULATE PERFORMANCE MEASURES

ANALYZE SENSITIVITY AND UNCERTAINTY

RESULTS
CALCULATIONAL MODELS

LEVEL I  SIMPLIFIED SYSTEM AND SUBSYSTEM MODELS

LEVEL II  INTEGRATED SYSTEM AND SUBSYSTEM MODELS
(MODELS TO CALCULATE PERFORMANCE MEASURES)

LEVEL III  SUBMODELS FOR PROCESSES, COMPONENTS
(E.G., FLOW MODELS, THERMAL MODELS)
PERFORMANCE ASSESSMENT PROCESS

SITE, ENGINEERED BARRIERS CHARACTERISTICS

PERFORMANCE MEASURES

DEVELOP PHYSICAL MODELS

DEVELOP CALCULATIONAL MODELS

CALCULATE PERFORMANCE MEASURES

ANALYZE SENSITIVITY AND UNCERTAINTY

RESULTS
CALCULATIONS OF PERFORMANCE MEASURES

ONLY ONE ASPECT OF PERFORMANCE ASSESSMENT

DETERMINISTIC vs PROBABILISTIC ANALYSIS

CONSERVATIVE ANALYSIS

BOUNDING ANALYSIS
TYPES OF UNCERTAINTIES

UNCERTAINTIES IN PHYSICAL MODELS

PARAMETER UNCERTAINTY

UNCERTAINTY DUE TO EXTRAPOLATION OF MODELS

UNCERTAINTIES DUE TO UNANTICIPATED PROCESSES OR EVENTS
UNCERTAINTY IN MODEL OF FLOW PROCESS
UNCERTAINTY IN PARAMETERS
UNCERTAINTY IN EXTRAPOLATION OF MODELS
ADDRESSING UNCERTAINTIES

MODIFY PERFORMANCE ASSESSMENTS TO ADDRESS UNCERTAINTIES

- CONSERVATIVE ANALYSES
- BOUNDING ANALYSES
- SCENARIO ANALYSIS TO ADDRESS UNANTICIPATED PROCESSES AND EVENTS
- SENSITIVITY AND UNCERTAINTY ANALYSIS

ADDITIONAL TESTING TO REDUCE UNCERTAINTIES

- SITE CHARACTERIZATION AND ENGINEERED BARRIERS TESTING
- MODEL VALIDATION
- PERFORMANCE CONFIRMATION

MODIFY DESIGN TO MITIGATE UNCERTAINTIES

- MULTIPLE BARRIERS
- DESIGN MARGIN
STRATEGY AND IMPLEMENTATION

SITE CHARACTERIZATION PLAN
STUDY PLANS

PERFORMANCE ASSESSMENT
STRATEGY PLAN (PASP)
IMPLEMENTATION PLAN (PAIP)

1. DEVELOP SYSTEM DESCRIPTION

IDENITFY REGULATORY REQUIREMENTS

DEFINE ISSUES

SET LICENSING STRATEGY

IDENTIFY INFORMATION NEEDS

SET PERFORMANCE MEASURES
SET RELEVANT "GOALS" AND "INDICATIONS OF CONFIDENCE"

DEVELOP TESTING STRATEGY
IDENTIFY TESTS, VARIABLES AND PARAMETERS TO BE MEASURED

CONDUCT INVESTIGATIONS

ANALYZE RESULTS

ESTABLISH THAT INFORMATION NEEDS ARE SATISFIED

USE INFORMATION TO RESOLVE ISSUES

DOCUMENT RESOLUTION

PERFORMANCE MEASURES

SITE, ENGINEERED BARRIERS CHARACTERISTICS

DEVELOP PHYSICAL MODELS

DEVELOP CALCULATIONAL MODELS

CALCULATE PERFORMANCE MEASURES

ANALYZE SENSITIVITY AND UNCERTAINTY

RESULTS