Canyon Fuel Company, LLC
Skyline Mines
C/007/005

2002 Annual Report

File in:
- ☐ Confidential
- ☐ Shelf
- ☒ Expandable

Refer to Record No 0047 Date 04282003
In C/007/005, 2003, Incoming
For additional information Confidential

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GENERAL INFORMATION

Permitte Name	Canyon Fuel Company, LLC
Mine Name	Skyline Mine
Operator Name (If other then permittee)	
Permit Expiration Date	April 30, 2007
Permit Number	C/007/005
Authorized Representative Title	Dan Meadors, General Manager
Phone Number	(435) 448-2619
Fax Number	(435) 448-2632
E-mail Address	dmeadors@archcoal.com
Mailing Address	Skyline Mine HCR 35 Box 380 Helper, UT 84526
Resident Agent	Corporation Trust Company
Resident Agent Mailing Address	Corporation trust Center 1209 Orange Street Wilmington, DE
Number of Binders Submitted	2

IDENTIFICATION OF OTHER PERMITS

Identify other permits that are required in conjunction with mining and reclamation activities.

Permit Type	ID Number	Description	Expiration Date
MSHA Mine ID(s)	1211-UT-09-01566-01	Skyline Mine	N/A
	1211-UT-09-01566-02	Skyline Mine Waste Rock Disposal Site	N/A
MSHA Impoundment(s)	None		
NPDES/UPDES Permit(s)	UT 0023540-01, 02, 03	UPDES Permit for Skyline Mine, Rail	10/30/04
		Loadout, Waste Rock Disposal Site	
PSD Permit(s) (Air)	147-98	Approval Order	N/A

Other

MSHA Mine ID(s)	1211-UT-09-01566-03	Skyline Mine Temporary Waste Rock	N/A
		Disposal Site	
Storm Water Permjit	UTR000578	Storm Water Discharge Permit	12/01/06

MAY 1 2003

CERTIFIED REPORTS

List the certified inspection reports as required by the rules and udder the approved plan that must be periodically submitted t the Division. Specify whether the information is included as Appendix A to this report or currently on file with the Division.

Certified Reports:	Required		Included or on file with DOGM		Comments
	Yes	No	Included	On File	
Excess Spoil Piles	☐	☒	☐	☐	
Refuse Piles	☒	☐	☒	☐	Appendix A
Impoundments	☒	☐	☒	☐	Appendix A
Other					
	☐	☐	☐	☐	
	☐	☐	☐	☐	

REPORTING OF OTHER TECHNICAL DATA

List other technical data and information as required under the approved plan, which must be periodically submitted to the Division. Specify whether the information is included as Appendix B to this report or currently on file with the Division.

Technical Data:	Required		Included or on file with DOGM		Comments
	Yes	No	Included	On file	
Climatological	☐	☒	☐	☐	
Subsidence Monitoring	☒	☐	☒	☐	Appendix B
Vegetation Monitoring	☒	☐	☒	☐	Appendix B
Raptor Survey	☒	☐	☒	☐	Appendix B
Soils Monitoring	☐	☒	☐	☐	
Water Monitoring	☐	☐	☐	☐	
First quarter	☒	☐	☐	☒	
Second quarter	☒	☐	☐	☒	
Third quarter	☒	☐	☐	☒	
Fourth quarter	☒	☐	☐	☒	
Geological / Geophysical	☐	☒	☐	☐	
Engineering	☐	☒	☐	☐	
Non Coal Waste / Abandoned Underground Equipment*	☐	☒	☐	☐	
Other Data					
James and Burnout Canyon Fish and Macroinvertabrate Studies	☒	☐	☒	☐	Appendix B
Eccles Creek Macroinvertabrate Study	☒	☐	☒	☐	Appendix B
TSS Tons Calculations for Mud Creek	☒	☐	☒	☐	Appendix B
EarthFax Mud/Eccles Creek Studies	☒	☐	☒	☐	

*Reminder: If equipment has been abandoned during 2002, an amendment must be submitted that includes a map showing its location, a description of what was abandoned, whether there was any hazardous or toxic materials and any revision to the PHC as necessary.

LEGAL, FINANCIAL, COMPLIANCE AND RELATED INFORMATION

Change in administration or corporate structure can often bring about necessary changes to information found in the mining and reclamation plan. The Division is Requesting that each permittee review and update the legal, financial, compliance and related information in the plan as part of the annual report. Provide the department of Commerce, annual Report of Officers, or other equivalent information as necessary to ensure that the information provided in the plan is current. Provide any other change as necessary regarding land ownership, lease acquisitions, legal results from appeals of violations, or other changes as necessary to update information required in the mining and reclamation plan. Include and certified financial statements, audits or worksheets which may be required to meet bonding requirements. Specify whether the information is currently on file with the Division or included as Appendix C to the report.

Legal / Financial Update	Required		Included or on File with DOGM		Comments
	Yes	No	Included	On file	
Department of Commerce, Annual Report Officers	☐	☐	☐	☐	
Other					
Officer and Directors	☒	☐	☒	☐	Appendix C
	☐	☐	☐	☐	
	☐	☐	☐	☐	

MINE MAPS

Copies of mine maps, current and up-to-date through at least December 31, 2001, are to be provided to the Division as Appendix D to this report in accordance with the requirements of R 645-301-525.270. These map copies shall be made in accordance with 30 CFR 75.1200 as required by MSHA. Upon request, the Division shall keep mine maps confidential.

Map Number(s)	Map Title/ Description	Confidential Yes	Confidential No
	Skyline Mine 3 Level 1 2002 No Production	☒	☐
	Skyline Mine 3 Level 2 and 3 2002 Longwall Production	☒	☐
	Mine 3 Level 2 & 3 2003 BOD-2 Best Case	☒	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐
		☐	☐

OTHER INFORMATION

Please provide any comments of further information to be included as part of the Annual Report. Any other attachments are to be provided as Appendix E to this report. If information is submitted as a group rather then by individual mine, please identify each of the mine's data in the list below.

Additional attachment to this report? **Yes** ☐ **No** ☐

APPENDIX A

Certified Reports

Excess Spoil Piles
Refuse Piles
Impoundments

As required under R645-301-514

CONTENTS

Waste Rock Site Inspections
Sediment Pond Annual Inspection

WASTE ROCK SITE

INSPECTION AND CERTIFIED REPORT ON EXCESS SPOIL PILE OR REFUSE PILE			
Permit Number	C/007/005	**Report Date**	May 16, 2002
Mine Name	Skyline Mines		
Company Name	Canyon Fuel Company, LLC		
Excess Spoil Pile or Refuse Pile Identification	**Pile Name**	Skyline Waste Rock Site	
	Pile Number	NA	
	MSHA ID Number	42-01566	
Inspection Date	Not Accessible through 1st Quarter 2002 due to snow cover, March 29, 2002		
Inspected By	Douglas E. Johnson		
Reason for Inspection (Annual, Quarterly or Other Periodic Inspection, Critical Installation, or Completion of Construction)		Quarterly	
		Attachments to Report? X No ☐ Yes	

Field Evaluation

1. **Foundation preparation, including the removal of all organic material and topsoil.**

NA
No gob was hauled to the site during the first quarter of 2002. The site is inaccessible due to snow cover.

2. **Placement of underdrains and protective filter systems.**

No underdrains are present or required at this site.

3. **Installation of final surface drainage systems.**

Existing surface is not at final contour. Therefore, final surface drainages have not yet been constructed. The existing surface drainage system includes a temporary ditch on the north side of the pile that captures undisturbed runoff from the drainage to the east of the site, the AML reclamation slopes north of the site, and the runoff from the ditch embankment. Runoff in the temporary ditch is treated through a straw bale dike before discharge. All other surface runoff from the refuse pile is treated by the sediment pond. Runoff from the main access road below the sediment pond is treated by straw bale dikes. No changes to the drainage system have been made since the previous quarter.

4. **Placement and compaction of fill materials.**

No waste rock was hauled this quarter

INSPECTION AND CERTIFIED REPORT ON EXCESS SPOIL PILE OR REFUSE PILE		

5. **Final grading and revegetation of fill.**

Contemporaneous reclamation of the waste rock pile is taking place as the site is backfilled with waste rock. The backfill slopes are built to 1 1/2h:1v or less and seeded as described in the final reclamation plan. The seed mix specified in the Reclamation Plan is planted after the placement of topsoil.

6. **Appearances of instability, structural weakness, and other hazardous conditions.**

Though the site was inaccessible due to deep snow, no structural weaknesses had been observed during previous visits to the site. The sedimentation pond did not contain significant water during the third quarter of 2001. The waste rock site has been inaccessible since November 2001

7. **Other Comments. Describe any changes in the geometry of the Excess Spoil/Refuse Pile structure, instrumentation, average and maximum lifts of materials placed in the pile, elevations of active benches, total and remining storage capacityof the structure, evidence of fires in the pile and abatement of such fires, volumes of materials placed in the structure during the year, and any other aspect of the structure affecting its stability or function which has occurred during the reporting period.**

The pile has a remaining storage capacity of approximately 55,231 tons. The total storage capacity as designed is 334,125.

Certification Statement

REGISTERED PROFESSIONAL ENGINEER
[Cert. Stamp]
No. 160554-2202
DOUGLAS E. JOHNSON
STATE OF UTAH

I hereby certify that; I am experienced in the construction of earth and rockfills; I am qualified and authorized in the State of Utah to inspect and certifythe condition and appearance of earth and rockfills in accordance with the certified and approved designs for this structure; that the fill structure has been maintained in accordance with approved design and meet or exceed the minimum design requirements under all applicable federal, state and local regulations; and, that inspections and inspection reports are mde by myself and include any appearances of instability, structural weakness or other hazardous conditions of the structure affecting stability

By: DOUGLAS E. JOHNSON, MGR. TECH. SERVICES
(Full Name and Title)

Signature: Douglas E Johnson **Date:** 5-16-02

INSPECTION AND CERTIFIED REPORT ON EXCESS SPOIL PILE OR REFUSE PILE			
Permit Number	C/007/005	**Report Date**	July 2, 2002
Mine Name	Skyline Mines		
Company Name	Canyon Fuel Company, LLC		
Excess Spoil Pile or Refuse Pile Identification	**Pile Name**	Skyline Waste Rock Site	
	Pile Number	NA	
	MSHA ID Number	42-01566	
Inspection Date	June 28, 2002		
Inspected By	Douglas E. Johnson		
Reason for Inspection (Annual, Quarterly or Other Periodic Inspection, Critical Installation, or Completion of Construction)		Quarterly	
		Attachments to Report? ☐ **No** ✗ **Yes**	

Field Evaluation

1. Foundation preparation, including the removal of all organic material and topsoil.

Approximately 4,600 tons of gob were hauled to the waste rock site. The material was placed in the northeast portion of the site. No topsoil cover was placed in this area since the area is not at final contour. No vegetation was present prior to placement.

2. Placement of underdrains and protective filter systems.

No underdrains are present or required at this site.

3. Installation of final surface drainage systems.

Existing surface is not at final contour. Therefore, final surface drainages have not yet been constructed. The existing surface drainage system includes a temporary ditch on the north side of the pile that captures undisturbed runoff from the drainage to the east of the site, the AML reclamation slopes north of the site, and the runoff from the ditch embankment. Runoff in the temporary ditch is treated through a straw bale dike before discharge. All other surface runoff from the refuse pile is treated by the sediment pond. Runoff from the main access road below the sediment pond is treated by straw bale dikes. No changes to the drainage system have been made since the previous quarter.

4. Placement and compaction of fill materials.

Approximately 4,620 tons of gob were hauled to the site between May 9, 2002 and May 20, 2002. The material was placed in the northeastern portion of the waste rock site. It was placed in lifts of 12-inches or less and compacted in place using a rubber tired front-end loader and end-dump trucks.

INSPECTION AND CERTIFIED REPORT ON EXCESS SPOIL PILE OR REFUSE PILE		

5. Final grading and revegetation of fill.

Contemporaneous reclamation of the waste rock pile is taking place as the site is backfilled with waste rock. The backfill slopes are built to 1 1/2h:1v or less and seeded as described in the final reclamation plan. The seed mix specified in the Reclamation Plan is planted after the placement of topsoil.

6. Appearances of instability, structural weakness, and other hazardous conditions.

No structural weaknesses were observed during the visit to the site. The sedimentation pond did not contain significant water at the time of the inspection.

7. Other Comments. Describe any changes in the geometry of the Excess Spoil/Refuse Pile structure, instrumentation, average and maximum lifts of materials placed in the pile, elevations of active benches, total and remining storage capacityof the structure, evidence of fires in the pile and abatement of such fires, volumes of materials placed in the structure during the year, and any other aspect of the structure affecting its stability or function which has occurred during the reporting period.

The pile has a remaining storage capacity of approximately 50,611 tons. The total storage capacity as designed is 334,125.

Certification Statement

REGISTERED PROFESSIONAL ENGINEER
[Cert. Stamp]
No. 160554-2202
DOUGLAS E. JOHNSON
STATE OF UTAH

I hereby certify that; I am experienced in the construction of earth and rockfills; I am qualified and authorized in the State of Utah to inspect and certifythe condition and appearance of earth and rockfills in accordance with the certified and approved designs for this structure; that the fill structure has been maintained in accordance with approved design and meet or exceed the minimum design requirements under all applicable federal, state and local regulations; and, that inspections and inspection reports are made by myself and include any appearances of instability, structural weakness or other hazardous conditions of the structure affecting stability

By: DOUGLAS E. JOHNSON, TECHNICAL SERVICES MANAGER
(Full Name and Title)

Signature: Douglas E Johnson **Date:** 7-19-02

INSPECTION AND CERTIFIED REPORT ON EXCESS SPOIL PILE OR REFUSE PILE			
Permit Number	C/007/005	**Report Date**	September 30, 2002
Mine Name	Skyline Mines		
Company Name	Canyon Fuel Company, LLC		
Excess Spoil Pile or Refuse Pile Identification	**Pile Name**	Skyline Waste Rock Site	
	Pile Number	NA	
	MSHA ID Number	42-01566	
Inspection Date	September 30, 2002		
Inspected By	Douglas E. Johnson		
Reason for Inspection (Annual, Quarterly or Other Periodic Inspection, Critical Installation, or Completion of Construction)	Quarterly		
	Attachments to Report? ✗ No ☐ Yes		

Field Evaluation

1. **Foundation preparation, including the removal of all organic material and topsoil.**

No gob was hauled to the waste rock site this quarter.

2. **Placement of underdrains and protective filter systems.**

No underdrains are present or required at this site.

3. **Installation of final surface drainage systems.**

Existing surface is not at final contour. Therefore, final surface drainages have not yet been constructed. The existing surface drainage system includes a temporary ditch on the north side of the pile that captures undisturbed runoff from the drainage to the east of the site, the AML reclamation slopes north of the site, and the runoff from the ditch embankment. Runoff in the temporary ditch is treated through a straw bale dike before discharge. All other surface runoff from the refuse pile is treated by the sediment pond. Runoff from the main access road below the sediment pond is treated by straw bale dikes. No changes to the drainage system have been made since the previous quarter.

4. **Placement and compaction of fill materials.**

No gob was hauled or placed in the waste rock site this quarter.

INSPECTION AND CERTIFIED REPORT ON EXCESS SPOIL PILE OR REFUSE PILE		

Final grading and revegetation of fill.

Contemporaneous reclamation of the waste rock pile is taking place as the site is backfilled with waste rock. The backfill slopes are built to 1 1/2h:1v or less and seeded as described in the final reclamation plan. The seed mix specified in the Reclamation Plan is planted after the placement of topsoil.

6. **Appearances of instability, structural weakness, and other hazardous conditions.**

No structural weaknesses were observed during the visit to the site. The sedimentation pond did not contain significant water at the time of the inspection.

7. **Other Comments. Describe any changes in the geometry of the Excess Spoil/Refuse Pile structure, instrumentation, average and maximum lifts of materials placed in the pile, elevations of active benches, total and remining storage capacity of the structure, evidence of fires in the pile and abatement of such fires, volumes of materials placed in the structure during the year, and any other aspect of the structure affecting its stability or function which has occurred during the reporting period.**

The pile has a remaining storage capacity of approximately 50.611 tons. The total storage capacity as designed is 334,125.

Certification Statement

PROFESSIONAL ENGINEER
11-26-02
[Cert. Stamp]
No. 1605942202
DOUGLAS E. JOHNSON
STATE OF UTAH

I hereby certify that; I am experienced in the construction of earth and rockfills; I am qualified and authorized in the State of Utah to inspect and certify the condition and appearance of earth and rockfills in accordance with the certified and approved designs for this structure; that the fill structure has been maintained in accordance with approved design and meet or exceed the minimum design requirements under all applicable federal, state and local regulations; and, that inspections and inspection reports are made by myself and include any appearances of instability, structural weakness or other hazardous conditions of the structure affecting stability

By: DOUGLAS E. JOHNSON, MGR. TECH SERVICES
(Full Name and Title)

Signature: Douglas E Johnson **Date:** 11-26-02

INSPECTION AND CERTIFIED REPORT ON EXCESS SPOIL PILE OR REFUSE PILE			
Permit Number	C/007/005	**Report Date**	December 19, 2002
Mine Name	Skyline Mines		
Company Name	Canyon Fuel Company, LLC		
Excess Spoil Pile or Refuse Pile Identification	**Pile Name**	Skyline Waste Rock Site	
	Pile Number	NA	
	MSHA ID Number	42-01566	
Inspection Date	December 19, 2002		
Inspected By	Douglas E. Johnson		
Reason for Inspection (Annual, Quarterly or Other Periodic Inspection, Critical Installation, or Completion of Construction)	Quarterly✗		
	Attachments to Report? ☐ No ✗ Yes		

Field Evaluation

1. **Foundation preparation, including the removal of all organic material and topsoil.**

Topsoil removal and foundation preparation was completed several years prior to the most recent placement of material.

2. **Placement of underdrains and protective filter systems.**

No underdrains are present or required at this site.

3. **Installation of final surface drainage systems.**

Existing surface is not at final contour. Therefore, final surface drainages have not yet been constructed. All surface runoff from the refuse pile is treated by the sediment pond. Runoff from the main access road below the sediment pond is treated by straw bale dikes.

4. **Placement and compaction of fill materials.**

Approximately 8448 tons of gob were hauled to the waste rock site in this quarter. The required analysis of 12 samples obtained of the placed material is included as an attachment to this report.
Gob was placed in lifts of 12-inches or less and compacted in place using rubber tired equipment and a tracked dozer. The majority of the material was placed in the northeastern portion of the waste rock site.

INSPECTION AND CERTIFIED REPORT ON EXCESS SPOIL PILE OR REFUSE PILE		

5. **Final grading and revegetation of fill.**

Contemporaneous reclamation of the waste rock pile is taking place as the site is backfilled with waste rock. The backfill slopes are built to 1 1/2h:1v or less and seeded as described in the final reclamation plan. The seed mix specified in the Reclamation Plan is planted after the placement of topsoil.

6. **Appearances of instability, structural weakness, and other hazardous conditions.**

No structural weaknesses were observed during the visit to the site. The sedimentation pond did not contain significant water at the time of the inspection.

7. **Other Comments. Describe any changes in the geometry of the Excess Spoil/Refuse Pile structure, instrumentation, average and maximum lifts of materials placed in the pile, elevations of active benches, total and remaining storage capacity of the structure, evidence of fires in the pile and abatement of such fires, volumes of materials placed in the structure during the year, and any other aspect of the structure affecting its stability or function which has occurred during the reporting period.**

The pile has a remaining storage capacity of approximately 42,163 tons. The total storage capacity as designed is 334,125. However, Skyline is currently re-evaluating the storage capacity of the site.

Certification Statement

REGISTERED PROFESSIONAL ENGINEER
3-20-03
(Seal Stamp)
No. 160554-2202
DOUGLAS E. JOHNSON
STATE OF UTAH

I hereby certify that; I am experienced in the construction of earth and rock fills; I am qualified and authorized in the State of Utah to inspect and certify the condition and appearance of earth and rock fills in accordance with the certified and approved designs for this structure; that the fill structure has been maintained in accordance with approved design and meet or exceed the minimum design requirements under all applicable federal, state and local regulations; and, that inspections and inspection reports are made by myself and include any appearances of instability, structural weakness or other hazardous conditions of the structure affecting stability.

By: DOUGLAS E. JOHNSON, MGR. TECH. SERVICES
(Full Name and Title)

Signature: Douglas E Johnson **Date:** 3-20-03

Water-Mountain Laboratories, Inc.

1633 Terra Avenue
Sheridan, WY 82801

Report ID: 010224415

Soil Analysis Report

Canyon Fuel Company, LLC
Skyline Mine
HC 35 Box 380
Helper, UT 84526

Client Project ID: Canyon Fuel
Date Received: 12/06/02

Set #0102S24415
Report Date: 02/24/03

Lab Id	Sample Id	pH	Saturation	EC @ 25°C	Calcium	Magnesium	Sodium	SAR
		s.u.	%	mmhos/cm	meq/L	meq/L	meq/L	
0102S24415	WR-1	6.9	32.8	3.84	27.0	19.4	3.05	0.63
0102S24416	WR-2	7.2	44.6	1.82	9.20	7.14	2.81	0.98
0102S24417	WR-3	6.9	32.6	2.26	16.2	10.2	2.63	0.72
0102S24418	WR-4	6.9	36.6	2.63	17.1	11.9	3.06	0.80
0102S24419	WR-5	6.9	32.7	2.61	18.2	12.1	5.45	1.40
0102S24420	WR-6	6.7	36.0	2.41	17.4	11.1	3.93	1.04
0102S24421	WR-7	6.6	31.3	2.48	17.9	12.1	4.38	1.13
0102S24422	WR-8	7.4	34.5	6.44	35.2	35.0	2.92	0.49
0102S24423	WR-9	6.9	34.6	4.81	29.5	23.6	2.78	0.54
0102S24424	WR-10	7.0	35.4	3.47	25.3	18.3	3.30	0.71
0102S24425	WR-11	6.9	32.7	5.41	30.3	26.6	2.71	0.51
0102S24426	WR-12	7.0	35.2	6.34	35.5	32.8	2.31	0.39

These results only apply to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neut. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed By: _____
Joey Sheeley, Soils Lab Supervisor

Ker-McGain Laboratories, Inc.

1633 Terra Avenue
Sheridan, WY 82801

Report ID: 010224415

Soil Analysis Report
Canyon Fuel Company, LLC
Skyline Mine
HC 35 Box 380
Helper, UT 84526

Client Project ID: Canyon Fuel
Date Received: 12/06/02

Set #0102S24415
Report Date: 02/24/03

Lab Id	Sample Id	Coarse Fragments %	Sand %	Silt %	Clay %	Texture	1/3 Bar %	15 Bar %	Available Sodium meq/100g	Exchangeable Sodium meq/100g
0102S24415	WR-1	71.4	70.0	17.0	13.0	SANDY LOAM	17.7	7.8	0.19	0.09
0102S24416	WR-2	26.3	68.0	23.0	9.0	SANDY LOAM	22.6	8.5	0.16	0.03
0102S24417	WR-3	51.1	71.0	17.0	12.0	SANDY LOAM	16.2	8.6	0.34	0.25
0102S24418	WR-4	64.5	74.0	16.0	10.0	SANDY LOAM	20.7	7.9	0.17	0.06
0102S24419	WR-5	66.4	69.0	17.0	14.0	SANDY LOAM	20.1	9.0	0.16	<0.01
0102S24420	WR-6	53.3	68.0	18.0	14.0	SANDY LOAM	20.8	9.0	0.17	0.03
0102S24421	WR-7	59.7	72.0	16.0	12.0	SANDY LOAM	20.8	8.8	0.20	0.06
0102S24422	WR-8	62.3	78.0	12.0	10.0	SANDY LOAM	17.5	7.1	0.16	0.06
0102S24423	WR-9	66.7	70.0	18.0	12.0	SANDY LOAM	18.9	7.8	0.16	3.14
0102S24424	WR-10	64.1	76.0	14.0	10.0	SANDY LOAM	20.7	7.6	0.16	0.04
0102S24425	WR-11	46.4	76.0	12.0	12.0	SANDY LOAM	11.4	7.1	0.18	0.09
0102S24426	WR-12	61.8	70.0	18.0	12.0	SANDY LOAM	12.2	7.3	0.16	0.08

These results only apply to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neut. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed By: _____
Joey Sheeley, Soils Lab Supervisor

Inter-Mountain Laboratories, Inc.
1633 Terra Avenue
Sheridan, WY 82801

Report ID: 010224415

Soil Analysis Report

Canyon Fuel Company, LLC

Skyline Mine
HC 35 Box 380
Helper, UT 84526

Client Project ID: Canyon Fuel
Date Received: 12/06/02

Set #0102S24415
Report Date: 02/24/03

Lab Id	Sample Id	TOC	Total Sulfur	T.S. AB	Neutral. Pot.	T.S. ABP	Boron	Nitrogen-Nitrate	Selenium	TKN
		%	%	t/1000t	t/1000t	t/1000t	ppm	ppm	ppm	%
0102S24415	WR-1	38.4	1.07	33.4	49.4	16.0	0.91	2.70	0.14	0.82
0102S24416	WR-2	53.5	0.42	13.1	73.7	60.6	0.98	0.34	0.04	0.95
0102S24417	WR-3	40.7	0.55	17.2	56.1	38.9	0.75	0.38	0.04	0.79
0102S24418	WR-4	44.2	0.67	20.9	56.5	35.6	1.03	0.90	0.06	0.96
0102S24419	WR-5	36.6	0.62	19.4	61.1	41.7	0.92	0.68	0.04	0.71
0102S24420	WR-6	33.1	0.54	16.9	59.7	42.9	1.08	0.38	0.04	0.75
0102S24421	WR-7	66.8	0.77	24.1	61.0	36.9	0.80	0.48	0.06	0.76
0102S24422	WR-8	49.5	0.82	25.6	54.9	29.3	1.01	3.38	0.12	0.92
0102S24423	WR-9	38.5	0.77	24.1	53.7	29.6	0.81	1.84	0.12	0.70
0102S24424	WR-10	47.6	0.84	26.2	56.5	30.2	0.77	2.32	0.10	0.80
0102S24425	WR-11	54.4	0.74	23.1	66.2	43.1	1.11	0.98	0.06	0.88
0102S24426	WR-12	44.6	0.87	27.2	95.4	68.2	1.17	0.30	0.10	0.57

These results only apply to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neut. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed By: _____
Joey Sheeley, Soils Lab Supervisor

Inter-Mountain Laboratories, Inc.

Report ID: 010224415

1633 Terra Avenue
Sheridan, WY 82801

Soil Analysis Report

Canyon Fuel Company, LLC

Skyline Mine
HC 35 Box 380
Helper, UT 84526

Client Project ID: Canyon Fuel
Date Received: 12/06/02

Set #0102S24415
Report Date: 02/24/03

Lab Id	Sample Id	pH	Saturation	EC @ 25°C	Calcium	Magnesium	Sodium	SAR
		s.u.	%	mmhos/cm	meq/L	meq/L	meq/L	
0102S24421	WR-7	6.6	31.3	2.48	17.9	12.1	4.38	1.13
0102S24421D	WR-7	6.6	31.3	2.51	16.8	11.5	4.18	1.11

These results only apply to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neut. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed By: _____
Joey Sheeley, Soils Lab Supervisor

Inter-Mountain Laboratories, Inc.

1633 Terra Avenue
Sheridan, WY 82801

Report ID: 010224415

Soil Analysis Report

Canyon Fuel Company, LLC

Skyline Mine
HC 35 Box 380
Helper, UT 84526

Client Project ID: Canyon Fuel
Date Received: 12/06/02

Set #0102S24415
Report Date: 02/24/03

Lab Id	Sample Id	Coarse Fragments %	Sand %	Silt %	Clay %	Texture	1/3 Bar %	15 Bar %	Available Sodium meq/100g	Exchangeable Sodium meq/100g
0102S24421	WR-7	59.7	72.0	16.0	12.0	SANDY LOAM	20.8	8.8	0.20	0.06
0102S24421D	WR-7								0.21	0.08

These results only apply to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: ~~T.S.=~~ Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neut. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed By: _____
Joey Sheeley, Soils Lab Supervisor

Inter-Mountain Laboratories, Inc.

1633 Terra Avenue
Sheridan, WY 82801

Report ID: 010224415

Soil Analysis Report

Canyon Fuel Company, LLC

Skyline Mine
HC 35 Box 380
Helper, UT 84526

Client Project ID: Canyon Fuel
Date Received: 12/06/02

Set #0102S24415
Report Date: 02/24/03

Lab Id	Sample Id	TOC	Total Sulfur	T.S. AB	Neutral. Pot.	T.S. ABP	Boron	Nitrogen-Nitrate	Selenium	TKN
		%	%	t/1000t	t/1000t	t/1000t	ppm	ppm	ppm	%
0102S24421	WR-7	66.8	0.77	24.1	61.0	36.9	0.80	0.48	0.06	0.76
0102S24421D	WR-7	69.0	0.78	24.4	57.7	33.3	1.10	0.58	0.08	0.77

These results only apply to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neut. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed By: _____
Joey Sheeley, Soils Lab Supervisor

POND 001

IMPOUNDMENT INSPECTION AND CERTIFIED REPORT			
Permit Number	C/007/005	Report Date	December 19, 2002
Mine Name	Skyline Mines		
Company Name	Canyon Fuel Company		
Impoundment Identification	Impoundment Name	Mine Site Sediment Pond	
	Impoundment Number	001	
	UPDES Permit Number	UT0023540	
	MSHA ID Number	NA	

IMPOUNDMENT INSPECTION

Inspection Date	December 19, 2002
Inspected By	Doug Johnson
Reason for Inspection (Annual, Quarterly or Other Periodic Inspection, Critical Installation, or Completion of Construction)	Annual / Quarterly

1. Describe any appearance of any instability, structural weakness, or any other hazardous condition.

No signs of instability were observed. No hazardous conditions were observed during the inspection of the pond.

Required for an impoundment which functions as a SEDIMENTATION POND.

2. Sediment storage capacity, including elevation of 60% and 100% sediment storage volumes, and, estimated average elevation of existing sediment.

Sediment Storage Capacity: 72,658 ft^3
60% Elevation: 8568.5 feet ASL (above sea level)
100% Elevation: 8571.5 feet ASL
The current elevation of the sediment within the pond at the discharge point was approximately 8562 ft ASL. At this elevation, approximately 90% of the storage volume remains. The remaining sediment volume storage capacity is approximately 65,392 ft^3.

3. Principle and emergency spillway elevations.

Principal and Emergency Spillway Elevations: 8579.6 feet ASL (The outlet structure for Pond 001 serves as both the Principal and Emergency Spillways)

IMPOUNDMENT INSPECTION AND CERTIFIED REPORT		

. Field Information. Provide current water elevation, whether pond is discharging, type and number of samples taken, monitoring/instrumentation information, inlet/outlet conditions, or other related activities associated with the pond including but not limited to sediment cleanout, pond decanting, embankment erosion/repairs, monitoring information, vegetation on outslopes of embankments, etc.

Water elevation at the time of inspection was 8579.72 feet ASL (0.04 feet above discharge elevation) and was discharging. A sample of the pond discharge water has been taken on weekly basis throughout the quarter and year as required by the mine's UPDES permit. On a biweekly basis the water sample is analyzed for total iron and total dissolved solids. Weekly samples include oil and grease, total suspended solids, pH and conductivity. A sample of the water had been obtained on 16th of December 2002. Therefore, no additional sample was obtained on the day of the inspection.

Surface water is collected from the upper mine pad and discharged to the pond through a culvert located on the west end of the pond. The culvert appeared to be functioning as designed. The outlet structure was working as designed and appeared to be in good working condition. Currently, the mine discharges water collected in Mine #3 directly to the pond outlet structure, by-passing the pond. The maximum volume of water discharged from Mine #3 to the outlet structure is approximately 1650gpm.

A small area on the north side of the pond has a colony of cattails. The colony poses no threat to the operation of the pond.

The pond was cleaned of most of its sediment in October and November of 2002. The sediment was hauled to the waste rock site for disposal.

5. **Field Evaluation.** Describe any changes in the geometry of the impounding structure, average and maximum depths and elevations of impounded water, estimated sediment or slurry volume and remaining storage capacity, estimated volume of water impounded, and any other aspect of the impounding structure affecting its stability or function which has occurred during the reporting period.

The overall geometry of the pond does not appear to have been modified this quarter. The pond has continually discharged this quarter, therefore the minimum elevation has been no less than 8579.6. Flow depth above the level of the discharge pipe can vary between less than 0.01 and 0.26 feet. The estimated sediment in the pond in the fourth quarter of this year was 7,266 ft^3 and remaining sediment storage capacity is 65,392 ft^3 (after pond cleanout in October and November 2002). Total storage volume for water and sediment combined is 179,014 ft^3 (4.1 ac-ft).

Based on the estimated volume of sediment, the estimated volume of water in the pond is 171,748 ft^3 (3.93 ac-ft).

Qualification Statement	I hereby certify that; I am experienced in the construction of impoundments; I am qualified and authorized under the direction of a Registered Professional Engineer to inspect the condition and appearance of impoundments in accordance with the certified and approved designs for this structure; that the impoundment has been maintained in accordance with approved design and meet or exceed the minimum design requirements under all applicable federal, state and local regulations; and, that inspections and inspection reports are made by myself and include any appearances of instability, structural weakness or other hazardous conditions of the structure affecting stability. **Signature:** _____ **Date:**

CERTIFIED REPORT

IMPOUNDMENT EVALUATION (If NO, explain under Comments)	YES	NO
1. Is impoundment designed and constructed in accordance with the approved plan?	Yes	
2. Is impoundment free of instability, structural weakness, or any other hazardous condition?	Yes	
3. Has the impoundment met all applicable performance standards and effluent limitations from the previous date of inspection?		No

COMMENTS AND OTHER INFORMATION

Exceedances of the UPDES permit limits of the allowable total tons per day of TDS discharged from the mine have occurred since the last inspection. These exceedances have been reported to the Utah Division of Water Quality (DWQ). The Skyline Mine UPDES permit is being modified to allow the mine to discharge water with a TDS concentration less than 500 mg/l with no daily tonnage limit.

Certification Statement:

REGISTERED PROFESSIONAL ENGINEER
3-20-03
No. 160554-2202
DOUGLAS E. JOHNSON
[RE Cert Stamp]
STATE OF UTAH

I hereby certify that: I am experienced in the construction of impoundments; I am qualified and authorized in the State of Utah to inspect and certify the condition and appearance of impoundments in accordance with the certified and approved designs for this structure; that the impoundment has been maintained in accordance with approved design and meet or exceed the minimum design requirements under all applicable federal, state and local regulations; and, that inspections and inspection reports are made by myself or under my direction and include any appearances of instability, structural weakness or other hazardous conditions of the structure affecting stability in accordance with the Utah R645 Coal Mining Rules.

By: DOUGLAS E. JOHNSON, MGR. TECH. SERVICES
(Full Name and Title)

Signature: Douglas E Johnson **Date:** 3-20-03

P.E. Number & State: 160554-2202 UTAH

POND 002

IMPOUNDMENT INSPECTION AND CERTIFIED REPORT			
Permit Number	C/007/005	**Report Date**	December 19, 2002
Mine Name	Skyline Mines		
Company Name	Canyon Fuel Company		
Impoundment Identification	**Impoundment Name**	Rail Loadout Sediment Pond	
	Impoundment Number	002	
	UPDES Permit Number	UT0023540	
	MSHA ID Number	NA	

IMPOUNDMENT INSPECTION

Inspection Date	December 19, 2002
Inspected By	Doug Johnson
Reason for Inspection (Annual, Quarterly or Other Periodic Inspection, Critical Installation, or Completion of Construction)	Annual / Quarterly

1. Describe any appearance of any instability, structural weakness, or any other hazardous condition.

No instability of the embankment was noted during the inspection. No hazardous conditions were noted at the time of the inspection.

Required for an impoundment which functions as a SEDIMENTATION POND.

2. Sediment storage capacity, including elevation of 60% and 100% sediment storage volumes, and, estimated average elevation of existing sediment.

Sediment Storage Capacity: 54,710 ft^3
60% Elevation: 7915.0 feet ASL (above sea level)
100% Elevation: 7915.6 ASL
Current Sediment Level Elevation: 7914 feet ASL

3. Principle and emergency spillway elevations.

Principle Spillway Elevation: 7919.7 feet ASL
Emergency Spillway Elevation: 7922 feet ASL

4. **Field Information.** Provide current water elevation, whether pond is discharging, type and number of samples taken, monitoring/instrumentation information, inlet/outlet conditions, or other related activities associated with the pond including but not limited to sediment cleanout, pond decanting, embankment erosion/repairs, monitoring information, vegetation on outslopes of embankments, etc.

The surface of the ice covering the pond is currently approximately 24-inches below discharge level of the primary spillway or at an elevation of 7917.7 feet ASL. No discharge from the pond occurred this quarter. The pond was cleaned of sediment in July 2000. the pond was not decanted in 2002. The pond embankment appears stable and without noticeable erosion. Vegetation growing on the embankment and outslopes do not appear to create hazardous conditions. The pond discharged periodically over a 5 day period in the 1st quarter of 2002. Analysis of the sample of the discharge water indicated the water discharged was in compliance with the mine's UPDES permit. The discharge and analysis information for this site was submitted to the Division in April 2002.

5. **Field Evaluation.** Describe any changes in the geometry of the impounding structure, average and maximum depths and elevations of impounded water, estimated sediment or slurry volume and remaining storage capacity, estimated volume of water impounded, and any other aspect of the impounding structure affecting its stability or function which has occurred during the reporting period.

The geometry of the pond does not appear to have changed recently. The pond was covered by an ice sheet several inches thick at the time of the annual inspection thus precluding an accurate measurement of the sediment held in the pond. The sediment volume in the was estimated to be 5,471 ft^3 in the 3rd quarter of 2002 with a remaining sediment storage capacity of 49,239 ft^3. Since the area did not experience significant runoff events in the 4th quarter of 2002, the sediment volume did not likely increase significantly. The water level at the time of the inspection was approximately 7,917.7 ft ASL. The average elevation of the water impounded in the pond in 2002 was 7,918.0 feet ASL. This average is based upon the water surface elevations obtained during each quarterly inspection. The maximum elevation of approximately 7919.8 feet ASL of the water occurred when the pond spilled in March of 2002.

Total storage volume of water and sediment combined is 95,380 ft^3 (2.2 ac-ft). Assuming the sediment volume is approximately 5,471 ft^3, the estimated total water capacity remaining in the pond is approximately 73,279 ft^3 (1.7 ac-ft).

Qualification Statement	I hereby certify that; I am experienced in the construction of impoundments; I am qualified and authorized under the direction of a Registered Professional Engineer to inspect the condition and appearance of impoundments in accordance with the certified and approved designs for this structure; that the impoundment has been maintained in accordance with approved design and meet or exceed the minimum design requirements under all applicable federal, state and local regulations; and, that inspections and inspection reports are made by myself and include any appearances of instability, structural weakness or other hazardous conditions of the structure affecting stability. **Signature:** _____ **Date:**

CERTIFIED REPORT

IMPOUNDMENT EVALUATION (If NO, explain under Comments)	YES	NO
1. Is impoundment designed and constructed in accordance with the approved plan?	Yes	
2. Is impoundment free of instability, structural weakness, or any other hazardous condition?	Yes	
3. Has the impoundment met all applicable performance standards and effluent limitations from the previous date of inspection?	Yes	

COMMENTS AND OTHER INFORMATION

Certification Statement:

REGISTERED PROFESSIONAL ENGINEER
3-20-03
No. 160554-2202
DOUGLAS E. JOHNSON
STATE OF UTAH

I hereby certify that; I am experienced in the construction of impoundments; I am qualified and authorized in the State of Utah to inspect and certify the condition and appearance of impoundments in accordance with the certified and approved designs for this structure; that the impoundment has been maintained in accordance with approved design and meet or exceed the minimum design requirements under all applicable federal, state and local regulations; and, that inspections and inspection reports are made by myself or under my direction and include any appearances of instability, structural weakness or other hazardous conditions of the structure affecting stability in accordance with the Utah R645 Coal Mining Rules.

By: DOUGLAS E. JOHNSON, MGR. TECH. SERVICES
(Full Name and Title)

Signature: Douglas E. Johnson **Date:** 3-20-03

P.E. Number & State: 160554-2202 UTAH

POND 003

IMPOUNDMENT INSPECTION AND CERTIFIED REPORT			
Permit Number	C/007/005	Report Date	December 19, 2002
Mine Name	Skyline Mines		
Company Name	Canyon Fuel Company		
Impoundment Identification	Impoundment Name	Waste Rock Site Sediment Pond	
	Impoundment Number	003	
	UPDES Permit Number	UT0023540	
	MSHA ID Number	NA	

IMPOUNDMENT INSPECTION

Inspection Date	December 19, 2002
Inspected By	Doug Johnson
Reason for Inspection (Annual, Quarterly or Other Periodic Inspection, Critical Installation, or Completion of Construction)	Annual / Quarterly

1. Describe any appearance of any instability, structural weakness, or any other hazardous condition.

No signs of instability, structural weaknesses, or any other hazardous conditions were found during the inspection of the pond.

Required for an impoundment which functions as a SEDIMENTATION POND.	
	2. Sediment storage capacity, including elevation of 60% and 100% sediment storage volumes, and, estimated average elevation of existing sediment. Sediment Storage Capacity: 6906 ft^3 60% Elevation: 7860.8 feet ASL (above sea level) 100% Elevation: 7861.3 ASL Current Sediment Level Elevation: No significant volume of sediment was observed during the 4th quarter of this year. A small delta has formed at the inlet to the pond and in the southeast corner of the pond. The pond was last cleaned in October 2000.
	3. Principle and emergency spillway elevations. Principal and Emergency Spillways Elevation: 7865.5 feet ASL (The outlet of Pond 003 serves as both the principal and emergency spillway).

4. **Field Information.** Provide current water elevation, whether pond is discharging, type and number of samples taken, monitoring/instrumentation information, inlet/outlet conditions, or other related activities associated with the pond including but not limited to sediment cleanout, pond decanting, embankment erosion/repairs, monitoring information, vegetation on outslopes of embankments, etc.

This pond did not discharge in 2002, therefore no water samples were been obtained. No water was present in the pond at the time of inspection. No repairs to the pond have been needed in 2002. The sediment pond was not cleaned of sediment in 2002 nor was the pond decanted. Vegetation on the outslopes of the pond embankment do not appear to present any type of hazardous conditions.

5. **Field Evaluation.** Describe any changes in the geometry of the impounding structure, average and maximum depths and elevations of impounded water, estimated sediment or slurry volume and remaining storage capacity, estimated volume of water impounded, and any other aspect of the impounding structure affecting its stability or function which has occurred during the reporting period.

The overall geometry of the pond has not changed since October 2000 when the pond sediment was cleaned out. Total estimated available storage volume of water and sediment combined is 42,689 cu. ft. (0.98 ac-ft). This assumption is based on the minimal volume of water noted in the pond and the lack of significant infilling of sediment since the October 2000 cleanout.

Qualification Statement	I hereby certify that: I am experienced in the construction of impoundments: I am qualified and authorized under the direction of a Registered Professional Engineer to inspect the condition and appearance of impoundments in accordance with the certified and approved designs for this structure; that the impoundment has been maintained in accordance with approved design and meet or exceed the minimum design requirements under all applicable federal, state and local regulations; and, that inspections and inspection reports are made by myself and include any appearances of instability, structural weakness or other hazardous conditions of the structure affecting stability. **Signature:** _____ **Date:**

CERTIFIED REPORT

IMPOUNDMENT EVALUATION (If NO, explain under Comments)	YES	NO
1. Is impoundment designed and constructed in accordance with the approved plan?	Yes	
2. Is impoundment free of instability, structural weakness, or any other hazardous condition?	Yes	
3. Has the impoundment met all applicable performance standards and effluent limitations from the previous date of inspection?	Yes	

COMMENTS AND OTHER INFORMATION

The pond has not discharged in 2002.

Certification Statement:

REGISTERED PROFESSIONAL ENGINEER
3-20-03
No. 160554-2202
DOUGLAS E. JOHNSON
(PE Cert. Stamp)
STATE OF UTAH

I hereby certify that; I am experienced in the construction of impoundments; I am qualified and authorized in the State of Utah to inspect and certify the condition and appearance of impoundments in accordance with the certified and approved designs for this structure; that the impoundment has been maintained in accordance with approved design and meet or exceed the minimum design requirements under all applicable federal, state and local regulations; and, that inspections and inspection reports are made by myself or under my direction and include any appearances of instability, structural weakness or other hazardous conditions of the structure affecting stability in accordance with the Utah R645 Coal Mining Rules.

By: DOUGLAS E. JOHNSON, MGR. TECH. SERVICES
(Full Name and Title)

Signature: Douglas E Johnson **Date:** 3-20-03

P.E. Number & State: 160554-2202 UTAH

APPENDIX B

Reporting of Technical Data

Including monitoring data, reports, maps, and other information
As required under the approved plan or as required by the Division

In accordance with the requirement of R645-310-130 and R645-301-140

CONTENTS

2002 Subsidence Monitoring Map
2002 Vegetation Monitoring Information
2002 Raptor Survey Map
James and Burnout Canyon Macroinvertabrate Study
Eccles Creek Macroinvertabrate Study
Mud Creek Tons of TSS Calculation
EarthFax Mud and Eccles Creek 2002 Study

2002 Vegetation Report for Skyline Mine

The following seedlings were purchased from the Lone Peak Nursery in Draper Utah:

- Rubber Rabbit Brush,
- Snowberry, and
- Wood Rose.

Two hundred seedlings of each species were purchased on May 1, 2002 and planted on May 2, 2002. The seedlings were planted along the conveyor bench just west of the former vegetative test plot. The plants were grown from seeds collected from plants in Utah and Colorado at elevations similar to the mine site. Because of the dry climatic conditions that have continued through 2002, only a few of the seedlings (about 20%) appear to have survived the summer. However, in the spring of 2003, the survival rate of the seedlings will be re-evaluated.

The following plants have been ordered for the the spring of 2003: Woods Rose, Snowberry, Rubber Rabbitbrush, and Mountain Sage Brush. These plants will be planted in early May of 2003 again in the former test plot area of the conveyor bench.

The Macrobenthos of Burnout Creek & James Canyon Creek, Tributaries to Electric Lake, Huntington Creek Drainage.

Spring 2002

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CONCLUSIONS 17

Prepared by

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Dennis K. Shiozawa, Ph.D.

for

CANYON FUEL COMPANY, LLC.
Skyline Mines
HC 35 Box 380
Helper, Utah 84526

March 2003

The Macrobenthos of Burnout Creek & James Canyon Creek, Tributaries to Electric Lake, Huntington Creek Drainage.

Spring 2002

INTRODUCTION

Community composition can be impacted by acute, transient perturbations or by chronic, long term changes in environmental conditions. In stream systems the macrobenthic communities have been widely used for monitoring both acute and chronic impacts in watersheds (Resh and McElravy 1993). Temperate stream organisms often have annual or biennial life cycles and many species have specific habitat requirements. Thus, while transient perturbations, such as a slug flow of a contaminant, may only be detected chemically in the stream for a short period of time, any significant impacts on the stream benthic communities will remain detectable for a much longer period. Sometimes several generations are required before numbers and biomass recover to pre-impact levels. Chronic impacts, such as sedimentation, may eliminate certain habitats or may reduce densities of sensitive species and invertebrate monitoring can document such changes.

PURPOSE

This report covers the results of samples taken in the spring of 2002, the third year of a monitoring program established to evaluate the impact of mining subsidence on the macrobenthos of James Canyon Creek and Burnout Creek, both tributaries to Huntington Creek and Electric Lake.

METHODS

Quantitative samples were taken on July 2, 2002 with a modified box sampler (Shiozawa 1986) composed of a net mesh of 253 microns. Three samples were taken at each stream as prescribed to Canyon Fuels Corporation by the Utah Division of Wildlife Resources. These were preserved in the field with ethyl alcohol and were returned to the laboratory for processing. The samples were sorted in an illuminated pan. Organisms were identified to the lowest taxonomic unit possible. Small specimens and those of questionable identity were further examined under magnification. Identification was based on the keys of Merritt and Cummins (1994). The mean and standard deviation were calculated for each taxon and the mean values were used to determine the density per square meter. Standing crop was estimated from wet weights of total invertebrates collected at each station.

Calculation of the USFS Biotic Condition Index (Winget and Mangum 1979) was completed using the abundances of the benthic taxa to generate the dominance weighted community tolerant quotient (CTQa). The predicted community tolerant quotient (CTQp) was calculated using water chemistry data provided in Winget (1972) for the Huntington Creek drainage.

Cluster analysis was run with NTSYS-pc, using the Bray-Curtis dissimilarity index with the UPGM clustering algorithm. Data from all sampling periods (fall 2000 through spring 2002) and both streams were combined in the analysis.

RESULTS

Thirty four taxonomic categories (including larvae and adults and unidentifiable immature insects as separate taxa) were identified in Burnout Creek (Table 1), about the same number as found in the spring or 2001. Twenty eight taxonomic categories were recorded from James Canyon (Table 2), eight fewer than were recorded in the spring of 2001 and four less than in the fall of 2001. Most of the differences were associated with rare taxa (Table 4). Burnout Creek had a density of 38,168 organisms per square meter. This is an increase of approximately 8% above the 35,259 per sq. m recorded for the spring 2001 samples. James Canyon Creek had a density of 28,886 organisms per square meter while the spring 2001 samples had an estimated 30,805 per sq. m recorded. James Canyon Creek total density is 6.6% lower than it was in the spring of 2001, despite the 66% reduction in densities in the fall of 2001. At that period the total densities fell from 34,758 per sq. m in the fall of 2000 to 11,741 per sq. m, in the fall of 2001. This suggests that the fall of 2001 decline was transient and that the James Canyon fauna is recovering.

Burnout creek biomass, wet weight, was 25.149 grams per square meter, lower than in the previous spring (32.12 grams per square meter). James Canyon Creek had a wet weight of 36.87 grams per square meter, higher than the biomass estimates of the previous spring (25.15 grams per square meter). The increased biomass in James Canyon also suggests that the system is recovering from the perturbations that impacted it in the fall of 2001.

Spatial Distribution

The variance to mean ratios were examined to evaluate the number of taxa demonstrating a contagious distribution (Elliott 1977). As discussed in the previous reports, a Chi Square value of 8 or above indicates that a taxon is contagiously distributed, and much of the total contagion generated for total taxa was due to the midges (Diptera: Chrironomidae). Seven taxa in Burnout Creek (Table 1) and eight taxa in James Canyon Creek (Table 2) were contagiously distributed. The remaining taxa in each stream followed a Poisson distribution. The seven contagiously distributed taxa in Burnout Creek represent about a 50% reduction in the number of contagious taxa when compared to previous sampling periods. Sixteen Burnout Creek taxa in the fall of 2000, 13 taxa in spring of 2001, and 13 taxa in the fall of 2001 were contagiously distributed. Eight James Canyon Creek taxa were contagiously distributed in the spring 2002 samples. This is close to the nine taxa in both the fall of 2000, and the fall of 2001. However 16 taxa were contagiously distributed in the spring of 2001, indicating a change in spatial distribution in the spring 2002 sampling series. While in previous years the most abundant taxa showed the contagious distributions, a number of abundant taxa in the spring 2002 samples were randomly distributed. The change in spatial distribution was not related to a drastic change in total density of invertebrates, since the overall numbers in both Burnout and James Canyon creeks were within 8% of the previous spring estimates (see above).

The change in spatial patterns is also unlikely to be due to the impact of drilling and pipeline construction activities in the James Canyon Creek Drainage in late summer of 2001 since both

streams had a reduction of contagiously distributed taxa. One factor that could have influenced the pattern was the timing of sampling. The spring 2002 samples were taken on July 2, 2002 while the spring of 2001 samples were taken on June 20, 2001. While the calendar dates of sampling, just under two weeks later in 2002, are relatively close together, the impact of the continued drought and the associated early onset of spring conditions in 2002 may have amplified the differences. It is known that pulsed aquatic invertebrates can become more randomly distributed as the cohort ages (Shiozawa and Barnes 1977) possibly because of foraging activities. If primary production becomes more important for the benthos as the spring and summer season progresses, herbivorous invertebrates could become more randomly distributed across the surface, and concurrent with that predators could also become more randomly distributed. The groups that did show a tendency for more random distributions include the predator *Rhyacophila*, the scraper-collector-gatherer *Heterlimnius* (*Optioservus* probably belongs in this category as well), the collector-gatherer-scraper *Baetis* and the scraper *Cinygmula*. This places a time-scale constraint on the distributional patterns which, like the seasonal signal seen in the stations, would require much more frequent sampling to fully decipher. Another potential cause, which was not monitored in the spring of 2002, may be related to reduced trout population density. The total fish population estimates in the fall of 2001 showed a decrease in Burnout Creek of 15% relative to that recorded in the previous fall and James Canyon Creek had a reduction of 84% from the fall of 2000. The reduction in fish densities (Turcotte and Harper 1982, Flecker 1992) could have also modified (diminished) the tendency for invertebrates to exhibit crepuscular feeding behavior. Such behavioral changes would favor daylight foraging, generating a more random distribution during daylight hours. However, while the two streams showed approximately the same

percentage reduction in contagiously distributed taxa, they did not show equivalent decreases in total fish population estimates for the fall of 2001, making this explanation less likely.

Biotic Condition Index

The community tolerant quotient (CTQa; Winget and Mangum 1979) was determined from the ratings for individual invertebrate taxa (Table 5). Burnout Creek, in the spring of 2002 had a CTQa rating of 64, and James Canyon Creek for the spring of 2000 had a CTQa rating of 66 (Table 5, Table 6). The BCI value for Burnout Creek was calculated at 125, while BCI for James Canyon Creek was 121. Both streams are in good condition, according to this index (Winget and Mangum 1979). Over the sampling period the CTQa values (Table 6) have changed little in either stream.

Table 1. Spring 2002 statistics for Burnout Creek.

		1	2	3	mean	S. D.	Chi Sq.	#/m²
Ephemeroptera	*Baetis*	15	16	23	18.00	4.36	2.11	545.4
	Cinygmula	17	32	14	21.00	9.64	8.85	636.3
	Drunella grandis	1	0	0	0.33	0.58	2.04	10.1
	Epeorus iron	2	5	0	2.33	2.52	5.45	70.7
	Ephemerella	2	3	2	2.33	0.58	0.29	70.7
	Paraleptophlebia	0	1	0	0.33	0.58	2.04	10.1
	Rhithrogena	1	0	0	0.33	0.58	2.04	10.1
Plecoptera	Early instar Plecoptera	0	1	0	0.33	0.58	2.04	10.1
	Isoperla	0	0	1	0.33	0.58	2.04	10.1
	Skwalla parallela	0	0	1	0.33	0.58	2.04	10.1
	Zapada	0	0	0	0	0	0	0
Trichoptera	*Brachycentrus echo*	0	1	0	0.33	0.58	2.04	10.1
	Dicosmoecus	0	0	0	0	0	0	0
	Lepidostoma	1	1	1	1.00	0.00	0.00	30.3
	Micrasema	1	8	15	8.00	7.00	12.25	242.4
	Neothremma alicia	2	2	1	1.67	0.58	0.40	50.5
	Oligophlebodes	1	2	0	1.00	1.00	2.00	30.3
	Rhyacophila (larvae).	4	5	11	6.67	3.79	4.31	202.0
	Rhyacophila (pupae)	0	0	0	0	0	0	0
Coleoptera	*Heterlimnius* (larvae)	18	17	10	15.00	4.36	2.53	454.5
	Heterlimnius (adult)	1	5	1	2.33	2.31	4.58	70.7
	Optioservus (larvae)	31	52	42	41.67	10.50	5.29	1262.5
	Optioservus (adult)	0	13	3	5.33	6.81	17.40	161.6
	Staphylinidae	0	0	0	0	0	0	0
Diptera	*Antocha* (Tipulidae)	1	1	3	1.67	1.15	4.58	50.5
	Ceratopogonidae	0	0	0	0	0	0	0
	Chelifera	0	0	0	0	0	0	0
	Chironomidae (larvae)	1056	319	1564	979.7	626.00	799.99	29683.9
	Chironomidae (pupae)	28	8	64	33.33	28.38	48.33	1010.0
	Dicranota	1	0	0	0.33	0.58	2.04	10.1
	Hemerodromia	0	0	0	0	0	0	0
	Pericoma (Psychodidae)	1	0	0	0.33	0.58	2.04	10.1
	Simulium (larvae)	5	0	3	2.67	2.52	4.76	80.8
	Simulium (pupae)	1	0	0	0.33	0.58	2.04	10.1
	Tipula	1	0	0	0.33	0.58	2.04	10.1
Crustacea	Cladocera	12	24	18	18.00	6.00	4.00	545.4
	Copepoda	0	1	0	0.33	0.58	2.04	10.1
	Ostracoda	46	88	22	52.00	33.41	42.93	1575.6
Arachnida	Hydracarina	0	1	0	0.33	0.58	2.04	10.1
Mollusca	*Sphaerium*	18	15	3	12.00	7.94	10.51	363.6
Misc.	Oligochaeta	15	31	17	21.00	8.72	7.24	636.3
	Planariidae	3	13	10	8.67	5.13	6.07	262.6
Total		1284	665	1830	1259.7	780.2	966.49	38167.9

Table 2. Spring 2002 statistics for James Canyon Creek.

		1	2	3	mean	S. D.	Chi Sq.	#/m^2
Ephemeroptera	*Baetis*	6	11	23	13.33	8.74	11.46	404
	Cinygmula	22	13	13	15.00	5.2	3.38	484.8
	Drunella grandis	67	34	46	49.0	16.7	11.38	1484.7
	Epeorus iron	0	0	1	0.33	0.58	2.04	10.1
	Ephemerella	6	0	3	3.00	3.00	6.00	90.9
	Paraleptophlebia	1	1	0	0.67	0.58	1.00	20.2
	Rhithrogena	0	0	0	0	0	0	0
Plecoptera	Early instar Plecoptera	15	8	6	9.76	4.73	4.63	292.9
	Isoperla	1	0	0	0.33	0.58	2.04	10.1
	Skwalla parallela	3	2	1	2.00	1.00	1.00	60.6
	Zapada	0	11	0	3.67	6.35	21.97	111.1
Trichoptera	*Brachycentrus echo*	0	0	0	0	0	0	0
	Dicosmoecus	0	2	1	1.00	1.00	2.10	30.3
	Lepidostoma	0	0	0	0	0	0	0
	Micrasema	0	0	0	0	0	0	0
	Neothremma alicia	26	11	35	24.00	12.12	12.24	727.2
	Oligophlebodes sp	1	0	1	0.67	0.58	1.00	20.2
	Rhyacophila (larvae).	17	16	24	19.00	4.36	2.00	575.7
	Rhyacophila (pupae)	3	0	0	1.00	1.76	5.99	20.2
Coleoptera	*Heterlimnius* (larvae)	0	0	0	0	0	0	0
	Heterlimnius (adult)	2	0	2	1.33	1.15	1.99	40.4
	Optioservus (larvae)	9	17	3	9.67	7.02	10.21	292.9
	Optioservus (adult)	0	0	0	0	0	0	0
	Staphylinidae	0	0	0	0	0	0	0
Diptera	*Antocha* (Tipulidae)	0	1	0	0.33	0.58	2.04	10.1
	Ceratopogonidae	0	1	0	0.33	0.58	2.04	10.1
	Chelifera	2	0	2	1.33	1.15	1.99	40.4
	Chironomidae (larvae)	468	1417	288	724.3	606.58	1015.99	21947.3
	Chironomidae (pupae)	5	24	3	10.67	11.59	25.18	323.2
	Dicranota	0	0	0	0	0	0	0
	Hemerodromia	0	1	0	0.33	0.58	2.04	10.1
	Pericoma (Psychodidae)	0	0	0	0	0	0	0
	Simulium (larvae)	0	0	0	0	0	0	0
	Simulium (pupae)	0	0	0	0	0	0	0
	Tipula	0	0	0	0	0	0	0
Crustacea	Cladocera	18	4	12	11.33	7.02	8.70	343.4
	Copepoda	0	0	0	0	0	0	0
	Ostracoda	5	6	8	5.30	0.58	0.13	161.6
Arachnida	Hydracarina	1	6	1	2.67	2.89	6.26	80.8
Mollusca	*Sphaerium*	3	6	5	4.67	1.53	1.00	141.4
Misc.	Oligochaeta	10	13	16	13.00	3.00	1.38	393.9
	Planariidae	37	22	42	33.67	10.41	6.44	1020.1
Total		729	1627	533	963	583.33	706.70	28886

Table 3. Summary of densities (#/m^2) for Burnout Creek.

		Fall 2000	Spring 2001	Fall 2001	Spring 2002
Ephemeroptera	*Baetis*	404	949	848	545
	Cinygmula	566	10	1051	636
	Drunella doddsi	0	0	10	0
	Drunella grandis	0	20	20	10
	Epeorus iron	0	0	0	71
	Ephemerella	182	20	101	71
	Early instar *Ephemerella*	0	0	0	0
	Heptagenia	91	0	0	0
	Paraleptophlebia	1160	40	525	10
	Rhithrogena	10	0	0	10
Plecoptera	Early instar Plecoptera	51	20	0	10
	Diura knowltoni	20	0	0	0
	Isoperla	71	10	10	10
	Malenka californica	142	0	0	0
	Megarcys signata	0	0	10	0
	Paraperla	0	0	0	0
	Skwalla parallela	0	10	0	10
	Sweltsa	51	0	20	0
	Zapada	10	10	0	0
Trichoptera	*Allomyia*	0	0	0	0
	Amiocentrus	0	0	10	0
	Arctopsyche grandis	0	0	0	0
	Brachycentrus echo	0	10	30	10
	Dicosmoecus	0	10	131	0
	Ecclisocosmoecus	20	0	0	0
	Lepidostoma	0	0	0	30
	Micrasema	0	131	142	242
	Moselyana	20	0	0	0
	Neothremma alicia	252	81	101	50.5
	Oligophlebodes	40	202	515	30
	Platycentropus	0	0	10	0
	Rhyacophila (larvae).	121	101	121	202
	Rhyacophila (pupae)	0	0	0	0
Coleoptera	*Heterlimnius* (larvae)	354	2827	2505	455
	Heterlimnius (adult)	40	51	152	71
	Optioservus (larvae)	71	0	0	1263
	Optioservus (adult)	0	0	0	162
	Staphylinidae	0	0	0	0
Diptera	*Antocha* (Tipulidae)	40	152	0	51
	Antocha (pupae)	0	20	0	0
	Atherix	0	0	0	0
	Caloparyphus	0	0	0	0
	Ceratopogonidae	0	20	20	0
	Chelifera	0	121	0	0
	Chironomidae (larvae)	3919	21928	2636	29684
	Chironomidae (pupae)	0	485	0	1010
	Dicranota	20	10	10	10

	Dixa	0	0	0	0
	Euparyphus	20	0	10	0
	Hemerodromia	0	0	0	0
	Limnophila	0	0	0	0
	Pericoma (Psychodidae)	111	0	10	10
	Phoridae	0	0	0	0
	Ptychoptera	81	0	0	0
	Simulium (larvae)	121	30	323	81
	Simulium (pupae)	0	30	0	10
	Tipula	10	30	40	10
	Trichoclinocera	0	0	0	0
	Wiedemannia	0	0	0	0
Crustacea	*Asellus*	10	0	0	0
	Cladocera	0	495	0	545
	Copepoda	0	0	0	10
	Ostracoda	4202	5181	5656	1576
Arachnida	Hydracarina	20	202	0	10
Mollusca	*Sphaerium*	40	364	252	364
Misc.	Oligochaeta	303	899	3596	636
	Planariidae	0	626	1111	263
Total		12595	35259	19998	38168

Table 4. Summary of densities (#/m^2) for James Canyon Creek.

