PRELIMINARY ENGINEERING REPORT
FOR THE
GOODRICH DRAIN #0896

PREPARED FOR:

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1. Introduction

This study was completed as a result of the Board of Determination meeting on the Goodrich Drain #0896 held at the Atlas Township Hall on November 22, 2011. The Goodrich Drain #0896 is over 100 years old and is comprised both of enclosed pipe and open drain. Over the years only maintenance (no improvements) has been completed on this drain. The northerly portion (downstream end) of the drain is enclosed tile. The upper portion, including Branch No. 1 and Branch No. 2 are open drain. The majority of the flooding issues heard at the Board of Determination meeting were located within the Willowgate Crossing development which is located in the central portion of the overall drainage district on the east side of Gale Road, south of Hegel Road. This subdivision was built in the early 2000s and the parcels within this development surround a large wetland system. According to the residents, following heavy rain events the water elevation within the wetland area rises to a point where it has inundated their yards and homes in the past. They mentioned that it seems to be getting worse every year and the water is taking longer to recede each time. The residents feel that the poor condition of the enclosed portion of the Goodrich Drain #0896 is contributing to the flooding issues.

2. Site Location

The contributing area to the Goodrich Drain #0896 consists of parts of Section 16, 17, 20, 21, 28, and 29 of Atlas Township. The drain itself and its two branches are located within Section 21. A location map identifying the overall drainage area may be found in Appendix A of this report.

3. Existing Drainage Course

The upper portions of the drainage district is comprised of farmland, cultivated fields, woodlands, open space, and residential properties located along the major roadways within the drainage area. The runoff from the upper area is predominately overland shallow concentrated flow. Located in the central portion of the drainage district is a large wetland area of approximately 150 acres. Within this wetland area is the southerly portion of the enclosed portion of the Goodrich Drain, as well as its open portion and the two branches. The majority of the runoff from the overall drainage district flows into this wetland system.

Branch No. 1 collects the runoff from the westerly portion of the drainage area once it crosses beneath Gale Road. This drainage area is west of Gale Road in the McCandlish Road area.

The southerly portion of the Goodrich Drain collects the southern portion of the drainage area, consisting of the area surrounding Green Road and the area in the southwest corner of the district on the west side of Gale Road.

Branch No.2 collects runoff from a smaller sub-area in the eastern central portion of the district.

The southern portion of the Goodrich Drain, Branch No. 1, and Branch No. 2 merge and then flow northerly through the wetland area, beneath Willowgate Lane, and into the tile portion of the Goodrich Drain. This tile system continues to the north, picking up additional areas within the wetland area and along its route to Hegel Road. The tile then crosses beneath Hegel Road before ultimately discharging into the Kearsley Creek.

4. <u>Basis of Evaluation and Design</u>

A. Hydrology – (Stormwater Runoff/Detention)

DRAINAGE AREAS

Topographic field data collected by Flies & VandenBrink Engineering, Inc., field visit observations, and Genesee County Drain Commissioner's Office two foot (2') contour maps were used to determine the overall drainage area of approximately 827 acres. Based on Genesee County Drain Commissioner's Office-SWM standards, the SCS Method was used to calculate peak runoff flows for a 4% chance (25-year) storm event. A map of the overall drainage area and subareas may be found in Appendix 'C'.

SCS METHOD

The SCS Method was used to determine the amount of storm water runoff from the drainage areas identified in this report. This hydrology method uses the characteristics of the drainage areas to generate hydrographs and flows from the sub-areas. These characteristics include hydrologic soil types (A, B, C or D), the land use/coverage type, and the time of concentration of the drainage areas.

The hydrologic soils group is used to classify the existing soils of the sub-areas into different types of infiltration rates. The infiltration rates of soils can vary from having high rates of infiltration similar to gravel and sandy soils to having very low rates of infiltration similar to dense clays. The hydrologic soil groups A, B, C and D are further described as follows.

Soil Group A - These soils have high infiltration rates and low runoff potential even when thoroughly wetted. Examples of these types of soils are sands and gravels.

Soil Group B - These soils have moderate infiltration rates when thoroughly wetted. These soils have moderately fine to moderately coarse textures and a moderate rate of water transmission.

Soil Group C - These soils have low infiltration rates when thoroughly wetted. These soils have moderately fine to fine texture and a low rate of water transmission.

Soil Group D - These soils have very low infiltration rates when thoroughly wetted and high runoff potential. Examples of these types of soils are clay soils which have high swelling potential and very low rates of water transmissions.

The land use/cover type of these soils further determines the amount of runoff from the drainage areas. The land use/cover type within the drainage sub-areas consist of various types of impervious surfaces such as pavements and buildings, and pervious areas such as lawns, meadows, and wooded areas. A land use and soils map is included in Appendix ‘C’.

The total drainage district area of 827 acres was divided into sub-areas and storm water runoff hydrographs for the sub-areas were determined. A drainage district map, depicting the sub-areas and collection points, is included in Appendix ‘D’.

The storm water runoff hydrograph from each sub-area was used to evaluate the existing system and design the various alternatives. In accordance with Genesee County Drain Commissioner's Office standards, a 4% chance (25-year) storm frequency was used as the basis to evaluate the existing system and to size the storm sewer and open drain for the alternatives. Further details of the sub-areas and flows generated may be found in Appendix ‘D’ which includes printouts of the hydrograph results.

TIME OF CONCENTRATION

The time of concentration for various drainage paths was calculated in order to determine the rainfall intensity (I_{25}) for the 4% chance (25-year) storm event for each drainage sub-area. The USDA NRCS TR-55 method was used to estimate the time of concentration by determining the length, slope, and surface for the three flow types (sheet, shallow concentrated, and channel) within each subarea.

EXISTING FLOWS AND ADJUSTMENTS FOR SURFACE PONDING

Once the land uses, hydrologic soil groups, and time of concentration were determined for each sub-area, these values were input into WinTR-55 to calculate the existing flow for each area within the watershed. Peak flows determined in this method assume that the topography is such that surface flow into ditches, drains, and streams is approximately uniform. In areas where ponding or swampy areas occur in the watershed, a considerable amount of surface runoff may be retained in temporary storage. Therefore, the peak rate may be reduced to reflect this condition. For this preliminary study, the areas anticipated to provide this temporary storage include wetlands, marshes, or large bodies of water which are located within depression areas of several feet according to the 2-foot contour map. Flat areas without depressions and the smaller residential ponds were not included as temporary storage.

