DRAINAGE STUDY REPORT

FOR

VILLAGE OF STILLMAN VALLEY

STUDY OF DRAINAGE CHANNEL LOCATED BETWEEN WALNUT STREET AND PINE STREET

2021

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WHA # 1309R21

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Introduction

Willett, Hofmann and Associates, Inc. (WHA) was retained by the Village of Stillman Valley to perform a drainage study on an existing drainage ditch/channel located between Pine Street and Walnut Street from Wilson Street to Main Street. The purpose of this study was threefold. First, the Village requested that WHA determine the runoff generated by the upstream area draining to the existing channel and determine if the existing channel has adequate capacity during various storm events. Second, the Village requested that WHA examine alternatives for improvements to the drainage channel that would alleviate the existing erosion due to scour while provided extra conveyance capacity. Third, provide an estimate of probable construction costs of the various alternatives examined.

Existing Conditions

In total, the existing drainage area contributing runoff to the studied drainage channel is approximately 86 acres in size and extends as far south as 2nd Street, as far west as Stillman Road, and as far east as Spruce Street. The defined drainage channel begins just north of Grant Street between Pine and Walnut Streets and continues to drain from the south to the north through the Village Limits. Exhibit 1 outlines the overall drainage limits and drainage channel location.

The section of the drainage channel of interest to this study is that section previously described from Wilson to Main Streets. This section has been further broken down into three (3) distinct segments as follows:

- Segment 1 – Main Street to the alley between Main Street and Roosevelt Street
- Segment 2 – The alley between Main Street and Roosevelt Street to Roosevelt Street
- Segment 3 – Roosevelt Street to Wilson Street

The channel in Segment 1 is rectangular in shape with a dirt and stone bottom and vertical walls consisting of concrete blocks on the east side and a homemade gabion basket-type system comprising the west wall. The channel bottom, while only constructed in dirt and rock, appears to be stable and does not show significant signs of erosion. The homemade gabion basket-type system comprising the west wall also appears to be stable showing only a few places of erosion along the base. The concrete block wall on the west side of the channel is leaning significantly, and pieces of the top of the wall have started to fall off into the channel. While not imminent, the failure of the west wall is only a matter of time. The capacity of this section of the drainage channel will be discussed later in this report.

The channel in Segment 2 is a trapezoidal channel with established short to medium grasses lining the bottom and sides. The channel bottom and sides do not show any significant signs of erosion; however, it does appear that eroded material has been deposited and collecting in this channel for a significant amount of time. The capacity of this section of the drainage channel will be discussed later in this report.

The channel in Segment 3 is also trapezoidal with varying lining as the channel drains from south to north. At the south end, Segment 3 is densely overgrown with trees, brush, and reeds which eventually recede into a section with a lining combination of dirt, rock, and medium height weeds as the channel extends to the north. The south end of the channel has been poorly maintained and the tree and brush growth will have a significant impact on the flow conveyance capacity of the drainage channel. At the north end, it appears that the adjacent homeowners have attempted to clean and maintain the ditch to a certain degree.

The capacity of this section of the drainage channel will be discussed later in this report. This cleaning has created a larger and uniform section while also removing a significant amount of the existing turf lining.

Between Wilson Street and Main Street, the drainage channel passes beneath Roosevelt Street and an alley. At Roosevelt Street, Segment 3 is conveyed beneath the roadway to Segment 2 in a concrete box culvert having approximate dimensions of 6'-4" wide x 2' tall. Immediately upstream and downstream of the box culvert, the sidewalks on the north and south sides of the street act as small bridges over the channel supported on concrete walls. The opening provided by these "bridges" is the same approximate size as the box culvert. At the alley, two (2) 15" corrugated metal pipe (CMP) culverts convey drainage from Segment 2 to Segment 1. At this location, the alley pavement is depressed and constructed out of concrete to act as a spillway for runoff to overtop the pavement and continue draining to the north during larger rainfall events. At Main Street, two (2) 27" equivalent round elliptical concrete culvert pipes convey drainage from Segment 1 to the north beyond the study limits. The capacity of these culverts will be discussed later in this report.

Photographs of the existing ditch Segments and the culvert crossings are provided in Exhibit 2.

Study Hydrologic Approach

Based on the size of the overall drainage basin and the type of facilities to be analyzed, the hydrology (runoff) for the drainage basin was calculated for the 2-, 5-, 10-, 25-, 50-, and 100-year recurrence storm events using two (2) different methodologies. The first method used was USGS Rural and Urban Regression Equation Method. The following Table 1 summarizes the results of this analysis:

Table 1
Regression Equation Method Runoff Calculation Results

Storm Recurrence Event	Segments 1 and 2		Segment 3	
	Rural Method	Urban Method	Rural Method	Urban Method
2 - Year	38.31 ft^3/s	74.70 ft^3/s	30.77 ft^3/s	60.00 ft^3/s
5 - Year	75.89 ft^3/s	130.53 ft^3/s	61.30 ft^3/s	105.44 ft^3/s
10 - Year	106.78 ft^3/s	172.99 ft^3/s	140.16 ft^3/s	140.16 ft^3/s
25 - Year	150.60 ft^3/s	231.92 ft^3/s	122.36 ft^3/s	188.43 ft^3/s
50 – Year	186.36 ft^3/s	275.81 ft^3/s	151.66 ft^3/s	224.46 ft^3/s
100 - Year	224.76 ft^3/s	325.91 ft^3/s	183.20 ft^3/s	265.64 ft^3/s

Since the existing channel is in a dense residential neighborhood and much of the runoff is generated by residential land uses, the results obtained from the urban method are more applicable to the specific channel being studied. The detailed calculations that generated the results provided in Table 1 can be found in Exhibit 3.

The second method used was the Rational Method. The following Table 2 summarizes the results of this analysis:

Table 2
Rational Method Runoff Calculation Results

Storm Recurrence Event	Segments 1 and 2 Rational Method	Segment 3 Rational Method
2 - Year	120.61 ft^3/s	93.07 ft^3/s
5 - Year	157.31 ft^3/s	121.24 ft^3/s
10 - Year	191.79 ft^3/s	147.54 ft^3/s
25 - Year	242.02 ft^3/s	185.50 ft^3/s
50 – Year	284.62 ft^3/s	218.10 ft^3/s
100 - Year	330.91 ft^3/s	253.45 ft^3/s

The detailed calculations that generated the results provided in Table 2 can be found in Exhibit 4.

The results derived from the Urban Method and Rational Method calculations for each of the segments are nearly identical in the 10- thru 100-year events. In the 2- and 5-Year recurrence events, the Rational Method generated the more conservative estimates. For this study, the Rational Method values were used to fulfill the first objective of determining whether-or-not the existing drainage channel provided sufficient runoff conveyance.

Existing Ditch Hydraulics

WHA personnel performed field measurements to determine the "average" ditch cross section in the various segments while also reviewing LIDAR data to determine the approximate ditch slopes. Once obtained, this data was used with the Chezy-Manning's equation to determine the theoretical peak runoff that could be conveyed by the various ditch segments. The results of this analysis are summarized in the following Table 3:

Table 3
Existing Ditch Full-Flow Hydraulic Capacity

	Full-Flow Hydraulic Velocity	Full-Flow Hydraulic Capacity
Segment 1	5.69 ft/s	62.7 ft^3/s
Segment 2	4.97 ft/s	69.6 ft^3/s
Segment 3	5.26 ft/s	69.4 ft^3/s

The detailed calculations that generated the results provided in Table 3 can be found in Exhibit 5.

As calculated, the existing ditch cross sections are insufficient when compared to the runoff values outlined in Table 2. Based on this analysis, the existing ditches should flow at capacity in every storm event throughout the year and are under capacity during significant storm events. Since these ditches provide the overland flow path through the Village for a significant drainage area, these ditches should be designed to convey the 100-year recurrence event without damage to permanent structures. Based on the calculations performed, the in-situ ditch sections have approximately 20 to 25% of the needed capacity to convey the 100-year recurrence event.

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Existing Culvert Hydraulics

WHA personnel performed field measurements to determine the approximate capacity of each of the culvert crossings in the study area. Each crossroad culvert was modeled using the HY-8 culvert modeling software created by the Federal Highway Authority (FHWA) at the various peak runoff volumes calculated previously. The following Table 4 summarizes the results of this analysis:

Table 4
Existing Culvert Crossing Full-Flow Hydraulic Capacity

Storm Recurrence Event	Main Street Culvert Crossing Discharge	Alley Culvert Crossing Discharge	Roosevelt Street Culvert Crossing Discharge
2 - Year	50.24 ft3/s	12.26 ft^3/s	81.86 ft3/s
5 - Year	52.28 ft3/s	12.66 ft^3/s	84.79 ft3/s
10 - Year	53.98 ft3/s	12.98 ft^3/s	85.48 ft3/s
25 - Year	56.14 ft3/s	13.42 ft^3/s	80.35 ft3/s
50 – Year	57.78 ft3/s	13.77 ft^3/s	76.17 ft3/s
100 - Year	59.42 ft3/s	14.05 ft^3/s	71.76 ft3/s

The detailed calculations reports from the HY-8 analysis that represent the detailed calculations provided in Table 4 can be found in Exhibit 6.

The results of this analysis indicate that the existing culvert sizes at each location are insufficient to convey the runoff generated by any of the modeled storm recurrence events without causing overtopping of the roadway to allow excess flow to continue to discharge downstream.

Analysis of the Existing System

Based on the hydrologic calculations and the capacity analyses performed for the ditch segments and roadway culvert crossings, the existing drainage channel should experience flooding on a common and routine basis during even minor rainfall events. However, flooding in these segments of the drainage channel does not occur at the rate expected. The reason for the lack of downstream flooding can be found in the performance of the upstream system.

As previously described, the main runoff pathway for this drainage basin channelizes just north of Grant Street and is conveyed through the back and side yards of residential homes before crossing streets via culverts at various other streets. The crossroad culverts serve as restrictions in the flow path that allows the upstream ditch sections and depressions in the yards to fill with water creating a complicated series of interconnected quasi-detention ponds. These detention ponds then attenuate the peak flow discharging downstream and serve to lower the values outlined in Tables 1 and 2. The lower, attenuated peak runoff then allows the drainage ditch and culvert system to convey adequate volumes of water without flooding the surrounding areas. To determine the attenuated peak runoff values would require a more significant study with larger scope than the purpose of this analysis.

Improvement Alternatives

Overall, the potential for making improvements to the drainage system for the purposes of increasing the overall system capacity is limited due to the restrictions at the existing culverts at Main Street, Roosevelt Street, and the alley. As outlined in Tables 3 and 4, the existing channel segments immediately upstream of the Main Street and alley culvert crossing have more capacity than the culverts. Increasing the capacity of the ditch cross section would not benefit the overall conveyance capacity of the system due to these restrictions. Each of the culvert crossings could be replaced; however, there are three potential impediments to be considered:

1. Jurisdictional control. The Village has the authority to replace the culverts beneath Main Street and the alley since they are located on Village right-of-way. However, the culvert beneath Roosevelt Street falls under the Illinois Department of Transportation's jurisdiction and would require the Village to permit the new culvert(s) and justify the sizing, improvement, etc.
2. Cost to benefit ratio. The cost to replace these culverts with those that could potentially convey larger storm events would be substantial, specifically the culverts beneath Main and Roosevelt Streets. This improvement would alleviate some of the local issues; however, significant lowering of upstream flood elevations would only be impactful if other bottlenecks were removed.
3. System stability. Replacing the existing culverts to allow for more conveyance would negatively impact the downstream channel and any culvert crossings downstream. The channel immediately downstream of the Main Street culverts appears to have sufficient capacity for the 100-year event; however, culvert crossings further downstream were not analyzed. Making improvements upstream without improving the downstream system would result in moving a problem in one location to another.

