

# Shorewood Forest Subdivision Storm Water Infrastructure Study

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Prepared for:

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& Storm Water Management

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## EXECUTIVE SUMMARY

This report presents the results of a comprehensive study of the stormwater infrastructure within the Shorewood Forest Subdivision completed by Christopher B. Burke Engineering, Ltd. (CBBEL). This study was undertaken on behalf of the Porter County Department of Development & Storm Water Management (Department), who is responsible for the inspection, repair, maintenance, construction, and reconstruction of regulated stormwater and drainage infrastructure throughout Unincorporated Porter County. The purpose of this effort was to assess the condition and performance of the existing stormwater infrastructure, identify problem areas and concerns, and analyze potential solutions to alleviate those issues. This report will serve as a guide for future stormwater infrastructure repair, maintenance, construction and reconstruction activities throughout the subdivision.

The initial phase of this study involved an extensive data collection effort to develop a comprehensive inventory of the various stormwater infrastructure components within the subdivision. Shorewood Forest has a unique blend of gray and green infrastructure serving the subdivision. In addition to traditional storm sewers and culverts, the subdivision includes numerous ravines, wetland areas, and Lake Louise. A database of the existing storm sewers, culverts, ravines and other infrastructure was compiled from a variety of sources, including: construction plans/as-built drawings, Porter County Geographic Information System (GIS) data, field survey performed by both Department and CBBEL staff, maintenance records from the Shorewood Forest Property Owner's Association (POA) and field reconnaissance performed by both Department and CBBEL staff.

Public input was a significant component of the development of this study. A virtual open house and an online flood questionnaire was made available to residents in the Fall of 2020 through the Department website. This outreach effort generated over 60 responses and numerous one-on-one resident meetings. A variety of drainage problems and concerns were reported by the residents, including: structural and roadway flooding, nuisance flooding in backyards, sinkholes, and overall concerns regarding the function and health of the existing ravines and Lake Louise.

As the physical layout of the stormwater drainage system and the scope of drainage concerns became known, the next phase of the study was to assess the function and condition of that infrastructure. This effort involved the visual inspection of the numerous ravines, storm sewers, and culverts to identify locations of deterioration or failure. In addition, the Department hired Accu-Dig, Inc. (Accu-Dig) to televise the entire storm sewer/culvert network within the subdivision so that the internal condition of each pipe segment could be assessed. As a result of this effort, each pipe segment was assigned a numeric rating based on its current condition.

Additionally, an XP-SWMM hydrologic and hydraulic analysis of the subdivision's drainage system was developed to analyze the function of the existing drainage network, verify the reported flood problem areas, and identify the cause(s) of those issues.

A total of 17 drainage issues were identified as candidates for capital improvement projects. While there are many drainage issues located throughout the study area, locations involving structural flooding, significant roadway flooding, and severe pipe failure/ravine erosion were given priority as they involve public safety

concerns. Where appropriate, the XP-SWMM modeling was used to simulate proposed drainage improvements to alleviate the existing drainage issues throughout the study area.

A conceptual engineer's estimate of probable cost for each of the proposed drainage improvement alternatives was prepared. These long-term capital improvements projects range in cost from \$18,000 to \$648,000 and total approximately \$2.7M.

In addition to the capital improvement projects, there are a number of widespread problems that can be addressed as part of a subdivision-wide program. Approximately 56% of the existing storm sewers/culverts throughout the subdivision were determined to be in either poor or moderate condition; in addition to being a public safety concern, the poor condition also causes the material loss below/around each pipe that is eventually deposited into Lake Louise. The cost to repair these storm sewers (either through lining or replacement) is estimated to be approximately \$2.5M. Additionally, restoration efforts are required to address the numerous stretches of ravines that have experienced erosion, head-cutting, and slope failure. These ravine restoration efforts are estimated to be approximately \$6.6M. Lastly, stormwater runoff from each residential lot is also a contributing point source of erosion along the ravines; this study outlines best management practices (BMPs) that can be implemented by individual property owners to better manage stormwater on their property and improve the health of the ravines and Lake Louise.

## CHAPTER 1 PROJECT OVERVIEW

### 1.1 STUDY BACKGROUND

In 2010, Porter County worked to develop a county-wide comprehensive drainage plan, which was intended to identify known flooding and drainage issues, identify action items, and identify problem areas and watersheds as a way of guiding future study and action to those areas most in need. An important recommendation of that study was the need for further study and evaluation of problem areas, such as subdivisions and watersheds, where groups of similar problems or a high density of interdependent problems are found. Such studies document and evaluate existing problems, analyze potential solutions, and provide a guide for future storm water infrastructure repair, maintenance, construction and reconstruction activities.

In 2016, Porter County enacted a stormwater user fee that provided funding to the Department to develop a comprehensive stormwater management program. An important element of this program is a responsibility for the inspection, repair, maintenance, construction, and reconstruction of stormwater and drainage infrastructure throughout Unincorporated Porter County. The Shorewood Forest Subdivision was identified as an area needing further study and evaluation by the Department and the Porter County Storm Water Management Board.

Prior to 2016, the repair and maintenance of the stormwater infrastructure throughout the right-of-way and common areas of the subdivision was undertaken by the Shorewood Forest Property Owner's Association (POA). Stormwater infrastructure located on private property was placed within dedicated drainage easements at the time of construction, but the maintenance and upkeep of that infrastructure remained the responsibility of the individual property owner. Because the drainage easements were never conveyed to the County, the County does not currently have access rights to inspect, maintain, or reconstruct stormwater infrastructure that is not located within road rights-of-way. Before the Department can begin a stormwater project, the drainage easements throughout the subdivision must be conveyed to the County by each individual property owner.

### 1.2 INTRODUCTION

The Shorewood Forest Subdivision is located in Unincorporated Porter County and is generally bounded by US Route 30 on the north, CR 350 W on the east, CR 100 N on the south, and CR 500 W on the west, as shown in **Figure 1**. The subdivision was constructed in 29 phases over an approximately 30-year period, from the early 1970s to the mid-2000s. The subdivision encompasses an area of almost 900 acres, and includes approximately 960 residential lots, numerous common areas including wetland/nature preserve areas, and Lake Louise. Lake Louise, which serves as the recreational centerpiece of Shorewood Forest, is an approximately 230-acre man-made lake that was created in the early 1970s by constructing a dam across a tributary to Salt Creek. The water level in Lake Louise is controlled by a 50-ft wide dam and spillway located at the northeast corner of the lake.



**Figure 1. Shorewood Forest Subdivision Location Map**

Shorewood Forest is unique in that its drainage system has a blend of both *gray* and *green* stormwater infrastructure. The gray infrastructure within the subdivision is made up of approximately 28,400 linear feet of storm sewers and culverts that convey stormwater runoff into Lake Louise. Because it was constructed in many phases over the years, there is a wide range in the age and condition of the gray stormwater infrastructure throughout the subdivision. The majority of the storm sewers and culverts in the older sections were generally constructed using corrugated metal pipe (CMP), while the newer portions of the subdivision were constructed using reinforced concrete pipe (RCP).

The green infrastructure consists of several wetland areas and numerous ravines with a total length of approximately 26,400 linear feet. The ravines generally outlet to Lake Louise along the southern boundary of the lake, although a small portion at the northeast corner of the subdivision is located downstream of Lake Louise. As shown on the *Drainage Area Summary Exhibit (Exhibit 3)*, approximately 33% of the total drainage area to Lake Louise is conveyed through the existing ravines. Over the years, those ravines have experienced erosion, downcutting, and slope instability which has led to increased sediment loading in the lake.

As shown in Table 1 below, the Lake Louise Watershed consists of approximately 1,680 acres, which includes a combination of residential, agricultural, open space, woods, wetlands, and open water. The Shorewood Forest Subdivision is completely built out with the exception of several vacant lots spread across the subdivision.

As shown on the *Drainage Area Summary Exhibit (Exhibit 3)*, of the 1,680 acres that is tributary to Lake Louise, approximately 912 acres (54%) consists of offsite area. These offsite drainage areas are generally located north of US 30, west of CR 500 W, and south of the subdivision. The offsite drainage area includes several large depressional storage (wetland) areas, agricultural land, and residential properties. Portions of the Sagamore, Arbor Lakes, and Edgewood Subdivisions are also included in this offsite drainage area.

**Table 1. Summary of Land Use Within Lake Louise Watershed**

Land Use	Area (acres)	Percentage of Total (%)
Residential	506	36.1%
Agricultural	205	12.2%
Open Space (Pasture/Grass)	188	11.2%
Woods	302	18.0%
Wetlands	123	7.3%
Open Water	256	15.2%
<b>Total</b>	<b>1,680</b>	<b>100%</b>

### 1.3 PURPOSE AND SCOPE

The purpose of this effort was to assess the condition and performance of the existing stormwater infrastructure, identify problem areas and concerns, and analyze potential solutions to alleviate those issues. The intention is for this study to serve as a guide for the Department to implement future stormwater infrastructure repair, maintenance, construction and reconstruction activities throughout the subdivision.

The scope of the study included the following phases:

- **Data Collection:** Compile information on the existing drainage system to develop a complete database of the storm sewers, culverts, structures, ravines, etc. that serve Shorewood Forest. This phase also includes public outreach to gather input from residents and other stakeholders on the existing problem areas/concerns.
- **Infrastructure Assessment:** Perform field reconnaissance to identify locations where deteriorated infrastructure (storm sewers, culverts and ravines) is causing adverse impacts. This phase also includes the review of televising footage of the subdivision's stormwater piping that can only be accessed with a camera.
- **Hydrologic and Hydraulic Modeling:** Detailed hydrologic and hydraulic modeling of the subdivision's drainage system to verify the reported flood problem areas and to determine the effectiveness of potential drainage improvements.
- **Conceptual Stormwater Improvements:** Based on the results of the previous phases of the study, develop proposed drainage improvements with preliminary costs to address and/or alleviate the existing problem areas and concerns. The recommended improvements are designed to:
  - Reduce existing structural and street flooding to provide a 100-year level of protection
  - Rehabilitate aging stormwater infrastructure to restore original function

- Improve the function and health of the existing ravines and Lake Louise
- Provide recommended BMPs for homeowners to better manage stormwater on each lot
- Help preserve and enhance stormwater quality.

## 1.4 DATA COLLECTION

Data collection was crucial to the development of this study and involved gathering information from various sources. Information from Department staff, residents, and the Shorewood Forest POA was gathered to prepare an inventory of the existing stormwater infrastructure and to document the existing drainage concerns throughout the subdivision. CBEL reviewed the provided information and identified areas of missing data that would be collected as part of the study.

### 1.4.1 Public Outreach & Involvement

Due to the COVID-19 worldwide pandemic, an in-person open house with residents was not possible at the beginning of the study. Therefore, a virtual resident open house presentation was posted on the Department website in the Fall of 2020. As part of that public outreach effort, residents were encouraged to submit online stormwater concern reports that are available to every resident/property owner through the Department website.

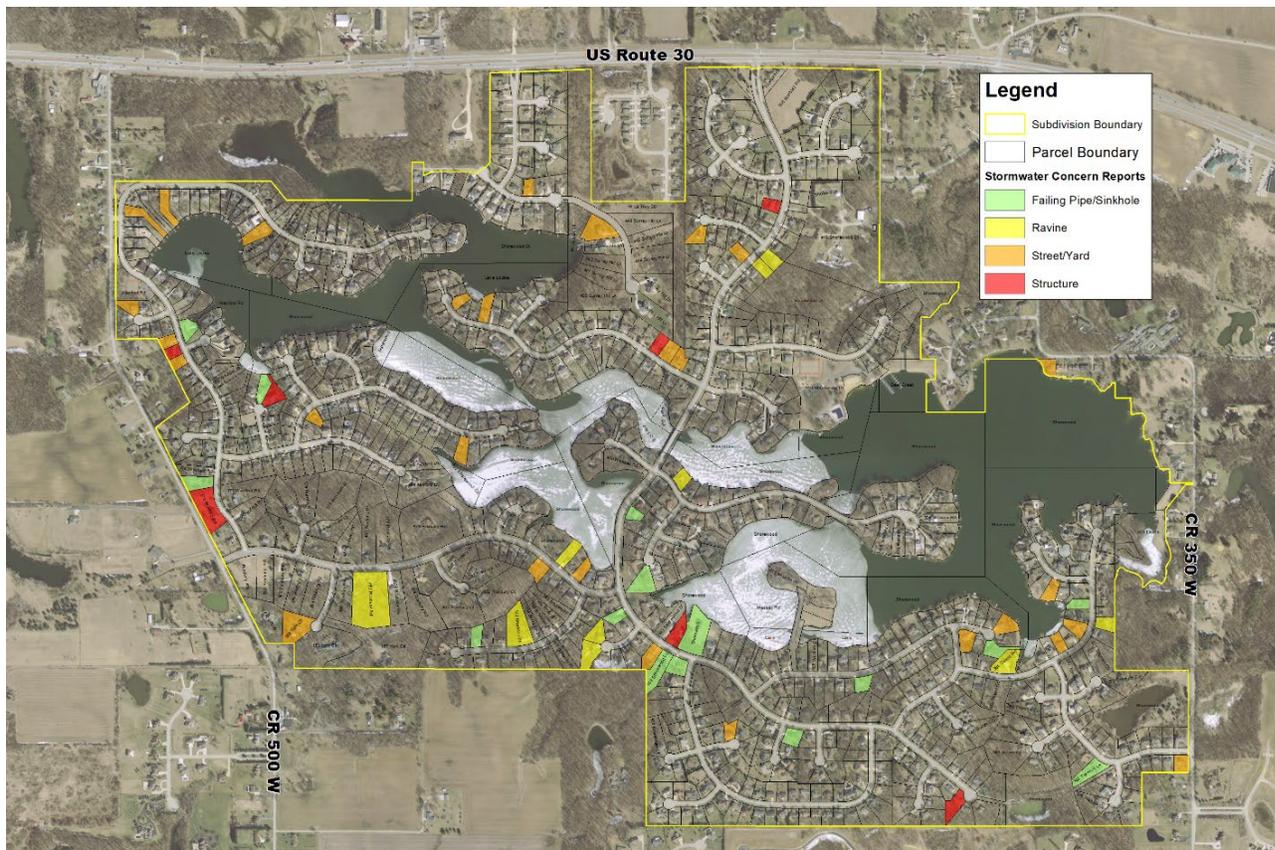


Figure 2. Compilation of Stormwater Concern Reports

A total of 62 existing stormwater concerns were documented as part of this study. These concerns were based on questionnaires received during the development of the County's 2010 comprehensive drainage plan, stormwater concern reports submitted to the Department from 2016 to the present, and emails/phone calls received from residents throughout the course of the study. In addition, numerous one-on-one meetings with individual property owners were conducted by Department and CBBEL staff to gather additional information when necessary. As shown in **Figure 2**, the stormwater concerns were categorized based on the type of problem reported: structural flooding (7), street/yard flooding (30), existing pipe failure/sinkhole (15), or ravine problem areas (10).

#### 1.4.2 Construction Plans/Previous Studies

The Department provided construction plans for the majority of the phases of the Shorewood Forest Subdivision, as well as as-built drawings for the Lake Louise dam and spillway. Additionally, since portions of the Edgewood, Sagamore, and Arbor Lakes Subdivisions are tributary to Lake Louise, construction plans and drainage reports from those developments were also provided to incorporate into the study.

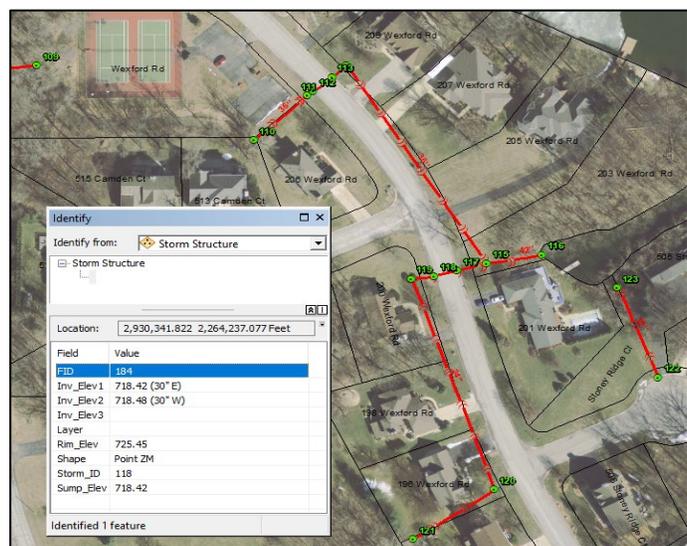
In addition, the Shorewood Forest POA provided the following documentation and reports that were previously completed for the subdivision:

- *Shorewood Forest: Lake Louise, A Study for the Improvement, Restoration, and Protection...*, prepared by Earth-Source, Inc., dated December 1990.
- *Lake Louise Watershed Assessment*, prepared by JFNew, dated July 2004.
- *Lake Louise Watershed Management Plan*, prepared by the Shorewood Forest POA, dated May 1, 2009.
- *Lake Louise Dam Incident and Emergency Action Plan (IEAP)*, prepared by Lawson-Fischer Associates, dated July 2016.

#### 1.4.3 Storm Sewer/Culvert Data Collection

During the summer of 2019, Department staff performed field survey and visual inspection of all stormwater structures (inlets, catch basins, manholes) located in the public right-of-way. As part of this study, CBBEL surveyed all remaining structures that were not picked up as part of the Department effort, which included the storm sewer outlets at the ravines and Lake Louise.

