Observations from Cross Drift Bulkheads Opening
January 22-25, 2001

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The terminal 944 m of the Cross Drift was isolated from ventilation effects by the construction of three bulkhead doors for the purpose of:

- Measuring *in-situ* drift conditions without ventilation
- Measuring drift re-wetting after drying from ventilation and excavation
- Monitoring for evidence of free liquid water either from seepage or condensation

Bulkhead Locations and Measurements

Initially bulkheads were installed at 17+63 m and 25+03 in June 1999. During July 2000 a third bulkhead was added at 26+00 m to isolate heating from active electrical transformers on the tunnel boring machine (TBM). When the third bulkhead was added the tunnel lights were turned off behind the bulkheads to eliminate another potential heat source.

The bulkheads partition the Cross Drift into three non-ventilated zones behind a front ventilated zone (Plate 1). The Cross Drift remains open and ventilated up to the first bulkhead at 17+63 m. The front non-ventilated zone from 17+63 m to 25+03 m does not contain any major faults and crosses the contact between the welded Topopah Sping Tuff lower non-lithophysal unit (Tptpln) and the welded Topopah Spring Tuff lower lithophysal unit (Tptpll). This contact is at 23+26 m. There is no overlying non-welded tuff (PTn) beyond about 24+00 m to the Solitario Canyon Fault (Plate 2). The middle non-ventilated zone from 25+03 m to 26+00 m contains a major splay of the Solitario Canyon Fault at 25+84 m. The back non-ventilated zone is heated by the active transformers on the TBM and contains a major splay of the Solitario Canyon Fault.

Rock matric potentials are monitored with heat dissipation probes (HDP's) at 25 m intervals throughout the entire length of the Cross Drift. The HDP's are installed in 2 m deep, 1.75" diameter drilled holes. Six meter deep, 3.0" diameter boreholes at 20+00 m and 25+00 m are instrumented with thermocouple psychrometers to monitor rock water potentials and re-wetting. Water content profiles of the Cross Drift walls are monitored with neutron probes in 2 m deep, 3" diameter boreholes located at 50 m intervals throughout the Cross Drift. Water content profiles were measured in September 1999, January 2000, July 2000, and January 2001 when the bulkheads were opened for periodic TBM maintenance. Temperature, relative humidity, and barometric pressure are also measured throughout the Cross Drift.

In July 2000, wind speed sensors capable of detecting wind velocities as low as 0.05 m/s were installed in the front and middle non-ventilated zones and thermocouples were installed to measure temperatures around the fault in the middle non-ventilated zone. Also in July 2000 canvas sheets treated with a pH indicator were hung across the top of the Cross Drift to detect the presence of liquid water behind the bulkheads. Liquid water is expected to be alkaline due to contact with the rock or accumulated dust on the drip cloths. Wet spots are identified by color changes on the canvas. These canvas sheets cover most of the middle non-ventilated zone from 25+10 m to 25+95 m and the area in front of the second bulkhead from about 24+75 m to 24+95 m.

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The first bulkhead was opened at noon on January 22, 2001. After ventilation was established behind the first bulkhead, the second bulkhead was opened (~1:30 pm) and ventilation was established behind the second bulkhead. By 2:00 PM after 30 minutes of ventilation into the third bulkhead, USGS and LBNL personnel entered behind the first and second bulkheads

The Cross Drift was dry from the first bulkhead (17+63) to about 19+00 m. Photographs from the initial entry show evidence of condensation on the metallic surfaces of the vent line, utility lines, and conveyor belt (Figures 1-3). Most of the glistening on metallic surfaces that was evident in the initial photographs had evaporated but there was some rust evident (Figure 4). Canvas sheets located between 24+75 m to 24+95 m were mottled blue and drip marks covered the entire sheets (Figure 5). The intensity of the mottling increased toward the second bulkhead.