		Fall 2000	Spring 2001	Fall 2001	Spring 2002
Ephemeroptera	*Baetis*	2848	1030	2444	404
	Cinygmula	313	384	404	485
	Drunella doddsi	0	0	30	0
	Drunella grandis	0	1030	0	1485
	Epeorus iron	0	0	0	10
	Ephemerella	980	20	10	91
	Early instar *Ephemerella*	30	0	495	0
	Heptagenia	30	0	0	0
	Paraleptophlebia	40	0	81	20
	Rhithrogena	0	51	0	0
Plecoptera	Early instar Plecoptera	646	879	30	293
	Diura knowltoni	0	0	0	0
	Isoperla	71	0	51	10
	Malenka californica	10	0	142	0
	Megarcys signata	0	0	10	0
	Paraperla	0	10	0	0
	Skwalla parallela	0	414	0	61
	Sweltsa	0	10	30	0
	Zapada	242	111	182	111
Trichoptera	*Allomyia*	131	0	0	0
	Amiocentrus	0	0	0	0
	Arctopsyche grandis	51	10	10	0
	Brachycentrus echo	0	171	0	0
	Dicosmoecus	10	0	0	30
	Ecclisocosmoecus	0	0	0	0
	Lepidostoma	0	30	10	0
	Micrasema	81	0	30	0
	Moselyana	0	0	0	0
	Neothremma alicia	3000	1384	758	727
	Oligophlebodes	0	364	153	20
	Platycentropus	0	0	0	0
	Rhyacophila (larvae).	394	798	293	576
	Rhyacophila (pupae)	0	30	0	20
Coleoptera	*Heterlimnius* (larvae)	30	192	51	0
	Heterlimnius (adult)	0	20	0	40
	Optioservus (larvae)	10	0	0	293
	Optioservus (adult)	0	0	0	0
	Staphylinidae	0	10	10	0
Diptera	*Antocha* (Tipulidae)	10	0	0	10
	Antocha (pupae)	0	0	0	10
	Atherix	10	0	0	0
	Caloparyphus	0	51	20	0
	Ceratopogonidae	40	61	0	10
	Chelifera	51	81	0	40
	Chironomidae (larvae)	23533	20614	4464	21947
	Chironomidae (pupae)	20	455	10	323
	Dicranota	20	0	0	0

	Dixa	0	10	0	0
	Euparyphus	10	0	0	0
	Hemerodromia	0	0	0	10
	Limnophila	0	20	0	0
	Pericoma (Psychodidae)	30	0	0	0
	Phoridae	0	0	10	0
	Ptychoptera	0	0	10	0
	Simulium (larvae)	91	10	111	0
	Simulium (pupae)	0	0	0	0
	Tipula	0	10	0	0
	Trichoclinocera	0	10	0	0
	Wiedemannia	81	0	20	0
Crustacea	*Asellus*	0	0	0	0
	Cladocera	0	51	0	343
	Copepoda	10	0	0	0
	Ostracoda	1778	858	323	162
Arachnida	Hydracarina	10	101	20	81
Mollusca	*Sphaerium*	20	353	71	141
Misc.	Oligochaeta	202	192	40	394
	Planariidae	0	828	1343	1020
Total		34757	30805	11716	28886

Table 5. Tolerance Quotients for taxa collected in the two streams (after Winget and Mangum 1979).

			Burnout	James Canyon
Ephemeroptera	*Baetis*	72	72	72
	Cinygmula	21	21	21
	Drunella doddsi	24		
	Drunella grandis	24	24	24
	Epeorus iron	21	21	21
	Ephemerella	48	48	21
	Early instar *Ephemerella*	48		
	Heptagenia	48		
	Paraleptophlebia	24	24	24
	Rhithrogena	21	21	
Plecoptera	Early instar Plecoptera	48	48	45
	Diura knowltoni	24		
	Isoperla	48	48	48
	Malenka californica	36		
	Megarcys signata	24		
	Paraperla	48		
	Skwalla parallela	18	18	18
	Sweltsa	24		
	Zapada	16		16
Trichoptera	*Allomyia*	108		
	Amiocentrus	24		
	Arctopsyche grandis	18		
	Brachycentrus echo	24	24	
	Dicosmoecus	24		24
	Ecclisocosmoecus	108		
	Lepidostoma	18	18	
	Micrasema	24	24	
	Moselyana	108		
	Neothremma alicia	8	8	8
	Oligophlebodes	24	24	24
	Platycentropus	108		
	Rhyacophila (larvae).	18	18	18
	Rhyacophila (pupae)	18		--
Coleoptera	*Heterlimnius* (larvae)	108	108	
	Heterlimnius (adult)	108	--	108
	Optioservus (larvae)	108	108	108
	Optioservus (adult)	108	--	--
	Staphylinidae	108		
Diptera	*Antocha* (Tipulidae)	24	24	24
	Antocha (pupae)	24		24
	Atherix	24		
	Caloparyphus	108		
	Ceratopogonidae	108		108

	Chelifera	108		108
	Chironomidae (larvae)	108	108	108
	Chironomidae (pupae)	108	--	--
	Dicranota	24	24	
	Dixa	108		
	Euparyphus	108		
	Hemerodromia	108		108
	Limnophila	108		
	Pericoma (Psychodidae)	108	108	
	Phoridae	108		
	Ptychoptera	108		
	Simulium (larvae)	108	108	
	Simulium (pupae)	108	--	
	Tipula	36	108	
	Trichoclinocera	108		
	Wiedemannia	108		
Crustacea	*Asellus*	108		108
	Cladocera	108	108	
	Copepoda	108	108	108
	Ostracoda	108	108	108
Arachnida	Hydracarina	108	108	108
Mollusca	*Sphaerium*	108	108	108
Misc.	Oligochaeta	108	108	108
	Planariidae	108	108	108
Total score			1796	1719
No. of Taxa			28	26
Mean score	CTQa		64.14	66.12

Table 6. Summary of CTQa values for the two Electric Lake tributaries.

CTQa	fall 2000	spring 2001	fall 2001	spring 2002
James Canyon Creek	65.64	72.00	68.72	66.12
Burnout Creek	58.32	60.77	60.00	64.14

Cluster Analysis

The cluster analysis (Figure 1) of the total data set (2000-2002) rearranged and clarified relationships among both seasons and streams. At a dissimilarity level of approximately 0.68 three clusters are apparent. The first, most dissimilar cluster, contains three fall samples from James Canyon, JC2F2000, JC1F2001, and JC2F2001. Two of these, JC2F2000 and JC1F2001 formed a separate cluster in the previous Fall 2001 report but in that analysis JC2F2001 occurred in a cluster containing a mix of spring and fall samples from James Canyon Creek and spring samples from Burnout Creek.

The second cluster contains all of the fall samples from Burnout Creek. This indicates that the seasonal signal is quite strong within Burnout Creek. The fall Burnout Creek cluster consists of two subclusters that differ at a dissimilarity level of approximately 0.65. Samples B2F2000 and B3F2000 which comprise one of these subclusters were also a separate cluster in the fall 2001 report. It separation was thought to be due to high densities of *Baetis*, *Cinygmula*, and ostracods, and the absence of *Lepidostoma*, *Ecclisocosmoecus*, and *Moseylyana*.

The third cluster contains the spring samples from both streams plus three James Canyon fall samples, two from 2000 and one from 2001. Two clear subclusters occur within this third cluster. Both subclusters contain a mix of James Canyon and Burnout spring samples, indicating that differences between the subclusters are unlikely to be due to differences between the two streams. Instead it appears that microhabitat differences (e.g. substrate size) influencing

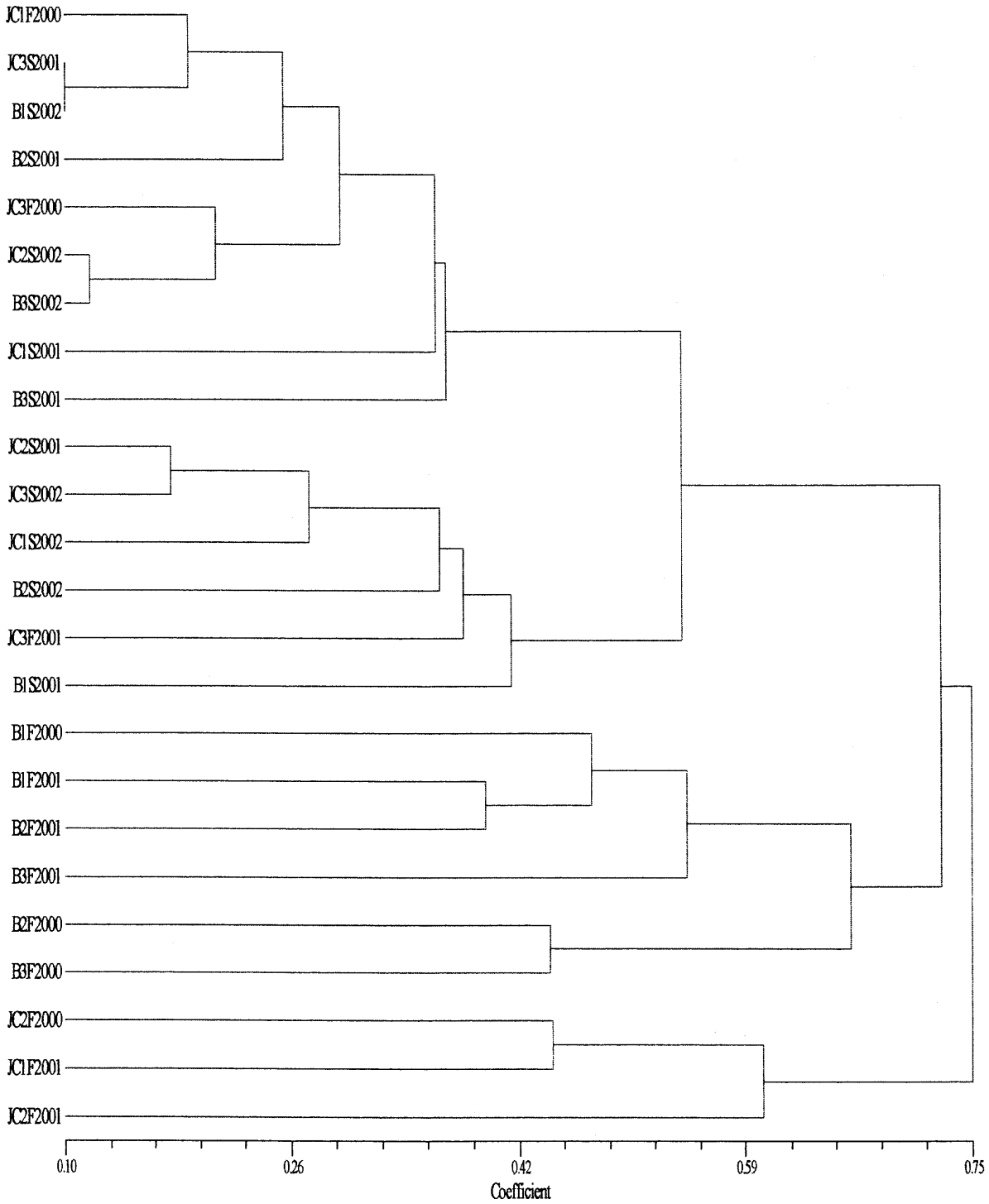
distributional patterns may be more critical. The first of the two subclusters contains JC1F2000, JC3F2001, B1S2002, B2S2001, JC3F2000, JC2S2002, B3S2002, JC1S2001, and B3S2001. The remaining samples are in the second subcluster (see Figure 1). The taxa that appear to be separating the two subclusters are *Baetis* (higher in the first subcluster), Chironomid larvae and pupae (both higher in the first subcluster), and planaria (higher in the second subcluster). Other taxa appear to be important in the structuring of relationships within the subclusters.

It is not clear why the James Canyon fall samples do not show a consistent seasonal signal as was seen in Burnout Creek. The low densities in the fall 2001 James Canyon samples would be expected to pull those samples out as a separate group and this analysis did place two of the samples together in the first, most dissimilar, cluster (see above), but a fall 2000 sample was also in this cluster (it also clustered with JC1F2001 in the fall 2001 report). This indicates that the fall 2001 samples from James Canyon were highly variable, and fall samples from James Canyon are more different in composition from one-another than are fall samples in Burnout Creek. The fall James Canyon samples (JC1F2000, JC3F2000 and JC3F2001) that fell with the spring cluster (cluster 3) were separated from each other by the same factors that separated the two major spring subclusters. They differed from the fall cluster of James Canyon samples (the first cluster with JC2F2000, JC1F2001, and JC2F2001) in having more ostracods, fewer planaria, and more chironomid larvae. The caddisfly Neothremma also appears to be somewhat influential (Table 4), although neither set of samples has all of the high or low densities.

CONCLUSIONS

Both streams can be considered to be in good condition. The impact recorded in the fall of 2001 in James Canyon appears to have been temporary. Burnout Creek has a much more consistent fall and spring signal than does James Canyon. The seasonal signal in James Canyon may be partially obscured by the lack of unimpacted data for the fall of 2001, but it appears that the stream, even though it is near Burnout Creek, may not be responding to the same sets of variables. This could be associated withhabitat differences between the two sample sites, which were established at a prescribed location above the high water level for Electric Lake. Still the indices and relatively consistent number of taxa suggests that the streams have not shown any directional change towards greater degradation during the period of the study.

Figure 1. Cluster dendrogram for all samples taken at James Canyon Creek(JC) and Burnout Creek (B) since the fall of 2000.



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The Benthos of Eccles Creek and the Impact of Increased Water Discharge in 2002

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INTRODUCTION

This project was undertaken to examine the changes in benthic invertebrates in Eccles Creek near Scofield, Utah between November 2001 and July 2002. Beginning in August of 2001 water discharging from Skyline Mine significantly increased the discharge in Eccles Creek. The discharge increased from about 1000 gpm to 4100 gpm, approximately bank full level. This survey was completed for Canyon Fuel Company.

METHODS

Quantitative samples were taken on November 24, 2001 (Shiozawa 2002) and on July 2, 2002. In November of 2001 four samples were taken at intervals separated by approximately 20 to 30 m. On July 2, 2002, samples were taken from three stations on the stream, with five replicates per station. These stations were Eccles Creek above South Fork (site 1), Eccles Creek at Whisky Canyon (site 2), and Lower Eccles Creek (site 3). The stations corresponded to stations EC2, EC4, and EC5 (Shiozawa 2002b) in the sampling surveys between 1979 and the present.

A box sampler was used to collect the samples. Samples were taken in areas with rubble or cobble substrates to insure that similar habitats were examined. Samples were taken from parts of the stream channel that had been submerged continuously throughout the year. The substrate was stirred to a depth of approximately 5 cm. All rocks within the area of the sampler were removed

and individually washed to insure quantitative assessment of the invertebrates. The box sampler had a net mesh of 250 microns. The samples were concentrated on a screen with a mesh of 64 microns and field preserved in ethyl alcohol.

In the laboratory the samples were sorted in a pan illuminated from below. All invertebrates were removed and identified to the lowest possible taxonomic level using the keys of Merritt and Cummins (1996). The mean density and standard deviation per sample was calculated for each taxon and the mean values were used to determine the density per square meter.

RESULTS

Only five taxa (*Baetis*, *Hydropsyche*, *Pedicia*, chironomids, and ostracods) were collected from Eccles Creek in the 2001 sampling series (Table 1) and a total density estimate of 61 per square meter was obtained. *Hydropsyche* was the most abundant taxa at Eccles Creek in 2001, being present at a density of 45 per square meter. In the 2002 samples 17 taxa were collected and the average density estimate for the three stations was 5,795 organisms per square meter, almost a 100 fold increase from the previous fall. *Hydropsyche* occurred at a density of 513 per square meter, over a ten fold increase from November 2001. Baetis, in 2001 were found at a mean density of eight per square meter, while in 2002 the density had increased to 311 per square meter. Chironomids (midges) showed the greatest increase, from eight per square meter in 2001 to 4,276 per square meter in 2002, a 500 fold increase.

The Biotic Condition Index (Winget and Mangum 1979) was also used to generate information about the condition of the stream. Water chemistry for Eccles Creek was provided EarthFax Engineering (2001). The following estimates were used for alkalinity and sulfate levels: Eccles Creek alkalinity recorded levels at 264 mg/l and sulfate estimated at 49 mg/l. The gradient in Eccles Creek it is approximately 3.3. Eccles Creek had a number of well sorted substrates, including sand, gravel, boulder, and rubble. With its combination of physical properties, it had an expected CTQp of 80 (Winget and Mangum 1979). The CTQa value for Eccles Creek in the fall of 2001 was 93.6. The three sites sampled in 2002 had CTQa values of 73.5, 67.6 and 74.3 respectively (Table 2). These values show an improvement from the 2001 CTQa value, and are actually better than the predicted value of 80.

DISCUSSION

The overall increase in densities of invertebrates in the stream from November 2001 to July 2002 suggests that the community is beginning to adjust to the new discharge regimen. The majority of the colonists are known vagrant taxa (*Baetis, Hydropsyche,* chironomids). The addition of other taxa, in particular the presence of small plecopterans, tipulids, and *Rhyacophila* indicates that some of the functional structure (Cummins 1974) of the stream invertebrate community is recovering, although those particular taxa are still at low densities. Historically, the total density of organisms at the three stations that were sampled in July, 2002 has been as high as almost 60,000 per square meter (Shiozawa 2002b), but more often the numbers during pre-mining times

were around 15,000 per square meter. The densities should increase about three fold as the stream recovers.

The total number of taxa in the stream in pre-mining sampling was about 25 to 30 (Shiozawa 2002b). The 2001 samples had just 5 taxa, and the 2002 samples had 6 to 13 taxa (Table 1, 2). These numbers should increase as additional species colonize. The chironomids appear to be in densities comparable to those collected in 1979 and much higher than what was collected in the 1990's (Shiozawa 2002b). When midges are assessed, mesh size can influence density estimates, and the mesh utilized in the 1990's study is unknown, so the estimates from that study could differ because of the mesh used in sampling, but the high sedimentation present during that sampling period should also have significantly reduced chironomid densities. Since none of the studies, including the present one, separated the chironomids to genera, it is not possible to determine differences in the chironomid community make up. It is highly likely that the midges collected in the 2002 samples are pioneering species and do not represent the same community complex that existed in the 1979 study. That is, the fact that the midge community is at similar densities can not be taken as evidence that the midge community has recovered..

Nevertheless, both the increased community structure and the increased densities of benthic invertebrates indicate that Eccles Creek is in a recovery mode. Densities should increase by 3 fold or more and the number of taxa should at least double as the stream community continues to stabilize. As noted before (Shiozawa 2002b) the community may not return to the same makeup as existed in 1979. The increased discharge, if sustained, will modify the organic material

retention rate as well as temperature regimens within the stream channel. These will then influence the structure of the developing stream community. While trophic complexity should increase, the successful taxa that become components of that trophic structure will be determined by the ambient physical conditions.

Based on the CTQa values for Eccles Creek in November 2001 and July 2002, Eccles Creek has improved. The predicted CTQp for the stream is 80 and the three stations in 2002 actually exceed (are lower than) that value. This implies that the communities have recovered. However the CTQa values are generated independent of densities of taxa and are a mean value of those taxa present. Thus the presence of just a single individual with a low assigned TQ value has as much significance as a thousand individuals of a single taxon with a high TQ. The equal weighting can be quite misleading. For that reason the CTQa values must be evaluated with consideration on the number of taxa and the relative densities of those taxa. The latter information indicates that the system has progressed, but has not recovered.

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Table 1 Sample data and total invertebrates per square meter.

	Eccles Creek, Nov. 2001					Eccles Creek above South Fork , Site 1, July 2002 (EC2)					
Taxa	1	2	3	4	#/ m^2	1	2	3	4	5	#/ m^2
Ephemeroptera											
Baetis	0	0	1	0	8	3	8	18	7	4	242
Cinygmula	0	0	0	0	0	0	0	0	0	1	6
Plecoptera											
Early instar Plecoptera	0	0	0	0	0	0	0	0	0	0	0
Trichoptera											
Brachycentrus sp.	0	0	0	0	0	0	0	0	0	0	0
Brachycentrus echo	0	0	0	0	0	0	1	0	0	0	6
Hydroptila sp.	0	0	0	0	0	0	0	0	0	0	0
Hydropsyche	0	0	4	2	45	1	0	2	0	0	18
Micrasema bactro	0	0	0	0	0	0	0	0	0	0	0
Rhyacophila	0	0	0	0	0	0	0	0	0	0	0
Trichoptera pupae	0	0	0	0	0	1	0	0	0	1	12
Coleoptera											
Optioservus	0	0	0	0	0	0	0	0	0	0	0
Diptera											
Chironomidae	1	0	0	0	8	110	78	93	165	76	3163
Chironomid pupae	0	0	0	0	0	8	4	3	10	4	176
Tipulidae *Tipula*	0	0	0	0	0	0	0	0	0	0	0
Copepoda	0	0	0	0	0	0	0	0	0	0	0
Ostracoda	1	0	1	0	16	0	0	0	0	0	0
Mollusca: Sphaerium	0	0	0	0	0	0	0	0	0	0	0
Oligochaeta	0	0	0	0	0	0	2	5	5	1	79
Tricladida Planariidae	0	0	0	0	0	0	0	0	0	0	0
totals	**2**	**0**	**4**	**2**	**61**	**123**	**93**	**121**	**187**	**87**	**3703**

Table 1 (continued)

	Eccles Creek at Whisky Canyon, Site 2, July 2002 (EC4)						Lower Eccles Creek, Site 3, July 2002 (EC5)					
Taxa	1	2	3	4	5	#/ m2	1	2	3	4	5	#/ m2
Ephemeroptera												
Baetis	6	2	27	2	44	491	8	1	4	4	16	200
Cinygmula	0	0	0	1	0	6	0	0	0	0	0	0
Plecoptera												
Early instar Plecoptera	1	0	1	0	0	12	0	1	0	0	1	12
Trichoptera												
Brachycentrus sp.	0	0	4	0	2	36	0	0	0	0	0	0
Brachycentrus echo	0	0	0	0	0	0	0	0	0	0	0	0
Hydroptila sp.	0	0	5	0	2	42	0	0	0	0	0	0
Hydropsyche	6	3	128	2	42	1097	20	1	0	5	44	424
Micrasema bactro	0	0	4	0	0	24	0	0	0	0	0	0
Rhyacophila	1	0	0	0	0	6	0	0	0	1	0	6
Trichoptera pupae	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera												
Optioservus	0	0	2	0	1	18	0	0	0	0	0	0
Diptera												
Chironomidae	80	142	346	100	342	6121	118	113	162	76	116	3545
Chironomid pupae	3	5	13	3	12	218	1	8	10	1	7	164
Tipulidae *Tipula*	0	0	1	0	0	6	0	1	0	0	1	15
Copepoda	0	1	0	0	0	6	0	0	0	0	0	0
Ostracoda	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca: Sphaerium	0	0	2	0	0	12	0	0	0	0	0	0
Oligochaeta	6	4	64	2	32	654	20	21	10	12	32	576
Tricladida Planariidae	0	0	0	0	1	6	0	0	0	0	0	0
totals	**103**	**157**	**597**	**110**	**478**	**8757**	**167**	**145**	**186**	**99**	**216**	**4927**

Table 2. Tolerance quotients and biotic condition index values.

	Eccles Creek 2001	Eccles Creek above South Fork (Site 1) 2002 (EC2)	Eccles Creek at Whisky Canyon (Site 2) 2002 (EC4)	Lower Eccles Creek (Site 3) 2002 (EC5)	Ideal stream (species list, including Boardinghouse Creek)
Taxa	TQ	TQ	TQ	TQ	TQ
Ephemeroptera					
Baetis	72	72	72	72	72
Cinygmula	0	21	21	0	21
Drunella sp.	0	0	0	0	48
Drunella dodsei	0	0	0	0	4
Seratella	0	0	0	0	48
Ephemerella	0	0	0	0	48
Paraleptophlebia	0	0	0	0	24
Plecoptera					
Early instar Plecoptera	0	0	36	36	36
Malenka californica	0	0	0	0	36
Isoperla	0	0	0	0	48
Zapada	0	0	0	0	16
Trichoptera					
Brachycentrus	0	24	24	0	24
Micrasema	0	0	24	0	24
Dicosmecus	0	0	0	0	24
Arctopsyche	0	0	0	0	18
Hydroptila	0	0		0	
Hydropsyche	108	108	108	108	108
Neothremma alica	0	0	0	0	8

Table 2 (continued)

Oligoplebodes	0	0	0	0	24
Rhyacophila	0	0	18	18	18
Coleoptera					
Optioservus	0	0	0	108	108
Diptera					
Ceratopogonidae	0	0	0	0	108
Chironomidae	108	108	108	108	108
Empidae *Chelifera*	0	0	0	0	108
Simuliidae *Simulium*	0	0	0	0	108
Tipulidae *Dicranota*	0	0	0	0	24
Tipulidae *Limnophila*	0	0	0	0	72
Tipulidae *Tipula*	0	0	36	36	36
Tipulidae *Pedicea*	72	0	0	0	72
Collembola	0	0	0	0	108
Ostracoda	108	0	0	0	108
Copepoda	0	0	108	0	108
Mollusca: Sphaerium	0	0	108	0	108
Oligochaeta	0	108	108	108	108
Tricladida Planariidae	0	0	108	0	108
totals	468	441	879	594	2041
n	5	6	13	8	34
CTQa	**93.6**	**73.5**	**67.6**	**74.3**	**60.0**

TONNAGE CALCULATIONS OF TSS IN MUD CREEK
3RD AND 4TH QUARTERS 2002

Water samples were obtained at the MC-1 through MC-5 sites on Mud Creek in the 3rd and 4th quarters of 2002 and analyzed for Total Suspended Solids (TSS). The samples were obtained in August and October 2002. The purpose of the sampling and analysis is to determine the suspended load of Mud Creek from above Eccles Creek to the Town of Scofield and ascertain the increase, if any, in the suspended load. This data is then used to determine if the increased discharge of water from Skyline Mine is causing erosion in Mud Creek and adding a significant load of sediment to Scofield Reservoir. Listed below is each of the monitoring sites in order of upstream to downstream locations. Exact locations of the monitoring sites can be found on M&RP Drawing 2.3.6-1, Locations of Hydrologic Monitoring Stations and in the attached EarthFax report.

	3RD QUARTER 2002 Flow (gpm) / TSS mg/l / Tons TSS	4TH QUARTER 2002 Flow (gpm) / TSS mg/l / Tons TSS
MC-1	5570 / 27 / 0.90	6420 / 5 / 0.19
MC-2	9400 / 24 / 1.4	7140 / 5 / 0.22
MC-4	7630 / 23 / 1.1	6600 / 5 / 0.20
MC-3	9050 / 14 / 0.76	6960 / < 5 / <0.21
MC-5	453 / 12 / 0.03	401 / 60 / 0.14

MC-5 is located above the confluence of Eccles and Mud Creeks

The above results indicate that the discharge volumes were fluctuating on the day of the 3rd quarter samples were obtained. The concentration of TSS in the water varied between 14 mg/l and 27 mg/l in Mud Creek below the confluence with Eccles Creek while the concentration of TSS in Mud Creek above the confluence was 12 mg/l. This suggests there was an approximate doubling of the TSS concentration in a portion of Mud Creek below its confluence with Eccles Creek. However, since these samples represent a point in time, the concentrations may have receded to levels similar to upper Mud Creek after the flow fluctuations subsided.

The 4th quarter results indicate a stable concentration of TSS in the water below the confluence with Eccles Creek and a fairly constant rate of flow. Tons of TSS in Mud Creek above the confluence equaled 0.14 tons and below the confluence a maximum increase to 0.22 tons. More importantly, the tons of TSS did not increase from the MC-1 to MC-3 sites suggesting no additional erosion was taking place at that time.

The monitoring will continue as long as the mine is discharging significant volumes of water to Eccles Creek. Additional information beyond these first two quarters will be needed to determine if erosion of Mud Creek is occurring as a result of the increased mine discharges.

EVALUATION OF MINE-WATER DISCHARGE IMPACTS IN ECCLES CREEK AND MUD CREEK

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December 2002

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EVALUATION OF MINE-WATER DISCHARGE IMPACTS IN ECCLES CREEK AND MUD CREEK

1.0 INTRODUCTION

In early August 2001, a fractured sandstone aquifer was encountered in the Skyline Mine, resulting in a significant inflow of groundwater to the mine. In an effort to minimize environmental impacts and meet effluent limitations, much of the water encountered was initially pumped to inactive sections of the mine for temporary storage.

It was assumed that the water encountered would have a high inflow for a short duration and then decrease with time, as frequently occurs in the area. However, rather than decreasing significantly with time, the inflow has only slightly diminished over time. Once available underground areas for water storage were filled, the mine began pumping both the inflow water and the stored water to the surface to prevent mine flooding and allow continued operation. Since early September 2001 discharges from the mine to Eccles Creek ranged between about 10,000 and 15,000 gallons per minute("gpm"), compared with an average discharge for the prior 18 months of about 4,000 gpm.

On October 11, 2001, EarthFax Engineering, Inc. conducted a reconnaissance geomorphic evaluation of Eccles Creek to assess potential impacts of the discharge on the stability of the stream channel. The results of this evaluation were combined with an assessment of potential water-quality impacts in a letter report to Canyon Fuel Company dated October 24, 2001. Additional information regarding potential impacts to phosphorus concentrations was provided on December 3, 2001 and December 13, 2001.

On November 26, 2001, EarthFax conducted a more extensive field evaluation of the impacts of mine-water discharges on Eccles and Mud Creeks. Samples of the bed and bank materials were collected to allow an assessment of the structural and erosional stability of the stream channels. In addition, subsequent analyses were conducted to determine the potential effects of mine-water discharges on peak annual flows in the streams and the potential impacts to man-made structures in the streams. An evaluation of alternative discharge points was also conducted. The results of these investigations were presented in a letter report to Canyon Fuel Company on February 27, 2002.

Following a review of the submitted information, Canyon Fuel Company and EarthFax met with representatives of the Utah Division of Oil, Gas and Mining (the "Division") to discuss the results. In these meetings, the Division requested additional information to better quantify and monitor potential impacts to Eccles and Mud Creeks. The objective of gathering this additional information is to:

1. Quantify whether or not increased flows may be causing erosion and/or sediment deposition in quantities that are adverse to the hydrologic regime of Eccles Creek and Mud Creek.

2. Quantify the degree to which the increased flows may be contributing to sediment and phosphorus loads in Scofield Reservoir.

3. Provide a means for monitoring potential long-term impacts to the morphology of Eccles and Mud Creeks.

4. Quantify whether or not changes are occurring in the elevation of the water table in the alluvial deposits adjacent to Eccles and Mud Creeks due to the increased flows.

5. Collect data to determine whether or not an Alluvial Valley Floor exists adjacent to Mud Creek.

6. Quantify whether or not changes are occurring to the vegetation adjacent to the stream corridor due to the increased flows. Also, quantify whether or not vegetative changes occur as a result of the potential future decrease in present discharge rates from the mine.

The purpose of this document is to present the results of the collection of data to address items 1 through 5 above. A separate report will address item 6.

2.0 FIELD DATA COLLECTION METHODS

2.1 Establish and Characterize Reference Sites

Reference sites were established on Eccles and Mud Creeks at the locations shown on Figure 2-1. Sites EC-1, 2, and 3 as well as MC-1, 2, and 3 correspond to cross section locations used in previous investigations (EarthFax Engineering, 2002). Sites MC-4, MC-5, and MC-6 were established to evaluate conditions on Mud Creek within a section of agricultural pasture (MC-4 and MC-6) and upstream from the Eccles Creek confluence (MC-5). A portion of the Mud Creek flows are diverted upstream of MC-4 for flood irrigation purposes in an extensive area near MC-4. As a result, the water table is artificially high at MC-4 and not representative of natural subirrigation that might occur in Pleasant Valley. MC-6 was therefore established upstream from the diversion to serve as a monitoring point in an area not affected by flood irrigation.

All reference sites were established in general conformance to the recommendations of Harrelson et al. (1994). The work at each site involved the following:

- Establishing benchmarks at each site. Benchmarks were installed by drilling an 8-inch diameter hole to a depth of at least 36-inches using a portable power auger. Each hole was filled with concrete and the monument was identified with a brass marker stamped with the site number. An exception to this method of benchmark establishment occurred at MC-6, where a UDOT benchmark existed at a location convenient to the location. A brass tag was attached to the fence adjacent to this UDOT benchmark to identify the location. Photographs were taken and descriptions provided to allow others to return to the sites in the future. Photographs are presented in Appendix A.

  Each benchmark position and elevation was determined in the field using a Trimble TSCe GPS unit. These locations were plotted on the USGS quadrangle

for the area (see Figure 2-1). Table 2-1 presents the coordinates of the benchmarks in both the WGS-84 and NAD-27 coordinate systems.

- Establishing monumented cross sections. The endpoints of cross sections were marked with 4 foot long, 1/2-inch diameter steel reinforcing bars that have been driven approximately 3.5 feet into the ground. The bars were capped with plastic survey end caps marked with the cross-section number.

  The locations of the cross section endpoints with respect to the benchmarks were measured, using a tape and Brunton compass or with the GPS unit, with the measurements noted in the field log book (see Appendix B).

- Surveying the channel cross section at each site. A measuring tape was attached to one of the cross section monuments and stretched tight and level across the stream to the other monument. Surveying was performed using a Sokkia survey level and rod. Elevations were shot at each important feature or change in elevation (e.g., slope breaks, channel banks, bankfull stages, etc.). The survey was closed by re-shooting the station benchmark. The readings were recorded in the field log book (see Appendix B).

- Surveying the longitudinal profile at each site. The profiles extend a distance of at least 20 times the channel width (half upstream and half downstream from the cross section location). Data were collected to indicate the elevation of the channel bottom, the water surface, indications of bankfull stage, and the top of the stream bank. Measurements were collected on intervals approximately equal to the channel width. Data were collected using a survey level and rod, with the location of the starting and endpoints being measured as noted above. Data readings were recorded in the field log book (see Appendix B).

- Establishment of photo points. As recommended by Harrelson et al. (1994), convenient locations were selected to take photographs upstream, downstream, and across the channel at each cross section location.

- Collection of streamflow data. The flow was measured at each site, using standard procedures, with a flow meter. The readings were recorded in the field book (see Appendix B).

Samples of the bed and bank materials were collected at the newly established stations (MC-4, MC-5, and MC-6) to evaluate geomorphic and stability relationships at those locations. Similar samples were collected in February 2002 at the sites EC-1 through EC-3 and MC-1 through MC-3 (EarthFax Engineering, 2002) and are still considered valid. These samples consisted of a combination of shelby tubes and grab samples for gradation, bulk specific gravity, soil moisture, void ratio, and shear testing (see Appendix C for data).

2.2 Determine Depth to Groundwater

The depth to groundwater was determined at each of the reference sites on Mud Creek. This was accomplished by installing temporary piezometers in the alluvium on each side of the stream. The locations of the piezometers were sited in an attempt to determine the slope of the water table perpendicular to the stream channel at each reference site. At reference sites MC-4 and MC-6, multiple piezometers were installed on each side of the creek. Due to the limited width of the valley or the accessible area, cross-sections MC-1, MC-3, and MC-5 had room for only one piezometer to be installed on each side of the creek. Cross-section MC-2 had room for two piezometers on both sides of the creek; however, three attempts to advance the borehole and install a second piezometer on the west side of the creek encountered refusal above the water table and were unsuccessful. Therefore, efforts were abandoned at this location.

The piezometers were installed using a 3-inch diameter portable flighted auger and a hammer drill to advanced each borehole to a depth where cuttings were saturated. Then a 3/4-inch diameter PVC pipe was installed in each borehole. The bottom 2 feet of pipe in each borehole was perforated with 1/8-inch diameter holes on 1- to 2-inch centers. Any excess pipe was cut off, leaving a 3- to 6-inches sticking up above the ground surface.

The water table was allowed to stabilize for a period of one week prior to measuring the depth to water in the boreholes. Water levels were obtained using a Slope Indicator 100 water level meter. Depth to water measurements were obtained from the top of casing.

The location and elevation of the piezometers were established by standard surveying techniques from the previously-established benchmark at each site. The locations were determined by distance and bearing measurements for those piezometers which were close to the benchmarks and by GPS for those which were located a substantial distance from the benchmark. Piezometers for reference sites MC-3, MC-4, and MC-6 were located using GPS.

Elevations of the piezometers were determined using a Sokkia level and stadia rod. The relative elevation of the benchmark and the top of casing and ground surface were determined.

2.3 Gather Available USGS Flow Data

Flow data on file with the U.S. Geological Survey were gathered for Eccles Creek near Scofield, Utah (station 09310600) and for Mud Creek below Winter Quarters Canyon at Scofield, Utah (station 09310700). These data are available electronically from the U.S. Geological Survey online database (http://waterdata.usgs.gov/nwis/discharge/?site_no=09310600 and http://waterdata.usgs.gov/nwis/discharge/?site_no=09310700).

2.4 Gather and Evaluate Historic Aerial Photographs

Historic aerial photographs were gathered of Pleasant Valley between the town of Scofield and the confluence of Mud Creek and Eccles Creeks. Both private sources (on file with aerial photography companies) and government sources (USDA, USGS, EROS) were searched. Very limited coverage in the Pleasant Valley area was available from private companies,

generally on the ridges adjacent to the valley and none on the valley bottom. The USDA had aerial coverage for the years 1962, 1980, 1987, 1993, and 1997. These photographs were evaluated to assess historic land use in this reach of Pleasant Valley.

2.5 Collect Additional Water-Quality Data

Water-quality samples were collected by Canyon Fuel personnel at monitoring points MC-1 through MC-5. In addition to the collection of flow data as indicated in Section 2.1, these samples were analyzed for total dissolved solids (TDS), total suspended solids (TSS), and total phosphorus. Appendix D presents the data sheets on the analyses of the samples collected.

2.6 Evaluate Bank Stability Indexes

Data were gathered to determine the bank erodibility hazard (Rosgen, 1996; 2001) for each reference site. The data collected included measurements of the following values:

- Bank height
- Bankfull depth
- Rooting depth
- Root density
- Bank slopes
- Degree of surface protection of the bank

The in-stream velocity gradient (between the core of maximum velocity and the stream bank) and the ratio of average hydraulic stress and near-bank hydraulic stress were calculated. These indexes are compared with typical values provided by Rosgen (1996; 2001) to provide another assessment of bank stability in addition to estimates provided previously (EarthFax Engineering, 2002).

2.7 Long-Term Monitoring

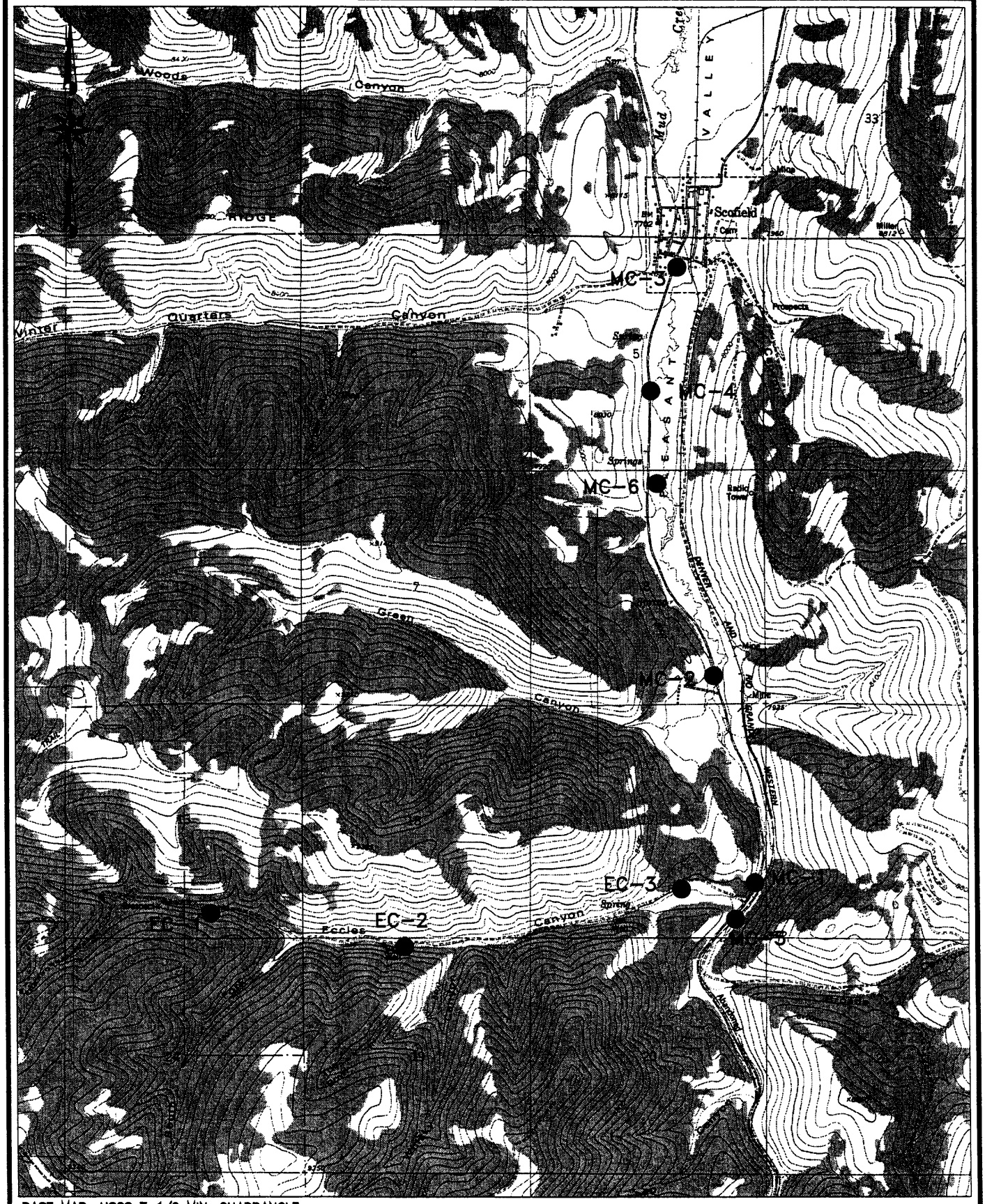
Flow and water-quality data (TDS, TSS, total phosphorus) will be collected at monitoring points MC-1 through MC-5 four times per year (i.e., seasonally), when accessible, for a period of one year following a sustained reduction in mine-water discharge to a rate of 350 gpm or less (i.e., pre-March 1999 levels). Average sediment yield contributions to Scofield Reservoir will be calculated from the TSS and flow data. Channel cross sections and longitudinal profiles will be collected from each reference site annually during the same period. Flow and water-quality data will also be collected any time there is an increase in discharge rates from the mine of at least 25% above the average rate for the prior month.

TABLE 2-1

BENCHMARK GPS COORDINATES

ID[a]	Elev. (ft)	WGS-84 Datum (Typical Default Field GPS Reading)				NAD-27 Datum (USGS Map Coordinate)			
		Latitude (N)	Longitude (W)	UTM Easting (m)	UTM Northing (m)	Latitude (N)	Longitude (W)	UTM Easting (m)	UTM Northing (m)
EC-1	8499.13	39° 41' 2.8"	111° 11' 52.3"	483033	4392717	39° 41' 2.9"	111° 11' 49.7"	483094	4392509
EC-2	8257.72	39° 40' 54.9"	111° 10' 56.3"	484365	4392471	39° 40' 55.0"	111° 10' 53.7"	484428	4392263
EC-3	7971.59	39° 41' 7.2"	111° 09' 36.6"	486264	4392844	39° 41' 7.3"	111° 09' 34.0"	486327	4392639
MC-1	7898.53	39° 41' 10.2"	111° 09' 02.0"	486750	4392937	39° 41' 10.3"	111° 09' 13.6"	486813	4392730
MC-2	7827.04	39° 41' 56.7"	111° 09' 27.9"	486476	4394370	39° 41' 56.8"	111° 09' 25.3"	486537	4394164
MC-3	7698.23	39° 43' 27.1"	111° 09' 37.1"	486262	4397159	39° 43' 27.2"	111° 09' 34.5"	486323	4396952
MC-4	7728.64	39° 43' 0.3"	111° 09' 47.1"	486023	4396331	39° 43' 0.4"	111° 09' 44.5"	486083	4396126
MC-5	7915.35	39° 41' 2.4"	111° 09' 21.2"	486633	4392697	39° 41' 2.5"	111° 09' 18.6"	486693	4392490
MC-6	7763.84	39° 42' 38.9"	111° 09' 47.0"	486022	4395673	39° 42' 39.0"	111° 09' 44.4"	486084	4395466

G:\UC794\03\FIG-2-1.DWG\12-02



BASE MAP: USGS 7-1/2 MIN. QUADRANGLE
SCOFIELD, UTAH (1979)

0' 3000'

FIGURE 2-1. LOCATION OF REFERENCE SITES

EarthFax

3.0 RESULTS SUMMARY

3.1 Characterize Reference Sites

As described in Section 2.1, the reference sites were established on Eccles and Mud Creeks at the locations shown on Figure 2-1. Photographs were taken and are presented in Appendix A.

Surveys of the channel cross section and longitudinal profile were conducted at each site. Data collected from the channel cross sections and profiles of the channel bottom, the water surface, indications of bankfull stage, and the top of the stream bank are presented in copies of the field book in Appendix B and in cross section and profile plots in Appendix E. Table 3-1 presents a summary of the channel dimensions and slopes for each reference site.

As can be seen from the average values presented in Table 3-1, the slope of Eccles Creek is considerably steeper than Mud Creek. Also, the Eccles Creek channel sideslopes are generally steeper and have a greater height than the Mud Creek channel. There are portions of the Mud Creek channel which have similar steep sideslopes, but these reaches tend to be limited in extent.

Streamflow data were measured at each site except MC-6, using standard procedures, with a rotating-cup flow meter. The field measurements are presented in Appendix B. Table 3-2 presents the flow data measured at each reference site. Station MC-6 was not established as a permanent reference site until approximately three months after establishment of the other sites, at the request of the Division. Given the time lapse, flow data would not be comparable and the decision was made to not collect flow data at this location.

As indicated in Table 3-2, the flow in Eccles Creek generally increases in the downstream direction. Near the confluence of Eccles Canyon and Mud Creek, the flow in Mud Creek at MC-1 on August 27, 2002 was only 62% of the sum of the components (as measured in Eccles Creek at EC-3 and in Mud Creek at MC-5). This decrease is likely due to a loss of surface flow to the coarse-grained alluvium in the area. As the gradient changes from the relatively steep grade for Eccles Creek to the relatively gentle grade for Mud Creek, as indicated in Table 3-1, the coarser bed load was rapidly deposited. This resulted in the stream bed and banks near the mouth of Eccles Creek being composed of very porous materials with high permeability. Thus, as the surface flow crosses the more permeable materials, the stream flow diminishes and the "lost" water is carried in the alluvial deposits adjacent to the channel. In the reach downstream of this area, toward MC-2 where the channel deposits are less permeable, the majority of the alluvial subsurface flows return to the stream channel.

Below MC-6, the flows in Mud Creek are diverted for irrigation. Approximately 10 cfs is removed from the creek flow. Thus, the flow reported at MC-4 is significantly lower than at MC-2. The majority of irrigation returns occur in the reach between MC-4 and MC-3. Therefore, the flows at MC-3 are representative of the majority of surface flow in the lower portion of Pleasant Valley.

3.2 Determine Depth to Groundwater

The depth to groundwater was determined at each of the reference sites on Mud Creek as described in Section 2.2 of this report. Table 3-3 presents the piezometer depths and ground surface and water level elevations.

The water level elevation data were placed on the channel cross-sections presented in Appendix E to aid in determining the relationship between the surface and groundwater

elevations. In the upper reaches of Mud Creek (i.e., cross-section locations MC-5, MC-1 and MC-2, see Attachment E), the piezometer water levels show different conditions at the reference sites. At MC-5, the piezometer water levels are higher than the water in the stream indicating that the groundwater flow is toward the creek. At MC-1 and MC-2, the piezometer water levels are different on both sides of the channel indicating that the groundwater is flowing across the canyon from areas of high water levels on the east of the channel to areas of lower water levels on the west of channel. The elevated groundwater on the east side of the channel may be influenced by the water loss from the stream channel at the mouth of Eccles Canyon or it may indicate recharge to the valley from the east..

For the lower reaches of Mud Creek (i.e., cross-section locations MC-3, MC-4 , and MC-6, see Attachment E), the piezometer water levels on both sides of the stream are higher than the water surface in the stream. Under such conditions, the groundwater flow direction is toward the stream and the stream is said to be gaining. Given the steep slope of the valley bottom toward the stream and the associated relatively steep slopes of the groundwater surface toward the stream, any increase in the water surface of the stream will only raise the potentiometric surface beneath the valley within a relatively small zone adjacent to the stream. **Thus, there is no significant potential for the combined base and mine water flow in the stream channel to increase the groundwater table under a substantial portion of the pastures.**

Utilizing the US Geological Survey stream flow data (Appendix F), the base flow contribution to Mud Creek was estimated. Using the fall and winter data for the early portion of the flow record, before significant mining activity and discharge occurred (i.e., 1978 through 1981), the base flow for Mud Creek was estimated to range between 1.6 and 5 cfs. The variation in base flow likely occurs due to variations in annual precipitation, with wet years yielding higher base flows.

Based on the flow readings in the stream channel at MC-1 (15.0 cfs) thru MC-3 (22.7 cfs), the stream flow increases in a downstream direction. While there are some interferences with inflows from contributing surface stream flow and irrigation return flows, the major portion of the increase likely represents base flow contributions. The flow difference between MC-1 and MC-3 is 7.7 cfs. Assuming that approximately 2 to 3 cfs is contributed from the side drainages, the base flow contribution would be on the order of 3 to 5 cfs. This falls in the range estimated from the US Geological Survey records.

3.3 Available USGS Flow Data

Flow data on file with the U.S. Geological Survey were gathered for Eccles Creek near Scofield, Utah (station 09310600) and for Mud Creek below Winter Quarters Canyon at Scofield, Utah (station 09310700). As indicated in Section 2.3, these data are available electronically. Plots of historical records of daily mean flows for both Eccles and Mud Creeks, obtained from these electronic sources, are presented in Figures 3-1 and 3-2, respectively. Average tabulations of the mean daily streamflow values for both Eccles and Mud Creeks for the period of record are provided in Appendix F.

3.4 Evaluate Historic Aerial Photographs

Historic aerial photographs were gathered of Pleasant Valley between the town of Scofield and the confluence of Mud Creek and Eccles Creeks. As indicated in Section 2.4, photos were obtained from the USDA for the years 1962, 1980, 1987, 1993, and 1997. Copies of these photographs are provided in Appendix G. These photographs were evaluated to assess historic land use in this reach of Pleasant Valley.

Based on a review of the aerial photographs, land use in the area of the Pleasant Valley has not changed significantly since 1962. The same areas that are now used for grazing were used for grazing in the early 1960's. The only significant change that could be identified was in the 1980 photograph, when construction activities were visible in and adjacent to Mud Creek in the area of the irrigation diversion structure located between reference sites MC-4 and MC-6.

3.5 Additional Water-Quality Data

Water-quality samples were collected at monitoring points MC-1 through MC-5 on August 15, 2002 and October 17, 2002. In addition to the collection of flow data and field analyses of pH, temperature, turbidity, dissolved oxygen, and specific conductance, these samples were analyzed for total dissolved solids (TDS), total suspended solids (TSS), and total phosphorus. Appendix C presents the water quality data.

Based on the data collected, the results of loading calculations for dissolved solids, suspended solids, and phosphorus at the reference sites on Mud Creek are presented in Table 3-4. Although concentrations of the analyzed constituents in Mud Creek are similar up- and downstream from the confluence with Eccles Creek (compare MC-5 results with other results), the load increases below the confluence with Eccles Creek due to the higher flow.

With the reduced flow for the fall samples, compared to the August data, the suspended solids concentrations and loading were typically lower. An exception to this generality occurred in the October sample at MC-5, where the suspended sediment concentration was significantly higher than the concentration from Eccles Creek (compare concentrations at MC-5 and MC-1). Due to the lower flow at MC-5, the load estimate is similar to the load from the Eccles Creek contribution. Total dissolved solids concentrations in Mud Creek increased in October relative to August. Hem (1985) indicates that such dissolved solids concentration are likely due to an

inverse function of concentration to the rate of discharge. Even though the flow decreased, dissolved solids loading in Mud Creek was higher in October than in August due to the magnitude of the concentration increase.

These sample results represent the conditions on the days sampled and may not be representative of the long term conditions of the water quality. Future water quality samples, collected as outlined in Section 2.7, will be compare to these values to determine if the load carried by the flow is increasing or decreasing.

3.6 Bank Stability Analyses

Bank stability was evaluated in several ways. First, traditional erosive stability was determined through maximum permissible velocity evaluations. Second, the bank erodibility hazard index for each site was determined.

The bank materials along the reaches of Mud Creek that were sampled in this study consist of clays, silty clays, and silty sands. These soils are well vegetated with a combination of natural grasses and willows. Bed materials range in size from sands through cobbles. As indicated in the maximum permissible velocity determinations, presented in Appendix H, the combination of the vegetation and erosion-resistant materials make the channel banks and beds erosionally stable under the evaluated flow conditions (5,000 to 30,000 gpm).

The field information gathered to determine the bank erodibility hazard (Rosgen, 1996; 2001) for each reference site is presented in Table 3-5. A summary of the analyses of these data is presented in Table 3-6. Rooting depth and density data in Table 3-5 were obtained from the soil survey of the area (Jensen and Borchert, 1988). All other data in this table were obtained from field measurements conducted for this investigation.

The bank hazard evaluation for the various reference sites indicates that all have a low hazard of bank failure, except EC-1, EC-3, and MC-5. These sites have a moderate hazard of bank failure. The major criterion for these sites being in the moderate category is the ratio of bank height to bankfull depth. In the area of these reference sites, the bank height is relatively high in comparison to the bankfull depth of flow. If the bank height value in the ratio were reduced, these sites would be adjusted to the low hazard category. EarthFax (2002) reached similar conclusions based on different methods.

The hydraulic stress methodology of Rosgen (1996 and 2001) was also applied to the reference sites to provide an alternative assessment of bank stability. This methodology utilizes three indices which include in-stream velocity gradient (between the core of maximum velocity and the stream bank), cross-sectional area ratio of channel to near bank, and the ratio of average hydraulic stress and near-bank hydraulic stress. Tables 3-7, 3-8, and 3-9 presents the results of the individual indices.

These hazard rating results generate conflicting classifications. Based on the velocity criteria, sites EC-1 and EC-3 are in the extreme and moderate hazard categories, respectively, while all other sites are in the very low hazard category. Using the area criteria, all sites except MC-1, are in the low hazard category. The MC-1 site under this criterion is in the moderate hazard category. Based on the stress ratio, all sites fall in a high hazard category.

This evaluation method has had limited usage and scientific peer review. No applicability criteria for the method regarding appropriate ranges in flow rates, bed and bank material gradations, or channel slopes and dimensions are provided. Therefore, it is unknown if the method is applicable to the reference sites and conditions on Eccles and Mud Creeks. Given the widely-varying, conflicting results, it is possible that Rosgen's hydraulic stress methodology is not applicable to this area.

As no specific guidance is given by Rosgen (1996 and 2001) to handle questionable classifications, some weighting based on professional judgement was applied to this evaluation. These judgements are based on site reconnaissance, prior stability evaluations (EarthFax, 2002), and more than 1 year of continuous duration elevated flows without significant bank failure. Of the criteria used in the stress evaluation, the velocity gradient and area ratio may be the major controlling criteria. Where there is a small distance between high velocity water and the bank, then there is a high potential for erosion to occur. Based on these criteria and the observed conditions, sites EC-1 and EC-3 are classified as moderate hazard sites. All other sites are classified as low erosion hazard.

The evaluations conducted generally show that there is a low hazard of bank failure as a result of the increased flow within Mud Creek. Other factors such as land use activities can also have an affect on bank stability. These activities are only marginally covered through vegetation cover estimates in the evaluation methods. For the sites selected, vegetation cover was good; however, several areas within the pasture, north of MC-4, shows signs of excessive grazing.

3.7 Geotechnical Data and Analyses

Samples of the bed and bank materials were collected at the newly established stations (MC-4, MC-5, and MC-6) to evaluate geomorphic and stability relationships at those locations. Similar samples were collected in February 2002 at the sites EC-1 through EC-3 and MC-1 through MC-3 (EarthFax Engineering, 2002) and are still considered valid. Appendix C presents the data collected for these samples.

These data were evaluated to determine the stability of the stream banks using standard geotechnical evaluations. The results of the studies addressing EC-1 through EC-3 and MC-1 through MC-3 were discussed in the EarthFax report (2002). EarthFax concluded that the

alluvial banks of Eccles Creek and Mud Creek are stable. Similar studies were conducted as part of this report for sites MC-4, MC-5, and MC-6. The results of these evaluations are presented in Appendix I. The banks at these sites were also found to be stable. Safety factors of 6.7, 2.8, and 2.5 were determined for sites MC-4, MC-5, and MC-6, respectively. Generally, a safety factor in excess of 1.3 is considered stable. Considering these results and the conservative analytical assumptions used in modeling stability, it is concluded that the stream banks of Mud Creek will maintain their structural stability with the continued discharge of excess water from the Skyline Mine.

TABLE 3-1

REFERENCE SITE CHANNEL DIMENSIONS

SITE I.D.	AVERAGE PROFILE SLOPE (ft/ft)	MAX. CHANNEL SIDESLOPE	
		LEFT* (ft/ft)	RIGHT* (ft/ft)
EC-1	0.061	0.31	11.43
EC-2	0.051	0.84	2.14
EC-3	0.024	1.80	1.19
Average	0.045	0.98	4.92
MC-1	0.007	0.87	0.70
MC-2	0.012	0.62	0.27
MC-3	0.026	1.66	0.70
MC-4	0.007	1.00	3.49
MC-5	0.016	11.43	0.21
MC-6	0.009	0.84	0.51
Average	0.013	2.74	0.98

* Orientation - looking upstream

TABLE 3-2

REFERENCE SITE FLOW MEASUREMENTS

SITE I.D.	MEASURED FLOW (cfs)
EC-1	21.6
EC-2	21.4
EC-3	23.0
MC-1	15.0
MC-2	24.9
MC-3	22.7
MC-4	13.7
MC-5	1.3
MC-6	-

Note: Flow data collected on August 27, 2002.

