ENGINEERING PLANNING SURVEYING CONSTRUCTION SERVICES

CANDIDATE ASSESSMENT REPORT
McMICKEN DAM/WHITE TANKS #3

PBS&J

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CANDIDATE ASSESSMENT REPORT
McMICKEN DAM/WHITE TANKS #3

Flood Control District of Maricopa County

February 24, 1999

PBS&J

ENGINEERING PLANNING SURVEYING CONSTRUCTION SERVICES

PBS&J Reference No. 54209

PBS&J

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CONSTRUCTION SERVICES
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February 24, 1999

Mr. Joe Tram, P.E.
Project Manager
Flood Control District of Maricopa County
2801 West Durango
Phoenix, Arizona 85009

RE: CANDIDATE ASSESSMENT REPORT
MCMICKEN DAM/WHITE TANKS #3
PBS&J PROJECT NUMBER 54209.00

Dear Mr. Tram:

Transmitted herewith are 3 copies of the McMicken Dam/White Tanks #3 Candidate Assessment Report. If you have any questions please contact our office at (702) 263-7275.

Sincerely,

PBS&J

Matt Baird

Matt Baird, P.E.
Project Manager

Todd Kenner

Todd Kenner, P.E.
Executive Vice President

Registered Professional Engineer (Civil)
CERTIFICATE NO.
23172
TODD J.
KENNER
Date Signed 2/24/99
ARIZONA U.S.A.

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Executive Summary

Problem Identification:

The Beardsley Canal Wash (Canal Wash) is adjacent to the west side of the Beardsley Canal. The Canal Wash if fed by two major tributaries, Waterfall Wash and Cholla Wash. Waterfall Wash runs within a few hundred feet of the southwest end of McMicken Dam and joins the Canal Wash just upstream of Olive Avenue. Cholla Wash joins the Canal Wash halfway between Olive Avenue and Northern Avenue. The Canal Wash drains to the White Tanks Flood Retention Structure #3. FRS #3 was constructed to detain all flow tributary to the Canal Wash. It was designed to accept large peak flows from the Canal Wash, detain them and discharge a small controlled volume of water, thus eliminating the damaging effects of high peak flow volumes downstream. Under current conditions a large portion of flow draining to the Canal Wash escapes collection by FRS #3 by overtopping the Beardsley Canal. Overtopping of the canal causes damage to the canal, increases repair costs to county roads downstream of the breakouts and is contributing to 6 miles of Federal Emergency Management Agency (FEMA) special flood hazard area downstream (east) of Northern Avenue. Proposed improvements to eliminate the breakouts was first analyzed in a report by AGK Engineers Inc., which proposed a subcritical concrete channel at a cost of $10,000,000. Proposed improvements to eliminate the breakouts are reanalyzed in this report to find a more cost effective solution. The improvements proposed in this report and discussed below are estimated to cost $1,592,000, which is 1/6th of the proposed channel improvements in the AGK report. In addition, the proposed replacements of the Olive Avenue and Northern Avenue crossings of the Canal Wash include full 60-foot right-of-way improvements that will need to be made at some point in the near future as this area develops. Construction of the proposed improvements will allow FRS #3 to fulfill its intended purpose, eliminate flood damage to the canal, reduce repair costs to county roads downstream and allow the FEMA special flood hazard area downstream (east) of Northern Avenue to be removed by Letter of Map Revision (LOMR).

Summary Recommendation:

In order to eliminate the breakouts it is recommended that four improvements be made to the existing system as follows:

1. Construct a diversion dike across Waterfall Wash to divert all flow in the wash to McMicken Dam. The Flood Control District has confirmed that McMicken Dam has the storage capacity required to accommodate the additional flow. This will reduce the peak flows in the Canal Wash and reduce the size of the proposed structures in items 2 and 3.
   Preliminary Cost Estimate = $284,000

2. Replace the existing culverts at Olive Avenue with 5 – 10' x 5' Reinforced Concrete Box Culverts (RCB's). This will provide the conveyance capacity needed to eliminate the breakout across the canal at this location.
   Preliminary Cost Estimate = $170,000

3. Realign and widen the confluence of Cholla Wash and Canal Wash and revegetate after construction is complete. The realignment of Cholla Wash will provide a more efficient hydraulic transition between the two washes. Widening the washes will provide the conveyance capacity required to reduce the water surface elevation. Revegetation will allow the area to return to its natural condition and maintain its hydraulic characteristics. These improvements will eliminate the breakout at this location.
   Preliminary Cost Estimate = $689,000
   Note: This cost could be reduced by $364,000 (53%) if a temporary grading permit could be obtained instead of acquiring right-of-way.

4. Replace the existing culverts at Northern Avenue with a 70-foot bridge and construct a grade control structure on the downstream side. This will provide the conveyance capacity needed to eliminate the breakout across the canal and maintain the existing profile of the wash.
   Preliminary Cost Estimate = $449,000

Total Preliminary Cost Estimate = $1,592,000
= $1,228,000 with 53% reduction in item 3 cost

Executive Summary ..... *i*

CHAPTER 1 - INTRODUCTION *1*

1.1 Study Purpose **1**

1.2 Location **1**

1.3 Previous Studies **3**

1.4 Hydrologic Analysis **3**

CHAPTER 2 – EXISTING CONDITION ANALYSIS *3*

2.1 Data Collection **3**

2.2 Field Investigation **4**

2.3 Manning's "n" Analysis **4**

2.4 Degradation and Scour Analysis **5**

2.5 Existing Condition HEC-2 and HEC-RAS Models **6**

CHAPTER 3 – ALTERNATIVE ANALYSIS *9*

3.1 Overview **9**

3.2 Alternative 1A **9**

3.3 Alternative 1B **9**

3.4 Alternative 2A **10**

3.5 Alternative 2B **10**

3.6 Alternative 3A **11**

3.7 Alternative 3B **11**

3.8 Alternative 3C **12**

CHAPTER 4 – RECOMMENDED ALTERNATIVE *13*

4.1 Alternative 3C – Recommended Alternative **13**

4.2 Hydraulic Analysis **17**

4.3 Cost Summary **19**

CHAPTER 5 – CONCLUSION *20*

CHAPTER 6 – BIBLIOGRAPHY *21*

APPENDICES

APPENDIX A	**PICTURES 1 – 17 NOVEMBER 1998**
APPENDIX B	**PICTURES FROM ADMS JUNE 1992**
APPENDIX C	**MANNING'S "n" CALCULATIONS**
APPENDIX D	**PRELIMINARY COST ESTIMATE CALCUALTIONS**
APPENDIX E	**DEGRADATION AND SCOUR CALCULATIONS**
APPENDIX F	**EXISTING CONDITION HEC-RAS OUPUT**
APPENDIX G	**RECOMMENDED ALTERNATIVE HEC-RAS OUTPUT**
APPENDIX H	**HEC-RAS INPUT FILES (DISKETTE)**
APPENDIX I	**HEC-RAS CROSS-SECTION MAPS**

LIST OF FIGURES

Figure 1-1	Vicinity Map	1
Figure 1-2	FEMA 100-year Floodplain Delineations	2
Figure 4-1	Waterfall Wash Diversion Dike	15
Figure 4-2	Cholla Wash	16
Figure 4-3	Gabion Drop Structure	17

LIST OF TABLES

Table 2-1	State Standard for Watercourse System Sediment Balance	6
Table 2-2	Water Surface Elevation Comparison, Model 1 vs. Model 2	8
Table 2-3	Water Surface Elevation Comparison, Model 2 vs. Model 3	8
Table 3-1	Alternatives Matrix	12
Table 4-1	Water Surface Elevation Comparison, Existing vs. Proposed	18

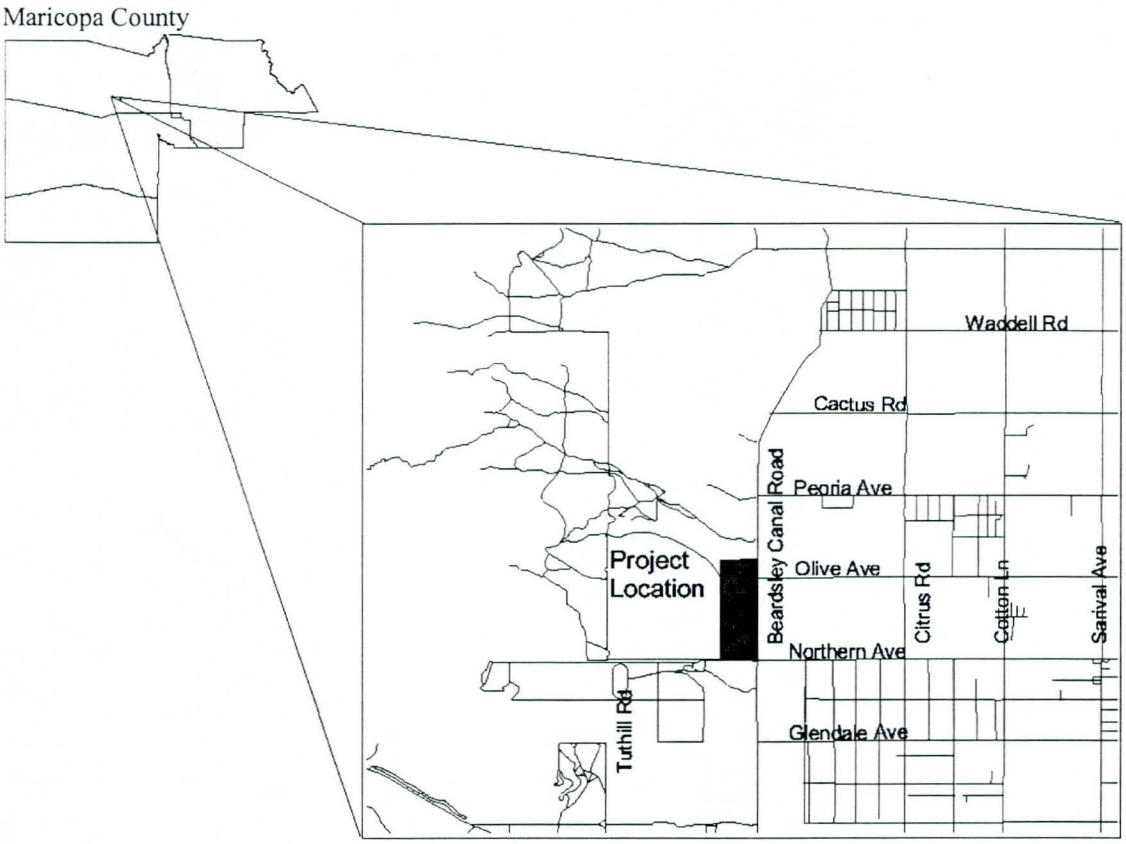
CHAPTER 1 - INTRODUCTION

1.1 Study Purpose

This study assesses the proposed improvements to enhance the inlet channel (Beardsley Canal Wash) performance for the White Tanks Flood Retention Structure (FRS) #3. This study determines the feasibility, based on hydraulic modeling and conceptual cost estimates, of eliminating the overtopping of the Beardsley Canal during a 100-year flood event.

1.2 Location

As shown in **Figure 1-1** and **Figure 1-2** the study area is located in the northern portion of Maricopa County and is approximately 5 miles west of Luke Air Force Base. The Beardsley Canal Wash is located on the west side of Beardsley Canal Road and extends from just north of Peoria Avenue to Glendale Avenue. At Glendale Avenue, FRS #3 begins and extends approximately 1 mile southwest. **Figure 1-2** was taken from the ADMS and shows the 100-year floodplain delineations.



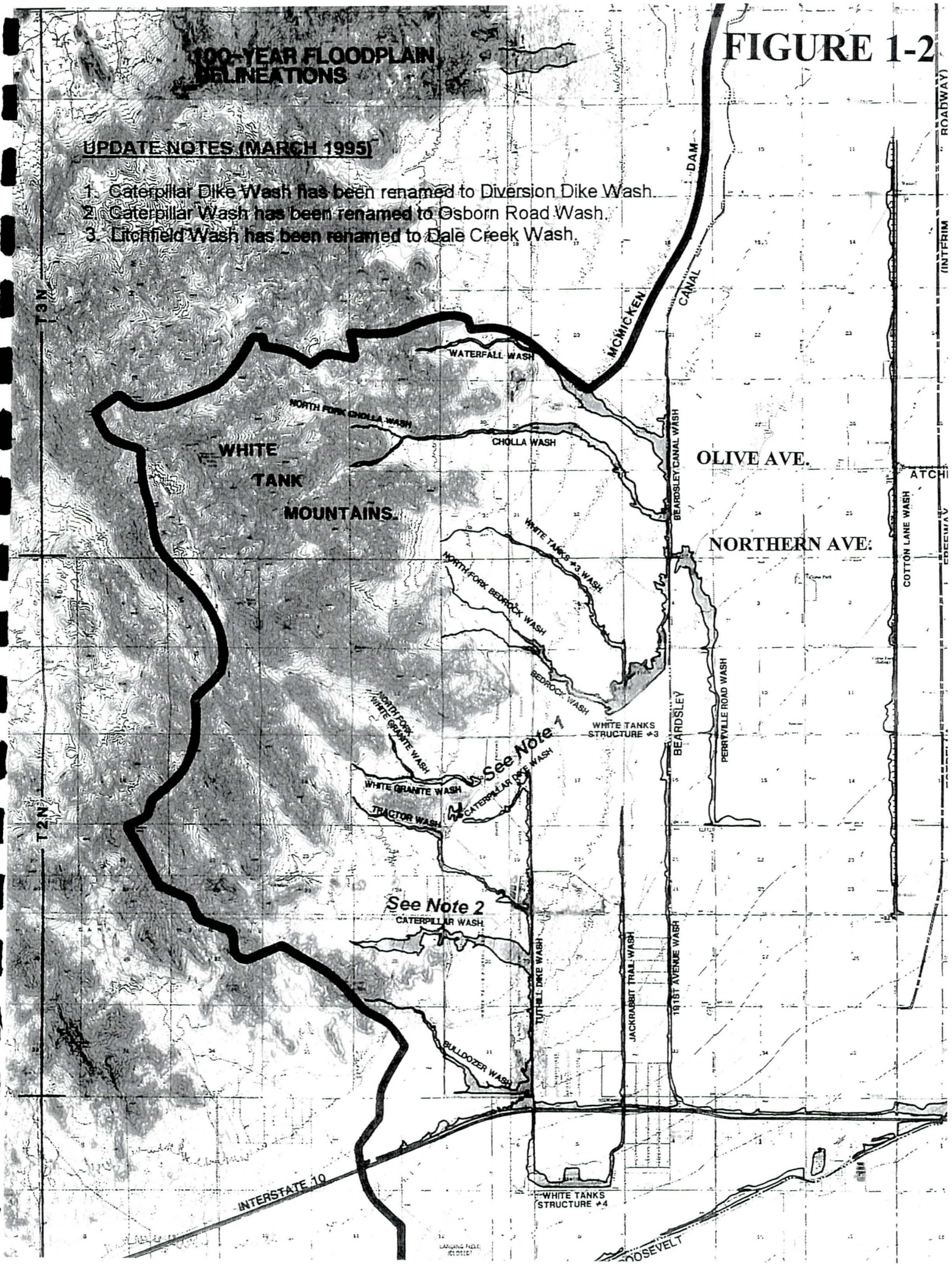
Vicinity Map
Figure 1-1

FIGURE 1-2

100-YEAR FLOODPLAIN DELINEATIONS

UPDATE NOTES (MARCH 1995)

1. Caterpillar Dike Wash has been renamed to Diversion Dike Wash.
2. Caterpillar Wash has been renamed to Osborn Road Wash.
3. Litchfield Wash has been renamed to Dale Creek Wash.



1.3 Previous Studies

The Beardsley Canal Wash was studied during the White Tanks/Agua Fria Area Drainage Master Study (ADMS), prepared by The WBL Group, Inc., dated June 1992. The ADMS completed both hydrologic and hydraulic models for the Beardsley Canal Wash and identified the breakout locations. The Beardsley Canal Wash was further analyzed in the Final Conceptual Design Report for the White Tanks Flood Retention Structure No. 3 Inlet Improvements, by AGK Engineers, Inc., dated December 1994. The AGK report recommended a concrete lined channel be constructed to replace the existing Beardsley Canal Wash at a cost of 10 million dollars.

1.4 Hydrologic Analysis

The hydrologic Analysis used in this report was taken from the ADMS. The existing condition peak 100-year flows beginning at the upstream end are as follows:

Waterfall Wash	= 2,048 cfs
Confluence of Waterfall Wash and Beardsley Canal	= 2,245 cfs
Breakout across Beardsley Canal upstream of Olive Avenue	= 490 cfs
Beardsley Canal at Olive Avenue	= 1,755 cfs
Cholla Wash	= 3,816 cfs
Confluence of Cholla Wash and Beardsley Canal	= 5,141 cfs
Breakout across Beardsley Canal upstream of Northern Avenue	= 1,486 cfs
Beardsley Canal at Northern Avenue	= 3,655 cfs

CHAPTER 2 – EXISTING CONDITION ANALYSIS

2.1 Data Collection

The Flood Control District provided PBS&J with all previously completed reports and information pertaining to the Beardsley Canal Wash. This included the ADMS and the AGK reports previously discussed. This also included digital topographic files for the study area, HEC-1 and HEC-2 input and output files from the ADMS and other reports related to the analyses being completed with this study. A list of all the data collected is included in **Chapter 6** of this report. Once the data collection and field investigation was complete a Data Collection Summary report was completed and submitted to the Flood Control District for approval.

During the data collection process PBS&J met with officials from the Maricopa County Department of Transportation (MCDOT) and the Maricopa County Water Conservation District (MCWCD). The purpose of these meetings was to notify these agencies about the study and obtain information on flooding problems,

planned public works projects in the study area and as-built plans for the culverts at Olive and Northern Avenues.

On October 9, 1998 PBS&J met with Glen Vorthems of MCWCD. Mr. Vorthems stated that in the last ten years there have been 2 occurrences where storm water has backed up at Olive Avenue and Northern Avenue and overtopped the Beardsley Canal. This overtopping undermines the gunnite lining of the canal and causes the lining to collapse. Mr. Vorthems also reported that the service road on the west side of the canal has been "washed out" at several locations. Evidence of the "wash out" was apparent at the Confluence of Cholla Wash and Beardsley Canal Wash. Mr. Vorthems said there were no planned improvements on the west side of the Canal, but that MCWCD was considering extending the gunite lining of the canal an additional 1 – 2 feet for a distance of 300 feet upstream of Olive and Northern Avenues.

On November 5, 1998 PBS&J met with Mike Smith of MCDOT. Mr. Smith indicated that he had reviewed MCDOT's planning projects and studies within the White Tanks area and had not discovered any that would be impacted by the project. Mr. Smith directed PBS&J to the location of MCDOT's as-built drawings, but none were found for Olive Avenue or Northern Avenue.

2.2 Field Investigation

During the field investigation particular attention was paid to the Beardsley Canal Wash and the Northern Avenue and Olive Avenue crossings of the wash. McMicken Dam and its proximity to Waterfall Wash was also investigated. Pictures 1 through 17 in **Appendix A** show some of the areas investigated during the field investigation. Included in **Appendix B** are pictures taken in conjunction with the ADMS, which are dated June 1992. The two sets of pictures were compared to determine if any noticeable changes to vegetation or other features had occurred since the ADMS. The area on the north (upstream) side of Northern Avenue has more dense vegetation than at the time of the ADMS. Currently there are two 60 inch diameter circular Corrugated Metal Pipes (CMP's) at Northern Avenue. At Olive Avenue there is an 84 inch diameter CMP and a 90 inch diameter CMP. It should be noted that the 84 inch and 90 inch diameter CMP's at Olive Avenue are half full of sediment (see Pictures 6 and 9).

2.3 Manning's "n" Analysis

An analysis and recalculation of Manning roughness coefficients (n) was completed and compared to previous studies. The Manning roughness coefficients used in the original ADMS HEC-2 model were reviewed and compared to conditions in the field. The Manning "n" values were recalculated at several locations using the "Estimated Manning's Roughness Coefficients for Stream Channels and Flood Plains in Maricopa County, Arizona," (EMRC) by the U.S. Geological Survey, dated April 1991. The conditions of the Beardsley Canal Wash were compared to the pictures and "n" values given in the EMRC. The "n"

values for the Beardsley Canal Wash were then calculated from Tables 1 and 2 of the EMRC. These "n" values were then compared to the values given in the original HEC-2 model from the ADMS. An "n" value was calculated for the channel bottom and another "n" value was calculated for the channel bank and overbank areas. The channel bottom is sandy with some small to medium size stone and little vegetation. The channel banks and overbanks are somewhat irregular with few obstructions but large and frequent vegetation in most areas. The "n' value calculations and Tables 1 and 2 from the EMRC are included in **Appendix C**.

The Manning "n" values were recalculated for the Beardsley Canal Wash immediately upstream and downstream of Olive Avenue. The results obtained were reasonably consistent with the "n" values in the original HEC-2 model upstream of Olive Avenue. Downstream of Olive Avenue the "n" values in the original HEC-2 model seem to be low in some overbank areas. The Manning "n" values were also recalculated immediately upstream of Northern Avenue. The original HEC-2 "n" values also seem low for the overbank areas at this location as well. The n values for the overbank area in the original HEC-2 model range from 0.030 to 0.060 with most of the overbanks shown as 0.030. The "n" values calculated in this report for the same area range from 0.045 to 0.070. It is also apparent from pictures taken in May of 1992 by The WBL Group, Inc. for the ADMS that the vegetation in the overbanks has become more dense since those pictures were taken. These pictures are included in **Appendix B**. The "n" values for the overbank areas between Olive Avenue and Northern Avenue were increased to a minimum of 0.045. The "n" values were also recalculated for the area downstream of Northern Avenue (see picture 15). The "n" values shown in the original HEC-2 model are 0.030 for the left bank and 0.040 for the right bank. The value calculated in this report is 0.035 for both banks. The left bank and right bank "n" values were changed to 0.035 in the hydraulic models for this report.

2.4 Degradation and Scour Analysis

A Level 1 analysis was completed for degradation and scour of the Beardsley Canal Wash based on the State Standard for Watercourse System Sediment Balance, by the Arizona Department of Water Resources, Flood Warning and Dam Safety Section, dated September 1996. The analysis was completed at Olive Avenue and at Northern Avenue for both the existing condition and recommended alternative. The analysis uses drainage area and peak 100-year flows to determine the expected setback allowance and channel degradation for both straight channels and at channel bends. The results of this analysis are given in **Table 2-1**. The setback allowance distance given in the table is the maximum amount of lateral channel migration that can be expected to occur during a 100-year frequency flood event. This estimated distance is used as a guide for the placement of structures and facilities in close proximity to the channel. The channel degradation depth given in the table is the maximum amount of vertical channel scour or degradation that can be expected to occur in a 100-year frequency flood event. This estimated depth is used as a guide for toe down

distances of bridge piers, channel lining and other structures in or near the channel bottom. The setback allowance and channel degradation estimates do not take into account soil type, vegetative cover or other channel characteristics that may vary between individual channels or between different reaches of the same channel. Therefore, these values should only be used as a guide. A more detailed and in depth analysis should be completed in the design phase.

State Standard for Watercourse System Sediment Balance
Level 1 Analysis
Table 2-1

Channel Location	Channel Type	Setback Allowance		Channel Degradation	
		Existing (feet)	Proposed (feet)	Existing (feet)	Proposed (feet)
At Olive Avenue:	Straight Channels	47	32	5.5	3.8
	Channel Bends	118	79	6.9	4.7
At Northern Avenue:	Straight Channels	74	67	8.4	7.7
	Channel Bends	185	168	10.4	9.5

Based on the field investigation it appears that sedimentation and scour have occurred at several locations along the Beardsley Canal Wash. Sedimentation is apparent at Olive Avenue. Although it is not readily apparent one would expect sedimentation to occur at Northern Avenue and at the Confluence of Cholla Wash and Beardsley Canal Wash under current conditions. Evidence of local scour can be see in many areas along the canal.

2.5 Existing Condition HEC-2 and HEC-RAS Models

The original HEC-2 model, which was completed with the ADMS has been converted to a HEC-RAS model and the results of each were compared for the existing condition. Minor modifications were made to the converted HEC-RAS model based on current field conditions and the revised Manning "n" values discussed in section 2.3. These modifications are described in the following paragraphs. All of the hydraulic models discussed in this section use the flow rates given in section 1.4. All of the hydraulic models were run in the subcritical flow regime to conform to FEMA criteria.

The Beardsley Canal was included in the HEC-2 model completed in the ADMS (Model 1). The culvert crossings of the Beardsley Canal Wash at Olive Avenue and Northern Avenue were modeled as bridges in the original HEC-2. In addition, it appears that there are gaps between the low chord and the channel cross-section in the overbank areas of the culvert crossings. This causes the amount of conveyance area under the road to appear larger in the model than it really is. The excess conveyance area was eliminated from the HEC-RAS model. The Olive and Northern Avenue crossings of the wash were modeled as culverts instead of bridges in the HEC-RAS model. There is a significant difference between the two models in the amount of flow conveyed through the culverts at

Olive and Northern Avenues. In the original HEC-2 model 1,085 cfs is conveyed through the Olive Avenue culverts and 1,447 cfs is conveyed through the Northern Avenue culverts. In the HEC-RAS model 662 cfs is conveyed through the Olive Avenue Culverts and 408 cfs is conveyed through the Northern Avenue Culverts. This is caused by the gaps between the low chord and the channel cross-section in the HEC-2 model as previously discussed.

The culverts at Olive Avenue were further revised by modeling them as semi-circular CMP culverts to account for sedimentation at that location (see Pictures 6 and 9). The results of the original HEC-2 model and the modified HEC-RAS model (Model 2) were compared. **Table 2-2** shows the water surface elevations computed in each model and the difference between them. The difference in the water surface elevations between the two models is less than 0.15 feet everywhere except immediately upstream of the Olive and Northern Avenue culvert crossings. The results given in the HEC-RAS model are believed to be more accurate at these locations since the HEC-2 model analyzes the culvert crossings as bridges and because the roadway data was not entered properly as previously discussed.

A third hydraulic model was also completed. This HEC-RAS model is the same as Model 2 except that the Manning "n" values have been revised as discussed in section 2.3 (Model 3). The water surface elevations from Models 2 and 3 are included and compared in **Table 2-3**. Model 3 represents current conditions for the Beardsley Canal and is included in this report as the existing condition model (see **Appendix F**). A diskette is included in **Appendix H** with the input files for Models 1 through 3.

The floodplain maps developed for the ADMS that show the HEC-2 cross-sections, 2-foot contour topography and FEMA special flood hazard areas are included in **Appendix I**. The cross-section plots for Model 3 are included in **Appendix F**. The plots show the distribution of the Manning "n" values for each cross-section and the areas where the water surface elevation overtops the Beardsley Canal (left bank). The overtopping occurs at several locations, upstream of Olive Avenue, upstream of Northern Avenue and where Cholla Wash intersects the Beardsley Canal Wash. Olive Avenue and Northern Avenue are also overtopped. The existing culverts at those locations are severely inadequate in terms of conveying the peak 100-year flow. The existing condition HEC-RAS model (Model 3) is used as a base model and is modified for each of the individual alternatives discussed in Chapter 3.

WATER SURFACE ELEVATION COMPARISON MODEL 1 VS. MODEL 2

TABLE 2-2

Cross Section Number	Water Surface Elevation Model 1 (feet)	Water Surface Elevation Model 2 (feet)	Change in Water Surface Elevation (feet)
0.000	1192.84	1192.85	0.01
0.070	1195.17	1195.17	0.00
0.156	1198.29	1198.29	0.00
0.231	1200.04	1200.11	0.07
0.307	1202.27	1202.24	-0.03
0.390	1208.15	1208.14	-0.01
0.465	1211.43	1211.44	0.01
0.543	1213.93	1213.93	0.00
0.620	1215.09	1215.15	0.06
0.696	1217.17	1217.18	0.01
0.770	1219.98	1220.02	0.04
0.846	1220.24	1220.28	0.04
0.920	1221.50	1221.54	0.04
0.998	1225.72	1225.76	0.04
1.074	1229.03	1228.99	-0.04
1.148	1234.59	1234.51	-0.08
Northern Ave.			
1.159	1238.18	1238.79	0.61
1.237	1238.34	1238.92	0.58
1.313	1238.51	1239.04	0.53
1.388	1240.74	1240.84	0.10
1.466	1245.55	1245.67	0.12
1.556	1249.07	1249.12	0.05
1.616	1250.67	1250.75	0.08
1.692	1250.78	1250.93	0.15
1.768	1253.62	1253.56	-0.06
1.844	1259.44	1259.41	-0.03
1.920	1262.78	1262.80	0.02
1.996	1265.60	1265.62	0.02
2.072	1269.12	1269.17	0.05
2.159	1274.66	1275.61	0.95
Olive Ave.			
2.167	1278.10	1277.56	-0.54
2.186	1278.10	1277.56	-0.54
2.267	1278.06	1277.51	-0.55
2.330	1278.58	1278.50	-0.08
2.392	1279.67	1279.71	0.04
2.468	1283.04	1283.13	0.09
2.553	1285.71	1285.76	0.05
2.640	1287.34	1287.39	0.05
2.741	1287.96	1288.01	0.05
2.826	1289.12	1289.15	0.03
2.907	1294.58	1294.59	0.01
3.009	1301.28	1301.30	0.02
3.081	1303.22	1303.22	0.00
3.167	1303.93	1303.93	0.00
3.214	1304.20	1304.21	0.01
3.301	1308.63	1308.61	-0.02
3.383	1311.62	1311.64	0.02
3.460	1315.53	1315.52	-0.01
3.540	1318.76	1318.77	0.01
3.610	1320.77	1320.77	0.00
3.678	1321.74	1321.75	0.01

WATER SURFACE ELEVATION COMPARISON MODEL 2 VS. MODEL 3

TABLE 2-3

Cross Section Number	Water Surface Elevation Model 2 (feet)	Water Surface Elevation Model 3 (feet)	Change in Water Surface Elevation (feet)
0.000	1192.85	1192.85	0.00
0.070	1195.17	1195.17	0.00
0.156	1198.29	1198.29	0.00
0.231	1200.11	1200.11	0.00
0.307	1202.24	1202.24	0.00
0.390	1208.14	1208.14	0.00
0.465	1211.44	1211.44	0.00
0.543	1213.93	1213.92	-0.01
0.620	1215.15	1215.08	-0.07
0.696	1217.18	1217.17	-0.01
0.770	1220.02	1220.01	-0.01
0.846	1220.28	1220.23	-0.05
0.920	1221.54	1221.55	0.01
0.998	1225.76	1225.76	0.00
1.074	1228.99	1228.98	-0.01
1.148	1234.51	1234.51	0.00
Northern Ave.			
1.159	1238.79	1238.79	0.00
1.237	1238.92	1238.92	0.00
1.313	1239.04	1239.04	0.00
1.388	1240.84	1240.87	0.03
1.466	1245.67	1245.89	0.22
1.556	1249.12	1249.50	0.38
1.616	1250.75	1250.95	0.20
1.692	1250.93	1251.24	0.31
1.768	1253.56	1253.77	0.21
1.844	1259.41	1259.41	0.00
1.920	1262.80	1262.80	0.00
1.996	1265.62	1265.82	0.20
2.072	1269.17	1269.36	0.19
2.159	1275.61	1275.61	0.00
Olive Ave.			
2.167	1277.56	1277.56	0.00
2.186	1277.56	1277.56	0.00
2.267	1277.51	1277.51	0.00
2.330	1278.50	1278.50	0.00
2.392	1279.71	1279.71	0.00
2.468	1283.13	1283.13	0.00
2.553	1285.76	1285.76	0.00
2.640	1287.39	1287.39	0.00
2.741	1288.01	1288.01	0.00
2.826	1289.15	1289.15	0.00
2.907	1294.59	1294.59	0.00
3.009	1301.30	1301.30	0.00
3.081	1303.22	1303.22	0.00
3.167	1303.93	1303.93	0.00
3.214	1304.21	1304.21	0.00
3.301	1308.61	1308.61	0.00
3.383	1311.64	1311.64	0.00
3.460	1315.52	1315.52	0.00
3.540	1318.77	1318.77	0.00
3.610	1320.77	1320.77	0.00
3.678	1321.75	1321.75	0.00

CHAPTER 3 – ALTERNATIVE ANALYSIS

3.1 Overview

Several alternatives are evaluated in this study. The purpose of this evaluation is to determine the minimum improvements necessary to eliminate the overtopping of the Beardsley Canal. All of the alternatives evaluated are modeled in HEC-RAS and included on the disk in **Appendix H**. The models are all run in the subcritical flow regime to conform to FEMA criteria. All of the models assume that no breakouts occur across the canal. Therefore, no flow is diverted out of the model at Olive Avenue or Northern Avenue. The total flow draining to the Beardsley Canal is used in these hydraulic models unless otherwise modified by proposed improvements. The total peak 100-year flows impacting the Beardsley Canal beginning at the upstream end are as follows:

Waterfall Wash	= 2,048 cfs
Confluence of Waterfall Wash and Beardsley Canal	= 2,245 cfs
Breakout across Beardsley Canal upstream of Olive Avenue	= 0 cfs
Beardsley Canal at Olive Avenue	= 2,245 cfs
Cholla Wash	= 3,816 cfs
Confluence of Cholla Wash and Beardsley Canal	= 5,141 cfs
Breakout across Beardsley Canal upstream of Northern Avenue	= 0 cfs
Beardsley Canal at Northern Avenue	= 5,141 cfs

3.2 Alternative 1A

Alternative 1A includes the replacement of the culvert crossings at Olive and Northern Avenues. The existing culverts are replaced with reinforced concrete box culverts (RCB's). The number of box culverts added is based on what was required by the HEC-RAS model to eliminate the overtopping of the canal, Olive Avenue and Northern Avenue. With this alternative the canal is still overtopped at the confluence of Cholla Wash and Beardsley Canal Wash.

<u>Alternative 1A</u>
Corresponding HEC-RAS model file name: culvert.prj
Replace Existing Olive Avenue Culverts with 10 – 10' x 5' RCB's .
(Freeboard = 0.51')
Replace Existing Northern Avenue Culverts with 10 – 12' x 8' RCB's.
(Freeboard = 0.34')

3.3 Alternative 1B

Alternative 1B is the same as Alternative 1A except bridges are used at Olive Avenue and Northern Avenue instead of RCB's.

Alternative 1B
Corresponding HEC-RAS model file name: bridge.prj
Replace Existing Olive Avenue Culverts with a 50' free span bridge.
(Freeboard = 3.02')
Replace Existing Northern Avenue Culverts with a 130' bridge with piers.
(Freeboard = 0.21')

3.4 Alternative 2A

Alternative 2A includes the construction of a diversion dike across Waterfall Wash to divert all flow (2,048 cfs) in the wash to McMicken Dam (see **Figure 4-1**). The Flood Control District has confirmed that McMicken Dam has the storage capacity required to accommodate the additional flow. This reduces the peak flow in the Beardsley Canal Wash at Olive Avenue from 2,245 cfs to 997 cfs. At Olive Avenue the existing culverts are left in place. Olive Avenue is still overtopped but not the canal. The canal is higher than the road. Olive Avenue is overtopped at and to the west of the culverts. At Northern Avenue the existing culverts are replaced with a 70' bridge and the overtopping is eliminated at this location. With this alternative the canal is still overtopped at the confluence of Cholla Wash and Beardsley Canal Wash.

Alternative 2A
Corresponding HEC-RAS model file name: divert.prj
Construct diversion dike across Waterfall Wash.
No improvements at Olive.
(Overtopped)
Replace Existing Northern Avenue Culverts with a 70' bridge with piers.
(Freeboard = 0.73')

3.5 Alternative 2B

Alternative 2B is the same as Alternative 2A except that the existing culverts at Olive Avenue are replaced with 5 – 10' x 5' RCB's. This eliminates the overtopping of Olive Avenue. A 20' free span bridge could be used at Olive Avenue instead of the RCB's, but based on the preliminary cost estimates (see **Appendix D**) it is more economical to use the RCB's.

Alternative 2B
Corresponding HEC-RAS model file name: divert2.prj
Construct diversion dike across Waterfall Wash.
Replace Existing Olive Avenue Culverts with 5 – 10' x 5' RCB's.
(Freeboard = 1.46')
Replace Existing Northern Avenue Culverts with a 70' bridge with piers.
(Freeboard = 0.73')

3.6 Alternative 3A

Alternative 3A includes the diversion dike across Waterfall Wash and the improvements at Olive Avenue as discussed in Alternative 2A and 2B, respectively. However, instead of replacing the existing culverts at Northern Avenue with a bridge, an on-line detention basin is proposed at the confluence of Cholla Wash and Beardsley Canal Wash. The detention basin would accept all flows from the two washes and discharge a maximum of 450 cfs during a 100-year event. The 450 cfs is based on the maximum amount of flow the existing culverts at Northern Avenue can accommodate without Northern Avenue or the canal being overtopped. With this alternative the Canal is not overtopped at any point.

Alternative 3A
Corresponding HEC-RAS model file name: basin.prj
Construct diversion dike across Waterfall Wash.
Replace Existing Olive Avenue Culverts with 5 – 10' x 5' RCB's.
(Freeboard = 1.06')
Construct an on-line detention basin at the confluence of Cholla Wash and Beardsley Canal Wash.
No improvements at Northern Avenue.
(Freeboard = 0.25')

Note: Although the proposed RCB's at Olive Avenue are more economical than a 20' free span bridge, the HEC-RAS model for this alternative and Alternative 3b include the free span bridge to show that it is hydraulically the same as the RCB's.

3.7 Alternative 3B

Alternative 3B is the same as Alternative 3A except that an off-line detention basin is constructed at the confluence of Cholla Wash and Beardsley Canal Wash and the existing culverts at Northern Avenue are replaced with 2 – 10' x 8' RCB's. The off-line detention basin accepts all but 1,500 cfs of the combined flow from Cholla Wash and Beardsley Canal Wash. The existing culverts at Northern Avenue must be replaced to convey the 1,500 cfs. As in Alternative 3A the canal is not overtopped at any point with this alternative.

Alternative 3B
Corresponding HEC-RAS model file name: basin2.prj
Construct diversion dike across Waterfall Wash.
Replace Existing Olive Avenue Culverts with 5 – 10' x 5' RCB's.
(Freeboard = 1.06')
Construct an off-line detention basin at the confluence of Cholla Wash and Beardsley Canal Wash.
Replace Existing Northern Avenue Culverts with 2 – 10' x 8' RCB's.
(Freeboard = 1.06')

3.8 Alternative 3C

Alternative 3C includes the construction of the diversion dike across Waterfall Wash as discussed in Alternative 2. It also includes the replacement of the existing culverts at Olive Avenue and Northern Avenue with 5 – 10' x 5' RCB's and a 70' bridge, respectively. In addition the confluence of Cholla Wash and Beardsley Canal Wash would be realigned, widened and revegetated after construction is complete. The realignment of Cholla Wash will provide a more efficient hydraulic transition between the two washes. Widening the washes will provide the conveyance capacity required to reduce the water surface elevation. Revegetation will allow the area to return to its natural condition and maintain its hydraulic characteristics. As in Alternative 3A and 3B the canal is not overtopped at any point with this alternative.

Alternative 3C
Corresponding HEC-RAS model file name: widen.prj
Construct diversion dike across Waterfall Wash.
Replace Existing Olive Avenue Culverts with 5 – 10' x 5' RCB's.
(Freeboard = 1.46')
Realign and widen the confluence of Cholla Wash and Beardsley Canal Wash.
Replace Existing Northern Avenue Culverts with a 70 bridge with piers.
(Freeboard = 0.73')

Alternatives Matrix
Table 3-1

Alternative	Location				
	Olive Ave.	Northern Ave.	Waterfall Wash Diverson Dike	Confluence Detention Basin	Cholla/Beardsly Wash Realignment
1A	10 – 10' x 5' RCB's	10 – 12' x 8' RCB's			
1B	50' Bridge	130' Bridge			
2A		70' Bridge	1,500' Dike		
2B	5 – 10' x 5' RCB's	70' Bridge	1,500' Dike		
3A	5 – 10' x 5' RCB's		1,500' Dike	On-line Detention Basin	
3B	5 – 10' x 5' RCB's	2 – 10' x 8' RCB's	1,500' Dike	Off-line Detention Basin	
3C	5 – 10' x 5' RCB's	70' Bridge	1,500' Dike		Wash Realignment

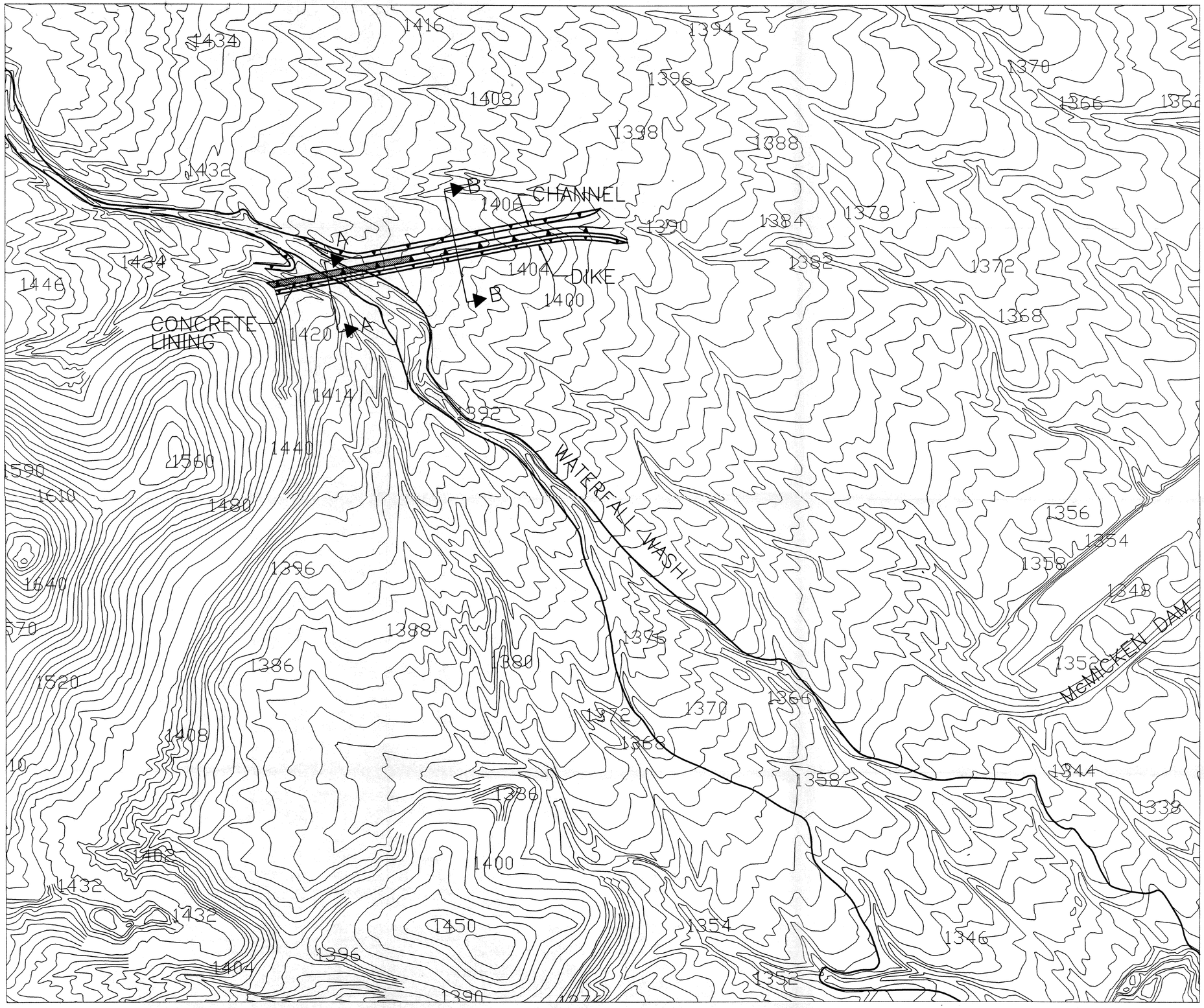
CHAPTER 4 – RECOMMENDED ALTERNATIVE

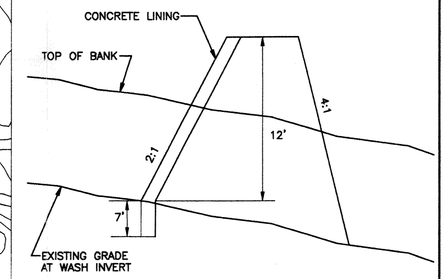
4.1 Alternative 3C – Recommended Alternative

Alternatives 3A, 3B and 3C are the only alternatives that eliminate flows overtopping the Beardsley Canal, Olive Avenue and Northern Avenue at all locations in a 100-year event. Alternatives 3A and 3B were eliminated because of the high capital improvement costs and significant maintenance costs associated with detention basin construction. Maintenance costs are all but eliminated with Alternative 3C and the capital improvement cost is much less. In addition, Alternative 3C allows the confluence of Cholla Wash and Beardsley Canal Wash to return to its natural condition after construction is complete.

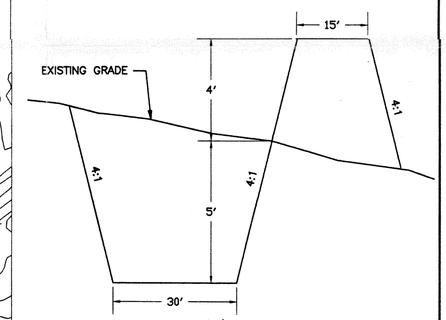
The diversion dike across Waterfall Wash is shown in **Figure 4-1**. The dike should be concrete lined for the first 600 feet. Soil cement lining was considered and a cost estimate was completed (see **Appendix D**). However, due to the high potential for scour where the dike intersects the wash, concrete is recommended based on material strength and long term durability. The realignment and widening of the confluence of Cholla Wash and Beardsley Canal Wash is shown in **Figure 4-2**. Typical sections of the existing and proposed channel dimensions at the confluence of Cholla Wash and Beardsley Canal Wash are located in the HEC-RAS output data in **Appendix F** and **Appendix G** (see cross-sections 1.556, 1.466 and 1.388).

Along with the construction of the 70' bridge at Northern Avenue it is recommended that a Gabion Drop/Grade Control Structure be built on the downstream side of the bridge as shown in **Figure 4-3**. This will prevent head cutting and pier scour. In addition clearing and grubbing should be competed at Olive Avenue 100 feet upstream and downstream of the proposed culverts in the channel bottom and channel sides. This will make the inlet and outlet of the proposed culverts much more hydraulically efficient and help prevent blockage of the culvert inlets by uprooted or dead vegetation.





DIVERSION DIKE
TYPICAL SECTION A–A
NOT TO SCALE



CHANNEL/DIKE
TYPICAL SECTION B–B
NOT TO SCALE

FIGURE 4-1

PBS&J
901 N. Green Valley Pkwy.
Suite 200, Henderson, Nevada 89014
Telephone: 702/263-7275
Fax: 702/263-7200
ENGINEERING · PLANNING · SURVEYING · CONSTRUCTION SERVICES

BAR SCALE
100 0 100 200
BAR REPRESENTS ONE AND ONE-HALF INCHES ON ORIGINAL

MARICOPA COUNTY FLOOD CONTROL

WATERFALL WASH
DIVERSION DIKE

SCALE
HORIZ. SCALE
1"=200'

DRAWN BY: P. A. THORNTON 1/7/99
CHECKED BY: M. BAIRD 1/19/99

DRAWING NUMBER F2
SHEET 2 OF 2

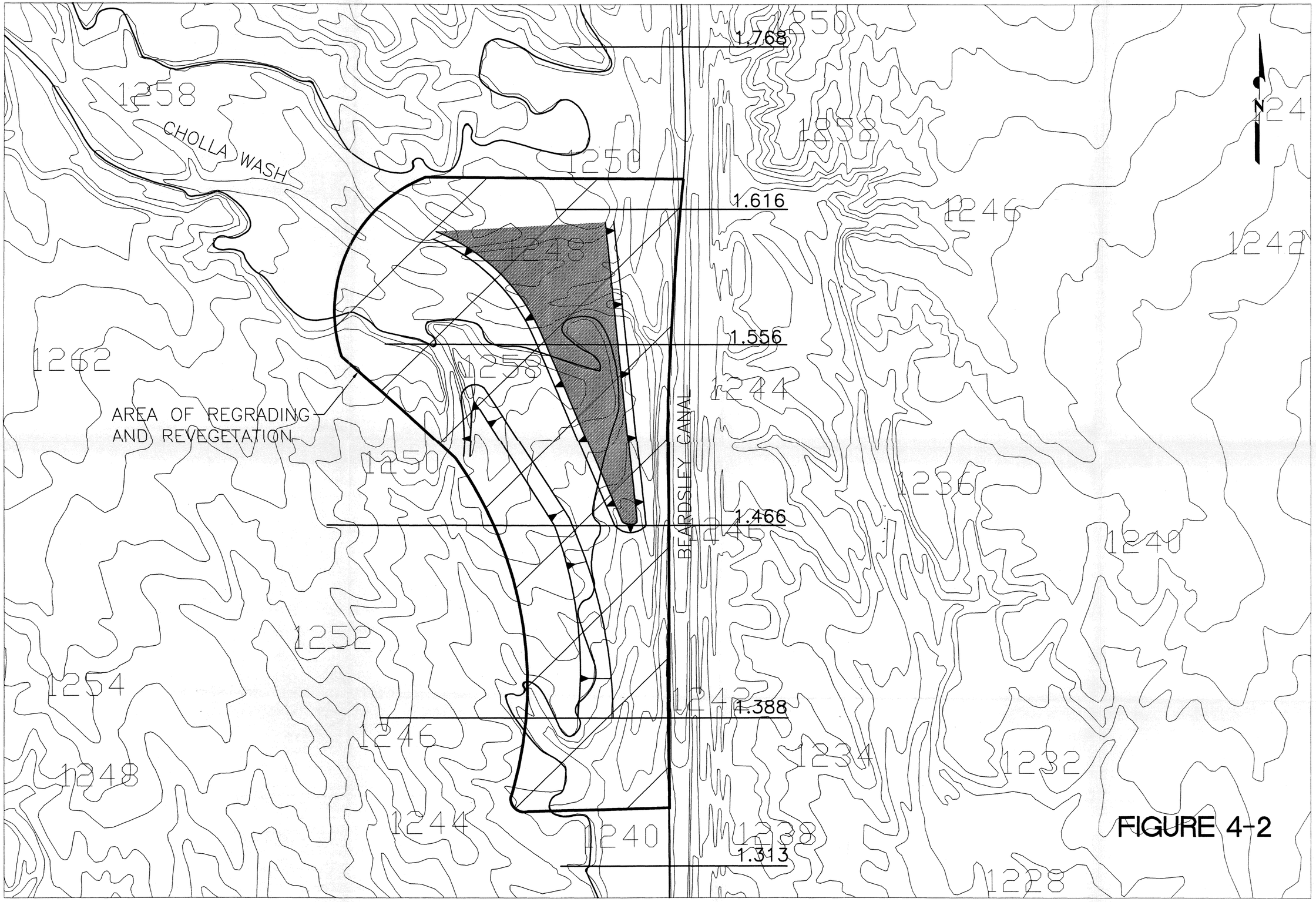


FIGURE 4-2

PBSJ
901 N. Green Valley Pkwy.
Suite 100
Henderson, Nevada 89014
Telephone: 702/263-7272
Fax: 702/263-7275
ENGINEERING · PLANNING · SURVEYING · CONSTRUCTION SERVICES

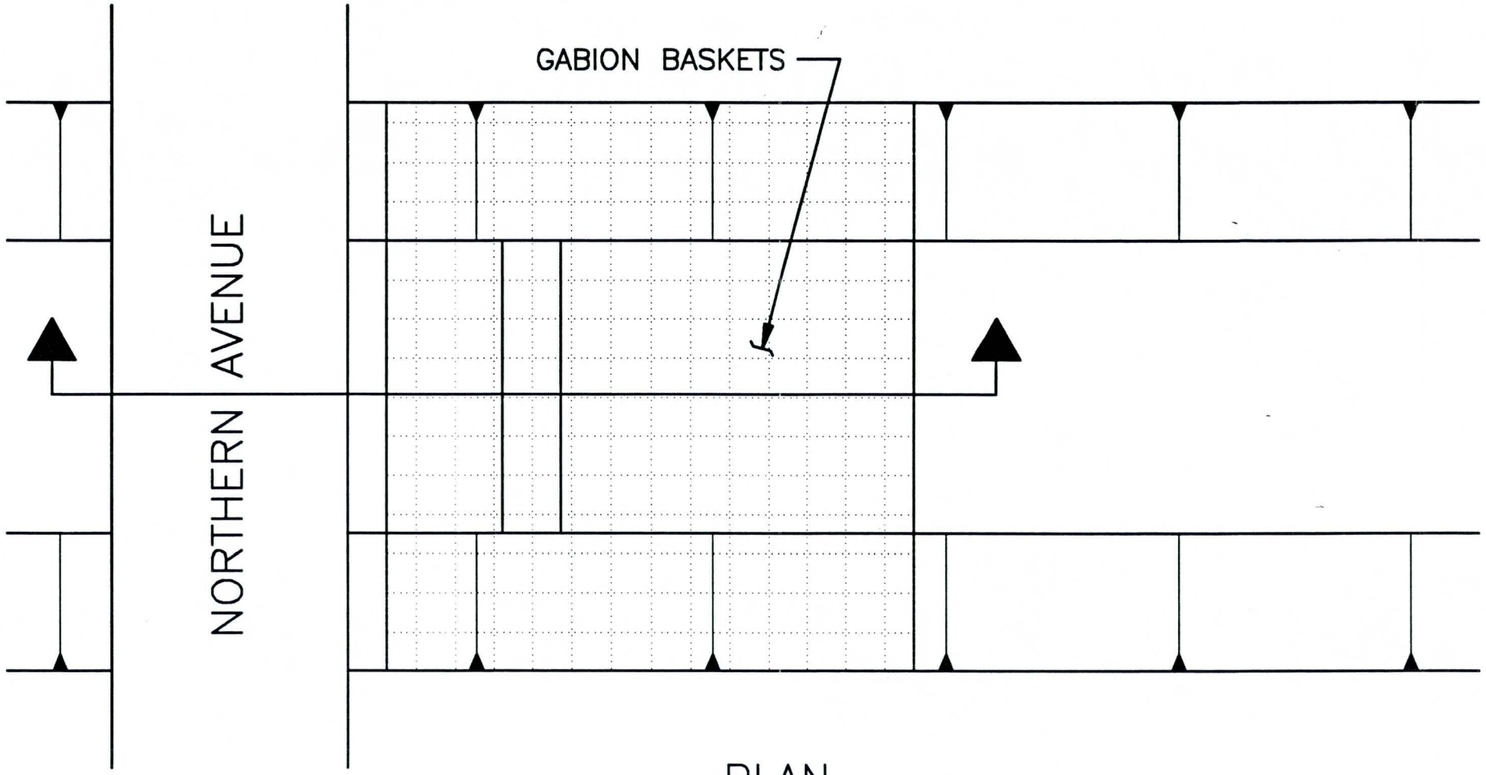
BAR SCALE
50 0 50 100
BAR REPRESENTS ONE INCH ON HALF INCHES ON ORIGINAL

MARICOPA COUNTY FLOOD CONTROL
CHOLLA WASH

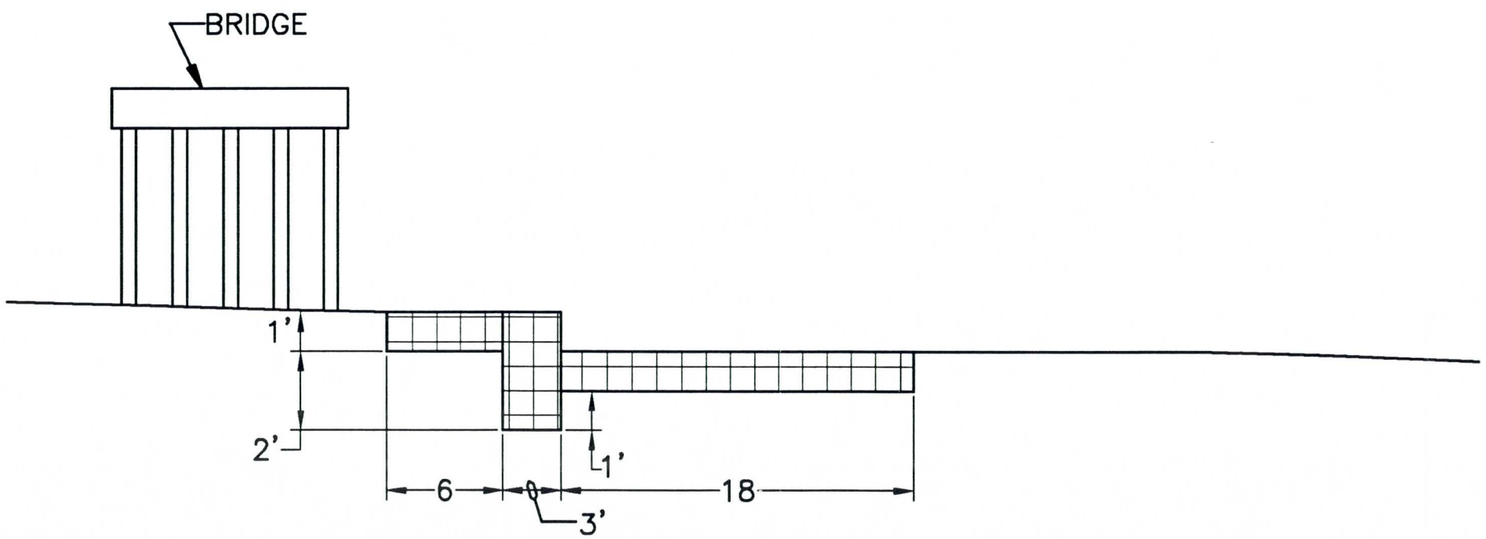
SCALE
HORIZ. SCALE 1"=100'

DRAWN BY: P. THORNTON 1/7/99
CHECKED BY: M. BAIRD 1/19/99

DRAWING NUMBER F1
SHEET 1 OF 2



PLAN



SECTION

GABION DROP STRUCTURE

NOT TO SCALE

FIGURE 4-3

4.2 Hydraulic Analysis

The flow rates used for the recommended alternative are as follows:

Waterfall Wash	= 2,048 cfs
Diversion to McMicken Dam	= 2,048 cfs
Confluence of Waterfall Wash and Beardsley Canal	= 997 cfs
Breakout across Beardsley Canal upstream of Olive Avenue	= 0 cfs
Beardsley Canal at Olive Avenue	= 997 cfs
Cholla Wash	= 3,816 cfs
Confluence of Cholla Wash and Beardsley Canal	= 4,504 cfs
Breakout across Beardsley Canal upstream of Northern Avenue	= 0 cfs
Beardsley Canal at Northern Avenue	= 4,504 cfs

The output summary and cross-section plots for the recommended alternative HEC-RAS model are included in **Appendix G**. The input files for this HEC-RAS model are included on the disk in **Appendix H**. The HEC-RAS model shows that no breakouts occur with this alternative. All of the proposed improvements discussed above have been incorporated into the model. The model was run in the subcritical flow regime to conform to FEMA criteria and the conceptual sizing and design of the alternatives was based on the hydraulic characteristics of that model. Cross-sections 1.556, 1.466 and 1.388 were modified for the proposed realignment and regrading of the Cholla Wash and Beardsley Canal Wash confluence and are included in **Appendix G**. These cross-sections can be compared to the existing condition cross-sections in **Appendix F** for proposed modifications to channel geometry. The location of the cross-sections along with the topography are shown on the cross-section maps in **Appendix I**.

The proposed condition water surface elevations and existing condition water surface elevations (model 3, see section 2.5) developed in the HEC-RAS models were compared in **Table 4-1**. As can be see from the table there is a significant reduction in the water surface elevations at several locations due to the proposed improvements. The elevation of the top of the left (east) bank (top of canal) is also shown in **Table 4-1** for each cross-section. These elevations were used to calculate the amount of freeboard there is between the 100-year water surface elevation and the top of the canal for the proposed condition. This was done for the subcritical flow regime and the mixed flow regime. The freeboard values are shown in the table.

WATER SURFACE ELEVATION COMPARISON
EXISTING VS. PROPOSED

TABLE 4-1

Cross Section Number	Water Surface Elevation Existing (Model 3) (feet)	Water Surface Elevation Proposed (feet)	Change in Water Surface Elevation (feet)	Left (East) Bank Elevation (feet)	Freeboard Subcritical Flow Regime (feet)	Freeboard Mixed Flow Regime (feet)
0.000	1192.85	1193.06	0.21	1210.0	16.9	16.9
0.070	1195.17	1195.36	0.19	1210.0	14.6	14.6
0.156	1198.29	1198.47	0.18	1210.0	11.5	11.5
0.231	1200.11	1200.30	0.19	1210.0	9.7	9.7
0.307	1202.24	1202.65	0.41	1210.0	7.3	8.5
0.390	1208.14	1208.51	0.37	1209.0	0.5	0.5
0.465	1211.44	1211.59	0.15	1217.4	5.8	5.8
0.543	1213.92	1214.60	0.68	1219.0	4.4	4.4
0.620	1215.08	1215.62	0.54	1220.7	5.1	5.1
0.696	1217.17	1217.80	0.63	1222.5	4.7	4.7
0.770	1220.01	1220.75	0.74	1221.0	0.3	0.3
0.846	1220.23	1220.78	0.55	1222.3	1.5	1.5
0.920	1221.55	1222.15	0.60	1227.2	5.0	6.2
0.998	1225.76	1226.66	0.90	1230.3	3.6	3.6
1.074	1228.98	1229.80	0.82	1231.8	2.0	2.0
1.148	1234.51	1231.82	-2.69	1234.5	2.7	2.7
Northern Ave.						
1.159	1238.79	1233.77	-5.02	1234.5	0.7	0.7
1.237	1238.92	1234.93	-3.99	1237.1	2.2	2.2
1.313	1239.04	1237.91	-1.13	1239.1	1.2	1.2
1.388	1240.87	1239.40	-1.47	1244.1	4.7	4.7
1.466	1245.89	1240.91	-4.98	1247.8	6.9	6.9
1.556	1249.50	1244.02	-5.48	1250.0	6.0	6.0
1.616	1250.95	1246.99	-3.96	1249.7	2.7	2.7
1.692	1251.24	1250.53	-0.71	1251.9	1.4	1.4
1.768	1253.77	1252.90	-0.87	1254.6	1.7	1.7
1.844	1259.41	1257.18	-2.23	1261.0	3.8	3.8
1.920	1262.80	1260.88	-1.92	1265.2	4.3	4.3
1.996	1265.82	1264.10	-1.72	1268.7	4.6	4.6
2.072	1269.36	1267.80	-1.56	1271.1	3.3	3.3
2.159	1275.61	1271.80	-3.81	1275.7	3.9	3.9
Olive Ave.						
2.167	1277.56	1275.54	-2.02	1277.0	1.5	1.5
2.186	1277.56	1275.74	-1.82	1277.0	1.3	1.3
2.267	1277.51	1275.75	-1.76	1277.8	2.0	2.0
2.330	1278.50	1277.77	-0.73	1280.3	2.5	2.5
2.392	1279.71	1279.71	0.00	1282.7	3.0	3.0
2.468	1283.13	1283.13	0.00	1285.8	2.7	2.7
2.553	1285.76	1285.76	0.00	1288.7	2.9	2.9
2.640	1287.39	1287.39	0.00	1298.8	11.4	11.4
2.741	1288.01	1288.01	0.00	1292.1	4.1	4.1
2.826	1289.15	1289.15	0.00	1291.0	1.8	1.8
2.907	1294.59	1294.59	0.00	1295.9	1.3	1.5
3.009	1301.30	1301.30	0.00	1301.8	0.5	0.5
3.081	1303.22	1303.22	0.00	1303.8	0.6	0.6
3.167	1303.93	1303.93	0.00	1306.3	2.4	2.4
3.214	1304.21	1304.21	0.00	1312.8	8.6	8.6
3.301	1308.61	1308.61	0.00	1314.5	5.9	5.9
3.383	1311.64	1311.64	0.00	1319.1	7.5	7.5
3.460	1315.52	1315.52	0.00	1320.4	4.9	4.9
3.540	1318.77	1318.77	0.00	1321.3	2.5	2.5
3.610	1320.77	1320.77	0.00	1324.0	3.2	3.2
3.678	1321.75	1321.75	0.00	1330.0	8.3	8.3

4.3 Cost Summary

Preliminary cost estimates were made for the recommended alternative. The unit cost data is based on the values given in the AGK report. These values were adjusted only for inflation unless otherwise noted in the cost calculations in **Appendix D**. The unit cost data includes installation, excavation and or inclusive materials such as rebar (see cost calculations for more detail). The unit cost data used is as follows:

Bridges: $65/square foot of bridge deck
Box Culverts: $320/cubic yard concrete
Concrete Channel Lining: $200/cubic yard concrete
Soil Cement Channel Lining: $60/cubic yard
Gabion Cost: $110/cubic yard
Dike Construction Cost (unlined): $24/LF
Excavation Cost: $4/cubic yard
Right-of-Way Cost: $14,000/acre
Revegetation Cost: $2,000/acre

Miscellaneous costs for grading and clearing and grubbing were also added to the total cost. A 10% utility conflict contingency was added into all of the estimates except the Waterfall Wash diversion dike. There is a fiber optic line on the west side of the Beardsley Canal under the maintenance road but it should not interfere with the recommended facilities. A 20% construction contingency was added to all cost estimates. Maintenance costs were assumed to be negligible for all facilities. However, a maintenance cost was calculated for the diversion dike across Waterfall Wash (see cost calculations). The cost of box culverts vs. bridges was completed for Olive Avenue and Northern Avenue. The box culverts are more cost effective at Olive Avenue and the bridge is more cost effective at Northern Avenue. The following cost estimates are for the recommend alternative and include the contingency estimates discussed above.

Diversion dike across Waterfall Wash = $284,000
Replace Existing Olive Avenue Culverts with 5 – 10' x 5' RCB's = $170,000
Realign and widen Cholla Wash/Beardsley Canal Wash confluence = $689,000*
Replace Existing Northern Avenue Culverts with a 70' bridge = $449,000**

Total Cost Recommended Alternative = $1,592,000

*This cost could be reduced by $364,000 (53%) if a temporary grading permit could be obtained instead of right-of-way.
**Includes Gabion Drop/Grade Control Structure

CHAPTER 5 – CONCLUSION

The Beardsley Canal Wash drains to the White Tanks Flood Retention Structure #3. FRS #3 was constructed to detain all flow tributary to the Beardsley Canal Wash. It was designed to accept large peak flows from the Beardsley Canal Wash, detain them and discharge a small controlled volume of water, thus eliminating the damaging effects of high peak flow volumes downstream. Under current conditions a large portion of flow draining to the Beardsley Canal Wash escapes collection by FRS #3 by overtopping the Beardsley Canal. Overtopping of the canal causes damage to the canal, increases repair costs to county roads downstream of the breakouts and is contributing to 6 miles of FEMA special flood hazard area downstream (east) of Northern Avenue. Proposed improvements to eliminate the breakouts were first analyzed in the AGK report, which proposed a subcritical concrete channel at a cost of $10,000,000. Proposed improvements to eliminate the breakouts were reanalyzed in this report to find a more cost effective solution. The proposed improvements will cost $1,592,000, which is 1/6th of the proposed channel cost in the AGK report. In addition, the proposed replacements of the Olive Avenue and Northern Avenue crossings of the Beardsley Canal Wash include full 60-foot right-of-way improvements that will need to be made anyway as this area develops. Construction of the proposed improvements will allow FRS #3 to fulfill its intended purpose, eliminate flood damage to the canal, reduce repair costs to county roads downstream and allow the FEMA special flood hazard area downstream (east) of Northern Avenue to be removed by Letter of Map Revision (LOMR).

CHAPTER 6 – BIBLIOGRAPHY

Studies:

1. AGK Engineers, Inc., "Final Conceptual Design Report, White Tanks Flood Retention Structure No. 3 Inlet Improvements," December 1994.

2. Arizona Department of Water Resources, Flood Warning and Dam Safety Section, "State Standard for Watercourse System Sediment Balance," September 1996.

3. U.S. Department of the Interior, Bureau of Reclamation, "Computing Degradation and Local Scour," January 1984.

4. U.S. Geological Survey, Water Resources Division, "Estimated Manning's Roughness Coefficients for Stream Channels and Flood Plains in Maricopa County, Arizona," April 1991.

Micellaneous Information:

1. AGK Engineers, Inc., "Plan and Profile, Recommended Alternative Design Concept, White Tanks No. 3 Flood Retention Structure Inlet Improvements Conceptual Design Report," December 1994.

2. The WBL Group Inc., "White Tanks/Agua Fria Area Drainage Master Study, Floodplain Map, Digital topographic files and HEC-1 and HEC-2 input and output files," October 1992.

