HYDROLOGY REPORT

The drainage basin characteristics for Gordon Bridge (#0836) in Garland on Avenue Road over Meadow Brook were provided by the Maine Department of Transportation Environmental Office - Hydrology Section. The flows were computed using the 1999 USGS full regression equation. No other flow data was available such as gage data and existing studies. Therefore, only the flows associated with the 1999 USGS full regression equation have been used in design. The following is a summary of the flow data used in design:

Summary

Drainage Area = 7.85 mi^2

Ordinary High Water ($Q_{1.1}$) = 130.5 cfs

10 Year Flood (Q_{10}) = 557.7 cfs

Design Discharge (Q_{50}) = 856.2 cfs

Check Discharge (Q_{100}) = 998.5 cfs

Q_{500} = 1354.1 cfs

Reported By: Richard E. Myers
Date: January 4, 2010

HYDRAULICS REPORT

(Existing Bridge)

Gordon Bridge (#0836) in Garland on Avenue Road over Meadow Brook was constructed sometime in the early 1970s. The bridge is a twin structural steel plate pipe arch structure consisting of (2) 11'-5" x 7'-3" pipe arches. The existing pipe arches are in poor condition with moderate to heavy rusting, pitting, and section loss below the waterline. There are also some areas of rust along the top of the pipe arches as well as efflorescence, particularly around the bolts. The pipe arches are also distorted which has likely caused the apparent gaps between some of the plate sections. Over time, undermining of the north culvert at the downstream end has created about an 8" drop from invert to streambed. Ice, debris, and flooding have not been a reported issue in the past.

The existing bridge was analyzed using HY-8, version 7.2, the culvert hydraulic analysis program distributed by the Federal Highway Administration. The hydraulic computations require only one representative downstream cross section. Following is a list of parameters used in the model:

Stream

- Cross section - Irregular; survey data was used to input stations and elevations of 13 points representing a typical downstream cross section. Bottom of streambed was set at an elevation of 328'.
- Stream slope - 0.0043 ft/ft
- Manning's "n" - 0.035 main channel
0.100 overbanks

Culverts

- Structural steel plate pipe arches: 136.8" x 86.9" (11.40' x 7.24')
- Slope = 0.0054 ft/ft
- Mitered ends
- Manning's "n" = 0.034

The results of the analysis are summarized below. Complete input and output is provided in the appendix of this report. The existing structure has an Hw/D (headwater elevation to culvert depth) ratio of 0.98 at Q50 which is larger than the recommended 0.90. Therefore, the structure is barely adequate and not up to current standards.

HYDRAULICS REPORT

(Proposed Bridge)

The original scope of the project was to rehabilitate the existing structure; therefore, the design team first analyzed invert and slipline options. Due to the deformations of the pipe arches as well as the condition of the top of the culverts described previously, it was decided that placing a concrete or composite invert would not provide enough extended life to justify this option.

The slipline option, which was driven by hydraulics, was evaluated using HY-8. The existing structure model discussed earlier was modified by adjusting the invert elevations at the ends of the culvert and changing the pipe arches to (2) 114.2" x 77.3" (9'-6" x 6'-5") which provided a 4" minimum clearance between the existing pipe arch and the slipline. This resulted in a 2'-0" increase in headwater at Q100 and an Hw/D ratio equal to 1.25 at Q50. According to FEMA regulations, a headwater increase of more than 1'-0" at Q100 is not allowed; therefore, the slipline option was deemed unacceptable and a replacement is necessary.

The replacement option was again analyzed using HY-8. In order to minimize the size and cost of the new structure, the design team determined that hydraulic conditions slightly better than existing would be adequate. In other words, an Hw/D ratio equal to 0.90-0.97 would be acceptable. This design exception was determined based on the fact that Avenue Road is a low volume road and that there has been no signs or reports of past flooding. The same stream parameters used in the existing structure model were also used in the proposed structure model. Following is a list of culvert input used for the proposed structure:

- Aluminum plate pipe arches: 151" x 89" (12'-7" span x 7'-5" rise)
- Slope = level
- Mitered ends
- Manning's "n" = 0.034

Aluminum pipe arches were used instead of steel due to the fact that the existing steel structure only lasted about 40 years. Aluminum pipe arches were used instead of a concrete structure in order to keep costs down. The above input resulted in an Hw/D ratio equal to an acceptable 0.96. However, the model does not account for the pipe arches being buried below streambed 1'-0". As a solution to this issue, it was determined that a 13'-1" x 8'-2" pipe arch buried 1'-0" has approximately the same area as the pipe arch used in the model. Therefore, it is recommended to use (2) 13'-1" x 8'-2" aluminum pipe arches. The results of the analysis are summarized below. Complete input and output is provided in the appendix of this report.

SUMMARY

	Existing Structure	Recommended Structure
	(2) 11'-5" x 7'-3" Stl. Pipe Arches	(2) 13'-1" x 8'-2" Alum. Pipe Arches
Total Area of Waterway Opening	128.0 ft^2	152.8 ft^2
Headwater Elevation @ $Q_{1.1}$	331.2 ft	330.6 ft
Headwater Elevation @ Q_{10}	334.4 ft	333.5 ft
Headwater Elevation @ Q_{25}	335.3 ft	334.5 ft
Headwater Elevation @ Q_{50}	336.1 ft	335.2 ft
Headwater Elevation @ Q_{100}	337.0 ft	335.9 ft
Headwater Elevation @ Q_{500}	339.2 ft	338.3 ft
Hw/D @ Q_{50}	0.98	0.96
Discharge Velocity @ $Q_{1.1}$	4.7 ft/s	2.5 ft/s
Discharge Velocity @ Q_{10}	7.3 ft/s	5.5 ft/s
Discharge Velocity @ Q_{25}	8.1 ft/s	6.3 ft/s
Discharge Velocity @ Q_{50}	8.7 ft/s	6.9 ft/s
Discharge Velocity @ Q_{100}	9.4 ft/s	7.5 ft/s
Discharge Velocity @ Q_{500}	10.8 ft/s	9.3 ft/s

Reported By: Richard E. Myers
Date: January 5, 2010

Plain riprap will be used on the upstream and downstream side-slopes in order to protect against erosion from road surface water runoff and stream flood water. Riprap aprons will be used on the upstream end of the culverts as well to protect against undermining of the culverts. On the downstream end, the natural bedrock will act as protection against undermining.

