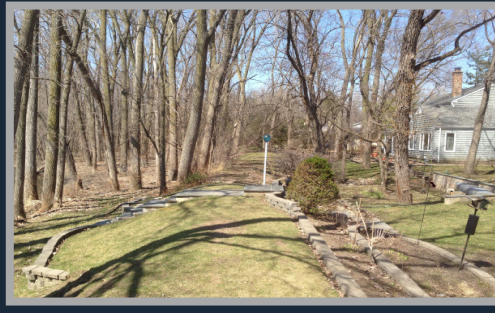
ENGINEERING
RESOURCE ASSOCIATES



Final Report for:

Des Plaines River Bank Stabilization
& Riverwoods Drainage Evaluation Phase I

Prepared for:

Village of Lincolnshire
One Olde Half Day Road
Lincolnshire, IL 60069-3035

October 27, 2016

Village of Lincolnshire

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1.0 INTRODUCTION

The Riverwoods subdivision has experienced repeated flooding problems in several areas during moderate and severe storm events. These problems are related to flood elevations of the Des Plaines River and to local runoff exceeding the capacity of the subdivision drainage system. In response to these flooding problems, the Village of Lincolnshire retained Engineering Resource Associates, Inc. (ERA) to evaluate the protective berm located in the rear yards of properties on Lincolnshire Drive and to analyze the subdivision's internal drainage system using XPSWMM 2D modeling.

1.1 Study Areas

The Des Plaines River runs generally north to south roughly through the center of the Village. The river divides the commercial district (to the west) and the residential district (to the east). The Riverwoods subdivision is located south of Half Day Road, on the eastern banks of the Des Plaines River. The subdivision contains residential properties, the Spring Lake Park, and the Lincolnshire Swim Club. The neighborhood is bound to the south approximately by the Rivershire Nature Center. The berm location and Riverwoods Watershed are shown on Figure 1.

Des Plaines River Protection Berm – A large portion of the subdivision is located within the 10-year and 100-year floodplain of the Des Plaines River. An earthen berm located in the rear yards of homes on Lincolnshire Drive protects four houses from flooding up to the Des Plaines River 10-year floodplain elevation. Sandbagging operations have been performed along the berm when the river approached the 10-year flood level and beyond. These operations can protect 70 houses from flooding during 100-year flood levels. Exhibit 4.2 shows the floodplain elevations overlaid onto a map of the subdivision to demonstrate the potential flooding of the neighborhood if not for the protective berm and/or sandbagging operations.

Internal Drainage System – The Riverwoods Subdivision Watershed is a 324-acre watershed that drains from east to west through six main storm sewer systems that outfall into the Des Plaines River. The watershed limits can be found on Exhibit 4.3. The drainage system can be overwhelmed during intense storm events, and its capacity is limited by high flood elevations within the Des Plaines River. Both of these situations can cause internal flooding within the subdivision.

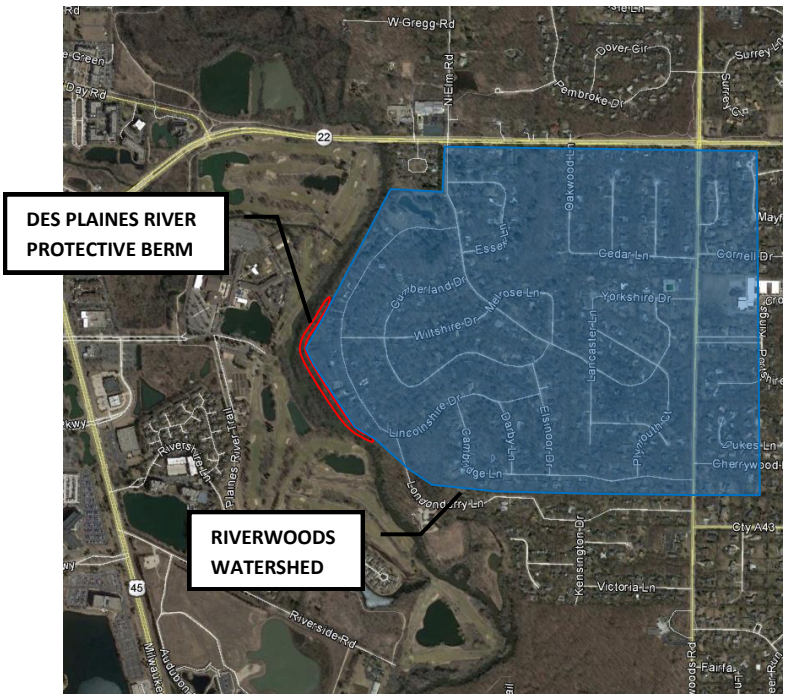

Figure 1. Riverwoods Subdivision Berm and Internal Drainage System

2.0 DES PLAINES RIVER PROTECTIVE BERM

2.1 Des Plaines River

The drainage area for the Des Plaines River at the southern end of the Riverwoods subdivision is approximately 326.5 square miles, at which the 10-year flood flow is 3,727 cfs and the 100-year flood flow is 6,018 cfs. There are two cross-sections in the regulatory floodplain model within the project reach (Cross-sections “F” and “G”). The average floodway velocities at these cross-sections are 0.7 fps and 1.5 fps, respectively (See Table 13 in Appendix 5.4, excerpt from Lake County, Illinois and Incorporated Areas Flood Insurance Study).

On September 27, 1986, floodwaters caused $35 million in damages to residences and businesses throughout its watershed. In July 1996 and August of 1997, flooding caused $564 million and $40 million in damages, respectively. The USGS and the Village of Lincolnshire operate a stream flow gage at Half Day Rd (USGS Station #05528100), which was installed in 2009. Within the recorded time period of that gage, the flood of record occurred on April 19, 2013, with flows of 3,630 cfs and a gage height of 16.32’ (646.29 NAVD88).

2.2 Berm History

In March 1981, an inspection of the berm was performed by the Village. The Village identified several hazards along the berm, including settlement, washout, and rodent holes. Three geotechnical borings of the berm were performed by Soil Testing Services, Inc. The report noted that the berm in general consisted of 7.25 feet to 9.5 feet of silty clay fill over natural granular soils. Topsoil, wood, rubber, and other materials were also encountered during the borings. The report noted that the variety of fill materials within the berm can create localized areas of high permeability and low stability.

After the significant flooding of the properties along Lincolnshire Drive in 1986, the Village of Lincolnshire retained Guillou and Associates to perform a preliminary flood protection study for the neighborhood. The consultant completed the study in December of 1986, originally proposing a levee that would protect up to 100-year flood levels. The estimated project cost for this levee was $500,000. In 1987, Guillou and Associates was given authorization to proceed with the phase II design of the levee project. In 1988, the project was put on hold due to a lack of support from the project stakeholders. In 1998 and 1999, two phases of maintenance work were performed to remove all unstable and compostable material on top of the existing berm, raise the berm crest to a uniform elevation of 645, and widen the berm crest to four (4) feet.

2.3 Berm Maintenance Recommendations

A walkthrough inspection along the berm at the eastern streambank of the Des Plaines River was performed on June 26, 2015. The following is a summary of various features and problem areas along the berm, and recommended actions. The recommendations are shown graphically on the Proposed Conditions in Appendix 5.2. The items are discussed on a stationing basis, which corresponds to the Existing Conditions Plan and Profile prepared by Engineering Resource Associates, provided as Appendix 5.1. Photos of the items noted below can be found in the Inspection Photos provided as Exhibit 4.1.

A. <u>Berm Protection Levels</u>

A detailed site survey was performed along the entire reach of the berm system within the project scope. According to the February 4, 2014 Flood Insurance Study for Lake County, IL, prepared by the Federal Emergency Management Agency, the 10-year floodplain elevations throughout the reach vary from 644.1’ to 644.7’ NAVD88 (See Graph 35P in Appendix 5.5, excerpt from Lake County, Illinois and Incorporated Areas Flood Insurance Study). Therefore, from the existing conditions survey, a majority of the berm is elevated to protect against the 10-year flood. However, there are

locations where the berm has settled and now provides lower levels of protection, which are noted below. A deficiency in the 10-year flood protection in any one location may affect all properties located below 10-year floodplain elevation levels. Furthermore, lower levels of protection allow the berm to be overtopped more frequently. Thus, the berm will be subjected more often to the scour associated with the overtopping floodwater velocities, which increases the erosion potential for the berm.

Below is a list of berm segments that have settled and are recommended to be repaired and raised. These are also shown in Appendix 5.1 and 5.2.

- Stations 101+20 to 101+70, near the common lot line of 53 Lincolnshire Dr. and 55 Lincolnshire Dr. This segment is up to 3" below 10-year flood protection, which corresponds to approximately 20 cubic yards of fill required.

- Stations 102+15 to 102+55, near the common lot line of 55 Lincolnshire Dr. and 57 Lincolnshire Dr. This segment is 1.5" below 10-year flood protection, which corresponds to approximately 10 cubic yards of fill required.

- Stations 104+95 to 105+15, near the common lot line of 59 Lincolnshire Dr. and 61 Lincolnshire Dr. This segment is up to 3" below 10-year flood protection, which corresponds to approximately 10 cubic yards of fill required.

- Stations 110+85 to 111+65, near the center of the 69 Lincolnshire Dr. This segment is up to 14" below 10-year flood protection, which corresponds to approximately 55 cubic yards of fill required.

Maintenance for the berm at the above locations will require topsoil stripping, engineered clay fill placement, topsoil respreading, seeding, and blanketing in order raise the berm and provide stability against future settlement.

B. Berm Materials

A stable flood protection system typically contains clean, compacted clay materials capped with a thick grassy plant community and minimal topsoil stratum. A compacted clay berm core minimizes erosion, settlement, and piping issues.

The berm segment from station 103+40 to 104+20 (57 Lincolnshire Dr. and 59 Lincolnshire Drive) appears to have poor stability. The visible berm in this section is made up of a sandy, gravelly material, which is very soft and has low stability. The Village has noted that this area has been very soft and unstable during previous sandbagging operations.

The replacement of materials for the berm at Station 103+40 to 104+20 is crucial, as the sandy materials are more prone to slope failure. This maintenance will require excavation of the existing materials at approximately a 5' depth, replacement with engineered fill, capping with compacted topsoil, seeding, and blanketing. This should also include widening of the berm crest to six feet.

C. Woody Materials and Debris

In general, much of the berm contains brush, shrubs, and trees, which are obstructions to emergency and maintenance operations. Large diameter tree roots create paths through which storm water is able to seep. Trees that collapse due to strong weather, disease, or age can pull up sections of the berm. Fallen trees and woody debris can be carried downstream and potentially clog the floodway or the river, which can increase flooding problems upstream. The trees along the berm have also created very shady conditions which block positive grass growth on the berm.

For berm stability, United States Army Corps of Engineers guidelines recommend that flood protection systems be maintained with a vegetation-free zone that includes the entire berm system and extends 15' from each side of the berm slope toes. However, due to the natural wooded character of the area, we recommend that at a minimum, the berm be maintained with a vegetation free zone from toe to toe. (Note: The toe of the slope is the point where the steeper berm slope transitions to the more gradual, natural land slope.)

A significant number of live trees and heavy brush areas are not noted specifically in this section, but are included in the proposed plans in Appendix 5.2. The following are notable areas with woody materials or woody debris:

- Station 103+40 to 104+20 (57 Lincolnshire Dr. & 59 Lincolnshire Dr.) – Several shrubs are present along the crest of the berm and long the residential slope.

- Station 106+75 (63 Lincolnshire Dr.) – A large oak tree is located within a railroad tie retaining wall near the crest of the berm. This creates significant blockage to maintenance vehicles and creates a potential for berm failure it were to fall. The root system is also likely decreasing the berm stability.

- Station 114+45 (73 Lincolnshire Dr.) – A large downed tree lies across the entire berm crest and side slopes.

All brush, shrubs, and trees between the toes of the slopes of the berm should be removed. Removal of trees smaller than 4" in diameter, shrubs, and woody undergrowth will require only additional seed and erosion control blanket to revegetate the cleared areas. Removal of live trees will require compacted engineered

fill and topsoil backfill in addition to seed and erosion control blanket in order to restore the proper berm height and width.

D. Bare and Eroded Areas

Native grass plant communities have deep root systems which can significantly stabilize the berm slopes. Barren or sparsely vegetated slopes are susceptible to erosion from flowing water, especially floodwater from the Des Plaines River. Areas with concentrated flows of water, such as drain outlets, that do not have erosion control protection measures are also susceptible. The following areas were noted to be missing vegetative cover or have eroded areas:

- Station 98+00 (outside of topographic survey limits) – The slope on the river-side of the berm has little vegetative cover.
- Station 103+40 to 104+20 (57 Lincolnshire Dr. and 59 Lincolnshire Dr.) – The berm crest and river-side slope are sparsely vegetated.
- Station 105+40 to 106+20 (61 Lincolnshire Dr.) – The slope of the river-side of the berm is sparsely vegetated.
- Station 106+50 & 107+40 (63 Lincolnshire Dr.) – There is significant erosion occurring around both 2" pvc drain lines on the river-side of the berm. There is woody debris partially covering one of the eroded areas.
- Station 112+85 (69 Lincolnshire Dr.) – There is a slightly barren and eroded area on the river-side of the berm, potentially from an abandoned rodent hole.
- Station 114+00 to 115+10 (73 Lincolnshire Dr. and 75 Lincolnshire Dr.) – The berm crest has very light vegetative cover, possibly due to pedestrian traffic.
- Station 115+40 (75 Lincolnshire Dr.) – There is a localized barren area on the berm crest, likely due to pedestrian traffic.
- Station 117+60 to 118+70 (79 Lincolnshire Dr.) – The berm crest has sparse vegetative cover.

Maintenance of eroded and barren areas along the berm will help prtoect against compounding erosion and berm failure. All of the barren areas should be planted with native grass seed. Any slopes steeper than 25% should also be stabilized with erosion control blanket. The tree removals throughout the berm will help establish a strong vegetative cover. The eroded areas from pvc drain outlets should be filled with clay

and topsoil, seeded, and blanketed. These areas are noted in Appendix 5.2 and Appendix 5.3.

E. Berm Crest Width

The crest of the berm is the relatively flat "top" of the berm which transitions from the river-side slope to the residence-side slope. In order to provide ample space for emergency activities, such as sand-bagging, and maintenance activities along the berm, a six-foot (6') crest width is recommended. There are several locations throughout the project in which the crest width is smaller than the minimum:

- Station 101+00 to 102+00 (53 Lincolnshire Dr. and 55 Lincolnshire Dr.) – The berm has a minimum 2' wide crest and an average 4' wide crest.
- Station 103+15 to 104+75 (57 Lincolnshire Dr. and 59 Lincolnshire Dr.) – The berm has a minimum 2' wide crest and an average 5' wide crest.
- Station 111+00 to 111+60 (69 Lincolnshire Dr.) – The berm has a minimum 4' wide crest.
- Station 113+50 to 115+00 (73 Lincolnshire Dr. and 75 Lincolnshire Dr.) – The berm has a minimum 5' wide crest.
- Station 115+50 to 116+60 (75 Lincolnshire Dr. and 77 Lincolnshire Dr.) – The berm has a minimum 5' wide crest.

Widening the berm crests at stations 101+00 to 102+00, 103+15 to 104+75, and 111+00 to 111+60 is crucial to providing a structurally stable berm as well as providing an adequately wide base for sand bags. Widening the crest for station 101+00 to 102+00 should be combined with raising the crest to a 10-year flood protection elevation, as previously discussed. Widening the crest from station 103+15 to 104+75 should be combined with removing and replacing the sandy berm materials.

F. Retaining Walls

A variety of materials throughout the project reach are serving as retaining walls for the berm slopes. Most of these materials are deteriorating and could cause slope failure if they dislodge or collapse. Dislodged railroad ties can also be carried into the river by floodwaters and create obstructions within the river, which may worsen flooding. The retaining materials are at the following locations:

- Station 98+00 (outside of topographic survey area) – A three-tiered railroad tie terrace is present on the river-side of the berm. The railroad ties are no longer fully upright and appear to be disintegrating from moist soil conditions.

- Station 100+75 (53 Lincolnshire Dr.) – A concrete block wall is present on the river-side of the berm. The wall appears to be well-maintained, but may be susceptible to damage from high velocity water since the blocks are not grouted into place. However, the wall doesn't appear to reduce berm stability.

- Station 101+15 (53 Lincolnshire Dr.) – A railroad tie wall is present on the river-side of the berm. The top railroad tie has dislodged, and all of the ties appear to be disintegrating from moist soil conditions.

- Station 101+50 (55 Lincolnshire Dr.) – A railroad tie wall is present on the river-side of the berm. The ties appear to be disintegrating from moist soil conditions.

- Stations 103+40 to 104+20 (57 Lincolnshire Dr. and 59 Lincolnshire Dr.) – Cobbles are present on the residential side of the berm and are functioning as retaining materials. The cobbles appear to be stable.

- Stations 104+25 to 104+50 (59 Lincolnshire Dr.) – A two-tiered railroad tie terrace is present on the residential side of the berm. The railroad ties appear to be stable but have some minor deterioration and may obstruct maintenance and emergency activities.

- Stations 105+00 to 106+20 (61 Lincolnshire Dr.) – A cinder block wall is present on the residence side of the berm crest. The cinder block wall does not provide any soil retention functions, so it is noted here solely for information purposes. The wall does not block maintenance access to the berm crest. A two-tiered railroad tie wall with metal posts and cinder blocks is present on the river-side of the berm, and appears to be deteriorating.

- Station 106+75 (63 Lincolnshire Dr.) – A railroad tie retaining wall is present on three sides of a large oak tree. The ties extend from the middle of the berm crest approximately 15' towards the river-side berm toe.

