

PRELIMINARY DESIGN REPORT

AND

COST ESTIMATE

LUM DRAIN & EXTENSION

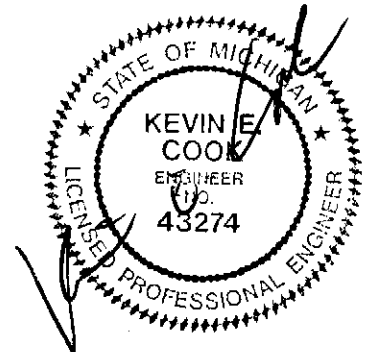
BRANCH #1, #0138

Submitted To:

Genesee County Drain Commissioner's Office
Jeffrey Wright, Drain Commissioner
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Submitted By:

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November 2012
Project No. 12003900

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I. Summary

The proposed project consists of the extension to Branch #1, #0138 of the Lum Drain located in section 13 of Gaines Township and sections 18 and 19 of Mundy Township. The drainage basin begins at a high point approximately 2,000 feet south of Grand Blanc Road, traverses north-northwesterly across Section 18 of Mundy Township, crosses Elms Road south of Reid Road, continues north across Section 13 of Gaines Township, crosses Reid Road west of Elms Road, and connects to the Lum & Extension Drain north of Reid Road. See attached map for drain location.

Drain improvements include constructing a 42-inch culvert under Grand Blanc Road and extending 2,000 feet of open ditch drain due north of Grand Blanc Road along the 1/8" line (west line of parcel #15-18-300-013). As an alternative to the open ditch from Grand Blanc Road north, an enclosed 54-inch diameter concrete pipe is also considered. Beyond the improvements described above, two options are proposed for consideration.

The first option further includes deepening and widening approximately 1-mile of existing drains in the northwesterly corner of Section 18 of Mundy Township and northeasterly corner of Section 13 of Gaines Township (existing drain west of Elms Road crossing northerly to Reid Road crossing). Also, the existing culvert crossings of Elms Road and Reid Road would be removed, upsized and replaced as both culverts are undersized. Lastly, the drain north of Reid Road would be widened and deepened to the outlet at the Lum Drain. The cost to construct this option with open ditch is \$147,700. *If the enclosed pipe alternate from Grand Blanc Road north is chosen, the additional cost would be \$221,000 (TOTAL = \$368,700)*

The second option further includes clearing approximately 1-mile of existing drains in the northwesterly corner of Section 18 of Mundy Township and northeasterly corner of Section 13 of Gaines Township. As an alternate to removing and replacing the two roadway culverts (Elms Road and Reid Road), a detention basin would be constructed east of the Elms Road crossing and be utilized to store heavy rain events. Stormwater would be released from the pond thru a control structure would be designed to not exceed the existing culvert capacity. Lastly, the existing drain downstream of the detention pond would be cleaned to the outlet at the Lum Drain. The cost to construct this option with open ditch is \$155,550. The cost of land acquisition for the detention basin is not included in this estimate. *Again, if the enclosed pipe alternate from Grand Blanc Road north is chosen, the additional cost would be \$221,000 (TOTAL \$376,550).*

Both options and associated alternatives are explained in greater detail in Section 4 of this report. All costs are estimated in year 2012 dollars and actual costs may be higher or lower depending upon final design, contractor's bid prices, and the year of construction.

II. Basin Characteristics

A. General

The Branch #1 of the Lum Drain and Extension drainage basin has an area of approximately 780 acres. The ground surface elevations range from 778' to 820'.

The Branch #1 of the Lum Drain and Extension drainage district was surveyed at the three (3) roadway crossings; Grand Blanc Road ¼ mile east of Elms Road, Elms Road ¼ mile south of Reid Road, and Reid Road 1/8 mile west of Elms Road. Also, the two proposed drain routes were field surveyed from Grand Blanc Road north approximately 2,000 feet to the existing natural water course.

Four (4) roadway cross culverts were located and invert elevations measured. All pipe invert elevations are noted on the crossing details (Plan Sheets 1 and 2). A 12-inch diameter corrugate metal pipe crosses Grand Blanc Road 950' east of Elms Road. A 12-inch diameter clay pipe crosses Grand Blanc Road approximately ¼ mile east of Reid Road (400' east of the first culvert). A 48-inch corrugate metal pipe crosses Elms Road approximately ¼ mile south of Reid Road. A 72-inch corrugate metal pipe crosses Reid Road approximately 1/8 mile west of Elms Road.

B. Existing Conditions

The following problem exists in the basin:

Based on testimony provided in the Board of Determinations minutes, several lots along Elms Road have experienced street flooding, rear yard flooding, and basement flooding in past years.

Two (2) 12-inch culverts crossing Grand Blanc Road are undersized for the 120 acre drainage area. The 48-inch culvert crossing Elms Road is undersized for the 460 acre drainage area. The 72-inch culvert crossing Reid Road is undersized for the 780 acre drainage area.

III. Basis of Design

A. Hydrology

1. Drainage Area

The drainage area of the district is approximately 630 acres.

2. Future Land Use

It has been assumed for the purposes of this study that land use for the year 2020 in the basin will remain essentially as it exists today.

3. Soils

The following soil types are found in the district. (See Figure A)

Map Symbol	Soil Series Name	Hydrologic Soil Group
Bw	Brookstone loam	D/B
CvA	Conover loam, 0 to 2% Slopes	C
CvB	Conover loam, 2% to 6% Slopes	C
DrB	Del Rey silt loam, 2% to 6% Slopes	C
MIa	Metamora sandy loam, 0% to 2% Slopes	B
SdA	Selfridge loamy sand, % to 2% Slopes	B

The hydrologic parameter, A, B, C or D, is an indicator of the minimum rate of infiltration obtained for a bare soil after prolonged wetting.

The hydrologic soil groups, as defined by SCS Soil Scientists, are:

- A. (Lowest Runoff Potential). Soils having a high infiltration rate even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels.
- B. (Moderately Low Runoff Potential). Soils having a moderate infiltration rate when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse texture.
- C. (Moderately High Runoff Potential). Soils having a slow

infiltration rate when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water or soils with moderately fine to fine textures.