Even though channel cross section improvements will not specifically increase the overall system capacity due to restrictions caused by the existing culverts, improvements to the ditch cross sections are warranted due to various factors. The existing concrete block wall along Segment 1, while not an imminent threat, will eventually collapse and should be replaced. The cross sections of both Segments 2 and 3 can be widened to allow for more flow while also removing any debris that has collected over the years. All segments should be further stabilized to prevent future erosion.

Both Segments 1 and 2 of the drainage channel appear to be located on private property. Consultation with the Ogle County GIS does not indicate the presence of a dedicated right-of-way or easement for the drainage path. Potential improvements to the channel in these segments were limited to a total width of approximately 16′ or less to limit the impact to the adjacent properties and reduce the amount of right-of-way/easement purchase by the Village.

The proposed improvement alternatives examined for Segment 1 were as follows:

- Alternative 1: Remove the existing concrete block and gabion basket walls and construct a new rectangular channel having an approximate size of 6′ wide x 3′ depth constructed out of precast concrete channel sections.
- Alternative 2: Remove the existing concrete block and gabion basket walls and construct a new rectangular channel having an approximate size of 6′ wide and 3′ depth constructed out of a cast-in-place concrete channel bottom and gabion basket walls.

- Alternative 3: Remove the existing concrete block and gabion basket walls and construct a new trapezoidal channel with a 4′ bottom width, 3′ depth, and 2:1 side slopes constructed out of cast-in-place concrete.

Estimates of probable construction cost for each of the three (3) alternatives are summarized in the following Tables 5, 6, and 7:

Table 5
Segment 1 – Alternative 1 Estimate of Probable Construction Cost

No.	Item	Quantity	Unit	Unit Price	Total Price
1	Tree Removal	L. Sum	1	$5,000	$5,000
2	Earth Excavation	Cu. Yd.	88	$30	$2,640
3	Seeding, Class 1 (Special)	Sq. Yd.	400	$15	$6,000
4	Inlet and Pipe Protection	Each	1	$300	$300
5	6′x3′ Precast Concrete Channel	Foot	130	$700	$91,000
6	Structural Concrete	Cu. Yd.	20	$700	$14,000
7	Fence Removal and Replacement	Foot	200	$55	$1,100
				Subtotal:	$129,940
				Contingency, 20%:	$25,988
				Total Estimated Construction:	$155,928

Table 6
Segment 1 – Alternative 2 Estimate of Probable Construction Cost

No.	Item	Quantity	Unit	Unit Price	Total Price
1	Tree Removal	L. Sum	1	$5,000	$5,000
2	Earth Excavation	Cu. Yd.	128	$30	$3,840
3	Seeding, Class 1 (Special)	Sq. Yd.	400	$15	$6,000
4	Inlet and Pipe Protection	Each	1	$300	$300
5	Concrete Channel Bottom, 8″ Thick	Sq. Yd.	130	$105	$13,650
6	Gabion Baskets	Cu. Yd.	47	$300	$14,100
7	Structural Concrete	Cu. Yd.	20	$700	$14,000
8	Fence Removal and Replacement	Foot	200	$55	$1,100
				Subtotal:	$57,990
				Contingency, 20%:	$11,598
				Total Estimated Construction:	$69,588

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Table 7
Segment 1 – Alternative 3 Estimate of Probably Construction Cost

No.	Item	Quantity	Unit	Unit Price	Total Price
1	Tree Removal	L. Sum	1	$5,000	$5,000
2	Earth Excavation	Cu. Yd.	184	$30	$5,520
3	Seeding, Class 1 (Special)	Sq. Yd.	400	$15	$6,000
4	Inlet and Pipe Protection	Each	1	$300	$300
5	Concrete Channel, 8″ Thick	Sq. Yd.	306	$125	$38,250
6	Structural Concrete	Cu. Yd.	20	$700	$14,000
7	Fence Removal and Replacement	Foot	200	$55	$1,100
				Subtotal:	$70,170
				Contingency, 20%:	$14,034
				Total Estimated Construction:	$84,204

Detailed drawings showing the typical cross sections for each of the described improvement alternatives is provided in Exhibit 7.

The proposed improvement alternatives examined for Segment 2 were as follows:

- Alternative 1: Reconstruct the existing channel to provide a new, larger trapezoidal channel with a 4′ bottom width, 2′ depth, and 3:1 side slopes. The channel bottom and sides would be soil reinforced with geo-web to allow for turf growth with reduced erosion impacts. The flatter side slopes provided would allow for easier maintenance by adjacent homeowners.
- Alternative 2: Reconstruct the existing channel to provide a new, larger trapezoidal channel with a 4′ bottom width, 2′ depth, and 3:1 side slopes. The channel bottom would be constructed out of concrete and the side slopes construed out of soil reinforced with geo-web to allow turf growth with reduced erosion impacts. The flatter side slopes provided would allow for easier maintenance by adjacent homeowners.
- Alternative 3: Reconstruction the existing channel to provide a new, larger trapezoidal channel with an 8′ bottom width, 2′ depth, and 2:1 side slopes. The channel bottom and side slopes would be constructed out of cast-in-place concrete.

Estimates of probable construction cost for each of the three (3) alternatives are summarized in the following Tables 8, 9, and 10:

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Table 8
Segment 2 – Alternative 1 Estimate of Probable Construction Cost

No.	Item	Quantity	Unit	Unit Price	Total Price
1	Tree Removal	L. Sum	1	$5,000	$5,000
2	Earth Excavation	Cu. Yd.	78	$30	$2,340
3	Seeding, Class 1 (Special)	Sq. Yd.	540	$15	$8,100
4	Inlet and Pipe Protection	Each	1	$300	$300
5	Geo-Web Reinforcement	Sq. Yd.	265	$60	$15,900
				Subtotal:	$31,640
				Contingency, 20%:	$6,328
				Total Estimated Construction:	$37,968

Table 9
Segment 2 – Alternative 2 Estimate of Probable Construction Cost

No.	Item	Quantity	Unit	Unit Price	Total Price
1	Tree Removal	L. Sum	1	$5,000	$5,000
2	Earth Excavation	Cu. Yd.	94	$30	$3,840
3	Seeding, Class 1 (Special)	Sq. Yd.	480	$15	$7,200
4	Inlet and Pipe Protection	Each	1	$300	$300
5	Concrete Channel Bottom, 8” Thick	Sq. Yd.	65	$105	$6,825
6	Geo-Web Reinforcement	Sq. Yd.	200	$60	$12,000
				Subtotal:	$35,165
				Contingency, 20%:	$7,033
				Total Estimated Construction:	$42,198

Table 10
Segment 2 – Alternative 3 Estimate of Probably Construction Cost

No.	Item	Quantity	Unit	Unit Price	Total Price
1	Tree Removal	L. Sum	1	$5,000	$5,000
2	Earth Excavation	Cu. Yd.	112	$30	$3,360
3	Seeding, Class 1 (Special)	Sq. Yd.	290	$15	$4,350
4	Inlet and Pipe Protection	Each	1	$300	$300
5	Concrete Channel, 8” Thick	Sq. Yd.	265	$125	$33,125
				Subtotal:	$46,135
				Contingency, 20%:	$9,227
				Total Estimated Construction:	$55,632

The proposed improvement alternatives examined for Segment 3 were the same as those developed for Segment 2. Estimates of probable construction cost for each of the three (3) alternatives are summarized in the following Tables 11, 12, and 13:

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Table 11
Segment 3 – Alternative 1 Estimate of Probable Construction Cost

No.	Item	Quantity	Unit	Unit Price	Total Price
1	Tree Removal	L. Sum	1	$7,500	$7,500
2	Earth Excavation	Cu. Yd.	170	$30	$5,100
3	Seeding, Class 1 (Special)	Sq. Yd.	1,730	$15	$25,950
4	Inlet and Pipe Protection	Each	1	$300	$300
5	Geo-Web Reinforcement	Sq. Yd.	815	$60	$48,900
				Subtotal:	$87,750
				Contingency, 20%:	$17,550
				Total Estimated Construction:	$105,300

Table 12
Segment 3 – Alternative 2 Estimate of Probable Construction Cost

No.	Item	Quantity	Unit	Unit Price	Total Price
1	Tree Removal	L. Sum	1	$7,500	$7,500
2	Earth Excavation	Cu. Yd.	213	$30	$6,390
3	Seeding, Class 1 (Special)	Sq. Yd.	1,530	$15	$22,950
4	Inlet and Pipe Protection	Each	1	$300	$300
5	Concrete Channel Bottom, 8" Thick	Sq. Yd.	200	$105	$21,000
6	Geo-Web Reinforcement	Sq. Yd.	615	$60	$36,900
				Subtotal:	$95,040
				Contingency, 20%:	$19,008
				Total Estimated Construction:	$114,048

Table 13
Segment 3 – Alternative 3 Estimate of Probably Construction Cost

No.	Item	Quantity	Unit	Unit Price	Total Price
1	Tree Removal	L. Sum	1	$7,500	$7,500
2	Earth Excavation	Cu. Yd.	270	$30	$8,100
3	Seeding, Class 1 (Special)	Sq. Yd.	1,020	$15	$15,300
4	Inlet and Pipe Protection	Each	1	$300	$300
5	Concrete Channel, 8" Thick	Sq. Yd.	815	$125	$101,875
				Subtotal:	$133,075
				Contingency, 20%:	$26,615
				Total Estimated Construction:	$159,690

Detailed drawings showing the typical cross sections for each of the described improvement alternatives is provided in Exhibit 8.

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Recommendations

Based on the previously described analysis of the existing drainage system, the potential for significant increase in conveyance capacity is limited by the crossroad culverts in the channel segments studied, as well as, in the areas upstream and downstream of the studied segments. The failing retaining wall on the west side of Segment 1 is a significant issue that the Village should consider addressing in the near future. The existing wall is leaning into the channel significantly and will eventually fall into the stream creating a significant obstruction to the drainage path. This failure is likely to take place during a significant rain event which will compound the issue. The possibility for damage to adjacent homes and property due to the failure of this wall is extremely high.

To address this issue with Segment 1, Alternative No. 2 appears to be an ideal solution due to multiple factors. Alternative No. 2 is the most cost-effective solution based on the estimates of probable costs prepared. The use of gabion baskets are a cost-effective replacement for the masonry block wall that is failing while keeping the shape of the overall channel consistent with the existing. Finally, the new channel will be sized such that the existing private fences on either side of the existing channel can be returned to their current positions without reducing the current side yards of the existing adjacent properties. This fact could prove to be a significant selling point to the property owners when attempting to acquire property and or easement for the construction and maintenance of the channel going forward.

