Transportation Committee Meeting

July 9, 2013

1

Agenda

- Road Project List
- Bridge and Culvert Update
- Sheep Farm Road
- Department Update

2

Road Project List

Contract Road Improvement Project

- Lakefront Rd (SE-429)
- Lake Ter (SE-430)
- Westlake Dr (SE-484)
- Jade Ln (WA-311)
- Topaz Ct (WA-310)
- Brookridge Dr (WA-330)
- Pine Terrace Dr (SE-243)
- Stratford Dr (SE-242)
- Ridgeview Ln (SE-331)
- Celtic Ct (SE-332)
- Debra Dr (CE-2)
- Wickliffe Ln (WA-256)
- Berry Ln (WA-260)

18,500 feet = 3.51 miles

Road Project List

- Contract Road Construction Project
  - Lynx Lane (CE-127)
  - RC Drive (CE-180)

2,210 feet = 0.42 miles

Action Requested

- Committee approve Road Improvement Project List and New Construction Road Project .
- Committee request County Council to approve the roads for projects, so that the work can be competitively bid.

Bridge and Culvert Update

- Cobb Bridge
- Mauldin Mill Road
- Megee Road

TU-37 Cobb Bridge Rd

Cobb Bridge Road

- As directed at the May 21, 2013, County Council meeting, Specifications and Bid documents are being finalized.
- Anticipate that bids for work will be received by October, 2013.

SE-56 Mauldin Mill Rd

9

Mauldin Mill Road

Important Drainage Information

- Watershed Area is **566** acres.
- Design Storm (100-year Runoff) is **1,400** cfs.
- Current design overtops road by **2' – 4'**.

10

Mauldin Mill Road

Options

1. 28'X8' Bottomless Arch Culvert (Con/Span) $339,000.
2. (4) 7'X7' Box Culverts $257,000.
3. *(4)8'X5' Box Culverts $200,000.
4. 30' Bridge $247,000 (Staff Recommended)

* Does not pass "Design Storm Event."

11

Con/Span Bridge Product

12

Action Requested

- Direct staff to finalize bridge design and specifications to be developed into bid documents and obtain necessary right-of-way.

18

Megee Road

Important Drainage Information

- Watershed Area is **1,725** acres.
- Design Storm (100-year Runoff) is **3,100** cfs.
- Current design overtops road by **3'-1"**.

Megee Road
Options

1. 60' Bridge $419,000.
2. *(2) 24'X7' Bottomless Arch Culverts (Con/Span) $690,000.
3. *(4)12'X6' Box Culverts $524,000.

* Does not pass Design Storm Event.

Action Requested

- Direct staff to finalize bridge design and specifications to be developed into bid documents and obtain necessary right-of-way.

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Sheep Farm Road

- SCDOT wishes to transfer some purchased right-of-way along County maintained to the County.
- Sheep Farm Road has modified some County maintained roadway such some section could be abandoned from maintenance.
- Coordinating both activities County Attorney.

18

Action Requested

- Presented a matter of information.

Department Activity Update

- Summary Handout Provided.

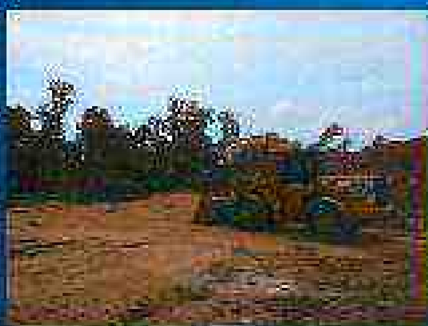
20

Upgrade to Chau Ram

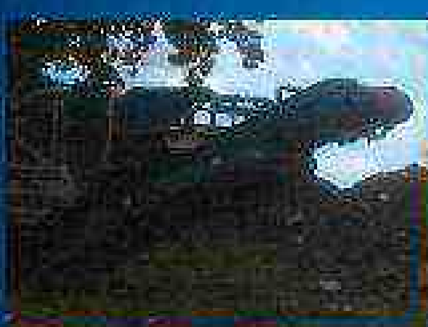
26 Sites and Bath House
Water, Electrical, and Gravel for Camper Sites
Patched Road and Trenches cut for Utilities.

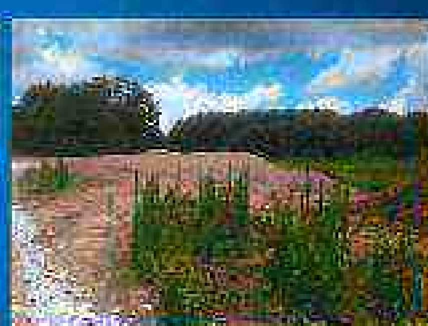
Asphalt Recycling

Asphalt Recycling



Asphalt Recycling





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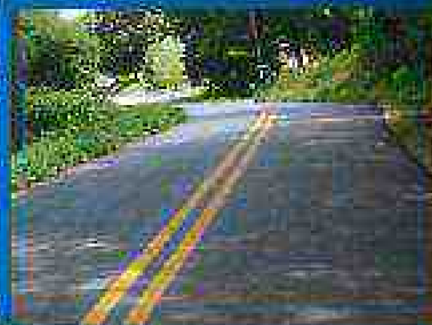
Striping Contract

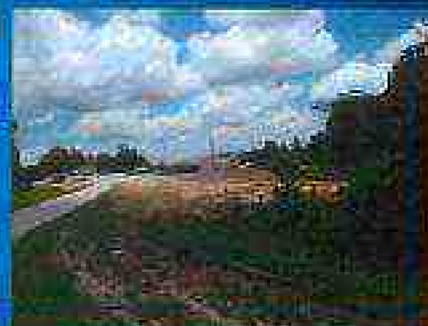
Thermal 126.5 Miles

Water 135 Miles

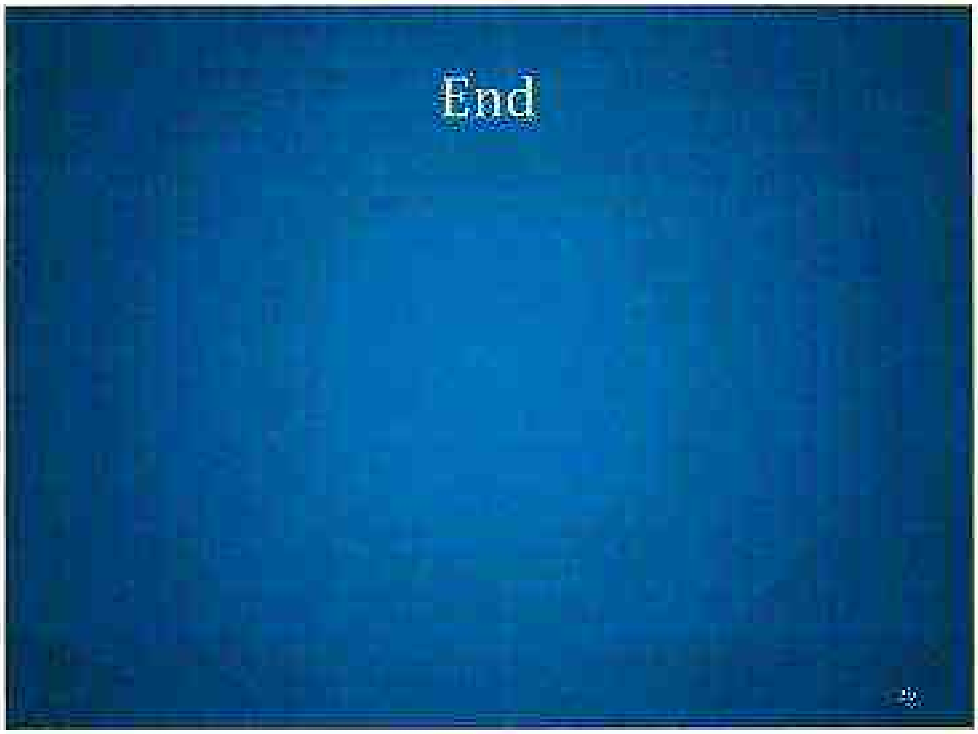


Trashing Trailers

Trashing Trailers



Scrape Metal Recycle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TENTATIVE RO..D IMPROVEMENT LIST
JULY 9, 2013

Road Name	Directions	Road Number	Length	Width
Lakefront Rd	EAST ON WEST OAK HWY FROM CROSSROADS THROUGH TOWNVILLE, LEFT ON S-92 (ANDERSON COUNTY), LEFT ON PLANTATION RD, CROSS BACK INTO OCONEE COUNTY, AT STOP SIGN LAKEFRONT RD WILL BEGIN STRAIGHT AHEAD OR LEFT TOWNVILLE	SE-429	1,700	21
Lake Terrace	EAST ON WEST OAK HWY FROM CROSSROADS THROUGH TOWNVILLE, LEFT ON S-92 (ANDERSON COUNTY), LEFT ON PLANTATION RD, RIGHT ON LAKEFRONT RD, WILL BE THE FIRST STREET ON THE LEFT	SE-430	206	20
Westlake Dr	NORTH ON ROCHESTER HWY FROM SENECA, LEFT ON KATELYNN LN WILL BE ON THE LEFT PAST EAST WATERFORD DR. WATERFORD POINTE SUB	SE-434	4,632	22
Jade Ln	NORTH ON KEOWEE SCHOOL RD, FROM BOUNTYLAND, WILL BE ON THE LEFT PAST HEBRON RD. (EMERALD POINTE SUB)	WA-311	453	20
Topaz Ct	NORTH ON KEOWEE SCHOOL RD FROM BOUNTYLAND, LEFT ON JADE LN, 600-699 WILL BE ON THE RIGHT, 700-799 WILL BE ON THE LEFT (EMERALD POINTE SUB)	WA-310	745	20
Brookridge Dr	NORTH ON N HIGHWAY 11 FROM WEST UNION, LEFT ON BROOKSIDE DR, WILL BE ON THE LEFT	WA-330	1,838	20
Pine Terrace Dr	EAST ON CLEMSON BLVD FROM SENECA, RIGHT ON DAVIS CREEK RD, LEFT ON HIGH HILL RD, LEFT ON STRATFORD DR, WILL BE FIRST STREET ON RIGHT	SE-243	406	21
Stratford Dr	EAST ON CLEMSON BLVD FROM SENECA, RIGHT ON DAVIS CREEK RD; LEFT ON HIGH HILL RD, WILL BE SECOND STREET, RUNS BOTH DIRECTIONS AT STOP SIGN, CAN BE ACCESSED FROM WAYSIDE CIR	SE-242	2,280	22
Ridgeview Ln	EAST ON WELLS HWY FROM FRIENDSHIP RD, WILL BE ON THE RIGHT PAST VILLA DR	SE-331	2,189	20
Celtic Ct	EAST ON WELLS HWY FROM FRIENDSHIP RD, RIGHT ON RIDGEVIEW LN, WILL BE THE FIRST STREET ON THE RIGHT	SE-332	185	20
Debra Dr	FROM E MAIN ST IN WESTMINSTER, SOUTH ON S BIBB ST WHICH TURNS INTO SEED FARM RD, RIGHT ON MILLER FARM RD, WILL BE THE FIRST STREET ON RIGHT	CE-2	2,692	19
Wickliffe Ln	NORTH ON BURNS MILL RD FROM WEST UNION, WILL BE ON THE LEFT APPROXIMATELY ONE HALF MILE (BURNS MILL SUB)	WA-256	1,250	20
Berry Ln	NORTH ON BURNS MILL RD FROM WEST UNION, LEFT ON WICKLIFFE LN, WILL BE THE FIRST STREET ON THE LEFT (BURNS MILL SUB)	WA-260	371	20

TENTATIVE ROAD CONSTRUCTION LIST
JULY 9, 2013

Road Name	Directions	Road Number	Length	Width
Lynx Ln	SOUTH ON HWY 59 FROM WEST OAK HWY, WILL BE THE SECOND ROAD ON THE LEFT AFTER WATERSHED RD.	CE-127	1,044	20
RC Dr	SOUTH ON HWY 59 FROM WEST OAK HWY IN WESTMINSTER, LEFT ON LYNX LN, WILL BE ON THE LEFT.	CE-180	1,004	20

"Mauldin Mill Road Culvert Analysis" for

Oconee County

Final Report - July 2013

Mauldin Mill Road Culvert

Hydrologic, Hydraulic and Alternatives Analysis

D&F Job No. 12975.01

Prepared for:

Oconee County, SC

D. Mack Kelly, Jr. PE, PLS, CFM

County Engineer

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Seneca, SC 29678

Prepared by:

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SOUTH CAROLINA PROFESSIONAL ENGINEER No. 27609 MICHAEL A. PUTNAM

SOUTH CAROLINA DAVIS & FLOYD, INC. No. C00538 CERTIFICATE OF AUTHORIZATION

DAVIS & FLOYD

Engineering | Architecture | Environmental | Laboratory

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1. PROJECT BACKGROUND AND LOCATION

Located off of Highway 76 approximately 2.4 Miles west of the intersection of Highway 76 and Blue Ridge Blvd, Mauldin Mill Road is a paved local roadway which provides vehicular access for residential and commercial properties east of Highway 76. Along its alignment, approximately 0.5 miles east of its intersection with Highway 76, Mauldin Mill Road crosses a sub-tributary to Richland Creek. As indicated by Oconee County Public Works, this crossing is subject to frequent roadway overtopping and inadequate culvert performance. The purpose of this project is to analyze this crossing and develop alternatives for supporting recommendations to the County for crossing improvements.

2. COMPILATION OF EXISTING DATA

2.1 Topographic Survey

To establish baseline conditions and support modeling efforts, field survey of existing features in the immediate area of the subject crossing was performed. This data included roadway cross sections, stream cross sections, invert elevations and length of the 60" Corrugated Metal Pipe (CMP) culvert, and surrounding structures which could be impacted by the hydraulic performance of this crossing.

2.2 Regional Topographic Data

Regional topographic data used in the delineation of hydrologic basins and the construction of the hydraulic model was obtained from Oconee County. This data provided information required for determining the area draining to the crossing as well as other hydrologic and hydraulic parameters.

3. HYDROLOGIC ANALYSIS

The hydrologic analysis of the drainage area served by the Mauldin Mill Road crossing was initiated by delineating the limits of the basin served by the crossing using the previously mentioned regional topographic data. Upon delineating the basin, a land cover analysis was then performed and in conjunction with USGS soils data a composite curve number was developed for the contributing basin using SCS methodology. SCS TR-55 methodology was then utilized to generate a time of concentration. In summary, the basin contributing flow to the Mauldin Mill Road crossing has an area of 565.8 acres, a composite curve number of 69.4, and time of concentration of 62.5 minutes. These variables were then used for runoff generation. **Figure 1** shows the local topography and resulting basin delineation and **Figure 2** shows the basin and aerial imagery used in determining the composite curve number.

Storm events considered for this analysis include the 2, 10, 25, 50, and 100-yr Type II 24-hr events with rainfall depths obtained from the SCDHEC Storm water Management BMP Handbook – Appendix F. Rainfall Values and resulting flows are tabulated in **Table 1** shown below. **Appendix A** contains detailed hydrologic data including computation of the composite curve number and time of concentration.

Table 1: Rainfall and Runoff

Storm Event	[1]24-hr Rainfall (in)	Runoff (cfs)
2-Yr	3.80	292.18
10-Yr	5.50	644.41
25-Yr	6.60	897.83
50-Yr	7.60	1138.94
100-Yr	8.60	1386.84

[1]Oconee South Rainfall Values

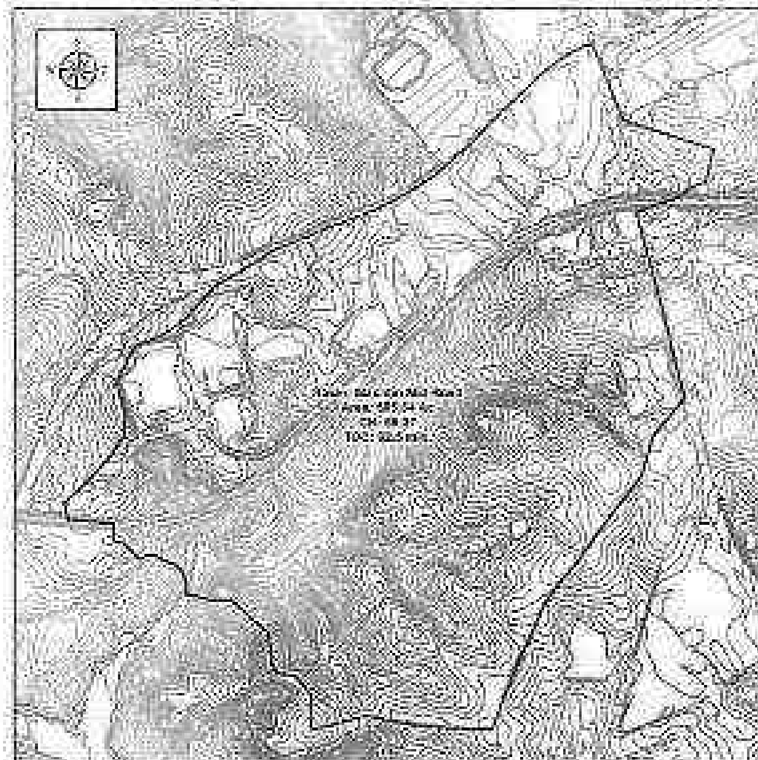


Figure 1: Basin Topography

Figure 2: Basin Land Cover

4. ANALYSIS OF EXISTING SYSTEM

The hydraulic analysis of the Mauldin Mill Road culvert was carried out using USACE's HEC-RAS. The aforementioned regional topographic data combined with the topographic field survey was utilized in the construction of model cross sections, roadway embankment, and culvert geometry. This data coupled with the flows from the previously completed hydrologic analysis were then used to analyze the performance of the culvert crossing for the 2, 10, 25, 50, and 100-yr events.

Modeling efforts show that the existing 60" CMP which provides conveyance under Mauldin Mill Road is grossly under sized and is inadequate to convey flows generated by the 2-yr event, overtopping by 0.9' with ≈ 53% of the flow being carried by the culvert. **Table 2** below tabulates water surface elevation and the depth that the roadway is overtopped for each storm event. **Appendix B** shows the corresponding water surface profile for each of the events shown below.

Table 2: Existing Conditions Hydraulic Performance

Storm Event	[1]Centerline Roadway Elevation:	792.90
	[1]Water Surface Elevation (ft)	Overtopping (ft)
2-Yr	793.80	0.9
10-Yr	794.64	1.74
25-Yr	794.84	1.94
50-Yr	795.03	2.13
100-Yr	795.22	2.32

[1]All Elevations Referenced to the North American Vertical Datum of 1988

5. DEVELOPMENT AND ANALYSIS OF CONCEPTUAL IMPROVEMENTS

Conceptual improvements were selected with the goal of providing a crossing which passes the design storm event without overtopping and without adversely impacting upstream properties. Conveyance type and size, as well as roadway elevation were manipulated to achieve the stated goal. As requested by the Oconee County Public works, the 100-yr storm event was considered as the basis of design. In addition to the 100-yr storm event and to offer an improvement option which could be constructed at a lower cost, the 25-yr storm event was also considered as a basis of design. During the development of proposed alternatives careful attention was given to the upstream water surface elevations at the crossing to determine if a modeled scenario would adversely impact upstream properties. In all cases and for all storm events, modeling demonstrates that the conceptual alternatives do not produce water surface elevations which would adversely impact upstream properties. **Appendix C** contains modeling output from each of the conceptual improvements.

5.1 Option 1 – 28' x 8' Bottomless Arch Culvert

Alternatives analysis shows that a large conveyance structure will be required to pass design flows without overtopping and producing water surface elevations that would adversely impact upstream properties. This led to the consideration of a CON/SPAN type bottomless arch culvert. Analysis shows that a 28' x 8' CON/SPAN arch culvert would be required to convey the design flows. Further site geometric analysis showed that this culvert would need to be approximately 36' in length and that the roadway itself would need to be raised approximately 4.6' from a low point elevation of 792.90' to an elevation of 797.50' to provide cover for the CON/SPAN without the roadway overtopping or adversely affecting upstream properties for the design event. Preliminary project costs for this option are estimated to be $338,611. **Table 3** summarizes water surface elevations and contrasts both existing and proposed conditions. **Appendix C.1** contains supporting modeling output including water surface profiles and cross sections and **Appendix D.1** contains the preliminary cost estimate.

Table 3: Option 1 Hydraulic Performance

Storm Event	[1]Existing Water Surface Elevation (ft)	[1]Proposed Water Surface Elevation (ft)	Change in Water Surface Elevation (ft)
2-Yr	793.80	790.94	-2.86
10-Yr	794.64	792.25	-2.39
25-Yr	794.84	793.03	-1.81
50-Yr	795.03	793.67	-1.36
*100-Yr	795.22	794.33	-0.89

[1]All Elevations Referenced to the North American Vertical Datum of 1988
*Design Storm Event

5.2 Option 2 – (4) 7' x 7' Reinforced Concrete Box Culverts

As an alternative to the large CON/SPAN bottomless Arch Culvert, large Reinforced Concrete Box Culverts (RCBC) were also considered. Modeling analysis shows that (4) 7x7 RCBCs will be required to pass the 100-yr event without overtopping or adversely affecting upstream properties. Similarly to the CONSPAN culvert, the RCBCs would need to be approximately 36' in length and that the roadway would need to be raised approximately 2.6' from a low point elevation of 792.90 to an elevation of 795.50. Preliminary project costs for this option are estimated to be $257,249. **Table 4** shown below provides hydraulic performance data for this option. **Appendix C.2** contains supporting modeling output including water surface profiles and cross sections and **Appendix D.2** contains the preliminary cost estimate.

Table 4: Option 2 Hydraulic Performance

Storm Event	[1]Existing Water Surface Elevation (ft)	[1]Proposed Water Surface Elevation (ft)	Change in Water Surface Elevation (ft)
2-Yr	793.80	790.92	-2.88
10-Yr	794.64	792.22	-2.42
25-Yr	794.84	792.98	-1.86
50-Yr	795.03	793.60	-1.43
*100-Yr	795.22	794.23	-0.99

[1]All Elevations Referenced to the North American Vertical Datum of 1988
*Design Storm Event

5.3 Option 3 – (4) 5' x 8' Reinforced Concrete Box Culverts

In order to provide additional options to the County, consideration was given to utilizing the 25-yr storm event for the basis of design and to allow the 50-yr and 100-yr storm events to overtop the roadway without adversely impacting upstream properties. Modeling shows that (4) 5' x 8' RCBC culverts will accomplish this goal without increasing upstream water surface elevations and allow the 50-yr event to pass without overtopping. Similarly to previous options, these culverts would need to be approximately 36' long and would require the roadway to be raised approximately 1.70' from a low point elevation of 792.90 to an elevation of 794.60. Preliminary project costs are estimated to be $199,677 for this option. **Table 5** summarizes hydraulic performance for this option, and **Appendix C.3** contains supporting modeling output including water surface profiles and cross sections and **Appendix D.3** contains the preliminary cost estimate.

Table 5: Option 3 Hydraulic Performance

Storm Event	[1]Existing Water Surface Elevation (ft)	[1]Proposed Water Surface Elevation (ft)	Change in Water Surface Elevation (ft)	Roadway Overtopping (ft)
2-Yr	793.8	790.85	-2.95	-
10-Yr	794.64	792.09	-2.55	-
*25-Yr	794.84	792.9	-1.94	-
50-Yr	795.03	793.68	-1.35	-
100-Yr	795.22	794.61	-0.61	0.01

[1]All Elevations Referenced to the North American Vertical Datum of 1988
*Design Storm Event

5.4 Option 4 – 30' Bridge

As an alternative to closed conveyance systems, bridging the sub tributary to Richland Creek was also considered. Similarly to the large closed conveyance structures previously considered, the 100-yr storm event would be used as the basis for design. Hydraulic modeling shows that a 30' bridge will pass the 100-yr storm event without overtopping, and without adversely affecting upstream or downstream properties. The construction of a bridge would require that the roadway be raised approximately 4.6' from a low point elevation of 792.90' to an elevation of 797.50' to provide for the passage of debris and to account for the structural depth of the bridge. Preliminary project costs are estimated at $246,650 for this option. **Table 6** tabulates hydraulic performance for this structure. **Appendix C.4** contains supporting modeling output including water surface profiles and cross sections and **Appendix D.4** contains the preliminary cost estimate.

Table 6: Option 4 Hydraulic Performance

Storm Event	[1]Existing Water Surface Elevation (ft)	[1]Proposed Water Surface Elevation (ft)	Change in Water Surface Elevation (ft)
2-Yr	793.8	790.93	-2.87
10-Yr	794.64	792.15	-2.49
25-Yr	794.84	792.8	-2.04
50-Yr	795.03	793.3	-1.73
*100-Yr	795.22	793.77	-1.45

[1]All Elevations Referenced to the North American Vertical Datum of 1988
*Design Storm Event

6. RECOMMENDATION FOR IMPROVEMENTS

6.1 Summary of Options

Option 1 - 28' x 8' Bottomless Arch Culvert – This option will pass the 100-yr storm event without overtopping and without adversely affecting upstream or downstream properties for all modeled storm events. This structure will also pass the 100-yr storm event un-pressurized with a free surface and will provide for debris passage. Construction will require that Mauldin Mill Road be elevated 4.6', and is estimated to cost $338,611.

Option 2 – (4) 7' x 7' Box Culverts – Similarly to Option 1 this alternative will pass the 100-yr storm event without overtopping in an un-pressurized free surface flow regime. All modeled storm events are conveyed without adversely affecting upstream or downstream properties, and with observed freeboard for all modeled storm events, this structure will provide passage for debris. Construction will require that Mauldin Mill Road be elevated 2.6', and is estimated to cost $257,249.

Option 3 – (4) 8' x 5' Box Culverts – Contrasting with both Option 1 and Option 2, this alternative will not pass the 100-yr storm event without overtopping. However, for all modeled storm events, upstream water surface elevations are reduced when compared to existing. Additionally this structure will not produce adverse impacts to upstream or downstream properties. As designed, this configuration will pass the 2, 10, 25, and 50-yr events without overtopping, but conveys the 25 and 50-yr events in a pressurized flow regime, which will not provide for optimal debris passage. Construction will require that Mauldin Mill Road be elevated 1.70' and is estimated to cost $199,677.

Option 4 – 30' Bridge – This alternative passes the 100-yr storm event while lowering upstream water surface elevations for all modeled events. Consistent with the previously suggested structures, this option will not produce adverse hydraulic impacts to upstream or downstream properties, and with freeboard provided for all storm events this structure will provided for the passage of debris. Construction will require that Mauldin Mill Road be elevated 4.6' and is estimated to cost $246,650.

6.2 Recommendation

Of the four options presented, Option 2 ((4) 7' x 7' Box Culverts) or Option 4 (30' Flat Slab Bridge) would be an acceptable alternative for the County. As originally requested, both options pass the 100-yr event without overtopping in an unpressurized free surface condition, and will provided for debris passage. When compared to Option 1, Option 2 and Option 4 are approximately $80,000 and $90,000 cheaper respectively. Contrasting the two acceptable alternatives, Option 2 will not require protection against invert scour or supporting foundations, but will be more susceptible to debris issues than Option 4 due to its multiple barrel configuration. Furthermore, Option 4 will require that the roadway be raised 4.6' vs. the 2.6' required for Option 2, and the cost difference between the two acceptable alternatives is approximately $10,000. Therefore, it is recommended that either Option 2 ((4) 7' x 7' Box Culverts) or Option 4 (30' Flat Slab Bridge) be considered by the County as preferred alternatives for improvements to Mauldin Mill Road.

Appendix A
Hydrologic Data

Appendix A.1
Composite Curve Number Analysis

<u>Appendix A.1 - Mauldin Mill Road Composite Curve Number Calculation</u>

Basin	ΣA	$\Sigma CN_i * A_i$	CN
MauldinMillRoad_1	565.84	39251.30	69.37

$$CN = \frac{\sum CN_i A_i}{\sum A_i}$$

Land Cover	Curve Numbers			
	A	B	C	D
Grass	36	61	74	80
Trees	25	55	70	77
Commercial	89	92	94	95
Residential	57	72	81	86
Impervious	98	98	98	98
Poor Cover	72	82	87	89
Railroad	76	85	87	89

Basin Name	Area (Ac)	Landuse	hydgrp	$CN_i * A_i$
MauldinMillRoad_1	0.03	Commercial	B	2.50
MauldinMillRoad_1	1.51	Commercial	B	138.98
MauldinMillRoad_1	12.60	Commercial	B	1159.17
MauldinMillRoad_1	0.06	Commercial	B	5.15
MauldinMillRoad_1	34.64	Commercial	B	3187.19
MauldinMillRoad_1	1.44	Commercial	B	132.82
MauldinMillRoad_1	0.04	Commercial	B	3.78
MauldinMillRoad_1	27.55	Commercial	B	2534.55
MauldinMillRoad_1	0.02	Commercial	B	1.72
MauldinMillRoad_1	0.12	Commercial	B	10.82
MauldinMillRoad_1	10.68	Commercial	B	982.34
MauldinMillRoad_1	0.02	Commercial	B	1.59
MauldinMillRoad_1	12.61	Commercial	B	1159.77
MauldinMillRoad_1	4.88	Commercial	B	449.38
MauldinMillRoad_1	3.17	Commercial	B	291.20
MauldinMillRoad_1	0.24	Commercial	B	22.22
MauldinMillRoad_1	2.48	Commercial	B	228.26
MauldinMillRoad_1	5.26	Commercial	B	483.62
MauldinMillRoad_1	3.31	Commercial	B	304.72
MauldinMillRoad_1	2.33	Commercial	B	214.20
MauldinMillRoad_1	5.81	Commercial	B	534.57
MauldinMillRoad_1	8.77	Commercial	B	807.09
MauldinMillRoad_1	2.85	Commercial	B	262.06
MauldinMillRoad_1	0.73	Commercial	B	66.83
MauldinMillRoad_1	6.94	Commercial	B	638.38
MauldinMillRoad_1	1.17	Commercial	B	107.96
MauldinMillRoad_1	1.66	Commercial	B	152.96
MauldinMillRoad_1	0.78	Commercial	B	71.71
MauldinMillRoad_1	1.61	Commercial	B	148.09
MauldinMillRoad_1	0.01	Commercial	B	1.06

MauldinMillRoad_1	1.06	Impervious	B	104.13
MauldinMillRoad_1	1.20	Impervious	B	117.68
MauldinMillRoad_1	0.02	Impervious	B	1.57
MauldinMillRoad_1	0.35	Impervious	B	33.99
MauldinMillRoad_1	0.51	Impervious	B	50.36
MauldinMillRoad_1	1.55	Impervious	B	151.58
MauldinMillRoad_1	0.43	Impervious	B	41.87
MauldinMillRoad_1	0.24	Impervious	B	23.67
MauldinMillRoad_1	0.08	Impervious	B	7.83
MauldinMillRoad_1	0.23	Impervious	B	22.36
MauldinMillRoad_1	0.17	Impervious	B	16.75
MauldinMillRoad_1	0.63	Impervious	B	61.92
MauldinMillRoad_1	0.18	Impervious	B	18.11
MauldinMillRoad_1	0.26	Impervious	B	25.79
MauldinMillRoad_1	0.00	Poor Cover	B	0.00
MauldinMillRoad_1	5.23	Poor Cover	B	429.08
MauldinMillRoad_1	1.91	Poor Cover	B	156.65
MauldinMillRoad_1	2.15	Poor Cover	B	176.44
MauldinMillRoad_1	0.58	Poor Cover	B	47.16
MauldinMillRoad_1	0.12	Poor Cover	B	9.83
MauldinMillRoad_1	17.02	Grass	B	1038.07
MauldinMillRoad_1	4.16	Grass	B	253.97
MauldinMillRoad_1	0.92	Grass	B	56.23
MauldinMillRoad_1	0.65	Grass	B	39.54
MauldinMillRoad_1	1.06	Grass	B	64.55
MauldinMillRoad_1	0.64	Grass	B	39.29
MauldinMillRoad_1	1.30	Grass	B	79.25
MauldinMillRoad_1	2.13	Grass	B	130.22
MauldinMillRoad_1	1.37	Grass	B	83.66
MauldinMillRoad_1	4.08	Grass	B	248.81
MauldinMillRoad_1	0.33	Grass	B	19.88
MauldinMillRoad_1	0.30	Grass	B	18.06
MauldinMillRoad_1	2.56	Grass	B	156.37
MauldinMillRoad_1	0.89	Grass	B	54.16
MauldinMillRoad_1	0.22	Grass	B	13.27
MauldinMillRoad_1	1.60	Grass	B	97.86
MauldinMillRoad_1	16.56	Trees	B	910.61
MauldinMillRoad_1	2.01	Trees	B	110.80
MauldinMillRoad_1	4.15	Trees	B	228.41
MauldinMillRoad_1	0.26	Trees	B	14.29
MauldinMillRoad_1	29.01	Trees	B	1595.47
MauldinMillRoad_1	0.36	Trees	B	19.61
MauldinMillRoad_1	0.84	Trees	B	46.13
MauldinMillRoad_1	19.65	Trees	B	1080.56
MauldinMillRoad_1	4.02	Trees	B	221.09
MauldinMillRoad_1	0.16	Trees	B	8.88
MauldinMillRoad_1	14.24	Trees	B	783.00

MauldinMillRoad_1	15.70	Trees	B	863.38
MauldinMillRoad_1	23.35	Trees	B	1284.36
MauldinMillRoad_1	3.58	Trees	B	196.83
MauldinMillRoad_1	3.85	Trees	B	211.93
MauldinMillRoad_1	11.42	Trees	B	628.29
MauldinMillRoad_1	10.57	Trees	B	581.30
MauldinMillRoad_1	2.72	Trees	B	149.82
MauldinMillRoad_1	1.63	Trees	B	89.86
MauldinMillRoad_1	7.61	Trees	B	418.31
MauldinMillRoad_1	3.62	Trees	B	199.18
MauldinMillRoad_1	4.15	Trees	B	228.05
MauldinMillRoad_1	0.15	Trees	B	8.14
MauldinMillRoad_1	5.15	Trees	B	283.34
MauldinMillRoad_1	0.80	Trees	B	43.95
MauldinMillRoad_1	9.68	Trees	B	532.62
MauldinMillRoad_1	12.75	Trees	B	701.33
MauldinMillRoad_1	3.28	Trees	B	180.26
MauldinMillRoad_1	1.64	Trees	B	90.02
MauldinMillRoad_1	10.87	Trees	B	598.05
MauldinMillRoad_1	23.08	Trees	B	1269.41
MauldinMillRoad_1	12.01	Trees	B	660.67
MauldinMillRoad_1	3.76	Trees	B	206.79
MauldinMillRoad_1	33.51	Residential	B	2412.75
MauldinMillRoad_1	0.02	Residential	B	1.28
MauldinMillRoad_1	0.17	Residential	B	12.57
MauldinMillRoad_1	5.61	Residential	B	403.69
MauldinMillRoad_1	11.02	Residential	B	793.61
MauldinMillRoad_1	0.54	Residential	B	39.02
MauldinMillRoad_1	35.03	Residential	B	2522.40
MauldinMillRoad_1	0.27	Residential	B	19.23
MauldinMillRoad_1	2.89	Residential	B	208.20
MauldinMillRoad_1	0.01	Railroad	B	1.15
MauldinMillRoad_1	0.09	Railroad	B	7.52
MauldinMillRoad_1	1.05	Railroad	B	89.30
MauldinMillRoad_1	0.02	Railroad	B	1.41
MauldinMillRoad_1	0.14	Railroad	B	11.80
MauldinMillRoad_1	0.98	Railroad	B	83.06
MauldinMillRoad_1	0.55	Railroad	B	46.96
MauldinMillRoad_1	0.27	Railroad	B	22.89
MauldinMillRoad_1	0.53	Railroad	B	45.04
MauldinMillRoad_1	0.25	Railroad	B	21.40
MauldinMillRoad_1	0.62	Railroad	B	52.67
MauldinMillRoad_1	0.19	Railroad	B	15.95

Appendix A.2
Time of Concentration Analysis

Time of Concentration Calculations

Project	Oconee County
Basin:	MauldinMillRdBasin_1
Date:	2013-06-10
Calc By:	JWB

Calculation of Overland Sheet Flow Travel Time

Using the Manning Kinematic Equation - U.S. units

Inputs			**Calculations**		
Manning Roughness Coefficient, **n** =	0.75		Overland Flow Time Travel, t_1 =	46.6	min
Length of Flow Path, **L** =	300	ft			
2 yr, 24 hr rainfall, **P** =	4.7	in			
Ground Slope, **S** =	0.0565	ft/ft			

Calculation of Shallow Concentrated Flow Travel Time

Using the NCRS Method - U.S. units

Inputs			**Calculations**		
Length of Flow Path, **L** =	2022.6	ft	**For Unpaved Surface**		
Ground Slope, **S** =	0.038	ft/ft	Flow Velocity, **V** =	3.15	ft/sec
			Travel time, t_2 =	10.7	min
Paved / Unpaved =	Unpaved				

Calculation of Channnel Flow Travel Time
Using the Manning Equation - U.S. units

For a Trapezoidal Channel Cross-section

Inputs			**Calculations**		
Bottom width, **b** =	9.27	ft	Cross-Sect. Area, **A** =	62.0	ft^2
Depth of flow, **y** =	4.5	ft	Wetted Perimeter, **P** =	22.0	ft
Side Slope, **z** = (H:V = **z**:1)	1		Hydraulic Radius, **R** =	2.82	ft
			Discharge, **Q** =	610.76	cfs
Manning roughness, **n** =	0.04		Ave. Velocity, **V** =	9.86	ft/sec
Channel bottom slope, **S** =	0.0176	ft/ft	Channel travel time, t_3 =	5.2	min
Length of Flow Path, **L** =	3061.099	ft			

Calculation of Time of Concentration
$(t_c = t_1 + t_2 + t_3)$

Inputs (values from above)			**Calculations**		
t_1 =	46.6	min	t_c =	62.5	min
t_2 =	10.7	min	t_c =	1.04	hrs
t_3 =	5.2	min			

Overland Flow Roughness Coefficient

Surface	Manning's n
Concrete, Asphalt, Bare Soil	0.01 - 0.016
Gravel, Clay-loam,eroded	0.012 - 0.03
Sparse Vegetation, Cultivated Soil	0.053 - 0.13
Short Grass	0.1 - 0.2
Dense Grass, Bluegrass, Bermuda Grass	0.17 - 0.48
Woods	0.4 - 0.8

$$t_1 = \frac{0.42\ (nL)^{0.8}}{P^{0.5}\ S^{0.4}}$$

Manning Kinematic Equation - U.S. units

t_1 = overland sheet flow runoff travel time, min

n = Manning roughness coefficient, dimensionless

L = length of the flow path, ft (Max. L should be 300 ft)

P = 2 year, 24 hr rainfall, in

S = ground slope, ft/ft

Equations for NCRS Method for Shallow Concentrated Flow

$$t_2 = L/(60V)$$

for unpaved surface: $V = 16.1345S^{0.5}$

for paved surface: $V = 20.3282S^{0.5}$

where: t_2 = shallow concentrated flow runoff travel time, min

L = length of the flow path, ft

V = shallow concentrated flow velocity, ft/sec

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

Manning Equation for Open Channel Flow

$$V = Q/A$$

$$R = A/P$$

$$t_3 = L/(60V)$$

Where: Q = channel flow rate, cfs

V = average velocity of flow, ft/sec

A = channel cross-sectional area, ft^2

P = wetted perimeter of channel, ft

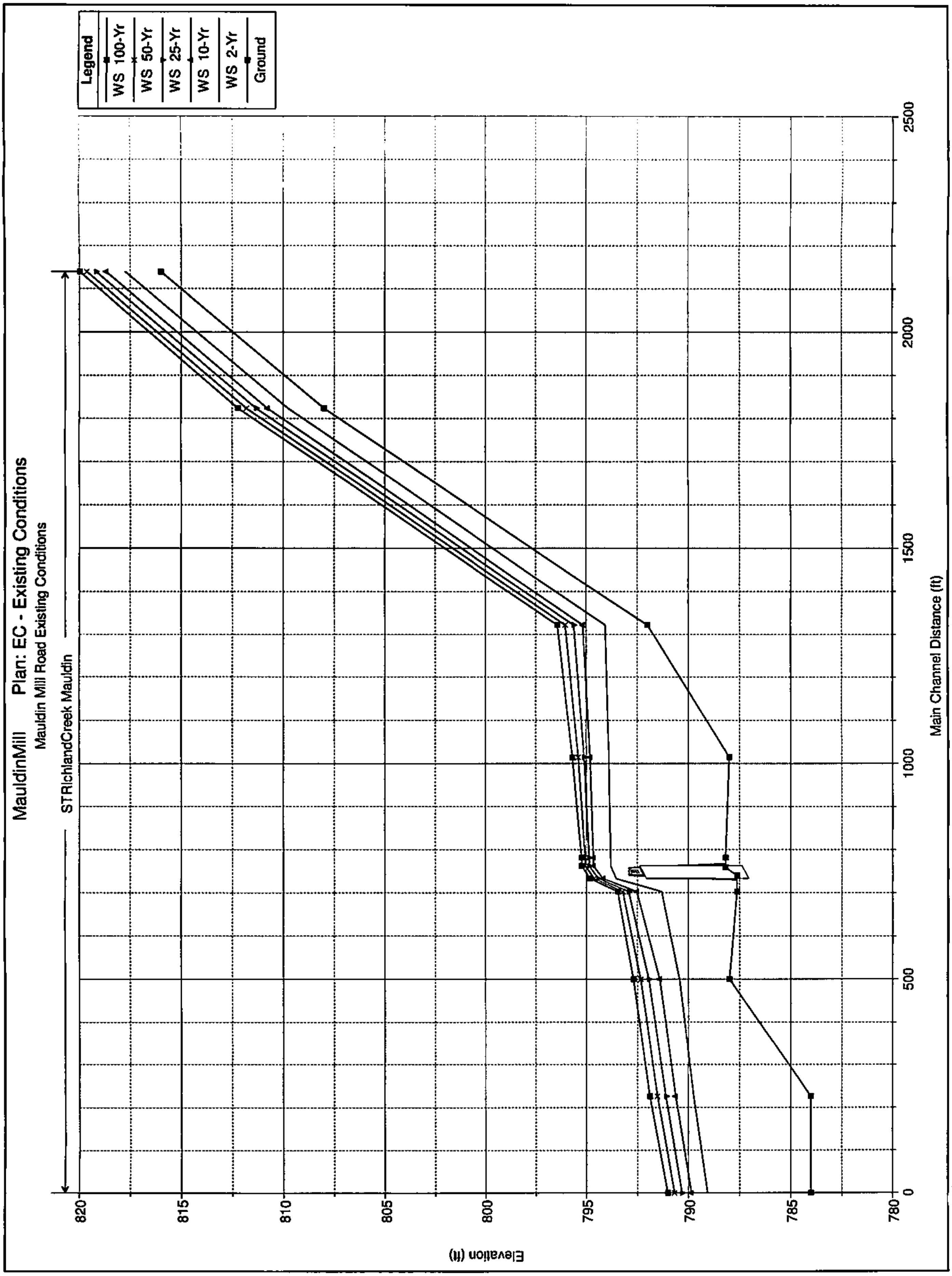
S = channel bottom slope, ft/ft

n = Manning roughness coefficient for channel

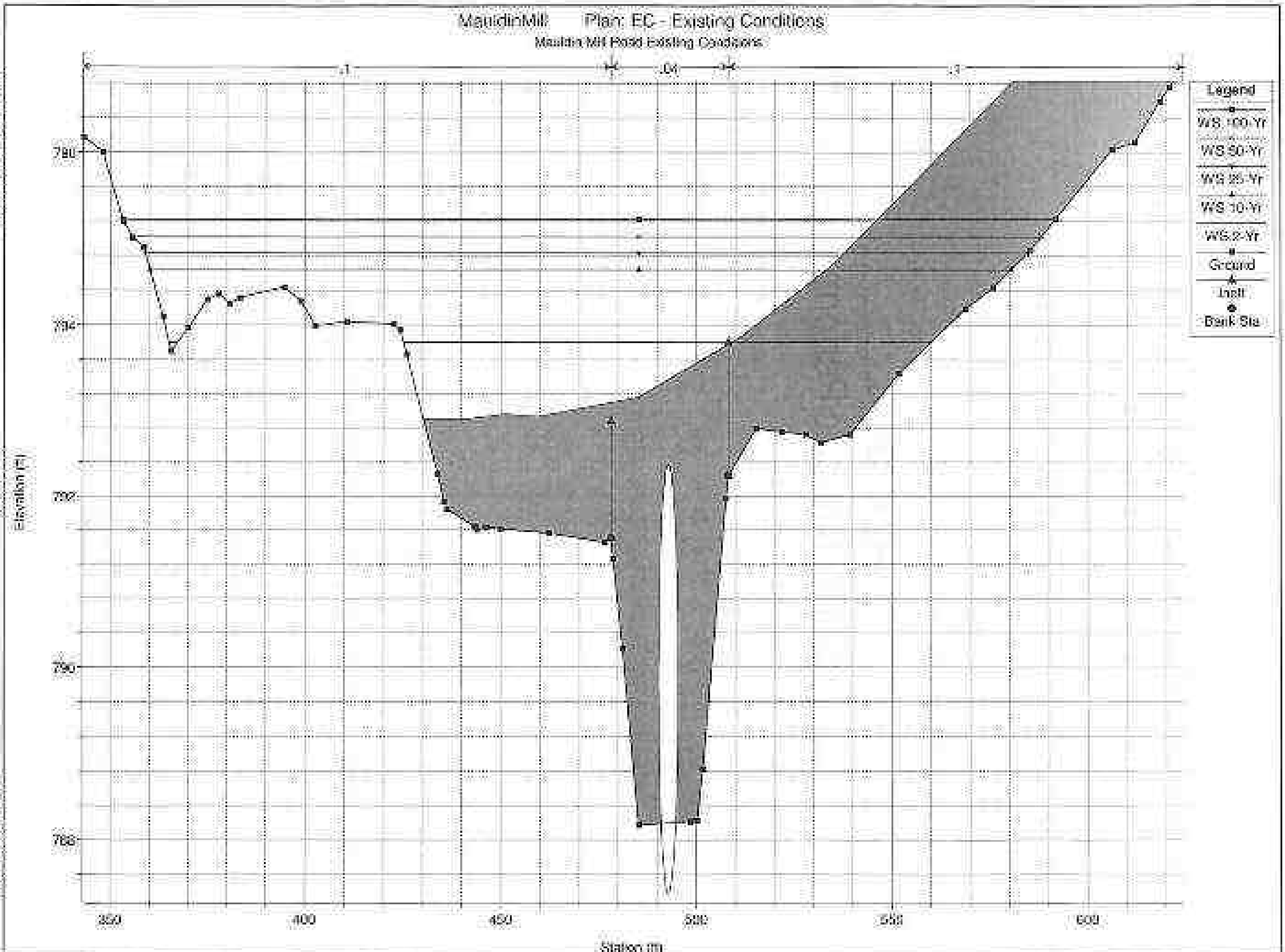
L = Length of Flow Path, ft

t_3 = travel time for channel flow, min

Appendix B
Existing Hydraulic Conditions


MauldinMill Plan: EC - Existing Conditions
Mauldin Mill Road Existing Conditions
STRichlandCreek Mauldin
Legend
WS 100-Yr
WS 50-Yr
WS 25-Yr
WS 10-Yr
WS 2-Yr
Ground
Main Channel Distance (ft)
Elevation (ft)
0
500
1000
1500
2000
2500
780
785
790
795
800
805
810
815
820

Mauldin Mill Road Culvert
Hydrologic, Hydraulic
And Alternatives Analysis



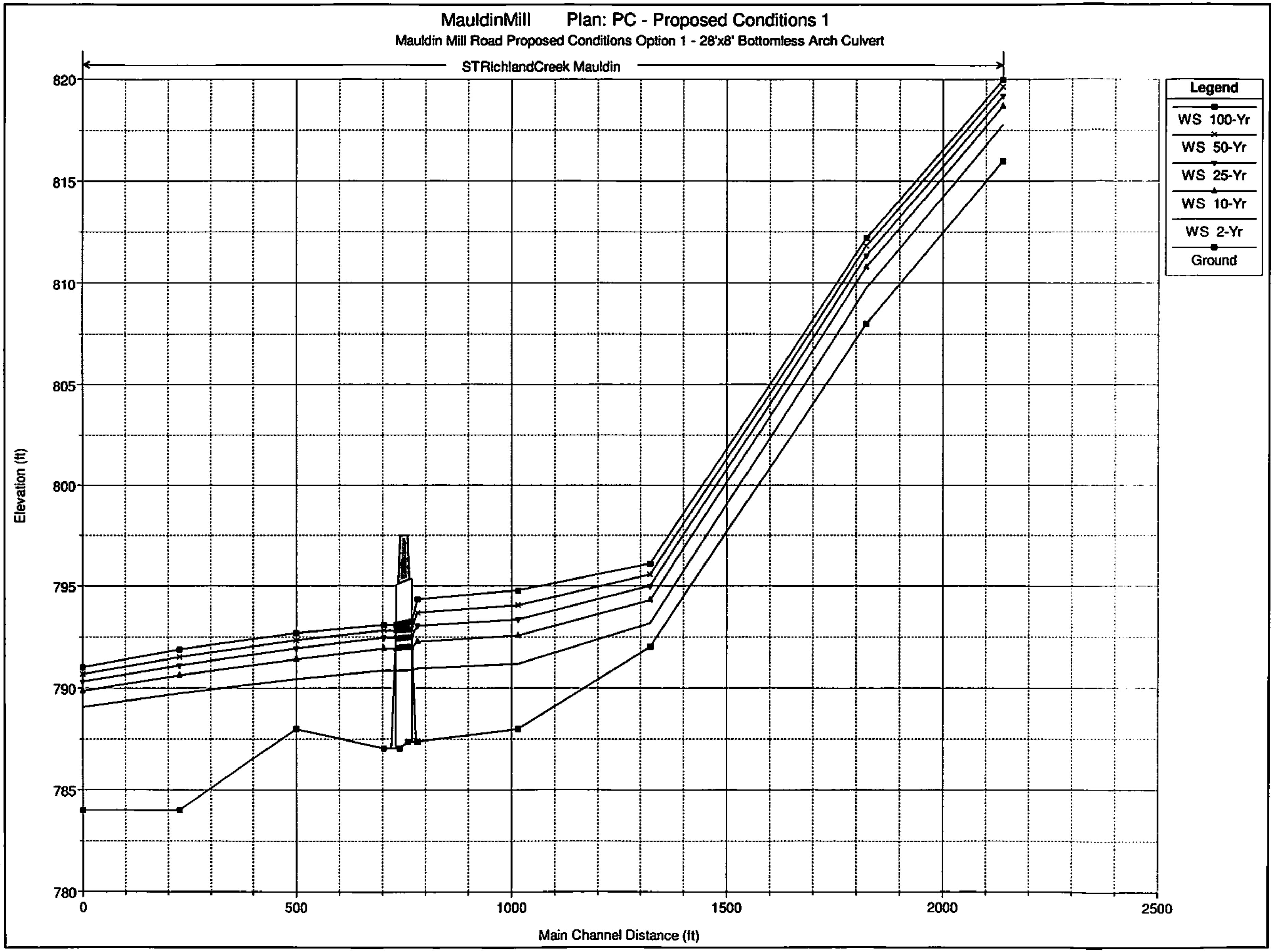
Appendix B
Existing Conditions Hydraulic Performance
B-2 of 2

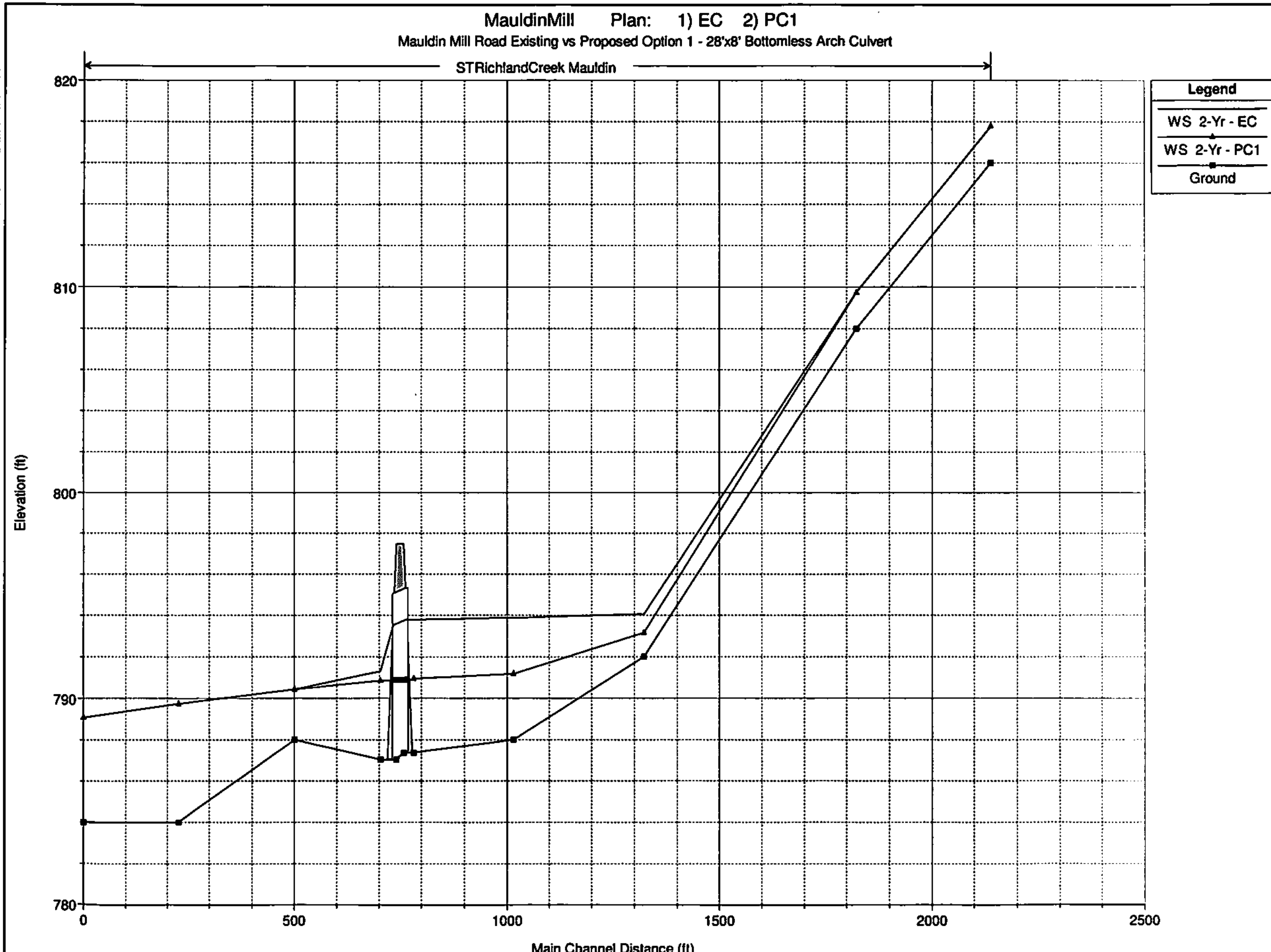
Davis & Floyd, Inc.
DF Job No. 12975.01
June 2013