Most water was observed in the middle non-ventilated zone between the second and third bulkheads from 25+03 m to 26+00 m. This zone crosses a major splay of the Solitario Canyon fault (Figure 6) and there is no overlying non-welded tuff (PTn) in front of the fault. All drip cloths hung in this zone were wet with some areas noticeably wetter. The blue color indicated moisture with a high pH had contacted the cloth. High pH could have come from condensation in contact with dust or from seepage. Ubiquitous moisture indicated much of the moisture was from condensation rather than point source seepage. There were rust spots, drip marks and streaks (Figures 7 and 8). Drip sheets had puddled water in low spots formed where rocks had fallen onto cloth and there was puddled water in low spots on the conveyer belt (Figures 9 and 10). Rock debris had fallen onto many areas of the drip sheets. Water was collected from puddles on the conveyer belt. This water had a dark color indicating mixture with unknown debris on the conveyer belts. Drier conditions were observed near the third bulkhead.

how much?

The back non-ventilated zone behind the third bulkhead to the terminal end of the Cross Drift (26+00 m 27+04 m) was dry.

Condensation could have been caused from warmer, moist air moving away from the TBM heat source into cooler zones or possibly by cool air moving down the Solitario Canyon Fault. Without eliminating the heat source, the source of the observed condensation cannot be identified. The source of condensation could be from seepage, temperature fluctuations associated with air moving through the fault, or with the hot moist air leaking through the third bulkhead. Moisture conditions are continuously monitored in each of the three non-ventilated zones to determine if local thermally induced effects and far field infiltration effects can be decoupled.

why not construction water?

?

why moist?

Temperature and relative humidity data from the three non-ventilated zones show that the temperature ranged between 25° and 32° C and the relative humidity ranged from ~ 85 % to close to saturation. Barometric pressure was the same throughout the Cross Drift. These changes will be compared to surface variations in barometric pressure and variations in barometric pressure in the ventilated zone of the Cross Drift. The low velocity wind speed sensors indicate a slight increase in air movement in the afternoon.

Neutron log data and the heat dissipation probe data show the continuing rock wetting after the bulkheads were constructed.

Harris
ARCT

Figure 1. Station 19+00. Water drops glisten on power cords behind the first bulkhead.

Figure 2. Station 19+00. Ventilation line behind the first bulkhead glistens with water drops.

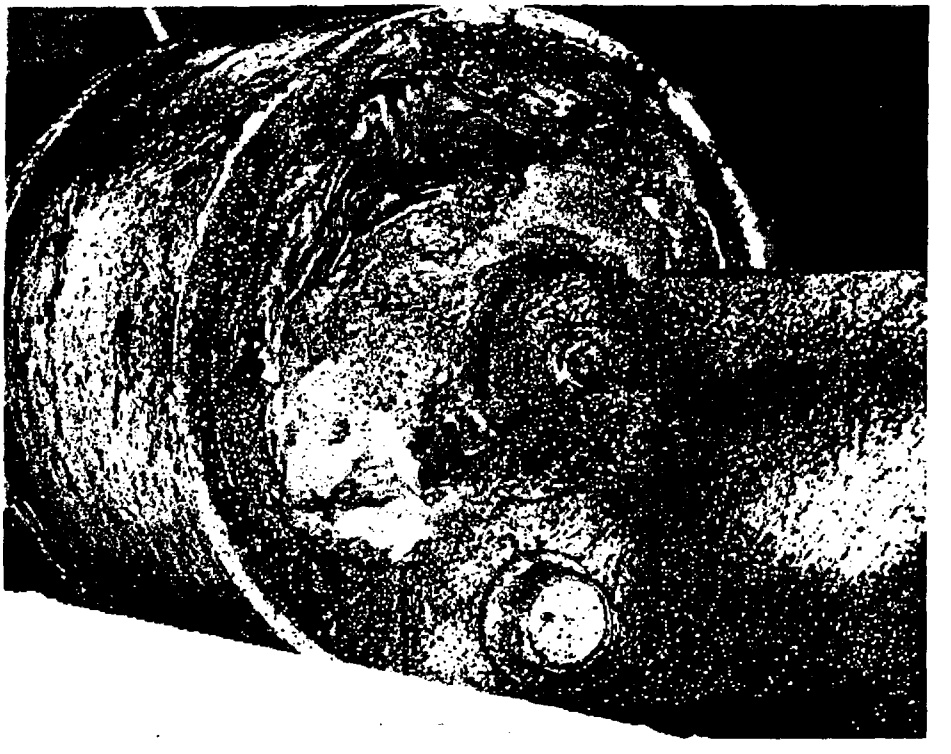


Figure 3. Station 24+80 (20m in front of the second bulkhead). A conveyor roller bearing with mold and rust shows evidence of moisture.