Most of the deteriorating railroad ties hold back a maximum of 8" of soil, with the exception of the railroad ties at station 105+50. These railroad ties should all be removed and the area regraded to a maximum slope of 2.5' Horizontal:1' Vertical. The railroad ties from stations 104+25 to 104+50 should be removed as part of the berm material replacement at this location. The railroad tie wall surrounding the oak tree at station 106+75 holds back a large amount of soil with a big potential causing berm

failure. The wall should be removed, and the area backfilled and stabilized. The modular block walls at Station 100+75 do not require any action.

G. Drain Lines

There are several plastic or vinyl drain lines that penetrate through the berm. In general, penetrations reduce the stability of the berm and can cause seepage through the berm. In addition, drains without any backflow preventers can allow floodwater into the residential side of the berm. The following berm penetrations are present:

- Station 100+75 (53 Lincolnshire Dr.) – One (1) 2" diameter and one (1) 3" diameter flexible pvc drain line from the residence penetrate the berm.
- Station 102+40 & 102+80 (57 Lincolnshire Dr.) – Two 4" diameter pvc drain lines from the residence penetrate the berm.
- Station 104+85 (59 Lincolnshire Dr.) – A storm sewer manhole with a 15" flap gate is present. The structure and flap gate appear to be in good working order, and no action is currently necessary with this manhole.
- Station 106+50 & 107+40 (63 Lincolnshire Dr.) – Two 2" diameter pvc drain lines from the residence penetrate the berm. There is significant erosion evident at the outlets.
- Station 112+90 (69 Lincolnshire Dr.) – A concrete end section with wingwalls and a 12" flap gate is present. The end section and flap gate appear to be in good working order, and no action is necessary.
- Station 117+50 (77 Lincolnshire Dr.) – Two 2" diameter pvc drain lines from the residence penetrate the berm.
- Station 118+80 (79 Lincolnshire Dr.) – One 2" diameter pvc drain line from the residence penetrates the berm.

None of the pvc penetrations through the berm are larger than 4" in diameter. However, all pvc drain penetrations should be safely removed and relocated over the berm and discharge beyond the toe of the slope, or discharge to the front yard of the residence. The berm at these locations should be restored with compacted fill and restabilized with topsoil, seed, and erosion control blanket.

H. Miscellaneous Landscaping

There are a few areas with miscellaneous landscaping, which may create obstructions for sandbagging. Additionally, landscaping materials typically provide less stability to the berm than deep rooted grasses. These areas are noted below:

- Station 100+75 (53 Lincolnshire Dr.) – A slate walkway and stairs are present on the berm crest and river-side slope.
- Station 102+35 (57 Lincolnshire Dr.) – A split rail fence is located along the property line, and encroaches on a small portion of the berm crest.
- Station 106+35 (61 Lincolnshire Dr.) – An 18" planter box is present along the berm crest.
- Station 116+50 (77 Lincolnshire Dr.) – Posts are located in the berm crest.
- Station 118+80 (79 Lincolnshire Dr.) – There is a gravel pedestrian trail, brick debris, and concrete debris on the crest of the berm.

In general, all fences, planter boxes, posts, stones, and any other landscaping items should be removed from the berm to provide clear access for sandbagging and to provide better stability to the berm with native vegetation.

I. Permit Requirements

A majority of the maintenance activities noted, including vegetation removal and minor grading, will require the homeowner to apply for a permit from the Village of Lincolnshire and potentially the Lake County Stormwater Management Commission (SMC). The Village Building Permit process is available on the Village website along with the appropriate forms and submittal requirements. The Village will also help homeowners determine whether or not they need a permit from Lake County, and what will be required for that application process. Lake County Watershed Development Permits are typically required for any project that is in a floodplain, may impact a wetland, will disturb more than 5,000 square feet or soil, or will hydrologically modify site drainage. Additionally, both Lake County and the Village will inform homeowners of any additional state or Federal permits that need to be secured.

J. Funding Sources

ERA has identified potential funding sources to assist homes within the floodplain. However, many of these programs are for buying out or elevating homes in the floodplain. They include: Hazard Mitigation Grant Program (HMGP), IDNR-OWR mitigation buyout program, Flood Mitigation Assistance (FMA) grant, and Pre-Disaster Mitigation (PDM) grant.

As this project is not a streambank stabilization or green infrastructure project it most likely wouldn't meet the requirements for Environmental Protection Agency (EPA) 319h and IEPA Illinois Green Infrastructure Grant. However, residents could contact Lake County SMC or the Des Plaines River Watershed Workgroup (DRWW). The DRWW is a voluntary, dues paying organization with a mission to bring together a diverse coalition of stakeholders to work together to improve water quality in the Des Plaines River and its tributaries in a cost effective manner to meet Illinois EPA requirements. The DRWW watershed communities and other stakeholders are currently in the planning process to develop an umbrella watershed-based plan for the entire Des Plaines River Watershed in Lake County thanks to an IL EPA $658,162 grant from its Section 319 voluntary Nonpoint Source Pollution Reduction Program awarded to SMC. The river is identified as an impaired waterbody by IL EPA and the watershed plan will address nonpoint source pollution, providing priority action items and projects to improve water quality. In the event that the berm and area between the berm and river are naturalized it may meet the requirements for potential future funding.

3.0 FLOOD PREPARATION

3.1 Emergency Preparation

The best way a homeowner can protect themselves from flooding is by floodproofing their property. Each home will have a unique solution for floodproofing. The Federal Emergency Management Agency has prepared general guidance literature for homeowners, located at https://www.fema.gov/media-library/assets/documents/480. However, in the short term, each resident should accomplish the following tasks for flood safety, whether or not they live in or near the floodplain:

1. Register with Blackboard connect, the Village-wide Emergency Telephone Notification System.
2. Designate meeting locations with all members of your household.
3. Designate an out-of-area contact person to notify as to where you are.
4. Create an emergency supply kit and a "go bag."
5. Determine the best escape routes from your home.
6. Locate and know how to operate utilities (particularly gas and electric) in your home in case an emergency shut off is needed.

3.2 Flood Insurance

The Village of Lincolnshire has participated in the National Flood Insurance Program's Community Rating System since 1992. The Village's efforts towards proper floodplain management have earned a Class 5 community rating. As part of these floodplain management efforts, all Village residents that live in the regulatory floodplain and own a home that is federally regulated or federally insured must purchase flood insurance. Lincolnshire's Class 5 community rating allows residents with structures in the floodplain a 25% discount on flood insurance premiums. Additionally, even residents that live outside of the 100-year floodplain may purchase flood insurance. Structures outside of the floodplain can receive a 10% discount on flood insurance premiums.

3.3 Village Flood Mitigation Activities

In addition to participating in the Community Rating System, the Village also provides a number of other services to manage flooding issues. At regular times throughout the year, the Village distributes flood preparedness information to residents via newsletters, Facebook posts, handouts, and information available on the Village website. The Village also performs day-to-day maintenance of the storm sewer system to prevent against non-floodplain related flooding. The Village has also performed drainage improvements projects along Lincolnshire Creek, including a current design contract for the stream near Coventry Lane. During heavy rainstorms and potential flood events, the Village monitors flood conditions and provides resident notification of issues throughout the area.

The Village has also created the "Lincolnshire Emergency Flood Response Plan," which was updated in May 2015. The report details specific action items dependent on the height of the Des Plaines River and includes procedures for flood protection operations, such as pumping and sandbagging. The report also identifies how Village staff will respond during a flood event and what resources will be available to residents, such as emergency notification platforms, base station locations, and post flood assistance.

In conjunction with the Lake County Stormwater Management Commission, U.S. Geological Survey, United States Department of the Interior, and NOAA National Weather Service Chicago, the Village has installed a stream gauge on the south side of Half Day Road to measure flood levels within the Des Plaines River. The gauge provides real-time data that the Village uses to monitor and prepare for flood events. The Des Plaines River flood alert stages are as follows:

- 10.5 feet – Observation Stage
- 11.5 feet – Action Stage – The Action Stage is a "heads-up" stage
- 12.5 feet – Minor Flood Stage – Water begins to overflow onto Londonderry Lane.
- 14.0 feet – Moderate Flood Stage – Water begins to pond on Lincolnshire Drive at Wiltshire Lane
- 15.5 feet – Major Flood Stage – Water approaches the top of the river bank on the east side of the Des Plaines River.
- 16.5 feet – Evacuation Stage – Village determines areas in need of evacuation
- 17.5 feet – 100 Year Flood Stage – Road closures and response as required

3.4 Flood Mitigation Activities by Outside Groups

The Village is not alone in its efforts to manage flooding hazards within Lake County. As mentioned, the Des Plaines River Watershed Workgroup is a local organization made up of local municipalities, local publicly-owned treatment plants, environmental groups, consultants, and citizens which was formed in response to water quality issues in the Des Plaines River watershed. The group studies alternate ways to meet Illinois EPA water quality standards through implementation of long-term development projects and long-term management strategies. While focusing on water quality, these projects often include components of flood reduction.

The Lake County Stormwater Management Commission (SMC) has received a grant from the Illinois EPA via Section 319 of the Clean Water Act to create a Des Plaines River Watershed Plan. The plan, which will is slated to be complete in 2018, will evaluate the Des Plaines River and all of its tributaries in Lake County and southern Wisconsin. The SMC will also be developing two pilot Small Watershed Assessment and Action Plans in conjunction with the watershed plan which will focus on detailed and specific concept designs and budgets for smaller streams and lakes in the watershed. The vision statement for the Des Plaines River Watershed Plan is as follows:

"The Des Plaines River Watershed will be a destination valued by residents, businesses and governments that join together to actively engage in education and participate in improving water quality. Stakeholders will preserve and enhance regional green infrastructure, resulting in cleaner streams and lakes, better plant and animal biodiversity and reduced flood damage while balancing a sustainable native landscape with development and economic growth."

Lake County also created the 2012 All Natural Hazard Mitigation Plan, which was adopted by 52 participating communities (including Lincolnshire), in order to be eligible for hazard mitigation grants from the Federal Emergency Management Agency. The plan identifies a variety of projects and activities that can reduce the impact of natural disasters, including flooding, tornados, winter storms, and summer heat. The County is currently in the process of updating the plan, which will be finalized in 2017.

4.0 INTERNAL DRAINAGE SYSTEM

The Village of Lincolnshire has historically experienced flooding problems in the Riverwoods subdivision during moderate and severe rainfall events. Section 2.0 of this report has discussed overbank flooding issues and proposed improvements for the protective berm along the DesPlaines River. Flooding, however, can also be associated with the internal drainage system due to inadequate storm sewer capacity and poorly defined overland flow paths.

The Riverwoods Subdivision Watershed is a 324 acre watershed that generally drains stormwater from an area south of Half Day Road, west of Riverwoods Road, north of Londonderry Lane, and east of the Des Plaines River. There is a small portion of the watershed that extends east of Riverwoods Road. The watershed limits can be found on Exhibit 4.3. In general, the watershed drains from east to west through six main storm sewer systems that outfall into the Des Plaines River or a small ditch tributary to it. These systems are described below and color coded on Exhibit 4.3.

Oxford Drive System – The storm sewer ranges in size from 8-inch pipe in the upper reaches of the system to 4-feet at the outfall. The system drains over half of the entire watershed, approximately 214 acres. The system extends east of Riverwoods Road and conveys water down Oxford Lane where it combines with the sewer system that discharges the Oakwood/Hickory/Elmwood area. The Oxford system eventually discharges to the Des Plaines River through twin 48-inch diameter sewers in Spring Lake Park.

Cumberland/Lincolnshire Drive North System – This system begins at a low spot on Cumberland Drive approximately halfway between Oxford and Wiltshire Drives. Runoff from approximately 11 acres is conveyed through an 8-inch storm sewer traversing through the side and rear yards

of homes located at 77 & 79 Cumberland Drive and 86 & 88 Lincolnshire Drive before crossing under Lincolnshire Drive and discharging to the Des Plaines River. It is our understanding that the pipe is failing which contributes to flooding at this location.

Wiltshire Drive System – This storm sewer system has 21 acres tributary to the low spot at the intersection of Lincolnshire and Wiltshire Drives. A 12-inch storm sewer drains the low spot westward through the Des Plaines River protective berm just south of the home located at 73 Lincolnshire Drive.

Cumberland/Lincolnshire Drive South System – The storm sewer system drains the low spots on Cumberland and Lincolnshire Drives just south of Wiltshire Drive. 21 acres are tributary to a 15-inch sewer which conveys flow between homes located at 55 & 57 Cumberland and 59 & 61 Lincolnshire Drive prior to discharging through the Des Plaines River protective berm.

Londonderry/Lincolnshire Drive System – A 15-inch storm sewer has 14 acres tributary to the local low point at the intersection of Lincolnshire Drive and Londonderry Lane. The sewer conveys water west and south through the Des Plaines River protective berm.

Cambridge Lane System – The sewer system consists of 10-inch to 15-inch pipes that convey stormwater from low spots on Elsinoor Drive and Cambridge Lane, Lancaster Lane and Sheffield Court, Plymouth Court and Sheffield Court, and Lincolnshire Drive and Elisnoor Drive. The drainage area tributary to the system is approximately 43 acres. The system drains to the ditch located just south of the homes located on the south side of Cambridge Lane.

4.1 Hydrology

Tributary areas to storm sewer systems were delineated using contour mapping provided by the Village of Lincolnshire. These tributary areas can be found on Exhibit 4.3 for the Riverwoods Watershed. Sub-basin areas and runoff characteristics were calculated using SCS methodology and input into the Rain Module for the XPSWMM 2D modeling.

Storm events studied were chosen based on the characteristics of the drainage basin. The critical duration storm event was evaluated and utilized for the basin. It was determined that the 2-hour event was critical. 2-, 10-, 50-, & 100-year, 2-hour storm events were input into XPSWMM 2D and analyzed. XPSWMM 2D uses the rainfall input to generate runoff hydrographs. These hydrographs are routed through storm sewers input into XPSWMM 2D hydraulics as discussed below.

4.2 Hydraulics

Existing storm sewer sizes and routings were developed based upon a combination of survey from ERA and GIS atlas information provided by the Village of Lincolnshire. Storm sewer information was input into the XPSWMM 2D model.

The hydraulic models developed for this study utilized the main trunk lines to identify where there were deficiencies in conveyance in the storm sewer network. The hydraulic models often represented multiple pipe segments as a single segment, and often combined several locations with stormwater runoff inflow into a single inflow point. The hydraulic model was incorporated into the 2D model, which represents a more comprehensive picture of the water flowing through the basins. The 2D model includes a 3-dimensional surface which depicts the topography of the drainage basins. When the water rises above the rims of the storm sewers in the XP SWMM 2D model the water follows the topography of the area as it would in a real storm event. The model then can demonstrate the extents, depth, and velocity of the water flowing over land after it surcharges the storm sewer system.

Five of the six storm sewer outlets discharge directly to the Des Plaines River. The river has a 10-year floodplain elevation of approximately 644.0 and a 100-year elevation of approximately 646.8. These elevations are well above the outlet elevations of five of six storm sewer systems. Therefore, tailwater conditions from the Des Plaines River can significantly impact how the internal drainage system of the Riverwoods subdivision functions. In order to fully understand the internal drainage system of the Riverwoods subdivision, two hydraulic models were run to reflect the full range of anticipated tailwater conditions.

Free Discharge Model – This model assumed that the Des Plaines River was at its normal water level and the storm sewer system outlets were free to discharge. The purpose of the free discharge hydraulic model was to determine the adequacy of the existing storm sewer capacity and overland flow paths. This model has been used to identify flood risk areas due to undersized storm sewers and inadequate overland flow paths. Results of this model can be found on Exhibits 4.4 through 4.6. It is anticipated that this model will be used in the proposed conditions analysis to identify proposed storm sewer improvements to alleviate local flooding.

Maximum Tailwater Condition – This model assumed that the Des Plaines River was at its approximate 10-year floodplain elevation of 644.0, restricting the storm sewer system outfalls. This elevation was chosen as the maximum tailwater because it closely matched the protective berm elevation. The purpose of this model was to demonstrate the impacts of the Des Plaines River elevations on the Riverwoods subdivision internal drainage system. Results of the model can be found on Exhibits 4.7 through 4.9. It is anticipated that this model will be used in the proposed conditions analysis to identify proposed pumping alternatives and pumping procedures when the river rises.

4.3 Existing Conditions Flooding Evaluation

Internal drainage flood limits are shown on Exhibits 4.4 through 4.9. The exhibits reflect the operations of the storm sewer and overland flow paths within the Riverwoods

Subdivision when the Des Plaines River is at its normal water level (free discharge) and when the river is at the 10-year flood stage (644.0) for the 2-, 10-, 100-year storm events. Below is a summary evaluation of each storm sewer system and specific flood prone locations.

Oxford Drive System – The system performs very well for smaller frequent storms (2-Year event) when the Des Plaines River is low. When the Des Plaines River elevations are high these frequent storms can inundate the area of Oxford Drive adjacent to Spring Lake Park if pumping operations are not performed. Flooding has the potential to impact four properties on the south side of Stone Gate Circle and block access to 3 homes and Spring Lake Park. Flood depths are approximately 1.0'.

During moderate storm events (10-Year), the storm sewer system surcharges at sag points in the roadways on Oxford Drive just north of Plymouth Court, Yorkshire Drive just north of Plymouth Court, Oakwood Lane just south of Half Day Road, the intersection of Cedar and Oakwood Lane, and the intersection of Oxford Drive and Essex Lane.

- Oxford Drive North of Plymouth – Water ponds approximately 1.5' within the roadway. It does not appear to impact any properties but does block access to 5 homes.
- Yorkshire Drive North of Plymouth – Water ponds approximately 3.0' within the roadway. Water overflows the cul-de-sac between two homes flowing northwest toward Essex Lane potentially impacting both Yorkshire properties in addition to two downstream properties located on Essex Lane. Flooding at the cul-de-sac blocks access to 8 homes. The depth of flooding also blocks emergency access to 3 homes.
- Oakwood Lane South of Half Day Road – Water ponds approximately 1.0' within the roadway. Ponding in the roadway appears to potentially impact two homes on the west side of Oakwood Lane. Roadway ponding blocks access to 6 homes.
- Cedar and Oakwood Lane – Water ponds approximately 0.5' and stays within the roadway. No properties appear to be impacted and ponding depths are not high enough to block access to homes.
- Oxford and Essex Lane – When the Des Plaines River elevations are high, flooding inundates the area if pumping operations are not performed. Flooding has the potential to impact four properties on the south side of Stone Gate Circle and block access to 3 homes and Spring Lake Park. Flood depths are approximately 1.0'.