TABLE 3-3

PIEZOMETER DETAILS

Piezometer I.D.	Ground Surface Elevation	Depth of Casing BGS*	TOC Stick-up AGS**	Depth to Water BTOC***	Water Elevation
PMC-1A	7897.84	5.30	0.25	4.32	7893.77
PMC-1B	7894.76	2.49	0.27	1.84	7893.19
PMC-2A	7829.53	10.00	1.26	8.20	7822.59
PMC-2B	7825.76	<5.0	1.11	5.04	7821.83
PMC-2C	7830.82	10.00	0.84	8.83	7822.83
PMC-3A	7697.95	5.00	0.23	3.56	7694.62
PMC-3B	7697.22	5.00	0.66	3.44	7694.44
PMC-4A	7727.86	4.5	0.41	1.38	7726.89
PMC-4B	7727.60	7.0	0.63	3.62	7724.61
PMC-4C	7727.60	5.5	0.05	3.95	7723.71
PMC-4D	7733.41	5.0	0.46	0.65	7733.22
PMC-4E	7738.05	3.0	0.16	0.93	7737.28
PMC-5A	7913.95	4.25	0.24	2.82	7911.37
PMC-5B	7914.70	5.93	0.30	3.32	7911.68
PMC-6A	7765.08	10.0	0.92	6.23	7759.77
PMC-6B	7761.96	8.5	0.49	6.10	7756.35
PMC-6C	7761.73	9.0	0.43	7.09	7755.07
PMC-6D	7761.77	7.5	0.48	>7.25	7755.00

* Below ground surface
** Above ground surface
*** Below top of casing

TABLE 3-4

WATER QUALITY LOADING ESTIMATES

Sample Site	Sample Date	Flow (cfs)	Phosphorous		Total Suspended Solids		Total Dissolved Solids	
			(mg/l)	(lb/day)	(mg/l)	(lb/day)	(mg/l)	(lb/day)
MC-1	08/15/02	12.42	<0.02	-	27	1,809	299	20,030
	10/17/02	14.3	<0.02	-	5	386	522	40,260
MC-2	08/15/02	20.95	<0.02	-	24	2,712	293	33,108
	10/17/02	15.9	<0.02	-	5	429	486	41,680
MC-3	08/15/02	20.17	<0.02	-	14	1,523	308	33,508
	10/17/02	15.5	<0.02	-	<5	418	481	40,210
MC-4	08/15/02	17.01	<0.02	-	23	2,110	297	27,249
	10/17/02	14.7	<0.02	-	5	396	489	38,770
MC-5	08/15/02	1.01	<0.02	-	12	65	312	1,698
	10/17/02	0.89	0.034	0.16	60	289	367	1,770

TABLE 3-5

BANK EROSION HAZARD INPUT DATA

Site I.D.	Bank Height (ft)	Bankfull Depth (ft)	Rooting Depth (ft)	Root Density (%)	Bank Slope (degrees)	Bank Surface Protection (%)
EC-1	1.96	0.87	0.75	70	85	80
EC-2	1.89	1.31	0.75	90	64	95
EC-3	5.95	1.16	1.25	85	60	80
MC-1	3.19	0.56	2.0	85	35	95
MC-2	1.33	0.84	2.25	90	9	95
MC-3	2.48	1.09	2.5	95	59	95
MC-4	2.11	0.92	2.5	80	74	80
MC-5	3.40	1.02	1.25	75	84	75
MC-6	1.27	1.20	2.5	80	39	80

TABLE 3-6

BANK ERODIBILITY HAZARD RATING EVALUATION - ECCLES AND MUD CREEKS

Site ID	Bank Height	Bankfull Depth	BH/BF Ratio	BH/BF Index	Rooting Depth	RD/BH Ratio	RD/BH Index	Root Density	Rden Index	Bank Slope	BS Index	Bank Surface Protection	BSP Index	Total Index	Bank Erosion Potential
EC-1	1.96	0.87	2.25	8.22	0.75	0.38	4.83	70	3.19	85	6.84	80	1.00	24.08	Mod
EC-2	1.89	1.31	1.44	5.54	0.75	0.40	4.97	90	1.45	64	4.30	95	1.68	17.93	Low
EC-3	5.95	1.16	5.13	10.00	1.25	0.21	9.78	85	1.23	60	3.90	80	1.00	25.90	Mod
MC-1	3.19	0.56	5.70	10.00	2.00	0.63	2.62	85	1.23	35	2.68	95	1.68	18.20	Low
MC-2	1.33	0.84	1.58	5.92	2.25	1.69	8.13	90	1.45	9	1.41	95	1.68	18.58	Low
MC-3	2.48	1.09	2.28	8.25	2.50	1.01	1.97	95	1.68	59	3.85	95	1.68	17.42	Low
MC-4	2.11	0.92	2.29	8.28	2.50	1.18	3.56	80	1.00	74	5.30	80	1.00	19.14	Low
MC-5	3.40	1.02	3.33	10.00	1.25	0.37	4.68	75	3.58	84	6.63	75	3.58	28.48	Mod
MC-6	1.27	1.20	1.06	1.53	2.50	1.97	10.62	80	1.00	39	2.88	80	1.00	17.02	Low

TABLE 3-7

HYDRAULIC STRESS HAZARD EVALUATION
VELOCITY GRADIENT RATING

Site I.D.	Core* Velocity (fps)	Near Bank Velocity (fps)	Width Distance (ft)	Velocity Gradient (fps/ft)	Stress Rating
EC-1	5.45	0.19	1.5	3.51	Extreme
EC-2	4.65	1.35	6.0	0.55	Very Low
EC-3	5.45	2.34	2.5	1.24	Moderate
MC-1	3.43	1.65	8.0	0.22	Very Low
MC-2	3.72	2.55	4.0	0.29	Very Low
MC-3	3.50	1.84	4.0	0.42	Very Low
MC-4	3.06	1.72	5.0	0.27	Very Low
MC-5	0.67	0.16	2.0	0.26	Very Low
MC-6	-	-	-	-	-

Notes: * (Core Velocity-Near Bank Velocity)/Width Distance

TABLE 3-8

HYDRAULIC STRESS HAZARD EVALUATION
AREA RATING

Site I.D.	Cross-Section Area (ft^2)	Bank Section Area* (ft^2)	Abs/A Ratio	Stress Rating
EC-1	7.45	1.64	0.22	Low
EC-2	6.95	2.18	0.31	Low
EC-3	5.56	1.73	0.31	Low
MC-1	8.00	2.76	0.35	Moderate
MC-2	7.60	2.26	0.30	Low
MC-3	8.10	2.46	0.30	Low
MC-4	7.33	2.01	0.27	Low
MC-5	3.65	0.82	0.22	Low
MC-6	-	-	-	-

Notes: * width*depth for 1/3 of channel width in the near bank region

TABLE 3-9

HYDRAULIC STRESS HAZARD EVALUATION
SHEAR STRESS RATING

Site I.D.	Mean Flow Depth (ft)	Channel Slope (ft/ft)	Mean Flow Shear	Near Bank Depth (ft)	Near Bank Shear	NBS/MFS Ratio	Stress Rating
EC-1	0.93	0.06	3.54	0.69	2.63	0.74	High
EC-2	0.99	0.05	3.15	0.95	3.02	0.96	High
EC-3	0.89	0.02	1.33	0.83	1.24	0.93	High
MC-1	0.57	0.01	0.25	0.60	0.26	1.05	High
MC-2	0.76	0.01	0.57	0.70	0.52	0.92	High
MC-3	0.81	0.03	1.31	0.73	1.18	0.90	High
MC-4	0.67	0.01	0.29	0.53	0.23	0.79	High
MC-5	0.52	0.02	0.51	0.38	0.37	0.72	High
MC-6	-	-	-	-	-	-	-

Notes: * Shear stress = depth*slope*water density

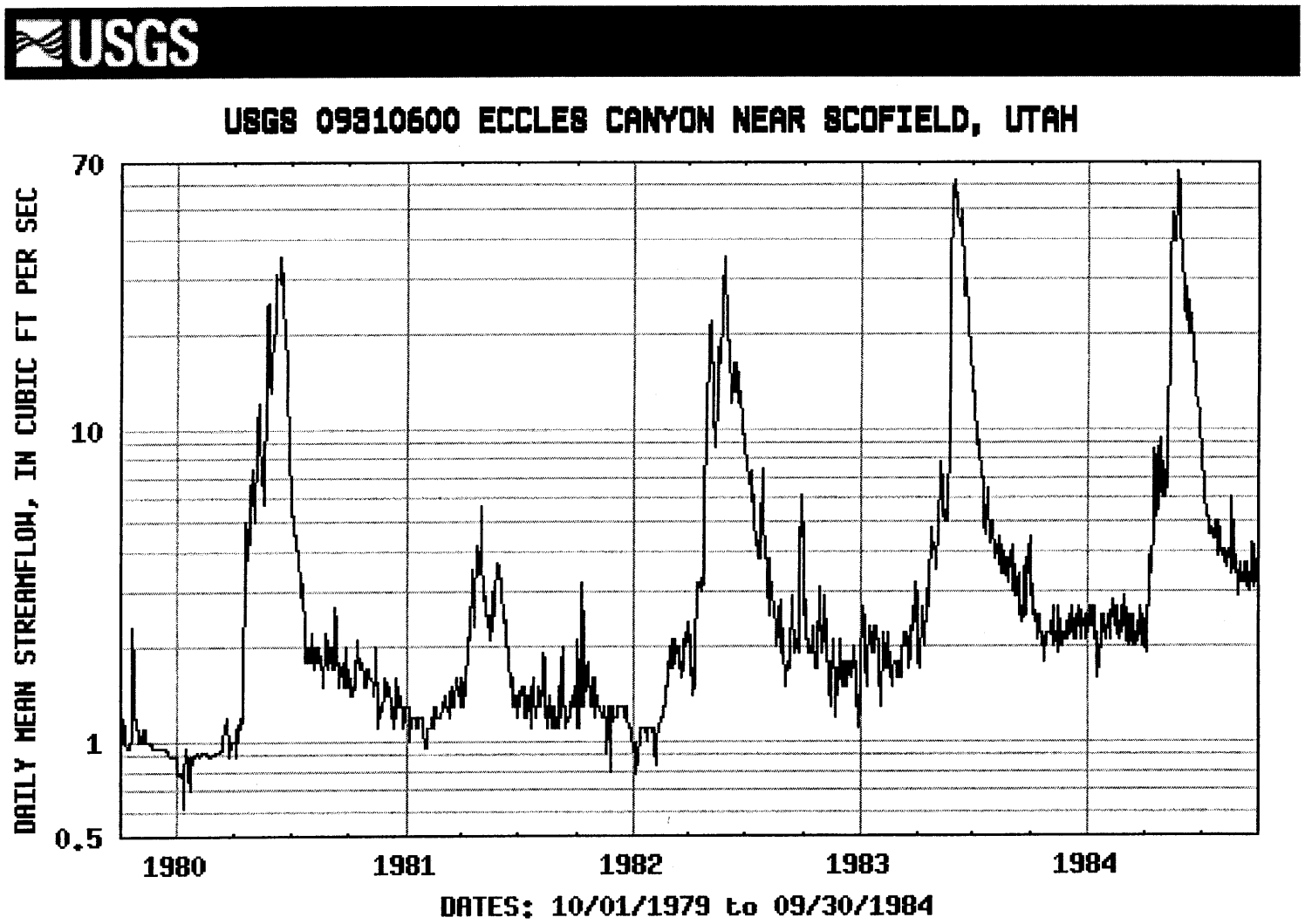


Figure 3-1. USGS Eccles Creek Streamflow Record

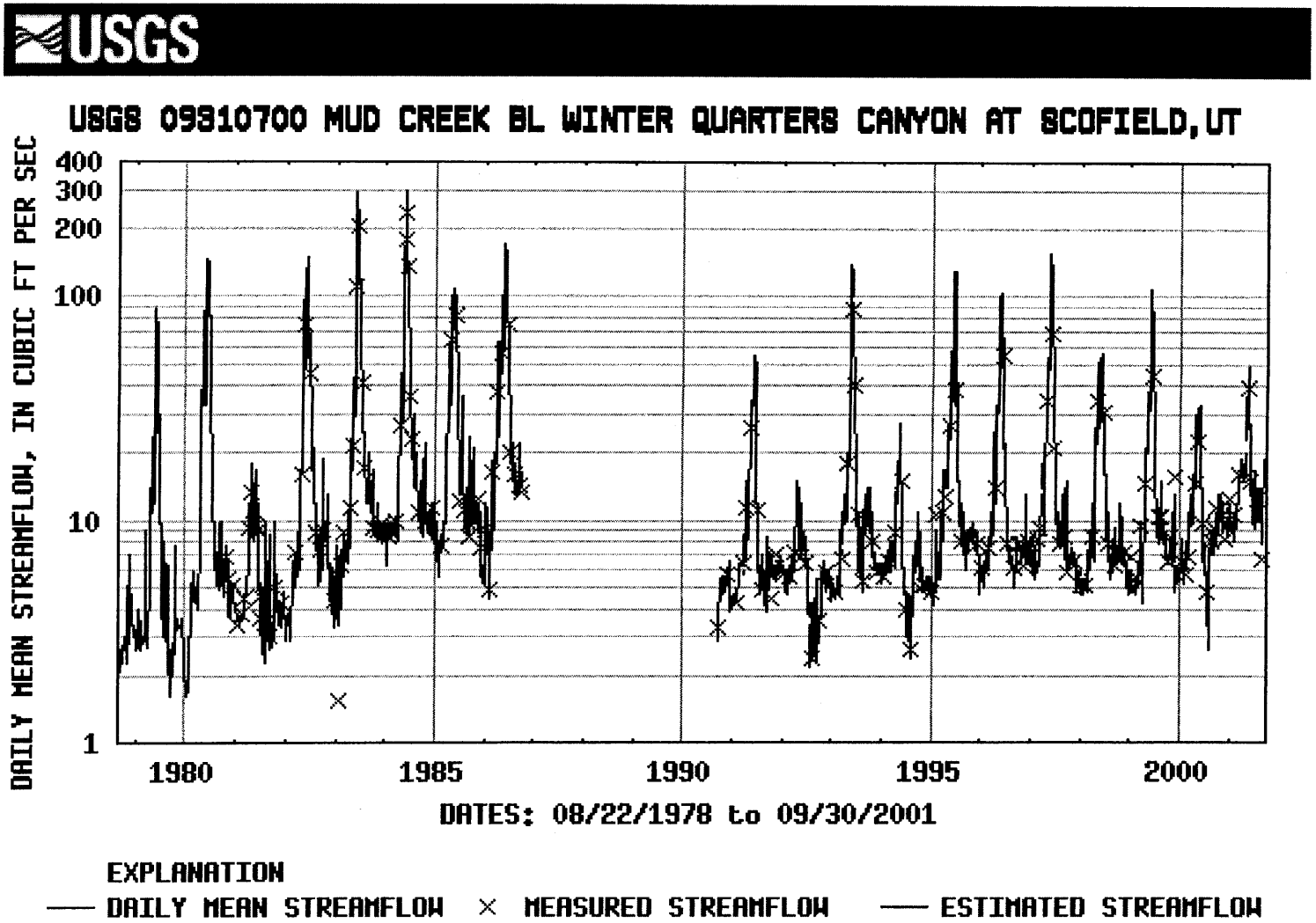


Figure 3-2. USGS Mud Creek Streamflow Record

4.0 REFERENCES

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APPENDIX A

Photographs of Reference Sites

Photograph 1 - EC-1 Cross Section

Photograph 2 - EC-1 View Upstream

Photograph 3 - EC-1 View Downstream

Photograph 4 - EC-2 Cross Section

Photograph 5 - EC-2 View Upstream

Photograph 6 - EC-2 Additional View Upstream

Photograph 7 - EC-2 View Downstream

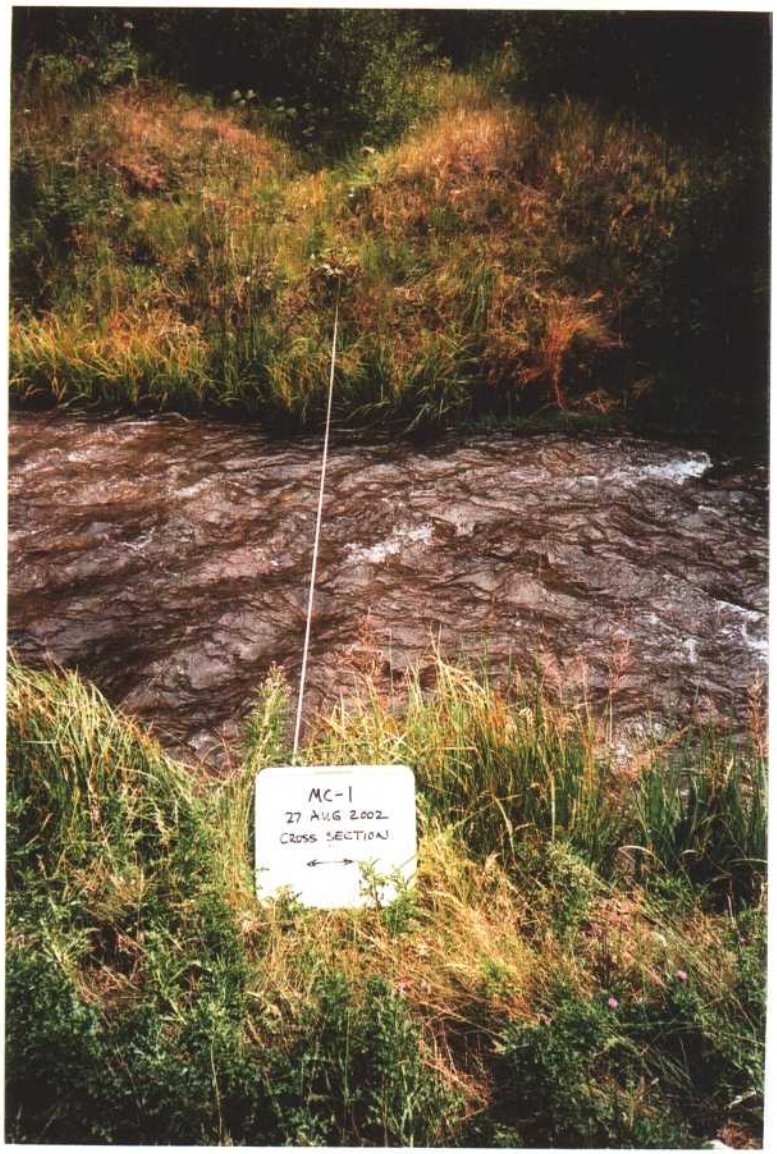
Photograph 9 - EC-3 Cross Section

Photograph 10 - EC-3 View Upstream

Photograph 11 - EC-3 Additional View Upstream

Photograph 12 - EC-3 View Downstream

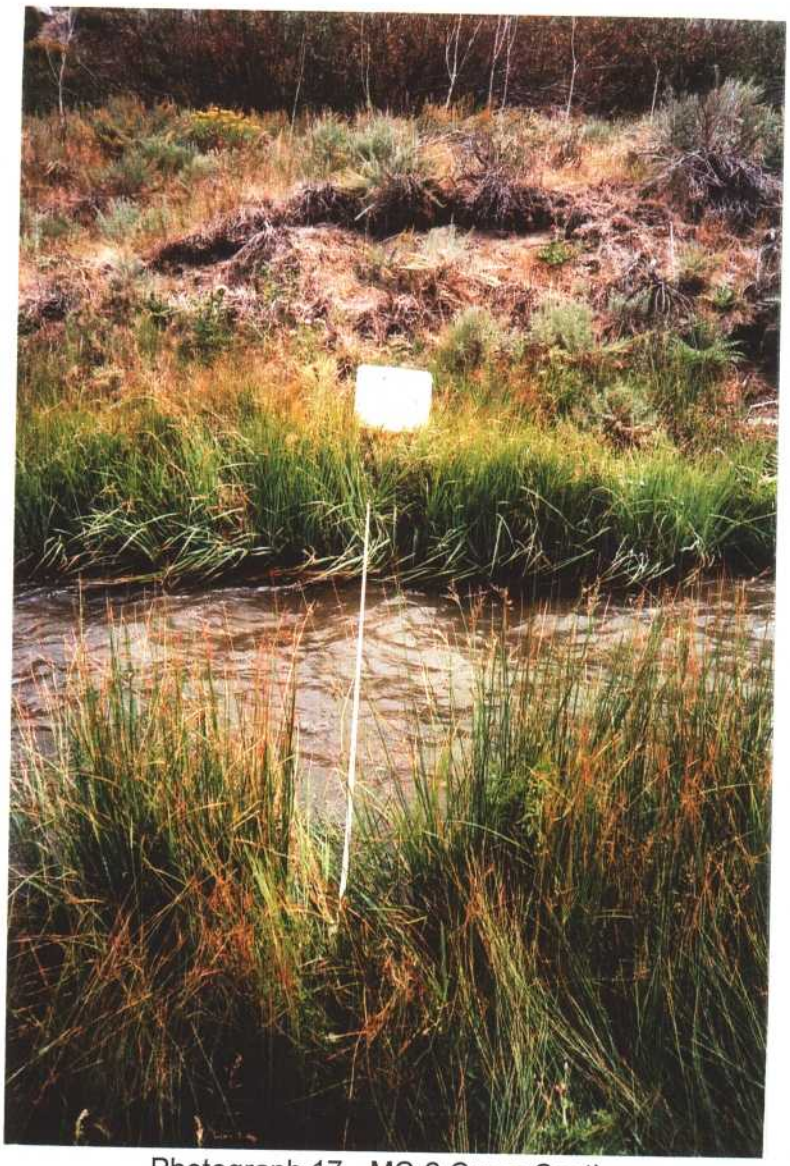
Photograph 13 - EC-3 Additional View Downstream



Photograph 14 - MC-1 Cross Section

Photograph 15 - MC-1 View Upstream

Photograph 16 - MC-1 View Downstream



Photograph 17 - MC-2 Cross Section

Photograph 18 - MC-2 View Upstream

Photograph 19 - MC-2 Additional View Upstream

Photograph 20 - MC-2 View Downstream

Photograph 21 - MC-2 Additional View Downstream

Photograph 22 - MC-2 Additional View Downstream

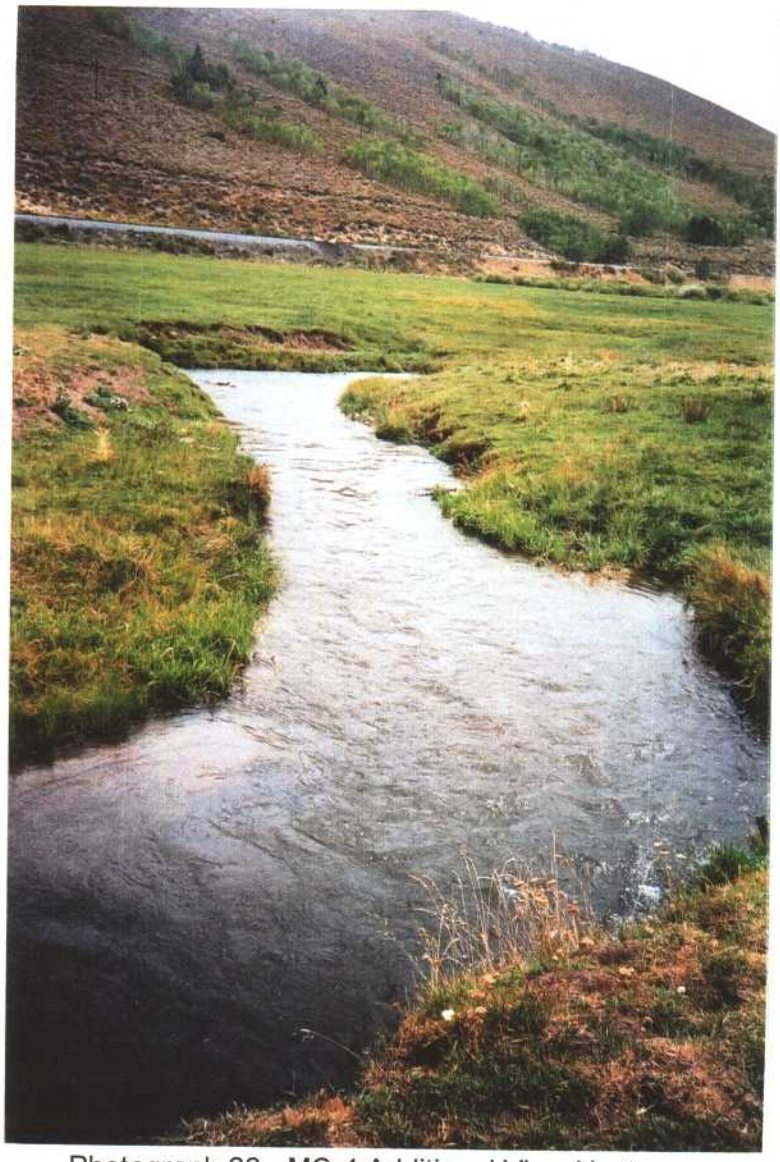
Photograph 23 - MC-3 Cross Section

Photograph 24 - MC-3 View Upstream

Photograph 25 - MC-3 View Downstream

Photograph 26 - MC-4 Cross Section

Photograph 27 - MC-4 View Upstream



Photograph 28 - MC-4 Additional View Upstream

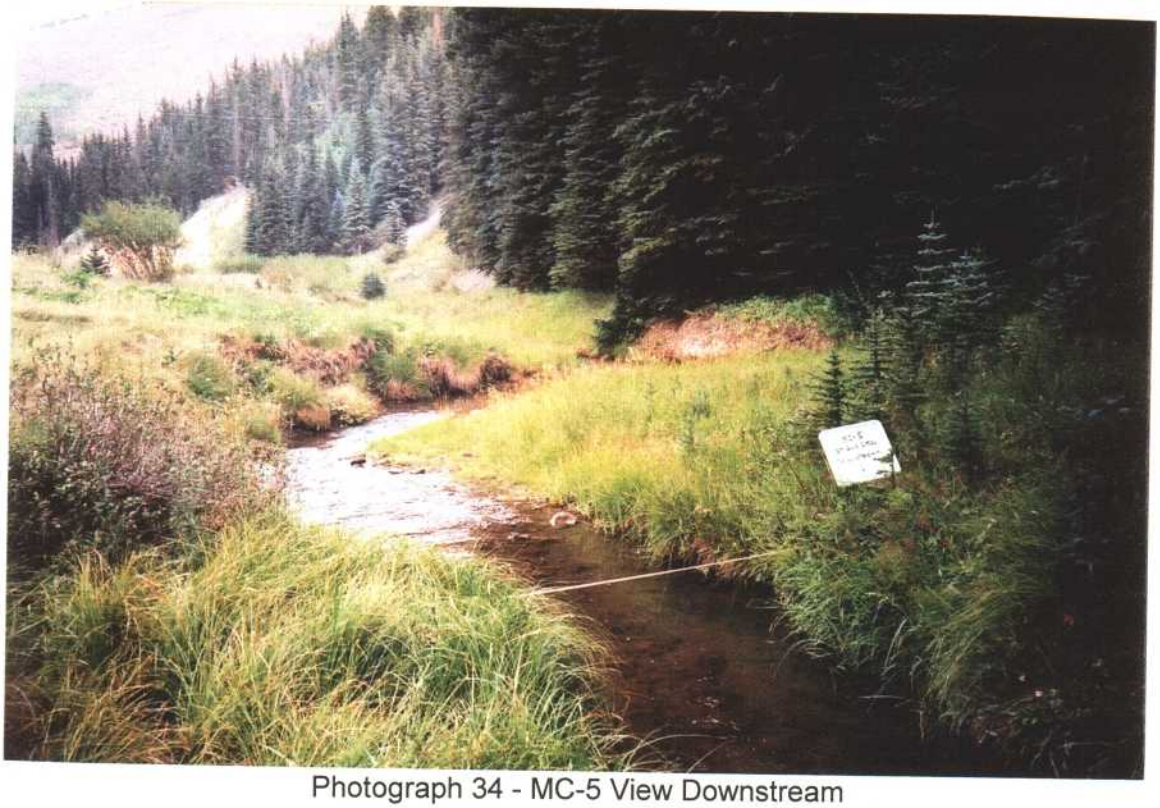
Photograph 29 - MC-4 View Downstream

Photograph 30 - MC-4 Additional View Downstream

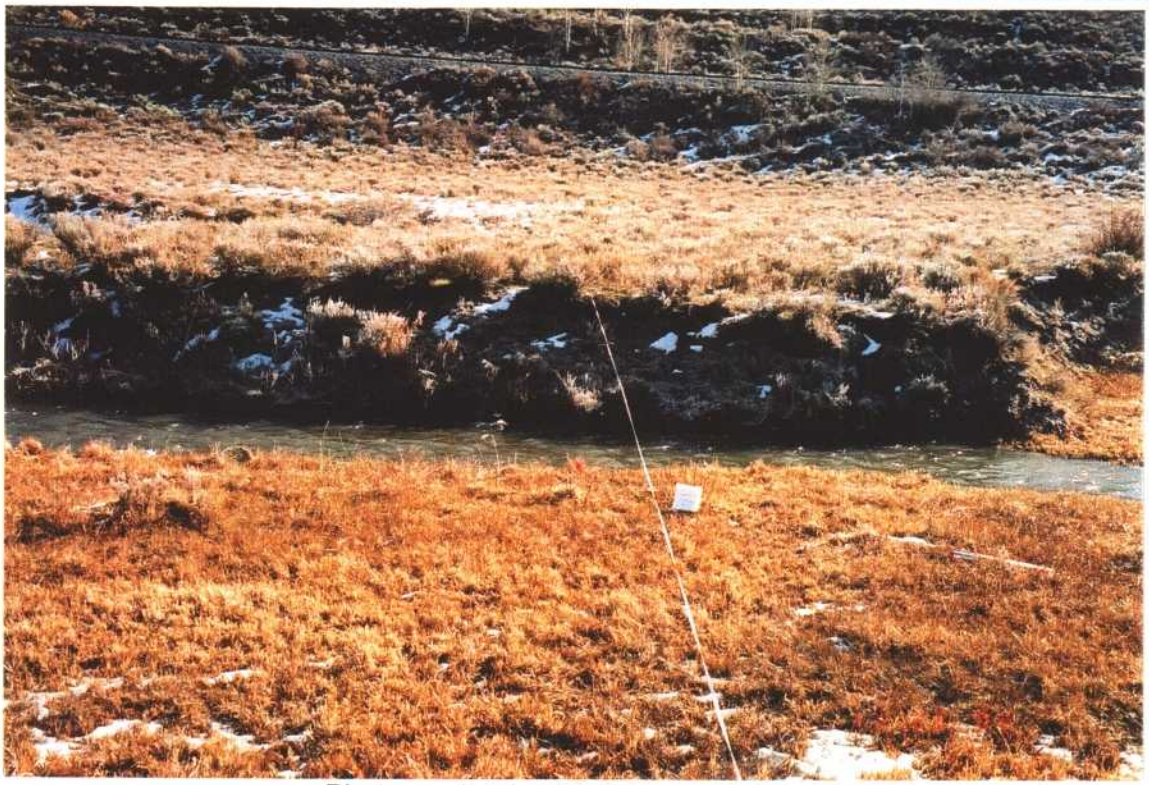
Photograph 31 - MC-4 Additional View Downstream

Photograph 32 - MC-5 Cross Section

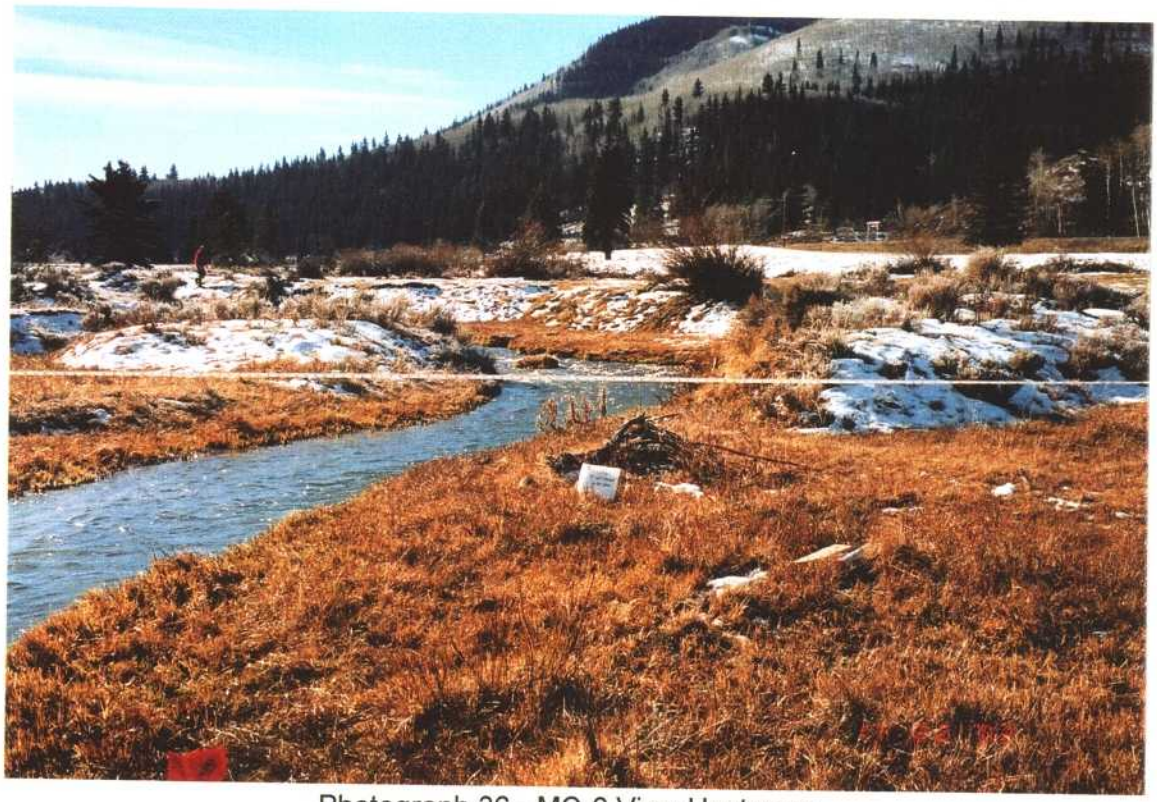
Photograph 33 - MC-5 View Upstream



Photograph 34 - MC-5 View Downstream



Photograph 35 - MC-6 Cross Section



Photograph 36 - MC-6 View Upstream

Photograph 37 - MC-6 View Downstream

APPENDIX B

Reproduction of Field Log Books

"Rite in the Rain"
ALL-WEATHER WRITING PAPER ®

Name _____

Address _____

Phone _____

Project _____

Clear Vinyl Protective Slipcovers (Item #32) are available for this style of notebook. Helps protect your notebook from wear & tear. Contact your dealer or the J. L. Darling Corporation.

UC-794-02

CONTENTS

PAGE	REFERENCE	DATE
	Results of stream surveys,	
	flow measurements, and	
	sample collection in	
	Eccles Cr. & Mud Cr.	
	26 Nov 2001	

EC-1 Approx 100 yd downstream from Skyline culvert outlet

Width (ft)	Depth (ft)	Vel. (ft/s)	Q (cfs)
2.0	1.0	1.96	3.92
2.0	1.5	5.74	17.22
3.0	1.0	0.865	1.70
	TOTAL =		22.84

flow area = 8.0 ft²

Narrow channel. No flood plain. Cobble bottom. Many rocks in bank soil. Could not collect Shelby tube sample. Collected bank grab soil sample & bed sample. South slope – evergreens. N. slope – willows, grasses

Cross Section EC-1

Dist (ft)	Depth (ft)
2.0	0.96
5.7	1.38
6.7	1.83
7.0	4.10
10.0	4.60
12.3	4.32
14.0	3.73
15.5	3.15
16.4	0.65

GPS readings:
12 – 483,096 E
H – 342,518 N
8572 Elev

4

Man-made structures

- ECS-1 Upper well access → 84" CMP w/ projecting inlet
- ECS-2 Lower well access → same as above
- ECS-3 Belina turnoff → 48" CMP proj. inlet, submerged outlet
- ECS-4 Logdout turnoff → 72" CMP w/ headwall & wingwalls
- ECS-5 Clear Cr. road crossing — 120" CMP w/ projecting inlet
- MCS-1 Pleasant Valley road crossing 0.4 mi from White Oak logdout - 72" CMP w/ headwall & wingwalls
- MCS-2 Alpine School road — 2 60" CMPs, projecting inlet

5

- MCS-3 Pleasant V. road at White Oak logdout - 72" CMP w/ headwall and wingwalls

6

EC-2 — Approx 240 yd downstream from gas well

Width (ft)	Depth (ft)	Vel. (ft/s)	Q (cfs)
2.0	0.9	5.20	9.36
2.0	0.8	4.85	7.76
2.5	1.0	3.21	8.03
		TOTAL =	25.15

Flow area = 5.9 ft²

No bed sample - well armored D_{50} ~ 4"-6". Shelby and grab samples collected. Well veg. flood plain. (willow & grass) D_{25} ~ 8"

Cross section

Dist (ft)	Depth (ft)
11	5.1
20	5.4
29	5.2
36	5.1
44	6.4
44.5	7.3
45	7.5
47	7.5
51	7.7
51.5	6.2
53	5.7
62	5.2
71	0.0

(0,0) to start

GPS: 12 484427 E 4397260 N 8250 Ft.

EC-3 + Approx 0.3 mi upstream from Mud Creek confluence

Width (ft)	Depth (ft)	Vel. (ft/s)	Q (cfs)
2.0	1.1	2.24	= 4.93
2.0	1.3	4.26	11.08
1.5	1.0	3.65	5.48
		TOTAL	= 21.49

Flow area = 6.3 ft²

All samples collected. Bed well armored. Banks well vegetated (thick grass growth). Channel meanders in this reach.

Cross section

Dist. (ft)		Depth (ft)
1.0		1.55
6.0		2.25
15.5		2.50
19.0		3.70
21.3		5.00
23.0	WEST BANK	6.45
25.4	MIDDLE	6.6
27.0	EAST BANK	6.4
30.4		4.70
33.6		3.75
47.0		4.20
53.0		3.50
74.0		5.55
85.0		0.50

GPS: NL 1: 486231 E 4892625 N 7975 ft

MAC-1 — Approx. 120 yd downstream from confluence of Eccles and Mud Cr.

Width (ft)	Depth (ft)	Vel (ft/s)	Q (cfs)
2.0	0.8	0.565	0.90
2.0	1.1	2.74	6.03
2.0	0.9	3.13	5.63
2.0	0.6	3.21	3.85
2.0	0.4	2.34	1.87
		TOTAL =	18.28

Flow area = 5.4 ft²

Collected all samples. Banks well vegetated w/ grasses. Bottom of gravel to cobbles.

Cross section

DIST. ft.	DEPTH ft
2.0	0.47
7.1	2.90
13.2	3.17
16.8	4.4
21.5	4.35
26.2	3.85
28.6	3.25
31.0	0.72

GPS:
12 486828 E
4392346 N
79 [illegible]8

MC-2 – Approx 80 yds downstream from pt where creek flows beneath Road.

Width (ft)	Depth (ft)	Vel. (ft/s)	Q (cfs)
3.0	0.6	2.61	4.70
2.0	0.7	2.55	3.57
2.0	0.7	3.28	4.59
2.0	0.8	3.65	5.84
2.0	0.6	1.96	2.35
		TOTAL =	21.05

Flow area = 7.4 ft²

All samples collected, Bank well vegetated.

Cross sect

Dist (ft)	Depth (ft)
2.0	0.60
6.0	1.40
10.7	2.42
13.0	2.43 WEST
17.5	2.30 MID
22.0	2.30 EAST
24.4	2.25
27.0	0.85

N 406 554 E
4359 153 N
Zone 2 EL

2x5 ft. Downstream Approx CURRENT OUTFALL

MC-3 Approx 30 yd upstream from mid-Scotland crossing

Width (ft)	Depth (ft)	Vel. (ft/s)	Q (cfs)
2.0	1.0	1.76	3.52
2.0	1.1	2.15	4.73
2.0	0.8	2.74	4.38
2.0	0.8	3.89	6.22
2.0	0.6	3.43	4.12
2.0	0.5	1.47	1.47
		TOTAL =	24.44

Flow area = 9.6 ft²

Collected all samples. Shelby tube may have cobble fines in portion. Bank well veg. (grasses & willows)

Cross section

Dist. (ft)	Depth (ft)
2.0	0.25
8.0	1.85
14.3	3.02
16.0	4.70 WEST
20.5	4.45 MID.
27.0	4.20 EAST

GPS:

12 486337E

4396941N

7,703 EL

CONTENTS

PAGE	REFERENCE	DATE

2 Aug 2002

Photo log

1 Installation of EC-1 benchmark
2 Ditto
3 Completed EC-1 benchmark w/ adjacent cross section marker
4 EC-2 benchmark installation
5 EC-2 cross section
6 Installation of EC-3 benchmark
7 Looking upstream at EC-3
8 ME5 benchmark
9 ME5 cross section
10 Installation of MC-1 benchmark
11 Downstream from MC-1
12 MC-2 bench mark
13 Upstream at MC-2
14 Installing MC-4 benchmark
15 Looking across valley at MC-4
16 Installation of MC-3 benchmark
17 Ditto

2 Aug 2002

EC-1

* Benchmark installed as follows:
  - Excavated hole ~8" diameter x 36" deep with power auger and post-hole digger
  - Poured in dry post mix, added water, and mixed in hole
  - Installed brass cap w/ stamped site number
* Cross section markers installed as follows:
  - Drove ½" rebar (4' long) into soil, leaving 2-3" above ground
  - Installed yellow plastic survey cap on rebar
  - Wrote cross section number on cap w/ waterproof marker.
* Steep adjacent roadbank necessitated installation of cross section marker and benchmark immediately adjacent to each other.

EC-2

Installed as above

EC-3

Installed as above

2 Aug 2002

MC-5

Installed as above

MC-1

Installed as above

MC-2

Installed as above

MC-4

Installed as above. Benchmark installed west of private property, in Hwy right of way.

MC-3

Installed as above. Benchmark just north of prop. fence.

Finished for the day.

5 Aug 2002

Photo log (continuing roll from 2 Aug 2002):

18 Piezometers at MC-5, prior to cutting stick-up
19 First attempt at PMC-1B. Ground too hard. Moved
20 Completed PMC-1A
21 Completed PMC-1B

5 Aug 2002

- Installation of piezometer at MC-5:
  - Used hammer drilling and flighted auger to drill to a depth where cuttings were saturated. Hole dia ~ 3".
  - Drilled bottom ~2' of $\frac{3}{4}$" PVC w/ $\frac{1}{8}$" bit, ~ 1-2" centers.
  - Installed $\frac{3}{4}$" PVC to bottom of hole
  - Cut excessive pipe, leaving 3-4" stick up.

PMC-5A → cut 5.75', leaving 4.25' in ground. Left bank, looking upstream
PMC-5B → cut 4.07', leaving 5.93' in ground. Rt bank looking upstream.

Holes completed at ~ 11:00

Valley not wide enough at this location for 2 piezos on each side of stream. Installed 1 only on each side.

5 Aug 2002

Installation of piezos at MC-1

- Installed as above
- Valley too narrow for 4 piezos. Installed only 2.

PMC-1A → 5.30' pipe in ground
PMC-1B → 2.49' pipe in ground

Piezos completed at ~ 12:15

Installation of piezos at MC-2

- Installed PMC-2B as above
- Attempted 3 holes to install second piezo on rt side of stream. All hit refusal above water table. Broke bit. Could not be repaired at mine shop.
- Headed for home.

7 Aug 2002

Photo log (continuing from prior roll)

22 PMC-2A
23 PMC-2C
24 PMC-2B
25 PMC-2A
26 PMC-5A, location of 5B in background

New roll of film

1 PMC-5A
2 Installation of PMC-5B
3 Refracting PVC at PMC-5C
4 PMC-5E
5 looking across valley from 5E to 5A
6 PMC-5D
7 PMC-6A
8 PMC-6B (Set up for 6C in background)
9 PMC-6C (set up on 6D in background)
10 PMC-6D
11 View across valley from PMC-6A to 6D

7 Aug 2002

Installation of piezos at MC-2

PMC-2A → installed as above, 10' of PVC in hole, Completed @ 09:15

PMC-2C → installed as above, 10' of PVC in hole, completed @ 09:45

Installation of Piezos at MC-3

PMC-3A → installed as above, 5' of PVC in hole. Completed @ 11:50

PMC-3B → installed as above. 5' PVC in hole. Completed 10:50

Area too narrow for more than two piezos.

Installation of piezos at MC-5

PMC-5A → Installed as above w/ 4.5' PVC. Completed at 12:30

PMC-5B → Installed as above w/ 7' PVC. Completed at 12:50

On west side of creek

7 Aug 2002

PMC-5C → Installed as above w/ 5.5' PVC. Completed @ 13:20

PMC-5D → As above w/ 5' PVC. Completed @ 13:50

PMC-5E → As above w 3' PVC. Completed @ 14:10

On east side of creek

All PMC-5 piezos installed in irrigated pasture. Decided to install additional row of piezos approximately 0.4 mile upstream, in an area that is not being irrigated. These piezos will be labeled PMC-6.

PMC-6A → As above, w/ 10' PVC, Completed 15:30

PMC-6B → As above w/ 8.5' PVC. Completed 17:25 after drilling problems

PMC-6C → As above w/ 9' PVC. Completed 18:00

PMC-6D → As above w/ 7.5' PVC. Completed @ 19:00 @ refusal (damp)

· Headed for home

12 Aug 2002

Field work still to be completed:

- Survey channel cross sections & piezos
- Survey longitudinal profiles
- Photograph each reference site
- Collect streamflow data
- Collect WL data from piezos
- Collect bank & bed samples @ MC-4 and MC-5
- Collect bank stability info at all sites

Equipment needs:

- ✓ Level and rod
- ✓ GPS unit
- ✓ 300' tape
- ✓ 100' tape
- ✓ Pin flags
- ✓ Camera and film
- ✓ Flow meter
- ✓ WL indicator
- ✓ Shovels (2)
- ✓ Shelby tubes (2)
- ✓ One-gallon zip lock bags
- ✓ Two 5-gal buckets
- ✓ Sledge hammer

14 Aug 2002

Survey instruments:

Level → Sokkia C40
WL indicator → Slope Indicator 100"
GPS unit → Trimble TSCe. Data will be downloaded and corrected prior to printout.

Photo log (continued from prior roll)

12 GPS measurement at MC-5
13 WL measurement at PMC-5A

14 Aug 2002

MC-5 data collection

WL measurements (depth below top of casing)

PMC-5B → 3.34' below TOC

PMC-5A → 2.82' below TOC

Channel width ~ 10'

Profile (BM = 1.40) orientation - looking upstream

Station	Top of Bank Left	Bankfull Left	Water Surface	Center Bottom	Top Bank Right
0+00	2.55	4.40	4.76	5.06	3.13
0+13	1.98	3.93	4.82	5.22	2.50
0+25	2.29	4.30	4.81	5.20	3.39
0+28	2.32	3.68	5.29	5.51	3.00
0+39	2.13	4.26	5.22	6.25	2.10
0+44	2.53	4.72	5.22	6.06	2.98
0+60	2.67	4.75	5.23	5.58	3.45
0+71	1.94	5.07	5.47	5.68	4.01
0+89	2.64	5.42	5.76	6.18	4.63
1+00	3.02	5.40	5.74	6.42	5.01
1+10	4.87	5.58	5.74	6.16	2.48
1+20	4.61	5.42	5.82	6.12	2.16
1+25	5.36	5.80	6.15	6.52	2.64
1+35	5.27	5.87	6.48	7.08	2.23
1+43	5.28	5.85	6.50	6.92	3.28
1+52	5.07	5.81	5.46	7.17	2.77

cross section location

14 Aug 2002

MC-5 Profile (cont.)

Station	Top Bank Left	Bankfull Left	Water Surface	Bottom Center	Top Bank Rt
1+60	3.26	6.08	6.47	7.02	5.35
1+78	3.08	6.00	6.60	7.08	5.56
1+84	4.72	6.25	6.60	7.30	5.50
1+97	5.50	6.25	6.62	7.07	5.58

(BM close → 1.40)

Location of cross section end points (from BM):

Rt – S 35° W, 13.6'

Lft – S 43° E, 53.6' 59.2

PMC-5B TOC = 1.75
Ground = 2.05

PMC-5A TOC = 2.56
Ground = 2.80

Collected shelby tube and disturbed soil samples from right bank, approx 50' downstream from cross section. Bottom sed sample from X sec. location.

Piezo locations w/ respect to BM:

PMC-5A = S 42° E, 36.8'

PMC-5B = S 14° W, 6.6'

14 Aug 2002

MC-5 cross section

Station	Elev.	
0+00	1.30	Left stake ground
0+05	2.33	
0+07	2.76	
0+24	2.47	
0+32	3.86	
0+33	5.09	
0+33.1	6.14	Left bottom stream
0+37	6.45	Center bottom
0+40	5.82	Rt bottom
0+44	5.03	
0+45	4.82	
0+48	4.55	
0+50	2.83	
0+52	2.01	Rt stake ground

BM close = 1.40

MC-1 Data collection

PMC-1A = 4.32 below TOC
PMC-1B = 1.84 below TOC

14 Aug 2002

MC-1 profile (BM = 0.74)

Station	Top Bank Left	Bankfull Left	Water Surf	Bottom Center	Top Bank Right
0+00	1.73	3.53	4.13	5.93	2.85
0+27	3.94	4.14	4.26	5.95	2.73
0+45	4.05	4.22	4.26	6.68	(-1.04)
0+65	4.04	4.33	4.38	5.43	0.93
0+78	3.08	4.48	4.56	5.60	1.45
0+90	4.65	4.75	4.75	5.70	2.61
1+10	4.50	4.93	4.95	5.70	1.83
1+24	4.47	5.04	5.04	5.72	1.39
1+37	5.26	5.35	5.36	5.94	2.28
1+50	3.56	5.49	5.51	6.05	2.86
1+65	5.26	5.88	5.88	6.46	5.32
1+80	5.66	5.97	5.97	6.94	5.74
1+95	4.08	5.91	6.09	6.90	5.07
2+10	4.99	6.12	6.15	7.08	5.12
2+25	2.88	5.90	6.30	7.09	5.02
2+46	6.15	6.45	6.45	7.00	6.07
2+55	6.52	6.75	6.75	7.41	4.90
2+70	4.55	6.75	6.75	7.47	4.10
2+85	6.17	6.17	6.87	7.71	4.52
3+00	4.66	5.66	6.96	7.73	4.98

BM close = 0.74

PMC-1A → Need turning pt

PMC-1B = 4.24 TOC, 4.51 ground } Approx sta 2+20

14 Aug 2002

Cross section end pts (from BM)
Left = N 20° E, 33.7'
Right = N 90° E, 16.7'

Piezo locations (from BM)
MC-1A = N 50° E, 91.6'
MC-1B = N 20° E, 80.7'

Cross section

Sta	Elev.	
0+00	1.21	Left stake
0+03	2.82	
0+06	5.39	
0+08	5.56	Left stream channel
0+15	6.00	Stream centre
0+22	5.52	Rt stream
0+26	2.73	
0+27	2.51	
0+32	1.66	Rt stake

Reset level to shoot PMC-1A
New BM level = 0.94
PMC-1A = 1.38 TOC
1.63 ground

BM close = 0.94

MC-2 data

14 Aug 2002

Piezo WLs:
PMC-2A = 8.20 below TOC
PMC-2B = 5.04' below TOC
PMC-2C = 8.83' below TOC

Cross section end pts (from BM):
Rt = S 3° E, 14.2'
Lft = S 60° E, 43.9'

Piezo location (from BM):
PMC-2A: S 57° E, 60.4'
PMC-2B: S 15° E, 16.4'
PMC-2C: S 70° E, 108.0'

Piezo elev.:
PMC-2A = 1.59' TOC, 2.85' ground
PMC-2B = 5.51 TOC, 6.62 ground
PMC-2C = 0.72' TOC, 1.56 ground
} At start profile sta 1+50

Channel 10-20' wide. Extend profile 150' upstream & downstream from X sec.

BM elev. = 5.34'

Profile (MC-2) 14 Aug 2002

Station	Top Bank Left	Bankfull Left	Water Surf	Bottom Center	Top Bank rt
0+00	7.62	8.42	8.52	9.35	8.24
0+15	8.13	8.71	8.71	9.60	8.17
0+30	8.40	8.78	8.88	9.78	8.32
0+45	8.39	8.97	8.97	9.72	8.96
0+60	8.11	9.08	9.15	10.12	9.07
0+75	8.71	9.47	9.47	10.17	9.21
0+90	8.44	9.49	9.56	10.19	9.67
1+05	8.98	9.63	9.74	10.43	9.62
1+20	8.70	10.00	10.00	10.57	9.72
1+35	8.92	10.13	10.13	10.93	9.53
1+50	9.82	10.31	10.31	11.15	10.14
1+65	10.44	10.60	10.60	11.42	10.37
1+77	9.70	10.63	10.86	12.06	10.65
1+90	10.19	10.86	10.86	12.22	10.79
2+10	10.56	11.09	11.09	12.31	10.79
2+25	10.18	11.21	11.21	12.79	11.05
2+40	10.05	11.12	11.25	13.55	10.44
2+55	9.09	11.36	11.52	13.74	10.51
2+70	10.37	11.51	11.51	12.64	11.03
2+85	10.35	11.30	11.65	12.80	10.95

BM close = 5.34

14 Aug 2002

MC-2 cross section

Sta	Elev	Comments
0+00	6.68	Left stake
0+03	8.55	
0+06	10.15	~~left stream~~
0+07	10.37	Left stream channel
0+12	11.19	Center stream
0+18	10.35	Rt stream
0+19	10.29	
0+29	7.69	
0+39	6.78	

BM close = 5.34

14 Aug 2002

MC-6 data

BM → UDOT marker
C/L 50
Sta 944
Elev ?
1959

7763.84
GPS on top of this marker

WLs:

Sta	Elev	WL (below TOC)	
BM (UDOT)	2.89		
PMC-6A (TOC)	1.78	6.23	59.77
7765.31 (ground)	2.70		
PMC-6B (TOC)	4.39	6.10	56.35
7761.96 (grnd)	4.88		
PMC-6C (TOC)	4.49	7.09	55.07
7761.73 (grnd)	4.92		
PMC-6D (TOC)	3.75	Dry	55.00
7761.78 (grnd)	4.23	(>7.25 from TOC)	
Stream water surface at section 7755.89	10.12	↑ 55.89	

Probe dang

Piezo locations surveyed w/ GPS (ground surface adjacent to piezo)

MC-4 data

14 Aug 2002

Will GPS benchmark and all piezo locations

Water levels:

Sta	Elev	Depth to WL (from TOC)
PMC-4A (TOC)	~~4.52~~ 11.10	1.38
(grnd)	~~4.92~~ 11.51	
PMC-4B (TOC)	~~4.68~~ 11.14	3.62
(grnd)	~~4.89~~ 11.77	
PMC-4C (TOC)	~~9.24~~ 11.71	3.95
(grnd)	~~9.26~~ 11.76	
PMC-4D (TOC)	~~3.00~~ 5.50	0.65
(grnd)	~~3.47~~ 5.96	
PMC-4E (TOC)	1.16	0.93
Piezos (grnd) pro[illegible]	~~1.32~~ 1.30	

Piezos at abt profile sta 1+20

BM = 10.73
(shot at end of piezo survey)

MC-4 profile (BM = 4.24) 14 Aug 2002

Sta	Top Bank Left	Bankfull Left	Water Surf	Bottom	Top Bank Rt
0+00	7.46	8.05	8.20	8.78	8.52
0+15	6.86	8.19	8.45	9.40	7.37
0+30	9.96	8.64	8.64	10.11	7.16
0+45	8.33	8.65	8.65	9.40	6.80
0+60	7.75	8.74	8.74	9.40	7.03
0+75	8.52	8.83	8.83	9.77	7.89
0+90	8.60	8.99	8.99	9.60	7.78
1+05	8.71	8.96	8.96	10.88	6.50
1+20	8.86	9.01	9.01	11.08	5.67
1+35	7.72	8.62	9.03	10.02	7.67
1+50	7.81	9.00	9.12	9.92	7.94
1+65	6.99	9.22	9.22	9.85	7.87
1+80	7.80	9.30	9.30	10.67	9.29
1+95	8.08	9.47	9.47	10.51	8.04
2+10	9.20	9.54	9.54	10.40	8.35
2+25	9.29	9.52	9.55	11.44	6.18
2+40	9.32	9.55	9.55	11.51	6.70
2+55	9.34	9.55	9.55	11.55	6.45
2+70	9.12	9.50	9.58	11.10	6.17
2+85	9.36	9.58	9.58	10.81	6.46
3+00	9.52	9.68	9.68	11.59	8.15

BM close = 4.25

14 Aug 2002

MC-4 cross section

Sta	Elev	Comments
0+00	5.73	Left stake grid
0+05	7.69	
0+10	7.76	~~Left edge stream~~
0+12	9.78	Left edge stream
0+17	9.82	Bottom center
0+23	9.44	Rt edge stream bottom
0+23.5	7.67	
0+43	6.85	
0+51	5.99	

BM close = 4.24

Shelby tube & grab samples collected abt 10 ft upstream from X sec.

Bottom sed sample collected from X sec location

Cross section stake locations (w/ respect to BM)
Left bank = S 80° E, 130.4'
Rt bank = N 87° E, 185.1'

14 Aug 2002

MC-3 data collection

GPS bench mark & piezos

WL measurements | BM = 9.72

Sta	Elev	WL (TOC)
PMC-3A (TOC)	~~10.07~~ 9.77	3.56
(gnd)	~~10.73~~ 10.00	
PMC-3B (TOC)	10.07	3.44
(gnd)	10.73	

BM close = 9.72

Will collect profile and cross section data later.

Other data

Collected GPS data from BMs at EC-1, EC-2 and EC-3. Will collect profile & X sec data later.

Water temp at EC-1 = 16°F

GPS reading at EC-1 taken w/ extended rod (8.81)

20 Aug 2002

MC-3 Survey (Profile)

BM = 7.53

Sta	Top Bank Left	Bankful Left	Water Surf.	Bottom Water	Top Bank Rt
0+00	In beaver pond		6.99	> 4' deep	
0+15	In beaver pond		6.95		
0+30	2' upstream from dam		6.97	10.47	Pond is 24.4' wide here
0+45	9.74	10.18	10.18	11.23	9.27
0+60	10.40	10.27	10.27	11.49	9.07
0+75	10.30	10.48	10.48	11.08	9.53
0+90	7.72	10.61	10.61	11.26	10.29
1+05	8.30	10.73	10.73	11.81	9.93
1+20	9.20	10.91	10.91	11.81	8.75
1+35	9.83	11.15	11.15	12.09	9.10
1+50	9.77	11.16	11.16	12.25	10.04
1+65	9.84	11.27	11.27	12.28	8.94
1+80	9.88	11.37	11.37	12.47	10.25
1+95	9.22	11.60	11.60	12.47	8.68
6' diameter culvert. Next sta 12' down from outlet					
2+55	10.97	12.10	12.10	13.26	11.10
2+70	11.35	12.30	12.30	13.41	11.09
2+85	12.18	12.33	12.33	13.82	9.72
2+96	11.54	12.31	12.31	13.74	12.15
3+00	13.09	13.47	13.47	14.67	12.37

BM close = 7.53

10' downstream for end of dam

Bottom of riffle. Small fall below?

Top of small wet area to the left

20 Aug 2002

Photo log (continue w/ prior roll)

15 Profile survey at MC-3 - center of stream
16 X sec at MC-3 - surveying
17 Laying out profile markers downstream from EC-2
18 Profile survey at EC-1, looking upstream

Cross section at MC-3

Sta	Elev.	Comments
0+00	8.24	Left stake
0+04	9.47	
0+07	9.96	
0+08	11.65	Left edge of stream bottom
0+17	12.19	Thalweg
0+18	12.21	Rt edge stream bottom
0+21	10.12	
0+24	8.90	
0+28	8.87	
0+30	8.17	Rt stake

BM check = 7.52

20 Aug 2002

EC-3 profile BM = 4.96

Sta	Top Bank Left	Bankful Left	Water Surf	Bottom	Top Bank Rt	
0+00	6.75	6.95	6.95	9.08	5.30	
0+10	5.70	6.80	6.98	8.49	5.46	
0+20	2.83	7.18	7.37	8.96	7.11	
0+30	7.21	7.83	7.83	9.86	6.23	
0+40	6.53	8.24	8.24	9.01	2.63	High vertical rt bank
0+50	7.89	8.41	8.41	10.29	2.50	
0+60	8.04	8.45	8.45	10.50	3.00	
0+70	7.98	8.48	8.48	10.04	2.42	
0+80	~~[illegible]~~ 2.70	7.90	9.00	10.01	3.22	High sloping rt bank
0+90	7.95	9.16	9.36	11.27	3.38	
1+00	6.64	9.86	9.86	11.02	5.07	
1+10	7.55	9.71	10.08	11.35	6.95	
1+20	7.39	10.00	10.19	11.59	7.91	
1+30	8.33	10.72	10.89	12.61	8.79	
1+40	8.35	10.85	10.98	12.38	9.43	
BM check = 4.96 Move level, New BM shot = 1.99						
1+50	7.80	8.59	8.59	9.35	5.06	
1+60	8.59	8.74	8.74	10.37	8.29	
1+70	7.21	9.21	9.41	10.87	8.85	
1+80	8.77	9.46	9.46	11.06	9.13	
1+90	9.21	9.80	9.80	11.01	5.27	Both vegetated, not recent
2+00	7.09	9.99	9.99	11.09	9.02	
BM close = 1.99						

Old vertical cut bank (RHS, exposing tree roots)

20 Aug 2002

EC-3 cross section

Sta	Elev	Comments
0+00	2.34	left stake
0+07	3.39	
0+15	3.92	
0+20	7.65	Bottom left stream
0+23	8.86	Thalweg
0+25	7.70	Bottom rt stream
0+26	6.50	
0+19	5.86	
0+31	2.40	Rt stake

BM close = 1.99

20 Aug 2002

EC-2 profile BM = ~~7.82~~ 5.53

Sta	Top Bank Left	Backfill Left	Water surf	Bottom	Top Bank Rt
0+00	3.37	3.28	3.28	4.25	2.97
0+10	3.34	3.51	3.51	4.96	3.75
0+15	2.98	3.95	4.11	5.43	3.83
0+20	3.68	3.93	4.11	5.46	3.87
0+30	4.10	4.38	4.38	5.33	4.22
0+35	4.22	4.48	4.48	5.67	4.50
0+45	4.70	4.91	4.91	5.45	4.54
0+50	5.13	5.58	5.58	7.36	4.76
0+60	5.15	5.68	5.80	6.67	5.30
0+70	5.80	5.94	5.94	7.24	6.10
0+75	5.91	6.27	6.27	7.88	6.00
0+80	6.01	6.28	6.28	7.50	5.79
0+85	6.21	6.61	6.61	7.61	6.19
0+90	6.18	6.72	6.72	7.78	6.79
1+00	6.32	6.90	6.90	8.21	7.01
1+04	7.04	7.43	7.43	8.94	6.98
1+14	7.61	8.12	8.20	8.96	6.78
1+20	7.93	8.22	8.22	9.48	7.58
1+26	7.46	8.20	8.20	9.51	8.37
1+30	7.68	8.23	8.23	10.18	8.35
1+37	8.08	8.91	8.91	10.60	8.82
1+40	7.94	8.94	8.94	10.71	8.45
1+50	7.74	9.16	9.16	10.48	8.06

Continued next pg

EC-2 profile (cont.) 20 Aug 2002

Sta	Top Bank Left	Bankfull Left	Water surf	Bottom	Top Bank Rt
1+57	8.41	9.38	9.38	10.90	8.51
1+65	8.73	9.75	9.75	12.14	9.10
1+70	8.69	9.82	9.82	11.56	8.71
1+80	8.62	10.22	10.22	11.86	9.53
1+95	9.86	10.18	10.18	11.68	10.56
2+00	10.27	11.50	11.50	13.25	10.64

BM close = 5.53

EC-2 cross section

Sta	Elev.	Comments
0+00	4.61	Left stake
0+05	6.43	
0+22	6.29	
0+25	7.00	
0+26	7.85	Left stream bottom
0+29	8.20	Thalweg
0+32	7.66	Rt stream bottom
0+32.2	7.24	
0+36	6.10	
0+56	5.63	
0+63	4.61	
0+69	2.60	Rt stake

BM close = 5.53

EC-1 profile BM = 0.91 20 Aug 2002

Rock in stream approx 20' upstream from BM = 2.31
Move instrument upstream
Shoot back to rock → 7.32

Sta	Top Bank Left	Bankfull Left	Water Surf	Bottom	Top Bank Rt
0+00	0.05	2.35	2.85	4.70	1.55
0+10	2.57	3.45	3.45	5.01	2.58
0+20	3.53	4.47	4.47	6.01	3.34
0+30	4.76	5.02	5.02	6.22	4.17
0+40	5.38	5.82	5.82	7.15	5.32
0+50	3.82	6.05	6.87	7.54	5.65
0+60	5.36	6.93	7.20	8.09	6.86
0+70	6.21	7.48	7.48	8.64	6.25
0+80	6.18	8.11	8.11	9.49	6.51

Top of aforementioned rock = 7.31
Move instrument downstream
Shoot back to rock = 1.55
Shoot to BM = 0.15
Resume profile survey

0+90	2.47	3.16	3.16	4.04	2.46
1+00	2.58	3.17	3.17	4.48	2.12
1+10	1.61	3.40	3.40	4.31	2.71
1+20	2.00	3.70	3.70	5.42	3.40
1+30	4.77	4.96	4.96	6.26	4.73
1+40	5.03	5.32	5.32	6.35	4.45

Continued on next pg

20 Aug 2002

EC-1 profile (cont.)

Sta	Top Bank Left	Bankfull Left	Water Surf	Bottom	Top Bank Rt
1+50	6.12	6.40	6.40	7.35	4.64
1+60	6.35	6.79	6.79	8.23	6.73
1+70	7.19	7.56	7.56	8.27	7.20
1+80	8.06	8.11	8.11	9.10	7.08
1+90	8.41	8.76	8.76	10.78	6.12
2+00	8.88	9.58	9.58	11.17	9.64

BM close = 0.16

New instrument location.
BM = ~~[illegible]~~ 7.43

EC-1 cross section

Sta	Elev.	Comment
0+00	6.60	Left stake
0+02	10.24	Left stream bottom
0+03	10.89	
0+06	11.73	Thalweg
0+10	11.33	Rt stream bottom
0+10.2	8.99	Rock
0+14	8.02	Rock
0+17	7.44	Rt stake

BM close = 7.43

27 Aug 2002

Collection of streamflow data

Photo log (continue w/ prior roll):

19 EC-1 cross section (R to L)
20 EC-1 upstream
21 EC-1 downstream
22 EC-2 cross section (R to L)
23 EC-2 upstream
24 EC-2 downstream
25 EC-2 from pt approx 50' upstream from cross section, looking upstream
26 EC-2 from pt approx 50' downstream from cross section, looking downstream

— New Roll —

1 EC-3 cross section (R to L)
2 EC-3 upstream
3 EC-3 downstream
4 EC-3 up, from 30' up from X sec.
5 EC-3 down, from 30' down from X sec.
6 MC-5 cross section
7 MC-5 upstream
8 MC-5 downstream

27 Aug 2002

EC-1

Width (ft)	Depth (ft)	Vel. (fps)	Flow (cfs)	Comments
1.50	0.95	2.20	3.14	Boulder on bank
1.50	1.10	4.07	6.72	
1.50	1.30	5.45	10.63	
1.50	0.95	0.193	0.28	
2.00	0.50	0.818	0.32	
Site finished 10:45			21.57	

AREA 7.45

NB 1.00

EC-2

Width (ft)	Depth (ft)	Vel (fps)	Flow (cfs)
1.50	0.85	1.35	1.72
1.50	1.05	3.57	5.62
1.50	0.90	3.65	4.93
1.50	1.00	4.65	6.98
1.00	1.25	2.05	2.15
Site finished 11:25			21.40

AREA 6.95

NB 2.10

27 Aug 2002

EC-3

Width (ft)	Depth (ft)	Vel. (fps)	Flow (cfs)
1.25	0.85	3.37	3.58
1.25	0.80	5.08	5.08
1.25	0.90	5.45	6.13
1.25	1.05	4.37	5.74
1.25	0.85	2.34	2.49
Site finished 12:05			23.01

AREA 5.50

NB 1.73

MC-5

Width (ft)	Depth (ft)	Vel. (fps)	Flow (cfs)
3.00	0.35	0.183	0.19
1.00	0.45	0.615	0.28
1.00	0.65	0.674	0.44
1.00	0.70	0.359	0.25
1.00	0.80	0.162	0.13
Site finished 12:45			1.29

AREA 3.65

NB 0.82

27 Aug 2002

MC-1

Width (ft)	Depth (ft)	Vel. (fps)	Flow (cfs)
2.0	0.65	1.65	2.15
2.0	0.55	2.55	2.81
2.0	0.55	2.74	3.01
2.0	0.50	3.28	3.28
2.0	0.55	3.43	3.77
2.0	0.50	2.50	2.50
2.0	0.70	2.74	3.84
Site finished 13:25			15.02

Affect 8.0

NB 2.76

MC-2

Width (ft)	Depth (ft)	Vel (fps)	Flow (cfs)
2.0	0.60	2.74	3.29
2.0	0.80	3.43	5.49
2.0	0.90	3.72	6.70
2.0	0.80	3.65	5.84
2.0	0.70	2.55	3.57
Site finished 13:55			24.88

Affect 7.6

NB 2.26

27 Aug 2002

Photo log (continued)

9 MC-1 cross section (R to L)
10 MC-1 upstream
11 MC-1 downstream
12 MC-2 cross section (R to L)
13 MC-2 upstream
14 MC-2 downstream
15 MC-2 up, from 30' upstream
16 MC-2 down, from 30' downstream
17 MC-2 down, from 50' downstream
18 MC-4 cross section (R to L)
19 MC-4 upstream
20 MC-4 downstream
21 MC-4 up, from 30' upstream
22 MC-4 down, from 50' downstream
23 MC-4 further down, from 50' downstream
24 MC-3 cross section
25 MC-3 upstream
26 MC-3 downstream

— New Roll —

1 Beaver dam, 120' up from MC-3
2 Pond above beaver dam
3 Downstream from culvert below MC-3

27 Aug 2002

MC-4

	Width (ft)	Depth (ft)	Vel. (fps)	Flow (cfs)
CHANNEL AREA 7.33	2.0	0.40	1.72	1.38
	1.5	0.70	2.68	2.81
	1.5	0.70	2.86	3.00
	1.5	0.70	3.06	3.21
NB AREA 2.01	1.5	0.80	2.74	3.29
	1.5	0.75	3.06	3.44
	1.5	0.70	3.06	3.21
Site finished 14:30				13.69

MC-3

	Width (ft)	Depth (ft)	Vel. (fps)	Flow (cfs)
CHANNEL AREA 8.1	2.0	0.90	2.61	4.70
	2.0	0.90	3.43	6.17
	2.0	0.80	3.50	5.60
	2.0	0.65	2.55	3.32
NB AREA 2.46	2.0	0.80	1.84	2.94
Site finished 15:00				22.73

22 Nov 2002

- Installed permanent cross section markers for MC-6
- Survey bench mark will be UDOT bench mark on east side of road, adjacent to piezometer.
- Bench mark & piezometers surveyed previously w/ GPS.