APPENDIX A

PICTURES 1 – 17
NOVEMBER 1998

Picture 1: Looking North At Beardsley Canal From Olive Avenue

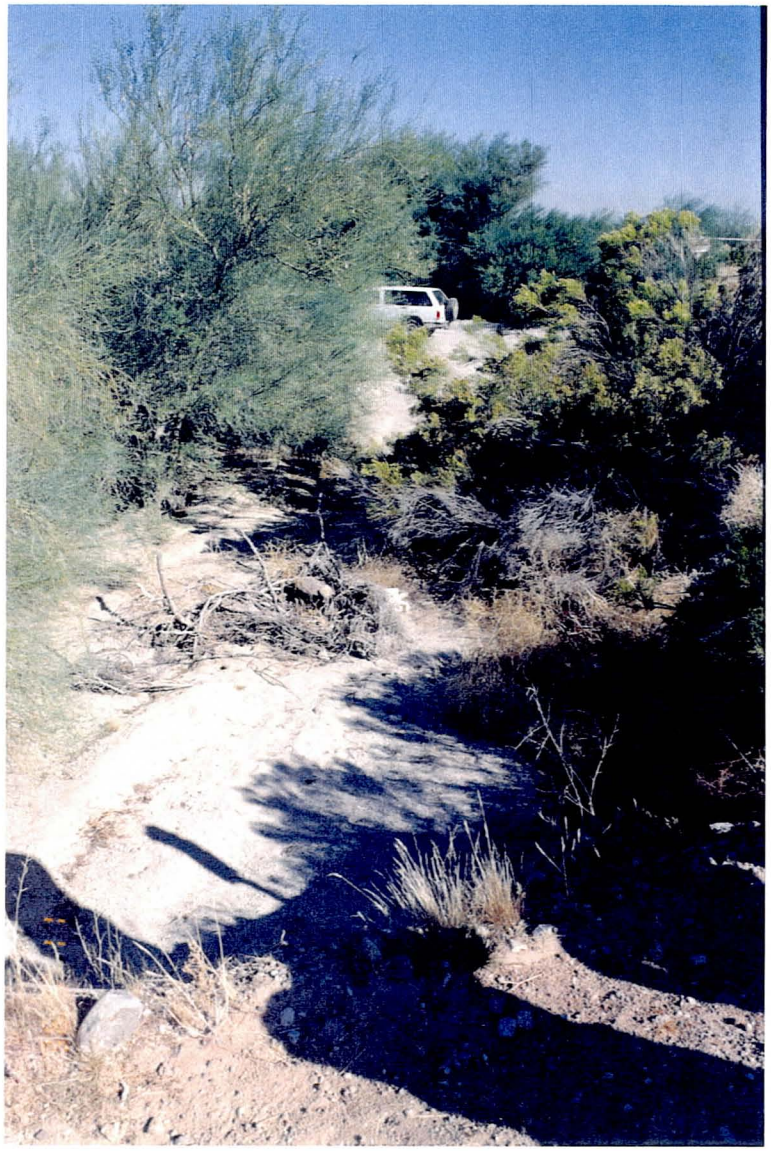
Picture 2: Looking West At Olive Avenue From Beardsley Canal

Picture 3: Looking South At Beardsley Canal From Olive Avenue

Picture 4: Looking North At Beardsley Canal Wash Just Upstream Of Olive Avenue

Picture 5: Looking At Vegetation Obstructing Beardsley Canal Wash Just Upstream Of Olive Avenue

Picture 6: Looking Downstream At Olive Avenue Culverts



Picture 7: Looking North (Upstream) At Beardsley Canal Wash From Olive Avenue

Picture 8: Looking South (Downstream) At Beardsley Canal Wash From Olive Avenue

Picture 9: Looking North (Upstream) At Olive Avenue Culverts

Picture 10: Looking North At Beardsley Canal From Northern Avenue

Picture 11: Looking North (Upstream) At Beardsley Canal Wash From Northern Avenue

Picture 12: Looking South (Downstream) At Northern Avenue Culverts

Picture 13: Looking South (Downstream) At Inlet To Northern Avenue Culverts

Picture 14: Looking West At Outlet Of Northern Avenue Culverts

Picture 15: Looking South (Downstream) At Beardsley Canal Wash (Improved Section) From Northern Avenue

Picture 16: Waterfall Wash Looking Upstream, Northwest Of McMicken Dam

Picture 17: Waterfall Wash Looking Downstream, Northwest Of McMicken Dam

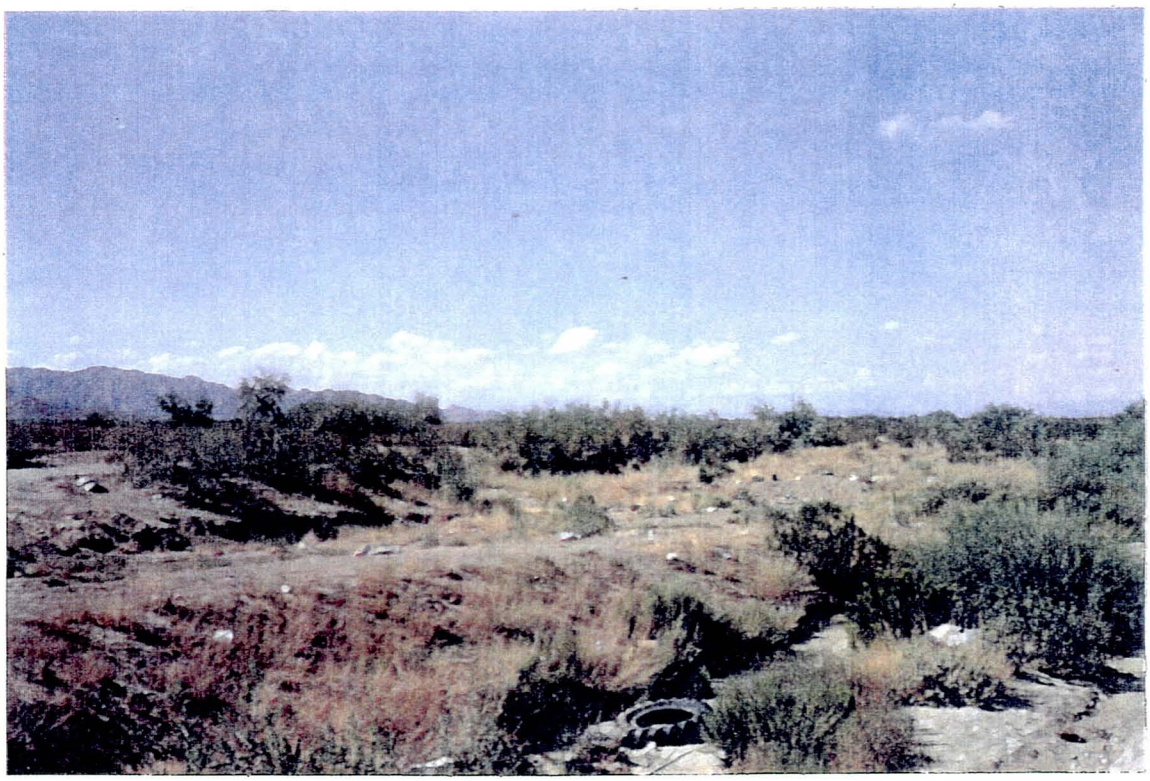
APPENDIX B

PICTURES FROM ADMS
MAY 1992

Wash 1 - Beardsley Canal Wash - Looking North of Peoria Avenue
Typical "n" Value: .05 ≈olive

Wash 1 - Beardsley Canal Wash - Looking South - Channel and West Overbank
Typical "n" Value: Channel = .035, Right = .07

Wash 1 - Beardsley Canal Wash Upstream of Northern Avenue
Typical "n" Values: Left = .06, Channel = .035, Right = .06



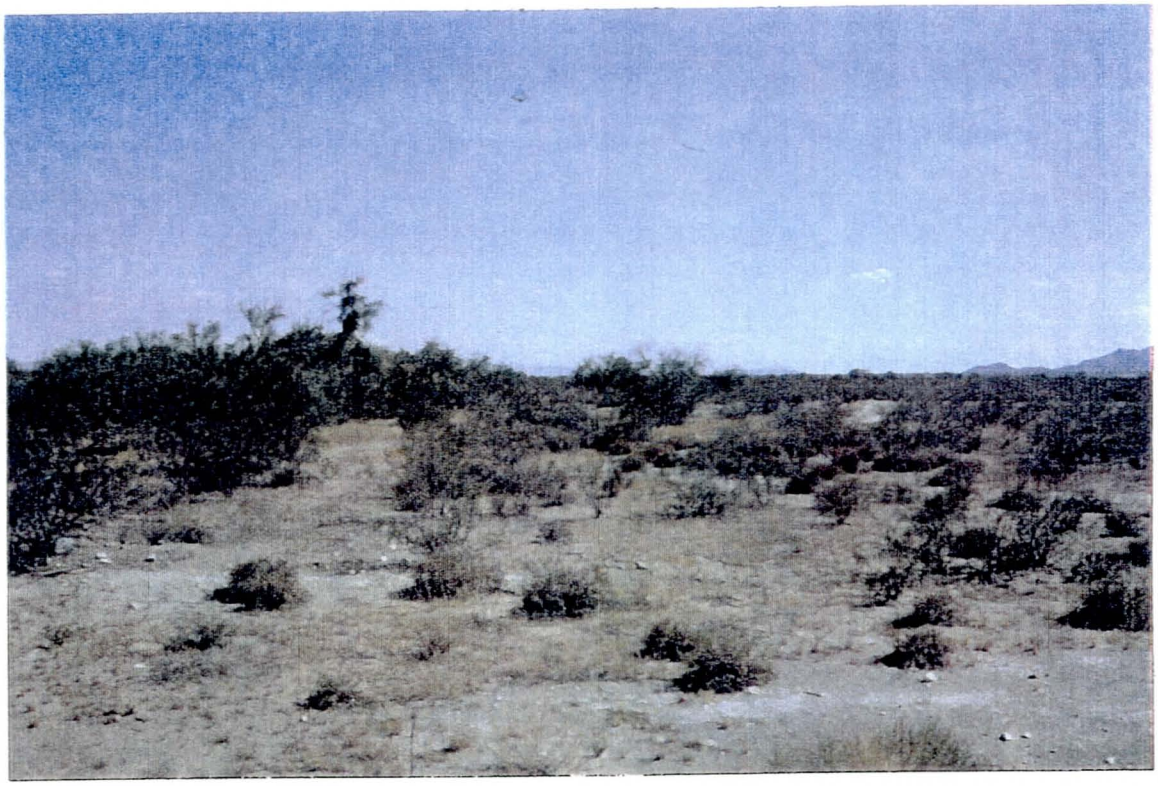
Wash 1 - Beardsley Canal Wash Upstream of Northern Avenue - West Overbank
Typical "n" Value: .07

Wash 1 - Beardsley Canal Wash - Looking North of Northern Avenue
Along West Side of Beardsley Canal
Typical "n" Values: Left = .05, Channel = .045, Right = .05

Wash 1 - Beardsley Canal Wash - Looking South Along the West Side of
Beardsley Canal Toward White Tank Structure #3
Typical "n" Values: Left = .035, Channel = .035, Right = .035

Wash 1 - Beardsley Canal Wash Downstream of Northern -
Looking South to White Tank Structure #3
Typical "n" Values: Left = .04, Channel = .02 - .04, Right = .04

Wash 1 - Beardsley Canal Wash - Looking South at Olive Avenue
Typical "n" Values: Left = .06, Channel = .05, Right = .07



Wash 1 - Beardsley Canal Wash Looking South at Olive Avenue - West Overbank
Typical "n" Value: .05

Wash 1 - Beardsley Canal Wash - West Overbank Looking South
Typical "n" Value: .05

APPENDIX C

MANNING'S "n" CALCULATIONS

PBS&J

COMP. BY: MSB
CHK. BY:
DATE:
SHEET NO.: 1
JOB NO.:

Subject: Beardsley Canal Wash
Mannings "N" Calculations

Location: Upstream and downstream of Olive Avenue, see pictures 4-9.

A.) Channel Bottom

Base Value = 0.03
Irregularity = 0.000
Obstructions = 0.002
Vegetation = 0.003
Variations = 0.000
Meandering = 1.00

$N = (0.03 + 0.002 + 0.003) \times 1.00 = 0.035$

B.) Channel Banks and Overbanks

Base Value = 0.03
Irregularity = 0.007
Obstructions = 0.003
Vegetation = 0.030 – 0.010
Variations = 0.000
Meandering = 1.00

$N_1 = (0.03 + 0.007 + 0.003 + 0.03) \times 1.00 = 0.070$
$N_2 = (0.03 + 0.007 + 0.003 + 0.01) \times 1.00 = 0.050$

$0.05 \leq N \leq 0.07$

PBSJ

COMP. BY: MSB
CHK. BY:
DATE:
SHEET NO.: 2
JOB NO.:

Subject: Beardsley Canal Wash
Mannings "N" Calculations

Location: Upstream of Northern Avenue
See pictures 11 - 13

A.) Channel Bottom

Same as at Olive $N = 0.035$

B.) Channel Banks and Overbanks

Base Value = 0.03
Irregularity = 0.007
Obstructions = 0.003
Vegetation = 0.020 - 0.005
Variations = 0.000
Meandering = 1.00

$N_1 = (0.03 + 0.007 + 0.003 + 0.020) \times 1.00 = 0.06$

$N_2 = (0.03 + 0.007 + 0.003 + 0.005) \times 1.00 = 0.045$

$0.045 \leq N \leq 0.06$

PBSJ

COMP. BY: MSB
CHK. BY:
DATE:
SHEET NO.: 2
JOB NO.:

Subject: Beardsley Canal Wash
Mannings "n" Calculations

Location: Downstream of Northern Avenue
See Pictures 14 and 15

A.) Channel Bottom

Base Value = 0.03
Irregularity = 0.000
Obstructions = 0.000
Vegetation = 0.000
Variations = 0.000
Meandering = 1.00

$N = 0.030 \times 1.00 = 0.030$

B.) Channel sides

Base Value = 0.03
Irregularity = 0.003
Obstructions = 0.000
Vegetation = 0.002
Variations = 0.000
Meandering = 1.00

$N = (0.03 + 0.003 + 0.002) \times 1.00 = 0.035$

A common method of selecting the roughness coefficient, *n*, is to first select a base value of *n* for the bed material (table 1). The base values of *n* are for a straight uniform channel of a given bed material. Cross-section irregularities, channel alignment, obstructions, vegetation, and other factors that increase roughness are accounted for by adding increments of roughness to the base value of *n*. Ranges of adjustments for the factors that may add to channel roughness are shown in table 2.

Many alluvial channels in Maricopa County have bed material that moves during floodflow. In addition to the changing channel geometry of these channels, the roughness coefficient may change during floodflow because of the changing form of the channel bed in parts of the channel cross section (Davidian, 1984). Bedforms, such as dunes, antidunes, and plane bed have been observed during large floods. Within a few minutes, dunes can appear, disappear, and reappear at different locations across a large stream channel. The Manning roughness coefficient can double or triple when the bedform changes from plane to dunes. A method of defining reliable values of Manning's *n* for unstable alluvial channels is not available. A plane bedform is common during large floods, and for this report, plane-bed conditions are assumed where the roughness coefficient is related to the size of the channel material and not the form of the channel bed. Plane-bed conditions were assumed for nearly all indirect measurements of peak discharge where the slope-area method was used.

Table 1.--*Base values of Manning's n for stable channels*

[Modified from Aldridge and Garrett, 1973, table 1]

Channel material	Size of bed material		Base *n* values	
	Millimeters	Inches	Benson and Dalrymple (1967)[1]	Chow (1959)[2]
Concrete.....	-------	--------	0.012-0.018	0.011
Rock cut.....	-------	--------	----------	.025
Firm soil.....	-------	--------	.025- .032	.020
Coarse sand.....	1-2	--------	.026- .035	-----
Fine gravel.....	-------	--------	----------	.024
Gravel.....	2-64	0.08-2.5	.028- .035	-----
Coarse gravel.....	-------	--------	----------	.028
Cobble.....	64-256	2.5-10.0	.030- .050	-----
Boulder.....	>256	>10.0	.040- .070	-----

[1]Straight uniform channel.
[2]Smoothest channel attainable in indicated material.

Table 2.--*Adjustment factors for the determination of overall Manning's n values*

[Modified from Chow, 1959]

Channel conditions	Manning's n adjustment[1]	Example
Degree of irregularity:		
Smooth	0.000	Smoothest channel attainable in given bed material.
Minor	.001- .005	Channels with slightly eroded or scoured side slopes.
Moderate	.006- .010	Channels with moderately sloughed or eroded side slopes.
Severe	.011- .020	Channels with badly sloughed banks; unshaped, jagged, and irregular surfaces of channels in rock.
Effects of obstruction[2]:		
Negligible	.000- .004	A few scattered obstructions, which include debris deposits, stumps, exposed roots, logs, piers, or isolated boulders, that occupy less than 5 percent of the cross-sectional area.
Minor	.005- .015	Obstructions occupy 5 to 15 percent of the cross-sectional area and the spacing between obstructions is such that the sphere of influence around one obstruction does not extend to the sphere of influence around another obstruction. Smaller adjustments are used for curved smooth-surfaced objects than are used for sharp-edged angular objects.
Appreciable	.020- .030	Obstructions occupy from 15 to 50 percent of the cross-sectional area or the space between obstructions is small enough to cause the effects of several obstructions to be additive, thereby blocking an equivalent part of a cross section.
Severe	.040- .060	Obstructions occupy more than 50 percent of the cross-sectional area or the space between obstructions is small enough to cause turbulence across most of the cross section.
Vegetation:		
Small	.002- .010	Dense growths of flexible turf grass, such as Bermuda, or weeds where the average depth of flow is at least two times the height of the vegetation; supple tree seedlings such as willow, cottonwood, arrow weed, or saltcedar where the average depth of flow is at least three times the height of the vegetation.
Medium	.010- .025	Grass or weeds where the average depth of flow is from one to two times the height of the vegetation; moderately dense stemmy grass, weeds, or tree seedlings where the average depth of flow is from two to three times the height of the vegetation; moderately dense brush, similar to 1- to 2-year-old saltcedar in the dormant season, along the banks and no significant vegetation along the channel bottoms where the hydraulic radius exceeds 2 feet.
Large	.025- .050	Turf grass or weeds where the average depth to flow is about equal to the height of vegetation; small trees intergrown with some weeds and brush where the hydraulic radius exceeds 2 feet.

See footnotes at end of table.

TabTe 2.--*Adjustment factors for the determination of overall Manning's n values*--Continued

Channel conditions	Manning's n adjustment[1]	Example
Vegetation—Continued:		
Very large	.050- .100	Turf grass or weeds where the average depth of flow is less than half the height of vegetation; small bushy trees intergrown with weeds along side slopes of dense cattails growing along channel bottom; trees intergrown with weeds and brush.
Variations in channel cross section:		
Gradual	.000	Size and shape of cross sections change gradually.
Alternating	.001- .005	Large and small cross sections alternate occasionally, or the main flow occasionally shifts from side to side owing to changes in cross-sectional shape.
Alternating	.010- .015	Large and small cross sections alternate frequently, or the main flow frequently shifts from side to side owing to changes in cross-sectional shape.
Degree of meadering[3]:		
Minor	1.00	Ratio of the meander length to the straight length of the channel reach is 1.0 to 1.2.
Appreciable	1.15	Ratio of the meader length to the straight length of channel is 1.2 to 1.5.
Severe	1.30	Ratio of the meander length to the straight length of channel is greater than 1.5.

[1]Adjustments for degree of irregularity, variations in cross section, effect of obstructions, and vegetation are added to the base n value (table 1) before multiplying by the adjustment for meander.

[2]Conditions considered in other steps must not be reevaluated or duplicated in this section.

[3]Adjustment values apply to flow confined in the channel and do not apply where downvalley flow crosses meanders. The adjustment is a multiplier.

For floodflows in sand channels with moveable beds, roughness mainly is a function of the size of the bed material as shown in the following table (Benson and Dalrymple, 1967, p. 22).

Median grain size, in millimeters	Manning's *n*	Median grain size, in millimeters	Manning's *n*
0.2	0.012	0.6	.023
.3	.017	.8	.025
.4	.020	1.0	.026
.5	.022		

APPENDIX D

PRELIMINARY COST ESTIMATE CALCULATIONS

WATERFALL WASH
DIVERSION DIKE

PBS&J

COMP. BY:
CHK. BY:
DATE:
SHEET NO.:
JOB NO.:

Subject: Water fall wash
Diversion Dike and Channel Calculations

Calculations for preliminary sizing of diversion dike and channel to divert waterfall wash to McMicken Dam.

Total diverted Flow = 2,048 cfs

Approximate slope of proposed channel ≈ 0.7%

Mannings "n" value = 0.025 at completion
= 0.035 after revegetation

Depth = 5' Side Slope = 4:1

Bottom width = 30'

From Normal depth calculations:

water surface with "n" = 0.025 = 4.20 ft
"n" = 0.035 = 5.00 ft

Excavated material to be used to build dike adjacent to channel and across existing wash.

Minimum dimentions = 4' tall, 15' top width, 4:1 side slope.

Channel should be completely incised below grade.
(See typical section and dimensions Figure 4-1)

PBS&J

COMP. BY:
CHK. BY:
DATE:
SHEET NO.:
JOB NO.:

Subject: Cost Estimate
Waterfall Wash Diversion Dike and Channel

Channel: Depth = 5' Bottom width = 30' side Slope = 4:1

Channel length = 1,500'

Total excavation volume $= \left((30')(5') + (4)(5')(5')\right)1500' = 375{,}000\ ft^3$

$= (375{,}000\ ft^3)\left(\frac{1\ yd^3}{27\ ft^3}\right) = 13{,}889\ yd^3$

Total excavation cost $= (13{,}889\ yd^3)\ \$4/yd^3 = \$55{,}556$

Dike construction cost $= (1500')(24\ \$/LF) = \$36{,}000$

Dike should be concrete lined for 600 feet as shown in Figure 4-1. Toe down depth is based on the scour analysis in Appendix E.

Lining Length $= (12')(2) + 7' = 31'$

Total concrete volume $= (31')(0.5')(600') = 9{,}300\ ft^3$

$= (9{,}300\ ft^3)\left(\frac{1\ yd^3}{27\ ft^3}\right) = 345\ yd^3$

Total concrete cost $= (345\ yd^3)(200\ \$/yd^3) = \$69{,}000$

Clearing and Grubbing $= \$10{,}000$

Right-of-Way = Channel 70' + Dike 50' + Access 12' + Misc. 5'

$= 137' \times 1500' = 205{,}500\ ft^2$

$= (205{,}500\ ft^2)\left(\frac{1\ acre}{43{,}560\ ft^2}\right) = 4.7\ acres$

PBSJ

COMP. BY:
CHK. BY:
DATE:
SHEET NO.:
JOB NO.:

Subject: Cost Estimate (Continued)
Waterfall Wash Diversion Dike and Channel

Right-of-Way cost $= (4.7 \text{ acres})\left(\frac{\$14,000}{\text{acre}}\right) = \$65,800$

Cost $= \$55,556 + \$36,000 + \$69,000 + \$10,000 + \$65,800$
$= \$236,356$

Plus 20% construction contingency

Total cost $= (\$236,356) + (\$236,356)(0.20) = \$283,627$

$\boxed{\text{Total cost} \approx \$284,000}$

Maintainance cost $= (1,500')(110\ \$/\text{LF-30 years}) = \$165,000$

Note: The 110 \$/LF-30 years maintainance cost for unlined channels was taken from the AGK report. However, the channel and dike were designed such that very little maintainance would be required. A more realistic maintainance cost might be 30 \$/LF 30 years.

PBS&J

COMP. BY:
CHK. BY:
DATE:
SHEET NO.:
JOB NO.:

Subject: Cost Estimate (Continued)
Water fall Wash Diversion Dike

Estimate cost of Soil Cement lined dike vs. Concrete lined dike.

From Previous Calculations:

Concrete lining of dike cost = \$69,000

Soil Cement Cost

Lining length = $((5' + 4')(4)) + 7'$ toedown = $43'$

Use 2' thick soil cement lining

Total soil cement volume = $(43')(2')(600') = 51{,}600\ ft^3$

$= (51{,}600\ ft^3)\frac{1\ yd^3}{27\ ft^3} = 1{,}911\ yd^3$

Total soil cement cost = $(1{,}911\ yd^3)(60\ \$/yd^3) = \$115{,}000$

Concrete cost = \$69,000 < soil cement cost = \$115,000

Note: 2 feet thick soil cement may be a conservative estimate in some areas. However, that portion of the dike that crosses water fall wash will have significant scour potential. For this reason concrete lining is recommended based on material strength and long term durability. In addition the 30 \$/yd³ soil cement cost listed in the AGK report Appendix O appears to be very unconservative. PBS&J estimate is 60 \$/yd³.

OLIVE AVENUE

PBSJ

COMP. BY:
CHK. BY:
DATE:
SHEET NO.:
JOB NO.:

Subject: Cost Estimate
Olive Avenue Box Culverts

Olive Avenue 5 - 10' x 5' RCBs, 68' Long

Wall and Roof thickness = 8" - 12½" use 12"

use 320 $/yd³ concrete → includes steel and installation

Concrete volume per L.F. of 5-10' x 5' RCBs

$$\text{Volume/LF} = (56')(1')(2) + (5')(1')(6) = 142 \frac{ft^2}{LF}$$

$$\text{Total volume for 5-10' x 5' RCBs, 68' Long} = \left(142 \frac{ft^2}{LF}\right)(68')\left(\frac{1 yd^3}{27 ft^3}\right)$$

$$= 357.6\ yd^3$$

$$\text{Box culvert cost} = (357.6\ yd^3)\left(320 \frac{\$}{yd^3}\right) = \$114,432$$

Right-of-way same as Bridge = $6,400

Clearing and grubbing = $10,000

Cost = 114,432 + 6,400 + 10,000 = $130,832

Plus 20% construction contingency and
10% utility conflict contingency

Total cost = 130,832 + (130,832)(0.30) = $170,082

$$\boxed{\text{Total cost} \approx \$170,000}$$

PBSJ

COMP. BY:
CHK. BY:
DATE:
SHEET NO.:
JOB NO.:

Subject: Cost Estimate
Olive Avenue Free Span Bridge

Olive Avenue 30' Span, 68' wide

Bridge cost $= (68')(30')(65\ \$/ft^2) = \$132,600$

Right-of-way 100' wide 100' upstream and downstream

$(100')(100')\left(\frac{1\ acre}{43,560\ ft^2}\right)\left(\$14,000/acre\right)(2) = \$6,400$

Clearing and Grubbing $= \$10,000$

Cost $= 132,600 + 6,400 + 10,000 = \$149,000$

Plus 20% construction contingency and
10% utility conflict contingency

Total cost $= (149,000) + (149,000)(0.30) = \$193,700$

$\boxed{\text{Total cost} \approx \$194,000}$

CHOLLA WASH/BEARDSLEY CANAL WASH CONFLUENCE

PBS&J

COMP. BY:
CHK. BY:
DATE:
SHEET NO.:
JOB NO.:

Subject: Cost Estimate
Cholla Wash, Beardsley Canal Confluence

This is essentially a grading and revegetation operation. Preliminary estimates show that the amount of excavation required balances the amount of fill required so no material needs to be imported. (See Figure 4-2 for grading limits)

Estimated excavation volume = 35,000 yd^3

Excavation cost = $(35{,}000\ yd^3)(4\ \$/yd^3)$ = \$140,000

Grading cost ≈ \$50,000

Clearing Grubbing = \$20,000

Right-of-Way, Area = $(800')(400') + (600')(450') + (400')(200')$
= 870,000 ft^2
= $(870{,}000\ ft^2)\left(\frac{1\ acre}{43560\ ft^2}\right)$ = 20 acres

Right-of-Way cost = (20 acres)(14,000 \$/acre) = \$280,000

Revegetation cost = (20 acres)(2,000 \$/acre) = \$40,000

Cost = \$140,000 + \$50,000 + \$20,000 + \$280,000 + \$40,000
= \$530,000

PBS&J

COMP. BY:
CHK. BY:
DATE:
SHEET NO.:
JOB NO.:

Subject: Cost Estimate (continued)
Cholla wash, Beardsley Canal Confluence

Cost = $530,000

Plus 30% construction contingency

Plus 10% utility contingency

Total cost = $530,000 + ($530,000)(0.3) = $689,000

$\boxed{\text{Total cost} \approx \$689,000}$

Note: The total cost could be reduced by $364,000 (53%) if a temporary grading permit could be obtained instead of acquiring right-of-way.

NORTHERN AVENUE

PBSJ

COMP. BY:
CHK. BY:
DATE:
SHEET NO.:
JOB NO.:

Subject: Cost Estimate
Northern Avenue Bridge

Northern Avenue 70' span, 68' wide

Bridge cost $= (68')(70')(65\ \$/ft^2) = \$309,400$

Right-of-Way 150' wide, 100' upstream

$(150')(100')\left(\frac{1\ acre}{43560\ ft^2}\right)(\$14,000/acre) = \$4,821$

Note: Right-of-Way downstream of Northern has already been acquired for Flood Retention Structure #3 Inlet Channel Per A&R Report.

Gabion Grade Control/Drop Structure 80' wide, 27' long
(See Figure 4-3 for Gabion Layout)

Gabion = \$110/cy

Gabion Volume $= (80')(1')(6'+18') + (80')(3')(3') = 2,640\ ft^3$

$= (2,640\ ft^3)\left(\frac{1\ yd^3}{27\ ft^3}\right) = 98\ yd^3$

Gabion Cost $= (98\ yd^3)(110\ \$/yd^3) = \$10,780$

Grading upstream and Downstream = \$20,000

Cost = \$309,400 + \$4,821 + \$10,780 + \$20,000 = \$345,001

Plus 20% construction contingency
10% utility conflict contingency

PBS&J

COMP. BY:
CHK. BY:
DATE:
SHEET NO.:
JOB NO.:

Subject: Cost Estimate (continued)
Northern Avenue Bridge

Total cost = \$345,001 + (\$345,001)(0.30) = \$448,501

Total cost ≈ \$449,000

PBSJ

COMP. BY:
CHK. BY:
DATE:
SHEET NO.:
JOB NO.:

Subject: Cost Estimate
Northern Avenue Box Culverts

Northern Avenue 10 - 12' x 8' RCB's

Wall and Roof Thickness = $8\frac{1}{2}$" - $14\frac{1}{2}$" use 14"

Use 320 \$/yd³ concrete → includes steel and installation

Concrete Volume per L.F. of 10-12'x8' RCB's

$$\text{Volume}/LF = (120' + 15.17')(1.17')(2) + (8')(1.17')(13) = 438 \frac{ft^2}{LF}$$

$$\text{Total Volume for } 10\text{-}12'\times 8' \text{ RCB's, } 68' \text{ Long} = \left(438 \frac{ft^2}{LF}\right)(68')\left(\frac{1 yd^3}{27 ft^3}\right)$$

$$= 1{,}103 yd^3$$

$$\text{Box Culvert Cost} = (1{,}103 yd^3)\left(320 \frac{\$}{yd^3}\right) = \$352{,}960$$

Northern Avenue Bridge Cost = \$309,400 < \$352,960

Go with Bridge at Northern Avenue.

APPENDIX E

DEGRADATION AND SCOUR CALCULATIONS

EXISTING CONDITON

PBSJ

COMP. BY:
CHK. BY:
DATE:
SHEET NO.: 2
JOB NO.:

Subject:

Part 2, Channel Degradation Estimation, Existing Condition

$d_s = d_{gs} + d_{lts}$

d_s = Total scour depth (ft)
d_{gs} = General degradation (ft)
d_{lts} = Long term degradation (ft)

$d_{gs} = 0.157 (Q_{100})^{0.4}$ for straight channels

$d_{gs} = 0.219 (Q_{100})^{0.4}$ for channel reaches with curvature

$d_{lts} = 0.02 (Q_{100})^{0.6}$

A. @ Olive $d_{gs} = 0.157(2245)^{0.4} = 3.44$ feet
or $d_{gs} = 0.219(2245)^{0.4} = 4.80$ feet
$d_{lts} = 0.02(2245)^{0.6} = 2.05$ feet

$d_s = 3.44 + 2.05 = 5.49$ feet
or
$d_s = 4.80 + 2.05 = 6.85$ feet

B. @ Northern $d_{gs} = 0.157(5504)^{0.4} = 4.92$ feet
or $d_{gs} = 0.219(5504)^{0.4} = 6.87$ feet
$d_{lts} = 0.02(5504)^{0.6} = 3.51$ feet

$d_s = 4.92 + 3.51 = 8.43$ feet
or
$d_s = 6.87 + 3.51 = 10.38$ feet

PBS&J

COMP. BY:
CHK. BY:
DATE:
SHEET NO.: 3
JOB NO.:

Subject:

Part 3, Evaluation of River Stability Impacts, Existing Condition

Use setback calculated in part 1 to determine minimum required erosion buffer between a near stream site and the active channel.

A. @ Olive = 47 feet for straight channels
= 118 feet at channel bends

B. @ Northern = 74 feet for straight channels
= 185 feet at channel bends

PBSJ

COMP. BY: Matt Baird
CHK. BY:
DATE:
SHEET NO.: 1
JOB NO.:

Subject: Scour Analysis, Task 6.1
State Standard for Watercourse System Sediment Balance

Level 1 Analysis

I. Existing Condition

Required information

1. Drainage Area

   A. @ Olive Avenue = 4.86 mi^2

   B. @ Northern Avenue = 10.87 mi^2

2. Peak 100-year Discharge

   Note: use total flow without diversions or breakouts across canal.

   A. @ Olive Avenue = 2,245 cfs

   B. @ Northern Avenue = 5,504 cfs

Part 1, Lateral Migration Setback Allowance, Existing Condition

set back = $1.0\,(Q_{100})^{0.5}$ for straight channels or channels with minor curvature

set back = $2.5\,(Q_{100})^{0.5}$ for channels with obvious curvature or channel bend.

A. setback @ olive = $(1.0)(2245)^{0.5}$ = 47 feet

or = $(2.5)(2245)^{0.5}$ = 118 feet

B. set back @ Northern = $1.0\,(5504)^{0.5}$ = 74 feet

or = $2.5\,(5504)^{0.5}$ = 185 feet

PROPOSED CONDITON

PBSJ

COMP. BY: Matt Baird
CHK. BY:
DATE:
SHEET NO.: 4
JOB NO.:

Subject: Scour Analysis, Task 6.1
State Standard for Watercourse System Sediment Balance

Level 1 Analysis

II. Proposed Condition

Required information

1. Drainage Area
   A. @ Olive Avenue = 1.10 mi^2
   B. @ Northern Avenue = 7.11 mi^2
2. Peak 100-year Discharge
   A. @ Olive Avenue = 997 cfs
   B. @ Northern Avenue = 4504 cfs

Part 1, Lateral Migration Setback Allowance, Proposed Condition

setback = $1.0 (Q_{100})^{0.5}$ for straight channels or channels with minor curvature.

setback = $2.5 (Q_{100})^{0.5}$ for channels with obvious curvature or channel bend.

A. setback @ Olive = $(1.0)(997)^{0.5}$ = 32 feet

or = $(2.5)(997)^{0.5}$ = 79 feet

B. setback @ Northern = $(1.0)(4504)^{0.5}$ = 67 feet

or = $2.5 (4504)^{0.5}$ = 168 feet

PBSJ

COMP. BY:
CHK. BY:
DATE:
SHEET NO.: 5
JOB NO.:

Subject:

Part 2, Channel Degradation Estimation, Proposed Condition

$d_s = d_{gs} + d_{lts}$ $\quad d_s$ = total scour depth (ft)

d_{gs} = General degradation (ft)

d_{lts} = Long Term degradation (ft)

$d_{gs} = 0.157 (Q_{100})^{0.4}$ for straight channels

$d_{gs} = 0.219 (Q_{100})^{0.4}$ for channel reaches with curvature

$d_{lts} = 0.02 (Q_{100})^{0.6}$

A. @ Olive $\quad d_{gs} = 0.157 (997)^{0.4} = 2.49$ feet

or

$d_{gs} = 0.219 (997)^{0.4} = 3.47$ feet

$d_{lts} = 0.02 (997)^{0.6} = 1.26$ feet

$d_s = 2.49 + 1.26 = 3.75$ feet

or

$d_s = 3.47 + 1.26 = 4.73$ feet

B. @ Northern $\quad d_{gs} = 0.157 (4504)^{0.4} = 4.54$ feet

or

$d_{gs} = 0.219 (4504)^{0.4} = 6.34$ feet

$d_{lts} = 0.02 (4504)^{0.6} = 3.11$ feet

$d_s = 4.54 + 3.11 = 7.65$ feet

or

$d_s = 6.34 + 3.11 = 9.45$ feet

PBS&J

COMP. BY:
CHK. BY:
DATE:
SHEET NO.: 6
JOB NO.:

Subject:

Part 3, Evaluation of River Stability Impacts, Proposed Condition

Use set back calculated in Part 1 to determine minimum required erosion buffer between a near stream site and the active channel.

A. @ Olive = 32 feet for straight channels
= 79 feet at channel bends

B. @ Northern = 67 feet for straight channels
= 168 feet at channel bends

State Standard for Watercourse System Sediment Balance
Level 1 Analysis

Channel Location	Channel Type	Setback Allowance		Channel Degradation	
		Existing (feet)	Proposed (feet)	Existing (feet)	Proposed (feet)
At Olive Avenue:	Straight Channels	47	32	5.5	3.8
	Channel Bends	118	79	6.9	4.7
At Northern Avenue:	Straight Channels	74	67	8.4	7.7
	Channel Bends	185	168	10.4	9.5

APPENDIX F

EXISTING CONDITION
HEC-RAS OUTPUT

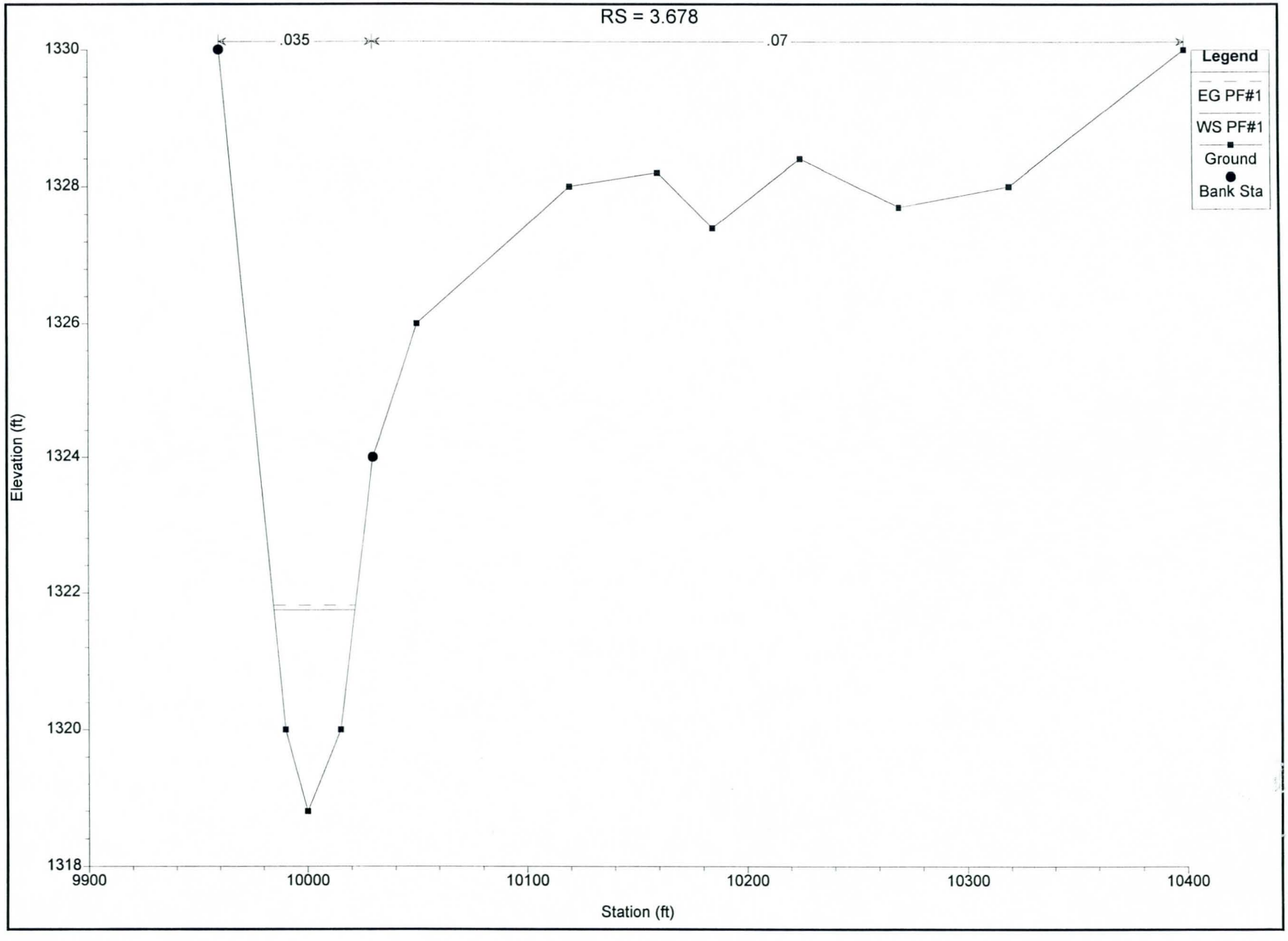
HEC-RAS Plan: Plan 02 River: RIVER-1 Reach: Reach-1

Reach	River Sta	Q Total	Crit W.S.	W.S. Elev	Sta W.S. Lft	Sta W.S. Rgt	Top Width	Min Ch El	Max Chl Dpth	Vel Chnl	E.G. Elev	E.G. Slope
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/s)	(ft)	(ft/ft)
Reach-1	3.678	148.00		1321.75	9984.76	10021.55	36.79	1318.80	2.95	2.15	1321.82	0.001132
Reach-1	3.61	148.00		1320.77	9987.12	10040.69	53.57	1318.30	2.47	4.12	1321.01	0.005814
Reach-1	3.54	296.00		1318.77	9993.32	10043.85	50.53	1316.30	2.47	3.94	1319.01	0.005175
Reach-1	3.46	296.00		1315.52	9988.74	10013.79	25.05	1312.60	2.92	6.15	1316.10	0.009332
Reach-1	3.383	296.00		1311.64	9985.91	10018.18	32.27	1309.10	2.54	5.72	1312.14	0.009893
Reach-1	3.301	296.00	1308.13	1308.61	9986.93	10040.37	53.44	1306.10	2.51	4.66	1308.95	0.005625
Reach-1	3.214	296.00	1304.21	1304.21	9949.65	10016.60	66.95	1302.70	1.51	5.27	1304.64	0.018817
Reach-1	3.167	296.00		1303.93	9980.18	10034.45	54.26	1299.80	4.13	2.07	1303.99	0.000671
Reach-1	3.081	710.00		1303.22	9974.84	10050.23	75.39	1297.50	5.72	3.88	1303.45	0.001561
Reach-1	3.009	710.00	1301.30	1301.30	9980.53	10067.32	86.78	1296.60	4.70	7.86	1302.17	0.009662
Reach-1	2.907	710.00	1294.59	1294.59	9980.38	10044.63	64.25	1291.30	3.29	7.67	1295.49	0.012803
Reach-1	2.826	710.00		1289.15	9983.18	10158.16	174.98	1285.70	3.45	3.08	1289.28	0.001415
Reach-1	2.741	710.00		1288.01	9984.96	10160.07	155.81	1283.90	4.11	4.82	1288.27	0.003946
Reach-1	2.64	997.00		1287.39	9969.60	10167.34	197.74	1282.90	4.49	2.57	1287.45	0.000874
Reach-1	2.553	997.00		1285.76	9976.19	10098.06	121.86	1282.10	3.66	7.02	1286.46	0.008530
Reach-1	2.468	997.00		1283.13	9983.25	10268.33	285.08	1279.70	3.43	3.97	1283.29	0.005409
Reach-1	2.392	997.00	1279.71	1279.71	9986.45	10209.42	162.18	1275.40	4.31	6.88	1280.24	0.011207
Reach-1	2.33	997.00		1278.50	9977.51	10203.61	226.10	1273.30	5.20	3.66	1278.67	0.001352
Reach-1	2.267	2245.00		1277.50	9972.46	10345.04	372.58	1272.00	5.50	6.00	1277.82	0.003691
Reach-1	2.186	2245.00		1277.56	9910.00	10422.66	512.66	1271.60	5.96	2.05	1277.61	0.000103
Reach-1	2.167	2245.00	1275.91	1277.56	9910.00	10516.74	606.74	1270.00	7.56	1.71	1277.59	0.000083
Reach-1	2.163	Culvert										
Reach-1	2.159	1755.00	1275.61	1275.61	9913.27	10392.89	479.63	1269.60	6.01	2.05	1275.67	0.000218
Reach-1	2.072	1755.00		1269.36	9971.60	10233.43	261.83	1263.50	5.86	4.87	1269.60	0.001881
Reach-1	1.996	2048.00	1265.82	1265.82	9973.64	10038.62	64.98	1260.40	5.42	11.32	1267.62	0.009309
Reach-1	1.92	2048.00		1262.80	9973.01	10049.95	76.94	1255.20	7.60	7.64	1263.70	0.004152
Reach-1	1.844	2048.00	1259.41	1259.41	9980.99	10055.13	74.14	1252.40	7.01	10.92	1261.21	0.009187
Reach-1	1.768	2048.00		1253.59	9963.05	10235.93	272.88	1250.70	2.89	4.75	1253.87	0.006205
Reach-1	1.692	2048.00		1252.06	9960.00	10145.75	185.75	1247.70	4.36	5.06	1252.33	0.002609
Reach-1	1.616	2048.00		1251.91	9950.00	10196.62	246.62	1244.00	7.91	2.59	1251.99	0.000323
Reach-1	1.556	5141.00		1249.53	9959.75	10121.01	161.26	1241.00	8.53	11.00	1251.32	0.005883
Reach-1	1.466	5141.00	1245.89	1245.89	9980.18	10157.58	177.40	1237.50	8.39	12.27	1247.61	0.010707
Reach-1	1.388	5141.00	1240.87	1240.87	9981.73	10180.25	198.52	1234.50	6.37	12.18	1242.30	0.014673
Reach-1	1.313	5141.00		1239.04	9951.39	10185.97	234.58	1230.80	8.24	6.75	1239.63	0.002381
Reach-1	1.237	4645.00		1238.92	9950.00	10304.22	354.22	1227.80	11.12	4.22	1239.08	0.000546
Reach-1	1.159	4150.00	1234.51	1238.79	9886.00	10271.51	385.51	1224.40	14.39	3.71	1238.95	0.000188
Reach-1	1.1535	Culvert										
Reach-1	1.148	3655.00	1234.51	1234.51	9880.00	10068.81	188.81	1224.00	10.51	7.65	1235.09	0.001293
Reach-1	1.074	3655.00		1228.98	9957.65	10032.45	74.80	1221.00	7.98	10.53	1230.70	0.005045

Reach	River Sta	Q Total	Crit W.S.	W.S. Elev	Sta W.S. Lft	Sta W.S. Rgt	Top Width	Min Ch El	Max Chl Dpth	Vel Chnl	E.G. Elev	E.G. Slope
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/s)	(ft)	(ft/ft)
Reach-1	0.998	3890.00	1225.76	1225.76	9969.12	10043.81	74.69	1218.30	7.46	12.36	1228.11	0.007148
Reach-1	0.92	3890.00	1221.55	1221.55	9966.12	10093.28	127.16	1215.60	5.95	10.36	1223.19	0.007726
Reach-1	0.846	3890.00		1220.23	9943.31	10148.45	205.14	1213.60	6.63	6.88	1220.86	0.001789
Reach-1	0.77	4125.00		1220.01	9949.81	10400.00	450.19	1211.30	8.71	5.20	1220.27	0.000868
Reach-1	0.696	4125.00	1217.17	1217.17	9954.13	10045.87	91.73	1210.00	7.17	12.15	1219.36	0.006530
Reach-1	0.62	4125.00		1215.08	9954.62	10333.08	378.47	1207.80	7.28	6.02	1215.49	0.001701
Reach-1	0.543	4125.00		1213.93	9940.37	10172.98	232.62	1206.70	7.23	7.42	1214.60	0.002689
Reach-1	0.465	4125.00		1211.43	9922.85	10040.73	117.88	1205.00	6.43	9.91	1212.94	0.006090
Reach-1	0.39	4414.00	1208.15	1208.15	9931.17	10041.53	110.37	1201.80	6.35	11.07	1210.06	0.008543
Reach-1	0.307	4414.00		1202.44	9875.86	10320.44	235.02	1197.70	4.74	8.16	1203.40	0.007312
Reach-1	0.231	4414.00		1200.13	9953.06	10268.09	292.79	1196.00	4.83	7.27	1200.85	0.005556
Reach-1	0.156	4414.00	1197.86	1198.29	9907.84	10260.79	352.95	1193.90	4.39	6.69	1198.96	0.004331
Reach-1	0.07	4414.00	1195.13	1195.17	9948.32	10160.31	211.99	1192.00	3.17	8.72	1196.34	0.007647
Reach-1	0	4414.00	1192.55	1192.85	9947.29	10139.24	191.95	1189.40	3.45	8.48	1193.94	0.005502

HEC-RAS Plan: Plan 02 River: RIVER-1 Reach: Reach-1

Reach	River Sta	E.G. US.	W.S. US.	E.G. IC	E.G. OC	Min Top Rd	Culv Q	Q Weir	Delta WS	Culv Vel In	Culv Vel Out
		(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(ft)	(ft/s)	(ft/s)
Reach-1	2.163 Culvert #1	1277.59	1277.56	1271.26	1277.59	1275.90	32.68	2062.61	1.95	1.48	1.48
Reach-1	2.163 Culvert #2	1277.59	1277.56	1274.69	1277.59	1275.90	149.71	2062.61	1.95	7.78	7.78
Reach-1	1.1535 Culvert #1	1238.95	1238.79	1233.06	1238.95	1234.50	408.42	3741.58	4.28	10.40	10.40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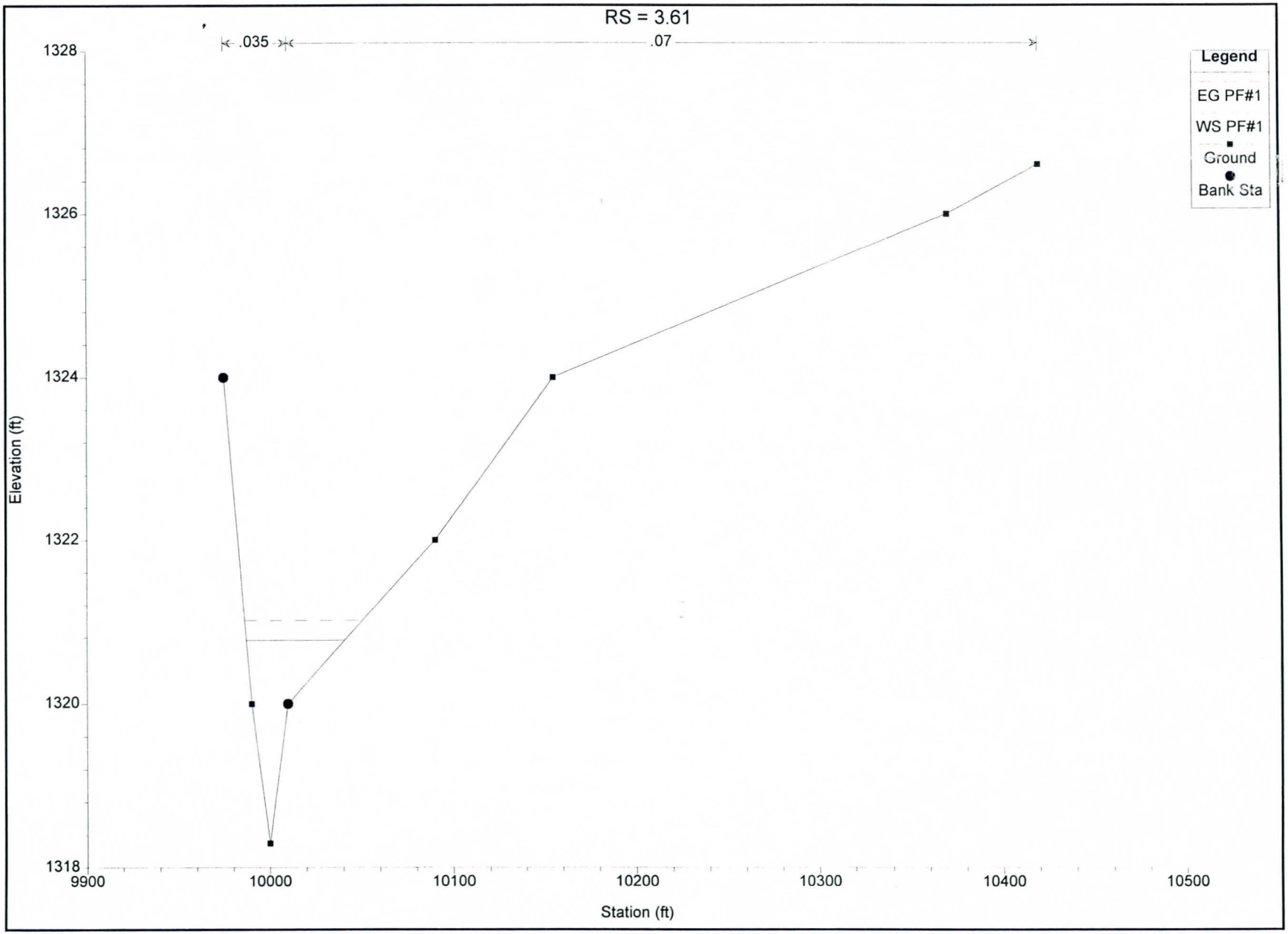
.07
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1330
1328
1326
1324
1322
1320
1318
9900
10000
10100
10200
10300
10400
Station (ft)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.07
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WS PF#1
Ground
Bank Sta
Elevation (ft)
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1326
1324
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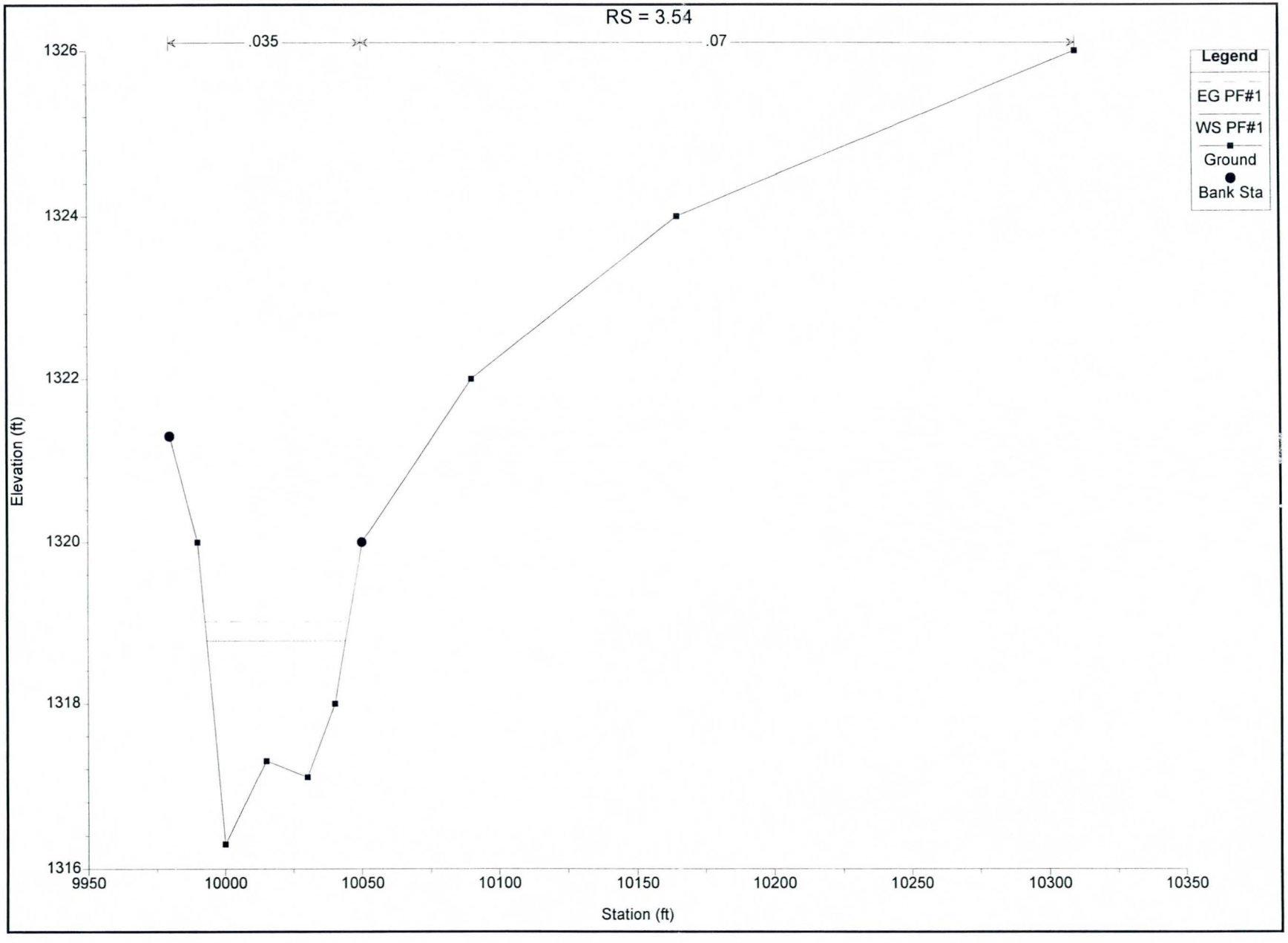
1318
9900
10000
10100
10200
10300
10400
10500
Station (ft)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Legend
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WS PF#1
Ground
Bank Sta
Elevation (ft)
1326
1324
1322
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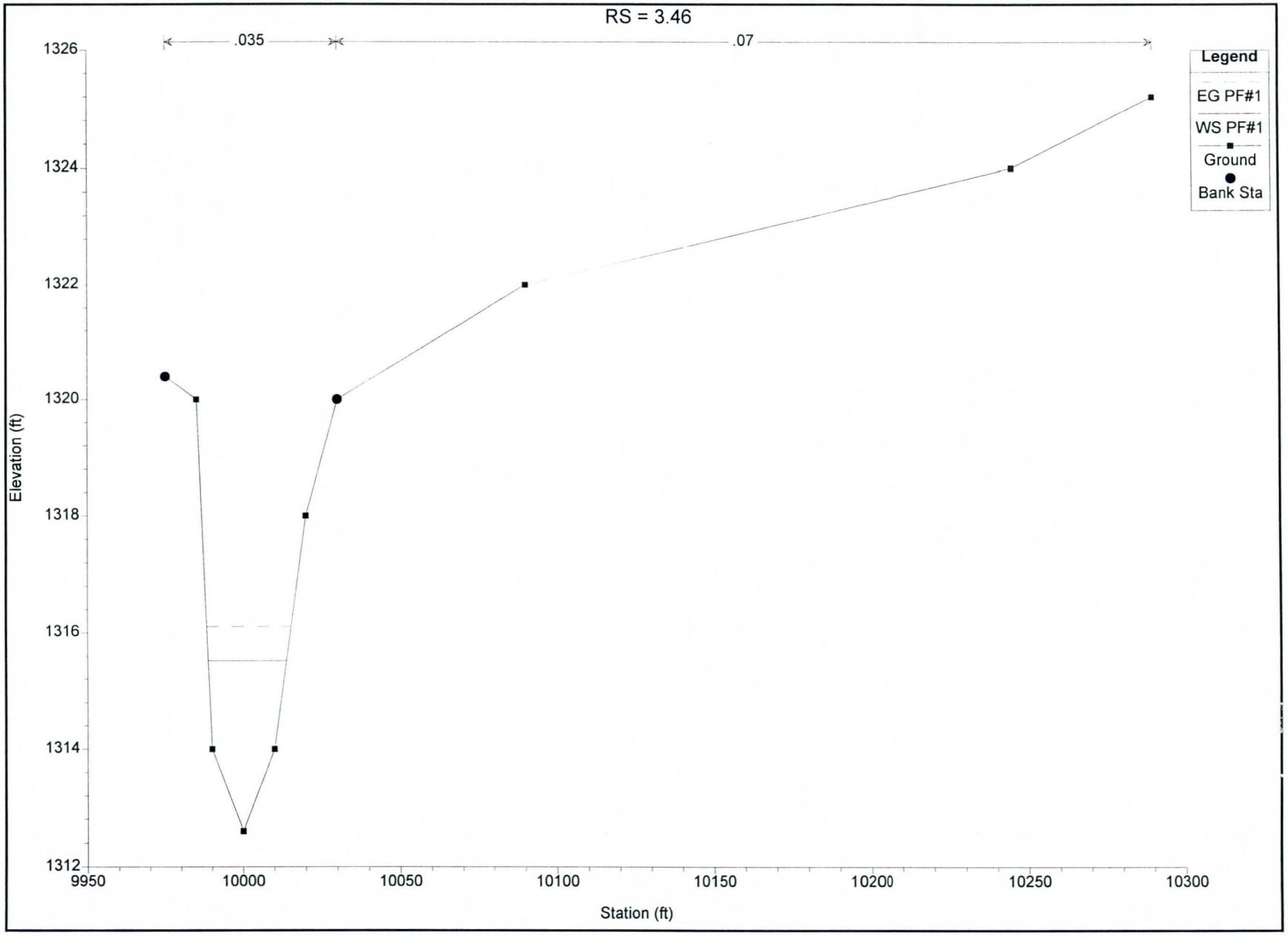
1316
9950
10000
10050
10100
10150
10200
10250
10300
10350
Station (ft)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WS PF#1
Ground
Bank Sta
Elevation (ft)
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1324
1322
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1312
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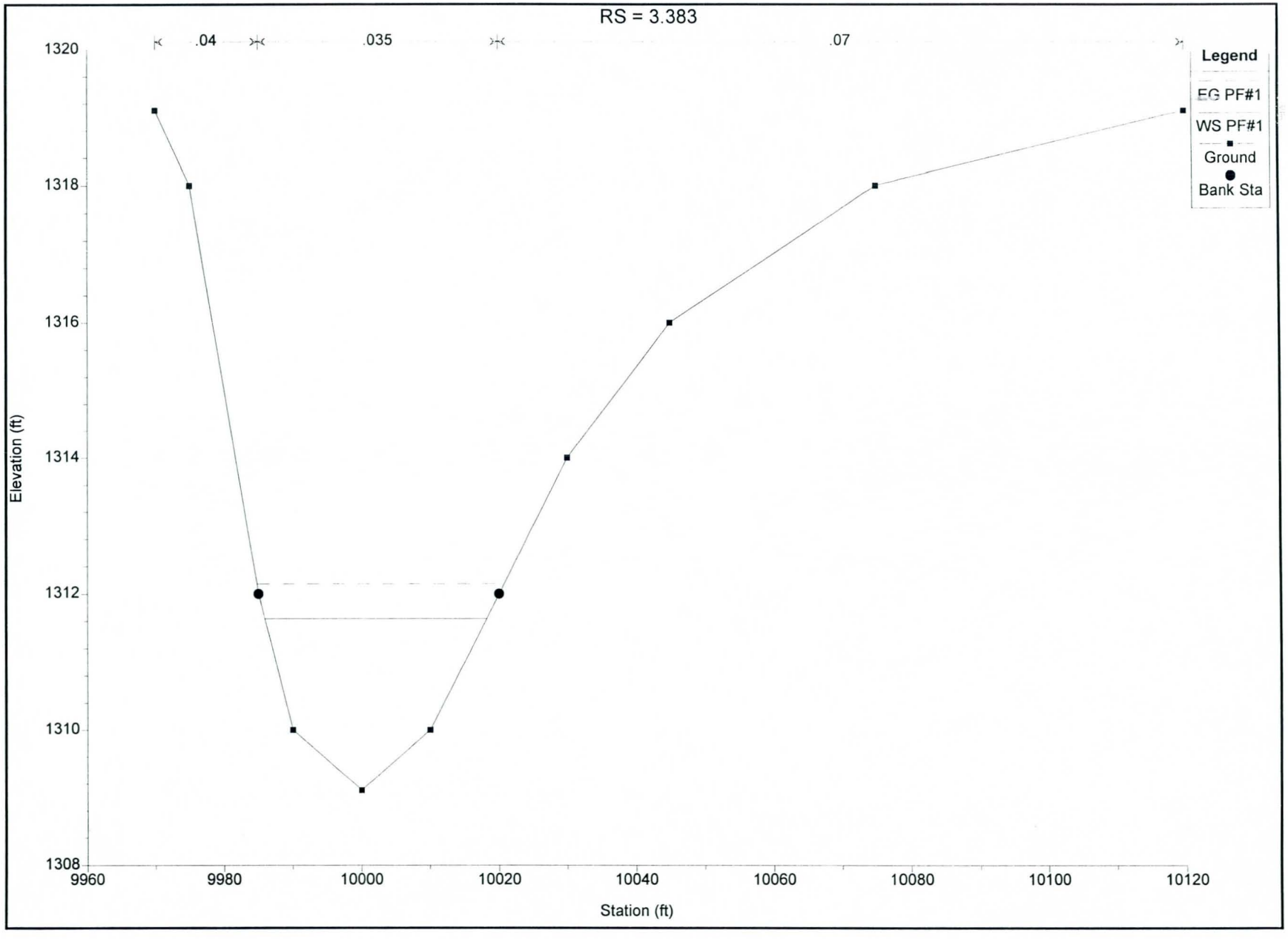
10000
10050
10100
10150
10200
10250
10300
Station (ft)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.07
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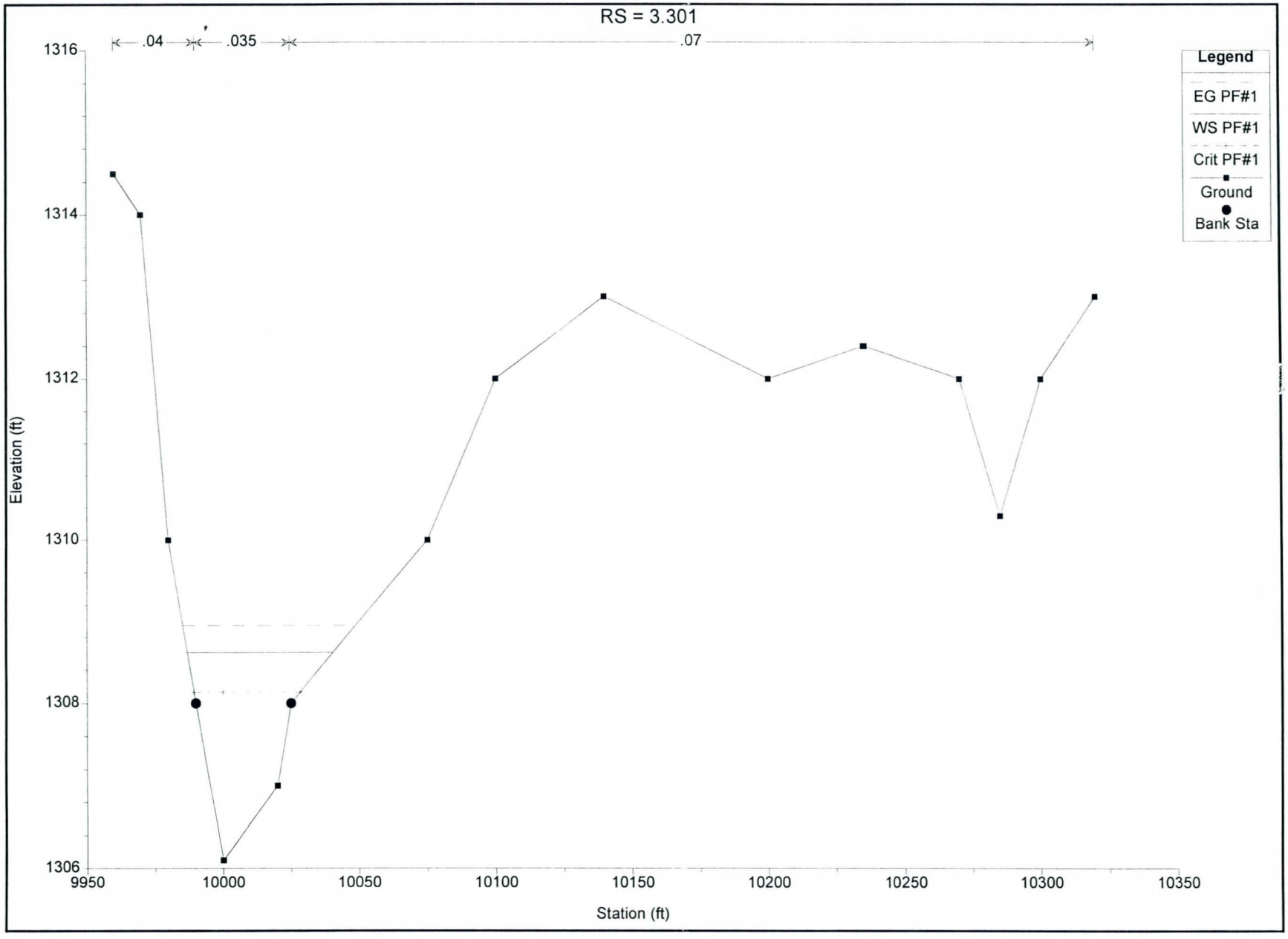
WS PF#1
Ground
Bank Sta
Elevation (ft)
1320
1318
1316
1314
1312
1310
1308
9960
9980
10000
10020
10040
10060
10080
10100
10120
Station (ft)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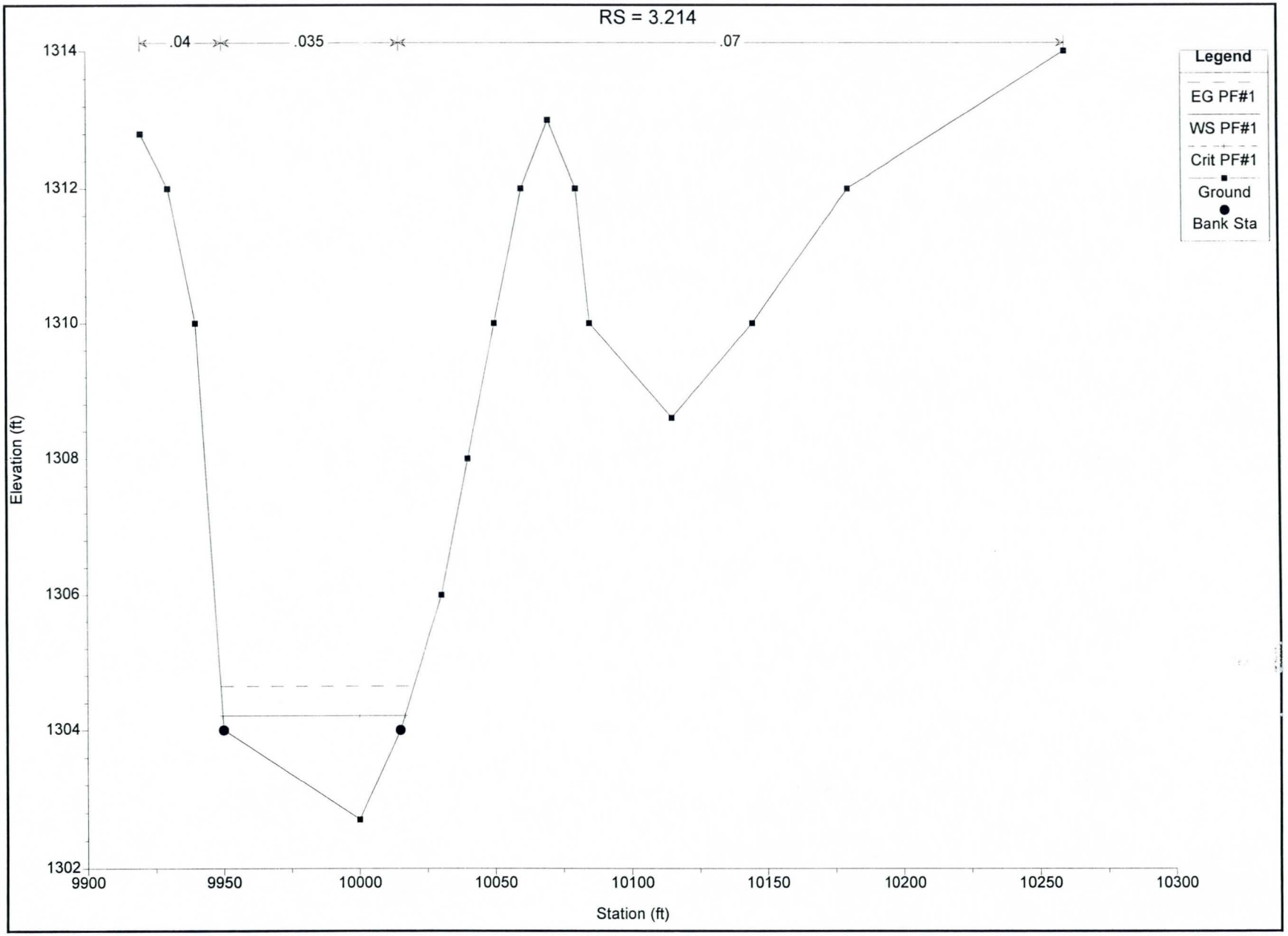
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1316
1314
1312
1310
1308
1306
9950
10000
10050
10100
10150
10200
10250
10300
10350
Station (ft)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.07
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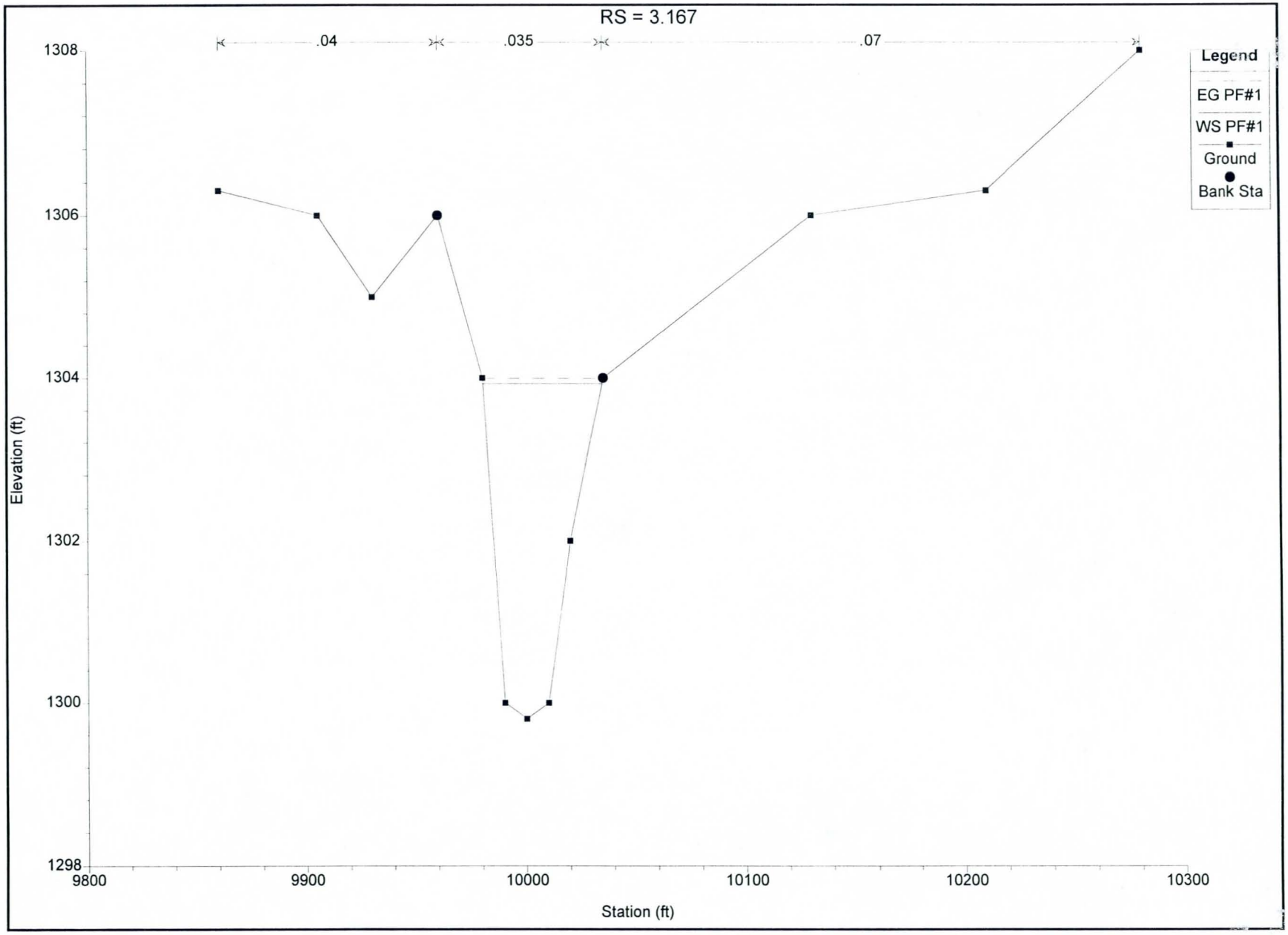
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1314
1312
1310
1308
1306
1304
1302
9900
9950
10000
10050
10100
10150
10200
10250
10300
Station (ft)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WS PF#1
Ground
Bank Sta
Elevation (ft)
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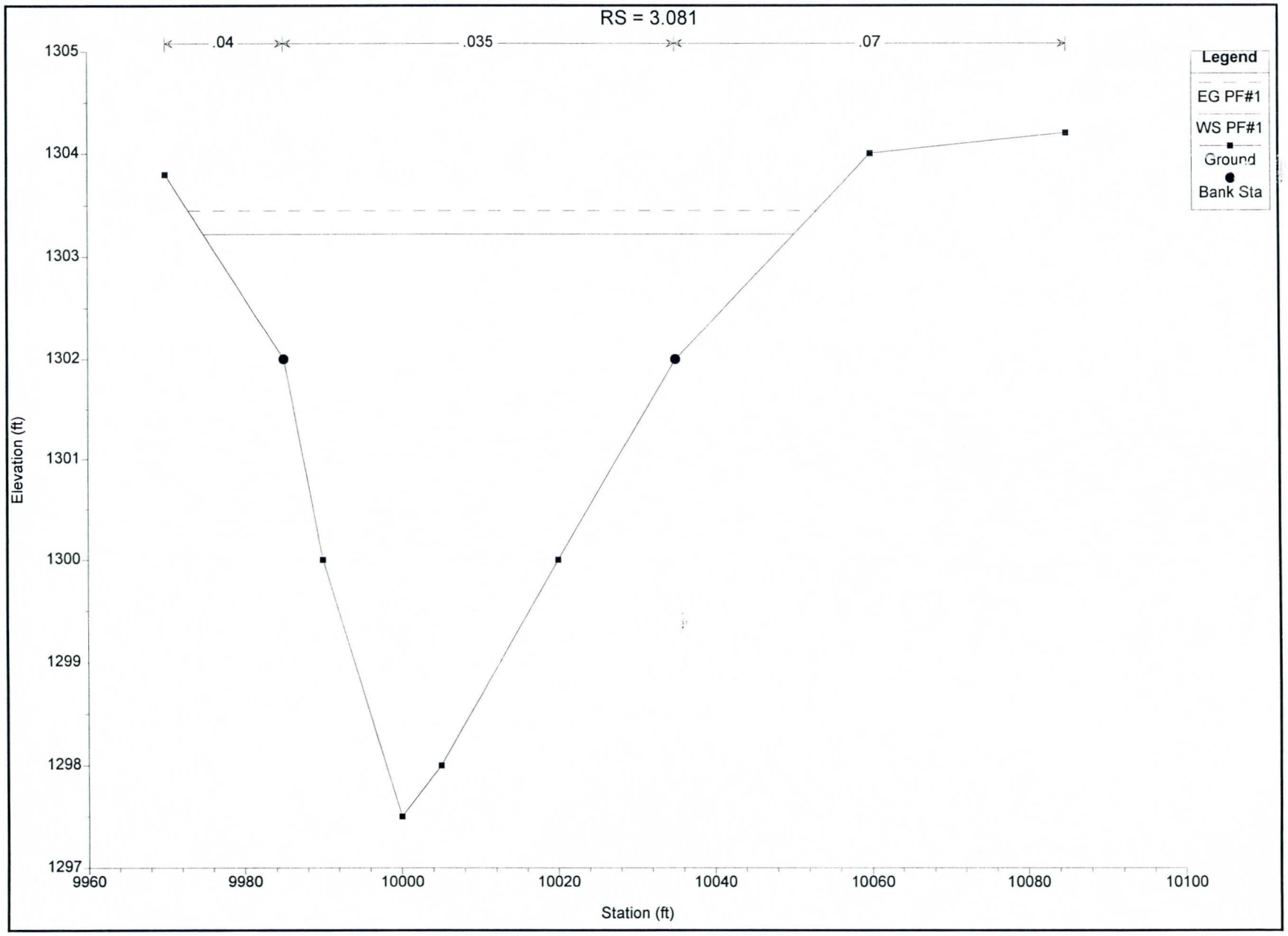
1304
1302
1300
1298
9800
9900
10000
10100
10200
10300
Station (ft)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.07
Legend
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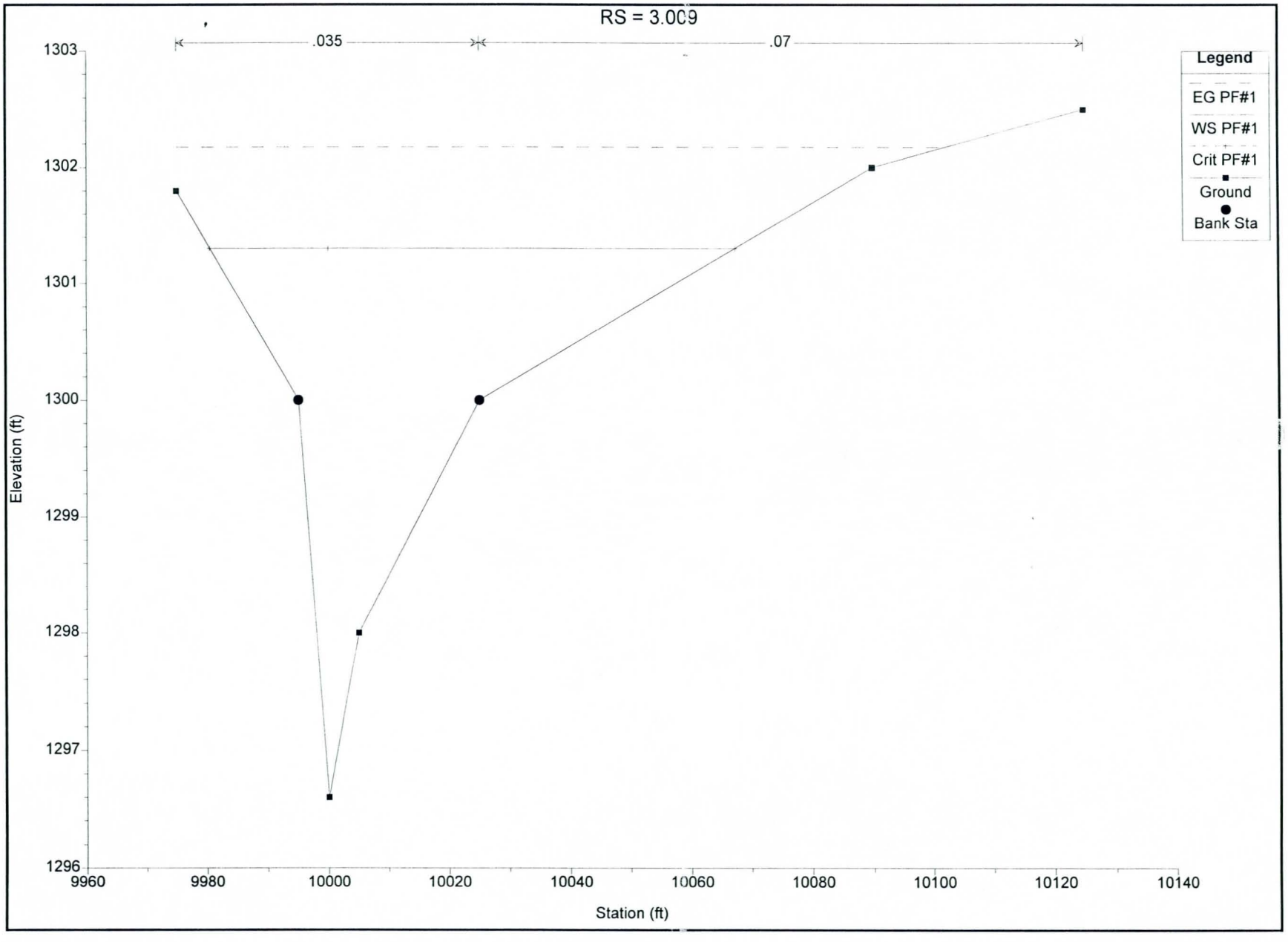
WS PF#1
Ground
Bank Sta
Elevation (ft)
1305
1304
1303
1302
1301
1300
1299
1298
1297
9960
9980
10000
10020
10040
10060
10080
10100
Station (ft)


