UMTRA PROJECT - RIFLE
ESTES GULCH DISPOSAL CELL

ADDITIONAL FIELD TESTING/MONITORING TO EVALUATE BATH-TUB POTENTIAL

APRIL 1992

PREPARED BY

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES DIVISION
180 Howard Street
San Francisco, California 94105

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SUMMARY

This report discusses additional field testing that is considered necessary to confirm the permeabilities of the bedrock at the Estes Gulch Disposal site. The proposed field efforts also provide for follow-up monitoring during and immediately following construction. This will ensure that the effects of remaining uncertainties regarding foundation permeabilities and other geohydrologic factors will not violate the integrity of the Disposal Cell or can be remedied during the latter stages of construction to preclude potential problems. Furthermore, the results obtained by the proposed testing and monitoring may allow us to relax the stringency of the radon cover permeability requirement and achieve lower cost in constructing the radon barrier. The concepts and field program presented here supplement the information presented in the recently completed report: "Evaluation of Surficial Soil and Rock Foundation Conditions, Estes Gulch Disposal Cell, UMTRA Project - Rifle" (Morrison Knudsen Corporation, March 1992).

EFFECT OF RADON BARRIER FLUX

The analysis described in this section supplements information included in Section 5 (Disposal Cell "Bath-Tub" Evaluation) of the recently issued Morrison Knudsen Environmental Services (MKES) report of March 1992. Analyses presented in this report employed the same computer simulation grid, modeling assumptions and input parameters as used in the March report. This report looks at sensitivity analyses to determine long-term cell performance with regard to the buildup potential of a "bath-tub" effect.

The long-term computer simulation results described here involve the incorporation of a downward water flux (cover flux) from the bottom of the radon barrier for the period from years 20 to 200 which corresponds to the saturated permeability of the barrier. This assumes that the radon barrier will be saturated after being in place 20 years and is a conservative assumption. A total of 12 production runs were made; they are summarized in Table 1*. For the analysis, the cover flux was varied from 2 x 10^{-8} to 1 x 10^{-7} cm/sec while the permeability of the assumed 100-ft wide sandstone unit (part of Group II) was varied from 2 x 10^{-8} to 1 x 10^{-6} cm/sec. During these runs, Group III of the bedrock materials beneath the disposal cell was generally assigned a permeability of 2 x 10^{-8} cm/sec. This permeability magnitude represent the lower bound of the geometric mean permeability derived from field and laboratory tests for the various sandstones tested.

The results of the analyses are plotted in Figure 1* with a curve separating the conditions of inundation at the toe of the Disposal Cell embankment from those of non-inundation. The curve selected as the division between the conditions of inundation vs. non-inundation is selected as approximately a straight line and is positioned on the graph to provide an assessment of the sandstone unit permeabilities which would result in inundation from a specified long-term cover flux, i.e., corresponding to the saturated permeability of the radon barrier. This curve will be used jointly with the field-determined permeability of the sandstone unit to determine the maximum design permeability of the radon barrier needed to prevent any long-term "bath-tub" effect within the Disposal Cell. For example, given 3 x 10^{-8} cm/sec as the reasonably achievable minimum permeability of the radon barrier, the sandstone unit needs to have a saturated permeability of at least 5.5 x 10^{-8} cm/sec to prevent any long-term inundation at the toe of the cell. Conversely, employing the best estimated average permeability to date of the sandstone unit as 3 x 10^{-7} cm/sec the required radon barrier permeability is expected to easily be in the reasonably achievable range (at 3 x 10^{-8} cm/sec or higher). However, the permeability of the sandstone unit has yet to be confirmed by field testing. A field test program to confirm the permeabilities of the sandstone strata is described in the next section.

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* Tables and figures are bound just after the main body of this report, i.e., just after the reference list.

PERMEABILITY TESTING IN TEST PITS

The purpose of this program is to further define the permeability of the sandstones at the bottom of the Estes Gulch cell excavation. The in-situ permeability testing program should be performed during the upcoming summer months after the subcontractor has reached the proposed cell grade elevations. This test program will help confirm the previous permeability values obtained from the borehole permeability tests. The results will be used to improve the computer model simulation predictions. Additionally, the permeability test results from the program may allow some modification to the current cover design allowing a relaxation of the radon barrier permeability requirements to a more achievable value if the sandstones are confirmed as being sufficiently permeable. This relaxation would result in a significant cost saving to the project.

Testing Procedure

Several in-situ permeability testing methods exist in the market. Some are highly sophisticated, expensive and time consuming; others are too specific or too narrow in application. After evaluating several field permeability testing methods it has been concluded that a simple single ring permeability test run in the bottom of a test pit will provide the needed information. The test will partially simulate future seepage conditions into the sandstone bedrock at the bottom of the cell.

A typical layout of the testing procedure is shown in Figure 2. The test consists of a simple form of double ring infiltrometer. The installation and head or water loss measurements from the center drum or an alternative infiltrometer will be the basis for calculating the bedrock permeability. Data reductions to calculate permeability will either be by the Green-Ampt method or by the Trautwein Data Reduction method.

Test Pit Installation

This section describes the design, installation, and operation of the proposed in-situ permeability test. A total of nine test pits will be installed at the bottom of the cell excavation in the approximate locations shown in Figure 3. The locations will be adjusted as needed to test the more competent sandstones. ?

MKF will arrange with the subcontractor to excavate to the proposed excavation grade in this area (probably in the spring and summer 1992) in order to place the test pits on bedrock. The locations are concentrated at the bottom of the Disposal Cell along the strata that have been identified as more permeable (Morrison Knudsen Corporation, March 1992). This area is also at the lowest portion of the cell excavation where most of the tailings drainage would be expected to converge and pond.

The test pit dimensions will be roughly 8 ft x 8 ft by 3 to 4 feet deep. A bottomless 55 gallon drum or alternative infiltrometer will be installed at the center of each test pit and will be properly sealed into bedrock with a bentonite slurry seal. Each drum will contain a calibrated gage to allow accurate water elevation or water loss measurements inside the drum or alternative infiltrometer. Thermal planking (insulation) will be used on the drum to protect the water surface from excessive evaporation (in summer) or freezing (in winter) and possibly on adjacent surfaces to control water temperature fluctuations. Access will be provided to each test pit and drum via the access plank shown for daily or more frequent water level or water loss readings.

Cost Estimate

Table 2 provides a rough estimate of the subcontract costs for this work. The estimate assumes approximately 3-1/2 months of readings will be required to provide sufficient information for calculation of long-term permeabilities. The total estimated subcontract cost, not including engineering costs, is approximately $30,000. If an alternative infiltrometer is employed for each test the total subcontract cost would increase approximately $7,000.

ADDITIONAL MONITORING

As there will still be some uncertainty with respect to the timing and significance of drainage of moisture from the tailings, particularly during construction and for a few years following construction, monitoring of the buildup of water within the Disposal Cell is provisionally recommended. The type and intensity of monitoring will depend on whether sufficiently high permeabilities are found during the test pit permeability testing described above. The currently planned drainage system and sumps will provide some information on this drainage; however, the significance of buildup of a saturated zone away from these sumps will be unknown. Furthermore, there may be some perched water zones that develop at intermediate levels above the base of the Disposal Cell.

As is stated in Section 7 of a previous seepage report (Morrison Knudsen Corporation, March 1991), a geomembrane may be installed as part of the remedial design. The geomembrane might cover the side slopes of the tailings cell to a distance of about 60 feet above the toe. This measure could be taken to prevent possible seepage of tailings leachate through the face of the cell. However, if the bedrock permeabilities are confirmed to be sufficiently high by the test pit permeability testing, the geomembrane might not be installed. If this is the case and the geomembrane is not installed or is not installed to a full height of at least 60 feet above the Disposal Cell embankment toe, then monitoring the hydrostatic pressure in the tailings with tensiometers and at the bedrock/tailings interface with wells is recommended. The duration of this monitoring should extend from early construction to potentially several years after construction of the cell. Appendices A and B describe the recommended monitoring system should the full 60-foot height of geomembrane above the Disposal Cell toe not be installed. The following subsection describes additional recommended monitoring to aid with interpreting Disposal Cell water balance performance, whether or not the monitoring described in Appendices A and B is implemented.

Climatologic Stations

Installation and operation of two climatologic stations is recommended for the Estes Gulch site to provide needed weather data to account for natural water losses and gains to the tailings during placement. Measurements needed are precipitation and evaporation data and parameters indicative of these so that measurements during the construction period and immediately after can be correlated with longer term climatologic stations such as at Rifle, Glenwood Springs or Palisade. Proposed instrumentation includes an evaporation pan with wooden grill support and measurement accessories, standard rain gage, anemometer, maximum-minimum thermometer and instrument shelter. Because of the relatively large area involved and the different exposure conditions likely around the site considering wind conditions, two stations are recommended, one on the upwind side of the site and the other on the downwind side of the site. Table 7 give the estimated cost for the instruments and their installation. Installation, operation and maintenance of the instruments would be performed by MKF site personnel with installation assistance from San Francisco MKES personnel.

Table 8 gives a summary cost estimate for the permeability tests, tensiometers, monitor wells, and climatologic stations. Engineering costs are not included in these estimates. As indicated before, the scope of the tensiometer and monitoring well installations may be reduced depending on whether the bedrock permeabilities found are so low as to warrant installing the full extent of the geomembrane or not.

RESULTS AND CONCLUSIONS

The results of previous studies performed by Morrison Knudsen Corporation (March 1991 and March 1992) and those described herein are summarized in Table 9. These studies indicate that the lower bound of the average bedrock permeabilities is 2×10^{-8} cm/sec. If this is a gross average bedrock permeability throughout the bottom of the Disposal Cell without any significant permeable zones, seepage through the face of the cell is predicted to occur during transient drainage of the tailings leachate. However, based on the results of the recent field investigations (Morrison Knudsen Corporation, March 1992) there are nearly vertical dipping sandstone strata underlying the bottom of the planned Disposal Cell in the vicinity of its toe. These strata, collectively designated as "sandstone unit", have a permeability of at least 1×10^{-6} cm/sec based on field tests to date. If this is the case, no adverse buildup of a saturated zone in the Disposal Cell is anticipated during transient drainage. Also, a relaxation of the permeability requirement for the radon barrier could be realized. The sandstone permeability, however, needs confirmation as recommended in this report.