CBBEL also surveyed the Lake Louise Dam to verify the overtopping elevation of the lake. Additionally, critical elevations where structural flooding was reported (window well elevations, low-entry elevations, etc.) were also collected.



**Figure 3. Storm Sewer/Culvert GIS Database**

Based on that survey data, a GIS database of all stormwater structures, storm sewers, and culverts was created for the subdivision., which includes:

- Unique ID for each stormwater structure and pipe segment
- Rim, invert, and sump elevations
- Storm sewer length
- Storm sewer diameter
- Storm sewer material

A snippet of the created GIS database is provided as **Figure 3** and a breakdown of the storm sewer/culvert inventory based on pipe material is provided in **Table 2**. As shown in the table, 50% of the storm sewers/culverts in Shorewood Forest consists of corrugated metal pipe (CMP), followed by 45% of reinforced concrete pipe (RCP). There is a small percentage (5%) of plastic pipe (either high-density polyethylene (HDPE) or polyvinyl chloride (PVC)).

**Table 2. Pipe Inventory by Material**

Storm Sewer/Culvert Material	Total Length (ft)	Percentage of Total (%)
Corrugated Metal Pipe (CMP)	14,238	50%
Plastic (HDPE or PVC)	1,337	5%
Reinforced Concrete Pipe (RCP)	12,819	45%
<b>Total</b>	<b>28,394</b>	<b>100%</b>

## CHAPTER 2 STORMWATER INFRASTRUCTURE ASSESSMENT

Through the data collection process, CBBEL determined the location and details of the various drainage system components, but field inspections were necessary to determine the actual condition of that infrastructure. Using the stormwater concern reports as a starting point, CBBEL staff inspected the ravines, storm sewers, and culverts to identify problem areas and assess the condition of the infrastructure. In addition to these field inspections, the subdivision's entire network of storm sewers and culverts was televised to determine the internal condition of the storm sewers.

### 2.1 STORM SEWER/CULVERT ASSESSMENT

As part of the field survey collected by Department staff in 2019, visual inspections of the stormwater infrastructure within the right-of-way were also completed at that time. Observations regarding pipe/structure condition were documented along with supporting pictures. CBBEL reviewed this documentation and performed additional field reconnaissance in those locations where there was uncertainty regarding the condition.

As documented in **Table 2**, there are more than five miles of storm sewers and culverts located throughout the

subdivision, with approximately half consisting of CMP. A total of 15 stormwater concern reports related to existing pipe failures were submitted by residents, and all but one of those cases involved CMPs.

The focus of the field reconnaissance was on those known problem areas and the stormwater infrastructure located outside of the public right-of-way. The observed pipe problem areas are depicted on the *Drainage Exhibit (Exhibit 5)*. These problem areas are a combination of those reported by the residents and those documented during the field reconnaissance performed by CBBEL and Department staff. The majority of these cases involved CMP culverts or storm sewer outfalls at ravines where the pipe bottom has rusted out, and material below and around the pipe has eroded away.

The results of this field reconnaissance was used in conjunction with the storm sewer televising (discussed in Section 2.2) to develop a condition rating for each storm sewer segment within the subdivision.



**Figure 4. Pipe Failure/Erosion**

## 2.2 SEWER TELEVISION

While the condition of storm structures (inlets, catch basins, manholes) and some portions of storm sewers/culverts can be ascertained from an in-person visual inspection, the internal condition of the pipe cannot be determined without the use of a video camera. To fully understand the condition of the subdivision's storm sewer and culvert networks, the Department hired Accu-Dig, Inc. (Accu-Dig) to inspect the entire storm sewer and culvert network via closed circuit television.

The storm sewer televising process allows for visual inspection of all storm sewer lines that would be otherwise inaccessible. Working between storm sewer access points, waterproof cameras are mounted on a robot crawler which provides live video footage as it moves through the pipe segment. Any deterioration, cross-connections, or blockages can be determined by reviewing that footage. And because the device measures linear footage as it travels along the pipe, the exact location of any defects can also be determined.

Approximately 23,430 LF of storm sewer was televised by Accu-Dig, which represents about 83% of the total length of storm sewers and culverts within Shorewood Forest. In some cases, the pipe segments were inaccessible due to accumulated debris, high water level, or severe deterioration.



**Figure 5. Sewer Televising Footage: RCP in Good Condition (Left), CMP with Missing Bottom (Right)**

In addition to the video footage captured by the camera, Accu-Dig provided notes that documented the defects, debris, and other observations as they performed the storm sewer televising. CBBEL staff reviewed the video footage to supplement the Accu-Dig observations.

### 2.3 PIPE CONDITION RATING

Using the information obtained from the field reconnaissance and storm sewer televising efforts, CBBEL developed the following rating system for the stormwater piping:

- A pipe in *Good Condition* was assigned a rating of “1.” This rating reflects a pipe that is free of major defects and still has a long service life.
- A pipe in *Moderate Condition* was assigned a rating of “2.” This rating reflects a pipe that has some defects but no critical failures. Pipe replacement/rehabilitation will likely be necessary in the coming years, but the function of the pipe is mostly intact and there are no immediate public safety concerns.
- A pipe in *Poor Condition* was assigned a rating of “3.” This rating reflects a pipe that has major defects or critical failures and should be considered a priority for replacement/rehabilitation.

As summarized in **Table 3**, pipes in good condition (Condition Rating 1) make up approximately 44% of the televised storm sewers, pipes in moderate condition (Condition Rating 2) make up approximately 27% of the televised storm sewers, and pipes in poor condition (Condition Rating 3) make up approximately 29% of the televised storm sewers. It should be noted that several pipe segments that could not be televised were assigned a Condition Rating of 3, as the poor condition of the pipe was apparent based on a visual inspection. The results of this assessment are also depicted on the Pipe Condition Assessment Exhibit (**Exhibit 7**).

**Table 3. Storm Sewer/Culvert Assessment Summary**

Pipe Condition	Condition Rating	Piping Length (ft)	Percentage of Televised Pipe Total (%)
Good Condition	1	10,417	44.4%
Moderate Condition	2	6,223	26.6%
Poor Condition	3	6,790	29.0%
<b>Total</b>	---	<b>23,430</b>	<b>100%</b>

## 2.4 RAVINE ASSESSMENT

The Shorewood Forest Subdivision contains numerous ravines with a total length of approximately 26,400 linear feet. The ravines generally outlet to Lake Louise along the southern boundary of the lake, with drainage areas varying between 28 – 274 acres, as shown in **Table 4**. This information is also depicted on the *Drainage Area Summary Exhibit (Exhibit 3)*.

Of the 1,680 acres that is tributary to Lake Louise, approximately 33% of this drainage area (553 acres) is conveyed into the lake through one of these ravines. There is also network of ravines located at the northeast corner of the subdivision which are situated downstream of Lake Louise and service a drainage area of approximately 227 acres.

Over the years, those ravines have experienced erosion, head-cutting, and slope instability which has led to increased sediment loading in the lake. Due to the highly erodible nature of the soils in this area, the ravines have experienced varying degrees of erosion from a number of sources, including: excessive flow velocities/flowrates resulting from large upstream drainage areas, deteriorated culverts and storm sewer outfalls, directly connected downspouts, and failure of previously installed stabilization measures. A total of 10 stormwater concern reports involving ravine erosion problems were submitted by residents. Throughout the course of the study, several other residents voiced their concerns over increased sediment loading in Lake Louise that they believe was directly related to the ravine erosion problem.



**Figure 6. Bank Erosion with Tree Undermining**

Using the concerns reported by the residents as a starting point, CBEL performed field reconnaissance to identify the significant problem areas associated with the subdivision's ravines; these observed problem areas are depicted on the *Drainage Exhibit (Exhibit 5)*. The majority of these problems were observed along the Roxbury and Devon Ravines, which was not entirely unexpected considering their sizable drainage areas.

**Table 4. Summary of Ravines Within Shorewood Forest**

Ravine Name	Total Length (ft)	Drainage Area (Acres)
Ashford Ravine	3,490	54
Chaucer Ravine	1,980	28
Devon Ravine	6,330	274
Roxbury Ravine	3,750	117
Westchester Ravine	1,300	45
Wilshire Ravine	1,450	35
Downstream of Lake Louise	8,100	227
<b>Total</b>	<b>26,400</b>	<b>780</b>

As part of this field assessment, concentrated discharges from the storm sewer system and private property were observed to be a significant source of erosion along the ravines. As discussed under the *Storm Sewer/Culvert Assessment* section, severe erosion was observed at several deteriorated CMP culverts. The displacement of material under and around the pipe will continue with each rainfall event. Additionally, severe erosion was observed at nearly every storm sewer outfall into the ravine which has resulted in a significant vertical drop between the pipe invert and the channel bottom. An example of this is provided in **Figure 7**.

**Figure 7. Severe Erosion at Storm Sewer Outfall**

The other most prevalent issue contributing to erosion is the discharge of rainwater into the ravines via downspouts from adjacent homes. Many downspouts were observed to discharge either at the top of the ravine or directly to the bottom of the ravine via slope drains. The velocity and volume of water from these point discharges results in the washing away of material within the ravine and gully erosion along the side slopes. Also contributing to these issues are debris jams, which cause water to flow along the banks instead of in the center of the channel.

It is clear that a significant effort was made in the past to stabilize portions of these ravines, as several turf reinforcement mat (TRM), riprap, and sandbag check dams were encountered along these two ravines. These

measures appear to be situated in appropriate locations, but have mostly become clogged with debris, show signs of failure, and are no longer providing their original function.



**Figure 8. Failed TRM/Riprap Check Dam (Left) and Failed Sandbag Check Dam (Right)**

## CHAPTER 3 EXISTING CONDITION XP-SWMM MODEL ANALYSIS

### 3.1 EXISTING CONDITION HYDROLOGIC AND HYDRAULIC MODEL DEVELOPMENT

The Shorewood Forest drainage system was analyzed using XP-SWMM computer software, which is a proprietary program based on the US Environmental Protection Agency's (EPA) Storm Water Management Model (SWMM). XP-SWMM is a dynamic hydrologic and hydraulic modeling program that is ideal for analyzing complex stormwater management systems. XP-SWMM simulates rainfall-runoff responses for user-specified storm events (hydrologic component) and analyzes the performance of the stormwater management system (hydraulic component). For a given storm simulation, the model is capable of calculating flowrates, flow velocities, and flood depths at the areas of interest specified by the user.

As described above, there are two main components to the XP-SWMM model: the hydrologic component (watershed characteristics, impervious area, topography, etc.) and the hydraulic component (pipe size, ravine cross-sectional area, slope, material, etc.). Input data for the hydrologic and hydraulic components was collected from various sources, including:

- Porter County one-foot aerial topographic mapping
- Residential stormwater concern reports
- GIS storm sewer/culvert database
- Construction plans, as-built drawings, and drainage reports for the Shorewood Forest, Edgewood, Sagamore, and Arbor Lakes Subdivisions
- Natural Resources Conservation Service (NRCS) Soil Survey
- Field investigations/survey completed by CBBEL and Department staff

The XP-SWMM model includes all offsite upstream drainage areas, the subdivision's drainage system including the Lake Louise dam, and extends to US Route 30, which is approximately 3,300 LF downstream of the Lake Louise dam. The extent of the modeling was chosen so that the tailwater effects of Lake Louise on the drainage system could be determined for various storm events.

### 3.1.1 Subbasin Delineation

The study area was delineated into subbasins based on Porter County one-foot aerial topography and the location of major hydraulic features (storm sewers, culverts, ravines, etc.). Subbasins were delineated at a level of detail to determine accurate drainage areas at various points throughout the watershed. The study area includes a total of 142 subbasins, as depicted on **Exhibit 4**.

### 3.1.2 Hydrologic Parameters

Hydrologic parameters, such as area, Runoff Curve Number (CN), and time of concentration ( $t_c$ ), were calculated in accordance with Porter County stormwater standards, which specify the use of Soil Conservation Service (SCS) TR-55 methodology.

The CN value is a measure of the runoff potential of each subbasin and is based on a weighted computation of the various land uses in conjunction with the soil types within each drainage area. As shown on **Exhibit 2**, the majority of the soils within the watershed are classified as Hydrologic Soil Group (HSG) "C" or "D" according to the NRCS. HSG Type C and D soils are considered moderately to very poorly-draining soils. These types of soils have limited infiltration capacity and result in the highest stormwater runoff.

The time of concentration is the longest time it takes a drop of water to reach the outlet of the subbasin. These parameters were calculated based on Porter County one-foot topography, land use according to current aerial photography, and NRCS soil information.

The supporting hydrologic parameter calculations for the study area are provided in **Appendix 2**.

### 3.1.3 Hydraulic Components

The subdivision's drainage system contains several complex hydraulic components, including: storm sewers, culverts, ravines, wetlands/depressional storage areas, overland flow paths, and the Lake Louise dam/spillway. The hydraulic characteristics of these components were entered into the model based on a combination of survey data, field reconnaissance, and Porter County 1-foot aerial topography.

Inlet capacity was included where appropriate to simulate the situations where the capacity of the pipe is not the limiting factor. When the capacity of an inlet, storm sewer or culvert is exceeded, stormwater will follow the topography in that location. If this occurs in a sag, stormwater will pond in that location until the system has the ability to catch up to rate of stormwater runoff. In other cases, stormwater will flow overland until it reaches the next downstream hydraulic feature.

The XP-SWMM modeling developed as part of this study includes the following hydraulic components:

- A total of 320 storm structures (inlets, catch basins, outlets, etc.)

- A total of 340 conduits (storm sewers, culverts, ravines or overland flow paths) with a total length of approximately 62,000 LF
- 62 individual storage areas, which includes Lake Louise, wetland/depressional storage areas, stormwater detention facilities, and low-lying roadway/yard areas
- Lake Louise dam and spillway

### 3.2 DESIGN STORMS AND CRITICAL DURATION

Once the physical components of the model were developed, rainfall information was entered into XP-SWMM to simulate storm events across the watershed and determine the response. The rainfall information included in the modeling consists of design storm events that have a statistical probability of occurring in any given year. As an example, the term “100-year storm” is used to define a rainfall event recurrence interval that statistically has a 1% chance of occurring in any given year. **Table 5** shows the recurrence and statistical probability of a storm happening in a given year.

**Table 5. Design Storm Statistics**

Recurrence Interval in Years	Probability of Occurrence in any Given Year	Percent Chance of Occurrence in any Given Year
100	1 in 100	1
10	1 in 10	10
5	1 in 5	20

Design rainfall depths for this analysis were taken from the *Porter County Stormwater Design Manual* and are summarized in **Table 6**. Using the Porter County design rainfall information, a critical duration analysis was completed using the XP-SWMM model for the study area. The critical duration refers to the duration of a storm that produces maximum water surface elevations, flood depths or flowrates. For example, the 100-year critical duration analysis included executing the XP-SWMM model for the 0.5-hour through 24-hour duration storm events. The storm event producing the highest flood elevation is the critical duration storm event, and all proposed improvements are then designed for the critical duration storm.

**Table 6. Porter County Design Rainfall Depths for Various Durations/Recurrence Intervals**

Storm Duration	Storm Recurrence Interval (Yrs)					
	2	5	10	25	50	100
5 min	0.35	0.43	0.51	0.63	0.73	0.85
10 min	0.61	0.76	0.89	1.10	1.28	1.50
15 min	0.78	0.97	1.14	1.41	1.65	1.92
20 min	0.88	1.09	1.28	1.58	1.85	2.16
30 min	1.07	1.34	1.56	1.93	2.26	2.63
40 min	1.17	1.46	1.70	2.10	2.46	2.87
50 min	1.26	1.58	1.84	2.28	2.67	3.11
1 hr	1.36	1.70	1.98	2.45	2.87	3.35
2 hr	1.68	2.09	2.45	3.03	3.54	4.13
3 hr	1.85	2.31	2.70	3.34	3.90	4.56
6 hr	2.17	2.71	3.16	3.91	4.57	5.34
12 hr	2.51	3.14	3.67	4.54	5.31	6.19
24 hr	2.89	3.61	4.22	5.22	6.10	7.12

The critical duration varies for locations throughout the watershed, and is dependent on a variety of factors, including drainage area. In general, the critical duration for large storage areas (such as Lake Louise) was the 24-hour duration, as this storm duration produces the largest stormwater runoff volume across the watershed. When analyzing small drainage areas, such as a single inlet/pipe located at the end of a cul-de-sac, the critical duration is much smaller since shorter, higher intensity storm events result in the highest flowrates.

