ARCH CULVERT DESIGN

FOR

STANISLAW OLEKSENKO

SUBDIVISION OF PROPERTY
AT
#11 CONE ROAD
EAST HAMPTON, CONNECTICUT

PREPARED BY

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PROJECT NARRATIVE

The property fronts along Cone Road and contains 14.766 acres with an existing single family residential dwelling. The eastern part of the site contains extensive wetland areas including a brook corridor that runs north / south thru the property with considerable ground elevation change on the area located west of the brook corridor.

The project proposes to subdivide the parcel into four lots, all to be served by individual on-site wells and subsurface sewage disposal systems. The three new lots will be accessed by a shared private driveway, starting at Cone Road and is 460 ft long terminating in a large circular turnaround. This driveway crosses a small brook to access the western part of the property and proposes to use an aluminum plate arch culvert at this crossing using the brook's natural channel bed.

STORMWATER ANALYSIS & METHODOLOGY

The purpose of this report is to determine the peak flow rate from a 50 year rainfall event and determine the hydraulic conditions as this flow rate passes thru the arch culvert.

The analysis uses the unit hydrograph method in the SCS TR-55 program by Intellisolve to determine the watershed conditions for the arch culvert including time of concentration and peak flow rate using the current NOAA rainfall frequency tables for the East Hampton address for this site. Time of concentration, Tc, has been determined for each watershed using the TR-55 method. The results of peak flow rate and hydrograph for the 50 year event has been computed for this analysis for the watershed conditions, the result of which are in this report.

The design document titled "Corrugated Steel Pipe Design Manual" by the National Corrugated Steel Pipe Association (NCSPA) was used to determine the hydraulic capacity of the proposed 13 ft wide x 3 ft high arch culvert.

WATERSHED DATA

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Project: Oleksenko - 11 Cone Rd Sht No:
Description: Watershed Data for 13' Culvert Xing Date: 2-18-20

Soil Type/Hydr. Group	Ground Cover/Area	RCN
(3) "D"	Woods - 12.83 ac.	77
84B/84C/85C "C"	Woods - 19.46 ac.	70
46/B	(17) 3/4 ac. lot Dev. - 10.42 ac.	79
	29.88 ac.	
Paved Road -	1900 LF x 22'w. / 43,560 = 0.960 ac.	98
73C "B"	Woods - 3.61 ac.	55
	Developed - 1.5 ac.	68
	5.11 ac.	

Total watershed = 48.78 ac

Tc = 17.9 min.

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TR55 Tc Worksheet

Hydraflow Hydrographs by Intelisolve

Hyd. No. 15

ARCH CULVERT BK CROSSING

Description	A		B		C		Totals
Sheet Flow							
Manning's n-value	= 0.011		0.011		0.011		
Flow length (ft)	= 200.0		0.0		0.0		
Two-year 24-hr precip. (in)	= 3.38		0.00		0.00		
Land slope (%)	= 2.50		0.00		0.00		
Travel Time (min)	**= 1.88**	**+**	**0.00**	**+**	**0.00**	**=**	**1.88**
Shallow Concentrated Flow							
Flow length (ft)	= 1250.00		1900.00		300.00		
Watercourse slope (%)	= 3.20		4.53		8.00		
Surface description	= Paved		Unpaved		Unpaved		
Average velocity (ft/s)	= 3.64		3.43		4.56		
Travel Time (min)	**= 5.73**	**+**	**9.22**	**+**	**1.10**	**=**	**16.05**
Channel Flow							
X sectional flow area (sqft)	= 0.00		0.00		0.00		
Wetted perimeter (ft)	= 0.00		0.00		0.00		
Channel slope (%)	= 0.00		0.00		0.00		
Manning's n-value	= 0.015		0.015		0.015		
Velocity (ft/s)	= 0.00		0.00		0.00		
Flow length (ft)	= 0.0		0.0		0.0		
Travel Time (min)	**= 0.00**	**+**	**0.00**	**+**	**0.00**	**=**	**0.00**