If the results of the proposed additional field permeability tests show that the permeability of the sandstone unit is nowhere close to being as high as 1×10^{-6} cm/sec, then remediation will be provided by a change in the design, i.e., extending the geomembrane to a higher elevation than currently planned along the sideslope to prevent seepage through the face of the cell. However, if the permeability of the sandstone unit is confirmed as being higher than 1 x 10^{-6} cm/sec by the proposed testing, then placement of the full extent of geomembrane at the face of the cell is unlikely and the well and tensiometer monitoring system provisionally recommended in this report would be implemented. That monitoring system would provide information on the buildup of a saturated zone, if any, within the Disposal Cell. If the saturated zone buildup becomes extensive, corrective action may be warranted. However, this corrective action would most likely require implementation after construction of the Disposal Cell has been initially completed.

REFERENCES

1. Gilbert, Richard O., Statistical Methods for Environmental Pollution Monitoring, VanNostrand Reinhold, New York, 1987.

2. Morrison Knudsen Corporation, Uranium Mill Remedial Action Project (UMTRAP) Rifle, Colorado, RFL-PHII, Calculations, Final Design for Construction (Revised), Volume VII: Tailings Embankment Seepage Evaluation. Collection and Removal - Estes Gulch Disposal Site, March 1991.

3. Morrison Knudsen Corporation, Evaluation of Surficial Soil and Rock Foundation Conditions, Estes Gulch Disposal Cell, UMTRA Project - Rifle, March 1992.

4. Wolfe, Philip M., and C. P. Koeling, BASIC Engineering and Scientific Programs for the IBM PC, Robert J. Brady Company, Prentice-Hall Company, 1983.

TABLE 1
DESCRIPTION OF COMPUTER RUNS
LONG-TERM SIMULATION

Run I.D.	Sandstone K (cm/sec)	K for Group III Foundation (cm/sec)	Cover Flux (cm/sec)	Inundation[1]
RIF28L2	1.0×10^{-6}	5×10^{-8}	1.0×10^{-7}	No
RIF28L3	1.0×10^{-6}	2×10^{-8}	1.0×10^{-7}	No
RIF28L4	2.0×10^{-7}	2×10^{-8}	1.0×10^{-7}	Yes
RIF28L5	7.5×10^{-7}	2×10^{-6}	1.0×10^{-7}	Yes
RIF28L6	9.1×10^{-7}	2×10^{-6}	1.0×10^{-7}	Yes
RIF28L7	5.1×10^{-7}	2×10^{-8}	2.0×10^{-8}	No
RIF28L8	5.1×10^{-7}	2×10^{-8}	5.0×10^{-8}	No
RIF28L9	2.0×10^{-7}	2×10^{-8}	5.0×10^{-8}	Yes
RIF28L10	5.1×10^{-7}	2×10^{-8}	7.5×10^{-8}	Yes
RIF28L11	1.0×10^{-7}	2×10^{-8}	3.0×10^{-8}	No
RIF28L12	7.5×10^{-8}	2×10^{-6}	2.0×10^{-8}	No
RIF28L13	2.0×10^{-8}	2×10^{-8}	2.0×10^{-6}	No

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[1] "Inundation" is defined as a buildup of a saturated zone within the Disposal Cell to an elevation above the Disposal Cell's embankment toe in its vicinity.

TABLE 2

TEST PIT PERMEABILITY TESTING

COST ESTIMATE

Item	Estimated Quantity	Unit Price (Dollars)	Amount (Dollars)
1.0 Mobilization/demobilization includes: (one time charge) mobilization of materials, personnel and equipment from the Subcontractor's yard to the site and demobilization back to Subcontractor's yard. This item shall include the movement to and from the jobsite of backhoe, water trucks, soil samples and any other equipment, personnel and supplies used in the completion of this Subcontract.	1	Lump Sum	1,000
2.0 Test Pit Equipment Installation	9 Inst.	200/Inst.	1,800
3.0 Backhoe (including operator) for Test Pit Preparation	18 hrs.	80/hr	1,440
3.1 Backhoe Standby	10 hrs.	80/hr.	800
4.0 Field Permeability Testing	80 hrs.	70/hr.	5,600
5.0 Water Truck/Tanks	120 day	150/day	18,000
6.0 Per Diem	25 man-days	67/man-day	1,675
ESTIMATED SUBCONTRACT COST			$30,315

Notes: 1. Test pit equipment installation includes, preparation of bottomless drum, access planks, gages, etc. [See In-situ Permeability Testing (Fig. 2)].

2. Cost estimate for some items would be substantially less if the Subcontractor has to complete the cell excavation this year.

TABLE 3

TENSIOMETER POSITIONS

Tensiometer Number	Coordinates		Elevation	
	North	East	Final Grade	Pt. A (Fig. 5)
1	56,850	53,350	6035.0	6018.5
2	56,950	53,150	6045.0	6028.5
3	56,830	53,150	6027.0	6010.5
4	56,990	52,920	6045.0	6028.5
5	56,880	52,910	6023.0	6006.5
6	57,030	52,710	6045.0	6028.5
7	56,930	52,690	6025.0	6008.5
8	57,080	52,460	6045.0	6028.5
9	56,980	52,440	6025.0	6008.5
10	57,070	52,220	6040.0	6023.5
11	56,960	52,800	6035.0	6018.5

TABLE 4
TENSIOMETER INSTALLATION
COST ESTIMATE

	Item	Estimated Quantity	Unit Price (Dollars)	Amount (Dollars)
1.0	Mobilization/Demobilization	1	lump sum	2,000
2.0	Tensiometers with current transducers (including concrete caps)	11 each	400/each	4,400
3.0	Drilling of 2" holes 18' deep at $15/feet	11 holes	270/hole	2,970
	3.1 Drill rig standby	60 hour	150/hours	9,000
4.0	Direct labor at $30/hour for 8 hours at each hole	11 hole	240/hole	2,640
5.0	Per Diem	20 man-day	67/man-day	1,340
	ESTIMATED SUBCONTRACT COST			$22,350

TABLE 5
MONITORING WELL POSITIONS

Well No.	Coordinates North	Coordinates East	Elevation Bottom	Elevation Top	Length (feet)	Type
MW-4	57,270	52,650	6000	6090	90	Bottom-cell
			5980		110	Bedrock
MW-5	57,100	52,780	5995	6072	77	Bottom-cell
			5975		97	Bedrock
MW-6	57,200	52,920	5995	6090	95	Bottom-cell
			5975		115	Bedrock

TABLE 6
MONITORING WELLS
COST ESTIMATE

	Item	Estimated Quantity	Unit Price (Dollars)	Amount (Dollars)
1.0	Mobilization/demobilization includes: (one time charge) mobilization of materials, personnel and equipment from the Subcontractor's yard to the site and demobilization back to Subcontractor's yard. This item shall include the movement to and from the jobsite of drill rigs, backhoe, water trucks, drilling equipment and any other equipment, personnel and supplies used in the completion of this Subcontract	1	Lump Sum	2,000
2.0	Drilling			
	- Vertical Hole Rock Core Drilling	100 lf	40/lf	4,000
	- Core boxes	30 boxes	3/box	90
	- Moving & Setup between Boreholes	3 holes	300/hole	900
	- Drill Rig Standby: includes all work stoppages or delays while drilling as authorized by MKF	6 hrs.	150/hr	900
3.0	Installation Bedrock Piezometer	12 hrs.	150/hr	1,800
4.0	Initial Installation Tailing Piezometer	8 hrs.	150/sample	1,200
5.0	Per Diem	24 man-day	67/man-day	1,608
6.0	Materials:			
	- 12" PVC flush joint threaded, blank	150 ft	41.15/ft	6,173
	- 12" PVC flush joint threaded, slotted	150/ft	53.0/ft	7,950
	- 1" Sch-80 PVC flush joint threaded, slotted	500/ft	3.25/ft	1,625
	- 1" Sch-80 PVC flush joint threaded, blank	200/ft	1.68/ft	336
	Sandbags	150 bags	2.80/bag	420
	Cement, bentonite (slurry/grout)	150 bags	3.80/bag	570
	ESTIMATED SUBCONTRACT COST			$ 29,572

TABLE 7
CLIMATOLOGIC STATIONS
COST ESTIMATE

	Item	Estimated Quantity	Unit Price (Dollars)	Amount (Dollars)
1.0	Site Preparation	2 locations	500/loc.	1,000
2.0	Evaporation Station, including Anemometer	2 stations	2,350/sta.	4,700
	2.1 Wooden Grillage	2 grills	200/grill	400
3.0	Standard Rain Gage	2 gages	350/gage	700
4.0	Maximum-Minimum Thermometer and Instrument Shelter	2 instal.	800/instal.	1,600
5.0	Instrument Installation and Testing	2 sites	2,500/site	5,000
6.0	Per Diem	10 man-day	67/man-day	670
	ESTIMATED COST			$14,070

* * * * *

TABLE 8
SUMMARY OF ESTIMATED COSTS

Component	Amount (Dollars)
Test Pit Permeability Testing	30,315
Tensiometer Installations	22,350*
Monitoring Wells	29,572*
Climatologic Stations	14,070
TOTAL COST	$96,307

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* Tensiometer and monitoring well installations are dependent on geomembrane installation.

TABLE 9

DISPOSAL CELL PERFORMANCE WITH RESPECT TO INUNDATION POTENTIAL[1]

Average Bedrock Permeability K (cm/sec)	Transient Case	Long-Term Case[3] Cover Flux (cm/sec) 1×10^{-8}	1×10^{-7}
2×10^{-8}	Not OK[2]	OK	Not OK[1]
1×10^{-7}	OK	OK	OK
1×10^{-6}	OK	OK	OK

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[1] Inundation is defined as a buildup of a saturated zone within the Disposal Cell to an elevation above the cell's embankment toe in its vicinity. An "OK" indicates there is no inundation potential.

[2] OK if K of sandstone unit > 1×10^{-6} cm/sec. (permeability of unit to be confirmed by the test pit method of field testing) or confirmed "OK" by the monitoring system, otherwise accommodate by design.

[3] For intermediate situations related to long-term drainage, see Figure 1.