During severe storm events (100-Year), the entire Oxford Lane storm sewer system surcharges. Stormwater runs down roadways to sag points on Oxford Drive just north of Plymouth Court, Yorkshire Drive just north of Plymouth Court, Oakwood Lane just south

of Half Day Road, the intersection of Cedar and Oakwood Lane, and the intersection of Oxford Drive and Essex Lane.

- Oxford Drive North of Plymouth – Water ponds approximately 2.0' within the roadway. It does not appear to impact any properties but does block access to seven homes.
- Yorkshire Drive North of Plymouth – Water ponds approximately 3.5' within the roadway. Water overflows the cul-de-sac between two homes flowing northwest toward Essex Lane. Flooding of the cul-de-sac and from the overflow between the homes impacts 10 structures. Access is blocked to 12 homes, three of which have water depths potentially deep enough to block emergency vehicles.
- Oakwood Lane South of Half Day Road – Water ponds over 1.0' within the roadway. Ponding in the roadway impacts three homes on the west side of Oakwood Lane. Roadway ponding blocks access to six homes. Overflow through side yards of Oakwood Lane contributes to rear yard flooding on Essex Lane and potential flooding of an additional two structures.
- Cedar and Oakwood Lane – Water ponds over 1.0' before overtopping through side yards at the intersection of Oakwood and Cedar Lanes. Overflow contributes to potential flooding of three structures.
- Oxford and Essex Lane – Flooding in this area has the potential to impact five properties, four located on the south side of Stone Gate Circle and one on the east side of Oxford Lane north of Essex Lane. Flood depths are approximately 1.5' deep and block access to 6 homes and Spring Lake Park.

Cumberland/Lincolnshire Drive North System – During frequent storms (2-year) ponding begins to occur in the rear yards of properties on Cumberland and Lincolnshire Drive. Rear yard ponding is approximately 0.5' deep and does not appear to impact any homes. Approximately 0.5' of ponding also occurs on Lincolnshire Drive. This is not deep enough to block access to homes.

During moderate storms (10-year), ponding occurs in the rear yards of properties on Cumberland and Lincolnshire Drive. Rear yard ponding is approximately 1.0' deep and appears to get close but not impact the homes. Approximately 0.5' of ponding also occurs on Lincolnshire Drive. This is not deep enough to block access to homes.

During severe storms (100-year) ponding occurs in the rear yards of properties on Cumberland and Lincolnshire Drive. Rear yard ponding is approximately 1.0' deep and appears to get close to homes but not impact them. Approximately 0.5' of ponding also occurs on Cumberland and Lincolnshire Drives. This is not deep enough to block access to homes.

Wiltshire Drive System – During frequent storms (2-year) ponding begins to occur at the intersection of Wiltshire and Lincolnshire Drives. Street ponding is approximately 0.5'

deep and does not appear to impact any homes. This is not deep enough to block access to homes. Flooding also begins to occur in rear yards of homes located on Lincolnshire Drive south of Wiltshire. It also appears that the home located on the northeast corner of Cumberland and Wiltshire Drive is susceptible to flooding when the Wiltshire Drive storm sewer surcharges.

During moderate storms (10-year), approximately 1.5' of ponding occurs at the intersection of Wiltshire and Lincolnshire Drives. The entire storm sewer is surcharged and runoff is conveyed down roads to this sag point contributing to flooding problems. Flooding at this location appears to block access to three homes but does not appear to impact any structures.

During extreme storms (100-year), approximately 2.0' of ponding occurs at the intersection of Wiltshire and Lincolnshire Drives. The entire storm sewer is surcharged and runoff is conveyed down roads to this sag point contributing to flooding problems. Flooding at this location appears to block access to 15 homes along Lincolnshire Drive and impacts approximately four structures. Flooding from the Wiltshire system combines with flooding from the Cumberland/Lincolnshire South and Londonderry/Lincolnshire Drive system during these extreme events.

Cumberland/Lincolnshire Drive South System – During frequent storms (2-year), ponding begins to occur on Cumberland and Lincolnshire Drives south of Wiltshire. Street ponding is less than 0.5' deep, but because the Lincolnshire Drive area is extremely flat, flooding threatens six homes on the southwest side of Lincolnshire Drive. Flooding in this area combines with flooding from the Londonderry/Lincolnshire Drive system during most storm events.

During moderate storms (10-year), approximately 1.0' of ponding occurs on Cumberland and Lincolnshire Drives south of Wiltshire. The ponding on Cumberland appears to impact one structure and contributes to the rear yard flooding of homes on Lincolnshire Drive, where two additional structures are impacted. The ponding on Lincolnshire impacts two structures, threatens four structures, and blocks access to 11 homes. A total of five structures are impacted by moderate storm flooding.

During extreme storms (100-year), over 1.0' of ponding occurs on Cumberland and Lincolnshire Drives south of Wiltshire. The ponding on Cumberland appears to impact seven structures and contributes to the rear yard flooding of homes on Lincolnshire Drive, where two additional structures are impacted. The ponding on Lincolnshire Drive impacts four structures, threatens two structures, and blocks access to 11 homes. A total of 13 structures are impacted by severe storm flooding.

Londonderry/Lincolnshire Drive System – During frequent storms (2-year), ponding begins to occur near the intersection of Londonderry and Lincolnshire Drive. Street ponding is approximately 1.0' deep blocking access to 1 home. Flooding in this area combines with flooding from the Cumberland/Lincolnshire Drive South system during most storm events.

Flooding during moderate storms (10-year) is similar to that experienced in frequent storms. Additional rear yard flooding occurs for two homes on the north side of Lincolnshire Drive. Rear yard flooding gets close to the home located at 50 Lincolnshire Drive but does not appear to impact the structure. The capacity of the eastern side yard overflow swale is extremely important in the protection of this home.

Flooding during severe storms (100-year) is similar to that experienced in moderate storms. Additional rear yard flooding occurs for two homes on the north side of Lincolnshire Drive. Rear yard flooding gets close to the home located at 50 Lincolnshire Drive but does not appear to impact the structure. The capacity of the eastern side yard overflow swale is extremely important in the protection of this home and several homes to the west.

Cambridge Lane System – During frequent storms (2-year), ponding begins to occur at the intersection of Lancaster Lane and Sheffield Court and just east of the Cambridge Lane and Elsinoor Drive intersection. Street ponding is less than 0.5' deep and 1.0' respectively. Flooding on Cambridge Lane blocks access to 2 homes.

During moderate storms (10-year) approximately 1.0' of ponding occurs at the intersection of Lancaster Lane and Sheffield Court and 1.5' just east of the Cambridge Lane and Elsinoor Drive intersection. Street ponding also begins at the intersection of Sheffield and Plymouth Courts. Flooding appears to be contained to the ROW. Approximately seven homes have their access blocked due to moderate storm flooding.

During severe storms (100-year) approximately 2.0' of ponding occurs at the intersection of Lancaster Lane and Sheffield Court, 2.5' occurs just east of the Cambridge Lane and Elsinoor Drive intersection, and 1.0' occurs at the intersection of Sheffield and Plymouth Courts. Flooding blocks access to 19 homes and impacts three structures on the south side of Cambridge Lane.

4.4 Recommendations

Localized flooding in the Riverwoods Subdivision is caused by the combination of undersized storm sewer and inadequate overland flow paths and by the Des Plaines River flood plain elevations restricting outfall capacities. It is recommended that the existing conditions hydrologic/hydraulic XPSWMM 2D models prepared for this study be used to evaluate proposed alternatives to minimize internal drainage flooding. It is recommended that several storm sewer and overland flow path alternatives be evaluated under the free discharge model to appropriately size the drainage system and that several storm sewer and pumping alternatives be evaluated under the 10-year tailwater model to appropriately size pump systems. It is also recommended that during a proposed conditions analysis detailed topographic surveys be completed of critical overland flow routes and low entry elevations of homes that are in close proximity to the determined flood limits.

5.0 EXHIBITS

5.1 Existing Conditions Berm Photos

EXHIBIT 5.1
Inspection Photos

Photo 1

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Sand bags along berm crest, Sta. 97+00.

Photo 2

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Railroad ties along river -side of berm, Sta. 98+00.

Photo 3

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Concrete stairs, block retaining wall, and railroad ties on river-side of berm, Sta. 100+80. 2" drain line over the berm crest.

Location: 53 Lincolnshire Drive.

EXHIBIT 5.1
Inspection Photos

Photo 4

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: 3” drain line penetration through berm Sta. 100+80.

Location: 53 Lincolnshire Drive

Photo 5

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Railroad ties on river-side of berm, Sta. 101+15.

Location: 53 Lincolnshire Drive

Photo 6

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Railroad ties along toe of berm slope, on river-side of berm, Sta. 101+50.

Location: 55 Lincolnshire Drive

EXHIBIT 5.1
Inspection Photos

Photo 7

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Railroad ties along toe of berm slope, on river-side of berm, Sta. 101+50.

Location: 55 Lincolnshire Drive

Photo 8

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: 4” drain penetration through berm, Sta. 102+40.

Location: 57 Lincolnshire Drive

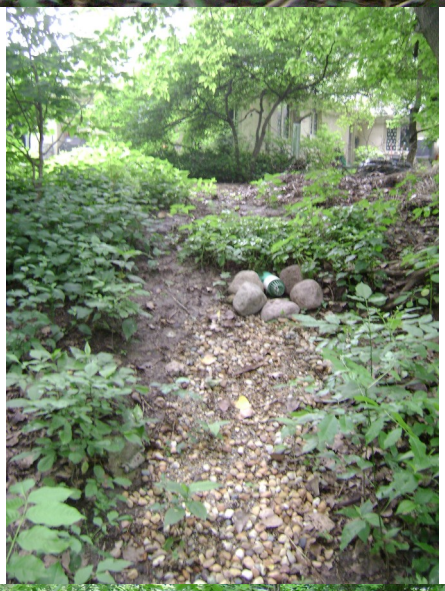

Photo 9

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Brush pile along berm crest, Sta. 102+35.

Location: 57 Lincolnshire Drive

EXHIBIT 5.1
Inspection Photos

Photo 10

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: 4" drain penetration through berm, Sta. 102+80.

Location: 57 Lincolnshire Drive

Photo 11

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Cobble stones on residence side of berm, sandy/gravely and barren on river-side of berm, Sta. 103+40 - 104+20.

Location: 57 & 59 Lincolnshire Drive

Photo 12

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Sandbags visible on river-side of berm, Sta. 103+80.

Location: 59 Lincolnshire Drive

EXHIBIT 5.1
Inspection Photos

Photo 13

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Railroad ties and landscaping on residence-side of berm, Sta. 104+40.

Location: 59 Lincolnshire Drive

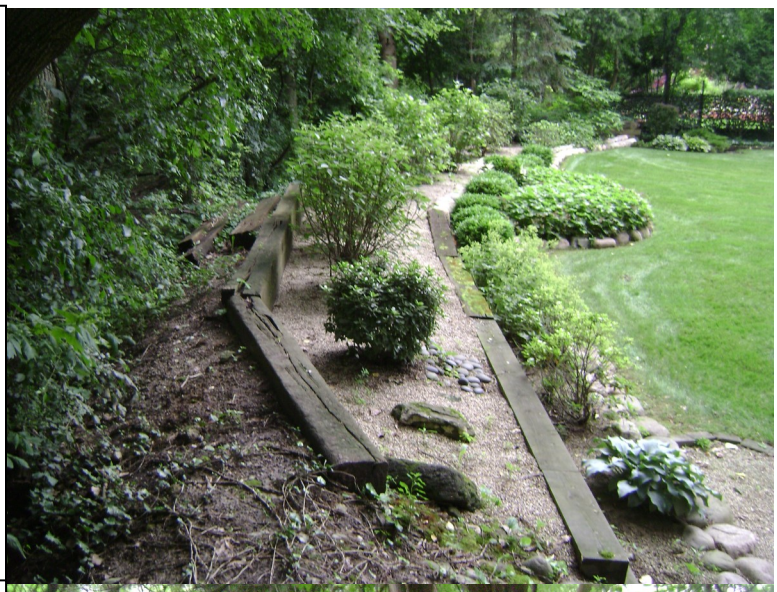

Photo 14

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: 2” drain line running over berm crest, Sta. 104+80.

Location: 59 Lincolnshire Drive

Photo 15

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Manhole and outlet (15”) with flapgate, Sta. 104+85.

Location: 59 Lincolnshire Drive

EXHIBIT 5.1
Inspection Photos

Photo 16

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Wide, grassy area on berm crest, cinder block retaining walls, fence, and garden structure on residence-side of berm, Sta. 105+40.

Location: 61 Lincolnshire Drive

Photo 17

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Barren area and railroad ties on river-side of berm, Sta. 105+50.

Location: 61 Lincolnshire Drive

Photo 18

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Railroad ties, metal posts, and cinder block stairs on river-side of berm, Sta. 105+60.

Location: 61 Lincolnshire Drive

EXHIBIT 5.1
Inspection Photos

Photo 19

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Planter box on berm crest, Sta. 106+40.

Location: 63 Lincolnshire Drive

Photo 20

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: 2” drain with woody debris and erosion penetrating through berm, Sta. 106+50.

Location: 63 Lincolnshire Drive

Photo 21

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Railroad ties around oak tree on river-side of berm crest, Sta. 106+75.

Location: 63 Lincolnshire Drive

EXHIBIT 5.1
Inspection Photos

Photo 22

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: 2” drain penetration through berm with heavy erosion, Sta. 107+40.

Location: 63 Lincolnshire Drive

Photo 23

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Slight bare area/low spot along berm crest, Sta. 108+50.

Location: 65 Lincolnshire Drive

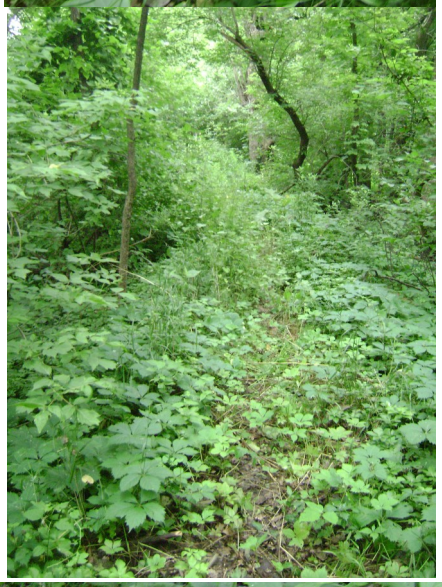

Photo 24

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Slightly bare/eroded area on river-side of berm, Sta. 112+85.

Location: 69 Lincolnshire Drive

EXHIBIT 5.1
Inspection Photos

Photo 25

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: 12” outlet pipe with concrete wingwalls and flapgate, Sta. 112+90.

Location: 71 Lincolnshire Drive

Photo 26

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Bare and narrow berm crest with debris, Sta. 114+10.

Location: 73 Lincolnshire Drive

Photo 27

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Stabilization netting over bare area along berm crest, Sta. 114+10.

Location: 73 Lincolnshire Drive

EXHIBIT 5.1
Inspection Photos

Photo 28

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Large downed tree over berm crest, Sta. 114+45.

Location: 73 Lincolnshire Drive

Photo 29

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Minor barren and narrow area, Sta. 115+10.

Location: 75 Lincolnshire Drive

Photo 30

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Barren path likely from pedestrian traffic, Sta. 115+40.

Location: 75 Lincolnshire Drive

EXHIBIT 5.1
Inspection Photos

Photo 31

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Substantial debris present at toe of slope on river-side of berm, Sta. 116+40.

Location: 77 Lincolnshire Drive

Photo 32

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: 3” drain penetration through berm, outlet for drain on river-side not found, Sta. 117+50.

Location: 77 Lincolnshire Drive

Photo 33

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: 3” drain penetration through berm, no evidence of erosion, Sta. 117+60.

Location: 77 Lincolnshire Drive

EXHIBIT 5.1
Inspection Photos

Photo 34

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Large downed tree on river-side of berm, Sta. 117+80.

Location: 79 Lincolnshire Drive

Photo 35

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Sparsely vegetated and gravelly area of berm crest, Sta. 117+60 - 118+70.

Location: 79 Lincolnshire Drive

Photo 36

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Sand bags present on river-side of berm, Sta. 118+40.

Location: 79 Lincolnshire Drive

EXHIBIT 5.1
Inspection Photos

Photo 37

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Gravel pedestrian trail over berm crest, Sta. 118+80.

Location: 79 Lincolnshire Drive

Photo 38

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: Debris (bricks and concrete) on river-side of berm, Sta. 118+80.

Location: 79 Lincolnshire Drive

Photo 39

Site: Lincolnshire, IL—Des Plaines River

Date: June 26, 2015

Description: 2” drain penetration through berm, no evidence of erosion, Sta. 118+90.