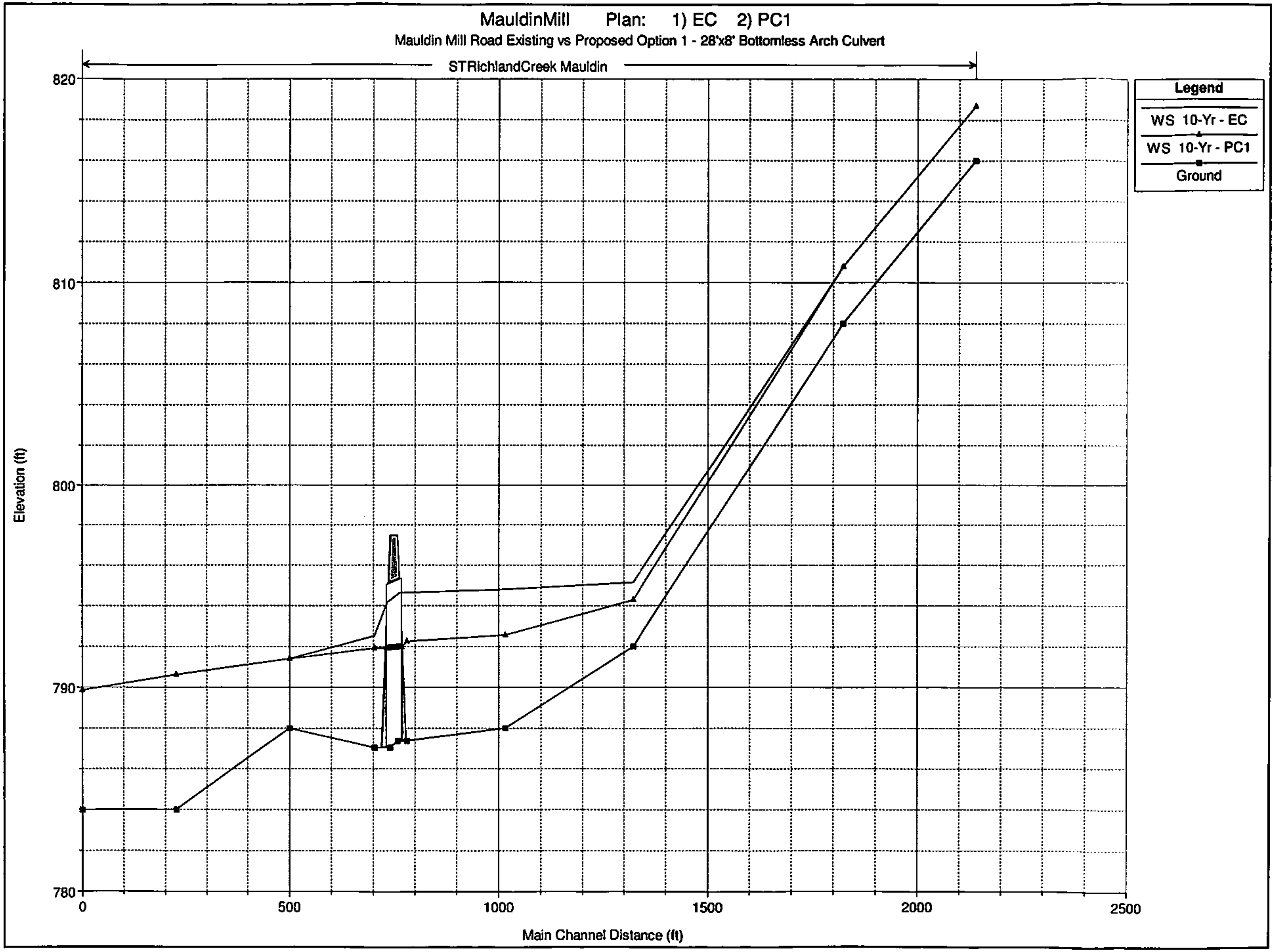
Appendix C
Conceptual Hydraulic Performance

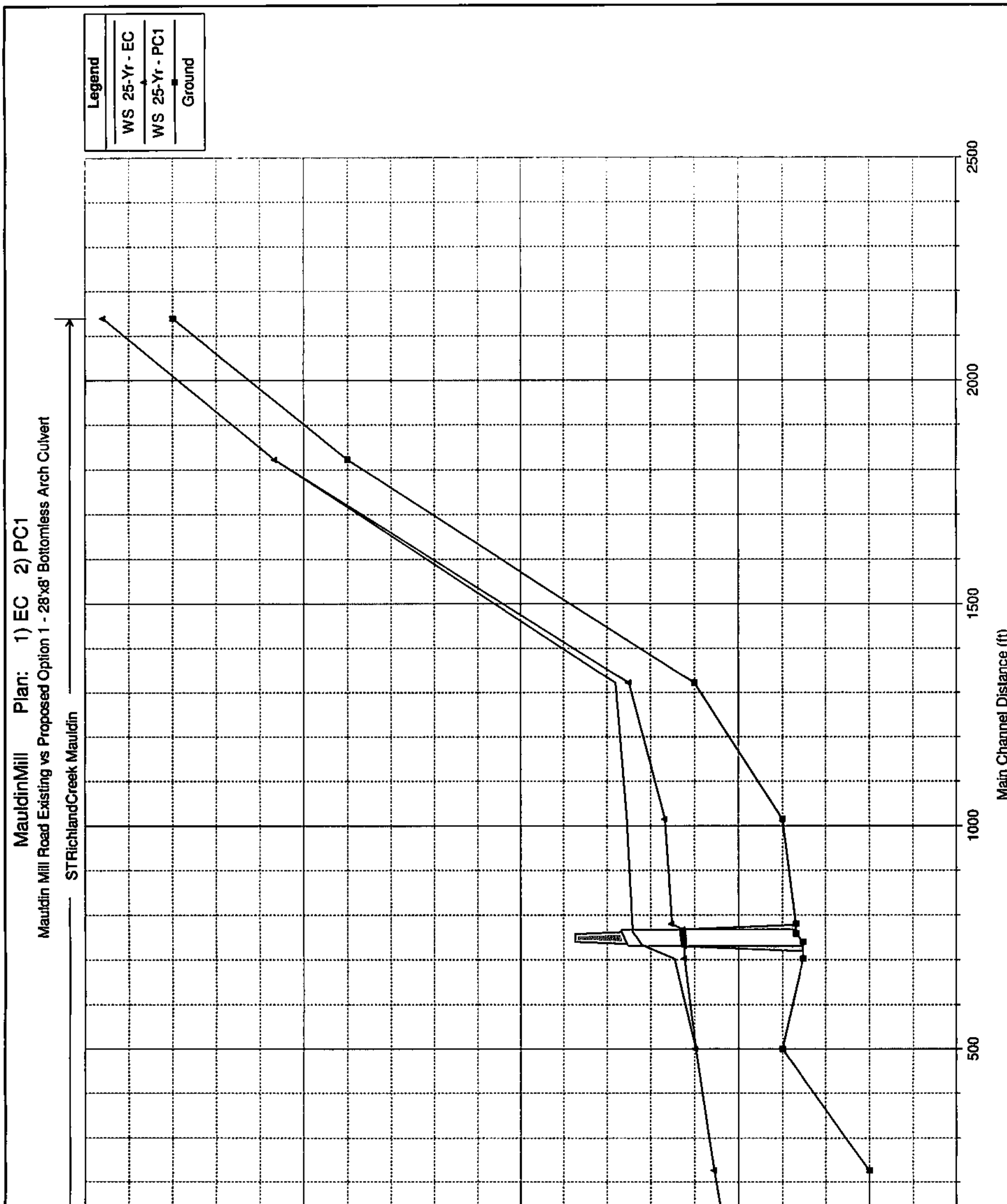
Appendix C.1
Option 1 Hydraulic Performance

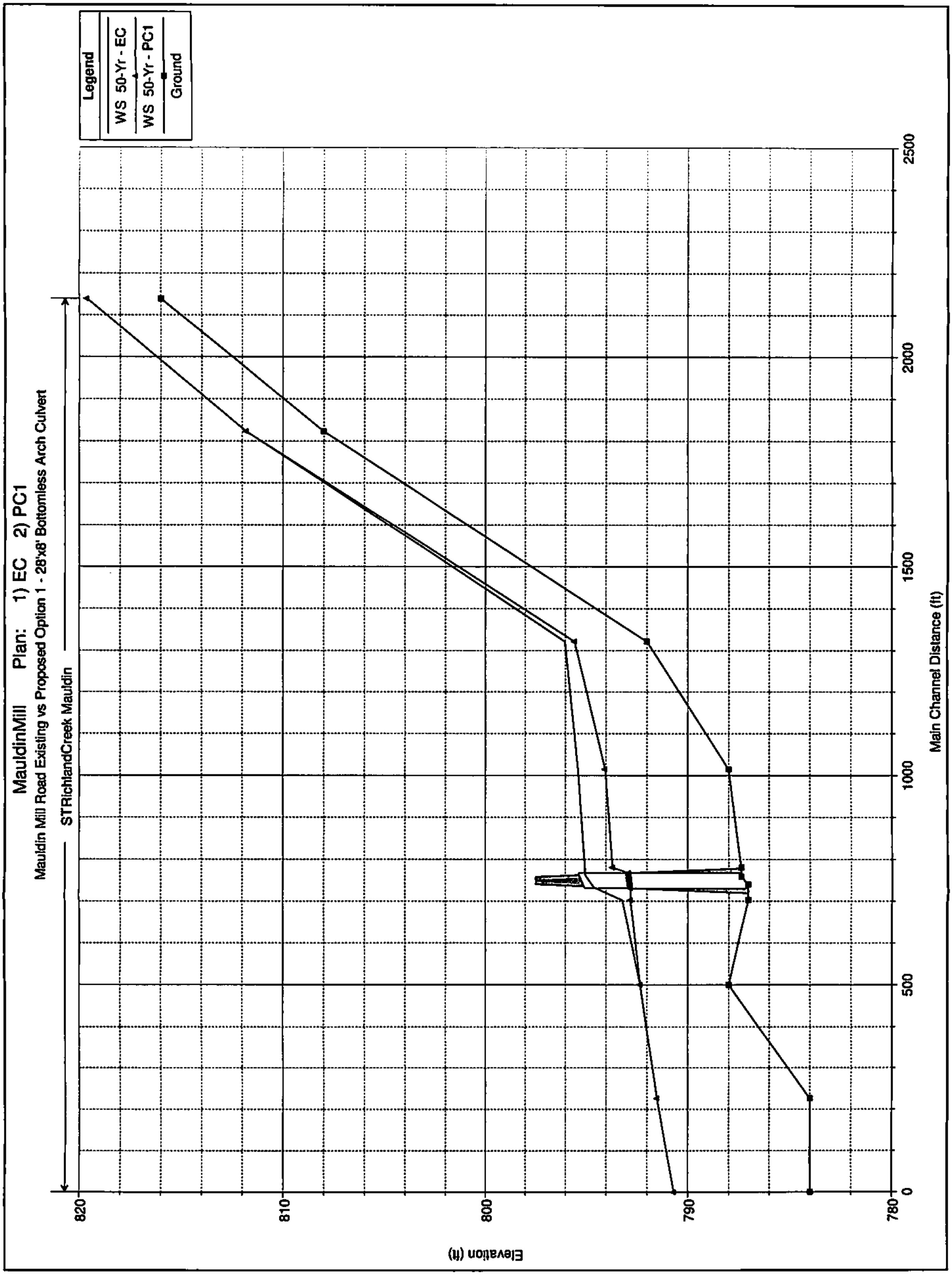
Appendix C.1
Option 1 - 28' x 8' Bottomless Arch Culvert Hydraulic Performance



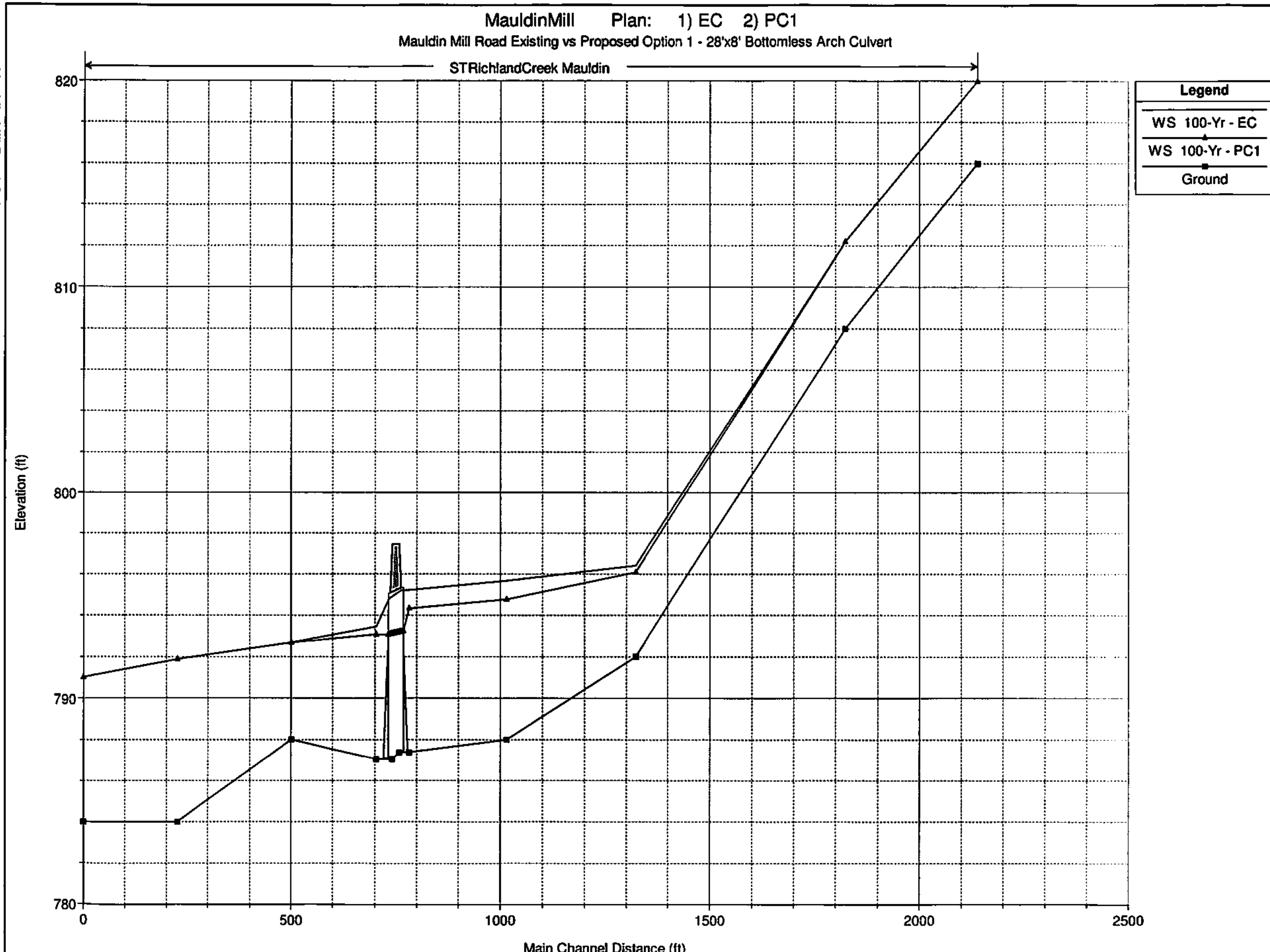

MauldinMill Plan: 1) EC 2) PC1
Mauldin Mill Road Existing vs Proposed Option 1 - 28'x8' Bottomless Arch Culvert
STRichlandCreek Mauldin
Legend
WS 2-Yr - EC
WS 2-Yr - PC1
Ground
Elevation (ft)
820
810
800
790
780
0
500
1000
1500
2000
2500
Main Channel Distance (ft)

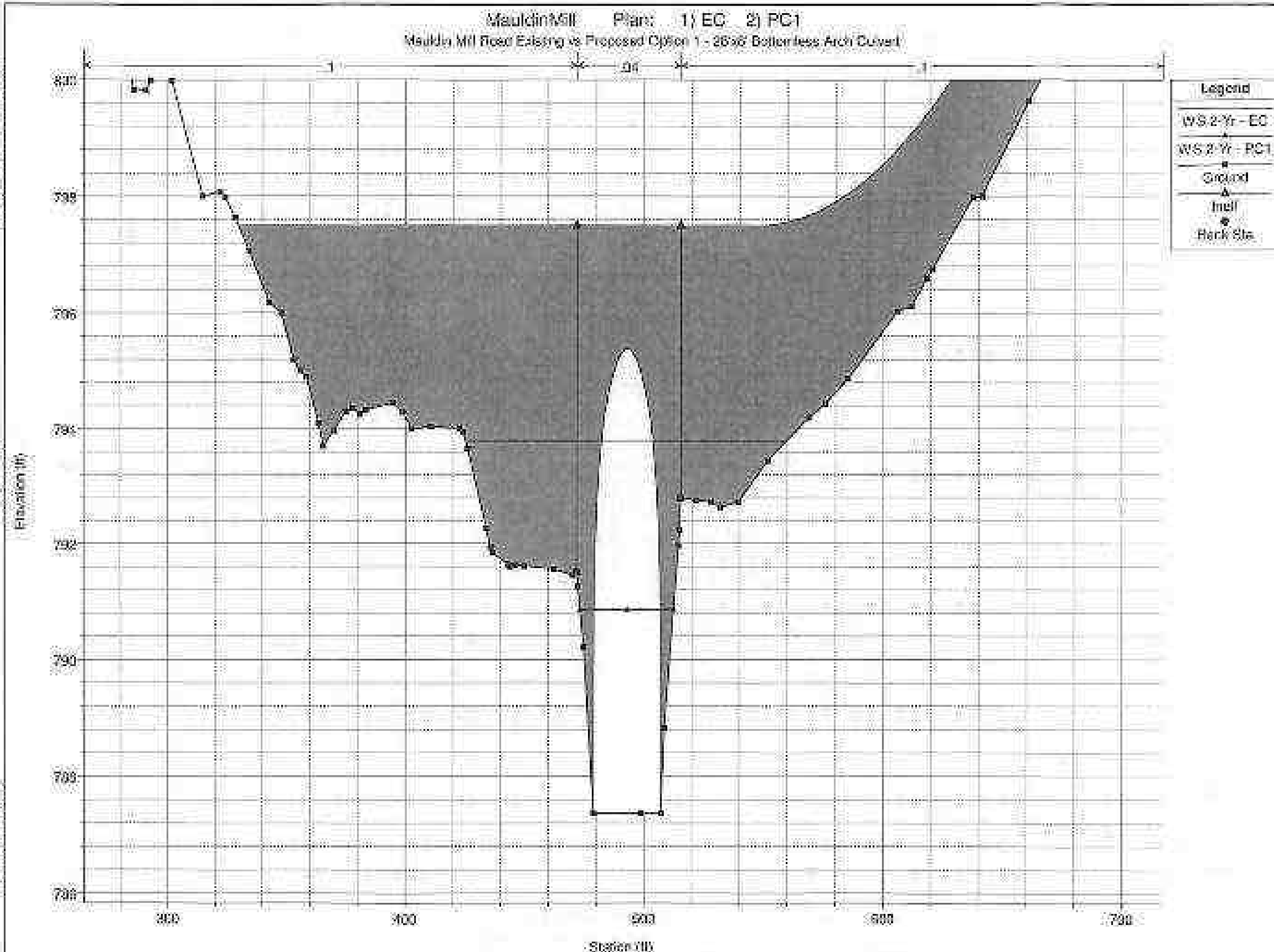

MauldinMill Plan: 1) EC 2) PC1
Mauldin Mill Road Existing vs Proposed Option 1 - 28'x8' Bottomless Arch Culvert
STRichlandCreek Mauldin
Legend
WS 10-Yr - EC
WS 10-Yr - PC1
Ground
Elevation (ft)
820
810
800
790
780
0
500
1000
1500
2000
2500
Main Channel Distance (ft)

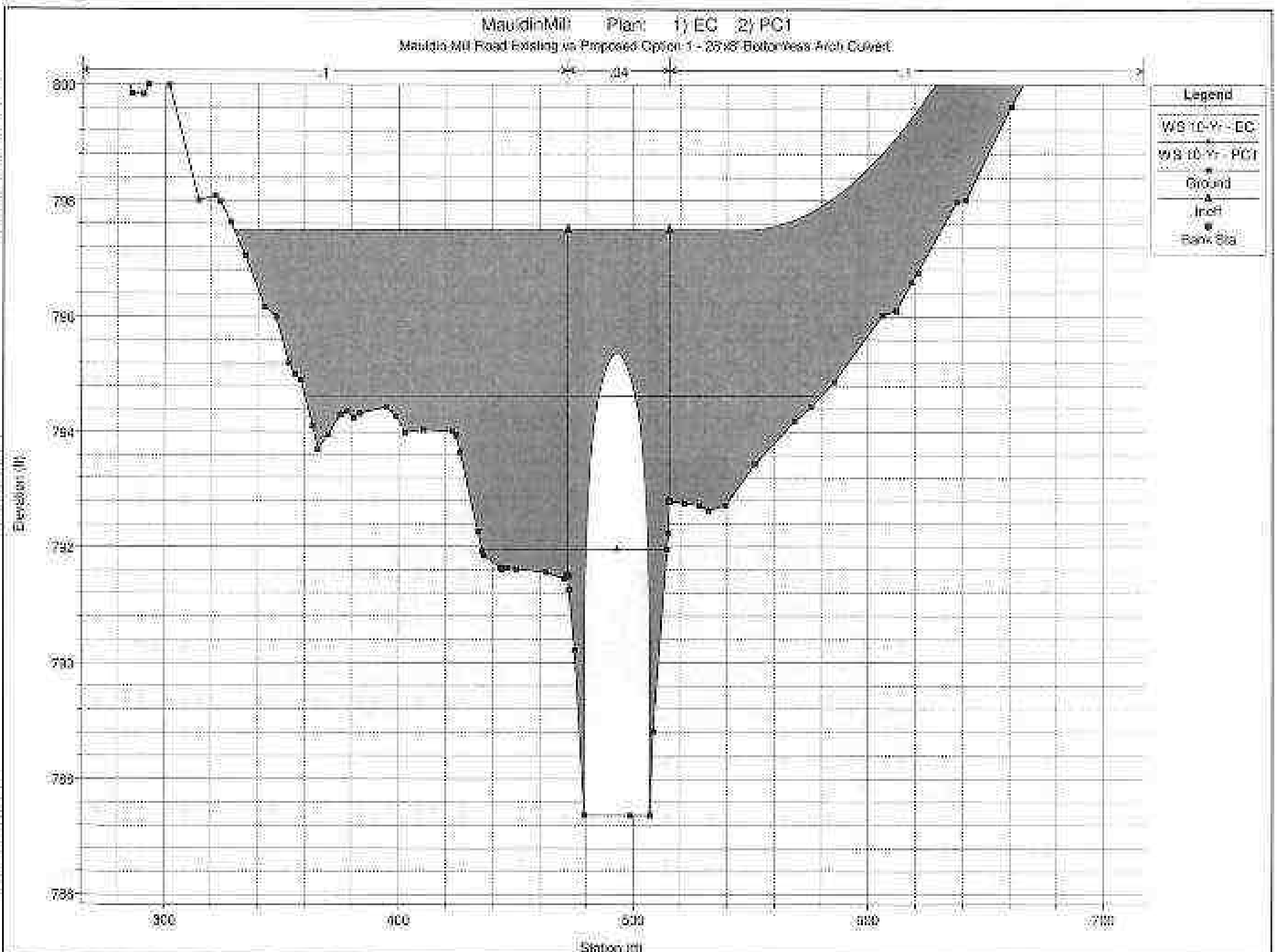

MauldinMill Plan: 1) EC 2) PC1
Mauldin Mill Road Existing vs Proposed Option 1 - 28'x8' Bottomless Arch Culvert
STRichlandCreek Mauldin
Legend
WS 25-Yr - EC
WS 25-Yr - PC1
Ground
Main Channel Distance (ft)
Elevation (ft)
0
500
1000
1500
2000
2500
780
790
800
810
820

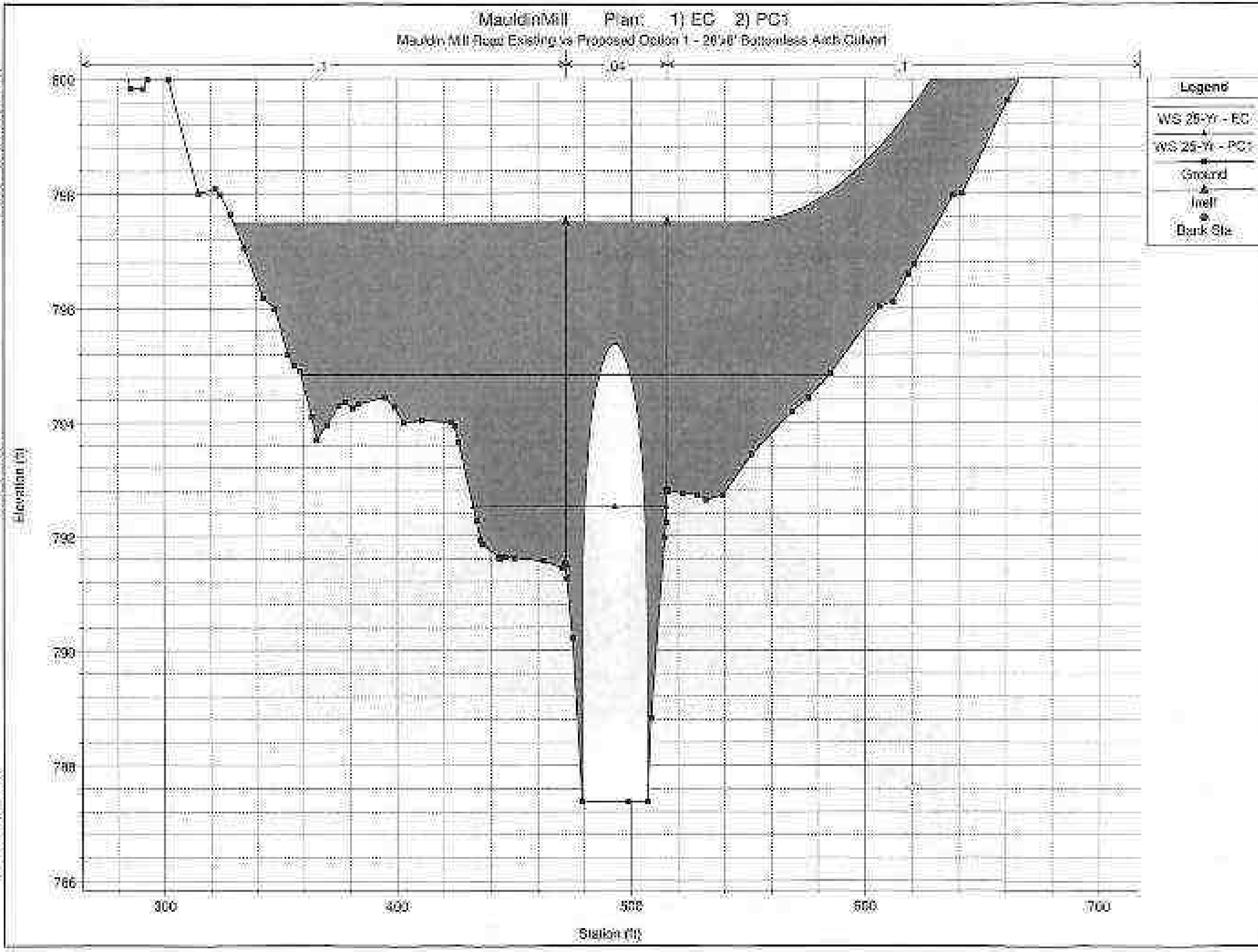


MauldinMill Plan: 1) EC 2) PC1
Mauldin Mill Road Existing vs Proposed Option 1 - 28'x8' Bottomless Arch Culvert
STRichlandCreek Mauldin
Legend
WS 50-Yr - EC
WS 50-Yr - PC1
Ground
Main Channel Distance (ft)
Elevation (ft)
0
500
1000
1500
2000
2500
780
790
800
810
820


MauldinMill Plan: 1) EC 2) PC1
Mauldin Mill Road Existing vs Proposed Option 1 - 28'x8' Bottomless Arch Culvert
STRichlandCreek Mauldin
Legend
WS 100-Yr - EC
WS 100-Yr - PC1
Ground
Elevation (ft)
Main Channel Distance (ft)
780
790
800
810
820
0
500
1000
1500
2000
2500


MauldinMill Plan: 1) EC 2) PC1
Mauldin Mill Road Existing vs Proposed Option 1 - 25x8 Bottomless Arch Culvert
.1
.04
.1
Legend
WS 2-Yr - EC
WS 2-Yr - PC1
Ground
Ineff
Bank Sta
800
798
796
794
792
790
788
786
Elevation (ft)
300
400
500
600
700
Station (ft)

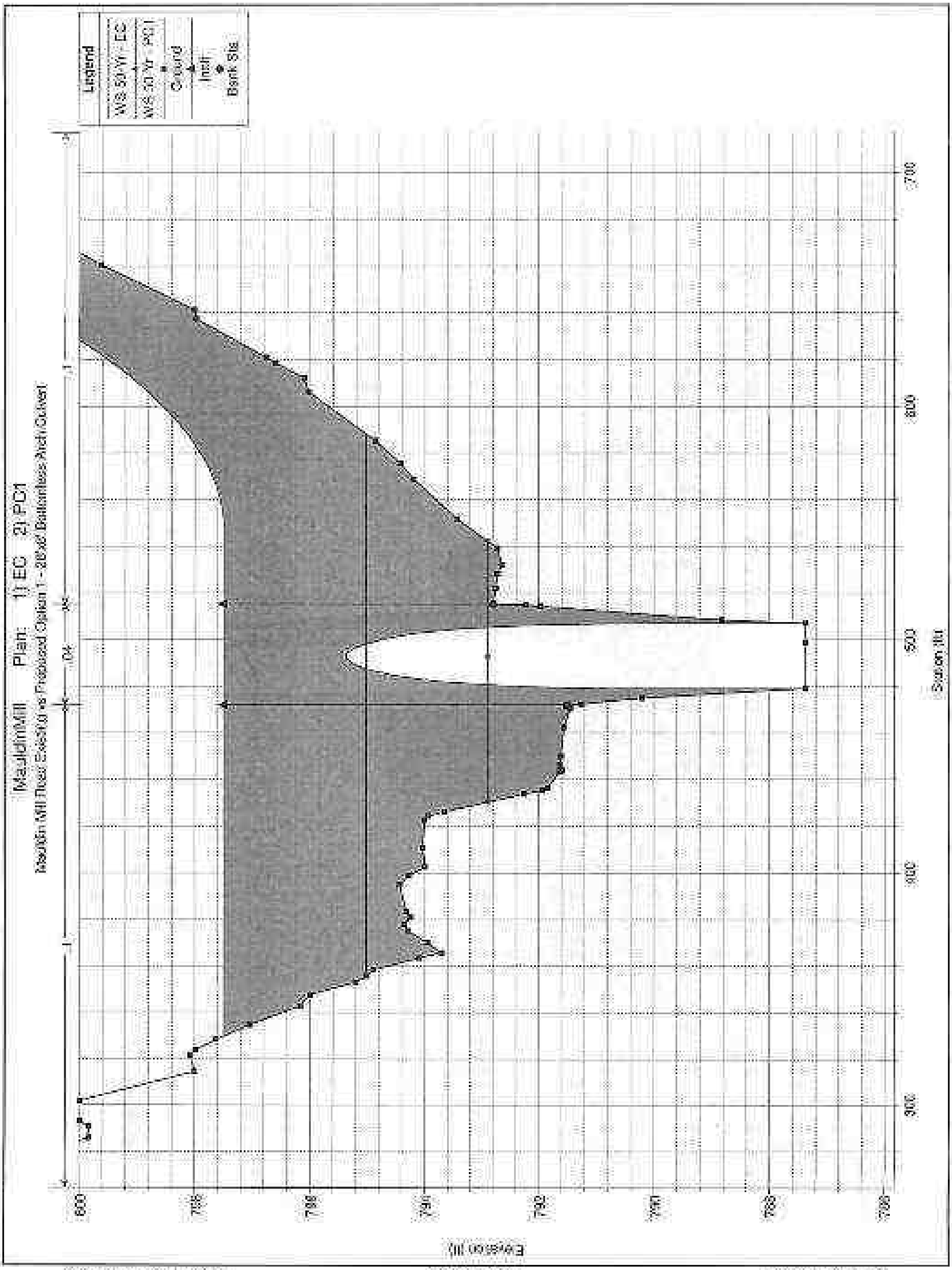

MauldinMill Plan: 1) EC 2) PC1
Mauldin Mill Road Existing vs Proposed Option 1 - 20'x8' Bottomless Arch Culvert
Legend
WS 10-Yr - EC
WS 10-Yr - PC1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
800
798
796
794
792
790
788
786
300
400
500
600
700
.1
.04
.1

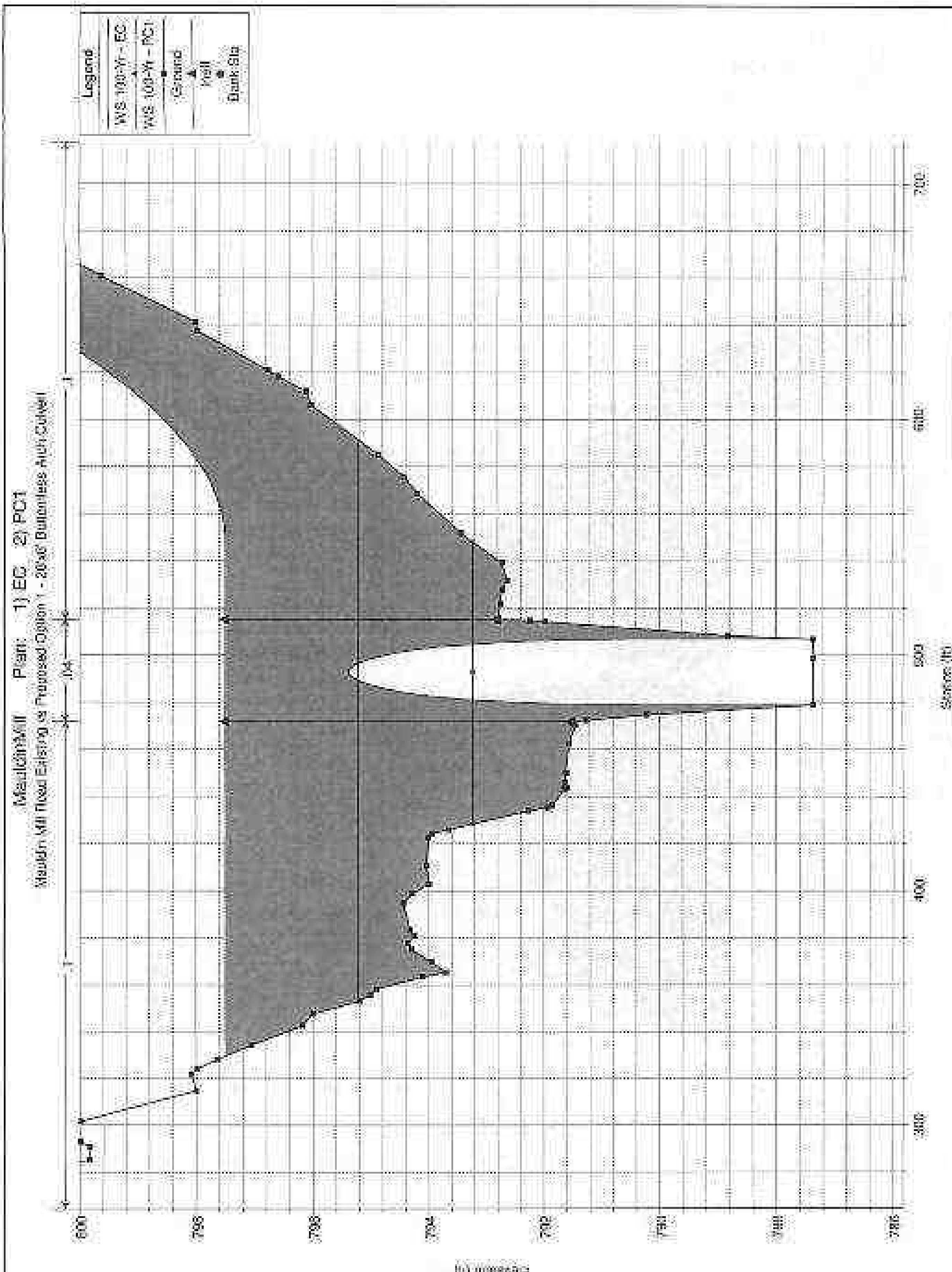


Mauldin Mill Road Culvert
Hydrologic, Hydraulic
And Alternatives Analysis

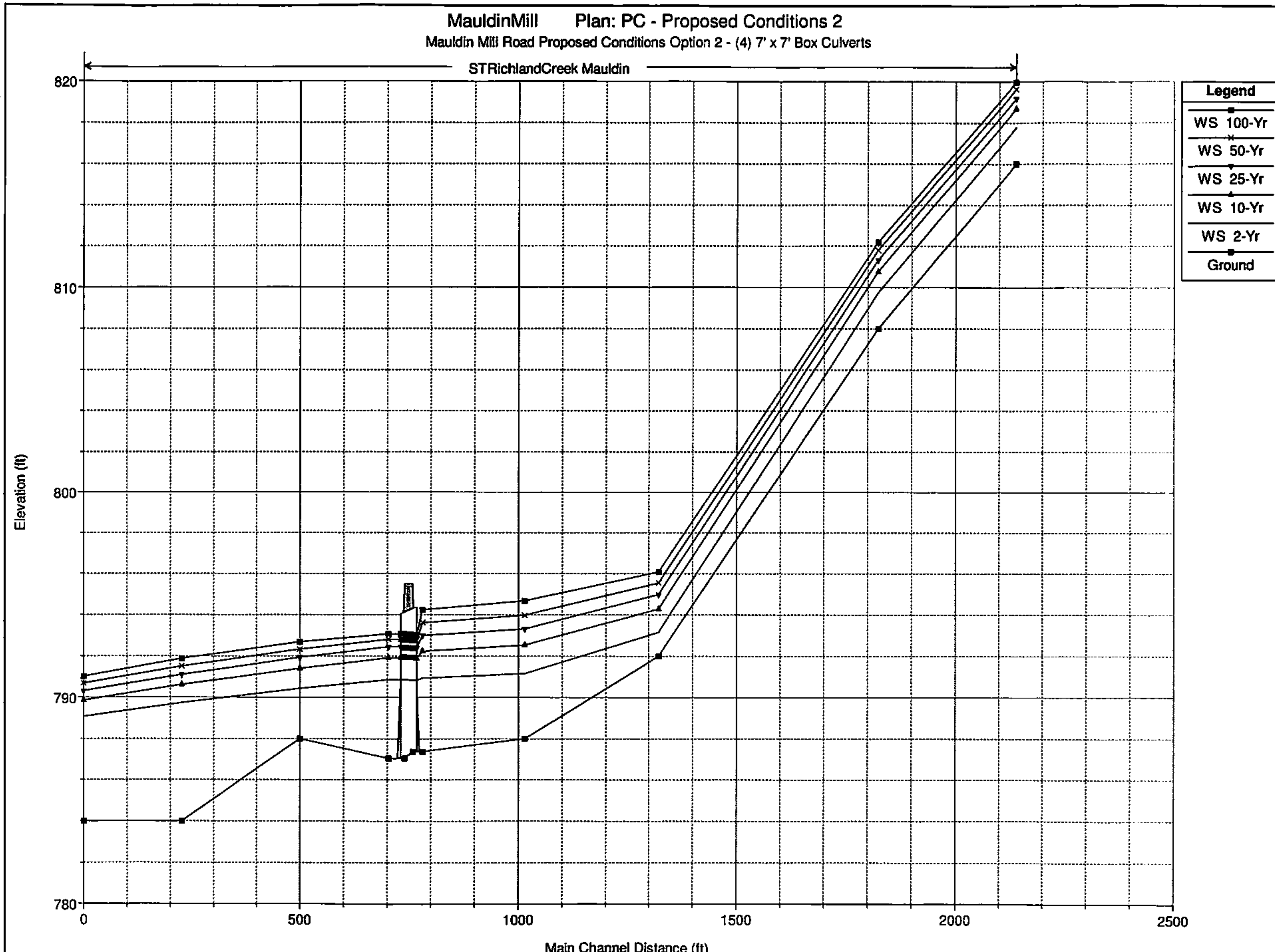
Appendix C.1
Option 1 - 26' x 6' Bottomless Arch Culvert Hydraulic Performance
Page C.1-9 of 11

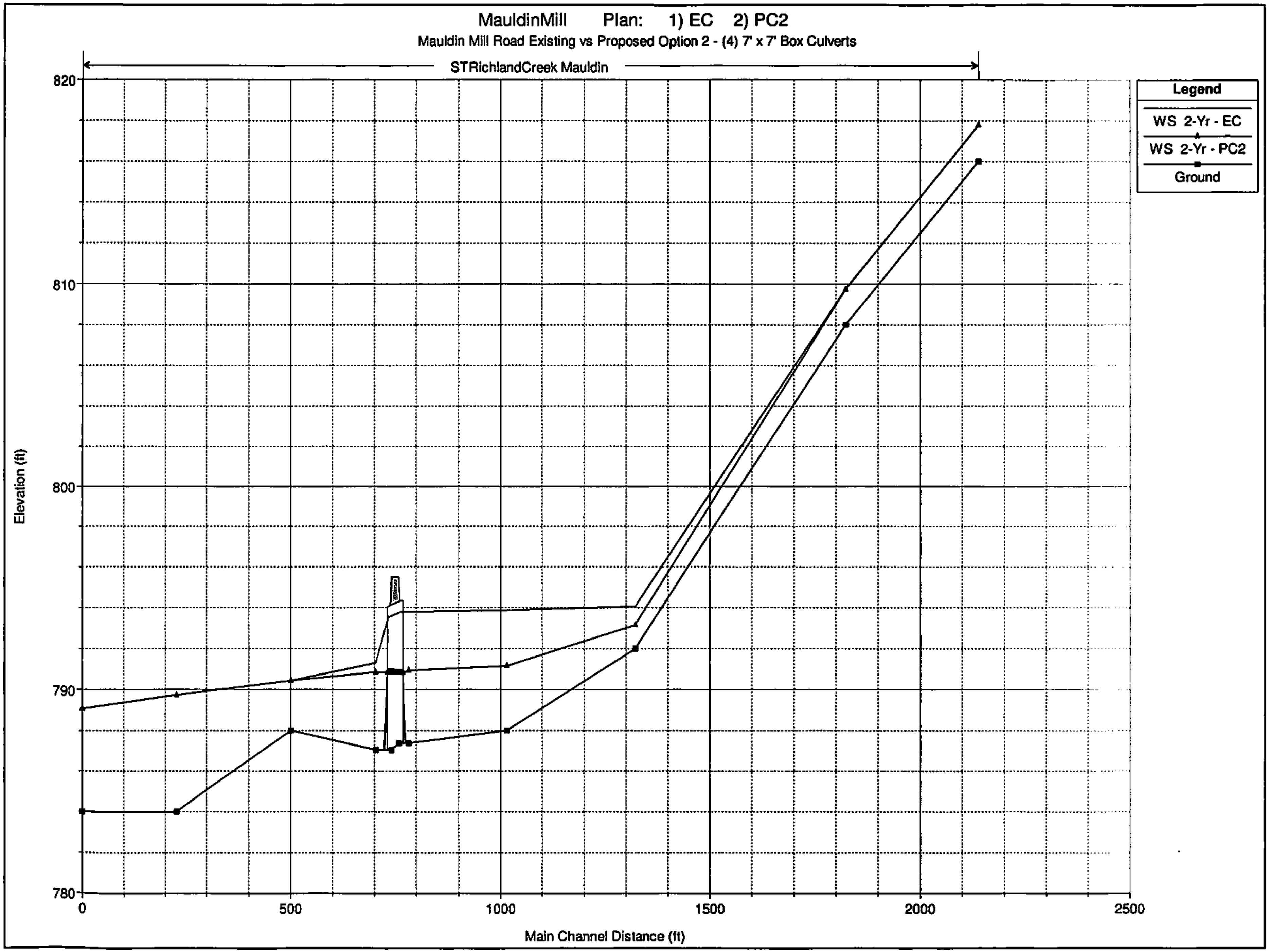
Davis & Floyd, Inc.
D&F Job No. 12975.01
June 2013

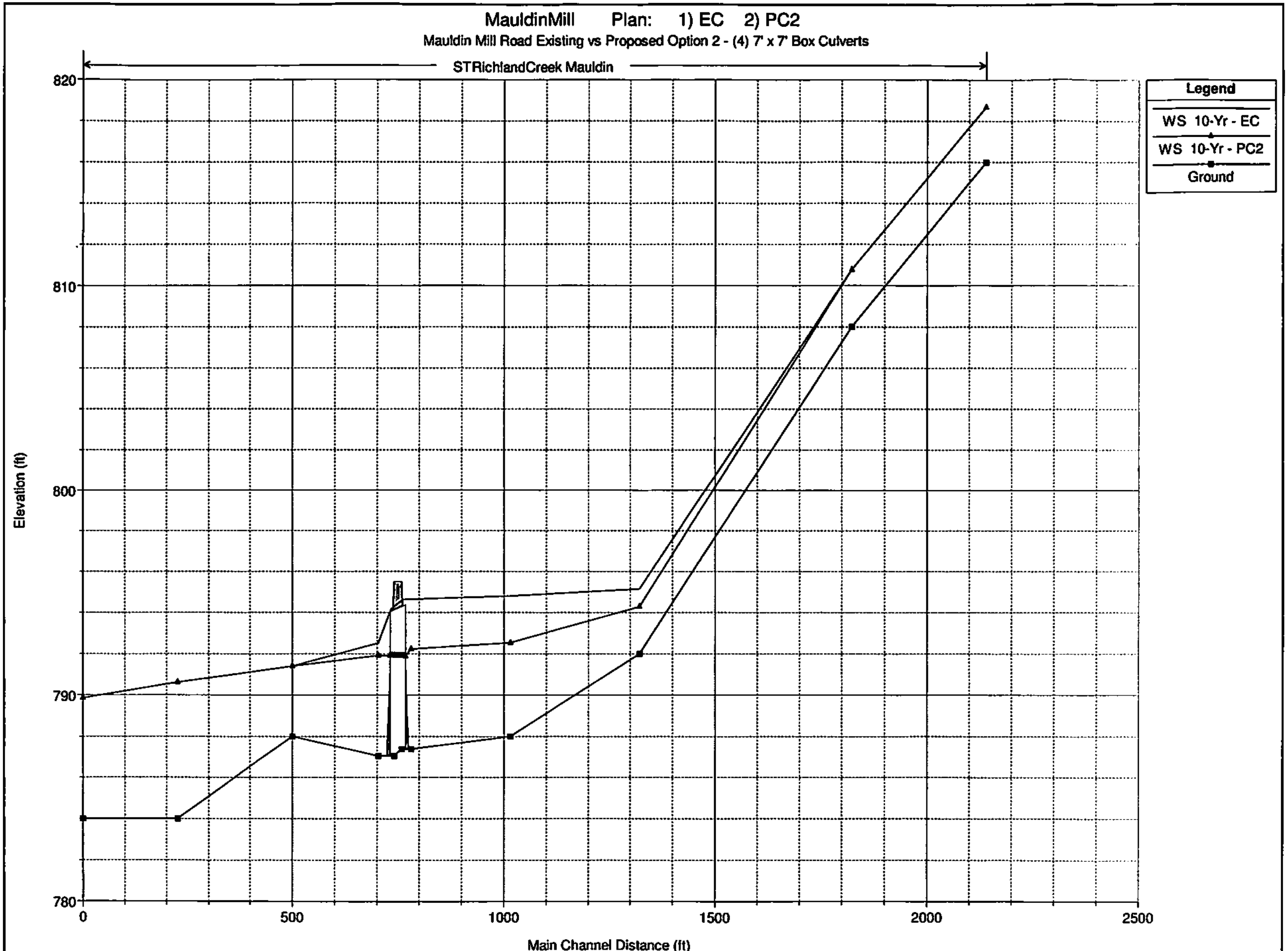

MauldinMill Plan: 1) EC 2) PC1
Legend
WS 50 Yr - EC
WS 50 Yr - PC1
Ground
Ineff
Bank Sta
.04
Elevation (ft)
Station (ft)
800
798
796
794
792
790
788
786
300
400
500
600
700

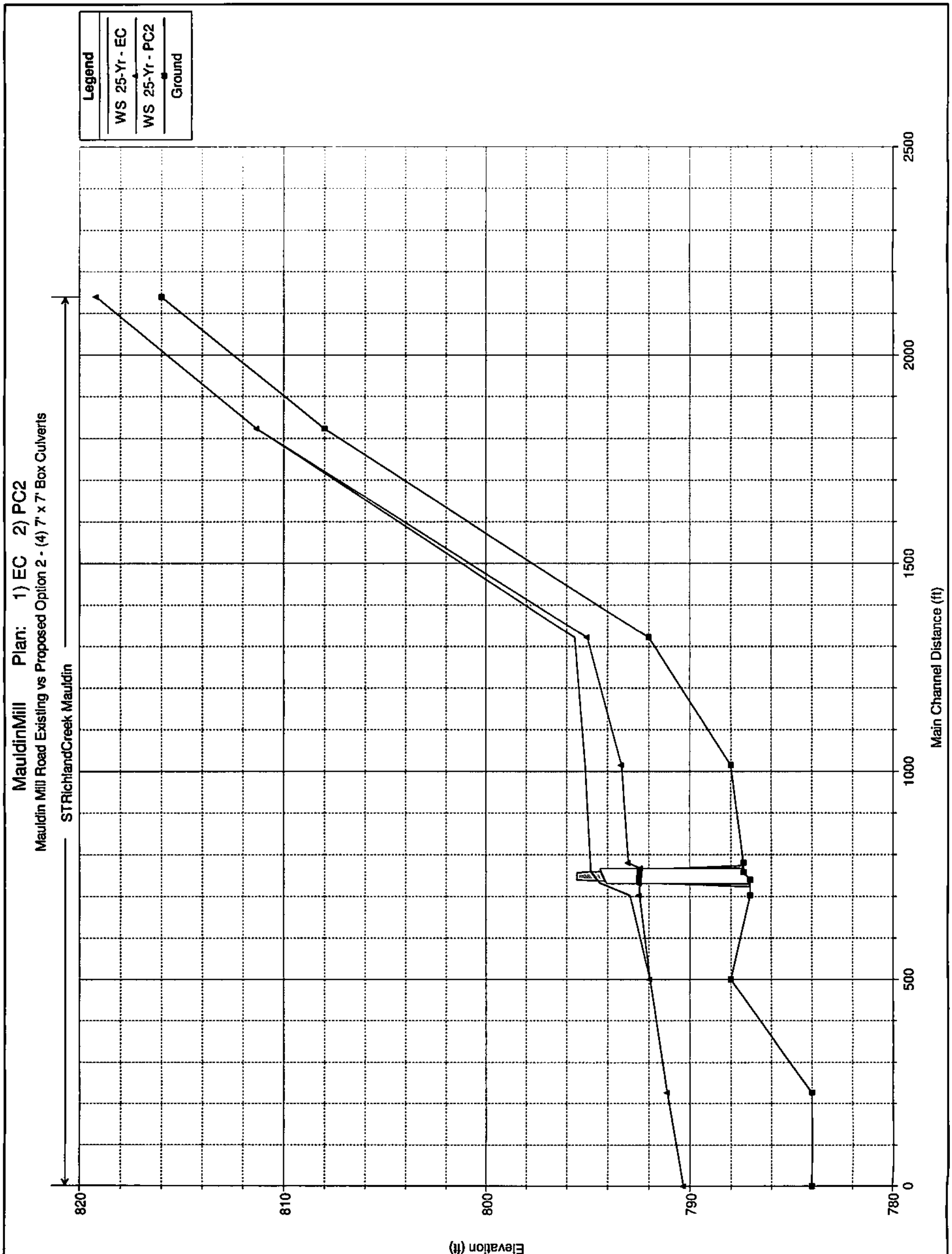

MauldinMill Plan: 1) EC 2) PC1
Mauldin Mill Road Existing vs Proposed Option 1 - 28'x6' Bottomless Arch Culvert
.1
.04
.1
Legend
WS 100-Yr - EC
WS 100-Yr - PC1
Ground
Ineff
Bank Sta
Elevation (ft)
800
798
796
794
792
790
788
786
Station (ft)
300
400
500
600
700

