Hydrology & Hydraulics Report

Industry Sawyer Bridge #5047

WIN 21695.00

WIN:	21695.00	**Project Name:**	Industry Sawyer Bridge
Town:	Industry	**Stream Name:**	Falls Brook
Route No.	Shaw Hill Rd (just S of ME148)	**Bridge Name:**	Sawyer Bridge
Asset ID:	5407	**Analysis by:**	CSH
Lat:	44.7644 **Long:** -70.0154	**Date:**	12/29/2016

Peak Flow Calculations by USGS Regression Equations (Hodgkins, 1999 & Lombard/Hodgkins, 2015)

Enter data in blue cells only!

	km^2	mi^2	ac	***Enter data in [mi^2]***
A	29.79	11.50	7360.0	Watershed Area *DRNAREA*
W	0.97	0.4	239.9	Wetlands area (by NWI)
P_c	416597	4958499		watershed centroid (E, N; UTM 19N; meters)
County	Franklin			*choose county from drop-down menu*
pptA	45.6			mean annual precipitation (inches; by look-up)
SG	0.00			sand & gravel aquifer as decimal fraction of watershed A

A (km^2)	29.79	**Conf Lvl**	0.67
W (%)	3.26		NWI Wetlands % *STORNWI*

Ret Pd	**Peak Flow Estimate**			
T (yr)	**Lower**	**Q_T (m^3/s)**	**Upper**	**Q_T (ft^3/s)**
1.1		4.87		171.8
2		9.88		349.0
5		15.37		542.8
10		19.44		686.3
25		24.91		879.5
50		29.30		1034.5
100		33.94		1198.3
500		45.54		1608.1

Worksheet prepared by:

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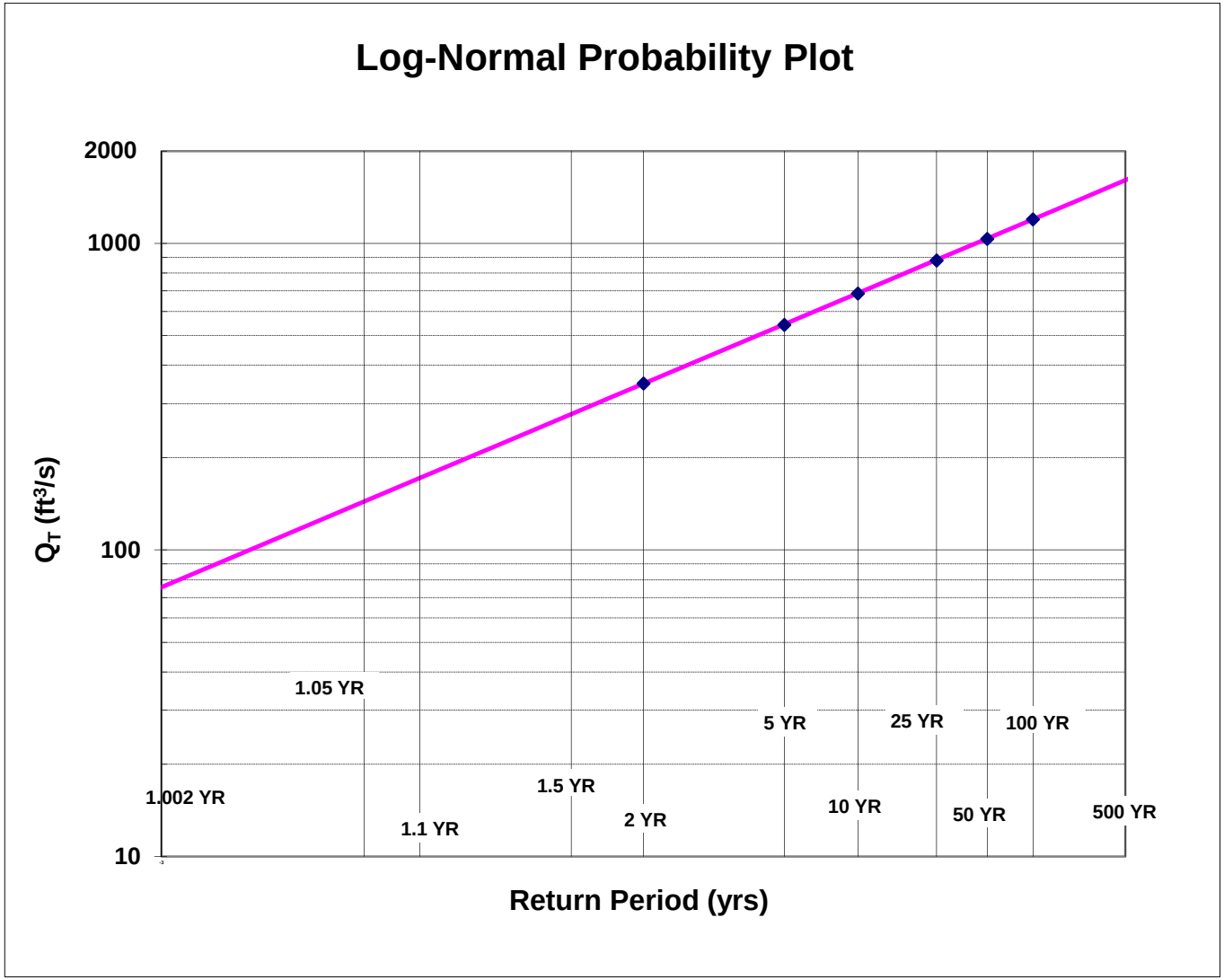
ver. 2016 Feb 05

References:

Hodgkins, G.A., 1999.
Estimating the magnitude of peak flows for streams in Maine for selected recurrence intervals
WRIR 99-4008, USGS Augusta, ME

Lombard, P.J. & G.A. Hodgkins, 2015.
Peak flow regression equations for small, ungaged streams in Maine - Comparing map-based to field-based variables
SIR 2015-4059, USGS, Augusta, ME

$Q_T = b \times A^a \times 10^{-wW}$


Log-Normal Probability Plot
2000
1000
100
10
Q_T (ft³/s)
1.05 YR
5 YR
25 YR
100 YR
1.002 YR
1.5 YR
10 YR
1.1 YR
2 YR
50 YR
500 YR
Return Period (yrs)

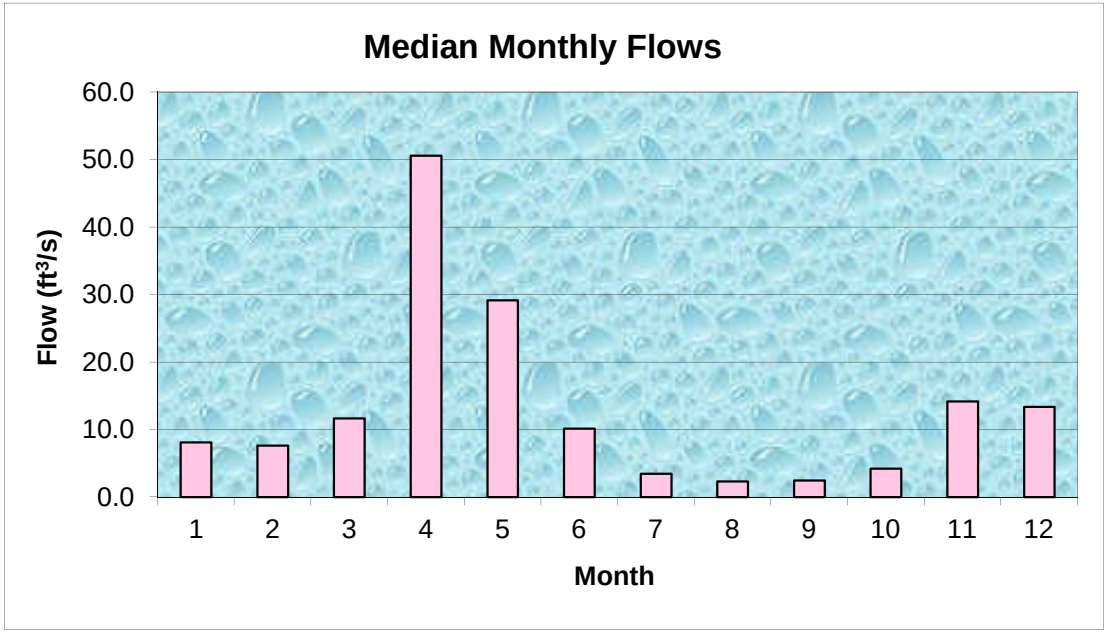
WIN:	21695.00	**Project Name:**	Industry Sawyer Bridge
Town:	Industry	**Stream Name:**	Falls Brook
Route No.	Shaw Hill Rd (just S of ME148)	**Bridge Name:**	Sawyer Bridge
Asset ID:	5407	**Analysis by:**	CSH
Lat:	44.76440 **Long:** -70.0154	**Date:**	12/29/2016

DO NOT ENTER ANY DATA ON THIS PAGE; EVERYTHING IS CALCULATED

MAINE MONTHLY MEDIAN FLOWS and HYDRAULIC GEOMETRY BY USGS REGRESSION EQUATIONS (2004)

	Value	Variable	Explanation
	11.50	*A*	Area (mi^2)
416597.2	4958499	P_c	Watershed centroid (E,N; UTM; Zone 19; meters)
	94.68	*DIST*	Distance from Coastal reference line (mi)
	45.6	*pptA*	Mean Annual Precipitation (inches)
	0.00	*SG*	Sand & Gravel Aquifer (decimal fraction of watershed area)

