BOLTON & MENK, INC.

Consulting Engineers & Surveyors

City of Worthington, MN

Flood Mitigation Study

Nobles County Ditch 12

Submitted By:
BOLTON & MENK, INC.
1960 Premier Drive
Mankato, MN 56001

May 24, 2013

WORTHINGTON, MN
FLOOD MITIGATION STUDY
NOBLES COUNTY DITCH 12

May, 2013

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision, and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

By: _____

William Douglass, P.E.
License No. 18240

Date: May 24, 2013

TABLE OF CONTENTS

TABLES

APPENDICES

APPENDIX B

Opinions of Probable Construction Cost

PROJECT BACKGROUND

In September, 2010, the City of Worthington asked Bolton & Menk, Inc. to further study the hydrologic and hydraulic conditions along County Ditch (CD) 12, specifically the drainage options in the vicinity of the Hwy 59 Industrial/Commercial Park. Prior to this study, several options were summarized in the Corridor Master Plan performed by SEH, which described several rate control and water quality basins throughout the anticipated North Industrial/Commercial Development area. Also, Barr Engineering presented several drainage alternatives, which included a large span bridge, triple 9' by 9' box culverts, and a combination of upstream and downstream retention, channel expansion, and additional culvert capacity throughout the system.

Bolton & Menk, Inc. was hired to analyze the previously proposed improvements, determine the viability of those options, and modify the proposed industrial/commercial park improvements accordingly. That study and its conclusions culminated in the construction plans and construction contract for the TH 59 Infrastructure Improvements was awarded to R.L. Excavating, Inc. in September, 2012. The improvements being constructed include:

1. Rerouting CD 12 to decrease the current skewed crossing and to improve the economics of the proposed western extension of Bioscience Drive.
2. Building regional detention/treatment ponds upstream of the TH 59 crossing to mitigate peak flows upstream of Hwy 59. These regional detention/treatment basins also eliminate the need for rate control and water quality basins on each individual lot within the Hwy 59 Industrial Park
3. Avoiding the existing wastewater treatment plant utilities east of Hwy 59.
4. Reducing the size of the TH 59 bridge/culvert crossing.

Upon completing the final design for the TH 59 Infrastructure Improvement Project, the City of Worthington requested the expansion of the study to include a more detailed analysis of the flood prone CD 12 corridor upstream (south) of I-90. Bolton & Menk further analyzed the CD 12 system from the diversion structure near Oxford and Diagonal Road. Our TH 59 report cited several recommendations for this area and noted that the improvements need to be sequenced to limit the possibility of inadvertently compounding the flood problems elsewhere in the corridor. The preliminary list of potential improvements included the following:

1. Excavate a dry detention basin in the open area immediately upstream of where CD 12 crosses I-90. If the City plans on improvements to better attenuate flow from flood prone areas upstream of Oxford, this pond must be built to mitigate the increase in flows downstream of the I-90 crossing.
2. Increase the capacity of the Oxford Crossing near Marine Avenue (Carquest Auto Parts). Replacing the existing 8'x10' box culvert with a 10'x10' box culvert will increase the flow at this crossing and provide a corresponding reduction in upstream flooding.
3. Replace the existing 84" culvert at McMillan and the 80"x 68" arch Culvert at Oslo with a single, block-long 10'x10' box culvert. This will effectively eliminate the ditch between Oslo and McMillan Streets.

4. Reconstruct and widen the ditch between Oxford (near Diagonal Road) and McMillan Streets to allow better conveyance and increased linear storage within the ditch.
5. As an optional improvement, construct up to a 2.5 acre storage basin along the corridor between Oxford (west) and McMillan where space appears available. This additional storage would help provide better flow characteristics for existing storm sewer pipes flowing into this reach of CD 12.

This report summarizes our investigation of these four basic improvements and further describes:

- The construction ramifications.
- The construction and permanent easements needed.
- The logical sequencing to ensure that a phased construction scenario does not inadvertently increase flooding elsewhere in the system.
- Detailed Opinions of Probable cost for each phased improvement.

COMPARISON WITH PREVIOUS HYDROLOGIC STUDIES

Prior to the TH 59 study, several options were summarized in the Corridor Master Plan performed by SEH and the CD 12 study performed by Barr Engineering. The SEH study described storm water management in the proposed industrial park area north of I-90, but did not address the existing flow rates and volumes in CD 12 through town. The Barr study addressed flood control in the existing CD 12 system, but did not specifically address water quality and rate control in the proposed industrial park area. Each of these studies was examined and compared to the results of the TH 59 study. The comparison is summarized below.

SEH CORRIDOR MASTER PLAN COMPARISON

As stated above, the SEH Corridor Master Plan addressed storm water management in the proposed industrial park without considering improvements to the CD 12 system for upstream flood control. The following comparisons were made between the SEH study and the Bolton & Menk, Inc. TH 59 study.

SEH Concept: The SEH Corridor Master Plan laid out several options for individual storm water detention basins throughout the industrial park that addressed both rate control and water quality. This design would allocate the costs of the detention ponds to the owner or developer of each lot.

TH59 Improvement: Since storm water management within the industrial park as well as flood control in the upstream watershed are goals addressed in the TH 59 study, regional detention/filtration basins were determined to be more appropriate. The cost of the regional basins were included in the cost of improving the TH 59 crossing and were designed to address water quality and rate control requirements for the entire industrial park watershed draining to it. Further, the TH 59 improvements are funded through a Transportation Economic Development (TED) grant through the Minnesota Department of Transportation.

BARR ENGINEERING STUDY COMPARISON

The Barr study addressed improvements to the TH 59 crossing as well as flood management in the upstream watershed. However, some of the conceptual designs appeared to be conservative from a capacity perspective. The following comparisons were made between the Barr study and the TH 59 study.

Barr Concept No. 1: One alternative to improving the TH 59 crossing and mitigating flooding in the upstream portions of the watershed included a 150' span bridge. Since this would dramatically increase the capacity of the crossing, a 15-acre detention basin was also proposed downstream of the crossing to account for the increase in discharge.

TH 59 Improvement: Not only would a 150' span bridge be very costly, the size of detention basin required downstream to mitigate the increase in flows would also have been very costly. Also, the Barr study did not address a second control structure required at the outfall of the downstream regional detention basin that would ultimately be required to limit the peak outflow from the pond. Instead, two box culverts were designed into the TH 59 crossing and used as the ultimate flow rate control for all of the upstream improvements. Regional detention basins were designed upstream of TH 59. These upstream basins proved more effective at controlling peak flow rates and eliminated the need for multiple control structures in the system.

Barr Concept No 2: Triple 9' by 9' concrete box culverts were proposed at the TH 59 crossing plus nearly 30-acres of cumulative storage upstream of the I-90 crossing and other channel improvements for flood control.

Proposed Alternative: Bolton & Menk approached the study from a different perspective. The goal was to use the capacity of the existing system wherever feasible and work with storm water management concepts to the current system. This approach includes smaller added culverts that provide the same flow control. This approach combined with smaller storage areas throughout the system is proposed to provide the CD 12 system flood control from the Diversion near Diagonal Road through the I-90 crossing.

FEMA FLOOD INSURANCE RATE MAPS

Floodplain modeling and flood insurance rate mapping has a rich history in the City of Worthington. CD 12 has been rerouted several times during the life of FEMA's National Flood Insurance Program (NFIP) and the known iterations are described as follows.

1. Currently, CD 12 has an approved Zone AE floodplain and Flood Insurance Study (FIS) with an effective date of 1984. The 1984 report includes the realignment of CD 12 north of Interstate 90, but not the realignment between Oxford and I-90. The model was created in the US Army Corps of Engineers HEC-2 hydraulic modeling software.
2. In 1998, a Letter of Map Revision (LOMR) was approved to correct the floodplain boundary based on modifications to CD 12 between Oxford and I-90. This modeling was also created using HEC-2.

3. Recently, preliminary Digital Flood Insurance Rate Maps (DFIRM) were released for Nobles County. The floodplain delineation was developed by projecting flood elevations on the LiDAR topography using a reproduction of the HEC-2 model developed in 1998. In other words, while the elevation data is current, the flood elevations were generated using out of date hydraulic modeling software that may be missing pertinent structure data. As of March 25, 2013, the public comment period associated with these new DFIRM maps has not begun for Nobles County. See Figure 4 for the preliminary DFIRM extents.
4. Barr Engineering produced a floodplain model of CD 12 utilizing both current topography and more current hydraulic modeling software called HEC-RAS by the US Army Corps of Engineers. The original intent of the model was for it to be adopted as the effective model in the new DFIRM production. However, the model was not submitted to FEMA because it did not provide significantly different results from the 1998 HEC-2 model.

Bolton & Menk, Inc. further developed the existing and proposed models using Storm and Sanitary Analysis developed by Autodesk, Inc. which utilizes TR-20 and TR-55 hydrology methodologies to route hydrographs through the system. SSA and the TR-20/55 methods were chosen to more accurately model the storage volumes associated with CD 12 through town. The HEC-RAS model produced by Barr has been reviewed and was used to calibrate the SSA hydrologic models. For this study, the 2-year, 10-year, and 100-year rainfall events were modeled. The corresponding rainfall depths for these events are 2.8 inches, 4.2 inches, and 6.0 inches, respectively. These events have respective probabilities of recurrence of 50%, 10%, and 1% in any given year. Due to the flat slopes along CD 12 and the expansive storage within the study area, we believe that volumetric modeling of time-varied flow rates and storage provides a more accurate representation of the flooding condition. This is because the HEC-RAS and HEC-2 models only dealt with peak flow rates at various input locations and the actual 100-year event (1% probability of return) flows are generated from a limited drainage area that will not deliver a continuous flow. Further, the existing models do not accurately consider the available flood storage in the system. They only analyze the flood conveyance capabilities of the delivery system of CD 12. Therefore, upon completion of this study and further construction of the recommended flood mitigation improvements, it may be in the City's best interest to redefine the floodplain through an official Letter of Map Revision (LOMR) to FEMA.