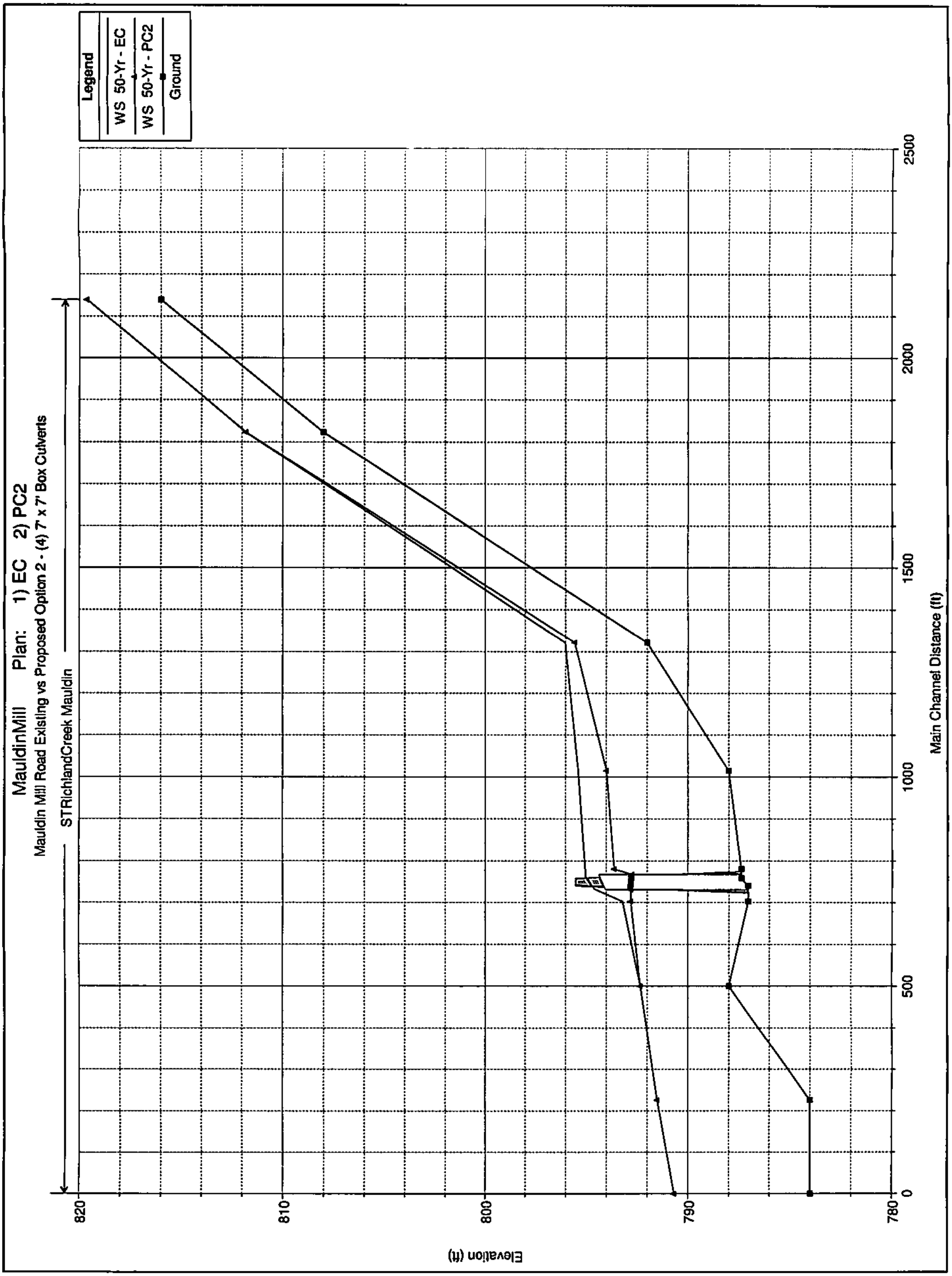
Appendix C.2
Option 2 Hydraulic Performance


MauldinMill Plan: PC - Proposed Conditions 2
Mauldin Mill Road Proposed Conditions Option 2 - (4) 7' x 7' Box Culverts
STRichlandCreek Mauldin
Legend
WS 100-Yr
WS 50-Yr
WS 25-Yr
WS 10-Yr
WS 2-Yr
Ground
Elevation (ft)
820
810
800
790
780
0
500
1000
1500
2000
2500
Main Channel Distance (ft)

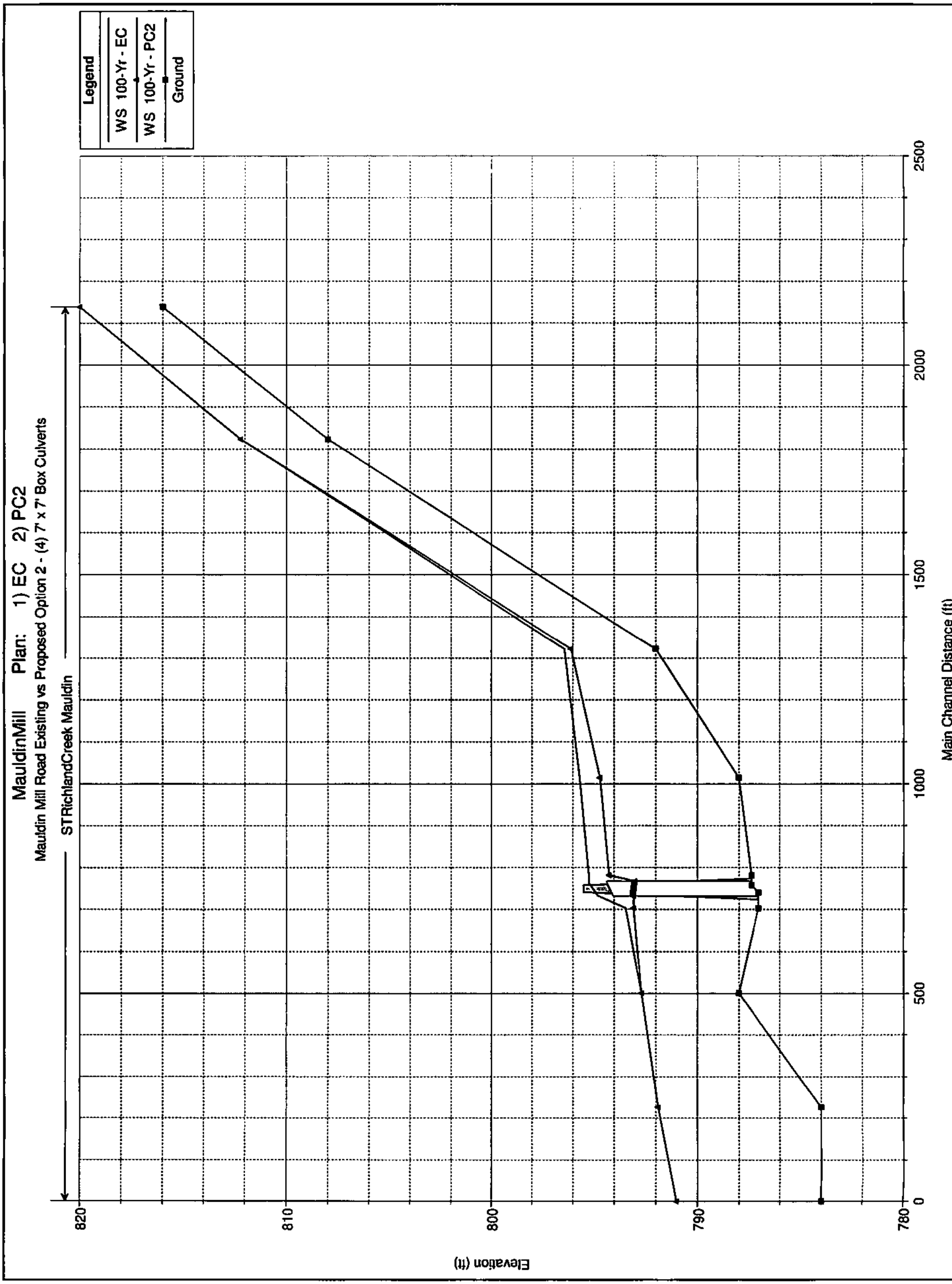

MauldinMill Plan: 1) EC 2) PC2
Mauldin Mill Road Existing vs Proposed Option 2 - (4) 7' x 7' Box Culverts
STRichlandCreek Mauldin
Legend
WS 2-Yr - EC
WS 2-Yr - PC2
Ground
Elevation (ft)
820
810
800
790
780
0
500
1000
1500
2000
2500
Main Channel Distance (ft)


MauldinMill Plan: 1) EC 2) PC2
Mauldin Mill Road Existing vs Proposed Option 2 - (4) 7' x 7' Box Culverts
STRichlandCreek Mauldin
Legend
WS 10-Yr - EC
WS 10-Yr - PC2
Ground
Elevation (ft)
820
810
800
790
780
0
500
1000
1500
2000
2500
Main Channel Distance (ft)


MauldinMill Plan: 1) EC 2) PC2
Mauldin Mill Road Existing vs Proposed Option 2 - (4) 7' x 7' Box Culverts
STRichlandCreek Mauldin
Legend
WS 25-Yr - EC
WS 25-Yr - PC2
Ground
Main Channel Distance (ft)
Elevation (ft)
0
500
1000
1500
2000
2500
780
790
800
810
820



MauldinMill Plan: 1) EC 2) PC2
Mauldin Mill Road Existing vs Proposed Option 2 - (4) 7' x 7' Box Culverts
STRichlandCreek Mauldin
Legend
WS 50-Yr - EC
WS 50-Yr - PC2
Ground
Main Channel Distance (ft)
Elevation (ft)
0
500
1000
1500
2000
2500
780
790
800
810
820



MauldinMill Plan: 1) EC 2) PC2
Mauldin Mill Road Existing vs Proposed Option 2 - (4) 7' x 7' Box Culverts
STRichlandCreek Mauldin
Legend
WS 100-Yr - EC
WS 100-Yr - PC2
Ground
Elevation (ft)
Main Channel Distance (ft)
820
810
800
790
780
0
500
1000
1500
2000
2500

Mauldin Mill Road Culvert
Hydrologic, Hydraulic
And Alternatives Analysis

Appendix C.2
Option 2 - (4) 7' x 7' Box Culverts Hydraulic Performance
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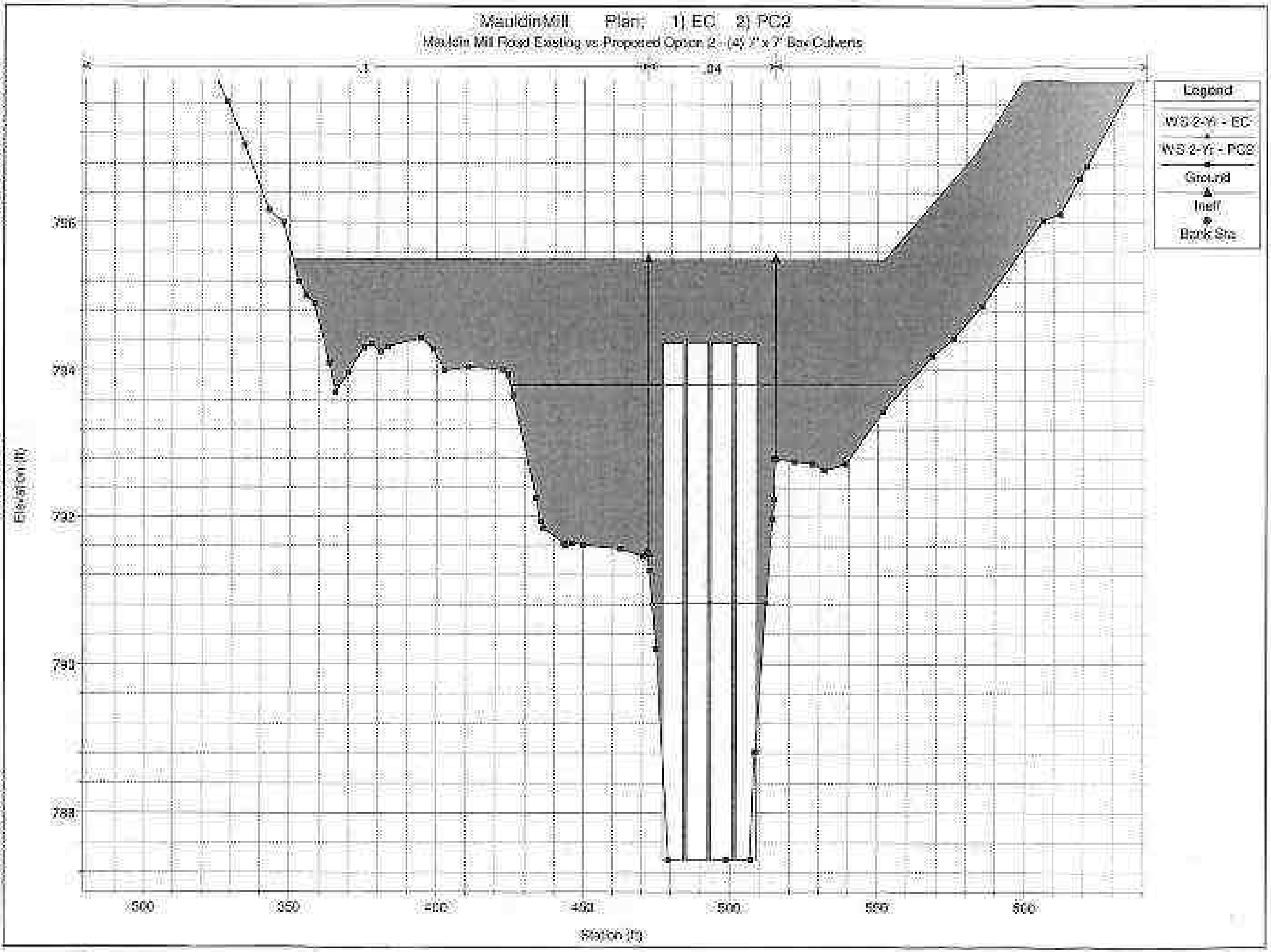
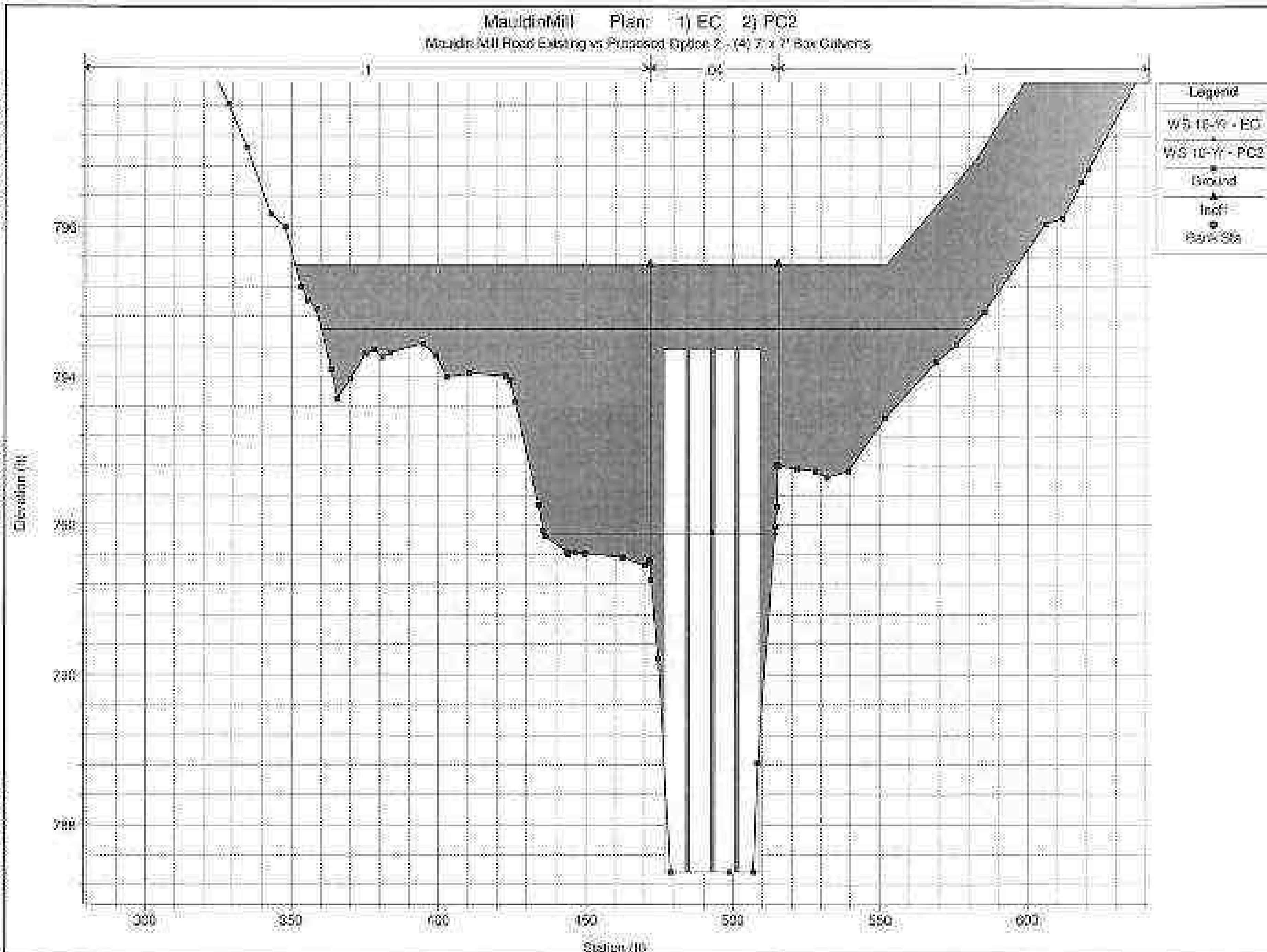
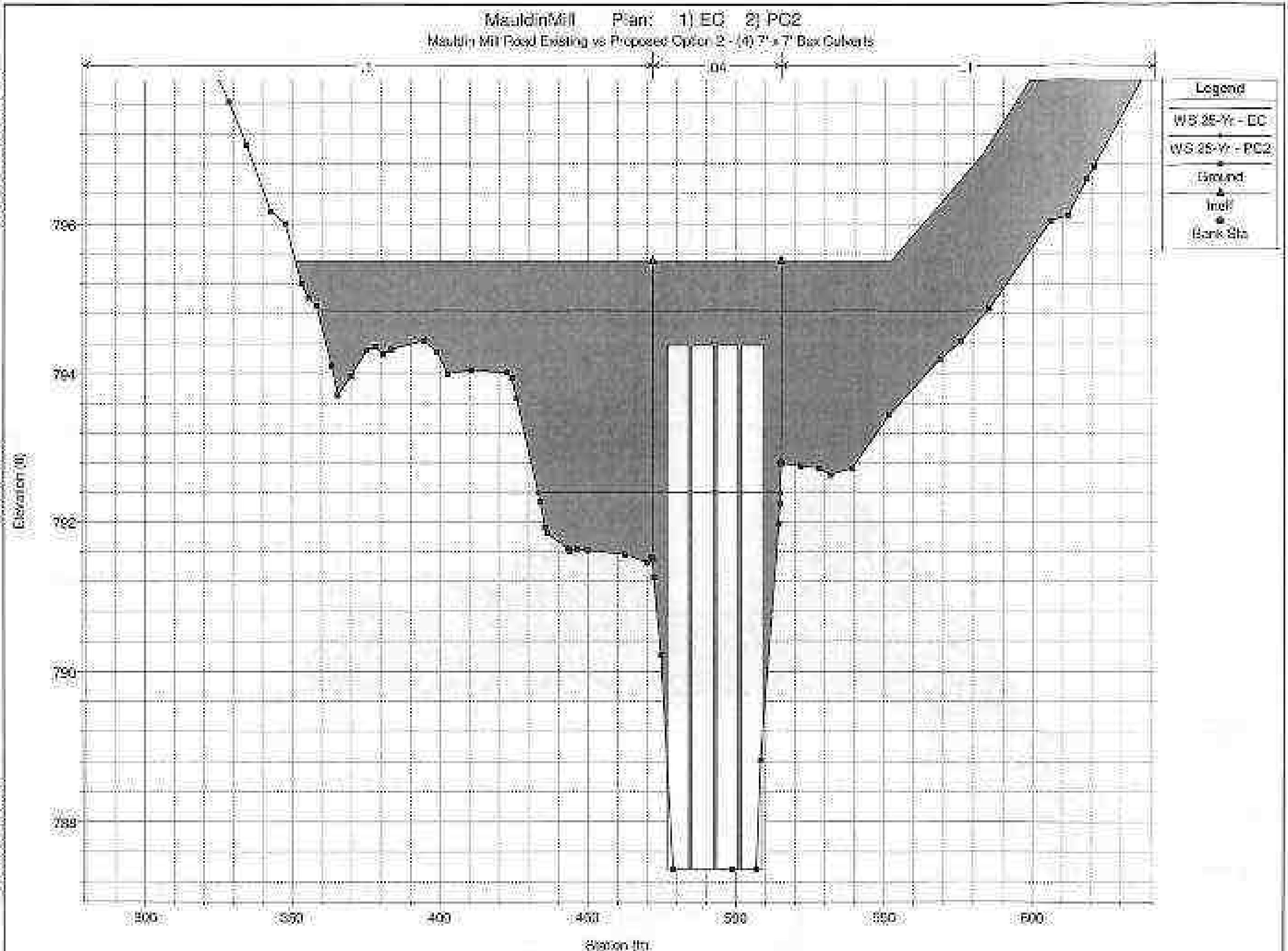
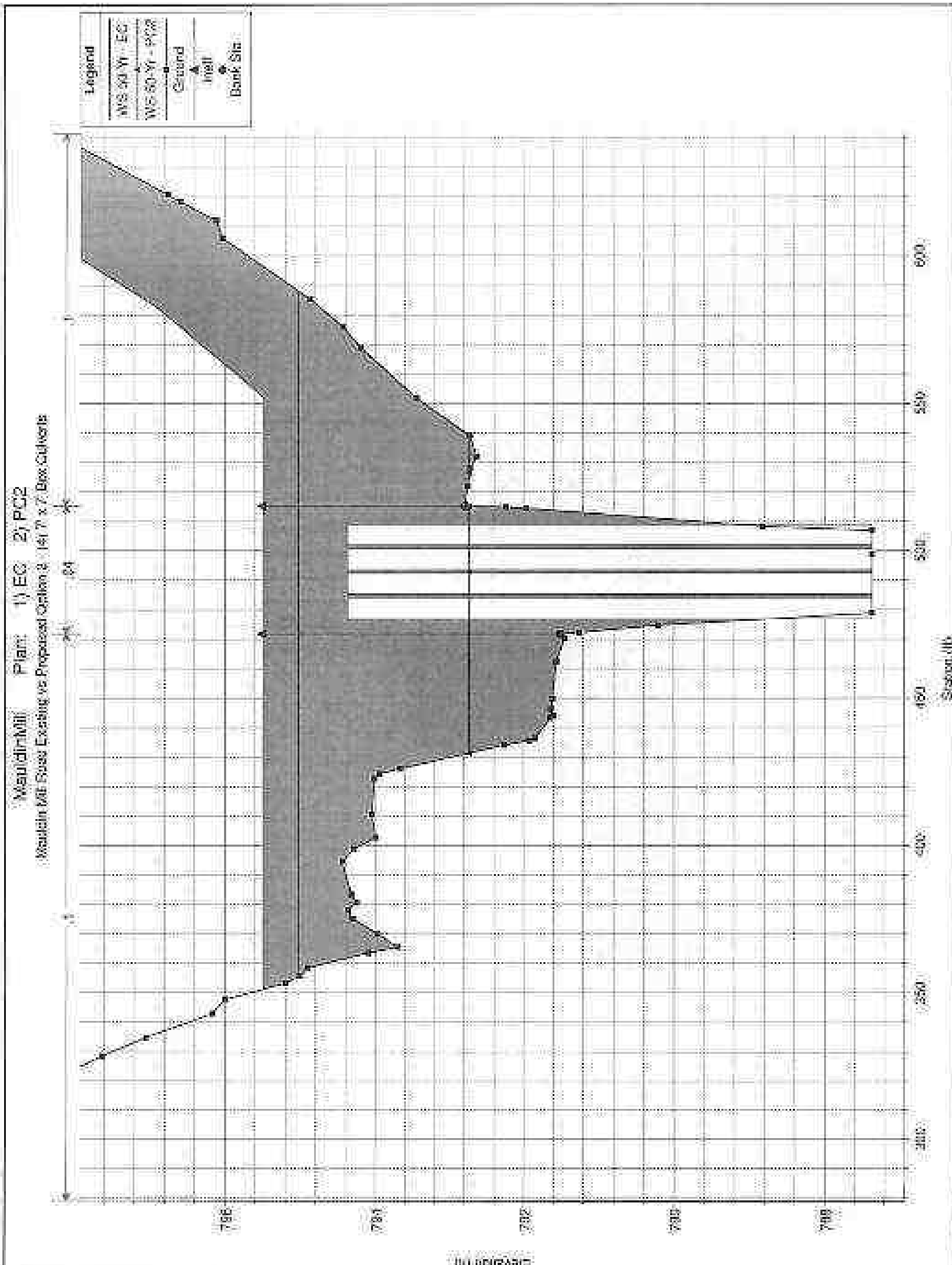
Davis & Floyd, Inc.
D&F Job No. 12975.01
June 2015



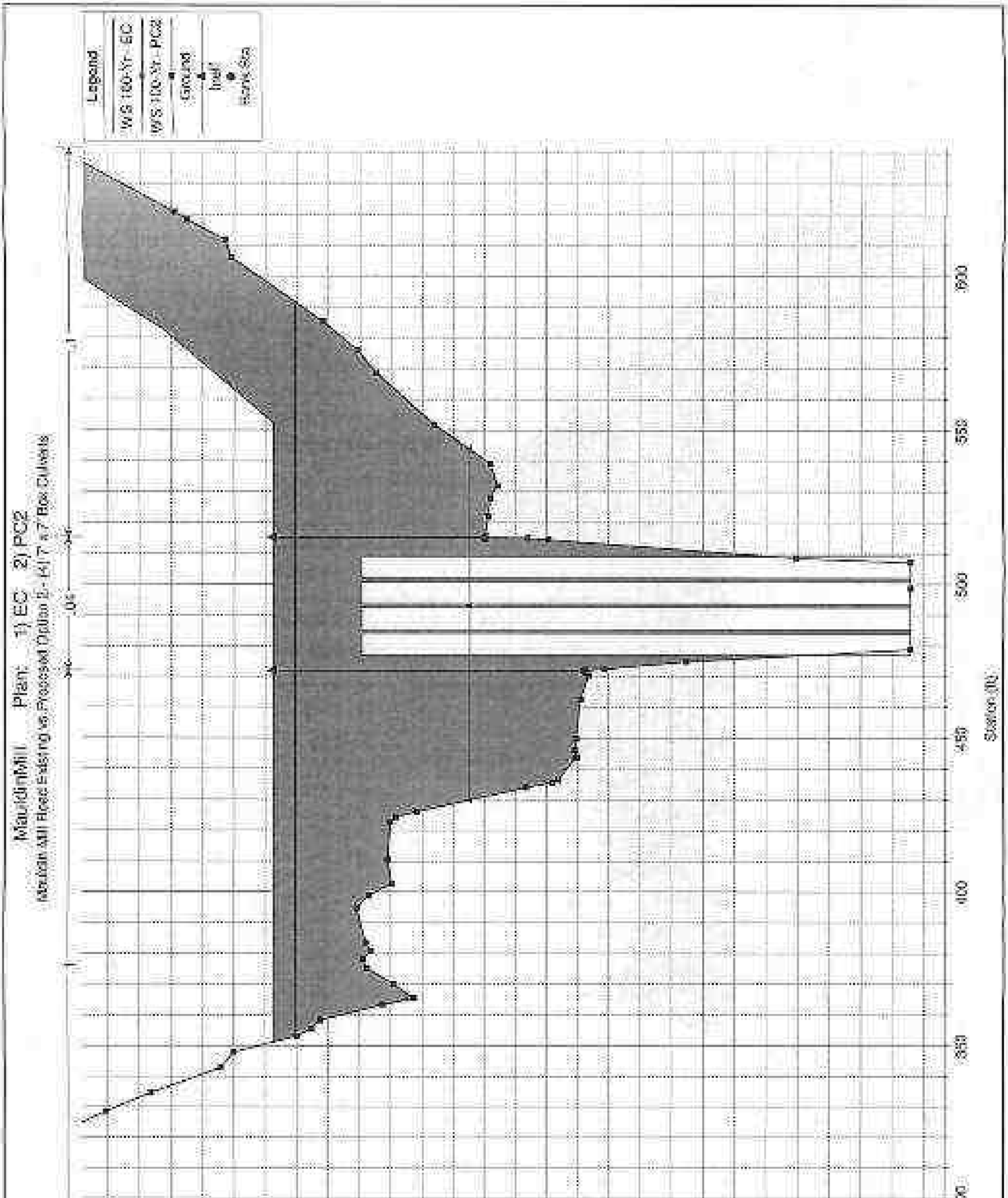


MauldinMill Plan: 1) EC 2) PC2
Mauldin Mill Road Existing vs Proposed Option 2 - (4) 7' x 7' Box Culverts
Legend
WS 10-Yr - EC
WS 10-Yr - PC2
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


MauldinMill Plan: 1) EC 2) PC2
Mauldin Mill Road Existing vs Proposed Option 2 - (4) 7' x 7' Box Culverts
Legend
WS 25-Yr - EC
WS 25-Yr - PC2
Ground
Ineff
Bank Sta
.04
Elevation (ft)
Station (ft)
796
794
792
790
788
300
350
400
450
500
550
600

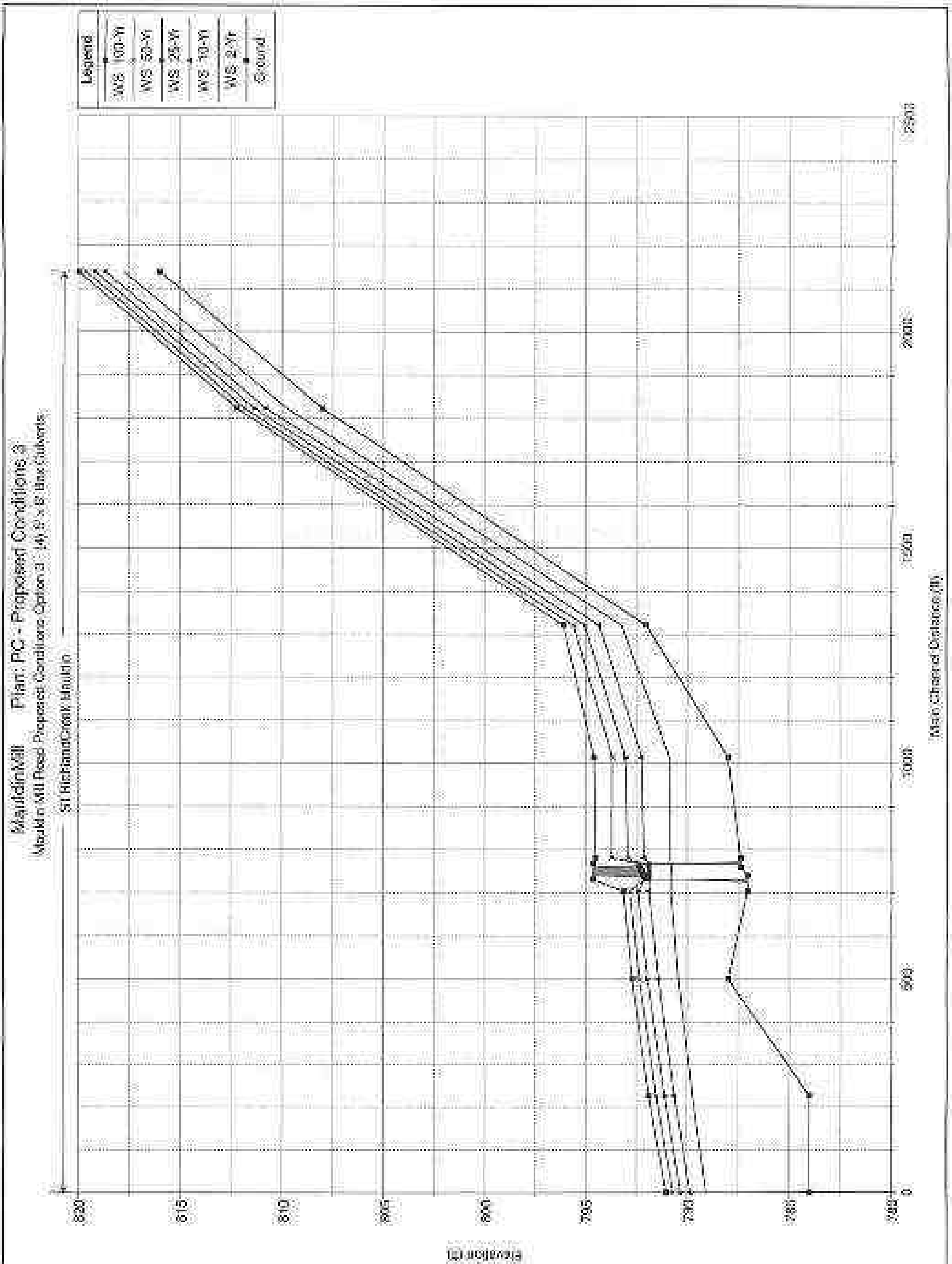


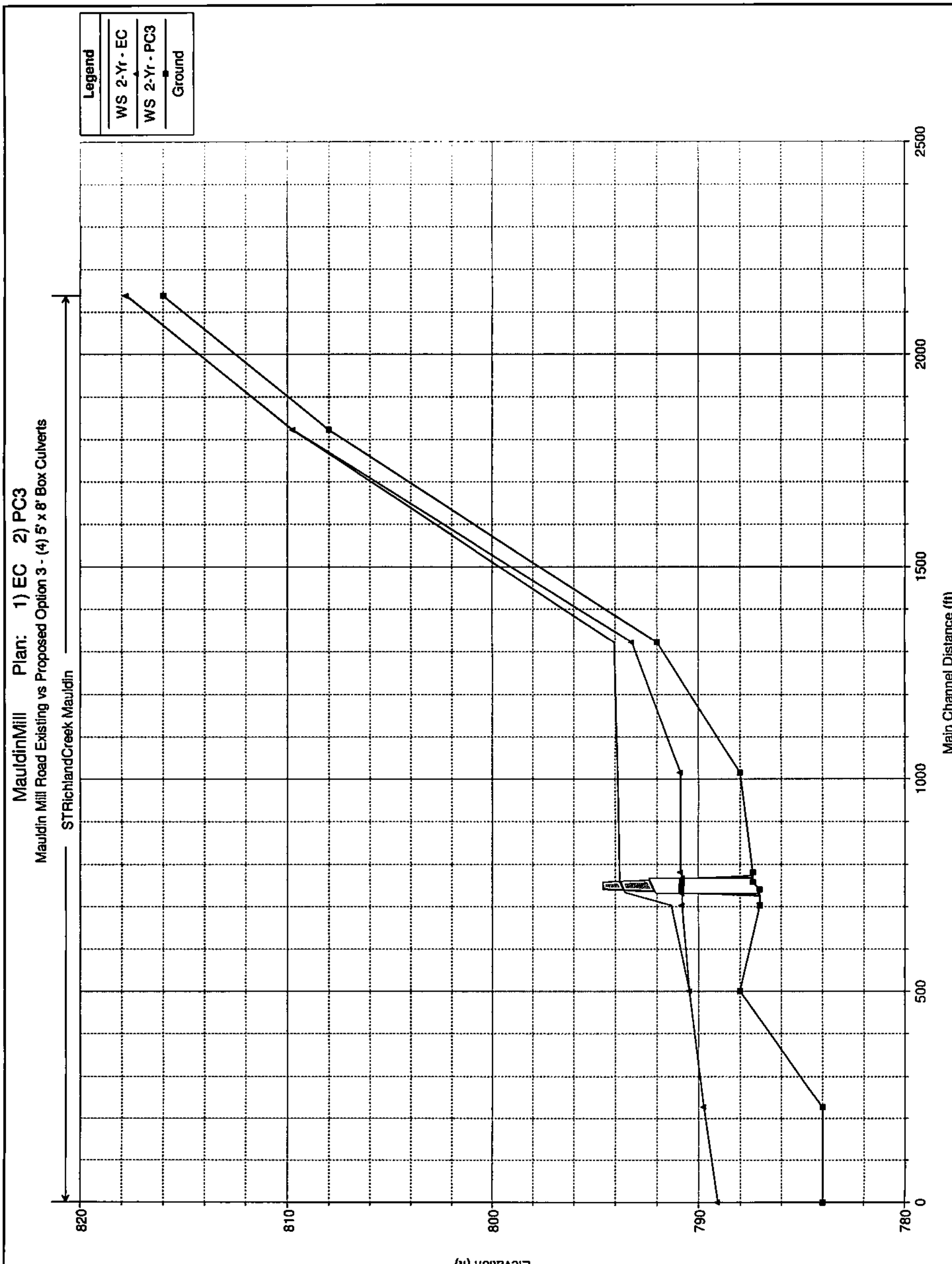
MauldinMill Plan: 1) EC 2) PC2
Mauldin Mill Road Existing vs Proposed Option 2 - (4) 7' x 7' Box Culverts
Legend
WS 50 Yr - EC
WS 50 Yr - PC2
Ground
Ineff
Bank Sta
Elevation (ft)
796
792
790
788
Station (ft)
300
350
400
450
500
550
600



MauldinMill Plan: 1) EC 2) PC2
Mauldin Mill Road Existing vs. Proposed Option 2 - (4) 7' x 7' Box Culverts
Legend
WS 100 Yr - EC
WS 100 Yr - PC2
Ground
Ineff
Bank Sta
Station (ft)
Elevation (ft)

Appendix C.3
Option 3 Hydraulic Performance


MauldinMill Plan: PC - Proposed Conditions 3
Mauldin Mill Road Proposed Conditions Option 3 - (4) 5' x 8' Box Culverts
St RichlandCreek Mauldin
Legend
WS 100-Yr
WS 50-Yr
WS 25-Yr
WS 10-Yr
WS 2-Yr
Ground
Elevation (ft)
820
815
810
805
800
795
790
785
780
0
500
1000
1500
2000
2500
Main Channel Distance (ft)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Mauldin Mill Road Existing vs Proposed Option 3 - (4) 5' x 8' Box Culverts
STRichlandCreek Mauldin
Legend
WS 2-Yr - EC
WS 2-Yr - PC3
Ground
Main Channel Distance (ft)
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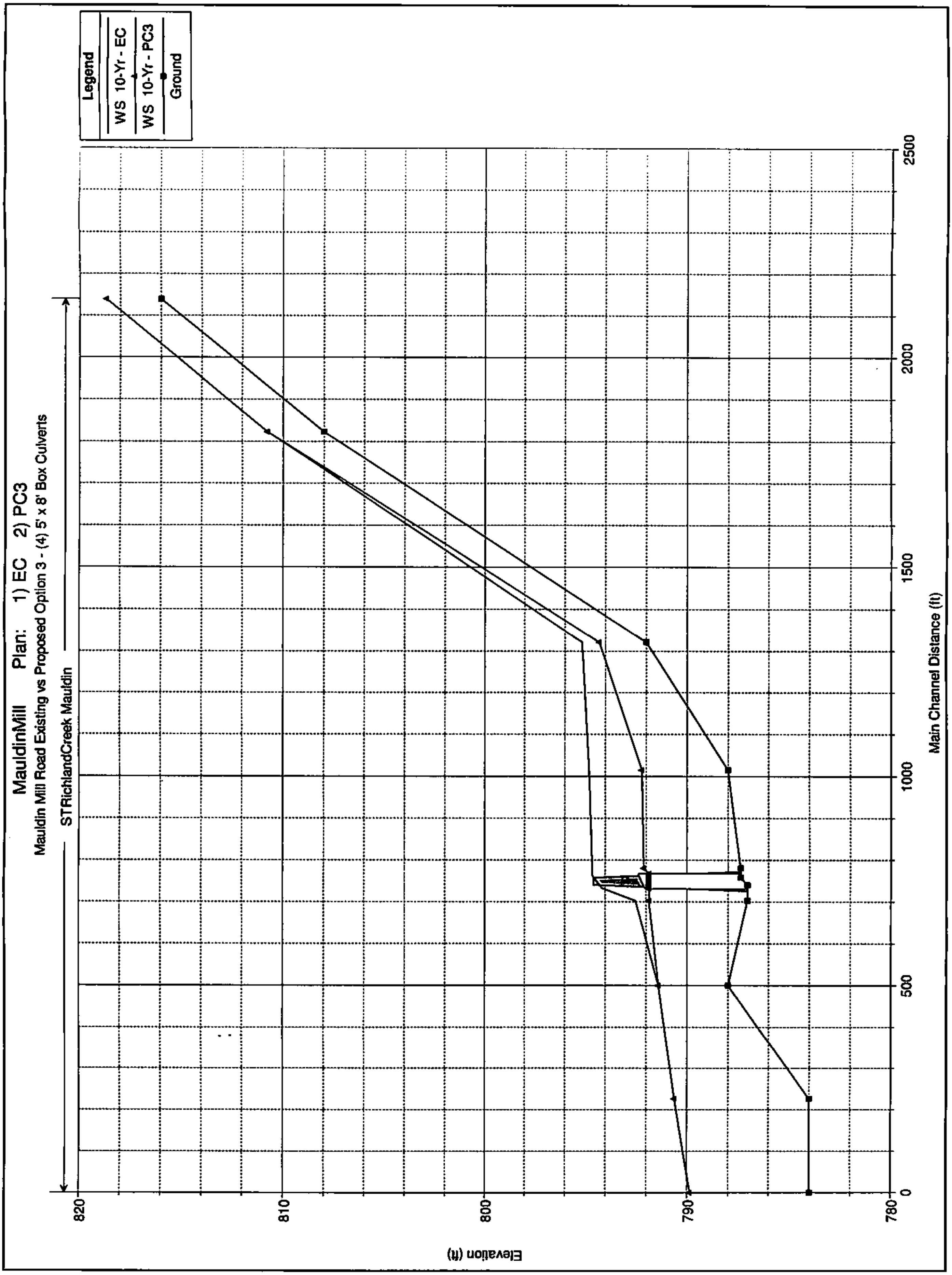
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Legend
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WS 10-Yr - PC3
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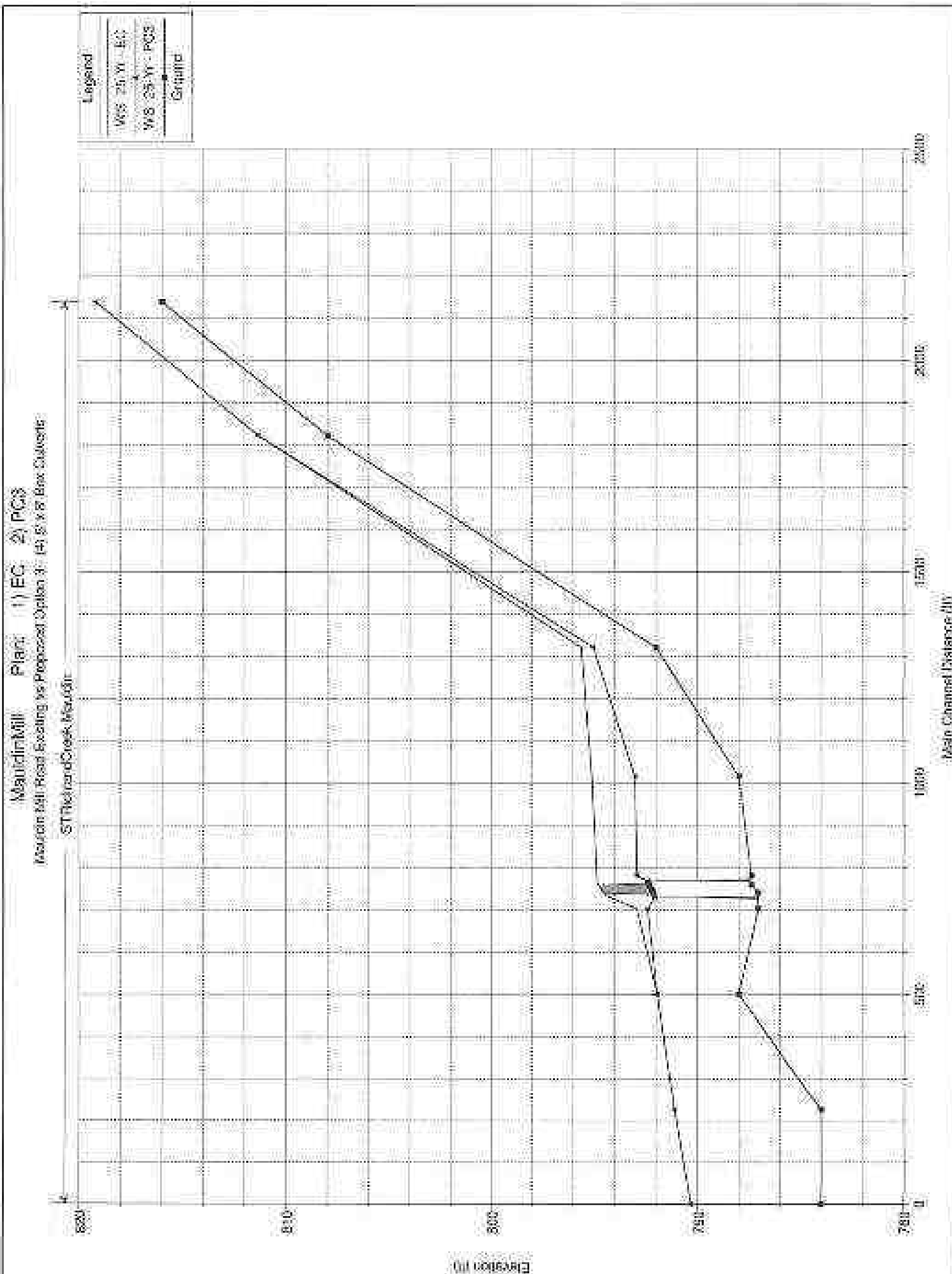

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Legend
WS 25 Yr - EC
WS 25 Yr - PC3
Ground
Elevation (ft)
Main Channel Distance (ft)
780
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Mauldin Mill Road Culvert
Hydrologic, Hydraulic
And Alternatives Analysis

Appendix C.3
Option 3 - (4) 5' x 8' Box Culverts Hydraulic Performance
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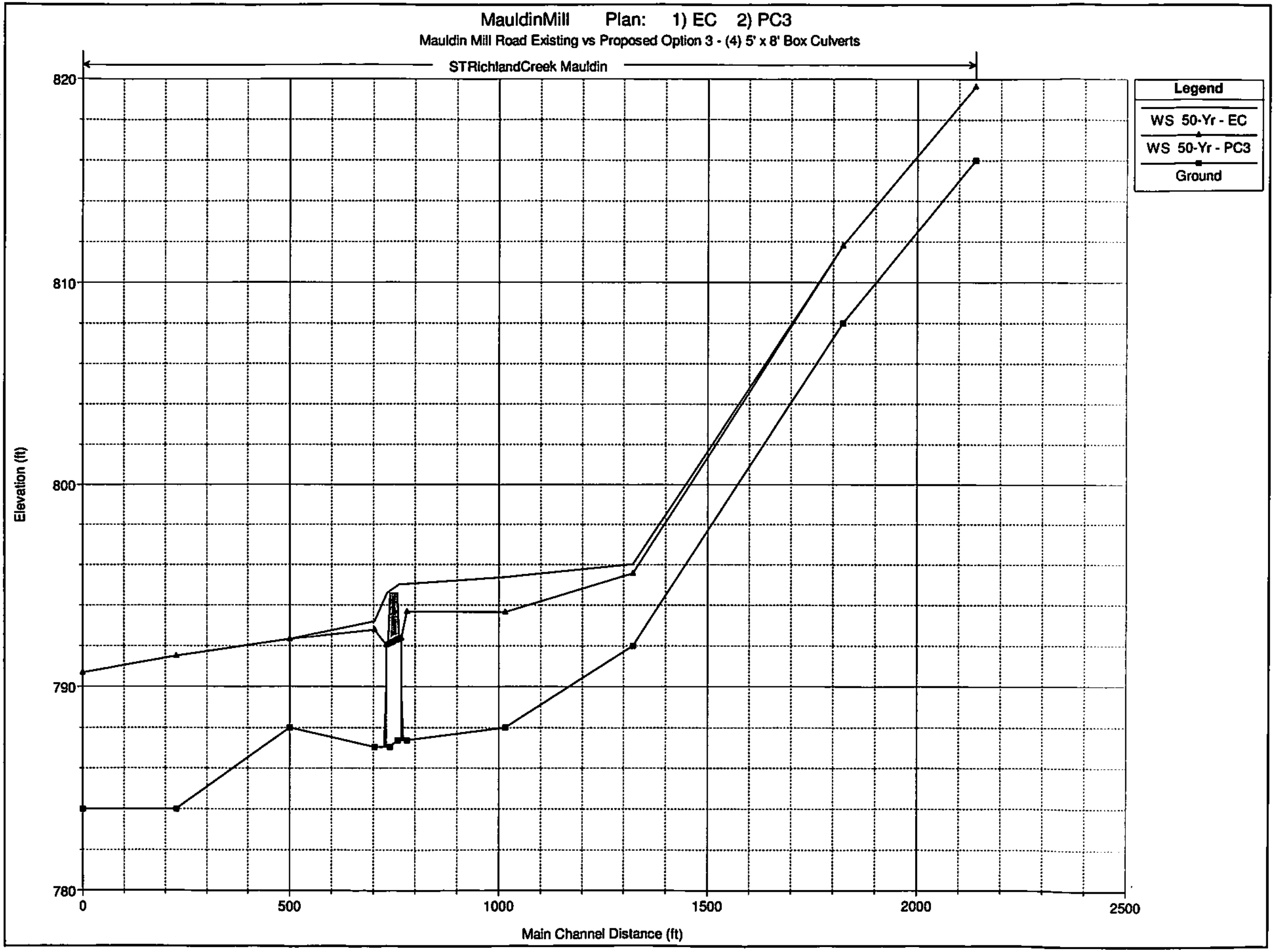

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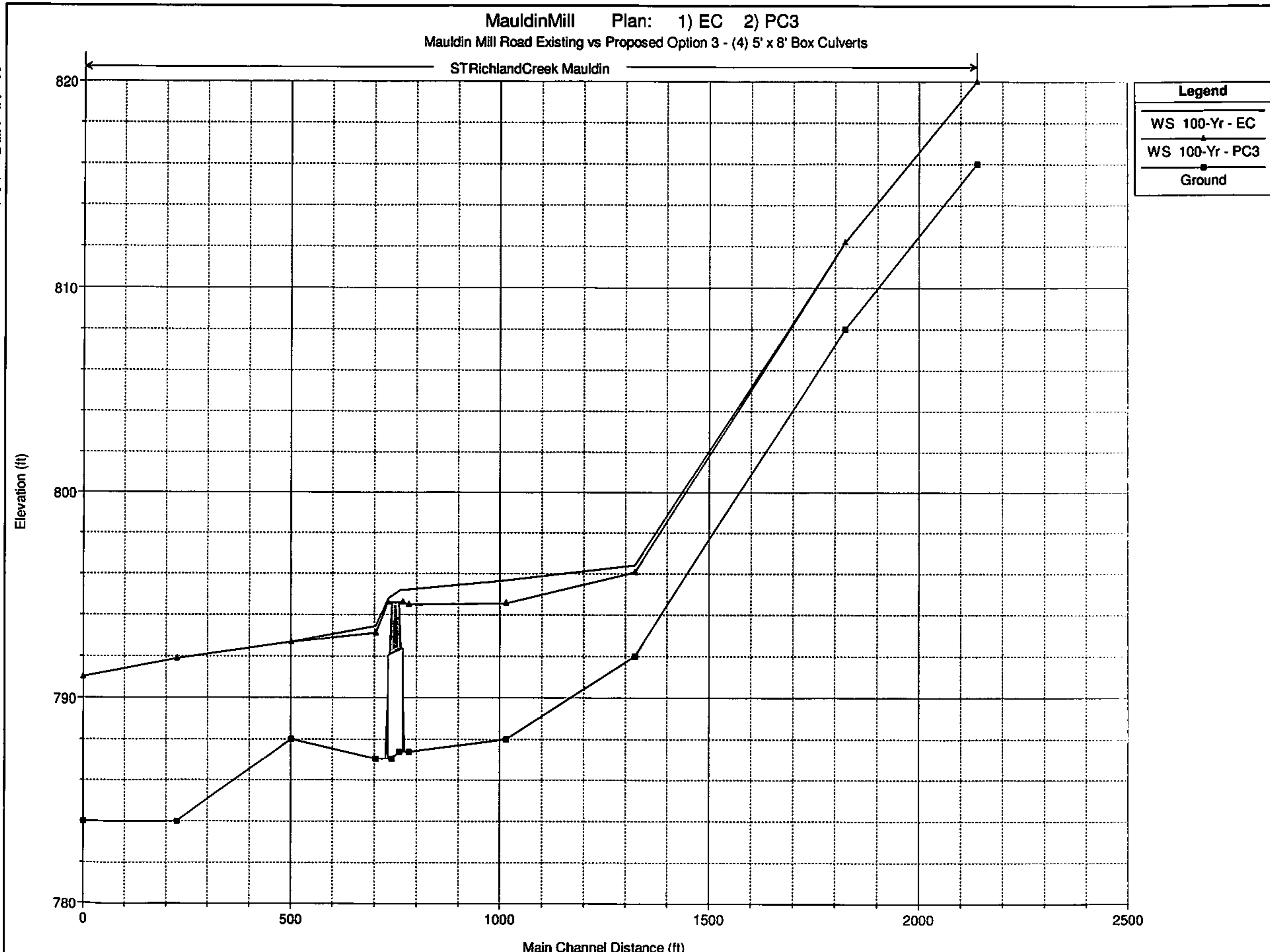
Mauldin Mill Road Culvert
Hydrologic, Hydraulic
And Alternatives Analysis