Location: 79 Lincolnshire Drive

5.2 Flood Limits Failed Protection Berm

Riverwoods Flood Limits Failed Protection Berm

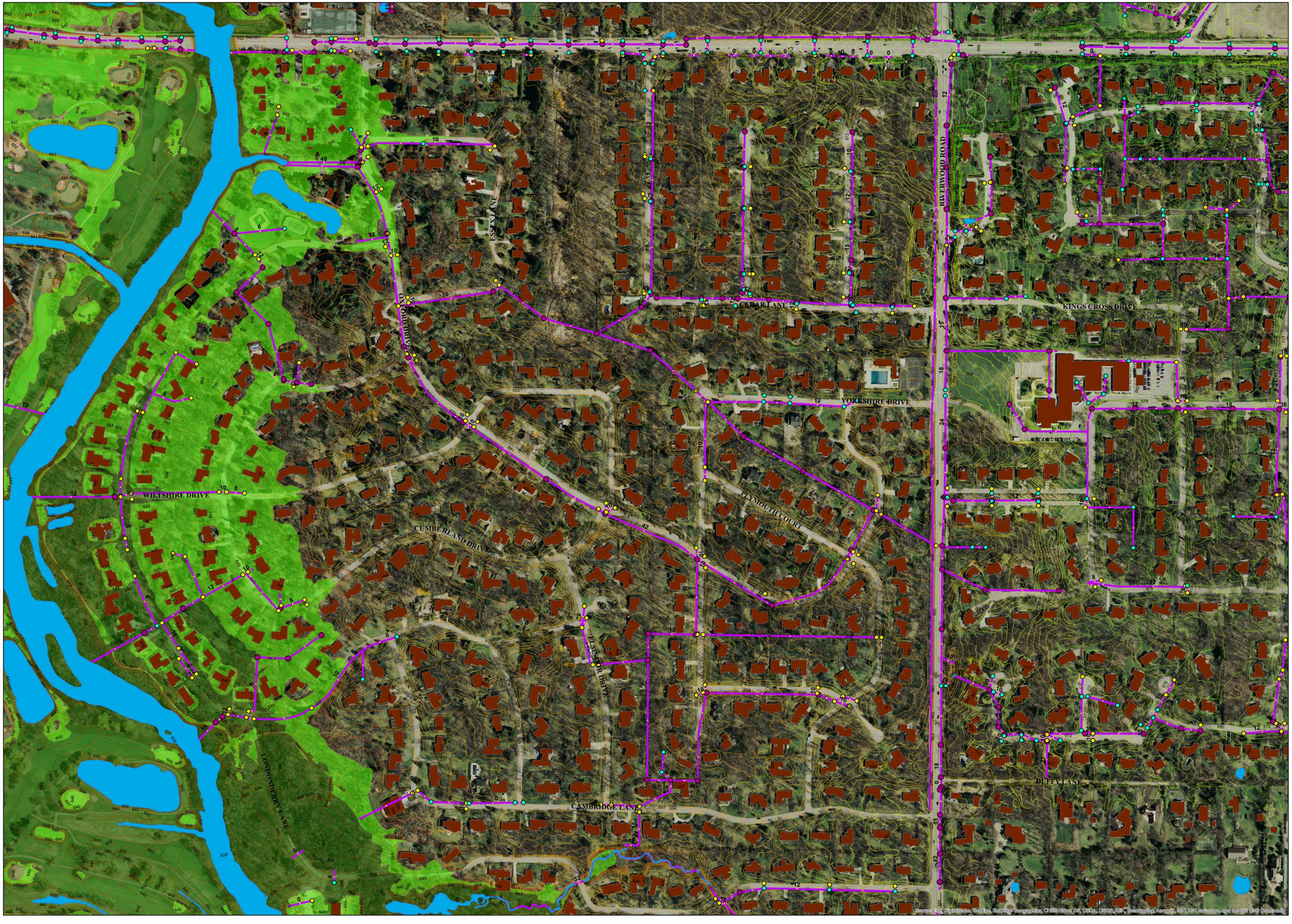

EXHIBIT 5.2

Legend

- Hydrology
- Catch Basin
- Inlet
- Discharge Point
- Manhole
- Storm Sewer
- Building
- 10-Year Flood Plain
- 100-Year Flood Plain

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ENGINEERING
RESOURCE ASSOCIATES

1 inch = 200 feet

0 100 200 400 600 800 Feet

5.3 Riverwoods Watershed Map

Riverwoods Watershed

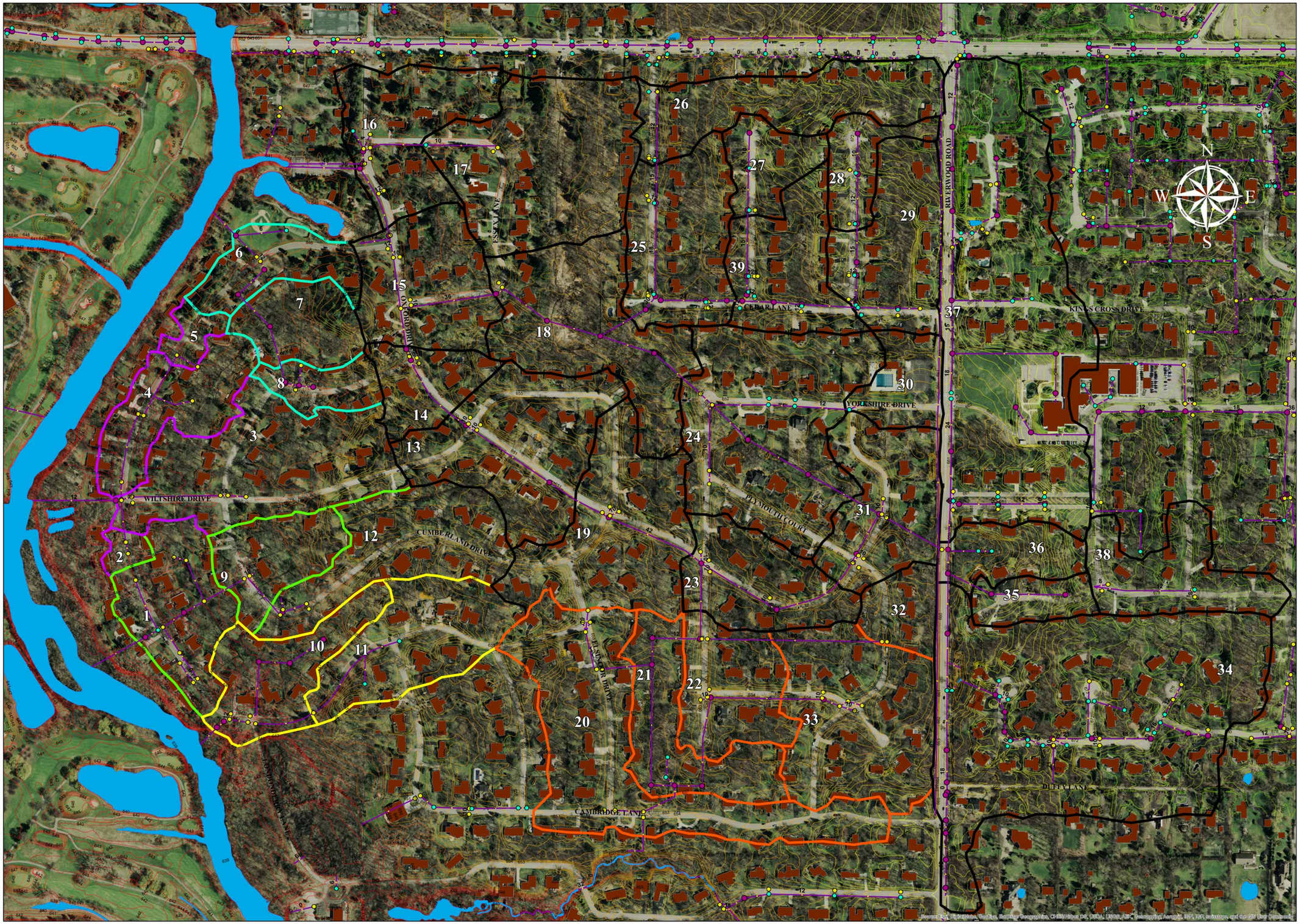

EXHIBIT 5.3

Legend

- Hydrology
- Catch Basin
- Inlet
- Discharge Point
- Manhole
- Storm Sewer

Oxford

- CAMBRIDGE LANE SYSTEM
- CUMBERLAND/LINCOLNSHIRE DRIVE NORTH SYSTEM
- CUMBERLAND/LINCOLNSHIRE DRIVE SOUTH SYSTEM
- LONDONDERRY/LINCOLNSHIRE DRIVE SYSTEM
- OXFORD DRIVE SYSTEM
- WILTSHIRE DRIVE SYSTEM
- Building

Basin Areas	
Basin	Area (Acres)
1	6.966
2	0.782
3	12.719
4	6.07
5	1.233
6	4.343
7	4.426
8	2.488
9	4.726
10	6.232
11	8.052
12	9.057
13	11.295
14	3.837
15	8.019
16	7.899
17	13.794
18	11.758
19	11.327
20	15.587
21	6.873
22	6.19
23	6.699
24	16.15
25	8.603
26	8.739
27	3.371
28	3.053
29	7.896
30	3.374
31	7.861
32	2.731
33	11.994
34	32.075
35	2.512
36	3.808
37	28.181
38	6.501
39	6.872
TOTAL	324.093

ENGINEERING
RESOURCE ASSOCIATES

1 inch = 200 feet

0 100 200 400 600 800 Feet

5.4 2-Year Internal Drainage Flood Limits (Free Outfall)

Riverwoods Watershed 2-Year Internal Drainage Flood Limits (Free Outfall)

EXHIBIT 5.4

Legend

- Hydrology
- Catch Basin
- Inlet
- Discharge Point
- Manhole
- Storm Sewer
- Building
- 2-year (2-hour) existing (no tailwater)m

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ENGINEERING
RESOURCE ASSOCIATES

1 inch = 200 feet

0 100 200 400 600 800 Feet

5.5 10-Year Internal Drainage Flood Limits (Free Outfall)

Riverwoods Watershed 10-Year Internal Drainage Limits (Free Outfall)

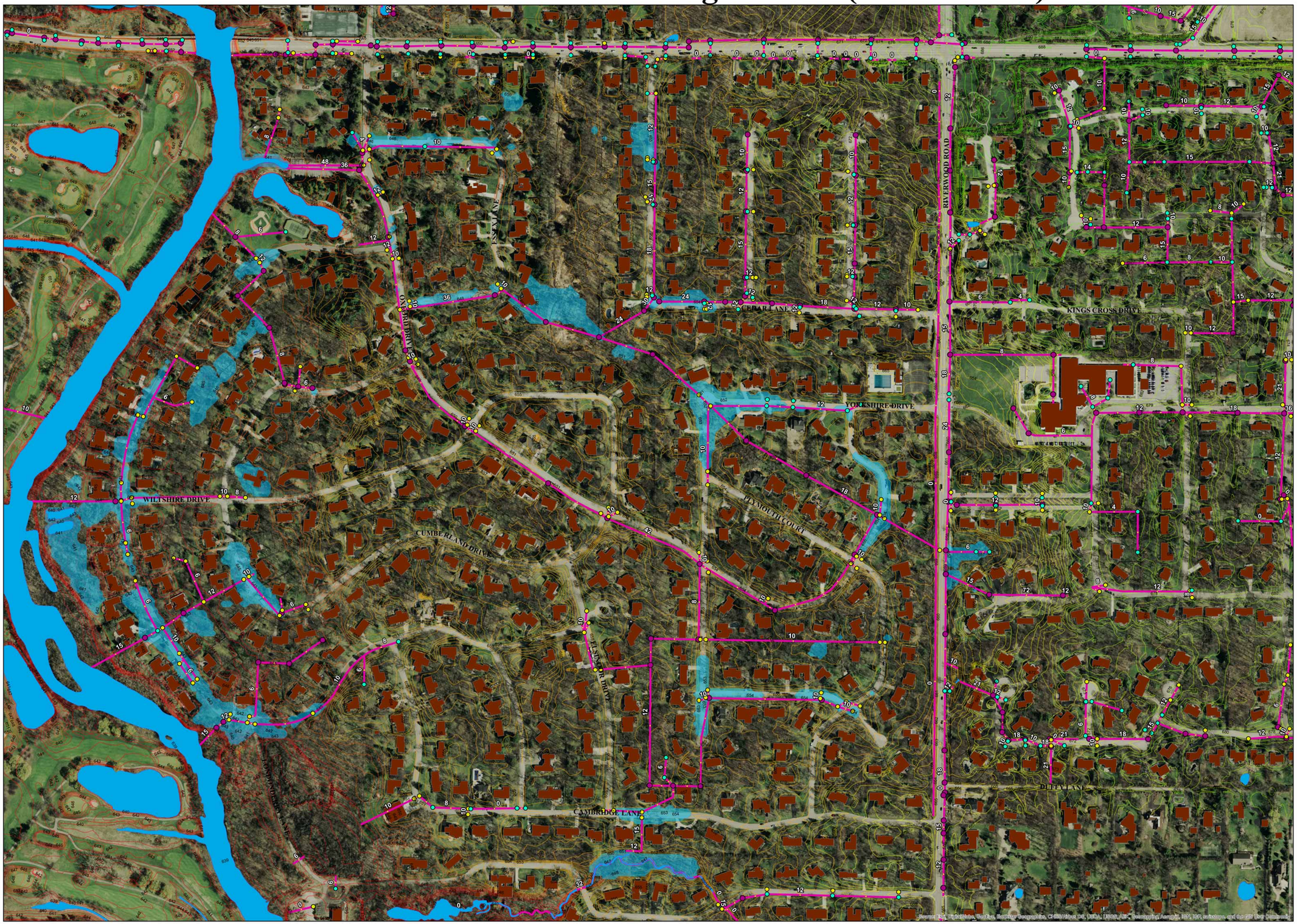

EXHIBIT 5.5

Legend

- Hydrology
- Catch Basin
- Inlet
- Discharge Point
- Manhole
- Storm Sewer
- Building
- 10-year (2-hour) existing (no tailwater)m

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ENGINEERING
RESOURCE ASSOCIATES

1 inch = 200 feet

0 100 200 400 600 800 Feet

5.6 100-Year Internal Drainage Flood Limits (Free Outfall)

Riverwoods Watershed 100-Year Internal Drainage Flood Limits (Free Outfall)

EXHIBIT 5.6

Legend

- Hydrology
- Catch Basin
- Inlet
- Discharge Point
- Manhole
- Storm Sewer
- Building
- 100-year (2-hour) existing (no tailwater)m

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ENGINEERING
RESOURCE ASSOCIATES

1 inch = 200 feet

0 100 200 400 600 800 Feet

5.7 2-Year Internal Drainage Flood Limits (10-Year Tailwater)

Riverwoods Watershed 2-Year Internal Drainage Flood Limits (10-Year Tailwater)

EXHIBIT 5.7

Legend

- Hydrology
- Catch Basin
- Inlet
- Discharge Point
- Manhole
- Storm Sewer
- Building
- 2-year (2-hour) existing tailwater

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ENGINEERING
RESOURCE ASSOCIATES

1 inch = 200 feet

0 100 200 400 600 800 Feet

5.8 10-Year internal Drainage Flood Limits (10-Year Tailwater)

Riverwoods Watershed 10-Year Internal Drainage Flood Limits (10-Year Tailwater)

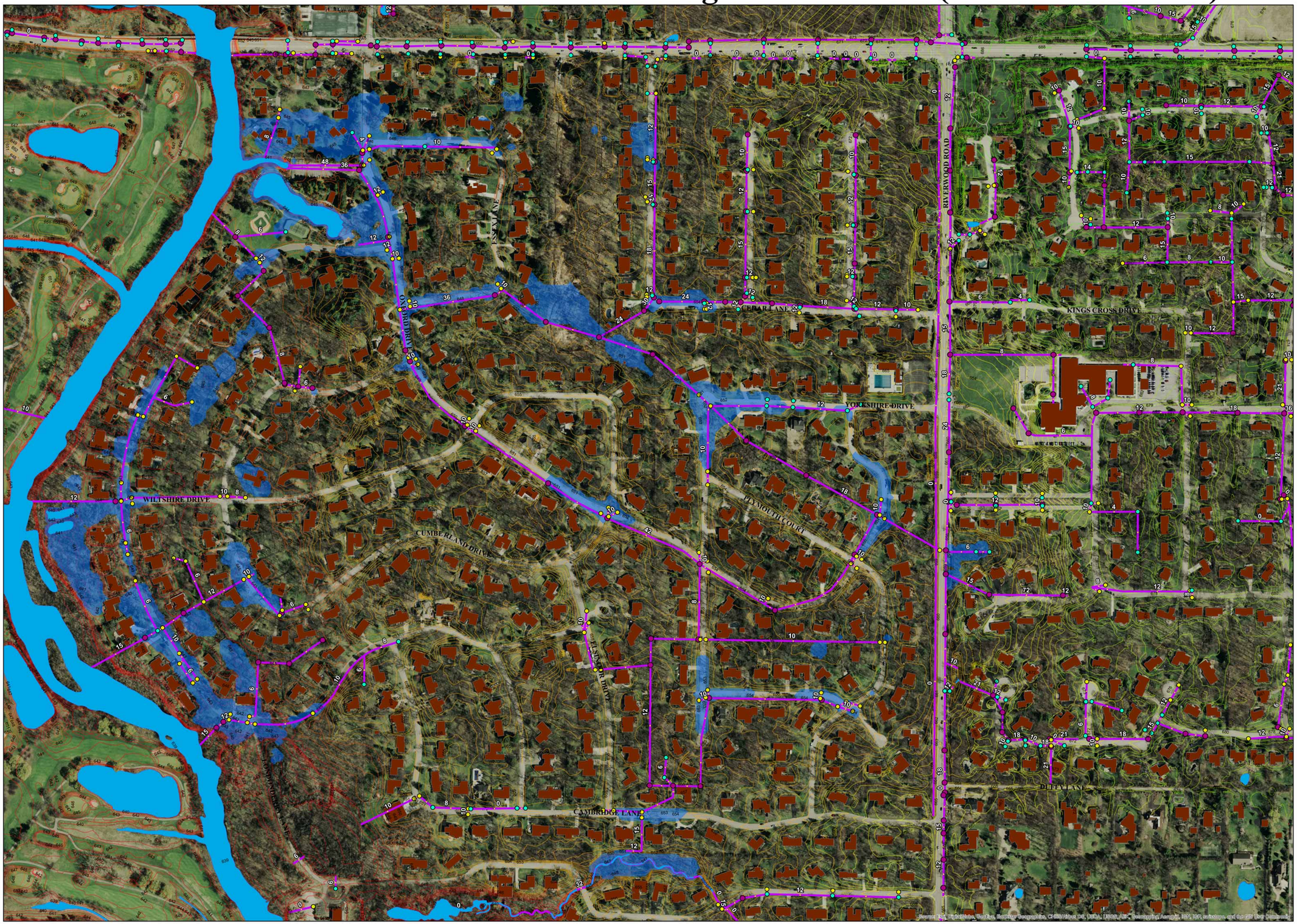

EXHIBIT 5.8

Legend

- Hydrology
- Catch Basin
- Inlet
- Discharge Point
- Manhole
- Storm Sewer
- Building
- 10-year (2-hour) existing tailwater