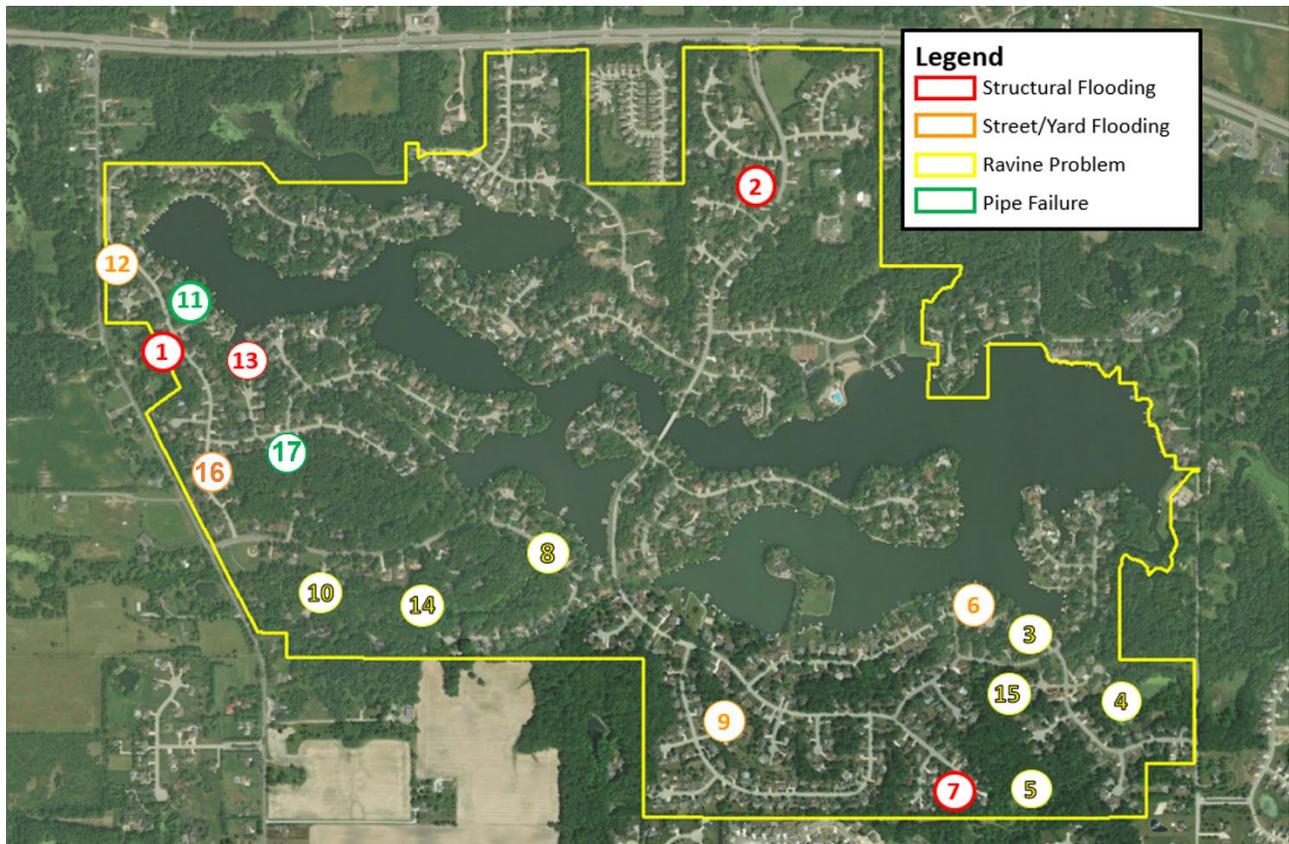
### 3.3 MODEL RESULTS

CBBEL used the critical duration water surface elevations from the XP-SWMM analysis to create existing conditions inundation mapping for the 100-year design storm for the subdivision. This inundation mapping is included as **Exhibit 6**.

The inundation mapping was compared to the stormwater concern reports to ensure the model was producing results that were consistent with the residents' observations during storm events.

## CHAPTER 4 PROPOSED IMPROVEMENTS

Based on the stormwater concern reports submitted by residents, the findings of the stormwater infrastructure assessment, and the results of the XP-SWMM existing conditions hydrologic and hydraulic analysis, a total of 15 projects were identified for the Shorewood Forest Subdivision. While there are many drainage problems located throughout the subdivision, these projects were chosen because they involve one or more of the following: (1) structural flooding, (2) significant roadway flooding, (3) failing infrastructure that poses public safety concerns, or (4) significant benefit to the public. A location map for these proposed improvements is shown as **Figure 9**.



**Figure 9. Proposed Project Location Map**

Where appropriate, these proposed improvements were analyzed using the XP-SWMM analysis developed for the subdivision. The model was used to simulate the conceptual drainage improvement and determine the flood-reduction benefits associated with each alternative. For cases involving structural flooding or significant structural flooding, the objective of the proposed improvements was to provide a 100-year level of flood protection.

A concept plan and an engineer's estimate of probable cost was prepared for each improvement alternative.

## 4.1 PROBLEM AREA 1

### 4.1.1 Existing Conditions

Problem Area 1 involves the three residences located at 194-198 Wexford Road and involves severe backyard flooding that causes structural flooding for one residence during extreme events. There is a total of 14 acres that drains through an existing ravine that originates on the east side of CR 500 W. The ravine drains to a single inlet located at the southwest corner of the 196 Wexford Property. The inlet is outfitted with a high-capacity stool-type grate that connects an existing 24-inch diameter CMP to the storm sewer along Wexford Road.



**Figure 10. Rear Yard Flooding - 194-198 Wexford Road**

During severe storm events, debris from the upstream drainage area will clog the existing inlet and cause significant ponding in the rear yards of 194, 196, and 198 Wexford. During more extreme events, the flood levels will rise above the rear window well of 196 Wexford and cause structural flooding.

Based on the existing conditions XP-SWMM modeling, the existing 24-inch CMP has an approximately 50-year capacity, assuming that the existing capacity is not reduced due to debris.

### 4.1.2 Proposed Conditions

As shown on **Exhibit 8**, the proposed improvements involve the following:

- Install secondary inlet outfitted with a high-capacity cone grate on the 24-inch CMP
- Create overflow swale between existing and new inlet
- Regrade side yard between 194 and 196 Wexford to create overland flow route eastward toward Wexford Road

The proposed improvements would provide a 100-year level of flood protection for the residence located at 196 Wexford Road. It is not anticipated that permits from any outside agencies will be required for this work, but the project will require coordination with the individual property owners. The conceptual cost estimate for these improvements is approximately \$18,000. A detailed breakdown of the costs for this project are included in **Appendix 3**.

## 4.2 PROBLEM AREA 2

### 4.2.1 Existing Conditions

Problem Area 2 involves significant yard flooding that causes structural flooding for one residence located at 228 Shorewood Drive. The rear (eastern) and side (southern) yard of this property are located within a low-lying area that drains to an existing 18-inch diameter CMP culvert under Shorewood Drive. There are approximately 6 acres of tributary area to the flared end section (FES) located on the subject property, with an additional 4 acres draining to the inlets on Shorewood Drive.

During severe storm events, ponding in the side and rear yard will rise above the elevation of the walk-out basement, resulting in structural flooding. Based on the results of the XP-SWMM modeling, structural flooding will occur at storm events with a 50-year return interval. The 100-year inundation area for this location is shown on **Exhibit 6**.

Based on the results of the pipe assessment, segments of this storm sewer system are in moderate or poor condition.

### 4.2.2 Proposed Conditions

As shown on **Exhibit 9** the proposed improvements involve the following:

- Replace existing FES with drop inlet structure outfitted with high-capacity cone grate
- Replace approximately 240 LF of 18-inch diameter CMP storm sewer with 18- to 24-diameter RCP storm sewer
- Regrade side yard and rear yard to improve positive drainage toward proposed drop inlet

The proposed improvements would provide a 100-year level of flood protection for the residence located at 228 Shorewood Drive. It is not anticipated that permits from any outside agencies will be required for this work, but the project will require coordination with two individual property owners. The conceptual cost estimate for these improvements is approximately \$103,000. A detailed breakdown of the costs for this project are included in **Appendix 3**.

## 4.3 PROBLEM AREA 3

### 4.3.1 Existing Conditions

Problem Area 3 involves an existing sediment forebay that was constructed to control sediment-laden stormwater runoff from the Devon Ravine. The entire 274-acre Devon Ravine drainage area is conveyed to this location through an existing 30-inch diameter PVC pipe (grouted within original 48-inch diameter CMP).

The existing forebay is approximately 20-ft wide by 50-ft (measured in the direction of flow) and was created by constructing a riprap dam across the bay in this location. Based on our field reconnaissance, portions of the riprap dam are failing and the effectiveness of the forebay has been significantly diminished. Several residents have reported large amounts of sediment-laden runoff, as well as the accumulation of debris, in this location during storm events.



**Figure 4. Existing Sediment Forebay Looking Upstream (Left) Deteriorated Riprap Dam (Right)**

#### 4.3.2 Proposed Conditions

Guidance for the sizing of sediment forebays generally specifies a minimum length to width ratio of 3:1 (with 4:1 being more desirable and 5:1 being ideal). Typical design guidance also recommends forebays should provide a capture volume that is at least equal to 0.1 – 0.25 inches of runoff from the upstream impervious area.

The objective of this project is to reconstruct the sediment forebay to the maximum extent practicable. In addition to the existing boat docks that serve the adjacent properties, the bay widens significantly as you move northward, so the ability to construct and perpetually maintain the facility becomes more challenging as the footprint is expanded. Working within these site constraints, an approximately 30-ft (width) by 120-ft (length) sediment forebay can be reconstructed using a riprap baffle wall (dam) across the bay, as shown on **Exhibit 10**. The provided volume within the forebay would provide approximately 0.6 acre-feet (970 yd<sup>3</sup>), which would translate to 0.25 inches of runoff from the upstream impervious area.

This project will require permitting through the US Army Corps of Engineering (USACE), the Indiana Department of Natural Resources (IDNR) and the Indiana Department of Environmental Management (IDEM). The project will require coordination with the two adjacent property owners, and an access easement agreement with the eastern property owner will be required to perpetually inspect and maintain this facility.

The conceptual cost estimate for these improvements is approximately \$353,000. A detailed breakdown of the costs for this project are included in **Appendix 3**.

## 4.4 PROBLEM AREA 4

### 4.4.1 Existing Conditions

The Blue Heron Nature Preserve is an existing wetland complex that provides numerous ecological and water quality benefits. In addition, it provides valuable flood storage benefits for the watershed, as it attenuates stormwater runoff from approximately 40 acres.

Under existing conditions, this wetland outlets through an 18-inch RCP storm sewer located at the southwest corner of the site, and ultimately drains to the Devon Ravine through a 24-inch diameter storm sewer adjacent to the Nature Walk, as shown in **Figure 12**.



**Figure 5. Blue Heron Nature Preserve**

### 4.4.2 Proposed Conditions

The Devon Ravine is the major source of sediment loading in Lake Louise and this report includes several recommendations for mitigating the problem. One strategy for reducing the erosion is to reduce the drainage area that is conveyed through the Devon Ravine. Bypassing this flow around the ravine will reduce the runoff volume, flowrates, and flow velocities through the ravine, which will in turn reduce the potential for erosion.

Based on our review of the existing topography, storm sewer network, and pipe condition assessment, the outlet for the Blue Heron Nature Preserve was identified as a logical option to reconfigure. As shown on **Exhibit 11**, the proposed improvements involve the following:

- Replace the existing 15-inch diameter inflow storm sewer at the northwest corner of the wetland with an 18-inch diameter outlet pipe
- Replace approximately 1,200 LF of 18- to 42-inch diameter RCP storm sewer
- Plug/abandon existing outlet to the wetland

This project will require permitting through the USACE, IDNR, and IDEM. The project will also require coordination with two property owners to reconfigure the proposed outlet pipe.

The conceptual cost estimate for these improvements is approximately \$630,000. A detailed breakdown of the costs for this project are included in **Appendix 3**.

## 4.5 PROBLEM AREA 5

### 4.5.1 Existing Conditions

The headwaters of the Devon Ravine within the Shorewood Forest Subdivision begin at the existing wetland areas located south of the Nature Walk. Approximately 130 acres of drainage area is conveyed through these two wetland areas, the majority of which is offsite area located south of the subdivision.

The normal water level (NWL) of the wetlands is controlled by two overflow grates that convey water to the Devon Ravine through 18- to 24-inch storm sewers under the Nature Walk. There is an existing berm located along the south side of the trail, which is set approximately 0.5 feet above the NWL of the wetland.



**Figure 13. Existing Outlet – Nature Walk Wetland**

Several residents have reported that the wetland areas will frequently overtop the existing berm during rainfall events. This overflow will scour the Devon Ravine on the downstream side of the Nature Walk and will also deposit sediment and debris in this location.

### 4.5.2 Proposed Conditions

Based on the field reconnaissance performed by CBBEL staff, these wetland areas are likely to be considered high-quality wetlands by the regulatory agencies. To be permissible, any proposed work in these areas cannot result in any adverse impacts to the wetland or its hydrology.

As shown on **Exhibit 12**, this project proposes to increase the flood storage by lowering the existing overflow grates approximately one foot from existing conditions. By lowering the grates, the available flood storage capacity between the NWL and the overtopping elevation is increased approximately 1.1 acre-feet over existing conditions.

Based on the results of the XP-SWMM analysis, these modifications would allow the 100-year flood elevation to be contained within the wetland areas without overtopping the berm/Nature Walk.

This project will require permitting through the USACE, IDNR, and IDEM. The conceptual cost estimate for these improvements is approximately \$35,000. A detailed breakdown of the costs for this project are included in **Appendix 3**.

## 4.6 PROBLEM AREA 6

### 4.6.1 Existing Conditions

Problem Area 6 involves significant roadway and yard flooding along Wilshire Court near the intersection of Guilford Circle. Several stormwater concern reports were submitted that document these conditions during severe storm events.

The existing drainage system consists of 12- to 15-inch CMP storm sewers that outlet to a channel located between 368 and 370 Wilshire Court. The overland drainage pattern along Wilshire Court is from west to east, while the drainage pattern is generally south to north along Guilford Circle. This system includes approximately 5 acres of drainage area, but additional runoff from Guilford Circle (south of Devon Road) may occur during intense storm events

There is a “bowl” located along Guilford Circle that connects to additional low-lying area within the rear/side yard of 374 Wilshire Court. When the capacity of the storm sewer system is exceeded, stormwater ponding occurs in the street and in the side/rear yard of this residence. Additional, during intense storm events, the existing inlets on Wilshire Court become overwhelmed and stormwater runoff is funneled toward the cul-de-sac. The capacity of the existing inlet located within the driveway of 370 Wilshire Court will be exceeded, resulting in stormwater ponding at the end of the cul-de-sac that eventually will overtop the driveway and flow overland between the homes. Based on the XP-SWMM existing conditions analysis, stormwater ponding will occur in this location for 25-year magnitude storm events or greater.

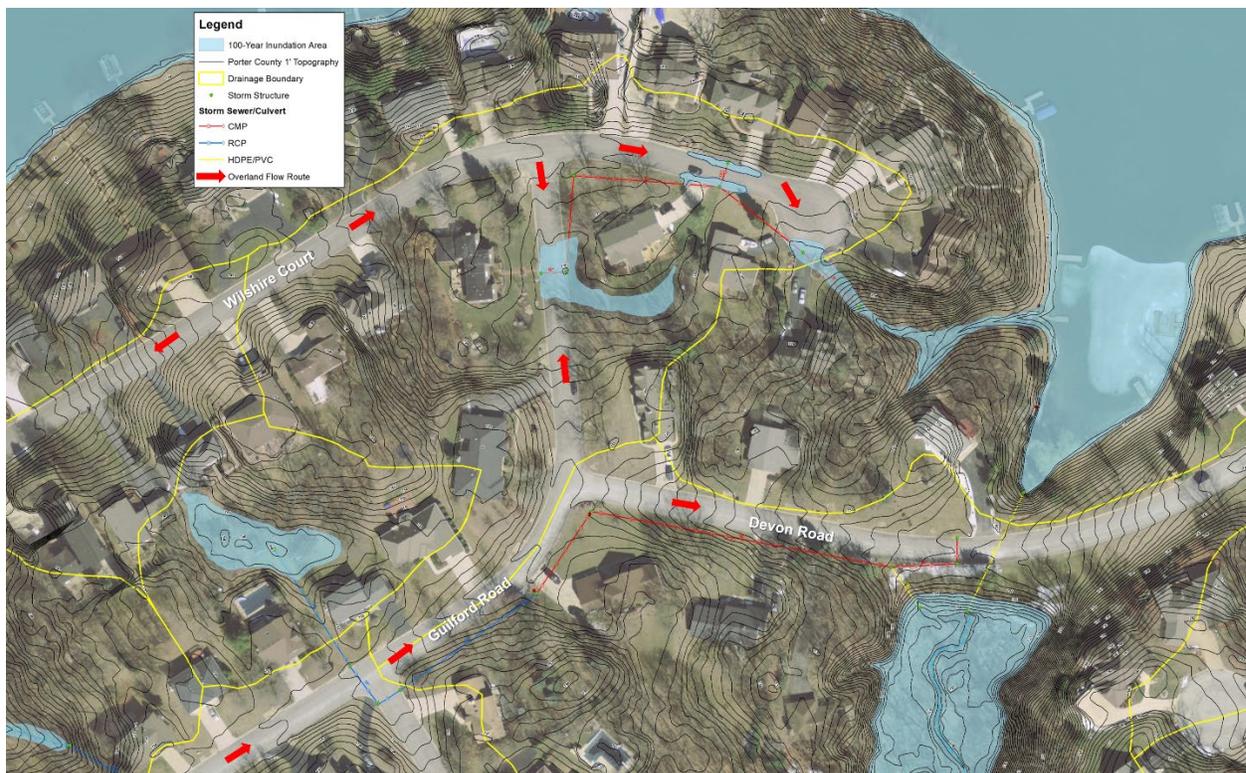


Figure 6. Existing Conditions Drainage - Problem Area 6

Based on the results of the pipe condition assessment, this existing storm sewer network is in moderate to poor condition.

#### 4.6.2 Proposed Conditions

As shown on **Exhibit 13**, the purpose of this project is to increase the inlet and pipe capacity of this drainage system to reduce the frequency and severity of street and yard flooding in this location. The proposed improvements consist of the following:

- Replace approximately 630 LF of 12- to 15-inch diameter CMP storm sewer with 15- to 30-inch diameter RCP storm sewer
- Construct additional inlets on upslope portions of Wilshire Court to improve interception of flow
- Decommissioned segments of existing CMP storm sewer will be plugged using flowable fill

Based on the results of the XP-SWMM analysis, these modifications would eliminate street and yard flooding for a 100-year magnitude storm event.