Month	Q_{median} (ft3/s)	(m^3/s)
Jan	**8.11**	0.2299
Feb	**7.63**	0.2163
Mar	**11.66**	0.3306
Apr	**50.60**	1.4339
May	**29.13**	0.8254
Jun	**10.16**	0.2880
Jul	**3.48**	0.0985
Aug	**2.34**	0.0664
Sep	**2.44**	0.0691
Oct	**4.23**	0.1199
Nov	**14.19**	0.4022
Dec	**13.37**	0.3788



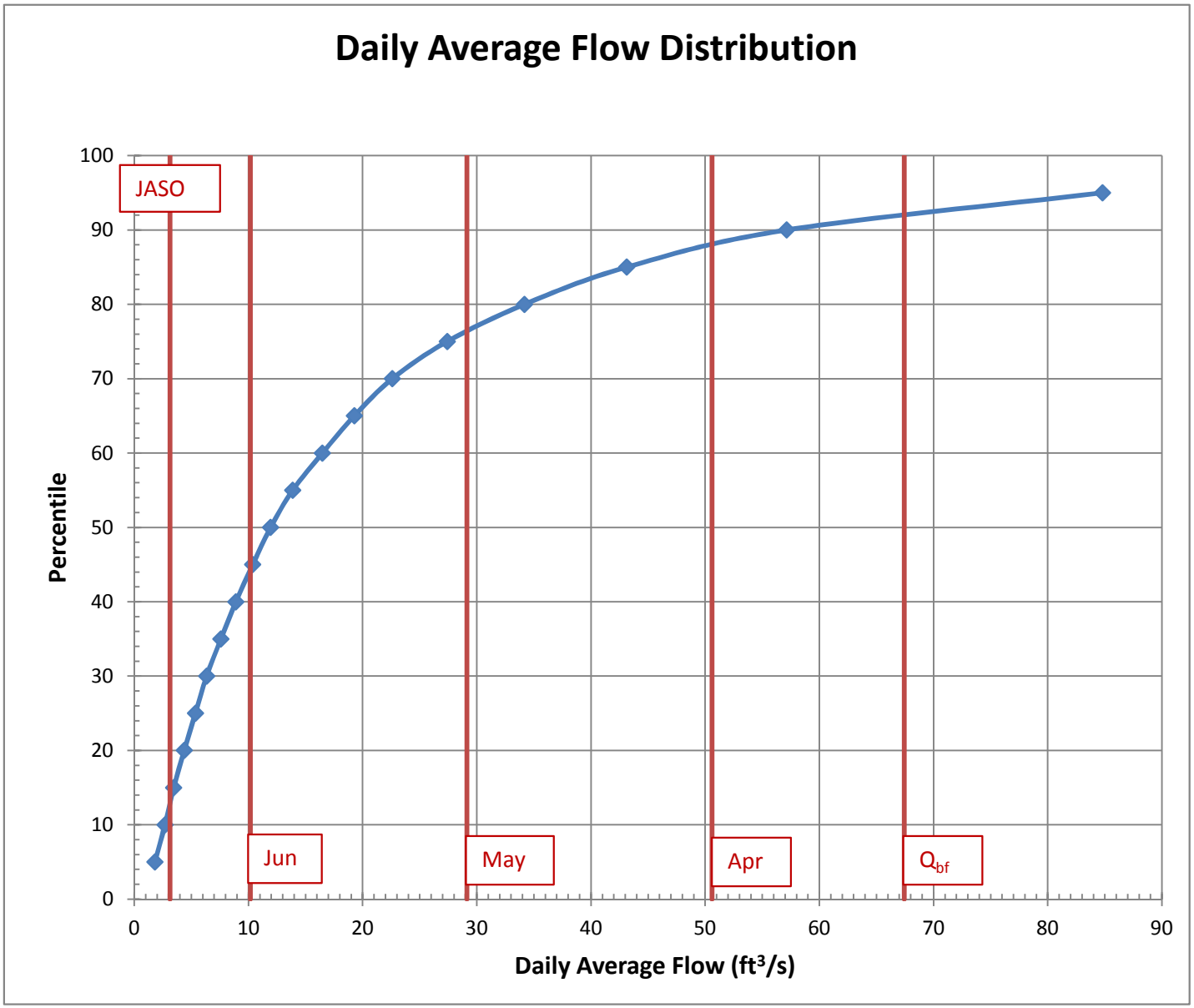
Q_{bf}	**67.4**	
ann avg	**23.7**	
ann med	**12.5**	
$Q_{1.002}$	**75.7**	
$Q_{1.01}$	**101.2**	
$Q_{1.05}$	**143.8**	
Q_{bf}	**148.9**	assume v = 4ft/s

W_{bf}	**27.3**	estimated bankfull width (ft)
d_{bf}	**1.4**	estimated bankfull depth (ft)
A_{bf}	**37.2**	estimated bankfull flow area (ft^2)

References

Dudley, R.W., 2004. Hydraulic Geometry Relations ..., SIR 2004-5042

Dudley, R.W., 2004. Estimating Monthly Streamflows … , SIR 2004-5026



Daily Avg Flow Dist		
A_{ws} = (mi^2)		11.5
Q (ft^3/s)		
Pctl	**Median**	**84th pctl**
5	1.81	2.91
10	2.69	4.04
15	3.46	5.05
20	4.38	6.12
25	5.35	7.18
30	6.34	8.17
35	7.59	9.34
40	8.90	10.74
45	10.38	12.15
50	11.95	14.34
55	13.87	16.69
60	16.48	19.59
65	19.27	22.82
70	22.61	26.63
75	27.41	32.02
80	34.18	38.23
85	43.13	49.00
90	57.13	65.79
95	84.79	102.31

Q_{bf}	67.4
$Q_{1.002}$	75.7
$Q_{1.1}$	171.8
Q_2	349.0

HYDROLOGY REPORT

Sawyer Bridge (#5047) carries Shaw Hill Road over Falls Brook in Industry, Maine. The watershed that contains Falls Brook extends west, north, and south from the bridge location. The watershed begins near Griffin Mountain in New Vinyard, with Mitchell Brook and Fish Brook flowing into Falls Brook. Fish Brook flows into Falls Brook near the beginning of Falls Brook, and Mitchell Brook joins Falls Brook just upstream from the bridge location. Falls Brook flows southeast from the bridge location and turns into Lemon Stream in Starks which eventually joins the Sandy River in Mercer.

The drainage basin characteristics for this bridge were provided by the MaineDOT Environmental Office, Hydrology Section. Peak flows were calculated using the 1999 USGS full regression equations and the 2015 USGS peak flow regression equations. No other flow data is available.

SUMMARY

Drainage Area	11.50	mi^2
April Avg. Flow	50.60	ft^3/s
August Avg. Flow	2.34	ft^3/s
Ordinary High (Q1.1)	171.8	ft^3/s
10-year flood (Q10)	686.3	ft^3/s
25-year flood (Q25)	879.5	ft^3/s
Design Discharge (Q50)	1034.5	ft^3/s
Check Discharge (Q100)	1198.3	ft^3/s
Scour Discharge (Q500)	1608.1	ft^3/s

Reported by: Bartlett, Benjamin J
Date: April 18, 2018

Note: All elevations based on North American Vertical Datum (NAVD) of 1988.

Hydraulic Modeling

The existing and proposed bridges were analyzed using HEC-RAS version 4.1.0 (Hydrologic Engineering Center's River Analysis System). HEC-RAS is a hydraulics software that was developed by the United States Army Corp of Engineers. A 325-foot-long section of Falls Brook intersecting the Sawyer Bridge crossing was modeled using eight total cross-sections, four upstream and four downstream of the bridge.

The HEC-RAS models were based on the following assumptions:

- Steady Flow
- Manning's Roughness Coefficients
    - Channel: n = 0.048 - 0.05
    - Overbank, Grass n = 0.03
    - Overbank, Trees/Brush n = 0.1
    - Overbank, Other n = 0.07
- Default expansion (0.3) and contraction (0.1) values.
- Ineffective flow areas
    - Existing Bridge: Used on all 4 corners of the bridge. The existing abutments and wingwalls create a slight constriction of the channel, which causes ineffective flows upstream and downstream.
    - Proposed Bridge: Used on all 4 corners. The proposed bridge is not constricting the stream, however the stream alignment creates areas where there may be ineffective flows.
- Flow Regime: Mixed
- Bridge Modeling Approach: Default settings
- Normal depth boundary condition
    - S=0.04 ft/ft – Downstream
    - S=0.004 ft/ft – Upstream

The normal depth boundary condition was used in this model, with the downstream slope being derived from a combination of survey and topography maps. Normally, the model would be calibrated based on known flow volumes and/or flood levels at or around the bridge. In this case, the model can't be calibrated due to there being no written documentation of flood levels. The only record of a flood level is some of the locals stating that at one point the bridge overtopped. There was no data found for this flood event and no way of quantifying what the flow volume was or what the elevation was. Downstream from the bridge, there are remnants of an old mill and dam. Based on when the locals believe the event happened, it was

assumed that this dam was still in place when the flood event happened. With the dam now removed and based on the topography around the bridge, especially with the falls just downstream from the bridge, it was assumed that future flood events would not overtop the bridge. The analysis for the existing bridge shows that this assumption is correct. With the steep grade of the stream and large elevation drops, the water levels shown in the analysis make sense.

The same site features and stream model was used to analyze both proposed bridge options. The voided slab option geometry is a 42’ single span, with a low point on the bottom chord of 507.6’. The superstructure depth is made up of a 21” voided slab with an 8” concrete deck. The buried arch option geometry was based on a 37’ span by 7’-2” rise Conspan O-series. The peak of the arch underside has an elevation of 507.73’.