MC-6 cross section (looking upstream)

BM = 3.22

Sta	Elev (ft)	Comments
0+00	5.50	Left bank stk
0+01	6.50	
0+07	11.46	Left bottom
0+09	11.65	Thalweg
0+17	11.05	Rt bottom
0+22	10.34	
0+23	10.08	
0+51	10.41	
0+58	6.90	
0+61	6.75	
0+63	5.33	Rt bank stk

MC-6 profile

22 NOV 2002

Sta	Top Bank Left	Bankfull Left	Water Surf	Thalweg Bottom	Top Bank Rt
0+00	6.02	8.61	8.61	9.37	8.05
0+25	6.56	8.91	8.91	9.78	8.45
0+45	9.04	9.08	9.08	10.20	8.19
0+65	9.25	9.23	9.23	10.52	9.04
0+85	9.31	9.29	9.29	10.10	8.58
1+05	9.38	9.58	9.58	10.60	8.84
1+25	9.01	9.83	9.83	10.49	9.32
1+45	8.77	10.15	10.15	11.38	9.36
1+65	9.79	10.23	10.23	11.47	9.38
1+85	10.25	10.36	10.36	11.72	10.05
2+05	10.33	10.41	10.41	11.42	10.12
2+25	x section location 9.24	10.55	10.55	11.75	10.48
2+45	10.19	10.78	10.78	11.52	10.74
2+65	10.78	11.05	11.05	12.28	11.09
2+85	10.70	11.37	11.37	13.29	11.29
3+05	11.27	11.56	11.56	13.03	11.29
3+25	11.45	11.65	11.65	12.52	11.11
3+45	11.31	11.63	11.63	13.04	8.33
3+65	11.80	11.96	11.96	13.10	6.26
3+85	11.58	12.23	12.23	13.07	6.32
4+05	11.71	12.25	12.25	13.13	11.38
4+25	11.95	12.42	12.42	14.55	12.30
4+50	11.90	12.46	12.46	13.25	11.83

BM close = 3.21

22 NOV 2002

- Took photos of MC-6 cross section and profile (up- and downstream)
- Collected samples:
  - Shelby tube from right bank
  - Grab (from left bank)
  - Bed

At cross section

Cross section marker on rt bank is 240' due E east of UDOT bench mark.

Elev. stamped on UDOT bench mark is 7752.14 (date 1959) station 944

APPENDIX C

Channel Bed and Bank Sample Data

SUMMARY OF TEST DATA

HOLE NO./ SAMPLE NO.	DEPTH BELOW GROUND SURFACE	STANDARD VOID RATIO e	IN-PLACE DENSITY		GRADATION			ATTERBERG LIMITS			SOIL CLASSIFICATION UNIFIED SYSTEM
			BULK SPECIFIC GRAVITY	MOISTURE PERCENT	% SAND	% GRAVEL	% PASSING NO. 200 SIEVE	L.L.	P.L.	P.I.	
EC-1S	NA			21.0	47.0	31.0	22.0	NON-PLASTIC			SM
EC-2S	NA	2.2	2.454	23.0	37.0	43.0	20.0	NON-PLASTIC			SM
EC-3S	NA			36.0	50.0	0.0	50.0	40.7	_	_	SM-ML
MC-1S	NA	2.7	2.575	28.0	37.0	0.0	63.0	30.7	31.1	_	ML
MC-2S	NA			25.0	37.0	0.0	63.0	34.0	21.6	12.4	CL
MC-3S	NA	2.8	2.499	49.0	39.0	7.0	54.0	38.6	_	_	ML-SM

SKYLINE MINES DISCHARGE STUDY
EARTHFAX ENGINEERING

Project: Skyline Mines Discharge Study
Client: Earthfax Engineering
Project #: 401356

LABORATORY SUMMARY

	SPECS	
Sample Location		EC-1S
Laboratory Number		277
Sample Type		Baggie
Date Received		11/27/01
Sampled By		Earthfax
Method Used	ASTM C136, C566, C117 & D4318	
Plastic Limit	The sample was non-plastic	

GRADING

SIEVE SIZE	% PASSING	
1/2"		100.0%
3/8"		77.7%
#4		69.4%
#8		63.4%
#16		55.5%
#30		49.7%
#50		44.1%
#100		34.7%
#200		21.9%

CMT ENGINEERING LABORITORIES

Project: Skyline Mines Discharge Study
Client: Earthfax Engineering
Project #: 401356

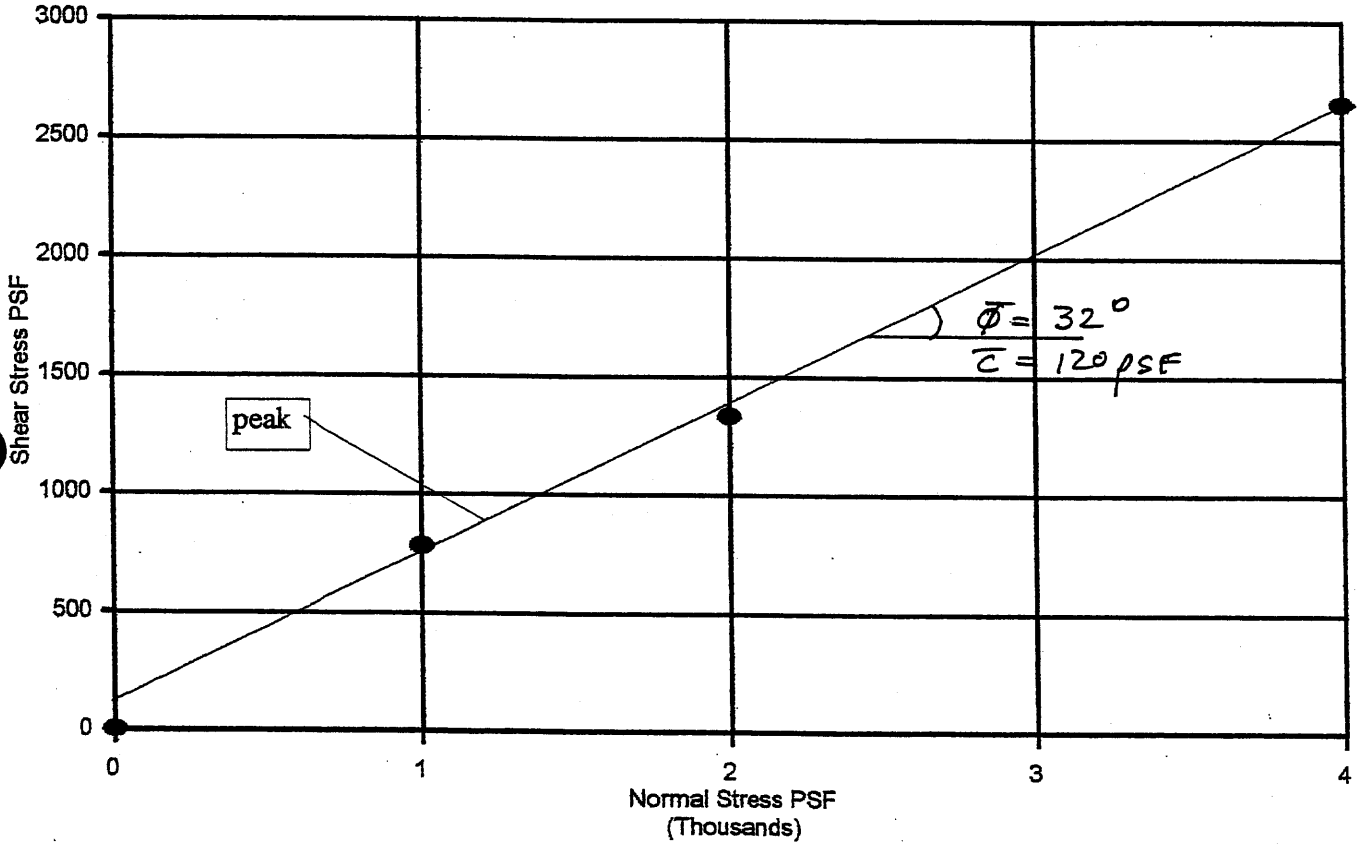
LABORATORY SUMMARY

		SPECS								
Sample Location			EC-2S							
Laboratory Number			277							
Sample Type			Baggie							
Date Received			11/27/01							
Sampled By			Earthfax							
Method Used		ASTM C136, C566, C117, D4318								
Plastic Limit		The sample was granular and non-plastic								
GRADING										
SIEVE SIZE	% PASSING	1/2"	100.0%							
		3/8"	66.8%							
		#4	56.6%							
		#8	50.4%							
		#16	44.9%							
		#30	41.1%							
		#50	35.3%							
		#100	25.5%							
		#200	19.7%							

CMT ENGINEERING LABORATORIES

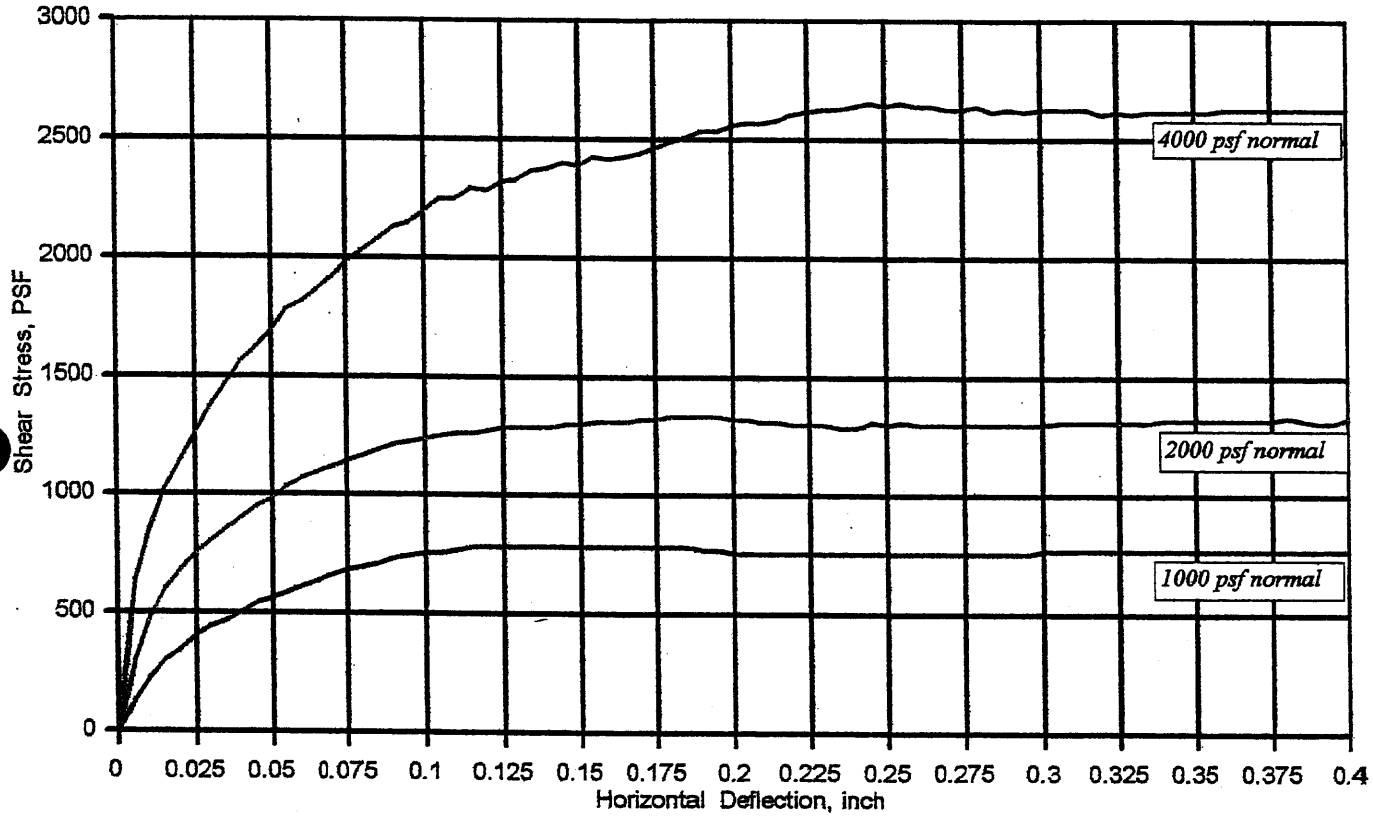
DIRECT SHEAR - Consolidated Drained

EC-2 S



Direct Shear

Sample EC-2 S



Project: Skyline Mines Discharge Study
Client: Earthfax Engineering
Project #: 401356

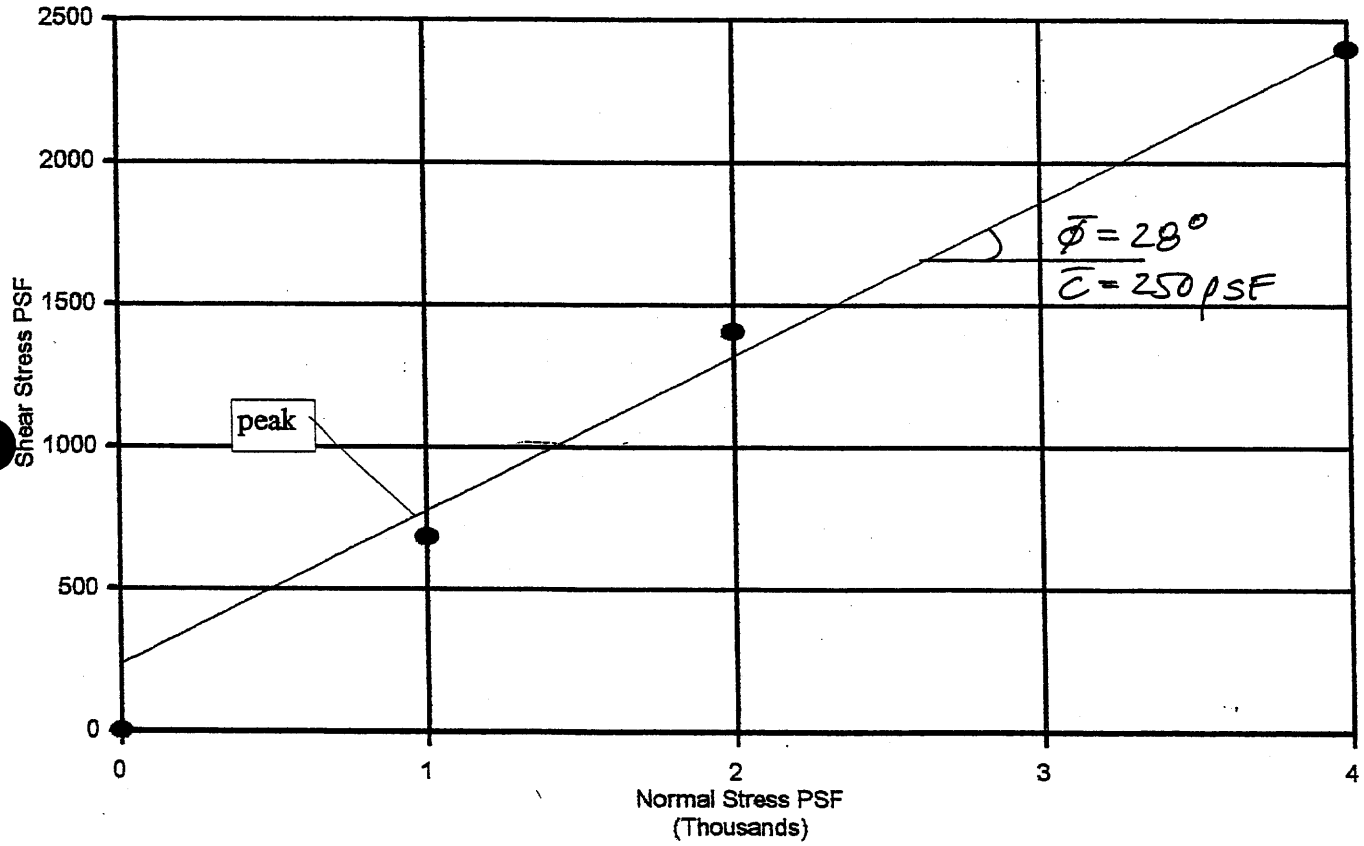
LABORATORY SUMMARY

	SPECS	
Sample Location		EC-3S
Laboratory Number		277
Sample Type		Baggie
Date Received		11/27/01
Sampled By		Earthfax
Method Used	ASTM C136, C566, C117 & D4318	
Plastic Limits	The sample was non-plastic	
GRADING		
SIEVE SIZE	% PASSING	
3/8"		100.0%
#4		99.8%
#8		99.2%
#16		97.5%
#30		95.2%
#50		91.3%
#100		75.8%
#200		49.5%

CMT ENGINEERING LABORATORIES

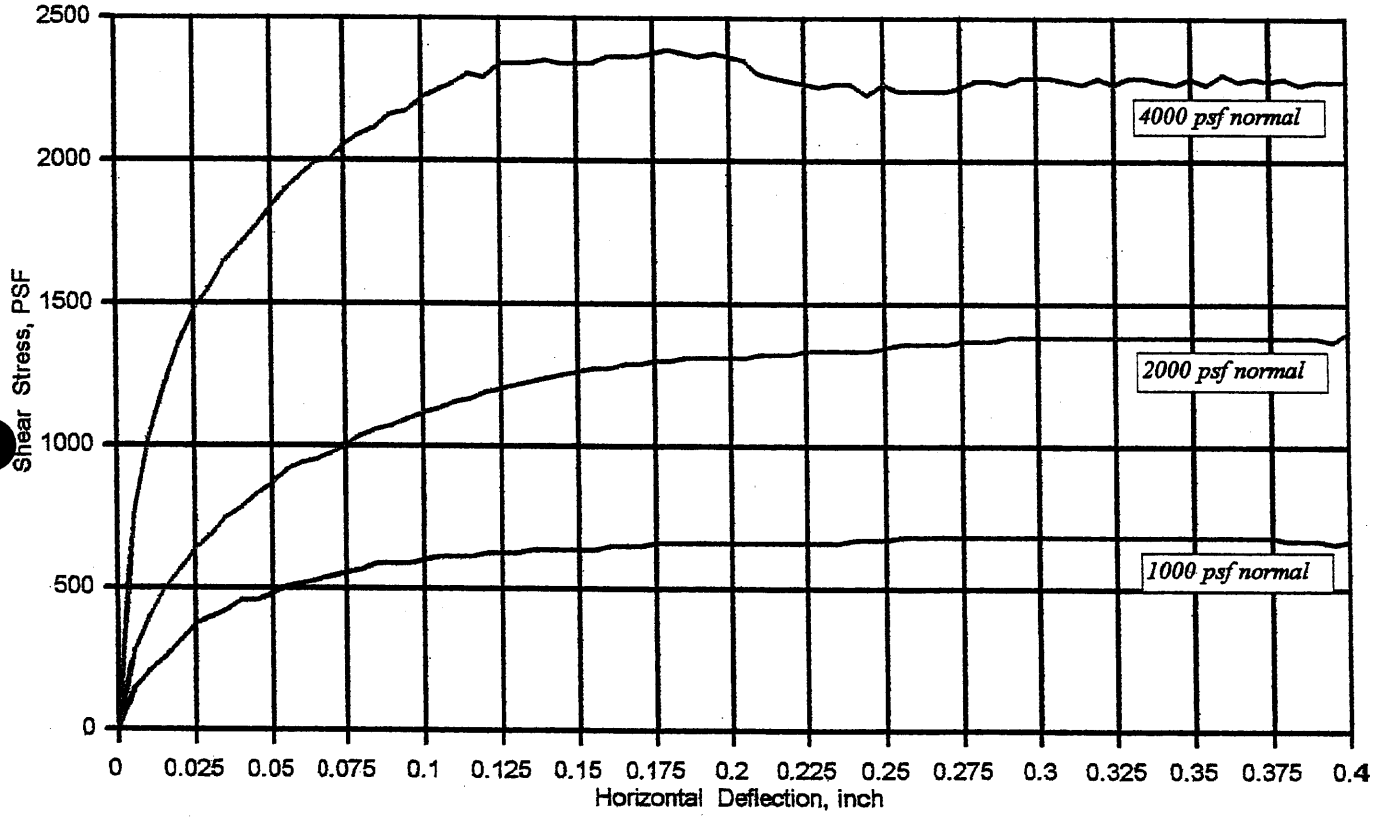
DIRECT SHEAR - Consolidated Drained

EC-3 S



Direct Shear

Sample EC-3 S



Project: Skyline Mines Discharge Study
Client: Earthfax Engineering
Project #: 401356

LABORATORY SUMMARY

	SPECS	
Sample Location		MC-1S
Laboratory Number		277
Sample Type		Baggie
Date Received		11/27/01
Sampled By		Earthfax
Method Used	ASTM C136, C566, C117 & D4318	

Plastic Limit

LL	PL
30.7	31.1

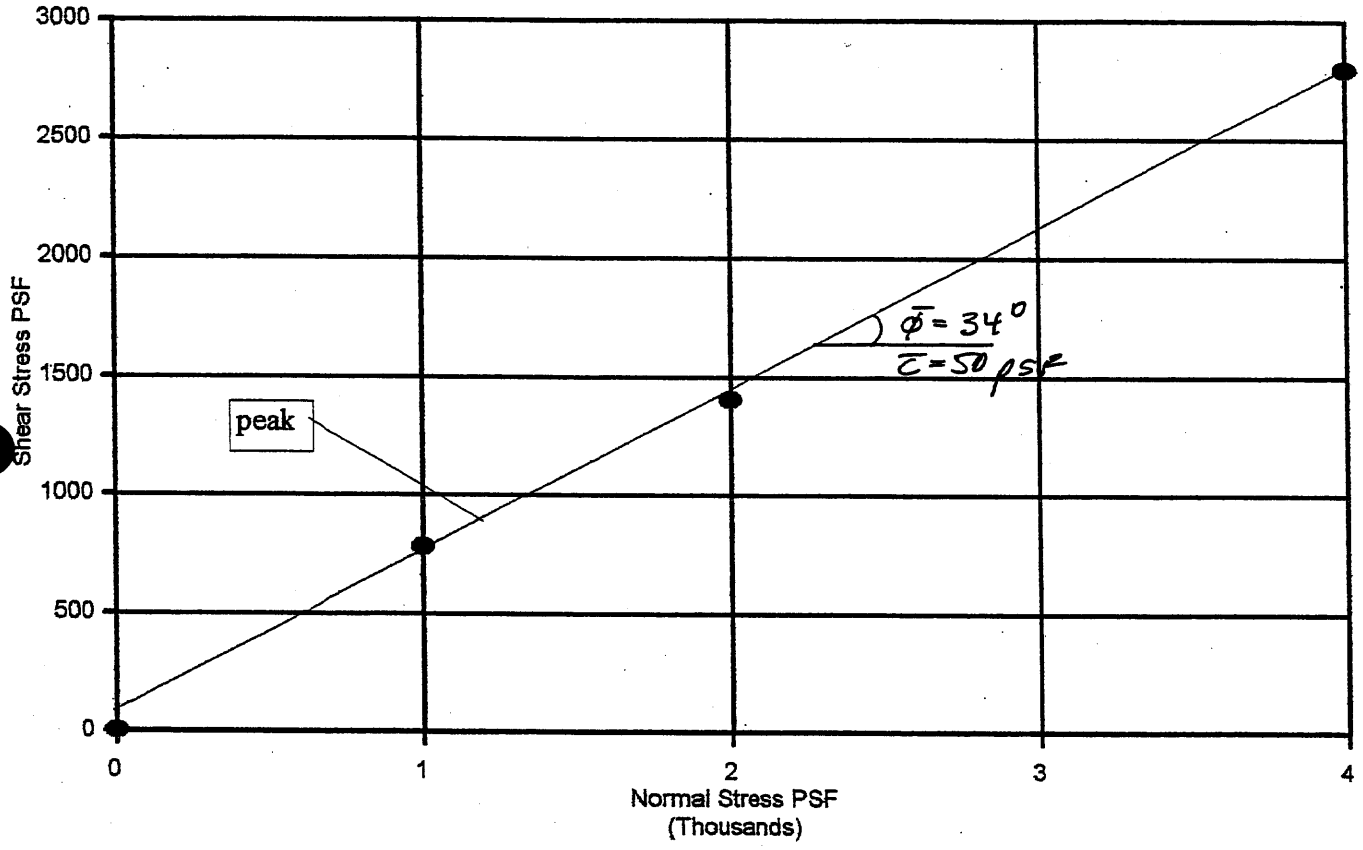
GRADING

SIEVE SIZE	% PASSING
#16	100.0%
#30	98.1%
#50	95.8%
#100	82.1%
#200	62.7%

CMT ENGINEERING LABORATORIES

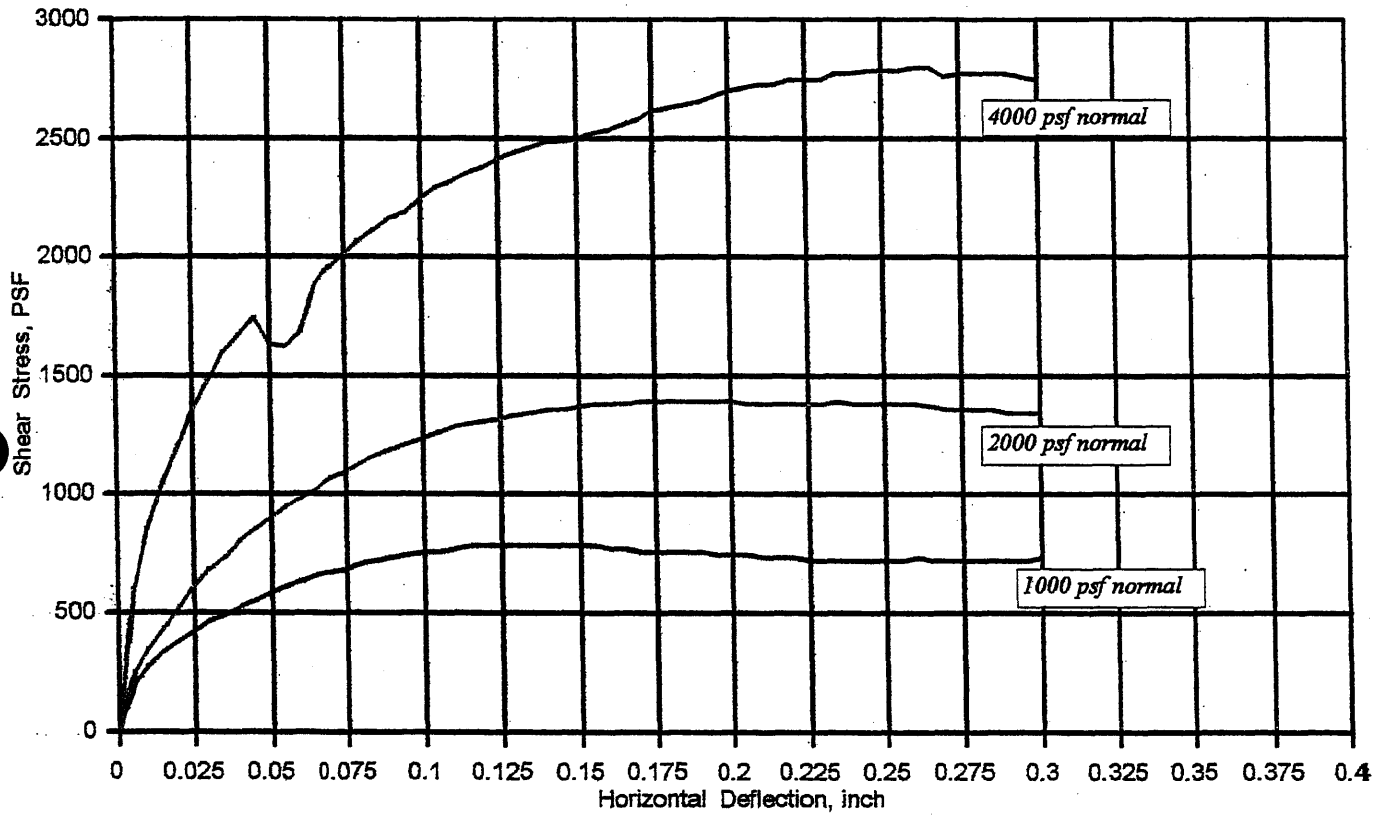
DIRECT SHEAR - Consolidated Drained

MC-1 S



Direct Shear

Sample MC-1 S



Project: Skyline Mines Discharge Study
Client: Earthfax Engineering
Project #: 401356

LABORATORY SUMMARY

	SPECS		
Sample Location		MC-2S	
Laboratory Number		277	
Sample Type		Baggie	
Date Received		11/27/01	
Sampled By		Earthfax	
Method Used	ASTM C136, C566, C117 & D4318		
Plastic Limits	LL	PL	PI
	34.0	21.6	12.4

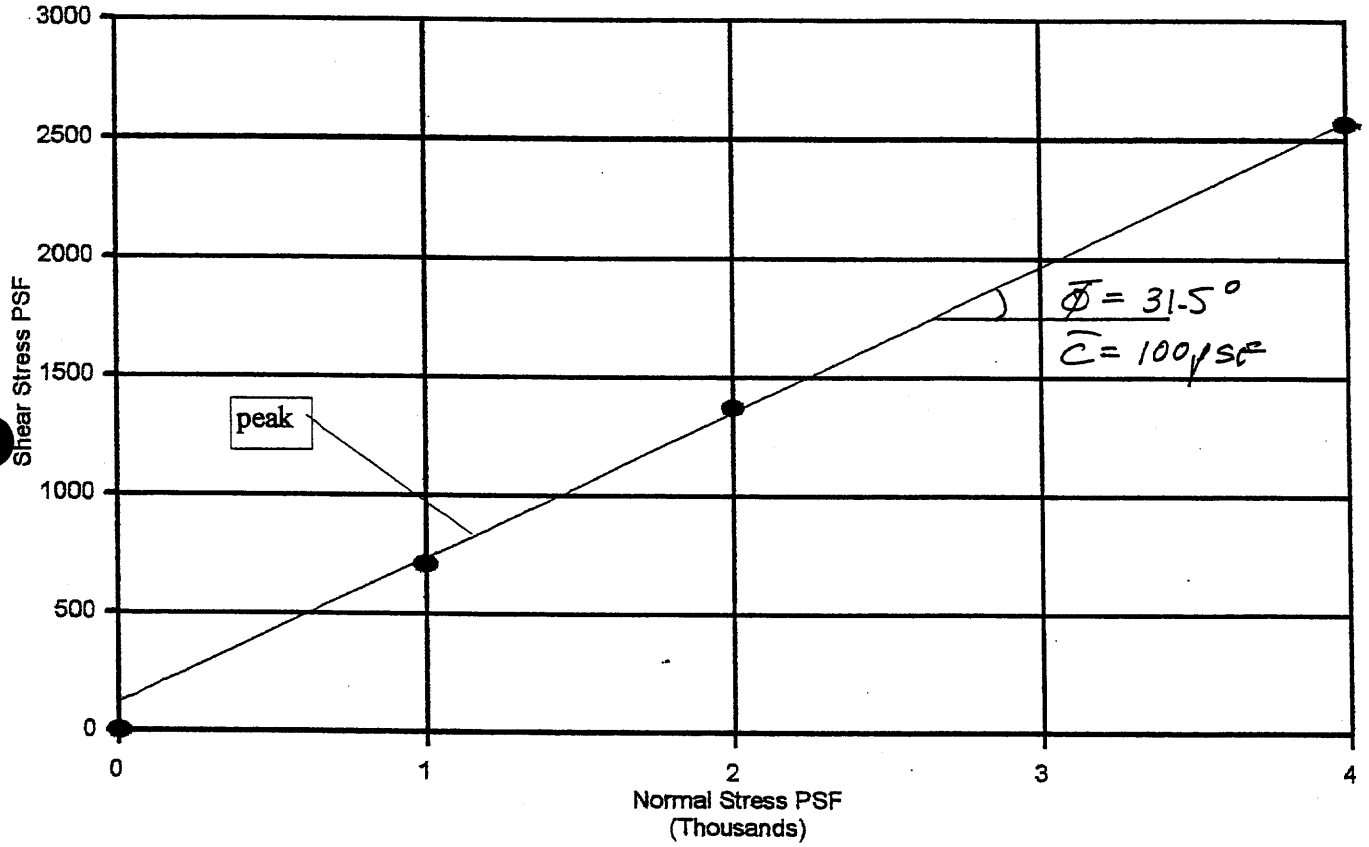
GRADING

SIEVE SIZE	% PASSING
3/8"	100.0%
#4	99.6%
#8	99.3%
#16	98.5%
#30	94.5%
#50	91.1%
#100	81.9%
#200	63.4%

CMT ENGINEERING LABORATORIES

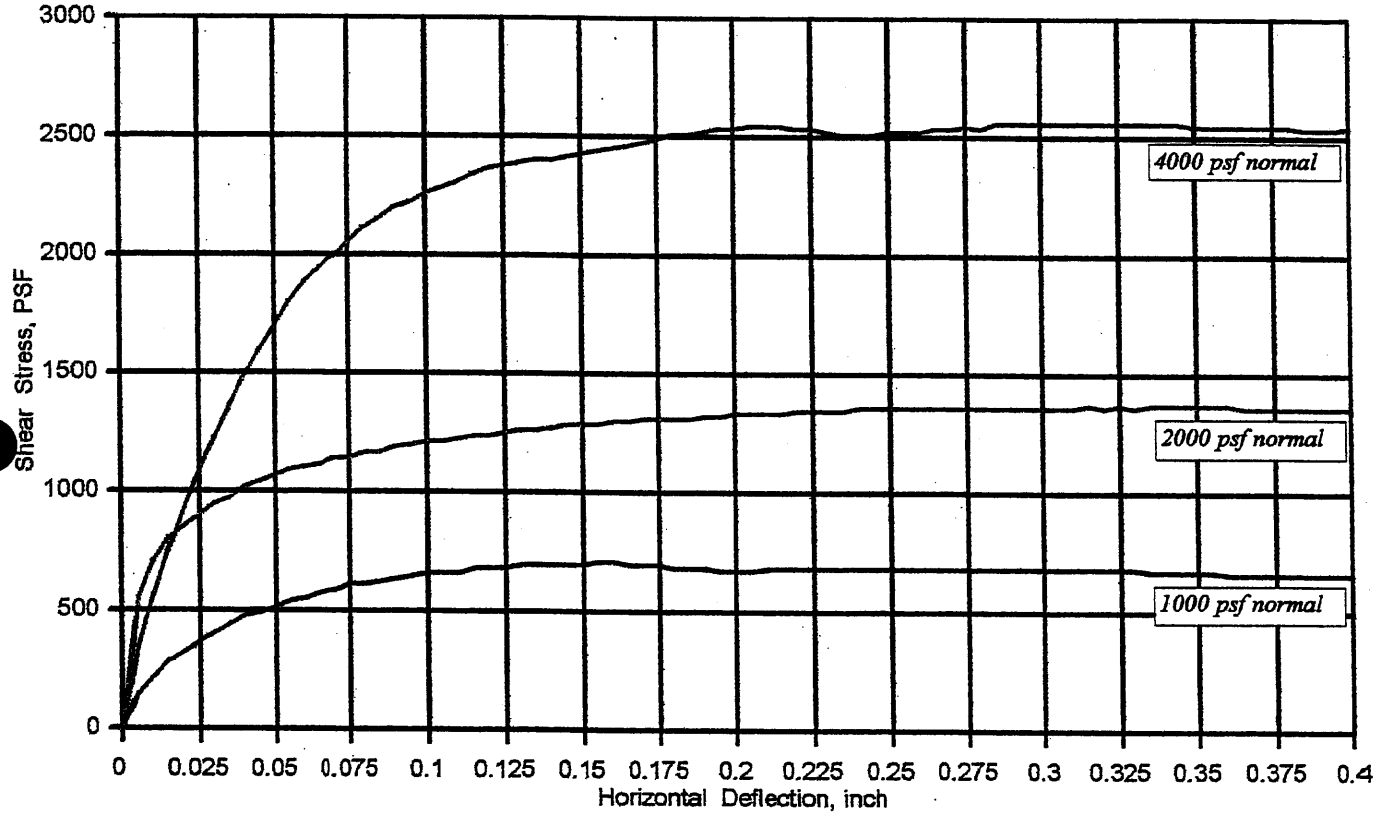
DIRECT SHEAR - Consolidated Drained

MC-2 S



Direct Shear

Sample MC-2 S



Project: Skyline Mines Discharge Study
Client: Earthfax Engineering
Project #: 401356

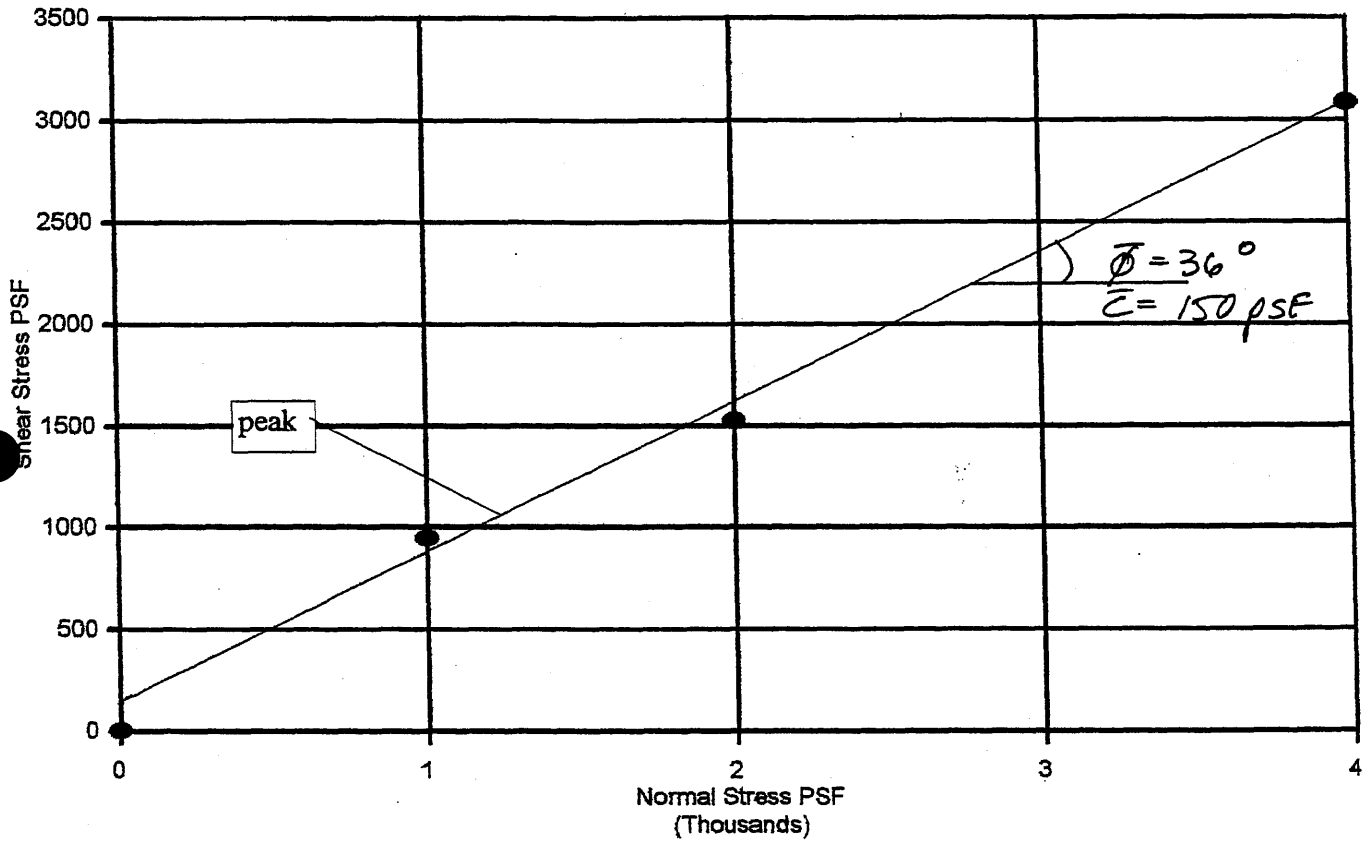
LABORATORY SUMMARY

		SPECS	
Sample Location			MC-3S
Laboratory Number			277
Sample Type			Baggie
Date Received			11/27/01
Sampled By			Earthfax
Method Used		ASTM C136, C566, C117 & D4318	
Plastic Limits		The sample was non-plastic	
GRADING			
SIEVE SIZE	% PASSING	1/2"	100.0%
		3/8"	96.3%
		#4	93.0%
		#8	90.6%
		#16	88.3%
		#30	84.2%
		#50	80.0%
		#100	70.1%
		#200	54.3%

CMT ENGINEERING LABORATORIES

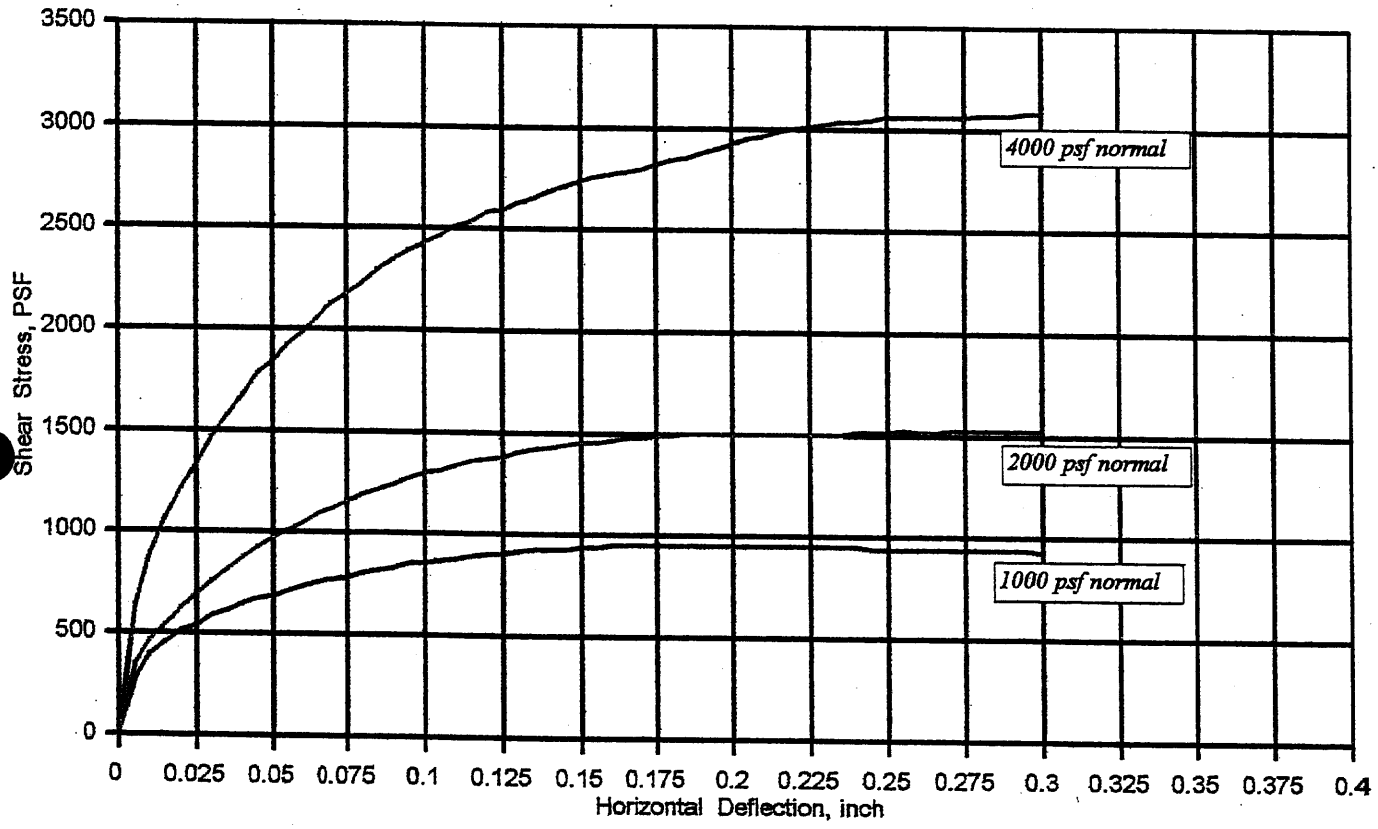
DIRECT SHEAR - Consolidated Drained

MC-3 S



Direct Shear

Sample MC-3 S



Project: Skyline Mine Discharge Study (UC-794-02)
Client: Earthfax Engineering
Project #: 401356

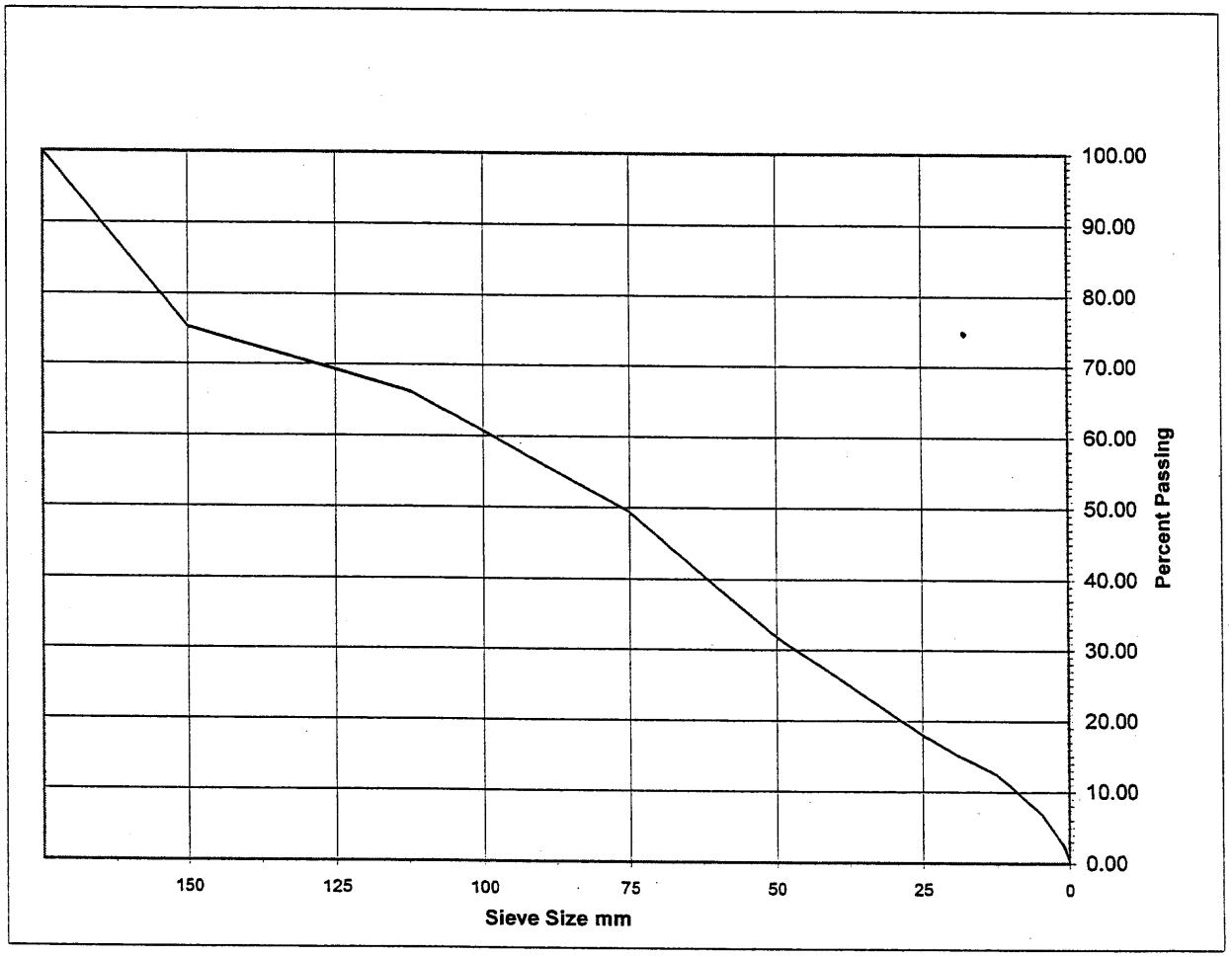
LABORATORY SUMMARY

Laboratory Number	278				
Sample Type	Bucket				
Date Received	11/26/01				
Method Used	ASTM C136, C566 & C117				
Sample Location	EC-3B	MC-3B	MC-2B	MC-1B	EC-1B
GRADING					
6" (150mm)	100.0%	79.6%	100.0%	100.0%	75.3%
4 1/2" (112.5mm)	66.1%	N/A	67.8%	81.9%	66.1%
3" (75mm)	35.3%	66.2%	39.1%	49.7%	49.4%
2" (50mm)	20.8%	46.0%	21.9%	31.7%	31.8%
1 1/2" (37.5mm)	20.4%	24.4%	13.2%	23.5%	22.6%
1" (25mm)	18.3%	17.7%	10.4%	18.1%	18.0%
3/4" (19mm)	16.2%	13.4%	8.3%	16.0%	15.1%
1/2" (12.5mm)	13.9%	9.0%	5.9%	12.5%	12.4%
3/8" (9.5mm)	12.3%	7.3%	5.1%	11.5%	10.9%
#4 (4.75mm)	7.7%	5.0%	3.5%	7.5%	6.8%
#8 (2.36mm)	5.3%	4.0%	2.6%	5.3%	4.5%
#16 (1.18mm)	3.0%	3.2%	1.9%	3.4%	2.8%
#30 (600um)	1.7%	2.6%	1.5%	2.1%	1.8%
#50 (300um)	1.0%	2.0%	1.1%	1.2%	1.1%
#100 (150um)	0.4%	1.5%	0.7%	0.8%	0.6%
#200 (75um)	0.2%	1.1%	0.5%	0.5%	0.3%

CMT ENGINEERING LABORATORIES

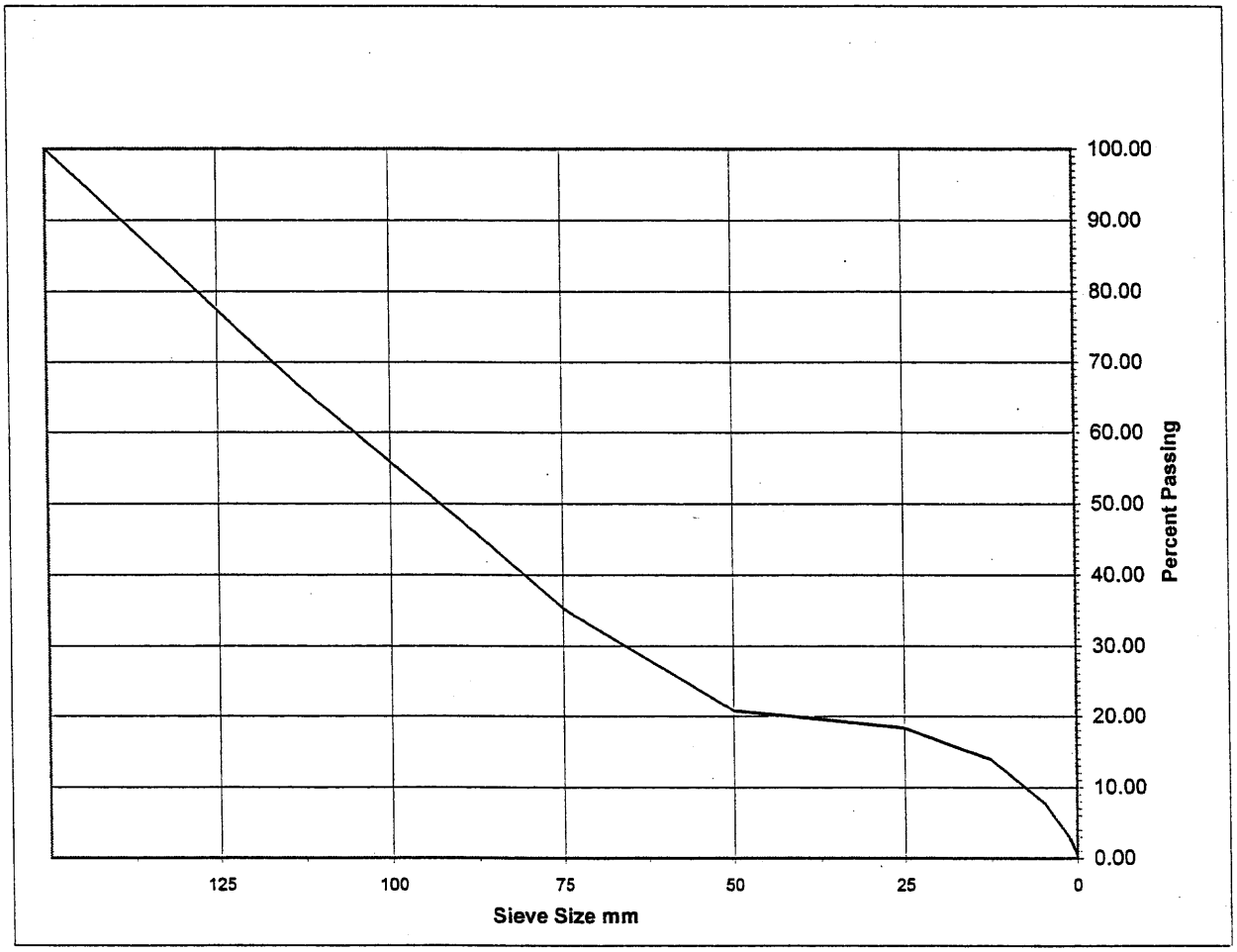
Gradation Curve

Project	Skyline Mine Discharge Study (UC-794-02)	**Date**	11/26/01
Client	Earthfax Engineering	**Project No.**	401356
Contractor		**Lab No.**	278
Soil Description	EC-1B	**Tech.**	Jeanne Richter
Source		**Method**	ASTM C 136
Use Of Material			



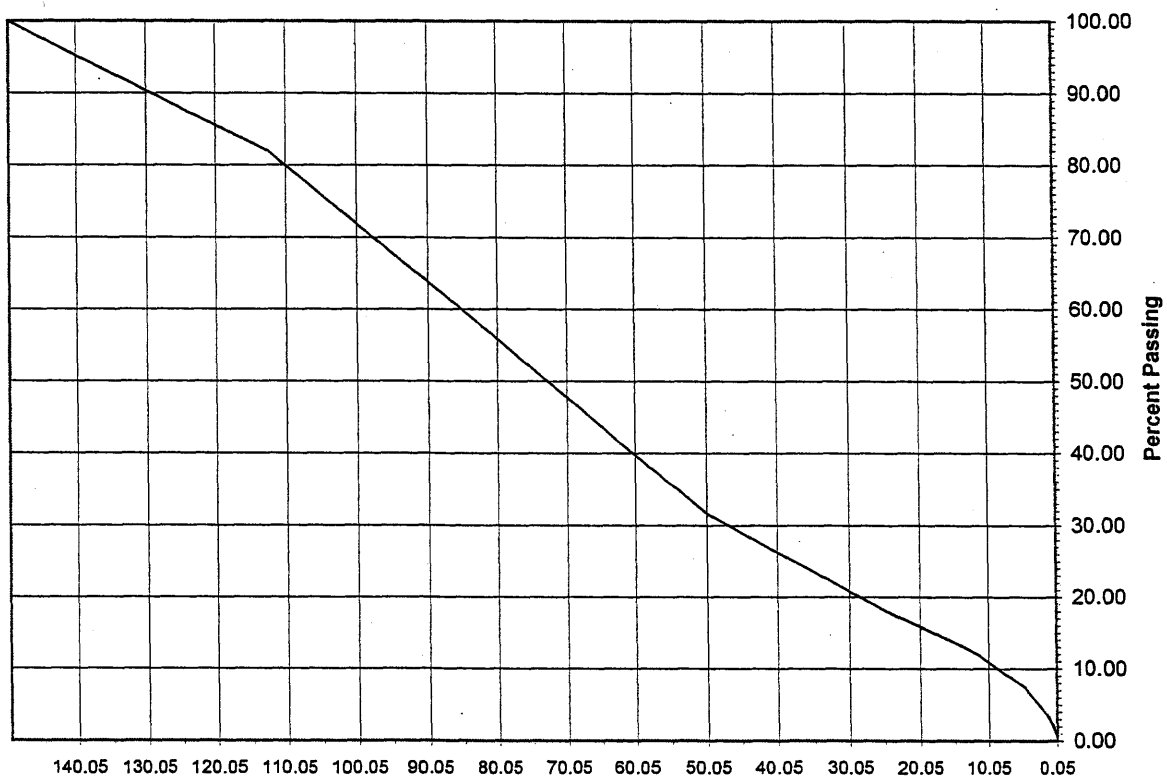
Gradation Curve

Project	Skyline Mine Discharge Study (UC-794-02)	**Date**	11/26/01
Client	Earthfax Engineering	**Project No.**	401356
Contractor		**Lab No.**	278
Soil Description	EC-3B	**Tech.**	Jeanne Richter
Source		**Method**	ASTM C 136
Use Of Material			



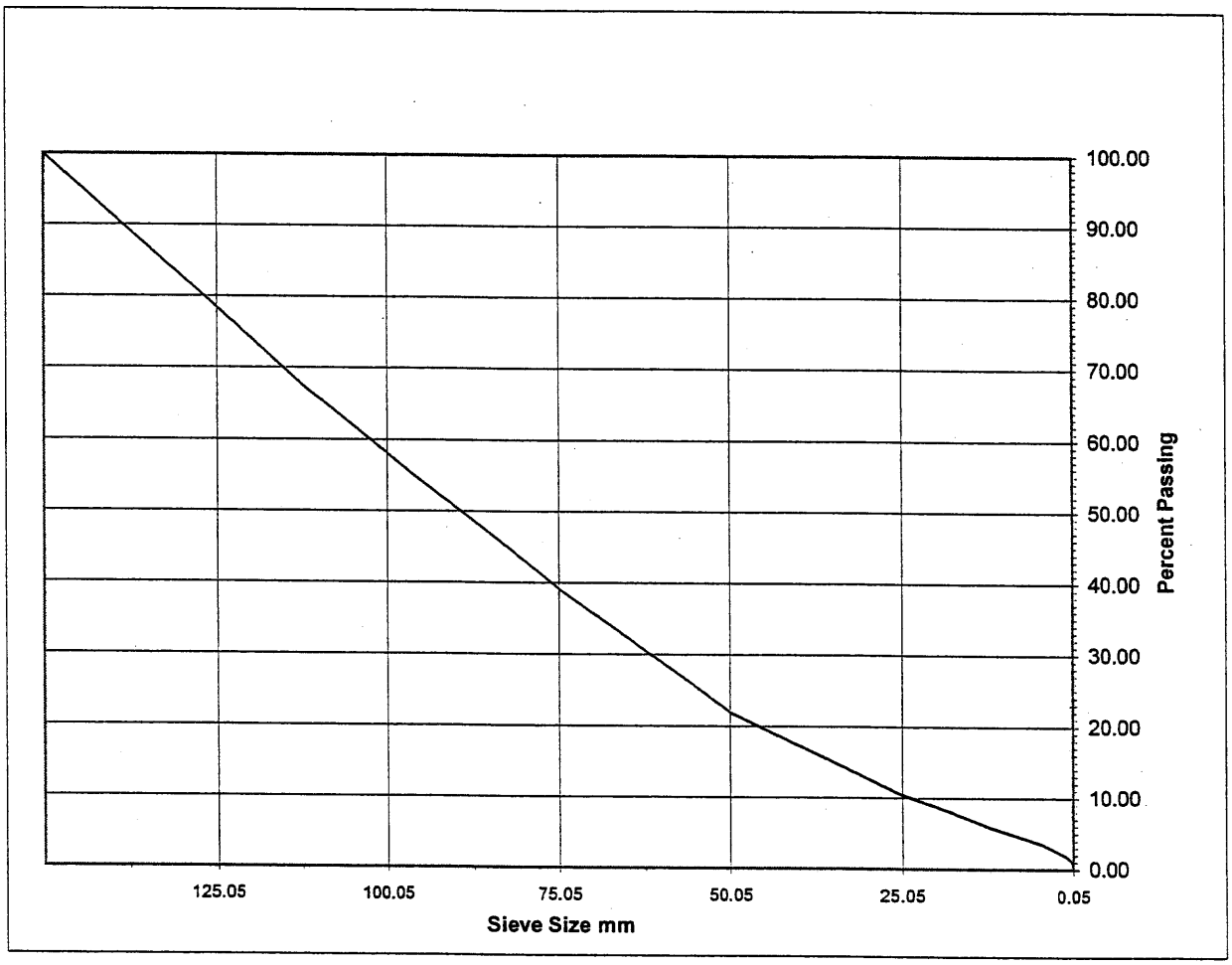
Gradation Curve

Project	Skyline Mine Discharge Study (UC-794-02)	**Date**	11/26/01
Client	Earthfax Engineering	**Project No.**	401356
Contractor		**Lab No.**	278
Soil Description	MC-1B	**Tech.**	Jeanne Richter
Source		**Method**	ASTM C 136
Use Of Material			



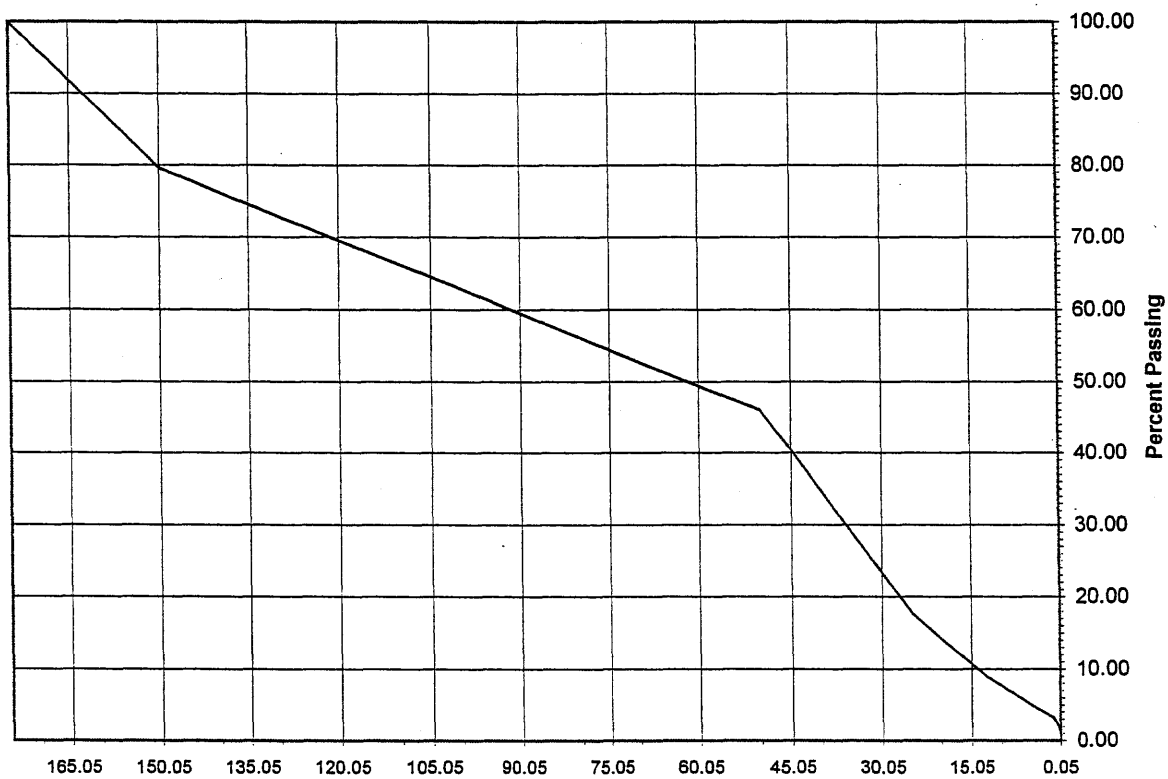
Gradation Curve

Project	Skyline Mine Discharge Study (UC-794-02)	**Date**	11/26/01
Client	Earthfax Engineering	**Project No.**	401356
Contractor		**Lab No.**	278
Soil Description	MC-2B	**Tech.**	Jeanne Richter
Source		**Method**	ASTM C 136
Use Of Material			