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ENGINEERING
RESOURCE ASSOCIATES

1 inch = 200 feet

0 100 200 400 600 800 Feet

5.9 100-Year Internal Drainage Flood Limits (10-Year Tailwater)

Riverwoods Watershed 100-Year Internal Drainage Flood Limits (10-Year Tailwater)

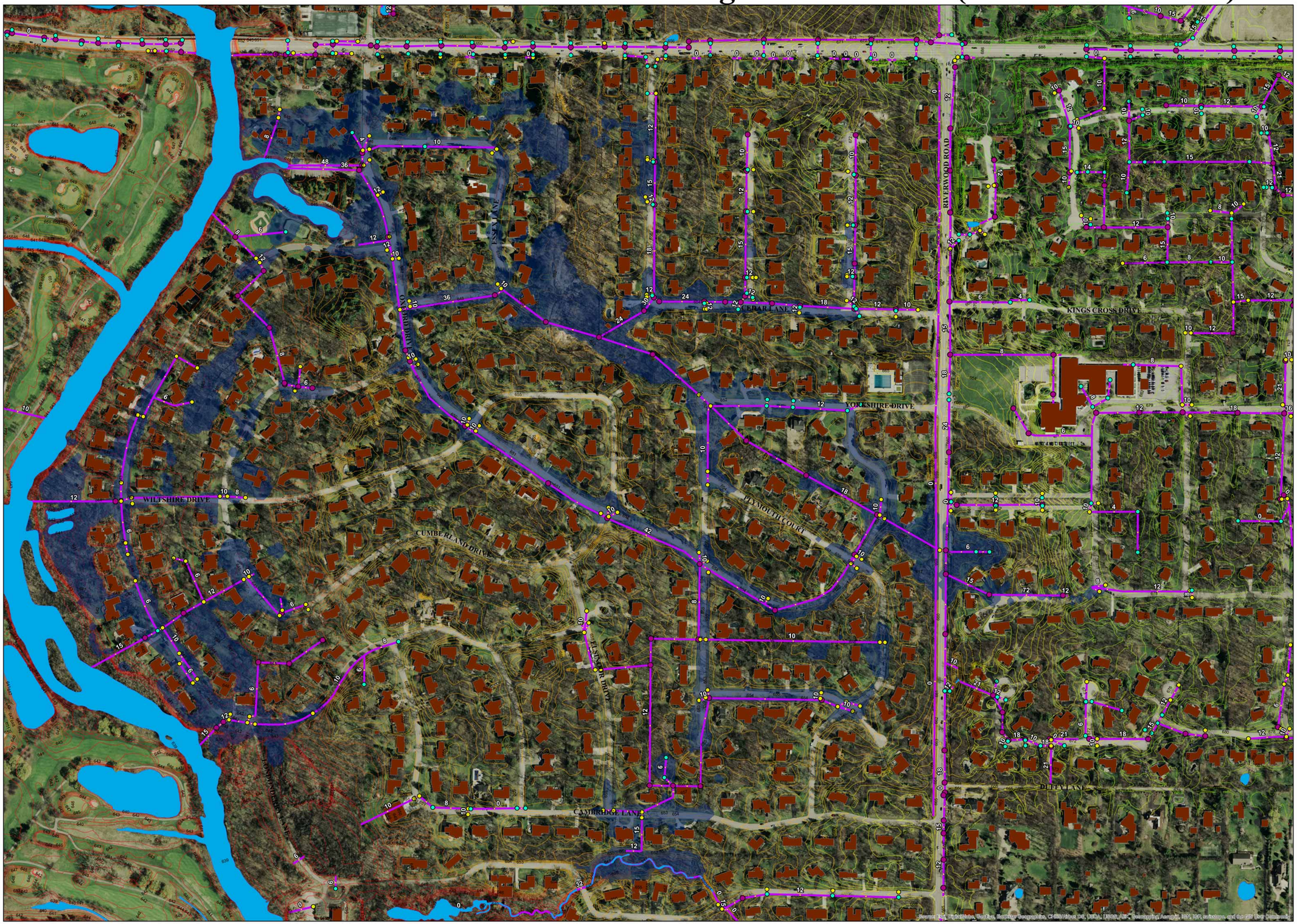

EXHIBIT 5.9

Legend

- Hydrology
- Catch Basin
- Inlet
- Discharge Point
- Manhole
- Storm Sewer
- Building
- 100-year (2-hour) existing tailwater

N
W E
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ENGINEERING
RESOURCE ASSOCIATES

1 inch = 200 feet

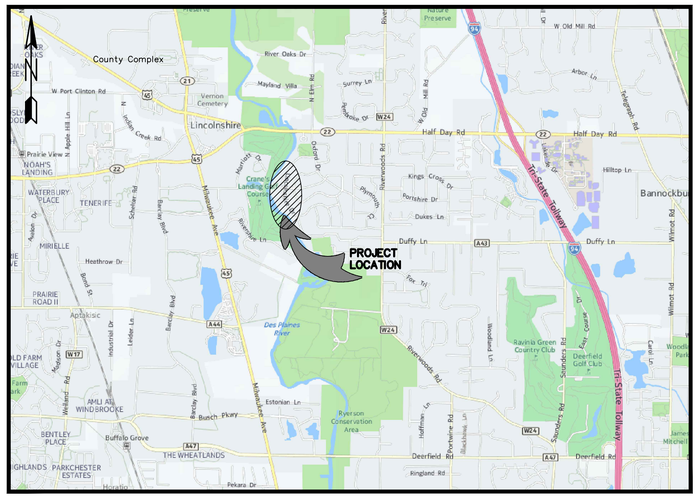
0 100 200 400 600 800 Feet

6.0 APPENDICES

6.1 Existing Conditions Plan & Profile

DES PLAINES RIVER STABILIZATION AND DRAINAGE EVALUATION PROJECT VILLAGE OF LINCOLNSHIRE, ILLINOIS

INDEX TO DRAWINGS



LOCATION MAP

PREPARED FOR:

VILLAGE OF LINCOLNSHIRE
ONE OLDE HALF DAY ROAD
LINCOLNSHIRE, ILLINOIS 60069-3035
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Marty J. Michalisko, P.E.
IL. P.E. NO. 062-058762
Expires: November 30, 2015

ORIGINAL SUBMITTAL: JUNE 2015

ERA JOB NO.: 150510

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DES PLAINES RIVER

EXISTING RIP RAP

EXISTING AGGREGATE

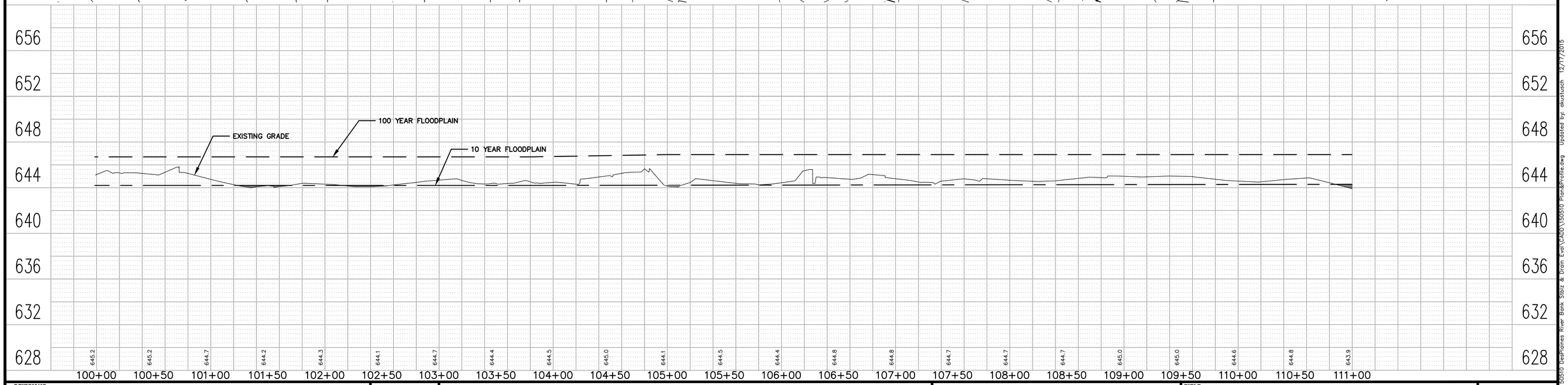
LINCOLNSHIRE DR.

MATCH LINE STA. 111+00

0 40' 80' HORZ.
0 4' 8' VERT.

100+00 100+50 101+00 101+22 101+50 102+00 102+28 102+50 103+14 103+50 103+60 103+84 104+00 104+30 104+40 105+00 105+23 105+50 106+00 106+30 106+78 107+00 107+70 108+24 108+50 109+00 109+50 110+00 110+60 111+50 111+00

53 55 57 59 61 63 65 67 69



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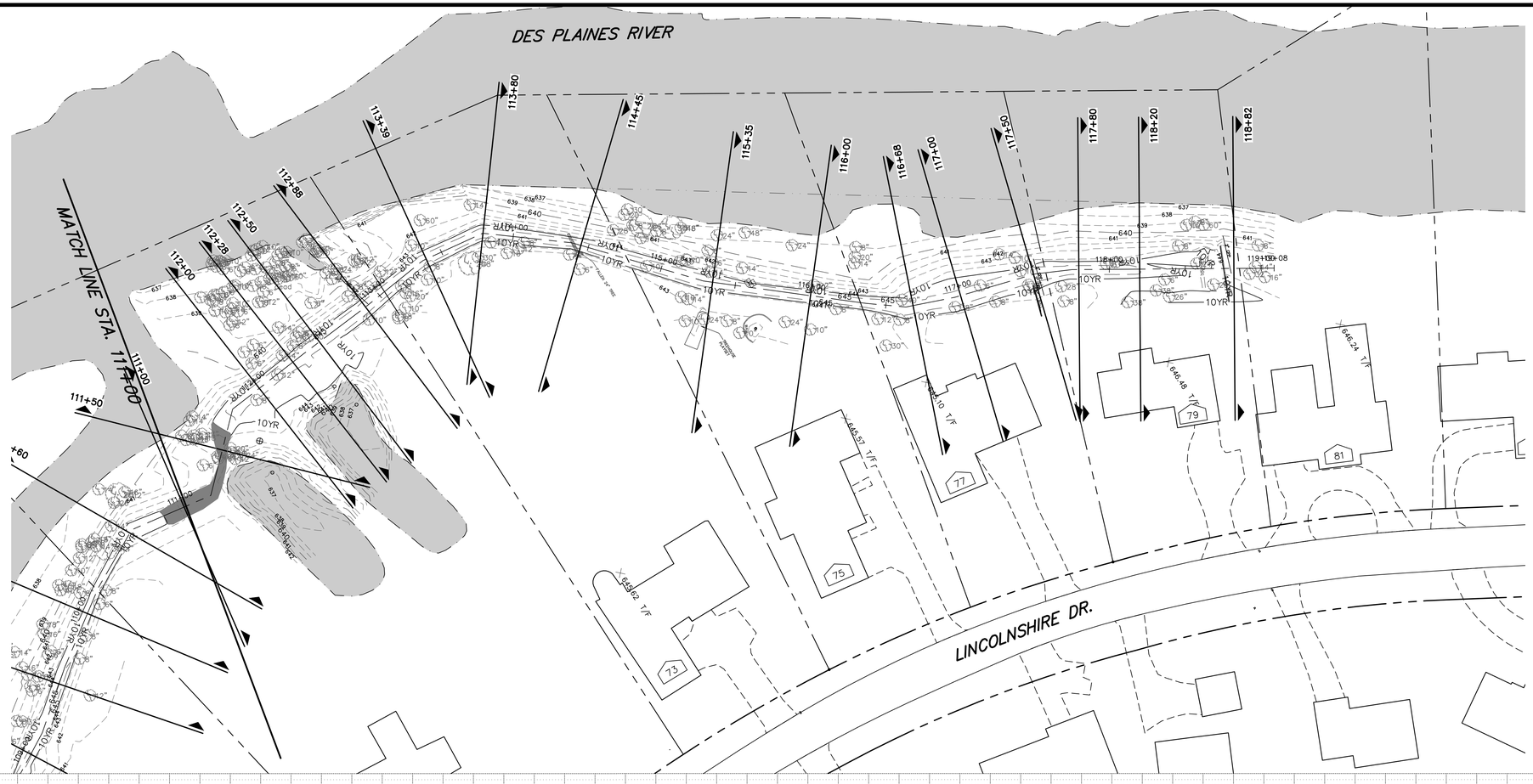
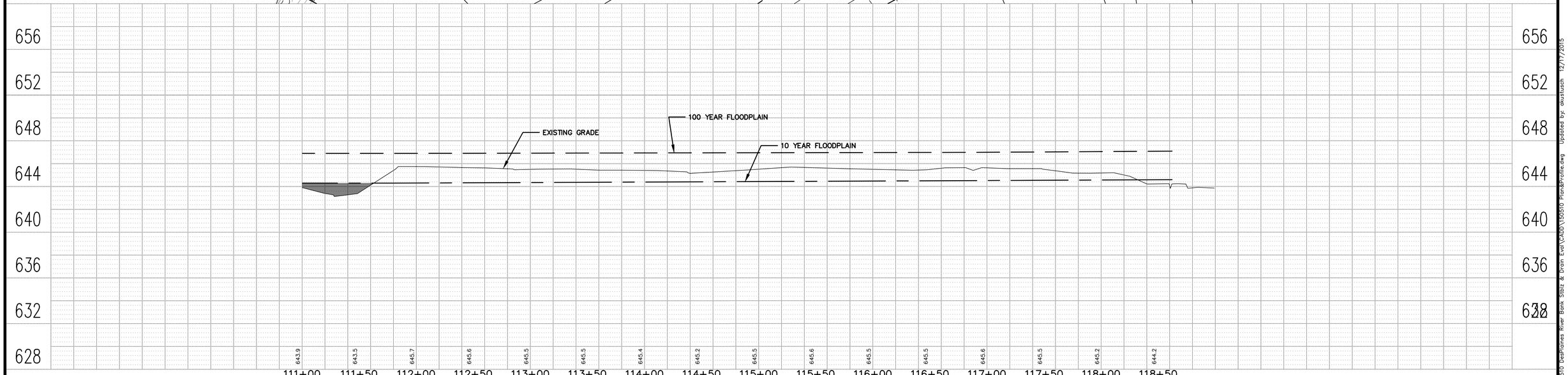
DES PLAINES RIVER STABILIZATION AND DRAINAGE EVALUATION PROJECT
VILLAGE OF LINCOLNSHIRE, ILLINOIS

TITLE: DES PLAINES RIVER STREAMBANK PLAN AND PROFILE STA. 100+00 TO STA. 111+00

SCALE: 1"=40'H; 1"=4'V
DATE: August, 2015
JOB NO: 150510
SHEET 2 OF 7

H:\Lincolnshire\150510 DesPlaines River Bank Stblz & Drain Eval\CAD\150510 Plan&Profile.dwg Updated by: ekustusch 12/17/2015





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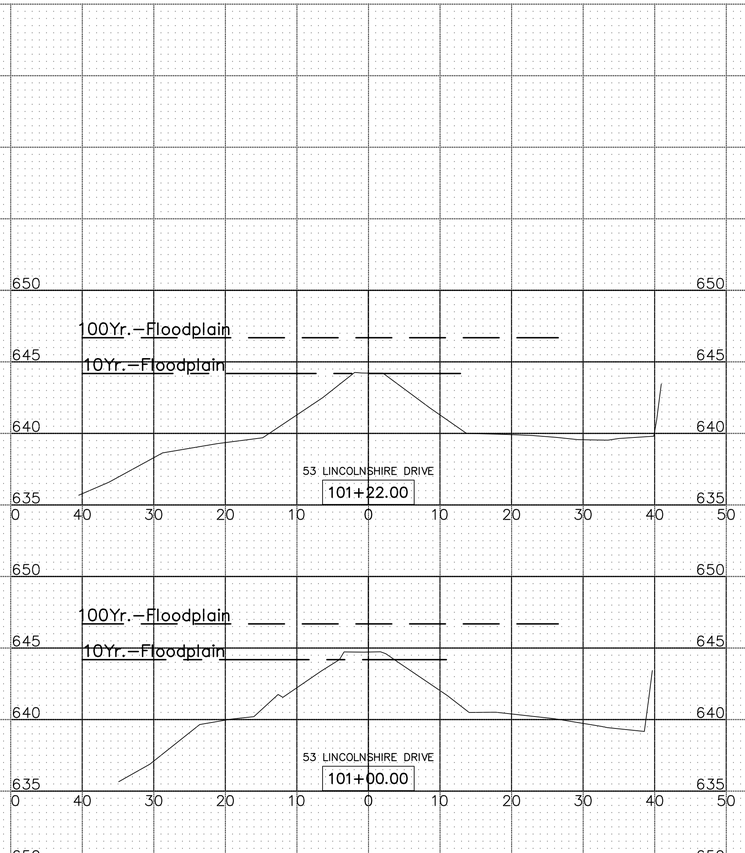
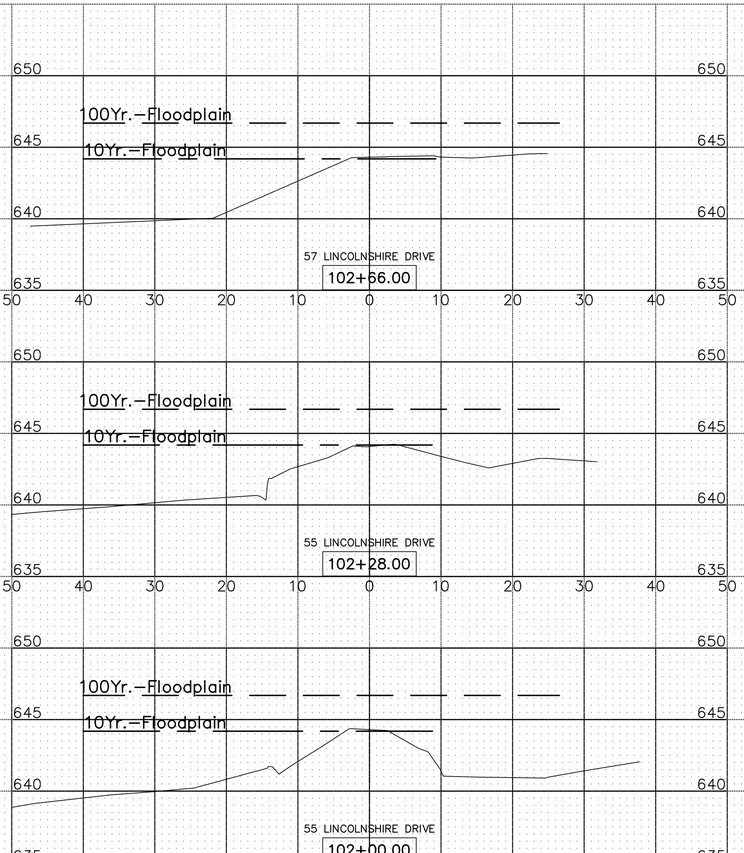
DES PLAINES RIVER STABILIZATION AND DRAINAGE EVALUATION PROJECT
VILLAGE OF LINCOLNSHIRE, ILLINOIS

