

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

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

**SUBJECT: POTENTIAL IMPACTS OF  
EXPLORATORY-SHAFT FACILITY  
(ESF) ON WASTE ISOLATION**

**PRESENTER: DR. FELTON W. BINGHAM**

**PRESENTER'S TITLE  
AND ORGANIZATION: SUPERVISOR,  
REPOSITORY PERFORMANCE ASSESSMENT DIVISION  
SANDIA NATIONAL LABORATORIES**

**PRESENTER'S  
TELEPHONE NUMBER: (505) 844-8816**

**MAY 16-17, 1989**

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# **SCOPE OF PRESENTATION (TWO EXAMPLE ANALYSES)**

## **1. THE REASON THE COMPLETE SET OF ANALYSES WAS DONE:**

**TO ANSWER NRC STAFF CONCERNS ABOUT THE  
EXPLORATORY-SHAFT FACILITY (ESF)**

## **2. EXAMPLE 1: MOVEMENT OF WATER USED IN CONSTRUCTING SHAFTS**

## **3. EXAMPLE 2: FLOODING OF SHAFTS**

## **4. CONCLUSIONS OF COMPLETE STUDY**

# **SCOPE OF ANALYSIS OF EFFECTS ON WASTE ISOLATION**

**THE NRC STAFF REQUESTED STUDIES OF HOW THE ESF  
MIGHT AFFECT THE SITE (LATE 1987)**

- **THE ESF WILL EVENTUALLY BECOME PART OF THE REPOSITORY**
- **NO WASTE WILL BE EMPLACED IN THE ESF**

**ANALYSES EXAMINE HOW ESF COULD AFFECT  
WASTE ISOLATION**

**ANALYSES EXAMINE CHANGES INDUCED BY ESF**

**EVALUATIONS ARE BASED ON THESE CHANGES BECAUSE  
CONSTRUCTION OF FULL CCDF, WITH AND WITHOUT ESF,  
IS IMPRACTICAL**

# **EVALUATIONS OF CHANGES INDUCED BY ESF CONSTRUCTION AND TESTING**

- **COMPILATION OF DATA:**
  - **LOCATIONS**
  - **AMOUNTS OF FLUIDS AND MATERIALS TO BE INTRODUCED**
  
- **ESTIMATIONS OF EFFECTS ON SITE CONDITIONS:**
  - **HYDROLOGIC**
  - **GEOCHEMICAL**
  - **MECHANICAL**
  
- **ANALYSES DETERMINE PERSISTENCE OF EFFECTS**
  - **TRANSIENT (INSIGNIFICANT AFTER CLOSURE)**
  - **PERMANENT (PERSISTING INTO ISOLATION PERIOD)**
  