- D. (Highest Runoff Potential). Soils having a very slow infiltration rate when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay pan or clay layer at or near the surface, and shallow sinks over nearly impervious materials.

Some soils area classified as belonging to two hydrologic groups by a symbol such as D/B. The first letter indicates the soil's hydrologic characteristics in the drained condition, the second describes its characteristics in the undrained condition.

The majority of the soil in the district are loam with somewhat poor drainage; seasonal high water table; moderately slow permeability; and wet depressions in some areas.

4. Land Use

Most of the land is farmed or idle agricultural land with some residential areas along Grand Blanc Road and Elms Road. This study is based on the existing conditions.

5. Rainfall Information

Rainfall information is obtained from the Soil Conservation Service. The 24-hour rainfalls for the drainage area are as follows:

Frequency (Years)	24 Hour Rainfall (Inches)
1	2.1
2	2.3
5	3.0
10	3.5
25	3.9
50	4.2
100	4.6

It is noted that there have been numerous rainfalls in the mid-Michigan area which have exceeded the 100 year frequency event.

The rainfall intensity curves used were provided by the Genesee County Drain Commissioner's Office.

6. Runoff Coefficients

"The runoff coefficient as used in the Rational Method expresses the percent of rainfall that appears as runoff. The coefficient C combines the effects of infiltration and surface storage of the watershed." (Handbook of Concrete Pipe Hydraulics) Below are the runoff coefficients used in this analysis.

	<u>Land Use</u>	<u>C</u>
A.	Flat undeveloped lands, farms, nonwooded	0.25
B.	Woodlands and sloped undeveloped land	0.30
C.	Residential	0.40
D.	Roads	1.00

7. Quantity of Flow

The methodology used to estimate flows is the Rational Method. This is one of the most widely used techniques for estimating peak runoff in an urbanized watershed. A description of the method as found in the Handbook of Concrete Culvert Pipe Hydraulics follows:

"The rational formula is fundamentally a ratio in which the total quantity of water falling at a uniform rate on an area is related by simple proportion to the total quantity of water that appears as runoff. This can be expressed in instantaneous form as $Q = CiA$ where Q is runoff in cubic feet per seconds, i is rainfall intensity in inches per hour, A is the area of the drainage basin in acres, and C is the ratio expressing the proportional amount of the rainfall that appears as runoff. This formula is only applicable where the rainfall can be assumed to be uniform both in intensity and in aerial distribution throughout the storm. This assumption applies fairly well to areas of less than 200 square miles."

8. Design

Based on the following criteria:

Runoff Coefficient (C) = 0.25
Time of Concentration (Tc1) = 48 minutes
Time of Concentration Tc2 = 61 minutes
Time of Concentration Tc3 = 69 minutes
10-Year Storm Event for Open Ditch and Enclosed Pipe
25-Year Storm Event for Roadways Crossings/Culverts

The flow generated from the upper end of the watershed south of Grand Blanc Road (120 acres) is approximately 71 cubic feet per second (cfs) (78 cfs for 25-year event). The watershed generated at the Elms Road crossing (460 acres) is approximately 230 cfs (254 cfs for 25-year event). The total watershed from the entire drainage basin (780 acres) is approximately 355 cfs (390 cfs for 25-year event).

IV. Proposed Improvements

Option #1A

Place 42-inch (or equivalent) culvert under Grand Blanc Road at existing culvert located approximately ¼ mile east of Elms Road. Construct 400 feet of 12" storm sewer from existing catch basin (400 feet west) to new culvert. Construct 2,000 feet of open ditch from Grand Blanc Road along 1/8th line to existing ditch. Widen and deepen existing ditch to Elms Road. Replace existing 48-inch culvert under Elms Road with 72-inch (or equivalent) culvert. Widen and deepen existing ditch from Elms Road to Reid Road. Replace existing 72-inch culvert under Reid Road with 108-inch (or equivalent) culvert. Widen and deepen existing ditch from Reid Road north to outlet.

Option #1B

Place 42-inch (or equivalent) culvert under Grand Blanc Road at existing culvert located approximately ¼ mile east of Elms Road. Construct 400 feet of 12" storm sewer from existing catch basin (400 feet west) to new culvert. *As an alternative to open ditch, construct 2,000 feet enclosed 54-inch concrete pipe from Grand Blanc Road along 1/8th line to existing ditch.* Widen and deepen existing ditch to Elms Road. Replace existing 48-inch culvert under Elms Road with 72-inch (or equivalent) culvert. Widen and deepen existing ditch from Elms Road to Reid Road. Replace existing 72-inch culvert under Reid Road with 108-inch (or equivalent) culvert. Widen and deepen existing ditch from Reid Road north to outlet.

Option #2A

Place 42-inch (or equivalent) culvert under Grand Blanc Road at existing culvert located approximately $\frac{1}{4}$ mile east of Elms Road. Construct 400 feet of 12" storm sewer from existing catch basin (400 feet west) to new culvert. Construct 2,000 feet of open ditch from Grand Blanc Road along $\frac{1}{8}$ th line to existing ditch. Construct a 24,000 cubic yard in line detention basin without outlet restriction to accommodate capacity of existing 48-inch culvert at Elms Road and capacity of existing 72-inch culvert at Reid Road. Clear and clean out 5,300 feet of existing ditch from proposed detention basin to drain outlet north of Reid Road.

Option #2B

Place 42-inch (or equivalent) culvert under Grand Blanc Road at existing culvert located approximately $\frac{1}{4}$ mile east of Elms Road. Construct 400 feet of 12" storm sewer from existing catch basin (400 feet west) to new culvert. *As an alternative to open ditch, construct 2,000 feet enclosed 54-inch concrete pipe from Grand Blanc Road along $\frac{1}{8}$ th line to existing ditch.* Construct a 24,000 cubic yard in line detention basin without outlet restriction to accommodate capacity of existing 48-inch culvert at Elms Road and capacity of existing 72-inch culvert at Reid Road. Clear and clean out 5,300 feet of existing ditch from proposed detention basin to drain outlet north of Reid Road.