Gradation Curve

Project	Skyline Mine Discharge Study (UC-794-02)	**Date**	11/26/01
Client	Earthfax Engineering	**Project No.**	401356
Contractor		**Lab No.**	278
Soil Description	MC-3B	**Tech.**	Jeanne Richter
Source		**Method**	ASTM C 136
Use Of Material			



SOIL SAMPLE ANALYSIS REQUEST

EarthFax Project No.: UC-794-03

Collection Date: 16 Aug 2002

Analytical Laboratory: CMT Engineering Laboratories
215 North Redwood Road
Suite 2
North Salt Lake, Utah 84054
(801)936-1567

Sample No.	Sample Type	Analyses Requested
MC-4D MC-4S MC-5D MC-5S	Grab Shelby tube Grab Shelby tube	Each sample to be analyzed (as appropriate to the sample type) for: Dry unit weight Direct shear Atterberg limits
MC-4SS MC-5SS	Bulk grab Bulk grab	Each sample to be analyzed for gradation by sieve analysis

Results to be reported to:

Rich White
EarthFax Engineering, Inc.
7324 South Union Park Ave.
Suite 100
Midvale, UT 84047

Phone: 801-561-1555
Fax: 801-561-1861
e-mail: rbwhite@earthfax.com

CMT
CONSTRUCTION MATERIALS TECHNOLOGIES

October 25, 2002

EarthFax Engineering, Inc.
Attn: Rich White
7324 South Union Park Ave.
Suite 100
Midvale, UT 84047

Project #: 0704, Lab Services
Lab #: 4674, 4675
Test Date: 08/21/02
EarthFax Project #: UC-794-03

ATTERBERG LIMITS ASTM D4318/AASHTO T89 & T90

Sample I.D.: MC-4D

Lab # 4674 – MC-4D

Non-Plastic

Sample I.D.: MC-5D

Lab # 4675 – MC-5D

Non-Plastic

Sincerely,

Manager

CONSTRUCTION MATERIALS TESTING • SPECIAL INSPECTION • GEOTECHNICAL ENGINEERING
215 NO. REDWOOD RD. UNIT 2 NORTH SALT LAKE, UT 84054 (voice) 801.936.1567 (fax) 801.936.1465

CMT
CONSTRUCTION MATERIALS TECHNOLOGIES

Earthfax Engineering, Inc.
Rich White
7324 South Union Park Ave. Suite #100
Midvale, UT 84047

Project #: 704, Lab Services – UC-794-03
Material: Pit Run
Source: MC-4SS
Lab #: 4677
Test: **C-117, 136 Sieve Analysis**

Sieve #	% Passing
5"	93
4"	93
3"	85
2"	76
1-1/2"	64
1"	50
3/4"	41
1/2"	32
3/8"	28
#4	23
#8	21
#16	18
#30	14
#50	9
#100	6
#200	3.2

Sincerely,

Manager

CMT
CONSTRUCTION MATERIALS TECHNOLOGIES

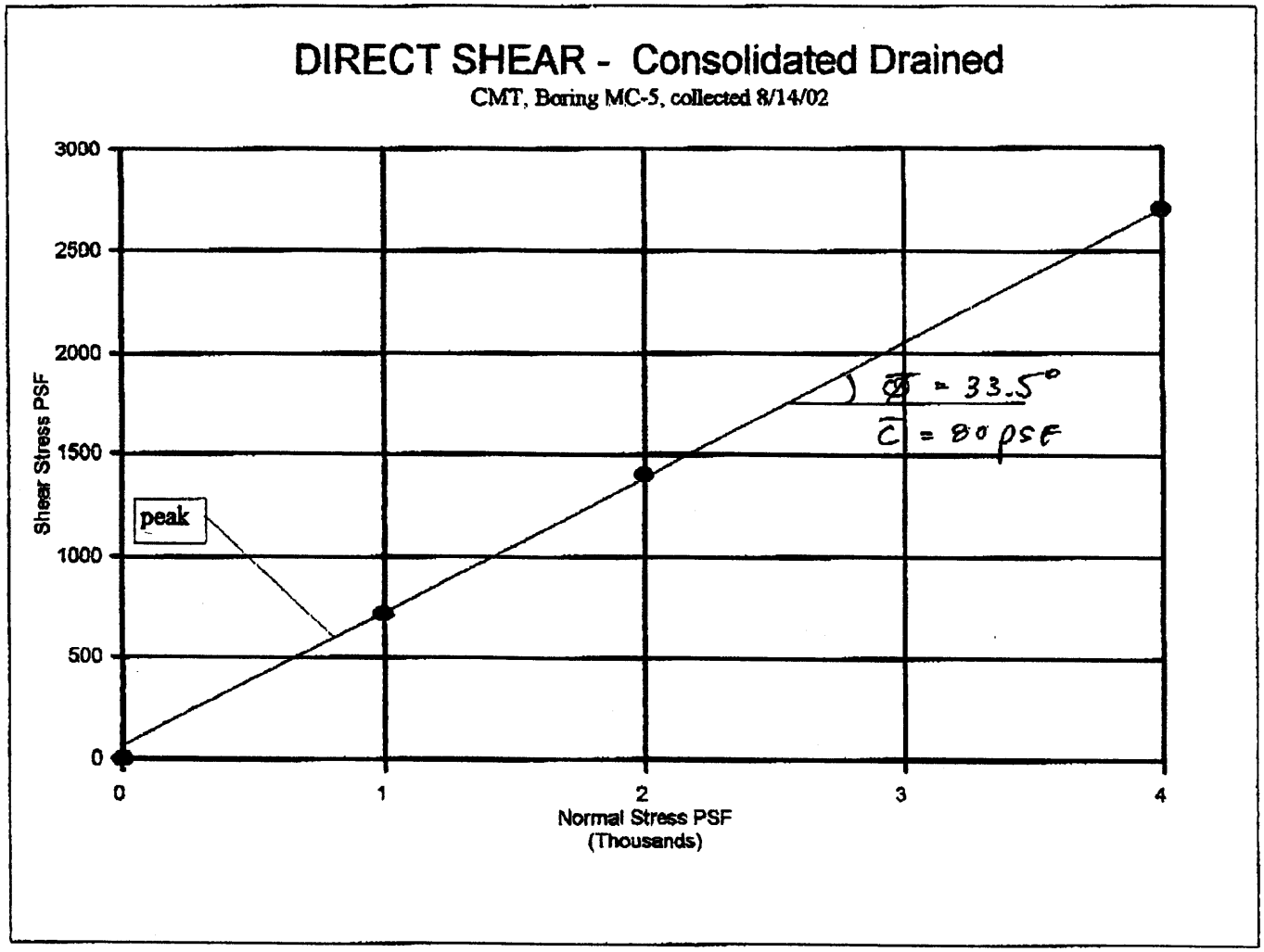
Earthfax Engineering, Inc.
Rich White
7324 South Union Park Ave. Suite #100
Midvale, UT 84047

Project #: 704, Lab Services – UC-794-03
Material: Pit Run
Source: MC-5SS
Lab #: 4676
Test: **C-117, 136 Sieve Analysis**

Sieve #	% Passing
5"	100
4"	82.6
3"	57
2 1/2"	38
2"	22.2
1-1/2"	17.3
1"	10.3
3/4"	7.6
1/2"	4.9
3/8"	4.1
#4	2.9
#8	2.4
#16	2
#30	1.6
#50	1.2
#100	0.8
#200	0.5

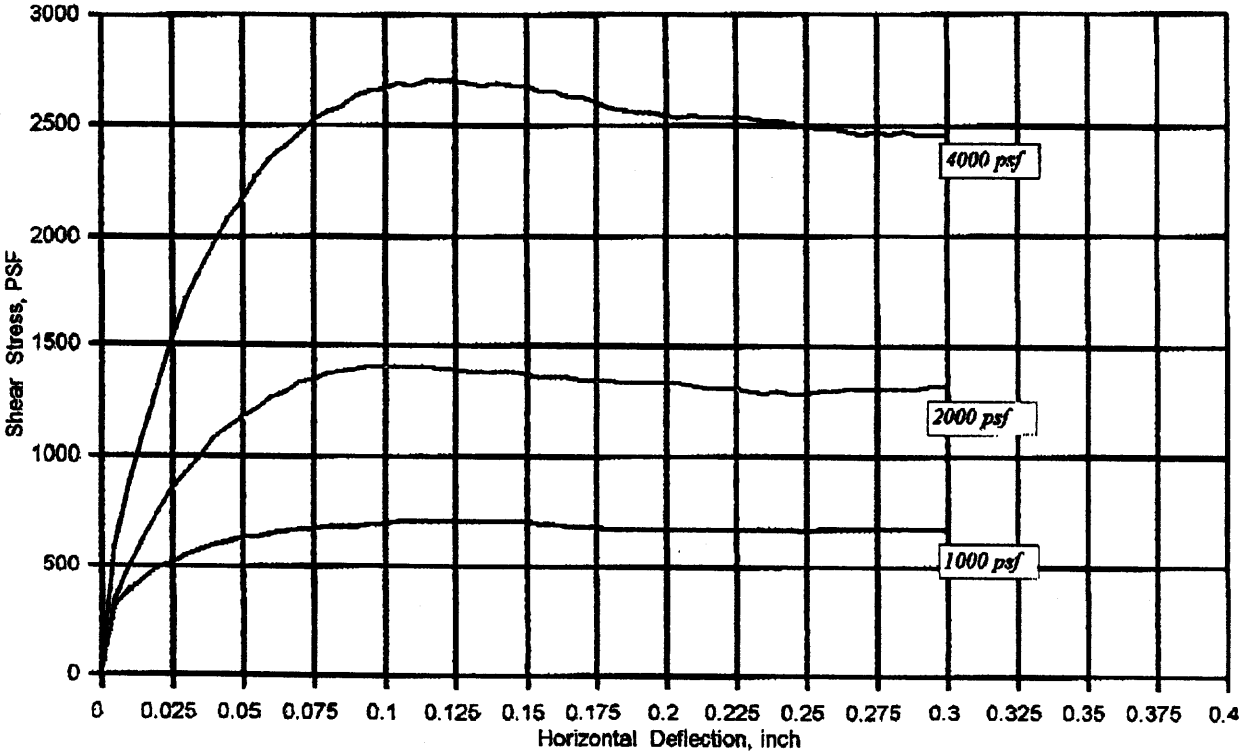
Sincerely,

Manager


DIRECT SHEAR - Consolidated Drained
CMT, Boring MC-5, collected 8/14/02
3000
2500
2000
1500
1000
500
0
Shear Stress PSF
0
1
2
3
4
Normal Stress PSF
(Thousands)
peak
$\bar{\phi}$ = 33.5°
$\bar{c}$ = 80 psf

Direct Shear

CMT, Boring MC-5



1

DIRECT SHEAR TEST DATA

ASTM D 3080

IGES

PROJECT CMT PROJECT NUMBER: LOCATION EARTHFAX

BORING NO. MC-5 SAMPLE NO. 8/14/02 DEPTH (FT) 1000 TYPE OF TEST CD

SOIL IDENTIFICATION TESTED BY: EGL 10,22,02

GENERAL DATA

	INITIAL	FINAL
SAMPLE HEIGHT (in.)	1.000	.9978
SAMPLE DIAMETER (in)	2.416	
SAMPLE AREA (in.^{2})	4.582	
SAMPLE VOLUME (in.^{3})		

VOID RATIO COMPUTATION

VOLUME TOTAL – V_t(cc)		
VOLUME OF SOLID – V_s(cc)		
VOLUME OF VOID – V_v(cc)		
VOID RATIO – e		
DEGREE OF SATURATION (%)		

MOISTURES & DENSITIES

SAMPLE WET WEIGHT & TARE (gms)	176.85	
WEIGHT OF TARE (gms)	46.74	
SAMPLE WET WEIGHT NET (gms)	130.11	130.31
WET DENSITY (pcf)	108.1	108.5

TARE NO. E

WET WEIGHT & TARE (gms)		151.55
DRY WEIGHT & TARE (gms)		122.80
WEIGHT OF WATER (gms)		
WEIGHT OF TARE (gms)		21.24
WEIGHT OF DRY SOIL (gms)	101.6	
WATER CONTENT (%)	28.1	28.3
DRY DENSITY – γ_d (pcf)	84.4	84.6

$\gamma d_f = \gamma d_o (V_o / V_f)$ =

SHEAR STRENGTH SUMMARY

	PEAK	ULTIMATE
HORIZONTAL DEFORMATION (in.)		
SHEAR STRESS (psf)		

REMARKS:

1000 720
2000 1404
4000 2708

ϕ = 33.5°
C = 80 PSF

51 – 10 – 22

SPECIFIC GRAVITY ☐ ASSUMED ☐ DETERMINED

THE DATA IN THIS GROUP ARE CHECKED AND IN ORDER BY EGL / /

☑ Approved for submission
☐ Disapproved for sumbmission
☐ Hold for further action

COMMENTS:

BY / /

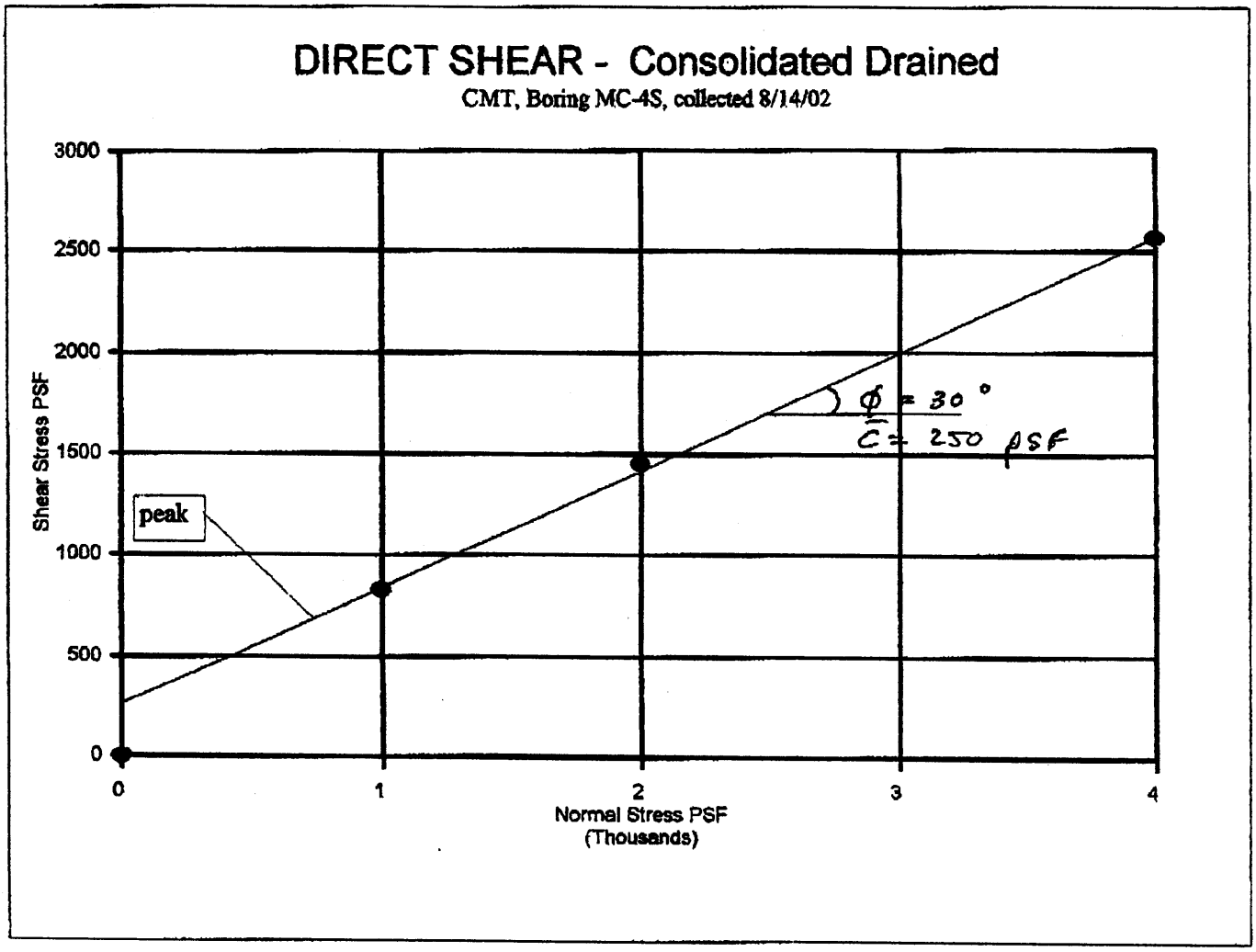
SHEARING RATE DETERMINATION

t_{90} = min.

$12t_{90}$ = min. = $t_{failure}$

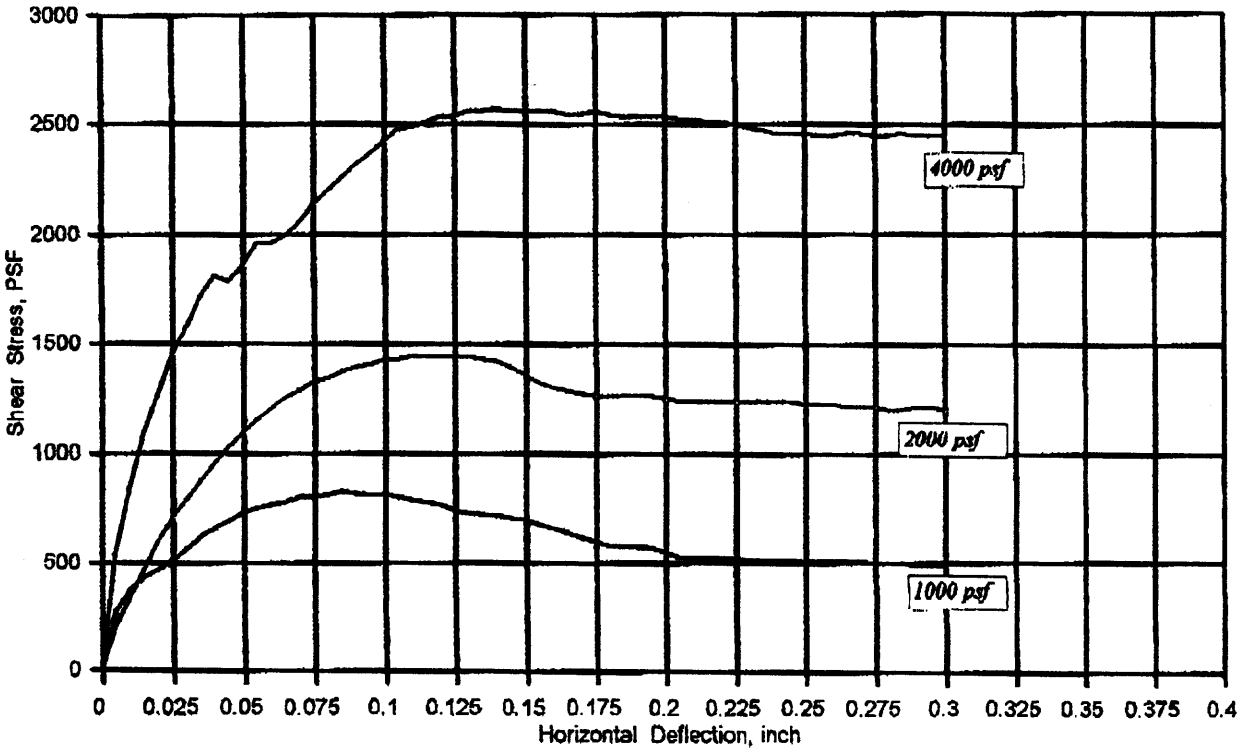
ESTIMATED HORIZONTAL DEFORMATION AT FAILURE (D_h) = in.

S.R. = D_h / $12t_{90}$ = in./min.


DIRECT SHEAR - Consolidated Drained
CMT, Boring MC-4S, collected 8/14/02
3000
2500
2000
1500
1000
500
0
Shear Stress PSF
peak
φ = 30°
C = 250 PSF
0
1
2
3
4
Normal Stress PSF
(Thousands)

Direct Shear

CMT, Boring MC-4S



1

DIRECT SHEAR TEST DATA

ASTM D 3080

IGES

PROJECT CMT PROJECT NUMBER: LOCATION EARTHCAX

BORING NO. MC-4S SAMPLE NO. 8/14/02 DEPTH (FT) 1600 TYPE OF TEST CD

SOIL IDENTIFICATION SP/SM TR ROOTS TESTED BY EEL 10,21,02

GENERAL DATA

	INITIAL	FINAL
SAMPLE HEIGHT (in.)	1.000	.9897
SAMPLE DIAMETER (in)	2.416	
SAMPLE AREA (in.^{2})	4.582	
SAMPLE VOLUME (in.^{3})		

VOID RATIO COMPUTATION

VOLUME TOTAL -- V_t(cc)		
VOLUME OF SOLID -- V_s(cc)		
VOLUME OF VOID -- V_v(cc)		
VOID RATIO -- e		
DEGREE OF SATURATION (%)		

MOISTURES & DENSITIES

SAMPLE WET WEIGHT & TARE (gms)	191.83	
WEIGHT OF TARE (gms)	45.97	
SAMPLE WET WEIGHT NET (gms)	145.86	143.57
WET DENSITY (pcf)	121.2	120.5

SHEAR STRENGTH SUMMARY

	PEAK	ULTIMATE
HORIZONTAL DEFORMATION (in.)		
SHEAR STRESS (psf)		

TARE NO. I

WET WEIGHT & TARE (gms)		166.52
DRY WEIGHT & TARE (gms)		136.68
WEIGHT OF WATER (gms)		
WEIGHT OF TARE (gms)		22.95
WEIGHT OF DRY SOIL (gms)	113.8	
WATER CONTENT (%)	28.2	26.2
DRY DENSITY -- γ_d (pcf)	94.5	95.5

$\gamma d_f = \gamma d_o (V_o / V_f) =$

REMARKS:

1000	828
2000	1452
4000	2568

$\bar{\phi} = 30°$

$\bar{c} = 250$ psf

S1 - 10 - 21

SPECIFIC GRAVITY ☐ ASSUMED ☐ DETERMINED

THE DATA IN THIS GROUP ARE CHECKED AND IN ORDER BY EEL

☒ Approved for submission
☐ Disapproved for sumbmission
☐ Hold for further action

COMMENTS:

BY / /

SHEARING RATE DETERMINATION

t_{90} = min.

$12t_{90}$ = min. = $t_{failure}$

ESTIMATED HORIZONTAL DEFORMATION AT FAILURE (D_h) = in.

S.R. = D_h / $12t_{90}$ = in./min.

SOIL SAMPLE ANALYSIS REQUEST

EarthFax Project No.: UC-794-03

Collection Date: 22 Nov 2002

Analytical Laboratory: AGEC
600 West Sandy Parkway
Sandy, UT 84070
Phone: 566-6399

Sample No.	Sample Type	Analyses Requested
MC-6	Grab (ziplock)	Atterberg limits
	Shelby tube	Direct shear, dry unit weight
	Bulk grab (bucket)	Gradation by sieve analysis

Results to be reported to:

Rich White
EarthFax Engineering, Inc.
7324 South Union Park Ave.
Suite 100
Midvale, UT 84047

Phone: 801-561-1555
Fax: 801-561-1861
e-mail: rbwhite@earthfax.com

Applied Geotechnical Engineering Consultants, Inc.

January 15, 2003

Earthfax Engineering
7324 South 1300 East, Suite 100
Midvale, UT 84047

Attention: Rich White
Fax No. 561-1861

Subject: Geotechnical Laboratory Testing
EarthFax Project No. UC-794-03
AGEC Project No. 1020023

Gentlemen:

Applied Geotechnical Engineering Consultants, Inc., was requested to conduct laboratory testing on 3 samples received in our laboratory on November 11, 2002. These samples(bucket, bag, and shelby tube) were all identified as MC-6. Laboratory testing was performed in general accordance with the following test methods.

Test	Test Method
Moisture Content	ASTM D 2216
Dry Density	ASTM D 2937
Sieve Analysis	ASTM C 136
Atterberg Limits	ASTM D 4318
Direct Shear	ASTM D 3080

The sieve analysis was performed on the bucket sample. The Atterberg limits were performed on the bag sample. Moisture content, dry density and direct shear testing were performed on the shelby tube sample.

The sieve analysis is presented graphically on Figure 1. The moisture content, dry density and direct shear results are presented on Figure 2. The results of the atterberg limits test indicate a liquid limit of 33% and a plasticity index of 11%.

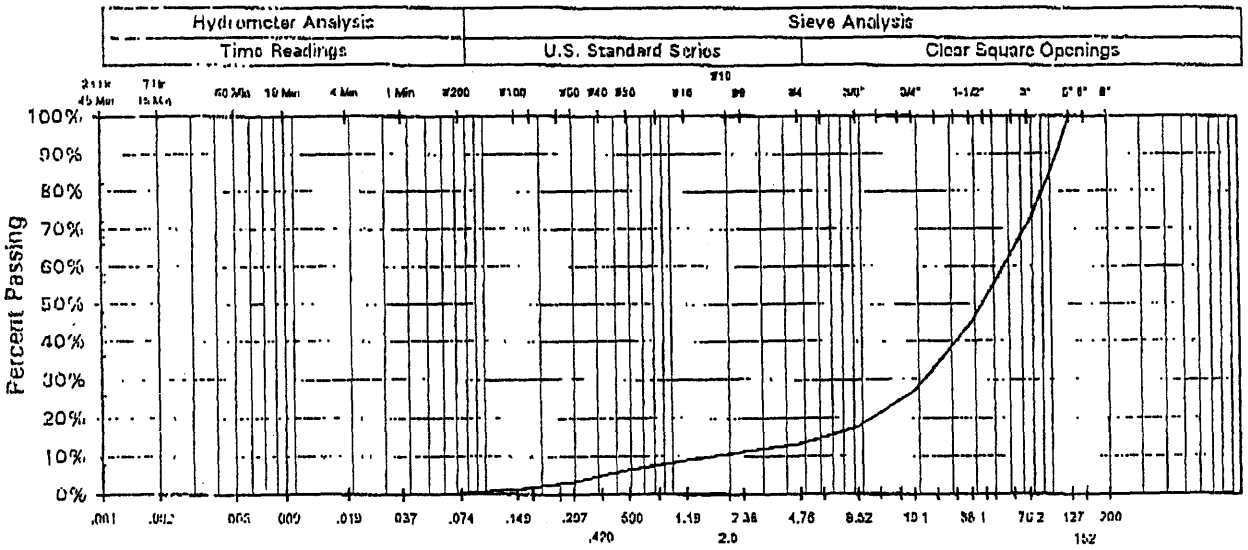
If we can be of further assistance, please do not hesitate to call.

Sincerely,

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

John Sylvester
Reviewed by SDA, P.E.

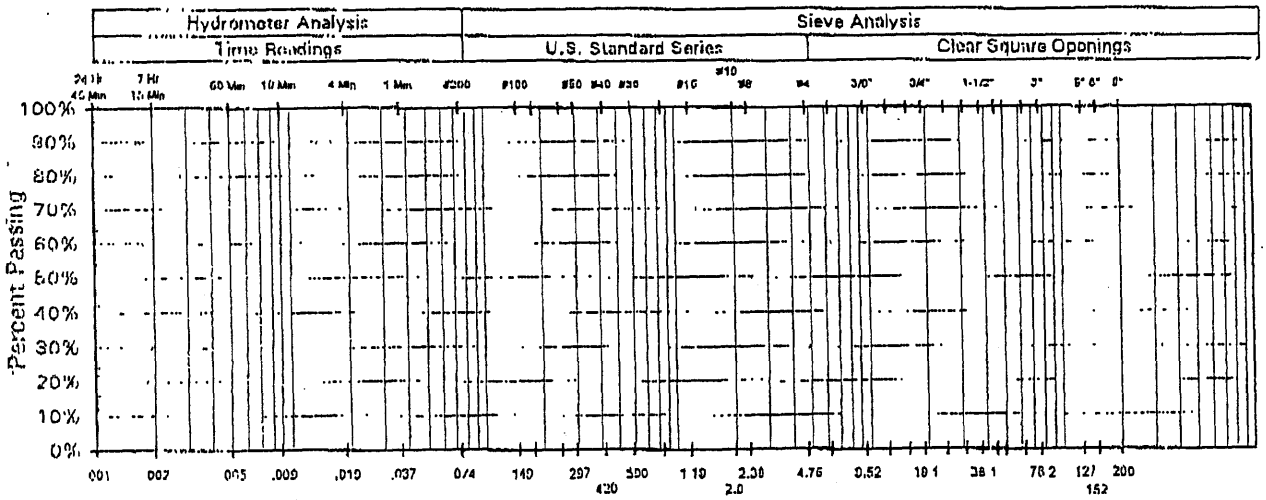
APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.



Clay to Silt	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

Gravel 87%
Sand 13%
Silt and Clay 1%
Sample Description Poorly Graded Gravel (GP)

Liquid Limit
Plasticity Index
Sample Location MC-6 Bucket



Clay to Silt	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

Gravel
Sand
Silt and Clay
Sample Description

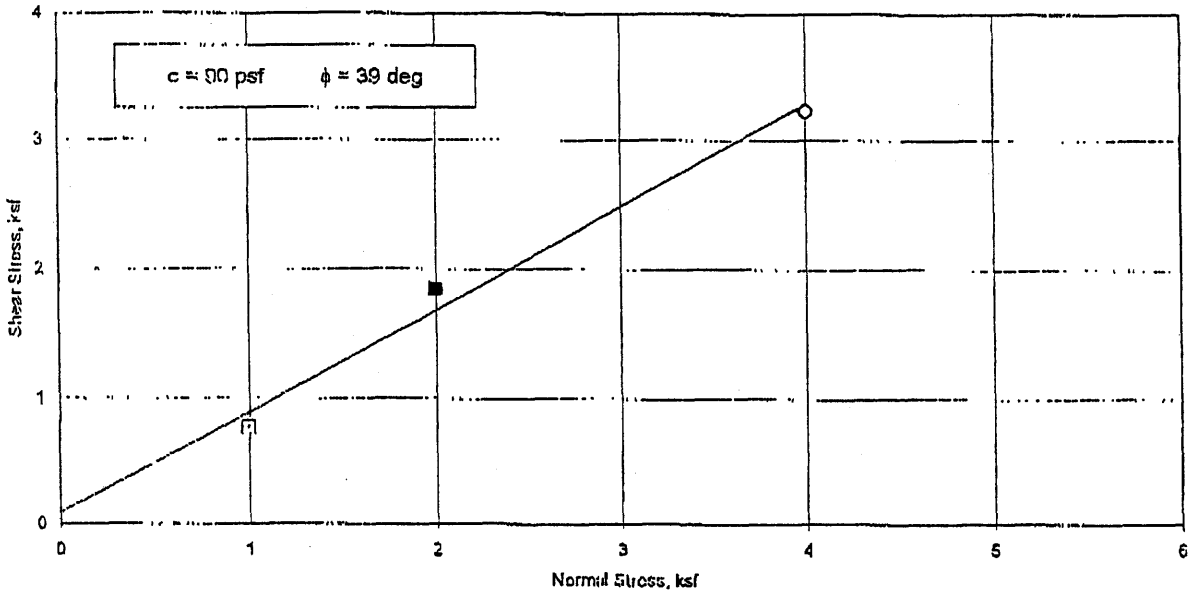
Liquid Limit
Plasticity Index
Sample Location

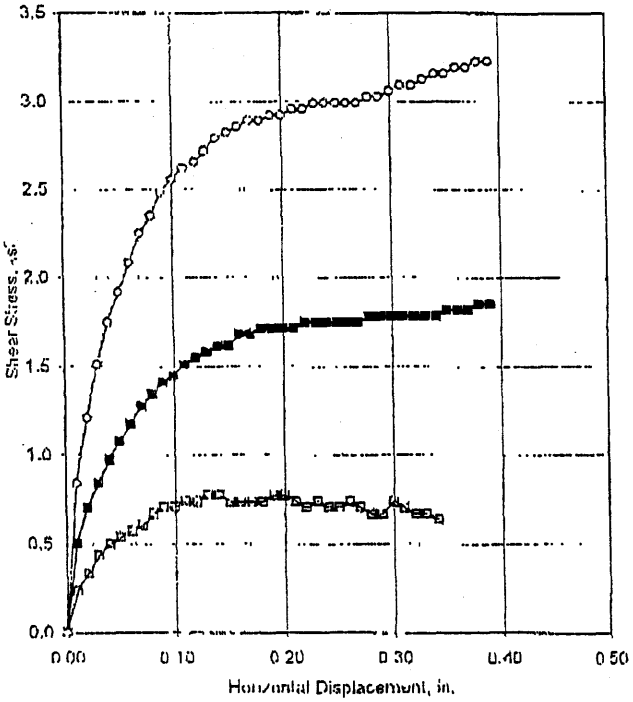
Project No. 1020023

GRADATION TEST RESULTS

Figure 1

Applied Geotechnical Engineering Consultants, Inc.





Test No. (Symbol)	1(□)	2(■)	3(○)
Sample Type	Undisturbed		
Length, in.	1.00	1.00	1.00
Diameter, in.	1.93	1.93	1.93
Dry Density, pcf	N/A	N/A	N/A
Moisture Content, %	N/A	N/A	N/A
Consolidation Load, ksf	1.0	2.0	4.0
Normal Load, ksf	1.0	2.0	4.0
Shear Stress, ksf	0.77	1.85	3.23
Remarks	Strain Rate 0.05 in/min.		

Sample Index Properties	
Dry Density, pcf	56
Moisture Content, %	71
Liquid Limit, %	N/A
Plasticity Index, %	N/A
Percent Gravel	N/A
Percent Sand	N/A
Percent Passing No. 200 Sieve	N/A

Type of Test: Consolidated, Wetted

Sample Description: Clayey Sand with organics From: MC-6 Shelby Tube

Project No. 1020023

Direct Shear Test Results

Figure 2

APPENDIX D

Water Quality Data Sheets

COMMERCIAL TESTING & ENGINEERING CO.
GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • TEL: 630-953-9300 FAX: 630-953-9306
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SGS Member of the SGS Group (Société Générale de Surveillance)

ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1020
HUNTINGTON, UT 84528
TEL: (435) 653-2311
FAX: (435) 653-2436
www.comteco.com

August 21, 2002

CANYON FUEL CO., SKYLINE MINES
HC 35 P.O. Box 380
Helper, Utah 84526

Sample identification by
Skyline

ID:MC-1

Kind of sample reported to us Water

Sample taken at Skyline

Sample taken by K2

Date sampled August 15, 2002

Date received August 15, 2002

RECEIVED 1650
SAMPLED 10.00
FIELD MEASUREMENTS

FLOW	12.42	TEMP	13.9
COND	496	pH	8.52
D.O.	6.75	TURBIDITY	3

NOTES:

Page 1 of 1

Analysis report no. 59-24335

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Solids, Total Dissolved	299	10	mg/l	EPA 160.1	08-19-2002 0800 SC
Solids, Total Suspended	27	5	mg/l	EPA 160.2	08-19-2002 0800 SC

FAXED 8-26-02

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Huntington Laboratory

MEMBER ACIL

F-465

TERMS AND CONDITIONS ON REVERSE

COMMERCIAL TESTING & ENGINEERING CO.
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P.O. BOX 1020
HUNTINGTON, UT 84528
TEL: (435) 653-2311
FAX: (435) 653-2436
www.comteco.com

August 21, 2002

CANYON FUEL CO., SKYLINE MINES
HC 35 P.O. Box 380
Helper, Utah 84526

Sample identification by
Skyline

ID:MC-2

Kind of sample reported to us Water

Sample taken at Skyline

Sample taken by K2

Date sampled August 15, 2002

Date received August 15, 2002

RECEIVED 1650
SAMPLED 1030

FIELD MEASUREMENTS

FLOW	20.95	TEMP	14.0
COND	495	pH	8.50
D.O.	6.88	TURBIDITY	2.6

NOTES:

Page 1 of 1

Analysis report no. 59-24336

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Solids, Total Dissolved	293	10	mg/l	EPA 160.1	08-19-2002 0800 SC
Solids, Total Suspended	24	5	mg/l	EPA 160.2	08-19-2002 0800 SC

FAXED 8-26-02

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Huntington Laboratory

MEMBER ACIL

COMMERCIAL TESTING & ENGINEERING CO.
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FAX: (435) 653-2436
www.comteco.com

August 21, 2002

CANYON FUEL CO., SKYLINE MINES
HC 35 P.O. Box 380
Helper, Utah 84526

Sample identification by
Skyline

ID:MC-3

Kind of sample reported to us Water

Sample taken at Skyline

Sample taken by K2

Date sampled August 15, 2002

Date received August 15, 2002

RECEIVED 1650
SAMPLED 1140
FIELD MEASUREMENTS

FLOW	20.17	TEMP	16.1
COND	526	pH	8.49
D.O.	7.35	TURBIDITY	2.1

NOTES:

Page 1 of 1

Analysis report no. 59-24337

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Solids, Total Dissolved	308	10	mg/l	EPA 160.1	08-19-2002 0800 SC
Solids, Total Suspended	14	5	mg/l	EPA 160.2	08-19-2002 0800 SC

FAXED 8-26-02

FL

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Huntington Laboratory

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FAX: (435) 653-2436
www.comteco.com

August 21, 2002

CANYON FUEL CO., SKYLINE MINES
HC 35 P.O. Box 380
Helper, Utah 84526

Sample identification by
Skyline

ID:MC-4

Kind of sample reported to us Water

Sample taken at Skyline

Sample taken by K2

Date sampled August 15, 2002

Date received August 15, 2002

RECEIVED 1650
SAMPLED 1100

FIELD MEASUREMENTS

FLOW	17.01	TEMP	15.9
COND	504	pH	8.50
D.O.	7.13	TURBIDITY	2.7

NOTES:

Page 1 of 1

Analysis report no. 59-24338

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Solids, Total Dissolved	297	10	mg/l	EPA 160.1	08-19-2002 0800 SC
Solids, Total Suspended	23	5	mg/l	EPA 160.2	08-19-2002 0800 SC

FAXED

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Huntington Laboratory

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FAX: (435) 653-2436
www.comteco.com

August 21, 2002

CANYON FUEL CO., SKYLINE MINES
HC 35 P.O. Box 380
Helper, Utah 84526

Sample identification by
Skyline

ID:MC-5

Kind of sample reported to us Water

Sample taken at Skyline

Sample taken by K2

Date sampled August 15, 2002

Date received August 15, 2002

RECEIVED 1650
SAMPLED 0930

FIELD MEASUREMENTS

FLOW	1.009	TEMP	9.1
COND	538	pH	8.36
D.O.	7.07	TURBIDITY	3.5

NOTES:

Analysis report no. 59-24339

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Solids, Total Dissolved	312	10	mg/l	EPA 160.1	08-19-2002 0800 SC
Solids, Total Suspended	12	5	mg/l	EPA 160.2	08-19-2002 0800 SC

FAXED

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Huntington Laboratory

MEMBER ACIL

TERMS AND CONDITIONS ON REVERSE

Mountain States Analytical, LLC

1645 West 2200 South · Salt Lake City, Utah 84119 · 800-973-6724

Client:	Mr. Chris Hansen	Report Number:	0208148-1
	Canyon Fuel Company, LLC	Date Reported:	08/26/02
	Skyline Mines	Work Order:	0208148
	HC 35 Box 380	Lab Sample ID:	0208148-01A
	Helper, UT 84526	Client Sample ID:	MC-1
	(435) 448-6463	Date Collected:	08/15/02
Project:	3rd Quarter	Date Received:	08/21/02 08:50
Project ID:		Matrix:	Water
Purchase Order:		COC ID:	25266

Parameter	Result	MDL	PQL	Units	DF	Date Analyzed	Analyst
EPA 365.3: Phosphorus, Total as P, Water							
Phosphorus, total	U	0.02	0.1	mg/L	1	08/22/02	NWL

U - Not detected above the MDL
J - Analyte detected below the PQL
* - Result is greater than the associated action level
B - Analyte detected in the associated Method Blank
E - Result is outside of quantitation range
S - Results outside normal recovery limits
R - RPD outside normal precision limits

Individual pages or portions of this report may not be separated and presented for regulatory compliance.

Mountain States Analytical, LLC

1645 West 2200 South · Salt Lake City, Utah 84119 · 800-973-6724

Client:	Mr. Chris Hansen	**Report Number:**	0208148-1
	Canyon Fuel Company, LLC	**Date Reported:**	08/26/02
	Skyline Mines	**Work Order:**	0208148
	HC 35 Box 380	**Lab Sample ID:**	0208148-02A
	Helper, UT 84526	**Client Sample ID:**	MC-2
	(435) 448-6463	**Date Collected:**	08/15/02
Project:	3rd Quarter	**Date Received:**	08/21/02 08:50
Project ID:		**Matrix:**	Water
Purchase Order:		**COC ID:**	25266

Parameter	Result	MDL	PQL	Units	DF	Date Analyzed	Analyst
EPA 365.3: Phosphorus, Total as P, Water							
Phosphorus, total	U	0.02	0.1	mg/L	1	08/22/02	NWL

U - Not detected above the MDL
J - Analyte detected below the PQL
* - Result is greater than the associated action level
B - Analyte detected in the associated Method Blank
E - Result is outside of quantitation range
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R - RPD outside normal precision limits

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Mountain States Analytical, LLC

1645 West 2200 South · Salt Lake City, Utah 84119 · 800-973-6724

Client:	Mr. Chris Hansen	Report Number:	0208148-1
	Canyon Fuel Company, LLC	Date Reported:	08/26/02
	Skyline Mines	Work Order:	0208148
	HC 35 Box 380	Lab Sample ID:	0208148-03A
	Helper, UT 84526	Client Sample ID:	MC-3
	(435) 448-6463	Date Collected:	08/15/02
Project:	3rd Quarter	Date Received:	08/21/02 08:50
Project ID:		Matrix:	Water
Purchase Order:		COC ID:	25266

Parameter	Result	MDL	PQL	Units	DF	Date Analyzed	Analyst
EPA 365.3: Phosphorus, Total as P, Water							
Phosphorus, total	U	0.02	0.1	mg/L	1	08/22/02	NWL

U - Not detected above the MDL
J - Analyte detected below the PQL
* - Result is greater than the associated action level
B - Analyte detected in the associated Method Blank
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Mountain States Analytical, LLC

1645 West 2200 South · Salt Lake City, Utah 84119 · 800-973-6724

Client:	Mr. Chris Hansen	Report Number:	0208148-1
	Canyon Fuel Company, LLC	Date Reported:	08/26/02
	Skyline Mines	Work Order:	0208148
	HC 35 Box 380	Lab Sample ID:	0208148-04A
	Helper, UT 84526	Client Sample ID:	MC-4
	(435) 448-6463	Date Collected:	08/15/02
Project:	3rd Quarter	Date Received:	08/21/02 08:50
Project ID:		Matrix:	Water
Purchase Order:		COC ID:	25266

Parameter	Result	MDL	PQL	Units	DF	Date Analyzed	Analyst
EPA 365.3: Phosphorus, Total as P, Water							
Phosphorus, total	U	0.02	0.1	mg/L	1	08/22/02	NWL

U - Not detected above the MDL
J - Analyte detected below the PQL.
* - Result is greater than the associated action level
B - Analyte detected in the associated Method Blank
E - Result is outside of quantitation range
S - Results outside normal recovery limits
R - RPD outside normal precision limits

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Mountain States Analytical, LLC

1645 West 2200 South · Salt Lake City, Utah 84119 · 800-973-6724

Client:	Mr. Chris Hansen	Report Number:	0208148-1
	Canyon Fuel Company, LLC	Date Reported:	08/26/02
	Skyline Mines	Work Order:	0208148
	HC 35 Box 380	Lab Sample ID:	0208148-05A
	Helper, UT 84526	Client Sample ID:	MC-5
	(435) 448-6463	Date Collected:	08/15/02
Project:	3rd Quarter	Date Received:	08/21/02 08:50
Project ID:		Matrix:	Water
Purchase Order:		COC ID:	25266

Parameter	Result	MDL	PQL	Units	DF	Date Analyzed	Analyst
EPA 365.3: Phosphorus, Total as P, Water							
Phosphorus, total	U	0.02	0.1	mg/L	1	08/22/02	NWL

U - Not detected above the MDL
J - Analyte detected below the PQL
* - Result is greater than the associated action level
B - Analyte detected in the associated Method Blank
E - Result is outside of quantitation range
S -Results outside normal recovery limits
R - RPD outside normal precision limits

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Mountain States Analytical, LLC

1645 West 2200 South · Salt Lake City, Utah 84119 · 800-973-6724

Client:	Mr. Chris Hansen	Report Number:	0208148-1
	Canyon Fuel Company, LLC	Date Reported:	08/26/02
	Skyline Mines	Work Order:	0208148
	HC 35 Box 380	Lab Sample ID:	0208148-06A
	Helper, UT 84526	Client Sample ID:	MD-1
	(435) 448-6463	Date Collected:	08/15/02
Project:	3rd Quarter	Date Received:	08/21/02 08:50
Project ID:		Matrix:	Water
Purchase Order:		COC ID:	25266

Parameter	Result	MDL	PQL	Units	DF	Date Analyzed	Analyst
EPA 365.3: Phosphorus, Total as P, Water							
Phosphorus, total	U	0.02	0.1	mg/L	1	08/22/02	NWI.

U - Not detected above the MDL
J - Analyte detected below the PQL
* - Result is greater than the associated action level
B - Analyte detected in the associated Method Blank
E - Result is outside of quantitation range
S -Results outside normal recovery limits
R - RPD outside normal precision limits

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October 25, 2002

CANYON FUEL CO., SKYLINE MINES
HC 35 P.O. Box 380
Helper, Utah 84526

Sample identification by
Skyline

ID:MC-1

Kind of sample reported to us Water

RECEIVED 1650
SAMPLED 1140

FIELD MEASUREMENTS

TEMP	12.8	COND	761
pH	8.63	TURB	9

Sample taken at Skyline Mine

Sample taken by E. Peterson

NOTES:

Date sampled October 17, 2002

Date received October 17, 2002

Page 1 of 1

Analysis report no. 59-24664

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Solids, Total Dissolved	522	10	mg/l	EPA 160.1	10-23-2002 1015 BLP
Solids, Total Suspended	5	5	mg/l	EPA 160.2	10-23-2002 1015 BLP

FAXED 10-31-02

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Huntington Laboratory

MEMBER ACIL

Mountain States Analytical, LLC

Analytical Report

1645 West 2200 South · Salt Lake City, Utah 84119 · 800-973-6724

Client:	Mr. Chris Hansen	**Report Number:**	0212012-1
	Canyon Fuel Company, LLC	**Date Reported:**	12/10/02
	Skyline Mines	**Work Order:**	0212012
	HC 35 Box 380	**Lab Sample ID:**	0212012-01A
	Helper, UT 84526	**Client Sample ID:**	MC-1
	(435) 448-6463	**Date Collected:**	11/29/02
Project:	4th Qtr Sampling	**Date Received:**	12/03/02 09:00
Project ID:		**Matrix:**	Water
Purchase Order:		**COC ID:**	26073

Parameter	Result	MDL	PQL	Units	DF	Date Analyzed	Analyst
EPA 365.3: Phosphorus, Total as P, Water							
Phosphorus, total	U	0.02	0.1	mg/L	1	12/04/02 09:50	JKH

U - Not detected above the MDL
J - Analyte detected below the PQL
* - Result is greater than the associated action level
B - Analyte detected in the associated Method Blank
E - Result is outside of quantitation range
S -Results outside normal recovery limits
R - RPD outside normal precision limits

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COMMERCIAL TESTING & ENGINEERING CO.

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www.comteco.com

October 25, 2002

CANYON FUEL CO., SKYLINE MINES
HC 35 P.O. Box 380
Helper, Utah 84526

Sample identification by
Skyline

ID:MC-2

Kind of sample reported to us Water

RECEIVED 1650
SAMPLED 1215

FIELD MEASUREMENTS

TEMP 13.5 COND 735
pH 8.64 TURB 8

Sample taken at Skyline Mine

Sample taken by E. Peterson

NOTES:

Date sampled October 17, 2002

Date received October 17, 2002

Page 1 of 1

Analysis report no. 59-24665

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Solids, Total Dissolved	486	10	mg/l	EPA 160.1	10-23-2002 1015 BLP
Solids, Total Suspended	5	5	mg/l	EPA 160.2	10-23-2002 1015 BLP

FAXED 10-31-02

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Huntington Laboratory

MEMBER ACIL

Mountain States Analytical, LLC

1645 West 2200 South · Salt Lake City, Utah 84119 · 800-973-6724

Analytical Report

Client:	Mr. Chris Hansen	**Report Number:**	0212012-1
	Canyon Fuel Company, LLC	**Date Reported:**	12/10/02
	Skyline Mines	**Work Order:**	0212012
	HC 35 Box 380	**Lab Sample ID:**	0212012-02A
	Helper, UT 84526	**Client Sample ID:**	MC-2
	(435) 448-6463	**Date Collected:**	11/29/02
Project:	4th Qtr Sampling	**Date Received:**	12/03/02 09:00
Project ID:		**Matrix:**	Water
Purchase Order:		**COC ID:**	26073

Parameter	Result	MDL	PQL	Units	DF	Date Analyzed	Analyst
EPA 365.3: Phosphorus, Total as P, Water							
Phosphorus, total	U	0.02	0.1	mg/L	1	12/04/02 09:50	JKH

U - Not detected above the MDL
B - Analyte detected in the associated Method Blank
S -Results outside normal recovery limits
J - Analyte detected below the PQL
E - Result is outside of quantitation range
R - RPD outside normal precision limits
* - Result is greater than the associated action level

Individual pages or portions of this report may not be separated and presented for regulatory compliance.

COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • TEL: 630-953-9300 FAX: 630-953-9306

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October 25, 2002

CANYON FUEL CO., SKYLINE MINES
HC 35 P.O. Box 380
Helper, Utah 84526

Sample identification by
Skyline

ID:MC-3

Kind of sample reported to us Water

Sample taken at Skyline Mine

Sample taken by E. Peterson

Date sampled October 17, 2002

Date received October 17, 2002

RECEIVED 1650
SAMPLED 1325
FIELD MEASUREMENTS
TEMP 12.5 COND 706
pH 8.86 TURB 8

NOTES:

Page 1 of 1

Analysis report no. 59-24666

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Solids, Total Dissolved	481	10	mg/l	EPA 160.1	10-23-2002 1015 BLP
lids, Total Suspended	<5	5	mg/l	EPA 160.2	10-23-2002 1015 BLP

FILED 10-31-02

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Huntington Laboratory

MEMBER ACIL

Mountain States Analytical, LLC

1645 West 2200 South · Salt Lake City, Utah 84119 · 800-973-6724

Client:	Mr. Chris Hansen	**Report Number:**	0212012-1
	Canyon Fuel Company, LLC	**Date Reported:**	12/10/02
	Skyline Mines	**Work Order:**	0212012
	HC 35 Box 380	**Lab Sample ID:**	0212012-03A
	Helper, UT 84526	**Client Sample ID:**	MC-3
	(435) 448-6463	**Date Collected:**	11/29/02
Project:	4th Qtr Sampling	**Date Received:**	12/03/02 09:00
Project ID:		**Matrix:**	Water
Purchase Order:		**COC ID:**	26073

Parameter	Result	MDL	PQL	Units	DF	Date Analyzed	Analyst
EPA 365.3: Phosphorus, Total as P, Water							
Phosphorus, total	U	0.02	0.1	mg/L	1	12/04/02 09:50	JKH

U - Not detected above the MDL
J - Analyte detected below the PQL
* - Result is greater than the associated action level
B - Analyte detected in the associated Method Blank
E - Result is outside of quantitation range
S -Results outside normal recovery limits
R - RPD outside normal precision limits

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October 25, 2002

CANYON FUEL CO., SKYLINE MINES
HC 35 P.O. Box 380
Helper, Utah 84526

Sample identification by
Skyline

ID:MC-4

Kind of sample reported to us Water

Sample taken at Skyline Mine

Sample taken by E. Peterson

Date sampled October 17, 2002

Date received October 17, 2002

RECEIVED 1650
SAMPLED 1255

FIELD MEASUREMENTS

TEMP	15.2	COND	681
pH	8.95	TURB	6

NOTES:

Page 1 of 1

Analysis report no. 59-24667

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Solids, Total Dissolved	489	10	mg/l	EPA 160.1	10-23-2002 1015 BLP
Solids, Total Suspended	5	5	mg/l	EPA 160.2	10-23-2002 1015 BLP

FAXED 10-31-02

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Huntington Laboratory

MEMBER ACIL

Mountain States Analytical, LLC

Analytical Report

1645 West 2200 South · Salt Lake City, Utah 84119 · 800-973-6724

Client:	Mr. Chris Hansen	**Report Number:**	0212012-1
	Canyon Fuel Company, LLC	**Date Reported:**	12/10/02
	Skyline Mines	**Work Order:**	0212012
	HC 35 Box 380	**Lab Sample ID:**	0212012-04A
	Helper, UT 84526	**Client Sample ID:**	MC-4
	(435) 448-6463	**Date Collected:**	11/29/02
Project:	4th Qtr Sampling	**Date Received:**	12/03/02 09:00
Project ID:		**Matrix:**	Water
Purchase Order:		**COC ID:**	26073

Parameter	Result	MDL	PQL	Units	DF	Date Analyzed	Analyst
EPA 365.3: Phosphorus, Total as P, Water							
Phosphorus, total	U	0.02	0.1	mg/L	1	12/04/02 09:50	JKH

U - Not detected above the MDL
J - Analyte detected below the PQL
* - Result is greater than the associated action level
B - Analyte detected in the associated Method Blank
E - Result is outside of quantitation range
S -Results outside normal recovery limits
R - RPD outside normal precision limits

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October 25, 2002

CANYON FUEL CO., SKYLINE MINES
HC 35 P.O. Box 380
Helper, Utah 84526

Sample identification by
Skyline

ID:MC-5

Kind of sample reported to us Water

RECEIVED 1650
SAMPLED 1425

FIELD MEASUREMENTS

TEMP	10.8	COND	575
pH	8.23	TURB	44

Sample taken at Skyline Mine

Sample taken by E. Peterson

NOTES:

Date sampled October 17, 2002

Date received October 17, 2002

Analysis report no. 59-24668

Parameter	Result	MRL	Units	Method	Analyzed Date/Time/Analyst
Solids, Total Dissolved	367	10	mg/l	EPA 160.1	10-23-2002 1015 BLP
Solids, Total Suspended	60	5	mg/l	EPA 160.2	10-23-2002 1015 BLP

FAXED 10-31-02

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Huntington Laboratory

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F-465
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TERMS AND CONDITIONS ON REVERSE

Mountain States Analytical, LLC

Analytical Report

1645 West 2200 South · Salt Lake City, Utah 84119 · 800-973-6724

Client:	Mr. Chris Hansen	**Report Number:**	0212012-1
	Canyon Fuel Company, LLC	**Date Reported:**	12/10/02
	Skyline Mines	**Work Order:**	0212012
	HC 35 Box 380	**Lab Sample ID:**	0212012-05A
	Helper, UT 84526	**Client Sample ID:**	MC-5
	(435) 448-6463	**Date Collected:**	11/29/02
Project:	4th Qtr Sampling	**Date Received:**	12/03/02 09:00
Project ID:		**Matrix:**	Water
Purchase Order:		**COC ID:**	26073

Parameter	Result	MDL	PQL	Units	DF	Date Analyzed	Analyst
EPA 365.3: Phosphorus, Total as P, Water							
Phosphorus, total	0.034 J	0.02	0.1	mg/L	1	12/04/02 09:50	JKH

U - Not detected above the MDL
J - Analyte detected below the PQL
* - Result is greater than the associated action level
B - Analyte detected in the associated Method Blank
E - Result is outside of quantitation range
S -Results outside normal recovery limits
R - RPD outside normal precision limits

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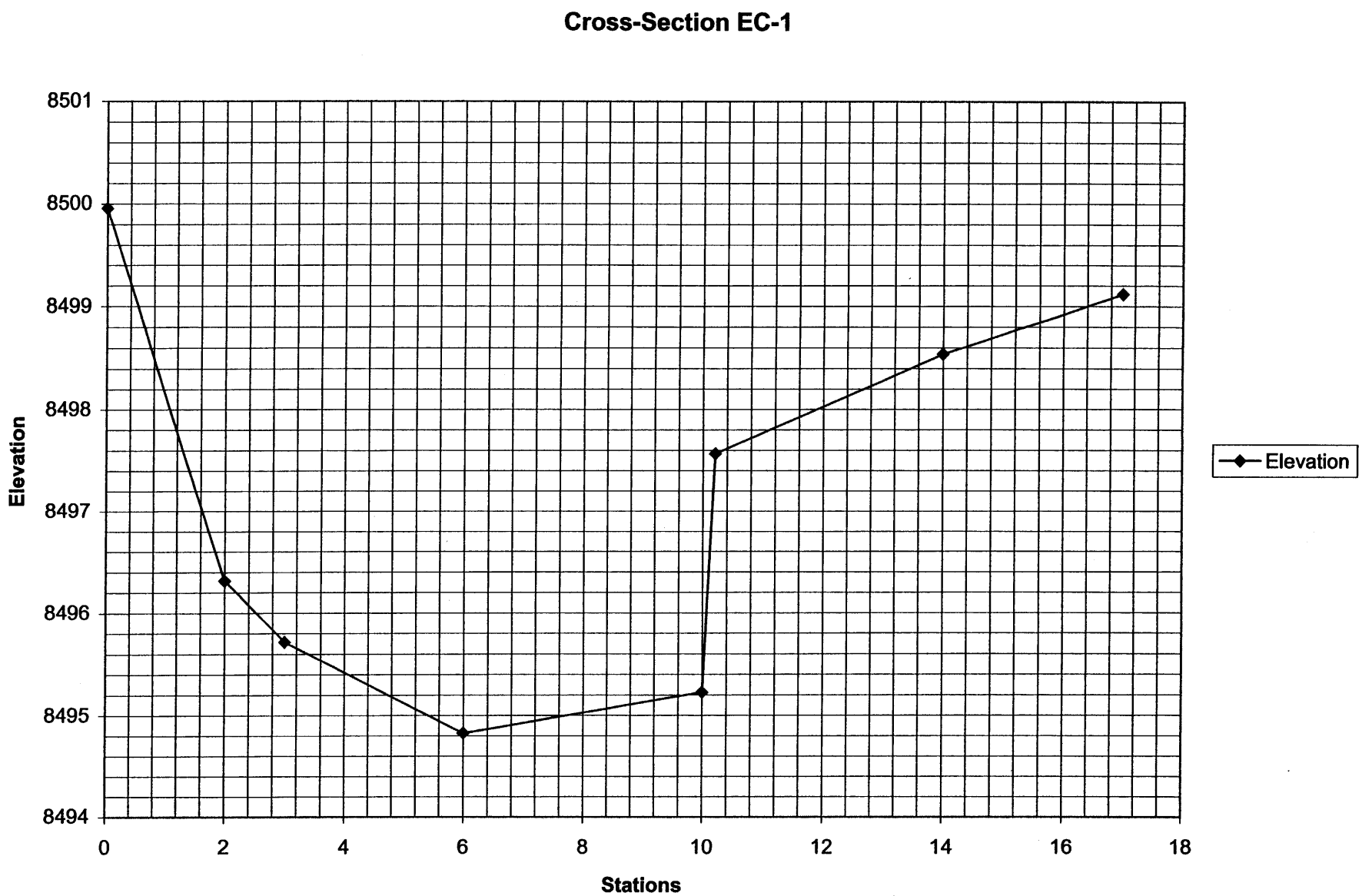
APPENDIX E

Channel Cross-Section and Profile Plots

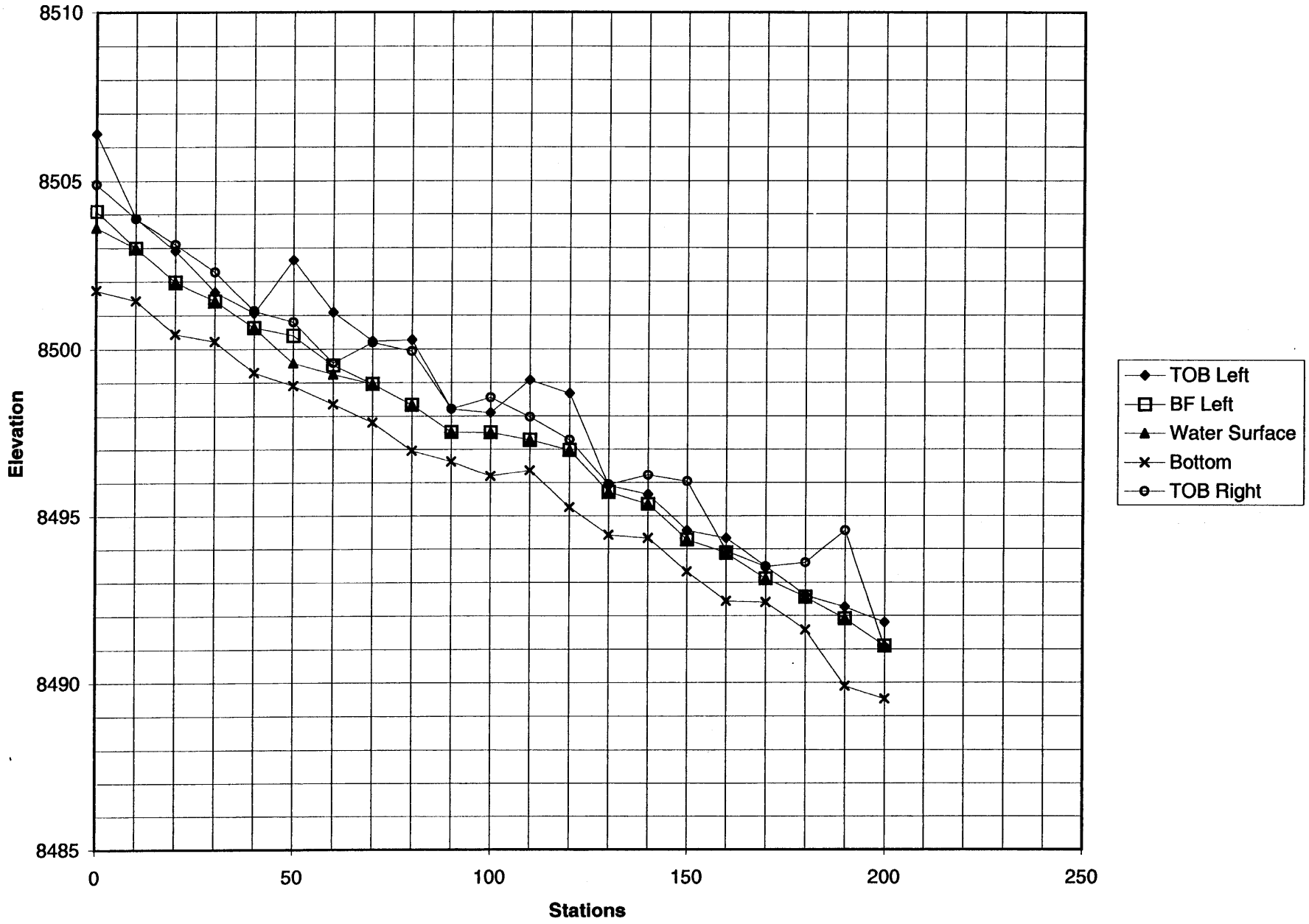

Cross-Section EC-1
8501
8500
8499
8498
8497
8496
8495
8494
Elevation
0
2
4
6
8
10
12
14
16
18
Stations
Elevation

Cross Section: EC-1 Elev: 8499.127

BenchMark1: 7.43

Station	Rod Reading	Elevation	El Change Ft	Distance Ft	Slope Degrees
0	6.6	8499.957			
2	10.24	8496.317	3.64	2	61
3	10.84	8495.717	0.6	1	31
6	11.73	8494.827	0.89	3	17
10	11.33	8495.227	-0.4	4	-6
10.2	8.99	8497.567	-2.34	0.2	-85
14	8.02	8498.537	-0.97	3.8	-14
17	7.44	8499.117	-0.58	3	-11