It is not anticipated that this project will require permitting through any outside agencies, although coordination with two property owners will be necessary to reconfigure the proposed outlet pipe.

The conceptual cost estimate for these improvements is approximately \$324,000. A detailed breakdown of the costs for this project are included in **Appendix 3**.

## 4.7 PROBLEM AREA 7

### 4.7.1 Existing Conditions

Problem Area 7 involves significant yard flooding that causes structural flooding for one residence located at 104 Shorewood Drive. The side (northern) yard of this property is located within a low-lying area that drains to an existing 15-inch diameter RCP culvert under Shorewood Drive. There are approximately 3 acres of tributary area to the flared end section (FES) located on the subject property, with an additional 2 acres draining to the storm sewer system located on Concord Circle/Shorewood Drive.

During severe storm events, ponding in the side and rear yard will rise above the elevation of the window wells and recessed entrance to the basement, resulting in structural flooding. Based on the results of the XP-SWMM modeling, structural flooding will occur at storm events with a 50-year return interval. The 100-year inundation area for this location is shown on **Exhibit 6**.

The results of the pipe condition assessment show that the existing storm sewers in this location are in good condition.

### 4.7.2 Proposed Conditions

The XP-SWMM modeling indicates that the existing 15-inch diameter pipe located on the 104 Shorewood Drive Property has the capacity to handle the upstream drainage area. However, the additional flow entering the system from Shorewood Drive/Concord Circle, with no increase in pipe diameter, results in a hydraulic bottleneck that diminishes positive drainage on the 104 Shorewood Drive Property.

As shown on **Exhibit 14**, the proposed improvements involve replacing approximately 90 LF of existing 15-inch diameter RCP storm sewer with 24-inch diameter RCP storm sewer. This eliminates the existing hydraulic bottleneck and minimizes the replacement of storm sewer that is in otherwise good condition. The proposed improvements would provide a 100-year level of flood protection for the residence located at 104 Shorewood Drive. It is not anticipated that permits from any outside agencies will be required for this work, but the project will require coordination with one property owner. The conceptual cost estimate for these improvements is approximately \$48,000. A detailed breakdown of the costs for this project are included in **Appendix 3**.

## 4.8 PROBLEM AREA 8

### 4.8.1 Existing Conditions

This problem area involves significant roadway and yard flooding along Roxbury Road. One of the sources of flooding in this location is the existing culverts under Roxbury Road that convey stormwater runoff from the approximately 117-acre tributary area associated with the Roxbury Ravine.

The culverts in this location consist of two CMP arch pipes with dimensions of approximately 36 inches (rise) by 54 inches (span). The poor condition of the pipes, in addition to sediment accumulation in this location, further diminish the conveyance capacity of the culverts.



**Figure 15. Existing Flooding Along Roxbury Road**

During severe storm events, the capacity of these culverts is exceeded which results in the flow of stormwater over the roadway. The inundation is exacerbated by the approximately 15 acres of overland drainage area to this low point of Roxbury Road. A depiction of the 100-year inundation area for this location is shown on **Exhibit 6**.

The results of the pipe condition assessment show that the existing culverts are in poor condition.

#### 4.8.2 Proposed Conditions

The goal of this project is to upsize the existing culverts under Roxbury Road to reduce the frequency and severity of roadway flooding in this location. As shown on **Exhibit 15**, the proposed improvements involve replacing approximately 60 LF of twin 36-inch (rise) by 54-inch (span) CMP culverts with twin 3-foot (rise) by 5-foot (span) reinforced concrete box culverts. Based on the XP-SWMM modeling, the proposed culverts will prevent ravine floodwaters from overtopping the roadway for storm events up to a 100-year return interval.

Although the flow from the ravine would not overtop the roadway under post-project conditions, temporary roadway inundation is anticipated to still occur due to the significant area that drains overland to the low point of Roxbury Road.

It is anticipated that permits from the USACE, IDNR, and IDEM will be required for this work, which is due to the work being performed within the Roxbury Ravine. The project will also require coordination with the two property owners adjacent to the ravine. The conceptual cost estimate for these improvements is approximately \$178,000. A detailed breakdown of the costs for this project are included in **Appendix 3**.

### 4.9 PROBLEM AREA 9

#### 4.9.1 Existing Conditions

This problem area involves significant roadway flooding at the Brookshire Court cul-de-sac. A single curb inlet draining to a 12-inch diameter pipe serves an approximately 2-acre drainage area, which becomes a source of flooding as the capacity of that inlet is overwhelmed during intense storm events.

Brookshire Court residents have reported flood depths of up to two feet during recent storm events. There are additional concerns regarding existing electrical equipment located within the ponding area. The existing conditions XP-SWMM modeling indicates an existing 100-year flood depth of approximately 2.5 ft, measured above the rim elevation of the inlet. A depiction of the 100-year inundation area for this location is shown on **Exhibit 6**.



**Figure 16. Existing Flooding Along Brookshire Court**

The results of the pipe condition assessment show that the downstream section of the existing 12-inch diameter RCP storm sewer is in poor condition.

#### 4.9.2 Proposed Conditions

The primary issue with this flood problem area is the limited inlet capacity. The existing conditions XP-SWMM modeling indicates that the storm sewer in this location has an approximately 25-year capacity, assuming that all stormwater flow can make its way into the pipe.

As shown on **Exhibit 16**, the proposed improvements involve the following:

- Construct additional high-capacity inlet in conjunction with 60 LF of 12-inch diameter RCP storm sewer at the southeast corner of the cul-de-sac
- Replace existing inlet with high-capacity inlet
- Replace approximately 175 LF of 12-inch diameter RCP storm sewer with 18-inch RCP storm sewer

No permits from outside agencies are anticipated for this work. Coordination with NIPSCO will be required to relocate the existing electrical infrastructure within the proposed work limits. The conceptual cost estimate for these improvements is approximately \$74,000. A detailed breakdown of the costs for this project are included in **Appendix 3**.

### 4.10 PROBLEM AREA 10

#### 4.10.1 Existing Conditions

This problem area involves an existing 36-inch diameter CMP culvert located under the private driveway of 157 York Circle. This culvert is located along the Roxbury Ravine with an upstream drainage area of approximately 48 acres.

Based on field reconnaissance performed by CBBEL staff, it was observed that the bottom of the pipe has corroded through, with significant material loss below and around pipe. Severe pipe deformation, joint separation, and settling of pipe sections was also noted. This section of pipe could not be televised due to the missing bottom sections.



**Figure 17. Existing Driveway Culvert – 157 York Circle**

#### 4.10.2 Proposed Conditions

As shown on **Exhibit 17**, the proposed improvements involve rehabilitating approximately 40 LF of 36-inch diameter through the cured-in-place-pipe (CIPP) lining process. The use of flowable fill will be necessary to bridge the missing bottom sections and to also fill voids around the pipe. Both the upstream and downstream metal end sections will also be replaced.

It is anticipated that permits from the USACE, IDNR, and IDEM will be required for this work, which is due to the work being performed within the Roxbury Ravine. The project will also require coordination with the property owner. The conceptual cost estimate for these improvements is approximately \$49,000. A detailed breakdown of the costs for this project are included in **Appendix 3**.

## 4.11 PROBLEM AREA 11



**Figure 7. Existing 42-Inch CMP Outlet**

around pipe also noted. The televising footage indicates that the bottom has corroded through for the last (downstream) 6 feet of pipe.

### 4.11.1 Existing Conditions

This problem area involves the 42-inch CMP outlet pipe to Lake Louise located on the undeveloped lot at 203 Wexford Road. The culvert serves a drainage area of approximately 39 acres, which consists of the existing storm network along Wexford Road.

Residents have reported safety concerns regarding the poor condition of the pipe and noted plumes of sediment in the bay following rainfall events.

Based on field reconnaissance performed by CBBEL staff, significant deterioration of the pipe was observed, with significant material loss below and

### 4.11.2 Proposed Conditions

As shown on **Exhibit 18**, this project involves the replacement of approximately 125 LF of 30- to 42-inch CMP storm sewer with 60-inch diameter RCP storm sewer. This will serve as the new outlet pipe to Lake Louise and has also been sized to accommodate upstream drainage improvements to alleviate severe roadway flooding along Wexford Road near the existing Tennis Courts (Problem Area 12).

It is anticipated that permits from the USACE, IDNR, and IDEM will be required for this work, which is due to the work being performed within the footprint of Lake Louise. The project will also require coordination with the property owner 203 Wexford Road owner. The conceptual cost estimate for these improvements is approximately \$171,000; a detailed breakdown of the costs for this project are included in **Appendix 3**.

## 4.12 PROBLEM AREA 12

### 4.12.1 Existing Conditions

Significant roadway flooding has been reported by residents along Wexford Road adjacent to the existing tennis courts. During recent severe storm events, the roadway was impassable due to the depth of inundation.

The total drainage area to this location is approximately 20 acres, 16 of which drains through the existing ditch/culvert located south of the tennis courts. The XP-SWMM existing conditions analysis indicates approximately two feet of flood depth in this location during the 100-year critical duration storm event.



**Figure 19. 100-Year Inundation Area – Problem Area 12**

Based on the pipe condition assessment, this entire storm sewer network consists of CMP and is in poor condition. The existing storm sewer outlet for this network is the deteriorated 42-inch CMP located at 203 Wexford Road (Problem Area 11).

### 4.12.2 Proposed Conditions

As shown on **Exhibit 19**, the proposed improvements involve the following:

- Construct additional high-capacity inlets at the low point of Wexford Road
- Construct approximately 90 LF of 12- to 36-inch diameter CMP storm sewer with 24- to 36-inch diameter RCP storm sewer
- Construct approximately 370 LF of 24- to 48-inch diameter RCP storm sewer
- Plug approximately 350 LF of abandoned 36-inch diameter CMP with flowable fill

These improvements can be combined with the reconstruction of the 42-inch outlet pipe (Problem Area 11), or it can be constructed separately as a later phase. It is not anticipated that permits from outside agencies will be required for this work, however, coordination with several private property owners will be required. The conceptual cost estimate for these improvements is approximately \$374,000. A detailed breakdown of the costs for this project are included in **Appendix 3**.

## 4.13 PROBLEM AREA 13

### 4.13.1 Existing Conditions

This problem area involves roadway flooding at the Ashford Court cul-de-sac that leads to structural flooding for one residence (189 Ashford Court). The drainage system in this location consists of a single curb inlet located between 187 and 189 Ashford Court. That inlet connects to a 12-inch CMP storm sewer that follows the property line before ultimately discharging to Lake Louise to the northwest. The curb inlet collects approximately 1 acre of roadway drainage, with another 1 acre of drainage picked up in a yard inlet located at the southeast corner of 189 Ashford Court.

During intense rainfall events, stormwater ponding in the cul-de-sac will overtop the curb and flow overland down the driveway/side yard of 189 Ashford Court, which results in structural flooding for this residence. The results of the XP-SWMM analysis indicate that the existing storm sewer has adequate capacity to convey the 100-year flowrates from the drainage area. The location and number of inlets (1) cannot adequately capture stormwater runoff during intense rainfall events.

The results of the pipe condition assessment show that the existing storm sewer is in moderate to poor condition.

### 4.13.2 Proposed Conditions

As shown on **Exhibit 20**, the proposed improvements involve adding a high-capacity inlet in conjunction with 22 LF of 12-inch diameter RCP storm sewer. These improvements allow the 100-year peak flowrates to be captured by the existing inlets/storm sewers.

To add an additional level of flood protection, the homeowner should re-pitch the asphalt driveway to the maximum extent practicable in order to direct stormwater runoff away from the residence.

No permits from outside agencies are anticipated for this project and all work is located within the public right-of-way. The conceptual cost estimate for these improvements is approximately \$18,000. A detailed breakdown of the costs for this project are included in **Appendix 3**.

## 4.14 PROBLEM AREA 14

### 4.14.1 Existing Conditions

This problem area involves the restoration of several stabilization measures that were previously constructed along the Roxbury Ravine. As part of the field reconnaissance performed for this study, a total of four check dams consisting of riprap and/or sandbags were noted along the Roxbury Ravine.

These check dams exhibit some signs of failure, particularly in the form of flanking (flow passing around the structure rather than over it). Erosion has occurred around the outer edges of these structures, which reduced their effectiveness. Portions of the riprap have toppled and provide limited impoundment capacity. Additionally, a significant amount of debris and sediment have accumulated on the upstream sides of these structures



**Figure 20. Existing Riprap Check Dam**

### 4.14.2 Proposed Conditions

As shown on **Exhibit 21**, the proposed improvements involve restoring the function of the previously installed stabilization measures along the Roxbury Ravine. The proposed scope of work for this effort includes:

- Repairing the collapsed riprap sections to restore design height (estimate at two feet)
- Key riprap into channel bank to prevent flow around the dam
- Remove sediment/debris accumulated on the upstream side of dam

It is anticipated that permits from the USACE, IDNR, and IDEM will be required for this work, which is due to the work being performed within the Roxbury Ravine. The project will also require coordination with multiple property owners along the ravine. The conceptual cost estimate for these improvements is approximately \$111,000; a detailed breakdown of the costs for this project are included in Appendix 3.

## 4.15 PROBLEM AREA 15

### 4.15.1 Existing Conditions

Problem Area 15 involves the existing wetland area associated with the Devon Ravine. The entire 274-acre drainage area drains through the wetland area and under Devon Road through an existing 30-inch diameter PVC pipe. This culvert connects the Devon Ravine to the existing sediment forebay in Lake Louise (Problem Area 3).

As shown in **Figure 21**, the PVC pipe was grouted inside of two previous CMP culverts with diameters of 42- and 48-inches, respectively. While this modification was likely performed from purely a maintenance standpoint, the reduction in pipe capacity allowed more utilization of the flood storage on the upstream side of Devon Road.



**Figure 21. Existing Devon Road Culvert**

### 4.15.2 Proposed Conditions

The purpose of this project is to reconstruct the existing Devon Road culvert using a pipe size that maximizes the flood storage benefits of the existing wetland on the upstream side of the roadway. In addition to reducing flowrates, this artificial creation of flood storage will allow sediment and debris to be captured.

The existing conditions XP-SWMM analysis was utilized to determine the required pipe size to maximum the available flood storage on the south side of Devon Road. Based on the results of the XP-SWMM analysis, a 24-inch culvert would maximize the upstream flood storage and maintain 100-year flood elevations below the roadway and adjacent structures. The proposed culvert would also be outfitted with a debris/trash guard to capture debris upstream of Lake Louise.

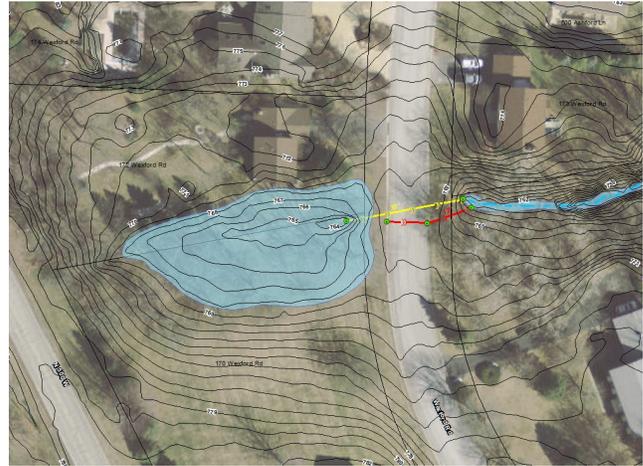
This project will require permitting through the USACE, IDNR, and IDEM in addition to coordination with the adjacent property owners.

The conceptual cost estimate for these improvements is approximately \$96,000. A detailed breakdown of the costs for this project are included in Appendix 3.

## 4.16 PROBLEM AREA 16

### 4.16.1 Existing Conditions

Problem Area 16 is located at the headwaters of the Ashford Ravine and involves significant side/rear yard flooding for two homes (170 and 172 Wexford Road). As shown in **Figure 22**, an approximately 13-acre area drains to an existing 15-inch diameter HPDE culvert located under Wexford Road. An additional 1.5 acres of roadway drainage is collected in the 12-inch diameter CMP storm sewer in this location, which discharges to the east side of the road as a separate outlet. Although the 15-inch diameter HDPE culvert was determined to be in good condition, the 12-inch storm sewer was assessed to be in poor condition.



**Figure 22. 100-Year Inundation Area – Problem Area 16**

Significant side and rear yard flooding has been reported by the residents in this location. According to the XP-SWMM analysis, the 100-year flood elevation in this location results in flood depths of approximately 3.5 feet on these properties. Although the modeling indicates that the 100-year inundation area does not reach the structures, structural flooding can occur if debris from upstream areas reduces the capacity of the 15-inch diameter culvert.

### 4.16.2 Proposed Conditions

The purpose of this project is to: (1) increase the capacity of the existing Wexford Road culvert to reduce the flood depths on the adjacent properties and (2) replace the storm sewer that is in poor condition. Since it is in good condition, the existing 15-inch diameter HDPE culvert could remain in-place; a new parallel culvert can be constructed that would also replace the deteriorated segments of CMP storm sewer.

The existing conditions XP-SWMM analysis was utilized to determine the pipe sizes that would be necessary to provide meaningful flood reductions on the upstream (west side) of Wexford Road. As depicted on **Exhibit 23**, the proposed project involves the construction of a 24- to 30-inch diameter RCP culvert in this location. Based on the results of the XP-SWMM analysis, the proposed improvements would reduce 100-year flood elevations on the upstream side of Wexford Road by approximately 2.4 feet.