IV. Cost Estimate

ENGINEER'S COST ESTIMATE

OPTION #1A

The drain improvement cost estimates are summarized below as follows:

Item No.	Description	Quantity	Unit	Unit Price	Amount
1	12" Dia. RCP Pipe	400	L.F.	\$40.00	\$16,000.00
2	42" Dia. CSP Culvert	80	L.F.	\$200.00	\$16,000.00
3	72" Dia. CSP Culvert	80	L.F.	\$300.00	\$24,000.00
4	108" Dia. CSP Culvert	60	L.F.	\$500.00	\$30,000.00
5	Open Ditch Excavation	2,000	L.F.	\$7.00	\$14,000.00
6	Open Ditch Excavation - Widen & Deepen	5,300	L.F.	\$6.00	\$31,800.00
7	Leveling Spoils	7,300	L.F.	\$1.00	\$7,300.00
8	Seed, Class B (125 lbs. per acre)	600	LB	\$4.00	\$2,400.00
9	Mulch	10	TON	\$500.00	\$5,000.00
10	Fertilizer	600	LB	\$2.00	\$1,200.00
TOTAL COST - OPTION #1A					\$147,700.00

OPTION #1B

The drain improvement cost estimates are summarized below as follows:

Item No.	Description	Quantity	Unit	Unit Price	Amount
1	12" Dia. RCP Pipe	400	L.F.	\$40.00	\$16,000.00
2	42" Dia. CSP Culvert	80	L.F.	\$200.00	\$16,000.00
3	72" Dia. CSP Culvert	80	L.F.	\$300.00	\$24,000.00
4	108" Dia. CSP Culvert	60	L.F.	\$500.00	\$30,000.00
5	54" Dia. RCP Pipe	2,000	L.F.	\$110.00	\$220,000.00
6	Drainage Structures	5	EACH	\$3,000.00	\$15,000.00
7	Open Ditch Excavation - Widen & Deepen	5,300	L.F.	\$6.00	\$31,800.00
8	Leveling Spoils	7,300	L.F.	\$1.00	\$7,300.00
9	Seed, Class B (125 lbs. per acre)	600	LB	\$4.00	\$2,400.00
10	Mulch	10	TON	\$500.00	\$5,000.00
11	Fertilizer	600	LB	\$2.00	\$1,200.00
TOTAL COST - OPTION #1B					\$368,700.00

IV. Cost Estimate

OPTION #2A

The drain improvement cost estimates are summarized below as follows:

Item No.	Description	Quantity	Unit	Unit Price	Amount
1	12" Dia. RCP Pipe	400	L.F.	\$40.00	\$16,000.00
2	42" Dia. CSP Culvert	80	L.F.	\$200.00	\$16,000.00
3	Open Ditch Excavation	2,000	L.F.	\$7.00	\$14,000.00
4	Ditch Cleanout	5,300	L.F.	\$3.50	\$18,550.00
5	Excavate Detention Basin	24,000	CYD	\$3.00	\$72,000.00
6	Leveling Spoils	7,300	L.F.	\$1.00	\$7,300.00
7	Seed, Class B (125 lbs. per acre)	700	LB	\$4.00	\$2,800.00
8	Mulch	15	TON	\$500.00	\$7,500.00
9	Fertilizer	700	LB	\$2.00	\$1,400.00
TOTAL COST - OPTION #2A					\$155,550.00

OPTION #2B

The drain improvement cost estimates are summarized below as follows:

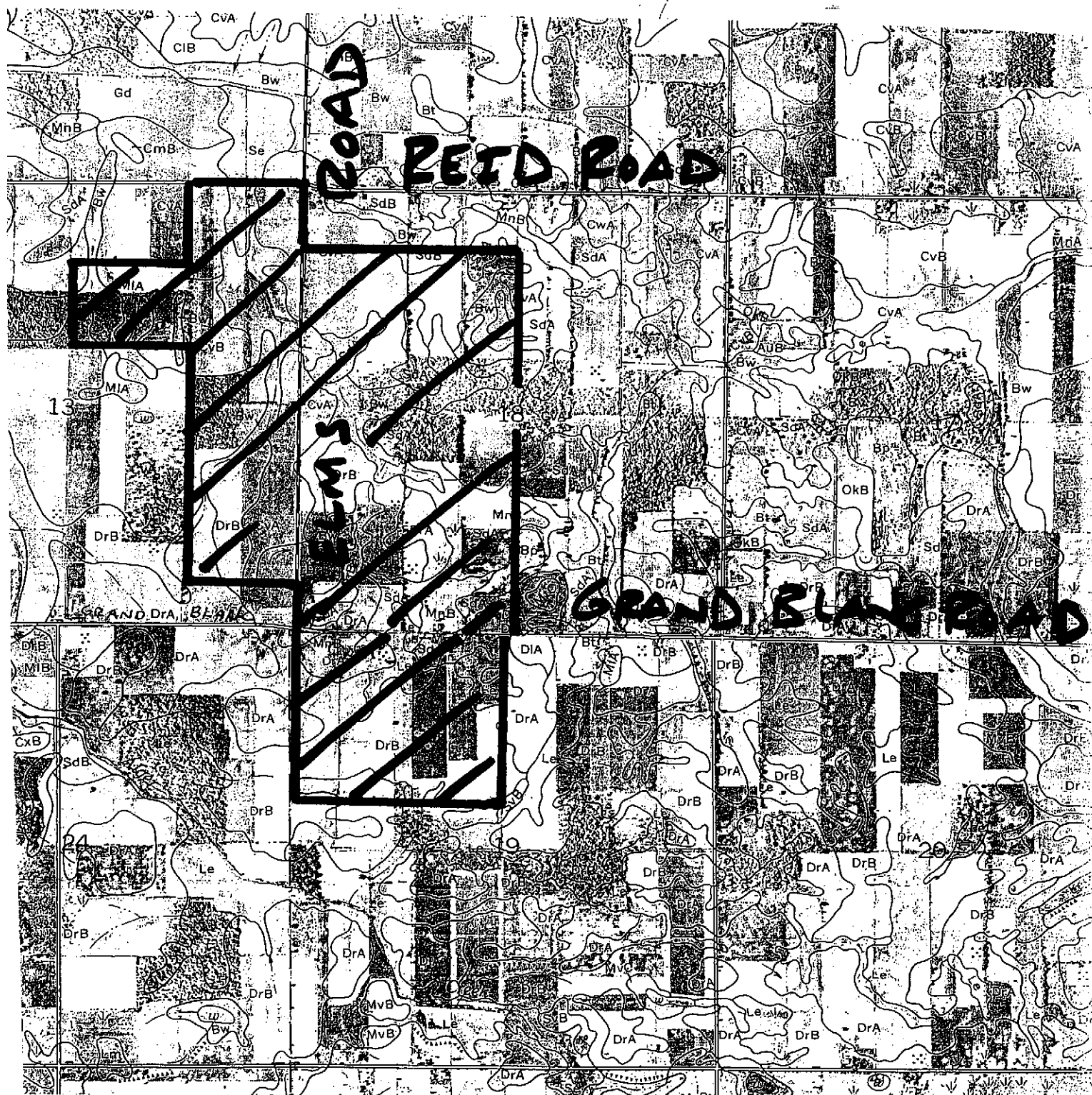
Item No.	Description	Quantity	Unit	Unit Price	Amount
1	12" Dia. RCP Pipe	400	L.F.	\$40.00	\$16,000.00
2	42" Dia. CSP Culvert	80	L.F.	\$200.00	\$16,000.00
3	54" Dia. RCP Pipe	2,000	L.F.	\$110.00	\$220,000.00
4	Drainage Structures	5	EACH	\$3,000.00	\$15,000.00
5	Ditch Cleanout	5,300	L.F.	\$3.50	\$18,550.00
6	Excavate Detention Basin	24,000	CYD	\$3.00	\$72,000.00
7	Leveling Spoils	7,300	L.F.	\$1.00	\$7,300.00
8	Seed, Class B (125 lbs. per acre)	700	LB	\$4.00	\$2,800.00
9	Mulch	15	TON	\$500.00	\$7,500.00
10	Fertilizer	700	LB	\$2.00	\$1,400.00
TOTAL COST - OPTION #2B					\$376,550.00