Figure 4. Station 23+35. Rust on pipes behind the Cross Drift first bulkhead.

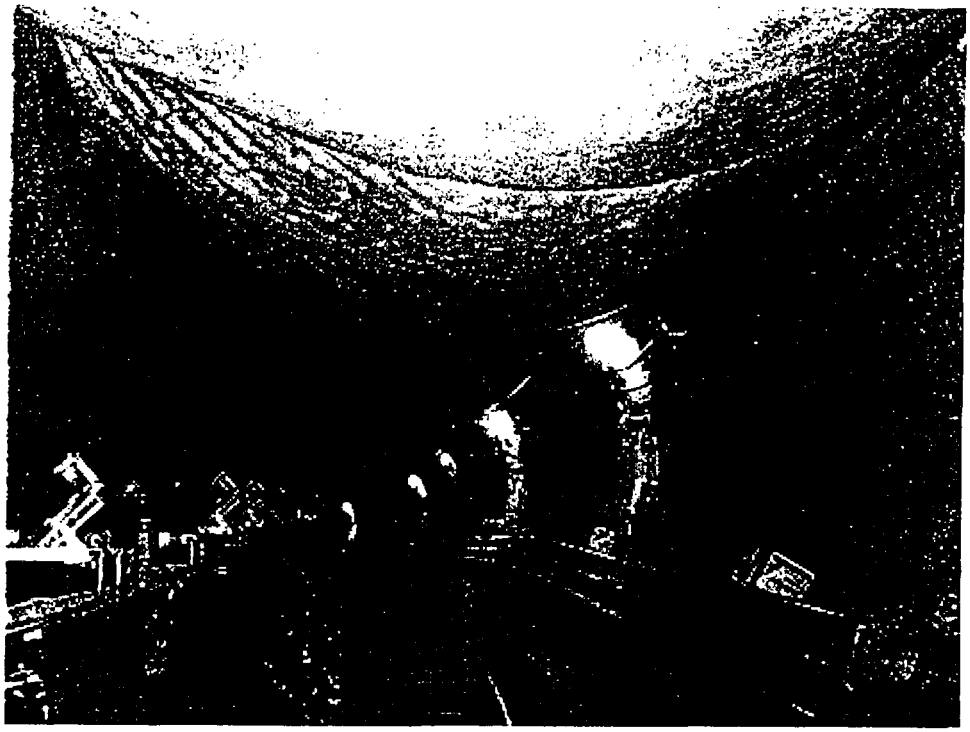


Figure 5. Station 24+90. Blue mottled drip cloth looking back toward the first bulkhead.

Figure 6. Station 25+85, left wall. The main splay of the Solitario Canyon fault zone exposed in the Cross Drift.