EXISTING DRAINAGE CONDITIONS

Figure 1 in Appendix A displays the watersheds for the CD 12 system. Approximately 9,232 acres of primarily agricultural land use drains to the Diagonal Rd diversion structure. The inflow to the City portion of CD 12 (i.e., between Diagonal Rd and Hwy 59) is regulated by a slide gate structure and three 42" corrugated metal pipes (CMP). During normal flows, the slide gates are closed and all discharge continues through Whiskey Ditch and into Okabena Lake. During high flows, Okabena Lake backflows into Whiskey Ditch and the flood control gates are opened to allow the higher flows to discharge into CD 12. The hydraulic conditions at Diagonal Rd are such that the Whiskey Ditch elevation at the diversion structure enables an estimated maximum 480 cubic feet per second (cfs) of flow into CD 12 for the 1% rainfall event. Based on the size of the contributing watershed upstream of the diversion stricture and the storage of Okabena Lake, this flow is assumed to be constant.

The McMillan St. crossing is a hydraulic bottleneck in the CD 12 system in that the current 84" reinforced concrete pipe (RCP) cannot attenuate the flow from the diversion structure plus the additional 330 acres of primarily residential watershed. In turn, the upstream (head water) elevation overtops McMillan St. and causes flooding in the low lying residential areas upstream of the crossing. A similar situation occurs at the east Oxford culvert crossing. Although the headwater elevation does not overtop the road, the elevation is high enough to cause flood waters to back up into the low lying residential areas. Peak water surface elevations tend to remain relatively low throughout the remainder of the system to the Hwy 59 crossing, and flooding is not an issue. Figure 4 displays the current flood extents according to FEMA as defined by preliminary Zone AE DFIRM.

PROPOSED DRAINAGE CONDITIONS

Prior to this study, several options for drainage improvements and flood mitigation were considered by the City. These options were presented by Barr Engineering and were further analyzed as part this study. For purposes of this report, the TH 59 Infrastructure Improvements, bid in September, 2012, are considered to be complete. Hence, only improvement recommendations between the diversion structure and I-90 are investigated as part of this report. The proposed drainage improvements include planning future measures to mitigate the impacts of flooding due to large rainfall events between the east and west Oxford St crossings by improving the capacity of the existing system and providing additional flood storage in the watershed upstream of I-90.

The previous TH 59 study proposed several different hydraulic scenarios and each were reviewed for its viability relative to the goals described above. By using a volumetric, watershed sensitive modeling software rather than a strictly flow rate driven software, it was discovered that several of the options proposed in the previous study were extremely conservative from a capacity perspective. In other words, in places where a bridge or triple box culverts were proposed, our volume based modeling found that fewer, smaller culverts will achieve the same flow conveyance goals. Where more than 30 acres of storage were proposed for flood mitigation in the previous study, our study found that approximately 20 acres will suffice.

RECOMMENDED DRAINAGE IMPROVEMENTS

FLOOD MITIGATION

The goal of this study is to determine the necessary future improvements to help mitigate the peak elevations from the 1% probability rainfall event in CD 12 through town. According to the existing hydrologic model, as well as the available HEC-RAS models, the McMillan crossing is undersized for the drainage area and diversion structure flow it serves. Therefore, the crossing is proposed to be increased. The increase in capacity will, in turn, increase discharge rates downstream. Therefore, additional storage and conveyance improvements are proposed. The order in which these improvements are constructed will have varying affects on the overall flood mitigation strategy. Based on available funding and the City's anticipated development plans, specific flood mitigation strategies should be constructed before others in order to reduce adverse downstream impacts due to increase in flow rates or runoff volume. When all of the proposed measures are constructed, the overall flood mitigation goals will be achieved,

but it is important to understand the overall affects on the system as each individual measure is constructed. The overall proposed drainage improvements are displayed in Figure 3 and the recommended construction sequence for flood mitigation at each stage are further described below. Also, see Figures 10 to 14 for a profile of CD 12 from the diversion structure to I-90 including culvert and channel improvements and existing and proposed water surface profiles.

1. **Construct I-90 Regional Basin -** Construct an 8.3-acre flood storage area, referred to as the I-90 Basin in Figure 3, immediately upstream of the I-90 crossing to mitigate the increase in discharge from the proposed McMillan and Oxford culvert enlargements. Since increasing culvert sizes upstream of I-90 will increase the flow rate to the current I-90 crossing, this basin must be constructed prior to upsizing any upstream culverts in order to avoid flooding in the industrial park. Constructing this pond will also reduce the current flood elevations upstream of the east Oxford crossing by lowering the downstream peak elevation at the culvert. The flooding upstream of the east Oxford culvert is partly the result of backwater effects. The effect of increased culvert capacity is further described below. See Figure 5 for the anticipated affect to the flood plain limits based on the I-90 regional basin construction.

2. **Replace East Oxford Crossing -** Replace the existing 8'x10' box culvert with a 10'x10' box culvert at the east Oxford crossing to help convey the additional discharge from the McMillan and Oslo improvements and to help reduce the peak water surface elevation at Oxford. The additional pipe should be constructed only if the I-90 Regional Basin is constructed. Also, the additional pipe should be constructed prior to any additional upstream culvert upsizing projects. Upsizing the eastern Oxford crossing will reduce the flood elevation between Oxford and McMillan. However, there will still be flooding upstream of Oslo and McMillan Streets due to the insufficient capacity of these existing culverts. See Figure 6 for the anticipated affect to the flood plain limits based on the I-90 regional basin construction and the proposed East Oxford crossing improvements.

3. **Replace Oslo & McMillan Crossings** - The existing McMillan and Oslo culvert crossings cause a significant back up of storm water resulting in widespread flooding upstream. In order to mitigate this flooding, we are recommending the construction of a long, single culvert extending from McMillan through Oslo. A 10'x10' concrete box culvert is recommended to "pull the plug" in this part of the CD 12 system. Increasing the pipe capacity will inevitably increase the discharge downstream. Therefore, it is vital that design components 1 and 2 above are constructed prior to the reconstruction of this crossing. See Figure 6 for the anticipated affect on the flood plain limits based on the proposed I-90 regional basin construction together with the east Oxford and the McMillan-Oslo culvert improvements.

   Since the homes along the proposed culvert corridor are relatively close to the construction area and would likely be situated in a utility easement, it is anticipated that these properties would need to be acquired. See Figure 7 for an exhibit showing the anticipated property acquisitions and utility easements. Once acquired, these lots should be left open.

4. **Ditch Cleanout and Widening –** The ditch between McMillan and Oxford (west) has become overgrown with trees that may be affecting the ditch capacity. Hence, we are recommending cleaning and widening the ditch in this vicinity. Figure 7 shows the anticipated widening area and a typical cross section of the improvements. To reduce the need for permanent easement on the south side of CD 12, channel improvements should be on the north side of the ditch, which will likely require acquisition of the north properties. While this option will improve flow conveyance during low flow periods and reduce the chance of debris interference during flood events, there isn't a significant reduction in flood elevation for the 100-year rainfall event. Therefore, Option 4 has not been included in Table 1 below.

5. **Additional Flood Storage (Optional) –** A 2.5 acre flood storage area, referred to as the Diagonal St Basin in Figure 3, will help further mitigate flooding upstream of Oslo. This additional flood storage will help reduce the hydraulic grade line in CD 12 and should reduce the backup of storm sewer that causes localized flooding in the adjacent landlocked low areas. This flood storage area can be constructed at any point during the City's proposed development plan as no other improvements are dependent on its construction. Figure 8 represents all of the constructed improvements.

   For purposes of this report, we have estimated the construction of a 2.5-acre optional storage basin. However, alternative flood storage could be effective and should be considered if reasonable acquisition opportunities become available. While these additional flood storage improvements are options, it is in the City's best interest to acquire properties along the flooding corridor, or those with the greatest risk of flooding to ensure the safety of its residents. Having surplus potential storage available will have the effect of lowering the overall peak flood levels and provide for improved capacity of the existing storm sewers outletting into CD 12.

The proposed flood mitigation improvements should be constructed in the order described herein so that the hydraulic changes do not cause adverse flooding conditions upstream or downstream of the improvement. While each improvement provides a localized flood mitigation benefit, the overall reduction in flood elevation for CD 12 will not be realized until all improvements are in place. Table 1 below is a summary of the individual flood elevation reduction as the projects are constructed. The shaded cells indicate that no improvement will be constructed at that location. The reconstruction of the Oslo/McMillan crossing will increase the discharge rate downstream and, hence, the peak water surface elevation at Oxford, I-90, and TH 59. However, even prior to any floodplain expansion projects, those elevations are still lower than the Post TH 59 improvements. After adding the recommended storage expansion, the water surface elevations at Oxford, I-90, and TH 59 will be further mitigated.

Table 1: Summary of 1% Peak Elevations based on recommended order of construction.

Improvement Project	1% Rainfall Event, Peak Flood (Head Water) Elevation (ft)			
	TH 59 Crossing	I-90 Culvert Crossing	Eastern Oxford Crossing	Oslo/McMillan Crossing
Post TH 59 Improvements	1567.6	1571.1	1572.5	1576.0
Flood Imp. Proj. 1	1566.3	1569.0	1570.7	1575.8
Flood Imp. Proj. 2	1566.3	1569.0	1570.4	1575.8
Flood Imp. Proj. 3	1567.1	1570.3	1572.1	1573.1
Flood Imp. Proj. 5	1567.0	1570.1	1571.7	1572.6

OTHER CONSIDERATIONS

1. Permitting Requirements

Several permits are expected to be part of the process in the comprehensive improvement plan.

A. A permit will be required from the Minnesota Pollution Control Agency (MPCA) for storm sewer and erosion control on the project. This permit requirement, which applies to any project that disturbs more than 1 acre of land, requires that the Contractor and Owner secure a permit for the project. The permit process will also require erosion control measures to be taken during the construction. Typical erosion control measures include placement of temporary ditch blocks, use of velocity check dams and silt fence as well as the establishment of turf within 14 days after construction activity in an area that has temporarily or permanently ceased.

B. A permit will be required from the Minnesota Department of Natural Resources (DNR) for work in protected waters, because this reach of County Ditch 12 is listed as a protected water. This permit is not anticipated to be difficult to obtain as the waterway has been previously altered. Also it is a designated County Ditch.

C. A permit will be required from the US Army Corps of Engineers (COE) for work in Federally protected waters. As with the DNR permit, this permit is not anticipated to be difficult to obtain as the waterway has been previously altered.

D. A permit will be required from the Minnesota Department of Transportation for work in Mn/DOT Right-of-way.

E. City will need to petition the County Board and the drainage authority for any proposed improvements to County Ditch 12.

