

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

**PRESENTATION TO  
THE NUCLEAR WASTE TECHNICAL REVIEW BOARD**

**SUBJECT: ESF DESIGN STUDIES STATUS  
AND RESULTS OF NORTH AREA  
REVIEW**

**PRESENTER: DR. R.L. BULLOCK**

**PRESENTER'S TITLE  
AND ORGANIZATION: TECHNICAL PROJECT OFFICER  
RAYTHEON SERVICES NEVADA  
LAS VEGAS, NEVADA**

**PRESENTER'S  
TELEPHONE NUMBER: (702) 794-7014**

**JULY 15, 1991**

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# **STATUS OF DESIGN STUDY**

- **THIS IS A PRELIMINARY DESIGN, EQUIVALENT IN DETAIL TO TITLE I DESIGN. SUBSTANTIAL WORK IS NEEDED BEFORE FINALIZATION OF DESIGN AND CONSTRUCTION STARTS. THIS WORK WILL BE DONE IN TITLE II.**

# **TITLE I LEVEL OF DETAIL**

- **THE PRELIMINARY STAGE OF PROJECT DESIGN UTILIZES THE CONCEPTUAL DESIGN AND DESIGN CRITERIA THAT HAVE BEEN PREPARED FOR THE PROJECT AS A DESIGN BASIS**
- **SUFFICIENT DESIGN NEEDS TO BE PERFORMED TO ILLUSTRATE THE EXTENT OF THE PROJECT SCOPE AND CONSTRUCTION FEATURES. FURTHERMORE, FROM THIS PRELIMINARY DESIGN, CONSTRUCTION COST AND SCHEDULES CAN BE DEVELOPED**

**DOE 4700.1**

# **TITLE II LEVEL OF DETAIL**

**TITLE II DEFINITIVE DESIGN IS THE FINAL DESIGN.  
A PARTIAL LIST OF WHAT THIS DESIGN USUALLY  
INCLUDES IS:**

- **RE STUDY AND REDESIGN WORK RESULTING FROM CHANGES AS MAY BE REQUIRED FROM PRELIMINARY DESIGN**
- **DEVELOPMENT OF FINAL WORKING DRAWINGS AND SPECIFICATIONS FOR PROCUREMENT AND CONSTRUCTION**
- **ESTIMATE DEVELOPMENT OF CONSTRUCTION LABOR, EQUIPMENT AND MATERIAL QUANTITIES**
- **DEVELOPMENT OF DETAILED ESTIMATES OF CONSTRUCTION AND PROCUREMENT COST AND SCHEDULES**
- **PREPARATION OF ANALYSIS OF HEALTH, SAFETY ENVIRONMENTAL AND OTHER PROJECT ASPECTS**

**DOE 4700.1**

**NOREVRB.125.NWTRB/7-15-91**

**ARTIST'S RENDERING OF TWO RAMPS  
OPTION FACILITY, YUCCA MOUNTAIN SITE  
CHARACTERIZATION PROJECT**

# **NORTH AREA**

- **ACCESS ROADS**
- **UTILITIES**
- **PORTAL PADS**
- **PORTAL FACILITY BUILDINGS**
- **RAMP TO TOPOPAH SPRINGS**
- **RAMP TO CALICO HILLS**
- **REVISED DESIGN SUMMARY REPORT (DRAFT)**
- **TEN PRELIMINARY TRADE-OFF STUDIES**
- **MUCK PILE LOCATION**
- **LOCATION OF SOUTH PORTAL**

# DESIGN STUDY PARTICIPANTS

- LANL (TESTING)
- USGS (RAMP DRILLING/SOIL AND ROCK STUDY)
- USBR (GEOLOGICAL ENGINEERING)
- SAIC (GEOTECHNICAL)
- SNL (PERFORMANCE ASSESMENT/WATER AND SEALS)
- PARSONS BRINKERHOFF (REPOSITORY INTERFACE)