- **SUMMARIES OF DATA ANALYSES: SCP SECTION 8.4.3.2**
  
- **THIS PRESENTATION REPORTS TWO EXAMPLES OF HYDROLOGIC ANALYSES**

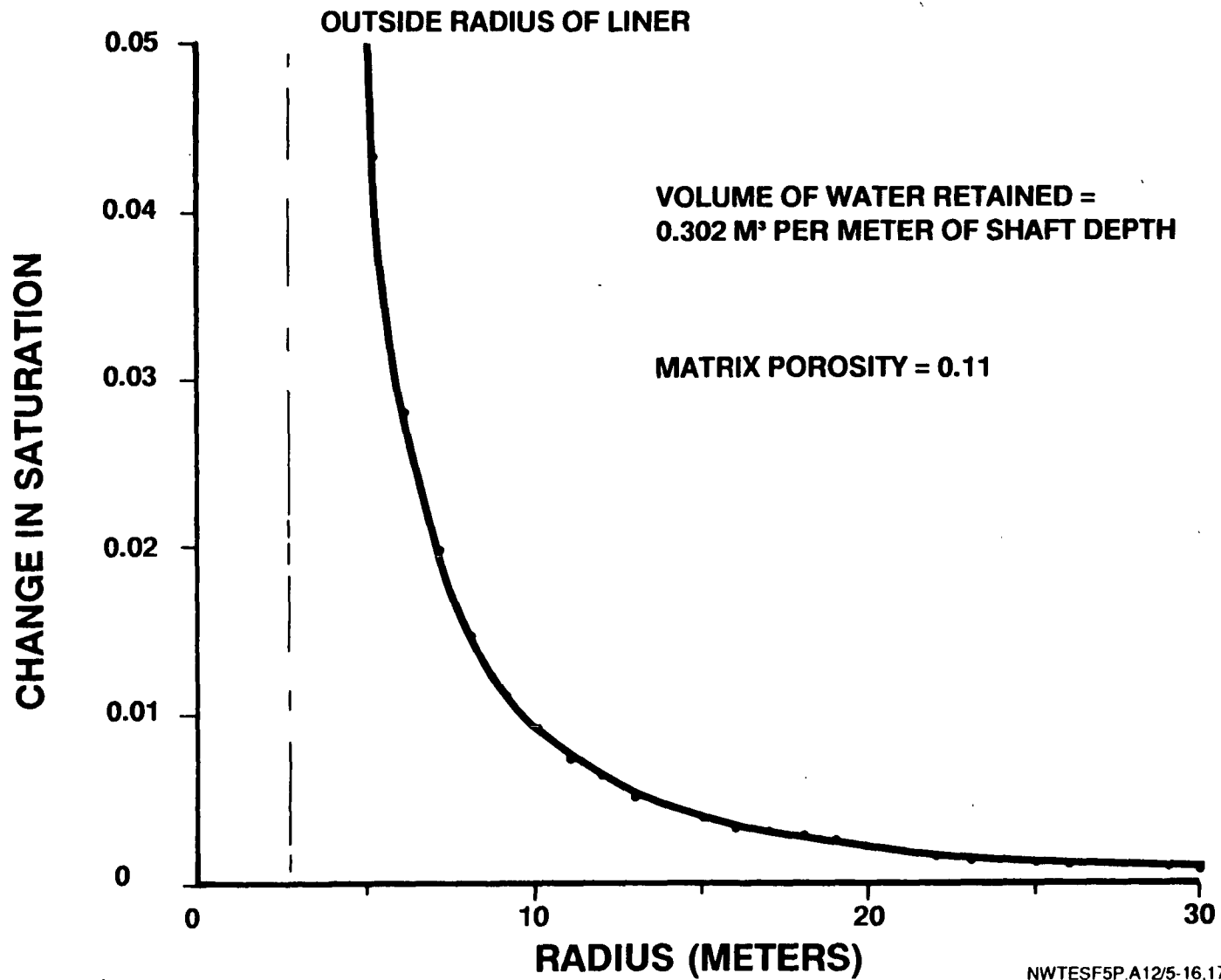
# **EXAMPLE 1:**

**WHAT HAPPENS TO THE WATER USED  
TO CONSTRUCT AN EXPLORATORY SHAFT?**

# **CALCULATIONAL APPROACH FOR ESTIMATES OF MOVEMENT OF RETAINED CONSTRUCTION WATER**

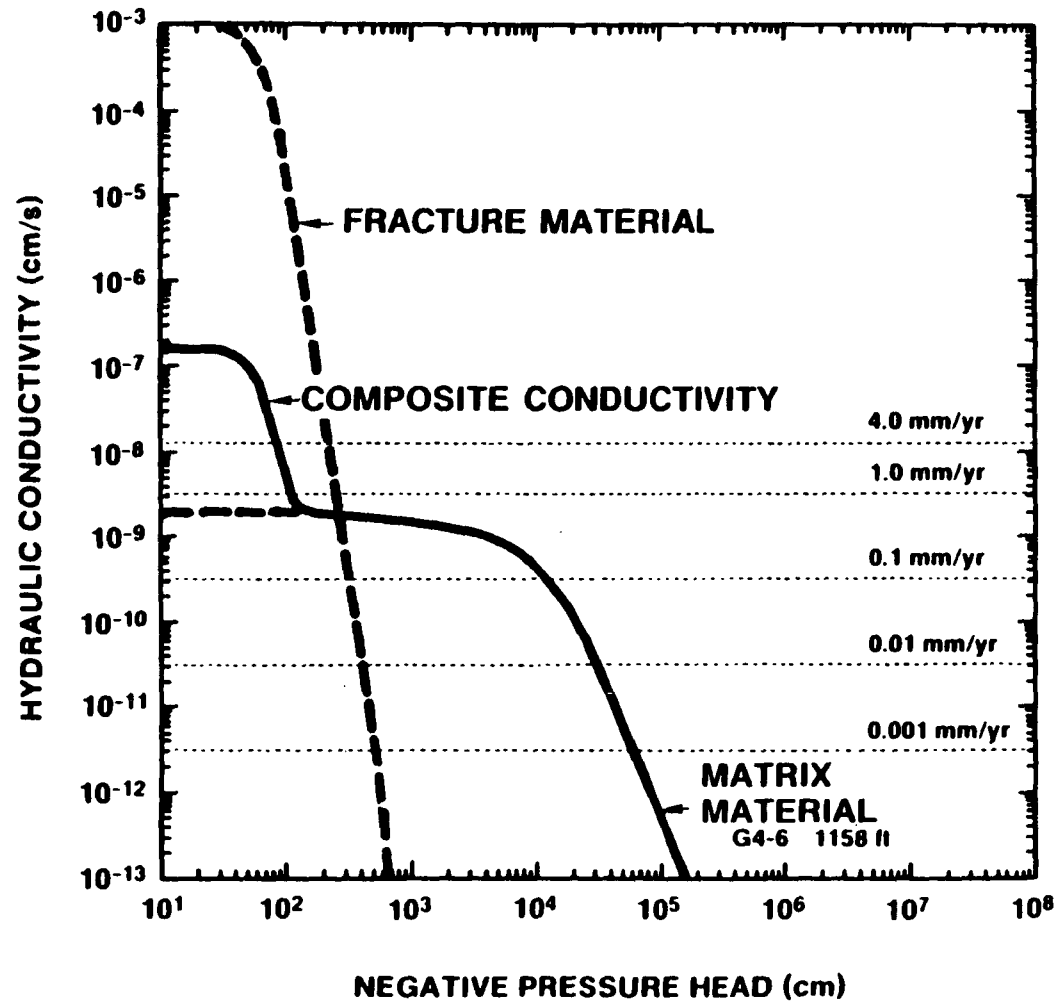
- **INITIAL ANALYTIC SOLUTION SHOWED ONLY SMALL CHANGES IN SATURATION**
- **RADIAL MOVEMENT CALCULATED WITH NORIA COMPUTER CODE**
  - **FINITE-ELEMENT CODE TO ANALYZE WATER, VAPOR, AIR, AND ENERGY TRANSPORT IN POROUS MEDIUM**
  - **USES COMPLEX DESCRIPTION OF HYDROLOGIC PROPERTIES**
- **RETAINED WATER INITIALLY CONTAINED IN MODIFIED-PERMEABILITY ZONE (MPZ)**
- **MATRIX PERMEABILITY INCREASED TO 80 TIMES NOMINAL IN MPZ**
  - **FROM CONSERVATIVE ANALYTICAL MODEL**
  - **TENDS TO OVERESTIMATE MOVEMENT OF WATER**