Note: All elevations based on North American Vertical Datum (NAVD) of 1988. Elevations based on the National Geodetic Vertical Datum (NGVD) of 1929 were converted to NAVD by subtracting 0.604 feet.

APPENDIX C

Hydrology & Hydraulics Data

Project Name:	GARLAND GORDON BRIDGE #0836	**PIN:**	17087
Stream Name:	Meadow Brook	**Town:**	Garland
Bridge Name:	Gordon Br	**Bridge No.**	0836
Route No.	Valley Avenue Rd	**USGS Quad:**	
Analysis by:	CSH	**Date:**	12/9/2009

Peak Flow Calculations by USGS Regression Equations (Hodgkins, 1999)

Enter data in blue cells only!

	km^2	mi^2	ac	***Enter data in [mi^2]***
A	20.34	7.853	5026.1	Watershed Area
W	1.92	0.741	474.4	Wetlands area (by NWI)
P_c	482200	4986500		watershed centroid (E, N; UTM 19N; meters)
County	Penobscot S			*choose county from drop-down menu*
pptA	39.5			mean annual precipitation (inches; by look-up)
SG	0.00			sand & gravel aquifer as decimal fraction of watershed A

A (km^2)	20.34	**Conf Lvl**	0.67
W (%)	9.44		

Worksheet prepared by:
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Chief Hydrologist
Maine Dept. Transportation
Augusta, ME 04333-0016
207-287-1105
Charles.Hebson@maine.gov

Ret Pd T (yr)	Peak Flow Estimate Lower	Q_T (m^3/s)	Upper	Q_T (ft^3/s)
1.1		3.70		130.5
2	5.54	7.76	10.87	274.0
5	8.77	12.34	17.37	435.9
10	11.11	15.79	22.45	557.7
25	14.22	20.51	29.59	724.2
50	16.60	24.25	35.41	856.2
100	19.12	28.28	41.82	998.5
500	25.09	38.35	58.61	1354.1

Reference:

Hodgkins, G., 1999.
Estimating the magnitude of peak flows for streams in Maine for selected recurrence intervals
Water-Resources Investigations Report 99-4008
US Geological Survey, Augusta, Maine

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

PRELIM. BY REM DATE 12/11/09 PROJ. NO. 17087.00 FILE NO. ____ OF ____
FINAL CHK. BY ____ DATE ____ LOCATION GARLAND SH. NO. ____ OF ____
ITEM NO. ____ SUBJECT HYDRAULIC COMPS. FOR SLIPLINE

STREAM SLOPE

→ AVERAGE SLOPE, USING GOOGLE EARTH TO DETERMINE LENGTH, AND THE USGS MAP TO DETERMINE ELEVATION,

$\frac{329' - 312'}{4000'}$ ELEVATION DIFFERENCE / APPROX. LENGTH = 0.00425

TYPICAL CROSS SECTION

→ DOWNSTREAM

- SEE MICROSTATION PLOT W/ ELEVATIONS WRITTEN ON.

EXISTING RESULTS

→ SEE HY-8 OUTPUT

INLET INVERT ELEV. = 329.00

HEADWATER ELEV. @ Q50 = 336.11'

ELEV. OF TOP OF PIPE = 329 + 7'-3" = 336'-3"