# **DESIGN DELIVERABLES REVIEWED**

- **DRAWINGS**
- **STUDIES**
- **ANALYSES/CALCULATIONS**

# DRAWINGS

● CIVIL	34
● ELECTRICAL	13
● MECHANICAL	13
● MINING	11
● STRUCTURAL/ARCHITECTURAL	21
	<hr/>
TOTAL OF	92

# DRAWINGS

- **DEPICT THE GENERAL ARRANGEMENT CONCEPTS**
  - PRELIMINARY NOT DETAIL
- **THE GENERAL ARRANGEMENTS OF MAJOR SYSTEMS ARE SUPPORTED BY STUDIES/ANALYSES**
- **EXCAVATION, SUBSURFACE LAYOUTS AND TESTING HAVE UNDERGONE TECHNICAL INTEGRATION WITH OTHER PARTICIPANTS**
  - LANL (TESTING)
  - PBQD (REPOSITORY INTERFACE)
  - SNL (PERFORMANCE ASSESSMENT)
  - SAIC (ENGINEERING DISCIPLINE INPUTS)
- **EXTERNAL INPUT IS DOCUMENTED BY MEETING MINUTES AND REPORTS**

# PRELIMINARY STUDIES

## ● PRELIMINARY TRADE-OFF STUDIES COMPLETED FOR REVIEW

- NORTH RAMP PORTAL - SITING REPORT
- SOUTH RAMP PORTAL - SITING REPORT
- OPTIONAL SHAFT COLLAR - SITING REPORT
- PRELIMINARY ACCESS - SITING REPORT
- SHAFT SIZING REPORT
- RAMP SIZING REPORT - TS NORTH RAMP
- RAMP SIZING REPORT - CH NORTH RAMP
- TRANSPORTATION METHODS ANALYSIS
- RAMP/SCF FUNCTIONAL ANALYSIS
- PRELIMINARY EXCAVATION PLAN
- POWER LOAD FLOW STUDY

## ● PRELIMINARY STUDIES IN PROGRESS RESULTING FROM REVIEW

- NORTH RAMP PORTAL - SITING REPORT
- NORTH RAMP GRADE AND LAYOUT

# DESIGN SUMMARY REPORT

## ● DESCRIPTION OF THE DESIGN

- BEING PREPARED AS DESIGN PROGRESSES
- REVIEW COPY IS FIRST DRAFT
- LIMITED INFORMATION ON SOUTH AREA

## ● DRAFT CONTENTS PREPARED FOR NORTH AREA REVIEW

- EXECUTIVE SUMMARY
- CHAPTER 1 INTRODUCTION
- CHAPTER 2 GEOLOGY
- CHAPTER 3 PROJECT DESCRIPTION
- CHAPTER 4 ENVIRONMENTAL ASPECTS
- CHAPTER 5 SAFETY AND HEALTH ASPECTS
- CHAPTER 6 DESIGN ASPECTS
- CHAPTER 7 ESF/POTENTIAL INTERFACES, DESIGN CRITERIA AND REQUIREMENTS, AND NRC CONCERNS
- CHAPTER 8 ESF CLOSURE AND DECOMMISSIONING
- CHAPTER 9 LONG-LEAD PROCUREMENT ITEMS
- CHAPTER 10 TITLE II DESIGN
- CHAPTER 11 CONSTRUCTION
- CHAPTER 12 OPERATIONS AND TESTING
- CHAPTER 13 SCHEDULES
- CHAPTER 14 COST ESTIMATES

