

SEISMIC FIELD STUDIES

AT

LUCKY FRIDAY MINE

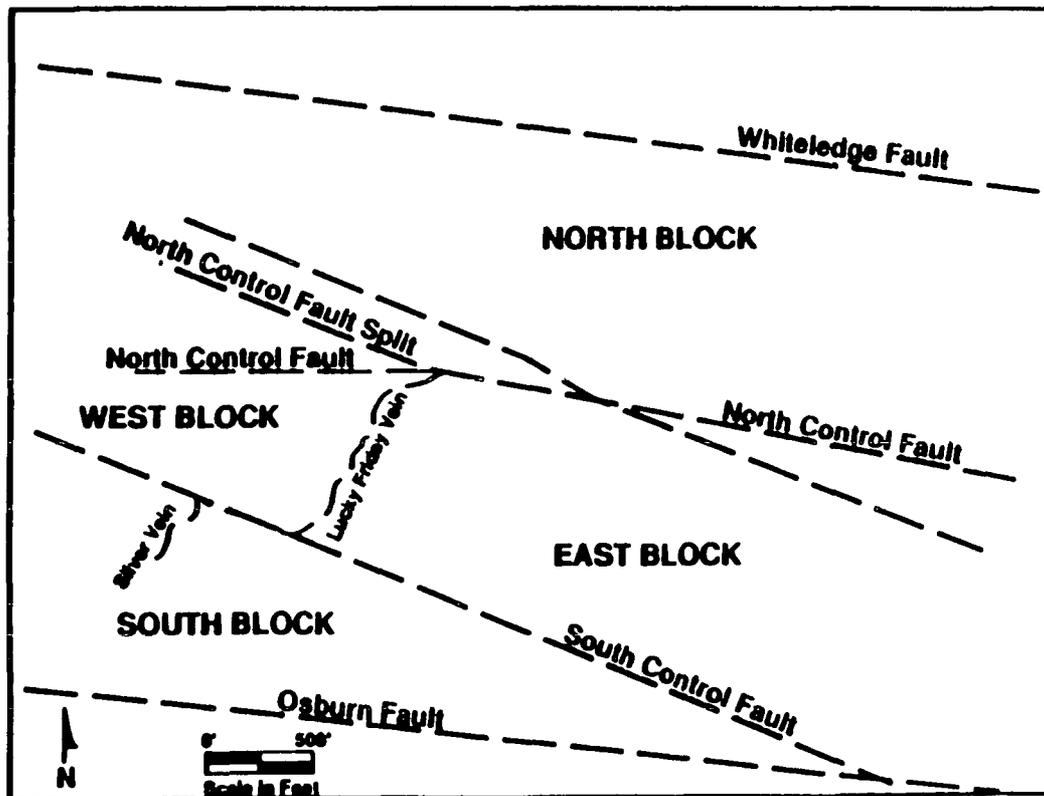
MULLAN, IDAHO

OBJECTIVES:

- **TO INVESTIGATE MECHANICAL RESPONSE OF UNDERGROUND MINE FACILITIES ASSOCIATED WITH SEISMIC EVENTS**
- **TO CLARIFY AND QUANTIFY THE RELATION BETWEEN SEISMICALLY-INDUCED GROUND MOTION AND CHANGES IN GROUNDWATER CONDITIONS**
- **TO GENERATE A RELIABLE DATA SET TO DETERMINE IF ESTABLISHED NUMERICAL MODELS CAN ADEQUATELY DESCRIBE EFFECTS OF SEISMIC ACTIVITIES ON UNDERGROUND STRUCTURES AND GROUNDWATER HYDROLOGY**

MINE SEISMIC EVENTS (TREMORS) VERSUS EARTHQUAKES:

- **STUDIES INDICATE NO SYSTEMATIC DIFFERENCES**
 - **SIMILAR IN SEISMIC SIGNALS**
 - **SIMILAR IN MECHANISM**
- **MOST PHYSICAL AND GEOMECHANICAL PRINCIPLES FOR EARTHQUAKES ALSO APPLY TO MINE SEISMIC EVENTS**
- **MINE SEISMIC EVENTS OCCUR MORE FREQUENTLY THAN NATURAL EARTHQUAKES**



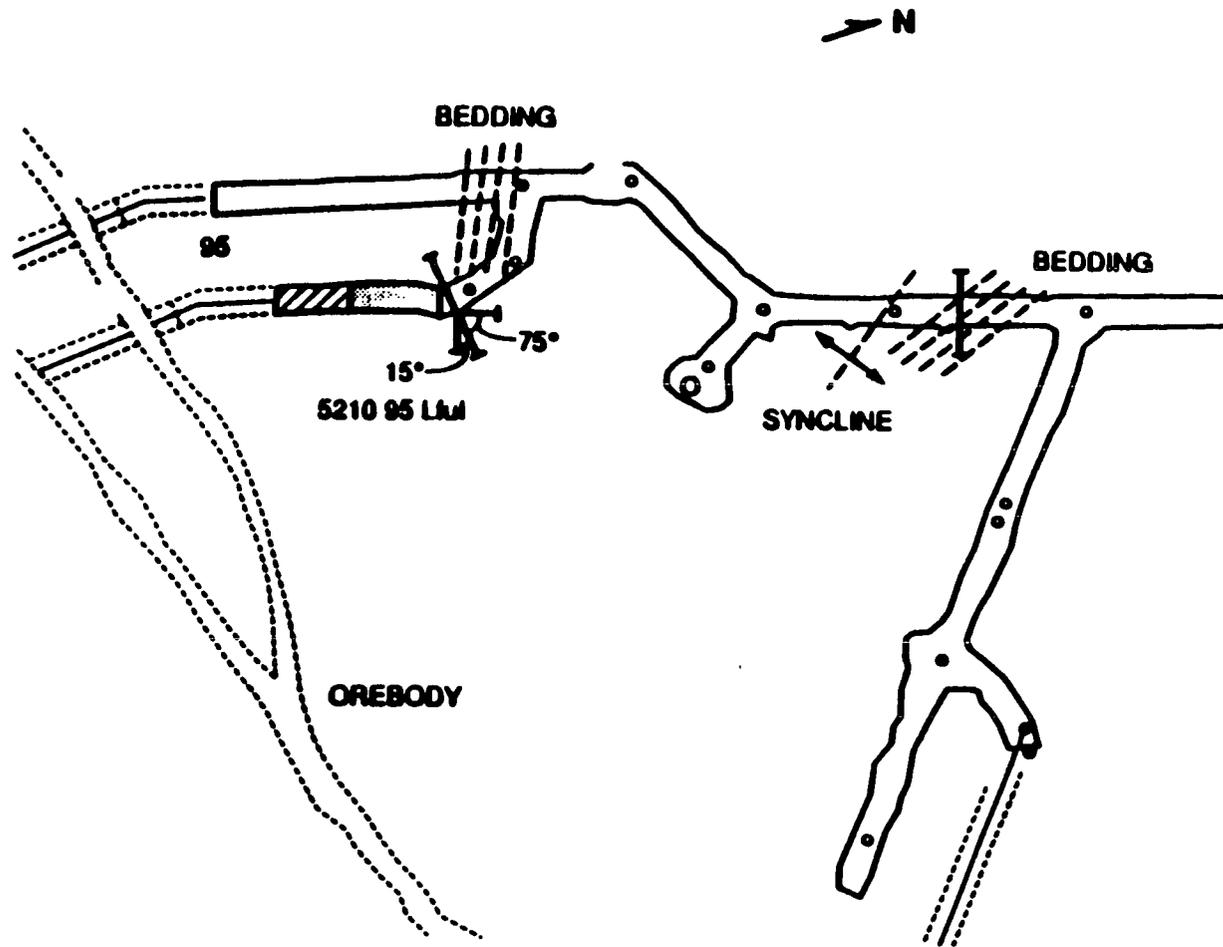
PLAN VIEW OF THE LUCKY FRIDAY OREBODY SHOWING FAULT STRUCTURES

ROCK FORMATION

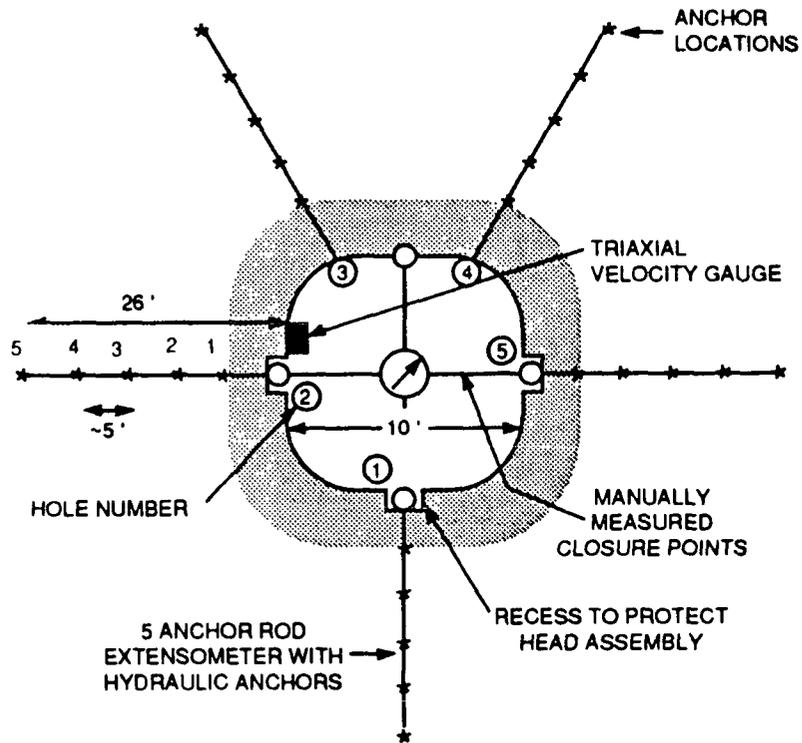
- **UPPER ROCK FORMATION -- ST. REGIS MEMBER
(427 ~ 610m THICK)**
 - **PURPLE ARGILLITE**
 - **IMPURE QUARTZITE**
- **LOWER ROCK FORMATION -- REVETTE MEMBER
(GREATER THAN 1,340m THICK)**
 - **UPPER REVETTE -- INTERBEDDED QUARTZITE AND SILTITE-
ARGILLITE**
 - **MIDDLE REVETTE -- LAYERED SILTITE AND ARGILLITE**
 - **LOWER REVETTE -- THICK-BEDDED QUARTZITE**