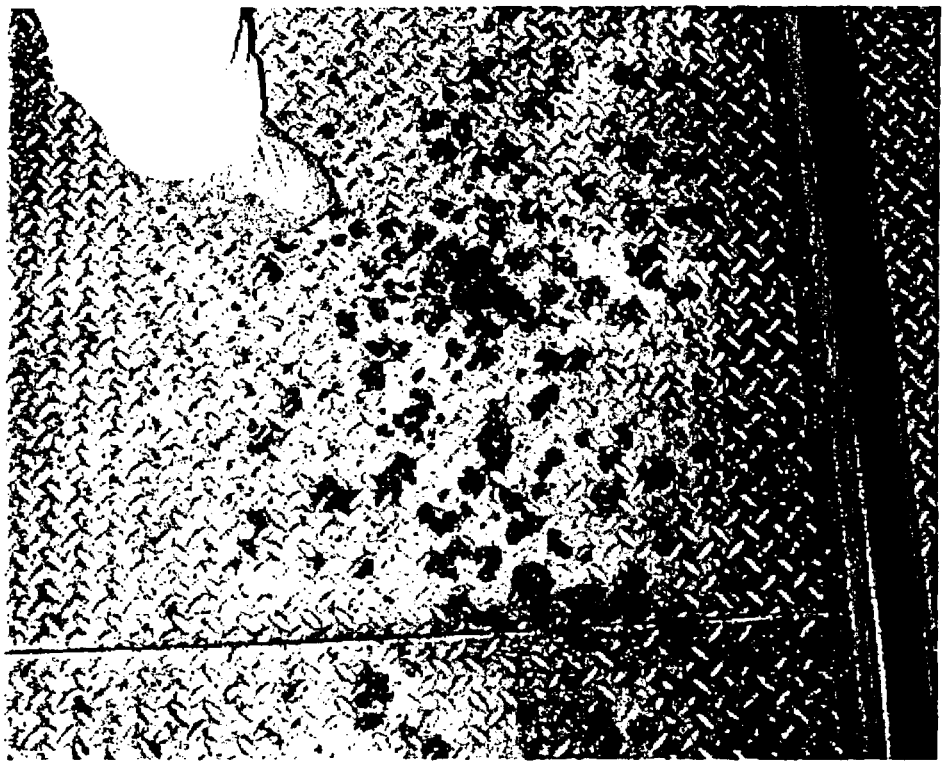


Figure 7. Rust on the metal walkway behind the second bulkhead in the Cross Drift.

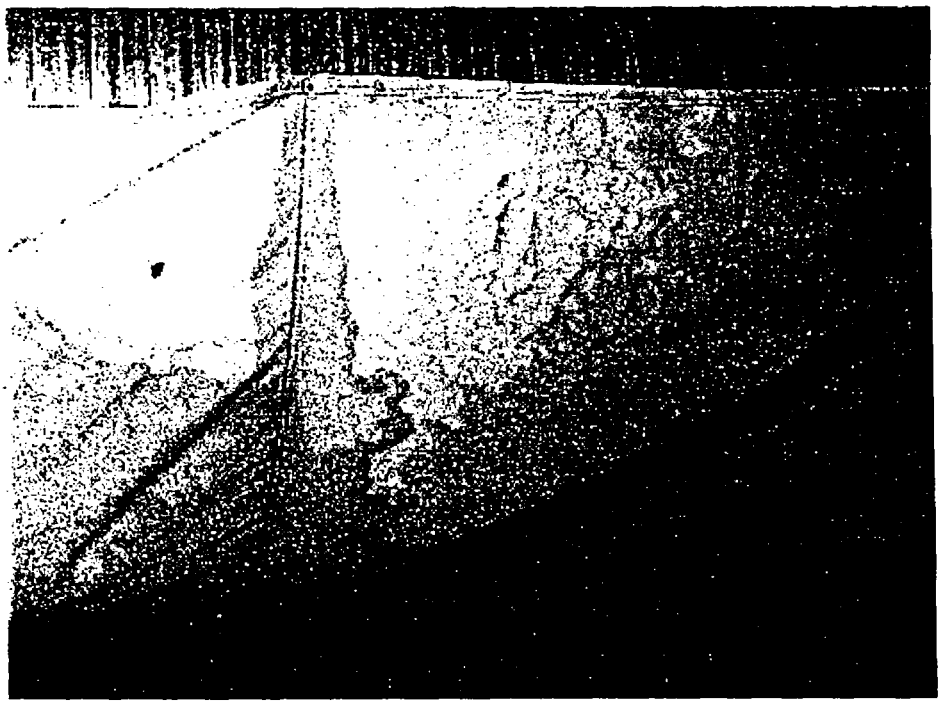


Figure 8. Station 25+20. Drip cloth behind the second Cross Drift bulkhead shows mottling and streaking caused by moisture from condensation dripping off a vent line.