2. Wetlands

A wetland investigation of the areas to be impacted by each proposed improvement should be conducted prior to final design and bidding.

3. FEMA Letters of Map Change (LOMC)

As flood mitigation measures are constructed, the floodplain delineation will change. In order for the new boundary and associated elevations to be altered and current policy holders to be effectively removed from the floodplain, a LOMR will need to be completed. This will officially publish the changed elevations with FEMA and allow for accurate regulation of the floodplain.

OPINIONS OF PROBABLE COST

The preliminary cost estimates associated with the storm water management alternatives described above include:

1. Opinions of construction costs.
2. 10% contingency factor.
3. Estimated engineering and administrative services.
4. Assumed utility relocation costs.
5. Property acquisition costs as supplied by the City of Worthington.

As with all estimates of this nature, they are based on current construction costs and should be adjusted annually to account for inflation, bonding costs, legal costs, interest costs, etc. This includes potential acquisition of properties in the vicinity of the Oslo/McMillan crossing improvements and other utility relocation costs associated with the flood management improvements along CD 12. The opinions are only based on past construction costs and can vary depending on the exact properties of the improvement area and site topography. Also, the opinions of probable cost include considerations for property acquisition, utility relocation, and temporary construction easements. These areas are further summarized in Figure 9. See Appendix B for further break down of the opinions of probable cost.

Table 2: Summary of estimated costs.

Improvement Stage	Estimated Cost
1. Construct I-90 Regional Basin	$2,860,000
2. Replace East Oxford Crossing	$244,000
3. Replace Oslo & McMillan Crossings	$841,000
4. Ditch Cleanout and Widening	$1,018,000
5. Additional Flood Storage (Optional)	$1,202,000
TOTAL:	**$6,165,000**

SUMMARY AND RECOMENDATIONS

Prior to this study, several hydraulic and hydrologic models were created to estimate the peak flows and hydraulic grade line profiles for the CD 12 system in Worthington, MN. The models were used to predict

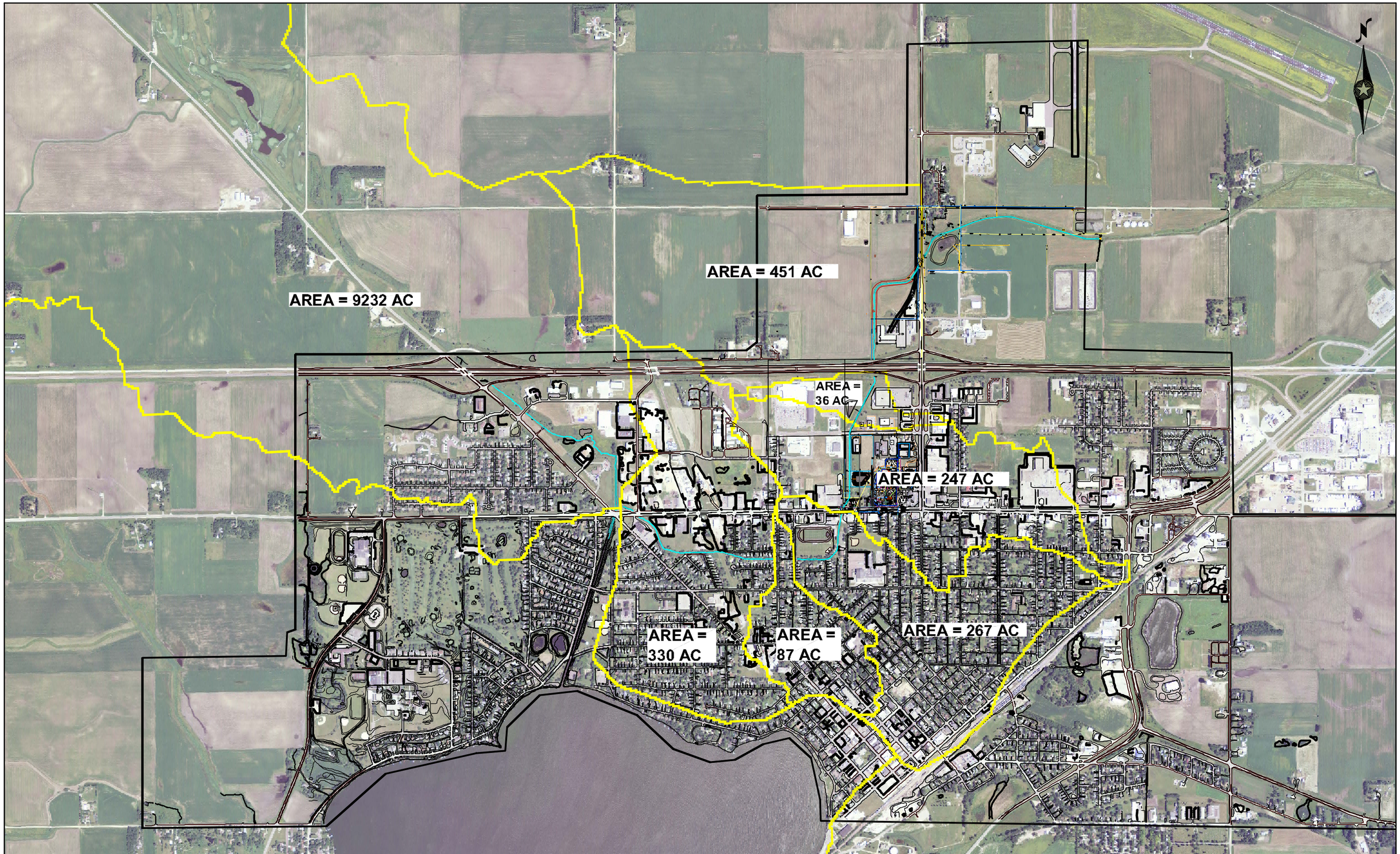
the existing conditions as well as calculate the impact of future development and propose several flood mitigation and storm water management concepts. The options discussed in studies performed by Barr Engineering and SEH in previous storm water management studies were reviewed and considered in this study, and additional recommendations were made based on the results of the Bolton & Menk, Inc. watershed based hydraulic and hydrologic modeling.

The proposed flood mitigation calculations include the affects of the Commercial/Industrial Park drainage improvements incorporated with the Hwy 59 crossing improvements, the Bioscience Drive extension, and the regional pond layout. The following is a sequential summary of the recommended Improvements. Again, it is imperative that these recommended improvements be constructed in sequence to avoid inadvertently causing localized increases in the floodplain elevations elsewhere in the study area.

1. The Ryans Rd crossing currently has available capacity to handle the additional discharge from the expanded McMillan/Oslo and Oxford crossings, but the I-90 crossing does not. Therefore, it is recommended that additional flood storage be provided in the triangular area south of the Interstate. An additional 49 acre-feet of storage is proposed to accommodate the additional discharge and maintain the existing I-90 crossing. This dry detention basin is needed to mitigate excess runoff sent downstream from the proposed McMillan, Oslo and Oxford crossing improvements.
2. We recommend replacing the existing 8'x10' box culvert at the eastern Oxford St crossing with a 10'x10' concrete box culvert. This will accommodate the additional flow as well as reduce the peak water surface elevations below the existing condition. This will, in turn, assist in mitigating flood conditions upstream of the Oxford crossing. The recommended Oxford crossing scenarios is needed to mitigate the excess runoff sent downstream from the recommended McMillan-Oslo culvert improvements.
3. From the study, it was determined that McMillan St. is a hydraulic bottleneck in the CD 12 system through town. Therefore, it is recommended that the McMillan and Oslo crossings be replaced by a single 380-ft long, 10'x10' concrete box culvert in order to reduce peak flood elevations upstream of McMillan. This work may be completed at a later date than when funding becomes available.
4. This report applies to the hydrologic and hydraulic assumptions for rainfall runoff computations up to February, 2013. It is anticipated that the Natural Resources Conservation Service (NRCS) will be re-releasing Technical Paper (TP) 40 which will redefine the probability of return for standard rainfall events based on several decades of new rainfall data. Upon completion of these updates, the storage computations performed in this report may change. To offset this possibility, we recommend securing available additional flood storage area just south of the industrial area located south of Oxford St and east of Diagonal Rd. There is currently a large green space in this area and the potential 7.0 ac-ft flood storage area would remain an open grassed area in the proposed conditions. This work may be done at a later date when funding becomes available.

When all of these improvements are complete, the peak flood levels will be reduced throughout the system from the diversion at Whiskey Ditch to the I-90 crossing. As such, other drainage improvements within the system may become more viable.