RS = 3.009
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.07
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1303
1302
1301
1300
1299
1298
1297
1296
9960
9980
10000
10020
10040
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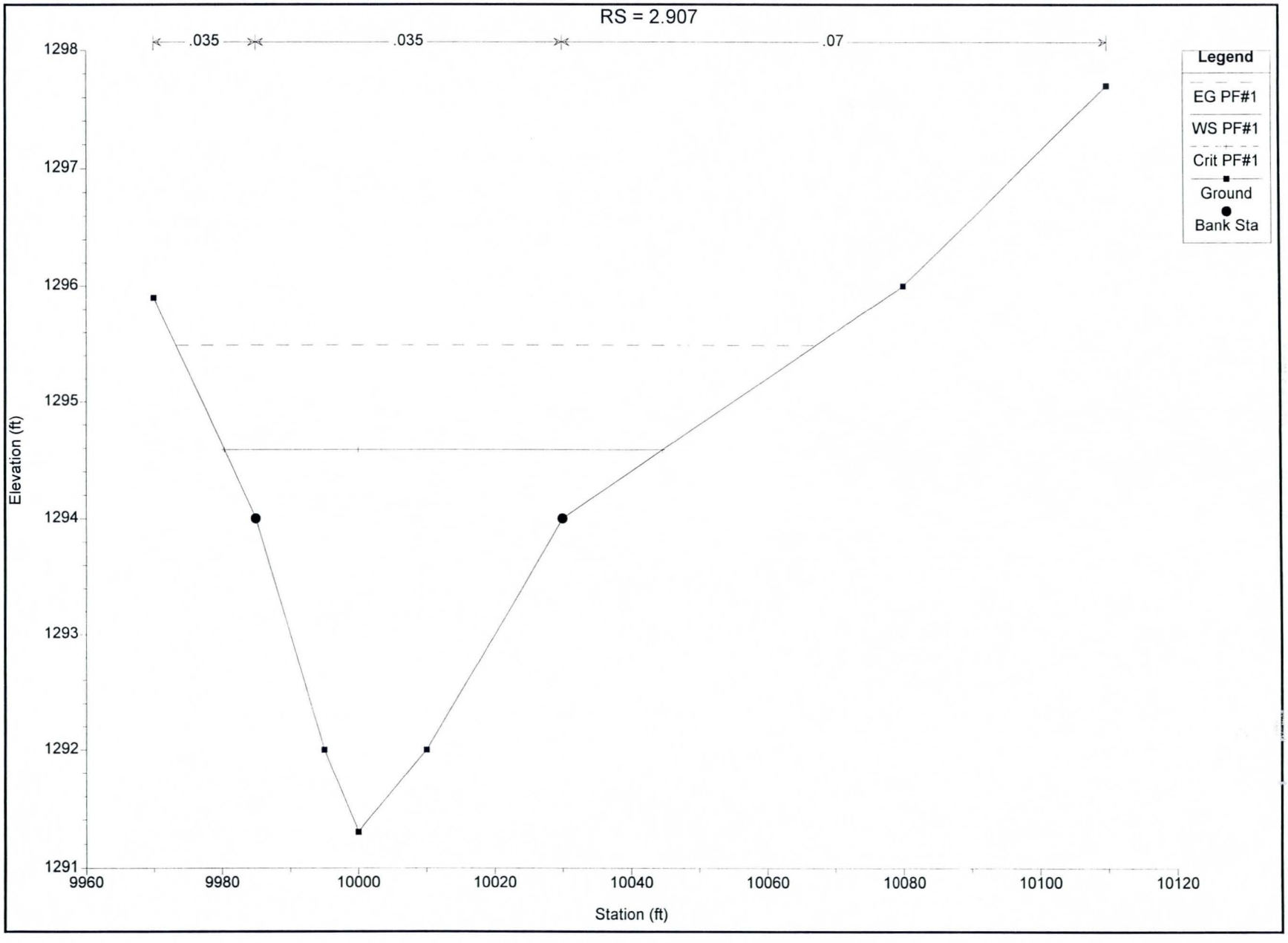
10100
10120
10140
Station (ft)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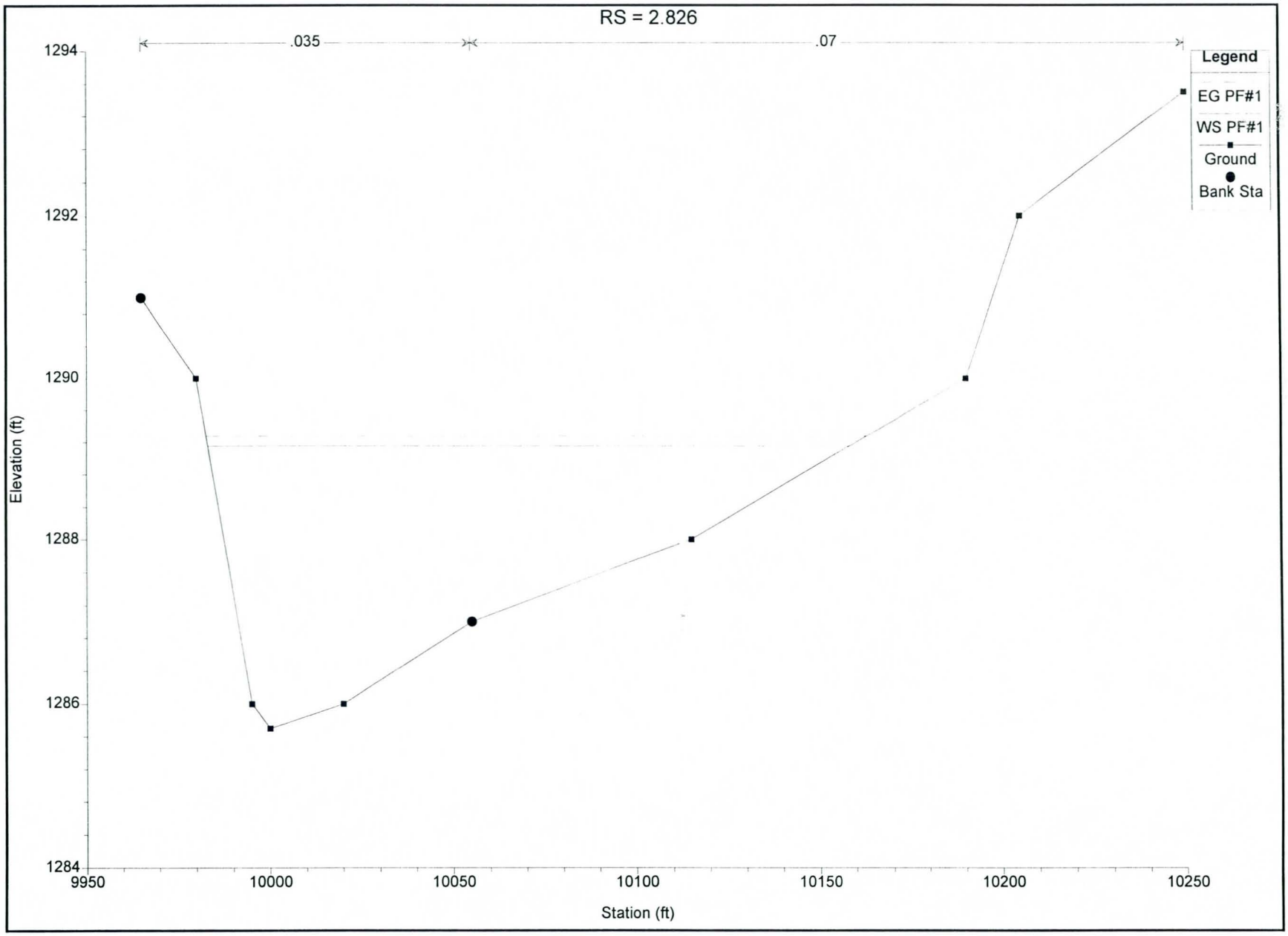
.035
.07
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1298
1297
1296
1295
1294
1293
1292
1291
9960
9980
10000
10020
10040
10060
10080
10100
10120
Station (ft)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WS PF#1
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Bank Sta
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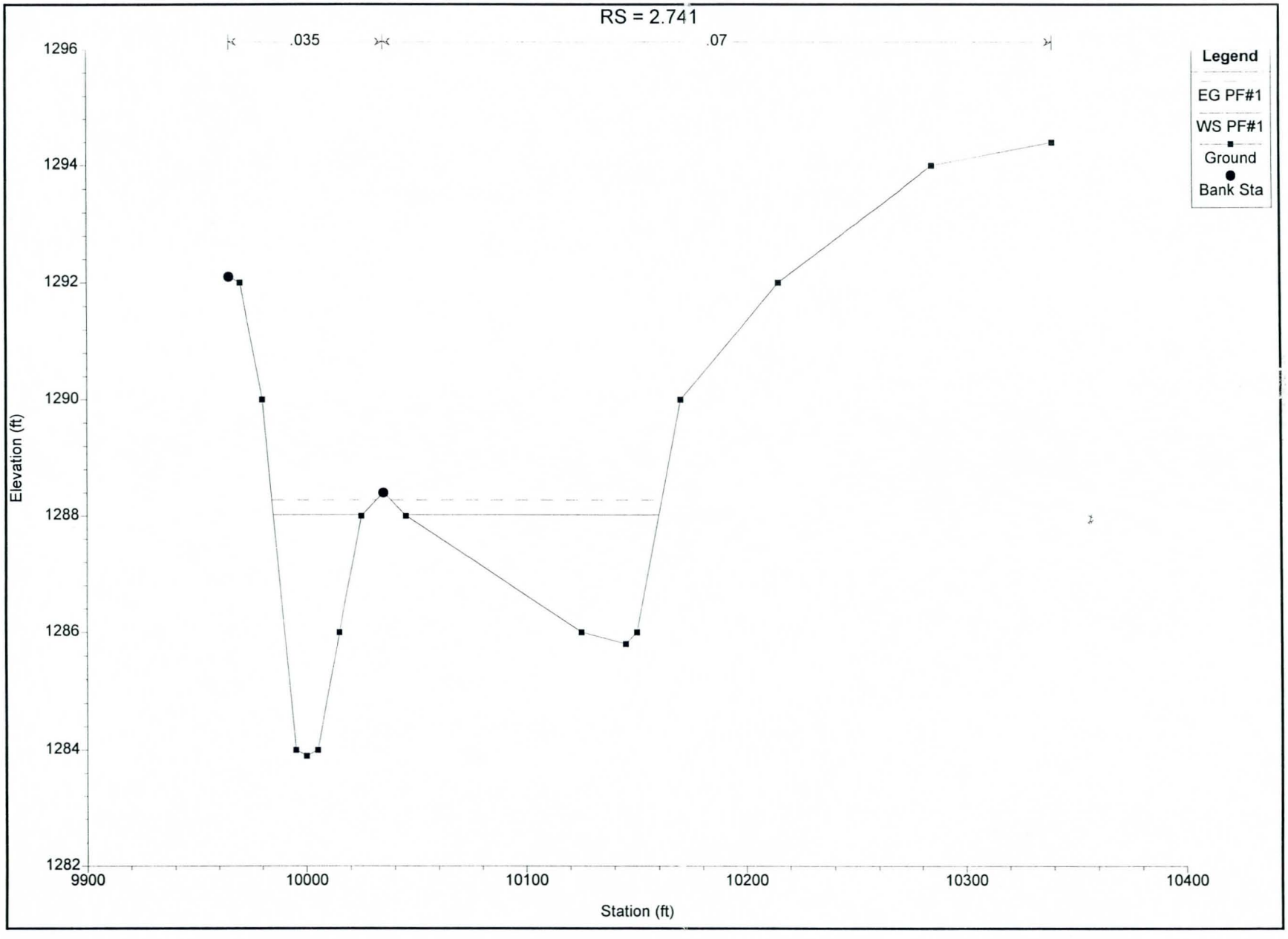
1284
9950
10000
10050
10100
10150
10200
10250
Station (ft)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WS PF#1
Ground
Bank Sta
Elevation (ft)
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1294
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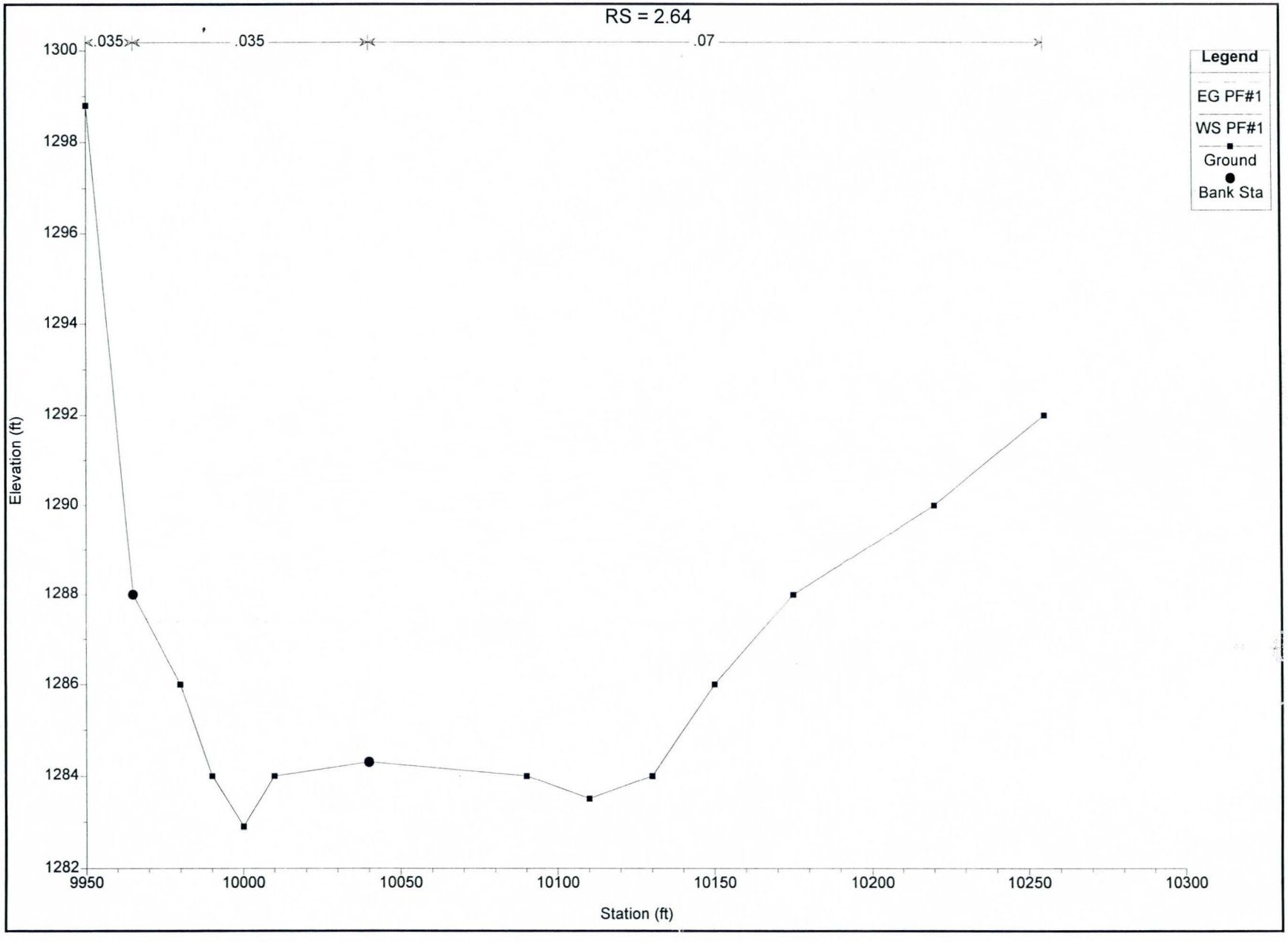
1290
1288
1286
1284
1282
9900
10000
10100
10200
10300
10400
Station (ft)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.035
.07
Legend
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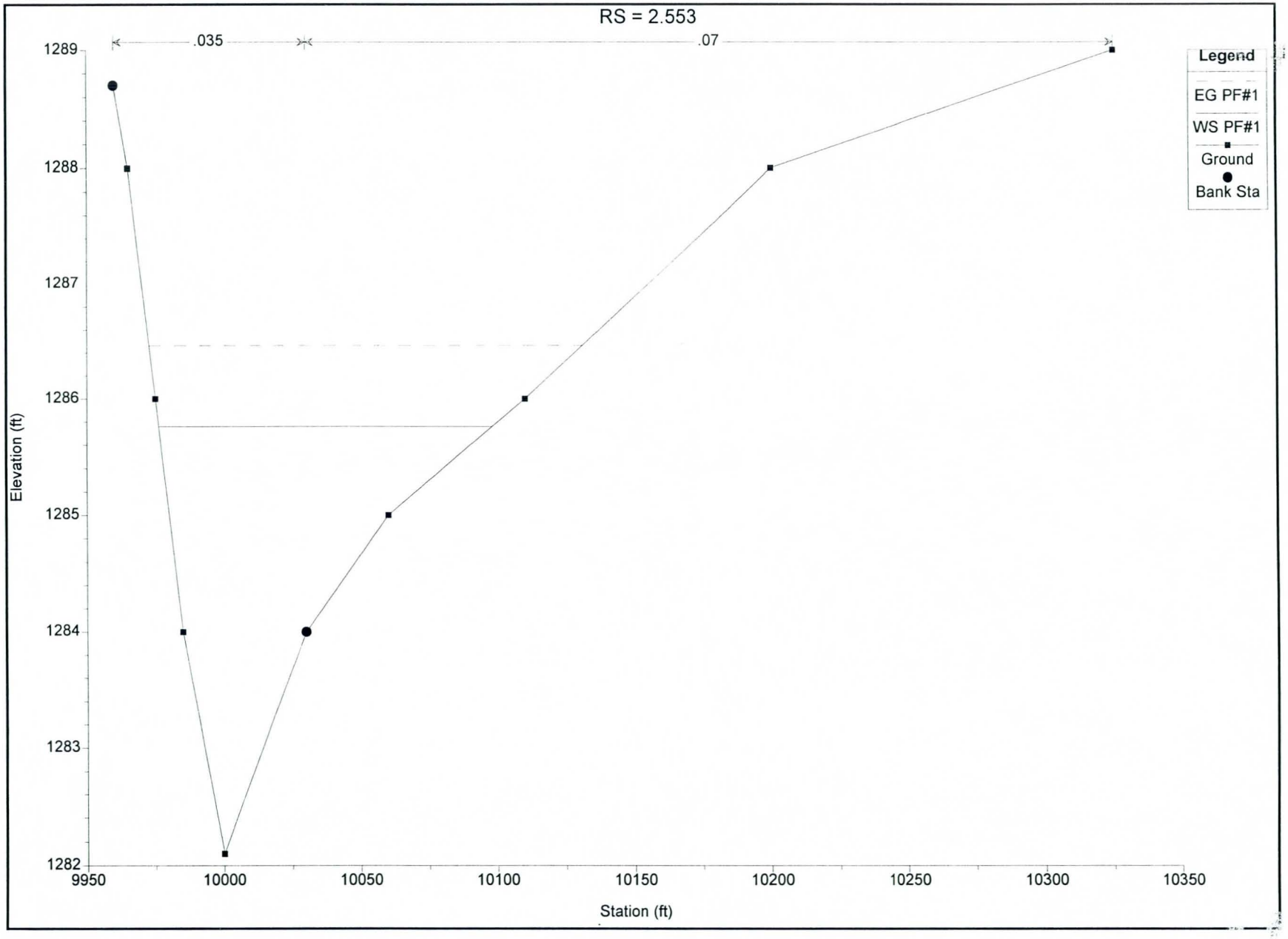
WS PF#1
Ground
Bank Sta
Elevation (ft)
1300
1298
1296
1294
1292
1290
1288
1286
1284
1282
9950
10000
10050
10100
10150
10200
10250
10300
Station (ft)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WS PF#1
Ground
Bank Sta
Elevation (ft)
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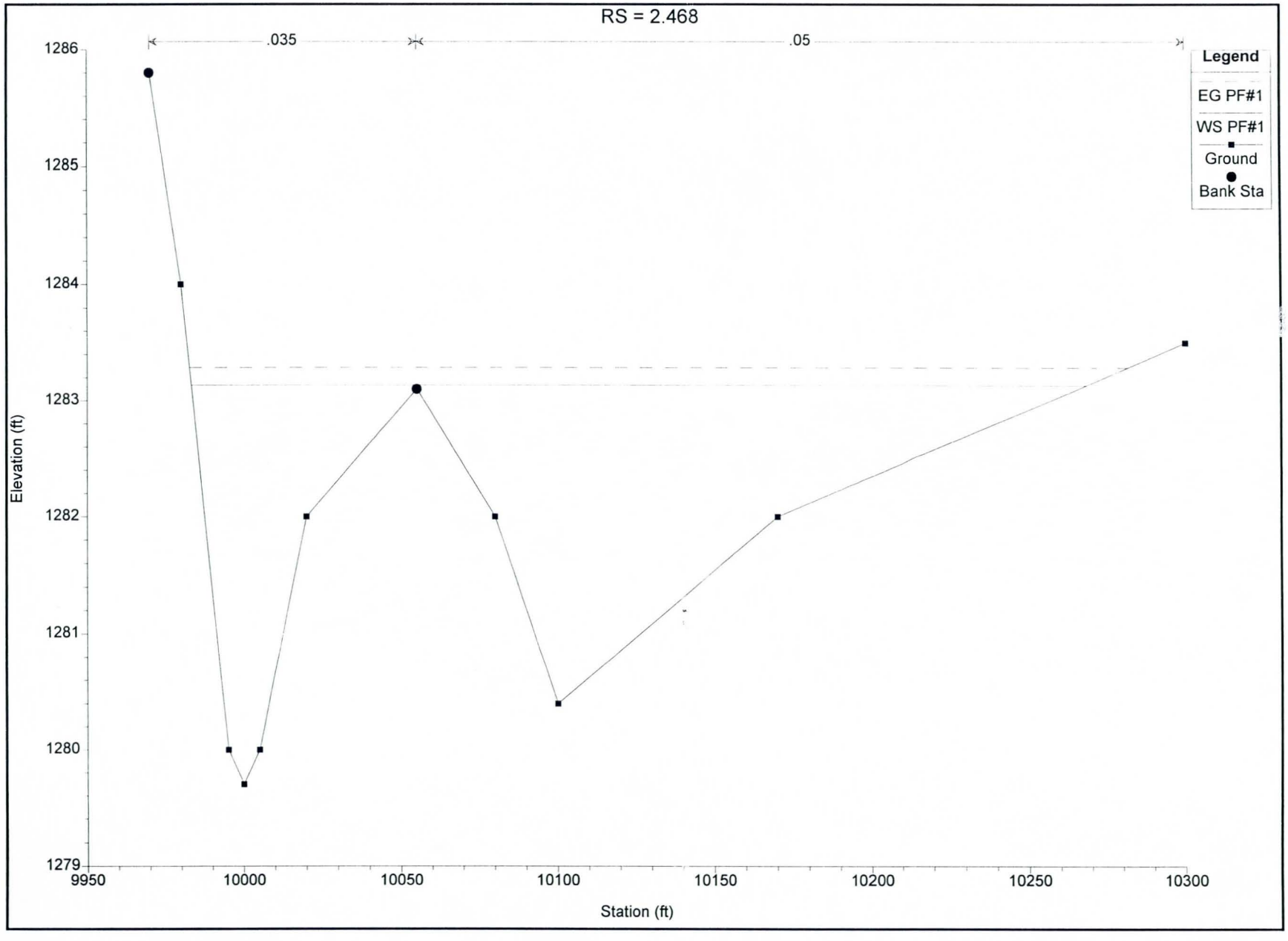
1288
1287
1286
1285
1284
1283
1282
9950
10000
10050
10100
10150
10200
10250
10300
10350
Station (ft)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Ground
Bank Sta
Elevation (ft)
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1285
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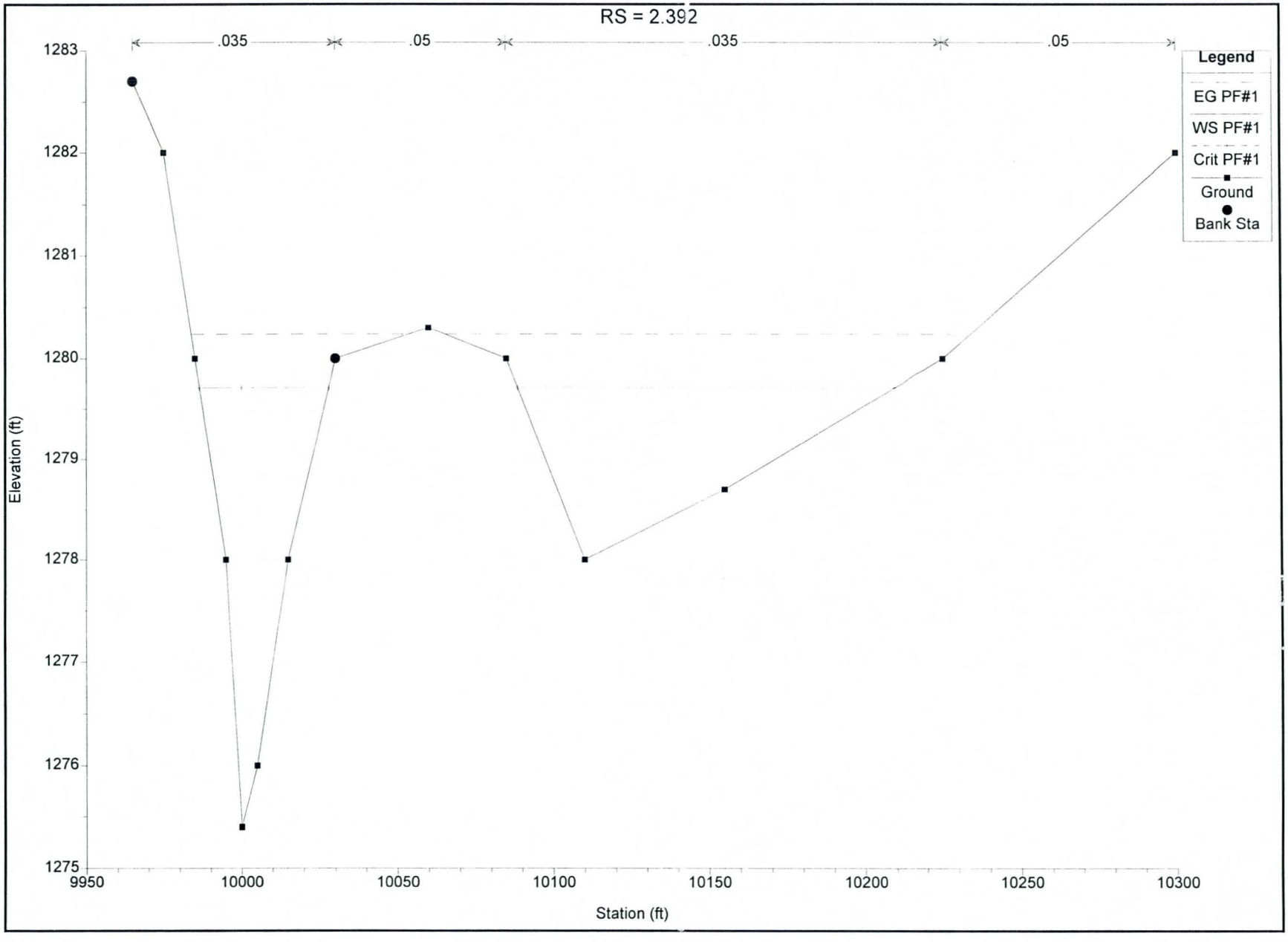
1281
1280
1279
9950
10000
10050
10100
10150
10200
10250
10300
Station (ft)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.035
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Crit PF#1
Ground
Bank Sta
Elevation (ft)
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1282
1281
1280
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1277
1276
1275
9950
10000
10050
10100
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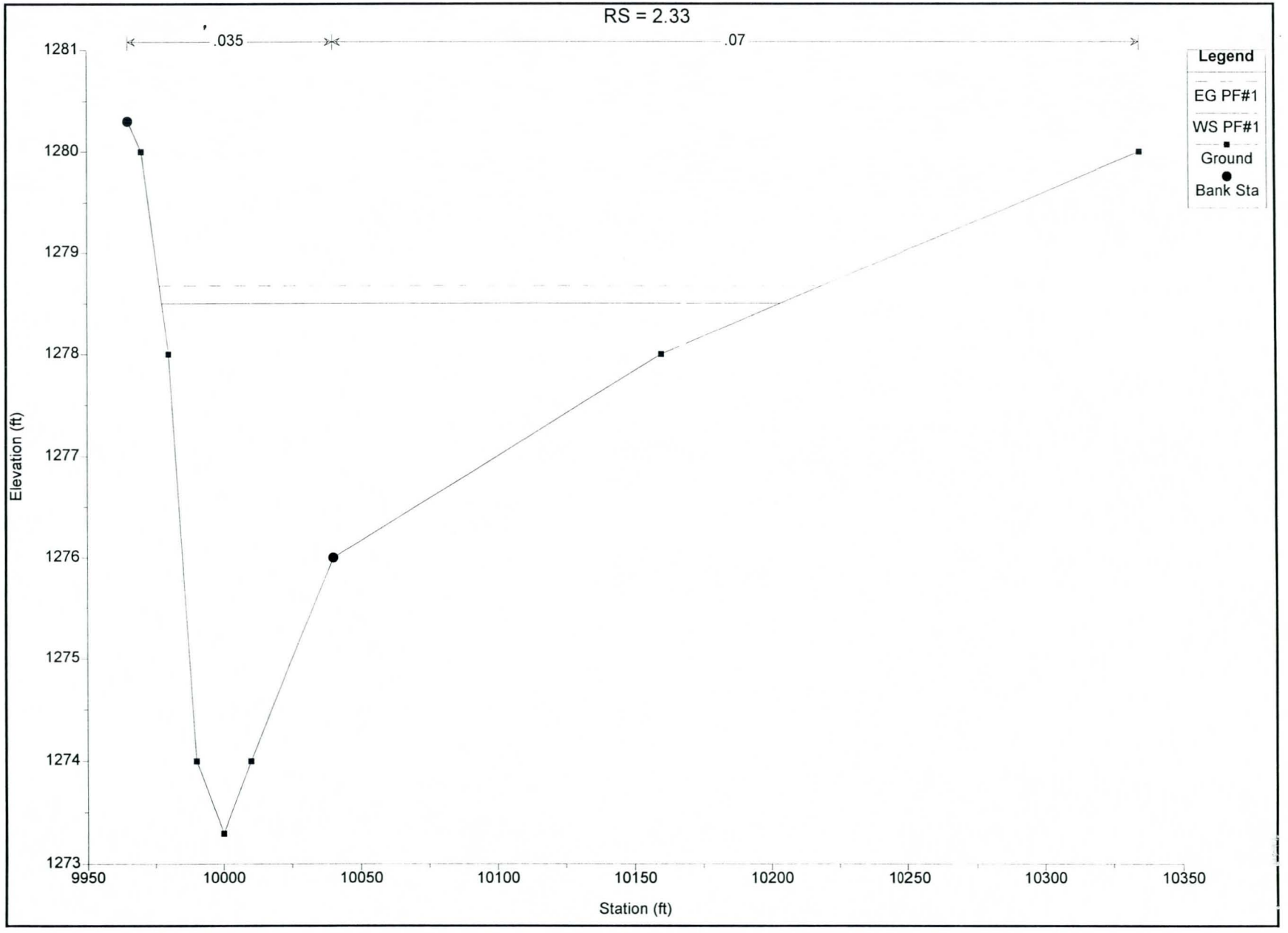
10200
10250
10300
Station (ft)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Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
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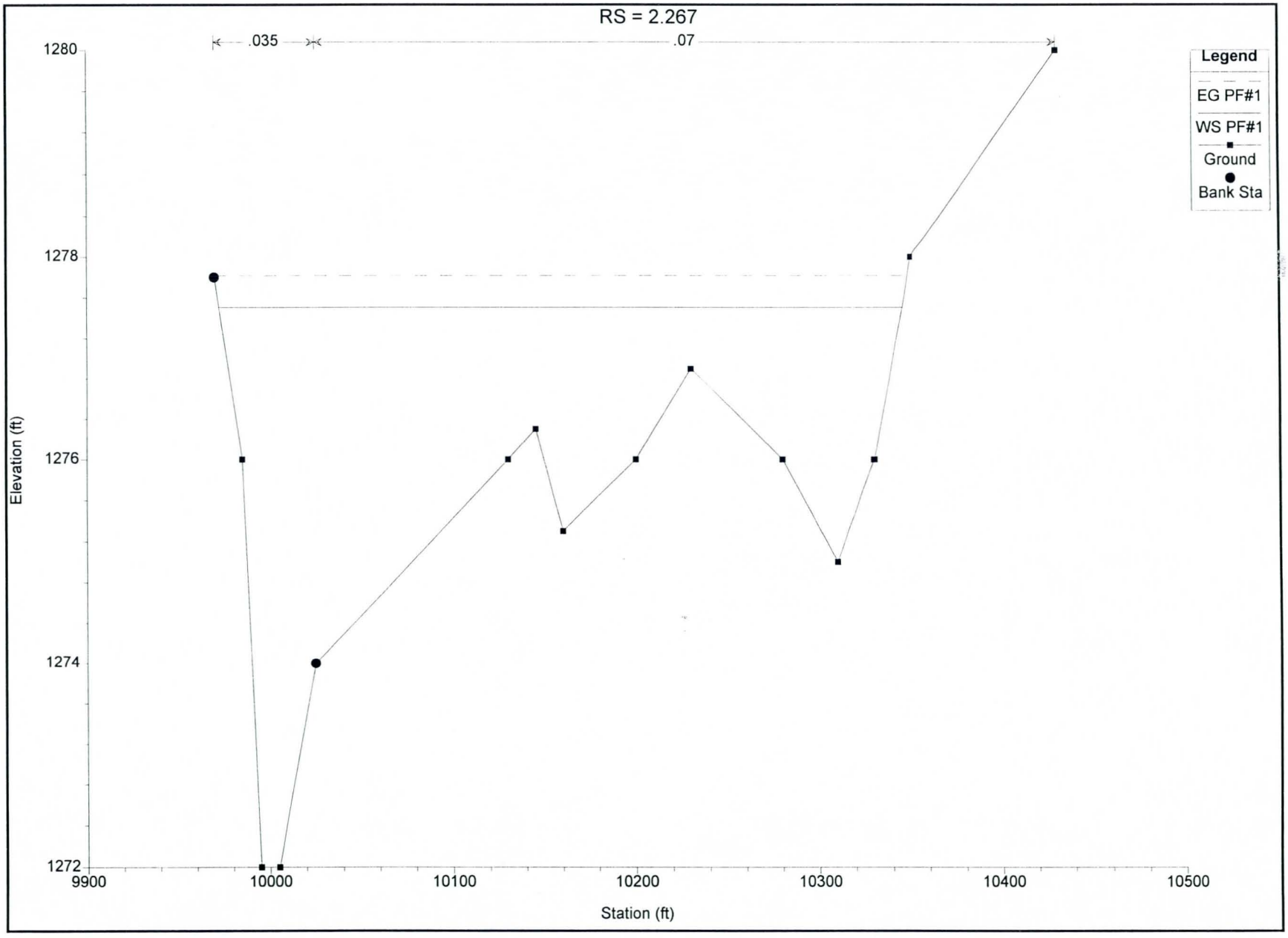
1280
1279
1278
1277
1276
1275
1274
1273
9950
10000
10050
10100
10150
10200
10250
10300
10350
Station (ft)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Legend
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WS PF#1
Ground
Bank Sta
Elevation (ft)
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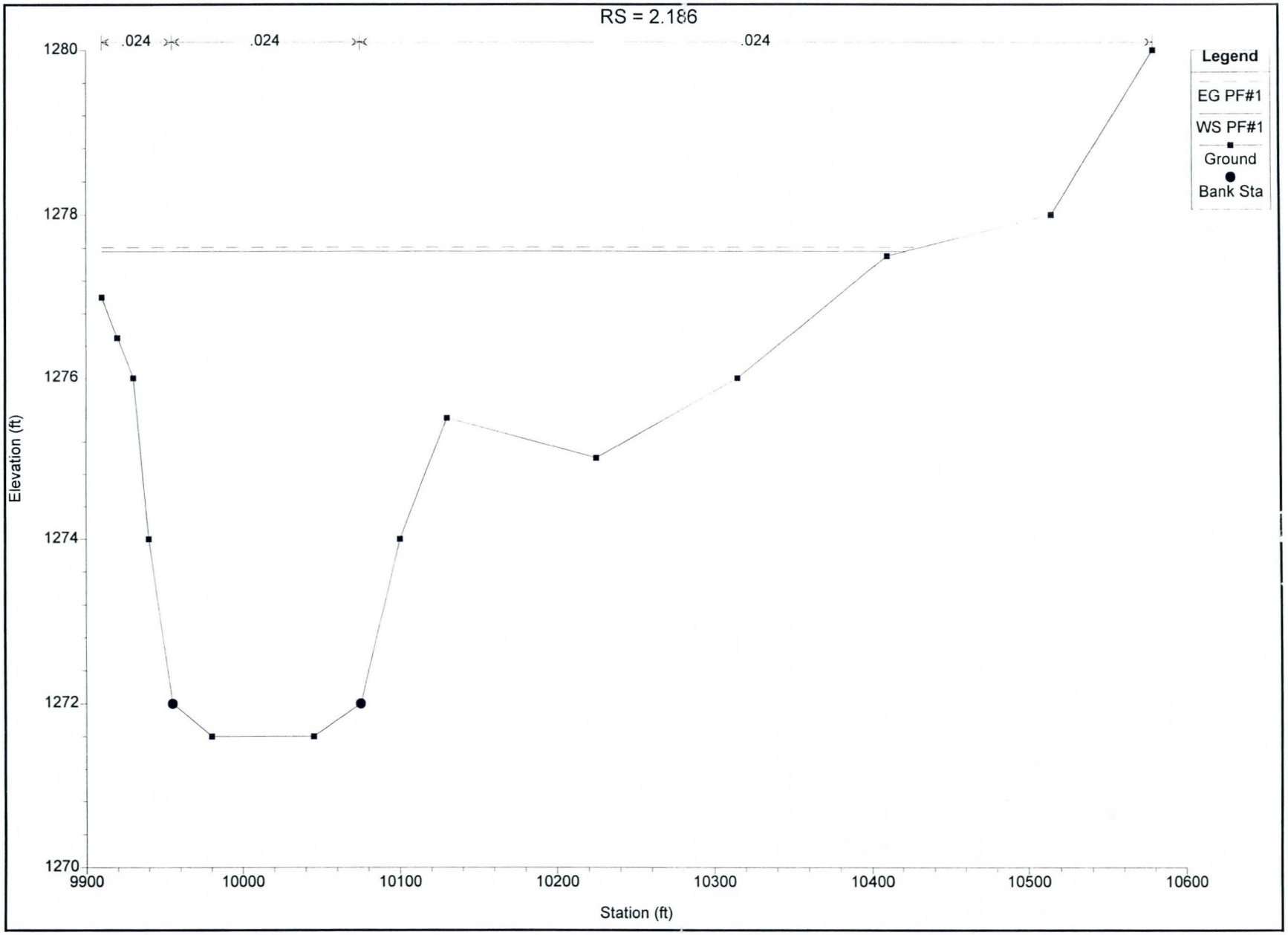
1278
1276
1274
1272
9900
10000
10100
10200
10300
10400
10500
Station (ft)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.024
.024
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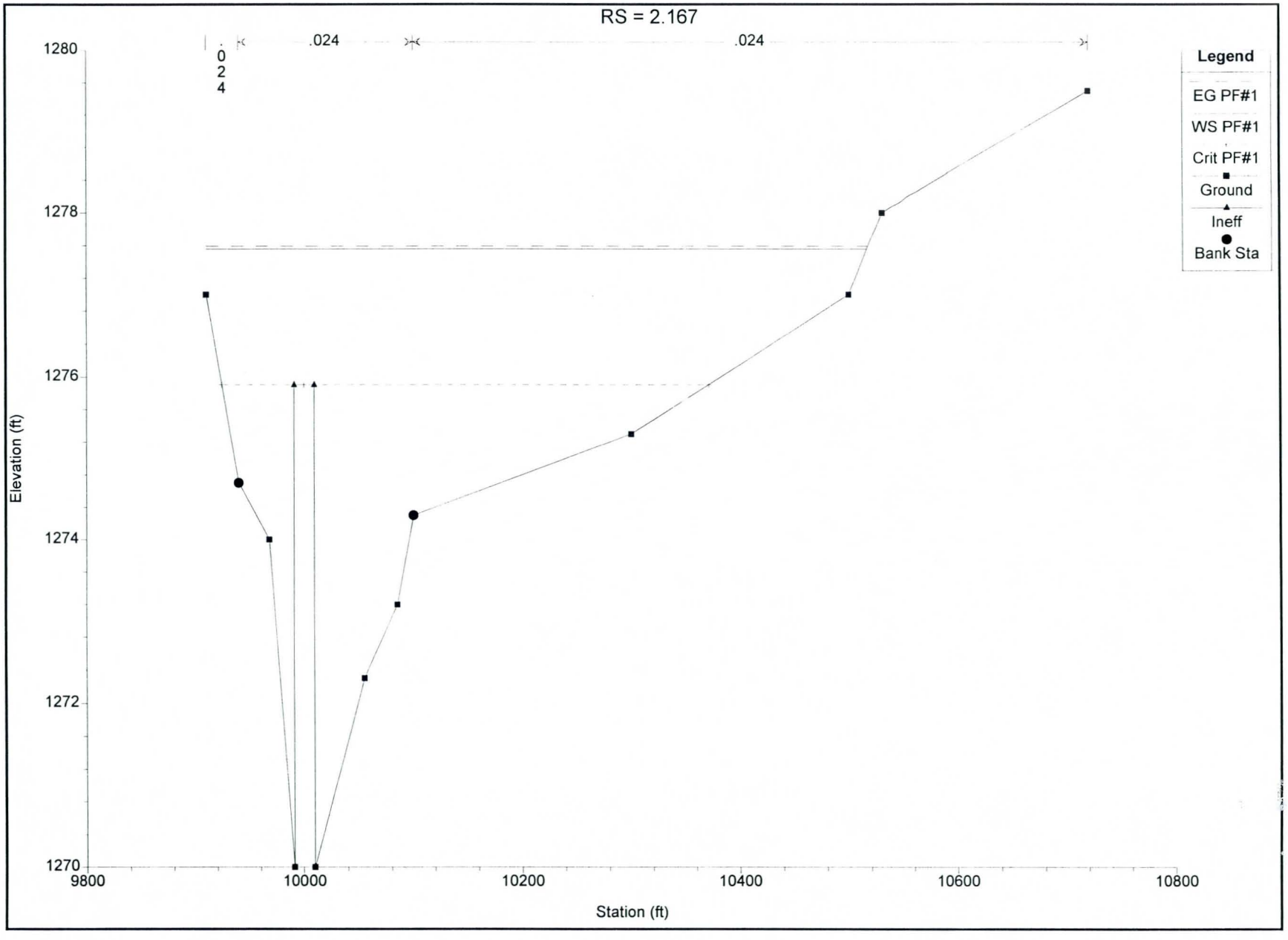
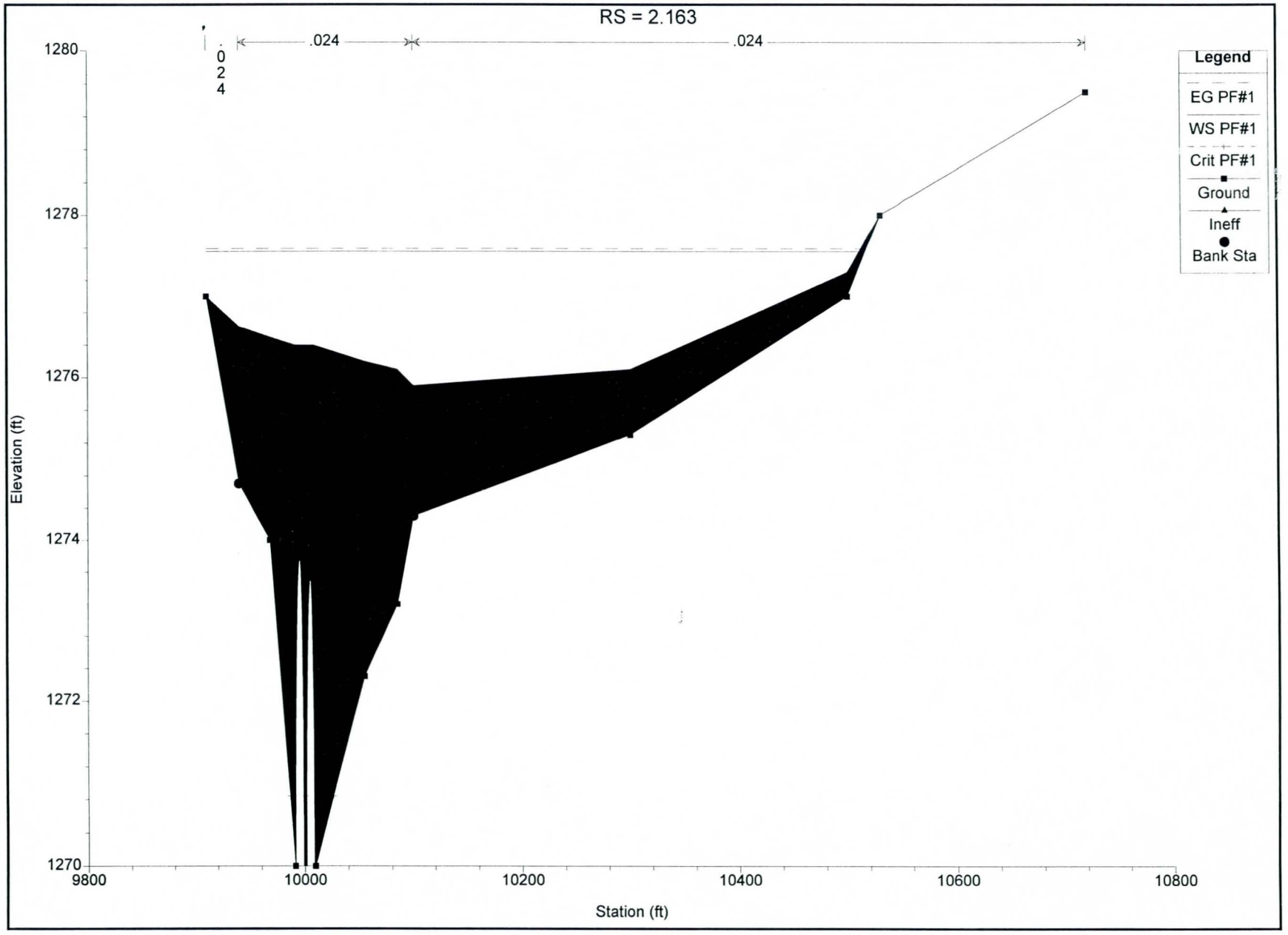
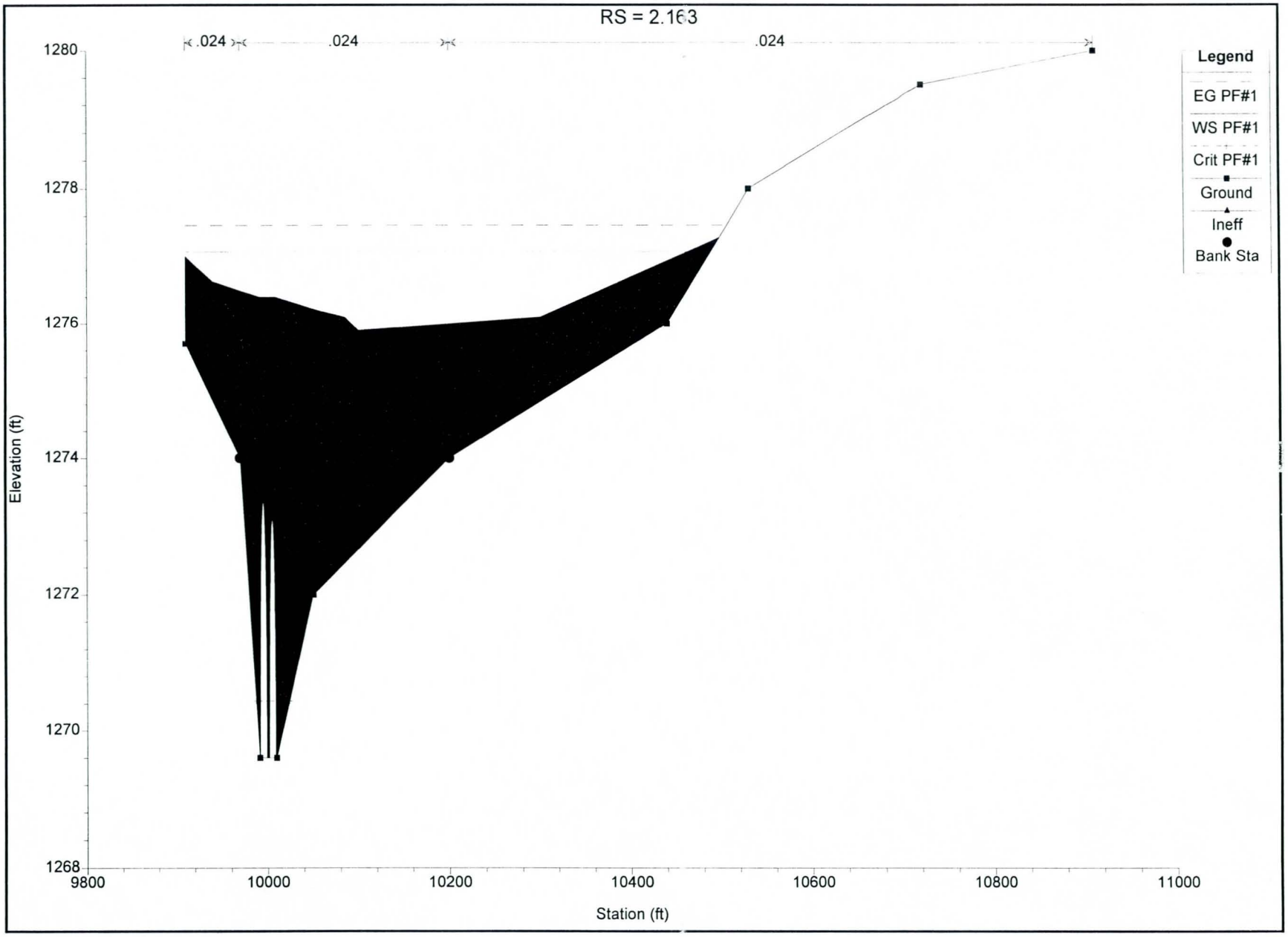
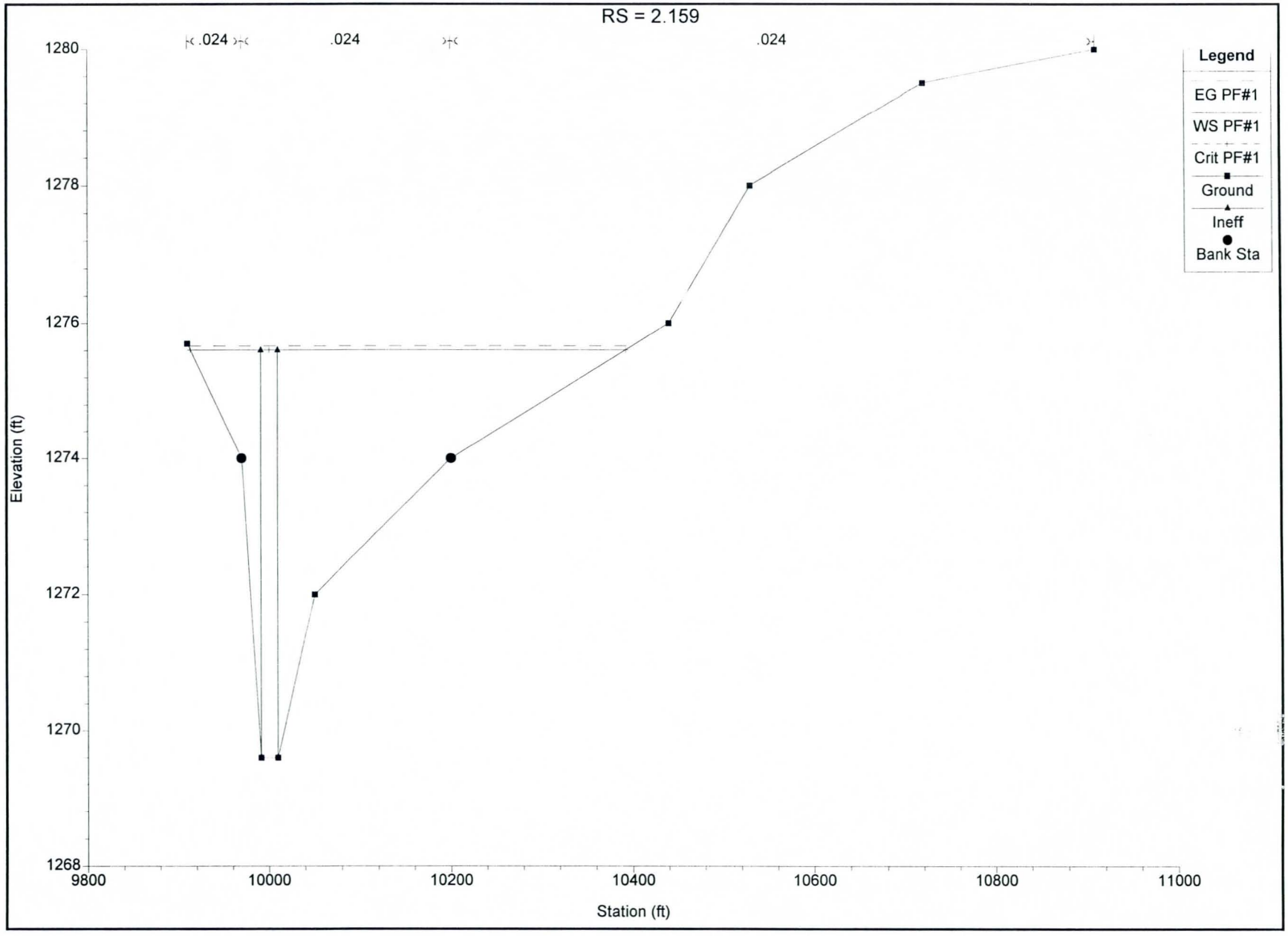
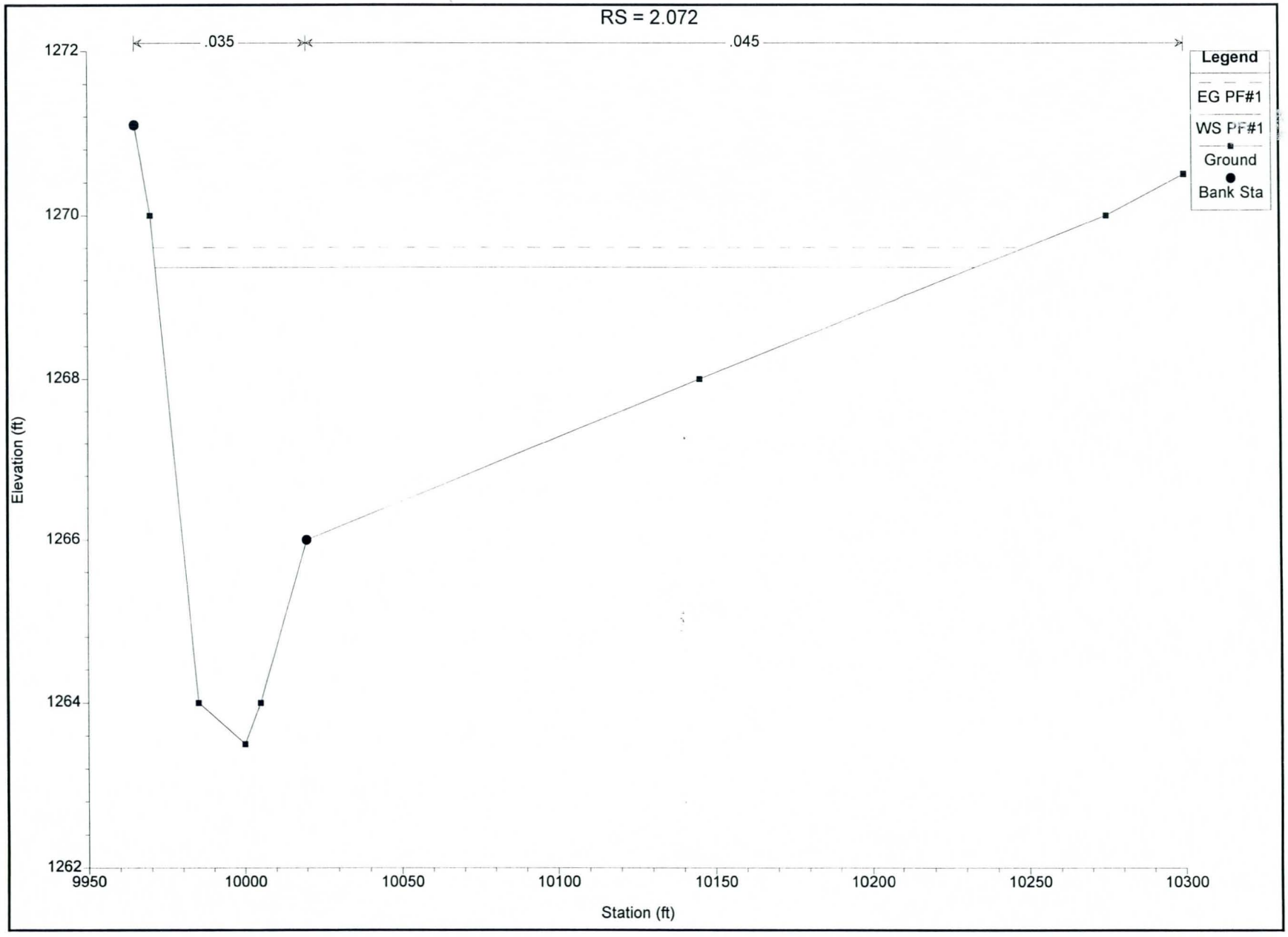
WS PF#1
Ground
Bank Sta
Elevation (ft)
1280
1278
1276
1274
1272
1270
9900
10000
10100
10200
10300
10400
10500
10600
Station (ft)