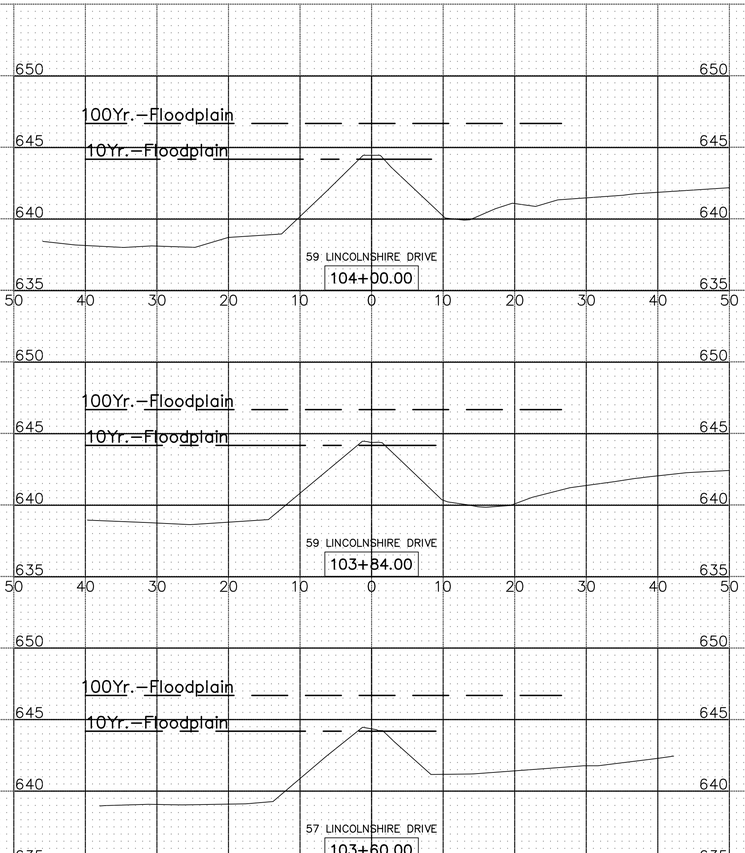
TITLE: DES PLAINES RIVER STREAMBANK PLAN AND PROFILE STA. 111+00 TO STA. 119+10

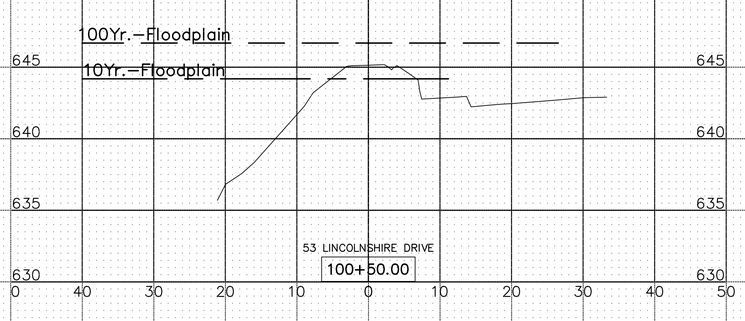
SCALE: 1"=40'H; 1"=4'V
DATE: June, 2015
JOB NO: 150510
SHEET 3 OF 7

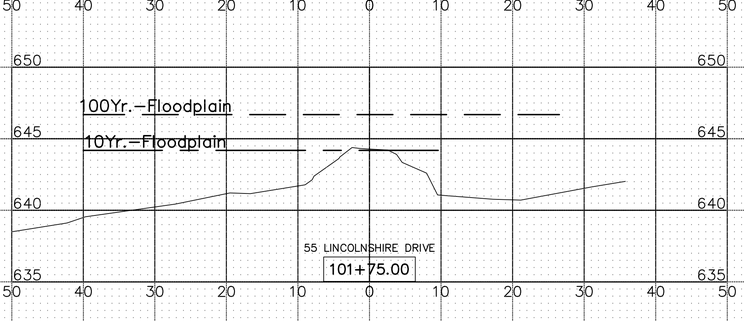
H:\Lincolnshire\150510 DesPlaines River Bank Stblz & Drain Eval\CADD\150510 Plan&Profile.dwg Updated by: akustusch 12/17/2015

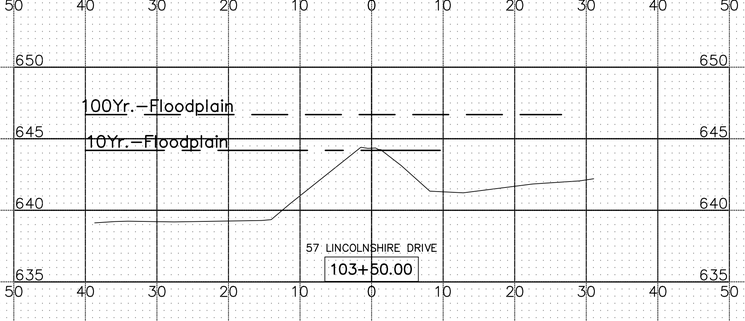


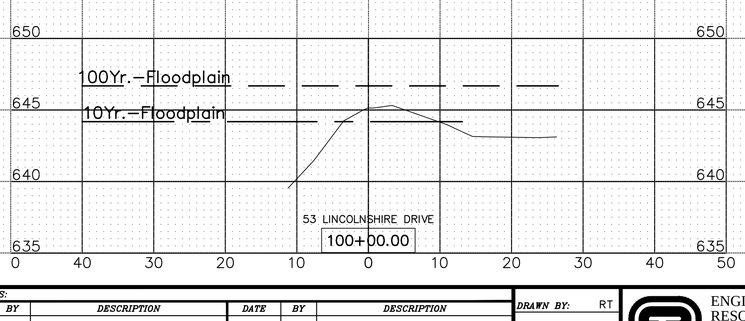


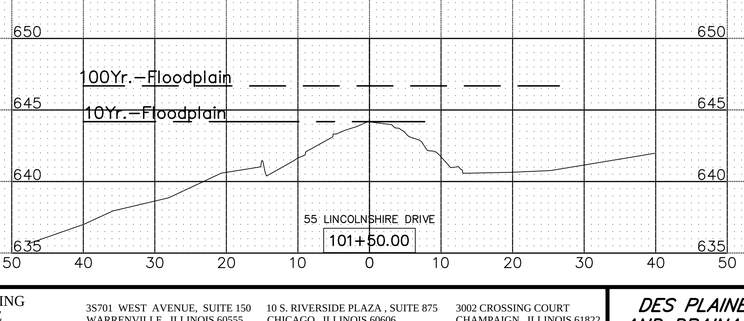


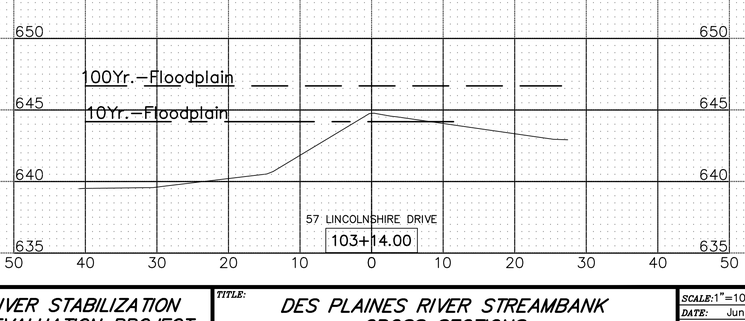












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DES PLAINES RIVER STABILIZATION AND DRAINAGE EVALUATION PROJECT
VILLAGE OF LINCOLNSHIRE, ILLINOIS

TITLE: DES PLAINES RIVER STREAMBANK CROSS SECTIONS STA. 100+00 TO STA. 104+00

SCALE: 1"=10'H; 1"=5'V
DATE: June, 2015
JOB NO: 150510
SHEET 4 OF 7

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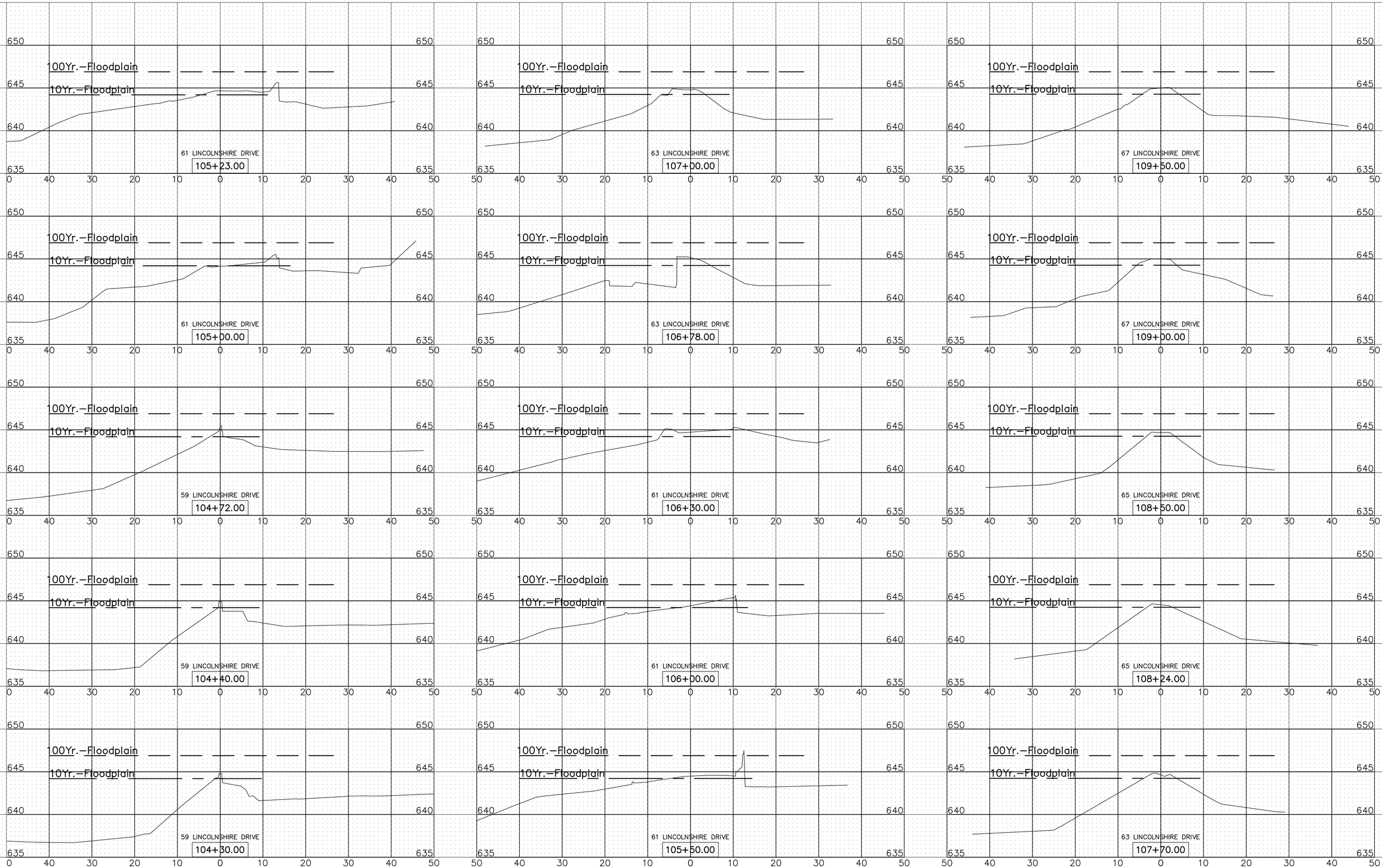

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VILLAGE OF LINCOLNSHIRE, ILLINOIS

TITLE: DES PLAINES RIVER STREAMBANK CROSS SECTIONS
STA. 104+30 TO STA. 109+50

SCALE: 1"=10'H; 1"=5'V
DATE: August, 2015
JOB NO: 150510
SHEET 5 OF 7

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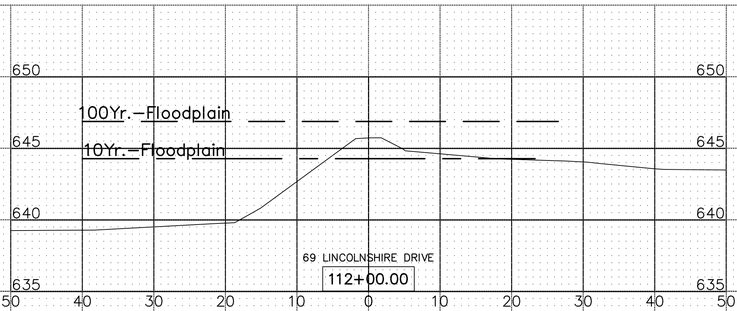