Due to the work within the ravine areas, this project will require permitting with the USACE, IDNR, and IDEM. Additionally, coordination with three adjacent property owners will also be necessary.

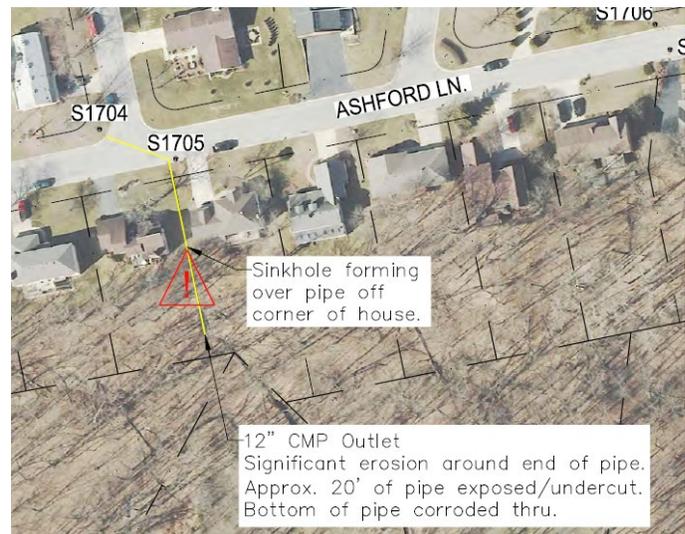
The conceptual cost estimate for these improvements is approximately \$73,000. A detailed breakdown of the costs for this project are included in **Appendix 3**.

## 4.17 PROBLEM AREA 17

### 4.17.1 Existing Conditions

Problem Area 17 involves a pipe failure associated with the 12-inch diameter CMP storm sewer located between 492 and 494 Ashford Lane. Based on field reconnaissance performed by CBBEL staff, severe corrosion along the pipe bottom was noted at the downstream end, which is causing significant erosion in this location. In addition, a sinkhole in close proximity to the eastern home was also documented.

The storm sewer televising confirmed the poor condition of this storm sewer segment, with several large holes shown in the footage. The upstream storm sewer segment along Ashford Lane could not be televised due to the presence of heavy debris.



**Figure 23. Pipe Failure at 492-494 Ashford Lane**

### 4.17.2 Proposed Conditions

As shown on **Exhibit 24**, the proposed improvements involve rehabilitating approximately 220 LF of 12-inch diameter CMP storm sewer using (CIPP) lining. The use of flowable fill will be necessary to bridge the missing bottom sections and to also fill voids around the pipe. Additionally, the downstream metal end section will also be replaced. While the upstream storm sewer segment could not be televised due to heavy debris, it is likely that this section is also in poor condition and therefore has been included with this project.

Permits from outside agencies will not be required for this project, however, coordination with the two adjacent property owners will be necessary.

The conceptual cost estimate for these improvements is approximately \$34,000. A detailed breakdown of the costs for this project are included in **Appendix 3**.

## 4.18 STORM SEWER LINING/REPLACEMENT

As shown in **Table 3**, approximately 56% (13,013 LF) of the storm sewers and culverts within Shorewood Forest were determined to be in either poor or moderate condition. Rehabilitation of this stormwater infrastructure through cured-in-place-pipe (CIPP) lining, or complete replacement, will be necessary to maintain functionality and preempt public safety issues.

Several portions of poor to moderate condition storm sewer will be either replaced or lined as part of the capital improvement projects described earlier in this chapter. The remainder of the poor/moderate condition storm sewers and culverts were analyzed further to determine their suitability for CIPP lining. Storm sewers that are free of major defects are considered good candidates for CIPP lining, while storm sewers with significant deformation or missing pipe sections would likely need to be replaced.

**Table 7. Storm Sewer/Culvert Lining/Replacement Summary**

Pipe Restoration Method	Storm Sewer/Culvert Length* (ft)	Cost of Improvements (\$)
CIPP Lining	7,125	\$1,234,000
Pipe Replacement	3,983	\$1,268,000
<b>TOTAL</b>	<b>11,108</b>	<b>\$2,502,000</b>

\*Excludes storm sewers/culverts addressed as part of capital improvement projects

As shown in **Table 7**, the majority of these storm sewers/culverts (approximately 63%) can be rehabilitated using CIPP lining at an estimated cost of \$1.23M. The remainder would likely need to be fully replaced, with an estimated cost of \$1.27M. **Appendix 1** contains an inventory of the storm sewers/culverts and the results of the condition assessment; this inventory also includes each storm sewer's suitability for CIPP lining.

## 4.19 RAVINE RESTORATION

As described earlier in this chapter, there are a number of recommended improvements to address the ongoing erosion issues for the various ravines within Shorewood Forest. These projects consist of large-scale infrastructure projects as well as smaller improvements that can be implemented on a subdivision-wide scale. The identified capital improvements consist of the following type of projects:

- The creation of flood storage to reduce flowrates and velocities through the ravine
- The restoration of previously constructed stabilization and sediment-control projects

- Storm sewer improvements to reduce ravine flowrates/velocities by diverting drainage area around sensitive areas
- Storm sewer/culvert rehabilitation and replacement to eliminate point sources of erosion

Subdivision-wide improvements consist of the restoration of deteriorated storm sewer outfalls and BMPs implemented by individual property owners to better manage stormwater runoff on each lot.

A summary of the recommended improvements for each ravine is provided in **Table 8**. As shown in the table, ravine restoration is a recommended improvement to address: (1) the numerous stretches of ravine where erosion, head-cutting, and/or slope failure is occurring, and (2) the deteriorated storm sewer outfalls throughout the subdivision. These are programmatic improvements to restore those ravine areas that are not covered by a capital improvement project. A universal cost of \$250/LF of ravine can be used to budget for these restoration efforts, which translates to \$6.6M for the approximately 26,400 LF of ravine located within the Shorewood Forest Subdivision.

**Table 8. Summary of Recommended Improvements for Ravines**

Ravine Name	Type of Improvement				
	Stabilization Improvements <sup>‡</sup>	Creation of Flood Storage <sup>‡</sup>	Ravine Restoration/Storm Sewer Outfall Improvements	Storm Sewer/Culvert Improvements <sup>‡</sup>	Property Owner BMPs
Ashford Ravine			X	X	X
Chaucer Ravine			X		X
Devon Ravine	X	X	X	X	X
Roxbury Ravine	X		X	X	X
Westchester Ravine			X		X
Wilshire Ravine			X	X	X
Downstream of Lake Louise			X	X	X

<sup>‡</sup>Covered under capital improvement project

## 4.20 OTHER RECOMMENDATIONS

### 4.20.1 Homeowner Best Management Practices (BMPs)

Throughout the course of this study, numerous erosion issues associated with houses were observed along the ravines. There are a number of best management practices (BMPs) that can be undertaken by Shorewood Forest residents to improve the management of stormwater on each lot and reduce the erosion that is taking place. These BMPs are fairly inexpensive to implement and would have significant benefits on the overall health of both the ravines and Lake Louise. These measures include:

- 1) Disconnection of building downspouts: A significant source of erosion is the discharge of rainwater into the ravines via downspouts and slope drains. Once rainwater discharges from the downspouts, the water travels along defined paths and rills are created. As the water travels downslope, the rills deepen and widen into large gullies. In cases where downspouts are connected to slope drains, the drains usually discharge directly into ravines, where the velocity and volume of this water causes erosion in the ravines. What may begin as a small discharge from a downspout quickly becomes a problem as the slope steepens and the highly erodible soil washes into the ravine. These downspouts should be disconnected and allow to discharge at-grade to promote infiltration prior to reaching the ravine.



**Figure 24. Downspouts Discharging at Top of Bank**

- 2) Green Infrastructure Practices: In conjunction with the disconnection of building downspouts, homeowners can implement green infrastructure practices to promote the infiltration of stormwater on their property. Several homeowners have already installed rain barrels on their property, which not only controls stormwater runoff but serves as a cheap irrigation source for watering gardens and landscaping. The installation of rain gardens would be another effective alternative for controlling stormwater. The size of the residential lots lends itself well to installing these types of practices and would provide a discharge point for building downspouts.
- 3) Ravine Buffers: In many cases, properties adjacent to ravines include turf grass installed up to the edge of bank. The establishment of a native-vegetated buffer strip along the ravines will promote the infiltration of stormwater and the removal of pollutants in the runoff.
- 4) Forest Management: Homeowners should be encouraged to plant trees on their properties, whose root structures will support the soil and reduce erosion. By limiting sunlight, the shade from the trees also prevents invasive plant species from flourishing. This is particularly critical on those properties with ash trees that have been affected by the emerald ash borer.

- 5) Landscape Management: Homeowners adjacent to ravines should keep their areas as debris-free as possible. While it does not appear to be a widespread issue, several instances of yard waste (leaves, grass clippings, tree limbs) and trash being disposed of in the ravines were observed.

#### 4.20.2 Storm Sewer Outfalls

As stated previously, concentrated discharges from the storm sewer system were also observed to be a significant source of erosion along the ravines. Severe erosion was observed at nearly every storm sewer outfall that discharge to a ravine. The erosion has resulted in a significant vertical drop between the pipe invert and the channel bottom, which will cause the displacement of additional material with each rainfall event.

The reconstruction or rehabilitation of each storm sewer outfall, along with implementing appropriate energy dissipation measures, will significantly improve the on-going erosion issues.



**Figure 25. Erosion at Storm Sewer Outfall**



**Figure 26. Example Slope Drain Installation**

Since access to these areas is challenging and some outfalls are in acceptable condition, another option to remediate this situation is to install slope drains on the outlet pipe that allow the flow to discharge at-grade in the bottom of the ravine. Energy dissipation measures, such as riprap, would need to be installed at the outlet to reduce the force of discharge. **Figure 26** provides an example of slope drain installation on an existing culvert that outlets to a ravine area.

While this option would provide a cost-effective solution in some locations, the disadvantage to these measures is that continual maintenance and monitoring will be required to ensure their effectiveness.

## CHAPTER 5 PRIORITIZATION OF PROPOSED PROJECTS

The summary table below ranks the proposed projects by different categories including the initial priority level based on the type of associated flooding within the project area, the cost of the project, the number of flooding areas addressed by the project, the estimated number of permits required, whether or not the project provides water quality benefits, and the compatibility of the proposed project with other identified projects for Shorewood Forest. CBBEL developed a ranking table where a score (1-6) has been associated with each category for each proposed project. The scores from each category were then added together to assign each project a total metric score, where the higher the total metric score is, the more favorable the project. Based on the total metric score, the proposed capital improvement projects were assigned an overall rank. Tie breakers were based on the type and number of areas addressed by the project, as well as by cost. See **Table 9** for a summary of the prioritization of all proposed capital improvement projects. It should be noted that this prioritization list does not necessarily reflect the order that the proposed projects will be installed. Other considerations including Department budget and downstream impacts will need to be evaluated prior to installation.

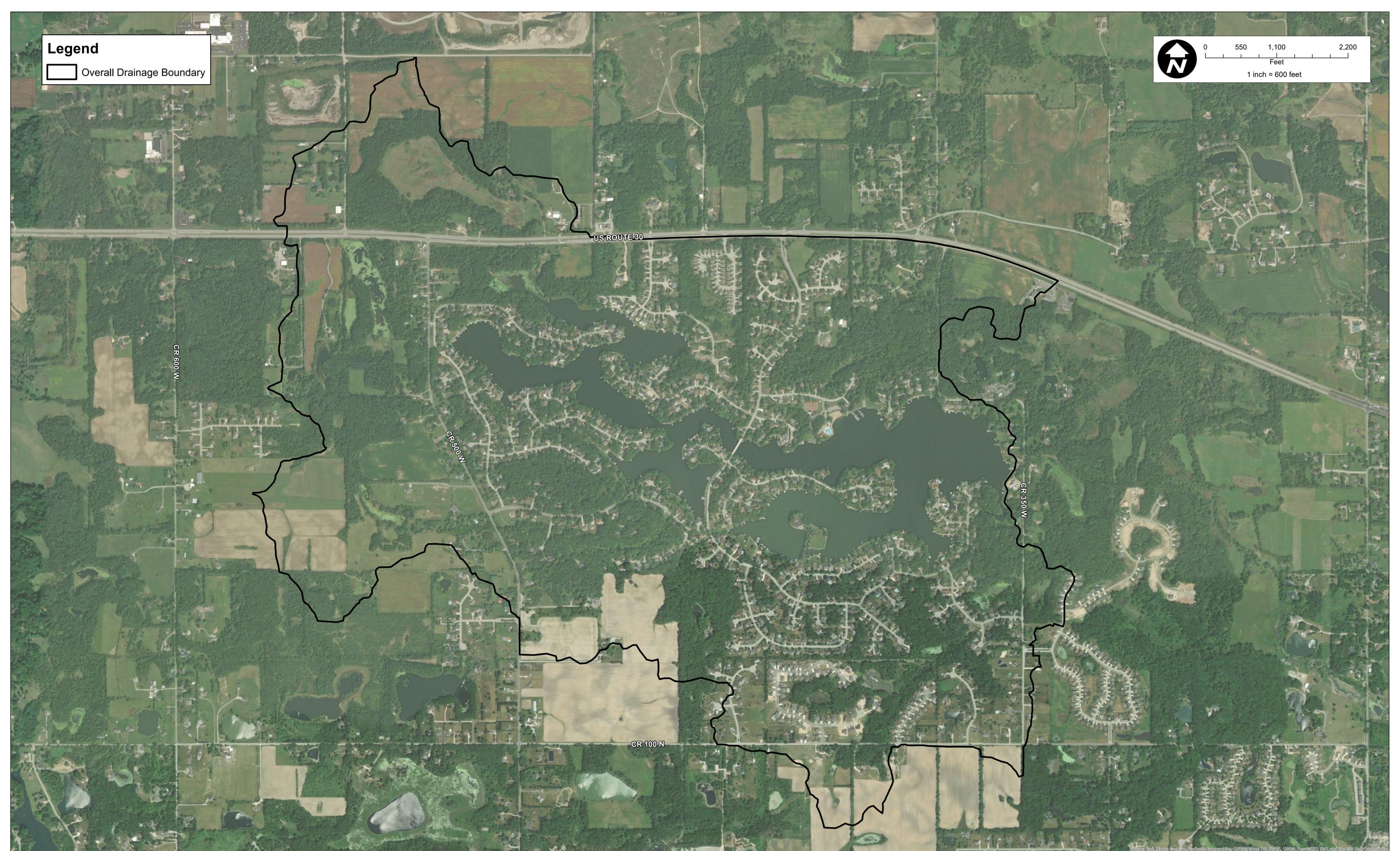
**Table 9. Summary of Project Prioritization**

Problem Area ID	Address	Problem Type	Priority Level	Cost	# of Properties Affected	Estimated # of Permits Required	Water Quality Benefits	Pre-Requisite to Other Projects	Total Metric Score	Overall Rank
			6 = Level 1 (Structure) 3 = Level 2 ( Severe Erosion) 1 = Level 3 (Street/Yard)	6 = < \$50K 3 = \$50K - \$200K 1 = > \$200K	6 = > 5 3 = 3-5 1 = 1-2	3 = 0 - 1 1 = >2	3 = Yes 1 = No	3 = >1 1 = None	Higher Score = More Favorable	
1	194-198 Wexford Road	Structural/Yard	6	6	3	3	1	1	20	1 (tie)
5	362-383 Tremont Lane	Devon Ravine Erosion	3	6	6	1	3	1	20	1 (tie)
11	201 Wexford Road	Pipe Failure/Sinkhole	3	3	6	1	3	3	19	3
13	189 Ashford Court	Pipe Failure/Structural Flooding	6	6	1	3	1	1	18	4 (tie)
7	104 Shorewood Drive	Structural	6	6	1	3	1	1	18	4 (tie)
15	385 Devon Road	Pipe Failure/Ravine Erosion	3	3	6	1	3	1	17	6 (tie)
14	448-490 Roxbury Road	Roxbury Ravine Erosion	3	3	6	1	3	1	17	6 (tie)
4	362-383 Tremont Lane	Devon Ravine Erosion	3	1	6	1	3	3	17	6 (tie)
17	492-494 Ashford Lane	Pipe Failure/Sinkhole	3	6	1	3	1	1	15	9 (tie)
2	228 Shorewood Drive	Structural/Yard	6	3	1	3	1	1	15	9 (tie)
3	386 Devon Road	Failed Sediment Forebay	3	1	6	1	3	1	15	9 (tie)
10	157 York Circle	Pipe Failure/Ravine Erosion	3	6	1	1	3	1	15	9 (tie)
8	451-452 Roxbury Road	Street/Yard	1	3	6	1	1	1	13	13 (tie)
6	367, 370 & 374 Wilshire	Street Flooding/Pipe Failure	1	1	6	3	1	1	13	13 (tie)
12	206 Wexford Road	Pipe Failure/Street Flooding	1	1	6	3	1	1	13	13 (tie)
9	423 Brookshire Court	Street/Yard	1	3	3	3	1	1	12	16
16	170-172 Wexford	Pipe Failure/Yard Flooding	1	3	1	1	1	1	8	17