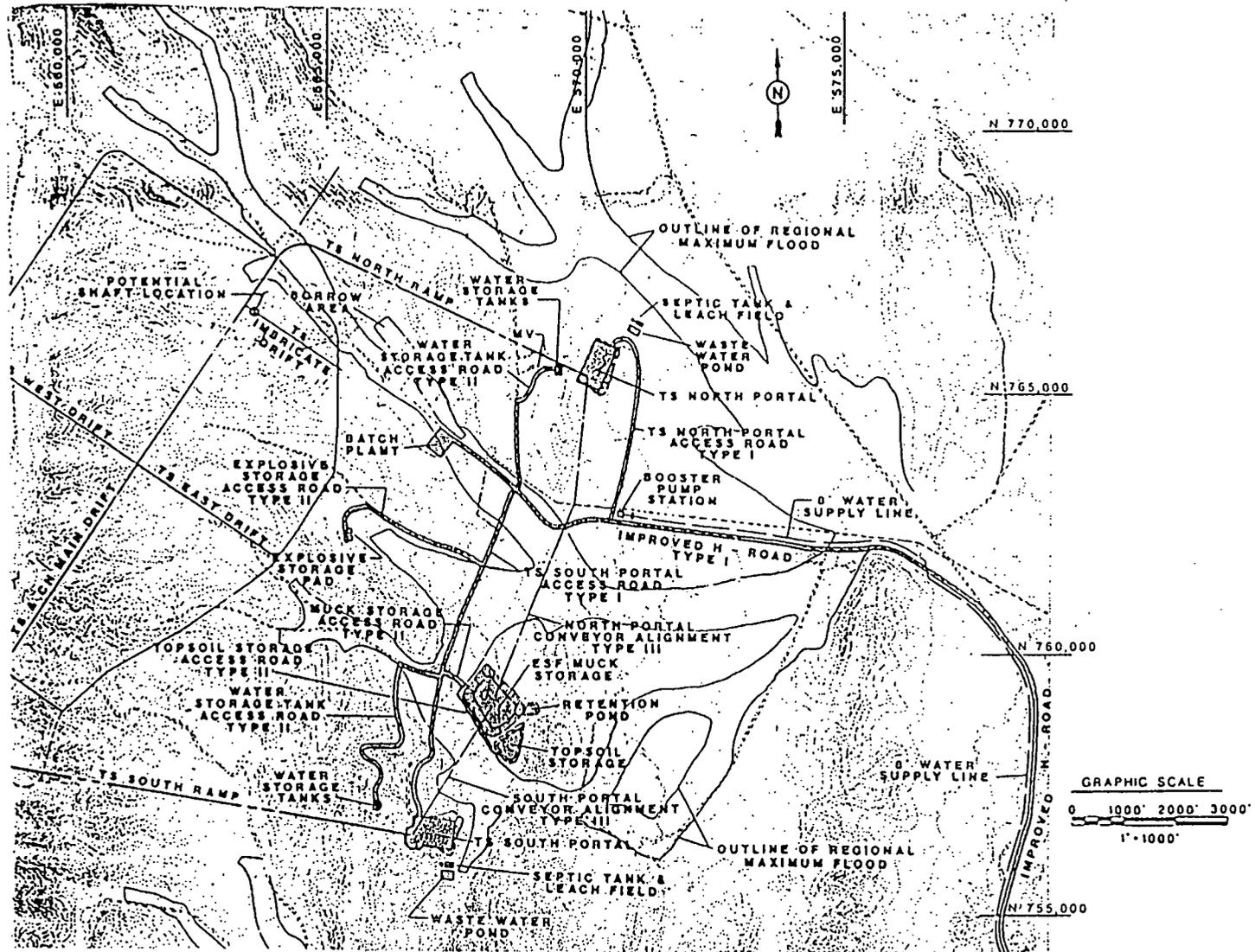
# **DESIGN SUMMARY REPORT**

(CONTINUED)