Total Travel Time, Tc ..... 17.92 min

NOAA Atlas 14, Volume 10, Version 3
Location name: East Hampton, Connecticut, USA*
Latitude: 41.5707°, Longitude: -72.5367°
Elevation: 461.51 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.334 (0.260-0.417)	0.405 (0.315-0.507)	0.522 (0.404-0.655)	0.619 (0.476-0.782)	0.752 (0.561-0.990)	0.852 (0.623-1.15)	0.957 (0.680-1.33)	1.07 (0.724-1.53)	1.24 (0.805-1.83)	1.38 (0.874-2.07)
10-min	0.473 (0.368-0.591)	0.574 (0.446-0.718)	0.739 (0.573-0.928)	0.876 (0.675-1.11)	1.07 (0.794-1.40)	1.21 (0.883-1.62)	1.36 (0.963-1.89)	1.52 (1.02-2.17)	1.76 (1.14-2.59)	1.96 (1.24-2.93)
15-min	0.556 (0.433-0.696)	0.675 (0.525-0.845)	0.870 (0.674-1.09)	1.03 (0.794-1.30)	1.25 (0.934-1.65)	1.42 (1.04-1.91)	1.60 (1.13-2.22)	1.79 (1.21-2.55)	2.07 (1.34-3.05)	2.30 (1.46-3.45)
30-min	0.760 (0.592-0.951)	0.922 (0.717-1.15)	1.19 (0.919-1.49)	1.41 (1.08-1.78)	1.71 (1.27-2.25)	1.94 (1.42-2.60)	2.17 (1.54-3.03)	2.44 (1.64-3.48)	2.82 (1.83-4.15)	3.14 (1.98-4.70)
60-min	0.964 (0.750-1.21)	1.17 (0.909-1.46)	1.50 (1.17-1.89)	1.78 (1.37-2.25)	2.16 (1.61-2.85)	2.45 (1.79-3.30)	2.75 (1.96-3.84)	3.09 (2.08-4.40)	3.57 (2.32-5.26)	3.97 (2.51-5.96)
2-hr	1.28 (1.00-1.59)	1.54 (1.20-1.91)	1.96 (1.53-2.44)	2.31 (1.79-2.89)	2.79 (2.10-3.65)	3.15 (2.32-4.21)	3.53 (2.53-4.91)	3.98 (2.69-5.61)	4.63 (3.01-6.76)	5.18 (3.29-7.70)
3-hr	1.49 (1.18-1.85)	1.79 (1.41-2.21)	2.27 (1.79-2.82)	2.67 (2.09-3.34)	3.23 (2.44-4.21)	3.64 (2.70-4.85)	4.08 (2.94-5.65)	4.60 (3.12-6.46)	5.37 (3.50-7.81)	6.02 (3.83-8.92)
6-hr	1.91 (1.52-2.34)	2.29 (1.82-2.81)	2.90 (2.30-3.58)	3.42 (2.69-4.23)	4.12 (3.14-5.34)	4.65 (3.47-6.16)	5.21 (3.79-7.18)	5.88 (4.01-8.20)	6.90 (4.51-9.94)	7.76 (4.95-11.4)
12-hr	2.36 (1.90-2.88)	2.85 (2.29-3.47)	3.64 (2.91-4.45)	4.30 (3.41-5.29)	5.20 (4.00-6.69)	5.88 (4.42-7.73)	6.60 (4.82-9.02)	7.46 (5.11-10.3)	8.77 (5.75-12.5)	9.88 (6.32-14.4)
24-hr	2.78 (2.25-3.36)	3.38 (2.74-4.10)	4.38 (3.53-5.32)	5.20 (4.17-6.35)	6.34 (4.91-8.11)	7.18 (5.45-9.39)	8.09 (5.97-11.0)	9.21 (6.32-12.6)	10.9 (7.18-15.5)	12.4 (7.95-17.9)
2-day	3.12 (2.55-3.74)	3.85 (3.15-4.63)	5.06 (4.12-6.10)	6.06 (4.90-7.34)	7.44 (5.82-9.47)	8.45 (6.48-11.0)	9.56 (7.14-13.0)	11.0 (7.56-14.9)	13.2 (8.71-18.5)	15.1 (9.75-21.7)
3-day	3.38 (2.78-4.05)	4.19 (3.44-5.02)	5.52 (4.51-6.62)	6.61 (5.37-7.98)	8.12 (6.39-10.3)	9.23 (7.11-12.0)	10.4 (7.84-14.2)	12.0 (8.30-16.3)	14.5 (9.59-20.3)	16.7 (10.8-23.7)
4-day	3.63 (3.00-4.33)	4.49 (3.70-5.35)	5.89 (4.84-7.05)	7.06 (5.76-8.49)	8.66 (6.83-11.0)	9.84 (7.60-12.7)	11.1 (8.37-15.1)	12.8 (8.86-17.3)	15.4 (10.2-21.5)	17.8 (11.5-25.2)
7-day	4.31 (3.59-5.11)	5.27 (4.38-6.25)	6.84 (5.66-8.14)	8.15 (6.69-9.74)	9.94 (7.88-12.5)	11.3 (8.74-14.4)	12.7 (9.57-17.0)	14.5 (10.1-19.5)	17.4 (11.6-24.1)	19.9 (12.9-28.0)
10-day	5.00 (4.18-5.90)	6.02 (5.02-7.11)	7.68 (6.39-9.10)	9.06 (7.48-10.8)	11.0 (8.72-13.7)	12.4 (9.61-15.7)	13.9 (10.5-18.4)	15.8 (11.0-21.0)	18.7 (12.4-25.7)	21.2 (13.7-29.6)
20-day	7.18 (6.06-8.41)	8.28 (6.97-9.70)	10.1 (8.44-11.8)	11.6 (9.62-13.7)	13.6 (10.9-16.7)	15.1 (11.8-18.9)	16.7 (12.6-21.7)	18.6 (13.1-24.5)	21.2 (14.2-28.9)	23.4 (15.2-32.5)
30-day	9.03 (7.66-10.5)	10.2 (8.61-11.9)	12.0 (10.1-14.1)	13.5 (11.3-15.9)	15.7 (12.6-19.1)	17.3 (13.5-21.4)	18.9 (14.2-24.2)	20.7 (14.6-27.1)	23.0 (15.5-31.2)	24.9 (16.2-34.4)
45-day	11.3 (9.67-13.2)	12.5 (10.7-14.5)	14.4 (12.2-16.8)	16.0 (13.5-18.8)	18.2 (14.7-22.0)	19.9 (15.6-24.5)	21.6 (16.1-27.2)	23.3 (16.5-30.3)	25.4 (17.1-34.1)	26.9 (17.6-36.9)
60-day	13.3 (11.4-15.3)	14.5 (12.4-16.8)	16.5 (14.0-19.1)	18.1 (15.3-21.2)	20.4 (16.5-24.5)	22.2 (17.4-27.1)	23.9 (17.8-29.9)	25.5 (18.1-33.1)	27.4 (18.5-36.7)	28.7 (18.8-39.3)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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PF graphical