The ponding adjustment factors used to reduce the peak flows were taken from Table 10.1 of the MDEQ’s report “Computing Flood Discharges for Small Ungaged Watersheds.” After determining the percentage of ponded or swampy areas and their location within each sub-area, the appropriate adjustment factor was applied to the calculated peak flow. As suggested in the MDEQ’s report, in most cases a ponding adjustment was applied more than once to account for ponding in the both the upper portion and lower portion of the sub-area watershed.

The following chart identifies the adjustment factors used in calculating the peak flow for each sub-area:

Subarea	Total Drainage Area	Swamp / Ponding Area		Ponding in Upper Portion of Watershed	25-Yr Adjust Factor	100-Yr Adjust Factor		Ponding in Lower Portion of Watershed	25-Yr Adjust. Factor	100-Yr Adjust. Factor
West Branch	221 Ac.	55 Ac.		5%	0.84	0.88		20%	0.55	0.64
South Branch	226 Ac.	42 Ac.		2%	0.90	0.93		16%	0.57	0.66
East Branch	55 Ac.	13 Ac.		8%	0.81	0.85		15%	0.62	0.69
South of Culv	95 Ac.	28 Ac.		9%	0.81	0.85		20%	0.55	0.64
North of Culv	189 Ac.	16 Ac.		4%	0.85	0.89		5%	0.67	0.75
NE Corner	41 Ac.	0 Ac.		-	-	-		-	-	-

Subarea	Total Adjustment Factor (25-year)	Total Adjustment Factor (100-year)
West Branch	0.46	0.56
South Branch	0.52	0.61
East Branch	0.50	0.59
South of Culv	0.45	0.55
North of Culv	0.57	0.67
NE Corner	-	-

The above reduction factors were applied to the peak flows calculated in Win TR-55 to determine the adjusted peak flow for each sub-area. Since the existing hydrology model includes combining and routing the hydrographs for the individual sub-areas, the model was adjusted to represent the reduced flow rates by adjusting the weighted curve number (CN) for each subarea until the 25-year and 100-year peak flows approximately equaled the adjusted values.

B. Hydraulics – (Storm Sewer, Open Drain, and Culverts)

OPEN DRAINS AND CULVERTS

The GCDC-SWM standard for open drain and culvert evaluation (existing conditions and design alternatives) for drainage areas greater than 300 acres but less than two (2) square miles is to evaluate and design for no surcharging for the 4% chance (25-year) storm event, where surcharging is defined as water rising above the crown of the culvert or the banks of a ditch. To satisfy these criteria and achieve maximum pipe efficiency, full pipe flow was designed for in all alternatives.

OPEN DRAIN EVALUATION

Haestad Method's FlowMaster program was used to analyze the existing and proposed open drain cross-sections. FlowMaster uses Manning's Equation to calculate the water surface elevation within each open drain cross-section using the input flow, taking into consideration the affects of the downstream slope. The roughness, shape, and height vary along an open drain; the Manning's Equation takes into consideration all of these factors and has become one of the most widely used uniform flow formulas for evaluating open channels. The Manning's coefficient of roughness (n) used to evaluate the existing open drain cross-sections was 0.080, as these are not maintained and contain brush, weeds, logs, and other debris. The Manning's coefficient of roughness (n) used to evaluate the proposed open drain cross-sections was 0.035, as these would be newly improved watercourses. The FlowMaster program also calculates the velocity of the water as it passes through the open drain cross-section. This information is necessary in determining whether the flow passing through the existing or proposed open drains are acceptable or whether they may cause erosion.

CULVERT EVALUATION

HY8 Version 7.3 was used to analyze the full flow capacity of the existing and proposed culverts along the drainage route. This program was developed by the Federal Highway Administration (FHWA), and utilizes the design methods of FHWA HDS No. 5 "Hydraulic Design of Highway Culverts". The program allows the user to specify the existing and proposed conditions of each culvert such as pipe size and shape, inlet type, site data, discharge data, tailwater elevations, irregular channel cross-sections, and overtopping elevations. In this way, the user can choose to evaluate existing culverts and design proposed culverts with or without considering the affects of downstream culverts. A Manning's roughness coefficient (n) of 0.024 was used by HY8 for corrugated steel pipe culverts.

STORM SEWER EVALUATION

Haestad Method's FlowMaster program was also used to evaluate the existing storm sewer and design the proposed storm sewer for the improvement alternatives. This program utilizes Manning's Equation to calculate capacities of circular pipe under partially full flow and full flow conditions for the calculated storm water runoff flows. The FlowMaster program also calculates the velocity of the water as it passes through the proposed storm sewer. This information is necessary in determining whether the velocities within the pipe are within the desirable range of approximately two (2) fps to ten (10) fps.

5. Evaluation of Existing Drainage System

Wetland Evaluation

As mentioned earlier in this report, the majority of the overall drainage area ultimately drains to the large wetland area located in the central portion of the drainage district. From analyzing the contours and aerial images, and from our field evaluation, there doesn't appear to be much problem with the runoff reaching this central wetland system. The overland flow routes appear to have adequate slope and the county road commission's crossings appear to be functioning adequately. While some of the existing culverts are in need of cleanout, the runoff appears to be draining in those locations. The central wetland area is heavily vegetated and contains a vast amount of available storage.

Prior to 2000 and the construction of the Willowgate Crossing development there doesn't appear to have been any homes immediately adjacent to this wetland area. The abutting properties had a substantial amount of vertical relief between their home sites and the wetland area. Considering that there was little reported flooding concerns outside of the Willowgate Crossing development, it is possible that fluctuations in the water elevation within the wetland area didn't raise a whole lot of concern. How long it took for this water to recede as a result of the deteriorating condition of the Goodrich Drain is unknown.

Following the construction of Willowgate Crossing, three homes were built immediately adjacent to this wetland area, and there are a number of other available building sites surrounding this wetland area. One of these homeowners was the petitioner and all three expressed flooding concerns at the Board of Determination meeting. The homeowner of the forth and remaining existing home within this development mentioned that he personally did not have an issue with floodwater but has noticed rising water on both sides of the Willowgate Lane crossing. This residence sits much higher than the other three.