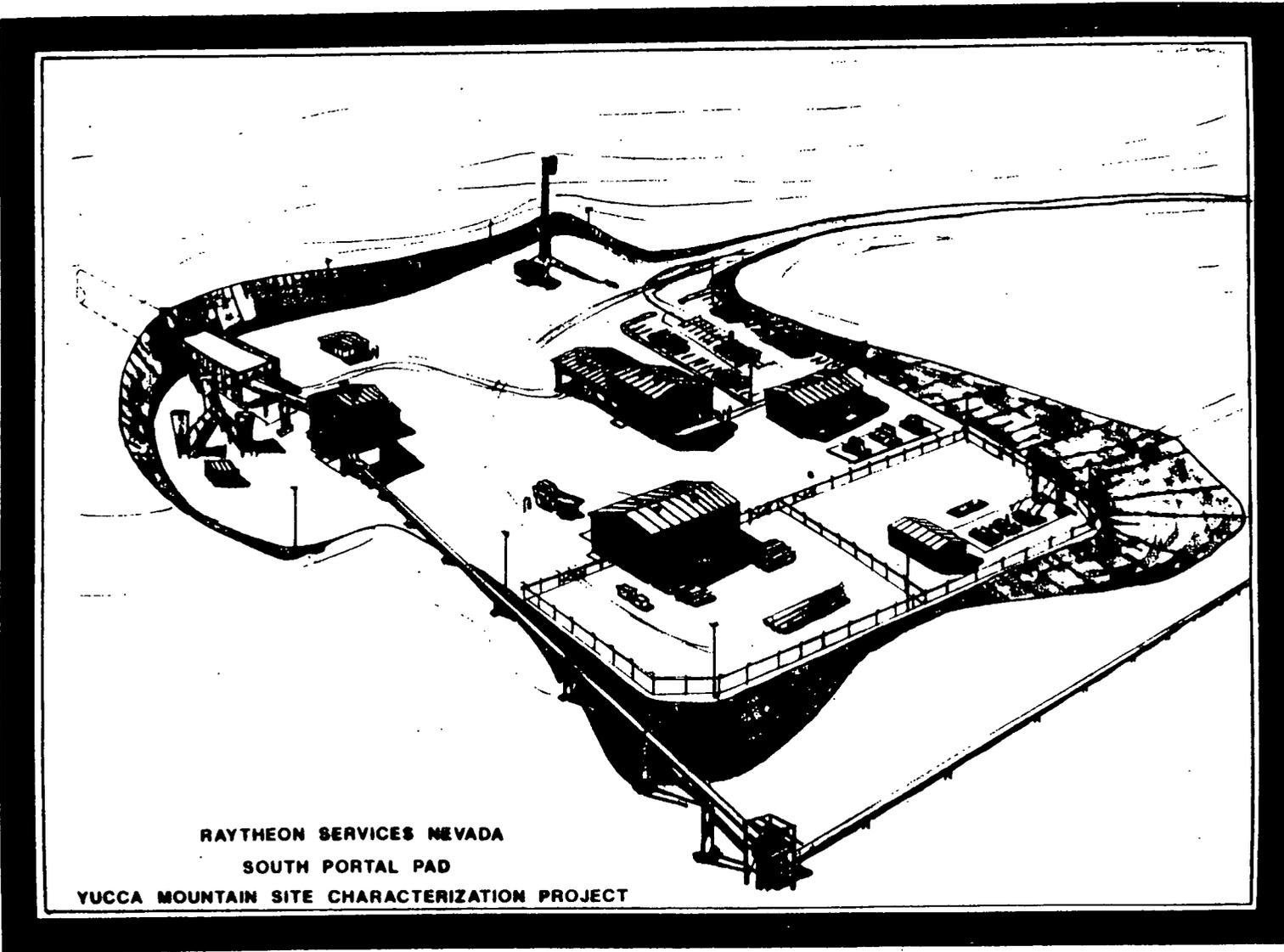
- **DRAFT CONTENTS THAT WILL BE ADDED FOR SOUTH AREA REVIEW**
  - **SECTION 9.2 ACQUISITION STRATEGY (SOUTH AREA REVIEW)**
  - **SECTION 12.1 OPERATIONS (SOUTH AREA REVIEW)**

# EXPLORATORY STUDIES FACILITY

## FACILITIES - GENERAL ARRANGEMENT



**ARTIST'S RENDERING OF NORTH PORTAL PAD,  
YUCCA MOUNTAIN SITE CHARACTERIZATION  
PROJECT**



**RAYTHEON SERVICES NEVADA  
SOUTH PORTAL PAD  
YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT**

# **NORTH PORTAL PAD**

- **ACCESS ROAD FROM "H" ROAD - 4,000 FT**
- **WIDTH - 24 FT**
- **PAVEMENT**
- **UTILITIES**
- **FRESH WATER PROVISIONS**
- **WASTE WATER PROVISIONS**

# **NORTH PORTAL PAD**

(CONTINUED)

- **PORTAL CONTROL BUILDING**
- **SURFACE DATA BUILDING**
- **TEST SUPPORT BUILDING**
- **CHANGE HOUSE**
- **MAIN WAREHOUSE**
- **FUEL STORAGE**
- **GENERATORS**

# **NORTH PORTAL PAD**

(CONTINUED)

- **ELECTRIC SUB-STATION CONTROL BUILDING**
- **TRANSFORMER**
- **SWITCHGEAR BUILDING**
- **CONVEYOR TRANSFER TOWER**
- **MICROWAVE COMMUNICATION BUILDING**
- **MICROWAVE COMMUNICATION TOWER**