**Legend**

 Overall Drainage Boundary

 0 550 1,100 2,200  
Feet  
1 inch = 600 feet



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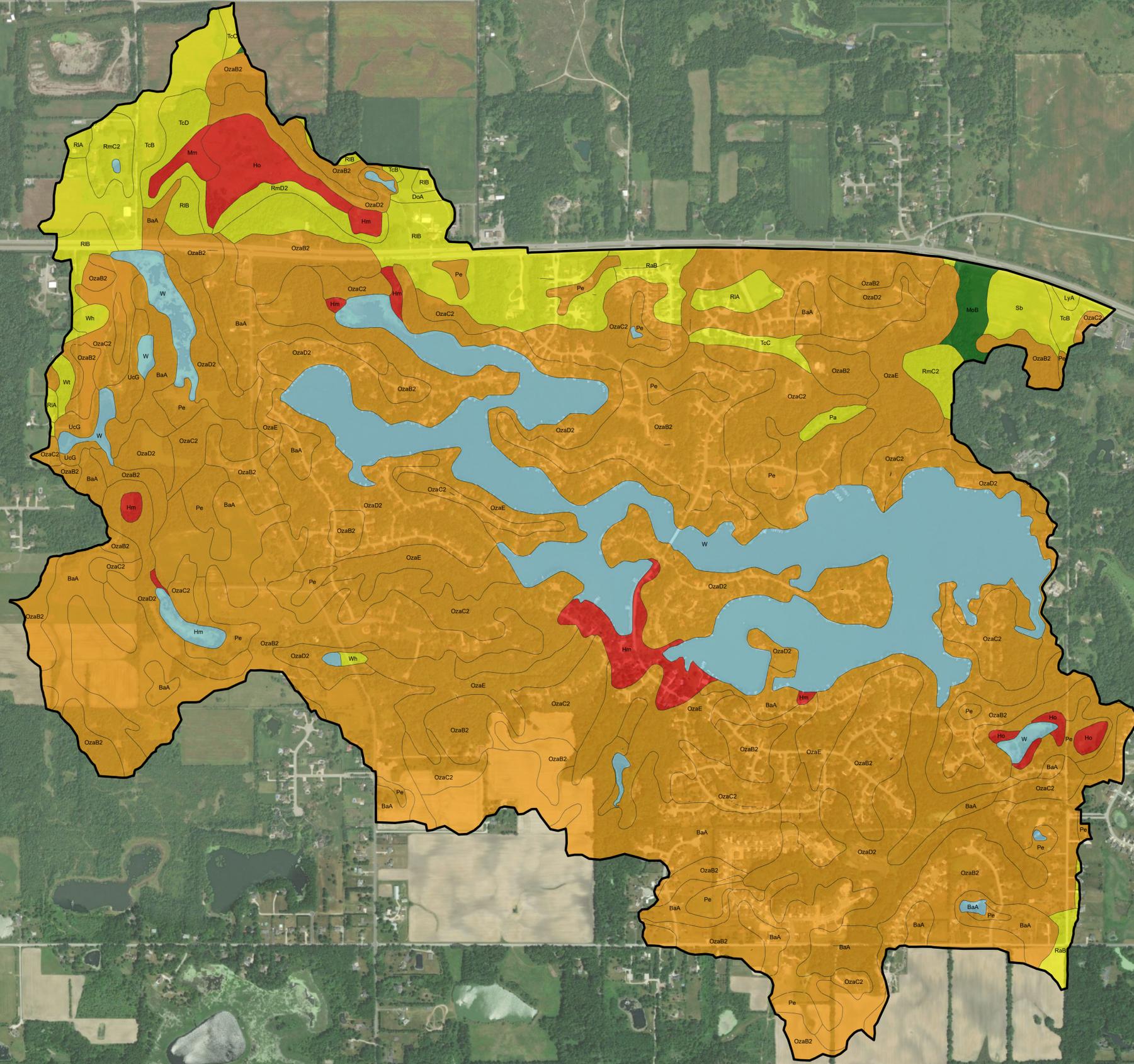
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**2021 AERIAL PHOTOGRAPHY**

PROJ. NO. 200085  
DATE:  
SHEET 1 OF 1  
DRAWING NO.  
**EXH 1**

**Legend**

-  Overall Drainage Boundary
- Hydrologic Soil Group (HSG)**
-  HSG A
-  HSG B
-  HSG C
-  HSG D
-  Open Water

 0 550 1,100 2,200  
Feet  
1 inch = 600 feet



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TITLE: **SHOREWOOD FOREST SUBDIVISION  
NATURAL RESOURCES CONSERVATION  
SERVICE (NRCS) SOIL SURVEY**

PROJ. NO. 200085  
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SHEET 1 OF 1  
DRAWING NO.  
**EXH 2**

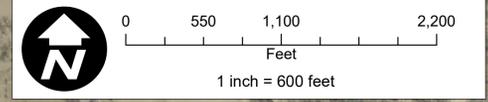
**Legend**

-  Stream Centerline
-  Overall Drainage Area

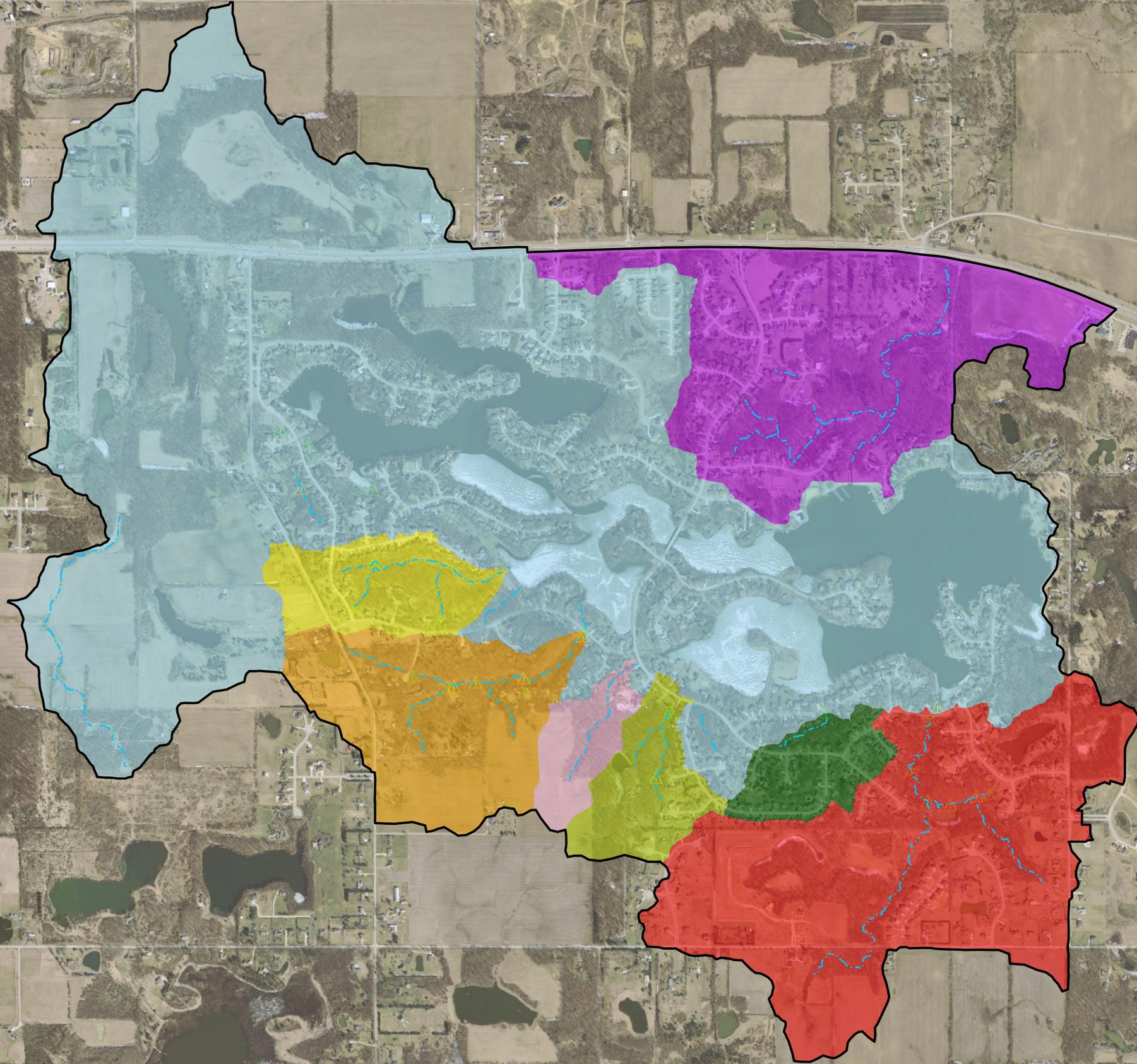
**Drainage Area**

**Tributary**

-  Wilshire Ravine (35 Acres)
-  Westchester Ravine (45 Acres)
-  Chaucer Ravine (28 Acres)
-  Ashford Ravine (54 Acres)
-  Roxbury Ravine (117 Acres)
-  Devon Ravine (274 Acres)
-  Lake Louise (1680 Acres)
-  Downstream of Lake Louise (227 Acres)



0 550 1,100 2,200  
Feet  
1 inch = 600 feet




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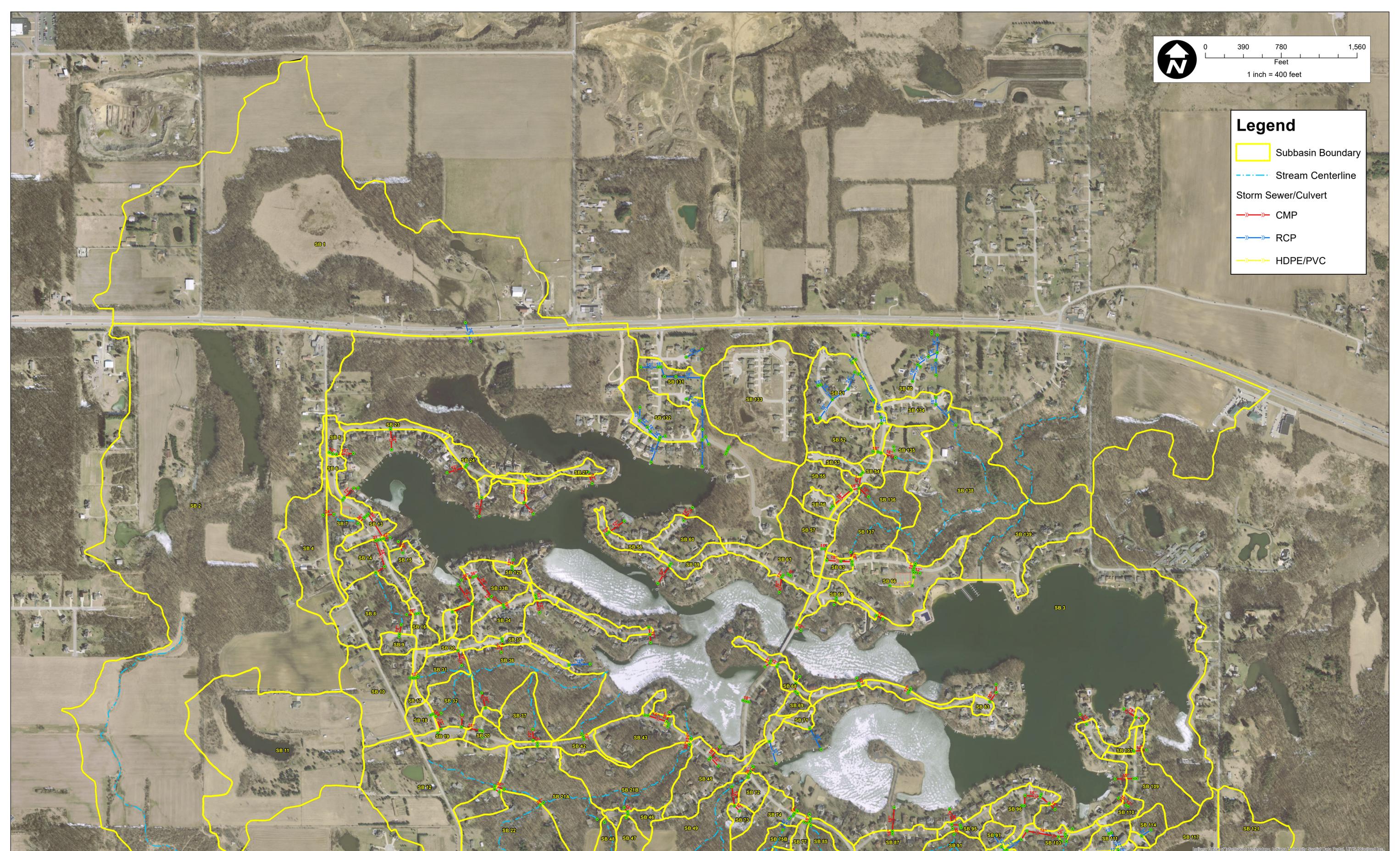
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**EXH 3**



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Feet  
1 inch = 400 feet

### Legend

- Subbasin Boundary
- Stream Centerline
- Storm Sewer/Culvert
- CMP
- RCP
- HDPE/PVC



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SUBBASIN BOUNDARY EXHIBIT**

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DRAWING NO.  
**EXH 4A**



0 390 780 1,560  
Feet  
1 inch = 400 feet

### Legend

- Subbasin Boundary
- Stream Centerline
- Storm Sewer/Culvert
- CMP
- RCP
- HDPE/PVC

Indiana Office of Information Technology, Indiana University, Spatial Data Portal, IITFS, Westport, Inc.



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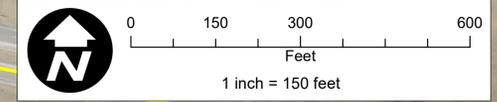
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DRAWING NO.

**EXH 4B**





**Legend**

- Storm Structure
- Stream Centerline
- ▭ Drainage Boundary
- ▭ Parcel Boundary
- Storm Sewer/Culvert**
- CMP
- RCP
- HDPE/PVC
- ⚠ Observed Ravine Problem Area
- ⚠ Observed Pipe Failure/Sinkhole
- Stormwater Concern Reports**
- Failing Pipe/Sinkhole
- Ravine
- Street/Yard
- Structure



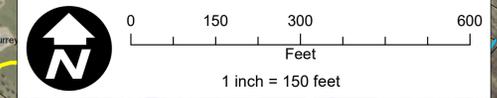
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 SHEET 2 OF 4  
 DRAWING NO.  
**EXH 5B**



**Legend**

- Storm Structure
- Stream Centerline
- ▭ Drainage Boundary
- ▭ Parcel Boundary
- Storm Sewer/Culvert**
- CMP
- RCP
- HDPE/PVC
- ⚠ Observed Ravine Problem Area
- ⚠ Observed Pipe Failure/Sinkhole
- Stormwater Concern Reports**
- Failing Pipe/Sinkhole
- Ravine
- Street/Yard
- Structure



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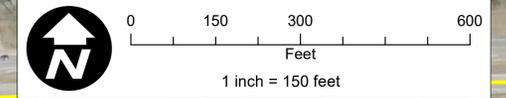
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NO.	DATE	NATURE OF REVISION	CHKD.	MODEL:	ArcGIS 9.2
FILE NAME	Map Document: (C:\Program Files\ArcGIS\Bin\Templates\CBBELTemplates\24x36 Landscape.mxd)				
DATE -- TIME	5/31/2007 -- 3:43:53 PM				

TITLE: **SHOREWOOD FOREST SUBDIVISION DRAINAGE EXHIBIT**

PROJ. NO. 20-0085  
 DATE:  
 SHEET 3 OF 4  
 DRAWING NO.  
**EXH 5C**





**Legend**

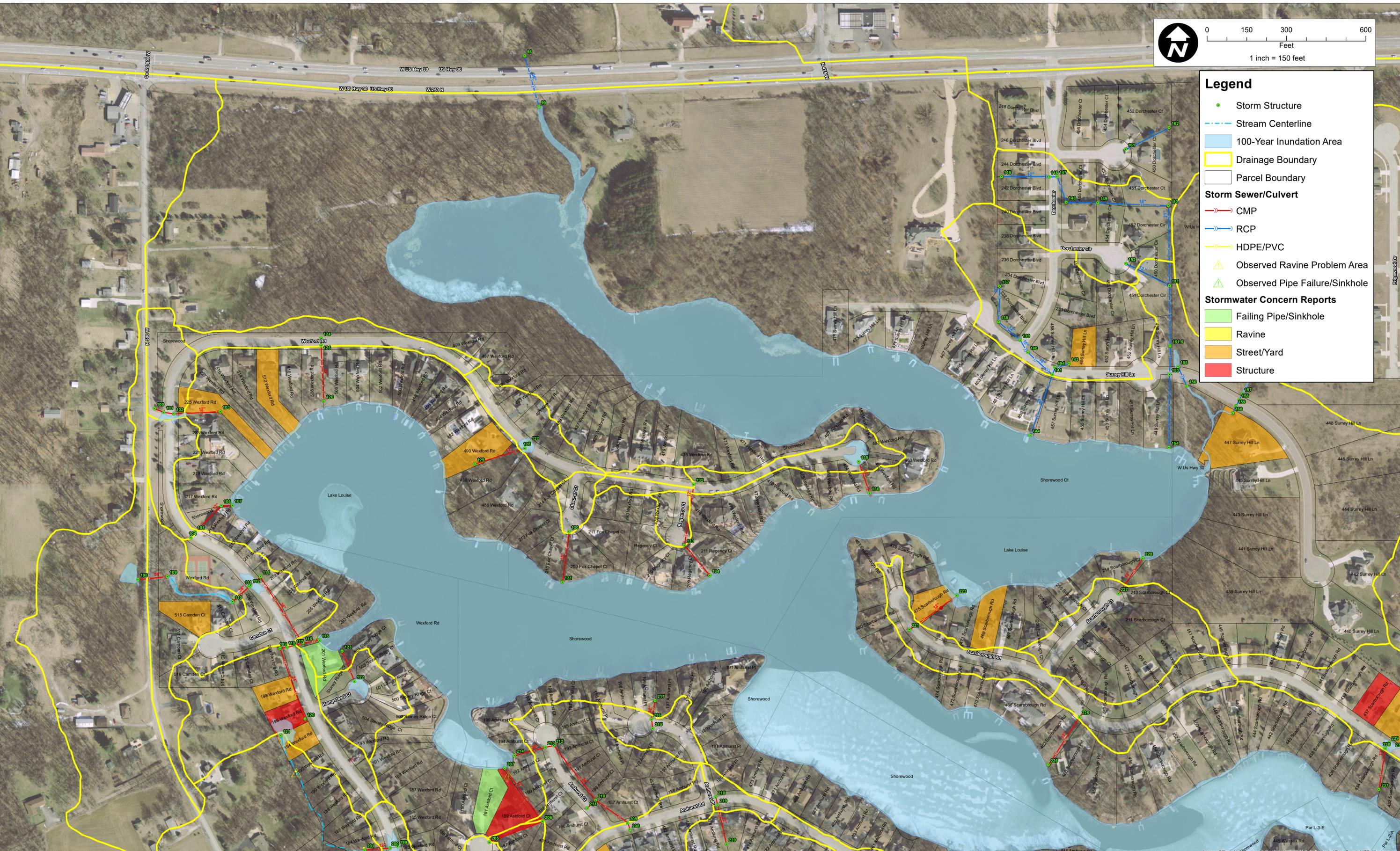
- Storm Structure
- Stream Centerline
- 100-Year Inundation Area
- Drainage Boundary
- Parcel Boundary