VI. Reference Materials

1. Computing Flood Discharges for Small Ungaged Watersheds, R.C. Sorrell, P.E., Michigan Department of Environmental Quality, Geological and Land Management Division, July 2003.
2. Genesee County Drain Map, Thetford Township and Vienna Township, February 1964.
3. Genesee County Composite Map, Thetford Township, Section 19 and Vienna Township, Section 24.
4. Soil Survey of Genesee County, Michigan, United States Department of Agriculture Soil Conservation Service, April, 1972.
5. Handbook of Concrete Culvert Pipe Hydraulics, Portland Cement Association, 1964.

VII. Appendix

Soil Survey Map (1)
Time of Concentration Calculations (1)
Flow Calculations (1)
Detention Basin Calculations (1)
Culvert Calculations (18)
Drainage District Map and Survey (2)



LUM DRAIN AND EXTENSION, BRANCH #1, #0138

Time of Concentration Calculations

Date: 9/18/2012

Initial Time

10 minutes

South of Grand Blanc Road - Section 19 Mundy Township

Surface flow over grass (300 foot maximum)

upper end elevation = 820

lower end elevation = 818

length = 300 feet

slope = 0.007

T-Surface flow = 9.41 minutes

Tc - Grass multiply by: 2

18.8 minutes

Shallow concentrated flow

upper end elevation = 818

lower end elevation = 803

length = 2500 feet

slope = 0.006

T-Surface flow = 9.78 minutes

Tc - Grass multiply by: 2

19.6 minutes

Time of Concentration (C1) =

48.4

North of Grand Blanc Road - Section 18 Mundy Township

Open Channel Flow to Elms Road Crossing

velocity = 5.5 feet per second

length = 4200 feet

T-Surface flow =

12.7 minutes

Time of Concentration (C2) =

61.1 minutes

East of Elms Road - Section 13 Gaines Township

Open Channel Flow to Reid Road Crossing

velocity = 5.8 feet per second

length = 2750 feet

T-Surface flow =

7.9 minutes

Total Time of Concentration/Peak Flow (C3)

69.0 minutes

LUM DRAIN AND EXTENSION, BRANCH #1, #0138

Flow Calculations

Date: 10/8/12

DESIGN FLOOD FREQUENCY = 10 YEAR STORM
 INTENSITY CONSTANTS FOR $I = A/(T+D)^N$

A = 166.37
 D = 22.35
 N = 1

DRAINAGE DISTRICT		AREA A (Acres)	RUNOFF COEFF. C	A x C	SUM A x C	TIME OF CONC. (Minutes)	INTENSITY I (In/Hr)	DISCHARGE Q (cfs)
UPPER	LOWER							
CP1	CP2A	120	0.25	30.00	30.00	48	2.36	70.80
CP2A	CP2B	195	0.25	48.75	78.75	61	2.00	157.50
CP2B	CP3	145	0.25	36.25	115.00	61	2.00	230.00
CP3	OUTLET	320	0.25	80.00	195.00	69	1.82	354.90

DESIGN FLOOD FREQUENCY = 25 YEAR STORM
 INTENSITY CONSTANTS FOR $I = A/(T+D)^N$

A = 191.76
 D = 25.93
 N = 1

DRAINAGE DISTRICT		AREA A (Acres)	RUNOFF COEFF. C	A x C	SUM A x C	TIME OF CONC. (Minutes)	INTENSITY I (In/Hr)	DISCHARGE Q (cfs)
UPPER	LOWER							
CP1	CP2A	120	0.25	30.00	30.00	48	2.59	77.82
CP2A	CP2B	195	0.25	48.75	78.75	61	2.21	173.72
CP2B	CP3	145	0.25	36.25	115.00	61	2.21	253.69
CP3	OUTLET	320	0.25	80.00	195.00	69	2.02	393.90