Existing Storm Sewer Evaluation

Due to the age of the existing storm sewer, the lack of any existing plans, and the heavily vegetated terrain, very little of the existing storm sewer could be located during our field evaluation. The upper terminus of the drain within the existing wetland area was found, as was the portion beneath Hegel Road. Very little of the other 2000± feet of enclosed sewer was found in the field, other than a few areas where old broken clay tile was found on the surface or within a shallow localized depression. These old broken clay tile appeared to be from a 12” to 15” diameter pipe.

Utilizing the information obtained from the two structures at the lower and upper end of the enclosed portion of the Goodrich Drain, a pipe slope of approximately 0.04% was calculated. For the 15” diameter pipe found at the upper portion of this storm drain, the existing full flow capacity of the storm sewer would be approximately 1 cfs. The existing runoff for the 4% chance (25-year) storm event, after the ponding adjustment factors are applied, is 172 cfs. Considering the age of this storm sewer, and the remnants of pipe found on the surface along the route, it is likely that there is very little conveyance capacity in the existing pipe. Portions of the pipe are likely either mostly filled in with settlement or have failed and collapsed. The remaining portion of the storm sewer conveys runoff at a very restricted rate. At Hegel Road the drain appears to increase to a 24” diameter pipe for the road crossing. With the existing slope of approximately 0.5%, the full flow capacity of this pipe is approximately 17 cfs. The required conveyance for the existing runoff from a 4% chance (25-year) storm event, after the ponding adjustment factors are applied, is 176 cfs. The upper portion of the

Goodrich Drain does not allow this amount of runoff to enter this pipe, and therefore the 24” diameter pipe appears to be draining the runoff it is currently receiving. The only way storm water can be conveyed from the wetland area to Hegel Road is through the existing 12” – 15” diameter old clay tile due to higher elevations along the route which eliminate the potential for overland flow along the drainage course. If the existing 12” – 15” diameter old clay tile isn’t functional, then the runoff is being stored over the wetland area.

Existing Open Drain Evaluation

The majority of the existing open drain portion of the Goodrich Drain lies within the large wetland area in the central portion of the overall drainage district. This portion of the Goodrich Drain, including Branch No. 1, consists of a shallow and narrow drainage depression through the wetland area. The drain varies in depth from a few inches to approximately twelve inches and has gently sloping side slopes, resulting in a top width in the range of 15 to 20 feet on average. In several areas it is difficult to identify the actual drain as it has filled in over the course of the past 100 plus years. Branch No. 2, which extends to the east through the wetland area from the main branch, was found to be very wet with dense vegetation. Our field crew was unable to traverse this area on foot at the time of survey due to the soft ground with thick cover. We anticipate that Branch No. 2 has much of the same characteristics as the rest of the open drain, a shallow depression that meanders through the wetland area.

The following chart identifies the capacity of existing drain based on the cross sections obtained as part of our field investigation:

Ex. Cross Section Identifier	**Ex. Cross-Section Description**	**Capacity of Ex. Drain Without Overflowing Top of Bank**	**Calculated Q_{25}**
1	Branch No. 1, Cross Section A	7.5 cfs	49 cfs
2	Branch No. 1, Cross Section B	0.5 cfs	49 cfs
3	Main Branch, Southerly Portion Cross Section A	2.3 cfs	78 cfs
4	Main Branch, Southerly Portion, Cross Section B	0.4 cfs	78 cfs
5	Main Branch, S. of Culv, Cross Section A	3.3 cfs	143 cfs
6	Main Branch, S. of Culv, Cross Section B	0.9 cfs	143 cfs

As shown above, the existing drains due little more than provide a route for low flow conditions. Due to the flat terrain of the natural wetland area, the existing drains could not be constructed deeper or at greater slopes. It is likely that many different storm water paths exist through the massive wetland area. A significant amount of natural storage is available in this area.

The remaining open drain portion of the Goodrich Drain is located near its confluence with the Kearsley Creek and extends from Kearsley Creek to Hegel Road. The upper portion of this drain begins at the discharge point of the 24" pipe beneath Hegel Road. Like the existing 24" pipe crossing, it is likely that this portion of the Goodrich Drain has been improved and/or cleaned out over the years during various projects. This open drain portion of the Goodrich Drain appears adequate to convey the existing flows expected to be discharged through the 24" pipe, but does not have the capacity to convey the calculated existing flow of 176 cfs for the 4% chance (25-year) storm event.

Existing Culvert Evaluation

When the Willowgate Crossing development was constructed in the early 2000s, a 83"x57" CMP culvert was installed along the open drain portion of the Goodrich Drain at the Willowgate Lane road crossing. According to the plans provided by the GCDC-SWM's office for this crossing, the culvert was designed to convey the 4% chance (25-year) storm event at full flow and pass the 1% chance (100-year) storm event with one foot of head.

The flows that were calculated at that time by the developer's engineer and used to size the culvert were 134 cfs for the 4% chance (25-year) storm event and 203 cfs for the 1% chance storm event.

The flows that were calculated for this preliminary engineering study at the crossing location were approximately 143 cfs for the 4% chance (25-year) and 260 cfs for the 1% (100-year) chance storm event. While these flows are slightly higher than those previously calculated, the 4% chance (25-year) storm event flows are similar when considering the size of the upstream drainage area and the amount of ponding and temporary storage that must be estimated. The similar flows support the ponding factors used to calculate the peak flows as described in Section 4 of this report.

As shown on the following chart, the existing culvert appears adequate to convey the 4% chance (25-year) storm event:

Ex. Culvert Location	**Ex. Culvert Size and Type**	**Ex. Capacity of Culvert, Q_{full}**	**Calculated Flow to Ex. Culvert, Q_{25}**
Willowgate Lane	83"x57" CMP	150 cfs	143 cfs

For the 1% chance (100-yr) storm event the culvert would be surcharged by more than one foot of headwater using the flow determined by Fleis & VandenBrink Engineering, Inc. The calculations indicate that weir flow over the road would be expected. However, it should be noted the calculations assume that the headwater and tailwater elevations would reach the calculated levels. With the lack of much of a defined channel both upstream and downstream of this culvert, and the characteristics of the wetland area on both sides of the culvert, it is possible that the water elevation would never reach these elevations due to the vast amount of ponding and temporary storage over the wetland area.