While still necessary on extremely flat channel slopes, using cast-in-place concrete to line ditch channels has decreased in popularity in recent years. There are several reasons for this change in engineering thought. First, concrete channel linings dramatically increase velocity in the channel over natural materials allowing for more flow to move downstream faster contributing to flooding and scour. Second, new rules established by the Environmental Protection Agency regarding the protection of surface water have driven the use of more ecologically friendly designs. Turf linings, when properly stabilized, serve as natural filters to remove eroded silt, road salts, and other pollutants that can more readily enter downstream surface water when conveyed through an impermeable and smooth ditch/channel lining. Third, the permeability of the channel allows for some absorption of surface water in lieu of straight conveyance downstream.

Based on this philosophy, the widening of the channel cross-sectional area in conjunction with the establishment of a stabilized turf lining as described in Alternative No. 1 appears to be the ideal improvement methodology for Segments 2 and 3. Increasing the cross-sectional area while maintaining a turf channel lining will reduce the velocity in the channel which will reduce the erosion that is currently taking place. The widening of the channel also provides an increased volume of storage upstream of the restrictions in the flow at the crossroads culverts. This increased volume will serve as further peak flow attenuation and provide positive impacts downstream while reducing flooding elevations upstream. Finally, the flattened side slopes of the channel will allow the adjacent property owners easier access to the channel for mowing and overall channel maintenance.

As determined from the analysis, the existing system is extremely intricate and appears to be sufficient during typical rainfall events. Making dramatic changes to this system without considerations for the downstream impacts will be a critical condition of any future improvements to be undertaken by the Village.

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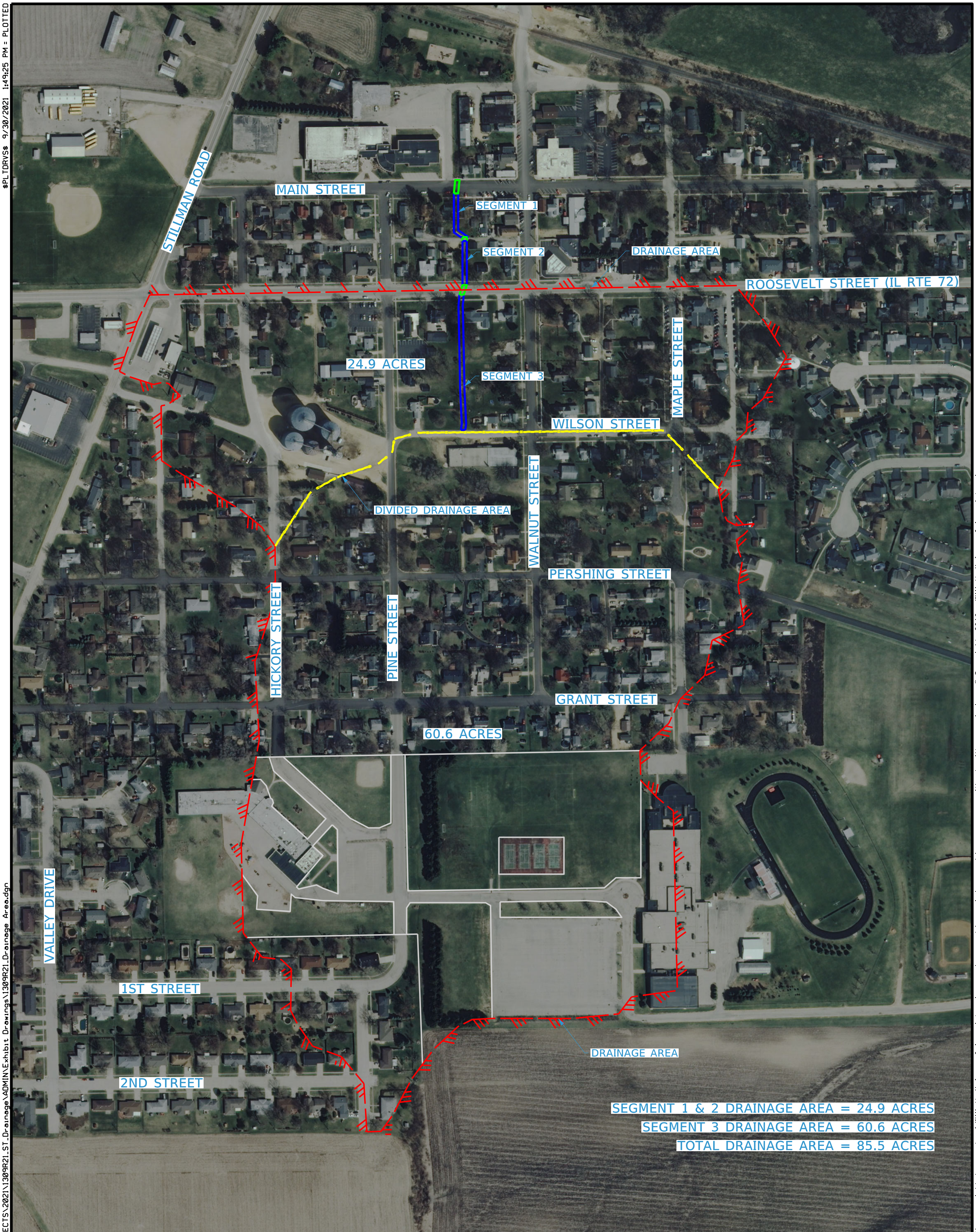
Exhibit 1

Overall Drainage Basin and Location Map



SCALE

0' 200' 300' 400'

PROJECT NORTH

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VILLAGE OF STILLMAN VALLEY

DRAINAGE AREA

SHEET 1 OF 1

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Exhibit 2

Photographs of the Existing Channel and Culverts

RIGHT PHOTO:

SEGMENT 1
MAIN STREET CULVERT

LEFT PHOTO:

SEGMENT 1
LOOKING SOUTH FROM
MAIN STREET CULVERT

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VILLAGE OF STILLMAN VALLEY

DRAINAGE DITCH STUDY

EXISTING DRAINAGE DITCH PHOTOS (PAGE 1 OF 4)

RIGHT PHOTO:

SEGMENT 2
ALLEY CULVERT

LEFT PHOTO:

SEGMENT 2
LOOKING SOUTH FROM
ALLEY CULVERT

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DRAINAGE DITCH STUDY

EXISTING DRAINAGE DITCH PHOTOS (PAGE 2 OF 4)

RIGHT PHOTO:

SEGMENT 2
NORTH SIDE OF
ROOSEVELT STREET (IL RTE 72)
CULVERT

LEFT PHOTO:

SEGMENT 3
SOUTH SIDE OF
ROOSEVELT STREET (IL RTE 72)
CULVERT

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VILLAGE OF STILLMAN VALLEY

DRAINAGE DITCH STUDY

EXISTING DRAINAGE DITCH PHOTOS (PAGE 3 OF 4)

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FILE = S:\PROJECTS\2021\1309R21_ST_Drainage\ADMIN\Exhibit Drawings\1309R21_Drainage Area.dgn

RIGHT PHOTO:

SEGMENT 3
LOOKING SOUTH FROM
ROOSEVELT STREET (IL RTE 72)
CULVERT

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VILLAGE OF STILLMAN VALLEY

DRAINAGE DITCH STUDY

EXISTING DRAINAGE DITCH PHOTOS (PAGE 4 OF 4)

Exhibit 3

Regression Equation Method Runoff Calculations

Client:	Village of Stillman Valley
Project Name:	Drainage Study of Unnamed Tributary to Stillman Creek
Project Number:	1309R21
Engineer:	Aaron M. Full, P.E.
Date:	August 24, 2021

DETERMINATION OF FLOWS USING THE USGS REGRESSION EQUATIONS

All locations in the study area fall in Hydrologic Region 1 as outlined in "Estimating Flood-Peak Discharge Magnitudes and Frequencies for Rural Streams in Illinois", Scientific Investigations Report 2004-5103 as published by the USGS.

For the purpose of determing the most conservative set of flow data, will calculate the flows for each location using both the rural and urban techniques and use the higher, more conservative value.

RURAL METHOD

Location: Segment 3 - Wilson Street to Roosevelt Street

Total Drainage Area (TDA):	60.553	Acres
	0.09	Sq. Miles
Main Channel Length (MCL):	2,514.00	Feet
	0.48	Miles
Elevetion of 10% Point:	772.75	
Elevation of 85% Point:	718	
Main Channel Slope (MCS):	153.32	Feet/Mile
Average Permeability of WS:	3.967	Inches/Hour

Region 2 Regression Equation:

$$Q_T = a(TDA)^b(MCS)^c(PermAvg)^dRF(2)$$

	a	TDA	^b	MCS	^c	PermAvg	^d	RF(2)	**Q**
Q_2 =	22.2	0.09	0.749	153.32	0.401	3.97	-0.224	1.467	**30.77**
Q_5 =	34.1	0.09	0.743	153.32	0.437	3.97	-0.223	1.563	**61.30**
Q_{10} =	41.8	0.09	0.74	153.32	0.457	3.97	-0.224	1.618	**86.52**
Q_{25} =	50.8	0.09	0.738	153.32	0.478	3.97	-0.224	1.686	**122.36**
Q_{50} =	57	0.09	0.737	153.32	0.491	3.97	-0.223	1.738	**151.66**
Q_{100} =	62.7	0.09	0.736	153.32	0.503	3.97	-0.222	1.79	**183.20**

Location: **Segments 1 and 2 - Roosevelt Street to Main Street**

Total Drainage Area (TDA):	85.54	Acres
	0.13	Sq. Miles
Main Channel Length (MCL):	2,996.00	Feet
	0.57	Miles
Elevetion of 10% Point:	771.1	
Elevation of 85% Point:	712	
Main Channel Slope (MCS):	138.87	Feet/Mile
Average Permeability of WS:	3.967	Inches/Hour

Region 2 Regression Equation:

$$Q_T = a(TDA)^b(MCS)^c(PermAvg)^dRF(2)$$

	a	TDA	^b	MCS	^c	PermAvg	^d	RF(2)	**Q**
Q_2 =	22.2	0.13	0.749	138.87	0.401	3.97	-0.224	1.467	**38.31**
Q_5 =	34.1	0.13	0.743	138.87	0.437	3.97	-0.223	1.563	**75.89**
Q_{10} =	41.8	0.13	0.74	138.87	0.457	3.97	-0.224	1.618	**106.78**
Q_{25} =	50.8	0.13	0.738	138.87	0.478	3.97	-0.224	1.686	**150.60**
Q_{50} =	57	0.13	0.737	138.87	0.491	3.97	-0.223	1.738	**186.36**
Q_{100} =	62.7	0.13	0.736	138.87	0.503	3.97	-0.222	1.79	**224.76**

URBAN METHOD

Population Density in Area:	737.5	Persons/Sq. Mile
Imperviousness Factor (I_f):	8.38	

Ratio of Flood Magnitudes, Urban to Rural:

	Ratio, U to R
Q_2 =	1.95
Q_5 =	1.72
Q_{10} =	1.62
Q_{25} =	1.54
Q_{50} =	1.48
Q_{100} =	1.45

Location: **Segment 3 - Wilson Street to Roosevelt Street**

	Rural Q	**Urban Q**
Q_2 =	30.77	**60.00**
Q_5 =	61.30	**105.44**
Q_{10} =	86.52	**140.16**
Q_{25} =	122.36	**188.43**
Q_{50} =	151.66	**224.46**
Q_{100} =	183.20	**265.64**

Location: **Segments 1 & 2 - Roosevelt Street to Main Street**

	Rural Q	**Urban Q**
Q_2 =	38.31	**74.70**
Q_5 =	75.89	**130.53**
Q_{10} =	106.78	**172.99**
Q_{25} =	150.60	**231.92**
Q_{50} =	186.36	**275.81**
Q_{100} =	224.76	**325.91**

Exhibit 4

Rational Method Runoff Calculations

Client:	Village of Stillman Valley
Project Name:	Drainage Study of Unnamed Tributary to Stillman Creek
Project Number:	1309R21
Engineer:	Aaron M. Full, P.E.
Date:	September 27, 2021

DETERMINATION OF FLOWS USING THE RATIONAL METHOD

Stillman Valley is located in Ogle County which falls in the Northwest Climatic Section (Section 1) as defined in the Illinois State Water Survey's Bulletin 75 - Precipitation Frequency Study for Illinois. Bulletin 75 will be used to derive the rainfall intensity factors (I's) for the variious storm events of each of the drainage basins.