$\frac{336.11' - 329'}{7'-3"} = 0.98$

SLIPLINE NOTES

→ EXISTING: APPROXIMATELY A 11'-5" × 7'-3" PIPE ARCH

→ TRY SLIPLINING W/ A 9'-6" (114") × 6'-5" (77") PIPE ARCH

→ SEE HY-8 OUTPUT

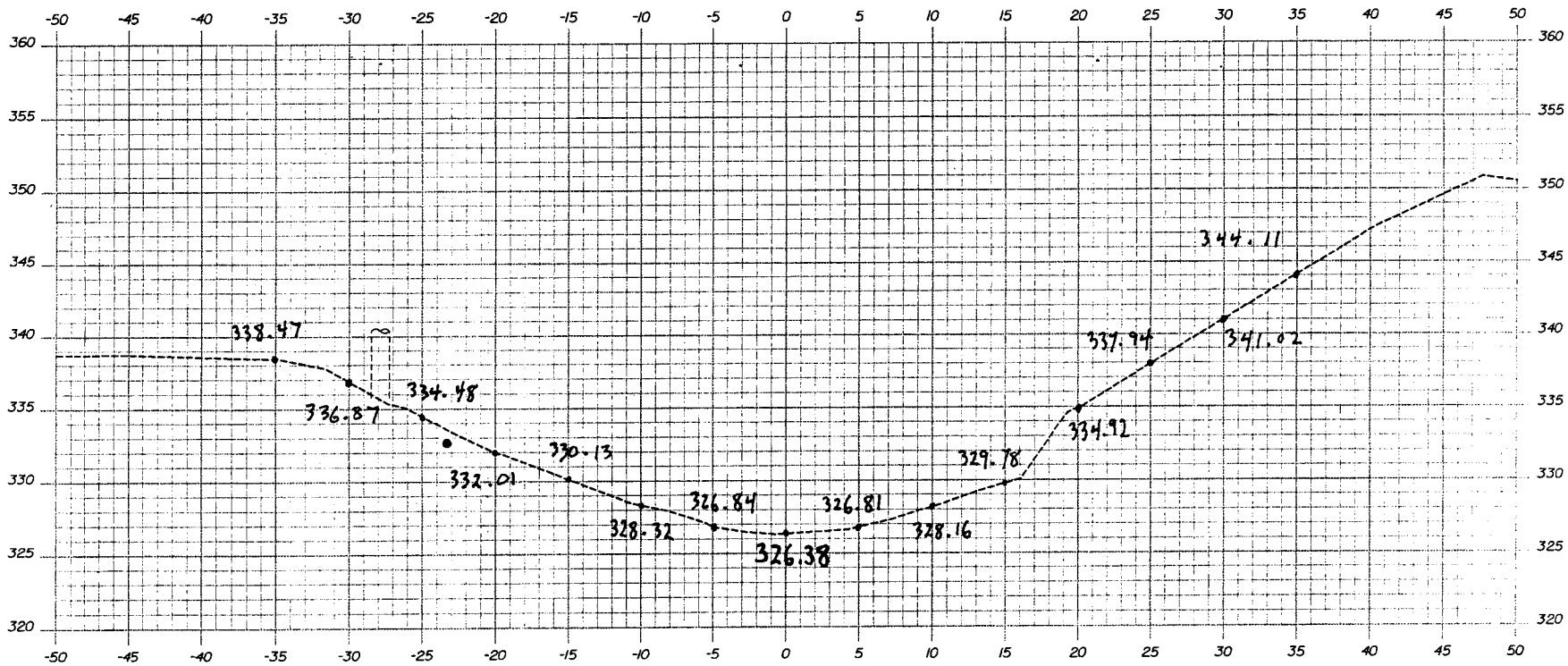
INLET INVERT ELEV. = 329'-5"

HEADWATER ELEV. @ Q50 = 337.43'

$\frac{337.43' - 329.42'}{6'-5"} = 1.25$ → HW/D

337.43' - 336.11' = 1.32' → INCREASE IN H.W.

DOWNSTREAM CROSS SECTION - STATIONS AND ELEVATIONS



HY-8 Culvert Analysis Report

Existing Pipe Arches

Table 1 - Summary of Culvert Flows at Crossing: Gordon Bridge

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
331.23	Q1.1 130.50	130.50	0.00	1
331.95	217.30	217.30	0.00	1
332.68	304.10	304.10	0.00	1
333.29	390.90	390.90	0.00	1
333.85	477.70	477.70	0.00	1
334.39	564.50	564.50	0.00	1
334.91	651.30	651.30	0.00	1
335.43	738.10	738.10	0.00	1
335.93	824.90	824.90	0.00	1
336.11	Q50 856.20	856.20	0.00	1
336.95	Q100 998.50	998.50	0.00	1
338.67	1260.22	1260.22	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
130.50	130.50	331.23	2.167	2.233	3-M2t	1.877	1.441	1.617	2.317	4.726	3.926
217.30	217.30	331.95	2.798	2.947	3-M2t	2.499	1.830	2.220	2.920	4.930	4.530
304.10	304.10	332.68	3.331	3.679	3-M2t	3.083	2.208	2.717	3.417	5.901	4.926
390.90	390.90	333.29	3.922	4.289	3-M2t	3.624	2.518	3.148	3.848	6.390	5.238
477.70	477.70	333.85	4.389	4.847	3-M2t	4.179	2.829	3.535	4.235	6.859	5.505
564.50	564.50	334.39	4.821	5.391	3-M2t	4.778	3.098	3.891	4.591	7.309	5.734
651.30	651.30	334.91	5.242	5.913	3-M2t	5.480	3.356	4.223	4.923	7.745	5.935
738.10	738.10	335.43	5.667	6.426	3-M2t	7.242	3.614	4.536	5.236	8.172	6.114
824.90	824.90	335.93	6.111	6.932	3-M2t	7.242	3.839	4.832	5.532	8.592	6.275
856.20	856.20	336.11	6.277	7.113	3-M2t	7.242	3.920	4.935	5.635	8.743	6.329
998.50	998.50	336.95	7.093	7.948	3-M2t	7.242	4.288	5.381	6.081	9.432	6.561

****

Inlet Elevation (invert): 329.00 ft, Outlet Elevation (invert): 328.70 ft

Culvert Length: 56.00 ft, Culvert Slope: 0.0054

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 329.00 ft

Outlet Station: 56.00 ft

Outlet Elevation: 328.70 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Pipe Arch

Barrel Span: 136.80 in - 11.40'

Barrel Rise: 86.90 in - 7.24'

Barrel Material: Steel Structural Plate

Embedment: 0.00 in

Barrel Manning's n: 0.0340

Inlet Type: Conventional

Inlet Edge Condition: Mitered

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Gordon Bridge)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
130.50	330.32	2.32	3.93	0.62	0.57
217.30	330.92	2.92	4.53	0.78	0.59
304.10	331.42	3.42	4.93	0.92	0.60
390.90	331.85	3.85	5.24	1.03	0.59
477.70	332.24	4.24	5.50	1.14	0.59
564.50	332.59	4.59	5.73	1.23	0.59
651.30	332.92	4.92	5.94	1.32	0.59
738.10	333.24	5.24	6.11	1.40	0.59
824.90	333.53	5.53	6.28	1.48	0.59
856.20	333.63	5.63	6.33	1.51	0.58
998.50	334.08	6.08	6.56	1.63	0.58