$$T_t = \frac{0.007\ (nL)^{0.8}}{(P_2)^{0.5}\ s^{0.4}} \qquad \text{[Eq. 3-3]}$$

Table 3-1.—Roughness coefficients (Manning's n) for sheet flow

Surface description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1]The n values are a composite of information compiled by Engman (1986).
[2]Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3]When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

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Table 7-1 Values of Roughness Coefficient n (Uniform Flow) (continued)

Type Of Channel and Description	Minimum	Normal	Maximum
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
1. Bottom: gravels, cobbles and few boulders	0.030	0.040	0.050
2. Bottom: cobbles with large boulders	0.040	0.050	0.070
2. Flood Plains			
a. Pasture, no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated area			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Dense Willows, summer, straight	0.110	0.150	0.200
2. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. Same as above, but with heavy growth of spouts	0.050	0.060	0.080
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. Same as above, but with flood stage reaching branches	0.100	0.120	0.160
3. Major Streams (top width at flood stage > 30 m). The n value is less than that for minor streams of similar description, because banks offer less effective resistance.			
a. Regular section with no boulders or brush	0.025	—	0.060
b. Irregular and rough section	0.035	—	0.100

Source: Chow, V.T.

Soil Map—State of Connecticut

Map Scale: 1:5,180 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 50 100 200 300

Feet: 0 250 500 1000 1500

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

Map Scale: 1:3,190 if printed on A landscape (11" x 8.5") sheet.

N

0 45 90 180 270 Meters

0 150 300 600 900 Feet

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
3 Hydr. Group "D"	Ridgebury, Leicester, and Whitman soils, 0 to 8 percent slopes, extremely stony	15.0	12.0%
46B "C/D"	Woodbridge fine sandy loam, 0 to 8 percent slopes, very stony	7.1	5.8%
60C	Canton and Charlton fine sandy loams, 8 to 15 percent slopes	2.8	2.3%
73C "B"	Charlton-Chatfield complex, 0 to 15 percent slopes, very rocky	35.3	28.5%
73E	Charlton-Chatfield complex, 15 to 45 percent slopes, very rocky	4.4	3.6%
84B "C"	Paxton and Montauk fine sandy loams, 3 to 8 percent slopes	9.6	7.7%
84C "C"	Paxton and Montauk fine sandy loams, 8 to 15 percent slopes	22.5	18.1%
85C "C"	Paxton and Montauk fine sandy loams, 8 to 15 percent slopes, very stony	27.5	22.1%
Totals for Area of Interest		**124.2**	**100.0%**

State of Connecticut

3—Ridgebury, Leicester, and Whitman soils, 0 to 8 percent slopes, extremely stony

