

**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

**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

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**

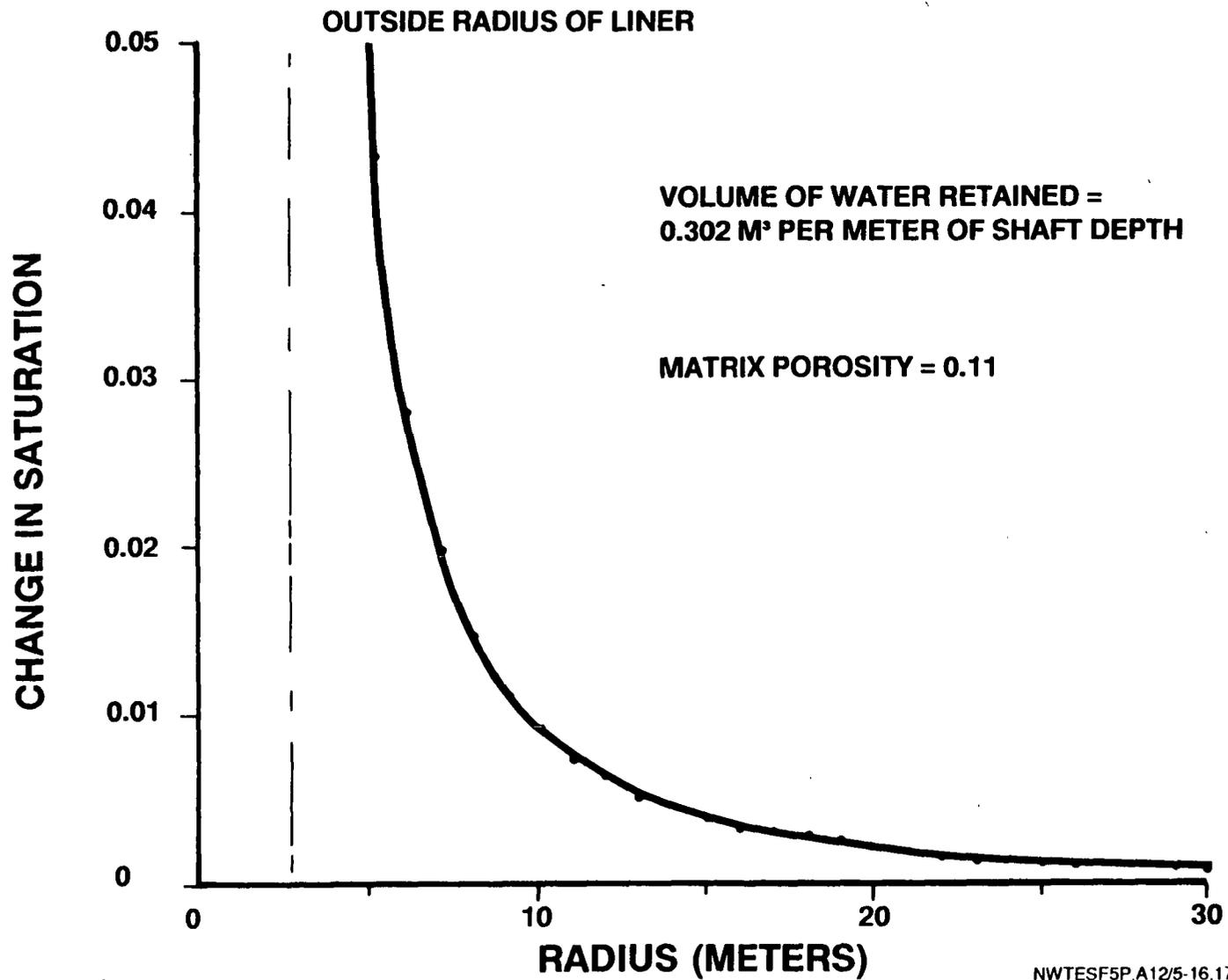
EXAMPLE 1:

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

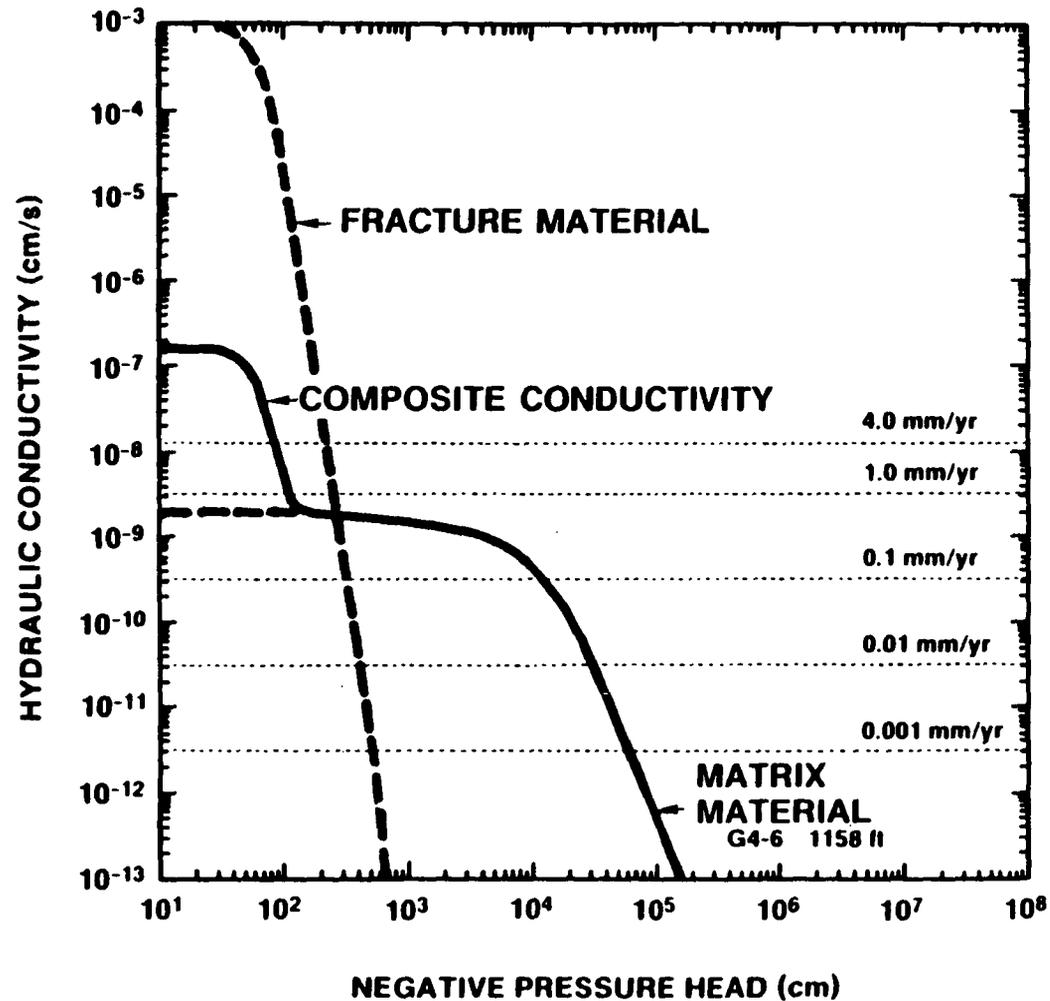
CALCULATIONAL APPROACH FOR ESTIMATES OF MOVEMENT OF RETAINED CONSTRUCTION WATER

- **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**

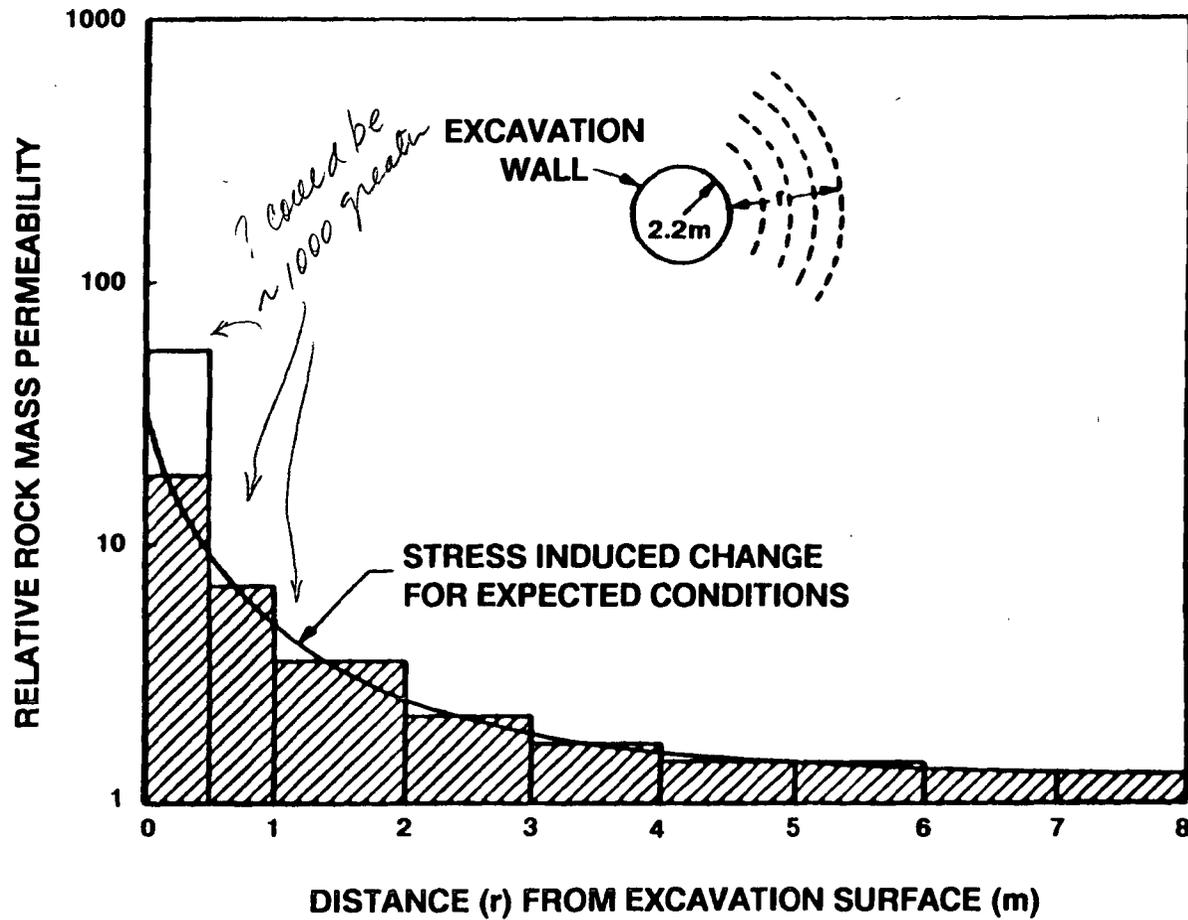
CHANGE IN SATURATION OF ROCK AROUND EXPLORATORY SHAFT



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



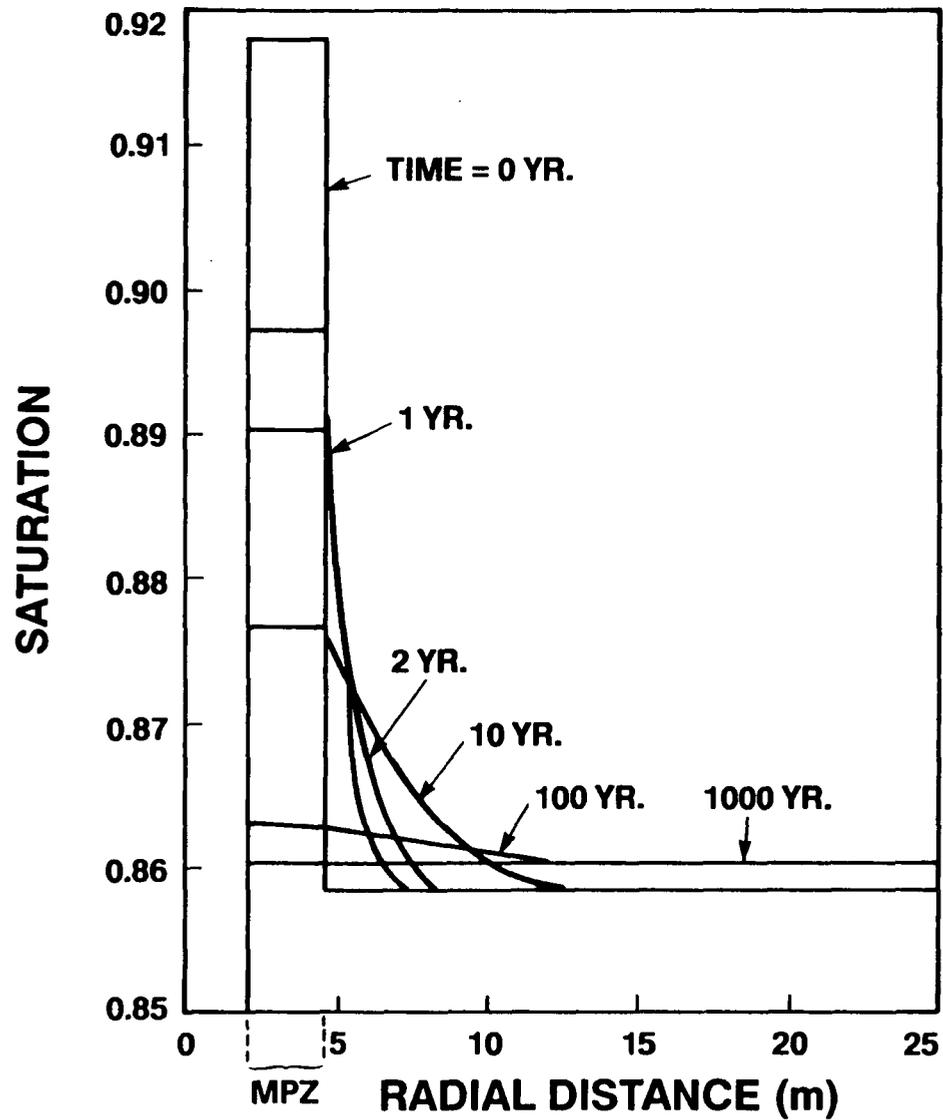
