SMI
Shepherd Miller, Inc.

Project #338
February 1994

Report:

Western Nuclear, Inc. Split Rock Mill February 1994 - Addendum A to Revision No. 5 To the June 30, 1987 Uranium Tailings Reclamation Plan

Split Rock Mill Site
Jeffrey City, Wyoming

Prepared for:

Western Nuclear, Inc.
Lakewood, Colorado

Volume 2 of 3

Report

Western Nuclear, Inc. Split Rock Mill October 1993 - Revision No. 5 to the June 30, 1987 Uranium Tailings Reclamation Plan

SMI

Shepherd Miller, Inc.

WESTERN NUCLEAR, INC.

SPLIT ROCK TAILING RECLAMATION PROJECT

ADDENDUM A (FEBRUARY 7, 1994) REVISIONS TO THE OCTOBER, 1993

REVISION NO. 5 TO THE JUNE 30, 1987

URANIUM TAILINGS RECLAMATION PLAN

Replacement Pages, Figures, and Tables:

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All of these page replace the corresponding pages in the October 1993 Revision #5 to the Split Rock Uranium Tailings Reclamation Plan.

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C	Erosion Protection Design Calculations
D	Alternate Channel Design Comparison
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F	Confluence Design Calculations
G	Radon Barrier Cover Design
H	Radiological Testing Procedures
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APPENDIX A

APPENDIX A

FIELD AND LABORATORY DATA

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Canonie Environmental

By SWM Date 1-18-92 Subject Radon Attenuation Sheet No. ___ of ___

Chkd. By ___ Date ___ Calculation Project No. 91-225-03

Reference # A.1

Geotechnical and Radiological Data

– Tailings Investigation –

Provided By: Water, Waste and Land, Inc. - 1988

This reference contains the following:

- Drill Hole (Boring) Locations
- Surface Sample Locations
- Boring Logs
- Summary of Geotechnical Results - Borings
- Summary of Radiological Results
- Summary of Geotechnical Results - Surface Samples

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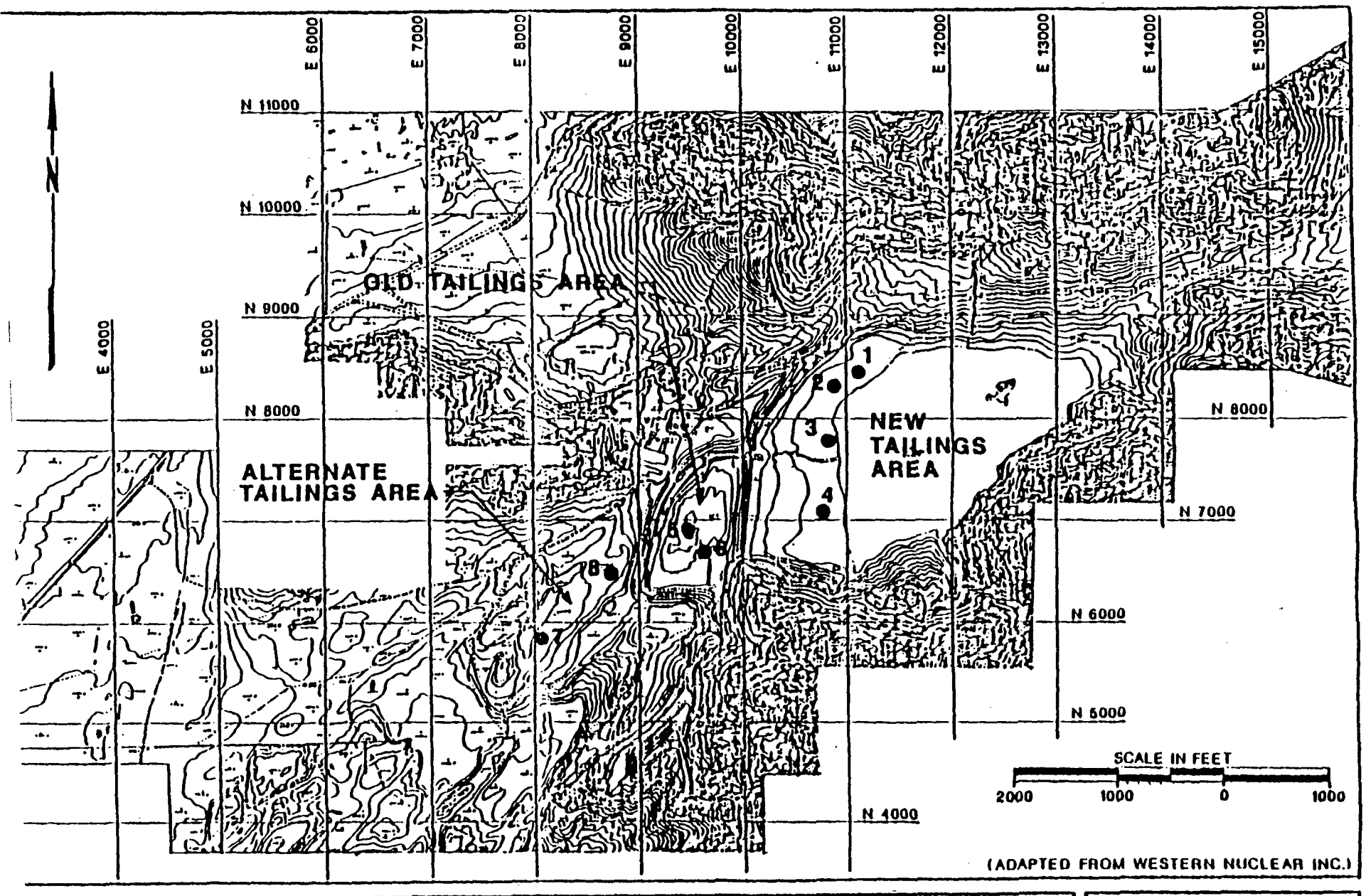
APPENDIX A.3

Tailings Investigation

A.3 TAILINGS INVESTIGATION

The field and laboratory results from the tailings investigation are presented in this appendix. Figure A.3.1 shows the location of the test borings and Figure A.3.2 shows the location of the surface tailings samples. The logs of the test borings are shown on Figures A.3.3 through A.3.7. The natural density and moisture content and the specific gravity of the sand and slime tailings are presented on Table A.3.1. The radium content and radon emanation coefficients for the tailings are presented on Table A.3.2. The results of the thorium content analyses are present on Table A.3.3. The results of the Proctor tests on the tailings sands are shown on Table A.3.4 and Figures A.3.8 and A.3.9. The radon diffusion coefficients for the tailings materials are presented on Tables A.3.5 through A.3.7.



Water, Waste & Land, Inc.

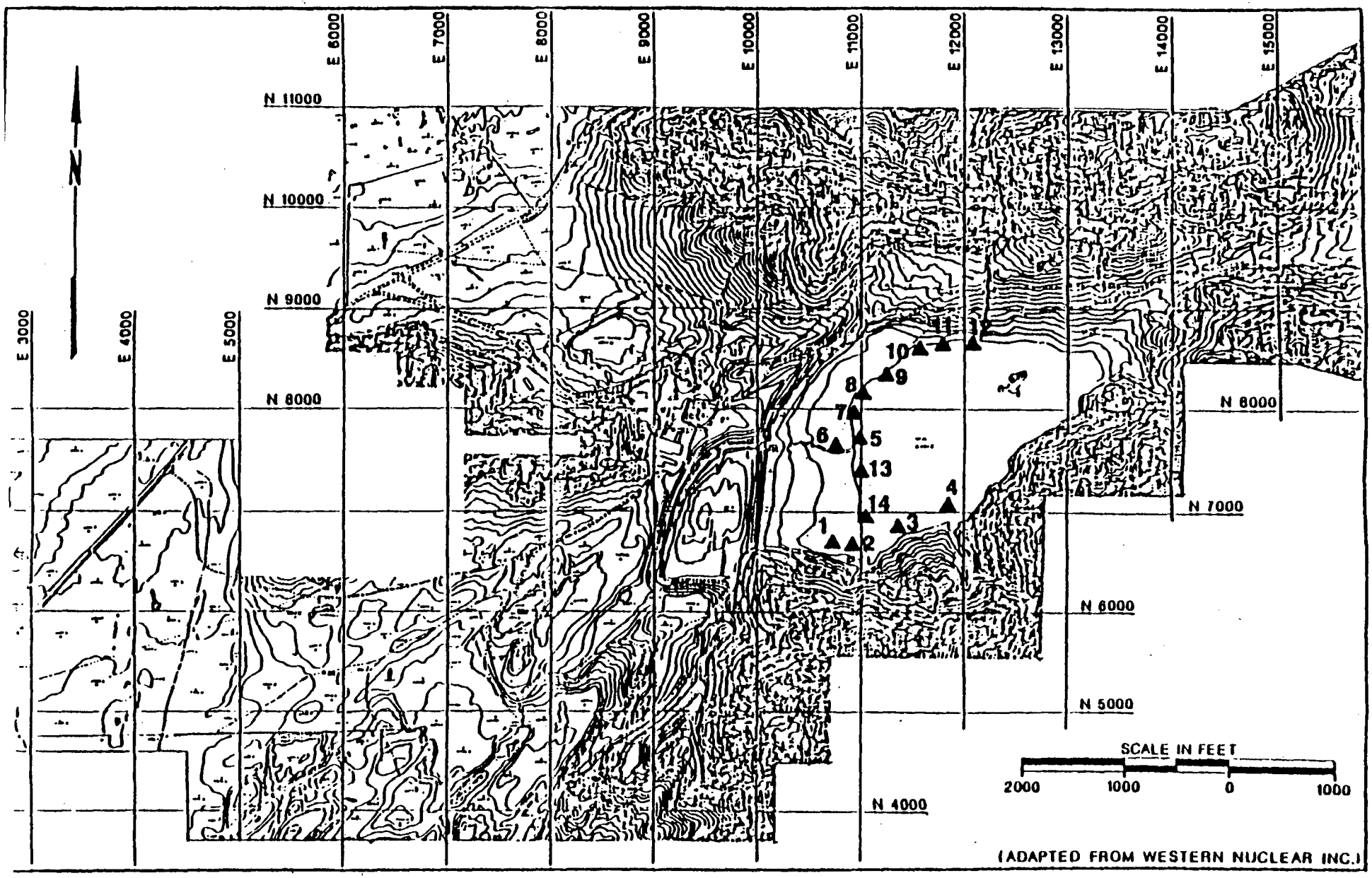
FIGURE A.3.1
DRILL HOLE LOCATIONS

Date: DEC 1988
Project: 080

A.3.3

A-5

A5



Water, Waste & Land, Inc.

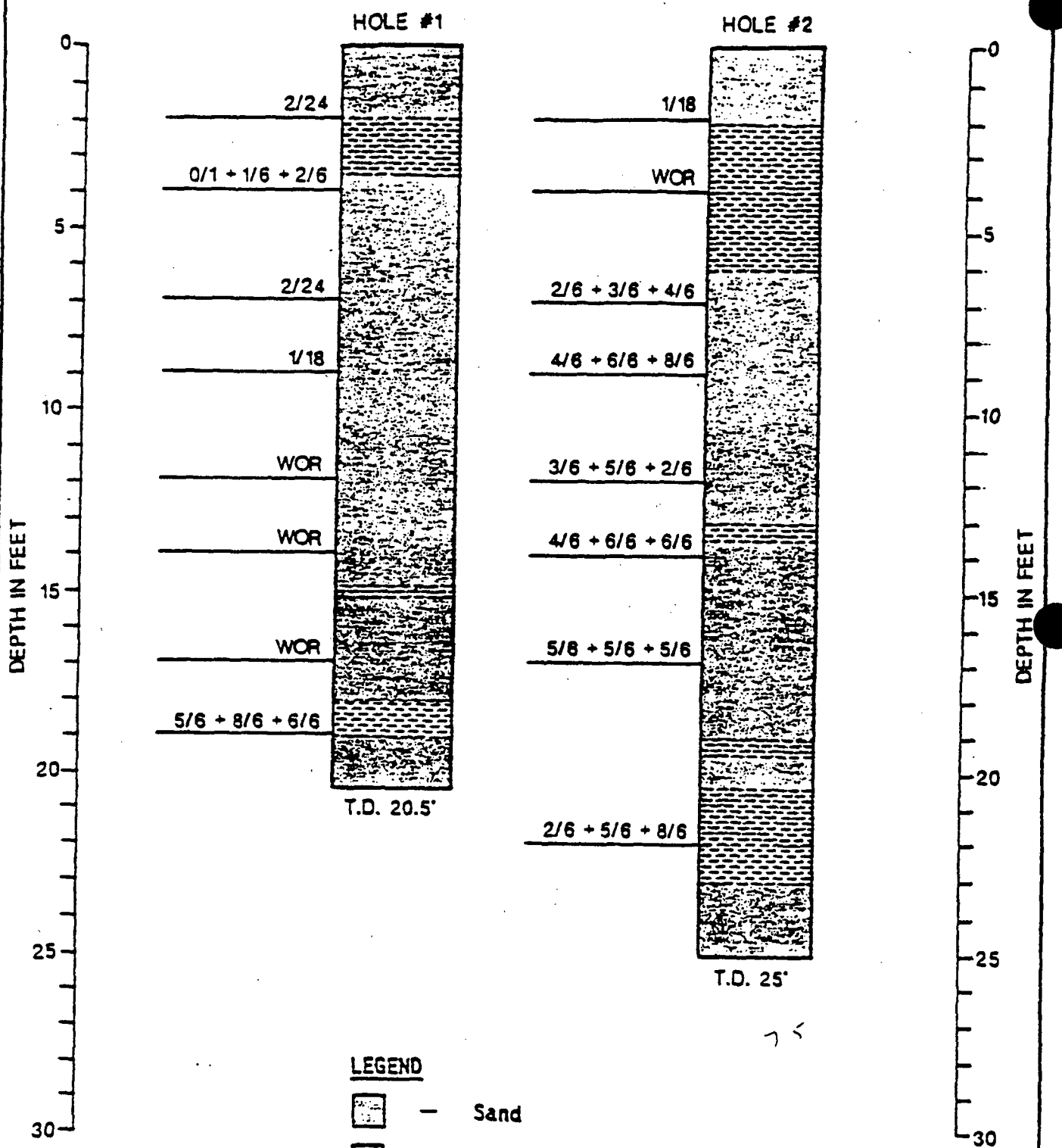
FIGURE A.3.2

SURFACE SAMPLE LOCATIONS

Date:	DEC 1988
Project:	080

A.3.4

A-6



LEGEND

— Sand

— Slimes

2/24 — Indicates standard penetration test of 2 blows for 24"

WOR — Weight of rod

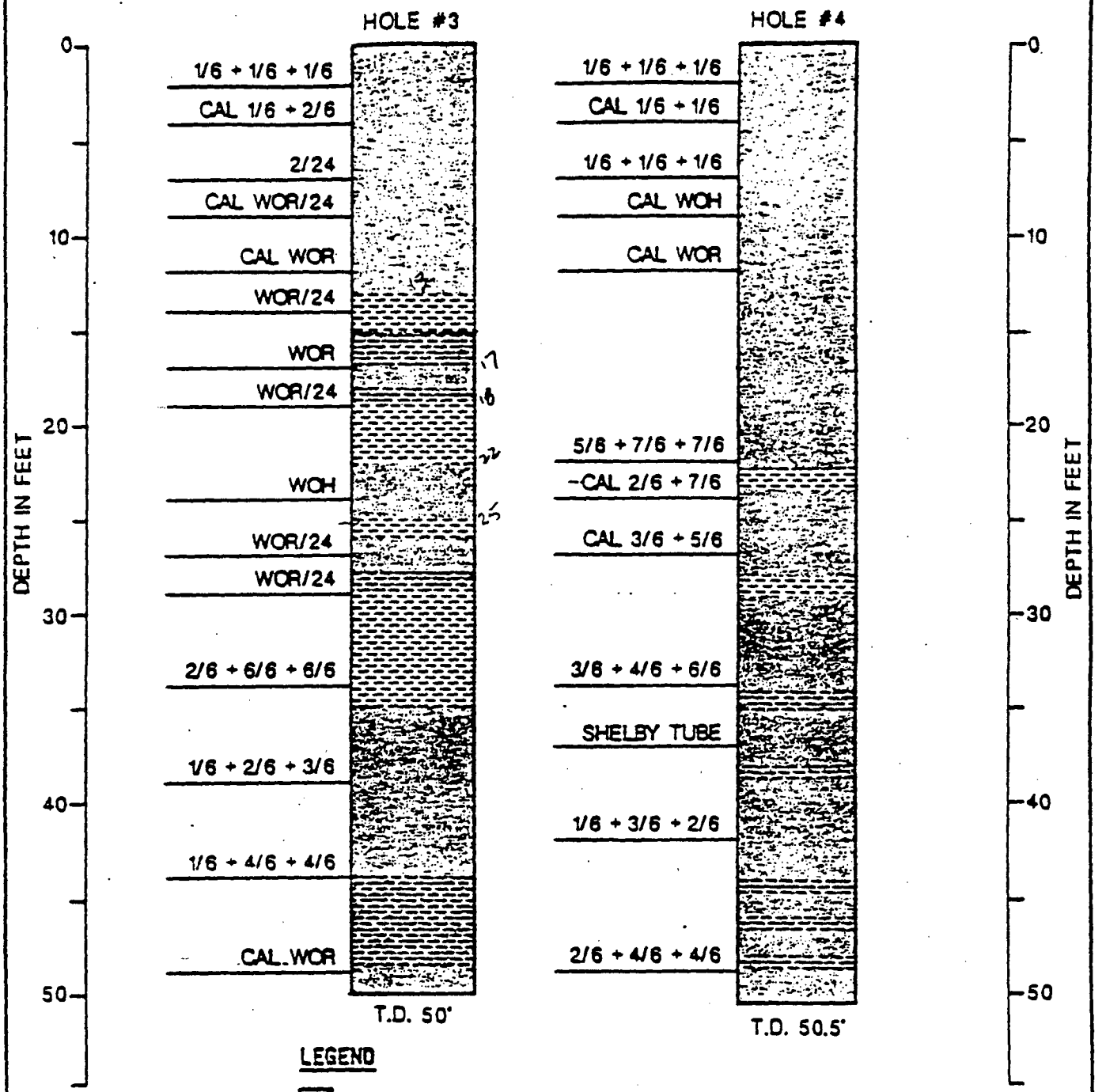
A-7

Water, Waste & Land, Inc.

FIGURE A.3.3
LOGS OF TAILINGS TEST
BORINGS, HOLES #1 AND #2

Date: DEC 1988

Project: 080



LEGEND

- Sand
- Slimes

2/24 – Indicates standard penetration test of 2 blows for 24"

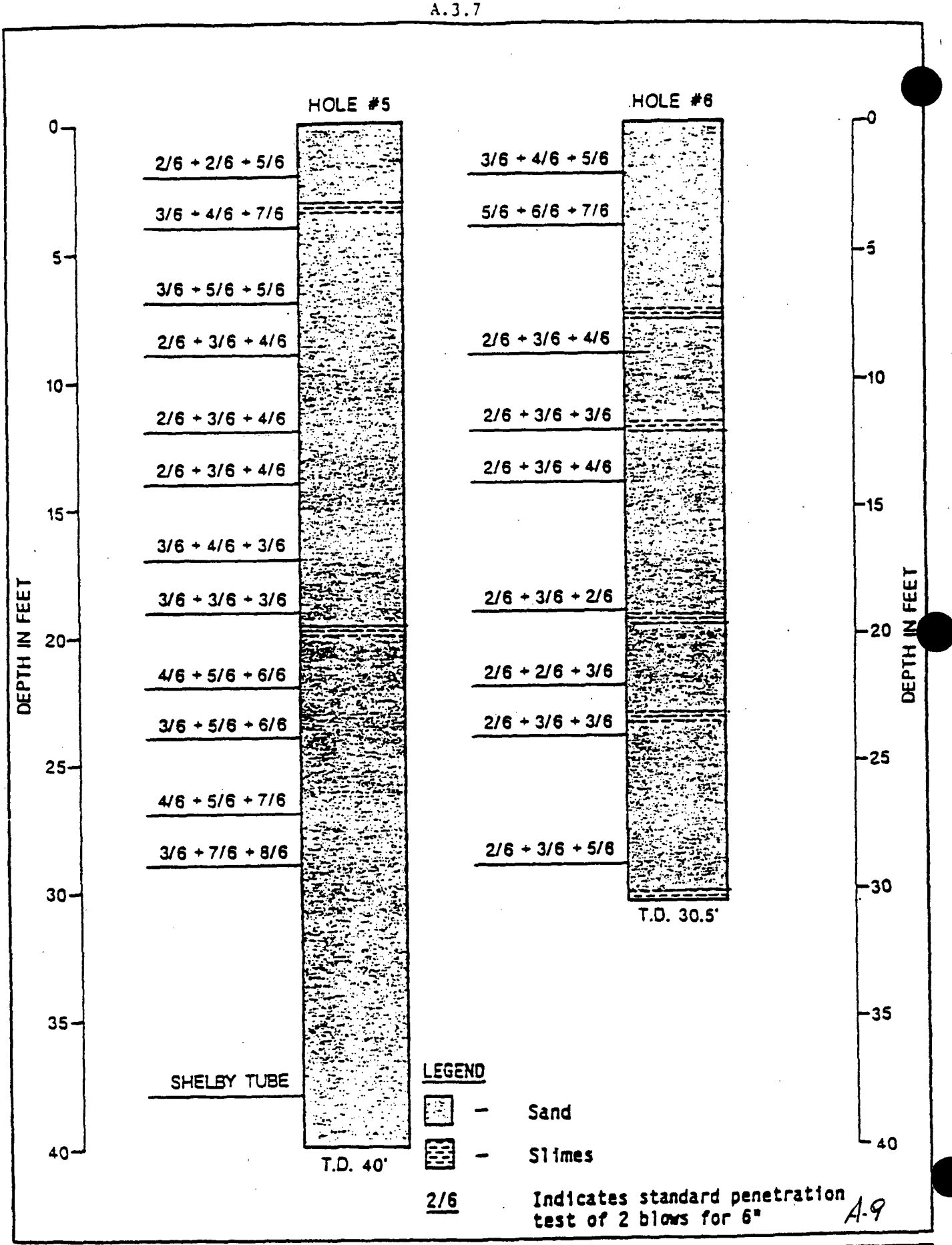
WOR – Weight of rod
WOH – Weight of hammer
CAL – California tube sample

A-8

Water, Waste & Land, Inc.

FIGURE A.3.4
LOGS OF TAILINGS TEST
BORINGS, HOLES #3 AND #4

Date: DEC 1988
Project: 080

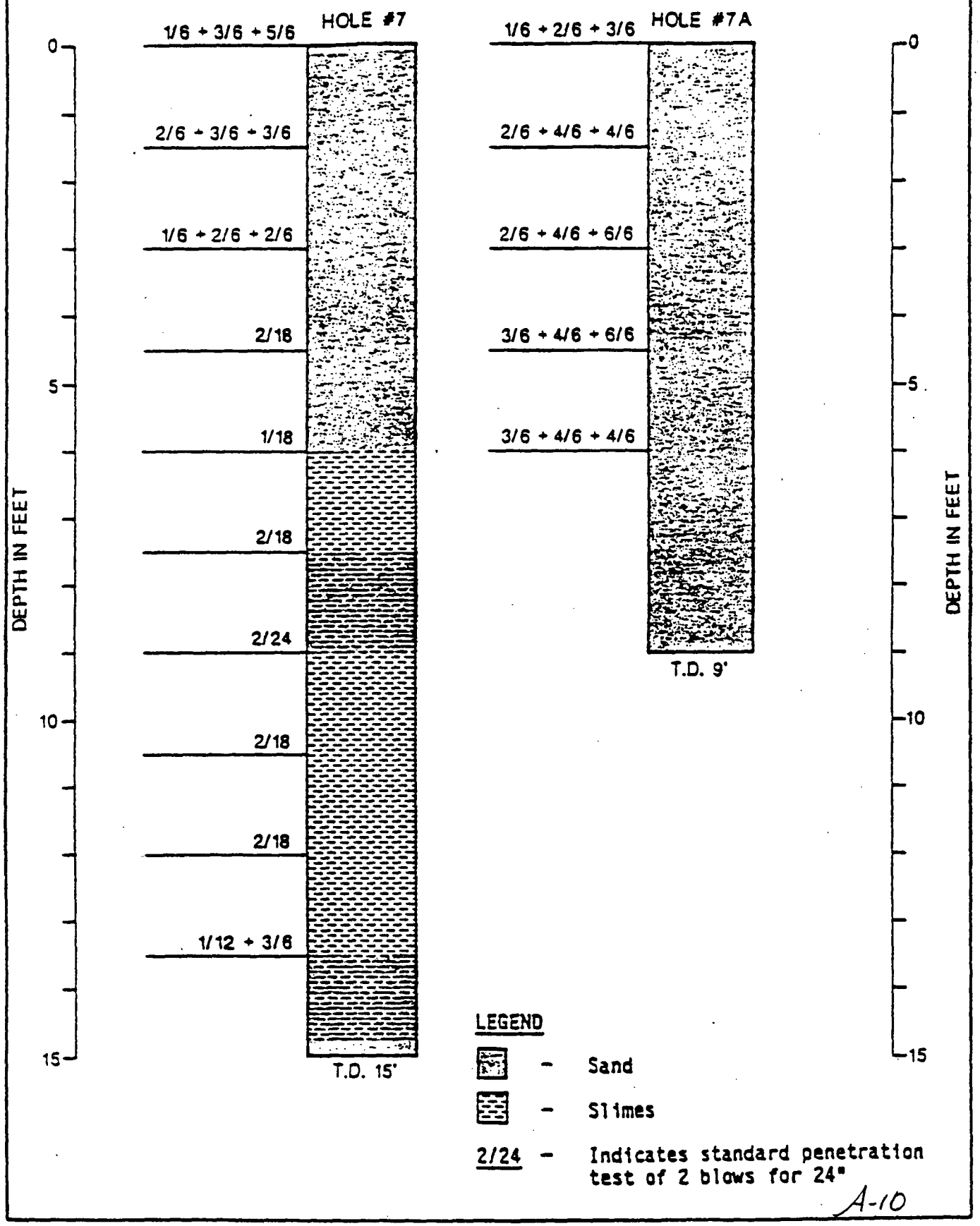


Water, Waste & Land, Inc.

FIGURE A.3.5
LOGS OF TAILINGS TEST
BORINGS, HOLES #5 AND #6

Date: DEC 1988

Project: 080



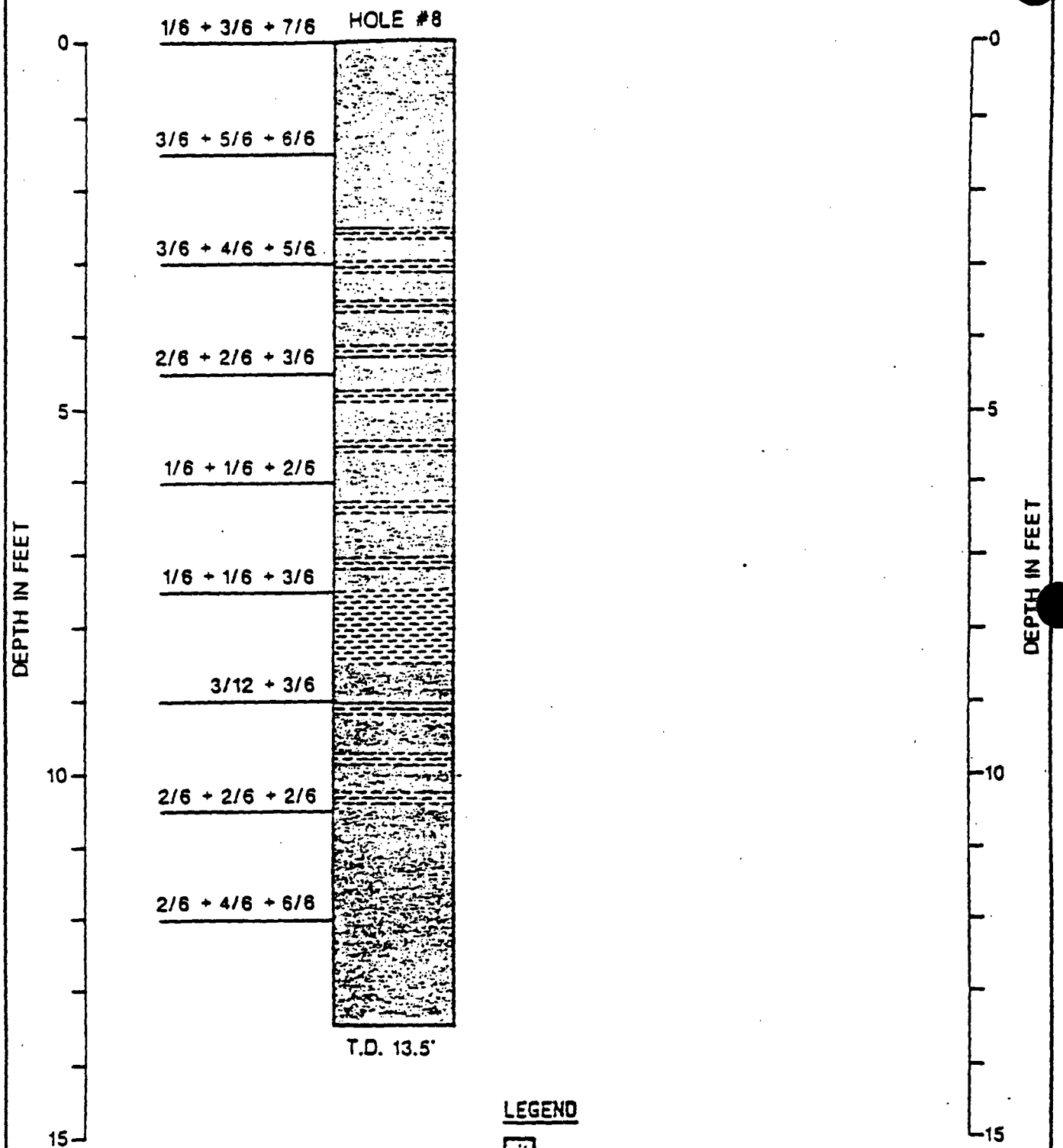
A-10

Water, Waste & Land, Inc.

FIGURE A.3.6
LOGS OF TAILINGS TEST
BORINGS, HOLES #7 AND #7A

Date: DEC 1988

Project: 080



A-11

Water, Waste & Land, Inc.

FIGURE A.3.7
LOGS OF TAILINGS TEST BORINGS, HOLE #8

Date: DEC 1988

Project: 080

TABLE A.3.1.
SUMMARY OF TEST RESULTS

Boring No.	Depth (Ft.)	Moisture (%)	Dry Density (PCF)	Visual Identification	Specific Gravity #4 Mat
3	24.0 - 25.0 ~~25.0 - 25.5~~	34.4	82.8	SAND	2.59
	25.0 - 26.0	52.9	66.7	SLIME	2.57
4	27.0 - 28.0	24.5	80.9	SAND	
	28.0 - 29.0	24.2	88.1	SAND	
	29.0 - 30.0	19.1	86.5	SAND	
	37.0 - 38.0	30.6	80.0	MIXTURE	
	38.0 - 39.0	38.7	70.1	MIXTURE	
	39.0 - 40.0	40.6	67.7	SLIME	
5	38.0 - 39.0	21.6	87.2	SAND	
	39.0 - 40.0	28.9	82.1	SAND	
	40.0 - 41.0	22.6	87.1	SAND	

See Figure A.3.1
for boring locations.
See Figures A.3.3 to A.3.7
for boring logs

Rogers & Associates Engineering Corporation

TABLE A.3.2
RADIUM CONTENT AND RADON EMANATION FRACTION

	Depth	Description	Radium (pCi/g)	Radon Emanation Coefficient	Moisture (Dry Weight %)
Hole #1	2-3.5	Sand/Slime	176 ± 3		29.6
	4-5.5	Sand	103 ± 2		20.3
	7-8.5	Sand	72 ± 2	0.28 ± .03	30.5
	9-10.5	Sand	47 ± 1		30.2
	12-13.5	Sand/Slime	97 ± 1		30.6
	19-20.0	Slime	764 ± 6		55.8
Hole #2	2-3.5	Slimey Sand	221 ± 3	0.34 ± 0.02	29.7
	4-5.5	Slime	483 ± 4		48.6
	7-8.5	Sand	59 ± 1	0.27 ± 0.02	20.6
	9-10.5	Sand	57 ± 1		9.7
	13-13.5	Slimey Sand	157 ± 2		31.0
	14-15.5	Sand	49 ± 1		25.9
	17-18.5	Sand	37 ± 1		24.2
	19-20.5	Slimey Sand	115 ± 2		28.7
	22-23	Slime	828 ± 6		51.4
Hole #3	2-3.5	Sand	34 ± 1		8.5
	4-5	Sand	53 ± 1	0.18 ± 0.02	6.3
	7-8.5	Sand	45 ± 1		9.3
	14-15	Slime	1140 ± 5	0.37 ± 0.01	67.9
	15-15.5	Sandy Slime	159 ± 3		35.3
	19-20.5	Slime	1009 ± 7		65.2
	22-23.5	Sand	107 ± 2		34.9
	24-25	Sand	88 ± 2		33.7
	25-26	Slime	780 ± 7		60.7
	27-28.5	Sand w/Slime	289 ± 4		65.6
	29-30.5	Slime w/Sand	699 ± 5	0.37 ± 0.01	47.0
	34-35	Slime	635 ± 5	0.36 ± 0.01	45.8
Hole #4	2-3.5	Sand	88 ± 2		11.1
	4-5	Sand	251 ± 2	0.27 ± 0.01	32.2
	7-8.5	Sand	61 ± 1		27.4
	14-15.5	Sand	85 ± 2		21.9
	22-23	Slime	1001 ± 7		59.6
	23-23.5	Sand	80 ± 2		42.0
	24-25	Sand	112 ± 2		23.8
	27-28	Sand	105 ± 2	0.35 ± 0.02	21.6
	29-30.5	Sand	153 ± 2		22.1
	34.5-35	Sand/Slime	367 ± 3	0.30 ± 0.01	25.9
	42-43.5	Sand w/Slime	458 ± 5		33.1

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TABLE A.3.2
RADIUM CONTENT AND RADON EMANATION FRACTION
(Continued)

	Depth	Description	Radium (pCi/g)	Radon Emanation Coefficient	Moisture (Dry Weight %)
Hole #5	2-3.5	Sand/Slime	510 ± 5		22.2
	7-8.5	Sand	189 ± 2	0.27 ± 0.02	6.4
	9-10.5	Sand	262 ± 3		9.5
	14-15.5	Sand	219 ± 3		8.7
	17-18.5	Sand	412 ± 4		12.1
	19-20.5	Mixture	381 ± 4		12.8
	22-23.5	Sand	246 ± 3		4.8
	27-28.5	Sand	186 ± 3		6.7
	29-30.5	Sand	179 ± 3		10.2
	32-33.5	Sand	250 ± 3		22.2
Hole #6	2-3.5	Sand	215 ± 3		10.0
	4-5.5	Sand	141 ± 2		6.3
	9-10.5	Sand	376 ± 4		10.1
	12-13.5	Sand	293 ± 3		8.3
	19-20.5	Sand	244 ± 3	0.18 ± 0.02	15.9
	24-25.5	Sand	257 ± 3		25.6
	29-30.25	Sand/Slime	736 ± 8		34.8
	30.25-30.5	Sand/Slime	413 ± 4	0.24 ± 0.01	28.5
Hole #7	0-1.5	Sand	1.3 ± .03		2.0
	1.5-3.0	Sand	1.1 ± .04		3.3
	3-4.5	Sand	1.0 ± 0.2		3.2
	6-7.5	Slimes	1350 ± 8	0.31 ± 0.01	52.3
	9-10.5	Slimes	3522 ± 16		74.3
	12-13.5	Slimes	2566 ± 13		64.0
Hole #8	0-1.5	Fine Sand	15 ± 1		0.5
	3-4.5	Fine Sand w/ Slime	226 ± 3	0.24 ± 0.02	5.7
	7.5-8.5	Slime	911 ± 6	0.27 ± 0.01	39.5
	8.5-9	Sand	204 ± 3	0.23 ± 0.02	9.2
	9-10.5	Sand/Slime	304 ± 4		27.1
	10.5-12	Sand	278 ± 4		18.1
	12.5-13.5	Silty Sand	3.4 ± 0.2		

See Figure A.3.1 for boring locations.
See Figures A.3.3 to A.3.7 for boring logs.

Rogers & Associates Engineering Corporation

TABLE A.3.2
RADIUM CONTENT AND RADON EMANATION FRACTION
(Continued)

Depth	Description	Radium (pCi/g)	Radon Emanation Coefficient	Moisture (Dry Weight %)
New Embankment	Sand w/Slime	74 ± 2	0.30 ± 0.03	3.7
Old Embankment	Sand w/Slime	144 ± 3	0.28 ± 0.02	7.9
SS-1	Slime	512 ± 6		74.1
SS-2	Slime	523 ± 5		47.0
SS-4	Slime	416 ± 5		52.5
SS-5	Slime	733 ± 6	0.29 ± 0.01	95.6
SS-7	Slime	91 ± 2		119.9
SS-8	Slime	1032 ± 8		131.5
SS-9	Slime	364 ± 4		61.7
SS-10	Slime	461 ± 5		67.2
SS-12	Slime	460 ± 5		26.3
SS-13	Slime	774 ± 8		123.7
SS-14	Slime	627 ± 8		160.1

See Figure A.3.2 for surface example locations.

TABLE A.3.4

Rogers & Associates Engineering Corporation

RAE

MOISTURE DENSITY RELATIONSHIP

SITE ID: Whitemarsh & Land

LOCATION ID: Salt Rock Mill

DATE: Oct 21 1988

CHECKED BY LAB: QIG

SAMPLE ID	DEPTH INTERVAL (FT)	TEST METHOD	MAXIMUM DRY DENSITY (PCF)	OPTIMUM MOISTURE CONTENT (%)	TEST NO.
New Embankment		SP	105.4	14.5	1
Old Embankment		SP	104.0	11.2	2

TEST RESULTS #1	
DRY DENSITY (PCF)	MOISTURE CONTENT (%)
96.7	9.0
101.2	11.8
102.2	12.2
105.0	15.5
104.7	17.0

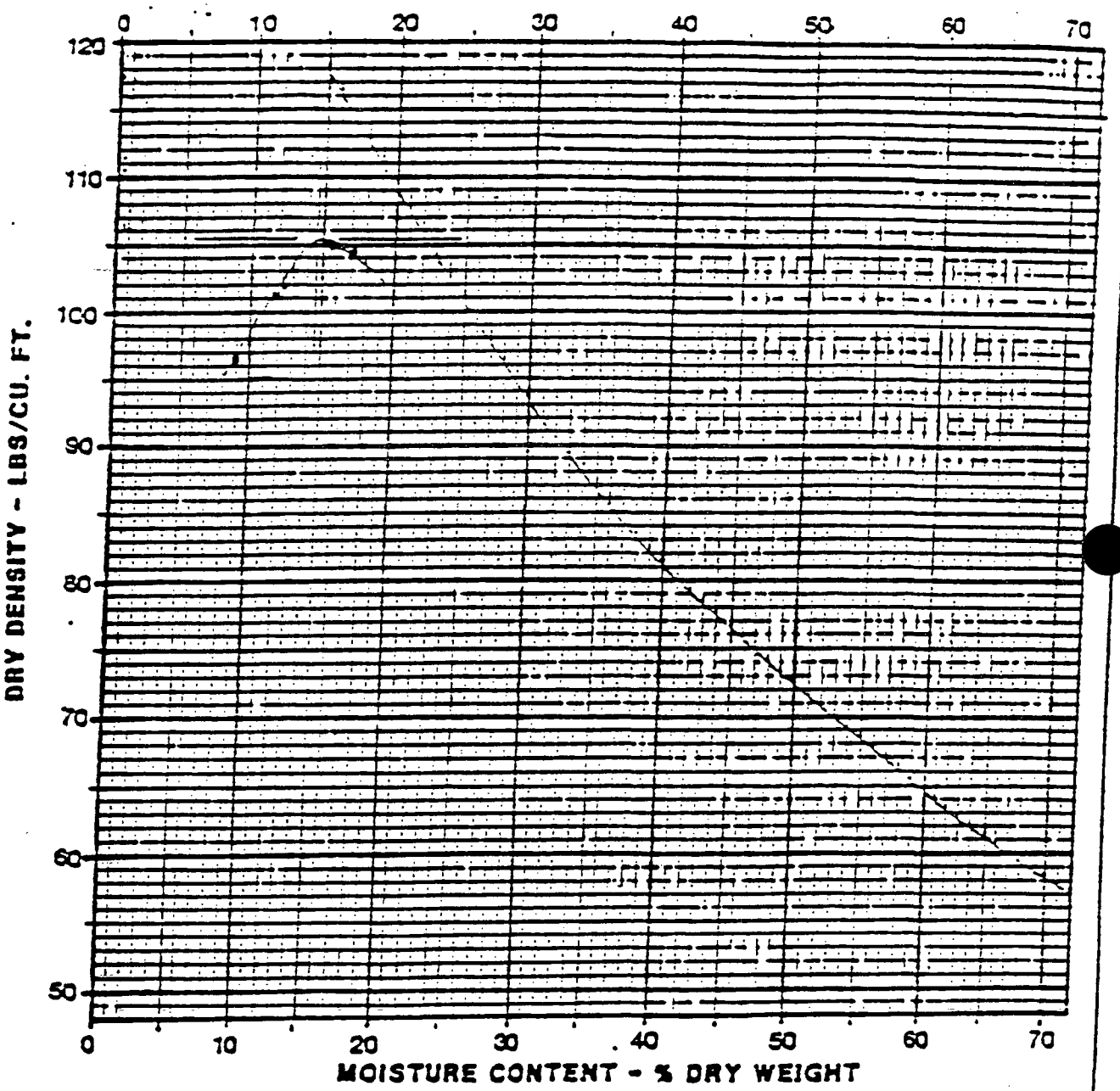
TEST RESULTS #2	
DRY DENSITY (PCF)	MOISTURE CONTENT (%)
97.2	6.0
99.5	7.4
103.3	12.8
101.6	14.0

RAE

Rogers & Associates Engineering Corporation

SUMMARY OF MOISTURE-DENSITY RELATIONSHIP TESTS

SITE ID: [illegible] LOCATION ID: [illegible] DATE: [illegible]



CURVE ID	SAMPLE ID	DEPTH INTERVAL (ft)	OPTIMUM MOISTURE CONTENT (%)	MAXIMUM DRY DENSITY LBS/CU. FT.	ASTM TEST	
					DESIGNATION	METHOD
	New Embankment		14.5	105.4	D 698	[illegible]

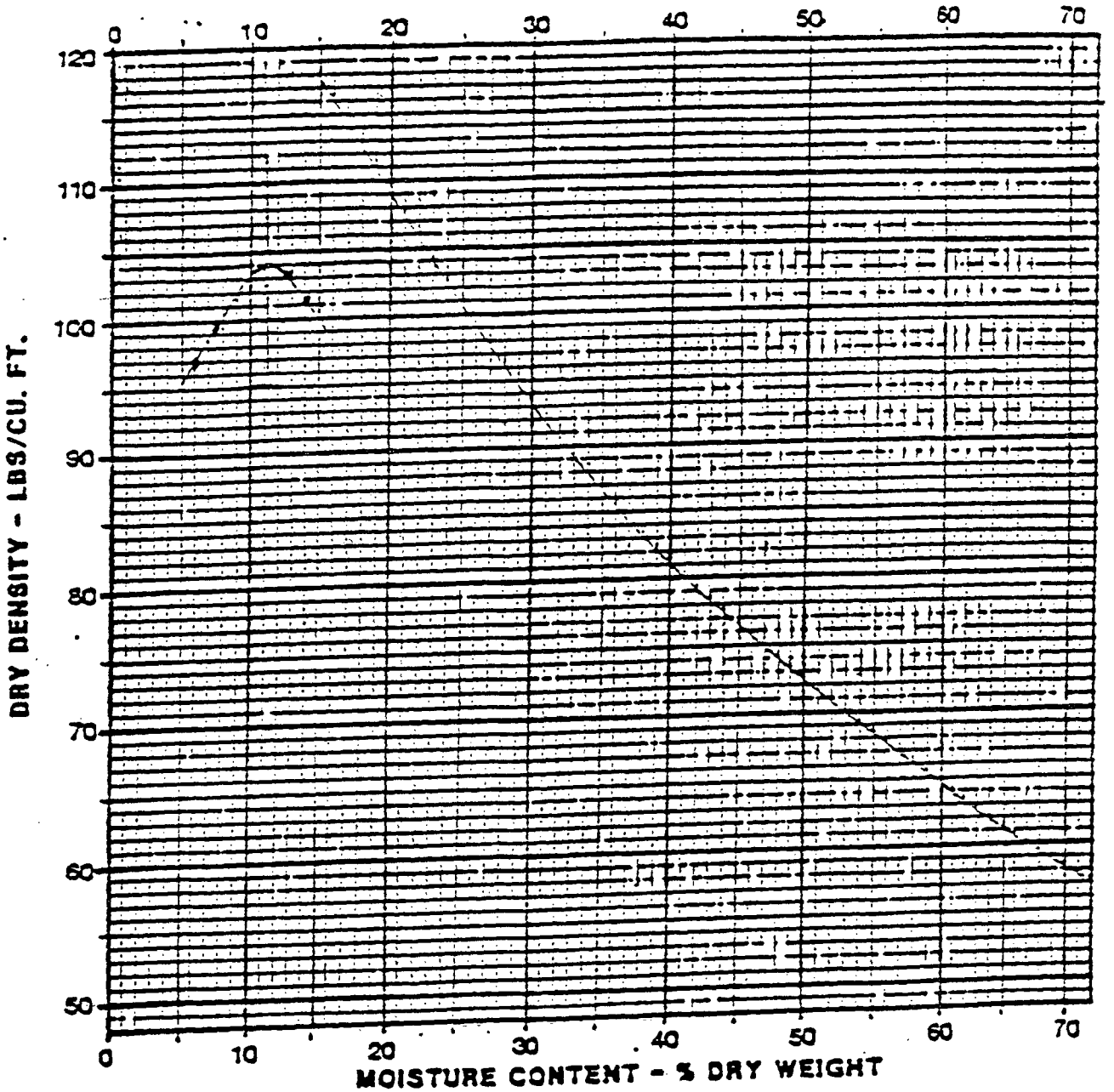
PLOT ZERO AIR-VOIDS CURVE FOR SPECIFIC GRAVITY OF 2.70.

RAE

Rogers & Associates Engineering Corporation

SUMMARY OF MOISTURE-DENSITY RELATIONSHIP TESTS

SITE ID: Waterwash & Land LOCATION ID: Sol & Pole 181.11 DATE: Oct 21, 1988



CURVE ID	SAMPLE ID	DEPTH INTERVAL (ft)	OPTIMUM MOISTURE CONTENT (%)	MAXIMUM DRY DENSITY LBS/CU. FT.	ASTM TEST	
					DESIGNATION	METHOD
	Old Embankment		11.2	104.0	D698	Standard

PLOT ZERO AIR-VOIDS CURVE FOR SPECIFIC GRAVITY OF 2.70.

TABLE A.3.5

Rogers & Associates Engineering Corporation

RAE

REPORT DATE Oct 26 1983

CONTRACT C8828

BY RLG

SAMPLE IDENTIFICATION Water Waste v Land - Split Rock Mill

SUBMITTED BY RLG DATE RECEIVED

SAMPLE ID	MOISTURE (DRY WT.%)	DENSITY (g/cm³)	RADON DIFFUSION COEFF. (cm²/s)	SATURATION [a] (Mp/P)	COMMENTS POROSITY
Now Sand *	4.9	1.52	1.6 E-02	0.18	0.41
" **	5.1	1.51	1.4 E-02	0.18	0.42
" **	4.6	1.35	3.1 E-02	0.13	0.48

*at 90% Max. Dry Dens. by Std. Proctor

** insitu density

TABLE A.3.6

Rogers & Associates Engineering Corporation

RAE

REPORT DATE Oct 26, 1988

CONTRACT C8828

BY RUB

SAMPLE IDENTIFICATION Water Waste + Land - Solit Rock Mill

SUBMITTED BY RUB DATE RECEIVED

SAMPLE ID	MOISTURE (DRY WT.%)	DENSITY (g/cm^3)	RADON DIFFUSION COEFF. (cm^2/s)	SATURATION [a] (Mp/P)	COMMENTS POROSITY
Alt Sand	4.8	1.50	1.3 E-02	0.17	0.42
(at 90% Max. Dry Dens. by Std. Proctor.					

[a] BASED ON A SPECIFIC GRAVITY OF g/cm³

TABLE A.3.7

Rogers & Associates Engineering Corporation

RAE

REPORT DATE Oct 31, 1988

CONTRACT C8828

BY RWB

SAMPLE IDENTIFICATION Water Waste + Land - Split Rock Mill

SUBMITTED BY RWB DATE RECEIVED

SAMPLE ID	MOISTURE (DRY WT.%)	DENSITY (g/cm^3)	RADON DIFFUSION COEFF. (cm^2/s)	SATURATION [a] (Mp/P)	COMMENTS POROSITY
Slime (SS-5)	19.0	1.09	1.9 E-02	0.36	0.58

[a] BASED ON A SPECIFIC GRAVITY OF [illegible] (2.57)

Reference # A.2

Geotechnical Testing Results

Canonie Sample

#'s 1,2,3,4a,4b,5,6, and 7

Provided By: Chen Northern, Inc.

- February, 1989 -

Chen-Northern, Inc.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

Job No. 1 465 89

SAMPLE LOCATION		OPT MOISTURE CONTENT (%) ASTM D-698	ASTM D 698 DENSITY (pcf)	GRADATION		PERCENT PASSING NO 200 SIEVE	ATTERBERG LIMITS		SPECIFIC GRAVITY	** POROSITY (%)	SOIL OR BEDROCK TYPE
SAMPLE NO				GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTICITY INDEX (%)			
1		16.5	100.0	0	96	4			2.64	42	Windblown tailings, sand*
2		13.9	108.9	0	96	4			2.62	37	Alternate area cover sand
3		18.1	107.4	0	4	96	44	25	2.71	40	Cody shale, lean clay
4a		15.0	109.1	0	80	20	35	14		37	Borrow sand with 7% Bentonite, clayey sand
4b		14.6	108.4	0	76	24	43	23	2.63	37	Borrow sand with 9% bentonite, clayey sand
5		9.0	114.0	4	85	11			2.61	30	Mill area soils, * slightly silty sand
6		-	-	0	18	82	32	13	2.69	-	Slimes, lean clay *
7		-	-	-	-						

*HANDLED AS BALANCED MATERIAL

February 16, 1989
Job No. 1 465 89

CHEN-NORTHERN, INC.
TABLE II

Summary of Capillary-Moisture Relationship Test Results

Sample Location	#3	4A	4B	7
Initial %MC (avg)	19.2	15.1	14.7	13.9
Density pcf	101.8	103.6	102.9	94.4
Tension, bar				
0.1	28.7	19.7	20.4	5.5
0.3	26.2	17.8	20.6	5.2
0.5	24.9	18.4	20.8	3.2
1.0	23.3	15.2	16.2	1.9
2.0	22.9	14.1	15.7	2.3
4.0	22.6	13.0	15.8	1.5
15.0	22.0	13.0	16.0	1.5

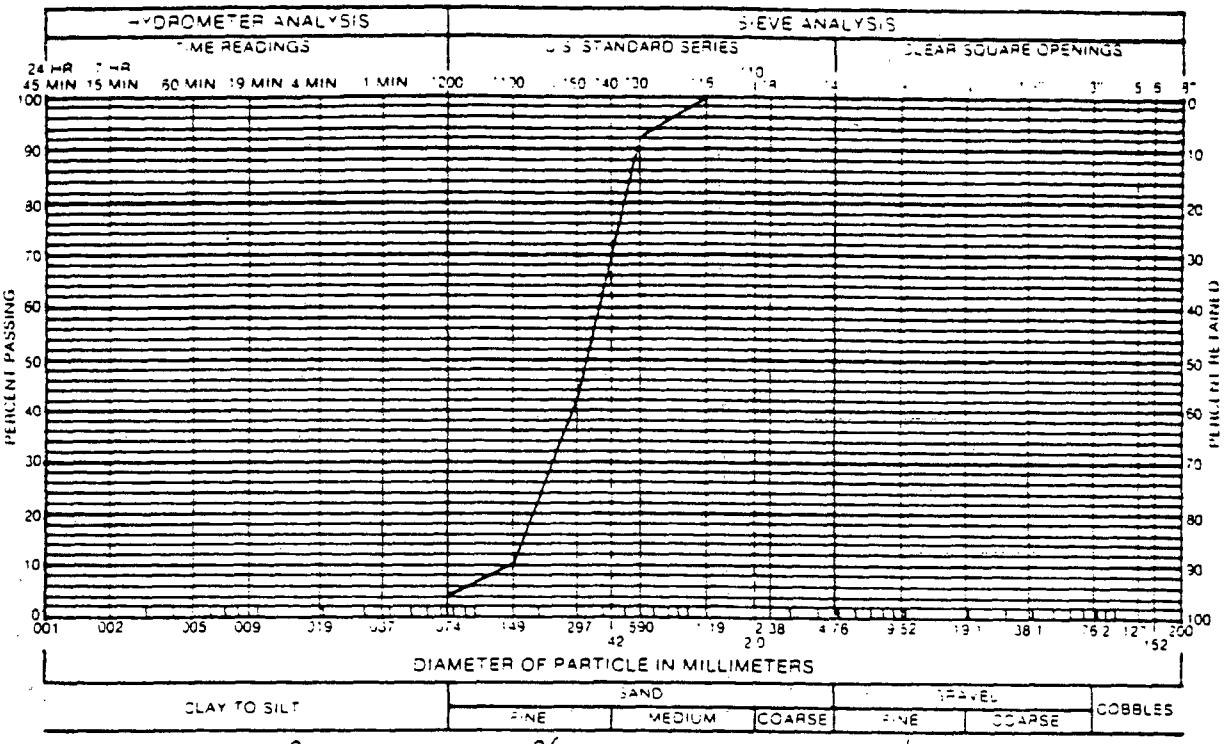
February 15,
Job No. 1 46

CHEN-NORTHERN, INC.
TABLE III

Summary of Permeability Test Results*

Sample No.	Initial Moisture Content, %	Initial Dry Density pcf	Final Moisture Content, %	Final Dry Density pcf	Final Percent Saturation	Coefficien Permeabil k cm/sec
3	18.1	102.0	NA	NA	NA	$7 \times 10^{-}$
4a	15.4	103.4	""	""	""	$3 \times 10^{-}$
4b	15.6	103.0	""	""	""	$8 \times 10^{-}$

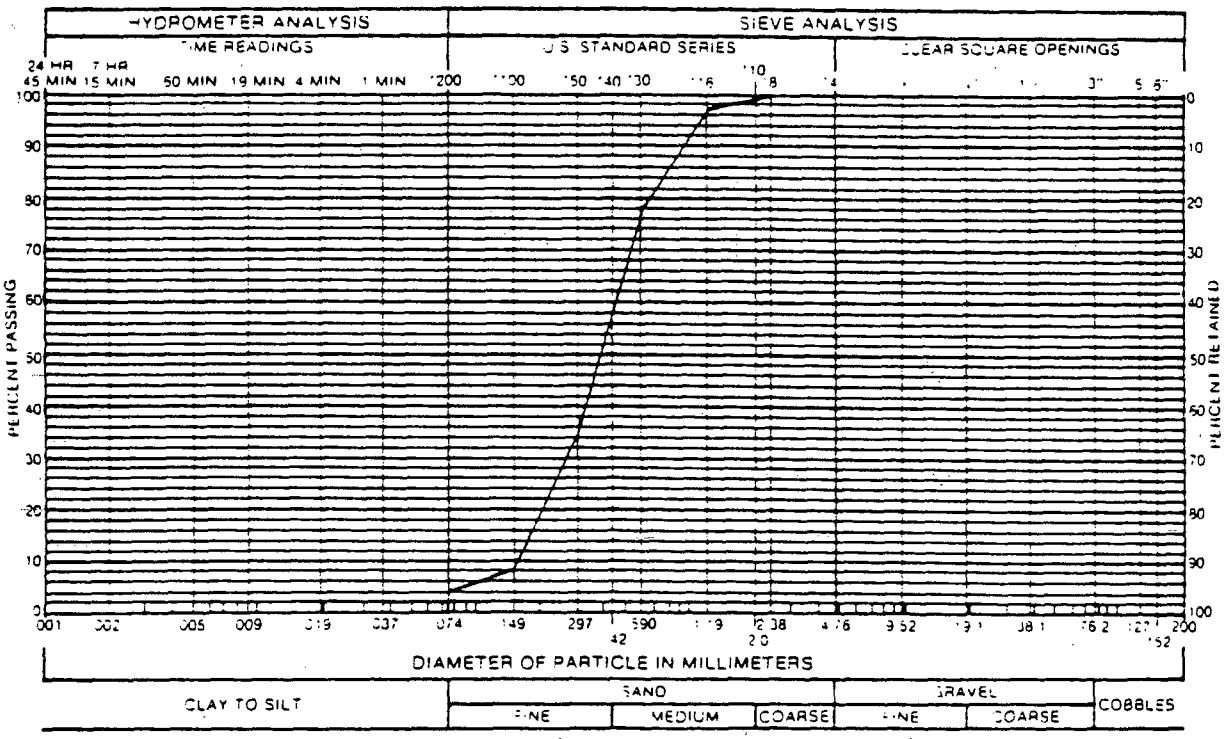
*Note above data is preliminary



GRAVEL 0 % SAND 96 % SILT AND CLAY 4 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Windblown tailings FROM Sample No. 1



GRAVEL 0 % SAND 96 % SILT AND CLAY 4 %

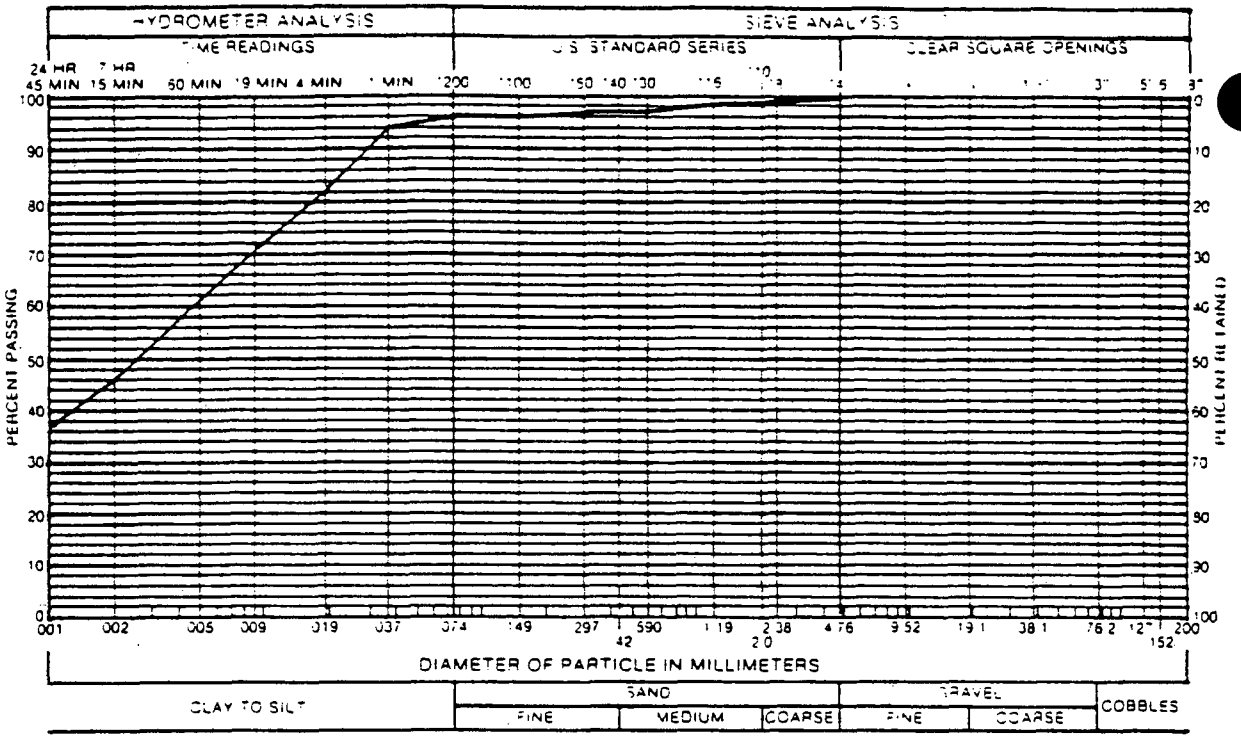
LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Alternate area cover FROM Sample No. 2

A-26

1 465 89	*Chen-Northern, Inc.*	GRADATION TEST RESULTS	Fig. 1

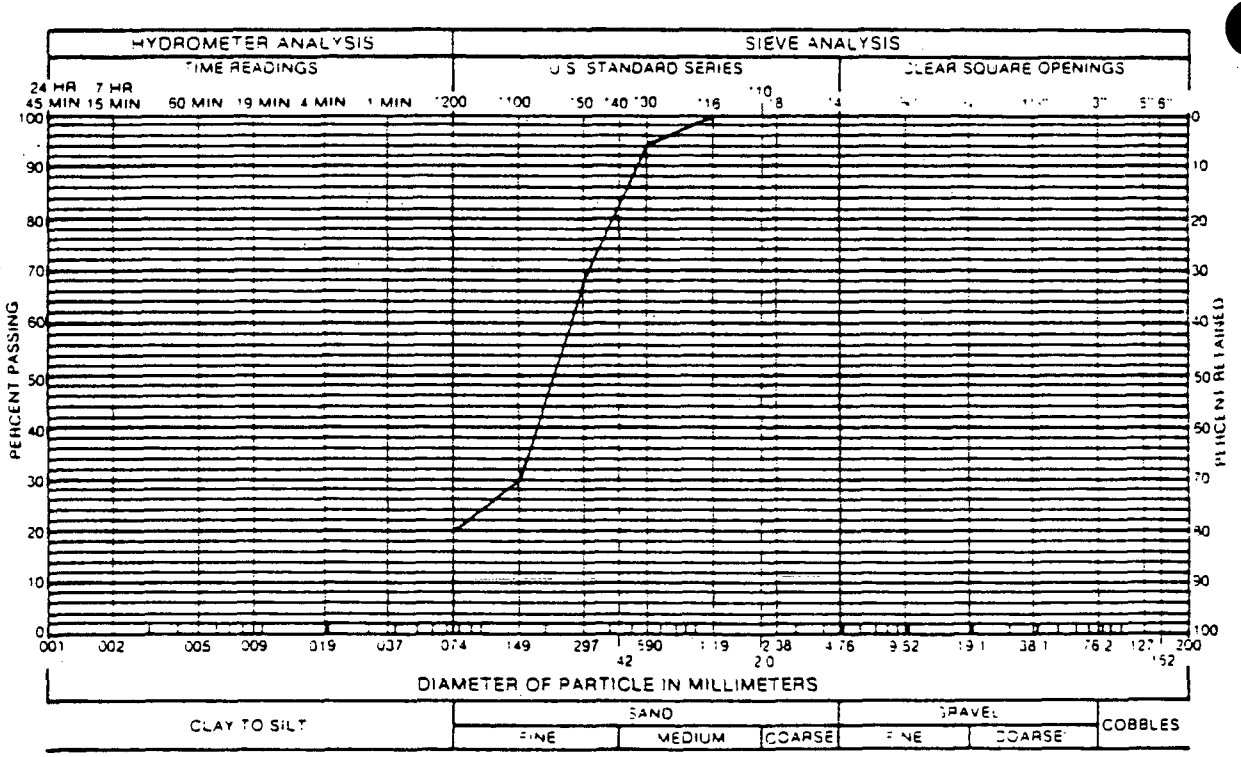
CA-2-79



GRAVEL 0 % SAND 4 % SILT AND CLAY 96 %

LIQUID LIMIT 44 % PLASTICITY INDEX 25 %

SAMPLE OF Cody shale FROM Sample No. 3



GRAVEL 0 % SAND 80 % SILT AND CLAY 20 %

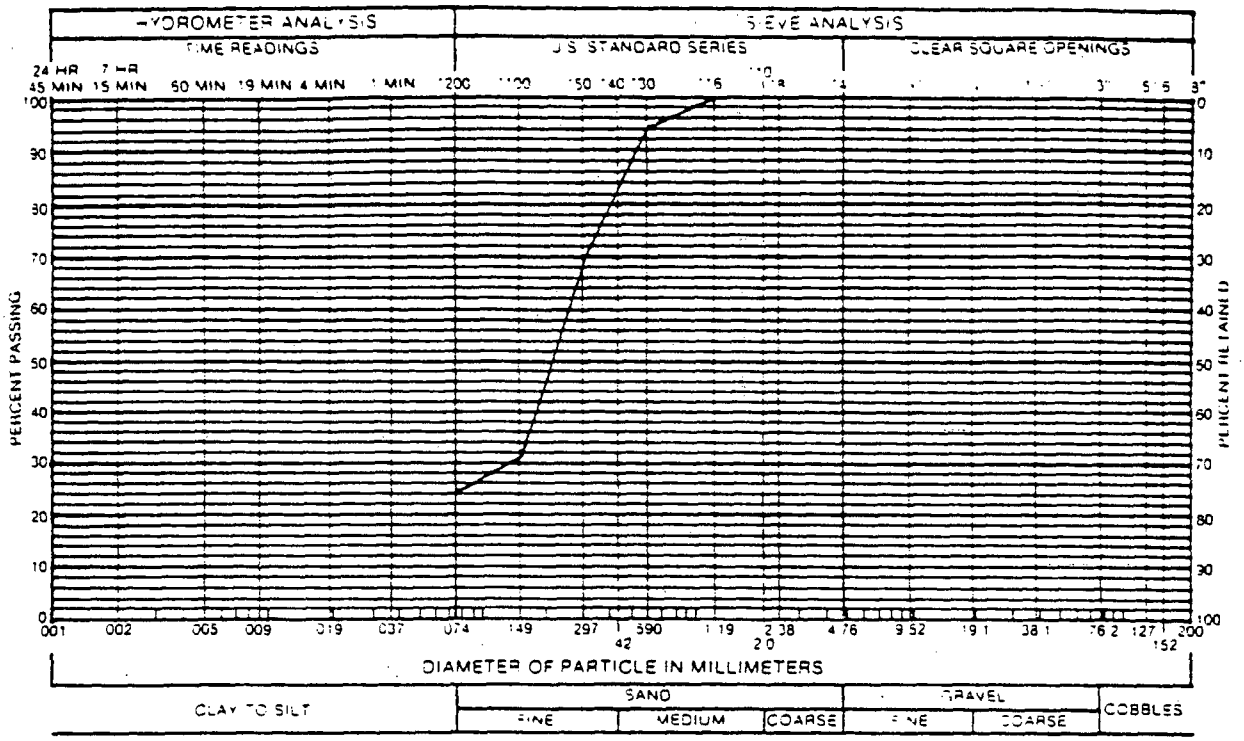
LIQUID LIMIT 35 % PLASTICITY INDEX 14 %

SAMPLE OF Borrow sand w/ 7% bentonite FROM Sample No. 4a

A-27

1 465 89	*Chen-Northern, Inc.*	GRADATION TEST RESULTS	Fig. 2

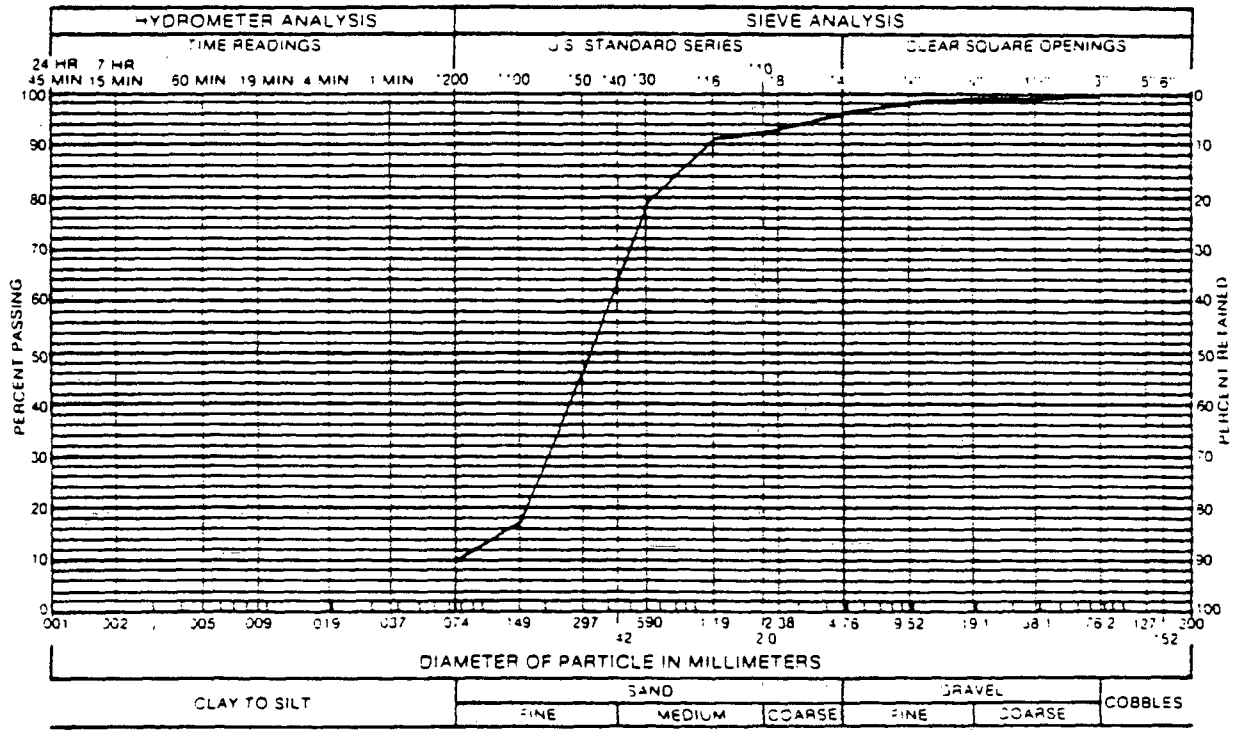
CA-2-79



GRAVEL 0 % SAND 76 % SILT AND CLAY 24 %

LIQUID LIMIT 43 % PLASTICITY INDEX 23 %

SAMPLE OF Borrow sand w/ 9% bentonite FROM Sample No. 4b



GRAVEL 4 % SAND 86 % SILT AND CLAY 10 %

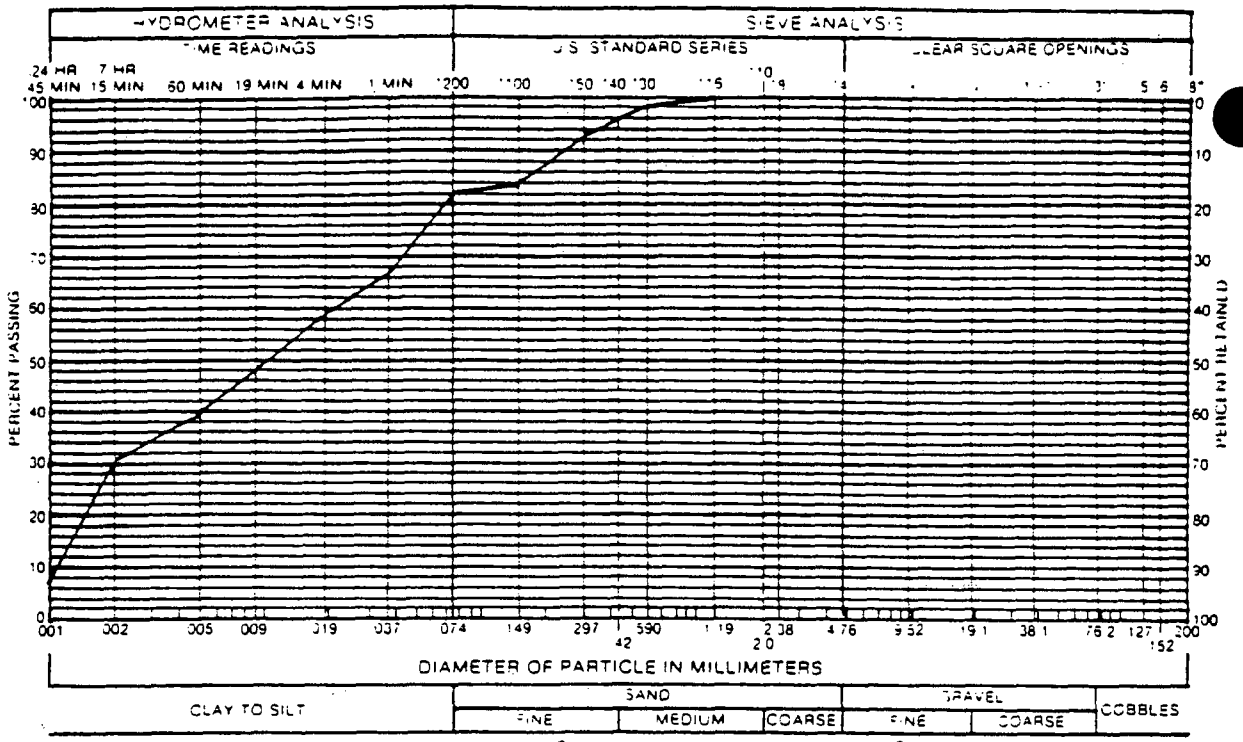
LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF Mill area soil FROM Sample No. 5

A-28

1 465 89	*Chen-Northern, Inc.*	GRADATION TEST RESULTS	Fig. 3

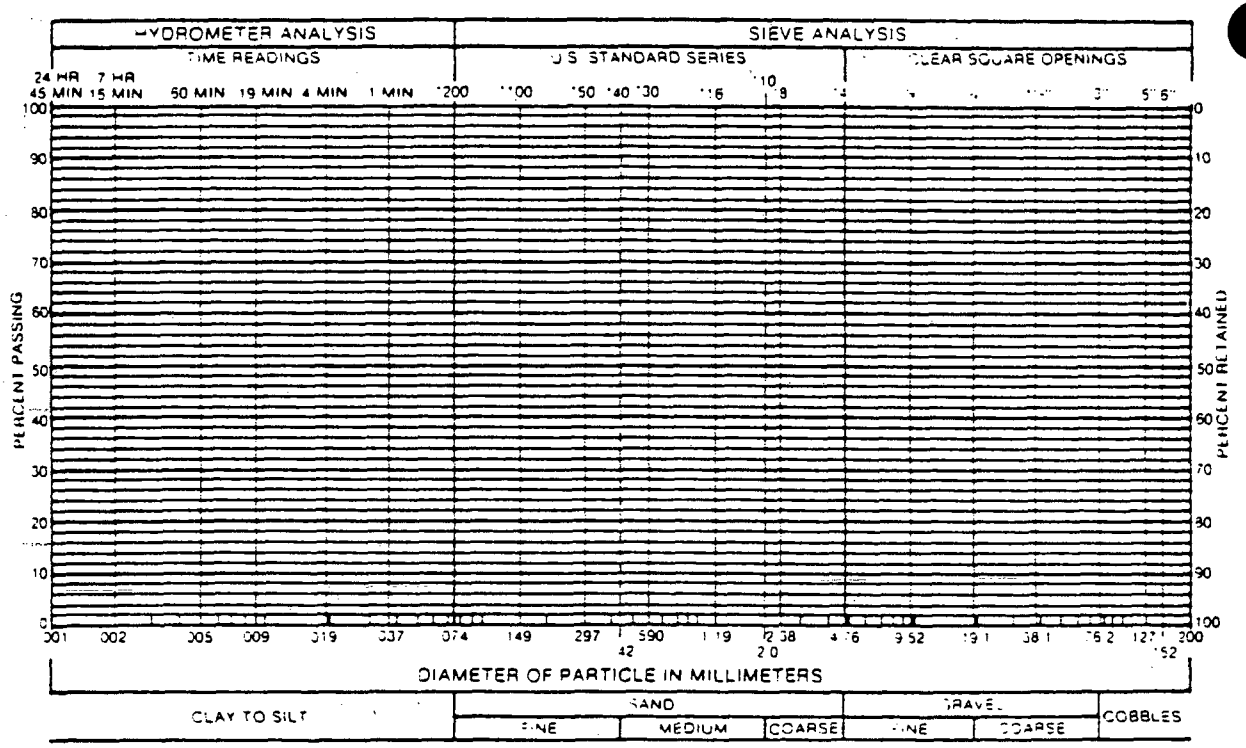
CA-2-79



GRAVEL 0 % SAND 18 % SILT AND CLAY 82 %

LIQUID LIMIT 32 % PLASTICITY INDEX 13 %

SAMPLE OF Slimes FROM Sample No. 6



GRAVEL % SAND % SILT AND CLAY %

LIQUID LIMIT % PLASTICITY INDEX %

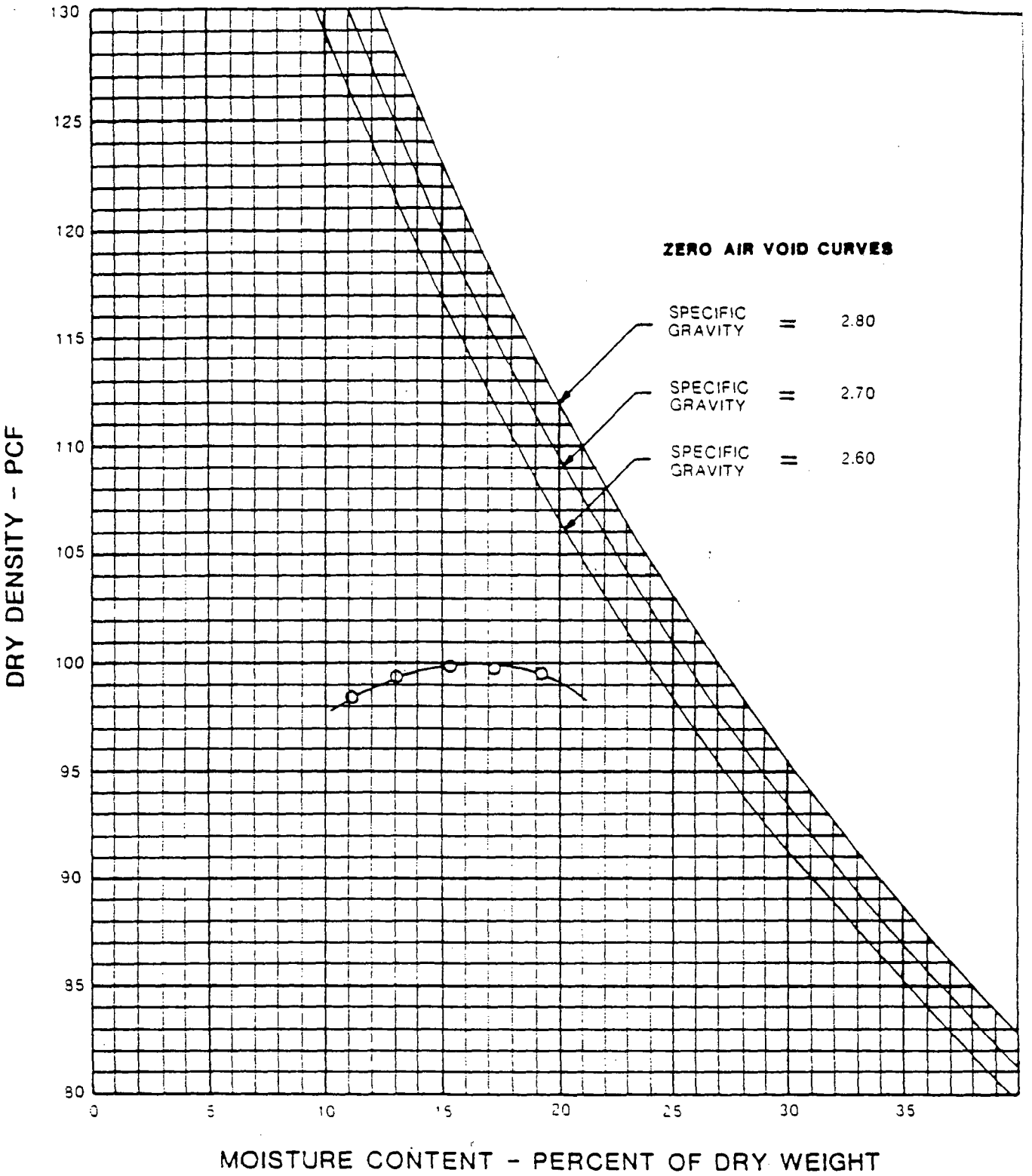
SAMPLE OF FROM

A-29

1 465 89	*Chen-Northern, Inc.*	GRADATION TEST RESULTS	Fig. 4

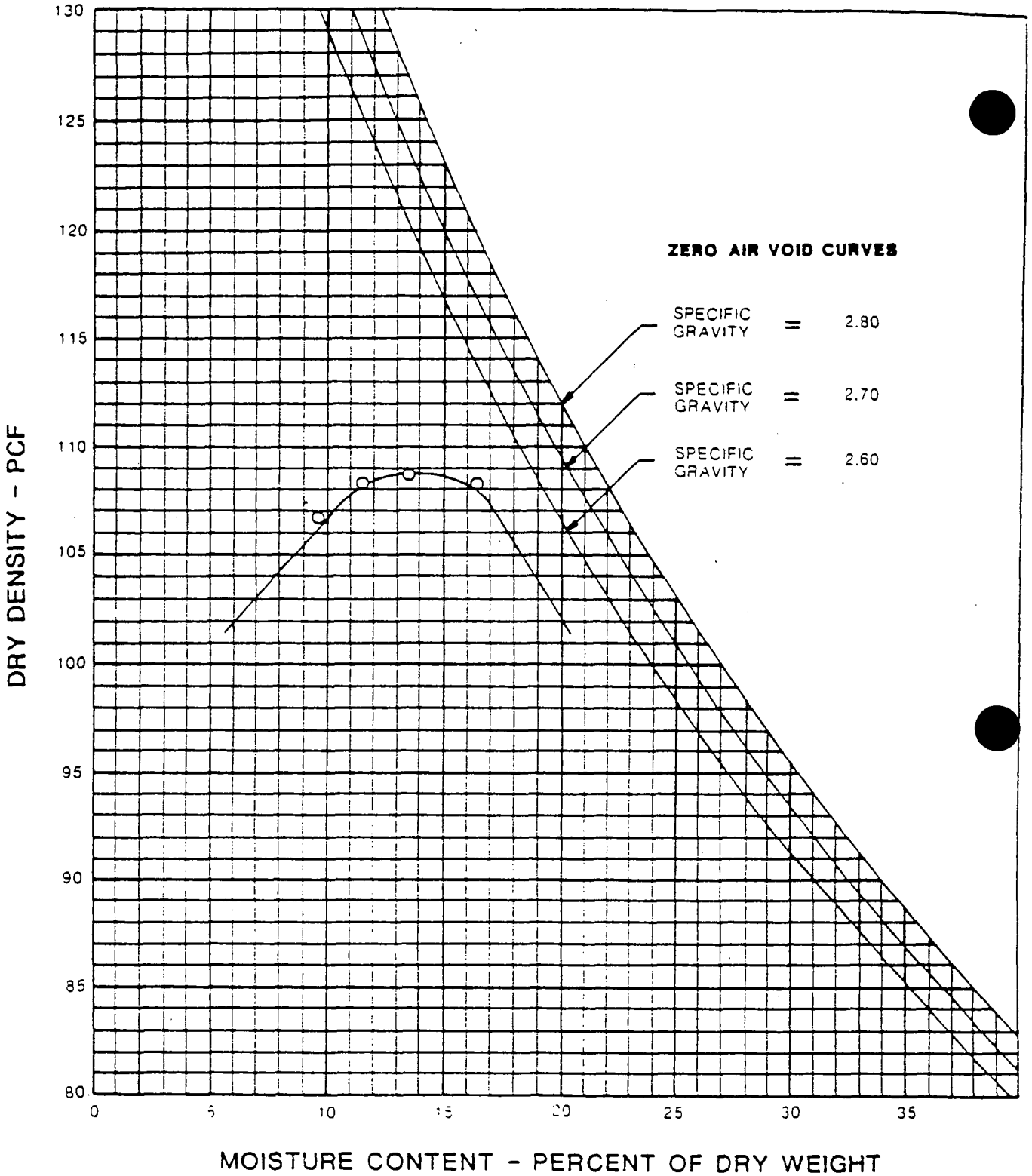
CA-2-79

A-30



A-30

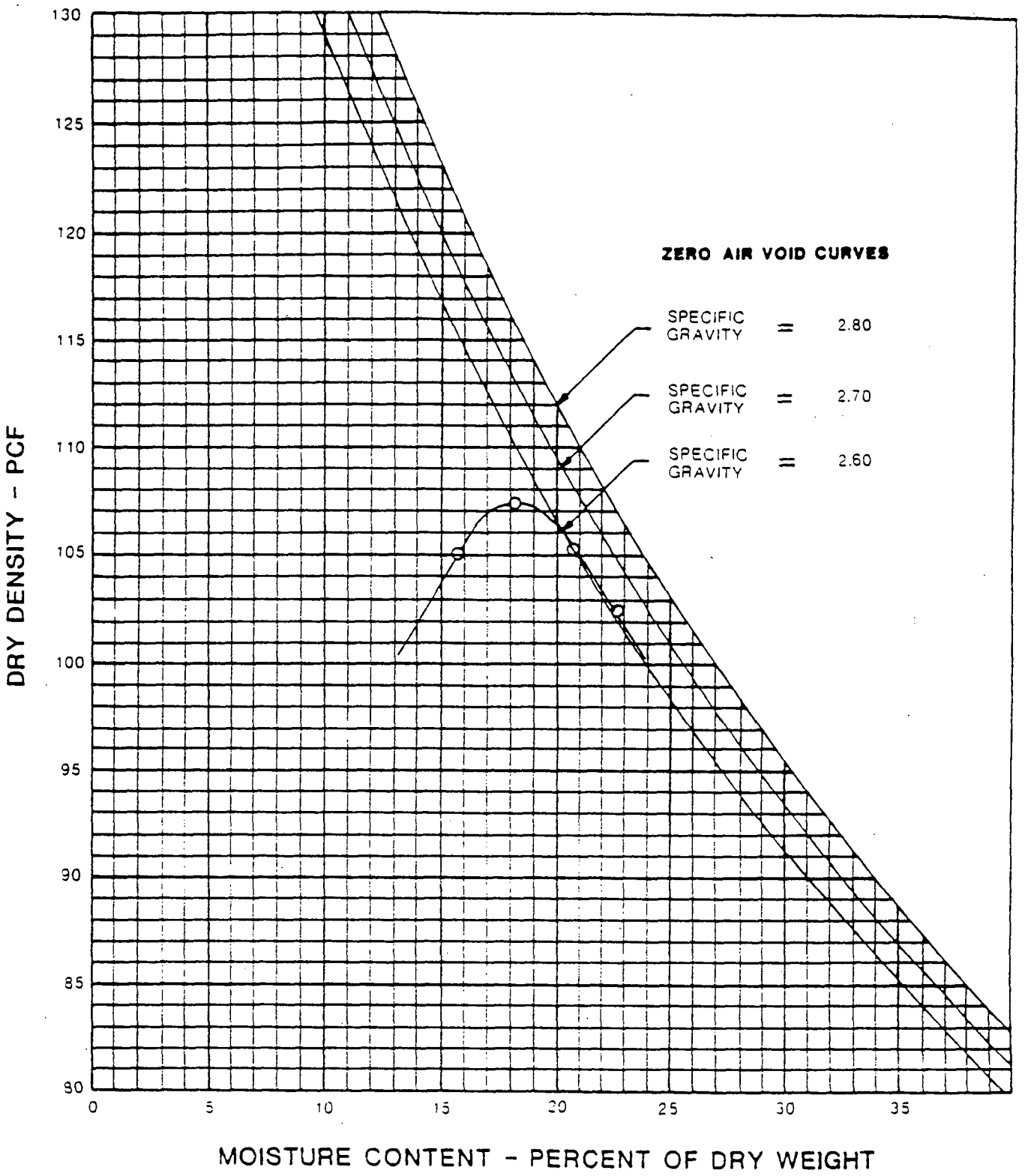
LOCATION : Windblown tailings		MOISTURE-DENSITY RELATIONSHIPS
HOLE NO. : DEPTH : SAMPLE NO : 1		
SOIL DESCRIPTION : Sand		*Chen-Northern, Inc.*
MAX. DRY DENSITY : 100.0 PCF OPT. MOIST. CONTENT : 16.5 %		PROCEDURE : ASTM D698-78, Method A
LIQUID LIMIT : - PLASTICITY INDEX : -	JOB NO. : 1 465 89	FIG. NO.
GRAVEL : 0 % SAND : 96 % SILT AND CLAY (-200) : 4 %	DATE : January 27, 1989	5



A-31

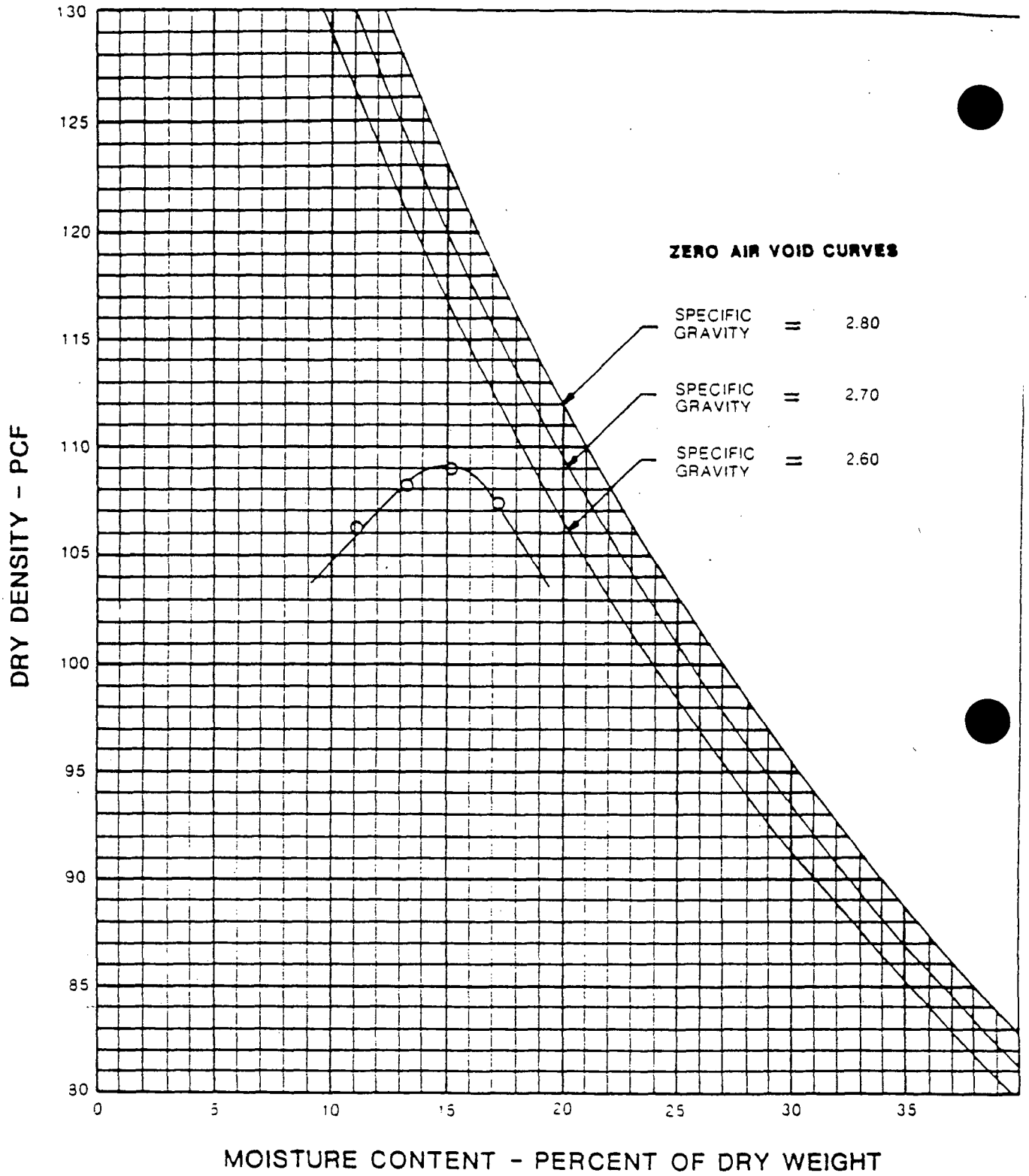
LOCATION : Alternate area cover		MOISTURE-DENSITY RELATIONSHIPS
HOLE NO. : DEPTH : SAMPLE NO. : 2		
SOIL DESCRIPTION Sand		Chen-Northern, Inc.
MAX. DRY DENSITY 108.9 PCF OPT MOIST CONTENT : 13.9 %		PROCEDURE : ASTM D698-78, Method A
LIQUID LIMIT : - PLASTICITY INDEX : -		JOB NO. : 1 465 89
GRAVEL : 0 % SAND : 96 % SILT AND CLAY (-200) : 4 %		DATE : January 27, 1989
		FIG. NO. 6

A35



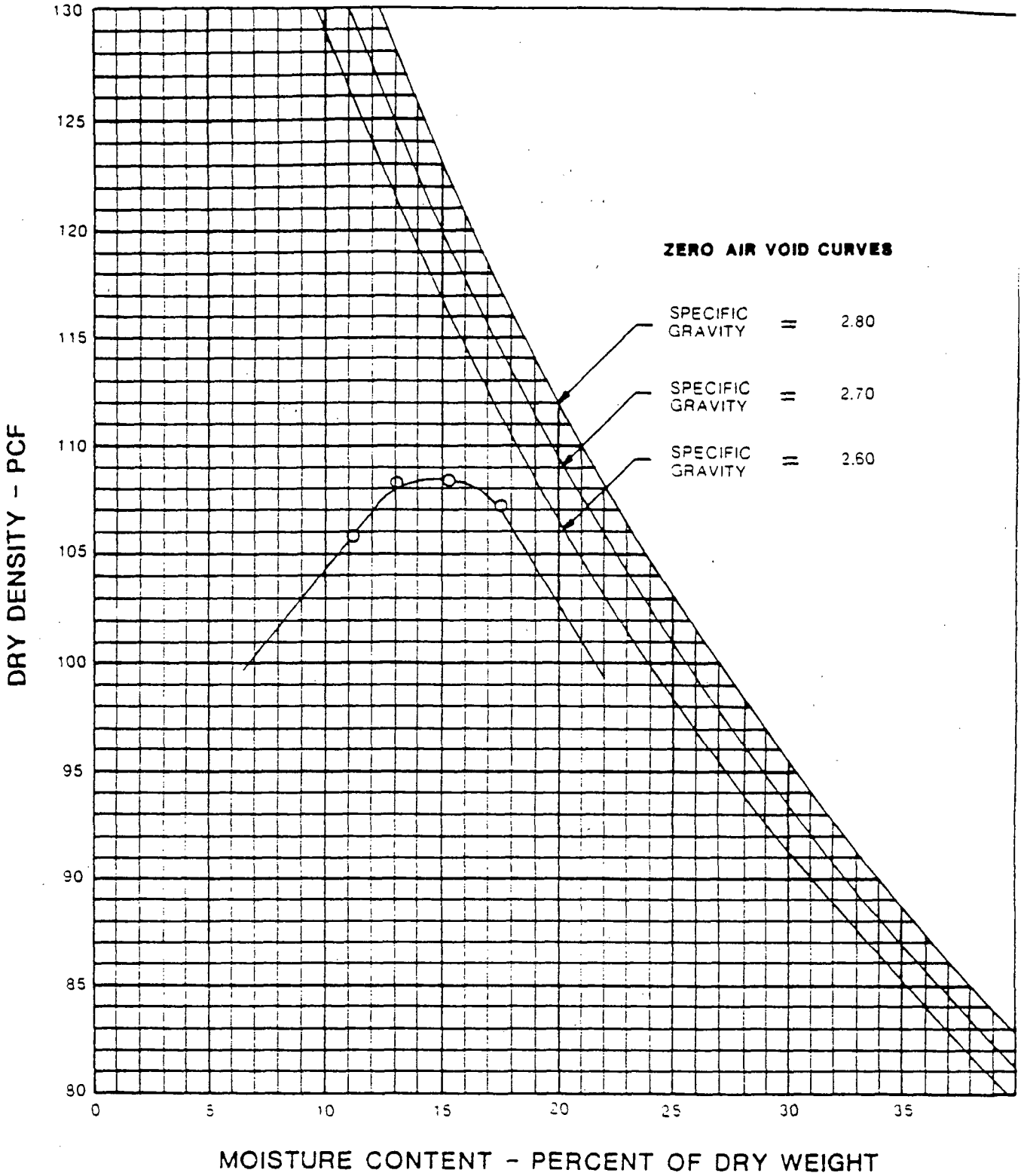
A-32

LOCATION : Cody Shale		MOISTURE-DENSITY RELATIONSHIPS
HOLE NO. : DEPTH : SAMPLE NO. : 3		
SOIL DESCRIPTION : Lean clay		*Chen-Northern, Inc.*
MAX. DRY DENSITY : 107.4 PCF OPT. MOIST. CONTENT : 18.1 %		PROCEDURE : ASTM D698-78, Method A
LIQUID LIMIT : 44 PLASTICITY INDEX : 25		JOB NO. : 1 465 89
GRAVEL : 0 % SAND : 4 % SILT AND CLAY (-200) : 96 %		DATE : January 27, 1989
		FIG. NO. 7



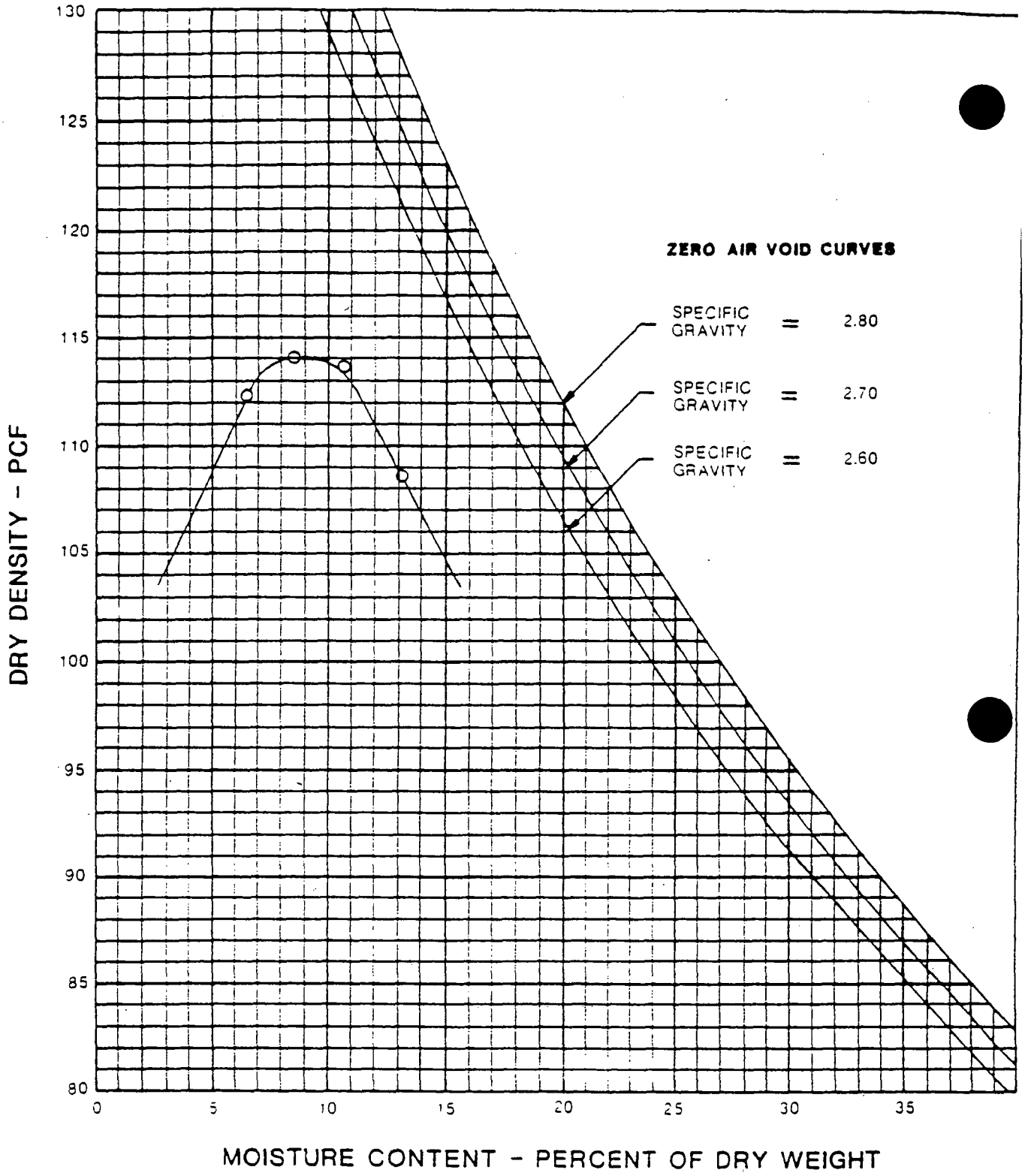
A-33

LOCATION : Borrow sand with 7% bentonite		MOISTURE-DENSITY RELATIONSHIPS
HOLE NO. : DEPTH : SAMPLE NO. : 4a		
SOIL DESCRIPTION Clayey sand		Chen-Northern, Inc.
MAX. DRY DENSITY 109.1 PCF OPT MOIST. CONTENT : 15.0 %		PROCEDURE : ASTM D698-78, Method A
LIQUID LIMIT : 35 PLASTICITY INDEX : 14		JOB NO. : 1 465 89
GRAVEL : 0 % SAND : 80 % SILT AND CLAY (-200) : 20 %		DATE : January 27, 1989
		FIG. NO. 8



A-34

LOCATION : Borrow sand with 9% bentonite		MOISTURE-DENSITY RELATIONSHIPS
HOLE NO. : DEPTH : SAMPLE NO. : 4b		
SOIL DESCRIPTION Clayey sand		Chen-Northern, Inc.
MAX. DRY DENSITY : 108.4 PCF OPT MOIST. CONTENT : 14.6 %		PROCEDURE : ASTM D698-78, Method A
LIQUID LIMIT : 43 PLASTICITY INDEX : 23		JOB NO. : 1 465 89
GRAVEL : 0 % SAND : 76 % SILT AND CLAY (-200) : 24 %		DATE : January 27, 1989
		FIG. NO. 9



A-35

LOCATION : Mill area soil		MOISTURE-DENSITY RELATIONSHIPS
HOLE NO. : DEPTH : SAMPLE NO. : 5		
SOIL DESCRIPTION : Slightly silty sand		Chen-Northern, Inc.
MAX. DRY DENSITY : 114.0 PCF OPT. MOIST. CONTENT : 9.0 %		PROCEDURE : ASTM D698-78, Method A
LIQUID LIMIT : - PLASTICITY INDEX : -		JOB NO. : 1 465 89 / FIG. NO.
GRAVEL : 0 % SAND : 85 % SILT AND CLAY (-200) : 11 %		DATE : January 27, 1989 / 10

00-174-03

Chen-Northern, Inc.