Map Unit Setting

National map unit symbol: 2t2qt
Elevation: 0 to 1,480 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Ridgebury, extremely stony, and similar soils: 40 percent
Leicester, extremely stony, and similar soils: 35 percent
Whitman, extremely stony, and similar soils: 17 percent
Minor components: 8 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ridgebury, Extremely Stony

Setting

Landform: Ground moraines, drumlins, drainageways, depressions, hills
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope, head slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Oe - 0 to 1 inches: moderately decomposed plant material
A - 1 to 6 inches: fine sandy loam
Bw - 6 to 10 inches: sandy loam
Bg - 10 to 19 inches: gravelly sandy loam
Cd - 19 to 66 inches: gravelly sandy loam

Properties and qualities

Slope: 0 to 8 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: 15 to 35 inches to densic material
Natural drainage class: Poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)

State of Connecticut

73C—Charlton-Chatfield complex, 0 to 15 percent slopes, very rocky

Map Unit Setting

National map unit symbol: 2w698
Elevation: 0 to 1,550 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Charlton, very stony, and similar soils: 50 percent
Chatfield, very stony, and similar soils: 30 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Charlton, Very Stony

Setting

Landform: Hills, ridges
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Crest, side slope, nose slope
Down-slope shape: Linear, convex
Across-slope shape: Convex
Parent material: Coarse-loamy melt-out till derived from granite, gneiss, and/or schist

Typical profile

Oe - 0 to 2 inches: moderately decomposed plant material
A - 2 to 4 inches: fine sandy loam
Bw - 4 to 27 inches: gravelly fine sandy loam
C - 27 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 3 to 15 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Moderate (about 8.7 inches)

State of Connecticut

84B—Paxton and Montauk fine sandy loams, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2t2qn
Elevation: 0 to 1,570 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Paxton and similar soils: 55 percent
Montauk and similar soils: 30 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Paxton

Setting

Landform: Hills, drumlins, ground moraines
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Side slope, crest, nose slope
Down-slope shape: Convex, linear
Across-slope shape: Convex
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Ap - 0 to 8 inches: fine sandy loam
Bw1 - 8 to 15 inches: fine sandy loam
Bw2 - 15 to 26 inches: fine sandy loam
Cd - 26 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 18 to 39 inches to densic material
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 37 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Low (about 3.1 inches)

State of Connecticut

84C—Paxton and Montauk fine sandy loams, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2w67b
Elevation: 0 to 1,550 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Paxton and similar soils: 55 percent
Montauk and similar soils: 30 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Paxton

Setting

Landform: Ground moraines, drumlins, hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear, convex
Across-slope shape: Convex
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Ap - 0 to 8 inches: fine sandy loam
Bw1 - 8 to 15 inches: fine sandy loam
Bw2 - 15 to 26 inches: fine sandy loam
Cd - 26 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 39 inches to densic material
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 37 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified

State of Connecticut

85C—Paxton and Montauk fine sandy loams, 8 to 15 percent slopes, very stony

Map Unit Setting

National map unit symbol: 2w67f
Elevation: 0 to 1,520 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Paxton, very stony, and similar soils: 55 percent
Montauk, very stony, and similar soils: 30 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Paxton, Very Stony

Setting

Landform: Hills, ground moraines, drumlins
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear, convex
Across-slope shape: Convex
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Oe - 0 to 2 inches: moderately decomposed plant material
A - 2 to 10 inches: fine sandy loam
Bw1 - 10 to 17 inches: fine sandy loam
Bw2 - 17 to 28 inches: fine sandy loam
Cd - 28 to 67 inches: gravelly fine sandy loam

Properties and qualities

Slope: 8 to 15 percent
Percent of area covered with surface fragments: 1.6 percent
Depth to restrictive feature: 20 to 43 inches to densic material
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 37 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Low (about 4.8 inches)

50 YEAR RUNOFF HYDROGRAPH

FRANK C. MAGNOTTA, P.E.