EXCAVATION RESPONSE STUDY

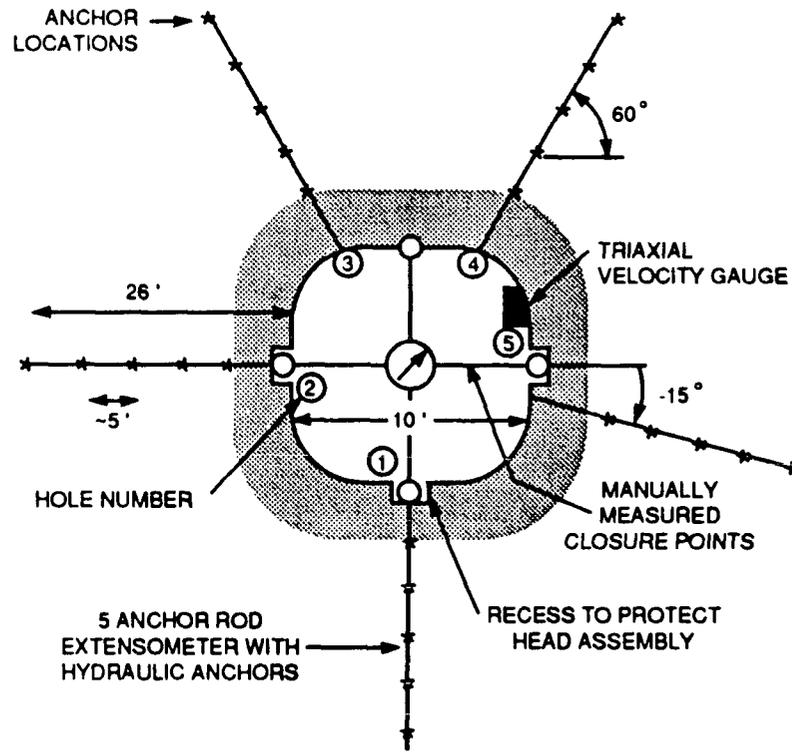
- **MEASURE ROCK DISPLACEMENTS AROUND EXCAVATIONS**
- **MEASURE CLOSURE OF EXCAVATIONS**
- **MONITOR SEISMIC WAVES AT THE LOCATIONS FOR INSTRUMENTATION**



INSTRUMENTATION SITES AT THE 5210 SUBLEVEL



(a) LFM95-C1 Site



(b) LFM95-C2 Site

INSTRUMENTATION ARRAY FOR CROSS SECTIONS OF THE 5210 SUBLEVEL

PLAN VIEW OF SEISMIC EVENT LOCATIONS AND INSTRUMENTATION SITES

X - SEISMIC EVENT

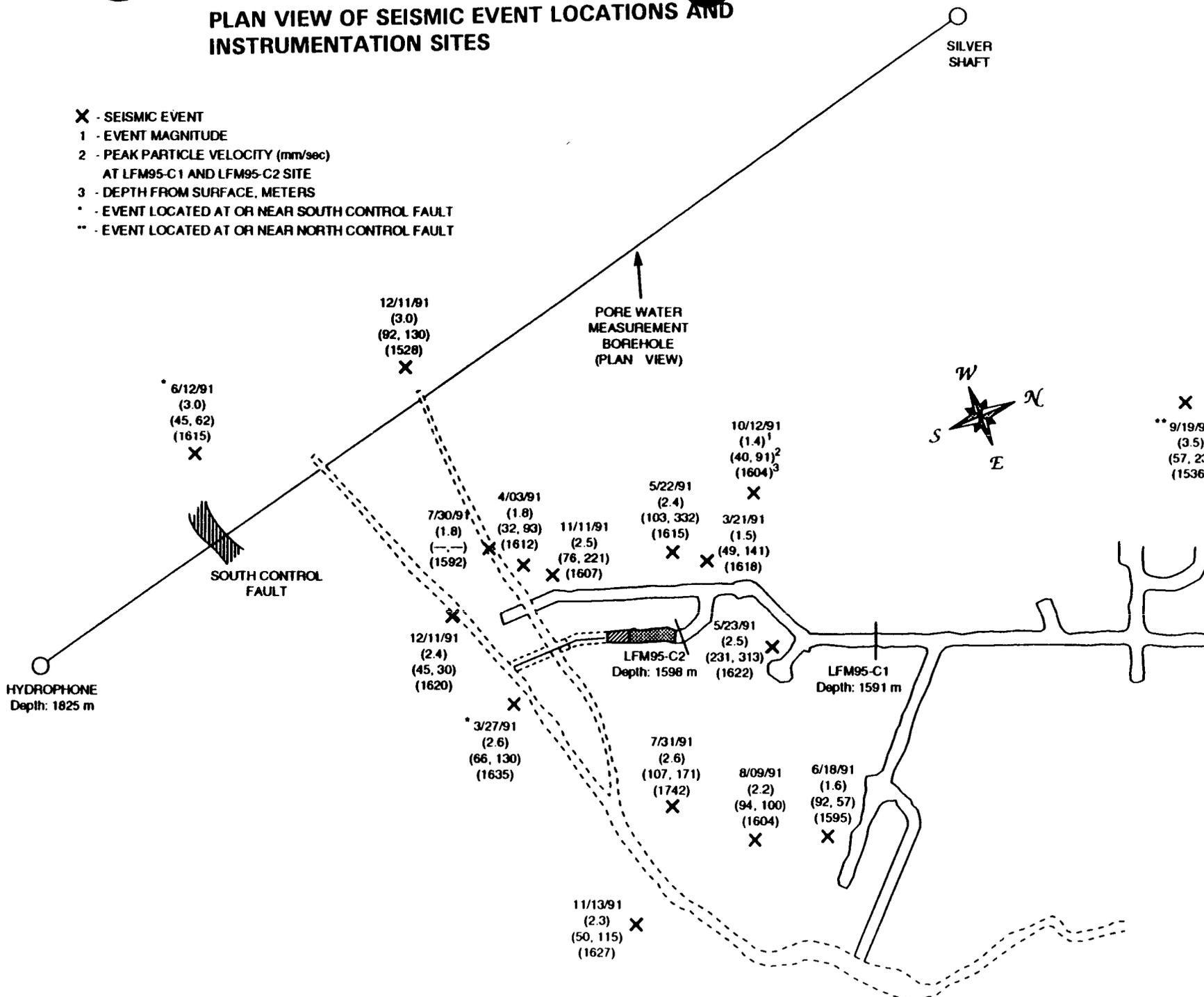
1 - EVENT MAGNITUDE

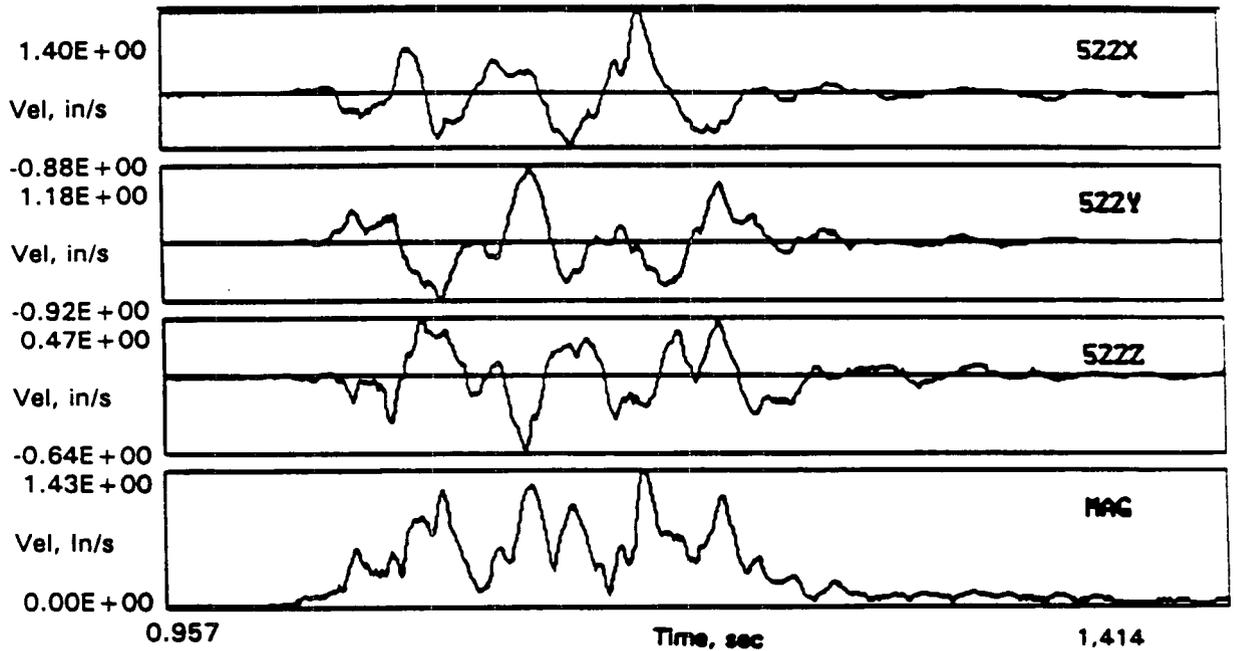
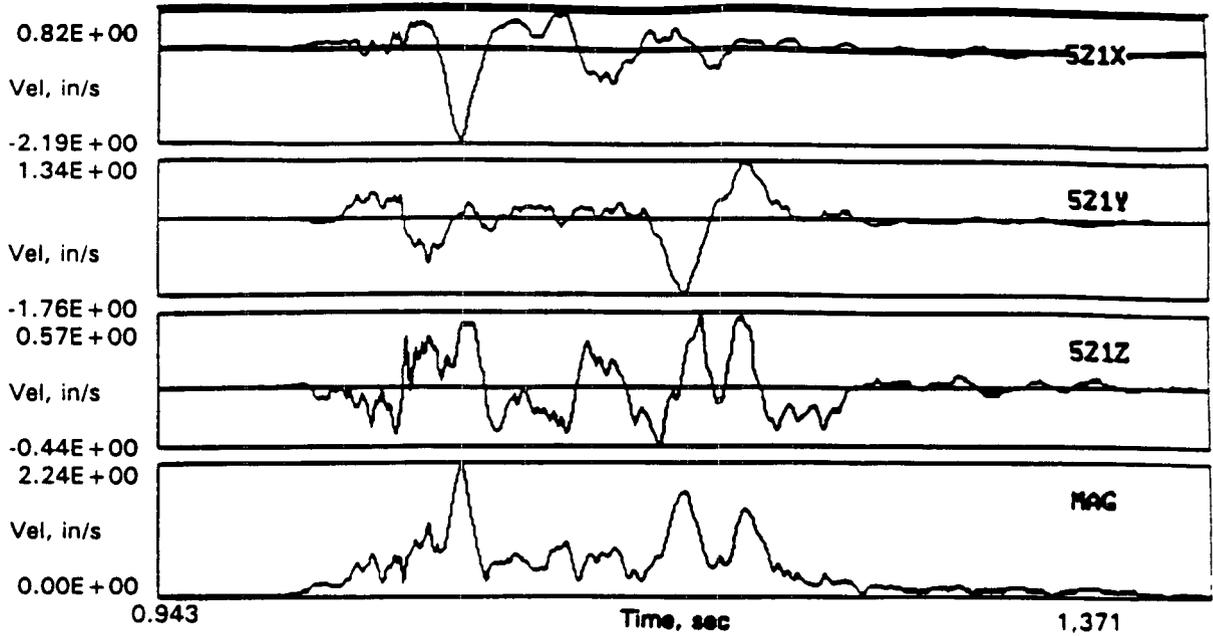
2 - PEAK PARTICLE VELOCITY (mm/sec)
AT LFM95-C1 AND LFM95-C2 SITE