6. Proposed Improvement Alternatives

Three (3) alternatives were analyzed in order to improve the existing drainage course within the existing drainage district and bring the existing drainage course up to date with current GCDC-SWM standards.

All three alternatives propose to follow the existing drainage route. Within the drainage district there isn't the opportunity to bypass or reroute any considerable amount of runoff to alternative locations.

Alternative 1 discusses open drain improvements along a small portion of the existing enclosed storm sewer route and enclosed pipe improvements along the majority of the existing drainage course to convey the 4% chance (25-year) storm event. Essentially, the existing pipe would be replaced with a larger pipe. Alternative 2 discusses open drain improvements along the drainage route and includes property access and road crossing culverts. The existing enclosed pipe would be replaced with an open drain. Alternative 3 discusses utilizing the natural storage ability of the wetlands in order to reduce the size of the outlet pipe, thus mimicking how the drainage system has appeared to function over the past 100 plus years. Each alternative also includes the option to clean out the existing open drain portion of the Goodrich Drain within the existing wetlands. This option is the same with all alternatives. While new easements could be required to help avoid existing infrastructure, the proposed alternatives approximately follow the route and course for this drain. The following discusses each alternative in more detail:

ALTERNATIVE 1:

The improvements for Alternative 1 include replacing the southerly 475'± of the existing pipe with an open drain and the remainder of the system northerly to Kearsley Creek with new storm sewer. The open drain would extend northerly from the northern limits of the wetlands to a point where the drain becomes approximately 9 to 10 feet deep. From this point a 66" storm sewer is proposed to Hegel Road to convey the calculated 4% chance (25-year) storm event discharge of 172 cfs to meet current GCDC-SWM standards. Due to the potential for lack of adequate cover on the north side of Hegel Road, a 66" elliptical equivalent is proposed from the south side of Hegel Road to Kearsley Creek. Under this option the existing landscape would remain as it exists today, with the exception of the southerly 400± feet of the westerly 50± feet of 9224 Hegel Road. This is the area where the existing enclosed tile would be replaced with the open drain until sufficient cover is reached for the installation of the 66" storm sewer.

An outbuilding at 9250 Hegel Road and a pond at 9302 Hegel Road exist along the route of the existing drain. Both the structure and the pond may be in close proximity to the existing enclosed drain (based on the existing route and course). It would likely be possible to move the proposed storm sewer further to the northwest to avoid the structure if desired. The same can likely be done at 9302 Hegel Road to avoid the existing pond.

The proposed improvements would require clearing and grubbing along the open drain, removal and replacement of an asphalt and gravel drive, and the removal and replacement of a portion of Hegel Road and the adjacent pathway. The existing small stretch of open drain on the north side of Hegel Road would become part of the enclosed system.

The Preliminary Opinion of Probable Construction Cost (POPCC) for Alternative 1 is approximately $487,360.50. Further information related to this POPCC may be found in Section 8.

Alternative 1 could also include optional drain cleanout in the wetland area. This drain cleanout option is the same for all alternatives and is reviewed in more detail following the Alternative discussions.

ALTERNATIVE 2:

The improvements for Alternative 2 include replacing the existing enclosed tile from the northern limits of the wetlands to Hegel Road with an open drain. The open drain would vary from 4 feet to approximately 9 feet deep, have a 5 foot bottom, and have 1:2 (Vert:Hor) side slopes. This drain would be capable of conveying the calculated 4% chance discharge within its banks. On the north side of Hegel Road the drain bottom would widen to approximately 6 feet to contain the flow within the banks. Under this option the existing landscape would be drastically altered. The open drain would be approximately 9 feet deep through three of the five parcels on the south side of Hegel Road. This depth results in a top width of approximately 41 feet, not including the spoil disposal areas on each side. This open drain would run in close proximity to the homes on two of the parcels and would eliminate now usable yard area.

In order to maintain access to the rear of the parcels along Hegel Road, 72” CMP culverts are proposed on each of the five parcels along the drain route. Because of the layout and terrain of the existing parcels, it doesn’t appear feasible to place one culvert near the common property line so that two properties could share one crossing. Furthermore, considering that round CMPs are possible for these crossings versus concrete box culverts, there wouldn’t be substantial cost savings with a shared culvert alternative. At Hegel Road a 9’x5’ concrete box culvert would need to be installed to adequately convey the 4% chance (25-year) storm event discharge. Since Hegel Road is a public road crossing, this culvert would also need to convey the 100-year flow within the parameters established by the GCDC-SWM. North of Hegel Road and beneath the berm adjacent to Kearsley Creek, an 11’x4’ concrete box would be needed to convey the design flow. For the preliminary opinion of probable construction cost, the depth of these culverts were increased one foot to allow for one foot of bury. The existing ditch between Hegel Road and this berm would need to be widened to a 6 foot bottom in order to convey the flow within its banks.

As with Alternative 1 an outbuilding at 9250 Hegel Road and a pond at 9302 Hegel Road exist along the route of the existing enclosed drain. Both the structure and the pond may be in close proximity to the existing drain (based on the existing route and course). Considering that the existing outbuilding is located in the bottom of the valley where the open drain would be installed, it may be difficult to avoid this structure without having the drain become excessively deep in this area. Furthermore, in order to not have a deep ditch immediately adjacent to the building, an additional culvert may be required in this area. For the purpose of this study, it is assumed that this structure would be moved outside of the storm route by the owner. The pond could likely be avoided in the same manner of Alternative 1 by obtaining a new easement and moving the proposed drain further to the northwest and outside of the natural low area. This would result in a greater amount of excavation but may save the existing pond if so desired.

The proposed improvements would require clearing and grubbing along the open drain route, removal and replacement of an asphalt and gravel drive, the installation of the property access culverts, the installation of a new concrete box culvert with wingwalls beneath Hegel Road, and the removal and replacement of a portion of Hegel Road and the adjacent pathway.

The Preliminary Opinion of Probable Construction Cost (POPCC) for Alternative 2 is approximately $409,970.00. Further information related to this POPCC may be found in Section 8.

Alternative 2 could also include optional drain cleanout in the wetland area. This drain cleanout option is the same for all alternatives and is reviewed in more detail following the Alternative discussions.