MODIFIED-PERMEABILITY ZONE (FOR EXPECTED CONDITIONS AT 310-M DEPTH)



LEGEND

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

SATURATION CHANGE WITH TIME AT REPOSITORY HORIZON



RESULTS OF NORIA CALCULATIONS

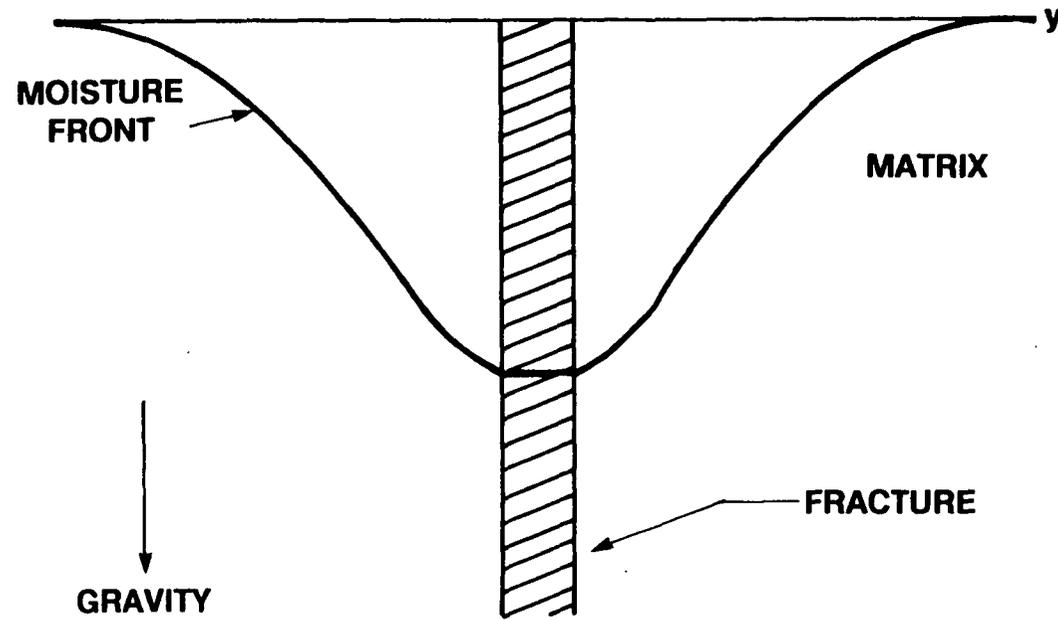
- **WATER MOVES RELATIVELY SLOWLY FROM MPZ INTO ROCK**
- **SATURATION INCREASES AT RADIAL DISTANCES GREATER THAN 5 m FROM SHAFT WALL WERE LESS THAN 0.03**
- **AT 10 YEARS WATER MOVED ABOUT 10 m FROM SHAFT WALL**