# NORTH RAMP - TOPOPAH SPRING

- DIAMETER - 25 FT
- LENGTH - 6,500 FT\*
- SLOPE - 9.57%
- TURNING RADIUS - 600 FT

## EQUIPMENT

- HVAC SYSTEM
- CONVEYOR
- UTILITIES

\* BEING RE-EVALUATED AS A RESULT OF REVIEW COMMENTS

# **NORTH RAMP - CALICO HILLS**

- **DIAMETER** - **16 FT**
- **LENGTH** - **5,300 FT**
- **SLOPE** - **10%**
- **TURNING RADIUS** - **300 FT**

## **EQUIPMENT**

- **HVAC SYSTEM**
- **CONVEYOR**
- **UTILITIES**

# STOCK PILE

- **TOP SOIL STORAGE** - **APPROX. 20 ACRES**
- **MUCK STORAGE PILE** - **APPROX. 55 ACRES**
- **STOCK PILE HEIGHT** - **APPROX. 50 FT  
TOPSOIL 6 FT**
- **RUN-OFF DIVERSION BERM**
- **RETENTION POND**
- **IMPERVIOUS LINER**

# MAJOR OPEN ISSUES

- **EARTH DISTURBING SOIL AND ROCK SURVEYS ARE REQUIRED PRIOR TO FINAL SELECTION OF PORTAL LOCATION**
- **RAMP EXPLORATORY BOREHOLES ARE REQUIRED PRIOR TO FINAL RAMP DESIGN**
- **TOPOPAH SPRING/CALICO HILLS RAMP INTERCEPT LOCATIONS MUST BE FINALIZED**
- **POTENTIAL REPOSITORY ELEVATION, DIP AND STRIKE WILL BE BETTER DEFINED AFTER THE FINAL DESIGN OF RAMPS AND MTL, BUT MAY INDEED BE SUBJECT TO CHANGE**
- **THE FINAL DESIGNATED LOCATION OF THE POTENTIAL REPOSITORY SEALS CANNOT BE DONE UNTIL THE PRECISE LOCATION OF THE CONTACT OF THE PAH CANYON MEMBER AND THE TOPOPAH SPRING MEMBER IS DETERMINED AT THE DECLINE INTERCEPTS**

**MANAGEMENT REVIEW SUMMARY  
(JUNE 3-7, 1991)**

# MANAGEMENT REVIEWERS

<b>PROJECT OFFICE</b>	<b>(PO)</b>
<b>SANDIA NATIONAL LABORATORIES</b>	<b>(SNL)</b>
<b>LOS ALAMOS NATIONAL LABORATORY</b>	<b>(LANL)</b>
<b>U.S. GEOLOGICAL SURVEY</b>	<b>(USGS)</b>
<b>U.S. BUREAU OF RECLAMATION</b>	<b>(USBR)</b>
<b>REYNOLDS ELECTRICAL AND ENGINEERING CO.</b>	<b>(REEC<sub>o</sub>)</b>
<b>SCIENCE APPLICATIONS INTERNATIONAL CORP.</b>	<b>(SAIC)</b>
<b>PROJECT OFFICE, QUALITY ASSURANCE</b>	
<b>NWMS M&amp;O/TRW</b>	

# REVIEW CRITERIA

- CAN DETAILED REGULATORY CONSIDERATIONS BE IMPLEMENTED IN THIS DESIGN?
- CAN DETAILED SITE CHARACTERIZATION TEST CONSIDERATIONS BE IMPLEMENTED IN THIS DESIGN?
- CAN THIS DESIGN BE ACCOMPLISHED CONSISTENT WITH MSHA, OSHA?
- CAN DETAILED RELIABILITY, MAINTAINABILITY, AND OPERABILITY CONSIDERATION BE IMPLEMENTED IN THIS DESIGN?
- CAN DETAILED STRESS AND THERMAL CONSIDERATIONS BE IMPLEMENTED IN THIS DESIGN?
- CAN DETAILED CONSTRUCTABILITY CONSIDERATIONS BE IMPLEMENTED IN THIS DESIGN?
- CAN DETAILED ENVIRONMENTAL CONSIDERATION BE IMPLEMENTED IN THIS DESIGN?
- CAN DETAILED SOCIO-ECONOMIC CONSIDERATIONS BE IMPLEMENTED IN THIS DESIGN?