ALTERNATIVE 3:

The improvements for Alternative 3 include replacing the existing pipe with a new storm sewer and utilizing the natural detention characteristics of the large wetland area. By temporarily detaining runoff from the 4% chance (25-year) storm event within the wetland area, a smaller diameter pipe is feasible to convey the discharge to Kearsley Creek. This alternative would allow the wetland and storm water management system to function much like it does now, but with an improved outlet.

For the analysis of this Alternative, a design high water elevation was used, based on 4% chance (25-year) storm event, of 856.3. This elevation is two feet (2') lower than the lowest basement floor elevation of the adjacent homes within Willowgate Crossing. The floor of the basin was established at 854.5, for a water depth of 1.8 feet. 854.5 is approximately the existing ground elevation within the wetland area south of Willowgate Lane. North of Willowgate Lane, the average elevation of the wetland area appears to be approximately 853.5, thus providing the opportunity for more storage that is not considered in our computations. The approximate water storage area is depicted on the Alternative 3 Improvements drawing. The area of the wetland considered for temporary detention is approximately 15% of the total central wetland area. The remainder of the wetland area is also anticipated to slow runoff and provide temporary storage as mentioned earlier in this report in the discussion of the peak flow ponding adjustment.

Utilizing the storage parameters described above, the required discharge was determined to be 33 cfs, which could be conveyed in a 36" diameter storm sewer.

The impacts of the 1% chance (100-year) storm event on this alternative was also reviewed. Utilizing the same 33 cfs outlet rate, which is the full flow capacity of the 36" pipe, and ignoring any increase in flow rate due to hydraulic head, the water elevation in this model during the 1% chance (100-year) storm event rose 1 foot to an elevation of 857.3. This elevation is approximately 1 foot below the lowest floor elevation of the adjacent home, and 2.7 feet below the lowest ground elevation adjacent to the home. Therefore, approximately 1 foot of freeboard between the high water and basement floor is still provided with the 1% chance (100-year) storm event. The homeowners adjacent to the wetland have built retaining walls around their walkout patios to raise the surrounding yard elevation which provides a freeboard depth of 2.7 feet. Additionally, the discharge required to convey the 1% chance (100-year) storm event at the design elevation of the 4% chance (25-year) storm (2 feet below the basement floor elevation) was also evaluated. The discharge required to maintain this elevation is 169 cfs, which is approximately the same flow of 172 cfs required to convey the 4% chance (25-year) unrestricted flow discussed in Alternative 1.

Similar to Alternative 1, this option would not significantly alter the existing landscape. Once the new pipe is installed the yard areas could be returned to their existing condition. A little less disturbance is anticipated with the installation of a 36" diameter sewer as opposed to the 66" diameter sewer proposed in Alternative 1. Also as with Alternative 1, the outbuilding at 9250 Hegel Road and a pond at 9302 Hegel Road may be able to be avoided by moving the proposed storm sewer further to the northwest which may also require additional easements.

All of the proposed temporary storage appears to be within State regulated wetland areas. An existing conservation easement may be in place over the wetlands as a result of the Willowgate Crossing development. The GCDC-SWM office may require an additional easement around the detention limits.

The proposed improvements would require removal and replacement of an asphalt and gravel drive, and the removal and replacement of a portion of Hegel

Road and the adjacent pathway. The existing small stretch of open drain on the north side of Hegel Road would become part of the enclosed system.

The Preliminary Opinion of Probable Construction Cost (POPCC) for Alternative 3 is approximately $324,340.50. Further information related to this POPCC may be found in Section 8.

Alternative 3 could also include optional drain cleanout in the wetland area. This drain cleanout option is the same for all alternatives and is discussed below.

OPTIONAL DRAIN CLEANOUT IN WETLAND AREA:

With all of the Alternatives discussed above, there is the option to further improve the existing drainage system by completing a drain cleanout on the southerly portion of the Goodrich Drain, on Branch No. 1, and on Branch No. 2. This work would primarily involve clearing and grubbing along the drain route and some minor excavation and grading to reshape the drain. The drain would remain three to twelve inches deep as it exists today. The optional drain cleanout is shown on each of the Alternative drawings and would extend southerly from the northern wetland limits to the Willowgate Lane crossing. The drain cleanout would continue southerly from that point to approximately the east-west ¼ line of the section, where it then would extend westerly to the Gale Road area and easterly to the eastern limits of the wetland. A final route would extend southerly to the southern limits of the wetland. Nearly all of the cleanout would be done within the wetland area.

The drain cleanout of this portion of the Goodrich Drain is considered optional and therefore was identified as an optional expense in the improvement alternatives costs in Section 8. This cleanout is the same regardless of what option is selected from the above.

The constructability of this drain cleanout option needs to be considered. During our initial field review during the summer months we were able to walk in the northern and westerly areas of the overall wetland, and also in the vicinity of the Willowgate Lane culvert crossing. This field review was completed after a period of little precipitation. During subsequent field evaluations and surveying following periods of more rain, the wetland area was found to be much wetter and the soils that were previously dry enough to traverse on foot had turned to muck. Even during times of drought, it may be difficult to get the required construction equipment onto the wetland soils to perform this work in a conventional fashion. With any amount of moisture in the soils, the operation may not be possible at all. The use of mats or other techniques to stabilize the surface, and the added degree of construction difficulty, would substantially increase the cost of this work.

The Preliminary Opinion of Probable Construction Cost (POPCC) for the drain cleanout within the wetland area is approximately $79,200.00. This cost is for construction in dry conditions using conventional methods and completed in conjunction with one of the improvement alternatives proposed above.

7. **<u>Recommendations</u>**

Based on the options discussed above, Alternative 3 is the recommended alternative. The advantages of this alternative are cost and less impacts to adjacent properties as compared to Alternatives 1 and 2. For all three improvement alternatives additional easements will be required.

By utilizing the natural storage characteristics of the wetland area, the required pipe size can be reduced from a 66” diameter to a 36” diameter. As mentioned earlier in this report, only 15% of the large wetland area in the central portion of the overall watershed is being used for temporary detention. The storage depth available is also on the conservative side because topographic elevations across the entire wetland surface were unknown.

The GCDC-SWM standard for a drainage area of this size is the ability to convey the peak flow for the 4% chance (25-year) storm event. For Alternative 3, the impacts of the larger 1% chance (100-year) storm event were also evaluated and it was determined that the 1% chance (100-year) event could also be detained within the natural wetland at an elevation that is anticipated to be approximately 1 foot below the lowest floor elevation.