# CHANGE IN SATURATION OF ROCK AROUND EXPLORATORY SHAFT

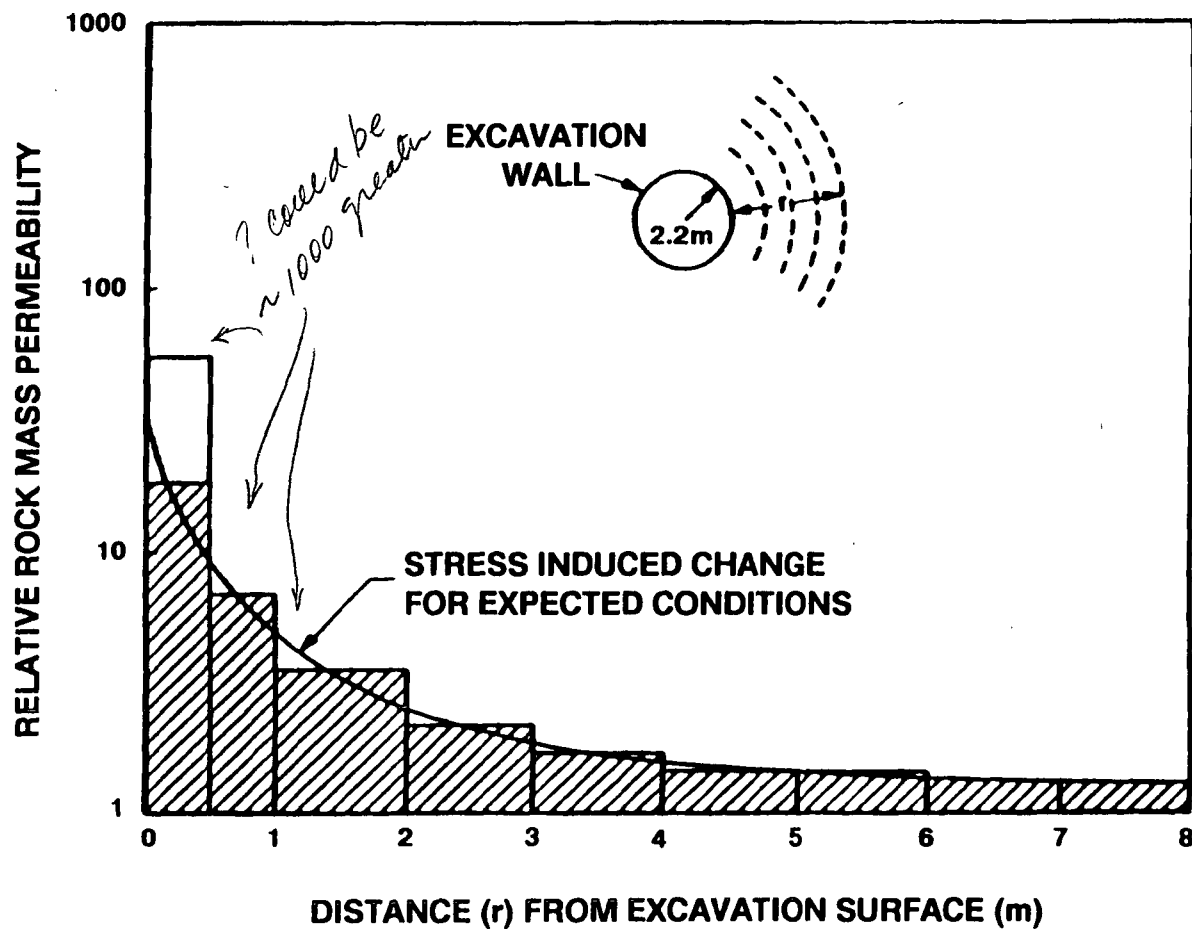




# COMPOSITE HYDRAULIC CONDUCTIVITY FOR TOPOPAH SPRING WELDED UNIT (REPOSITORY ZONE)



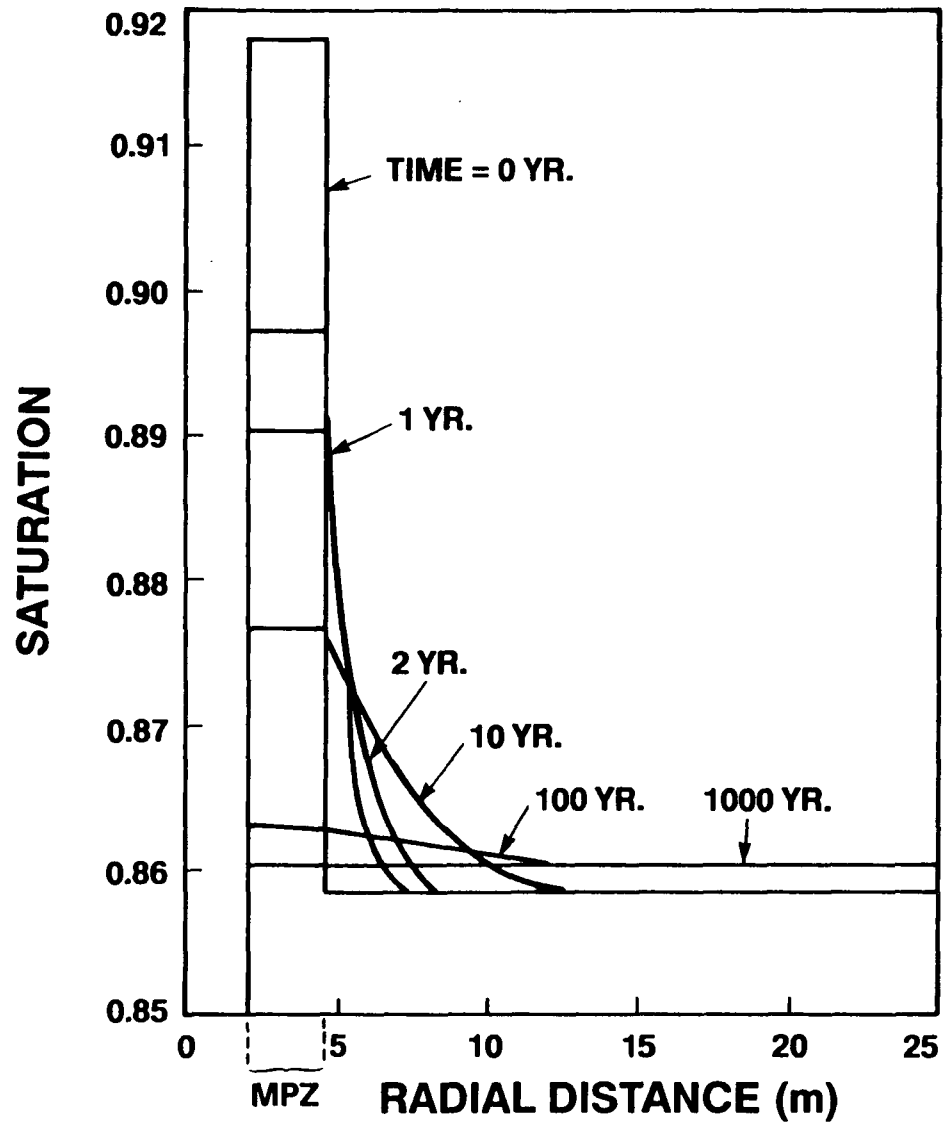
## MODIFIED-PERMEABILITY ZONE (FOR EXPECTED CONDITIONS AT 310-M DEPTH)