3 - DEPTH FROM SURFACE, METERS

* - EVENT LOCATED AT OR NEAR SOUTH CONTROL FAULT

** - EVENT LOCATED AT OR NEAR NORTH CONTROL FAULT

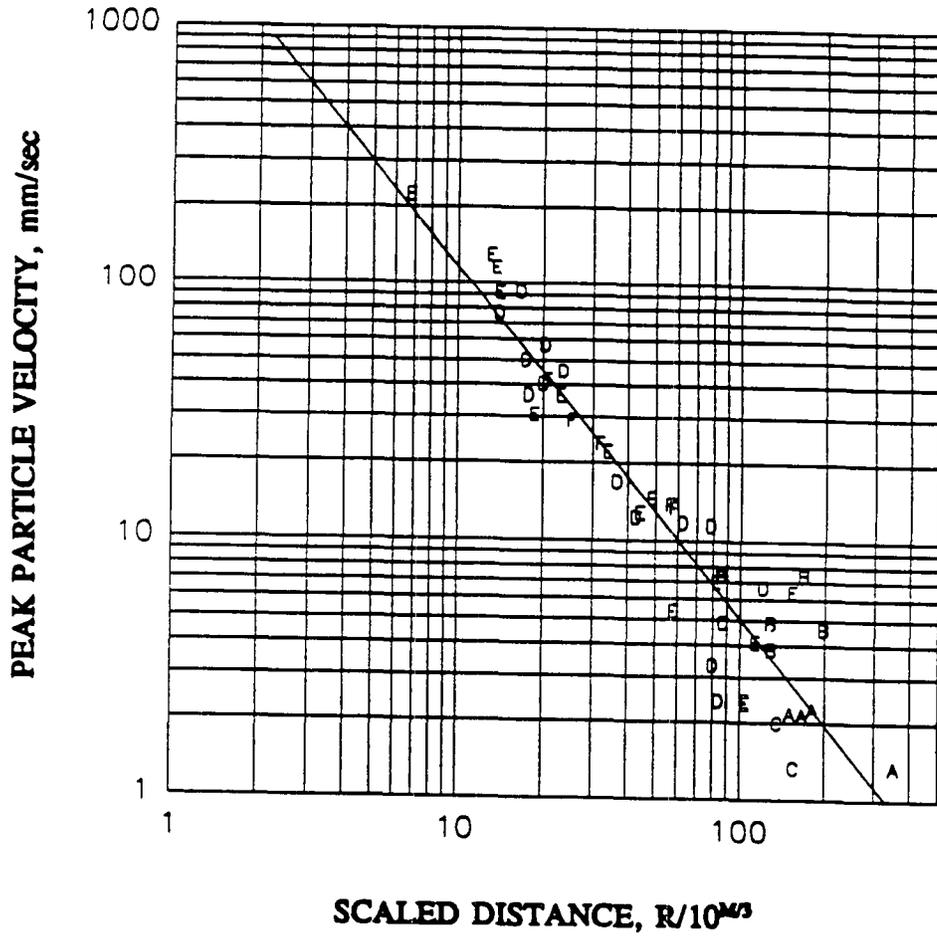




A TYPICAL TIME HISTORY OF SEISMIC VELOCITY ALONG THREE AXES AND RESULTANT VELOCITY

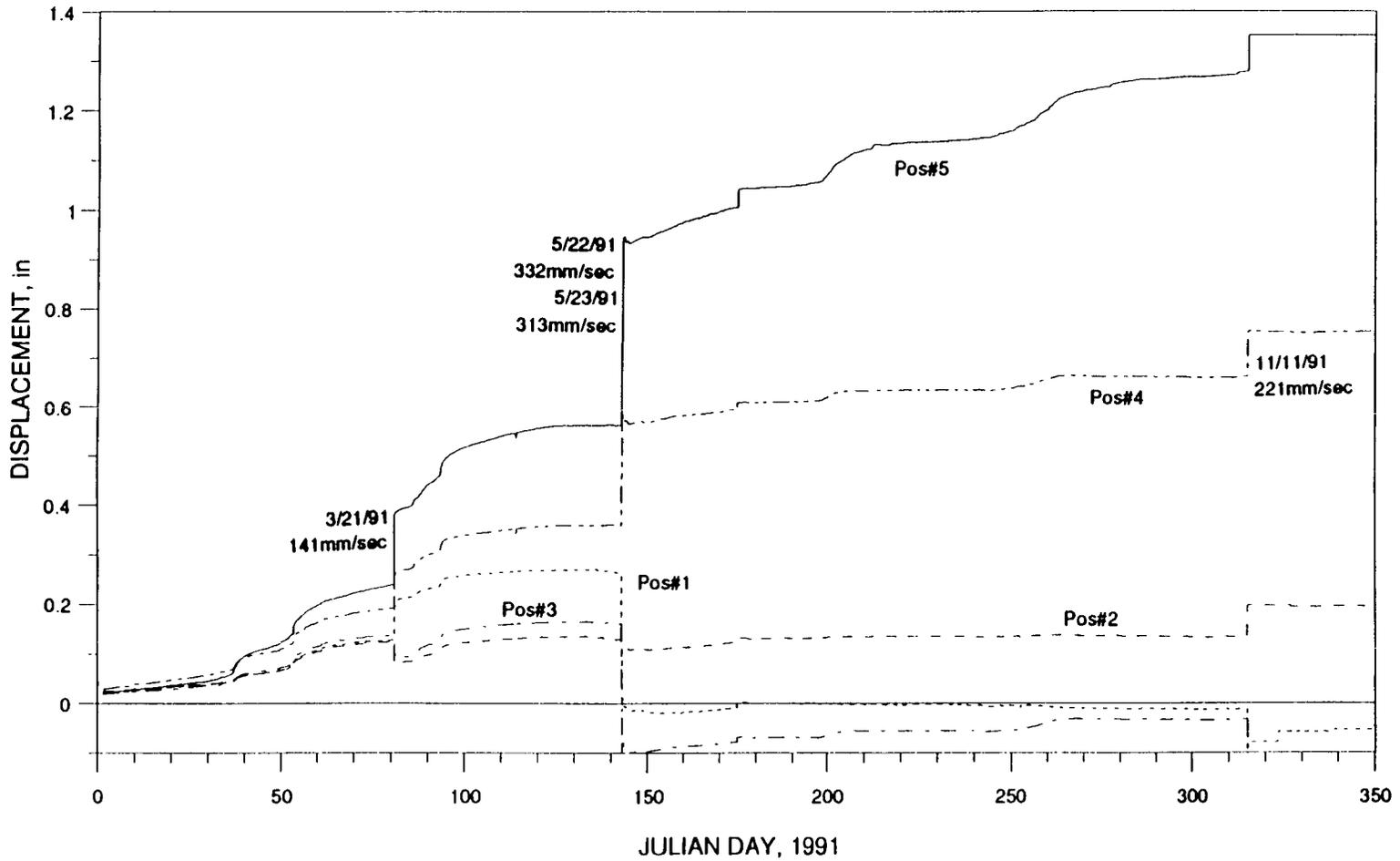
PPV = PEAK PARTICLE VELOCITY
R = SOURCE DISTANCE, m
M = EVENT MAGNITUDE

$$PPV = 2,648 (R/10^{M/3})^{-1.3604}$$



RELATIONSHIP AMONG PEAK PARTICLE VELOCITY (PPV), SEISMIC EVENT SOURCE DISTANCE (R), AND EVENT MAGNITUDE (M)