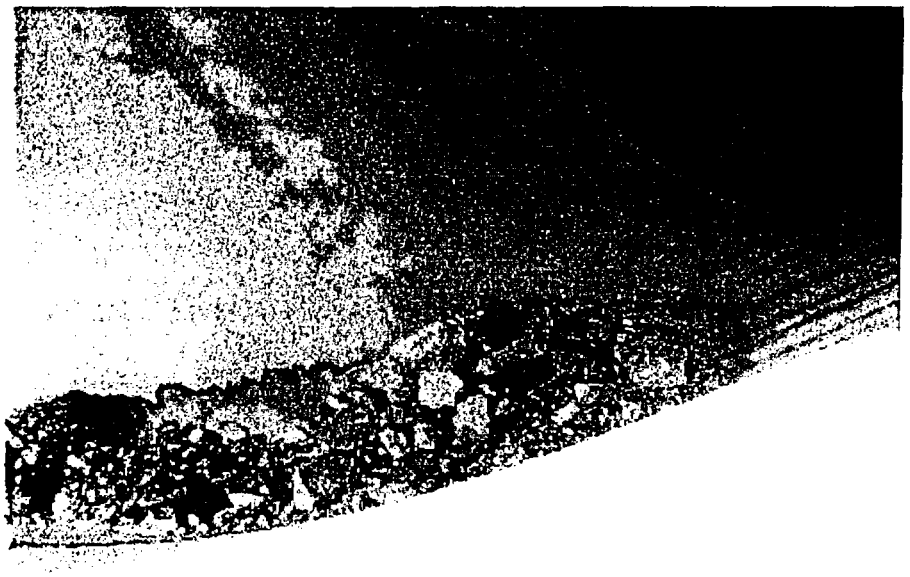


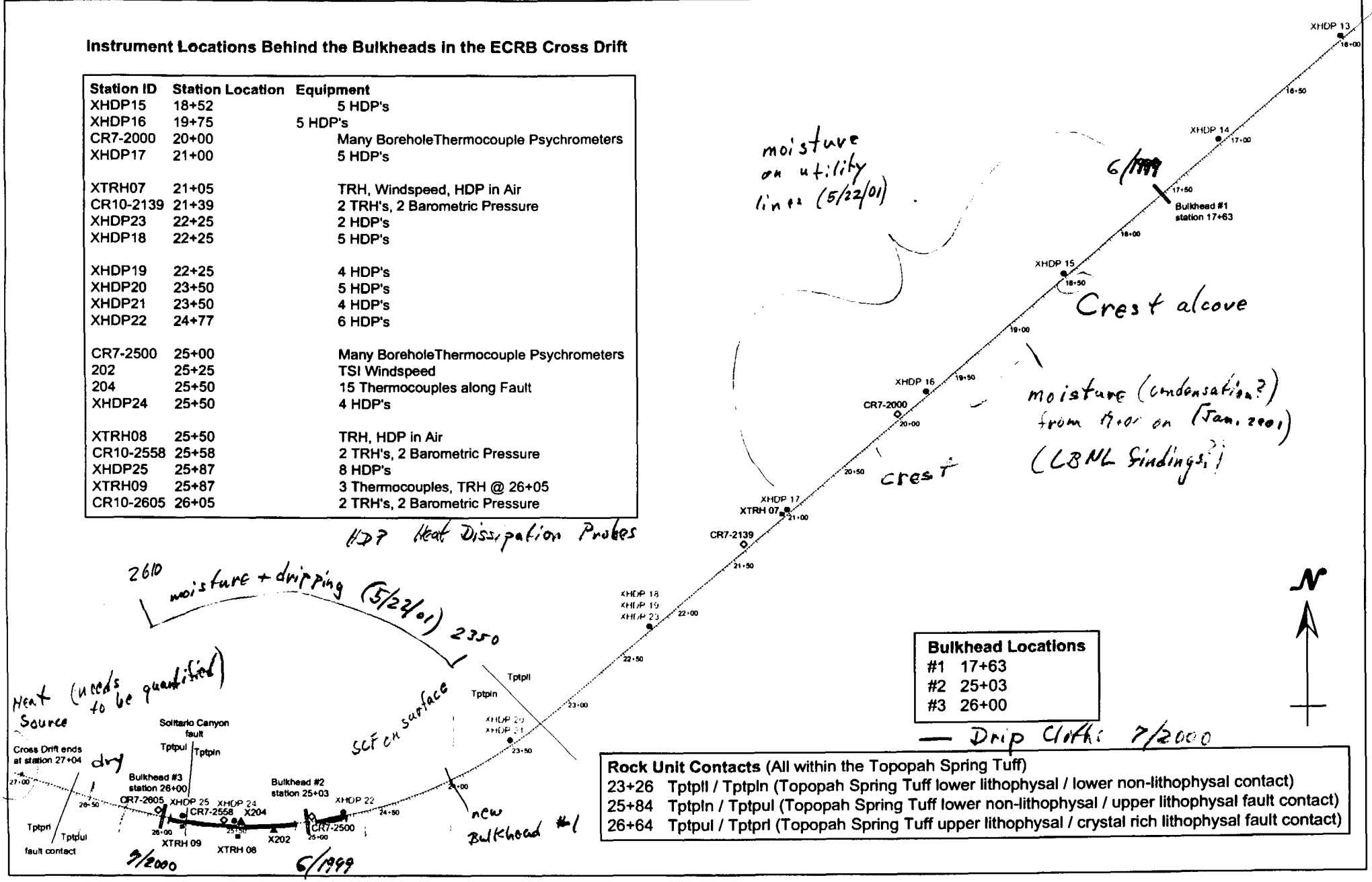
Figure 9. Station 25+16. Rock debris and water marks inside a drip cloth behind the second bulkhead. The volume of debris is about 0.25 cubic meter. There were at least three other areas in the drip cloths with similar amounts of rock in this area.