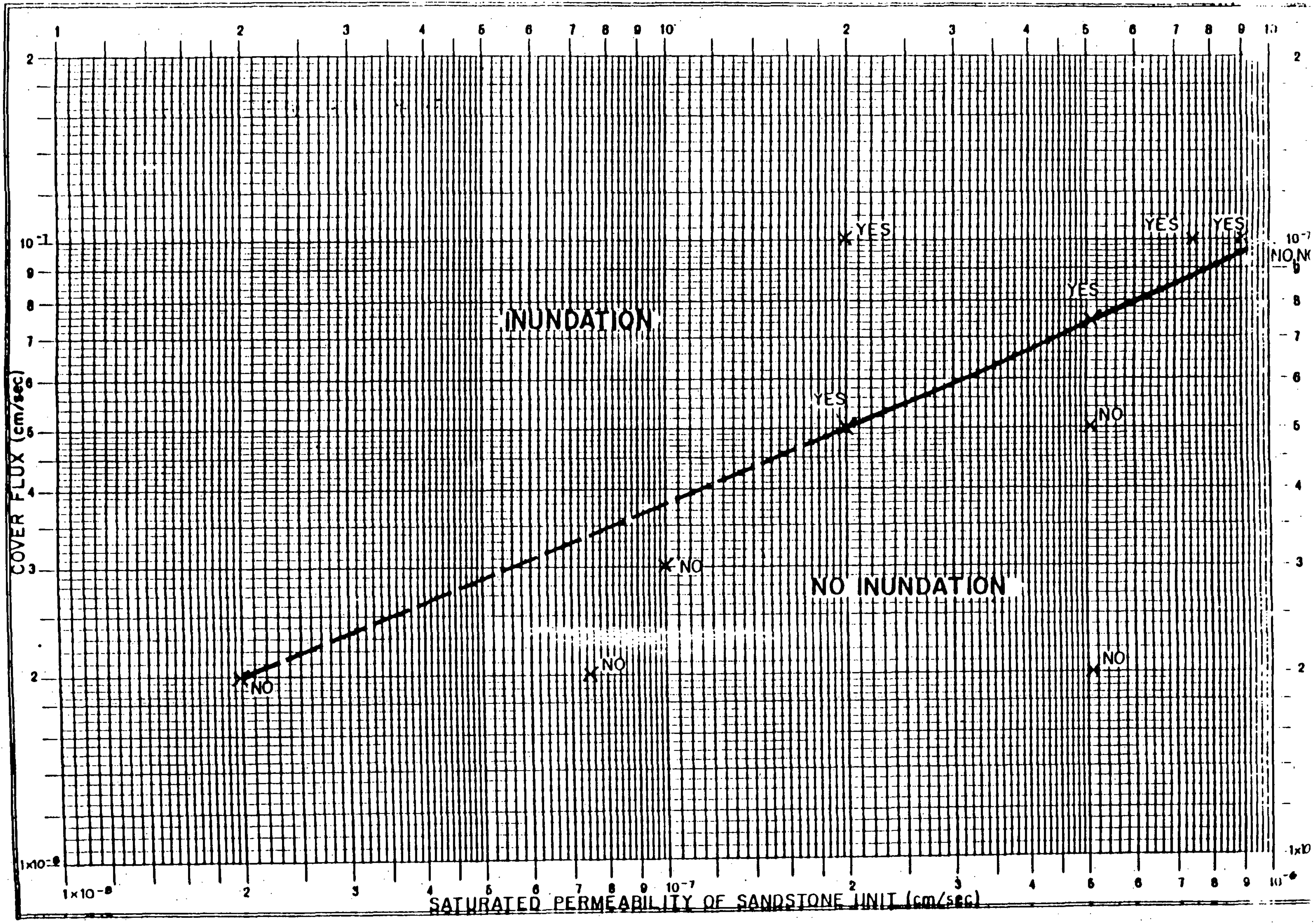
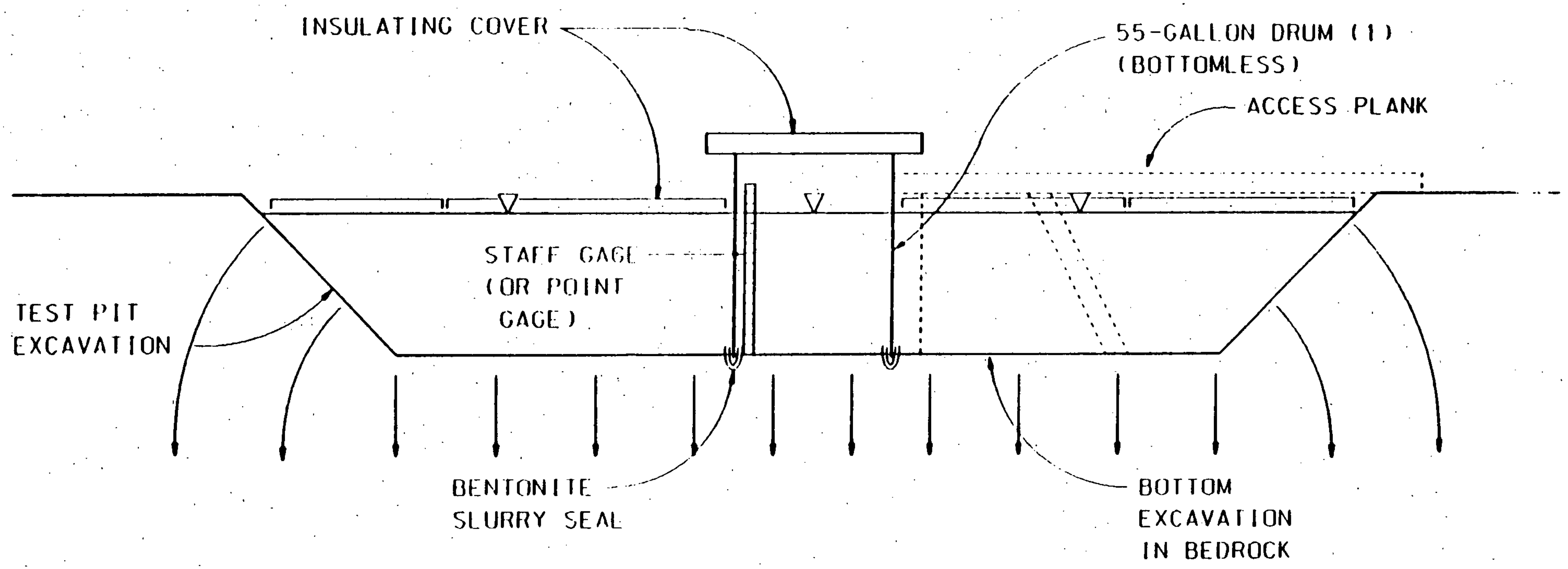


FIGURE 1

EMBANKMENT TOE INUNDATION POTENTIAL



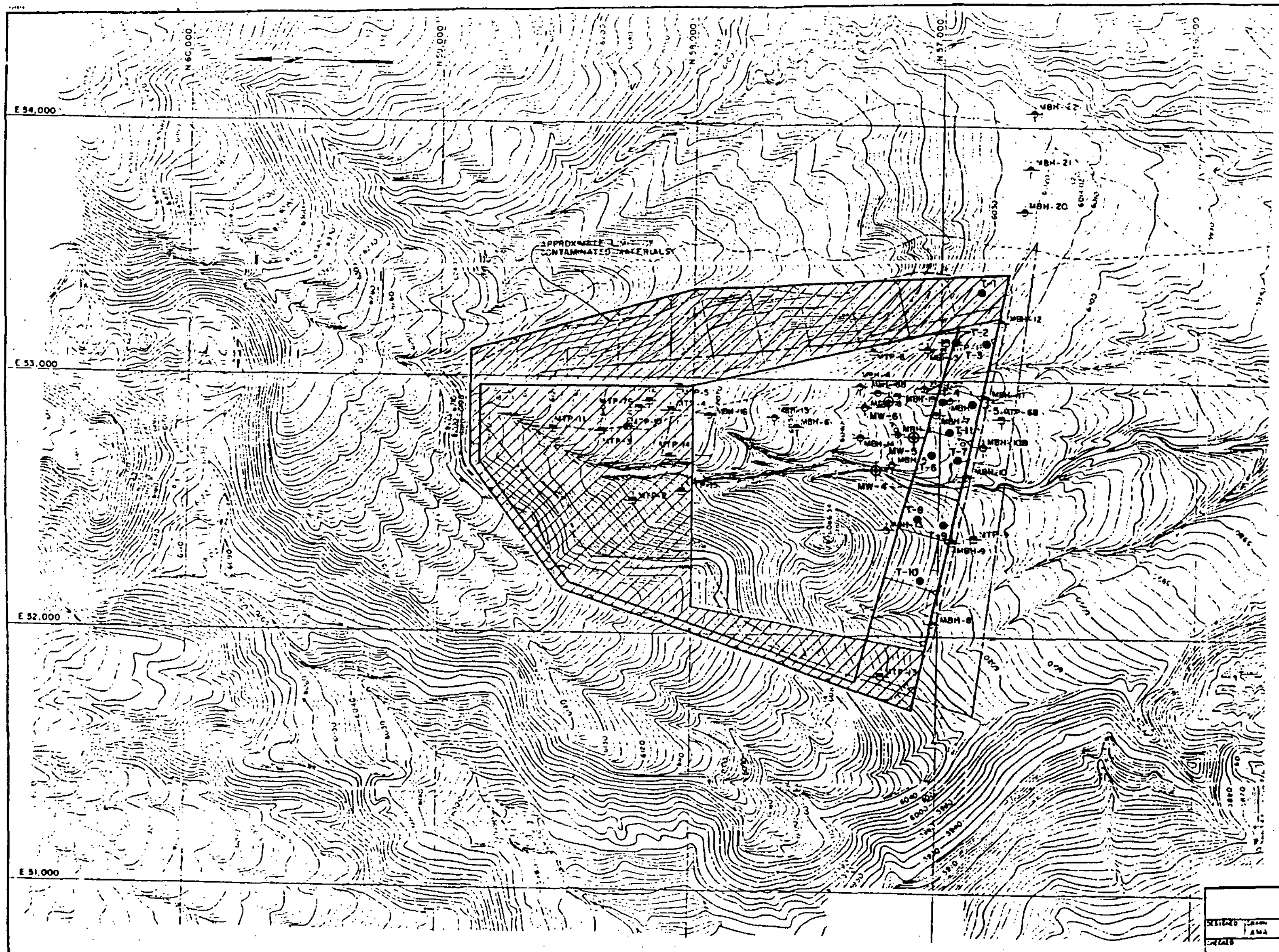
NOTES:

(1) AN ALTERNATIVE TO THE DRUM IS A CLOSED
INFILTROMETER WITH ACCESSORIES.