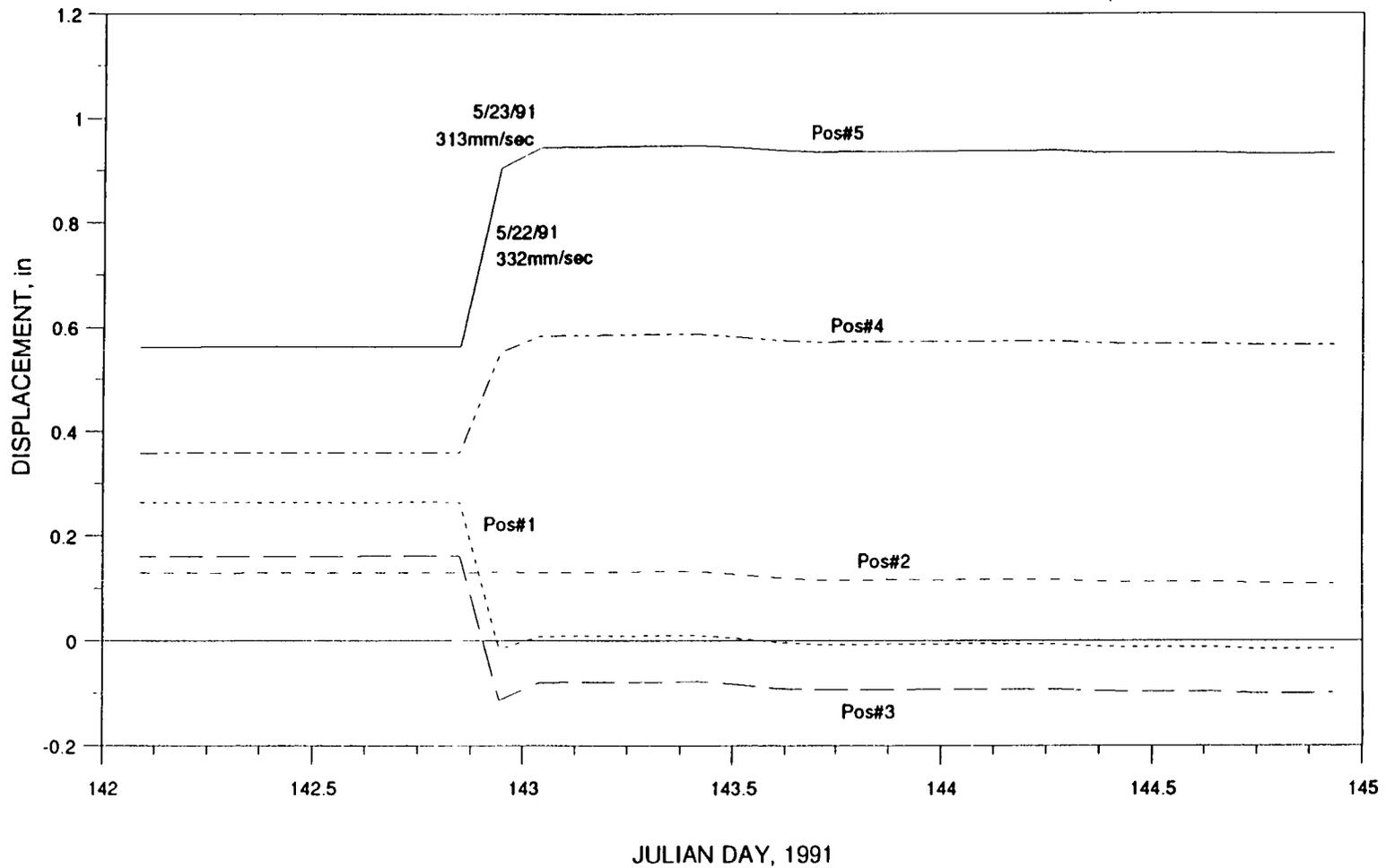
EXT NO. 1 AT LFM95-C2 SITE



RELATIVE ANCHOR DISPLACEMENTS FROM EXTENSOMETER NO. 1 AT LFM95-C2 SITE

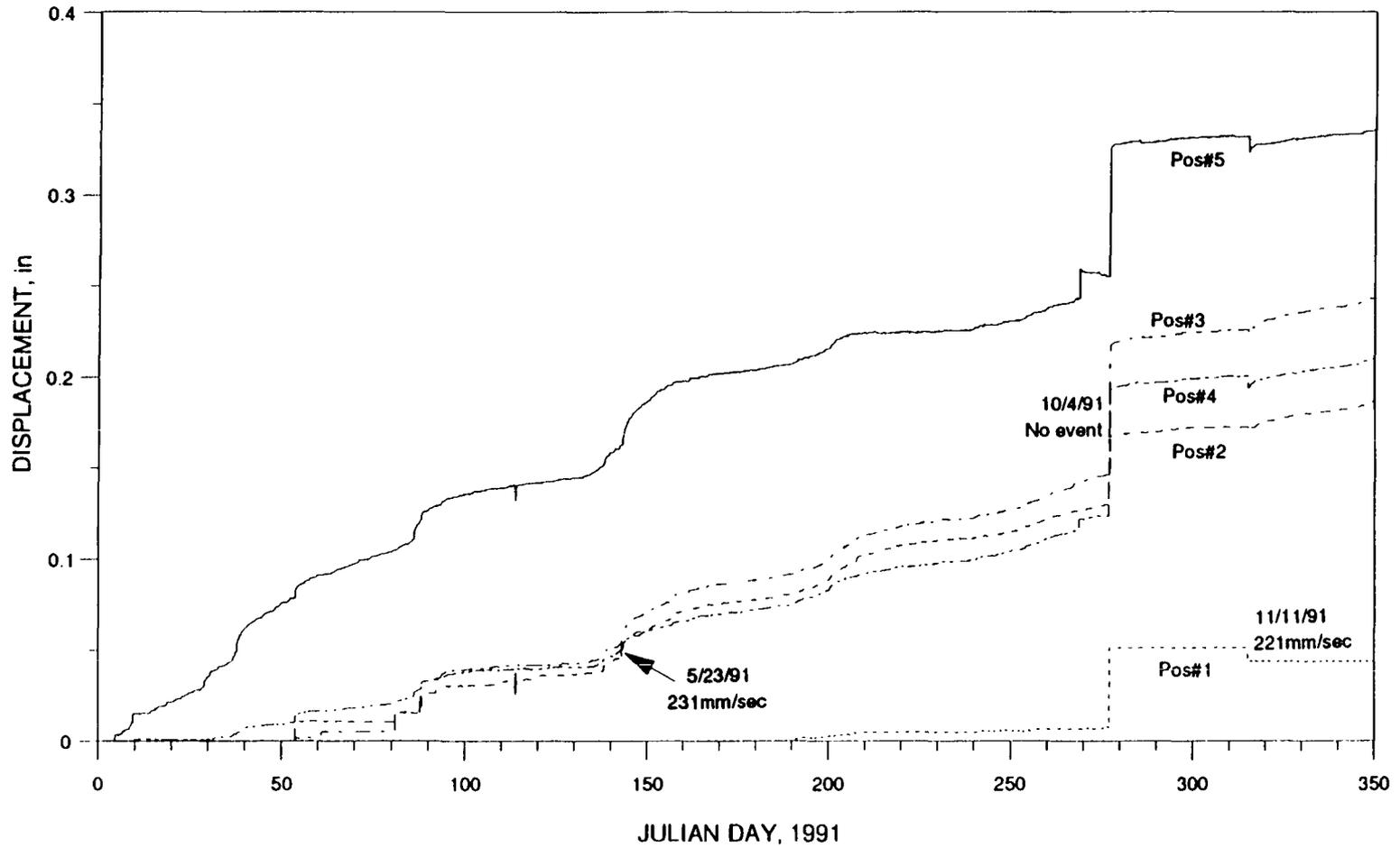
EXT NO. 1 READINGS AT LFM95-C2 SITE

MAY 22, 1991 TO MAY 25, 1991



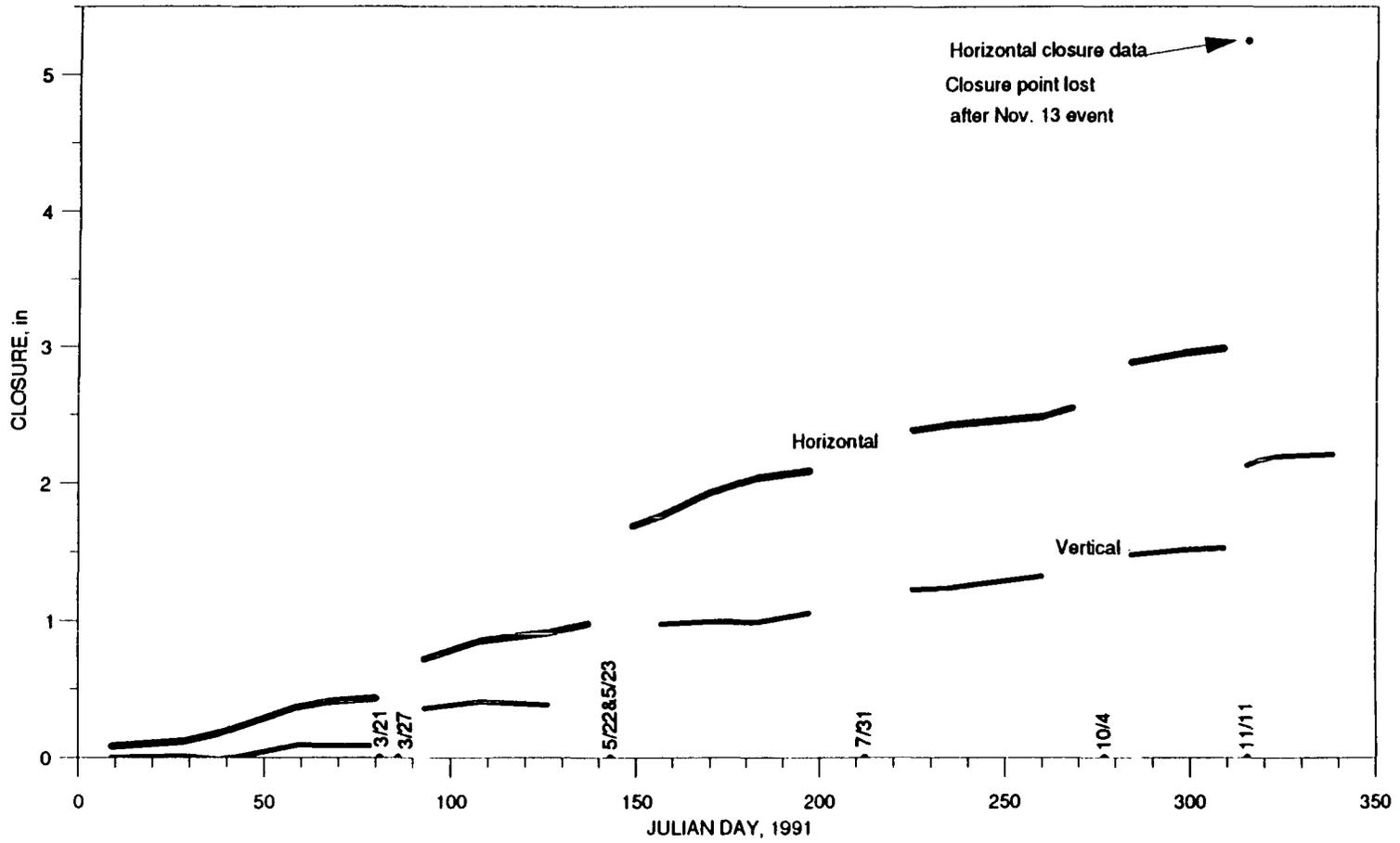