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

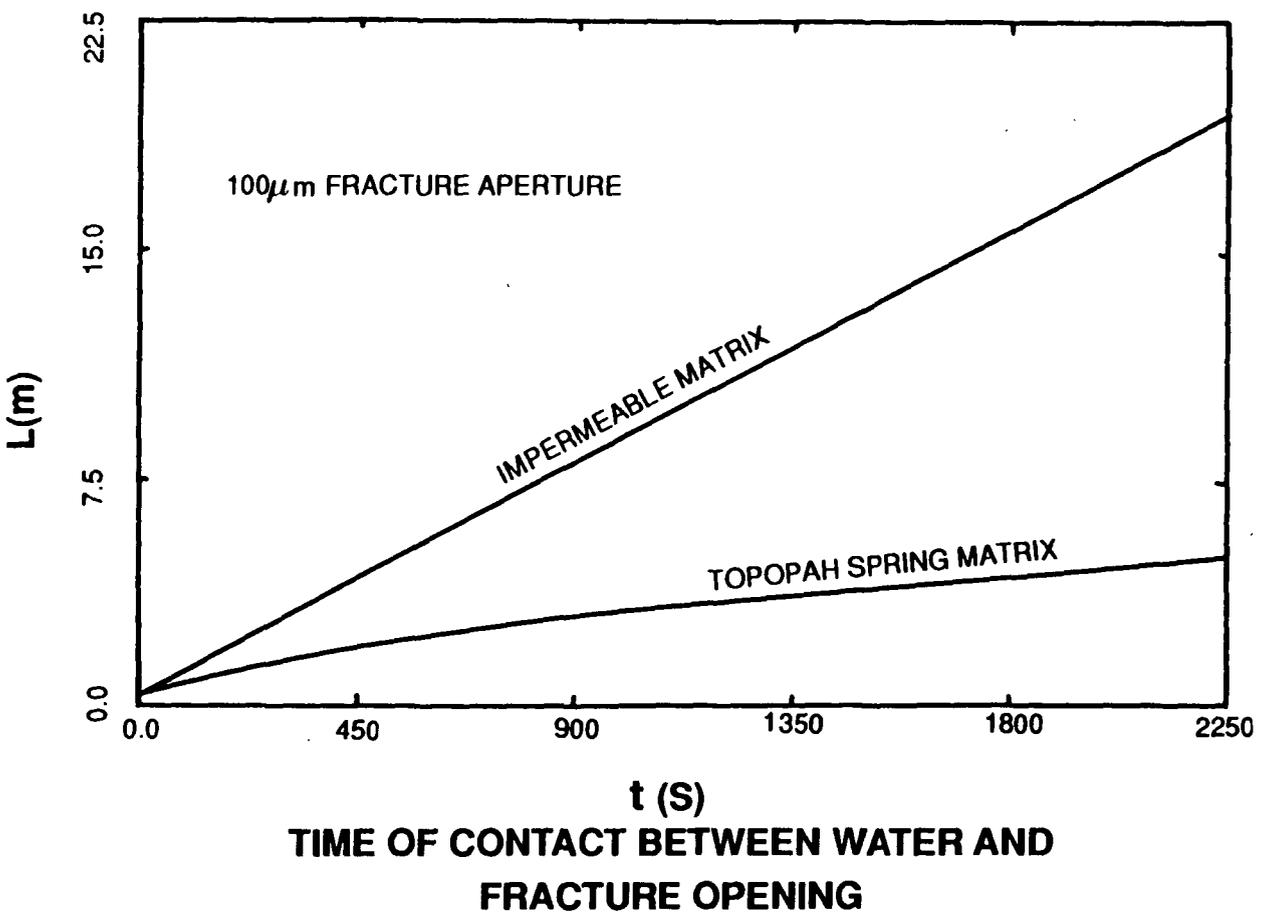
- **FRACTURE-PENETRATION DISTANCES DEPEND ON THE SQUARE ROOT OF THE RATIO OF MATRIX PERMEABILITY AND FRACTURE PERMEABILITY**