Tailwater Channel Data - Gordon Bridge

Tailwater Channel Option: Irregular Channel

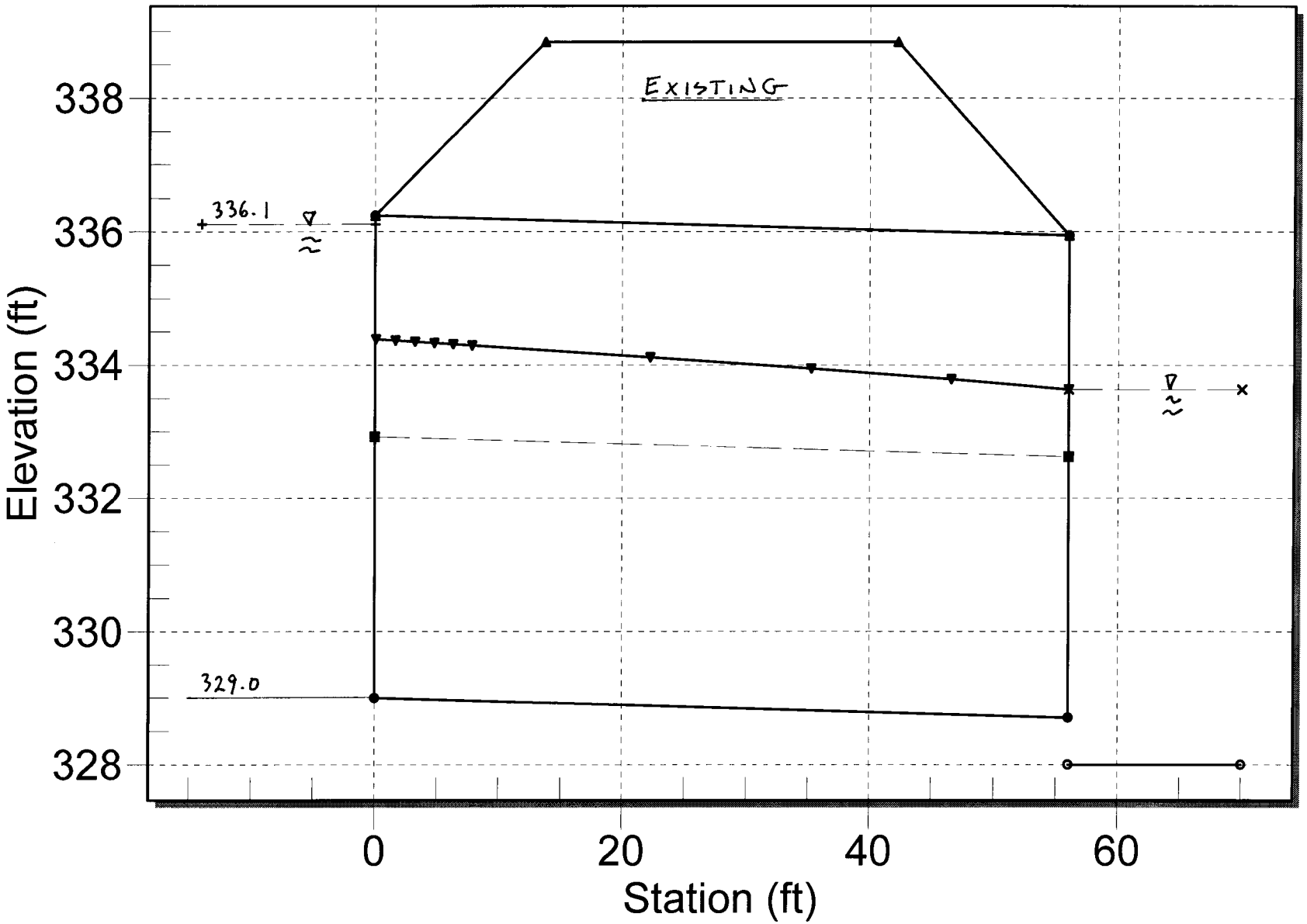
Channel Slope: 0.0043

User Defined Channel Cross-Section:

Coord No.	Station (ft)	Elevation (ft)	Manning's n
1	-30.00	338.49	0.1000
2	-25.00	336.10	0.1000
3	-20.00	333.63	0.1000
4	-15.00	331.75	0.1000
5	-10.00	329.94	0.0350
6	-5.00	328.46	0.0350
7	0.00	328.00	0.0350
8	5.00	328.43	0.0350
9	10.00	329.78	0.1000
10	15.00	331.40	0.1000
11	20.00	336.54	0.1000
12	25.00	339.56	0.1000
13	30.00	342.64	0.0000

Crossing - Gordon Bridge, Design Discharge - 856.2 cfs

Culvert - Culvert 1, Culvert Discharge - 856.2 cfs (Q50)