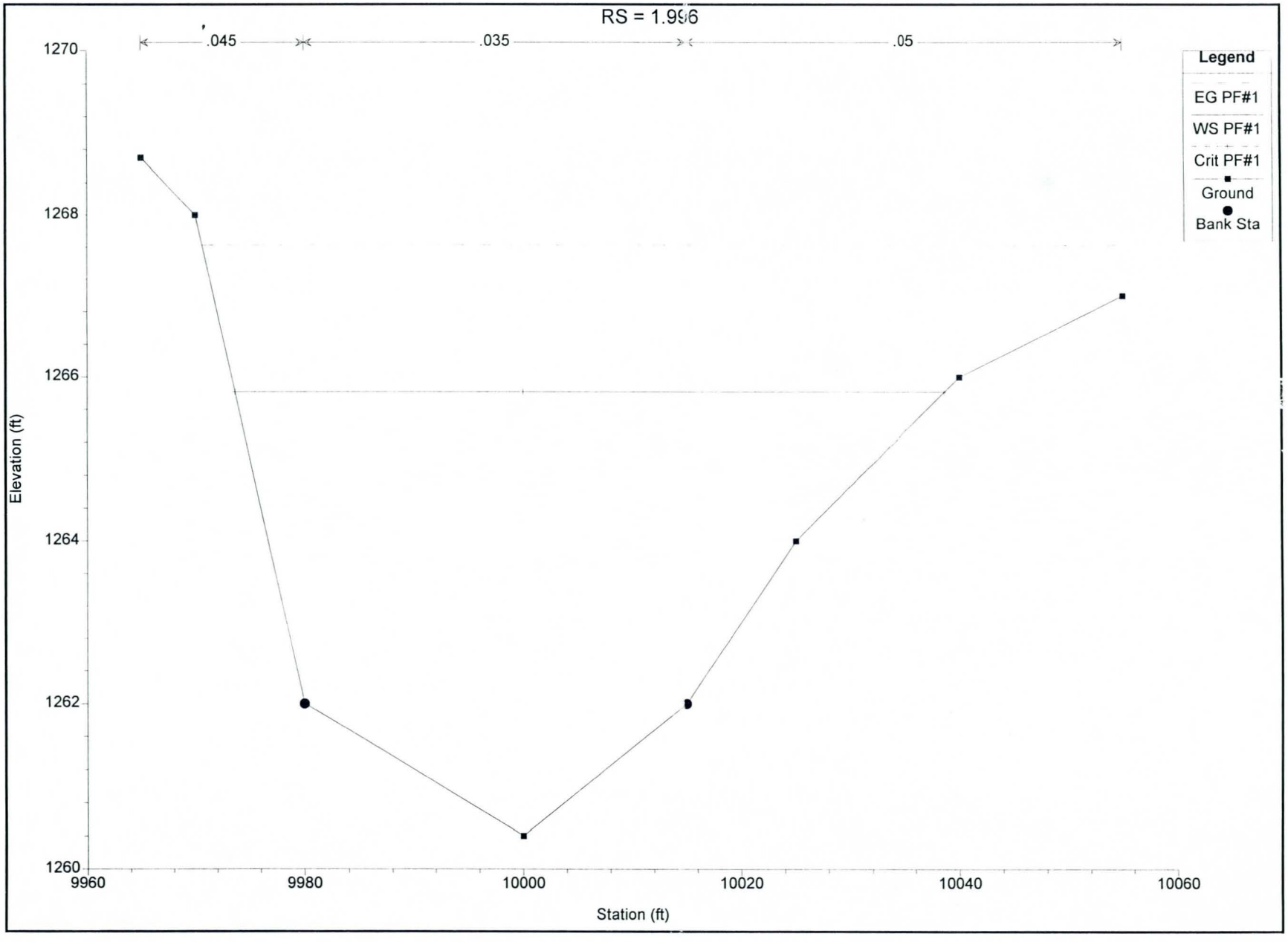

RS = 2.167
.024
.024
.024
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
1280
1278
1276
1274
1272
1270
9800
10000
10200
10400
10600
10800
Station (ft)

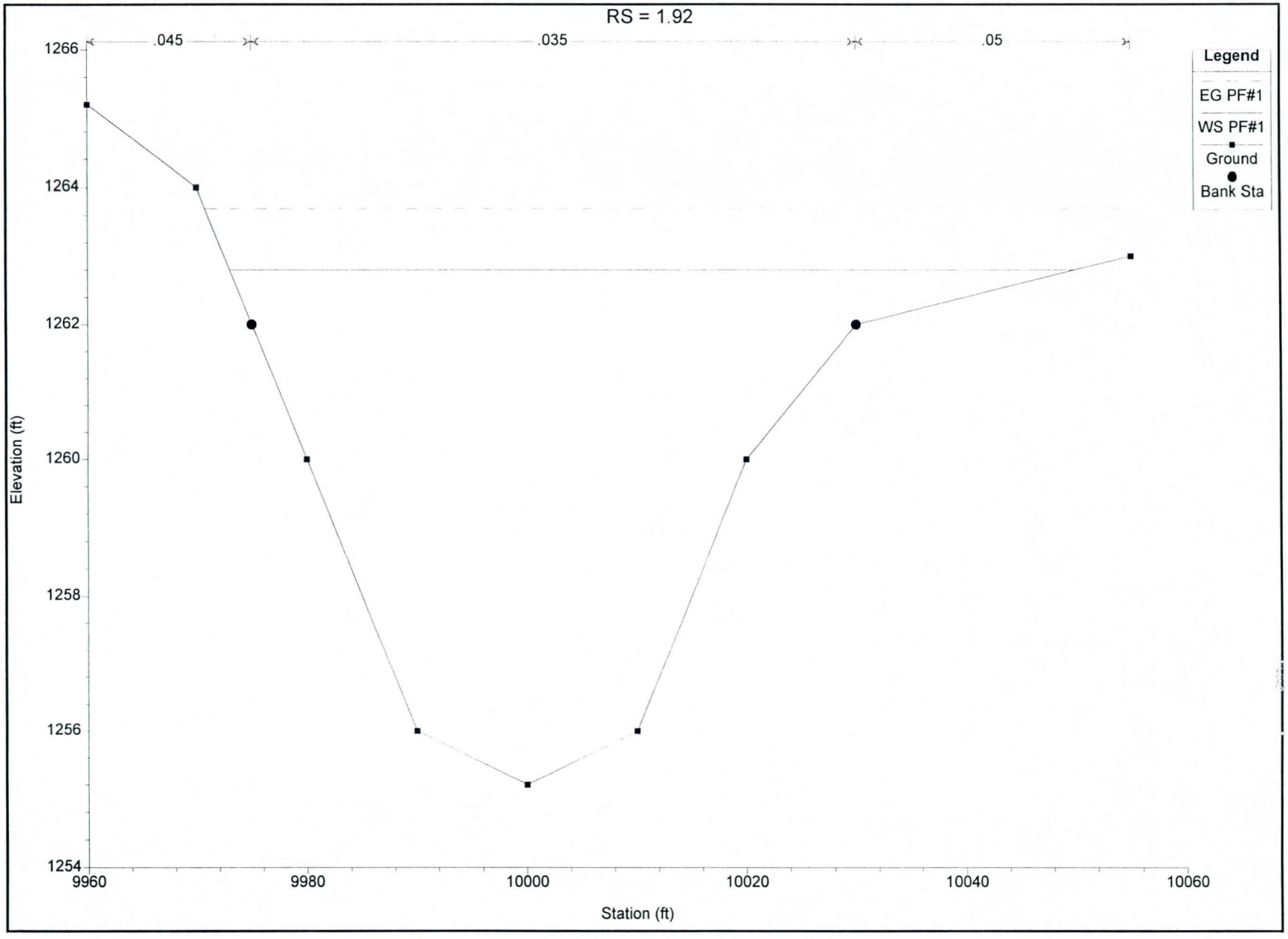

RS = 2.163
.024
.024
.024
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
1280
1278
1276
1274
1272
1270
9800
10000
10200
10400
10600
10800
Station (ft)

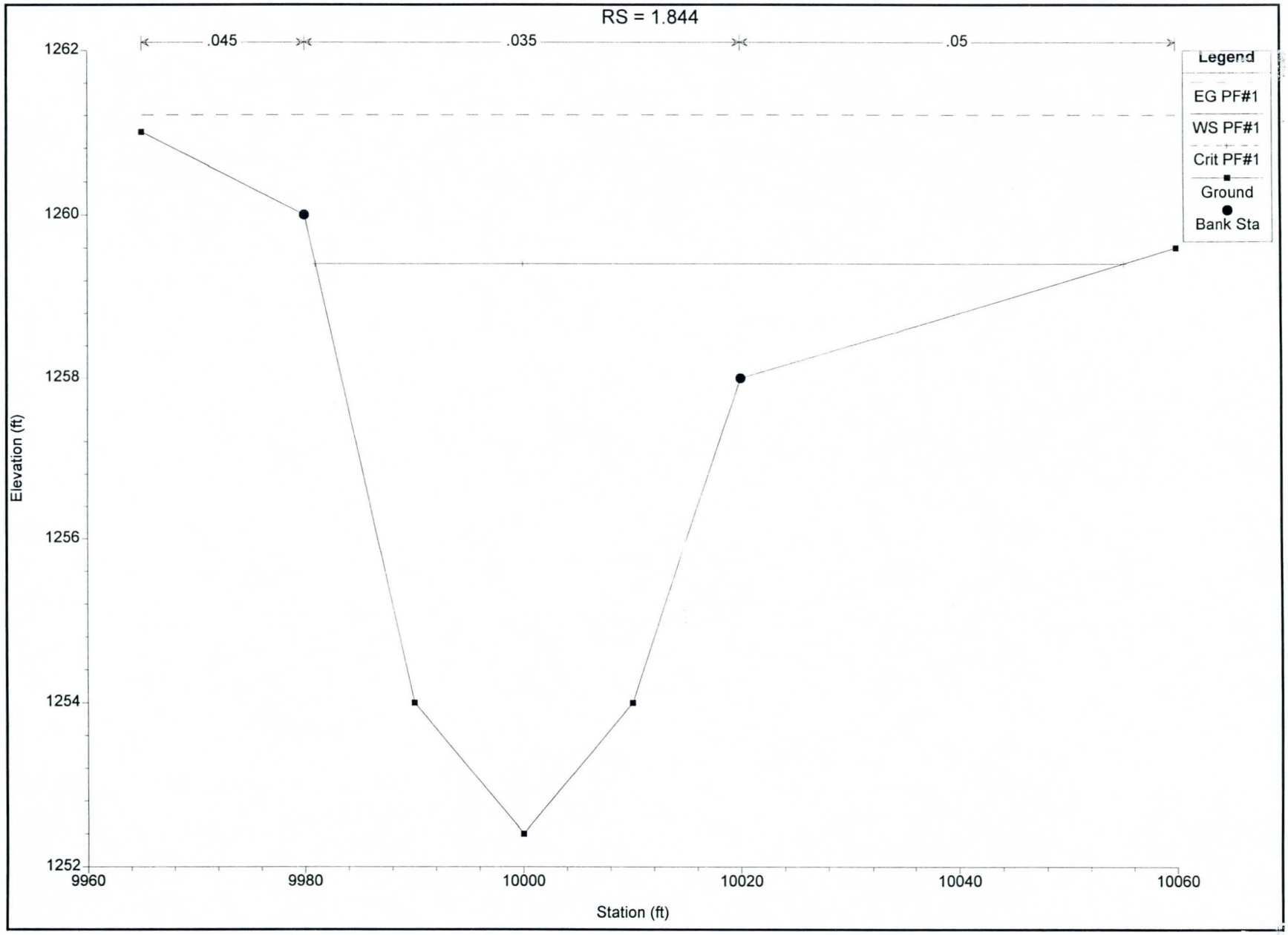

RS = 2.163
.024
.024
.024
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
1280
1278
1276
1274
1272
1270
1268
9800
10000
10200
10400
10600
10800
11000
Station (ft)

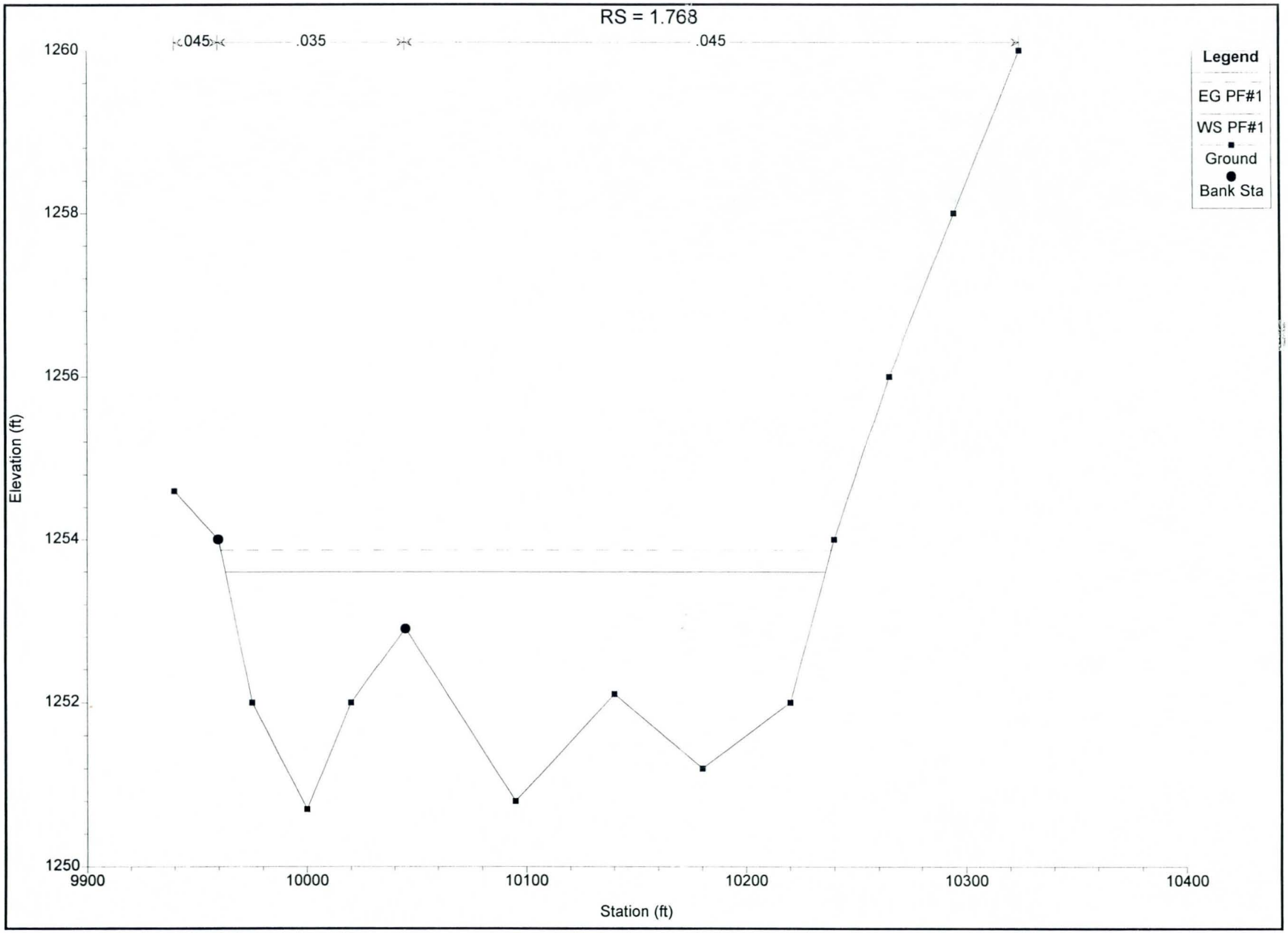

RS = 2.159
.024
.024
.024
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
1280
1278
1276
1274
1272
1270
1268
9800
10000
10200
10400
10600
10800
11000
Station (ft)

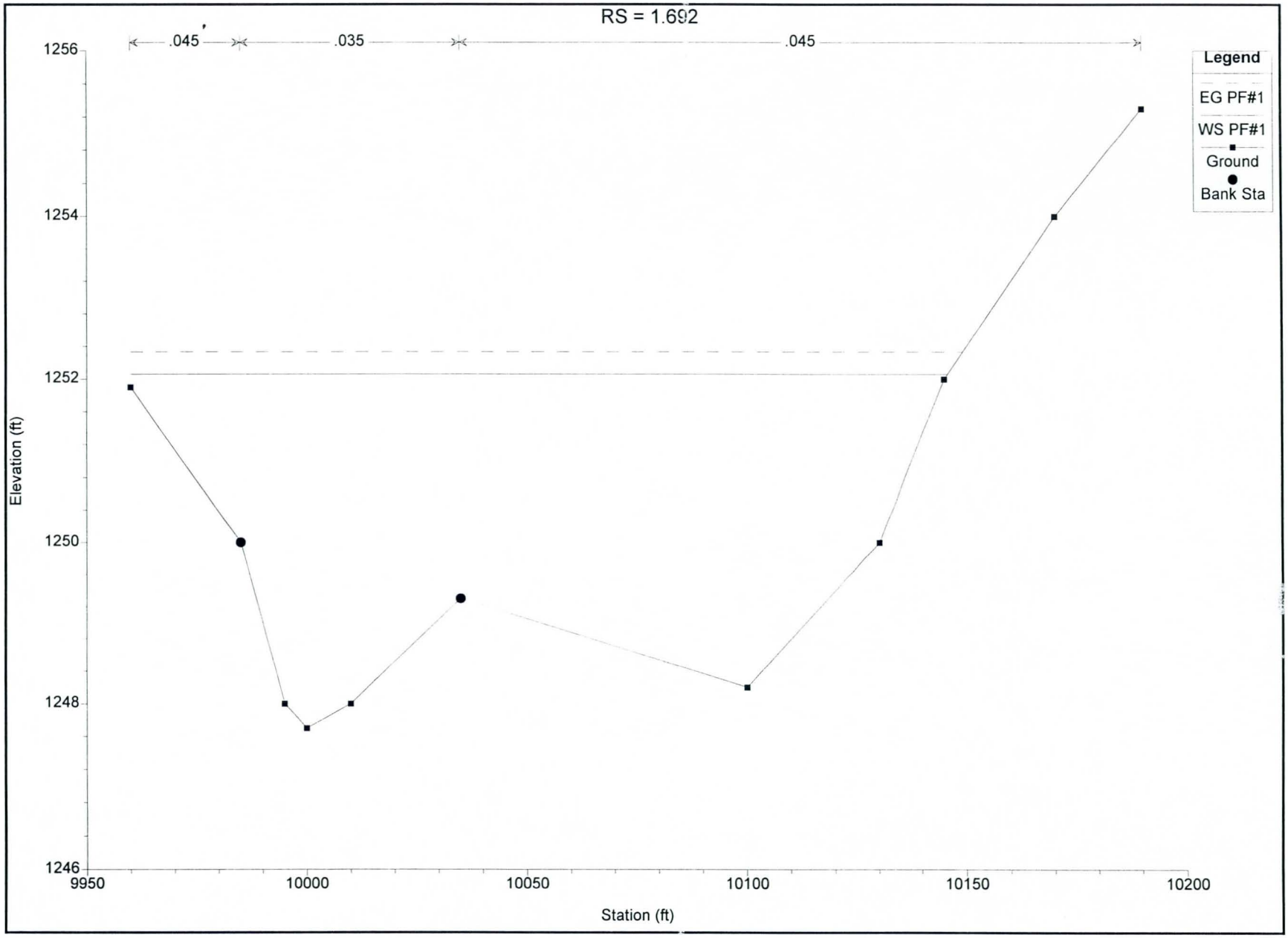

RS = 2.072
.035
.045
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1272
1270
1268
1266
1264
1262
9950
10000
10050
10100
10150
10200
10250
10300
Station (ft)

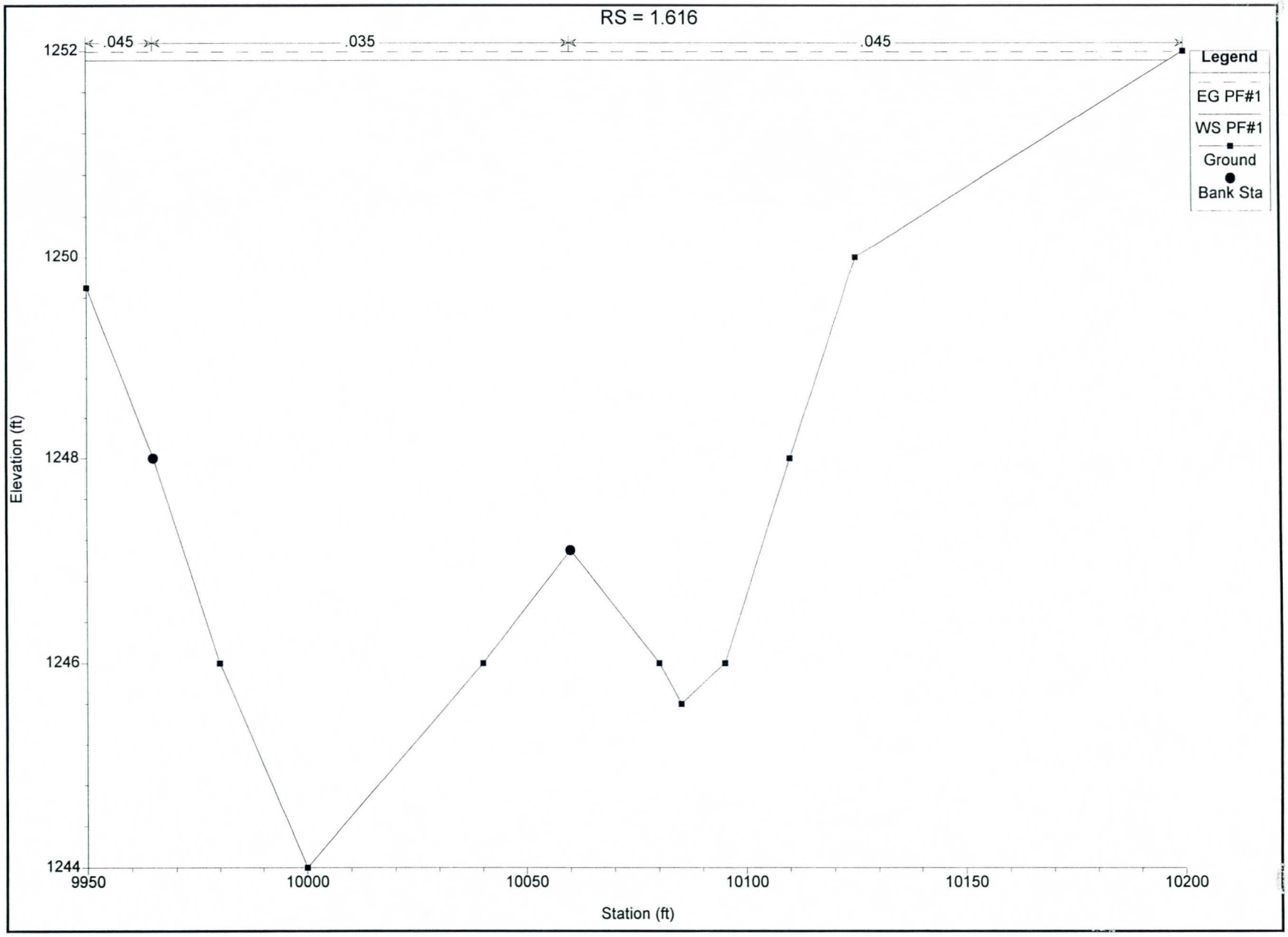

RS = 1.996
.045
.035
.05
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1270
1268
1266
1264
1262
1260
9960
9980
10000
10020
10040
10060
Station (ft)

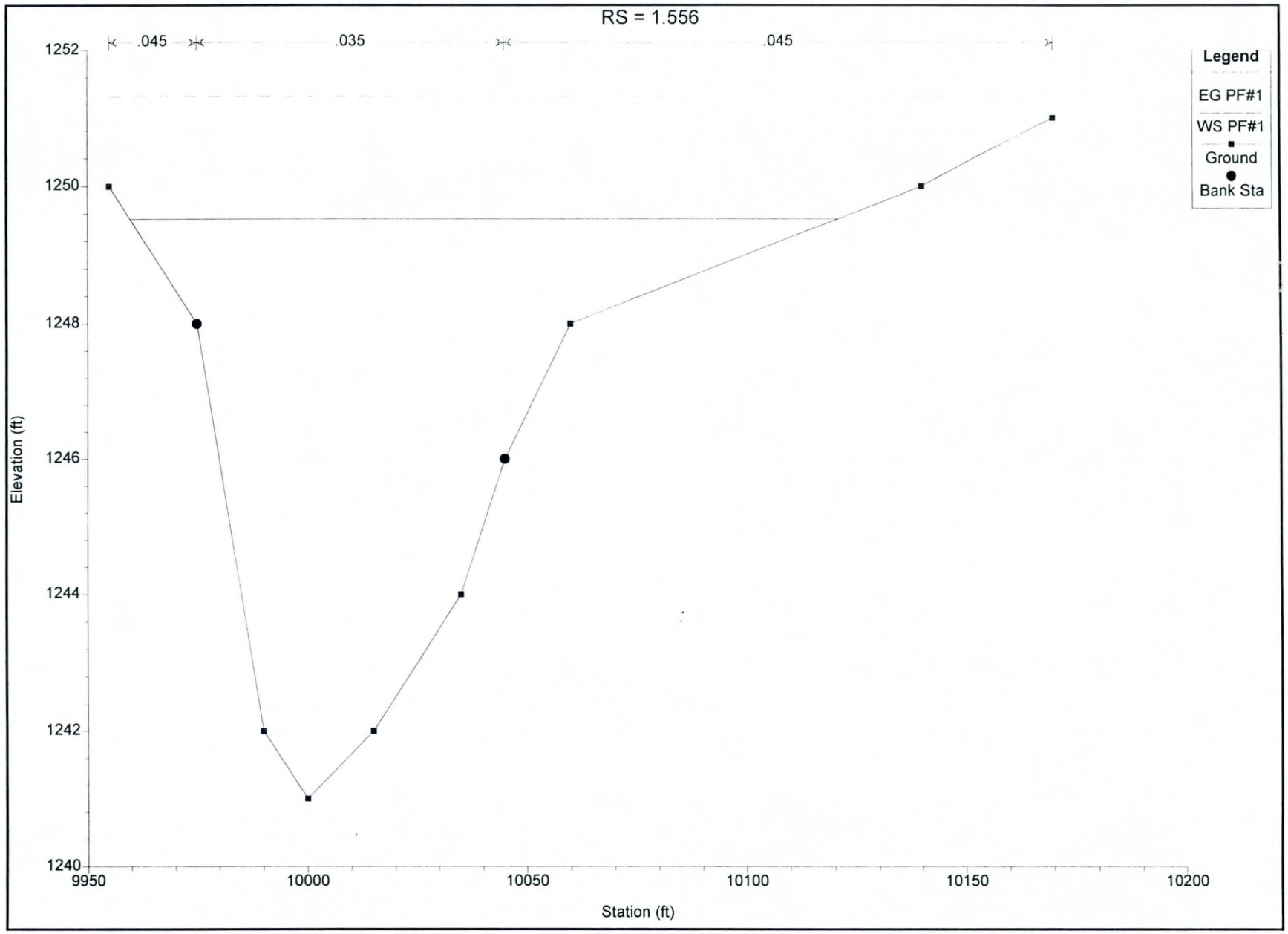

RS = 1.92
.045
.035
.05
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1266
1264
1262
1260
1258
1256
1254
9960
9980
10000
10020
10040
10060
Station (ft)

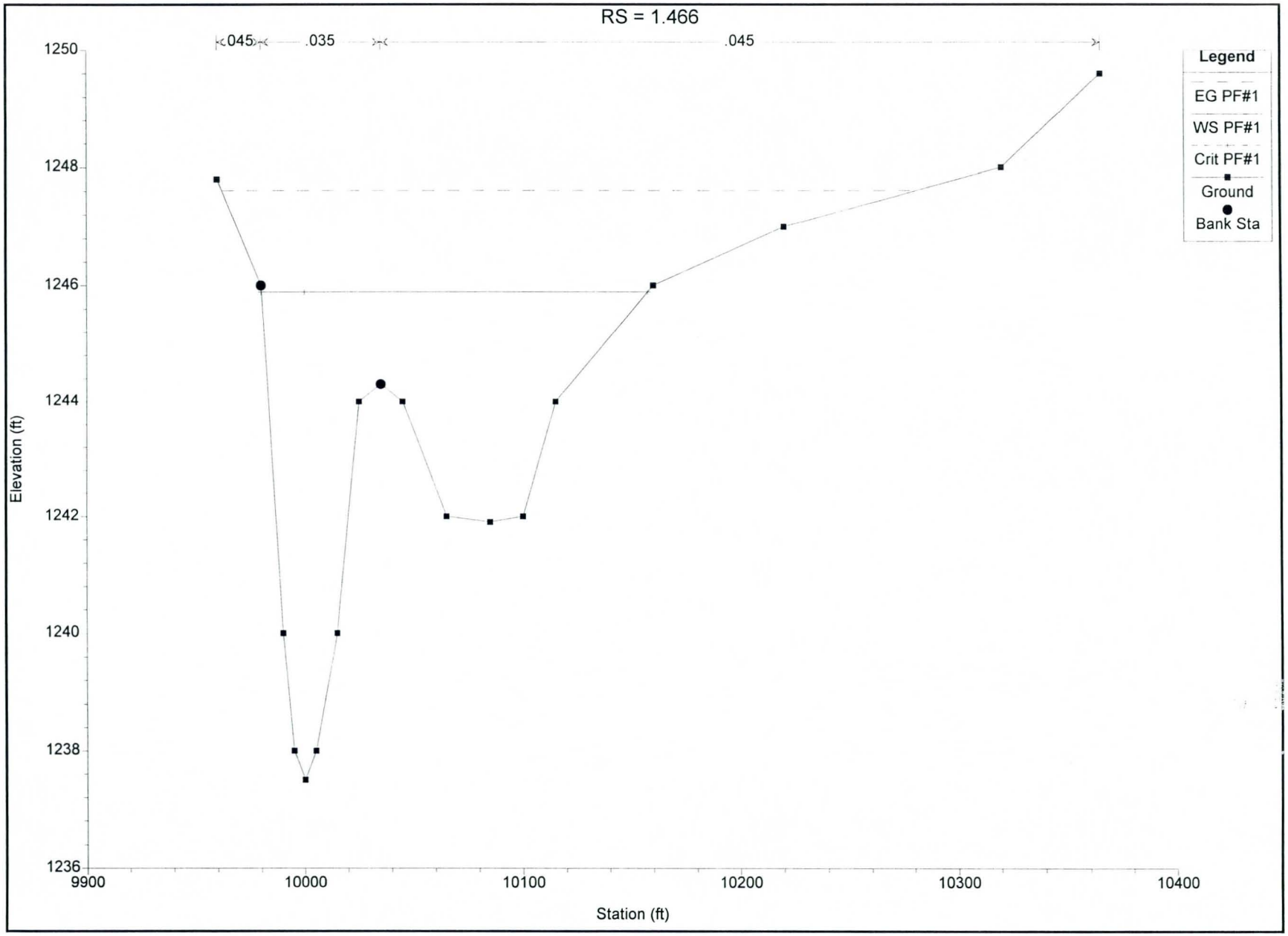

RS = 1.844
.045
.035
.05
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1262
1260
1258
1256
1254
1252
9960
9980
10000
10020
10040
10060
Station (ft)

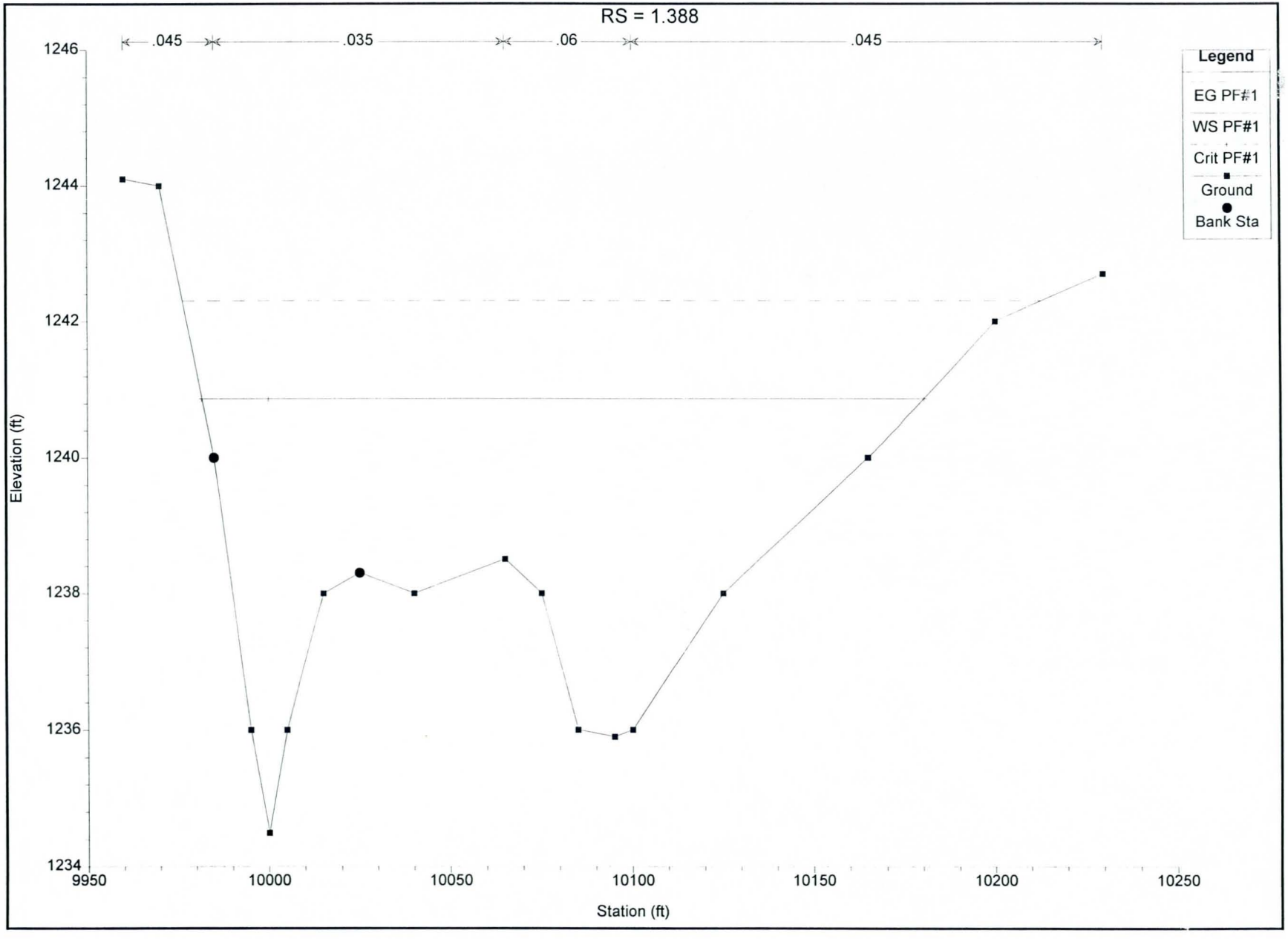

RS = 1.768
.045
.035
.045
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1260
1258
1256
1254
1252
1250
9900
10000
10100
10200
10300
10400
Station (ft)

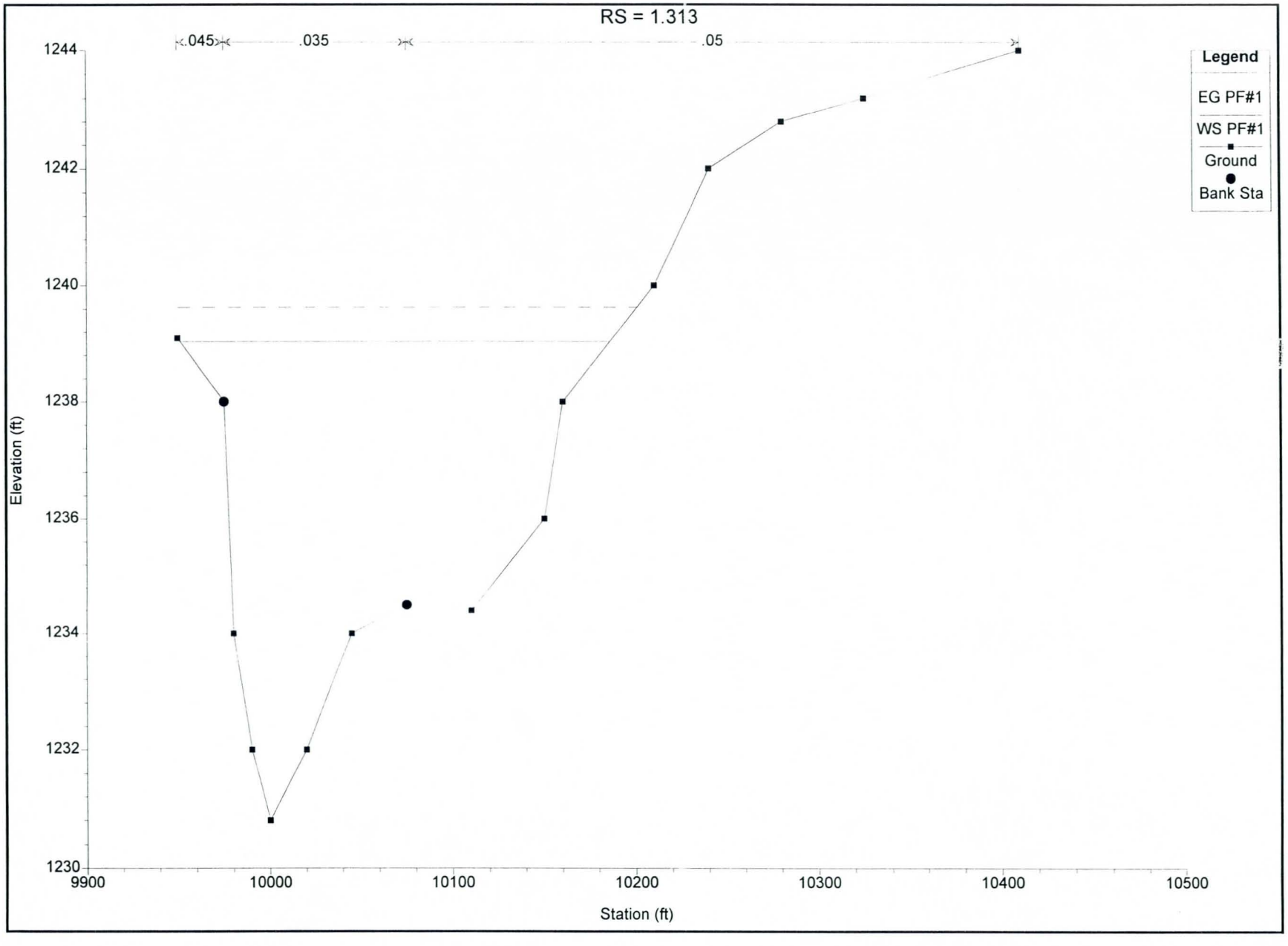

RS = 1.692
.045
.035
.045
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1256
1254
1252
1250
1248
1246
9950
10000
10050
10100
10150
10200
Station (ft)

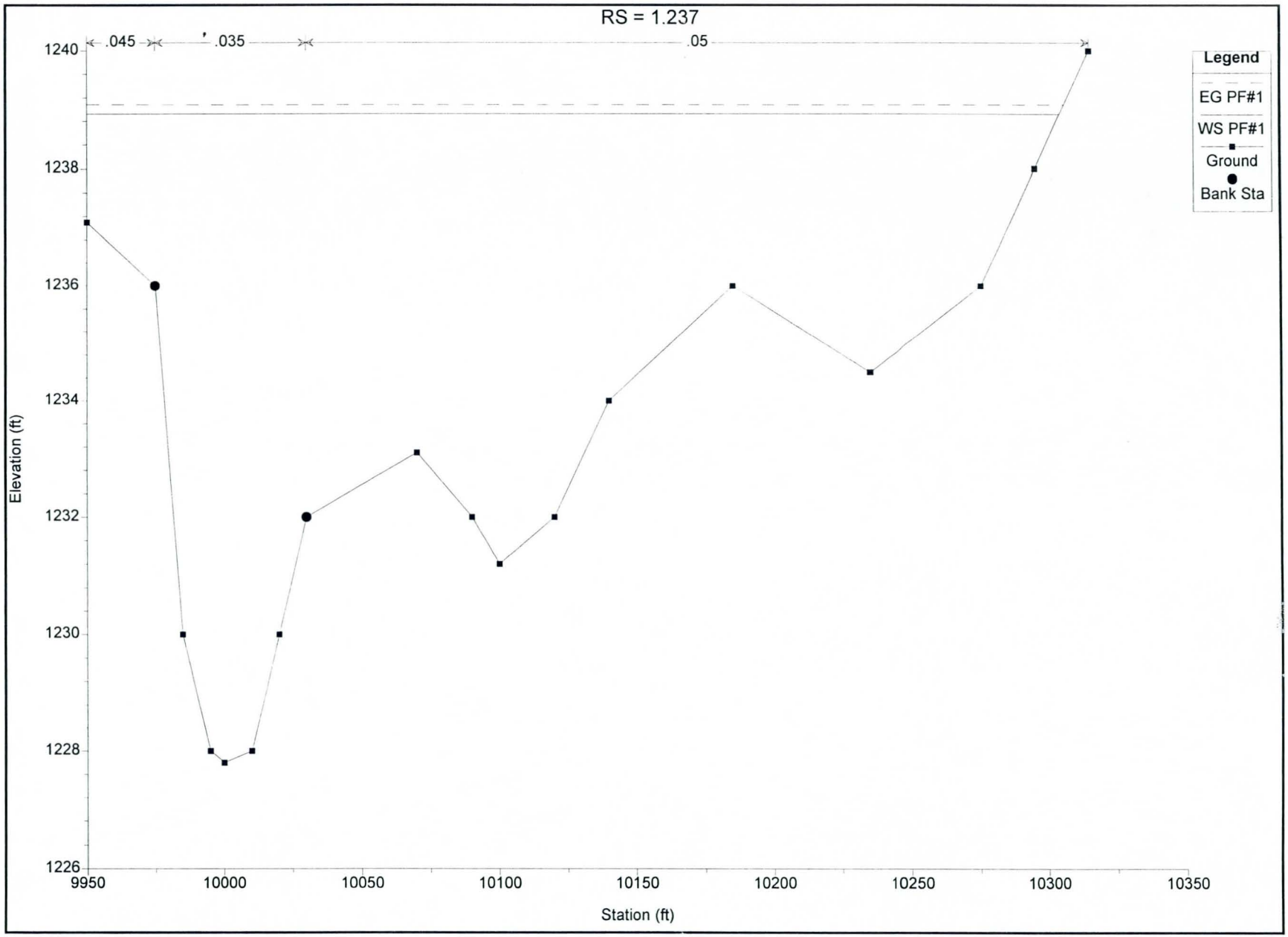

RS = 1.616
.045
.035
.045
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
1252
1250
1248
1246
1244
Elevation (ft)
9950
10000
10050
10100
10150
10200
Station (ft)

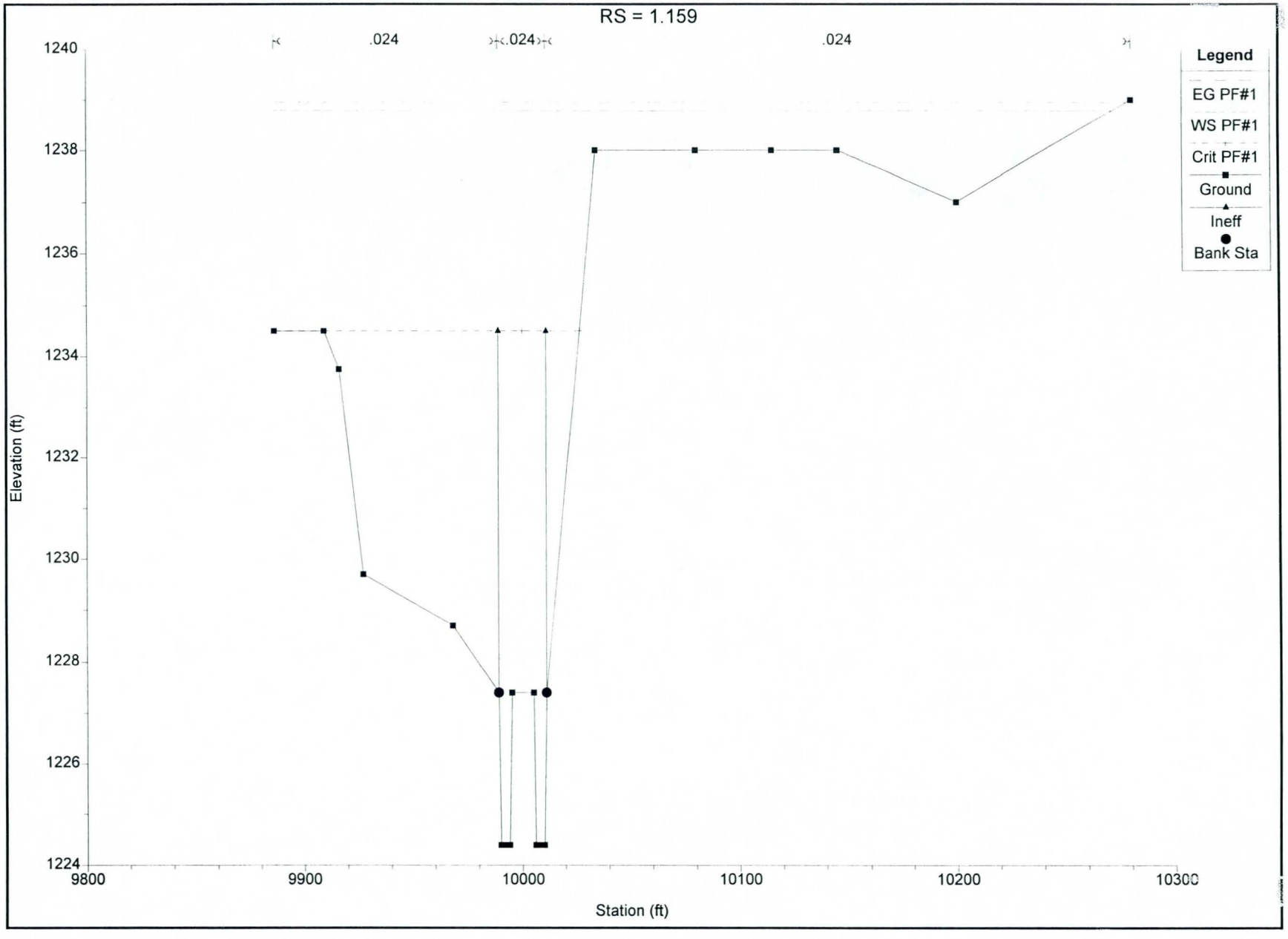

RS = 1.556
.045
.035
.045
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1252
1250
1248
1246
1244
1242
1240
9950
10000
10050
10100
10150
10200
Station (ft)

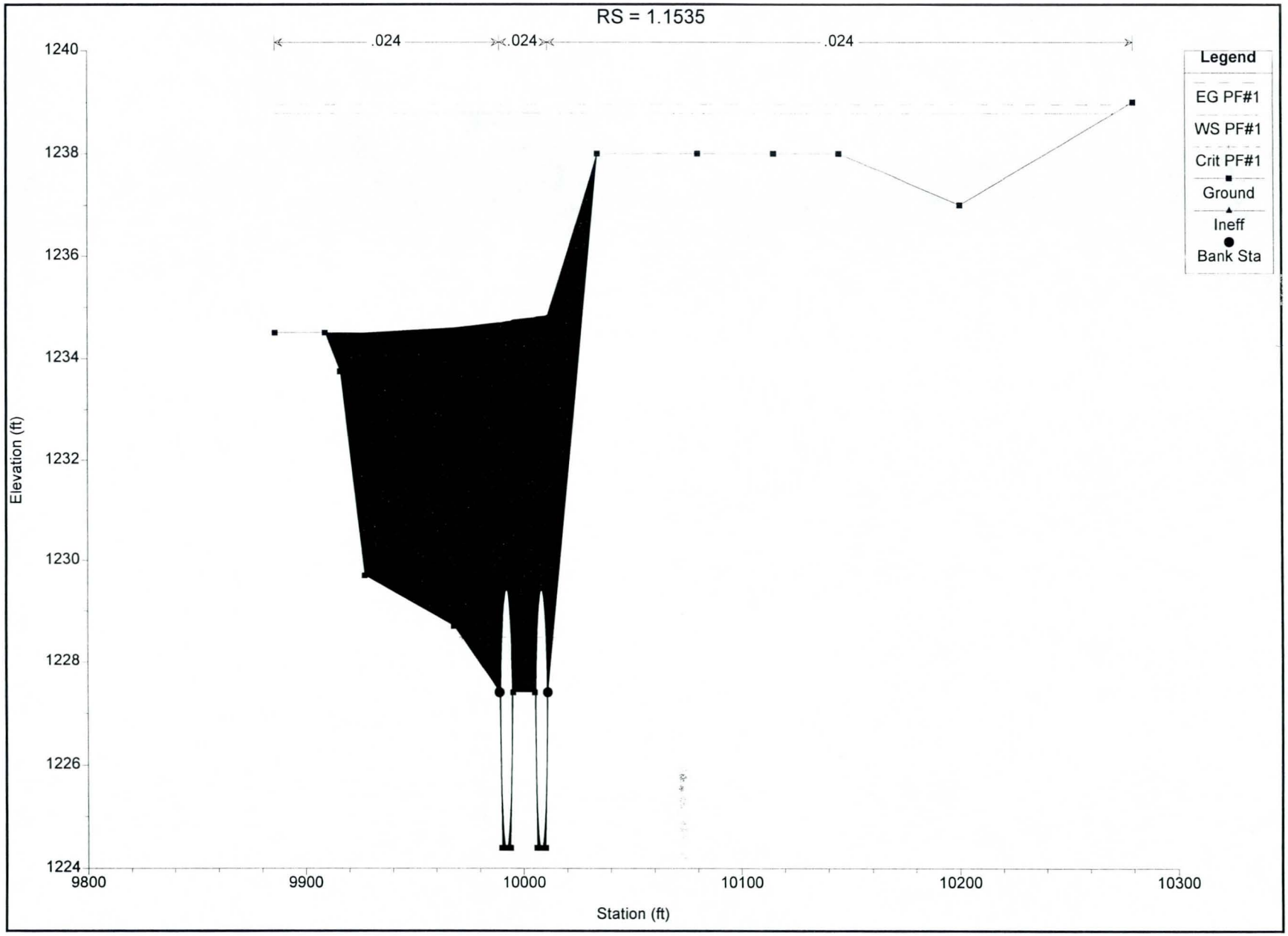

RS = 1.466
.045
.035
.045
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1250
1248
1246
1244
1242
1240
1238
1236
9900
10000
10100
10200
10300
10400
Station (ft)

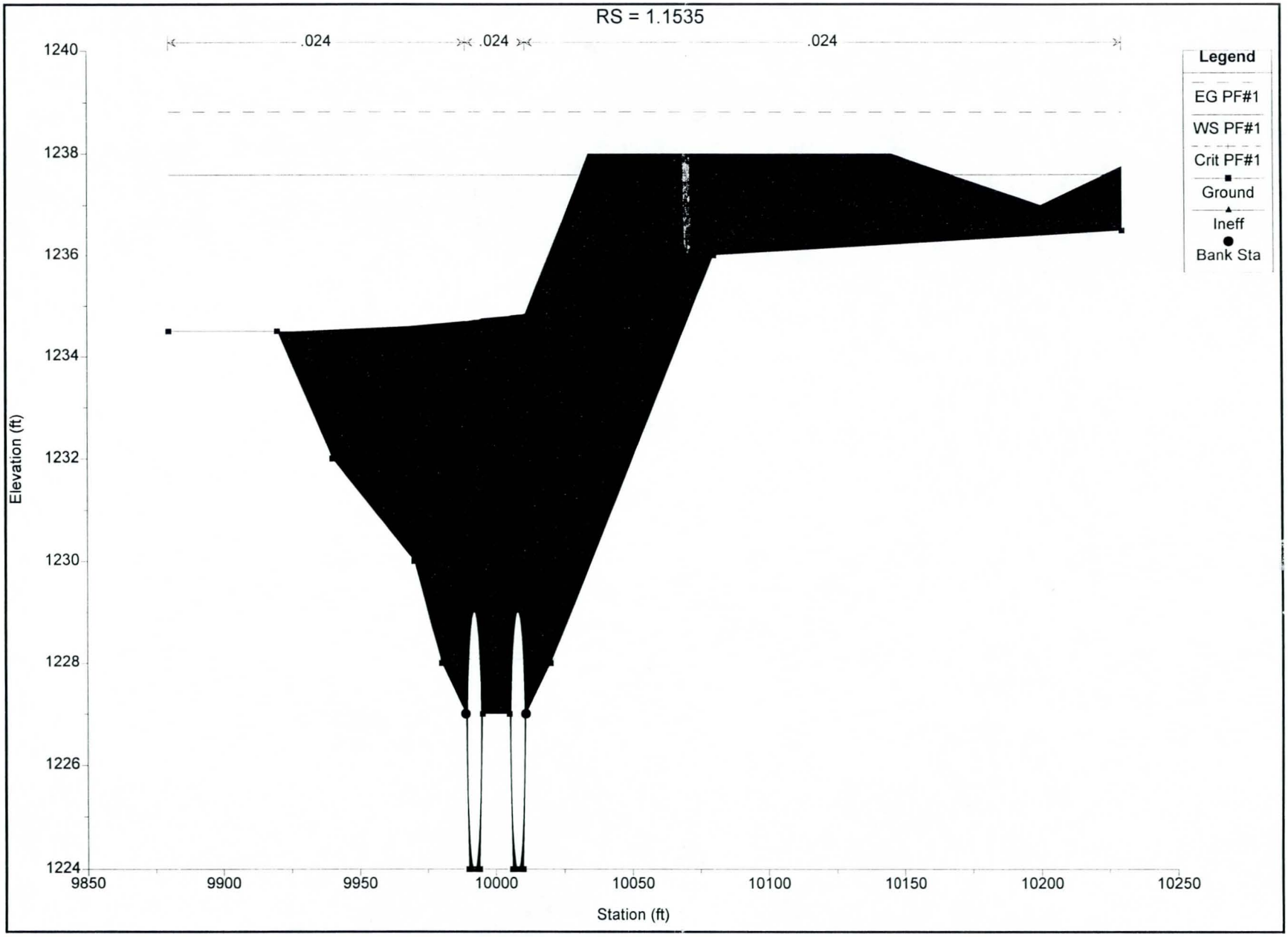

RS = 1.388
.045
.035
.06
.045
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1246
1244
1242
1240
1238
1236
1234
9950
10000
10050
10100
10150
10200
10250
Station (ft)

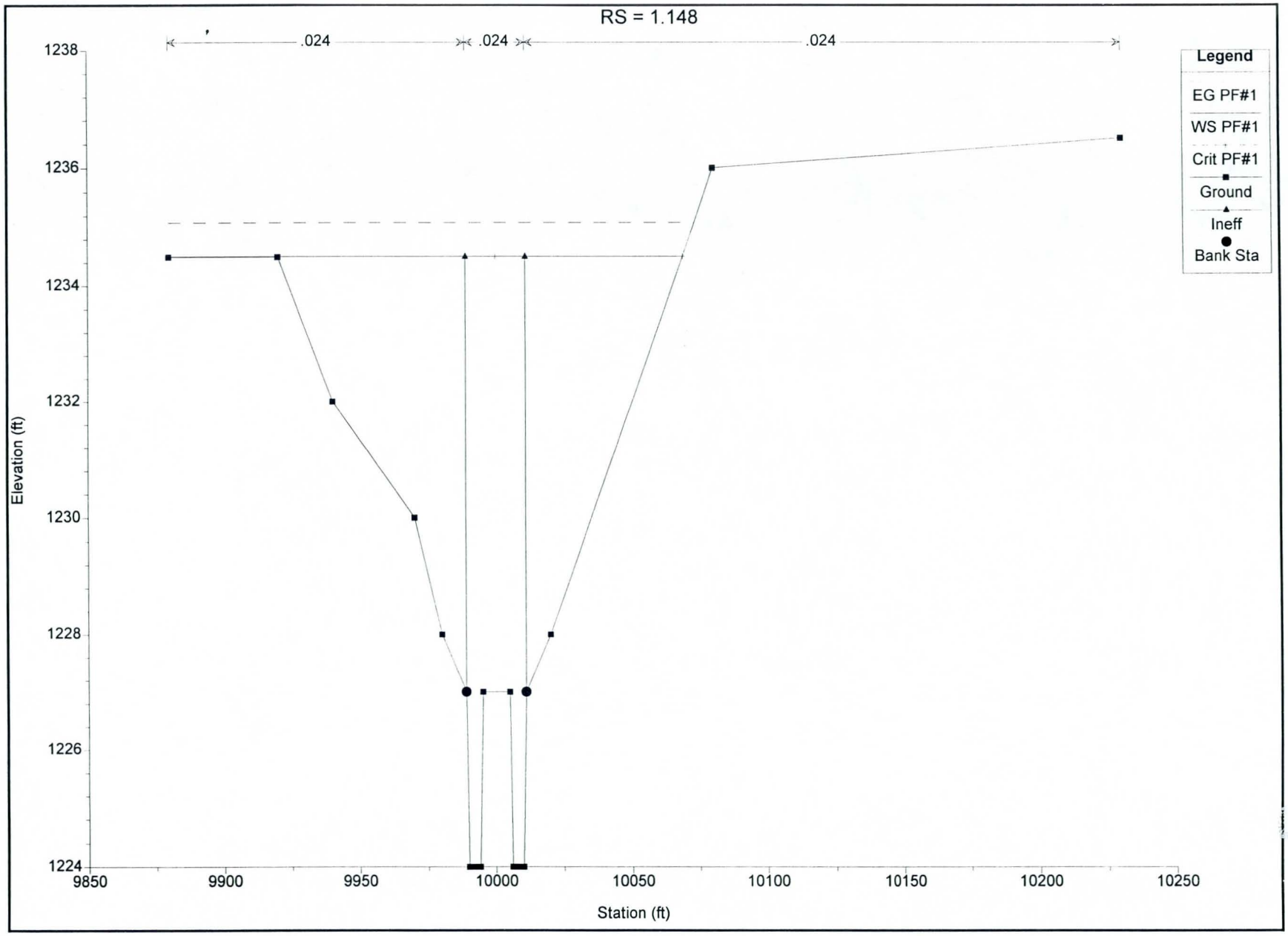

RS = 1.313
.045
.035
.05
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1244
1242
1240
1238
1236
1234
1232
1230
9900
10000
10100
10200
10300
10400
10500
Station (ft)

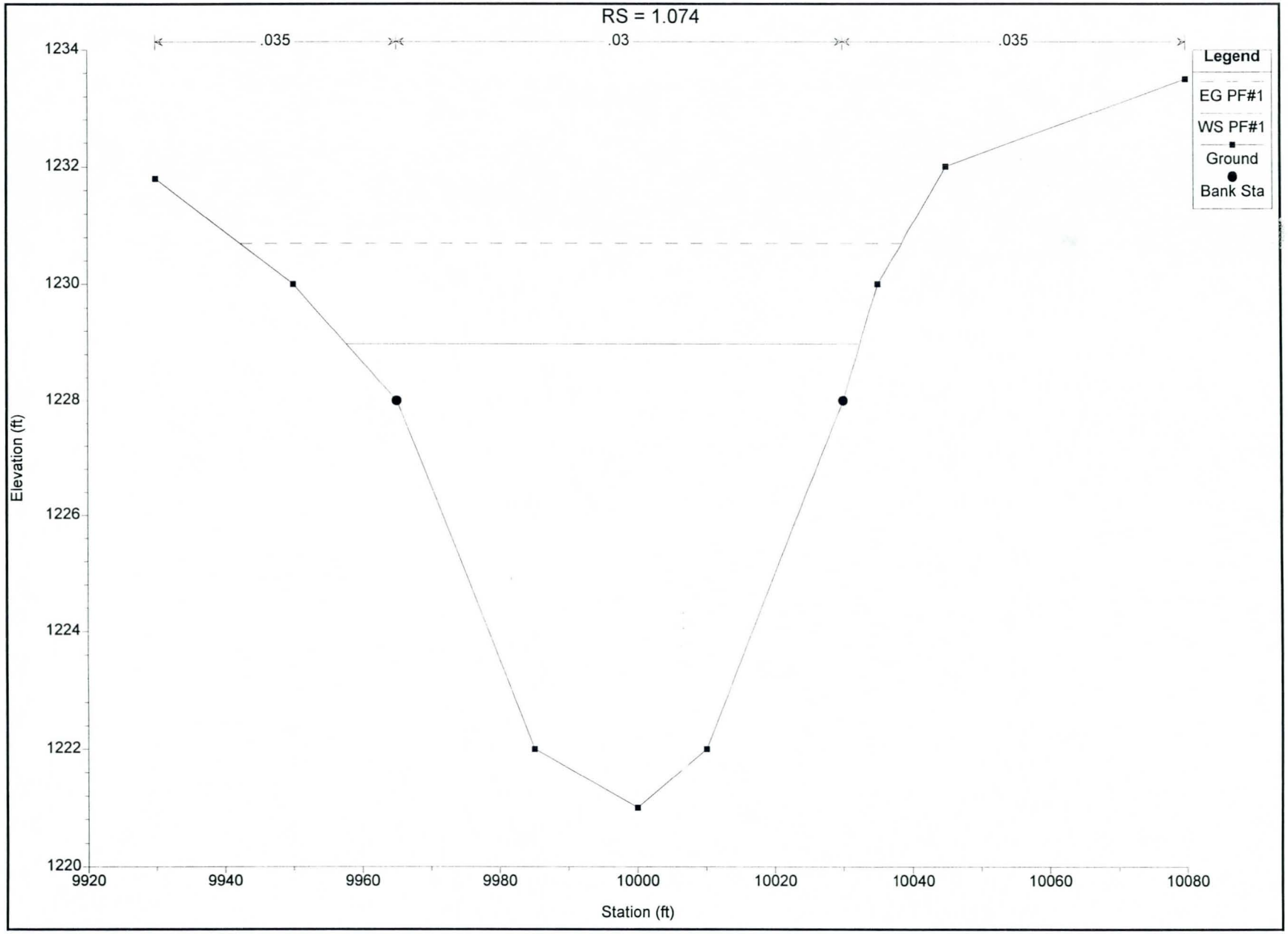

RS = 1.237
.045
.035
.05
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1240
1238
1236
1234
1232
1230
1228
1226
9950
10000
10050
10100
10150
10200
10250
10300
10350
Station (ft)

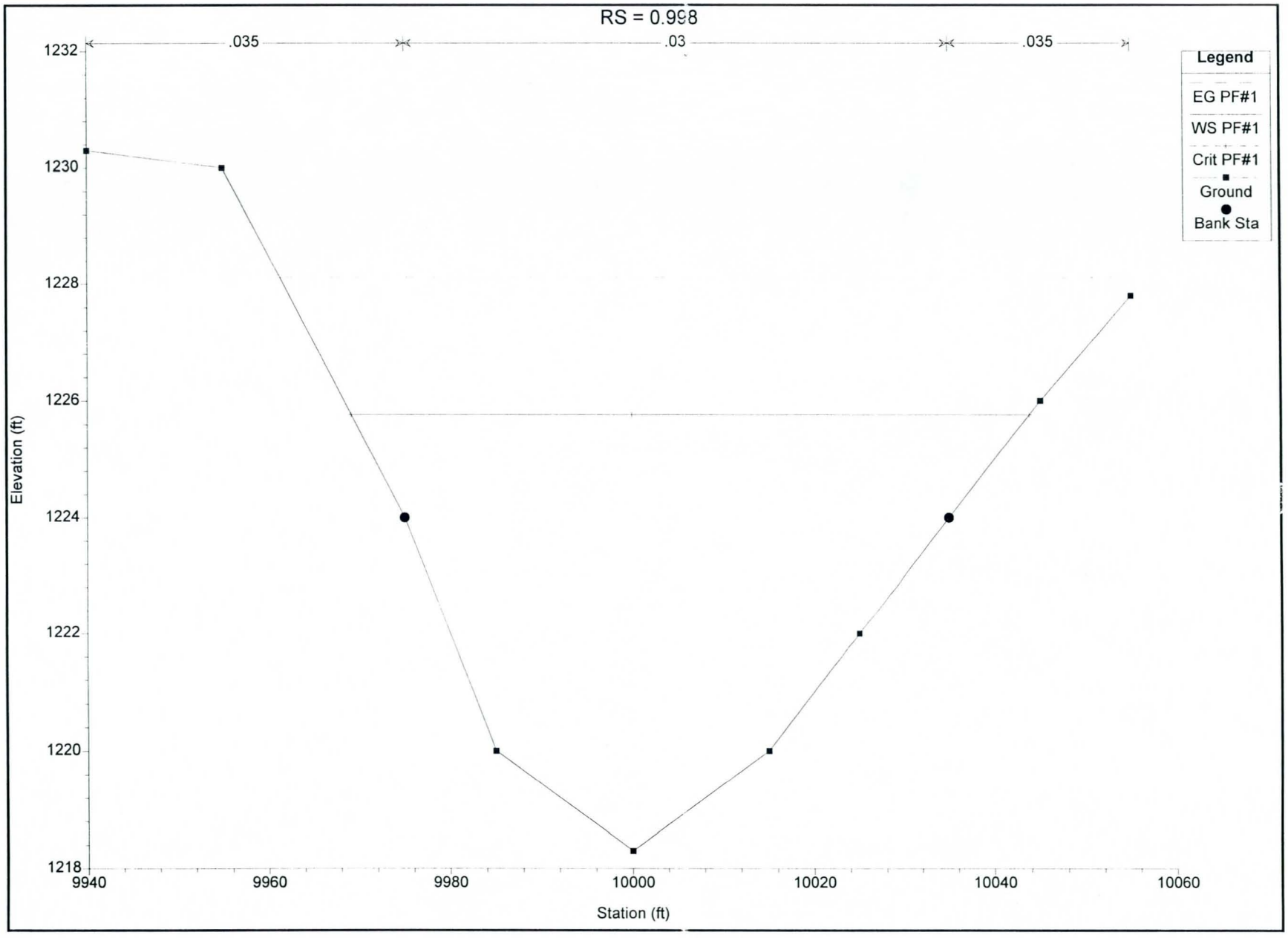

RS = 1.159
.024
.024
.024
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
1240
1238
1236
1234
1232
1230
1228
1226
1224
9800
9900
10000
10100
10200
10300
Station (ft)

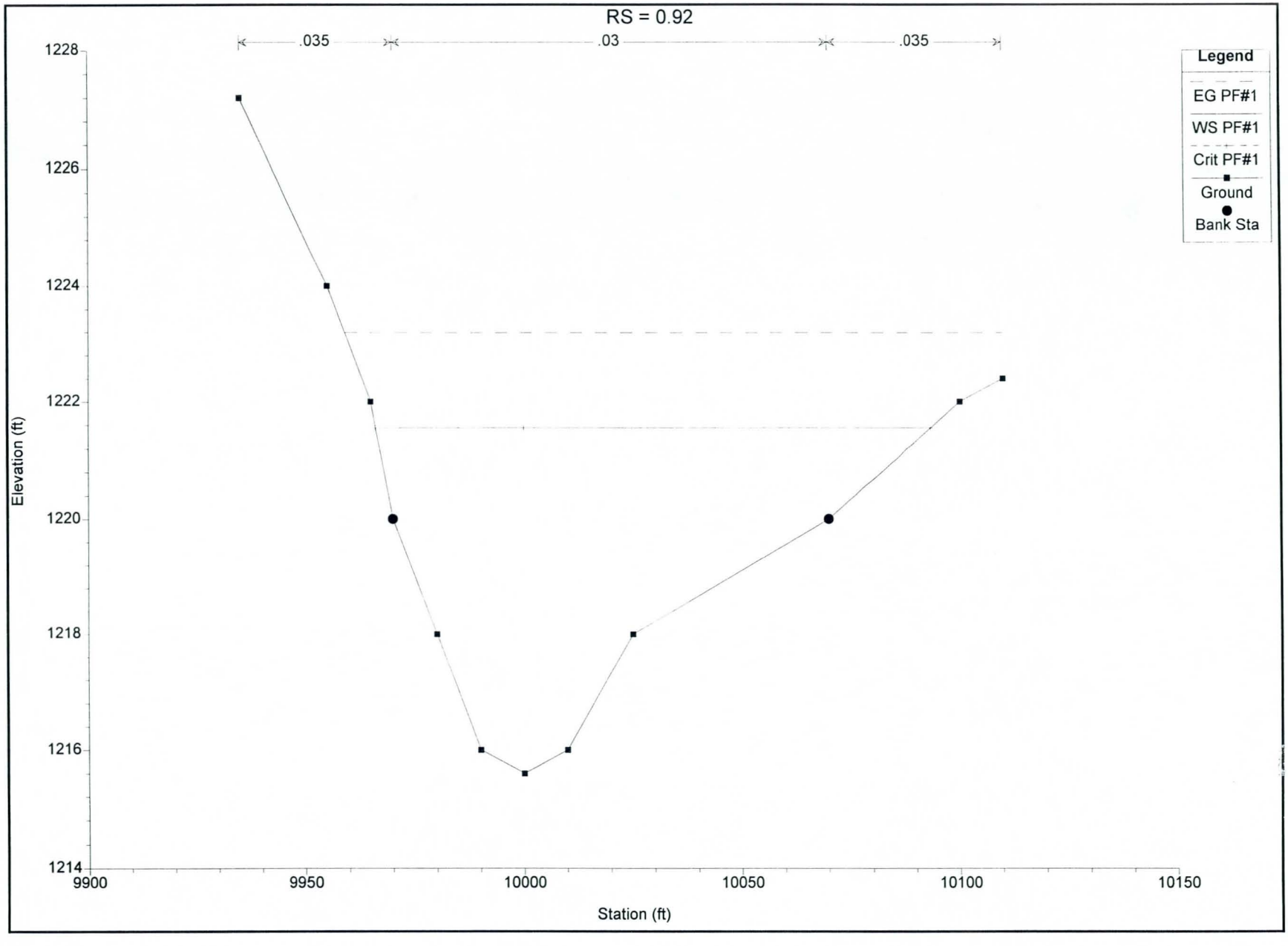

RS = 1.1535
.024
.024
.024
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
1240
1238
1236
1234
1232
1230
1228
1226
1224
9800
9900
10000
10100
10200
10300
Station (ft)