(2) ONLY MAIN FEATURES ARE SHOWN

FIGURE 2 - INSITU PERMEABILITY TESTING

NOT TO SCALE



NOTES:

SEE FIGURE 5 FOR GEOLOGIC CROSS-SECTIONS A-B (FIGURE REFERRED TO IS THAT IN REPORT BY MK CORPORATION MARCH 1992).

LEGEND:

6100	EXISTING SITE FEATURES & CONTOURS (1982 SURVEY)
N 53,000	CONSTRUCTION GRID COORDINATES
	EXCAVATION
	AREA LIMITS OF MATERIAL SUITABLE FOR RADON BARRIER MATERIAL
MBH-5	BOREHOLE BY MK-FERGUSON (1991)
MTP-8	TEST PIT BY MK-FERGUSON (1991)
▨	EXTENT OF COLLAPSIBLE SOILS
● T-5	PROPOSED TENSIOMETER LOCATION
⊕	PROPOSED MONITORING WELL LOCATION

200 0 200 400
SCALE FEET

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

DESIGNED
DRAWN AMA
CHECKED
INSPECTED
RECOMMENDED
APPROVED
DATE
DOE PROJECT ENGINEER
DATE

ESTES GULCH DISPOSAL SITE
RIFLE, COLORADO

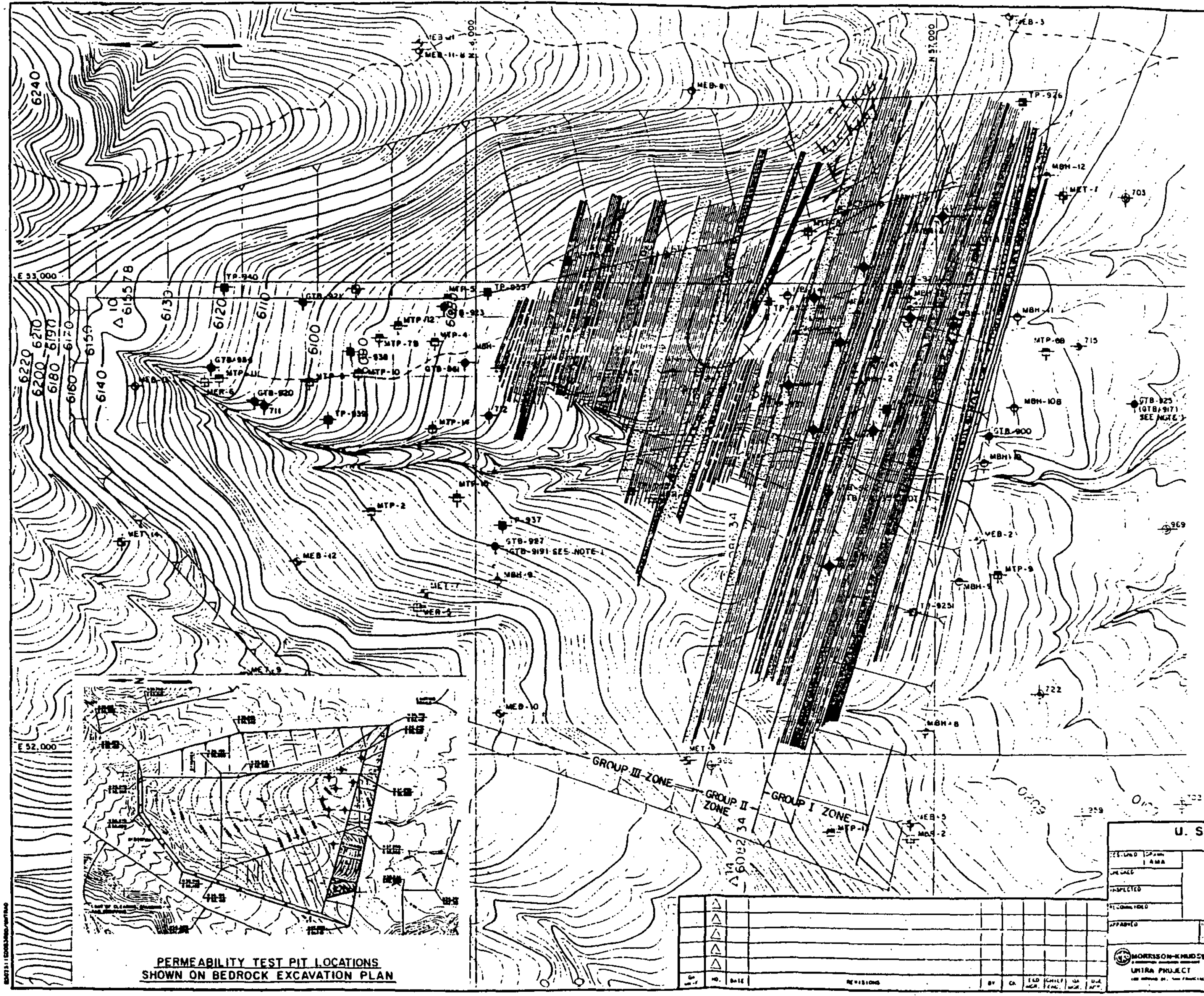
TENSIOMETER AND
MONITORING WELL LOCATIONS

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO.
DE-AC04-83AL18796

DRAWING NO.
FIGURE 4

NO.	DATE	REVISIONS	BY	CK	ENG. MGR.	CHIEF ENG.	QA MGR.	DOE APP.
△								
△								
△								
△								
△								



NOTES:

1. SEE FIGURE 6. FOR TYPICAL STRATIGRAPHIC SECTION OF ESTES GULCH DISPOSAL SITE. (FIGURE REFERRED TO IS THAT IN REPORT BY MK CORPORATION, MARCH 1992)
2. FOR THE GROUNDWATER ANALYSIS, THE DISPOSAL SITE BEDROCK HAS BEEN DIVIDED INTO THREE GROUPS:

GROUP I ZONE	40 % SILTSTONE 30 % SANDSTONE 30 % SHALE
GROUP II ZONE	49 % SILTSTONE 46 % SANDSTONE 5 % SHALE
GROUP III ZONE	60 % SILTSTONE 10 % SANDSTONE 30 % SHALE/CLAYSTONE

LEGEND:

░	SANDSTONE
▤	SILTSTONE
▦	SHALE
722	ANGLE HOLE BY UMTRA TECHNICAL ASSISTANCE CONTRACTOR
959	MONITORING WELL BY UMTRA TECHNICAL ASSISTANCE CONTRACTOR
GTB-922	BOREHOLE BY UMTRA TECHNICAL ASSISTANCE CONTRACTOR
TP-930	TEST PIT BY UMTRA TECHNICAL ASSISTANCE CONTRACTOR
MEB-6	BOREHOLE BY MK-FERGUSON (1987)
MET-4	TEST PIT BY MK-FERGUSON (1987)
MER-2	TEST PIT BY MK-FERGUSON (1989)
MBH-5	BOREHOLE BY MK-FERGUSON (1991)
MTP-8	TEST PIT BY MK-FERGUSON (1991)
◆	PROPOSED TEST PIT LOCATION FOR PERMEABILITY TESTING (1992)

100 0 100 200
SCALE FEET

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

DESIGNED
DRAWN AMA
CHECKED
INSPECTED
RECOMMENDED
APPROVED
DATE
DOE PROJECT ENGINEER
DATE

ESTES GULCH DISPOSAL SITE
RIFLE, COLORADO

PERMEABILITY TEST PIT LOCATIONS

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO.
DE-AC04-83AL18796

DRAWING NO.
FIGURE 3

REV.