APPENDIX A



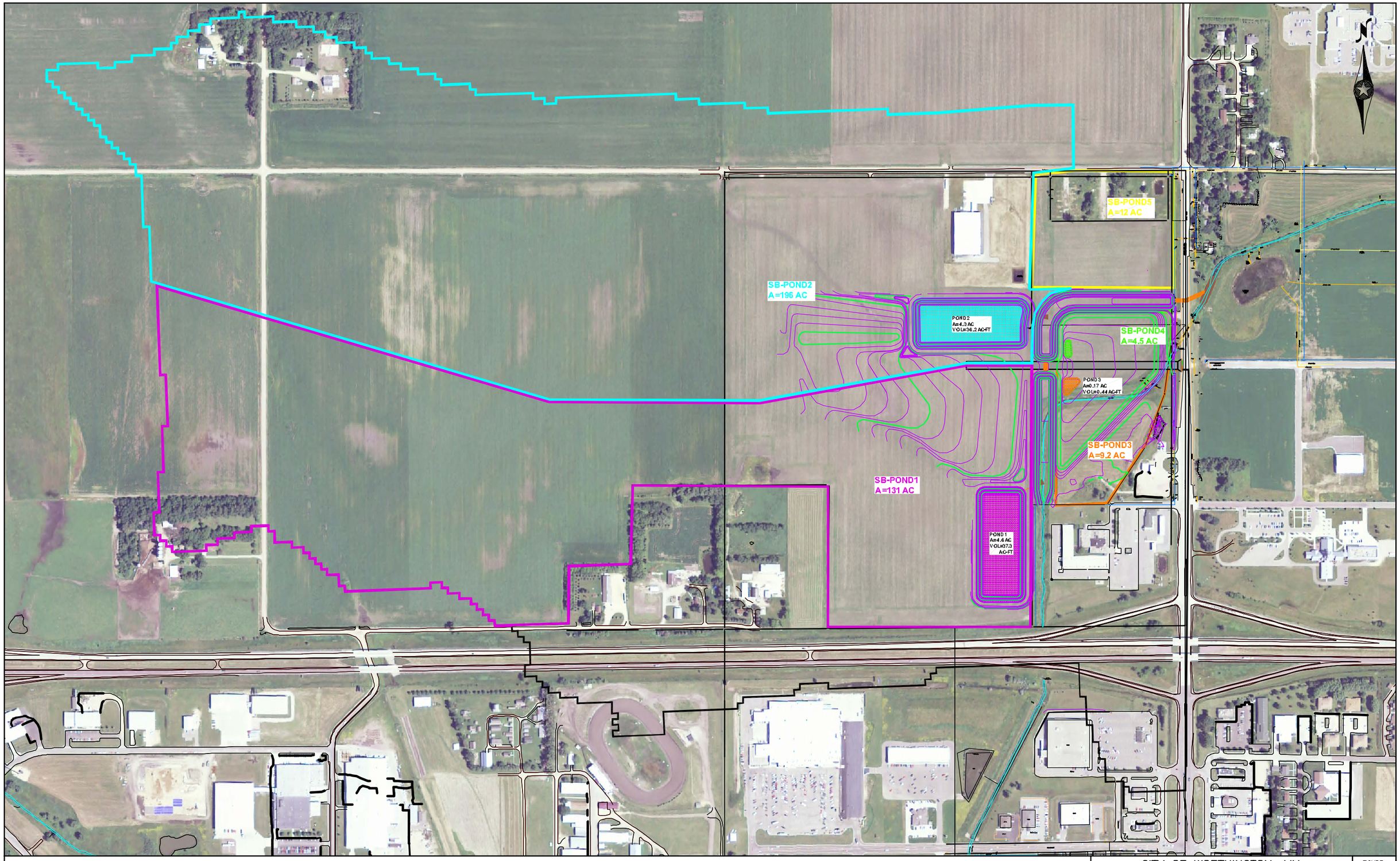
0 1500 3000
SCALE FEET

H:\WGTN\F13102940\EP\102940BSE_figures.dwg 11/27/12 4:17 pm

BOLTON & MENK, INC.
Consulting Engineers & Surveyors
MANKATO, MN FAIRMONT, MN SLEEPY EYE, MN WILLMAR, MN
BURNSVILLE, MN CHASKA, MN RAMSEY, MN AMES, IA

CITY OF WORTHINGTON, MN
2010 INDUSTRIAL/COMMERICAL PARK
CD 12 WATERSHED EXHIBIT

FIGURE 1



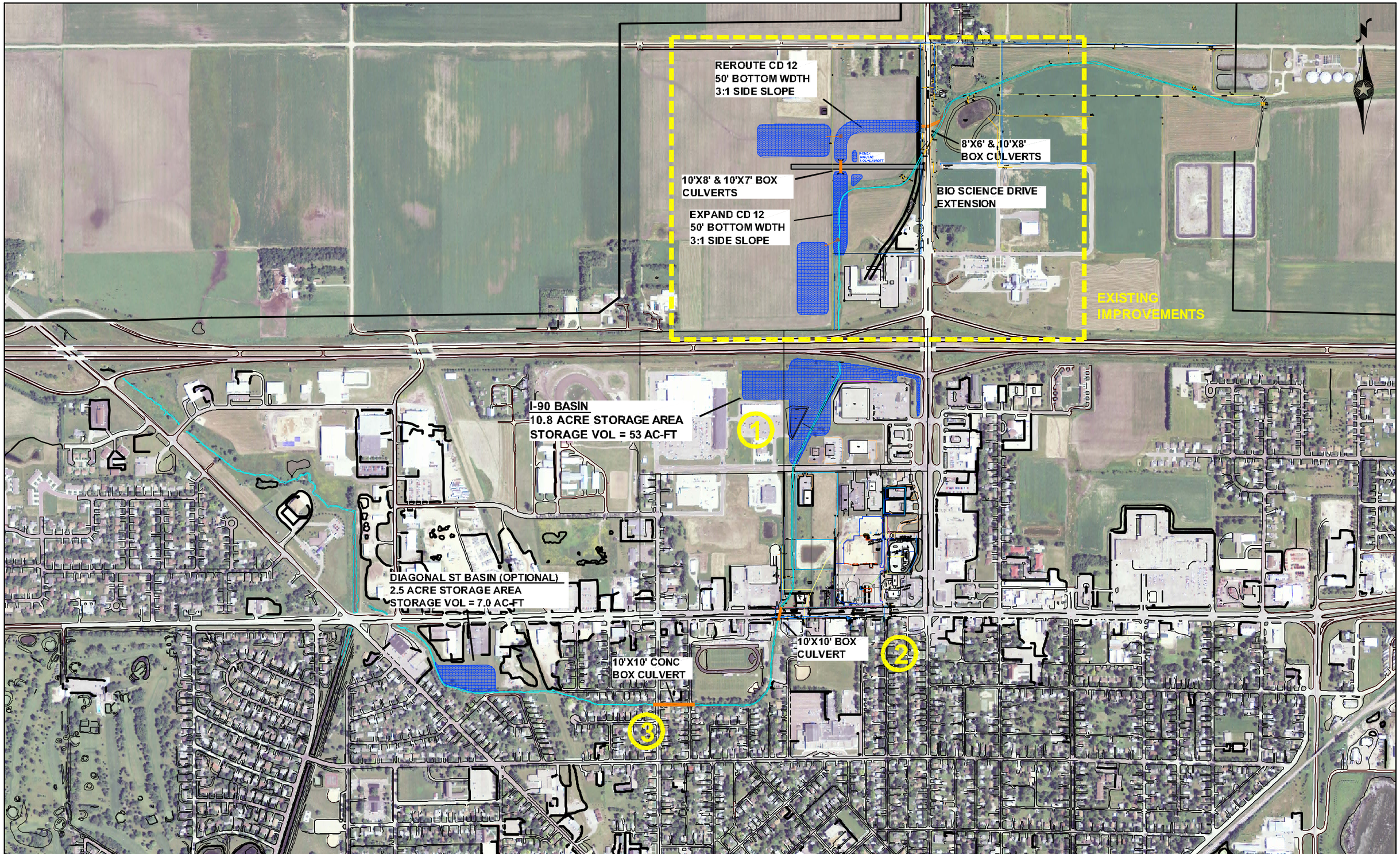
0 250 500
SCALE FEET

H:\WGTN\F13102940\EP\102940BSE_figures.dwg 11/27/12 4:17 pm

BOLTON & MENK, INC.
Consulting Engineers & Surveyors
MANKATO, MN FAIRMONT, MN SLEEPY EYE, MN WILLMAR, MN
BURNSVILLE, MN CHASKA, MN RAMSEY, MN AMES, IA

CITY OF WORTHINGTON, MN
2010 INDUSTRIAL/COMMERICAL PARK
FUTURE INDUSTRIAL/COMMERCIAL PARK
REGIONAL POND LAYOUT CONCEPT

FIGURE
2



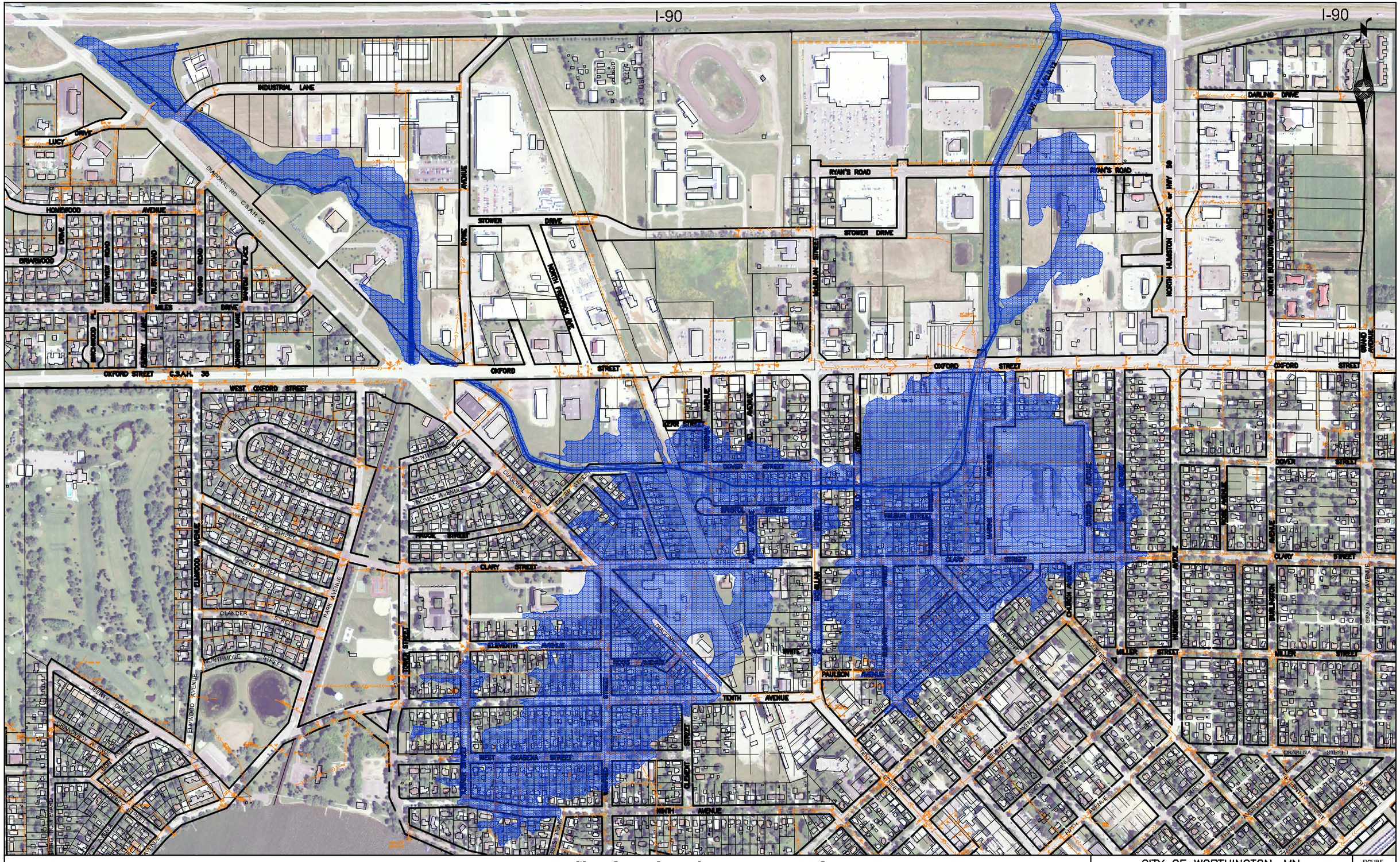
0 400 800
SCALE FEET

H:\WGTN\F13102940\EP\1029408SE_figures.dwg 3/25/13 7:22 am

BOLTON & MENK, INC.
Consulting Engineers & Surveyors
MANKATO, MN FAIRMONT, MN SLEEPY EYE, MN WILLMAR, MN
BURNSVILLE, MN CHASKA, MN RAMSEY, MN AMES, IA