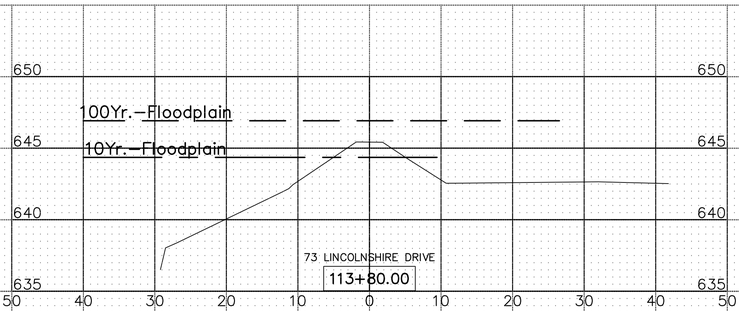

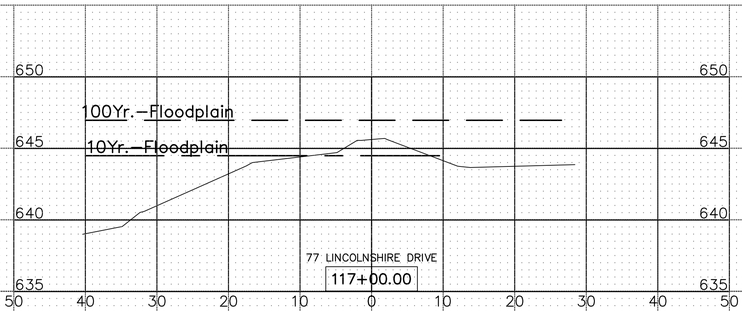

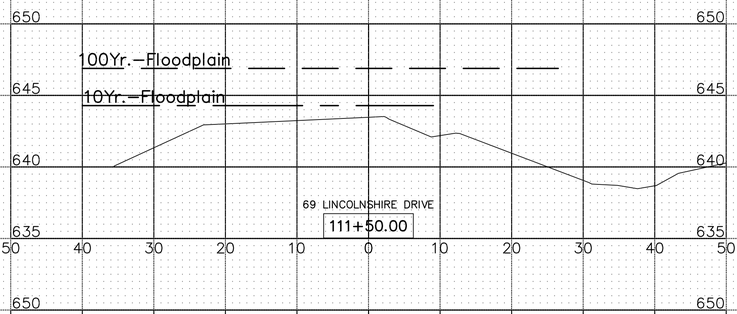

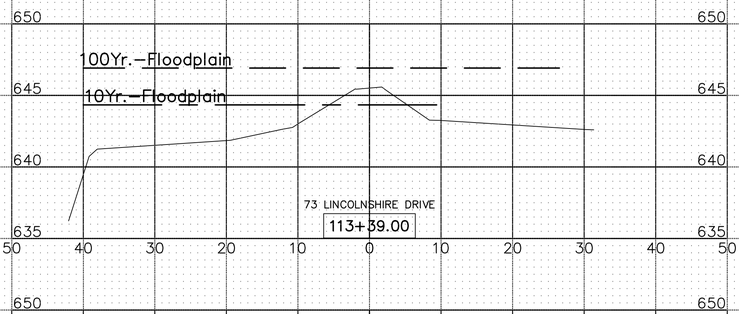

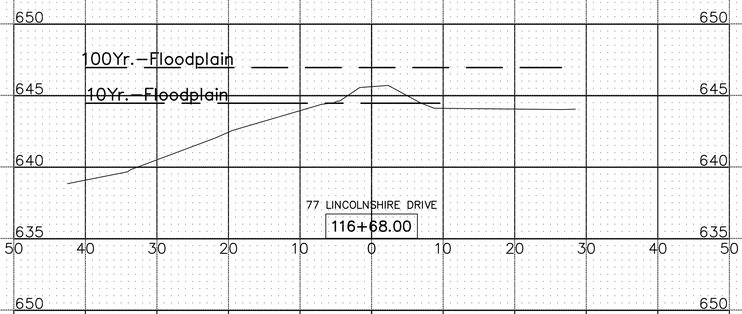

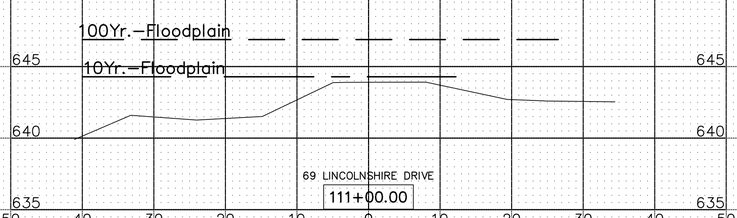

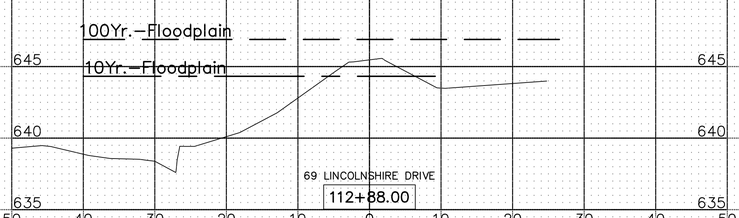

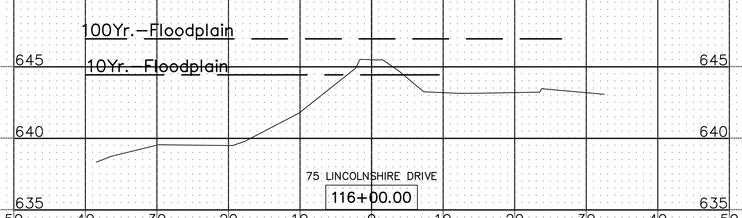

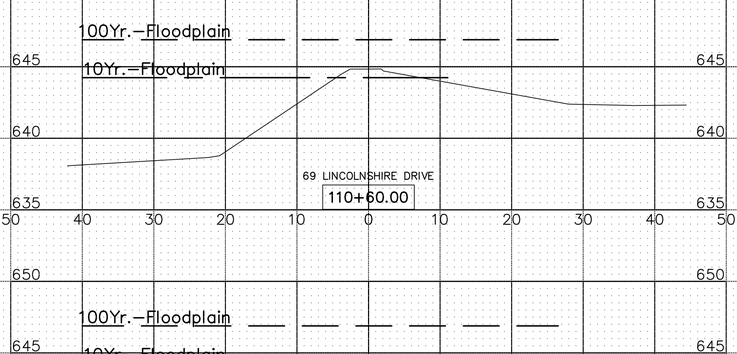

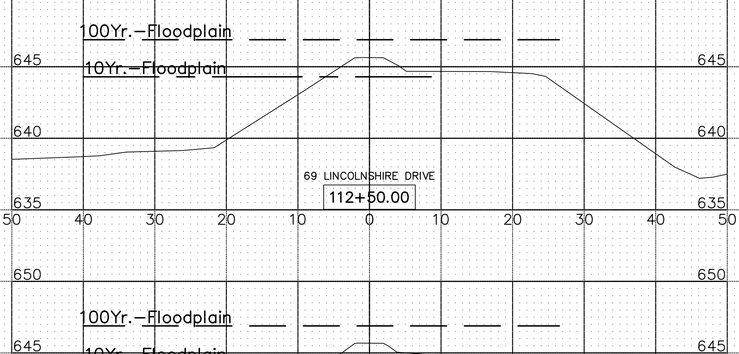

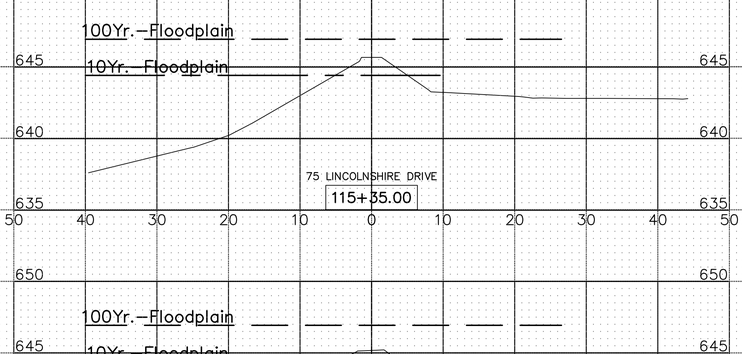

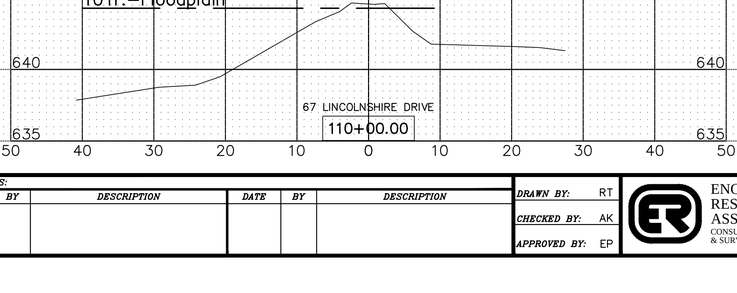

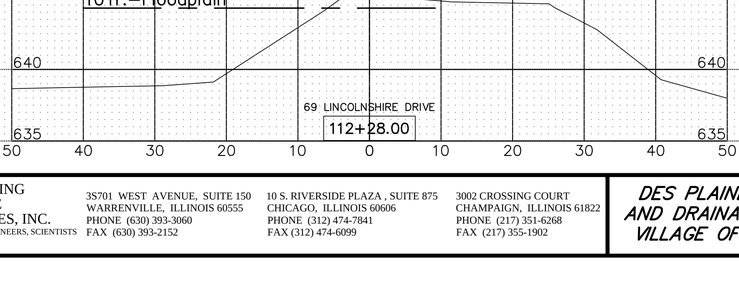

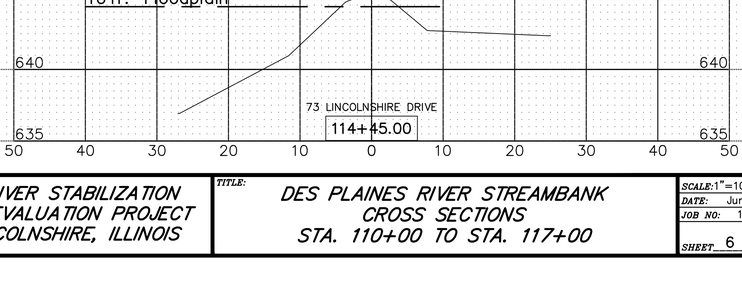

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DES PLAINES RIVER STABILIZATION AND DRAINAGE EVALUATION PROJECT
VILLAGE OF LINCOLNSHIRE, ILLINOIS

TITLE: DES PLAINES RIVER STREAMBANK CROSS SECTIONS
STA. 110+00 TO STA. 117+00

SCALE: 1"=10'H; 1"=5'V
DATE: June, 2015
JOB NO: 150510
SHEET 6 OF 7

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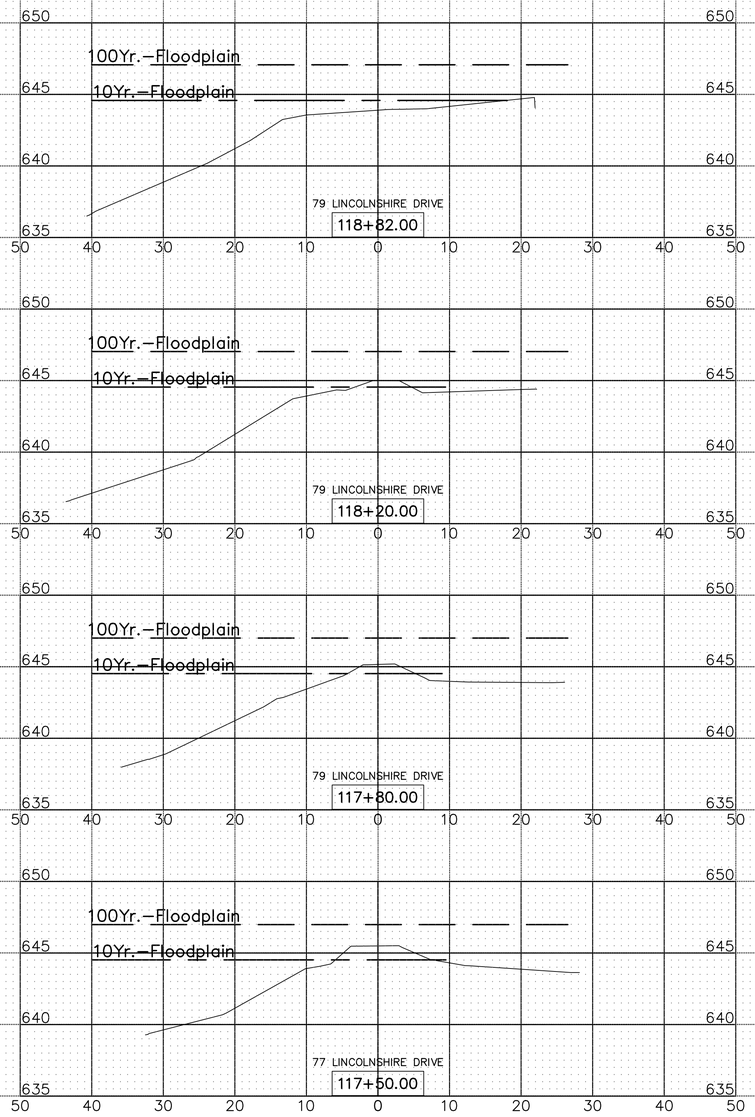

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DES PLAINES RIVER STABILIZATION AND DRAINAGE EVALUATION PROJECT
VILLAGE OF LINCOLNSHIRE, ILLINOIS

TITLE:
DES PLAINES RIVER STREAMBANK CROSS SECTIONS STA. 117+50 TO STA. 119+10

SCALE: 1"=10'H; 1"=5'V
DATE: June, 2015
JOB NO: 150510
SHEET 7 OF 7

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6.2 Improvements Plan

59

LEGEND

	EXISTING
EXISTING POST	
ELECTRIC	E
SANITARY SEWER	S
STORM SEWER/DRAIN LINE	D
PROPERTY LINE	
MANHOLE	
CATCH BASIN/YARD DRAIN	
YARD LIGHT	
WATER VALVE	
HYDRANT	
UTILITY POLE	
EXISTING TREE LINE EDGE	
EXISTING CONIFEROUS TREE	
EXISTING DECIDUOUS TREE	
TREE/STUMP TO BE REMOVED	
ELEVATION	+645.00
EXISTING CONTOUR	645
PROPOSED CONTOUR	645
EXISTING FENCE	X
10-YEAR FLOODPLAIN	10YR
PROPOSED SILT FENCE	XX
EXISTING AGGREGATE	
EXISTING COBBLES	
OPEN WATER	
BRUSH CLEARING	
WOOD RETAINING WALL REMOVAL	
DEBRIS REMOVAL	

NOTES:

1. TREE REMOVAL SHOULD INCLUDE REMOVAL OF STUMPS AND ALL ROOTS LARGER THAN 1.5 INCHES IN DIAMETER WITHIN 3' OF THE TREE TRUNK PERIMETER. EXCAVATION SHOULD THEN BE BACKFILLED WITH COMPACTED ENGINEERED FILL AND A MINIMUM 6" OF TOPSOIL.

2. PVC DRAIN REMOVAL SHOULD INCLUDE PROPER BACKFILL OF THE REMAINING AIR GAP WITH ENGINEERED FILL OR FLOWABLE FILL.

3. RAILROAD TIE REMOVAL SHOULD INCLUDE PROPER REGRADING OF THE SLOPE TO A MINIMUM 2.5' HORIZONTAL:1' VERTICAL SLOPE. FILL GREATER THAN 6" IN DEPTH SHOULD CONSIST OF COMPACTED ENGINEERED FILL AND 6" OF TOPSOIL.

4. COBBLE REMOVAL SHOULD INCLUDE FILLING OF ALL GAPS WITH TOPSOIL. FILL GREATER THAN 6" SHOULD CONSIST OF COMPACTED ENGINEERED FILL AND 6" OF TOPSOIL.

4. AREAS NOTED FOR EXCAVATION AND REPLACEMENT OF THE BERM SHOULD HAVE POOR SOILS REMOVED TO A MINIMUM 1' BELOW THE TOE OF SLOPE ELEVATION AND REPLACED WITH COMPACTED ENGINEERED FILL AND 6" OF TOPSOIL TO A MINIMUM ELEVATION CORRESPONDING WITH THE 10-YEAR FLOODPLAIN ELEVATION.

5. AREAS NOTED FOR BERM CREST WIDENING SHOULD HAVE ALL TOPSOIL STRIPPED PRIOR TO PLACEMENT OF COMPACTED ENGINEERED FILL. THESE SEGMENTS SHOULD RECEIVE 6" OF TOPSOIL.

6. ERODED AREAS NOTED FOR REPAIR SHOULD HAVE ALL REMAINING TOPSOIL STRIPPED PRIOR TO PLACEMENT OF COMPACTED ENGINEERED FILL. THESE AREAS SHOULD RECEIVE 6" OF TOPSOIL.

7. POST REMOVALS THAT REQUIRE FOUNDATION REMOVAL SHOULD INCLUDE BACKFILL WITH COMPACTED ENGINEERED FILL AND 6" OF TOPSOIL.

8. ALL AREAS OF LAND DISTURBANCE SHOULD BE RESTORED WITH SEED AND EROSION CONTROL BLANKET.

REVISIONS:					
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

DRAWN BY: A.J.
CHECKED BY: A.K.
APPROVED BY: J.M.

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DES PLAINES RIVER STABILIZATION AND DRAINAGE EVALUATION PROJECT
VILLAGE OF LINCOLNSHIRE, ILLINOIS

TITLE: DES PLAINES RIVER STREAMBANK PROPOSED CONDITIONS STA. 100+00 TO STA. 105+00

SCALE: 1"=40'
DATE: FEBRUARY, 2016
JOB NO: 150510
SHEET 1 OF 4

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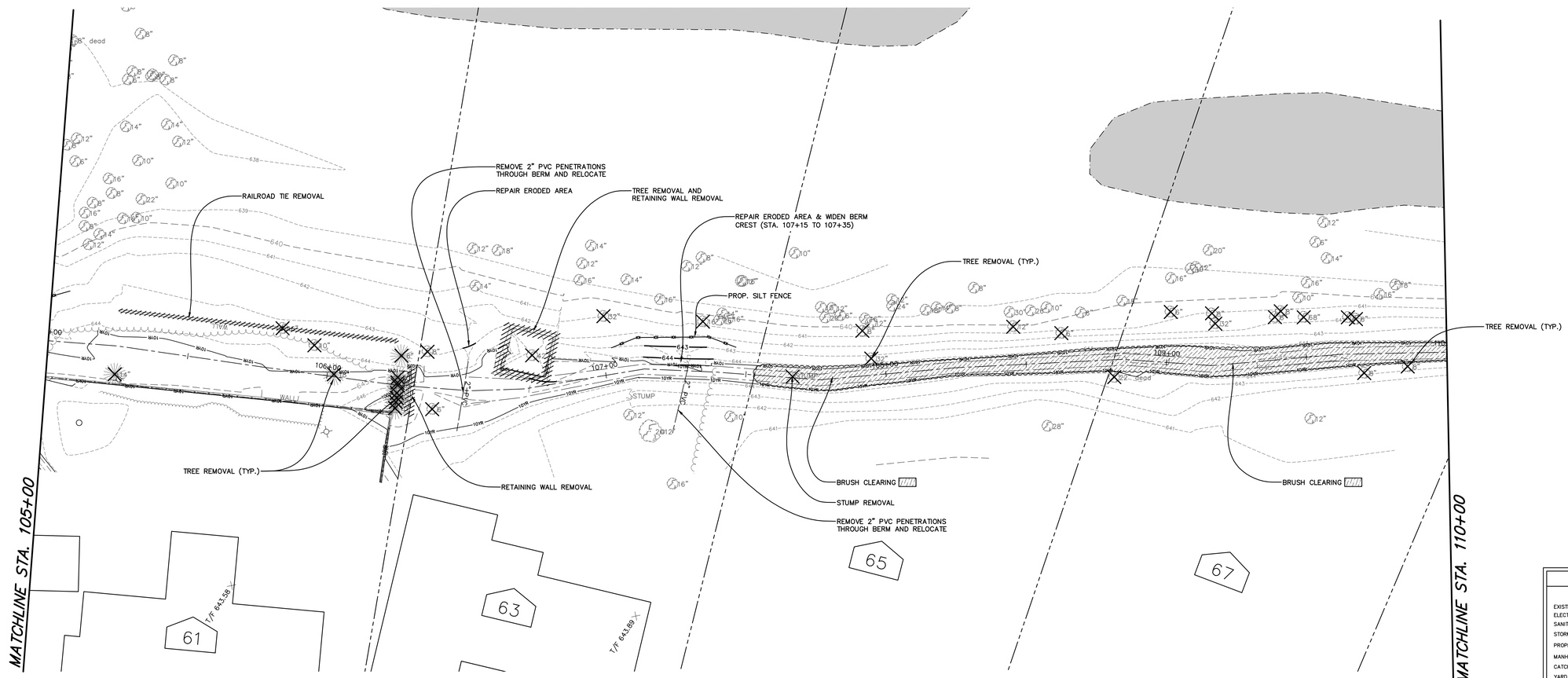

NOTES:

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LEGEND

	EXISTING
EXISTING POST	
ELECTRIC	E
SANITARY SEWER	S
STORM SEWER/DRAIN LINE	D
PROPERTY LINE	
MANHOLE	
CATCH BASIN/YARD DRAIN	
YARD LIGHT	
WATER VALVE	
HYDRANT	
UTILITY POLE	
EXISTING TREE LINE EDGE	
EXISTING CONIFEROUS TREE	
EXISTING DECIDUOUS TREE	
TREE/STUMP TO BE REMOVED	
ELEVATION	+ 645.00
EXISTING CONTOUR	645
PROPOSED CONTOUR	645
EXISTING FENCE	X
10-YEAR FLOODPLAIN	10YR
PROPOSED SILT FENCE	
EXISTING AGGREGATE	
EXISTING COBBLES	
OPEN WATER	
BRUSH CLEARING	
WOOD RETAINING WALL REMOVAL	
DEBRIS REMOVAL	

REVISIONS:					
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

DRAWN BY: A.J.
CHECKED BY: A.K.
APPROVED BY: J.M.