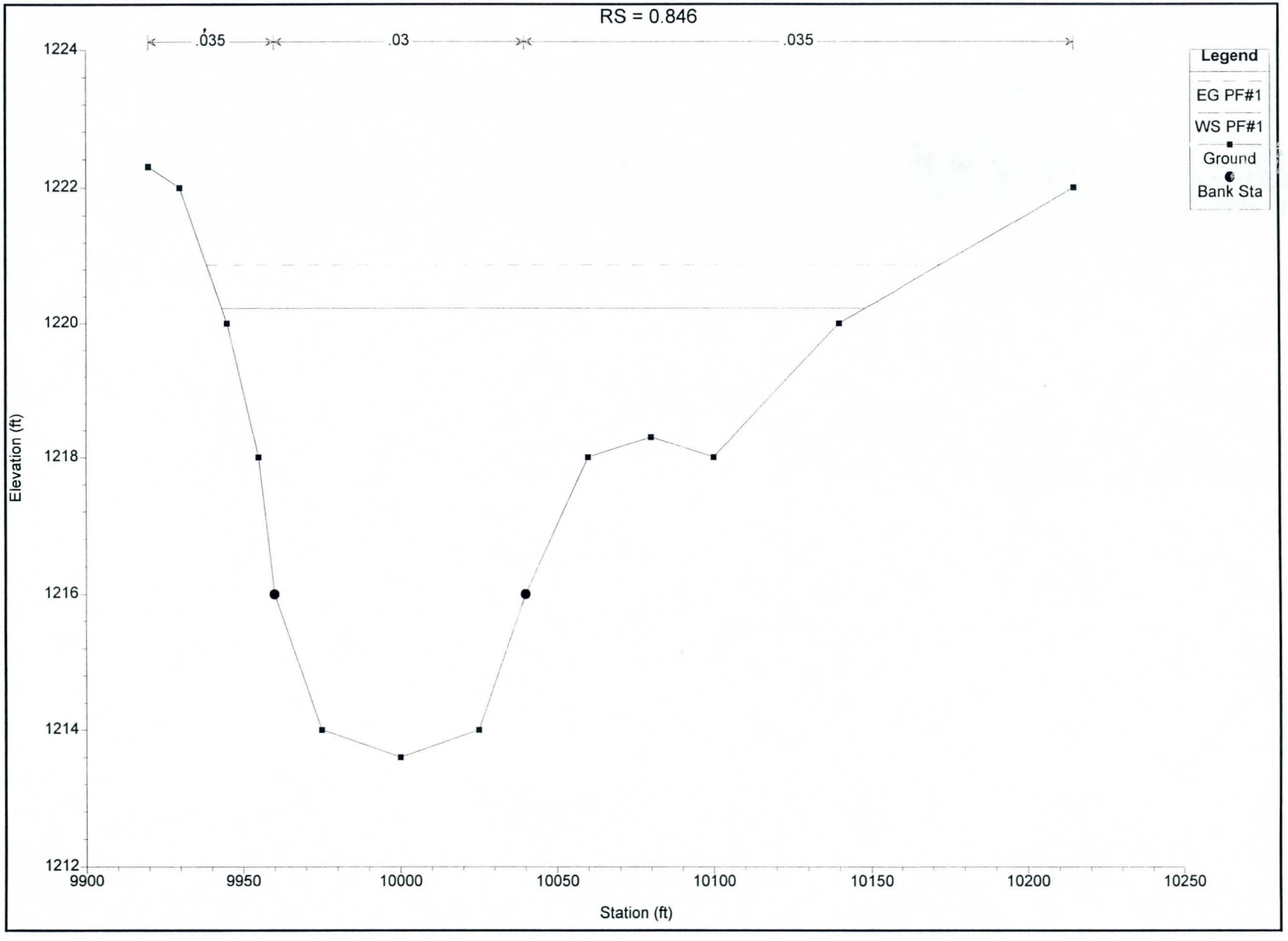

RS = 1.1535
.024
.024
.024
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
1240
1238
1236
1234
1232
1230
1228
1226
1224
9850
9900
9950
10000
10050
10100
10150
10200
10250
Station (ft)

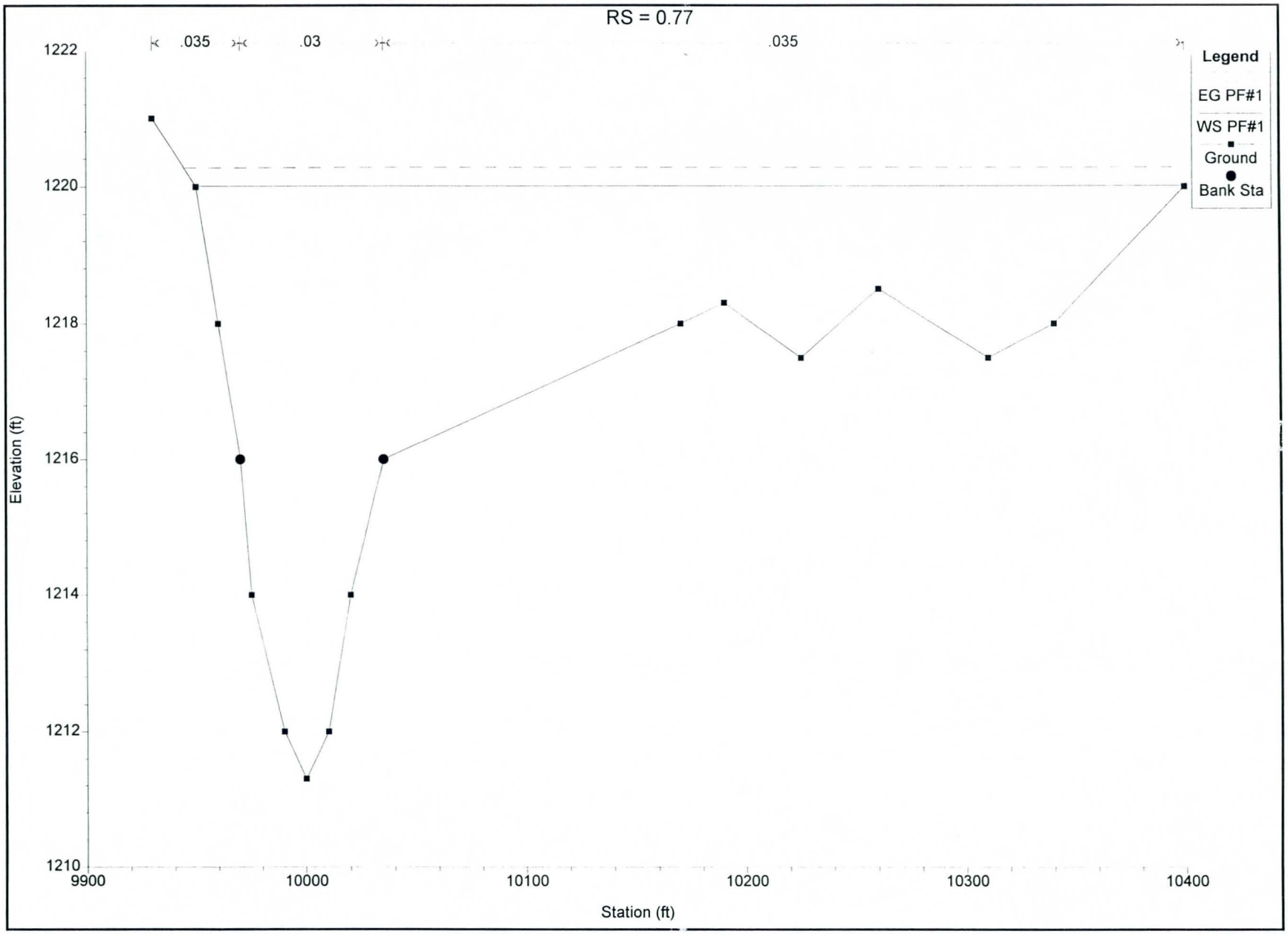

RS = 1.148
.024
.024
.024
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
1238
1236
1234
1232
1230
1228
1226
1224
9850
9900
9950
10000
10050
10100
10150
10200
10250
Station (ft)

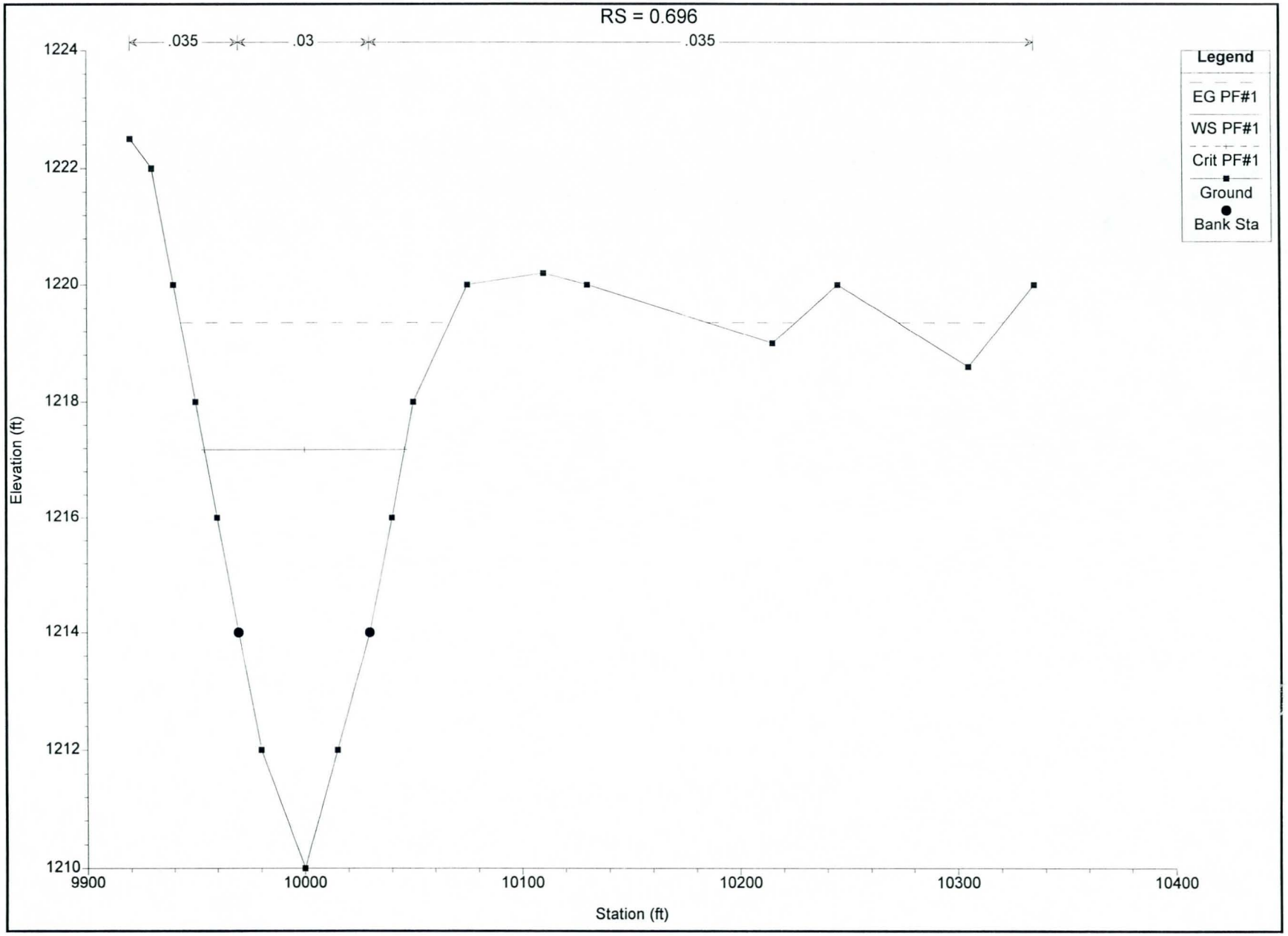

RS = 1.074
.035
.03
.035
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1234
1232
1230
1228
1226
1224
1222
1220
9920
9940
9960
9980
10000
10020
10040
10060
10080
Station (ft)

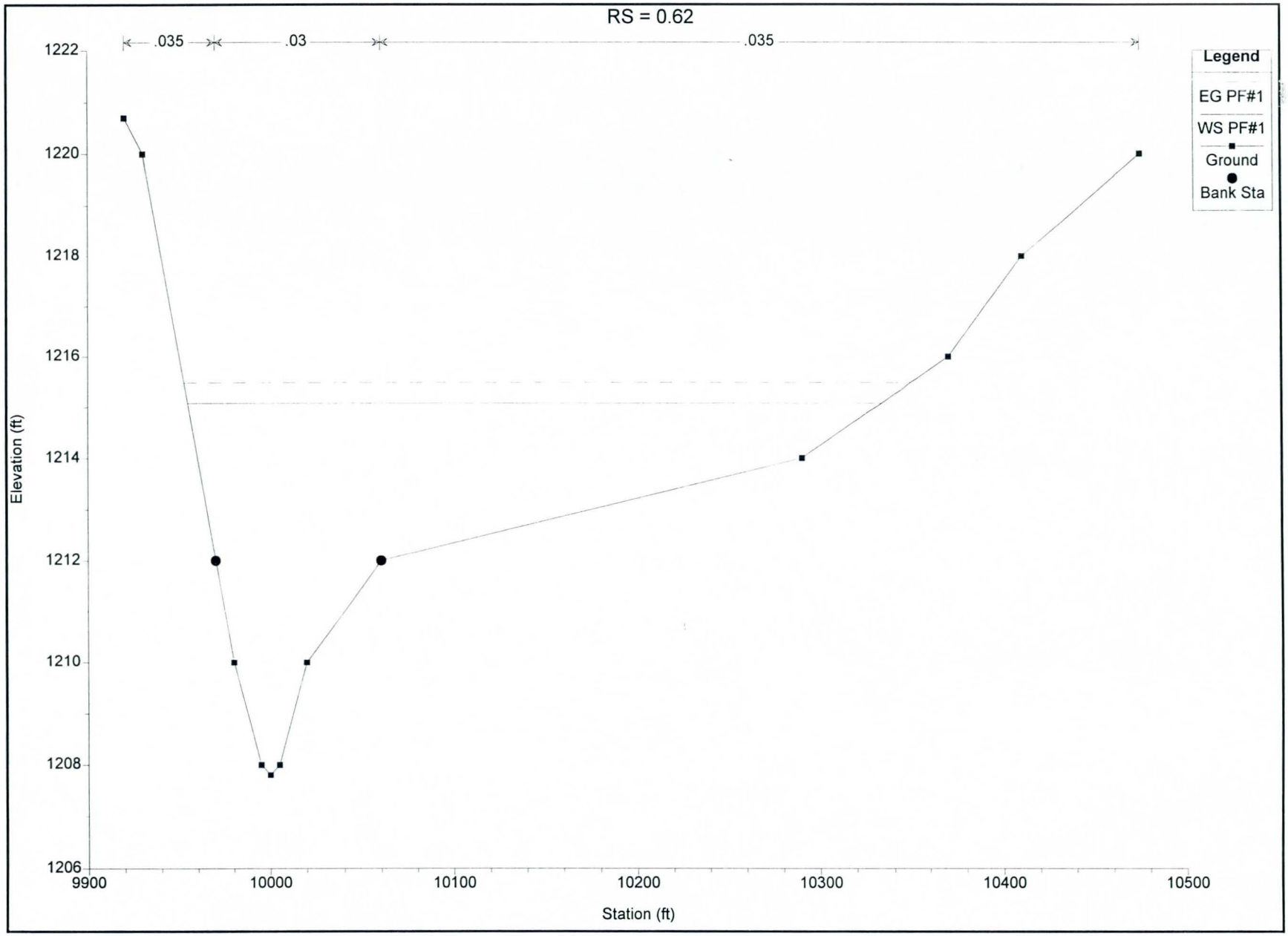

RS = 0.998
.035
.03
.035
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1232
1230
1228
1226
1224
1222
1220
1218
9940
9960
9980
10000
10020
10040
10060
Station (ft)

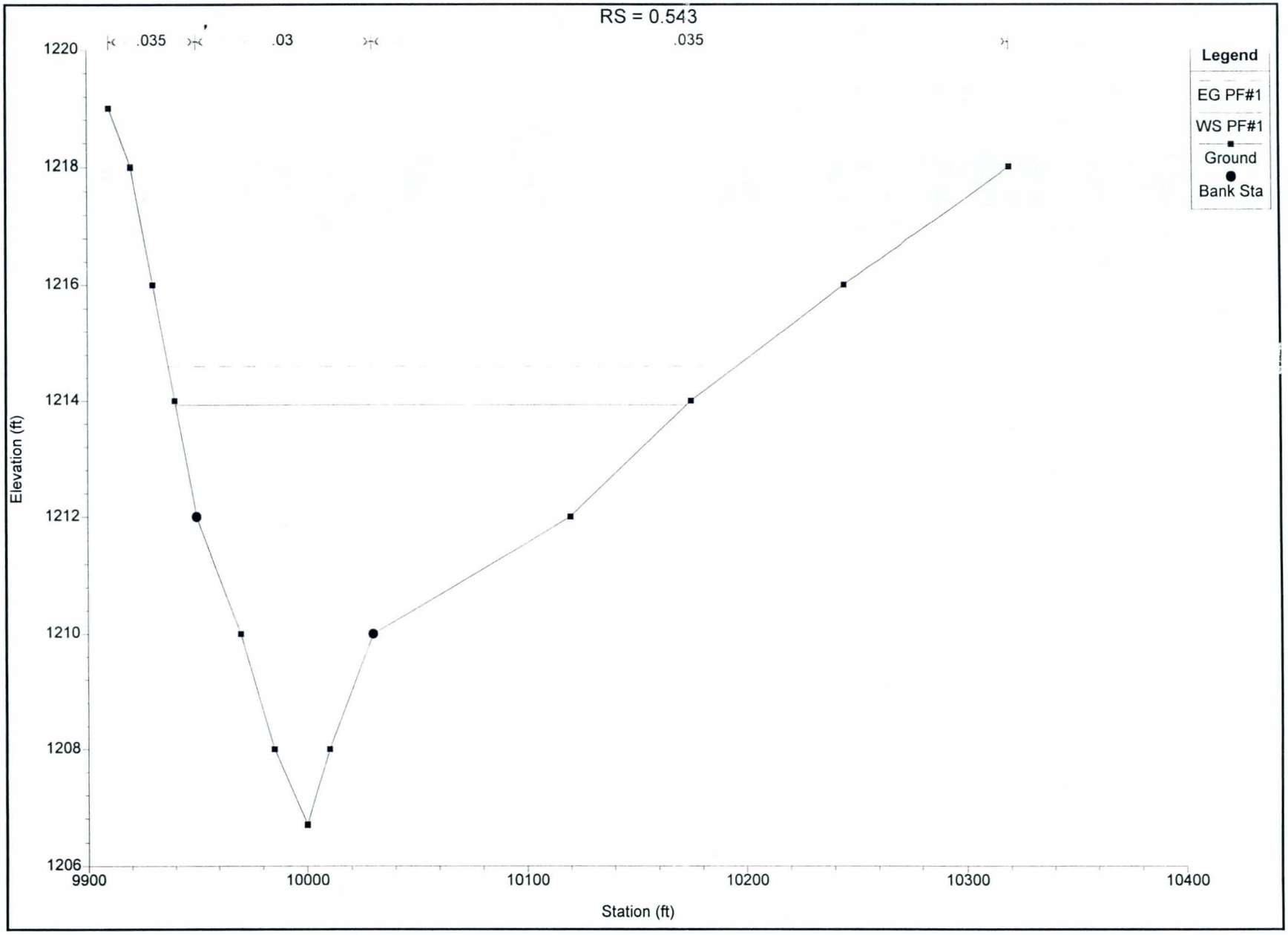

RS = 0.92
.035
.03
.035
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1228
1226
1224
1222
1220
1218
1216
1214
9900
9950
10000
10050
10100
10150
Station (ft)

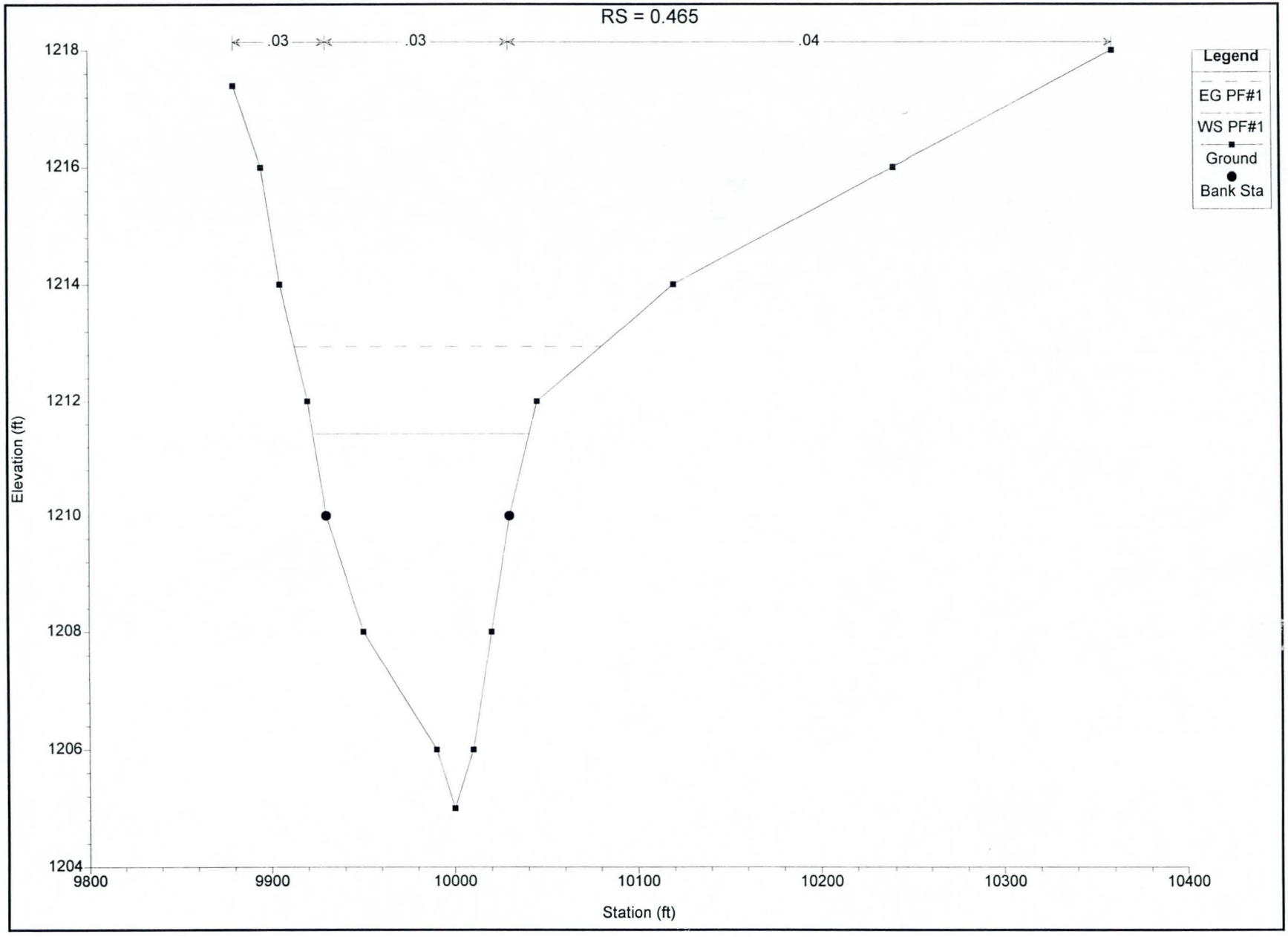

RS = 0.846
.035
.03
.035
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1224
1222
1220
1218
1216
1214
1212
9900
9950
10000
10050
10100
10150
10200
10250
Station (ft)

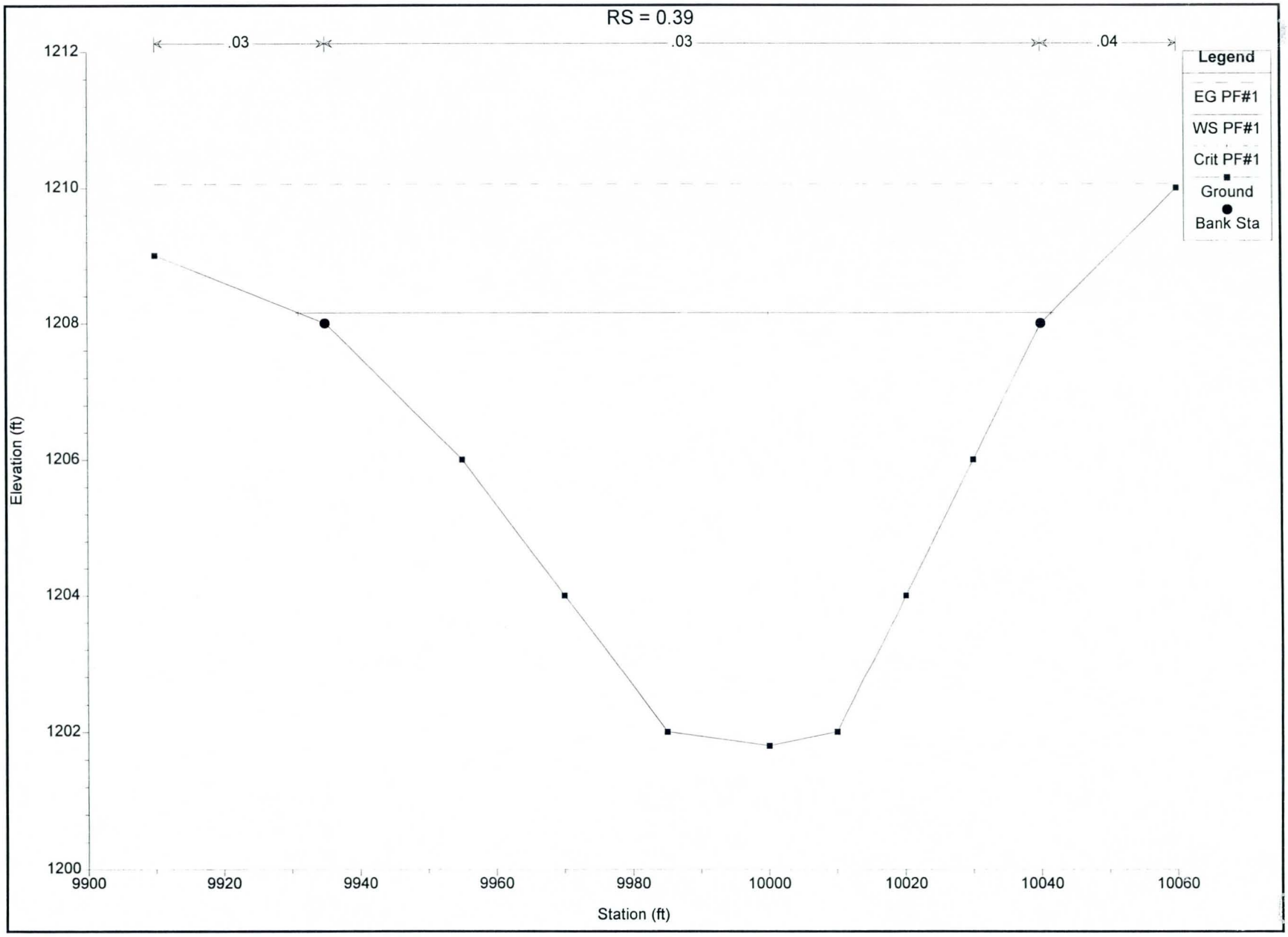

RS = 0.77
.035
.03
.035
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1222
1220
1218
1216
1214
1212
1210
9900
10000
10100
10200
10300
10400
Station (ft)

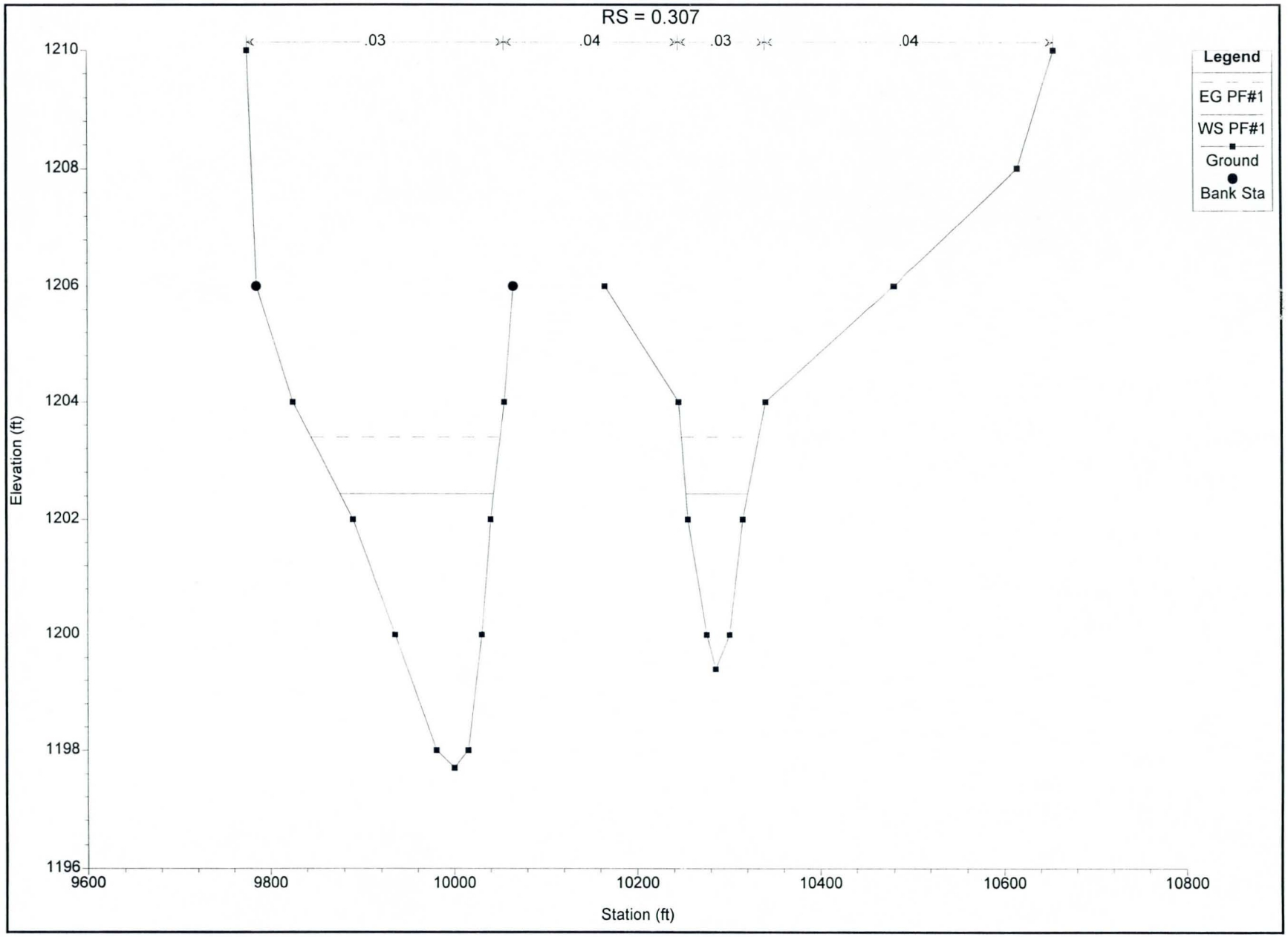

RS = 0.696
.035
.03
.035
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1224
1222
1220
1218
1216
1214
1212
1210
9900
10000
10100
10200
10300
10400
Station (ft)

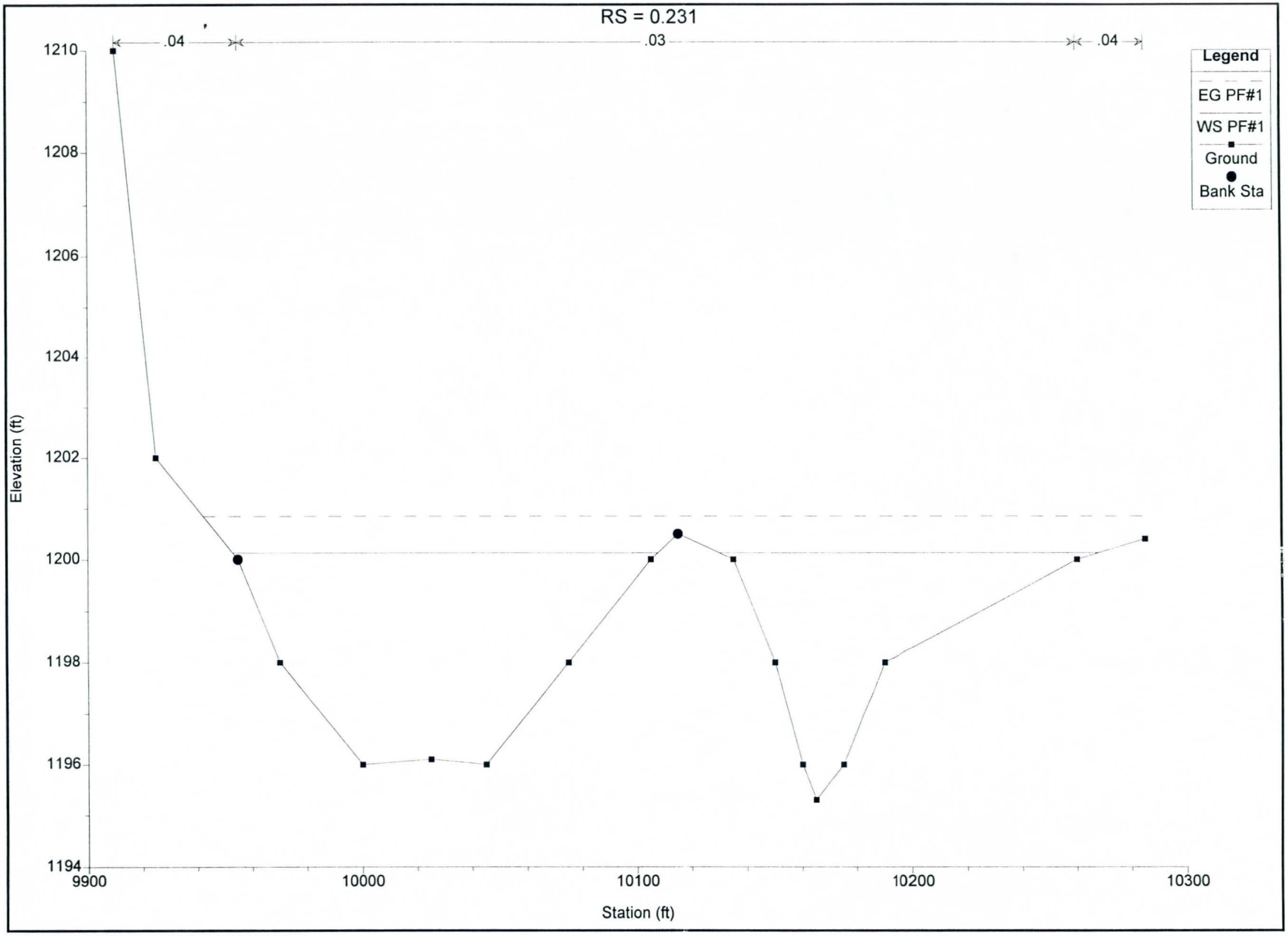

RS = 0.62
.035
.03
.035
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1222
1220
1218
1216
1214
1212
1210
1208
1206
9900
10000
10100
10200
10300
10400
10500
Station (ft)

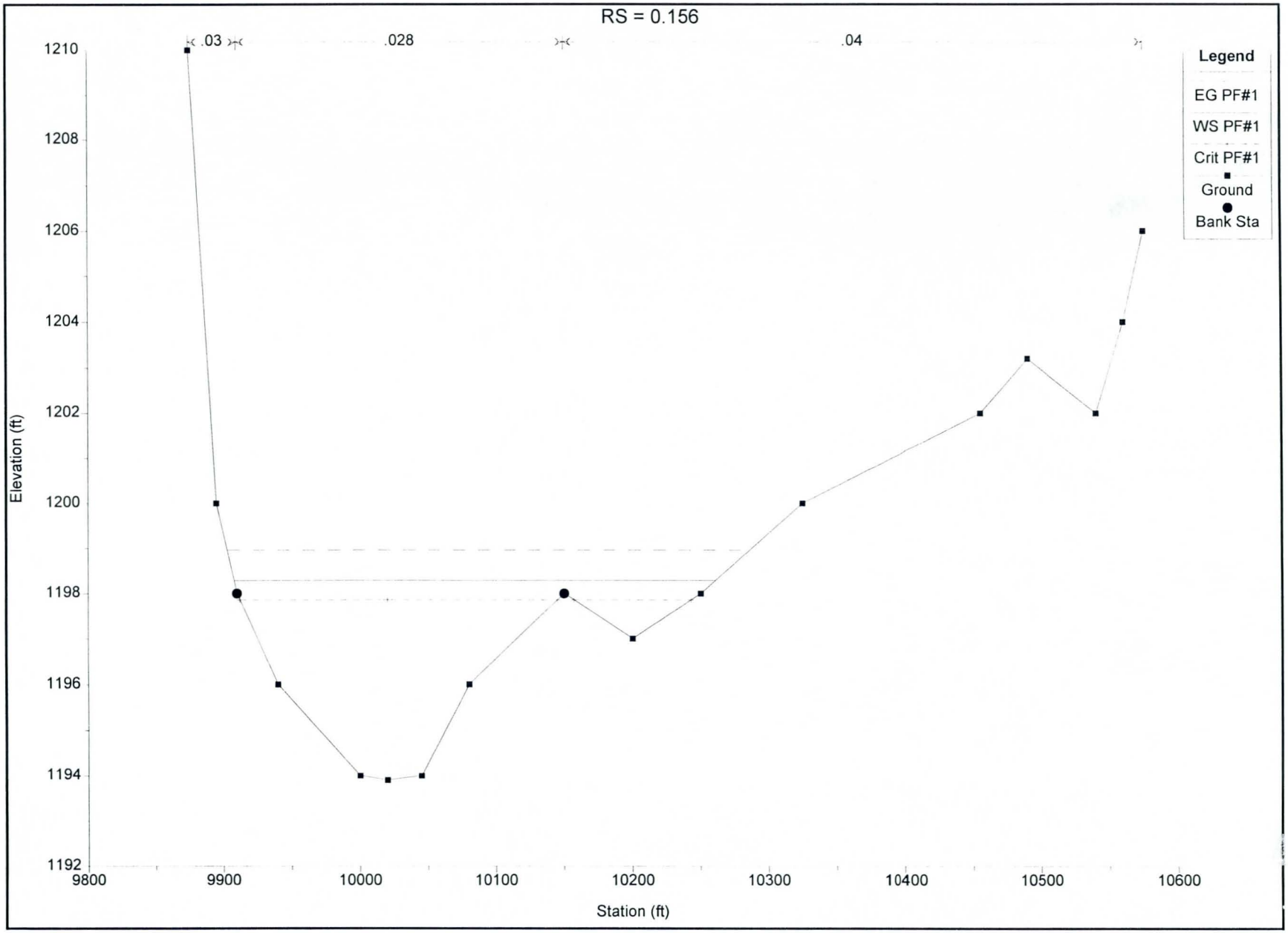

RS = 0.543
.035
.03
.035
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1220
1218
1216
1214
1212
1210
1208
1206
9900
10000
10100
10200
10300
10400
Station (ft)

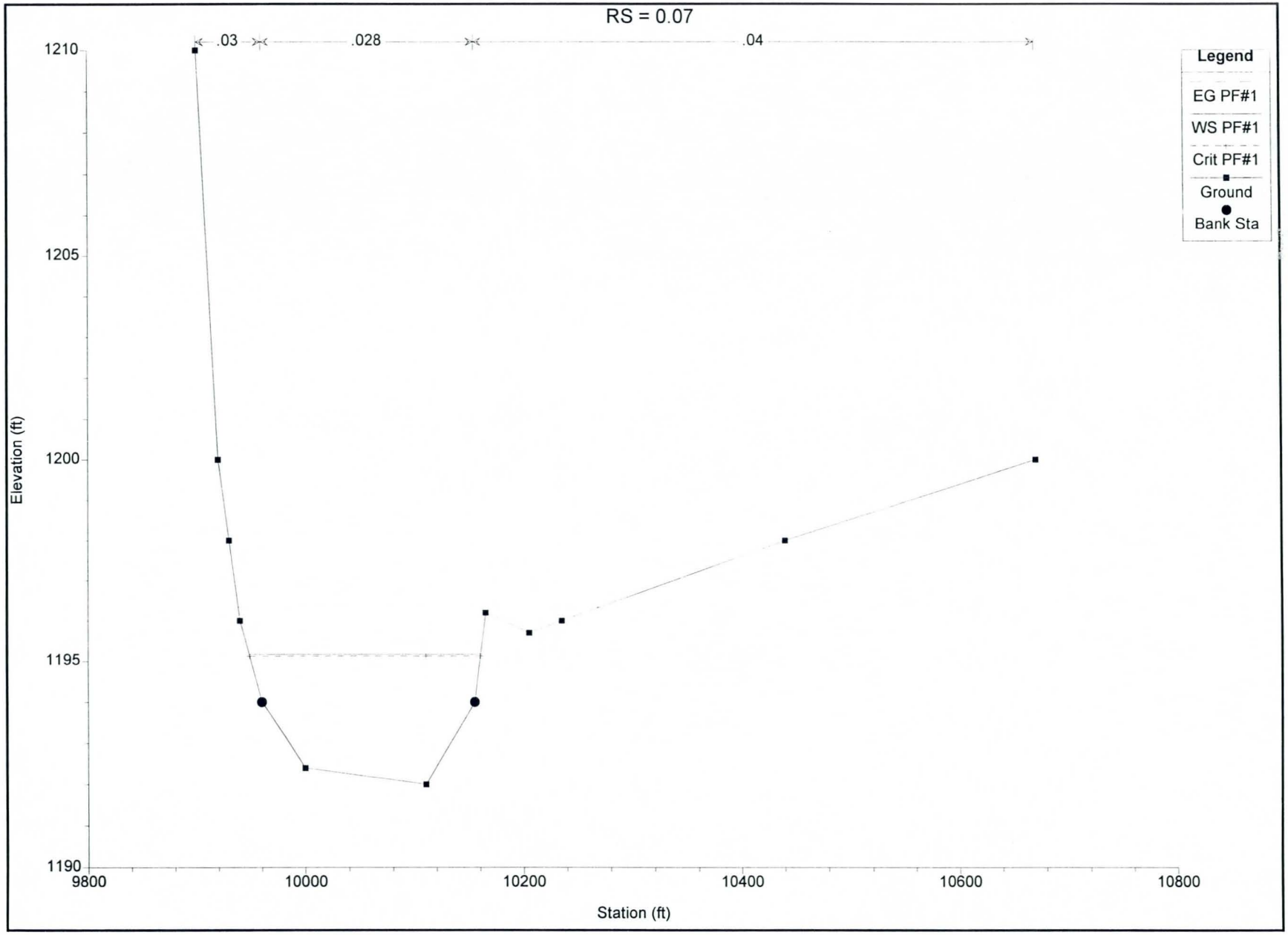

RS = 0.465
.03
.03
.04
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1218
1216
1214
1212
1210
1208
1206
1204
9800
9900
10000
10100
10200
10300
10400
Station (ft)


RS = 0.39
.03
.03
.04
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1212
1210
1208
1206
1204
1202
1200
9900
9920
9940
9960
9980
10000
10020
10040
10060
Station (ft)


RS = 0.307
.03
.04
.03
.04
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1210
1208
1206
1204
1202
1200
1198
1196
9600
9800
10000
10200
10400
10600
10800
Station (ft)


RS = 0.231
.04
.03
.04
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1210
1208
1206
1204
1202
1200
1198
1196
1194
9900
10000
10100
10200
10300
Station (ft)


RS = 0.156
.03
.028
.04
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1210
1208
1206
1204
1202
1200
1198
1196
1194
1192
9800
9900
10000
10100
10200
10300
10400
10500
10600
Station (ft)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WS PF#1
Crit PF#1
Ground
Bank Sta
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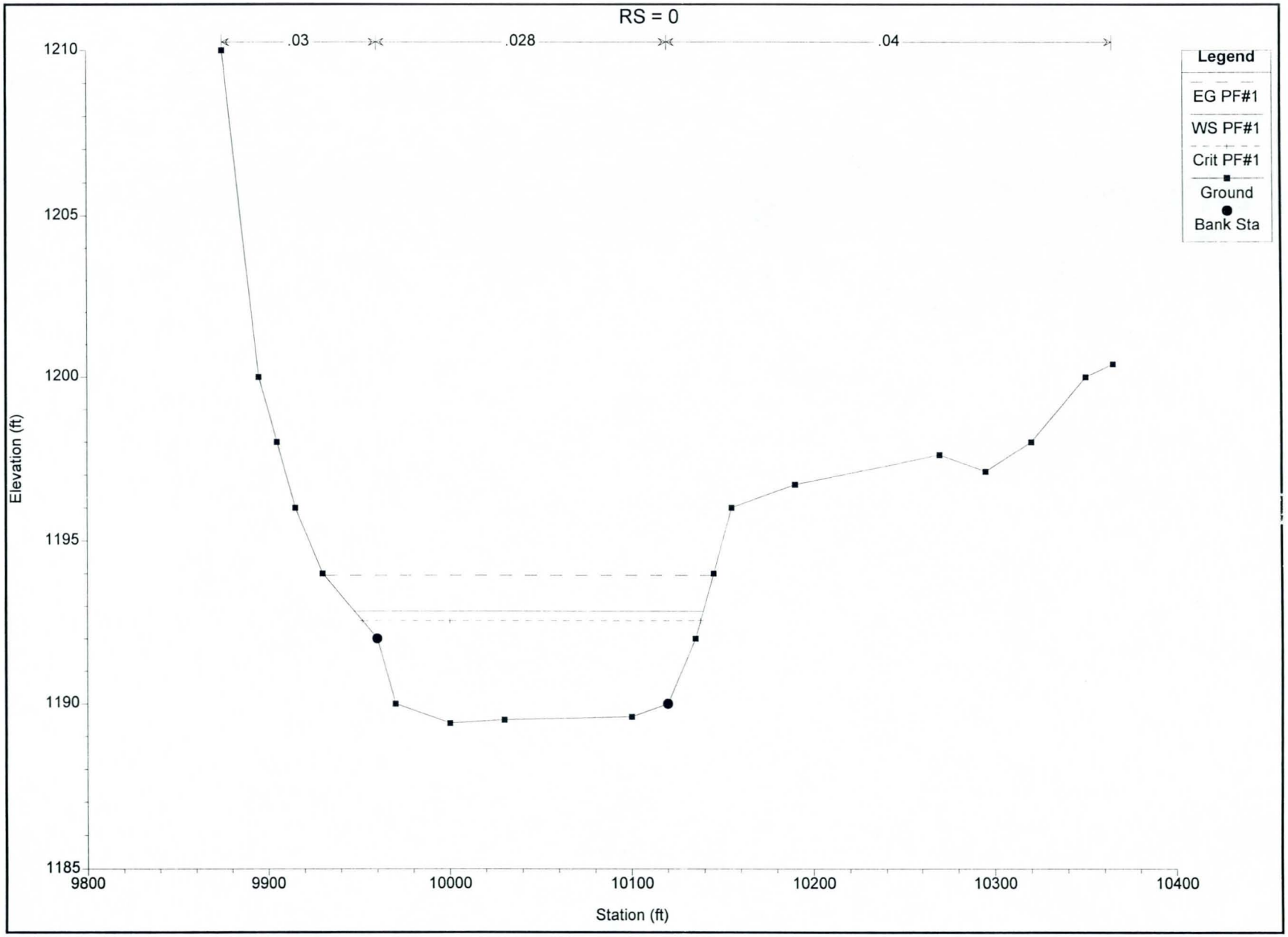
1210
1205
1200
1195
1190
9800
10000
10200
10400
10600
10800
Station (ft)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Crit PF#1
Ground
Bank Sta
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1205
1200
1195
1190
1185
9800
9900
10000
10100
10200
10300
10400
Station (ft)

APPENDIX G

RECOMMENDED ALTERNATIVE
HEC-RAS OUTPUT

HEC-RAS Plan: imp. bridge River: RIVER-1 Reach: Reach-1

Reach	River Sta	Q Total	Crit W.S.	W.S. Elev	Sta W.S. Lft	Sta W.S. Rgt	Top Width	Min Ch El	Max Chl Dpth	Vel Chnl	E.G. Elev	E.G. Slope
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/s)	(ft)	(ft/ft)
Reach-1	3.678	148.00		1321.75	9984.76	10021.55	36.79	1318.80	2.95	2.15	1321.82	0.001132
Reach-1	3.61	148.00		1320.77	9987.12	10040.69	53.57	1318.30	2.47	4.12	1321.01	0.005814
Reach-1	3.54	296.00		1318.77	9993.32	10043.85	50.53	1316.30	2.47	3.94	1319.01	0.005175
Reach-1	3.46	296.00		1315.52	9988.74	10013.79	25.05	1312.60	2.92	6.15	1316.10	0.009332
Reach-1	3.383	296.00		1311.64	9985.91	10018.18	32.27	1309.10	2.54	5.72	1312.14	0.009893
Reach-1	3.301	296.00	1308.13	1308.61	9986.93	10040.37	53.44	1306.10	2.51	4.66	1308.95	0.005625
Reach-1	3.214	296.00	1304.21	1304.21	9949.65	10016.60	66.95	1302.70	1.51	5.27	1304.64	0.018817
Reach-1	3.167	296.00		1303.93	9980.18	10034.45	54.26	1299.80	4.13	2.07	1303.99	0.000671
Reach-1	3.081	710.00		1303.22	9974.84	10050.23	75.39	1297.50	5.72	3.88	1303.45	0.001561
Reach-1	3.009	710.00	1301.30	1301.30	9980.53	10067.32	86.78	1296.60	4.70	7.86	1302.17	0.009662
Reach-1	2.907	710.00	1294.59	1294.59	9980.38	10044.63	64.25	1291.30	3.29	7.67	1295.49	0.012803
Reach-1	2.826	710.00		1289.15	9983.18	10158.16	174.98	1285.70	3.45	3.08	1289.28	0.001415
Reach-1	2.741	710.00		1288.01	9984.96	10160.07	155.81	1283.90	4.11	4.82	1288.27	0.003946
Reach-1	2.64	997.00		1287.39	9969.60	10167.34	197.74	1282.90	4.49	2.57	1287.45	0.000874
Reach-1	2.553	997.00		1285.76	9976.19	10098.06	121.86	1282.10	3.66	7.02	1286.46	0.008530
Reach-1	2.468	997.00		1283.13	9983.25	10268.33	285.08	1279.70	3.43	3.97	1283.29	0.005409
Reach-1	2.392	997.00	1279.71	1279.71	9986.45	10209.42	162.18	1275.40	4.31	6.88	1280.24	0.011207
Reach-1	2.33	997.00		1277.77	9980.58	10146.13	165.55	1273.30	4.47	4.89	1278.10	0.003015
Reach-1	2.267	997.00	1275.75	1275.75	9985.63	10324.93	200.61	1272.00	3.75	7.60	1276.51	0.008378
Reach-1	2.186	997.00		1275.74	9931.31	10291.34	360.02	1270.50	5.24	1.50	1275.77	0.000071
Reach-1	2.167	997.00	1272.19	1275.54	9929.03	10328.38	399.35	1270.00	5.54	3.33	1275.71	0.000295
Reach-1	2.163	Culvert										
Reach-1	2.159	997.00	1271.80	1271.80	9980.00	10049.50	69.49	1269.60	2.20	8.40	1272.89	0.006431
Reach-1	2.072	997.00		1267.80	9975.51	10132.33	156.82	1263.50	4.30	5.69	1268.21	0.003963
Reach-1	1.996	997.00	1264.10	1264.10	9976.51	10025.71	49.21	1260.40	3.70	9.37	1265.40	0.011859
Reach-1	1.92	997.00		1260.88	9977.79	10024.41	46.62	1255.20	5.68	6.00	1261.44	0.003862
Reach-1	1.844	997.00	1257.18	1257.18	9984.70	10017.96	33.26	1252.40	4.78	9.90	1258.70	0.013272
Reach-1	1.768	997.00		1252.90	9968.28	10228.97	260.51	1250.70	2.20	3.69	1253.06	0.006733
Reach-1	1.692	997.00		1250.53	9977.97	10134.01	156.03	1247.70	2.83	4.76	1250.79	0.004844
Reach-1	1.616	997.00	1246.99	1246.99	9972.57	10102.43	129.48	1244.00	2.99	6.74	1247.64	0.014408
Reach-1	1.556	4504.00		1244.02	9984.96	10561.27	385.44	1241.00	3.02	4.36	1244.31	0.002840
Reach-1	1.466	4504.00		1240.91	9988.48	10232.99	181.79	1237.50	3.41	8.37	1242.00	0.009278
Reach-1	1.388	4504.00		1239.40	9986.50	10161.72	175.21	1234.50	4.90	5.91	1239.94	0.002759
Reach-1	1.313	4504.00		1237.91	9975.12	10159.54	184.42	1230.80	7.11	7.47	1238.65	0.003836
Reach-1	1.237	4504.00	1234.93	1234.93	9976.78	10246.48	210.00	1227.80	7.13	11.24	1236.41	0.007909
Reach-1	1.159	4504.00	1229.47	1233.77	9915.86	10040.00	124.14	1224.40	9.36	6.87	1234.50	0.000791
Reach-1	1.1535	Bridge										
Reach-1	1.148	4504.00	1229.03	1231.82	9942.63	10059.12	116.49	1224.00	7.82	8.22	1232.87	0.001357
Reach-1	1.074	4504.00		1229.80	9951.49	10034.50	83.01	1221.00	8.80	11.16	1231.72	0.004683

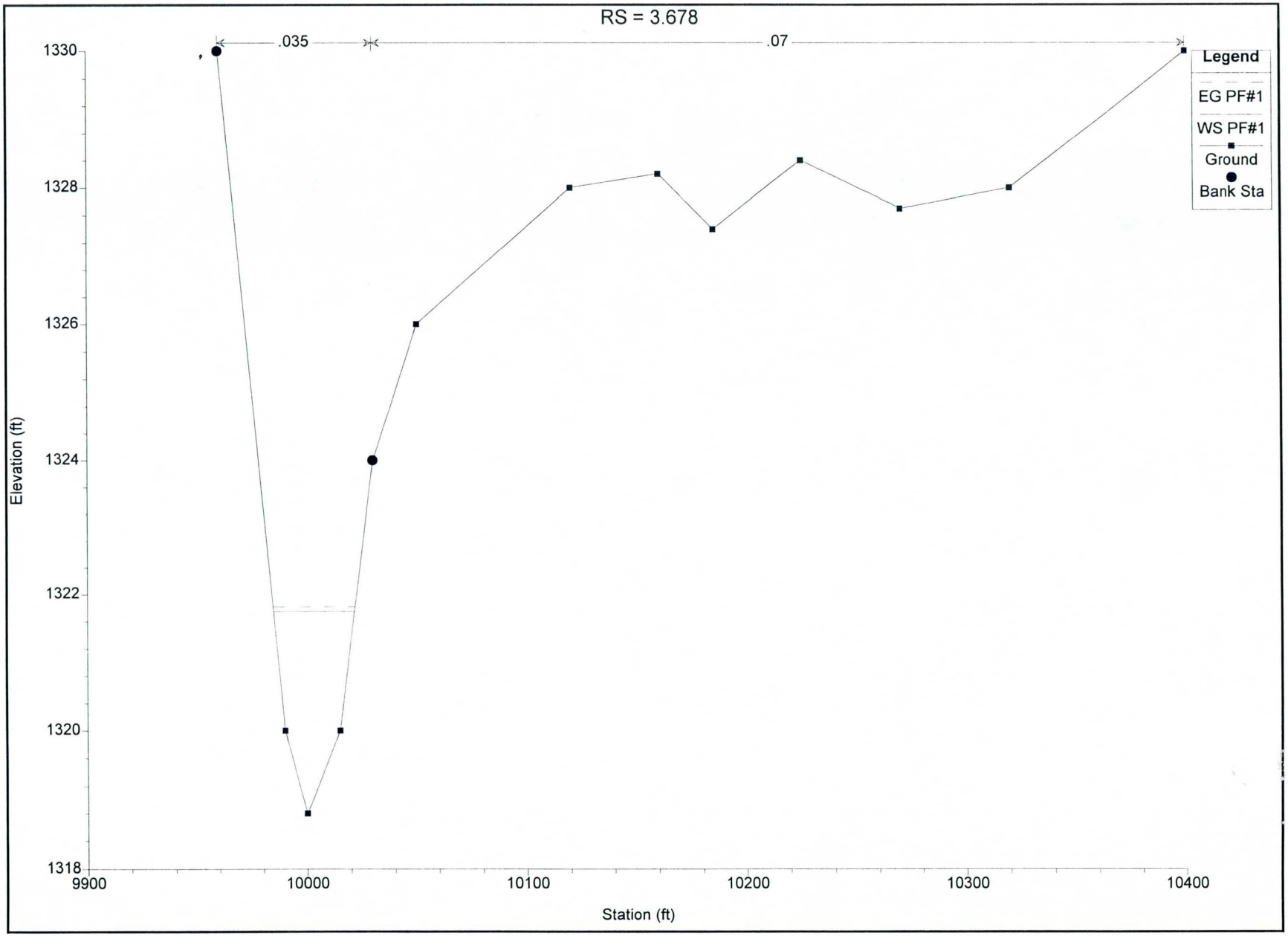
Reach	River Sta	Q Total	Crit W.S.	W.S. Elev	Sta W.S. Lft	Sta W.S. Rgt	Top Width	Min Ch El	Max Chl Dpth	Vel Chnl	E.G. Elev	E.G. Slope
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft/s)	(ft)	(ft/ft)
Reach-1	0.998	4925.00	1226.66	1226.66	9966.13	10048.68	82.55	1218.30	8.36	13.16	1229.29	0.006542
Reach-1	0.92	4925.00	1222.15	1222.15	9964.24	10103.82	139.58	1215.60	6.55	11.13	1224.02	0.007288
Reach-1	0.846	4925.00		1220.78	9939.13	10169.33	230.20	1213.60	7.18	7.68	1221.56	0.001980
Reach-1	0.77	4925.00		1220.75	9935.09	10400.00	464.91	1211.30	9.45	4.86	1220.96	0.000662
Reach-1	0.696	4925.00	1217.80	1217.80	9950.99	10049.01	98.01	1210.00	7.80	12.73	1220.16	0.006182
Reach-1	0.62	4925.00		1215.62	9951.92	10354.68	402.77	1207.80	7.82	5.99	1216.01	0.001472
Reach-1	0.543	4925.00		1214.60	9937.02	10195.87	258.85	1206.70	7.90	7.41	1215.24	0.002260
Reach-1	0.465	4925.00	1211.59	1211.59	9922.04	10041.94	119.90	1205.00	6.59	11.36	1213.58	0.007608
Reach-1	0.39	4925.00	1208.51	1208.51	9922.34	10045.06	122.72	1201.80	6.71	11.29	1210.48	0.007885
Reach-1	0.307	4925.00		1202.65	9868.91	10323.11	247.32	1197.70	4.95	8.33	1203.65	0.007332
Reach-1	0.231	4925.00		1200.30	9950.45	10278.96	316.71	1196.00	5.00	7.55	1201.07	0.005689
Reach-1	0.156	4925.00	1198.06	1198.47	9906.51	10267.45	360.95	1193.90	4.57	6.93	1199.18	0.004264
Reach-1	0.07	4925.00	1195.32	1195.36	9946.40	10161.18	214.78	1192.00	3.36	9.04	1196.62	0.007466
Reach-1	0	4925.00	1192.77	1193.06	9944.17	10140.28	196.11	1189.40	3.66	8.85	1194.24	0.005501

HEC-RAS Plan: imp. bridge River: RIVER-1 Reach: Reach-1

Reach	River Sta	E.G. US.	W.S. US.	E.G. IC	E.G. OC	Min Top Rd	Culv Q	Q Weir	Delta WS	Culv Vel In	Culv Vel Out
		(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(ft)	(ft/s)	(ft/s)
Reach-1	2.163 Culvert #1	1275.72	1275.54	1273.67	1275.72	1277.00	997.00		3.74	3.99	8.63