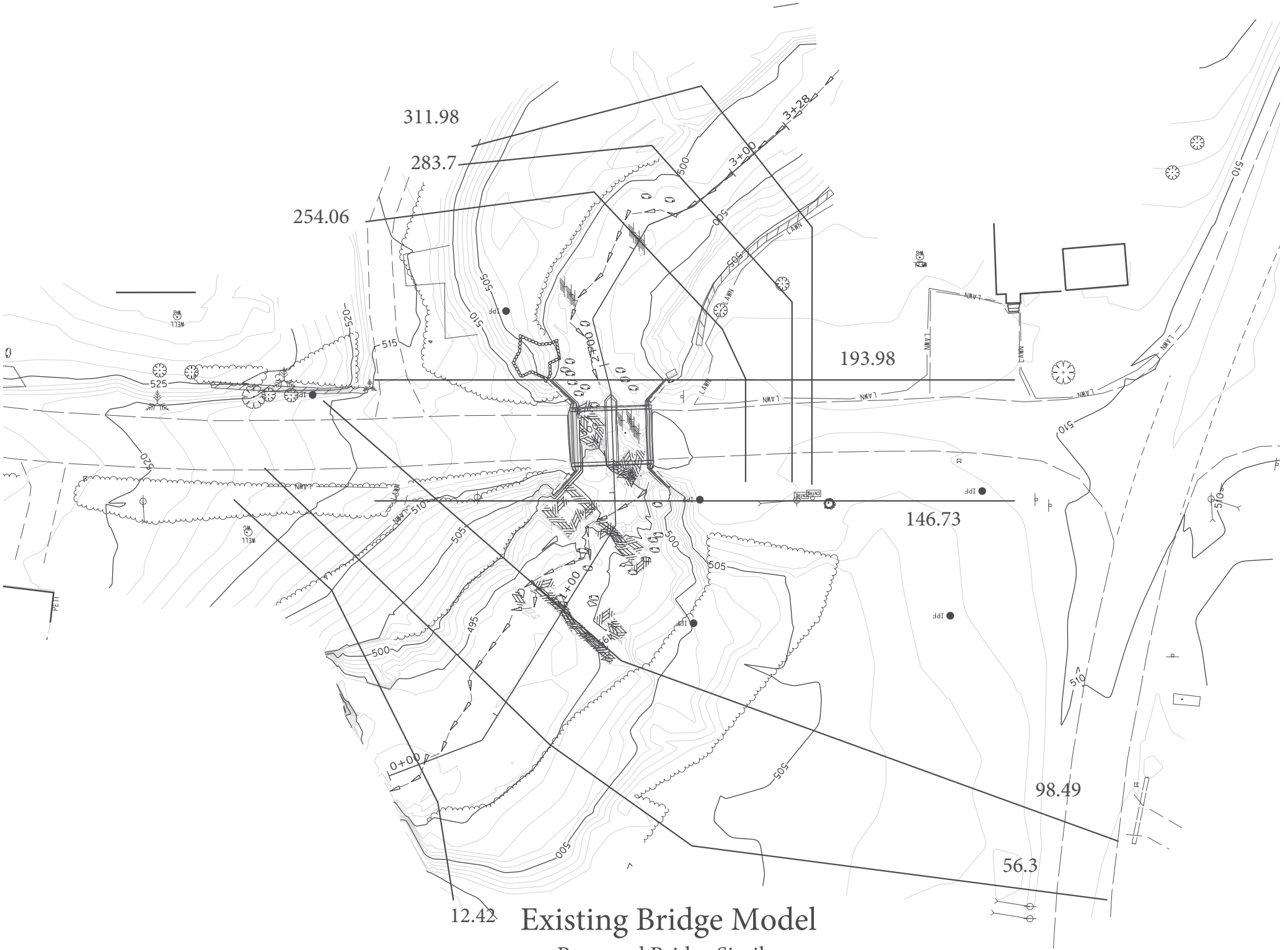
The results of the existing and both proposed bridge options are presented in the summary table on the following page.

SUMMARY

		Existing Structure	Recommended Structure	
		32', 2-Span Concrete Slab	37' Span x 7'-2" Rise Precast Arch	42' Span Voided Slab Bridge
Total Area of Waterway Opening	ft^2	288.7	346.6	378.7
Headwater elevation @ $Q_{1.1}$	ft	499.69	499.33	499.35
Headwater elevation @ Q_{10}	ft	502.31	501.16	500.94
Headwater elevation @ Q_{25}	ft	503.09	501.72	501.41
Headwater elevation @ Q_{50}	ft	503.68	502.15	501.75
Headwater elevation @ Q_{100}	ft	504.27	502.57	502.09
Headwater elevation @ Q_{500}	ft	505.62	504.07	502.90
Freeboard @ Q_{50}	ft	4.96	5.58	5.85
Freeboard @ Q_{100}	ft	4.37	5.16	5.51
Flood Of Record				
Outlet Velocity @ $Q_{1.1}$	ft/s	3.88	2.93	2.93
Outlet Velocity @ Q_{10}	ft/s	9.98	6.83	6.61
Outlet Velocity @ Q_{25}	ft/s	10.87	8.03	7.57
Outlet Velocity @ Q_{50}	ft/s	11.45	8.89	8.18
Outlet Velocity @ Q_{100}	ft/s	11.91	9.76	8.74
Outlet Velocity @ Q_{500}	ft/s	13.02	12.18	9.71

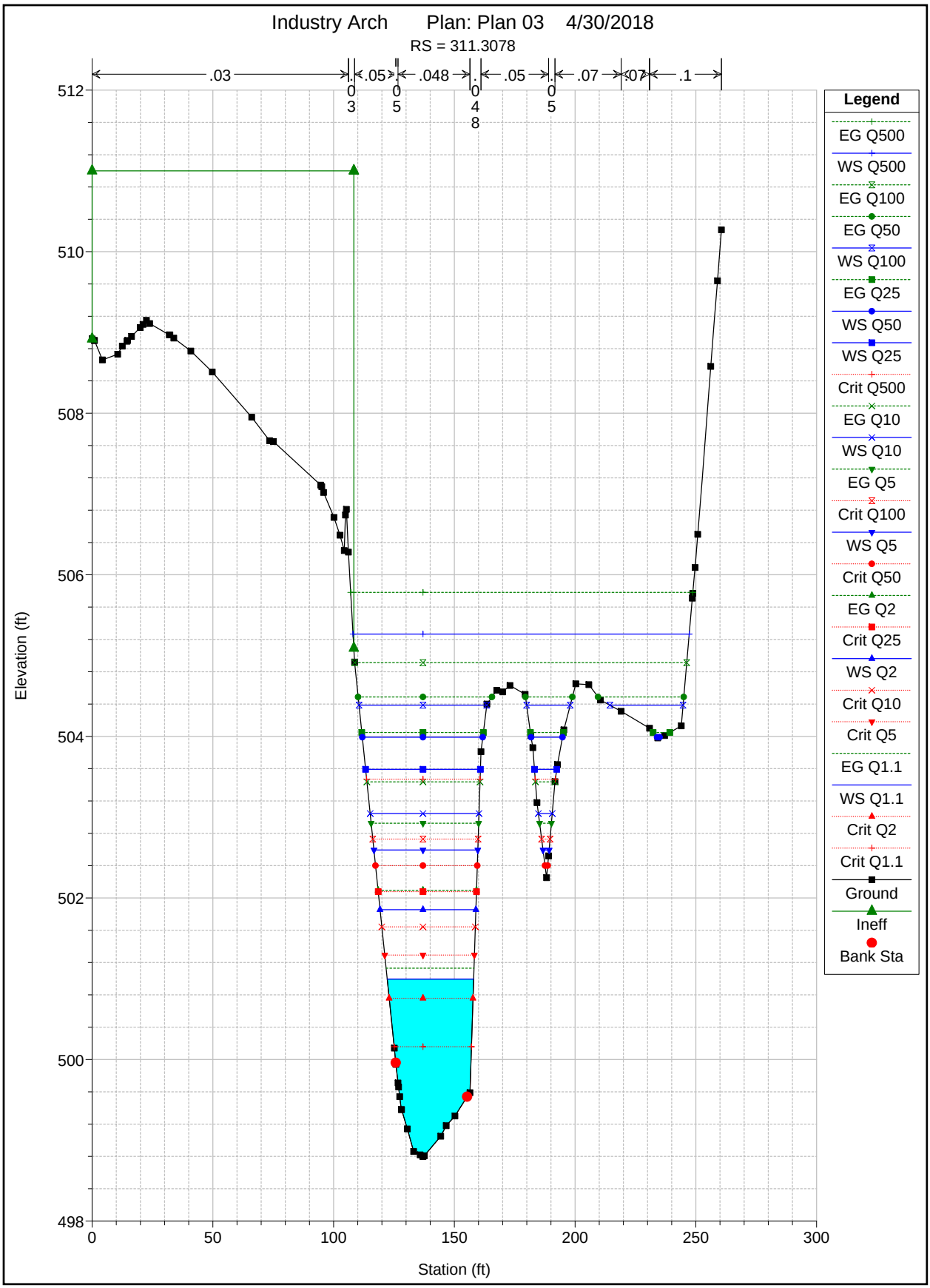
Reported by: Bartlett, Benjamin J
Date: May 1, 2018

Note: All elevations based on North American Vertical Datum (NAVD) of 1988.