Davis & Floyd, Inc.
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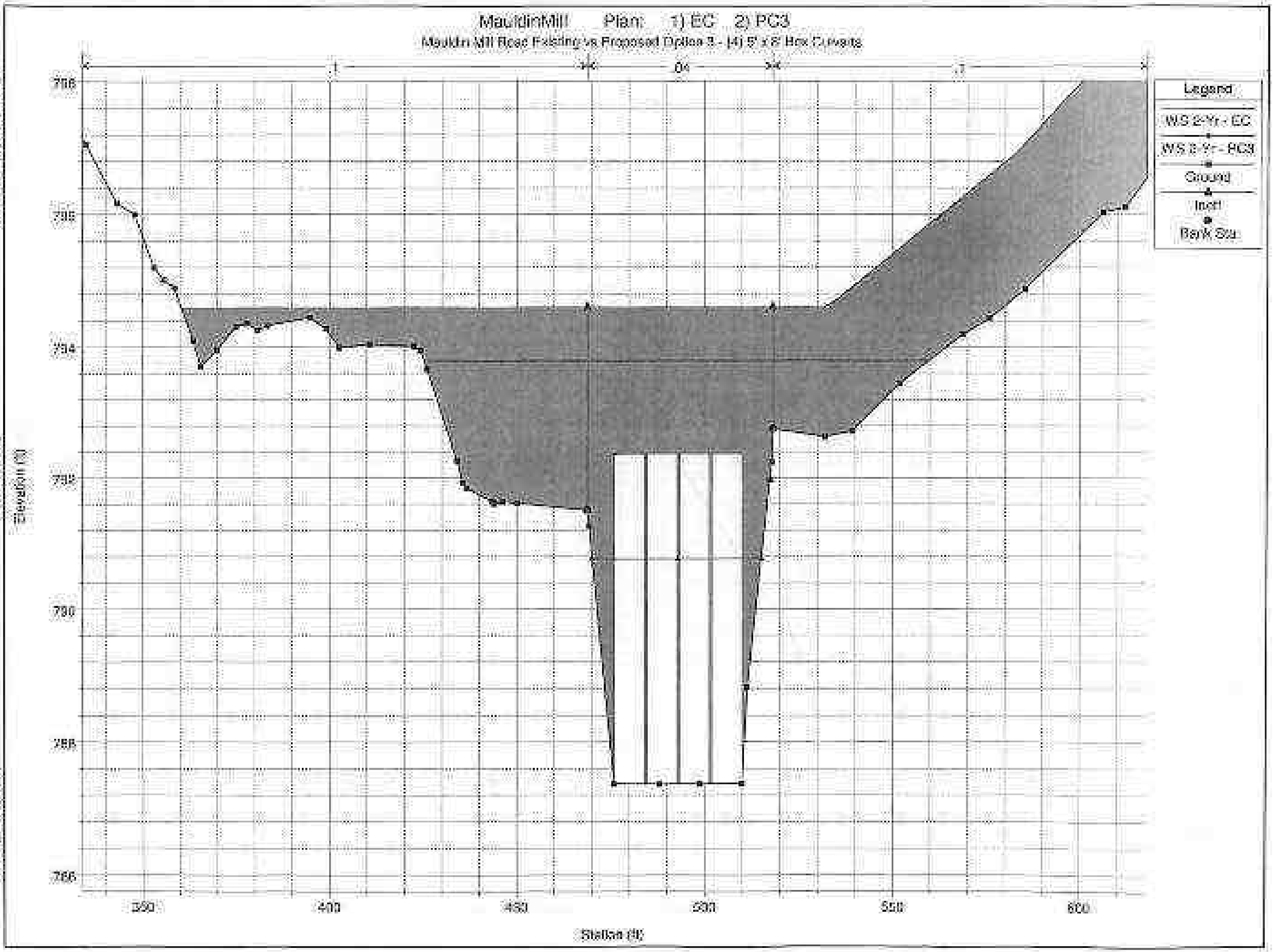
June 2013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Station (ft)
Legend
WS 2-Yr - EC
WS 2-Yr - PC3
Ground
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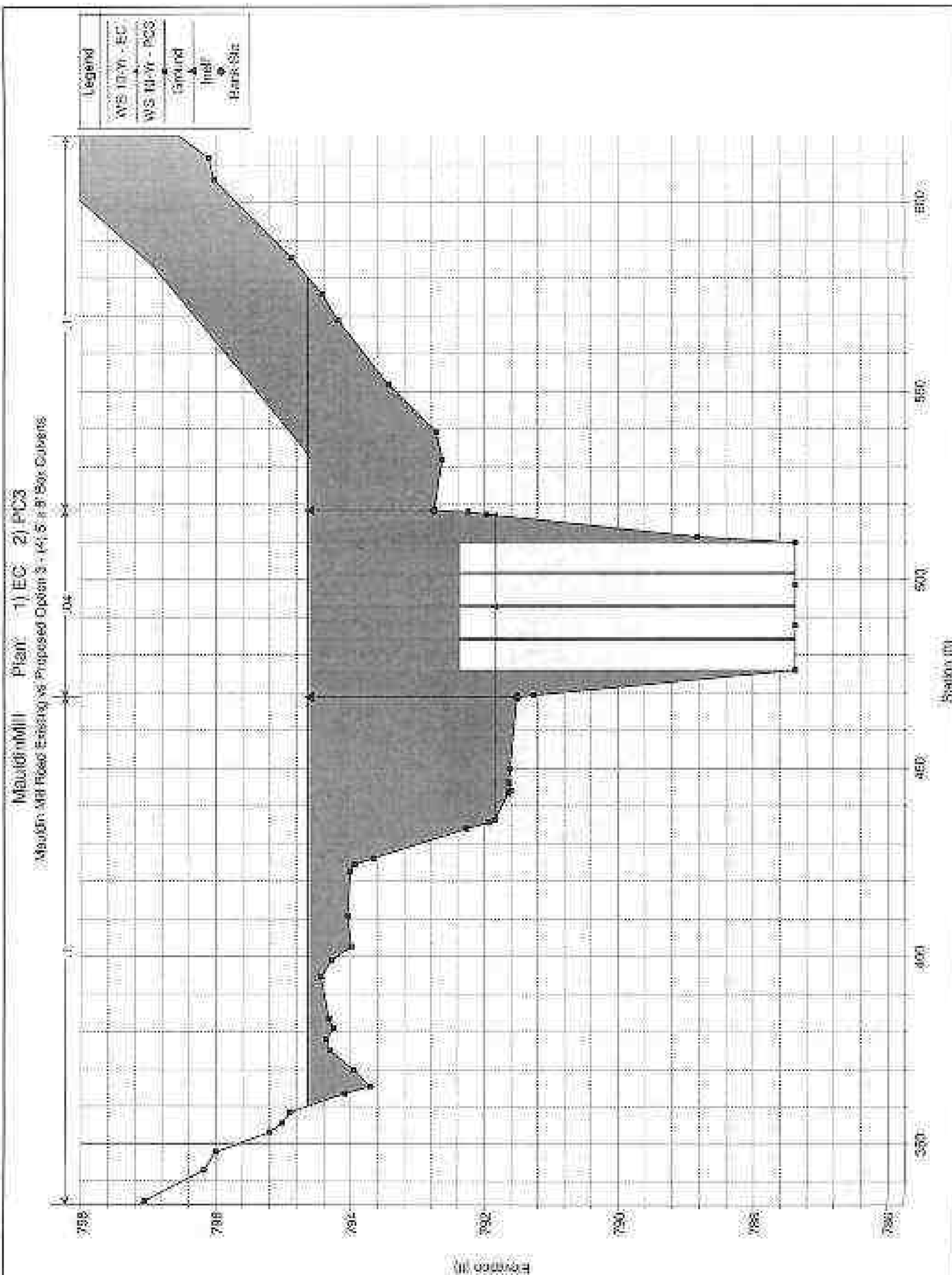
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Legend
WS 10-Yr - EC
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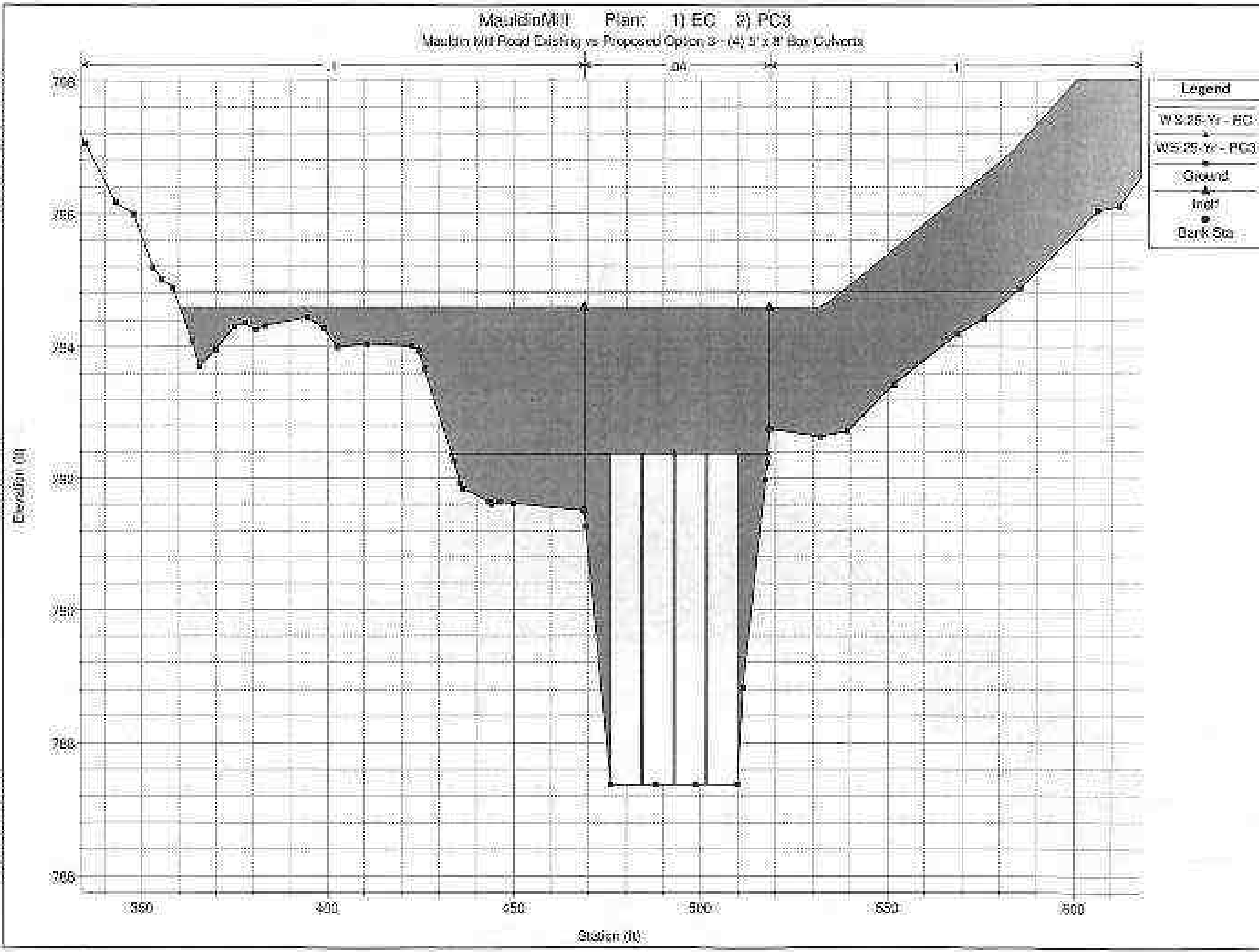

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Legend
WS 25-Yr - EC
WS 25-Yr - PC3
Ground
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Bank Sta
Elevation (ft)
Station (ft)
350
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450
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550
600

Mauldin Mill Road Culvert
Hydrologic, Hydraulic
And Alternatives Analysis

Appendix C.3
Option 3 - (4) 8' x 8' Box Culverts Hydraulic Performance
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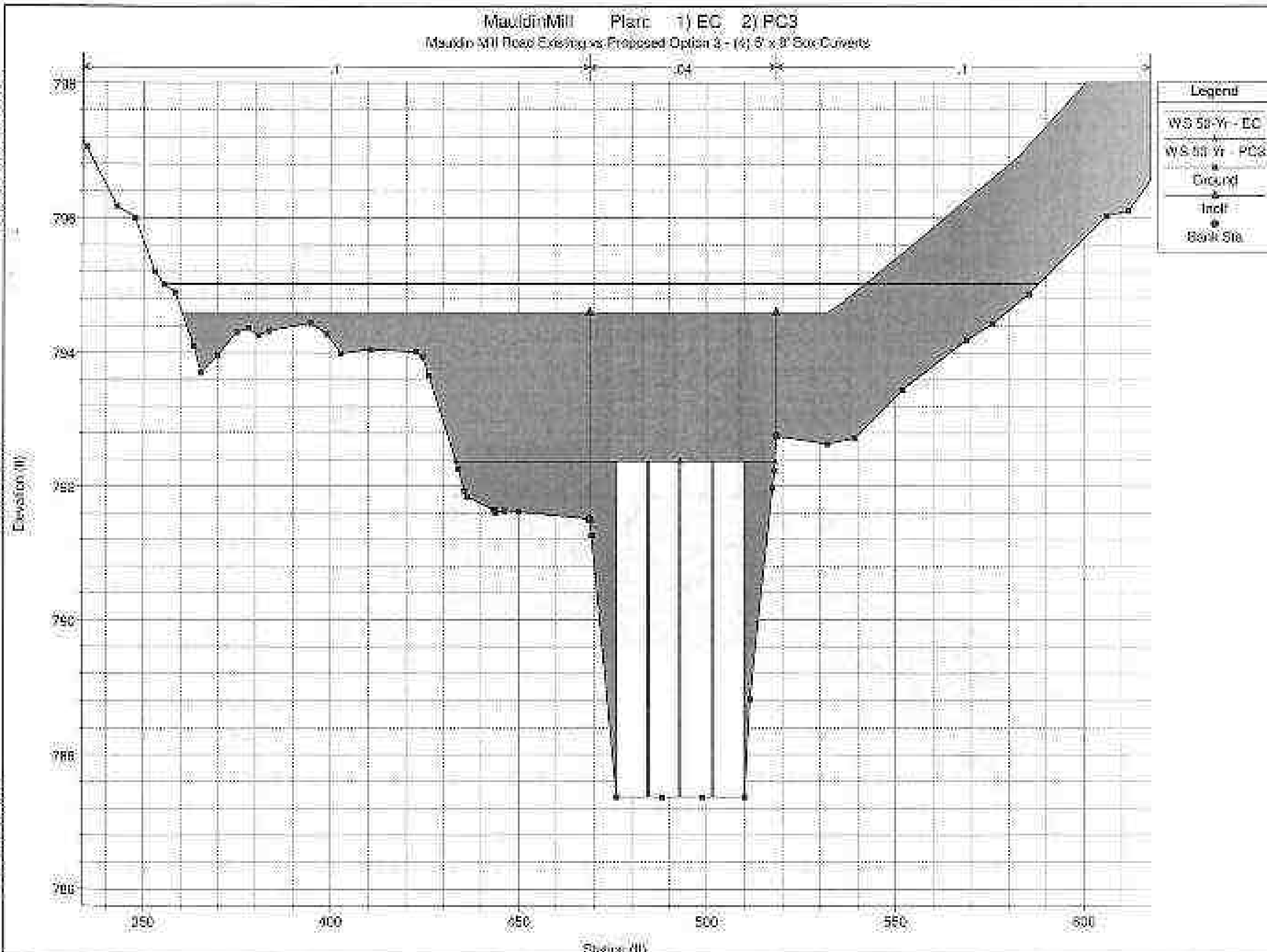
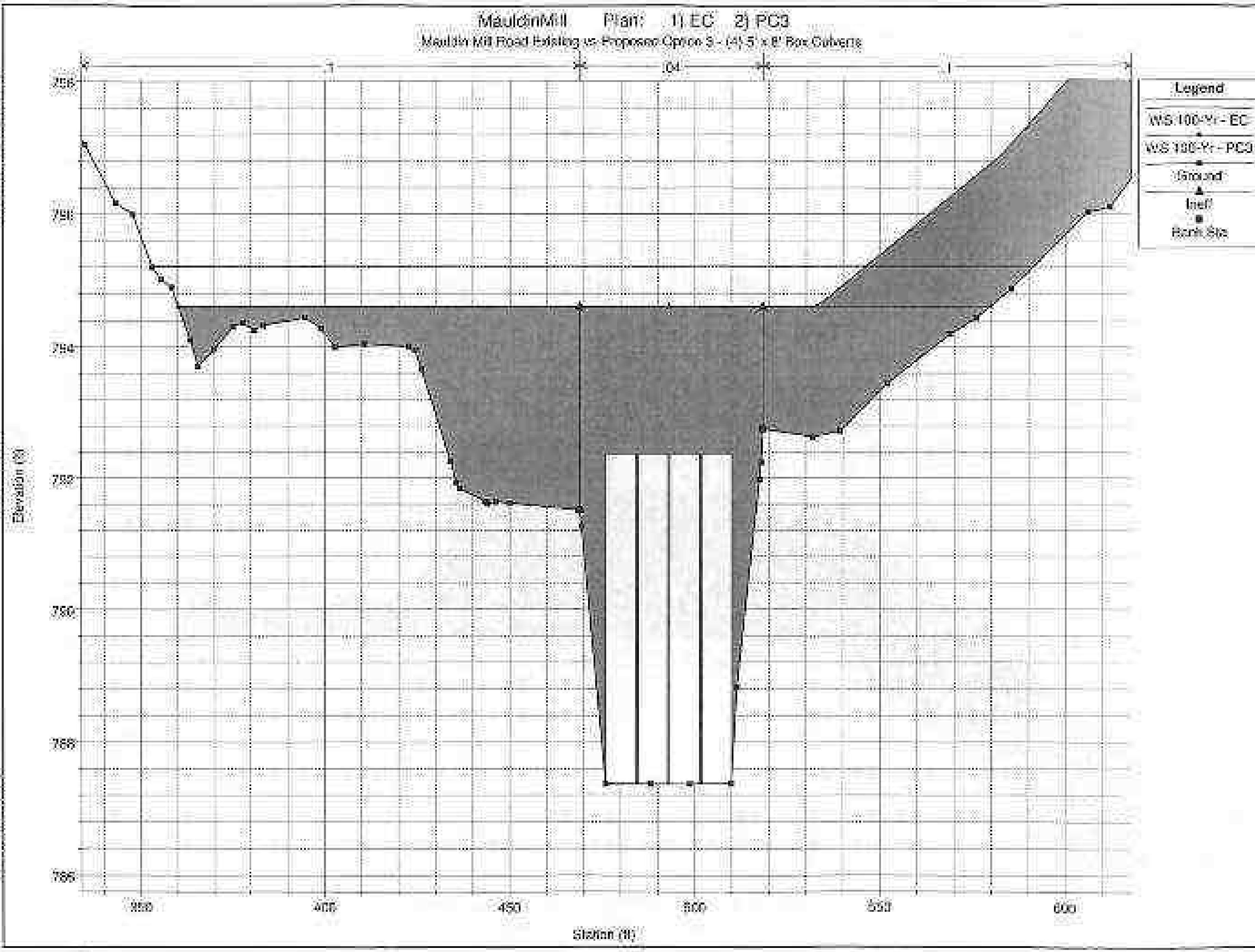
Davis & Floyd, Inc.
D&F Job No. 12072.01
June 2013

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Legend
WS 100-Yr - EC
WS 100-Yr - PC3
Ground
Ineff
Bank Sta
Elevation (ft)
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Station (ft)
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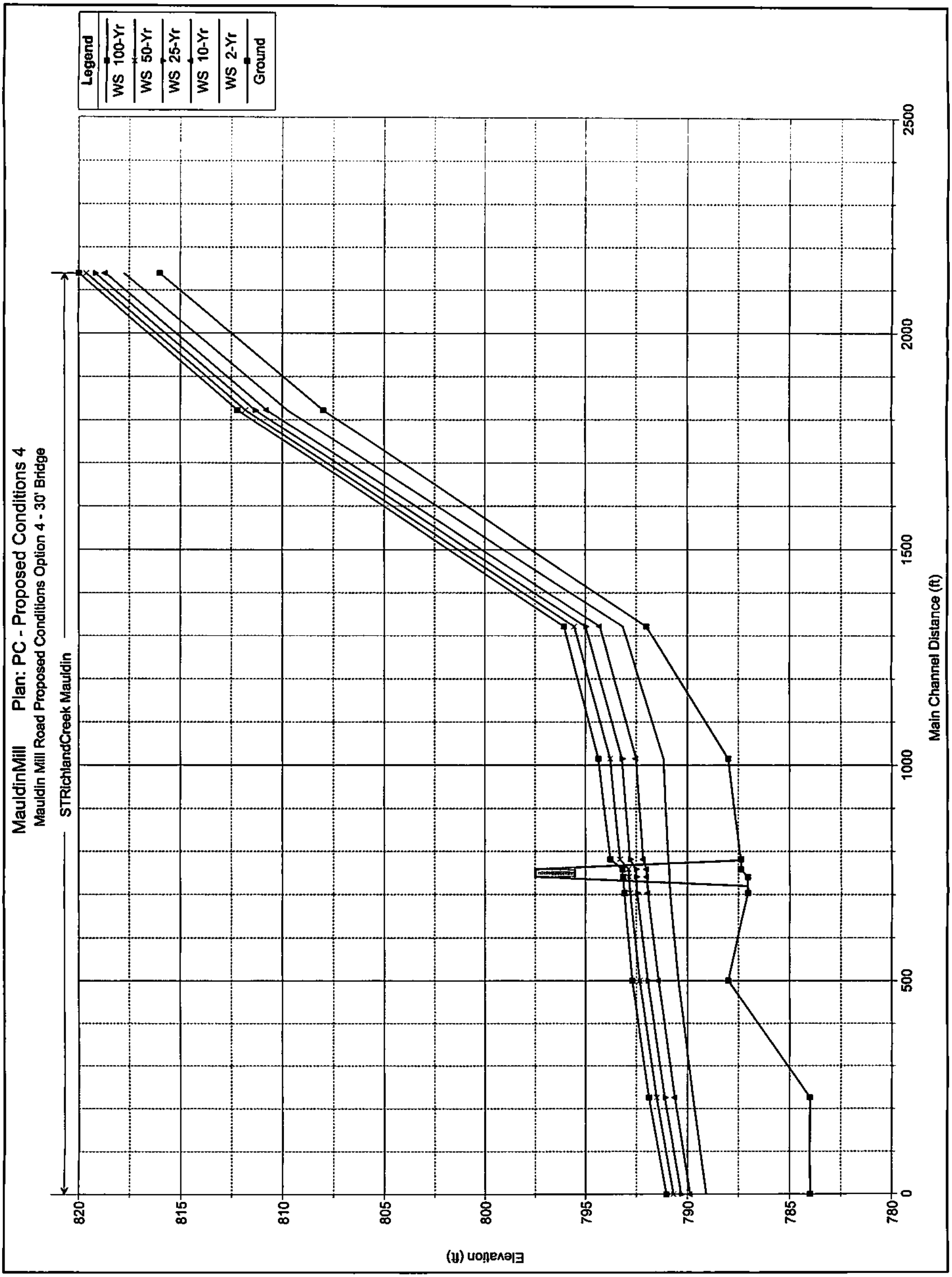
Appendix C.4
Option 4 Hydraulic Performance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Mauldin Mill Road Proposed Conditions Option 4 - 30' Bridge
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Legend
WS 100-Yr
WS 50-Yr
WS 25-Yr
WS 10-Yr
WS 2-Yr
Ground
Elevation (ft)
Main Channel Distance (ft)
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815
810
805
800
795
790
785
780
0
500
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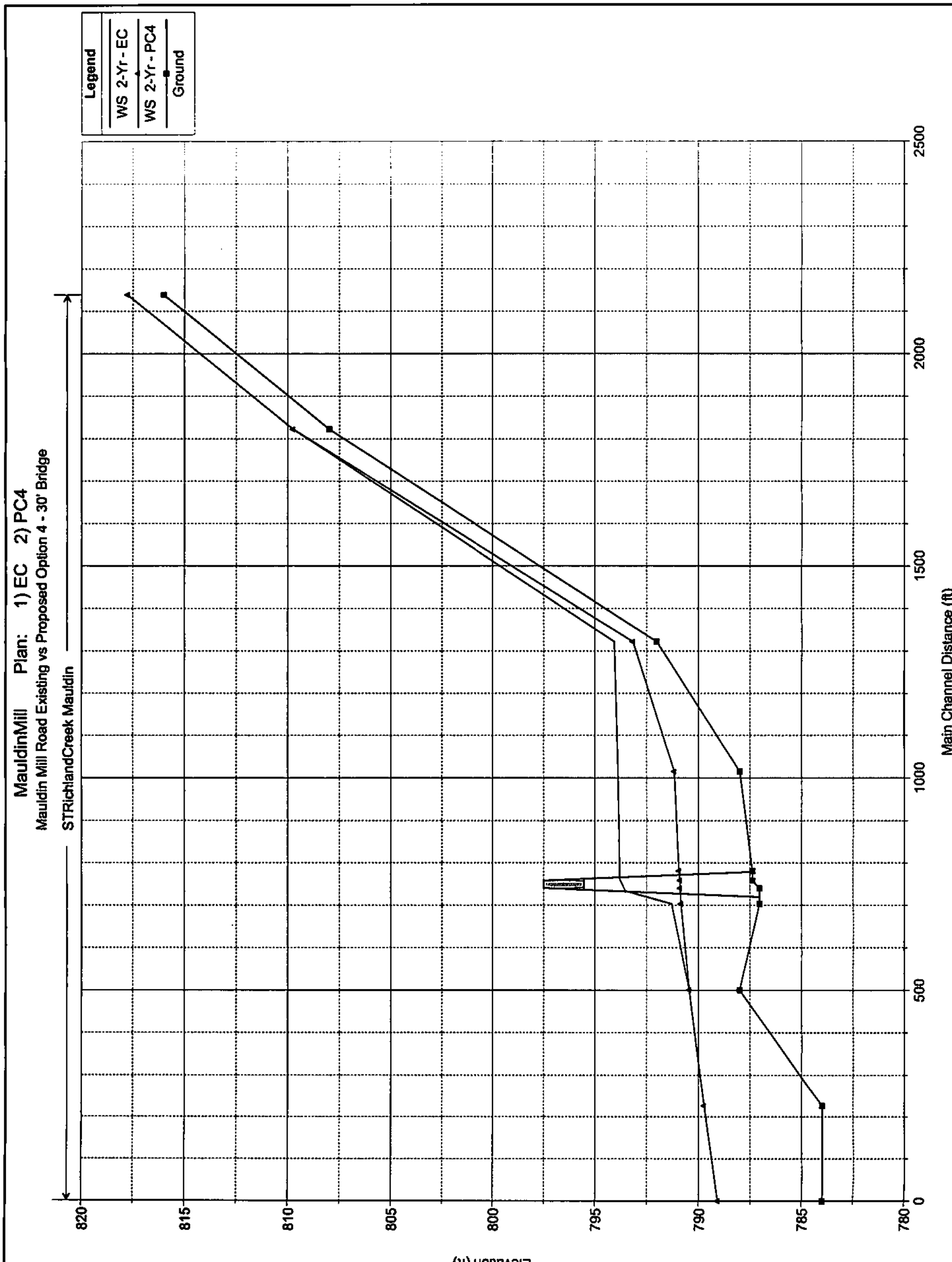
1500
2000
2500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STRichlandCreek Mauldin
Legend
WS 2-Yr - EC
WS 2-Yr - PC4
Ground
Elevation (ft)
Main Channel Distance (ft)
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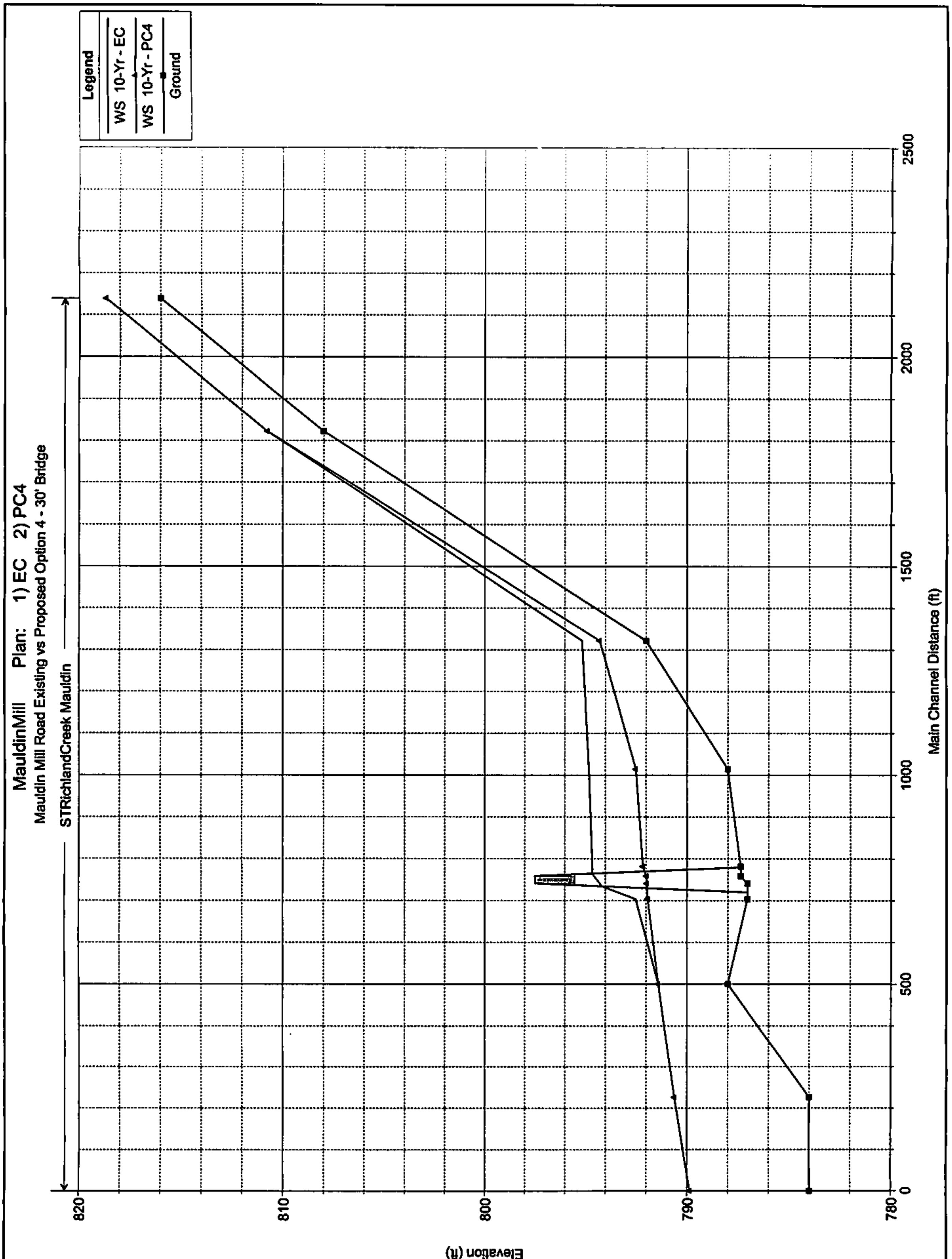

MauldinMill Plan: 1) EC 2) PC4
Mauldin Mill Road Existing vs Proposed Option 4 - 30' Bridge
STRichlandCreek Mauldin
Legend
WS 10-Yr - EC
WS 10-Yr - PC4
Ground
Elevation (ft)
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Main Channel Distance (ft)
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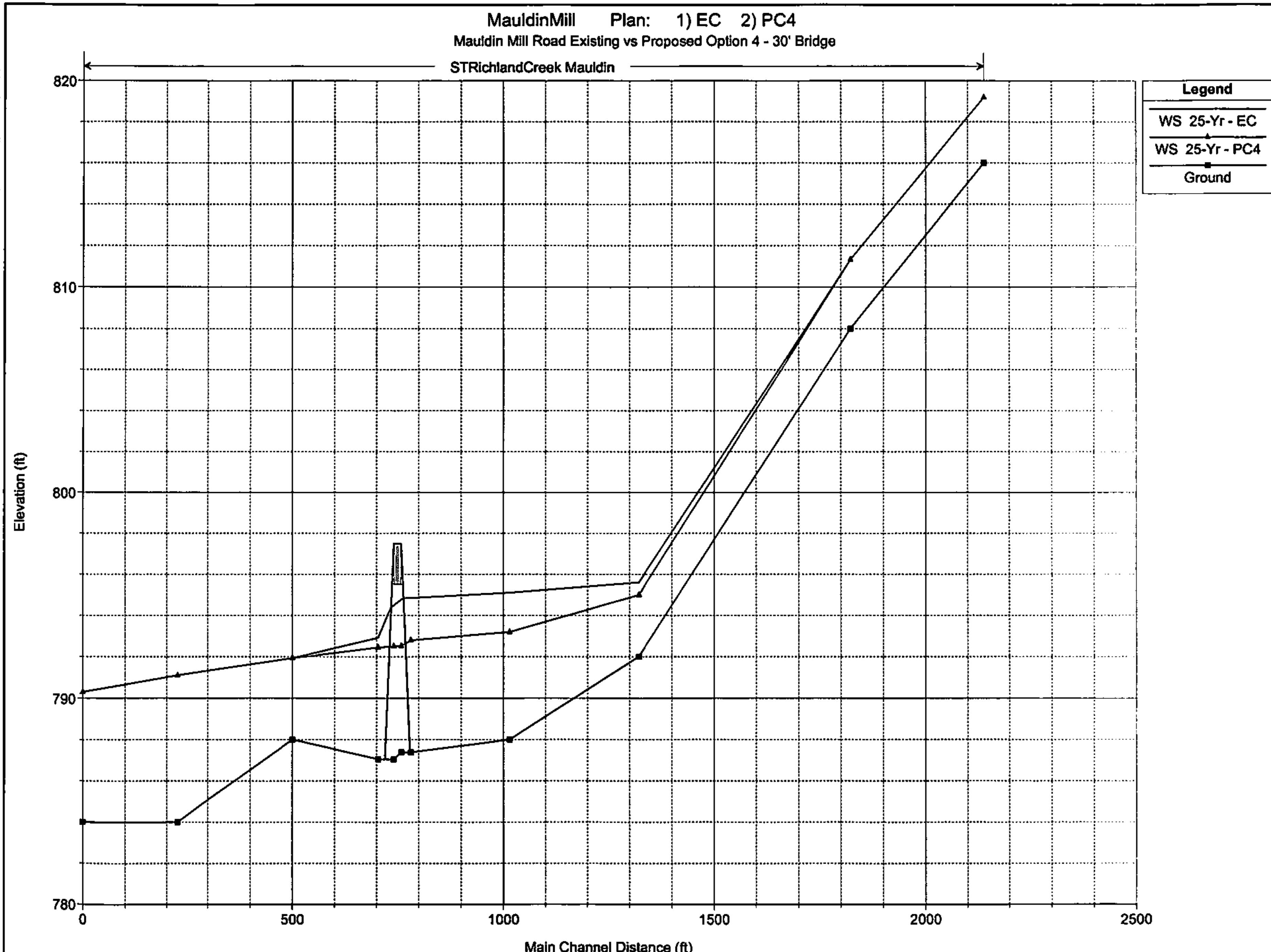
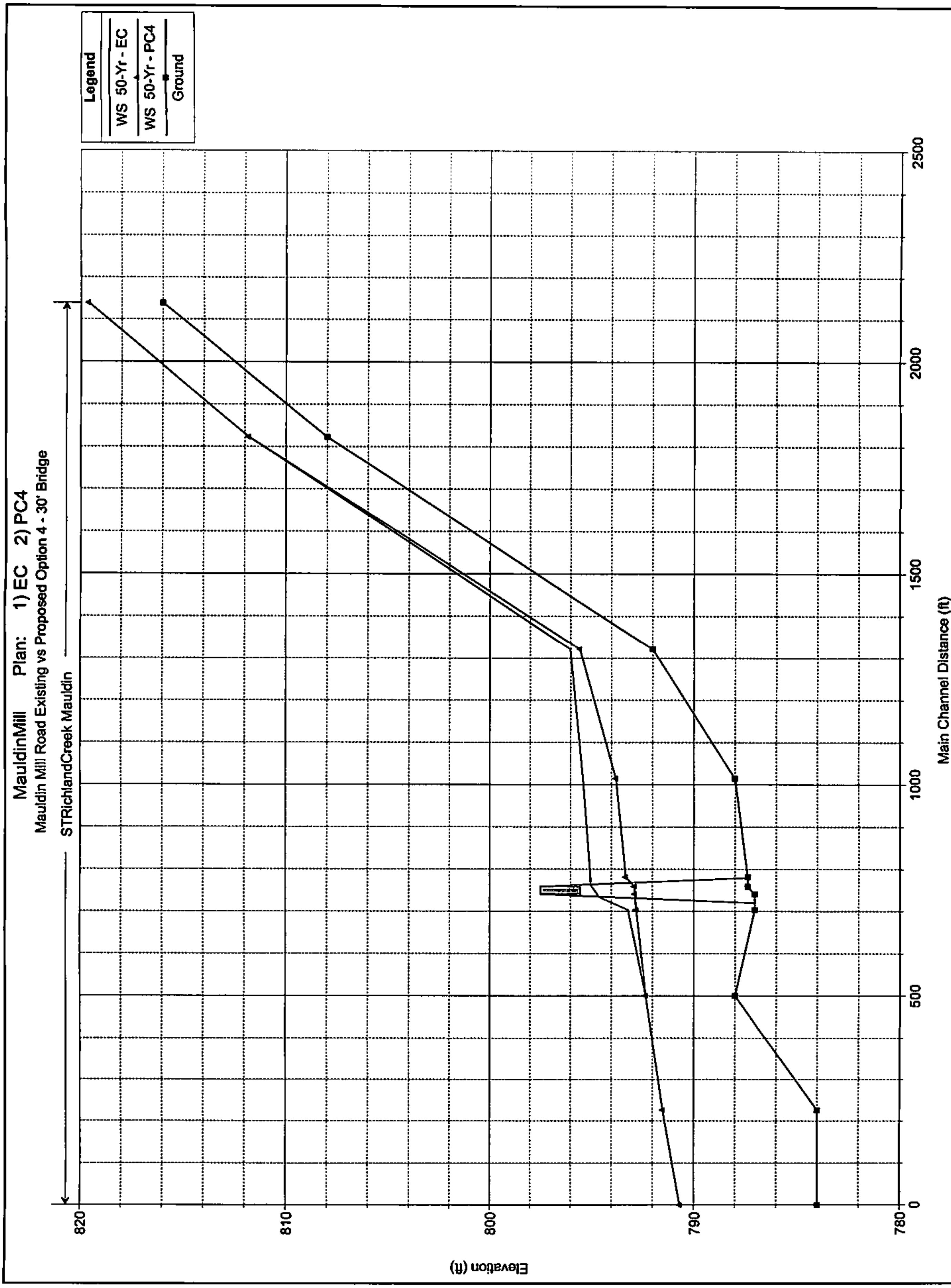
Mauldin Mill Road Culvert
Hydrologic, Hydraulic
And Alternatives Analysis

Appendix C.4
Option 4 - 30' Bridge Hydraulic Performance

Davis & Floyd, Inc.
D&F Job No. 12975.01
July 2013

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STRichlandCreek Mauldin
Legend
WS 50-Yr - EC
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Ground
Main Channel Distance (ft)
Elevation (ft)
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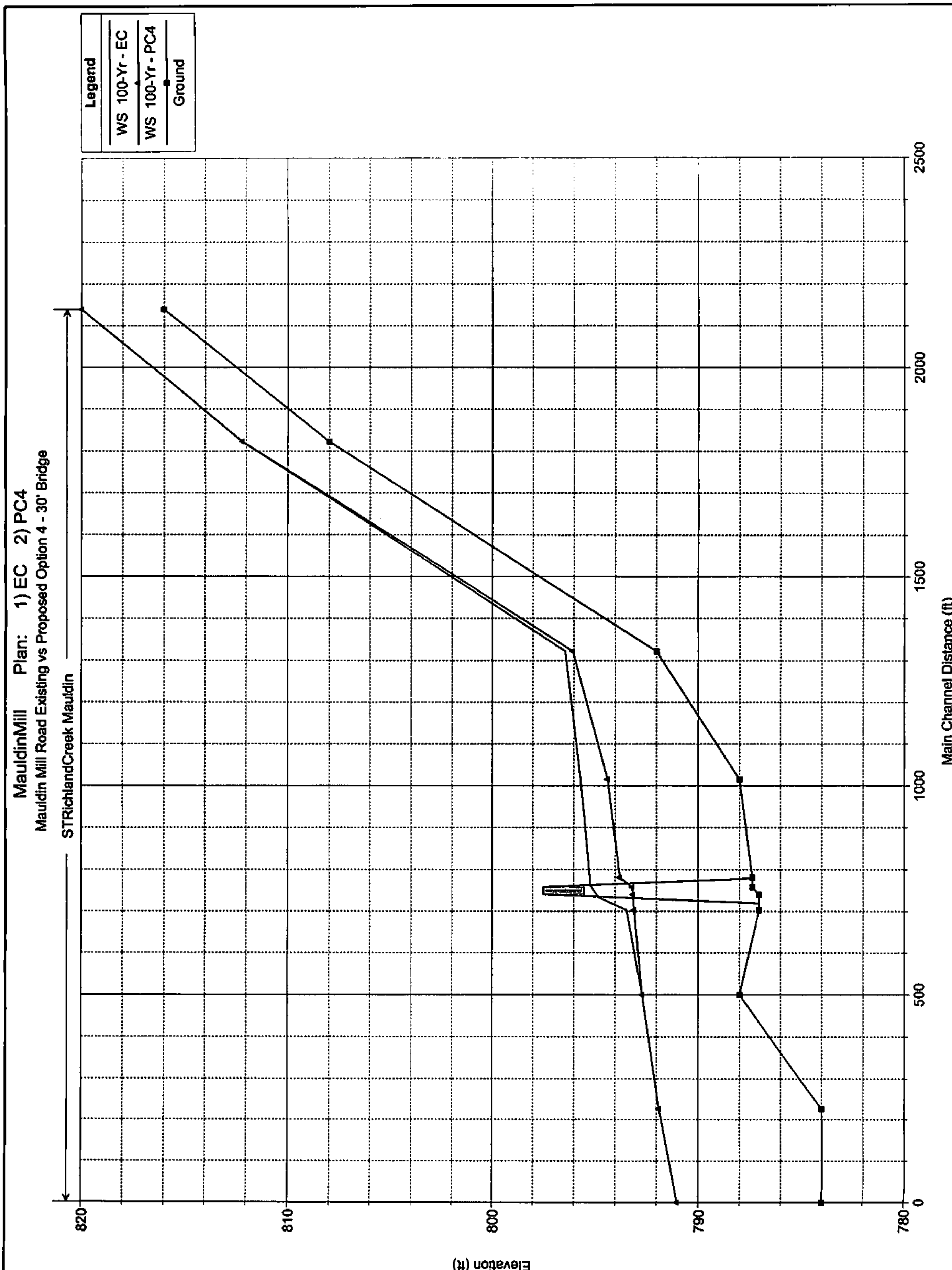

MauldinMill Plan: 1) EC 2) PC4
Mauldin Mill Road Existing vs Proposed Option 4 - 30' Bridge
STRichlandCreek Mauldin
Legend
WS 100-Yr - EC
WS 100-Yr - PC4
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Main Channel Distance (ft)
Elevation (ft)
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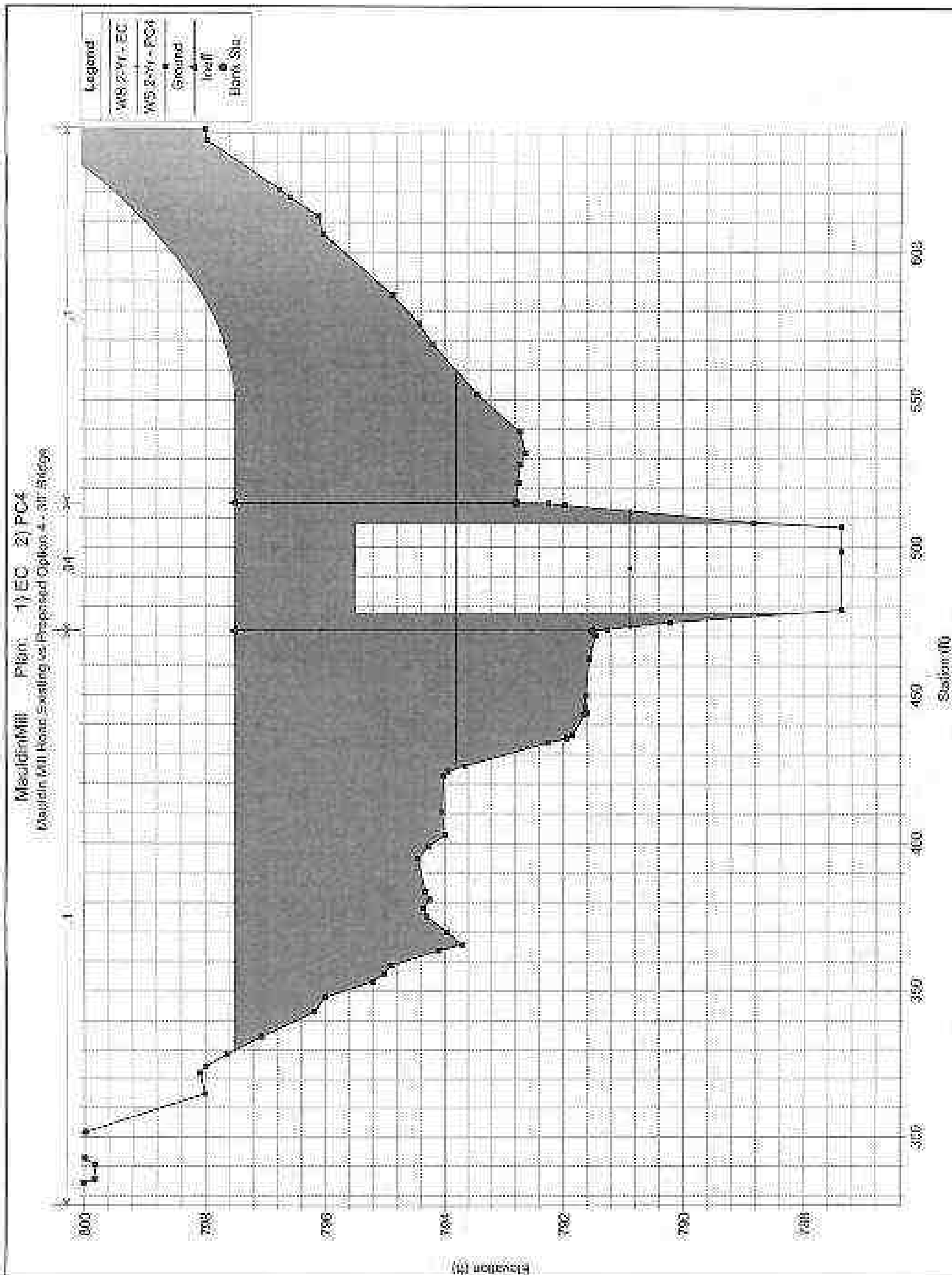
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Mauldin Mill Road Existing vs Proposed Option 4 - 30ft Bridge
Legend
WS 2-Yr - EC
WS 2-Yr - PC4
Ground
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Station (ft)
Elevation (ft)
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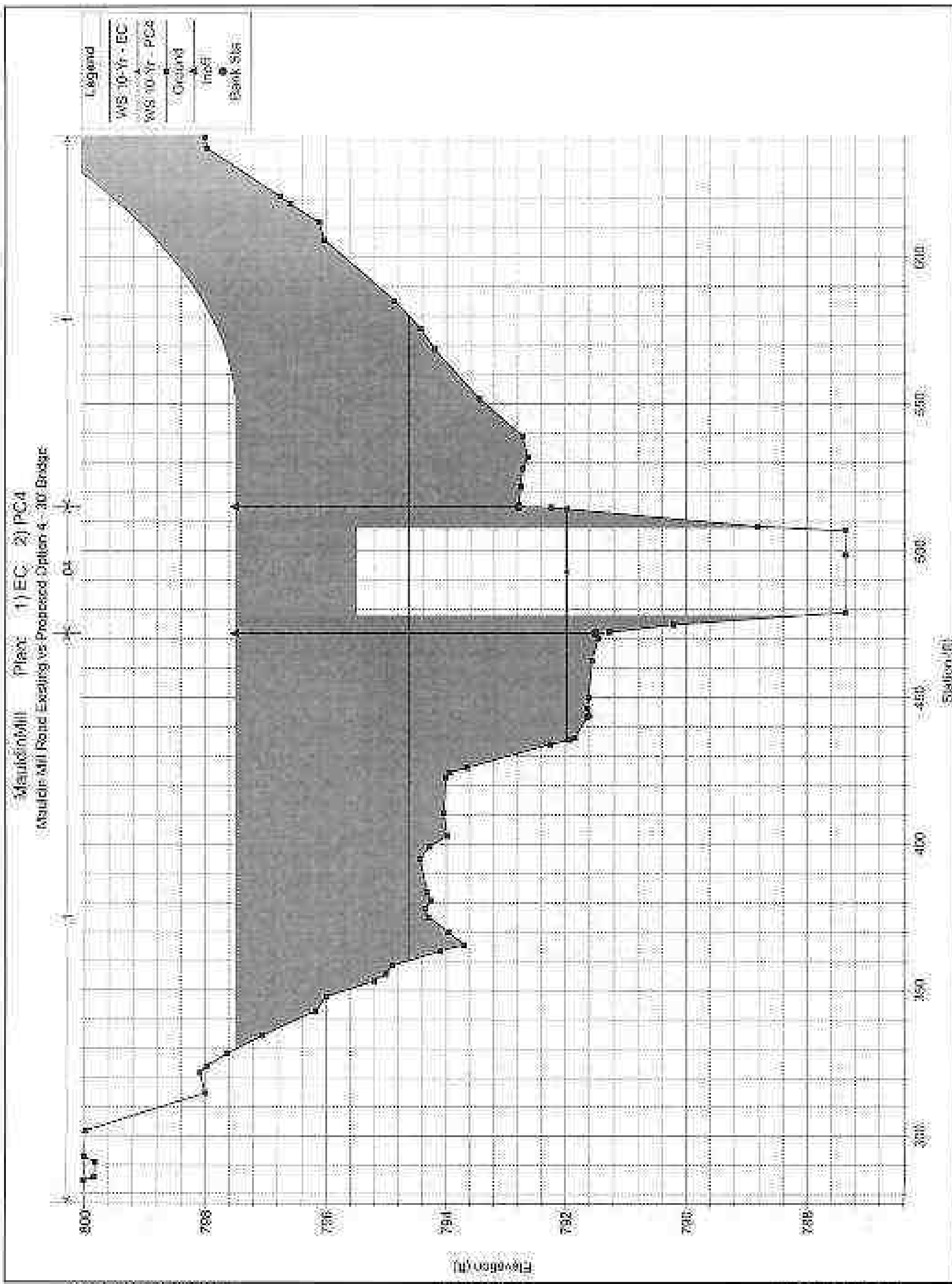
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Mauldin Mill Road Existing vs Proposed Option 4 - 30' Bridge
Legend
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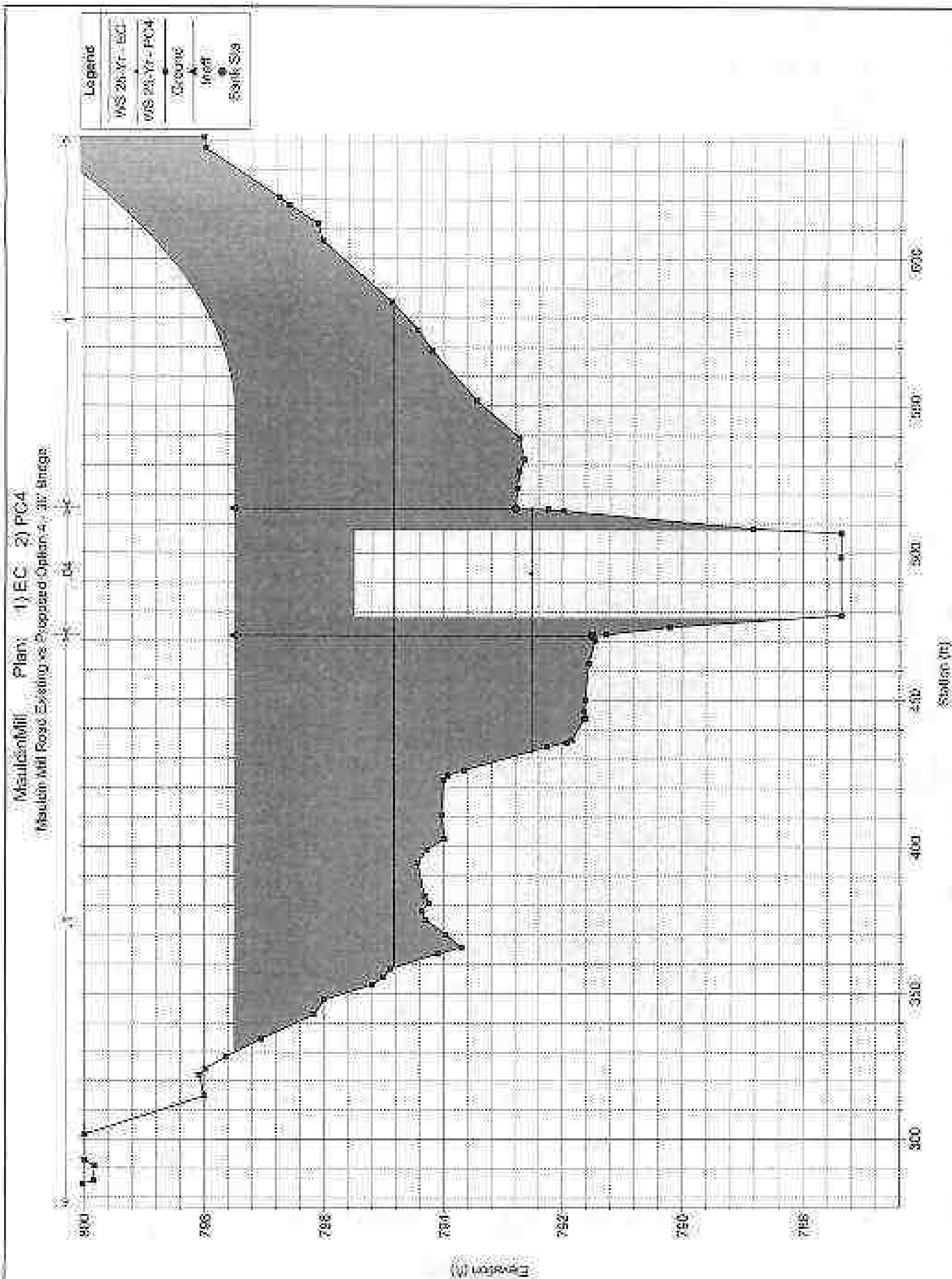