**LEGEND**

- PRELIMINARY ESTIMATE  
BLAST INDUCED DAMAGE
- STRESS INDUCED CHANGE  
IN PERMEABILITY

# SATURATION CHANGE WITH TIME AT REPOSITORY HORIZON



# RESULTS OF NORIA CALCULATIONS

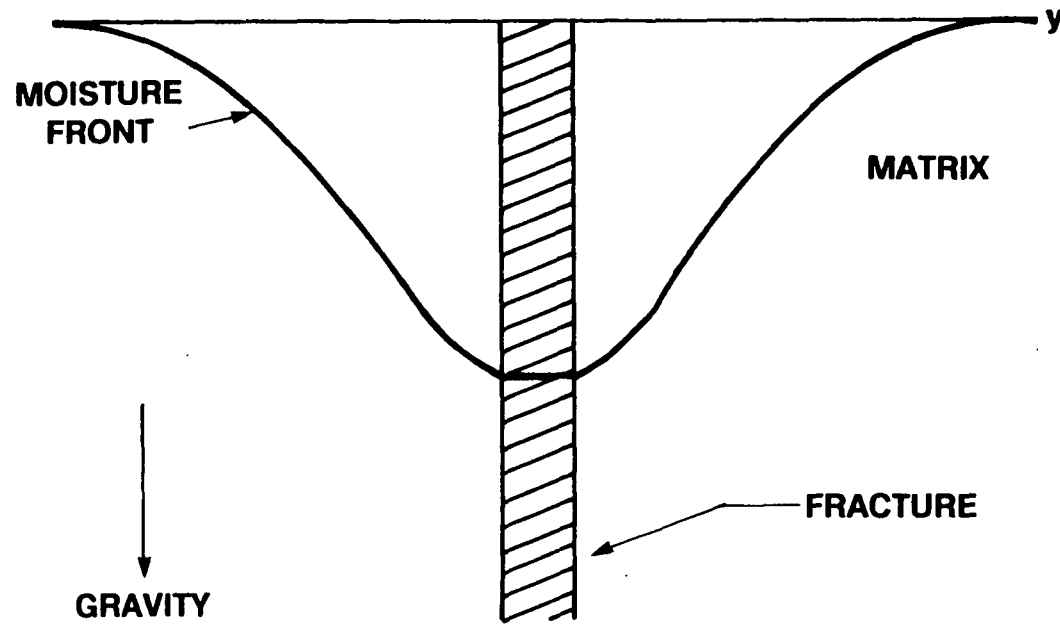
- **WATER MOVES RELATIVELY SLOWLY FROM MPZ INTO ROCK**
- **SATURATION INCREASES AT RADIAL DISTANCES GREATER THAN 5 m FROM SHAFT WALL WERE LESS THAN 0.03**
- **AT 10 YEARS WATER MOVED ABOUT 10 m FROM SHAFT WALL**

# **CALCULATIONAL APPROACH TO ESTIMATE PENETRATION DISTANCES IN FRACTURES**

**REFERENCE: "CAPILLARY-DRIVEN FLOW IN A FRACTURE LOCATED IN A  
POROUS MEDIUM," BY M. J. MARTINEZ, SAND84-1697, 1988**

- **MODEL INCORPORATES CAPILLARY-DRIVEN IMMISCIBLE  
DISPLACEMENT OF AIR BY WATER IN A SINGLE FRACTURE**
- **ANALYSES ASSUME EITHER PERMEABLE MATRIX OR IMPER-  
MEABLE MATRIX SURROUNDING THE FRACTURE**
- **DATA CONSIDERED REPRESENTATIVE OF CURRENT ESTIMATES  
OF YUCCA MOUNTAIN HYDROLOGIC PROPERTIES**

## SCHEMATIC OF FRACTURE-ANALYSIS MODEL



# ANALYSIS RESULTS

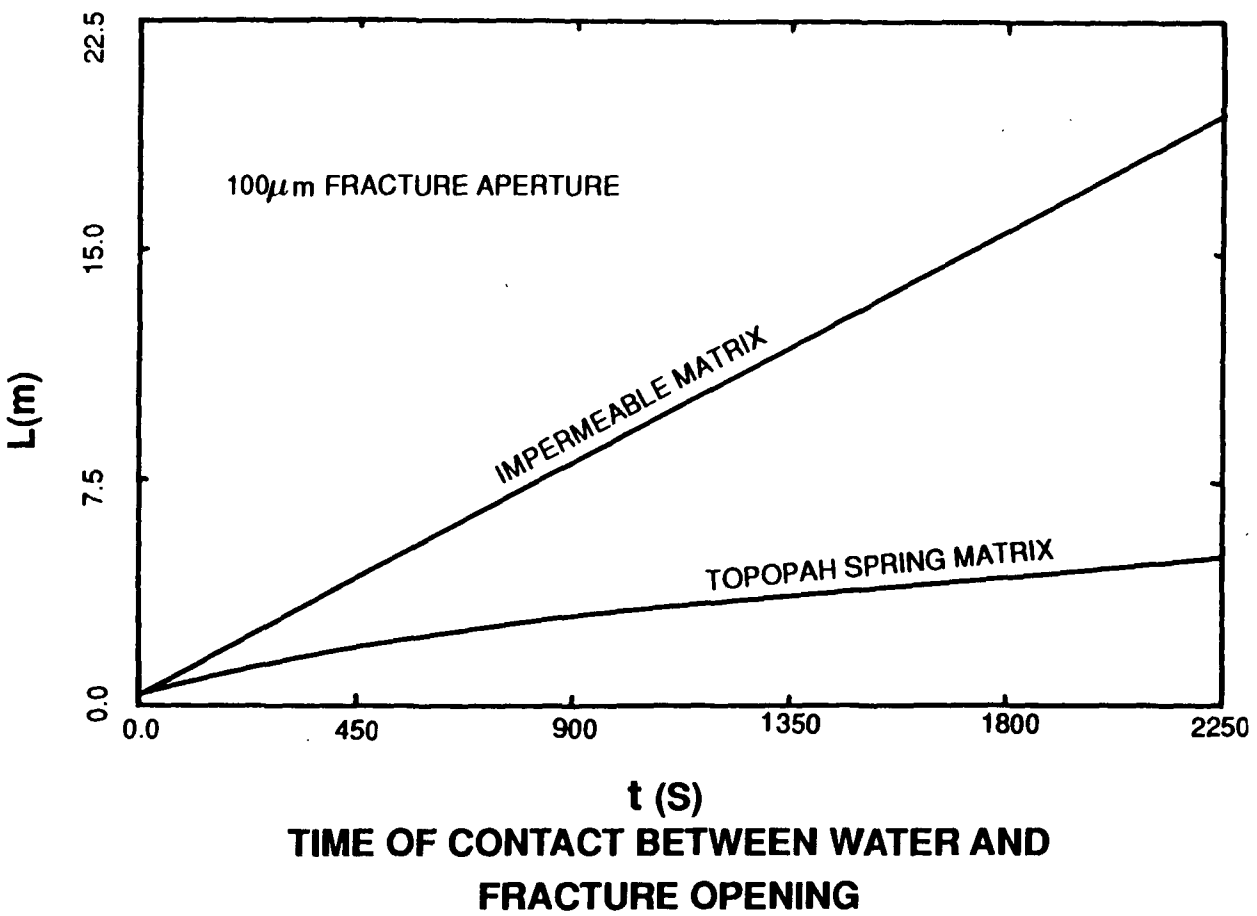
- **FRACTURE-PENETRATION DISTANCES DEPEND ON THE SQUARE ROOT OF THE RATIO OF MATRIX PERMEABILITY AND FRACTURE PERMEABILITY**