HY-8 Culvert Analysis Report

Slipline

Table 1 - Summary of Culvert Flows at Crossing: Gordon Bridge

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
331.79	Q1.1 130.50	130.50	0.00	1
332.64	217.30	217.30	0.00	1
333.37	304.10	304.10	0.00	1
334.04	390.90	390.90	0.00	1
334.68	477.70	477.70	0.00	1
335.31	564.50	564.50	0.00	1
335.93	651.30	651.30	0.00	1
336.56	738.10	738.10	0.00	1
337.20	824.90	824.90	0.00	1
337.43	Q50 856.20	856.20	0.00	1
338.92	Q100 998.50	986.62	11.78	9
338.67	987.53	987.53	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
130.50	130.50	331.79	2.138	2.367	2-M2c	2.011	1.403	1.400	2.317	5.510	3.926
217.30	217.30	332.64	3.040	3.219	2-M2c	2.744	1.903	1.809	2.920	6.272	4.530
304.10	304.10	333.37	3.701	3.947	3-M2t	3.453	2.289	2.297	3.417	8.053	4.926
390.90	390.90	334.04	4.261	4.624	3-M2t	4.205	2.654	2.728	3.848	8.523	5.238
477.70	477.70	334.68	4.796	5.265	3-M2t	5.127	2.977	3.115	4.235	9.014	5.505
564.50	564.50	335.31	5.348	5.892	3-M2t	6.442	3.289	3.471	4.591	9.505	5.734
651.30	651.30	335.93	5.949	6.509	3-M2t	6.442	3.570	3.803	4.923	9.995	5.935
738.10	738.10	336.56	6.618	7.135	3-M2t	6.442	3.851	4.116	5.236	10.485	6.114
824.90	824.90	337.20	7.365	7.782	3-M2t	6.442	4.096	4.412	5.532	10.978	6.275
856.20	856.20	337.43	7.654	8.014	3-M2t	6.442	4.184	4.515	5.635	11.158	6.329
998.50	986.62	338.92	8.969	10.833	7-M2t	6.442	4.543	4.961	6.081	11.850	6.561

****

Inlet Elevation (invert): 329.42 ft, Outlet Elevation (invert): 329.12 ft

Culvert Length: 56.00 ft, Culvert Slope: 0.0054

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 329.42 ft

Outlet Station: 56.00 ft

Outlet Elevation: 329.12 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Pipe Arch

Barrel Span: 114.20 in - 9.52'

Barrel Rise: 77.30 in - 6.44'

Barrel Material: Steel Structural Plate

Embedment: 0.00 in

Barrel Manning's n: 0.0340

Inlet Type: Conventional

Inlet Edge Condition: Mitered

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Gordon Bridge)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
130.50	330.32	2.32	3.93	0.62	0.57
217.30	330.92	2.92	4.53	0.78	0.59
304.10	331.42	3.42	4.93	0.92	0.60
390.90	331.85	3.85	5.24	1.03	0.59
477.70	332.24	4.24	5.50	1.14	0.59
564.50	332.59	4.59	5.73	1.23	0.59
651.30	332.92	4.92	5.94	1.32	0.59
738.10	333.24	5.24	6.11	1.40	0.59
824.90	333.53	5.53	6.28	1.48	0.59
856.20	333.63	5.63	6.33	1.51	0.58
998.50	334.08	6.08	6.56	1.63	0.58