96 South Zuni
Denver, Colorado 80223
303/744-7105
Fax: 303/744-0210

Billings, Boise, Casper, Colorado Springs, Denver, Elko, Evanston, Gillette, Glenwood Springs, Great Falls, Helena, Phoenix, Pocatello, Rock Springs, Salt Lake City, San Antonio, Tri Cities, Yakima

February 16, 1989

Subject: Laboratory Testing, Canonie
Project No. 88-194-03, P.O. No. 5307

Job No. 1 465 89

Mr. Terry Braun
Canonie Environmental
94 Inverness Terrace East, Suite 100
Englewood, Colorado 80112

Dear Mr. Braun:

Enclosed are laboratory tests results for the referenced project. The testing includes, five gradation analyses, two hydrometer analyses, four Atterberg limits, six standard compaction tests, seven specific gravity tests, six porosity determinations, four capillary moisture tests and three preliminary permeability test results. The tests were conducted on soil and mine tailing samples received at our laboratory on January 23, 1989.

Final results for the permeability tests in progress will be sent to you upon completion. We estimate approximately one week for this. If you have any questions or if we can be of any further assistance, please call.

Sincerely,

CHEN-NORTHERN, INC.

By _____
Kenneth R. Criley, S.E.T.
Laboratory Manager

KRC/mq
Rev. By: RJT
Enclosures

Reference # A.3

Radium, Emanation Coefficients and Radon Diffusion Coefficient Analysis Results

Canonie Sample #'s 1,2,5, and 7

Provided By: Rogers and Associates Engineering Corporation

- February, 1989 -

Rogers & Associates Engineering Corporation

REPORT OF RADIUM AND EMANATION COEFFICIENT MEASUREMENTS
(LAB PROCEDURE RAE-SQAP-3.1)

REPORT DATE 2-13-89

CONTRACT C3900/6

BY RYB

SAMPLE IDENTIFICATION Canonie Soil & Tailing Samples

SUBMITTED BY RYB

DATE RECEIVED

SAMPLE NUMBER	MOISTURE (DRY WT. %)	RADON EMANATION COEFFICIENT*	RADIUM* (pCi/gram)	COMMENTS
#1 Windblown Tailings	5.5	0.21 ± 0.03	41 ± 1	
#2 Alternate Area Cover	2.3	Below Detection Limit	1.2 ± 0.04	
#5 Contaminated Mill Area Soils	5.8	0.25 ± 0.03	26 ± 1	
#7 Coarse Tailings	4.0	0.22 ± 0.02	45 ± 1	

*UNCERTAINTIES BASED ON GAMMA-RAY COUNTING STATISTICS ONLY.

RAE

POST OFFICE BOX 350
SALT LAKE CITY • UTAH 84110
(801) 233-1600

Rogers & Associates Engineering Corporation

REPORT OF RADON DIFFUSION COEFFICIENT MEASUREMENTS
(TIME-DEPENDENT DIFFUSION TEST METHOD RAE-SQAP-3.6)

REPORT DATE 2-13-89

CONTRACT C8900/6

BY RYB

SAMPLE IDENTIFICATION Canonie Soil & Tailing Samples

SUBMITTED BY RYB DATE RECEIVED

SAMPLE NUMBER	MOISTURE (DRY WT.%)	DENSITY (g/cm^3)	RADON DIFFUSION COEFF. (cm^2/s)	SATURATION[a] ($M\rho/P$)	COMMENTS Porosity
#1 Windblown Tailings	8.0	1.44	1.8E-02	0.26	0.448
#2 Alternate Area Cover	8.2	1.57	2.0E-02	0.32	0.404
#3 Cody Shale	13.6	1.64	3.9E-03	0.56	0.401
#4a Borrow w/ 7%Bentonite	10.8	1.66	4.9E-03	0.49	0.365
#4b Borrow w/ 9% Bentonite	11.0	1.65	3.5E-03	0.49	0.370
#5 Contaminated Mill Area	7.9	1.75	1.3E-02	0.45	0.310
#7 Coarse Tailings	8.6	1.51	1.7E-02	0.31	0.418

[a]BASED ON A SPECIFIC GRAVITY OF as specified g/cm^3.

RAE

POST OFFICE BOX 330
SALT LAKE CITY • UTAH 84110
(801) 263-1600

Reference # A.4

Geotechnical Testing Results

Density Tests and Standard Proctors

Provided By: Inberg-Miller Engineers

- September, 1991 -

QC: - FILE: LABORATORY RESULTS - 91-225 K-1
- PEC

INBERG-MILLER ENGINEERS

124 EAST MAIN STREET RIVERTON, WYOMING 82501-4397 307-856-8136

September 12, 1991 4779.3-RM

RECEIVED
SEP 19 1991
CANONIE-DENVER

Western Nuclear, Inc.
P.O. Box 630
Jeffrey City, Wyoming 82310

ATTENTION: MR. ROLAND COLLINS

RE: FIELD DENSITY TESTING RESULTS SUMMARY
JEFFREY CITY MINE RECLAMATION
JEFFREY CITY, WYOMING

Gentlemen:

This is a summary report of the field density tests which were performed in the mill area on the above-referenced project.

DATE TEST PERFORMED:	August 30, 1991
FIELD DENSITY TEST NUMBER:	Nos. MA-1 through MA-4 (Nuclear Method), MA-1A through MA-2A (Sand Cone Method), inclusive

In addition, a laboratory compaction test (Standard Proctor ASTM D698) was performed on a sample of the soils tested. This information was used to calculate the percent compaction at each test location. Results are attached.

As requested, one nuclear test and one sand cone test were performed next to each other at each test location. We have also enclosed copies of the raw field data generated for these tests, per your request.

We appreciate the opportunity to be of service to you on this project. If there are any questions regarding the enclosed information or if we may be of further assistance, please contact us.

Sincerely

INBERG-MILLER ENGINEERS

Jon C. Howell

Jon C. Howell, P.E.
Geotechnical Engineer

JCH:dcr:FC24

Enclosures as stated

A42

INBERG-MILLER ENGINEERS

124 EAST MAIN STREET RIVERTON, WYOMING 82501-4397 307-856-6136

REPORT OF FIELD COMPACTION TEST RESULTS

Project: Jeffrey City Mine Reclamation Date: September 12, 1991

To: Western Nuclear, Inc.
ATTENTION: MR. ROLAND COLLINS
P.O. Box 630
Jeffrey City, WY 82310

Job. No.: 4779.3-RM Test Date: August 30, 1991 Tests By: LEV

TEST METHODS:

FIELD DENSITY DETERMINATION
x Sand Cone Method (ASTM D1556)
x Nuclear Method (ASTM D2922)

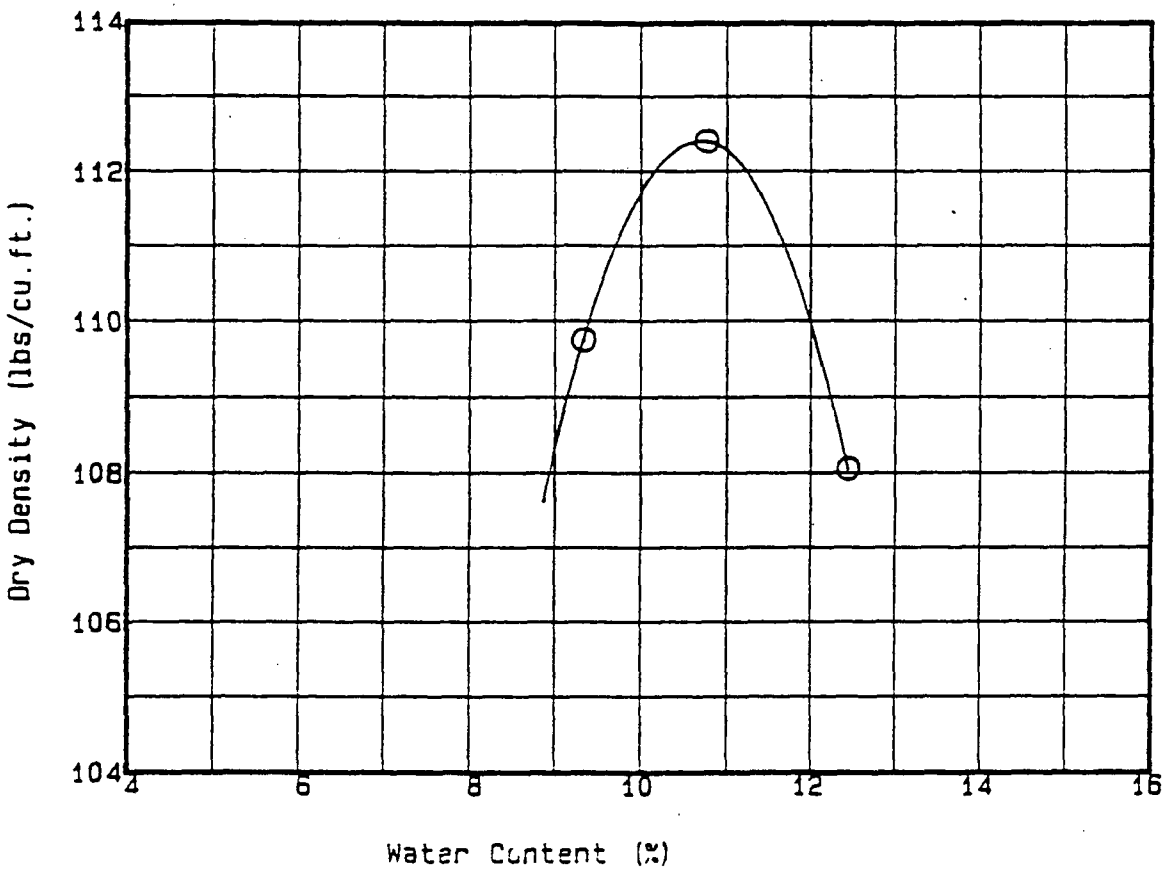
MOISTURE-DENSITY RELATIONSHIP
x Standard Proctor (ASTM D698)
___ Modified Proctor (ASTM D1557)

Test	Location	Test Elevation	Material Description	TEST RESULT Moisture Content %	Dry Density pcf	Optimum Moisture Content %	Maximum Dry Density pcf	Percent Compaction
	East side MA 1-2, see map	8" below existing grade	Brown, silty SAND	4.1	113.7	10.5	112.4	101
A-1A	East side MA 1-2, see map	4" below existing grade	"	5.0	106.1	10.5	112.4	94
A-2	West side MA 1-2, see map	8" below existing grade	"	2.5	110.0	10.5	112.4	98
A-2A	West side MA 1-2, see map	4" below existing grade	"	7.0	110.3	10.5	112.4	98
A-3	North side MA 3-4, see map	8" below existing grade	"	4.2	110.7	10.5	112.4	98
A-3A	North side MA 3-4, see map	4" below existing grade	"	7.1	109.5	10.5	112.4	97
-4	South side MA 3-4, see map	8" below existing grade	"	3.4	112.5	10.5	112.4	100
-4A	South side MA 3-4, see map	4" below existing grade	"	8.3	110.9	10.5	112.4	99

MOISTURE-DENSITY ANALYSIS

Project: J C MINE RECLAMATION
Job No.: 4779.3 RM
Client: WESTERN NUCLEAR

Test Date: 8/26/91
Tested By: LEV
Test Method:



Soil Description: BROWN SILTY SAND

Sample No.: 1
Sampled By: LEV
Source: COVER MATERIAL

% passing #200 sieve:

Liquid Limit:
Plasticity Index:

Optimum Water Content: 10.5 %
Max. Dry Density: 112.4 lbs/cu.ft.

Date 8-[illegible]-91

NUCLEAR DENSITY FIELD TEST

DIRECT TRANSMISSION METHOD

Technician LEU

A-44

Client Western Nuclear

Contractor Unknown

Job No. 4779.3 RM

Project JC Mine Reclamation

Model: 3401 B ___ 3411 B ✓ 2401 ___ Proctor: Standard ✓ Modified ___ Standard Count: Density 3070 Moisture 676

TEST NO.	LOCATION	TEST ELEVATION	MATERIAL DESCRIPTION	PROBE DEPTH	DC	DCR	WD	MC	MCR	MOIST. PCF	% MOIST.	DRY DENSITY	OPT. MOIST.	MAX DENSITY	COMP. / SPEC
MA-1 157	E side MA1-2 see map	8" Below Exsisting Grade	Brown silty Sand	8	2320		117.9	68		4.5	4.1	113.71	10.5	112.4	101 / 95
MA-2 158	W side MA1-2 "	" "	" "	8	2489		112.5	50		3.1	2.49	110.01	"	"	98 / 95
MA-3 159	N side MA-3-4 "	" "	" "	8	2331		114.6	65		4.0	4.2	110.7	"	"	98 / 95
MA-4 160	S side MA 3-4 "	" "	" "	8	2250		116.0	61		3.6	3.4	112.5	"	"	100 / 95

Date 8-20-91

Client Western Nuclear

Job No 4729.3 RM

UNIT WEIGHT BY SAND CONE METHOD

Sand Density #1 97.01, #2 96.33, #3 97.93, Avg 97.93 P.C.F. Date Calibrated 8-20-91 (8-20-91, 7-12-91, 8-29-91, 8-29-91)

Technician LEL

Contractor Unknown

Project JC Mine Reclamation

A-45

	FUNNEL CALIBRATION			WEIGHT OF WET SOIL			VOLUME OF HOLE						MOISTURE CONTENT						DENSITY	
TEST NO.	WT. JUG FULL	WT. JUG EMPTY	WT. SAND IN FUNNEL	WT. WET SOIL W/ TARE	WT. TARE	WT. SOIL	WT. JUG FULL	WT. JUG EMPTY	WT. SAND USED	WT. SAND IN FUNNEL	WT. SAND TO FILL HOLE	HOLE VOLUME	WT. WET SOIL W/ TARE	WT. DRY SOIL W/ TARE	WT. WATER	WT. TARE	WT. DRY SOIL	% MOISTURE	WET DENSITY	DRY DENSITY
1.A	15.00 lb	12.07 lb	2.93 lbs	5.55 lb	258.5 gr	4.98 lb	15.00 lb	7.73 lbs	7.27 lbs	2.93 lbs	4.34 lb	.0447 ft³	2961.1 g	1923.97 gr	92.14 gr	829.2 gr	1094.0 gr	5.00	111.41	106.1
2A	14.92 lb	11.02 lbs	3.90 lbs	3.43 lbs	1686.2 lb	2.74 lb	8.75 lb	2.60 lbs	6.15 lb	3.90 lb	2.25 lb	.0232 ft³	1392.3 gr	1306.2 gr	86.1 gr	84.79 gr	1221.81 gr	7.05	118.1	110.3
3A	14.95 lb	11.01	3.94 lbs	1673.73 gr	338.79 g	1335.34 g	12.16 lb	5.76 lb	6.40 lb	3.94 lb	2.46 lb	.0251 ft³	525.52 g	496.1 gr	29.41 g	82.85 gr	413.26 gr	7.12	117.28	109.5
4A	"	"	3.94 lbs	1896.05 gr	338.0 gr	1558.05 g	15.06 lb	8.32 lb	6.74 lb	3.94 lb	2.80 lb	.0286 ft³	699.0 g	651.1 g	47.90 g	82.31 gr	569.29 g	8.33	120.10	110.9

REPORT DATA

TEST NO.	LOCATION	TEST ELEVATION	MATERIAL DESCRIPTION	% MOISTURE	DRY DENSITY	OPT. MOISTURE	MAX. DENSITY	% COMP.
1A	E side MA-1-2 see map for location	4" Below Existing Grade	Brown Silty Sand	5.0	106.1	10.5	112.4	94
2A	W side MA-1-2 " " "	" " "	" " "	7.0	110.3	10.5	112.4	98
3A	N side MA 3-4 " " "	" " "	" " "	7.1	109.5	10.5	112.4	97
4A	S side MA 3-4 " " "	" " "	" " "	8.3	110.9	10.5	112.4	99

A46

Reference #A.5

Tailing Sampling Summary

Provided by: Shepherd Miller, Inc.

- January 1993 -

Reference A.5
Tailing Sampling Summary

The drilling and sampling segment of the program to characterize the tailings in the mill area, the alternative tailings area, the eastern portion of the new tailings and the old tailings impoundment at Jeffrey City, Wyoming was completed between January 11, 1993 and January 15, 1993. Chen Northern, Inc. out of Denver, Colorado performed the drilling and sampling. The drilling was performed with a hollow stem auger mounted on an all terrain vehicle (ATV) that facilitated accessibility.

A total of 25 borings were drilled. Sampling was performed with a 18" long, 1' diameter, Split Spoon sampler and a 12" long, 1" diameter, California tube sampler. The California tube sampler contained four 3" long tubes that slipped out of the sampler tube to allow for transport to the laboratory. The samples in the California tubes are considered to be "undisturbed" and will, therefore, be tested for in situ density. The Split Spoon samples will be tested for radium and percent passing the No. 200 sieve. Once these two initial tests are conducted, the samples will be composited to provide for the determination of emanation coefficient, specific gravity and 15-bar moisture content.

A total of seven samples were taken per hole with the samplers described above. The samplers were alternated as depth increased in the hole. For example, after drilling the first two feet of each hole, a sample was taken with the Split Spoon sampler, drilling then progressed to four feet and a California tube sample was taken. This alternating of samplers progressed through to the prescribed 15 foot depth. The location of each of the borings is provided in Figure A.5.1. (page A-49).

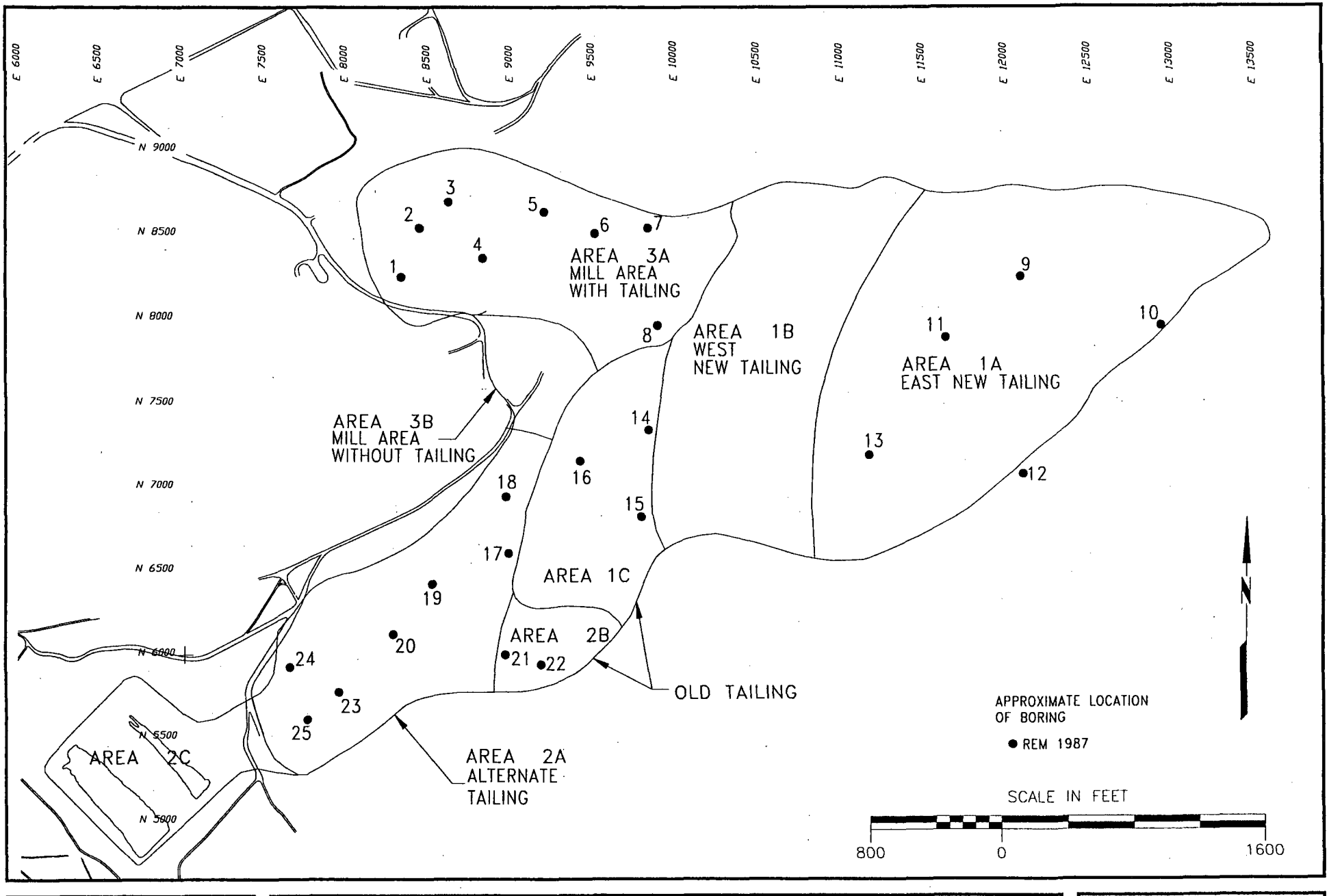
The Split Spoon samples were visually identified as sand, sandy slimes, slimes, or, in some cases, native soil with organics and separated accordingly into plastic bags. The California tube samples were taped together, marked and capped on the ends. The visual description of the Split Spoon samples and depth of each sample was recorded on a borehole log. The borehole logs for each of the locations presented in Figure A.5.1 are provided on pages A-50 to A-74 along with this report.

The two holes marked #10 and #12 on the location in Figure A.5.1 were drilled to native soil. According to Roland Collins, native soil was considered to be brown sand with organics. Native soil was reached at approximately 14.5 feet to 15 feet.

A total of 375 feet of borehole was drilled. After visually separating the Split Spoon samples and counting each individual tube in the California tube sampler, a total of 431 separated samples were taken which amounted to a volume of approximately 0.769 ft^3. A summary of the daily drilling progress is provided in Table A.5.1.

Table A.5.1: Summary of Daily Drilling Progress

Date	Borehole	Footage	# Samples	Volume (ft^3)
1-11	1	15	21	0.034
1-11	2	15	18	0.032
1-11	3	15	12	0.023
1-12	4	15	16	0.027
1-13	5	15	16	0.027
1-13	6	15	18	0.033
1-13	7	15	17	0.030
1-13	8	15	17	0.030
1-13	9	15	20	0.038
1-14	10	15	19	0.035
1-13	11	15	17	0.030
1-14	12	15	19	0.035
1-13	13	15	17	0.030
1-14	14	15	18	0.033
1-14	15	15	18	0.033
1-14	16	15	18	0.033
1-14	17	15	17	0.030
1-14	18	15	16	0.027
1-14	19	15	14	0.026
1-15	20	15	16	0.027
1-15	21	15	16	0.027
1-15	22	15	16	0.027
1-15	23	15	18	0.033
1-15	24	15	18	0.034
1-15	25	15	19	0.035
Totals		375	431	0.769



SMI
SHEPHERD MILLER, INC.

FIGURE A.5.1
BORING LOCATIONS

Date: OCT., 1993
Project: 336
File: BO

(REVISED ADDENDUM A 1/94) A49

A50

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 1
PROJECT NO.: 333 DATE: 01/11/93
BORING NO.: 1 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-1

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
				0	SAND-TAN, FINE TO MEDIUM COARSE
1					
2					
			>50 6"	10"	SAND-TAN, FINE TO MEDIUM COARSE MOIST, SOME YELLOW CLODS
3					
				0	
4			26 12"	3"	
5					
				0	
6			26 12"	12"	SAND-TAN, FINE TO MEDIUM COARSE
7				0	
8			26 12"	12"	
9				0	
10			26 12"	12"	SAND-TAN AND RUST, FINE TO MEDIUM COARSE SOME YELLOW POCKETS, MOIST
1					
				0	
2			14 12"	12"	
3				0	
4			15 12"	12"	SAND-TAN, FINE TO MEDIUM COARSE MOIST
5					

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

HS1

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 2
PROJECT NO.: 333 DATE: 01/11/9
BORING NO.: 2 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-2

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
				0	SAND-TAN, FINE TO MEDIUM COARSE
1			65 12"	12"	
2				0	
3			23 12"	12"	SAND-TAN, FINE TO MEDIUM COARSE MOIST
4				0	
5			8 12"	12"	
6					
7			7 12"	12"	SAND-TAN WITH BROWN LAYERS FINE TO MEDIUM COARSE, MOIST
8				0	
9			7 12"	12"	
10				0	
1			6 12"	12"	TOP 10" SAND-TAN, FINE, MOIST BOTTOM 2" ORANGE, OLIVE, RUST SLIMES
2				0	
3			11 12"	18"	SAND-TAN AND RUST MEDIUM COARSE BOTTOM 8" BROWN/GRAY FINE SAND
4					
5					

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

A-52

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 3
PROJECT NO.: 333 DATE: 01/11/93
BORING NO.: 3 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-3

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	1
2			>50 12"	12"	2 SAND-TAN, FINE TO MEDIUM COARSE MOIST
3				0	3
4			>50 12"	3"	4 SAND-TAN, FINE TO MEDIUM COARSE MOIST (LAST 3 TUBES IN BAG)
5				0	5
6			6 12"	18"	6 SAND-TAN, FINE TO MEDIUM COARSE MOIST
7					7
8				0	8
9			8 12"	12"	9
10				0	0
1			4 12"	16"	1 SAND-TAN W/SOME BUFF, FINE TO MEDIUM COARSE, MOIST
2				0	2
3			7 12"	6"	3
4				0	4
5			<1 12"	6"	5 VERY SOFT - SAND, TAN-RUST FINE TO MEDIUM COARSE, MOIST

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

A53

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 4
PROJECT NO.: 333 DATE: 01/12/9
BORING NO.: 4 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-4

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	
2			15 12"	12"	
3				0	
4			8 12"	12"	SAND-TAN, FINE TO MEDIUM COARSE MOIST
5				0	
6			13 12"	12"	
7				0	
8			4 12"	12"	SAND-TAN, FINE TO MEDIUM COARSE MOIST
9				0	
10			8 12"	12"	
1				0	
2			7 12"	12"	SAND-TAN, FINE TO COARSE, MOIST SOME WOOD AND FIBERS
3				0	
4				12"	SAND WITH WOOD FIBERS, TAN AT TOP RUST IN BOTTOM 2", SOME WOOD FIBER, FINE TO MEDIUM COARSE
5					

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

A54

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 5
PROJECT NO.: 333 DATE: 01/13/93
BORING NO.: 5 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-5

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	
2			>50 12"	12"	SAND-TAN & RUST, FINE TO MEDIUM COARSE
3				0	TOP 6" FROZEN, MOIST BELOW
4			>50 12"	12"	
5				0	
6			22 12"	12"	TOP 4" SAND-TAN, FINE TO MEDIUM COARSE
7				0	BOTTOM 8" RUST FINE SAND, MOIST
8			37 12"	12"	
9				0	
10			27 12"	12"	SAND-TAN, FINE TO MEDIUM, MOIST
1				0	TOP 1-2" SOME RUST
2				12"	
3				0	
4			26 12"	0	SAMPLE WOULD NOT STAY IN SPOON
5					

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

A55

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 6
PROJECT NO.: 333 DATE: 01/13/9
BORING NO.: 6 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-6

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	
2				12"	
3				0	
4			26	12"	BOTTOM 6" BROWN SAND MEDIUM TO FINE
5			12"		TOP 6" TAN SAND FINE TO MED. COARSE
				0	
6			28	12"	
7			12"		
				0	
8			42	12"	TOP 6" TAN W/BROWN LAYER SAND
9			12"		BOTTOM 6" GRAY-BROWN SLIMES, MOIST
				0	
10				12"	
1				0	
2			41	12"	SAND-TAN & BROWN, FINE TO MED., MOIST
3			12"		
				0	
4			21	12"	TOP 6" BROWN BOTTOM 6" TAN FINE
5			12"		TO COARSE SAND, MOIST

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

A56

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 7
PROJECT NO.: 333 DATE: 01/13/93
BORING NO.: 7 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-7

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN , FINE TO MEDIUM COARSE
1				0	
2			21 12"	12"	SAND-TAN , FINE TO MEDIUM COARSE COLD
3				0	
4			17 12"	12"	
5				0	
6			19 12"	12"	TOP 4" SAND-TAN, FINE TO MEDIUM COARSE BOTTOM 8" BRN SAND FINE TO MED., MOIST
7				0	
8				12"	
9				0	
10			14 12"	12"	SAND-TAN, FINE TO MEDIUM COARSE, MOIST
1				0	
2			30 12"	12"	
3				0	
4			17 12"	0	SAND-TAN, FINE TO MEDIUM COARSE, MOIST
5					

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

A57

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 8
PROJECT NO.: 333 DATE: 01/13/97
BORING NO.: 8 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-8

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	
2			68 12"	12"	
3				0	
4			31 12"	12"	TOP 4" GRAY-BUFF MED. COARSE SAND
5					BOTTOM 8" TAN, BUFF, YELLOW MED COARSE
				0	
6				12"	
7				0	
8			50 12"	12"	SAND-TAN, FINE TO MEDIUM COARSE
9					MOIST
				0	
10			40 12"	12"	
1				0	
2			30 12"	12"	SAND-TAN, BUFF MED. COARSE, MOIST
3				0	
4			23 12"	12"	SAND-TAN MED. COARSE WITH GRANULE SIZE
5					QUARTZ GRAINS, MOIST

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

A 58

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 9
PROJECT NO.: 333 DATE: 01/13/93
BORING NO.: 9 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-9

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN FINE TO MED COARSE
1				0	1
2			7 12"	12"	2 TOP 8" TAN SAND
3					3 BOTTOM 4" GRAY SLIMES
				0	
4				12"	4
5					5
				0	
6			17 12"	18"	6 TOP 6" GRAY SLIMES MOIST
7					7 BOTTOM 12" TAN SAND WITH GRAY SLIMES, MOIST
				0	
8				12"	8
9					9
				0	
10			44 12"	18"	0 TOP 6" GRAY SLIMES, MOIST MIDDLE 6" TAN
1					1 MED. TO FINE SAND, MOIST BOTTOM 6" SAND/SLIMES BUFF, GRAY BRN/BLK
				0	
2				12"	2
3					3
				0	
4			23 12"	18"	4 SAND-TAN FINE TO MED COARSE
5					5 WET TO MOIST

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

A 57

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 10
PROJECT NO.: 333 DATE: 01/13/9
BORING NO.: 10 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-10

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	1
2			50/6"	6"	2 SAND-TAN, FINE TO MEDIUM COARSE
3				0	3
4			24 12"	12"	4
5				0	5
6			38 12"	18"	6 TOP 15" GRAY TO BUFF SANDY SLIMES
7					7 W/POCKET OF ORANGE-RUST SLIME BOTTOM 3" SAND-TAN MED TO FINE, MOIST
8			22 12"	0 12"	8
9				0	9
10			10 12"	18"	0 TOP 17" TAN & GRAY BUFF FINE TO MED.
1					1 SAND, MOIST BOTTOM 1" DK BRN SILTY-CLAYEY SAND W/ORGANICS
2			13 12"	0 12"	2
3				0	3
4				18"	4 BOTTOM 14" BROWN FINE SAND W/SOME
5					5 ORGANICS, MOIST TOP 4" DK BROWN CLAYEY SAND W/ORGANICS

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

n6U

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 11
PROJECT NO.: 333 DATE: 01/13/93
BORING NO.: 11 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-11

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	1
2			20 12"	12"	2 SAND-TAN, FINE TO MEDIUM COARSE
3				0	3 FROZEN
4			15 12"	12"	4
5				0	5
6			7 12"	18"	6 TOP 9" GRAY & TAN SLIME & SAND, MOIST
7					7 BOTTOM 9" TAN SAND FINE TO MED. COARSE WET
8				0	8
				12"	VERY WET
9				0	9
10			23 12"	12"	0 SAND-TAN, FINE TO MEDIUM COARSE
1				0	1 WET
2				12"	2
3				0	3
4			14 12"	0	4 SAND-TAN FINE TO COARSE, WET
5					5

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

A 6'

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 12
PROJECT NO.: 333 DATE: 01/14/97
BORING NO.: 12 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-12

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MED COARSE
1				0	
2			60 6"	6"	SAND-TAN TO BUFF, FINE TO MED COARSE W/ QUARTZ GRANULES TOP 4" MOIST
3				0	
4			21 12"	12"	
5				0	
6			11 12"	12"	TAN SOME GRAY, FINE TO MED. COARSE SAND MOIST, QUARTZ GRANULES
7				0	
8			10 12"	12"	
9				0	
10			12 12"	18"	TOP 6" TAN SAND MIDDLE 2" GRAY SLIMES BOTTOM 10" DK BRN SILTY SAND WITH PEBBLES, ORGANICS
1				0	
2			12 12"	12"	
3				0	
4			21 12"	18"	TOP 6" DK BRN SILTY-CLAY-SAND W/PEBBLES & ORGANICS BOTTOM 12" SAND TAN MED. COARSE FINE
5					

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

A 62

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 13
PROJECT NO.: 333 DATE: 01/13/93
BORING NO.: 13 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-13

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MED COARSE
1				0	
2			50 12"	12"	BOTTOM 4" GRAY SLIMES W/SAND
3					TOP 8" SAND-FROZEN TAN FINE TO MED
				0	
4			27 12"	12"	
5					
				0	
6			8 12"	12"	SAND-FINE TO MED COARSE, TAN W/SOME YELLOW, WET
7					
				0	
8			3 12"	12"	
9					
				0	
10			1 12"	12"	GRAY SLIMES, WET
1					
				0	
2			1 12"	12"	
3					
				0	
4			1 12"	12"	GRAY SLIMES, VERY WET
5					

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

A 63

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 14
PROJECT NO.: 333 DATE: 01/14/9
BORING NO.: 14 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-14

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	1
2			50 12"	10"	2 TOP 2" RUST SAND & BOTTOM 8" TAN-BUFF SAND MED-FINE
3				0	3
4			24 12"	12"	4
5				0	5
6			50 12"	12"	6 TAN-FINE TO MED SAND, MOIST & BUFF
7				0	7
8			29 12"	12"	8
9				0	9
10			20 12"	18"	0 TOP 8" SAND-BUFF W/YELLOW, BOTTOM 8" SAND BUFF W/YELLOW, MIDDLE 2" GRAY SLIME, MOIST
1					1
2			18 12"	0 12"	2
3				0	3
4			21 12"	18"	4 TOP 3" AND BOTTOM 13" SAND GRAY TO BUFF W/TAN LAYERS FINE TO MED COARSE MIDDLE 2" GRAY SANDY SLIMES
5					5

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY
PAGE: 15
PROJECT NO.: 333
DATE: 01/14/93
BORING NO.: 15
LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER
ACAD FILE: BLOG-15

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	1
2			27 12"	12"	2 TAN W/SOME YELLOW POCKETS FINE TO MED
3				0	3 COARSE SAND, MOIST
4			17 12"	12"	4
5				0	5
6			24 12"	12"	6 TAN & GRAY FINE TO MED COARSE SAND
7				0	7 1/4" SANDY SLIME LAYERS 3" FROM BOTTOM
8				12"	8
9				0	9
10			25 12"	12"	0 TOP 4" BUFF GRAY SAND FINE TO MED
1				0	1 NEXT 4" SANDY SLIME W/GRAY SAND LAST 4" MOIST SAND W/SOME YELLOW
2				12"	2
3				0	3
4			17 12"	12"	4 GRAY-BUFF SAND MED TO FINE W/1/2"
5					5 POCKET OF SANDY SLIME GRAY 4" FROM BOTTOM

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

A65

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 16
PROJECT NO.: 333 DATE: 01/14/9
BORING NO.: 16 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-16

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	1
2					2
			50		TOP 8" RED SANDY-CLAY OR CLAYEY SAND
			12"	18"	BOTTOM 10" BUFF-GRAY SAND
3					3
				0	
4			23		4
			12"	12"	
5					5
				0	
6					6
			17		TOP 6" BUFF, GREY, RED SAND FINE
			12"	18"	NEXT 1" MOIST, RED SAND
7					7 LAST 5" SANDY SLIME RED-GREY, MOIST
				0	
8			17		8
			12"	12"	
9					9
				0	
10					0
			16		SAND BUFF-GRAY FINE MED COARSE, MOIST
			12"	18"	GRAY SANDY SLIME @ 10'6" (1/2" LAYER)
1					1
				0	
2			16		2
			12"	12"	
3					3
				0	
4					4
			14		SAND GRAY BUFF FINE TO MED COARSE
			12"	18"	W/ 1/2" GRAY SANDY SLIME @ 14'6"
5					5

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 17
PROJECT NO.: 333 DATE: 01/14/93
BORING NO.: 17 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-17

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	1
2			50 12"	8"	2 SAND TAN & RUST FINE TO MED COARSE
3				0	3
4			15 12"	12"	4
5				0	5
6			13 12"	18"	6 TOP 6" SAND-TAN GRAY, FINE TO MED, MOIST
7					7 BOTTOM 12" SAND-GREY MED COARSE, MOIST
8				0	8
9			16 12"	12"	9
10				0	0
1			32 12"	18"	1 SAND-GRAY MED TO COARSE, MOIST (SOME TAN-VERY LITTLE AT TOP)
2				0	2
3			17 12"	12"	3
4				0	4 SAND BUFF GRAY MED TO COARSE, MOIST
5			19 12"	18"	5 TOP 1" HAS GRAY (DARK) LENSES 1/4" THICK

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 18
PROJECT NO.: 333 DATE: 01/14/9
BORING NO.: 18 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-18

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	
2			50/12"	4"	V. HARD, TAN, SAND, FINE TO MED. FROZEN
3				0	
4			26 12"	12"	
5				0	
6			10 12"	18"	SAND-TAN W/ BUFF LAYERS MEDIUM TO FINE, MOIST
7					
8			11 12"	0 12"	
9				0	
10			14 12"	18"	SAND GREY-BUFF MED TO FINE, MOIST
1					
2			17 12"	0 12"	
3				0	
4			11 12"	18"	14'-15' TAN/BUFF GRAY MED SAND, MOIST
5					15"-15 1/2" SANDY (SLIMES?) GRAY 15 1/2"-15'6" BUFF GRAY SAND MED MOIST, 1/2" YELLOW BUFF SAND BELOW

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

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SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 19
PROJECT NO.: 333 DATE: 01/14/93
BORING NO.: 19 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-19

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	1
2					2
			27		SAND-TAN, FINE TO MEDIUM COARSE
3			12"	18"	3 SOME WOOD FIBERS
				0	
4			11		4
			12"	12"	
5					5
				0	
6					6 SAND-TAN, FINE TO MEDIUM COARSE, MOIST
			12		
7			12"	18"	7
				0	
8					8
				3"	
9					9
				0	
10					0 SAND-TAN, FINE TO MEDIUM, MOIST
			30		
1			12"	18"	1 TOP 3" LITTLE MORE FINE
				0	
2			16		2
			12"	12"	
3					3
				0	
4					4 TOP 8" SAND-TAN, FINE TO MED, MOIST
			19		
5			12"	18"	5 BOTTOM 10" SAND-BROWN & RUST, FINE MOIST

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 20
PROJECT NO.: 333 DATE: 01/15/9
BORING NO.: 20 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-20

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	1
2			50 12"	12"	2 SAND-TAN, FINE TO MEDIUM COARSE SOME FROZEN
3				0	3
4			16 12"	12"	4
5				0	5
6			17 12"	18"	6 SAND-TAN, FINE TO MEDIUM COARSE, MOIST
7					7
8			24 12"	0 12"	8
9				0	9
10			18 12"	18"	0 SAND-TAN, FINE TO MEDIUM COARSE, MOIST TOP 2" LIGHT BROWN LAYERS 1/4" THICK
1				0	1
2			16 12"	12"	2
3				0	3
4			19 12"	18"	4 TAN TO RUST FINE TO MED COARSE, RUST AT BOTTOM 1-2", BROWN AT TOP 2"
5					5

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

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SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 21
PROJECT NO.: 333 DATE: 01/15/93
BORING NO.: 21 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-21

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	1
2			50 12"	12"	2 SAND-TAN, FINE TO MEDIUM COARSE, MOIST
3				0	3
4			21 12"	12"	4
5				0	5
6			19 12"	18"	6 SAND-TAN, FINE TO MEDIUM COARSE, MOIST
7					7
8			13 12"	0 12"	8
9				0	9
10			20 12"	18"	0 SAND-TAN, FINE TO MEDIUM COARSE, MOIST
1				0	1
2			12 12"	12"	2
3				0	3
4			14 12"	12"	4 SAND-TAN, FINE TO MEDIUM COARSE, MOIST
5					5

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

A 71

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY
PAGE: 22
PROJECT NO.: 333
DATE: 01/15/9
BORING NO.: 22
LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER
ACAD FILE: BLOG-22

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	
2			50 12"	12"	SAND-TAN TO RUSTY BROWN FINE TO MED., FROZEN CLODS (LIGHT AT BOTTOM)
3				0	
4			36 12"	12"	
5				0	
6			30 12"	18"	TAN LAYERS W/LITE BROWN FINE TO MED. COARSE, MOIST, SAND
7					
8			24 12"	0 12"	
9				0	
10			24 12"	18"	SAND-TAN, FINE TO MEDIUM, COARSE
1					
2			17 12"	0 12"	
3				0	
4			15 12"	18"	RUSTY BROWN FINE TO MED COARSE, SAND MOIST
5					

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

A 76

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 23
PROJECT NO.: 333 DATE: 01/15/93
BORING NO.: 23 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-23

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	
2			10 12"	12"	2'-2'9" TAN FINE TO MED. COARSE SAND
3					2'9"-3' GRAY SANDY SLIME, MOIST
				0	
4			8 12"	12"	
5					
				0	
6			11 12"	12"	6'-6'3" SAND TAN FINE TO MED COARSE
7					6'3"-6'6" GRAY SLIMES NO SAND, MOIST
				0	6'6"-7' SAND TAN FINE TO MED COARSE
8			15 12"	12"	
9					
				0	
10			26 12"	12"	TAN MED TO FINE MOIST SAND
1					
				0	
2			16 12"	12"	
3					
				0	
4			26 12"	18"	TAN TO RUSTY BROWN FINE TO MED SAND
5					MOIST- DARKER TOWARDS BOTTOM

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

A 73

SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 24
PROJECT NO.: 333 DATE: 01/15/9
BORING NO.: 24 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-24

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	1
2			50 12"	10"	2 SAND-TAN, FINE TO MEDIUM COARSE, MOIST
3				0	3
4			17 12"	12"	4
5				0	5
6			36 12"	18"	6 6" -6'3" SAND-TAN, MOIST, FINE TO MED.
7					7 6'3"-7'3" SANDY SLIMES, MOIST, GRAY 7'3"-7'6" GRAY SANDY, SOME SLIMES, MED.
8				0	8
9			22 12"	12"	9
10				0	0
1			15 12"	18"	1 10'-10'6" & 11'-11'6" GRAY SANDY SLIMES 10'6"-11' GRAY SAND, MEDIUM COARSE
2				0	2
3			23 12"	12"	3
4				0	4
5			13 12"	16"	5 SAND TAN BUFF FINE TO MED COARSE, MOIST

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

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SMI
SHEPHERD MILLER, INC.

DRILLING LOG

PROJECT: WNI JEFFERY CITY PAGE: 25
PROJECT NO.: 333 DATE: 01/15/93
BORING NO.: 25 LOCATION:
TYPE OF DRILLING: HOLLOW STEM AUGER ACAD FILE: BLOG-25

DEPTH (FT)	WELL LOG	SAMPLE TYPE	NO. OF BLOWS	RECOVERY (FT)	SOIL DESCRIPTION
					SAND-TAN, FINE TO MEDIUM COARSE
1				0	1
2			>50 12"	16"	2 SAND TAN TO BUFF FINE TO MED COARSE
3					3
				0	
4			32 12"	12"	4
5					5
				0	
6			43 12"	18"	6 6'-7'2" TAN LAYERS W/GRAY SAND & SANDY SLIME, MOIST.
7					7 7'2"-7'6" TAN FINE TO MED COARSE SAND
				0	
8			41 12"	12"	8
9					9
				0	
10			38 12"	12"	0 TAN W/ BROWN LAYERS TOWARD BOTTOM FINE TO MED COARSE SAND
1					1
				0	
2			36 12"	12"	2
3					3
				0	
4			30 12"	18"	4 14'-14'3" GRAY SANDY SLIMES, MOIST
5					5 14'3"-14'9" DARK BROWN SAND W/ORGANIC FIBERS
					14'9"-15'6" TAN/BUFF FINE SAND, MOIST

SPLIT SPOON CALIFORNIA TUBE NO RECOVERY

Reference #A.6

Geotechnical and Radiological Testing Results

Provided by: Shepherd Miller, Inc.

- January 1993 -

Reference A.6
Tailing Geotechnical and Radiological Testing Results

This section presents the laboratory test results for the tailing samples taken during the January 1993 field program. In place densities, moisture contents, percent passing the #200 sieve, and Ra-226 content tests were performed on individual samples. The results of these tests are attached (pages A-77 to A-89).

Based on these individual test results, three composites were made to represent the materials encountered. These composite were numbered 1, 3, and 4 and were tested for specific gravity, 15-bar moisture content, and radon emanation coefficient. The results are presented in Table A.6.2. No composite 2 was made because of a lack of sufficient sample material. Individual samples used to develop the composite sample are presented in Table A.6.1.

Some of the results of the tests performed on the composite samples were used in the radon barrier thickness calculations presented in Appendix G.

Table A.6.1 - Individual Samples Used to Form Tailing Composites

COMPOSITE	BORING	DEPTH	% -200 SIEVE	Ra-226 (pCi/g)
1	15	12' - 13'	23	1204
	16	2' - 3'	43	728
	22	14' - 15'	10	753
	15	10' - 11'	53	441
2 (Not Made)	13	14' - 15'	86	84
	12	10.5' - 11'	73	382
3	21	2' - 3'	2.5	6.6
	22	4' - 5'	5.1	3.2
	3	6' - 7'	5.4	5.8
	6	2' - 3'	15.8	2.4
	7	6' - 7'	18.9	1.2
	7	12' - 13'	6.5	1.8
4	5	8' - 9'	8.8	138
	2	9' - 10'	4	283
	6	8' - 9'	10.2	152
	18	4' - 5'	9.4	186
	19	6' - 7'	1.9	321
	25	2' - 3'	12	283

Table A.6.2 - Tailing Composite Test Results

TAILING COMPOSITE	SPECIFIC GRAVITY	RADON EMANATION COEFFICIENT	15-BAR MOISTURE CONTENT (%)
1	2.65	0.22	3.58
3	2.63	0.23	1.98
4	2.62	0.17	2.15

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Individual Sample Test Results

DENSITY OF SOIL IN PLACE BY THE DRIVE-CYLINDER METHOD
(ASTM DESIGNATION D 2937-83)

Client: Shepherd Miller, Inc.
Date: January 25, 1993

Project: Jeffrey City, Wyoming #335
Job No. SHEMI-93015E-04-702

Tare No.	Boring No.	Wet Wt. (#)	Wet Density (#/Ft^3)	Water (%)	Dry Density (#/Ft^3)
1	#1 @ 12'6" - 12'9"	0.743	109.3	2.6	106.5
2	#2 @ 9'0" - 9'3"	0.679	99.9	3.5	96.5
3	#3 @ 8'-8'3"	0.737	108.3	7.0	101.2
4	#4 @ 10' - 10'3"	0.680	100.0	8.2	92.4
5	#5 @ 4'6" - 4'9"	0.769	113.1	6.9	105.8
6	#6 @ 6'9" - 7'0"	0.777	114.2	5.7	108.1
7	#6 @ 10'0" - 10'3"	0.846	124.4	9.8	113.3
8	#7 @ 4'0" - 4'3"	0.672	98.8	3.4	95.5
9	#8 @ 2'9" - 3'0"	0.798	117.4	11.0	105.8
10	#9 @ 4'6" - 4'9"	0.770	113.2	31.5	86.1
11	#10 @ 12'9" - 13'0"	0.803	118.0	10.5	106.8
12	#11 @ 8'9" - 9'0"	0.855	125.8	16.1	108.3
13	#12 @ 4'9" - 5'0"	0.770	113.2	9.1	103.8
14	#14 @ 4'6" - 4'9"	0.762	112.0	4.8	106.9
15	#15 @ 8'9" - 9'0"	0.783	115.2	6.8	107.8
16	#15 @ 12'6" - 12'9"	0.708	104.1	19.5	87.1
17	#13 @ 8'9" - 9'0"	0.586	86.1	84.3	46.7
18	#16 @ 4'0" - 4'3"	0.688	101.1	17.3	86.2
19	#16 @ 8'9" - 9'0"	0.782	115.0	16.0	99.2
20	#17 @ 12'0" - 12'-3"	0.769	113.1	7.7	105.0

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Tare No.	Boring No.	Wet Wt. (#)	Wet Density (#/Ft^3)	Water (%)	Dry Density (#/Ft^3)
21	#18 @ 12'9" - 13'0"	0.692	101.7	7.4	94.7
22	#19 @ 8'9" - 9'0"	0.716	105.4	3.0	102.3
23	#20 @ 4'9" - 5'0"	0.725	106.6	3.4	103.1
24	#21 @ 4'0" - 4'3"	0.736	108.2	3.5	104.6
25	#22 @ 8'0" - 8'3"	0.755	111.0	4.4	106.3
26	#22 @ 12'9" - 13'0"	0.739	108.7	3.2	105.3
27	#23 @ 4'9" - 5'0"	0.668	98.2	10.6	88.8
28	#24 @ 8'9" - 9'0"	0.780	114.7	9.8	104.5
29	#24 @ 12'6" - 12'9"	0.839	123.4	14.5	107.7
30	#25 Bottom 3" (4'9" - 5'0")	0.860	126.4	13.4	111.5

All Drive Cylinders Were 1.94" I.D. x 4" California Tubes. Volume = 0.0068 Ft.^{3}

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LANDMARK ENGINEERING LTD
3521 West Eisenhower Blvd., Loveland, Colorado (303) 667-6286 Metro (303) 629-71

CLIENT: Shepherd Miller Inc. DATE: January - March 1993

PROJECT: Jeffrey City, WY #335 PROJECT NO. SHEMI-93015E-04-702

AMOUNT OF MATERIAL IN SOILS FINER THAN THE NO. 200 SIEVE
(ASTM D 1140-54)

TEST NO.	BORING NO.	% PASSING NO. 200
1	1 @ 2'8" - 3'6"	11.6
2	1 @ 8' - 9'	12.2
3	1 @ 14' - 15'	4.4
4	2 @ 3' - 4'	4.7
5	2 @ 9' - 10'	4.0
6	2 @ 11'10" - 12'	46.2
7	3 @ 4' - 5'	12.7
8	3 @ 6' - 7'	5.4
9	3 @ 12' - 13'	6.3
10	4 @ 2' - 3'	6.8
11	4 @ 8' - 9'	25.6
12	4 @ 10' - 11'	17.4
13	5 @ 4' - 5'	17.6
14	5 @ 8' - 9'	8.8
15	5 @ 10' - 11'	4.6
16	6 @ 2' - 3'	15.8
17	6 @ 8.5' - 9'	10.2
18	6 @ 10' - 11'	21.2
19	7 @ 6'4" - 7'	18.9

TEST NO.	BORING NO.	% PASSING NO. 200
20	7 @ 12' - 13'	6.5
21	7 @ 14' - 15'	5.5
22	8 @ 2' - 3'	20.1
23	8 @ 4'4" - 5'	11.1
24	8 @ 12' - 13'	9.0
25	9 @ 2' - 2'8"	5.1
26	9 @ 10' - 10.5'	32.5
27	10 @ 4' - 5'	8.9
28	10 @ 12' - 12'6"	15.6
29	11 @ 6' - 6'9"	14.8
30	11 @ 8' - 9'	11.4
31	12 @ 10'6" - 10'8"	73.2
32	12 @ 14' - 14'6"	17.7
33	13 @ 2'8" - 3'	16.8
34	13 @ 14' - 15'	85.9
35	14 @ 4' - 5'	8.1
36	14 @ 14'3" - 14'5"	27.7
37	15 @ 10'4" - 10'8"	52.8
38	15 @ 12' - 13'	22.6
39	16 @ 2' - 2' 8"	43.4
40	16 @ 6'6" - 7-6"	16.3
41	17 @ 6' - 7'6"	10.9
42	17 @ 8' - 9'	11.2
43	18 @ 4' - 5'	9.4
44	18 @ 8' - 9'	10.4
45	18 @ 10' - 11.5'	6.8
46	18 @ 14' - 15.5'	11.5
47	19 @ 2' - 2'6"	4.1

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TEST NO.	BORING NO.	% PASSING NO. 200
48	19 @ 6' - 7.5'	1.9
49	19 @ 10' - 11.5'	4.4
50	19 @ 14' - 15.5'	9.5
51	20 @ 2' - 3'	4.4
52	20 @ 10' - 11.5'	4.6
53	20 @ 12' - 13'	4.8
54	21 @ 2' - 3'	2.5
55	21 @ 6' - 7.5'	1.9
56	21 @ 10' - 11.5'	2.0
57	22 @ 4' - 5'	5.1
58	22 @ 6' - 7.5'	3.9
59	22 @ 14' - 15.5'	9.9
60	23 @ 2'9" - 3'	53.1
61	23 @ 6'3" - 6'6"	78.1
62	23 @ 8' - 9'	12.9
63	23 @ 14' - 15.5'	5.2
64	24 @ 4' - 5'	5.0
65	24 @ 8'2" - 9'	37.8
66	24 @ 12' - 12'9"	32.3
67	25 @ 2' - 3'4"	12.0
68	25 @ 6' - 7'2"	24.2
69	25 @ 14' - 14'3"	11.8

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Rogers & Associates Engineering Corporation

Sample	Moisture (dry wt. %)	Radium-226 (pCi/g)	Radium-226 uncertainty (pCi/g)
#1 @ 2'8"-3'6"	4.9	132.6	0.7
#1 @ 8'-9'	8.8	2.5	0.4
#1 @ 14'-15'	3.5	55.1	0.5
#2 @ 9'-10'	4.0	283.3	0.8
#2 @ 11'10"-11'12"	75.1	24.4	1.6
#2 @ 3'-4'	3.3	128.1	0.5
#3 @ 12'-13'	6.1	1.8	0.3
#3 @ 4'-5'	4.1	3.8	0.3
#3 @ 6'-7'	4.9	5.8	0.4
#4 @ 10'-11'	9.1	36.7	0.5
#4 @ 2'-3'	7.3	95.5	0.6
#4 @ 8'-9'	11.5	33.2	0.4
#5 @ 10'-11'	3.4	90.2	0.5
#5 @ 4'-5'	7.7	1.9	0.3
#5 @ 8'-9'	4.9	138.1	0.6
#6 @ 10'-11'	8.2	66.2	0.5
#6 @ 2'-3'	15.5	2.4	0.3
#6 @ 8'6"-9'	6.3	152.3	0.7
#7 @ 12'-13'	3.5	1.8	0.4
#7 @ 14'-15'	3.4	91.0	0.5
#7 @ 6'4"-7'	5.2	12.0	0.4
#8 @ 2'-3'	8.6	45.0	0.5
#8 @ 4'-4"-5'	5.4	2.0	0.4
#8 @ 12'-13'	5.7	285.3	0.9
#9 @ 10'-10'6"	23.6	1.9	0.5
#9 @ 2'-2'8"	5.6	353.2	1.0
#10 @ 4'-5'	4.8	264.0	0.9
#10 @ 12'-12'6"	8.7	2.4	0.4
#11 @ 8'-9'	13.7	179.1	0.6
#11 @ 6'-6'9"	16.9	419.3	0.9
#12 @ 14'-14'6"	7.8	201.2	0.6
#12 @ 10'6"-10'8"	40.5	381.7	2.9
#13 @ 14'-15'	63.2	84.8	0.7
#13 @ 2'8"-3'	12.0	148.4	0.8
#14 @ 14'3"-14'5"	20.4	60.5	0.6
#14 @ 4'-5'	5.9	2.2	0.4
#15 @ 12'-13'	11.0	1204.1	1.6
#15 @ 10'4"-10'8"	21.3	440.7	1.7
#16 @ 2'-2'8"	23.9	728.3	1.2
#16 @ 6'6"-7'6"	11.1	8.0	0.4
#18 @ 10'-11'6"	6.9	205.8	0.7
#18 @ 14'-15'6"	12.1	12.8	0.4

A 05

Rogers & Associates Engineering Corporation

Sample	Moisture (dry wt. %)	Radium-226 (pCi/g)	Radium-226 uncertainty (pCi/g)
#18 @ 4'-5'	6.7	186.4	0.6
#18 @ 8'-9'	7.2	9.0	0.4
#17 @ 6'6"-7'6"	8.1	150.3	0.6
#17 @ 8'-9'	8.8	2.7	0.4
#19 @ 10'-11'6"	4.7	177.1	0.7
#19 @ 14'8"-15'6"	4.4	2.2	0.3
#19 @ 2'-3'4"	4.1	286.6	0.8
#19 @ 6'-7'6"	3.1	321.2	0.8
#20 @ 10'-11'6"	4.1	2.0	0.4
#20 @ 12'-13'	3.6	2.4	0.3
#20 @ 2'-3'	4.7	85.8	0.5
#21 @ 10'-11'6"	3.4	318.3	0.8
#21 @ 2'-3'	2.7	6.6	0.3
#21 @ 6'-7'6"	2.8	396.6	1.0
#22 @ 14'-15'6"	4.5	753.1	1.2
#22 @ 4'-5'	6.1	3.2	0.3
#22 @ 6'-7'6"	4.0	21.8	0.4
#23 @ 14'-15'6"	4.8	5.6	0.4
#23 @ 2'9"-3'	34.3	9.3	0.9
#23 @ 6'3"-6'-6"	64.2	24.5	1.1
#23 @ 8'-9'	9.2	131.4	0.7
#24 @ 12'-13'	9.4	2.5	0.3
#24 @ 4'-5'	4.1	146.9	0.6
#24 @ 8'2"-9'	16.2	3.1	0.3
#25 @ 14'3"-14'9"	7.9	3.0	0.5
#25 @ 2'-3'4"	5.7	283.8	0.8
#25 @ 6'-7'2"	11.2	98.3	0.6

H 06

Composite Test Results

LANDMARK ENGINEERING LTD.

3521 West Eisenhower Blvd., Loveland, Colorado 80537
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SPECIFIC GRAVITY OF SOIL SOLIDS (G_s)

(ASTM D 854-92)

Project Shepherd Miller, Inc. Job No. SHEMI-93015E-04-702

Location of Project Jeffery City #335

Description of Soil Composite Samples #1, 3 & 4

Tested By LAM Date of Testing 4-22-94

	1	3	4
Vol. of Flask at 20° C.	500 mL	500 mL	1000mL
Method of Air Removal	Boiling & Aspiration	Boiling/Aspirator	Boiling/Aspirator
Wt. Flask + Water + Soil = W_{bws}	722.5	730.2	1333.7
Temperature, °C	20	20	20
Wt. Flask + Water = W_{bw}	680.8	684.7	1283.8
Evap. Dish No.	A	B	C
Wt. Evap. Dish + Dry Soil	316.7	322.8	331.3
Wt. of Evap. Dish	249.8	249.4	250.7
Wt. of Dry Soil = W_s	66.9	73.4	80.6
$W_w = W_s + W_{bw} - W_{bws}$	25.2	27.9	30.7
$G_s = \alpha W_s/W_w$	2.65	2.63	2.62
-#200 Wash	17.8%	8.8	7.3

Remarks:

Rogers & Associates Engineering Corporation

REPORT OF RADIUM AND EMANATION
COEFFICIENT MEASUREMENTS
(LAB PROCEDURE RAE-SQAP-3.1)

Report Date 5/5/93

Contract C9300/7

By LMN

Sample Identification Western Nuclear's Jeffrey City Tailings Impoundment

Submitted by Shepherd and Miller Inc. Date Received 4/12/93

Sample Number	Moisture (Dry Wt. %)	Radon Emanation Coefficient	Radium (pCi/g)	Comments
# 1	3.8	0.22 +/- 0.004	227.3 +/- 0.7	20 Day
# 3	2.3	0.23 +/- 0.06	7.2 +/- 0.3	20 Day
# 4	2.9	0.17 +/- 0.01	62.1 +/- 0.5	20 Day

RAE

Post Office Box 330
Salt Lake City • Utah 84110
(801) 263-1600

Shepherd Miller, Inc
1600 Specht Pt.
Ft. Collins, CO 80521

Colorado State University
Soil, Water and Plant Testing laboratory
Room 6, Vocational Education Building
Fort Collins, CO 80523
303-491-5061 05/17/93
BILLING: S14555

DATE RECEIVED: 11/19/92
DATE REPORTED: 05/14/93

RESEARCH SOIL ANALYSIS REPORT

Lab #	Sample ID #	% H_2O 15 BAR	ring height (cm)	ring diameter (cm)	Volume of ring (cm^3)	for 90 pcf Soil wt (g) B.D=1.44 g/cm^3	Ring + wet Soil 8 Days (g)	Ring + dry soil 8 Days (g)	ring wt (g)
R7828	1	3.58	2.6	4	32.76	47.18	59.7500	58.0569	10.8803
7829	3	1.98	2.5	4	31.64	45.56	57.0180	56.1123	10.5490
7830	4	2.15	2.3	4	28.97	41.72	53.3656	52.4672	10.7468

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Reference #A.7

Cody Shale Geotechnical Sampling

PRELIMINARY REPORT - CODY SHALE DRILLING

Introduction

Western Nuclear, Inc. (WNI) is currently engaged in the reclamation of the old Split Rock Uranium Mill and tailings basin. This facility is located in portions of sections 1, 2, 11 and 12 of Township 29 North, Range 92 West in Fremont County, Wyoming. During these reclamation activities WNI is required by the Nuclear Regulatory Commission and the Environmental Protectiion Agency to construct an attenuation barrier across the mill site and tailings basin to control the release of radon gas.

Numerous options have been investigated as to which type of material would be best suited to construct this protective barrier. One option that was identified was to locate, sample and test a locally available naturally occurring clay.

Through geological field work, an outcrop of Cretaceous age Cody Shale (Kc) was located in sections 6 and 7 Township 28 North, Range 92 West and in sections 1 and 12 Township 28 North, Range 93 West. This outcrop is located approximately seven miles southwest of Jeffrey City.

An application to conduct exploration by drilling was submitted to the WDEQ/LQD and the BLM on September 25, 1992. Approval to proceed with the program was received on November 17, 1992. Drilling activities were started on November 24 and completed on December 7, 1992.

Drilling Program

A thirty (30) core hole drilling program was planned to recover sufficient quantities of Cody Shale with which to perform certain geotechnical tests. These holes were placed over approximately 380 surface acres comprised of both federal and fee surface ground. The minerals are owned by the federal government.

U.S. Energy Corporation (USE), Riverton, Wyoming was selected as the drilling contractor. The equipment consisted of an Acker model 35 drawworks mounted on an International 1600 single axle chassis. A dual wall conventional wire line core barrel outfitted with a "PQ" 3.345 inch core bit was used for the drilling. Cuttings circulation was maintained by a Leroi air compressor. Later in the project, the Acker 35 was replaced by a Midway 1500 series drilling unit for high speed overburden penetration and identification. Compressed air was provided by an onboard compressor and used for the cuttings circulation medium.

The drilling operations were started on November 24. The first hole drilled was Kc 1-3 located in section 1. A five inch pilot hole was plug drilled to a depth of five feet, the outer liner and core barrel installed in the bore, and the first core run made to a depth of ten feet. There was no core recovered from this run.

The barrel was reinserted into the bore hole and a second run attempted to a depth of sixteen feet with no core being recovered. The location was abandoned after this second attempt. Refer to enclosed map for hole locations. Please note that this map only shows the relative locations of the drill holes. The project area has been mapped from aerial photography and the exact locations and hole identification numbers will be provided when new maps of the appropriate sacle are available.

The drill was moved to location Kc 1-6 and plug drilled to a depth of forty feet with no Cody Shale being encountered. This location was abandoned. A third location, Kc 12-1, was prepared on Cody Shale outcrop. A pilot hole was drilled to a depth of five feet, the outer liner and core barrel installed and two runs were made to a depth of seventeen feet. There was no recovery from either run. The material being dry and hard, fragmented into small pieces and circulated back to the surface rather than remaining inside the barrel.

The decision was made to alter the program to collect bulk samples rather than core samples. The drilling unit was outfitted with a 5 1/8 inch milltooth drag bit attached to 2 3/8 inch drill pipe via a two foot tool joint. Compressed air was used as the cuttings circulation medium. The remaining portion of the sampling holes were completed in this fashion.

Drill cuttings samples were collected every two feet from the surface to the final depth of the hole. The samples were placed in one gallon plastic bags, labeled and sealed. A total of 24 holes, sampling 700 vertical feet of Cody Shale were completed.

The individual samples were examined under a microscope, described and marked for composite sample makeup. During these examinations, special attention was paid to the recognition of any intact invertebrate microfossils or fragments of larger invertebrate bivalves and remains of vertebrate fossils. There were none identified in the samples. Refer to Attachment "A" for the individual sample descriptions. The samples were transported to Inberg - Miller Engineers, Riverton, Wyoming for testing.

The composite samples made from each bore hole will be tested in a two phase program. The first phase will consist of testing for Atterberg Limits, particle size analysis, residual moisture content, and the samples classified per the Unified Soils Classification system. The first series of results will be reviewed and the determination made if the material is acceptable for radon barrier construction. If the material is acceptable, additional composite samples will be made up by geographic area, stratigraphic interval, or a combination of both. The composite samples will be tested for the following:

Specific Gravity
Proctor Dry Density
Permeability - Falling Head
Dispursion
15-Bar Moisture

If the materials pass this second series of tests the Cody will be considered a candidate for the construction of the radon barrier. Please be advised that Western Nuclear, Inc. shall consider the results of the laboratory testing of the Cody Shale to be propriety and confidential Corporate information and will be labeled as such and may not be made available to the public nor to Western's competitors.

Upon the completion of the sampling program, USE mobilized a Midway 1500 series drill rig for high speed penetration of the overburden. These holes were drilled with a 5 1/8 inch milltooth drag bit and cuttings were circulated via high pressure compressed air provided by an onboard compressor. This phase of the program was designed to furnish information pertaining to the thickness and composition of the overburden covering the Cody. There were no samples collected during this operation. Ten holes totalling 214 feet were drilled.

Including the unsuccessful core holes and the overburden drilling, 38 bore holes were drilled totalling 997 vertical feet of penetration.

Drill Hole Abandonment

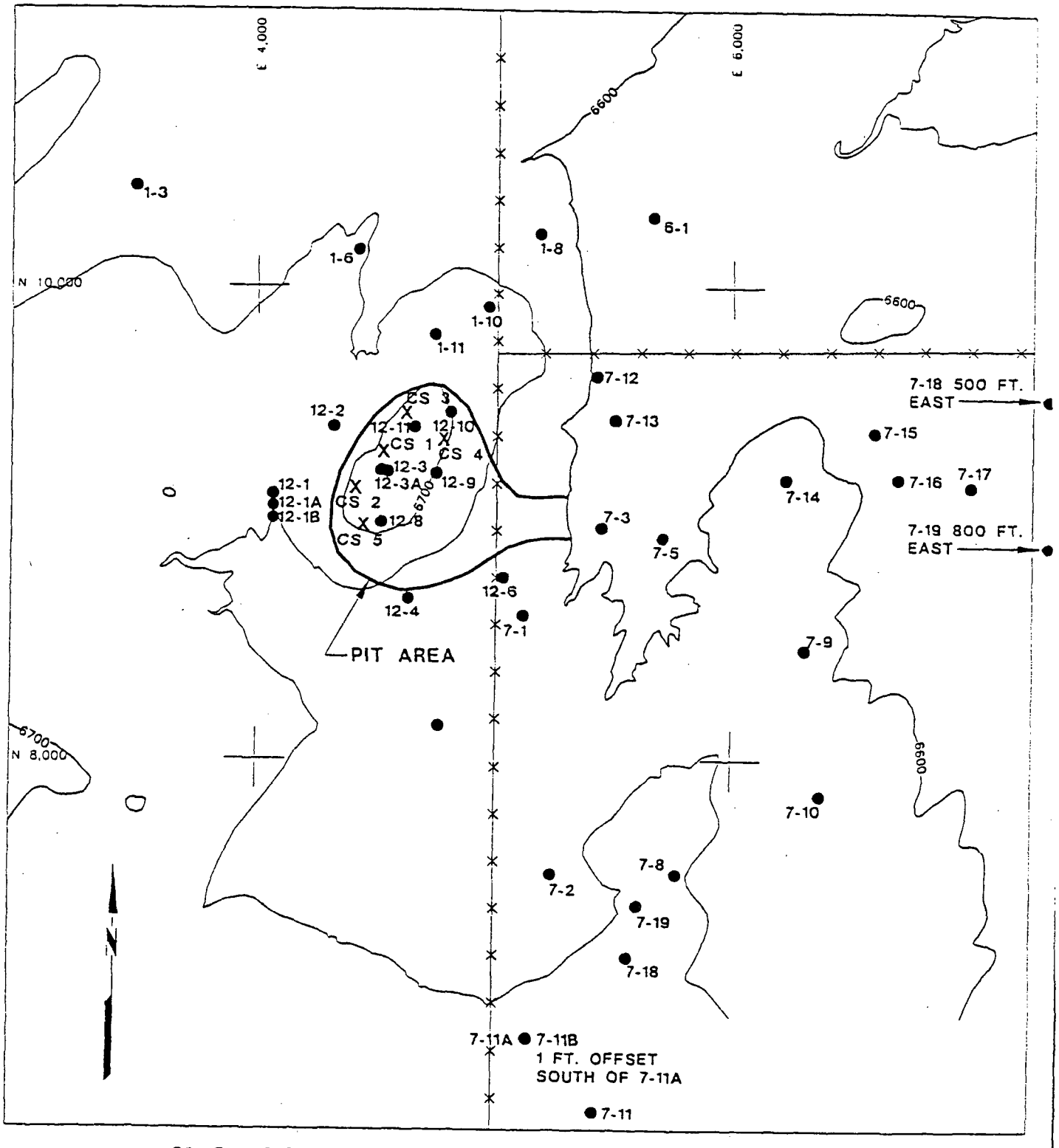
Upon the completion of each drill hole, the location was abandoned. Drill cuttings were placed back inside the bore hole to the extent possible. The remaining portion of the annular space was backfilled to within three feet of the surface with Cody Shale recovered from outcrop and the material tamped. A column of neet cement slurry was then placed in the bore hole to within one foot of the surface. The cement slurry was allowed time to set and shrink, the remaining portion of the hole filled with Cody and salvaged topsoil replaced. Each location will be inspected during the spring of 1993 to confirm the stability of the holes and additional work performed if required.

Access Into The Project Area

During the duration of the project, heavy snowfall and high winds were present. Snow removal was provided by Western Nuclear's Clark 275-B rubber tire frontend loader. Traffic was restricted to existing roadways and draws and steep inclines were avoided. Due to the accumulation of packed snow and the avoidance of areas requiring road construction, disturbance to the surface was minimized. At this time, due to the accumulation of snow, inspection of the roadways is not possible. This will be done in the spring of 1993 in conjunction with the drill hole inspections and all necessary work performed at that time.

Once the final inspection and required reclamation work has been completed, a report will be filed with your office.

(REVISED ADDENDUM A 2/94) A94



SCALE IN FEET

600' 0 1200'

12-8 ● - BORINGS

CS 2 X - SURFACE SAMPLES

SMI SHEPHERD MILLER, INC.	CODY SHALE BORING LOCATIONS	Date: DEC., 1993 Project: 338 File: SHALE-HL

A 95

DRILL HOLE CUTTINGS DESCRIPTION SECTION 1, T. 28 N., R 93 W.

DRILL HOLES Kc 1-3, Kc 1-6, Kc 1-8, Kc 1-10, Kc 1-11

A 96

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 11-24-92 PAGE: 1

HOLE NO.: KC-1-3 SECT: 1 , T. 28 N., R. 93 W.

PLANNED T.D.: 45 FINAL T.D.: 16

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

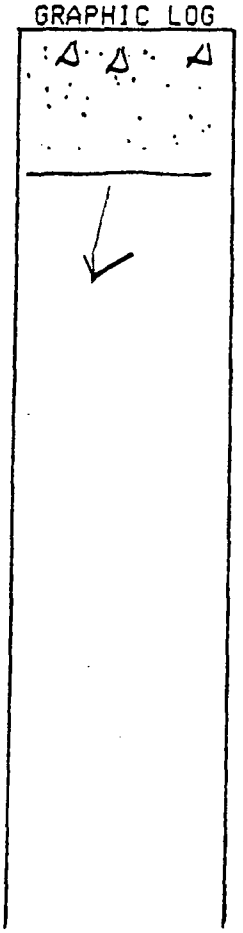
CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: No Core recovery

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		Fine To Cse SAND & rock frags
2-5		Fine To Cse SAND w/ interbedded Gravel
5-10		1st Core run - No recovery
10-16		2nd Core run - No recovery

SPECIAL INSTRUCTIONS :

A 97

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 11-24-92 PAGE: 1

HOLE NO.: Kc-1-6 SECT: 1 , T. 28 N., R. 93 W.

PLANNED T.D.: 40 FINAL T.D.: 40

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-4		TAN TO WHITE CSE SAND AND GRAVELS
4-16		MIXED FINE TO CSE SANDS
16-18		YELLOW REWORKED SHALE W/ VRY FINE SAND
18-22		MED GRAVEL AND CSE SAND, FE STAINS
22-30		TAN TO YELLOW FINE TO CSE SAND W/ REWORKED CLAYS
30-34		CSE SAND TO FINE/MED GRAVELS
34-40		FINE TO CSE SAND W/ REWORKED CLAYS

SPECIAL INSTRUCTIONS :

A 96

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-04-92 PAGE: 1 of 2

HOLE NO.: KC-1-8 SECT: 1 , T. 28 N., R. 95 W.

PLANNED T.D.: 30 FINAL T.D.: 38

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
0-2		Fine To Csc SAND, Gravel, rock frags	overburden
2-4		TAN To Yellow Csc SAND, fine Gravel	
4-6		TAN To yellow fine To med SAND. Fe STAINS	
6-8		TAN To yellow Vry fine SAND Y/remarked clay STRONG TO HCL	
8-10		TAN Vry fine SAND Y/remarked clay, SOME CASOY	
10-12		WEATHERED TAN CLAY Y/ fine SAND grains, CASOY + mica WEAK HCL	
12-14		WEATHERED TAN CLAY Y/ fine QTZ grains CASOY	
14-16		Vry fine SAND Y/ yellow CLAY particles. CASOY, moderate TO HCL	
16-18		BRN shale Y/Vry fine SAND grains minor mica	Composite #1
18-20		BRN shale Y/Vry fine TO fine SAND grains. WEAK TO HCL	
20-22		BRN shale Y/Vry fine SAND inclusions SOME mica	
22-24		BRN shale Y/Vry fine TO fine SAND grains WEAK TO HCL	
24-26		BRN shale Y/ very fine SAND grains SOME mica	
26-28		BRN shale Y/ Vry fine SAND grains AND inclusions	

SPECIAL INSTRUCTIONS : See Page 2

A 97

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-04-92 PAGE: 2/2

HOLE NO.: Kc-1-8 SECT: 1 , T. 28 N., R. 93 W.

PLANNED T.D.: 30 FINAL T.D.: 38

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
28-30		Brn to Blk shale w/ fine sand grains, some mica	Composite #1
30-32		Tan to Blk shale w/ fine sand grains + inclusions	
32-34		Brn to Blk shale w/ fine sand + inclusions, weak fizz	
34-36		Tan to Brn shale w/ fine sand grains minor mica	
36-38		Tan to Blk shale w/ very fine sand inclusions	

SPECIAL INSTRUCTIONS : Composite from 8-10 to 36-38 as one sample number 1-8CP #1, check moisture

A 100

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-07-92 PAGE: 1

HOLE NO.: Kc-1-10 SECT: 1 , T. 28 N., R. 93 W.

PLANNED T.D.: 40 FINAL T.D.: 20

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: No samples collected. Overburden I.D. Lost Circulation 20'

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		Fine To Cse sand, Rock Frags
2-4		Fine To Cse sand, Rock Frags
4-6		Fine sands, reworked yellow clay
6-8		Fine sands reworked yellow clay
8-10		Yellow To LT Brn clays w/ fine sands
10-12		Yellow To LT Brn clays w/ sand inclusions
12-14		Yellow To LT Brn clays w/ fine sands
14-16		LT Brn To Tan clay w/ fine sand inclusions
16-18		LT Brn To Tan clay w/ 8 T2 grains- moist
18-20		Lost Circulation

SPECIAL INSTRUCTIONS :

A 101

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-17-92 PAGE: 1

HOLE NO.: Kc-1-11 SECT: 1 , T. 28 N., R. 93 W.

PLANNED T.D.: 40 FINAL T.D.: 16

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: No samples collected - Overburden I.D. - Lost circulation 16'

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		Fine To Cse sand, Rock Frags
2-4		Cse sand, med Gravel, Rock Frags
4-6		Cse sands, fine Gravel, Rock Frags
6-8		Cse To fine sands, Hi stains
8-10		Fine sands w/ reworked yellow clays
10-12		Yellow To Tan clay, w/ moderate fine sand
12-14		Yellow To Tan clay w/ abundant fine sand
14-16		Yellow To Tan clay w/ [illegible]
		Lost Circulation

SPECIAL INSTRUCTIONS :

A 103

DRILL HOLE CUTTINGS DESCRIPTION SECTION 6, T. 28 N., R 92 W.

DRILL HOLE Kc 6-1

A 103

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-04-92 PAGE: 1

HOLE NO.: KG-6-1 SECT: 6 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 20

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: Lost circulation at 20'

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
0-2		Tan to yellow fine to crse sands, rock frags	overburden
2-4		Tan to yellow fine to crse sand, med gravel, Fe stain	
4-6		Tan to yellow fine to med sand and fine gravels	
6-8		LT Tan fine sand and fine gravel	
8-10		LT Tan very fine sand, Fe stain weak to HCL	
10-12		LT Tan to yellow fine to med gravel	
12-14		LT Tan fine to crse sand w/ reworked clay mica	
14-16		weathered clay w/ very fine to fine sand + mica	composite #1
16-18		weathered clay w/ fine tumed sand, rock chips	
18-20		LT Tan clay w/ fine sand grains very weak to HCL	

SPECIAL INSTRUCTIONS : Composite from 12-14 to 18-20, number 6-1CP#1 check moisture

DRILL HOLE CUTTINGS DESCRIPTION SECTION 7, T. 28 N., R 92 W.

DRILL HOLES Kc 7-1, Kc 7-2, Kc 7-3, Kc 7-4, Kc 7-5, Kc 7-8, Kc 7-9, Kc 7-10, Kc 7-11, Kc 7-11A, Kc 7-11B, Kc 7-12, Kc 7-13, Kc 7-14, Kc 7-15, Kc 7-16, Kc 7-17, Kc 7-18, Kc 7-19

A 105

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-01-92 PAGE: 1 of 2

HOLE NO.: Kc-7-1 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 30

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
0-2		mixed Csc SAND w/reworked clay moderate to HCL	overburden
2-4		LtGry mixed Csc SAND w/reworked clay	
4-6		Dk Brn to Blk shale w/minor fine SAND	
6-8		Blk shale w/minor vfg fine gtz & mica weak to HCL	
8-10		Blk shale w/L SAND some mica present	
10-12		Dk Gry to Blk shale Lmoisture weak to HCL	
12-14		Dk Gry to Tan shale w/CO3 coating moderate to HCL	
14-16		Gry to Dk Brn shale, Hvy Fe stains minor mica	Composite #1
16-18		Gry to Dk Brn shale, L Fe stain	
18-20		Gry to Blk shale, Fe stain, CO3 coating, moderate to HCL	
20-22		Gry to Dk Brn shale, Fe stain CO3 coating	
22-24		Gry to Blk shale L Fe stains, CO3 minor mica	
24-26		Dk Brn to Blk shale L Fe stains moderate to HCL	
26-28		Dk Gry to Dk Brn shale, Fe stains CO3	

SPECIAL INSTRUCTIONS : See Page #2

A 106

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-01-92 PAGE: 2/2

HOLE NO.: Ke-7-1 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 30

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
28-30		DKGy To BlK shale, Fe stain, Carbonaceous moderate Tough } Composite #1

SPECIAL INSTRUCTIONS : Composite As 1 Sample, Number 7-1CP#1, Check moisture

A 107

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-05-92 PAGE: 1 of 2

HOLE NO.: KC-7-2 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 30

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: outcrop

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		Blk shale w/ minor vry fine sand, mica, CaSO4
2-4		Blk shale w/ cse mica, minor CaSO4 no sand
4-6		Blk shale, cse mica some CaSO4 weak to HCL
6-8		Blk shale, cse mica, vry small sand inclusions
8-10		Blk to Gry shale w/ cse mica flakes
10-12		Blk to Brn shale, cse mica weak to HCL
12-14		Blk shale cse mica, no visible sand
14-16		Blk shale, cse mica, some CaSO4
16-18		Blk to Dnk Brn shale, mica + CaSO4
18-20		Blk shale vry hard + dry
20-22		Blk shale cse mica some CaSO4
22-24		Blk shale - vry hard + dry
24-26		Blk to Brn shale, ↑ mica content weak to HCL
26-28		Blk shale hard + dry

SPECIAL INSTRUCTIONS : See Page #2

H 108

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-03-92 PAGE: 2/2

HOLE NO.: Kc-7-2 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 30

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
28-30		Blk, hard dry shale

SPECIAL INSTRUCTIONS : Composite as 1 sample 7-2CP#1 check moisture

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-02-92 PAGE: 1

HOLE NO.: Kc-2-3 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 14

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: Hole Too wet below 14' To return cuttings

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		Very fine sand mixed w/ blk shale
2-4		LT Tan clay w/ very fine sand grains, Fe stain - wet
4-6		LT Tan clay w/ fine to csc sand, mica - wet
6-8		Dark Brown clay w/ fine sand weak to HCL - wet
8-10		Dark Brown to Blk shale, c sand wet
10-12		Blk shale w/ very fine sand some mica wet
12-14		Blk shale w/ very fine sand minor mica

SPECIAL INSTRUCTIONS : Composite All as 2-3 cp#1, check moisture

A 113

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-02-92 PAGE: 2/2

HOLE NO.: Kc-2-4 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 26 FINAL T.D.: 30

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
28-30		Dark Brown To Blk, 7 Clay Content weak To Hcl

SPECIAL INSTRUCTIONS : Composite into 1 sample 7-8-CP#1 Check moisture

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-01-92 PAGE: 1 of 2

HOLE NO.: Kc-7-5 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 30

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: outcrop

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		BLK shale w/minor fine sand grains
2-4		BLK shale w/minor fine sand & CaSO4 weak to HCL
4-6		BLK shale < sand content - dry
6-8		BLK shale very little sand - dry
8-10		BLK shale, hard, dry, some CaSO4
10-12		Hard Dry BLK shale no sand
12-14		Hard Dry BLK shale No sand
14-16		Hard Blk shale dry some CaSO4
16-18		BLK shale hard dry some CaSO4 weak to HCL
18-20		BLK shale, hard dry CaSO4 some mica
20-22		BLK shale, hard dry No sand
22-24		BLK shale
24-26		BLK shale
26-28		BLK shale

SPECIAL INSTRUCTIONS : See page #2

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-02-92 PAGE: 1 of 2

HOLE NO.: Kc-2-4 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 26 FINAL T.D.: 30

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: outcrop

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		TAN TO LT Brwn shale CASOY + Fe STAINS moderate TO HCL
2-4		TAN TO LT Brwn shale, moderate STAINS
4-6		LT Gry TO Drk Brwn, CASOY common WEAK TO HCL
6-8		LT Gry TO Brwn shale, Csc CASOY Grains, Fe STAINS
8-10		LT Gry TO Brwn shale < CASOY from above
10-12		LT Gry TO Brwn shale CASOY present CO2 reaction mod TO HCL
12-14		Drk Brwn TO Blk shale, minor CASOY, no CO2 in sample
14-16		Drk Brwn TO Blk shale, minor CASOY, hvy Fe STAINS
16-18		Drk Brwn TO Blk, > CASOY content TO Fe STAIN WEAK TO HCL
18-20		Drk Gry TO Brwn, > CASOY minor Fe STAINS
20-22		Drk Gry TO Brwn, Csc CASOY Grains hvy Fe STAINS
22-24		LT TO Drk Brwn, Csc CASOY, WEAK TO HCL
24-26		LT TO Drk Brwn, < CASOY content > Fe STAIN
26-28		Drk Gry TO Brwn, > CASOY content

SPECIAL INSTRUCTIONS : See Page 2

A 113

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-01-92 PAGE: 1 of 2

HOLE NO.: Kc-7-5 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 30

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: outcrop

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		Blk shale w/minor fine sand grains
2-4		Blk shale w/minor fine sand + CaSO4 weak to HCL
4-6		Blk shale < sand content - dry
6-8		Blk shale very little sand - dry
8-10		Blk shale, hard, dry, some CaSO4
10-12		Hard Dry Blk shale no sand
12-14		Hard Dry Blk shale No sand
14-16		Hard Blk shale dry some CaSO4
16-18		Blk shale hard dry some CaSO4 weak to HCL
18-20		Blk shale, hard dry CaSO4 some mica
20-22		Blk shale, hard dry No sand
22-24		Blk shale
24-26		Blk shale
26-28		Blk shale

SPECIAL INSTRUCTIONS : See page #2

A 114

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-01-92 PAGE: 2/2

HOLE NO.: Kc-7-5 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 30

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
28-30		Blk shale hard dry w/minor musc

SPECIAL INSTRUCTIONS : Composite from 0-2 To 28-30 as 25cp#1

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-02-92 PAGE: 1

HOLE NO.: Kc-7-8 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 40

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
0-20		white To Red, fine To Csc sand & Gravels	overburden
20-22		white To Blk shale, sand, qTz grains, and rock chips	
22-24		LTGry shale w/mica, CaSO4 fine To med qTz grains	
24-26		LTGry To Brwn shale w/mica, CaSO4 weak To HCL	
26-28		LT Brwn To Blk shale w/minor mica & CaSO4 weak To HCL	
28-30		LT Brwn To Blk shale, < CaSO4 + mica from above	
30-32		LT To Drk Brwn shale, Csc mica flakes, minor Fe stain	
32-34		LT To Drk Brwn shale, reduced mica + CaSO4 weak To HCL	
34-36		Drk Brwn To Blk shale, minor mica, No CaSO4 in sample	
36-38		Blk shale w/fine mica flakes weak To HCL	
38-40		Blk shale w/fine mica flakes	

SPECIAL INSTRUCTIONS : Composite from 22'-24' To 38' To 40' Number 7-8CP #1
check moisture

A 116

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-03-92 PAGE: 1 of 2

HOLE NO.: KG-7-9 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 32

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
0-2		LT TAN fine To Cse SAND W/ GRAVEL	overburden
2-4		LT Gry shale W/ fine To Cse qTz + rock fragments weak To HCL	Composite #1
4-6		LT Gry shale W/ fine To med qTz minor CASOY + Fe STAIN	
6-8		LT Gry shale W/ fine qTz minor CASOY	
8-10		Gry To Blk shale < qTz fm above < CASOY fm above	
10-12		Gry To Brwn, minor mica flake & CASOY, very fine qTz grains	Composite #2
12-14		Gry To Brwn shale, minor mica, no qTz in sample	
14-16		Gry To Brwn, > in CASOY fm above weak To HCL	
16-18		Gry To Brwn, > in mica, < CASOY weak To HCl	
18-20		Gry To Brwn, > in mica	
20-22		Gry To Brwn, mica common < CASOY weak To HCL	
22-24		Gry To Brwn, < in mica, minor Fe STAIN	
24-26		Gry To Brwn, minor mica, weak To HCL	
26-28		Gry To Blk, minor mica, minor Fe STAIN	

SPECIAL INSTRUCTIONS : See Page #2

A117

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-23-92 PAGE: 2/2

HOLE NO.: KC-7-9 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 38

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
28-30		Gry To Brwn, minor mica, No CASO4
30-32		Gry To Brwn, 7 mica, 7 CASO4 weak To HCL

SPECIAL INSTRUCTIONS : Composite #1 2-4 To 8-10 number 7-9CP#1, 10-12 To 30-32 : 7-9CP#2
Check moisture on both

A 118

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-03-92 PAGE: 1 of 2

HOLE NO.: Kc-7-10 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 34

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
0-2		TAN med To Csc SAND & GRAVEL	overburden
2-4		TAN fine To med SAND & GRAVEL	
4-6		TAN To LT Gry shale w/ fine To med qtz grains, CASOY	Composite #1
6-8		LT Gry To Brn w/ fine qtz csc CASOY minor mica moderate HCL	
8-10		LT Gry To Brn shale, minor mica, csc CASOY	Composite #2
10-12		LT Gry To Brn shale, minor mica, CASOY common	
12-14		LT To Brn shale, < mica AND CASOY weak To HCL	
14-16		LT Gry To Brn shale < mica, > CASOY	
16-18		LT Gry To Brn shale, mica minor Fe stains	
18-20		LT Brn To Blk shale, minor mica weak To HCL	
20-22		LT Brn To Blk shale, > mica & CASOY	
22-24		LT Gry To Brn shale, mica + CASOY common	
24-26		LT Brn To Blk shale, < mica + CASOY	
26-28		LT Brn To Blk shale, minor mica	

SPECIAL INSTRUCTIONS : See Page #2

A 119

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-03-92 PAGE: 2/2

HOLE NO.: Kc-7-10 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 32

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
28-30		LT Brn To Blk shale, minor mica + [illegible]	Composite #2
30-32		LT Brn To Blk shale, minor mica	

SPECIAL INSTRUCTIONS : Composite Sample #1 4-6 To 6-8' number 7-10CP#1, second
Composite 6-8 To 30-32 Number 7-10CP#2, moisture on both

A120

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-03-92 PAGE: 1

HOLE NO.: Kc-7-11 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 40 FINAL T.D.: 20

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: Lost circulation at 20'. did not reach Kc

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		White to tan csc sand, fine gravels
2-4		white to tan csc sand + fine gravels
4-6		white to tan csc sand + gravel
6-8		tan csc gtz. hvy Fe stains some reworked Kc (?)
8-10		tan to yellow fine gravel
10-12		tan csc sands w/ reworked Kc (?)
12-16		No samples lost circulation
16-18		tan to yellow fine gravel
18-20		lost circulation, some returns had black clay chips
		Top of Kc (?)

SPECIAL INSTRUCTIONS : No samples collected for testing

A 121

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-03-92 PAGE: 1

HOLE NO.: Kc-7-11A SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 10

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: moved 100' East And 40' North of 7-11 Lost circulation AT 10'

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-10		No samples Recovered

SPECIAL INSTRUCTIONS :

A 122

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-07-92 PAGE: 1

HOLE NO.: Kc-7-11B SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 50 FINAL T.D.: 20

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: No Samples - Overburden I.D. - Lost Circulation at 20'

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		Cse sand w/ rock frags
2-4		Cse sand w/ rock frags
4-6		Cse sand w/ rock frags
6-8		Cse sand to fine Gravel
8-10		fine to cse sands
10-12		fine to cse sands w/ reworked yellow clay
12-14		fine to cse sands w/ reworked yellow clay
14-16		fine to cse sand w/ reworked yellow clay
16-18		weathered yellow clay w/ fine sand
18-20		weathered yellow clay w/ very fine sand
		Lost Circulation

SPECIAL INSTRUCTIONS :

A133

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-01-92 PAGE: 1 of 2

HOLE NO.: Kc-7-12 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 30

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: cutrop

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		TAN to Gry vry fine sand & reworked clay
2-4		LT Gry vry fine sand, & minor amounts of clay
4-6		LT Gry mixed weathered clay & vry fine sands
6-8		Mixed vry fine sands and Gry to Blue clay weak to HCL
8-10		LT Gry shale & vry fine sand minor casey
10-12		mixed clays & vry fine sands weak to HCL
12-14		LT TAN mixed clay & vry fine sands
14-16		LT TAN mixed clay & sands
16-18		LT Gry shale & vry fine sand cuttings
18-20		LT TAN mixed clay & sand weak to HCL
20-22		LT Gry mixed clay & vry fine sands
22-24		LT Gry mixed clay & vry fine sand
24-26		LT Gry mixed clay & vry fine sand
26-28		Dark Gry mixed clay & L sand content

SPECIAL INSTRUCTIONS : See Page #2

A/24

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-01-92 PAGE: 2/2

HOLE NO.: KC-7-12 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 50 FINAL T.D.: 50

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
28-30		Drk Gry mixed clay & vry fine sand

SPECIAL INSTRUCTIONS : Composite from 2-4 To 28-30, number 7-12CP#1
check moisture

A/25

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-02-92 PAGE: 1 of 2

HOLE NO.: Kc-7-13 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 30

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: outcrop

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
0-2		mixed very fine sand, clays, mica, CASOY	Composite #1
2-4		mixed CSE To fine sand, clays weak To HCL	
4-6		mixed CSE To fine sand, remarked clays, CSE CASOY	
6-8		TAN clay & very fine gTz, CSE mica weak To HCL	
8-10		LTGry shale & very fine gTz, FeStain, < CASOY	Composite #2
10-12		LTGry shale & > gTz content, > CASOY	
12-14		LTGry shale & fine To CSE gTz, CSE CASOY weak To HCL	
14-16		LTGry shale & fine To CSE gTz and Angular rock frags	
16-18		LTGry shale & < sand content, CSE CASOY + mica	
18-20		LTGry To Brwn shale & fine sands CSE CASOY weak HCL	
20-22		LT Brwn shale & CSE CASOY mica, rock frags	
22-24		LT Brwn shale & CSE CASOY, minor very fine gTz	
24-26		LT Brwn shale & > sand content very fine grain	
26-28		LT Brwn shale & CSE CASOY, minor very fine sand	

SPECIAL INSTRUCTIONS : See Page #2

A 126

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-02-92 PAGE: 2/2

HOLE NO.: Kc-7-13 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 30

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
28-30		LT Brown shale w/ vary fine ATZ grains [illegible] mixed	Composite #2

SPECIAL INSTRUCTIONS : Composite 0-2 To 6-8 AS 7-13CP#1, 8-10 To 28-30 AS 7-13CP#2, check moisture

A 127

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-03-92 PAGE: 1 of 2

HOLE NO.: Kc-7-14 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 32

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
0-2		TAN fine To Cse SAND + Gravel Angular rock frags	overburden
2-4		LTGry shale w/ fine To Cse gTz, mica & CASOY, strong To HCL	Composite #1
4-6		LTGry To Brn shale w/ fine To med gTz, Cse mica & CASOY	
6-8		LTGry To Brn shale w/ fine gTz, Cse mica, minor CASOY	
8-10		LTGry To Brn shale w/ minor gTz, Cse mica, CASOY, Fe STAINS	
10-12		DrkGry To Brn shale w/ Cse mica + CASOY weak To HCL	Composite #2
12-14		DrkGry To Brn shale, < mica, > CASOY, Fe STAINS	
14-16		DrkGry To BlK shale, < mica, CASOY common	
16-18		DrkGry To BlK shale, Cse CASOY common, minor mica	
18-20		DrkGry To Brn shale, CASOY, > in mica Fe STAIN	
20-22		DrkGry To Brn shale, CASOY, > in mica weak To HCL	
22-24		Gry To DrkGry, > in CASOY, mica	
24-26		LTGry To BlK, Cse mica & CASOY, weak To HCL	
26-28		LTGry To BlK, mica & CASOY common	

SPECIAL INSTRUCTIONS : See Page 2

A 128

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-03-92 PAGE: 2/2

HOLE NO.: Kc-214 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 32

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
28-30		LT BWN TO BLK shale, CSe CASOY, Fe STAIN	Composite #2
30-32		LT BWN TO BWN shale, CSe CASOY, minor MICA	

SPECIAL INSTRUCTIONS : Composite samples 2-4 To 8-10 Number 7-14 CP#1, Composite 8-10 To 30-32 Number 7-14 CP#2, check moisture on both

A 124

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-04-92 PAGE: 1 of 2

HOLE NO.: KC-7-15 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 34

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
0-2		TAN TO YELLOW FINE TO CSE SAND W/ MOD GRAVEL	OVERBURDEN
2-4		TAN TO YELLOW FINE TO CSE SAND W/ REWORKED CLAY	
4-6		TAN VERY FINE SAND W/ MINOR REWORKED CLAY	
6-8		TAN TO YELLOW VERY FINE SAND, SOME CLAY, MICA, WEAK TO HCL	
8-10		TAN TO YELLOW VERY FINE TO FINE SAND W/ SOME WEATHERED CLAY	
10-12		TAN WEATHERED SHALE W/ VERY FINE SAND	
12-14		TAN TO LT GRY SHALE W/ L SAND CONTENT	COMPOSITE #1
14-16		LT GRY SHALE, MINOR VERY FINE SAND INCLUSIONS	
16-18		LT GRY TO TAN SHALE LESS SAND THAN ABOVE	
18-20		LT TAN SHALE W/ LITTLE SAND PRESENT	
20-22		LT TAN SHALE W/ MINOR SAND, SLIGHTLY WEAK TO HCL	COMPOSITE #2
22-24		LT TAN TO LT BROWN SHALE W/ MINOR VERY FINE SAND	
24-26		LT BROWN TO DRK BROWN SHALE, L SAND CONTENT	
26-28		DRK GRY TO BROWN SHALE, CALCAREOUS WEAK TO HCL	COMPOSITE #3

SPECIAL INSTRUCTIONS : See Page #2

A 130

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-04-92 PAGE: 2/2

HOLE NO.: Kc-7-15 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 34

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
28-30		Dark Brown To Blk shale w/minor (NSCW) water To HCL	Composite #3
30-32		Dark Brown To Blk shale w/no visible sand	
32-34		Blk shale w/no visible sand	

SPECIAL INSTRUCTIONS : Composite from 10-12 To 16-18 as 7-15CP #1, from 18-20 To 24-26 as 7-15CP #2, From 26-28 To 32-34 as 7-15CP #3, check moisture in All 3

A131

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-04-92 PAGE: 1 of 2

HOLE NO.: Kc-2-16 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 40

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
0-2		LT TAN CSE TO fine SANDS	overburden
2-4		white TO TAN med TO CSE SAND	
4-6		white TO TAN CSE SAND + GRAVEL	
6-8		TAN TO Yellow fine GRAVEL	
8-10		Yellow CSE TO fine SAND minor yellow CLAYS	
10-12		Yellow weathered CLAY, % fine gTz, STRONG TO HCL	Composite #1
12-14		Yellow weathered clay, fine gTz, minor CASOY	
14-16		LT TAN weathered clay, > CASOY STRONG TO HCL	
16-18		LT Brn SHALE, < CASOY some Fe STAIN WEAK TO HCL	Composite #2
18-20		Dark Brn shale % very fine sand inclusions, minor CASOY	
20-22		LT Brn shale % banded CASOY, WEAK TO HCL	
22-24		LT Brn shale % CASOY inclusions of very fine SAND STRONG TO HCL	
24-26		LT Brn shale % CASOY, inclusions of very fine SAND	
26-28		LT Brn SHALE, inclusions very fine SAND, banded CASOY moderate TO HCL	

SPECIAL INSTRUCTIONS : See Page 2

A 132

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-04-92 PAGE: 2/2

HOLE NO.: KC-7-16 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 40

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
28-30		Drk Gry shale, Csc mica, Fe stains	Composite #2
30-32		LT Gry, To Brn shale, Csc mica, weak To HCL	
32-34		LT Tan To Brn, banded CaSO4, CO3 coatings strong To HCL	
34-36		Drk Tan, Csc mica, minor CO3 coatings weak To HCL	
36-38		Drk Tan, Csc mica, minor CaSO4	
38-40		Drk Tan To LT Gry, Csc mica, > CaSO4	

SPECIAL INSTRUCTIONS : Composite #1 10-12 To 14-16 number 7-16CP#1, second 16-18 To 38-40 7-16CP#2, check moisture both samples

A 133

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-04-92 PAGE: 1 of 2

HOLE NO.: Kc-2-17 SECT: 2 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 38

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
0-2		TAN med TO CSE SANDS	overburden
2-4		TAN TO yellow fine TO med SANDS	
4-6		TAN TO yellow CSE SAND + fine GRAVEL	
6-8		TAN fine TO med SAND, mottled CLAY WEAK TO HCL	
8-10		TAN shale W/ fine SAND, MICA FLAKES	Composite #1
10-12		LT TAN shale W/ fine SAND, MICA, CSE CASCY WEAK TO HCL	
12-14		TAN TO Brn shale W/ fine TO CSE ATR, CSE MICA	
14-16		LT Brn shale W/ fine SAND, fine MICA FLAKES	
16-18		LT Brn shale W/ very fine SAND fine MICA, moderate TO HCL	
18-20		LT Brn shale W/ fine SAND, fine MICA, minor Fe STAIN	
20-22		LT Brn shale W/ very fine SAND INCLUSIONS fine MICA	
22-24		LT Brn shale W/ fine SAND grains, > MICA WEAK HCL	
24-26		LT TO DRK Brn SHALE W/ fine SAND, < in MICA	
26-28		DRK Brn shale W/ very fine SAND, Fe STAIN	

SPECIAL INSTRUCTIONS : See Page # 2

A137

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-01-92 PAGE: 2/2

HOLE NO.: Kc-7-17 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 38

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
28-30		LT Brwn shale w/ fine sand some PASOy weak to HCL	Composite #1
30-32		LT to Drk Brwn shale w/ very fine sand inclusions, PASOy	
32-34		LT Brwn shale w/ fine sand Fe stains	
34-36		LT to Drk Brwn shale w/ fine sand weak to HCL	
36-38		LT Brwn shale w/ very fine inclusions, >CASOy + mica	

SPECIAL INSTRUCTIONS : Composite from 8-10 to 36-38 into 1 sample 7-17CP #1
check moisture

A 135

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-07-92 PAGE: 1

HOLE NO.: Kc-7-18 SECT: 7 , T. 23 N., R. 92 W.

PLANNED T.D.: 40 FINAL T.D.: 38

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: No Shangles Bibo Tcd. Overburden T.D.

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-14		mixed fine To Cse sands w/ interbedded Gravels
14-20		weathered yellow clay w/ interbedded fine sands
20-35		mixed fine To Cse sands w/ Graves
35-38		Black Shale, hard, moist

SPECIAL INSTRUCTIONS :

A136

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-07-92 PAGE: 1

HOLE NO.: Kc-7-19 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 40 FINAL T.D.: 40

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: No Samples Collected- Overburden I.D.

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-15		mixed fine To Cse sands And Gravels
15-18		weathered yellow clays w/interbedded sands
18-24		mixed fine To Cse sand And Gravel, Oil Cuttings
24-36		weathered yellow clay w/interbedded sands
36-40		Black shale, hard & moist

SPECIAL INSTRUCTIONS :

A137

DRILL HOLE CUTTINGS DESCRIPTION SECTION 12, T. 28 N., R 93 W.

DRILL HOLES Kc 12-1, Kc 12-1A, Kc 12-1B, Kc 12-2, Kc 12-3A, Kc 12-4,

Kc 12-6, Kc 12-7, Kc 12-8, Kc 12-9, Kc 12-10, Kc 12-11

A 13

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 11-25-92 PAGE: 1

HOLE NO.: Kc-12-1 SECT: 12 , T. 28 N., R. 93 W.

PLANNED T.D.: 20 FINAL T.D.: 10

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: No Core Recovery

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		Dark Gray To Brown shale, Vry fine sand
2-5		Dark Brown shale w/ minor sand some mica
5-10		1st Core run - No recovery

SPECIAL INSTRUCTIONS :

A134

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 11-25-92 PAGE: 1

HOLE NO.: Kc12-1 A SECT: 12 , T. 28 N., R. 93 W.