CHMP, INC.
*architecture, engineering
planning, interior design
landscape architecture
surveying*

LUM DRAIN AND EXTENSION, BRANCH #1, #0138

GCDC Detention Basin Calculations

Date: 10/8/2012

Tributary Area (A) =	315	Acres
Runoff Coefficient (C) =	0.25	
Elms Road 48" Culvert Capacity =	78	cfs
Watershed Generated Down Stream of Proposed Pond =	77	
Allowable Pond Outflow Rate =	1	cfs

Duration (Minutes)	Intensity	On-Site Inflow Rate (cfs)	On-Site Outflow Rate (cfs)	Storage Volume (Cu. Ft.)
	25 Year Storm (In/Hr)			
10	5.34	420.29	1	251,575
20	4.18	328.79	1	393,342
30	3.43	270.00	1	484,200
40	2.91	229.05	1	547,314
50	2.53	198.88	1	593,646
60	2.23	175.74	1	629,054
70	2.00	157.42	1	656,955
80	1.81	142.56	1	679,475
90	1.65	130.26	1	698,007
100	1.52	119.92	1	713,500
110	1.41	111.09	1	726,625
120	1.31	103.48	1	737,869

HY-8 Analysis Results

Crossing Summary Table

Culvert Crossing: Grand Blanc Road - Existing 12"

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
808.19	50.00	3.11	46.72	7
808.21	55.00	3.07	51.84	3
808.23	60.00	3.03	56.91	3
808.25	65.00	2.99	61.97	3
808.27	70.00	2.95	67.02	3
808.29	75.00	2.91	72.07	3
808.30	80.00	2.88	76.85	2
808.32	85.00	2.84	82.14	3
808.34	90.00	2.81	87.06	2
808.35	95.00	2.78	92.08	2
808.37	100.00	2.75	97.17	2
807.90	2.93	2.93	0.00	Overtopping

HY-8 Analysis Results

Culvert Summary Table - Culvert 1

Culvert Crossing: Grand Blanc Road - Existing 12"

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)
50.00	3.11	808.19	1.49	4.64	4-FFf	1.00	0.75	1.00	2.10	3.97	3.83
55.00	3.07	808.21	1.46	4.66	4-FFf	1.00	0.75	1.00	2.19	3.91	3.93
60.00	3.03	808.23	1.44	4.68	4-FFf	1.00	0.74	1.00	2.28	3.86	4.01
65.00	2.99	808.25	1.42	4.70	4-FFf	1.00	0.74	1.00	2.36	3.81	4.09
70.00	2.95	808.27	1.40	4.72	4-FFf	1.00	0.73	1.00	2.44	3.76	4.17
75.00	2.91	808.29	1.38	4.73	4-FFf	1.00	0.73	1.00	2.51	3.71	4.24
80.00	2.88	808.30	1.37	4.75	4-FFf	1.00	0.73	1.00	2.59	3.66	4.31
85.00	2.84	808.32	1.35	4.77	4-FFf	1.00	0.72	1.00	2.65	3.62	4.38
90.00	2.81	808.34	1.33	4.79	4-FFf	1.00	0.72	1.00	2.72	3.58	4.44
95.00	2.78	808.35	1.32	4.80	4-FFf	1.00	0.71	1.00	2.79	3.54	4.51
100.00	2.75	808.37	1.30	4.82	4-FFf	1.00	0.71	1.00	2.85	3.50	4.56

HY-8 Analysis Results

Water Surface Profiles

Culvert Crossing: Grand Blanc Road - Existing 12"

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Length Full (ft)	Length Free (ft)	Last Step (ft)	Mean Slope (%)	First Depth (ft)	Last Depth (ft)
50.00	3.11	808.19	1.49	4.64	4-FFf	80.01	0.00	0.00	0.00	1.00	1.00
55.00	3.07	808.21	1.46	4.66	4-FFf	80.01	0.00	0.00	0.00	1.00	1.00
60.00	3.03	808.23	1.44	4.68	4-FFf	80.01	0.00	0.00	0.00	1.00	1.00
65.00	2.99	808.25	1.42	4.70	4-FFf	80.01	0.00	0.00	0.00	1.00	1.00
70.00	2.95	808.27	1.40	4.72	4-FFf	80.01	0.00	0.00	0.00	1.00	1.00
75.00	2.91	808.29	1.38	4.73	4-FFf	80.01	0.00	0.00	0.00	1.00	1.00
80.00	2.88	808.30	1.37	4.75	4-FFf	80.01	0.00	0.00	0.00	1.00	1.00
85.00	2.84	808.32	1.35	4.77	4-FFf	80.01	0.00	0.00	0.00	1.00	1.00
90.00	2.81	808.34	1.33	4.79	4-FFf	80.01	0.00	0.00	0.00	1.00	1.00
95.00	2.78	808.35	1.32	4.80	4-FFf	80.01	0.00	0.00	0.00	1.00	1.00
100.00	2.75	808.37	1.30	4.82	4-FFf	80.01	0.00	0.00	0.00	1.00	1.00

HY-8 Analysis Results

Crossing Summary Table

Culvert Crossing: Grand Blanc Road - Proposed 42"

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
805.44	50.00	50.00	0.00	1
805.73	55.00	55.00	0.00	1
806.07	60.00	60.00	0.00	1
806.51	65.00	65.00	0.00	1
806.98	70.00	70.00	0.00	1
807.47	75.00	75.00	0.00	1
807.91	80.00	79.36	0.48	38
807.97	85.00	79.63	5.25	7
808.01	90.00	79.50	10.33	5
808.04	95.00	79.34	15.41	4
808.07	100.00	79.18	20.66	4
807.90	79.25	79.25	0.00	Overtopping

HY-8 Analysis Results

Culvert Summary Table - Culvert 1

Culvert Crossing: Grand Blanc Road - Proposed 42"