Tailwater Channel Data - Gordon Bridge

Tailwater Channel Option: Irregular Channel

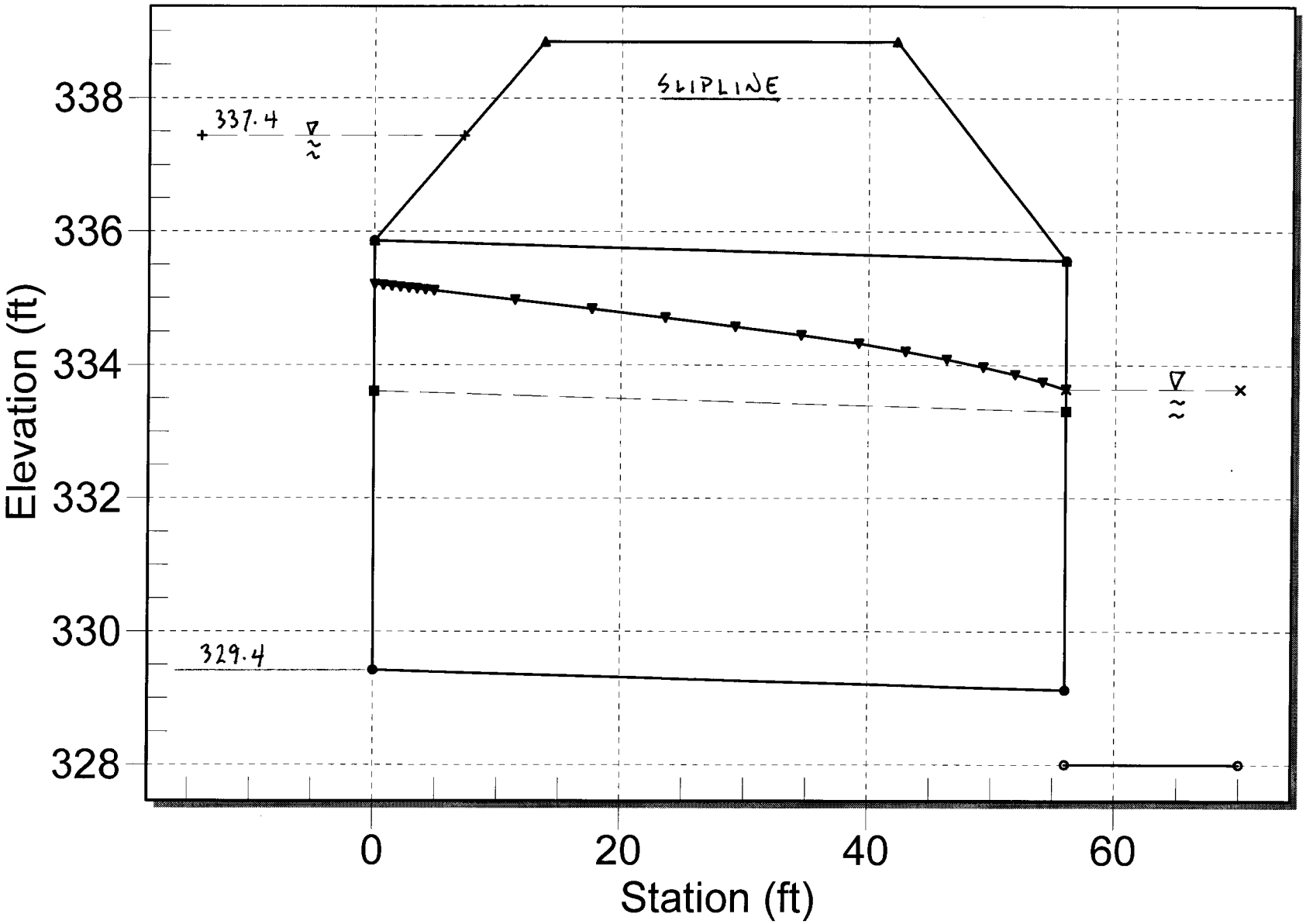
Channel Slope: 0.0043

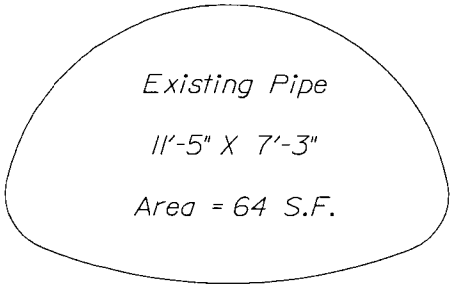
User Defined Channel Cross-Section:

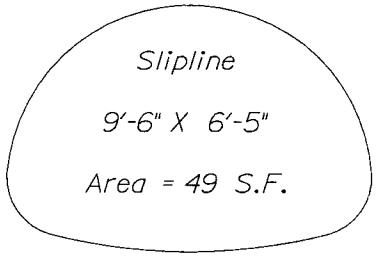
Coord No.	Station (ft)	Elevation (ft)	Manning's n
1	-30.00	338.49	0.1000
2	-25.00	336.10	0.1000
3	-20.00	333.63	0.1000
4	-15.00	331.75	0.1000
5	-10.00	329.94	0.0350
6	-5.00	328.46	0.0350
7	0.00	328.00	0.0350
8	5.00	328.43	0.0350
9	10.00	329.78	0.1000
10	15.00	331.40	0.1000
11	20.00	336.54	0.1000
12	25.00	339.56	0.1000
13	30.00	342.64	0.0000

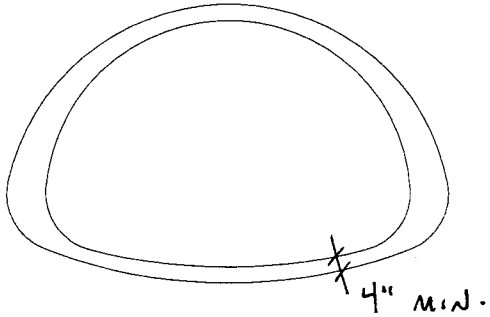
Crossing - Gordon Bridge, Design Discharge - 856.2 cfs

Culvert - Culvert 1, Culvert Discharge - 856.2 cfs (Q50)




Existing Pipe
11'-5" X 7'-3"
Area = 64 S.F.


Slipline
9'-6" X 6'-5"
Area = 49 S.F.


4" MIN.

PRELIM. BY REM DATE 12/29/09 PROJ. NO. 17087.00 FILE NO. ____ OF ____
FINAL CHK. BY ____ DATE ____ LOCATION GARLAND SH. NO. ____ OF ____
ITEM NO. ____ SUBJECT ALUMINUM PIPE ARCH PROPOSED

ALUMINUM PIPE ARCH

FROM HY-8, USING (2) 13'-1" x 8'-2" PIPE ARCHES,

Q50 H.W. ELEV. = 335.08'

ASSUME INVERT ELEV. = STREAM BED ELEV.,

TO DETERMINE IF AREA IS ADEQUATE

INVERT ELEV. = 328.0'

$\frac{H_w}{D} = \frac{335.08' - 328'}{8'-2''} = 0.87 < 0.90$ ok

AREA OF PIPE ARCH = 83 S.F.

★ HOWEVER, PIPE ARCHES WILL BE BURIED 1'-0", AND HY-8 DOES NOT ACCURATELY ACCOUNT FOR THIS, THEREFORE DETERMINE WHAT PIPE SIZE HAS AN EQUAL AREA (83 S.F.) OR LARGER WHEN BURIED 1'-0".

MICROSTATION WAS USED TO DETERMINE THAT:

13'-11" x 8'-5" PIPE ARCH BURIED 1'-0"

HAS AN AREA = 84 S.F.

★ SEE ATTACHED OUTPUT & DWGS.

→ REVISED ON 1/4/10, SEE REVISION

PRELIM. BY REM DATE 1/4/10 PROJ. NO. 17087.00 FILE NO. ____ OF ____
FINAL CHK. BY ____ DATE ____ LOCATION GARLAND SH. NO. ____ OF ____
ITEM NO. ____ SUBJECT ALUMINUM PIPE ARCH PROPOSED

* REVISION

ALLOW H_w/D = 0.97 OR LESS

FOLLOW SAME PROCEDURE USED BEFORE

FROM HY-8, USING (2) 12'-7" x 7'-5" ALUM. PIPE ARCHES,

Q50 H.W. ELEV. = 335.15'