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Mauldin Mill Road Existing vs Proposed Option 4, 30' Bridge
Legend
WS 25-Yr - EC
WS 25-Yr - PO4
Ground
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Station (ft)
Elevation (ft)

Mauldin Mill Road Culvert
Hydrologic, Hydraulic
And Alternatives Analysis

Appendix E.4
Option 4 - 30' Bridge Hydraulic Performance
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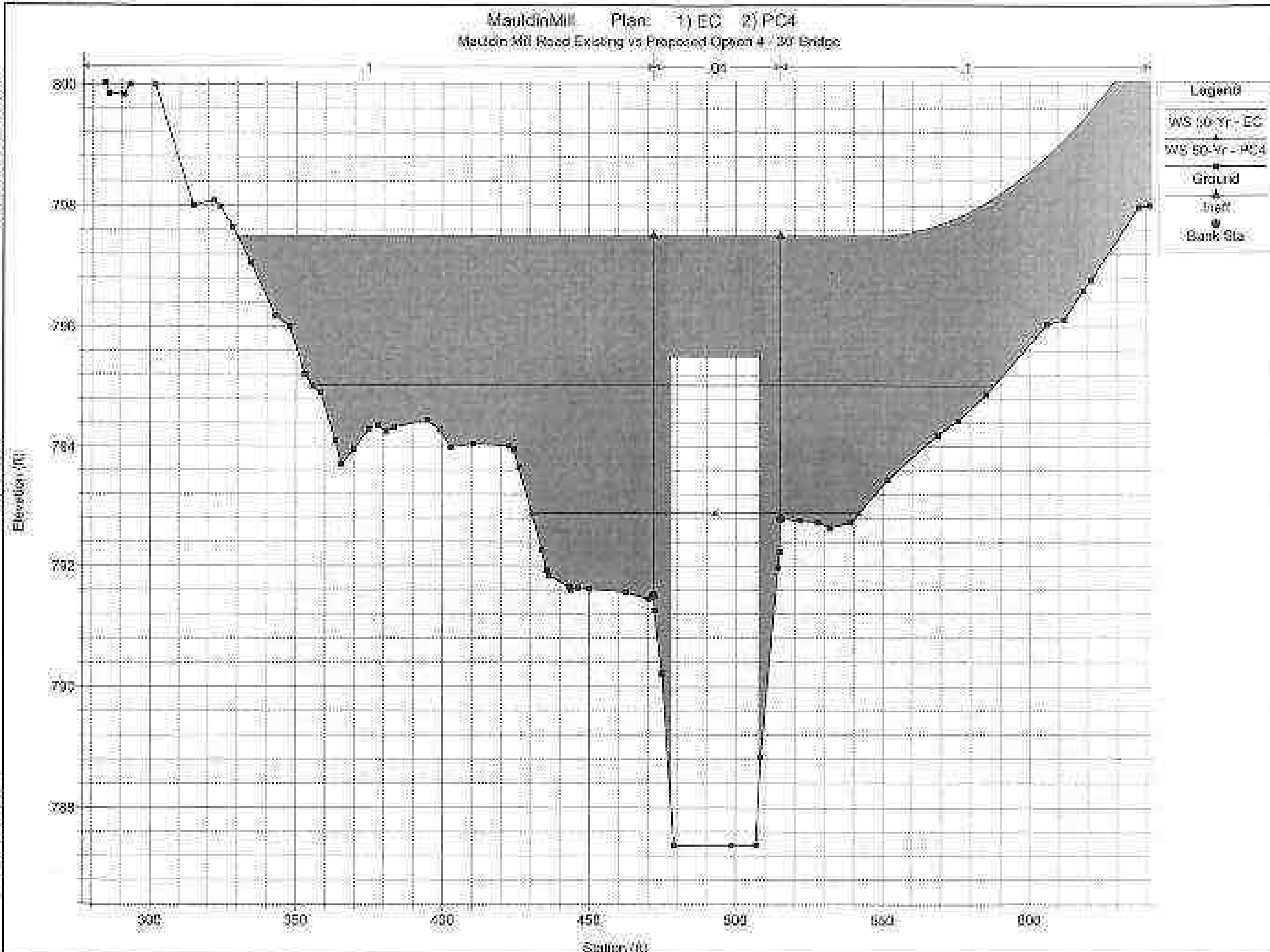
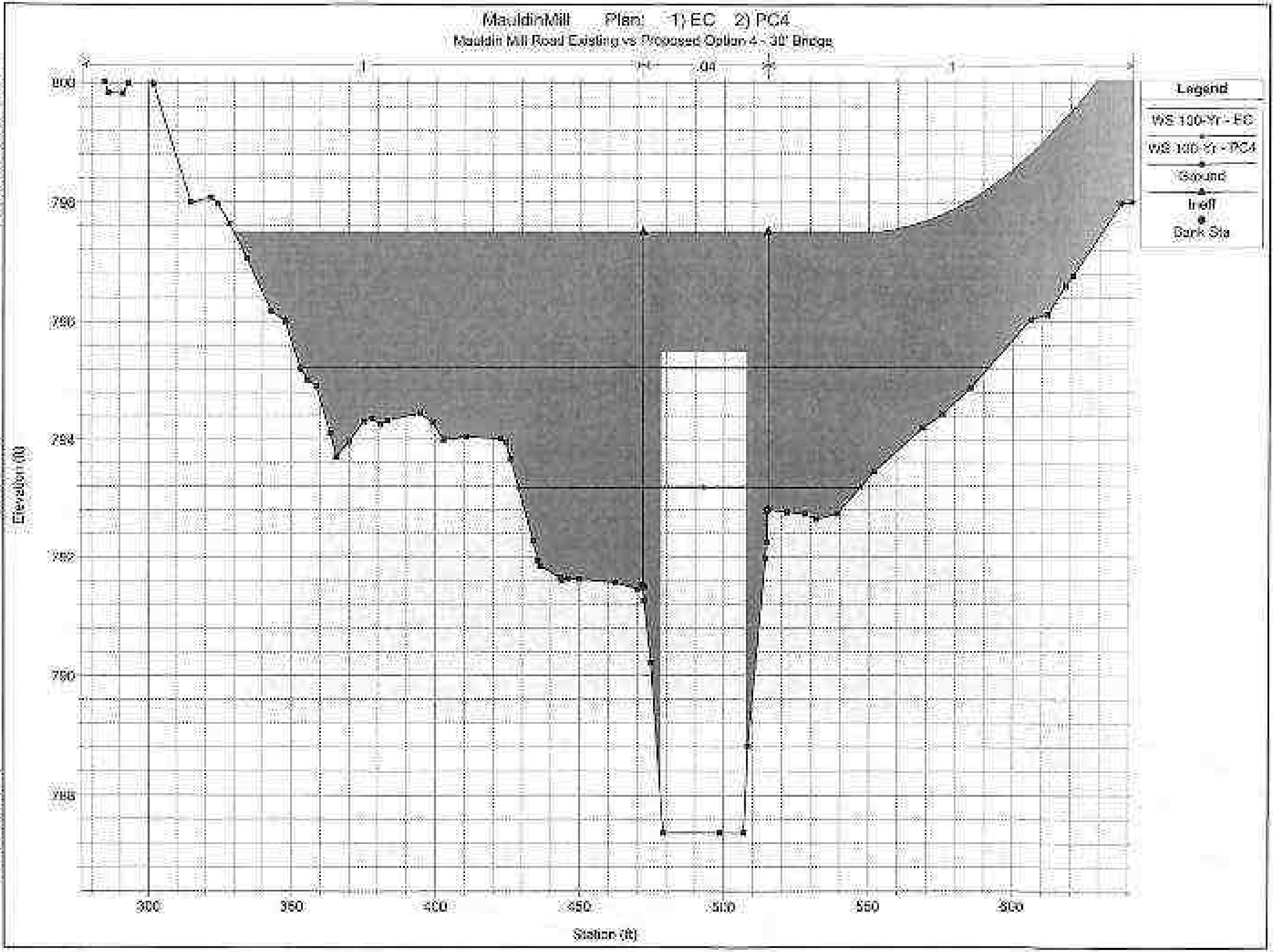
Davis & Floyd, Inc.
D&F Job No. 12925.01
July 2015

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Mauldin Mill Road Existing vs Proposed Option 4 - 30' Bridge
Legend
WS 100-Yr - EC
WS 100-Yr - PC4
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Elevation (ft)
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Appendix D
Cost Estimates

DAVIS & FLOYD

Appendix D: Cost Estimate Option 1
Date: 2013-06-28
Project Name: Mauldin Mill Road Culvert Analysis
Job No.: 12975.01
Calculated by: M. Putnam

Option 1 - 28' x 8' Bottomless Arch Culvert

Item	Description	Quantity	Unit	Unit Cost		Total Cost	
1	Culvert						
	a. Foundation	2	EA	$	7,000	$	14,000
	b. 28' x 8' Bottomless Arch Culvert	36	LF	$	3,500	$	126,000
2	Roadway Embankment						
	a. Pavement	1100	SY	$	20	$	22,000
	b. Embankment Fill	1800	CY	$	25	$	45,000
	c. Driveway Replacement	1	EA	$	1,500	$	1,500
3	Channel Grading/Approaches						
	a.Channel Grading/Shaping	1	LS	$	5,000	$	5,000
4	Contractor General Conditions and Mobilization	-	%		12%	$	25,620.00
5	Design/Permitting	-	%		10%	$	21,350
6	Contingency	-	%		30%	$	78,141.00
			Total Estimated Project Cost			**$**	**338,611**

DAVIS & FLOYD

Appendix D: Cost Estimate Option 2
Date: 2013-06-28
Project Name: Mauldin Mill Road Culvert Analysis
Job No.: 12975.01
Calculated by: M. Putnam

Option 2 - (4) 7' x 7' Box Culverts

Item	Description	Quantity	Unit	Unit Cost		Total Cost	
1	Culvert						
	a. 7' x 7' Box Culvert	144	LF	$	800	$	115,200
2	Roadway Embankment						
	a. Pavement	900	SY	$	20	$	18,000
	b. Embankment Fill	900	CY	$	25	$	22,500
	c. Driveway Replacement	1	EA	$	1,500	$	1,500
3	Channel Grading/Approaches						
	a.Channel Grading/Shaping	1	LS	$	5,000	$	5,000
4	Contractor General Conditions and Mobilization	-	%		12%	$	19,464
5	Design/Permitting	-	%		10%	$	16,220
6	Contingency	-	%		30%	$	59,365
			Total Estimated Project Cost			**$**	**257,249**

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Appendix D: Cost Estimate Option 3
Date: 2013-06-28
Project Name: Mauldin Mill Road Culvert Analysis
Job No.: 12975.01
Calculated by: M. Putnam

Option 3 - (4) 8' x 5' Box Culverts

Item	Description	Quantity	Unit	Unit Cost		Total Cost	
1	Culvert						
	a. 8' x 5' Bottomless Arch Culvert	144	LF	$	600	$	86,400
2	Roadway Embankment						
	a. Pavement	900	SY	$	20	$	18,000
	b. Embankment Fill	600	CY	$	25	$	15,000
	c. Driveway Replacement	1	EA	$	1,500	$	1,500
3	Channel Grading/Approaches						
	a.Channel Grading/Shaping	1	LS	$	5,000	$	5,000
4	Contractor General Conditions and Mobilization	-	%		12%	$	15,108.00
5	Design/Permitting	-	%		10%	$	12,590
6	Contingency	-	%		30%	$	46,079.40
			Total Estimated Project Cost			**$**	**199,677**

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Appendix D: Cost Estimate Option 4
Date: 2013-07-08
Project Name: Mauldin Mill Road Culvert Analysis
Job No.: 12975.01
Calculated by: M. Putnam

Option 4 - 30' Flat Slab Bridge

Item	Description	Quantity	Unit	Unit Cost		Total Cost	
1	Bridge						
	a. Foundation	1	LS	$	20,000	$	20,000
	b. Span (30' Hollow Core)	1	LS	$	81,000	$	81,000
2	Roadway Embankment						
	a. Pavement	1100	SY	$	13	$	14,300
	b. Embankment Fill	1500	CY	$	25	$	37,500
	c. Driveway Replacement	1	EA	$	1,500	$	1,500
3	Channel Grading/Approaches						
	a.Channel Grading/Shaping	1	LS	$	5,000	$	5,000
4	Contractor General Conditions and Mobilization	-	%		12%	$	19,116
5	Design/Permitting	-	%		10%	$	15,930
6	Contingency	-	%		30%	$	52,304
			Total Estimated Project Cost			**$**	**246,650**

"Megee Road Culvert Analysis" for

Oconee County

Final Report – June 2013

Megee Road Culvert
Hydrologic, Hydraulic and Alternatives Analysis
D&F Job No. 12975.02

Prepared for:
Oconee County, SC
D. Mack Kelly, Jr. PE, PLS, CFM
County Engineer
15022 Wells Highway
Seneca, SC 29678

Prepared by:
Davis & Floyd, Inc.
3229 West Montague Avenue
North Charleston, SC 29418
(843) 554 8602

South Carolina Professional Engineer No. 27509 Michael A. Putnam 2013/06/28

South Carolina Davis & Floyd, Inc. No. C00538 Certificate of Authorization

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1. PROJECT BACKGROUND AND LOCATION

Located off of Highway 130 approximately 0.6 Miles north of the intersection of Highway 130 and Highway 11, Megee Road is a dirt roadway which provides vehicular access for residential properties west of Highway 130. Along its alignment, approximately 0.4 miles west of its intersection with Highway 130, Megee Road crosses Smeltzer Creek. As indicated by Oconee County Public Works, this crossing is subject to frequent roadway overtopping and inadequate culvert performance. The purpose of this project is to analyze this crossing and develop alternatives for supporting recommendations to the County for crossing improvements.

2. COMPILATION OF EXISTING DATA

2.1 Topographic Survey

To establish baseline conditions and support modeling efforts, field survey of existing features in the immediate area of the subject crossing was performed. This data included roadway cross sections, stream cross sections, invert elevations and length of the 60" Corrugated Metal Pipe (CMP) culvert, and surrounding structures which could be impacted by the hydraulic performance of this crossing.

2.2 Regional Topographic Data

Regional topographic data used in the delineation of hydrologic basins and the construction of the hydraulic model was obtained from Oconee County. This data provided information required for determining the area draining to the crossing as well as other hydrologic and hydraulic parameters.

3. HYDROLOGIC ANALYSIS

The hydrologic analysis of the drainage area served by the Megee Road crossing was initiated by delineating the limits of the basin served by the crossing using the previously mentioned regional topographic data. Upon delineating the basin, a land cover analysis was then performed, and in conjunction with USGS soils data a composite curve number was developed for the contributing basin using SCS methodology. SCS TR-55 methods were then utilized to generate a time of concentration. In summary, the basin contributing flow to the Megee Road crossing has an area of 1725.19 acres, a composite curve number of 55.75, and time of concentration of 76.3 minutes. These variables were then used for runoff generation. **Figure 1** shows the local topography and resulting basin delineation and **Figure 2** shows the basin and aerial imagery used in determining the composite curve number.

Storm events considered for this analysis include the 2, 10, 25, 50, and 100-yr Type II 24-hr events with rainfall depths obtained from the SCDHEC Storm water Management BMP Handbook – Appendix F. Rainfall Values and resulting flows are tabulated in Error! Reference source not found. shown below. **Appendix A** contains detailed hydrologic data including computation of the composite curve number and time of concentration.

Table 1: Rainfall and Runoff

Storm Event	[1]Rainfall (in)	MegeeRoad_1 Runoff (cfs)	*MegeeRoad_2 Runoff (cfs)	MegeeRoad_3 Runoff (cfs)
2-Yr	4.70	196.94	513.95	60.00
10-Yr	6.70	497.93	1387.25	156.73
25-Yr	7.80	690.27	1965.03	219.09
50-Yr	8.80	876.17	2527.35	279.53
100-Yr	9.80	1069.87	3117.81	342.75

[1]Oconee North Rainfall Values
*Flows at Megee Road Crossing

Figure 1: Basin Topography

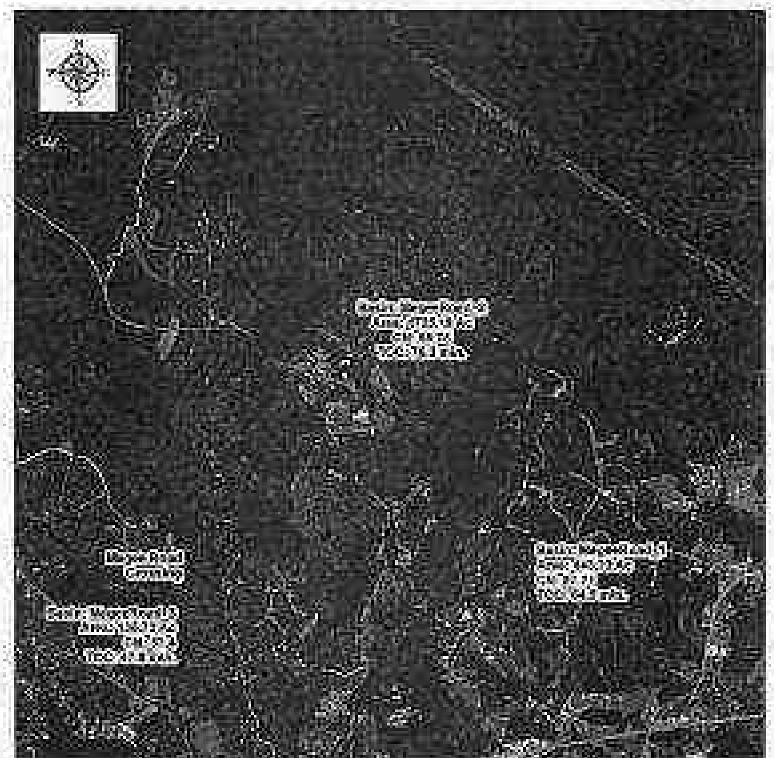


Figure 2: Basin Land Cover

4. ANALYSIS OF EXISTING SYSTEM

The hydraulic analysis of the Megee Road culvert was carried out using USACE's HEC-RAS. The aforementioned regional topographic data combined with the topographic field survey was utilized in the construction of model cross sections, roadway embankment, and culvert geometry. This data coupled with the flows from the previously completed hydrologic analysis were then used to analyze the performance of the culvert crossing for the 2, 10, 25, 50, and 100-yr events.

Modeling efforts show that the existing 48" RCP which provides conveyance under Megee Road is grossly under sized and is inadequate to convey flows generated by the 2-yr event, overtopping by 1.41' with ≈ 20% of the flow being carried by the culvert. Qualitative analysis of Smeltzer Creek upstream of Megee Road also supports this conclusion. Approximately 1.25 miles upstream of Megee Road Highway 130 crosses Smeltzer Creek. Examination of aerial imagery at this crossing shows that conveyance under Highway 130 is provided by a bridge approximately 50 to 60 feet in length. This supports the conclusion drawn from the quantitative analysis that the current Megee Road culvert is grossly under sized. **Table 2** below tabulates water surface elevation and the depth that the roadway is overtopped for each storm event. **Appendix B** shows the corresponding water surface profile for each of the events shown below.

Table 2: Existing Hydraulic Performance

Storm Event	[1]Centerline Roadway Elevation:	985.67
	[1]Water Surface Elevation (ft)	Overtopping (ft)
2-Yr	987.08	1.41
10-Yr	987.96	2.29
25-Yr	988.24	2.57
50-Yr	988.51	2.84
100-Yr	988.74	3.07

[1]All Elevations Referenced to the North American Vertical Datum of 1988

5. DEVELOPMENT AND ANALYSIS OF CONCEPTUAL IMPROVEMENTS

Conceptual improvements were selected with the goal of providing a crossing which passes the design storm event without overtopping and without adversely impacting upstream properties. Conveyance type and size, as well as roadway elevation were manipulated to achieve the stated goal. As requested by the Oconee County Public works, the 100-yr storm event was considered as the basis of design. In addition to the 100-yr storm event and to offer an improvement option which could be constructed at a lower cost, the 25-yr storm event was also considered as a basis of design. During the development of proposed alternatives careful attention was given to the upstream water surface elevations at the crossing to determine if a modeled scenario would adversely impact upstream properties. In all cases and for all storm events, modeling demonstrates that the conceptual alternatives do not produce water surface elevations which would adversely impact upstream properties. **Appendix C** contains modeling output from each of the conceptual improvements.

5.1 Option 1 – 60' Flat Slab Bridge

With conveyance for the next upstream crossing provided by a bridge the first replacement option for consideration is a bridge. Analysis shows that a 60' bridge would be required to convey the design flows. Site geometric analysis combined with hydraulic analysis also demonstrates that the roadway would need to be raised 4.83' from a low point elevation of 985.67 to and elevation of 990.50 to provide clearance for an estimated structural depth of 2' and to pass the design flows without adversely affecting upstream properties. Preliminary construction costs for this option are estimated to be $418,704. **Table 3** summarizes water surface elevations and contrasts both existing and proposed conditions. **Appendix C.1** contains supporting modeling output including water surface profiles and cross sections, and **Appendix D.1** contains the preliminary cost estimate.

Table 3: Option 1 Hydraulic Performance

Storm Event	[1]Existing Water Surface Elevation (ft)	[1]Proposed Water Surface Elevation (ft)	Change in Water Surface Elevation (ft)
2-Yr	987.08	982.28	-4.8
10-Yr	987.96	984.2	-3.76
25-Yr	988.24	985.1	-3.14
50-Yr	988.51	985.84	-2.67
*100-Yr	988.74	986.51	-2.23

[1]All Elevations Referenced to the North American Vertical Datum of 1988
*Design Storm Event

5.2 Option 2 – (2) 24' x 7' Bottomless Arch Culverts

In order to provide additional options to the County, consideration was given to utilizing the 25-yr storm event for the basis of design and to allow the 50-yr and the 100-yr storm events to overtop the roadway, if required, without adversely impacting upstream properties. Analysis of CON/SPAN type bottomless arch culverts demonstrated that in order to pass the design event that 24' x 7' arch culverts would be required. Additionally, the road would need to be raised 2.83' from a low point elevation of 985.67 to an elevation of 988.50 to provide cover for the CON/SPAN without the roadway overtopping for the design event or adversely affecting upstream properties for the design event. Conceptual site geometric analysis shows that these culverts would need to be approximately 70' in length. Preliminary construction costs are estimated to be $689,926, and **Table 4** summarizes hydraulic performance for this option. **Appendix C.2** contains supporting modeling output including water surface profiles and cross sections, and **Appendix D.2** contains the preliminary cost estimate.

Table 4: Option 2 Hydraulic Peformance

Storm Event	[1]Existing Water Surface Elevation (ft)	[1]Proposed Water Surface Elevation (ft)	Change in Water Surface Elevation (ft)	Roadway Overtopping (ft)
2-Yr	987.08	982.66	-4.42	-
10-Yr	987.96	984.87	-3.09	-
*25-Yr	988.24	986.15	-2.09	-
50-Yr	988.51	987.45	-1.06	-
100-Yr	988.74	988.73	-0.01	0.23

[1]All Elevations Referenced to the North American Vertical Datum of 1988
*Design Storm Event

5.3 Option 3 – (4) 12' x 6' Reinforced Concrete Box Culverts

Continuing with the premise established in option 2 for using the 25-yr storm event as the basis of design and allowing the 50-yr or 100-yr storm events to overtop the roadway, if required, without adversely affecting upstream properties, consideration was also given to the use of reinforced concrete box culverts. Modeling shows that (4) 12' x 6' box culverts will accomplish this goal without increasing upstream water surface elevations. Similarly to previous options, these culverts would need to be approximately 70' long and would require the roadway to be raised approximately 2.33' from a low point elevation of 985.67 to an elevation of 988.00. Preliminary construction costs are estimated to be $524,411 for this option. **Table 5** summarizes hydraulic performance of the box culverts, and **Appendix C.3** contains supporting modeling output including water surface profiles and cross sections and **Appendix D.3** contains the preliminary cost estimate.

Table 5: Option 3 Hydraulic Performance

Storm Event	[1]Existing Water Surface Elevation (ft)	[1]Proposed Water Surface Elevation (ft)	Change in Water Surface Elevation (ft)	Roadway Overtopping (ft)
2-Yr	987.08	982.74	-4.34	-
10-Yr	987.96	984.98	-2.98	-
*25-Yr	988.24	986.13	-2.11	-
50-Yr	988.51	987.46	-1.05	-
100-Yr	988.74	988.4	-0.34	0.4

[1]All Elevations Referenced to the North American Vertical Datum of 1988
*Design Storm Event

6. RECOMMENDATION FOR IMPROVEMENTS

6.1 Summary of Options

Option 1 – 60' Flat Slab Bridge – This option will pass the 100-yr storm event without overtopping and without adversely affecting upstream or downstream properties for all modeled storm events. Additionally this structure will convey the 100-yr storm event un-pressurized with a free surface and provides a wide opening for debris passage. Construction will require that Megee Road be raised 4.83', and is estimated to cost $418,704.

Option 2 – (2) 24' x 7' Bottomless Arch Culverts – This option is designed to pass the 25-yr storm event without overtopping, and does so un-pressurized with a free surface. Similarly to the 25-yr storm event, this configuration will pass the 50-yr storm event un-pressurized and with a free surface. However, for the 100-yr storm event, this structure will overtop. Also, this option will not provide for optimal debris passage due to low or no observed freeboard during higher frequency events. For all modeled storm events this option reduces upstream water surface elevations when compared to existing conditions, and will not produce adverse impacts to upstream or downstream properties. Construction will require that Megee Road be raised 2.83', and is estimated to cost $689,926.

Option 3 – (4) 12' x 6' Box Culverts – Similarly to Option 2, this structure is designed to pass the 25-yr storm event without overtopping, and does so un-pressurized with a free surface. Additionally, this option will convey the 50-yr storm event without overtopping, but does so in a pressurized flow regime, and as designed will overtop Megee Road during the 100-yr storm event. Also, due low or no freeboard during higher frequency events, this structure will not provide for optimal debris passage. Construction will require that Megee Road be raised 2.33' and is estimated to cost $524,411.

6.2 Recommendation

Considering the three options presented and the basin served by this crossing, Option 1 (60' Flat Slab Bridge) would provide the best alternative for the County. As requested, this structure will convey the 100-yr storm event without overtopping while providing a free surface for optimal debris passage. When compared to Option 2 ((2) 24' x 7' Bottomless Arch Culverts) and Option 3 ((4) 12' x 6' Box Culverts), which do not pass the 100-yr storm event without overtopping, Option 1 is $271,000 and $105,707 cheaper respectively. Therefore, given the conditions listed above, it is recommended that Option 1 (60' Flat Slab Bridge) be considered by the County as the preferred alternative for improvements to Megee Road.

Appendix A
Hydrologic Data

Appendix A.1
Composite Curve Number Analysis

Appendix A.1 - Megee Road Composite Curve Number Calculation

Basin	ΣA$_i$	ΣCN$_i$*A$_i$	CN
MegeeRoad_1	443.73	25607.77	57.71
MegeeRoad_2	1725.19	96174.06	55.75
MegeeRoad_3	135.73	7790.25	57.40

$$CN = \frac{\sum CN_i A_i}{\sum A_i}$$

Land Cover	Curve Numbers			
	A	B	C	D
Grass	36	61	74	80
Trees	25	55	70	77
Commercial	89	92	94	95
Residential	51	68	79	84
Impervious	98	98	98	98
Poor Cover	72	82	87	89
Railroad	76	85	87	89
Tree-Min Cover	45	66	77	83
Farmland	72	81	88	91
Dirt Road	72	82	87	89

Basin Name	Area (Ac)	Landuse	Hydgrp	CN$_i$*A$_i$
MegeeRoad_1	0.82	Impervious	B	80.39
MegeeRoad_1	0.15	Impervious	B	14.25
MegeeRoad_1	0.42	Impervious	B	41.49
MegeeRoad_1	0.19	Impervious	B	18.42
MegeeRoad_1	0.17	Impervious	B	16.70
MegeeRoad_1	0.34	Impervious	B	33.66
MegeeRoad_1	0.96	Impervious	B	94.23
MegeeRoad_1	0.75	Impervious	B	73.57
MegeeRoad_1	0.52	Impervious	B	51.11
MegeeRoad_1	0.00	Impervious	B	0.09
MegeeRoad_1	0.05	Impervious	B	5.07
MegeeRoad_1	0.83	Impervious	B	81.74
MegeeRoad_1	0.62	Impervious	B	60.95
MegeeRoad_1	0.19	Impervious	B	18.94
MegeeRoad_1	0.59	Impervious	B	57.36
MegeeRoad_1	0.48	Impervious	B	46.93
MegeeRoad_1	0.81	Impervious	B	79.07
MegeeRoad_1	0.46	Impervious	B	45.52
MegeeRoad_1	0.07	Impervious	B	7.33
MegeeRoad_1	0.60	Impervious	B	58.74
MegeeRoad_1	0.19	Impervious	B	18.19
MegeeRoad_1	0.78	Impervious	B	76.35
MegeeRoad_1	0.17	Impervious	B	16.80
MegeeRoad_1	0.50	Grass	B	30.72
MegeeRoad_1	3.49	Grass	B	212.67

MegeeRoad_1	0.46	Grass	B	28.28
MegeeRoad_1	0.01	Grass	B	0.34
MegeeRoad_1	0.03	Grass	B	1.93
MegeeRoad_1	0.66	Grass	B	40.29
MegeeRoad_1	0.32	Residential	B	21.75
MegeeRoad_1	23.32	Tree-Min Cover	B	1538.90
MegeeRoad_1	1.15	Tree-Min Cover	B	75.77
MegeeRoad_1	0.14	Tree-Min Cover	B	9.11
MegeeRoad_1	1.13	Residential	B	76.80
MegeeRoad_1	0.19	Residential	B	12.66
MegeeRoad_1	0.58	Residential	B	39.53
MegeeRoad_1	0.55	Trees	B	30.35
MegeeRoad_1	3.32	Trees	B	182.58
MegeeRoad_1	1.58	Trees	B	86.69
MegeeRoad_1	2.48	Trees	B	136.16
MegeeRoad_1	0.01	Trees	B	0.54
MegeeRoad_1	15.83	Trees	B	870.54
MegeeRoad_1	0.38	Trees	B	21.17
MegeeRoad_1	2.41	Trees	B	132.55
MegeeRoad_1	0.25	Residential	B	16.71
MegeeRoad_1	1.09	Residential	B	74.30
MegeeRoad_1	0.54	Residential	B	36.97
MegeeRoad_1	0.55	Residential	B	37.57
MegeeRoad_1	2.40	Trees	B	132.06
MegeeRoad_1	0.01	Trees	B	0.42
MegeeRoad_1	10.77	Trees	B	592.22
MegeeRoad_1	17.65	Trees	B	970.84
MegeeRoad_1	0.20	Trees	B	11.24
MegeeRoad_1	0.03	Trees	B	1.48
MegeeRoad_1	0.25	Trees	B	13.68
MegeeRoad_1	3.18	Trees	B	174.65
MegeeRoad_1	0.20	Residential	B	13.93
MegeeRoad_1	0.16	Residential	B	11.17
MegeeRoad_1	0.32	Residential	B	21.92
MegeeRoad_1	0.17	Residential	B	11.84
MegeeRoad_1	1.30	Trees	B	71.27
MegeeRoad_1	4.29	Trees	B	236.11
MegeeRoad_1	0.10	Trees	B	5.74
MegeeRoad_1	0.00	Trees	B	0.19
MegeeRoad_1	0.23	Trees	B	12.69
MegeeRoad_1	0.83	Trees	B	45.66
MegeeRoad_1	0.46	Residential	B	31.50
MegeeRoad_1	0.60	Residential	B	40.99
MegeeRoad_1	0.00	Tree-Min Cover	B	0.02
MegeeRoad_1	0.03	Tree-Min Cover	B	1.92
MegeeRoad_1	5.59	Tree-Min Cover	B	368.66
MegeeRoad_1	30.33	Trees	B	1668.12

MegeeRoad_1	3.32	Trees	B	182.53
MegeeRoad_1	14.80	Trees	B	813.76
MegeeRoad_1	6.68	Trees	B	367.24
MegeeRoad_1	5.47	Trees	B	300.60
MegeeRoad_1	5.44	Trees	B	299.22
MegeeRoad_1	13.50	Trees	B	742.39
MegeeRoad_1	5.15	Trees	B	283.37
MegeeRoad_1	5.44	Trees	B	299.20
MegeeRoad_1	13.04	Trees	B	717.03
MegeeRoad_1	0.51	Trees	B	28.31
MegeeRoad_1	0.05	Trees	B	2.59
MegeeRoad_1	2.28	Trees	B	125.56
MegeeRoad_1	2.41	Trees	B	132.41
MegeeRoad_1	0.04	Residential	B	2.91
MegeeRoad_1	0.15	Residential	B	10.09
MegeeRoad_1	0.17	Residential	B	11.41
MegeeRoad_1	0.55	Grass	B	33.75
MegeeRoad_1	0.20	Grass	B	12.44
MegeeRoad_1	0.27	Residential	B	18.19
MegeeRoad_1	0.38	Grass	B	23.22
MegeeRoad_1	0.36	Trees	B	19.93
MegeeRoad_1	0.20	Grass	B	12.10
MegeeRoad_1	0.09	Grass	B	5.70
MegeeRoad_1	0.74	Trees	B	40.55
MegeeRoad_1	0.00	Trees	B	0.10
MegeeRoad_1	0.28	Trees	B	15.31
MegeeRoad_1	1.22	Trees	B	66.86
MegeeRoad_1	1.28	Residential	B	87.19
MegeeRoad_1	1.37	Trees	B	75.55
MegeeRoad_1	0.07	Trees	B	3.75
MegeeRoad_1	0.10	Trees	B	5.55
MegeeRoad_1	5.36	Grass	B	327.11
MegeeRoad_1	0.09	Grass	B	5.72
MegeeRoad_1	0.01	Residential	B	0.66
MegeeRoad_1	2.96	Residential	B	201.00
MegeeRoad_1	3.13	Residential	B	212.80
MegeeRoad_1	0.32	Residential	B	21.55
MegeeRoad_1	0.90	Residential	B	61.54
MegeeRoad_1	0.83	Residential	B	56.44
MegeeRoad_1	1.09	Residential	B	74.18
MegeeRoad_1	0.25	Residential	B	17.16
MegeeRoad_1	0.20	Residential	B	13.63
MegeeRoad_1	0.82	Grass	B	50.08
MegeeRoad_1	0.26	Residential	B	17.58
MegeeRoad_1	0.10	Residential	B	6.63
MegeeRoad_1	4.49	Trees	B	246.96
MegeeRoad_1	60.16	Trees	B	3309.03

MegeeRoad_1	53.41	Trees	B	2937.35
MegeeRoad_1	0.98	Trees	B	53.73
MegeeRoad_1	15.26	Trees	B	839.51
MegeeRoad_1	2.90	Trees	B	159.31
MegeeRoad_1	4.51	Trees	B	248.00
MegeeRoad_1	4.16	Trees	B	228.66
MegeeRoad_1	20.95	Trees	B	1152.19
MegeeRoad_1	1.52	Trees	B	83.78
MegeeRoad_1	5.58	Trees	B	306.94
MegeeRoad_1	0.02	Trees	B	0.94
MegeeRoad_1	0.12	Trees	B	6.67
MegeeRoad_1	1.15	Trees	B	63.28
MegeeRoad_1	0.56	Trees	B	30.55
MegeeRoad_1	0.88	Residential	B	59.77
MegeeRoad_1	0.24	Residential	B	16.21
MegeeRoad_1	0.17	Grass	B	10.13
MegeeRoad_1	0.19	Grass	B	11.60
MegeeRoad_1	0.31	Trees	B	17.24
MegeeRoad_1	0.14	Trees	B	7.68
MegeeRoad_1	1.26	Trees	B	69.17
MegeeRoad_1	0.59	Impervious	B	57.92
MegeeRoad_1	1.21	Grass	B	74.10
MegeeRoad_1	1.28	Grass	B	77.79
MegeeRoad_1	9.08	Grass	B	553.85
MegeeRoad_1	0.00	Grass	B	0.12
MegeeRoad_1	0.49	Grass	B	30.07
MegeeRoad_2	0.41	Impervious	B	40.02
MegeeRoad_2	0.39	Impervious	B	37.93
MegeeRoad_2	0.24	Impervious	B	23.96
MegeeRoad_2	0.86	Impervious	B	84.16
MegeeRoad_2	0.21	Impervious	B	20.64
MegeeRoad_2	1.48	Impervious	B	144.77
MegeeRoad_2	0.33	Impervious	B	32.02
MegeeRoad_2	1.12	Impervious	B	109.71
MegeeRoad_2	0.47	Impervious	B	46.48
MegeeRoad_2	0.07	Impervious	B	6.50
MegeeRoad_2	0.57	Impervious	B	56.10
MegeeRoad_2	0.06	Impervious	B	6.06
MegeeRoad_2	0.06	Impervious	B	5.50
MegeeRoad_2	2.53	Farmland	B	204.98
MegeeRoad_2	0.13	Farmland	B	10.16
MegeeRoad_2	0.08	Farmland	B	6.34
MegeeRoad_2	7.60	Grass	B	463.41
MegeeRoad_2	1.97	Grass	B	120.44
MegeeRoad_2	2.13	Grass	B	130.23
MegeeRoad_2	1.87	Grass	B	113.93
MegeeRoad_2	3.08	Grass	B	187.87

MegeeRoad_2	2.13	Impervious	B	208.50
MegeeRoad_2	0.53	Impervious	B	51.84
MegeeRoad_2	0.24	Grass	B	14.76
MegeeRoad_2	0.14	Grass	B	8.72
MegeeRoad_2	1.69	Grass	B	103.04
MegeeRoad_2	2.02	Grass	B	123.41
MegeeRoad_2	3.06	Grass	B	186.74
MegeeRoad_2	0.03	Grass	B	1.83
MegeeRoad_2	6.75	Grass	B	411.82
MegeeRoad_2	2.96	Grass	B	180.68
MegeeRoad_2	1.48	Grass	B	90.51
MegeeRoad_2	6.18	Grass	B	376.77
MegeeRoad_2	0.93	Grass	B	56.62
MegeeRoad_2	0.97	Grass	B	59.18
MegeeRoad_2	2.57	Grass	B	156.62
MegeeRoad_2	1.28	Grass	B	78.28
MegeeRoad_2	0.27	Residential	B	18.46
MegeeRoad_2	0.91	Residential	B	62.20
MegeeRoad_2	1.19	Grass	B	72.44
MegeeRoad_2	0.18	Grass	B	10.82
MegeeRoad_2	2.77	Grass	B	169.16
MegeeRoad_2	0.56	Residential	B	38.13
MegeeRoad_2	0.10	Residential	B	6.91
MegeeRoad_2	1.23	Residential	B	83.69
MegeeRoad_2	0.18	Residential	B	12.47
MegeeRoad_2	1.55	Residential	B	105.53
MegeeRoad_2	0.69	Residential	B	47.10
MegeeRoad_2	1.62	Residential	B	110.13
MegeeRoad_2	1.59	Residential	B	108.17
MegeeRoad_2	1.68	Residential	B	114.17
MegeeRoad_2	0.48	Residential	B	32.69
MegeeRoad_2	0.07	Residential	B	4.57
MegeeRoad_2	5.89	Residential	B	400.26
MegeeRoad_2	0.02	Residential	B	1.37
MegeeRoad_2	2.38	Residential	B	161.79
MegeeRoad_2	0.08	Residential	B	5.33
MegeeRoad_2	0.32	Residential	B	21.87
MegeeRoad_2	0.31	Residential	B	21.27
MegeeRoad_2	0.40	Residential	B	27.47
MegeeRoad_2	27.82	Trees	B	1529.84
MegeeRoad_2	139.65	Trees	B	7680.95
MegeeRoad_2	5.65	Trees	B	310.72
MegeeRoad_2	7.08	Trees	B	389.56
MegeeRoad_2	351.90	Trees	B	19354.28
MegeeRoad_2	2.29	Trees	B	125.82
MegeeRoad_2	7.11	Trees	B	391.03
MegeeRoad_2	0.02	Trees	B	1.13

MegeeRoad_2	21.17	Trees	B	1164.14
MegeeRoad_2	59.12	Trees	B	3251.51
MegeeRoad_2	15.48	Trees	B	851.36
MegeeRoad_2	3.23	Trees	B	177.68
MegeeRoad_2	227.11	Trees	B	12491.13
MegeeRoad_2	11.38	Trees	B	626.02
MegeeRoad_2	0.02	Trees	B	1.00
MegeeRoad_2	40.88	Trees	B	2248.19
MegeeRoad_2	15.62	Trees	B	859.31
MegeeRoad_2	155.81	Trees	B	8569.33
MegeeRoad_2	13.54	Trees	B	744.70
MegeeRoad_2	58.69	Trees	B	3228.19
MegeeRoad_2	5.80	Trees	B	319.06
MegeeRoad_2	5.95	Trees	B	327.29
MegeeRoad_2	0.84	Trees	B	46.17
MegeeRoad_2	3.43	Trees	B	188.69
MegeeRoad_2	3.17	Trees	B	174.57
MegeeRoad_2	0.61	Grass	B	37.26
MegeeRoad_2	0.12	Residential	B	8.48
MegeeRoad_2	0.31	Residential	B	20.93
MegeeRoad_2	2.03	Residential	B	138.19
MegeeRoad_2	0.57	Residential	B	38.91
MegeeRoad_2	0.56	Residential	B	38.27
MegeeRoad_2	0.00	Residential	B	0.01
MegeeRoad_2	0.62	Residential	B	42.29
MegeeRoad_2	0.06	Residential	B	4.02
MegeeRoad_2	0.48	Residential	B	32.55
MegeeRoad_2	1.27	Residential	B	86.22
MegeeRoad_2	0.29	Residential	B	19.65
MegeeRoad_2	0.58	Grass	B	35.15
MegeeRoad_2	0.37	Grass	B	22.72
MegeeRoad_2	0.01	Residential	B	0.35
MegeeRoad_2	0.29	Residential	B	20.03
MegeeRoad_2	0.29	Residential	B	19.86
MegeeRoad_2	0.71	Residential	B	48.05
MegeeRoad_2	0.03	Residential	B	1.98
MegeeRoad_2	0.39	Residential	B	26.23
MegeeRoad_2	0.35	Grass	B	21.42
MegeeRoad_2	1.13	Grass	B	68.94
MegeeRoad_2	0.00	Grass	B	0.08
MegeeRoad_2	0.64	Grass	B	39.16
MegeeRoad_2	0.49	Residential	B	33.38
MegeeRoad_2	0.38	Residential	B	25.88
MegeeRoad_2	0.08	Residential	B	5.55
MegeeRoad_2	0.22	Residential	B	14.75
MegeeRoad_2	0.24	Grass	B	14.89
MegeeRoad_2	0.06	Grass	B	3.82

MegeeRoad_2	0.94	Dirt Road	B	77.39
MegeeRoad_2	0.16	Dirt Road	B	13.32
MegeeRoad_2	0.29	Dirt Road	B	23.56
MegeeRoad_2	0.27	Dirt Road	B	22.05
MegeeRoad_2	0.69	Residential	B	46.86
MegeeRoad_2	4.82	Trees	B	265.16
MegeeRoad_2	0.18	Trees	B	9.75
MegeeRoad_2	5.54	Trees	B	304.93
MegeeRoad_2	1.55	Trees	B	85.09
MegeeRoad_2	5.66	Trees	B	311.03
MegeeRoad_2	1.38	Trees	B	75.95
MegeeRoad_2	0.20	Trees	B	10.94
MegeeRoad_2	15.52	Trees	B	853.61
MegeeRoad_2	13.64	Trees	B	750.45
MegeeRoad_2	0.32	Residential	B	21.87
MegeeRoad_2	0.30	Residential	B	20.32
MegeeRoad_2	3.55	Trees	B	195.44
MegeeRoad_2	0.71	Trees	B	38.84
MegeeRoad_2	0.31	Trees	B	17.27
MegeeRoad_2	0.43	Grass	B	26.39
MegeeRoad_2	0.38	Residential	B	26.03
MegeeRoad_2	0.10	Residential	B	6.57
MegeeRoad_2	0.03	Grass	B	1.70
MegeeRoad_2	0.41	Residential	B	28.11
MegeeRoad_2	0.00	Grass	B	0.30
MegeeRoad_2	0.01	Grass	B	0.82
MegeeRoad_2	2.42	Trees	B	133.20
MegeeRoad_2	0.72	Trees	B	39.37
MegeeRoad_2	0.25	Trees	B	13.77
MegeeRoad_2	0.36	Residential	B	24.39
MegeeRoad_2	0.37	Residential	B	25.05
MegeeRoad_2	0.52	Impervious	B	50.93
MegeeRoad_2	0.02	Impervious	B	1.59
MegeeRoad_2	1.70	Grass	B	103.51
MegeeRoad_2	30.80	Trees	B	1693.77
MegeeRoad_2	18.16	Trees	B	998.73
MegeeRoad_2	17.24	Trees	B	948.18
MegeeRoad_2	18.04	Trees	B	991.98
MegeeRoad_2	35.45	Trees	B	1949.65
MegeeRoad_2	0.41	Trees	B	22.79
MegeeRoad_2	1.71	Trees	B	94.00
MegeeRoad_2	11.98	Trees	B	659.07
MegeeRoad_2	17.20	Trees	B	945.82
MegeeRoad_2	7.13	Trees	B	391.95
MegeeRoad_2	3.34	Trees	B	183.84
MegeeRoad_2	5.24	Trees	B	288.25
MegeeRoad_2	5.77	Trees	B	317.53

MegeeRoad_2	20.30	Trees	B	1116.56
MegeeRoad_2	4.04	Trees	B	222.45
MegeeRoad_2	3.12	Trees	B	171.47
MegeeRoad_2	8.53	Trees	B	469.35
MegeeRoad_2	38.82	Trees	B	2135.15
MegeeRoad_2	62.47	Trees	B	3435.68
MegeeRoad_2	0.83	Trees	B	45.39
MegeeRoad_2	4.07	Trees	B	223.72
MegeeRoad_2	19.61	Trees	B	1078.53
MegeeRoad_2	0.90	Trees	B	49.48
MegeeRoad_2	28.72	Trees	B	1579.47
MegeeRoad_2	9.57	Trees	B	526.53
MegeeRoad_2	2.64	Trees	B	145.25
MegeeRoad_2	3.77	Trees	B	207.09
MegeeRoad_2	1.89	Trees	B	104.22
MegeeRoad_2	0.30	Trees	B	16.27
MegeeRoad_2	0.26	Trees	B	14.07
MegeeRoad_2	0.09	Trees	B	4.99
MegeeRoad_3	0.77	impervious	B	75.78
MegeeRoad_3	0.04	impervious	B	4.04
MegeeRoad_3	0.04	impervious	B	4.02
MegeeRoad_3	0.28	impervious	B	27.23
MegeeRoad_3	0.88	impervious	B	86.24
MegeeRoad_3	0.08	impervious	B	8.18
MegeeRoad_3	0.77	impervious	B	75.07
MegeeRoad_3	0.12	impervious	B	11.62
MegeeRoad_3	0.21	impervious	B	20.89
MegeeRoad_3	0.28	impervious	B	27.54
MegeeRoad_3	0.28	impervious	B	27.48
MegeeRoad_3	0.11	impervious	B	11.14
MegeeRoad_3	3.34	Trees	B	183.76
MegeeRoad_3	2.39	Trees	B	131.58
MegeeRoad_3	0.07	Trees	B	4.10
MegeeRoad_3	0.67	Residential	B	45.72
MegeeRoad_3	1.31	Residential	B	88.98
MegeeRoad_3	0.06	Residential	B	3.99
MegeeRoad_3	2.56	Residential	B	174.18
MegeeRoad_3	0.75	Grass	B	45.75
MegeeRoad_3	0.82	Residential	B	55.78
MegeeRoad_3	0.04	Trees	B	2.00
MegeeRoad_3	0.01	Trees	B	0.58
MegeeRoad_3	1.07	Trees	B	59.11
MegeeRoad_3	0.26	Residential	B	17.40
MegeeRoad_3	0.85	Residential	B	58.06
MegeeRoad_3	2.12	Residential	B	144.22
MegeeRoad_3	0.74	Residential	B	50.46
MegeeRoad_3	0.10	Residential	B	6.82

MegeeRoad_3	0.18	Residential	B	12.36
MegeeRoad_3	0.03	Residential	B	2.37
MegeeRoad_3	1.01	Residential	B	68.77
MegeeRoad_3	0.02	Grass	B	1.27
MegeeRoad_3	0.14	Grass	B	8.42
MegeeRoad_3	0.37	Residential	B	25.48
MegeeRoad_3	0.52	Trees	B	28.72
MegeeRoad_3	1.46	Trees	B	80.49
MegeeRoad_3	1.01	Trees	B	55.33
MegeeRoad_3	0.01	Residential	B	0.86
MegeeRoad_3	0.34	Residential	B	23.00
MegeeRoad_3	3.31	Trees	B	182.12
MegeeRoad_3	14.82	Trees	B	815.25
MegeeRoad_3	13.83	Trees	B	760.43
MegeeRoad_3	1.50	Trees	B	82.37
MegeeRoad_3	1.50	Trees	B	82.52
MegeeRoad_3	20.49	Trees	B	1126.89
MegeeRoad_3	2.01	Trees	B	110.53
MegeeRoad_3	3.51	Trees	B	192.97
MegeeRoad_3	4.50	Trees	B	247.25
MegeeRoad_3	4.72	Trees	B	259.53
MegeeRoad_3	4.07	Trees	B	223.66
MegeeRoad_3	4.91	Trees	B	270.19
MegeeRoad_3	0.06	Trees	B	3.50
MegeeRoad_3	0.08	Trees	B	4.44
MegeeRoad_3	0.34	Residential	B	23.22
MegeeRoad_3	3.59	Trees	B	197.69
MegeeRoad_3	0.00	Trees	B	0.15
MegeeRoad_3	7.96	Trees	B	437.88
MegeeRoad_3	18.23	Trees	B	1002.48
MegeeRoad_3	0.10	Trees	B	5.58
MegeeRoad_3	0.04	Trees	B	2.45
MegeeRoad_3	0.01	Trees	B	0.36

Appendix A.2
Time of Concentration Analysis

Appendix A.2 - Time of Concentration Calculations

Time of Concentration Calculations

Project	Oconee County
Basin:	MegeeRdBasin_1
Date:	2013-06-10
Calc By:	JWB

Calculation of Overland Sheet Flow Travel Time

Using the Manning Kinematic Equation - U.S. units

Inputs

Manning Roughness Coefficient, **n** = 0.75

Length of Flow Path, **L** = 300 ft

2 yr, 24 hr rainfall, **P** = 4.7 in

Ground Slope, **S** = 0.073 ft/ft

Calculations

Overland Flow Time Travel, t_1 = 42.0 min

Calculation of Shallow Concentrated Flow Travel Time
Using the NCRS Method - U.S. units

Inputs

Length of Flow Path, **L** = 921.6 ft

Ground Slope, **S** = 0.998 ft/ft

Paved / Unpaved = Unpaved

Calculations

For Unpaved Surface

Flow Velocity, **V** = 16.12 ft/sec

Travel time, t_2 = 1.0 min

Appendix A.2 - Time of Concentration Calculations

Calculation of Channnel Flow Travel Time
Using the Manning Equation - U.S. units

For a Trapezoidal Channel Cross-section

Inputs

Bottom width, **b** =	10	ft
Depth of flow, **y** =	2.5	ft
Side Slope, **z** = (H:V = **z**:1)	2	
Manning roughness, **n** =	0.032	
Channel bottom slope, **S** =	0.018	ft/ft
Length of Flow Path, **L** =	6302.1	ft