- **FOR TOPOPAH SPRING (THE REPOSITORY HORIZON) HYDROLOGIC PROPERTIES:**

- **FRACTURE APERTURE IS 25  $\mu\text{m}$   $\rightarrow$  PENETRATION DISTANCE  $< 1$  m**
  - **FRACTURE APERTURE IS 100  $\mu\text{m}$   $\rightarrow$  PENETRATION DISTANCE  $< 10$  m**
- [ FOR 30 MIN OF WATER INFILTRATION ]**
- **FRACTURE APERTURES IN THE UNIT ARE GENERALLY MUCH LESS THAN 100  $\mu\text{m}$**

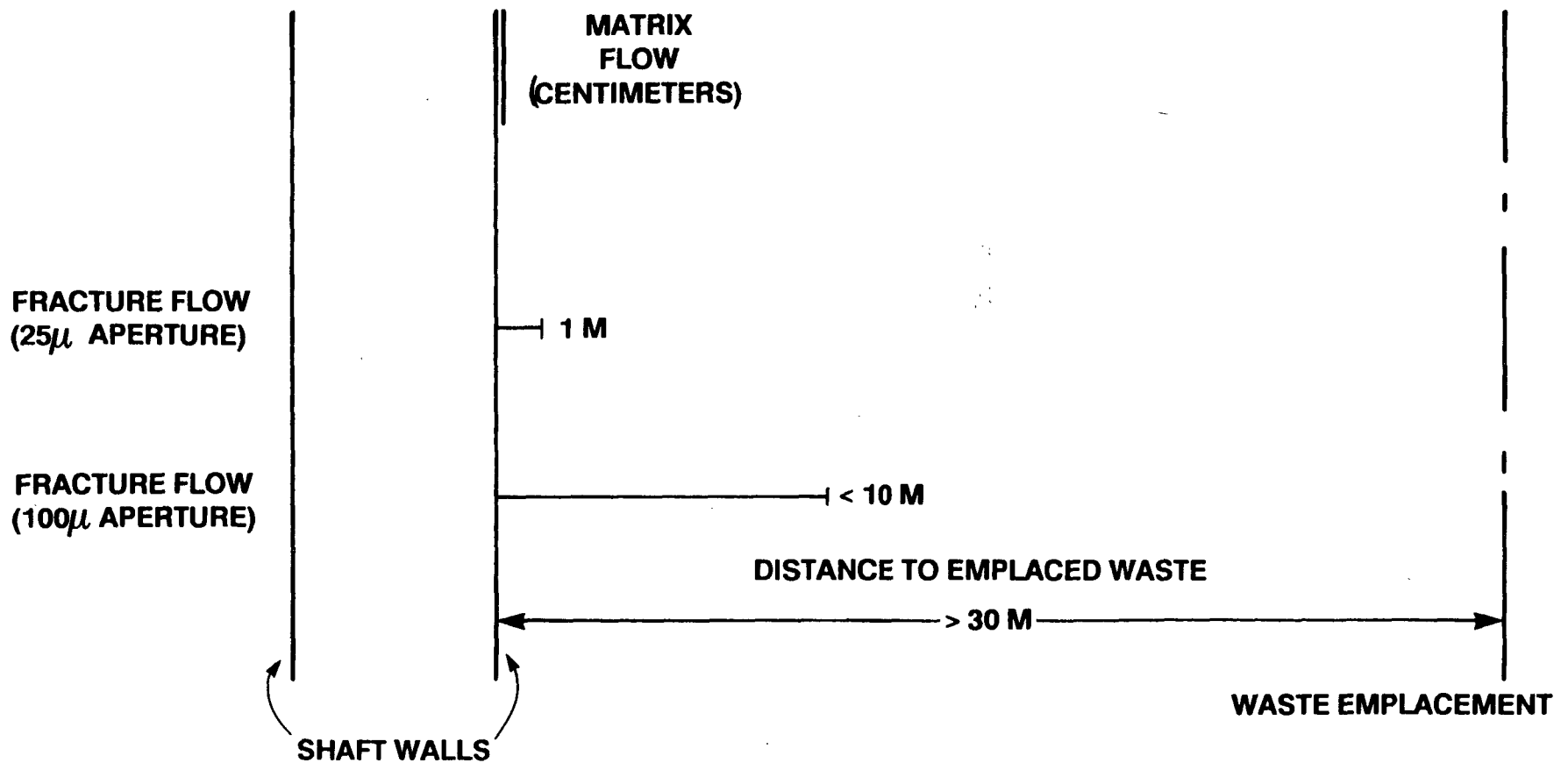
- **OTHER STUDIES GIVE SIMILAR RESULTS**

DISTANCE MOISTURE PENETRATES INTO FRACTURE





# SCHEMATIC SHOWING PENETRATION DISTANCES FOR MATRIX AND FRACTURE FLOWS AT REPOSITORY HORIZON RELATIVE TO DISTANCE FROM EMPLACED WASTE



# **EFFECTS ON HYDROLOGIC CONDITIONS**

(CONTINUED)