RATIONAL METHOD

Location: **Segment 3 - Wilson Street to Roosevelt Street**

Total Drainage Area (A):	60.56	Acres
Composite Rational "C" Factor:	0.53	
Catchment CxA:	32.25	Acres

	t_c (hr)	I (in/hr)	CxA (acre)	Q (ft^3/s)
Q_2 =	0.414	2.863	32.25	93.07
Q_5 =	0.394	3.730	32.25	121.24
Q_{10} =	0.381	4.539	32.25	147.54
Q_{25} =	0.367	5.707	32.25	185.50
Q_{50} =	0.358	6.710	32.25	218.10
Q_{100} =	0.350	7.797	32.25	253.45

Location: **Segments 1 & 2 - Roosevelt Street to Main Street**

Total Drainage Area (A):	85.54	Acres
Composite Rational "C" Factor:	0.54	
Catchment CxA:	45.99	Acres

	t_c (hr)	I (in/hr)	CxA (acre)	Q (ft^3/s)
Q_2 =	0.473	2.602	45.99	120.61
Q_5 =	0.452	3.394	45.99	157.31
Q_{10} =	0.439	4.137	45.99	191.79
Q_{25} =	0.425	5.221	45.99	242.02
Q_{50} =	0.416	6.140	45.99	284.62
Q_{100} =	0.408	7.139	45.99	330.91

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Exhibit 5

Existing Ditch Hydraulic Capacity Calculations

OPEN CHANNEL FLOW CALCULATIONS

Location: Stillman Valley, IL

Seqment: Main Street to Alley - Existing Ditch Channel

Rectangular, Dirt Bottom with Walls

Manning's Rougness Coefficient (r		0.025	
Channel Slope (S_o):	0.75% =	0.0075	ft/ft
Channel Width (W):		4	ft
Channel Left Side Slope:		0.001	:1
Channel Right Side Slope:		0.001	:1
Angle of Left Side Slope (θ_L):		1.57	radians
Angle of Left Side Slope (θ_L):		1.57	radians
Depth of Flow (d):		2.75	ft
Top Width (W_t):		4.0	ft
Area of Flow (A):		11.0	ft^2
Wetted Perimeter (P):		9.50	ft
Hydraulic Radius (R_h):		1.16	ft
Open Channel Velocity (v):		5.69	ft/s
Open Channel Flow (Q):		62.7	ft^3/s

OPEN CHANNEL FLOW CALCULATIONS

Location: Stillman Valley, IL
Seqment: Roosevelt Street to Alley - Existing Ditch
Channel: Trapezoidal, Dense Vegetation

Manning's Rougness Coefficient (r			0.030	
Channel Slope (S_o):	0.81%	=	0.0081	ft/ft
Channel Width (W):			3	ft
Channel Left Side Slope:			2	:1
Channel Right Side Slope:			2	:1
Angle of Left Side Slope (θ_L):			0.46	radians
Angle of Left Side Slope (θ_L):			0.46	radians
Depth of Flow (d):			2	ft
Top Width (W_t):			11	ft
Area of Flow (A):			14.00	ft^2
Wetted Perimeter (P):			11.94	ft
Hydraulic Radius (R_h):			1.17	ft
Open Channel Velocity (v):			4.97	ft/s
Open Channel Flow (Q):			69.6	ft^3/s

OPEN CHANNEL FLOW CALCULATIONS

Location: Stillman Valley, IL
Seqment: Wilson Street to Roosevelt Street - Existing Ditch
Channel: Trapezoidal, Dense Vegetation

Manning's Rougness Coefficient (r			0.035	
Channel Slope (S_o):	1.23%	=	0.0123	ft/ft
Channel Width (W):			3	ft
Channel Left Side Slope:			1.8	:1
Channel Right Side Slope:			1.8	:1
Angle of Left Side Slope (θ_L):			0.51	radians
Angle of Left Side Slope (θ_L):			0.51	radians
Depth of Flow (d):			2.5	ft
Top Width (W_t):			12	ft
Area of Flow (A):			18.75	ft^2
Wetted Perimeter (P):			13.30	ft
Hydraulic Radius (R_h):			1.41	ft
Open Channel Velocity (v):			5.94	ft/s
Open Channel Flow (Q):			111.3	ft^3/s

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Exhibit 6

Existing Culvert Capacity Calculations

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Recurrence

Table 1 - Summary of Culvert Flows at Crossing: Main Street

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
706.62	2 year	120.61	50.24	70.23	8
706.73	5 year	157.31	52.28	104.75	4
706.83	10 year	191.79	53.98	137.70	4
706.96	25 year	242.02	56.14	185.83	4
707.06	50 year	284.62	57.78	226.66	3
707.17	100 year	330.91	59.42	271.43	3
706.24	Overtopping	42.81	42.81	0.00	Overtopping

Rating Curve Plot for Crossing: Main Street

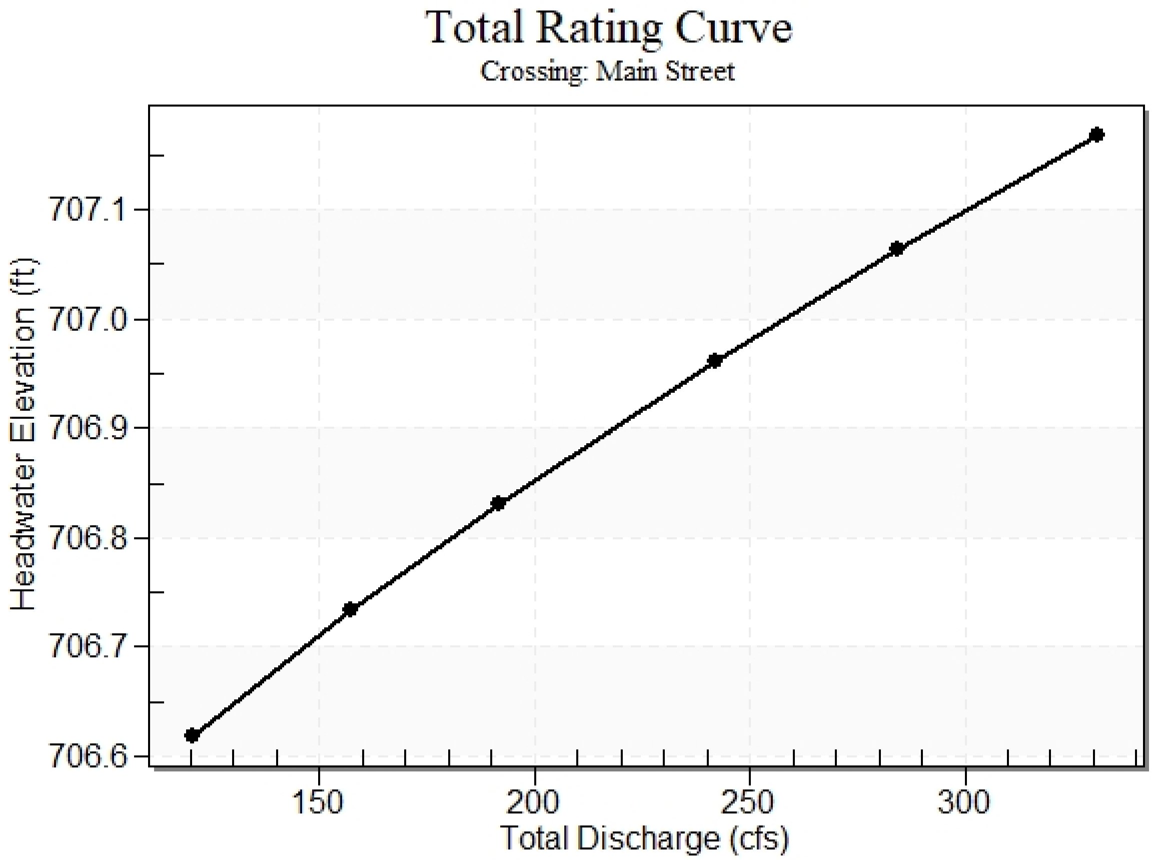

Table 2 - Culvert Summary Table: Culvert 1

Discharge Names	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)
2 year	120.61	50.24	706.62	2.619	1.381	6-FFt	0.928	1.466	1.623	1.623	6.328	6.260
5 year	157.31	52.28	706.73	2.733	1.713	4-FFf	0.947	1.494	1.833	1.857	6.150	6.736
10 year	191.79	53.98	706.83	2.831	1.991	4-FFf	0.965	1.516	1.833	2.051	6.350	7.110
25 year	242.02	56.14	706.96	2.961	2.351	4-FFf	0.987	1.542	1.833	2.300	6.604	7.570
50 year	284.62	57.78	707.06	3.063	2.627	4-FFf	1.004	1.561	1.833	2.489	6.797	7.905
100 year	330.91	59.42	707.17	3.168	2.905	4-FFf	1.021	1.579	1.833	2.676	6.990	8.227