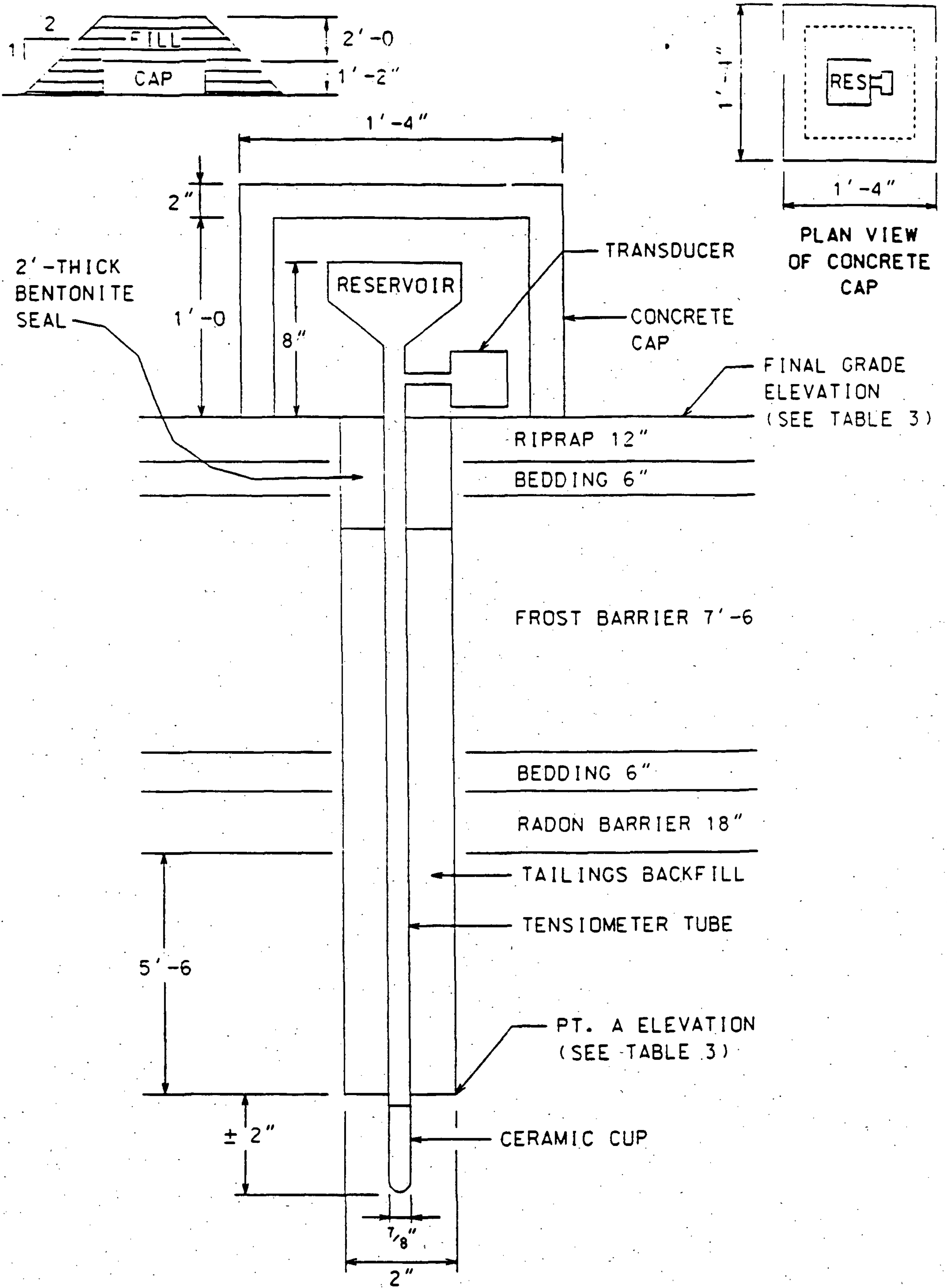
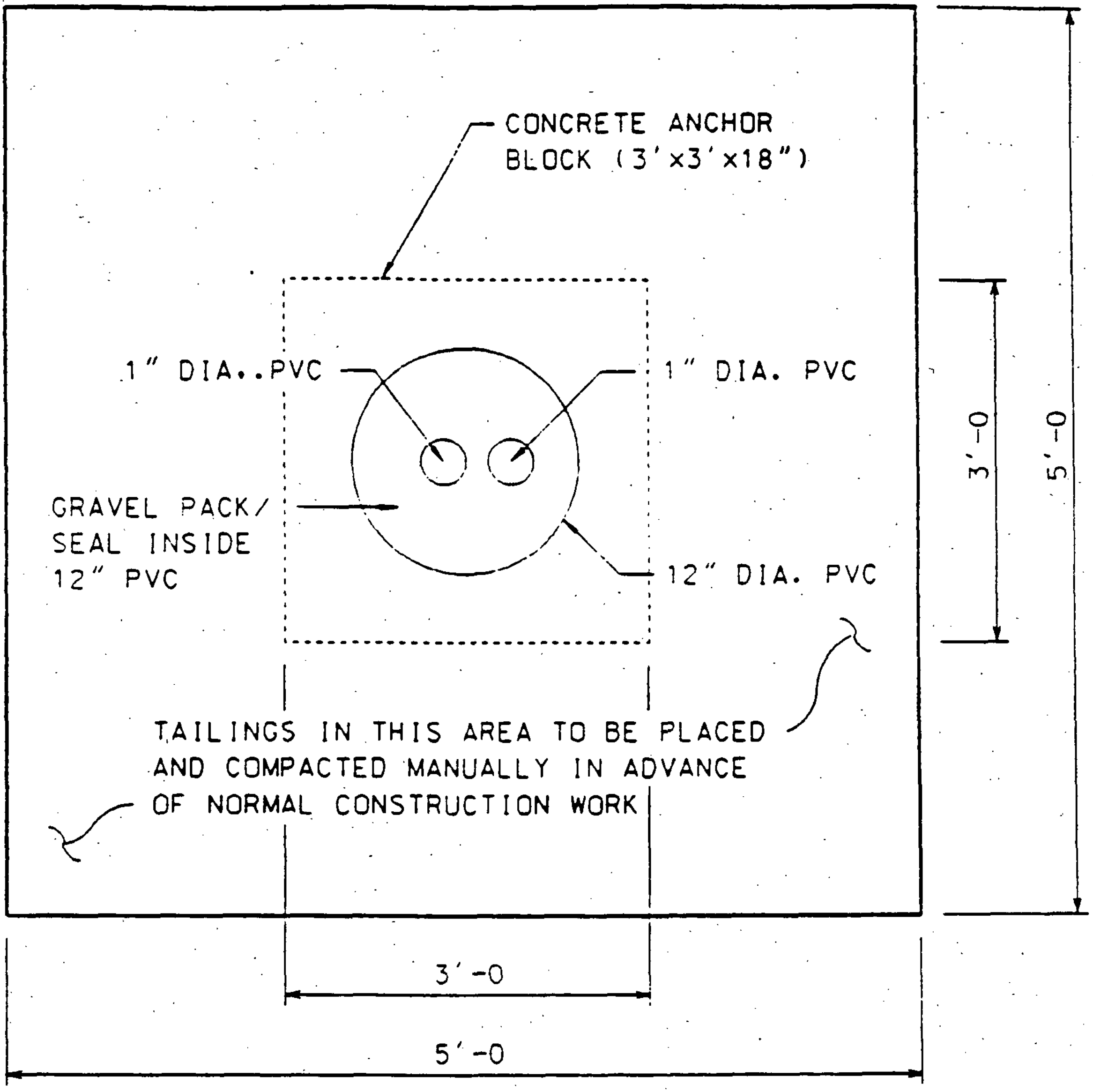


FIGURE 5 - SCHEMATIC OF A JET FILL TENSIOMETER

NOT TO SCALE



NOTES:

- SEE FIGURE 6 FOR CONSTRUCTION DETAILS
- 12" AND 1" PVC PIPES WILL BE ADDED IN ACCORDANCE WITH FIELD CONSTRUCTION (TAILINGS PLACING) PROGRESS: PIPES SHOULD ALWAYS BE AT LEAST 5' ABOVE SURROUNDING GROUND TO PREVENT CONSTRUCTION EQUIPMENT RUN-OVER (FLAGGED FENCE PROBABLY ALSO NEEDED)

FIGURE 7 - MONITORING WELL PLAN VIEW CONSTRUCTION

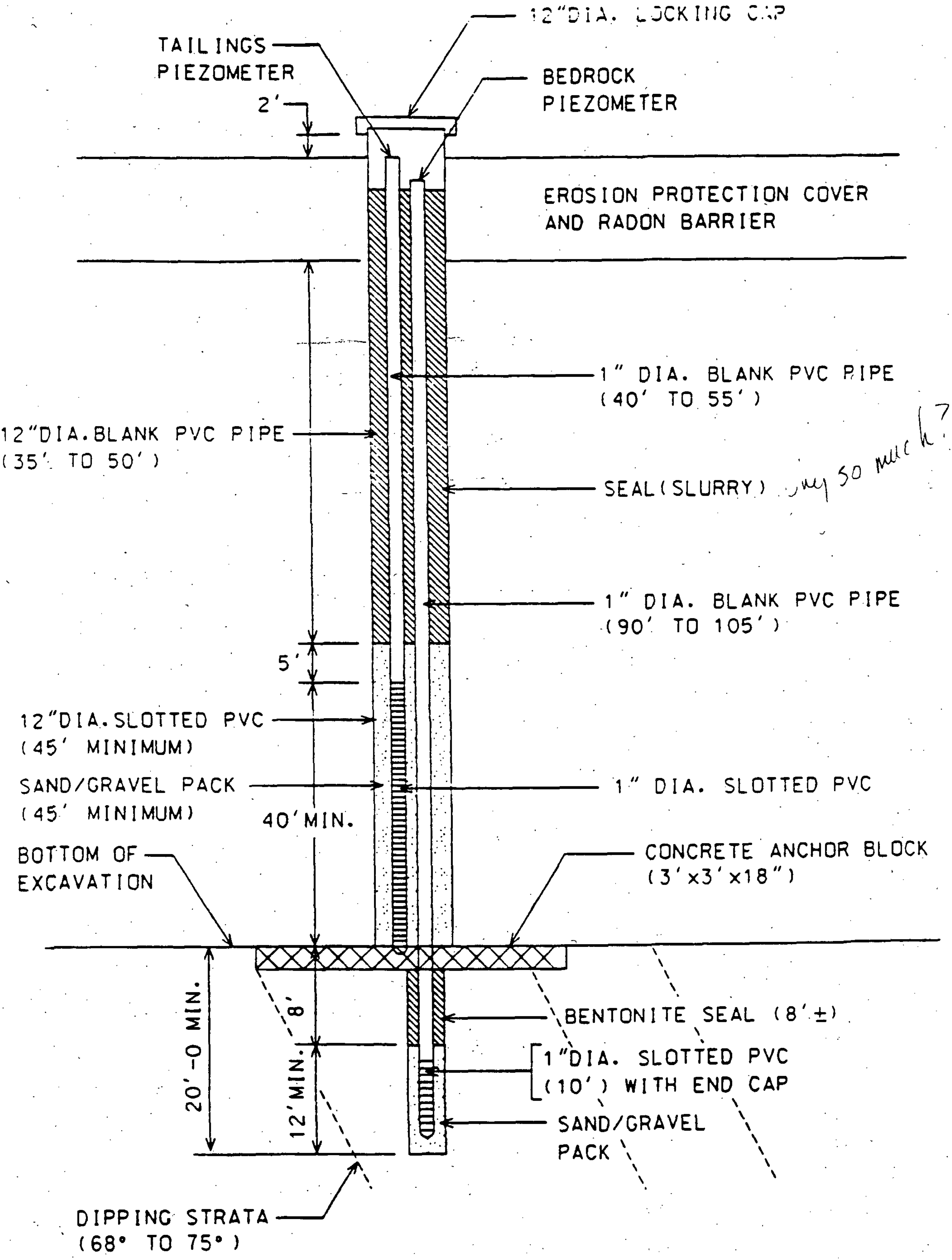


FIGURE 6 - MONITORING WELL FINAL CONSTRUCTION

NOT TO SCALE

APPENDIX A
UMTRA PROJECT - RIFLE
ADDITIONAL MONITORING

INTRODUCTION

The purpose of this appendix is to describe the design, installation, and operation of a monitoring system of tensiometers and monitoring wells to assess the potential of hydrostatic pressure buildup in the cell should the full extent of the geomembrane not be installed. Should the monitoring system indicate that leachate seepage from the tailings will not occur through the face of the cell in the absence of the geomembrane, further remedial measures associated with buildup of water in the cell will no longer be needed. However, should water levels in the Disposal Cell build up to relatively high levels or should significant zones of saturation buildup within the tailings themselves, remedial actions would be implemented to eliminate the adverse buildup of water.