Hydrograph Plot

Hydraflow Hydrographs by Intelisolve

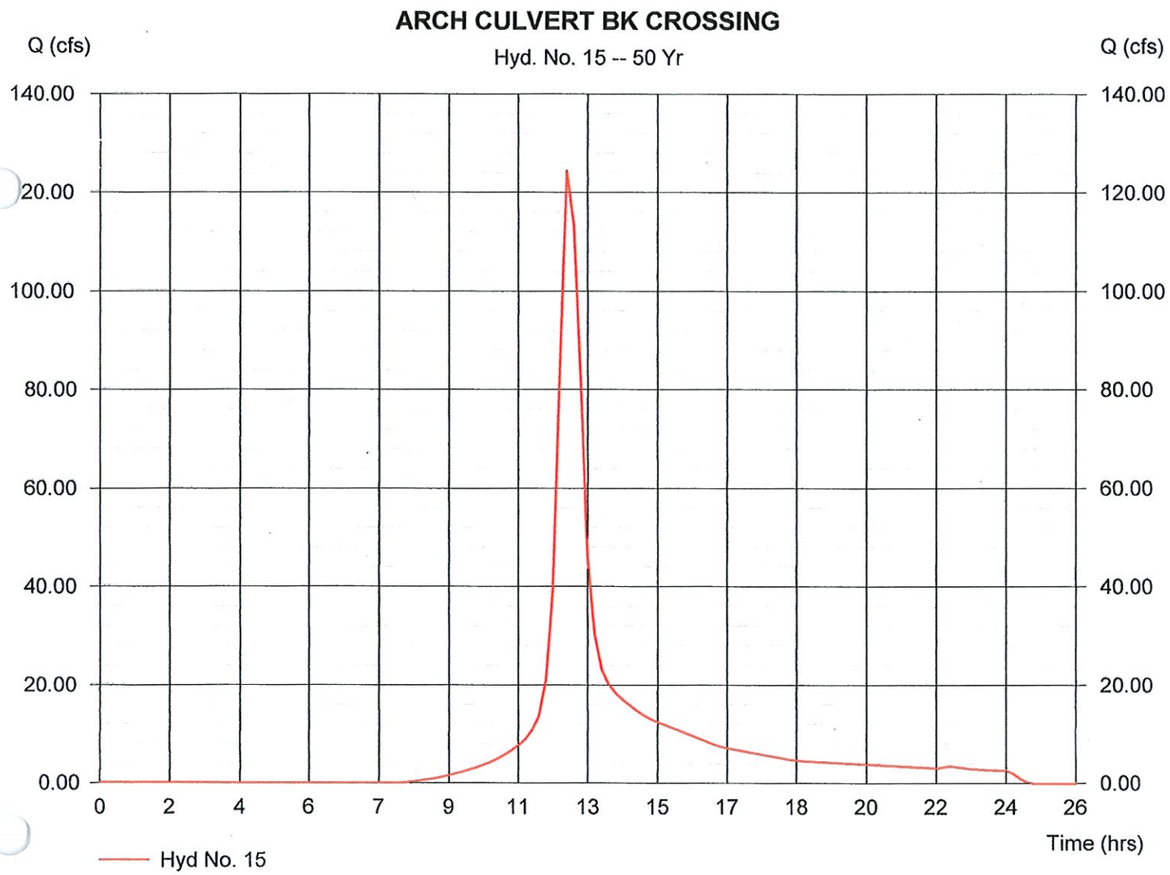
Tuesday, Feb 18 2020, 3:45 PM

Hyd. No. 15

ARCH CULVERT BK CROSSING

Hydrograph type	= SCS Runoff	Peak discharge	= 124.42 cfs
Storm frequency	= 50 yrs	Time interval	= 11 min
Drainage area	= 48.78 ac	Curve number	= 73
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= TR55	Time of conc. (Tc)	= 17.9 min
Total precip.	= 7.18 in	Distribution	= Type III
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 677,623 cuft