Calculations

Cross-Sect. Area, **A** =	37.5	ft^2
Wetted Perimeter, **P** =	21.2	ft
Hydraulic Radius, **R** =	1.77	ft
Discharge, **Q** =	342.85	cfs
Ave. Velocity, **V** =	9.143	ft/sec
Channel travel time, t_3 =	11.5	min

Calculation of Time of Concentration
($t_c = t_1 + t_2 + t_3$)

Inputs (values from above)

t_1 =	42.0	min
t_2 =	1.0	min
t_3 =	11.5	min

Calculations

t_c =	54.5	min
t_c =	0.9	hrs

Appendix A.2 - Time of Concentration Calculations

Overland Flow Roughness Coefficient

Surface	Manning's n
Concrete, Asphalt, Bare Soil	0.01 - 0.016
Gravel, Clay-loam,eroded	0.012 - 0.03
Sparse Vegetation, Cultivated Soil	0.053 - 0.13
Short Grass	0.1 - 0.2
Dense Grass, Bluegrass, Bermuda Grass	0.17 - 0.48
Woods	0.4 - 0.8

$$t_1 = \frac{0.42\ (nL)^{0.8}}{P^{0.5}S^{0.4}}$$

Manning Kinematic Equation - U.S. units

t_1 = overland sheet flow runoff travel time, min

n = Manning roughness coefficient, dimensionless

L = length of the flow path, ft (Max. L should be 300 ft)

P = 2 year, 24 hr rainfall, in

S = ground slope, ft/ft

Equations for NCRS Method for Shallow Concentrated Flow

$t_2 = L/(60V)$

for unpaved surface: $V = 16.1345S^{0.5}$

for paved surface: $V = 20.3282S^{0.5}$

where: t_2 = shallow concentrated flow runoff travel time, min

L = length of the flow path, ft

V = shallow concentrated flow velocity, ft/sec

Appendix A.2 - Time of Concentration Calculations

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

Manning Equation for Open Channel Flow

$V = Q/A$

$R = A/P$

$t_3 = L/(60V)$

Where: Q = channel flow rate, cfs

V = average velocity of flow, ft/sec

A = channel cross-sectional area, ft^2

P = wetted perimeter of channel, ft

S = channel bottom slope, ft/ft

n = Manning roughness coefficient for channel

L = Length of Flow Path, ft

t_3 = travel time for channel flow, min

Time of Concentration Calculations

Project	Oconee County
Basin:	MegeeRdBasin_2
Date:	2013-06-10
Calc By:	JWB

Calculation of Overland Sheet Flow Travel Time

Using the Manning Kinematic Equation - U.S. units

Inputs			**Calculations**		
Manning Roughness Coefficient, **n** =	0.35		Overland Flow Time Travel, t_1 =	32.6	min
Length of Flow Path, **L** =	300	ft			
2 yr, 24 hr rainfall, **P** =	4.7	in			
Ground Slope, **S** =	0.03	ft/ft			

Calculation of Shallow Concentrated Flow Travel Time

Using the NCRS Method - U.S. units

Inputs			**Calculations**		
Length of Flow Path, **L** =	2440.6	ft	**For Unpaved Surface**		
Ground Slope, **S** =	0.0356	ft/ft	Flow Velocity, **V** =	3.0442514	ft/sec
			Travel time, t_2 =	13.4	min
Paved / Unpaved =	Unpaved				

Calculation of Channnel Flow Travel Time
Using the Manning Equation - U.S. units

For a Trapezoidal Channel Cross-section

Inputs			**Calculations**		
Bottom width, **b** =	13.5	ft	Cross-Sect. Area, **A** =	70.0	ft^2
Depth of flow, **y** =	4	ft	Wetted Perimeter, **P** =	24.8	ft
Side Slope, **z** = (H:V = **z**:1)	1		Hydraulic Radius, **R** =	2.82	ft
			Discharge, **Q** =	320.91	cfs
Manning roughness, **n** =	0.04		Ave. Velocity, **V** =	4.584	ft/sec
Channel bottom slope, **S** =	0.0038	ft/ft	Channel travel time, t_3 =	30.4	min
Length of Flow Path, **L** =	8349.44	ft			

Calculation of Time of Concentration
($t_c = t_1 + t_2 + t_3$)

Inputs (values from above)			**Calculations**		
t_1 =	32.6	min	t_c =	76.3	min
t_2 =	13.4	min	t_c =	1.3	hrs
t_3 =	30.4	min			

Overland Flow Roughness Coefficient

Surface	Manning's n
Concrete, Asphalt, Bare Soil	0.01 - 0.016
Gravel, Clay-loam,eroded	0.012 - 0.03
Sparse Vegetation, Cultivated Soil	0.053 - 0.13
Short Grass	0.1 - 0.2
Dense Grass, Bluegrass, Bermuda Grass	0.17 - 0.48
Woods	0.4 - 0.8

$$t_1 = \frac{0.42\ (nL)^{0.8}}{P^{0.5}\ S^{0.4}}$$

Manning Kinematic
Equation - U.S. units

t_1 = overland sheet flow runoff travel time, min

n = Manning roughness coefficient, dimensionless

L = length of the flow path, ft (Max. L should be 300 ft)

P = 2 year, 24 hr rainfall, in

S = ground slope, ft/ft

Equations for NCRS Method for Shallow Concentrated Flow

$$t_2 = L/(60V)$$

for unpaved surface: $V = 16.1345S^{0.5}$

for paved surface: $V = 20.3282S^{0.5}$

where: t_2 = shallow concentrated flow runoff travel time, min

L = length of the flow path, ft

V = shallow concentrated flow velocity, ft/sec

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

Manning Equation for Open Channel Flow

$$V = Q/A$$

$$R = A/P$$

$$t_3 = L/(60V)$$

Where:
- Q = channel flow rate, cfs
- V = average velocity of flow, ft/sec
- A = channel cross-sectional area, ft^2
- P = wetted perimeter of channel, ft
- S = channel bottom slope, ft/ft
- n = Manning roughness coefficient for channel
- L = Length of Flow Path, ft
- t_3 = travel time for channel flow, min

Time of Concentration Calculations

Project	Oconee County
Basin:	MegeeRdBasin_3
Date:	2013-06-10
Calc By:	JWB

Calculation of Overland Sheet Flow Travel Time

Using the Manning Kinematic Equation - U.S. units

Inputs

Manning Roughness Coefficient, **n** = 0.75

Length of Flow Path, **L** = 300 ft

2 yr, 24 hr rainfall, **P** = 4.7 in

Ground Slope, **S** = 0.106 ft/ft

Calculations

Overland Flow Time Travel, t_1 = 36.2 min

Calculation of Shallow Concentrated Flow Travel Time
Using the NCRS Method - U.S. units

Inputs

Length of Flow Path, **L** = 1119.78 ft

Ground Slope, **S** = 0.078 ft/ft

Paved / Unpaved = Unpaved

Calculations

For Unpaved Surface

Flow Velocity, **V** = 4.5061206 ft/sec

Travel time, t_2 = 4.1 min

Calculation of Channnel Flow Travel Time
Using the Manning Equation - U.S. units

For a Trapezoidal Channel Cross-section

Inputs			**Calculations**		
Bottom width, **b** =	13.5	ft	Cross-Sect. Area, **A** =	70.0	ft^2
Depth of flow, **y** =	4	ft	Wetted Perimeter, **P** =	24.8	ft
Side Slope, **z** = (H:V = **z**:1)	1		Hydraulic Radius, **R** =	2.82	ft
			Discharge, **Q** =	356.42	cfs
Manning roughness, **n** =	0.032		Ave. Velocity, **V** =	5.092	ft/sec
Channel bottom slope, **S** =	0.003	ft/ft	Channel travel time, t_3 =	7.6	min
Length of Flow Path, **L** =	2310.465	ft			

Calculation of Time of Concentration
($t_c = t_1 + t_2 + t_3$)

Inputs (values from above)			**Calculations**		
t_1 =	36.2	min	t_c =	47.9	min
t_2 =	4.1	min	t_c =	0.8	hrs
t_3 =	7.6	min			

Overland Flow Roughness Coefficient

Surface	Manning's n
Concrete, Asphalt, Bare Soil	0.01 - 0.016
Gravel, Clay-loam,eroded	0.012 - 0.03
Sparse Vegetation, Cultivated Soil	0.053 - 0.13
Short Grass	0.1 - 0.2
Dense Grass, Bluegrass, Bermuda Grass	0.17 - 0.48
Woods	0.4 - 0.8

$$t_1 = \frac{0.42\ (nL)^{0.8}}{P^{0.5}\ S^{0.4}}$$

Manning Kinematic Equation - U.S. units

t_1 = overland sheet flow runoff travel time, min

n = Manning roughness coefficient, dimensionless

L = length of the flow path, ft (Max. L should be 300 ft)

P = 2 year, 24 hr rainfall, in

S = ground slope, ft/ft

Equations for NCRS Method for Shallow Concentrated Flow

$t_2 = L/(60V)$

for unpaved surface: $V = 16.1345S^{0.5}$

for paved surface: $V = 20.3282S^{0.5}$

where: t_2 = shallow concentrated flow runoff travel time, min

L = length of the flow path, ft

V = shallow concentrated flow velocity, ft/sec

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

Manning Equation for Open Channel Flow

$$V = Q/A$$

$$R = A/P$$

$$t_3 = L/(60V)$$

Where: Q = channel flow rate, cfs

V = average velocity of flow, ft/sec

A = channel cross-sectional area, ft^2

P = wetted perimeter of channel, ft

S = channel bottom slope, ft/ft

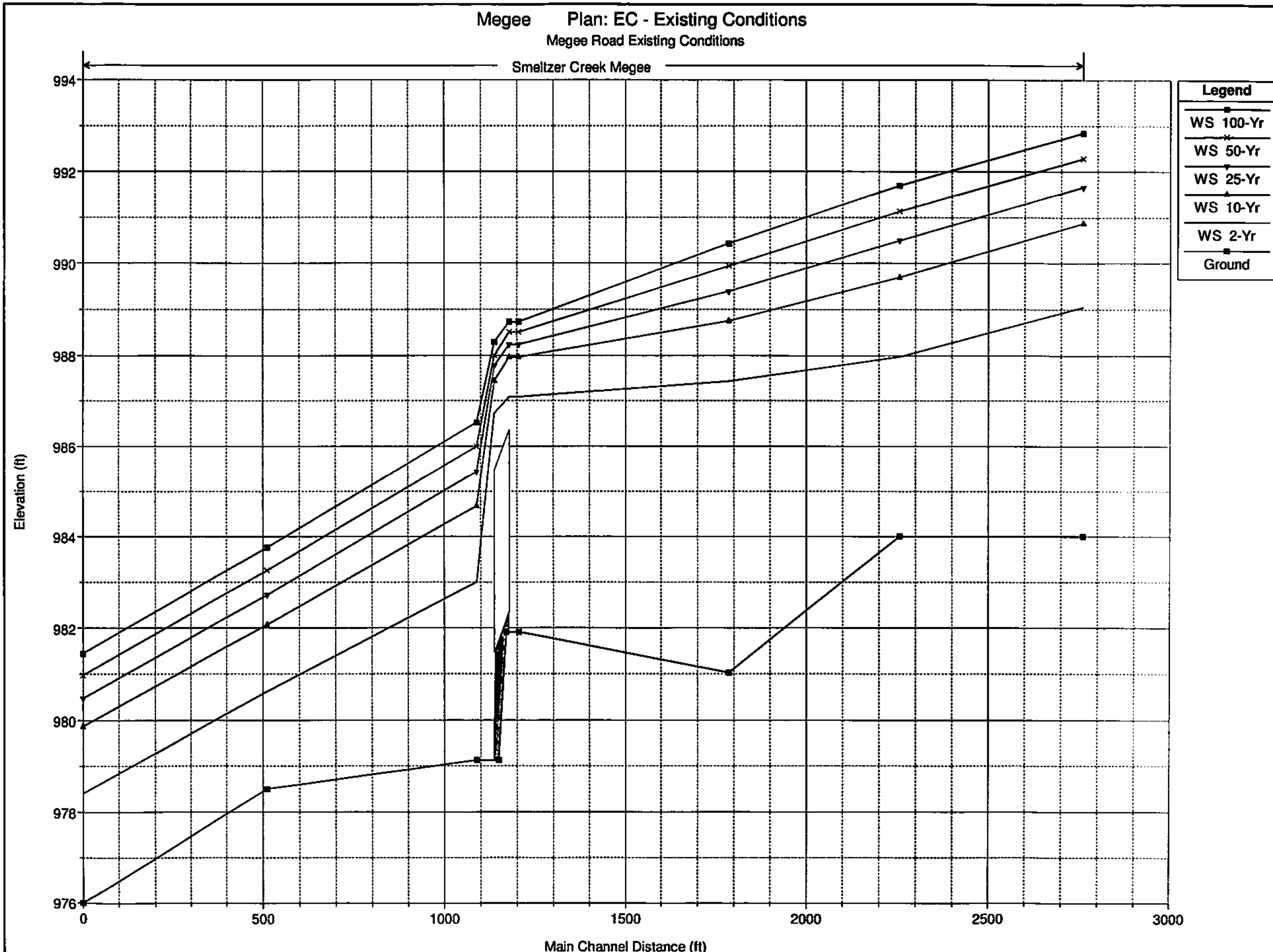
n = Manning roughness coefficient for channel

L = Length of Flow Path, ft

t_3 = travel time for channel flow, min

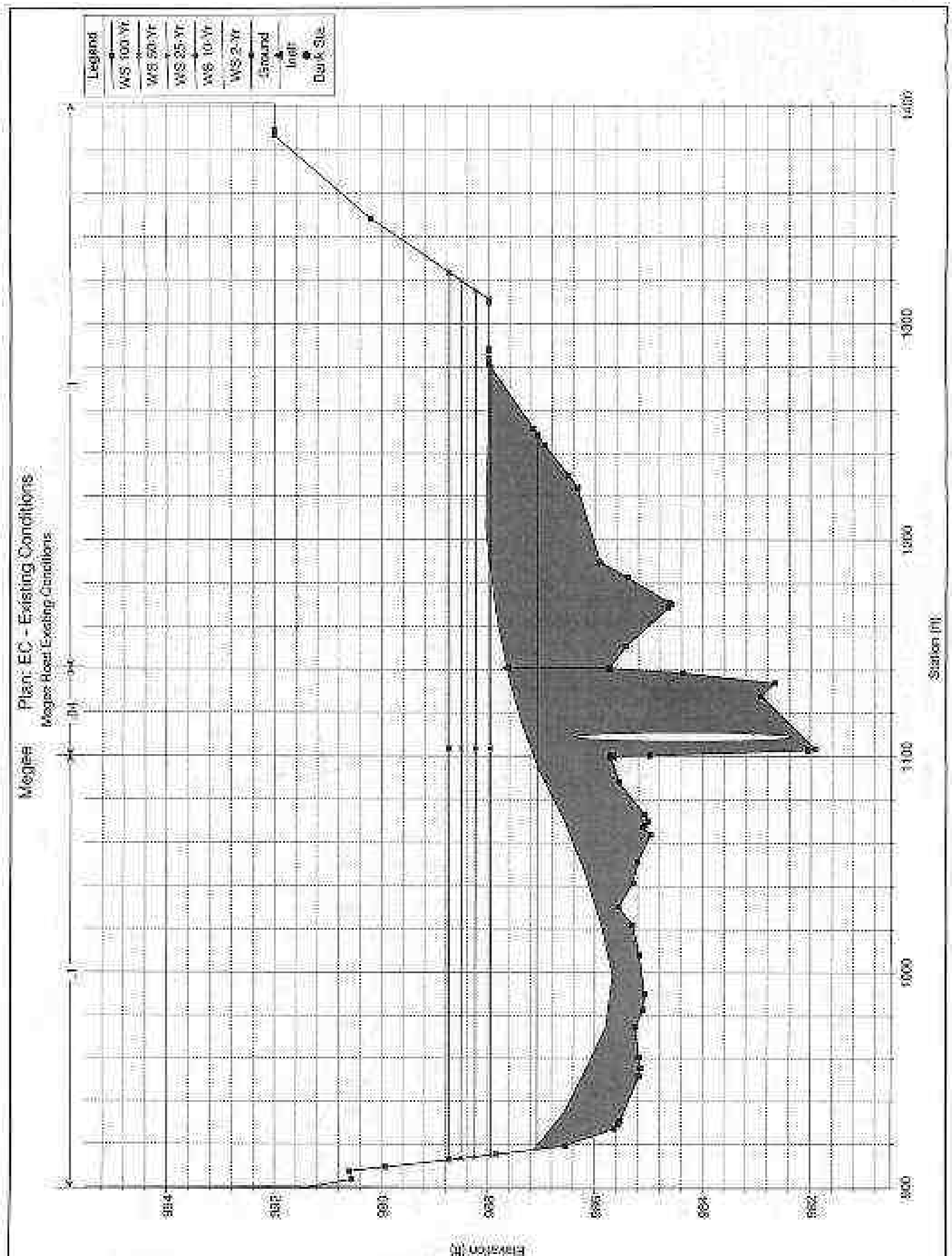
Appendix B
Existing Hydraulic Conditions

Megee Road Culvert
Hydrologic, Hydraulic
And Alternatives Analysis



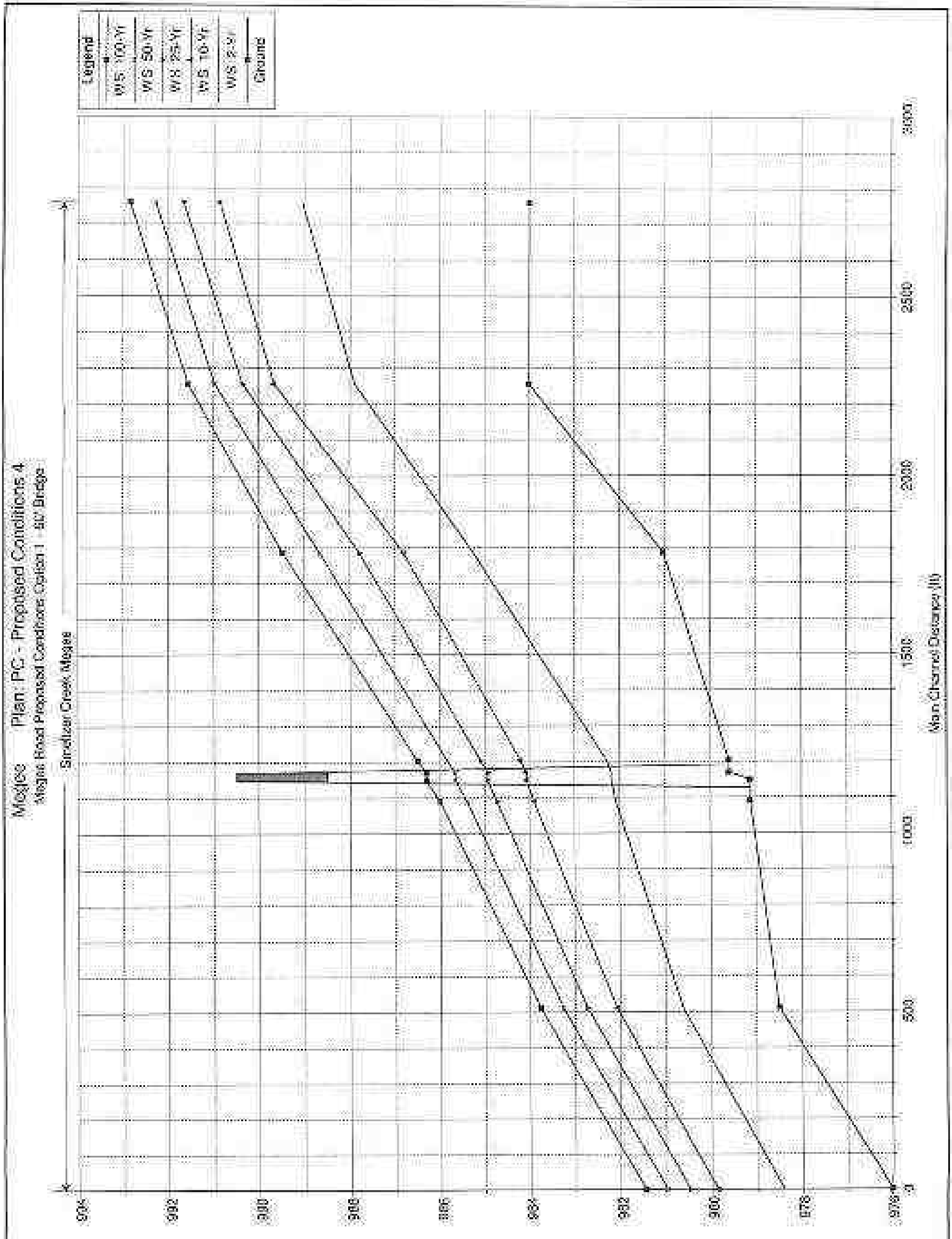
Appendix B
Existing Conditions Hydraulic Performance
B-1 of 2

Davis & Floyd, Inc.
D&F Job No. 12975.02
June 2013

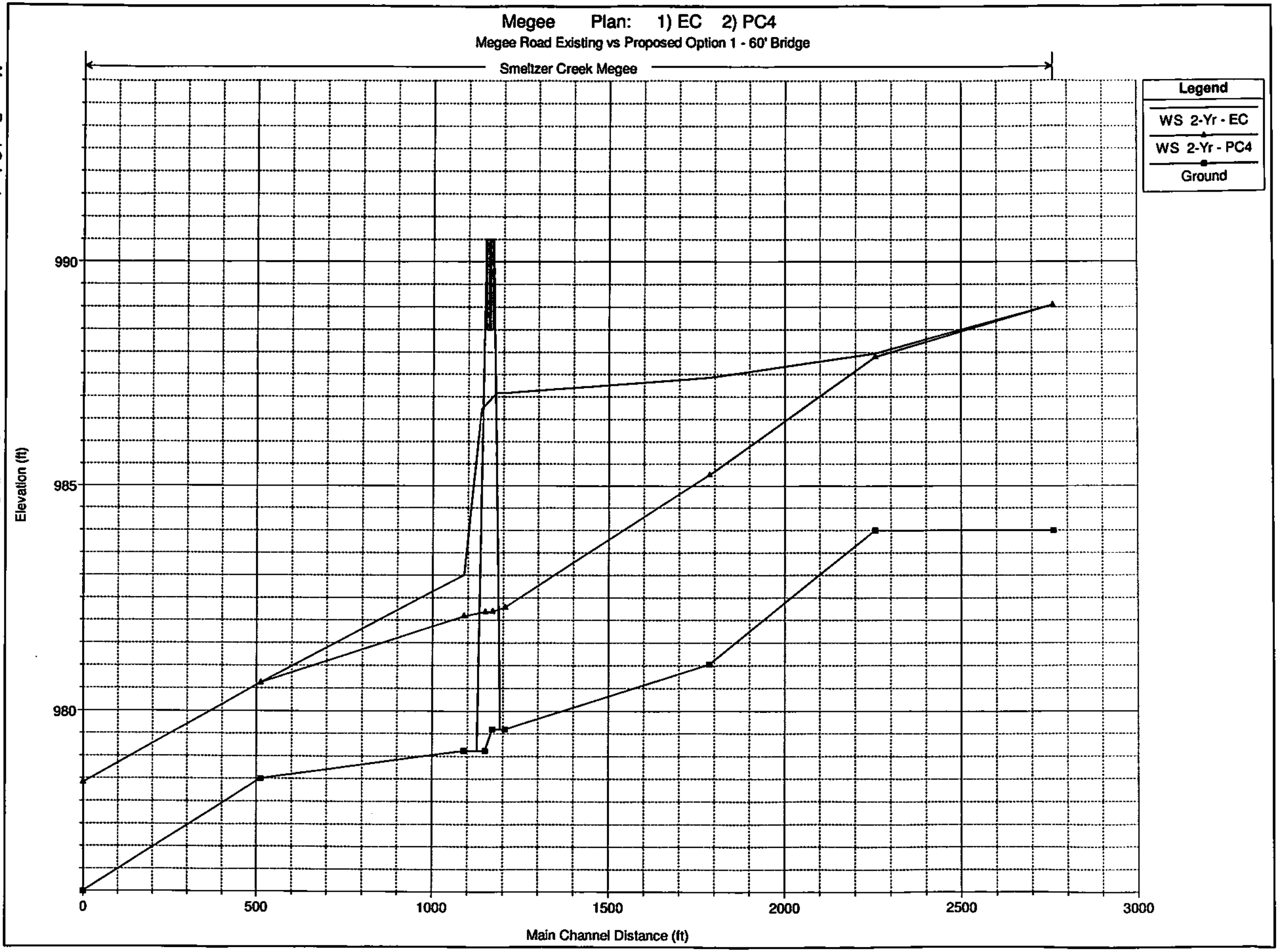

Megee Plan: EC - Existing Conditions
Megee Road Existing Conditions
Legend
WS 100 Yr
WS 50 Yr
WS 25 Yr
WS 10 Yr
WS 2 Yr
Ground
Ineff
Bank Sta
Station (ft)
Elevation (ft)
900
1000
1100
1200
1300
1400

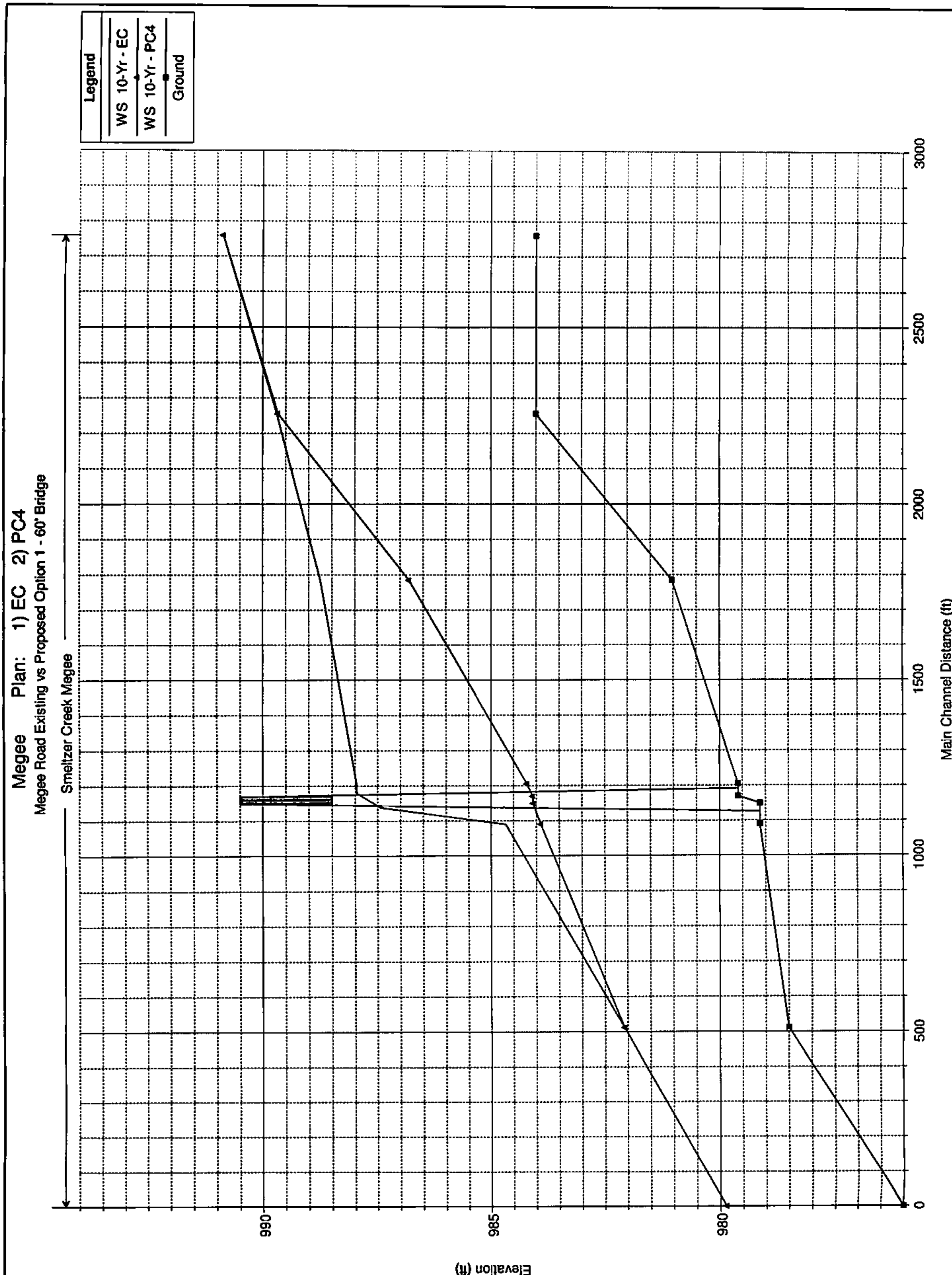
Appendix C
Conceptual Hydraulic Performance

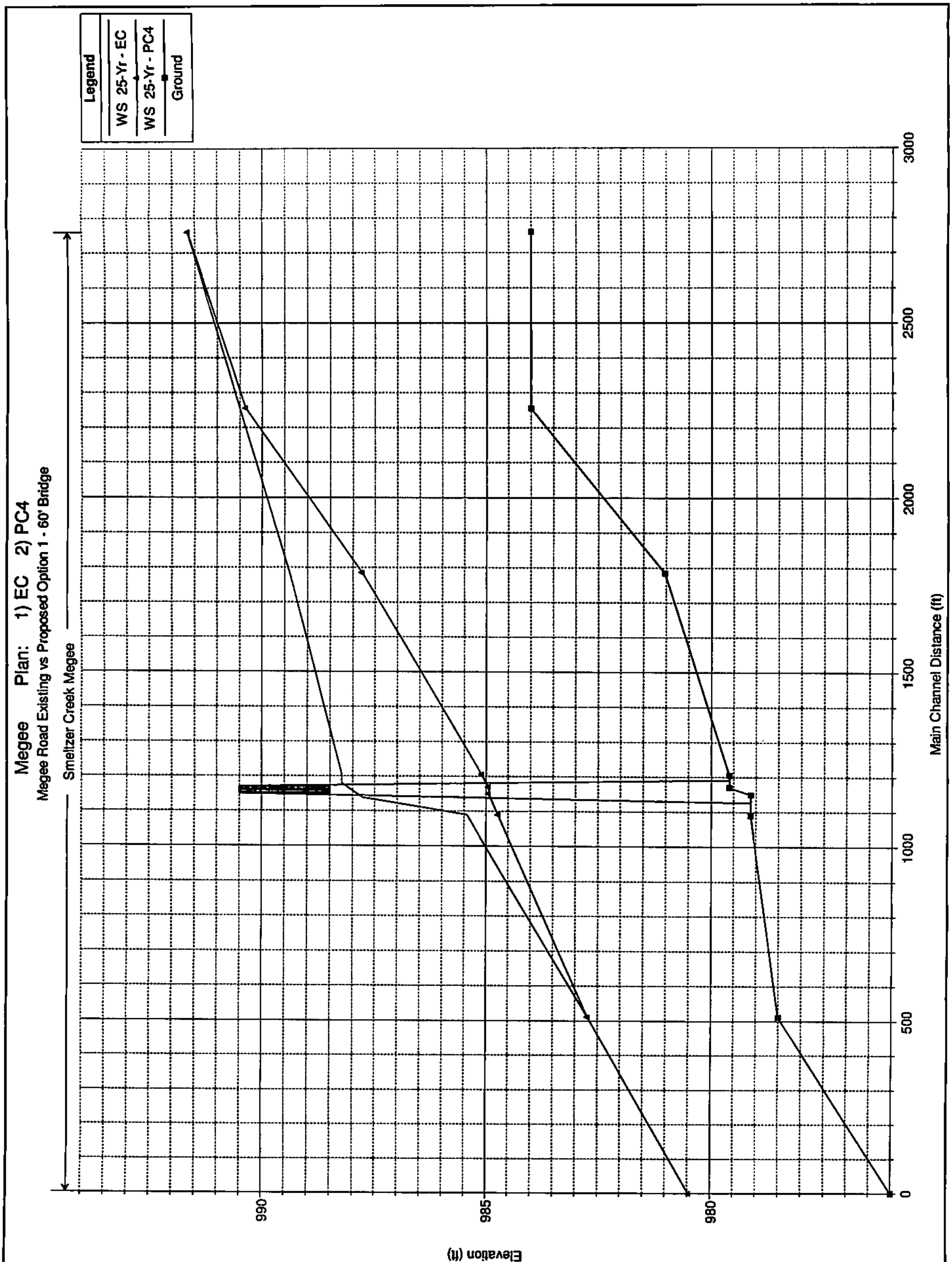
Appendix C.1
Option 1 Hydraulic Performance

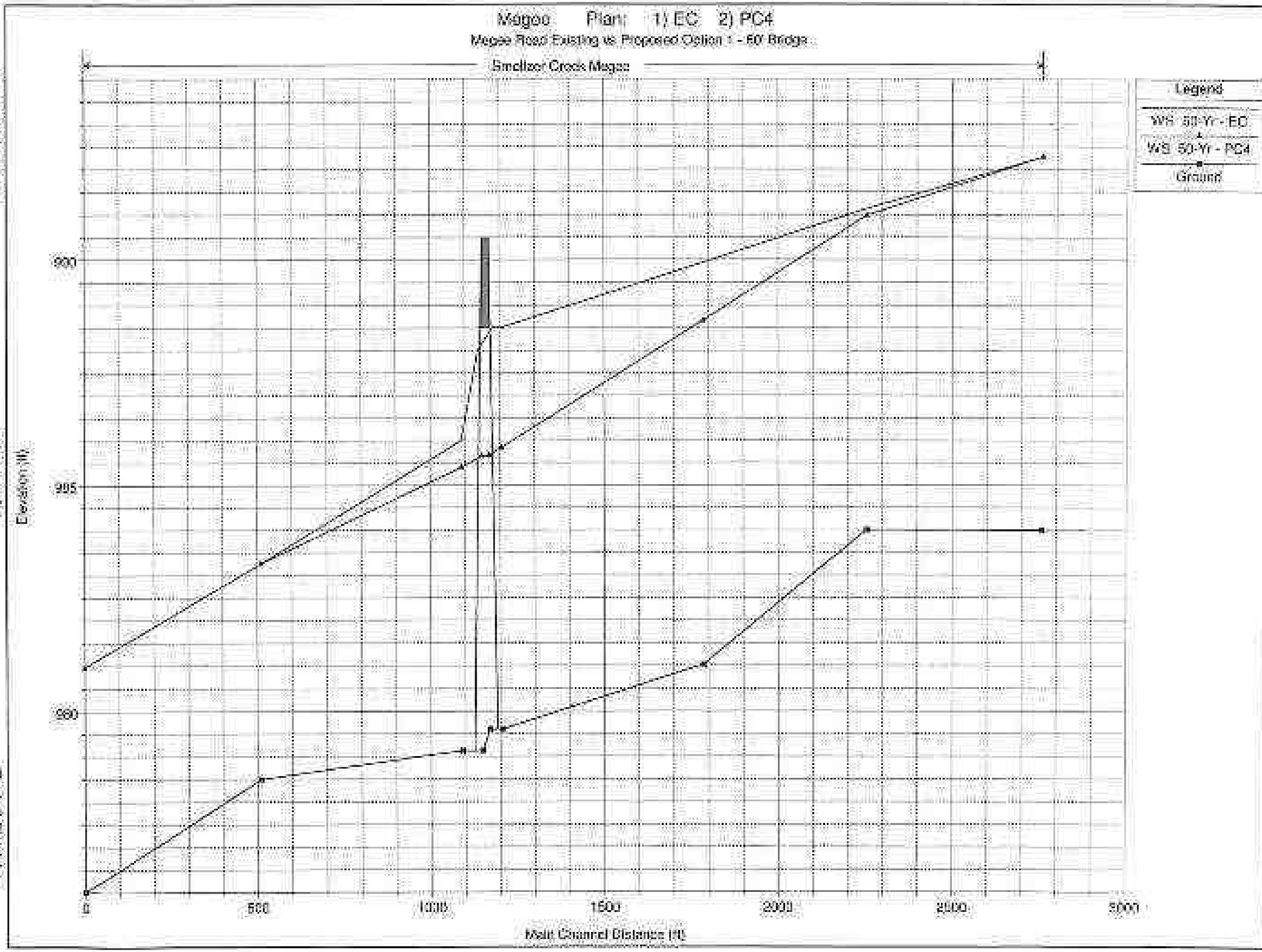


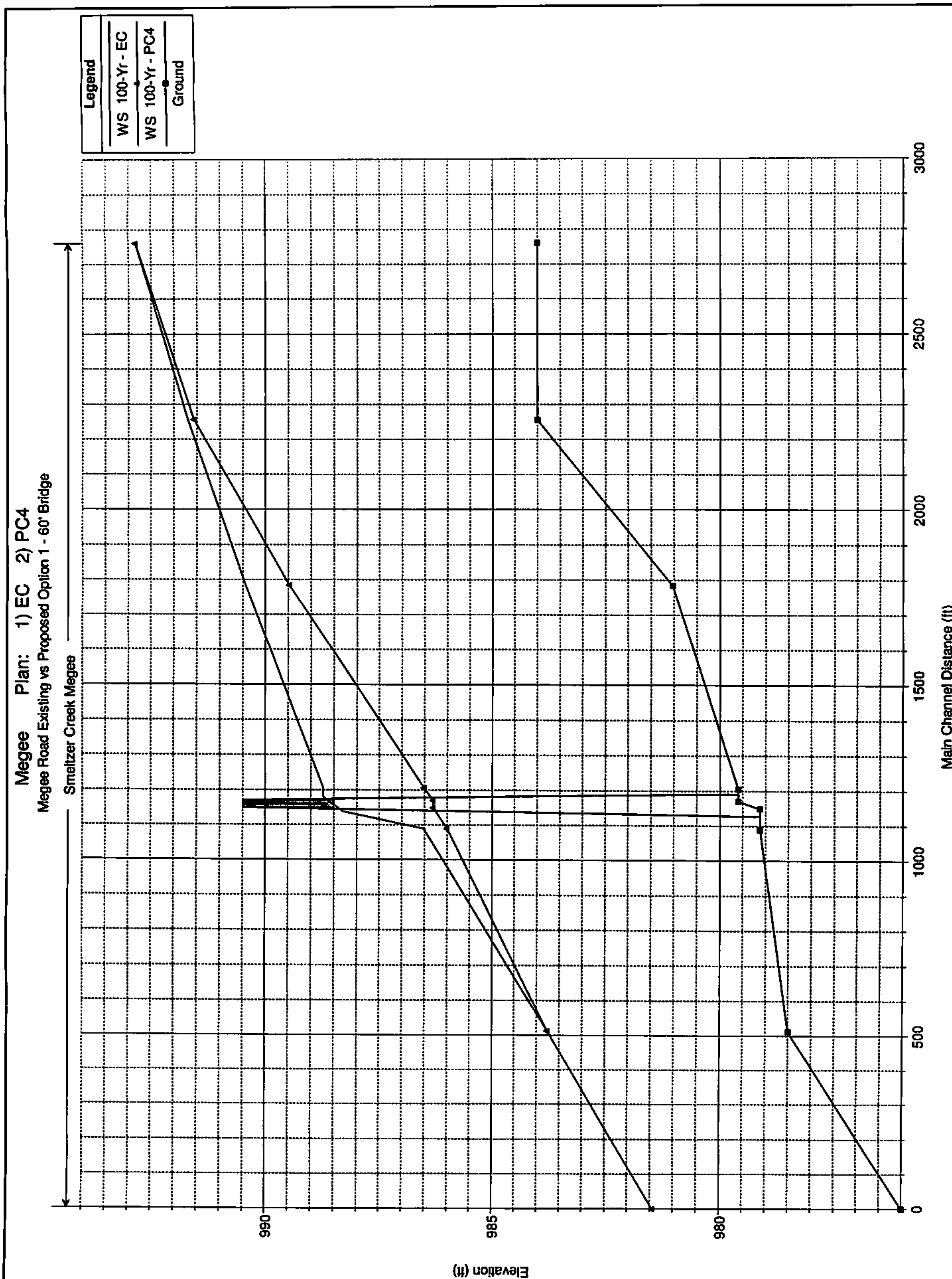
Megee Plan: PC - Proposed Conditions 4
Megee Road Proposed Conditions Option 1 - 50' Bridge
Stratizer Creek Megee
Legend
WS 100-Yr
WS 50-Yr
WS 25-Yr
WS 10-Yr
WS 2-Yr
Ground
Elevation (ft)
Main Channel Distance (ft)
0
500
1000
1500
2000
2500
3000
976
978
980
982
984
986
988
990
992
994

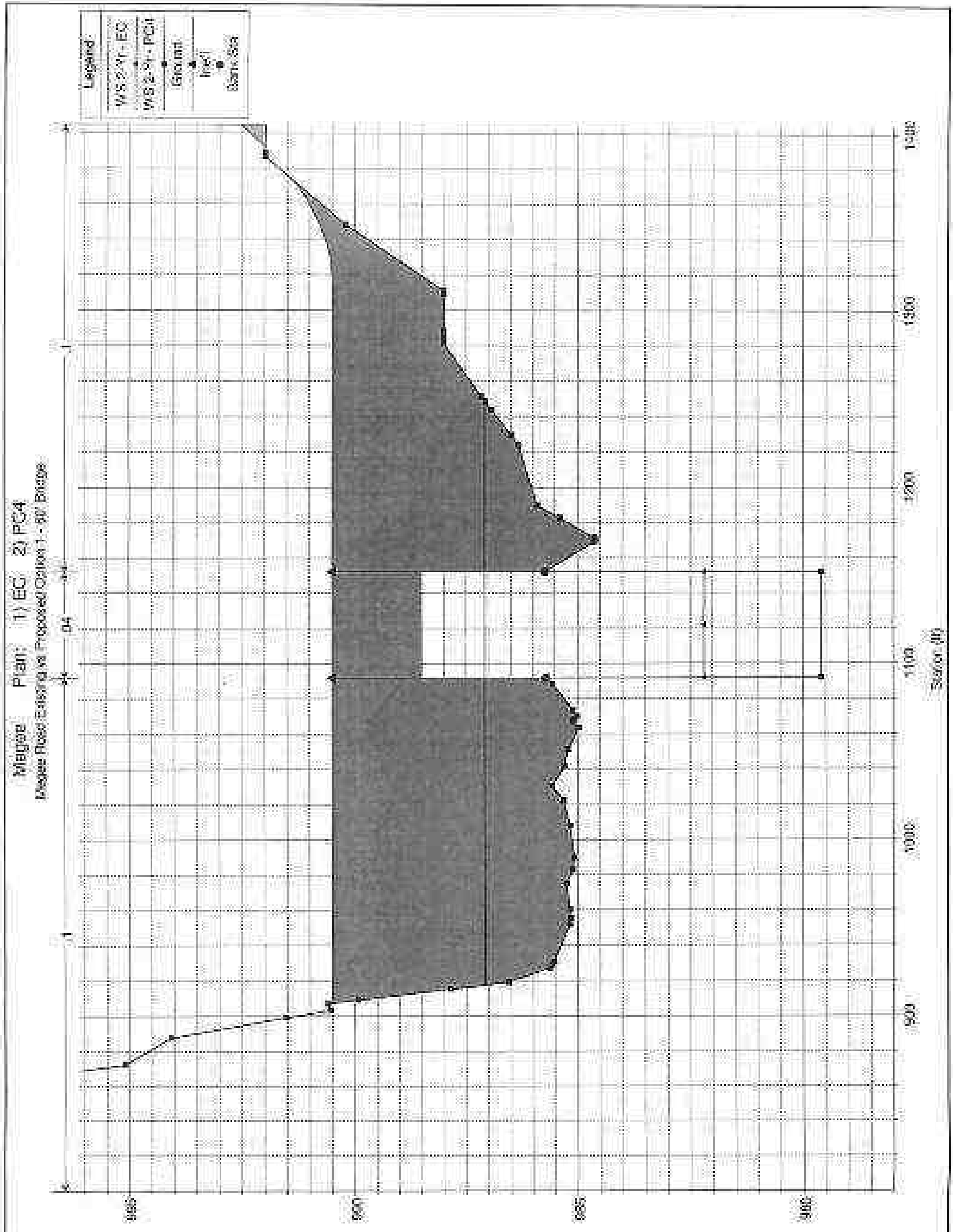

Megee Plan: 1) EC 2) PC4
Megee Road Existing vs Proposed Option 1 - 60' Bridge
Smeltzer Creek Megee
Legend
WS 2-Yr - EC
WS 2-Yr - PC4
Ground
Elevation (ft)
990
985
980
0
500
1000
1500
2000
2500
3000
Main Channel Distance (ft)

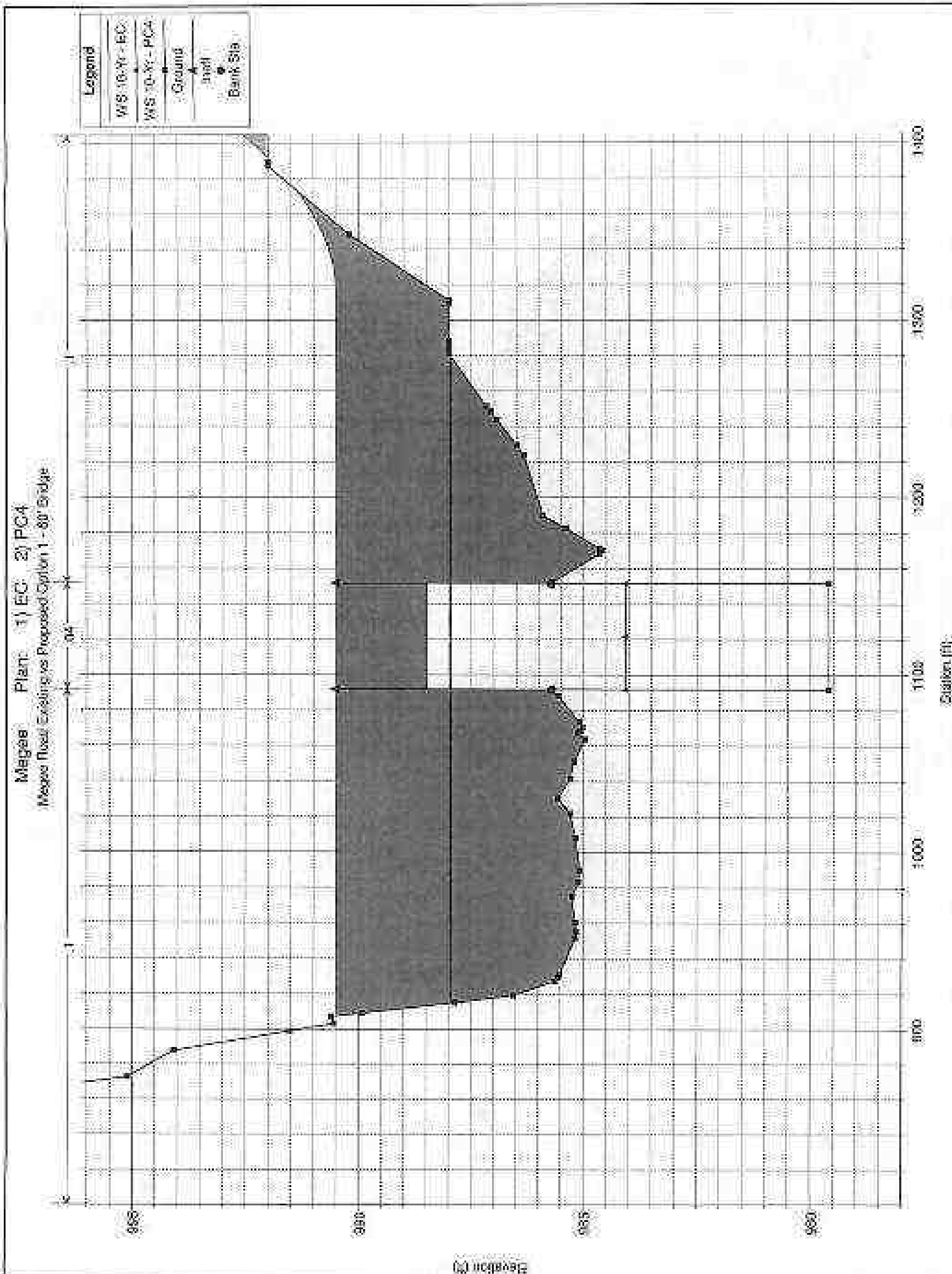

Megee Plan: 1) EC 2) PC4
Megee Road Existing vs Proposed Option 1 - 60' Bridge
Smeltzer Creek Megee
Legend
WS 10-Yr - EC
WS 10-Yr - PC4
Ground
Main Channel Distance (ft)
Elevation (ft)
0
500
1000
1500
2000
2500
3000
980
985
990

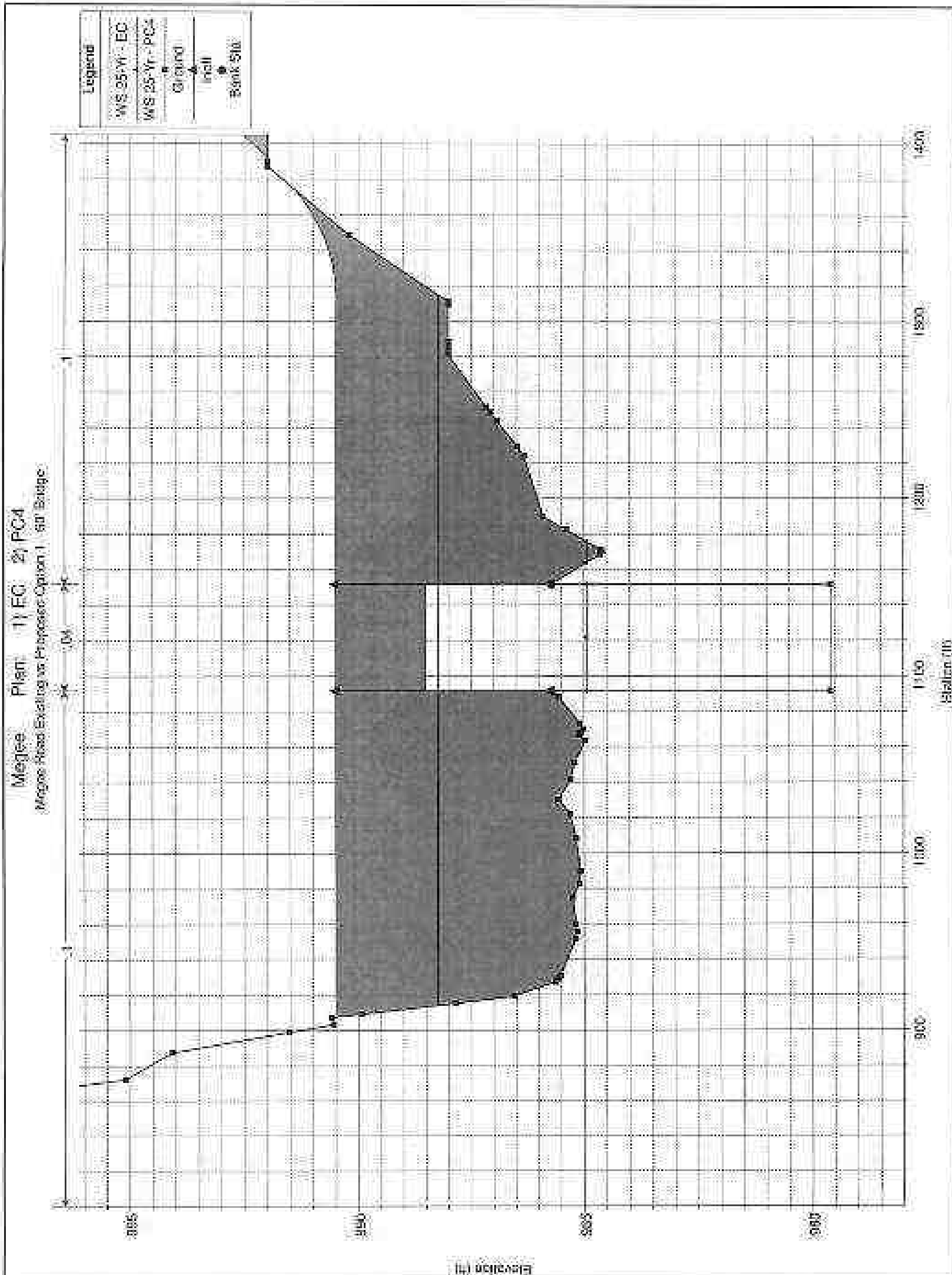

Megee Plan: 1) EC 2) PC4
Megee Road Existing vs Proposed Option 1 - 60' Bridge
Smeltzer Creek Megee
Legend
WS 25-Yr - EC
WS 25-Yr - PC4
Ground
990
985
980
Elevation (ft)
0
500
1000
1500
2000
2500
3000
Main Channel Distance (ft)