Existing Bridge Model

Proposed Bridge Similar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.05
.048
.05
.07
.07
.1
Elevation (ft)
Station (ft)
Legend
EG Q500
WS Q500
EG Q100
EG Q50
WS Q100
EG Q25
WS Q50
WS Q25
Crit Q500
EG Q10
WS Q10
EG Q5
Crit Q100
WS Q5
Crit Q50
EG Q2
Crit Q25
WS Q2
Crit Q10
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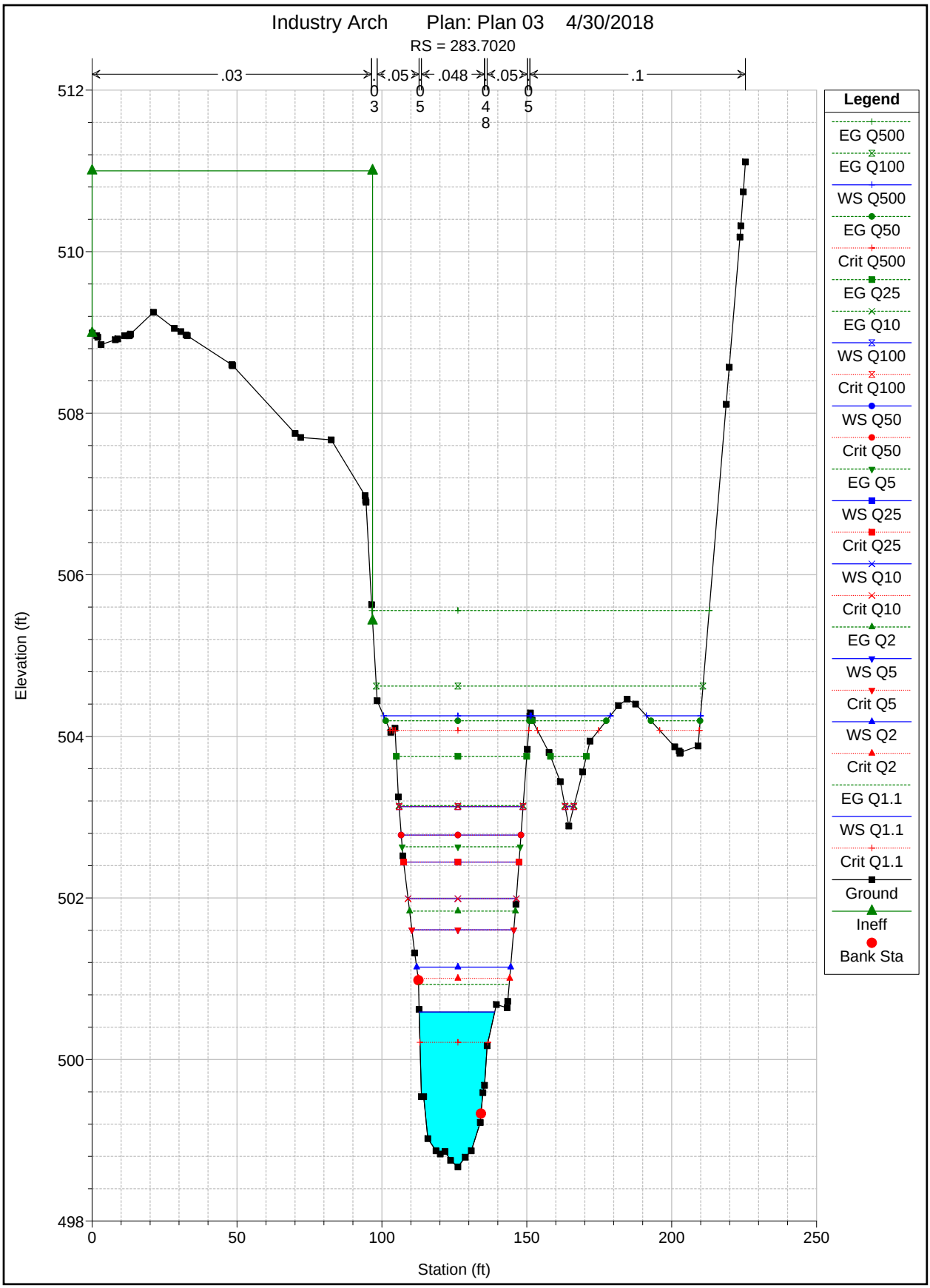
Crit Q2
Crit Q1.1
Ground
Ineff
Bank Sta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0 5
0 4 8
0 5
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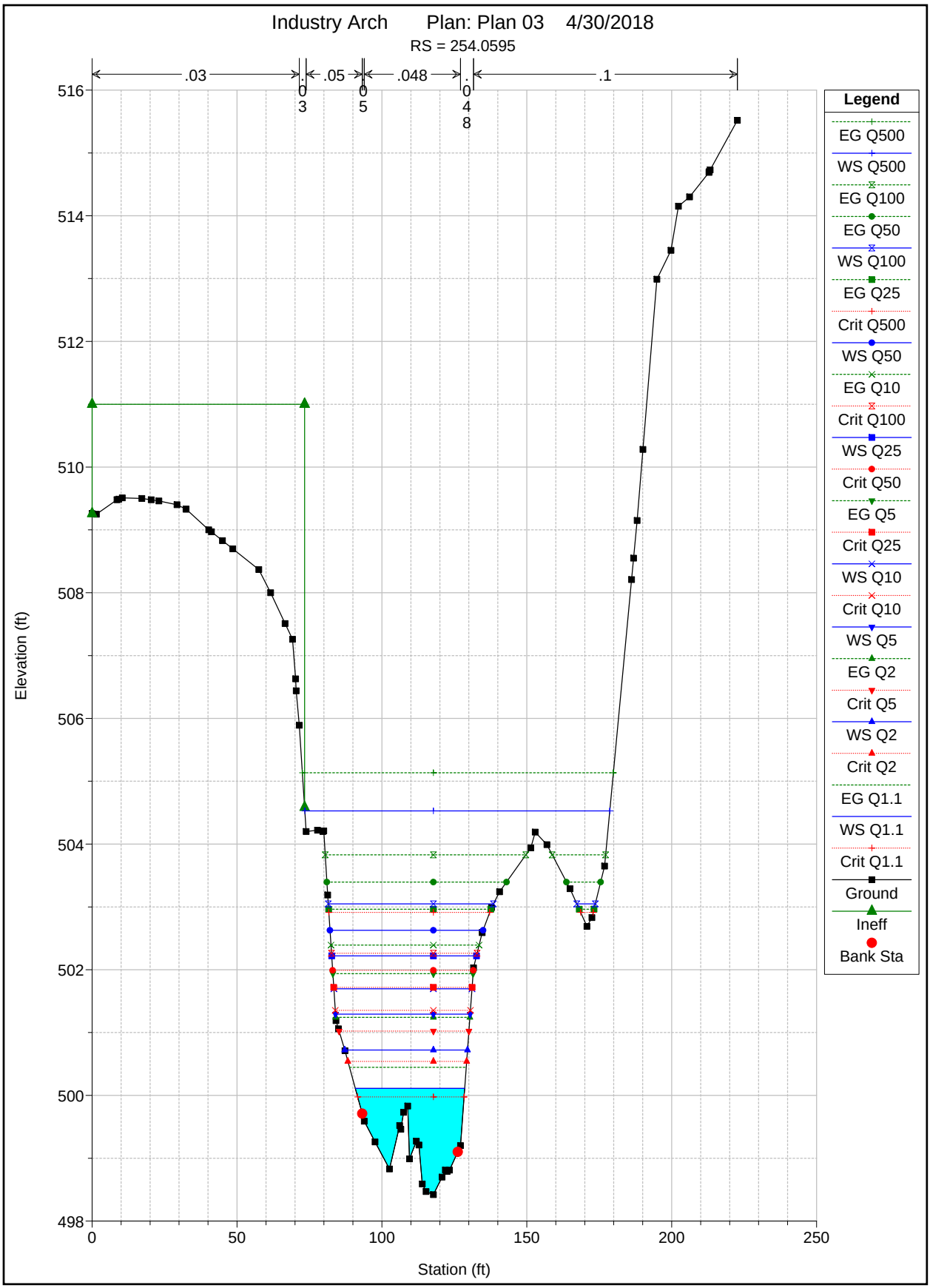
Crit Q500
EG Q25
EG Q10
WS Q100
Crit Q100
WS Q50
Crit Q50
EG Q5
WS Q25
Crit Q25
WS Q10
Crit Q10
EG Q2
WS Q5
Crit Q5
WS Q2
Crit Q2
EG Q1.1
WS Q1.1
Crit Q1.1
Ground
Ineff
Bank Sta
Elevation (ft)
512
510
508