Profile EC-1


8510
8505
8500
8495
8490
8485
Elevation
0
50
100
150
200
250
Stations
TOB Left
BF Left
Water Surface
Bottom
TOB Right

Profile: EC-1 BenchMark Elev: 8499.127

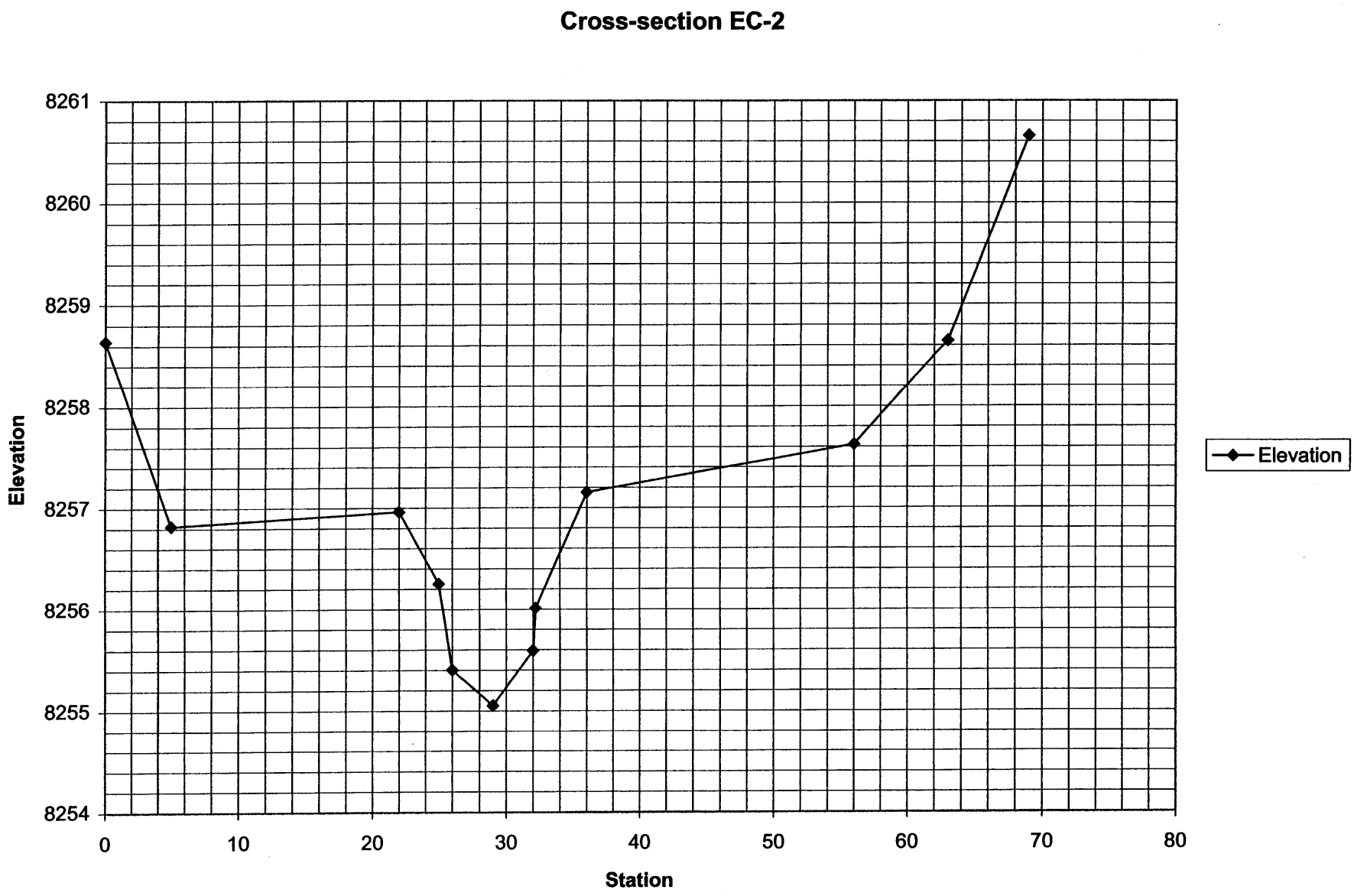
BenchMark1: 7.32 BenchMark2: 1.55

Station	TOB Left		BF Left		Water Surface		Bottom		TOB Right	
	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation
0	0.05	8506.397	2.35	8504.097	2.85	8503.597	4.7	8501.747	1.55	8504.897
10	2.57	8503.877	3.45	8502.997	3.45	8502.997	5.01	8501.437	2.58	8503.867
20	3.53	8502.917	4.47	8501.977	4.47	8501.977	6.01	8500.437	3.34	8503.107
30	4.76	8501.687	5.02	8501.427	5.02	8501.427	6.22	8500.227	4.17	8502.277
40	5.38	8501.067	5.82	8500.627	5.82	8500.627	7.15	8499.297	5.32	8501.127
50	3.82	8502.627	6.05	8500.397	6.87	8499.577	7.54	8498.907	5.65	8500.797
60	5.36	8501.087	6.93	8499.517	7.2	8499.247	8.09	8498.357	6.86	8499.587
70	6.21	8500.237	7.48	8498.967	7.48	8498.967	8.64	8497.807	6.25	8500.197
80	6.18	8500.267	8.11	8498.337	8.11	8498.337	9.49	8496.957	6.51	8499.937
New Bench Mark										
90	2.47	8498.207	3.16	8497.517	3.16	8497.517	4.04	8496.637	2.46	8498.217
100	2.58	8498.097	3.17	8497.507	3.17	8497.507	4.48	8496.197	2.12	8498.557
110	1.61	8499.067	3.4	8497.277	3.4	8497.277	4.31	8496.367	2.71	8497.967
120	2	8498.677	3.7	8496.977	3.7	8496.977	5.42	8495.257	3.4	8497.277
130	4.77	8495.907	4.96	8495.717	4.96	8495.717	6.26	8494.417	4.73	8495.947
140	5.03	8495.647	5.32	8495.357	5.32	8495.357	6.35	8494.327	4.45	8496.227
150	6.12	8494.557	6.4	8494.277	6.4	8494.277	7.35	8493.327	4.64	8496.037
160	6.35	8494.327	6.79	8493.887	6.79	8493.887	8.23	8492.447	6.73	8493.947
170	7.19	8493.487	7.56	8493.117	7.56	8493.117	8.27	8492.407	7.2	8493.477
180	8.06	8492.617	8.11	8492.567	8.11	8492.567	9.1	8491.577	7.08	8493.597
190	8.41	8492.267	8.76	8491.917	8.76	8491.917	10.78	8489.897	6.12	8494.557
200	8.88	8491.797	9.58	8491.097	9.58	8491.097	11.17	8489.507	9.64	8491.037

Max. Slope: 9.5 degrees

Min. Slope: -1.0 degrees

Ave Slope: 3.5 degrees

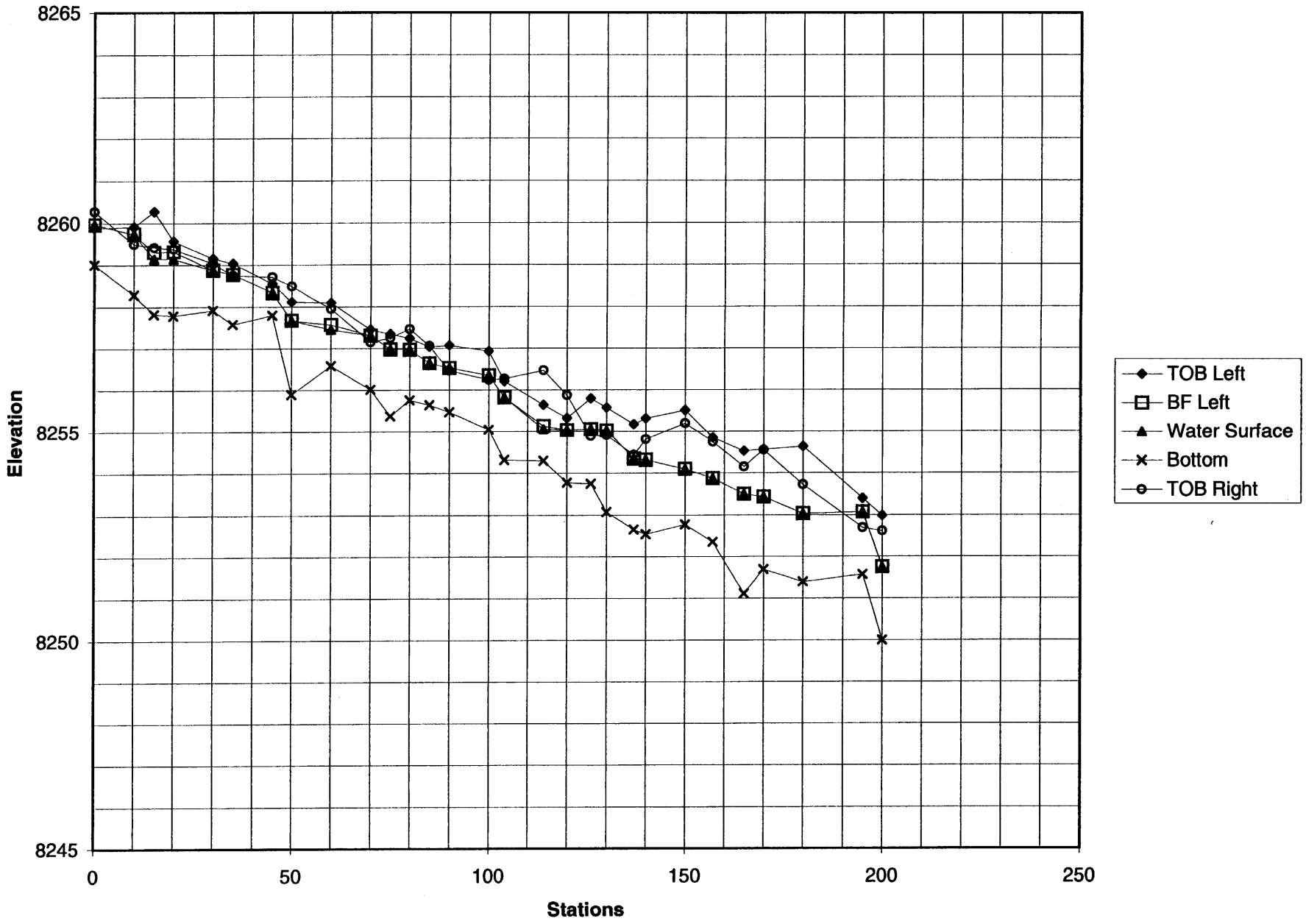

Cross-section EC-2
8261
8260
8259
8258
8257
8256
8255
8254
Elevation
0
10
20
30
40
50
60
70
80
Station
Elevation

Cross Section: EC-2 Elev: 8257.723

BenchMark1: 5.53

Station	Rod Reading	Elevation	El Change Ft	Distance Ft	Slope Degrees
0	4.61	8258.643			
5	6.43	8256.823	1.82	5	20
22	6.29	8256.963	-0.14	17	0
25	7	8256.253	0.71	3	13
26	7.85	8255.403	0.85	1	40
29	8.2	8255.053	0.35	3	7
32	7.66	8255.593	-0.54	3	-10
32.2	7.24	8256.013	-0.42	0.2	-65
36	6.1	8257.153	-1.14	3.8	-17
56	5.63	8257.623	-0.47	20	-1
63	4.61	8258.643	-1.02	7	-8
69	2.6	8260.653	-2.01	6	-19

Profile EC-2


8265
8260
8255
8250
8245
Elevation
0
50
100
150
200
250
Stations
TOB Left
BF Left
Water Surface
Bottom
TOB Right

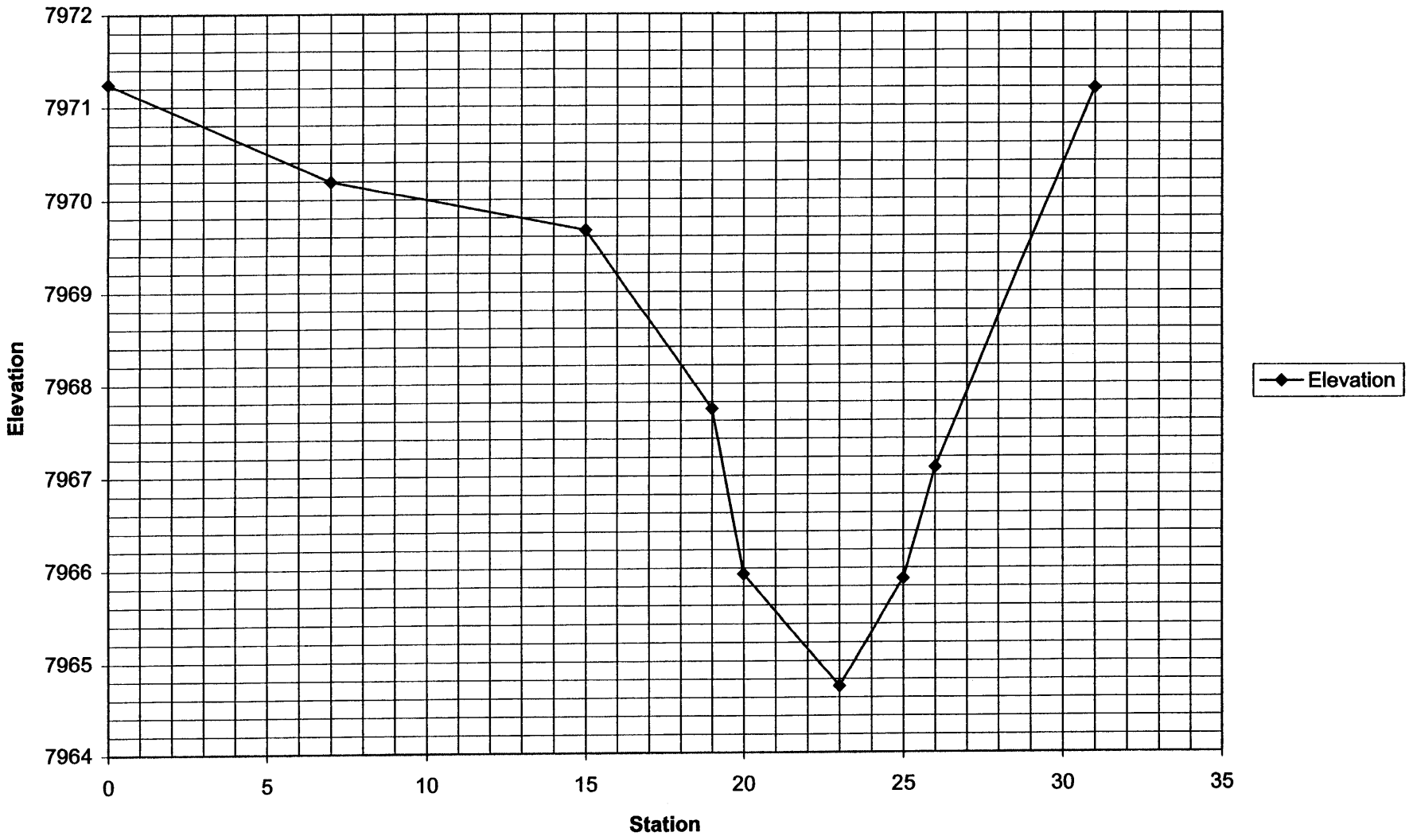
Profile: EC-2 BenchMark Elev: 8257.723

BenchMark1: 5.53

Station	TOB Left		BF Left		Water Surface		Bottom		TOB Right	
	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation
0	3.37	8259.883	3.28	8259.973	3.28	8259.973	4.25	8259.003	2.97	8260.283
10	3.34	8259.913	3.51	8259.743	3.51	8259.743	4.96	8258.293	3.75	8259.503
15	2.98	8260.273	3.95	8259.303	4.11	8259.143	5.43	8257.823	3.83	8259.423
20	3.68	8259.573	3.93	8259.323	4.11	8259.143	5.46	8257.793	3.87	8259.383
30	4.1	8259.153	4.38	8258.873	4.38	8258.873	5.33	8257.923	4.22	8259.033
35	4.22	8259.033	4.48	8258.773	4.48	8258.773	5.67	8257.583	4.5	8258.753
45	4.7	8258.553	4.91	8258.343	4.91	8258.343	5.45	8257.803	4.54	8258.713
50	5.13	8258.123	5.58	8257.673	5.58	8257.673	7.36	8255.893	4.76	8258.493
60	5.15	8258.103	5.68	8257.573	5.8	8257.453	6.67	8256.583	5.3	8257.953
70	5.8	8257.453	5.94	8257.313	5.94	8257.313	7.24	8256.013	6.1	8257.153
75	5.91	8257.343	6.27	8256.983	6.27	8256.983	7.88	8255.373	6	8257.253
80	6.01	8257.243	6.28	8256.973	6.28	8256.973	7.5	8255.753	5.79	8257.463
85	6.21	8257.043	6.61	8256.643	6.61	8256.643	7.61	8255.643	6.19	8257.063
90	6.18	8257.073	6.72	8256.533	6.72	8256.533	7.78	8255.473	6.79	8256.463
100	6.32	8256.933	6.9	8256.353	6.9	8256.353	8.21	8255.043	7.01	8256.243
104	7.04	8256.213	7.43	8255.823	7.43	8255.823	8.94	8254.313	6.98	8256.273
114	7.61	8255.643	8.12	8255.133	8.2	8255.053	8.96	8254.293	6.78	8256.473
120	7.93	8255.323	8.22	8255.033	8.22	8255.033	9.48	8253.773	7.38	8255.873
126	7.46	8255.793	8.2	8255.053	8.2	8255.053	9.51	8253.743	8.37	8254.883
130	7.68	8255.573	8.23	8255.023	8.23	8255.023	10.18	8253.073	8.35	8254.903
137	8.08	8255.173	8.91	8254.343	8.91	8254.343	10.6	8252.653	8.82	8254.433
140	7.94	8255.313	8.94	8254.313	8.94	8254.313	10.71	8252.543	8.45	8254.803
150	7.74	8255.513	9.16	8254.093	9.16	8254.093	10.48	8252.773	8.06	8255.193
157	8.41	8254.843	9.38	8253.873	9.38	8253.873	10.9	8252.353	8.51	8254.743
165	8.73	8254.523	9.75	8253.503	9.75	8253.503	12.14	8251.113	9.1	8254.153
170	8.69	8254.563	9.82	8253.433	9.82	8253.433	11.56	8251.693	8.71	8254.543
180	8.62	8254.633	10.22	8253.033	10.22	8253.033	11.86	8251.393	9.53	8253.723
195	9.86	8253.393	10.18	8253.073	10.18	8253.073	11.68	8251.573	10.56	8252.693
200	10.27	8252.983	11.5	8251.753	11.5	8251.753	13.25	8250.003	10.64	8252.613

Max. Slope: 17.4 degrees
Min. Slope: -6.6 degrees
Ave Slope: 2.9 degrees

Cross-section EC-3

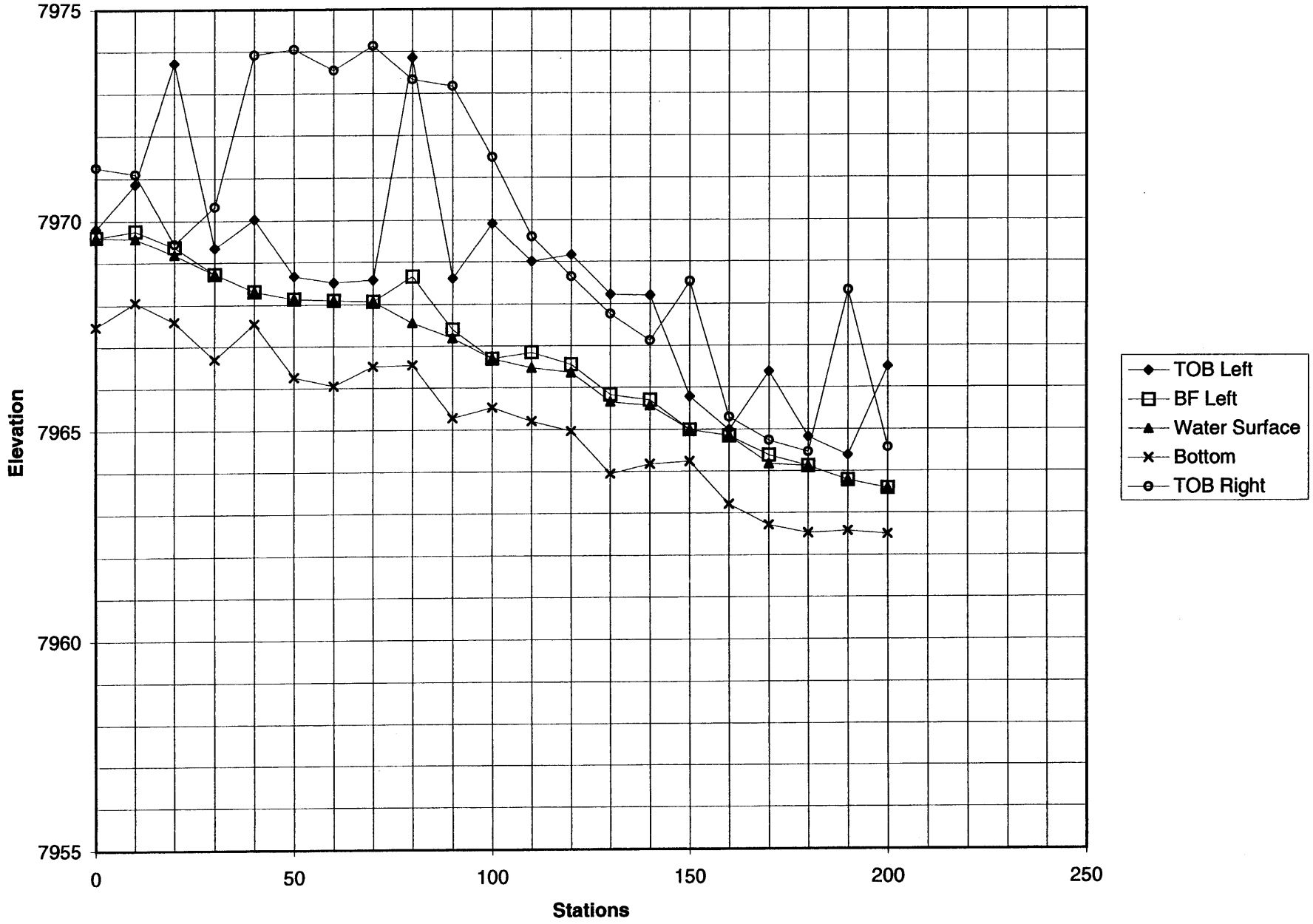


Cross Section: EC-3 Elev: 7971.594

BenchMark1: 1.99

Station	Rod Reading	Elevation	El Change Ft	Distance Ft	Slope Degrees
0	2.34	7971.244			
7	3.39	7970.194	1.05	7	9
15	3.92	7969.664	0.53	8	4
19	5.86	7967.724	1.94	4	26
20	7.65	7965.934	1.79	1	61
23	8.86	7964.724	1.21	3	22
25	7.7	7965.884	-1.16	2	-30
26	6.5	7967.084	-1.2	1	-50
31	2.4	7971.184	-4.1	5	-39

Profile EC-3


7975
7970
7965
7960
7955
Elevation
0
50
100
150
200
250
Stations
TOB Left
BF Left
Water Surface
Bottom
TOB Right

Profile: EC-3 BenchMark Elev: 7971.594

BenchMark1: 4.96 BenchMark2: 1.99

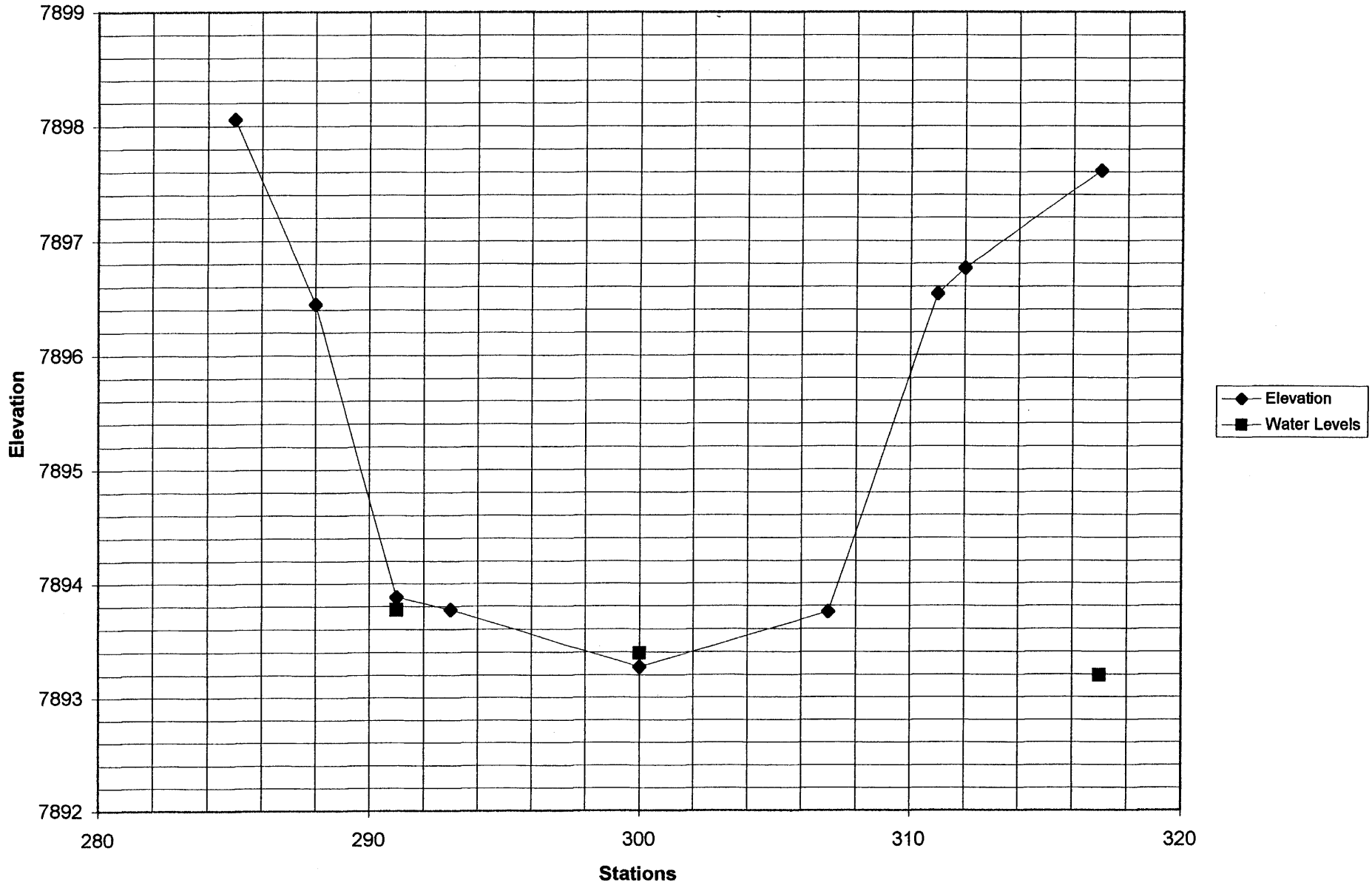
Station	TOB Left		BF Left		Water Surface		Bottom		TOB Right	
	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation
0	6.75	7969.804	6.95	7969.604	6.95	7969.604	9.08	7967.474	5.3	7971.254
10	5.7	7970.854	6.8	7969.754	6.98	7969.574	8.49	7968.064	5.46	7971.094
20	2.83	7973.724	7.18	7969.374	7.37	7969.184	8.96	7967.594	7.11	7969.444
30	7.21	7969.344	7.83	7968.724	7.83	7968.724	9.86	7966.694	6.23	7970.324
40	6.53	7970.024	8.24	7968.314	8.24	7968.314	9.01	7967.544	2.63	7973.924
50	7.89	7968.664	8.41	7968.144	8.41	7968.144	10.29	7966.264	2.5	7974.054
60	8.04	7968.514	8.45	7968.104	8.45	7968.104	10.5	7966.054	3	7973.554
70	7.98	7968.574	8.48	7968.074	8.48	7968.074	10.04	7966.514	2.42	7974.134
80	2.7	7973.854	7.9	7968.654	9	7967.554	10.01	7966.544	3.22	7973.334
90	7.95	7968.604	9.16	7967.394	9.36	7967.194	11.27	7965.284	3.38	7973.174
100	6.64	7969.914	9.86	7966.694	9.86	7966.694	11.02	7965.534	5.07	7971.484
110	7.55	7969.004	9.71	7966.844	10.08	7966.474	11.35	7965.204	6.95	7969.604
120	7.39	7969.164	10	7966.554	10.19	7966.364	11.59	7964.964	7.91	7968.644
130	8.33	7968.224	10.72	7965.834	10.89	7965.664	12.61	7963.944	8.79	7967.764
140	8.35	7968.204	10.85	7965.704	10.98	7965.574	12.38	7964.174	9.43	7967.124
New Bench Mark										
150	7.8	7965.784	8.59	7964.994	8.59	7964.994	9.35	7964.234	5.06	7968.524
160	8.59	7964.994	8.74	7964.844	8.74	7964.844	10.37	7963.214	8.29	7965.294
170	7.21	7966.374	9.21	7964.374	9.41	7964.174	10.87	7962.714	8.85	7964.734
180	8.77	7964.814	9.46	7964.124	9.46	7964.124	11.06	7962.524	9.13	7964.454
190	9.21	7964.374	9.8	7963.784	9.8	7963.784	11.01	7962.574	5.27	7968.314
200	7.09	7966.494	9.99	7963.594	9.99	7963.594	11.09	7962.494	9.02	7964.564

Max. Slope: 7.3 degrees

Min. Slope: -4.9 degrees

Ave Slope: 1.4 degrees

Cross-Section MC-1

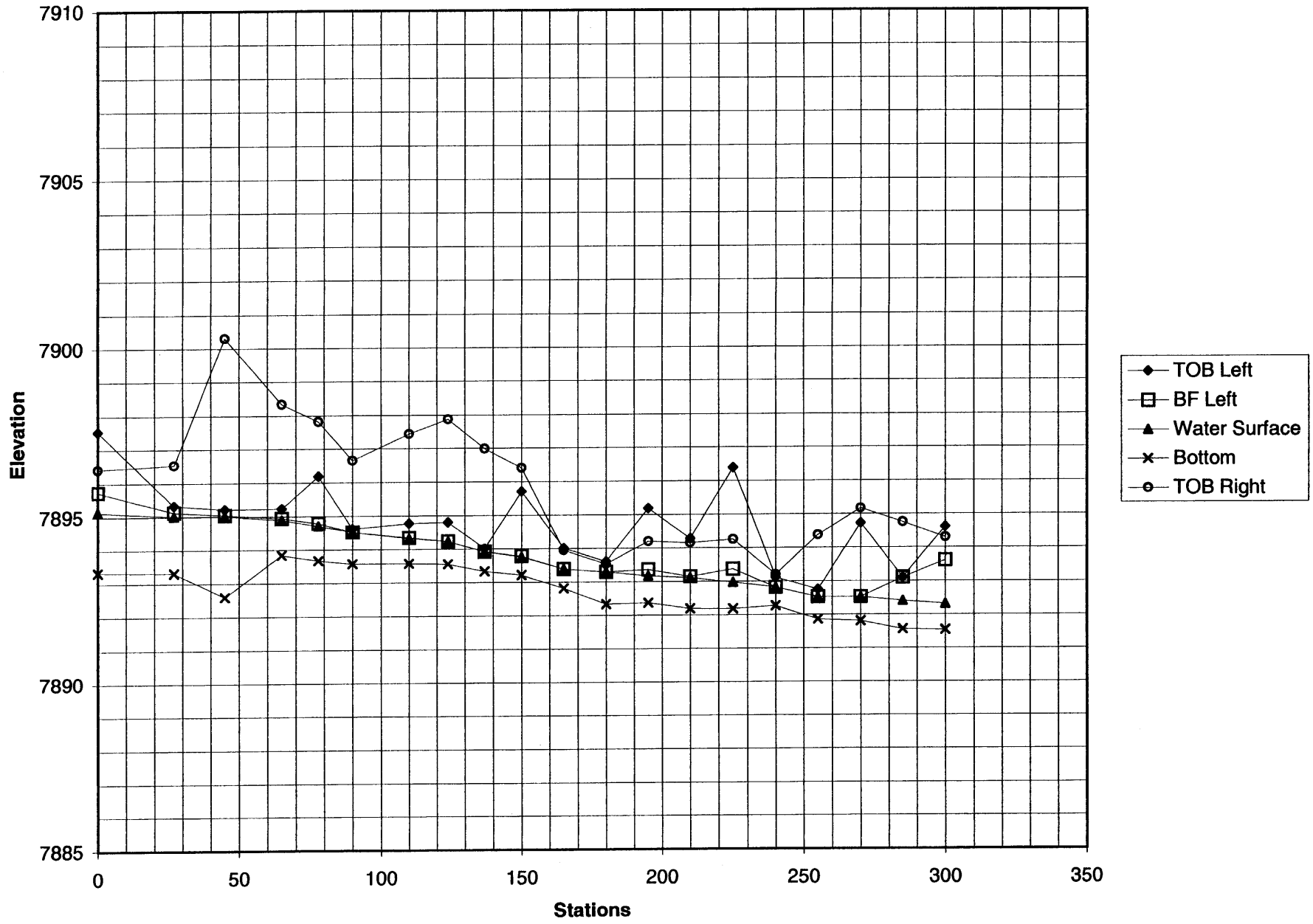


Cross Section: MC-1 Elev: 7898.53

BenchMark1: 0.74

Station	Adj. Station	Rod Reading	Elevation	Water Levels	Well I.D.s	El Change Ft	Distance Ft	Slope Degrees
0	285	1.21	7898.06					
3	288	2.82	7896.45			1.61	3	28
6	291	5.39	7893.88	7893.77	1a	2.57	3	41
8	293	5.5	7893.77			0.11	2	3
15	300	6	7893.27	7893.39		0.5	7	4
22	307	5.52	7893.75			-0.48	7	-4
26	311	2.73	7896.54			-2.79	4	-35
27	312	2.51	7896.76			-0.22	1	-12
32	317	1.66	7897.61	7893.19	1b	-0.85	5	-10

Profile MC-1


7910
7905
7900
7895
7890
7885
Elevation
0
50
100
150
200
250
300
350
Stations
TOB Left
BF Left
Water Surface
Bottom
TOB Right

Profile: MC-1 BenchMark Elev: 7898.53

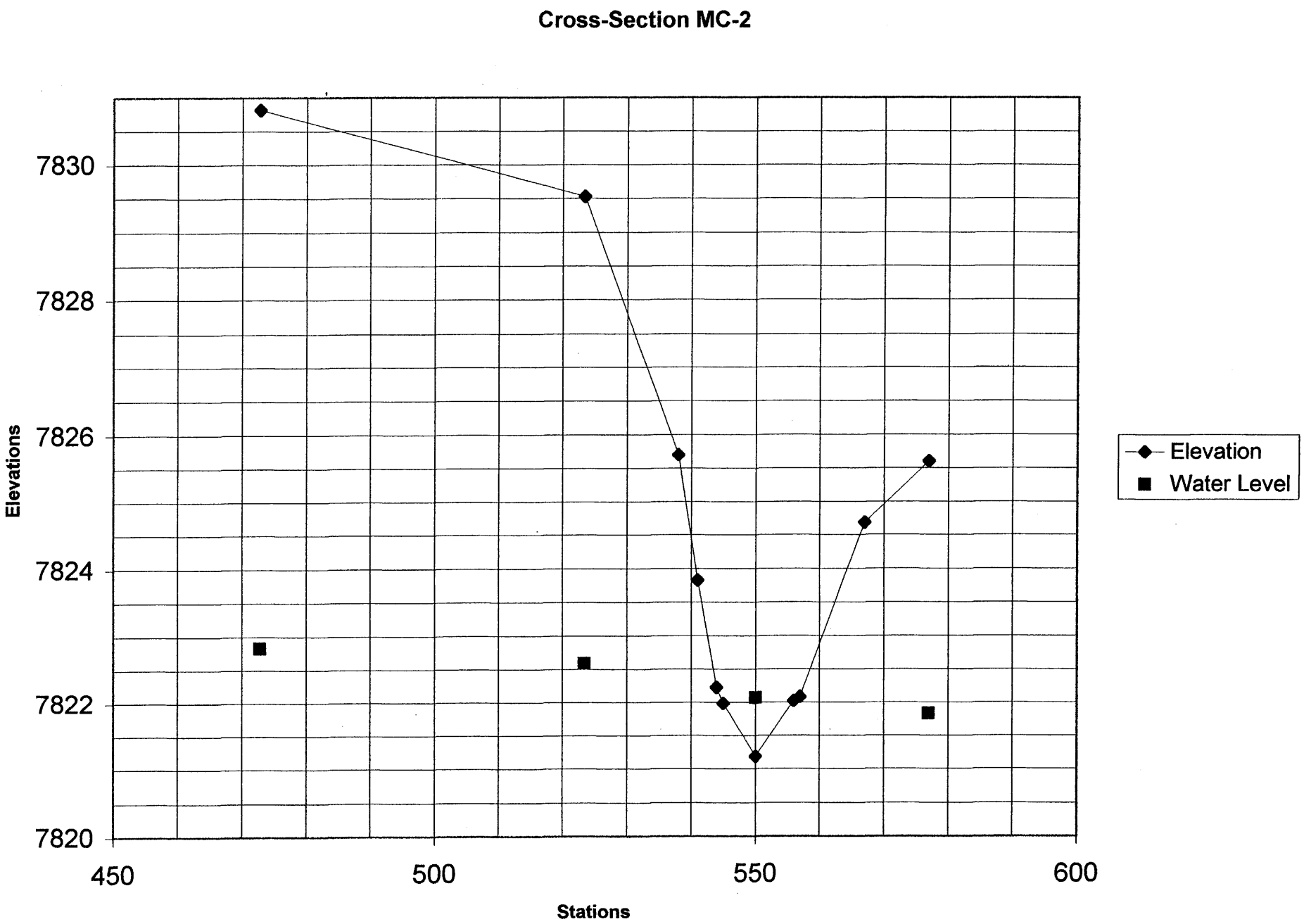
BenchMark: 0.74

Station	TOB Left Rod Reading	Elevation	BF Left Rod Reading	Elevation	Water Surface Rod Reading	Elevation	Bottom Rod Reading	Elevation	TOB Right Rod Reading	Elevation
0	1.73	7897.54	3.53	7895.74	4.13	7895.14	5.93	7893.34	2.85	7896.42
27	3.94	7895.33	4.14	7895.13	4.26	7895.01	5.95	7893.32	2.73	7896.54
45	4.05	7895.22	4.22	7895.05	4.26	7895.01	6.68	7892.59	-1.04	7900.31
65	4.04	7895.23	4.33	7894.94	4.38	7894.89	5.43	7893.84	0.93	7898.34
78	3.08	7896.19	4.48	7894.79	4.56	7894.71	5.6	7893.67	1.45	7897.82
90	4.65	7894.62	4.75	7894.52	4.75	7894.52	5.7	7893.57	2.61	7896.66
110	4.5	7894.77	4.93	7894.34	4.95	7894.32	5.7	7893.57	1.83	7897.44
124	4.47	7894.8	5.04	7894.23	5.04	7894.23	5.72	7893.55	1.39	7897.88
137	5.26	7894.01	5.35	7893.92	5.36	7893.91	5.94	7893.33	2.28	7896.99
150	3.56	7895.71	5.49	7893.78	5.51	7893.76	6.05	7893.22	2.86	7896.41
165	5.26	7894.01	5.88	7893.39	5.88	7893.39	6.46	7892.81	5.32	7893.95
180	5.66	7893.61	5.97	7893.3	5.97	7893.3	6.94	7892.33	5.74	7893.53
195	4.08	7895.19	5.91	7893.36	6.09	7893.18	6.9	7892.37	5.07	7894.2
210	4.99	7894.28	6.12	7893.15	6.15	7893.12	7.08	7892.19	5.12	7894.15
225	2.88	7896.39	5.9	7893.37	6.3	7892.97	7.09	7892.18	5.02	7894.25
240	6.15	7893.12	6.45	7892.82	6.45	7892.82	7	7892.27	6.07	7893.2
255	6.52	7892.75	6.75	7892.52	6.75	7892.52	7.41	7891.86	4.9	7894.37
270	4.55	7894.72	6.75	7892.52	6.75	7892.52	7.47	7891.8	4.1	7895.17
285	6.17	7893.1	6.17	7893.1	6.87	7892.4	7.71	7891.56	4.52	7894.75
300	4.66	7894.61	5.66	7893.61	6.96	7892.31	7.73	7891.54	4.98	7894.29

Max. Slope: 2.3 degrees

Min. Slope: -3.6 degrees

Ave Slope: 0.4 degrees

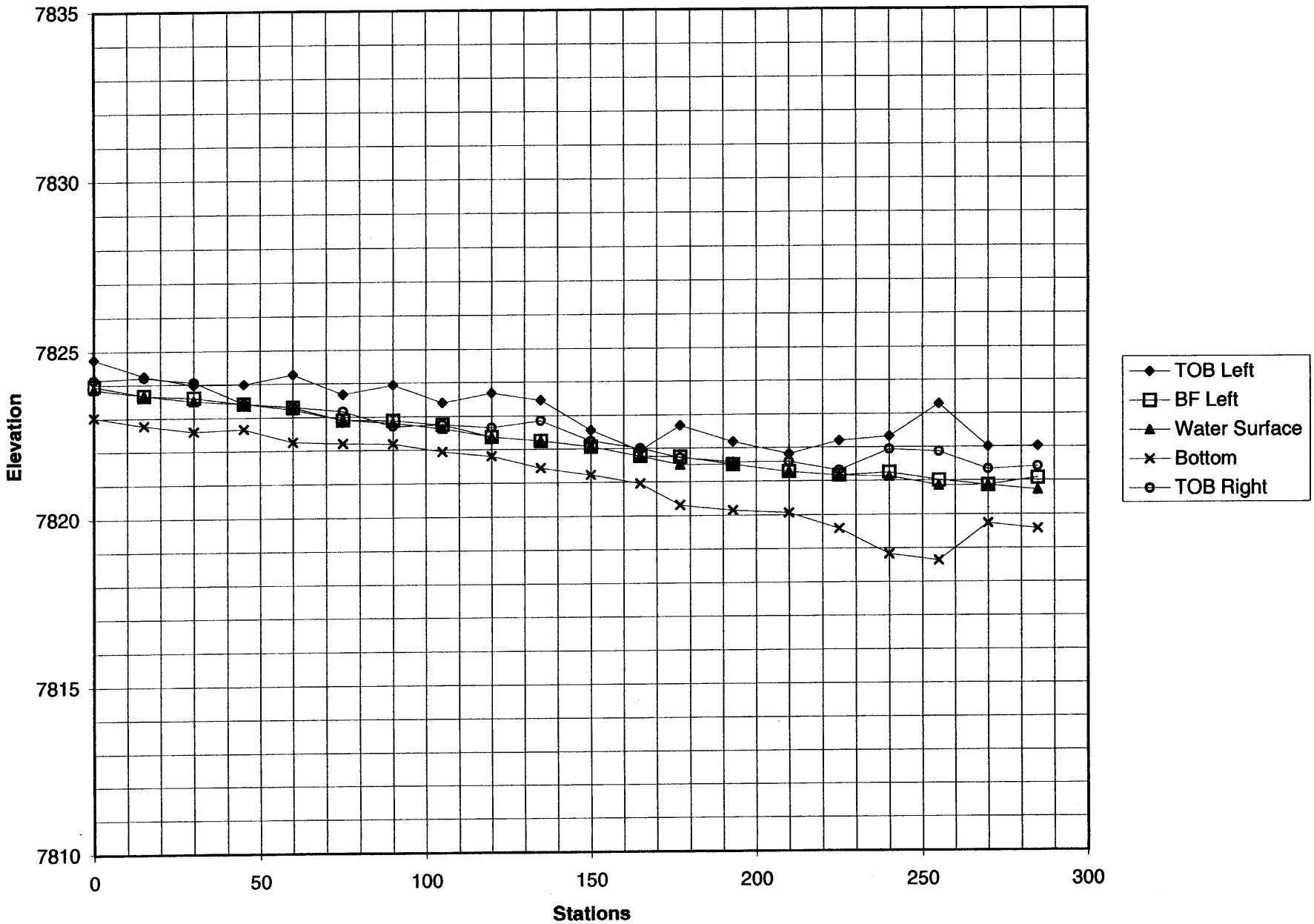

Cross-Section MC-2
7830
7828
7826
7824
7822
7820
Elevations
450
500
550
600
Stations
Elevation
Water Level

Cross Section: MC-2 Elev: 7827.037

BenchMark1: 5.34

Station	Adj. Station	Rod Reading	Elevation	Water Levels	Well I.D.s	El Change Ft	Distance Ft	Slope Degrees
-65.19	472.81		7830.82	7822.83	2c			
-14.6	523.4		7829.53	7822.59	2a	1.29	50.59	1
0	538	6.68	7825.697			3.833	14.6	15
3	541	8.55	7823.827			1.87	3	32
6	544	10.15	7822.227			1.6	3	28
7	545	10.39	7821.987			0.24	1	13
12	550	11.19	7821.187	7822.067		0.8	5	9
18	556	10.35	7822.027			-0.84	6	-8
19	557	10.29	7822.087			-0.06	1	-3
29	567	7.69	7824.687			-2.6	10	-15
39	577	6.78	7825.597	7821.83	2b	-0.91	10	-5

Profile MC-2

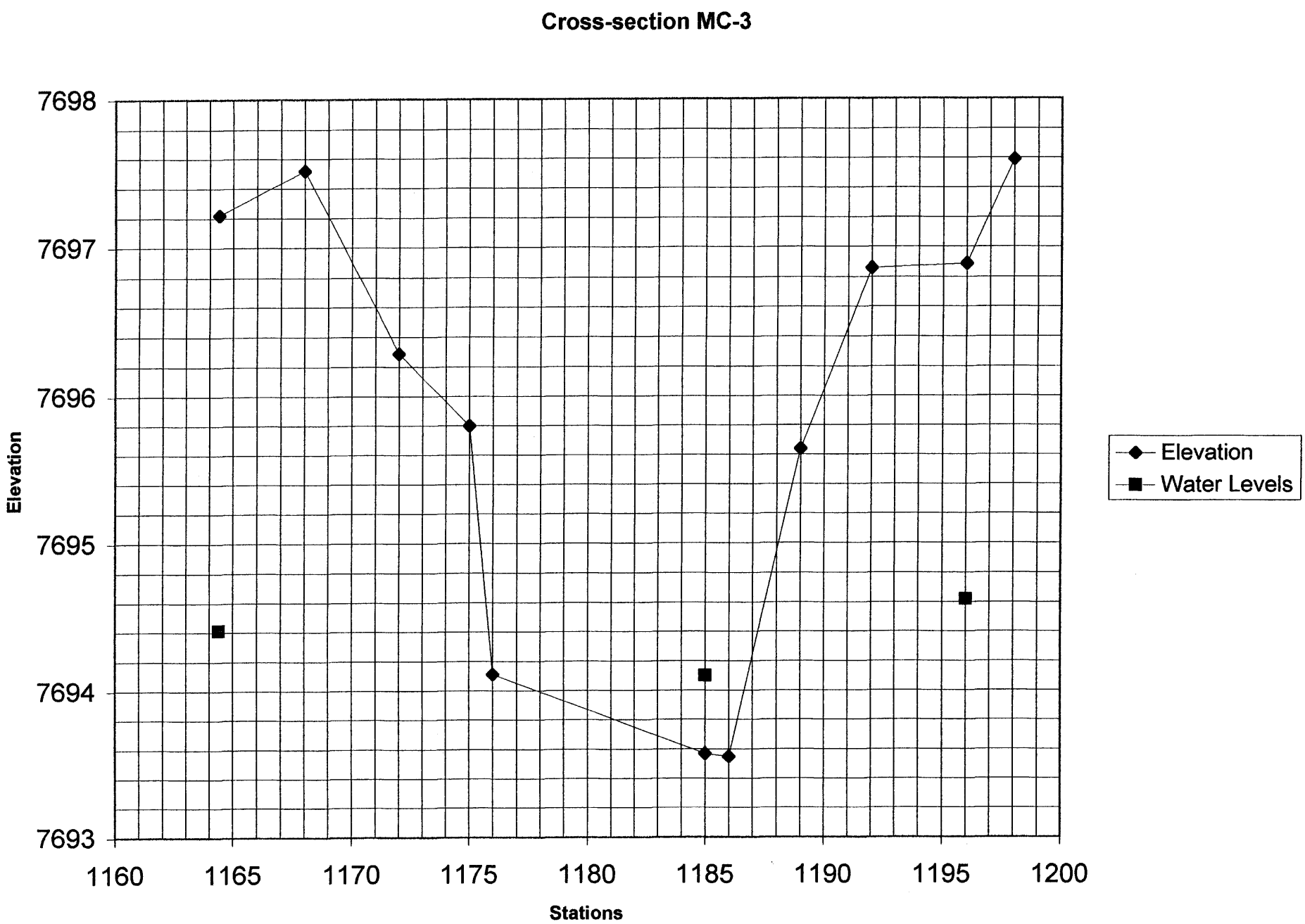

7835
7830
7825
7820
7815
7810
Elevation
0
50
100
150
200
250
300
Stations
TOB Left
BF Left
Water Surface
Bottom
TOB Right

Profile: MC-2 BenchMark Elev: 7827.037

BenchMark: 5.34

Station	TOB Left		BF Left		Water Surface		Bottom		TOB Right	
	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation
0	7.62	7824.757	8.42	7823.957	8.52	7823.857	9.35	7823.027	8.24	7824.137
15	8.13	7824.247	8.71	7823.667	8.71	7823.667	9.6	7822.777	8.17	7824.207
30	8.4	7823.977	8.78	7823.597	8.88	7823.497	9.78	7822.597	8.32	7824.057
45	8.39	7823.987	8.97	7823.407	8.97	7823.407	9.72	7822.657	8.96	7823.417
60	8.11	7824.267	9.08	7823.297	9.15	7823.227	10.12	7822.257	9.07	7823.307
75	8.71	7823.667	9.47	7822.907	9.47	7822.907	10.17	7822.207	9.21	7823.167
90	8.44	7823.937	9.49	7822.887	9.56	7822.817	10.19	7822.187	9.67	7822.707
105	8.98	7823.397	9.63	7822.747	9.74	7822.637	10.43	7821.947	9.62	7822.757
120	8.7	7823.677	10	7822.377	10	7822.377	10.57	7821.807	9.72	7822.657
135	8.92	7823.457	10.13	7822.247	10.13	7822.247	10.93	7821.447	9.53	7822.847
150	9.82	7822.557	10.31	7822.067	10.31	7822.067	11.15	7821.227	10.14	7822.237
165	10.44	7821.937	10.6	7821.777	10.6	7821.777	11.42	7820.957	10.37	7822.007
177	9.7	7822.677	10.63	7821.747	10.86	7821.517	12.06	7820.317	10.65	7821.727
193	10.19	7822.187	10.86	7821.517	10.86	7821.517	12.22	7820.157	10.79	7821.587
210	10.56	7821.817	11.09	7821.287	11.09	7821.287	12.31	7820.067	10.79	7821.587
225	10.18	7822.197	11.21	7821.167	11.21	7821.167	12.79	7819.587	11.05	7821.327
240	10.05	7822.327	11.12	7821.257	11.25	7821.127	13.55	7818.827	10.44	7821.937
255	9.09	7823.287	11.36	7821.017	11.52	7820.857	13.74	7818.637	10.51	7821.867
270	10.37	7822.007	11.51	7820.867	11.51	7820.867	12.64	7819.737	11.03	7821.347
285	10.35	7822.027	11.3	7821.077	11.65	7820.727	12.8	7819.577	10.95	7821.427

Max. Slope:	3.1 degrees
Min. Slope:	-4.2 degrees
Ave Slope:	0.7 degrees

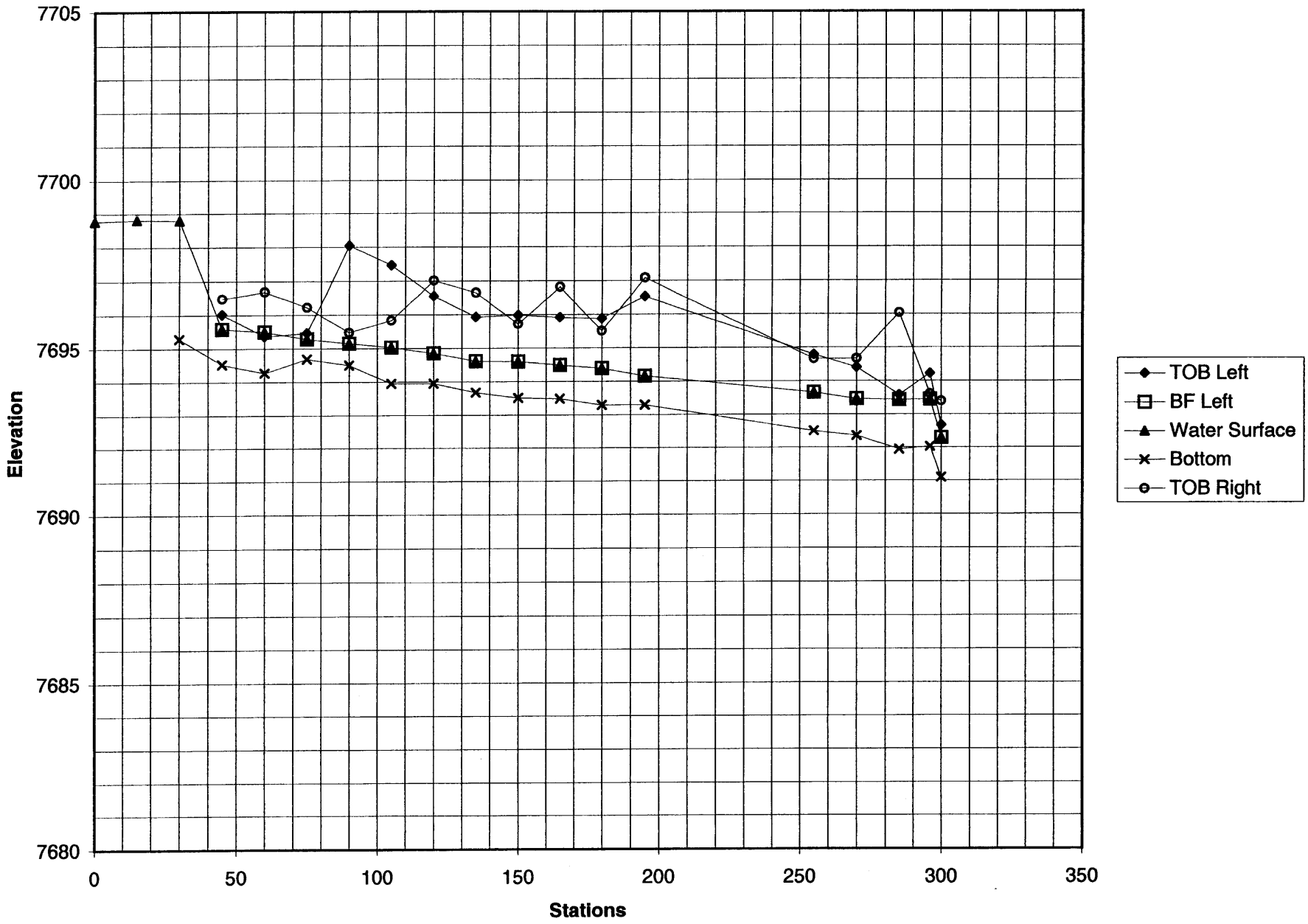

Cross-section MC-3
7698
7697
7696
7695
7694
7693
Elevation
1160
1165
1170
1175
1180
1185
1190
1195
1200
Stations
Elevation
Water Levels

Cross Section: MC-3 Elev: 7698.23

BenchMark1: 7.53

Station	Adj. Station	Rod Reading	Elevation	Water Levels	Well I.D.s	El Change Ft	Distance Ft	Slope Degrees
-3.6	1164.4		7697.22	7694.41	3b			
0	1168	8.24	7697.52			-0.3	3.6	-5
4	1172	9.47	7696.29			1.23	4	17
7	1175	9.96	7695.8			0.49	3	9
8	1176	11.65	7694.11			1.69	1	59
17	1185	12.19	7693.57	7694.1		0.54	9	3
18	1186	12.21	7693.55			0.02	1	1
21	1189	10.12	7695.64			-2.09	3	-35
24	1192	8.9	7696.86			-1.22	3	-22
28	1196	8.87	7696.89	7694.62	3a	-0.03	4	0
30	1198	8.17	7697.59			-0.7	2	-19

Profile MC-3


7705
7700
7695
7690
7685
7680
Elevation
0
50
100
150
200
250
300
350
Stations
TOB Left
BF Left
Water Surface
Bottom
TOB Right

Profile: MC-3 BenchMark Elev: 7698.232

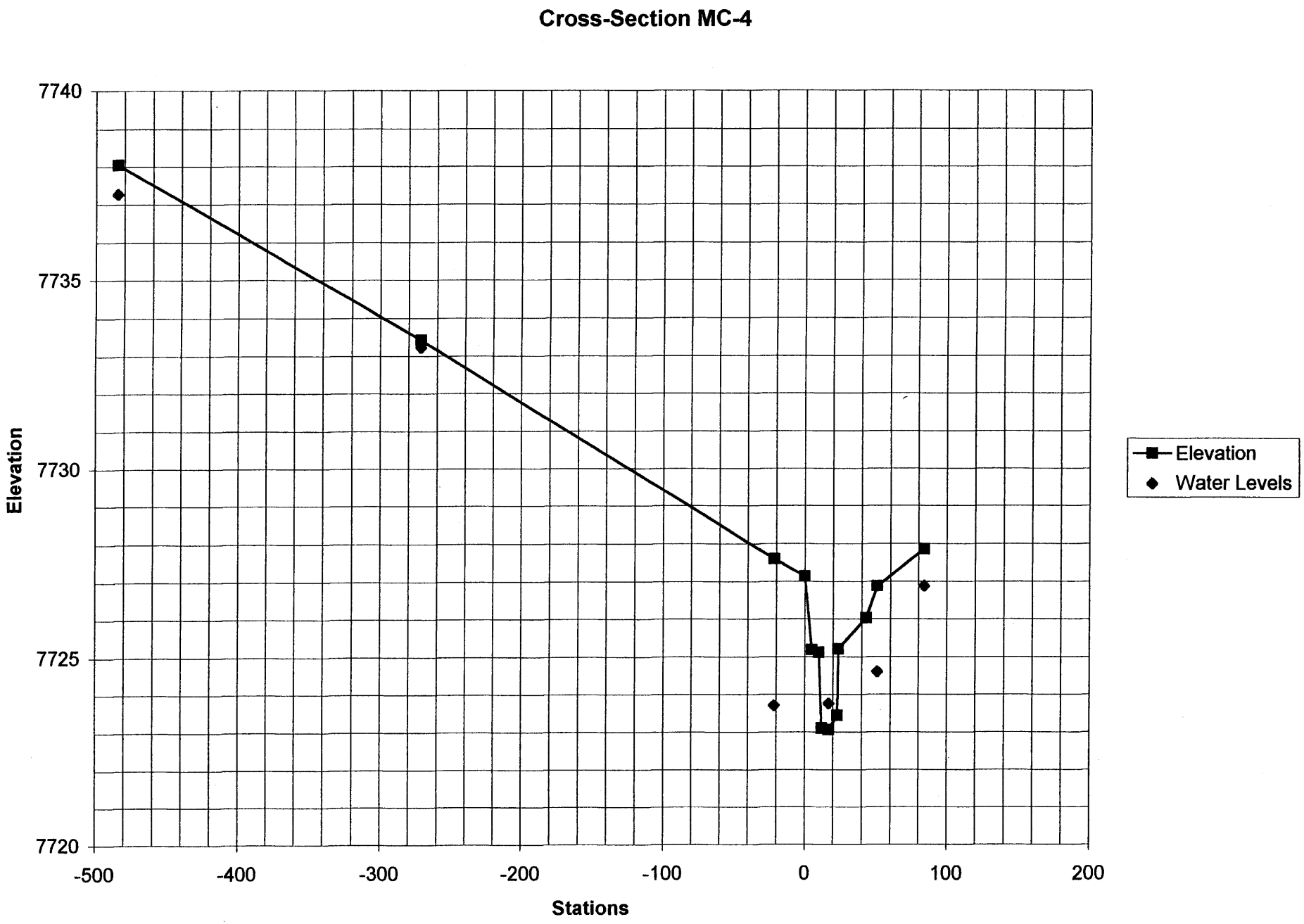
BenchMark: 7.53

Station	TOB Left Rod Reading	Elevation	BF Left Rod Reading	Elevation	Water Surface Rod Reading	Elevation	Bottom Rod Reading	Elevation	TOB Right Rod Reading	Elevation
0	-		-		6.99	7698.772	-		-	
15	-		-		6.95	7698.812	-		-	
30	-		-		6.97	7698.792	10.47	7695.292	-	
45	9.74	7696.022	10.18	7695.582	10.18	7695.582	11.23	7694.532	9.27	7696.492
60	10.4	7695.362	10.27	7695.492	10.27	7695.492	11.49	7694.272	9.07	7696.692
75	10.3	7695.462	10.48	7695.282	10.48	7695.282	11.08	7694.682	9.53	7696.232
90	7.72	7698.042	10.61	7695.152	10.61	7695.152	11.26	7694.502	10.29	7695.472
105	8.3	7697.462	10.73	7695.032	10.73	7695.032	11.81	7693.952	9.93	7695.832
120	9.2	7696.562	10.91	7694.852	10.91	7694.852	11.81	7693.952	8.75	7697.012
135	9.83	7695.932	11.15	7694.612	11.15	7694.612	12.09	7693.672	9.1	7696.662
150	9.77	7695.992	11.16	7694.602	11.16	7694.602	12.25	7693.512	10.04	7695.722
165	9.84	7695.922	11.27	7694.492	11.27	7694.492	12.28	7693.482	8.94	7696.822
180	9.88	7695.882	11.37	7694.392	11.37	7694.392	12.47	7693.292	10.25	7695.512
195	9.22	7696.542	11.6	7694.162	11.6	7694.162	12.47	7693.292	8.68	7697.082
255	10.97	7694.792	12.1	7693.662	12.1	7693.662	13.26	7692.502	11.1	7694.662
270	11.35	7694.412	12.3	7693.462	12.3	7693.462	13.41	7692.352	11.09	7694.672
285	12.18	7693.582	12.33	7693.432	12.33	7693.432	13.82	7691.942	9.72	7696.042
296	11.54	7694.222	12.31	7693.452	12.31	7693.452	13.74	7692.022	12.15	7693.612
300	13.09	7692.672	13.47	7692.292	13.47	7692.292	14.67	7691.092	12.37	7693.392