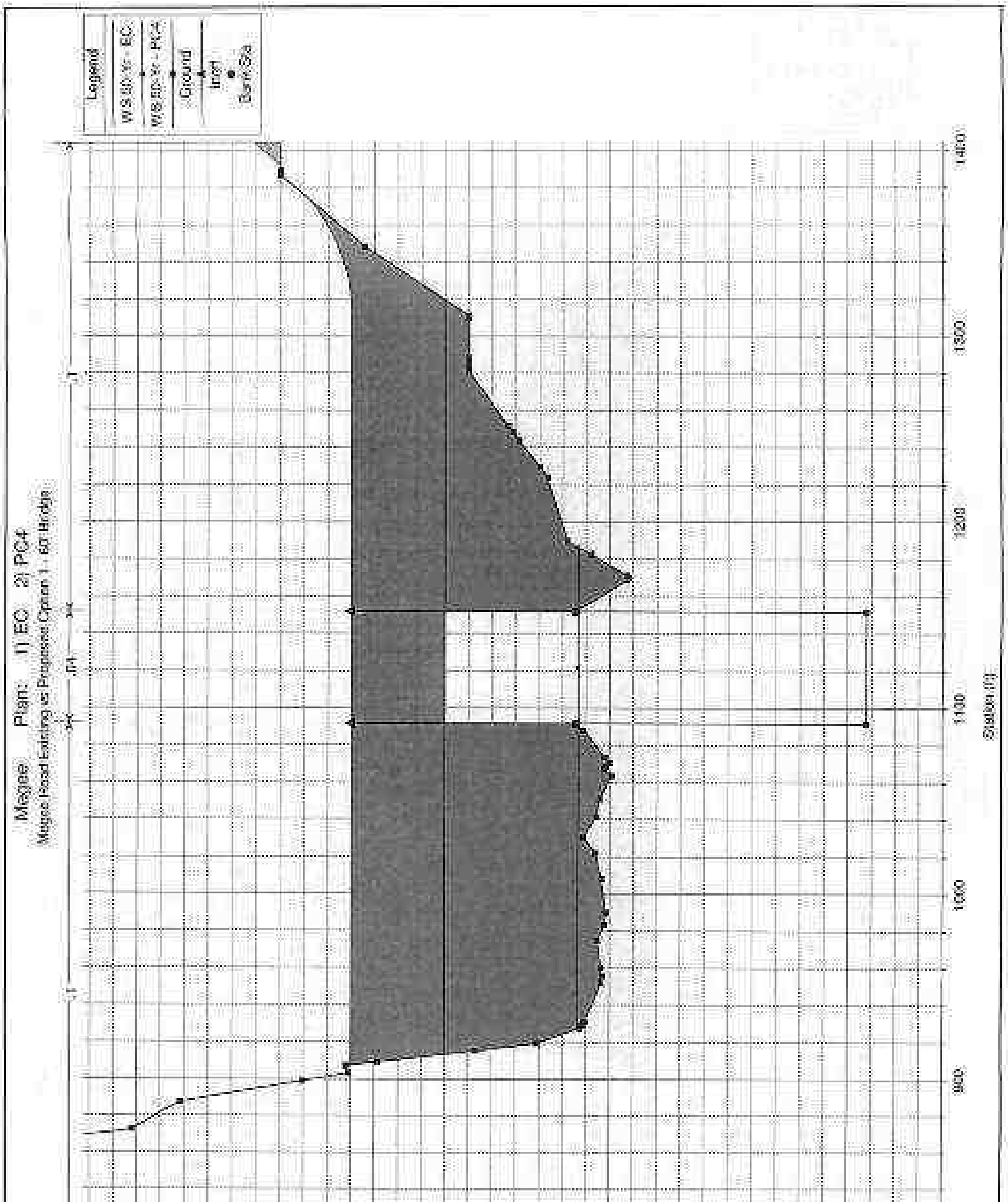

Magee Plan: 1) EC 2) PC4
Magee Road Existing vs Proposed Option 1 - 60' Bridge
Smeltzer Creek Magee
Legend
WS 50-Yr - EC
WS 50-Yr - PC4
Ground
Elevation (ft)
990
985
980
0
500
1000
1500
2000
2500
3000
Main Channel Distance (ft)


Megee Plan: 1) EC 2) PC4
Megee Road Existing vs Proposed Option 1 - 60' Bridge
Smeltzer Creek Megee
Legend
WS 100-Yr - EC
WS 100-Yr - PC4
Ground
Main Channel Distance (ft)
Elevation (ft)
0
500
1000
1500
2000
2500
3000
990
985
980

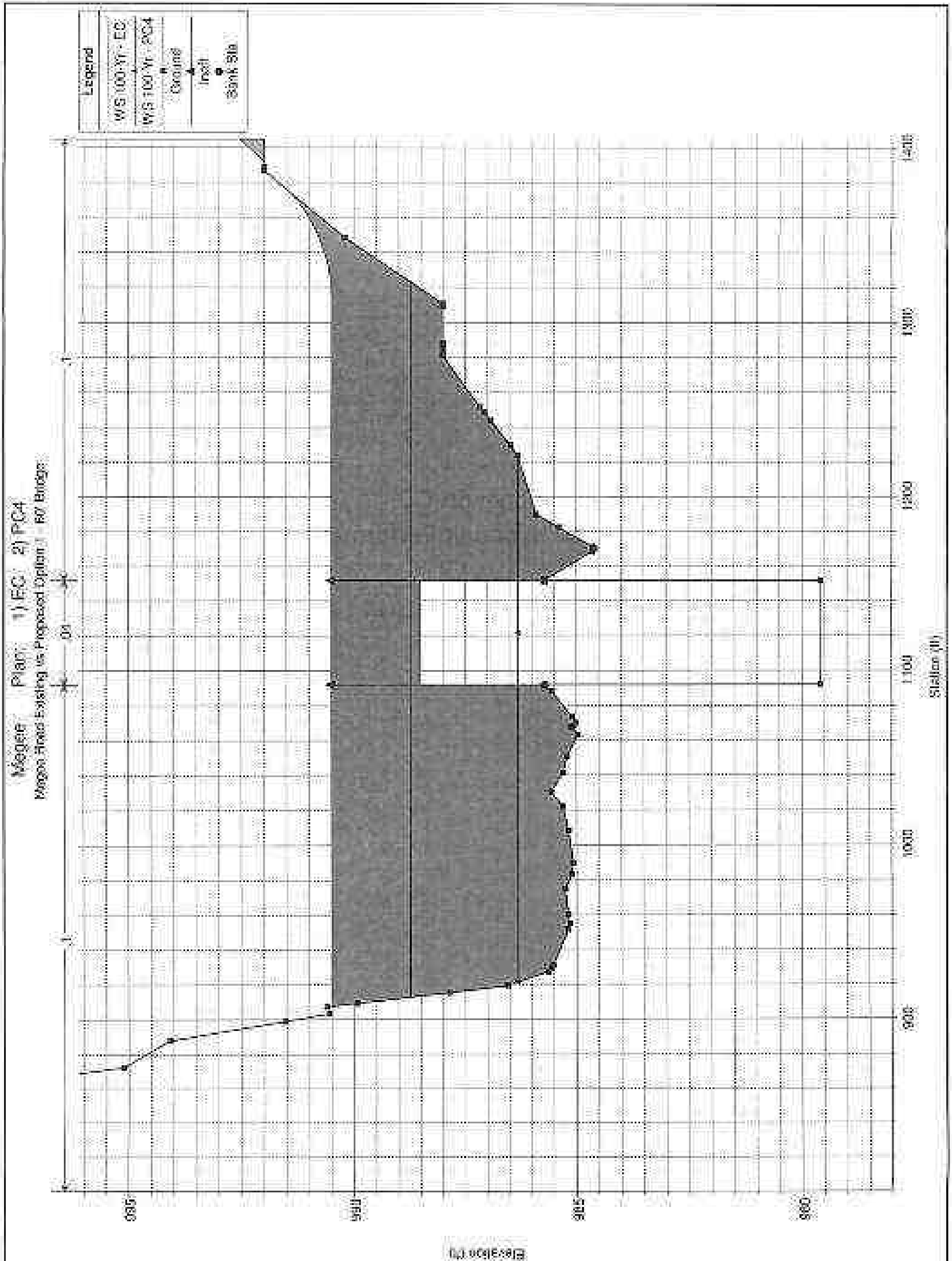

Megee Plan: 1) EC 2) PC4
Megee Road Existing vs Proposed Option 1 - 60' Bridge
Legend
WS 2-Yr - EC
WS 2-Yr - PC4
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
900
1000
1100
1200
1300
1400
.04


Megee Plan: 1) EC 2) PC4
Megee Road Existing vs Proposed Option 1 - 60' Bridge
Legend
WS 10-Yr - EC
WS 10-Yr - PC4
Ground
Ineff
Bank Sta
Elevation (ft)
995
990
985
980
Station (ft)
900
1000
1100
1200
1300
1400

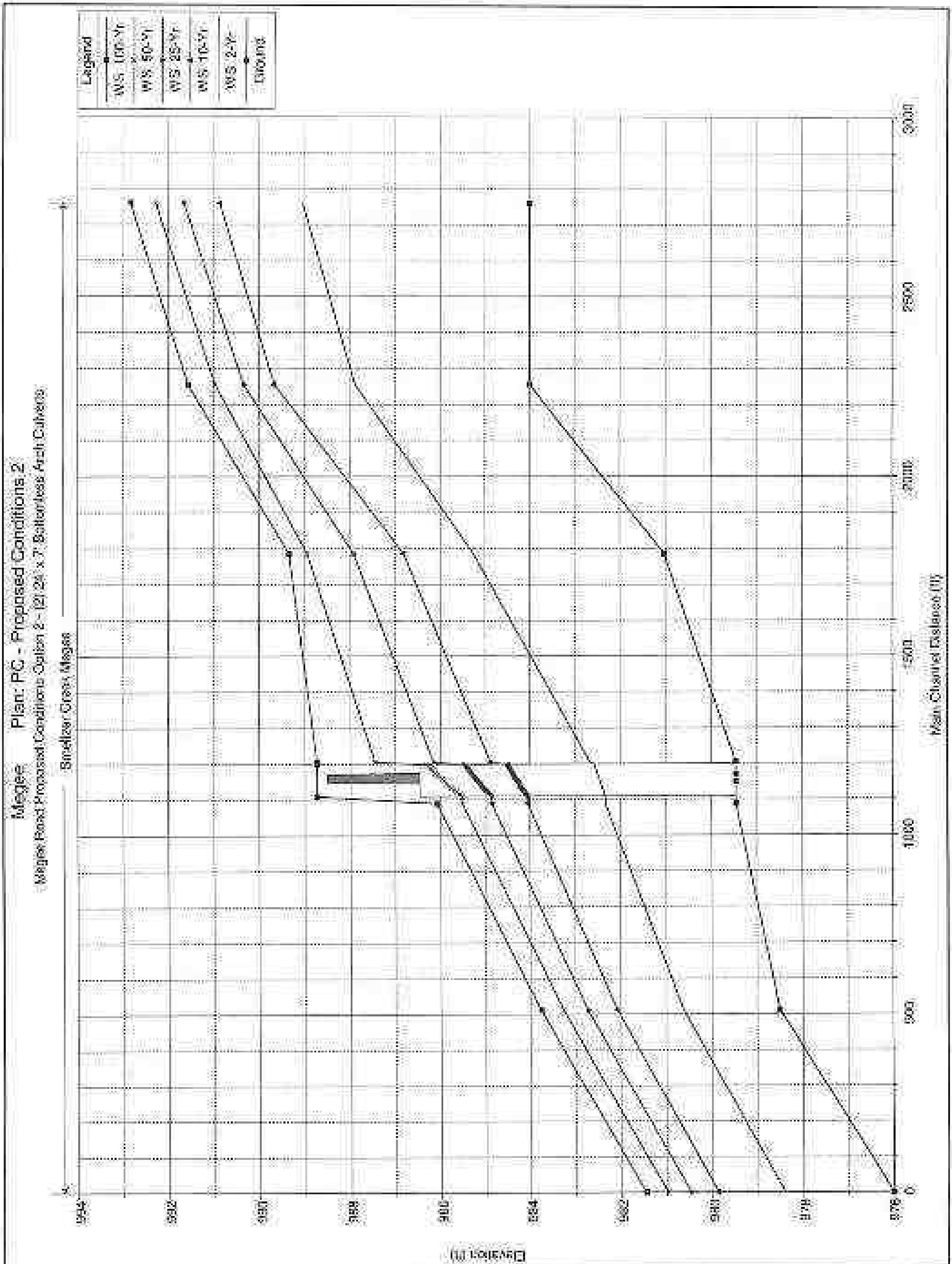

Megee Plan: 1) EC 2) PC4
Megee Road Existing vs Proposed Option 1 80' Bridge
Legend
WS 25-Yr - EC
WS 25-Yr - PC4
Ground
Ineff
Bank Sta
Station (ft)
Elevation (ft)



Magee Plan: 1) EC 2) PC4
Magee Road Existing vs Proposed Option 1 - 60' Bridge
Legend
Ground
Ineff
Bank Sta
.04
.1
995
990
985
980
Elevation (ft)
900
1000
1100
1200
1300
1400
Station (ft)


Magee Plan: 1) EC 2) PC4
Magee Road Existing vs Proposed Option 1 - 60' Bridge
Legend
WS 100 Yr - EC
WS 100 Yr - PC4
Ground
Ineff
Bank Sta
Station (ft)
Elevation (ft)
900
1000
1100
1200
1300
1400
995
990
985
980

Appendix C.2
Option 2 Hydraulic Performance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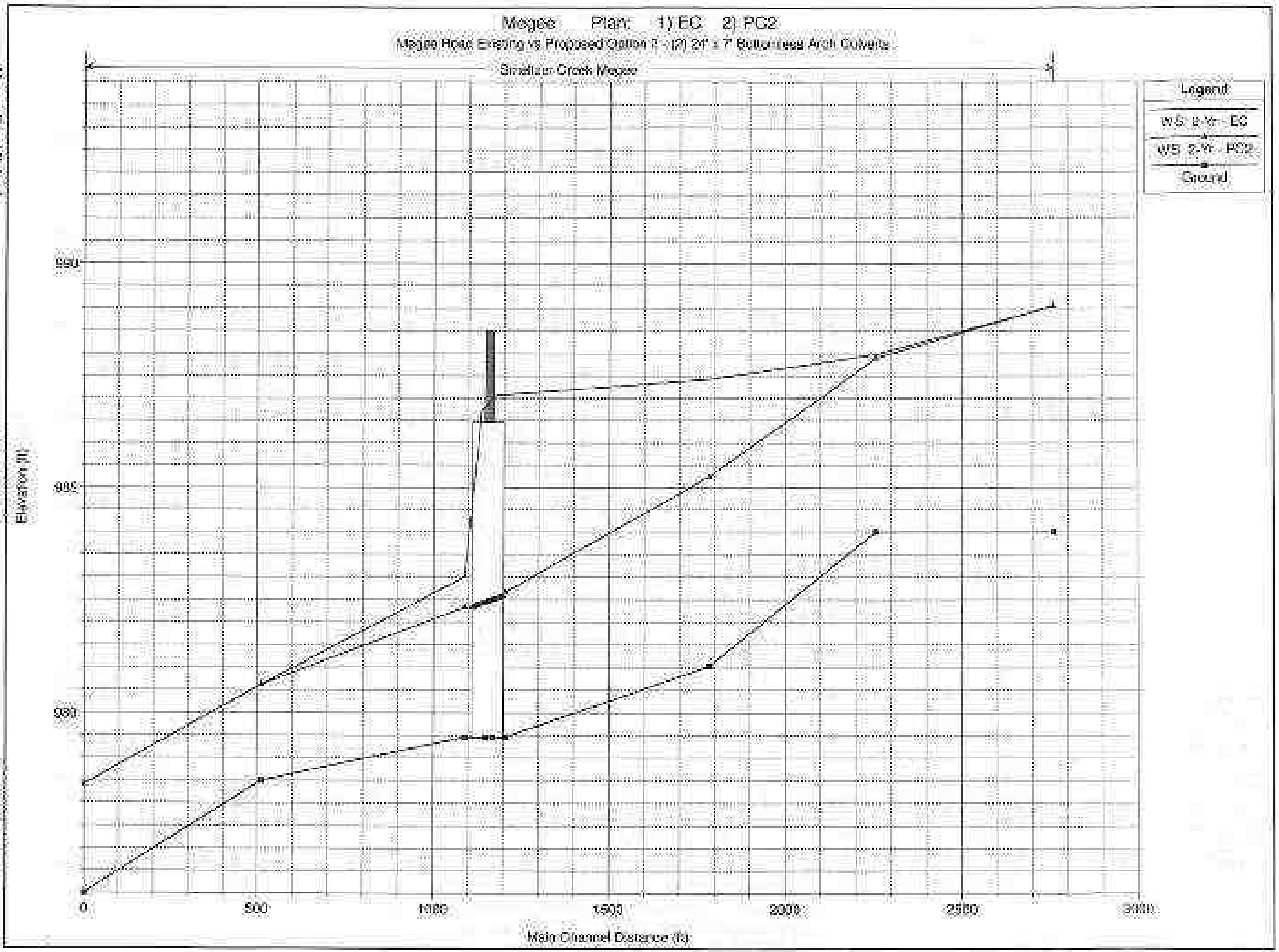
Megee Road Proposed Conditions Option 2 - (2) 24' x 7' Bottomless Arch Culverts
Legend
WS 100-Yr
WS 50-Yr
WS 25-Yr
WS 10-Yr
WS 2-Yr
Ground
Elevation (ft)
Main Channel Distance (ft)
976
978
980
982
984
986
988
990
992
994
0
500
1000
1500
2000
2500
3000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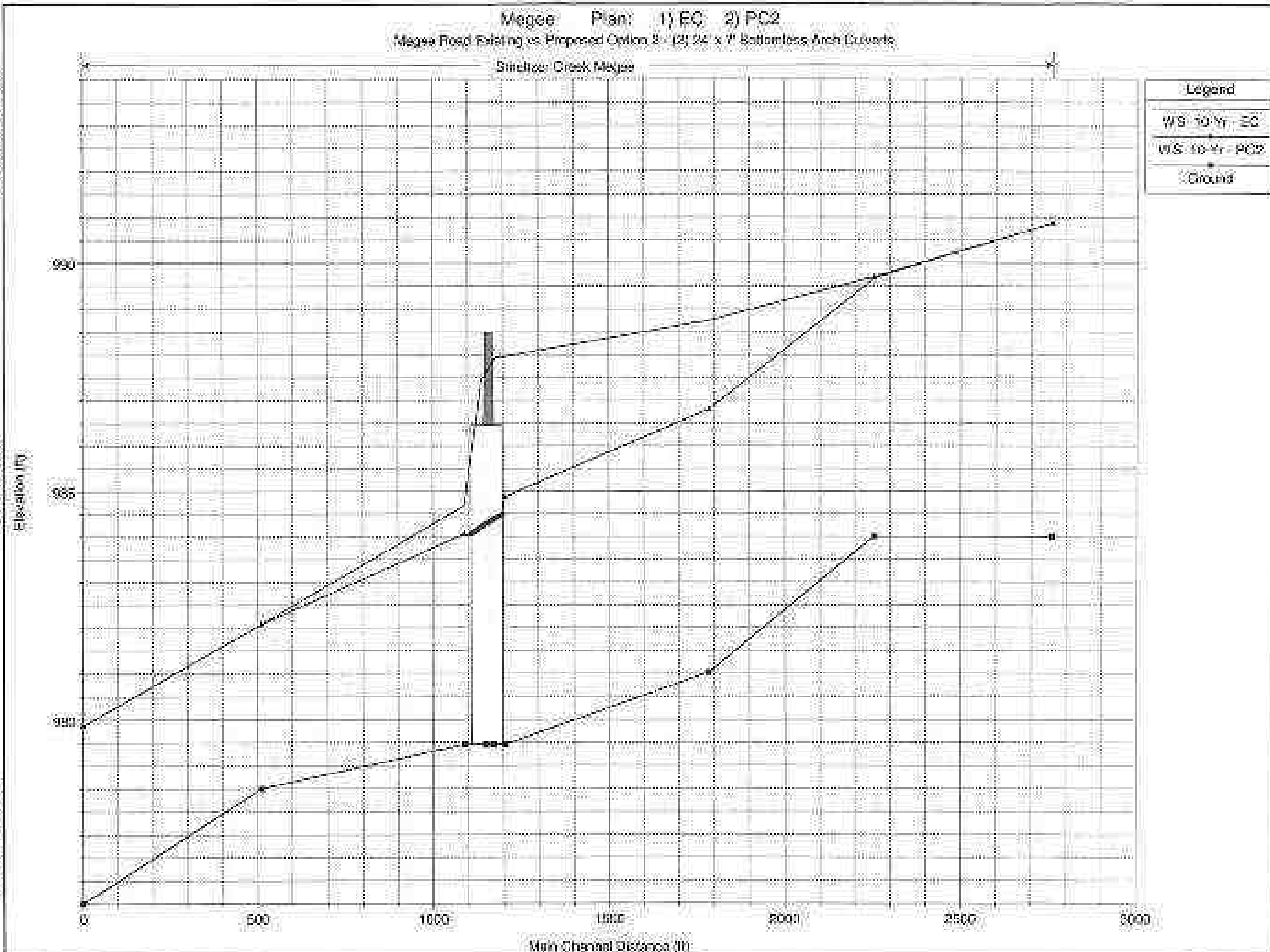
Smeltzer Creek Magee
Legend
WS 2-Yr - EC
WS 2-Yr - PC2
Ground
990
985
980
Elevation (ft)
0
500
1000
1500
2000
2500
3000
Main Channel Distance (ft)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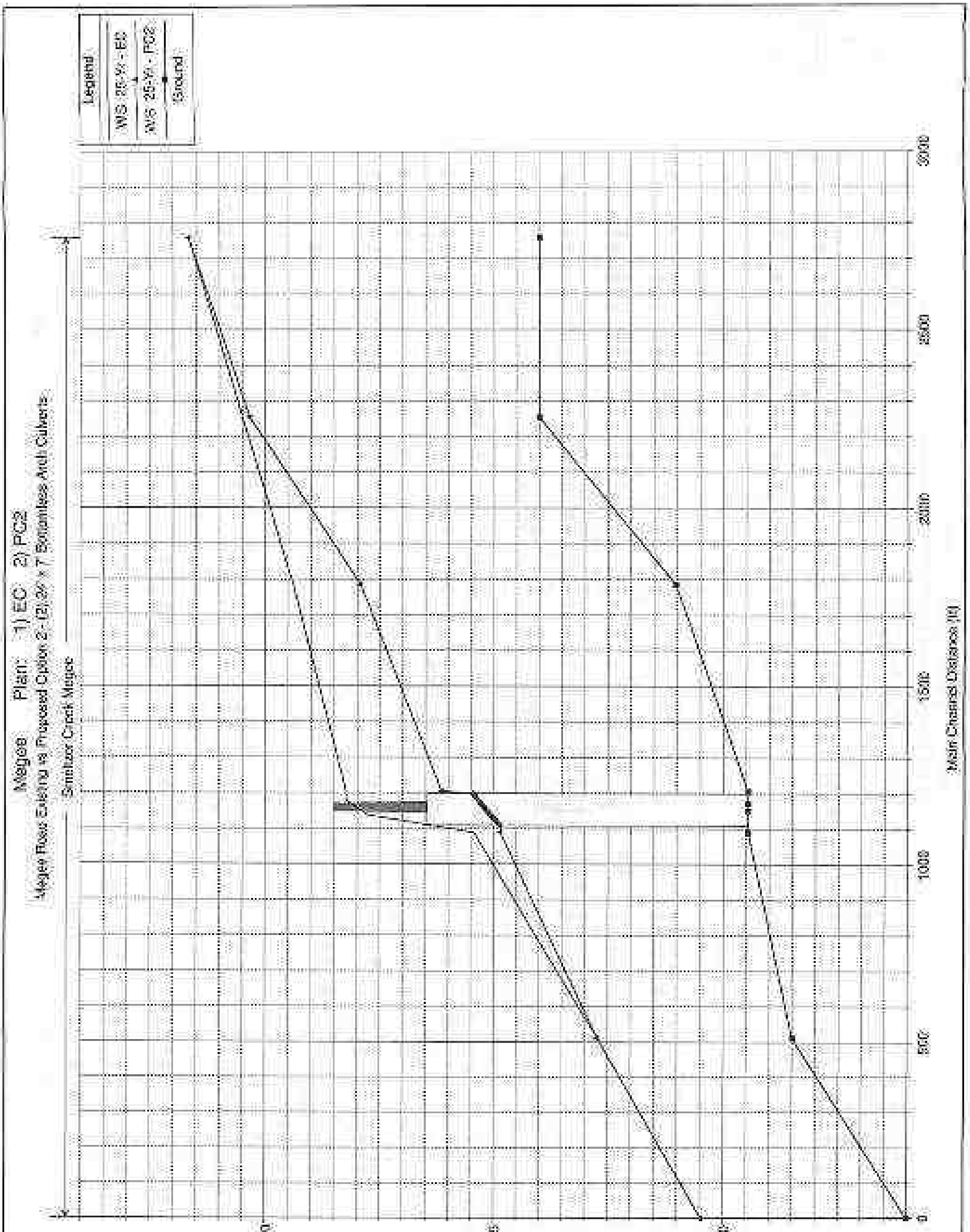
Megee Road Existing vs Proposed Option 2 - (2) 24' x 7' Bottomless Arch Culverts
Sinelizer Creek Megee
Legend
W.S. 10-Yr - EC
W.S. 10-Yr - PC2
Ground
Elevation (ft)
990
985
980
0
500
1000
1500
2000
2500
3000
Main Channel Distance (ft)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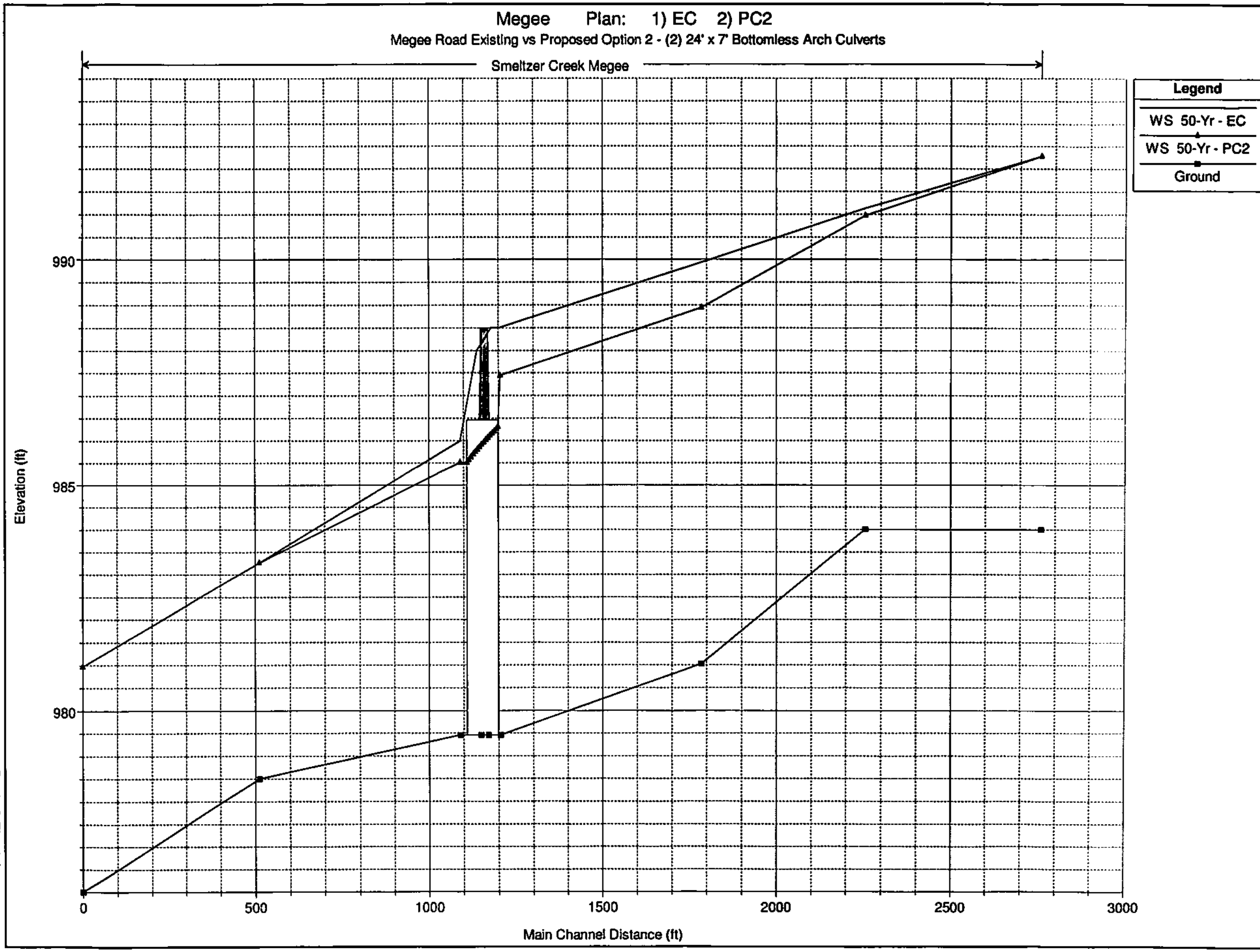
Megee Road Existing vs Proposed Option 2 - (2) 24' x 7' Bottomless Arch Culverts
Smeltzer Creek Megee
Legend
WS 25-Yr - EC
WS 25-Yr - PC2
Ground
Main Channel Distance (ft)
0
500
1000
1500
2000
2500
3000
Elevation (ft)

Megee Road Culvert
Hydrologic, Hydraulic
And Alternatives Analysis

Appendix C.2
Option 2 - (2) 24' x 7' Bottomless Arch Culverts
Page C.5 of 11

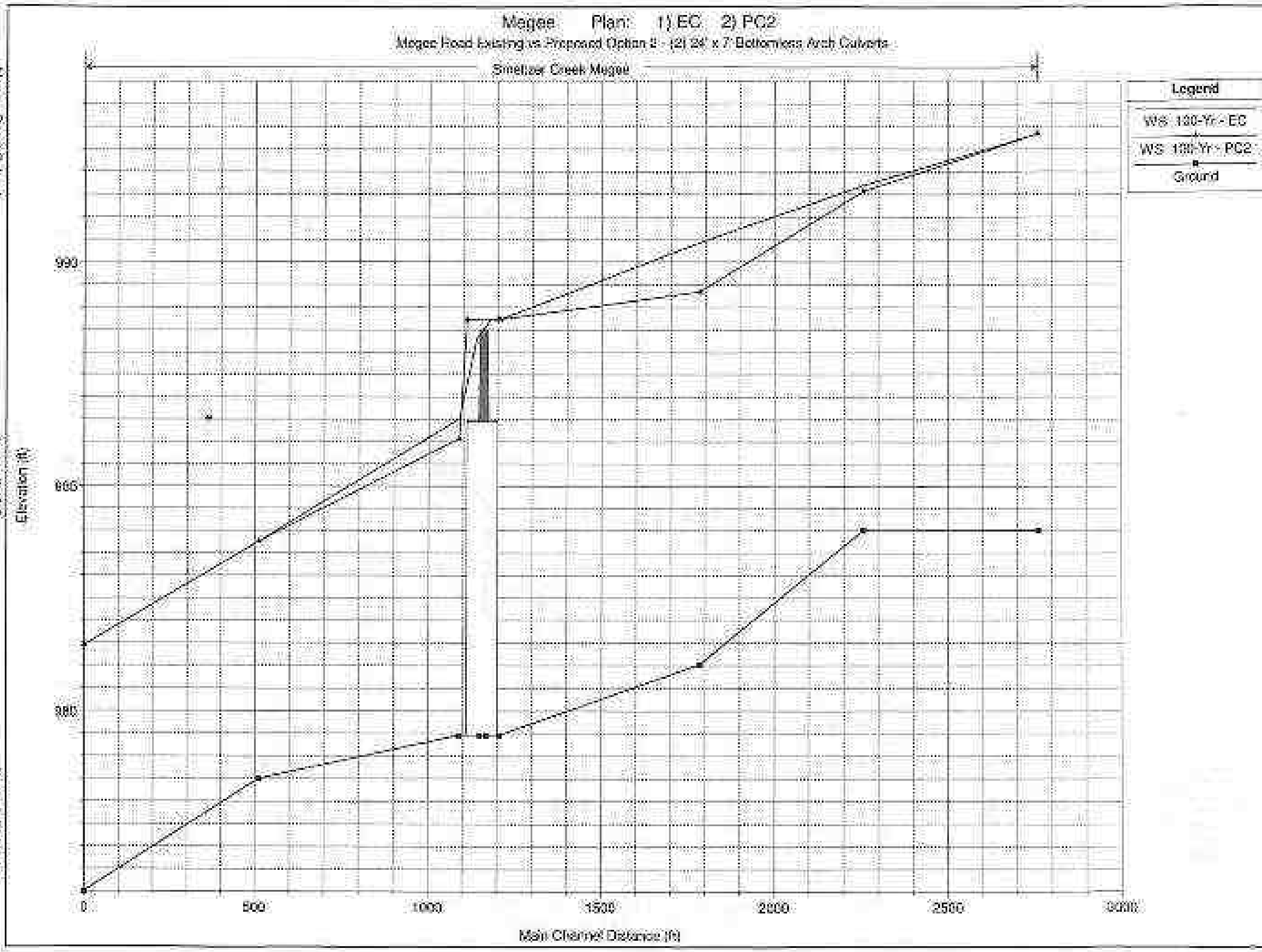
Davis & Floyd, Inc.
D&F Job No. 12975.02
June 2013

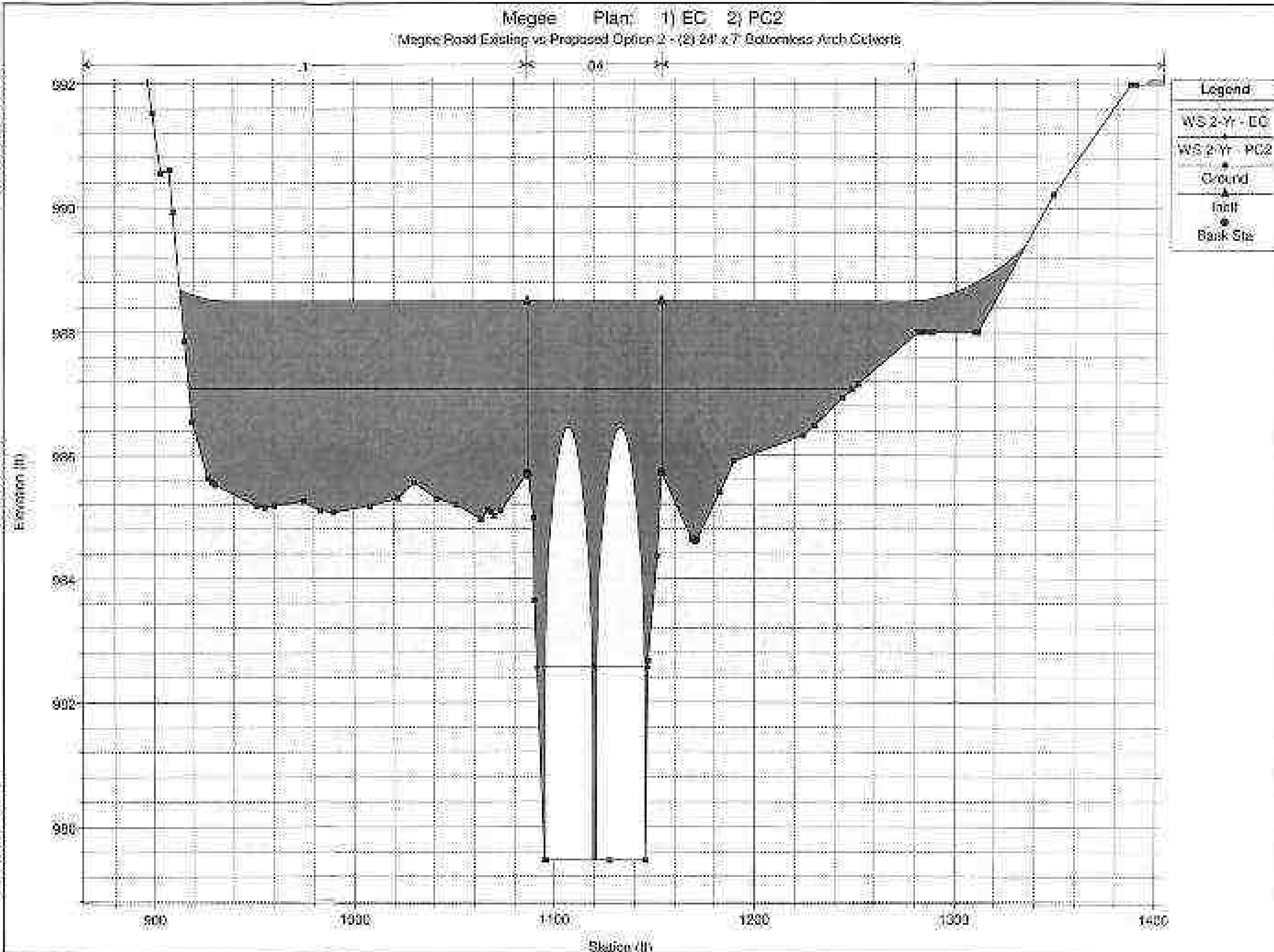


Megee Road Culvert
Hydrologic, Hydraulic
And Alternatives Analysis

Appendix C.2
Option 2 - (2) 24' x 7' Bottomless Arch Culverts
Page C.6 of 11

Davis & Floyd, Inc.
D&F Job No. 12975.02
June 2013

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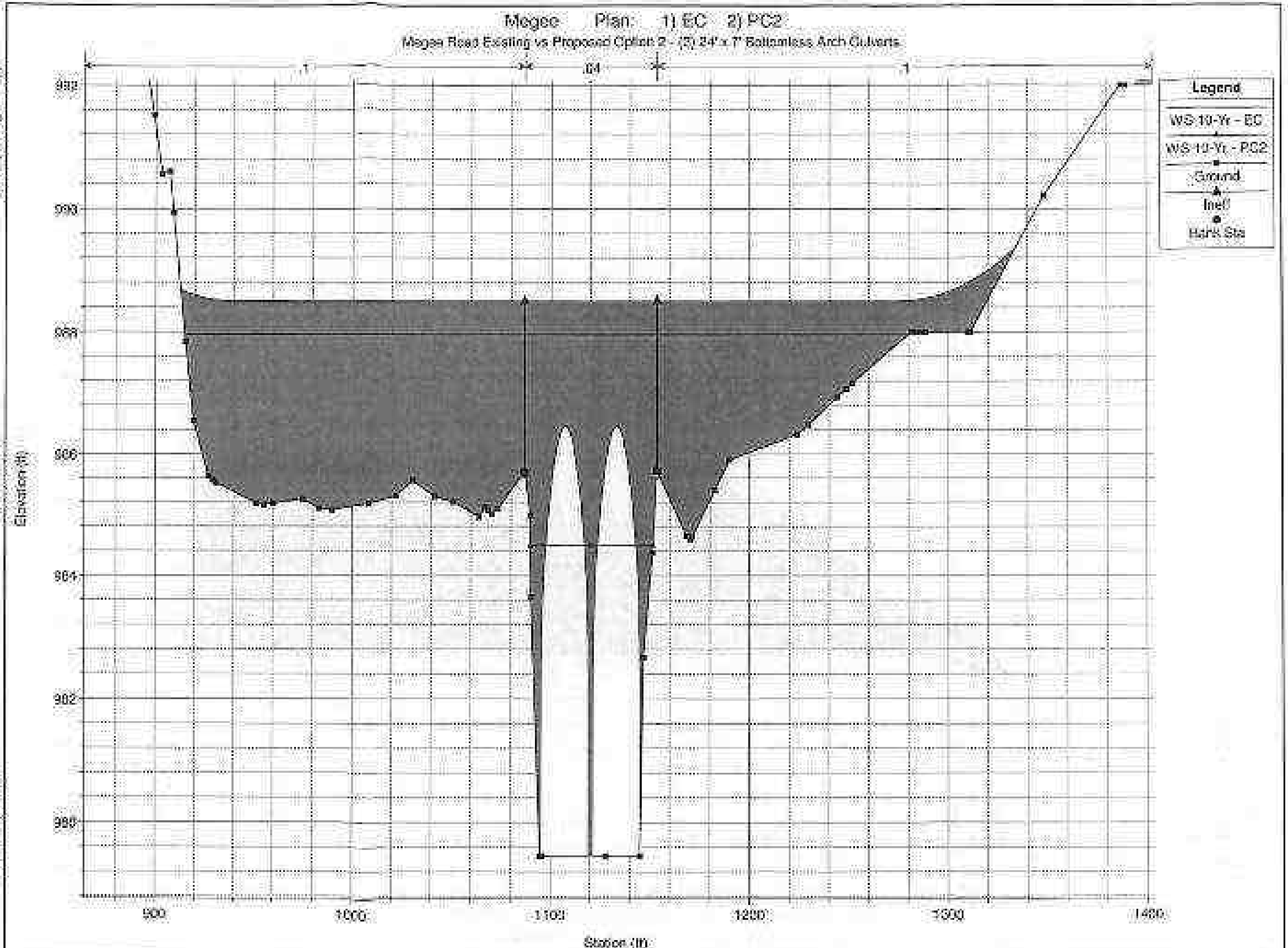
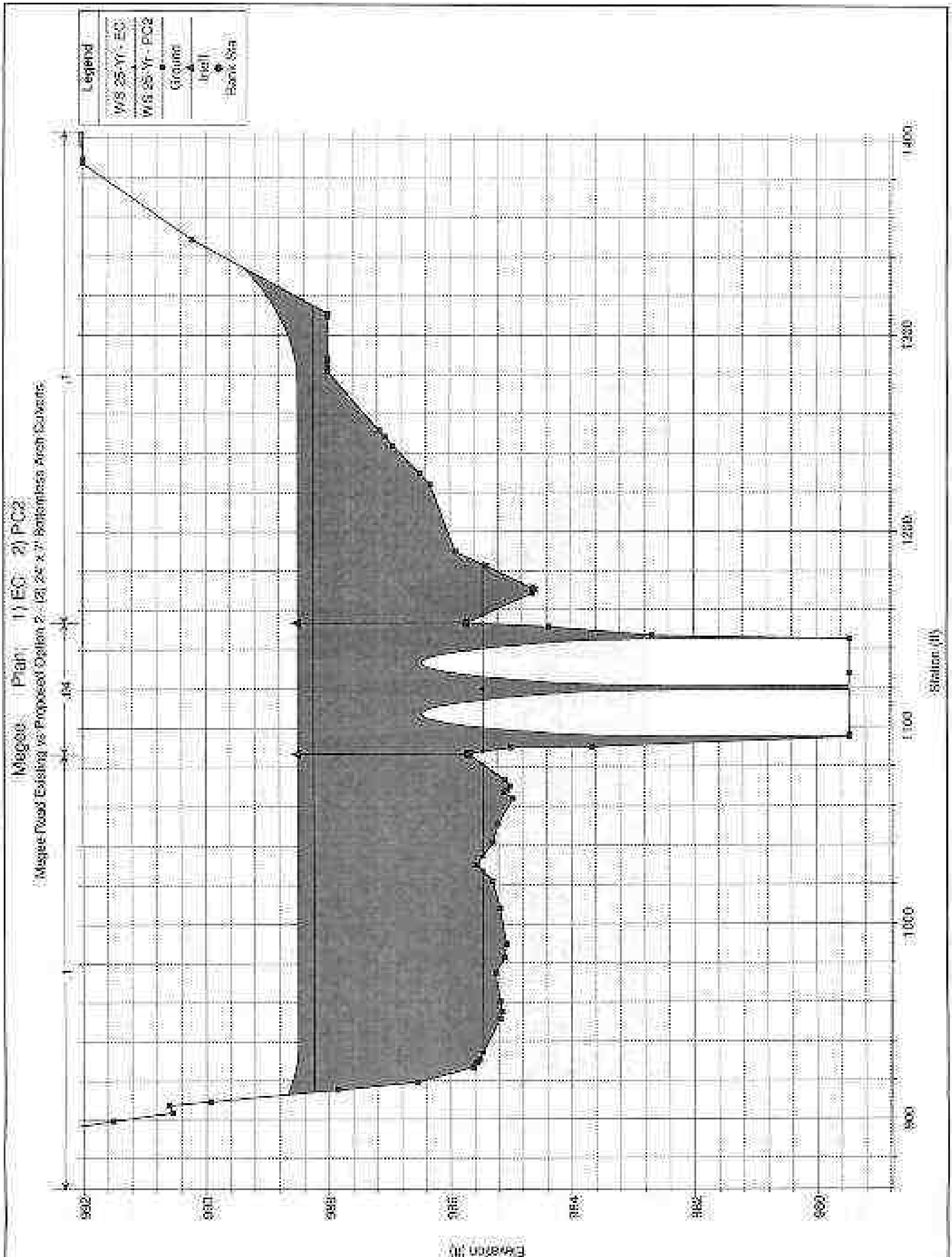
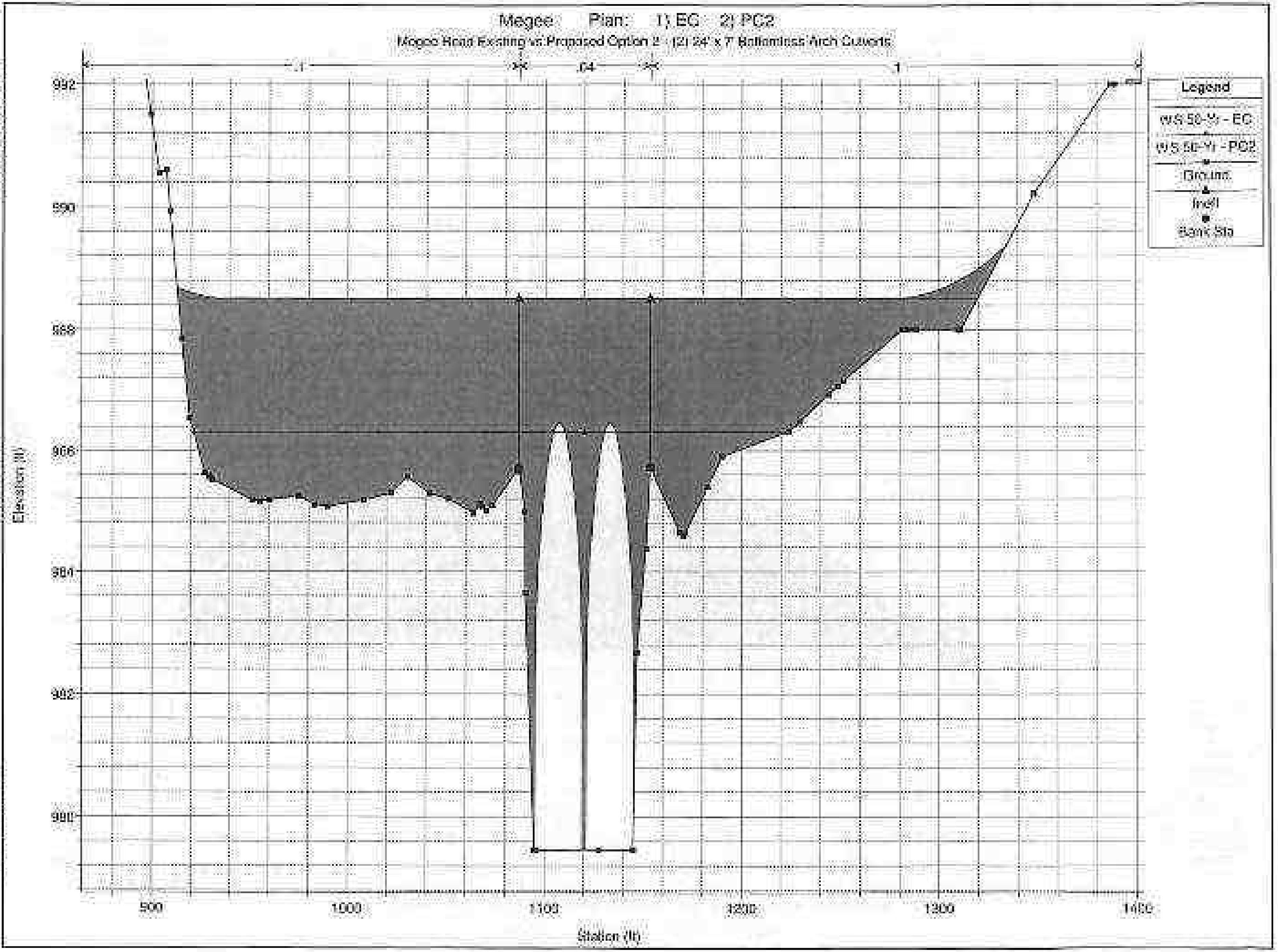
Megee Road Existing vs Proposed Option 2 - (2) 24' x 7' Bottomless Arch Culverts
.1
.04
.1
Legend
WS 2-Yr - EC
WS 2-Yr - PC2
Ground
Ineff
Bank Sta
992
990
988
986
984
982
980
900
1000
1100
1200
1300
1400
Station (ft)



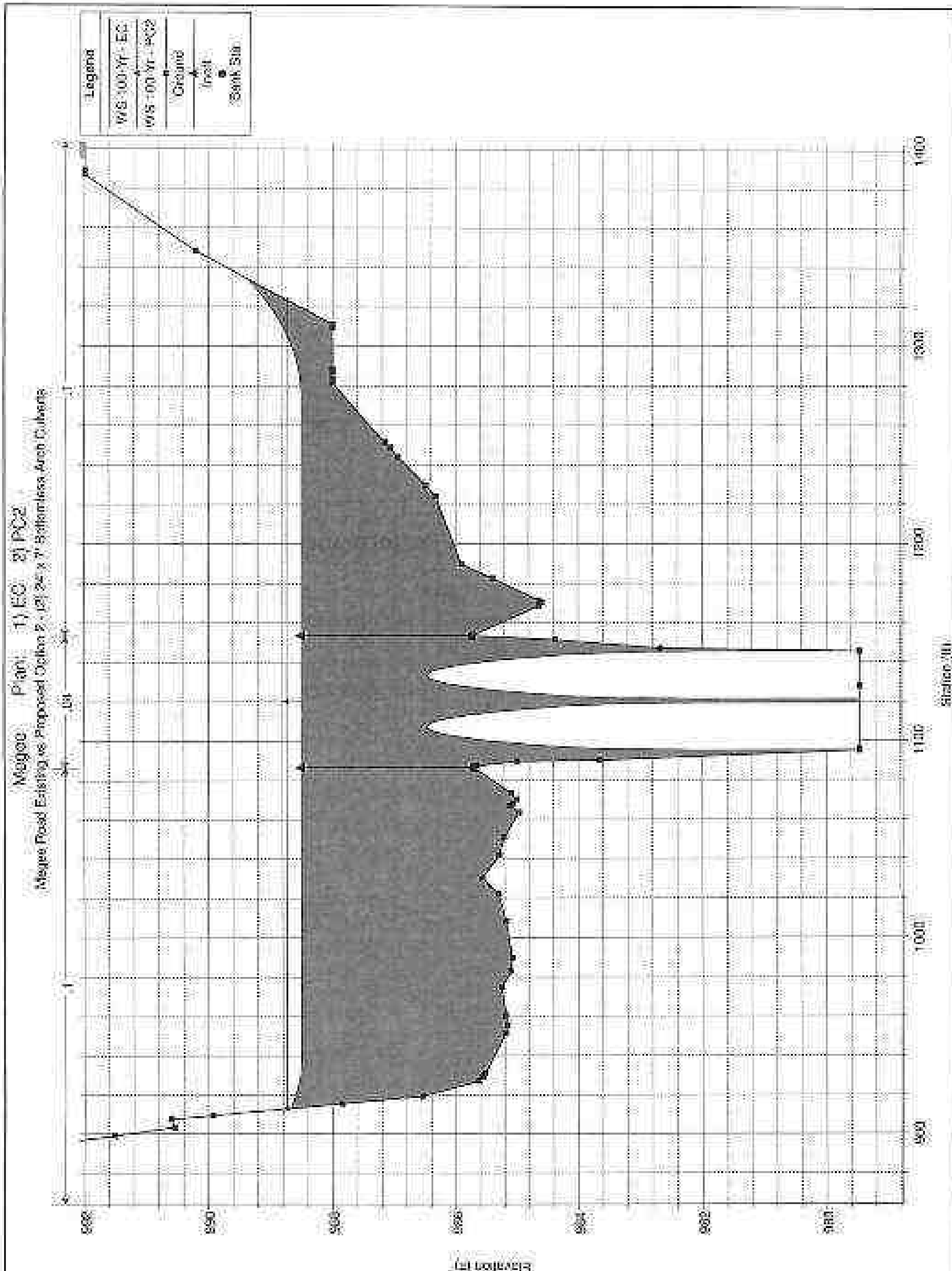
Megee Plan: 1) EC 2) PC2
Megee Road Existing vs Proposed Option 2 - (3) 24' x 7' Bottomless Arch Culverts
.1
.04
.1
Legend
WS 10-Yr - EC
WS 10-Yr - PC2
Ground
Ineff
Bank Sta
Elevation (ft)
992
990
988
986
984
982
980
Station (ft)
900
1000
1100
1200
1300
1400



Megee Plan: 1) EC 2) PC2
Megee Road Existing vs Proposed Option 2 - (2) 24' x 7' Bottomless Arch Culverts
Legend
WS 25-Yr - EC
WS 25-Yr - PC2
Ground
Ineff
Bank Sta
.1
.04
.1
Elevation (ft)
980
982
984
986
988
990
992
Station (ft)
900
1000
1100
1200
1300
1400