HEC-RAS Plan: imp. bridge River: RIVER-1 Reach: Reach-1

Reach	River Sta	E.G. US.	Min El Prs	BR Open Area	Prs O WS	Q Total	Min Top Rd	Q Weir	Delta EG
		(ft)	(ft)	(sq ft)	(ft)	(cfs)	(ft)	(cfs)	(ft)
Reach-1	1.1535	1234.50	1231.00	429.00	1233.77	4504.00	1234.50		1.62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WS PF#1
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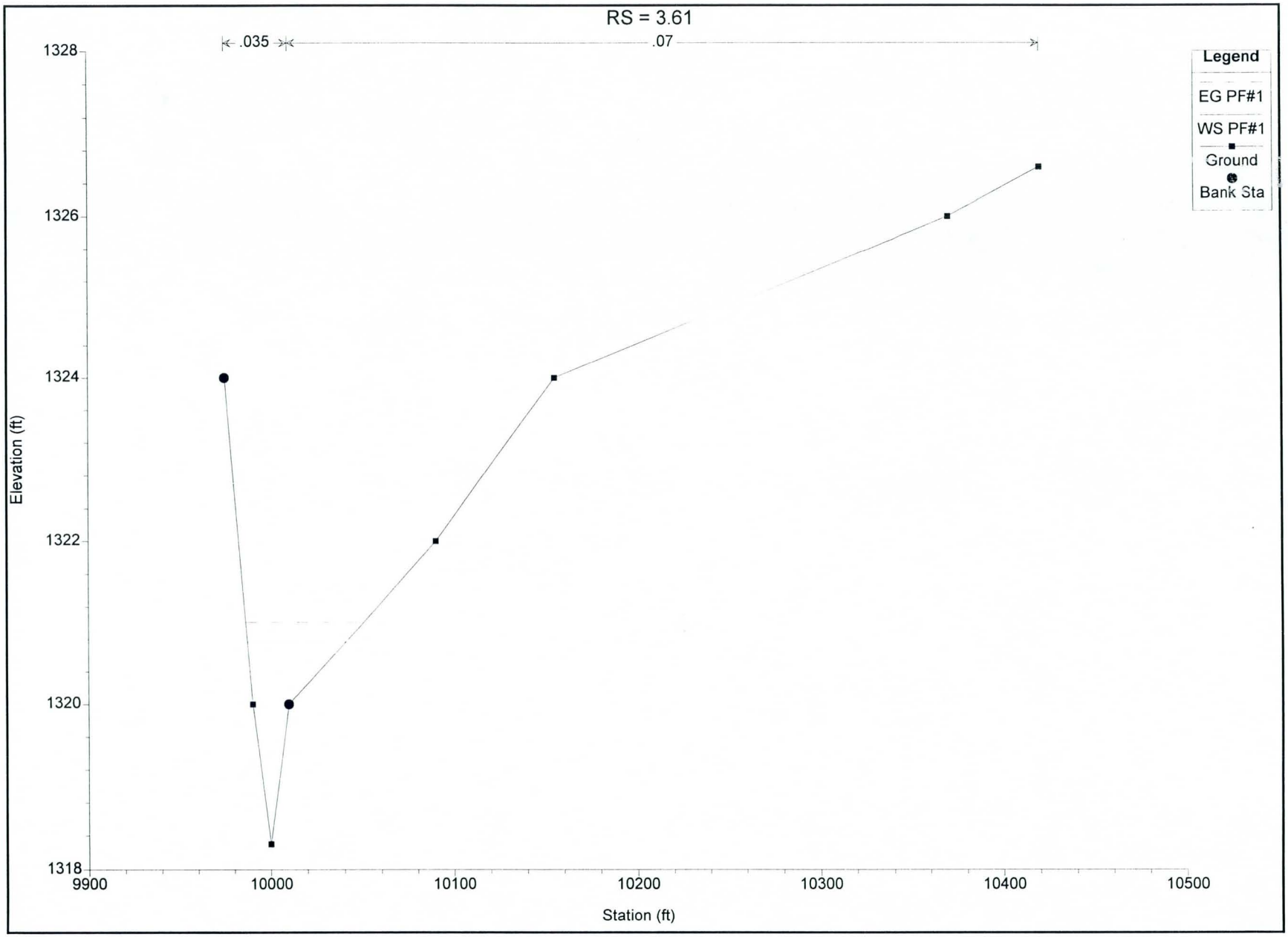
1326
1324
1322
1320
1318
9900
10000
10100
10200
10300
10400
Station (ft)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Bank Sta
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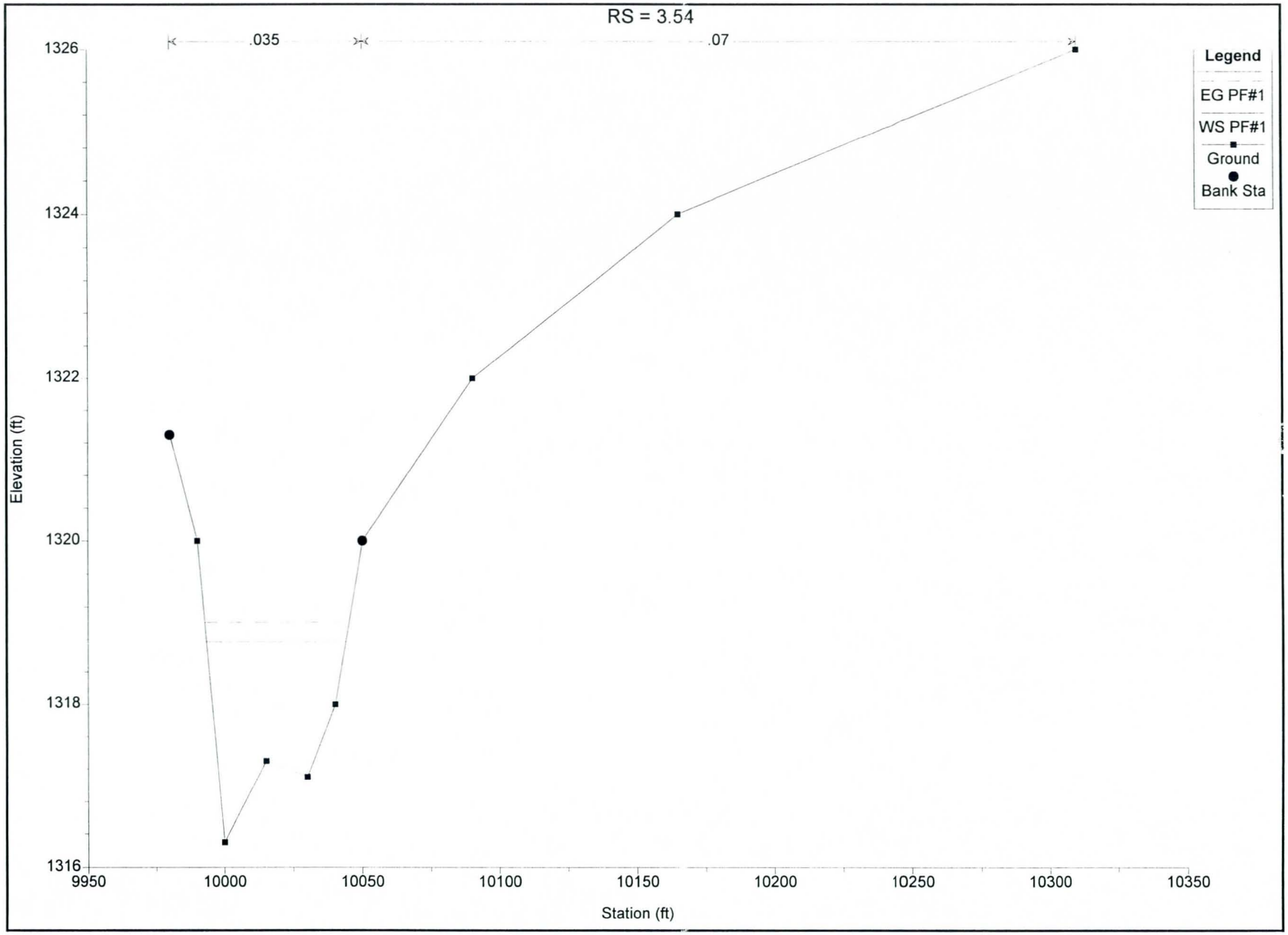
10000
10100
10200
10300
10400
10500
Station (ft)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Bank Sta
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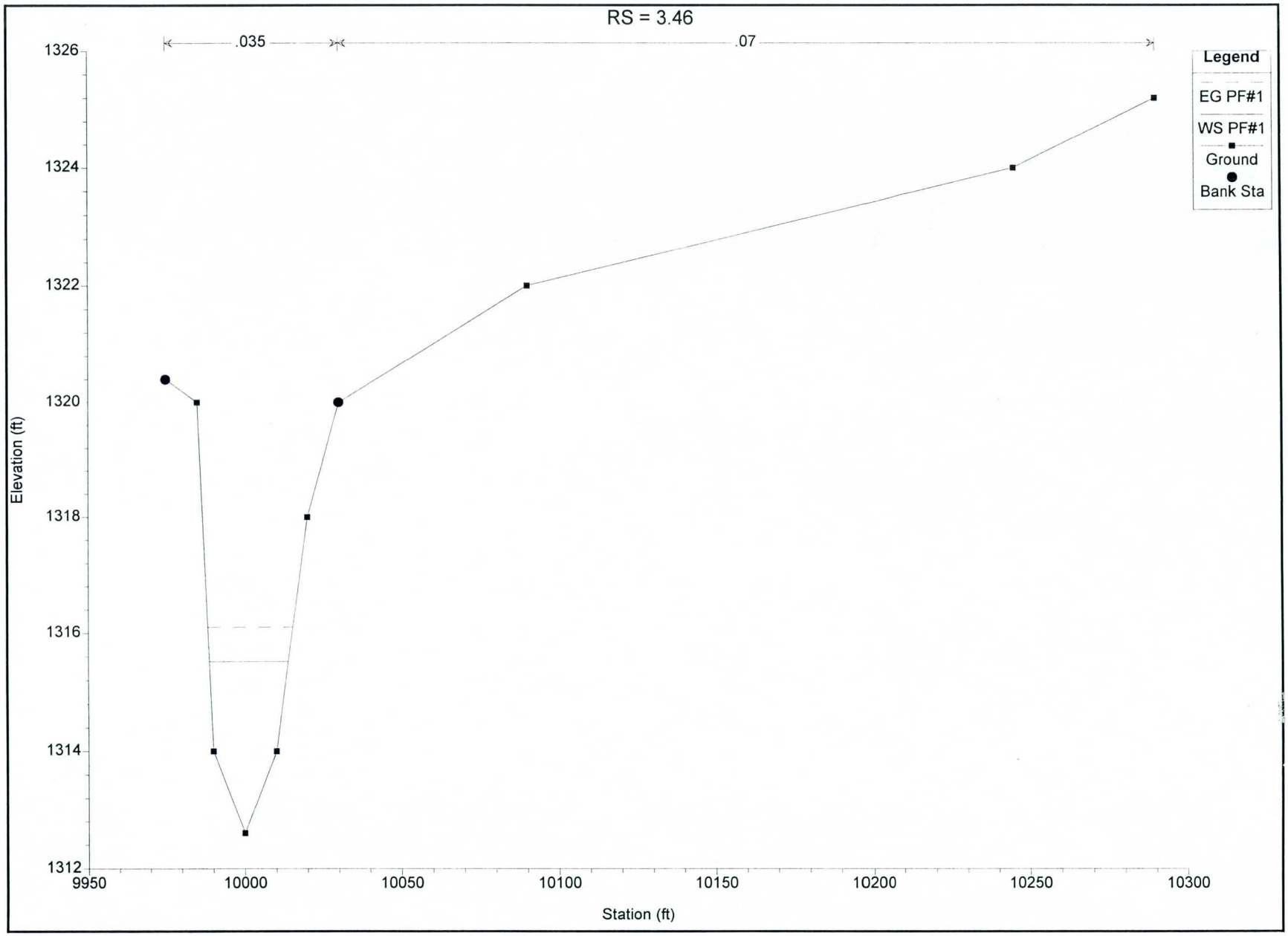
10250
10300
10350
Station (ft)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WS PF#1
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Bank Sta
Elevation (ft)
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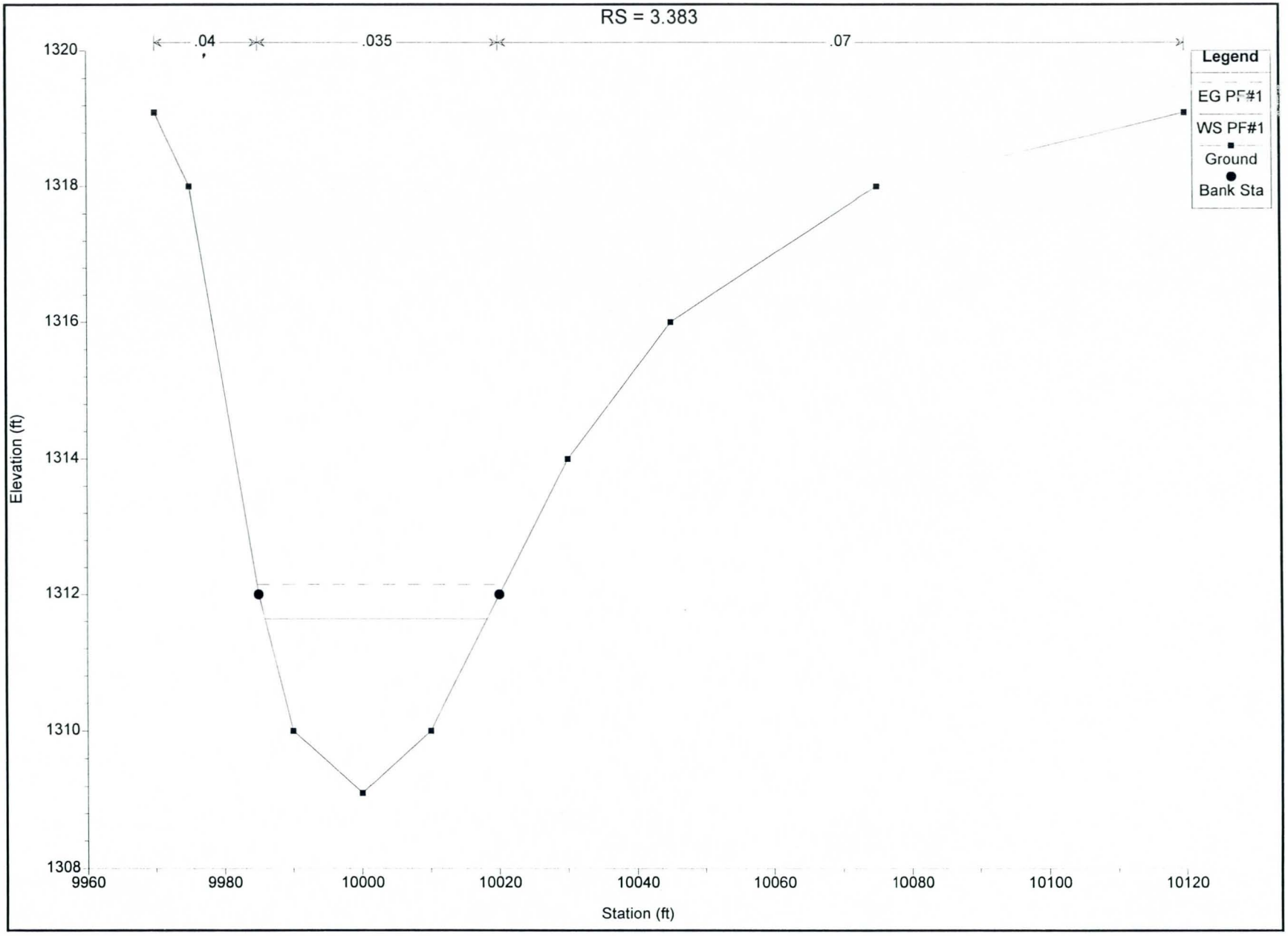
1324
1322
1320
1318
1316
1314
1312
9950
10000
10050
10100
10150
10200
10250
10300
Station (ft)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WS PF#1
Ground
Bank Sta
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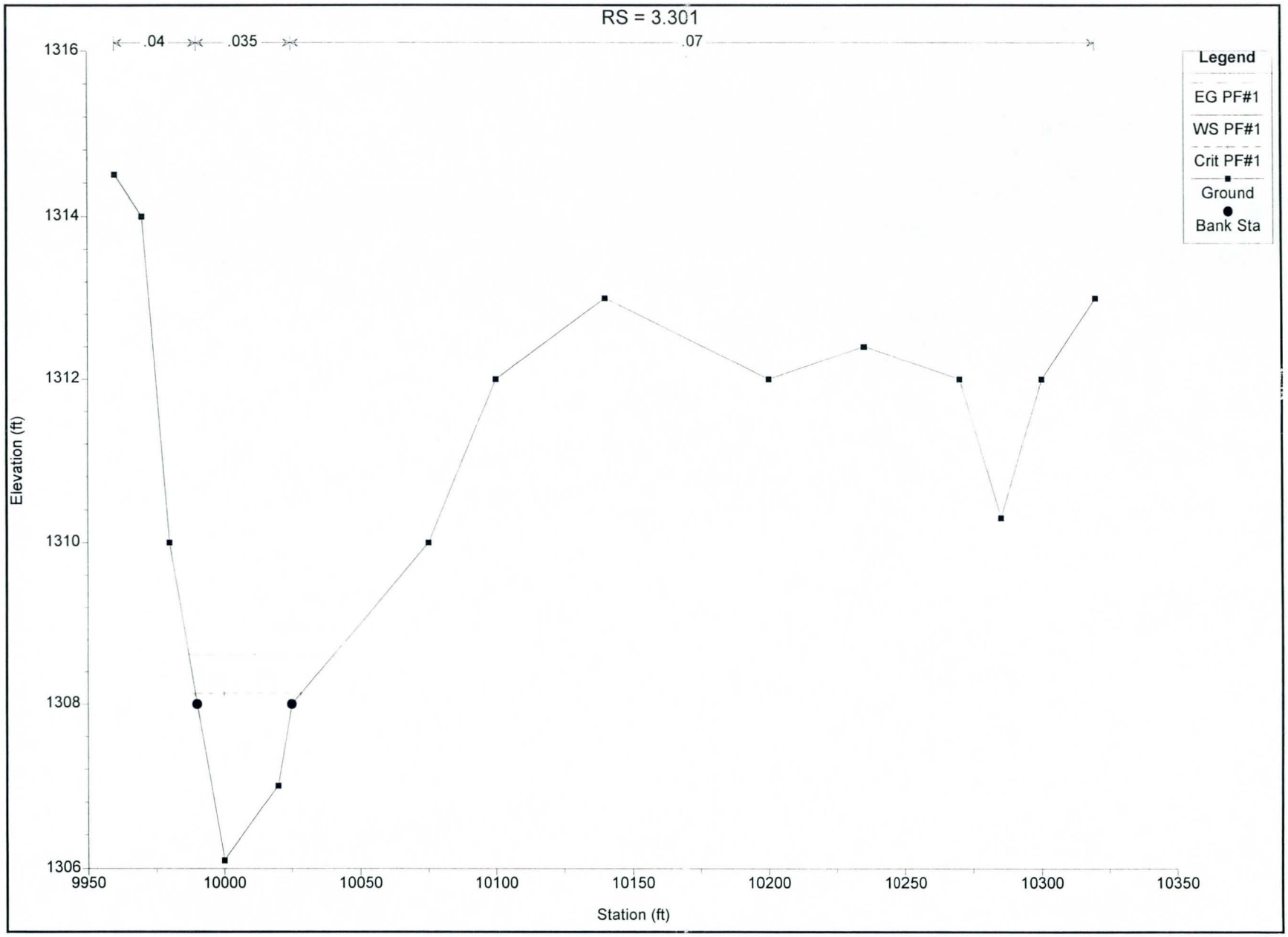
1310
1308
9960
9980
10000
10020
10040
10060
10080
10100
10120
Station (ft)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WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
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1312
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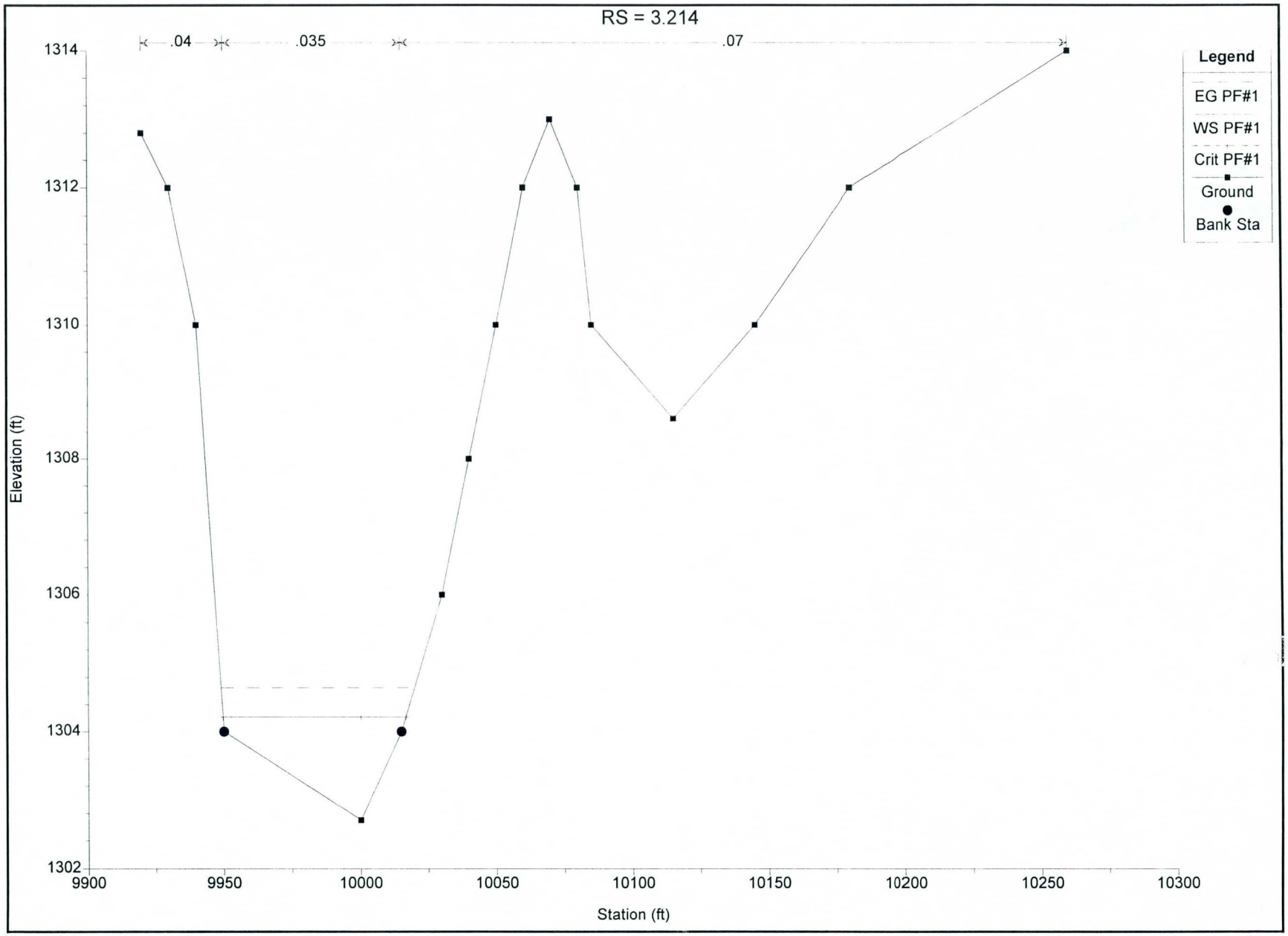
1308
1306
9950
10000
10050
10100
10150
10200
10250
10300
10350
Station (ft)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Crit PF#1
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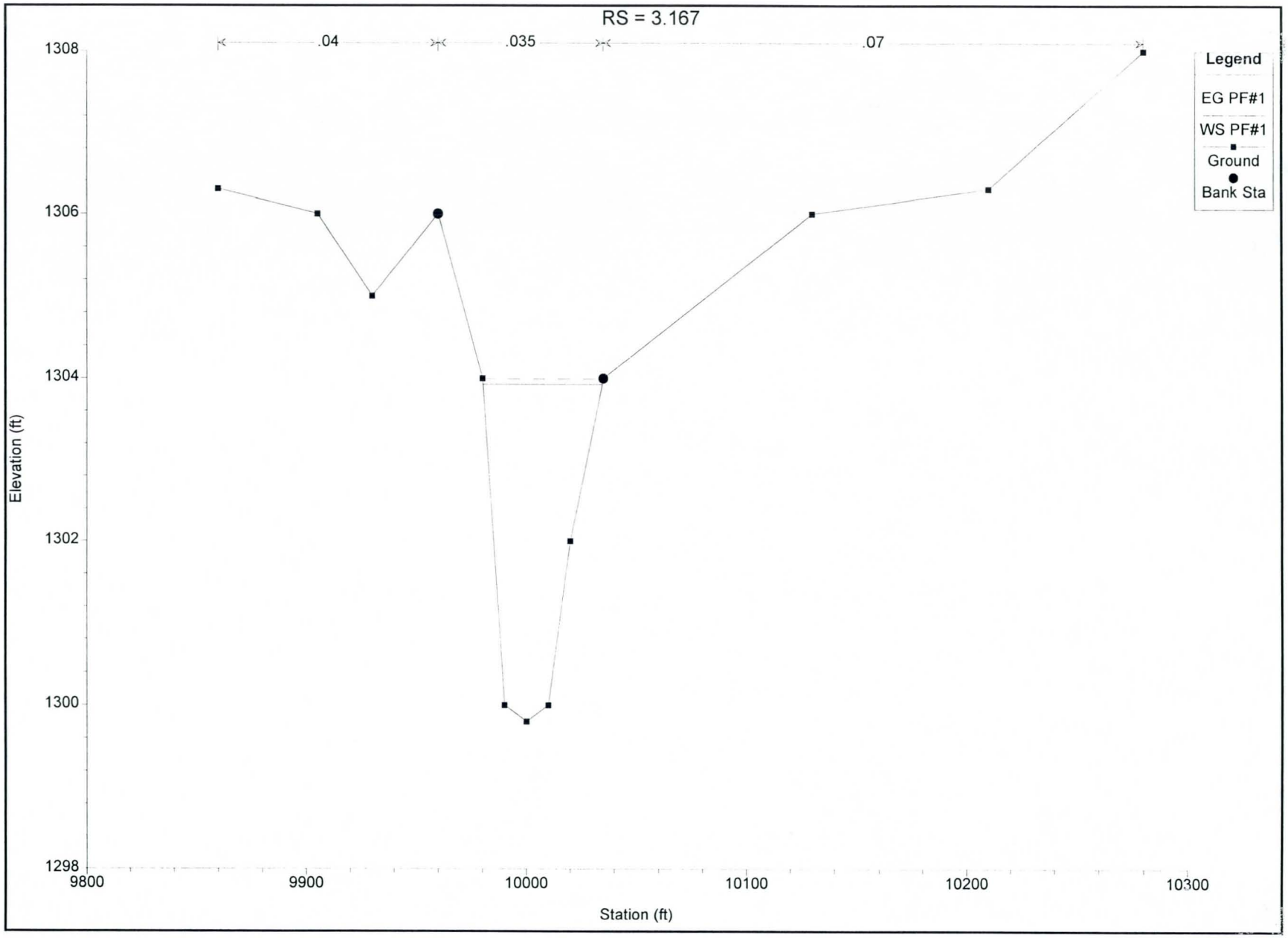
1304
1302
9900
9950
10000
10050
10100
10150
10200
10250
10300
Station (ft)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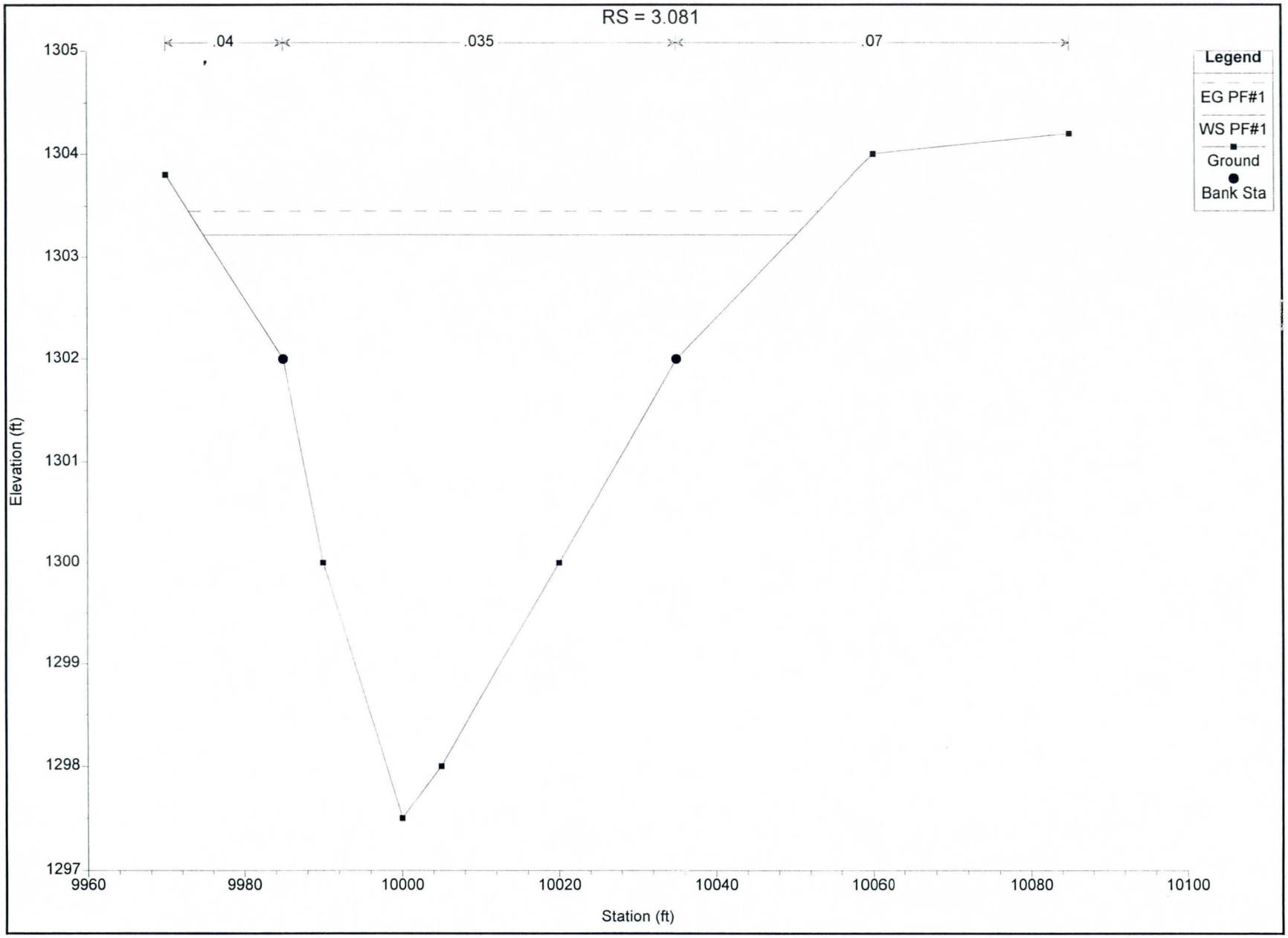
1304
1302
1300
1298
9800
9900
10000
10100
10200
10300
Station (ft)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WS PF#1
Ground
Bank Sta
Elevation (ft)
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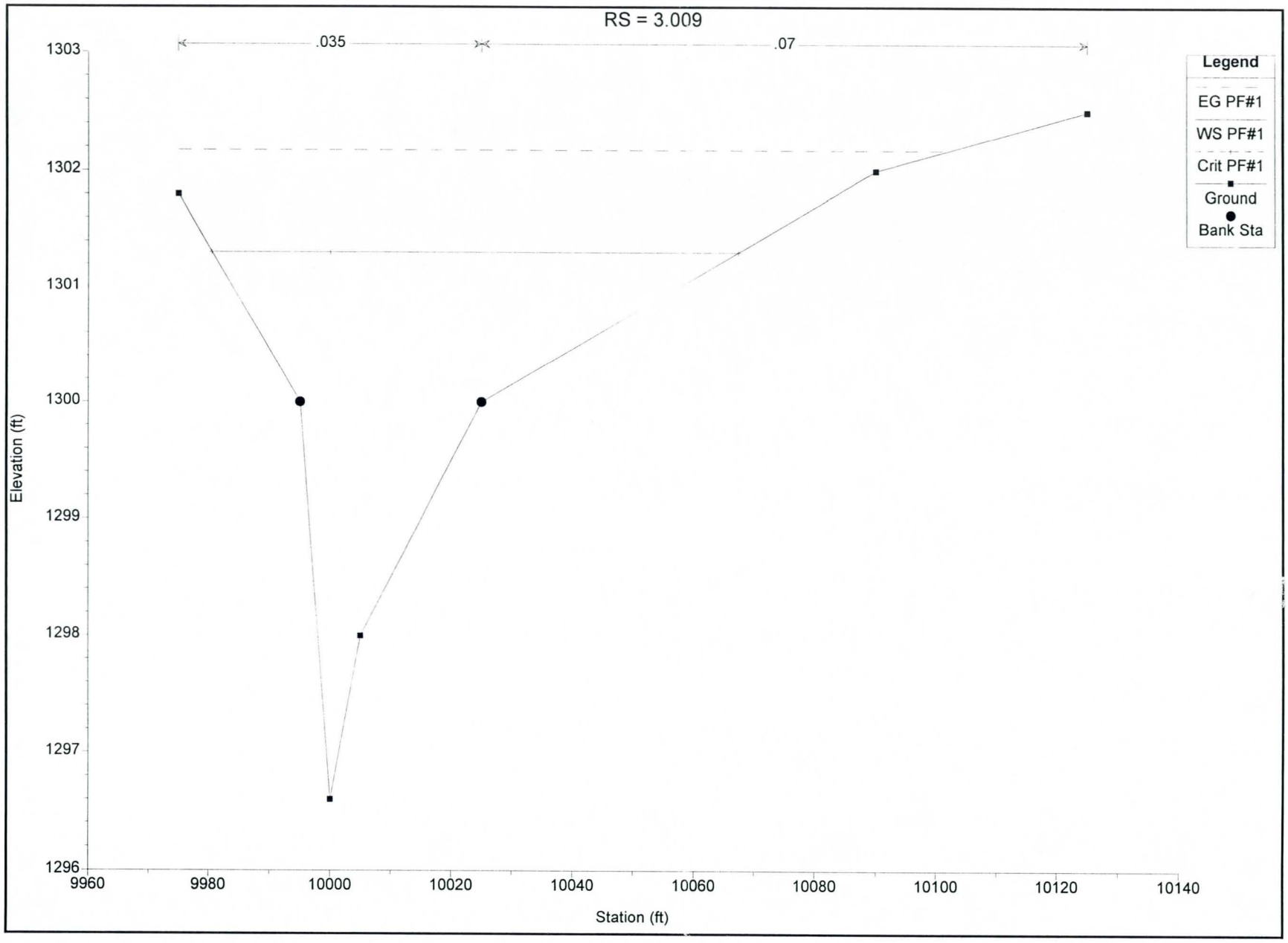
1304
1303
1302
1301
1300
1299
1298
1297
9960
9980
10000
10020
10040
10060
10080
10100
Station (ft)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Crit PF#1
Ground
Bank Sta
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1301
1300
1299
1298
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1296
9960
9980
10000
10020
10040
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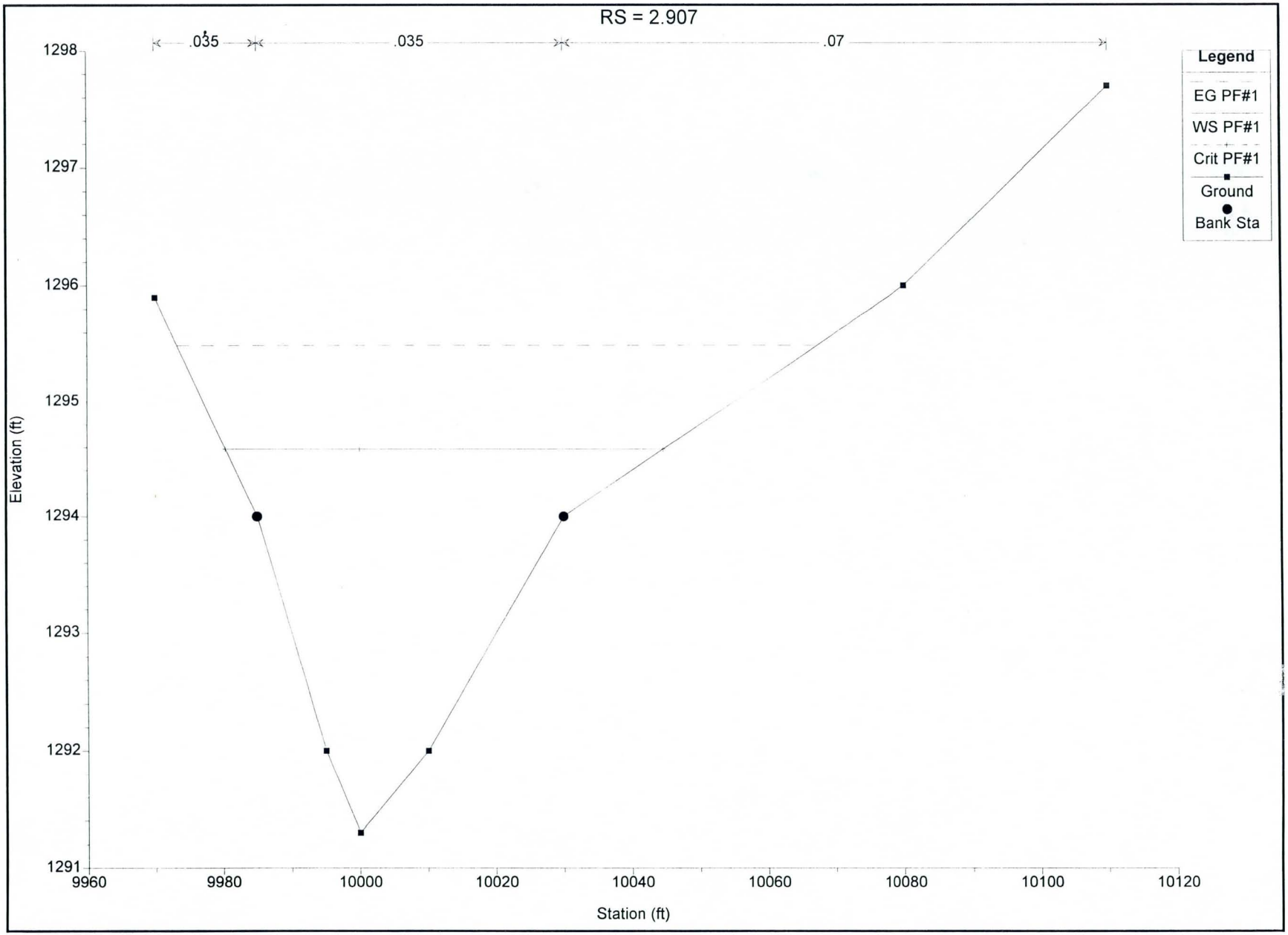
10100
10120
10140
Station (ft)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WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1298
1297
1296
1295
1294
1293
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1291
9960
9980
10000
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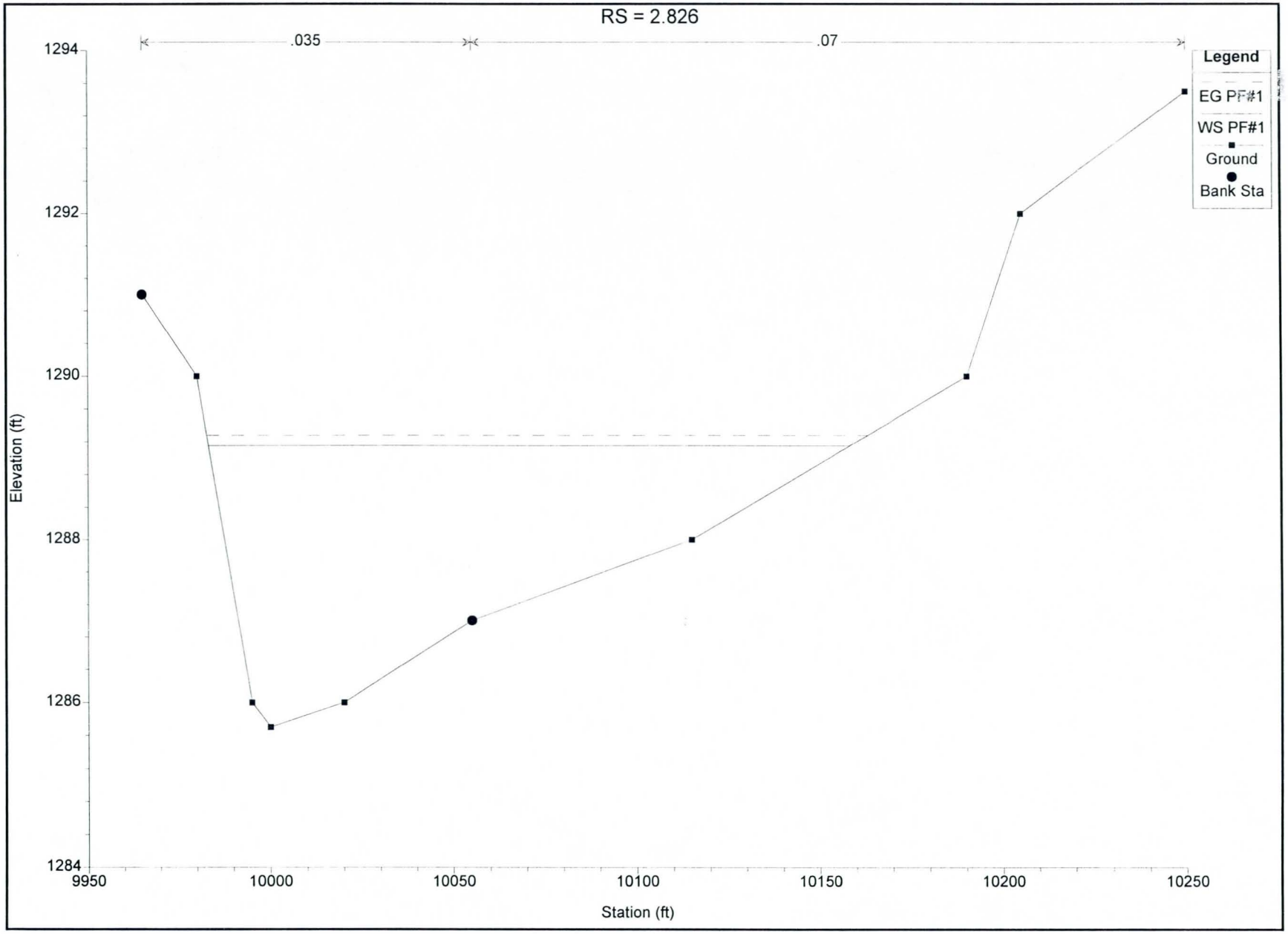
10040
10060
10080
10100
10120
Station (ft)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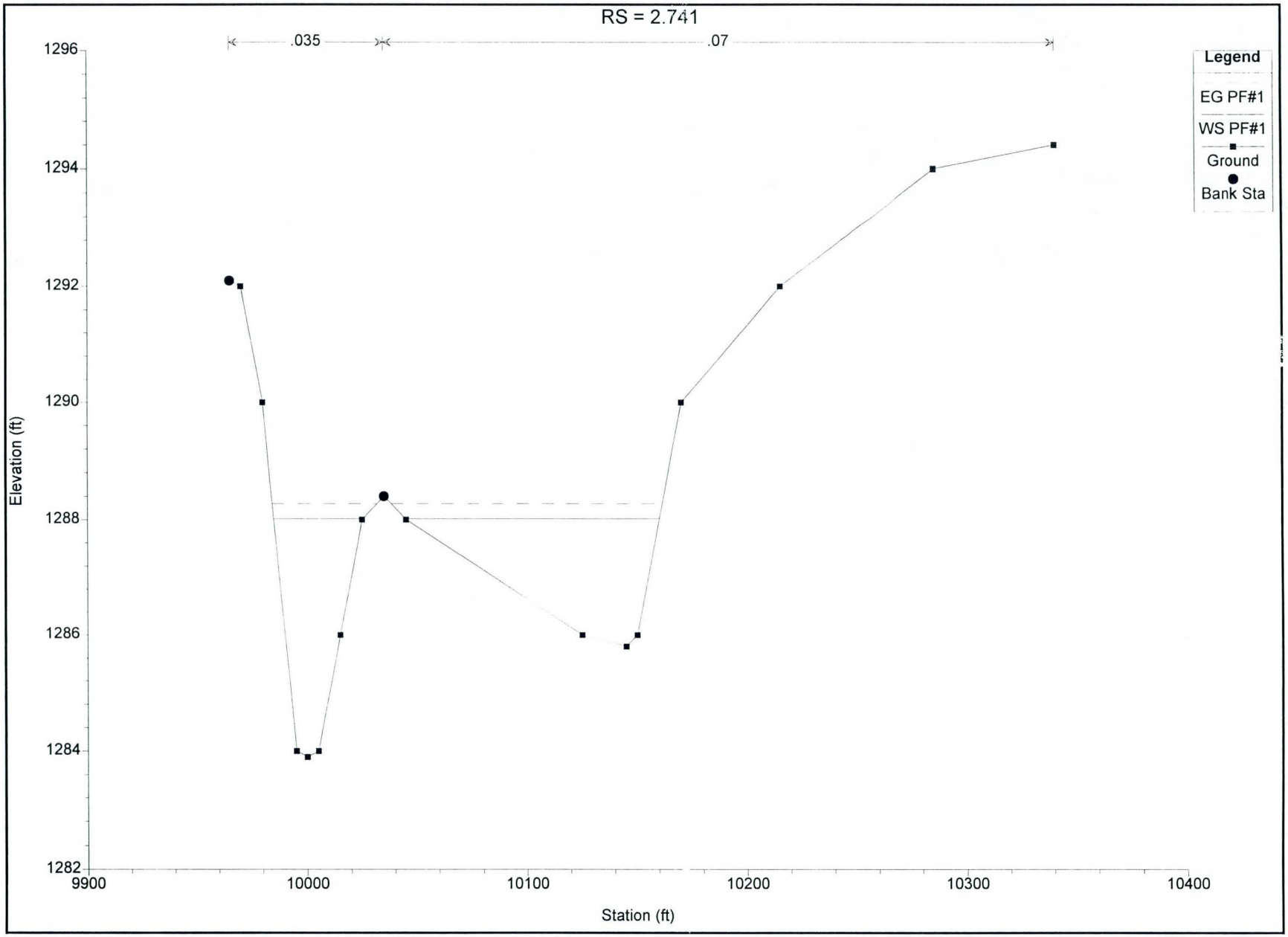
Station (ft)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9900
10000
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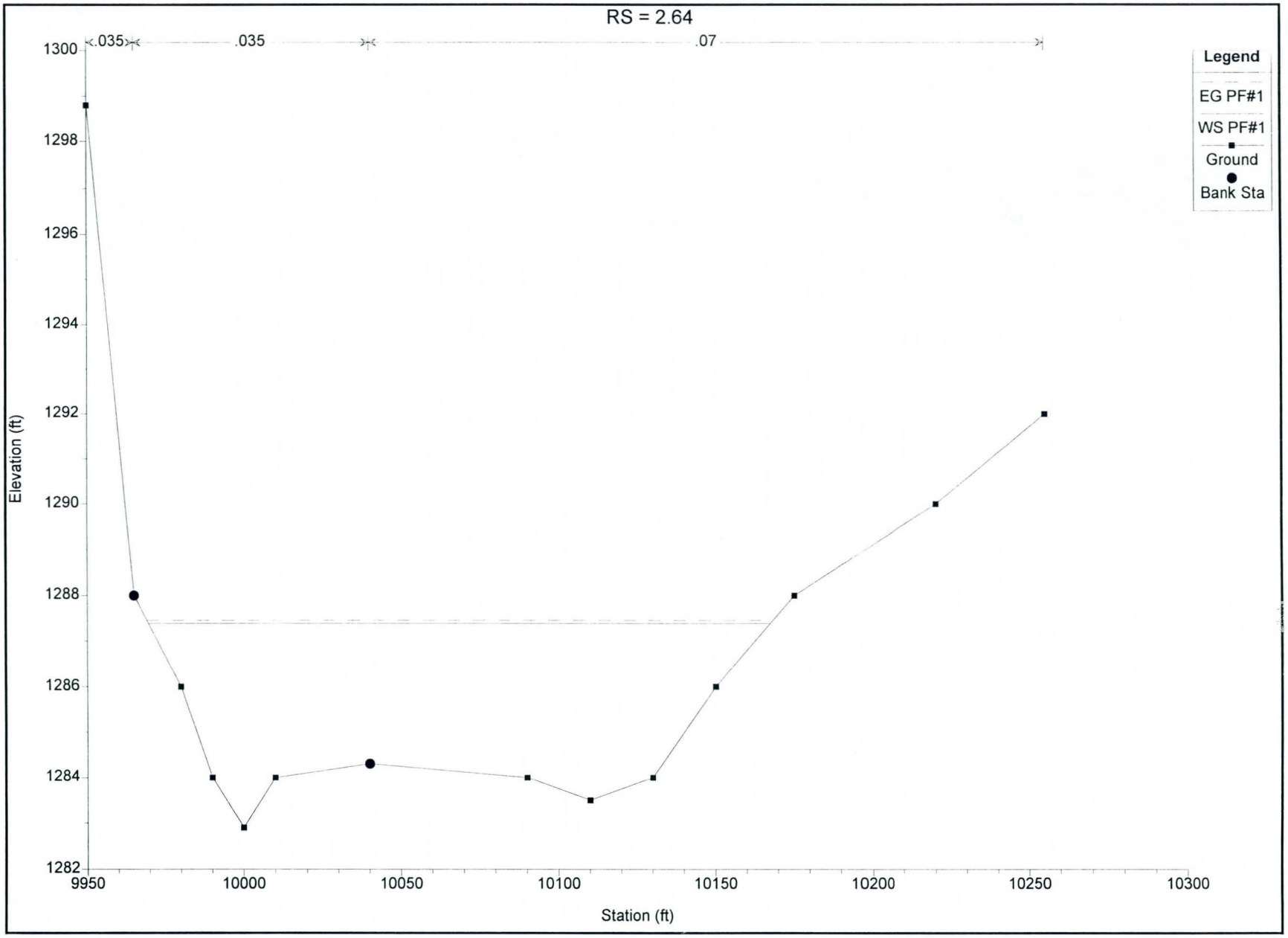
10200
10300
10400
Station (ft)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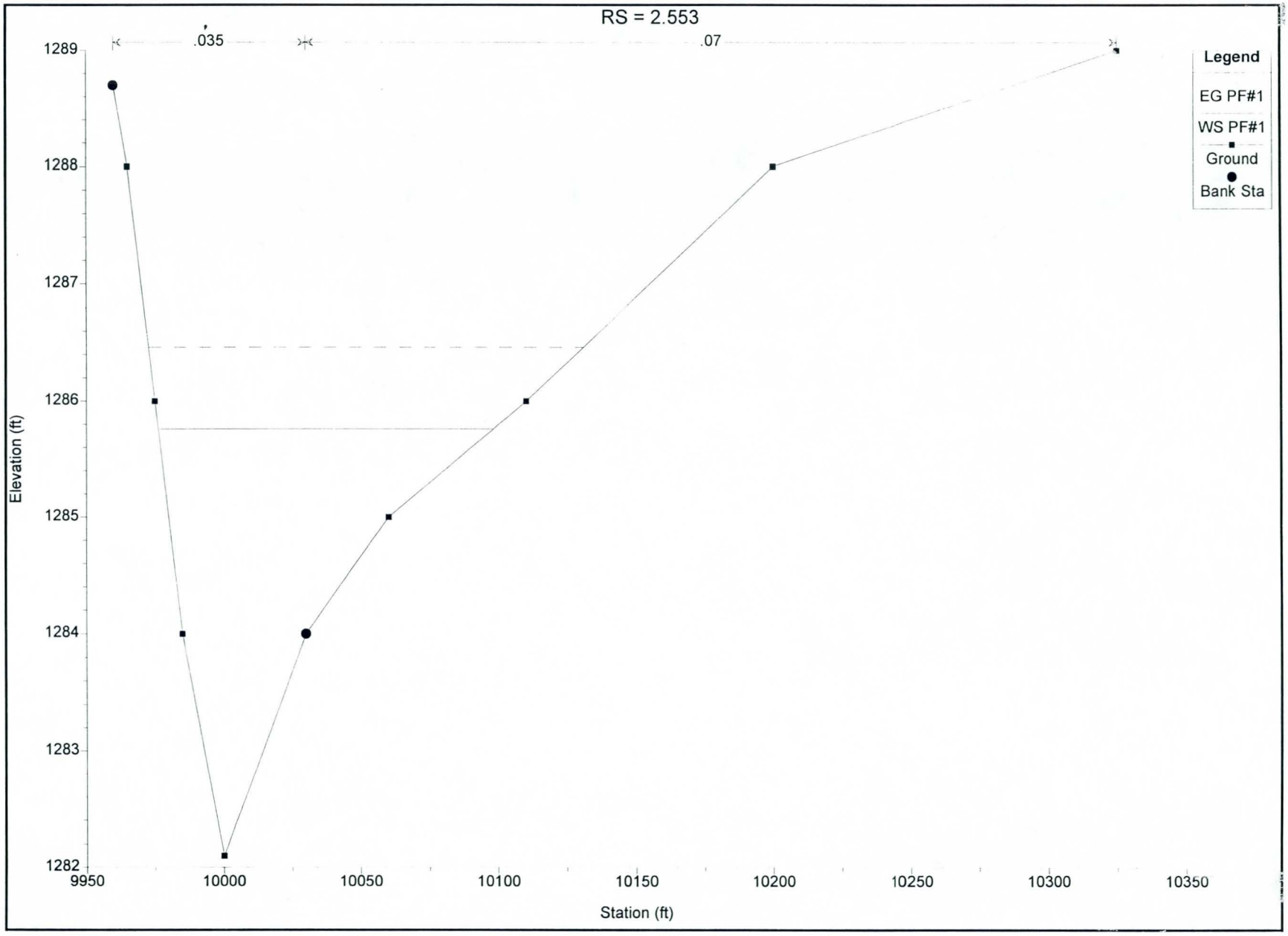
Station (ft)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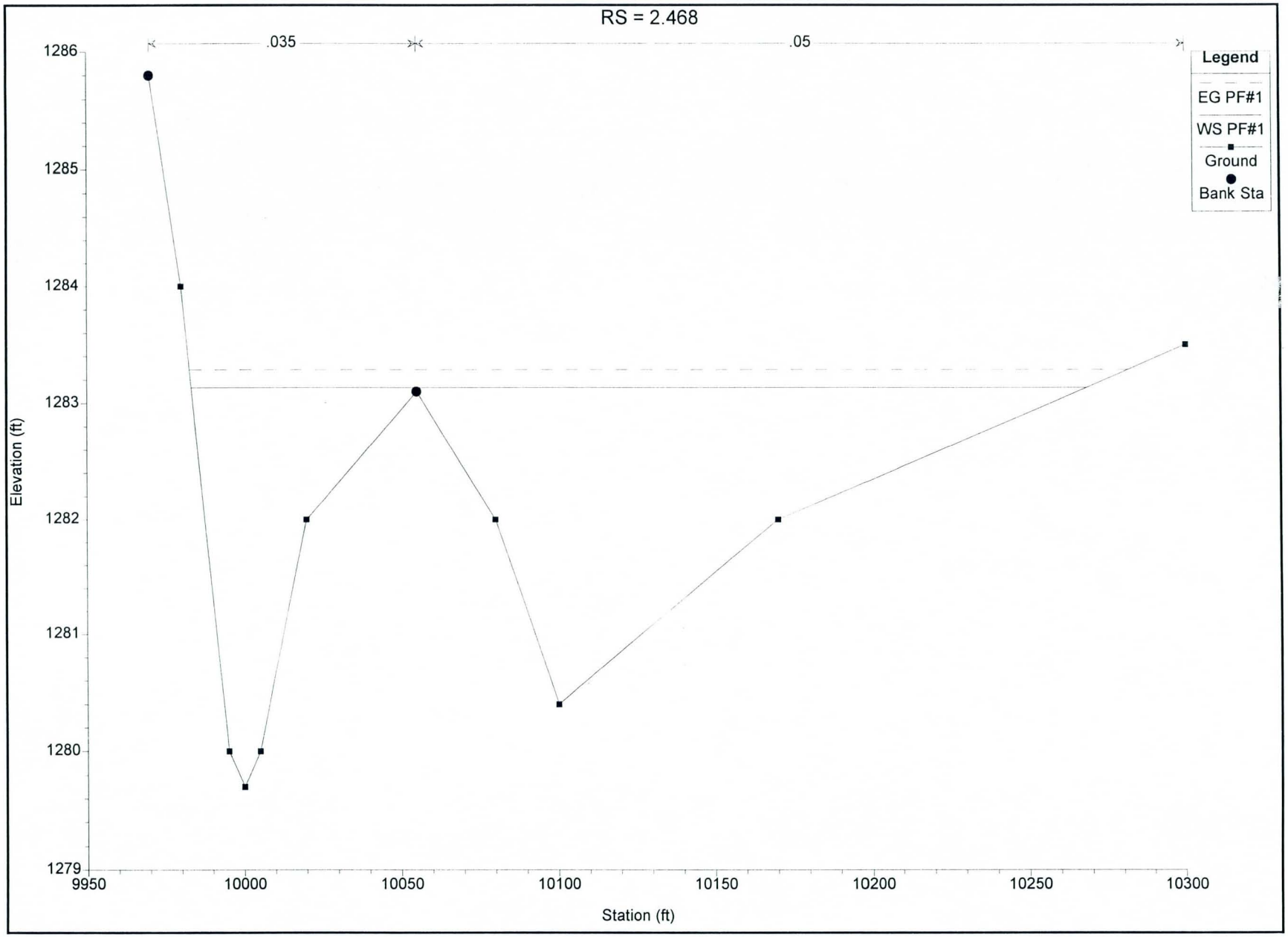
10200
10250
10300
10350
Station (ft)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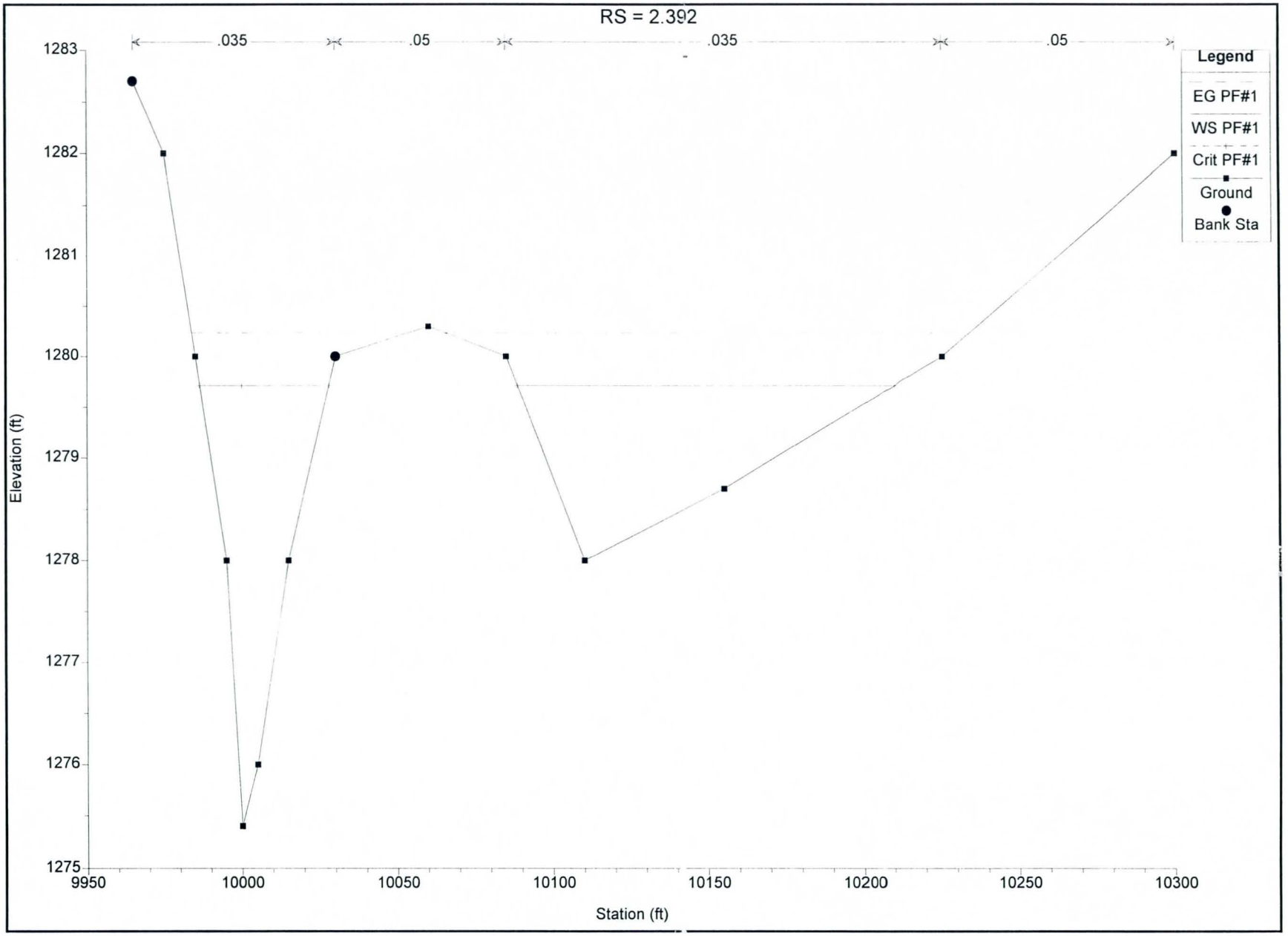
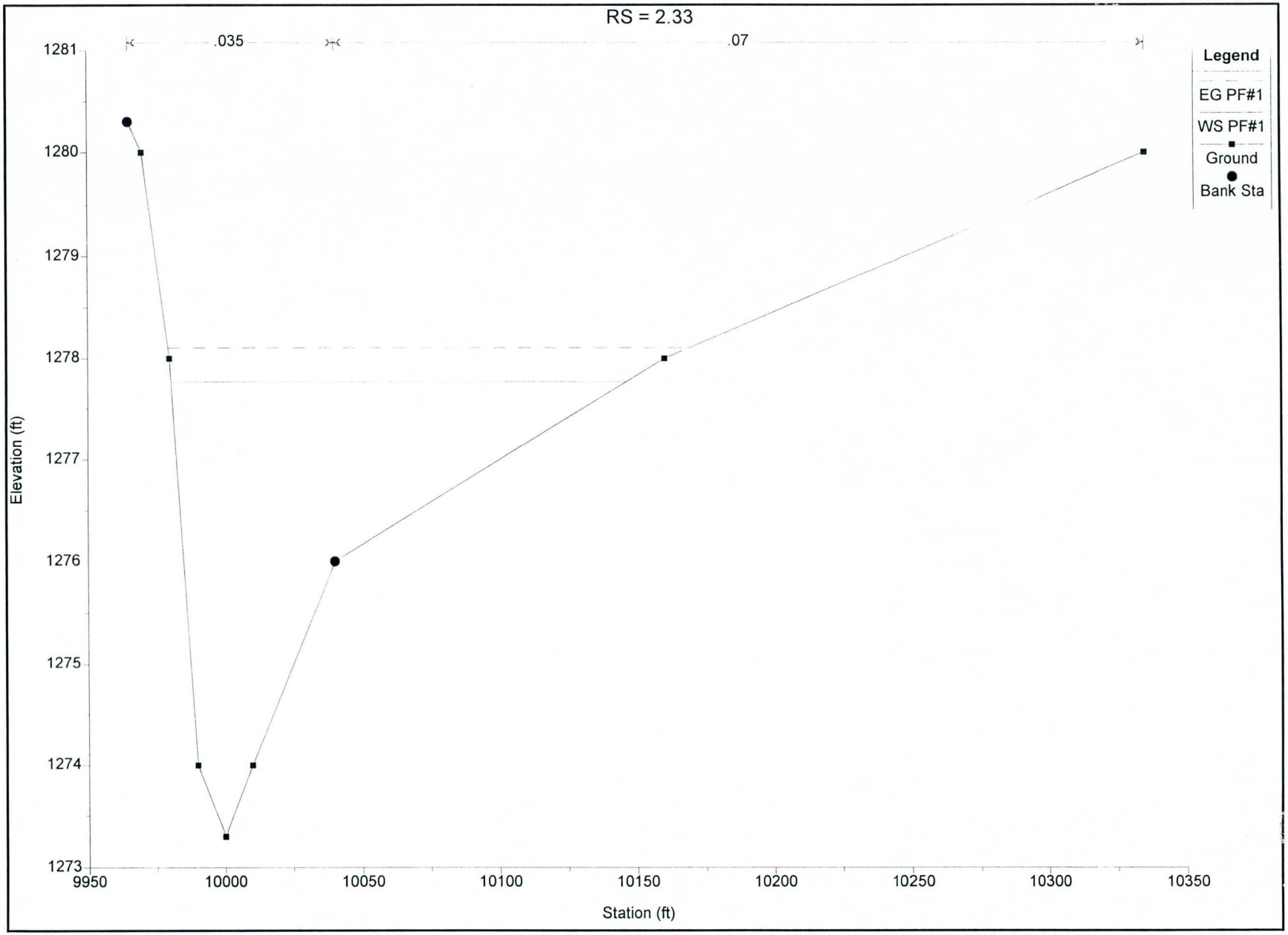
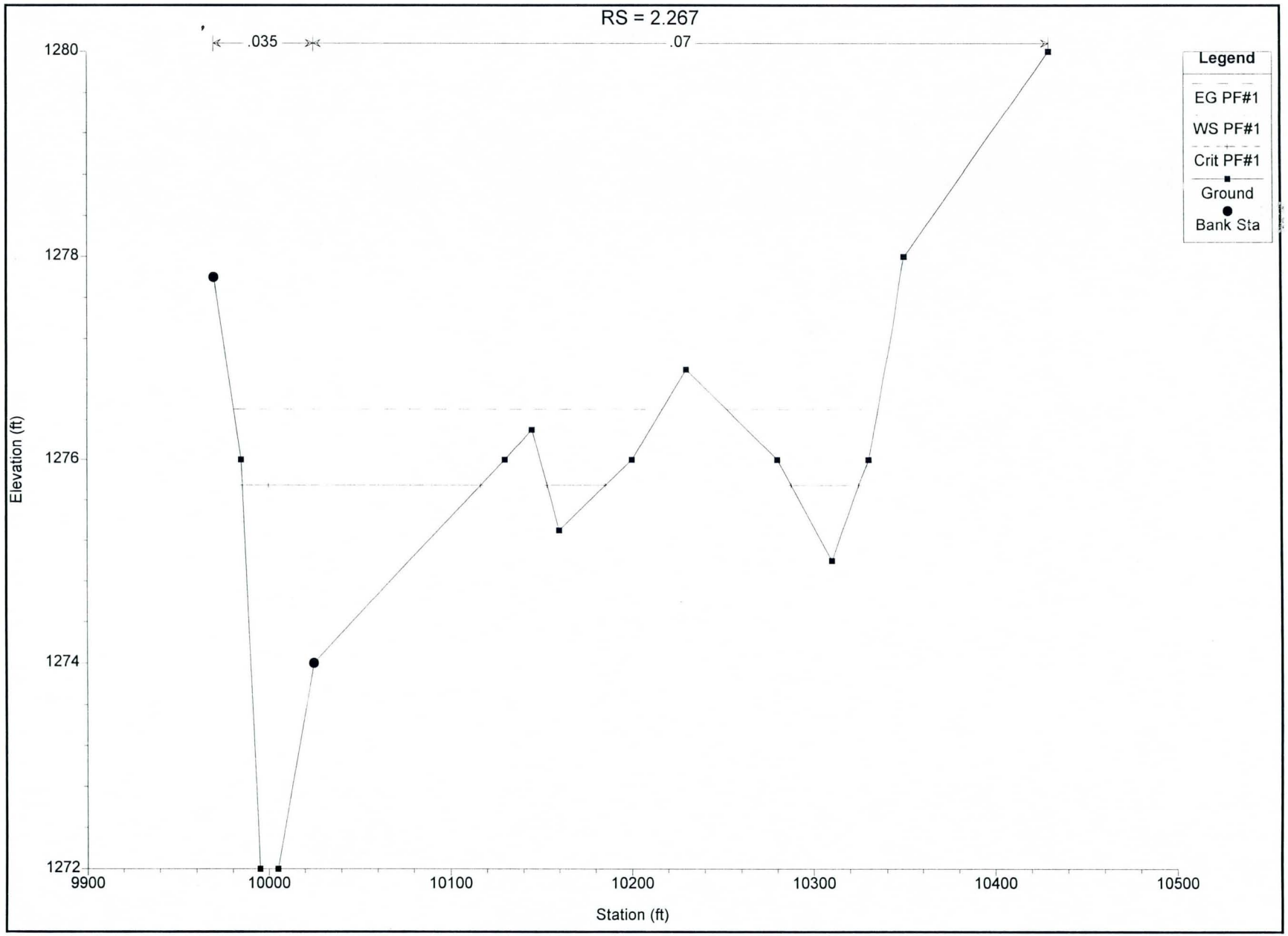
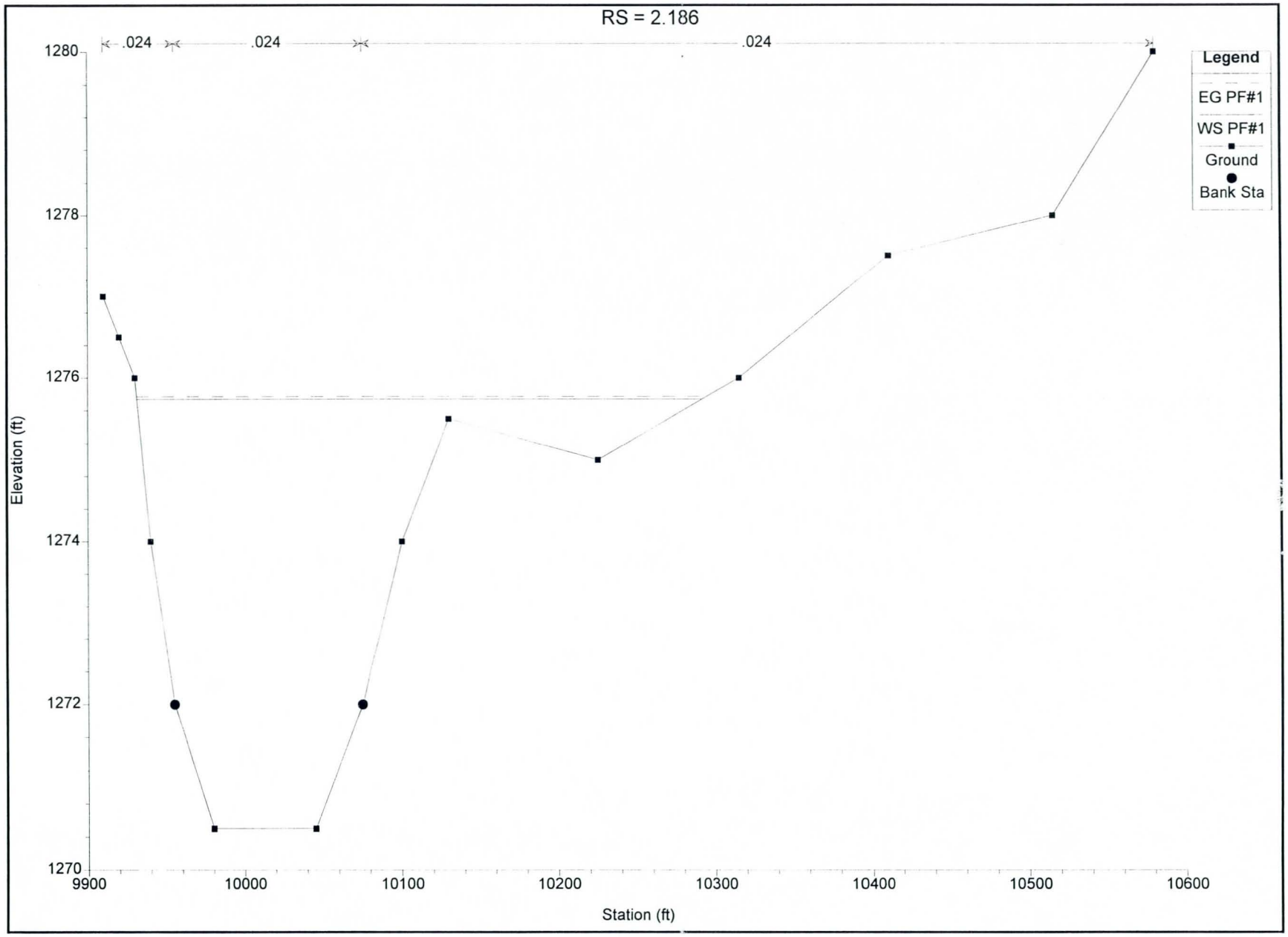
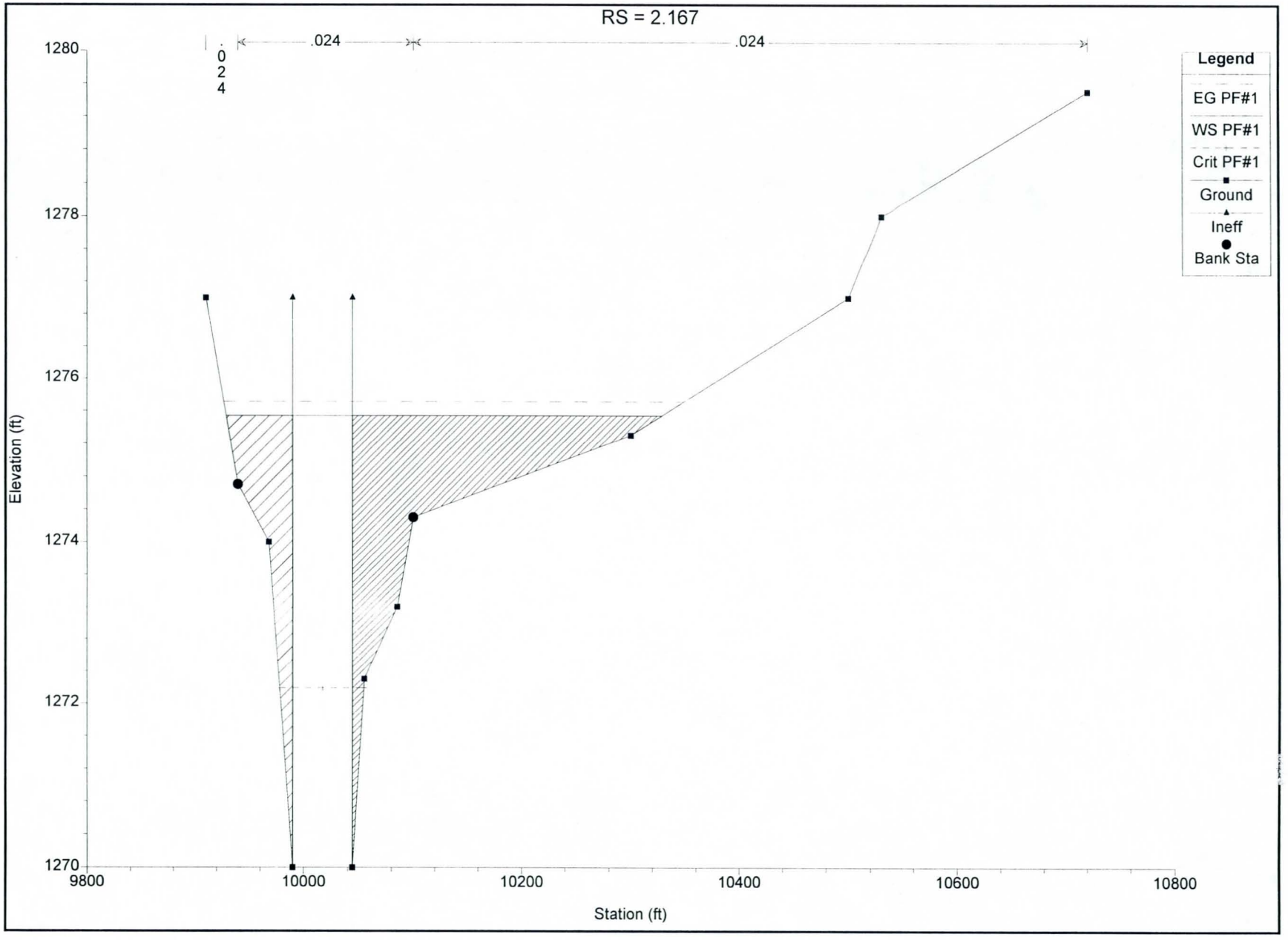
1281
1280
1279
9950
10000
10050
10100
10150
10200
10250
10300
Station (ft)

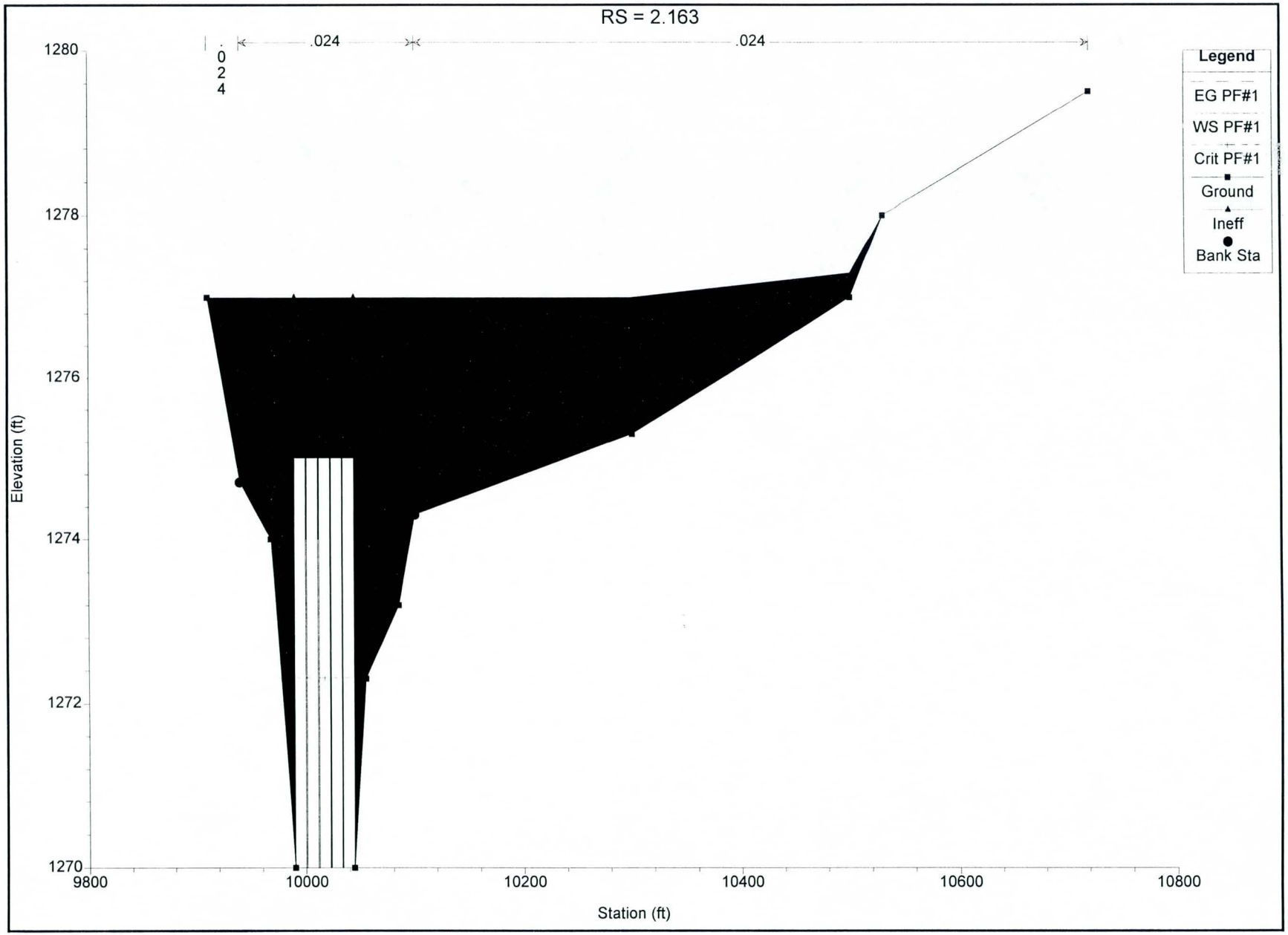

RS = 2.392
.035
.05
.035
.05
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1283
1282
1281
1280
1279
1278
1277
1276
1275
9950
10000
10050
10100
10150
10200
10250
10300
Station (ft)

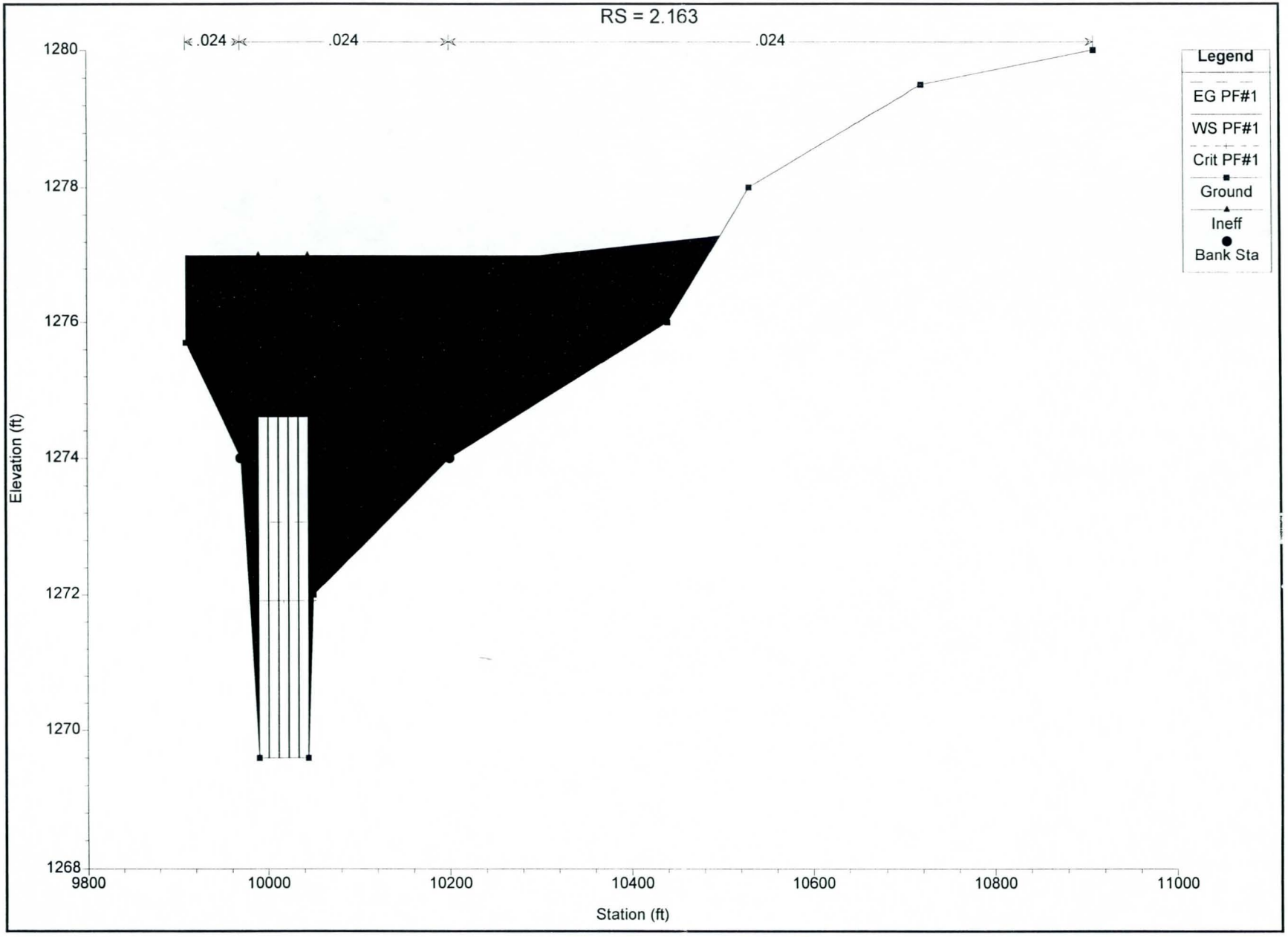

RS = 2.33
.035
.07
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1281
1280
1279
1278
1277
1276
1275
1274
1273
9950
10000
10050
10100
10150
10200
10250
10300
10350
Station (ft)