- **FOR TOPOPAH SPRING (THE REPOSITORY HORIZON) HYDROLOGIC PROPERTIES:**
 - **FRACTURE APERTURE IS 25 μm \rightarrow PENETRATION DISTANCE < 1 m**
 - **FRACTURE APERTURE IS 100 μm \rightarrow PENETRATION DISTANCE < 10 m**

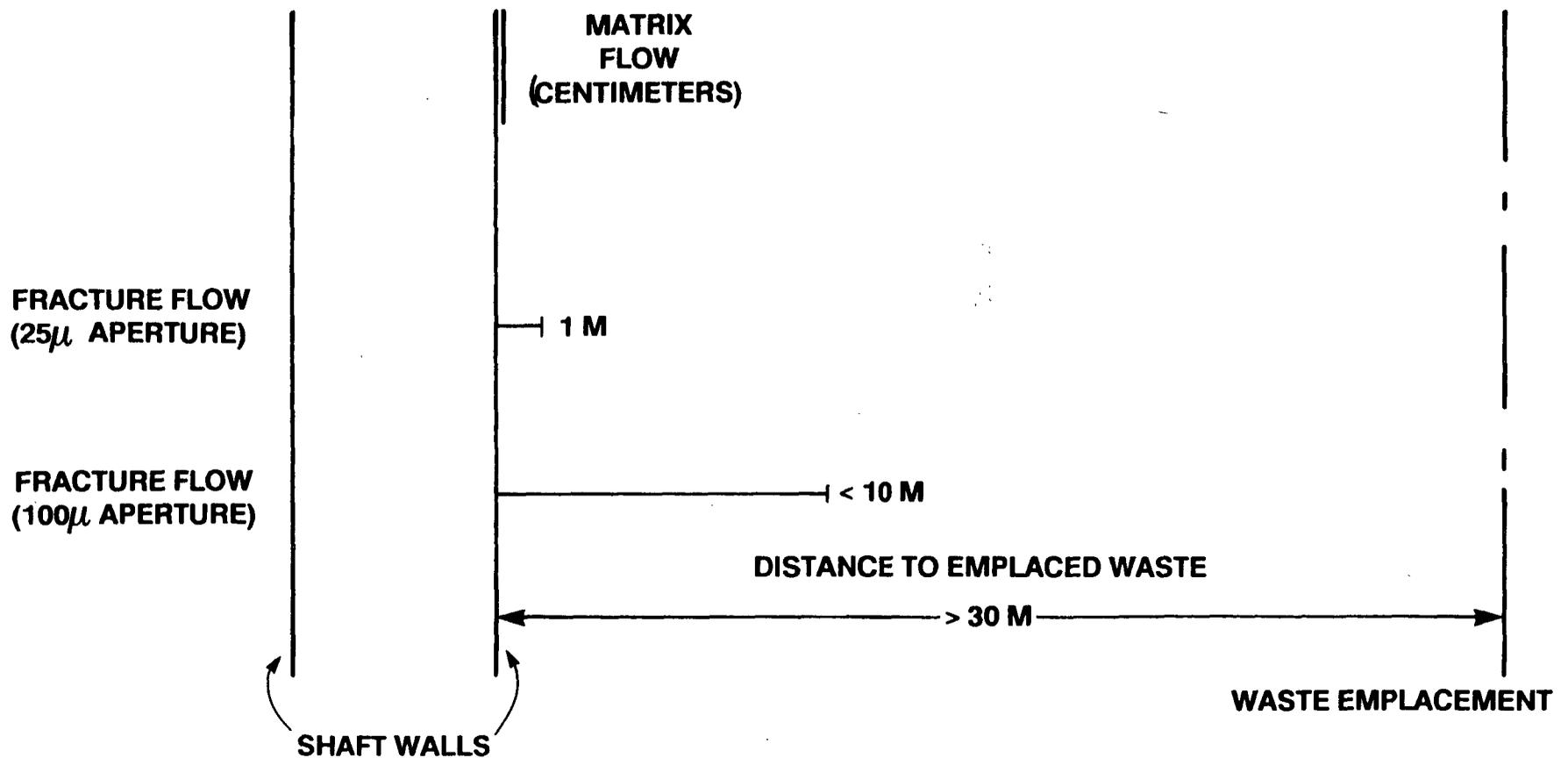
- **FRACTURE APERTURES IN THE UNIT ARE GENERALLY MUCH LESS THAN 100 μm**

- **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)