The design high water elevation for the 4% chance (25-year) storm event is approximately 856.3, which is 2 feet below the lowest basement floor elevation and 3.7 feet below the lowest elevation of the top of the retaining wall surrounding the sunken patio and walkout of this dwelling. This 856.3 elevation is approximately the same elevation that water will need to reach in order to be conveyed through the channel of Alternative No. 2 or within the large 66" diameter pipe of Alternative 1 at full pipe flow. Therefore, in order for the other two alternatives to convey the 4% chance (25-year) storm event, the water elevation would still need to be at the same elevation as the calculated detention level. A similar situation exists in evaluating the feasibility of constructing an open drain above the storm sewer to convey the higher flows. The placement of the 36" diameter pipe with one foot of cover would equal the design high water elevation. Any water flowing through the channel above the pipe would be encroaching into the freeboard. Additionally, an open drain above the pipe would result in disturbance to the adjacent properties similar to Alternative 2.

The drain cleanout option that involves the same work under all alternatives may not be necessary. The open drain portions of the Goodrich Drain within the large central wetland area are very shallow and contain very little grade. Storm water runoff is still conveyed along this route, as well as many others throughout the wetland area, effectively finding its own path to the northern limits of the wetland. Rising water elevations quickly exceed the existing defined channel and are spread over the immensive wetland area. Because there is minimal grade along the drain, the channel cannot be cleaned out to a depth that would contain the flows within the top of banks of the drain.

8. Preliminary Opinion of Probable Construction Costs (POPCC)

- **ALTERNATIVE 1:**

Item Description	Qty	Pay Unit	Unit Price	Amount
1. Clearing and Grubbing	475±	L.F.	$15.00±	$7,125.00±
2. Open Drain Excavation, 5' Bottom (475 L.F.)	2,100±	CYD	$5.00±	$10,500.00±
3. Machine Grading	475±	L.F.	$3.00±	$1,425.00±
4. Dr Structure, Rem	2±	Each	$400.00±	$800.00±
5. Culv, Rem, 24 inch to 48 inch	2±	Each	$600.00±	$1,200.00±
6. Heavy Rip Rap	50±	S.Y.	$75.00±	$3,750.00±
7. Chemical Fertilizer Nutrients (240 Lbs/Acres)	665±	Lb.	$2.00±	$1,330.00±
8. Class A Seeding (200 Lbs/Acre)	200±	Lb.	$6.00±	$1,200.00±
9. Class B Seeding (125 Lbs/Acre)	225±	Lb.	$5.00±	$1,125.00±
10. Mulch (2 Tons/Acre)	5.5±	Ton	$600.00±	$3,300.00±
11. Drainage Structure Covers	6±	Each	$450.00±	$2,700.00±
12. 24" Sewer, C76-III	80±	L.F.	$80.00±	$6,400.00±
13. 66" Sewer, C76-III	1,260±	L.F.	$190.00±	$239,400.00±
14. 66" Elliptical Sewer, HE-III (53"x83")	340±	L.F.	$250.00±	$85,000.00±
15. 24" End Section, Conc	5±	Each	$600.00±	$3,000.00±
16. 66" End Section, Conc	1±	Each	$3,000.00±	$3,000.00±
17. 66" Elliptical End Section, Conc	1±	Each	$3,500.00±	$3,500.00±
18. 66" PreFab Bend, C76-III	4±	Each	$1,500.00±	$6,000.00±
19. 66" Prefab Bend, HE-III	2±	Each	$1,500.00±	$3,000.00±
20. 66" x 48" Manhole Tee	6±	Each	$2,700.00±	$16,200.00±
21. 24" Pipe Tee	5±	Each	$1,000.00±	$5,000.00±
22. Compacted Sand Backfill	300±	L.F.	$20.00±	$6,000.00±
23. Road Surface Removal & Replacement	115±	S.Y.	$75.00±	$8,625.00±
24. Aggregate Shoulder Replacement	70±	S.Y.	$20.00±	$1,400.00±
25. Driveway Removal & Replacement, Asphalt	65±	S.Y.	$65.00±	$4,225.00±
26. Driveway Removal & Replacement, Aggregate	40±	S.Y.	$15.00±	$600.00±
27. Path Surface Removal & Replacement	50±	S.Y.	$65.00±	$3,250.00±
28. Remove and Replace Railing	50±	L.F.	$50.00±	$2,500.00±
29. Remove and Replace Guardrail	50±	L.F.	$30.00±	$1,500.00±
30. Soil Erosion & Sedimentation Control	1	LSum	$5,000.00±	$5,000.00±
31. Traffic Control	1	LSum	$5,000.00±	$5,000.00±
		Total		$443,055.00±
		Contingency 10%		$ 44,305.50±
		Grand Total		**$487,360.50±**

OPTIONAL DRAIN CLEANOUT IN WETLAND AREA				
Item Description	**Qty**	**Pay Unit**	**Unit Price**	**Amount**
1. Drain Cleanout, Clearing, and Grubbing	4,800±	LSum	$15.00±	$72,000.00±
		Total		$72,000.00±
		Contingency 10%		$ 7,200.00±
		Grand Total		$79,200.00±

Note: The figures given for each item and the total figure of the POPCC is only a preliminary opinion based on data from similar projects as of the date of this study and are subject to change. Easement acquisitions, legal, financial, contract administration, engineering, permits, construction staking, and as-builts drawings are not included in these figures.