**Storm Sewer/Culvert**

- CMP
- RCP
- HDPE/PVC
- △ Observed Ravine Problem Area
- △ Observed Pipe Failure/Sinkhole

**Stormwater Concern Reports**

- Falling Pipe/Sinkhole
- Ravine
- Street/Yard
- Structure



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 Rosemont, Illinois 60018  
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 Porter County, Indiana

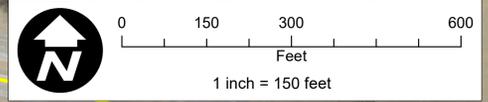
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 DATE -- TIME: 5/31/2007 -- 3:43:53 PM

DSGN. DWN. DRW.  
 CHKD. 1"= 150'  
 SCALE: LSHERRY  
 GIS USER: ArcGIS 9.2

**TITLE: SHOREWOOD FOREST SUBDIVISION  
 XP-SWMM SIMULATED  
 100-YEAR INUNDATION EXHIBIT**

PROJ. NO. 20-0085  
 DATE:  
 SHEET 1 OF 4  
 DRAWING NO.  
**EXH 6A**



**Legend**

- Storm Structure
- Stream Centerline
- 100-Year Inundation Area
- ▭ Drainage Boundary
- ▭ Parcel Boundary
- Storm Sewer/Culvert**
- CMP
- RCP
- HDPE/PVC
- △ Observed Ravine Problem Area
- △ Observed Pipe Failure/Sinkhole
- Stormwater Concern Reports**
- ▭ Failing Pipe/Sinkhole
- ▭ Ravine
- ▭ Street/Yard
- ▭ Structure



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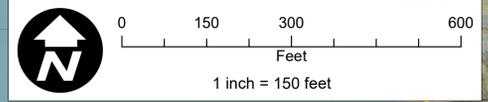
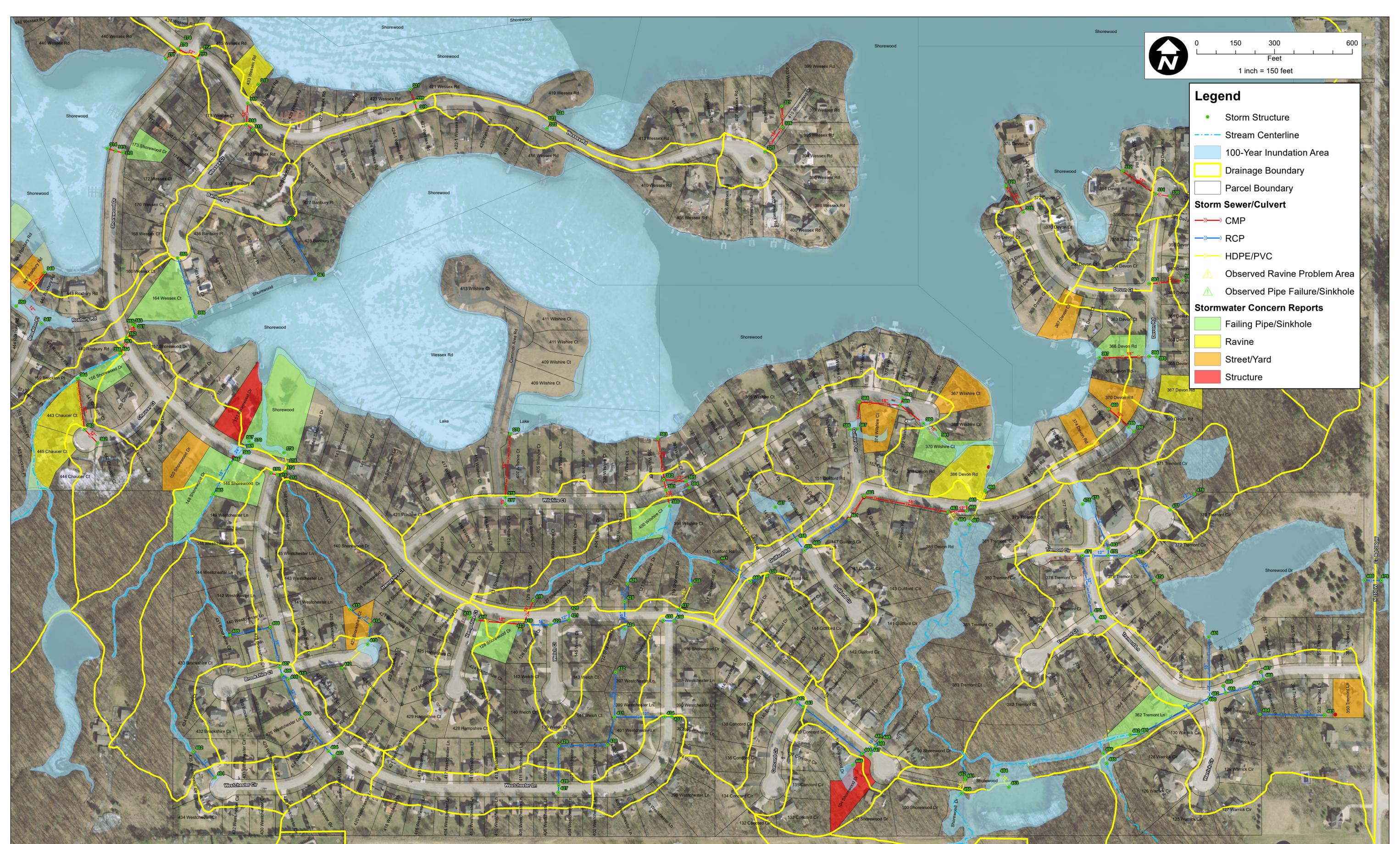
CLIENT: **The Department of DEVELOPMENT & STORM WATER MANAGEMENT**  
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NO.	DATE	NATURE OF REVISION	CHKD.	MODEL:	ArcGIS 9.2
FILE NAME	Map Document: (C:\Program Files\ArcGIS\Bin\Templates\CBBELTemplates\24x36 Landscape.mxd)				
DATE -- TIME	5/31/2007 -- 3:43:53 PM				

TITLE: **SHOREWOOD FOREST SUBDIVISION  
 XP-SWMM SIMULATED  
 100-YEAR INUNDATION EXHIBIT**

PROJ. NO. 20-0085  
 DATE:  
 SHEET 2 OF 4  
 DRAWING NO.  
**EXH 6B**





- Legend**
- Storm Structure
  - Stream Centerline
  - 100-Year Inundation Area
  - ▭ Drainage Boundary
  - ▭ Parcel Boundary
  - Storm Sewer/Culvert**
  - CMP
  - RCP
  - HDPE/PVC
  - △ Observed Ravine Problem Area
  - △ Observed Pipe Failure/Sinkhole
  - Stormwater Concern Reports**
  - ▭ Failing Pipe/Sinkhole
  - ▭ Ravine
  - ▭ Street/Yard
  - ▭ Structure

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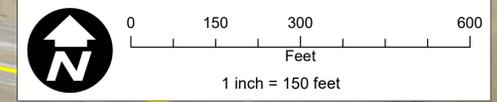
CLIENT: **The Department of DEVELOPMENT & STORM WATER MANAGEMENT**  
 Porter County, Indiana

NO.	DATE	NATURE OF REVISION	CHKD.	MODEL:
FILE NAME	Map Document: (C:\Program Files\ArcGIS\Bin\Templates\CBBELTemplates\24x36 Landscape.mxd)			ArcGIS 9.2
DATE -- TIME	5/31/2007 -- 3:43:53 PM			

TITLE: **SHOREWOOD FOREST SUBDIVISION  
 XP-SWMM SIMULATED  
 100-YEAR INUNDATION EXHIBIT**

PROJ. NO. 20-0085  
 DATE:  
 SHEET 4 OF 4  
 DRAWING NO.  
**EXH 6D**





**Legend**

- Storm Structure
- Pipe Condition**
- No Survey
- 1 (Good)
- 2 (Moderate)
- 3 (Poor)
- ▭ Drainage Boundary
- ▭ Parcel Boundary
- ⚠ Observed Ravine Problem Area
- ⚠ Observed Pipe Failure/Sinkhole
- Stormwater Concern Reports**
- ▭ Failing Pipe/Sinkhole
- ▭ Ravine
- ▭ Street/Yard
- ▭ Structure



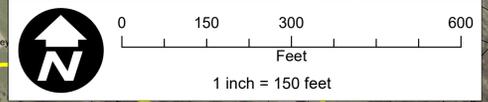
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CLIENT: **The Department of DEVELOPMENT & STORM WATER MANAGEMENT**  
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NO.	DATE	NATURE OF REVISION	CHKD.	MODEL:	ArcGIS 9.2
FILE NAME	Map Document: (C:\Program Files\ArcGIS\Bin\Templates\CBBELTemplates\24x36 Landscape.mxd)				
DATE -- TIME	5/31/2007 -- 3:43:53 PM				

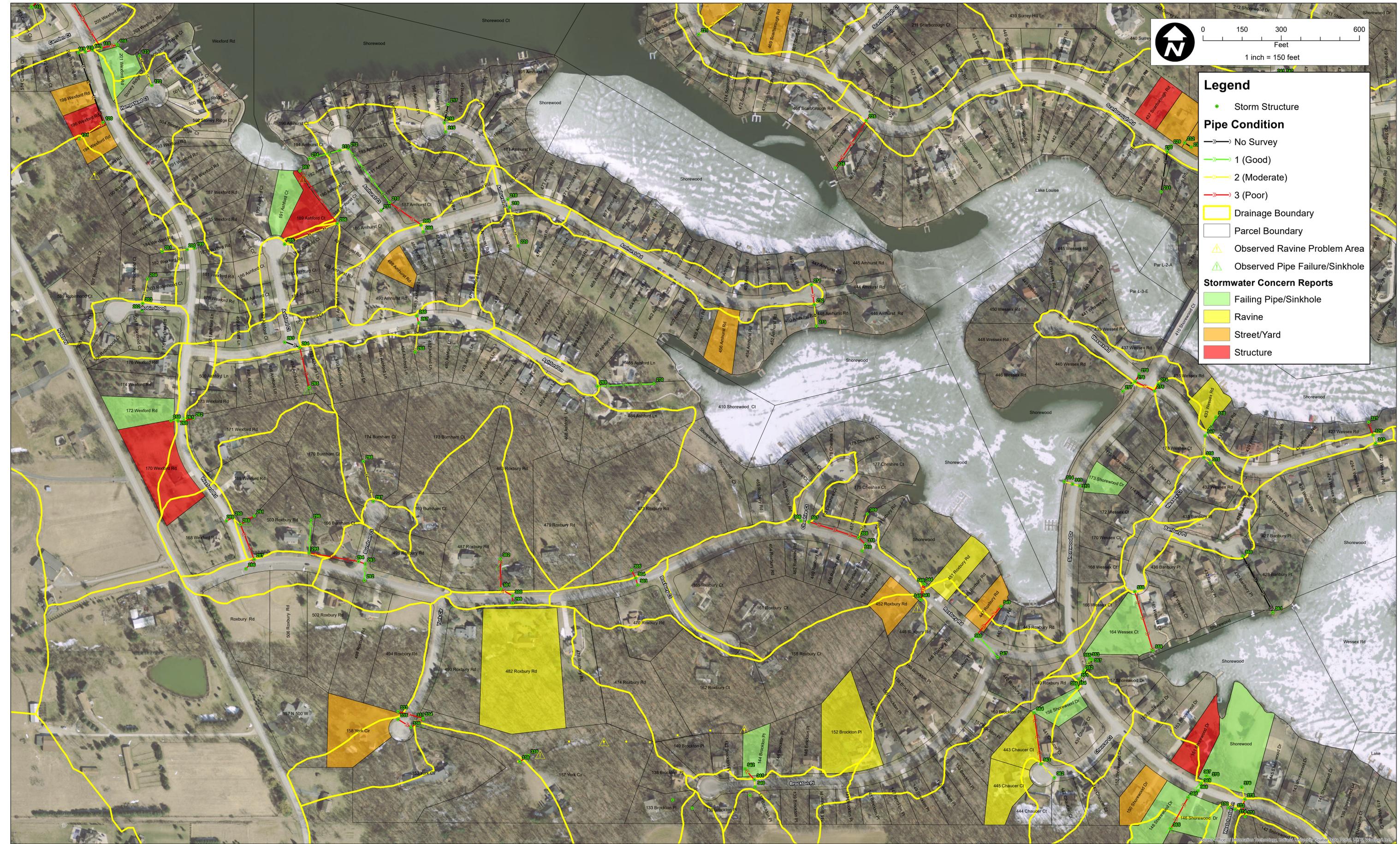
TITLE: **SHOREWOOD FOREST SUBDIVISION PIPE CONDITION ASSESSMENT EXHIBIT**

PROJ. NO. 20-0085  
 DATE:  
 SHEET 2 OF 4  
 DRAWING NO. **EXH 7B**



**Legend**

- Storm Structure
- Pipe Condition**
  - No Survey
  - 1 (Good)
  - 2 (Moderate)
  - 3 (Poor)
- ▭ Drainage Boundary
- ▭ Parcel Boundary
- ⚠ Observed Ravine Problem Area
- ⚠ Observed Pipe Failure/Sinkhole
- Stormwater Concern Reports**
  - ▭ Failing Pipe/Sinkhole
  - ▭ Ravine
  - ▭ Street/Yard
  - ▭ Structure



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NO.	DATE	NATURE OF REVISION	CHKD.	MODEL:
FILE NAME	Map Document: (C:\Program Files\ArcGIS\Bin\Templates\CBBELTemplates\24x36 Landscape.mxd)			
DATE -- TIME	5/31/2007 -- 3:43:53 PM			

DSGN. DWN. DRW

CHKD.