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Straight Culvert

Inlet Elevation (invert): 704.00 ft,   Outlet Elevation (invert): 702.58 ft

Culvert Length: 75.01 ft,   Culvert Slope: 0.0189

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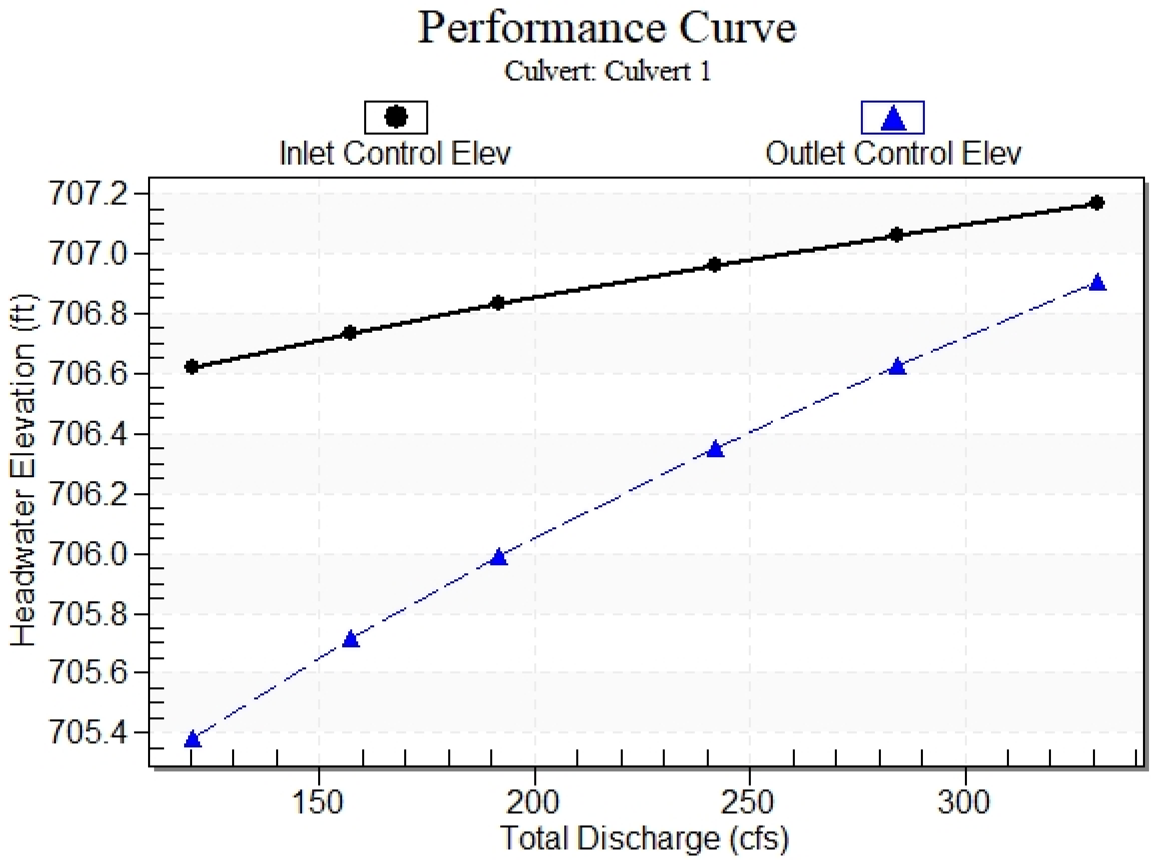
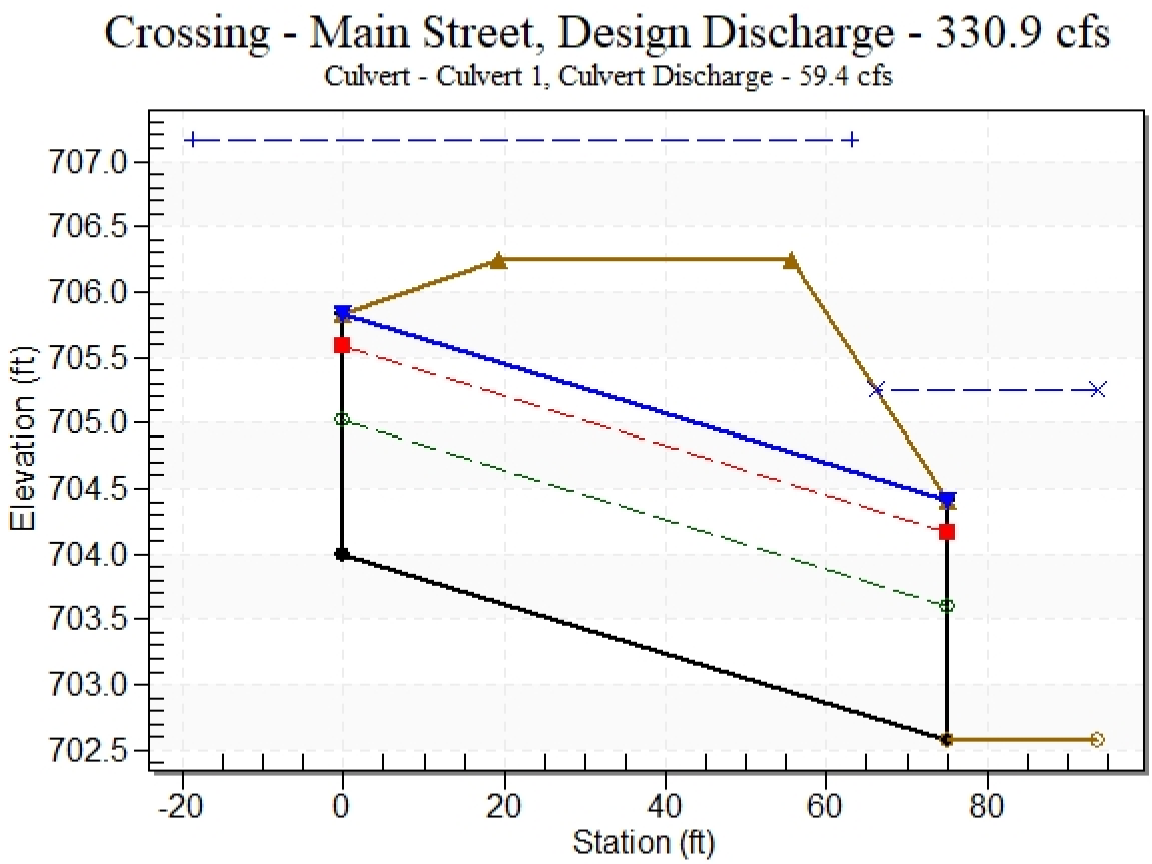
Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 704.00 ft

Outlet Station: 75.00 ft

Outlet Elevation: 702.58 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Elliptical

Barrel Span: 34.00 in

Barrel Rise: 22.00 in

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Main Street)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
120.61	704.20	1.62	6.26	1.40	1.03
157.31	704.44	1.86	6.74	1.60	1.05
191.79	704.63	2.05	7.11	1.77	1.06
242.02	704.88	2.30	7.57	1.98	1.08
284.62	705.07	2.49	7.90	2.14	1.09
330.91	705.26	2.68	8.23	2.30	1.10

Tailwater Channel Data - Main Street

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 7.00 ft

Side Slope (H:V): 3.00 (_:1)

Channel Slope: 0.0138

Channel Manning's n: 0.0300

Channel Invert Elevation: 702.58 ft

Roadway Data for Crossing: Main Street

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 100.00 ft

Crest Elevation: 706.24 ft

Roadway Surface: Paved

Roadway Top Width: 36.50 ft

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Recurrence

Table 1 - Summary of Culvert Flows at Crossing: Alley

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
707.51	2 year	120.61	12.26	108.34	5
707.68	5 year	157.31	12.66	144.50	4
707.82	10 year	191.79	12.98	178.74	4
708.02	25 year	242.02	13.42	228.58	4
708.18	50 year	284.62	13.77	270.68	3
708.33	100 year	330.91	14.05	316.86	3
706.50	Overtopping	0.00	0.00	0.00	Overtopping

Rating Curve Plot for Crossing: Alley

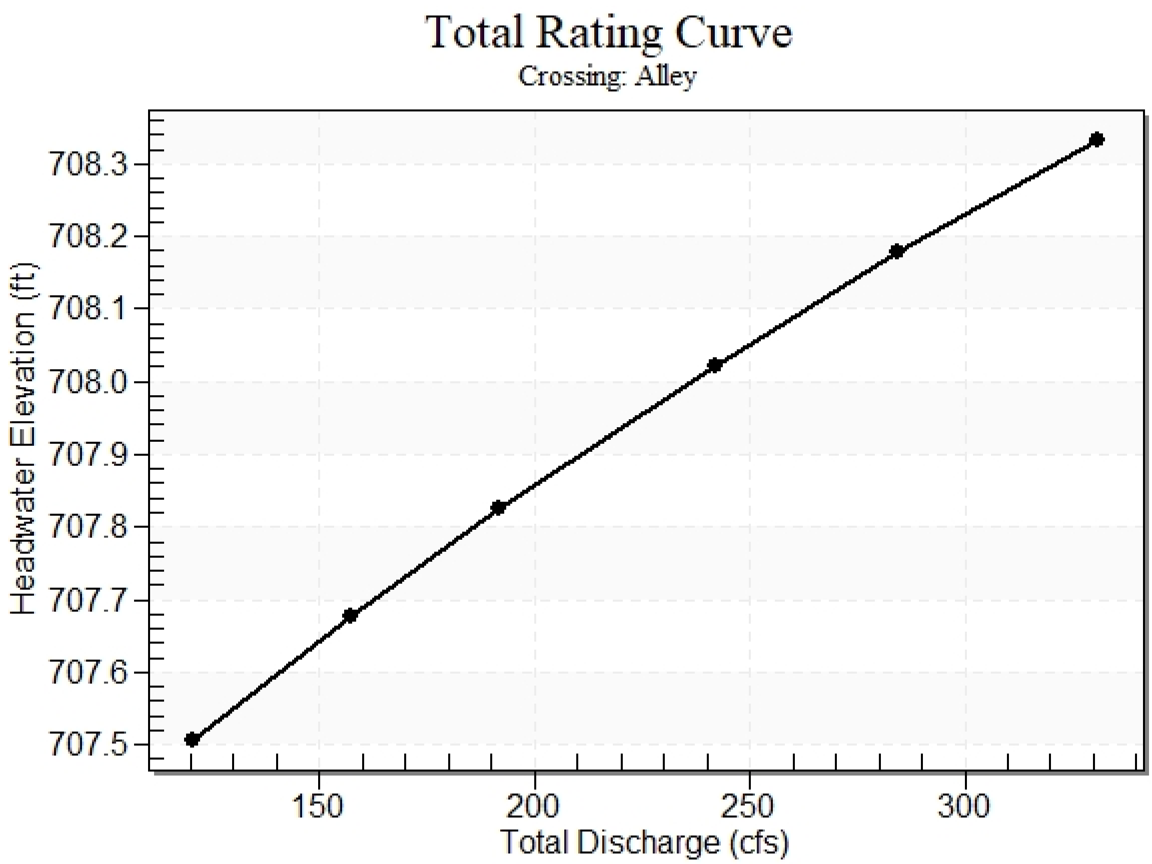


Table 2 - Culvert Summary Table: Culvert 1

Discharge Names	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)
2 year	120.61	12.26	707.51	1.806	2.506	4-FFf	1.250	1.000	1.250	1.720	4.994	0.000
5 year	157.31	12.66	707.68	1.869	2.676	4-FFf	1.250	1.015	1.250	1.830	5.160	0.000
10 year	191.79	12.98	707.82	1.920	2.823	4-FFf	1.250	1.026	1.250	1.930	5.288	0.000
25 year	242.02	13.42	708.02	1.992	3.021	4-FFf	1.250	1.041	1.250	2.060	5.466	0.000
50 year	284.62	13.77	708.18	2.052	3.178	4-FFf	1.250	1.053	1.250	2.160	5.609	0.000
100 year	330.91	14.05	708.33	2.101	3.334	4-FFf	1.250	1.061	1.250	2.270	5.723	0.000