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)
50.00	50.00	805.44	3.74	3.94	3-M2t	3.50	2.20	2.60	2.10	6.52	3.83
55.00	55.00	805.73	4.05	4.23	3-M2t	3.50	2.31	2.69	2.19	6.92	3.93
60.00	60.00	806.07	4.37	4.57	3-M2t	3.50	2.42	2.78	2.28	7.32	4.01
65.00	65.00	806.51	4.72	5.01	7-M2t	3.50	2.52	2.86	2.36	7.72	4.09
70.00	70.00	806.98	5.10	5.48	7-M2t	3.50	2.61	2.94	2.44	8.12	4.17
75.00	75.00	807.47	5.50	5.97	7-M2t	3.50	2.70	3.01	2.51	8.51	4.24
80.00	79.36	807.91	5.88	6.41	7-M2t	3.50	2.78	3.09	2.59	8.84	4.31
85.00	79.63	807.97	5.90	6.47	7-M2t	3.50	2.79	3.15	2.65	8.72	4.38
90.00	79.50	808.01	5.89	6.51	7-M2t	3.50	2.78	3.22	2.72	8.58	4.44
95.00	79.34	808.04	5.88	6.54	7-M2t	3.50	2.78	3.29	2.79	8.46	4.51
100.00	79.18	808.07	5.86	6.57	7-M2t	3.50	2.78	3.35	2.85	8.36	4.56

HY-8 Analysis Results

Water Surface Profiles

Culvert Crossing: Grand Blanc Road - Proposed 42"

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Length Full (ft)	Length Free (ft)	Last Step (ft)	Mean Slope (%)	First Depth (ft)	Last Depth (ft)
50.00	50.00	805.44	3.74	3.94	3-M2t	0.00	79.47	3.65	0.82	2.60	2.95
55.00	55.00	805.73	4.05	4.23	3-M2t	0.00	79.44	0.26	0.89	2.69	3.16
60.00	60.00	806.07	4.37	4.57	3-M2t	0.00	79.51	1.53	1.16	2.78	3.39
65.00	65.00	806.51	4.72	5.01	7-M2t	20.55	59.45	0.01	1.42	3.50	3.50
70.00	70.00	806.98	5.10	5.48	7-M2t	41.23	38.77	0.01	1.65	3.50	3.50
75.00	75.00	807.47	5.50	5.97	7-M2t	53.86	26.14	0.01	1.89	3.50	3.50
80.00	79.36	807.91	5.88	6.41	7-M2t	61.12	18.89	0.00	2.12	3.50	3.50
85.00	79.63	807.97	5.90	6.47	7-M2t	63.31	16.69	0.00	2.13	3.50	3.50
90.00	79.50	808.01	5.89	6.51	7-M2t	66.66	13.35	0.00	2.13	3.50	3.50
95.00	79.34	808.04	5.88	6.54	7-M2t	69.75	10.25	0.00	2.12	3.50	3.50
100.00	79.18	808.07	5.86	6.57	7-M2t	72.74	7.26	0.00	2.11	3.50	3.50

HY-8 Analysis Results

Crossing Summary Table

Culvert Crossing: Elms Road - Existing 48"

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
787.86	100.00	81.82	18.02	11
787.94	120.00	84.26	35.41	5
788.02	140.00	85.66	54.19	5
788.09	160.00	86.87	72.86	4
788.16	180.00	86.88	92.93	4
788.22	200.00	85.70	114.16	4
788.29	220.00	84.18	135.73	4
788.30	225.00	83.69	141.14	3
788.41	260.00	80.31	179.63	4
788.46	280.00	78.47	201.27	3
788.52	300.00	76.68	223.17	3
787.70	77.95	77.95	0.00	Overtopping

HY-8 Analysis Results

Culvert Summary Table - Culvert 1

Culvert Crossing: Elms Road - Existing 48"

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)
100.00	81.82	787.86	4.88	4.92	3-M2t	3.09	2.74	2.97	2.47	8.17	4.52
120.00	84.26	787.94	5.01	5.01	7-M1t	3.17	2.78	3.19	2.69	7.83	4.74
140.00	85.66	788.02	5.09	5.07	7-M1t	3.22	2.80	3.40	2.90	7.56	4.94
160.00	86.87	788.09	5.16	5.15	7-M1t	3.29	2.82	3.58	3.08	7.32	5.11
180.00	86.88	788.16	5.16	5.23	7-M1t	3.29	2.82	3.75	3.25	7.09	5.26
200.00	85.70	788.22	5.09	5.29	7-M1t	3.23	2.81	3.91	3.41	6.86	5.41
220.00	84.18	788.29	5.01	5.36	4-FFf	3.17	2.78	4.00	3.57	6.70	5.54
225.00	83.69	788.30	4.98	5.37	4-FFf	3.15	2.77	4.00	3.60	6.66	5.57
260.00	80.31	788.41	4.80	5.47	4-FFf	3.04	2.71	4.00	3.85	6.39	5.78
280.00	78.47	788.46	4.70	5.53	4-FFf	2.98	2.68	4.00	3.98	6.24	5.89
300.00	76.68	788.52	4.61	5.59	4-FFf	2.92	2.64	4.00	4.10	6.10	6.00

HY-8 Analysis Results

Water Surface Profiles

Culvert Crossing: Elms Road - Existing 48"

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Length Full (ft)	Length Free (ft)	Last Step (ft)	Mean Slope (%)	First Depth (ft)	Last Depth (ft)
100.00	81.82	787.86	4.88	4.92	3-M2t	0.00	39.61	0.96	1.29	2.97	3.06
120.00	84.26	787.94	5.01	5.01	7-M1t	0.00	41.79	5.29	1.24	3.19	3.18
140.00	85.66	788.02	5.09	5.07	7-M1t	0.00	39.90	0.88	1.19	3.40	3.34
160.00	86.87	788.09	5.16	5.15	7-M1t	0.00	40.15	0.54	1.14	3.58	3.50
180.00	86.88	788.16	5.16	5.23	7-M1t	0.00	39.91	0.63	1.13	3.75	3.70
200.00	85.70	788.22	5.09	5.29	7-M1t	0.00	40.47	0.87	1.16	3.91	3.87
220.00	84.18	788.29	5.01	5.36	4-FFf	40.00	0.00	0.00	0.00	4.00	4.00
225.00	83.69	788.30	4.98	5.37	4-FFf	40.00	0.00	0.00	0.00	4.00	4.00
260.00	80.31	788.41	4.80	5.47	4-FFf	40.00	0.00	0.00	0.00	4.00	4.00
280.00	78.47	788.46	4.70	5.53	4-FFf	40.00	0.00	0.00	0.00	4.00	4.00
300.00	76.68	788.52	4.61	5.59	4-FFf	40.00	0.00	0.00	0.00	4.00	4.00