**CONCLUSION:**

**CHANGES ARE TRANSIENT AND LIMITED  
TO ABOUT 10 METERS FROM ESF**

**WATER WILL THEREFORE NOT REACH WASTE  
AND TRANSPORT RADIONUCLIDES**

**FURTHER ACTION:**

**CONTROL WATER USE: LOW PRESSURES,  
SMALL VOLUMES, TAGGED WATER**

## **EXAMPLE 2:**

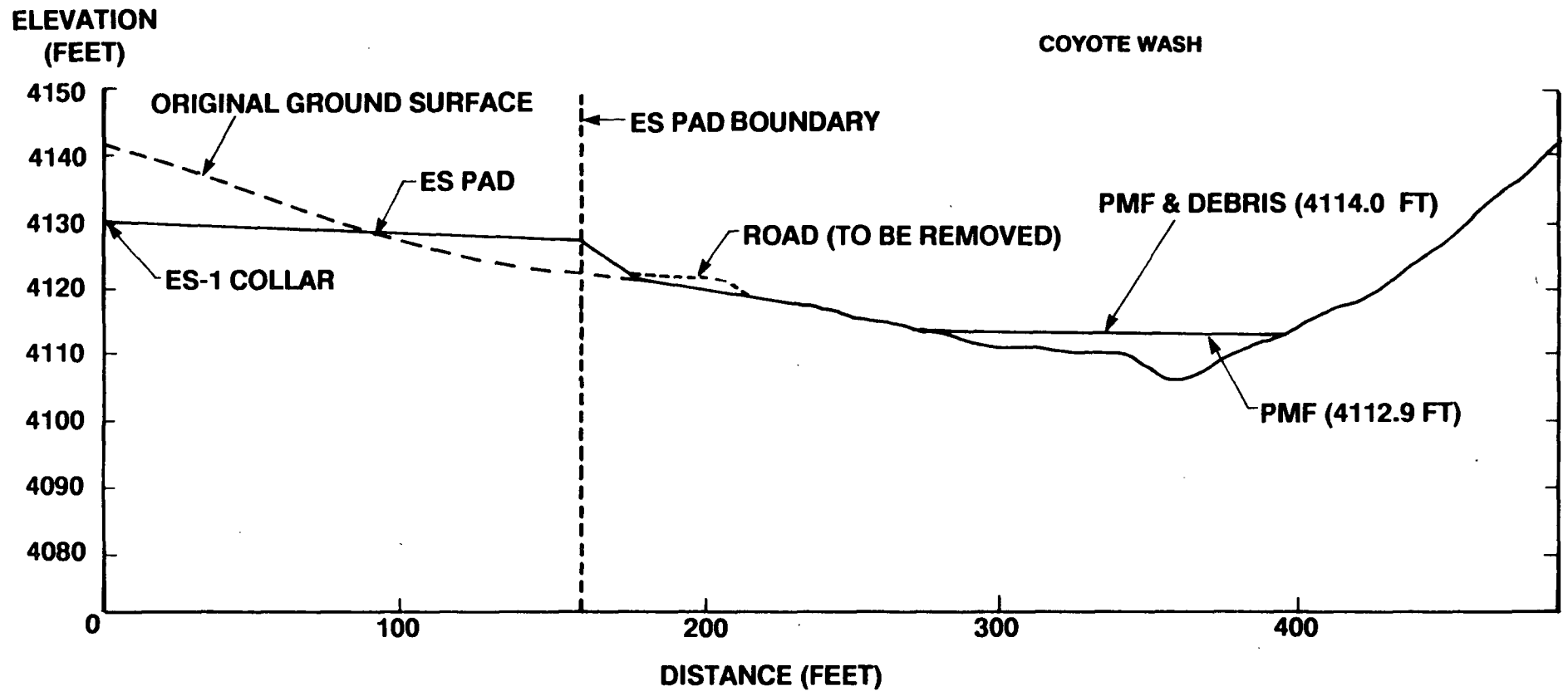
**CAN FLOOD WATERS ENTER A SHAFT  
AND AFFECT WASTE ISOLATION?**

# **LIQUID-PHASE MOVEMENT THROUGH SHAFTS**

## **ANALYSES ASSUME FLOODING FROM PROBABLE MAXIMUM FLOOD (PMF)**

- **ELEVATION OF SHAFT COLLARS IS ABOVE ELEVATION OF PMF PLUS ASSOCIATED DEBRIS**
  
- **SEVERAL ANALYSES HAVE BEEN REPORTED**
  
- **THIS PRESENTATION DESCRIBES TWO ANALYSES:**
  - **“BOUNDING” CASE**
  
  - **“REALISTIC” CASE**

# PMF LEVELS AND LOCATION OF EXPLORATORY SHAFT ES-1 (THUNDERSTORM EVENT)



# COMPARATIVE FLOOD PEAK DISCHARGES IN YUCCA MOUNTAIN AREA

## ESTIMATED

<u>WASH</u>	<u>DRAINAGE AREA (SQUARE MILES)</u>	<u>PEAK FLOOD DISCHARGE (CUBIC FEET PER SECOND)</u>
FORTYMILE	312	540,000 <sup>(1)</sup>
BUSTED BUTTE	6.6	44,000 <sup>(1)</sup>
DRILL HOLE	15.4	86,000 <sup>(1)</sup>
YUCCA	16.6	92,000 <sup>(1)</sup>
COYOTE	0.2	3,350 <sup>(2)</sup>
COYOTE - DISCHARGE TO REACH ES-1 COLLAR	0.2	150,000 <sup>(3)</sup>
COYOTE - DISCHARGE TO REACH ES-2 COLLAR	0.2	820,000 <sup>(4)</sup>

<sup>(1)</sup> FROM SQUIRES AND YOUNG FOR THE REGIONAL MAXIMUM FLOOD

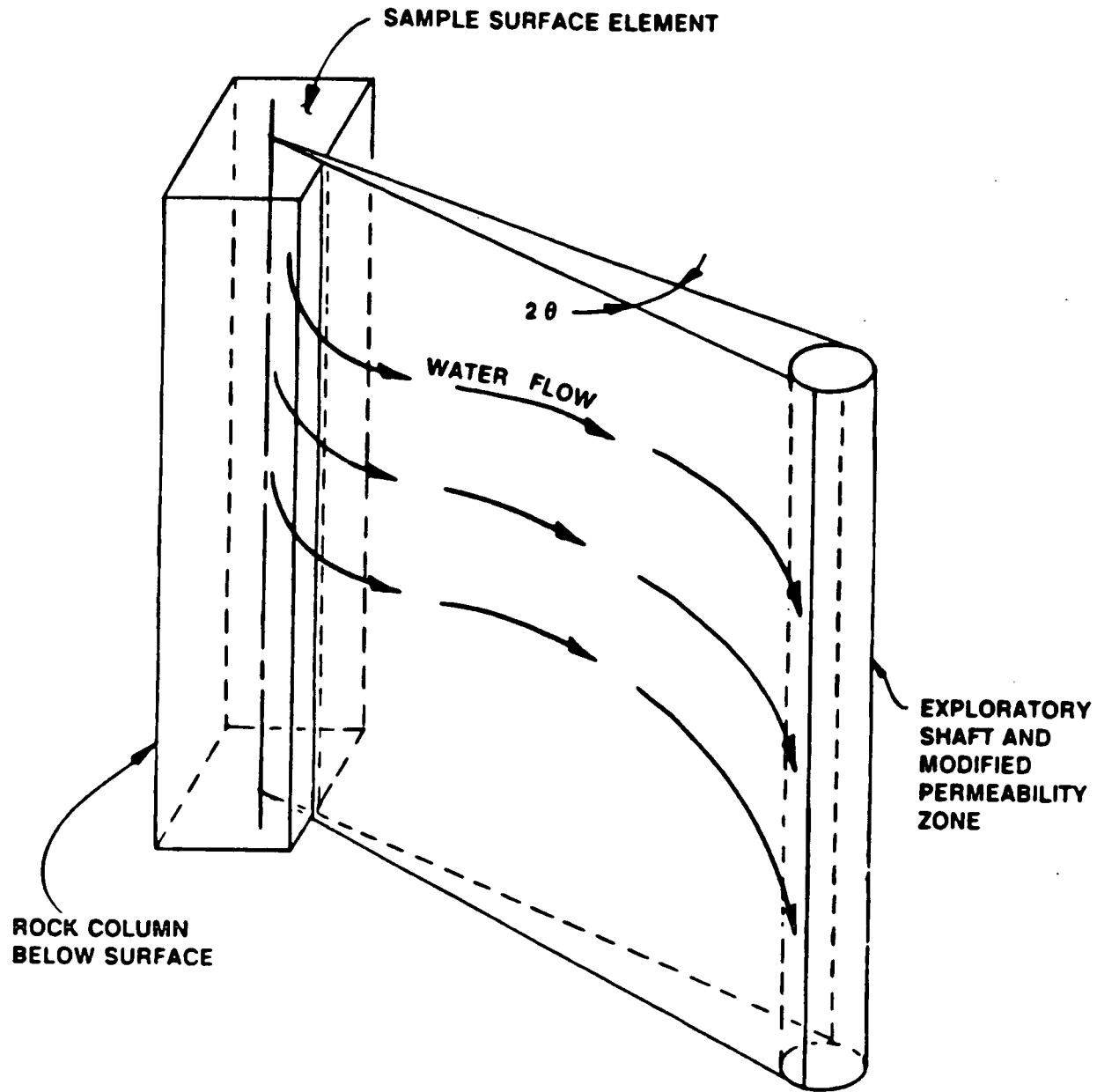
<sup>(2)</sup> FROM BULLARD 1986 FOR THUNDERSTORM PMF