ARCH CULVERT HYDRAULICS
&
DESIGN

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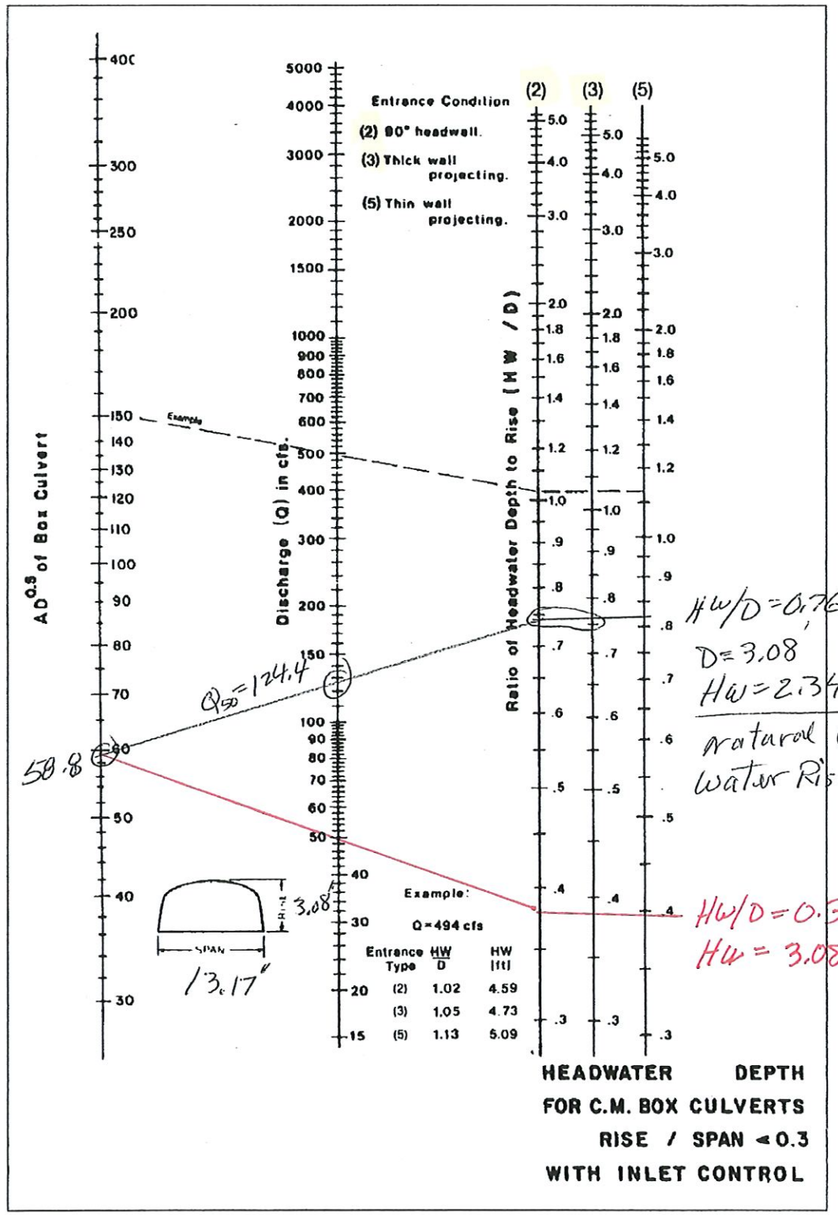
ARCH CULVERT HYDRAULICS & DESIGN

The resulting headwater depth, created by the discharge from a 50 year rainfall event of 124.4 CFS, was determined using "Flow Master" hydraulic program and a nomograph from the NCSPA document titled "Headwater Depth For C.M. Box Culverts, Rise / Span less than 0.3 with inlet control". Because of the 7-9 % slope of the natural channel at the culvert location, using an inlet control analysis was appropriate.

The design proposes to leave the natural channel bottom undisturbed and set the bottom toe of the arch culvert 6"-8" above the existing channel bottom. The flow capacity of the existing channel was analyzed at 8" depth of flow and showed a flow of 63.64 cfs. This flow subtracted from the 50 year of 124.4 cfs leaves 60.8 cfs passing thru the arch culvert. Attached to this section are, Table 4.19 Hydraulic Section Parameters and the fore mentioned nomograph. The results of the analysis show a flow depth at the culvert entrance of 1.14 ft which is based on the assumption that the elevation of the channel and culvert bottoms are the same.

Worksheet for Trapezoidal Channel - Capacity of Existing Channel @ Culvert

Project Description		
Flow Element:	Trapezoidal Channel	
Friction Method:	Manning Formula	
Solve For:	Discharge	
Input Data		
Roughness Coefficient:	0.040	
Channel Slope:	0.07400	ft/ft
Normal Depth:	0.67	ft
Left Side Slope:	0.10 } vertical	ft/ft (H:V)
Right Side Slope:	0.10	ft/ft (H:V)
Bottom Width:	13.00	ft
Results		
Discharge:	63.65	ft^3/s
Flow Area:	8.75	ft^2
Wetted Perimeter:	14.35	ft
Top Width:	13.13	ft
Critical Depth:	0.90	ft
Critical Slope:	0.02825	ft/ft
Velocity:	7.27	ft/s
Velocity Head:	0.82	ft
Specific Energy:	1.49	ft
Froude Number:	1.57	
Flow Type:	Supercritical	
GVF Input Data		
Downstream Depth:	0.00	ft
Length:	0.00	ft
Number Of Steps:	0	
GVF Output Data		
Upstream Depth:	0.00	ft
Profile Description:		
Headloss:	0.00	ft
Downstream Velocity:	Infinity	ft/s
Upstream Velocity:	Infinity	ft/s
Normal Depth:	0.67	ft
Critical Depth:	0.90	ft
Channel Slope:	0.07400	ft/ft



■ **Figure 4.44** Headwater depths for structural plate box culverts, with rise/span < 0.3, under inlet control.