PLANNED T.D.: 20 FINAL T.D.: 26

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: offset 4' east of 12-1

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		Dark Gry To Black shale w/very fine sands
2-4		Dark Gry To Dark Brwn shale w/minor sand & mica
4-6		Dark Brwn shale w/mica & CASOY
6-8		Dark Brwn To Blk shale > CASOY content
8-10		Dark Gry To Brwn shale, mica & CASOY in sample
10-12		Dark Gry To Brwn shale, Fe STAIN common
12-14		LT To Dark Brwn shale, Fe STAIN, CASOY
14-19		1st Core run - No Recovery
19-24		2nd Core run - No Recovery
24-26		3rd Core run - No Recovery

SPECIAL INSTRUCTIONS :

A 143

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-01-92 PAGE: 1

HOLE NO.: Kc-12-1B SECT: 12 , T. 28 N., R. 95 W.

PLANNED T.D.: 30 FINAL T.D.: 20

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: Hole booted off AT 20' could not re-enter - collar on outcrop

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
0-2		Dark Gry To Brn shale w/minor Vry fine sand	Composite #1
2-4		Dark Brn shale w/< sand, some mica weak To HCL	
4-6		Dark Brn shale w/minor mica and CaSO4	
6-8		LT Brn To Dark Gry shale w/mica > CaSO4	
8-10		Dark Gry shale w/CaSO4 + mica, weak To HCL	
10-12		Dark Gry shale some Fe stain, mica, CaSO4	
12-14		Dark Gy To Brn shale, Fe stain, mica, CaSO4	
14-16		LT Brn shale w/Fe stain, mica, CaSO4 weak To HCL	
16-18		Dry Gry shale Fe stain < CaSO4, > mica	
18-20		LT Brn To Gry shale, Fe stain, CaSO4 cuttings mod. To HCL	

SPECIAL INSTRUCTIONS : Composite as 12-1CP#1, check moisture

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-02-92 PAGE: 1 of 2

HOLE NO.: Kc-12-2 SECT: 12 , T. 28 N., R. 93 W.

PLANNED T.D.: 30 FINAL T.D.: 30

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: Kc outcrop

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		LT gry To Brwn shale, CaSO4 reaction To HCL, weathered
2-4		LT gry shale, CaSO4, Fe STAIN, weathered
4-6		LT Gry To Brwn shale, CaSO4 Fe STAIN
6-8		LT Brwn shale, CaSO4 Fe STAINS
8-10		Gry To Blk shale, CaSO4 common in sample
10-12		Gry To Blk shale, CaSO4 common, some Fe STAINS
12-14		Brwn To Blk shale, CaSO4 common, CO3 coating present + HCL
14-16		LT Brwn To Blk, CaSO4 common, CO3 coating + HCL
16-18		Gry To Brwn, CaSO4, minor Fe STAINS
18-20		Gry To Brwn, large pieces of CaSO4 weak reaction To HCL
20-22		Gry To Brwn, CaSO4 common, minor Fe STAIN
22-24		Brwn To Blk, < CaSO4 than Above, weak reaction HCL
24-26		Brwn To Blk, > CaSO4 from Above, minor Fe STAIN
26-28		Brwn To Blk, CaSO4 common, weak To HCL

SPECIAL INSTRUCTIONS : See Page 2

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BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-02-92 PAGE: 2/2

HOLE NO.: Kc-12-2 SECT: 12 , T. 28 N., R. 93 W.

PLANNED T.D.: 30 FINAL T.D.: 30

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
28-30		Gry To Blk, Casoy Common, Vry minor mica

SPECIAL INSTRUCTIONS : Composite As 1 Sample. Kc-12-2CP Check moisture

A143

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-07-92 PAGE: 1

HOLE NO.: Kc-12-30 SECT: 12 , T. 28 N., R. 95 W.

PLANNED T.D.: 20 FINAL T.D.: 18

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: No Samples Collected - Overburden I.D.

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		Fine To Csc SANDS W/Rock frags
2-4		Fine To Csc SAND, med Gravel W/rock frags
4-6		Fine To Csc Gravel, Hvy Fe STAIN
6-8		Csc SAND, fine gravel, Fe STAIN
8-10		Fine To Csc SAND W/minor reworked clay
10-12		Yellow reworked clay W/fine SAND
12-14		Black shale hard, dry W/Fe STAIN
16-18		Black shale

SPECIAL INSTRUCTIONS :

A144

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-01-92 PAGE: 1

HOLE NO.: Kc-12-4 SECT: 12 , T. 28 N., R. 93 W.

PLANNED T.D.: 26 FINAL T.D.: 26

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: Kc outcrop

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		Drk gry To brwn shale, minor qTz + mica flakes, weathered
2-4		Drk gry To brwn shale, minor qTz + mica, some oxidation of Fe
4-6		Gry To Blk shale, minor mica, banded CaSoy (?)
6-8		Blk shale, mica more common, no CaSoy, moist
8-10		Blk shale mica common, minor Fe oxidation, moist
10-12		Blk shale, mica common, Fe oxidation, moist
12-14		Blk shale, less mica than above, no oxidation, moist
14-16		Blk shale, mica present, moist
16-18		Drk Brwn To Blk shale, minor qTz + mica, moist
18-20		Drk Brwn To Blk shale, minor mica + CaSoy, Fe stain
20-22		Drk Brwn To Blk shale, mica CaSoy more common, Fe stain
22-24		Blk shale, mica + CaSoy present, less Fe stain
24-26		Olive Grn To Blk shale, mica, no CaSoy no Fe

SPECIAL INSTRUCTIONS : Composite entire hole as 12-1CP, Check moisture

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BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-01-92 PAGE: 1 of 2

HOLE NO.: Kc-12-6 SECT: 12 , T. 28 N., R. 93 W.

PLANNED T.D.: 30 FINAL T.D.: 30

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY	
0-2		TAN, fine To Cse SAND Y reworked Kc, Fe STAIN, Rock Chips	overburden
2-4		TAN, med. To Cse SAND Y minor clay, mica + rock chips	
4-6		LT gry shale Y Cse gTz, mica, CaSOy, Fe STAIN, weathered	Composite #1
6-8		LT gry shale Y fine To Cse SAND, CaSOy, weathered	
8-10		Drk Gry shale Y fine To med SAND, mica + Fe STAIN - moist	
10-12		LT gry To brwn shale Y fine gTz grains, CaSOy, mica - moist	
12-14		Drk gry To brwn shale, fine gTz, mica, minor Fe STAIN - moist	
14-16		Drk gry To LT grn shale, fine gTz, mica, CaSOy - moist	
16-18		Drk gry shale, Cse gTz, mica, CaSOy - moist	
18-20		Drk gry To blk shale, fine gTz, mica - moist	
20-22		Drk gry shale fine To Cse mica, no gTz - moist	Composite #2
22-24		Drk gry shale Cse mica, minor CaSOy - moist	
24-26		Drk gry To Blk shale Cse mica, some CaSOy - moist	
26-28		Drk Gry shale, fine To Cse mica, minor CaSOy - moist	

SPECIAL INSTRUCTIONS : See Page #2

A146

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-01-92 PAGE: 2/2

HOLE NO.: Kc-12-6 SECT: 12 , T. 28 N., R. 93 W.

PLANNED T.D.: 30 FINAL T.D.: 30

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS:

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
28-30		Dark Gry shale, fine To Ese mica, No gTe - moist } Composite #2

SPECIAL INSTRUCTIONS : Composite 1-6 To 18-20 AS #1, Composite 20-22 To 28-30 AS #2 - Number 12-6CP#1 + 12-6CP#2 moisture on both

A147

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-01-92 PAGE: 1

HOLE NO.: KC-12-7 SECT: 7 , T. 28 N., R. 92 W.

PLANNED T.D.: 30 FINAL T.D.: 26

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: OUTCROP, BOOTED OFF AT 29' COULD NOT MONITOR

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		DRK BRWN TO BLK SHALE, HVY FE STAIN, MINOR VRY FINE QTZ
2-4		DRK BRWN SHALE W/ FE STAIN, CASO4, CO2 COATINGS WEAK TO HCL
4-6		DRK BRWN SHALE, FE STAIN, CASO4, < CO2 CONTENT
6-8		LT BRWN TO GRY SHALE, FE STAIN, MICA, CASO4
8-10		BRWN TO BLK SHALE W/ FE STAIN, < MICA, > CASO4, WEAK HCL
10-12		DRK GRY TO BLK SHALE, FE STAIN, < MICA, > CASO4
12-14		DRK GRY TO BRWN, FE STAIN, CSE CASO4
14-16		DRK GRY TO BRWN, < FE STAIN, CSE CASO4, VRY FINE MICA
16-18		LT BRWN SHALE, < FE STAIN, CSE CASO4, > MICA
18-20		LT TO DRK BRWN SHALE, MINOR FE STAIN WEAK HCL
20-22		DRK BRWN SHALE, > FE STAIN, CSE CASO4, FINE MICA
22-24		DRK BRWN SHALE, FE STAIN, < CASO4, < MICA
24-26		DRK BRWN SHALE, < FE STAINS WEAK TO HCL

SPECIAL INSTRUCTIONS : COMPOSITE AT 12-7 CP #1, CHECK MOISTURE

A148

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-07-92 PAGE: 1

HOLE NO.: Kc-12-8 SECT: 12 , T. 28 N., R. 93 W.

PLANNED T.D.: 40 FINAL T.D.: 20

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: No Samples Collected - Overburden I.D.

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		fine To Cse SAND & rock frags
2-4		fine To Cse SAND, med Gravel, Rock frags
4-6		fine To Cse SAND, med Gravel, Rock frags
6-8		Vry fine To fine SANDS
8-10		fine SAND w/ Rock frags (uplole ?)
10-12		med Gravel w/ hvy Fe STAINS
12-14		fine To Cse SAND, med Gravel
14-16		Cse SANDS w/ reworked yellow Clay
16-18		LT Brn shale w/ fine sands
18-20		BLK shale, hard + dry

SPECIAL INSTRUCTIONS :

A 147

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-07-92 PAGE: 1

HOLE NO.: Kc-12-9 SECT: 12 , T. 28 N., R. 93 W.

PLANNED T.D.: 40 FINAL T.D.: 12

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: No Samples Collected - overburden I.b.

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		Fine To Cse SAND, Rock Frags
2-4		Fine To Cse SAND, med Gravel, Rock Frags
4-6		Fine To Cse SANDS
8-10		Fine SANDS & yellow remarked clays
10-12		Black shale, hard, dry

SPECIAL INSTRUCTIONS :

A/5

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-07-82 PAGE: 1

HOLE NO.: Kc-12-10 SECT: 12 , T. 28 N., R. 23 W.

PLANNED T.D.: 40 FINAL T.D.: 10

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: No Samples Collected - Overburden I.D.

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		Fine To Csc sands, Rock frags
2-4		Csc sands, fine gravel, Rock frags
4-6		Fine sand w/ rounded frags
6-8		Black shale, hard, dry
8-10		Black shale, hard, dry some Fe stain

SPECIAL INSTRUCTIONS :

A 13

BORE CUTTINGS DESCRIPTION

PROJECT : CODY SHALE DATE : 12-07-92 PAGE: 1

HOLE NO.: Kc-12-11 SECT: 12 , T. 28 N., R. 93 W.

PLANNED T.D.: 40 FINAL T.D.: 20

METHOD OF DRILLING : 5-1/8" DRAG BIT, AIR CIRCULATION

CONTRACTOR : U.S. ENERGY CORP. RIVERTON, WY.

ADDITIVES/HOLE STABILIZERS ADDED : NONE

COMMENTS: No Samples Collected - Overburden I.A.

SUPERVISING GEOLOGIST : ROLAND COLLINS, CPG # 650

CUTTINGS DESCRIPTION

DEPTH	GRAPHIC LOG	LITHOLOGY
0-2		Fine To Cse SANDS, Rock Frags
2-4		Fine To Cse SANDS, Rock Frags
4-6		med Gravel, Rock frags
6-8		Cse SAND, fine To med Gravel
8-10		fine To Cse SAND, remarked yellow Clay
10-12		Yellow To LT Brown Clay, w/ mixed SANDS
12-14		Dark Brown To Black shale, minor SANDS
14-16		Dark Brown To Blk shale, FeSTAIN, GASCY
16-18		Blk shale, hard, dry
18-20		Blk shale, hard, dry

SPECIAL INSTRUCTIONS :

A/52

Reference #A.8

Cody Shale Geotechnical Testing Results

Reference A.8
Cody Shale Geotechnical Testing Results

This section presents the laboratory test result for the Cody Shale. In place densities, moisture contents, percent passing the #200 sieve, and Atterberg limits tests were performed on individual samples for classification.

After the index testing was performed on the individual samples taken from the borings, four samples were made by compositing similar samples together. The composites were made to represent the range of clay encountered in borings.

A total of four composites were made. These composites were made using material that had the following % passing the #200 sieve:

Composite 1	49 - 90%
Composite 2	90 - 92%
Composite 3	92 - 95%
Composite 4	95 - 98.6%

The individual samples used for each composite are presented in Table A.8.1.

Composite 1 was made using the material that contained the highest percentage of sand. The individual samples for this composite were all obtained from near surface soils and in an area that will not be part of the borrow area. Therefore, Composite 1 was determined to not be indicative of the material that will be used for the cover.

The other three composites (i.e. composites 2, 3 and 4) represent the range of materials that are expected to be encountered in the borrow area. Of these three composites, composite 2 was found to have the lowest 15-bar moisture content and therefore the highest calculated radon diffusion coefficient. Therefore, composite 2 was used to conservatively represent the material expected from the borrow area for radon barrier calculations. The average properties of the clay in the radon barrier will therefore give better radon attenuation than assumed in the calculation. The construction specifications require that the Cody shale used for the radon barrier come from the area tested and have at least 90% passing the number 200 sieve. This will ensure that the constructed radon barrier is consistent with the input parameters used in the radon model. The results of the composite testing are presented in Table A.8.2.

Table A.8.1 - Cody Shale Composites

COMPOSITE	BORING	% -200 SIEVE
1	1-8	79.4
	6-1	64.3
	7-3(1)	49.1
	7-12(1)	79.0
	7-13(1)	72.5
2	7-8(1)	91.7
	7-10(1)	92.0
	7-13(2)	90.9
	7-15(2)	90.5
	7-16(1)	90.1
	7-16(2)	90.5
3	7-1(1)	93.1
	7-2(1)	94.9
	7-5(1)	95.0
	7-9(1)	95.0
	7-14(1)	94.7
	7-15(1)	94.0
	7-15(3)	94.9
	12-1(1)	94.4
	12-6(1)	94.4
4	7-4(1)	97.5
	7-9(2)	95.7
	7-10(2)	96.7
	7-14(2)	98
	7-17(1)	95.5
	12-2	98.6
	12-4	96.7
	12-6(2)	95.5
	12-7(1)	92.3

Table A.8.2
Cody Shale Composite Testing Results

COMPOSITE	MAXIMUM DRY DENSITY (pcf)	SPECIFIC GRAVITY	15-BAR MOISTURE CONTENT
1	115.2	2.79	13.1
2	108.2	2.78	16.9
3	108.0	2.76	17.6
4	107.6	2.77	19.0

Individual Sample Results

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INBERG-MILLER ENGINEERS

124 EAST MAIN STREET RIVERTON, WYOMING 82501-4397 307-856-8136

December 21, 1992 4779.4-RM

Western Nuclear, Inc.
P.O. Box 630
Jeffrey City, Wyoming 82310

ATTENTION: ROLAND COLLINS

RE: LABORATORY TEST RESULTS
CODY SHALE TEST BORING COMPOSITE SAMPLES

Gentlemen:

As you know, we received approximately 85 Cody Shale test boring bag samples in our Riverton, Wyoming soil laboratory on December 4, 1992. We received an additional approximately 188 samples on December 7, 1992. A total of twenty-nine composite samples were prepared as directed in the test boring logs you included with the samples. Per your November 20, 1992 letter, we performed a #200 sieve analysis, Atterberg Limits test and Unified Soil Classification on each of the twenty-nine composite samples. In addition, a sieve analysis (#4 through #200 sieve) was performed on five samples containing less than 90 percent passing the #200 sieve. Particle Size Analysis Curves for these five samples are attached. The laboratory test results for the twenty-nine composite samples tested are as follows:

	Sample No.	% Moisture	% Passing #200 Sieve	Atterberg Limits LL	PL	PI	USCS Class.	
	~~1-8 CP #1~~	~~11.7~~	~~79.4~~	~~36~~	~~20~~	~~16~~	~~CL~~	omit
	~~6-1 CP #1~~	~~10.9~~	~~64.3~~	~~40~~	~~16~~	~~24~~	~~CL~~	
7-UCS #1	7-1 CP #1	12.7	93.1	48	20	28	CL	
	7-2 CP #1	11.1	94.9	55	22	33	CH	
	~~7-3 CP #1~~	~~10.8~~	Shale present AT ~~49.1~~ 8 feet	~~37~~	~~16~~	~~21~~	~~SC~~	omit
	7-4 CP #1	11.4	97.5	54	24	30	CH	
	7-5 CP #1	11.1	95.0	55	21	34	CH	
7-UCS #2	7-8 CP #1	12.7	91.7	46	23	23	CL	
	7-9 CP #1	15.1	95.0	56	22	34	CH	
	7-9 CP #2	12.8	95.7	53	20	33	CH	
	7-10 CP #1	10.9	92.0	57	21	36	CH	
	7-10 CP #2	11.8	96.7	58	24	34	CH	
7-UCS #3	7-12 CP #1	11.8	79.0	33	19	14	CL	marginal
	7-13 CP #1	10.5	72.5	42	18	24	CL	
	7-13 CP #2	13.5	90.9	46	20	26	CL	
	7-14 CP #1	12.6	94.7	51	19	32	CH	

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	Sample No.	% Moisture	% Passing #200 Sieve	Atterberg Limits LL	PL	PI	USCS Class.
7-UCS #3	7-14 CP #2	12.7	98.0	58	21	37	CH
	7-15 CP #1	16.9	94.0	53	22	31	CH
	7-15 CP #2	17.5	90.5	49	25	24	CL
	7-15 CP #3	17.2	94.9	46	22	24	CL
7-UCS #2	7-16 CP #1	10.9	90.1	42	20	22	CL
	7-16 CP #2	11.0	90.5	40	19	21	CL
	7-17 CP #1	15.0	95.5	51	21	30	CH
	12-1 CP #1	11.5	94.4	48	21	27	CL
	12-2 CP	11.7	98.6	52	23	29	CH
	12-4 CP	12.2	96.7	56	21	35	CH
12-UCS #1	12-6 CP #1	12.2	94.4	53	21	32	CH
	12-6 CP #2	9.6	95.5	55	23	32	CH
	12-7 CP #1	12.0	97.3	63	26	37	CH

We appreciate the opportunity to be of service to you thus far. If you have any questions regarding the enclosed information or if we may be of further assistance, please contact us.

Sincerely,

INBERG-MILLER ENGINEERS

Jon C. Howell

Jon C. Howell, P.E.
Geotechnical Engineer

JCH:dcr:wni

Enclosures as stated

7-UCS #1 % Pass 200 : 95.1%
% moisture : 11.5%

7-UCS #2 % Pass 200 : 93.3
% moisture : 13.8%

7-UCS #3 % Pass 200 : 84.3%
% moisture : 12.2%

12-UCS #1 % Pass 200 : 96.2%
% moisture : 11.5%

A159

File 333

MEMORANDUM

DATE : DECEMBER 22, 1992
TO : LOU MILLER
STEPHANIE BAKER
FROM : ROLAND COLLINS
SUBJECT : RESULTS OF CODY SHALE TESTING

Today I received the results of the initial series of tests performed on the Cody shale from Inberg-Miller.

After reviewing the results, following are my recommendations for further composits for these samples. From a geographic location, there doesn't seem to be much variance except in samples 7-12 and 7-13 which was suspected from the cuttings. There isn't as much variance in the grain size from different stratigraphic intervals as I would have thought after looking at the cuttings. The average moisture content is 12.2 % which is about average for inplace clays.

The additional composites selections have been made by geographic area as shown on the attached map. I have selected a total of four, however, these may be reduced to three by eliminating sample 7- UCS #3 which is marginal material.

Section 1 - No additional testing be done

Section 6 - No additional testing be done

Section 7 - As Below

Unified Composite Sample #1 (7-UCS #1) :
7-1 CP #1
7-2 CP #1
7-4 CP #1
7-5 CP #1

7- UCS #2 :
7-8 CP #1
7-9 CP #1,#2
7-10 CP #1,#2
7-15 CP #1,#2,#3
7-16 CP #1,#2
7-17 CP #1

7- UCS #3 :
7-12 CP #1
7-13 CP #1,#2
7-14 CP #1,#2

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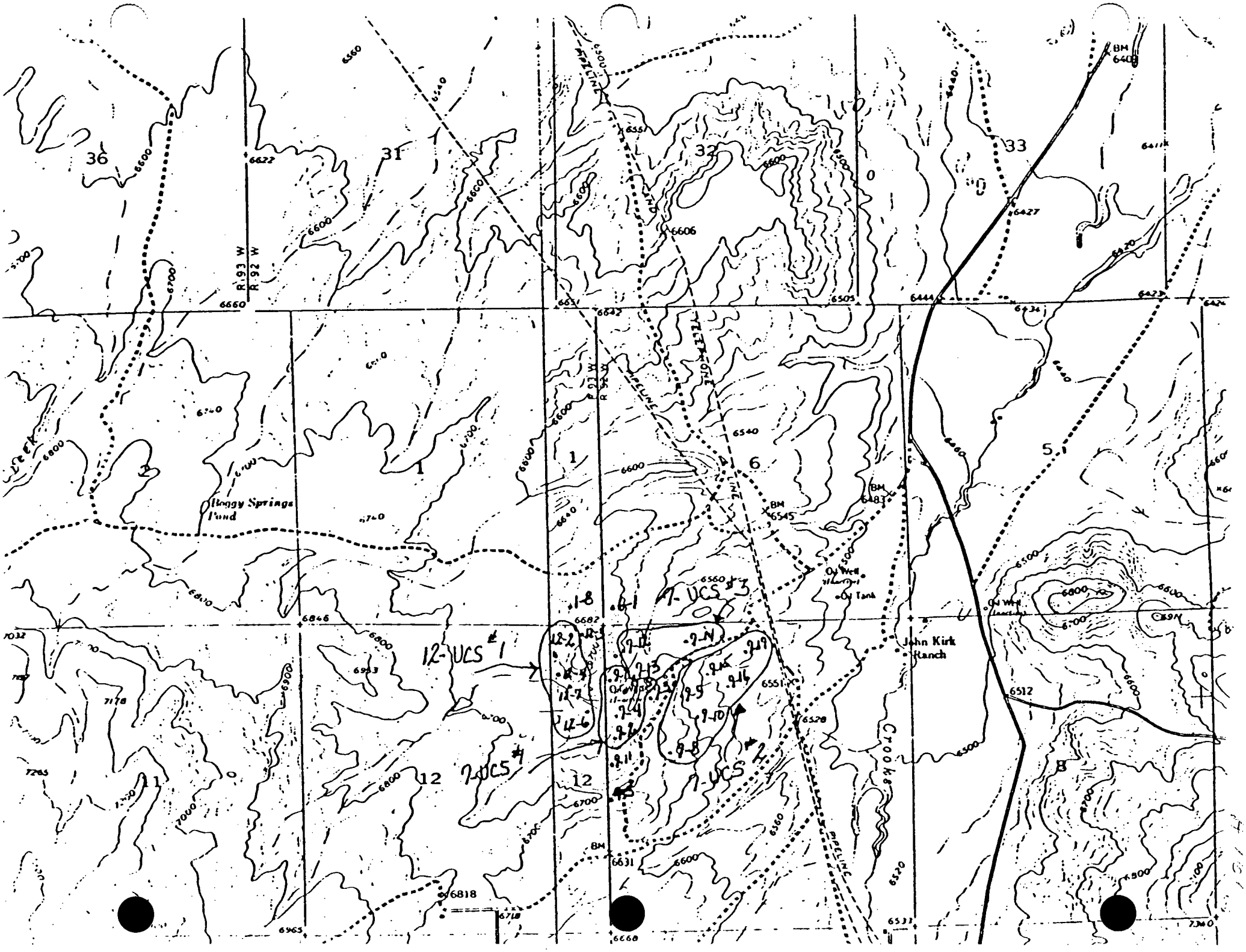
Section 12 - As Below

12- UCS #1 :

12-1 CP #1
12-2 CP #1
12-4 CP #1
12-6 CP #1, #2
12-7 CP #1

As soon as I receive your recommendations, I will get with Inberg - Miller and begin the second suite of testing. Approximately one pint of sample will reserved for 15-bar moisture from each UCS blend.


36
31
32
33
1
6
5
12
11
8
R.93 W
R.92 W
Boggy Springs Pond
John Kirk Ranch
Crooks
PIPELINE
12-UCS #1
7-UCS #2
7-UCS #3
7-UCS #4
Oil Well
Oil Tank
BM 6545
BM 6631
BM 6818
BM 6427
6660
6622
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6503
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Composite Sample Results

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INBERG-MILLER ENGINEERS

124 EAST MAIN STREET RIVERTON, WYOMING 82501-4397 307-856-8136

February 15, 1993

4779.4-RM

Western Nuclear, Inc.
P.O. Box 630
Jeffrey City, Wyoming 82310

ATTENTION: ROLAND COLLINS

RE: LABORATORY TEST RESULTS
CODY SHALE TEST BORING
UNIFIED COMPOSITE SAMPLES

Gentlemen:

As requested in your letter of December 28, 1992, we have prepared four (4) "unified composite samples" which were comprised of the indicated composite samples. We have subsequently performed a specific gravity, proctor dry density (95% compaction), falling head permeability and a dispersion test on each of the four (4) unified composite samples. Test results are as follows:

Unified Composite Sample No.	Standard Proctor Max. D.D.(PCF)	Standard Proctor OPT W/C(%)	Specific Gravity	Dispersivity(%)	Coeff. of Permeability k (cm/sec)
UCS#1	115.2	13.8	2.79	9.8	1.24×10^{-8}
UCS#2	108.2	17.6	2.78	3.7	1.74×10^{-8}
UCS#3	108.0	17.7	2.76	5.4	9.23×10^{-9}
UCS#4	107.6	18.3	2.77	4.1	4.58×10^{-9}

Note: Standard Proctor (ASTM D698) compaction curves are enclosed. Permeability coefficients are based on samples remolded to 95 percent of the Standard Proctor dry density near optimum water content.

We appreciate the opportunity to be of service to you thus far. If you have any questions regarding the enclosed information or if we may be of further assistance, please contact us.

Sincerely,

INBERG-MILLER ENGINEERS

Jon C. Howell

Jon C. Howell, P.E.
Geotechnical Engineer

JCH:dcr:wmi

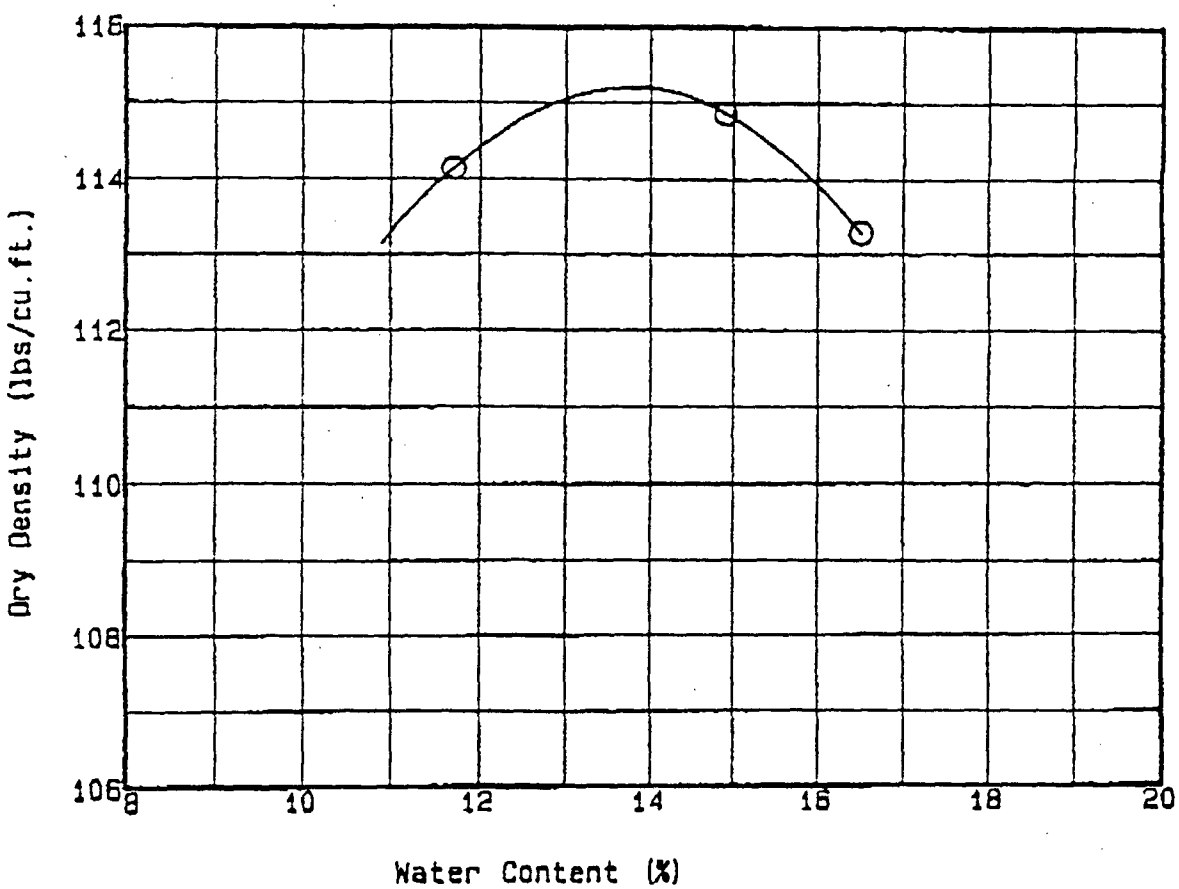
Enclosures as stated

A/64

MOISTURE-DENSITY ANALYSIS

Project: J.C. MINE REC.
Job No.: 4774.9-RM
Client: WNI

Test Date: 1-11-93
Tested By: RER
Test Method: ASTM D-698



Soil Description: CLAY W/SAND

Sample No.: UCS #1
Sampled By: CLIENT
Source: BORING

% passing #200 sieve: _____

Optimum Water Content: 13.8 %

Liquid Limit: _____
Plasticity Index: _____

Max. Dry Density: 115.2 lbs/cu.ft.

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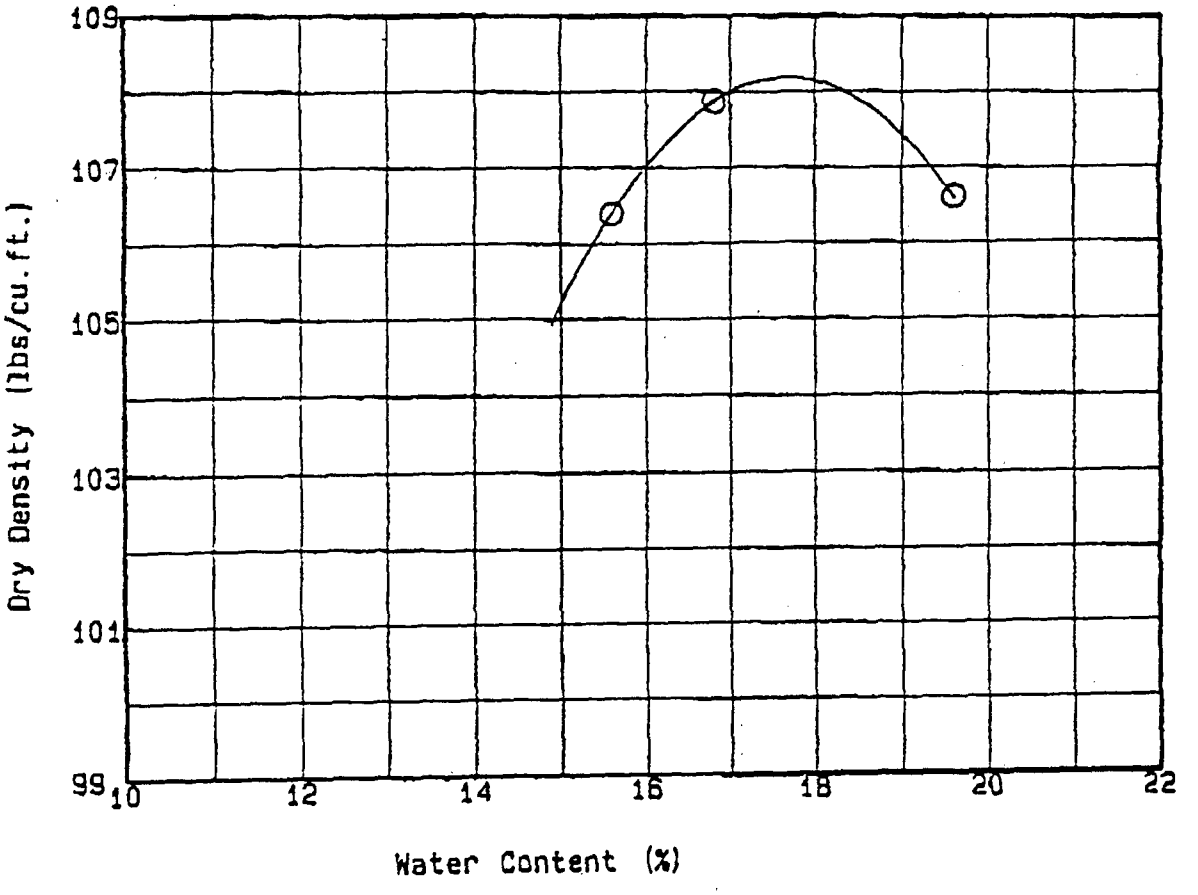
MOISTURE-DENSITY ANALYSIS

Project: J.C. MINE REC.
Job No.: 4774.9-RM
Client: WNI

Test Date: 1-11-93
Tested By: RER
Test Method: ASTM D-698



Soil Description: CLAY W/SAND

% passing #200 sieve: _____

Liquid Limit: _____

Plasticity Index: _____

Sample No.: UCS #2

Sampled By: CLIENT

Source: BORING

Optimum Water Content: 17.6 %

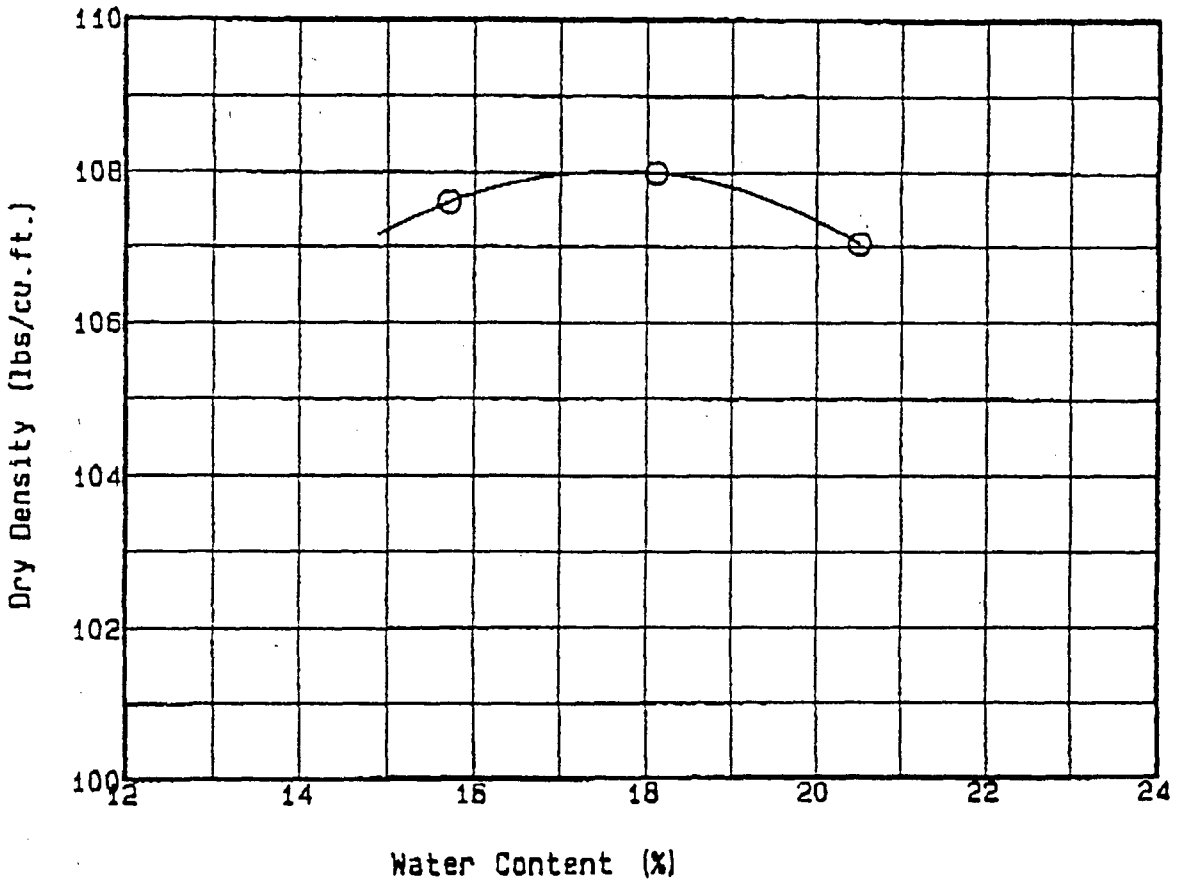
Max. Dry Density: 108.2 lbs/cu.ft.

A.166

MOISTURE-DENSITY ANALYSIS

Project: J.C. MINE REC.
Job No.: 4774.9-RM
Client: WNI

Test Date: 1-11-93
Tested By: RER
Test Method: ASTM D-698



Soil Description: CLAY W/SAND

Sample No.: UCS #3
Sampled By: CLIENT
Source: BORING

% passing #200 sieve: _____

Optimum Water Content: 17.7 %

Liquid Limit: _____
Plasticity Index: _____

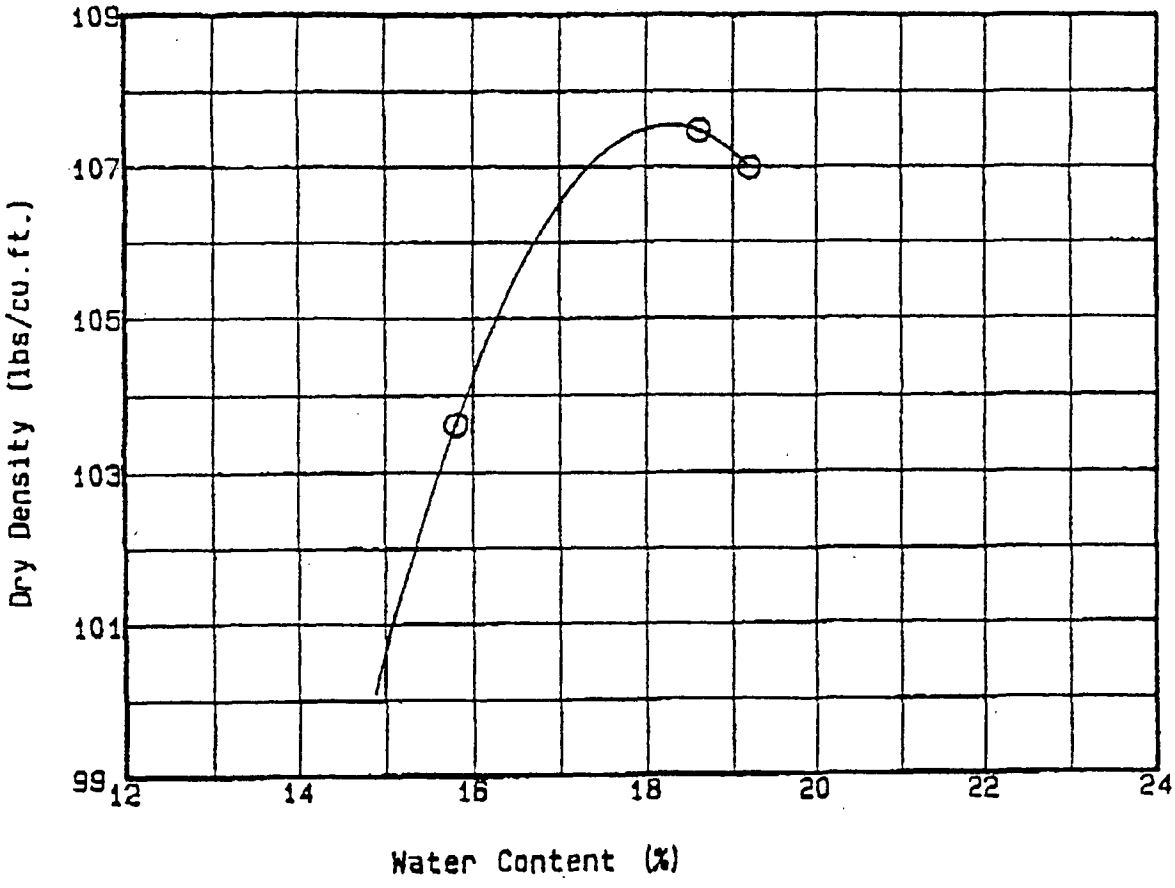
Max. Dry Density: 108.0 lbs/cu.ft.

A167

MOISTURE-DENSITY ANALYSIS

Project: J.C. MINE REC.
Job No.: 4774.9-RM
Client: WNI

Test Date: 1-11-93
Tested By: RER
Test Method: ASTM D-698



Soil Description: CLAY W/SAND

% passing #200 sieve: _____

Liquid Limit: _____

Plasticity Index: _____

Sample No.: UCS #4

Sampled By: CLIENT

Source: BORING

Optimum Water Content: 18.3 %

Max. Dry Density: 107.6 lbs/cu.ft.

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Reference #A.9

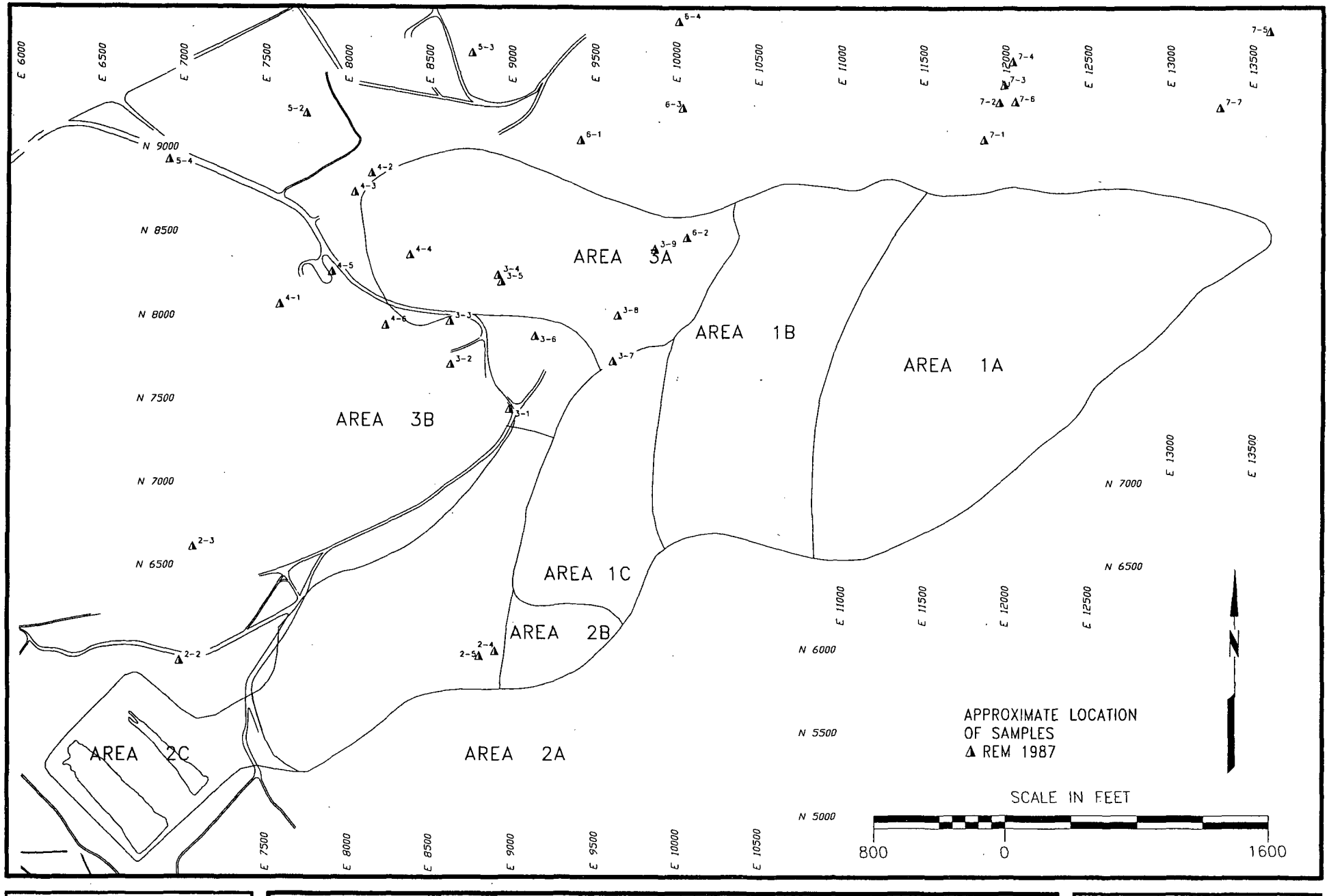
Tailing Radiological Testing Results

Provided by: Radiant Energy Management

- December 1987 -

Reference A.9
Tailing Radiological Testing Results

This section presents the laboratory data from radiological testing conducted on tailing samples collected by Radiant Energy management (REM) in December of 1987. Figure A.9.1 presents the locations of the tailing samples. Portions of these results are used in Appendix G, see Appendix G for details. The number of samples, sample depth, and other assumptions are included in correspondence from REM dated December 11, 1991. The results for U-natural and Ra-226 are tabulated on pages A-174 through A-179.



SMI
SHEPHERD MILLER, INC.

FIGURE A.9.1
SAMPLE LOCATIONS

Date:	OCT., 1993
Project:	336
File:	BORE-1

H170

H171

REM

RADIANT ENERGY MANAGEMENT

LYDA W. HERSLOFF, Ph.D.

Health Physicist

December 11, 1991

Ms. Stephanie Baker
Western Nuclear
Union Plaza Suite #300
200 Union Blvd
Lakewood, CO 80228

Dear Stephanie,

I have reviewed the soil data collected during the 1987 radiological survey at the Split Rock Uranium mill site, Jeffrey City, Wyoming for Areas 1, 5, 6, and 7. Area 1 is designated the background area. Areas 5, 6, and 7 represent borrow areas for final soil cover.

In Area 1, a total of nine samples were collected to a depth of 6 feet at each of five sites, the five sites being representative of the range of gamma exposure readings in Area 1. The mean Radium-226 (Ra-226) concentration was determined to be 1.4 pCi/g with a sample standard deviation of 0.8 pCi/g. The mean Ra-226 concentration of 1.4 plus three standard deviations is equivalent to 3.4 pCi/g. The average gamma exposure rate in Area 1 was 16 ± 1.2 μR/hr (1988 report). Using the regression equations developed in the January, 1988 report, the predicted uncorrected gamma exposure rate for 1.4 pCi/g is 23 μR/hr, whereas the predicted corrected gamma exposure rate is 14 μR/hr.

In Area 5, there were 6 samples which exceeded the above value of 3.4 pCi/g including 5-1-1, 5-3-1, 5-4-1, 5-4-2, 5-4-6, and 5-4-8. In reading these sample numbers, the first number refers to the area, the second number to the location in the area and the third number to the sample depth. For example, 5-1-1 refers to Area 5, first location, surface interval 0-6" where the third numbers of 8 and 9 refer to composite samples of 4 to 5' and 5 to 6' respectively. As in Area 1, the soil sample locations in Areas 5, 6, and 7 represented the range of external gamma readings in each area. The mean value for all 29 samples collected to a depth of 6 feet in Area 5 was 9.84 ± 28.27 pCi/g. However, since the top 6" of soil from Areas 5, 6, and 7 were designated windblown tails based on the 1987 survey and were removed to the tailings pond, evaluation

10854 DIANE DR. GOLDEN, Co. 80403 (303) 642-7530

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of the soil samples at depth below the surface 6" indicated a mean Ra-226 concentration of 2.3 ± 1.9 pCi/g in Area 5.

In Area 6, there were also 6 samples which exceeded the above value of 3.4 pCi/g including 6-1-1, 6-1-3, 6-1-9, 6-3-1, 6-4-1, and 6-4-2. The mean value for all 27 samples collected to a depth of 6 feet in Area 6 was 6.1 ± 12.3 pCi/g. As per above, excluding the samples in the top 6" of soil, the mean Ra-226 concentration is 5.1 ± 12.4 pCi/g.

In Area 7, there were 7 samples which exceeded the above value of 3.4 pCi/g including 7-1-1, 7-2-1, 7-3-1, 7-5-1, 7-6-1, and 7-6-5. The mean value the 63 samples collected to a depth of 6 feet in Area 7 was 3.1 ± 7.1 pCi/g. Again excluding the sample values in the top 6" of soil, the mean Ra-226 concentration at depths greater than 6" is 1.4 ± 1.6 pCi/g.

Evaluating all the soil data together, excluding the samples from 0-6" which have been removed as windblown tailings, the mean Ra-226 concentration is 2.5 ± 6.3 pCi/g based on 103 samples. The average Ra-226 concentration of 2.5 is 1.1 pCi/g above the average background concentration of 1.4 pCi/g and is within the 95% confidence interval of 1.96σ (1.6 pCi/g) associated with the background in Area 1. Further, the standard deviation of 6.3 pCi/g, is within the regulation for surface concentration for Ra-226 of 5 pCi/g above background or 6.4 pCi/g for the Split Rock site. Finally, given that a total of 103 soil samples were collected below 6" and only 9 samples deeper than 6" had Ra-226 concentrations in excess of the above value of background mean plus 3σ of 3.4, it is likely that the average Ra-226 concentration in soils in the top 6" will be well within EPA guidelines of an average of 5 pCi/g above background in the top 6" (15 cm) and 15 pCi/g above background in successive 15 centimeter increments of depth there after.

I believe that the above evaluation accurately represents the Radium-226 concentrations of soils to a depth of 6 feet in Areas 1, 5, 6, and 7. The statistical approach of including the standard deviation to a confidence level of 99% (3σ), given the large mixing which occurs during earth moving, should closely approximate the final conditions. Possible sources of the elevated Ra-226 concentrations at depth include elevated

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naturally occurring radioactive materials known to be associated with the Sweetwater area as well as windblown tailings and ore from uranium milling operations. Evidence for all three sources exists in the data to depth in Areas 5, 6, and 7 with ratios of Uranium to Radium-226 ranging from 1.2 to 0.02.

If you have any questions, please do not hesitate to call.

Sincerely

Lyda

Lyda W. Bersloff, Ph.D.

A174
called Wamco to ch
circled values
12/21/87

WAMCO LAB

P. O. Box 2953 - Casper, WY 82602

ANALYSIS REPORT

COMPANY: Western Nuclear, Inc

Sample Type: Soils From Split Rock Properties

DATE Dec. 15, 1987
Date Rec'd 9/18/87
W. O. No. 7014
P. O. # D- 301689

Analysis in picoCuries per Gram except where Noted

No.	I.D.	U-Nat	Ra-226	No.	I.D.	U-Nat	Ra-226
1	1-1-1	4.2+-1.2	2.2+-0.4	37	1-5-1	2.0+-0.8	1.3+-0.3
2	1-1-2	2.5+-0.9	1.6+-0.3	38	1-5-2	1.7+-0.7	0.8+-0.2
3	1-1-3	1.7+-0.7	1.5+-0.3	39	1-5-3	2.4+-0.9	1.1+-0.3
4	1-1-4	1.1+-0.6	1.3+-0.3	40	1-5-4	4.8+-1.2	1.6+-0.3
5	1-1-5	1.7+-0.7	1.7+-0.3	41	1-5-5	8.9+-2.1	3.7+-0.5
6	1-1-6	2.8+-0.9	1.1+-0.2	42	1-5-6	10.4+-2.3	5.1+-0.6
7	1-1-7	1.1+-0.6	1.4+-0.3	43	1-5-7	5.5+-1.5	1.7+-0.3
8	1-1-8	7.4+-1.5	1.0+-0.2	44	1-5-8	1.9+-0.8	1.5+-0.3
9	1-1-9	4.0+-1.2	1.1+-0.2	45	1-5-9	1.3+-0.7	1.2+-0.3
10	1-2-1	2.0+-0.8	1.1+-0.2	46	2-1-1	0.9+-0.6	1.2+-0.3
11	1-2-2	1.1+-0.6	1.2+-0.2	47	2-1-2	0.8+-0.5	1.2+-0.3
12	1-2-3	1.7+-0.7	1.0+-0.2	48	2-1-3	1.1+-0.6	0.8+-0.2
13	1-2-4	0.6+-0.5	1.0+-0.2	49	2-1-4	1.8+-0.6	0.9+-0.2
14	1-2-5	1.7+-0.7	1.2+-0.2	50	2-1-5	1.5+-0.7	1.1+-0.3
15	1-2-6	2.2+-0.8	0.7+-0.2	51	2-1-6	0.8+-0.5	1.1+-0.3
16	1-2-7	1.1+-0.6	1.1+-0.3	52	2-1-7	1.1+-0.6	0.8+-0.2
17	1-2-8	0.6+-0.5	1.0+-0.2	53	2-1-8	4.5+-1.2	1.3+-0.3
18	1-2-9	1.1+-0.6	2.1+-0.4	54	2-1-9	1.0+-0.6	1.0+-0.3
19	1-3-1	2.2+-0.8	1.1+-0.3	55	2-2-1	1.2+-0.6	1.5+-0.3
20	1-3-2	2.2+-0.8	1.0+-0.2	56	2-2-3	1.0+-0.6	1.0+-0.2
21	1-3-3	1.7+-0.7	1.2+-0.3	57	2-2-3	1.2+-0.6	1.1+-0.3
22	1-3-4	4.5+-1.2	1.8+-0.3	58	2-2-4	0.9+-0.6	1.6+-0.3
23	1-3-5	4.7+-1.2	1.4+-0.3	59	2-2-5	0.8+-0.5	1.1+-0.3
24	1-3-6	3.9+-1.1	2.2+-0.4	60	2-2-6	0.8+-0.5	1.1+-0.3
25	1-3-7	5.7+-1.4	1.3+-0.3	61	2-2-7	0.8+-0.5	1.0+-0.3
26	1-3-8	10.0+-2.3	1.4+-0.3	62	2-2-8	2.8+-0.5	1.1+-0.3
27	1-3-9	3.0+-0.9	1.0+-0.2	63	2-2-9	0.8+-0.5	0.8+-0.2
28	1-4-1	2.2+-0.8	1.2+-0.3	64	2-3-1	1.1+-0.6	0.8+-0.2
29	1-4-2	2.3+-0.8	1.8+-0.3	65	2-3-2	0.8+-0.5	1.0+-0.2
30	1-4-3	2.7+-0.8	1.1+-0.3	66	2-3-3	1.3+-0.7	1.6+-0.3
31	1-4-4	2.5+-0.9	1.2+-0.3	67	2-3-4	0.9+-0.6	1.0+-0.3
32	1-4-5	2.8+-0.9	1.4+-0.3	68	2-3-5	0.9+-0.6	1.1+-0.3
33	1-4-6	1.1+-0.6	0.9+-0.2	69	2-3-6	1.1+-0.6	1.7+-0.3
34	1-4-7	1.4+-0.7	0.8+-0.2	70	2-3-7	0.8+-0.5	1.0+-0.3
35	1-4-8	1.3+-0.7	0.8+-0.2	71	2-3-8	1.0+-0.6	0.9+-0.2
36	1-4-9	12.5+-2.5	1.0+-0.2	72	2-3-9	0.8+-0.5	1.6+-0.3

Area 1 background $\bar{x}$ 1.5pCi/g below surface n=4

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WAMCO LAB

P. O. Box 2953 - Casper, WY 82602

ANALYSIS REPORT

COMPANY: Western Nuclear, Inc

Sample Type: Soils From Split Rock Properties

DATE Dec. 15, 1987
Date Rec'd 9/18/87
W. O. No. 7014
P. O. # D- 301689

Analysis in picoCuries per Gram except where Noted

No.	I.D.	U-Nat	Ra-226	No.	I.D.	U-Nat	Ra-226
73	2-4-1	0.7+-0.5	0.9+-0.2	110	3-3-7	4.0+-1.1	1.5+-0.3
74	2-4-2	0.8+-0.5	0.9+-0.2	111	3-3-8	5.2+-1.2	2.0+-0.4
75	2-4-3	1.0+-0.6	1.5+-0.3	112	3-4-1	21.0+-2.5	16.4+-1.1
76	2-4-4	3.3+-1.0	0.9+-0.2	113	3-4-2	7.8+-1.5	4.8+-0.6
77	2-4-5	26.9+-4.0	1.0+-0.3	114	3-4-3	20.7+-2.5	22.7+-1.3
78	2-4-6	212+-11	30.7+-1.5	115	3-4-4	6.0+-1.3	6.9+-0.7
79	2-5-1	5.2+-1.2	1.3+-0.3	116	3-4-5	3.4+-1.0	5.3+-0.6
80	2-5-2	5.0+-1.2	1.0+-0.3	117	3-4-6	4.6+-1.2	1.5+-0.3
81	2-5-3	1.4+-0.7	0.9+-0.2	118	3-4-7	8.0+-1.6	1.1+-0.3
82	2-5-4	2.0+-0.8	1.5+-0.3	119	3-4-8	12.1+-1.9	1.2+-0.3
83	2-5-5	1.1+-0.6	0.9+-0.2	120	3-4-9	21.0+-2.5	0.9+-0.2
84	2-5-6	1.4+-0.7	0.7+-0.2	121	3-5-1	115+-5.9	33.4+-
85	2-5-7	1.9+-0.7	1.0+-0.3	122	3-5-2	274+-9.1	38.5+-
86	2-5-8	12.1+-1.9	9.3+-2.6	123	3-3-5	286+-9.3	3.0+-0.5
87	3-1-10	123+-6.1	1.9+-0.4	124	3-5-4	228+-8.3	1.0+-0.3
88	3-1-2	44.5+-3.7	8.9+-0.8	125	3-5-5	301+-9.5	1.3+-0.3
89	3-1-3	31.6+-3.1	6.2+-0.7	126	3-5-6	416+-11	1.3+-0.3
90	3-1-4	35.9+-3.3	7.5+-0.7	127	3-5-7	502+-12	0.9+-0.3
91	3-1-5	28.1+-2.9	7.8+-0.7	128	3-5-8	139+-6.5	1.4+-0.3
92	3-1-6	21.4+-2.5	7.5+-0.7	129	3-5-9	17.4+-2.3	1.1+-0.3
93	3-1-7	102+-5.5	6.8+-0.7	130	3-6-1	63.2+-4.4	47.1+-1.8
94	3-1-8	17.8+-2.3	7.4+-0.7	131	3-6-2	34.4+-3.2	42.5+-1.7
95	3-2-1	4.6+-1.2	0.9+-0.3	132	3-6-3	51.7+-3.9	14.1+-1.0
96	3-2-2	2.9+-0.9	1.1+-0.3	133	3-6-4	54.5+-4.0	28.5+-1.4
97	3-2-3	2.3+-0.8	1.1+-0.3	134	3-6-5	87.6+-5.1	16.4+-1.1
98	3-2-4	2.3+-0.8	1.4+-0.3	135	3-6-6	89.8+-5.2	13.7+-0.9
99	3-2-5	2.2+-0.8	1.1+-0.3	136	3-6-7	50.2+-3.9	15.0+-1.0
100	3-2-6	1.9+-0.7	1.1+-0.3	137	3-6-8	66.0+-4.5	11.2+-0.8
101	3-2-7	2.0+-0.8	1.2+-0.3	138	3-6-9	70.3+-4.6	14.9+-1.0
102	3-2-8	1.7+-0.7	1.2+-0.3	139	3-7-1	48.8+-3.8	28.9+-1.3
103	3-2-9	2.3+-0.8	1.0+-0.3	140	3-7-2	10.9+-1.8	10.3+-0.8
104	3-3-1	45.9+-3.7	18.6+-1.2	141	3-7-3	6.6+-1.4	10.0+-0.8
105	3-3-2	21.0+-2.5	4.5+-0.6	142	3-7-4	66.0+-4.5	20.7+-1.1
106	3-3-3	16.6+-2.2	1.4+-0.3	143	3-7-5	210+-7.9	29.5+-1.4
107	3-3-4	18.9+-2.4	0.3+-0.1	144	3-7-6	68.9+-4.5	23.6+-1.2
108	3-3-5	14.1+-2.1	0.9+-0.3	145	3-8-1	47.4+-3.8	23.2+-1.3
109	3-3-6	6.7+-1.4	1.5+-0.3				

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WAMCO LAB

P. O. Box 2953 - Casper, WY 82602

ANALYSIS REPORT

COMPANY: Western Nuclear, Inc

Sample Type: Soils From Split Rock Properties

DATE Dec. 15,1987
Date Rec'd 9/18/87
W. O. No. 7014
P. O. # D- 301689

Analysis in picoCuries per Gram except where Noted

No.	I.D.	U-Nat	Ra-226	No.	I.D.	U-Nat	Ra-226
146	3-8-2	15.5+-2.2	0.8+-0.2	183	4-3-3	25.8+-2.8	1.6+-0.3
147	3-8-3	10.9+-1.8	1.2+-0.3	184	4-3-4	20.1+-2.5	1.5+-0.3
148	3-8-4	23.8+-2.7	0.9+-0.3	185	4-3-5	14.4+-2.1	2.1+-0.4
149	3-8-5	16.4+-2.2	0.1+-0.1	186	4-3-6	14.6+-2.1	1.8+-0.3
150	3-8-6	8.6+-1.6	0.8+-0.2	187	4-3-7	6.0+-1.3	0.8+-0.2
151	3-8-7	8.0+-1.6	0.8+-0.2	188	4-3-8	5.2+-1.2	1.2+-0.3
152	3-8-8	5.5+-1.3	0.8+-0.2	189	4-3-9	9.8+-1.7	20+-0.4
153	3-8-9	15.8+-2.2	1.0+-0.3	190	4-4-1	617+-13.6	109.2+-2.7
154	3-9-1	181+-7.4	142+-3.2	191	4-4-2	144+-6.6	34.9+-1.5
155	3-9-2	44.5+-3.7	154+-3.2	192	4-4-3	746+-15	45.3+-1.8
156	3-9-3	60.3+-4.3	7.5+-0.7	193	4-4-4	718+-15	75.2+-2.3
157	3-9-4	24.1+-2.7	3.5+-0.5	194	4-4-5	574+-13	5.2+-0.6
158	3-9-5	9.5+-1.7	2.2+-0.4	195	4-4-6	35.9+-3.3	1.2+-0.3
159	3-9-6	6.0+-1.3	2.0+-0.4	196	4-4-7	16.6+-2.2	3.0+-0.5
160	3-9-7	5.2+-1.2	1.3+-0.3	197	4-4-8	2.7+-0.9	0.9+-0.2
161	3-9-8	48.8+-3.8	1.8+-0.4	198	4-4-9	4.6+-1.2	0.9+-0.3
162	3-9-9	58.8+-4.2	1.3+-0.3	199	4-5-1	10.8+-1.8	6.9+-0.7
163	4-1-1	30.7+-3.0	7.3+-0.7	200	4-5-2	23.0+-2.6	19.3+-1.2
164	4-1-2	74.6+-4.7	2.4+-0.4	201	4-5-3	12.3+-1.9	1.9+-0.4
165	4-1-3	459+-11.7	1.3+-0.3	202	4-5-4	8.8+-1.6	3.2+-0.5
166	4-1-4	91.9+-5.3	1.0+-0.3	203	4-5-5	6.3+-1.4	1.3+-0.3
167	4-1-5	21.2+-2.5	1.8+-0.3	204	4-5-6	2.9+-0.9	1.1+-0.3
168	4-1-6	31.6+-3.1	1.0+-0.3	205	4-5-7	2.2+-0.8	1.3+-0.3
169	4-1-7	25.5+-2.8	1.4+-0.3	206	4-5-8	2.4+-0.9	2.1+-0.4
170	4-1-8	34.4+-3.2	0.7+-0.2	207	4-5-9	2.3+-0.8	0.8+-0.2
171	4-1-9	3.40+1.03	1.6+-0.3	208	4-6-1	7.2+-1.5	2.3+-0.4
172	4-2-1	3.2+-1.0	1.6+-0.3	209	5-1-1	3.3+-1.0	134+-6.0
173	4-2-2	101+-5.5	0.9+-0.3	210	5-2-1	2.0+-0.8	2.4+-0.4
174	4-2-3	70.3+-4.6	10.0+-0.8	211	5-2-2	2.2+-0.8	1.4+-0.3
175	4-2-4	5.2+-1.2	1.6+-0.3	212	5-2-3	1.9+-0.7	1.4+-0.3
176	4-2-5	4.6+-1.2	1.2+-0.3	213	5-2-4	2.7+-0.9	1.2+-0.3
177	4-2-6	3.4+-1.0	1.5+-0.3	214	5-2-5	2.6+-0.9	0.9+-0.2
178	4-2-7	12.1+-1.9	1.2+-0.3	215	5-2-6	5.2+-1.2	1.2+-0.3
179	4-2-8	15.5+-2.2	1.0+-0.2	216	5-2-7	0.6+-0.4	1.3+-0.3
180	4-2-9	40.2+-3.5	2.4+-0.4	217	5-3-1	0.6+-0.4	3.0+-0.5
181	4-3-1	2167+-26	93+-5.4	218	5-3-2	0.6+-0.4	2.3+-0.4
182	4-3-2	33.0+-3.1	3.3+-0.5	219	5-3-3	1.0+-0.5	8.4+-0.8

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WAMCO LAB

P. O. Box 2953 - Casper, WY 82602

ANALYSIS REPORT

COMPANY: Western Nuclear, Inc

Sample Type: Soils From Split Rock Properties

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W. O. No. 7014
P. O. # D- 301689

Analysis in picoCuries per Gram except where Noted

No.	I.D.	U-Nat	Ra-226	No.	I.D.	U-Nat	Ra-226
220	5-3-4	1.9+-0.7	0.6+-0.2	257	6-3-5	2.3+-0.8	1.0+-0.3
221	5-3-5	1.3+-0.6	1.0+-0.3	258	6-3-6	1.7+-0.7	1.1+-0.3
222	5-3-6	1.4+-0.7	2.1+-0.4	259	6-3-7	2.3+-0.8	1.1+-0.3
223	5-3-7	2.7+-0.9	1.4+-0.3	260	6-3-8	1.7+-0.7	0.8+-0.2
224	5-3-8	1.4+-0.7	1.6+-0.3	261	6-3-9	1.1+-0.6	0.6+-0.2
225	5-3-9	1.4+-0.7	0.8+-0.2	262	6-4-1	16.4+-2.2	23.3+-1.3
226	5-4-1	488+-12	65.9+-2.1	263	6-4-2	1.4+-0.7	4.4+-0.5
227	5-4-2	9.9+-1.7	4.1+-0.5	264	6-4-3	2.0+-0.8	1.7+-0.3
228	5-4-3	4.3+-1.1	1.8+-0.3	265	6-4-4	1.9+-0.7	1.0+-0.3
229	5-4-4	5.6+-1.3	1.6+-0.3	266	6-4-5	1.7+-0.7	1.3+-0.3
230	5-4-5	3.7+-1.1	2.3+-0.4	267	6-4-6	1.9+-0.7	1.2+-0.3
231	5-4-6	3.9+-1.1	4.0+-0.5	268	6-4-7	2.6+-0.9	1.0+-0.3
232	5-4-7	3.9+-1.1	2.7+-0.4	269	6-4-8	1.7+-0.7	1.6+-0.3
233	5-4-8	2.3+-0.8	6.1+-0.6	270	6-4-9	1.4+-0.7	0.8+-[illegible]
234	5-4-9	6.9+-1.4	2.4+-0.4	271	7-1-1	19.5+-2.4	35.6+-[illegible]6
235	6-1-1	38.8+-3.4	12.8+-0.9 .33	272	7-1-2	2.2+-0.8	3.0+-0.5
236	6-1-2	2.9+-0.9	1.2+-0.3	273	7-1-3	1.4+-0.7	1.5+-0.3
237	6-1-3	1.7+-0.7	44.1+-1.7 25.94	274	7-1-4	2.2+-0.8	1.3+-0.3
238	6-1-4	2.0+-0.8	1.1+-0.3	275	7-1-5	2.0+-0.8	1.1+-0.3
239	6-1-5	1.6+-0.7	1.1+-0.3 .63	276	7-1-6	1.4+-0.7	1.0+-0.3
240	6-1-6	1.6+-0.6	3.0+-0.4 .16	277	7-1-7	1.4+-0.8	0.9+-0.2
241	6-1-7	2.4+-0.9	2.0+-0.4	278	7-1-8	1.7+-0.7	0.8+-0.2
242	6-1-8	1.9+-0.7	1.3+-0.3	279	7-1-9	1.7+-0.7	0.7+-0.2
243	6-1-9	1.1+-0.6	46.5+-1.8 47.27	280	7-2-1	13.2+-2.0	42.5+-1.7
244	6-2-1	21.0+-2.5	2.3+-0.4	281	7-2-2	2.0+-0.8	1.2+-0.3
245	6-2-2	373.2+-10.6	1.1+-0.3	282	7-2-3	1.7+-0.7	1.5+-0.3
246	6-2-3	1.9+-0.7	1.4+-0.3	283	7-2-4	3.2+-1.0	0.9+-0.3
247	6-2-4	1.7+-0.7	1.3+-0.3	284	7-2-5	2.4+-0.9	0.8+-0.2
248	6-2-5	1.4+-0.7	0.9+-0.2	285	7-2-6	1.7+-0.7	1.1+-0.3
249	6-2-6	1.9+-0.7	0.1+-0.1	286	7-2-7	1.6+-0.7	0.8+-0.2
250	6-2-7	2.2+-0.8	1.4+-0.3	287	7-2-8	1.7+-0.7	0.7+-0.2
251	6-2-8	2.2+-0.8	0.9+-0.3	288	7-2-9	1.9+-0.7	1.3+-0.3
252	6-2-9	2.0+-0.8	0.9+-0.3	289	7-3-1	7.8+-1.5	13.9+-1.0
253	6-3-1	8.8+-1.6	5.5+-0.6	290	7-3-2	3.6+-1.0	6.4+-0.7
254	6-3-2	6.6+-1.4	2.9+-0.4	291	7-3-3	1.7+-0.7	1.1+-0.3
255	6-3-3	2.2+-0.8	0.6+-0.2	292	7-3-4	1.4+-0.7	1.0+-0.3
256	6-3-4	2.3+-0.8	1.3+-0.3	293	7-3-5	1.7+-0.7	1.7+-0.4

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WAMCO LAB

P. O. Box 2953 - Casper, WY 82602

ANALYSIS REPORT

COMPANY: Western Nuclear, Inc

Sample Type: Soils From Split Rock Properties

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W. O. No. 7014
P. O. # D- 301689

Analysis in picoCuries per Gram except where Noted

No.	I.D.	U-Nat	Ra-226	No.	I.D.	U-Nat	Ra-226
294	7-3-6	1.9+-0.7	0.5+-0.2	331	7-7-7	1.4+-0.7	0.9+-0.3
295	7-3-7	2.3+-0.8	1.1+-0.3	332	7-7-8	1.7+-0.7	1.0+-0.3
296	7-3-8	2.0+-0.8	1.1+-0.3	333	7-7-9	5.7+-1.3	3.3+-0.4
297	7-3-9	1.7+-0.7	0.9+-0.3	334	8-1-1	1.9+-0.7	0.9+-0.2
298	7-4-1	63.+-1.4	0.7+-0.2	335	8-1-2	2.7+-0.9	0.6+-0.2
299	7-4-2	2.6+-0.9	1.2+-0.3	336	8-1-3	1.6+-0.7	1.1+-0.3
300	7-4-3	2.4+-0.9	1.8+-0.3	337	8-1-4	1.6+-0.7	0.7+-0.2
301	7-4-4	1.7+-0.7	1.6+-0.3	338	8-1-5	2.3+-0.8	0.7+-0.2
302	7-4-5	2.0+-0.8	0.6+-0.2	339	8-1-6	2.0+-0.8	0.8+-0.2
303	7-4-6	1.1+-0.6	1.4+-0.3	340	8-1-7	2.0+-0.8	1.0+-0.2
304	7-4-7	1.9+-0.7	1.0+-0.3	341	8-1-8	2.2+-0.8	0.7+-0.2
305	7-4-8	2.0+-0.8	0.8+-0.2	342	8-1-9	4.3+-1.1	4.2+-0.5
306	7-4-9	1.6+-0.7	1.2+-0.3	343	8-2-1	2.4+-0.9	0.8+-0.2
307	7-5-1	3.4+-1.0	12.2+-0.9	344	8-2-2	1.1+-0.6	0.6+-0.2
308	7-5-2	1.4+-0.7	1.7+-0.3	345	8-2-3	1.1+-0.6	0.6+-0.2
309	7-5-3	1.1+-0.6	1.1+-0.3	346	8-2-4	1.4+-0.7	0.9+-0.2
310	7-5-4	1.1+-0.6	1.1+-0.3	347	8-2-5	1.1+-0.6	1.0+-0.2
311	7-5-5	1.6+-0.7	0.8+-0.2	248	8-2-6	0.9+-0.5	0.6+-0.2
312	7-5-6	1.4+-0.7	0.5+-0.2	349	8-2-7	1.3+-0.6	0.8+-0.2
313	7-5-7	1.7+-0.7	0.9+-0.2	350	8-2-8	1.6+-0.7	0.9+-0.2
314	7-5-8	1.7+-0.7	0.9+-0.2	351	8-2-9	1.1+-0.6	0.8+-0.2
315	7-5-9	2.6+-0.9	0.9+-0.2	352	8-3-1	1.3+-0.6	2.0+-0.3
316	7-6-1	5.7+-1.3	9.4+-0.8	353	8-3-2	1.1+-0.6	0.8+-0.2
317	7-6-2	1.7+-0.7	1.05+0.38	354	8-3-3	1.6+-0.7	0.7+-0.2
318	7-6-3	2.7+-0.9	2.2+-0.4	355	8-3-4	1.6+-0.7	1.1+-0.3
319	7-6-4	1.9+-0.76	1.0+-0.3	356	8-3-5	1.4+-0.7	0.9+-0.2
320	7-6-5	1.6+-0.7	11.1+-0.9	357	8-3-6	1.9+-0.7	1.1+-0.3
321	7-6-6	0.9+-0.5	0.5+-0.2	358	8-3-7	2.6+-0.9	0.7+-0.2
322	7-6-7	1.1+-0.6	0.9+-0.3	359	8-3-8	1.7+-0.7	0.8+-0.2
323	7-6-8	1.3+-0.6	1.1+-0.3	360	8-3-9	1.6+-0.7	0.5+-0.2
324	7-6-9	1.3+-0.6	1.0+-0.3	361	8-4-1	1.7+-0.7	1.1+-0.3
325	7-7-1	1.1+-0.6	1.6+-0.3	362	8-4-2	1.7+-0.7	0.9+-0.2
326	7-7-2	1.4+-0.7	1.1+-0.3	363	8-4-3	1.7+-0.7	0.6+-0.2
327	7-7-3	1.1+-0.6	0.8+-0.2	364	8-4-4	2.4+-0.9	1.4+-0.3
328	7-7-4	1.6+-0.7	1.2+-0.3	365	8-4-5	1.7+-0.7	0.9+-0.2
329	7-7-5	2.0+-0.8	1.5+-0.3	366	8-4-6	1.1+-0.6	0.8+-0.2
330	7-7-6	2.0+-0.8	0.7+-0.2	367	8-4-7	1.6+-0.7	0.8+-0.2

A179

WAMCO LAB

P. O. Box 2953 - Casper, WY 82602

ANALYSIS REPORT

COMPANY: Western Nuclear, Inc

Sample Type: Soils From Split Rock Properties

DATE Dec. 15,1987
Date Rec'd 9/18/87
W. O. No. 7014
P. O. # D- 301689

Analysis in picoCuries per Gram except where Noted

No.	I.D.	U-Nat	Ra-226	No.	I.D.	U-Nat	Ra-226
368	8-4-8	1.1+-0.6	0.9+-0.2	405	8-8-9	0.9+-0.5	1.1+-0.2
369	8-4-9	1.6+-0.7	0.5+-0.2	406	GR-1-1	2.2+-0.8	0.7+-0.2
370	8-5-1	2.0+-0.8	1.3+-0.3				
371	8-5-2	1.7+-0.7	0.8+-0.2				
372	8-5-3	1.7+-0.7	1.0+-0.2				
373	8-5-4	0.9+-0.5	1.1+-0.3				
374	8-5-5	1.7+-0.7	0.8+-0.2				
375	8-5-6	1.4+-0.7	1.2+-0.3				
376	8-5-7	1.6+-0.7	0.7+-0.2				
377	8-5-8	1.1+-0.6	0.8+-0.2				
378	8-5-9	1.4+-0.7	1.1+-0.3				
379	8-6-1	1.4+-0.7	1.2+-0.3				
380	8-6-2	1.7+-0.7	0.6+-0.2				
381	8-6-3	0.7+-0.5	1.1+-0.3				
382	8-6-4	0.7+-0.5	0.7+-0.2				
383	8-6-5	1.1+-0.6	1.0+-0.2				
384	8-6-6	1.3+-0.6	0.7+-0.2				
385	8-6-7	1.7+-0.7	0.9+-0.2				
386	8-6-8	0.9+-0.5	1.2+-0.3				
387	8-6-9	1.1+-0.6	0.6+-0.2				
388	8-7-1	1.3+-0.6	1.4+-0.3				
389	8-7-2	0.3+-0.3	1.0+-0.2				
390	8-7-3	0.4+-0.4	0.8+-0.2				
391	8-7-4	0.6+-0.4	0.6+-0.2				
392	8-7-5	0.9+-0.5	1.4+-0.3				
393	8-7-6	0.6+-0.4	0.5+-0.2				
394	8-7-7	0.4+-0.4	0.6+-0.2				
395	8-7-8	1.6+-0.7	0.9+-0.2				
396	8-7-9	0.7+-0.5	0.6+-0.2				
397	8-8-1	2.6+-0.9	1.6+-0.3				
398	8-8-2	1.1+-0.6	1.3+-0.3				
399	8-8-3	2.2+-0.8	0.9+-0.2				
400	8-8-4	1.1+-0.6	0.9+-0.2				
401	8-8-5	1.4+-0.7	1.0+-0.2				
402	8-8-6	1.1+-0.6	0.6+-0.2				
403	8-8-7	1.3+-0.6	0.9+-0.2				
404	8-8-8	0.6+-0.4	1.1+-0.2				

APPENDIX
B

APPENDIX B

SURFACE WATER CONTROL DESIGN CALCULATIONS

APPENDIX B

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SECTION B.1

SURFACE WATER HYDROLOGY - PROBABLE MAXIMUM FLOOD CALCULATION

SURFACE WATER HYDROLOGY
PMF CALCULATION
WESTERN NUCLEAR, INC.

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SURFACE WATER HYDROLOGY
PMF CALCULATION
WESTERN NUCLEAR, INC.

PURPOSE. The purpose of this calculation brief is to determine the probable maximum flood (PMF) for the various drainage areas at Western Nuclear, Inc.'s (WNI's) Split Rock Mill and tailings site in Jeffrey City, Wyoming.

METHOD. PMF for each proposed surface water ditch was determined using the "HEC-1" computer model, developed by the U.S. Army Corp of Engineers and coded by Haestad Methods, Inc. The September, 1990, Version 4.0, as released of HEC-1 was used to develop flood hydrographs for each drainage ditch reach. Basin characteristics used as input parameters to HEC-1 were developed using the Soil Conservation Service (SCS) curve number method described in Design of Small Dams, 1977, Bureau of Reclamation. The following describes the procedures used:

(1) Determine the probable maximum precipitation (PMP) for the 1-hour storm event. See Attachment B (page B-46), calculation taken from Canonie TRP#4, Appendix B.

(2) Delineate the respective drainage basins for each surface water diversion ditch. Figure B.1.1 indicates the location of each diversion ditch and the direction of flow in each ditch. Drainage basins serving each reach are identified in Figure B.1.2, based on the site topographic conditions. Existing contours in the tailings area were adjusted to represent actual hydraulic conditions after reclamation.

(3) Determine the curve number (CN) for each type of material present, specially, the granite outcrops, native site soil, and proposed tailings cover material.

(4) Determine the characteristics of each drainage basin, specifically:

A) Drainage Basin
B) Weighted curve number for each basin
C) Drainage basin characteristics: maximum relief, hydraulic length, and mean elevation

(5) Determine lag time (tp)

(6) Determine rainfall duration

(7) Determine rainfall sequence

(8) Use Hec-1 computer code to develop a hydrograph for each surface water diversion ditch reach, and determine peak flow for use in design of ditches.

RESULTS. The calculated PMFs for the diversion ditch reaches are summarized in Table B.1.1 (page B-13). Figure B.1.1 (page B-24) shows diversion ditch alignment and reach locations.

CALCULATIONS.

(1) Probable Maximum Precipitation (PMP):

PMP is 9.2 inches for a one hour storm event. The calculation brief for the PMP is in Attachment C (page B-56) and is taken from Canonie TRP#4, Appendix B.

(2) Delineate Drainage Basins

Figure B.1.1 indicates the location of each surface water diversion ditch, and indicates the respective reaches of each ditch where a distinction between reaches is made. Direction of flow in each ditch is also found on Figure B.1.1. Figure B.1.2 indicates the drainage basins which contribute runoff to each reach, based on the proposed final grading plan. For clarity, a summary is provided on Table B.1.2 (page B-14).

(3) Curve Numbers

The curve number for a watershed defines its runoff potential. The curve number is based on soil and vegetation characteristics such as infiltration potential, land use, and density of vegetation. For each soil type and vegetative cover in a particular drainage area, a curve number is determined. A weighted curve number can then be determined for the area contributing to each reach or ditch.

At the specific request of the Nuclear Regulatory Commission, (NRC), conservative assumptions are made to account for high soil moisture content prior to the PMP. Per NRC, for each soil type, curve number is selected at antecedent moisture content (AMC) III as defined by Bureau of Reclamation's Design of Small Dams, 1977, Table A-7, Page 543 (See attachment A, page B-28).

Three soil types will occur at the tailings impoundment at the WNI site:

1) Granite Outcrops

2) Native Site Soil

3) Proposed Tailings Cover Material

Soil Type I: Granite Outcrops

Description: Impervious materials, highly fractured with some shallow, loose soil deposits and poor vegetation. By definition of the hydrologic soil group (listed below), the granite outcrops may be classified as a Type D soil group.

Soil Type D: (High runoff potential). Soils having very slow infiltration rates when thoroughly wetted and consisting mainly of clay soils with high swelling potential, soils with permanent high water table, soils with claypan, or clay layer at or near the surface, and shallow soils over nearly, impervious material. These soils have a very slow rate of water transmission.

The general hydrologic condition for the granite outcrop is assumed to be poor. The land use is classified as "pasture or range" with "no mechanical treatment". Therefore, the runoff curve number for the granite outcrop is estimated as 96 under AMC III.

Soil Type II: Native Soil

Fairly deep sandy soil with few sagebrush or other vegetation cover. The native soil is ranked as type A soil group. General hydrologic condition for native soil is between Poor and Fair condition. The poor condition is chosen for conservative estimation. Land use and treatment was considered to be: "Range contoured." Runoff curve number for the native soil is 67 at AMC III.

Soil Type III: Proposed Tailings Cover

Description: 6" of Soil/Rock Matrix, placed over 12" of clean sand. A Cody shale radon barrier layer of varying thickness underlies the clean sand. The proposed cover is classified as a type A soil group for this PMF calculation.

Soil Type A: (Low runoff potential). Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sand or gravels. These soils have a high rate of water transmission. Therefore, a curve number of 89 at AMC III is used.

In Summary: The following curve numbers were determined using AMC III from Design of Small Dams, 1977, Table A-7, (see Attachment A, page B-28).

Soil Type	AMC III
Granite Outcrop	96
Native Site Soil	67
Proposed Tailings Cover	89

(4) Basin Characteristics

(A) Determine Draining Areas: The area of each drainage basin (see Figure B.1.2) was estimated using AutoCAD and are summarized in Table B.1.3 (page B-15).

(B) Using areas from above, and estimating proportions of granite, native soil, and tailings cover material within each drainage basin, the weighted curve number for each drainage basin can be calculated.

Table B.1.4 (page B-17) indicates the proportions of each soil type within each drainage area based on Figure B.1.2. Proportions were estimated by using Autocad. Based on these proportions, a weighted curve number was determined for each drainage basin per the following equation. Results are found on Table B.1.4.

FORMULA 1:

CN Weighted Per Drainage Basin = (% Granite) (CN = 96) + (% Native Soil) (CN = 67) + (% Tailings Cover) (CN = 89)

Table B.1.5 (page B-19) indicates the critical physical parameters for the drainage basins serving each surface water diversion reach which will be used to define the lag time (tp) in each reach.

For each surface water diversion reach the following parameters were determined as follows:

A Total Area (in square miles): sum of drainage basin(s) area(s) serving each ditch reach.

L Hydraulic Length Maximum Distance of Flow (feet): Longest flow path within watershed serving ditch reach, i.e. the length from ditch reach outlet to most distant ridge; determined from Figure B.1.2.

H Elevation Difference (Feet): difference in elevation between watershed outlet and most distant ridge: determined from Figure B.1.2. (Excluding Ditch Depth - thus conservative)

CN Weighted Curve Number: Reprinted For Convenience from Table B.1.4.

(5) Determine Lag Time (tp):

The lag time for each basin using the following equation:

- Lag time calculations:

$$t_p = \frac{L^{0.8}(S+1)^{0.7}}{1900y^{0.5}}$$

where

t_p = lag time (hr.)
L = length to divide (ft.) (From Fig. B.1.1)
y = average watershed slope (%)
S = (1000/CN)-10
CN = curve number

$$S = \frac{1000}{78} - 10 = 2.82$$

(6) Determine Unit Rainfall Duration (D):

For the purpose of generating hydrographs for each reach a unit, rainfall duration of 2.5 minutes will be used as recommended by the NRC.

(7) Determine Rainfall Sequence:

Using a unit rainfall duration of 2.5 minutes, and Figure B.1.3 (page B-26), reprinted from Hydrometeorological Report 55A, June, 1988) which shows percent PMP vs. duration, the storm sequence is estimated for the area of the Jeffrey City facility. Note that HMR-55A is specific to the area between the continental divide and 103rd meridian. The storm sequence is given in Table B.1.6 (page B-21).

Note that NRC has requested that the rainfall sequence be reorganized to account for "worst case" probable maximum flood. Essentially, PMF is increased and diversion ditch design is more conservative when highest rainfall values for a given 2.5 minute duration occur near the middle of the design storm event (in this case, a one-hour event is being used). Figure B.1.4 (page B-27) shows how he rainfall distribution looks when reorganized to simulate "worst case".

From Figure B.1.4, a reorganized rainfall sequence is derived, and cumulative rainfall calculated (as needed for HEC-1 input). This is presented in table B.1.7.

(8) Determine Peak Flow (PMF) For Each Diversion Ditch Reach:

Enclosed in Attachment C (page B-56) are the input file and hydrographs generated for each reach using HEC-1 computer model, Table B.1.5, and rainfall sequence in Table B.1.7. Results are summarized in Table B.1.1 (page B-13).

TABLES

Table B.1.1
Summary of PMF Calculations

Diversion Ditch	Reach #	PMF
North	Transition	1112
North Reach	1	1645
North Reach	2	1954
North Reach	3	2468
North Reach	4	2539
North Reach	5	4217
North Reach	6	4618
North Reach	7 (Discharge)	4985
Swale Reach	1	590
Swale Reach	2	1601
Swale Reach	3	1736
North Central Reach	1	327
North Central Reach	2	471
North Central Reach	3 (Discharge)	960
South Central Reach	1	799
South Central Reach	2 (Discharge)	1609
South	Transition	24
South Reach	1	864
South Reach	2	2052
South Reach	3	3171
South Reach	4	4654
South Reach	5 (Discharge)	4896

Table B.1.2
Summary of Contributing Drainage Basins

Diversion Ditch	Reach #	Contributing Drainage Basin(s)
North	Transition	G_1, G_2
North Reach	1	G,G_1,G_2
North Reach	2	F,F_1,G,G_1,G_2
North Reach	3	E,E_1,F,F_1,G,G_1,G_2
North Reach	4	$D,D_1,E,E_1,F,F_1,G,G_1,G_2$
North Reach	5	$C,C_1,D,D_1,E,E_1,F,F_1,G,G_1,G_2,$ R,R_1,S,S_1,T,T_1,T_2
North Reach	6	$B,B_1,C,C_1,D,D_1,E,E_1,F,F_1,G,G_1,$ $G_2,R,R_1,S,S_1,T,T_1,T_2$
North Reach	7 (Discharge)	$A,A_1,B,B_1,C,C_1,D,D_1,E,E_1,F,F_1,G,$ $G_1,G_2,R,R_1,S,S_1,T,T_1,T_2$
Swale Reach	1	T,T_1
Swale Reach	2	S,S_1,T,T_1
Swale Reach	3	R,R_1,S,S_1,T,T_1,T_2
North Central Reach	1	P,P_1,P_2
North Central Reach	2	O,O_1,P,P_1,P_2
North Central Reach	3 (Discharge)	M,M_1,O,O_1,P,P_1,P_2
South Central Reach	1	Q,Q_1,Q_2
South Central Reach	2 (Discharge)	N,N_1,Q,Q_1,Q_2
South	Transition	H_2
South Reach	1	H,H_1,H_2
South Reach	2	I,I_1,H,H_1,H_2
South Reach	3	J,J_1,I,I_1
South Reach	4	$K,K_1,J,J_1,I,I_1,H,H_1,H_2$
South Reach	5 (Discharge)	$L,L_1,K,K_1,J,J_1,I,I_1,H,H_1,H_2$

Table B.1.3
Summary of Drainage Basin Areas

DRAINAGE BASIN	TOTAL AREA ACRES
A	21.5
A_1	0.8
B	26.4
B_1	1.3
C	3.9
C_1	1.3
D	3.2
D_1	1.7
E	32.4
E_1	1.4
F	47.7
F_1	2.8
G	78.9
G_1	3.4
G_2	35.0
H	24.4
H_1	1.2
H_2	0.7
I	41.2
I_1	1.1
J	37.9
J_1	5.6

Table B.1.4

Proportions of Each Soil Type Within Each Drainage Area
And Drainage Basin Weighted Curve Number

DRAINAGE BASIN	TOTAL AREA ACRES	GRANITE AREA FRACTION (CN=96)	NATIVE AREA FRACTION (CN=67)	TAILING COVER AREA FRACTION (CN=89)	WEIGHTED CN
A	21.5	0.52	0.48	0.00	82
A_1	0.8	0.00	0.00	1.00	89
B	26.4	0.20	0.80	0.00	73
B_1	1.3	0.00	0.00	1.00	89
C	3.9	0.00	1.00	0.00	67
C_1	1.3	0.00	0.00	1.00	89
D	3.2	0.00	1.00	0.00	67
D_1	1.7	0.00	0.00	1.00	89
E	32.4	0.61	0.39	0.00	85
E_1	1.4	0.00	0.00	1.00	89
F	47.7	0.26	0.74	0.00	74
F_1	2.8	0.00	0.00	1.00	89
G	78.9	0.61	0.39	0.00	85
G_1	3.4	0.40	0.16	0.44	88
G_2	35.0	1.00	0.00	0.00	96
H	24.4	0.91	0.09	0.00	94
H_1	1.2	0.00	0.00	1.00	89
H_2	0.7	0.66	0.34	0.00	86
I	41.2	0.87	0.13	0.00	92
I_1	1.1	0.00	0.00	1.00	89
J	37.9	0.59	0.41	0.00	84

Table B.1.4 (cont.)

DRAINAGE BASIN	TOTAL AREA ACRES	GRANITE AREA FRACTION (CN=96)	NATIVE AREA FRACTION (CN=67)	TAILING COVER AREA FRACTION (CN=89)	WEIGHTED CN
J_1	5.6	0.00	0.00	1.00	89
K	65.0	0.87	0.13	0.00	92
K_1	2.6	0.00	0.00	1.00	89
L	15.6	0.00	1.00	0.00	67
L_1	2.5	0.00	0.00	1.00	89
M	21.0	0.70	0.30	0.00	87
M_1	0.5	0.00	0.00	1.00	89
N	42.3	0.40	0.60	0.00	79
N_1	0.8	0.00	0.00	1.00	89
O	5.4	0.47	0.53	0.00	81
O_1	0.7	0.00	0.00	1.00	89
P	1.7	0.06	0.94	0.00	69
P_1	9.7	0.00	0.00	1.00	89
P_2	0.3	0.00	0.00	1.00	89
Q	15.4	0.37	0.63	0.00	78
Q_1	20.6	0.00	0.00	1.00	89
Q_2	7.3	0.34	0.58	0.08	79
R	7.9	0.00	0.00	1.00	89
R_1	1.9	0.00	0.00	1.00	89
S	46.6	0.00	0.00	1.00	89
S_1	19.2	0.00	0.00	1.00	89
T	9.8	0.00	0.00	1.00	89
T_1	28.7	0.00	0.00	1.00	89
T_2	1.0	0.00	0.00	1.00	89

Table B.1.5

Surface Water Diversion Ditch Reach Parameters
For Use In HEC-1 Computer Model

DIVERSION DITCH	BASIN TITLE	Area (mi^2)	Horizontal Length (ft)	Elevation Difference (ft)	Hydraulic Length (ft)	Slope (%)	WEIGHTED CN	Lag Time (hrs)
NORTH (Before Junction With Swale)	G_2	0.055	2193	345	2220	15.7	96	0.081
	G	0.124	3797	339	3812	8.9	85	0.263
	G_1	0.005	666	120	677	18.0	88	0.042
	F	0.075	3414	280	342	8.2	74	0.355
	F_1	0.004	84	15	85	17.9	89	0.008
	E	0.051	1695	260	1715	15.3	85	0.106
	E_1	0.002	338	15	338	4.4	89	0.046
	D	0.005	738	60	740	8.1	67	0.127
	D_1	0.003	514	40	516	7.8	89	0.049
SWALE	T_2	0.002	34	10	342	2.9	89	0.058
	T	0.015	956	12	956	1.3	89	0.200
	T_1	0.039	1439	23	1439	1.6	89	0.246
	S	0.073	1450	23	1450	1.6	89	0.248
	S_1	0.030	747	23	747	3.1	89	0.105
	R	0.012	1328	40	1329	3.0	89	0.168
	R_1	0.003	538	35	539	6.5	89	0.056
NORTH (After Junction With Swale)	C	0.006	772	60	774	7.8	67	0.134
	C_1	0.002	433	15	433	3.5	89	0.064
	B	0.041	1945	326	1972	16.8	73	0.164
	B_1	0.002	115	12	116	10.4	89	0.013
	A	0.035	2415	290	2432	12.0	82	0.175
	A_1	0.001	114	12	115	10.5	89	0.013

Table B.1.5 (cont.)

DIVERSION DITCH	BASIN TITLE	Area (mi^2)	Horizontal Length (ft)	Elevation Difference (ft)	Hydraulic Length (ft)	Slope (%)	WEIGHTED CN	Lag Time (hrs)
SOUTH	H_2	0.001	396	160	427	40.4	86	0.021
	H	0.038	1300	330	1341	25.4	94	0.047
	H_1	0.002	66	10	67	15.2	89	0.007
	I	0.064	1443	340	1483	23.6	92	0.058
	I_1	0.002	66	10	67	15.2	89	0.007
	J	0.059	1574	360	1615	22.9	84	0.086
	J_1	0.009	467	10	467	2.1	89	0.086
	K	0.102	2762	320	2780	11.6	92	0.136
	K_1	0.004	169	10	169	5.9	89	0.023
	L	0.024	1071	125	1078	11.7	67	0.143
	L_1	0.004	176	10	176	5.7	89	0.024
NORTH CENTRAL	P	0.003	500	40	502	8.0	69	0.089
	P_1	0.019	1300	330	1341	25.4	89	0.058
	P_2	0.000	66	10	67	15.2	89	0.007
	O	0.008	470	120	485	25.5	81	0.034
	O_1	0.001	65	10	66	15.4	89	0.007
	M	0.033	1627	190	1638	11.7	87	0.109
	M_1	0.001	51	10	52	19.6	89	0.005
SOUTH CENTRAL	Q_2	0.002	48	8	49	16.7	79	0.007
	Q_1	0.032	1491	125	1496	8.4	89	0.111
	Q	0.024	896	45	897	5.0	78	0.138
	N	0.066	1646	200	1658	12.2	79	0.141
	N_1	0.001	54	10	55	18.5	89	0.005

Table B.1.6
Storm Sequence

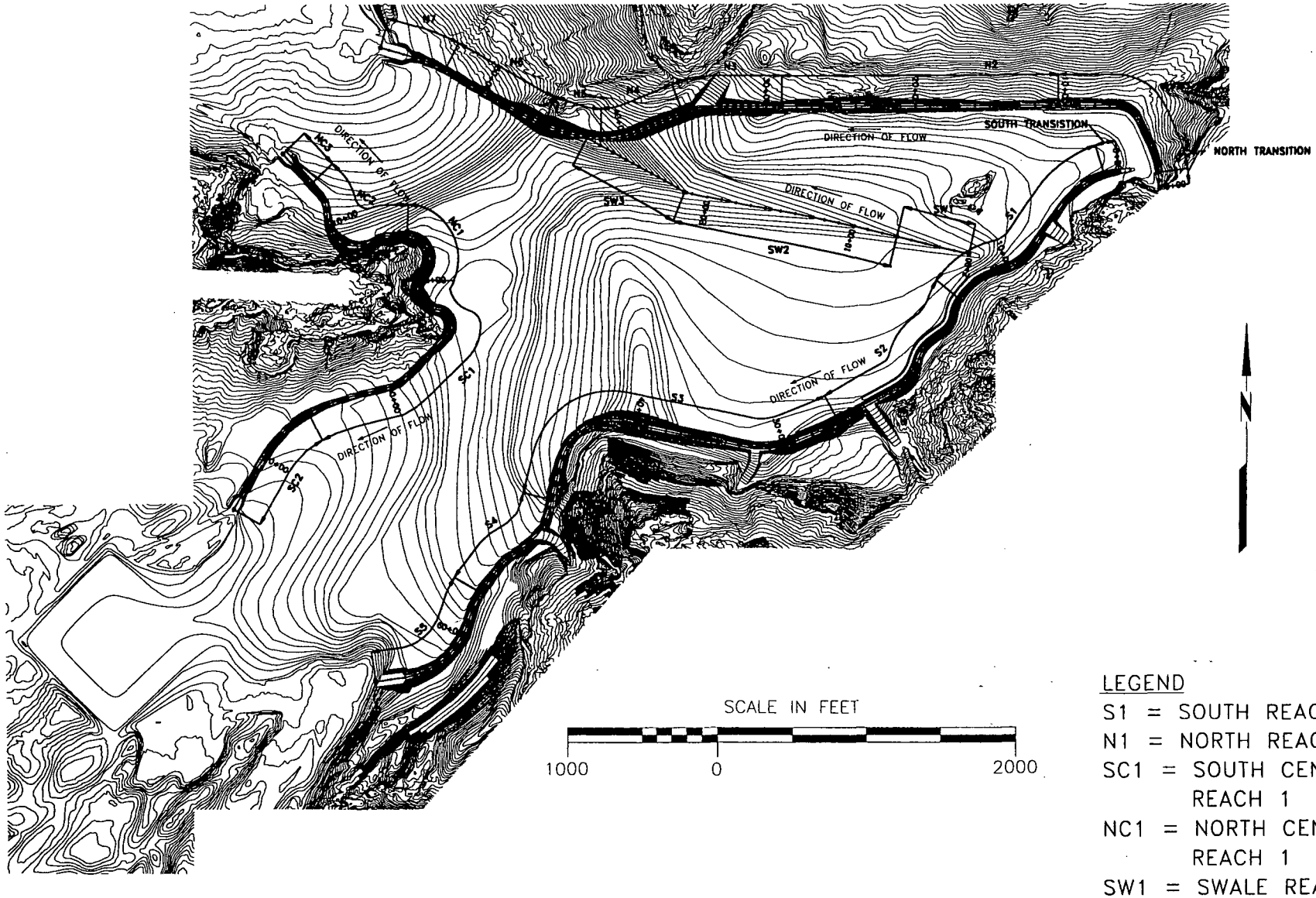
Time Elapsed (Min.)	% Of PMP	Time Elapsed (Min.)	% Of PMP	Time Elapsed	% Of PMP
2.5	23	22.5	80.5	42.5	93
5.0	37	25.0	82.5	45.0	94([1])
7.5	48	27.5	84.5	47.5	95
10.0	56	30.0	86([1])	50.0	96
12.5	62.5	32.5	87.5	52.5	97
15.0	68([1])	35.0	89	55.0	98
17.5	73	37.5	90.5	57.5	99
20.0	77.5	40.0	92.0	60.0	100([1])

([1]) If marked, taken from Table 12.4, HMR-55A, Page 200. If not marked, interpolated from Figure 12.10, HMR-55A, pg. 200

Table B.1.7
Reorganized Rainfall Sequence and Cumulative Rainfall

Time Elapsed (Min.)	Cumulative % PMP	Cumulative Rainfall (in.)	Time Elapsed (Min.)	Cumulative % PMP	Cumulative Rainfall (in)
2.5	1.0	0.09	32.5	65.5	6.03
5.0	2.0	0.18	35.0	76.5	7.04
7.5	3.0	0.28	37.5	83.0	7.64
10.0	4.0	0.37	40.0	88.0	8.10
12.5	5.5	0.51	42.5	91.0	8.37
15.0	7.0	0.64	45.0	93.0	8.56
17.5	8.5	0.78	47.5	94.5	8.69
20.0	10.5	0.97	50.0	96.0	8.83
22.5	15.0	1.38	52.5	97.0	8.92
25.0	20.5	1.89	55.0	98.0	9.02
27.5	28.5	2.62	57.5	99.0	9.11
30.0	42.5	3.91	60.0	100.0	9.20

FIGURES



LEGEND

S1 = SOUTH REACH 1

N1 = NORTH REACH 1

SC1 = SOUTH CENTRAL REACH 1

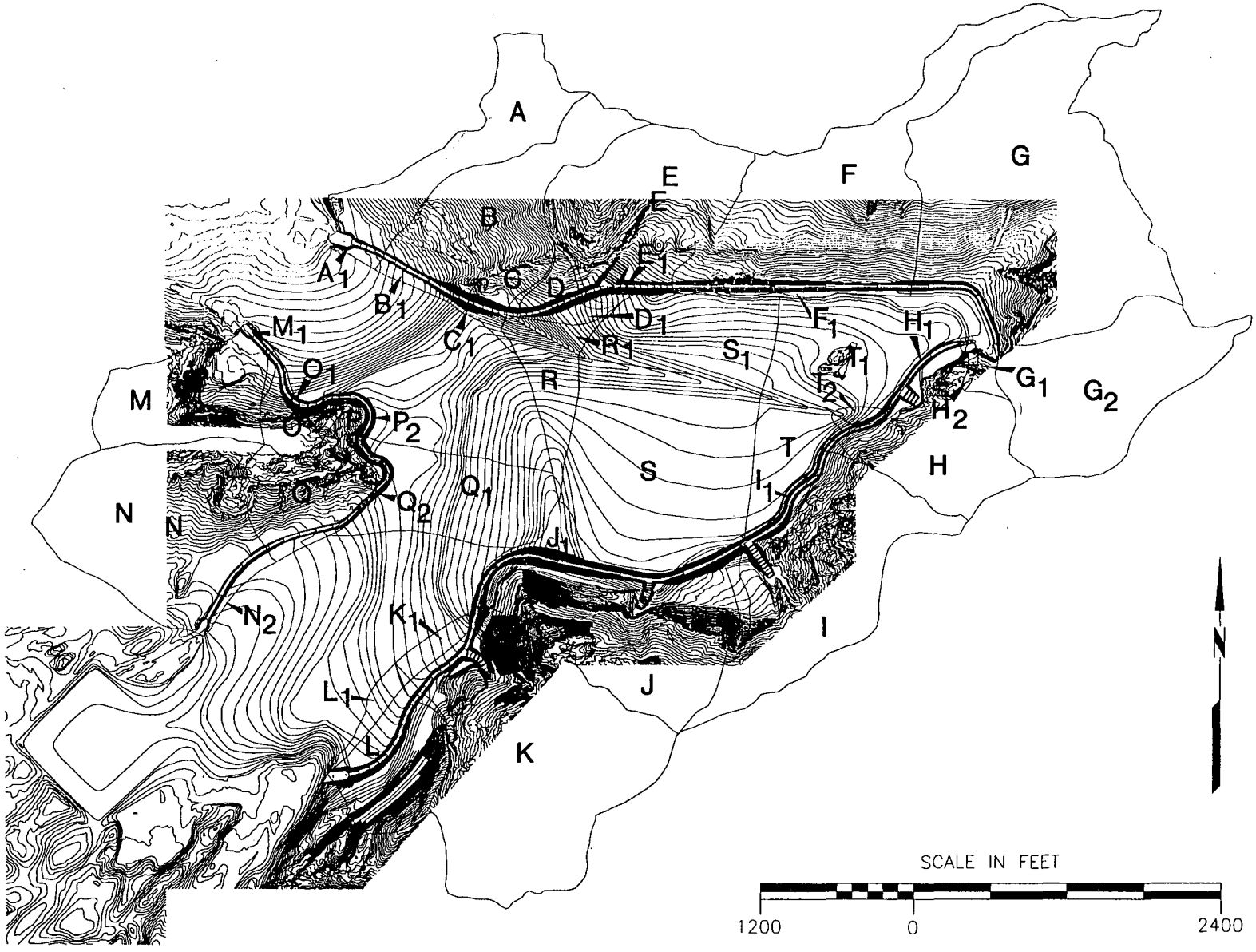
NC1 = NORTH CENTRAL REACH 1

SW1 = SWALE REACH 1

SMI
SHE[redacted] MILLER, INC.