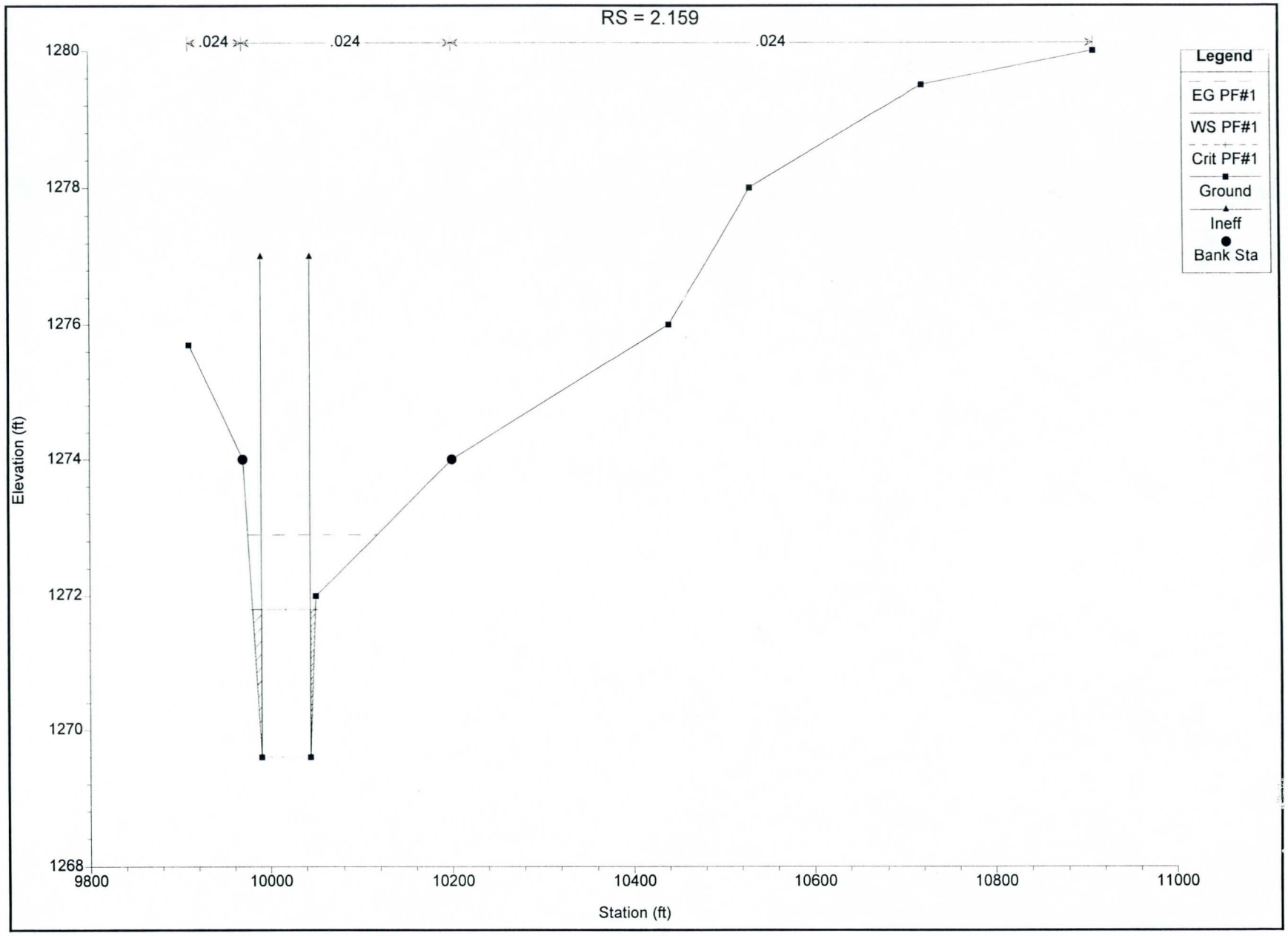

RS = 2.267
.035
.07
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1280
1278
1276
1274
1272
9900
10000
10100
10200
10300
10400
10500
Station (ft)

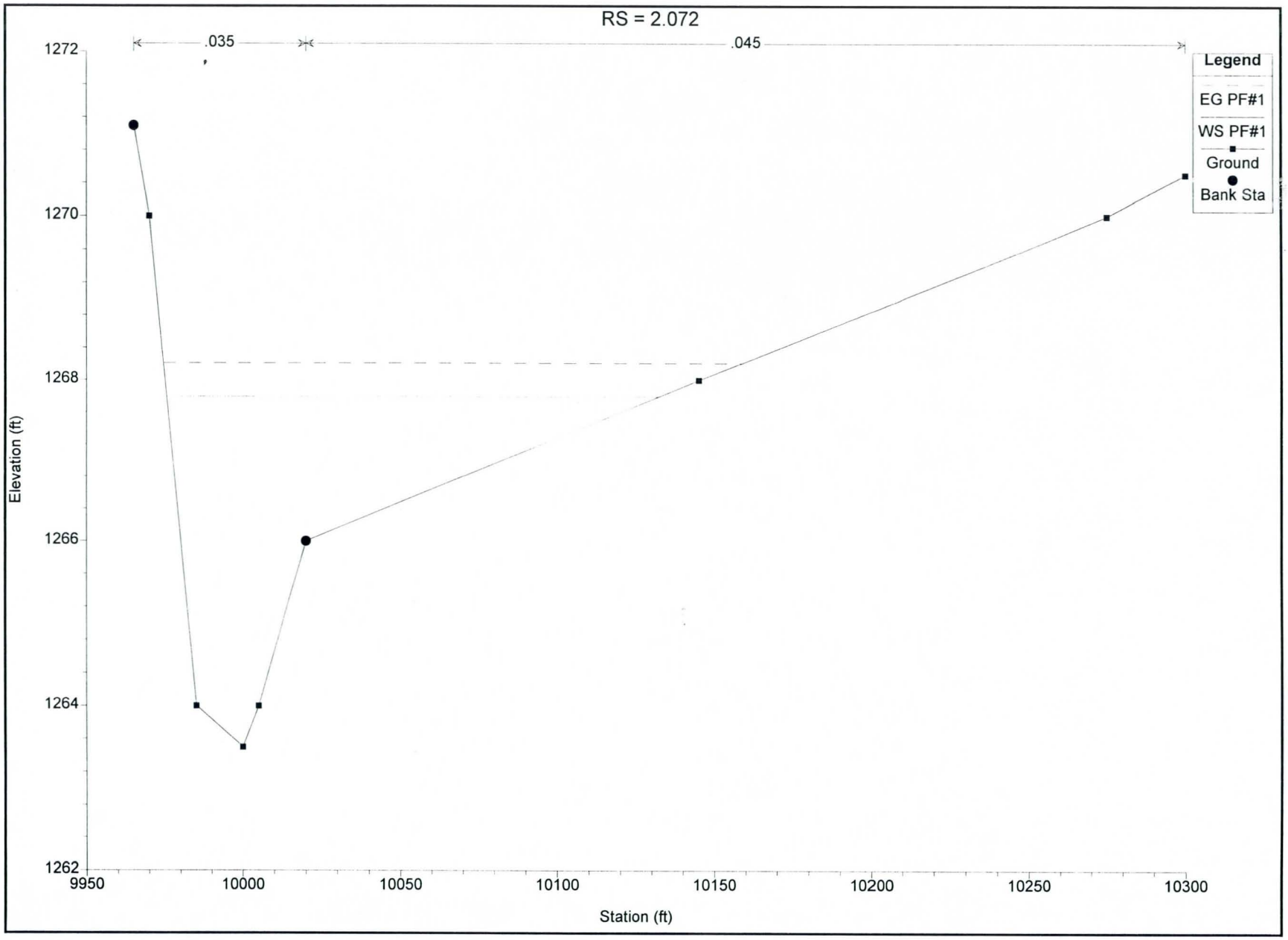

RS = 2.186
.024
.024
.024
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1280
1278
1276
1274
1272
1270
9900
10000
10100
10200
10300
10400
10500
10600
Station (ft)

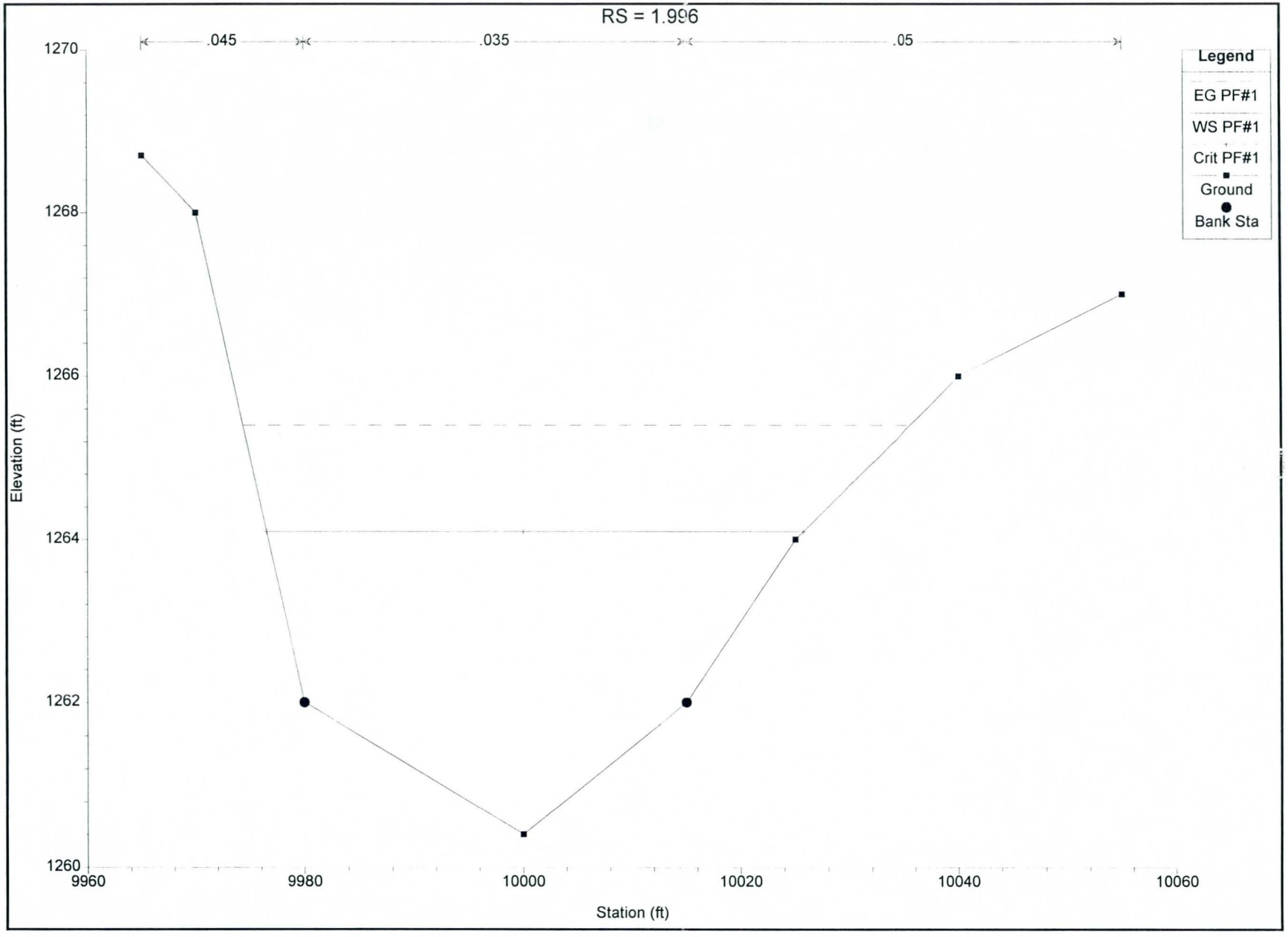

RS = 2.167
.024
.024
.024
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
1280
1278
1276
1274
1272
1270
9800
10000
10200
10400
10600
10800
Station (ft)

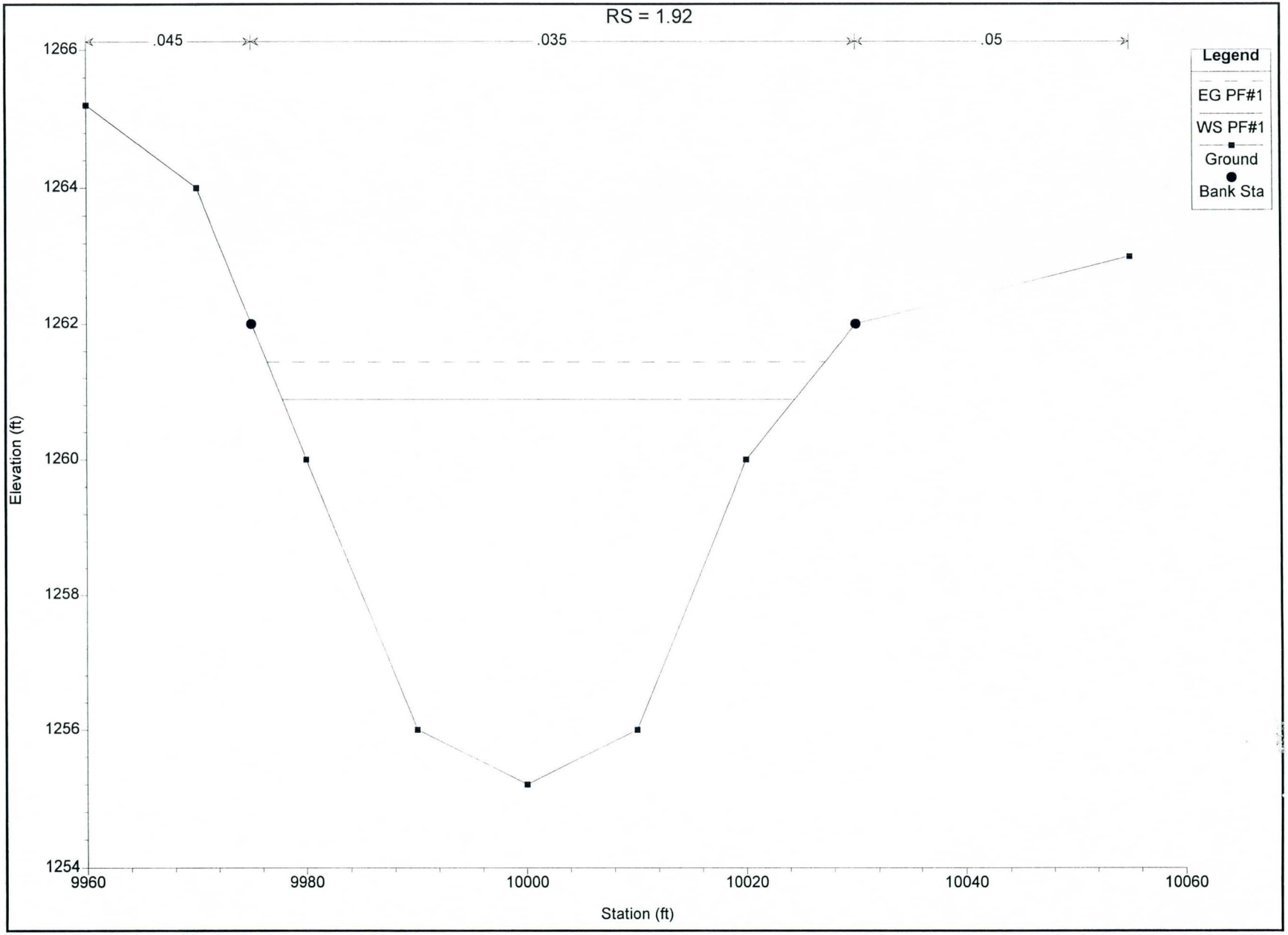

RS = 2.163
.024
.024
.024
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
1280
1278
1276
1274
1272
1270
9800
10000
10200
10400
10600
10800
Station (ft)

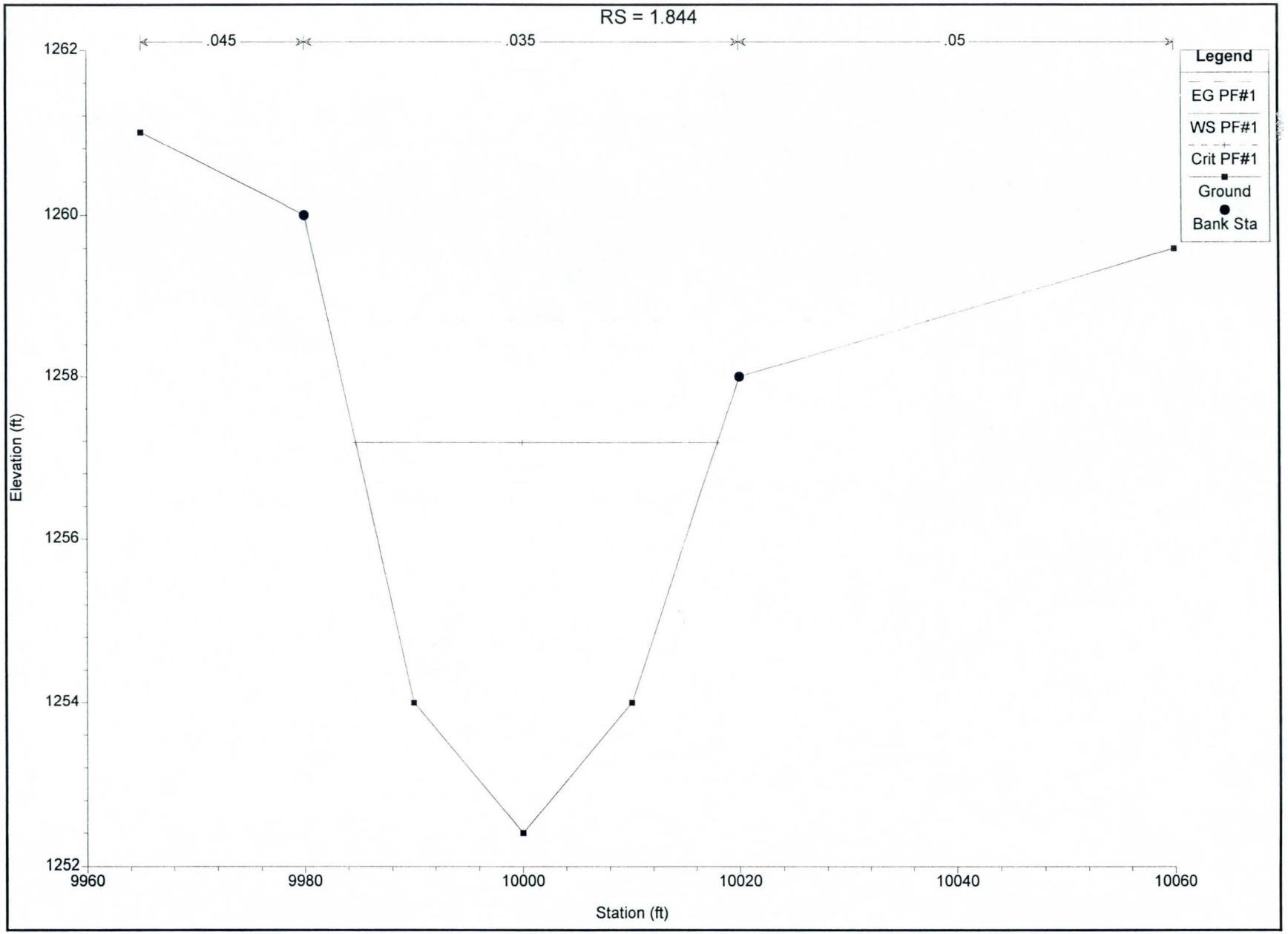

RS = 2.163
.024
.024
.024
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
1280
1278
1276
1274
1272
1270
1268
9800
10000
10200
10400
10600
10800
11000
Station (ft)

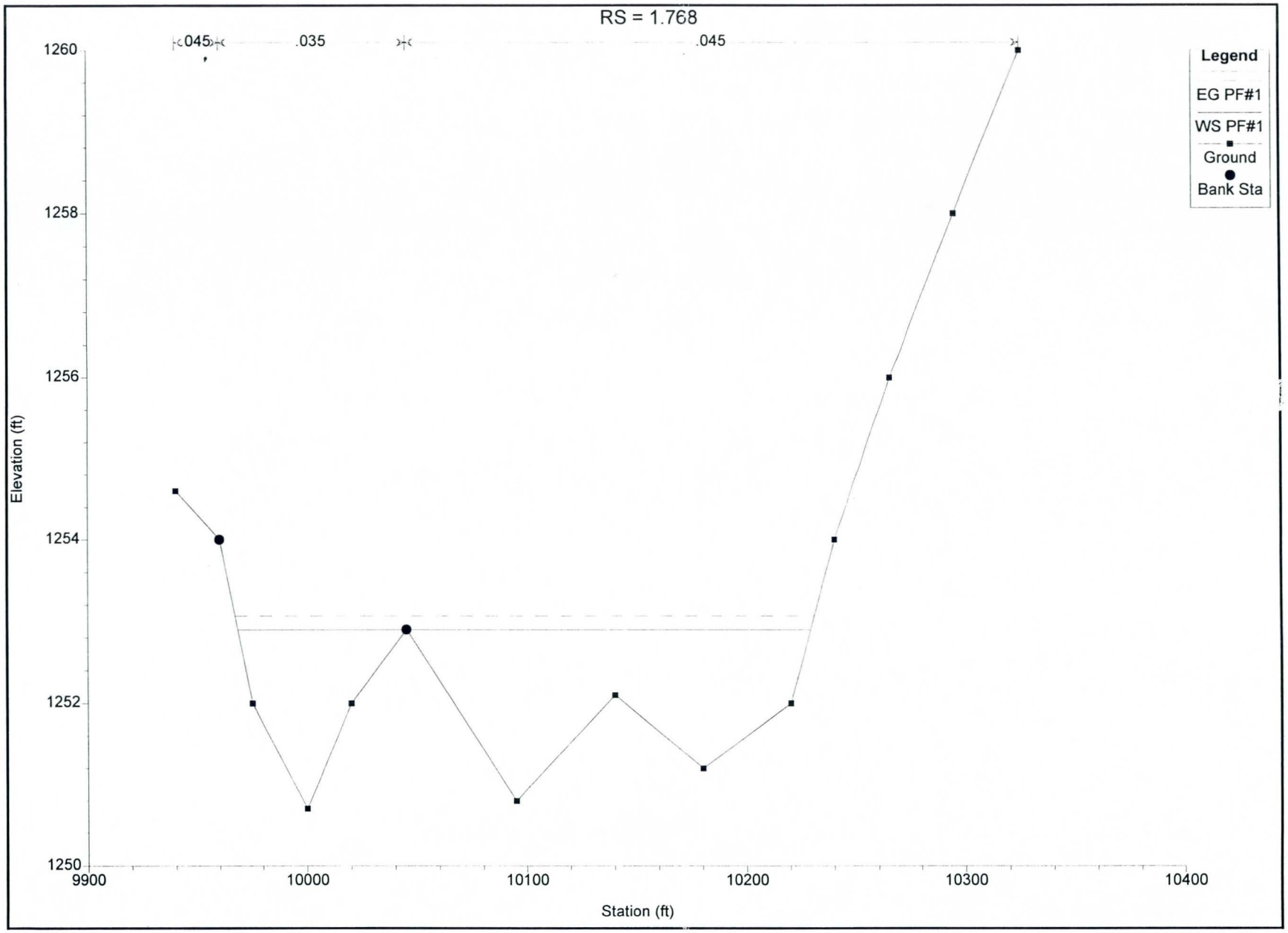

RS = 2.159
.024
.024
.024
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
1280
1278
1276
1274
1272
1270
1268
9800
10000
10200
10400
10600
10800
11000
Station (ft)

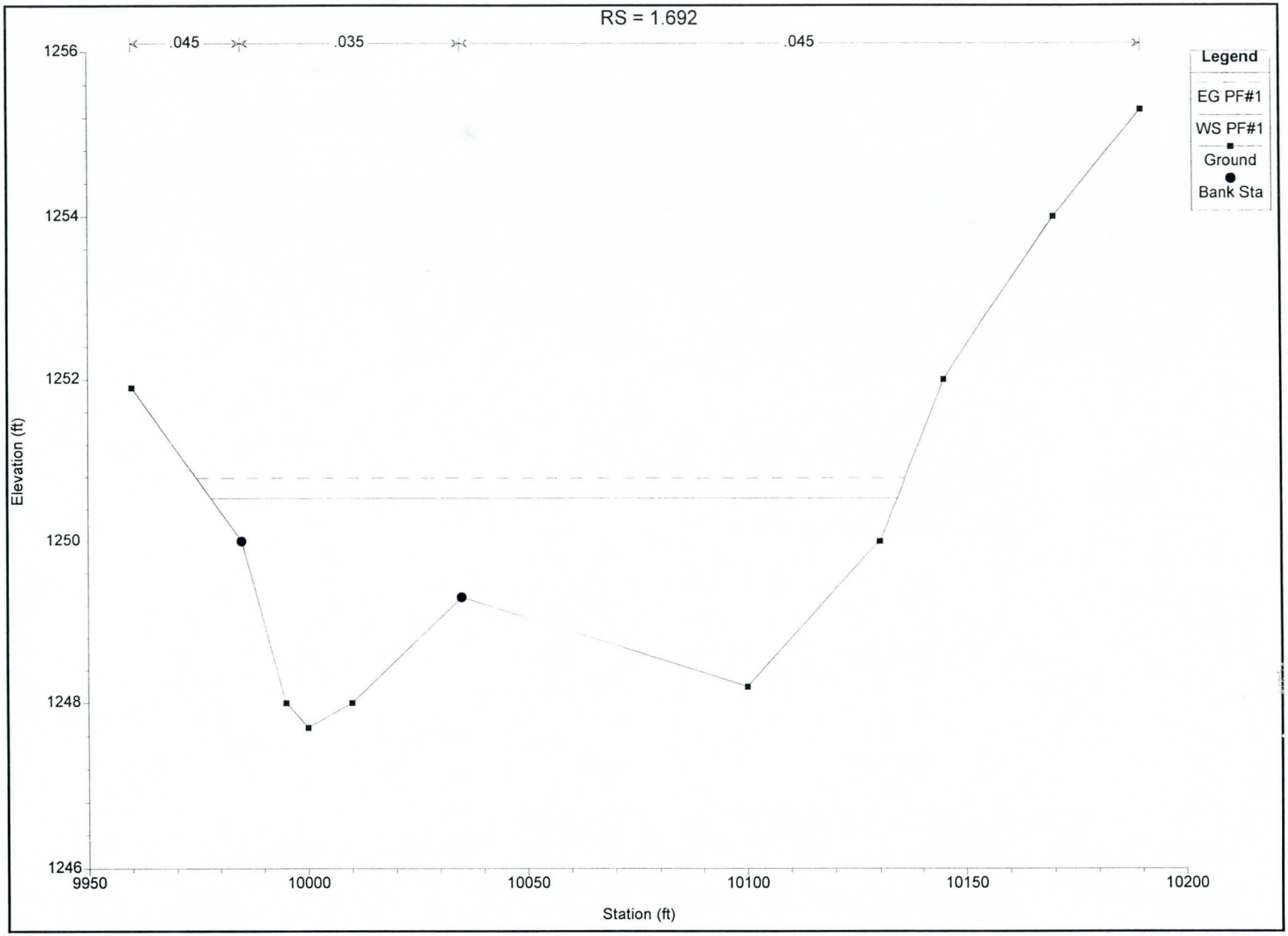

RS = 2.072
.035
.045
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1272
1270
1268
1266
1264
1262
9950
10000
10050
10100
10150
10200
10250
10300
Station (ft)

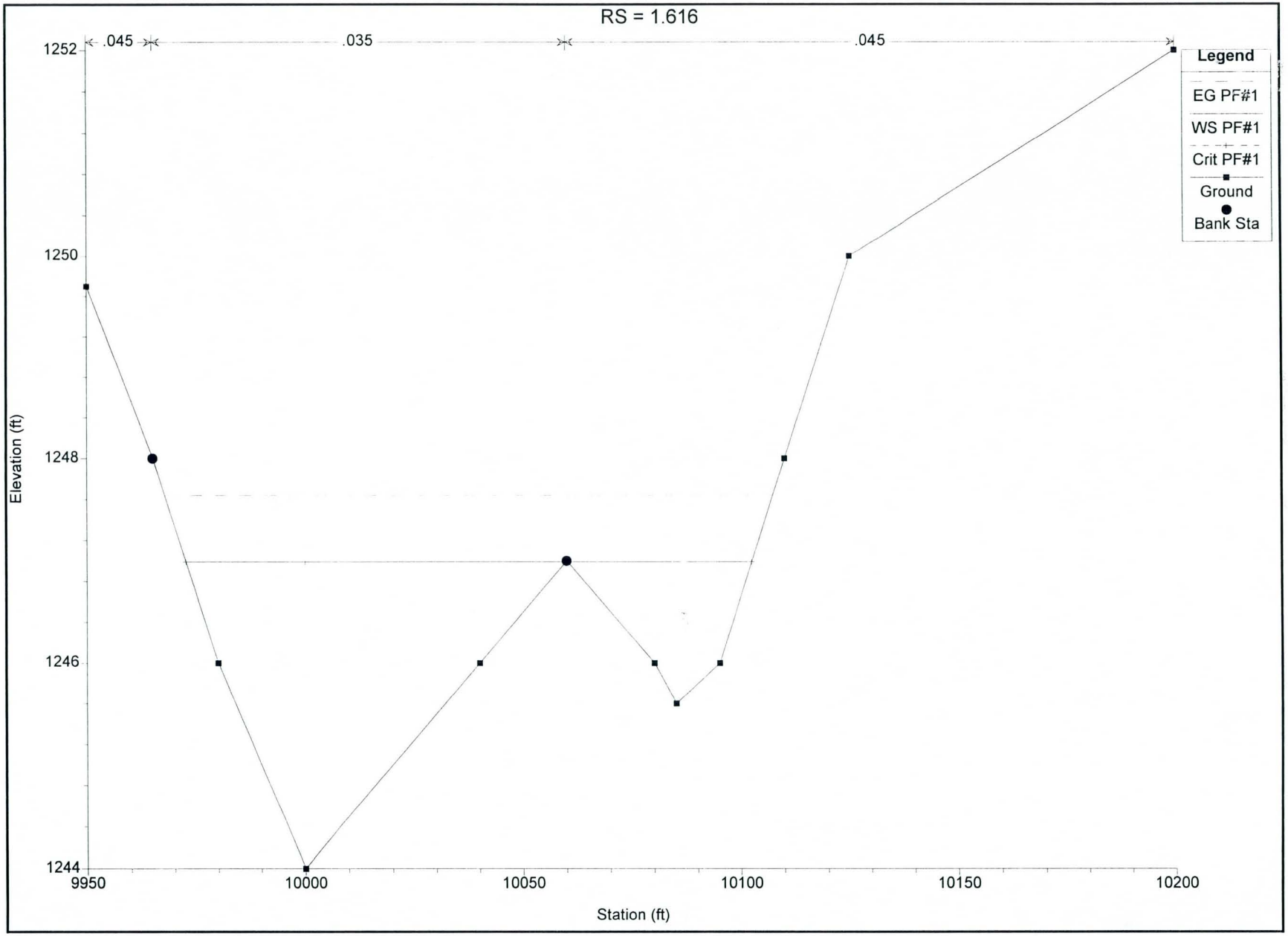

RS = 1.996
.045
.035
.05
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1270
1268
1266
1264
1262
1260
9960
9980
10000
10020
10040
10060
Station (ft)

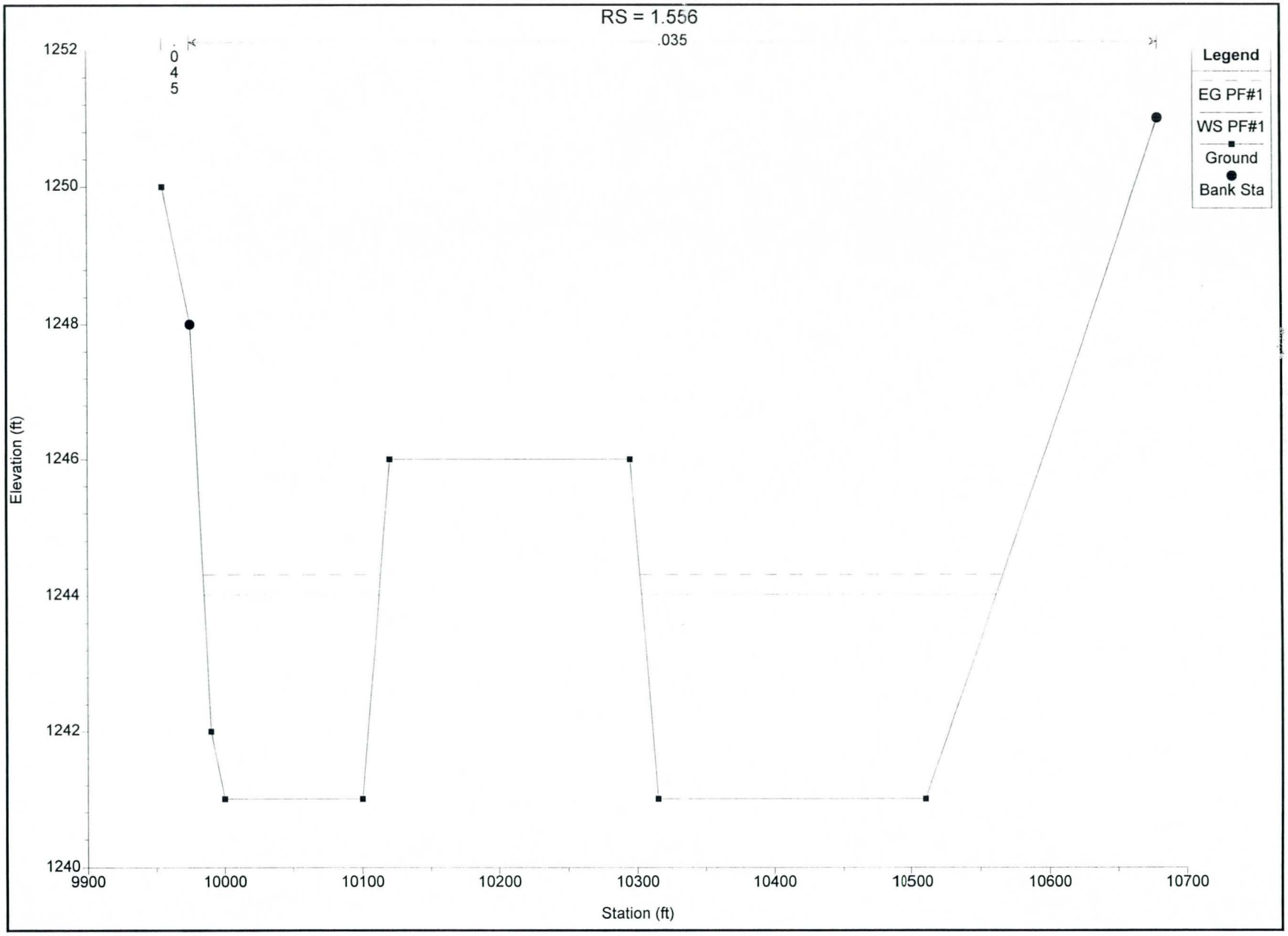

RS = 1.92
.045
.035
.05
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1266
1264
1262
1260
1258
1256
1254
9960
9980
10000
10020
10040
10060
Station (ft)

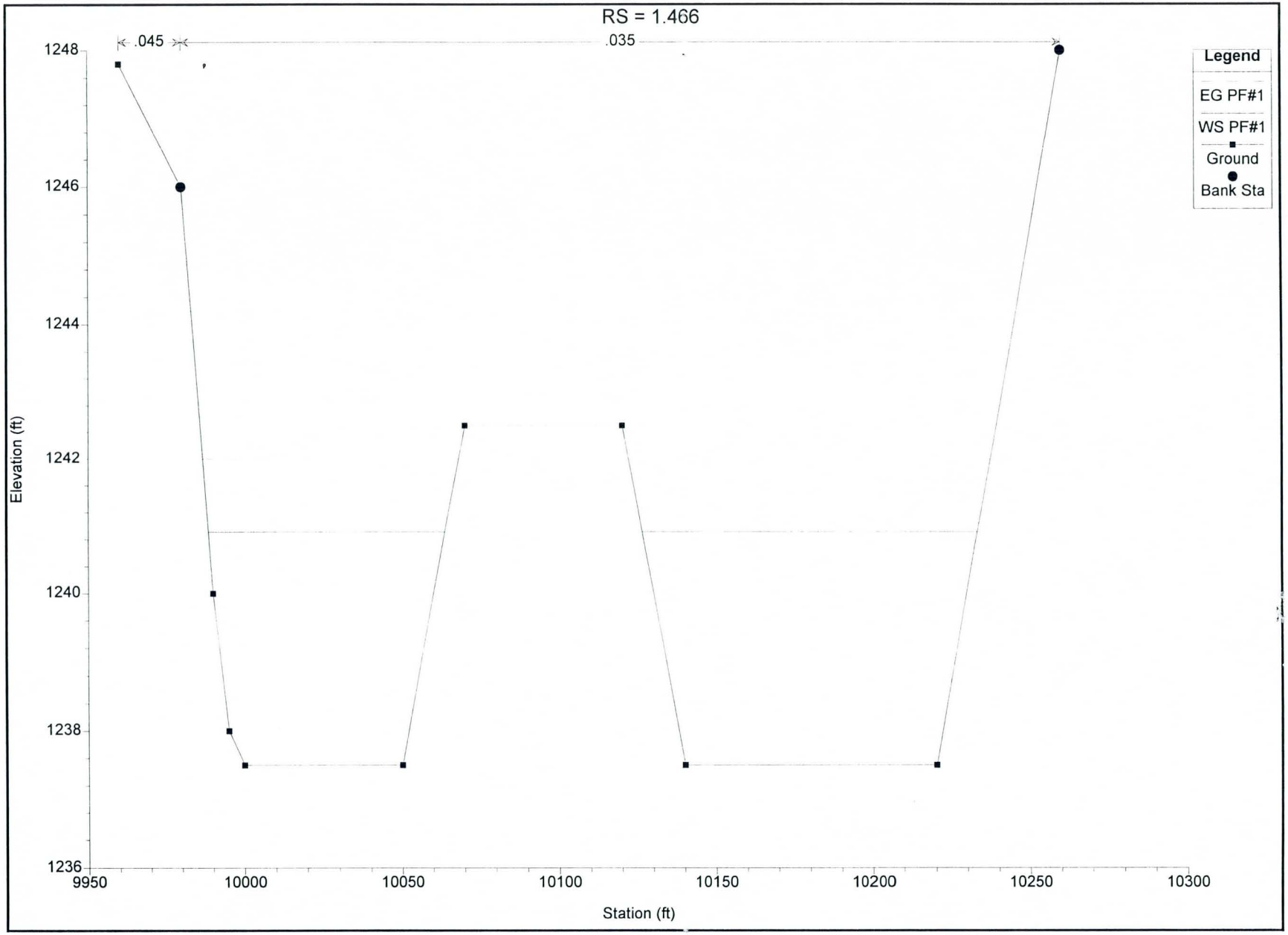

RS = 1.844
.045
.035
.05
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1262
1260
1258
1256
1254
1252
9960
9980
10000
10020
10040
10060
Station (ft)

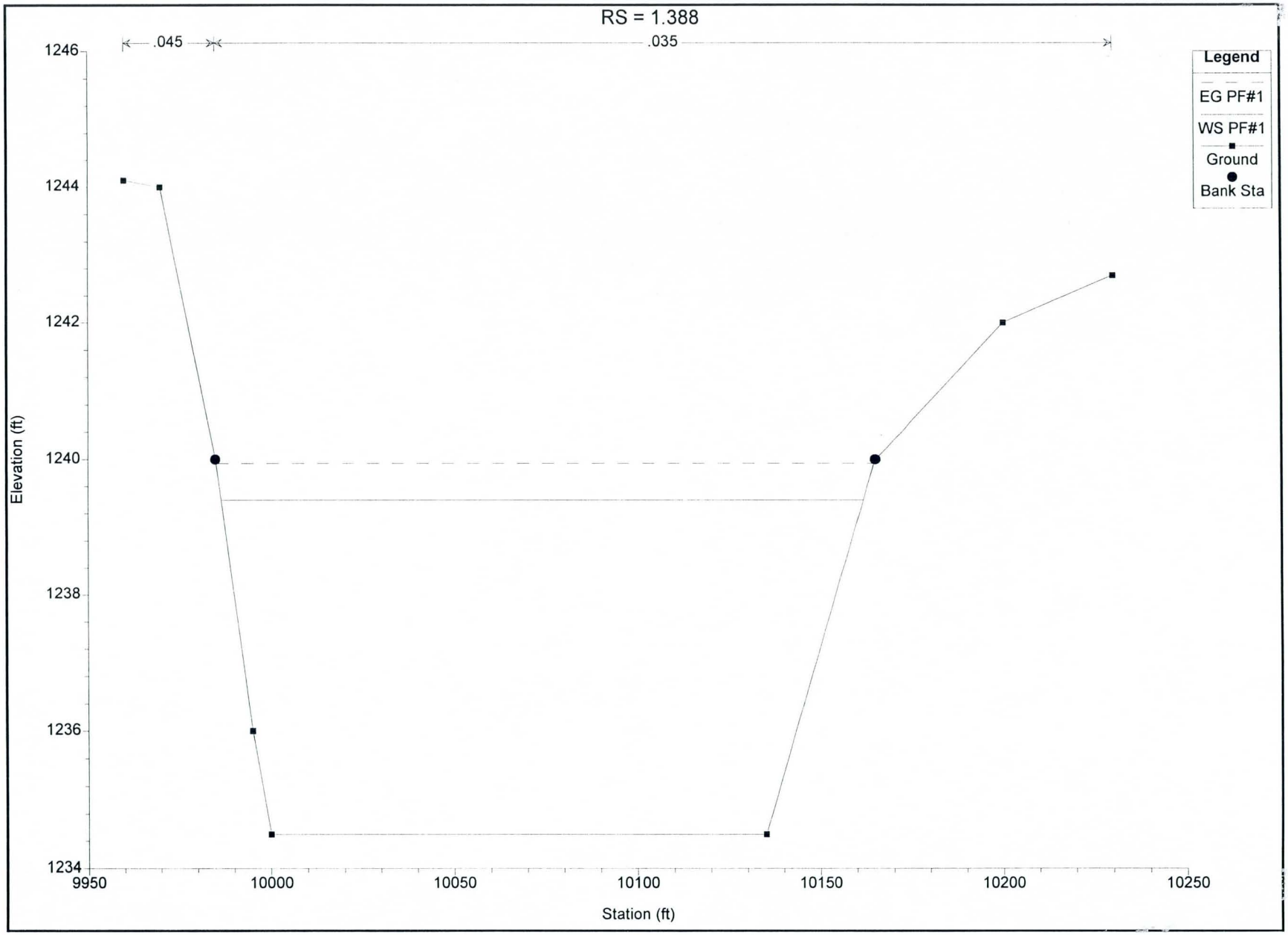

RS = 1.768
.045
.035
.045
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1260
1258
1256
1254
1252
1250
9900
10000
10100
10200
10300
10400
Station (ft)

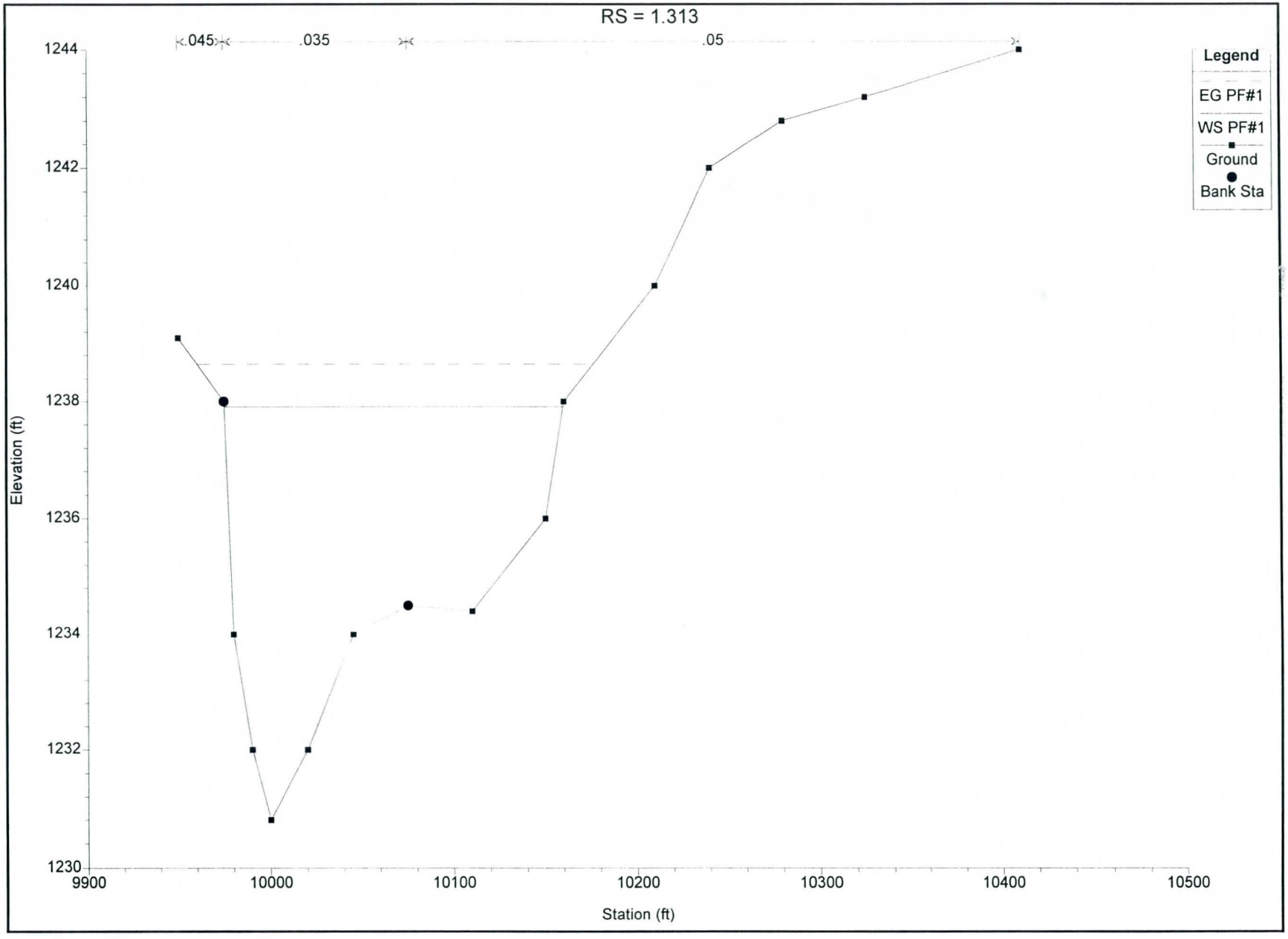

RS = 1.692
.045
.035
.045
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1256
1254
1252
1250
1248
1246
9950
10000
10050
10100
10150
10200
Station (ft)

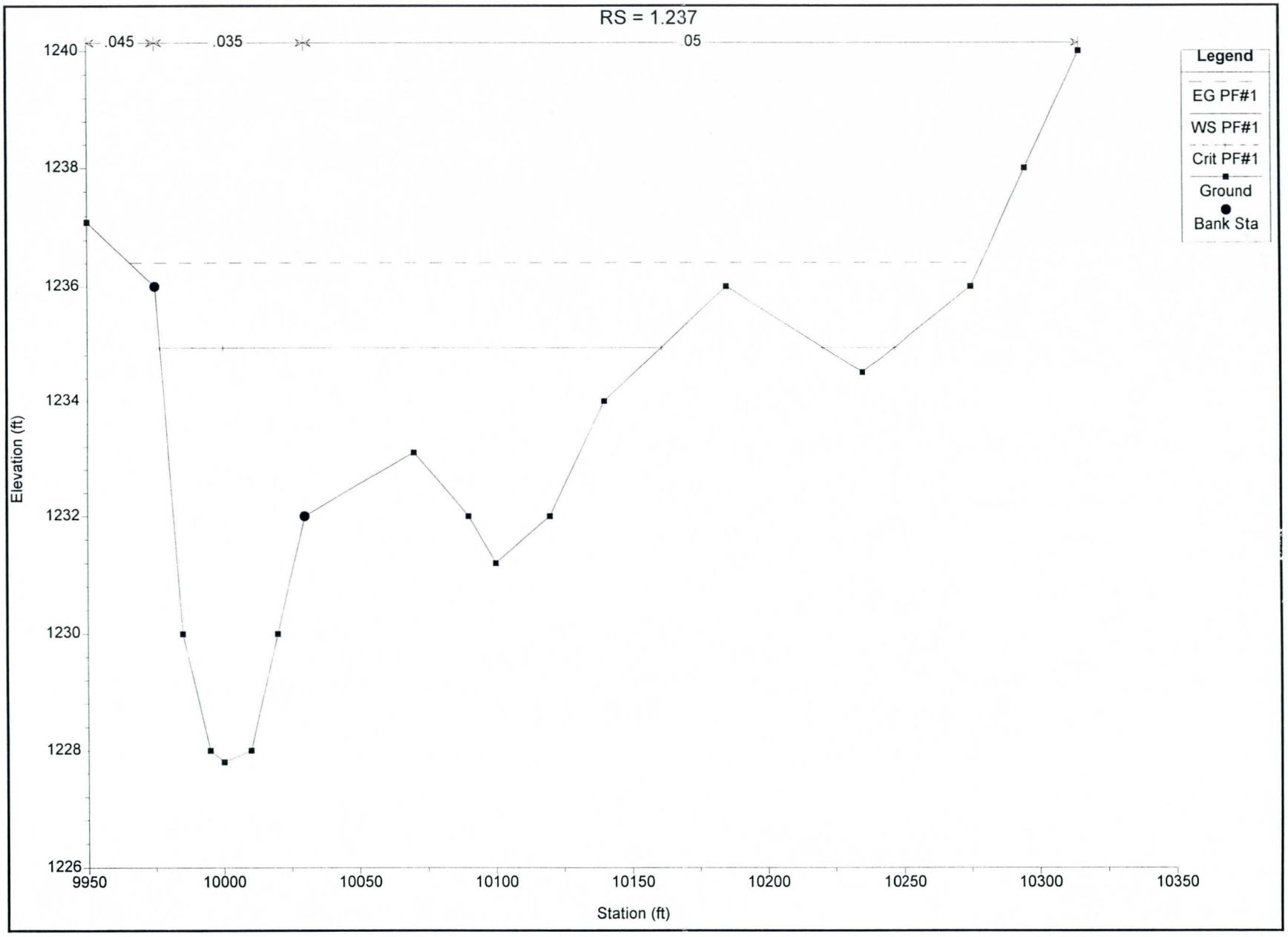

RS = 1.616
.045
.035
.045
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1252
1250
1248
1246
1244
9950
10000
10050
10100
10150
10200
Station (ft)

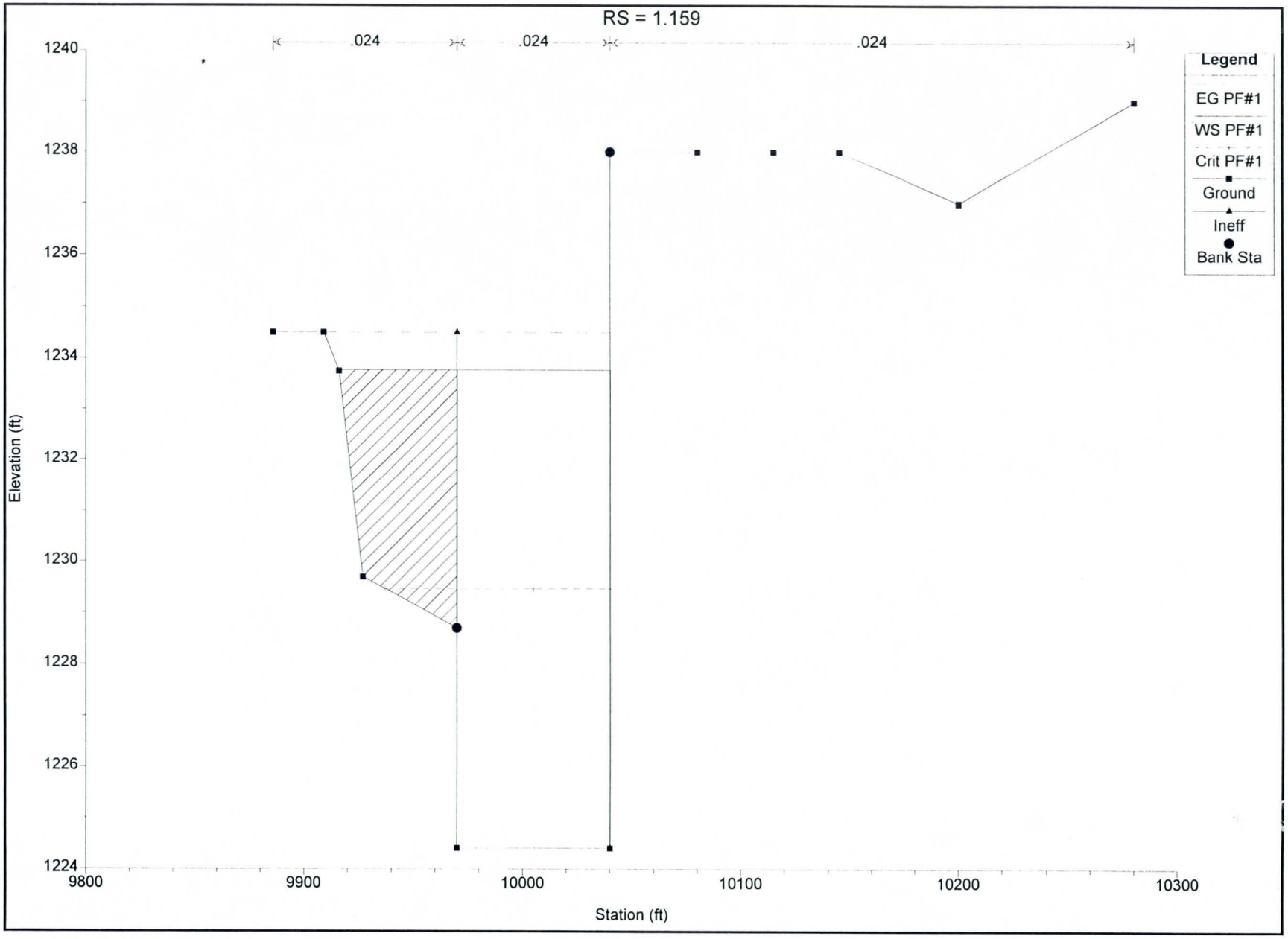

RS = 1.556
.035
.045
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1252
1250
1248
1246
1244
1242
1240
9900
10000
10100
10200
10300
10400
10500
10600
10700
Station (ft)

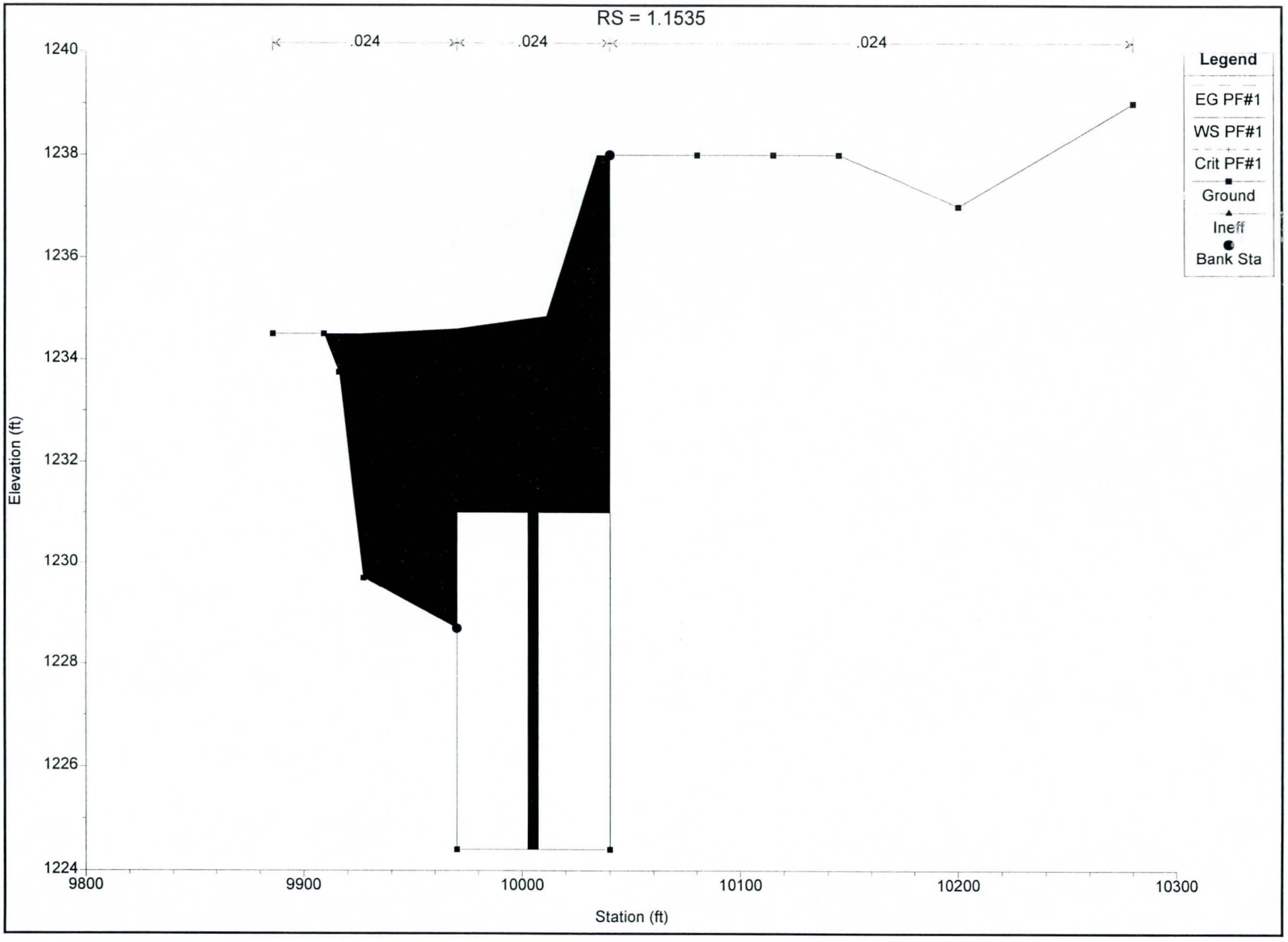

RS = 1.466
.045
.035
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1248
1246
1244
1242
1240
1238
1236
9950
10000
10050
10100
10150
10200
10250
10300
Station (ft)

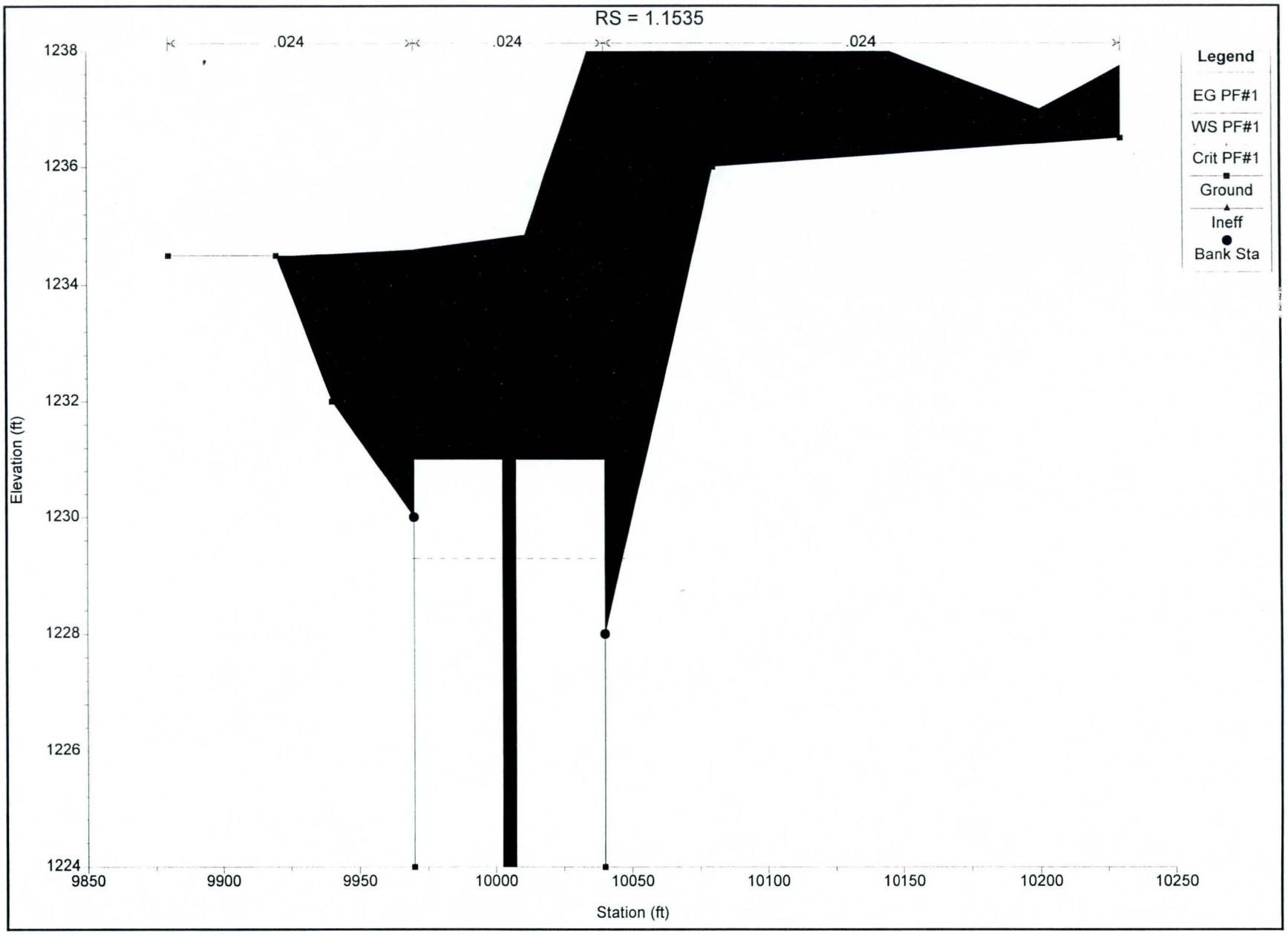

RS = 1.388
.045
.035
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1246
1244
1242
1240
1238
1236
1234
9950
10000
10050
10100
10150
10200
10250
Station (ft)

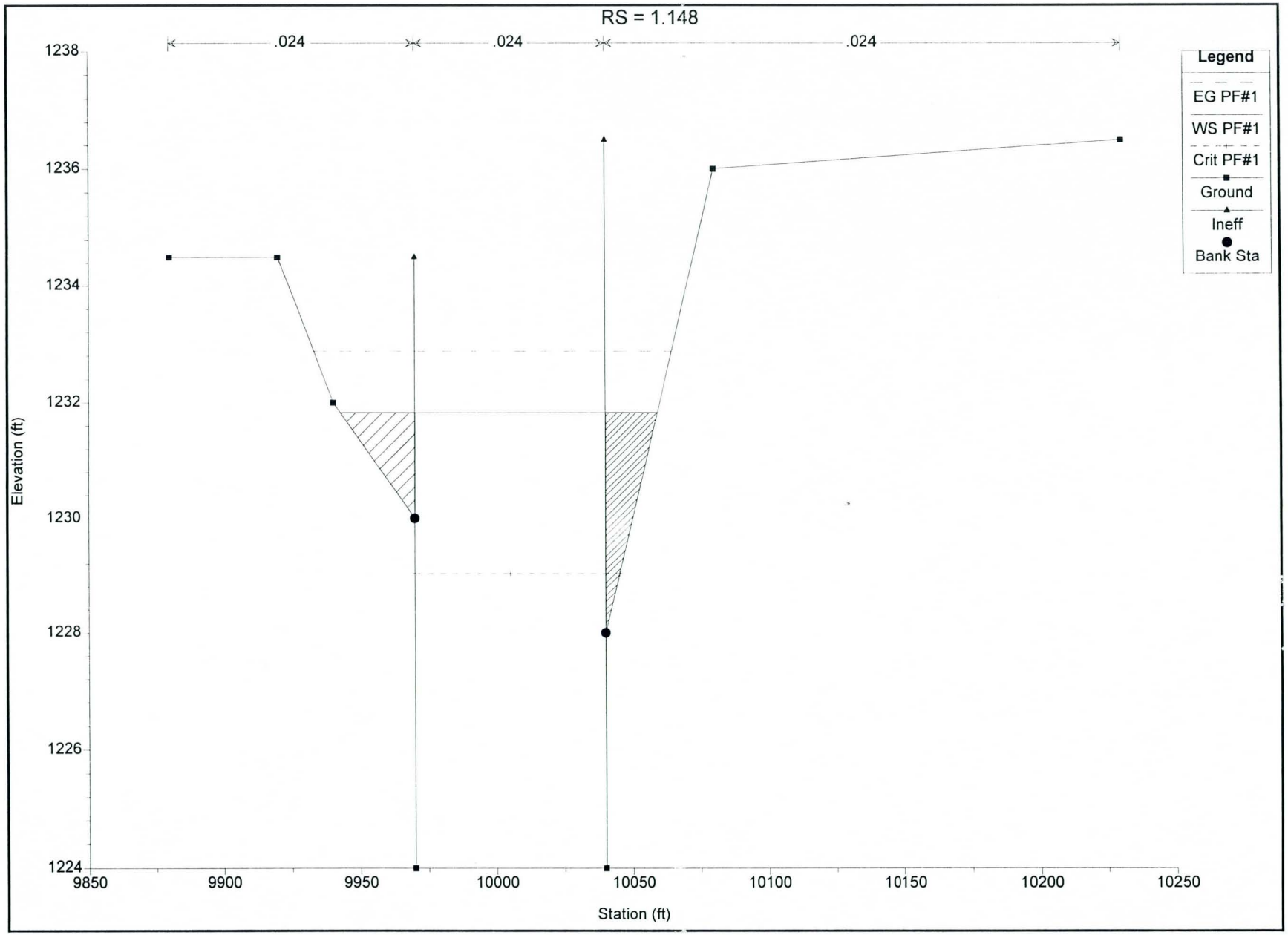

RS = 1.313
.045
.035
.05
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1244
1242
1240
1238
1236
1234
1232
1230
9900
10000
10100
10200
10300
10400
10500
Station (ft)

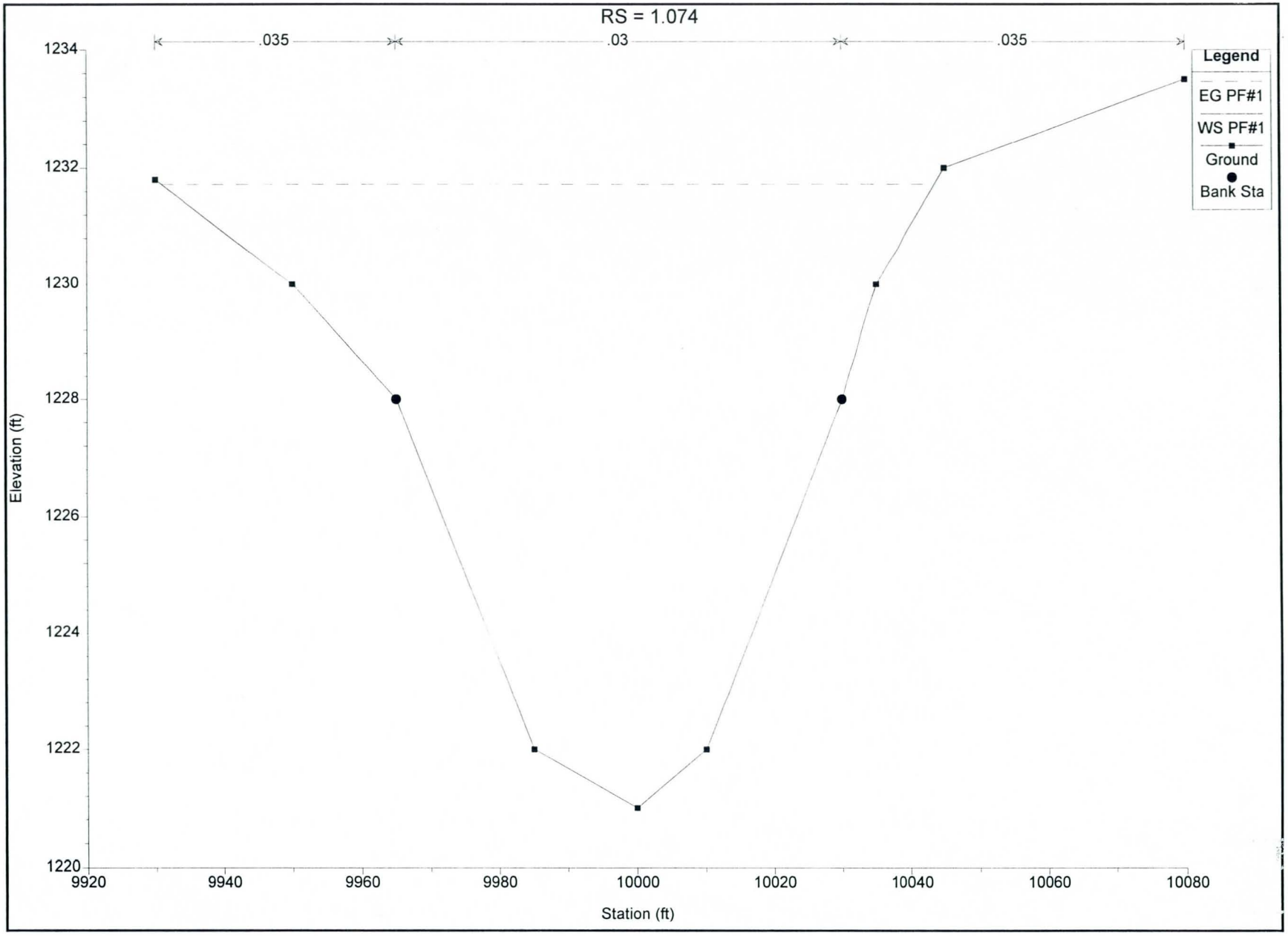

RS = 1.237
.045
.035
.05
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1240
1238
1236
1234
1232
1230
1228
1226
9950
10000
10050
10100
10150
10200
10250
10300
10350
Station (ft)