CITY OF WORTHINGTON, MN
2010 INDUSTRIAL/COMMERICAL PARK
FLOOD MANAGEMENT CONCEPTS

FIGURE
3



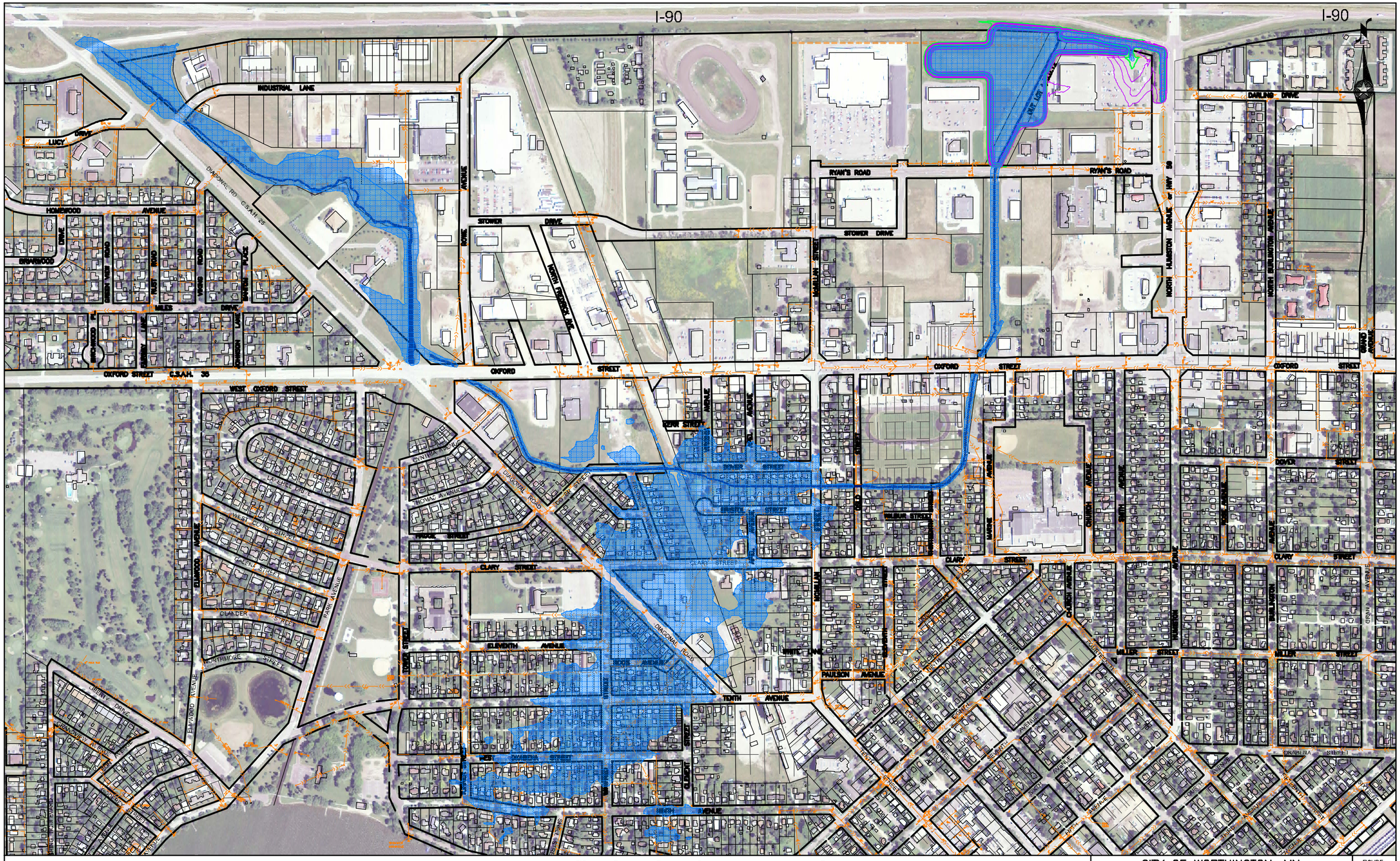
0 300 600
SCALE FEET

H:\WGTN\F13102940\C3D\102940_flooding2.dwg 3/25/13 6:51 am

BOLTON & MENK, INC.
Consulting Engineers & Surveyors
MANKATO, MN FAIRMONT, MN SLEEPY EYE, MN WILLMAR, MN
BURNSVILLE, MN CHASKA, MN RAMSEY, MN AMES, IA

CITY OF WORTHINGTON, MN
2010 INDUSTRIAL/COMMERICAL PARK
EXISTING FLOOD CONDITIONS
FEMA PRELIMINARY ZONE AE

FIGURE 4



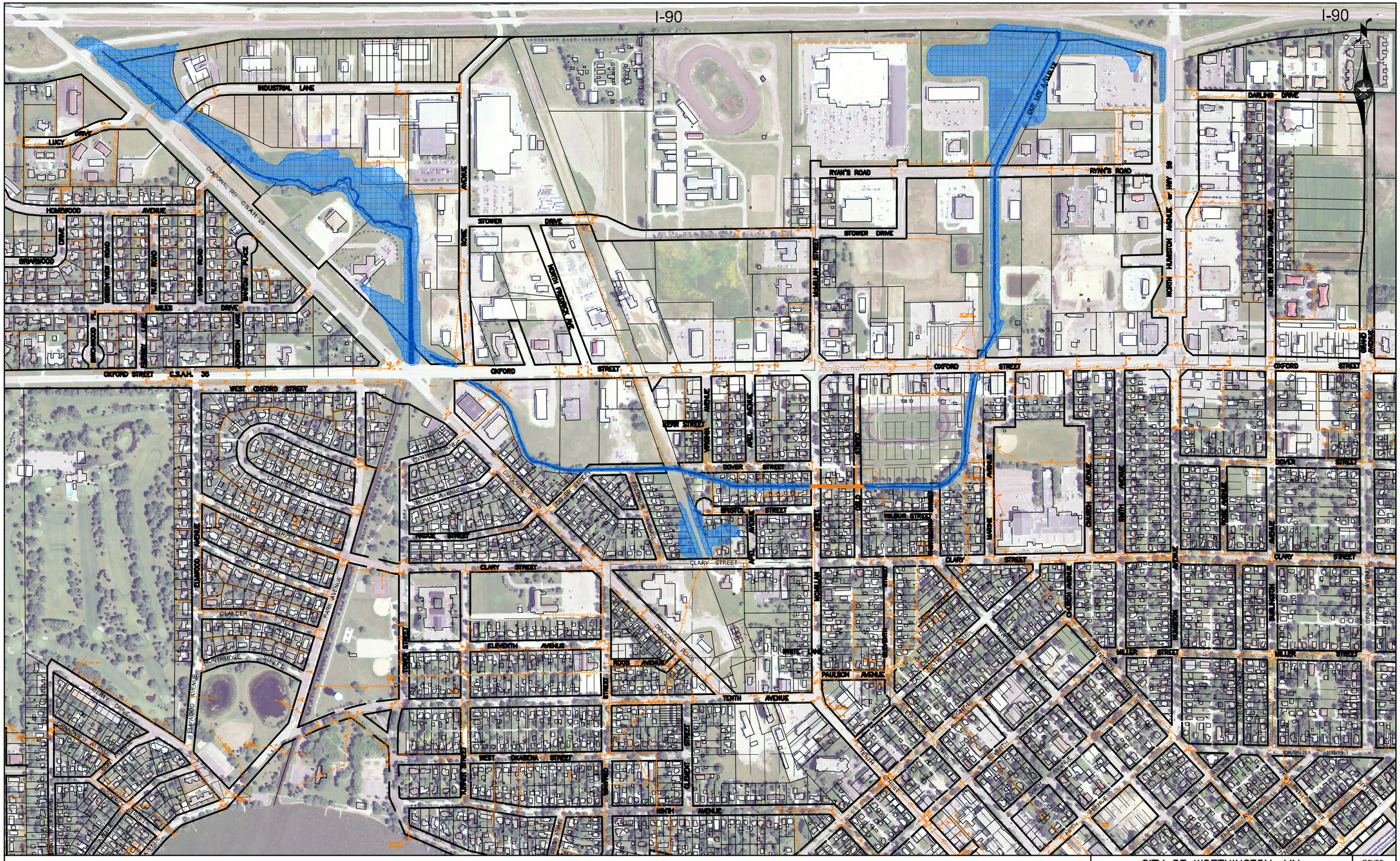
0 300 600
SCALE FEET

H:\WGTN\F13102940\C3D\102940_flooding2.dwg 3/25/13 6:51 am

BOLTON & MENK, INC.
Consulting Engineers & Surveyors
MANKATO, MN FAIRMONT, MN SLEEPY EYE, MN WILLMAR, MN
BURNSVILLE, MN CHASKA, MN RAMSEY, MN AMES, IA

CITY OF WORTHINGTON, MN
2010 INDUSTRIAL/COMMERICAL PARK
PROPOSED FLOOD CONDITIONS
I-90 REGIONAL BASIN & OXFORD EAST IMPROVEMENTS

FIGURE 5



0 300 600
SCALE FEET

H:\WGTN\F13102940\C3D\102940_flooding2.dwg 3/25/13 6:51 am

BOLTON & MENK, INC.
Consulting Engineers & Surveyors
MANKATO, MN FAIRMONT, MN SLEEPY EYE, MN WILLMAR, MN
BURNSVILLE, MN CHASKA, MN RAMSEY, MN AMES, IA