506
504
502
500
498
0
50
100
150
200
250
Station (ft)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Station (ft)
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WS Q50
EG Q10
Crit Q100
WS Q25
Crit Q50
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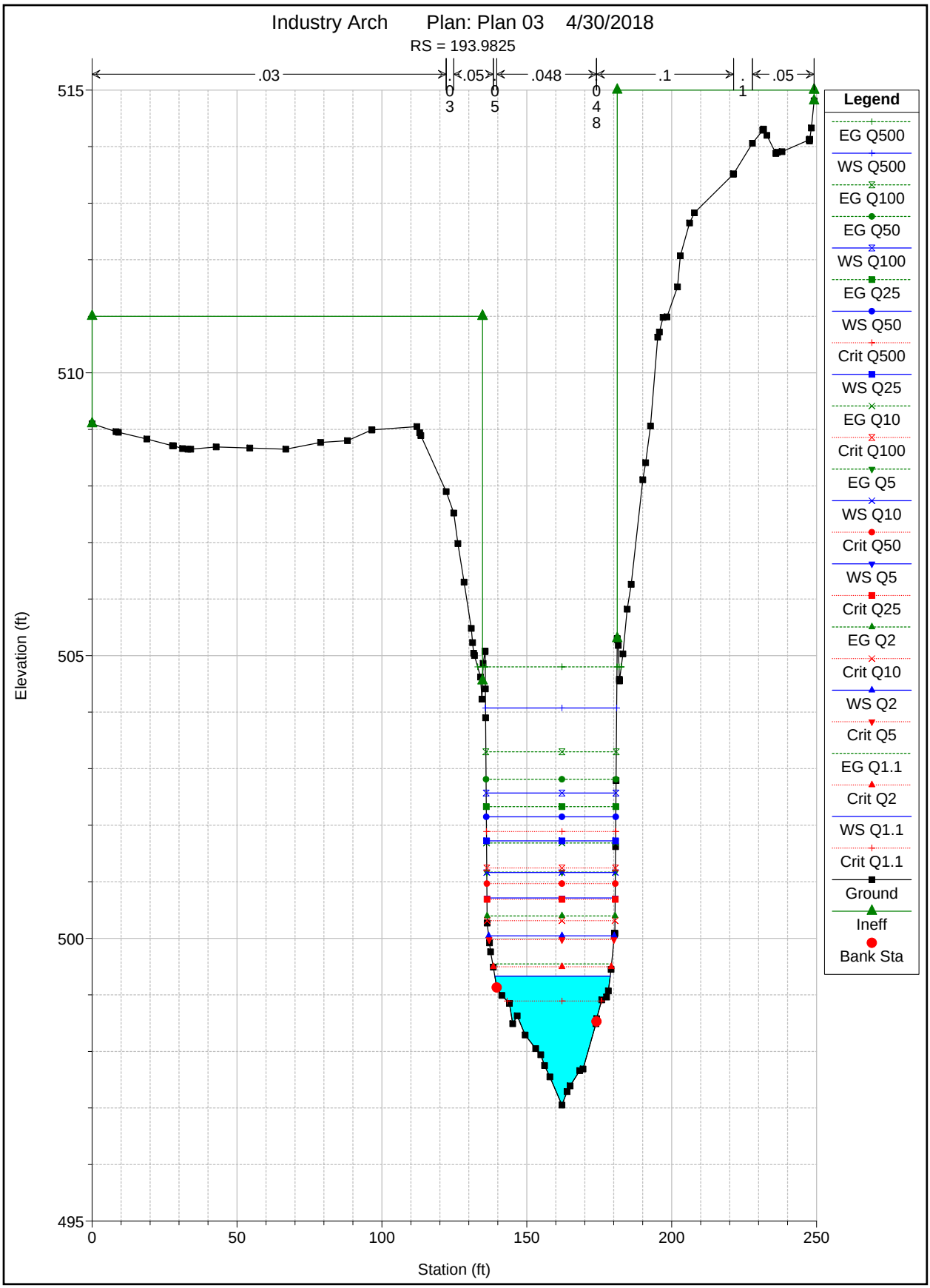
Crit Q25
WS Q10
Crit Q10
WS Q5
EG Q2
Crit Q5
WS Q2
Crit Q2
EG Q1.1
WS Q1.1
Crit Q1.1
Ground
Ineff
Bank Sta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Station (ft)
Legend
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WS Q500
EG Q100
EG Q50
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EG Q25
WS Q50
Crit Q500
WS Q25
EG Q10
Crit Q100
EG Q5
WS Q10
Crit Q50
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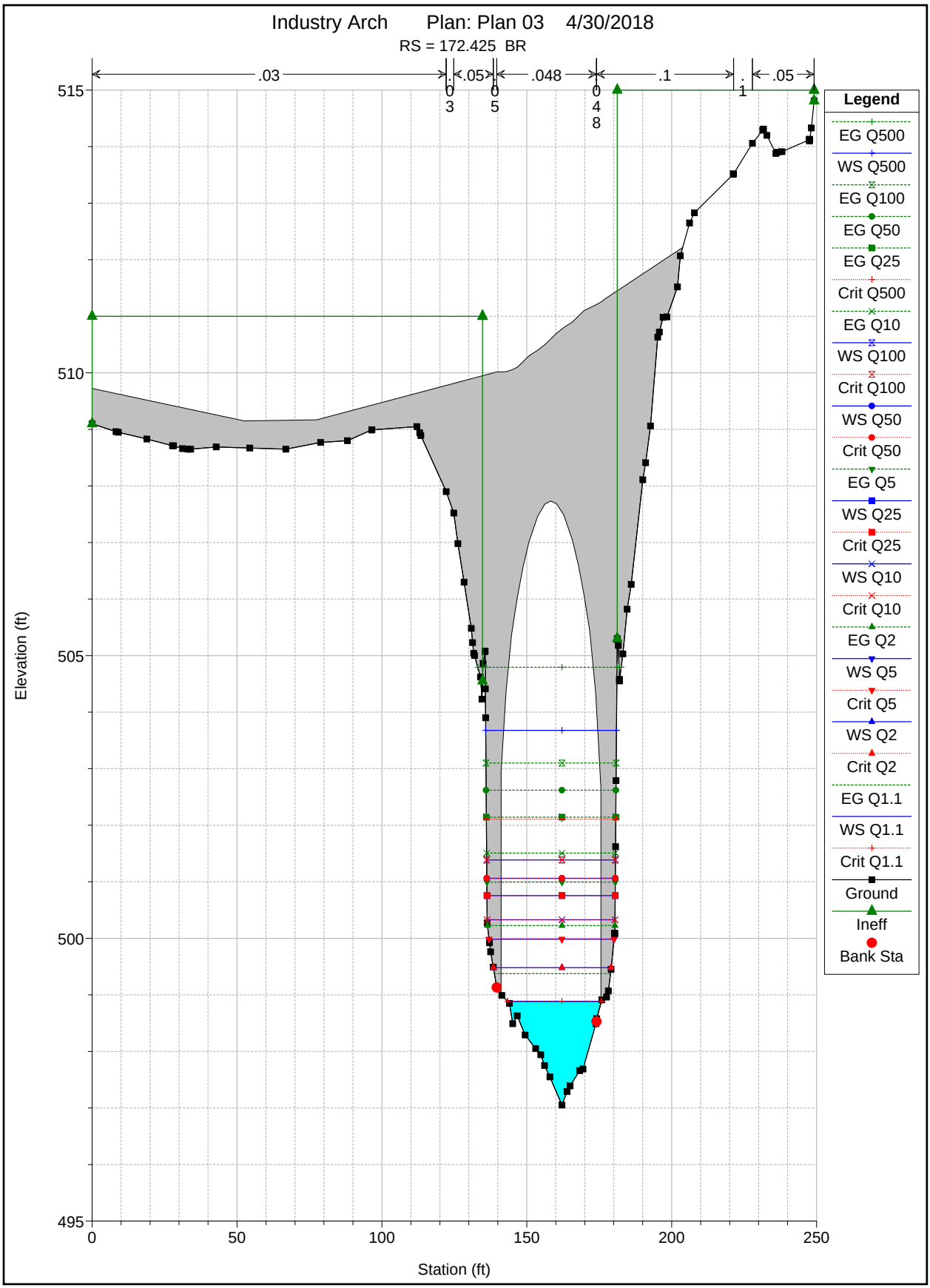
Crit Q25
EG Q2
Crit Q10