Figure 10. Station 25+20. Water collects on the conveyor behind the second bulkhead. There were at least three other puddles in the area. Water samples were collected by LBNL for analysis.

Instrument Locations Behind the Bulkheads in the ECRB Cross Drift

Station ID	Station Location	Equipment
XHDP15	18+52	5 HDP's
XHDP16	19+75	5 HDP's
CR7-2000	20+00	Many BoreholeThermocouple Psychrometers
XHDP17	21+00	5 HDP's
XTRH07	21+05	TRH, Windspeed, HDP in Air
CR10-2139	21+39	2 TRH's, 2 Barometric Pressure
XHDP23	22+25	2 HDP's
XHDP18	22+25	5 HDP's
XHDP19	22+25	4 HDP's
XHDP20	23+50	5 HDP's
XHDP21	23+50	4 HDP's
XHDP22	24+77	6 HDP's
CR7-2500	25+00	Many BoreholeThermocouple Psychrometers
202	25+25	TSI Windspeed
204	25+50	15 Thermocouples along Fault
XHDP24	25+50	4 HDP's
XTRH08	25+50	TRH, HDP in Air
CR10-2558	25+58	2 TRH's, 2 Barometric Pressure
XHDP25	25+87	8 HDP's
XTRH09	25+87	3 Thermocouples, TRH @ 26+05
CR10-2605	26+05	2 TRH's, 2 Barometric Pressure