HY-8 Analysis Results

Crossing Summary Table

Culvert Crossing: Elms Road - Proposed 72"

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
784.10	100.00	100.00	0.00	1
784.59	120.00	120.00	0.00	1
785.07	140.00	140.00	0.00	1
785.56	160.00	160.00	0.00	1
786.55	180.00	180.00	0.00	1
786.94	200.00	200.00	0.00	1
787.36	220.00	220.00	0.00	1
787.47	225.00	225.00	0.00	1
787.85	260.00	242.91	16.79	8
787.94	280.00	245.70	33.94	5
788.01	300.00	248.07	51.79	5
787.70	235.94	235.94	0.00	Overtopping

HY-8 Analysis Results

Culvert Summary Table - Culvert 1

Culvert Crossing: Elms Road - Proposed 72"

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)
100.00	100.00	784.10	4.10	0.0*	1-S2n	2.59	2.68	2.60	2.47	8.53	4.52
120.00	120.00	784.59	4.59	0.0*	1-S2n	2.88	2.96	2.89	2.69	8.92	4.74
140.00	140.00	785.07	5.07	0.0*	1-S2n	3.16	3.20	3.16	2.90	9.29	4.94
160.00	160.00	785.56	5.56	0.0*	1-S2n	3.43	3.43	3.43	3.08	9.58	5.11
180.00	180.00	786.55	6.07	6.55	7-M1t	3.70	3.65	3.75	3.25	9.67	5.26
200.00	200.00	786.94	6.60	6.94	3-M2t	3.99	3.85	3.91	3.41	10.24	5.41
220.00	220.00	787.36	7.16	7.36	3-M2t	4.28	4.05	4.07	3.57	10.79	5.54
225.00	225.00	787.47	7.30	7.47	3-M2t	4.36	4.10	4.10	3.60	10.92	5.57
260.00	242.91	787.85	7.85	7.83	3-M2t	4.66	4.26	4.35	3.85	11.09	5.78
280.00	245.70	787.94	7.94	7.89	3-M2t	4.71	4.29	4.48	3.98	10.89	5.89
300.00	248.07	788.01	8.01	7.92	3-M2t	4.75	4.30	4.60	4.10	10.68	6.00

HY-8 Analysis Results

Water Surface Profiles

Culvert Crossing: Elms Road - Proposed 72"

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Length Full (ft)	Length Free (ft)	Last Step (ft)	Mean Slope (%)	First Depth (ft)	Last Depth (ft)
100.00	100.00	784.10	4.10	0.0*	1-S2n	0.00	40.00	37.93	1.25	2.68	2.60
120.00	120.00	784.59	4.59	0.0*	1-S2n	0.00	40.00	43.51	1.26	2.96	2.89
140.00	140.00	785.07	5.07	0.0*	1-S2n	0.00	40.00	49.30	1.25	3.20	3.16
160.00	160.00	785.56	5.56	0.0*	1-S2n	0.00	40.00	40.00	1.26	3.43	3.43
180.00	180.00	786.55	6.07	6.55	7-M1t	0.00	40.24	11.82	1.25	3.75	3.71
200.00	200.00	786.94	6.60	6.94	3-M2t	0.00	40.00	40.00	1.23	3.91	4.01
220.00	220.00	787.36	7.16	7.36	3-M2t	0.00	40.32	1.89	1.26	4.07	4.27
225.00	225.00	787.47	7.30	7.47	3-M2t	0.00	40.25	0.84	1.28	4.10	4.33
260.00	242.91	787.85	7.85	7.83	3-M2t	0.00	40.04	0.49	1.30	4.35	4.59
280.00	245.70	787.94	7.94	7.89	3-M2t	0.00	39.70	5.14	1.30	4.48	4.65
300.00	248.07	788.01	8.01	7.92	3-M2t	0.00	40.46	0.86	1.28	4.60	4.71

HY-8 Analysis Results

Crossing Summary Table

Culvert Crossing: Reid Road - Existing 72"

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
786.08	300.00	256.13	44.33	9
786.12	310.00	256.23	53.56	5
786.15	320.00	257.52	62.25	4
786.18	330.00	258.65	71.17	4
786.21	340.00	259.71	80.16	4
786.24	350.00	260.77	89.10	4
786.27	360.00	261.87	98.04	4
786.30	370.00	262.72	107.18	4
786.33	380.00	263.53	116.06	3
786.36	390.00	264.27	125.64	4
786.38	400.00	264.92	134.75	3
785.80	244.77	244.77	0.00	Overtopping

HY-8 Analysis Results

Culvert Summary Table - Culvert 1

Culvert Crossing: Reid Road - Existing 72"

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)
300.00	256.13	786.08	8.31	8.29	2-M2c	6.00	4.37	4.38	4.10	11.59	6.00
310.00	256.23	786.12	8.31	8.35	2-M2c	6.00	4.37	4.38	4.16	11.57	6.05
320.00	257.52	786.15	8.36	8.38	2-M2c	6.00	4.38	4.40	4.22	11.60	6.09
330.00	258.65	786.18	8.39	8.41	2-M2c	6.00	4.39	4.41	4.28	11.63	6.14
340.00	259.71	786.21	8.43	8.44	2-M2c	6.00	4.40	4.41	4.34	11.65	6.19
350.00	260.77	786.24	8.46	8.47	2-M2c	6.00	4.41	4.42	4.39	11.67	6.23
360.00	261.87	786.27	8.50	8.50	3-M2t	6.00	4.42	4.45	4.45	11.68	6.28
370.00	262.72	786.30	8.53	8.53	3-M2t	6.00	4.42	4.50	4.50	11.57	6.32
380.00	263.53	786.33	8.56	8.55	3-M2t	6.00	4.43	4.56	4.55	11.47	6.37
390.00	264.27	786.36	8.58	8.59	7-M2t	6.00	4.44	4.61	4.61	11.34	6.41
400.00	264.92	786.38	8.61	8.61	7-M2t	6.00	4.44	4.66	4.66	11.25	6.45