WS Q2
Crit Q5
EG Q1.1
Crit Q2
WS Q1.1
Crit Q1.1
Ground
Ineff
Bank Sta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Crit Q5
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Elevation (ft)
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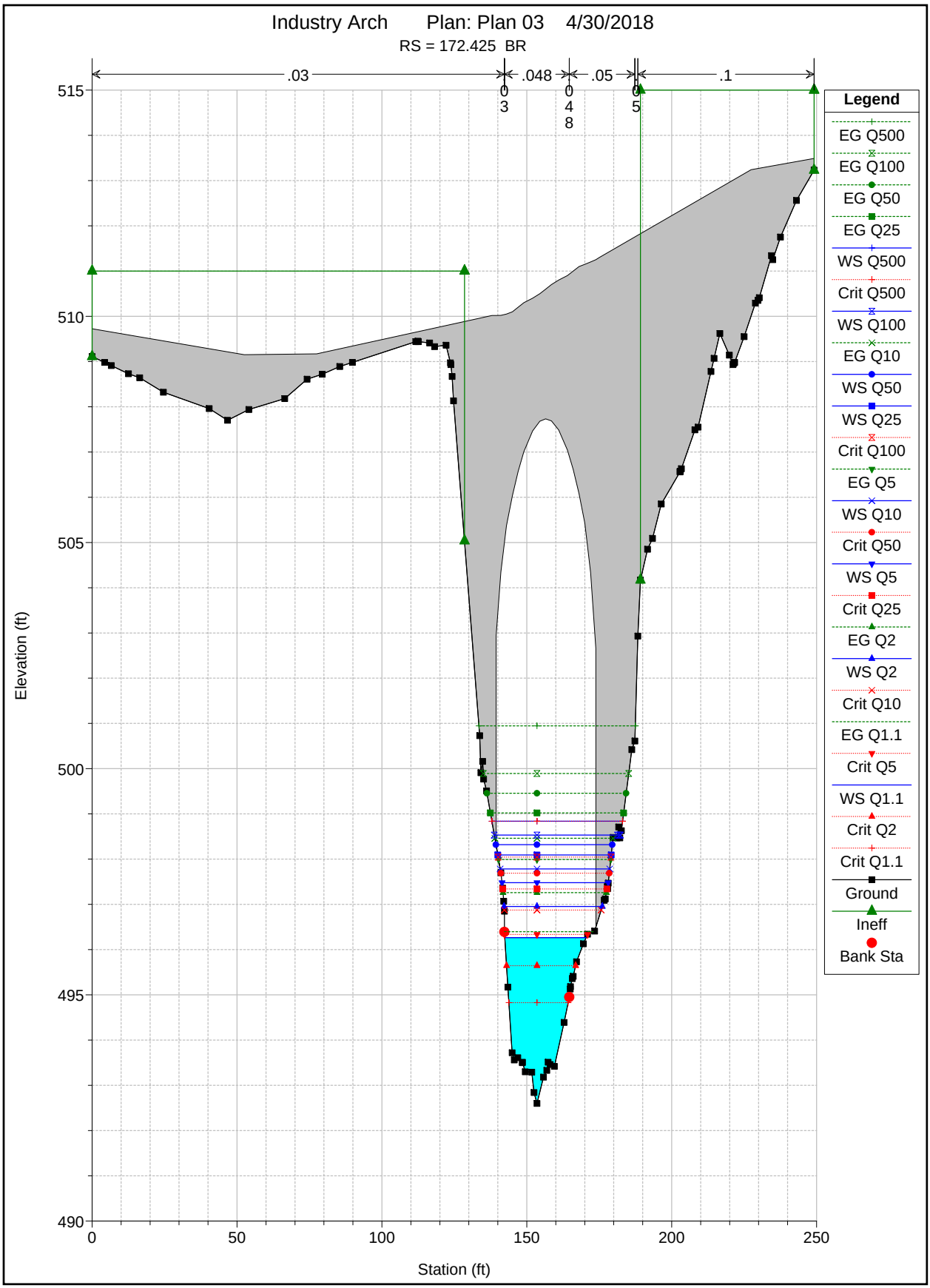
Station (ft)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Elevation (ft)
Station (ft)
Legend
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Crit Q500
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Crit Q1.1
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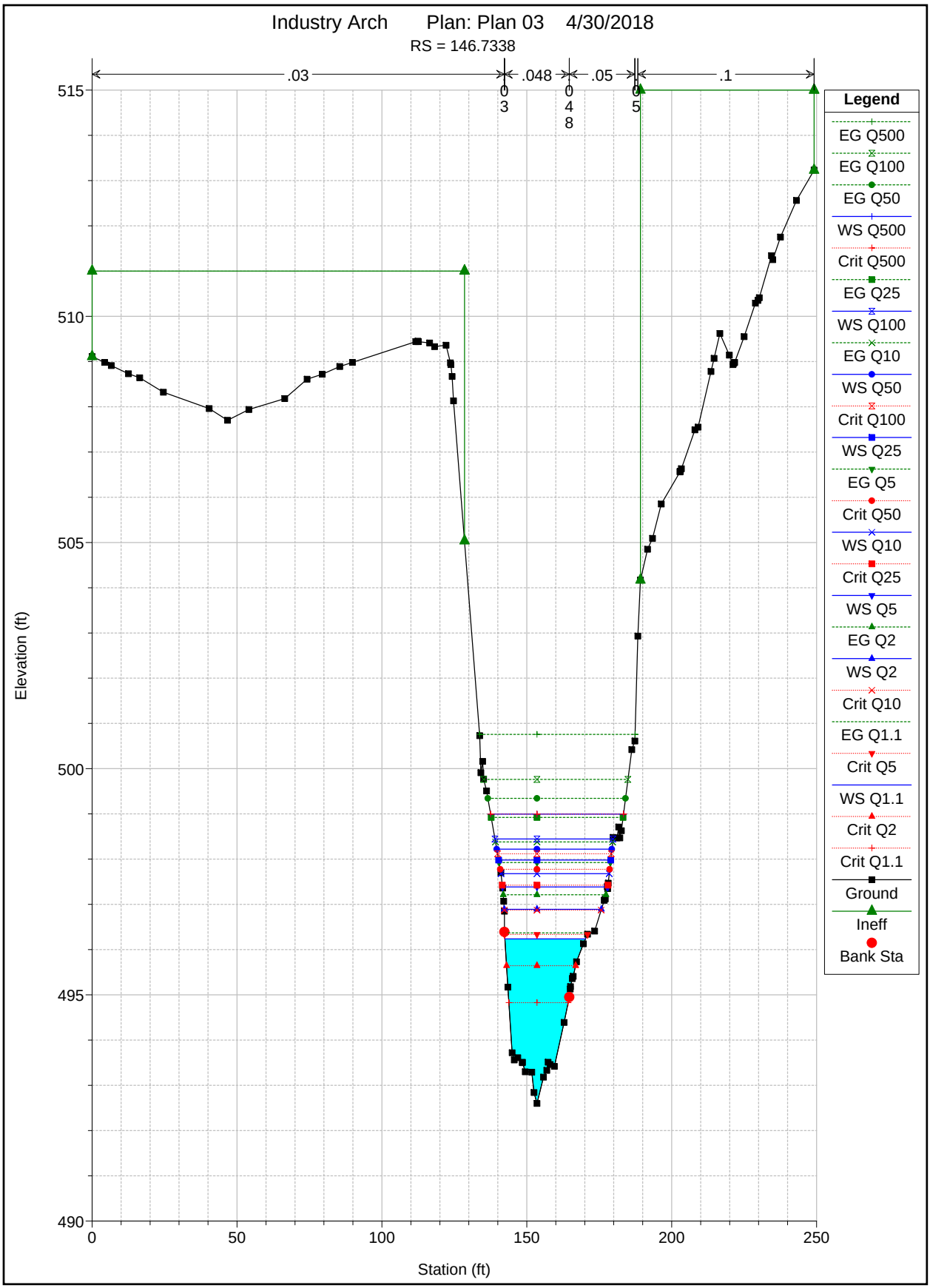
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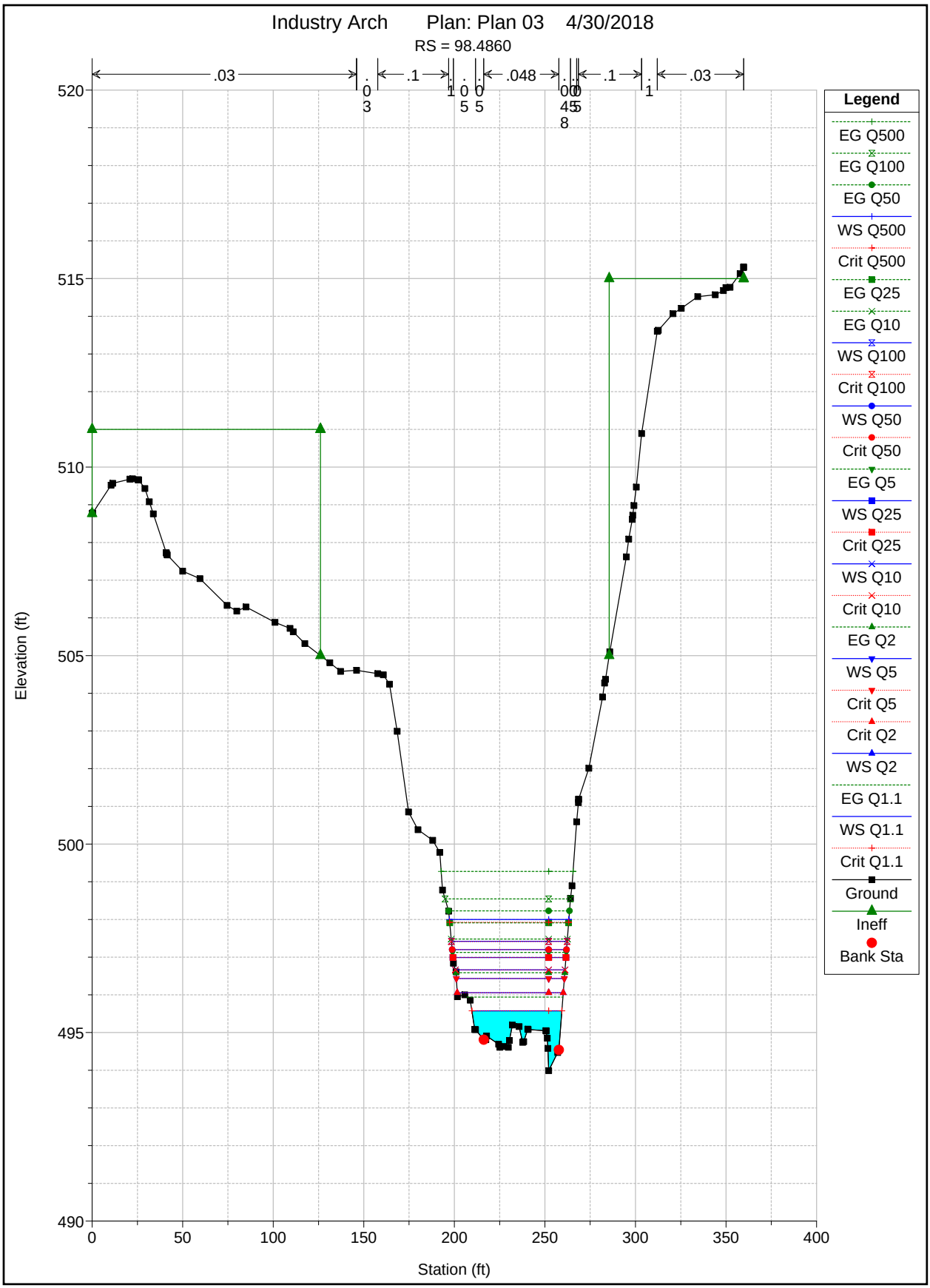
Station (ft)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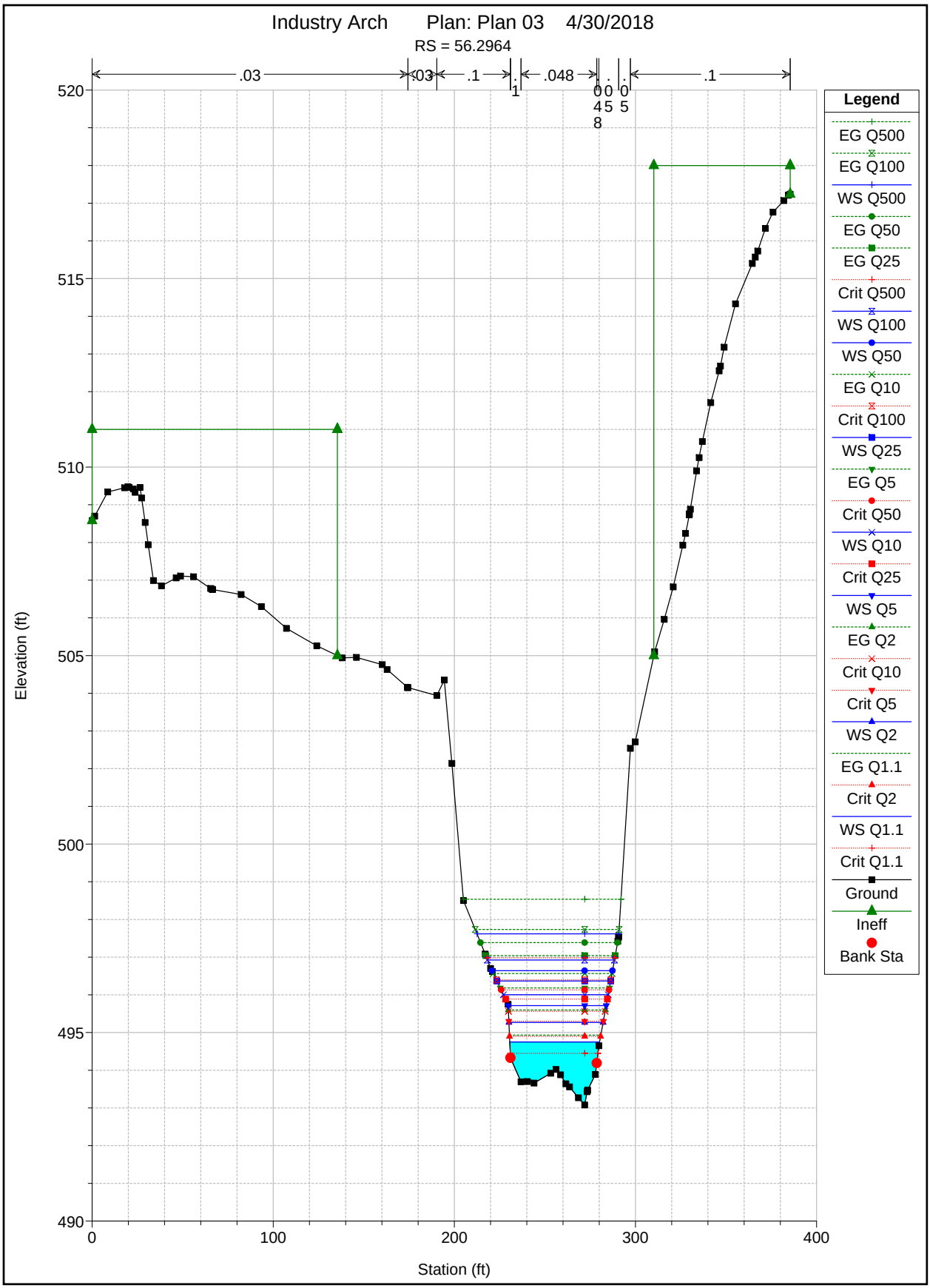