Megee Plan: 1) EC 2) PC2
Megee Road Existing vs Proposed Option 2 - (2) 24' x 7' Bottomless Arch Culverts
.1
.04
.1
Legend
WS 50-Yr - EC
WS 50-Yr - PC2
Ground
Ineff
Bank Sta
Elevation (ft)
992
990
988
986
984
982
980
Station (ft)
900
1000
1100
1200
1300
1400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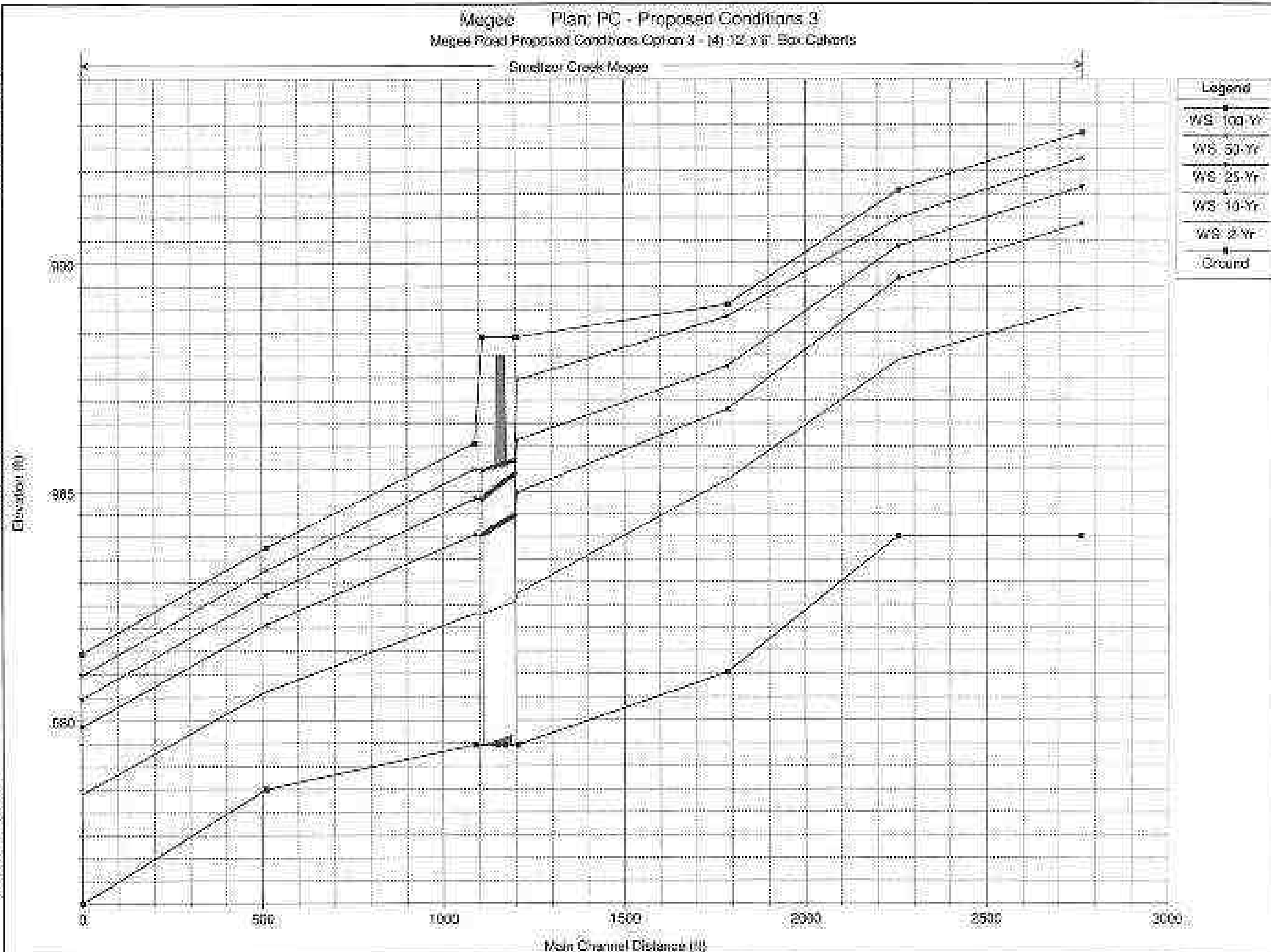
Megee Road Existing vs Proposed Option 2 - (2) 24' x 7' Bottomless Arch Culverts
Legend
WS 100 Yr - EC
WS 100 Yr - PC2
Ground
Ineff
Bank Sta
900
1000
1100
1200
1300
1400
Station (ft)
Elevation (ft)

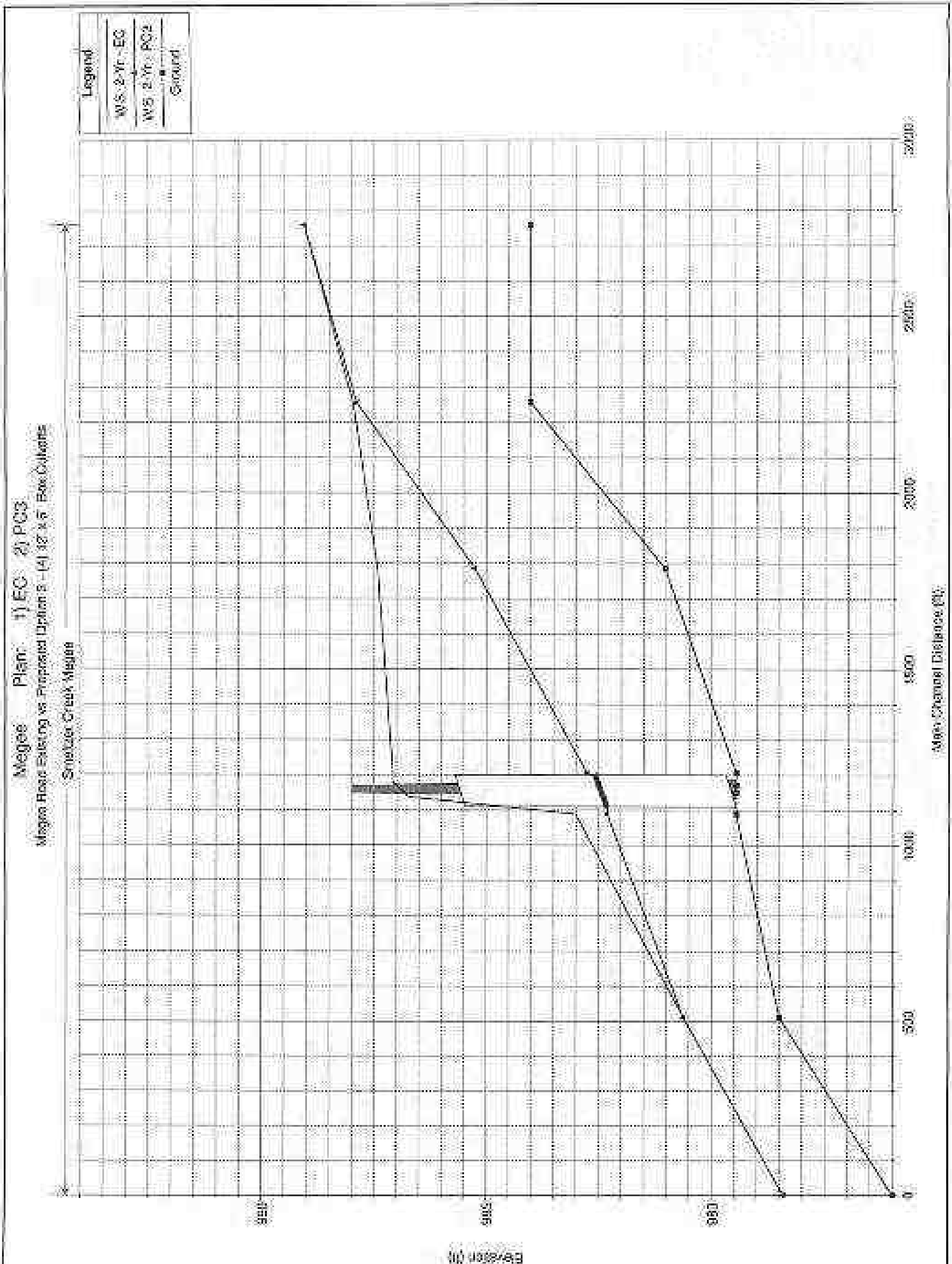
Appendix C.3
Option 3 Hydraulic Performance

Megee Road Culvert
Hydrologic, Hydraulic
And Alternatives Analysis

Appendix C.3
Option 3 - (4) 12' x 6' Box Culverts
Page C.3-1 of 11

Davis & Floyd, Inc.
D&F Job No. 12975.02
June 2013

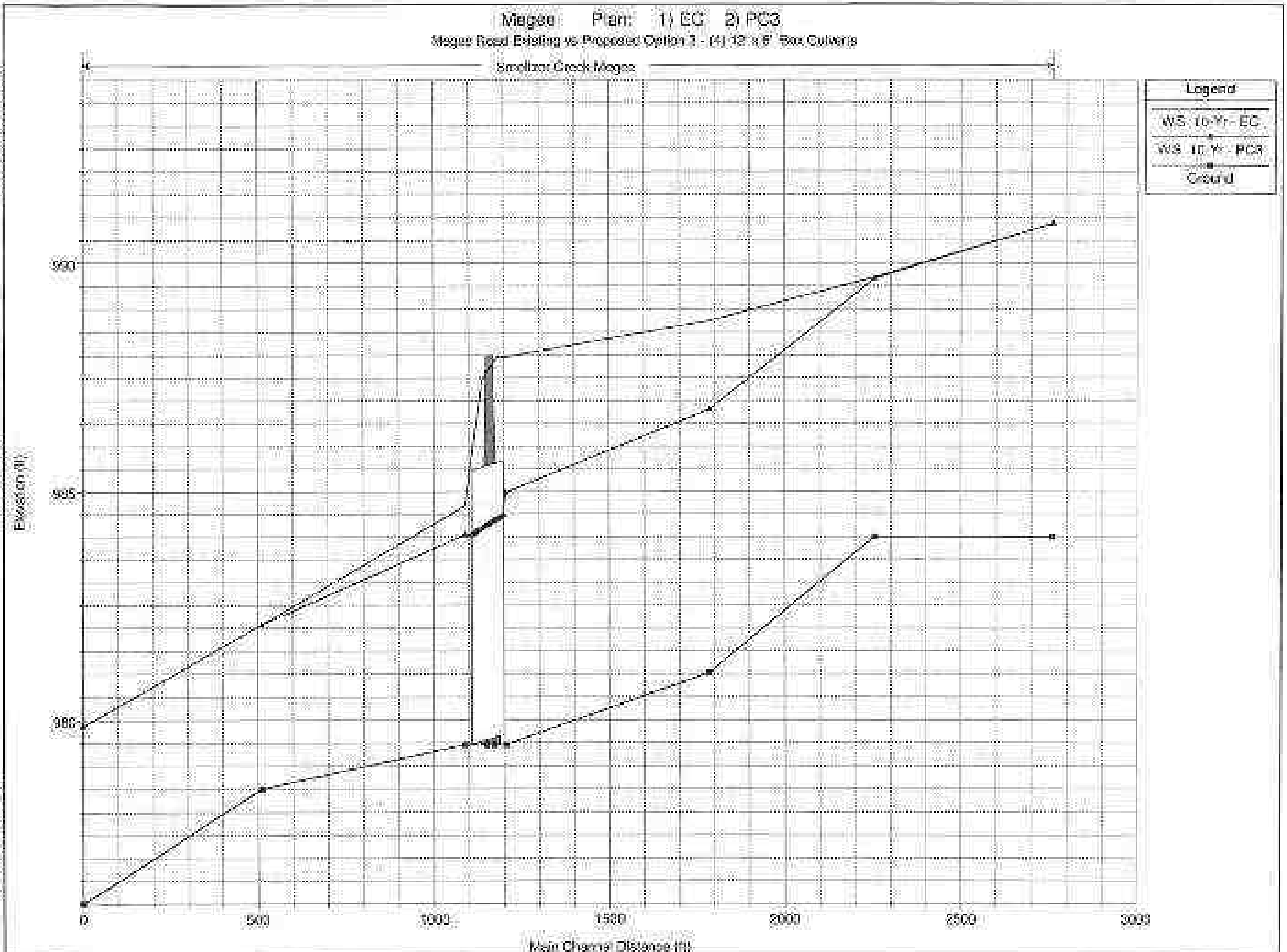


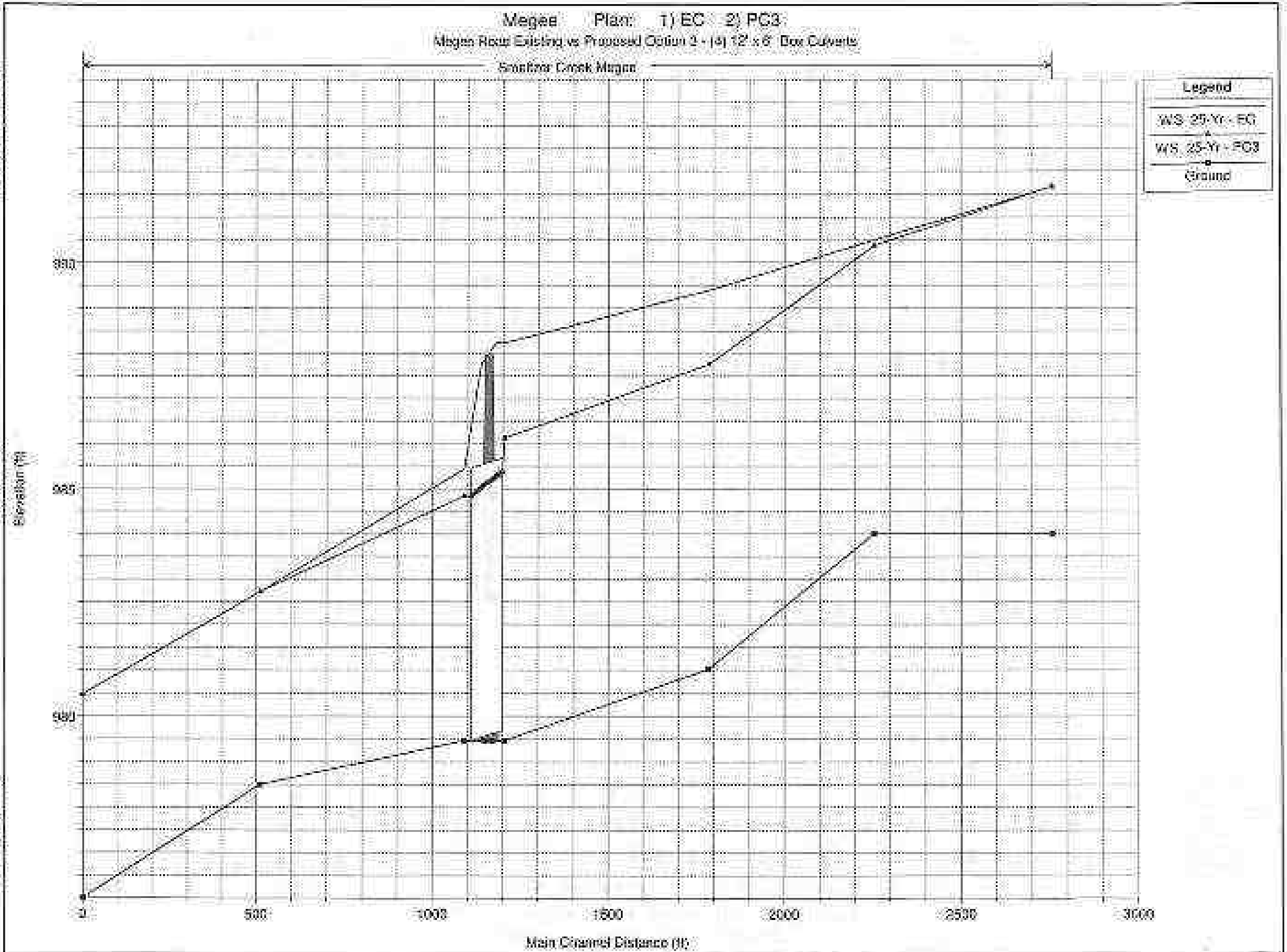

Megee Plan: 1) EC 2) PC3
Megee Road Existing vs Proposed Option 3 - (4) 12' x 6' Box Culverts
Snetzer Creek Megee
Legend
W.S. 2-Yr - EC
W.S. 2-Yr - PC3
Ground
Main Channel Distance (ft)
Elevation (ft)
0
500
1000
1500
2000
2500
3000
980
985
990

Magee Road Culvert
Hydrologic, Hydraulic
And Alternatives Analysis

Appendix C.3
Option 3 - (4) 12' x 6' Box Culverts
Page C.3-5 of 11

Davis & Floyd, Inc.
D&F Job No. 12975.02
June 2013





Megee Road Culvert
Hydrologic, Hydraulic
And Alternatives Analysis

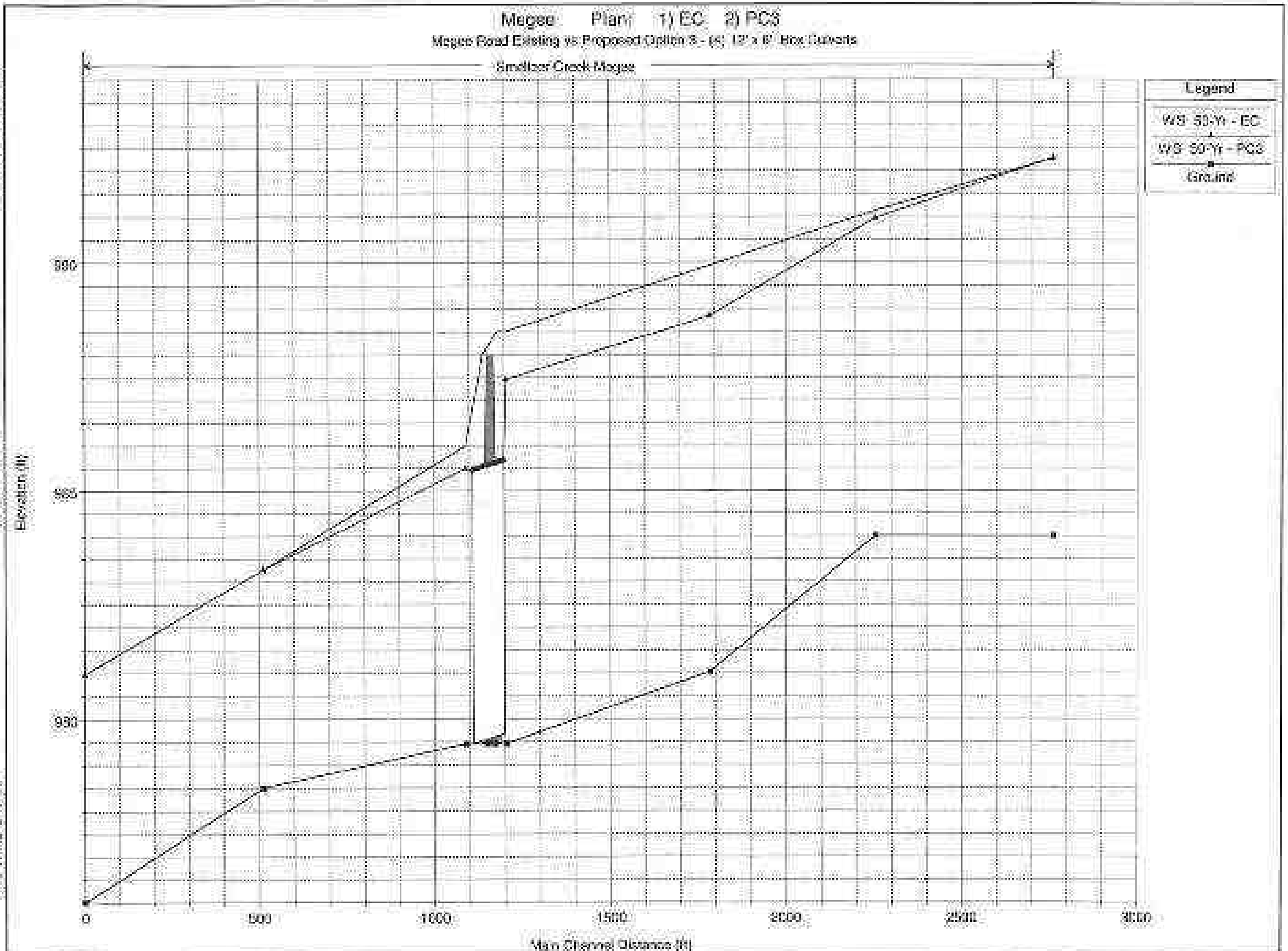
Appendix C.3
Option 3 - (4) 12' x 6' Box Culverts
Page C.3-4 of 11

Davis & Floyd, Inc.
D&F Job No. 12876.82
June 2013

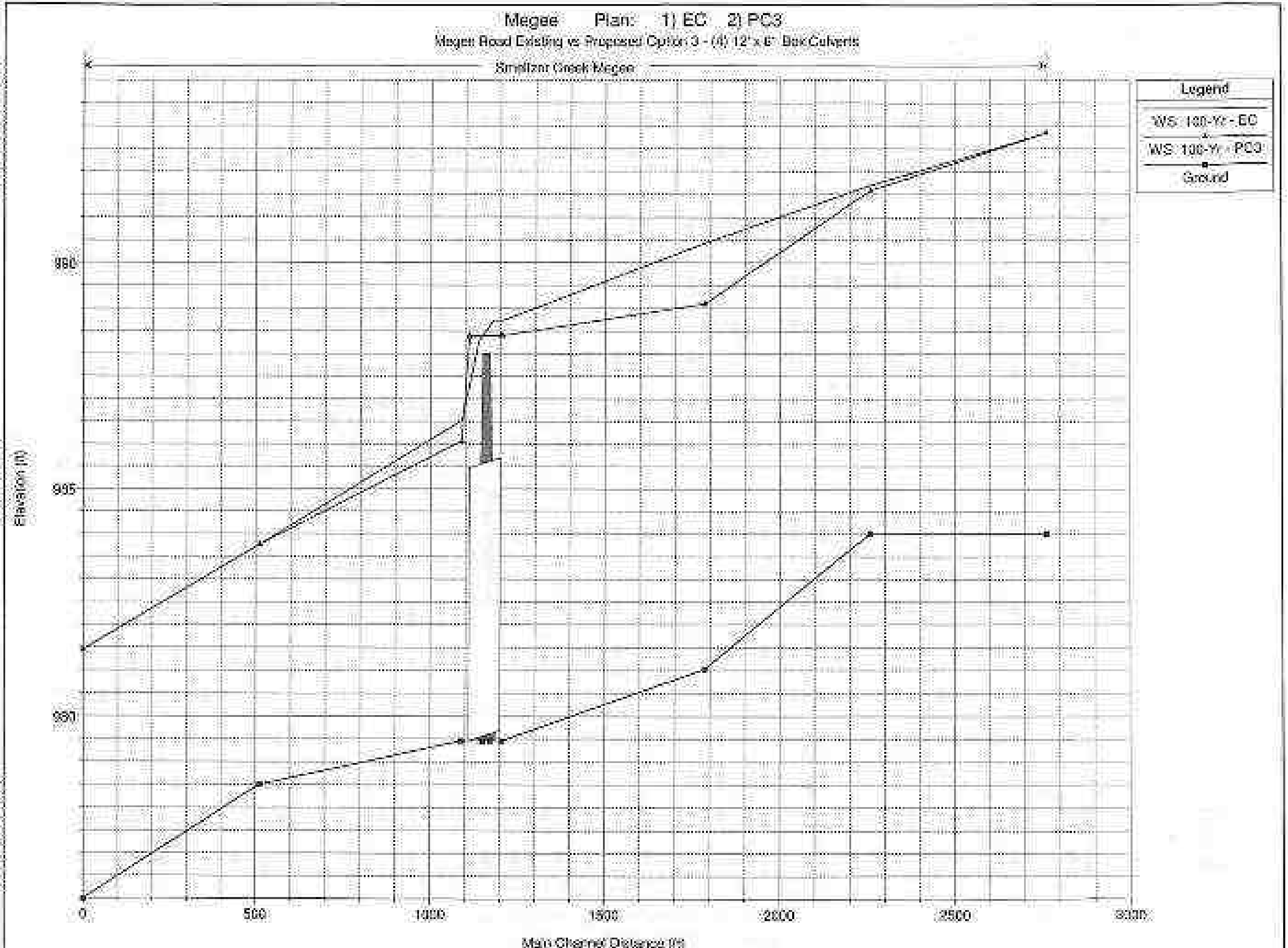
Magee Road Culvert
Hydrologic, Hydraulic
And Alternatives Analysis

Appendix C.3
Option 3 - (4) 12' x 6' Box Culverts
Page C.3.5 of 11

Davis & Floyd, Inc.
D&F Job No. 12975.02
June 2013

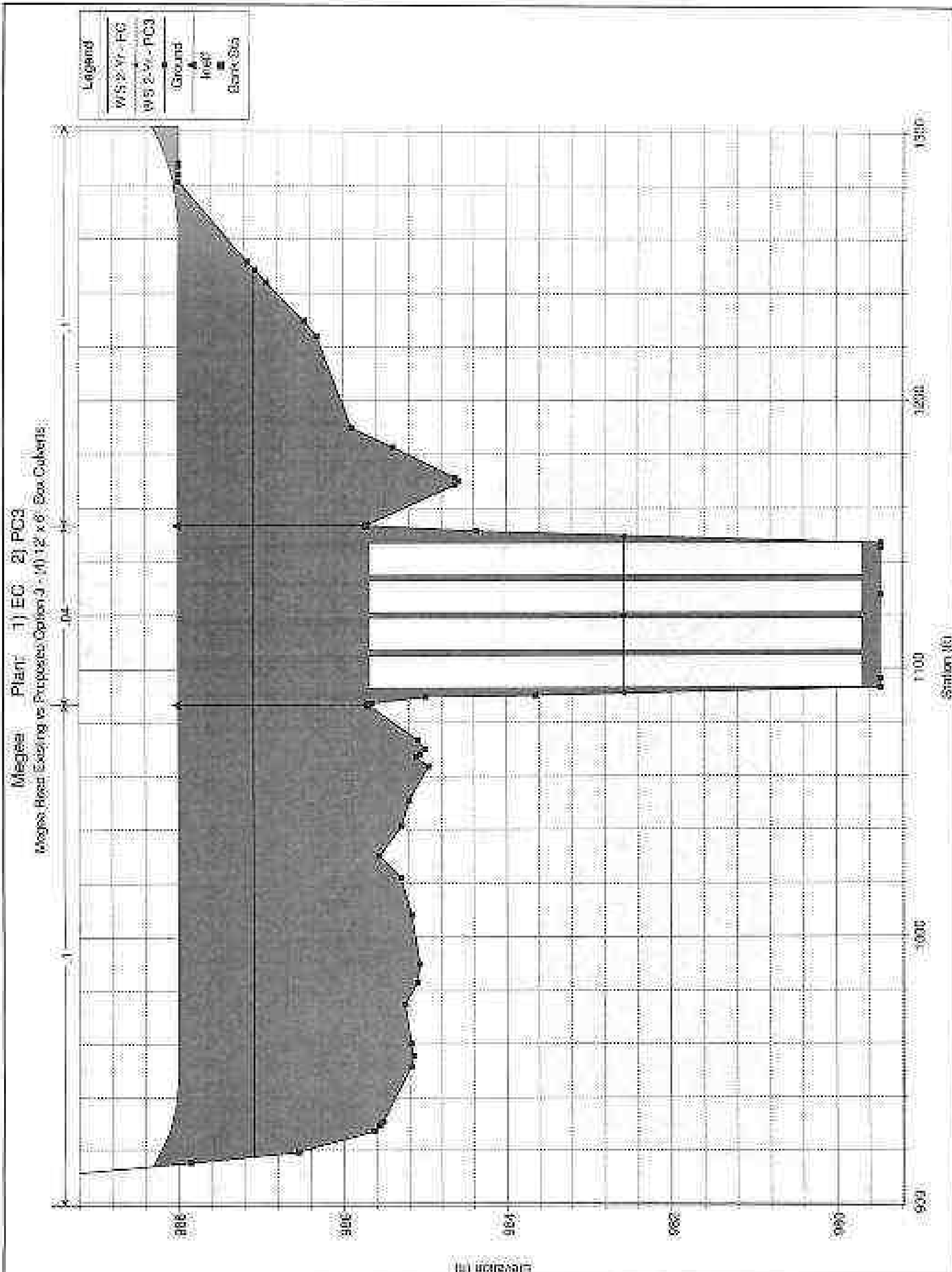


Megee Road Culvert
Hydrologic, Hydraulic
And Alternatives Analysis

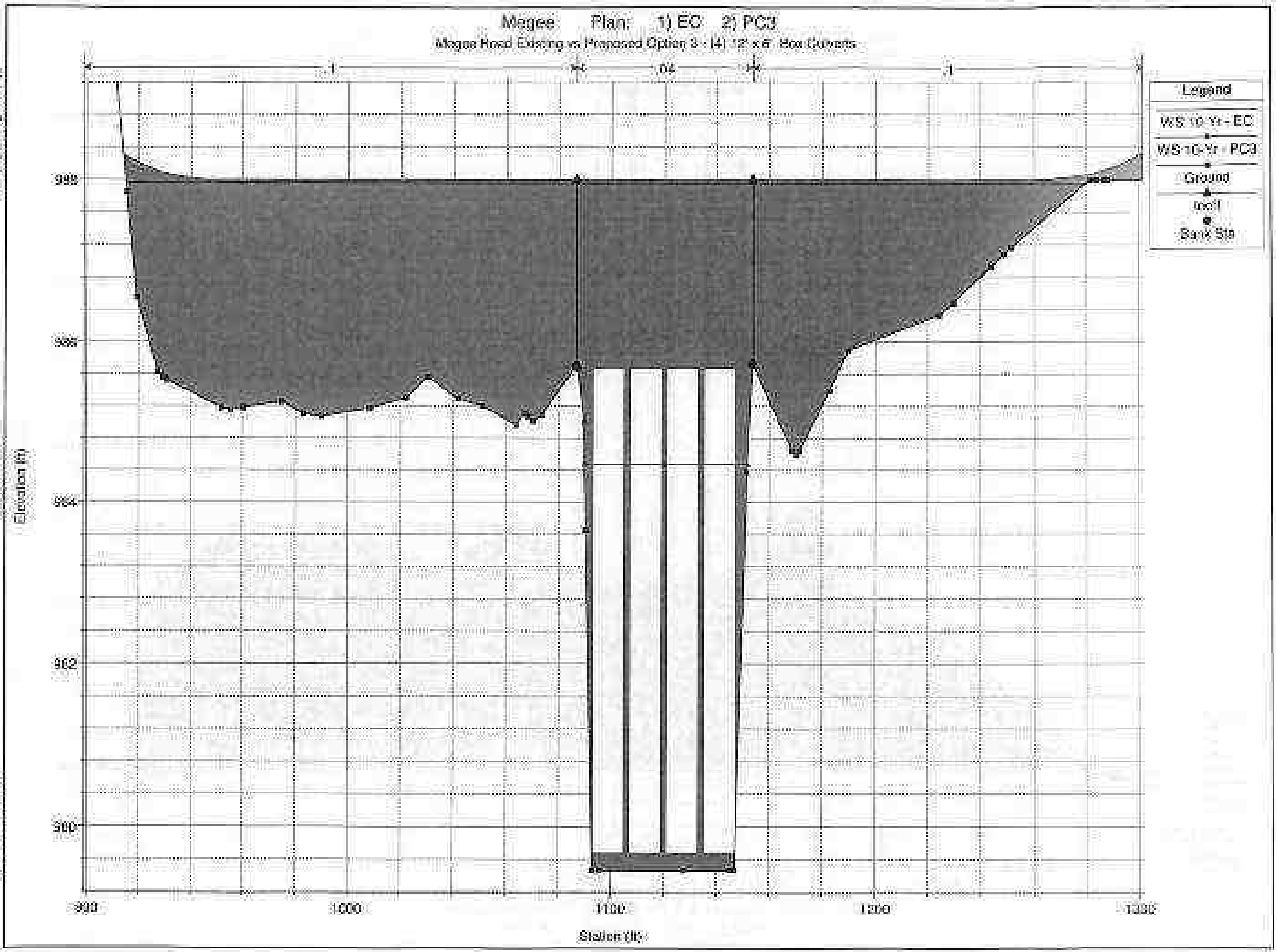


Appendix C.3
Option 3 - (4) 12' x 6' Box Culverts
Page C.3-6 of 11

Davis & Floyd Inc.
D&F Job No. 12075.02
June 2013



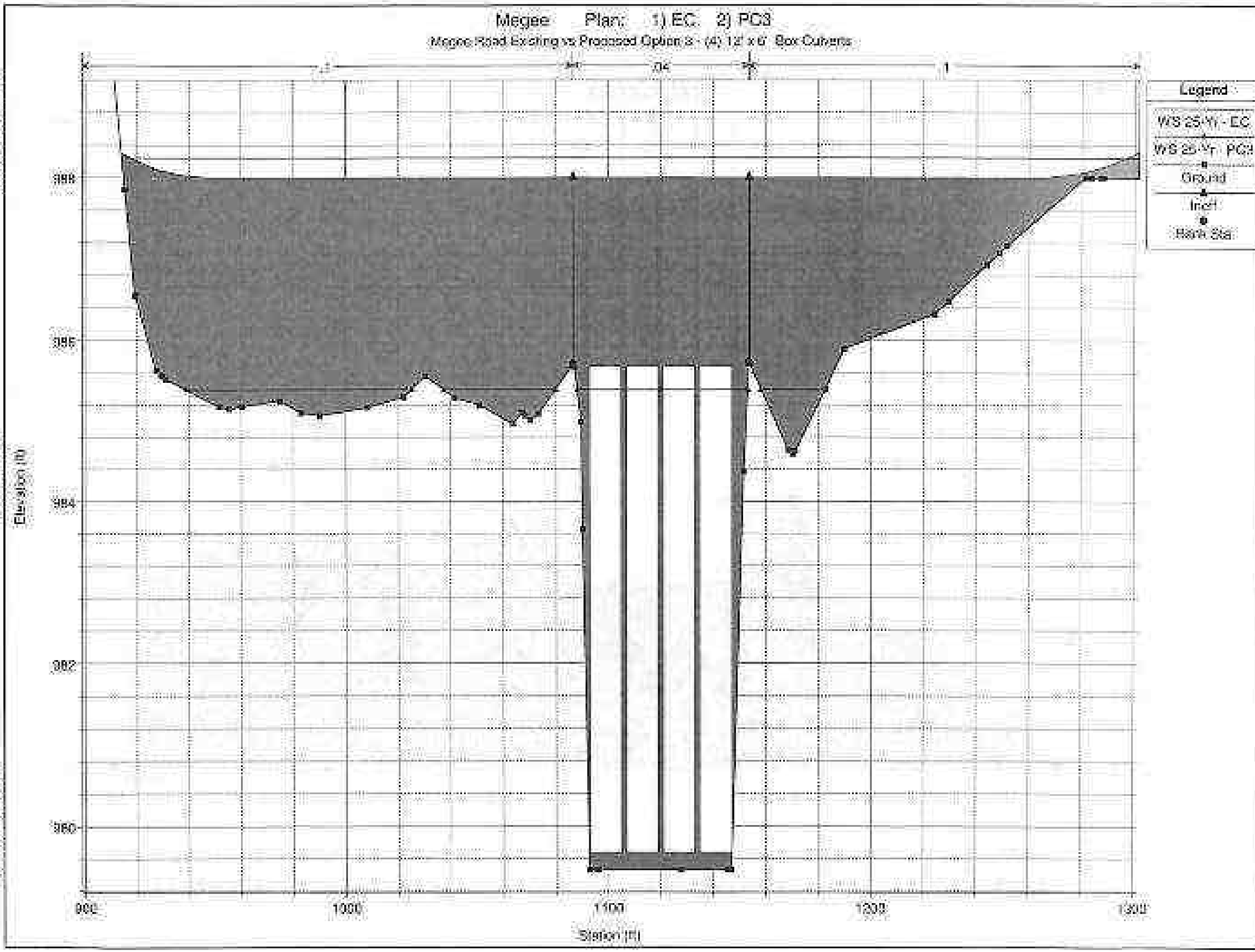
Megee   Plan: 1) EC   2) PC3
Megee Road Existing vs Proposed Option 3 - (4) 12' x 6' Box Culverts
Legend
Ground
Ineff
Bank Sta
Station (ft)
Elevation (ft)

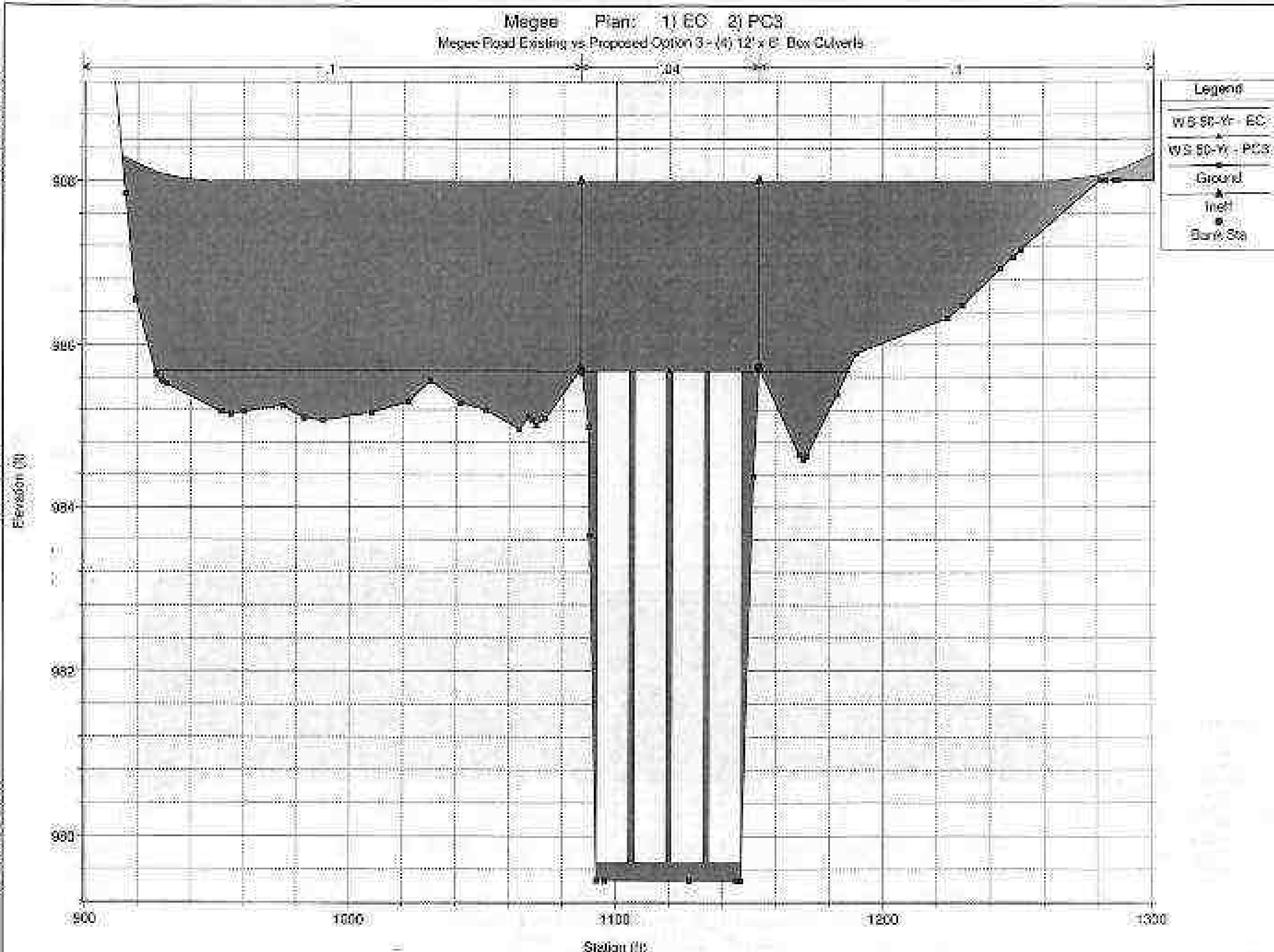


Megee Road Culvert
Hydrologic, Hydraulic
And Alternatives Analysis

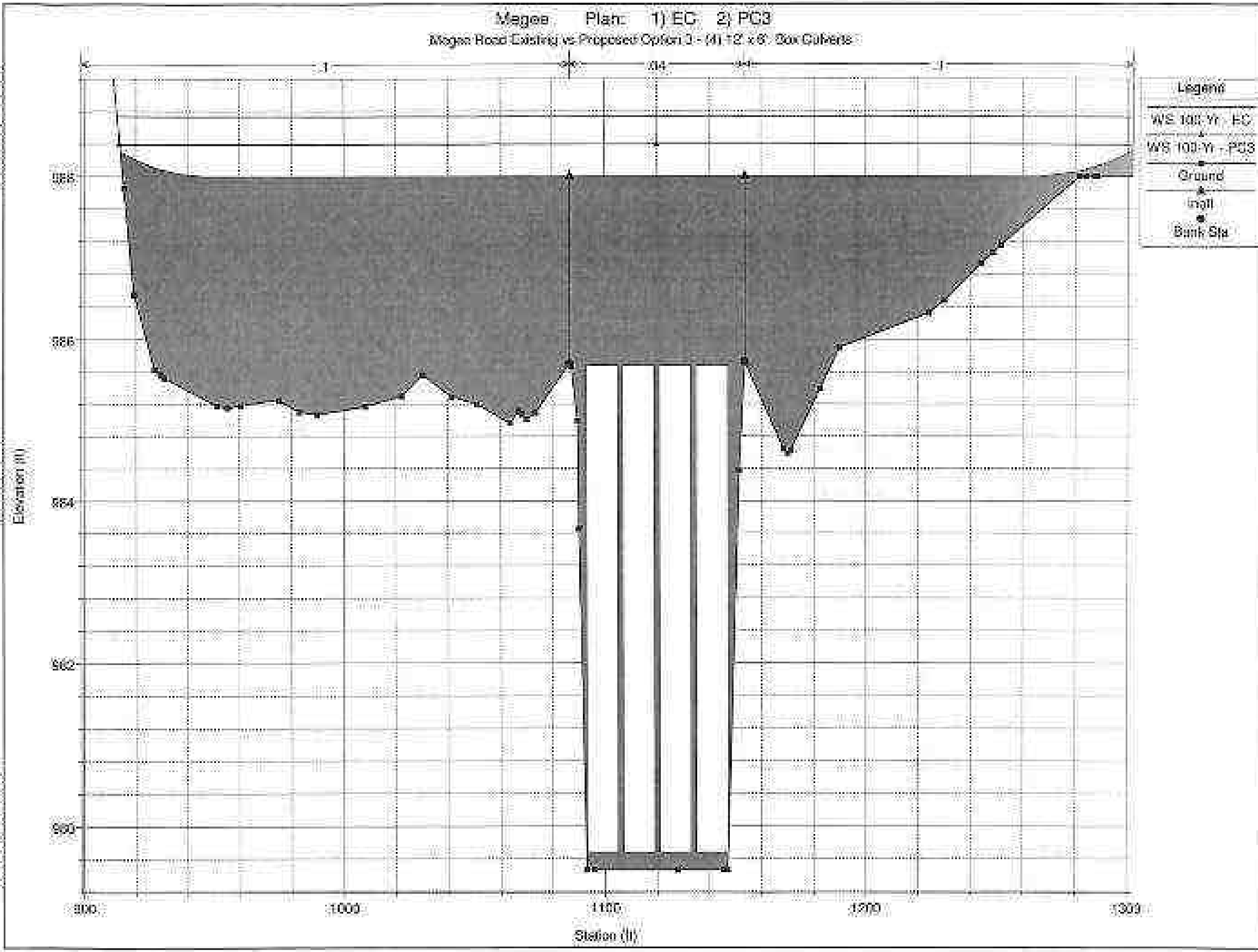
Appendix C.3
Option 3 - (4) 12' x 6' Box Culverts
Page C.3-9 of 11

Davis & Floyd, Inc.
D&F Job No. 12375.02
June 2013


Megee Plan: 1) EC 2) PC3
Megee Road Existing vs Proposed Option 3 - (4) 12' x 6' Box Culverts
.04
Legend
WS 25-Yr - EC
WS 25-Yr - PC3
Ground
Ineff
Bank Sta
Elevation (ft)
988
986
984
982
980
900
1000
1100
1200
1300
Station (ft)



Magee Plan: 1) EC 2) PC3
Magee Road Existing vs Proposed Option 3 - (4) 12' x 6' Box Culverts
.1
.04
.1
Legend
WS 50-Yr - EC
WS 50-Yr - PC3
Ground
Ineff
Bank Sta
988
986
984
982
980
Elevation (ft)
900
1000
1100
1200
1300
Station (ft)


Magee Plan: 1) EC 2) PC3
Magee Road Existing vs Proposed Option 3 - (4) 12' x 8' Box Culverts
.1
.04
.1
Legend
WS 100-Yr - EC
WS 100-Yr - PC3
Ground
Ineff
Bank Sta
Elevation (ft)
900
1000
1100
1200
1300
Station (ft)

Appendix D
Cost Estimates

DAVIS & FLOYD

Appendix D: Cost Estimate Option 1
Date: 2013-06-28
Project Name: Megee Road Culvert Analysis
Job No.: 12975.02
Calculated by: M. Putnam

Option 1 - 60' Flat Slab Bridge

Item	Description	Quantity	Unit	Unit Cost	Total Cost
1	Bridge				
	a. Foundation	1	LS	$ 20,000	$ 20,000
	b. Span (60' Hollow Core)	1	LS	$ 144,000	$ 144,000
2	Roadway Embankment				
	a. Pavement (GABC)	2000	SY	$ 13	$ 26,000
	b. Embankment Fill	1800	CY	$ 25	$ 45,000
	c. Driveway Replacement	1	EA	$ 1,500	$ 1,500
3	Channel Grading/Approaches				
	a.Channel Grading/Shaping	1	LS	$ 5,000	$ 5,000
	b. Rock Removal	250	CY	$ 90	$ 22,500
4	Contractor General Conditions and Mobilization	-	%	12%	$ 31,680
5	Design/Permitting	-	%	10%	$ 26,400
6	Contingency	-	%	30%	$ 96,624
				Total Estimated Project Cost	**$ 418,704**

DAVIS & FLOYD

Appendix D: Cost Estimate Option 2
Date: 2013-06-28
Project Name: Megee Road Culvert Analysis
Job No.: 12975.02
Calculated by: M. Putnam

Option 2 - (2) 24' x 7' Bottomless Arch Culverts

Item	Description	Quantity	Unit	Unit Cost	Total Cost
1	Culvert				
	a. Foundation	3	EA	$ 7,000	$ 21,000
	b. 24' x 7' Bottomless Arch Culvert	140	LF	$ 2,500	$ 350,000
2	Roadway Embankment				
	a. Pavement (GABC)	1170	SY	$ 13	$ 15,210
	b. Embankment Fill	900	CY	$ 25	$ 22,500
	c. Driveway Replacement	1	EA	$ 1,500	$ 1,500
3	Channel Grading/Approaches				
	a.Channel Grading/Shaping	1	LS	$ 5,000	$ 5,000
	b. Rock Removal	220	CY	$ 90	$ 19,800
4	Contractor General Conditions and Mobilization	-	%	12%	$ 52,201
5	Design/Permitting	-	%	10%	$ 43,501
6	Contingency	-	%	30%	$ 159,214
				Total Estimated Project Cost	**$ 689,926**

DAVIS & FLOYD

Appendix D: Cost Estimate Option 3
Date: 2013-06-28
Project Name: Megee Road Culvert Analysis
Job No.: 12975.02
Calculated by: M. Putnam

Option 3 - (4) 12' x 6' Box Culverts

Item	Description	Quantity	Unit	Unit Cost	Total Cost
1	Culvert				
	a. 12' x 6' Box Culvert	280	LF	$ 1,000	$ 280,000
2	Roadway Embankment				
	a. Pavement (GABC)	800	SY	$ 13	$ 10,400
	b. Embankment Fill	630	CY	$ 25	$ 15,750
	c. Driveway Replacement	1	EA	$ 1,500	$ 1,500
3	Channel Grading/Approaches				
	a.Channel Grading/Shaping	1	LS	$ 5,000	$ 5,000
	b. Rock Removal	200	CY	$ 90	$ 18,000
4	Contractor General Conditions and Mobilization	-	%	12%	$ 39,678
5	Design/Permitting	-	%	10%	$ 33,065
6	Contingency	-	%	30%	$ 121,018
			Total Estimated Project Cost		**$ 524,411**

Roads and Bridges

Date	Job Description	Number of Staff	Staff Hours	Equipment Hours
2/25/2013	Picking up sand & taking to Camp, Holly Springs, Wells Hwy; backhoe to Holly Springs	6	42	42
3/6/13-4/3/13	Old Flat Shoals Rd -patching	11	910	416
4/10/2013-6/27/13	Inspecting for striping contract	3	218	218
4/11/2013-4/12/2013	PWC-blading parking lot & putting up handrails at front steps	4	70	25
5/2/2013	Move 973 to Motor Pool	2	2	2
5/7/2013-5/8/13	Jocassee Lake Rd-crossline	8	160	90
5/20/13-5/21/13	Busch Creek Rd-replace crossline	5	100	60
5/31/2013 & 6/4/2013	Inspecting for crack sealing at Grandview Subdivision	1	10	10
6/11/2013-6/13/2013	Bent Tree Subd-pipe replacement	4	60	20
6/11/13-6/28/13	Camp-asphalt screenings	8	880	616
	Total	52	2452	1499

Sheriff's Dept

Date	Job Description	Number of Staff	Staff Hours	Equipment Hours
2/27/2013-2/28/2013	Firing Range	5	27	9
5/8/2013	Animal Shelter-parking lot	2	8	7
6/17/2013-6/25/2013	Camp Rd Mobile Home Demo	11	96	64
	Total	18	131	80

Solid Waste

Date	Job Description	Number of Staff	Staff Hours	Equipment Hours
4/2/2013	Landfill - Scraping Roads	1	8	8
4/23/2013	Landfill-hydroseeding	1	5	5
4/25/2013	Oil Separator	1	2	2
5/8/2013	Moved mower to Five Forks landfill	1	2	2
5/15/2013	Moved mower from Five Forks back to Solid Waste	1	3	3
5/31/13-6/24/13	Solid Waste-Glass pad	6	76	58
	Total	11	96	78

Forestry Service

Date	Job Description	Number of Staff	Staff Hours	Equipment Hours
3/6/2013	Piedmont Tree Nursery-haul, spread and compact gravel	1	4	4
5/13/2013	Piedmont Tree Nursery-haul, spread and compact gravel	1	4	4
	Total	2	8	8

Golden Corner Commerce Park

Date	Job Description	Number of Staff	Staff Hours	Equipment Hours
2/19/2013	Spot weld on catch basins	3	9	6
	Total	3	9	6

Roads Bridges — Special Projects — 2/1/13 - 6/30/13

PRT

Date	Job Description	Number of Staff	Staff Hours	Equipment Hours
2/3/13-2/24/2013	Chau Ram - Grading for storage building pad	5	178	108
2/6/2013	Chau Ram - Taking down trees	4	40	24
3/22/2013-3/26/13	Chau Ram-demolishing old house	5	104	75
3/27/2013-5/30/13	Chau Ram-Waterlines	12	1056	494
4/15/13-4/17/13	South Cove-Sewer problem	4	64	40
6/5/2013	High Falls -water line	2	5	5
6/13/2013	High Falls - tree	5	8	2
6/27/2013	Chau Ram-haul 3 loads gravel	2	8	8
	Total	39	1463	756

Airport

Date	Job Description	Number of Staff	Staff Hours	Equipment Hours
6/6/2013	Shed Removal	5	35	21
	Total	5	35	21

Administration

Date	Job Description	Number of Staff	Staff Hours	Equipment Hours
3/9/2013	Removing steps behind Keowee Courier	4	20	12
4/24/2013	New Heritage Fair - Hauling gravel	1	4	4
5/31/2013	New Heritage Fair-haul 6 loads gravel	3	10	10
	Total	8	34	26

LEC

Date	Job Description	Number of Staff	Staff Hours	Equipment Hours
2/12/2013	Hauled gravel	1	2	2
2/23/2013	Scrape parking lot	2	6	6
	Total	3	8	8

Emergency Servies

Date	Job Description	Number of Staff	Staff Hours	Equipment Hours
2/5/2013	Holly Springs Fire Station-Apron	5	40	24
2/5/2013-2/6/2013	Foxwood Fire Station-Apron	5	50	28
2/15/2013	Bruce Rd-pipe replacement	1	4	4
5/29/2013	Foxwood Fire Station-haul gravel	1	3	3
	Total	12	97	59

LakeView Assisted Facility

Date	Job Description	Number of Staff	Staff Hours	Equipment Hours
2/21/2013	Dig footings	3	12	4
	Total	3	12	4

Pine Street

Date	Job Description	Number of Staff	Staff Hours	Equipment Hours
2/19/2013	Bucket truck	1	2	2
2/26/2013	Bucket truck-flag pole maintenance	1	2	2
4/19/2013-5/2/2013	Drainage Issues	6	53	23
	Total	8	57	27

Roads Bridges — Special Projects — 2/1/13 - 6/30/13

VA

Date	Job Description	Number of Staff	Staff Hours	Equipment Hours
5/21/2013	Cut trees for carport	4	10	4
	Total	4	10	4

Oconee Focus

Date	Job Description	Number of Staff	Staff Hours	Equipment Hours
6/12/2013	Fish Hatchery Rd-fixing cut	5	30	16
	Total	5	30	16

DSS

Date	Job Description	Number of Staff	Staff Hours	Equipment Hours
3/26/2013	Bucket truck-flag pole maintenance	1	1	1
3/27/2013	Tree	4	12	5
6/12/2013	Bucket truck-painting	1	3	3
	Total	6	16	9

Collins Children's Home

Date	Job Description	Number of Staff	Staff Hours	Equipment Hours
6/13/2013	Haul gravel	2	4	4
	Total	2	4	4

Pending Special Projects

- Camp Rd Crushing and Screening
- Paving Contract 2013/2014 and in-house culvert replacement
- New Construction Contract 2013/2014
- Cobb Bridge Revitalization
- Mauldin Mill & Megee Rd Crossing Replacement
- Airport House Demolition
- GCCP Access
- Hospital Property Access
- Dyar Bridge - Waiting on determination from Norfolk Southern
- Title II Grant Money - Land Bridge

Total Staff Hours	4462
Percent of Hours worked on Special Projects	21%