- **ALTERNATIVE 2:**

Item Description	Qty	Pay Unit	Unit Price	Amount
2. Open Drain Excavation, 5' Bottom (1425 L.F.)	9,500±	CYD	$5.00±	$47,500.00±
3. Open Drain Excavation, 6' Bottom (250 L.F.)	275±	CYD	$5.00±	$1,375.00±
4. Machine Grading	1,675±	L.F.	$3.00±	$5,025.00±
5. Dr Structure, Rem	2±	Each	$400.00±	$800.00±
6. Culv, Rem, 24 inch to 48 inch	2±	Each	$600.00±	$1,200.00±
7. Heavy Rip Rap	50±	S.Y.	$75.00±	$3,750.00±
8. Chemical Fertilizer Nutrients (240 Lbs/Acres)	1,150±	Lb.	$2.00±	$2,300.00±
9. Class B Seeding (125 Lbs/Acre)	600±	Lb.	$5.00±	$3,000.00±
10. Mulch (2 Tons/Acre)	9.5±	Ton	$600.00±	$5,700.00±
11. 72" Corrugated Steel Pipe	315±	L.F.	$150.00±	$47,250.00±
9. 4' Dia. Drainage Structure	4±	Each	$2,500.00±	$10,000.00±
11. Drainage Structure Cover	4±	Each	$450.00±	$1,800.00±
12. 24" Sewer, C76-III	60±	L.F.	$80.00±	$4,800.00±
11. Drainage Structure Covers	10±	Each	$450.00±	$4,500.00±
12. 9' x 6' Precast Concrete Box Culvert	96±	L.F.	$1,000.00±	$96,000.00±
13. 11' x 5' Precast Concrete Box Culvert	24±	L.F.	$1,100.00±	$26,400.00±
14. Concrete Wingwalls, Footings & Headers (9' x 6' Box)	2±	Each	$18,000.00±	$36,000.00±
15. Concrete Wingwalls, Footings & Headers (11' x 5' Box)	2±	Each	$16,000.00±	$32,000.00±
16. Compacted Sand Backfill	435±	L.F.	$20.00±	$8,700.00±
17. Road Surface Removal & Replacement	115±	S.Y.	$75.00±	$8,625.00±
18. Aggregate Shoulder Replacement	70±	S.Y.	$20.00±	$1,400.00±
19. Driveway Removal & Replacement, Asphalt	65±	S.Y.	$65.00±	$4,225.00±
20. Driveway Removal & Replacement, Aggregate	40±	S.Y.	$15.00±	$600.00±
21. Path Surface Removal & Replacement	50±	S.Y.	$65.00±	$3,250.00±
22. Remove and Replace Railing	50±	L.F.	$50.00±	$2,500.00±
23. Remove and Replace Guardrail	50±	L.F.	$30.00±	$1,500.00±
24. Soil Erosion & Sedimentation Control	1	LSum	$7,500.00±	$7,500.00±
25. Traffic Control	1	LSum	$5,000.00±	$5,000.00±
		Total		$372,700.00±
		Contingency 10%		$ 37,270.00±
		Grand Total		**$409,970.00±**

OPTIONAL DRAIN CLEANOUT IN WETLAND AREA				
Item Description	**Qty**	**Pay Unit**	**Unit Price**	**Amount**
1. Drain Cleanout, Clearing, and Grubbing	4800±	L.F.	$15.00±	$72,000.00±
		Total		$72,000.00±
		Contingency 10%		$ 7,200.00±
		Grand Total		$79,200.00±

Note: The figures given for each item and the total figure of the POPCC is only a preliminary opinion based on data from similar projects as of the date of this study and are subject to change. Easement acquisitions, legal, financial, contract administration, engineering, permits, construction staking, and as-builts drawings are not included in these figures.

- **ALTERNATIVE 3:**

Item Description	Qty	Pay Unit	Unit Price	Amount
1. Selective Clearing & Grubbing	2,050±	L.F.	$10.00±	$20,500.00±
2. Dr Structure, Rem	2±	Each	$400.00±	$800.00±
3. Culv, Rem, 24 inch to 48 inch	2±	Each	$600.00±	$1,200.00±
4. Heavy Rip Rap	25±	S.Y.	$75.00±	$1,875.00±
5. Chemical Fertilizer Nutrients (240 Lbs/Acres)	665±	Lb.	$2.00±	$1,330.00±
6. Class A Seeding (200 Lbs/Acre)	200±	Lb.	$6.00±	$1,200.00±
7. Class B Seeding (125 Lbs/Acre)	225±	Lb.	$5.00±	$1,125.00±
8. Mulch (2 Tons/Acre)	5.5±	Ton	$600.00±	$3,300.00±
9. 5' Dia. Drainage Structure	8±	Each	$2,700.00±	$21,600.00±
10. 6' Dia. Drainage Structure	2±	Each	$3,700.00±	$7,400.00±
11. Drainage Structure Covers	10±	Each	$450.00±	$4,500.00±
12. 24" Sewer, C76-III	80±	L.F.	$80.00±	$6,400.00±
13. 36" Sewer, C76-III	2,050±	L.F.	$90.00±	$184,500.00±
14. 24" End Section, Conc	5±	Each	$600.00±	$3,000.00±
15. 42" End Section, Steel	1±	Each	$1,500.00±	$1,500.00±
16. Compacted Sand Backfill	300±	L.F.	$20.00±	$6,000.00±
17. Road Surface Removal & Replacement	95±	S.Y.	$75.00±	$7,125.00±
18. Aggregate Shoulder Replacement	65±	S.Y.	$20.00±	$1,300.00±
19. Driveway Removal & Replacement, Asphalt	55±	S.Y.	$65.00±	$3,575.00±
20. Driveway Removal & Replacement, Aggregate	35±	S.Y.	$15.00±	$525.00±
21. Path Surface Removal & Replacement	40±	S.Y.	$65.00±	$2,600.00±
22. Remove and Replace Railing	50±	L.F.	$50.00±	$2,500.00±
23. Remove and Replace Guardrail	50±	L.F.	$30.00±	$1,500.00±
24. Soil Erosion & Sedimentation Control	1	LSum	$4,500.00±	$4,500.00±
25. Traffic Control	1	LSum	$5,000.00±	$5,000.00±
		Total		$294,855.00±
		Contingency 10%		$ 29,485.50±
		Grand Total		**$324,340.50±**

OPTIONAL DRAIN CLEANOUT IN WETLAND AREA				
Item Description	**Qty**	**Pay Unit**	**Unit Price**	**Amount**
1. Drain Cleanout, Clearing, and Grubbing	4800±	L.F.	$15.00±	$72,000.00±
		Total		$72,000.00±
		Contingency 10%		$ 7,200.00±
		Grand Total		$79,200.00±

Note: The figures given for each item and the total figure of the POPCC is only a preliminary opinion based on data from similar projects as of the date of this study and are subject to change. Easement acquisitions, legal, financial, contract administration, engineering, permits, construction staking, and as-builts drawings are not included in these figures.