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WS Q10
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EG Q2
Crit Q10
Crit Q5
WS Q2
EG Q1.1
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Station (ft)
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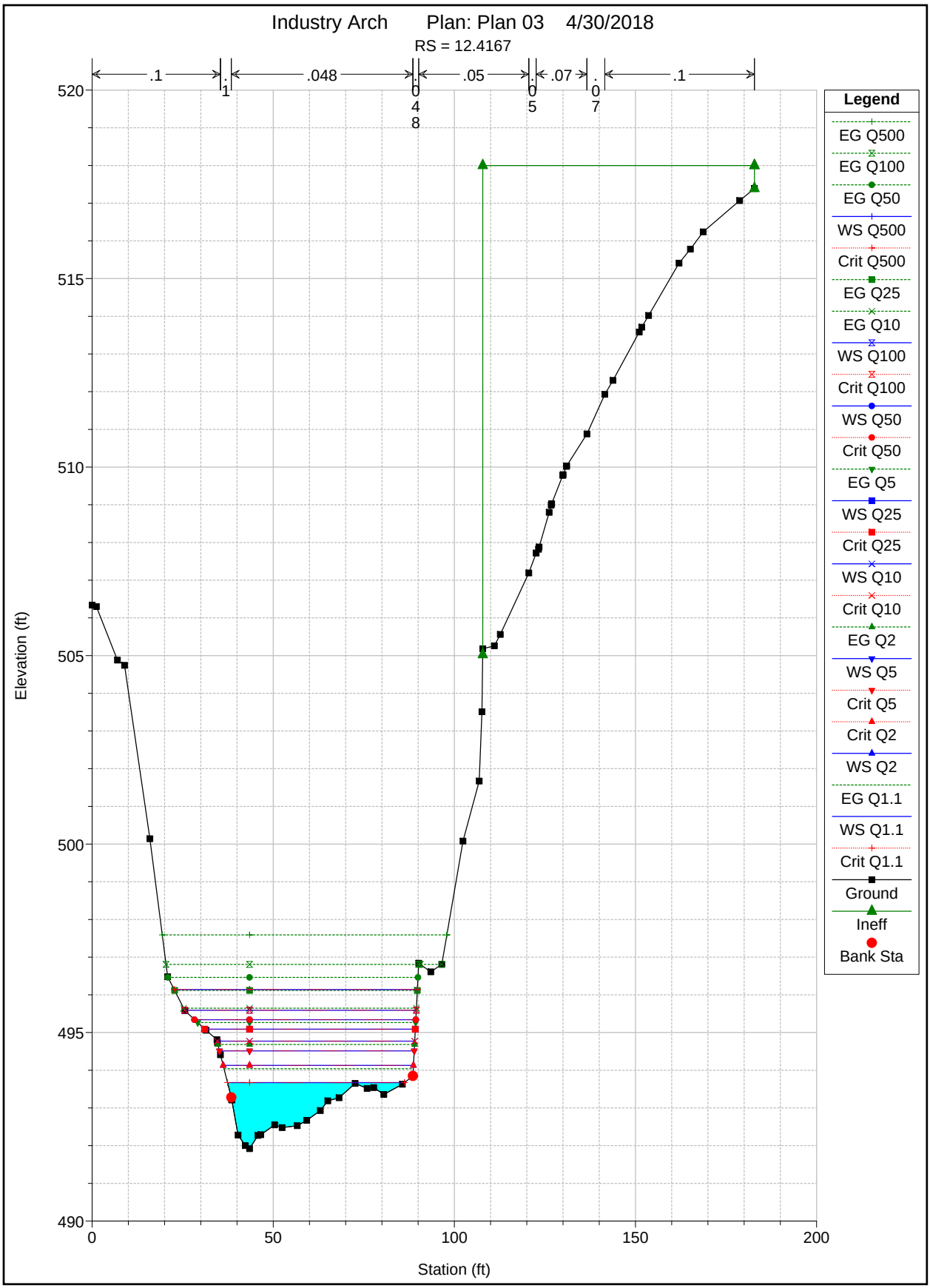
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100
150
200
Legend
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EG Q100
EG Q50
WS Q500
Crit Q500
EG Q25
EG Q10
WS Q100
Crit Q100
WS Q50
Crit Q50
EG Q5
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Crit Q25
WS Q10
Crit Q10
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WS Q2
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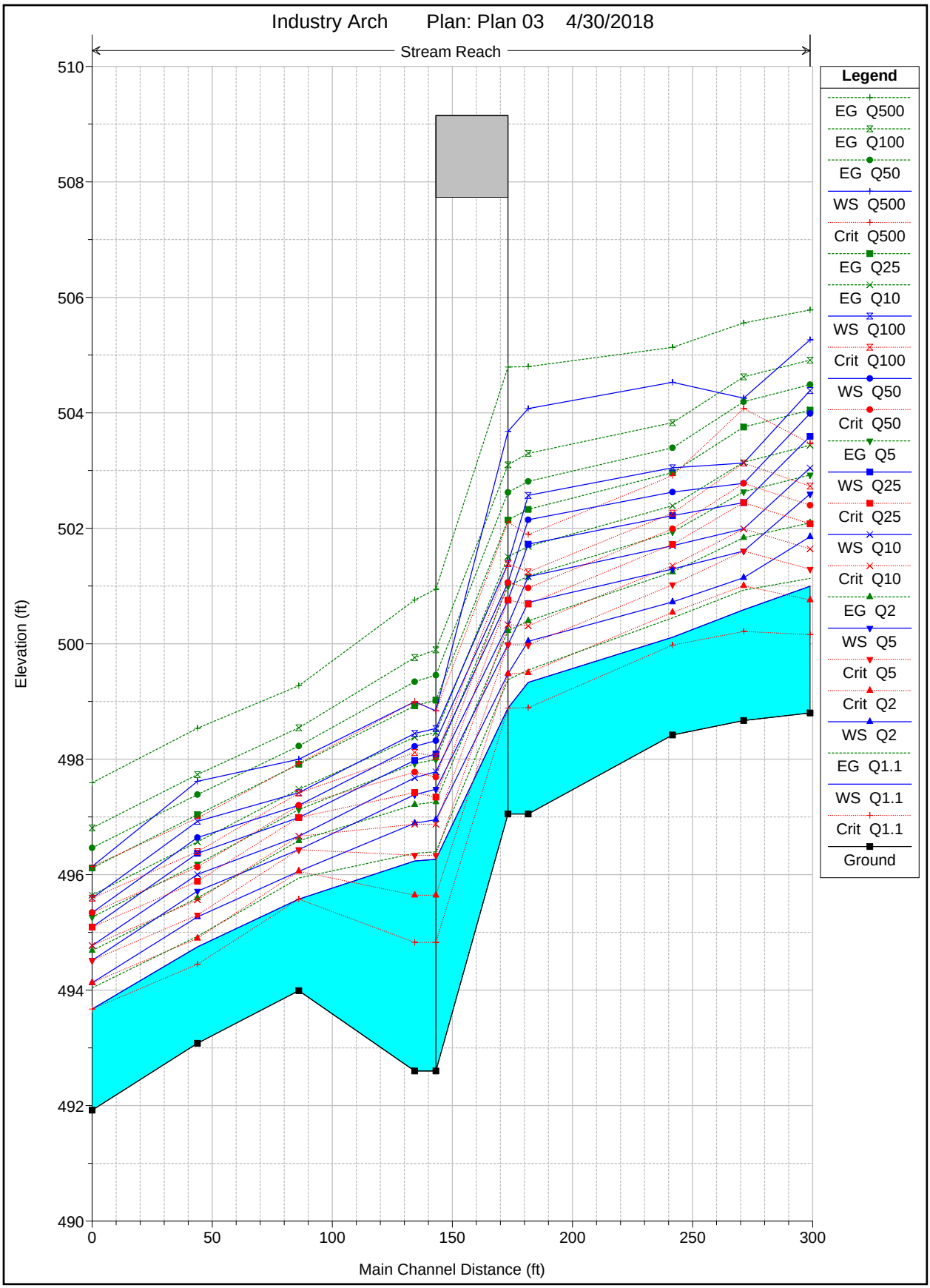
WS Q1.1
Crit Q1.1
Ground
Ineff
Bank Sta