Max. Slope: 13.1 degrees

Min. Slope: -1.6 degrees

Ave Slope: 1.5 degrees

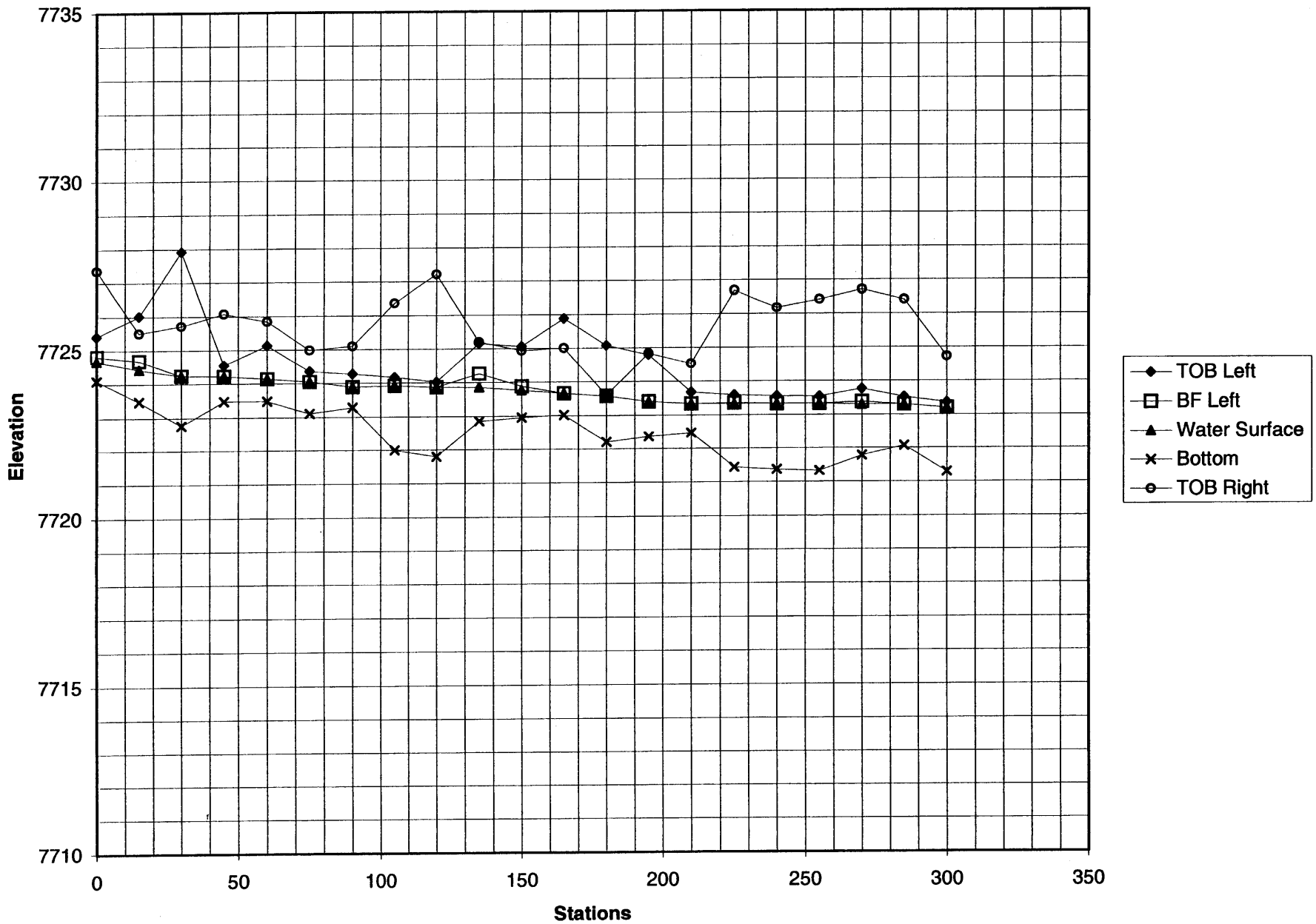

Cross-Section MC-4
7740
7735
7730
7725
7720
Elevation
-500
-400
-300
-200
-100
0
100
200
Stations
Elevation
Water Levels

Cross Section: MC-4 Elev.: 7728.638

BenchMark1: 4.24

Station		Rod Reading	Elevation	Water Levels	Well I.D.s	El Change Ft	Distance Ft	Slope Degrees
-484.65	338.35		7738.05	7737.28	4e			
-271.3	551.7		7733.41	7733.22	4d	4.64	213.35	1
-21.7	801.3		7727.6	7723.71	4c	5.81	249.6	1
0	823	5.73	7727.148			0.452	21.7	1
5	828	7.69	7725.188			1.96	5	21
10	833	7.76	7725.118			0.07	5	1
12	835	9.78	7723.098			2.02	2	45
17	840	9.82	7723.058	7723.76		0.04	5	0
23	846	9.44	7723.438			-0.38	6	-4
23.5	846.5	7.67	7725.208			-1.77	0.5	-74
43	866	6.85	7726.028			-0.82	19.5	-2
51	874	5.99	7726.888	7724.61	4b	-0.86	8	-6
83.94	906.94		7727.86	7726.89	4a	-0.972	32.94	-2

Profile MC-4


7735
7730
7725
7720
7715
7710
Elevation
0
50
100
150
200
250
300
350
Stations
TOB Left
BF Left
Water Surface
Bottom
TOB Right

Profile: MC-4 BenchMark Elev: 7728.638

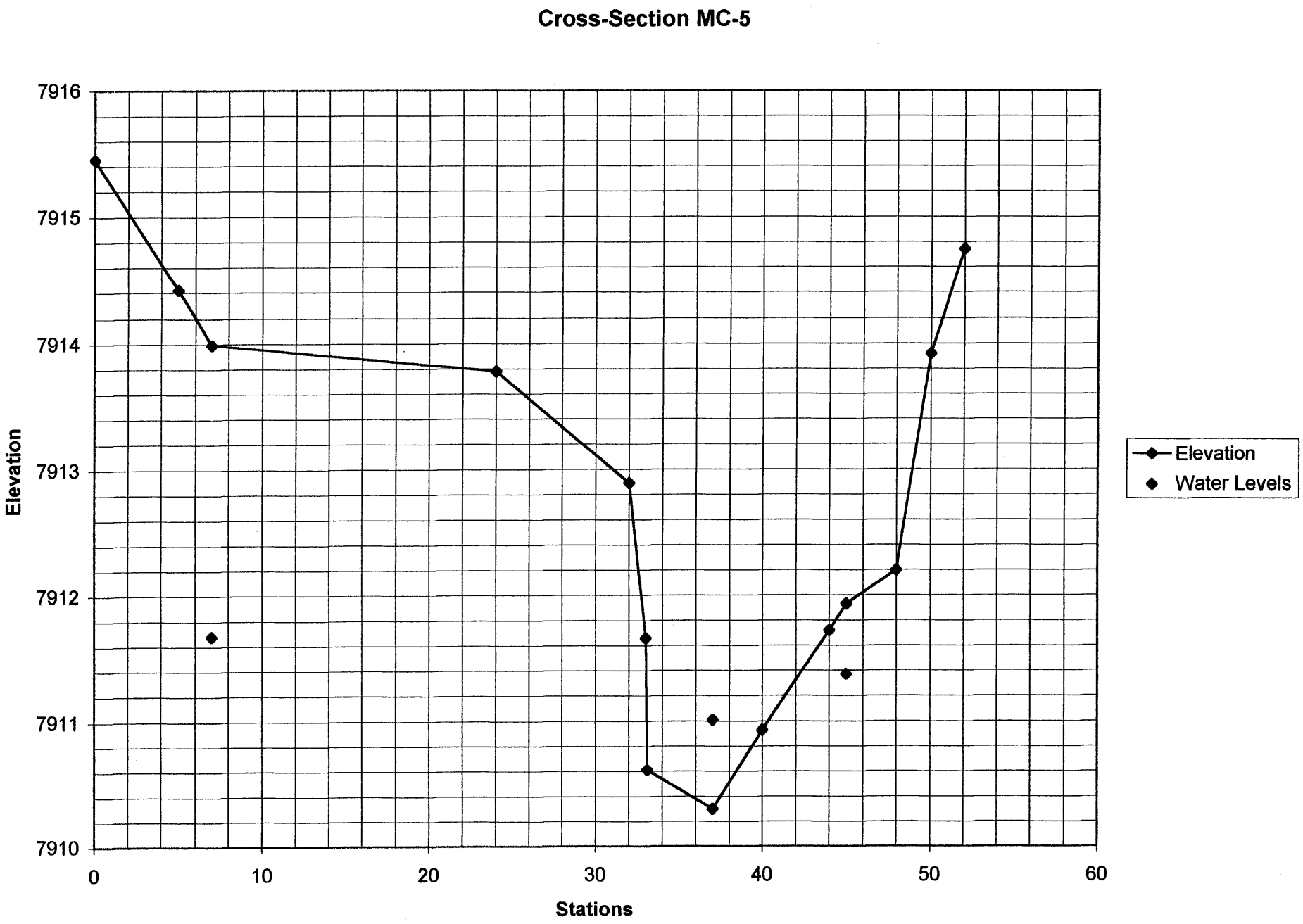
BenchMark: 4.24

Station	TOB Left		BF Left		Water Surface		Bottom		TOB Right	
	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation
0	7.46	7725.418	8.05	7724.828	8.2	7724.678	8.78	7724.098	5.52	7727.358
15	6.86	7726.018	8.19	7724.688	8.45	7724.428	9.4	7723.478	7.37	7725.508
30	4.96	7727.918	8.64	7724.238	8.64	7724.238	10.11	7722.768	7.16	7725.718
45	8.33	7724.548	8.65	7724.228	8.65	7724.228	9.4	7723.478	6.8	7726.078
60	7.75	7725.128	8.74	7724.138	8.74	7724.138	9.4	7723.478	7.03	7725.848
75	8.52	7724.358	8.83	7724.048	8.83	7724.048	9.77	7723.108	7.89	7724.988
90	8.6	7724.278	8.99	7723.888	8.99	7723.888	9.6	7723.278	7.78	7725.098
105	8.71	7724.168	8.96	7723.918	8.96	7723.918	10.88	7721.998	6.5	7726.378
120	8.86	7724.018	9.01	7723.868	9.01	7723.868	11.08	7721.798	5.67	7727.208
135	7.72	7725.158	8.62	7724.258	9.03	7723.848	10.02	7722.858	7.67	7725.208
150	7.81	7725.068	9	7723.878	9.12	7723.758	9.92	7722.958	7.94	7724.938
165	6.99	7725.888	9.22	7723.658	9.22	7723.658	9.85	7723.028	7.87	7725.008
180	7.8	7725.078	9.3	7723.578	9.3	7723.578	10.67	7722.208	9.29	7723.588
195	8.08	7724.798	9.47	7723.408	9.47	7723.408	10.51	7722.368	8.04	7724.838
210	9.2	7723.678	9.54	7723.338	9.54	7723.338	10.4	7722.478	8.35	7724.528
225	9.29	7723.588	9.52	7723.358	9.55	7723.328	11.44	7721.438	6.18	7726.698
240	9.32	7723.558	9.55	7723.328	9.55	7723.328	11.51	7721.368	6.7	7726.178
255	9.34	7723.538	9.55	7723.328	9.55	7723.328	11.55	7721.328	6.45	7726.428
270	9.12	7723.758	9.5	7723.378	9.58	7723.298	11.1	7721.778	6.17	7726.708
285	9.36	7723.518	9.58	7723.298	9.58	7723.298	10.81	7722.068	6.46	7726.418
300	9.52	7723.358	9.68	7723.198	9.68	7723.198	11.59	7721.288	8.15	7724.728

Max. Slope: 4.9 degrees

Min. Slope: -4.0 degrees

Ave Slope: 0.4 degrees

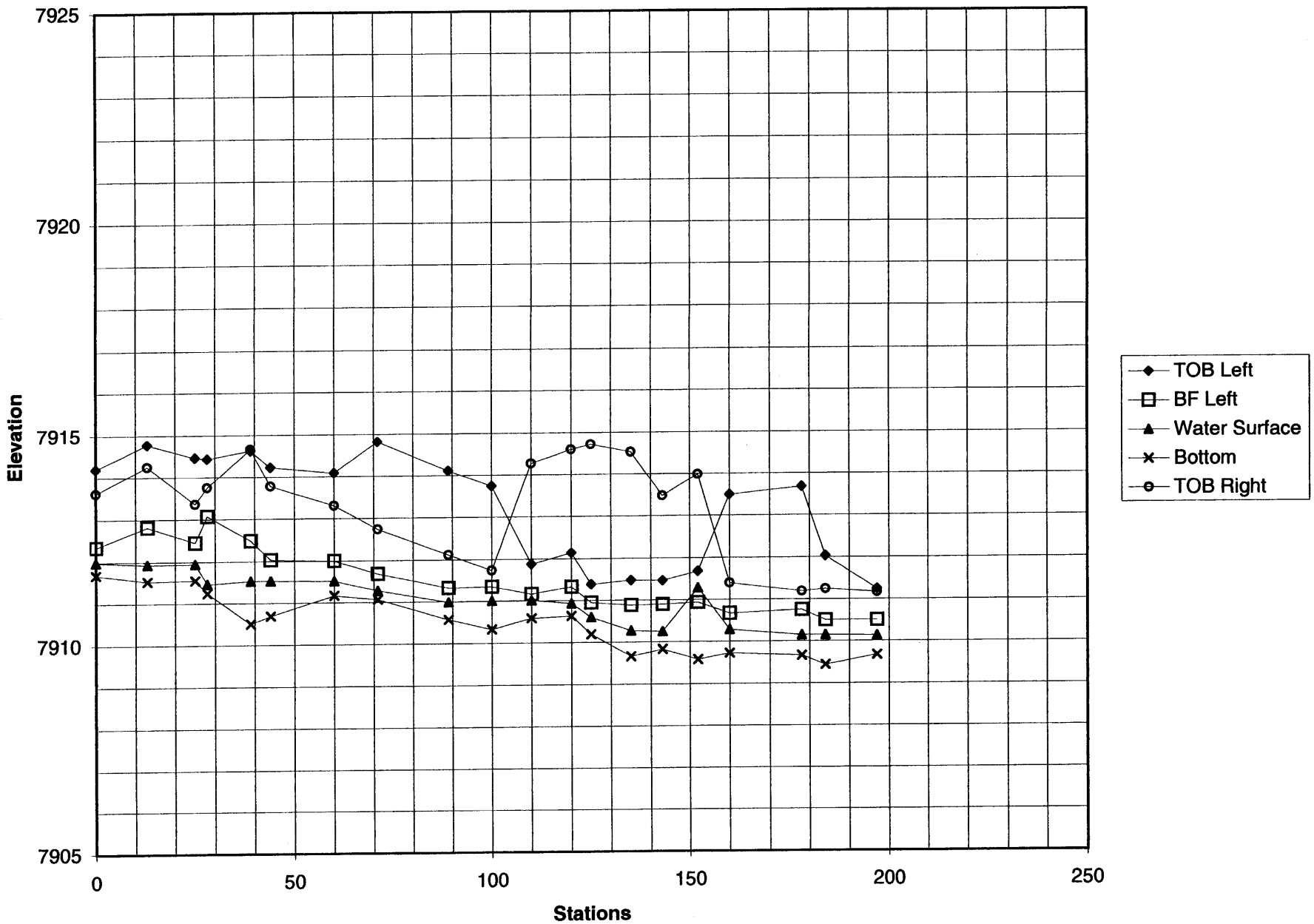

Cross-Section MC-5
7916
7915
7914
7913
7912
7911
7910
Elevation
0
10
20
30
40
50
60
Stations
Elevation
Water Levels

Cross Section: MC-5 Elev.: 7915.351

BenchMark1: 1.4

Station	Rod Reading	Elevation	Water Levels	Well I.D.s	El Change Ft	Distance Ft	Slope Degrees
0	1.3	7915.451					
5	2.33	7914.421			1.03	5	12
7	2.76	7913.991	7911.68	5b	0.43	2	12
24	2.97	7913.781			0.21	17	1
32	3.86	7912.891			0.89	8	6
33	5.09	7911.661			1.23	1	51
33.1	6.14	7910.611			1.05	0.1	85
37	6.45	7910.301	7911.011		0.31	3.9	5
40	5.82	7910.931			-0.63	3	-12
44	5.03	7911.721			-0.79	4	-11
45	4.82	7911.931	7911.37	5a	-0.21	1	-12
48	4.55	7912.201			-0.27	3	-5
50	2.83	7913.921			-1.72	2	-41
52	2.01	7914.741			-0.82	2	-22

Profile MC-5


7925
7920
7915
7910
7905
Elevation
0
50
100
150
200
250
Stations
TOB Left
BF Left
Water Surface
Bottom
TOB Right

Profile: MC-5 BenchMark Elev: 7915.351

BenchMark: 1.4

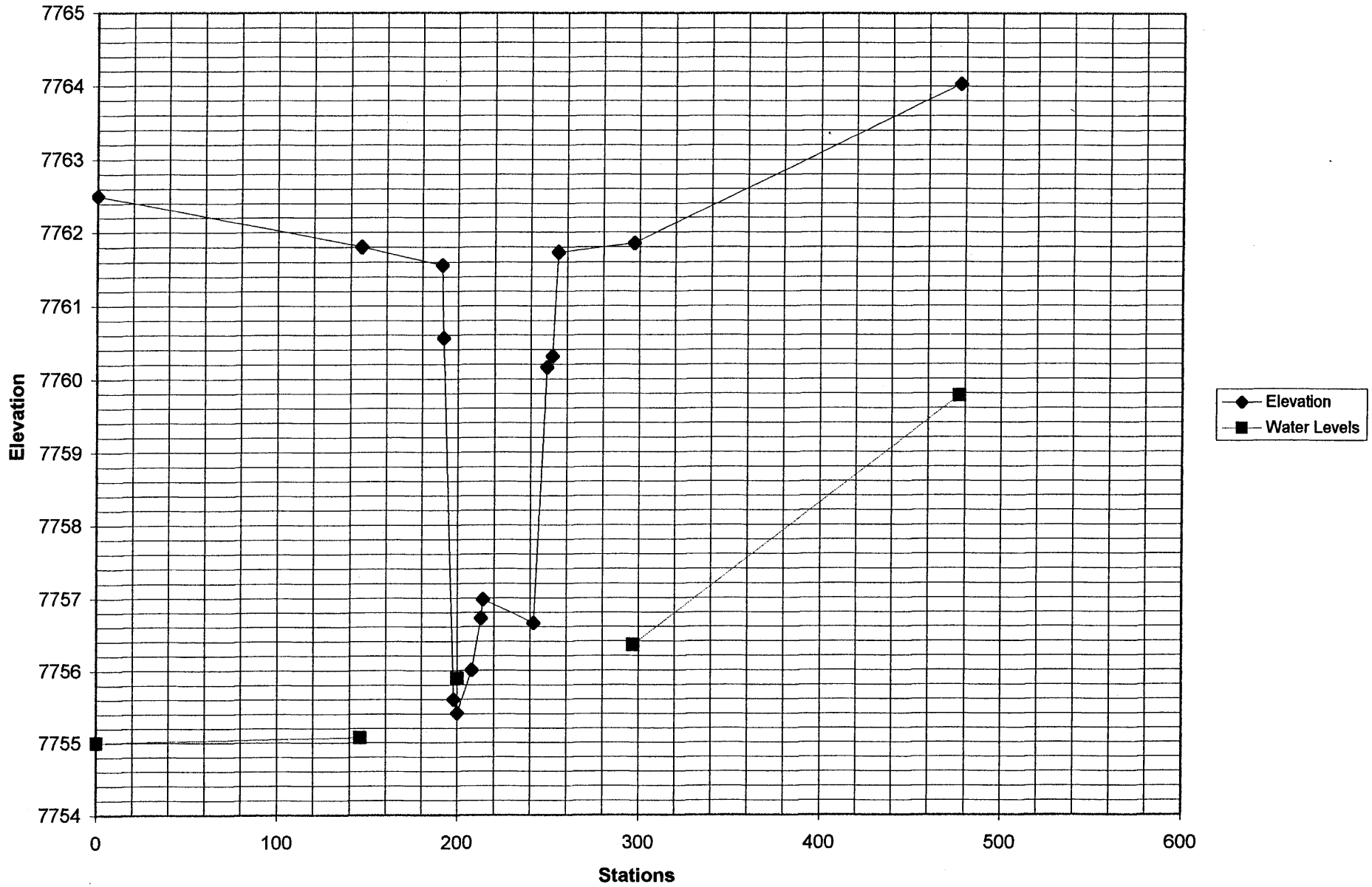
Station	TOB Left		BF Left		Water Surface		Bottom		TOB Right	
	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation
0	2.55	7914.201	4.4	7912.351	4.76	7911.991	5.06	7911.691	3.13	7913.621
13	1.98	7914.771	3.93	7912.821	4.82	7911.931	5.22	7911.531	2.5	7914.251
25	2.29	7914.461	4.3	7912.451	4.81	7911.941	5.2	7911.551	3.39	7913.361
28	2.32	7914.431	3.68	7913.071	5.29	7911.461	5.51	7911.241	3	7913.751
39	2.13	7914.621	4.26	7912.491	5.22	7911.531	6.25	7910.501	2.1	7914.651
44	2.53	7914.221	4.72	7912.031	5.22	7911.531	6.06	7910.691	2.98	7913.771
60	2.67	7914.081	4.75	7912.001	5.23	7911.521	5.58	7911.171	3.45	7913.301
71	1.94	7914.811	5.07	7911.681	5.47	7911.281	5.68	7911.071	4.01	7912.741
89	2.64	7914.111	5.42	7911.331	5.76	7910.991	6.18	7910.571	4.63	7912.121
100	3.02	7913.731	5.4	7911.351	5.74	7911.011	6.42	7910.331	5.01	7911.741
110	4.87	7911.881	5.58	7911.171	5.74	7911.011	6.16	7910.591	2.48	7914.271
120	4.61	7912.141	5.42	7911.331	5.82	7910.931	6.12	7910.631	2.16	7914.591
125	5.36	7911.391	5.8	7910.951	6.15	7910.601	6.56	7910.191	2.04	7914.711
135	5.27	7911.481	5.87	7910.881	6.48	7910.271	7.08	7909.671	2.23	7914.521
143	5.28	7911.471	5.85	7910.901	6.5	7910.251	6.92	7909.831	3.28	7913.471
152	5.07	7911.681	5.81	7910.941	5.46	7911.291	7.17	7909.581	2.77	7913.981
160	3.26	7913.491	6.08	7910.671	6.47	7910.281	7.02	7909.731	5.35	7911.401
178	3.08	7913.671	6	7910.751	6.6	7910.151	7.08	7909.671	5.56	7911.191
184	4.72	7912.031	6.25	7910.501	6.6	7910.151	7.3	7909.451	5.5	7911.251
197	5.5	7911.251	6.25	7910.501	6.62	7910.131	7.07	7909.681	5.58	7911.171

Max. Slope: 5.9 degrees

Min. Slope: -2.2 degrees

Ave Slope: 0.9 degrees

Cross-section MC-6



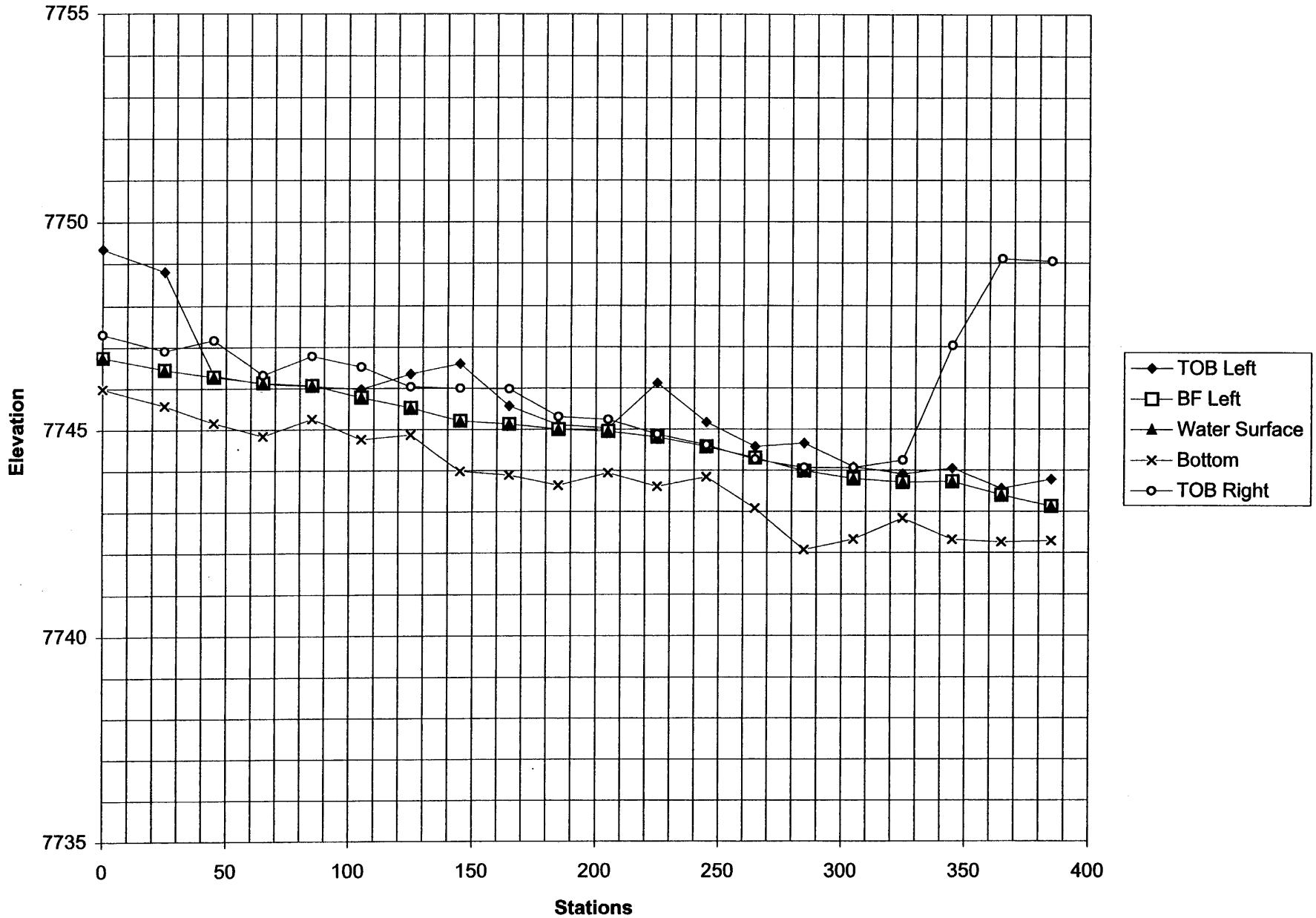
Cross Section: MC-6 Elev.: 7763.84

BenchMark1: 2.89

BenchMark2: 3.22

Station	Rod Reading	Elevation	Water Levels	Well I.D.s	El Change Ft	Distance Ft	Slope Degrees
0	4.23	7762.5	7755	6d			
146	4.92	7761.81	7755.07	6c	0.69	146	0
191	5.5	7761.56			0.25	45	0
192	6.5	7760.56			1	1	45
198	11.46	7755.6			4.96	6	40
200	11.65	7755.41	7755.89		0.19	2	5
208	11.05	7756.01			-0.6	8	-4
213	10.34	7756.72			-0.71	5	-8
214	10.08	7756.98			-0.26	1	-15
242	10.41	7756.65			0.33	28	1
249	6.9	7760.16			-3.51	7	-27
252	6.75	7760.31			-0.15	3	-3
255	5.33	7761.73			-1.42	3	-25
297	4.88	7761.85	7756.35	6b	-0.12	42	0
477	2.7	7764.03	7759.77	6a	-2.18	180	-1

Profile MC-6


7755
7750
7745
7740
7735
Elevation
0
50
100
150
200
250
300
350
400
Stations
TOB Left
BF Left
Water Surface
Bottom
TOB Right

Profile: MC-6 BenchMark Elev: 7752.14

BenchMark: 3.22

Station	TOB Left		BF Left		Water Surface		Bottom		TOB Right	
	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation	Rod Reading	Elevation
0	6.02	7749.34	8.61	7746.75	8.61	7746.75	9.37	7745.99	8.05	7747.31
25	6.56	7748.8	8.91	7746.45	8.91	7746.45	9.78	7745.58	8.45	7746.91
45	9.04	7746.32	9.08	7746.28	9.08	7746.28	10.2	7745.16	8.19	7747.17
65	9.25	7746.11	9.23	7746.13	9.23	7746.13	10.52	7744.84	9.04	7746.32
85	9.31	7746.05	9.29	7746.07	9.29	7746.07	10.1	7745.26	8.58	7746.78
105	9.38	7745.98	9.58	7745.78	9.58	7745.78	10.6	7744.76	8.84	7746.52
125	9.01	7746.35	9.83	7745.53	9.83	7745.53	10.49	7744.87	9.32	7746.04
145	8.77	7746.59	10.15	7745.21	10.15	7745.21	11.38	7743.98	9.36	7746
165	9.79	7745.57	10.23	7745.13	10.23	7745.13	11.47	7743.89	9.38	7745.98
185	10.25	7745.11	10.36	7745	10.36	7745	11.72	7743.64	10.05	7745.31
205	10.33	7745.03	10.41	7744.95	10.41	7744.95	11.42	7743.94	10.12	7745.24
225	9.24	7746.12	10.55	7744.81	10.55	7744.81	11.75	7743.61	10.48	7744.88
245	10.19	7745.17	10.78	7744.58	10.78	7744.58	11.52	7743.84	10.74	7744.62
265	10.78	7744.58	11.05	7744.31	11.05	7744.31	12.28	7743.08	11.09	7744.27
285	10.7	7744.66	11.37	7743.99	11.37	7743.99	13.29	7742.07	11.29	7744.07
305	11.27	7744.09	11.56	7743.8	11.56	7743.8	13.03	7742.33	11.29	7744.07
325	11.45	7743.91	11.65	7743.71	11.65	7743.71	12.52	7742.84	11.11	7744.25
345	11.31	7744.05	11.63	7743.73	11.63	7743.73	13.04	7742.32	8.33	7747.03
365	11.8	7743.56	11.96	7743.4	11.96	7743.4	13.1	7742.26	6.26	7749.1
385	11.58	7743.78	12.23	7743.13	12.23	7743.13	13.07	7742.29	6.32	7749.04
405	11.71	7743.65	12.25	7743.11	12.25	7743.11	13.13	7742.23	11.38	7743.98
425	11.95	7743.41	12.42	7742.94	12.42	7742.94	14.55	7740.81	12.3	7743.06
450	11.9	7743.46	12.46	7742.9	12.46	7742.9	13.25	7742.11	11.83	7743.53

Max. Slope: 4.1 degrees

Min. Slope: -3.0 degrees

Ave Slope: 0.5 degrees

APPENDIX F

Streamflow Data Tabulations

Water Resources

Data Category: Surface Water | Geographic Area: United States | GO

Daily Streamflow Statistics for the Nation

USGS 09310600 ECCLES CANYON NEAR SCOFIELD, UTAH

Available data for this site | Surface-water: Daily streamflow statistics | GO

Carbon County, Utah
Hydrologic Unit Code 14060005
Latitude 39°41'07", Longitude 111°09'43" NAD27
Drainage area 5.50 square miles
Gage datum 7,980 feet above sea level NGVD29

Output formats

HTML table of all data
Tab-separated data
Reselect output format

Day of month	Mean of daily mean values for this day for 5 years of record[1], in ft^3/s											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1.38	1.42	1.74	1.90	6.88	25.1	7.26	3.24	2.48	2.48	1.64	1.51
2	1.36	1.30	1.66	1.70	7.94	24.7	6.90	3.08	2.24	1.94	1.60	1.57
3	1.49	1.36	1.66	1.58	8.36	23.9	6.76	3.12	2.18	2.02	1.70	1.51
4	1.62	1.42	1.60	1.54	8.66	23.4	6.34	2.90	2.40	1.90	1.82	1.49
5	1.60	1.40	1.58	1.60	8.60	24.0	5.88	2.88	2.32	2.00	1.76	1.55
6	1.54	1.41	1.58	1.78	8.78	24.1	5.78	2.82	2.16	1.78	1.66	1.49
7	1.58	1.48	1.62	1.80	8.04	23.3	5.44	2.78	2.30	1.68	1.68	1.47
8	1.47	1.46	1.66	1.86	8.56	22.7	5.28	3.06	2.56	1.82	1.70	1.59
9	1.47	1.56	1.76	2.20	9.80	22.1	5.34	2.78	2.56	1.64	1.54	1.51
10	1.35	1.50	1.71	2.12	9.90	22.3	5.26	2.84	2.52	1.65	1.52	1.47
11	1.42	1.46	1.71	2.32	9.74	23.6	4.82	3.00	2.36	1.97	1.56	1.43
12	1.40	1.56	1.71	2.32	10.9	23.0	4.68	2.84	2.24	1.83	1.58	1.43
13	1.40	1.58	1.70	2.50	12.1	21.2	4.66	2.88	2.46	1.77	1.48	1.49
14	1.47	1.60	1.78	2.62	13.1	19.6	4.28	2.68	2.20	1.71	1.38	1.55
15	1.47	1.48	1.76	2.94	14.7	17.6	4.08	2.70	2.12	1.78	1.36	1.57
16	1.42	1.48	1.72	3.32	14.4	16.9	4.08	2.66	2.22	1.76	1.54	1.58
17	1.44	1.58	1.68	4.10	13.5	16.5	3.90	2.60	2.14	1.76	1.50	1.58
18	1.36	1.56	1.68	4.14	14.1	16.9	3.66	2.52	2.10	1.78	1.54	1.56
19	1.36	1.50	1.64	4.58	14.4	15.7	3.56	3.02	2.08	1.76	1.44	1.54
20	1.40	1.40	1.60	3.68	15.8	14.5	3.42	2.50	2.20	1.94	1.37	1.56

21	1.40	1.48	1.64	3.58	18.9	13.7	3.32	2.52	2.38	1.80	1.39	1.54
22	1.38	1.52	1.74	3.76	20.9	12.5	3.50	2.68	2.40	1.70	1.47	1.54
23	1.48	1.50	1.80	4.60	23.7	11.9	3.64	2.56	2.40	1.58	1.35	1.52
24	1.56	1.58	1.80	5.10	27.3	11.1	3.44	2.40	2.40	1.56	1.45	1.48
25	1.60	1.62	1.82	5.86	29.1	10.2	3.42	2.48	2.48	1.64	1.51	1.44
26	1.60	1.58	1.96	5.62	28.6	9.60	3.56	2.50	2.84	1.74	1.43	1.36
27	1.54	1.60	1.90	6.04	28.1	9.06	3.92	2.58	3.02	1.82	1.35	1.38
28	1.52	1.58	1.80	6.22	28.3	8.46	3.46	2.36	2.84	1.70	1.51	1.36
29	1.50	1.70	1.86	6.78	27.3	7.98	3.40	2.36	2.90	1.74	1.63	1.32
30	1.45		1.96	6.62	28.3	7.58	3.38	2.38	3.22	1.72	1.57	1.26
31	1.40		2.06		26.5		3.40	2.36		1.68		1.35

1 -- Available period of record may be less than value shown for certain days of the year.

Questions about data h2oteam@usgs.gov
Feedback on this websitegs-w_support_nwisweb@usgs.gov
Surface Water data for USA: Daily Streamflow Statistics
http://waterdata.usgs.gov/nwis/dvstat?

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Water Resources

Data Category: Surface Water | Geographic Area: United States | GO

Daily Streamflow Statistics for the Nation

USGS 09310700 MUD CREEK BL WINTER QUARTERS CANYON AT SCOFIELD,UT

Available data for this site: Surface-water: Daily streamflow statistics | GO

Carbon County, Utah
Hydrologic Unit Code 14060007
Latitude 39°43'18", Longitude 111°09'38" NAD27
Drainage area 29.10 square miles
Gage datum 7,720.0 feet above sea level NGVD29

Output formats

HTML table of all data
Tab-separated data
Reselect output format

Day of month	Mean of daily mean values for this day for 21 years of record[1], in ft^3/s											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	5.73	5.27	6.82	11.5	30.0	75.6	20.1	8.82	7.66	7.39	7.18	6.34
2	5.64	5.33	6.87	11.5	32.9	73.1	19.1	8.56	7.91	7.57	7.27	6.23
3	5.69	5.45	6.96	10.8	35.7	70.1	18.6	8.42	7.90	7.80	7.31	6.27
4	5.76	5.58	7.08	10.8	37.2	67.7	17.1	8.12	7.84	7.51	7.26	6.22
5	5.79	5.55	7.11	11.2	37.7	66.4	16.4	7.98	7.60	7.16	7.22	6.14
6	5.68	5.45	7.34	11.7	39.0	66.4	15.2	7.91	7.93	6.97	6.92	6.13
7	5.75	5.56	7.69	12.0	37.3	63.1	14.7	7.76	7.76	7.53	7.03	6.15
8	5.79	5.47	7.64	12.1	38.0	60.2	14.3	7.96	7.96	7.59	7.01	6.19
9	5.97	5.51	7.70	13.0	39.7	58.1	14.0	7.82	8.08	7.05	6.86	6.20
10	5.91	5.53	7.69	13.3	40.1	56.1	13.8	8.53	8.06	6.97	6.65	6.07
11	5.73	5.58	7.74	13.6	40.7	55.0	13.1	8.66	8.50	7.43	6.58	5.94
12	5.77	5.69	7.71	14.0	43.2	53.8	12.6	8.11	8.68	7.37	6.57	5.94
13	5.82	6.01	7.55	14.1	43.8	52.5	12.3	7.90	8.53	6.85	6.58	5.93
14	5.85	6.15	7.61	14.4	46.4	50.3	11.6	7.85	8.13	6.99	6.62	5.95
15	5.93	6.08	7.75	15.3	50.2	47.9	11.5	8.05	7.97	6.95	6.68	5.93
16	5.74	6.09	8.06	16.3	53.5	45.1	11.3	7.94	8.13	7.14	6.56	5.95
17	5.66	6.14	7.92	17.4	55.8	43.6	11.1	7.75	8.07	7.17	6.58	5.85
18	5.67	6.13	8.08	18.2	59.1	41.7	11.0	7.80	8.52	7.48	6.63	5.75
19	5.79	6.25	8.35	18.2	60.2	39.3	11.1	8.17	8.68	7.41	6.82	5.74

20	5.88	6.16	8.44	18.1	64.0	37.1	11.3	7.89	7.83	7.27	6.40	5.77
21	5.78	6.24	8.79	18.5	71.4	35.3	11.5	8.01	8.00	7.24	6.46	5.78
22	5.79	6.28	8.87	19.4	74.7	33.0	11.2	7.77	7.51	7.33	6.66	5.85
23	5.62	6.22	9.15	21.1	76.9	30.9	11.0	7.85	7.64	7.76	6.39	5.80
24	5.68	6.36	9.23	22.5	81.0	29.3	10.5	7.70	8.19	7.78	6.48	5.76
25	5.67	6.55	9.34	22.9	81.6	28.5	10.0	7.82	7.91	7.29	6.54	5.77
26	5.81	6.46	9.31	22.6	79.3	26.3	10.3	7.72	8.19	7.65	6.45	5.69
27	5.63	6.54	9.53	23.6	79.5	25.0	10.1	7.95	8.23	7.46	6.34	5.68
28	5.58	6.61	9.78	25.1	81.0	23.3	9.63	7.72	8.13	7.57	6.39	5.69
29	5.46	7.10	10.2	27.2	79.0	22.1	9.23	7.61	8.38	7.24	6.43	5.63
30	5.36		10.9	27.8	80.4	20.9	9.73	7.70	8.61	7.25	6.41	5.54
31	5.36		11.6		79.2		9.15	7.90		7.25		5.59

1 -- Available period of record may be less than value shown for certain days of the year.

Questions about data h2oteam@usgs.gov
Feedback on this websitegs-w_support_nwisweb@usgs.gov
Surface Water data for USA: Daily Streamflow Statistics
http://waterdata.usgs.gov/nwis/dvstat?

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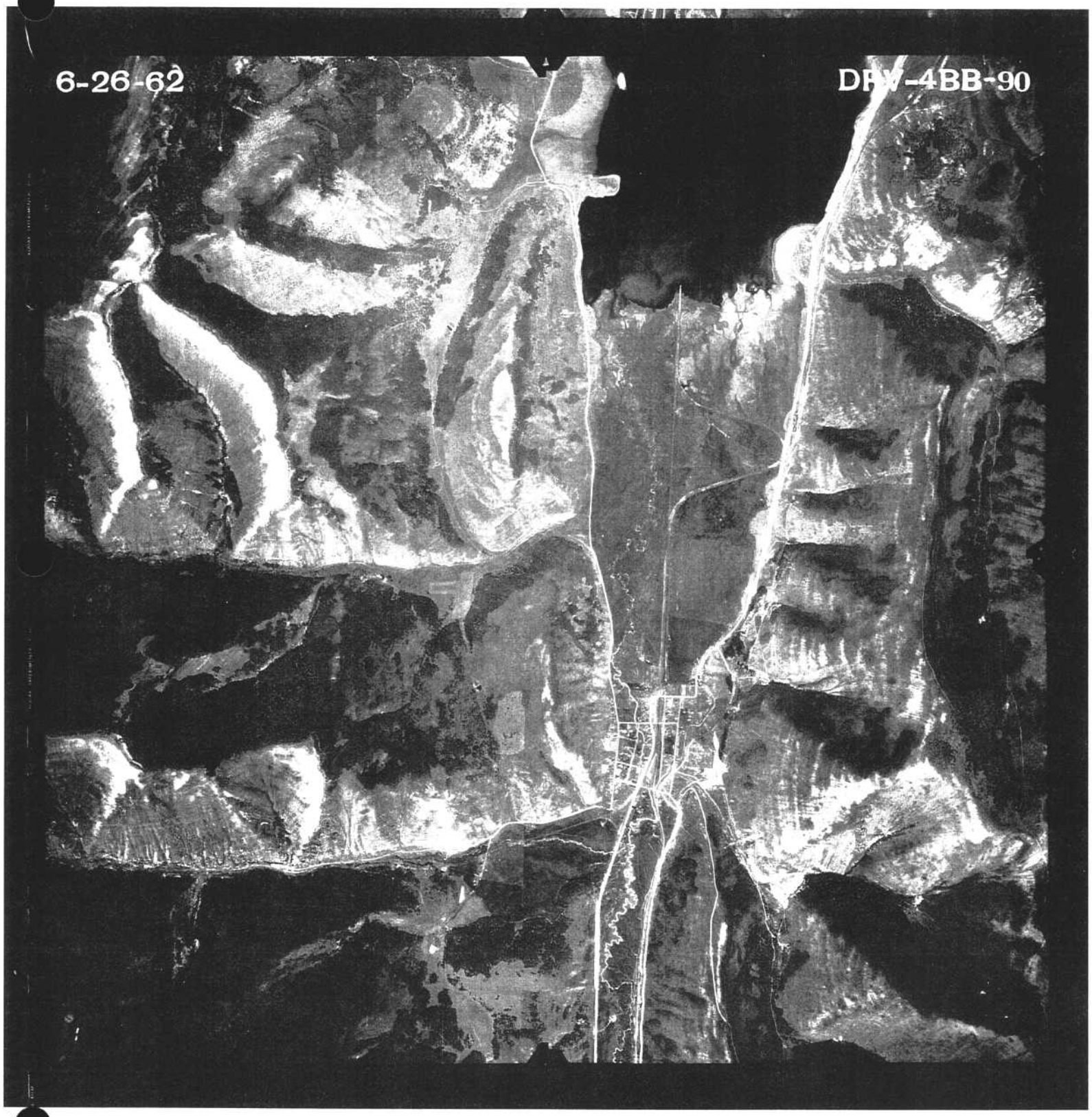
APPENDIX G

Aerial Photographs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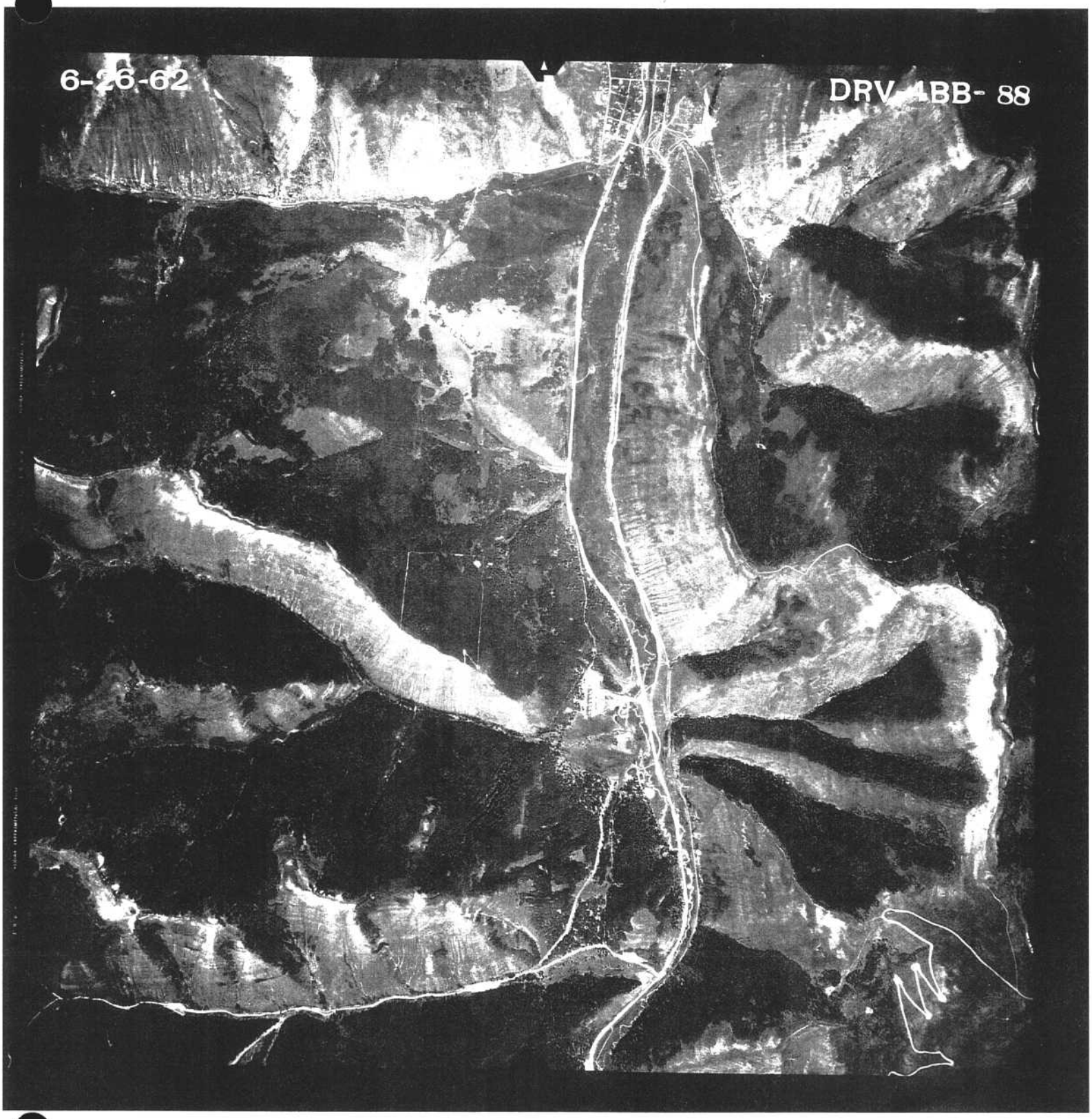
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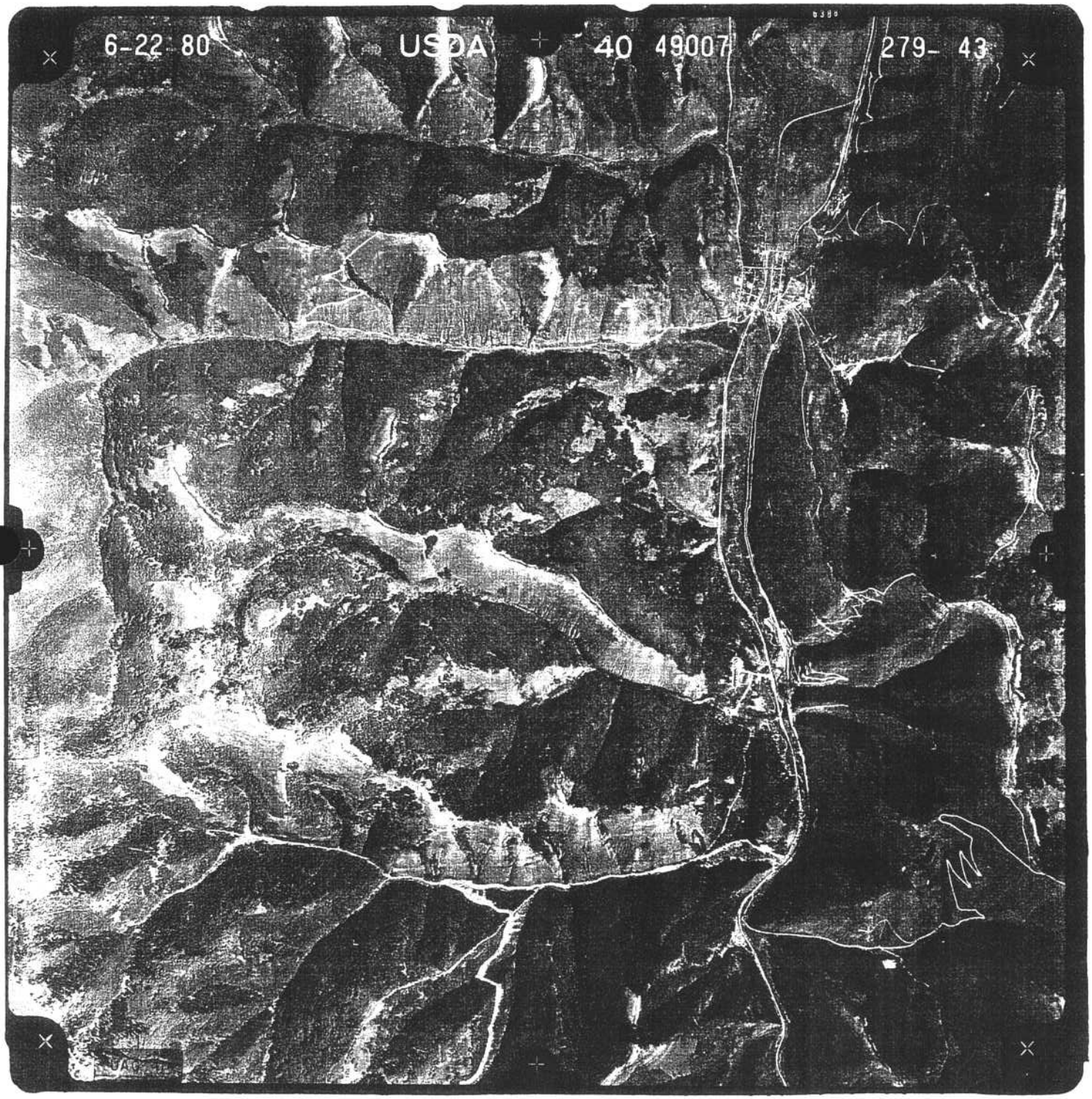
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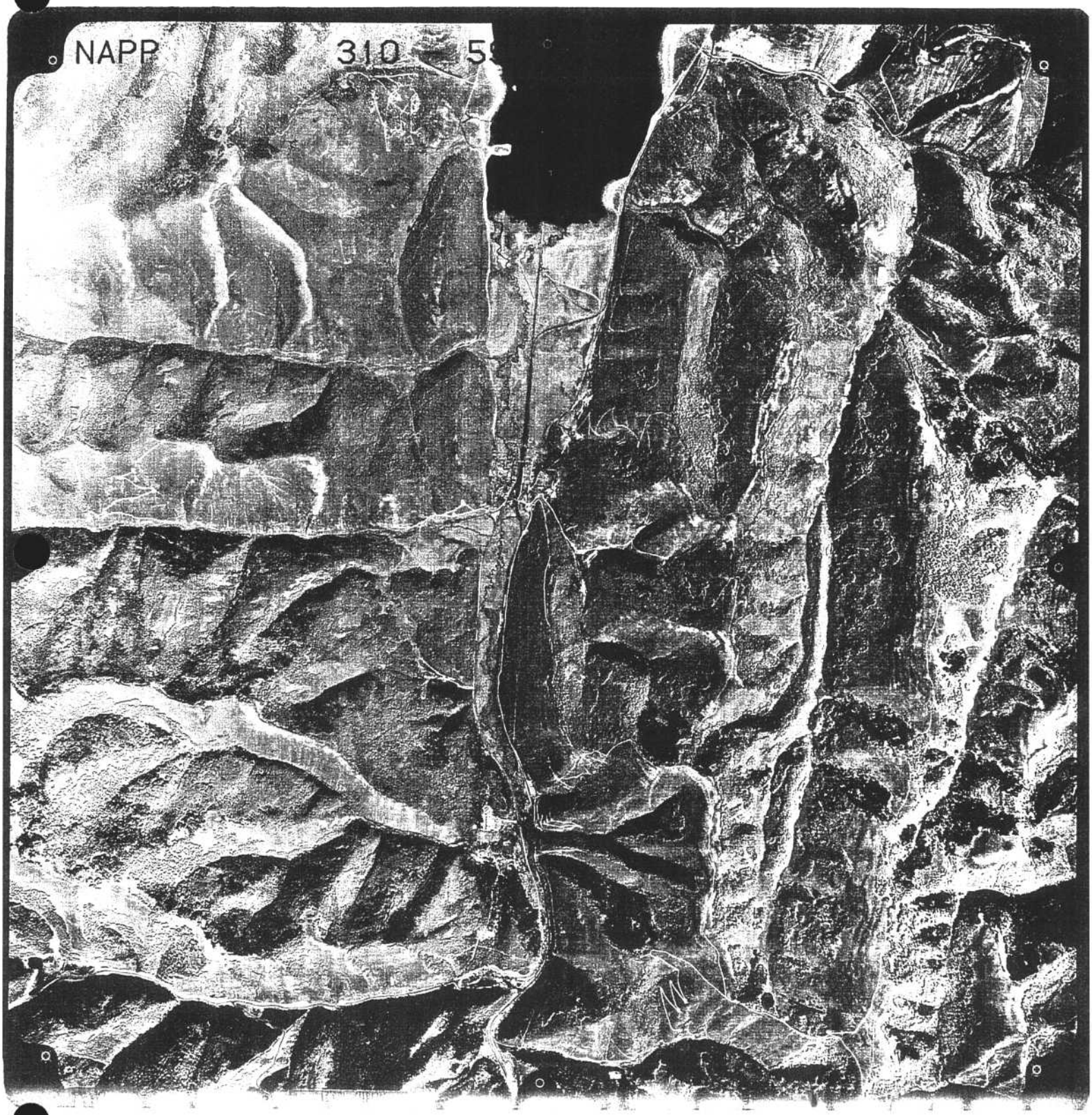
USDA
40 49007
279- 43


NAPP
310 - 5

AUG 1970
660

2-3 1

APPENDIX H

Erosional Stability Analyses

EROSIONAL STABILITY OF MUD CREEK

- Determine allowable velocity according to US Soil Conservation Service (1977) for channel bed and Haan et al. (1994) for channel banks
- Evaluate stability under both sediment-laden and sediment-free conditions at flows varying from 5,000 to 30,000 gpm (11.1 to 66.9 cfs)
- Evaluate stability of the stream bank and bed at each sample location (see map on pg 2 of this calculation)

Calculate rating tables and curves for each cross section using FlowMaster PE (Haestad Methods, 1998). For flows within the channel banks, use Manning's "n" calculated based on field measurements:

Station	Q (cfs)	A (ft^2)	Avg. V (ft/s)	WP (ft)	R (ft)	S (ft/ft)	n
MC-4	13.69	5.6	2.4	12.05	0.46	0.007	0.031
MC-5	1.29	1.1	1.2	5.7	0.19	0.0157	0.053
MC-6	-	-	-	-	-	-	-

For MC-6, as no flow measurements were taken, an average Manning's 'n' of 0.031 was used to approximate the channel conditions. This value was selected based on site conditions and professional judgement.

For flows outside of the channel banks, use a Manning's "n" of 0.060 (typical of vegetated flood plains).

Rating tables and curves for each of the three Mud Creek cross sections are provided on pages 3-6 of this calculation. Cross sections are presented in Appendix E of this report. Water surface plots are shown on pages 7-9. Allowable velocities were determined for flows within the channel banks at discharge rates of 5,000 gpm (11.1 cfs), 10,000 gpm (22.3 cfs), 20,000 gpm (44.6 cfs), and 30,000 gpm (66.9 cfs). As the flow depths never exceeded the channel banks, no flood plain evaluation was conducted.

Channel bed results - see pp 10-11 of this calculation. All velocities at the design discharge rates are less than the allowable velocities. Hence, the channels will be erosionally stable.

Channel bank results - see pg 13 of this calculation. All velocities at the design discharge rates are less than the allowable velocities. Hence, the channel banks will be erosionally stable during the design discharges.