# RESULTS OF MANAGEMENT REVIEW

## NUMBER OF COMMENTS

DRAWINGS	250
TRADE STUDIES	76
DESIGN SUMMARY REPORT	164
TOTAL	<u>496 *</u>

## ANALYSIS OF COMMENTS

APPLICABLE TO TITLE I DETAIL	365 **
APPLICABLE TO TITLE II DETAIL	131

### EXAMPLES OF APPROPRIATE MINOR COMMENTS

- THE FIRE PLUG SHOULD BE 45 FT FROM THE BUILDING BY NTS CODE
- WATER SPRAYS ARE NEEDED AT TRANSFER POINTS BETWEEN CONVEYORS

### EXAMPLES OF APPROPRIATE SIGNIFICANT COMMENTS

- RESTUDY LOCATION OF WATER TANK AND BORROW PIT LOCATIONS IN REFERENCE TO THE SITE CHARACTERIZATION STUDY AREA
- RE-EVALUATE PROBABLE MAXIMUM FLOOD DATA BASED ON VARIOUS CONFIDENCE LEVELS AND MOST RECENT FINDINGS

**ADDED TRADE STUDIES RESULTING FROM REVIEW - NONE**

\* ALL COMMENTS REACHED RESOLUTION  
ALL ACCEPTED COMMENTS ON DELIVERABLE DOCUMENTS WERE INCORPORATED  
79 COMMENTS REQUIRED NO CHANGE IN DESIGN

NOREVRB.125.NWTRB/7-15-9

**INDEPENDENT TECHNICAL REVIEW  
(JUNE 17-21, 1991)**

# INDEPENDENT TECHNICAL REVIEW

## ● TECHNICAL REVIEWERS

- |                               |                         |
|-------------------------------|-------------------------|
| - CIVIL                       | RSN CENTRAL ENGINEERING |
| - ELECTRICAL                  | RSN CENTRAL ENGINEERING |
| - MECHANICAL                  | RSN CENTRAL ENGINEERING |
| - MINING                      | NEW RSN EMPLOYEE        |
| - STRUCTURAL                  | RSN CENTRAL ENGINEERING |
| - TESTING SUPPORT             | LANL TEST MANAGER       |
| - PERFORMANCE ASSESSMENT      | SNL                     |
| - QA                          | PROJECT OFFICE          |
| - CONSTRUCTION                | REEC <sub>o</sub>       |
| - REPOSITORY INTERFACE        | TRW                     |
| - MAINTAINABILITY/OPERABILITY | T&MSS                   |
| - ENVIRONMENTAL               | T&MSS                   |
| - REGULATORY                  | T&MSS                   |
| - SAFETY                      | RSN SAFETY DEPARTMENT   |

# **INDEPENDENT TECHNICAL REVIEW**

(CONTINUED)

## **● OBSERVERS**

- DOE/YMPO**
- OCRWM/WESTON**
- DOE/NTSO**
- MSHA**
- USBM**
- STATE OF NEVADA**
- COUNTIES**
- NWTRB REPRESENTATIVE**
- NRC REPRESENTATIVE**

# DESIGN CRITERIA

- **CAN DETAILED REGULATORY CONSIDERATIONS BE IMPLEMENTED IN THIS DESIGN?**
- **CAN DETAILED SITE CHARACTERIZATION TEST CONSIDERATIONS BE IMPLEMENTED IN THIS DESIGN?**
- **CAN THIS DESIGN BE ACCOMPLISHED CONSISTENT WITH MSHA, OSHA?**
- **CAN DETAILED RELIABILITY, MAINTAINABILITY, AND OPERABILITY CONSIDERATIONS BE IMPLEMENTED IN THIS DESIGN?**
- **CAN DETAILED STRESS AND THERMAL CONSIDERATIONS BE IMPLEMENTED IN THIS DESIGN?**
- **CAN DETAILED CONSTRUCTABILITY CONSIDERATIONS BE IMPLEMENTED IN THIS DESIGN?**
- **CAN DETAILED ENVIRONMENTAL CONSIDERATIONS BE IMPEMENTED IN THIS DESIGN?**
- **CAN DETAILED SOCIO-ECONOMIC CONSIDERATIONS BE IMPLEMENTED IN THIS DESIGN?**