HY-8 Analysis Results

Water Surface Profiles

Culvert Crossing: Reid Road - Existing 72"

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Length Full (ft)	Length Free (ft)	Last Step (ft)	Mean Slope (%)	First Depth (ft)	Last Depth (ft)
300.00	256.13	786.08	8.31	8.29	2-M2c	0.00	59.44	6.45	1.19	4.37	5.87
310.00	256.23	786.12	8.31	8.35	2-M2c	0.00	59.46	0.06	1.21	4.37	5.87
320.00	257.52	786.15	8.36	8.38	2-M2c	0.00	59.48	0.63	1.22	4.38	5.89
330.00	258.65	786.18	8.39	8.41	2-M2c	0.00	59.63	0.62	1.24	4.39	5.91
340.00	259.71	786.21	8.43	8.44	2-M2c	0.00	59.80	0.61	1.26	4.40	5.93
350.00	260.77	786.24	8.46	8.47	2-M2c	0.00	59.95	0.60	1.27	4.41	5.95
360.00	261.87	786.27	8.50	8.50	3-M2t	0.00	59.67	0.60	1.29	4.45	5.96
370.00	262.72	786.30	8.53	8.53	3-M2t	0.00	59.51	0.59	1.30	4.50	5.97
380.00	263.53	786.33	8.56	8.55	3-M2t	0.00	59.91	0.58	1.32	4.56	6.00
390.00	264.27	786.36	8.58	8.59	7-M2t	0.70	59.30	0.01	1.33	6.00	6.00
400.00	264.92	786.38	8.61	8.61	7-M2t	1.69	58.31	0.01	1.33	6.00	6.00

HY-8 Analysis Results

Crossing Summary Table

Culvert Crossing: Reid Road - Proposed 108"

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
784.81	300.00	300.00	0.00	1
784.95	310.00	310.00	0.00	1
785.08	320.00	320.00	0.00	1
785.20	330.00	330.00	0.00	1
785.35	340.00	340.00	0.00	1
785.48	350.00	350.00	0.00	1
785.61	360.00	360.00	0.00	1
785.74	370.00	370.00	0.00	1
785.83	380.00	377.89	1.87	10
785.89	390.00	381.99	7.63	6
785.93	400.00	385.60	14.21	6
785.80	375.06	375.06	0.00	Overtopping

HY-8 Analysis Results

Culvert Summary Table - Culvert 1

Culvert Crossing: Reid Road - Proposed 108"

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)
300.00	300.00	784.81	6.53	7.04	2-M2c	9.00	4.20	4.22	4.10	10.24	6.00
310.00	310.00	784.95	6.67	7.18	2-M2c	9.00	4.28	4.29	4.16	10.35	6.05
320.00	320.00	785.08	6.80	7.31	2-M2c	9.00	4.35	4.36	4.22	10.46	6.09
330.00	330.00	785.20	6.93	7.43	2-M2c	9.00	4.43	4.43	4.28	10.57	6.14
340.00	340.00	785.35	7.06	7.58	2-M2c	9.00	4.50	4.50	4.34	10.68	6.19
350.00	350.00	785.48	7.20	7.71	2-M2c	9.00	4.57	4.57	4.39	10.78	6.23
360.00	360.00	785.61	7.33	7.84	2-M2c	9.00	4.63	4.64	4.45	10.88	6.28
370.00	370.00	785.74	7.46	7.97	2-M2c	9.00	4.70	4.71	4.50	10.98	6.32
380.00	377.89	785.83	7.56	8.07	2-M2c	9.00	4.75	4.76	4.55	11.06	6.37
390.00	381.99	785.89	7.62	8.12	2-M2c	9.00	4.77	4.79	4.61	11.11	6.41
400.00	385.60	785.93	7.67	8.16	2-M2c	9.00	4.79	4.81	4.66	11.14	6.45

HY-8 Analysis Results

Water Surface Profiles

Culvert Crossing: Reid Road - Proposed 108"

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Length Full (ft)	Length Free (ft)	Last Step (ft)	Mean Slope (%)	First Depth (ft)	Last Depth (ft)
300.00	300.00	784.81	6.53	7.04	2-M2c	0.00	59.90	1.20	0.47	4.20	5.27
310.00	310.00	784.95	6.67	7.18	2-M2c	0.00	59.62	1.18	0.48	4.28	5.36
320.00	320.00	785.08	6.80	7.31	2-M2c	0.00	59.47	1.16	0.48	4.35	5.44
330.00	330.00	785.20	6.93	7.43	2-M2c	0.00	59.86	11.33	0.51	4.43	5.53
340.00	340.00	785.35	7.06	7.58	2-M2c	0.00	59.45	0.11	0.50	4.50	5.61
350.00	350.00	785.48	7.20	7.71	2-M2c	0.00	59.48	0.11	0.51	4.57	5.69
360.00	360.00	785.61	7.33	7.84	2-M2c	0.00	59.49	0.11	0.52	4.63	5.78
370.00	370.00	785.74	7.46	7.97	2-M2c	0.00	59.41	0.11	0.53	4.70	5.86
380.00	377.89	785.83	7.56	8.07	2-M2c	0.00	59.83	1.06	0.53	4.75	5.93
390.00	381.99	785.89	7.62	8.12	2-M2c	0.00	59.45	0.11	0.53	4.77	5.96
400.00	385.60	785.93	7.67	8.16	2-M2c	0.00	59.42	1.05	0.54	4.79	5.98