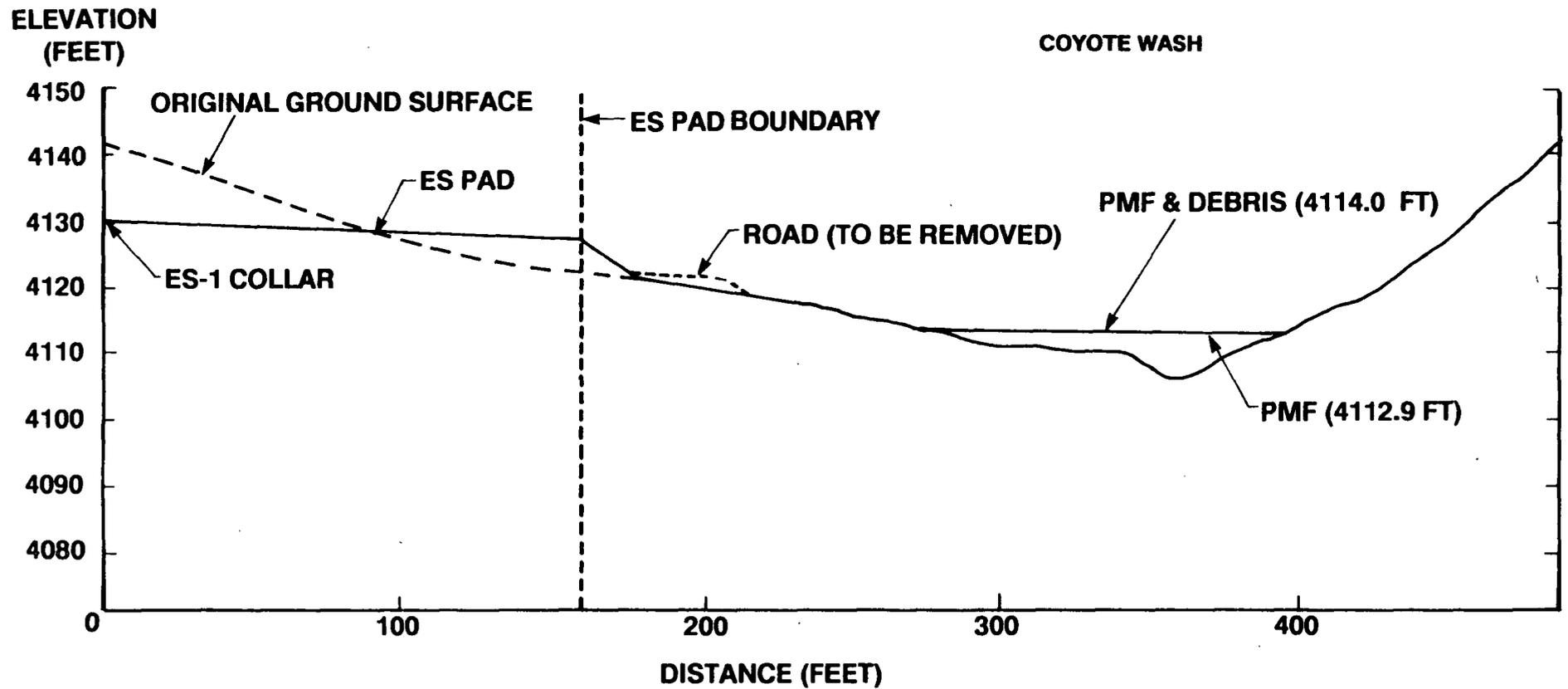
- **ELEVATION OF SHAFT COLLARS IS ABOVE ELEVATION OF PMF PLUS ASSOCIATED DEBRIS**

- **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 ⁽¹⁾
BUSTED BUTTE	6.6	44,000 ⁽¹⁾
DRILL HOLE	15.4	86,000 ⁽¹⁾
YUCCA	16.6	92,000 ⁽¹⁾
COYOTE	0.2	3,350 ⁽²⁾
COYOTE - DISCHARGE TO REACH ES-1 COLLAR	0.2	150,000 ⁽³⁾
COYOTE - DISCHARGE TO REACH ES-2 COLLAR	0.2	820,000 ⁽⁴⁾