CITY OF WORTHINGTON, MN
2010 INDUSTRIAL/COMMERICAL PARK
PROPOSED FLOOD CONDITIONS
UPSIZE OSLO/MCMILLAN CROSSING

FIGURE
6

PROPERTY ACQUISITION

DOVER STREET

PROPERTY ACQUISITION

84" PROPOSED 10'X10' CONC BOX CULVERT

CHANNEL CLEANING/WIDENING

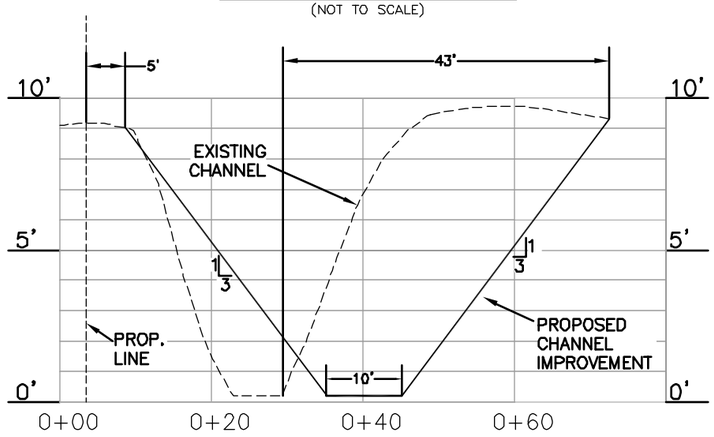
ACQUIRE UTILITY EASEMENT

MCMILLAN STREET

OSLO STREET

BRISTOL STREET

CHANNEL WIDENING CONCEPT
(NOT TO SCALE)



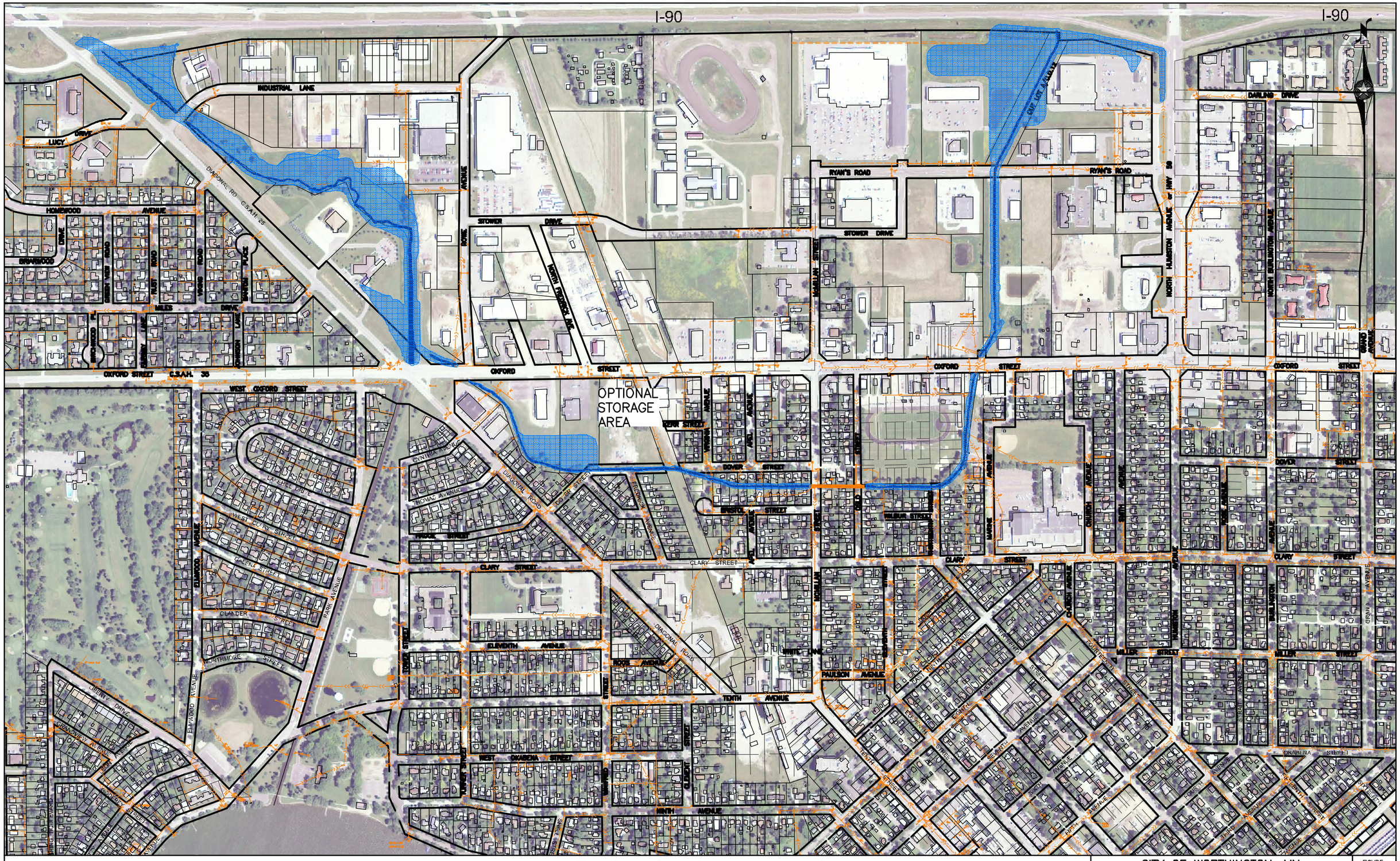
SCALE 0 40 80 FEET

H:\WGTN\F13102940\C3D\102940_flooding.dwg 4/18/13 7:51 am

BOLTON & MENK, INC.
Consulting Engineers & Surveyors
MANKATO, MN FAIRMONT, MN SLEEPY EYE, MN WILLMAR, MN
BURNSVILLE, MN CHASKA, MN RAMSEY, MN AMES, IA

CITY OF WORTHINGTON, MN
2010 INDUSTRIAL/COMMERICAL PARK
OSLO/MCMILLAN CROSSING & CHANNEL IMPROVEMENTS PROPERTY ACQUISITION

FIGURE 7



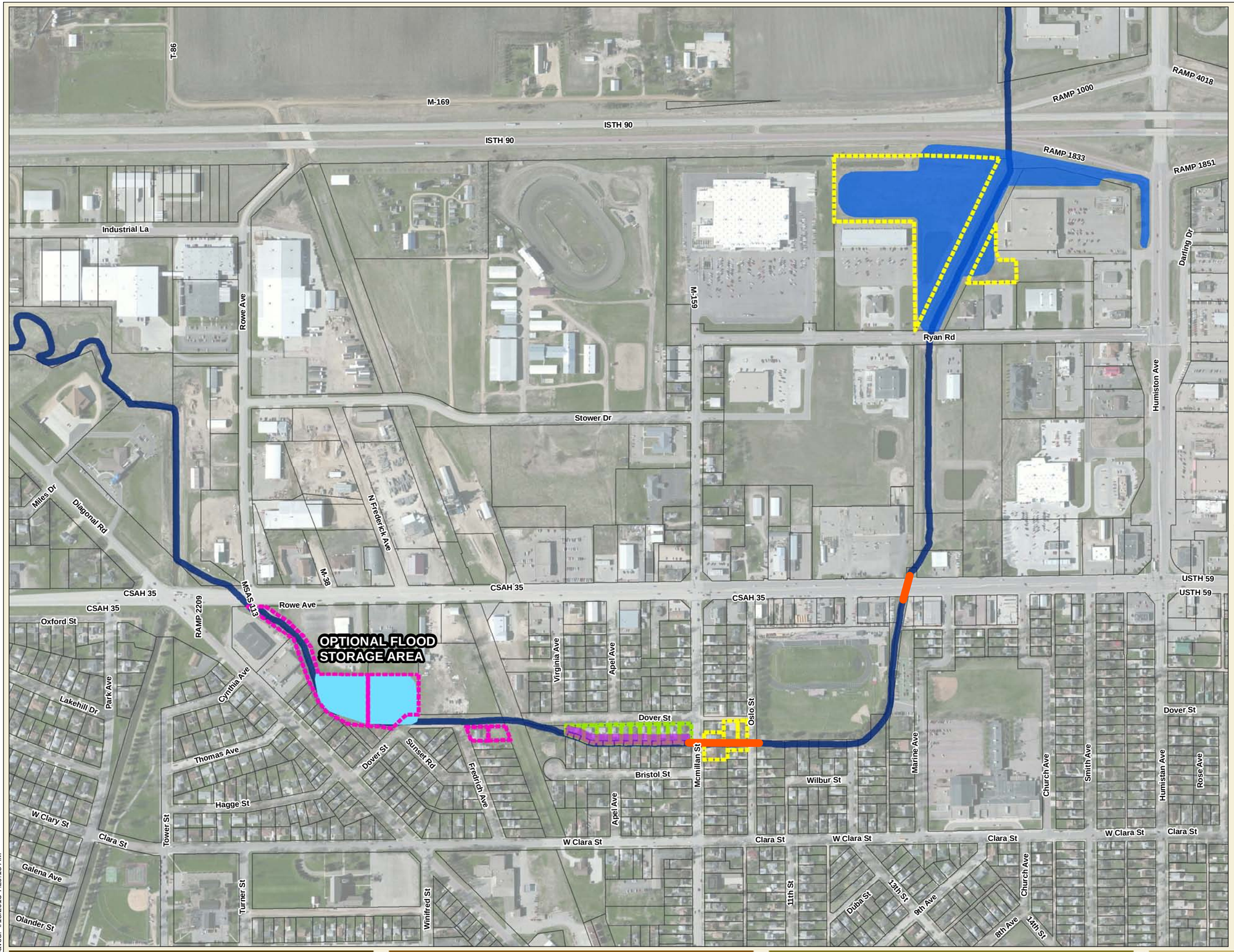
0 300 600
SCALE FEET

H:\WGTN\F13102940\C3D\102940_flooding2.dwg 3/25/13 7:21 am

BOLTON & MENK, INC.
Consulting Engineers & Surveyors
MANKATO, MN FAIRMONT, MN SLEEPY EYE, MN WILLMAR, MN
BURNSVILLE, MN CHASKA, MN RAMSEY, MN AMES, IA