# RESULTS OF TECHNICAL REVIEW

## NUMBER OF COMMENTS

DRAWINGS	102
TRADE STUDIES	128
DESIGN SUMMARY REPORT	116
TOTAL	<u>346 *</u>

## ANALYSIS OF COMMENTS

APPLICABLE TO TITLE I DETAIL	252 **
APPLICABLE TO TITLE II DETAIL	94

### EXAMPLES OF APPROPRIATE MINOR COMMENTS

- 4-WHEEL DRIVE TRUCK IS NOT NEEDED FOR THE GRADES SPECIFIED - 2-WHEEL DRIVE IS ADEQUATE
- LINE WEIGHTS ON DRAWING SHOULD BE VARIED
- 15° CONVEYOR INCLINATION AT THE PORTAL IS TOO STEEP - CHANGE TO 13° MAXIMUM

### EXAMPLES OF APPROPRIATE SIGNIFICANT COMMENTS

- IT IS STATED THAT THE GRADES OF RAMPS SHALL BE 10% (MAXIMUM) ON STRAIGHT SECTIONS AND 6% ON CURVED SECTIONS. SINCE THE NORTH RAMP MAY BE USED FOR FUTURE WASTE RAMP AND CONSIDERING NORMAL SAFETY PRECAUTIONS, CONCERN IS EXPRESSED TOWARDS THIS RELATIVELY HIGH GRADE

## ADDED TRADE STUDIES RESULTING FROM REVIEW - TWO

- FUTURE ANALYSIS OF NORTH RAMP GRADES BETWEEN 5 AND 10%
- ADDITIONAL SITE SCREENING ANALYSIS FOR NORTH RAMP LOCATION

\* ALL COMMENTS REACHED RESOLUTION  
ALL ACCEPTED COMMENTS ON DELIVERABLE DOCUMENTS WERE INCORPORATED  
\*\* 29 COMMENTS REQUIRED NO CHANGE IN DESIGN

# **A/Es TRACKING OF REQUIREMENTS**

- **WITH DELIVERABLES DESCRIPTION DOCUMENT**
- **MATRIX CROSSWALK FROM REQUIREMENTS TO STUDY, ANALYSIS OR DRAWING**

# EXAMPLE OF DELIVERABLE DESCRIPTION

**WBS NO: 1.2.6.6.0      ENGINEER: M. ESP      DISCIPLINE: MINING**

**ACTIVITY TITLE: ESF PRELIMINARY EXCAVATION PLAN**

**ACTIVITY ID: ST-MN-020**

**NO. OF DOCUMENTS: 1**

**CATEGORY: TITLE I**

**QUALITY AFFECTING: YES**

**DURATION HRS. EA. DOCUMENT: 160**

## **ACTIVITY DESCRIPTION:**

**PREPARE A REPORT WHICH IS INTENDED AS A PRELIMINARY MINE PLAN TO OUTLINE VARIOUS ASSUMPTIONS AND MAJOR CONCEPTS TO BE DESIGNED AND DETAILED. THIS INCLUDES IDENTIFYING AN ACCEPTED LAYOUT, EXTENT OF EXCAVATION, PLAN FOR EQUIPMENT SEQUENCING AND USEAGE, POLICIES ON MULTIPLE HEADING DEVELOPMENT, SHIFT ACTIVITY SEQUENCING, HANDLING OF MATERIALS SUCH AS EXPLOSIVES, FUELS AND LUBRICANTS, ETC. THE DOCUMENT WILL SERVE AS A REFERENCE DOCUMENT FOR OTHER DESIGN DOCUMENTS SUCH AS DRAWINGS, STUDIES, CALCULATIONS, EQUIPMENT FLEET STUDIES, ETC.**

## **COMPILE A FILE FOLDER WHICH WILL INCLUDE:**

- **THIS DELIVERABLE DESCRIPTION SHEET (COMPLETED)**
- **ALL COMMUNICATIONS (MEETING MINUTES, TELECONS, ETC.)**
- **SKETCHES, DRAFTS, ETC.**
- **REVIEW AND COMMENT FORMS**
- **FINAL COPY OF THE REPORT**