FIGURE B.1.1
DIVERSION DITCH ALIGNMENT
AND REA[redacted]LOCATIONS

Date:	OCT., 1993
Project:	336[redacted]
File:	FI[redacted]EA

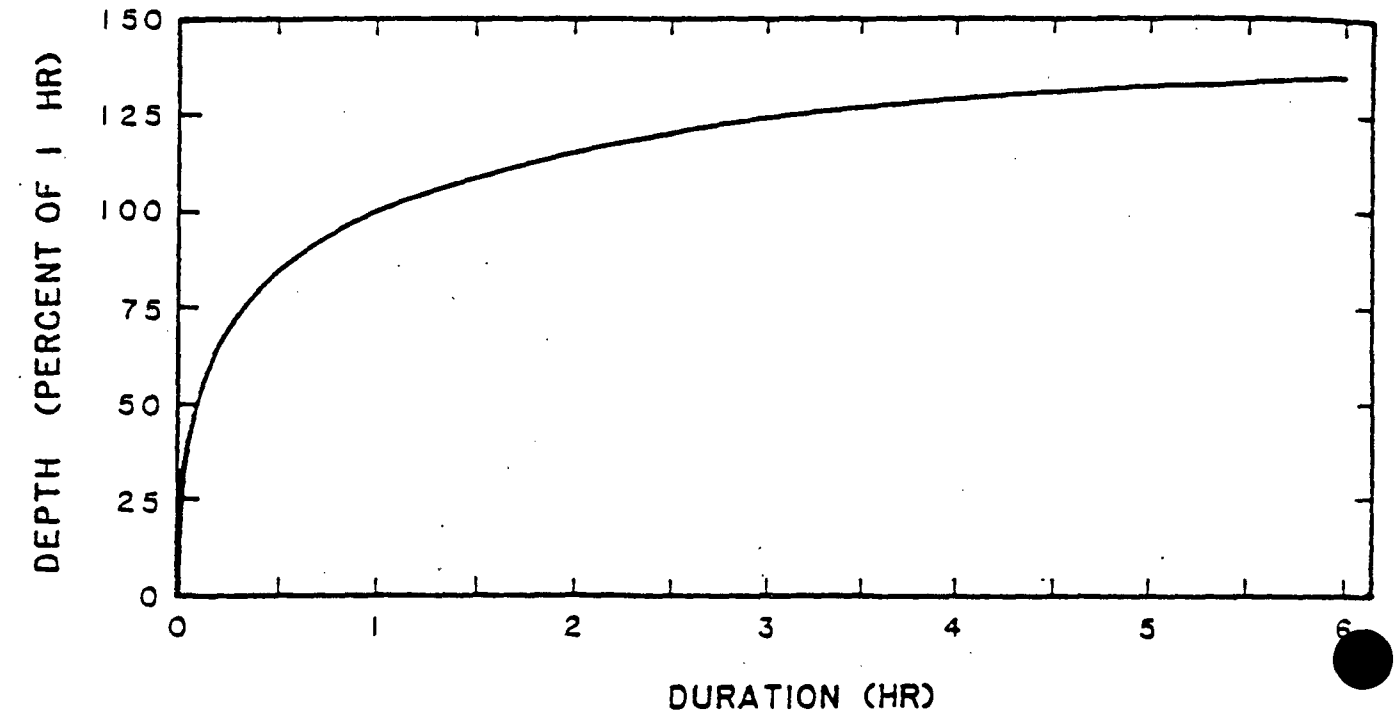


SMI
SHEPHERD MILLER, INC.

FIGURE B.1.2
SUB-BASIN DELINIATION
JEFFERY CITY, WYOMING

Date:	SEPT., 1993
Project:	336
File:	336BSN

FIGURE B.1.3
HMR-55A ESTIMATE OF RAINFALL SEQUENCE



.—Depth-duration curve for 6-/1-hr ratio of 1.35.

.—Percent of 1-hr local-storm PMP for selected durations for 6-/1-hr ratio of 1.35 (HMR No. 49)

Duration (hr)	Percent of 1 hr
1/4	.68
1/2	.86
3/4	.94
1	1.00
2	1.16
3	1.23
4	1.28
5	1.32
6	1.35

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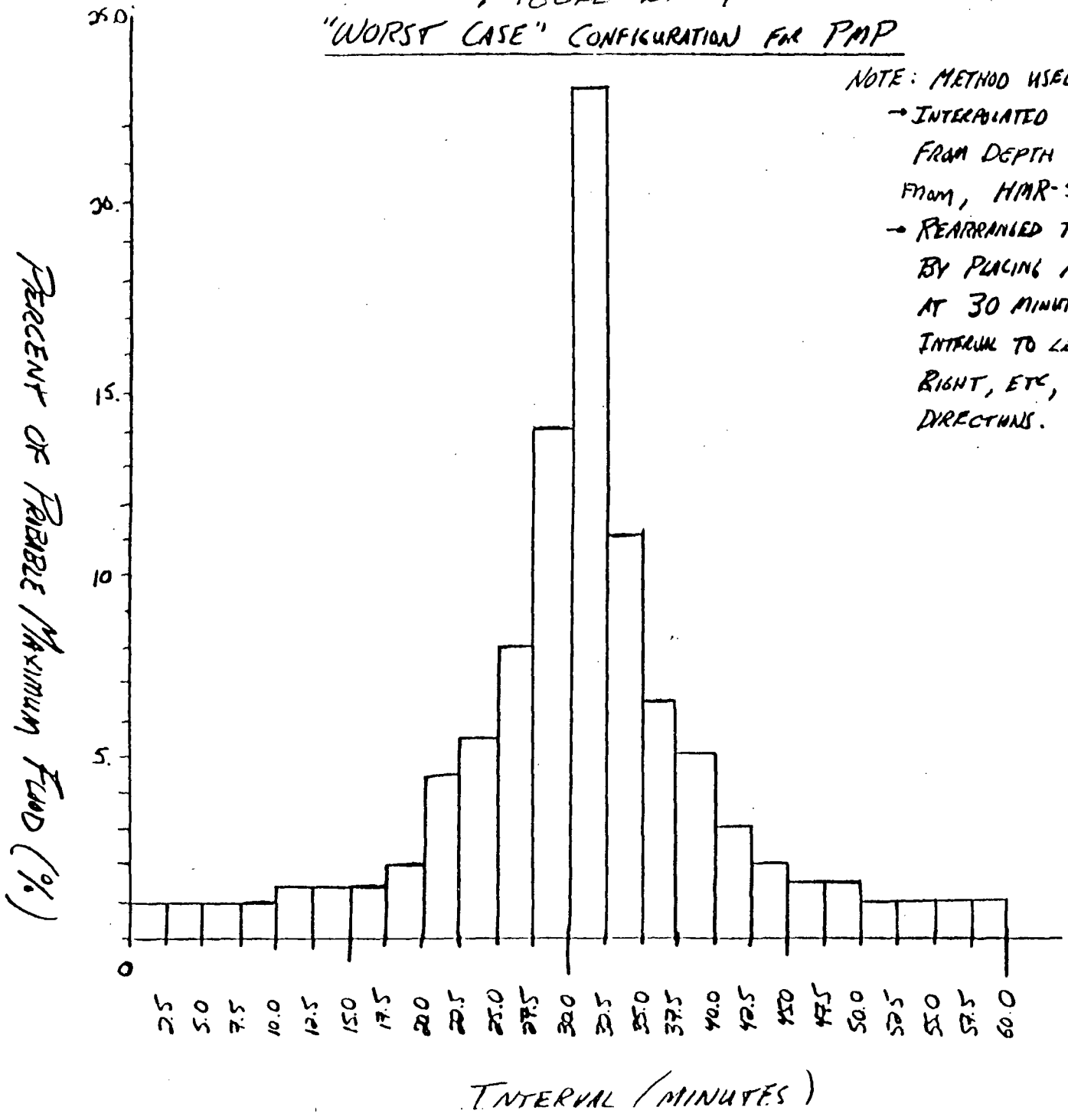
1/4" X 1/4"

FIGURE B.1.4

"WORST CASE" CONFIGURATION FOR PMP



ATTACHMENT A

REFERENCES

B29

PB86-183494

United States
Department of
Agriculture

Soil
Conservation
Service

National Engineering Handbook

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Section 4

Hydrology

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CHAPTER 7. HYDROLOGIC SOIL GROUPS

This chapter gives definitions of four soil groups that are used in determining hydrologic soil-cover complexes (chap. 9), which are used in a method for estimating runoff from rainfall (chap. 10). A table gives the group-classifications of more than 4,000 soils in the United States and Puerto Rico. Methods of making and using the classifications are briefly discussed.

Watershed-Soils Classification

Soil properties influence the process of generation of runoff from rainfall and they must be considered, even if only indirectly, in methods of runoff estimation. When runoff from individual storms is the major concern, as in flood prevention work, the properties can be represented by a hydrologic parameter: the minimum rate of infiltration obtained for a bare soil after prolonged wetting. The influences of both the surface and the horizons of a soil are thereby included. The influence of ground cover is treated independently, as discussed in chapters 8, 9, and 10.

The parameter, which indicates the runoff potential of a soil, is the qualitative basis of the classification in this chapter of all soils into four groups. The classification is broad but the groups can be divided into subgroups, as shown in example 7.1, whenever such a refinement is justified. Chapter 9 describes how the groups are given quantitative significance in the runoff-estimation method of chapter 10.

DEFINITIONS

In the definitions to follow, the infiltration rate is the rate at which water enters the soil at the surface and which is controlled by surface conditions, and the transmission rate is the rate at which the water moves in the soil and which is controlled by the horizons. The hydrologic soil groups, as defined by SCS soil scientists, are:

A. (Low runoff potential). Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.

B. Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

C. Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

D. (High runoff potential). Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

The Soil List

The list at the end of this chapter contains the names of more than 4,000 soils in the United States and Puerto Rico. The capital letter following a name designates the hydrologic soil group classification.

The original classifications were based on the use of rainfall-runoff data from small watersheds or infiltrometer plots, but the majority are based on the judgments of soil scientists and correlators who used physical properties of the soil in making their decisions. They classified a soil in a particular group by comparing its profile with profiles of soils already classified. They assumed that the soil surfaces were bare, maximum swelling had taken place, and rainfall rates exceeded surface intake rates. Thus, most of the classifications are based on the premise that similar soils (similar in depth, organic-matter content, structure, and degree of swelling when saturated) will respond in an essentially similar manner during a rainstorm having excessive intensities.

The classification of a soil in the list can be checked by using the procedure of example 5.4. The soil in question must be the only one

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ESTIMATING RUNOFF FROM SMALL WATERSHEDS

A Summary of the Soil Conservation Service Method*

1972

INTRODUCTION

SCS National Eng. Handbook

The SCS method of estimating direct runoff from storm rainfall is based on methods developed by SCS hydrologists in the last three decades, and it is in effect a consolidation of these earlier methods. The hydrologic principles of the method are not new, but they are put to new uses. Because most SCS work is with ungaged watersheds (not gaged for runoff) the method was made to be usable with rainfall and watershed data that are ordinarily available or easily obtainable for such watersheds.

The principal application of the method is in estimating quantities of runoff in flood hydrographs or in relation to flood peak rates. These quantities consist of one or more types of runoff. An understanding of the types is necessary to apply the method properly in different climatic regions. The classification of types used in this handbook is based on the time from the beginning of a storm to the time of the appearance of a type in the hydrograph. Four types are distinguished:

> Channel runoff occurs when rain falls on a flowing stream or on the impervious surfaces of a streamflow-measuring installation. It appears in the hydrograph at the start of the storm and continues throughout it, varying with the rainfall intensity. It is generally a negligible quantity in flood hydrographs, and no attention is given to it except in special studies.
>
> Surface runoff occurs only when the rainfall rate is greater than the infiltration rate. The runoff flows on the watershed surface to the point of reference. This type appears in the hydrograph after the initial demands of interception, infiltration, and surface storage have been satisfied. It varies during the storm and ends during or soon after it. Surface runoff flowing down dry channels of watersheds in arid, semiarid, or subhumid climates is reduced by transmission losses, which may be large enough to eliminate the runoff entirely.

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*Soil Conservation Service. 1972. SCS National Engineering Handbook. Section 4. Hydrology. U.S. Department of Agriculture, Washington, D.C.

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Subsurface flow occurs when infiltrated rainfall meets an underground zone of low transmission, travels above the zone to the soil surface downhill, and appears as a seep or spring. This type is often called "quick return flow" because it appears in the hydrograph during or soon after the storm.

Base flow occurs when there is a fairly steady flow from natural storage. The flow comes from lakes or swamps, or from an aquifer replenished by infiltrated rainfall or surface runoff, or from "bank storage", which is supplied by infiltration into channel banks as the stream water level rises and which drains back into the stream as the water level falls. This type seldom appears soon enough after a storm to have any influence on the rates of the hydrograph for that storm, but base flow from a previous storm will increase the rates. Base flow must be taken into account in the design of the principal spillway of a floodwater-retarding structure.

All types do not regularly appear on all watersheds. Climate is one indicator of the probability of the types. In arid regions the flow on smaller watersheds is nearly always surface runoff, but in humid regions it is generally more of the subsurface type. But a long succession of storms produces subsurface or base flow even in dry climates although the probability of this occurring is less in dry climates than in wet climates.

In flood hydrology it is customary to deal separately with base [illegible] combine all other types into direct runoff, which consists of channel runoff, surface runoff, and subsurface flow in unknown proportions. The SCS method estimates direct runoff, but the proportions of surface runoff and subsurface flow (channel runoff is ignored) can be appraised by means of the runoff curve number (CN), which is another indicator of the probability of flow types: the larger the CN the more likely that the estimate is of surface runoff.

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THE RAINFALL-RUNOFF RELATION

The most generally available rainfall data in the United States are the amounts measured at nonrecording rain gages, and it was for the use of such data or their equivalent that the rainfall-runoff relation was developed. The data are totals for one or more storms occurring in a calendar day, and nothing is known about the time distributions. The relation therefore excludes time as an explicit variable; this means that rainfall intensity is ignored.

If records of natural rainfall and runoff for a large storm over a small area are used, a plotting of accumulated runoff versus accumulated rainfall will show that runoff starts after some rain accumulates (there is an "initial abstraction" or rainfall) and that the double-mass line curves, becoming asymptotic to a straight line has a 45-degree slope. The relation between rainfall and runoff can be developed from this plotting, but a better understanding of the relation is had by first studying a storm in which rainfall and runoff begin simultaneously (the initial abstraction does not occur). For the simpler storm the relation between rainfall, runoff, and retention (the rain not converted to runoff) at any point on the mass curve can be expressed as:

$$\frac{F}{S'} = \frac{Q}{P} \qquad (1)$$

where

F = actual retention

S' = potential maximum retention ($S' \geq F$)

Q = actual runoff

P = potential maximum runoff ($P \geq Q$)

Equation 1 applies to on-site runoff; for large watersheds there is a lag in the appearance of the runoff at the stream gage, and the double-mass curve produces a different relation. But if storm totals for P and Q are used equation 1 does apply even for large watersheds because the effects of the lag are removed.

The parameter S' in equation 1 does not contain the initial abstraction and differs from the parameter S to be used later. The retention S' is a constant for a particular storm because it is the maximum that can

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occur under the existing conditions of the storm continues without limit. The retention F varies because it is the difference between P and Q at any point on the mass curve, or:

$$F = P - Q \tag{2}$$

Equation 1 can therefore be rewritten:

$$\frac{P - Q}{S'} = \frac{Q}{P} \tag{3}$$

Solving for Q produces the equation:

$$Q = \frac{P^2}{P + S'} \tag{4}$$

which is a rainfall-runoff relation in which the initial abstraction is ignored.

The initial abstraction is brought into the relation by subtracting it from the rainfall. The equivalent of equation 1 becomes:

$$\frac{F}{S} = \frac{Q}{P - I_a} \tag{5}$$

where I_a is the initial abstraction, $F \leq S$, and $Q \leq (P - I_a)$. The parameter S includes I_a; that is, $S = S' + I_a$.

Equation 2 becomes:

$$F = (P - I_a) - Q \tag{6}$$

equation 3 becomes:

$$\frac{(P - I_a) - Q}{S} = \frac{Q}{(P - I_a} \tag{7}$$

and equation 4 becomes:

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \tag{8}$$

which is the rainfall-runoff relation with the initial abstraction taken into account.

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The initial abstraction consists mainly of interception, infiltration, and surface storage, all of which occur before runoff beings. The insert on Figure 1 shows the position of I_a in a typical storm. To remove the necessity for estimating these variables in equation 8, the relation between I_a and S (which includes I_a) was developed by means of rainfall and runoff data from experimental small watersheds. The empirical relationship is:

$$I_a = 0.2\ S \tag{9}$$

Substituting 9 in 8 gives:

$$\boxed{Q = \frac{(P - 0.2\ S)^2}{P + 0.8\ S}} \tag{10}$$

Equation 10 is the rainfall-runoff relation used in the SCS method of estimating direct runoff from storm rainfall where the units generally used are

Q = storm runoff in inches

P = storm rainfall in inches

S = potential maximum retention in inches

CURVE NUMBERS

The potential maximum retention S is related to a curve number (CN) by the empirical expression

$$CN = \frac{1000}{10 + S} \tag{11}$$

Curve numbers are dependent on

- Soil type
- General hydrologic condition of watershed
- Land use and treatment or practice
- Antecedent moisture condition (AMC)

Curve numbers for various hydrologic soil-cover complexes were obtained from an analysis of the historical records of many watersheds. First, the antecedent moisture condition was grouped into three levels according to the total amount of rainfall in a 5-day period preceding a storm (see Table 1) Then, relationships were obtained between rainfall and runoff

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for a variety of on-site watershed parameters. Results are shown in Table 2 for AMC II, the average antecedent moisture condition. The soil types are described in Table 3 while Table 4 presents a description of the hydrologic condition for different land uses.

Table 1. -- Antecedent moisture conditions for estimating runoff curve numbers

Antecedent Moisture Condition (AMC)	Rain in previous 5 days
I	Less than 0.50 inches
II	0.50 to 1.50 inches
III	More than 1.50 inches

Table 5 relates the runoff curve number (CN) for wet (AMC III) and dry (AMC I) antecedent moisture conditions to the CN for AMC II.

Table 2 was developed primarily for humid and sub humid watersheds. For forest-range complexes in the more arid western United States, Fig. 1 is preferred to estimate runoff curve numbers for various soil types and ground cover densities.

Table 3. -- Soil groups for estimating runoff curve numbers

Soil Group:	Description of soil characteristics
A	Soils having very low runoff potential. For example, deep sands with very little silt or clay.
B	Light soils and/or well structured soils having above-average infiltration when thoroughly wetted. For example, light sandy loams, silty loams.
C	Medium soils and shallow soils having below-average infiltration when thoroughly wetted. For example, clay loams.
D	Soils having high runoff potential. For example, heavy soils, particularly clays of high swelling capacity, and very shallow soils underlain by dense clay horizons.

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(Antecedent moisture condition II, and $I_a = 0.2S$)

Land use	Cover: Treatment or practice	Cover: Hydrologic condition	Hydrologic soil group A	B	C	D
	TAILINGS PILE COVER					
Fallow	Straight row	----	77	86	91	94
Row crops	"	Poor	72	81	88	91
	"	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	"	Good	65	75	82	86
	"and terraced	Poor	66	74	80	82
	" " "	Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	"and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes 1/ or grass meadow	Straight row	Poor	66	77	85	89
	" "	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
		Good	[illegible]		[illegible]	[illegible]
	"and terraced	Poor	63	73	80	83
	"and terraced	Good	51	67	76	80
Pasture or range	GRANITE OUTCROPS	Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured NATIVE	Poor	47	67	81	88
	" SOIL	Fair	25	59	75	83
	"	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		----	59	74	82	86
Roads (dirt) 2/		----	72	82	87	89
(hard surface) 2/		---	74	84	90	92

1/ Close-drilled or broadcast.
2/ Including right-of-way.

AMC II CONDITI
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TABLE A-
FOR AMC II
CURVE NU

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-- Characterization of hydrologic condition for various land uses

Land Use	Hydrologic condition
Native pastures	Pasture in poor condition is sparse, heavily grazed pasture with less than half the total watershed area under plant cover. Pasture in fair condition is moderately grazed and with between half and three-quarters of the catchment under plant cover. Pasture in good condition is lightly grazed and with more than three-quarters of the catchment area under plant cover.
Timbered areas	Poor areas are sparsely timbered and heavily grazed with no undergrowth. Fair areas are moderately grazed, with some undergrowth. Good areas are densely timbered and ungrazed, with considerable undergrowth.
Improved permanent pastures	Densely sown permanent legume pastures subject to careful grazing management are considered to be in good hydrologic condition.
Rotation pastures	Dense, moderately grazed pastures used as part of a well planned, crop-pasture-fallow rotation are considered to be in good hydrologic condition. Sparse, overgrazed or "opportunity" pastures are considered to be in poor condition.
Crops	Good hydrologic condition refers to crops which form part of a well-planned and managed crop-pasture-fallow rotation. Poor hydrologic condition refers to crops managed according to a simple crop fallow rotation.

A graphical solution to the runoff equation (10) is shown in Fig. 2.

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SYNTHETIC HYDROGRAPH

After the runoff volume has been estimated, the next step is to distribute this quantity in time. This is done by developing a synthetic hydrograph. Using the schematic representation of the hydrograph shown in Fig. 3, various relationships between the hydrograph components can be determined as follows:

$$Q = \frac{q_p T_p}{2} + \frac{q_p T_r}{2} \tag{11}$$

from which

$$q_p = \frac{2Q}{T_p + T_r} \tag{12}$$

Letting $T_r = HT_p$, where H is a constant to be determined for a particular watershed

$$q_p = \frac{2Q}{(1+H)\,T_p} \tag{13}$$

Converting from inches per hour to cubic feet per second by introducing the drainage area A in square miles (1 inch per hour = 645.3 cfs per square mile) gives the peak rate as

$$q_p = \frac{1290.6\ A\ Q}{(1+H)\,T_p} \tag{14}$$

Analyses by the SCS have resulted in their adoption of H = 1.67 as a general average value for ungaged watersheds. Thus, the equation for the peak rate is expressed as

$$q_p = \frac{484\ A\ Q}{T_p} \tag{15}$$

From Fig. 3, it can be seen that

$$T_p = 0.5\ D + T_l \tag{16}$$

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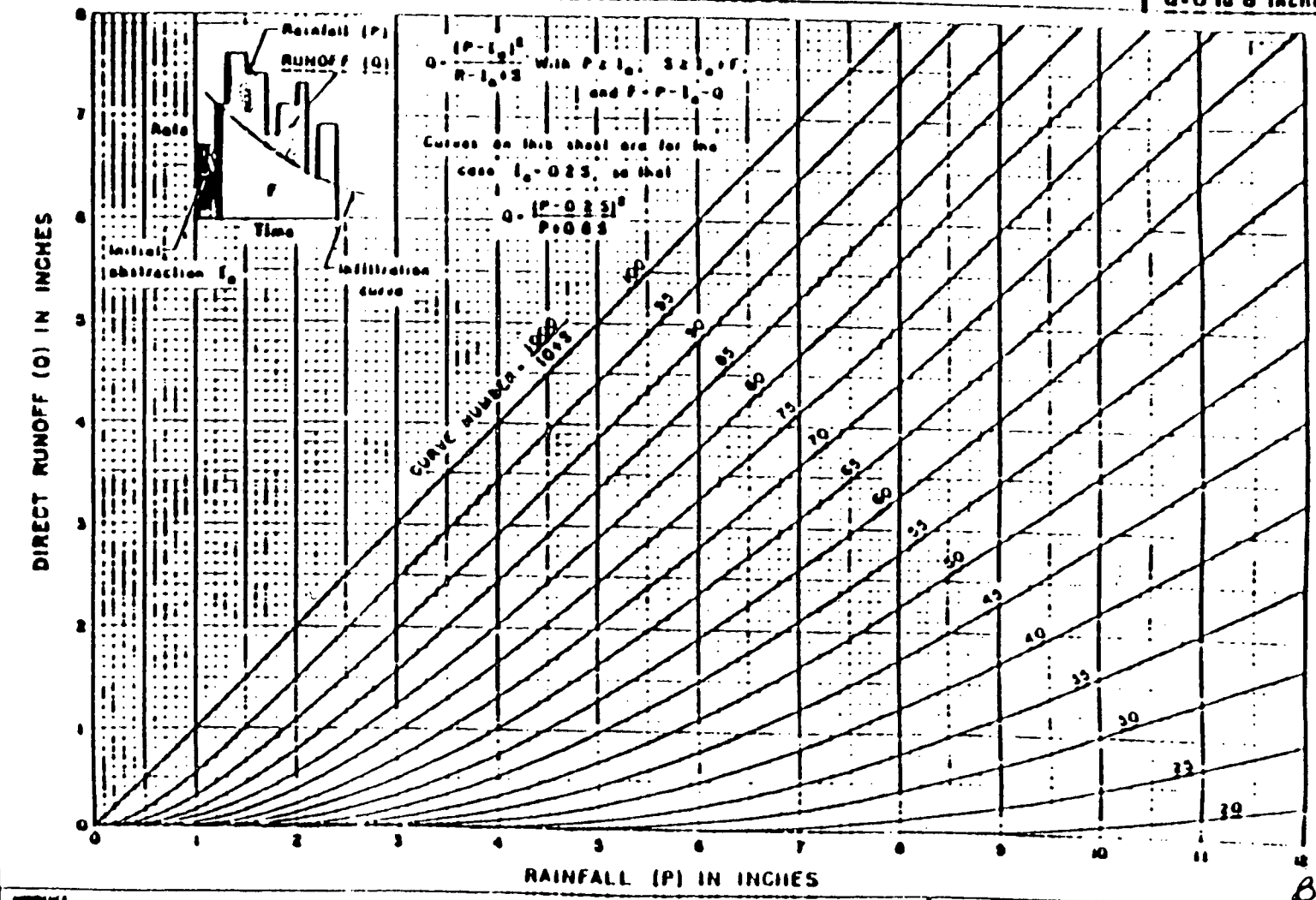
HYDROLOGY: SOLUTION OF RUNOFF EQUATION $Q = \frac{(P-0.2S)^2}{P+0.8S}$

P = 0 to 12 inches
Q = 0 to 8 inches



Mockus, Victor, Estimating direct runoff amounts from storm rainfall: Central Technical Unit, October 1955

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SOIL CONSERVATION SERVICE

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SOLUTION OF RUNOFF EQUATION

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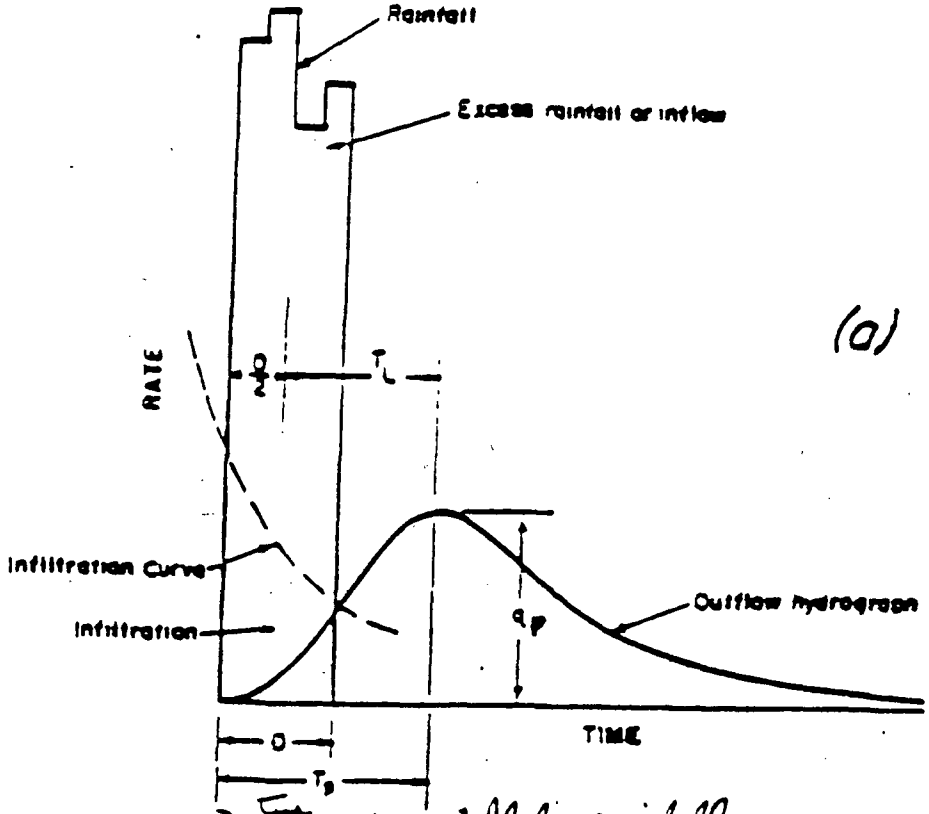


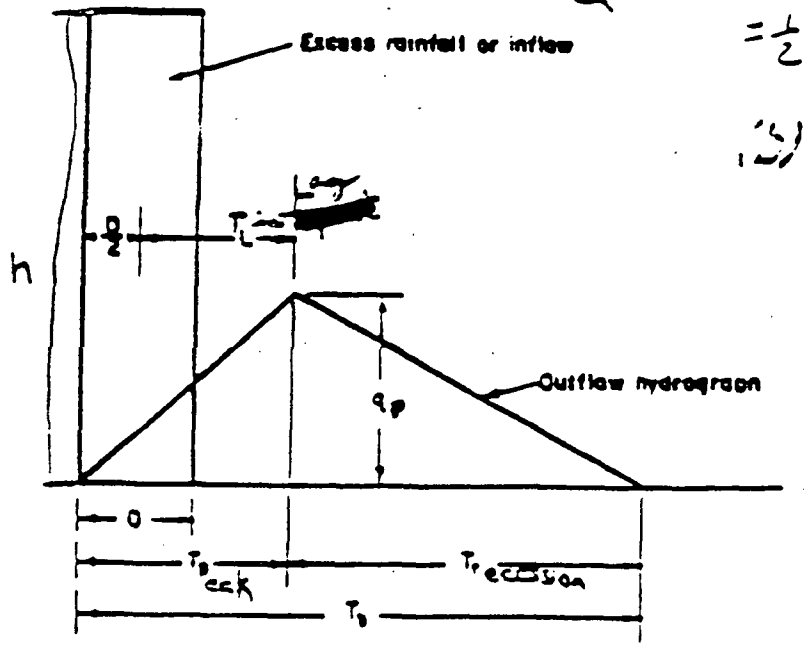
(a)

D = Time amount rainfall has rainfall excess

$Q = D \times h$ = Area of Triangle

$= \frac{1}{2} q_p (T_p + T_R)$

(b)



DEVELOPMENT OF TRIANGULAR HYDROGRAPH

$T_p = \frac{D}{2} + .6T_c$

$T_R = \frac{5}{3} T_p$

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where D = duration of excess rainfall often taken to be, as a first approximation, storm duration

T_L = time lag constant generally taken to be the time from the center of mass excess rainfall to the peak flow

A study of many hydrographs has led to the empirical relationship for time lag, namely

$$T_L = 0.6T_c \tag{17}$$

where T_c is the time of concentration for a watershed, or the time it takes runoff to travel from the hydraulically most distant part of the storm area to the watershed outlet. In hydrograph analysis, T_c is the time from the end of excessive rainfall to the point on the falling link of the hydrograph (inflection point) where the recession curve begins. T_c may be estimated by the following formula:

$$T_c = \frac{L^{1.15}}{7{,}700H^{0.38}} \tag{18}$$

where T_c = time of concentration in hours

L = length of the watershed along the mainstream from the outlet to the most distant ridge in feet

H = the difference in elevation between the watershed outlet and the most distant ridge in feet

A solution to equation 18 is presented in the nomograph shown in Fig. 4.

Substituting equations 16 and 17 into equation 15 results in the following expression for estimating peak runoff rates for ungaged watersheds:

$$q_p = \frac{484\ AQ}{0.5D + 0.6T_c}$$

where q_p = peak runoff rate in cfs

A = drainage area in square miles

Q = runoff volume in inches

D = duration of excess rainfall in hours

T_c = time of concentration in hours

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2/13/92

DESIGN OF SMALL DAMS

A Water Resources Technical Publication

Second Edition
1973
Revised Reprint
1977

B45

AMC-II.—The average case for *annual floods*, that is, an average of the conditions which have preceded the occurrence of the maximum annual flood on numerous watersheds.

AMC-III.—When heavy rainfall or light rainfall and low temperatures have occurred during the 5 days previous to the given storm, and the soil is nearly saturated.

The numbers on tables A–2, A–3, A–4 and A–5 and figures A–2 and A–3 are for the average watershed condition, AMC-II. Curve numbers for one antecedent moisture condition may be converted to a different antecedent moisture condition by the use of table A–7. For example, the computations in table A–6 give an AMC-II number of 73. The corresponding curve number for AMC-I and AMC-III can be obtained from columns 2 and 3, table A–7. The curve numbers for AMC-I and AMC-III are 54 and 87, respectively.

(b) *Thunderstorm Rainfall.*—Estimates of direct runoff from thunderstorm rainfall are more difficult than for general storm rainfall because data for thunderstorm-caused floods are meager. Type and density of vegetative cover on a watershed, as well as the time-sequence of rainfall, appear to have more influence on thunderstorm runoff than do antecedent moisture condition and soil group.

A definite time-sequence of 15-minute incremental rainfall has been assigned for each designated geographical zone for thunderstorm precipitation values given in this text. A simplified "Thunderstorm Cover Index" relating to vegetative cover type and ground cover density for watersheds west of the 105° meridian has been developed. After design thunderstorm precipitation values have been arranged in respective time-sequence magnitude (see table A–8), direct runoff increments are computed by the procedure in the examples, section 58(c), using appropriate runoff curve number, table A–9, and minimum 15-minute retention loss rate for respective hydrologic soil group, table A–10.

TABLE A–7.—*Curve numbers (CN) and constants*

[*For the case $I_a = 0.2S$*]

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
CN for conditions II	CN for conditions		S adjustment factor	Curve number factor	CN for conditions II	CN for conditions		S adjustment factor	Curve number factor
	I	III				I	III		
100	100	100	0	0	50	40	73	4.97	1.33
99	97	100	0.101	0.2	49	39	72	5.101	1.39
98	94	99	0.204	0.4	48	38	72	5.241	1.45
97	91	99	0.309	0.6	47	37	71	5.391	1.51
96	89	99	0.417	0.8	46	36	70	5.541	1.57
95	87	98	0.526	1.1	45	35	70	5.698	1.64
94	85	98	0.638	1.3	44	34	69	5.858	1.70
93	83	98	0.753	1.5	43	33	68	6.021	1.77
92	81	97	0.870	1.7	42	32	67	6.188	1.85
91	80	97	0.990	2.0	41	31	66	6.361	1.92
90	78	96	1.111	2.2	40	31	66	10.0	2.00
89	77	96	1.235	2.5	39	30	65	10.4	2.08
88	75	95	1.363	2.7	38	29	64	10.8	2.16
87	73	95	1.493	3.0	37	28	63	11.2	2.25
86	72	94	1.628	3.3	36	27	62	11.7	2.34
85	70	94	1.767	3.5	35	26	61	12.2	2.44
84	68	93	1.910	3.8	34	25	60	12.7	2.54
83	67	93	2.058	4.1	33	25	59	13.2	2.64
82	66	92	2.210	4.4	32	24	58	13.8	2.76
81	64	92	2.368	4.7	31	23	57	14.4	2.88
80	63	91	2.530	5.0	30	22	56	15.0	3.00
79	62	91	2.698	5.3	29	21	55	15.6	3.12
78	60	90	2.872	5.6	28	21	54	16.3	3.26
77	59	89	3.050	6.0	27	20	53	17.0	3.40
76	58	89	3.235	6.3	26	19	52	17.8	3.56
75	57	88	3.425	6.7	25	18	51	18.6	3.72
74	55	88	3.621	7.0	24	18	50	19.4	3.88
73	54	87	3.823	7.4	23	17	49	20.3	4.06
72	53	86	3.990	7.8	22	16	48	21.2	4.24
71	52	86	4.208	8.2	21	16	47	22.2	4.44
70	51	85	4.428	8.6	20	15	46	23.3	4.66
69	50	84	4.659	9.0					
68	49	84	4.770	9.4	19	14	45	30.0	6.00
67	47	83	4.992	9.8	18	13	44	40.0	8.00
66	46	82	5.215	10.3	17	12	43	50.7	11.34
65	45	82	5.778	10.8	16	11	42	90.0	18.00
64	44	81	5.942	11.2	15	10	41	190.0	38.00
63	43	80	6.107	11.7	14	9	40	Infinity	Infinity
62	42	79	6.213	12.2					
61	41	78	6.330	12.8					

For CN in column 1.

Duration limit of zone rainfall.

RANITE SRAP

NATIVE SOIL

TAILINGS ARE COVER

Design of Small Dams
1977

ATTACHMENT B

PMF CALCULATIONS FROM CANONIE 1992, APPENDIX B.2

Canonie Environmental

By PMW Date 2/10/92 Subject PMP using HMR55A WNI Sheet No. 1 of 9
Chkd. By [illegible] Date [illegible] Jeffrey City Site Proj. No. [illegible]
[illegible] by DGC 2/13/92 1.4 X 1.4

PURPOSE: TO DETERMINE THE PROBABLE MAXIMUM PRECIPITATION (PMP) FOR THE 1-HR STORM EVENT.

METHODS: USING THE METHODS DESCRIBED IN HYDROMETEOROLOGICAL REPORT NO. 55A (HMR55A), JUNE 1988, IT IS EASY TO DETERMINE THE PMP FOR A GIVEN BASIN.

FROM THE STEPWISE PROCEDURE:

1. FROM PLATE VI-b, 1-hr 1-mi² at 5000 ft elevation PMP = 9.55 inches.

2. MEAN ELEVATION = 6400 FEET
FROM FIG. 14.3, ELEVATION ADJ. FACTOR = 0.96
(Fig 4.11 GIVES 1-hr MAXIMUM DEW POINTS)

3. INDEX 1-HR 1-MI² MEAN ELEVATION
PMP = 9.55" x 0.96 = 9.2"

4. TABLE 12.4 FOR PERCENT OF 1-HR-LOCAL-STORM PMP for selected durations

5. AREAL REDUCTIONS.
FIGURE 12.12 GIVES THE AREAL REDUCTION FACTORS - IN THIS CASE, OUR AREA ≈ 1.2 mi² therefore OUR FACTOR IS 100%.

6. PMP ESTIMATES - SEE TABLE 1

RESULTS: FROM TABLE 1, PMP FOR THE 1-HR LOCAL STORM AT THE WNI JEFFREY CITY SITE = 9.2 INCHES

TABLE 1

..P CALCULATION FOR AREAS BETWEEN THE CONTINENTAL DIVIDE AND THE 103rd MERIDIAN USING HMRSSA.

LOCAL STORM CALCULATION

WATERSHED NAME:	WNI. JEFFREY CITY		
WATERSHED AREA:	1.2 sq mi		(Topo map)
INDEX PMP:	9.5 inches		Plate VI a-c)
MEAN BASIN ELEV:	6400 ft		(Topo map)
MAX DEWPOINT:	75.5 deg F		(Fig 4.11)
ELEV ADJUSTMENT:	0.96		(Fig 14.3)
ELEV ADJ INDEX PMP:	9.2 inches		(Index PMP x Elev Adj)

DURATION (hr)	0.25	0.5	0.75	1	3	6
PERCENT OF 1-hr (Table 12.4)	0.68	0.86	0.94	1.00	1.23	1.35
DEPTH (inches) (Elev Adj Index PMP x % 1-hr)	6.2	7.9	8.6	9.2	11.3	12.4
AREAL REDUCTION (%): (Fig 12.12)	100	100	100	100	100	100
PMP ESTIMATES: (Depth x Areal Reduction)	6.2	7.9	8.6	9.2	11.3	12.4

14.3 Stepwise Procedure, Local Storm

1. Index 1-hr 1-mi^2 PMP estimate at 5,000-ft elevation

Locate the drainage in Plate VI a-c, and determine the drainage average index 1-mi^2 1-hr PMP in inches at 5,000 ft. This is readily accomplished by eye because of the smooth gradient, and linear interpolation is assumed to apply.

2. Adjustment for mean elevation of drainage

Determine the mean drainage elevation to the nearest 100 ft. An adjustment needs to be determined and applied to the depth from step 1 if this elevation differs from 5,000 ft by more than 1,000 ft. If the mean terrain elevation of the drainage is greater than 6,000 ft or less than 4,000 ft, the correct vertical adjustment factor can be obtained by reference to figure 14.3. This is a nomogram of vertical elevation adjustments as discussed in section 12.3.2.4. To use the nomogram, enter the horizontal scale (abscissa) at the maximum persisting 12-hr 1000-mb dew point obtained from figure 4.11 for the location of the drainage. Move vertically in the figure to intersect the mean elevation of the drainage (to the nearest 100 ft) and read off the adjustment factor on the vertical scale (ordinate).

As an example of this determination, take a drainage that has a mean elevation of 7,800 ft and a maximum persisting 12-hr dew point of 70°F. Entering figure 14.3 at 70° on the abscissa and moving vertically to 7,800 ft, an adjustment factor of 0.82 is read from the ordinate.

3. Index 1-hr 1-mi^2 PMP estimate at mean elevation of drainage

Multiply the adjustment factor determined in step 2, if needed, by the index 1-mi^2 1-hr depth from step 1 to obtain a representative surface adjusted index PMP estimate.

4. Depth-duration curve for 1 mi^2

Refer to table 12.4 to obtain the 1-mi^2 factors for durations up to 6 hr. Multiply these factors by the estimate from step 3. These can be plotted on linear graph paper and a smooth curve drawn to obtain intermediate durational amounts if these are needed for the 1-mi^2 area.

5. Areal reduction factors

To obtain areal reduction factors, use the relations provided in figure [illegible]. Find the drainage area on the abscissa and read the corresponding reduction factors as percent of the 1-mi^2 PMP.

5. PMP estimates for basin

Multiply percentages of step 3 by the index PMP amounts from step 4. These values should be plotted on linear graph paper and a smooth curve drawn through the points. Values for the intermediate durations may be determined from this curve.

6. Incremental PMP amounts

If needed, local-storm PMP incremental amounts obtained through subtraction of adjacent amounts in step 6 may be arranged in temporal sequences recommended in tables 12.5 and 12.6.

No example is believed necessary for local-storm PMP determination, as the adjustment for elevation is the only complex element in the determination, and an example calculation of this factor is given in step 2.

15. FUTURE STUDIES

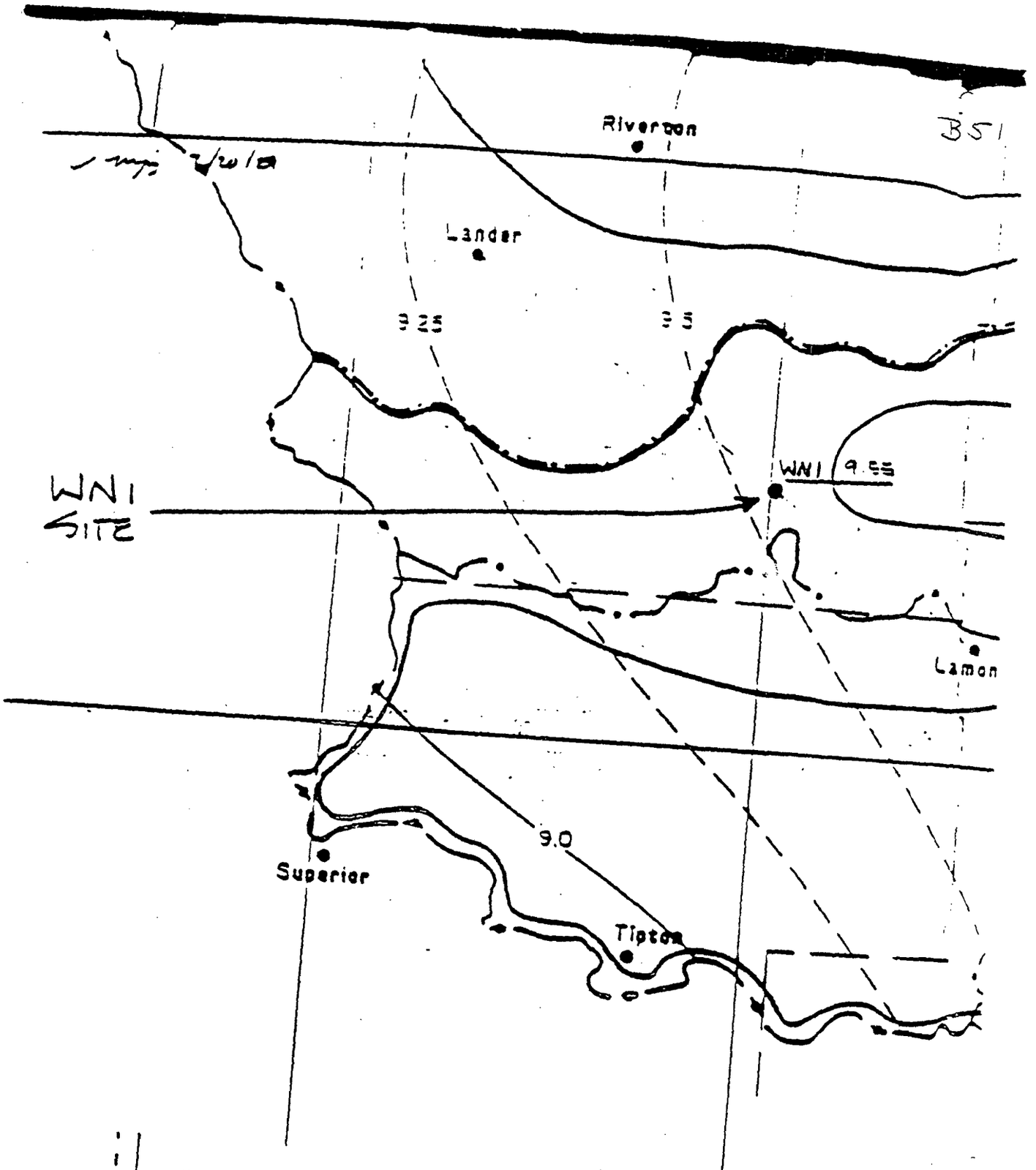
There are several problems involved in the development of design estimates that should be resolved. The purpose of this chapter is to briefly discuss these needed future studies.

15.1 Seasonal Variation

In the present study, it has been possible to develop only all-season PMP estimates. Although no attempt has been made to define the season of occurrence, some observations are possible. In the northern portion of the study region among the more important storms are Gibson Dam, MT (75), June 6-8, 1964; Warrick, MT (10), June 6-8, 1906; Springbrook, MT (32), June 17-21, 1921; and Savageton, WY (38), September 27-October 1, 1923. Through the central portion of the study region, Cherry Creek (47) and Hale (101), CO, May 30-31, 1935, Plum Creek (76), CO, June 13-20, 1965, Big Elk Meadow (77), CO May 4-8, 1969, and Big Thompson, July 31, 1976 are important in determining PMP estimates. In the extreme southern part of the study region, tropical storms or their remnants will be the causative mechanism for the longer duration PMP event. Such storms as Rancho Grande (60), NM, August 28-September 1, 1942, and Meek (27), NM, September 15-17, 1919 are typical of these events. Shorter duration storms similar to that at White Sands, NM, August 19, 1978 are important in this region. These storm dates suggest that the all-season PMP event will occur from early summer through fall. In those portions of the study region where snowmelt can be a critical factor, the probable maximum flood (PMF) may be the result of the lesser magnitude spring PMP event and accompanying snowmelt. The definition of the seasonal variation of PMP is, therefore, a necessary addition to the present report.

15.2 Permissible Snowpack With PMP and Snowmelt Criteria

To adequately evaluate the spring PMF, two additional factors are required. The first is an evaluation of the snowpack that could exist prior to the PMP event. The question to be answered is the depth and extent of the snow cover. Could, for example, the probable maximum snowpack (PMSP) occur just prior to the



HYDROMETEOROLOGICAL REPORT NO. 55A

0 10 20 30 40 50 MILES

SCALE: 1:1,000,000

ARIZONA
NEW MEXICO

PLATE VIb. Local storm PMP in inches
6-hr 1-mi^2 at 5,000 ft. elevation

Revised 1987

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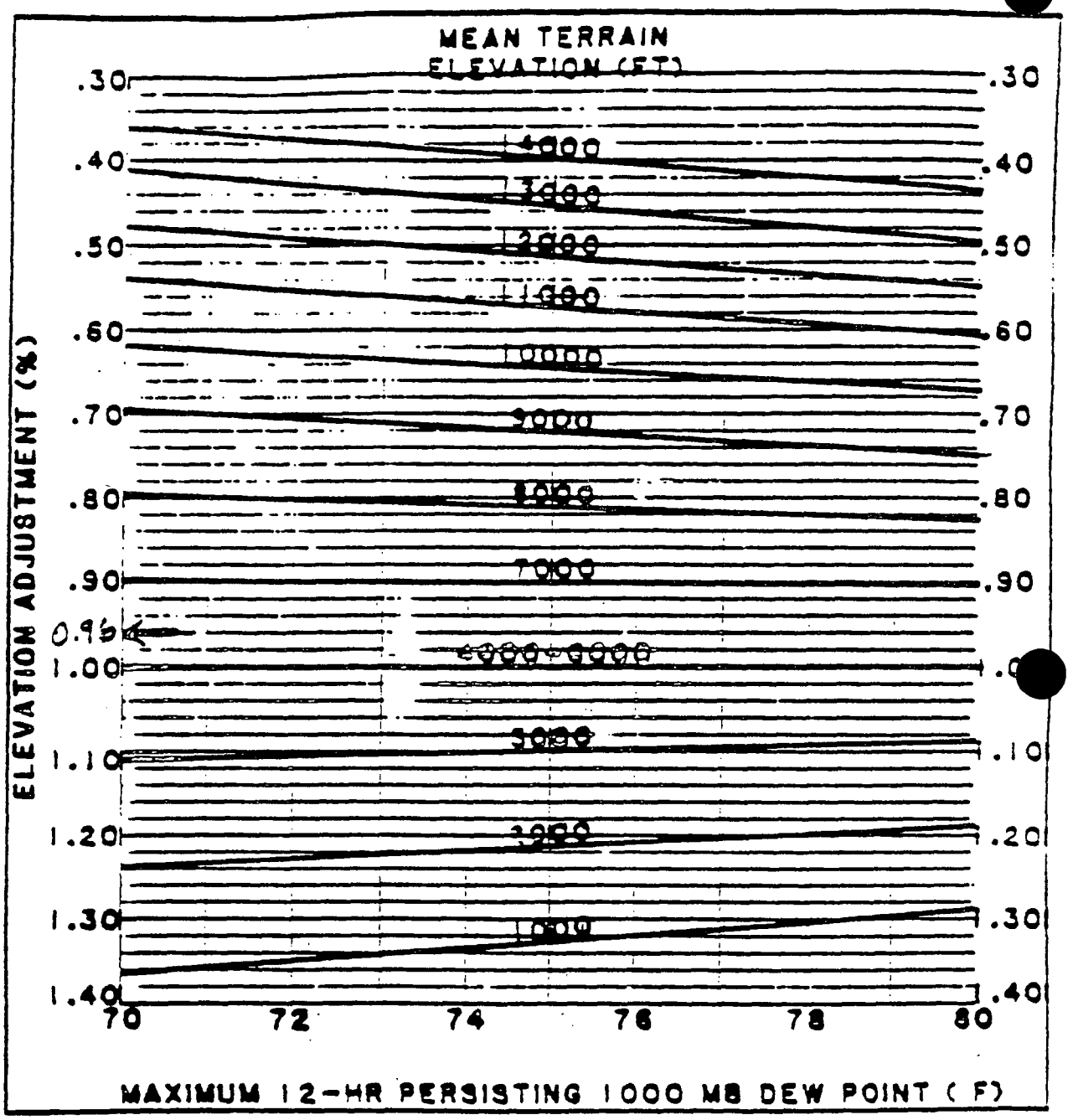

Figure 14.3.—Adjustment for elevation for local-storm PMP based on procedures developed in the report and maximum persisting 12-hr 1000-mb dew point (F).

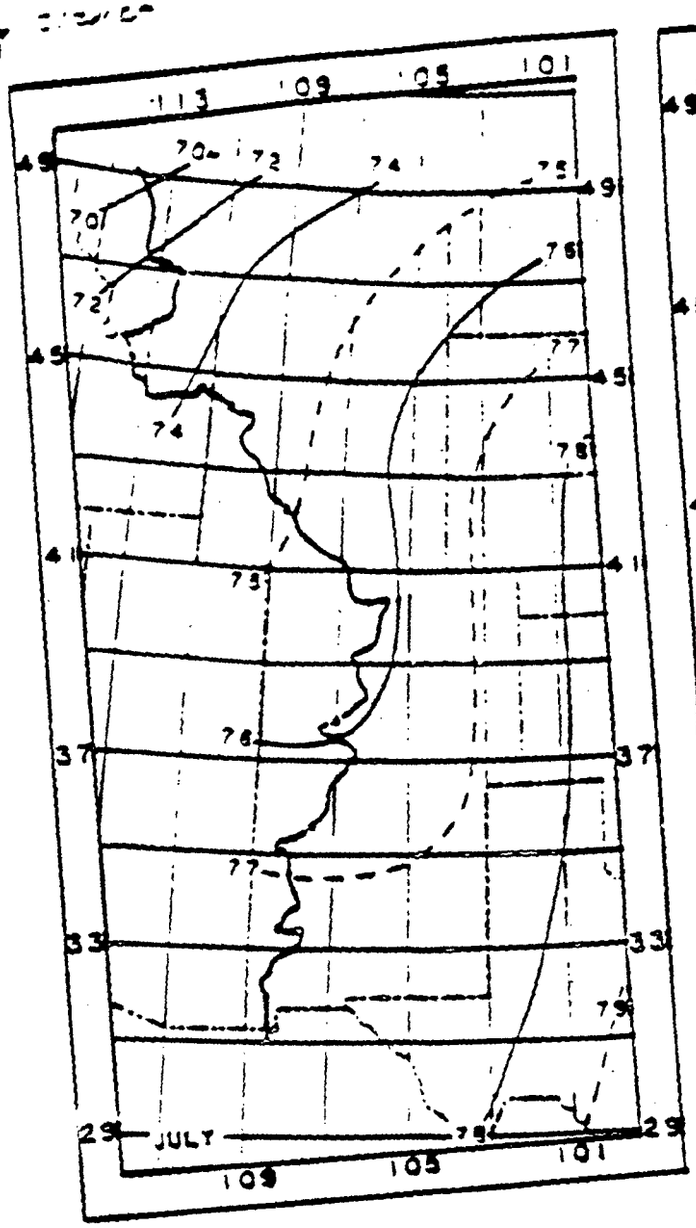

Figure 4.11.—Maximum persisting 12-hr 1000-mb dew points (°F) for July.

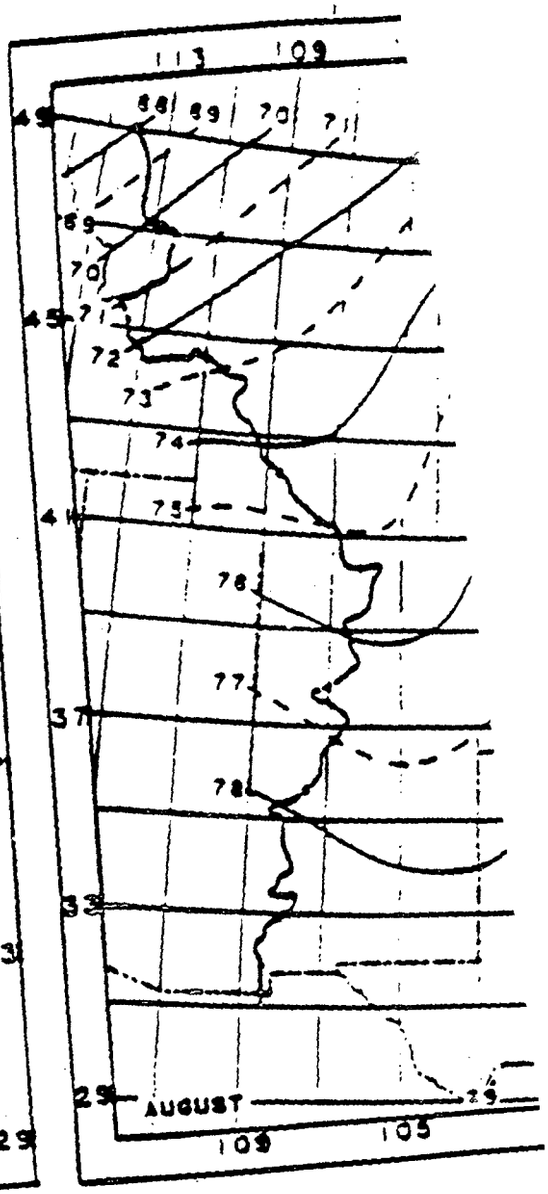

Figure 4.12.—Maximum persistin 1000-mb dew points (°F) for Au

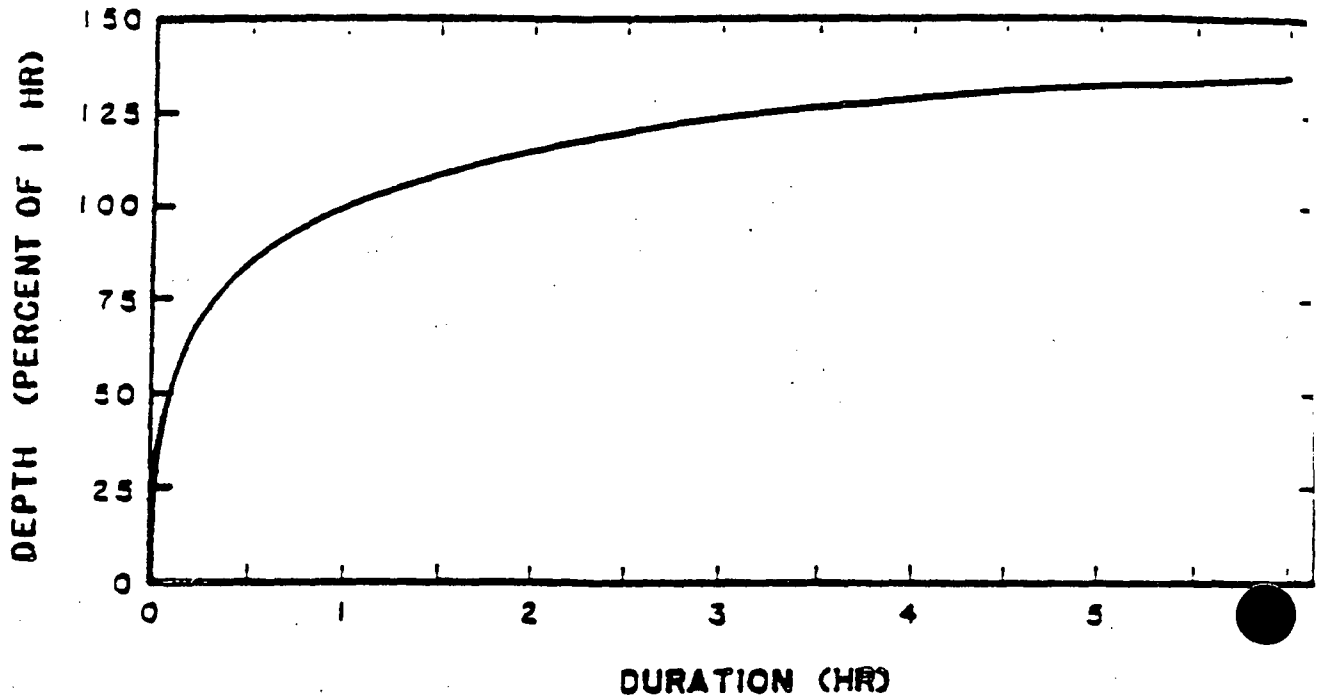

Figure 12.10.—Depth-duration curve for 6-/1-hr ratio of 1.35.

Table 12.4.—Percent of 1-hr local-storm PMP for selected durations for 6-/1-hr ratio of 1.35 (HMR No. 49)

Duration (hr)	Percent of 1 hr
1/4	.68
1/2	.86
3/4	.94
1	1.00
2	1.16
3	1.23
4	1.28
5	1.32
6	1.35

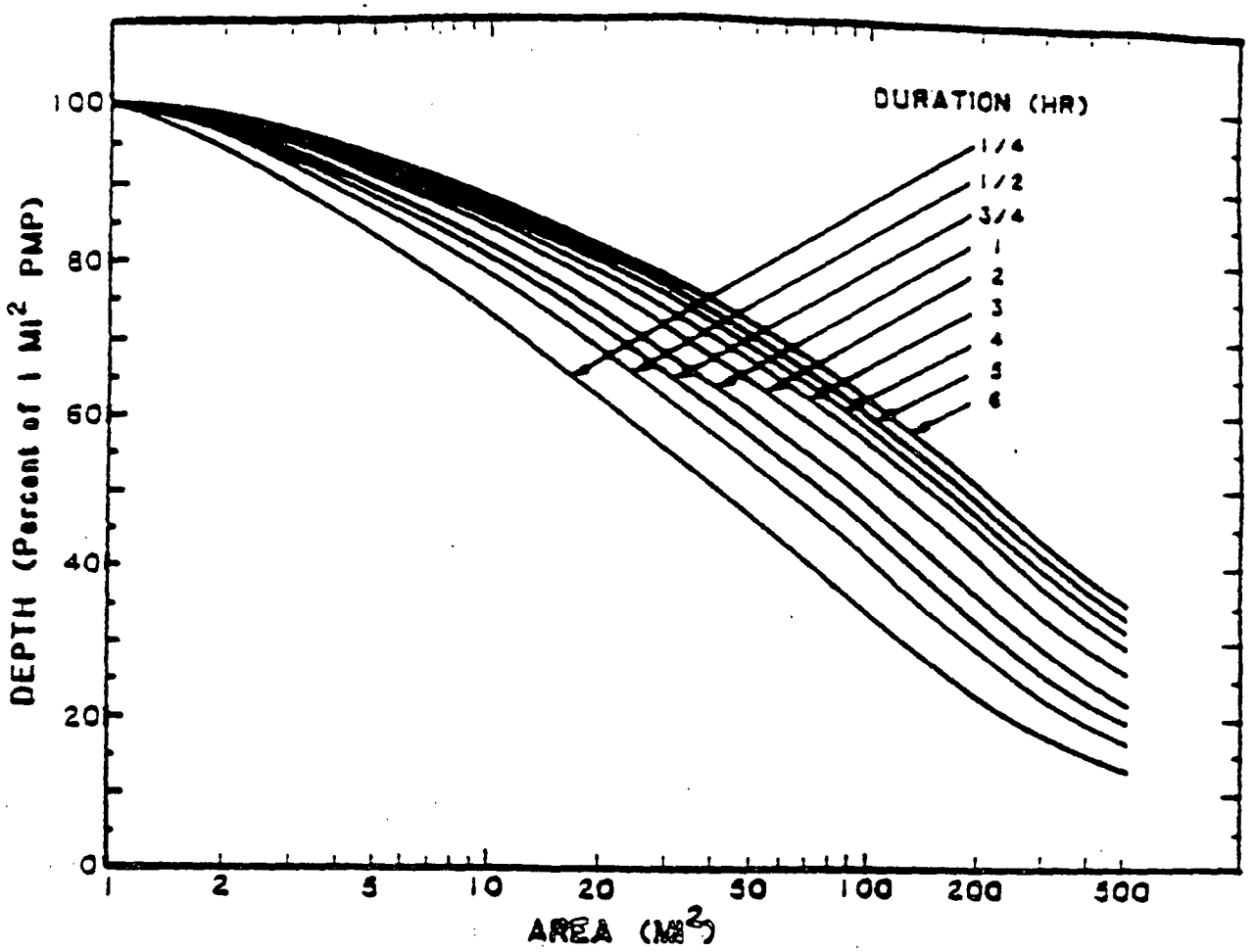

Figure 12.12.—Depth-area relations adopted for local-storm PMP in the CD-103 region (Hansen et al. 1977).

the storm in figure 12.9 that was constructed from a written account of the storm. The sequence of the hourly incremental rainfall for the storm shows that the storm decreased each succeeding hour after the first hour. However, meaningful conclusions cannot be drawn from this one example.

To supplement the lack of available data in the CD-103 region, data from HMR No. 49 was utilized. These data are presented in table 12.5 and include time distribution measurements from 6-hr storms, as utilized by the U.S. Weather Bureau (1947) and by the U.S. Army Corps of Engineers (1965). The choice of which of the two to apply is left to the user, as one sequence may be more critical than the other in a specific case.

There were no data available for the extreme local storms in the CD-103 region from which to determine the sequence of 15-min increments in the 1-hr storm. The 15-min incremental sequence taken from HMR No. 49 is, therefore, recommended. This incremental sequence appears in table 12.6. It is the result of percentages of total rainfall for thunderstorm rainfall determined by the U.S. Weather Bureau (1947).

B56

ATTACHMENT C

HEC-1 COMPUTER MODEL OUTPUT

B57

```
*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*             MAY   1991                *
*           VERSION 4.0.1E              *
*                                       *
*  RUN DATE  10/13/93  TIME  07:37:55   *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*    HYDROLOGIC ENGINEERING CENTER      *
*          609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616         *
*          (916) 551-1748               *
*                                       *
*****************************************
```

NORTH DITCH
+
TAILING SWALE

```
X     X  XXXXXXX   XXXXX           X
X     X  X        X     X         XX
X     X  X        X                X
XXXXXXX  XXXX     X        XXXXX   X
X     X  X        X                X
X     X  X        X     X          X
X     X  XXXXXXX   XXXXX          XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   Input File Name:     R:\PROJECTS\336\HEC1\CANONIE.PMP\NORTH2.IH1
  2           ID   DATE:06-14-93          DESIGN
  3           ID   HEC-1 PMP RUNOFF STUDY,JEFFREY CITY, WYOMING
  4           ID   DIVERSION CHANNEL MODIFICATIONS - NORTH CHANNEL
  5           ID            CURVE NUMBER = SPECIFIC TO BASINS
  6           ID   DESIGNED FOR 1 HOUR PMP AT 9.20 INCHES WITH SCS TYPE II DISTRIBUTION
  7           ID   ANTECEDENT MOISTURE CONDITION III
              *DIAGRAM
  8           IT       1       0    0000     120       0       0
  9           IN       3       0       0
 10           IO       5       0
              *

 11           KK     BG2 RUNOFF FROM BASIN G2 (INTO TRANSITION)
 12           KO                                     21
 13           PB     9.2
 14           PC     .01     .02     .03     .04    .055     .07    .085    .105     .15    .205
 15           PC    .285    .425    .655    .765     .83     .88     .91     .93    .945     .96
 16           PC     .97     .98     .99     1.0
 17           BA    .055
 18           LS       0      96
 19           UD    .081
              *

 20           KK     BG1 RUNOFF FROM BASIN G1 (INTO TRANSITION)
 21           KO                                     21
 22           BA    .005
 23           LS       0      79
 24           UD    .042
              *

 25           KK     NT1  COMBINE G1 AND G2
 26           KO                                     21
 27           HC       2
              *

 28           KK    R-T1  ROUTE NORTH TRANSITION TO NORTH 1
 29           KO                                     21
 30           RD     100   .0598   .0313            TRAP      15       3
              *

 31           KK     BG  RUNOFF FROM BASIN G
 32           KO                                     21
 33           BA    .124
 34           LS       0      85
 35           UD    .263
              *

 36           KK      N1  COMBINE G1 AND G2 AND G
 37           KO                                     21
 38           HC       2
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  39          KK    R-12  ROUTE NORTH 1-2
  40          KO                                    21
  41          RD     950    .005    .0313          TRAP      15       3
              *

  42          KK      BF  RUNOFF FROM BASIN F
  43          KO                                    21
  44          BA    .075
  45          LS       0      74
  46          UD    .355
              *

  47          KK     BF1  RUNOFF FROM BASIN F1
  48          KO                                    21
  49          BA    .004
  50          LS       0      89
  51          UD    .008
              *

  52          KK      N2  COMBINE ROUTED REACH WITH BASIN F AT NODE 2
  53          KO                                    21
  54          HC       3
              *

  55          KK    R-23  ROUTE NORTH 2-3
  56          KO                                    21
  57          RD    1850    .005    .0313          TRAP      15       3
              *

  58          KK      BE  RUNOFF FROM BASIN E
  59          KO                                    21
  60          BA    .051
  61          LS       0      85
  62          UD    .106
              *

  63          KK     BE1  RUNOFF FROM BASIN E1
  64          KO                                    21
  65          BA    .002
  66          LS       0      89
  67          UD    .046
              *

  68          KK      N3  COMBINE ROUTED REACH WITH BASIN E AT NODE 3
  69          KO                                    21
  70          HC       3
              *

  71          KK    R-34  ROUTE NORTH 3-4
  72          KO                                    21
  73          RD     770   .0387   .0410          TRAP      15       3
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  74          KK      BD  RUNOFF FROM BASIN D
  75          KO                                      21
  76          BA    .005
  77          LS       0      67
  78          UD    .127
              *

  79          KK     BD1  RUNOFF FROM BASIN D1
  80          KO                                      21
  81          BA    .003
  82          LS       0      89
  83          UD    .049
              *

  84          KK      N4  COMBINE ROUTED REACH WITH BASIN D AT NODE 4
  85          KO                                      21
  86          HC       3
              *

  87          KK    R-45  ROUTE NORTH 4-5
  88          KO                                      21
  89          RD     580   .0387   .0431          TRAP       15       3
              *

  90          KK      BC  RUNOFF FROM BASIN C
  91          KO                                      21
  92          BA    .006
  93          LS       0      67
  94          UD    .134
              *

  95          KK     BC1  RUNOFF FROM BASIN C1
  96          KO                                      21
  97          BA    .002
  98          LS       0      89
  99          UD    .064
              *

 100          KK     BT2  RUNOFF FROM SWALE BASIN T2
 101          KO                                      21
 102          BA    .002
 103          LS       0      89
 104          UD    .058
              *

 105          KK      BT  RUNOFF FROM SWALE BASIN T
 106          KO                                      21
 107          BA    .015
 108          LS       0      89
 109          UD    .200
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 110          KK     BT1  RUNOFF FROM SWALE BASIN T1
 111          KO                                   21
 112          BA    .039
 113          LS       0      89
 114          UD    .246
              *

 115          KK      S1  COMBINE SWALE REACH S-12 AND BASIN S
 116          KO                                   21
 117          HC       3
              *

 118          KK    S-12  ROUTE SWALE 1-2
 119          KO                                   21
 120          RD     500    .007   .0313           TRAP      15      16
              *

 121          KK      BS  RUNOFF FROM SWALE BASIN S
 122          KO                                   21
 123          BA    .073
 124          LS       0      89
 125          UD    .248
              *

 126          KK     BS1  RUNOFF FROM SWALE BASIN S1
 127          KO                                   21
 128          BA     .03
 129          LS       0      89
 130          UD    .105
              *

 131          KK      S1  COMBINE SWALE REACH S-12 AND BASIN S
 132          KO                                   21
 133          HC       3
              *

 134          KK    S-23  ROUTE SWALE 2-3
 135          KO                                   21
 136          RD    1450    .007   .0313           TRAP      15      16
              *

 137          KK      BR  RUNOFF FROM SWALE BASIN R
 138          KO                                   21
 139          BA    .012
 140          LS       0      89
 141          UD    .168
              *

 142          KK     BR1  RUNOFF FROM SWALE BASIN R1
 143          KO                                   21
 144          BA    .003
 145          LS       0      89
 146          UD    .056
              *
```

B62


```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 147          KK      S2  COMBINE SWALE REACH 2-3 AND BASIN R
 148          KO                                      21
 149          HC       3
              *

 150          KK    S-34  ROUTE SWALE REACH 3-4
 151          KO                                      21
 152          RD     745   .0409   .0383            TRAP      15       8
              *

 153          KK      N5  COMBINE ROUTED REACH, BASIN C, AND SWALE  AT NODE 5 AND BASIN C1
 154          KO                                      21
 155          HC       4
              *

 156          KK    R-56  ROUTE NORTH 5-6
 157          KO                                      21
 158          RD     400   .0303   .0431            TRAP      15       3
              *

 159          KK      BB  RUNOFF FROM BASIN B
 160          KO                                      21
 161          BA    .041
 162          LS       0      73
 163          UD    .164
              *

 164          KK     BB1  RUNOFF FROM BASIN B1
 165          KO                                      21
 166          BA    .002
 167          LS       0      89
 168          UD    .013
              *

 169          KK      N6  COMBINE ROUTED REACH WITH BASIN B AT NODE 6
 170          KO                                      21
 171          HC       3
              *

 172          KK    R-67  ROUTE NORTH 6-7
 173          KO                                      21
 174          RD     650     .02   .0377            TRAP      15       3
              *

 175          KK      BA  RUNOFF FROM BASIN A
 176          KO                                      21
 177          BA    .034
 178          LS       0      82
 179          UD    .175
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


 180          KK     BA1  RUNOFF FROM BASIN A1
 181          KO                                   21
 182          BA    .001
 183          LS       0      89
 184          UD    .013
              *

 185          KK      N7  COMBINE ROUTED REACH WITH BASIN A AT NODE 7
 186          KO                                   21
 187          HC       3
              *

 188          KK    R-78  ROUTE NORTH 7-8
 189          KO
 190          RD     460    .005   .0329           TRAP      15       3
 191          ZZ
```

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
INPUT
NO.   (V) ROUTING          (--->) DIVERSION OR PUMP FLOW
      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

 11     BG2
         .
         .
 20      .        BG1
         .          .
         .          .
 25     NT1............
         V
         V
 28    R-T1
         .
         .
 31      .        BG
         .          .
         .          .
 36     N1............
         V
         V
 39    R-12
         .
         .
         .        BF
         .          .
         .          .
 47      .          .        BF1
         .          .          .
         .          .          .
 52     N2......................
         V
         V
 55    R-23
         .
         .
 58      .        BE
         .          .
         .          .
 63      .          .        BE1
         .          .          .
         .          .          .
 68     N3......................
         V
         V
 71    R-34
         .
         .
 74      .        BD
         .          .
         .          .
         .          .        BD1
         .          .          .
         .          .          .
 84     N4......................
```

D6

```
          V
          V
 87     R-45
          .
          .
 90       .        BC
          .         .
          .         .
 95       .         .       BC1
          .         .         .
          .         .         .
100       .         .         .      BT2
          .         .         .        .
          .         .         .        .
105       .         .         .        .        BT
          .         .         .        .         .
          .         .         .        .         .
110       .         .         .        .         .        BT1
          .         .         .        .         .         .
          .         .         .        .         .         .
115       .         .         .       S1.........................
          .         .         .        V
          .         .         .        V
118       .         .         .      S-12
          .         .         .        .
          .         .         .        .
121       .         .         .        .        BS
          .         .         .        .         .
          .         .         .        .         .
126       .         .         .        .         .        BS1
          .         .         .        .         .         .
          .         .         .        .         .         .
131       .         .         .       S1.........................
          .         .         .        V
          .         .         .        V
134       .         .         .      S-23
          .         .         .        .
          .         .         .        .
137       .         .         .        .        BR
          .         .         .        .         .
          .         .         .        .         .
142       .         .         .        .         .        BR1
          .         .         .        .         .         .
          .         .         .        .         .         .
147       .         .         .       S2.........................
          .         .         .        V
          .         .         .        V
150       .         .         .      S-34
          .         .         .        .
          .         .         .        .
153      N5.......................................
          V
          V
156     R-56
          .
          .
159       .        BB
          .         .
          .         .
164       .         .       BB1
```

```
                .          .          .
                .          .          .
169           N6.......................
                V
                V
172         R-67
                .
                .
175             .          BA
                .           .
                .           .
180             .           .         BA1
                .           .           .
                .           .           .
185           N7.......................
                V
                V
188         R-78
```

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

NORTH DITCH

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	BG2	1032.	0.65	156.	156.	156.	0.05		
HYDROGRAPH AT	BG1	96[illegible]	0.62	11.	11.	11.	0.00		
2 COMBINED AT	NT1	1115.	0.65	167.	167.	167.	0.06		
ROUTED TO	R-T1	1112.	0.65	167.	167.	167.	0.06	FLOW IN NORTH TRANSITION	
HYDROGRAPH AT	BG	1181[illegible]	0.87	297.	297.	297.	0.12		
2 COMBINED AT	N1	1654.	0.70	464.	464.	464.	0.18		
ROUTED TO	R-12	1645.	0.72	464.	464.	464.	0.18	FLOW IN NORTH REACH 2	
HYDROGRAPH AT	BF	481.	0.97	145.	145.	145.	0.08		
HYDROGRAPH AT	BF1	106.	0.60	10.	10.	10.	0.00		
3 COMBINED AT	N2	1961.	0.83	619.	619.	619.	0.26		
ROUTED TO	R-23	1954.	0.87	618.	618.	618.	0.26	FLOW IN NORTH REACH 2	
HYDROGRAPH AT	BE	781.	0.68	122.	122.	122.	0.05		
HYDROGRAPH AT	BE1	42.	0.62	5.	5.	5.	0.00		
3 COMBINED AT	N3	2472.	0.75	745.	745.	745.	0.32		
ROUTED TO	R-34	2468.	0.75	745.	745.	745.	0.32	FLOW IN NORTH REACH 3	
HYDROGRAPH AT	BD	50.	0.72	8.	8.	8.	0.00		
HYDROGRAPH AT	BD1	62.	0.63	8.	8.	8.	0.00		
3 COMBINED AT	N4	2542.	0.75	761.	761.	761.	0.32		
ROUTED TO	R-45	2539.	0.77	760.	760.	760.	0.32	FLOW NORTH REACH 4	
HYDROGRAPH AT	BC	59.	0.73	10.	10.	10.	0.01		
HYDROGRAPH AT	BC1	38.	0.65	5.	5.	5.	0.00		
HYDROGRAPH AT	BT2	40.	0.63	5.	5.	5.	0.00		
HYDROGRAPH AT	BT	178.	0.78	38.	38.	38.	0.01		
HYDROGRAPH AT	BT1	409.	0.83	100.	100.	100.	0.04		
3 COMBINED AT	S1	591.	0.82	143.	143.	143.	0.06		
ROUTED TO	S-12	590.	0.83	143.	143.	143.	0.06	FLOW IN SWALE REACH 1	

HYDROGRAPH AT	BS	762.	0.83	187.	187.	187.	0.07	
HYDROGRAPH AT	BS1	484.	0.68	77.	77.	77.	0.03	
3 COMBINED AT	S1	1609.	0.80	407.	407.	407.	0.16	
ROUTED TO	S-23	1601.	0.85	406.	406.	406.	0.16	FLOW IN SWALE REACH 2
HYDROGRAPH AT	BR	156.	0.75	31.	31.	31.	0.01	
HYDROGRAPH AT	BR1	61.	0.63	8.	8.	8.	0.00	
3 COMBINED AT	S2	1739.	0.83	445.	445.	445.	0.17	
ROUTED TO	S-34	1736.	0.85	445.	445.	445.	0.17	FLOW IN SWALE REACH 3
4 COMBINED AT	N5	4220.	0.80	1220.	1220.	1220.	0.51	
ROUTED TO	R-56	4217.	0.82	1220.	1220.	1220.	0.51	FLOW IN NORTH REACH 5
HYDROGRAPH AT	BB	417.	0.77	79.	79.	79.	0.04	
HYDROGRAPH AT	BB1	52.	0.60	5.	5.	5.	0.00	
3 COMBINED AT	N6	4623.	0.80	1303.	1303.	1303.	0.55	
ROUTED TO	R-67	4618.	0.80	1302.	1302.	1302.	0.55	FLOW IN NORTH REACH 6
HYDROGRAPH AT	BA	393.	0.77	78.	78.	78.	0.03	
HYDROGRAPH AT	BA1	26.	0.60	3.	3.	3.	0.00	
3 COMBINED AT	N7	5002.	0.80	1382.	1382.	1382.	0.58	
ROUTED TO	R-78	4985.	0.82	1382.	1382.	1382.	0.58	FLOW IN NORTH REACH 7

```
****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*              MAY   1991              *
*           VERSION 4.0.1E             *
*                                      *
*  RUN DATE  10/07/93  TIME  14:41:26  *
*                                      *
****************************************
```

```
****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
*   HYDROLOGIC ENGINEERING CENTER      *
*         609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616        *
*           (916) 551-1748             *
*                                      *
****************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X              X
XXXXXXX  XXXX     X        XXXXX  X
X     X  X        X              X
X     X  X        X     X        X
X     X  XXXXXXX   XXXXX         XXX
```

NORTH CENTRAL DITCH

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID  File N     me:R:\PROJECTS\336\HEC1\NC2.IH1                                DATE:
  2           ID  06-14-                  DESIGN                                           HEC-1
  3           ID  PMP RUOFF STUDY,JEFFRE Y CITY, WYOMING                                   DIVER
  4           ID  SION CNNEL MODIFICATIONS - NORTH CENTRAL CHANN      EL
  5           ID     CURVE NUMBER = SPEC IFIC TO  BASINS                                   DESIG
  6           ID  NED FOPMP, 9.20 in  IN 1 HOURS WITH SCS TYPE II DISTRI  BUTION           ANTEC
  7           ID  EDENT ISTURE CONDITION     III
              *DIAGRAM
  8           IT       1       0    0000     120       0       0
  9           IN       3       0       0
 10           IO       5       0
              *

 11           KK      BP  RUNOFF FROM BASIN P
 12           KO                                     21
 13           PB    9.20
 14           PC     .01     .02     .03     .04    .055     .07    .085    .105     .15    .205
 15           PC    .285    .425    .655    .765     .83     .88     .91     .93    .945     .96
 16           PC     .97     .98     .99     1.0
 17           BA    .003
 18           LS       0      69
 19           UD    .089
              *

 20           KK     BP1  RUNOFF FROM BASIN P1
 21           KO                                     21
 22           BA    .015
 23           LS       0      89
 24           UD    .058
              *

 25           KK     BP2  RUNOFF FROM BASIN P2
 26           KO                                     21
 27           BA   .0005
 28           LS       0      89
 29           UD    .007
              *

 30           KK      N1  COMBINE BP, BP1, BP2
 31           KO                                     21
 32           HC       3
              *

 33           KK    R-12  ROUTE NORTH CENTRAL 1-2
 34           KO                                     21
 35           RD     495    .005   .0313            TRAP      10       3
              *

 36           KK      BO  RUNOFF FROM BASIN O
 37           KO                                     21
 38           BA    .008
 39           LS       0      81
 40           UD    .034
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  41          KK     BO1  RUNOFF FROM BASIN O1
  42          KO                                   21
  43          BA    .001
  44          LS       0      89
  45          UD    .007
              *

  46          KK      N2  COMBINE ROUTED REACH WITH BASIN O AT NODE 2 (AND O1
  47          KO                                   21
  48          HC       3
              *

  49          KK    R-23  ROUTE NORTH CENTRAL 2-3
  50          KO                                   21
  51          RD     695     .03   .0382           TRAP      10       3
              *

  52          KK      BM  RUNOFF FROM BASIN M
  53          KO                                   21
  54          BA    .033
  55          LS       0      87
  56          UD    .109
              *

  57          KK     BM1  RUNOFF FROM BASIN M1
  58          KO                                   21
  59          BA    .001
  60          LS       0      89
  61          UD    .005
              *

  62          KK      N3  COMBINE ROUTED REACH WITH BASIN M AT NODE 3 (AND M1)
  63          KO                                   21
  64          HC       3
              *

  65          KK    R-34  ROUTE NORTH CENTRAL 3-4
  66          KO                                   21
  67          RD     336    .005   .0313           TRAP      10       3
  68          ZZ
```

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
INPUT
LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

 NO.      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

  11         BP
              .
              .
  20          .         BP1
              .           .
              .           .
  25          .           .         BP2
              .           .           .
              .           .           .
  30         N1.......................
              V
              V
  33       R-12
              .
              .
  36          .          BO
              .           .
              .           .
  41          .           .         BO1
              .           .           .
              .           .           .
  46         N2.......................
              V
              V
  49       R-23
              .
              .
  52          .          BM
              .           .
              .           .
  57          .           .         BM1
              .           .           .
              .           .           .
  62         N3.......................
              V
              V
  65       R-34
```

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

NORTH CENTRAL DITCH

RUNOFF SUMMARY

FLOW IN CUBIC FEET PER SECOND

TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	BP	37.	0.68	5.	5.	5.	0.00		
HYDROGRAPH AT	BP1	299.	0.63	38.	38.	38.	0.01		
HYDROGRAPH AT	BP2	13.	0.60	1.	1.	1.	0.00		
3 COMBINED AT	N1	337.	0.63	45.	45.	45.	0.02		
ROUTED TO	R-12	327.	0.65	45.	45.	45.	0.02	FLOW IN REACH 1	
HYDROGRAPH AT	BO	168.	0.62	18.	18.	18.	0.01		
HYDROGRAPH AT	BO1	26.	0.60	3.	3.	3.	0.00		
3 COMBINED AT	N2	470.	0.63	65.	65.	65.	0.03		
ROUTED TO	R-23	471.	0.65	65.	65.	65.	0.03	FLOW IN REACH 2	
HYDROGRAPH AT	BM	512.	0.68	82.	82.	82.	0.03		
HYDROGRAPH AT	BM1	26.	0.60	3.	3.	3.	0.00		
3 COMBINED AT	N3	970.	0.67	150.	150.	150.	0.06		
ROUTED TO	R-34	960.	0.68	150.	150.	150.	0.06	FLOW IN REACH 3	

D 17

```
*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              MAY   1991               *
*           VERSION 4.0.1E              *
*                                       *
*  RUN DATE  09/17/93  TIME  10:21:20   *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*    HYDROLOGIC ENGINEERING CENTER      *
*          609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616         *
*          (916) 551-1748               *
*                                       *
*****************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X              X
XXXXXXX  XXXX     X       XXXXX  X
X     X  X        X              X
X     X  X        X     X        X
X     X  XXXXXXX   XXXXX         XXX
```

SOUTH CENTRAL DITCH

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   Input File Name:     R:\PROJECTS\336\HEC1\C\SC2.IH1
  2           ID   DATE:06-17-93         DESIGN
  3           ID   HEC-1 PMP RUNOFF STUDY,JEFFREY CITY, WYOMING
  4           ID   DIVERSION CHANNEL MODIFICATIONS - SOUTH CENTRAL CHANNEL
  5           ID             CURVE NUMBER = SPECIFIC TO BASINS
  6           ID   DESIGNED FOR PMP, 9.20 in. IN 1 HOURS WITH SCS TYPE II DISTRIBUTION
  7           ID   ANTECEDENT MOISTURE CONDITION III
              *DIAGRAM
  8           IT       1       0    0000     120       0       0
  9           IN       3       0       0
 10           IO       5       0
              *

 11           KK      BQ  RUNOFF FROM BASIN Q
 12           KO                                      21
 13           PB     9.2
 14           PC     .01     .02     .03     .04    .055     .07    .085    .105     .15    .205
 15           PC    .285    .425    .655    .765     .83     .88     .91     .93    .945     .96
 16           PC     .97     .98     .99     1.0
 17           BA    .024
 18           LS       0      78
 19           UD    .138
              *

 20           KK     BQ2  RUNOFF FROM BASIN Q2
 21           KO                                      21
 22           BA    .002
 23           LS       0      89
 24           UD    .007
              *

 25           KK     BQ1  RUNOFFROM BASIN Q1
 26           KO                                      21
 27           BA    .032
 28           LS       0      89
 29           UD    .111
              *

 30           KK      N1  COMBINE BASINS  Q AND Q1 AND Q2 AT NODE 1
 31           KO                                      21
 32           HC       3
              *

 33           KK    R-12  ROUTE SOUTH CENTRAL 1-2
 34           KO                                      21
 35           RD    1575     .04   .0329            TRAP      15       3
              *

 36           KK      BN RUNOFF FROM BASIN N
 37           KO                                      21
 38           BA    .066
 39           LS       0      79
 40           UD    .141
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


  41          KK     BN1  RUNOFF FROM BASIN N1
  42          KO                                     21
  43          BA    .001
  44          LS       0      89
  45          UD    .005
              *

  46          KK      N2  COMBINE ROUTED REACH WITH BASINS N1 AND N2
  47          KO                                     21
  48          HC       3
              *

  49          KK    R-23  ROUTE SOUTH CENTRAL 2-3
  50          KO                                     21
  51          RD     728    .009   .0352            TRAP      15       3
              *
  52          ZZ
```

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
INPUT
NO.     (V) ROUTING          (--->) DIVERSION OR PUMP FLOW
        (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

 11       BQ
           .
           .
 20        .        BQ2
           .          .
           .          .
 25        .          .        BQ1
           .          .          .
           .          .          .
 30       N1.......................
           V
           V
 33      R-12
           .
           .
 36        .         BN
           .          .
           .          .
 41        .          .        BN1
           .          .          .
           .          .          .
         N2.......................
           V
           V
 49      R-23
```

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

South Central Ditch

RUNOFF SUMMARY

FLOW IN CUBIC FEET PER SECOND

TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	BQ	293.	0.73	51.	51.	51.	0.02		
HYDROGRAPH AT	BQ2	53.	0.60	5.	5.	5.	0.00		
HYDROGRAPH AT	BQ1	503.	0.68	82.	82.	82.	0.03		
3 COMBINED AT	N1	801.	0.70	138.	138.	138.	0.06		
ROUTED TO	R-12	799.	0.73	138.	138.	138.	0.06	Flow in Reach 1	
HYDROGRAPH AT	BN	811.	0.73	142.	142.	142.	0.07		
HYDROGRAPH AT	BN1	26.	0.60	3.	3.	3.	0.00		
3 COMBINED AT	N2	1616.	0.73	283.	283.	283.	0.13		
ROUTED TO	R-23	1609.	0.75	283.	283.	283.	0.13	Flow in Reach 2	

```
****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*             MAY   1991               *
*          VERSION 4.0.1E              *
*                                      *
*  RUN DATE  10/07/93  TIME  16:52:31  *
*                                      *
****************************************
```


```
****************************************
*                                      *
*    U.S. ARMY CORPS OF ENGINEERS      *
*    HYDROLOGIC ENGINEERING CENTER     *
*          609 SECOND STREET           *
*       DAVIS, CALIFORNIA 95616        *
*           (916) 551-1748             *
*                                      *
****************************************
```


SOUTH DITCH

```
X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X               X
XXXXXXX  XXXX     X        XXXXX  X
X     X  X        X               X
X     X  X        X     X         X
X     X  XXXXXXX   XXXXX         XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   Input File Name:     R:\PROJECTS\336\HEC1\SOUTH2.IH1
  2           ID   DATE:06-17-93        DESIGN D50
  3           ID   HEC-1 PMP RUNOFF STUDY,JEFFREY CITY, WYOMING
  4           ID   DIVERSION CHANNEL MODIFICATIONS - SOUTH CHANNEL
  5           ID            CURVE NUMBER = SPECIFIC TO BASINS
  6           ID   DESIGNED FOR PMP, 9.2 in. IN  1 HOUR WITH SCS TYPE II DISTRIBUTION
  7           ID   ANTECEDENT MOISTURE CONDITION III
              *DIAGRAM
  8           IT       1       0    0000     120       0       0
  9           IN       3       0       0
 10           IO       5       0
              *

 11           KK     BH2  RUNOFF FROM BASIN H2
 12           KO                                   21
 13           PB    9.20
 14           PC     .01     .02     .03     .04    .055     .07    .085    .105     .15    .205
 15           PC    .285    .425    .655    .765     .83     .88     .91     .93    .945     .96
 16           PC     .97     .98     .99     1.0
 17           BA    .001
 18           LS       0      89
 19           UD    .021
              *

 20           KK    R-T1  ROUTE SOUTH T-1
 21           KO                                   21
 22           RD     100    .065   .0369            TRAP      15       3
              *

 23           KK      BH  RUNOFF FROM BASIN H
 24           KO                                   21
 25           BA    .038
 26           LS       0      94
 27           UD    .047
              *

 28           KK     BH1  RUNOFF FROM BASIN H1
 29           KO                                   21
 30           BA    .002
 31           LS       0      89
 32           UD    .007
              *

 33           KK      N1  COMBINE ROUTED REACH WITH BASIN H, H1, AND H2 AT NODE 1
 34           KO                                   21
 35           HC       3
              *

 36           KK    R-12  ROUTE SOUTH 1-2
 37           KO                                   21
 38           RD    1300   .0082   .0313            TRAP      15       3
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  39          KK      BI  RUNOFF FROM BASIN I
  40          KO                                      21
  41          BA    .064
  42          LS       0      92
  43          UD    .058
              *

  44          KK     BI1  RUNOFF FROM BASIN I1
  45          KO                                      21
  46          BA    .002
  47          LS       0      89
  48          UD    .007
              *

  49          KK      N2  COMBINE ROUTED REACH WITH BASIN I AT NODE 2
  50          KO                                      21
  51          HC       3
              *

  52          KK    R-23  ROUTE SOUTH 2-3
  53          KO                                      21
  54          RD    1200    .004   .0313            TRAP      15       3
              *

  55          KK      BJ  RUNOFF FROM BASIN J
  56          KO                                      21
  57          BA    .059
  58          LS       0      84
  59          UD    .086
              *

  60          KK     BJ1  RUNOFF FROM BASIN J1
  61          KO                                      21
  62          BA    .009
  63          LS       0      89
  64          UD    .086
              *

  65          KK      N3  COMBINE ROUTED REACH WITH BASIN J AT NODE 3
  66          KO                                      21
  67          HC       3
              *

  68          KK    R-34  ROUTE SOUTH 3-4
  69          KO                                      21
  70          RD    2300   .0229   .0313            TRAP      15       3
              *

  71          KK      BK  RUNOFF FROM BASIN K
  72          KO                                      21
  73          BA    .102
  74          LS       0      92
  75          UD    .136
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  76          KK     BK1  RUNOFF FROM BASIN K1
  77          KO                                   21
  78          BA    .004
  79          LS       0      89
  80          UD    .023
              *

  81          KK      N4  COMBINE ROUTED REACH WITH BASIN K AT NODE 4
  82          KO                                   21
  83          HC       3
              *

  84          KK    R-45  ROUTE SOUTH 4-5
  85          KO                                   21
  86          RD     800   .0231   .0366          TRAP       15       3
              *

  87          KK      BL  RUNOFF FROM BASIN L
  88          KO                                   21
  89          BA    .024
  90          LS       0      67
  91          UD    .143
              *

  92          KK     BL1  RUNOFF FROM BASIN L1
  93          KO                                   21
  94          BA    .004
  95          LS       0      89
  96          UD    .024
              *

  97          KK      N5  COMBINE ROUTED REACH WITH BASIN L AT NODE 5
  98          KO                                   21
  99          HC       3
              *

 100          KK    R-56  ROUTE SOUTH 5-6
 101          KO                                   21
 102          RD    1000   .0231   .0379          TRAP       15       3
 103          ZZ
```

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
INPUT
NO.   (V) ROUTING          (--->) DIVERSION OR PUMP FLOW
      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

11      BH2
         V
         V
20     R-T1
         .
         .
23       .          BH
         .           .
         .           .
28       .           .         BH1
         .           .           .
         .           .           .
33      N1.......................
         V
         V
36     R-12
         .
         .
39       .          BI
         .           .
         .           .
         .           .         BI1
         .           .           .
         .           .           .
49      N2.......................
         V
         V
52     R-23
         .
         .
55       .          BJ
         .           .
         .           .
60       .           .         BJ1
         .           .           .
         .           .           .
65      N3.......................
         V
         V
68     R-34
         .
         .
71       .          BK
         .           .
         .           .
76       .           .         BK1
         .           .           .
         .           .           .
        N4.......................
         V
         V
84     R-45
```

```
              .
              .
  87          .         BL
              .          .
              .          .
              .          .        BL1
              .          .          .
              .          .          .
  97         N5.......................
              V
              V
 100       R-56
```

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

South Ditch

RUNOFF SUMMARY

FLOW IN CUBIC FEET PER SECOND

TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	BH2	25.	0.60	3.	3.	3.	0.00		
ROUTED TO	R-T1	24.	0.60	3.	3.	3.	0.00	Flow in Transition	
HYDROGRAPH AT	BH	829.	0.62	105.	105.	105.	0.04		
HYDROGRAPH AT	BH1	53.	0.60	5.	5.	5.	0.00		
3 COMBINED AT	N1	885.	0.62	112.	112.	112.	0.04		
ROUTED TO	R-12	864.	0.65	112.	112.	112.	0.04	Flow in Reach 1	
HYDROGRAPH AT	BI	1310.	0.63	171.	171.	171.	0.06		
HYDROGRAPH AT	BI1	53.	0.60	5.	5.	5.	0.00		
3 COMBINED AT	N2	2161.	0.65	289.	289.	289.	0.11		
ROUTED TO	R-23	2052.	0.67	289.	289.	289.	0.11	Flow in Reach 2	
HYDROGRAPH AT	BJ	971.	0.67	139.	139.	139.	0.06		
HYDROGRAPH AT	BJ1	157.	0.67	23.	23.	23.	0.01		
3 COMBINED AT	N3	3179.	0.67	451.	451.	451.	0.17		
ROUTED TO	R-34	3171.	0.70	451.	451.	451.	0.17	Flow in Reach 3	
HYDROGRAPH AT	BK	1516.	0.72	273.	273.	273.	0.10		
HYDROGRAPH AT	BK1	98.	0.60	10.	10.	10.	0.00		
3 COMBINED AT	N4	4704.	0.70	734.	734.	734.	0.28		
ROUTED TO	R-45	4654.	0.70	735.	735.	735.	0.28	Flow in Reach 4	
HYDROGRAPH AT	BL	229.	0.75	40.	40.	40.	0.02		
HYDROGRAPH AT	BL1	97.	0.60	10.	10.	10.	0.00		
3 COMBINED AT	N5	4905.	0.72	785.	785.	785.	0.31		
ROUTED TO	R-56	4896.	0.72	785.	785.	785.	0.31	Flow in Reach 5	

APPENDIX
C

APPENDIX C

EROSION PROTECTION DESIGN CALCULATIONS

APPENDIX C

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C.1

OPEN CHANNEL HYDRAULICS and RIPRAP SIZE CALCULATIONS

OPEN CHANNEL HYDRAULICS and RIPRAP SIZING CALCULATION WESTERN NUCLEAR, INC.

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OPEN CHANNEL HYDRAULICS and RIPRAP SIZING CALCULATION WESTERN NUCLEAR, INC.

PURPOSE. The purpose of this calculation brief is to determine the ditch flow characteristics and size of riprap required to provide erosion protection for the probable maximum flood (PMF) in each diversion ditch at WNI's Split Rock Mill and Tailing Site in Jeffrey City, Wyoming. This calculation has been done previously using the Safety Factors Method for sizing riprap (see "Western Nuclear, Inc. Split Rock Mill March 1992-Responses to NRC comments on the Uranium Tailing Reclamation Plan", Appendix B, Section B.2.)in TRP #3 and the U.S. Army Corps of Engineers (COE) method, submitted September 1992 in TRP #4. In this calculation, the U.S. Army Corp of Engineers (COE) method is used and where applicable, the Safety Factors Method is also used.

METHOD. Standard Corp of Engineers Floodplain Analysis Computer Programs (HEC1 and HEC2) are used to calculate the surface hydrology, ditch hydraulics and the required D_{50} for riprap erosion protection. The COE method is described in NUREG/CR-4620, NRC, June 1986, NUREG/CR 4651, NRC, MAY 1986, and EM 1110-2-16-1 (U.S. Army Corps of Engineers, July 1970). The specific steps taken to size the ditches and the required riprap are as follows:

1. Surface hydrology (HEC1)
2. Open-channel hydraulics (HEC2)
3. Calculate D_{50} using COE 70 and Safety Factors Method
4. Calculate a value for Manning's n
5. Using an iterative method repeat steps 1 through 4 until D_{50} and n are compatible

Spreadsheets were developed to facilitate the multiple iterations required to implement the COE Method. The "Spreadsheets" section of the calculation brief contains print-outs of these spreadsheets for each ditch design.

SURFACE HYDROLOGY. Watershed run-off and ditch routing was calculated using the Corps of Engineers HEC-1 model (COE, 1990) for the sub-basins shown in Figure C.1.1 (page C-13). This computer model uses the characteristics of the drainage basins and the precipitation

distribution to determine the discharge. These calculations are provided in Appendix B.