⁽¹⁾ FROM SQUIRES AND YOUNG FOR THE REGIONAL MAXIMUM FLOOD

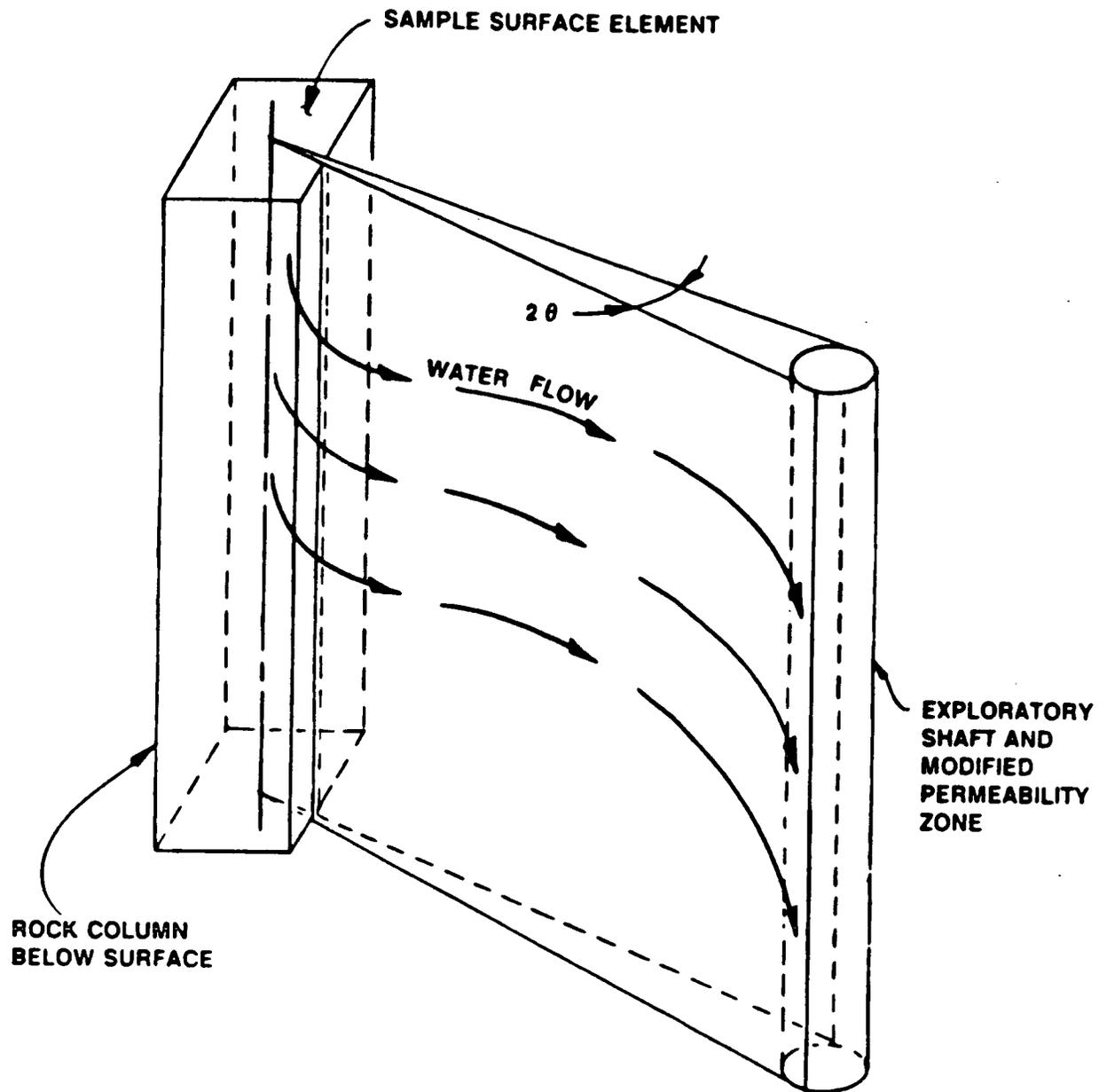
⁽²⁾ FROM BULLARD 1986 FOR THUNDERSTORM PMF

⁽³⁾ COMPUTED PEAK DISCHARGE TO REACH ES-1 COLLAR (45 TIMES PMF DISCHARGE)

⁽⁴⁾ 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 m³**
 - * **VOLUME COULD BE CONTAINED (EVEN WITHOUT DRAINAGE) WITHIN ESF**
- **WATER THEREFORE WOULD NOT REACH WASTE-EMPLACEMENT AREA**

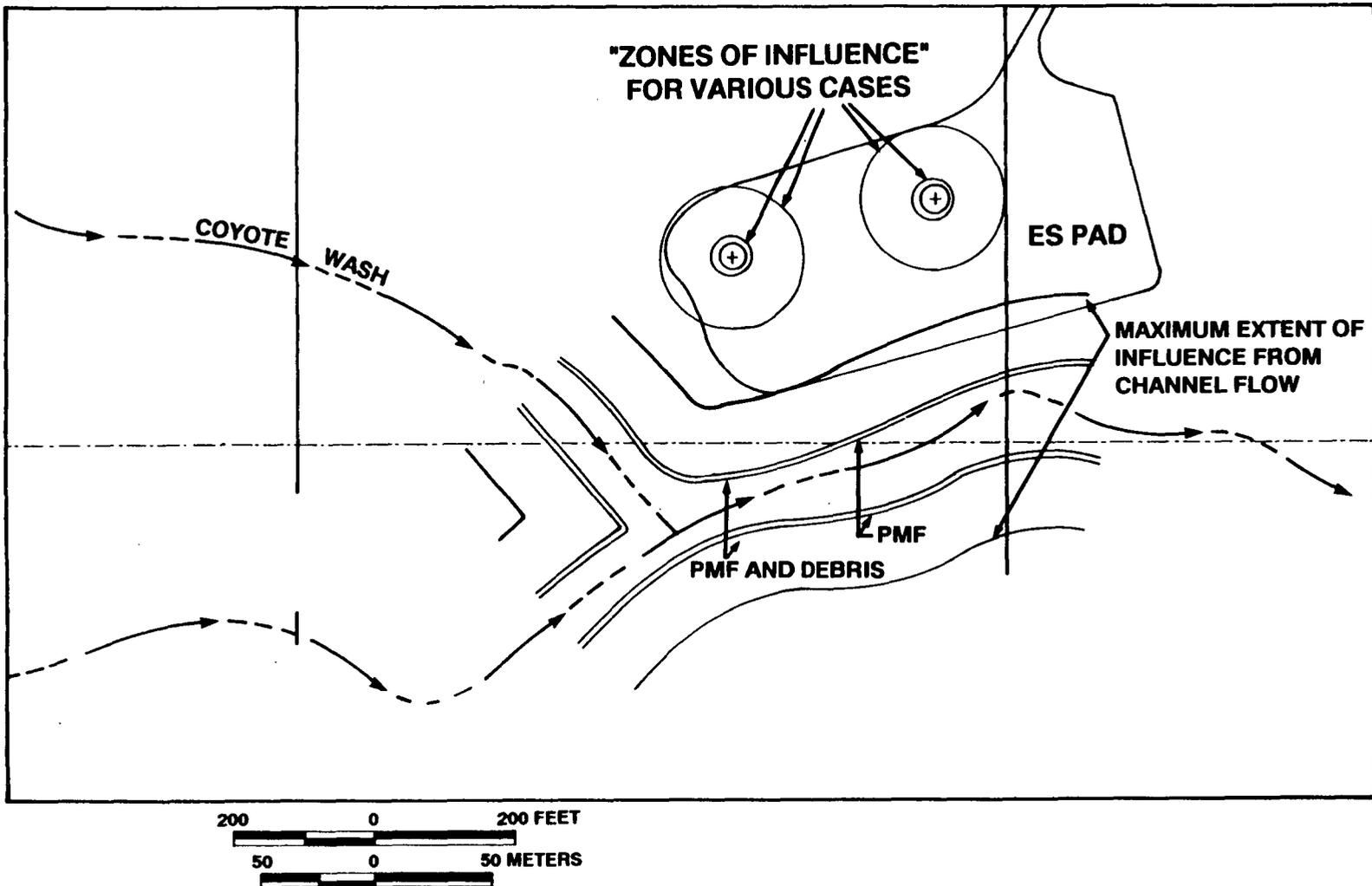
- **ESTIMATION: A MORE REALISTIC INFLOW (CONSIDERING RUNOFF AND RETENTION WITHIN FORMATION) IS LIKELY TO BE 1-2 ORDERS OF MAGNITUDE LESS THAN FLOW PREDICTED ABOVE**
- 