$\frac{H_w}{D} = \frac{335.15' - 328'}{7'-5''} = 0.96$ ok

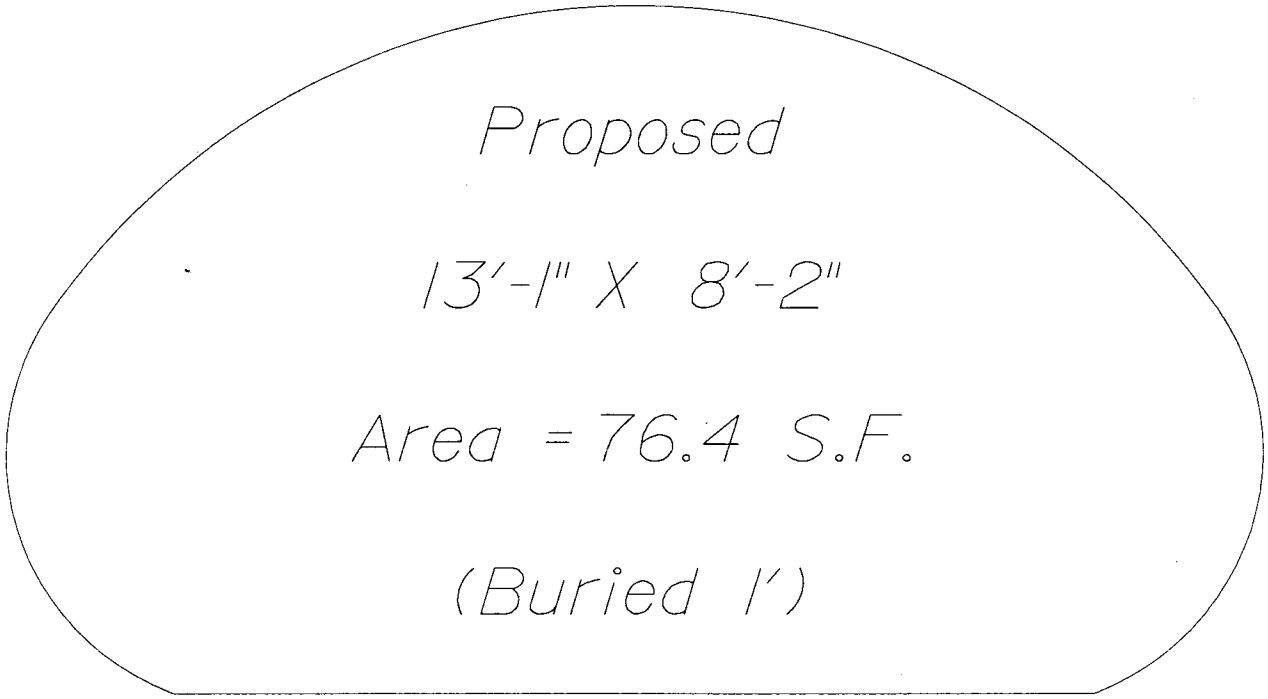
AREA OF ONE PIPE ARCH = 73.7 ft^2

USING MICROSTATION, IT WAS DETERMINED THAT A 13'-1" x 8'-2" PIPE ARCH PROVIDES AN AREA OF 76.4 ft^2 WHEN BURIED 1'-0"

→ THIS SIZE IS 2 SIZES LARGER THAN THE SIZE USED IN HY-8

∴ USE (2) 13'-1" x 8'-2" ALUM. PIPE ARCHES

* SEE ATTACHED OUTPUT + SKETCH


Proposed
13'-1" X 8'-2"
Area = 76.4 S.F.
(Buried 1')

HY-8 Culvert Analysis Report

Replacement
Twin Aluminum Pipe Arches

Table 1 - Summary of Culvert Flows at Crossing: Gordon Bridge

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
330.56	Q1.1 130.50	130.50	0.00	1
331.23	217.30	217.30	0.00	1
331.95	304.10	304.10	0.00	1
332.58	390.90	390.90	0.00	1
333.09	477.70	477.70	0.00	1
333.59	564.50	564.50	0.00	1
334.06	651.30	651.30	0.00	1
334.53	738.10	738.10	0.00	1
334.99	824.90	824.90	0.00	1
335.15	Q50 856.20	856.20	0.00	1
335.91	Q100 998.50	998.50	0.00	1
338.67	1418.75	1418.75	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
130.50	130.50	330.56	2.147	2.550	3-M2t	5.045	1.324	2.317	2.317	2.455	3.926
217.30	217.30	331.23	2.781	3.220	3-M2t	7.417	1.721	2.920	2.920	2.907	4.530
304.10	304.10	331.95	3.296	3.936	3-M2t	7.417	2.055	3.417	3.417	4.204	4.926
390.90	390.90	332.58	3.754	4.566	3-M2t	7.417	2.342	3.848	3.848	4.675	5.238
477.70	477.70	333.09	4.221	5.082	3-M2t	7.417	2.582	4.235	4.235	5.118	5.505
564.50	564.50	333.59	4.654	5.577	3-M2t	7.417	2.823	4.591	4.591	5.539	5.734
651.30	651.30	334.06	5.067	6.051	3-M2t	7.417	3.109	4.923	4.923	5.945	5.935
738.10	738.10	334.53	5.475	6.516	3-M2t	7.417	3.467	5.236	5.236	6.343	6.114
824.90	824.90	334.99	5.886	6.977	3-M2t	7.417	3.770	5.532	5.532	6.736	6.275
856.20	856.20	335.15	6.037	7.136	3-M2t	7.417	3.839	5.635	5.635	6.877	6.329
998.50	998.50	335.91	6.756	7.900	3-M2t	7.417	4.152	6.081	6.081	7.525	6.561

****

Inlet Elevation (invert): 328.01 ft, Outlet Elevation (invert): 328.00 ft

Culvert Length: 56.00 ft, Culvert Slope: 0.0002

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 328.01 ft

Outlet Station: 56.00 ft

Outlet Elevation: 328.00 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Pipe Arch

Barrel Span: 151.00 in - 12.58'

Barrel Rise: 89.00 in - 7.42'