9. Appendices

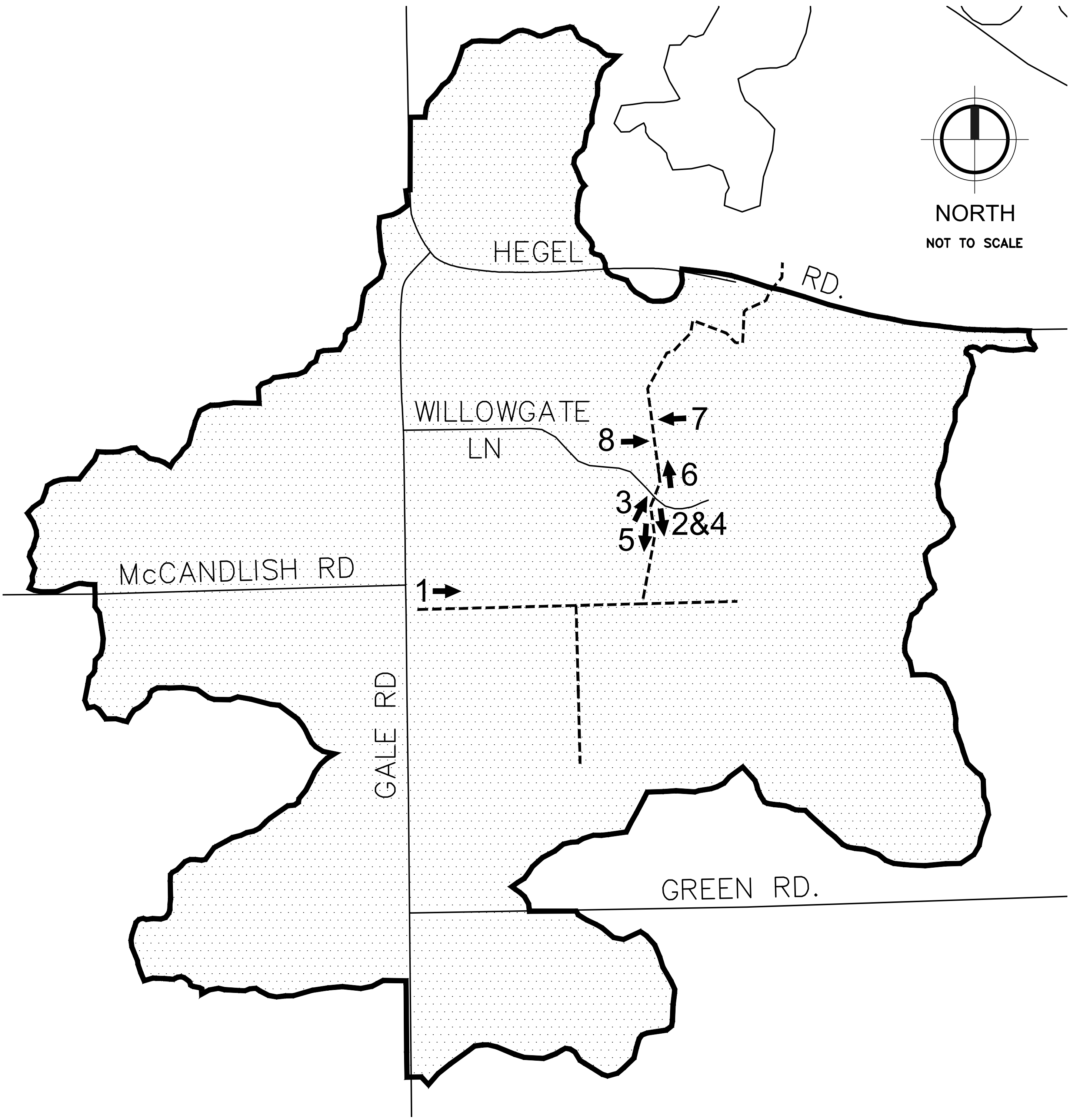
Appendix 'A'

● Location Map

Appendix ‘B’

- **Photo Location Map**
- **Photos of Existing Drainage Course**

812100_PHOTO LOC MAP\gericr 121212



\# - INDICATES PHOTO LOCATION AND DIRECTION TAKEN

GOODRICH DRAIN #0896

GCDC-SWM
PRELIMINARY ENGINEERING REPORT

PHOTO LOCATION MAP
APPENDIX 'B'

DECEMBER 2012 812100

FLEIS & VANDENBRINK ENGINEERING, INC.

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PHOTO 1
LOOKING EAST FROM McCANDLISH RD. & GALE RD. AREA (BRANCH NO. 1)

PHOTO 2
LOOKING SOUTHERLY FROM SOUTH END OF WILLOWGATE LN CROSSING

GOODRICH DRAIN #0896

GCDC-SWM
PRELIMINARY ENGINEERING REPORT

PHOTOGRAPHS 1 & 2
APPENDIX 'B'

DECEMBER 2012 812100

FLEIS & VANDENBRINK ENGINEERING, INC.

PHOTO 3
LOOKING NORTH AT SOUTH END OF WILLOWGATE LN CULVERT

PHOTO 4
LOOKING SOUTHERLY AT DRAINAGE COURSE SOUTH OF WILLOWGATE LN CULVERT

GOODRICH DRAIN #0896

GCDC-SWM
PRELIMINARY ENGINEERING REPORT

PHOTOGRAPHS 3 & 4
APPENDIX 'B'
DECEMBER 2012 812100

FLEIS & VANDENBRINK ENGINEERING, INC.

PHOTO 5
LOOKING SOUTHERLY AT DRAINAGE COURSE SOUTH OF WILLOWGATE LANE CULVERT

PHOTO 6
LOOKING NORTHERLY AT DRAINAGE COURSE NORTH OF WILLOWGATE LN CULVERT

GOODRICH DRAIN #0896

GCDC-SWM
PRELIMINARY ENGINEERING REPORT

PHOTOGRAPHS 5 & 6
APPENDIX 'B'

DECEMBER 2012 812100

FLEIS & VANDENBRINK ENGINEERING, INC.

PHOTO 7
BROKEN SECTION OF PIPE FOUND ALONG APPARENT PATH OF ENCLOSED DRAIN

PHOTO 8
DRAINAGE STRUCTURE LOCATED AT UPPER TERMINUS OF ENCLOSED PORTION OF GOODRICH DRAIN

GOODRICH DRAIN #0896

GCDC-SWM
PRELIMINARY ENGINEERING REPORT

PHOTOGRAPHS 7 & 8
APPENDIX 'B'

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