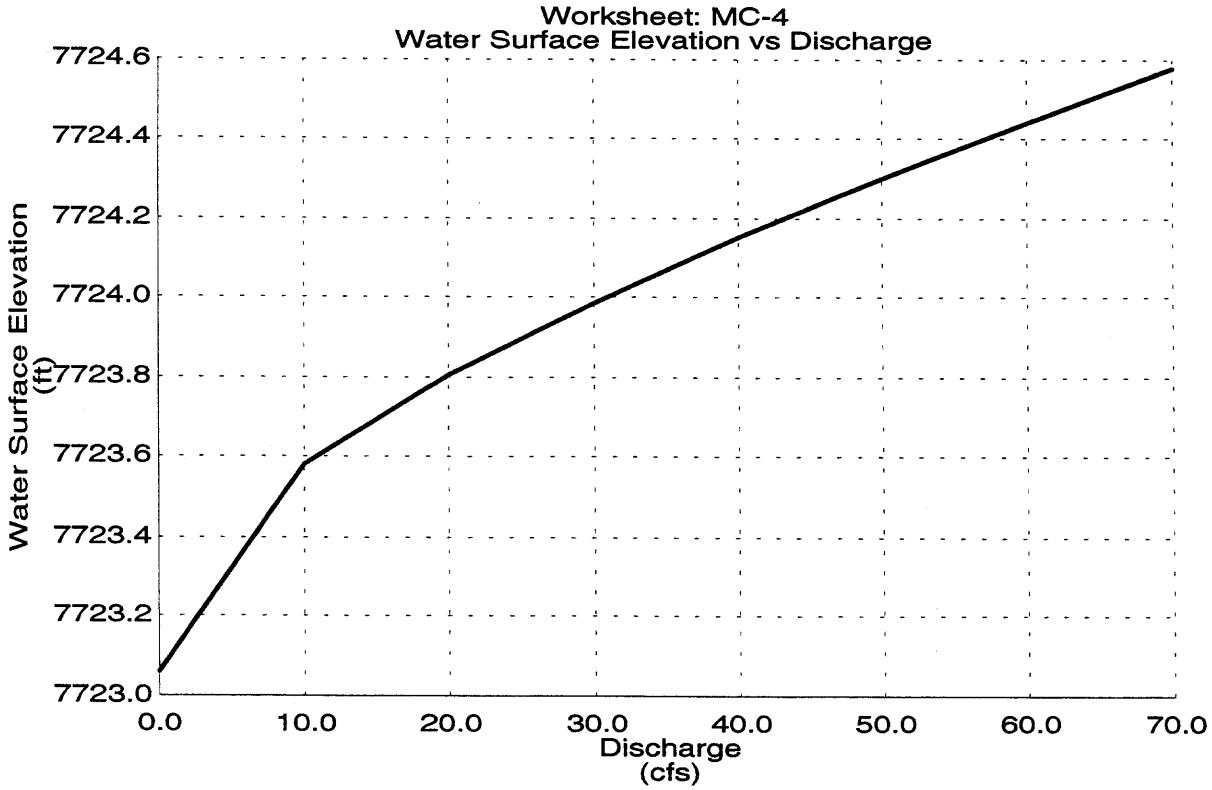
Rating Table and Discharge Curve for MC-4

Project Description	
Worksheet	MC-4
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Slope	0.007000	ft/ft

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Discharge (cfs)	Water Surface Elevation (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
10.00	7,723.58	2.17	4.6	11.83	11.52
20.00	7,723.80	2.78	7.2	12.38	11.80
30.00	7,723.99	3.20	9.4	12.83	12.03
40.00	7,724.15	3.51	11.4	13.23	12.24
50.00	7,724.30	3.77	13.2	13.60	12.43
60.00	7,724.44	4.00	15.0	13.95	12.61
70.00	7,724.57	4.19	16.7	14.27	12.78



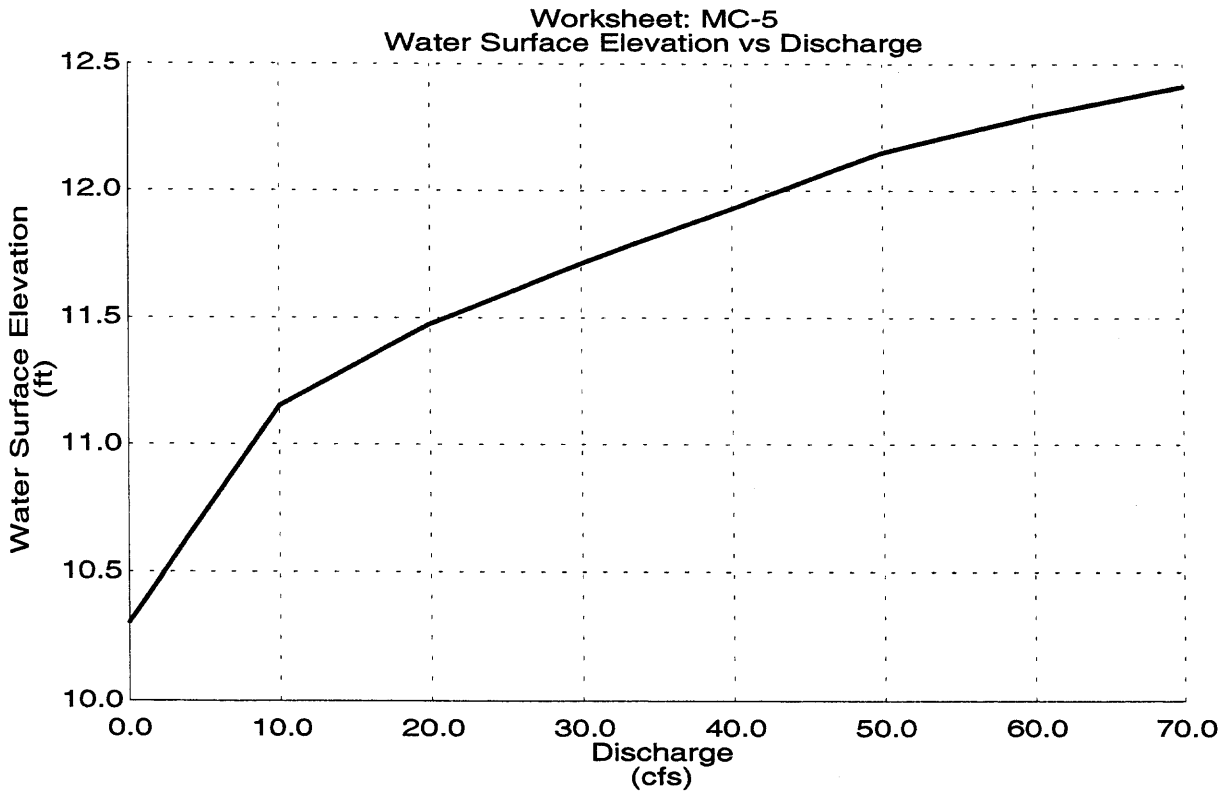
Rating Table and Discharge Curve for MC-5

Project Description	
Worksheet	MC-5
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Slope	0.015700	ft/ft

Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

Discharge (cfs)	Water Surface Elevation (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
0.00	10.30	0.00	0.0	0.00	0.00
10.00	11.15	2.25	4.4	8.65	8.06
20.00	11.47	2.74	7.3	10.64	9.72
30.00	11.72	3.05	9.8	12.16	11.02
40.00	11.92	3.27	12.2	13.43	12.18
50.00	12.15	3.28	15.2	16.15	14.77
60.00	12.29	3.44	17.4	17.09	15.61
70.00	12.41	3.63	19.3	17.42	15.84



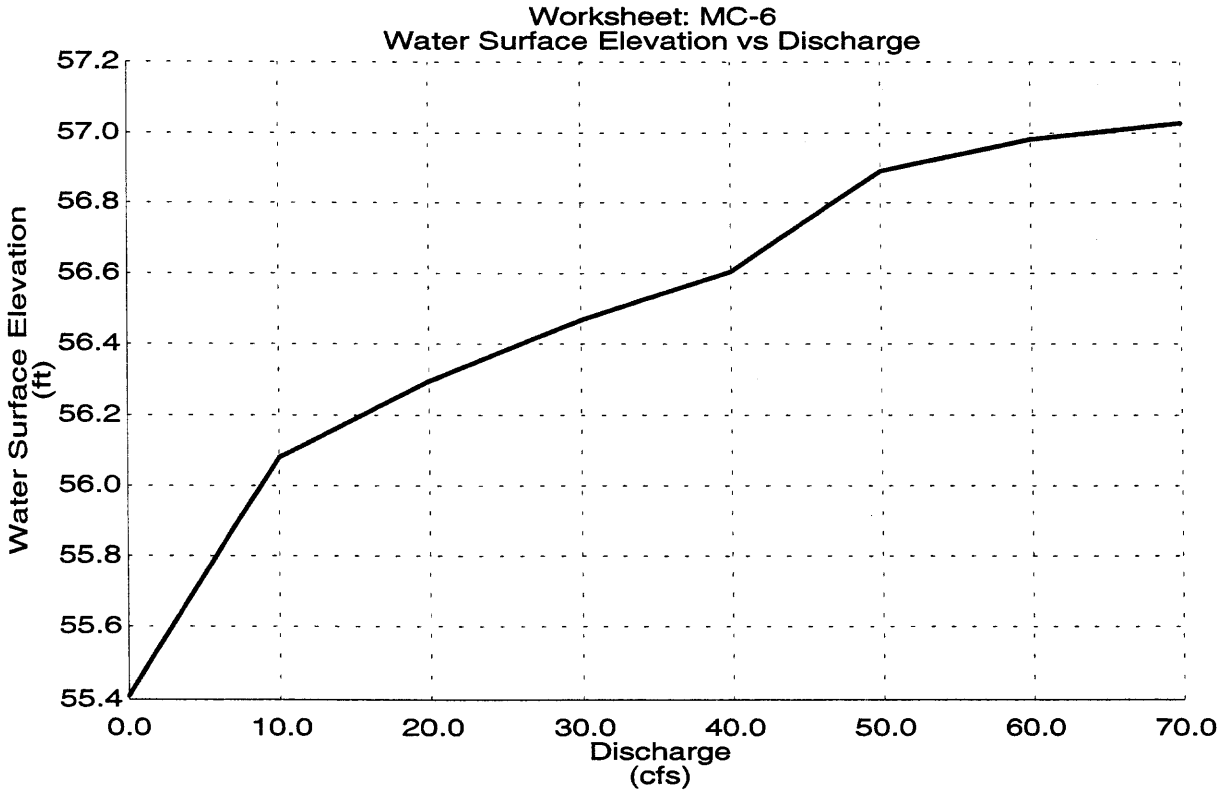
Rating Table and Discharge Curve for MC-6

Project Description	
Worksheet	MC-6
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

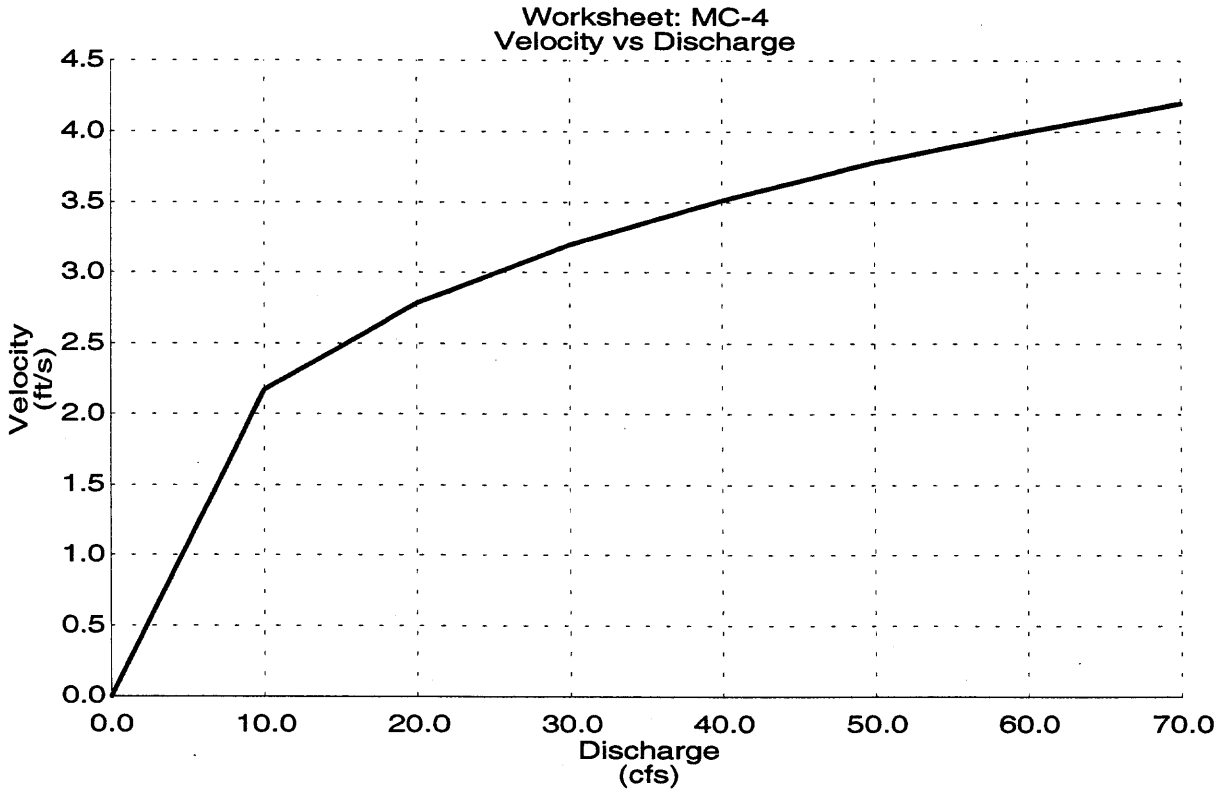
Input Data		
Slope	0.008700	ft/ft

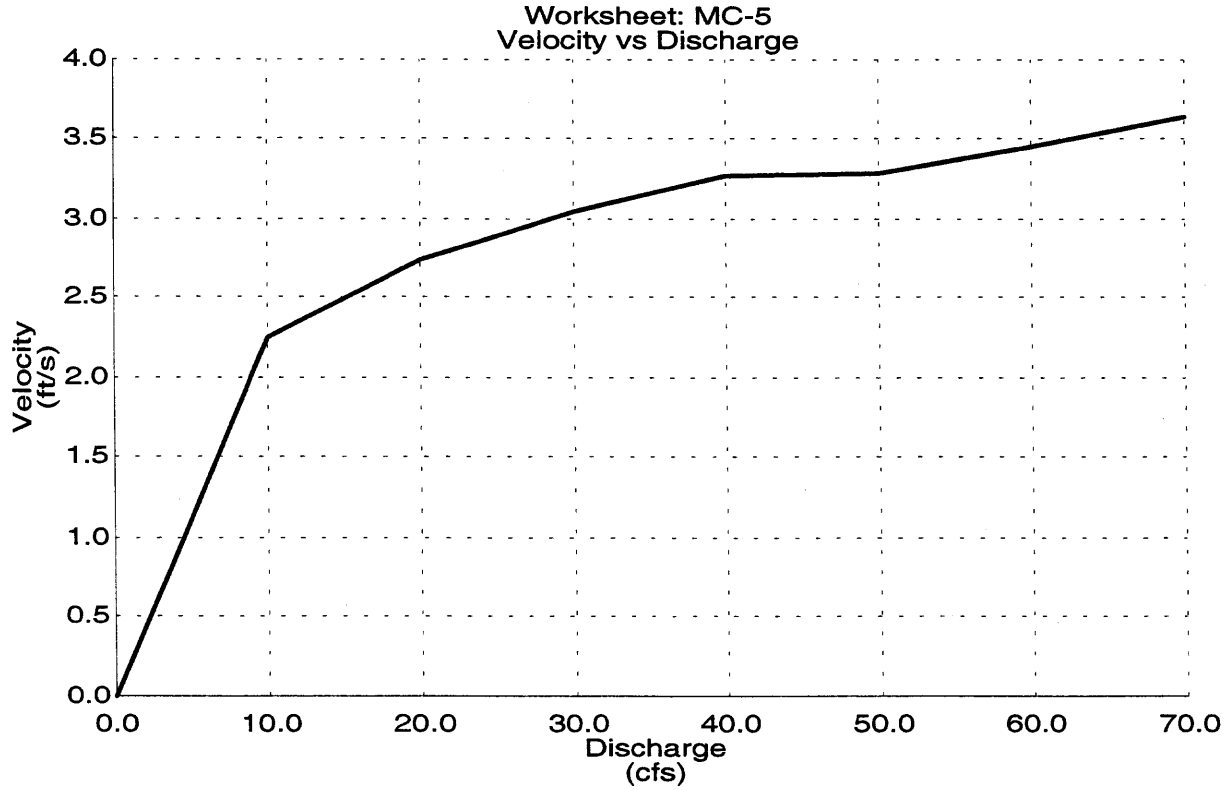
Options	
Current Roughness Method	Improved Lotter's Method
Open Channel Weighting Method	Improved Lotter's Method
Closed Channel Weighting Method	Horton's Method

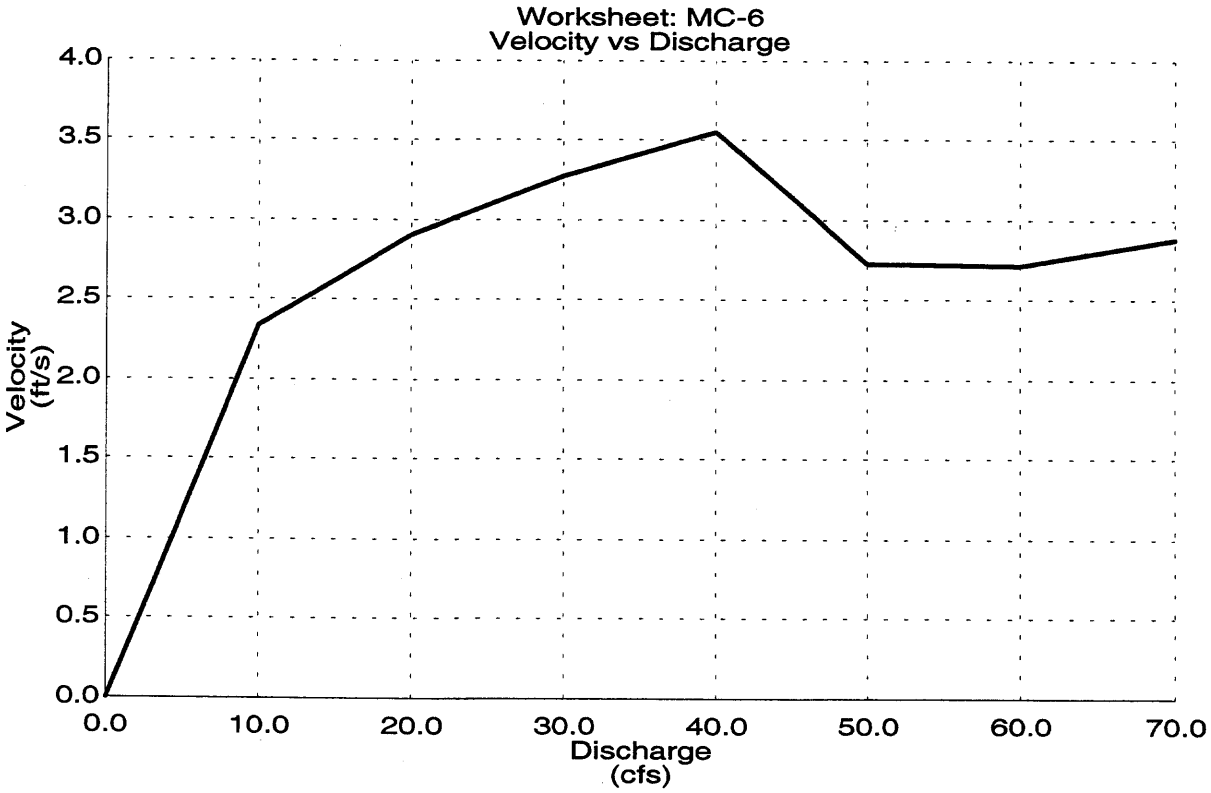
Discharge (cfs)	Water Surface Elevation (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
0.00	55.41	0.00	0.0	0.00	0.00
10.00	56.08	2.34	4.3	11.29	11.08
20.00	56.30	2.90	6.9	13.19	12.88
30.00	56.47	3.27	9.2	14.64	14.27
40.00	56.61	3.56	11.2	15.86	15.42
50.00	56.89	2.72	18.3	38.56	37.94
60.00	56.98	2.71	22.1	46.90	46.21
70.00	57.03	2.88	24.3	47.19	46.48



Velocity Rating Curves for all Stations:





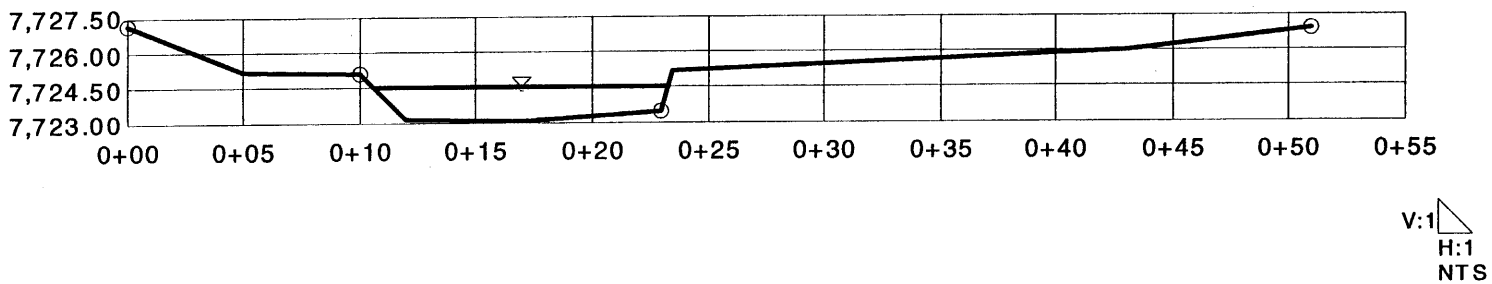

Worksheet: MC-6
Velocity vs Discharge
Velocity (ft/s)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
Discharge (cfs)

Cross Section

Cross Section for Irregular Channel

Project Description	
Worksheet	MC-4
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

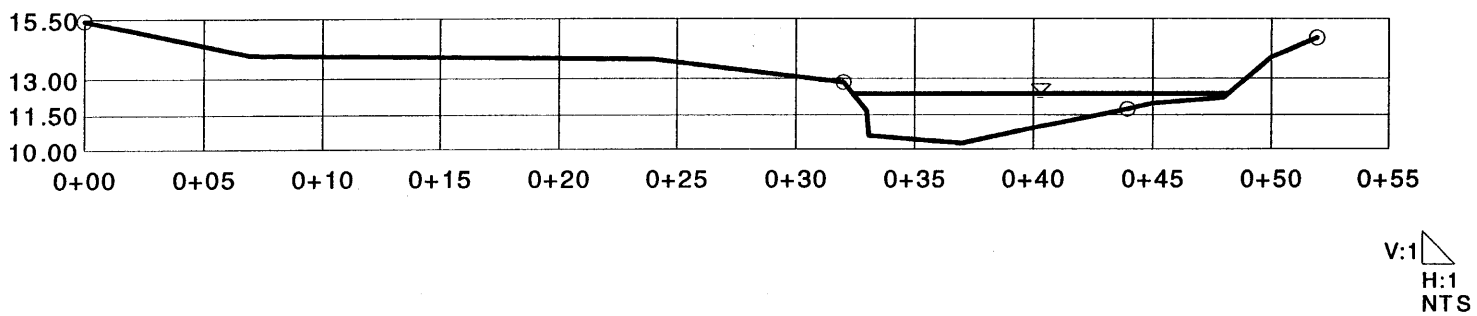
Section Data		
Mannings Coefficient	0.033	
Slope	0.007000	ft/ft
Water Surface Elevation	7,724.53	ft
Elevation Range	7,723.06 to 7,727.15	
Discharge	66.90	cfs



Cross Section
Cross Section for Irregular Channel

Project Description	
Worksheet	MC-5
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

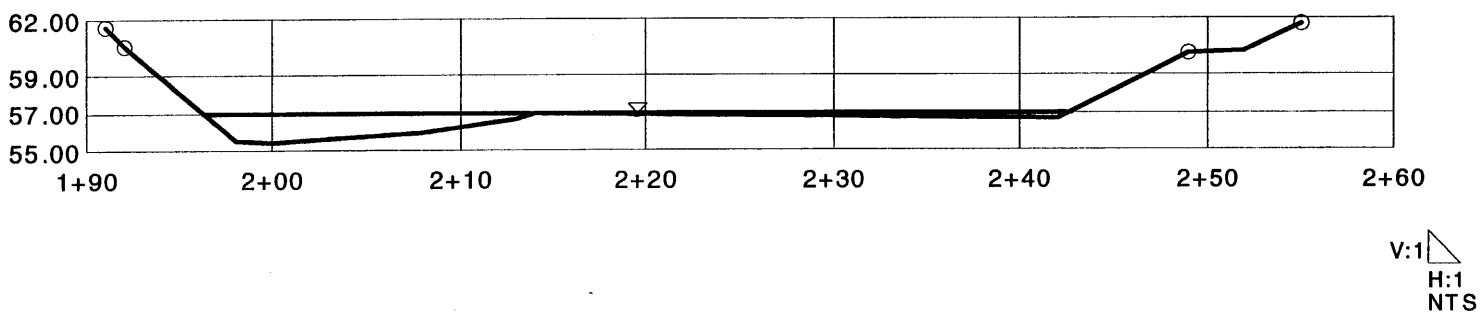
Section Data	
Mannings Coefficient	0.055
Slope	0.015700 ft/ft
Water Surface Elevation	12.37 ft
Elevation Range	10.30 to 15.45
Discharge	66.90 cfs



Cross Section
Cross Section for Irregular Channel

Project Description	
Worksheet	MC-6
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data	
Mannings Coefficient	0.031
Slope	0.008700 ft/ft
Water Surface Elevation	57.01 ft
Elevation Range	55.41 to 61.73
Discharge	66.90 cfs



Allowable velocities on the channel bottom (i.e., no bank slope correction factor needed):

Stream Station	D_{75} (mm)[a]	Sediment-Laden Conditions[b]				Sediment-Free Conditions[b]				Actual Velocity (ft/s)[c]	Comments
		Basic Vel. (ft/s)	Depth Factor	Alignment Factor	Allowable Vel. (ft/s)	Basic Vel. (ft/s)	Depth Factor	Alignment Factor	Allowable Vel. (ft/s)		
Discharge Rate = 5,000 gpm (11.1 cfs)											
MC-4	49	8.2	0.9	1.0	7.4	5.9	0.9	1.0	5.3	2.3	OK
MC-5	94	10.7	0.9	1.0	9.6	8.3	0.9	1.0	7.5	2.3	OK
MC-6	119	11.1	0.9	1.0	10.0	9.0	0.9	1.0	8.1	2.4	OK
Discharge Rate = 10,000 gpm (22.3 cfs)											
MC-4	49	8.2	0.9	1.0	7.4	5.9	0.9	1.0	5.3	2.9	OK
MC-5	94	10.7	0.9	1.0	9.6	8.3	0.9	1.0	7.5	2.8	OK
MC-6	119	11.1	0.9	1.0	10.0	9.0	0.9	1.0	8.1	3.0	OK

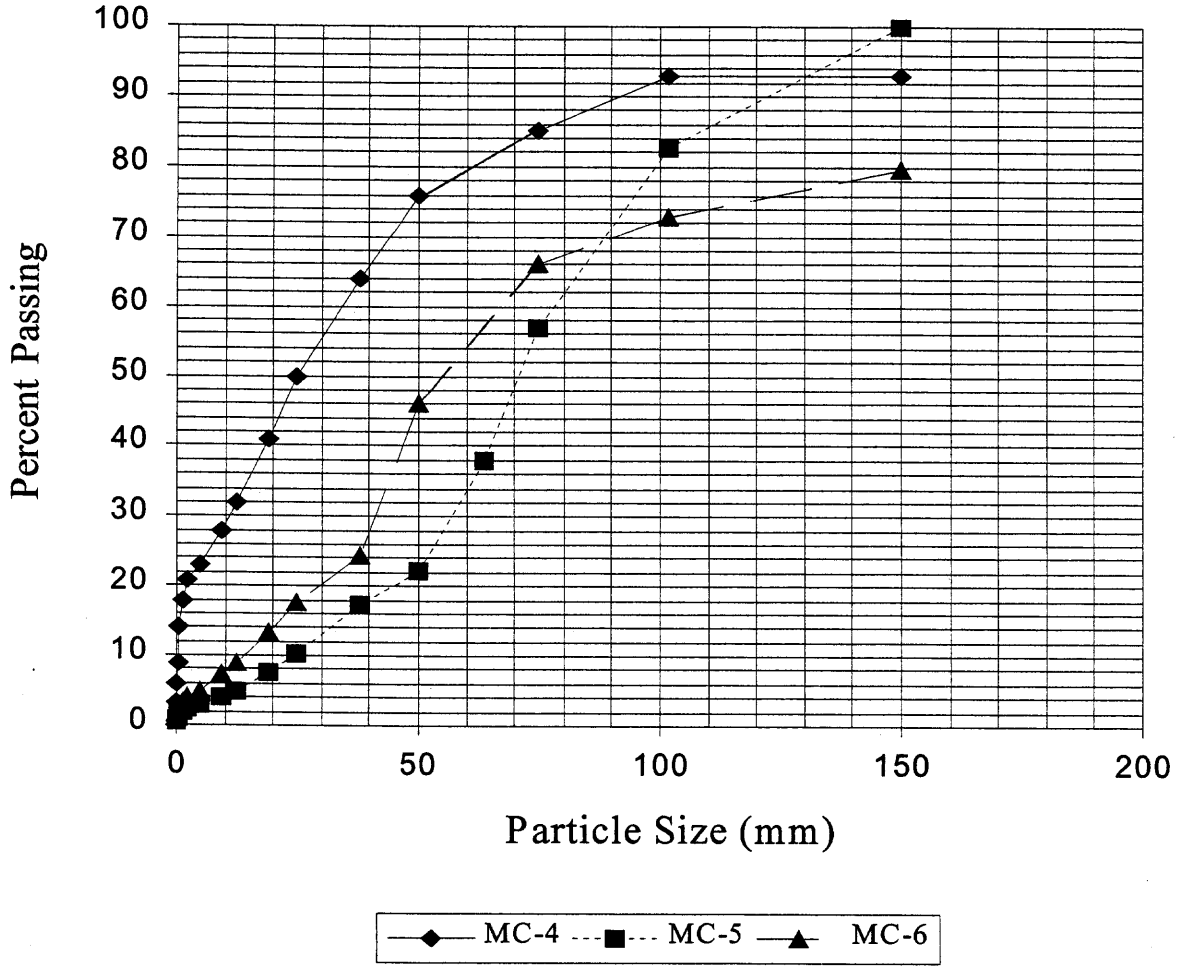
(a) See gradation results (pp. 12 of this calculation)
(b) See graphs on pg. 13 of this calculation
(c) See velocity rating curves (pp.5-6 of this calculation)

Allowable velocities on the channel bottom (continued):

Stream Station	D_{75} (mm)[a]	Sediment-Laden Conditions[b]				Sediment-Free Conditions[b]				Actual Velocity (ft/s)[c]	Comments
		Basic Vel. (ft/s)	Depth Factor	Alignment Factor	Allowable Vel. (ft/s)	Basic Vel. (ft/s)	Depth Factor	Alignment Factor	Allowable Vel. (ft/s)		
Discharge Rate = 20,000 gpm (44.6 cfs)											
MC-4	49	8.2	0.9	1.0	7.4	5.9	0.9	1.0	5.3	3.6	OK
MC-5	94	10.7	0.9	1.0	9.6	8.3	0.9	1.0	7.5	3.3	OK
MC-6	119	11.1	0.9	1.0	10.0	9.0	0.9	1.0	8.1	2.8	OK
Discharge Rate = 30,000 gpm (66.9 cfs)											
MC-4	49	8.2	0.9	1.0	7.4	5.9	0.9	1.0	5.3	4.1	OK
MC-5	94	10.7	0.9	1.0	9.6	8.3	0.9	1.0	7.5	3.6	OK
MC-6	119	11.1	0.9	1.0	10.0	9.0	0.9	1.0	8.1	2.8	OK

(a) See gradation results (pp. 12 of this calculation)
(b) See graphs on pg. 15 of this calculation
(c) See velocity rating curves (pp.5-6 of this calculation)

Mud Creek Bed Gradations



MC-4

$D_{10} = 0.32$

$D_{30} = 11$

$D_{60} = 34$

$C_u = D_{60}/D_{10} = 106 > 4$

$C_z = \frac{D_{30}^2}{D_{10} D_{60}} = 11 > 3 \Rightarrow GP$

MC-5

$D_{10} = 24$

$D_{30} = 57$

$D_{60} = 78$

$C_u = 3.2 < 4 \Rightarrow GP$

MC-6

$D_{10} = 14$

$D_{30} = 41$

$D_{60} = 67$

$C_u = 4.8 > 4$, $C_z = 1.8$ $\Rightarrow GW$

Calculate allowable velocities on channel banks. Channel banks below the grass line are comprised of material typical of the bed materials. Therefore, base the analysis on the vegetated portion of the channel banks (i.e., gravelly soil). The vegetation consists of a good stand of native grasses, approx 12" tall. Evaluate each cross section at its maximum velocity. Assume the average cross section velocity is representative of the velocity against the bank. Soils are erosion resistant:

Stream Station	Bank Soil Type[a]	Channel Slope (%)	Allowable Vel. (ft/s)[b]	Max. Actual Vel. (ft/s)[c]	Comments
MC-4	GP	0.7	7	4.1	OK
MC-5	GP	1.6	7	3.6	OK
MC-6	GW	0.9	7	2.8	OK

[a] See gradation results (pp. 12 of this calculation)
[b] See table on pg 14 of this calculation
[c] Maximum velocity of flow $\leq$ 30,000 gpm from velocity rating curves (pp. 8 of this calc.)

Allowable Velocities for Vegetated Channels
(From Haan et al., 1994)

	Allowable Velocity (ft/s)					
	Erosion-Resistant Soils (% Slope)			Easily Eroded Soils (% Slope)		
	0-5	5-10	>10	0-5	5-10	>10
Bermuda grass	8	7	6	6	5	4
Buffalo grass Kentucky bluegrass Smooth brome Blue gramma Tall fescue	7	6	5	5	4	3
Lespedeza sericea Weeping lovegrass Kudzu Alfalfa Crabgrass	3.5	NR[a]	NR	2.5	NR	NR
Grass mixture	5	4	NR	4	3	NR
Annuals for temporary protection	3.5	NR	NR	2.5	NR	NR

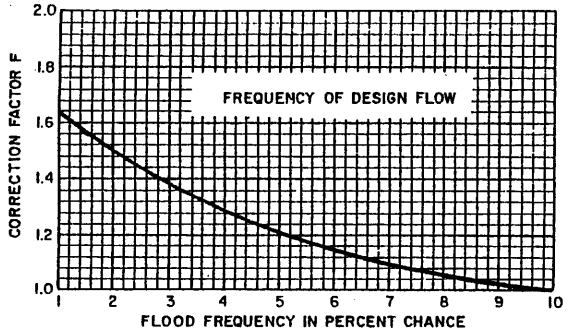
[a] Not recommended
Note: Shaded row considered representative of natural grasses along Mud Creek.

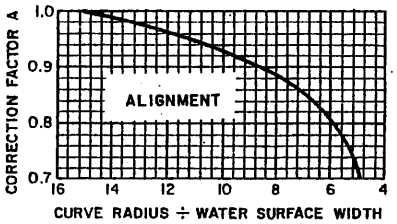
References Cited

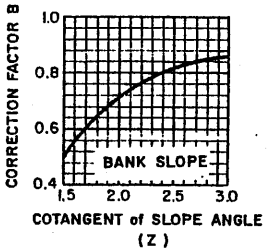
Haan, C.T., B.J. Barfield, and J.C. Hayes. 1994. Design Hydrology and Sedimentology for Small Catchments. Academic Press. San Diego, CA.

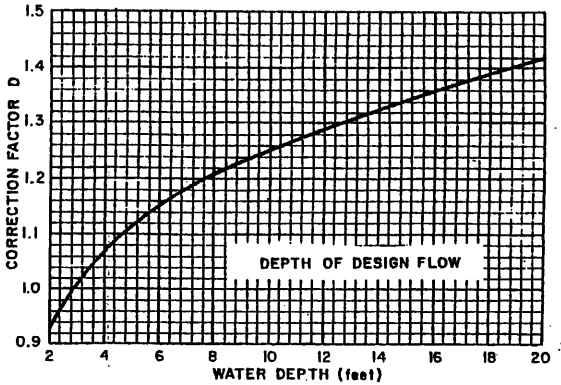
Haestad Methods, Inc. 1998. FlowMaster Professional Edition for Windows, Version 6.0. Waterbury, CT.

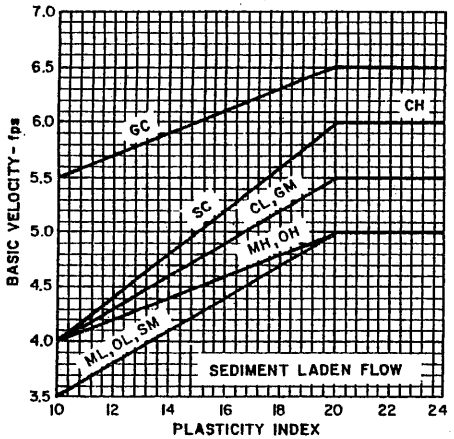
U.S. Soil Conservation Service. 1977. Design of Open Channels. Technical Release No. 25. U.S. Department of Agriculture. Washington, D.C.



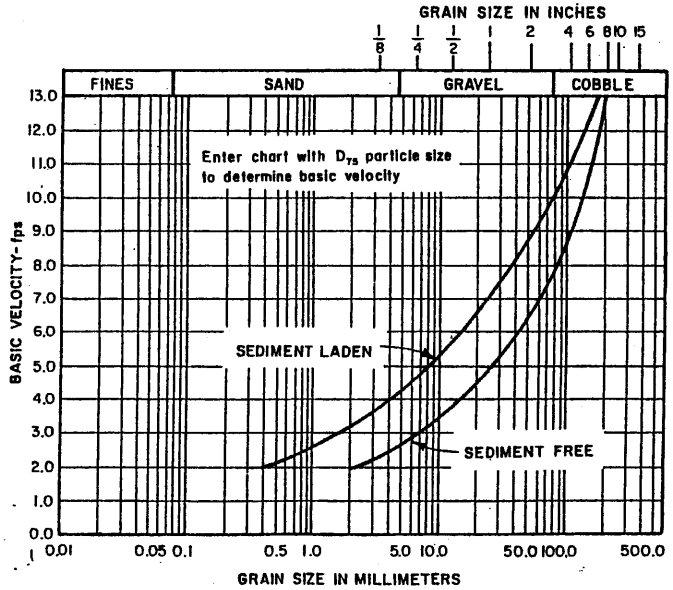




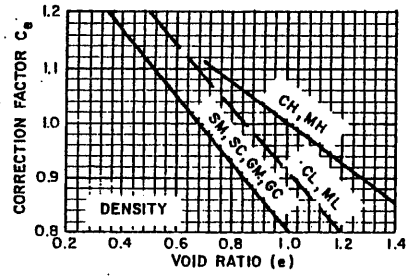




BASIC VELOCITIES FOR COHERENT EARTH MATERIALS (v_b)



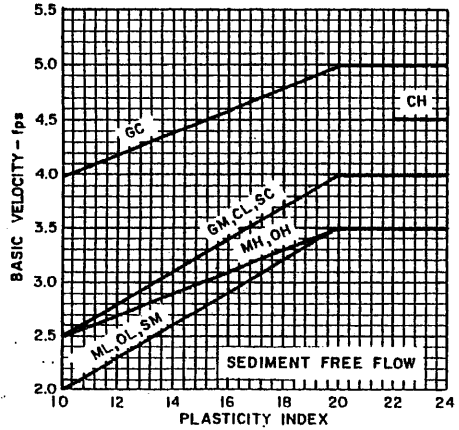
BASIC VELOCITY FOR DISCRETE PARTICLES OF EARTH MATERIALS (v_b)



NOTES:

1. In no case should the allowable velocity be exceeded when the 10% chance discharge occurs, regardless of the design flow frequency.

Source: US SCS (1977)



BASIC VELOCITIES FOR COHERENT EARTH MATERIALS (v_b)

ALLOWABLE VELOCITIES FOR UNPROTECTED EARTH CHANNELS	
CHANNEL BOUNDARY MATERIALS	ALLOWABLE VELOCITY
DISCRETE PARTICLES	
Sediment Laden Flow	
$D_{75} > 0.4$ mm	Basic velocity chart value x D x A x B
$D_{75} < 0.4$ mm	2.0 fps
Sediment Free Flow	
$D_{75} > 2.0$ mm	Basic velocity chart value x D x A x B
$D_{75} < 2.0$ mm	2.0 fps
COHERENT EARTH MATERIALS	
PI > 10	Basic velocity chart value x D x A x F x C_e
PI < 10	2.0 fps

ALLOWABLE VELOCITIES FOR UNPROTECTED EARTH CHANNELS

Revised –

O - 78 (Face blank p. 153)

APPENDIX I

Geotechnical Stability Analyses

RESULTS OF SLOPE STABILITY ANALYSES
MUD CREEK SECTIONS MC-4, MC-5, AND MC-6

Following are cross-sections and results of slope stability analyses for Mud Creek at Sections MC-4, MC-5, and MC-6. The following assumptions were made for these analyses:

1. Results of direct shear tests on soil samples collected from the channel bank were used for the analyses. Soil property parameters used in the evaluation are summarized in Table 1 of this appendix.

2. The soils drain rapidly, and excess pore pressures do not develop in response to strains and stress changes.

3. The steepest slope was analyzed at each section.

Slope stability analyses were performed using the computer program GEOSLOPE (Version 5.0). GEOSLOPE utilizes the limit equilibrium procedure of slices (Simplified Bishop's method) to determine the safety factor of potential failure surfaces for circular shapes.

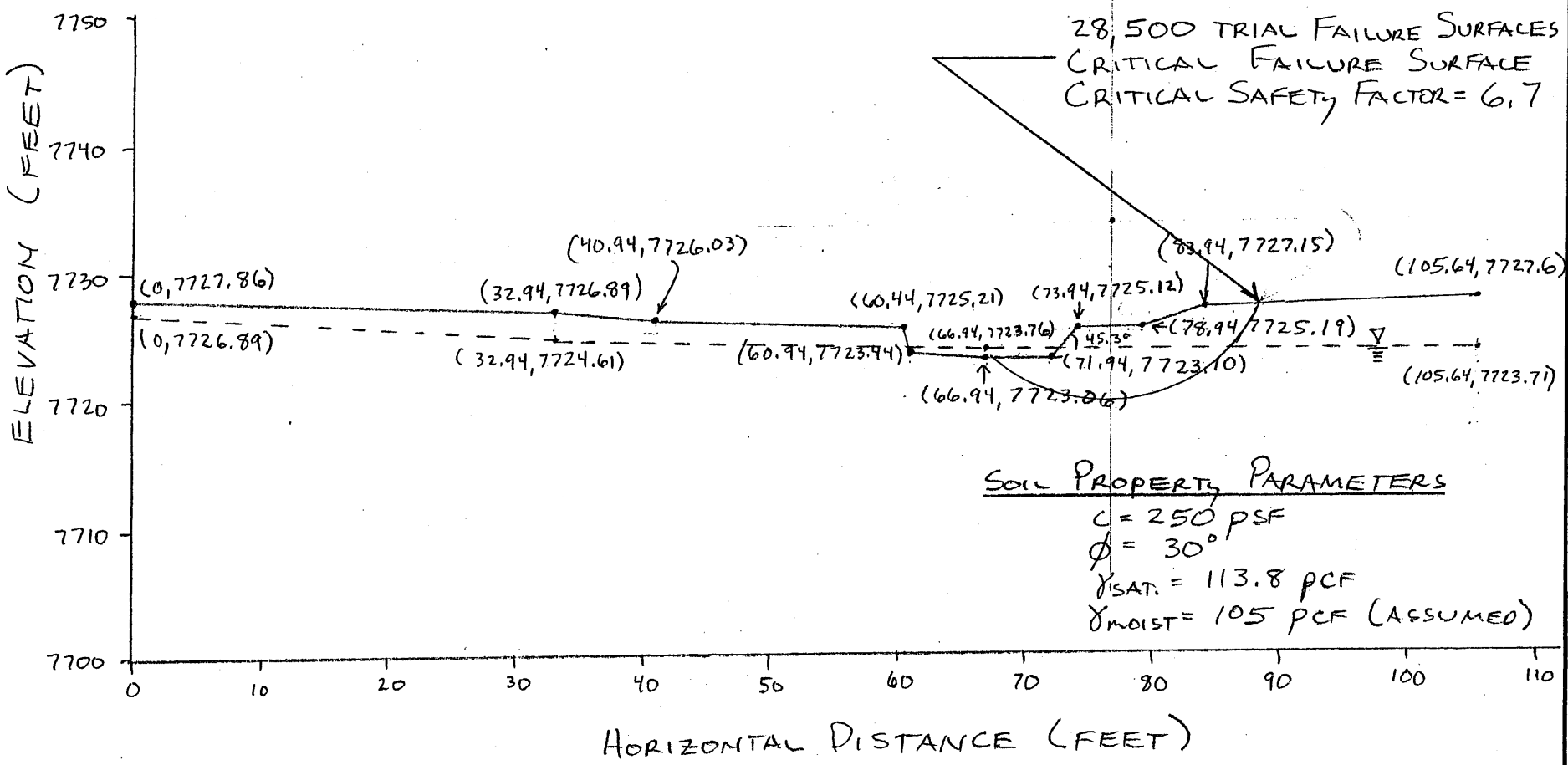
Using the assumptions presented above, the results of the slope stability analyses are attached and summarized in Table 1 of this appendix. The results of the analyses include cross-sections with the critical failure surface, the data files, and the output files. Table 1 includes the number of trial failure surfaces and the critical safety factors against slope failure.

TABLE 1

SOIL PROPERTY PARAMETERS AND RESULTS OF SLOPE STABILITY ANALYSES

Section	Direct Shear Test Values		Number of Trial Failure Surfaces	Safety Factor
	Cohesive Strength (psf)	Angle of Internal Friction (degrees)		
MC-4	250	30	28,500	6.7
MC-5	80	33.5	14,200	2.8
MC-6	90	39	24,200	2.5

Canyon Fuel Company
Skyline Mine Discharge Study
Section MC-4



Soil Property Parameters

$c = 250$ psf

$\phi = 30°$

$\gamma_{SAT.} = 113.8$ pcf

$\gamma_{MOIST} = 105$ pcf (assumed)

EARTHFAX ENGINEERING, INC.
ENGINEERS / SCIENTISTS

PROJECT UC794.03 PAGE 1 OF 1
COMPUTED RKB DATE 1/7/03
CHECKED ____ DATE ____

```
TITLE
SKYLINE MINES DISCHARGE STUDY
MUD CREEK CROSS SECTION MC-4
MEASURED WATER LEVEL; MC4.DAT
PROFIL
10 10
0 7727.86 32.94 7726.89 1
32.94 7726.89 40.94 7726.03 1
40.94 7726.03 60.44 7725.21 1
60.44 7725.21 60.94 7723.44 1
60.94 7723.44 66.94 7723.06 1
66.94 7723.06 71.94 7723.1 1
71.94 7723.1 73.94 7725.12 1
73.94 7725.12 78.94 7725.19 1
78.94 7725.19 83.94 7727.15 1
83.94 7727.15 105.64 7727.6 1
SOIL
1
105 113.8 250 30 0 0 1
WATER
1 62.4
4
0 7726.89
32.94 7724.61
66.94 7723.76
105.64 7723.71
CIRCL2
95 300 63 72.5 73.94 95 7700 1 40 -45
END
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*****************************************************************
*****                    GeoSlope                           *****
*****                  Version 5.00                         *****
*****                                                       *****
*****   (c)1992 by GEOCOMP Corp, Concord, MA                *****
*****   Licensed to EarthFax Engineering                    *****
*****************************************************************
```

Problem Title: SKYLINE MINES DISCHARGE STUDY
Description: MUD CREEK CROSS SECTION MC-4
Remarks: MEASURED WATER LEVEL; MC4.DAT

```
*****************************************************************
*****                    INPUT DATA                         *****
*****************************************************************
```

Profile Boundaries

Number of Boundaries: 10
Number of Top Boundaries: 10

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	7727.86	32.94	7726.89	1
2	32.94	7726.89	40.94	7726.03	1
3	40.94	7726.03	60.44	7725.21	1
4	60.44	7725.21	60.94	7723.44	1
5	60.94	7723.44	66.94	7723.06	1
6	66.94	7723.06	71.94	7723.10	1
7	71.94	7723.10	73.94	7725.12	1
8	73.94	7725.12	78.94	7725.19	1
9	78.94	7725.19	83.94	7727.15	1
10	83.94	7727.15	105.64	7727.60	1

Soil Parameters

Number of Soil Types: 1

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	105.0	113.8	250.0	30.0	0.00	0.0	1

Piezometric Surfaces

Number of Surfaces: 1
Unit Weight of Water: 62.40 pcf

Piezometric Surface No.: 1
Number of Coordinate Points: 4

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	7726.89
2	32.94	7724.61
3	66.94	7723.76
4	105.64	7723.71

****
***** TRIAL SURFACE GENERATION *****
****

Data for Generating Circular Surfaces

Number of Initiation Points:	95
Number of Surfaces From Each Point:	300
Left Initiation Point:	63.00 ft
Right Initiation Point:	72.50 ft
Left Termination Point:	73.94 ft
Right Termination Point:	95.00 ft
Minimum Elevation:	7700.00 ft
Segment Length:	1.00 ft
Positive Angle Limit:	40.00 deg
Negative Angle Limit:	-45.00 deg

****
***** RESULTS *****
****

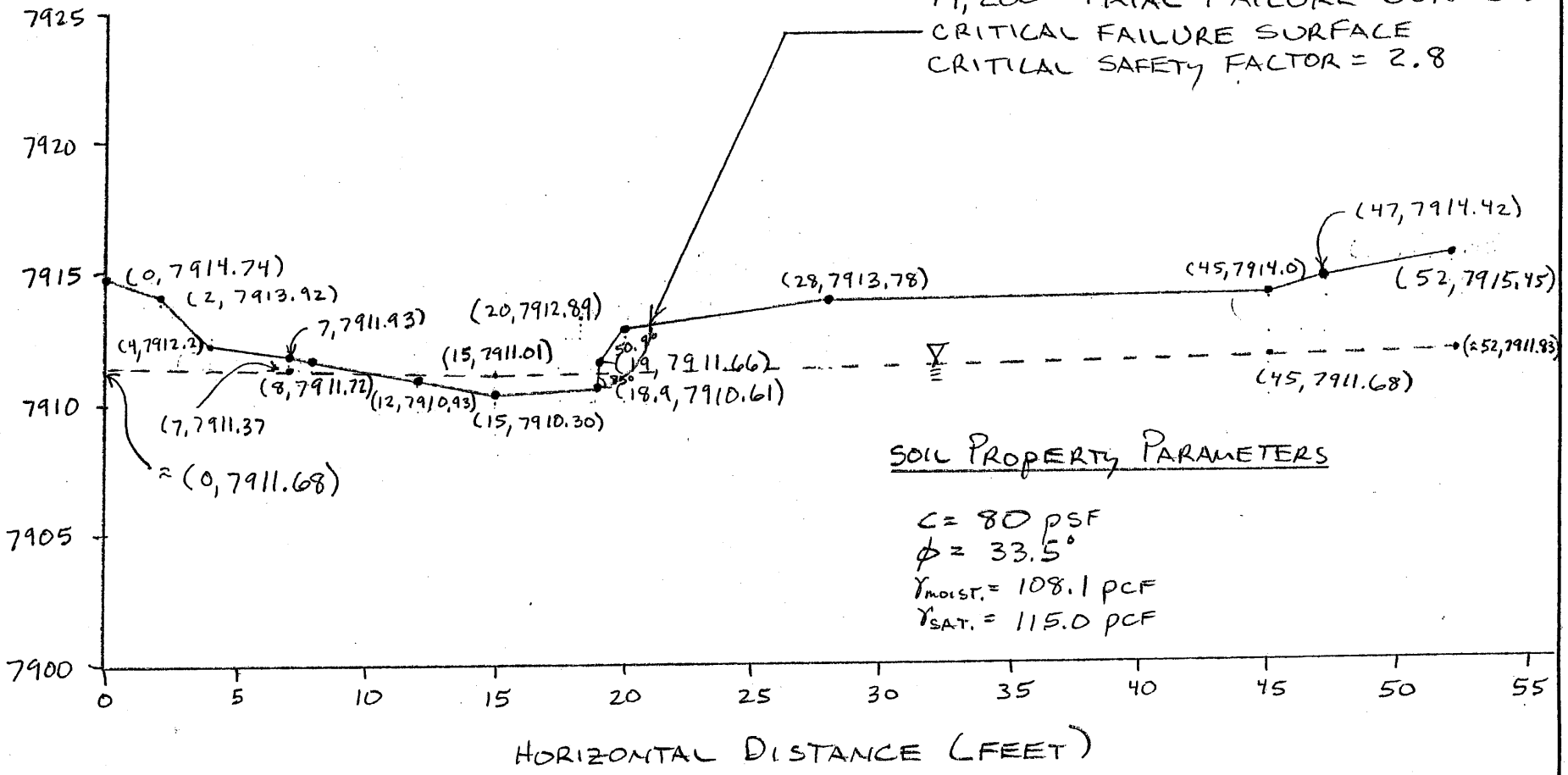
Critical Surfaces

No.	Safety Factor	Center X (ft)	Center Y (ft)	Circle Radius (ft)
1	6.774	76.73	7733.52	14.33
2	6.774	76.59	7733.83	14.98
3	6.777	76.34	7733.48	14.55
4	6.778	76.36	7733.99	14.93
5	6.778	76.52	7733.93	14.55
6	6.779	76.87	7733.12	14.06
7	6.782	76.43	7734.83	15.67
8	6.783	76.83	7733.63	14.93
9	6.784	76.63	7733.10	14.42
10	6.784	76.79	7734.62	15.68

PROJECT UC794.03 PAGE 1 OF 1
COMPUTED RKB DATE 1/6/03
CHECKED DATE

EARTHFAX ENGINEERING, INC.
ENGINEERS / SCIENTISTS

CANYON FUEL COMPANY
SKYLINE MINE DISCHARGE STUDY
SECTION MC-5



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TITLE
SKYLINE MINES DISCHARGE STUDY
MUD CREEK CROSS SECTION MC-5
MEASURED WATER LEVEL; MC5.DAT
PROFIL
13 13
0 7914.74 2 7913.92 1
2 7913.92 4 7912.2 1
4 7912.2 7 7911.93 1
7 7911.93 8 7911.72 1
8 7911.72 12 7910.93 1
12 7910.93 15 7910.3 1
15 7910.3 18.9 7910.61 1
18.9 7910.61 19 7911.66 1
19 7911.66 20 7912.89 1
20 7912.89 28 7913.78 1
28 7913.78 45 7914 1
45 7914 47 7914.42 1
47 7914.42 52 7915.45 1
SOIL
1
108.1 115 80 33.5 0 0 1
WATER
1 62.4
5
0 7911.68
7 7911.37
15 7911.01
45 7911.68
52 7911.83
CIRCL2
71 200 12 18.95 19.5 30 7900 1 80 -45
END
```

```
*****************************************************************
*****                    GeoSlope                           *****
*****                  Version 5.00                         *****
*****                                                       *****
*****   (c)1992 by GEOCOMP Corp, Concord, MA                *****
*****          Licensed to EarthFax Engineering             *****
*****************************************************************
```

Problem Title: SKYLINE MINES DISCHARGE STUDY
Description: MUD CREEK CROSS SECTION MC-5
Remarks: MEASURED WATER LEVEL; MC5.DAT

```
*****************************************************************
*****                    INPUT DATA                         *****
*****************************************************************
```

Profile Boundaries

Number of Boundaries: 13
Number of Top Boundaries: 13

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	7914.74	2.00	7913.92	1
2	2.00	7913.92	4.00	7912.20	1
3	4.00	7912.20	7.00	7911.93	1
4	7.00	7911.93	8.00	7911.72	1
5	8.00	7911.72	12.00	7910.93	1
6	12.00	7910.93	15.00	7910.30	1
7	15.00	7910.30	18.90	7910.61	1
8	18.90	7910.61	19.00	7911.66	1
9	19.00	7911.66	20.00	7912.89	1
10	20.00	7912.89	28.00	7913.78	1
11	28.00	7913.78	45.00	7914.00	1
12	45.00	7914.00	47.00	7914.42	1
13	47.00	7914.42	52.00	7915.45	1

Soil Parameters

Number of Soil Types: 1

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	108.1	115.0	80.0	33.5	0.00	0.0	1

Piezometric Surfaces

Number of Surfaces: 1
Unit Weight of Water: 62.40 pcf

Piezometric Surface No.: 1
Number of Coordinate Points: 5

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	7911.68
2	7.00	7911.37
3	15.00	7911.01
4	45.00	7911.68
5	52.00	7911.83

****
***** TRIAL SURFACE GENERATION *****
****

Data for Generating Circular Surfaces

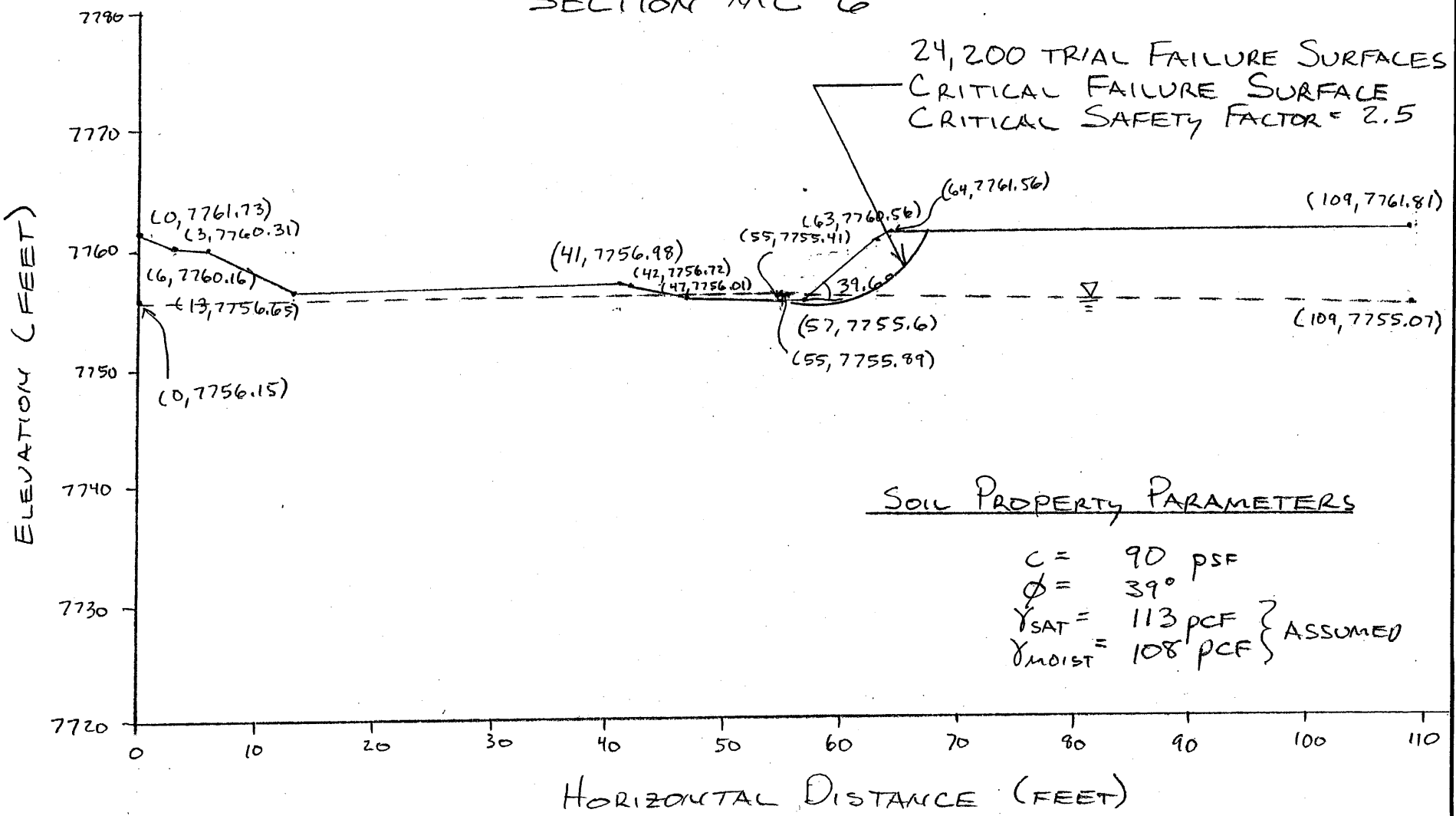
Number of Initiation Points:	71
Number of Surfaces From Each Point:	200
Left Initiation Point:	12.00 ft
Right Initiation Point:	18.95 ft
Left Termination Point:	19.50 ft
Right Termination Point:	30.00 ft
Minimum Elevation:	7900.00 ft
Segment Length:	1.00 ft
Positive Angle Limit:	80.00 deg
Negative Angle Limit:	-45.00 deg

****
***** RESULTS *****
****

Critical Surfaces

No.	Safety Factor	Center X (ft)	Center Y (ft)	Circle Radius (ft)
1	2.859	18.34	7913.23	2.75
2	2.861	18.72	7912.72	2.36
3	2.862	18.48	7914.10	3.57
4	2.878	18.25	7913.45	2.94
5	2.879	18.40	7913.41	2.94
6	2.884	18.37	7913.54	3.06
7	2.907	18.69	7913.90	3.42
8	2.909	18.61	7913.66	3.22
9	2.911	18.71	7912.88	2.50
10	2.915	18.48	7912.97	2.56

CANYON FUEL COMPANY
SKYLINE MINE DISCHARGE STUDY
SECTION MC-6



SOIL PROPERTY PARAMETERS

$c = 90$ psf
$\phi = 39°$
$\gamma_{SAT} = 113$ pcf
$\gamma_{MOIST} = 108$ pcf
} ASSUMED

EARTHFAX ENGINEERING, INC.
ENGINEERS / SCIENTISTS

PROJECT UC 794.03 PAGE 1 OF 1
COMPUTED RKB DATE 1/9/03
CHECKED ____ DATE ____

```
TITLE
SKYLINE MINES DISCHARGE STUDY
MUD CREEK CROSS SECTION MC-6
MEASURED WATER LEVEL; MC6.DAT
PROFIL
11 11
0 7761.73 3 7760.31 1
3 7760.31 6 7760.16 1
6 7760.16 13 7756.65 1
13 7756.65 41 7756.98 1
41 7756.98 42 7756.72 1
42 7756.72 47 7756.01 1
47 7756.01 55 7755.41 1
55 7755.41 57 7755.6 1
57 7755.6 63 7760.56 1
63 7760.56 64 7761.56 1
64 7761.56 109 7761.81 1
SOIL
1
105 113 90 39 0 0 1
WATER
1 62.4
3
0 7756.15
55 7755.89
109 7755.07
CIRCL2
121 200 47 59 62.5 90 7730 2 35 -45
END
```

```
*****************************************************************
*****                    GeoSlope                           *****
*****                  Version 5.00                         *****
*****                                                       *****
*****   (c)1992 by GEOCOMP Corp, Concord, MA                *****
*****              Licensed to EarthFax Engineering         *****
*****************************************************************
```

Problem Title: SKYLINE MINES DISCHARGE STUDY
Description: MUD CREEK CROSS SECTION MC-6
Remarks: MEASURED WATER LEVEL; MC6.DAT

```
*****************************************************************
*****                    INPUT DATA                         *****
*****************************************************************
```

Profile Boundaries

Number of Boundaries: 11
Number of Top Boundaries: 11

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	7761.73	3.00	7760.31	1
2	3.00	7760.31	6.00	7760.16	1
3	6.00	7760.16	13.00	7756.65	1
4	13.00	7756.65	41.00	7756.98	1
5	41.00	7756.98	42.00	7756.72	1
6	42.00	7756.72	47.00	7756.01	1
7	47.00	7756.01	55.00	7755.41	1
8	55.00	7755.41	57.00	7755.60	1
9	57.00	7755.60	63.00	7760.56	1
10	63.00	7760.56	64.00	7761.56	1
11	64.00	7761.56	109.00	7761.81	1

Soil Parameters

Number of Soil Types: 1

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	105.0	113.0	90.0	39.0	0.00	0.0	1

Piezometric Surfaces

Number of Surfaces: 1
Unit Weight of Water: 62.40 pcf

Piezometric Surface No.: 1
Number of Coordinate Points: 3

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	7756.15
2	55.00	7755.89
3	109.00	7755.07

****
***** TRIAL SURFACE GENERATION *****
****

Data for Generating Circular Surfaces

Number of Initiation Points:	121
Number of Surfaces From Each Point:	200
Left Initiation Point:	47.00 ft
Right Initiation Point:	59.00 ft
Left Termination Point:	62.50 ft
Right Termination Point:	90.00 ft
Minimum Elevation:	7730.00 ft
Segment Length:	2.00 ft
Positive Angle Limit:	35.00 deg
Negative Angle Limit:	-45.00 deg

****
***** RESULTS *****
****

Critical Surfaces

No.	Safety Factor	Center X (ft)	Center Y (ft)	Circle Radius (ft)
1	2.518	57.01	7764.94	9.36
2	2.519	57.30	7764.13	8.55
3	2.528	57.87	7764.41	8.85
4	2.529	57.23	7764.17	8.60
5	2.530	55.97	7766.33	10.77
6	2.531	57.99	7763.87	8.33
7	2.532	57.27	7764.04	8.47
8	2.533	57.61	7765.29	9.72
9	2.535	56.37	7765.30	9.72
10	2.536	57.42	7765.34	9.81

APPENDIX C

Legal Financial, Compliance and Related Information

Annual Report of Officers
As submitted to the Utah Department of Commerce

Other change in ownership and control information
As required under R645-301-110

CONTENTS

Officers and Directors for Canyon Fuel Company, LLC

Canyon Fuel Company, LLC
2002 Annual Report

Officers and Directors

The following lists describe the officers and directors of Canyon Fuel Company, LLC, Arch Western Resources, LLC, Arch Coal, Inc., Itochu Corporation, and Itochu Coal International, Inc. The addresses for the officers, directors, representatives to the management board listed are the same as those of the respective business entities as listed above, for which the individuals are officers, directors or representatives.

ADDRESSES:

Canyon Fuel Company, LLC
6955 South Union Park Center, Suite 540
Midvale, UT 84047

Arch Western Resources, LLC
City Place One, Suite 300
St. Louis, MO 63141

Arch Coal, Inc.
City Place One, Suite 300
St. Louis, MO 63141

Delta Housing, Inc.
515 South Flower Street
Los Angeles, CA 90071

Atlantic Richfield Company
515 South Flower Street
Los Angeles, CA 90071

ITOCHU Coal International Inc.
555 17th Street, Suite 845
Denver, Colorado 80202

ITOCHU Corporation, 5-1
Kita-Aoyama 2-Chome
Minato-ku, Tokyo 107-77, Japan

CANYON FUEL COMPANY, LLC:

Directors:

Robert W. Shanks Effective: 06/01/1998	Chairman
Masayoshi Araya Effective: 06/01/2001	
Yuzo Hirono Effective: 12/14/1999	
Steven F. Leer Effective: 06/01/1998	
Kenneth G. Woodring Effective: 12/01/2000	
Thomas A. Lockhart Effective: 02/24/03	
John W. Eaves Effective: 12/01/2000	Alternative Representative
Joe Y. Nakazawa Effective: 06/01/2001	Alternative Representative
Tsutomu Niwa Effective: 10/09/2001	Alternative Representative

Officers

Richard D. Pick Effective: 06/01/1998	President, Chief Executive Officer and General Manager
Robert J. Messey Effective: 10/09/2001	Chief Financial Officer
James E. Florczak Effective: 05/25/1999	Vice President, Finance
John W. Eaves Effective: 06/23/1998	Vice President, Marketing
Robert G. Jones Effective: 03/08/2000	Vice President, General Counsel and Assistant Secretary

Janet L. Hogan — Secretary
Effective: 10/11/2000

William H. Rose — Assistant Secretary
Effective: 06/01/1998

ARCH COAL, INC.: 2/03/03

Directors:

James R. Boyd — Chairman
Effective: 07/01/1997

Frank M. Burke
Effective: 09/07/2000

Robert G. Potter
Effective: 04/26/2001

Theodore D. Sands
Effective: 02/25/1999

Michael A. Perry
Effective: 09/28/1998

Douglas H. Hunt
Effective: 04/04/1995

Steven F. Leer
Effective: 07/1/1997

James L. Parker
Effective: 07/01/1997

Officers:

Steven F. Leer — President and Chief Executive Officer
Effective: 07/1/1997

Kenneth G. Woodring — Executive Vice President-Mining Operations
Effective: 07/01/1997

C. Henry Besten, Jr. — Vice President - Strategic Marketing
Effective: 07/01/1997

Larry R. Brown Effective: 07/01/1997	Vice President & Chief Information Officer
John W. Eaves Effective: 07/01/1997	Executive Vice President/COO
David B. Peugh Effective: 07/01/1997	Vice President - Business Development
Robert W. Shanks Effective: 07/01/1997	Vice President - Operations
William H. Rose Effective: 04/22/1998	Vice President - Tax Planning
Robert J. Messey Effective: 12/1/2000	Vice President, Chief Financial Officer
Robert G. Jones Effective: 10/16/2000	Vice President, General Counsel and Secretary
James E. Florczak Effective: 08/17/1998	Vice President, Finance, Treasurer
Deck S. Slone Effective: 04/26/2001	Vice President
Bradley M. Allbritten Effective: 03/1/2000	Vice President, Marketing
Janet L. Hogan Effective: 10/16/2000	Assistant Secretary
John W. Lorson Effective: 04/9/1999	Controller
Charles David Steele Effective: 06/22/1998	Internal Auditor
Shiela Feldman Effective: 02/03/2003	Vice President, Human Resources

ARCH WESTERN RESOURCES, LLC 1/10/03

Directors:

Patrick A. Kriegshauser
Effective: 05/07/98

David B. Peugh
Effective: 05/07/98

Jeffry N. Quinn
Effective: 05/07/98

Officers:

Robert W. Shanks Effective: 06/28/98	President - Operations
David B. Peugh Effective: 05/17/98	Vice President
William H. Rose Effective: 05/07/98	Assistant Secretary
Robert G. Jones Effective: 03/01/00 and 6/2/98	Vice President and Assistant Secretary
Janet L. Hogan Effective: 3/17/98	Secretary
James E. Florczak Effective: 05/15/98	Vice President, Finance, Treasurer

ITOCHU Coal International Inc. Representatives to the Management Board:

Akio Shigetomi
Effective: 11/30/1996

Masayoshi Araya
Effective: 11/30/1996

Yuzo Hirono
Effective: 12/31/1999

Alternates:

Tsutomu Niwa
Effective: 6/01/2001

Yutaka Nakazawa
Effective: 12/20/1996

ITOCHU CORPORATION 9/1/02

Name	Title	Date of Appointment
Minoru Murofushi	Chairman	April 1998
Masahisa Naitoh	Vice Chairman	April 2000
Uichiro Niwa	President, CEO	April 1998
Hiroshi Sumie	Executive Vice President	April 2000
Makoto Kato	Executive Vice President	April 2001
Yushin Okazaki	Executive Vice President	April 2001
Sumitaka Fujita	Executive Vice President	April 2001
Mitsuaki Fukuda	Sr. Managing Director	April 2000
Akira Yokota	Sr. Managing Director	April 2001
Kouhei Watanabe	Managing Director	April 2002
Hiroshi Ueda	Managing Director	April 2002
Motonori Toyota	Managing Director	June 2001

ITOCHU COAL INTERNATIONAL INC.

Masayoshi Araya — Chairman of the Board
Effective: Dec. 1999

Yuzo Hirono — President and Chief Executive Officer
Effective: Dec. 1999

Tsutomu Niwa — Chief Financial Officer
Effective: June 1996

Dietz Fry — Vice President, Finance and Administration
Effective: March 1997

Yutaka Nakazawa — Vice President Commercial and Secretary
Effective: Dec. 1996

Hiroshi Akiba — Assistant Secretary
Effective: Feb. 2000

APPENDIX D

Mine Maps

As required under R645-302-525-270

CONTENTS

Skyline Mine Level 1 2002 No Production
Skyline Mine Level 2 and 3 2002 Longwall Production
Mine 3 Level 2 & 3 2003 BOD-2 Best Case