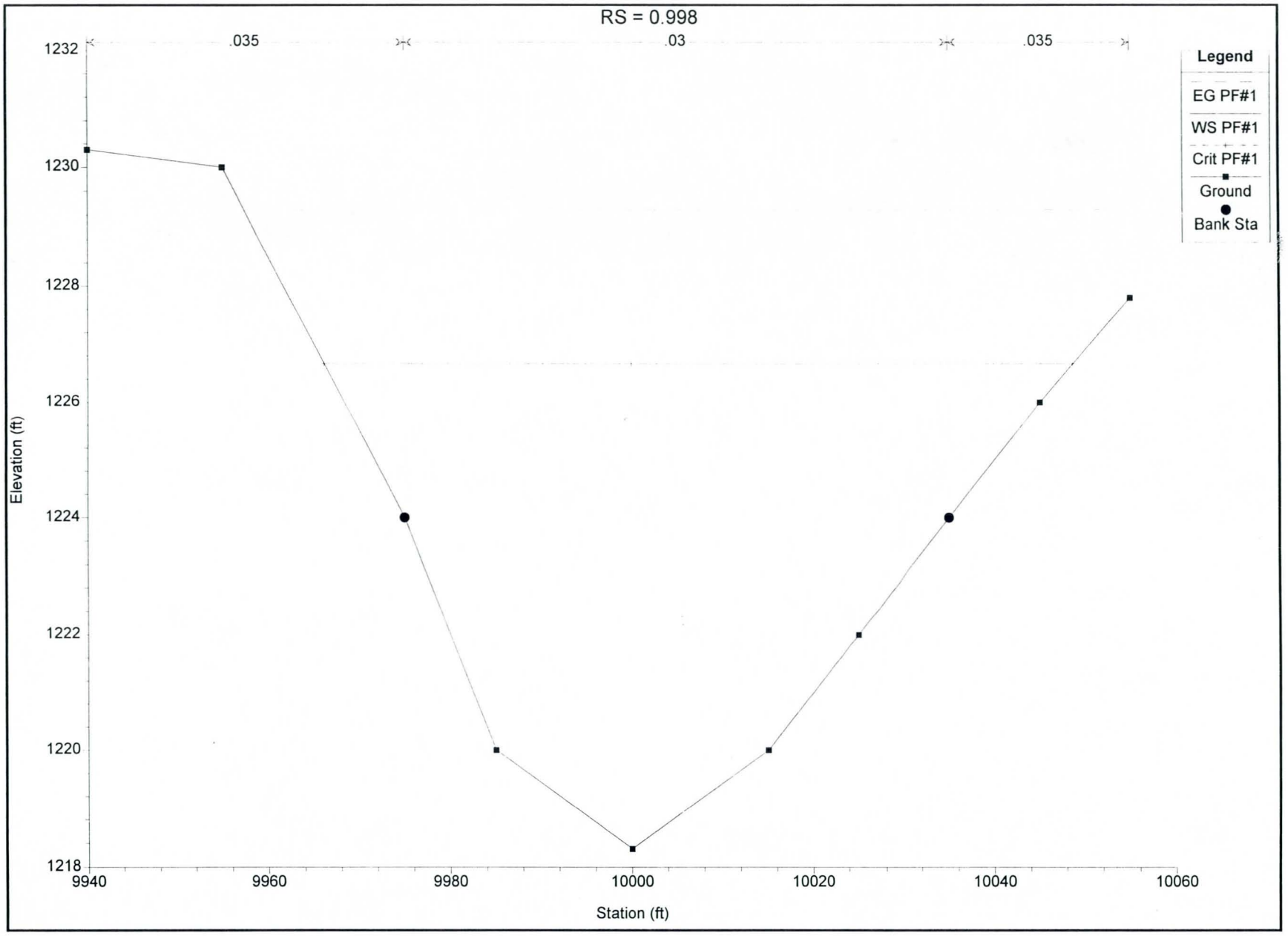

RS = 1.159
.024
.024
.024
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
1240
1238
1236
1234
1232
1230
1228
1226
1224
9800
9900
10000
10100
10200
10300
Station (ft)

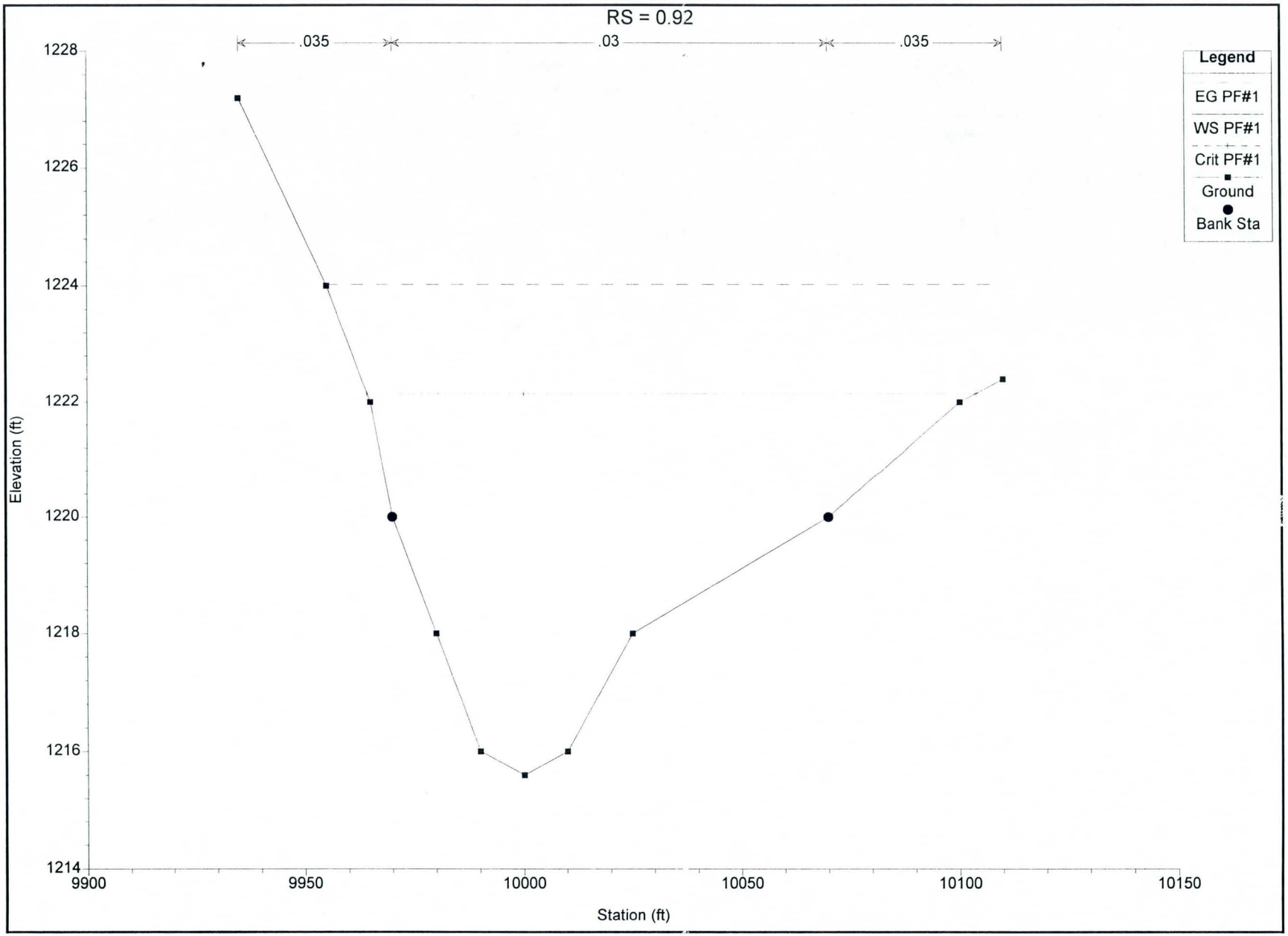

RS = 1.1535
.024
.024
.024
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
1240
1238
1236
1234
1232
1230
1228
1226
1224
9800
9900
10000
10100
10200
10300
Station (ft)

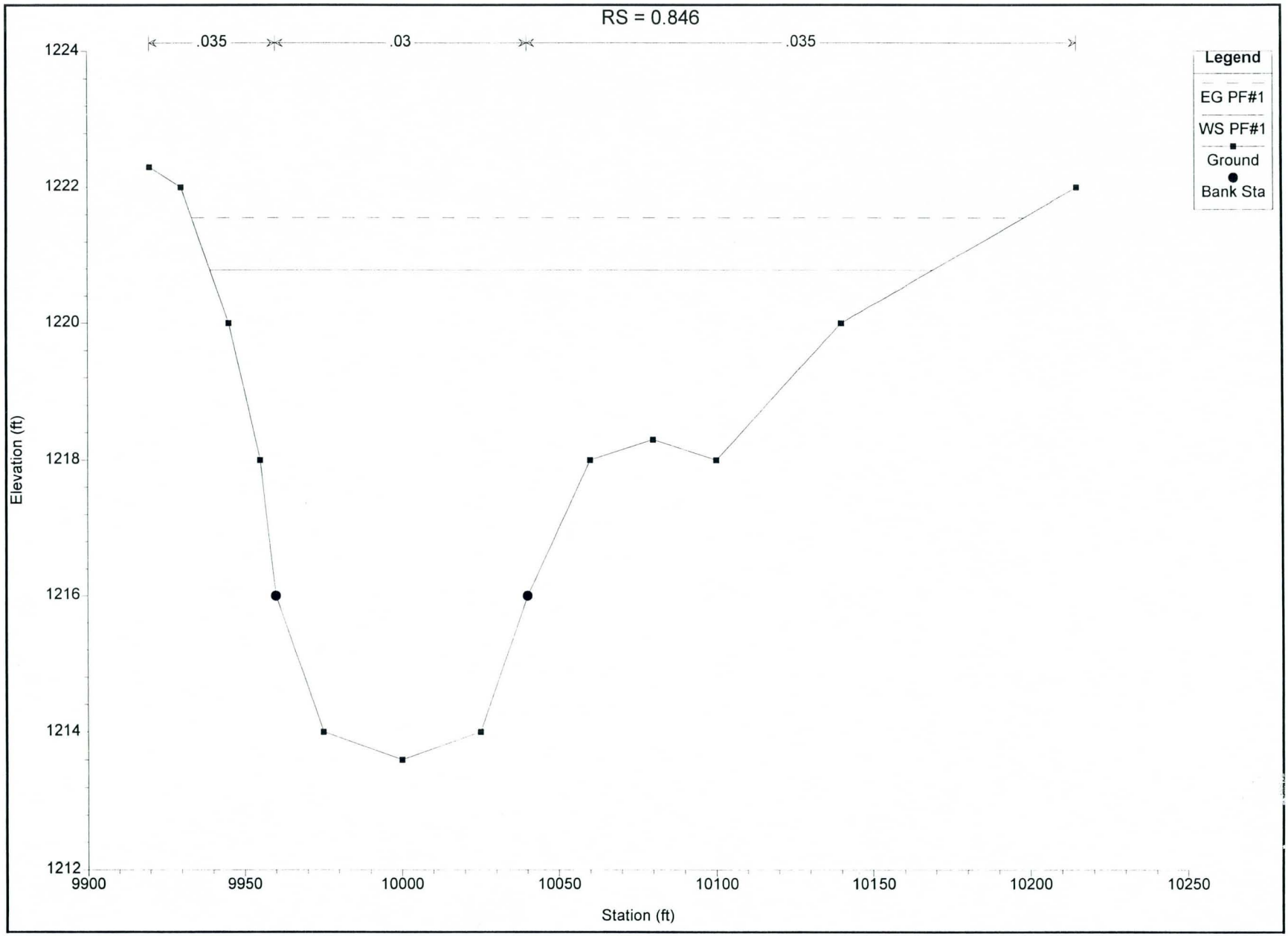

RS = 1.1535
.024
.024
.024
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
1238
1236
1234
1232
1230
1228
1226
1224
9850
9900
9950
10000
10050
10100
10150
10200
10250
Station (ft)

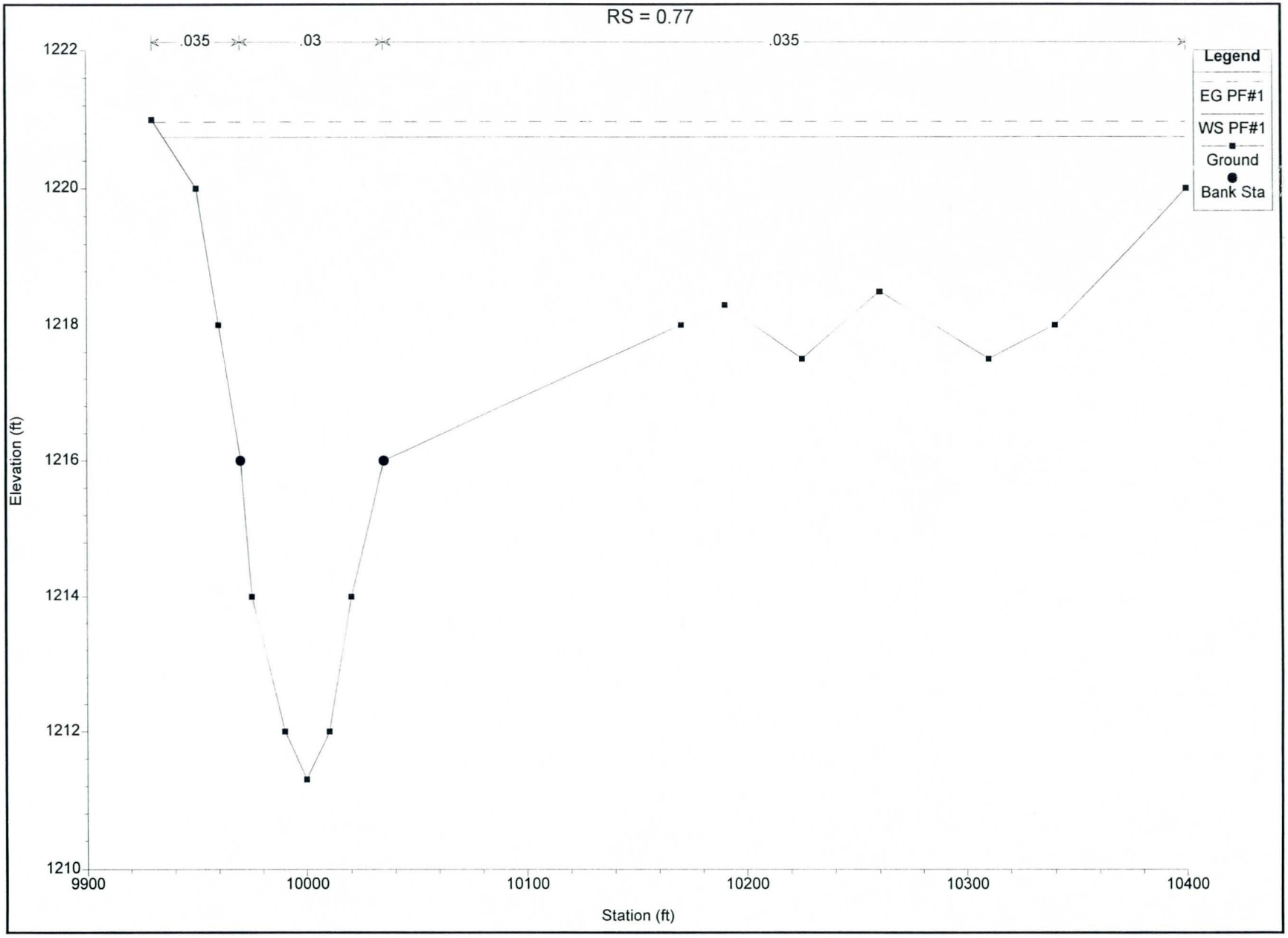

RS = 1.148
.024
.024
.024
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
1238
1236
1234
1232
1230
1228
1226
1224
9850
9900
9950
10000
10050
10100
10150
10200
10250
Station (ft)

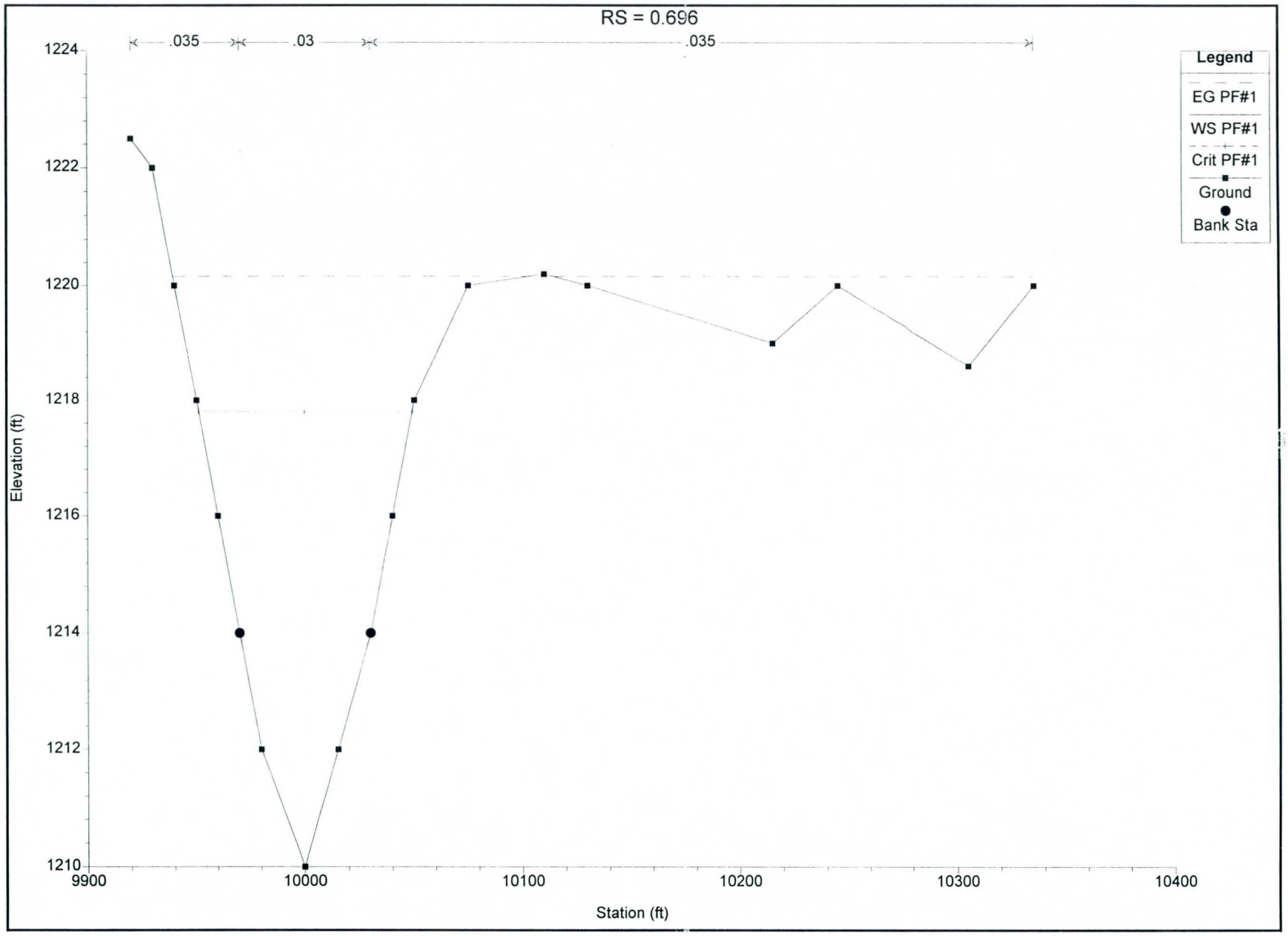

RS = 1.074
.035
.03
.035
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1234
1232
1230
1228
1226
1224
1222
1220
9920
9940
9960
9980
10000
10020
10040
10060
10080
Station (ft)

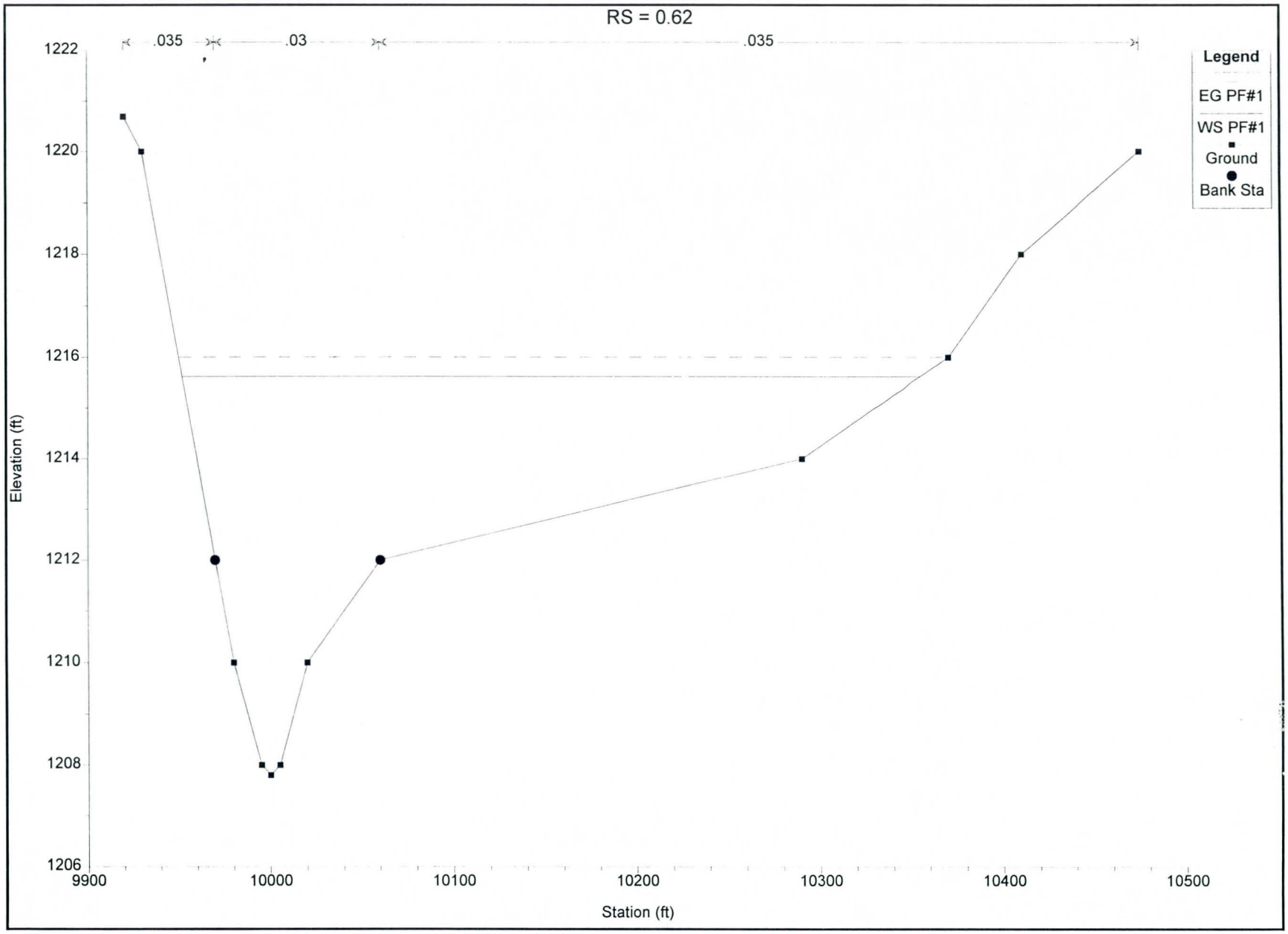

RS = 0.998
.035
.03
.035
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1232
1230
1228
1226
1224
1222
1220
1218
9940
9960
9980
10000
10020
10040
10060
Station (ft)

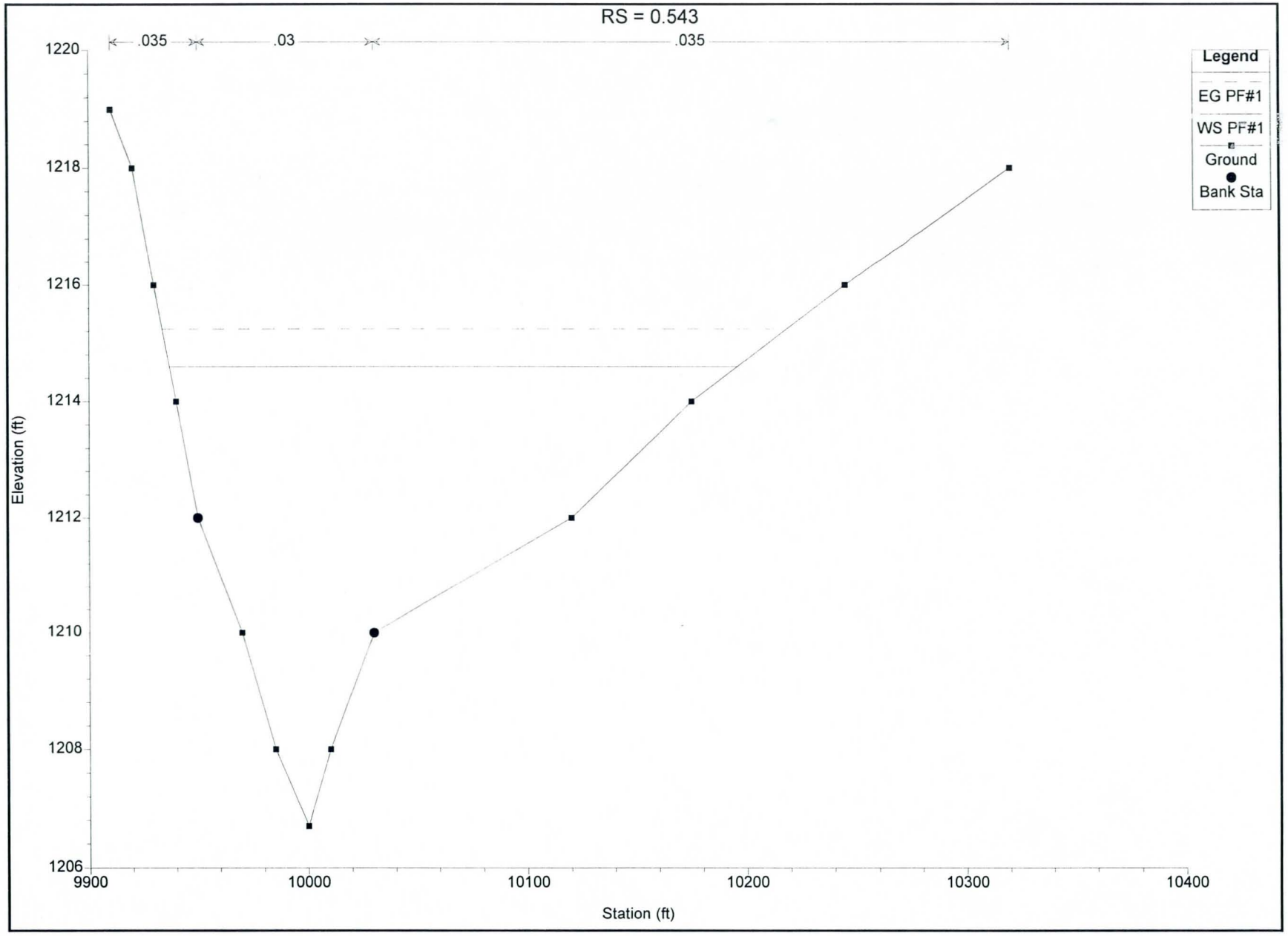

RS = 0.92
.035
.03
.035
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1228
1226
1224
1222
1220
1218
1216
1214
9900
9950
10000
10050
10100
10150
Station (ft)

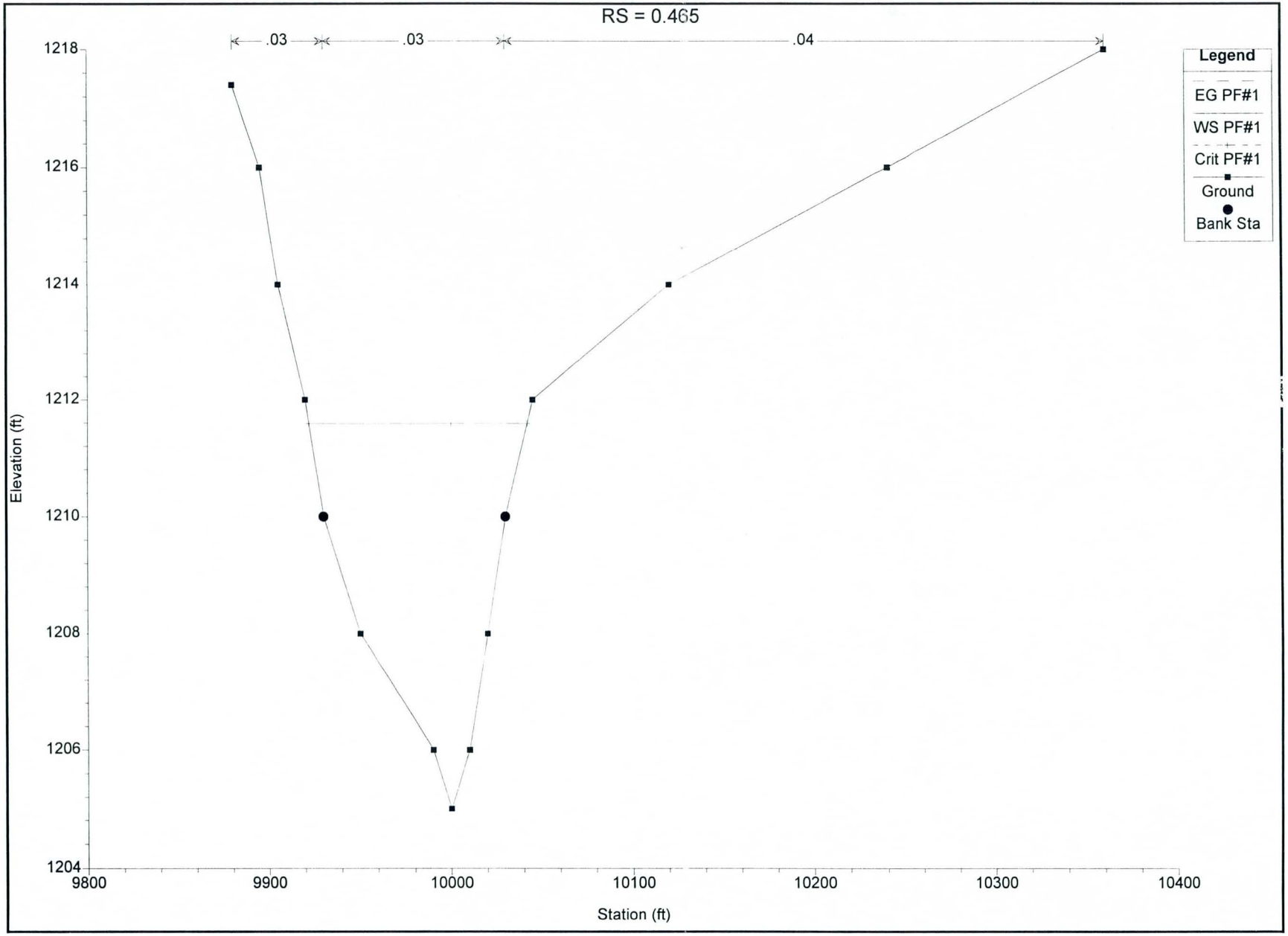

RS = 0.846
.035
.03
.035
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1224
1222
1220
1218
1216
1214
1212
9900
9950
10000
10050
10100
10150
10200
10250
Station (ft)

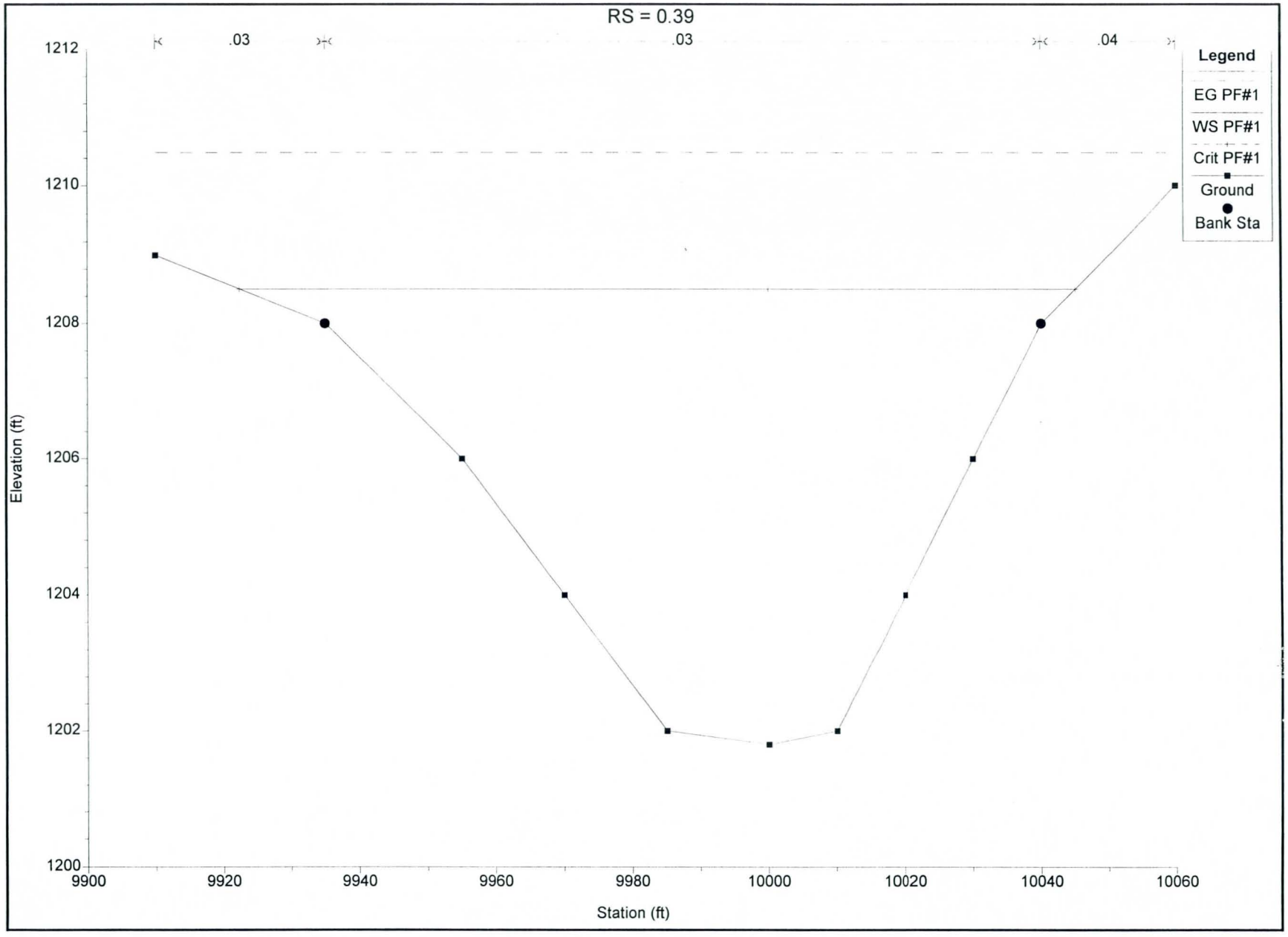

RS = 0.77
.035
.03
.035
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1222
1220
1218
1216
1214
1212
1210
9900
10000
10100
10200
10300
10400
Station (ft)

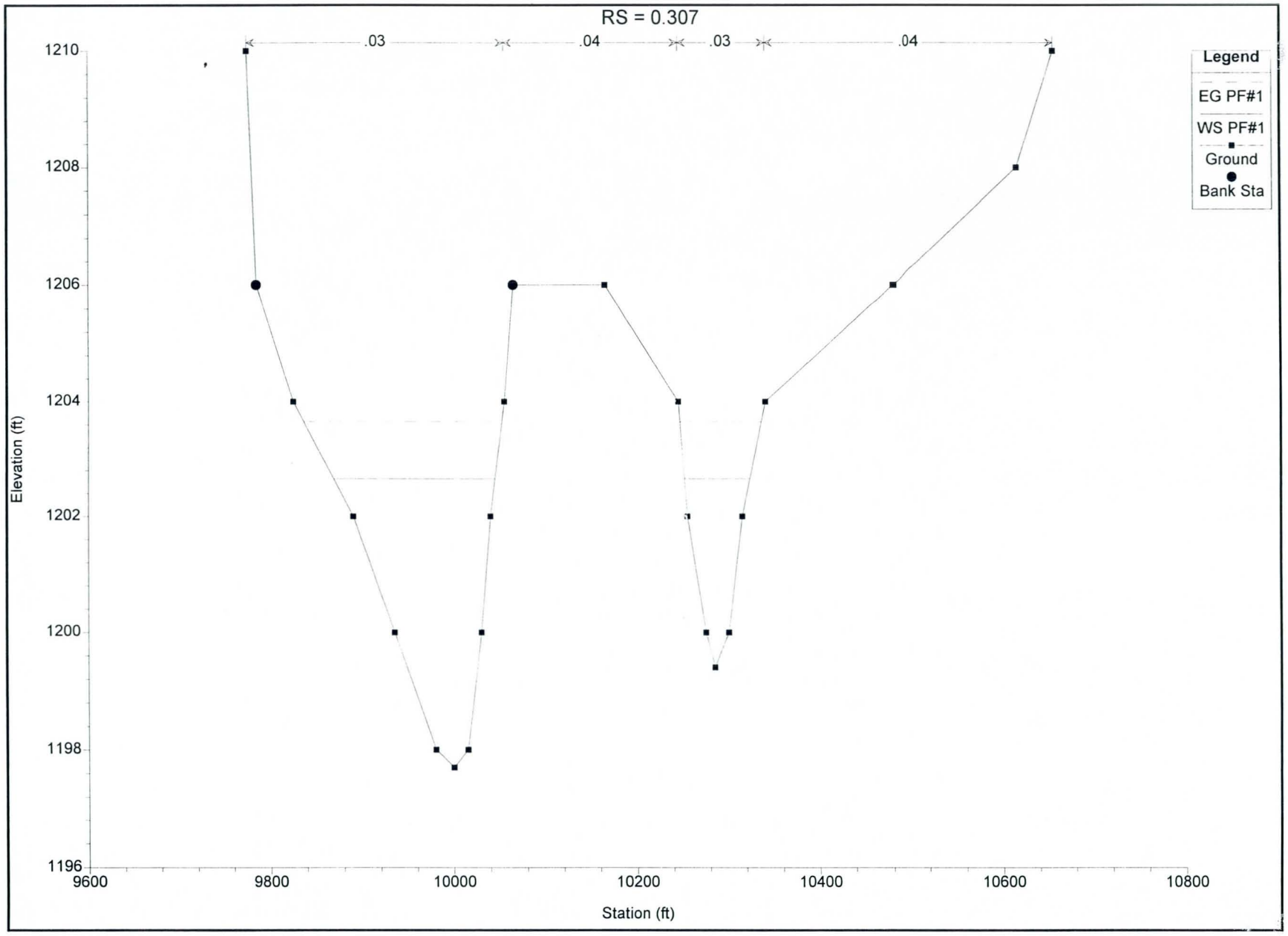

RS = 0.696
.035
.03
.035
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1224
1222
1220
1218
1216
1214
1212
1210
9900
10000
10100
10200
10300
10400
Station (ft)

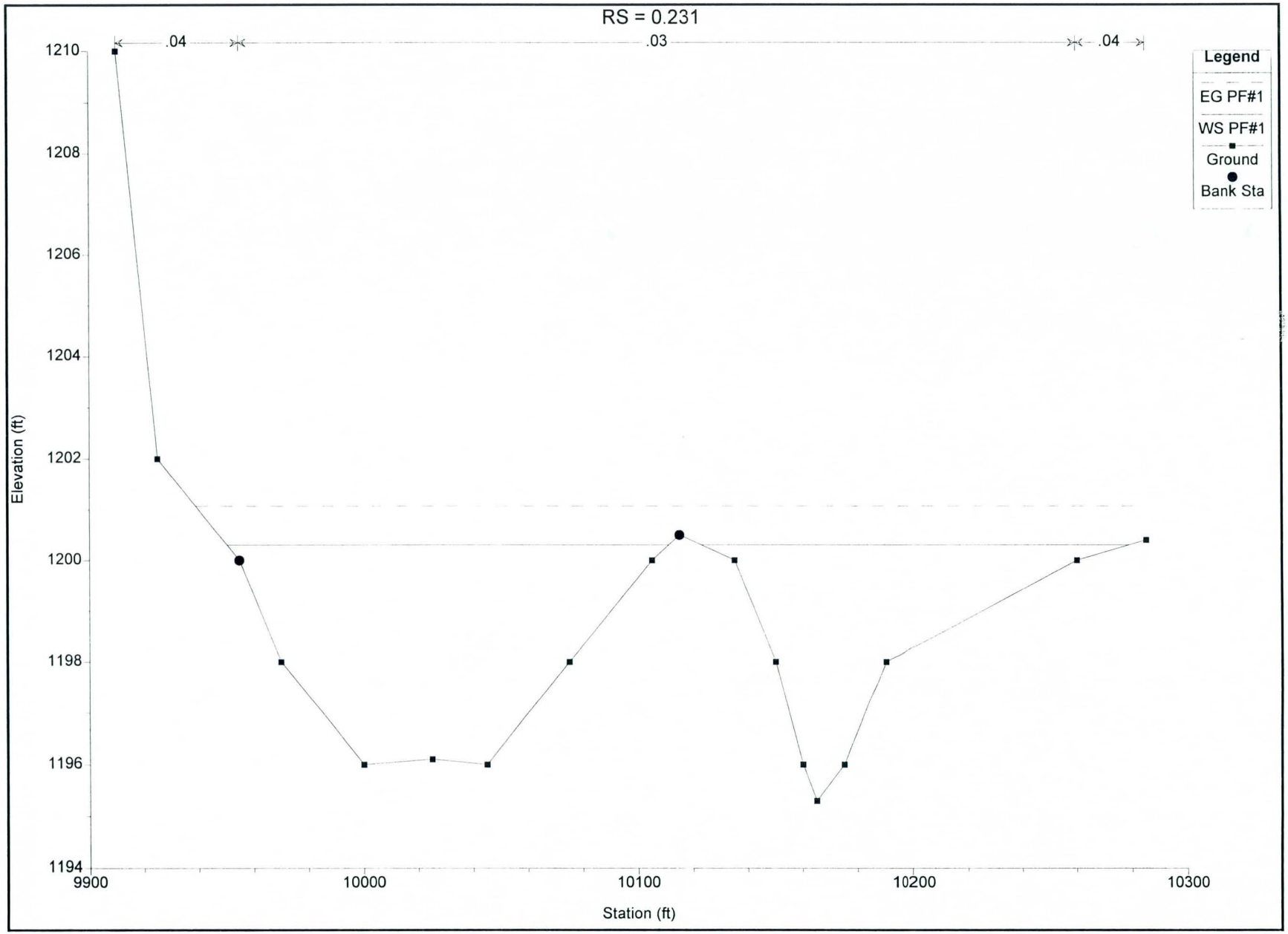

RS = 0.62
.035
.03
.035
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1222
1220
1218
1216
1214
1212
1210
1208
1206
9900
10000
10100
10200
10300
10400
10500
Station (ft)

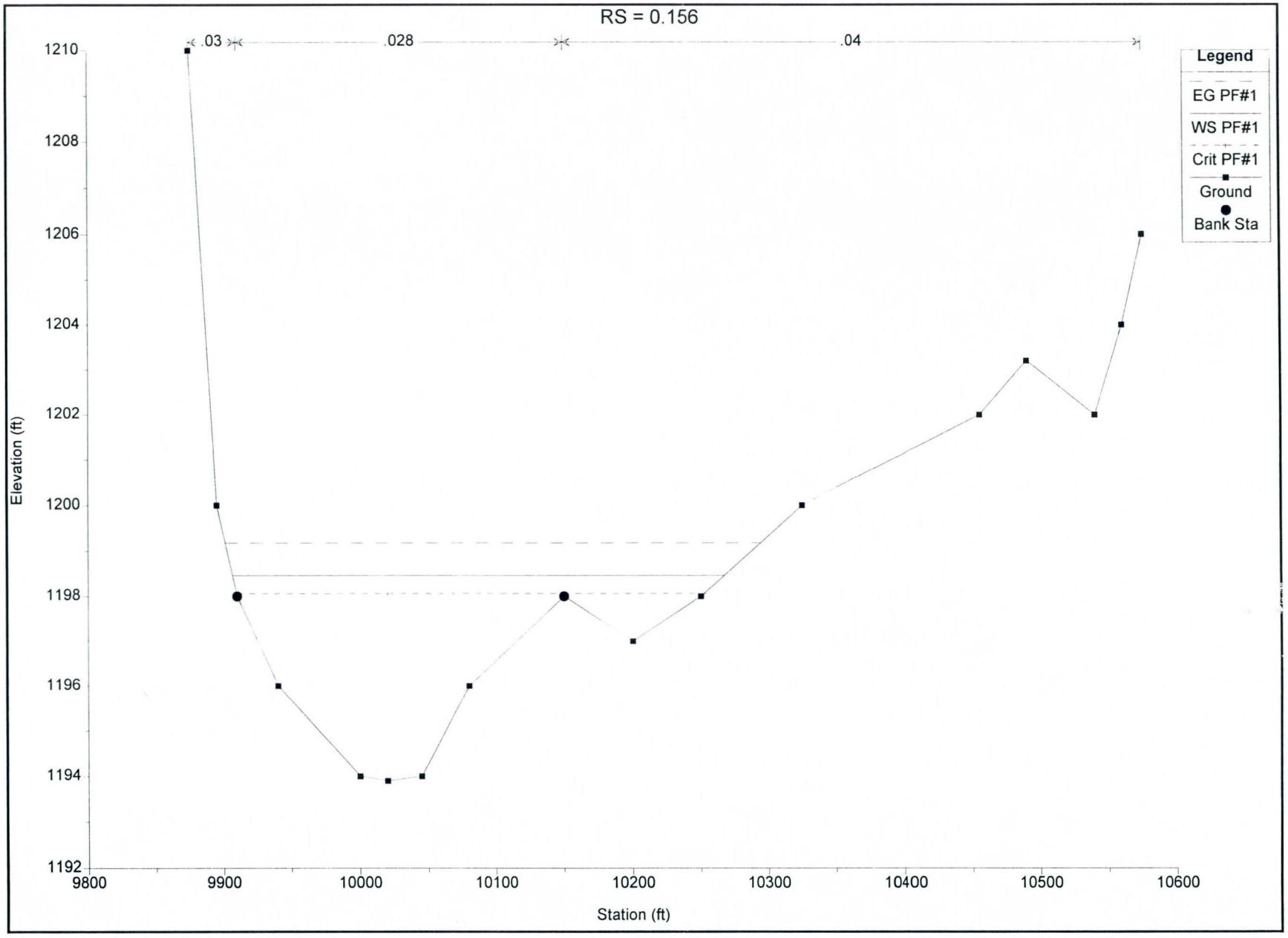

RS = 0.543
.035
.03
.035
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1220
1218
1216
1214
1212
1210
1208
1206
9900
10000
10100
10200
10300
10400
Station (ft)

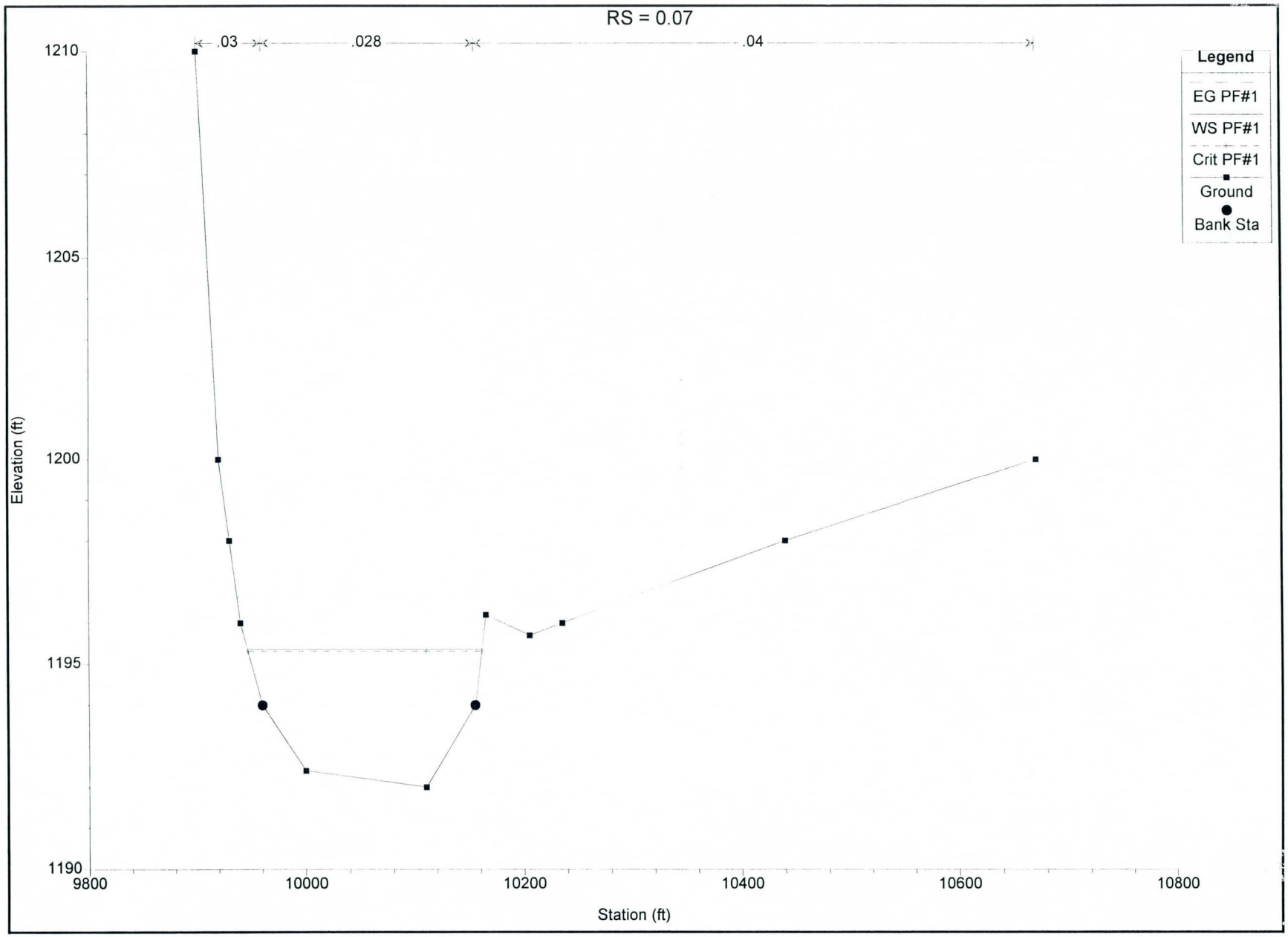

RS = 0.465
.03
.03
.04
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1218
1216
1214
1212
1210
1208
1206
1204
9800
9900
10000
10100
10200
10300
10400
Station (ft)

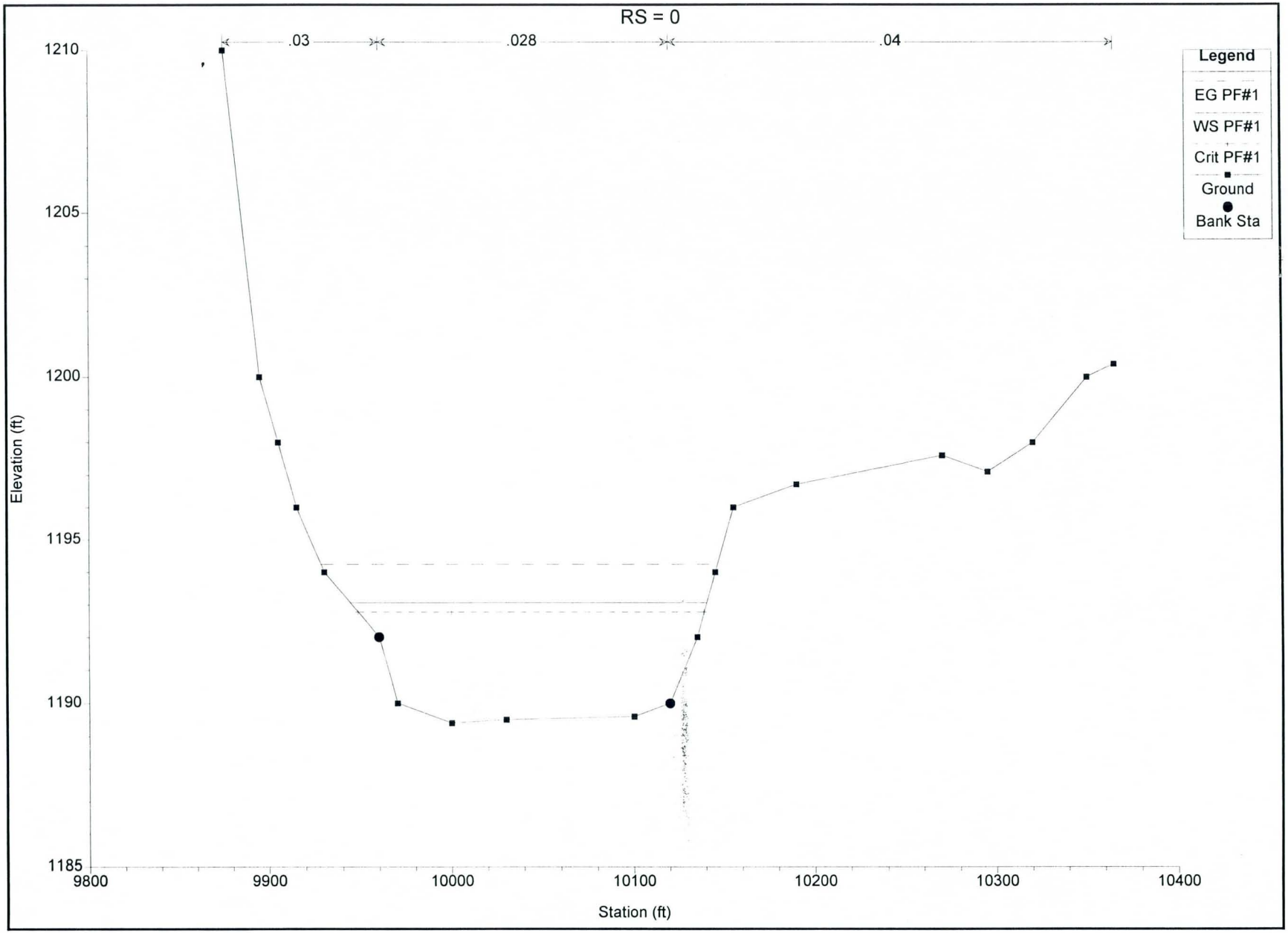

RS = 0.39
.03
.03
.04
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1212
1210
1208
1206
1204
1202
1200
9900
9920
9940
9960
9980
10000
10020
10040
10060
Station (ft)


RS = 0.307
.03
.04
.03
.04
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1210
1208
1206
1204
1202
1200
1198
1196
9600
9800
10000
10200
10400
10600
10800
Station (ft)


RS = 0.231
.04
.03
.04
Legend
EG PF#1
WS PF#1
Ground
Bank Sta
Elevation (ft)
1210
1208
1206
1204
1202
1200
1198
1196
1194
9900
10000
10100
10200
10300
Station (ft)


RS = 0.156
.03
.028
.04
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1210
1208
1206
1204
1202
1200
1198
1196
1194
1192
9800
9900
10000
10100
10200
10300
10400
10500
10600
Station (ft)


RS = 0.07
.03
.028
.04
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1210
1205
1200
1195
1190
9800
10000
10200
10400
10600
10800
Station (ft)

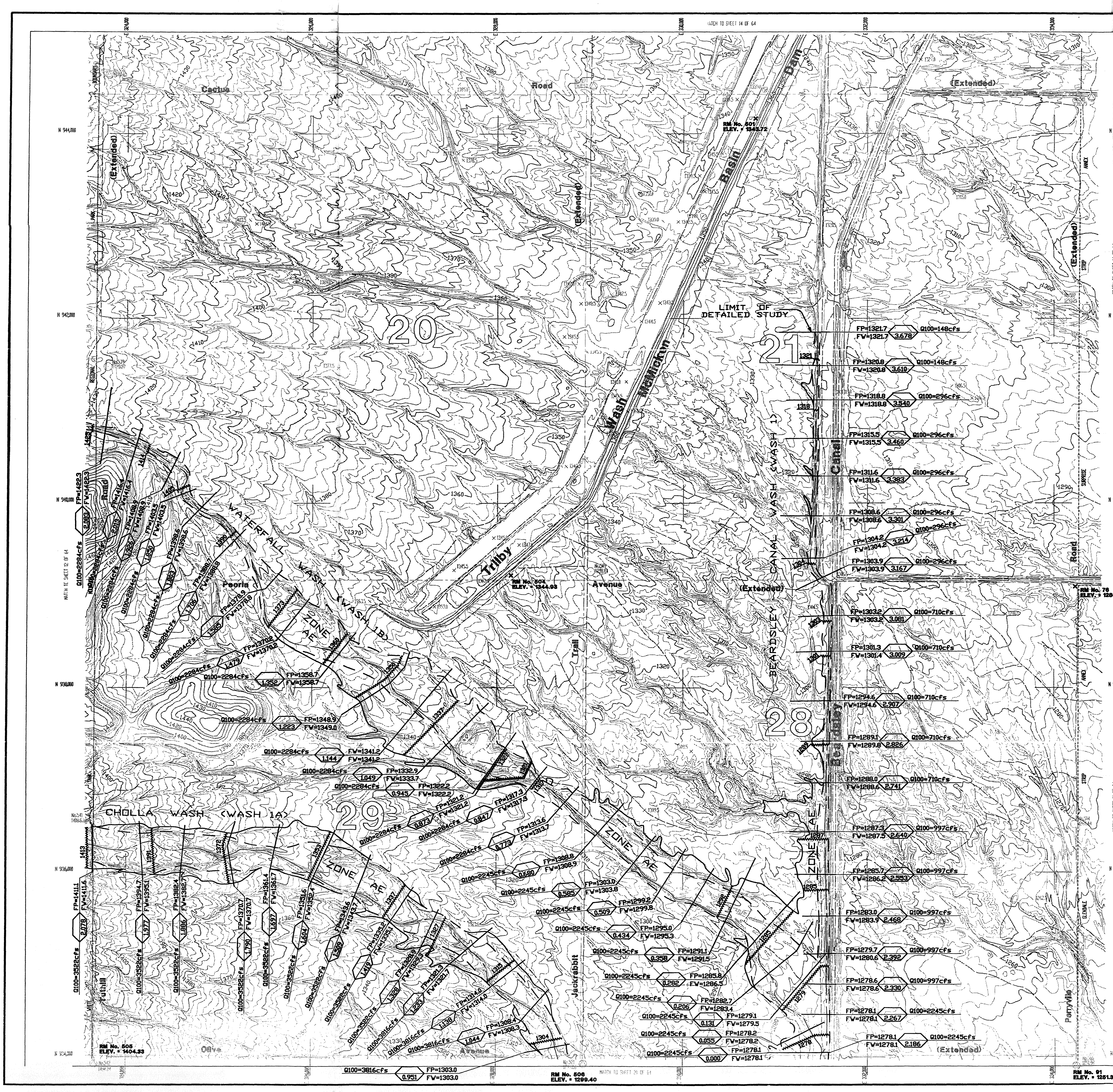

RS = 0
.03
.028
.04
Legend
EG PF#1
WS PF#1
Crit PF#1
Ground
Bank Sta
Elevation (ft)
1210
1205
1200
1195
1190
1185
9800
9900
10000
10100
10200
10300
10400
Station (ft)

APPENDIX H

HEC-RAS INPUT FILES
(DISKETTE)

APPENDIX I

HEC-RAS CROSS-SECTION MAPS



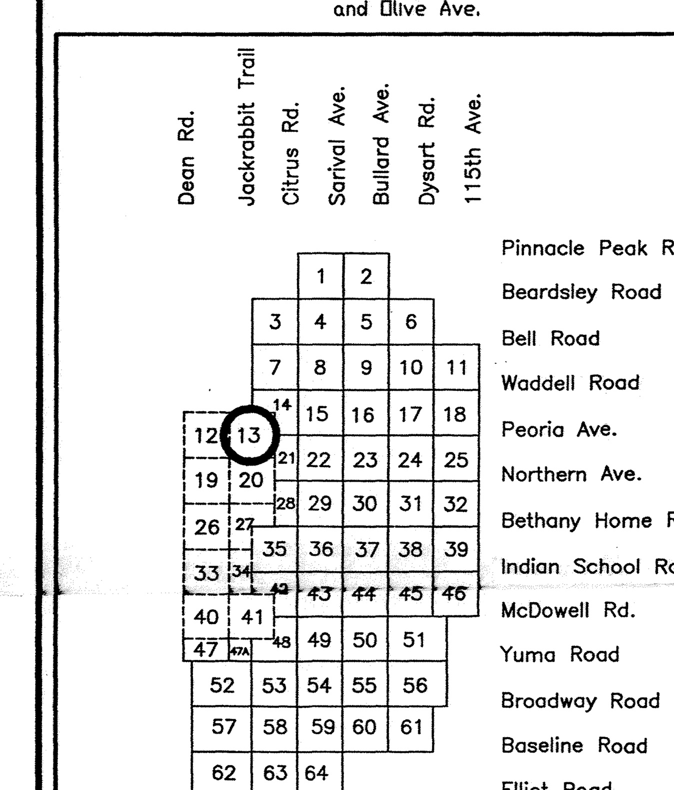
WHITE TANKS/AGUA FRIA

AREA DRAINAGE MASTER STUDY

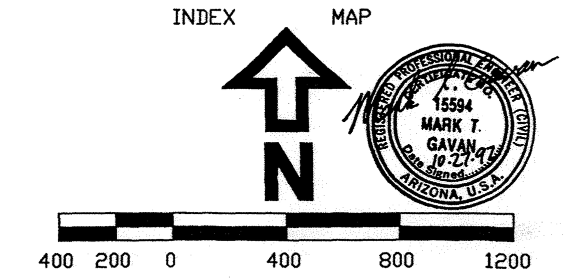
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

REFERENCE MARKS (RM'S)

NO.	ELEVATION	DESCRIPTION
76	1280.02	"X" on Top Concrete Ditch Southwest Corner of Intersection of Perryville Rd. and Peoria Ave.
91	1251.30	1" Open Pipe in Pothole on Olive Ave. ±1/2 Mile East of Beardsley Canal
501	1343.72	Chiseled "X" in Concrete Base of Fence Post on West Side of McMicken Dam, ±250' South of Section Line (Cactus Rd. Extended)
504	1344.93	Chiseled "X" on Concrete Base of Fence Post ±250' North of Peoria Ave. (Extended) at East Side of McMicken Dam, 0.33 miles North and East along the dam from Gate at South end of the Dam
505	1404.33	Iron Pin in Hand Hole at Centerline of Intersection of Tuthill Rd. and Olive Ave.
506	1299.40	1" Pipe in Hand Hole at Centerline Intersection of Jackrabbit Tr. and Olive Ave.



INDEX MAP



BASE MAP: WHITE TANKS/AGUA FRIA A.D.M.S. TOPOGRAPHIC MAPS
CONTOUR INTERVAL = 2'

LEGEND

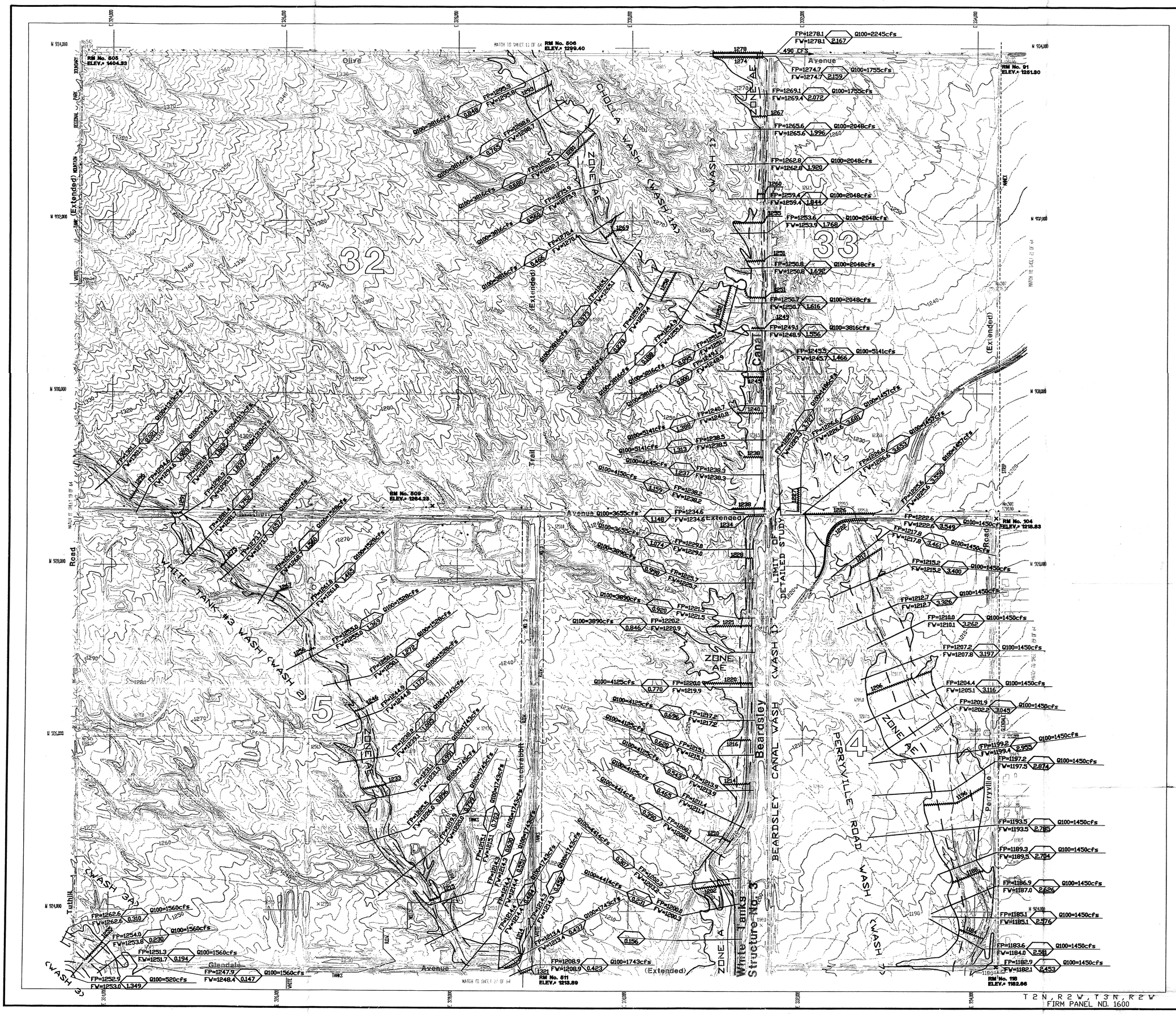
Symbol	Meaning
1.452	CROSS SECTION NUMBER
FP=1158.9	FLOODPLAIN WATER SURFACE ELEVATION = 1158.9
FW=1159.8	FLOODWAY WATER SURFACE ELEVATION = 1159.8
Q100=764cfs	100-YEAR PEAK DISCHARGE = 764 CUBIC FEET PER SEC.
1157 (wavy line)	BASE FLOOD ELEVATION
— - — - —	STREAM CENTERLINE
— — —	FLOODWAY BOUNDARY
———	FLOODPLAIN BOUNDARY
RM NO. 100	ELEVATION REFERENCE MARK
ZONE AE	FLOOD INSURANCE RATE ZONE

SHEET TITLE: **FLOODPLAIN MAP**

STUDY CONSULTANT: **The WLB Group, INC.**

MAPPING COMPANY: Cooper Aerial of Phoenix, Inc.

SHEET 13 OF 64 | DATE FLOWN 12/22/89



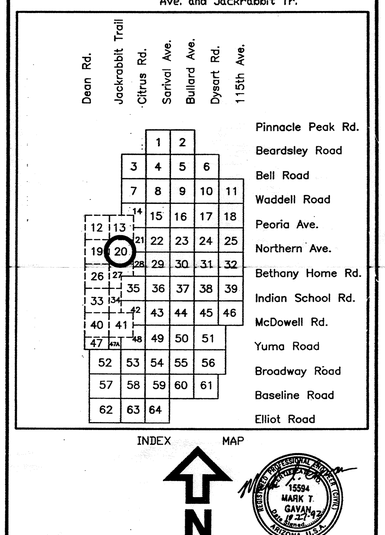
WHITE TANKS/AGUA FRIA

AREA DRAINAGE MASTER STUDY

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

REFERENCE MARKS (RM'S)

NO.	ELEVATION	DESCRIPTION
91	1251.30	1" Open Pipe in Pothole on Olive Ave. ±1/2 Mile East of Beardsley Canal
104	1218.83	Chiseled "a" in Concrete Base Electrical Transformer WSC 363 at Southeast Corner of Intersection of Perryville Rd. and Northern Ave.
118	1182.66	1 1/2" Iron Pin in Pothole, Perryville Rd. and Glendale Ave.
505	1404.33	Iron Pin in Hand Hole at Centerline Intersection of Tuthill Rd. and Olive Ave.
506	1299.40	1" Pipe in Hand Hole at Centerline Intersection of Jackrabbit Tr. and Olive Ave.
509	1264.23	National Geodetic Survey Bench Mark - Stainless Steel Rod Encased in Pipe and Stamped "L475 1981" 0.7 Mile West of Beardsley Canal along Northern Ave.
511	1213.89	Iron Pin at Centerline Intersection of Glendale Ave. and Jackrabbit Tr.



INDEX MAP

N

400 200 0 400 800 1200

BASE MAP: WHITE TANKS/AGUA FRIA A.D.M.S. TOPOGRAPHIC MAPS
CONTOUR INTERVAL = 2'

LEGEND

1.452	CROSS SECTION NUMBER
FP=1158.9	FLOODPLAIN WATER SURFACE ELEVATION = 1158.9
FV=1159.8	FLOODWAY WATER SURFACE ELEVATION = 1159.8
Q100=764cfs	100-YEAR PEAK DISCHARGE = 764 CUBIC FEET PER SEC.
1157	BASE FLOOD ELEVATION
	STREAM CENTERLINE
	FLOODWAY BOUNDARY
	FLOODPLAIN BOUNDARY
RM NO. 100	ELEVATION REFERENCE MARK
ZONE AE	FLOOD INSURANCE RATE ZONE

SHEET TITLE: **FLOODPLAIN MAP**

STUDY CONSULTANT: **The WLB Group** INC.

MAPPING COMPANY: Cooper Aerial of Phoenix, Inc.

SHEET 20 OF 64 | DATE FLOWN 12/22/89