CITY OF WORTHINGTON, MN
2010 INDUSTRIAL/COMMERICAL PARK
PROPOSED FLOOD CONDITIONS
FLOODPLAIN EXPANSION

FIGURE
8



CITY OF WORTHINGTON, MN
COUNTY DITCH 12
FLOOD MITIGATION

Legend

- County Ditch 12
- Property Acq./Utility Easement for Prop. Imp.
- Property Acq. for Channel Improvements
- Potential Future Acq./Utility Easement (Flood Storage)
- Proposed Channel Improvements
- Culvert Impreovements
- I-90 Flood Storage Improvements
- Compensatory Flood Storage

Source:

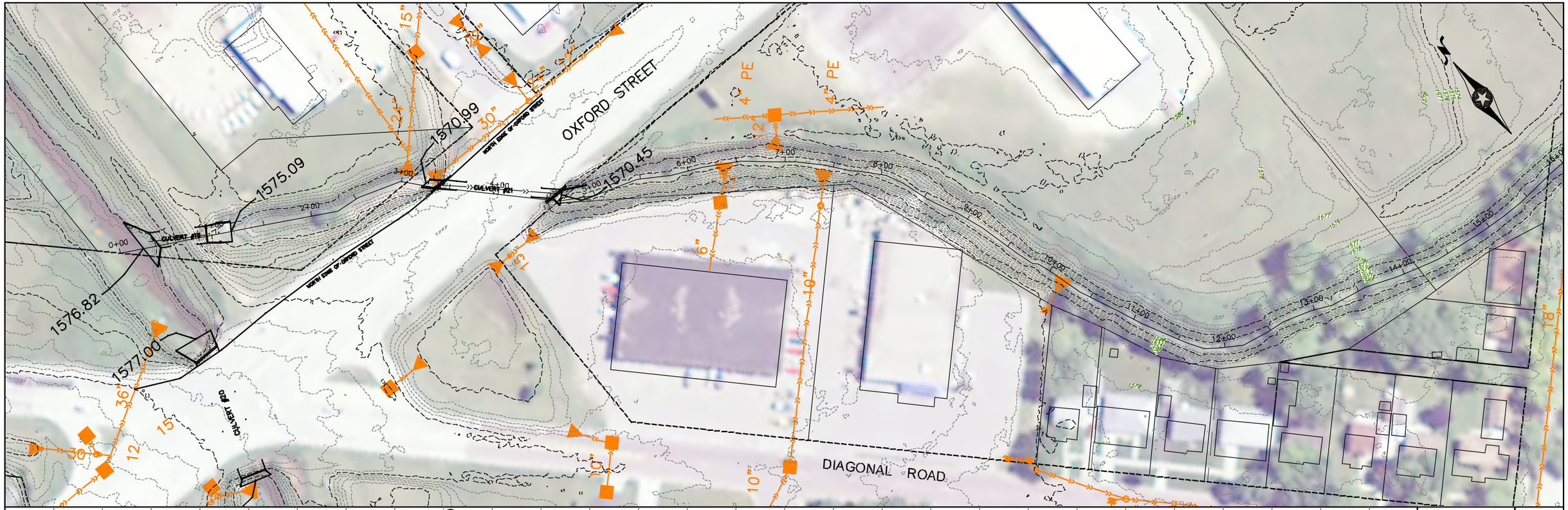
0 500 Feet

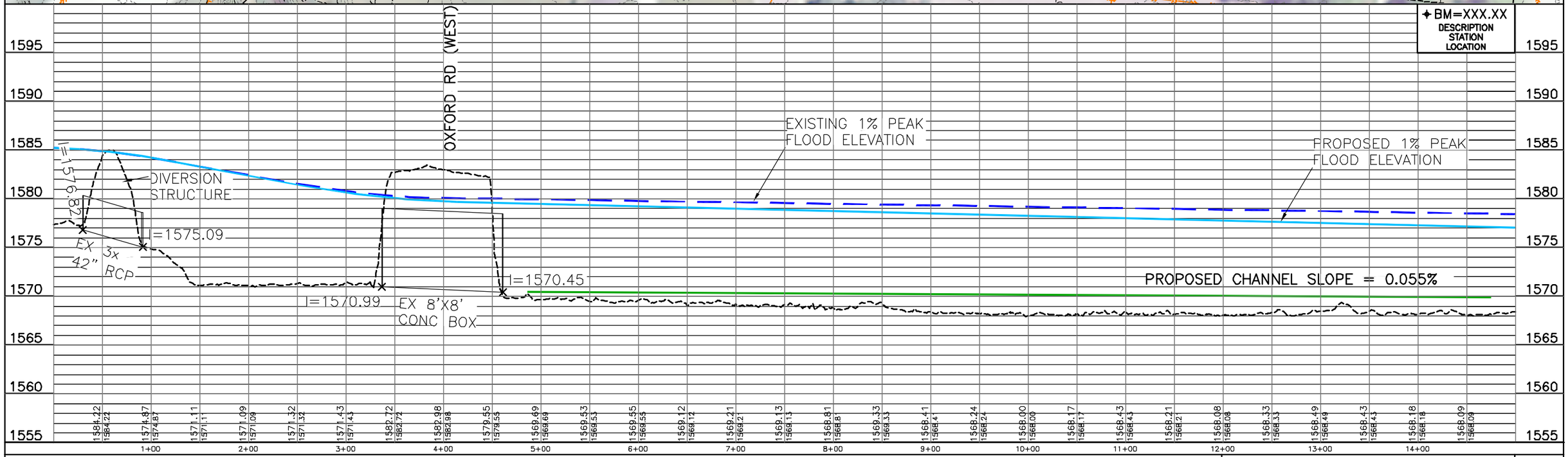
PROPERTY ACQUISITION EXHIBIT

Figure 9

MARCH, 2013

Map Document: H:\WGTN\F13102940\Arcview\CD12_PROPERTY_ACQ.mxd
Date Saved: 4/18/2013 7:29:13 AM





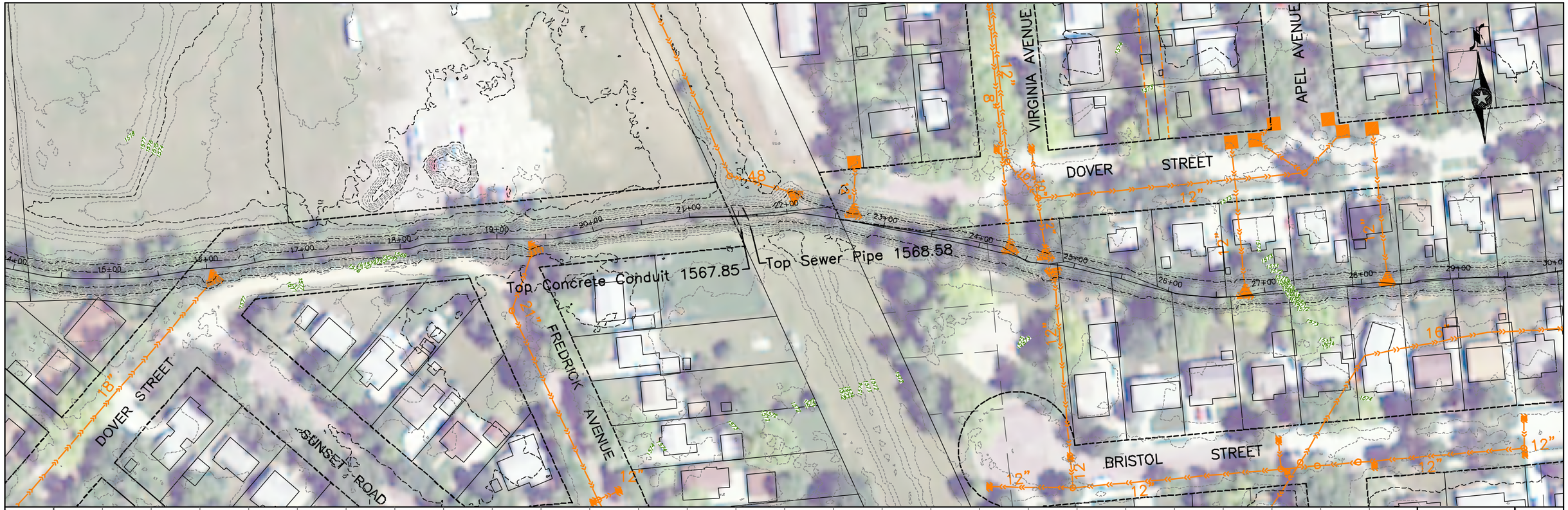
HORZ. SCALE 0 50 100 FEET
VERT. SCALE 0 5 10 FEET

I:\Projects\F13102940\C3D\102940_profile.dwg 3/22/13 11:25 am

BOLTON & MENK, INC.
Consulting Engineers & Surveyors
MANKATO, MN FAIRMONT, MN SLEEPY EYE, MN BURNSVILLE, MN
WILLMAR, MN CHASKA, MN RAMSEY, MN MAPLEWOOD, MN
BAXTER, MN ROCHESTER, MN AMES, IA SPENCER, IA