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

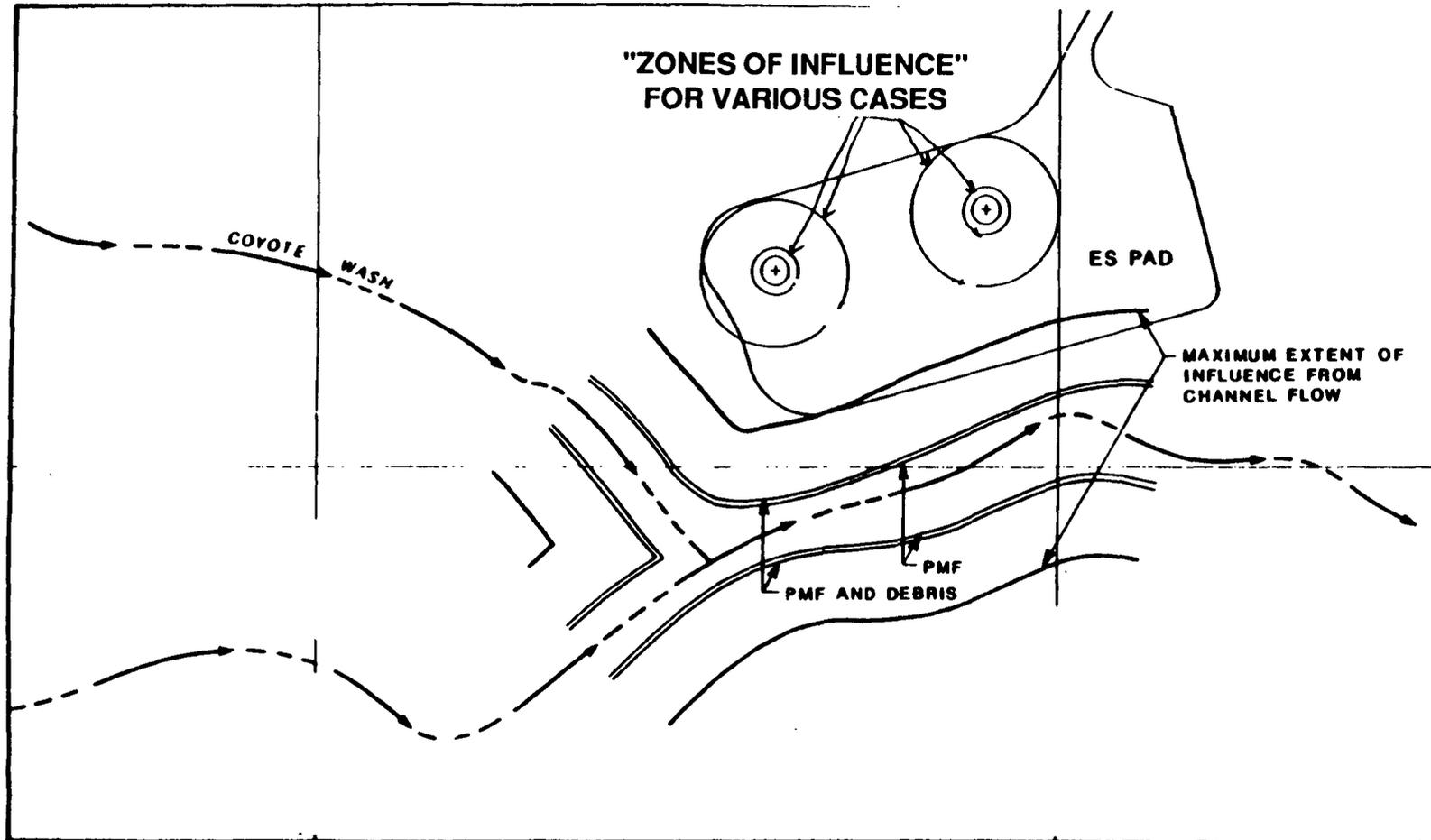
- TOTAL PREDICTED FLOW (EITHER EVENT) IS LESS THAN 50 m³**
 - * VOLUME COULD EASILY BE CONTAINED AND DRAINED WITHIN ESF**
- WATER THEREFORE WOULD NOT REACH WASTE-EMPLACEMENT AREA**

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**