According to the results of seepage analyses in Section 5 of the recent foundation evaluation report (Morrison Knudsen Corporation, March 1992), the computer simulation model predicts that saturated flow will occur along the tailings-rock interface (i.e., bottom of excavation), but will be below the toe of the Disposal Cell embankment. However, one part of the proposed monitoring system will consist of a series of open system piezometers or wells placed along the tailings-rock interface to measure possible buildup of water above that interface near the embankment toe. This is recommended because of uncertainties about the actual distribution of bedrock permeabilities and placement of the various tailings, including their hydraulic properties and moisture contents, as this can have a significant effect on drainage of water from the tailings and the resultant buildup of water at the interface.

Tensiometer installations are also provisionally recommended; though it is likely that the piezometers or wells discussed above will provide more important indications of water buildup problems developing in the cell. Due to the nature of the sand-slimes mixture of the tailings and likely construction practices to be applied, the tailings being placed will be heterogeneous and layered rather than homogeneous as was assumed in the seepage analyses (Morrison Knudsen

Corporation, March 1992). In fact, lenses of high permeability sands are expected to occur sporadically throughout the tailings and, therefore, there will be a tendency for localized pockets of saturation to exist in the cell. Should this phenomenon occur close to the boundary of the cell, seepage through the faces of the cell may be possible. Thus, it is imperative to install tensiometers along the sideslopes of the cell to monitor the suction change in the tailings to help predict whether large pockets of saturation will occur. These tensiometers will provide an early warning of a trend toward saturation in the tailings so that corrective actions (e.g., installating dewatering wells) can be planned for and implemented if necessary. If a substantial portion of the tensiometers in one area are approaching saturation, this may indicate something more than a localized phenomena which may require the corrective action. The design details of the monitoring system of piezometers and tensiometers are presented below.

Tensiometer Monitoring

Tensiometers will be used to measure the matric suction of the tailings in-place near the face of the Disposal Cell. The tensiometer principle is based on the condition that water in the porous medium (e.g., the tailings) comes to a suction equilibrium through a porous cup with the water in the instrument. Although tensiometers are generally limited to measuring suctions less than one bar, their measurements are accurate for suctions close to saturation pressures. Therefore, they are adequate for use on the Rifle site to monitor the potential formation of a saturated zone underneath the side slopes of the cell. Also, their response times are fast, about a few minutes to an hour, compared to the anticipated rates of pressure change in the Disposal Cell.

A total of 11 Jet Fill tensiometers, T-1 through T-11 (Soilmoisture Equipment Corporation 2725 Series or approved equal) will be installed along the sideslopes of the cell in the area shown in Figure 4*. Their locations are concentrated at the bottom of the side slopes and in the vicinity of the lowest elevation of the

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* Tables and figures are bound just after the main body of this report, i.e., just after the reference list.

tailings-foundation contact surface where most of the flow is expected to converge and where the highest potential for pressure buildup is anticipated.

The tensiometers will be spaced at approximately 200-feet intervals and will be installed about 7 feet vertically into the tailings. They will all be placed when the tailings placement elevation has reached Elev. 6060. At such time, the radon barrier cover should have already been placed on the part of the slopes where installation is to take place. Table 3 gives the approximate coordinates and elevations for the proposed tensiometers. A drill rig with auger will be required to bore a hole into which a tensiometer can be inserted. The length of a tensiometer can be increased up to 18 feet by adding extension tubes, this is about the limit beyond which vacuum created by atmospheric pressure will become ineffective. A schematic of a tensiometer installation is presented in Figure 5. For best performance of the equipment, it is critical to keep the porous cup in good contact with the tailings and to ensure that no free air is trapped in the water of the equipment. A detailed description of the Jet Fill tensiometer and its field installation procedure are included in the appendix.

An approximate estimate of the cost of subcontract work for the installation is included in Table 4. Engineering costs are not included.

Monitoring Wells

Three monitoring wells (MW-4 through MW-6) are recommended to be installed at the Estes Gulch disposal site. The purpose of these wells will be to measure potential water buildup during and after the placing of the tailings on the weathered and unweathered Wasatch formation strata at the base of the Disposal Cell.

Field recommendations will be followed in the selection of minimum distance between holes and method of installation and maintenance to minimize interference with construction operation since these wells will have to be built concurrent with the Disposal Cell construction.

The monitoring wells are designed as multiple piezometers: one piezometer embedded in bedrock for long term monitoring of strata seepage and one at the base of the Disposal Cell excavation for monitoring migration of water into the base. Tentative locations, depths and lengths of each monitoring well are indicated in Table 5 and are shown in Figure 4.

Schematics of a typical monitoring well installed in the field are shown in Figures 6 and 7. Details on the field installation procedures are included in the appendix.

An approximate estimate of the cost of the subcontract for the monitoring well work is included in Table 6.

MONITORING SCHEDULE AND ACTION PLAN

The monitoring schedule will begin with weekly monitoring of the monitoring wells and tensiometers once they are installed in the tailings. This monitoring frequency will be adjusted according to the trend of hydrostatic pressure change in the tailings. When about five or more measurements are available at a station, the Mann-Kendall test (Gilbert, 1987) will be used to detect whether a trend exists. This test is nonparametric and is neither affected by missing data nor restricted by a particular statistical distribution. A trend at a station is established when it lasts through at least two consecutive measurement periods. If an upward trend of pressure is predicted to prevail, then a time series analysis (Wolfe, 1983) will be performed to forecast the pressure distribution in the cell. A diagram illustrating the steps involved in adjustments of the monitoring frequency is included in Figure 8.

Another forecasting tool that can be employed is the finite element UNSAT2 model used in the MKES seepage study (Morrison Knudsen Corporation, March 1992). By adjusting the model parameters to produce pressure distributions that match the monitored data with time, the model can reliably predict whether or not seepage will occur through the faces of the cell and how long the monitoring system should be kept operational.

Although the monitoring frequency schedule applies during and after the construction of the Disposal Cell, corrective actions will only be tied to monitoring performance after completion of the cell. Any seepage water emerging from the cell during the approximately three-year construction period will be collected and directed to a retention pond. Therefore any seepage out of the cell during that period will not pose an environmental threat to the public. The retention pond, however, will be removed after completion of the cell. Post-construction monitoring will be more meaningful than during construction because the long term trend will be more truly represented after construction when pressure begins stabilizing in the cell. According to the recent model predictions (Morrison Knudsen Corporation, March 1992), the saturated zone buildup in the Disposal Cell will reach its maximum about 7 years after completion of the cell.

If, during post-construction monitoring, there is an upward pressure trend and the projected saturated front will come within 5 feet of the sideslopes of the cell (i.e., top of the tailings) within a month and it appears that an extensive zone of saturation will occur within the tailings, then a decision will be made regarding possible corrective action. However, if measurements continuing for 5 years after completion of construction indicate that the pressures have been dropping and the UNSAT2 modeling confirms this trend is likely to continue, the monitoring will be discontinued and the associated system will be properly sealed and abandoned. This decision will be made in consultation with the State of Colorado.

APPENDIX B

APPPENDIX B
UMTRA PROJECT - RIFLE
FIELD INSTALLATION PROCEDURES FOR THE MONITORING WELLS AND TENSIOMETERS

MONITORING WELL INSTALLATION

For construction data and details, refer to Figures 6 and 7.

A. A drill rig with appropriate power and equipment shall be used to drill a 4" to 6" borehole 20 to 30 feet into bedrock for the bedrock piezometer installation.

B. Bedrock piezometers shall be constructed (see Figure 6) as follows:

  1. Install a slotted 1" diameter, 10-foot long, schedule 40, PVC pipe to the bottom of the hole. Add additional 1" blank PVC (approximate 20 feet).

  2. Backfill with gravel/sand up to approximately 2 feet above the slotted pipe section.

C. Installation of second (cell) piezometer and completion of well construction (see Figure 6 and 7).

  1. Place 12" diameter, 2-foot-long blank, schedule 40 PVC pipe on top of bedrock and around 1" pipe bedrock piezometer.

  2. Build concrete block (anchor) 3' x 3' x 18" around 12" pipe. Wait until concrete sets (3-days minimum) to start construction of the second piezometer.

  3. Start second piezometer. Install a slotted 1" diameter 10-foot-long schedule 40 PVC pipe at bottom of 12" PVC pipe. Add 10-foot-long- blank 1" PVC pipe to first piezometer (bedrock).

Note: *To avoid small pipe twisting and improve constructability, the small pipes should be braced (taped) together at 5 feet intervals.*

4. Add slotted (perforated) 12" diameter, 5-foot-long, schedule 40 PVC pipe. Backfill space inside 12" pipe with sand/gravel.

5. Build a 5' x 5' (approximate) tailings pad around the 12" PVC pipe in accordance with field specification. This operation has to be done manually using a portable compactor.

Note: *The construction of the well is concurrent with the Disposal Cell construction (tailings placing); therefore, it is recommended that the monitoring well be always higher (at least 5 feet) than the actual tailing pile. Also the placing of flagging around the 5' x 5' pad is recommended to protect the well from damage by construction equipment.*

6. Repeat Steps 3 through 5 until the monitoring wells reach tailings pile final placement elevations.

D. Monitoring well completion.

1. Continue with all construction stages; radon barrier and erosion protection, as shown in Figure 6.

2. As described above in Section C.5, the completion of the well will have to be done manually. A small front end loader would be acceptable to place the erosion protection materials.

3. Place a bentonite seal at the surface of the hole through the radon barrier and frost protection cover.

4. The 12" PVC casing should have a 2-foot stick-up above the surrounding finished surface.

TENSIOMETER INSTALLATION

Described below is a summary of the installation procedure with reference to Figure 5.

A. Drill a 2" diameter hole through the cover into the tailings to the elevation shown in Table 3.

B. Assemble the tensiometer to the desired length (about 17' 4" from the tip to the top of the reservoir) and ensure it is filled with previously de-aired water.

C. Wet the bottom of the hole and insert the tensiometer into the hole with the entire ceramic cup pushed into the tailings at the bottom of the hole. Thus, a good contact will be maintained between the cup and the tailings.