The flood event used to evaluate the surface hydrology was the Probable Maximum Flood (PMF), which will result from the Probable Maximum Precipitation (PMP) of 9.2-inches for a 1-hour storm. This storm event was selected based on the requirements of the NRC as set forth in the Final Staff Technical Position, Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailing Sites (NRC, 1990). The calculations for determination of the PMP value are given in Appendix B. The precipitation event was distributed for the HEC-1 analysis using the SCS Type II distribution (SCS, 1973) also discussed in Appendix B.

The SCS curve number method was used to estimate the precipitation loss rate. Curve numbers of 96 (granite), 89 (tailing cover) and 67 (native soil) were used in the analysis when obtaining the weighted curve numbers required for each basin. Information detailing the generation of weighted curve numbers is discussed in Appendix B.

The SCS dimensionless Unit Graph method was used to generate the runoff and routing hydrographs. This method requires the determination of the SCS Lag Time which is expressed as:

$$t_p = \frac{l^{0.8}(S+1)^{0.7}}{1900y^{0.5}}$$

where
tp = lag time (hr.)
l = length to divide (ft.)
y = average watershed slope (%)
S = (1000/CN)-10
CN = curve number

The lag time values for each watershed and the values used to calculate the lag time are discussed in Appendix B.

Hydraulic routing was used to determine the movement of a flood wave through the ditch. Each ditch reach began at a major confluence (node) and ended at the next major downstream tributary. Thus the water surface profile is determined in each reach assuming that all the flow in the reach occurs at the upstream end. Figure C.1.2 (page C-14) shows the reaches in each diversion ditch and the tailing swale. The results of the hydrological analysis are presented in hydrographs at each of the tributary inflow points along the ditches, and the routed flows through each of the ditch reaches.

OPEN-CHANNEL HYDRAULICS. Using the routed peak discharges from the HEC-1 model, the hydraulic characteristics of the ditches were determined using the Corps of Engineers HEC-2 model (COE, 1991). Both Super Critical and Sub Critical flows are taken into account in the HEC2 analysis.

Manning's n for the HEC-2 analysis was determined based on the bed slope and riprap sizes in the ditch. Manning's n values were calculated using two methods; one for relatively flat ditches (less than 2% slope) and another for steep ditches (greater than 2% slope) both of which are encountered at the Jeffrey City site.

for slopes $\leq$ 2.0%
$n = 0.0395\ (D_{50})^{0.1667}$
where:

D_{50} = mean grain diameter, ft.
[Ref NUREG/CR 4620,EQN.4.8, pp.59]

for slopes > 2.0%
$n = 0.0456\ [(D_{50})(s)]^{0.159}$
where

D_{50} = mean grain diameter, inches
s = slope in ft/ft
[Ref NUREG/CR 4651,EQN.4.41 pp.60]

Given the results of the hydraulic analysis, an iterative approach was used to determine riprap sizes. Riprap size required in the ditches was determined using COE Shear Stress method and Safety Factors Method.

Iterative Process

The HEC1 and HEC2 models along with D_{50} spreadsheets were iterated until the estimated Mannings n in HEC1 was comparable to the Mannings n in HEC2. First a ditch cross section was established, along with side slopes and bed slope. Estimated riprap sizes were then used to calculate the Mannings n value used in the HEC1 model. Routed flow volumes from HEC1 were then input into HEC2 producing depth and velocity of flow. With ditch flow information from HEC2 Riprap was sized using USACE Shear Stress, and Safety Factors methods. New Mannings n values were then calculated and input back into the HEC2 model. With a comparable result for Mannings n reached by the iteration of HEC2 and D_{50}, new Mannings n

values were then input back into HEC1. New routed flow volumes were then input into HEC2 and the HEC2/D_{50} iteration was run again. This process was continued until the HEC1, HEC2 and D_{50} iterations were comparable. A schematic of the iteration process is shown in Figure C.1.3 (page C-15).

INPUT PARAMETERS.

Ditch Parameters. The ditch dimensions (ditch slope, side slope, and bottom width) for each reach at the Split Rock have been modified in this TRP from those included in "Western Nuclear, Inc. Split Rock Mill March 1992-Responses to NRC comments on the Uranium Tailing Reclamation Plan", Appendix B, Section B.2). New ditch parameters are based on minimizing cut and fill quantities and this revision optimizes ditch excavation and rock sizes contained in the TRP #4 design. All ditches are 15 feet wide with 3:1 side slopes. Radii of curvature are given in Figure C.1.4 (page C-16).

The PMF values are taken from the revised Appendix B.

Rock Characteristics. For the purpose of riprap design, the specific gravity of the rock is assumed as 2.65. This value is considered conservative since Water, Waste and Land, Inc. of Fort Collins, Colorado performed rock durability tests on rock borrow sources adjacent to the Tailing's Impoundment and reported values of 2.71 for specific gravity. (see Appendix C of the 1992 WNI report - Responses to NRC comments on the Uranium Tailing Reclamation Plan). This rock source is an igneous outcrop that will be angular after blasting. An angle of repose of 42 degrees is used for the crushed rock (See Figure 3.14 in Attachment A).

Table C.1.1 (page C-11) is a summary of the input parameters and the results of the ditch design calculations.

RESULTS. Spreadsheets using the COE method for riprap design and, where applicable, using the Safety Factors method are included for each ditch in the spreadsheet section of this calculation brief. Table C.1.1 (page C-11) summarizes the resulting ditch designs and the parameters used for sizing riprap in each ditch section. It should be noted that Table C.1.1 presents the worst case design parameters for each ditch section.

REFERENCES

Nelson, Abt, Volpe, Zyl, Hinkle, Staub, "Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailing Impoundments," U.S. Nuclear Regulatory Commission, NUREG/CR-4620, June 1986.

U.S. Army Corps of Engineers, "Hydraulic Design of Flood Control Channels," EM 1110-2-1601, July 1970.

Barfield, B.J., Warner, R.C., "Applied Hydrology and Sedimentology for Disturbed Areas," Oklahoma Technical Press," 1981.

Abt, S.R. et al., "Development of Riprap Design Criteria by Riprap testing in Flumes Phase I, " NUREG/CR-4651, Vol.I, 1987.

TABLES

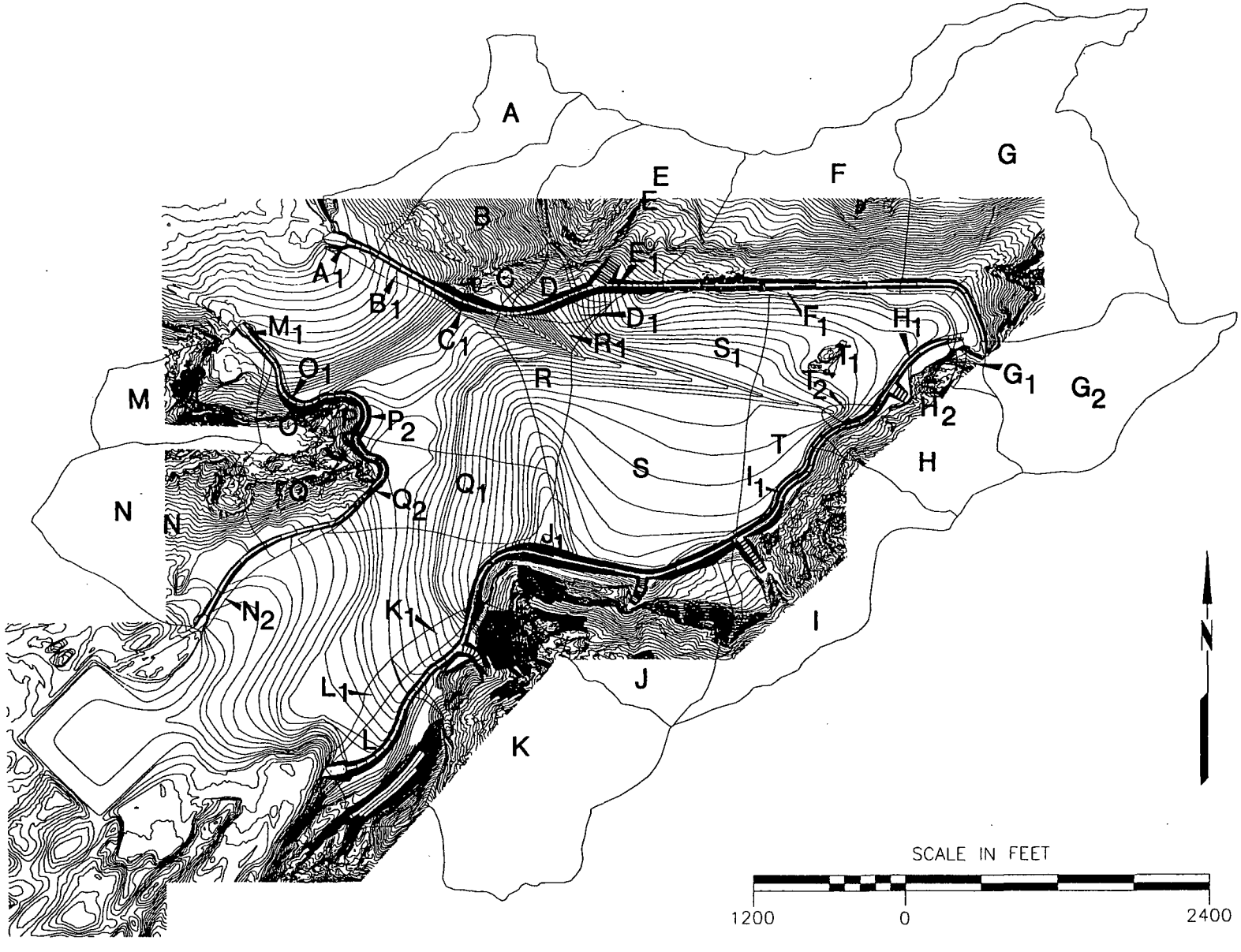
Revised: December 17, 1993

TABLE C.1.1
SUMMARY OF DIVERSION DITCH
PARAMETERS USED FOR RIPRAP SIZING

DITCH	STATION	INCLUDED REACHES	SLOPE (ft/ft)	BOTTOM WIDTH (ft)	SIDE SLOPE (ft:ft)	DESIGN RADIUS CURV.	PMF (cfs)	DEPTH OF FLOW (ft)	VELOCITY OF FLOW (ft/sec)	Necessary D50 (in)	Design D50 (in)
Transition	0+00 to 1+00	Transition	0.0598	15	3:1		1112	3.26	13.79	18	18
North	1+00 to 29+50	N1,N2,N3	0.005	15	3:1	500	1645	6.6	8.52	3	3
North	29+50 to 30+00	N3	0.0387	15	3:1		2468	5.32	15	15	18
North	30+00 to 46+50	N3,N4,N5	varies	15	3:1	525	varies	7.03	16.6	18	18
North	46+50 to 53+00	N6	0.02	15	3:1	1173	4616	7.71	15.74	15	18
North	53+00 to 56+00	N7	0.03	15	3:1	1173	4985	7.65	17.16	18	18
North	56+00 to 56+60	N7	0.03	15	3:1		4985	7.66	17.16	6	18(a)
North	56+60 to 57+60	N7 (apron)	0.005	15	3:1		4985	6.39	17.9	6	18(a)
Swale	2+00 to 21+50	SW1,SW2	varies	15	16:1		varies	3.56	6.26	2	3
Swale	21+50 to 28+95	SW3	0.0409	15	varies		1737	3.42	11.98	12	12
Transition	0+00 to 1+00	Transition	0.065	15	3:1		24	0.32	4.66	3	3
South	1+00 to 45+00	S1,S2,S3	varies	15	3:1	230	varies	7.79	6.87	3	3
South	45+00 to 48+00	S3	0.0239	15	3:1	354	3171	6.3	14.84	18	18
South	48+00 to 66+00	S4,S5	0.0231	15	3:1	500	varies	7.7	16.69	18	18
South	66+00 to 67+00	S5 (apron)	0.005	15	3:1		4896	5.99	19.31	6	18(a)
North Central	0+00 to 4+95	NC1	0.005	15	3:1	155	327	3.46	3.72	3	3
North Central	4+95 to 11+90	NC2	0.03	15	3:1	169	471	2.6	7.95	12	12
North Central	11+90 to 14+75	NC2,NC3	0.005	15	3:1		varies	4.65	7.14	2	3
North Central	14+75 to 15+15	NC3	0.005	15	3:1		960	3.86	9.36	3	3
North Central	15+15 to 15+75	NC3 (apron)	0.005	15	3:1		960	2.75	5.99	2	3
South Central	0+00 to 6+50	SC1	0.0069	15	3:1	105	799	3.49	8.98	4	6
South Central	6+50 to 8+00	SC1	0.04	15	3:1		799	2.87	11.79	12	12
South Central	8+00 to 15+50	SC1	0.0154	15	3:1		799	3.32	9.66	6	6
South Central	15+50 to 23+00	SC1,SC2	varies	15	3:1	895	1609	5.07	10.5	6	6
South Central	23+00 to 24+00	SC2 (apron)	0.0068	15	3:1		1609	4.3	10.2	6	6

(a) The riprap size for the last section of the north ditch (N7, 56+00 - 56+60) and for the aprons of the north and south diversion ditches has been increased to a D50 of 18 inches to be consistent with the rock size in the reach immediately upstream of each of these sections.

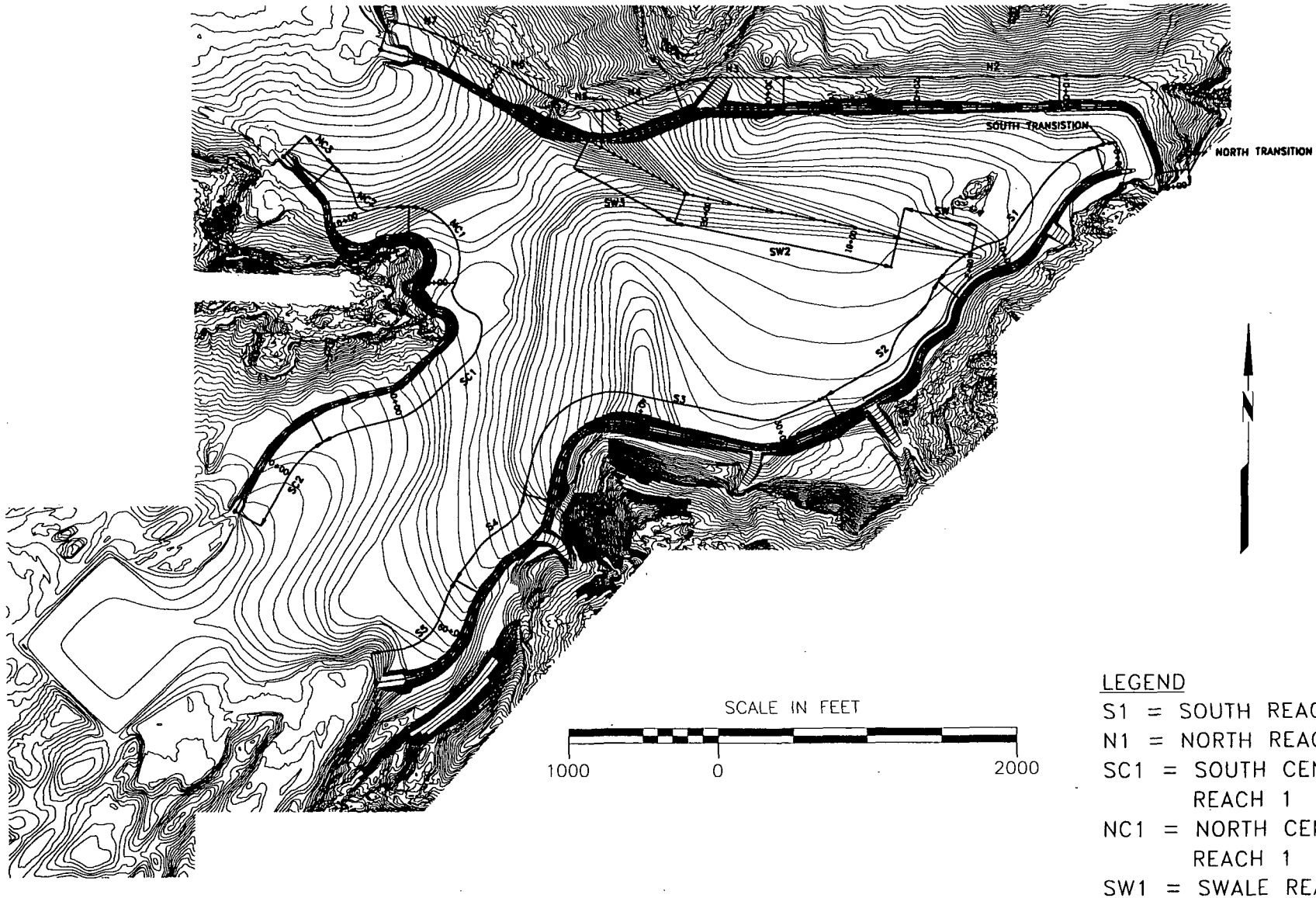
FIGURES



SMI
SHEPI[illegible]MILLER, INC.

FIGURE C.1.1
SUB-BASIN DELINIATION
JEFFERY C[illegible] WYOMING

Date:	SEPT., 1993
Project:	336[illegible]
File:	33[illegible]N



LEGEND

S1 = SOUTH REACH 1

N1 = NORTH REACH 1

SC1 = SOUTH CENTRAL REACH 1

NC1 = NORTH CENTRAL REACH 1

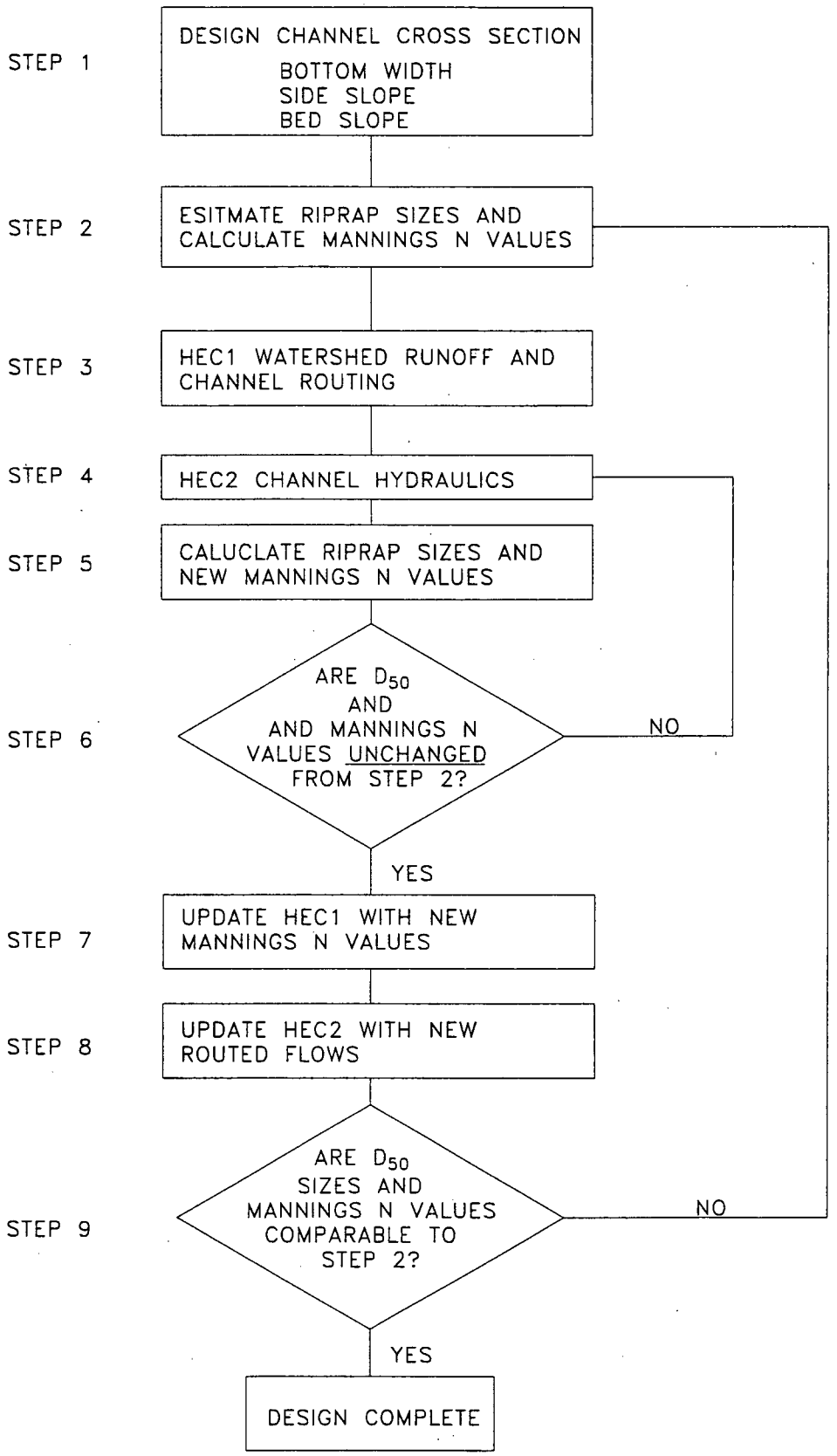
SW1 = SWALE REACH 1

SMI
SHEPHERD MILLER, INC.

FIGURE C.1.2
DIVERSION DITCH REACHES
JEFFERY CITY, WYOMING

Date:	OCT., 1993
Project:	336
File:	FIG-REA

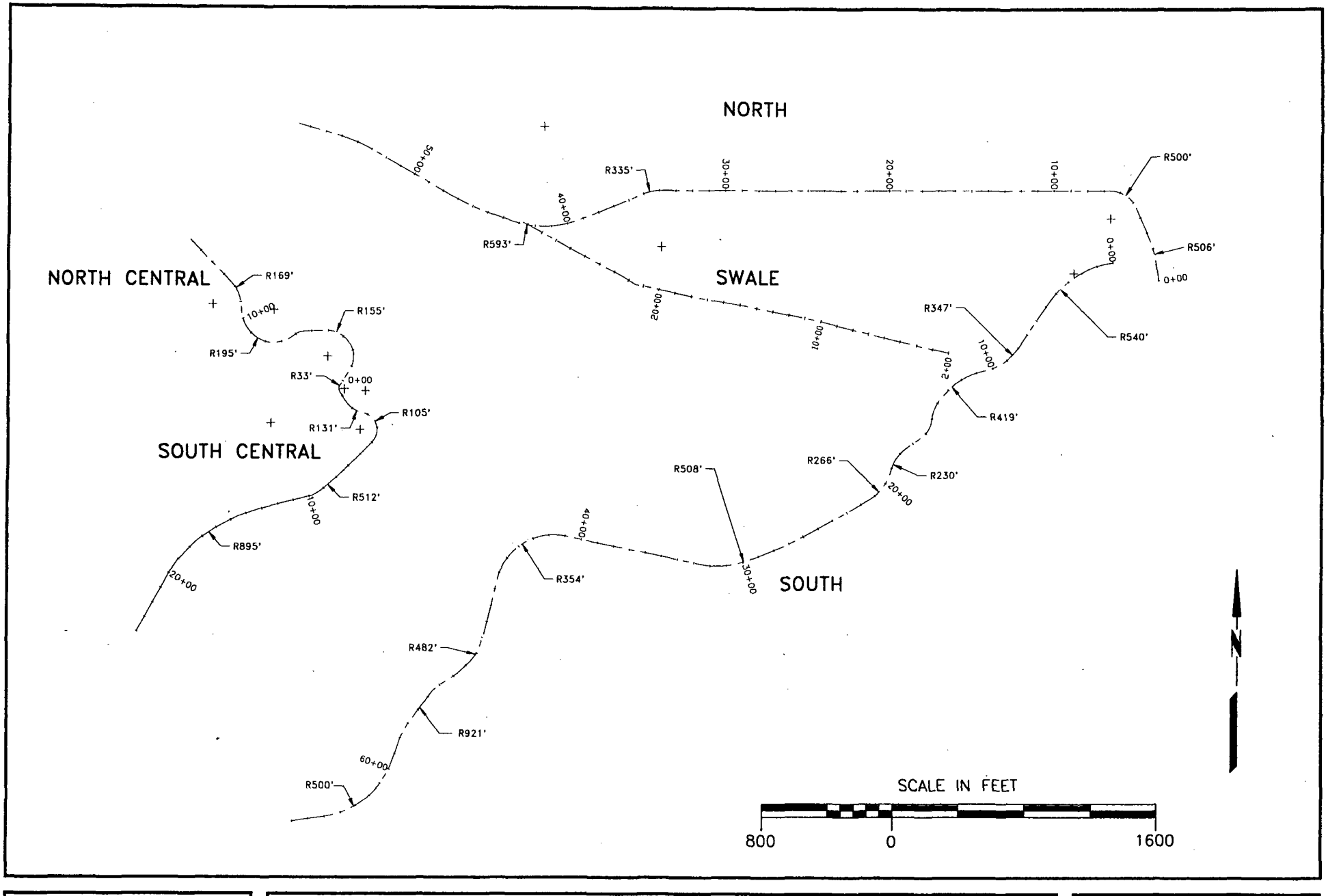
C.17



SMI
SHEPHERD MILLER, INC.

FIGURE C.1.3
DIVERSION DITCH RIPRAP DESIGN
ITERATION PROCESS

Date:	SEPT., 199[illegible]
Project:	336
File:	336FLOW



SMI
SHEPHERD MILLER, INC.

FIGURE C.1.4
DIVERSION DITCH RADII OF CURVATURE

Date:	SEPT., 1993
Project:	336
File:	CENTERLN

SPREADSHEETS

C18

RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 37 - 47.

File: R:\PROJECTS\336\COE70.WQ1
Date:10-14-93
Location: NORTH DIVERSION DITCH
STATION 0+00 - 1+00

INPUT COEFFICIENTS: (see manual for description)

INPUT: radius of curv. (ft)=	100000
INPUT: topwidth of flow (ft)=	34.53
R/W=	2896.0
INPUT: side slope (xH:1V)=	3
side slope angle (deg)=	18.4
INPUT: angle of repose (deg)=	42
INPUT: rock specific gravity=	2.65
INPUT: velocity (fps)=	13.790
INPUT: depth (ft)=	3.260

D-50 (ft)	BOUNDARY SHEAR (psf)	BEND SHEAR (psf)	BOTTOM SHEAR (psf)	SIDE SLOPE SHEAR (psf)	BOTTOM SF	SIDE SLOPE SF
1	4.364	4.364	4.118	3.629	0.94	0.8
1.25	4.945	4.945	5.148	4.537	1.04	0.9
1.33	5.127	5.127	5.477	4.827	1.07	0.9
→ 1.5	5.510	5.510	6.178	5.444	1.12	1.0
2	6.622	6.622	8.237	7.259	1.24	1.1

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RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 37 - 47.

File: R:\PROJECTS\336\COE70.WQ1
Date:10-14-93
Location: NORTH DIVERSION DITCH
STATION 1+00 - 29+50

INPUT COEFFICIENTS: (see manual for description)

INPUT: radius of curv. (ft)=	500
INPUT: topwidth of flow (ft)=	54.58
R/W=	9.2
INPUT: side slope (xH:1V)=	3
side slope angle (deg)=	18.4
INPUT: angle of repose (deg)=	42
INPUT: rock specific gravity=	2.65
INPUT: velocity (fps)=	8.520
INPUT: depth (ft)=	6.600

D-50 (ft)	BOUNDARY SHEAR (psf)	BEND SHEAR (psf)	BOTTOM SHEAR (psf)	SIDE SLOPE SHEAR (psf)	BOTTOM SF	SIDE SLOPE SF
0.16	0.584	0.608	0.659	0.581	1.08	0.96
→ 0.25	0.678	0.705	1.030	0.907	1.46	1.29
0.33	0.748	0.778	1.359	1.198	1.75	1.54
1	1.173	1.221	4.118	3.629	3.37	2.97
1.5	1.424	1.482	6.178	5.444	4.17	3.67

C 20

RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 37 - 47.

File: R:\PROJECTS\336\COE70.WQ1
Date:10-14-93
Location: NORTH DIVERSION DITCH
STATION 29+50 - 30+00

INPUT COEFFICIENTS: (see manual for description)

INPUT: radius of curv. (ft)=	10000
INPUT: topwidth of flow (ft)=	57.22
R/W=	174.8
INPUT: side slope (xH:1V)=	3
side slope angle (deg)=	18.4
INPUT: angle of repose (deg)=	42
INPUT: rock specific gravity=	2.65
INPUT: velocity (fps)=	15.000
INPUT: depth (ft)=	5.320

D-50 (ft)	BOUNDARY SHEAR (psf)	BEND SHEAR (psf)	BOTTOM SHEAR (psf)	SIDE SLOPE SHEAR (psf)	BOTTOM SF	SIDE SLOPE SF
1	4.022	4.022	4.118	3.629	1.02	0.90
1.25	4.490	4.490	5.148	4.537	1.15	1.01
1.33	4.634	4.634	5.477	4.827	1.18	1.04
1.5	4.935	4.935	6.178	5.444	1.25	1.10
2	5.784	5.784	8.237	7.259	1.42	1.25

C21

RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 37 - 47.

File: R:\PROJECTS\336\COE70.WQ1
Date:10-14-93
Location: NORTH DIVERSION DITCH
STATION 30+00 - 46+50

INPUT COEFFICIENTS: (see manual for description)

INPUT: radius of curv. (ft)=	525
INPUT: topwidth of flow (ft)=	57.22
R/W=	9.2
INPUT: side slope (xH:1V)=	3
side slope angle (deg)=	18.4
INPUT: angle of repose (deg)=	42
INPUT: rock specific gravity=	2.65
INPUT: velocity (fps)=	16.620
INPUT: depth (ft)=	7.030

D-50 (ft)	BOUNDARY SHEAR (psf)	BEND SHEAR (psf)	BOTTOM SHEAR (psf)	SIDE SLOPE SHEAR (psf)	BOTTOM SF	SIDE SLOPE SF
1	4.339	4.512	4.118	3.629	0.91	0.80
1.25	4.809	5.001	5.148	4.537	1.03	0.91
1.33	4.953	5.151	5.477	4.827	1.06	0.94
→ 1.5	5.252	5.462	6.178	5.444	1.13	1.00
2	6.087	6.330	8.237	7.259	1.30	1.15

C-2

RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 37 - 47.

File: R:\PROJECTS\336\COE70.WQ1
Date:10-14-93
Location: NORTH DIVERSION DITCH
STATION 46+50 - 53+00

INPUT COEFFICIENTS: (see manual for description)

INPUT: radius of curv. (ft)=	1173
INPUT: topwidth of flow (ft)=	61.19
R/W=	19.2
INPUT: side slope (xH:1V)=	3
side slope angle (deg)=	18.4
INPUT: angle of repose (deg)=	42
INPUT: rock specific gravity=	2.65
INPUT: velocity (fps)=	15.740
INPUT: depth (ft)=	7.710

D-50 (ft)	BOUNDARY SHEAR (psf)	BEND SHEAR (psf)	BOTTOM SHEAR (psf)	SIDE SLOPE SHEAR (psf)	BOTTOM SF	SIDE SLOPE SF
0.16	1.897	1.897	0.659	0.581	0.35	0.31
1	3.735	3.735	4.118	3.629	1.10	0.97
1.25	4.131	4.131	5.148	4.537	1.25	1.10
1.5	4.503	4.503	6.178	5.444	1.37	1.21
2	5.201	5.201	8.237	7.259	1.58	1.40

C23

RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 37 - 47.

File: R:\PROJECTS\336\COE70.WQ1
Date:10-14-93
Location: NORTH DIVERSION DITCH
STATION 53+00 - 56+00

INPUT COEFFICIENTS: (see manual for description)

INPUT: radius of curv. (ft)=	1173
INPUT: topwidth of flow (ft)=	60.89
R/W=	19.3
INPUT: side slope (xH:1V)=	3
side slope angle (deg)=	18.4
INPUT: angle of repose (deg)=	42
INPUT: rock specific gravity=	2.65
INPUT: velocity (fps)=	17.150
INPUT: depth (ft)=	7.650

D-50 (ft)	BOUNDARY SHEAR (psf)	BEND SHEAR (psf)	BOTTOM SHEAR (psf)	SIDE SLOPE SHEAR (psf)	BOTTOM SF	SIDE SLOPE SF
0.16	2.257	2.257	0.659	0.581	0.29	0.26
1	4.450	4.450	4.118	3.629	0.93	0.82
1.25	4.922	4.922	5.148	4.537	1.05	0.92
→ 1.5	5.366	5.366	6.178	5.444	1.15	1.01
2	6.200	6.200	8.237	7.259	1.33	1.17

C24

RIPRAP SIZING USING SAFETY FACTORS METHOD
REF: NUREG/CR-4651, pp. 18
FOR SLOPES LESS THAN 10%
Depth of flow is calculated in HEC-2
File: R:\PROJECTS\336\SF.WQ1
Date: 10-14-93
Location: NORTH DIVERSION DITCH
STATION 56+00 TO 56+65

INPUT	Flow Depth:	7.66
INPUT	Steepest Bank Slope (zH:1V):	3
INPUT	Bed Slope (rise/run):	0.005
INPUT	Riprap Angle of Repose:	42

	RISE/RUN	RADS	DEGREES
Bed Slope:	0.005	0.005	0.29
Steepest Bank Slope:	0.333333333333	0.322	18.43
Angle of Repose:		0.733	42.00

D-50 (ft)	DEPTH (ft)	T TRACTIVE FORCE	N STABILITY PARAMETER	B (RADS)	B DEGREES	N'	SAFETY FACTOR
0.25	7.66	1.82	1.48	1.12	64.40	1.41	0.61
0.33	7.66	1.82	1.12	1.01	57.76	1.04	0.77
0.5	7.66	1.82	0.74	0.81	46.38	0.64	1.08
0.75	7.66	1.82	0.49	0.61	35.02	0.39	1.40
1	7.66	1.82	0.37	0.48	27.75	0.27	1.63
1.25	7.66	1.82	0.30	0.40	22.83	0.21	1.79
1.5	7.66	1.82	0.25	0.34	19.34	0.16	1.91
1.75	7.66	1.82	0.21	0.29	16.75	0.14	2.00

C25

RIPRAP SIZING USING SAFETY FACTORS METHOD
REF: NUREG/CR-4651, pp. 18
FOR SLOPES LESS THAN 10%
Depth of flow is calculated in HEC-2
File: R:\PROJECTS\336\SF.WQ1
Date: 10-14-93
Location: NORTH DIVERSION DITCH
STATION 56+65 TO 57+60

INPUT	Flow Depth:	6.39
INPUT	Steepest Bank Slope (zH:1V):	3
INPUT	Bed Slope (rise/run):	0.005
INPUT	Riprap Angle of Repose:	42

	RISE/RUN	RADS	DEGREES
Bed Slope:	0.005	0.005	0.29
Steepest Bank Slope:	0.333333333333	0.322	18.43
Angle of Repose:		0.733	42.00

D-50 (ft)	DEPTH (ft)	T TRACTIVE FORCE	N STABILITY PARAMETER	B (RADS)	B DEGREES	N'	SAFETY FAC[illegible]
0.25	6.39	1.52	1.24	1.05	60.18	1.16	[illegible]
0.33	6.39	1.52	0.94	0.92	52.95	0.84	0.90
→ 0.5	6.39	1.52	0.62	0.72	41.22	0.51	1.22
0.75	6.39	1.52	0.41	0.53	30.32	0.31	1.54
1	6.39	1.52	0.31	0.41	23.70	0.22	1.76
1.25	6.39	1.52	0.25	0.34	19.36	0.17	1.91
1.5	6.39	1.52	0.21	0.28	16.32	0.13	2.02
1.75	6.39	1.52	0.18	0.25	14.10	0.11	2.10

C26

RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 37 - 47.

File: R:\PROJECTS\336\COE70.WQ1
Date:10-14-93
Location: TAILING SWALE
STATION 2+00 - 21+50

INPUT COEFFICIENTS: (see manual for description)

INPUT: radius of curv. (ft)=	100000
INPUT: topwidth of flow (ft)=	128.85
R/W=	776.1
INPUT: side slope (xH:1V)=	3
side slope angle (deg)=	18.4
INPUT: angle of repose (deg)=	42
INPUT: rock specific gravity=	2.65
INPUT: velocity (fps)=	6.260
INPUT: depth (ft)=	3.560

D-50 (ft)	BOUNDARY SHEAR (psf)	BEND SHEAR (psf)	BOTTOM SHEAR (psf)	SIDE SLOPE SHEAR (psf)	BOTTOM SF	SIDE SLOPE SF
0.16	0.388	0.388	0.659	0.581	1.70	1.49
0.25	0.459	0.459	1.030	0.907	2.24	1.98
0.33	0.512	0.512	1.359	1.198	2.65	2.34
1	0.858	0.858	4.118	3.629	4.80	4.23
1.5	1.077	1.077	6.178	5.444	5.74	5.06

C27

RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 37 - 47.

File: R:\PROJECTS\336\COE70.WQ1
Date:10-14-93
Location: TAILING SWALE
STATION 21+50 - 28+95

INPUT COEFFICIENTS: (see manual for description)

INPUT: radius of curv. (ft)=	100000
INPUT: topwidth of flow (ft)=	69.72
R/W=	1434.3
INPUT: side slope (xH:1V)=	3
side slope angle (deg)=	18.4
INPUT: angle of repose (deg)=	42
INPUT: rock specific gravity=	2.65
INPUT: velocity (fps)=	11.980
INPUT: depth (ft)=	3.420

D-50 (ft)	BOUNDARY SHEAR (psf)	BEND SHEAR (psf)	BOTTOM SHEAR (psf)	SIDE SLOPE SHEAR (psf)	BOTTOM SF	SIDE SLOPE SF
0.16	1.443	1.443	0.659	0.581	0.46	0.40
0.25	1.706	1.706	1.030	0.907	0.60	0.53
0.75	2.766	2.766	3.089	2.722	1.12	0.98
1	3.209	3.209	4.118	3.629	1.28	1.13
1.5	4.040	4.040	6.178	5.444	1.53	1.35

C28

RIPRAP SIZING USING SAFETY FACTORS METHOD
REF: NUREG/CR-4651, pp. 18
FOR SLOPES LESS THAN 10%
Depth of flow is calculated in HEC-2
File: R:\PROJECTS\336\SF.WQ1
Date: 10-14-93
Location: SOUTH DIVERSION DITCH
STATION 0+00 TO 1+00

INPUT	Flow Depth:	0.32
INPUT	Steepest Bank Slope (zH:1V):	3
INPUT	Bed Slope (rise/run):	0.065
INPUT	Riprap Angle of Repose:	42

	RISE/RUN	RADS	DEGREES
Bed Slope:	0.065	0.065	3.72
Steepest Bank Slope:	0.333333333333	0.322	18.43
Angle of Repose:		0.733	42.00

D-50 (ft)	DEPTH (ft)	T TRACTIVE FORCE	N STABILITY PARAMETER	B (RADS)	B DEGREES	N'	SAFETY FACTOR
0.25	0.32	0.99	0.80	0.82	46.78	0.71	1.00
0.33	0.32	0.99	0.61	0.69	39.35	0.51	1.21
0.5	0.32	0.99	0.40	0.50	28.86	0.31	1.54
0.75	0.32	0.99	0.27	0.36	20.40	0.19	1.83
1	0.32	0.99	0.20	0.27	15.67	0.13	2.01
1.25	0.32	0.99	0.16	0.22	12.70	0.10	2.13
1.5	0.32	0.99	0.13	0.19	10.66	0.08	2.21
1.75	0.32	0.99	0.11	0.16	9.18	0.07	2.27

C29

RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 37 - 47.

File: R:\PROJECTS\336\COE70.WQ1
Date:10-14-93
Location: SOUTH DIVERSION DITCH
STATION 1+00 - 45+00

INPUT COEFFICIENTS: (see manual for description)

INPUT: radius of curv. (ft)=	230
INPUT: topwidth of flow (ft)=	61.71
R/W=	3.7
INPUT: side slope (xH:1V)=	3
side slope angle (deg)=	18.4
INPUT: angle of repose (deg)=	42
INPUT: rock specific gravity=	2.65
INPUT: velocity (fps)=	6.870
INPUT: depth (ft)=	7.790

D-50 (ft)	BOUNDARY SHEAR (psf)	BEND SHEAR (psf)	BOTTOM SHEAR (psf)	SIDE SLOPE SHEAR (psf)	BOTTOM SF	SIDE SLOPE SF
0.16	0.360	0.588	0.659	0.581	1.12	0.99
→ 0.25	0.416	0.679	1.030	0.907	1.52	1.34
0.5	0.534	0.871	2.059	1.815	2.37	2.08
1.5	0.854	1.393	6.178	5.444	4.44	3.91
2	0.986	1.608	8.237	7.259	5.12	4.51

C 30

RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 37 - 47.

File: R:\PROJECTS\336\COE70.WQ1
Date:10-14-93
Location: SOUTH DIVERSION DITCH
STATION 45+00 - 48+00

INPUT COEFFICIENTS: (see manual for description)

INPUT: radius of curv. (ft)=	354
INPUT: topwidth of flow (ft)=	52.82
R/W=	6.7
INPUT: side slope (xH:1V)=	3
side slope angle (deg)=	18.4
INPUT: angle of repose (deg)=	42
INPUT: rock specific gravity=	2.65
INPUT: velocity (fps)=	14.840
INPUT: depth (ft)=	6.300

D-50 (ft)	BOUNDARY SHEAR (psf)	BEND SHEAR (psf)	BOTTOM SHEAR (psf)	SIDE SLOPE SHEAR (psf)	BOTTOM SF	SIDE SLOPE SF
0.16	1.798	2.188	0.659	0.581	0.30	0.27
0.25	2.089	2.542	1.030	0.907	0.41	0.36
1	3.636	4.425	4.118	3.629	0.93	0.82
→ 1.5	4.424	5.383	6.178	5.444	1.15	1.01
2	5.149	6.265	8.237	7.259	1.31	1.16

C31

RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 37 - 47.

File: R:\PROJECTS\336\COE70.WQ1
Date:10-14-93
Location: SOUTH DIVERSION DITCH
STATION 48+00 - 66+00

INPUT COEFFICIENTS: (see manual for description)

INPUT: radius of curv. (ft)=	500
INPUT: topwidth of flow (ft)=	61.19
R/W=	8.2
INPUT: side slope (xH:1V)=	3
side slope angle (deg)=	18.4
INPUT: angle of repose (deg)=	42
INPUT: rock specific gravity=	2.65
INPUT: velocity (fps)=	16.690
INPUT: depth (ft)=	7.700

D-50 (ft)	BOUNDARY SHEAR (psf)	BEND SHEAR (psf)	BOTTOM SHEAR (psf)	SIDE SLOPE SHEAR (psf)	BOTTOM SF	SIDE SLOPE SF
0.16	2.134	2.351	0.659	0.581	0.28	0.2
1	4.202	4.631	4.118	3.629	0.89	0.8
1.25	4.648	5.121	5.148	4.537	1.01	0.9
1.33	4.784	5.272	5.477	4.827	1.04	0.9
→ 1.5	5.066	5.583	6.178	5.444	1.11	1.0

C32

RIPRAP SIZING USING SAFETY FACTORS METHOD
REF: NUREG/CR-4651, pp. 18
FOR SLOPES LESS THAN 10%
Depth of flow is calculated in HEC-2
File: R:\PROJECTS\336\SF.WQ1
Date: 10-14-93
Location: SOUTH DIVERSION DITCH
STATION 66+00 TO 67+00

INPUT	Flow Depth:	5.99
INPUT	Steepest Bank Slope (zH:1V):	3
INPUT	Bed Slope (rise/run):	0.005
INPUT	Riprap Angle of Repose:	42

	RISE/RUN	RADS	DEGREES
Bed Slope:	0.005	0.005	0.29
Steepest Bank Slope:	0.333333333333	0.322	18.43
Angle of Repose:		0.733	42.00

D-50 (ft)	DEPTH (ft)	T TRACTIVE FORCE	N STABILITY PARAMETER	B (RADS)	B DEGREES	N'	SAFETY FACTOR
0.25	5.99	1.42	1.16	1.02	58.57	1.08	0.75
0.33	5.99	1.42	0.88	0.89	51.16	0.78	0.95
0.5	5.99	1.42	0.58	0.69	39.40	0.47	1.27
0.75	5.99	1.42	0.39	0.50	28.74	0.29	1.60
1	5.99	1.42	0.29	0.39	22.37	0.20	1.81
1.25	5.99	1.42	0.23	0.32	18.23	0.15	1.95
1.5	5.99	1.42	0.19	0.27	15.35	0.12	2.06
1.75	5.99	1.42	0.17	0.23	13.25	0.10	2.14

C33

RIPRAP SIZING USING SAFETY FACTORS METHOD
REF: NUREG/CR-4651, pp. 18
FOR SLOPES LESS THAN 10%
Depth of flow is calculated in HEC-2
File: R:\PROJECTS\336\SF.WQ1
Date: 10-14-93
Location: NORTH CENTRAL DIVERSION DITCH
STATION 0+00 TO 4+95

INPUT	Flow Depth:	3.46
INPUT	Steepest Bank Slope (zH:1V):	3
INPUT	Bed Slope (rise/run):	0.005
INPUT	Riprap Angle of Repose:	42

	RISE/RUN	RADS	DEGREES
Bed Slope:	0.005	0.005	0.29
Steepest Bank Slope:	0.333333333333	0.322	18.43
Angle of Repose:		0.733	42.00

D-50 (ft)	DEPTH (ft)	T TRACTIVE FORCE	N STABILITY PARAMETER	B (RADS)	B DEGREES	N'	SAFETY FAC
0.25	3.46	0.82	0.67	0.76	43.48	0.57	1.16
0.33	3.46	0.82	0.51	0.62	35.73	0.40	1.38
0.5	3.46	0.82	0.33	0.44	25.42	0.24	1.70
0.75	3.46	0.82	0.22	0.31	17.60	0.15	1.97
1	3.46	0.82	0.17	0.23	13.38	0.10	2.13
1.25	3.46	0.82	0.13	0.19	10.78	0.08	2.23
1.5	3.46	0.82	0.11	0.16	9.02	0.06	2.30
1.75	3.46	0.82	0.10	0.14	7.75	0.05	2.36

C 34

RIPRAP SIZING USING SAFETY FACTORS METHOD
REF: NUREG/CR-4651, pp. 18
FOR SLOPES LESS THAN 10%
Depth of flow is calculated in HEC-2
File: R:\PROJECTS\336\SF.WQ1
Date: 10-14-93
Location: NORTH CENTRAL DIVERSION DITCH
STATION 4+95 TO 11+90

INPUT	Flow Depth:	2.6
INPUT	Steepest Bank Slope (zH:1V):	3
INPUT	Bed Slope (rise/run):	0.03
INPUT	Riprap Angle of Repose:	42

	RISE/RUN	RADS	DEGREES
Bed Slope:	0.03	0.030	1.72
Steepest Bank Slope:	0.333333333333	0.322	18.43
Angle of Repose:		0.733	42.00

D-50 (ft)	DEPTH (ft)	T TRACTIVE FORCE	N STABILITY PARAMETER	B (RADS)	B DEGREES	N'	SAFETY FACTOR
0.25	2.60	3.70	3.02	1.31	75.27	2.98	0.31
0.33	2.60	3.70	2.29	1.25	71.36	2.24	0.40
0.5	2.60	3.70	1.51	1.11	63.63	1.44	0.59
0.75	2.60	3.70	1.01	0.94	53.92	0.92	0.84
→ 1	2.60	3.70	0.75	0.81	46.13	0.66	1.05
1.25	2.60	3.70	0.60	0.70	39.94	0.50	1.23
1.5	2.60	3.70	0.50	0.61	35.02	0.40	1.38
1.75	2.60	3.70	0.43	0.54	31.07	0.33	1.50

C 35

RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 37 - 47.

File: R:\PROJECTS\336\COE70.WQ1
Date:10-14-93
Location: NORTH CENTRAL DIVERSION DITCH
STATION 11+90 - 14+75

INPUT COEFFICIENTS: (see manual for description)

INPUT: radius of curv. (ft)=	100000
INPUT: topwidth of flow (ft)=	42.89
R/W=	2331.5
INPUT: side slope (xH:1V)=	3
side slope angle (deg)=	18.4
INPUT: angle of repose (deg)=	42
INPUT: rock specific gravity=	2.65
INPUT: velocity (fps)=	7.140
INPUT: depth (ft)=	4.650

D-50 (ft)	BOUNDARY SHEAR (psf)	BEND SHEAR (psf)	BOTTOM SHEAR (psf)	SIDE SLOPE SHEAR (psf)	BOTTOM SF	SIDE SLOPE SF
0.16	0.460	0.460	0.659	0.581	1.43	1.26
0.25	0.539	0.539	1.030	0.907	1.91	1.68
0.33	0.599	0.599	1.359	1.198	2.27	2.00
1.33	1.127	1.127	5.477	4.827	4.86	4.28
1.5	1.203	1.203	6.178	5.444	5.14	4.53

C36

RIPRAP SIZING USING SAFETY FACTORS METHOD
REF: NUREG/CR-4651, pp. 18
FOR SLOPES LESS THAN 10%
Depth of flow is calculated in HEC-2
File: R:\PROJECTS\336\SF.WQ1
Date: 10-14-93
Location: NORTH CENTRAL DIVERSION DITCH
STATION 14+75 TO 15+15

INPUT	Flow Depth:	3.86
INPUT	Steepest Bank Slope (zH:1V):	3
INPUT	Bed Slope (rise/run):	0.005
INPUT	Riprap Angle of Repose:	42

	RISE/RUN	RADS	DEGREES
Bed Slope:	0.005	0.005	0.29
Steepest Bank Slope:	0.333333333333	0.322	18.43
Angle of Repose:		0.733	42.00

D-50 (ft)	DEPTH (ft)	T TRACTIVE FORCE	N STABILITY PARAMETER	B (RADS)	B DEGREES	N'	SAFETY FACTOR
0.25	3.86	0.92	0.75	0.81	46.60	0.65	1.07
0.33	3.86	0.92	0.57	0.68	38.73	0.46	1.29
0.5	3.86	0.92	0.37	0.49	27.93	0.27	1.62
0.75	3.86	0.92	0.25	0.34	19.48	0.17	1.91
1	3.86	0.92	0.19	0.26	14.86	0.12	2.08
1.25	3.86	0.92	0.15	0.21	11.99	0.09	2.19
1.5	3.86	0.92	0.12	0.18	10.04	0.07	2.26
1.75	3.86	0.92	0.11	0.15	8.63	0.06	2.32

C37

RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 37 - 47.

File: R:\PROJECTS\336\COE70.WQ1
Date:10-14-93
Location: NORTH CENTRAL DIVERSION DITCH
STATION 15+15 - 15+75

INPUT COEFFICIENTS: (see manual for description)

INPUT: radius of curv. (ft)=	100000
INPUT: topwidth of flow (ft)=	66.50
R/W=	1503.8
INPUT: side slope (xH:1V)=	3
side slope angle (deg)=	18.4
INPUT: angle of repose (deg)=	42
INPUT: rock specific gravity=	2.65
INPUT: velocity (fps)=	5.990
INPUT: depth (ft)=	2.750

D-50 (ft)	BOUNDARY SHEAR (psf)	BEND SHEAR (psf)	BOTTOM SHEAR (psf)	SIDE SLOPE SHEAR (psf)	BOTTOM SF	SIDE SLOPE SF
0.16	0.391	0.391	0.659	0.581	1.69	1.49
0.25	0.465	0.465	1.030	0.907	2.21	1.95
0.33	0.523	0.523	1.359	1.198	2.60	2.29
1.33	1.072	1.072	5.477	4.827	5.11	4.50
1.5	1.157	1.157	6.178	5.444	5.34	4.71

C 38

RIPRAP SIZING USING SAFETY FACTORS METHOD
REF: NUREG/CR-4651, pp. 18
FOR SLOPES LESS THAN 10%
Depth of flow is calculated in HEC-2
File: R:\PROJECTS\336\SF.WQ1
Date: 10-14-93
Location: SOUTH CENTRAL DIVERSION DITCH
STATION 0+00 TO 6+50

INPUT	Flow Depth:	3.49
INPUT	Steepest Bank Slope (zH:1V):	3
INPUT	Bed Slope (rise/run):	0.0068
INPUT	Riprap Angle of Repose:	42

	RISE/RUN	RADS	DEGREES
Bed Slope:	0.0068	0.007	0.39
Steepest Bank Slope:	0.333333333333	0.322	18.43
Angle of Repose:		0.733	42.00

D-50 (ft)	DEPTH (ft)	T TRACTIVE FORCE	N STABILITY PARAMETER	B (RADS)	B DEGREES	N'	SAFETY FACTOR
0.25	3.49	1.13	0.92	0.91	52.34	0.82	0.91
0.33	3.49	1.13	0.70	0.78	44.53	0.59	1.12
0.5	3.49	1.13	0.46	0.58	33.05	0.36	1.46
0.75	3.49	1.13	0.31	0.41	23.48	0.21	1.77
1	3.49	1.13	0.23	0.32	18.06	0.15	1.96
1.25	3.49	1.13	0.18	0.26	14.63	0.12	2.08
1.5	3.49	1.13	0.15	0.21	12.27	0.09	2.17
1.75	3.49	1.13	0.13	0.18	10.56	0.08	2.24

C39

RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 37 - 47.

File: R:\PROJECTS\336\COE70.WQ1
Date:10-14-93
Location: SOUTH CENTRAL DIVERSION DITCH
STATION 6+50 - 8+00

INPUT COEFFICIENTS: (see manual for description)

INPUT: radius of curv. (ft)=	10000
INPUT: topwidth of flow (ft)=	32.22
R/W=	310.4
INPUT: side slope (xH:1V)=	3
side slope angle (deg)=	18.4
INPUT: angle of repose (deg)=	42
INPUT: rock specific gravity=	2.65
INPUT: velocity (fps)=	11.790
INPUT: depth (ft)=	2.870

D-50 (ft)	BOUNDARY SHEAR (psf)	BEND SHEAR (psf)	BOTTOM SHEAR (psf)	SIDE SLOPE SHEAR (psf)	BOTTOM SF	SIDE SLOPE SF
0.25	1.772	1.772	1.030	0.907	0.58	0.51
0.33	1.989	1.989	1.359	1.198	0.68	0.60
0.5	2.397	2.397	2.059	1.815	0.86	0.76
1	3.423	3.423	4.118	3.629	1.20	1.06
1.5	4.360	4.360	6.178	5.444	1.42	1.25

C40

RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 37 - 47.

File: R:\PROJECTS\336\COE70.WQ1
Date:10-14-93
Location: SOUTH CENTRAL DIVERSION DITCH
STATION 8+00 - 15+50

INPUT COEFFICIENTS: (see manual for description)

INPUT: radius of curv. (ft)=	512
INPUT: topwidth of flow (ft)=	34.89
R/W=	14.7
INPUT: side slope (xH:1V)=	3
side slope angle (deg)=	18.4
INPUT: angle of repose (deg)=	42
INPUT: rock specific gravity=	2.65
INPUT: velocity (fps)=	9.660
INPUT: depth (ft)=	3.320

D-50 (ft)	BOUNDARY SHEAR (psf)	BEND SHEAR (psf)	BOTTOM SHEAR (psf)	SIDE SLOPE SHEAR (psf)	BOTTOM SF	SIDE SLOPE SF
0.25	1.122	1.122	1.030	0.907	0.92	0.81
0.33	1.256	1.256	1.359	1.198	1.08	0.95
0.5	1.504	1.504	2.059	1.815	1.37	1.21
1	2.120	2.120	4.118	3.629	1.94	1.71
1.5	2.674	2.674	6.178	5.444	2.31	2.04

C 41

RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 37 - 47.

File: R:\PROJECTS\336\COE70.WQ1
Date:10-14-93
Location: SOUTH CENTRAL DIVERSION DITCH
STATION 15+50 - 23+00

INPUT COEFFICIENTS: (see manual for description)

INPUT: radius of curv. (ft)=	895
INPUT: topwidth of flow (ft)=	47.03
R/W=	19.0
INPUT: side slope (xH:1V)=	3
side slope angle (deg)=	18.4
INPUT: angle of repose (deg)=	42
INPUT: rock specific gravity=	2.65
INPUT: velocity (fps)=	10.500
INPUT: depth (ft)=	5.070

D-50 (ft)	BOUNDARY SHEAR (psf)	BEND SHEAR (psf)	BOTTOM SHEAR (psf)	SIDE SLOPE SHEAR (psf)	BOTTOM SF	SIDE SLOPE SF
0.25	1.130	1.130	1.030	0.907	0.91	0.80
0.33	1.253	1.253	1.359	1.198	1.08	0.96
0.5	1.479	1.479	2.059	1.815	1.39	1.23
1	2.017	2.017	4.118	3.629	2.04	1.80
1.5	2.481	2.481	6.178	5.444	2.49	2.19

C46

RIPRAP SIZING USING SAFETY FACTORS METHOD
REF: NUREG/CR-4651, pp. 18
FOR SLOPES LESS THAN 10%
Depth of flow is calculated in HEC-2
File: R:\PROJECTS\336\SF.WQ1
Date: 10-14-93
Location: SOUTH CENTRAL DIVERSION DITCH
STATION 23+00 TO 24+00

INPUT	Flow Depth:	4.3
INPUT	Steepest Bank Slope (zH:1V):	3
INPUT	Bed Slope (rise/run):	0.0068
INPUT	Riprap Angle of Repose:	42

	RISE/RUN	RADS	DEGREES
Bed Slope:	0.0068	0.007	0.39
Steepest Bank Slope:	0.333333333333	0.322	18.43
Angle of Repose:		0.733	42.00

D-50 (ft)	DEPTH (ft)	T TRACTIVE FORCE	N STABILITY PARAMETER	B (RADS)	B DEGREES	N'	SAFETY FACTOR
0.25	4.30	1.39	1.13	1.01	57.88	1.05	0.77
0.33	4.30	1.39	0.86	0.88	50.43	0.76	0.96
0.5	4.30	1.39	0.57	0.68	38.69	0.46	1.29
0.75	4.30	1.39	0.38	0.49	28.14	0.28	1.61
1	4.30	1.39	0.28	0.38	21.88	0.20	1.82
1.25	4.30	1.39	0.23	0.31	17.82	0.15	1.96
1.5	4.30	1.39	0.19	0.26	15.00	0.12	2.07
1.75	4.30	1.39	0.16	0.23	12.94	0.10	2.15

HEC2 OUTPUT

C44

NORTH DITCH
HEC-2
SUMMARY OUTPUT

SUPER-CRITICAL

THIS RUN EXECUTED 13OCT93 14:57:47

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

JEFFREY CITY ------- CHA

SUMMARY PRINTOUT

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
	.000	418.00	46.10	3.29	13.59	590.57	1112.00	34.74
	12.500	417.25	46.10	3.28	13.63	595.90	1112.00	34.69
	25.000	416.50	46.10	3.28	13.65	597.56	1112.00	34.68
	35.000	415.90	46.10	3.27	13.66	599.13	1112.00	34.67
	50.000	415.00	46.10	3.27	13.66	598.77	1112.00	34.67
	51.000	414.90	46.10	3.26	13.77	613.00	1112.00	34.55
	52.500	414.80	46.10	3.26	13.79	615.01	1112.00	34.53
	55.000	414.70	46.10	3.32	13.44	572.14	1112.00	34.90
	60.000	414.40	46.10	3.31	13.48	577.51	1112.00	34.85
	65.000	414.10	46.10	3.30	13.52	581.71	1112.00	34.82
	75.000	413.50	46.10	3.29	13.57	587.63	1112.00	34.77
	80.000	413.20	46.10	3.29	13.59	590.32	1112.00	34.74
	90.000	412.60	46.10	3.28	13.63	595.53	1112.00	34.70
	95.000	412.30	46.10	3.28	13.62	593.97	1112.00	34.71
*	100.000	412.00	31.30	5.13	10.56	101.31	1645.00	45.77
*	125.000	411.88	31.30	5.14	10.54	100.69	1645.00	45.81
*	150.000	411.75	31.30	5.13	10.54	100.86	1645.00	45.80

D_{50} = 13" COE 7-9

TRANSITION

REACH 1

VALUES USED IN SPREADSHEETS ARE BOXED

C45

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
*	200.000	411.50	31.30	5.13	10.54	100.79	1645.00	45.80
*	300.000	411.00	31.30	5.13	10.54	100.82	1645.00	45.80
*	400.000	410.50	31.30	5.13	10.54	100.80	1645.00	45.80
*	500.000	410.00	31.30	5.13	10.54	100.81	1645.00	45.80
*	600.000	409.50	31.30	5.13	10.54	100.79	1645.00	45.80
*	700.000	409.00	31.30	5.13	10.54	100.80	1645.00	45.80
*	800.000	408.50	31.30	5.13	10.54	100.80	1645.00	45.80
*	900.000	408.00	31.30	5.13	10.54	100.80	1645.00	45.80
*	1000.000	407.50	31.30	5.13	10.54	100.80	1645.00	45.80
*	1050.000	407.25	31.30	5.61	10.94	98.57	1954.00	48.66
*	1100.000	407.00	31.30	5.61	10.94	98.48	1954.00	48.67
*	1200.000	406.50	31.30	5.61	10.94	98.48	1954.00	48.67
*	1300.000	406.00	31.30	5.61	10.94	98.50	1954.00	48.67
*	1400.000	405.50	31.30	5.61	10.94	98.50	1954.00	48.67
*	1500.000	405.00	31.30	5.61	10.94	98.50	1954.00	48.67
*	1600.000	404.50	31.30	5.61	10.94	98.50	1954.00	48.67
*	1700.000	404.00	31.30	5.61	10.94	98.50	1954.00	48.67
*	1800.000	403.50	31.30	5.61	10.94	98.50	1954.00	48.67
*	1900.000	403.00	31.30	5.61	10.94	98.50	1954.00	48.67
*	2000.000	402.50	31.30	5.61	10.94	98.50	1954.00	48.67
*	2100.000	402.00	31.30	5.61	10.94	98.50	1954.00	48.67
*	2200.000	401.50	31.30	5.61	10.94	98.50	1954.00	48.67
*	2300.000	401.00	31.30	5.61	10.94	98.50	1954.00	48.67
*	2400.000	400.50	31.30	5.61	10.94	98.50	1954.00	48.67
*	2500.000	400.00	31.30	5.61	10.94	98.50	1954.00	48.67
*	2600.000	399.50	31.30	5.61	10.94	98.50	1954.00	48.67

SEE SUB-CRITICAL FLOW OUTPUT

REACH 1

SEE - SUB-CRITICAL FLOW OUTPUT

REACH 2

C46

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
*	2700.000	399.00	31.30	5.61	10.94	98.50	1954.00	48.67
*	2800.000	398.50	31.30	5.61	10.94	98.50	1954.00	48.67
*	2900.000	398.00	31.30	6.33	11.48	94.88	2468.00	52.97
*	2950.000	397.80	41.00	6.32	11.51	164.06	2468.00	52.90
	2962.500	397.30	41.00	5.65	13.63	259.59	2468.00	48.97
	2975.000	396.80	41.00	5.48	14.31	296.32	2468.00	47.91
	2987.500	396.30	41.00	5.37	14.75	322.33	2468.00	47.25
	3000.000	395.80	43.10	5.32	15.00	372.63	2468.00	46.90
	3050.000	393.90	43.10	5.31	15.06	376.61	2468.00	46.81
	3100.000	392.00	43.10	5.30	15.10	379.26	2468.00	46.76
	3200.000	388.10	43.10	5.25	15.28	391.97	2468.00	46.51
	3300.000	384.20	43.10	5.26	15.24	388.69	2468.00	46.57
	3400.000	380.40	43.10	5.31	15.04	375.42	2468.00	46.84
	3500.000	376.50	43.10	5.25	15.28	391.55	2468.00	46.52
	3600.000	372.60	43.10	5.26	15.24	388.83	2468.00	46.57
	3670.000	369.90	43.10	5.44	14.95	361.47	2539.00	47.58
	3700.000	368.70	43.10	5.35	15.28	383.86	2539.00	47.11
	3725.000	367.70	43.10	5.32	15.39	391.13	2539.00	46.96
	3750.000	366.80	43.10	5.42	14.96	362.23	2539.00	47.56
	3775.000	365.87	43.10	5.40	15.03	367.20	2539.00	47.45
	3800.000	364.90	43.10	5.37	15.17	376.64	2539.00	47.25
	3900.000	361.00	43.10	5.33	15.38	390.72	2539.00	46.97
	3950.000	359.00	43.10	5.31	15.48	397.44	2539.00	46.84
	4000.000	357.10	43.10	5.37	15.19	377.47	2539.00	47.24
	4100.000	353.30	43.10	5.37	15.22	379.46	2539.00	47.20
	4200.000	349.40	43.10	5.33	15.39	391.08	2539.00	46.96

REACH 2

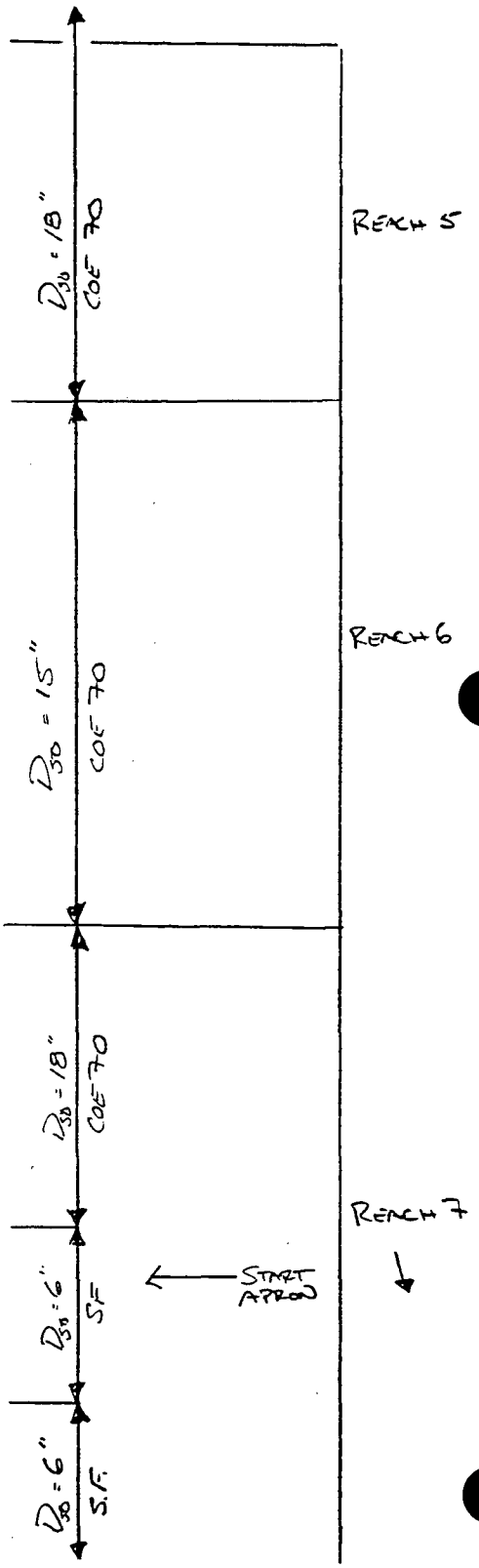
D_{50} = 15" COE 70

REACH 3

D_{50} = 18" COE 70

REACH 4

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
*	4250.000	347.40	41.40	8.23	12.91	156.57	4217.00	64.38
	4275.000	346.60	41.40	7.40	15.28	246.82	4217.00	59.47
	4300.000	345.80	41.40	7.23	15.89	274.26	4217.00	58.40
	4400.000	342.80	41.40	7.09	16.39	298.49	4217.00	57.55
	4500.000	339.80	41.40	7.09	16.42	299.73	4217.00	57.51
	4600.000	336.70	41.40	7.03	16.62	309.55	4217.00	57.19
*	4650.000	335.40	41.40	8.60	13.16	154.75	4618.00	66.61
*	4662.500	335.10	37.70	8.62	13.12	127.31	4618.00	66.70
	4675.000	334.80	37.70	8.17	14.32	161.35	4618.00	63.98
	4700.000	334.20	37.70	7.84	15.31	192.98	4618.00	62.01
	4800.000	332.20	37.70	7.79	15.48	198.86	4618.00	61.69
	4900.000	330.20	37.70	7.77	15.52	200.28	4618.00	61.61
	5000.000	328.20	37.70	7.77	15.51	200.05	4618.00	61.62
	5100.000	326.10	37.70	7.71	15.74	207.93	4618.00	61.21
	5200.000	324.10	37.70	7.81	15.39	195.70	4618.00	61.86
*	5300.000	322.10	37.70	8.96	13.28	124.80	4985.00	68.77
	5325.000	321.35	41.30	8.06	15.77	237.93	4985.00	63.39
	5350.000	320.60	41.30	7.90	16.30	259.95	4985.00	62.42
	5400.000	319.10	41.30	7.75	16.81	282.72	4985.00	61.51
	5500.000	316.10	41.30	7.65	17.15	298.25	4985.00	60.94
	5600.000	316.10	41.30	7.66	17.16	299.08	4985.00	60.91
*	5660.000	315.80	35.20	8.97	13.25	108.23	4985.00	68.84
	5662.500	315.79	35.20	7.30	16.43	197.57	4985.00	63.47
	5665.000	315.78	35.20	6.39	17.90	257.34	4985.00	62.74
	5670.000	315.75	32.90	5.14	19.67	317.55	4985.00	64.65
	5680.000	315.70	32.90	3.69	21.27	492.16	4985.00	74.63



C48

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
	5700.000	315.60	32.90	2.39	21.50	789.05	4985.00	104.32
	5715.000	315.52	32.90	2.70	18.80	516.95	4985.00	106.22
	5730.000	315.45	32.90	3.06	16.43	339.37	4985.00	108.36
*	5760.000	315.30	32.90	4.33	11.16	102.92	4985.00	116.01

$D_{50} = 6''$ SF

END APRON

REACH 7

NORTH DITCH
HEC-2
SUMMARY SHEET
SUB-CRITICAL

THIS RUN EXECUTED 13OCT93 15:00:15

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

JEFFREY CITY ------- CHA

SUMMARY PRINTOUT

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
	5760.000	315.40	32.90	5.32	8.84	50.70	4985.00	121.92
	5700.000	315.70	32.90	5.33	8.84	50.57	4985.00	121.95
*	5600.000	316.10	41.30	8.93	13.35	151.84	4985.00	68.61
*	5500.000	316.10	41.30	8.94	13.33	151.41	4985.00	68.64
*	5400.000	319.10	41.30	8.94	13.34	151.50	4985.00	68.63
*	5325.000	320.60	41.30	8.94	13.34	151.50	4985.00	68.63
*	5300.000	322.10	37.70	8.94	13.34	126.25	4985.00	68.63
*	5200.000	324.10	37.70	8.64	13.06	125.87	4618.00	66.84
*	5100.000	326.10	37.70	8.61	13.14	127.95	4618.00	66.65
*	5000.000	328.10	37.70	8.62	13.12	127.40	4618.00	66.70
*	4900.000	330.10	37.70	8.61	13.13	127.54	4618.00	66.68
*	4800.000	332.10	37.70	8.61	13.12	127.49	4618.00	66.69
*	4700.000	334.10	37.70	8.61	13.13	127.51	4618.00	66.69
*	4675.000	334.80	37.70	8.61	13.13	127.51	4618.00	66.69
*	4650.000	335.40	41.40	8.61	13.13	153.76	4618.00	66.69
	4625.000	335.90	41.40	9.63	9.98	78.26	4217.00	72.78
	4600.000	336.70	41.40	8.57	12.07	130.77	4217.00	66.45

SEE SUPER CRITICAL FLOW OUTPUT

REACH 7

REACH 6

REACH 5

C50

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
*	4575.000	337.50	41.40	8.27	12.81	153.49	4217.00	64.61
*	4550.000	338.30	41.40	8.24	12.90	156.17	4217.00	64.41
	4500.000	339.80	41.40	8.41	12.48	142.93	4217.00	65.42
*	4400.000	342.80	41.40	8.25	12.85	154.61	4217.00	64.53
*	4300.000	345.80	41.40	8.24	12.89	155.88	4217.00	64.43
*	4250.000	347.40	41.40	8.24	12.88	155.54	4217.00	64.46
	4200.000	349.40	43.10	8.67	7.15	49.05	2539.00	67.00
*	4100.000	353.30	43.10	6.40	11.59	181.30	2539.00	53.41
*	4000.000	357.10	43.10	6.41	11.57	180.14	2539.00	53.47
*	3900.000	361.00	43.10	6.41	11.57	180.44	2539.00	53.46
*	3800.000	364.90	43.10	6.41	11.57	180.33	2539.00	53.46
*	3700.000	368.70	43.10	6.41	11.57	180.34	2539.00	53.46
*	3670.000	369.90	43.10	6.41	11.57	180.37	2539.00	53.46
*	3600.000	372.60	43.10	6.29	11.58	184.21	2468.00	52.76
*	3500.000	376.50	43.10	6.33	11.48	180.30	2468.00	52.95
*	3400.000	380.40	43.10	6.32	11.51	181.21	2468.00	52.91
*	3300.000	384.20	43.10	6.32	11.50	180.97	2468.00	52.92
*	3200.000	388.10	43.10	6.32	11.50	181.04	2468.00	52.91
*	3100.000	392.00	43.10	6.32	11.50	181.01	2468.00	52.92
*	3000.000	395.80	43.10	6.32	11.50	181.03	2468.00	52.91
*	2950.000	397.75	31.30	6.32	11.50	95.47	2468.00	52.91
*	2937.500	397.81	31.30	6.90	10.02	65.67	2468.00	56.40
	2925.000	397.88	31.30	6.94	9.94	64.36	2468.00	56.60
	2912.500	397.94	31.30	7.03	9.72	60.56	2468.00	57.20
	2900.000	398.00	31.30	7.06	9.68	59.93	2468.00	57.30
	2875.000	398.12	31.30	7.95	6.33	22.43	1954.00	62.67

OUTFLOW

REACH 5

SUPERCRITICAL FLOW

REACH 4

SEE

REACH 3

D_{50} = 3"

COEF 70

REACH 2

C51

SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
2850.000	398.25	31.30	7.86	6.44	23.50	1954.00	62.16
2800.000	398.50	31.30	7.70	6.66	25.66	1954.00	61.21
2700.000	399.00	31.30	7.42	7.07	30.18	1954.00	59.51
2600.000	399.50	31.30	7.18	7.43	34.50	1954.00	58.15
2500.000	400.00	31.30	7.00	7.75	38.68	1954.00	57.01
2400.000	400.50	31.30	6.86	8.00	42.18	1954.00	56.17
2300.000	401.00	31.30	6.76	8.19	44.93	1954.00	55.56
2200.000	401.50	31.30	6.69	8.32	46.88	1954.00	55.16
2100.000	402.00	31.30	6.65	8.40	48.11	1954.00	54.92
2000.000	402.50	31.30	6.63	8.45	48.85	1954.00	54.77
1900.000	403.00	31.30	6.62	8.48	49.29	1954.00	54.69
1800.000	403.50	31.30	6.61	8.49	49.56	1954.00	54.64
1700.000	404.00	31.30	6.60	8.51	49.74	1954.00	54.61
1600.000	404.50	31.30	6.60	8.51	49.84	1954.00	54.59
1500.000	405.00	31.30	6.60	8.52	49.90	1954.00	54.58
1400.000	405.50	31.30	6.59	8.52	49.94	1954.00	54.57
1300.000	406.00	31.30	6.59	8.52	49.97	1954.00	54.56
1200.000	406.50	31.30	6.59	8.52	49.98	1954.00	54.56
1100.000	407.00	31.30	6.59	8.52	49.99	1954.00	54.56
1050.000	407.25	31.30	6.59	8.52	49.99	1954.00	54.56
1000.000	407.50	31.30	7.06	6.45	26.53	1645.00	57.33
900.000	408.00	31.30	6.78	6.86	31.35	1645.00	55.71
800.000	408.50	31.30	6.57	7.21	35.87	1645.00	54.44
700.000	409.00	31.30	6.40	7.51	40.13	1645.00	53.41
600.000	409.50	31.30	6.28	7.75	43.64	1645.00	52.66
500.000	410.00	31.30	6.20	7.91	46.13	1645.00	52.17

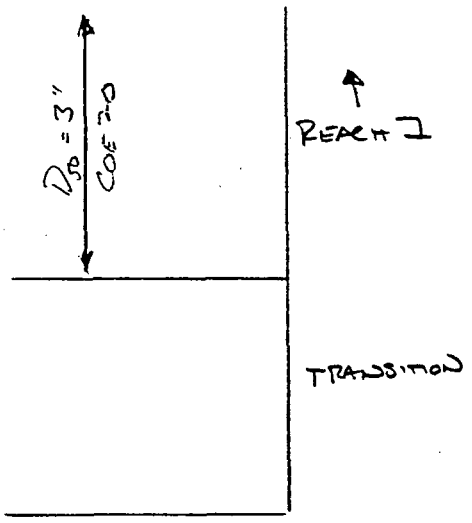
D_{50} = 3"
COE 70

REACH 2

REACH 1

C52

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
	400.000	410.50	31.30	6.15	8.00	47.69	1645.00	51.88
	300.000	411.00	31.30	6.12	8.06	48.60	1645.00	51.71
	200.000	411.50	31.30	6.10	8.09	49.14	1645.00	51.61
	150.000	411.75	31.30	6.10	8.10	49.28	1645.00	51.59
	100.000	412.00	31.30	6.47	7.37	38.07	1645.00	53.89
*	87.500	412.75	45.80	6.22	5.31	44.39	1112.00	52.31
	75.000	413.50	45.80	5.37	6.66	81.96	1112.00	47.22
*	50.000	415.00	46.10	4.17	9.69	231.81	1112.00	40.03
*	.000	418.00	46.10	4.18	9.67	230.39	1112.00	40.07



SWALE HEC-2
SUMMARY

SUPER-CRITICAL

THIS RUN EXECUTED 13OCT93 07:57:05

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

JEFFREY CITY ------- CHA

SUMMARY PRINTOUT

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
	200.000	391.50	31.30	1.50	10.09	499.13	590.00	63.00
*	225.000	391.32	31.30	2.01	6.24	136.79	590.00	79.22
	250.000	390.97	31.30	1.98	6.35	143.36	590.00	78.56
*	300.000	390.80	31.30	2.01	6.22	135.41	590.00	79.36
*	350.000	390.50	31.30	2.00	6.25	137.44	590.00	79.15
*	400.000	390.10	31.30	2.01	6.24	136.77	590.00	79.22
*	600.000	388.70	31.30	2.01	6.24	137.02	590.00	79.19
*	700.000	388.00	31.30	3.17	7.68	120.54	1601.00	116.50
*	800.000	387.30	31.30	3.18	7.65	119.58	1601.00	116.67
*	1000.000	385.90	31.30	3.18	7.66	119.80	1601.00	116.64
*	1200.000	384.50	31.30	3.18	7.66	119.75	1601.00	116.64
*	1400.000	383.10	31.30	3.18	7.66	119.76	1601.00	116.64
*	1600.000	381.70	31.30	3.18	7.66	119.80	1601.00	116.64
*	1800.000	380.30	31.30	3.18	7.66	119.75	1601.00	116.64
*	2000.000	378.90	31.30	3.18	7.66	119.76	1601.00	116.64
*	2150.000	377.90	40.70	4.08	8.92	184.81	1736.00	80.34
*	2175.000	376.88	40.70	3.48	11.71	384.85	1736.00	70.49

SEE SUB-CRITICAL FLOW SUMMARY

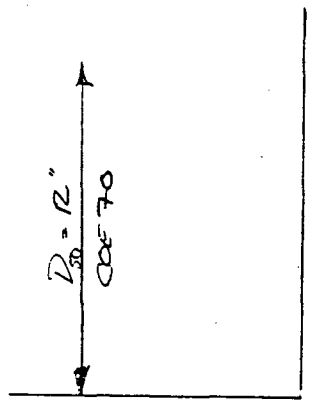
REACH 1

REACH 2

REACH

C57

SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
2200.000	375.85	40.70	3.43	11.93	404.95	1736.00	69.86
2300.000	371.76	40.70	3.42	11.98	409.66	1736.00	69.72
2400.000	367.68	40.70	3.41	11.98	409.19	1736.00	69.73
2600.000	359.50	40.70	3.42	11.97	408.22	1736.00	69.76
2800.000	351.32	40.70	3.41	11.98	409.66	1736.00	69.72
2895.000	347.40	40.70	3.37	12.32	441.69	1736.00	68.79



VALUES USED FOR RIPRAP SPREADSHEETS ARE BOXED

C55

SWALE
HEC-2
SUMMARY SHEET

SUB-CRITICAL

THIS RUN EXECUTED 13OCT93 07:50:12

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

JEFFREY CITY ------- CHA

SUMMARY PRINTOUT

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
*	2895.000	347.40	40.70	4.09	8.90	184.09	1736.00	80.40
*	2800.000	351.28	40.70	4.09	8.90	183.96	1736.00	80.41
*	2600.000	359.46	40.70	4.09	8.90	183.98	1736.00	80.41
*	2400.000	367.64	40.70	4.09	8.90	183.94	1736.00	80.41
*	2200.000	375.82	40.70	4.09	8.90	183.94	1736.00	80.41
*	2150.000	377.90	40.70	4.09	8.90	183.94	1736.00	80.41
*	2100.000	378.25	31.30	5.07	3.28	12.42	1601.00	177.34
	2000.000	378.90	31.30	4.52	4.06	21.91	1601.00	159.61
*	1800.000	380.30	31.30	3.60	6.13	65.88	1601.00	130.20
	1600.000	381.70	31.30	3.54	6.29	70.69	1601.00	128.52
	1400.000	383.10	31.30	3.55	6.28	70.29	1601.00	128.66
	1200.000	384.50	31.30	3.56	6.24	69.28	1601.00	129.00
	1000.000	385.90	31.30	3.55	6.28	70.34	1601.00	128.64
	800.000	387.30	31.30	3.55	6.28	70.41	1601.00	128.62
	700.000	388.00	31.30	3.56	6.26	69.72	1601.00	128.85
	600.000	388.70	31.30	3.74	2.11	7.44	590.00	134.70
	550.000	389.05	31.30	3.42	2.48	11.46	590.00	124.39

SEE SUPER-CRITICAL FLOW SUMMARY

REACH 3

REACH 2

D_{50} = 3" COE 70

REACH 1

VALUES USED FOR SPREADSHEETS ARE BOXED

C56

SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
500.000	389.40	31.30	3.11	2.92	17.83	590.00	114.69
450.000	389.75	31.30	2.84	3.45	27.77	590.00	105.75
400.000	390.10	31.30	2.61	4.01	41.66	590.00	98.21
300.000	390.80	31.30	2.35	4.75	65.79	590.00	90.39
200.000	391.50	31.30	2.32	4.87	70.20	590.00	89.33

$D_{50} = 3''$

COE 70

REACH I

C57

SOUTH DITCH
HEC-2
SUMMARY SHEET
SUPER-CRITICAL

THIS RUN EXECUTED 07OCT93 17:27:37

****
HEC-2 WATER SURFACE PROFILES

FILE: SM1SOSUP.

Version 4.6.2; May 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

JEFFREY CITY ------- CHA

SUMMARY PRINTOUT

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
	.000	411.91	36.90	.32	4.66	661.76	24.00	16.93
	100.000	406.00	31.30	.31	4.82	529.13	24.00	16.87
*	125.000	405.85	31.30	5.53	9.69	112.67	864.00	31.43
*	200.000	405.18	31.30	3.64	9.14	110.32	864.00	36.86
*	400.000	403.54	31.30	3.65	9.14	110.09	864.00	36.87
*	600.000	401.91	31.30	3.65	9.14	110.13	864.00	36.87
*	800.000	400.27	31.30	3.65	9.14	110.10	864.00	36.87
*	1000.000	398.63	31.30	3.64	9.14	110.16	864.00	36.87
*	1150.000	397.40	31.30	3.65	9.14	110.10	864.00	36.87
*	1200.000	397.20	31.30	3.64	9.14	110.16	864.00	36.87
*	1400.000	396.40	31.30	5.75	11.08	98.40	2052.00	49.47
*	1600.000	395.60	31.30	5.75	11.05	97.75	2052.00	49.53
*	1800.000	394.80	31.30	5.75	11.06	97.89	2052.00	49.52
*	2000.000	394.00	31.30	5.75	11.06	97.84	2052.00	49.52
*	2200.000	393.20	31.30	5.75	11.06	97.88	2052.00	49.52
*	2400.000	392.40	31.30	5.75	11.06	97.84	2052.00	49.52
*	2600.000	391.60	31.30	7.15	12.16	92.90	3171.00	57.92

D_{50} = 3" SF

TRANSITION

REACH 1

REACH 2

VALUES USED FOR RIPRAP SPREADSHEETS ARE BOXED

C58

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
*	2800.000	390.80	31.30	7.17	12.12	92.22	3171.00	58.00
*	3000.000	390.00	31.30	7.16	12.13	92.39	3171.00	57.98
*	3200.000	389.20	31.30	7.16	12.13	92.35	3171.00	57.98
*	3400.000	388.40	31.30	7.16	12.13	92.35	3171.00	57.98
*	3600.000	387.30	31.30	7.16	12.13	92.36	3171.00	57.98
*	3800.000	386.80	31.30	7.16	12.13	92.36	3171.00	57.98
*	4000.000	386.00	31.30	7.16	12.13	92.36	3171.00	57.98
*	4100.000	385.60	31.30	7.16	12.13	92.36	3171.00	57.98
*	4200.000	385.20	31.30	7.16	12.13	92.36	3171.00	57.98
*	4400.000	384.40	31.30	7.16	12.13	92.36	3171.00	57.98
*	4500.000	384.00	39.60	7.16	12.13	147.84	3171.00	57.98
	4600.000	381.71	39.60	6.30	14.84	255.07	3171.00	52.82
	4700.000	379.42	39.60	6.60	13.80	209.76	3171.00	54.60
	4775.000	377.70	39.60	6.48	14.24	228.03	3171.00	53.83
	4800.000	377.13	39.70	6.45	14.29	231.52	3171.00	53.74
	4825.000	376.55	39.70	6.48	14.22	228.31	3171.00	53.87
	4850.000	375.98	39.70	6.47	14.22	228.27	3171.00	53.87
*	4900.000	374.82	39.70	8.65	13.14	141.20	4654.00	66.89
	4950.000	373.67	39.70	7.85	15.37	215.31	4654.00	62.11
	5000.000	372.51	39.70	7.77	15.64	225.66	4654.00	61.61
	5025.000	371.94	39.70	7.78	15.61	224.47	4654.00	61.66
	5050.000	371.36	39.70	7.76	15.69	227.45	4654.00	61.52
	5100.000	370.20	39.70	7.73	15.77	230.84	4654.00	61.36
	5200.000	367.89	39.70	7.73	15.77	230.85	4654.00	61.36
	5400.000	363.27	39.70	7.71	15.79	231.48	4654.00	61.33
	5600.000	358.65	39.70	7.73	15.76	230.27	4654.00	61.39

REACH 3

D_{50} = 18" COE 70

D_{50} = 18" COE 70

REACH 4

VALUES USED FOR RIPRAP SPECIFICATIONS ARE BOXED

C59

07OCT93 17:27:26

REACH 4

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
	5675.000	356.92	39.70	7.72	15.78	231.06	4654.00	61.35
*	5700.000	356.34	39.70	8.89	13.23	138.59	4896.00	68.32
	5800.000	354.03	39.70	7.78	16.40	247.33	4896.00	61.71
	5850.000	352.88	39.70	7.99	15.73	221.09	4896.00	62.93
	5900.000	351.72	39.70	7.93	15.92	228.38	4896.00	62.57
	5950.000	350.57	39.70	7.92	15.94	229.14	4896.00	62.54
	6000.000	349.41	39.70	7.91	15.99	230.95	4896.00	62.45
	6200.000	344.79	39.70	7.90	15.99	231.32	4896.00	62.44
	6300.000	342.48	39.70	7.94	15.91	228.10	4896.00	62.59
	6400.000	340.17	39.70	7.89	16.02	232.22	4896.00	62.39
	6500.000	337.86	39.70	7.94	15.91	227.98	4896.00	62.59
	6600.000	335.51	35.20	7.70	16.69	204.06	4896.00	61.19
	6605.000	335.48	35.20	5.99	19.31	321.69	4896.00	60.31
	6610.000	335.46	35.20	4.89	20.68	425.58	4896.00	63.08
	6620.000	335.41	35.20	3.54	21.90	626.35	4896.00	73.75
	6630.000	335.36	35.20	2.79	22.03	802.06	4896.00	88.00
	6640.000	335.31	35.20	2.37	21.24	886.69	4896.00	104.24
*	6700.000	335.01	35.20	3.83	12.62	174.80	4896.00	112.95

D_{50} = 18" CODE 70

START APRON

D_{50} = 9" FT

END APRON

REACH 5

VALUES USED FOR RIPRAP SPREADSHEETS ARE BOXED

X 43+00

43+01

C6C

South Ditch
HEC-2
Summary Sheet
Sub-Critical

THIS RUN EXECUTED 07OCT93 17:30:28

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991 FILE: SN11SCSNCP.
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

JEFFREY CITY ------- CHA

SUMMARY PRINTOUT

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
	6700.000	335.01	35.20	5.49	8.38	50.19	4896.00	122.94
	6650.000	335.26	35.20	5.49	8.37	50.16	4896.00	122.95
	6640.000	335.31	35.20	5.49	8.37	50.14	4896.00	122.95
	6635.000	335.33	35.20	5.24	9.69	72.22	4896.00	112.09
*	6630.000	335.36	35.20	4.89	11.66	115.97	4896.00	100.57
*	6620.000	335.41	35.20	5.76	12.19	111.54	4896.00	87.05
*	6610.000	335.46	35.20	6.97	12.84	111.21	4896.00	75.60
*	6600.000	335.51	35.20	8.85	13.31	110.89	4896.00	68.10
*	6400.000	340.17	39.70	8.86	13.28	140.13	4896.00	68.18
*	6200.000	344.79	39.70	8.86	13.29	140.37	4896.00	68.16
*	6000.000	349.41	39.70	8.86	13.29	140.31	4896.00	68.17
*	5900.000	351.72	39.70	8.86	13.29	140.33	4896.00	68.17
*	5800.000	354.03	39.70	8.86	13.29	140.31	4896.00	68.17
*	5675.000	356.92	39.70	8.66	13.11	140.07	4654.00	66.98
*	5600.000	358.65	39.70	8.64	13.16	141.56	4654.00	66.85
*	5400.000	363.27	39.70	8.65	13.14	141.16	4654.00	66.89
*	5200.000	367.89	39.70	8.65	13.15	141.29	4654.00	66.88

Reach 5

Reach 4

C61

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
*	5100.000	370.20	39.70	8.65	13.15	141.25	4654.00	66.88
*	5000.000	372.51	39.70	8.65	13.15	141.27	4654.00	66.88
*	4900.000	374.82	39.70	8.65	13.15	141.19	4654.00	66.83
	4800.000	377.13	39.70	9.00	8.38	54.84	3171.00	69.03
	4775.000	377.70	39.60	8.40	9.38	73.95	3171.00	65.42
	4750.000	378.27	39.60	7.78	10.63	103.58	3171.00	61.67
*	4700.000	379.42	39.60	7.15	12.16	148.73	3171.00	57.92
*	4650.000	380.57	39.60	7.17	12.12	147.62	3171.00	58.00
*	4600.000	381.71	39.60	7.16	12.13	147.88	3171.00	57.98
*	4500.000	384.00	39.60	7.16	12.13	147.82	3171.00	57.98
*	4400.000	384.40	31.30	8.60	9.03	41.66	3171.00	66.62
	4200.000	385.20	31.30	8.64	8.96	40.83	3171.00	66.86
	4000.000	386.00	31.30	8.66	8.93	40.38	3171.00	66.99
	3800.000	386.80	31.30	8.67	8.91	40.16	3171.00	67.06
	3600.000	387.60	31.30	8.68	8.90	40.08	3171.00	67.08
	3400.000	388.40	31.30	8.68	8.90	40.05	3171.00	67.09
	3200.000	389.20	31.30	8.68	8.90	40.03	3171.00	67.09
	3000.000	390.00	31.30	8.68	8.90	40.01	3171.00	67.10
	2800.000	390.80	31.30	8.68	8.90	40.00	3171.00	67.10
	2600.000	391.60	31.30	8.68	8.90	40.00	3171.00	67.10
	2400.000	392.40	31.30	9.25	5.19	12.67	2052.00	70.50
	2200.000	393.20	31.30	8.67	5.77	16.89	2052.00	67.01
	2000.000	394.00	31.30	8.17	6.37	21.98	2052.00	63.97
	1800.000	394.80	31.30	7.79	6.87	27.00	2052.00	61.71
	1600.000	395.60	31.30	7.50	7.29	31.65	2052.00	60.03
	1400.000	396.40	31.30	7.32	7.58	35.14	2052.00	58.95

REACH 4

REACH 3

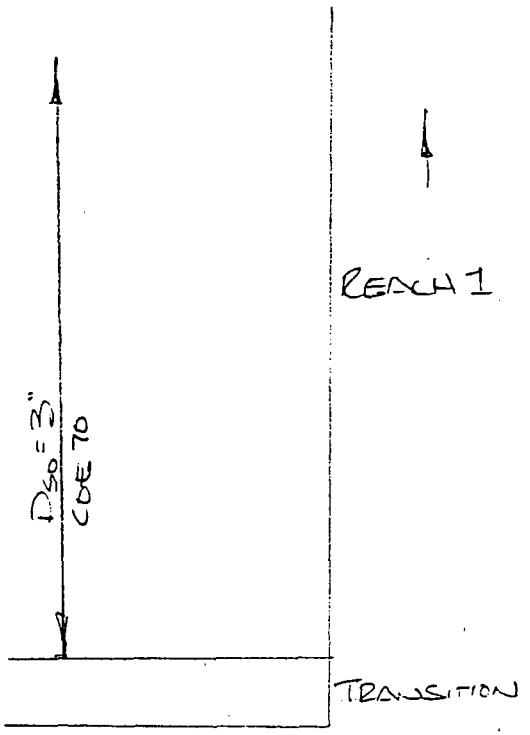
REACH 2

DS = 3"

COE 70

C62

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
	1200.000	397.20	31.30	7.68	2.96	5.09	864.00	61.06
	1100.000	397.81	31.30	7.10	3.35	7.13	864.00	57.59
	1000.000	398.63	31.30	6.31	4.03	11.74	864.00	52.88
	900.000	399.45	31.30	5.56	4.91	20.00	864.00	48.36
	800.000	400.27	31.30	4.87	5.99	34.55	864.00	44.21
*	600.000	401.91	31.30	3.90	8.30	84.27	864.00	38.40
	400.000	403.54	31.30	3.95	8.15	80.22	864.00	38.70
	200.000	405.18	31.30	3.93	8.23	82.33	864.00	38.54
	125.000	405.85	31.30	3.86	8.40	87.37	864.00	38.19
	100.000	406.00	36.90	4.96	.16	.03	24.00	44.72
*	.000	411.91	36.90	.42	3.55	278.19	24.00	17.50



North Central Ditch
HEC-2 Summary
Super-Critical

C63

THIS RUN EXECUTED 09OCT93 12:29:47

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

FILE NEWNCSUB

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

JEFFREY CITY ------- CHA

SUMMARY PRINTOUT

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
*	.000	358.00	31.30	2.11	7.27	126.84	327.00	27.65
*	100.000	357.50	31.30	2.11	7.27	126.81	327.00	27.65
*	200.000	357.00	31.30	2.11	7.27	126.86	327.00	27.65
*	300.000	356.50	31.30	2.11	7.27	126.77	327.00	27.65
*	400.000	356.00	31.30	2.11	7.27	126.86	327.00	27.65
*	495.000	355.52	38.20	$\boxed{2.60}$	7.95	179.67	471.00	30.59
	500.000	355.37	38.20	2.42	8.73	233.81	471.00	29.53
	525.000	354.62	38.20	2.26	9.54	299.96	471.00	28.60
	550.000	353.87	38.20	2.29	9.46	293.14	471.00	28.68
	600.000	352.37	38.20	2.26	9.57	303.09	471.00	28.56
	700.000	349.37	38.20	2.27	9.51	297.73	471.00	28.62
	800.000	346.37	38.20	2.26	9.56	302.00	471.00	28.57
	900.000	343.37	38.20	2.27	9.51	297.24	471.00	28.63
	1000.000	340.37	38.20	2.26	9.56	302.18	471.00	28.57
	1100.000	337.37	38.20	2.27	9.50	297.15	471.00	28.63
	1190.000	334.67	31.30	2.10	10.51	265.21	471.00	27.62
*	1195.000	334.64	31.30	2.41	8.79	159.94	471.00	29.46

Reach 1

Reach 2

Depth = 12 ft

VALUES USED FOR RIPRAP SPREADSHEETS ARE $\boxed{\text{BOXED}}$

C64

NC

REACH 2

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID	
*	1200.000	334.62	31.30	2.60	7.95	120.35	471.00	30.60	
*	1300.000	334.12	31.30	3.87	9.31	107.00	960.00	38.24	
*	1400.000	333.62	31.30	3.86	9.37	108.84	960.00	38.14	
*	1475.000	333.24	31.30	3.86	9.36	108.45	960.00	38.16	← START APRON
*	1480.000	333.22	31.30	2.88	11.91	227.49	960.00	36.64	
	1485.000	333.20	31.30	2.43	12.70	297.84	960.00	38.35	
	1495.000	333.14	31.30	1.89	13.28	409.36	960.00	43.86	
	1505.000	333.10	31.30	1.62	12.87	448.04	960.00	50.96	
	1515.000	333.04	31.30	1.47	12.02	431.22	960.00	58.81	← END APRON (STA 15+25)
*	1575.000	332.74	31.30	2.15	7.90	116.67	960.00	62.92	

REACH 3

VALUES USED FOR RIPRAP SPREADSHEETS ARE BOXED

North Central Ditch
HEC-2 Summary

C65

Sub-Critical

THIS RUN EXECUTED 060CT93 10:35:14

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

FILE: MEWORCE.10

JEFFREY CITY ------- CHA

SUMMARY PRINTOUT

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
	1575.000	332.74	31.30	2.75	5.99	50.23	960.00	66.50
	1515.000	333.04	31.30	2.75	5.99	50.15	960.00	66.51
*	1505.000	333.10	31.30	2.44	8.08	107.89	960.00	55.93
*	1495.000	333.14	31.30	2.74	8.60	111.88	960.00	48.95
*	1485.000	333.20	31.30	3.21	8.96	108.79	960.00	43.01
*	1475.000	333.24	31.30	3.86	9.37	108.99	960.00	38.13
*	1400.000	333.62	31.30	4.65	7.14	51.53	960.00	42.89
	1300.000	334.12	31.30	4.68	7.06	50.02	960.00	43.09
	1200.000	334.62	31.30	5.10	3.05	8.48	471.00	45.61
	1195.000	334.64	31.30	5.08	3.06	8.57	471.00	45.53
	1190.000	334.67	31.30	5.06	3.09	8.79	471.00	45.34
*	1100.000	337.37	38.20	2.60	7.95	179.56	471.00	30.59
*	1000.000	340.37	38.20	2.60	7.94	178.79	471.00	30.61
*	900.000	343.37	38.20	2.60	7.94	178.92	471.00	30.60
*	800.000	346.37	38.20	2.60	7.94	178.87	471.00	30.61
*	700.000	349.37	38.20	2.60	7.94	178.87	471.00	30.61
*	600.000	352.37	38.20	2.60	7.94	178.87	471.00	30.61

3" COE 70

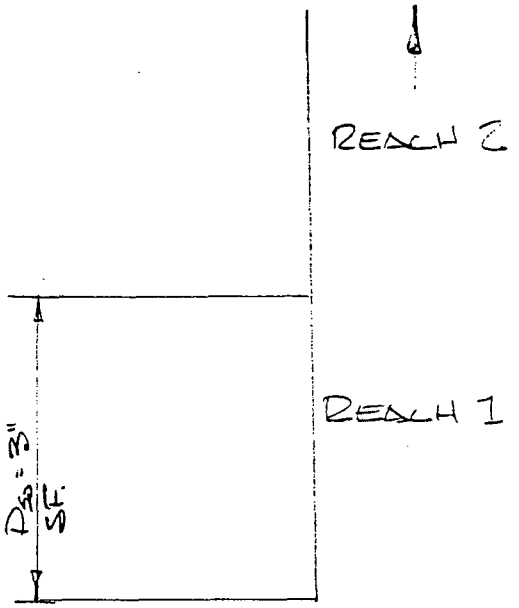
Reach 3

D_{50} = 3" COE 70

Reach 2

VALUES USED FOR RIPRAP SPREADSHEETS ARE BOXED

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
*	550.000	353.87	38.20	2.60	7.94	178.87	471.00	30.61
*	525.000	354.62	38.20	2.60	7.94	178.87	471.00	30.61
*	500.000	355.37	38.20	2.60	7.94	178.87	471.00	30.61
*	495.000	355.52	38.20	2.60	7.94	178.87	471.00	30.61
*	400.000	356.00	31.30	3.46	3.72	19.31	327.00	35.77
	300.000	356.50	31.30	3.15	4.26	28.03	327.00	33.87
	200.000	357.00	31.30	2.93	4.70	36.97	327.00	32.56
	100.000	357.50	31.30	2.80	5.00	43.92	327.00	31.78
	.000	358.00	31.30	2.74	5.14	47.63	327.00	31.43



VALUES USED FOR BRAN SPREADSHEETS ARE BOXED

C67

SOUTH CENTRAL DITCH
HEC-2 SUMMARY
SUPER-CRITICAL

THIS RUN EXECUTED 09OCT93 14:40:32

****
HEC-2 WATER SURFACE PROFILES

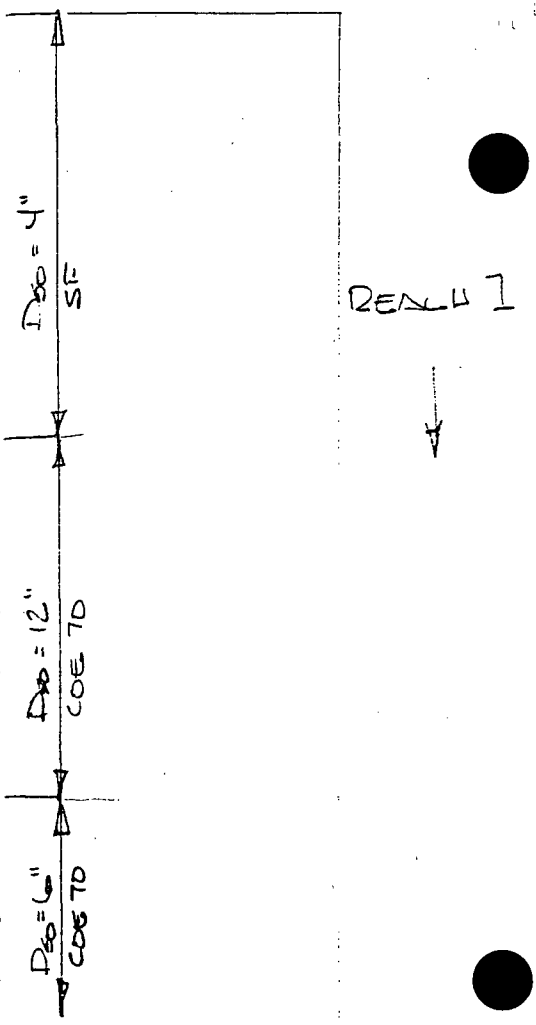
Version 4.6.2; May 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

VERTICAL ALIGNMENT BY SM

SUMMARY PRINTOUT

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
*	.000	358.00	32.90	3.49	8.99	123.58	799.00	35.93
*	100.000	357.31	32.90	3.49	8.98	122.89	799.00	35.96
*	200.000	356.62	32.90	3.49	8.98	123.01	799.00	35.96
*	300.000	355.92	32.90	3.49	8.98	122.98	799.00	35.96
*	400.000	355.23	32.90	3.49	8.98	122.98	799.00	35.96
*	500.000	354.54	32.90	3.49	8.98	122.98	799.00	35.96
*	600.000	353.85	32.90	3.49	8.98	122.98	799.00	35.96
*	650.000	353.50	40.60	3.49	8.98	187.29	799.00	35.96
	660.000	353.10	40.60	3.07	10.73	307.58	799.00	33.44
	675.000	352.50	40.60	2.96	11.30	354.79	799.00	32.77
	700.000	351.50	40.60	2.89	11.65	386.73	799.00	32.37
	725.000	350.50	40.60	2.88	11.75	395.92	799.00	32.27
	750.000	349.50	40.60	2.87	11.79	399.89	799.00	32.22
	800.000	347.50	40.60	2.88	11.76	397.25	799.00	32.25
*	850.000	346.80	35.20	3.49	8.99	141.47	799.00	35.93
	900.000	346.00	35.20	3.32	9.61	170.26	799.00	34.96
*	950.000	345.20	35.20	3.49	8.99	141.38	799.00	35.94



VALUES USED FOR RIPRAP SPREADSHEETS ARE BOXED

C68

SC

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
	1000.000	344.40	35.20	3.32	9.62	170.32	799.00	34.96
*	1100.000	342.90	35.20	3.49	8.99	141.43	799.00	35.93
	1200.000	341.30	35.20	3.32	9.66	172.68	799.00	34.89
*	1300.000	339.80	35.20	3.49	8.99	141.39	799.00	35.93
	1400.000	338.30	35.20	3.39	9.34	156.97	799.00	35.38
	1500.000	336.70	35.20	3.38	9.42	160.99	799.00	35.25
*	1550.000	336.00	35.20	3.49	8.99	141.44	799.00	35.93
*	1575.000	335.60	35.20	5.09	10.44	126.28	1609.00	45.54
*	1600.000	335.38	35.20	5.07	10.50	128.29	1609.00	45.43
*	1700.000	334.48	35.20	5.08	10.49	127.80	1609.00	45.45
*	1800.000	333.58	35.20	5.07	10.49	127.90	1609.00	45.45
*	1900.000	332.68	35.20	5.08	10.49	127.86	1609.00	45.45
*	2000.000	331.78	35.20	5.07	10.49	127.87	1609.00	45.45
*	2100.000	330.88	35.20	5.07	10.49	127.89	1609.00	45.45
*	2200.000	329.98	35.20	5.08	10.49	127.85	1609.00	45.45
*	2250.000	329.52	35.20	5.07	10.49	127.89	1609.00	45.45
*	2300.000	329.18	35.20	5.08	10.49	127.85	1609.00	45.45
*	2310.000	329.11	35.20	4.30	10.20	129.34	1609.00	49.57
	2315.000	329.08	35.20	3.38	12.45	241.84	1609.00	48.39
	2320.000	329.04	35.20	2.94	13.22	308.36	1609.00	50.17
	2330.000	328.98	35.20	2.41	13.74	400.75	1609.00	55.74
	2340.000	328.91	35.20	2.09	13.62	453.22	1609.00	62.59
*	2400.000	328.50	35.20	2.98	9.15	134.78	1609.00	67.89

REACH 1

D_{50} = 6" COE 70

REACH 2

START APRON

D_{50} = 6" SE

END APRON (STA 23+50)

VALUES USED FOR RIPRAP SPREAD SHEETS ARE BOXED.