RELATIVE ANCHOR DISPLACEMENTS FROM EXTENSOMETER NO. 1 AT LFM95-C2 SITE

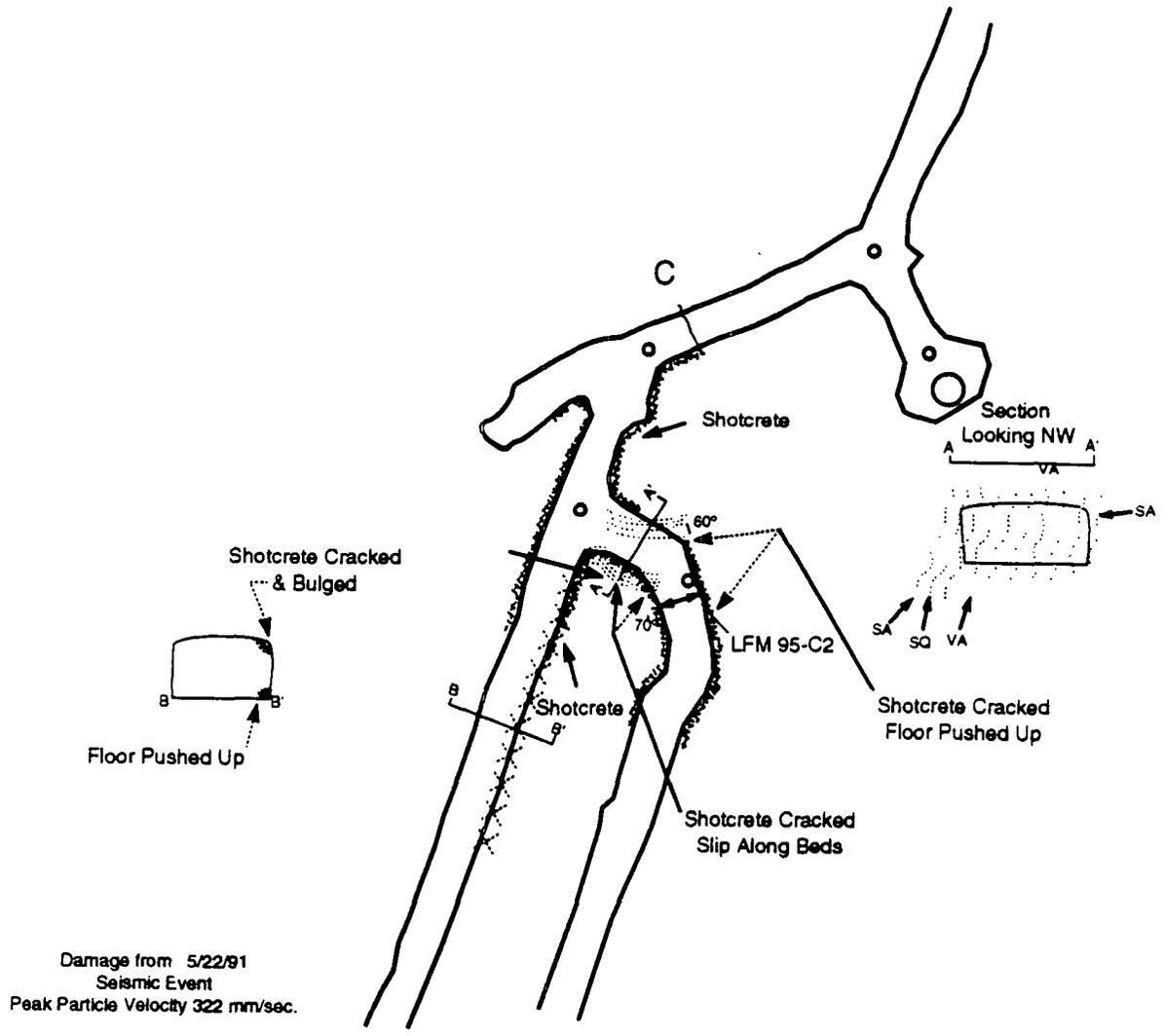
EXT NO. 3 AT LFM95-C2 SITE



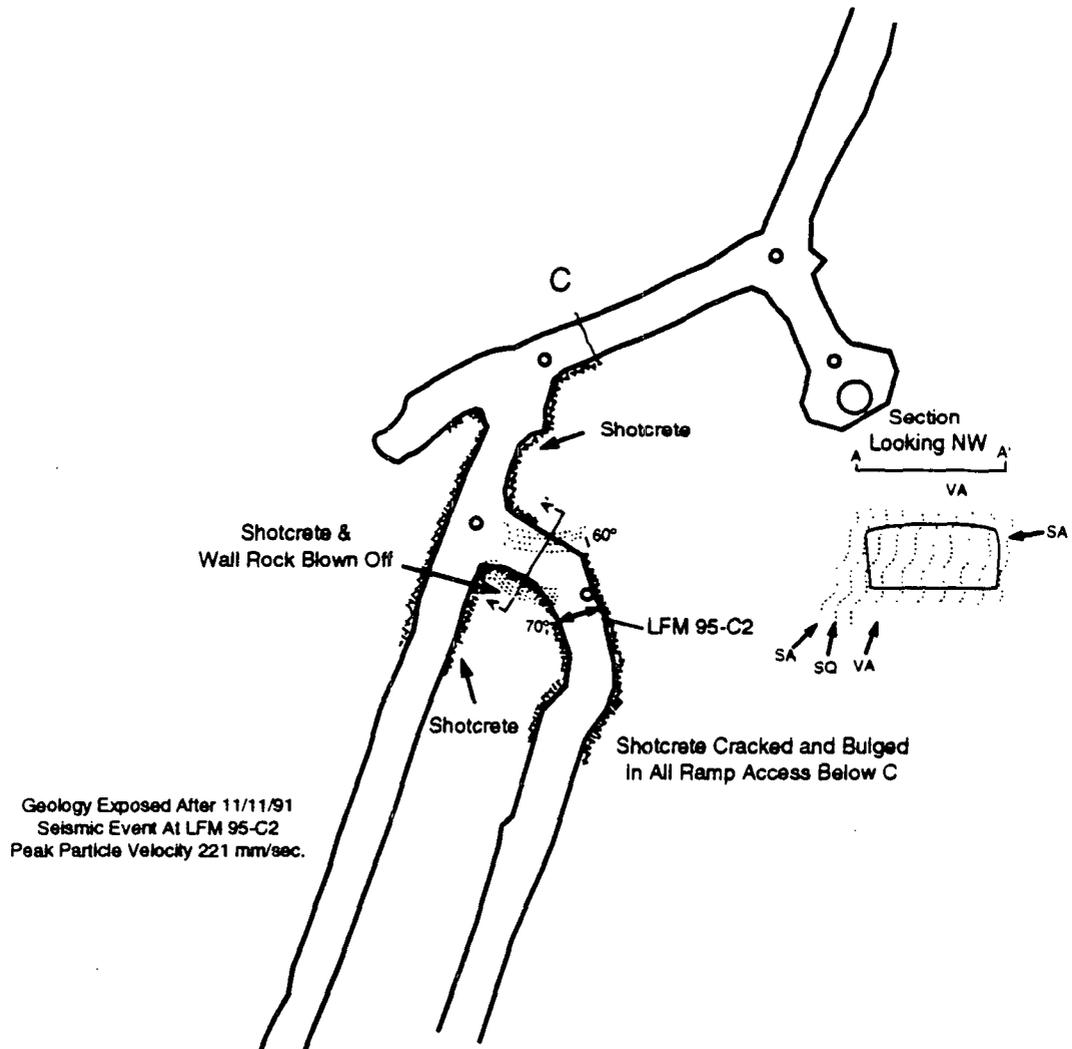
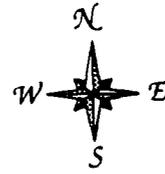
RELATIVE ANCHOR DISPLACEMENTS FROM EXTENSOMETER NO. 3 AT LFM95-C2 SITE