CORRUGATED STEEL PIPE
Design Manual

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NCSPA
National Corrugated Steel Pipe Association

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HYDRAULICS OF STEEL BOX CULVERTS

Where large waterway openings are required with no or minimal ponding, a box culvert is often used. With a HW ratio of less than one (1.0), the steel structural plate box culvert may be designed as an open channel. This is the most efficient hydraulic design for this condition.

By examining the geometry, it can be seen that the nearly vertical legs and flat bottom will provide a linear relationship with lower depths of flow (to 0.6D, where D is the box culvert rise). As the water surface elevation increases and begins to contact the corner or haunch sections, the wetted perimeter increases at a rate faster than the rate of increase in the waterway area. At water depths of 0.8D to 1.0D, there is a rapid increase in wetted perimeter and very little increase in area. Therefore, it can be seen that maximum flow will occur at a point somewhat less than full (0.8 to 0.9D).

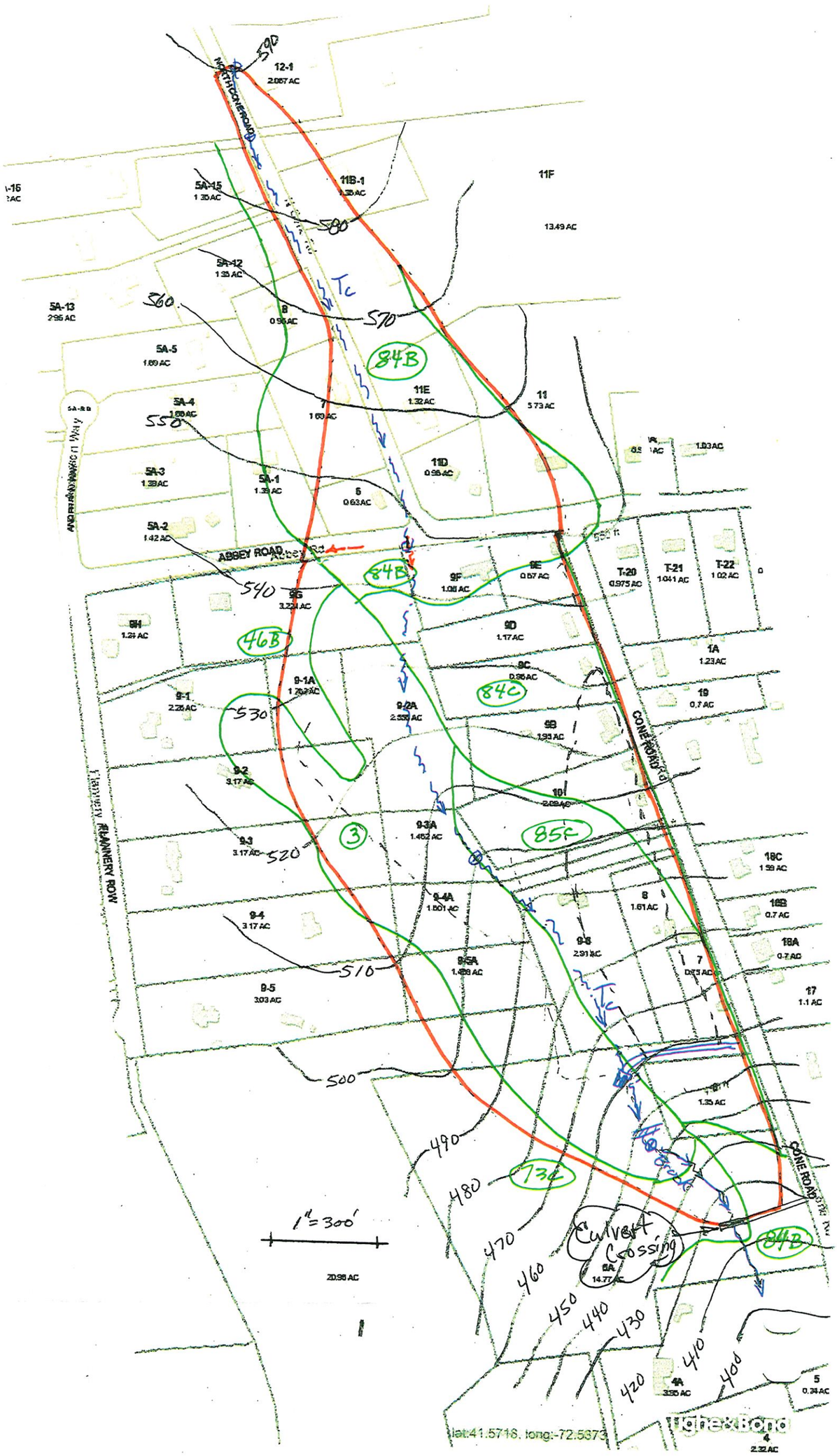
Manning's equation is the accepted design method for open channel flow. Table 4.19 and Figures 4.44 through 4.57 provide hydraulic design information for steel box culverts with a 6 x 2 inch corrugation. The procedure is similar to that summarized previously.