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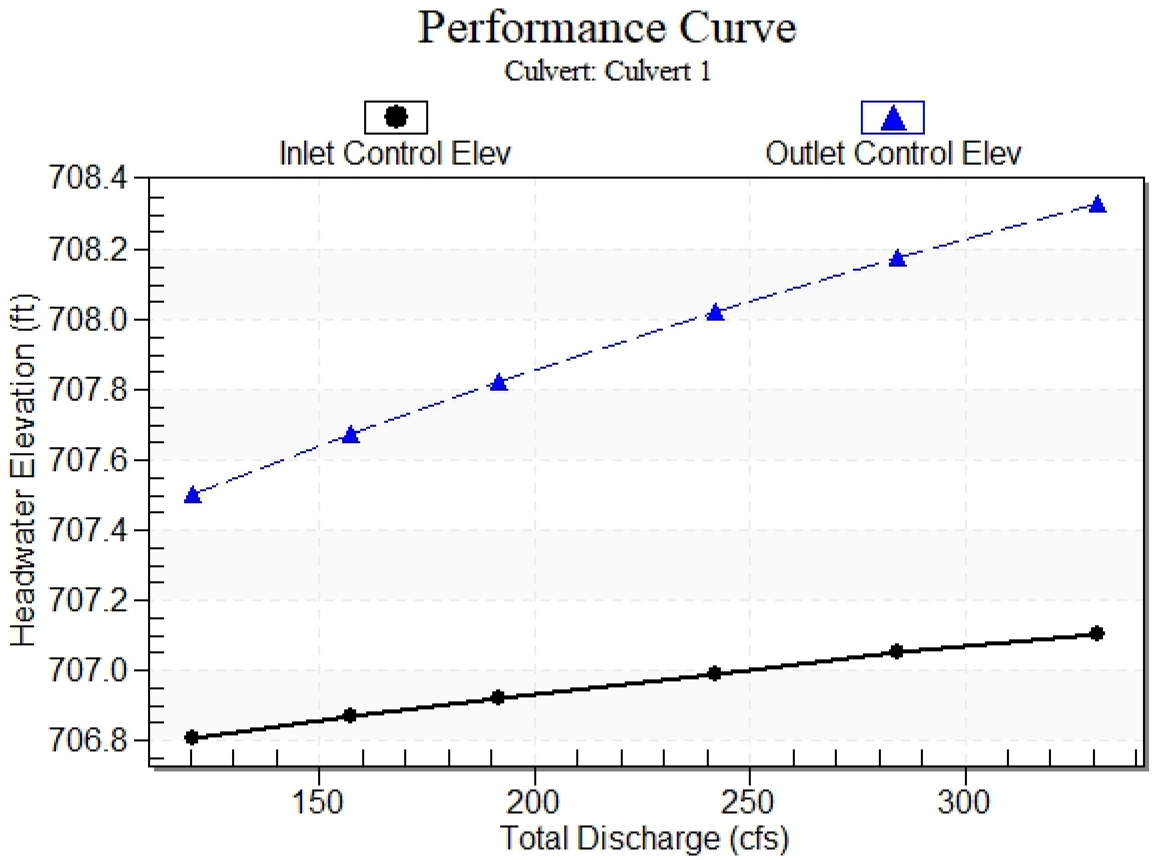
Straight Culvert

Inlet Elevation (invert): 705.00 ft, Outlet Elevation (invert): 704.90 ft

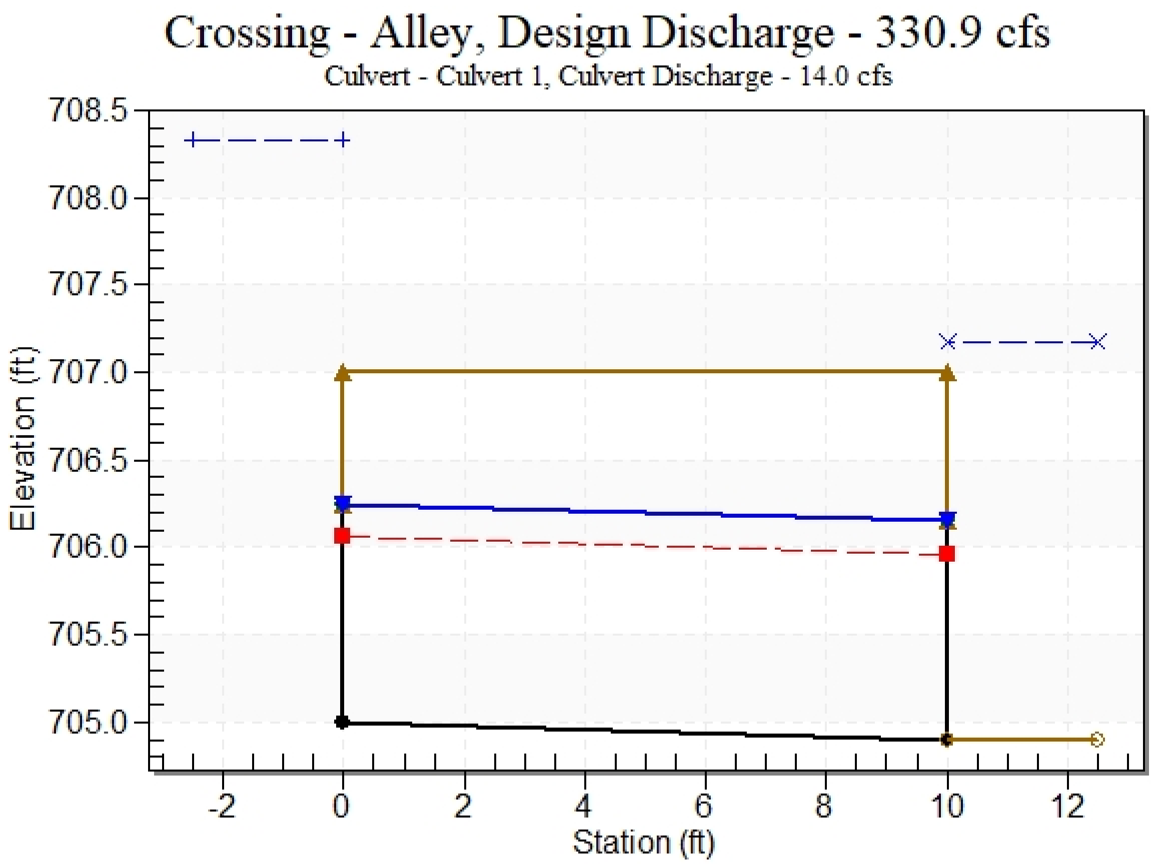
Culvert Length: 10.00 ft, Culvert Slope: 0.0100

****

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 705.00 ft

Outlet Station: 10.00 ft

Outlet Elevation: 704.90 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 1.25 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Alley)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)
120.61	706.62	706.62	0.00
157.31	706.73	706.73	0.00
191.79	706.83	706.83	0.00
242.02	706.96	706.96	0.00
284.62	707.06	707.06	0.00
330.91	707.17	707.17	0.00

Tailwater Channel Data - Alley

Tailwater Channel Option: Enter Rating Curve

Channel Invert Elevation: 704.90 ft

Roadway Data for Crossing: Alley

Roadway Profile Shape: Irregular Roadway Shape (coordinates)

Irregular Roadway Cross-Section:

Coord No.	Station (ft)	Elevation (ft)
0	0.00	707.00
1	24.00	706.50
2	32.00	706.50
3	50.00	707.00

Roadway Surface: Paved

Roadway Top Width: 10.00 ft

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Recurrence

Table 1 - Summary of Culvert Flows at Crossing: Roosevelt Street

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
710.31	2 year	93.07	81.86	10.98	10
710.45	5 year	121.24	84.79	36.31	6
710.55	10 year	147.54	85.48	61.99	5
710.69	25 year	185.50	80.35	104.87	4
710.80	50 year	218.10	76.17	141.86	4
710.91	100 year	253.45	71.76	181.31	3
710.20	Overtopping	79.31	79.31	0.00	Overtopping

Rating Curve Plot for Crossing: Roosevelt Street

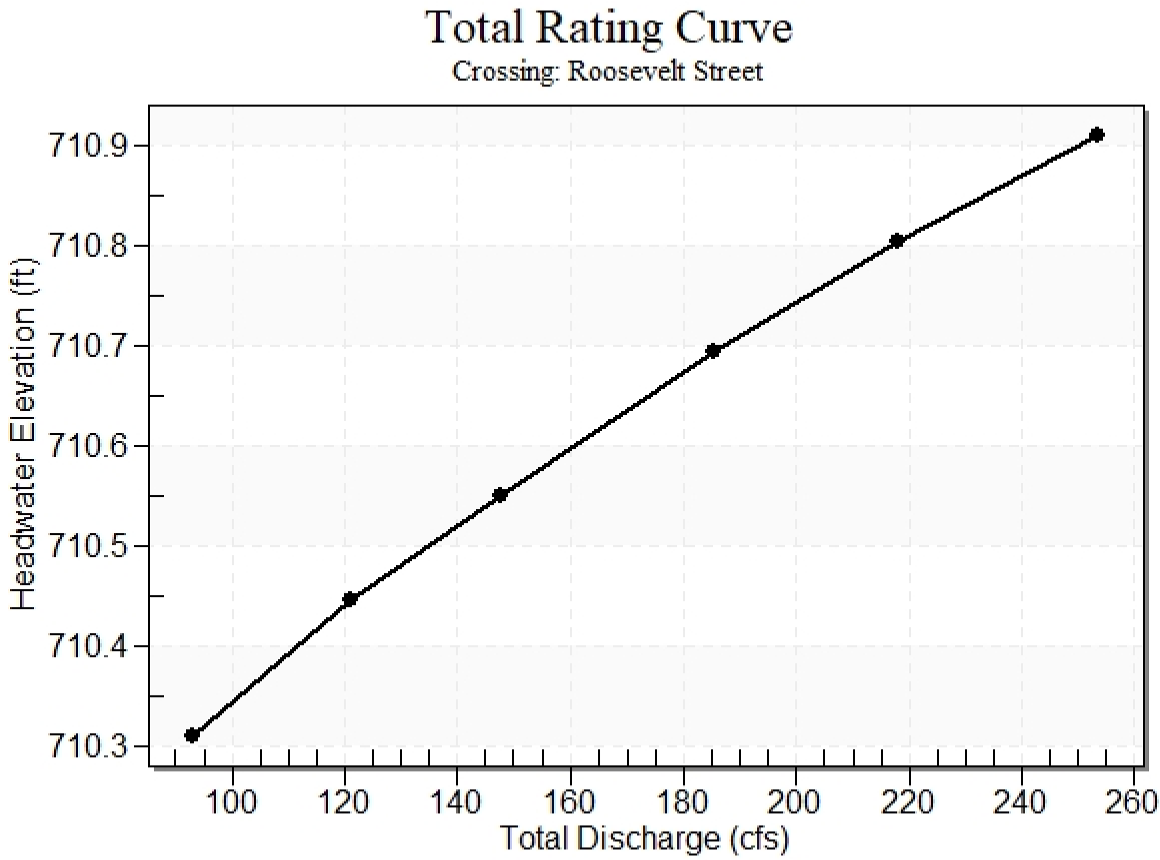


Table 2 - Culvert Summary Table: Culvert 1

Discharge Names	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)
2 year	93.07	81.86	710.31	3.312	2.896	4-FFf	1.039	1.731	1.039	2.294	12.445	5.345
5 year	121.24	84.79	710.45	3.445	3.286	4-FFf	1.063	1.772	1.063	2.591	12.593	5.719
10 year	147.54	85.48	710.55	3.477	3.549	4-FFf	1.069	1.782	1.917	2.832	7.041	6.013
25 year	185.50	80.35	710.69	3.245	3.694	4-FFf	1.026	1.710	1.917	3.138	6.619	6.372
50 year	218.10	76.17	710.80	3.066	3.803	4-FFf	0.990	1.650	1.917	3.372	6.274	6.639
100 year	253.45	71.76	710.91	2.887	3.909	4-FFf	0.952	1.586	1.917	3.602	5.911	6.895