**FUNCTION: 6.6 FR1**

# EXAMPLE OF DELIVERABLE DESCRIPTION

(CONTINUED)

## CRITERIA/REQUIREMENTS: YMP/CC-0013, REV. 1

6.0 PC1h.  
6.5 PC1a.i  
6.5 PC1c.iii  
6.5 PC1d.viii  
6.5 PC1f.i  
6.5 PC1f.iv  
6.5 PC2a.ii.a  
6.5 PC2i.iv  
6.6 PC1a.iii  
6.6 PC1a.iv  
6.6 PC1i.iii  
6.6 PC2j.v  
APPENDIX A.1.1a  
APPENDIX A.1.1b

**CONSTRAINTS: NONE**

**ASSUMPTIONS ESFDR - NONE**

**SEE TEXT FOR ASSUMPTIONS TO BE VERIFIED (2)**

**INTERFACES: COST & SCHEDULE**

**REFERENCE DOCUMENTS:**

1. **ENGINEERING PLAN FOR THE DESIGN STUDY NEEDED FOR THE REVISION OF TITLE I DESIGN STUDY REPORT, RSN, REV 2, MAY 1991**
2. **ESF ALTERNATIVES STUDY - OPTION 30, FSN-AS-430, REV 2, ALTERNATIVES STUDY, OPTION B7, SCENARIO 2**
3. **RVC, R. COPPAGE TO DISTR 4/9/91, USBR MEETING RE: RAMP MAPPING**
4. **RVC, B. STANLEY TO N. TAMONDONG, 4/9/91, SUBJECT: LAYOUT OF WASTE RAMP & CALICO HILLS ACCESS RAMP**
5. **YUCCA MOUNTAIN PROJECT - REFERENCE REPOSITORY COORDNIATED, CLTR 88-PB07, M. FOWLER, PBQ&D, JAN. 1990, FOR SNL**

# **EXAMPLE OF MATRIX CROSSWALK**

## **REGULATORY REQUIREMENTS IMPLEMENTATION IN TITLE I STUDIES/ANALYSIS**

### **ESF DESIGN REQUIREMENT**

### **RSN STUDY/ANALYSIS**

**1.2.6.2 C F**

**ST-MN-015 PRELIMINARY ESF FUNCTIONAL REQUIREMENTS**

**1.2.6.4 PC 1b**

**ST-MN-015 PRELIMINARY ESF FUNCTIONAL REQUIREMENTS**

**1.2.6.4 PC 1c**

**ST-MN-006 PRELIMINARY SIZING OF OPTIONAL SHAFT**

**ST-MN-015 PRELIMINARY ESF FUNCTIONAL REQUIREMENTS**

**1.2.6.4 PC 1d**

**ST-MN-003 OPTIONAL SHAFT SITING ANALYSIS**

**ST-MN-004 PRELIMINARY SITING ANALYSIS - N. & S. RAMP  
PORTALS & SHAFT COLLAR**

**1.2.6.4 PC 1i**

**ST-MN-006 PRELIMINARY SIZING OF OPTIONAL SHAFT**

**1.2.6.4 PC 2a**

**ST-MN-004 PRELIMINARY SITING ANALYSIS - N. & S. RAMP  
PORTALS & SHAFT COLLAR**

**1.2.6.4 PC 2b**

**ST-MN-003 OPTIONAL SHAFT SITING ANALYSIS**

**ST-MN-004 PRELIMINARY SITING ANALYSIS - N. & S. RAMP  
PORTALS & SHAFT COLLAR**

**ST-MN-015 PRELIMINARY ESF FUNCTIONAL REQUIREMENTS**

**1.2.6.4 PC 2c**

**1.2.6.4 PC 2d**

**ST-MN-003 OPTIONAL SHAFT SITING ANALYSIS**

**1.2.6.4 PC 2e**

**ST-MN-003 OPTIONAL SHAFT SITING ANALYSIS**

**ST-MN-004 PRELIMINARY SITING ANALYSIS - N. & S. RAMP  
PORTALS & SHAFT COLLAR**