Table 4.19

Hydraulic section parameters for structural plate box culverts

No.	Span ft-in.	Rise ft-in.	Area (sq ft)	WP ft.	$AR^{2/3}$	$AD^{1/2}$	No.	Span ft-in.	Rise ft-in.	Area (sq ft)	WP ft.	$AR^{2/3}$	$AD^{1/2}$
1	9-2	2-6	18.4	20.0	17.4	29.1	28	11-2	4-3	39.4	27.7	49.8	81.2
2	9-8	2-7	20.2	22.2	19.0	32.5	29	19-5	4-3	66.0	42.6	88.4	136.1
3	10-6	2-8	22.6	23.8	21.8	36.9	30	11-9	4-4	42.4	28.3	55.6	88.3
4	11-1	2-9	24.8	24.3	25.1	41.1	31	16-3	4-4	59.5	37.0	81.7	123.9
5	11-10	2-10	27.8	26.7	28.5	46.8	32	12-6	4-5	46.9	30.7	62.3	98.6
6	12-9	2-11	30.6	28.3	32.2	52.3	33	13-3	4-6	49.4	31.5	66.7	104.8
7	13-2	3-1	33.5	29.6	36.3	58.8	34	16-10	4-6	64.1	38.8	89.5	136.0
8	14-1	3-2	36.6	31.3	40.6	65.1	35	20-0	4-6	70.8	43.2	98.5	150.2
9	14-6	3-3	39.0	31.7	44.8	70.3	36	17-9	4-7	67.2	40.0	95.0	143.9
10	9-0	3-4	24.2	21.4	26.3	44.2	37	20-8	4-7	74.7	45.0	104.7	159.9
11	10-1	3-4	27.7	23.5	30.9	50.6	38	13-9	4-8	54.8	33.0	76.8	118.4
12	10-10	3-5	30.8	25.7	34.8	56.9	39	14-7	4-9	59.1	35.0	83.9	128.8
13	15-4	3-5	43.3	34.1	50.8	80.0	40	18-4	4-9	73.1	42.0	105.8	159.3
14	11-6	3-6	33.2	26.6	38.5	62.1	41	10-0	4-11	39.1	25.7	51.7	86.7
15	16-0	3-6	46.2	35.5	55.0	86.4	42	11-0	4-11	44.2	28.2	59.7	98.0
16	12-2	3-8	37.2	28.6	44.3	71.2	43	15-0	4-11	63.2	35.7	92.5	140.1
17	16-8	3-8	50.7	37.3	62.2	97.1	44	19-2	4-11	78.2	43.2	116.1	173.4
18	12-10	3-9	39.7	29.4	48.5	76.9	45	21-6	4-11	83.8	47.3	122.6	185.8
19	13-6	3-10	44.0	31.0	55.6	86.1	46	11-8	5-0	48.2	29.0	67.6	107.8
20	17-6	3-10	54.0	38.0	68.2	105.7	47	15-10	5-0	68.1	37.8	100.8	152.3
21	14-4	4-0	47.8	33.2	61.0	95.6	48	12-5	5-1	52.5	31.3	74.2	118.4
22	18-2	4-0	58.8	40.0	76.0	117.6	49	19-8	5-1	82.3	44.5	124.0	185.6
23	9-6	4-1	31.1	23.6	37.4	62.8	50	12-10	5-2	56.6	32.0	82.8	128.7
24	14-10	4-1	51.3	34.2	67.2	103.7	51	16-4	5-2	72.2	38.8	109.2	164.1
25	10-7	4-2	35.9	26.2	44.3	73.3	52	17-2	5-3	77.6	40.6	119.5	177.8
26	15-7	4-2	55.6	36.1	74.1	113.5	53	20-8	5-3	88.4	46.5	135.6	202.5
27	18-9	4-2	62.2	40.7	82.6	127.0	54	13-8	5-4	60.8	34.0	89.6	140.4

(continued)



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- Watershed Map -
Arch Culvert Design
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