C69

SOUTH CENTRAL DITCH
HEC-2 SUMMARY
SUB-CRITICAL

THIS RUN EXECUTED 09OCT93 14:41:32

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

FILE: NPWDCCCDR.HZ

JEFFREY CITY ------- CHA

SUMMARY PRINTOUT

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
	2400.000	328.50	35.20	3.61	7.33	69.15	1609.00	71.66
	2340.000	328.91	35.20	3.62	7.32	68.83	1609.00	71.69
*	2330.000	328.98	35.20	3.31	9.51	133.38	1609.00	61.09
*	2320.000	329.04	35.20	3.75	9.82	129.97	1609.00	54.97
*	2310.000	329.11	35.20	4.32	10.15	127.66	1609.00	49.66
*	2300.000	329.18	35.20	5.09	10.43	125.94	1609.00	45.56
*	2250.000	329.52	35.20	5.07	10.50	128.36	1609.00	45.42
	2200.000	329.97	35.20	5.65	8.94	82.64	1609.00	48.84
	2100.000	330.87	35.20	5.56	9.12	87.36	1609.00	48.39
	2000.000	331.77	35.20	5.53	9.24	90.39	1609.00	48.12
	1900.000	332.67	35.20	5.53	9.22	90.08	1609.00	48.15
	1800.000	333.57	35.20	5.54	9.19	89.26	1609.00	48.22
	1700.000	334.47	35.20	5.53	9.19	89.21	1609.00	48.23
	1600.000	335.37	35.20	5.52	9.22	89.97	1609.00	48.16
	1575.000	335.60	35.20	5.52	9.24	90.53	1609.00	48.11
	1550.000	336.00	35.20	6.44	3.62	11.68	799.00	53.64
	1500.000	336.70	35.20	5.75	4.30	18.74	799.00	49.53

REACH 2

DUE TO

REACH 1

VALUES USED FOR RIPRAP SPREADSHEETS ARE FIXED

C70

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
	1450.000	337.53	35.20	4.93	5.44	35.53	799.00	44.58
	1400.000	338.30	35.20	4.21	6.88	67.51	799.00	40.24
*	1300.000	339.80	35.20	3.49	8.99	141.46	799.00	35.93
*	1200.000	341.30	35.20	3.49	8.98	140.67	799.00	35.96
*	1100.000	342.90	35.20	3.49	8.98	140.81	799.00	35.96
*	1000.000	344.40	35.20	3.49	8.98	140.78	799.00	35.96
*	950.000	345.20	35.20	3.49	8.98	140.78	799.00	35.96
*	900.000	346.00	35.20	3.49	8.98	140.78	799.00	35.96
*	850.000	346.80	35.20	3.49	8.98	140.78	799.00	35.96
	800.000	347.50	40.60	3.75	8.14	142.99	799.00	37.45
*	750.000	349.50	40.60	3.49	8.99	188.14	799.00	35.93
*	725.000	350.50	40.60	3.49	8.97	187.11	799.00	35.96
*	700.000	351.50	40.60	3.49	8.98	187.36	799.00	35.96
*	675.000	352.50	40.60	3.49	8.98	187.28	799.00	35.96
*	650.000	353.50	40.60	3.49	8.98	187.28	799.00	35.96
	600.000	354.24	32.90	3.53	8.82	117.00	799.00	36.23
*	500.000	355.70	32.90	3.48	9.02	124.41	799.00	35.90
*	400.000	357.16	32.90	3.50	8.97	122.67	799.00	35.97
*	300.000	358.62	32.90	3.49	8.98	123.07	799.00	35.95
*	200.000	360.08	32.90	3.49	8.98	123.00	799.00	35.96
*	100.000	361.54	32.90	3.49	8.98	123.01	799.00	35.96
*	.000	363.00	32.90	3.49	8.98	122.98	799.00	35.96

REACH 1

HEC2 INPUT

North Ditch HEC-2 input
Super-critical

C72

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ED          NO

T1      INPUT FILE NAME: R:\PROJECTS\336\HEC2\NEWNOSUP.IH2---ANALYSIS BY SBG
T2      DATE:10-14-93 NORTH DIVERSION DITCH WITH 3:1 SIDE SLOPES AND 15' WIDE
T3      JEFFREY CITY ------- CHANNEL BED SLOPE WAS DESIG NED BY     JGC.
T4      JEFFREY CITY ------- CROSS SECTIONS INPUT FOR SUPERCRITICAL FLOW

J1     0       2              1   .0598       0       0       0  411.29
J2    -1             -1
J3    38      23      17      8      26       5      43       4
J5   -10     -10

NC .0461   .0461   .0461     .1      .3
QT     1    1112
X1     0       4       0     75    12.5    12.5    12.5
GR 418.0       0   408.0     30   408.0      45   418.0      75

X1  12.5       4       0     75    12.5    12.5    12.5
GR417.25       0  407.25     30  407.25      45  417.25      75

X1    25       4       0     75      10      10      10
GR 416.5       0   406.5     30   406.5      45   416.5      75

X1    35       4       0     75      15      15      15
GR 415.9       0   405.9     30   405.9      45   415.9      75

X1    50       4       0     75       1       1       1
GR 415.0       0   405.0     30   405.0      45   415.0      75

X1    51       4       0     75     1.5     1.5     1.5
GR 414.9       0   404.9     30   404.9      45   414.9      75

X1  52.5       4       0     75     2.5     2.5     2.5
GR 414.8       0   404.8     30   404.8      45   414.8      75

X1    55       4       0     75       5       5       5
GR 414.7       0   404.7     30   404.7      45   414.7      75

X1    60       4       0     75       5       5       5
GR 414.4       0   404.4     30   404.4      45   414.4      75

X1    65       4       0     75      10      10      10
GR 414.1       0   404.1     30   404.1      45   414.1      75

X1    75       4       0     75       5       5       5
GR 413.5       0   403.5     30   403.5      45   413.5      75

X1    80       4       0     75      10      10      10
GR 413.2       0   403.2     30   403.2      45   413.2      75

X1    90       4       0     75       5       5       5
GR 412.6       0   402.6     30   402.6      45   412.6      75
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X1     95       4       0      75       5       5       5
GR 412.3        0   402.3      30   402.3      45   412.3      75

NC .0313   .0313   .0313      .1      .3
QT      1    1645
X1    100       4       0      75   23.67   26.33      25
GR 412.0        0   402.0      30   402.0      45   412.0      75

X1    125       4       0      75   23.67   26.33      25
GR411.88        0  401.88      30  401.88      45  411.88      75

X1    150       4       0      75   47.34   52.66      50
GR411.75        0  401.75      30  401.75      45  411.75      75

X1    200       4       0      75   96.82  103.18     100
GR 411.5        0   401.5      30   401.5      45   411.5      75

X1    300       4       0      75  100.21   99.79     100
GR 411.0        0   401.0      30   401.0      45   411.0      75

X1    400       4       0      75   94.10   105.9     100
GR 410.5        0   400.5      30   400.5      45   410.5      75


X1    500       4       0      75   82.35  117.65     100
GR 410.0        0   400.0      30   400.0      45   410.0      75

X1    600       4       0      75   89.34  110.66     100
GR 409.5        0   399.5      30   399.5      45   409.5      75

X1    700       4       0      75     100     100     100
GR 409.0        0   399.0      30   399.0      45   409.0      75

X1    800       4       0      75     100     100     100
GR 408.5        0   398.5      30   398.5      45   408.5      75

X1    900       4       0      75     100     100     100
GR 408.0        0   398.0      30   398.0      45   408.0      75

X1   1000       4       0      75      50      50      50
GR 407.5        0   397.5      30   397.5      45   407.5      75

QT      1    1954
X1   1050       4       0      75      50      50      50
GR407.25        0  397.25      30  397.25      45  407.25      75

X1   1100       4       0      75     100     100     100
GR 407.0        0   397.0      30   397.0      45   407.0      75

X1   1200       4       0      75     100     100     100
GR 406.5        0   396.5      30   396.5      45   406.5      75
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C74

X1	1300	4	0	75	100	100	100	
GR	406.0	0	396.0	30	396.0	45	406.0	75
X1	1400	4	0	75	100	100	100	
GR	405.5	0	395.5	30	395.5	45	405.5	75
X1	1500	4	0	75	100	100	100	
GR	405.0	0	395.0	30	395.0	45	405.0	75
X1	1600	4	0	75	100	100	100	
GR	404.5	0	394.5	30	394.5	45	404.5	75
X1	1700	4	0	75	100	100	100	
GR	404.0	0	394.0	30	394.0	45	404.0	75
X1	1800	4	0	75	100	100	100	
GR	403.5	0	393.5	30	393.5	45	403.5	75
X1	1900	4	0	75	100	100	100	
GR	403.0	0	393.0	30	393.0	45	403.0	75
X1	2000	4	0	75	100	100	100	
GR	402.5	0	392.5	30	392.5	45	402.5	75
X1	2100	4	0	75	100	100	100	
GR	402.0	0	392.0	30	392.0	45	402.0	75
X1	2200	4	0	75	100	100	100	
GR	401.5	0	391.5	30	391.5	45	401.5	75
X1	2300	4	0	75	100	100	100	
GR	401.0	0	391.0	30	391.0	45	401.0	75
X1	2400	4	0	75	100	100	100	
GR	400.5	0	390.5	30	390.5	45	400.5	75
X1	2500	4	0	75	100	100	100	
GR	400.0	0	390.0	30	390.0	45	400.0	75
X1	2600	4	0	75	100	100	100	
GR	399.5	0	389.5	30	389.5	45	399.5	75
X1	2700	4	0	75	100	100	100	

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GR 399.0      0   389.0     30   389.0     45   399.0     75

X1  2800      4       0     75     100    100     100
GR 398.5      0   388.5     30   388.5     45   398.5     75

QT     1   2468
X1  2900      4       0     75      50     50      50
GR 398.0      0   388.0     30   388.0     45   398.0     75

NC  .041   .041    .041     .1      .3
X1  2950      4       0     75    12.5   12.5    12.5
GR 397.8      0   387.8     30   387.8     45   397.8     75

X12962.5      4       0     75    12.5   12.5    12.5
GR 397.3      0   387.3     30   387.3     45   397.3     75

X1  2975      4       0     75    12.5   12.5    12.5
GR 396.8      0   386.8     30   386.8     45   396.8     75

X12987.5      4       0     75    12.5   12.5    12.5
GR 396.3      0   386.3     30   386.3     45   396.3     75

NC .0431  .0431   .0431     .1      .3
X1  3000      4       0     75      50     50      50
GR 395.8      0   385.8     30   385.8     45   395.8     75

X1  3050      4       0     75      50     50      50
GR 393.9      0   383.9     30   383.9     45   393.9     75

X1  3100      4       0     75     100    100     100
GR 392.0      0   382.0     30   382.0     45   392.0     75

X1  3200      4       0     75     100    100     100
GR 388.1      0   378.1     30   378.1     45   388.1     75

X1  3300      4       0     75   99.08  100.92     100
GR 384.2      0   374.2     30   374.2     45   384.2     75

X1  3400      4       0     75   93.24  106.76     100
GR 380.4      0   370.4     30   370.4     45   380.4     75

X1  3500      4       0     75   99.13  100.87     100
GR 376.5      0   366.5     30   366.5     45   376.5     75

X1  3600      4       0     75      70     70      70
GR 372.6      0   362.6     30   362.6     45   372.6     75

QT     1   2539
X1  3670      4       0     75      30     30      30
GR 369.9      0   359.9     30   359.9     45   369.9     75

X1  3700      4       0     75      25     25      25
GR 368.7      0   358.7     30   358.7     45   368.7     75
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X1  3725      4       0      75      25      25      25
GR 367.7      0   357.7      30   357.7      45   367.7      75

X1  3750      4       0      75      25      25      25
GR 366.8      0   356.8      30   356.8      45   366.8      75

X1  3775      4       0      75      25      25      25
GR365.87      0  355.87      30  355.87      45  365.87      75

X1  3800      4       0      75     100     100     100
GR 364.9      0   354.9      30   354.9      45   364.9      75

X1  3900      4       0      75   51.58   48.42      50
GR 361.0      0   351.0      30   351.0      45   361.0      75

X1  3950      4       0      75   51.58   48.42      50
GR 359.0      0   349.0      30   349.0      45   359.0      75

X1  4000      4       0      75  104.03   95.97     100
GR 357.1      0   347.1      30   347.1      45   357.1      75

X1  4100      4       0      75  104.04   95.96     100
GR 353.3      0   343.3      30   343.3      45   353.3      75

X1  4200      4       0      75   52.24   47.76      50
GR 349.4      0   339.4      30   339.4      45   349.4      75

NC .0414   .0414   .0414      .1      .3
QT     1    4217
X1  4250      4       0      75   26.12   23.88      25
GR 347.4      0   337.4      30   337.4      45   347.4      75


X1  4275      4       0      75   26.12   23.88      25
GR 346.6      0   336.6      30   336.6      45   346.6      75

X1  4300      4       0      75  101.58   98.42     100
GR 345.8      0   335.8      30   335.8      45   345.8      75

X1  4400      4       0      75  100.82   99.18     100
GR 342.8      0   332.8      30   332.8      45   342.8      75

X1  4500      4       0      75  102.08   98.12     100
GR 339.8      0   329.8      30   329.8      45   339.8      75

X1  4600      4       0      75   50.96   48.93      50
GR 336.7      0   326.7      30   326.7      45   336.7      75

QT     1    4618
X1  4650      4       0      75   12.74   12.24      25
GR 335.4      0   325.4      30   325.4      45   335.4      75

NC .0377   .0377   .0377      .1      .3
X14662.5      4       0      75   12.74   12.24    12.5
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GR 335.1      0   325.1     30   325.1     45   335.1     75

X1  4675      4       0     75   25.48   24.47     25
GR 334.8      0   324.8     30   324.8     45   334.8     75

X1  4700      4       0     75  100.89   99.11    100
GR 334.2      0   324.2     30   324.2     45   334.2     75

X1  4800      4       0     75     100    100    100
GR 332.2      0   322.2     30   322.2     45   332.2     75

X1  4900      4       0     75     100    100    100
GR 330.2      0   320.2     30   320.2     45   330.2     75

X1  5000      4       0     75     100    100    100
GR 328.2      0   318.2     30   318.2     45   328.2     75

X1  5100      4       0     75     100    100    100
GR 326.1      0   316.1     30   316.1     45   326.1     75

X1  5200      4       0     75   99.12  100.88    100
GR 324.1      0   314.1     30   314.1     45   324.1     75

QT     1   4985
X1  5300      4       0     75   24.31   25.68     25
GR 322.1      0   312.1     30   312.1     45   322.1     75

NC .0413   .0413   .0413     .1     .3
X1  5325      4       0     75   24.31   25.68     25
GR321.35      0  311.35     30  311.35     45  321.35     75

X1  5350      4       0     75   48.63   51.37     50
GR 320.6      0   310.6     30   310.6     45   320.6     75

X1  5400      4       0     75   97.42  102.58    100
GR 319.1      0   309.1     30   309.1     45   319.1     75

X1  5500      4       0     75   98.45  101.55    100
GR 316.1      0   306.1     30   306.1     45   316.1     75

X1  5600      4       0     93      60     60     60
GR 316.1      0   303.1     39   303.1     54   316.1     93

NC .0352   .0352   .0352     .1     .3
X1  5660      4       0     93      5      5      5
GR 315.8      0   302.8     39   302.8     54   315.8     93

X15662.5      4       0  97.69    2.5    2.5    2.5
GR315.79      0  302.79     39  302.79  58.69  315.79  97.69

X1  5665      4       0 102.38      5      5      5
GR315.78      0  302.78     39  302.78  63.38  315.78 102.38

NC .0329   .0329   .0329     .1     .3
```

C78

```
X1  5670      4       0  111.75      10      10      10
GR315.75      0  302.75      39  302.75   72.75  315.75  111.75

X1  5680      4       0   130.5      20      20      20
GR 315.7      0   302.7      39   302.7    91.5   315.7   130.5

X1  5700      4       0     168      15      15      15
GR 315.6      0   302.6      39   302.6     129   315.6     168

X1  5715      4       0     168      15      15      15
GR315.52      0  302.52      39  302.52     129  315.52     168

X1  5730      4       0     168      30      30      30
GR315.45      0  302.45      39  302.45     129  315.45     168

X1  5760      4       0     168       0       0       0
GR 315.3      0   302.3      39   302.3     129   315.3     168

EJ
ER
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North Ditch HEC-2 Input
Sub-Critical

C79

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ED            NO


T1      INPUT FILE NAME: R:\PROJECTS\336\HEC2\NEWNOSUB.IH2---ANALYSIS BY SBG
T2      DATE:10-14-93 NORTH DIVERSION DITCH WITH 3:1 SIDE SLOPES AND 15' WIDE
T3      JEFFREY CITY ------- CHANNEL BED SLOPE WAS DESIGNED BY       JGC
T4      JEFFREY CITY ------- CROSS SECTIONS INPUT FOR SUBCRITICAL FLOW


J1     0       2              0    .005       0       0       0  307.72
J2    -1              -1
J3    38      23      17       8      26       5      43       4
J5   -10     -10


NC .0329   .0329   .0329     0.1     0.3
QT     1    4985
X1  5760       4       0     168       0       0       0
GR 315.4       0   302.4      39   302.4     129   315.4     168


X1  5700       4       0     168      60      60      60
GR 315.7       0   302.7      39   302.7     129   315.7     168

NC .0413   .0413   .0413      .1      .3
X1  5600       4       0      93     100     100     100
GR 316.1       0   303.1      39   303.1      54   316.1      93

X1  5500       4       0      75   97.42  101.55     100
GR 316.1       0   306.1      30   306.1      45   316.1      75

X1  5400       4       0      75   97.42  102.58     100
GR 319.1       0   309.1      30   309.1      45   319.1      75

X1  5325       4       0      75   72.94   77.06      75
GR 320.6       0   310.6      30   310.6      45   320.6      75

NC .0377   .0377   .0377      .1      .3
X1  5300       4       0      75   24.32   25.68      25
GR 322.1       0   312.1      30   312.1      45   322.1      75


QT     1    4618
X1  5200       4       0      75   99.12  100.88     100
GR 324.1       0   314.1      30   314.1      45   324.1      75


X1  5100       4       0      75     100     100     100
GR 326.1       0   316.1      30   316.1      45   326.1      75

X1  5000       4       0      75     100     100     100
GR 328.1       0   318.1      30   318.1      45   328.1      75

X1  4900       4       0      75     100     100     100
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C80

```
GR 330.1      0   320.1     30   320.1     45   330.1     75

X1  4800      4       0     75     100    100     100
GR 332.1      0   322.1     30   322.1     45   332.1     75

X1  4700      4       0     75  100.89  99.11     100
GR 334.1      0   324.1     30   324.1     45   334.1     75

X1  4675      4       0     75   25.48  24.47      25
GR 334.8      0   324.8     30   324.8     45   334.8     75

NC .0414   .0414   .0414     .1      .3
X1  4650      4       0     75   25.48  24.47      25
GR 335.4      0   325.4     30   325.4     45   335.4     75

QT     1   4217
X1  4625      4       0     75   25.48  24.47      25
GR 335.9      0   325.9     30   325.9     45   335.9     75

X1  4600      4       0     75   25.48  24.47      25
GR 336.7      0   326.7     30   326.7     45   336.7     75

X1  4575      4       0     75   25.52  24.53      25
GR 337.5      0   327.5     30   327.5     45   337.5     75

X1  4550      4       0     75   25.52  24.53      25
GR 338.3      0   328.3     30   328.3     45   338.3     75

X1  4500      4       0     75   51.04  49.06     100
GR 339.8      0   329.8     30   329.8     45   339.8     75

X1  4400      4       0     75  100.82  99.18     100
GR 342.8      0   332.8     30   332.8     45   342.8     75

X1  4300      4       0     75  101.58  98.42     100
GR 345.8      0   335.8     30   335.8     45   345.8     75

X1  4250      4       0     75   52.24  47.76      50
GR 347.4      0   337.4     30   337.4     45   347.4     75

NC .0431   .0431   .0431     .1      .3
QT     1   2539
X1  4200      4       0     75   52.24  47.76      50
GR 349.4      0   339.4     30   339.4     45   349.4     75


X1  4100      4       0     75  104.04  95.96     100
GR 353.3      0   343.3     30   343.3     45   353.3     75


X1  4000      4       0     75  104.03  95.97     100
GR 357.1      0   347.1     30   347.1     45   357.1     75
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C81

```
X1  3900      4       0      75  103.15   96.85     100
GR 361.0      0   351.0      30   351.0      45   361.0      75

X1  3800      4       0      75     100     100     100
GR 364.9      0   354.9      30   354.9      45   364.9      75

X1  3700      4       0      75     100     100     100
GR 368.7      0   358.7      30   358.7      45   368.7      75

X1  3670      4       0      75      30      30      30
GR 369.9      0   359.9      30   359.9      45   369.9      75

QT     1   2468
X1  3600      4       0      75      70      70      70
GR 372.6      0   362.6      30   362.6      45   372.6      75

X1  3500      4       0      75   99.13  100.87     100
GR 376.5      0   366.5      30   366.5      45   376.5      75

X1  3400      4       0      75   93.24  106.76     100
GR 380.4      0   370.4      30   370.4      45   380.4      75

X1  3300      4       0      75   99.08  100.92     100
GR 384.2      0   374.2      30   374.2      45   384.2      75

X1  3200      4       0      75     100     100     100
GR 388.1      0   378.1      30   378.1      45   388.1      75

X1  3100      4       0      75     100     100     100
GR 392.0      0   382.0      30   382.0      45   392.0      75

X1  3000      4       0      75     100     100     100
GR 395.8      0   385.8      30   385.8      45   395.8      75

NC .0313  .0313   .0313      .1      .3
X1  2950      4       0      75      50      50      50
GR397.75      0  387.75      30  387.75      45  397.75      75

X12937.5      4       0      75    12.5    12.5    12.5
GR397.81      0  387.81      30  387.81      45  397.81      75

X1  2925      4       0      75    12.5    12.5    12.5
GR397.88      0  387.88      30  387.88      45  397.88      75

X12912.5      4       0      75    12.5    12.5    12.5
GR397.94      0  387.94      30  387.94      45  397.94      75

X1  2900      4       0      75    12.5    12.5    12.5
GR 398.0      0   388.0      30   388.0      45   398.0      75
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C 82

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QT      1    1954
X1   2875      4       0      75      25      25      25
GR398.12       0  388.12      30  388.12      45  398.12      75

X1   2850      4       0      75      25      25      25
GR398.25       0  388.25      30  388.25      45  398.25      75

X1   2800      4       0      75      50      50      50
GR 398.5       0   388.5      30   388.5      45   398.5      75


X1   2700      4       0      75     100     100     100
GR 399.0       0   389.0      30   389.0      45   399.0      75


X1   2600      4       0      75     100     100     100
GR 399.5       0   389.5      30   389.5      45   399.5      75


X1   2500      4       0      75     100     100     100
GR 400.0       0   390.0      30   390.0      45   400.0      75

X1   2400      4       0      75     100     100     100
GR 400.5       0   390.5      30   390.5      45   400.5      75

X1   2300      4       0      75     100     100     100
GR 401.0       0   391.0      30   391.0      45   401.0      75

X1   2200      4       0      75     100     100     100
GR 401.5       0   391.5      30   391.5      45   401.5      75

X1   2100      4       0      75     100     100     100
GR 402.0       0   392.0      30   392.0      45   402.0      75

X1   2000      4       0      75     100     100     100
GR 402.5       0   392.5      30   392.5      45   402.5      75

X1   1900      4       0      75     100     100     100
GR 403.0       0   393.0      30   393.0      45   403.0      75

X1   1800      4       0      75     100     100     100
GR 403.5       0   393.5      30   393.5      45   403.5      75

X1   1700      4       0      75     100     100     100
GR 404.0       0   394.0      30   394.0      45   404.0      75

X1   1600      4       0      75     100     100     100
GR 404.5       0   394.5      30   394.5      45   404.5      75

X1   1500      4       0      75     100     100     100
GR 405.0       0   395.0      30   395.0      45   405.0      75

X1   1400      4       0      75     100     100     100
GR 405.5       0   395.5      30   395.5      45   405.5      75
```

```
X1  1300      4       0      75     100     100     100
GR 406.0      0   396.0      30   396.0      45   406.0      75

X1  1200      4       0      75     100     100     100
GR 406.5      0   396.5      30   396.5      45   406.5      75

X1  1100      4       0      75     100     100     100
GR 407.0      0   397.0      30   397.0      45   407.0      75

X1  1050      4       0      75      50      50      50
GR407.25      0  397.25      30  397.25      45  407.25      75

QT     1   1645
X1  1000      4       0      75      50      50      50
GR 407.5      0   397.5      30   397.5      45   407.5      75

X1   900      4       0      75     100     100     100
GR 408.0      0   398.0      30   398.0      45   408.0      75

X1   800      4       0      75     100     100     100
GR 408.5      0   398.5      30   398.5      45   408.5      75

X1   700      4       0      75     100     100     100
GR 409.0      0   399.0      30   399.0      45   409.0      75

X1   600      4       0      75   89.34  110.66     100
GR 409.5      0   399.5      30   399.5      45   409.5      75

X1   500      4       0      75   82.35  117.65     100
GR 410.0      0   400.0      30   400.0      45   410.0      75

X1   400      4       0      75   94.10  105.90     100
GR 410.5      0   400.5      30   400.5      45   410.5      75

X1   300      4       0      75  100.21   99.79     100
GR 411.0      0   401.0      30   401.0      45   411.0      75

X1   200      4       0      75   96.82  103.18     100
GR 411.5      0   401.5      30   401.5      45   411.5      75

X1   150      4       0      75   47.34   52.66      50
GR411.75      0  401.75      30  401.75      45  411.75      75

X1   100      4       0      75   47.34   52.66     100
GR 412.0      0   402.0      30   402.0      45   412.0      75

NC .0458   .0458   .0458      .1      .3
QT     1   1112
X1  87.5      4       0      75    12.5    12.5    12.5
GR412.75      0  402.75      30  402.75      45  412.75      75

X1    75      4       0      75    12.5    12.5    12.5
GR 413.5      0   403.5      30   403.5      45   413.5      75
```

C84

```
NC .0461   .0461   .0461     .1     .3
X1    50      4      0     75     25     25     25
GR 415.0      0  405.0     30  405.0     45  415.0     75

X1     0      4      0     75     50     50     50
GR 418.0      0  408.0     30  408.0     45  418.0     75
EJ
ER
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SWALE HEC-2 INPUT
SUPERCRITICAL

C85

```
ED          NO


T1      INPUT FILE NAME: R:\PROJECTS\336\HEC2\SWALESUP.IH2---ANALYSIS BY SBG
T2      DATE:10-08-93      SWALE          WITH 16:1 SIDE SLOPES AND 20' WIDE
T3      JEFFREY CITY ------- CHANNEL BED SLOPE WAS DESIGNED BY  SPURLOCKOCK
T4      JEFFREY CITY ------- CROSS SECTIONS INPUT FOR SUPERCRITICAL FLOW


J1     0      2              1     .05      0      0      0    383
J2    -1             -1
J3    38     23     17      8      26      5     43      4
J5   -10    -10


NC .0313  .0313  .0313    0.1     0.3
QT     1    590
X1   200      4      0    335      25     25     25
GR 391.5      0  381.5    160   381.5    175  391.5    335

X1   225      4      0    335      25     25     25
GR391.32      0 381.32    160  381.32    175 391.32    335

X1   250      4      0    335      50     50     50
GR390.97      0 380.97    160  380.97    175 390.97    335

X1   300      4      0    335      50     50     50
GR 390.8      0  380.8    160   380.8    175  390.8    335

X1   350      4      0    335      50     50     50
GR 390.5      0  380.5    160   380.5    175  390.5    335

X1   400      4      0    335     200    200    200
GR 390.1      0  380.1    160   380.1    175  390.1    335

X1   600      4      0    335     100    100    100
GR 388.7      0  378.7    160   378.7    175  388.7    335

QT     1   1601
X1   700      4      0    335     100    100    100
GR 388.0      0  378.0    160   378.0    175  388.0    335

X1   800      4      0    335     200    200    200
GR 387.3      0  377.3    160   377.3    175  387.3    335

X1  1000      4      0    335     200    200    200
GR 385.9      0  375.9    160   375.9    175  385.9    335

X1  1200      4      0    335     200    200    200
GR 384.5      0  374.5    160   374.5    175  384.5    335

X1  1400      4      0    335     200    200    200
GR 383.1      0  373.1    160   373.1    175  383.1    335
```

```
X1   1600      4       0     335     200     200     200
GR 381.7       0   371.7     160   371.7     175   381.7     335

X1   1800      4       0     335     200     200     200
GR 380.3       0   370.3     160   370.3     175   380.3     335

X1   2000      4       0     335     150     150     150
GR 378.9       0   368.9     160   368.9     175   378.9     335

NC .0407   .0407   .0407      .1      .3
QT      1    1736
X1   2150      4       0     175      25      25      25
GR 377.9       0   367.9      80   367.9      95   377.9     175

X1   2175      4       0     175      25      25      25
GR376.88       0  366.88      80  366.88      95  376.88     175

X1   2200      4       0     175     100     100     100
GR375.85       0  365.85      80  365.85      95  375.85     175

X1   2300      4       0     175     100     100     100
GR371.76       0  361.76      80  361.76      95  371.76     175

X1   2400      4       0     175     200     200     200
GR367.68       0  357.68      80  357.68      95  367.68     175

X1   2600      4       0     175     200     200     200
GR 359.5       0   349.5      80   349.5      95   359.5     175

X1   2800      4       0     175      90      90      90
GR351.32       0  341.32      80  341.32      95  351.32     175

X1   2895      4       0     175       0       0       0
GR 347.4       0   337.4      80   337.4      95   347.4     175

EJ
ER
```

C87

SWALE HEC-2 INPUT
SUB-CRITICAL

```
ED          NO


T1      INPUT FILE NAME: R:\PROJECTS\336\HEC2\SWALESUB.IH2---ANALYSIS BY SBG
T2      DATE:10-09-93      SWALE            WITH16:1 SIDE SLOPES AND ~~20' WIDE~~ 15' WIDE
T3      JEFFREY CITY ------- CHANNEL BED SLOPE WAS DESIGNED BY  SPURLOCKOCK
T4      JEFFREY CITY ------- CROSS SECTIONS INPUT FOR SUBCRITICAL FLOW


J1     0      2              0   .0357      0      0      0  341.49
J2    -1             -1
J3    38     23     17      8     26      5     43      4
J5   -10    -10


NC .0407   .0407   .0407    0.1    0.3
QT     1   1736
X1  2895      4      0    175      0      0      0
GR 347.4      0  337.4     80  337.4     95  347.4    175

X1  2800      4      0    175     95     95     95
GR351.28      0 341.28     80 341.28     95 351.28    175

X1  2600      4      0    175    200    200    200
GR359.46      0 349.46     80 349.46     95 359.46    175

X1  2400      4      0    175    200    200    200
GR367.64      0 357.64     80 357.64     95 367.64    175

X1  2200      4      0    175    200    200    200
GR375.82      0 365.82     80 365.82     95 375.82    175

X1  2150      4      0    175     50     50     50
GR 377.9      0  367.9     80  367.9     95  377.9    175

QT     1   1601
NC .0313   .0313   .0313     .1     .3
X1  2100      4      0    335     50     50     50
GR378.25      0 368.25    160 368.25    175 378.25    335

X1  2000      4      0    335    100    100    100
GR 378.9      0  368.9    160  368.9    175  378.9    335

X1  1800      4      0    335    200    200    200
GR 380.3      0  370.3    160  370.3    175  380.3    335

X1  1600      4      0    335    200    200    200
GR 381.7      0  371.7    160  371.7    175  381.7    335

X1  1400      4      0    335    200    200    200
GR 383.1      0  373.1    160  373.1    175  383.1    335

X1  1200      4      0    335    200    200    200
GR 384.5      0  374.5    160  374.5    175  384.5    335
```

C88

```
X1  1000      4       0     335     200     200     200
GR 385.9      0   375.9     160   375.9     175   385.9     335

X1   800      4       0     335     200     200     200
GR 387.3      0   377.3     160   377.3     175   387.3     335

X1   700      4       0     335     100     100     100
GR 388.0      0   378.0     160   378.0     175   388.0     335

QT     1    590
X1   600      4       0     335     100     100     100
GR 388.7      0   378.7     160   378.7     175   388.7     335

X1   550      4       0     335      50      50      50
GR389.05      0  379.05     160  379.05     175  389.05     335

X1   500      4       0     335      50      50      50
GR 389.4      0   379.4     160   379.4     175   389.4     335

X1   450      4       0     335      50      50      50
GR389.75      0  379.75     160  379.75     175  389.75     335

X1   400      4       0     335      50      50      50
GR 390.1      0   380.1     160   380.1     175   390.1     335

X1   300      4       0     335     100     100     100
GR 390.8      0   380.8     160   380.8     175   390.8     335

X1   200      4       0     335     100     100     100
GR 391.5      0   381.5     160   381.5     175   391.5     335

EJ
ER
```

SOUTH DITCH HEC-2 INPUT
SUPERCRITICAL

C89

```
ED            NO

T1      INPUT FILE NAME: R:\PROJECTS\336\HEC2\NEWBGSO.IH2---ANALYSIS BY      SBG
T2      DATE:09-22-93   SOUTH DIVERSION DITCH WITH 3:1 SIDE SLOPES AND 15' WIDE
T3      JEFFREY CITY ------- CHANNEL BED SLOPE AND ALIGNMENT WAS DESIGNED BY SMI
T4      JEFFREY CITY ------- CROSS SECTIONS INPUT FOR SUPERCRITICAL FLOW

J1     0      2              1    .065      0      0      0  402.23
J2    -1             -1
J3    38     23     17      8     26      5     43      4
J5   -10    -10

NC .0369  .0369  .0369    0.1     0.3
QT     1     24
X1     0      4      0     75    96.5  103.5    100
GR411.91      0 401.91     30  401.91     45 411.91     75

NC .0313  .0313  .0313     .1      .3
X1   100      4      0     75  28.195 21.775     25
GR 406.0      0  396.0     30   396.0     45  406.0     75

QT     1    864
X1   125      4      0     75  71.805 78.225     75
GR405.85      0 391.85     30  395.85     45 405.85     75

X1   200      4      0     75  191.39 208.61    200
GR405.18      0 395.18     30  395.18     45 405.18     75

X1   400      4      0     75   194.1 205.91    200
GR403.54      0 393.54     30  393.54     45 403.54     75

X1   600      4      0     75     200    200    200
GR401.91      0 391.91     30  391.91     45 401.91     75

X1   800      4      0     75  209.24 190.77    200
GR400.27      0 390.27     30  390.27     45 400.27     75

X1  1000      4      0     75  155.29 144.70    150
GR398.63      0 388.63     30  388.63     45 398.63     75

X1  1150      4      0     75   51.76  48.23     50
GR 397.4      0  387.4     30   387.4     45  397.4     75

X1  1200      4      0     75   185.7  214.3    200
GR 397.2      0  387.2     30   387.2     45  397.2     75

QT     1   2052
X1  1400      4      0     75  181.75 218.31    200
```

C90

```
GR 396.4      0   386.4      30   386.4      45   396.4      75

X1  1600      4       0      75  225.09  174.87     200
GR 395.6      0   385.6      30   385.6      45   395.6      75

X1  1800      4       0      75  178.01  221.99     200
GR 394.8      0   384.8      30   384.8      45   394.8      75

X1  2000      4       0      75  223.72  176.31     200
GR 394.0      0   384.0      30   384.0      45   394.0      75

X1  2200      4       0      75  203.29  196.68     200
GR 393.2      0   383.2      30   383.2      45   393.2      75

X1  2400      4       0      75     200     200     200
GR 392.4      0   382.4      30   382.4      45   392.4      75

QT     1   3171
X1  2600      4       0      75  203.01     197     200
GR 391.6      0   381.6      30   381.6      45   391.6      75

X1  2800      4       0      75  201.16  198.84     200
GR 390.8      0   380.8      30   380.8      45   390.8      75

X1  3000      4       0      75  210.78  189.23     200
GR 390.0      0   380.0      30   380.0      45   390.0      75

X1  3200      4       0      75  209.19   190.8     200
GR 389.2      0   379.2      30   379.2      45   389.2      75

X1  3400      4       0      75     200     200     200
GR 388.4      0   378.4      30   378.4      45   388.4      75

X1  3600      4       0      75     200     200     200
GR 387.3      0   377.3      30   377.3      45   387.3      75

X1  3800      4       0      75     200     200     200
GR 386.8      0   376.8      30   376.8      45   386.8      75

X1  4000      4       0      75   99.01  105.49     100
GR 386.0      0   376.0      30   376.0      45   386.0      75
```

C71

```
X1  4100      4       0      75   99.01  105.49     100
GR 385.6      0   375.6      30   375.6      45   385.6      75

X1  4200      4       0      75  180.85  219.15     200
GR 385.2      0   375.2      30   375.2      45   385.2      75


X1  4400      4       0      75   90.54  109.46     100
GR 384.4      0   374.4      30   374.4      45   384.4      75

NC .0396   .0396   .0396      .1      .3
X1  4500      4       0      75   90.54  109.46     100
GR 384.0      0   374.0      30   374.0      45   384.0      75

X1  4600      4       0      75   90.67  109.33     100
GR381.71      0  371.71      30  371.71      45  381.71      75


X1  4700      4       0      75  73.575   76.44      75
GR379.42      0  369.42      30  369.42      45  379.42      75

X1  4775      4       0      75  26.425   23.56      25
GR 377.7      0   367.7      30   367.7      45   377.7      75

NC .0397   .0397   .0397      .1      .3
X1  4800      4       0      75   25.03   24.97      25
GR377.13      0  367.13      30  367.13      45  377.13      75
       1
X1  4825      4       0      75   25.03   24.97      25
GR376.55      0  366.55      30  366.55      45  376.55      75

X1  4850      4       0      75   50.06   49.94      50
GR375.98      0  365.98      30  365.98      45  375.98      75

QT     1   4654
X1  4900      4       0      75   50.06   49.94      50
GR374.82      0  364.82      30  364.82      45  374.82      75

X1  4950      4       0      75   50.06   49.94      50
GR373.67      0  363.67      30  363.67      45  373.67      75

X1  5000      4       0      75   26.62   23.37      25
GR372.51      0  362.51      30  362.51      45  372.51      75


X1  5025      4       0      75   26.62   23.37      25
GR371.94      0  361.94      30  361.94      45  371.94      75

X1  5050      4       0      75   53.24   46.74      50
GR371.36      0  361.36      30  361.36      45  371.36      75

X1  5100      4       0      75  106.48   93.65     100
GR 370.2      0   360.2      30   360.2      45   370.2      75
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```
X1  5200      4       0      75  208.79  191.21     200
GR367.89      0  357.89      30  357.89      45  367.89      75

X1  5400      4       0      75  190.17  209.83     200
GR363.27      0  353.27      30  353.27      45  363.27      75


X1  5600      4       0      75   73.53   76.46      75
GR358.65      0  348.65      30  348.65      45  358.65      75


X1  5675      4       0      75   24.51   25.49      25
GR356.92      0  346.92      30  346.92      45  356.92      75

QT     1   4896
X1  5700      4       0      75   98.04  101.96     100
GR356.34      0  346.34      30  346.34      45  356.34      75


X1  5800      4       0      75   48.90   51.09      50
GR354.03      0  344.03      30  344.03      45  354.03      75

X1  5850      4       0      75   48.90   51.09      50
GR352.88      0  342.88      30  342.88      45  352.88      75

X1  5900      4       0      75   48.90   51.09      50
GR351.72      0  341.72      30  341.72      45  351.72      75

X1  5950      4       0      75   48.90   51.09      50
GR350.57      0  340.57      30  340.57      45  350.57      75

X1  6000      4       0      75  206.73  193.29     200
GR349.41      0  339.41      30  339.41      45  349.41      75

X1  6200      4       0      75  109.36   90.64     100
GR344.79      0  334.79      30  334.79      45  344.79      75

X1  6300      4       0      75  109.36   90.64     100
GR342.48      0  332.48      30  332.48      45  342.48      75

X1  6400      4       0      75  103.61   96.38     100
GR340.17      0  330.17      30  330.17      45  340.17      75

X1  6500      4       0      75  103.61   96.38     100
GR337.86      0  327.86      30  327.86      45  337.86      75

NC .0352   .0352   .0352      .1      .3
X1  6600      4       0      75       5       5       5
GR335.51      0  325.51      30  325.51      45  335.51      75

X1  6605      4       0   84.38       5       5       5
GR335.48      0 325.485      30 325.485   54.38 335.485   84.38

X1  6610      4       0   93.75      10      10      10
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GR335.46      0  325.46      30  325.46   63.75  335.46   93.75

X1  6620      4       0   112.5      10      10      10
GR335.41      0  325.41      30  325.41    82.5  335.41   112.5

X1  6630      4       0  131.25      10      10      10
GR335.36      0  325.36      30  325.36  101.25  335.36  131.25

X1  6640      4       0     150      60      60      60
GR335.31      0  325.31      30  325.31     120  335.31     150

X1  6700      4       0     150       0       0       0
GR335.01      0  325.01      30  325.01     120  335.01     150

EJ
ER
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South Ditch HEC-2 input
Subcritical

C94

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ED            NO


T1      INPUT FILE NAME: R:\PROJECTS\336\HEC2\NEWBGSO1.IH2---ANALYSIS BY     SBG
T2      DATE:08-12-93   SOUTH DIVERSION DITCH WITH 3:1 SIDE SLOPES AND 15' WIDE
T3      JEFFREY CITY ------- CHANNEL BED SLOPE AND ALIGNMENT WAS DESIGNED BY SMI
T4      JEFFREY CITY ------- CROSS SECTIONS INPUT FOR SUBCRITICAL FLOW


J1   -10       2              0    .005      0       0       0   330.5
J2    -1              -1
J3    38      23      17       8      26      5      43       4
J5   -10     -10

NC .0352   .0352   .0352     0.1     0.3
QT     1    4896
X1  6700       4       0     150       0      0       0
GR335.01       0  325.01      30  325.01    120  335.01     150

X1  6650       4       0     150      50     50      50
GR335.26       0  325.26      30  325.26    120  335.26     150

X1  6640       4       0     150      10     10      10
GR335.31       0  325.31      30  325.31    120  335.31     150

X1  6635       4       0  140.62       5      5       5
GR335.33       0 325.335      30 325.335  110.62 335.335  140.62

X1  6630       4       0  131.25       5      5       5
GR335.36       0  325.36      30  325.36  101.25  335.36  131.25

X1  6620       4       0   112.5      10     10      10
GR335.41       0  325.41      30  325.41    82.5  335.41   112.5

X1  6610       4       0   93.75      10     10      10
GR335.46       0  325.46      30  325.46   63.75  335.46   93.75

X1  6600       4       0      75      10     10      10
GR335.51       0  325.51      30  325.51     45  335.51      75

NC .0397   .0397   .0397      .1      .3
X1  6400       4       0      75  207.23  192.77     200
GR340.17       0  330.17      30  330.17     45  340.17      75

X1  6200       4       0      75  218.72  181.28     200
GR344.79       0  334.79      30  334.79     45  344.79      75

X1  6000       4       0      75  206.73  193.29     200
GR349.41       0  339.41      30  339.41     45  349.41      75

X1  5900       4       0      75   97.80  102.19     100
GR351.72       0  341.72      30  341.72     45  351.72      75

X1  5800       4       0      75   97.80  102.19     100
```

C 95

```
GR354.03      0  344.03      30  344.03      45  354.03      75

QT     1    4654
X1  5675      4       0      75  122.56  127.44     125
GR356.92      0  346.92      30  346.92      45  356.92      75

X1  5600      4       0      75   73.54   76.46      75
GR358.65      0  348.65      30  348.65      45  358.65      75

X1  5400      4       0      75  190.17  209.83     200
GR363.27      0  353.27      30  353.27      45  363.27      75

X1  5200      4       0      75  208.79  191.21     200
GR367.89      0  357.89      30  357.89      45  367.89      75

X1  5100      4       0      75  106.48   93.52     100
GR 370.2      0   360.2      30   360.2      45   370.2      75

X1  5000      4       0      75  106.48   93.52     100
GR372.51      0  362.51      30  362.51      45  372.51      75

X1  4900      4       0      75  100.13   99.87     100
GR374.82      0  364.82      30  364.82      45  374.85      75

QT     1    3171
X1  4800      4       0      75  100.13   99.87     100
GR377.13      0  367.13      30  367.13      45  377.13      75

NC .0396   .0396   .0396      .1      .3
X1  4775      4       0      75   24.52   25.48      25
GR 377.7      0   367.7      30   367.7      45   377.7      75

X1  4750      4       0      75   24.52   25.48      25
GR378.27      0  368.27      30  368.27      45  378.27      75


X1  4700      4       0      75   49.05   50.96      50
GR379.42      0  369.42      30  369.42      45  379.42      75


X1  4650      4       0      75   45.33   54.66      50
GR380.57      0  370.57      30  370.57      45  380.57      75

X1  4600      4       0      75   45.33   54.66      50
GR381.71      0  371.71      30  371.71      45  381.71      75

X1  4500      4       0      75   90.54  109.46     100
GR 384.0      0   374.0      30   374.0      45   384.0      75

NC .0313   .0313   .0313      .1      .3
X1  4400      4       0      75   90.54  109.46     100
GR 384.4      0   374.4      30   374.4      45   384.4      75
```

```
X1  4200      4       0      75  180.85  219.15     200
GR 385.2      0   375.2      30   375.2      45   385.2      75

X1  4000      4       0      75  198.01  201.97     200
GR 386.0      0   376.0      30   376.0      45   386.0      75

X1  3800      4       0      75     200     200     200
GR 386.8      0   376.8      30   376.8      45   386.8      75

X1  3600      4       0      75     200     200     200
GR 387.6      0   377.6      30   377.6      45   387.6      75

X1  3400      4       0      75     200     200     200
GR 388.4      0   378.4      30   378.4      45   388.4      75

X1  3200      4       0      75  209.19   190.8     200
GR 389.2      0   379.2      30   379.2      45   389.2      75

X1  3000      4       0      75  210.78  189.23     200
GR 390.0      0   380.0      30   380.0      45   390.0      75

X1  2800      4       0      75  201.16  198.84     200
GR 390.8      0   380.8      30   380.8      45   390.8      75

X1  2600      4       0      75  203.01     197     200
GR 391.6      0   381.6      30   381.6      45   391.6      75

QT     1   2052
X1  2400      4       0      75     200     200     200
GR 392.4      0   382.4      30   382.4      45   392.4      75

X1  2200      4       0      75  203.29  196.68     200
GR 393.2      0   383.2      30   383.2      45   393.2      75

X1  2000      4       0      75  223.72  176.31     200
GR 394.0      0   384.0      30   384.0      45   394.0      75

X1  1800      4       0      75  178.01  221.99     200
GR 394.8      0   384.8      30   384.8      45   394.8      75

X1  1600      4       0      75  225.09  174.87     200
```

```
GR 395.6      0   385.6      30   385.6      45   395.6      75


X1  1400      4       0      75  181.75  218.31     200
GR 396.4      0   386.4      30   386.4      45   396.4      75

QT     1    864
X1  1200      4       0      75  185.70   214.3     200
GR 397.2      0   387.2      30   387.2      45   397.2      75

X1  1100      4       0      75  103.53   96.47     100
GR397.81      0  387.81      30  387.81      45  397.81      75

X1  1000      4       0      75  103.53   96.47     100
GR398.63      0  388.63      30  388.63      45  398.63      75

X1   900      4       0      75  104.62   95.39     100
GR399.45      0  389.45      30  389.45      45  399.45      75

X1   800      4       0      75  104.62   95.39     100
GR400.27      0  390.27      30  390.27      45  400.27      75


X1   600      4       0      75     200     200     200
GR401.91      0  391.91      30  391.91      45  401.91      75

X1   400      4       0      75   194.1  205.91     200
GR403.54      0  393.54      30  393.54      45  403.54      75


X1   200      4       0      75  191.39  208.61     200
GR405.18      0  395.18      30  395.18      45  405.18      75

X1   125      4       0      75   72.09  77.925      75
GR405.85      0  395.85      30  395.85      45  405.85      75

NC .0369   .0369   .0369      .1      .3
QT     1     24
X1   100      4       0      75   27.90   22.08      25
GR 406.0      0   396.0      30   396.0      45   406.0      75

X1     0      4       0      75   48.06   51.95      50
GR411.91      0  401.91      30  401.91      45  411.91      75

EJ
ER
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NORTH CENTRAL HEC-2 INPUT
SUPERCRITICAL

C 58

```
ED          NO


T1      INPUT FILE NAME: R:\PROJECTS\336\HEC2\NC2SUP.IH2-----ANALYSIS BY JGC
T2      DATE:08- 18-93  NORTH CENTRAL DIVERSION DITCH 3: 1 SIDE SLOPES 15' WIDE
T3      JEFFREY CITY ------- CHANNEL BED SLOPE AND ALIGNMENT BY SPURLOCK
T4      JEFFREY CITY ------- CROSS SECTIONS INPUT FOR SUPER CRITICAL FLOW


J1   -10      2              1   0.005      0      0      0  350.11
J2    -1             -1
J3    38     23     17      8      26      5     43      4
J5   -10    -10


NC .0313   .0313   .0313    0.1     0.3
QT     1    327
X1     0      4      0     75   97.39  102.61    100
GR   358      0    348     30     348     45    358     75


X1   100      4      0     75   89.72  110.47    100
GR 357.5      0  347.5     30   347.5     45  357.5     75


X1   200      4      0     75   89.72  110.28    100
GR   357      0    347     30     347     45    357     75


X1   300      4      0     75   89.54  110.46    100
GR 356.5      0  346.5     30   346.5     45  356.5     75


X1   400      4      0     75   93.86   96.14     95
GR   356      0    346     30     346     45    356     75


NC .0382   .0382   .0382    0.1     0.3
QT     1    471
X1   495      4      0     75    4.94    5.06      5
GR355.52      0 345.52     30  345.52     45 355.52     75

X1   500      4      0     75   22.87   27.14     25
GR355.37      0 345.37     30  345.37     45 355.37     75

X1   525      4      0     75   22.87   27.14     25
GR354.62      0 344.62     30  344.62     45 354.62     75

X1   550      4      0     75   45.73   54.27     50
GR353.87      0 343.87     30  343.87     45 353.87     75

X1   600      4      0     75  104.41   95.59    100
GR352.37      0 342.37     30  342.37     45 352.37     75
```

```
X1    700      4       0      75  107.32   92.68     100
GR349.37       0  339.37      30  339.37      45  349.37      75

X1    800      4       0      75  107.28   92.72     100
GR346.37       0  336.37      30  336.37      45  346.37      75

X1    900      4       0      75  109.54   90.46     100
GR343.37       0  333.37      30  333.37      45  343.37      75

X1   1000      4       0      75   99.98  100.02     100
GR340.37       0  330.37      30  330.37      45  340.37      75

X1   1100      4       0      75   82.92   97.07      90
GR337.37       0  327.37      30  327.37      45  337.37      75

NC .0313   .0313   .0313     0.1     0.3
X1   1190      4       0      75     4.6     5.4       5
GR334.67       0  324.67      30  324.67      45  334.67      75

X1   1195      4       0      75     4.6     5.4       5
GR334.64       0  324.64      30  324.64      45  334.64      75

X1   1200      4       0      75   49.16   50.84      50
GR334.62       0  324.62      30  324.62      45  334.62      75

QT      1    960
X1   1300      4       0      75     100     100     100
GR334.12       0  324.12      30  324.12      45  334.12      75


X1   1400      4       0      75      75      75      75
GR333.62       0  323.62      30  323.62      45  333.62      75

X1   1475      4       0      75       5       5       5
GR333.24       0  323.24      30  323.24      45  333.24      75

X1   1480      4       0   79.38       5       5       5
GR333.22       0  323.22      30  323.22   49.38  333.22   79.38

X1   1485      4       0   83.75      10      10      10
GR 333.2       0   323.2      30   323.2   53.75   333.2   83.75

X1   1495      4       0   92.50      10      10      10
GR333.14       0  323.14      30  323.14    62.5  333.14   92.50

X1   1505      4       0  101.25      10      10      10
GR 333.1       0   323.1      30   323.1   71.25   333.1  101.25

X1   1515      4       0     110      60      60      60
GR333.04       0  323.04      30  323.04      80  333.04     110

X1   1575      4       0     110       0       0       0
GR332.74       0  322.74      30  322.74      80  332.74     110
```

C100

NORTH CENTRAL HEC-2 INPUT
SUBCRITICAL

```
ED            NO


T1      INPUT FILE NAME: R:\PROJECTS\336\HEC2\NC2SUB.IH2-----ANALYSIS BY JGC
T2      DATE:08-18-93   NORTH CENTRAL DIVERSION DITCH 3: 1 SIDE SLOPES 15' WIDE
T3      JEFFREY CITY ------- CHANNEL BED SLOPE AND ALIGNMENT BY SPURLOCK
T4      JEFFREY CITY ------- CROSS SECTIONS INPUT FOR SUB CRITICAL FLOW


J1   -10       2              0   0.005       0       0       0  325.49
J2    -1              -1
J3    38      23      17       8      26       5      43       4
J5   -10     -10



NC .0313   .0313   .0313     0.1     0.3
QT     1     960

X1  1575       4       0     110       0       0       0
GR332.74       0  322.74      30  322.74      80  332.74     110

X1  1515       4       0     110      60      60      60
GR333.04       0  323.04      30  323.04      80  333.04     110

X1  1505       4       0  101.25      10      10      10
GR 333.1       0   323.1      30   323.1   71.25   333.1  101.25

X1  1495       4       0   92.50      10      10      10
GR333.14       0  323.14      30  323.14   62.50  333.14   92.50

X1  1485       4       0   83.75      10      10      10
GR 333.2       0   323.2      30   323.2   53.75   333.2   83.75

X1  1475       4       0      75      10      10      10
GR333.24       0  323.24      30  323.24      45  333.24      75

X1  1400       4       0      75      75      75      75
GR333.62       0  323.62      30  323.62      45  333.62      75


X1  1300       4       0      75     100     100     100
GR334.12       0  324.12      30  324.12      45  334.12      75

QT     1     471
X1  1200       4       0      75   98.32  101.68     100
GR334.62       0  324.62      30  324.62      45  334.62      75

X1  1195       4       0      75     4.6     5.4       5
GR334.64       0  324.64      30  324.64      45  334.64      75

X1  1190       4       0      75     4.6     5.4       5
GR334.67       0  324.67      30  324.67      45  334.67      75
```

```
NC .0382   .0382   .0382    0.1     0.3
X1  1100      4       0     75   82.92   97.07     90
GR337.37      0  327.37     30  327.37      45  337.37     75

X1  1000      4       0     75   99.98  100.02    100
GR340.37      0  330.37     30  330.37      45  340.37     75

X1   900      4       0     75  109.54   90.56    100
GR343.37      0  333.37     30  333.37      45  343.37     75

X1   800      4       0     75  107.28   92.72    100
GR346.37      0  336.37     30  336.37      45  346.37     75

X1   700      4       0     75  107.32   92.68    100
GR349.37      0  339.37     30  339.37      45  349.37     75

X1   600      4       0     75  104.41   95.59    100
GR352.37      0  342.37     30  342.37      45  352.37     75

X1   550      4       0     75   45.73   54.27     50
GR353.87      0  343.87     30  343.87      45  353.87     75

X1   525      4       0     75   22.87   27.14     25
GR354.62      0  344.62     30  344.62      45  354.62     75

X1   500      4       0     75   22.87   27.14     25
GR355.37      0  345.37     30  345.37      45  355.37     75

X1   495      4       0     75    4.94    5.06      5
GR355.52      0  345.52     30  345.52      45  355.52     75

NC .0313   .0313   .0313    0.1     0.3
QT     1     327
X1   400      4       0     75   93.86   96.14     95
GR   356      0     346     30     346      45    356     75

X1   300      4       0     75   89.54  110.46    100
GR 356.5      0   346.5     30   346.5      45  356.5     75


X1   200      4       0     75   89.72  110.28    100
GR   357      0     347     30     347      45    357     75

X1   100      4       0     75   89.72  110.47    100
GR 357.5      0   347.5     30   347.5      45  357.5     75


X1     0      4       0     75   97.39  102.61    100
GR   358      0     348     30     348      45    358     75

EJ
ER
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C/02

SOUTH CENTRAL HEC-2 INPUT
SUPERCRITICAL

```
ED          NO


T1      INPUT FILE NAME: R:\PROJECTS\336\HEC2\NEWSCSUP.IH2---ANALYSIS BY JGC
T2      DATE:08-17-93   SOUTH CENTRAL DIVERSION DITCH 3: 1 SIDE SLOPES 15' WIDE
T3      VERTICAL ALIGNMENT BY SMI - HORIZONTAL BY SPURLOCK
T4      JEFFREY CITY ------- CROSS SECTIONS INPUT FOR SUPER CRITICAL FLOW


J1   -10      2              1   .0069      0      0  351.49
J2    -1             -1
J3    38     23     17      8     26      5     43      4
J5   -10    -10


NC .0329  .0329  .0329    0.1     .03
QT     1    799
X1     0      4      0     75  83.42 116.58    100
GR 358.0      0  348.0     30  348.0     45  358.0     75


X1   100      4      0     75  95.28 104.72    100
GR357.31      0 347.31     30 347.31     45 357.31     75


X1   200      4      0     75  97.87 102.13    100
GR356.62      0 346.62     30 346.62     45 356.62     75


X1   300      4      0     75 113.48  86.52    100
GR355.92      0 345.92     30 345.92     45 355.92     75


X1   400      4      0     75 113.38  86.62    100
GR355.23      0 345.23     30 345.23     45 355.23     75

X1   500      4      0     75    100    100    100
GR354.54      0 344.54     30 344.54     45 354.54     75


X1   600      4      0     75     50     50     50
GR353.85      0 343.85     30 343.85     45 353.85     75

NC .0406  .0406  .0406    0.1     0.3
X1   650      4      0     75     10     10     10
GR 353.5      0  343.5     30  343.5     45  353.5     75

X1   660      4      0     75     15     15     15
GR 353.1      0  343.1     30  343.1     45  353.1     75

X1   675      4      0     75     25     25     25
GR 352.5      0  342.5     30  342.5     45  352.5     75

X1   700      4      0     75  25.04  24.97     25
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```
GR 351.5      0   341.5     30   341.5     45   351.5     75

X1   725      4       0     75   25.04   24.97      25
GR 350.5      0   340.5     30   340.5     45   350.5     75

X1   750      4       0     75   50.07   49.93      50
GR 349.5      0   339.5     30   339.5     45   349.5     75

X1   800      4       0     75   50.48   49.52      50
GR 347.5      0   337.5     30   337.5     45   347.5     75

NC .0352   .0352   .0352    0.1     0.3
X1   850      4       0     75   50.48   49.52      50
GR 346.8      0   336.8     30   336.8     45   346.8     75

X1   900      4       0     75   51.29   48.62      50
GR 346.0      0   336.0     30   336.0     45   346.0     75

X1   950      4       0     75   51.29   48.62      50
GR 345.2      0   335.2     30   335.2     45   345.2     75

X1  1000      4       0     75  100.69   99.30     100
GR 344.4      0   334.4     30   334.4     45   344.4     75

X1  1100      4       0     75     100     100     100
GR 342.9      0   332.9     30   332.9     45   342.9     75

X1  1200      4       0     75     100     100     100
GR 341.3      0   331.3     30   331.3     45   341.3     75


X1  1300      4       0     75     100     100     100
GR 339.8      0   329.8     30   329.8     45   339.8     75

X1  1400      4       0     75     100     100     100
GR 338.3      0   328.3     30   328.3     45   338.3     75


X1  1500      4       0     75   49.68   50.33      50
GR 336.7      0   326.7     30   326.7     45   336.7     75

X1  1550      4       0     75   24.84   25.16      25
GR 336.0      0   326.0     30   326.0     45   336.0     75

NC .0352   .0352   .0352    0.1     0.3
QT     1    1609
X1  1575      4       0     75   24.84   25.16      25
GR 335.6      0   325.6     30   325.6     45   335.6     75

X1  1600      4       0     75   97.98  102.02     100
GR335.38      0  325.38     30  325.38     45  335.38     75


X1  1700      4       0     75   97.58  102.42     100
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```
GR334.48      0  324.48     30  324.48     45  334.48     75

X1  1800      4       0     75   97.52 102.48    100
GR333.58      0  323.58     30  323.58     45  333.58     75

X1  1900      4       0     75   97.50 102.50    100
GR332.68      0  322.68     30  322.68     45  332.68     75

X1  2000      4       0     75   98.03 101.97    100
GR331.78      0  321.78     30  321.78     45  331.78     75

X1  2100      4       0     75   95.53 104.47    100
GR330.88      0  320.88     30  320.88     45  330.88     75

X1  2200      4       0     75   46.28  53.73     50
GR329.98      0  319.98     30  319.98     45  329.98     75

X1  2250      4       0     75      50     50     50
GR329.52      0  319.52     30  319.52     45  329.52     75

X1  2300      4       0     75     100    100    100
GR329.18      0  319.18     30  319.18     45  329.18     75

NC .0352  .0352   .0352     .1     .3
X1  2310      4       0  83.75      5      5      5
GR329.11      0  319.11     30  319.11  53.75  329.11  83.75

X1  2315      4       0  88.12      5      5      5
GR329.08      0  319.08     30  319.08  58.12  329.08  88.12

X1  2320      4       0  92.50     10     10     10
GR329.04      0  319.04     30  319.04  62.50  329.04  92.50

X1  2330      4       0 101.25     10     10     10
GR328.98      0  318.98     30  318.98  71.25  328.98 101.25

X1  2340      4       0    110     60     60     60
GR328.91      0  318.91     30  318.91     80  328.91    110

X1  2400      4       0    110      0      0      0
GR 328.5      0   318.5     30   318.5     80   328.5    110

EJ
ER
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SOUTH CENTRAL HEC-2 INPUT
SUBCRITICAL

C/05

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ED          NO


T1      INPUT FILE NAME: R:\PROJECTS\336\HEC2\SC2SUB.IH2-----ANALYSIS BY JGC
T2      DATE:08-15-93   SOUTH CENTRAL DIVERSION DITCH 3: 1 SIDE SLOPES 15' WIDE
T3      JEFFREY CITY ------- CHANNEL BED SLOPE AND ALIGNMENT BY SPURLOCK
T4      JEFFREY CITY ------- CROSS SECTIONS INPUT FOR SUBCRITICAL FLOW


J1   -10      2              0   .0068       0       0       0  322.11
J2    -1             -1
J3    38     23     17       8      26       5      43       4
J5   -10    -10

NC .0352  .0352  .0352     0.1     0.3
QT     1   1609
X1  2400      4      0     110       0       0       0
GR 328.5      0  318.5      30   318.5      80   328.5     110

X1  2340      4      0     110      60      60      60
GR328.91      0 318.91      30  318.91      80  328.91     110

X1  2330      4      0  101.25      10      10      10
GR328.98      0 318.98      30  318.98   71.25  328.98  101.25

X1  2320      4      0   92.50      10      10      10
GR329.04      0 319.04      30  319.04   62.50  329.04   92.50

X1  2310      4      0   83.75      10      10      10
GR329.11      0 319.11      30  319.11   53.75  329.11   83.75

NC .0352  .0352  .0352      .1      .3
X1  2300      4      0      75      10      10      10
GR329.18      0 319.18      30  319.18      45  329.18      75

X1  2250      4      0      75       0       0       0
GR329.52      0 319.52      30  319.52      45  329.52      75

X1  2200      4      0      75   46.28   53.73      50
GR329.97      0 319.97      30  319.97      45  329.97      75

X1  2100      4      0      75   95.53  104.47     100
GR330.87      0 320.87      30  320.87      45  330.87      75

X1  2000      4      0      75   98.03  101.97     100
GR331.77      0 321.77      30  321.77      45  331.77      75

X1  1900      4      0      75   97.50  102.50     100
GR332.67      0 322.67      30  322.67      45  332.67      75

X1  1800      4      0      75   97.52  102.48     100
GR333.57      0 323.57      30  323.57      45  333.57      75

X1  1700      4      0      75   97.58  102.42     100
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GR334.47      0  324.47     30  324.47     45  334.47     75

X1  1600      4       0     75   97.98  102.02    100
GR335.37      0  325.37     30  325.37     45  335.37     75

X1  1575      4       0     75   24.84   25.16     25
GR 335.6      0   325.6     30   325.6     45   335.6     75

NC .0352   .0352   .0352    0.1     0.3
QT     1     799
X1  1550      4       0     75   24.84   25.16     25
GR 336.0      0   326.0     30   326.0     45   336.0     75

X1  1500      4       0     75   49.68   50.30     50
GR 336.7      0   326.7     30   326.7     45   336.7     75

X1  1450      4       0     75      50      50     50
GR337.53      0  327.53     30  327.53     45  337.53     75

X1  1400      4       0     75      50      50     50
GR 338.3      0   328.3     30   328.3     45   338.3     75

X1  1300      4       0     75     100     100    100
GR 339.8      0   329.8     30   329.8     45   339.8     75

X1  1200      4       0     75     100     100    100
GR 341.3      0   331.3     30   331.3     45   341.3     75

X1  1100      4       0     75     100     100    100
GR 342.9      0   332.9     30   332.9     45   342.9     75

X1  1000      4       0     75  100.69   99.30    100
GR 344.4      0   334.4     30   334.4     45   344.4     75

X1   950      4       0     75   51.29   48.62     50
GR 345.2      0   335.2     30   335.2     45   345.2     75

X1   900      4       0     75   51.29   48.62     50
GR 346.0      0   336.0     30   336.0     45   346.0     75

X1   850      4       0     75   50.48   49.52     50
GR 346.8      0   336.8     30   336.8     45   346.8     75

NC .0406   .0406   .0406    0.1     0.3
X1   800      4       0     75   50.48   49.52     50
GR 347.5      0   337.5     30   337.5     45   347.5     75

X1   750      4       0     75   50.07   49.93     50
GR 349.5      0   339.5     30   339.5     45   349.5     75

X1   725      4       0     75   25.04   24.97     25
GR 350.5      0   340.5     30   340.5     45   350.5     75

X1   700      4       0     75   25.04   24.97     25
```

```
GR 351.5      0   341.5     30   341.5     45   351.5     75

X1   675      4       0     75      25     25      25
GR 352.5      0   342.5     30   342.5     45   352.5     75

X1   650      4       0     75      25     25      25
GR 353.5      0   343.5     30   343.5     45   353.5     75

NC .0329   .0329   .0329    0.1     0.3
X1   600      4       0     75      50     50      50
GR354.24      0  344.24     30  344.24     45  354.24     75

X1   500      4       0     75     100    100     100
GR 355.7      0   345.7     30   345.7     45   355.7     75

X1   400      4       0     75  113.38  86.62     100
GR357.16      0  347.16     30  347.16     45  357.16     75

X1   300      4       0     75  113.48  86.52     100
GR358.62      0  348.62     30  348.62     45  358.62     75

X1   200      4       0     75   97.87 102.13     100
GR360.08      0  350.08     30  350.08     45  360.08     75

X1   100      4       0     75   95.28 104.72     100
GR361.54      0  351.54     30  351.54     45  361.54     75

X1     0      4       0     75   83.42 116.58     100
GR 363.0      0   353.0     30   353.0     45   363.0     75


EJ
ER
```

C108

ATTACHMENT A

APPLIED HYDROLOGY AND SEDIMENTOLOGY FOR DISTURBED AREAS

APPLIED HYDROLOGY AND SEDIMENTOLOGY FOR DISTURBED AREAS

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and

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A book entitled Hydrology and Sedimentology of Surface Mined Lands was written by Haan and Barfield in 1978 and published by the University of Kentucky. Some of the materials in Chapters 2, 3, and 4 were from that original book. The Office of Informational Services of the Kentucky Institute for Mining and Minerals Research has granted their permission for the use of this material.

Applied Hydrology and Sedimentology of Disturbed Lands

Third Printing 1985

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Library of Con Card Catalog No. applied for.

TO

Annette, Margaret, and Jan

Patty, Michelle, Chris, Peter, Will and Pam.

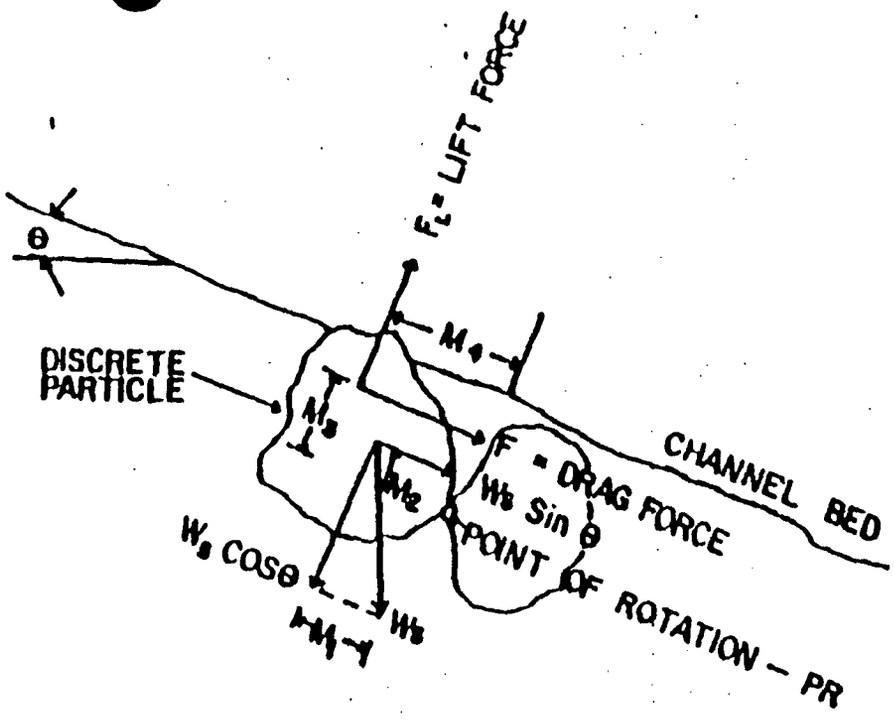

Figure 3.13. Forces on a particle in a channel bed.

One readily measurable parameter is the angle of repose of a given riprap, given in Figure 3.14. When there is no flow, the lift and drag forces are zero. Under these conditions, if the angle of the channel bottom, θ, is increased until the particles just begin to move, the particles are at their angle of repose ϕ, and the safety factor is 1.0, hence

$$\tan\phi = \frac{M_1}{M_3} \tag{3.26}$$

Using equation 3.26 in 3.25,

$$SF_b = \frac{\cos\theta \tan\phi}{\sin\theta + \frac{F_L}{W_s}\frac{M_4}{M_2} + \frac{F_d}{W_s}\frac{M_3}{M_2}} \tag{3.27}$$

or

$$SF_b = \frac{\theta \tan\phi}{\theta + \eta_b \tan\phi} \tag{3.28}$$

where η_b is a stability parameter given by

$$\eta_b = \frac{F_L}{W_s}\frac{M_4}{M_1} + \frac{F_d}{W_s}\frac{M_3}{M_1} \tag{3.29}$$

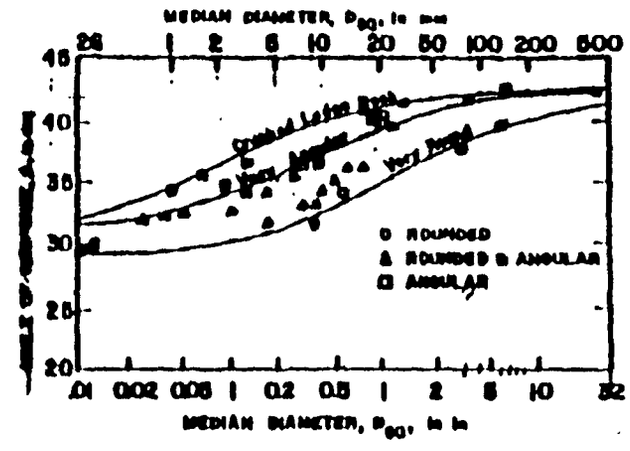

Figure 3.14. Angle of repose of dumped riprap. (After Simons and Senturk, 1977)

The nature of η can be determined by looking at the safety factor for a plane horizontal bed where θ is equal to zero. Under these conditions, the safety factor becomes

$$SF_{plane} = \frac{W_s M_1}{F_L M_4 + F_d M_3} = \frac{1}{\frac{F_L}{W_s}\frac{M_4}{M_1} + \frac{F_d}{W_s}\frac{M_3}{M_1}}$$

or

$$SF_{plane} = \frac{1}{\eta_b} \tag{3.30}$$

For SF_{plane} equal to 1.0, the bed is at the point of incipient motion, and the tractive force is equal to the critical tractive force. Under conditions other than incipient motion on a plane bed it is reasonable to assume that the safety factor can be given by the ratio of critical to actual tractive force since there is no gravity component along the channel bed. Therefore

$$SF_{plane} = \frac{1}{\eta_b} = \frac{\tau_c}{\tau}$$

C.2
REVISED ROCK APRON DESIGN CALCULATIONS

REVISED ROCK APRON DESIGN
WESTERN NUCLEAR, INC.

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REVISED ROCK APRON DESIGN
WESTERN NUCLEAR, INC.

PURPOSE. The network of drainage ditches at WNI's Split Rock Mill and Tailing Site in Jeffrey City, Wyoming has four outlet points. These outlet points are located at the ends of the following ditches:

* North Diversion Ditch (Reach 7)
* North Central Diversion Ditch (Reach 3)
* South Central Diversion Ditch (Reach 2)
* South Diversion Ditch (Reach 5)

The above outlet points must be protected from headcuts that form as a result of scour and subsequently propagate upstream, potentially impinging on tailing. These outlets will be protected by rock aprons and cut-off walls. The purpose of this calculation brief is to state the design criteria and document the design procedures for the rock aprons and cut-off walls.

DESIGN CRITERIA. The rock aprons will be designed as follows:

* The apron begins at the end of the ditch and widens (or flares) until the end of the apron is reached. This flare provides a greater width, thus decreasing the flow depth of the water so that the apron may be daylighted with the natural ground surface.

* A buried cutoff wall (composed of riprap) will be installed at the end of the apron. The total depth of flow will be contained throughout the length of the apron until the point where the buried cut-off wall starts.

* Engineering controls end at the beginning of the buried cut-off wall. The depth of flow will no longer be maintained at this point.

* The design depth of the cut-off wall is equal to the calculated depth of scour. This wall will be constructed using riprap. The riprap will be placed at or less than the angle of repose for the riprap so that if a scour hole develops, the riprap will remain in-place (i.e. not caved-in) thus maintaining protection against headcutting.

* The design width of the cut-off wall will be as wide as the calculated width of scour.

* The nominal size (D_{50}) of the riprap in each of the four ditch outlets will be maintained throughout each rock apron and cut-off wall, respectively.

* The bottom slope of each of the rock aprons will be held constant to the same slope as their respective ditches. This is necessary in order to keep the flow depth to a minimum.

* The aprons will have 3:1 sideslopes (same as ditches).

* The design length of each apron will be determined.

METHOD. To determine the optimal configuration of the end of the apron, the bottom width of the end of the apron must be wide enough to reduce the depth of flow yet still be economically feasible.

Once the depths of flow and the bottom widths have been determined, the design length of the rock aprons is calculated.

Additionally, knowing the configuration at the end of the apron allows for the computing of the depth and width of scour using the method documented on pages V-1 to V-11 in the Federal Highway Administration's (September 1983) "Hydraulic Design of Energy Dissipators for Culverts and Channels" (see References, Attachment B). This method is prescribed for use on page D-17 of the NRC's Staff Technical Position (see References).

The design depth of the buried cut-off wall is equal to the depth of scour.

It should be noted that a closed basin exists in the area surrounding the winter storage ponds west of the South Central Ditch outlet. The outlet elevation of the ditch is 6318.5 feet, while the outlet of the basin is 6318 feet. A tailwater situation should not exist, although retention of water will exist around the winter storage ponds. This situation was not a concern in TRP#4 because the ponded water was outside of the cap. However, with the reclamation of the winter stroage ponds in TRP#5, the ponding area is now of some concern. Several options described below were explored as to the outlet location of the ditch, possibly limiting or eliminating the ponding of water in this area.

1. Extension of the South Central ditch to the Northwest around the ponds.

2. Extension of the South Central ditch to the West Southwest, which would require that the North half of the ponds be relocated to the South.

3. Leaving the ditch outlet at its present location as incorporated inTRP#4 and allowing the retention of water to occur.

Due to the flat topography which exists west of the South Central ditch outlet, extending the ditch is not an option. Even at a minimum bed slope of .40%, which would not meet the selfcleaning criteria, the ditch could not be daylighted. Therefore, due to the topography, options 1 and 2 are not feasible. However, by setting the cap elevation of the ponds at 6320 feet the ponding water (6318 ft) will not have an affect on the tailing cap. In addition, the apron at the end of the South Central diversion ditch will sufficiently dissipate the energy of the flow exiting ditch such that this flow will not erode the side of the tailing cap which will be protected with the soil/rock matrix erosion protection layer as designed in Appendix E. Figure C.2.1 (page C-123) outlines the ponding area, cap and South Central ditch outlet.

RESULTS. The calculated dimensions of the diversion ditch aprons are presented in Table C.2.1 (page C-123).

REFERENCES

1. U.S. Department of Transportation (USDOT), "Hydraulic Design of Energy Dissipators for Culverts and Channels", Hydraulic Engineering Circular No. 14, 1983.

2. U.S. Nuclear Regulatory Commission, "Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailing Sites, Final Staff Technical Position"; August 1990.

3. Applied Hydrology and Sedimentary for Disturbed Areas; Barfield, B.J., Warner, R.C. and Haan, C.T.; Oklahoma Technical Press, 1981.

TABLES

Table C.2.1

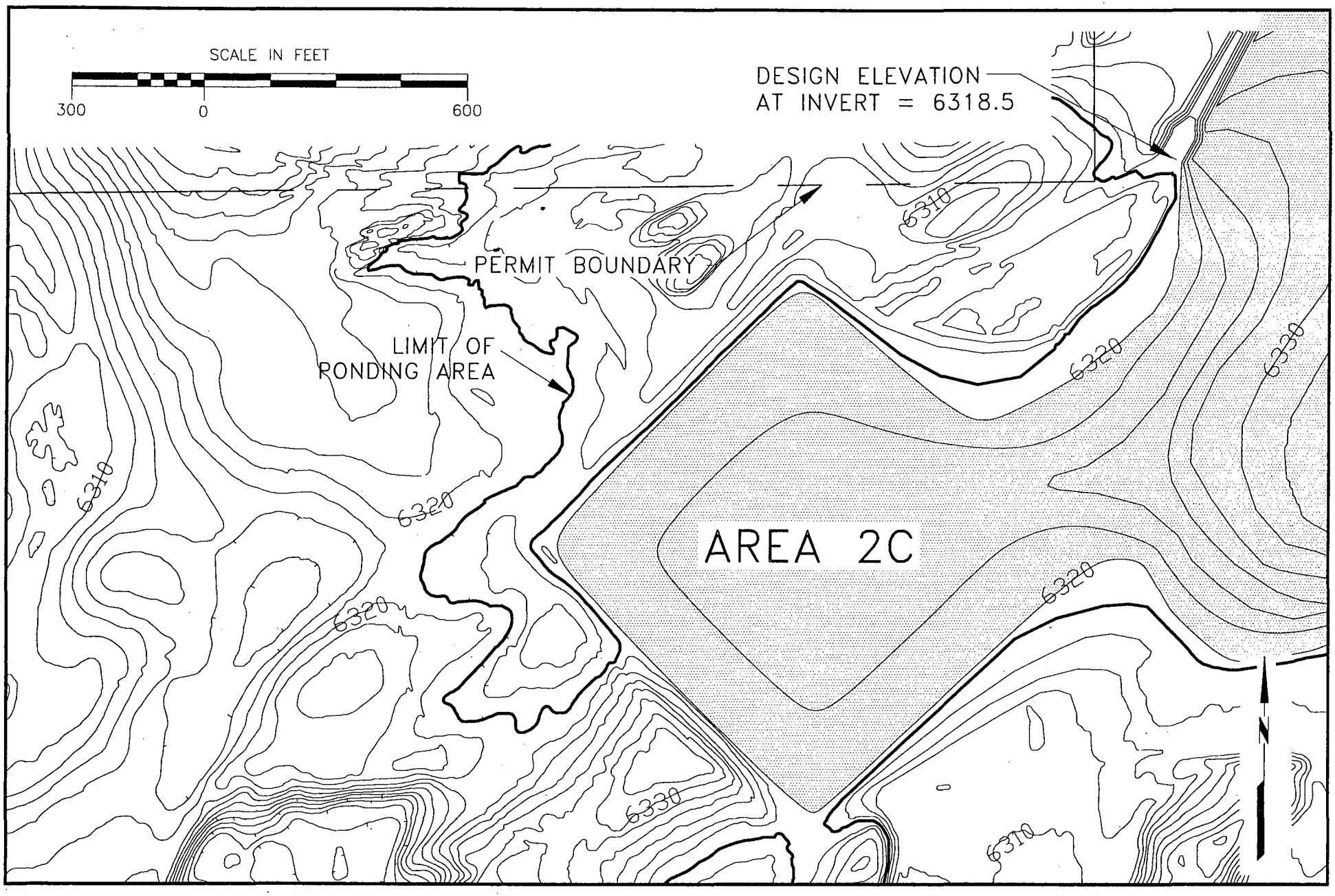
Summary of Apron Characteristics

Ditch Reach	Bottom Width (ft)		Flow Depth (ft)		Length (ft)	Scour Depth (ft)
	Initial	Final	Initial	Final		
North Diversion Ditch Outlet (Reach 7)	15	90	7.5	3.06	100	13.1
North Central Diversion Ditch Outlet (Reach 3)	15	50	3.86	1.47	50	5.4
South Central Diversion Ditch Outlet (Reach 2)	15	50	5.08	2.09	50	7.0
South Diversion Ditch Outlet (Reach 5)	15	90	7.70	2.37	100	12.6

Initial = Beginning of Apron

Final = End of Apron

FIGURES



SMI
SHEPHERD MILLER, INC.

FIGURE C.2.1
SOUTH CENTRAL DIVERSION DITCH APRON LOCATION

Date:	SEPT., 1993
Project:	336
File:	PERMIT

ATTACHMENT A

Calculations

FLOW CHARACTERISTICS AT START AND END OF APRON

North Ditch Apron Flow Characteristics

	5000.000	328.20	37.70	7.77	15.51	200.05	4618.00	61.62	D_{50} COE
	5100.000	326.10	37.70	7.71	15.74	207.93	4618.00	61.21	
	5200.000	324.10	37.70	7.81	15.39	195.70	4618.00	61.86	
*	5300.000	322.10	37.70	8.96	13.28	124.80	4985.00	68.77	
	5325.000	321.35	41.30	8.06	15.77	237.93	4985.00	63.39	
	5350.000	320.60	41.30	7.90	16.30	259.95	4985.00	62.42	D_{50} = 18" COE 7.0
	5400.000	319.10	41.30	7.75	16.81	282.72	4985.00	61.51	
	5500.000	316.10	41.30	7.65	17.15	298.25	4985.00	60.94	
	5600.000	316.10	41.30	7.66	17.16	299.08	4985.00	60.91	
	660.000	315.80	35.20	8.97	13.25	108.23	4985.00	68.84	D_{50} = 6" S.F. ← START APRON
	5662.500	315.79	35.20	7.30	16.43	197.57	4985.00	63.47	ASSUME 7.5 FPS @ START
	5665.000	315.78	35.20	6.39	17.90	257.34	4985.00	62.74	
	5670.000	315.75	32.90	5.14	19.67	317.55	4985.00	64.65	D_{50} = 6" S.F.
	5680.000	315.70	32.90	3.69	21.27	492.16	4985.00	74.63	

REACH 7

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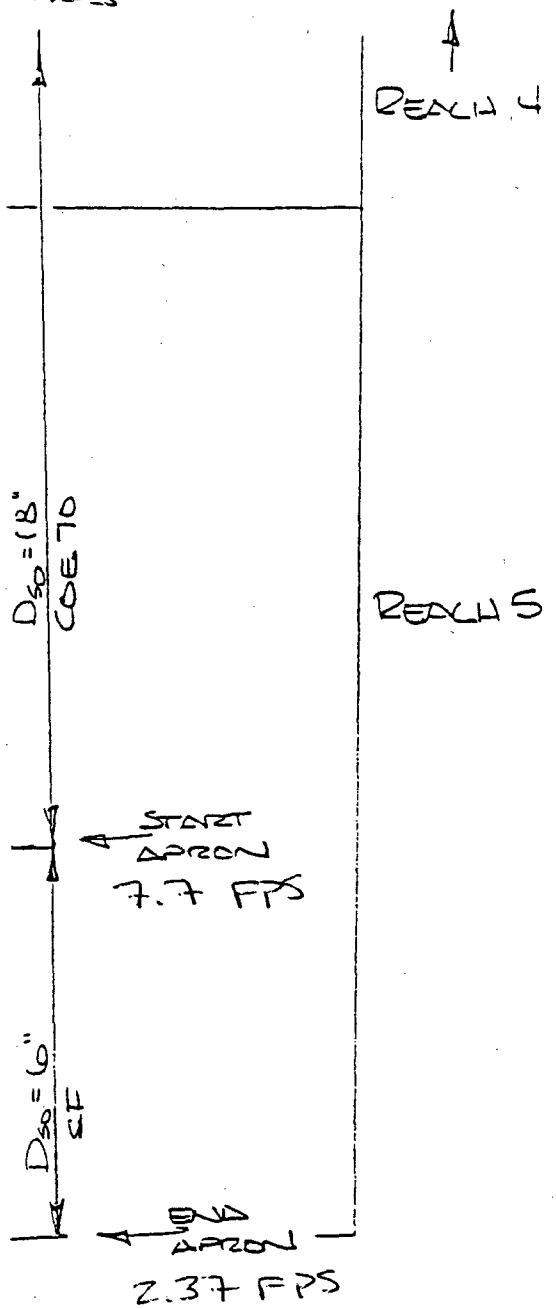
	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID	
	5700.000	315.60	32.90	2.39	21.50	789.05	4985.00	104.32	D_{50} = 6" S.F.
	5715.000	315.52	32.90	2.70	18.80	516.95	4985.00	106.22	Flow @ END IS 3.06 FPS
	30.000	315.45	32.90	3.06	16.43	339.37	4985.00	108.36	
*	5760.000	315.30	32.90	4.33	11.16	102.92	4985.00	116.01	END APRON

REACH 7

C/26

SOUTH DITCH APRON FLOW CHARACTERISTICS

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
	5675.000	356.92	39.70	7.72	15.78	231.06	4654.00	61.35
*	5700.000	356.34	39.70	8.89	13.23	138.59	4896.00	68.32
	5800.000	354.03	39.70	7.78	16.40	247.33	4896.00	61.71
	5850.000	352.88	39.70	7.99	15.73	221.09	4896.00	62.93
	5900.000	351.72	39.70	7.93	15.92	228.38	4896.00	62.57
	5950.000	350.57	39.70	7.92	15.94	229.14	4896.00	62.54
	6000.000	349.41	39.70	7.91	15.99	230.95	4896.00	62.45
	6200.000	344.79	39.70	7.90	15.99	231.32	4896.00	62.44
	6300.000	342.48	39.70	7.94	15.91	228.10	4896.00	62.59
	6400.000	340.17	39.70	7.89	16.02	232.22	4896.00	62.39
	6500.000	337.86	39.70	7.94	15.91	227.98	4896.00	62.59
	6600.000	335.51	35.20	7.70	16.69	204.06	4896.00	61.19
	6605.000	335.48	35.20	5.99	19.31	321.69	4896.00	60.31
	6610.000	335.46	35.20	4.89	20.68	425.58	4896.00	63.08
	6620.000	335.41	35.20	3.54	21.90	626.35	4896.00	73.75
	6630.000	335.36	35.20	2.79	22.03	802.06	4896.00	88.00
	6640.000	335.31	35.20	2.37	21.24	886.69	4896.00	104.24
*	6700.000	335.01	35.20	3.83	12.62	174.80	4896.00	112.95



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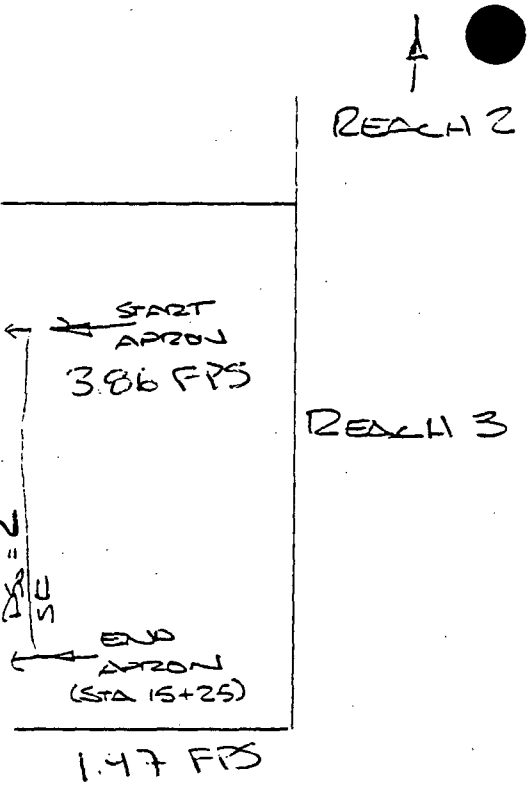
NE NORTH CENTRAL APRON FLOW CHARACTERISTICS

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
*	1200.000	334.62	31.30	2.60	7.95	120.35	471.00	30.60
*	1300.000	334.12	31.30	3.87	9.31	107.00	960.00	38.24
*	1400.000	333.62	31.30	3.86	9.37	108.84	960.00	38.14
*	1475.000	333.24	31.30	3.86	9.36	108.45	960.00	38.16
*	1480.000	333.22	31.30	2.88	11.91	227.49	960.00	36.64
	1485.000	333.20	31.30	2.43	12.70	297.84	960.00	38.35
	1495.000	333.14	31.30	1.89	13.28	409.36	960.00	43.86
	1505.000	333.10	31.30	1.62	12.87	448.04	960.00	50.96
	1515.000	333.04	31.30	1.47	12.02	431.22	960.00	58.81
*	1575.000	332.74	31.30	2.15	7.90	116.67	960.00	62.92



C128

~~SE~~ SOUTH CENTRAL APRON FLOW CHARACTERISTICS

	SECNO	XLBEL	K*XNCH	DEPTH	VCH	10*KS	Q	TOPWID
	1000.000	344.40	35.20	3.32	9.62	170.32	799.00	34.96
*	1100.000	342.90	35.20	3.49	8.99	141.43	799.00	35.93
	1200.000	341.30	35.20	3.32	9.66	172.68	799.00	34.89
*	1300.000	339.80	35.20	3.49	8.99	141.39	799.00	35.93
	1400.000	338.30	35.20	3.39	9.34	156.97	799.00	35.38
	1500.000	336.70	35.20	3.38	9.42	160.99	799.00	35.25
*	1550.000	336.00	35.20	3.49	8.99	141.44	799.00	35.93
*	1575.000	335.60	35.20	5.09	10.44	126.28	1609.00	45.54
*	1600.000	335.38	35.20	5.07	10.50	128.29	1609.00	45.43
*	1700.000	334.48	35.20	5.08	10.49	127.80	1609.00	45.45
*	1800.000	333.58	35.20	5.07	10.49	127.90	1609.00	45.45
	1900.000	332.68	35.20	5.08	10.49	127.86	1609.00	45.45
	2000.000	331.78	35.20	5.07	10.49	127.87	1609.00	45.45
*	2100.000	330.88	35.20	5.07	10.49	127.89	1609.00	45.45
*	2200.000	329.98	35.20	5.08	10.49	127.85	1609.00	45.45
*	2250.000	329.52	35.20	5.07	10.49	127.89	1609.00	45.45
*	2300.000	329.18	35.20	5.08	10.49	127.85	1609.00	45.45
*	2310.000	329.11	35.20	4.30	10.20	129.34	1609.00	49.57
	2315.000	329.08	35.20	3.38	12.45	241.84	1609.00	48.39
	2320.000	329.04	35.20	2.94	13.22	308.36	1609.00	50.17
	2330.000	328.98	35.20	2.41	13.74	400.75	1609.00	55.74
	2340.000	328.91	35.20	2.09	13.62	453.22	1609.00	62.59
*	2400.000	328.50	35.20	2.98	9.15	134.78	1609.00	67.89

$D_{50} = 6''$ COE 70

REACH 1

REACH 2

START APRON 5.08 FPS

$D_{50} = 6''$ SE

END APRON (STA 23+50)

2.09 FPS

DESIGN LENGTH OF ROCK APRONS

Determine Length of Rock Aprons

The length of the rock aprons was determined by adapting a method specified in "Applied Hydrology and Sedimentology for Disturbed Areas", (see Reference #3).

This method was originally developed for designing a rock apron for protecting an outlet of a circular pipe or culvert. Since the outflow at the end of an open trapezoidal ditch will be less turbulent than the outflow from a circular pipe flowing full, a significant degree of conservatism is present when using this method for the outlet of an open trapezoidal ditch.

Given the aforementioned degree of conservatism coupled with the reduction in the depth of flow (due to the apron flare and energy dissipation from flow over the riprap) by approximately one-half from the start to the end of the rock aprons, the following formula was used to determine the length of the aprons (see Reference #3, page 538).

$La = W - D$; where La = Length of rock apron

W = Width of the end of the apron

D = Depth of flow at start of apron

The width of the end of each apron (W) is stated in Table C.2.1 (page C-12). The depths of flow (D) at the start of the aprons are calculated using the Corp of Engineer's method spreadsheet. These parameters along with the calculated La are shown on the following page in Table C.2.2 (page C-13).

Table C.2.2

Length of Rock Aprons

	D (ft)	W (ft)	La (calc.) ft	La (design) (ft)
North Diversion Ditch (Reach 7)	7.5	90	71.5	100
North Central Diversion Ditch (Reach 3)	3.86	50	36.9	50
South Central Diversion Ditch (Reach 2)	5.08	50	45.3	50
South Diversion Ditch (Reach 5)	7.70	90	70.9	100

Note: Calculation are presented on pages C- , C- , C- , and C- .

SCOUR DIMENSIONS

Compute Scour Dimensions

In order to determine the dimensions of scour by using the USFHA method, coefficients of scour must be chosen using Table V-1 from page V-11 of Reference #1.

Determine whether soil at the end of the rock aprons (i.e. the material that is subject to scour) is graded or uniform sand. The ditch outlets will be on native soils near the proposed borrow areas. The average particle size distribution was determined based on 132 samples from the Borrow Area soils which is described in the Borrow Soil compositing methodology calculation. Since the soils in the area are fairly homogeneous, the average particle size of the borrow soils is used to determine whether the soils at the outlets are graded or only uniform. DOT's criteria is as follows:

S.D. = (d_{84}/d_{16}) ^.5 (S.D. = Standard Deviation)

If S.D. < 1.5, then material is uniform

If S.D. > 1.5, then material is graded.

As shown on Figure C.2.2 (page C-), the average d_{84} is 0.73mm and the average d_{16} is 0.12mm.

Substituting these values into the equation for standard deviation,

$$S.D. = (0.73/0.12)^{1/2} = 2.5 > 1.5$$

Therefore, material is graded based on DOT's criteria.

The coefficients of scour (from Table V-1 in Reference #1), for a graded sand are summarized in Table C.2.3:

Table C.2.3

Coefficients of Scour

	Alpha (e)	Beta	Theta
Depth of Scour, Hs	0.75	0.85	0.07
Width of Scour, Ws	4.78	0.76	0.06
Length of Scour, Ls	12.62	0.41	0.04
Volume of Scour, Vs	12.94	2.09	0.19

Given the coefficients of scour from Table C.2.3 and the configuration of the end of the apron, calculate the dimensions of scour at this location using a spreadsheet.

FIGURE C.2.2

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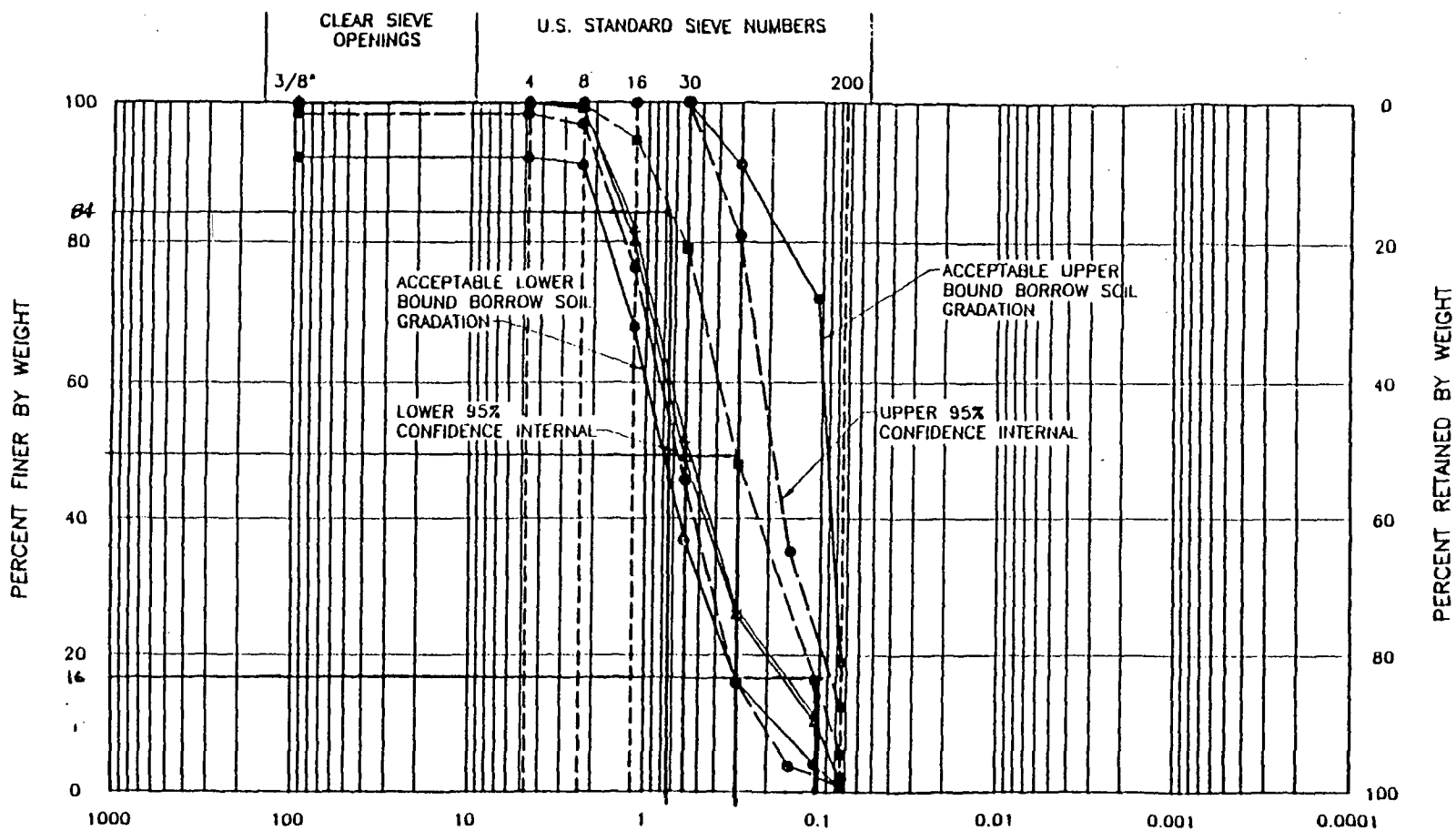
DRAWING NUMBER 91-225-B27



$d_{16} = 0.12$ mm

$d_{84} = 0.73$ mm

LEGEND:

— ■ — AVERAGE (132 SAMPLES)

— ▲ — COMPOSITE SPLIT SAMPLES

NOTES:

1. COMPOSITE SPLIT SAMPLES USED TO DETERMINE RADON PARAMETERS.
2. BORROW SOIL TO BE USED IN SOIL/BENTONITE LAYER AND SOIL LAYER OF SOIL COVER.
3. ACCEPTABLE GRADATION TESTING RESULTS PROVIDED IN APPENDIX B.