<sup>(3)</sup> COMPUTED PEAK DISCHARGE TO REACH ES-1 COLLAR ( 45 TIMES PMF DISCHARGE)

<sup>(4)</sup> COMPUTED PEAK DISCHARGE TO REACH ES-2 COLLAR ( 2401 TIMES PMF DISCHARGE)

# **SURFACE-WATER INFLOW ANALYSES BOUNDING CASE - PMF**

- **INTENSE RAINFALL IN COYOTE WASH - PROBABLE MAXIMUM FLOOD**
- **ALL RAINFALL INFILTRATES GROUND SURFACE (2 CASES: UNIFORMLY AND IN DRAINAGE COURSES)**
- **UNIFORM LATERAL DISPERSION OF FLOW UNDERGROUND**
- **NO RETENTION OF FLOW IN FORMATION**
- **FLOW INTO EXPLORATORY SHAFTS CALCULATED ON BASIS OF DISTANCE FROM SHAFTS AND CROSS SECTION OF SHAFTS AND MPZ POTENTIALLY INTERSECTED BY FLOW**





# **SURFACE-WATER INFLOW ANALYSES BOUNDING CASE-PMF**

(CONTINUED)

## ● **RESULTS**

- **TOTAL PREDICTED FLOW (EITHER CASE) INTO EXPLORATORY SHAFTS IS ABOUT 1200 m<sup>3</sup>**
  - \* **VOLUME COULD BE CONTAINED (EVEN WITHOUT DRAINAGE) WITHIN ESF**
- **WATER THEREFORE WOULD NOT REACH WASTE-EMPLACEMENT AREA**

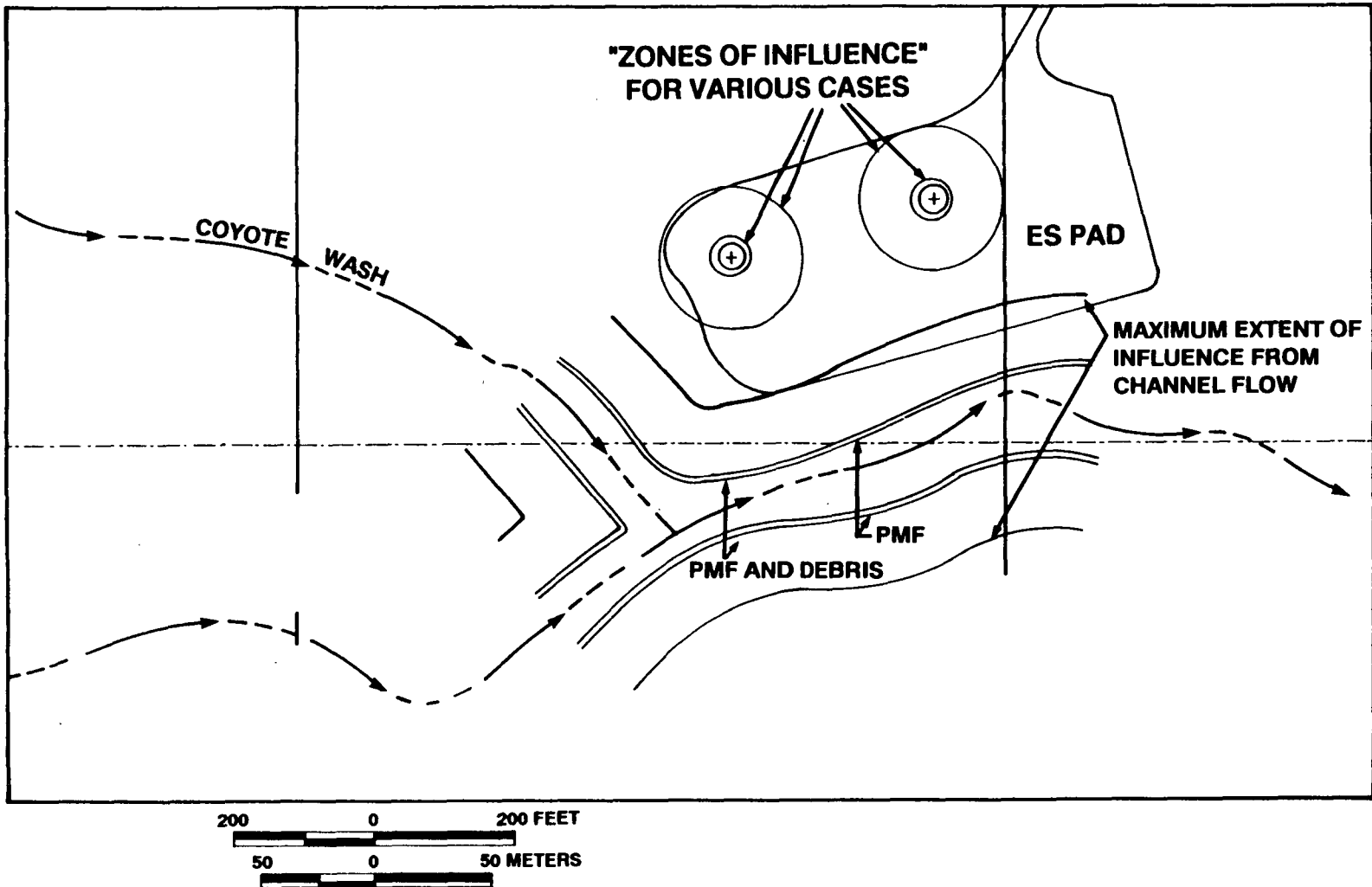
- **ESTIMATION: A MORE REALISTIC INFLOW (CONSIDERING RUNOFF AND RETENTION WITHIN FORMATION) IS LIKEY TO BE 1-2 ORDERS OF MAGNITUDE LESS THAN FLOW PREDICTED ABOVE**
- 