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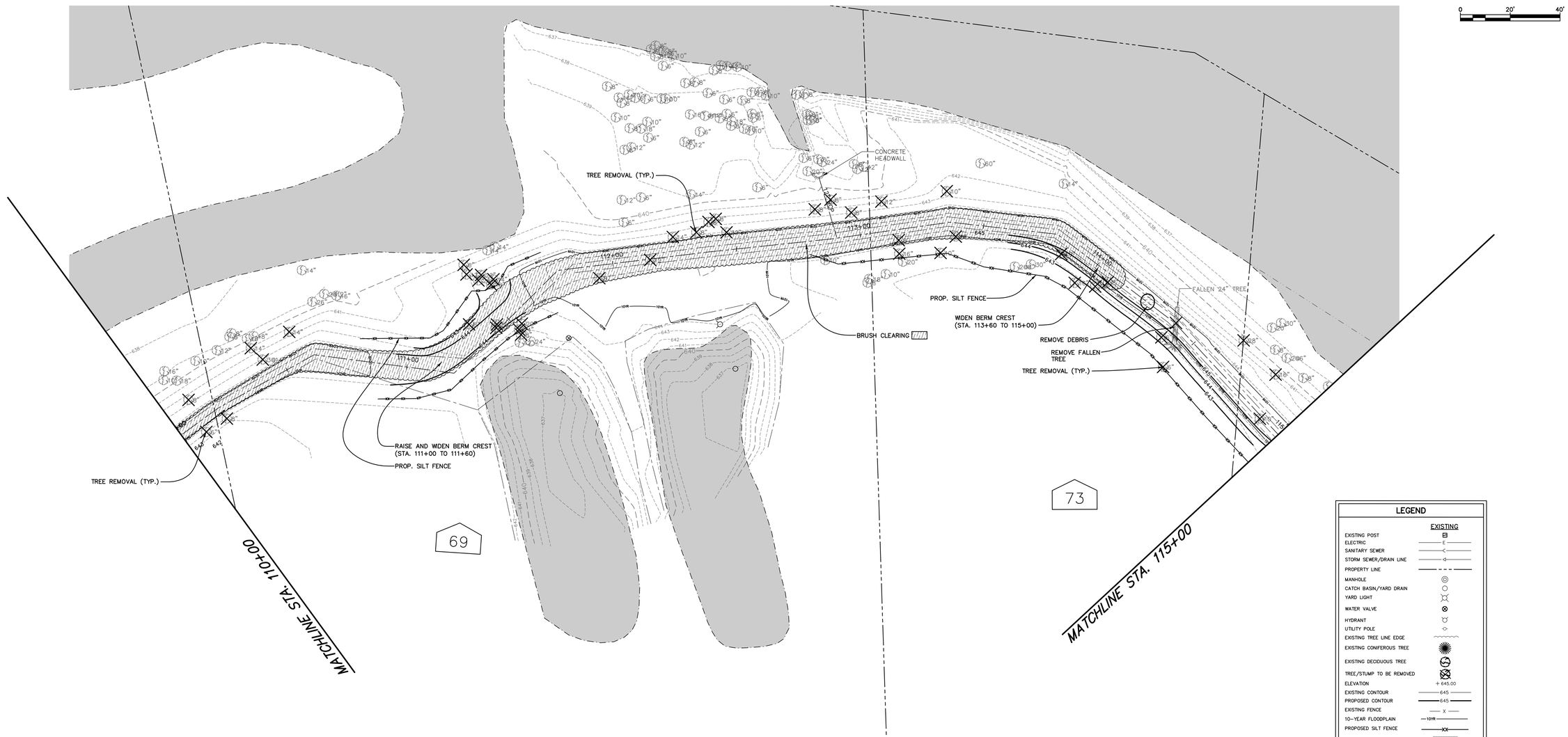
DES PLAINES RIVER STABILIZATION AND DRAINAGE EVALUATION PROJECT
VILLAGE OF LINCOLNSHIRE, ILLINOIS

TITLE: DES PLAINES RIVER STREAMBANK PROPOSED CONDITIONS STA. 105+00 TO STA. 110+00

SCALE: 1"=20'
DATE: FEBRUARY, 2016
JOB NO: 150510
SHEET 2 OF 4

H:\Lincolnshire\150510 Desplaines River Bank Stblz & Drain Eval\CADD\150510desPlainesRiverLincolnshire-GIS.dwg Updated by: dkostusch 10/17/2016



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	EXISTING
EXISTING POST	
ELECTRIC	E
SANITARY SEWER	S
STORM SEWER/DRAIN LINE	D
PROPERTY LINE	
MANHOLE	
CATCH BASIN/YARD DRAIN	
YARD LIGHT	
WATER VALVE	
HYDRANT	
UTILITY POLE	
EXISTING TREE LINE EDGE	
EXISTING CONIFEROUS TREE	
EXISTING DECIDUOUS TREE	
TREE/STUMP TO BE REMOVED	
ELEVATION	+ 645.00
EXISTING CONTOUR	645
PROPOSED CONTOUR	645
EXISTING FENCE	X
10-YEAR FLOODPLAIN	10YR
PROPOSED SILT FENCE	XX
EXISTING AGGREGATE	
EXISTING COBBLES	
OPEN WATER	
BRUSH CLEARING	
WOOD RETAINING WALL REMOVAL	
DEBRIS REMOVAL	

REVISIONS:					
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

DRAWN BY: A.J.
CHECKED BY: A.K.
APPROVED BY: J.M.

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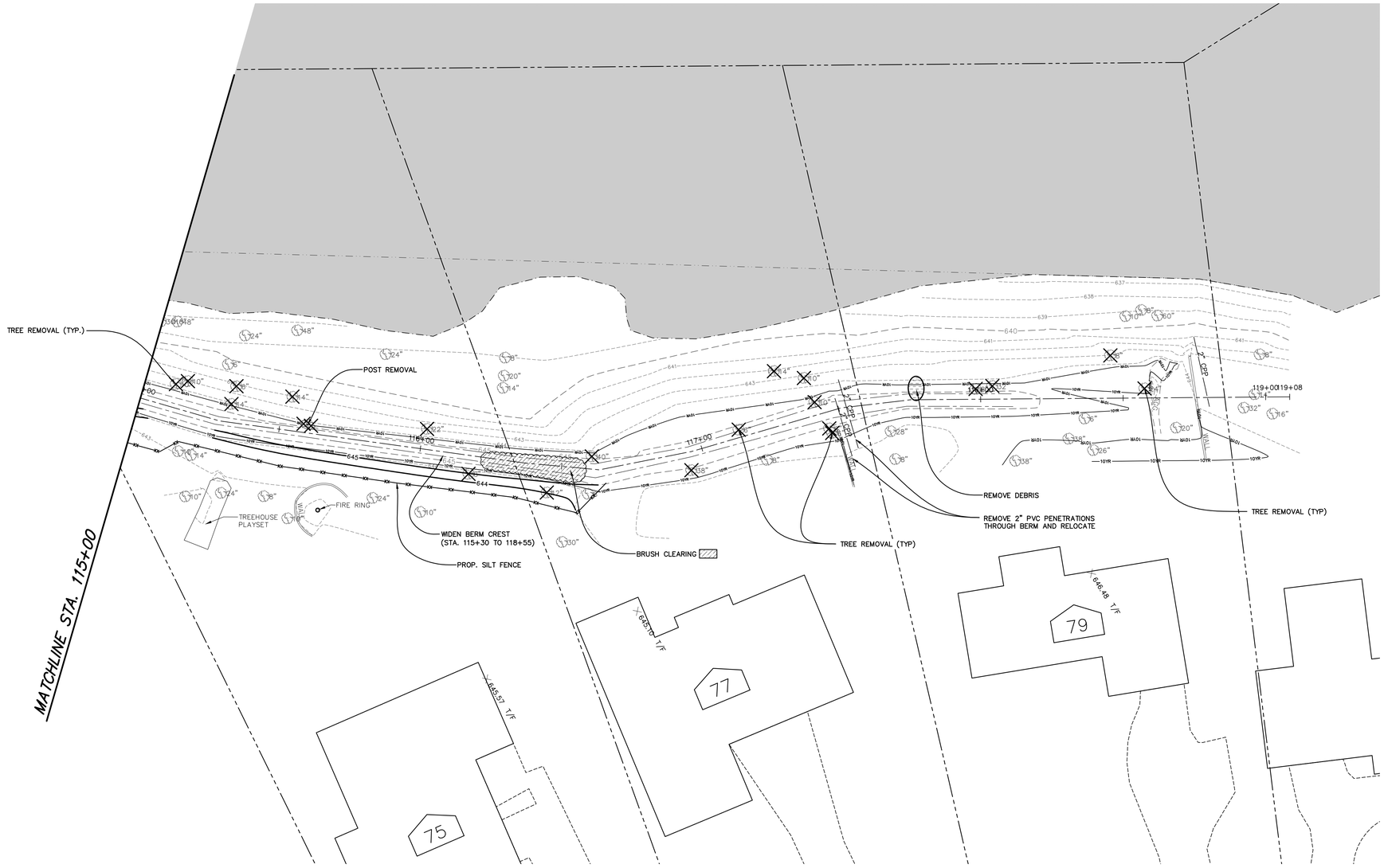
DES PLAINES RIVER STABILIZATION AND DRAINAGE EVALUATION PROJECT
VILLAGE OF LINCOLNSHIRE, ILLINOIS

TITLE: DES PLAINES RIVER STREAMBANK PROPOSED CONDITIONS STA. 110+00 TO STA. 115+00

SCALE: 1"=20'
DATE: FEBRUARY, 2016
JOB NO: 150510
SHEET 3 OF 4

H:\Lincolnshire\150510 DesPlaines River Bank Stblz & Drain Eval\CADD\150510desPlainesRiverLincolnshire-dtls.dwg Updated by: dkustusch 10/17/2016



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YARD LIGHT	
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SCALE: 1"=20'
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SHEET 4 OF 4

H:\Lincolnshire\150510 Desplaines River Bank Stblz & Drain Eval\CAD\150510DesPlainesRiverLincolnshire-GIS.dwg Updated by: okusturch 10/17/2016

6.3 Des Plaines River Floodway Data

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Deer Lake Drain								
A	2,982 [1]	340	319	0.4	759.6	759.6	759.7	0.1
B	4,412 [1]	80	78	1.5	761.6	761.6	761.7	0.1
C	4,625 [1]	76	154	0.8	762.2	762.2	762.3	0.1
D	6,935 [1]	140	140	0.8	766.2	766.2	766.3	0.1
E	7,042 [1]	200	576	0.2	768.3	768.3	768.4	0.1
F	8,912 [1]	107	186	0.6	769.2	769.2	769.3	0.1
G	9,023 [1]	340	1,045 [2]	0.1 [2]	770.5	770.5	770.6	0.1
H	11,263 [1]	850	9,340 [2]	0.1 [2]	770.5	770.5	770.6	0.1
I	12,343 [1]	220	158	0.3	770.8	770.8	770.9	0.1
J	12,454 [1]	520	1,400	0.0	771.4	771.4	771.5	0.1
K	16,254 [1]	1,180	6,820 [2]	0.1 [2]	771.4	771.4	771.5	0.1
Des Plaines River								
A	405,233 [3]	822	6,306	1.0	644.4	644.4	644.5	0.1
B	408,433 [3]	1,850	13,373	0.5	644.7	644.7	644.8	0.1
C	412,983 [3]	2,050	9,908	0.6	645.5	645.5	645.6	0.1
D	416,183 [3]	2,557	14,354	0.4	645.7	645.7	645.8	0.1
E	418,783 [3]	1,630	9,472	0.6	645.9	645.9	646.0	0.1
F	424,183 [3]	1,920 [4]	8,220	0.7	646.7	646.7	646.8	0.1
G	426,323 [3]	1,475 [4]	3,833	1.5	647.3	647.3	647.3	0.0
H	430,174 [3]	1,770	13,658	0.4	648.3	648.3	648.3	0.0
I	433,374 [3]	1,200	6,656	0.9	648.6	648.6	648.6	0.0
J	438,934 [3]	1,198	6,302	0.9	649.7	649.7	649.8	0.1

[1] Feet above confluence with North Mill Creek
[2] Approximate value
[3] Feet above mouth
[4] Widths include areas not inundated by the 1-percent-annual-chance flood

TABLE 13

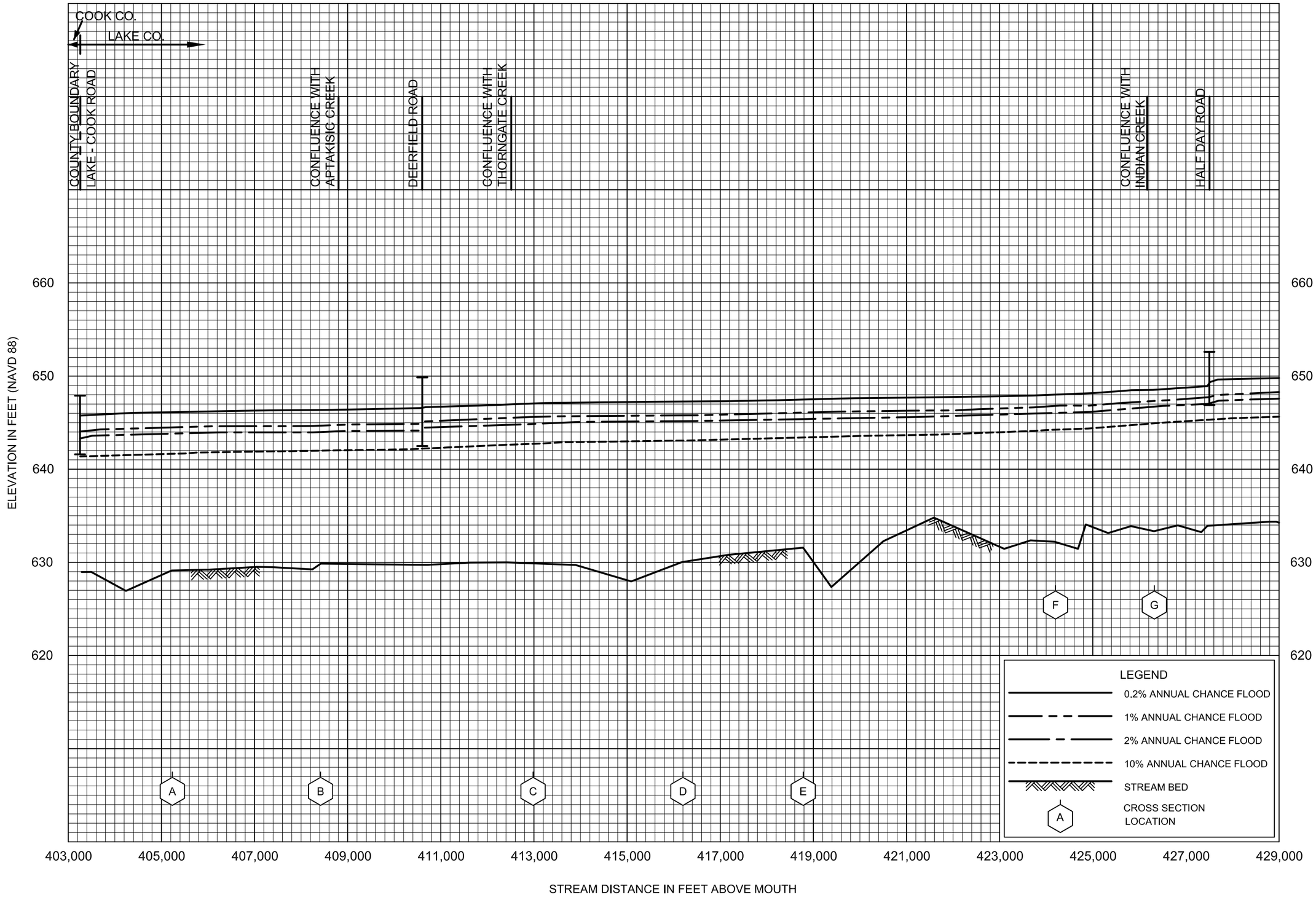
FEDERAL EMERGENCY MANAGEMENT AGENCY

LAKE COUNTY, IL AND INCORPORATED AREAS

FLOODWAY DATA

DEER LAKE DRAIN DES PLAINES RIVER

6.4 Des Plaines River Flood Profile



FLOOD PROFILES

DES PLAINES RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

LAKE COUNTY, IL

AND INCORPORATED AREAS

35P

6.5 Electronic Files (Available Upon Request)

1. **2-Year, 10-Year, and 100-Year Flood Limit High Resolution Images**
2. **Riverwoods Subdivision Drainage High Resolution Map**
3. **Existing Conditions Survey File**

7.0 REFERENCES

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