Industry Arch Plan: Plan 03 4/30/2018
Stream Reach
Elevation (ft)
Main Channel Distance (ft)
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508
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502
500
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496
494
492
490
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100
150
200
250
300
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EG Q100
EG Q50
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EG Q10
WS Q100
Crit Q100
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Crit Q25
WS Q10
Crit Q10
EG Q2
WS Q5
Crit Q5
Crit Q2
WS Q2
EG Q1.1
WS Q1.1
Crit Q1.1
Ground

HEC-RAS Plan: Plan 03 River: Stream Reach: Reach

Reach	River Sta	Profile	E.G. US.	Min El Prs	BR Open Area	Prs O WS	Q Total	Min El Weir Flow	Q Weir	Delta EG	W.S. Elev
			(ft)	(ft)	(sq ft)	(ft)	(cfs)	(ft)	(cfs)	(ft)	(ft)
Reach	172.425	Q1.1	499.55	507.73	288.33		171.80	509.96		3.18	499.33
Reach	172.425	Q2	500.40	507.73	288.33		349.00	509.96		3.18	500.04
Reach	172.425	Q5	501.17	507.73	288.33		542.80	509.96		3.25	500.71
Reach	172.425	Q10	501.69	507.73	288.33		686.30	509.96		3.31	501.16
Reach	172.425	Q25	502.33	507.73	288.33		879.50	509.96		3.40	501.72
Reach	172.425	Q50	502.81	507.73	288.33		1034.50	509.96		3.47	502.15
Reach	172.425	Q100	503.30	507.73	288.33		1198.30	509.96		3.54	502.57
Reach	172.425	Q500	504.80	507.73	288.33		1608.10	509.96		4.04	504.07

HEC-RAS Plan: Plan 03 River: Stream Reach: Reach

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Crit W.S.	Frctn Loss	C & E Loss	Top Width	Q Left	Q Channel	Q Right	Vel Chnl
			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft/s)
Reach	254.0595	Q1.1	500.45	500.11	499.98	0.87	0.04	37.75	0.71	165.48	5.61	4.69
Reach	254.0595	Q2	501.24	500.72	500.54	0.80	0.05	42.37	7.82	326.85	14.33	5.90
Reach	254.0595	Q5	501.94	501.29	501.02	0.71	0.06	46.45	24.54	492.45	25.80	6.64
Reach	254.0595	Q10	502.39	501.70	501.35	0.65	0.05	47.67	43.53	607.38	35.39	6.94
Reach	254.0595	Q25	502.96	502.22	501.72	0.59	0.04	49.96	71.91	756.71	50.88	7.22
Reach	254.0595	Q50	503.40	502.63	501.99	0.55	0.03	52.83	96.16	872.25	66.09	7.38
Reach	254.0595	Q100	503.83	503.05	502.26	0.52	0.02	63.37	122.79	991.20	84.31	7.51
Reach	254.0595	Q500	505.13	504.53	502.91	0.32	0.01	105.24	174.67	1246.12	187.32	6.89
Reach	193.9825	Q1.1	499.55	499.33	498.89	0.14	0.03	39.82	0.04	170.07	1.69	3.74
Reach	193.9825	Q2	500.40	500.04	499.50	0.13	0.04	43.36	2.57	338.30	8.13	4.83
Reach	193.9825	Q5	501.17	500.71	499.98	0.12	0.06	44.24	9.47	515.75	17.58	5.54
Reach	193.9825	Q10	501.69	501.16	500.31	0.11	0.07	44.37	15.56	645.87	24.87	5.95
Reach	193.9825	Q25	502.33	501.72	500.69	0.11	0.08	44.54	24.15	820.71	34.64	6.42
Reach	193.9825	Q50	502.81	502.15	500.97	0.10	0.09	44.67	31.21	960.90	42.39	6.74
Reach	193.9825	Q100	503.30	502.57	501.24	0.10	0.10	44.79	38.74	1109.11	50.46	7.06
Reach	193.9825	Q500	504.80	504.07	501.89			45.26	60.07	1477.26	70.77	7.07
Reach	172.425 BR U	Q1.1	499.38	498.88	498.88	0.20	0.11	32.23		171.58	0.22	5.63
Reach	172.425 BR U	Q2	500.23	499.48	499.48	0.30	0.13	34.43		347.01	1.99	6.95
Reach	172.425 BR U	Q5	501.00	499.99	499.99	0.37	0.15	34.43		538.89	3.91	8.09
Reach	172.425 BR U	Q10	501.51	500.33	500.33	0.41	0.15	34.42		681.03	5.27	8.74
Reach	172.425 BR U	Q25	502.14	500.76	500.76	0.46	0.14	34.42		872.49	7.01	9.49
Reach	172.425 BR U	Q50	502.62	501.06	501.06	0.50	0.13	34.42		1026.16	8.34	10.06
Reach	172.425 BR U	Q100	503.10	501.39	501.39	0.53	0.11	34.42		1188.61	9.69	10.54
Reach	172.425 BR U	Q500	504.79	503.68	502.11			32.45		1597.56	10.54	8.50
Reach	172.425 BR D	Q1.1	496.40	496.26	494.83	0.02	0.00	28.05		168.77	3.03	2.93
Reach	172.425 BR D	Q2	497.26	496.95	495.64	0.04	0.00	31.68	0.01	331.40	17.59	4.54
Reach	172.425 BR D	Q5	497.99	497.48	496.34	0.06	0.00	32.39	0.36	501.43	41.01	5.92
Reach	172.425 BR D	Q10	498.46	497.78	496.87	0.07	0.00	33.02	1.22	625.18	59.90	6.83
Reach	172.425 BR D	Q25	499.02	498.09	497.34	0.09	0.00	33.86	3.32	790.62	85.56	8.03
Reach	172.425 BR D	Q50	499.46	498.32	497.69	0.11	0.00	34.43	6.19	921.11	107.20	8.89
Reach	172.425 BR D	Q100	499.89	498.53	498.05	0.12	0.01	34.43	10.39	1057.63	130.28	9.76
Reach	172.425 BR D	Q500	500.95	498.84	498.84			34.43	19.94	1403.12	185.04	12.18
Reach	146.7338	Q1.1	496.37	496.24	494.83	0.41	0.02	27.83		168.92	2.88	2.97
Reach	146.7338	Q2	497.21	496.89	495.64	0.61	0.02	33.52	0.01	332.99	16.01	4.66
Reach	146.7338	Q5	497.92	497.39	496.34	0.78	0.02	36.32	0.24	501.90	40.65	6.07
Reach	146.7338	Q10	498.38	497.68	496.88	0.89	0.01	37.36	0.91	621.98	63.42	6.97
Reach	146.7338	Q25	498.92	497.98	497.43	1.01	0.01	38.67	2.54	780.81	96.15	8.14
Reach	146.7338	Q50	499.34	498.22	497.78	1.09	0.03	39.73	4.99	903.65	125.86	8.92
Reach	146.7338	Q100	499.76	498.45	498.12	1.16	0.06	40.72	8.57	1031.31	158.42	9.69
Reach	146.7338	Q500	500.76	499.00	499.00	1.24	0.15	45.86	23.90	1345.88	238.32	11.34
Reach	98.4860	Q1.1	495.94	495.58	495.58	0.84	0.05	49.70	13.80	155.01	2.99	4.94
Reach	98.4860	Q2	496.59	496.06	496.06	0.79	0.06	58.54	32.90	308.84	7.25	6.02
Reach	98.4860	Q5	497.13	496.43	496.43	0.78	0.07	59.58	65.92	464.23	12.64	6.94
Reach	98.4860	Q10	497.48	496.66	496.66	0.78	0.08	60.49	91.96	577.24	17.10	7.55
Reach	98.4860	Q25	497.91	496.99	496.99	0.75	0.08	62.39	130.82	724.74	23.94	8.06
Reach	98.4860	Q50	498.23	497.20	497.20	0.74	0.09	63.13	163.96	840.88	29.66	8.53
Reach	98.4860	Q100	498.55	497.42	497.41	0.72	0.09	63.91	200.41	961.70	36.19	8.93
Reach	98.4860	Q500	499.27	498.00	497.93	0.63	0.11	65.94	297.66	1255.38	55.07	9.53