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ACCEPTABLE BORROW SOIL GRAIN SIZE ENVELOPE

PREPARED FOR

WESTERN NU[illegible]R, INC.

Canonie Environmental

SCOUR CALCULATIONS

North Diversion Apron - 10/11/93

SCOUR CALCLATIONS USING METHOD PRESENTED IN CHAPTER V OF U.S.D.O.T'S HYDRAULIC CIRCULAR NO. 14 - HYDRAULIC DESIGN OF ENERGY DISSIPATORS FOR CULVERTS AND CHANNELS - SEPTEMBER 1983

ASSUME NON-CIRCULAR CULVERT (CHANNEL) WITH COHESIONLESS MATERIAL AT END OF CULVERT (i.e. LOCATION OF SCOUR)

WNI - JEFFREY CITY, WYOMING

PMF Flow, Q =	4985	cfs	
Area of Flow, A =	281.25	ft^2	
Peak Flow Duration, t1 =	60	minutes	(1 hour storm event)
t0 =	316	minutes	(From reference #1
Ye =	11.86		
Discharge Intensity, D.I. =	1.81		

Coefficients of Scour for a Graded Sand:

	Alpha(e)	Beta	Theta
Depth of Scour	0.75	0.85	0.07
Width of Scour	4.78	0.76	0.06
Length of Scour	12.62	0.41	0.04
Volume of Scour	12.94	2.09	0.19

Depth of Scour, Hs =	13.1
Volume of Scour, Ws =	80.7
Length of Scour, Ls =	178.8

Location of Maximum Scour:

.4*Ls = 71.5 ft downstream of the end of the channel

SCOUR CALCULATIONS

North Central Diversion Apron - 10/11/93

SCOUR CALCLATIONS USING METHOD PRESENTED IN CHAPTER V OF U.S.D.O.T'S HYDRAULIC CIRCULAR NO. 14 - HYDRAULIC DESIGN OF ENERGY DISSIPATORS FOR CULVERTS AND CHANNELS - SEPTEMBER 1983

ASSUME NON-CIRCULAR CULVERT (CHANNEL) WITH COHESIONLESS MATERIAL AT END OF CULVERT (i.e. LOCATION OF SCOUR)

WNI - JEFFREY CITY, WYOMING

PMF Flow, Q =	960	cfs	
Area of Flow, A =	102.60	ft^2	
Peak Flow Duration, t1 =	60	minutes	(1 hour storm event)
t0 =	316	minutes	(From reference #1,
Ye =	7.16		
Discharge Intensity, D.I. =	1.23		

Coefficients of Scour for a Graded Sand:

	Alpha(e)	Beta	Theta
Depth of Scour	0.75	0.85	0.07
Width of Scour	4.78	0.76	0.06
Length of Scour	12.62	0.41	0.04
Volume of Scour	12.94	2.09	0.19

Depth of Scour, Hs =	5.7
Volume of Scour, Ws =	36.3
Length of Scour, Ls =	92.1

Location of Maximum Scour:

.4*Ls = 36.9 ft downstream of the end of the channel

SCOUR CALCULATIONS

South Central Diversion Apron - 10/11/93

SCOUR CALCLATIONS USING METHOD PRESENTED IN CHAPTER V OF U.S.D.O.T'S HYDRAULIC CIRCULAR NO. 14 - HYDRAULIC DESIGN OF ENERGY DISSIPATORS FOR CULVERTS AND CHANNELS - SEPTEMBER 1983

ASSUME NON-CIRCULAR CULVERT (CHANNEL) WITH COHESIONLESS MATERIAL AT END OF CULVERT (i.e. LOCATION OF SCOUR)

WNI - JEFFREY CITY, WYOMING

PMF Flow, Q =	1609	cfs	
Area of Flow, A =	154.07	ft^2	
Peak Flow Duration, t1 =	60	minutes	(1 hour storm event)
t0 =	316	minutes	(From reference #1
Ye =	8.78		
Discharge Intensity, D.I. =	1.24		

Coefficients of Scour for a Graded Sand:

	Alpha(e)	Beta	Theta
Depth of Scour	0.75	0.85	0.07
Width of Scour	4.78	0.76	0.06
Length of Scour	12.62	0.41	0.04
Volume of Scour	12.94	2.09	0.19

Depth of Scour, Hs =	7.0
Volume of Scour, Ws =	44.8
Length of Scour, Ls =	113.3

Location of Maximum Scour:

.4*Ls = 45.3 ft downstream of the end of the channel

SCOUR CALCULATIONS

South Diversion Apron - 10/11/93

SCOUR CALCLATIONS USING METHOD PRESENTED IN CHAPTER V OF U.S.D.O.T'S HYDRAULIC CIRCULAR NO. 14 - HYDRAULIC DESIGN OF ENERGY DISSIPATORS FOR CULVERTS AND CHANNELS - SEPTEMBER 1983

ASSUME NON-CIRCULAR CULVERT (CHANNEL) WITH COHESIONLESS MATERIAL AT END OF CULVERT (i.e. LOCATION OF SCOUR)

WNI - JEFFREY CITY, WYOMING

PMF Flow, Q =	4896	cfs	
Area of Flow, A =	293.37	ft^2	
Peak Flow Duration, t1 =	60	minutes	(1 hour storm event)
t0 =	316	minutes	(From reference #1,
Ye =	12.11		
Discharge Intensity, D.I. =	1.69		

Coefficients of Scour for a Graded Sand:

	Alpha(e)	Beta	Theta
Depth of Scour	0.75	0.85	0.07
Width of Scour	4.78	0.76	0.06
Length of Scour	12.62	0.41	0.04
Volume of Scour	12.94	2.09	0.19

Depth of Scour, Hs =	12.6
Volume of Scour, Ws =	78.1
Length of Scour, Ls =	177.4

Location of Maximum Scour:

.4*Ls = 70.9 ft downstream of the end of the channel

ATTACHMENT B

EXCERPTS FROM "HYDRAULIC DESIGN OF ENERGY DISSIPATORS FOR CULVERTS AND CHANNELS", HYDRAULIC CIRCULAR 14, 1983

CHAPTER V

ESTIMATING EROSION AT CULVERT OUTLETS

Estimating erosion at culvert outlets is difficult because of the many complex factors affecting erosion. Some of these factors are the discharge, culvert diameter, soil type, duration of flow and tailwater depth. In addition, the magnitude of the total erosion can consist of local scour and channel degradation, the two types of erosion discussed in Chapter II-8. Maintenance history, site reconnaissance and data on soils, flows and flow duration provide the best estimate of the potential erosion hazard at a culvert outlet.

The objective of this chapter is to present a method for predicting local scour at the outlet of structures based on soil and flow data and culvert geometry. This scour prediction is intended to serve together with the maintenance history and site reconnaissance information for determining energy dissipator needs.

Investigations (1), (3), indicate that the scour hole geometry varies with tailwater conditions with the maximum scour geometry occuring at tailwater depths less than half the culvert diameter (1); and that the maximum depth of scour (h_s) occurs at a location approximately 0.4 L_s downstream of the culvert outlet (3) where L_s is the length of scour.

Empirical equations defining the relationship between the culvert discharge intensity, time, and the length, width, depth, and volume of scour hole are presented for the maximum or extreme scour case.

Cohesionless Material

The general expression for determining scour geometry in a cohesionless soil for a circular pipe flowing full is

$$\text{Dimensionless Scour Geometry} = \alpha\left(\frac{Q}{\sqrt{g}\,D^{5/2}}\right)^{\beta}\left(\frac{t}{t_o}\right)^{\theta} \qquad \text{(V-1)}$$

where:

Dimensionless Scour Geometry is $\frac{h_s}{y_e}$, $\frac{W_s}{y_e}$, $\frac{L_s}{y_e}$, or $\frac{V_s}{y_e}$

h_s, W_s, L_s, and V_s are depth, width, length and volume of scour respectively.

D is the diameter of the culvert

Q is the discharge, g is the acceleration of gravity

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t is the time in minutes

t_o is a base time used in the experiments to derive coefficients (316 minutes unless specified otherwise).

For noncircular or part full culverts, the diameter D can be replaced by a n equivalent depth y_e, where y_e is defined as

$$y_e = (A/2)^{1/2}$$

and A is the cross sectional area of flow. Modifying Equation (V-1) to include the equivalent depth results in the general expression.

$$\text{Dimensionless Scour Geometry} = \alpha_e \left(\frac{Q}{\sqrt{g}\, y_e^{5/2}}\right)^{\beta} \left(\frac{t}{t_o}\right)^{\theta} \qquad \text{(V-2)}$$

where:

$\alpha_e = \alpha\, 0.63^{2.5\,\beta-1}$ for h_s, W_s, and L_s

$\alpha_e = \alpha\, 0.63^{2.5\,\beta-3}$ for V_s

values of the coefficients α_e, β, and θ in Equations V-1 and V-2 are given Table V-1.

Gradation

The cohensionless bed materials presented in Table V-1 are categorized as either uniform (U) or graded (G). The grain size distribution is determined by performing a sieve analysis (ASTM DA22-63). The standard deviation (σ) is computed as:

$$\sigma = \left(\frac{d_{84}}{d_{16}}\right)^{1/2}$$

where the values of d_{84} and d_{16} are extracted from the grain size distribution. If ≤ 1.5, the material is considered to be uniform; if ≥ 1.5, the material is classified as graded.

ohesive Soils

f the cohesive soil is a sandy clay similar to the one tested at Colorado State niversity by Abt et al (8), Equation (V-1) or (V-2) and the appropriate oefficients in Table V-1 can be used to estimate the scour hole dimensions. he sandy clay tested had 58 percent sand, 27 percent clay, 15 percent silt and percent organic matter; had a mean grain size of 0.15 mm and had a plasticity ndex, PI, of 15.

Since Equations V-1 and V-2 do not include soil characterisitcs, they can only be used for soils similar to the ones tested. Shear number expressions, that related scour to the critical shear stress of the soil, were derived to have a wider range of applicability for cohesive soils besides the one specific sandy clay that was tested. The shear number expressions for circular culverts are:

$$\left[\frac{h_s}{D}, \frac{W_s}{D}, \frac{L_s}{D}, \text{ or } \frac{V_s}{D}\right] = \alpha\left(\frac{\rho V^2}{\tau_c}\right)^{\beta}\left(\frac{t}{t_o}\right)^{\theta} \qquad \text{(V-3)}$$

and for other shaped culverts:

$$\left[\frac{h_s}{y_e}, \frac{W_s}{y_e}, \frac{L_s}{y_e}, \text{ or } \frac{V_s}{y_e}\right] = \alpha_e\left(\frac{\rho V^2}{\tau_c}\right)^{\beta}\left(\frac{t}{t_o}\right)^{\theta} \qquad \text{(V-4)}$$

where: $\frac{\rho V^2}{\tau_c}$ is the modified shear number

V = outlet mean velocity

τ_c = critical tractive shear stress

ρ = fluid density

$\alpha_e = \frac{\alpha}{.63}$ for h_s, W_s, and L_s

$\alpha_e = \frac{\alpha}{(.63)^3}$ for V_s

The values of the coefficients α, β, θ, and α_e in Equations V-4 and V-5 are presented in Table V-1. The critical tractive shear stress (2) is defined as

$$\tau_c = 0.0001\ (S_v + 180)\ \tan\ (30 + 1.73\ PI) \qquad \text{(V-5)}$$

where S_v is the saturated shear strength in pounds per square inch and PI is the Plasticity Index from the Atterberg Limits.

It is recommended that Equations V-3 and V-4 be limited to sandy clay soils with a plasticity index of 5-16.

Time of Scour

The time of scour is estimated based upon a knowledge of peak flow duration. Lacking this knowledge, it is recommended that a time of 30 minutes be used in Equations V-1, V-2, V-3, and V-4. The tests indicate that approximately 2/3 to 3/4 of the maximum scour occurs in the first 30 minutes ~~of the flow~~ duration.

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It should be noted that the exponents for the time parameter in Table V-1 reflect the relatively flat part of the scour-time relationship and are not applicable for the first 30 minutes of the scour process.

Headwalls

Installation of headwalls (6) flush with the culvert outlet moves the scour hole downstream. However, the magnitude of the scour geometries remain essentially the same as for the case without the headwall. If the culvert is installed with a headwall, the headwall should extend to a depth equal to the maximum depth of scour.

SUMMARY

The prediction equations presented in this chapter are intended to serve along with field reconnaissance as guidance for determining the need for energy dissipators at culvert outlets. It should be remembered that the equations do not include long-term channel degradation of the downstream channel. The equations are based on tests which were conducted to determine maximum scour for the given condition and therefore represent what might be termed worst case scour geometries. The equations were derived from tests conducted by the Corps of Engineers (1), and Colorado State University (5), (6), (7), (8) and (9).

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Design Procedure

1. Perform a hydrologic analysis of the drainage in which the culvert is located or to be placed. Estimate the magnitude and duration of the peak discharge. Express the discharge in cfs and the duration in minutes.

   The discharge intensity is

   $$D.I. = \frac{Q}{\sqrt{g}\, D^{5/2}} \text{ for circular culverts flowing full}$$

   $$D.I. = \frac{Q}{\sqrt{g}\, y_e^{5/2}} \text{ for other shapes}$$

   where $y_e = \left(\frac{A}{2}\right)^{1/2}$

   FOR COHESIONLESS MATERIALS, OR THE 0.15mm SANDY CLAY

2. Compute the discharge intensity when the culvert is flowing at the peak discharge.

3. Determine scour coefficients from Table V-1.

4. Compute the scour hole dimensions from

   $$\left[\frac{h_s}{D}, \frac{W_s}{D}, \frac{L_s}{D}, \text{ or } \frac{V_s}{D^3}\right] = \alpha \left(\frac{Q}{\sqrt{g}\, D^{5/2}}\right)^{\beta} \left(\frac{t}{316}\right)^{\theta} \qquad \text{(V-1)}$$

   or

   $$\left[\frac{h_s}{y_e}, \frac{W_s}{y_e}, \frac{L_s}{y_e}, \text{ or } \frac{V_s}{y_e}\right] = \alpha_e \left(\frac{Q}{\sqrt{g}\, y_e^{5/2}}\right)^{\beta} \left(\frac{t}{316}\right)^{\theta} \qquad \text{(V-2)}$$

   FOR OTHER COHESIVE MATERIALS WITH PI FROM 5 TO 16

   a. Compute the culvert outlet velocity in feet/sec.

   b. Obtain a soil sample at the proposed culvert location.

   c. Perform Atterberg limits tests and determine the plasticity index, PI (ASTM D423-36).

d. Saturate a sample and perform an unconfined compressive test (ASTM D211-66-76) to determine the saturated shear stress, Sv, in pounds per square inch.

e. Compute the critical tractive shear strength, τ_c, from equation V-5.

f. Compute the modified shear number $\frac{\rho v^2}{\tau_c}$

3. Determine scour coefficients from Table V-1.

4. Compute the desired scour hole dimensions from

$$\left[\frac{h_s}{D}, \frac{W_s}{D}, \frac{L_s}{D}, \text{ or } \frac{V_s}{D}\right] = \alpha \left(\frac{V^2}{\tau_c}\right)^{\beta} \left(\frac{t}{316}\right)^{\theta}$$

for circular culvert

or

$$\left[\frac{h_s}{Y_e}, \frac{W_s}{Y_e}, \frac{L_s}{Y_e}, \frac{V_s}{Y_e^3}\right] = \alpha_e \left(\frac{V^2}{\tau_c}\right)^{\beta} \left(\frac{t}{316}\right)^{\theta}$$

for noncircular culverts.

Example Problem Cohesionless Material

Determine the scour geometry--maximum depth, width, length and volume of scour--for a proposed circular 30-inch C.M.P. discharging an estimated 50 cfs when flowing full. The downstream channel is composed of a graded gravel material.

1. The duration of the peak discharge of 50 cfs is not known. Therefore, a peak flow duration of 30 minutes will be estimated.

2. The circular, 30-inch C.M.P. at 50 cfs will have a discharge intensity of

$$D.I. = \frac{50}{\sqrt{g}\,\left(\frac{30}{12}\right)^{5/2}} = \frac{50}{(5.67)(2.5)^{5/2}} = 0.89$$

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3. The coefficients of scour obtained from Table V-1 are:

	α	β	θ
Depth of Scour	1.49	.50	.03
Width of Scour	8.76	0.89	.10
Length of Scour	13.09	0.62	.07
Volume of Scour	42.31	2.28	.17

4. Scour hole dimensions:

depth: $\frac{h_s}{D} = \alpha\left(\frac{\bar{U}}{\sqrt{g}\,D^{2.5}}\right)^{\beta}\left(\frac{t}{316}\right)^{\theta}$

$= 1.49\ (0.89)^{0.50}\ (0.09)^{.03};\ h_s = 3.27$ ft

width: $\frac{W_s}{D} = 8.76(0.89)^{0.89}\ (.09)^{.10};\ W_s = 15.5$ ft

Length: $\frac{L_s}{D} = 13.09(0.89)^{0.62}\ (.09)^{.07};\ L_s = 25.72$ ft

Volume: $\frac{V_s}{D^3} = 42.31(0.89)^{2.28}\ (.09)^{.17};\ V_s = 335.79\ ft^3$

5. The location of the maximum scour (Figure V-2)

$0.4\ (L_s) = .4\ (25.72) = 10.3$ ft downstream of the culvert outlet.

Table V-1. Experimental Coefficients for Culvert Outlet Scour

MATERIAL	NOMINAL GRAIN SIZE d_{50} (mm)	SCOUR EQUATION	DEPTH h_s				WIDTH W_s				LENGTH L_s				VOLUME V_s			
			α	β	θ	α_c	α	β	θ	α_c	α	β	θ	α_c	α	β	θ	α_c
Uniform Sand	0.20	V-1 or V-2	2.32	.375	0.10	2.39	11.73	0.92	.15	6.44	16.82	0.71	0.125	11.76	203.36	2.0	0.325	80.71
Uniform Sand	2.0	V-1 or V-2	1.86	0.45	0.09	1.76	8.46	0.57	0.06	6.94	10.28	0.51	0.17	16.10	101.48	1.41	0.34	79.62
Graded Sand	2.0	V-1 or V-2	1.22	0.85	0.07	.75	7.25	0.76	0.06	4.78	12.77	0.41	0.04	12.62	36.17	2.09	0.19	12.94
Uniform Gravel	8.0	V-1 or V-2	1.78	0.45	0.04	1.68	9.13	0.62	0.08	7.08	14.36	0.95	0.12	7.61	65.91	1.86	0.19	12.15
Graded Gravel	8.0	V-1 or V-2	1.49	0.50	0.03	1.33	8.76	0.89	0.10	4.97	13.09	0.62	0.07	10.15	42.31	2.28	0.17	32.82
Cohesive Sandy Clay 80% Sand PI 15	0.15	V-1 or V-2	1.86	0.57	0.10	1.53	8.63	0.35	0.07	9.14	15.30	0.43	0.09	14.78	79.73	1.42	0.23	61.81
Clay PI 5-16	Various	V-3 or V-4	0.86	0.18	0.18	1.37	3.55	0.17	0.07	5.63	2.82	0.33	0.09	4.48	0.62	0.93	0.23	2.48

EQUATIONS:

V-1. FOR CIRCULAR CULVERTS. Cohesionless material or the 0.15mm cohesive sandy clay

$$\left(\frac{h_s}{D}, \frac{W_s}{D}, \frac{L_s}{D}, \text{ or } \frac{V_s}{D^3}\right) = \alpha\left(\frac{Q}{\sqrt{g}\,D^{5/2}}\right)^{\beta}\left(\frac{t}{t_o}\right)^{\theta}$$

where t_o = 316 min.

V-2. FOR OTHER CULVERTS SHAPES. Same material as above.

$$\left(\frac{h_s}{y_o}, \frac{W_s}{y_o}, \frac{L_s}{y_o}, \text{ or } \frac{V_s}{y_o^3}\right) = \alpha_o\left(\frac{V}{\sqrt{g}\,y_o^{3/2}}\right)^{\beta}\left(\frac{t}{t_o}\right)^{\theta}$$

where t_o = 316 min.

V-3. FOR CIRCULAR CULVERTS. Cohesive sandy clay with PI = 5-16

$$\left(\frac{h_s}{D}, \frac{W_s}{D}, \frac{L_s}{D}, \text{ or } \frac{V_s}{D^3}\right) = \alpha_c\left(\frac{\sigma V^2}{\tau_c}\right)^{\beta}\left(\frac{t}{t_o}\right)^{\theta}$$

where: t_o = 316 min.

V-4. FOR OTHER CULVERT SHAPES. Cohesive sandy clay with PI = 5-16

$$\left(\frac{h_s}{y_o}, \frac{W_s}{y_o}, \frac{L_s}{y_o}, \text{ or } \frac{V_s}{y_o^3}\right) = \alpha_o\left(\frac{\sigma V^2}{\tau_c}\right)^{\beta}\left(\frac{t}{t_o}\right)^{\theta}$$

where: t_o = 316 min.

C.3

REVISED ROCK GRADATION ANALYSIS

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REVISED GRADATION ANALYSIS
WESTERN NUCLEAR, INC.

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GRADATION ANALYSIS
WESTERN NUCLEAR, INC.

PURPOSE. The purpose of this calculation brief is to determine the gradation requirements and layer thickness for the riprap and filters in the diversion ditches at WNI's Split Rock Mill and Tailing's site in Jeffrey City, Wyoming. The riprap D_{50} size used in the gradation analysis are based on Probable Maximum Flood (PMF) using the U.S. Army Corp of Engineers Method. (See Appendix B.)

METHOD.

1) Riprap gradations requirements are determined using the methods described in "Surface Mining Water Diversion Manual", by Simons (1982)

2) Filter rock gradation requirements are based on the

$$\frac{D_{15\ (riprap)}}{D_{85\ (filter)}}$$

ratio and the

$$\frac{D_{15\ (filter)}}{D_{85\ (base)}}$$

ratio where D_{15} is the grain diameter where 15% of the material is finer by weight and D_{85} is the grain diameter where 85% of the material is finer by weight. The criteria for these ratios are described in NUREG 4620 (1986) and Sherard, et. al. (1984).

RESULTS. There are four different riprap gradation types ranging from D_{50} = 18.0 inches to D_{50} = 3 inches and two filter gradations that will be used for riprap rock and filter rock in the diversion ditches. Table C.3.1 (page C-158) summarizes the gradation types by percent finer by weight for specific rock sizes. The gradation types (A,B,C, and D) shown on Table C.3.1 (page C-158) were determined by listing the minimum required D_{50} values for each ditch reach in descending order. This list is shown on Table C.3.4 (page C-161).

Each riprap gradation type has at least one 6 inch filter layer, labeled as FILTER 1. Additionally, riprap types A, B, and C have a second intermediate filter gradation because these gradations are too large to be protected by a single filter gradation. This second filter is labeled

as FILTER II $_{ABC}$.

Table C.3.2 (page C-159) lists the D_{max}, D_{50}, and D_{10} ranges of sizes for each gradation type. How these ranges were determined is discussed in the calculation section below.

Table C.3.3 (page C-160) summarizes the filters required for each gradation type and the placement location.

CALCULATIONS

1) Riprap Gradation Requirements. The procedure to determine the riprap is as follows a) Group D_{50} values by ditches requiring similar D_{50}'s, b) Determine D_{max}, D_{20}, and D_{10}, and c) Plot the riprap envelope. Each of these steps is discussed below.

a) Grouping. D_{50} values for each of the diversion ditches at the Split Rock Mill and Tailing's site have been calculated in Section C.1. No oversizing based on durability and roundness was required for the riprap. The D_{50} sizes were arranged in descending order and grouped based on similar D_{50} sizes. The largest D_{50} of each grouping was selected as a design D_{50} for the entire group. Table C.3.4 (page C-161) summarizes this procedure. Each of the group areas have been assigned a letter (A,B,C, or D) to facilitate calculations.

b) D_{max}, D_{20}, and D_{10} determination. Simons (1982) recommends that D_{max} be determined based on the Froude number as follows:

D_{max}	Slope	Froude Number, F_R
$2XD_{50}$	Mild	$F_R < 1$
$1.25XD_{50}$	Steep	$F_R > 1$

The Froude number, F_R is determined as follows:

$$F_R = V/\sqrt{gL}$$

where V = velocity in ditch, fps

L = Characteristics Length, ft

$$= \frac{\text{cross sectional area of water in ditch, ft}^2}{\text{topwidth at free surface, ft}}$$

g = acceleration of gravity, 32.2ft/sec^2

Ditch dimension, depth of flow, and velocities for the diversion ditches were obtained from Appendix B. Table C.3.5 (page C-162) summarizes the Froude number calculations for each diversion ditch.

D_{20} and D_{10} are determined from these relationships:

$$D_{20} = D_{50} /2$$

$$D_{10} = D_{50} /3$$

found in Simons (1982).

Table C.3.6 (page C-163) summarizes D_{max}, D_{50}, D_{20}, and D_{10} sizes for gradation types A,B,C, and D.

c) Riprap Envelope Development. To provide flexibility during reclamation, a range of particle sizes for each gradation is developed. A lower limit curve is drawn using calculated D_{max}, D_{50}, D_{20}, and D_{10} values. An upper limit curve is then drawn with the intent of maintaining a well graded riprap layer and providing a range of required riprap sizes. The Corp of Engineers recommend a coefficient, C_u, $\geq$ 1.75 for well graded riprap (NUREG 4651). This will be used as a guide in determining the envelopes. Figures C.3.1 (page C-167) through C.3.4 (page C-170) show riprap gradation envelopes.

2) Filter Rock Gradation Requirements. To prevent the fine grained soils (base) from migrating into the riprap layer, one or more layers of rock filter is placed beneath the riprap. The filter size is determined by the $D_{15(base)}/D_{85(filter)}$ ratio. The particle size distribution is extrapolated from this point to form a well graded gradation (i.e.$C_u \geq 1.75$).

$$\frac{D_{15}\text{ (filter)}}{D_{85}\text{ (base)}} \leq 5 \quad (1)$$

This is the criteria used for filters in earthen dams which are exposed to significantly higher hydraulic gradients. Since these conditions are typically not present in open ditches, the criteria is overly conservative.

Sherard (1984) performed several tests on filters overlying sands and gravels and concluded:

$$\frac{D_{15}\text{ (filter)}}{D_{85}\text{ (base)}} \leq 9 \qquad (2)$$

This ratio increased significantly for finer filters that are used for silts and clays but may be less conservative for coarser or gravel filters.

The average particle size is determined for the base soil. The riprapped diversion ditches will be constructed over the soil cover overlying the tailing sands or in the native soil. In either case, the base soil will consist of the native soils. In the areas where diversion ditch are constructed through tailing, a six-inch layer of native soil will be placed to act as a filter between the cody shale radon barrier and Filter I.

Table C.3.7 (page C-164) shows the percent finer of borrow or native soils based on 132 samples collected by Canonie during the 1991 borrow soil investigation.

Since the base soils have some fines (#200 5.5%), the size of the filter with respect to the base will be determined by criteria (2). The size of the filter with respect to the riprap may be determined by criteria (1).

If the filter gradations developed with respect to the riprap and base overlap, the filter is adequate. However, if the two do not overlap, a second filter is required. The second filter (FILTER II) is determined as described above, but FILTER I is used as the base material. If the second filter gradation overlaps the filter gradation with respect to the riprap, then the second filter is adequate. The average particle size between the overlapping gradations is used as the design gradation for the second filter. Table C.3.8 (page C-165) summarizes the D_{85} and D_{15} sizes calculated according to the criteria and procedure discussed above. Figures C.3.5 (page C-171) through C.3.8 (page C-174) show the base, filter, and riprap gradations.

REFERENCES

Simons, Li & Associates, Inc. "Surface Mining Water Diversions Design Manual", U.S. Dept. of The Interior, OSRA/TR-52/2; Sept. 1982

NUREG 4620 "Methodologies For Evaluating Long-Term Stabilization Designs of Uranium Mill Tailing Impoundments", June, 1986.

L. Sherard ET, AL, "Basic Properties of Sand and Gravel Filters", Journal of Geotechnical Engineering Volume 110; No.6, June 1984.

Final Staff Technical Position Design of Erosion Protection Covers For Stabilization of Uranium Mill Tailing Sites", NRC 1990.

NUREG 4651, "Development of Riprap Design Criteria By Riprap Testing In Flumes: Phase II", Sept. 1988.

TABLES

Table C.3.1

Gradation Requirements

RIRAP TYPE	Percent Finer By Weight														D_{50} (in)	LAYER THICKNESS (inches)
	24"	20"	15"	12"	10"	6"	4"	3"	2"	1"	3/4"	1/2"	3/8"	Sieve 4		
A	100	30-60	15-37	10-32	4-20	0-10	0-5	0-1							18	27
B		100	30-100	25-50	17-42	5-20	0-13	0-10	0-6	0-1					12	18
C			100	85-100	71-92	30-50	10-35	2-20	0-10						6	12
D					100	89-100	55-69	35-50	10-30	0-10	0-6				3	6.0
FILTER I									100	85-95	61-78	38-52	26-39	10-21	.62	6.0
FILTER IIABC						100	56-74	32-51	12-26	0-1					3.0	6.0

Table C.3.2

Dmax, D_{50}, and D_{10} Sizes for Riprap and Filters for Gradation Types

RIRAP GRADATION TYPE	RIPRAP			FILTER I			FILTER II		
	D_{max} (in)	D_{50} (in)	D_{10} (in)	D_{max} (in)	D_{50} (in)	D_{10} (in)	D_{max} (in)	D_{50} (in)	D_{10} (in)
A	22.5 - 30	18 - 26	6 - 12	1.5 - 1.8	0.47 - 0.63	0.12 - 0.19	5.4 - 6.0	3.0 - 3.7	1.4 - 1.9
B	15 - 18	12 - 14	4 - 8.5	1.5 - 1.8	0.47 - 0.63	0.12 - 0.19	5.4 - 6.0	3.0 - 3.7	1.4 - 1.9
C	12 - 17	6 - 9	2 - 4	1.5 - 1.8	0.47 - 0.63	0.12 - 0.19	NR	NR	NR
D	6 - 7	3 - 3.75	1 - 1	1.5 - 1.8	0.47 - 0.63	0.12 - 0.19	NR	NR	NR

NR = Not required

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Revised April 15

Table C.3.3

Filters and Locations for Riprap Types

RIPRAP TYPE	FILTER TYPES(S)	LOCATION
A	I, II_{ABC}	North 0+00 - 1+00 North 29+50 - 56+00 South 45+00 - 66+00 South Confluence 2 & 4 North Central Confluence 1
B	I,II_{ABC}	North Confluence 1 Swale 21+50 - 28+95 North Central 4+95 - 11+90 South Confluence 1 & 3 South Central 6+50 - 8+00
C	I	North 56+00 - 57+60 South 66+00 - 67+00 South Central 0+00 - 6+50 South Central 8+00 - 24+00
D	I	Swale 2+00 - 21+50 North 1+00 - 29+50 North Central 0+00 - 4+95 North Central 11+90 - 15+75 South 0+00 - 45+00

Table C.3.4

D_{50} Groupings

DIVERSION DITCH	STATION	NECESSARY D_{50} (inches)	DESIGN D_{50} (inches)	% OVERSIZE	RIPRAP GROUP
NORTH	0+00 - 1+00 29+50 - 30+00 30+00 - 46+50 46+50 - 53+00 53+00 - 56+00	18 15 18 15 18	18	0 20 0 20 0	A
NORTH CENTRAL	CONFLUENCE 1	13	18	38.5	A
SOUTH	45+00 - 66+00 CONFLUENCE 2 CONFLUENCE 4	18 16 16		0 12.5 12.5	
SWALE	21+50 - 28+95	12	12	0	B
NORTH	CONFLUENCE 1	12		0	
NORTH CENTRAL	4+95 - 11+90	12		0	
SOUTH	CONFLUENCE 1 CONFLUENCE 3	8 10	12	50 20	B
SOUTH CENTRAL	6+50 - 8+50	12		0	
NORTH	56+00 - 56+65 56+65 - 57+60	6 4	6	0 50	C
SOUTH	66+00 - 67+00	6		0	
SOUTH CENTRAL	0+00 - 6+50 8+00 - 24+00	4 6	6	50 0	C
SWALE	2+00 - 21+50	2	3	33	D
NORTH	1+00 - 29+50	3		0	
NORTH CENTRAL	0+00 - 4+95 11+90 - 15+15 15+15 - 15+75	3 3 2		0 0 33	
SOUTH	0+00 - 45+00	3		0	

Table C.3.5
Froude Number Calculations for Diversion Ditches

DITCH	STATION	INCLUDED REACHES	SLOPE (ft/ft)	BOTTOM WIDTH (ft)	SIDE SLOPE (ft:ft)	DEPTH OF FLOW (ft)	VELOCIT OF FLOW (ft/sec)	FROUDE NUMBER (Fr)	RIPRAP GROUP
North Transition	0+00 to 1+00	Transition	0.0598	15	3:1	3.26	13.79	1.6	A
North	29+50 to 30+00	N3	0.0387	15	3:1	5.32	15	1.4	A
North	30+00 to 46+50	N3,N4,N5	varies	15	3:1	7.03	16.6	1.4	A
North	46+50 to 53+00	N6	0.02	15	3:1	7.71	15.74	1.3	A
North	53+00 to 56+00	N7	0.03	15	3:1	7.65	17.16	1.4	A
South	45+00 to 48+00	S3	varies	15	3:1	6.3	14.84	1.3	A
South	48+00 to 66+00	S4,S5	varies	15	3:1	7.7	16.69	1.3	A
Swale	21+50 to 28+95	SW3	0.0409	15	varies	3.42	11.98	1.4	B
South Central	6+50 to 8+00	SC1	0.04	15	3:1	2.87	11.79	1.4	B
North Central	4+95 to 11+90	NC2	varies	15	3:1	2.6	7.95	1.0	B
North	56+00 to 57+60	N7	0.005	15	3:1	6.39	17.9	1.6	C
South Central	0+00 to 6+50	SC1	0.0069	15	3:1	3.49	8.98	1.0	C
South Central	8+00 to 15+50	SC1	0.0154	15	3:1	3.32	9.66	1.3	C
South Central	15+50 to 23+00	SC1,SC2	varies	15	3:1	5.07	10.5	1.0	C
South Central	23+00 to 24+00	SC2	0.0068	15	3:1	4.3	10.2	1.0	C
South Transition	0+00 to 1+00	Transition	0.065	15	3:1	0.32	4.66	1.5	C
South	66+00 to 67+00	S5	0.005	15	3:1	5.99	19.31	1.7	C
South*	2100*	S2	0.009	15	3:1	5.56	9.12	0.8	C
North	1+00 to 29+50	N1,N2,N3	0.005	15	3:1	6.6	8.52	0.7	D
Swale	2+00 to 21+50	SW1,SW2	varies	15	16:1	3.56	6.26	0.7	D
North Central	0+00 to 4+95	NC1	0.005	15	3:1	3.46	3.72	0.4	D
North Central	11+90 to 14+75	NC2,NC3	varies	15	3:1	4.65	7.14	0.7	D
North Central	14+75 to 15+15	NC3	0.005	15	3:1	3.86	9.36	1.0	D
North Central	15+15 to 15+75	NC3	0.005	15	3:1	2.75	5.99	0.7	D
South	1+00 to 45+00	S1,S2,S3	varies	15	3:1	7.79	6.87	0.6	D

* Included to show that some of the flow within reaches containing 6 inch rock is sub-critical

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Table C.3.6

Calculated Grain Sizes for Riprap Gradation Types

Gradation Type	Dmax (1) (in)	D50 (2) (in)	D20(3) (in)	D10(4) (in)
A	22.5	18.0	9.0	6.0
B	15.0	12.0	6.0	4.0
C	12.0	6.0	3.0	2.0
D	6.0	3.0	1.5	1.0

1) Dmax = 1.25*D50 when Fr $\geq$ 1
Dmax = 2.0*D50 when FR < 1

2) D50 see Table C.3.4

3) D20 = D50/2 (Simons 1982)

4) D10 = D50/3 (Simons 1982)

Table C.3.7

Base Soil Gradation

	Particle mm	Size inches	Percent Finer by Weight
	9.5	0.374	99.9
	4.75	0.187	99.9
	2.36	0.093	99.5
	1.18	0.046	94.5
	0.60	0.024	79.3
	0.30	0.012	48.2
	0.15	0.006	15.9
(#200)	0.075	0.003	5.5

Table C.3.8

Dmax, D_{15}, and D_{85} Sizes for Filters

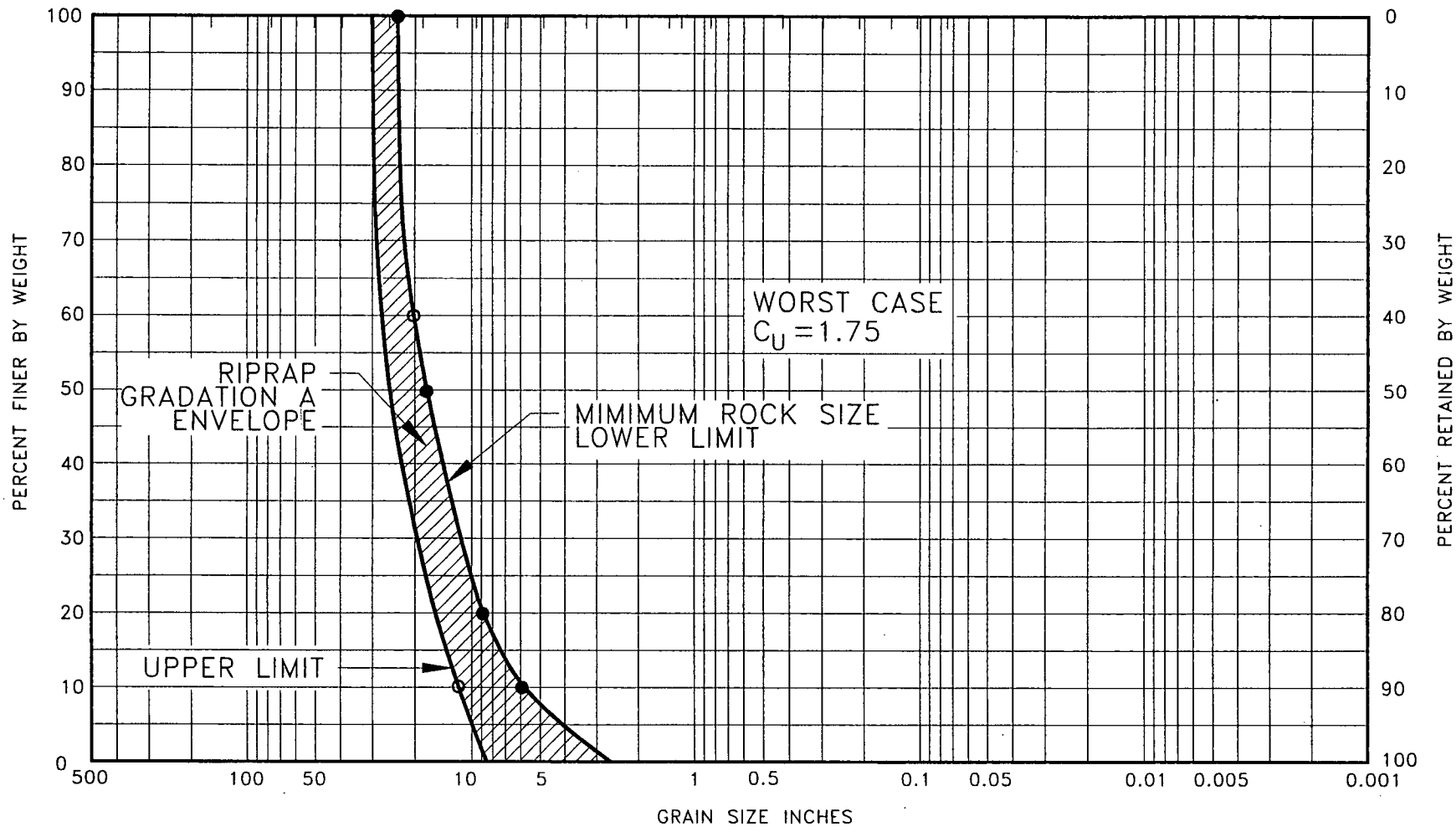
RIRAP GRADATION TYPE	MINIMUM FILTER SIZE WITH RESPECT TO RIPRAP		FILTER WITH RESPECT TO BORROW SOIL BASE			[6]SECOND FILTER REQUIRED?	FILTER II WITH RESPECT TO FILTER I		[9]THIRD FILTER REQUIRED?
	[1]RIPRAP D_{15} (in)	[2]FILTER D_{85} (in)	[3]BASE D_{85} (in)	FILTER I					
				[4]D_{15} (in)	[5]D_{85} (in)		[7]D_{15} (in)	[8]D_{85} (in)	
A	15	3.0	0.29	0.261	1.0	YES	5.0	10.2	NO
B	9	1.8	0.29	0.261	1.0	YES	5.0	10.2	NO
C	4.5	0.9	0.29	0.261	1.0	NO	NA	NA	NA
D	2.2	0.44	0.29	0.261	1.0	NO	NA	NA	NA

Notes:

1) Riprap D_{15} determined from pages C- to C-
2) $D_{85Filter} = D_{15Riprap}/5$
3) D_{85Base} from average of 132 borrow soil samples, interpolated after plotting
4) $D_{85Filter} = 9 * D_{85Base}$
5) $D_{85Filter}$ determined from well graded curve using $D_{15Filter}$
6) Second filter required if filter gradation with respect to base does not overlap filter gradation with respect to riprap
7) $D_{15FilterII} = 5 * D_{85FilterI}$
8) $D_{85FilterII}$ determined from well graded gradation curve using $D_{15FilterII}$
9) Third filter required if filter gradation with respect to Filter I does not overlap the filter gradation with respect to riprap

C/90

FIGURES



SMI
STEPHE[illegible]ILLER, INC.

FIGURE C.3.1
RIPRAP G[illegible]ATION A

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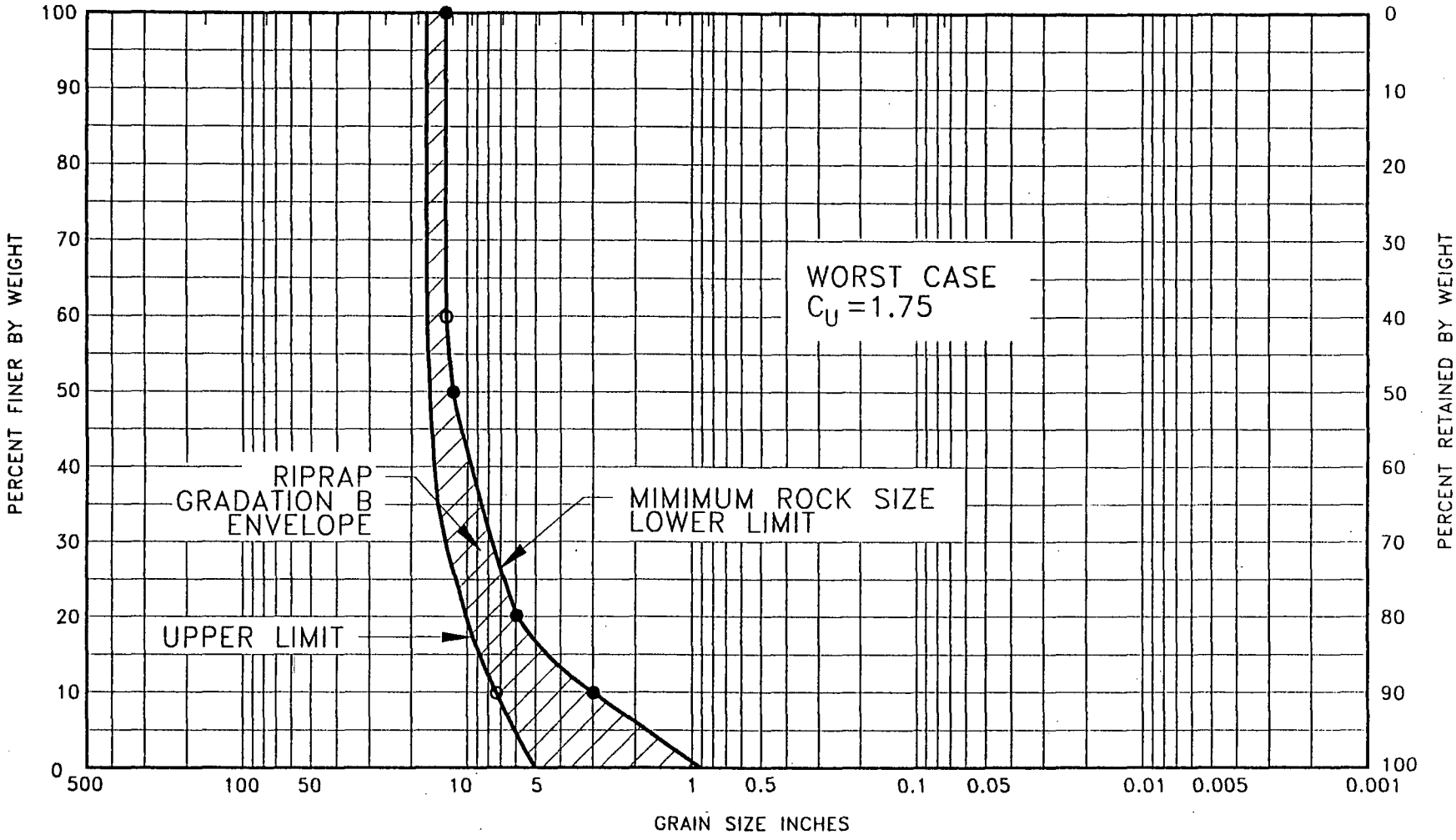
Project:	336[illegible]
File:	G[illegible]1

C161



REVISED MARCH 1994

C 168

SMI
SHEPHERD MILLER, INC.

FIGURE C.3.2
RIPRAP GRADATION B

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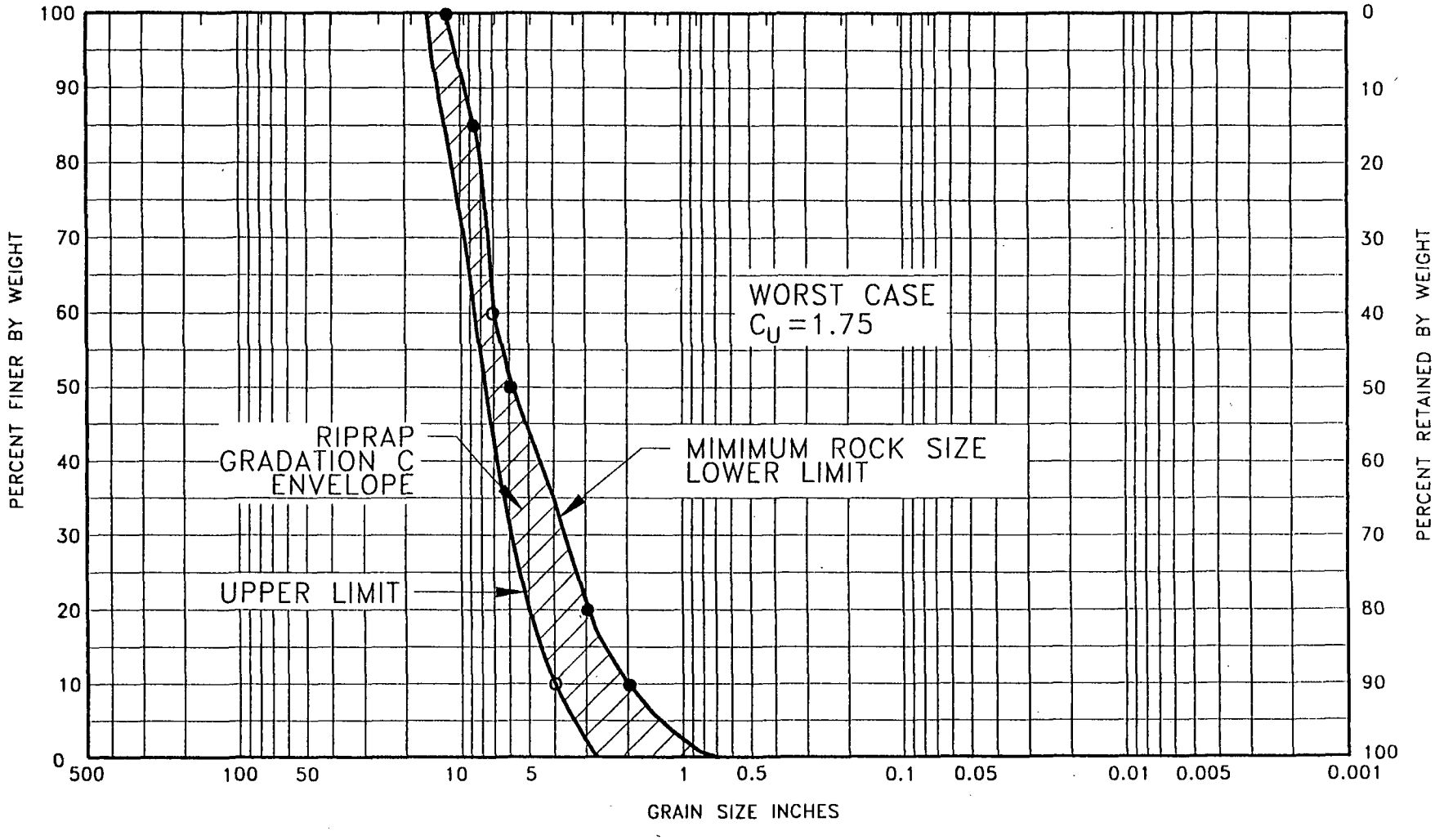
Project: 336
File: GSD-2



REVISED MARCH 1994

C 169

SMI
SHEPHE[illegible]ILLER, INC.

FIGURE C.3.3
RIPRAP GRADATION C

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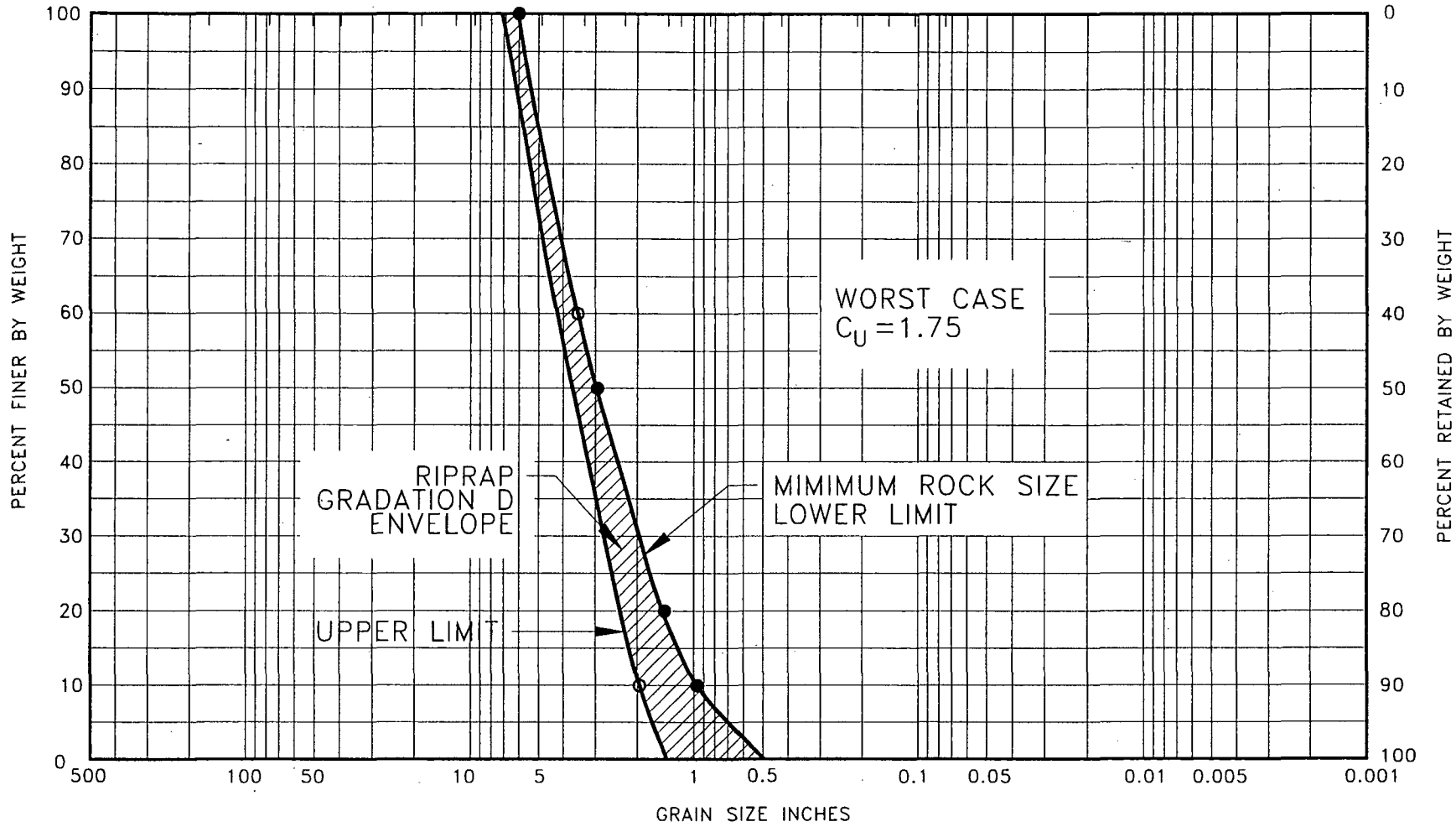
Project: 336
File: G[illegible]



SMI
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FIGURE C.3.4
RIPRAP GRADATION D

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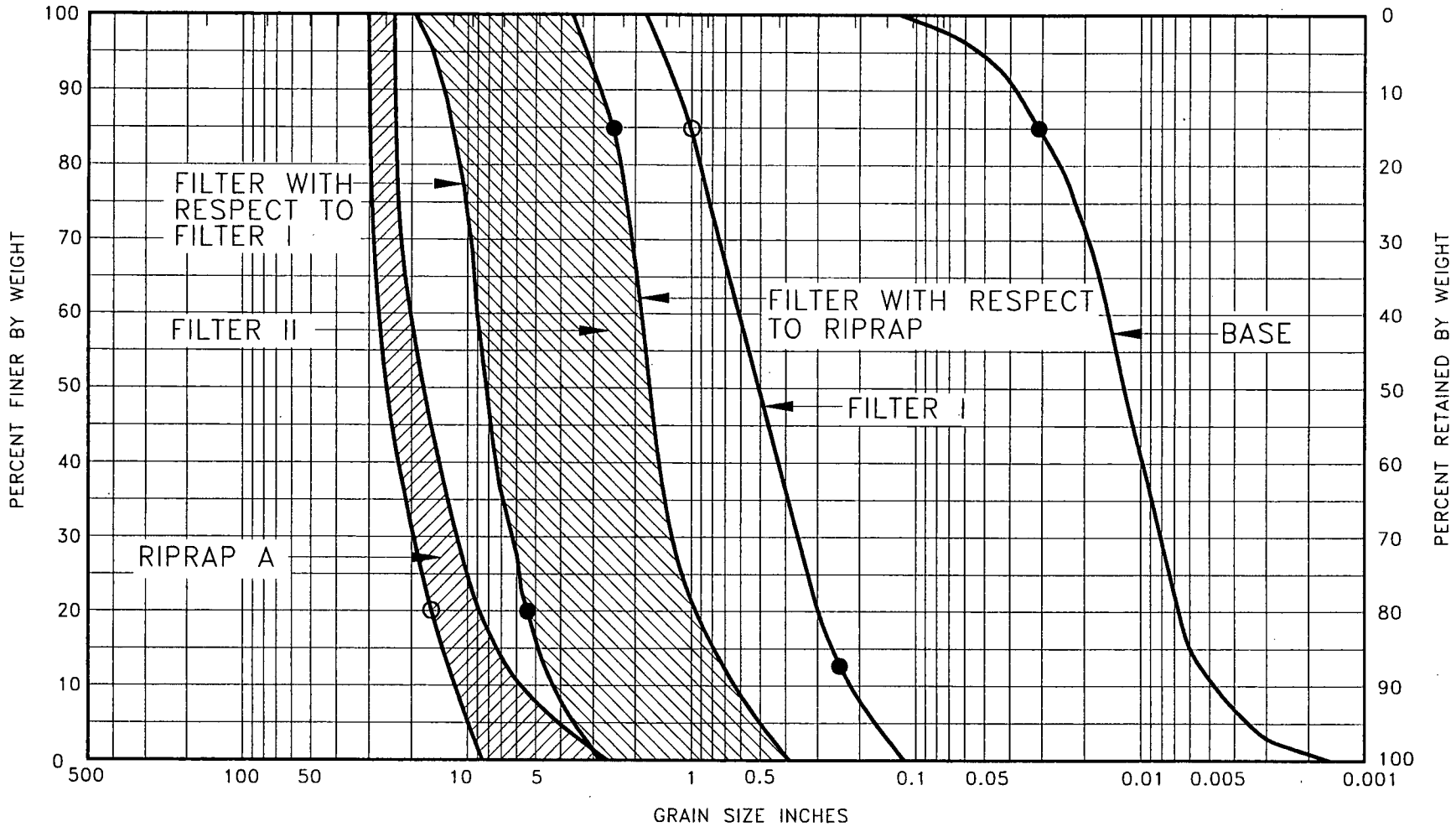
Project:	336
File:	GSD-4

C76



SMI
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FIGURE C.3.5
FILTER REQUIREMENT
RIPRAP GRADATION A

Date:	OCT., 1993
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C71

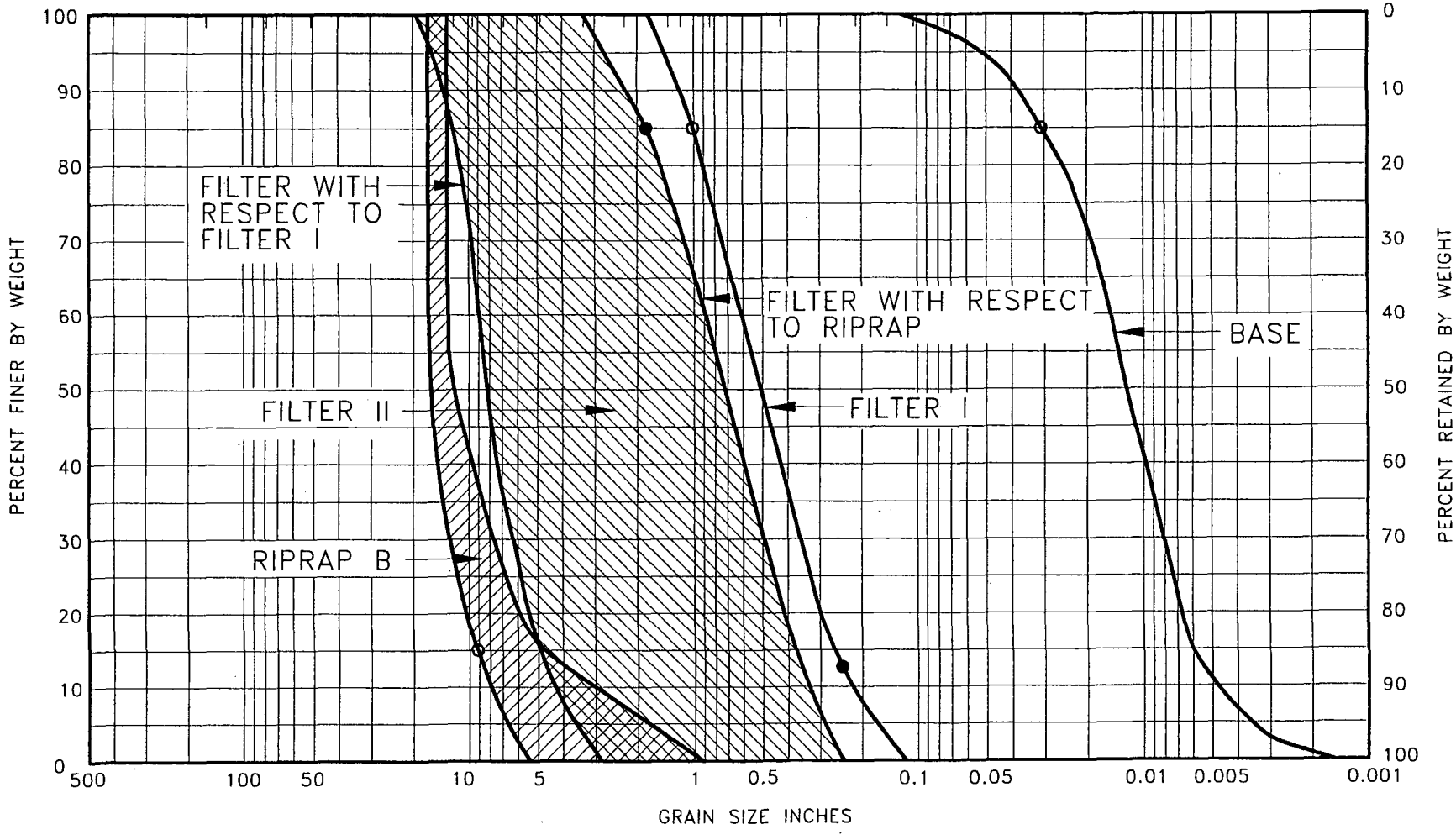

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FIGURE C.3.6
FILTER REQUIREMENT
RIPRAP GRADATION B

Date:	OCT., 1993
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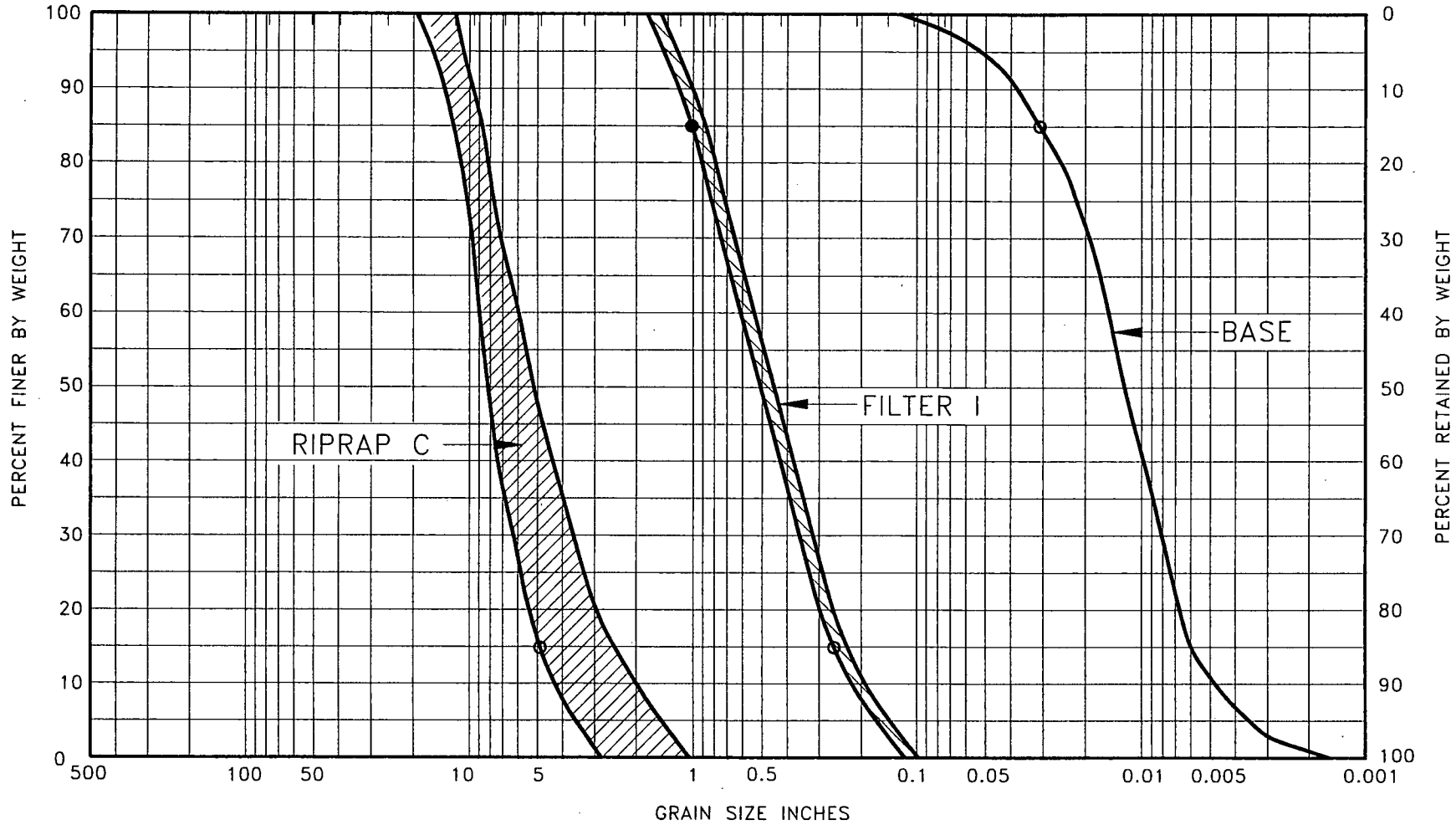
C172



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SHEPHE[illegible]LLER, INC.

FIGURE C.3.7
FILTER REQUIREMENT
RIPRAP GR[illegible]ATION C

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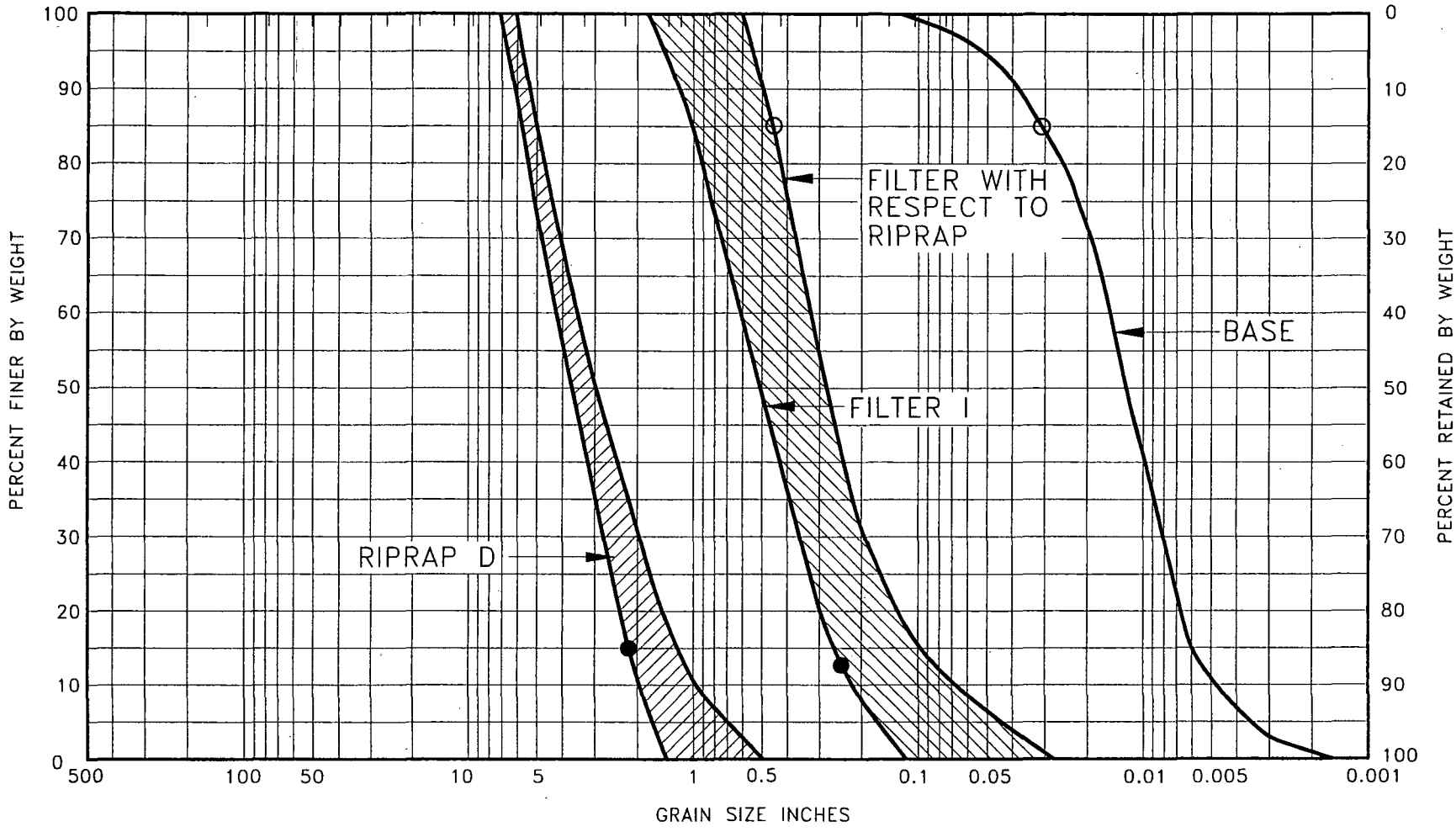
C173



SMI
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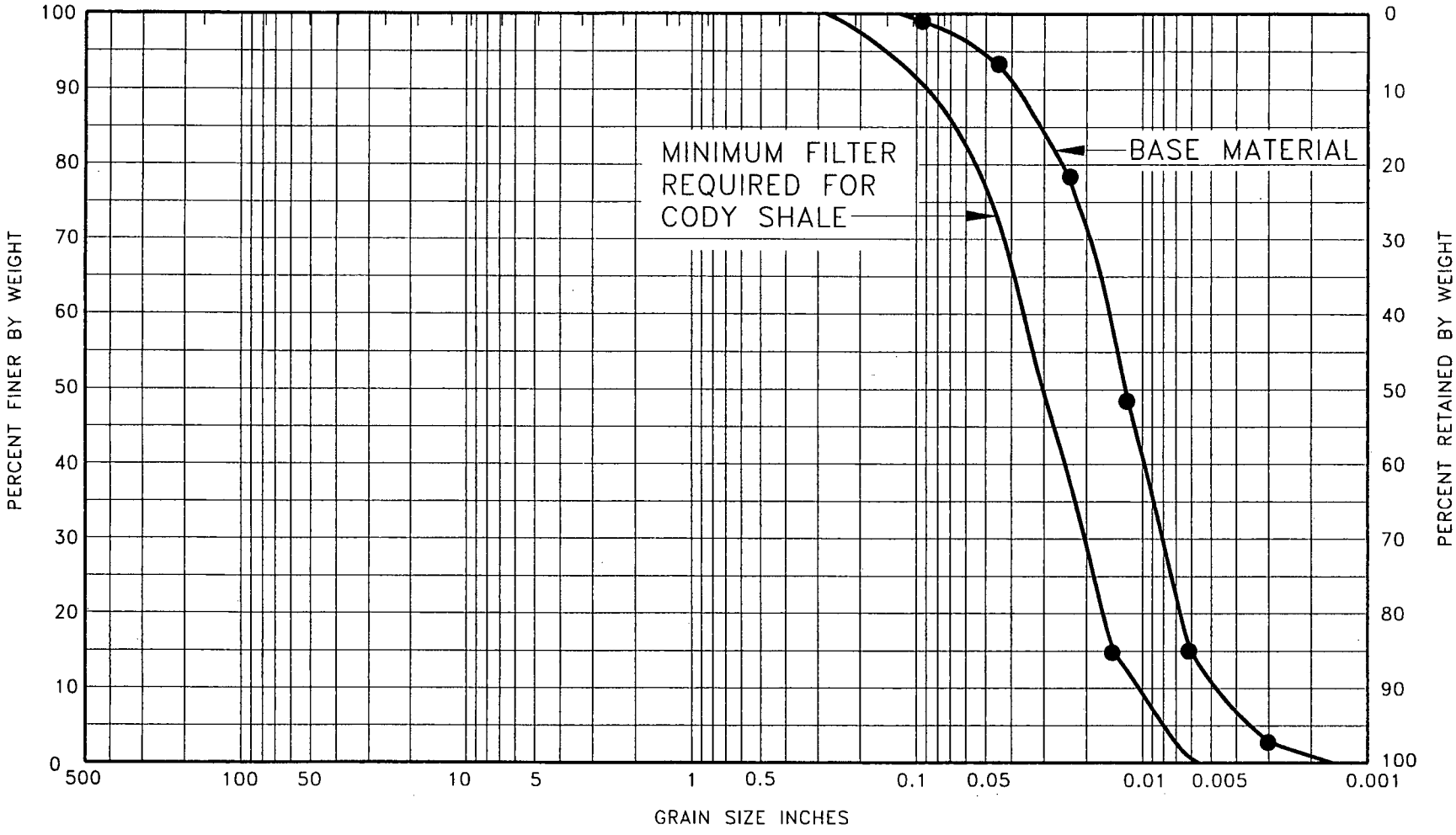
FIGURE C.3.8
FILTER REQUIREMENT
RIPRAP GRADATION D

Date:	OCT., 1993
Project:	336
File:	GSD-8

C174



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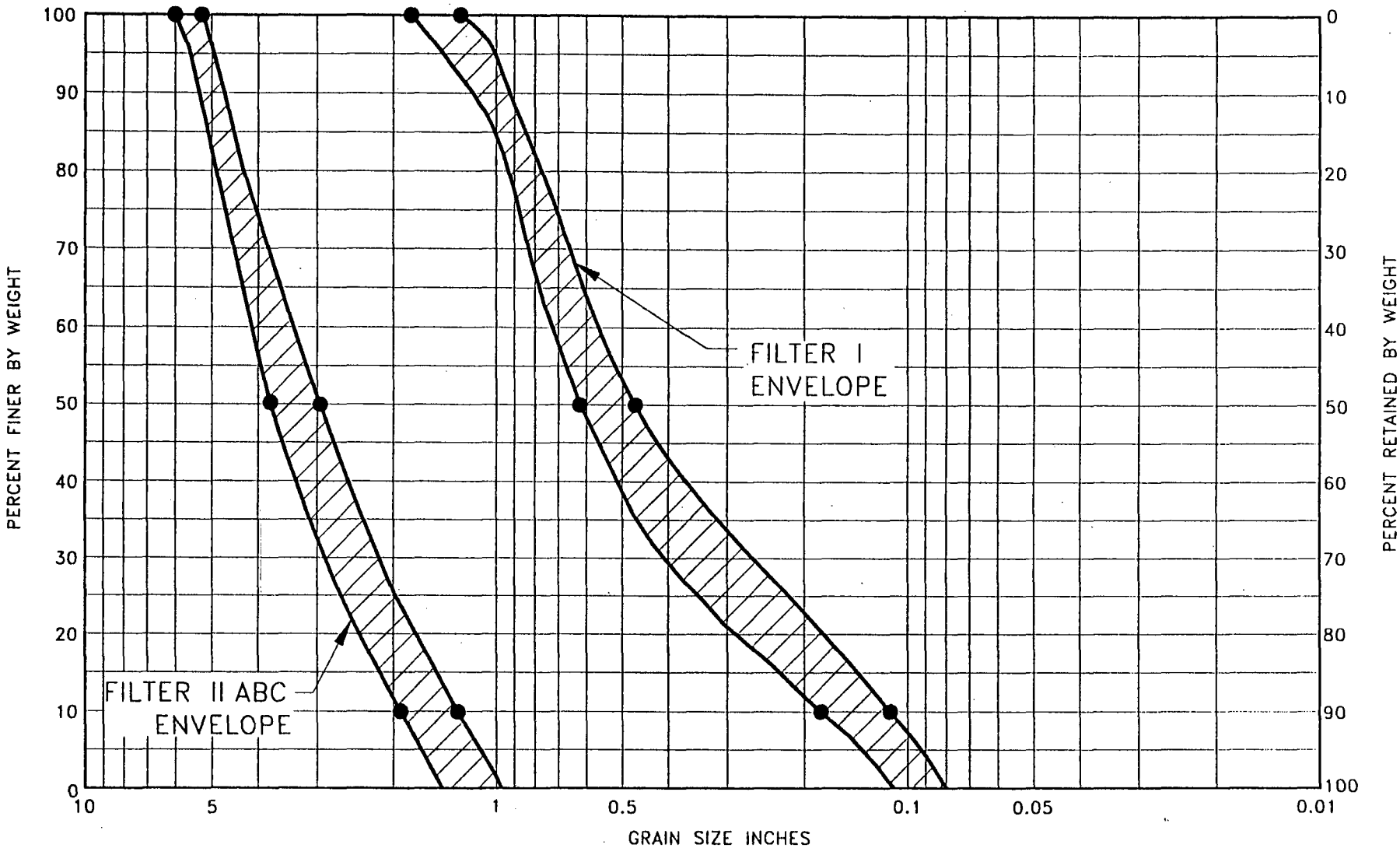
SHEPH[illegible]ILLER, INC.

FIGURE C.3.9
FILTER REQURIMENT FOR
CODY[illegible]HALE

Date:	OCT., 1993
Project:	336[illegible]
File:	G[illegible]9

C175



REVISED APRIL 1994

C 176

SMI
SHEPHERD MILLER, INC.

FIGURE C.3.10
FILTER ENVELOPES

Date: REV. APR., 1994
Project: 336
File: GSD-11

C.4

REVISED SELF CLEANING ANALYSIS

REVISED SELF CLEANING ANALYSIS
WESTERN NUCLEAR, INC.

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SELF CLEANING ANALYSIS
WESTERN NUCLEAR, INC.

PURPOSE. The purpose of this calculation brief is to determine if the diversion ditches at WNI's Split Rock Mill and Tailing's site in Jeffrey City, Wyoming are self cleaning in the event of the 25 year, one hour storm and the 50 year, one hour storm.

METHOD.

1) Determine the minimum velocity required in the ditches to remove sediment.

2) Determine the precipitation depths for the 25 year, 1hour storm and the 50 year, 1 hour storm.

3) Input the precipitation depths into the HEC-1 computer model to determine the resulting flow in the ditches.

4) Determine the lowest velocity for each ditch reach using the design D_{50} riprap size and the flows calculated for the above storms in the normal depth riprap sizing spreadsheets.

5) Tabulate results and compare ditch velocities to the minimum velocity required for the ditch to be "self-cleaning."

RESULTS. The results of these calculations are summarized in Table C.4.1 (page C-183). The selected minimum velocity required to remove sediment from the ditches is 2.5 feet per second. Reach 2 and 3 of the tailing swale and all reaches of the south, north, and south central ditches achieved velocities greater than 2.5 feet per second for the 25 year, 1 hour storm. Reaches 2 and 3 of the north central ditch achieved velocities greater than 2.5 feet per second for the 50 year, 1 hour storm. The flow in the first reach of the north central ditch and the flow in the first reach of the tailing swale are too small for these reaches to self clean. These two reaches, however, are at the beginning of their respective ditches and therefore will not impede flow from other reaches in the same ditches. In addition, in the event of the PMF, the rising limb of the hydrograph will produce enough velocity to clean these two reaches before the peak flow occurs.

CALCULATIONS

1) Minimum Velocity Requirement. Table C.4.2 (page C-186) lists the statistical grain size distribution for borrow soils at the Split Rock Mill. Based on the information presented in the table, 99.5% of the site soils are less than the #8 sieve, or less than 2.38 mm. Figure C.4.1 (page C-188) shows velocity of current versus particle size, and indicates where erosion will occur. At a velocity of 2.5 feet per second, particles of 3.7 mm diameter or less will be removed from the ditch (by erosion). Therefore, a velocity of 2.5 feet per second will remove windblown soils from the diversion ditches.

2) Precipitation Depths. Using the procedures set forth in the NOAA Atlas 2, Volume II - Wyoming, the 1 hour precipitation depths can be obtained for the 25 year and 50 year storms. The procedure is as follows:

A) Region of applicability is Region 1.

B) Using the equations below, the 2 year and 100 year precipitation depths are calculated:

2 year:

$$y_2 = 0.028 + 0.898[x_2(x_1/x_2)]$$

Where:

y2 = 2 year 1 hour estimated precipitation depth
x1 = 2 year 6 hour precipitation depth
x2 = 2 year 24 hour precipitation depth

From NOAA frequency maps:

x1 = 0.8"
x2 = 1.2"

Therefore:

$$y_2 = 0.028 + 0.898[0.8(0.8/1.2)] = 0.50''$$

100 year:

$$y_{100} = 0.671 + 0.757(x_3 x_3/x_4) - 0.003z$$

Where:

y100 = 100 year 1 hour estimated precipitation depth
x3 = 100 year 6 hour precipitation depth
x4 = 100 year 24 hour precipitation depth
z = elevation in hundreds of feet

From frequency maps:

x3 = 2.0"
x4 = 3.0"

Elevation is approximately 6400 feet,
z = 6.4

Therefore:

$$y_{100} = 0.671 + 0.757(2.0 \; x \; 2.0/3.0) - 0.003(6.4) = 1.66''$$

C) The 100 year and 2 year 1 hour values are plotted on Figure C.4.2 (page C-) and the values for the 25 year and 50 year 1 hour storm are interpolated.

The precipitation depth for the 25 year 1 hour storm is 1.15".

The precipitation depth for the 50 year 1 hour storm is 1.3".

3) HEC 1 Model. The 25 year 1 hour precipitation depth was input into the HEC1 input files for the north, south, and south central ditches. The 50 year 1 hour precipitation depth was entered into the HEC1 input file for the north central ditch. All other HEC1 parameters are as used for the diversion ditch design as described in Appendix B. HEC1 output files are attached.

4) Determination of Flow Velocity. The new peak flow volumes calculated by HEC1 are input into a riprap design spreadsheet that calculates ditch hydraulic properties using normal depth calculations to determine the flow velocity. For reaches with varying slopes and riprap sizes, the slope and respective riprap size that resulted in the lowest velocity was used to determine if that reach would self-clean. The parameters used for each reach are presented in Table C.4.1 (page C-~~18~~5). Spreadsheets are attached.

5) Tabulate Results. Table C.4.1 presents the results of the self cleaning analysis. All reaches self clean except for North Central Reach 1 and Tailing Swale Reach 1.

REFERENCES

Simons, Li & Associates, Inc. "Surface Mining Water Diversions Design Manual", U.S. Dept. of The Interior, OSRA/TR-52/2; Sept. 1982

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Final Staff Technical Position Design of Erosion Protection Covers For Stabilization of Uranium Mill Tailing Sites", NRC 1990.

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TABLES

TABLE C.4.1
Summary of Diversion Ditch Parameters Used for Self Cleaning Analysis

	SLOPE** (ft/ft)	BOTTOM WIDTH (ft)	SIDE SLOPE (ft:ft)	DESIGN** D50 (in)	25-Year 1-Hour Flow (cfs)	25-Year 1-Hour Velocities (fps)	Velocity >2.5?
North Transition	0.0598	15	3:1	18	101	6.5	Y
North Reach 1 (N1)	0.005	15	3:1	3	104	3.7	Y
North Reach 2 (N2)	0.005	15	3:1	3	101	3.7	Y
North Reach 3 (N3)	0.0387	15	3:1	18	120	6.4	Y
North Reach 4 (N4)	0.0387	15	3:1	18	121	6.4	Y
North Reach 5 (N5)	0.0303	15	3:1	18	187	6.7	Y
North Reach 6 (N6)	0.02	15	3:1	18	190	5.9	Y
North Reach 7 (N7)	0.005	15	3:1	6	196	4.2	Y
Swale Reach 1 (SW1)	0.007	15	16:1	3	37*	2.3*	N
Swale Reach 2 (SW2)	0.007	15	16:1	3	77	2.8	Y
Swale Reach 3 (SW3)	0.0409	15	varies	12	82	5.0	Y
South Transition	0.065	15	3:1	3	N/A	N/A	N/A
South Reach 1 (S1)	0.0082	15	3:1	3	68	3.8	Y
South Reach 2 (S2)	0.004	15	3:1	3	131	3.7	Y
South Reach 3 (S3)	0.0229	15	3:1	18	163	5.9	Y
South Reach 4 (S4)	0.0231	15	3:1	18	251	6.7	Y
South Reach 5 (S5)	0.005	15	3:1	6	256	4.5	Y
North Central Reach 1 (NC1)	0.005	15	3:1	3	19*	2.1*	N
North Central Reach 2 (NC2)	0.03	15	3:1	12	23*	3.4*	Y
North Central Reach 3 (NC3)	0.005	15	3:1	3	50*	2.9*	Y
South Central Reach 1 (SC1)	0.0069	15	3:1	6	29	2.5	Y
South Central Reach 2 (SC2)	0.0068	15	3:1	6	41	2.8	Y

N/A Because the contrubuting basins are small and the length of the reach is short the self-cleaning for the transition is not considered

* 50-year, 1-hour storm flow and velocity

** Although slopes and rock size vary in some reaches, the design parameters that result in the lowest velocity are used for each reach.

Table C.4.2

Summary of Statistical Information - Borrow Soils at WNI Jeffrey City Facility

Number of Samples: 132 Percentage of SP = 45%
Percentage of SP-SM = 48%
Percentage of SM = 7%

Statistics for all Borrow Areas	3/8"	#4	#8	#16	#30	#50	#100	#200
Maximum Percent Passing	100.0	100.0	100.0	100.0	100.0	91.0	44.0	19.0
Minimum Percent Passing	92.0	92.0	91.0	58.0	37.0	15.0	4.0	1.0
Average Percent Passing Overall	99.9	99.9	**99.5**	94.5	79.3	48.2	15.9	5.5
Stabdard Deviation	0.8	0.8	1.3	9.0	16.8	15.5	8.2	8.5
Maximum for Composite Envelope	100	100	100	100	86	48.2	15.9	9.5
95% Confidence Interval Upper	100.0	100.0	100.0	100.0	100.0	81.2	32.3	12.5
95% Confidence Interval Lower	98.4	98.3	96.9	76.5	45.7	15.2	--	--

Taken from Canonie TRP #4 Page ___

FIGURES

Canonie Environmental

By J.W. Date 2/15/92 Subject WNI - DITCH DESIGN AND RIPRAP SIZING Sheet No. 41 of 43

Chkd. By PE Date 2-17-92 Proj. No. 91-225-06

1/4" X 1/4"

FIGURE C 4.1

VELOCITY VERSUS PARTICLE SIZE CURVE INDICATING ZONES OF DEPOSITION, TRANSPORTATION, AND EROSION

SELECTED MIN. VELOCITY = 2.5 FT/SEC :

$\frac{2.5\ FT}{SEC} \times \frac{12\ INCHES}{FT.} \times \frac{2.54\ cm}{INCH}$

= 76.2 cm/SEC.

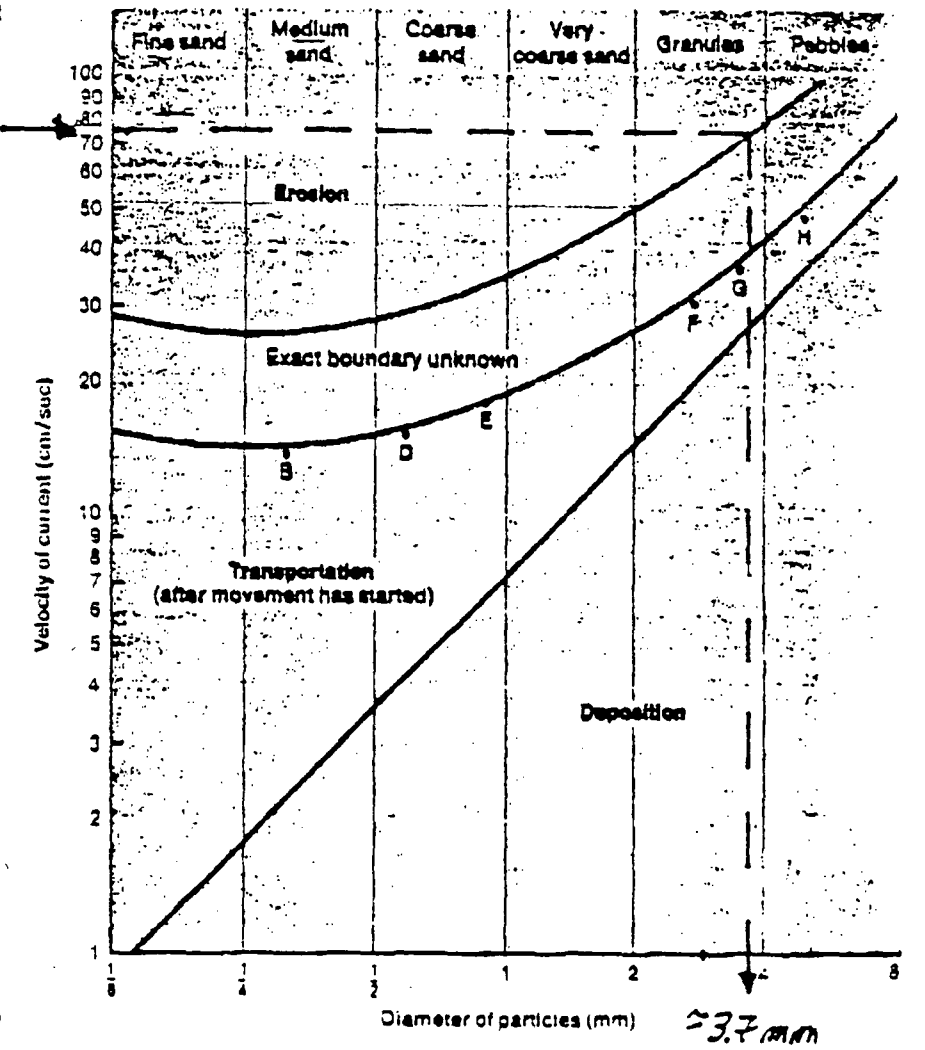
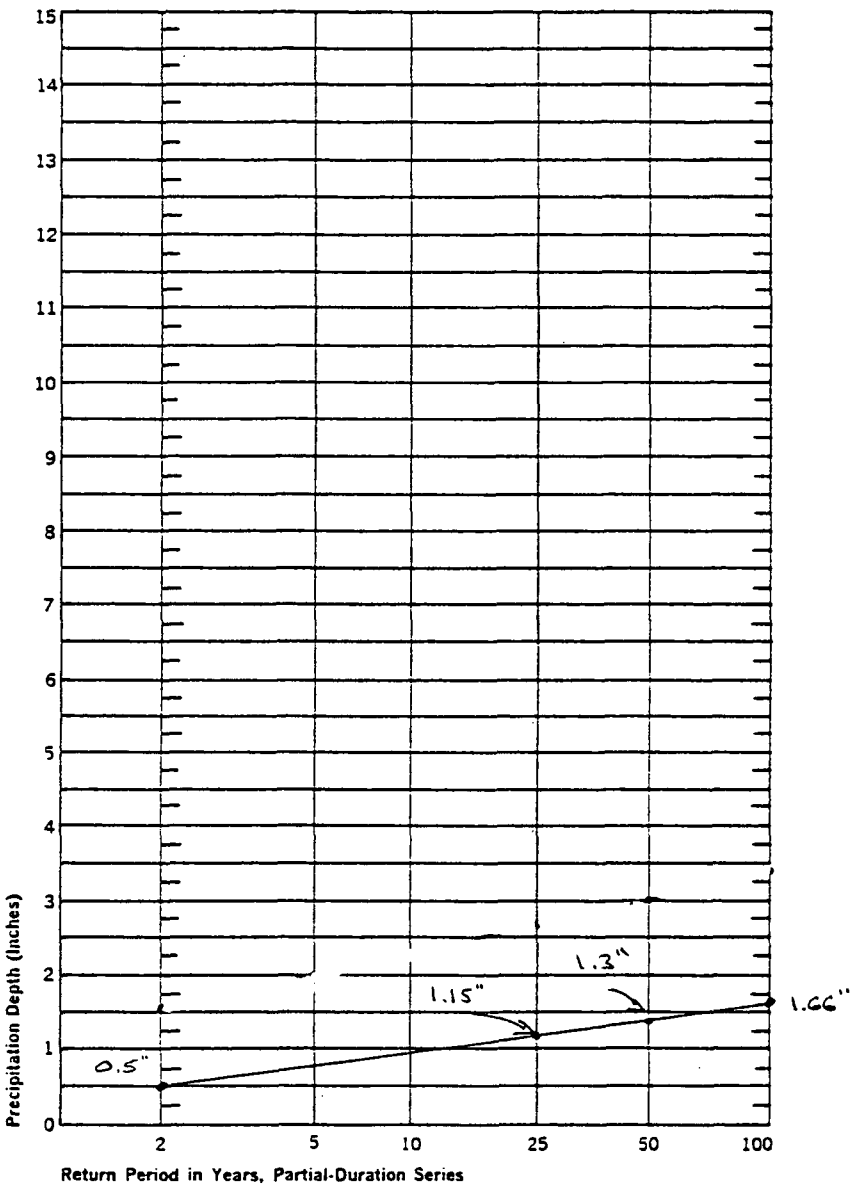


Figure 6.8. Portion of Hjulstrom curve with size grades B to H placed on diagram. Compare figures 6.6 and 6.7. (From Rubey 1938)

SOURCE: PROCESS GEOMORPHOLOGY, RITTER, DALE F., 1978, PAGE 217.

FIGURE C.4.2
PRECIPITATION DEPTH VS. RETURN PERIOD
FOR PARTIAL DURATION SERIES



SPREADSHEETS

C191

NORMAL DEPTH CALCULATION AND RIPRAP SIZING USING SAFETY FACTORS METHOD
REF: NUREG/CR-4651, pp. 18
FOR SLOPES LESS THAN 10%

File: R:\PROJECTS\336\QPRO\MANSF.WQ1
Date: 9-27-93

Location: NORTH TRANSITION
25-YEAR STORM

Channel hydraulic properties using normal depth calculation

INPUT Flow (cfs):	101
INPUT Riprap D-50 (ft):	1.5
Manning's n:	0.0461
INPUT Bottom Width (ft):	15
INPUT Right Side Slope, z:	3
INPUT Left Side Slope, z:	3
INPUT Channel Slope (ft/ft):	0.0598

QPro "Solve For" tool:

variable:	formula:
Depth	F(y)
0.8768	0.00

Depth (ft) =		0.877
Hydraulic Radius (ft) =		0.752
Cross-Sectional Area (sq ft) =		15.46
Average Velocity (fps) =		6.53 ←
Topwidth (ft) =		20.26
Froude Number =		1.32
Flow Condition:	supercritical	

C192

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 10/09/93

Location: JEFFREY CITY, WYOMING
NORTH REACH 1
25 YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	104		
Riprap D-50 (ft):	0.250	3.00	in
Manning's n:	0.0313		
Bottom Width (ft):	15		
Right Side Slope, z:	3		
Left Side Slope, z:	3		
Channel Slope (ft/ft):	0.005		

QPro "Solve For" tool:

variable:	formula:
Depth	F(y)
1.4487	0.00

Depth (ft) =		1.449
Hydraulic Radius (ft) =		1.160
Cross-Sectional Area (sq ft) =		28.03
Average Velocity (fps) =		3.71 ←
Topwidth (ft) =		23.69
Froude Number =		0.60
Flow Condition:	subcritical	

C/93

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 10/09/93

Location: JEFFREY CITY, WYOMING
NORTH REACH 2
25 YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	101	
Riprap D-50 (ft):	0.250	3.00 in
Manning's n:	0.0313	
Bottom Width (ft):	15	
Right Side Slope, z:	3	
Left Side Slope, z:	3	
Channel Slope (ft/ft):	0.005	

QPro "Solve For" tool:

variable:	formula:
Depth	F(y)
1.4253	0.00

Depth (ft) =		1.425
Hydraulic Radius (ft) =		1.144
Cross-Sectional Area (sq ft) =		27.47
Average Velocity (fps) =		3.68
Topwidth (ft) =		23.55
Froude Number =		0.60
Flow Condition:	subcritical	

C194

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 10/09/93

Location: JEFFREY CITY, WYOMING
NORTH REACH 3
25 YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	120	
Riprap D-50 (ft):	1.500	18.00 in
Manning's n:	0.0423	
Bottom Width (ft):	15	
Right Side Slope, z:	3	
Left Side Slope, z:	3	
Channel Slope (ft/ft):	0.0387	

QPro "Solve For" tool:

variable:	formula:
Depth	F(y)
1.0428	0.00

Depth (ft) =		1.043
Hydraulic Radius (ft) =		0.875
Cross-Sectional Area (sq ft) =		18.90
Average Velocity (fps) =		6.35 ←
Topwidth (ft) =		21.26
Froude Number =		1.19
Flow Condition:	supercritical	

C195

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 10/09/93

Location: JEFFREY CITY, WYOMING
NORTH REACH 4
25 YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	121	
Riprap D-50 (ft):	1.500	18.00 in
Manning's n:	0.0423	
Bottom Width (ft):	15	
Right Side Slope, z:	3	
Left Side Slope, z:	3	
Channel Slope (ft/ft):	0.0387	

QPro "Solve For" tool:

variable:	formula:
Depth	F(y)
1.0479	-0.00

Depth (ft) =		1.048
Hydraulic Radius (ft) =		0.879
Cross-Sectional Area (sq ft) =		19.01
Average Velocity (fps) =		6.36
Topwidth (ft) =		21.29
Froude Number =		1.19
Flow Condition:	supercritical	

C196

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 10/09/93

Location: JEFFREY CITY, WYOMING
NORTH REACH 5
25 YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	187		
Riprap D-50 (ft):	1.500	18.00	in
Manning's n:	0.0423		
Bottom Width (ft):	15		
Right Side Slope, z:	3		
Left Side Slope, z:	3		
Channel Slope (ft/ft):	0.0303		

QPro "Solve For" tool:

variable:	formula:
Depth	F(y)
1.4364	-0.00

Depth (ft) =		1.436
Hydraulic Radius (ft) =		1.152
Cross-Sectional Area (sq ft) =		27.74
Average Velocity (fps) =		6.74 ←
Topwidth (ft) =		23.62
Froude Number =		1.10
Flow Condition:	supercritical	

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD

C197

Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 10/09/93

Location: JEFFREY CITY, WYOMING
NORTH REACH 6
25 YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	190	
Riprap D-50 (ft):	1.500	18.00 in
Manning's n:	0.0423	
Bottom Width (ft):	15	
Right Side Slope, z:	3	
Left Side Slope, z:	3	
Channel Slope (ft/ft):	0.02	

QPro "Solve For" tool:

variable:	formula:
Depth	F(y)
1.6268	0.00

Depth (ft) =		1.627
Hydraulic Radius (ft) =		1.279
Cross-Sectional Area (sq ft) =		32.34
Average Velocity (fps) =		5.87
Topwidth (ft) =		24.76
Froude Number =		0.91
Flow Condition:	subcritical	

C198

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 10/09/93

Location: JEFFREY CITY, WYOMING
NORTH REACH 7
25 YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	196	
Riprap D-50 (ft):	0.500	6.00 in
Manning's n:	0.0352	
Bottom Width (ft):	15	
Right Side Slope, z:	3	
Left Side Slope, z:	3	
Channel Slope (ft/ft):	0.005	

QPro "Solve For" tool:

variable:	formula:
Depth	F(y)
2.1871	-0.00

Depth (ft) =		2.187
Hydraulic Radius (ft) =		1.636
Cross-Sectional Area (sq ft) =		47.16
Average Velocity (fps) =		4.16 ←
Topwidth (ft) =		28.12
Froude Number =		0.57
Flow Condition:	subcritical	

C199

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 10/09/93

Location: JEFFREY CITY, WYOMING
TAILING SWALE REACH 1
50 YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	37	
Riprap D-50 (ft):	0.250	3.00 in
Manning's n:	0.0313	
Bottom Width (ft):	20	
Right Side Slope, z:	16	
Left Side Slope, z:	16	
Channel Slope (ft/ft):	0.007	

QPro "Solve For" tool:

variable:	formula:
Depth	F(y)
0.5633	0.00

Depth (ft) =		0.563
Hydraulic Radius (ft) =		0.429
Cross-Sectional Area (sq ft) =		16.34
Average Velocity (fps) =		2.26
Topwidth (ft) =		38.03
Froude Number =		0.61
Flow Condition:	subcritical	

C200

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 9/27/93

Location: JEFFREY CITY, WYOMING
TAILING SWALE REACH 2
25-YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	77	
Riprap D-50 (ft):	0.250	3.00 in
Manning's n:	0.0313	
Bottom Width (ft):	20	
Right Side Slope, z:	16	
Left Side Slope, z:	16	
Channel Slope (ft/ft):	0.007	

QPro "Solve For" tool:

variable:	formula:
Depth	F(y)
0.8272	0.00

Depth (ft) =		0.827
Hydraulic Radius (ft) =		0.591
Cross-Sectional Area (sq ft) =		27.49
Average Velocity (fps) =		2.80 ←
Topwidth (ft) =		46.47
Froude Number =		0.64
Flow Condition:	subcritical	

C201

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 9/27/93

Location: JEFFREY CITY, WYOMING
TAILING SWALE REACH 3
25-YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	82	
Riprap D-50 (ft):	1.000	12.00 in
Manning's n:	0.0395	
Bottom Width (ft):	20	
Right Side Slope, z:	8	
Left Side Slope, z:	8	
Channel Slope (ft/ft):	0.0409	

QPro "Solve For" tool:

variable:	formula:
Depth	F(y)
0.6472	0.00

Depth (ft) =		0.647
Hydraulic Radius (ft) =		0.535
Cross-Sectional Area (sq ft) =		16.29
Average Velocity (fps) =		5.03
Topwidth (ft) =		30.36
Froude Number =		1.21
Flow Condition:	supercritical	

C202

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 10/09/93

Location: JEFFREY CITY, WYOMING
SOUTH REACH 1
25 YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	68	
Riprap D-50 (ft):	0.250	3.00 in
Manning's n:	0.0313	
Bottom Width (ft):	15	
Right Side Slope, z:	3	
Left Side Slope, z:	3	
Channel Slope (ft/ft):	0.0082	

QPro "Solve For" tool:

variable:	formula:
Depth	F(y)
0.9900	0.00

Depth (ft) =		0.990
Hydraulic Radius (ft) =		0.837
Cross-Sectional Area (sq ft) =		17.79
Average Velocity (fps) =		3.82 ←
Topwidth (ft) =		20.94
Froude Number =		0.73
Flow Condition:	subcritical	

C 203

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 10/09/93

Location: JEFFREY CITY, WYOMING
SOUTH REACH 2
25 YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	131	
Riprap D-50 (ft):	0.250	3.00 in
Manning's n:	0.0313	
Bottom Width (ft):	15	
Right Side Slope, z:	3	
Left Side Slope, z:	3	
Channel Slope (ft/ft):	0.004	

QPro "Solve For" tool:

variable: Depth	formula: F(y)
1.7520	0.00

Depth (ft) =		1.752
Hydraulic Radius (ft) =		1.361
Cross-Sectional Area (sq ft) =		35.49
Average Velocity (fps) =		3.69
Topwidth (ft) =		25.51
Froude Number =		0.55
Flow Condition:	subcritical	

C204

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 10/09/93

Location: JEFFREY CITY, WYOMING
SOUTH REACH 3
25 YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	163	
Riprap D-50 (ft):	1.500	18.00 in
Manning's n:	0.0423	
Bottom Width (ft):	15	
Right Side Slope, z:	3	
Left Side Slope, z:	3	
Channel Slope (ft/ft):	0.0229	

QPro "Solve For" tool:

variable:	formula:
Depth	F(y)
1.4384	0.00

Depth (ft) =	1.438
Hydraulic Radius (ft) =	1.153
Cross-Sectional Area (sq ft) =	27.78
Average Velocity (fps) =	5.87 ←
Topwidth (ft) =	23.63
Froude Number =	0.95
Flow Condition:	subcritical

C205

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 10/09/93

Location: JEFFREY CITY, WYOMING
SOUTH REACH 4
25 YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	251	
Riprap D-50 (ft):	1.500	18.00 in
Manning's n:	0.0423	
Bottom Width (ft):	15	
Right Side Slope, z:	3	
Left Side Slope, z:	3	
Channel Slope (ft/ft):	0.0231	

QPro "Solve For" tool:

variable: Depth	formula: F(y)
1.8230	-0.00

Depth (ft) =		1.823
Hydraulic Radius (ft) =		1.407
Cross-Sectional Area (sq ft) =		37.32
Average Velocity (fps) =		6.73
Topwidth (ft) =		25.94
Froude Number =		0.99
Flow Condition:	subcritical	

C206

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 10/09/93

Location: JEFFREY CITY, WYOMING
SOUTH REACH 5
25 YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	256	
Riprap D-50 (ft):	0.500	6.00 in
Manning's n:	0.0352	
Bottom Width (ft):	15	
Right Side Slope, z:	3	
Left Side Slope, z:	3	
Channel Slope (ft/ft):	0.005	

QPro "Solve For" tool:

variable:	formula:
Depth	F(y)
2.5233	0.00

Depth (ft) =		2.523
Hydraulic Radius (ft) =		1.840
Cross-Sectional Area (sq ft) =		56.95
Average Velocity (fps) =		4.50 ←
Topwidth (ft) =		30.14
Froude Number =		0.58
Flow Condition:	subcritical	

NORMAL DEPTH CALCULATION AND RIPRAP SIZING USING SAFETY FACTORS METHOD C207
REF: NUREG/CR-4651, pp. 18
FOR SLOPES LESS THAN 10%

File: R:\PROJECTS\336\QPRO\MANSF.WQ1
Date: 9-27-93

Location: NORTH CENTRAL REACH 1 - 50 YEAR STORM

Channel hydraulic properties using normal depth calculation

INPUT Flow (cfs):	19
INPUT Riprap D-50 (ft):	0.25
Manning's n:	0.0313
INPUT Bottom Width (ft):	15
INPUT Right Side Slope, z:	3
INPUT Left Side Slope, z:	3
INPUT Channel Slope (ft/ft):	0.005

QPro "Solve For" tool:

variable:	formula:
Depth	F(y)
0.5452	0.00

Depth (ft) =		0.545
Hydraulic Radius (ft) =		0.492
Cross-Sectional Area (sq ft) =		9.07
Average Velocity (fps) =		2.09
Topwidth (ft) =		18.27
Froude Number =		0.52
Flow Condition:	subcritical	

C208

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 9/27/93

Location: JEFFREY CITY, WYOMING
NORTH CENTRAL REACH 2 - 50 YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	23	
Riprap D-50 (ft):	1.000	12.00 in
Manning's n:	0.0395	
Bottom Width (ft):	15	
Right Side Slope, z:	3	
Left Side Slope, z:	3	
Channel Slope (ft/ft):	0.03	

QPro "Solve For" tool:

variable:	formula:
Depth	F(y)
0.4126	0.00

Depth (ft) =		0.413
Hydraulic Radius (ft) =		0.380
Cross-Sectional Area (sq ft) =		6.70
Average Velocity (fps) =		3.43 ←
Topwidth (ft) =		17.48
Froude Number =		0.98
Flow Condition:	subcritical	

C209

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 9/27/93

Location: JEFFREY CITY, WYOMING
NORTH CENTRAL REACH 3 - 50 YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	50	
Riprap D-50 (ft):	0.250	3.00 in
Manning's n:	0.0313	
Bottom Width (ft):	15	
Right Side Slope, z:	3	
Left Side Slope, z:	3	
Channel Slope (ft/ft):	0.005	

QPro "Solve For" tool:

variable: Depth	formula: F(y)
0.9567	-0.00

Depth (ft) =		0.957
Hydraulic Radius (ft) =		0.812
Cross-Sectional Area (sq ft) =		17.10
Average Velocity (fps) =		2.92 ←
Topwidth (ft) =		20.74
Froude Number =		0.57
Flow Condition:	subcritical	

C210

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 10/09/93

Location: JEFFREY CITY, WYOMING
SOUTH CENTRAL REACH 1
25 YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	29	
Riprap D-50 (ft):	0.500	6.00 in
Manning's n:	0.0352	
Bottom Width (ft):	15	
Right Side Slope, z:	3	
Left Side Slope, z:	3	
Channel Slope (ft/ft):	0.0069	

QPro "Solve For" tool:

variable:	formula:
Depth	F(y)
0.6800	-0.00

Depth (ft) =		0.680
Hydraulic Radius (ft) =		0.600
Cross-Sectional Area (sq ft) =		11.59
Average Velocity (fps) =		2.50 ←
Topwidth (ft) =		19.08
Froude Number =		0.57
Flow Condition:	subcritical	

C211

NORMAL DEPTH CALCULATION & RIPRAP SIZING USING 1970 COE METHOD
Ref: COE, 1970. Hydraulic Design of Flood Control Channels,
EM 1110-2-1601, pp. 3-1 - 3-7.