OPENING CLOSURE MEASUREMENT AT LFM95-C2



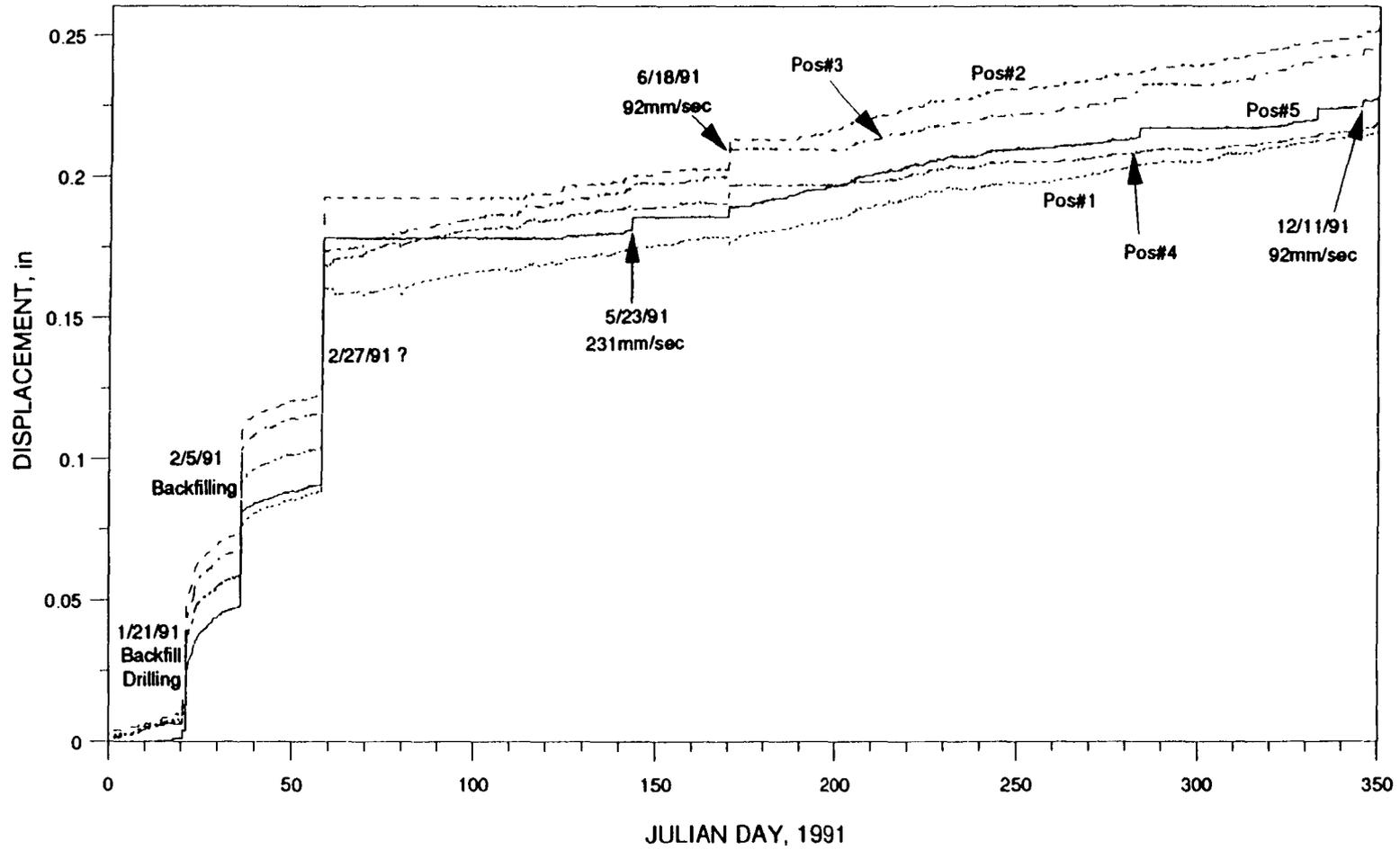


DAMAGE FROM 5/22/91 SEISMIC EVENT AT LFM95-C2 SITE



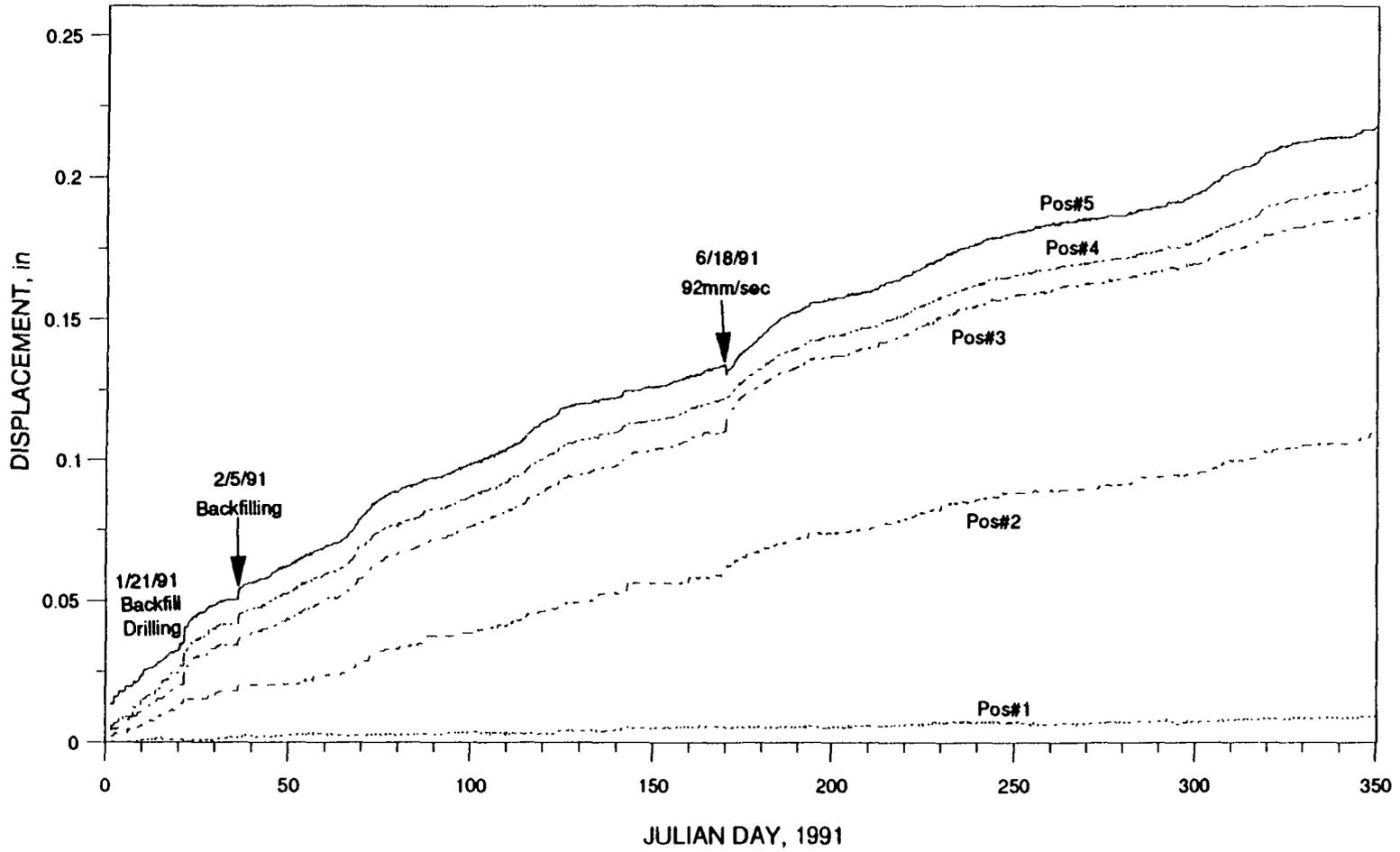
DAMAGE FROM 11/11/91 SEISMIC EVENT AT LFM95-C2 SITE

EXT NO. 3 AT LFM95-C1 SITE



RELATIVE ANCHOR DISPLACEMENTS FROM EXTENSOMETER NO. 3 AT LFM95-C1 SITE

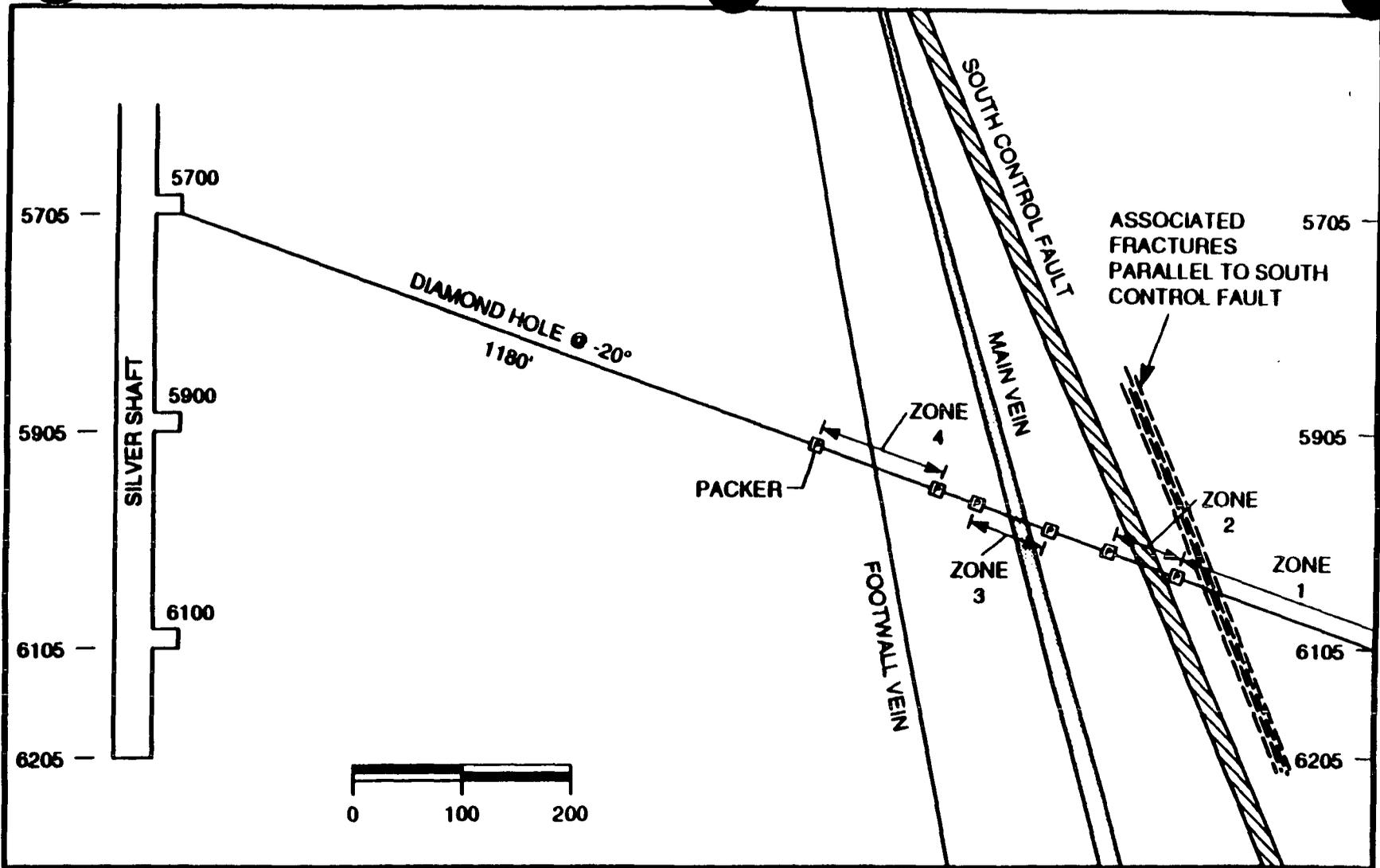
EXT NO. 2 AT LFM95-C1 SITE



RELATIVE ANCHOR DISPLACEMENTS FROM EXTENSOMETER NO. 2 AT LFM 95-C1 SITE

GROUND WATER CHANGE STUDY