D. Backfill the hole with tailings and tamp it around the body tube of the tensiometer.

E. Place a bentonite seal at the surface of the hole.

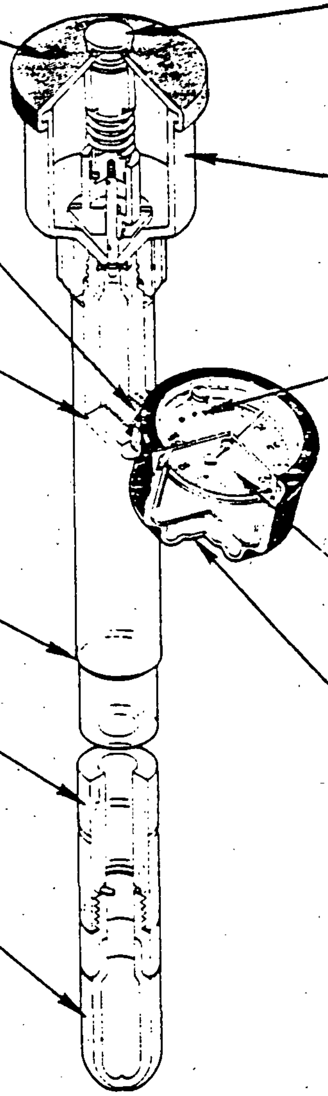
F. Wait 4 to 5 hours after installation to take a correct reading. This is to ensure disturbance to the tailings during installation will not affect the reading.

G. Put a concrete cap over the tensiometer at the ground surface.

H. A 2-foot-thick fill placed on the cap is optional and is required only when construction equipment is anticipated to run over the installed area at a later time.

THE MODEL 2725 JET FILL

IS THE BEST TENSIOMETER IN THE WORLD



The flexible reservoir cover allows for convenient filling and sealing of stored water.

Time proven "O" ring seals throughout assure leak proof vacuum joints while allowing easy removal or replacement of critical components.

Angle molded port in the sidewall provides a strong connection, keeping the dial gauge continuously filled with water and easy to view. The Vacuum Dial Gauge is readily replaceable in the field and can be oriented in any position for reading convenience. Port also accepts Electrical Switching Gauge and Pressure Transducers.

Convenient molded shoulder indicates soil surface position for easy, accurate depth placement.

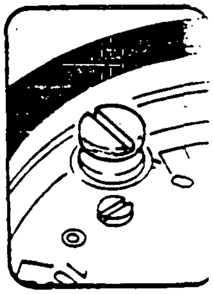
Heavy walled tube constructed of rigid, clear plastic assures accurate readings at high soil suction values, and is completely immune to damage by sun, water, or soil conditions.

Unique superporous ceramic tip has 10 times the water conductivity of comparable units, providing the ultimate in sensitivity and long life. Convenient thread adaptor design allows the ceramic tip to be readily removed or replaced, as well as permitting the addition of extension tubes to vary the placement depth of the tensiometer.

At a push of the button, patented Jet Fill action instantly injects water int the body of the tensiometer an removes accumulated air with no disturbance to the soil. Recovery is in minutes—not hours!

Large volume, detachable reserv holds sufficient water for months of servicing. All materials are complete weatherproof for years of use.

Optional recalibrator style gauge allows for adjustment of zero point setting for careful research work. Also permits compensation for water table reference point.



The large 2 inch diameter easy-to-rea dial face has a fixed pointer and is gra uated from 0 to 100 centibars (Kpa) soil suction.

A flexible temperature adjusting oute jacket interlocks with the unbreakab clear plastic coverplate to hermetical seal the gauge, protecting again weather and shock. Complete wi vent screw to compensate for altitu variations.

Superior Features Protected by Pate No. 3898872

JET FILL TENSIOMETERS

Are more precise than any other method of measuring soil moisture conditions in the field.

Do not require calibration.

Do not require transporting bulky measuring equipment into the field.

Do not require attaching electrical leads to make a measurement—simply look at the dial gauge.

Do not require any power source.

Can be read instantly—simply look at the dial gauge.

Available in nine stock lengths from 6" (15 c to 60" (150 cm) to meet varying installatio requirements.

Extra long lengths, extension tubes and sp cial modification supplied on short notice.

Simple "field replaceable" parts assure yea of service.

The single most inexpensive instrument to gi precise, direct, continuous measurement soil moisture conditions.

Available throughout the world.

5301 OPERATIN INSTRUCTION

CURRENT TRANSDUCER

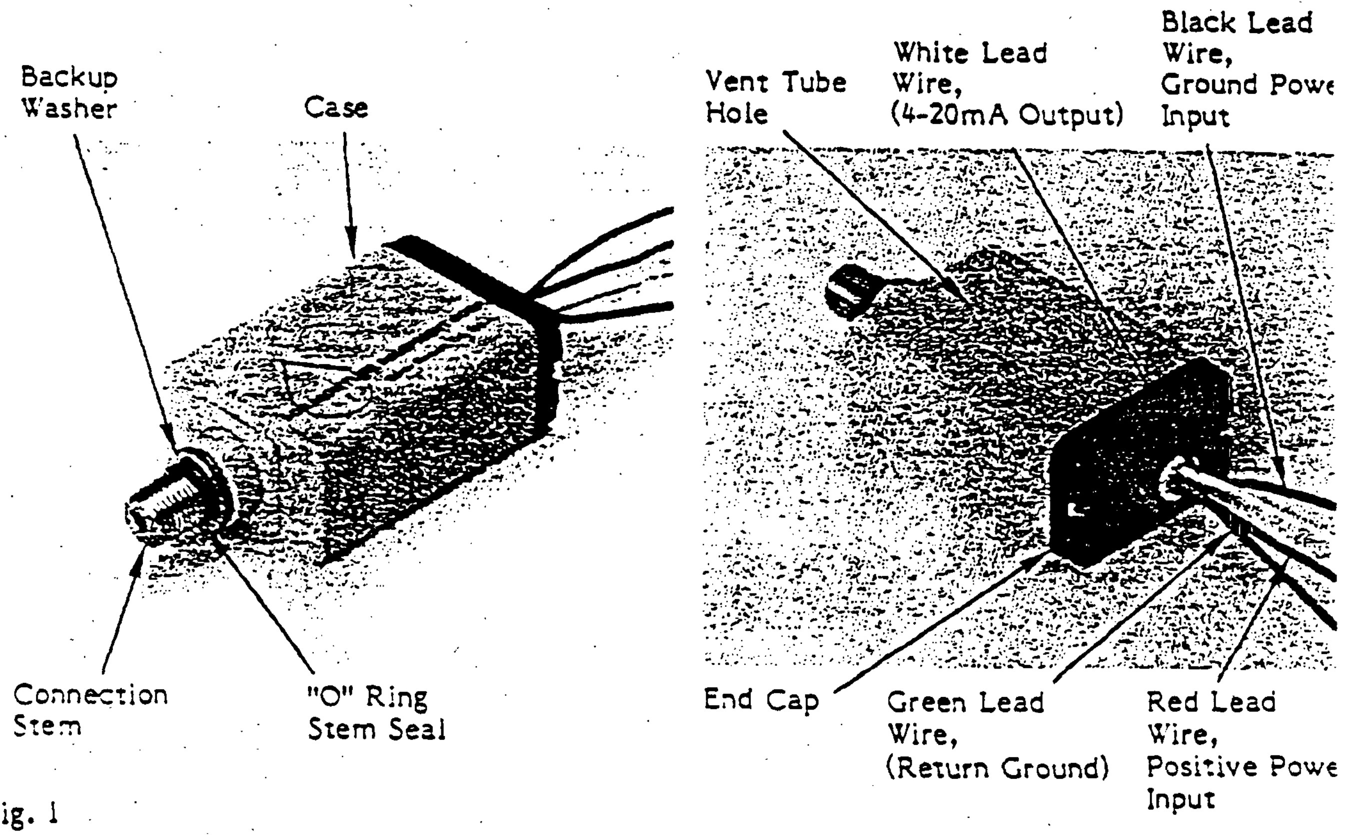


Fig. 1

SOILMOISTURE EQUIPMENT CORP.
P.O. Box 30025
Santa Barbara, CA 93105
U.S.A.

Telephone No. 805-964-3525
Telex No. 65-8424 Fax No. 805-683-2189
Cable Address: SOILCORP

SOILMOIST

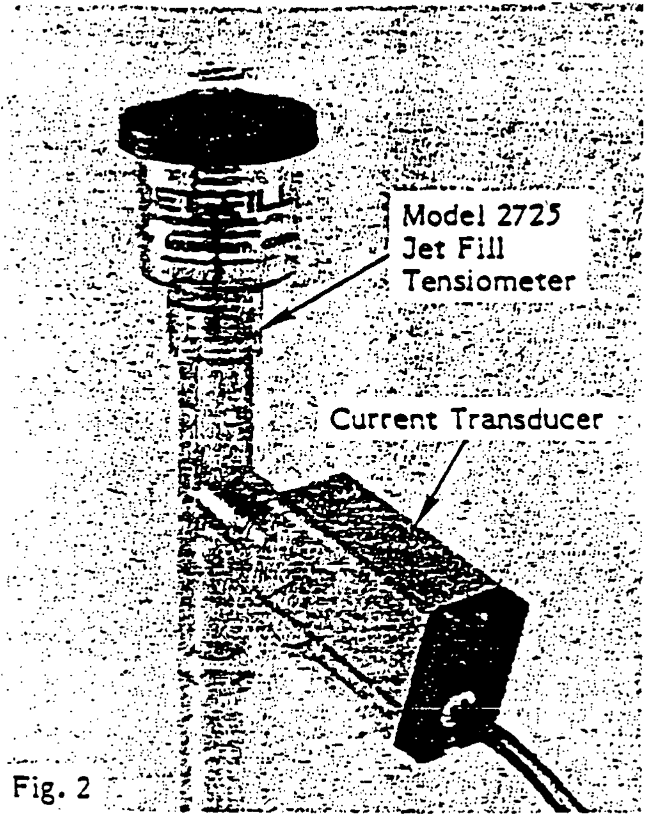


Fig. 2

The Model 5301 Current Transducer is one of the most advanced, versatile, accurate means converting soil moisture tension measurements into a continuous analog output. The Current Transducer can be readily used with Model 2100 Model 2710, Model 2725A and Model 2725AR Soilmoisture Tensiometers. Special adaptors are available to facilitate use of the Current Transducer with virtually any device which measures vacuum. The standard Current Transducer incorporates a 0-1 bar range transducer and solid state circuitry which allows continuous monitoring of soil moisture suction with time. Optional Transducer elements with operating ranges of 0 to .1 bars and 0 to .5 bars are also available. The special four-wire design assures excellent linearity, accuracy of output, and ease of installations.