HDP Heat Dissipation Probes



Bulkhead Locations

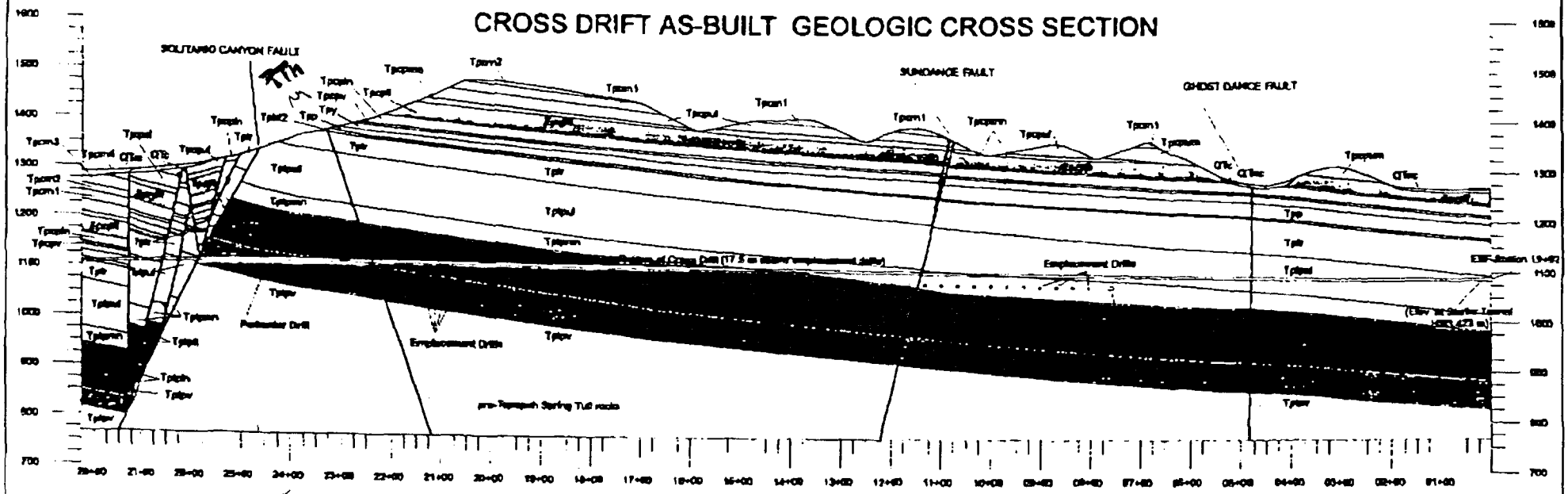
#1	17+63
#2	25+03
#3	26+00

— Drip Cloth 7/2000

Rock Unit Contacts (All within the Topopah Spring Tuff)

23+26 Tptpll / Tptpln (Topopah Spring Tuff lower lithophysal / lower non-lithophysal contact)
25+84 Tptpln / Tptpul (Topopah Spring Tuff lower non-lithophysal / upper lithophysal fault contact)
26+64 Tptpul / Tptprl (Topopah Spring Tuff upper lithophysal / crystal rich lithophysal fault contact)

CROSS DRIFT AS-BUILT GEOLOGIC CROSS SECTION



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Quaternary

- QTac — Alluvial and colluvial deposits
- QTc — Colluvial deposits

Tiva Canyon Tuff

Crystal-rich member

- Tpcrn4 — Subvitric transition subzone
- Tpcrn3 — Pumice-poor subzone
- Tpcrn2 — Mixed-pumice subzone (Tpcrn2, Tpcrt2)
- Tpcrn1 — Crystal transition subzone (Tpcrn1, Tpcrt1)

Crystal-poor member

- Tpcpul — Upper lithophysal zone
- Tpcpun — Upper lithophysal zone and middle nonlithophysal zone undivided
- Tpcpmn — Middle nonlithophysal zone
- Tpcpll — Lower lithophysal zone
- Tpcpln — Lower nonlithophysal zone
- Tpcpv — Vitric zone

- Tpy — Yucca Mountain Tuff, includes pre-Tiva Canyon Tuff bedded tuff (Tpbt4)
- Tpp — Pah Canyon Tuff, non- to moderately welded, includes pre-Yucca Mountain Tuff bedded tuff (Tpbt3)
- Pre-Pah Canyon bedded tuff
- Tpu — Undifferentiated Paintbrush Tuff

Topopah Spring Tuff

Crystal-rich member

- Tpt — Crystal-rich zone

Crystal-poor member

- Tptpul — Upper lithophysal zone
- Tptpmn — Middle nonlithophysal zone
- Lower lithophysal zone
- Lower nonlithophysal zone
- Tptpv — Vitric zone

7-25-96 — REVISION 0

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF INTERIOR
BUREAU OF RECLAMATION / GEOLOGIC SURVEY
YUCCA MOUNTAIN PROJECT
GEOLOGIC MAPPING OF THE ESF

COMPARATIVE GEOLOGIC CROSS SECTION ALONG THE CROSS DRIFT

GEOLOGY: USBR SHAFTIE BEAN — FIELD REVIEW: MARK H. MCKEOWN
DRAWN: USBR CADD TEAM — PROJECT ENGINEER: STEVEN C. BOLSON
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SCALE: 1" = 20'

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Route List

NAME	DATE	INITIALS	FILE	RECYCLE
Bill	3/7			
Chad			2nd to last	
Bob	3/7	RMJ		
Vivian			LAST	