****

Straight Culvert

Inlet Elevation (invert): 707.00 ft, Outlet Elevation (invert): 706.33 ft

Culvert Length: 48.00 ft, Culvert Slope: 0.0140

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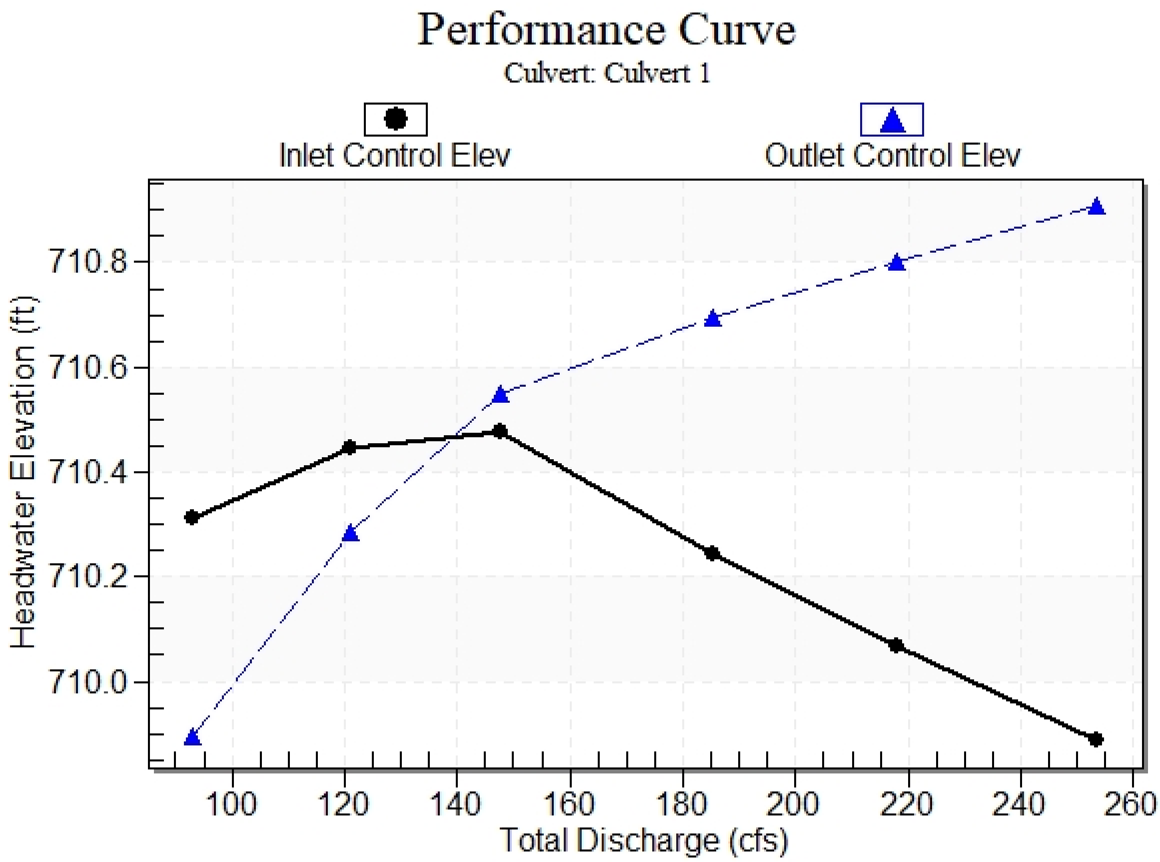
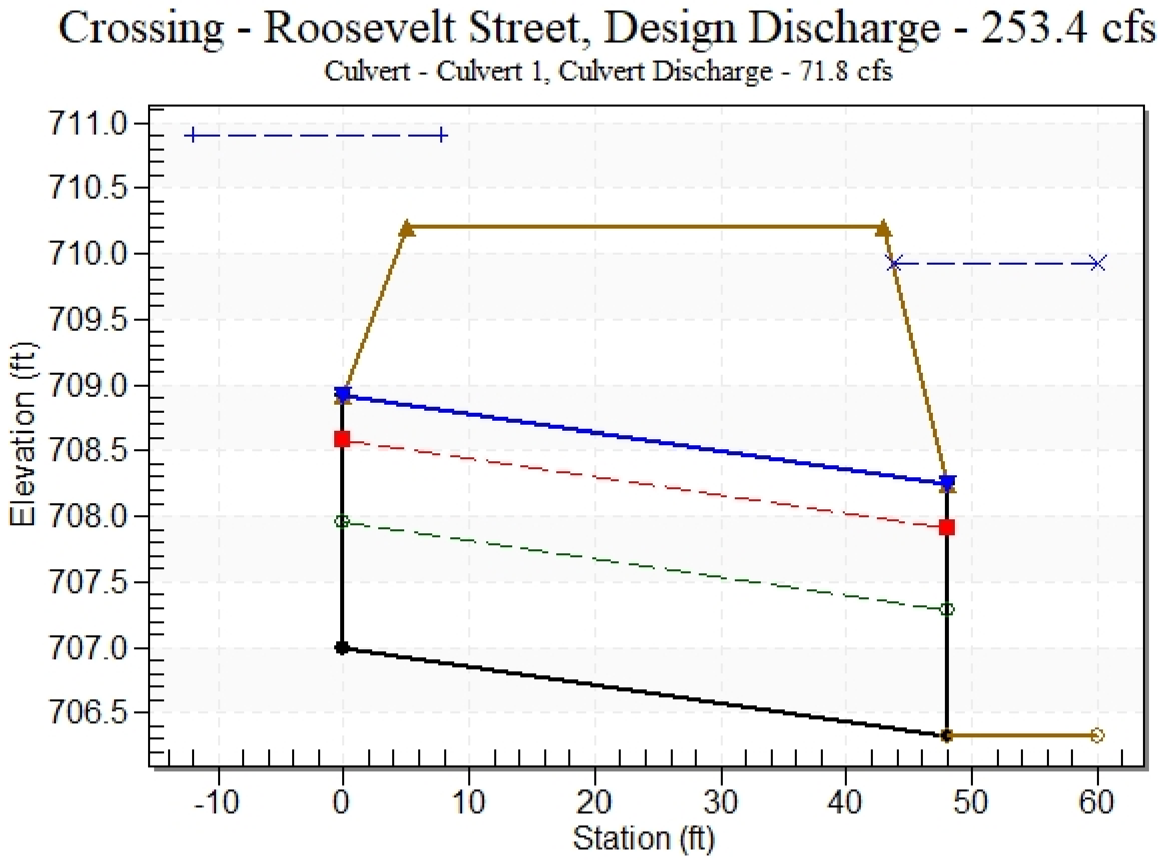
Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 707.00 ft

Outlet Station: 48.00 ft

Outlet Elevation: 706.33 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 6.33 ft

Barrel Rise: 1.92 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge (90º) Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Roosevelt Street)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
93.07	708.62	2.29	5.35	1.16	0.79
121.24	708.92	2.59	5.72	1.31	0.80
147.54	709.16	2.83	6.01	1.43	0.81
185.50	709.47	3.14	6.37	1.59	0.82
218.10	709.70	3.37	6.64	1.70	0.83
253.45	709.93	3.60	6.90	1.82	0.84

Tailwater Channel Data - Roosevelt Street

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 3.00 ft

Side Slope (H:V): 2.00 (_:1)