UNPACKING

The Model 5301 Current Transducer shipped to you has been thoroughly tested before shipment. When packed, it was in perfect order. Unpack with care being sure to remove all packing material. Follow the instructions carefully in order to assure long, trouble-free service.

If Jet Fill Tensiometers were ordered at the same time, the Current Transducer ma mounted on the tensiometer, see Fig. 2 bove. In this case, you will also rece separate instruction for the tensiomet Handle the complete units with care and r all instruction information before insta tion.

NOTICE: ANY DAMAGE FOUND UP RECEIPT SHOULD BE REPORTED IMME ATELY TO THE TRANSPORT CARRI FOR CLAIM. IT IS IMPORTANT THAT Y SAVE THE SHIPPING CONTAINER AND A EVIDENCE TO SUPPORT YOUR CLAIM.

Be sure to read all operating instructi thoroughly before operating unit.

SPECIFICATIONS

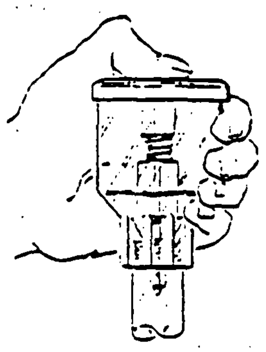
Power Requirement:	12 to 40 VDC at 50 mA. (internall regulated)
Operating Range:	0 to 1 bar (15 P
Operating Temperature Range:	32° to 140°F
Transducer Element:	Solid state, differential silico shear stress/str gauge.
Linearity:	.25% full scale (typically +/- ..
Output:	4 to 20 mA.
Hysteresis:	less than 1%
Maximum Pressure Differential:	2 bars (30 PSI)
Connecting Stem:	1/4" NPT Male

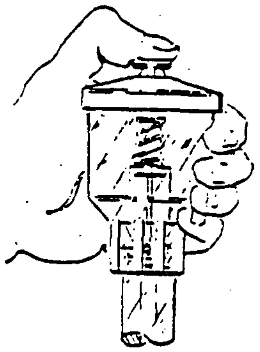
NOT LIABLE FOR IMPROPER USE

Soilmoisture Equipment Corp. is not respon ble for any damage actual or inferred misuse of improper handling of this equ ment. The Current Transducer is designed be used soley as directed, by a prodent in vidual under normal conditions in the appli tions intended for this instrument.

ACQUAINT YOURSELF WITH THE PARTS

Fig. 1 on the cover sheet shows several vie of the Current Transducer. The rugged ou case protects and hermetically seals





Push the reservoir button down, as far as it will go, several times to remove air from the reservoir pump cylinder and any accumulated air in the tensiometer.

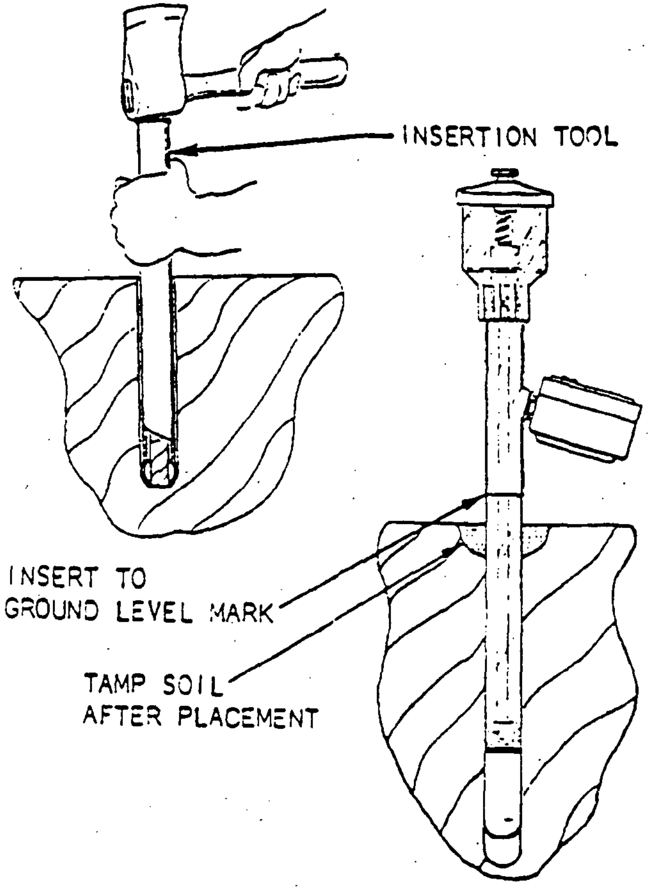
If the hand vacuum pump is not available, air can adequately be removed from the dial gauge by pushing the reservoir button down repeatedly after the tensiometer and reservoir have been filled. Push the button down quickly 50 to 60 times over a period of a minute or so, while observing the stem of the dial gauge through the transparent wall of the body tube. Continue this pumping action until air bubbles stop coming from the gauge stem. Tip the tensiometer at an angle with the dial gauge pointing down while pumping, so air can more easily escape from the dial gauge stem.

The tensiometer is now filled and ready for installation.

If there is to be a delay in installing the tensiometer, store the unit so that the sensing tip is covered with a plastic bag to prevent evaporation of water from the sensing tip.

TO INSTALL

In firm soils, a hole should be cored in the soil to accept the tensiometer. Our Insertion Tools, available in several lengths, should be used. The hole cored by the Insertion Tool is the right size to insure a snug fit between the ceramic sensing tip and the soil.



The Insertion Tool is driven into the soi by a mallot or hammer to the depth requir

The tensiometer is then pushed down into soil until the "ground level mark" is in with the soil surface.

The soil around the body tube is then tam at the surface to seal around the body tu and prevent surface water from running d around the body tube.

The body tube and the ceramic sensing tip 7/8" in diameter. In the event our Inser Tool is not available, a length of standa 1/2" water pipe may be driven into the so and used to create a hole to accept the tensiometer. It should be kept in mind t the ceramic sensing tip must be in intima contact with the soil in order for the te ometer to function properly.

If a rock or other impediment is encounte move to an adjacent location to avoid pos damage to the tensiometer when putting it place.

For shallow depths, a hole can be dug wit a spade to accept the tensiometer. Make sure that the soil is packed firmly around the tensiometer after it is set in place.

In loose cultivated soils, such as frequently encountered in commercial row crops, it is possible to simply push the tensiometer into the soil without coring a hole. This method of installation is completely satisfactory where applicable. Here again, be sure that the surface soil is packed firmly around the body tube after installation.

In rocky soils, a soil auger such as our Model 230 Soil Auger, 2", 3" or 4" size, can be used to core out a hole to accept the tensiometer. In this case, the soil removed is screened to remove large pebbles and rocks. The screened soil is then used to backfill around the tensiometer. A 1/4" mesh screen is usually suitable for screening the soil.

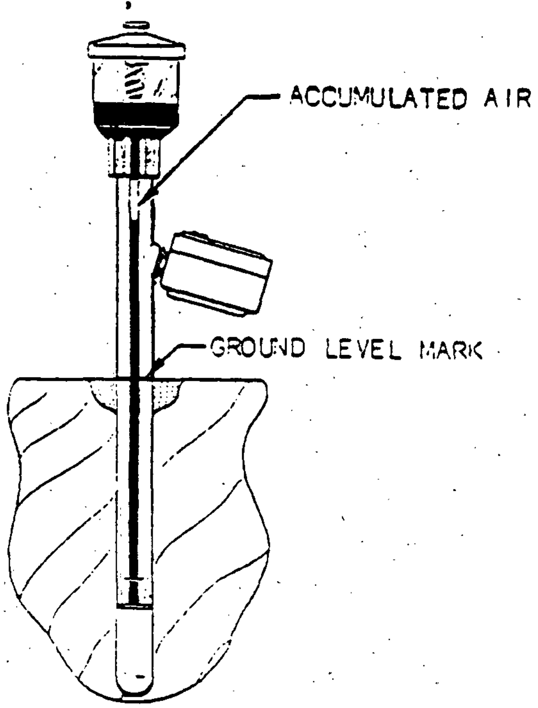
In difficult installations, such as in rocky soils or deep installations, a slurry of water and soil can be made up and poured into the bottom of the hole. The sensing tip of the tensiometer is then pushed into the slurry to assure good contact between sensing tip and soil. Large holes cored to accept the tensiometer are always backfilled and the soil at the surface tamped tightly around the body tube.

After installation, several hours may be required before the tensiometer reads the correct soil suction value. This is due to the disturbance to the soil caused by the installation procedure. The correct reading will be reached more quickly in moist soils than in dry soils.

After this initial installation period, the tensiometer will accurately indicate the soil suction value and will follow closely changes in soil suction from hour to hour.

TO SERVICE IN THE FIELD

The Jet Fill Tensiometer is completely weatherproof and requires very little servicing other than occasionally pushing the button on the Jet Fill reservoir to remove accumulated air within the tensiometer.



If the soil in which the tensiometer has been installed is moist and the soil suc- readings are low, very little air will ac- cumulate in the body tube of the tensiome If, however, the tensiometer has been installed in relatively dry soil and soil suction values are in the range of 40 to centibars, air will accumulate rather qui for the first few days after installatio This initial accumulation of air is due t air coming out of solution and air detach itself from the internal walls of the te- ometer when it is exposed to high vacuums for the first time. After initial insta lation, check the tensiometer every day c two and remove accumulated air by pushing the button of the Jet Fill reservoir.

After the first few air removal servicing operations, the rate of air accumulation drop off markedly, and air removal servic will then be required only on a weekly or longer basis. Since the Jet Fill operati is so convenient and does not disturb soi moisture conditions, it is suggested that the reservoir button be pushed down to service the unit after each reading that made on the tensiometer. By this means, internal air will be limited to a minimum which will assure maximum sensitivity of instrument. Due to the fast filling acti the tensiometer will recover to its corre reading within a few minutes after servic