File: R:\PROJECTS\336\QP\MANCOE70.WQ1
Date: 10/09/93

Location: JEFFREY CITY, WYOMING
SOUTH CENTRAL REACH 2
25 YEAR STORM

Channel hydraulic properties using normal depth calculation

Flow (cfs):	41	
Riprap D-50 (ft):	0.500	6.00 in
Manning's n:	0.0352	
Bottom Width (ft):	15	
Right Side Slope, z:	3	
Left Side Slope, z:	3	
Channel Slope (ft/ft):	0.0068	

QPro "Solve For" tool:

variable:	formula:
Depth	F(y)
0.8345	0.00

Depth (ft) =	0.835
Hydraulic Radius (ft) =	0.720
Cross-Sectional Area (sq ft) =	14.61
Average Velocity (fps) =	2.81 ←
Topwidth (ft) =	20.01
Froude Number =	0.58
Flow Condition:	subcritical

HEC1 OUTPUT

C213

```
*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*              MAY   1991               *
*           VERSION 4.0.1E              *
*                                       *
*  RUN DATE  10/11/93  TIME  13:44:06   *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*    HYDROLOGIC ENGINEERING CENTER      *
*          609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616         *
*           (916) 551-1748              *
*                                       *
*****************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X               X
XXXXXXX  XXXX     X        XXXXX  X
X     X  X        X               X
X     X  X        X     X         X
X     X  XXXXXXX   XXXXX         XXX
```

NORTH DITCH & SWALE
25 YR 1HR STORM

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   Input File Name:     R:\PROJECTS\336\HEC1\CANONIE.PMP\NORTH2.IH1
  2           ID   DATE:06-14-93          DESIGN
  3           ID   HEC-1 PMP RUNOFF STUDY,JEFFREY CITY, WYOMING
  4           ID   DIVERSION CHANNEL MODIFICATIONS - NORTH CHANNEL
  5           ID             CURVE NUMBER = SPECIFIC TO BASINS
  6           ID   DESIGNED FOR 1 HOUR PMP AT 9.20 INCHES WITH SCS TYPE II DISTRIBUTION
  7           ID   ANTECEDENT MOISTURE CONDITION III
              *DIAGRAM
  8           IT       1       0    0000     120       0       0
  9           IN       3       0       0
 10           IO       5       0
              *

 11           KK     BG2 RUNOFF FROM BASIN G2 (INTO TRANSITION)
 12           KO                                     21
 13           PB    1.15
 14           PC     .01     .02     .03     .04    .055     .07    .085    .105     .15    .205
 15           PC    .285    .425    .655    .765     .83     .88     .91     .93    .945     .96
 16           PC     .97     .98     .99     1.0
 17           BA    .055
 18           LS       0      96
 19           UD    .081
              *

 20           KK     BG1 RUNOFF FROM BASIN G1 (INTO TRANSITION)
 21           KO                                     21
 22           BA    .005
 23           LS       0      79
 24           UD    .042
              *

 25           KK     NT1  COMBINE G1 AND G2
 26           KO                                     21
 27           HC       2
              *

 28           KK    R-T1  ROUTE NORTH TRANSITION TO NORTH 1
 29           KO                                     21
 30           RD     100   .0598   .0313            TRAP      15       3
              *

 31           KK     BG  RUNOFF FROM BASIN G
 32           KO                                     21
 33           BA    .124
 34           LS       0      85
 35           UD    .263
              *

 36           KK      N1  COMBINE G1 AND G2 AND G
 37           KO                                     21
 38           HC       2
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  39          KK    R-12  ROUTE NORTH 1-2
  40          KO                                    21
  41          RD     950    .005   .0313           TRAP      15       3
              *

  42          KK      BF  RUNOFF FROM BASIN F
  43          KO                                    21
  44          BA    .075
  45          LS       0      74
  46          UD    .355
              *

  47          KK     BF1  RUNOFF FROM BASIN F1
  48          KO                                    21
  49          BA    .004
  50          LS       0      89
  51          UD    .008
              *

  52          KK      N2  COMBINE ROUTED REACH WITH BASIN F AT NODE 2
  53          KO                                    21
  54          HC       3
              *

  55          KK    R-23  ROUTE NORTH 2-3
  56          KO                                    21
  57          RD    1850    .005   .0313           TRAP      15       3
              *

  58          KK      BE  RUNOFF FROM BASIN E
  59          KO                                    21
  60          BA    .051
  61          LS       0      85
  62          UD    .106
              *

  63          KK     BE1  RUNOFF FROM BASIN E1
  64          KO                                    21
  65          BA    .002
  66          LS       0      89
  67          UD    .046
              *

  68          KK      N3  COMBINE ROUTED REACH WITH BASIN E AT NODE 3
  69          KO                                    21
  70          HC       3
              *

  71          KK    R-34  ROUTE NORTH 3-4
  72          KO                                    21
  73          RD     770   .0387   .0410           TRAP      15       3
              *
```

C216


```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  74          KK      BD  RUNOFF FROM BASIN D
  75          KO                                      21
  76          BA    .005
  77          LS       0      67
  78          UD    .127
              *

  79          KK     BD1  RUNOFF FROM BASIN D1
  80          KO                                      21
  81          BA    .003
  82          LS       0      89
  83          UD    .049
              *

  84          KK      N4  COMBINE ROUTED REACH WITH BASIN D AT NODE 4
  85          KO                                      21
  86          HC       3
              *

  87          KK    R-45  ROUTE NORTH 4-5
  88          KO                                      21
  89          RD     580   .0387   .0431           TRAP       15       3
              *

  90          KK      BC  RUNOFF FROM BASIN C
  91          KO                                      21
  92          BA    .006
  93          LS       0      67
  94          UD    .134
              *

  95          KK     BC1  RUNOFF FROM BASIN C1
  96          KO                                      21
  97          BA    .002
  98          LS       0      89
  99          UD    .064
              *

 100          KK     BT2  RUNOFF FROM SWALE BASIN T2
 101          KO                                      21
 102          BA    .002
 103          LS       0      89
 104          UD    .058
              *

 105          KK      BT  RUNOFF FROM SWALE BASIN T
 106          KO                                      21
 107          BA    .015
 108          LS       0      89
 109          UD    .200
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 110          KK     BT1  RUNOFF FROM SWALE BASIN T1
 111          KO                                   21
 112          BA    .039
 113          LS       0      89
 114          UD    .246
              *

 115          KK      S1  COMBINE SWALE REACH S-12 AND BASIN S
 116          KO                                   21
 117          HC       3
              *

 118          KK    S-12  ROUTE SWALE 1-2
 119          KO                                   21
 120          RD     500    .007   .0313           TRAP      20      16
              *

 121          KK      BS  RUNOFF FROM SWALE BASIN S
 122          KO                                   21
 123          BA    .073
 124          LS       0      89
 125          UD    .248
              *

 126          KK     BS1  RUNOFF FROM SWALE BASIN S1
 127          KO                                   21
 128          BA     .03
 129          LS       0      89
 130          UD    .105
              *

 131          KK      S1  COMBINE SWALE REACH S-12 AND BASIN S
 132          KO                                   21
 133          HC       3
              *

 134          KK    S-23  ROUTE SWALE 2-3
 135          KO                                   21
 136          RD    1450    .007   .0313           TRAP      20      16
              *

 137          KK      BR  RUNOFF FROM SWALE BASIN R
 138          KO                                   21
 139          BA    .012
 140          LS       0      89
 141          UD    .168
              *

 142          KK     BR1  RUNOFF FROM SWALE BASIN R1
 143          KO                                   21
 144          BA    .003
 145          LS       0      89
 146          UD    .056
              *
```

C218


```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 147          KK      S2  COMBINE SWALE REACH 2-3 AND BASIN R
 148          KO                                      21
 149          HC       3
              *

 150          KK    S-34  ROUTE SWALE REACH 3-4
 151          KO                                      21
 152          RD     745   .0409   .0383            TRAP      20       8
              *

 153          KK      N5  COMBINE ROUTED REACH, BASIN C, AND SWALE  AT NODE 5 AND BASIN C1
 154          KO                                      21
 155          HC       4
              *

 156          KK    R-56  ROUTE NORTH 5-6
 157          KO                                      21
 158          RD     400   .0303   .0431            TRAP      15       3
              *

 159          KK      BB  RUNOFF FROM BASIN B
 160          KO                                      21
 161          BA    .041
 162          LS       0      73
 163          UD    .164
              *

 164          KK     BB1  RUNOFF FROM BASIN B1
 165          KO                                      21
 166          BA    .002
 167          LS       0      89
 168          UD    .013
              *

 169          KK      N6  COMBINE ROUTED REACH WITH BASIN B AT NODE 6
 170          KO                                      21
 171          HC       3
              *

 172          KK    R-67  ROUTE NORTH 6-7
 173          KO                                      21
 174          RD     650     .02   .0377            TRAP      15       3
              *

 175          KK      BA  RUNOFF FROM BASIN A
 176          KO                                      21
 177          BA    .034
 178          LS       0      82
 179          UD    .175
              *
```

C219


```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


 180          KK     BA1  RUNOFF FROM BASIN A1
 181          KO                                  21
 182          BA    .001
 183          LS       0      89
 184          UD    .013
              *

 185          KK      N7  COMBINE ROUTED REACH WITH BASIN A AT NODE 7
 186          KO                                  21
 187          HC       3
              *

 188          KK    R-78  ROUTE NORTH 7-8
 189          KO
 190          RD     460    .005   .0329           TRAP      15       3
 191          ZZ
```

C22C

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
INPUT
 LINE     (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

 NO.      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

  11        BG2
              .
              .
  20          .         BG1
              .           .
              .           .
  25        NT1............
              V
              V
  28       R-T1
              .
              .
  31          .         BG
              .           .
              .           .
  36         N1............
              V
              V
  39       R-12
              .
              .
  42          .          BF
              .           .
              .           .
  47          .           .        BF1
              .           .          .
              .           .          .
  52         N2........................
              V
              V
  55       R-23
              .
              .
  58          .          BE
              .           .
              .           .
  63          .           .        BE1
              .           .          .
              .           .          .
  68         N3........................
              V
              V
  71       R-34
              .
              .
  74          .          BD
              .           .
              .           .
  79          .           .        BD1
              .           .          .
              .           .          .
  84         N4........................
```

C221

```
            V
            V
 87      R-45
            .
            .
 90         .        BC
            .         .
            .         .
 95         .         .       BC1
            .         .         .
            .         .         .
100         .         .         .       BT2
            .         .         .         .
            .         .         .         .
105         .         .         .         .        BT
            .         .         .         .         .
            .         .         .         .         .
110         .         .         .         .         .        BT1
            .         .         .         .         .          .
            .         .         .         .         .          .
115         .         .         .        S1.........................
            .         .         .         V
            .         .         .         V
118         .         .         .       S-12
            .         .         .         .
            .         .         .         .
121         .         .         .         .        BS
            .         .         .         .         .
            .         .         .         .         .
126         .         .         .         .         .        BS1
            .         .         .         .         .          .
            .         .         .         .         .          .
131         .         .         .        S1.........................
            .         .         .         V
            .         .         .         V
134         .         .         .       S-23
            .         .         .         .
            .         .         .         .
137         .         .         .         .        BR
            .         .         .         .         .
            .         .         .         .         .
142         .         .         .         .         .        BR1
            .         .         .         .         .          .
            .         .         .         .         .          .
147         .         .         .        S2.........................
            .         .         .         V
            .         .         .         V
150         .         .         .       S-34
            .         .         .         .
            .         .         .         .
153        N5.......................................
            V
            V
156      R-56
            .
            .
159         .        BB
            .         .
            .         .
164         .         .       BB1
```

C222

```
              .          .          .
              .          .          .
169         N6.......................
              V
              V
172       R-67
              .
              .
175           .         BA
              .          .
              .          .
180           .          .        BA1
              .          .          .
              .          .          .
185         N7.......................
              V
              V
188       R-78
```

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	BG2	100.	0.67	14.	14.	14.	0.05		
HYDROGRAPH AT	BG1	1.	0.67	0.	0.	0.	0.00		
2 COMBINED AT	NT1	102.	0.67	14.	14.	14.	0.06		
ROUTED TO	R-T1	101.	0.67	14.	14.	14.	0.06	TRANSITION FLOW	
HYDROGRAPH AT	BG	39.	0.93	10.	10.	10.	0.12		
2 COMBINED AT	N1	107.	0.68	24.	24.	24.	0.18		
ROUTED TO	R-12	104.	0.73	24.	24.	24.	0.18	REACH 1 FLOW	
HYDROGRAPH AT	BF	4.	1.15	1.	1.	1.	0.08		
HYDROGRAPH AT	BF1	6.	0.60	0.	0.	0.	0.00		
3 COMBINED AT	N2	106.	0.73	26.	26.	26.	0.26		
ROUTED TO	R-23	101.	0.85	25.	25.	25.	0.26	REACH 2 FLOW	
HYDROGRAPH AT	BE	26.	0.73	4.	4.	4.	0.05		
HYDROGRAPH AT	BE1	2.	0.63	0.	0.	0.	0.00		
3 COMBINED AT	N3	120.	0.83	30.	30.	30.	0.32		
ROUTED TO	R-34	120.	0.87	29.	29.	29.	0.32	REACH 3 FLOW	
HYDROGRAPH AT	BD	0.	1.15	0.	0.	0.	0.00		
HYDROGRAPH AT	BD1	3.	0.63	0.	0.	0.	0.00		
3 COMBINED AT	N4	120.	0.87	30.	30.	30.	0.32		
ROUTED TO	R-45	121.	0.88	30.	30.	30.	0.32	REACH 4 FLOW	
HYDROGRAPH AT	BC	0.	1.15	0.	0.	0.	0.01		
HYDROGRAPH AT	BC1	2.	0.67	0.	0.	0.	0.00		
HYDROGRAPH AT	BT2	2.	0.65	0.	0.	0.	0.00		
HYDROGRAPH AT	BT	9.	0.83	2.	2.	2.	0.01		
HYDROGRAPH AT	BT1	20.	0.88	5.	5.	5.	0.04		
3 COMBINED AT	S1	29.	0.87	7.	7.	7.	0.06		
ROUTED TO	S-12	29.	0.92	7.	7.	7.	0.06	SWALE REACH 1 FLOW	

HYDROGRAPH AT	BS	37.	0.88	9.	9.	9.	0.07	
HYDROGRAPH AT	BS1	24.	0.72	4.	4.	4.	0.03	
3 COMBINED AT	S1	78.	0.87	20.	20.	20.	0.16	
ROUTED TO	S-23	77.	0.98	20.	20.	20.	0.16	SWALE REACH 2 FLOW
HYDROGRAPH AT	BR	8.	0.80	1.	1.	1.	0.01	
HYDROGRAPH AT	BR1	3.	0.65	0.	0.	0.	0.00	
3 COMBINED AT	S2	82.	0.97	21.	21.	21.	0.17	
ROUTED TO	S-34	82.	1.00	21.	21.	21.	0.17	SWALE REACH 3 FLOW
4 COMBINED AT	N5	188.	0.90	51.	51.	51.	0.51	
ROUTED TO	R-56	187.	0.92	51.	51.	51.	0.51	NORTH REACH 5 FLOW
HYDROGRAPH AT	BB	2.	0.90	1.	1.	1.	0.04	
HYDROGRAPH AT	BB1	3.	0.60	0.	0.	0.	0.00	
3 COMBINED AT	N6	190.	0.92	52.	52.	52.	0.55	
ROUTED TO	R-67	190.	0.95	52.	52.	52.	0.55	NORTH REACH 6 FLOW
HYDROGRAPH AT	BA	9.	0.83	2.	2.	2.	0.03	
HYDROGRAPH AT	BA1	1.	0.60	0.	0.	0.	0.00	
3 COMBINED AT	N7	197.	0.95	54.	54.	54.	0.58	
ROUTED TO	R-78	196.	0.97	53.	53.	53.	0.58	NORTH REACH 7 FLOW

```
****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*             MAY   1991               *
*           VERSION 4.0.1E             *
*                                      *
*  RUN DATE  10/11/93  TIME  13:44:53  *
*                                      *
****************************************
```

```
****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
*   HYDROLOGIC ENGINEERING CENTER      *
*         609 SECOND STREET            *
*      DAVIS, CALIFORNIA 95616         *
*          (916) 551-1748              *
*                                      *
****************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X              X
XXXXXXX  XXXX     X       XXXXX  X
X     X  X        X              X
X     X  X        X     X        X
X     X  XXXXXXX   XXXXX         XXX
```

NORTH DITCH & SWALE
50 YR 1 HR STORM

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   Input File Name:     R:\PROJECTS\336\HEC1\CANONIE.PMP\NORTH2.IH1
  2           ID   DATE:06-14-93          DESIGN
  3           ID   HEC-1 PMP RUNOFF STUDY,JEFFREY CITY, WYOMING
  4           ID   DIVERSION CHANNEL MODIFICATIONS - NORTH CHANNEL
  5           ID            CURVE NUMBER = SPECIFIC TO BASINS
  6           ID   DESIGNED FOR 1 HOUR PMP AT 9.20 INCHES WITH SCS TYPE II DISTRIBUTION
  7           ID   ANTECEDENT MOISTURE CONDITION III
              *DIAGRAM
  8           IT       1       0    0000     120       0       0
  9           IN       3       0       0
 10           IO       5       0
              *

 11           KK     BG2 RUNOFF FROM BASIN G2 (INTO TRANSITION)
 12           KO                                     21
 13           PB     1.3
 14           PC     .01     .02     .03     .04    .055     .07    .085    .105     .15    .205
 15           PC    .285    .425    .655    .765     .83     .88     .91     .93    .945     .96
 16           PC     .97     .98     .99     1.0
 17           BA    .055
 18           LS       0      96
 19           UD    .081
              *

 20           KK     BG1 RUNOFF FROM BASIN G1 (INTO TRANSITION)
 21           KO                                     21
 22           BA    .005
 23           LS       0      79
 24           UD    .042
              *

 25           KK     NT1  COMBINE G1 AND G2
 26           KO                                     21
 27           HC       2
              *

 28           KK    R-T1  ROUTE NORTH TRANSITION TO NORTH 1
 29           KO                                     21
 30           RD     100   .0598   .0313            TRAP      15       3
              *

 31           KK     BG  RUNOFF FROM BASIN G
 32           KO                                     21
 33           BA    .124
 34           LS       0      85
 35           UD    .263
              *

 36           KK      N1  COMBINE G1 AND G2 AND G
 37           KO                                     21
 38           HC       2
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  39          KK    R-12  ROUTE NORTH 1-2
  40          KO                                    21
  41          RD     950    .005   .0313           TRAP      15       3
              *

  42          KK      BF  RUNOFF FROM BASIN F
  43          KO                                    21
  44          BA    .075
  45          LS       0      74
  46          UD    .355
              *

  47          KK     BF1  RUNOFF FROM BASIN F1
  48          KO                                    21
  49          BA    .004
  50          LS       0      89
  51          UD    .008
              *

  52          KK      N2  COMBINE ROUTED REACH WITH BASIN F AT NODE 2
  53          KO                                    21
  54          HC       3
              *

  55          KK    R-23  ROUTE NORTH 2-3
  56          KO                                    21
  57          RD    1850    .005   .0313           TRAP      15       3
              *

  58          KK      BE  RUNOFF FROM BASIN E
  59          KO                                    21
  60          BA    .051
  61          LS       0      85
  62          UD    .106
              *

  63          KK     BE1  RUNOFF FROM BASIN E1
  64          KO                                    21
  65          BA    .002
  66          LS       0      89
  67          UD    .046
              *

  68          KK      N3  COMBINE ROUTED REACH WITH BASIN E AT NODE 3
  69          KO                                    21
  70          HC       3
              *

  71          KK    R-34  ROUTE NORTH 3-4
  72          KO                                    21
  73          RD     770   .0387   .0410           TRAP      15       3
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  74          KK      BD  RUNOFF FROM BASIN D
  75          KO                                      21
  76          BA    .005
  77          LS       0      67
  78          UD    .127
              *

  79          KK     BD1  RUNOFF FROM BASIN D1
  80          KO                                      21
  81          BA    .003
  82          LS       0      89
  83          UD    .049
              *

  84          KK      N4  COMBINE ROUTED REACH WITH BASIN D AT NODE 4
  85          KO                                      21
  86          HC       3
              *

  87          KK    R-45  ROUTE NORTH 4-5
  88          KO                                      21
  89          RD     580   .0387   .0431          TRAP       15       3
              *

  90          KK      BC  RUNOFF FROM BASIN C
  91          KO                                      21
  92          BA    .006
  93          LS       0      67
  94          UD    .134
              *

  95          KK     BC1  RUNOFF FROM BASIN C1
  96          KO                                      21
  97          BA    .002
  98          LS       0      89
  99          UD    .064
              *

 100          KK     BT2  RUNOFF FROM SWALE BASIN T2
 101          KO                                      21
 102          BA    .002
 103          LS       0      89
 104          UD    .058
              *

 105          KK      BT  RUNOFF FROM SWALE BASIN T
 106          KO                                      21
 107          BA    .015
 108          LS       0      89
 109          UD    .200
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 110          KK     BT1  RUNOFF FROM SWALE BASIN T1
 111          KO                                   21
 112          BA    .039
 113          LS       0      89
 114          UD    .246
              *

 115          KK      S1  COMBINE SWALE REACH S-12 AND BASIN S
 116          KO                                   21
 117          HC       3
              *

 118          KK    S-12  ROUTE SWALE 1-2
 119          KO                                   21
 120          RD     500    .007   .0313           TRAP      20      16
              *

 121          KK      BS  RUNOFF FROM SWALE BASIN S
 122          KO                                   21
 123          BA    .073
 124          LS       0      89
 125          UD    .248
              *

 126          KK     BS1  RUNOFF FROM SWALE BASIN S1
 127          KO                                   21
 128          BA     .03
 129          LS       0      89
 130          UD    .105
              *

 131          KK      S1  COMBINE SWALE REACH S-12 AND BASIN S
 132          KO                                   21
 133          HC       3
              *

 134          KK    S-23  ROUTE SWALE 2-3
 135          KO                                   21
 136          RD    1450    .007   .0313           TRAP      20      16
              *

 137          KK      BR  RUNOFF FROM SWALE BASIN R
 138          KO                                   21
 139          BA    .012
 140          LS       0      89
 141          UD    .168
              *

 142          KK     BR1  RUNOFF FROM SWALE BASIN R1
 143          KO                                   21
 144          BA    .003
 145          LS       0      89
 146          UD    .056
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 147          KK      S2  COMBINE SWALE REACH 2-3 AND BASIN R
 148          KO                                      21
 149          HC       3
              *

 150          KK    S-34  ROUTE SWALE REACH 3-4
 151          KO                                      21
 152          RD     745   .0409   .0383            TRAP      20       8
              *

 153          KK      N5  COMBINE ROUTED REACH, BASIN C, AND SWALE  AT NODE 5 AND BASIN C1
 154          KO                                      21
 155          HC       4
              *

 156          KK    R-56  ROUTE NORTH 5-6
 157          KO                                      21
 158          RD     400   .0303   .0431            TRAP      15       3
              *

 159          KK      BB  RUNOFF FROM BASIN B
 160          KO                                      21
 161          BA    .041
 162          LS       0      73
 163          UD    .164
              *

 164          KK     BB1  RUNOFF FROM BASIN B1
 165          KO                                      21
 166          BA    .002
 167          LS       0      89
 168          UD    .013
              *

 169          KK      N6  COMBINE ROUTED REACH WITH BASIN B AT NODE 6
 170          KO                                      21
 171          HC       3
              *

 172          KK    R-67  ROUTE NORTH 6-7
 173          KO                                      21
 174          RD     650     .02   .0377            TRAP      15       3
              *

 175          KK      BA  RUNOFF FROM BASIN A
 176          KO                                      21
 177          BA    .034
 178          LS       0      82
 179          UD    .175
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


 180          KK     BA1  RUNOFF FROM BASIN A1
 181          KO                                   21
 182          BA    .001
 183          LS       0      89
 184          UD    .013
              *

 185          KK      N7  COMBINE ROUTED REACH WITH BASIN A AT NODE 7
 186          KO                                   21
 187          HC       3
              *

 188          KK    R-78  ROUTE NORTH 7-8
 189          KO
 190          RD     460    .005   .0329           TRAP      15       3
 191          ZZ
```

C232

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
INPUT
 LINE     (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

  NO.     (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

  11        BG2
              .
              .
  20          .        BG1
              .          .
              .          .
  25        NT1............
              V
              V
  28       R-T1
              .
              .
  31          .        BG
              .          .
              .          .
  36         N1............
              V
              V
  39       R-12
              .
              .
  42          .         BF
              .          .
              .          .
  47          .          .        BF1
              .          .          .
              .          .          .
  52         N2........................
              V
              V
  55       R-23
              .
              .
  58          .         BE
              .          .
              .          .
  63          .          .        BE1
              .          .          .
              .          .          .
  68         N3........................
              V
              V
  71       R-34
              .
              .
  74          .         BD
              .          .
              .          .
  79          .          .        BD1
              .          .          .
              .          .          .
  84         N4........................
```

C 233

```
            V
            V
 87       R-45
            .
            .
 90         .        BC
            .         .
            .         .
 95         .         .       BC1
            .         .         .
            .         .         .
100         .         .         .       BT2
            .         .         .         .
            .         .         .         .
105         .         .         .         .        BT
            .         .         .         .         .
            .         .         .         .         .
110         .         .         .         .         .        BT1
            .         .         .         .         .          .
            .         .         .         .         .          .
115         .         .         .        S1.........................
            .         .         .         V
            .         .         .         V
118         .         .         .       S-12
            .         .         .         .
            .         .         .         .
121         .         .         .         .        BS
            .         .         .         .         .
            .         .         .         .         .
126         .         .         .         .         .        BS1
            .         .         .         .         .          .
            .         .         .         .         .          .
131         .         .         .        S1.........................
            .         .         .         V
            .         .         .         V
134         .         .         .       S-23
            .         .         .         .
            .         .         .         .
137         .         .         .         .        BR
            .         .         .         .         .
            .         .         .         .         .
142         .         .         .         .         .        BR1
            .         .         .         .         .          .
            .         .         .         .         .          .
147         .         .         .        S2.........................
            .         .         .         V
            .         .         .         V
150         .         .         .       S-34
            .         .         .         .
            .         .         .         .
153        N5.......................................
            V
            V
156       R-56
            .
            .
159         .        BB
            .         .
            .         .
164         .         .       BB1
```

C234

```
              .          .          .
              .          .          .
169         N6.......................
             V
             V
172       R-67
              .
              .
175           .         BA
              .          .
              .          .
180           .          .        BA1
              .          .          .
              .          .          .
185         N7.......................
             V
             V
188       R-78
```

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	BG2	118.	0.67	16.	16.	16.	0.05		
HYDROGRAPH AT	BG1	2.	0.67	0.	0.	0.	0.00		
2 COMBINED AT	NT1	120.	0.67	16.	16.	16.	0.06		
ROUTED TO	R-T1	120.	0.67	17.	17.	17.	0.06	NORTH TRANSITION FLOW	
HYDROGRAPH AT	BG	52.	0.92	13.	13.	13.	0.12		
2 COMBINED AT	N1	129.	0.68	30.	30.	30.	0.18		
ROUTED TO	R-12	125.	0.73	30.	30.	30.	0.18		
HYDROGRAPH AT	BF	6.	1.12	2.	2.	2.	0.08		
HYDROGRAPH AT	BF1	8.	0.60	1.	1.	1.	0.00		
3 COMBINED AT	N2	128.	0.73	32.	32.	32.	0.26		
ROUTED TO	R-23	123.	0.83	32.	32.	32.	0.26		
HYDROGRAPH AT	BE	35.	0.73	5.	5.	5.	0.05		
HYDROGRAPH AT	BE1	3.	0.63	0.	0.	0.	0.00		
3 COMBINED AT	N3	148.	0.83	38.	38.	38.	0.32		
ROUTED TO	R-34	148.	0.85	38.	38.	38.	0.32		
HYDROGRAPH AT	BD	0.	0.90	0.	0.	0.	0.00		
HYDROGRAPH AT	BD1	4.	0.63	0.	0.	0.	0.00		
3 COMBINED AT	N4	149.	0.85	38.	38.	38.	0.32		
ROUTED TO	R-45	150.	0.87	38.	38.	38.	0.32		
HYDROGRAPH AT	BC	0.	0.92	0.	0.	0.	0.01		
HYDROGRAPH AT	BC1	2.	0.67	0.	0.	0.	0.00		
HYDROGRAPH AT	BT2	3.	0.65	0.	0.	0.	0.00		
HYDROGRAPH AT	BT	11.	0.83	2.	2.	2.	0.01		
HYDROGRAPH AT	BT1	26.	0.88	6.	6.	6.	0.04		
3 COMBINED AT	S1	37.	0.87	9.	9.	9.	0.06		
ROUTED TO	S-12	37.	0.90	9.	9.	9.	0.06	SWALE REACH 1	

HYDROGRAPH AT	BS	48.	0.88	11.	11.	11.	0.07
HYDROGRAPH AT	BS1	31.	0.72	5.	5.	5.	0.03
3 COMBINED AT	S1	99.	0.87	25.	25.	25.	0.16
ROUTED TO	S-23	98.	0.97	25.	25.	25.	0.16
HYDROGRAPH AT	BR	10.	0.78	2.	2.	2.	0.01
HYDROGRAPH AT	BR1	4.	0.65	0.	0.	0.	0.00
3 COMBINED AT	S2	105.	0.95	27.	27.	27.	0.17
ROUTED TO	S-34	105.	0.98	27.	27.	27.	0.17
4 COMBINED AT	N5	236.	0.92	66.	66.	66.	0.51
ROUTED TO	R-56	236.	0.92	65.	65.	65.	0.51
HYDROGRAPH AT	BB	5.	0.88	1.	1.	1.	0.04
HYDROGRAPH AT	BB1	4.	0.60	0.	0.	0.	0.00
3 COMBINED AT	N6	240.	0.92	67.	67.	67.	0.55
ROUTED TO	R-67	241.	0.93	66.	66.	66.	0.55
HYDROGRAPH AT	BA	13.	0.83	3.	3.	3.	0.03
HYDROGRAPH AT	BA1	2.	0.60	0.	0.	0.	0.00
3 COMBINED AT	N7	252.	0.93	69.	69.	69.	0.58
ROUTED TO	R-78	250.	0.95	69.	69.	69.	0.58

```
****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*              MAY   1991              *
*           VERSION 4.0.1E             *
*                                      *
*  RUN DATE  10/11/93  TIME  13:43:17  *
*                                      *
****************************************
```

```
****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
*   HYDROLOGIC ENGINEERING CENTER      *
*         609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616        *
*          (916) 551-1748              *
*                                      *
****************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X       X     X        XX
X     X  X       X               X
XXXXXXX  XXXX    X       XXXXX   X
X     X  X       X               X
X     X  X       X     X         X
X     X  XXXXXXX   XXXXX        XXX
```

SOUTH DITCH 25 YR 1HR STORM

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   Input File Name:     R:\PROJECTS\336\HEC1\~~SOUTH2.IN1~~ SLFS2S.IN1
  2           ID   DATE:10-08-93        DESIGN D50
  3           ID   HEC-1 PMP RUNOFF STUDY,JEFFREY CITY, WYOMING
  4           ID   DIVERSION CHANNEL MODIFICATIONS - SOUTH CHANNEL
  5           ID            CURVE NUMBER = SPECIFIC TO BASINS
  6           ID   DESIGNED FOR PMP, 9.2 in. IN  1 HOUR WITH SCS TYPE II DISTRIBUTION
  7           ID   ANTECEDENT MOISTURE CONDITION III
              *DIAGRAM
  8           IT       1       0    0000     120       0       0
  9           IN       3       0       0
 10           IO       5       0
              *

 11           KK     BH2  RUNOFF FROM BASIN H2
 12           KO                                    21
 13           PB    1.15
 14           PC     .01     .02     .03     .04    .055     .07    .085    .105     .15    .205
 15           PC    .285    .425    .655    .765     .83     .88     .91     .93    .945     .96
 16           PC     .97     .98     .99     1.0
 17           BA    .001
 18           LS       0      89
 19           UD    .021
              *

 20           KK    R-T1  ROUTE SOUTH T-1
 21           KO                                    21
 22           RD     100    .065   .0369            TRAP      15       3
              *

 23           KK      BH  RUNOFF FROM BASIN H
 24           KO                                    21
 25           BA    .038
 26           LS       0      94
 27           UD    .047
              *

 28           KK     BH1  RUNOFF FROM BASIN H1
 29           KO                                    21
 30           BA    .002
 31           LS       0      89
 32           UD    .007
              *

 33           KK      N1  COMBINE ROUTED REACH WITH BASIN H, H1, AND H2 AT NODE 1
 34           KO                                    21
 35           HC       3
              *

 36           KK    R-12  ROUTE SOUTH 1-2
 37           KO                                    21
 38           RD    1300   .0082   .0313            TRAP      15       3
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 39           KK      BI  RUNOFF FROM BASIN I
 40           KO                                  21
 41           BA    .064
 42           LS       0      92
 43           UD    .058
              *

 44           KK     BI1  RUNOFF FROM BASIN I1
 45           KO                                  21
 46           BA    .002
 47           LS       0      89
 48           UD    .007
              *

 49           KK      N2  COMBINE ROUTED REACH WITH BASIN I AT NODE 2
 50           KO                                  21
 51           HC       3
              *

 52           KK    R-23  ROUTE SOUTH 2-3
 53           KO                                  21
 54           RD    1200    .004   .0313          TRAP      15       3
              *

 55           KK      BJ  RUNOFF FROM BASIN J
 56           KO                                  21
 57           BA    .059
 58           LS       0      84
 59           UD    .086
              *

 60           KK     BJ1  RUNOFF FROM BASIN J1
 61           KO                                  21
 62           BA    .009
 63           LS       0      89
 64           UD    .086
              *

 65           KK      N3  COMBINE ROUTED REACH WITH BASIN J AT NODE 3
 66           KO                                  21
 67           HC       3
              *

 68           KK    R-34  ROUTE SOUTH 3-4
 69           KO                                  21
 70           RD    2300   .0229   .0313          TRAP      15       3
              *

 71           KK      BK  RUNOFF FROM BASIN K
 72           KO                                  21
 73           BA    .102
 74           LS       0      92
 75           UD    .136
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 76           KK     BK1  RUNOFF FROM BASIN K1
 77           KO                                   21
 78           BA    .004
 79           LS       0      89
 80           UD    .023
              *

 81           KK      N4  COMBINE ROUTED REACH WITH BASIN K AT NODE 4
 82           KO                                   21
 83           HC       3
              *

 84           KK    R-45  ROUTE SOUTH 4-5
 85           KO                                   21
 86           RD     800   .0231   .0366          TRAP       15       3
              *

 87           KK      BL  RUNOFF FROM BASIN L
 88           KO                                   21
 89           BA    .024
 90           LS       0      67
 91           UD    .143
              *

 92           KK     BL1  RUNOFF FROM BASIN L1
 93           KO                                   21
 94           BA    .004
 95           LS       0      89
 96           UD    .024
              *

 97           KK      N5  COMBINE ROUTED REACH WITH BASIN L AT NODE 5
 98           KO                                   21
 99           HC       3
              *

100           KK    R-56  ROUTE SOUTH 5-6
101           KO                                   21
102           RD    1000   .0231   .0379          TRAP       15       3
103           ZZ
```

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
INPUT
 LINE     (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

 NO.      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

 11         BH2
              V
              V
 20        R-T1
              .
              .
 23           .          BH
              .           .
              .           .
 28           .           .         BH1
              .           .           .
              .           .           .
 33         N1.......................
              V
              V
 36        R-12
              .
              .
 39           .          BI
              .           .
              .           .
 44           .           .         BI1
              .           .           .
              .           .           .
 49         N2.......................
              V
              V
 52        R-23
              .
              .
 55           .          BJ
              .           .
              .           .
 60           .           .         BJ1
              .           .           .
              .           .           .
 65         N3.......................
              V
              V
 68        R-34
              .
              .
 71           .          BK
              .           .
              .           .
 76           .           .         BK1
              .           .           .
              .           .           .
 81         N4.......................
              V
              V
 84        R-45
```

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```
                .
                .
  87            .          BL
                .           .
                .           .
  92            .           .         BL1
                .           .           .
                .           .           .
  97          N5.......................
               V
               V
 100        R-56
```

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

SOUTH DITCH 25 YR 1 HR STORM

RUNOFF SUMMARY

FLOW IN CUBIC FEET PER SECOND

TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	BH2	1.	0.60	0.	0.	0.	0.00		
ROUTED TO	R-T1	1.	0.62	0.	0.	0.	0.00	TRANSITION	
HYDROGRAPH AT	BH	69.	0.63	8.	8.	8.	0.04		
HYDROGRAPH AT	BH1	3.	0.60	0.	0.	0.	0.00		
3 COMBINED AT	N1	72.	0.63	8.	8.	8.	0.04		
ROUTED TO	R-12	68.	0.70	8.	8.	8.	0.04	REACH 1 FLOW	
HYDROGRAPH AT	BI	89.	0.65	11.	11.	11.	0.06		
HYDROGRAPH AT	BI1	3.	0.60	0.	0.	0.	0.00		
3 COMBINED AT	N2	143.	0.68	19.	19.	19.	0.11		
ROUTED TO	R-23	131.	0.75	19.	19.	19.	0.11	REACH 2 FLOW	
HYDROGRAPH AT	BJ	28.	0.70	4.	4.	4.	0.06		
HYDROGRAPH AT	BJ1	8.	0.68	1.	1.	1.	0.01		
3 COMBINED AT	N3	164.	0.75	24.	24.	24.	0.17		
ROUTED TO	R-34	163.	0.82	24.	24.	24.	0.17	REACH 3 FLOW	
HYDROGRAPH AT	BK	100.	0.75	17.	17.	17.	0.10		
HYDROGRAPH AT	BK1	5.	0.62	0.	0.	0.	0.00		
3 COMBINED AT	N4	252.	0.80	42.	42.	42.	0.28		
ROUTED TO	R-45	251.	0.83	42.	42.	42.	0.28	REACH 4 FLOW	
HYDROGRAPH AT	BL	0.	1.17	0.	0.	0.	0.02		
HYDROGRAPH AT	BL1	5.	0.62	0.	0.	0.	0.00		
3 COMBINED AT	N5	252.	0.83	43.	43.	43.	0.31		
ROUTED TO	R-56	256.	0.85	43.	43.	43.	0.31	REACH 5 FLOW	

```
*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*             MAY   1991                *
*          VERSION 4.0.1E               *
*                                       *
*  RUN DATE  10/11/93  TIME  13:45:40   *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*    HYDROLOGIC ENGINEERING CENTER      *
*          609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616         *
*          (916) 551-1748               *
*                                       *
*****************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X              X
XXXXXXX  XXXX     X       XXXXX  X
X     X  X        X              X
X     X  X        X     X        X
X     X  XXXXXXX   XXXXX        XXX
```

NORTH CENTRAL DITCH
50 YR. STORM

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID  File N     me:R:\PROJECTS\336\HEC1\~~NC2.IH1~~ SLFNC50.IH2          DATE:
  2           ID  06-14-                  DESIGN                                     HEC-1
  3           ID  PMP RUOFF STUDY,JEFFRE Y CITY, WYOMING                             DIVER
  4           ID  SION CNNEL MODIFICATIONS - NORTH CENTRAL CHANN      EL
  5           ID     CURVE NUMBER = SPEC IFIC TO  BASINS                             DESIG
  6           ID  NED FOPMP, 9.20 in  IN 1 HOURS WITH SCS TYPE II DISTRI  BUTION     ANTEC
  7           ID  EDENT ISTURE CONDITION     III
              *DIAGRAM
  8           IT       1       0    0000     120       0       0
  9           IN       3       0       0
 10           IO       5       0
              *

 11           KK      BP  RUNOFF FROM BASIN P
 12           KO                                    21
 13           PB     1.3
 14           PC     .01     .02     .03     .04    .055     .07    .085    .105     .15    .205
 15           PC    .285    .425    .655    .765     .83     .88     .91     .93    .945     .96
 16           PC     .97     .98     .99     1.0
 17           BA    .003
 18           LS       0      69
 19           UD    .089
              *

 20           KK     BP1  RUNOFF FROM BASIN P1
 21           KO                                    21
 22           BA    .015
 23           LS       0      89
 24           UD    .058
              *

 25           KK     BP2  RUNOFF FROM BASIN P2
 26           KO                                    21
 27           BA   .0005
 28           LS       0      89
 29           UD    .007
              *

 30           KK      N1  COMBINE BP, BP1, BP2
 31           KO                                    21
 32           HC       3
              *

 33           KK    R-12  ROUTE NORTH CENTRAL 1-2
 34           KO                                    21
 35           RD     495    .005   .0313            TRAP      10       3
              *

 36           KK      BO  RUNOFF FROM BASIN O
 37           KO                                    21
 38           BA    .008
 39           LS       0      81
 40           UD    .034
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  41          KK     BO1  RUNOFF FROM BASIN O1
  42          KO                                   21
  43          BA    .001
  44          LS       0      89
  45          UD    .007
              *

  46          KK      N2  COMBINE ROUTED REACH WITH BASIN O AT NODE 2 (AND O1
  47          KO                                   21
  48          HC       3
              *

  49          KK    R-23  ROUTE NORTH CENTRAL 2-3
  50          KO                                   21
  51          RD     695     .03   .0382           TRAP      10       3
              *

  52          KK      BM  RUNOFF FROM BASIN M
  53          KO                                   21
  54          BA    .033
  55          LS       0      87
  56          UD    .109
              *

  57          KK     BM1  RUNOFF FROM BASIN M1
  58          KO                                   21
  59          BA    .001
  60          LS       0      89
  61          UD    .005
              *

  62          KK      N3  COMBINE ROUTED REACH WITH BASIN M AT NODE 3 (AND M1)
  63          KO                                   21
  64          HC       3
              *

  65          KK    R-34  ROUTE NORTH CENTRAL 3-4
  66          KO                                   21
  67          RD     336    .005   .0313           TRAP      10       3
  68          ZZ
```

C247

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
INPUT
 LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

 NO.       (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

  11          BP
               .
               .
  20           .         BP1
               .           .
               .           .
  25           .           .        BP2
               .           .          .
               .           .          .
  30          N1.......................
               V
               V
  33        R-12
               .
               .
  36           .          BO
               .           .
               .           .
  41           .           .        BO1
               .           .          .
               .           .          .
  46          N2.......................
               V
               V
  49        R-23
               .
               .
  52           .          BM
               .           .
               .           .
  57           .           .        BM1
               .           .          .
               .           .          .
  62          N3.......................
               V
               V
  65        R-34
```

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	BP	0.	0.83	0.	0.	0.	0.00		
HYDROGRAPH AT	BP1	19.	0.65	2.	2.	2.	0.01		
HYDROGRAPH AT	BP2	1.	0.60	0.	0.	0.	0.00		
3 COMBINED AT	N1	20.	0.65	2.	2.	2.	0.02		
ROUTED TO	R-12	19.	0.70	2.	2.	2.	0.02	REACH 1 FLOW	
HYDROGRAPH AT	BO	5.	0.63	1.	1.	1.	0.01		
HYDROGRAPH AT	BO1	2.	0.60	0.	0.	0.	0.00		
3 COMBINED AT	N2	23.	0.70	3.	3.	3.	0.03		
ROUTED TO	R-23	23.	0.73	3.	3.	3.	0.03	REACH 2 FLOW	
HYDROGRAPH AT	BM	27.	0.72	4.	4.	4.	0.03		
HYDROGRAPH AT	BM1	2.	0.60	0.	0.	0.	0.00		
3 COMBINED AT	N3	51.	0.73	8.	8.	8.	0.06		
ROUTED TO	R-34	50.	0.75	8.	8.	8.	0.06	REACH 3 FLOW	

```
****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*             MAY   1991               *
*          VERSION 4.0.1E              *
*                                      *
*  RUN DATE  10/11/93  TIME  13:46:12  *
*                                      *
****************************************
```

```
****************************************
*                                      *
*    U.S. ARMY CORPS OF ENGINEERS      *
*    HYDROLOGIC ENGINEERING CENTER     *
*          609 SECOND STREET           *
*       DAVIS, CALIFORNIA 95616        *
*          (916) 551-1748              *
*                                      *
****************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X              X
XXXXXXX  XXXX     X       XXXXX  X
X     X  X        X              X
X     X  X        X     X        X
X     X  XXXXXXX   XXXXX        XXX
```

SOUTH CENTRAL DITCH
25 YR 1HR STORM

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   Input File Name:     R:\PROJECTS\336\HEC1\C\SC2.IH1
  2           ID   DATE:06-17-93         DESIGN
  3           ID   HEC-1 PMP RUNOFF STUDY,JEFFREY CITY, WYOMING
  4           ID   DIVERSION CHANNEL MODIFICATIONS - SOUTH CENTRAL CHANNEL
  5           ID            CURVE NUMBER = SPECIFIC TO BASINS
  6           ID   DESIGNED FOR PMP, 9.20 in. IN 1 HOURS WITH SCS TYPE II DISTRIBUTION
  7           ID   ANTECEDENT MOISTURE CONDITION III
              *DIAGRAM
  8           IT       1       0    0000     120       0       0
  9           IN       3       0       0
 10           IO       5       0
              *

 11           KK      BQ  RUNOFF FROM BASIN Q
 12           KO                                    21
 13           PB    1.15
 14           PC     .01     .02     .03     .04    .055     .07    .085    .105     .15    .205
 15           PC    .285    .425    .655    .765     .83     .88     .91     .93    .945     .96
 16           PC     .97     .98     .99     1.0
 17           BA    .024
 18           LS       0      78
 19           UD    .138
              *

 20           KK     BQ2  RUNOFF FROM BASIN Q2
 21           KO                                    21
 22           BA    .002
 23           LS       0      89
 24           UD    .007
              *

 25           KK     BQ1  RUNOFFROM BASIN Q1
 26           KO                                    21
 27           BA    .032
 28           LS       0      89
 29           UD    .111
              *

 30           KK      N1  COMBINE BASINS  Q AND Q1 AND Q2 AT NODE 1
 31           KO                                    21
 32           HC       3
              *

 33           KK    R-12  ROUTE SOUTH CENTRAL 1-2
 34           KO                                    21
 35           RD    1575     .04   .0329            TRAP      15       3
              *

 36           KK      BN RUNOFF FROM BASIN N
 37           KO                                    21
 38           BA    .066
 39           LS       0      79
 40           UD    .141
              *
```

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  41          KK     BN1  RUNOFF FROM BASIN N1
  42          KO                                   21
  43          BA    .001
  44          LS       0      89
  45          UD    .005
              *

  46          KK      N2  COMBINE ROUTED REACH WITH BASINS N1 AND N2
  47          KO                                   21
  48          HC       3
              *

  49          KK    R-23  ROUTE SOUTH CENTRAL 2-3
  50          KO                                   21
  51          RD     728    .009   .0352           TRAP      15       3
              *
  52          ZZ
```

C252

SCHEMATIC DIAGRAM OF STREAM NETWORK

```
INPUT
 LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

  NO.      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

   11          BQ
                .
                .
   20           .         BQ2
                .           .
                .           .
   25           .           .         BQ1
                .           .           .
                .           .           .
   30          N1.......................
                V
                V
   33        R-12
                .
                .
   36           .          BN
                .           .
                .           .
   41           .           .         BN1
                .           .           .
                .           .           .
   46          N2.......................
                V
                V
   49        R-23
```

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

C25

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	BQ	4.	0.82	1.	1.	1.	0.02		
HYDROGRAPH AT	BQ2	3.	0.60	0.	0.	0.	0.00		
HYDROGRAPH AT	BQ1	25.	0.72	4.	4.	4.	0.03		
3 COMBINED AT	N1	29.	0.73	5.	5.	5.	0.06		
ROUTED TO	R-12	29.	0.80	5.	5.	5.	0.06	REACH 1 FLOW	
HYDROGRAPH AT	BN	13.	0.82	3.	3.	3.	0.07		
HYDROGRAPH AT	BN1	2.	0.60	0.	0.	0.	0.00		
3 COMBINED AT	N2	42.	0.80	8.	8.	8.	0.13		
ROUTED TO	R-23	41.	0.85	8.	8.	8.	0.13	REACH 2 FLOW	

APPENDIX D

APPENDIX D

ALTERNATE CHANNEL DESIGN COMPARISON

Canonie Environmental

D-1

By EPH Date 3/10/92 Subject ALT. CHANNEL DESIGN COMPARISON Sheet No. i of 33
Chkd. By TL Date 3/11/92 Proj. No 91-225-11

1/4" X 1/4"

TABLE OF CONTENTS

DESCRIPTION	SHEET
Purpose + Method	1 of 33
Summary of Results	4 of 33
Required Channel Depth Calc.	6 of 33
Required Rock Excavation Calc.	10 of 33
Altered Cut Areas	11 of 33
Volume of Excavation	12 of 33
Additional Cost of Rock Channel over Channel in Tailings (MS1)	13 of 33
Rock Channel Cost (MS1)	14 of 33
Conventional Cost of Riprap	14 of 33
Tailings Channel Cost (MS1)	15 of 33
Comparison of Costs	16 of 33
Additional Cost of Rock Channel over Channel in Tailings (US1, LS1, LS2, TOTAL)	17 of 33
Scale Factor Calculation	19 of 33
Additional Costs (TOTAL)	20 of 33
Figure 1 - Rock Channel Route	21 of 33
Attachment A - Modified Spurlock Cross Sections	22 of 33
Attachment B - Drill + Shoot Cost Estimate	29 of 33

By EPH Date 03-05-92 Subject Alt. Channel Design Sheet No. 1 of 33

Chkd. By [illegible] Date 3/11/92 Comparison Project No. 91-225-11

PURPOSE:

It has been suggested by the NRC that portions of the South Diversion Ditch could be routed through the rock outcrop flanking the mine tailings rather than at the edge of the tailings. The purpose of this calc is to compare the cost of the two routes for the Upper South, Middle South, and Lower South Reaches 1 and 2.

C.E. Spurlock & Associates (Spurlock) provided an initial design for a channel cut through the rock outcrop for the Middle South Reach 1. After the initial design was completed, the required design flow rate for that section was increased. This calc. estimates the increased rock excavation required to upgrade the Spurlock design to meet the new design flow rate.

The additional cost requirements for constructing the modified rock channel versus a channel at the edge of the tailings is developed for the Middle South section.

Since no preliminary designs were prepared for the other reaches which can be routed in rock, rough cost estimates are developed using information from the Middle South Reach.

METHOD:

The method used to calculate the cost of the channel excavated in the rock outcropping is as follows:

- Determine required channel depth given the current PMF and drainage information.

The Spurlock design used a 2H:1V side slope for the channel's downhill embankment, and a 1H:1V side slope for the channel's uphill embankment. Manning's equation is used to calculate the depth of flow for trapezoidal channels with 2:1 and 1:1 side slopes. The average of these depths is used as an estimate of the depth of flow in a channel with one 2:1 side slope and one 1:1 side slope.

One foot of freeboard is added to the calculated depth of flow to obtain the depth of channel.

- Compare calculated channel depth for the Middle South Reach to channel cross-sections provided by

By EPH Date 03-05-92 Subject Alt. Channel Design Sheet No. 2 of 33

Chkd. By Jmb Date 3/11/92 Comparison Project No. 91-225-11

Spurlock for the Middle South Reach (See Attachment A). If SPURLOCK'S channel-section is too shallow, deepen channel to new required depth. Maintain trapezoidal channel configuration by cutting into the rock face. Maintain Spurlock's 10 foot channel bottom.

- For cross-sections that needed to be deepened, use Tamaya Planix 7 digital planimeter (average of three passes used) to determine the amount of additional rock excavation required to obtain the modified channel depth.

- Determine the volume of rock that is required to be excavated by using the average-end area method over the modified Spurlock cross-sections.

Note: Since not all channel cross sections were deepened in this process, maintaining channel slope may require additional excavation. Therefore, this method produces a conservative (LOW) estimate of the amount rock excavation required.

- Develop an additional cost (i.e. change in cost) for the construction of the rock channel versus the channel at the edge of the tailings. The production of riprap during excavation is included as a cost benefit since riprap is required for other diversion ditches.

A preliminary design is not available for a channel cut in the rock outcropping for the Upper South Reach 1 and Lower South Reaches 1 and 2. To estimate the additional cost of a rock channel for the Upper South reach 1 and the Lower South reaches 1 & 2, the result from the Middle South section is scaled according to ditch size and length as follows:

- Calculate a length scale factor by dividing the reach's length by the length of the Middle South reach.

- Calculate a channel size scale factor by dividing the channel cross sectional area by that of the Middle South reach. THE CROSS SECTIONAL AREAS FROM THE TAILINGS CHANNEL DESIGN ARE USED TO DEVELOP THE SIZE SCALE FACTOR

- Multiply the above scale factors to get a combined scale factor.

By EPH Date 03-05-92 Subject Alt. Channel Design Sheet No. 3 of 33

Chkd. By [illegible] Date 3/11/92 Comparison Project No. 91-225-11

- Multiply the additional cost of the rock channel for the Middle South section by a reach's combined scale factor to obtain a rough additional cost estimate for that reach.

This method will yield "Order-of-Magnitude" estimated additional costs based on limited available information.

Canonie Environmental

D-5

By EPH Date 3/5/92 Subject ALT CHANNEL DESIGN COMPARISON Sheet No. 4 of 33

Chkd. By JWB Date 3/11/92 Proj. No. 91-225

1/4" X 1/4"

Summary of Results

Middle South Reach 1

Required Channel Depth (at New DMF) 10.41 ft

Volume of Rock Excavation 68,293 yd^3

Cost of Rock Channel Excavation = $ 809,272

Conventional Cost to Produce Resulting RipRap = -[$ 366,187] CREDIT

Cost of Channel in Tailings = -[$ 99,736] CREDIT

Cost of Rock Channel Over Tailings Channel $\boxed{\$ 343,350}$

Canonie Environmental

D-6

By EPH Date 3/5/92 Subject ALT CHANNEL DESIGN COMPARISON Sheet No. 5 of 33

Chkd. By [illegible] Date 3/11/92 Proj. No

1/4" X 1/4"

Summary of Results

Reach	Scale Factor	Additional Cost
Upper South 1	0.75	$257,513
Middle South 1 (SEE SHEET 4 OF 33)	1.00	$ 343,350
Lower South 1	1.89	$ 648,932
Lower South 2	0.52	$ 178,542
Total Increase in Cost for Channel in Rock		$ 1,430,000

Canonie Environmental

D-7

By EPH Date 3/5/92 Subject ALT CHANNEL DESIGN COMPARISON Sheet No. 6 of 33

Chkd. By JWB Date 3/11/92 Proj. No. 91-225-11

1/4" X 1/4"

Calculate Required Channel Depth for New PMF

Middle South: Reach 1

By: EFH 3/5/92 ALT CHANNEL DESIGN COMP Sheet 7 of 32
CKD JWL 3/11/92

Project: 91-225-11

CHANNEL CONFIGURATION DESIGN USING MANNING'S EQUATION METHOD MS1_11.WR1

PROJECT: Western Nuclear Inc. 03-Mar-92
PROJECT #: 91-225-06 02:46 PM

LOCATION: **Middle South Diversion Ditch Reach 1:** Ditch Depth

INPUT PARAMETERS
****

Q(input)	=	1957 CFS	= NEW PMF
BOTTOM WIDTH	=	10 FT	= SPILLOCK DESIGN
Z (SIDE SLOPE)	=	1 (ZH:1V)	= CHANNEL SIDESLOPE OPPOSITE IMPOUNDMENT
CHANNEL SLOPE	=	0.005 FT/FT	
RIPRAP S.G.	=	2.65	
COEF FOR t	=	0.75	
Phi	=	42.00 Degrees	

SAFETY FACTORS METHOD
****

Alpha	=	45.00 Degrees
Theta	=	0.29 Degrees

CHANNEL CONFIGURATION
---

n	=	0.035	= ASSUMED MANNING'S "N" FOR CHANNEL IN ROCK
d (ASSUMED)	=	~~10.35 FT~~	== ITERATED UNTIL Q(CALC) = Q(INPUT)
A	=	210.75 FT^2	
R	=	5.36 FT	
Q (CALC)	=	1957.2 CFS	
v	=	9.29 FPS	

By: EPL 3/5/92 ALT CHANNEL DESIGN COMPARISON Sheet 8 of 33 M-1

CKD: JAL 3/11/92

Project: 91-225-11

CHANNEL CONFIGURATION DESIGN USING MANNING'S EQUATION METHOD MS1_12.WR1

PROJECT: Western Nuclear Inc. 03-Mar-92

PROJECT #: 91-225-06 02:47 PM

LOCATION: **Middle South Diversion Ditch Reach 1: Ditch Depth**

INPUT PARAMETERS
****

Q(input)	=	1957 CFS	= NEW PMF
BOTTOM WIDTH	=	10 FT	= SPILLOCK DESIGN
Z (SIDE SLOPE)	=	2 (ZH:1V)	= CHANNEL SIDE SLOPE ADJACENT TAILINGS IMPOUNDMEN
CHANNEL SLOPE	=	0.005 FT/FT	
RIPRAP S.G.	=	2.65	
COEF FOR t	=	0.75	
Phi	=	42.00 Degrees	

SAFETY FACTORS METHOD
****

Alpha	=	26.57 Degrees
Theta	=	0.29 Degrees

CHANNEL CONFIGURATION

n	=	0.035	= ASSUMED MANNING'S "N" FOR CHANNEL IN ROCK
d (ASSUMED)	=	[illegible]	<= ITERATED UNTIL Q(Calc) = Q(Input)
A	=	228.05 FT^2	
R	=	4.76 FT	
Q (CALC)	=	1956.9 CFS	
v	=	8.58 FPS	

Canonie Environmental

D-10

By EPH Date 7/5/92 Subject ALT CHANNEL DESIGN COMPARISON Sheet No. 9 of 33

Chkd. By [illegible] Date 3/11/92 Proj. No. 91-225-11

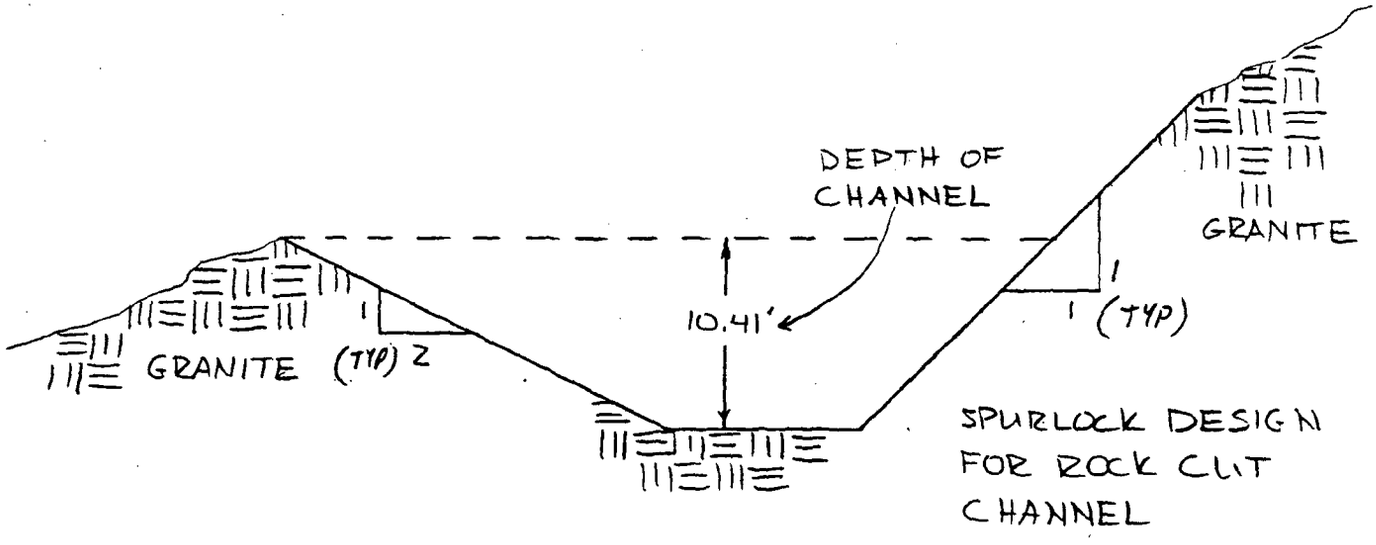
1/4" X 1/4"

Average Depth of Channel (Middle South; Reach)

The channel designed by Spurlock had a slope of 2:1 on the downhill bank and a slope of 1:1 on the uphill bank. (See Figure Below)

The required depth of channel was calculated using the Manning's equation for a 1:1 and a 2:1 slope. (See Sheets 7+8) The results are averaged below to estimate the depth of channel required for Spurlock's design.

1:1 Sideslope	⇒	Depth of Flow	= 10.35 ft
2:1 Sideslope	⇒	Depth of Flow	= 8.47 ft
		Average Depth of Flow	= 9.41 ft
		Freeboard	= 1.00 ft
		Required Depth of Channel	= 10.41 ft



SPURLOCK DESIGN FOR ROCK CUT CHANNEL

Canonie Environmental

D-11

By EPH Date 3/5/92 Subject ALT CHANNEL DESIGN COMPARISON Sheet No. 10 of 33

Chkd. By JWB Date 3/11/92 Proj. No. 91-225-11

1/4" X 1/4"

Calculate Required
Rock Excavation

Middle South: Reach 1

Altered Cut Areas

Spurlock channel cross sections every 200 ft with their preliminary design. These cross sections were deepened where required to meet the new depth of Channel requirement. (The Spurlock Design used a superceded PMF value.)
The sections that must be altered are:

STA 2+00
STA 4+00
STA 6+00
STA 14+00 (See Attachment A)

The required cut area for these sections were measured using a Tamaya Planix 7 digital planimeter (average of 3 passes used).

Section	Cut Area
STA 2+00	1038.5
STA 4+00	852.5
STA 6+00	1193.5
STA 14+00	1395.0

The cut areas calculated by Spurlock are used for the sections that did not require alterations (Attachment A).

Canonie Environmental

D-13

By EP Date 3/4/92 Subject ALT CHANNEL DESIGN COMPARISON Sheet No. 12 of 33

Chkd. By [illegible] Date 3/11/92 Proj. No. 91-225-11

1/4" X 1/4"

Volume of Rock Excavation

Cross Section	Cut Area	Rock ** Volume
STA 0+00	0	
		103,850 ft^3
STA 2+00	*1038.5 ft^2	
		189,100 ft^3
STA 4+00	*852.5 ft^2	
		204,600 ft^3
STA 6+00	*1193.5 ft^2	
		288,850 ft^3
STA 8+00	1695.0 ft^2	
		283,200 ft^3
STA 10+00	1137.0 ft^2	
		268,700 ft^3
STA 12+00	1550.0 ft^2	
		294,500 ft^3
STA 14+00	*1395.0 ft^2	
		211,100 ft^3
STA 16+00	716.0 ft^2	
	TOTAL	1,843,900 ft^3

1,843,000 ft^3 x 1 yd / 27 ft^3

$$\boxed{\text{Volume} = 68{,}293 \text{ yd}^3}$$

* Represents an Increase in the Spillback design.

* Using Average End Area Method.

Canonie Environmental

D-14

By EPH Date 3/4/82 Subject ALT. CHANNEL DESIGN COMPARISON Sheet No. 17 of 33

Chkd. By [illegible] Date 3/11/82 Proj. No. 91-225-11

1/4" X 1/4"

Calculate Additional Cost
Of Channel in Rock over
Channel in Tailings

Middle South: Reach 1

Canonie Environmental

D-15

By EPH Date 3/4/92 Subject ALT CHANNEL DESIGN COMPARISON Sheet No. 14 of 33
Chkd. By [illegible] Date 3/11/92 Proj. No. 91-225-11
1/4" X 1/4"

Rock Channel Cost: (MSI)

Cost to Drill - Shoot Channel

$9.35 / yd³ (ATTACHMENT B)

Cost to Crush - Screen Rip Rap

$2.50 / yd³ (ENGINEERING ESTIMATE *)

Total Cost to Produce Rip Rap

$11.85/yd³

Rock Channel Cost

68,293 yd³ x $11.85/yd³ = $809,272

Conventional Cost to Produce Resulting Riprap.

Assume: 30% Waste in processing
Given: Conventional Riprap unit cost = $7.66
(From initial Cost Estimate submitted to NRC, 1989 TRP)

68,293 yd³ x 0.7 x $7.66/yd³ = $366,187

* Assuming crusher + screening plant, front end loader, stacker, 3 operators, 2 laborers.

Canonie Environmental

D-16

By EJH Date 3/4/92 Subject ALT. CHANNEL DESIGN COMPARISON Sheet No. 15 of 33

Chkd. By JAB Date 3/4/92 Proj. No. 91-225-11

1/4" X 1/4"

Cost of Channel in Tailings at the Interface
(BASED ON CURRENT COST ESTIMATES)

Tailings Excavation Cost

22,381 yd^3 x \$2.00/yd^3 * = \$44,762

Filter Cost (Placed)

1,492 yd^3 x \$10.83/yd^3 * = \$16,169

Riprap Cost (Placed)

3,583 yd^3 x \$10.83/yd^3 * = \$38,804

TOTAL \$99,736

* Engineering estimates, 1992.
Note: Rates have been adjusted up from 1989 TRP Estimate.

Canonie Environmental

D-17

By EPH Date 3/4/92 Subject ALT. CHANNEL DESIGN COMPARISON Sheet No. 16 of 37

Chkd. By JAB Date 3/11/92 Proj. No. 91-225-11

1/4" X 1/4"

Additional Cost of Rock Channel over Interface Channel

Cost of blasting Rock channel + Producing Riprap	+ $ 809,272
Cost of Interface Channel	− $ 99,73[illegible]
Conventional Cost of Rip Rap	− $ 366,18[illegible]
Additional Cost of Rock Channel	≈ $ 343,350

Canonie Environmental

D-18

By EPH Date 3/5/92 Subject ALT CHANNEL DESIGN COMPARISON Sheet No. 17 of 33

Chkd. By JWB Date 3/11/92 Proj. No. 91-225-11

1/4" X 1/4"

. Estimate Additional Cost of Rock Cut Channel for:

Upper South : Reach 1
Lower South : Reach 1
Lower South : Reach 2

Preliminary designs for a CHANNEL CUT IN ROCK ARE not available for the upper and lower runs of the South ditch. The additional costs of a channel cut in the rock are estimated by scaling the result obtained for Middle South Reach 1. The cross sectional areas and the lengths of the channel sections are used to calculate a scale factor for each section of channel.

The cross sectional areas of the Upper and Lower South channels are compared to that of the Middle South channel to obtain a scale factor for channel size. The channel design in the tailings is used for this comparison.

The channel length of the Upper + Lower South channels are compared to that of the Middle South channel to obtain a scale factor for channel length. The probable channel route has been marked on figure 1. This route was measured to obtain channel length.
(See Sheet 21, Figure 1)

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D-20

By EPH Date 3/5/92 Subject ALT. CHANNEL DESIGN COMPARISON Sheet No. 19 of 33

Chkd. By [illegible] Date 3/11/92 Proj. No. 91-225-11

1/4" X 1/4"

Channel Lengths

Refer to Figure 1 ⇒ Scale: 1 in = 300 ft

Section	Length on Drawing	Length of Channel
US 1	4 3/8 in	1312 ft
MS 1	5 5/16 in	1594 ft
LS 1	7 1/8 in	2137 ft
LS 2	* 3 in	900 ft

Scale Factors

Section	** Cross Sectional Area (ft^2)	Area Scale Factor (A_{reach}/A_{MS1})	Channel Length (ft)	Length Scale Factor (L_{reach}/L_{MS1})	Combined Scale Factor ($A_{sf} \times L_{sf}$)
MS 1	247		1594		
US 1	224	0.91	1312	0.82	0.75
LS 1	348	1.41	2137	1.34	1.89
LS 2	227	0.92	900	0.56	0.52

* Length of LS2 that would be <u>in rock</u>: Not Entire Reach

** From Ditch Design Calc, See Appendix B

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D-24

By EPH Date 3/5/92 Subject ALT CHANNEL DESIGN COMPARISON Sheet No. 20 of 33

Chkd. By [illegible] Date 3/11/92 Proj. No. 91-225-11

1/4" X 1/4"

Additional Cost for Rock Channel

Upper South 1 Scale Factor: 0.75

$343,350 × 0.75 = $ 257,513

Lower South 1 Scale Factor: 1.89

$343,350 × 1.89 = $ 648,932

Lower South 2 Scale Factor: 0.52

$343,350 × 0.52 = $ 178,542

TOTALS

Upper South 1	$ 257,513
Middle South 1	$ 343,350
Lower South 1	$ 648,932
Lower South 2	$ 178,542
	$ 1428,337

TOTAL ADDITIONAL COST OF ROCK CHANNEL DESIGN $1,430,000

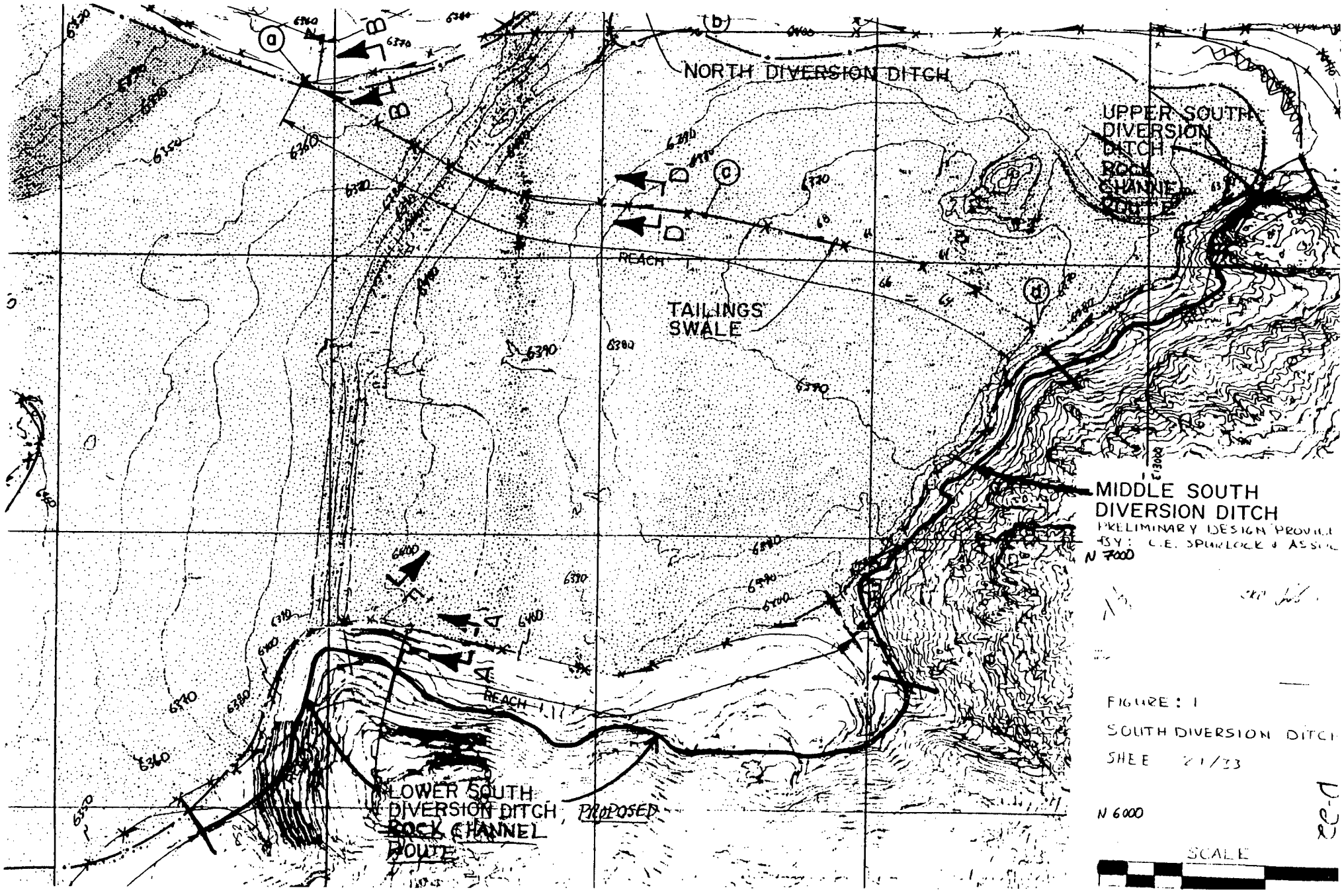

FIGURE : 1

SOUTH DIVERSION DITCH

SHEET 21/33

P-32

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D-23

By EDH Date 3/5/92 Subject ALT CHANNEL DESIGN COMPARISON Sheet No. 22 of 23

Chkd. By [illegible] Date 3/11/92 Proj. No. 91-225-11

1/4" X 1/4"

Attachment A:

Adjusted Cross Sections
For Middle South Diversion
Ditch

D-24

22/33

CKD Jnb 3/11/93

NOTE:

FOLLOWING PAGES (X-SECTIONS) ARE FROM THIS DRAWING-

PRELIMINARY DRAWING
MIDDLE SOUTH DIVERSION DITCH
CROSS SECTIONS

MAY 29, 1991

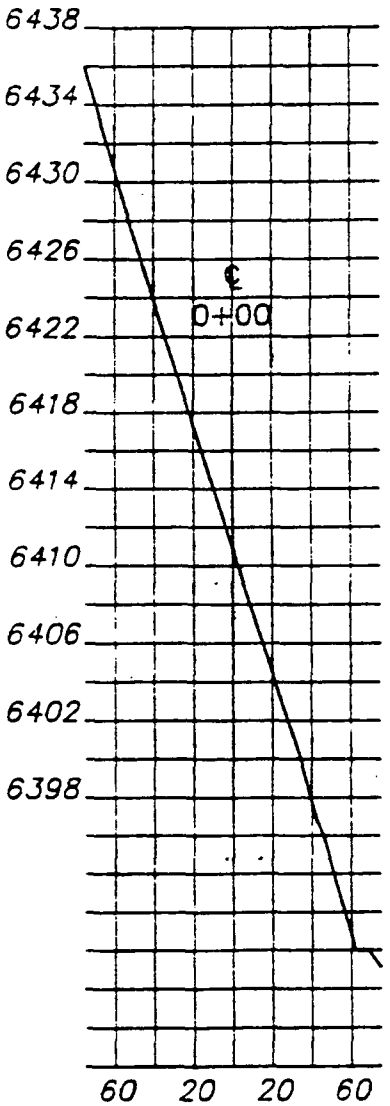
SCALES:
1"= 100' HORIZONTAL
1"= 10' VERTICAL

SHEET 21.

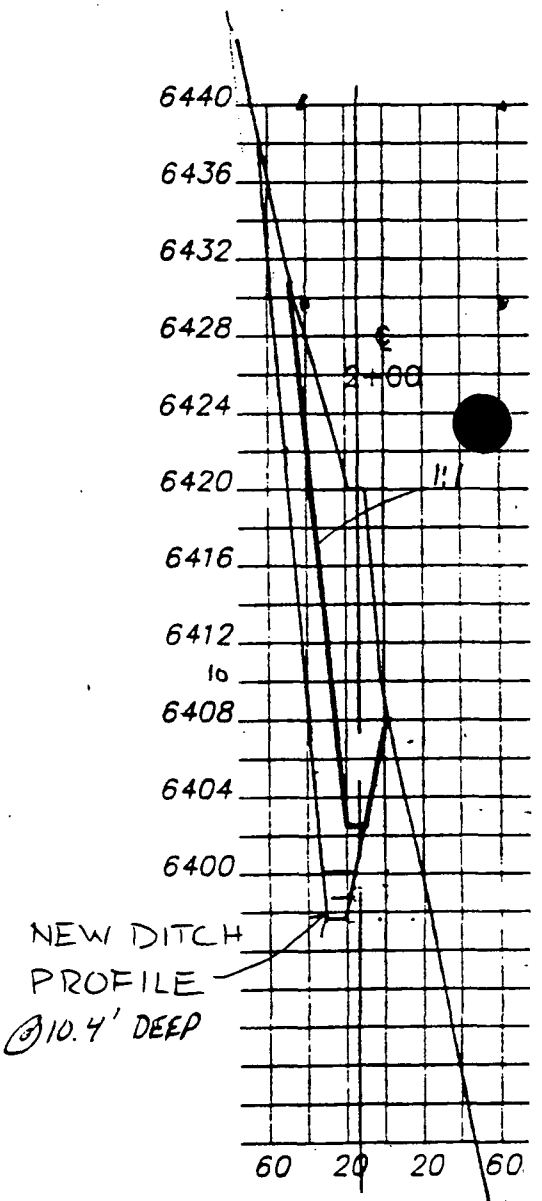
D-25

24/22

-CKO Jwb 3/11/92



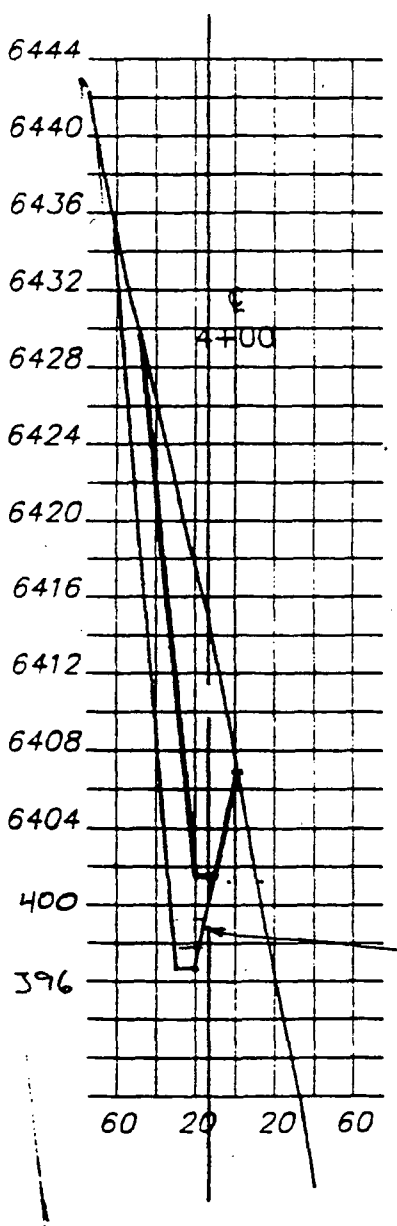
STA 0+00
FILL AREA = 0 sq ft
CUT AREA = 0 sq ft

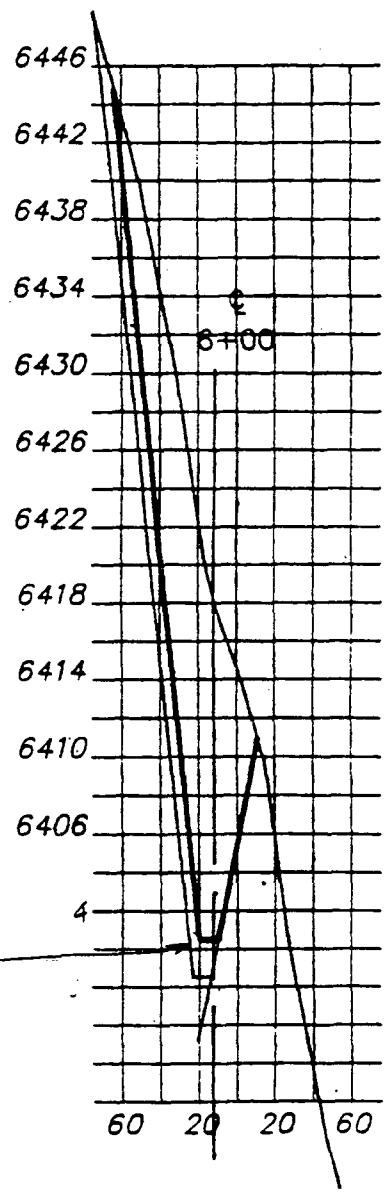


STA 2+00
FILL AREA = 0 sq ft
~~CUT AREA = 521 sq~~
NEW CUT AREA = 1038.5

D-6
25/33

CKD JWL 3/11/92





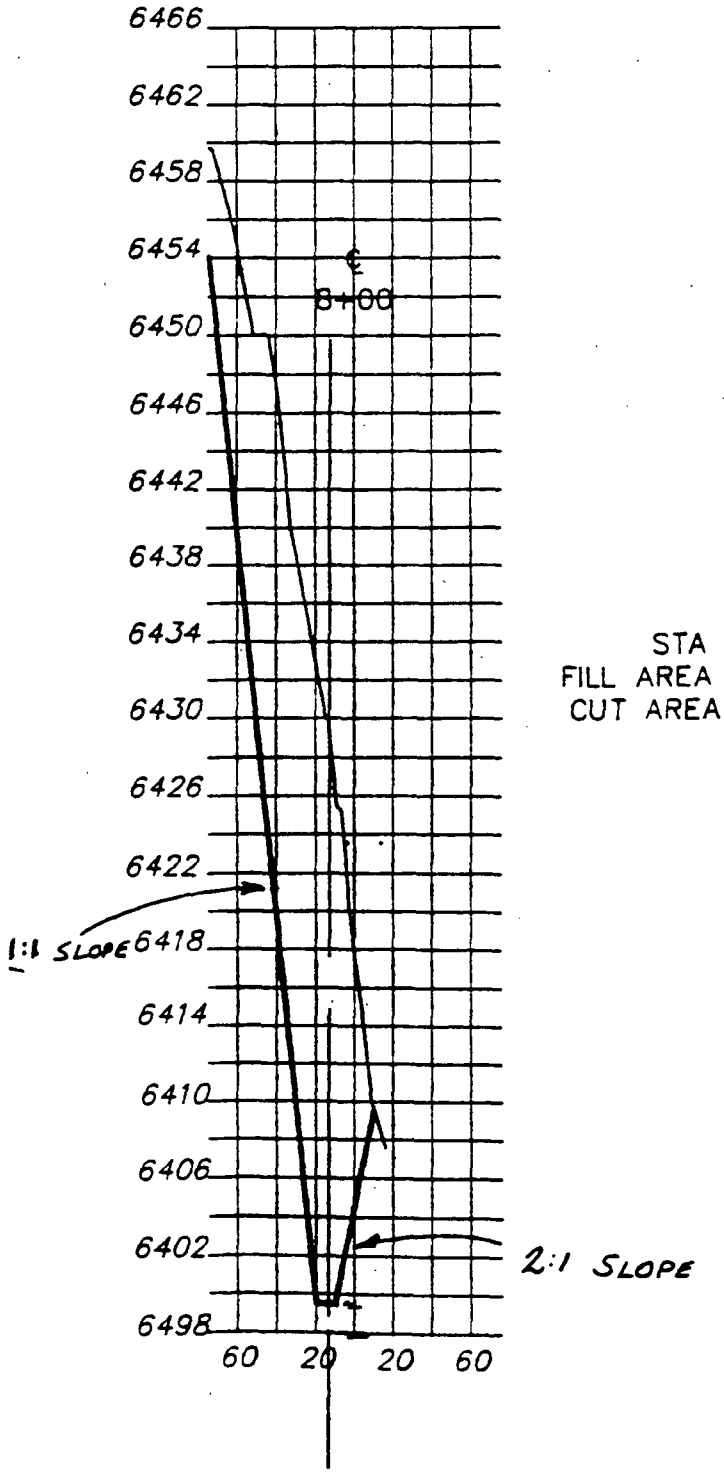
NEW DITCH PROFILES AT 10.4' DEEP

STA 4+00
FILL AREA = 0 sq ft
~~CUT AREA = 422 sq ft~~
NEW CUT AREA = 852.5 ft²

STA 6+00
FILL AREA = 0 sq ft
~~CUT AREA = 881 sq ft~~
NEW CUT AREA = 1193.5 ft²

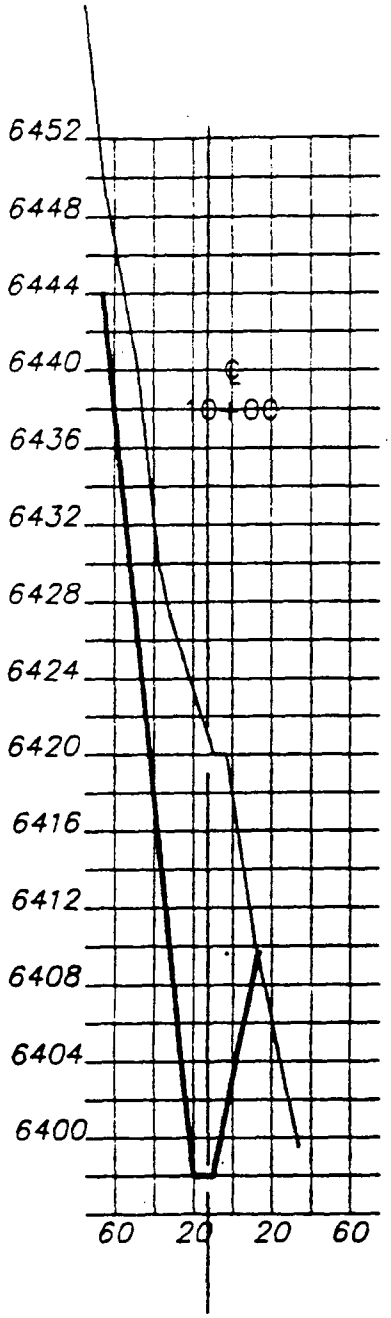
D-2
26/33

CKD. DW 3/11/17

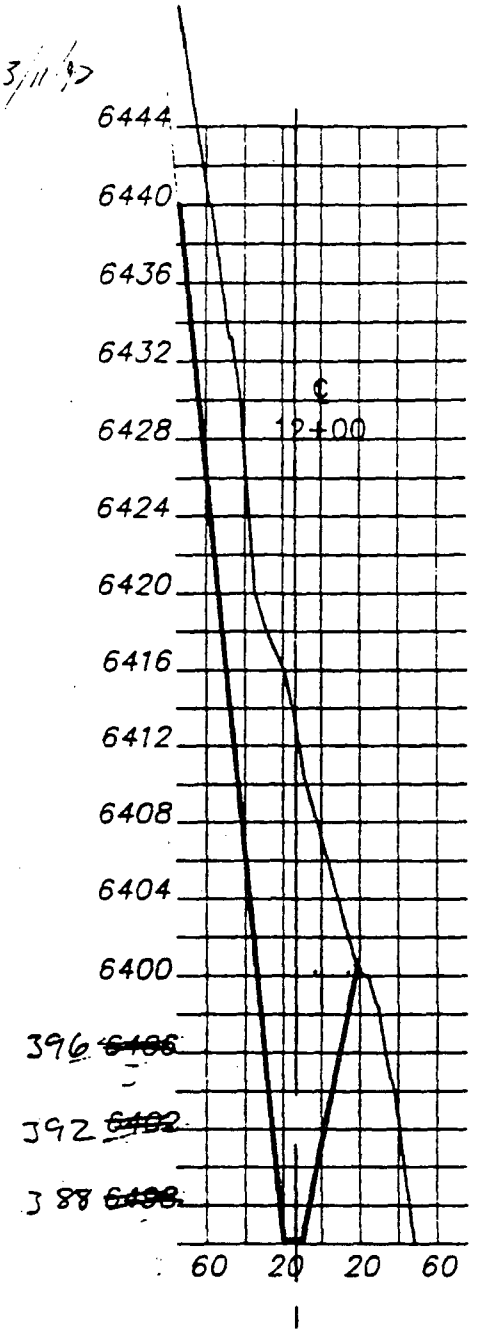


STA 8+00
FILL AREA = 0 sq ft
CUT AREA = 1695 sq ft

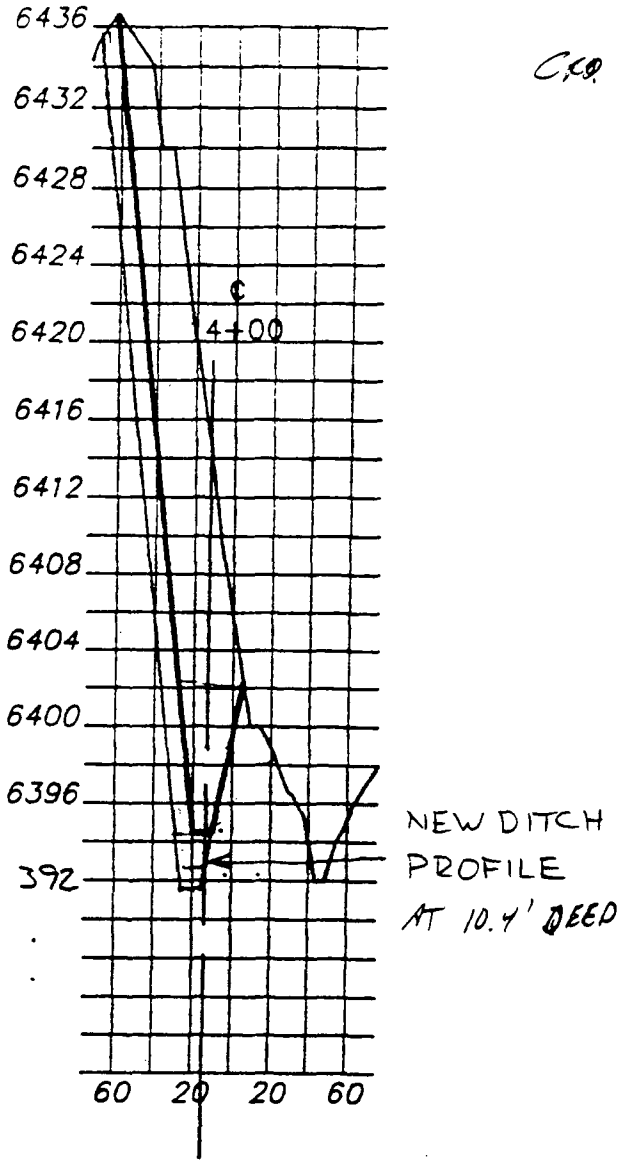
CKD 3/11/92

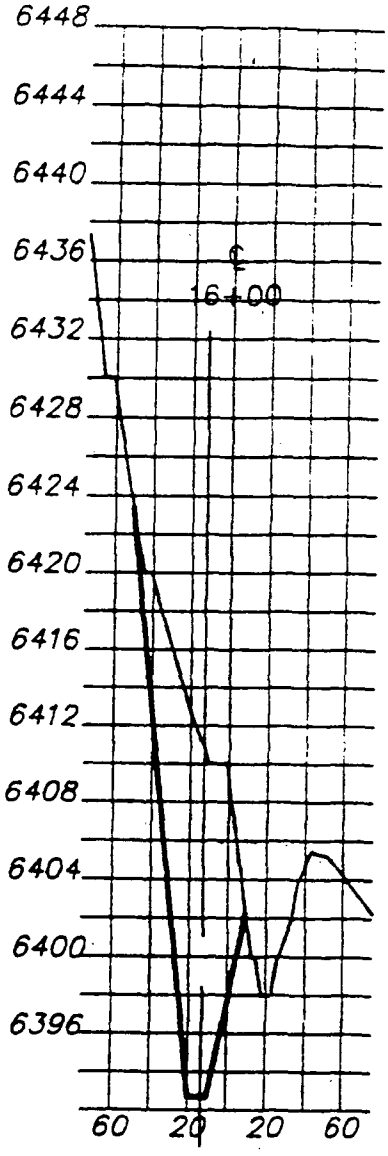


STA 10+00
FILL AREA = 0 sq ft
CUT AREA = 1137 sq ft



STA 12+00
FILL AREA = 0 sq ft
CUT AREA = 1550 sq ft





STA 14+00
FILL AREA = 0 sq ft
~~CUT AREA~~ = ~~994 sq ft~~
NEW CUT AREA = 1395.0 ft²

STA 16+00
FILL AREA = 0 sq ft
CUT AREA = 716 sq ft

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By EPH Date 3/5/92 Subject ALT. CHANNEL DESIGN COMPARISON Sheet No. 29 of 33

Chkd. By [illegible] Date 3/11/92 Proj. No. 91-225-11

1/4" X 1/4"

Attachment B

Estimated Cost to
Drill + Shoot
Rock Channel

Form 147-A—Printed in U.S.A. 10/67

ITEM ANALYSIS

Job 3/11/92

Project
Description DRILL & SHOOT
Bid Quantity 57311 cy

Location
Estimator KF Checked By
Take Off Quantity 57311 cy

Item No.
Sheet No. 1/1 30/33
Date 12-4-91

DESCRIPTION NO.	EQUIPMENT	NO.	CREW	QUANTITY	EQUIPMENT RENTAL CO. OWNED U.P.	TOTAL	OTHER U.P.	TOTAL	OPERATING EXPENSE TIRES & TRACKS U.P.	TOTAL	EQUIP REPAIR U.P.	TOTAL	FUEL-OIL-GREASE U.P.	TOTAL	SERVICES TOOLS & SUPPLIES U.P.	TOTAL	LABOR EXPENSE WAGES U.P.	TOTAL	ADD-ONS U.P.	TOTAL	SUBTOTAL U.P.	TOTAL	PERMANENT MATERIALS U.P.	TOTAL	SUB CONTRACTS U.P.	TOTAL	TOTAL DIRECT COST U.P.	TOTAL
1	HD	1	4 MAN				3		7.50		1		1				25		8		38.50							
2	DRILL	2	DRILLER				48		0.40		7.20		12				36		12		108.40							
2	350 A/C	2	TENDER				24		0.70		0.30		16				34		12		88.50							
1	D8 W/RIPPER	1	OP				10		6		8		10				18		6		118							
		1	LBR														15		5		20							
	HRLY COST						145		6.80		9.50		39				130		43		373.30							
		x 1100 HR																										
																					414303							
MATERIALS															98408						98408							
OVERHEADS	@	15 %																			76216							
																					589687							
																			÷63042									
																					9.35 /cy							
MARGIN	@	20 %																										

ANALYSIS

DRILL & SHOOT WEATHERED GRANITE
- EST. VELOCITY OF ROCK = 12000 FPS (WEATHERED)
- SCALE HT = 60 TO 70+ FT.
- ALLOW FOR MIN 20' WIDE BENCH.
- ALLOW FOR 10 % OVER BREAK
- ASSUME NO PRESPLIT REQ'D
- ROCK HARDNESS = ± 65
- SPECIFIC GRAVITY ≅ 2.7

PRODUCTION

ALL PRODUCTION BASED ON DRILLS

INCLUDING MOVING TO HOLES AND CLEARING BENCH, ALLOW FOR 30 LF/HR PER DRILL
USE 2 DRILLS
DURATION = 63610 LF / 60 / 1060
ALLOW 30 HR SETUP & CLEANUP
= 1400

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30/33

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D-32

By KF Date 12/3 Subject DRILL & SHOOT CALCS. Sheet No. 31 of 33

Chkd. By ____ Date ____ Proj. No ____

1/4 X 1.4

GRANITE (WEATHERED)
$V_{SO} \equiv$ 12,000 FPS
S.G. = 2.70
HARDNESS = 6.50

1. FIND IMPEDENCE OF ROCK (Z)

$$Z = 1.31 * S.G. * V_{SO} * 10^{-3}$$
$$= 1.31 * 2.7 * 12 = 42.44 \leftarrow$$

2. USE AN-FO EXPLOSIVES
- V_{OD} = 10 500 FPS
- DENSITY = 0.85 GR/CC
- ASSUME 3" BOREHOLE

DETERMINE DETONATION PRESSURE (K)

$$K = \frac{0.418 * (V_{OD}^2 * 10^{-6}) * D_E}{(0.8 D_E + 1)}$$

$$= \frac{0.418 * 110.25 * 0.85}{0.8 * 0.85 + 1} = 23.31 \leftarrow$$

3. DETERMINE POWDER FACTOR (PF)

$$PF = \frac{Z}{K} = \frac{42.44}{23.31} = 1.82 \text{ LB/CU} \leftarrow$$

4. DETERMINE SPACING (S)

$$S = \sqrt{\frac{D_E * C^2}{PF}} * 3 = \sqrt{\frac{0.85 * 9}{1.82}} * 3 = 6.15 \text{ FT}$$

6 FT. ←

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D-33

By _____ Date _____ Subject _____ Sheet No. 32 of 33

Chkd. By _____ Date _____ Proj. No. _____

1/4" X 1/4"

5. DETERMINE BURDEN (B)

$B = 0.833 * S = 0.833 * 6 = 5.0$ FT. ←

6. DETERMINE SUBDRILL (S/D)

$S/D = 0.4 * S = 0.4 \times 60 = 24$ FT. ←

7. DETERMINE STEMMING (T_S)

$T_S = B = 50$ FT ←

8. DETERMINE CY OF ROCK PER FT OF BORE HOLE.

$CY/FT = \frac{S * B}{27} = \frac{50 \times 60}{27} = 11$ CY/FT. ←

9. DETERMINE CY PER BOREHOLE
* ASSUME BENCH HT = 20'

∴ CY/HOLE = 11 × 20 FT = 222 CY/HOLE ←

10. # OF HOLES REQ'D.

$\# = \frac{57{,}311 \times 110}{222} = 2840$ EA ←

11. TOTAL LF DRILLING = 2840 * (20 + 24) = 63,610 LF ←

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D-34

By _____ Date _____ Subject _____ Sheet No. 33 of 33

Chkd. By _____ Date _____ _____ Proj. No. _____

1/4" X 1/4"

12 LB OF EXPLOSIVES REQ'D

LB/HOLE * 2840 HOLES

$$LB/HOLE = \frac{DE * C^2 * (HD - TS)}{3}$$

$$= \frac{0.85 * (3)^2 (22^{4} - 5^{2})}{3} = 44^{37} \#/HOLE$$

TOTAL EXPL = 44^{37} #/HOLE * 2840 HOLES

= 126,011 LB AN-FO

13. BLAST CAPS REQ'D = 2840 x 1^{05} = 2982 EA.

14 PRIMERS REQ'D

1 STICK = 2" x 16" x $2^{\frac{1}{2}}$ LB x 2840 x 1^{05} = 6560 LB.

SUMMARY MATERIAL COSTS.

ANFO :	126,011 LB x $0^{40}	=	$50405
PRIMERS:	6560 LB x $2^{00}	=	$13120
CAPS :	2982 EA * $3^{85}	=	$11,481
MISC STS @ 10% OF COST		=	$7500
			$82506
DRILL STS @ 0^{25}/LF		=	$15,902
			$98408