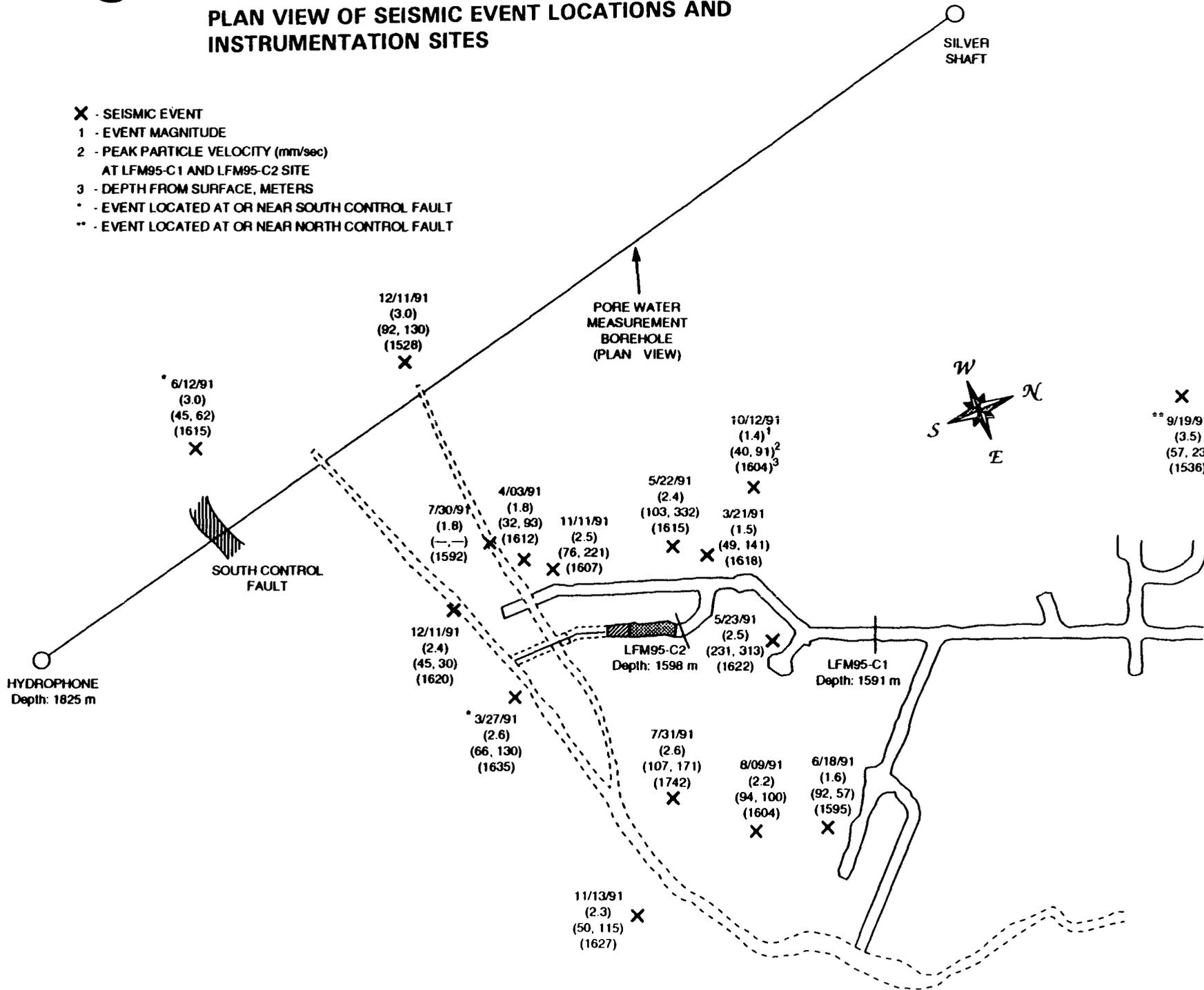
- **MONITOR WATER PRESSURE AT SELECTED GEOLOGIC FEATURES**
- **MONITOR GROUND MOTION ACCELERATION**



LUCKY FRIDAY SILVER SHAFT CROSS SECTION DIAMOND DRILL HOLE FOR GROUNDWATER HYDROLOGY STUDY, LOOKING N 74° E

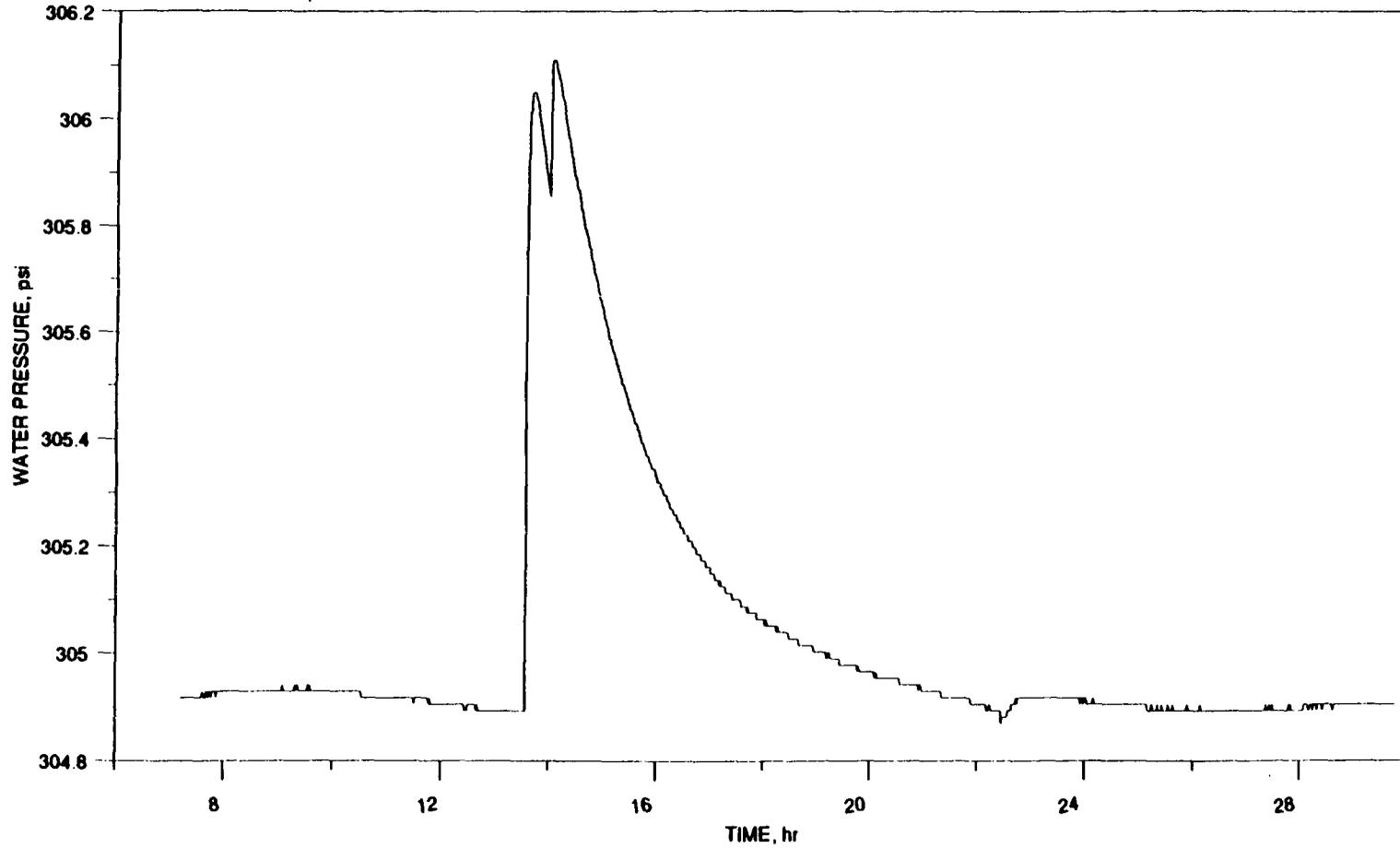
PLAN VIEW OF SEISMIC EVENT LOCATIONS AND INSTRUMENTATION SITES

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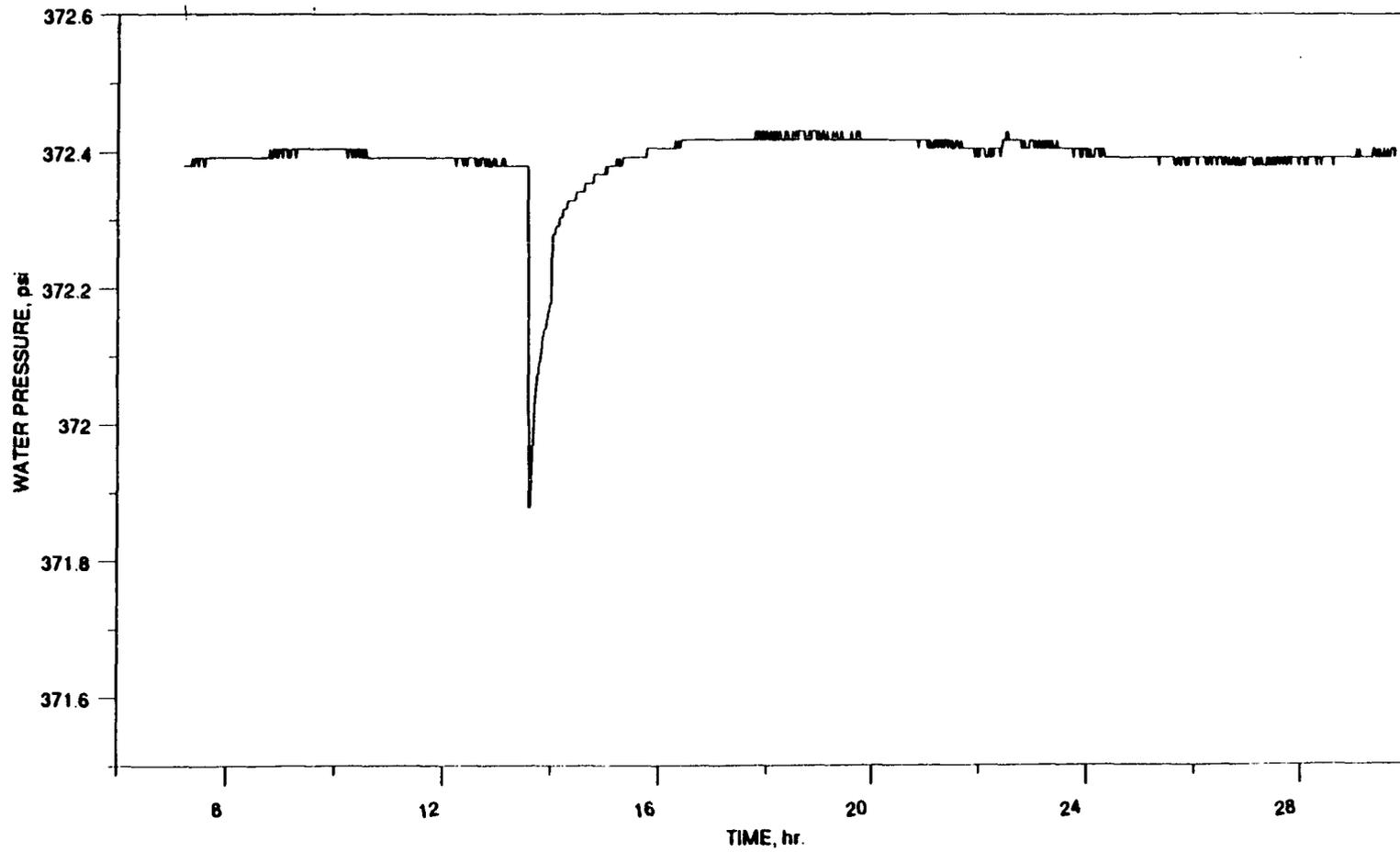
WATER PRESSURE CHANGE FOR ZONE 3