SCALE: 1"= 150'

GIS USER: LSHERRY

ARC GIS 9.2

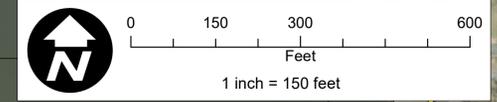
TITLE: **SHOREWOOD FOREST SUBDIVISION**  
**PIPE CONDITION ASSESSMENT EXHIBIT**

PROJ. NO. 20-0085

DATE:

SHEET 3 OF 4

DRAWING NO. **EXH 7C**



**Legend**

- Storm Structure
- Pipe Condition**
  - No Survey
  - 1 (Good)
  - 2 (Moderate)
  - 3 (Poor)
- ▭ Drainage Boundary
- ▭ Parcel Boundary
- ⚠ Observed Ravine Problem Area
- ⚠ Observed Pipe Failure/Sinkhole
- Stormwater Concern Reports**
  - ▭ Failing Pipe/Sinkhole
  - ▭ Ravine
  - ▭ Street/Yard
  - ▭ Structure



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NO.	DATE	NATURE OF REVISION	CHKD.	MODEL:
FILE NAME	Map Document: (C:\Program Files\ArcGIS\Bin\Templates\CBBELTemplates\24x36 Landscape.mxd)			
DATE -- TIME	5/31/2007 -- 3:43:53 PM			

DSGN. DWN. DRW.  
 CHKD.  
 SCALE: 1"= 150'  
 GIS USER: LSHERRY  
 ArcGIS 9.2

TITLE: **SHOREWOOD FOREST SUBDIVISION  
 PIPE CONDITION ASSESSMENT EXHIBIT**

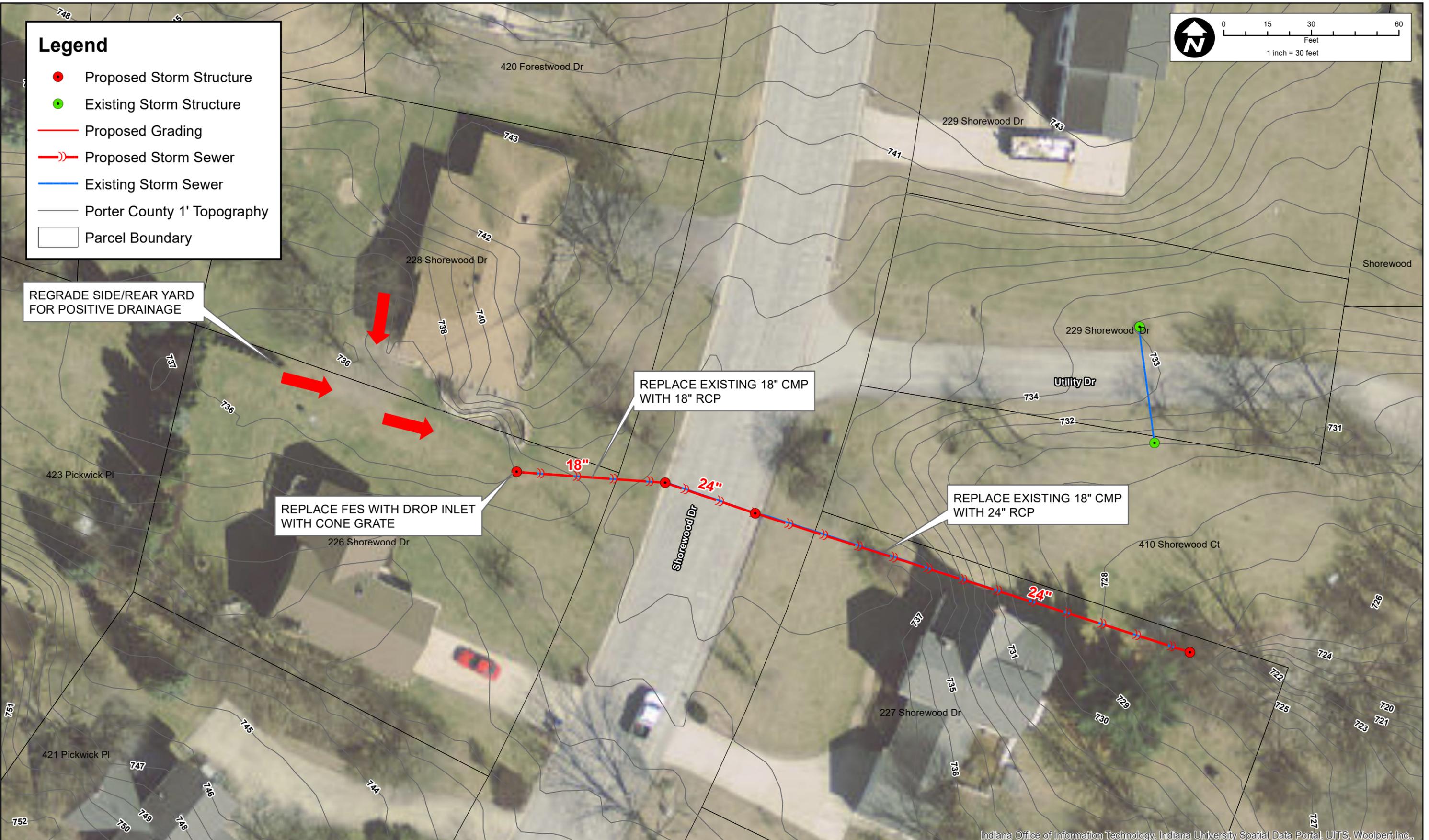
PROJ. NO. 20-0085  
 DATE:  
 SHEET 4 OF 4  
 DRAWING NO. **EXH 7D**



**Legend**

- Proposed Storm Structure
- Existing Storm Structure
- Proposed Grading
- Proposed Storm Sewer
- Existing Storm Sewer
- Porter County 1' Topography
- ▭ Parcel Boundary

0 15 30 60  
Feet  
1 inch = 30 feet



REGRADE SIDE/REAR YARD FOR POSITIVE DRAINAGE

REPLACE EXISTING 18" CMP WITH 18" RCP

REPLACE FES WITH DROP INLET WITH CONE GRATE

REPLACE EXISTING 18" CMP WITH 24" RCP

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NO.	DATE	NATURE OF REVISION	CHKD.	MODEL

TITLE:

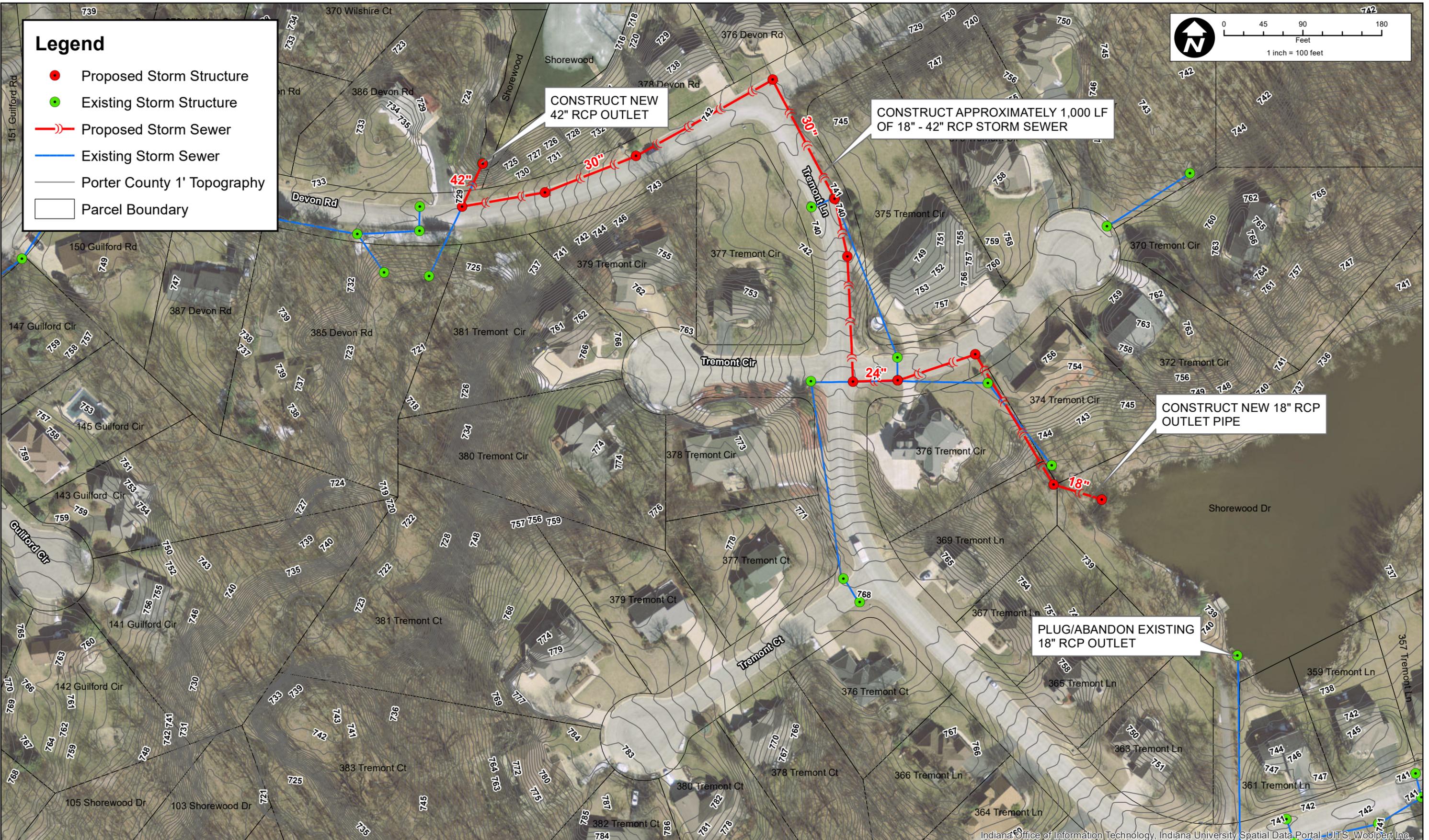
**SHOREWOOD FOREST SUBDIVISION  
PROPOSED IMPROVEMENTS  
PROBLEM AREA 2**

PROJ. NO. 20-0085  
DATE:  
SHEET 1 OF 1  
DRAWING NO.  
**EXH 9**



### Legend

- Proposed Storm Structure
- Existing Storm Structure
- Proposed Storm Sewer
- Existing Storm Sewer
- Porter County 1' Topography
- Parcel Boundary



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NO.	DATE	NATURE OF REVISION	CHKD.	MODEL

TITLE:

**SHOREWOOD FOREST SUBDIVISION  
 PROPOSED IMPROVEMENTS  
 PROBLEM AREA 4**

PROJ. NO. 20-0085  
 DATE:  
 SHEET 1 OF 1  
 DRAWING NO.  
**EXH 11**











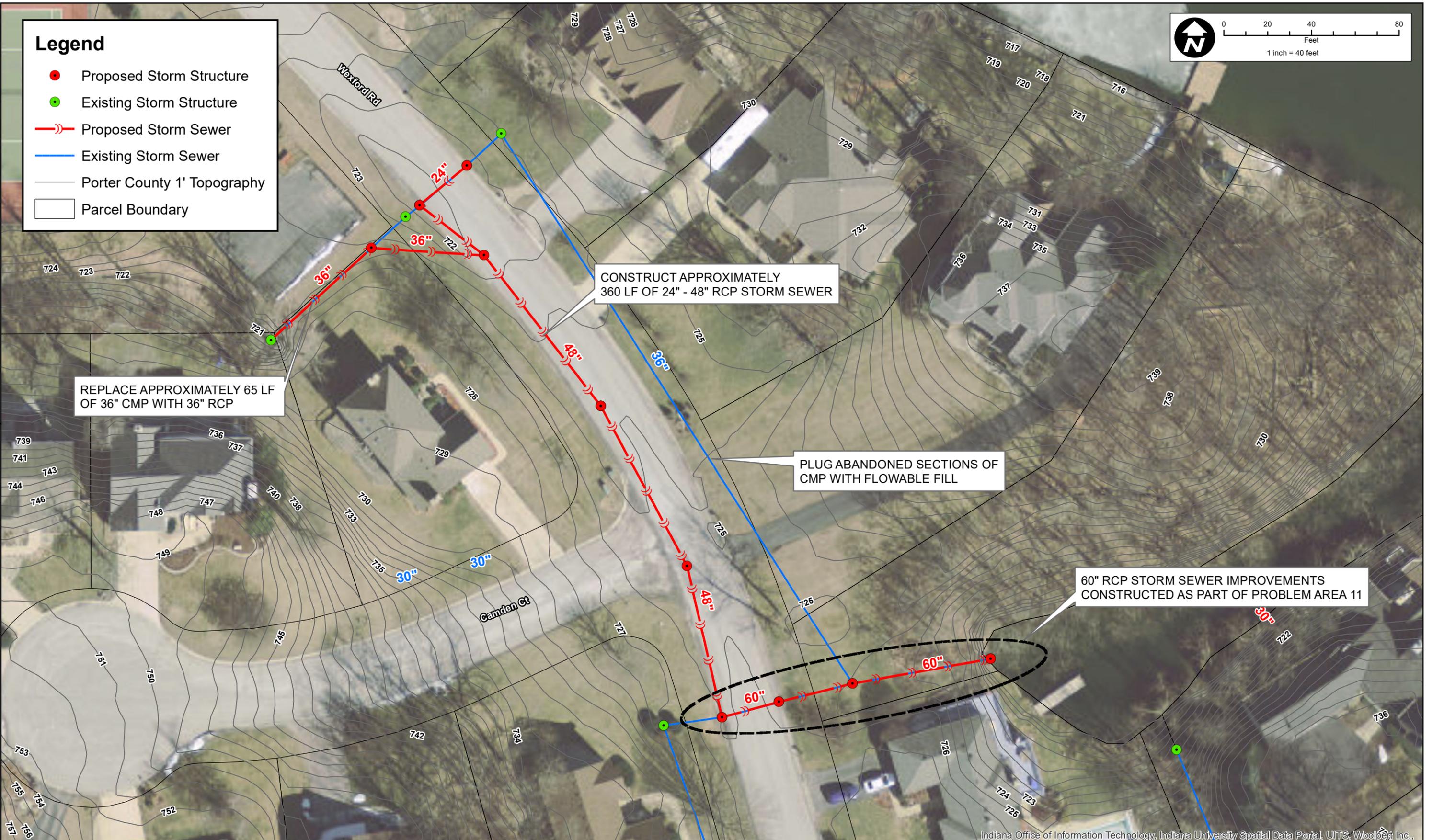




**Legend**

- Proposed Storm Structure
- Existing Storm Structure
- Proposed Storm Sewer
- Existing Storm Sewer
- Porter County 1' Topography
- ▭ Parcel Boundary

0 20 40 80  
Feet  
1 inch = 40 feet



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TITLE:

**SHOREWOOD FOREST SUBDIVISION  
PROPOSED IMPROVEMENTS  
PROBLEM AREA 12**

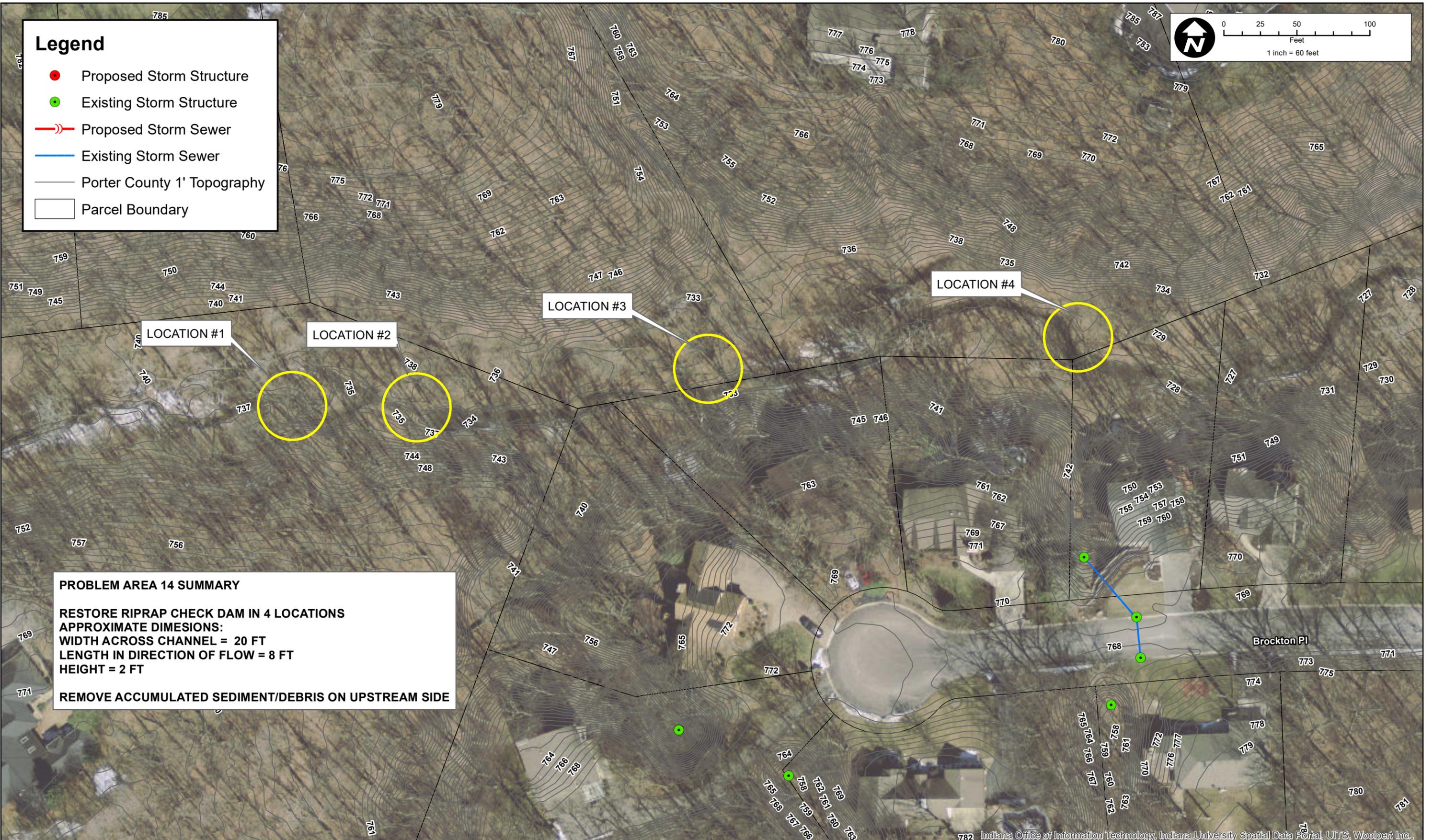
PROJ. NO. 20-0085  
DATE:  
SHEET 1 OF 1  
DRAWING NO.  
**EXH 19**



**Legend**

- Proposed Storm Structure
- Existing Storm Structure
- Proposed Storm Sewer
- Existing Storm Sewer
- Porter County 1' Topography
- Parcel Boundary

0 25 50 100  
Feet  
1 inch = 60 feet



**PROBLEM AREA 14 SUMMARY**

RESTORE RIPRAP CHECK DAM IN 4 LOCATIONS  
 APPROXIMATE DIMENSIONS:  
 WIDTH ACROSS CHANNEL = 20 FT  
 LENGTH IN DIRECTION OF FLOW = 8 FT  
 HEIGHT = 2 FT

REMOVE ACCUMULATED SEDIMENT/DEBRIS ON UPSTREAM SIDE

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TITLE:

**SHOREWOOD FOREST SUBDIVISION  
 PROPOSED IMPROVEMENTS  
 PROBLEM AREA 14**

PROJ. NO. 20-0085  
 DATE:  
 SHEET 1 OF 1  
 DRAWING NO.  
**EXH 21**