Barrel Material: Aluminum Structural Plate

Embedment: 0.00 in

Barrel Manning's n: 0.0340

Inlet Type: Conventional

Inlet Edge Condition: Mitered

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Gordon Bridge)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
130.50	330.32	2.32	3.93	0.62	0.57
217.30	330.92	2.92	4.53	0.78	0.59
304.10	331.42	3.42	4.93	0.92	0.60
390.90	331.85	3.85	5.24	1.03	0.59
477.70	332.24	4.24	5.50	1.14	0.59
564.50	332.59	4.59	5.73	1.23	0.59
651.30	332.92	4.92	5.94	1.32	0.59
738.10	333.24	5.24	6.11	1.40	0.59
824.90	333.53	5.53	6.28	1.48	0.59
856.20	333.63	5.63	6.33	1.51	0.58
998.50	334.08	6.08	6.56	1.63	0.58

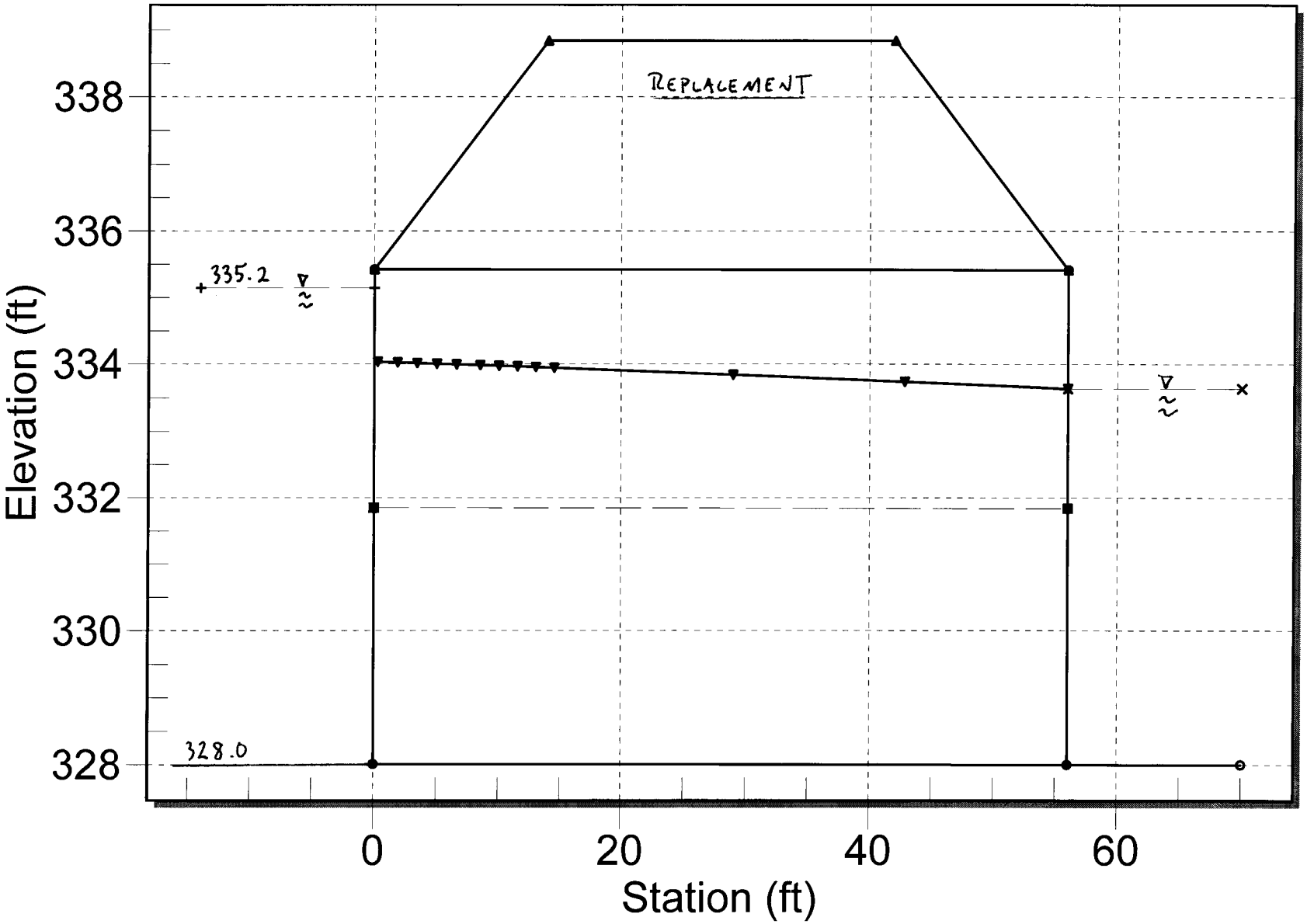
Tailwater Channel Data - Gordon Bridge

Tailwater Channel Option: Irregular Channel

Channel Slope: 0.0043

User Defined Channel Cross-Section:

Coord No.	Station (ft)	Elevation (ft)	Manning's n
1	-30.00	338.49	0.1000
2	-25.00	336.10	0.1000
3	-20.00	333.63	0.1000
4	-15.00	331.75	0.1000
5	-10.00	329.94	0.0350
6	-5.00	328.46	0.0350
7	0.00	328.00	0.0350
8	5.00	328.43	0.0350
9	10.00	329.78	0.1000
10	15.00	331.40	0.1000
11	20.00	336.54	0.1000
12	25.00	339.56	0.1000
13	30.00	342.64	0.0000

Crossing - Gordon Bridge, Design Discharge - 856.2 cfs

Culvert - Culvert 1, Culvert Discharge - 856.2 cfs (Q50)