Channel Slope: 0.0081

Channel Manning's n: 0.0300

Channel Invert Elevation: 706.33 ft

Roadway Data for Crossing: Roosevelt Street

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 100.00 ft

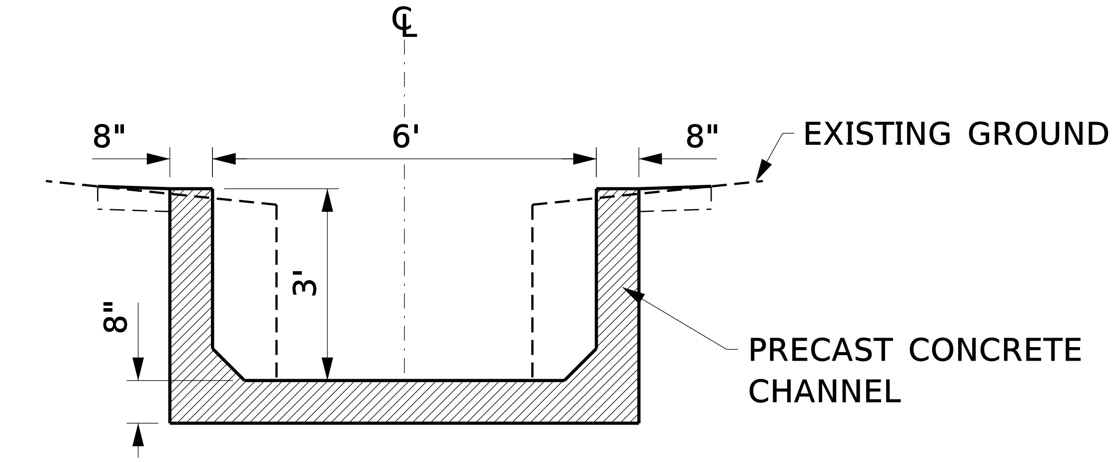
Crest Elevation: 710.20 ft

Roadway Surface: Paved

Roadway Top Width: 38.00 ft

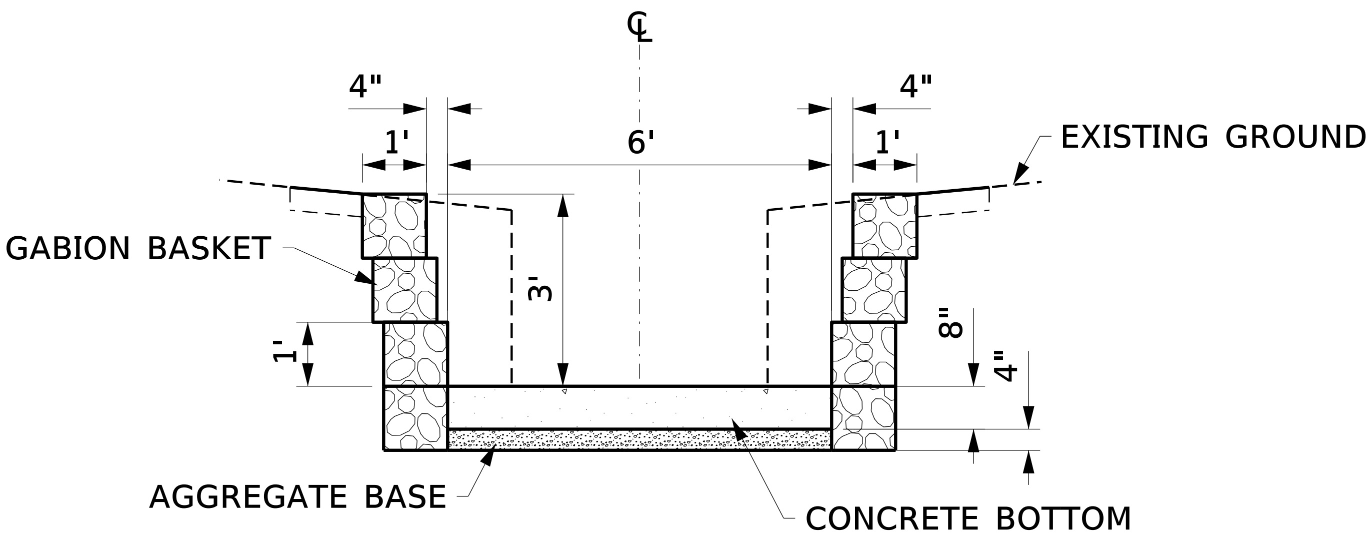
Exhibit 7

Segment 1 Improvement Alternatives Typical Sections



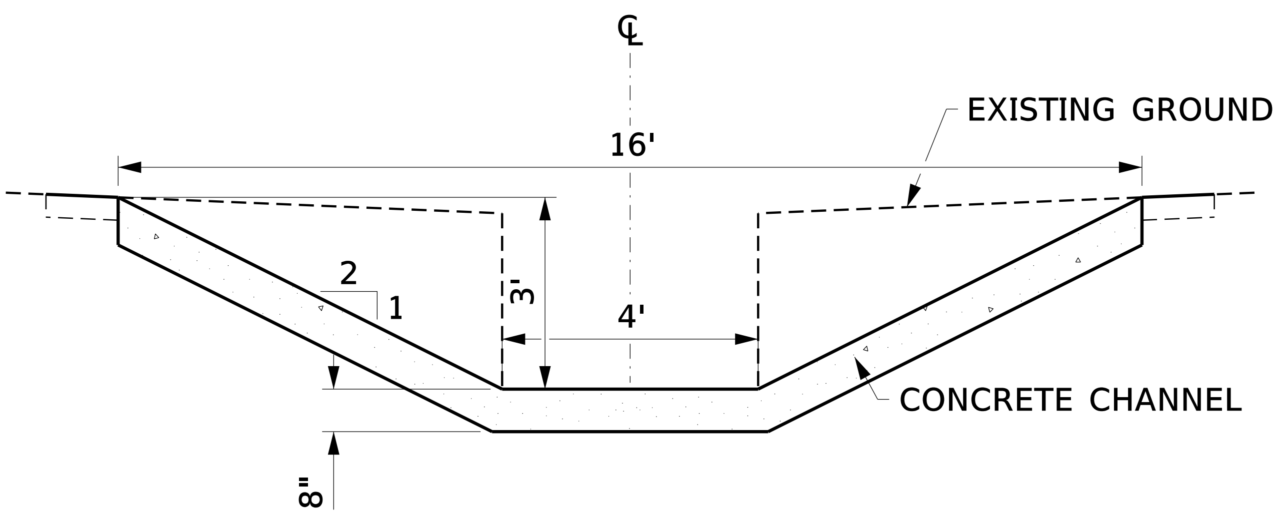
TYPICAL SECTION - SEGMENT 1

ALTERNATIVE NO. 1



TYPICAL SECTION - SEGMENT 1

ALTERNATIVE NO. 2



TYPICAL SECTION - SEGMENT 1

ALTERNATIVE NO. 3

WILLETT HOFMANN
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VILLAGE OF STILLMAN VALLEY

DRAINAGE DITCH STUDY

SEGMENT 1 ALTERNATIVES

WILLETT HOFMANN & ASSOCIATES INC
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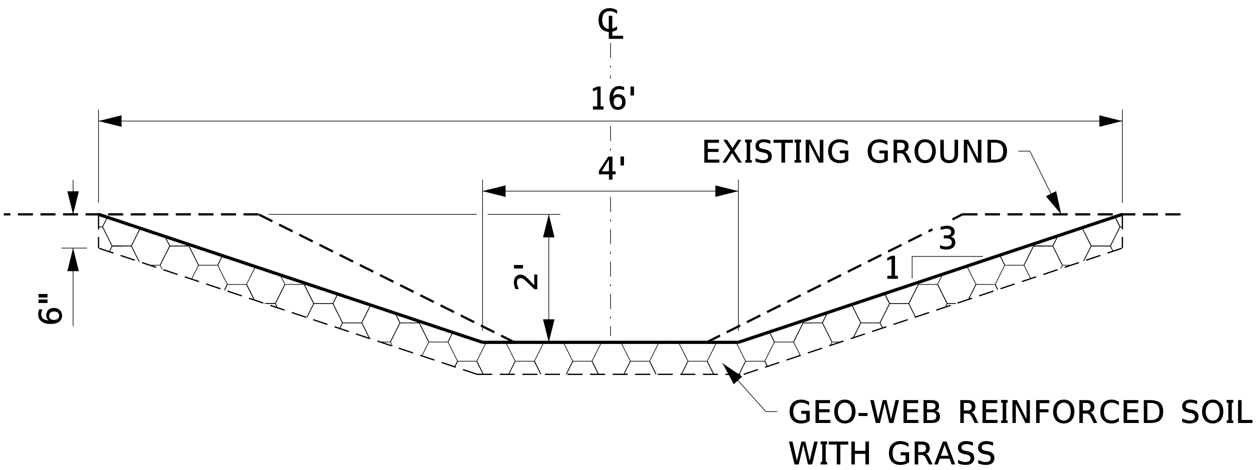
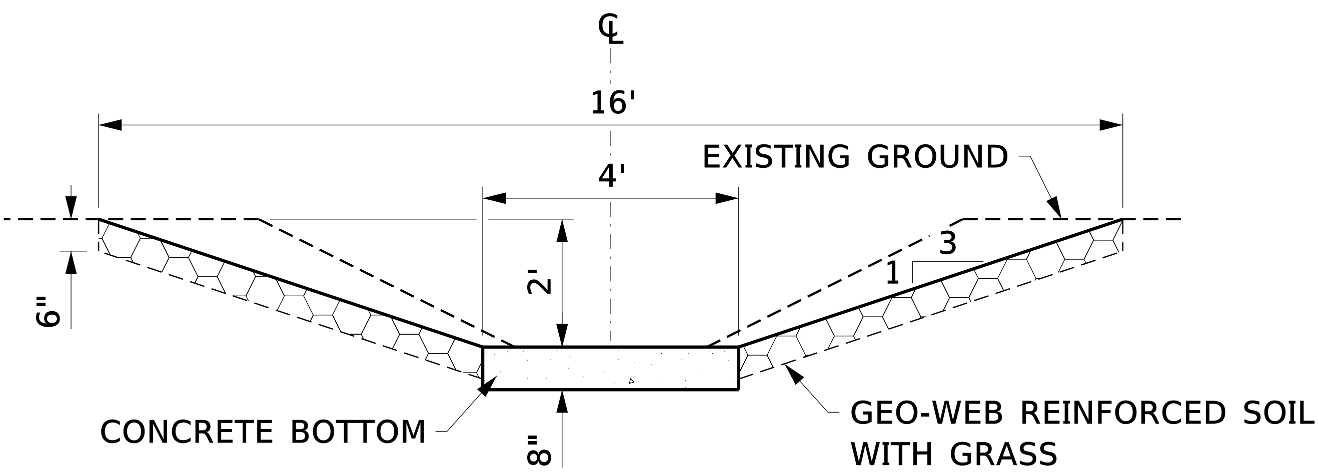
57 AIRPORT DRIVE, ROCKFORD, IL 61109
T: 815-964-2897 DESIGN FIRM: #184-000918

Exhibit 8

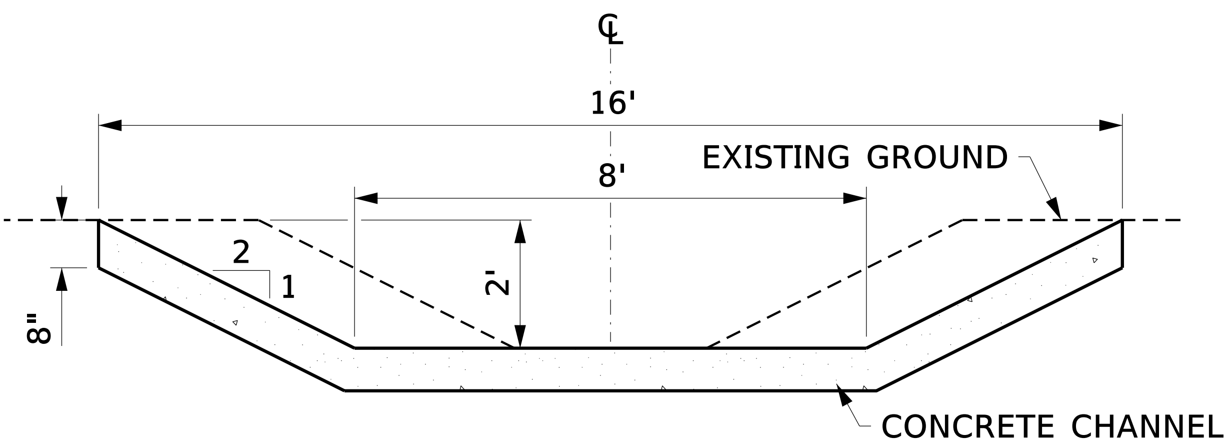
Segments 2 & 3 Improvement Alternatives Typical Sections



TYPICAL SECTION - SEGMENTS 2 & 3
ALTERNATIVE NO. 1



TYPICAL SECTION - SEGMENTS 2 & 3
ALTERNATIVE NO. 2



TYPICAL SECTION - SEGMENTS 2 & 3
ALTERNATIVE NO. 3

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VILLAGE OF STILLMAN VALLEY

DRAINAGE DITCH STUDY

SEGMENTS 2 & 3 ALTERNATIVES

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