# **SURFACE-WATER INFLOW ANALYSES REALISTIC CASE - PMF**

*Prob. Max. Flood*

- **TWO PMF EVENTS: GENERAL STORM AND THUNDERSTORM**
- **NEAR-SURFACE FRACTURES ARE OPEN**
- **FRACTURE FLOW OCCURS FROM WATER IN CHANNEL  
AND OVER PAD**
- **NO ALLUVIAL RESISTANCE OCCURS**
- **MATRIX IMBIBITION OCCURS**

# SURFACE-WATER INFLOW ANALYSES REALISTIC CASE-PMF



# **SURFACE-WATER INFLOW ANALYSES REALISTIC CASE - PMF**

## **● RESULTS**

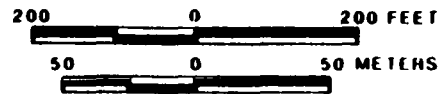
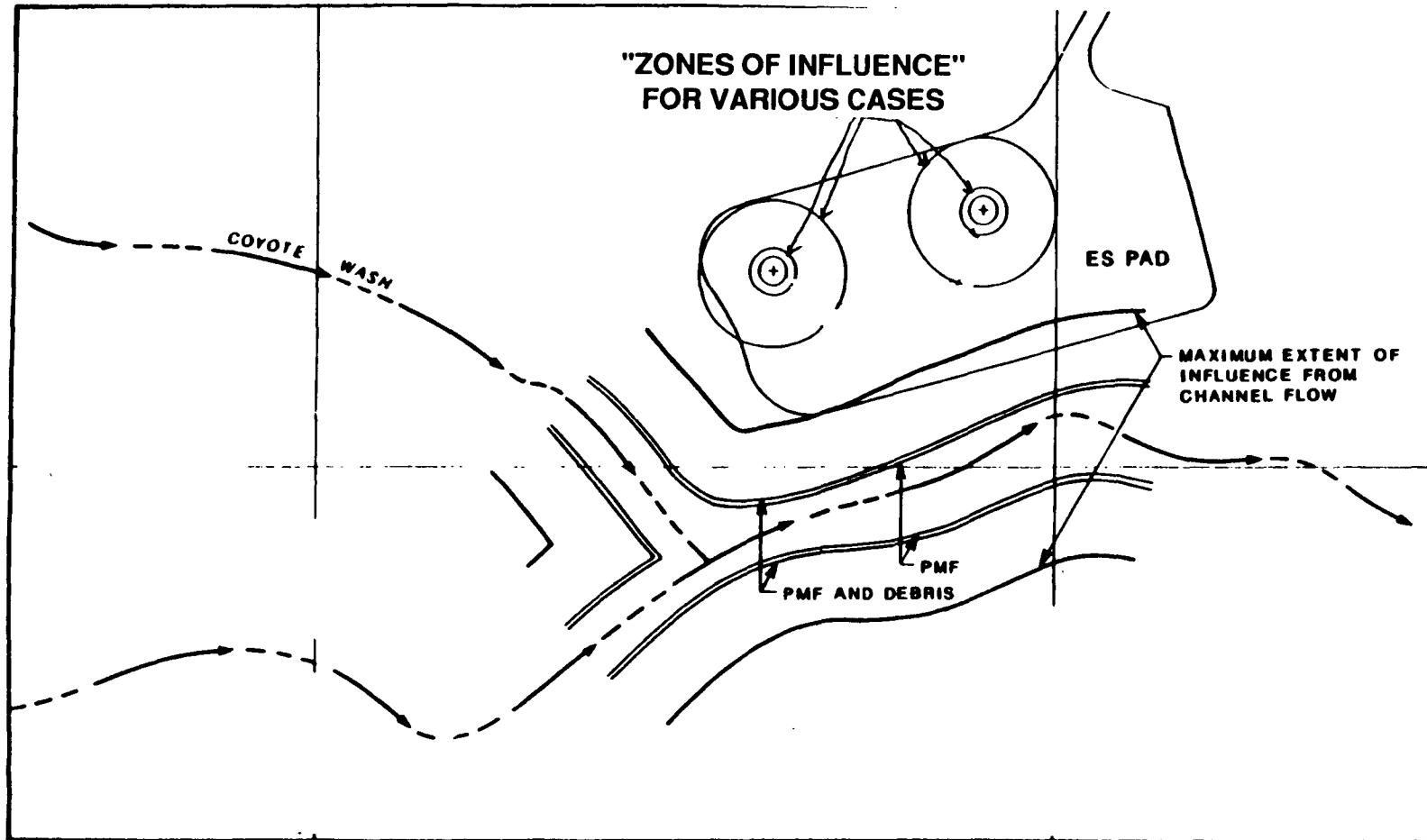
- TOTAL PREDICTED FLOW (EITHER EVENT) IS LESS THAN 50 m<sup>3</sup>**
  - \* VOLUME COULD EASILY BE CONTAINED AND DRAINED WITHIN ESF**
- WATER THEREFORE WOULD NOT REACH WASTE-EMPLACEMENT AREA**

## **CONCLUSIONS OF COMPLETE STUDY (ONLY TWO EXAMPLES PRESENTED HERE)**

### **PRESENCE OF ESF DOES NOT PRECLUDE ABILITY OF SITE TO MEET TOTAL-SYSTEM PERFORMANCE OBJECTIVE**

- **CHANGES TO HYDROLOGIC PROPERTIES ARE LIMITED IN EXTENT**
- **CHANGES TO WATER FLUX ARE SMALL AND LIMITED IN EXTENT**
- **PENETRATIONS DO NOT CREATE PREFERENTIAL PATHWAYS FOR RELEASES**
  - **LOCALIZED EFFECTS ARE LATERALLY SEPARATED FROM EMPLACED WASTE**
  - **ESF DRAINS AWAY FROM WASTE**
  - **PENETRATIONS ARE TO BE SEALED**

# SURFACE-WATER INFLOW ANALYSES REALISTIC CASE-PMF



# SCHEMATIC SHOWING PENETRATION DISTANCES FOR MATRIX AND FRACTURE FLOWS AT REPOSITORY HORIZON RELATIVE TO DISTANCE FROM EMPLACED WASTE