7AM DECEMBER 11 TO 4AM DECEMBER 12, 1991



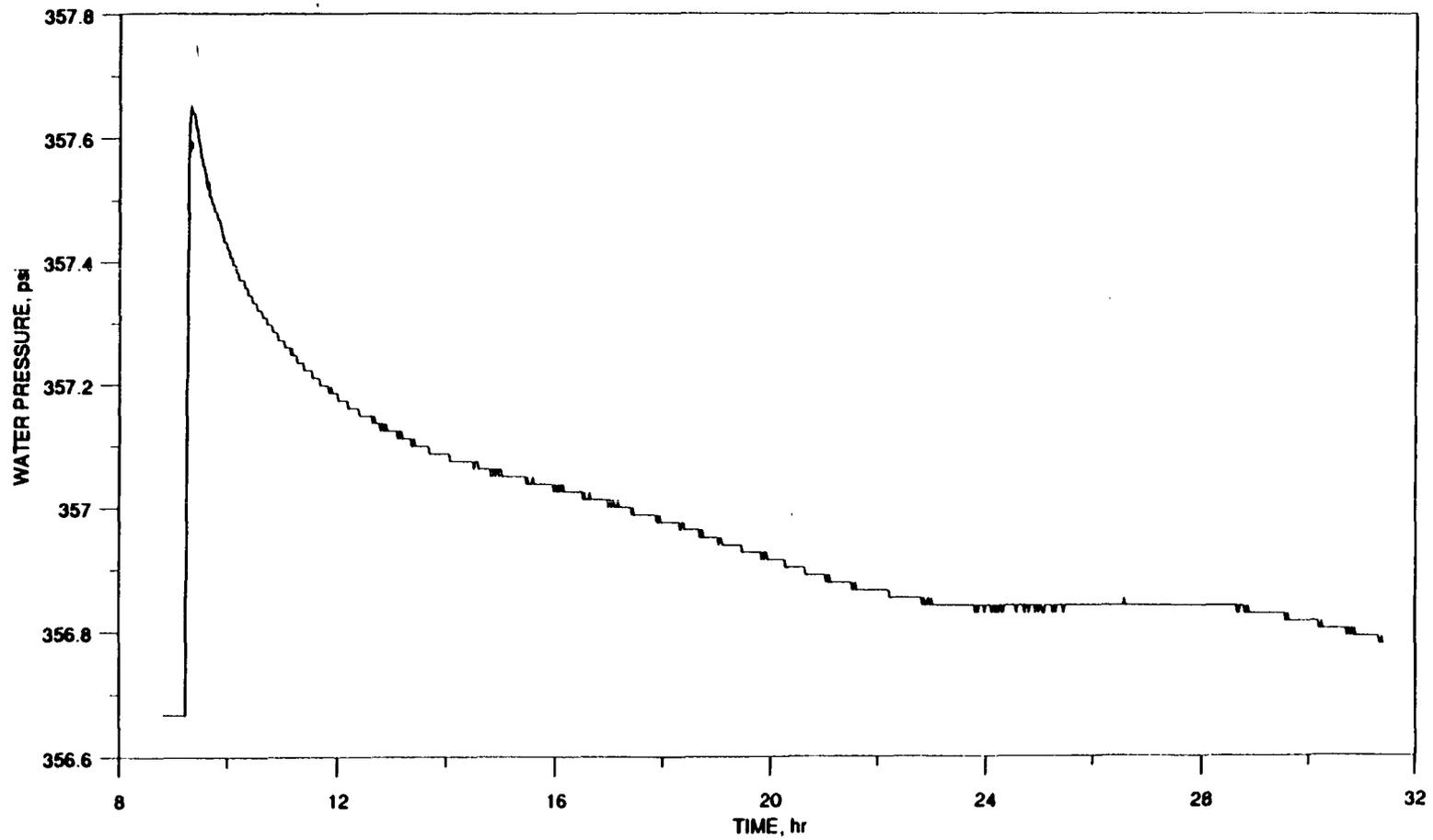
WATER PRESSURE CHANGE FOR ZONE 1

7AM DECEMBER 11 TO 4AM DECEMBER 12, 1991



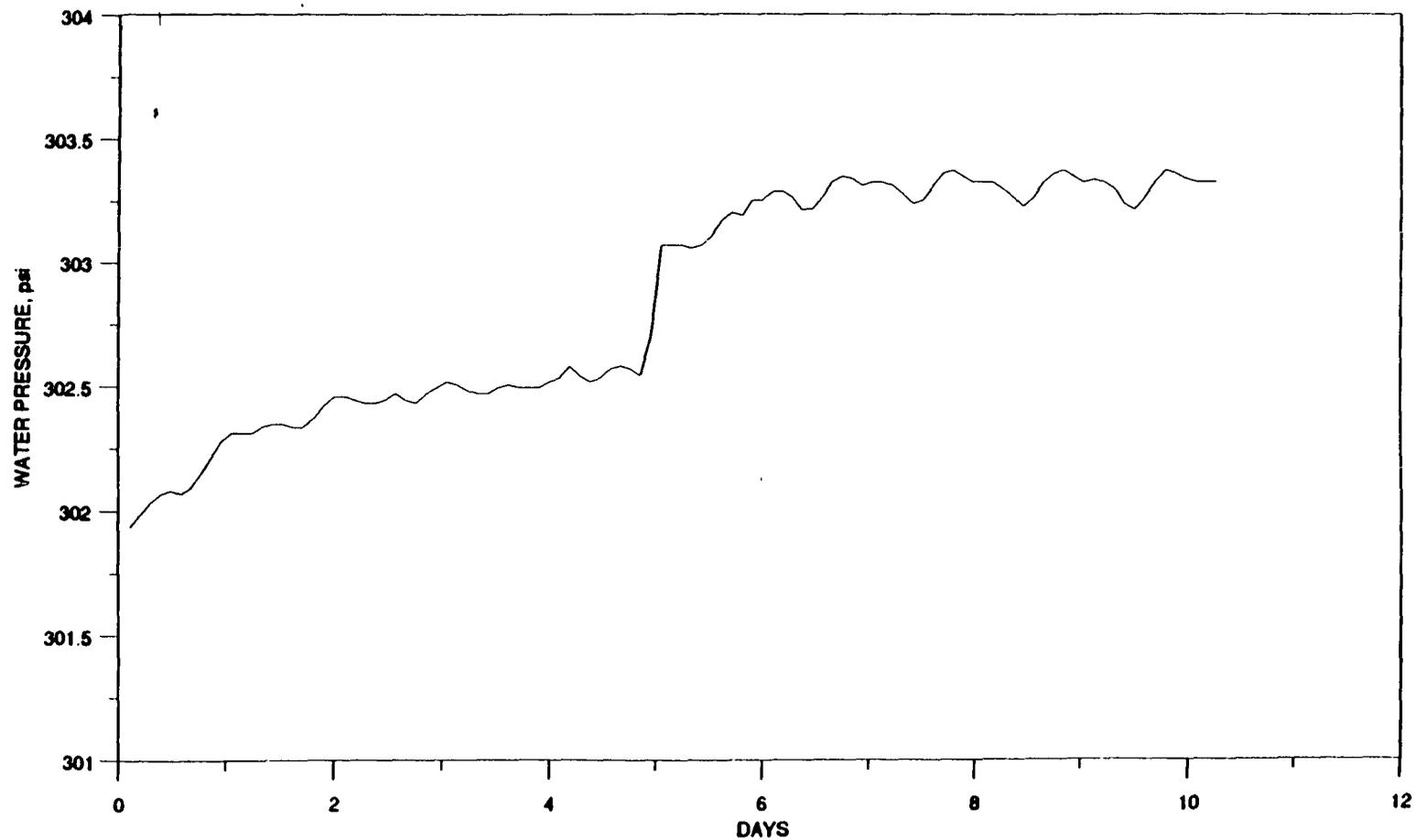
WATER PRESSURE VARIATION IN ZONE 2

8AM SEPTEMBER 19 TO 8AM SEPTEMBER 20, 1991



WATER PRESSURE VARIATION IN ZONE 3

1:30AM MAY 18 TO 5AM MAY 28, 1991



SUMMARY:

- **CAUSES OF STEP DISPLACEMENT CHANGE**
 - **SEISMIC IMPACT**
 - **MINING (STRESS REDISTRIBUTION)**
 - **BACKFILL OPERATION**
- **OPENINGS DID NOT NECESSARILY RESPOND TO ALL SEISMIC EVENTS WITH HIGHER THAN "THRESHOLD" PEAK PARTICLE VELOCITY**
- **OPENINGS AT HIGH STATE OF STRESS ARE MORE SENSITIVE TO SEISMIC EVENTS**
- **BEDDING OR JOINT STICK-SLIP MECHANISM MAY BE USED TO EXPLAIN:**
 - **THE DIFFERENCE IN DISPLACEMENT CHANGES INDUCED BY EVENTS WITH SIMILAR PEAK PARTICLE VELOCITIES,**
 - **WHY OPENINGS SOMETIMES DO NOT RESPOND TO MINE SEISMIC EVENTS WITH HIGH ENOUGH PEAK PARTICLE VELOCITY**
- **CURRENT OBSERVATION INDICATES THAT GROUND WATER RESPONDED TO MINE SEISMIC EVENTS WITH MAGNITUDES GREATER THAN 2.0**
- **GROUNDWATER PRESSURE NORMALLY INCREASES AFTER A SEISMIC IMPACT, WITH ONE EXCEPTION**
- **WATER PRESSURE CHANGES OCCURRED IN ALL THREE ZONES THAT ARE PACKED OFF AS A RESULT OF SEISMIC EVENTS, WITH ONE EXCEPTION**