CITY OF WORTHINGTON, MN
CD 12 FLOOD MITIGATION
VFG – 1 – CD 12 – DITCH PROFILE
0+00–15+00

FIGURE 10



HORZ. SCALE 0 50 100 FEET

VERT. SCALE 0 5 10 FEET

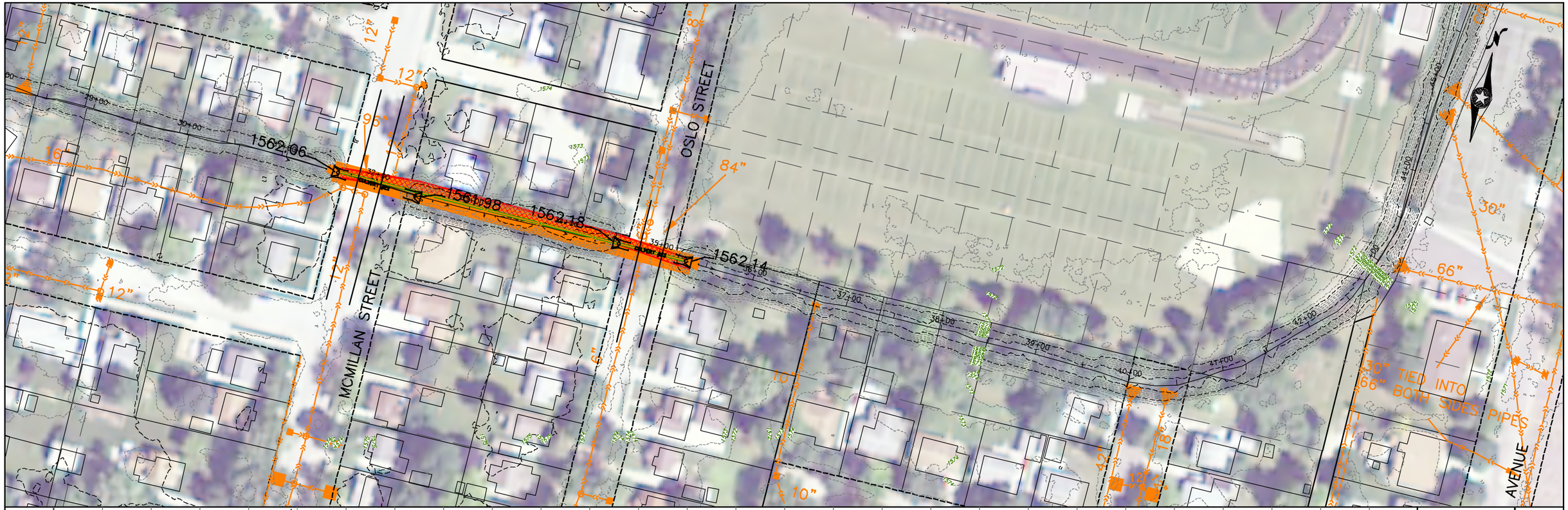
I:\Projects\F13102940\C3D\102940_profile.dwg 3/22/13 11:25 am

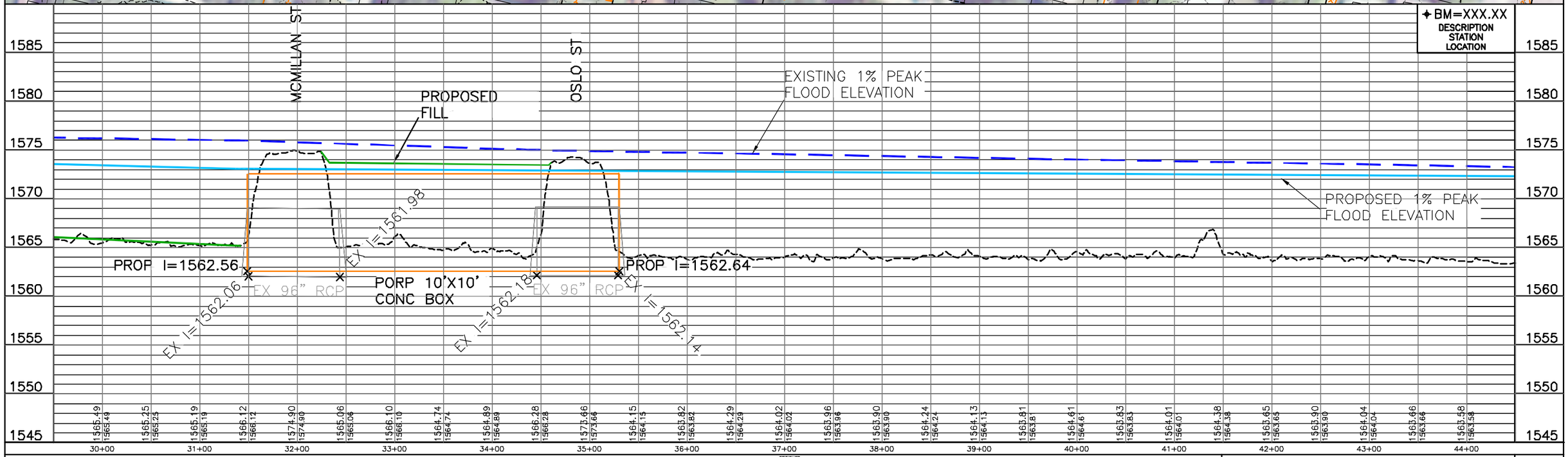
DESIGNED

BOLTON & MENK, INC.
Consulting Engineers & Surveyors
MANKATO, MN FAIRMONT, MN SLEEPY EYE, MN BURNSVILLE, MN
WILLMAR, MN CHASKA, MN RAMSEY, MN MAPLEWOOD, MN
BAXTER, MN ROCHESTER, MN AMES, IA SPENCER, IA

CITY OF WORTHINGTON, MN
CD 12 FLOOD MITIGATION
VFG – 1 – CD 12 – DITCH PROFILE
15+00–30+00

FIGURE 11





HORZ. SCALE 0 50 100 FEET

VERT. SCALE 0 5 10 FEET

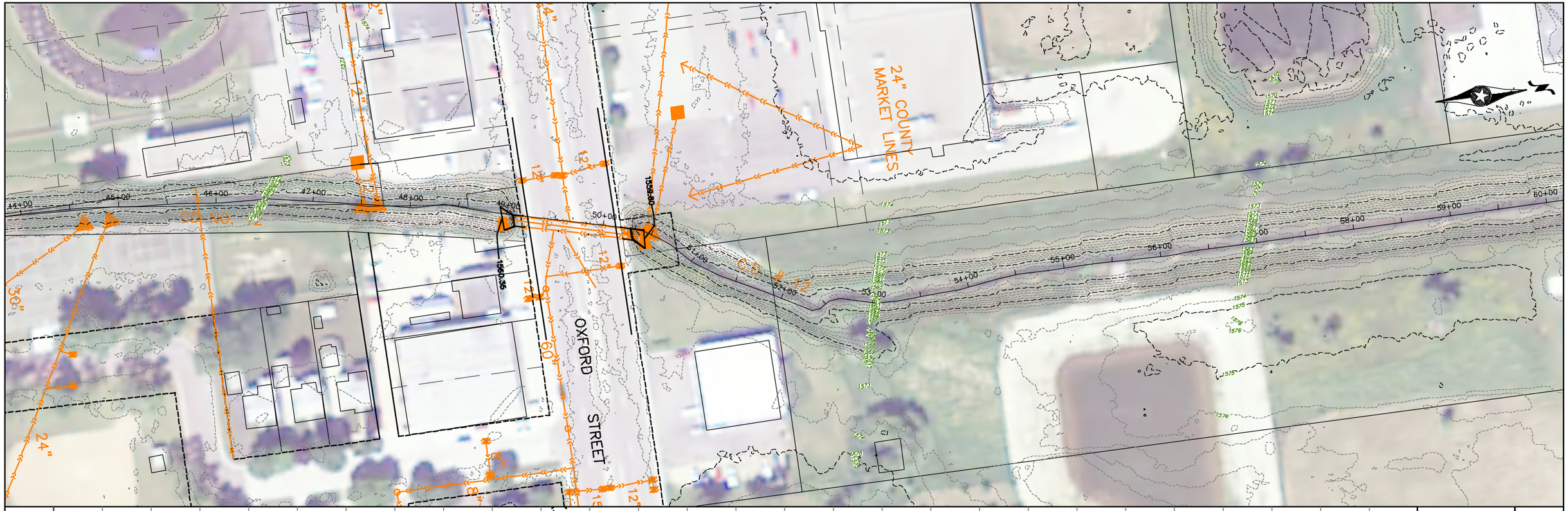
J:\Projects\F13102940\C3D\102940_profile.dwg 3/22/13 11:25 am

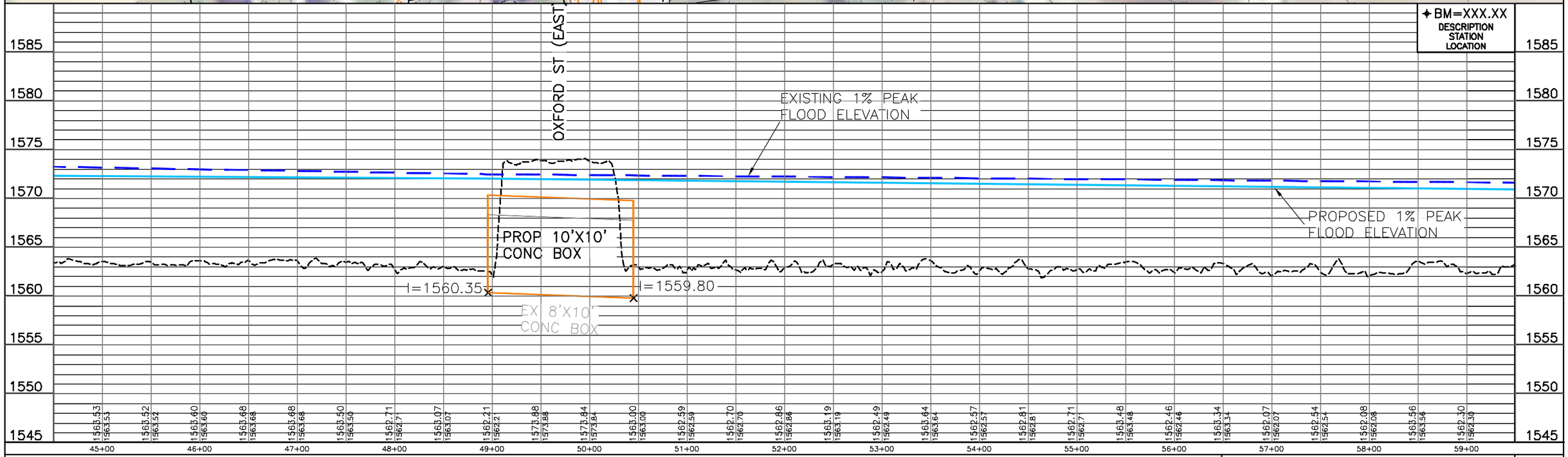
DESIGNED

BOLTON & MENK, INC.
Consulting Engineers & Surveyors
MANKATO, MN FAIRMONT, MN SLEEPY EYE, MN BURNSVILLE, MN
WILLMAR, MN CHASKA, MN RAMSEY, MN MAPLEWOOD, MN
BAXTER, MN ROCHESTER, MN AMES, IA SPENCER, IA

CITY OF WORTHINGTON, MN
CD 12 FLOOD MITIGATION
VFG – 1 – CD 12 – DITCH PROFILE
30+00–45+00

FIGURE 12





HORZ. SCALE 0 50 100 FEET

VERT. SCALE 0 5 10 FEET

I:\Worthington\F13102940\C3D\102940_profile.dwg 3/22/13 11:25 am

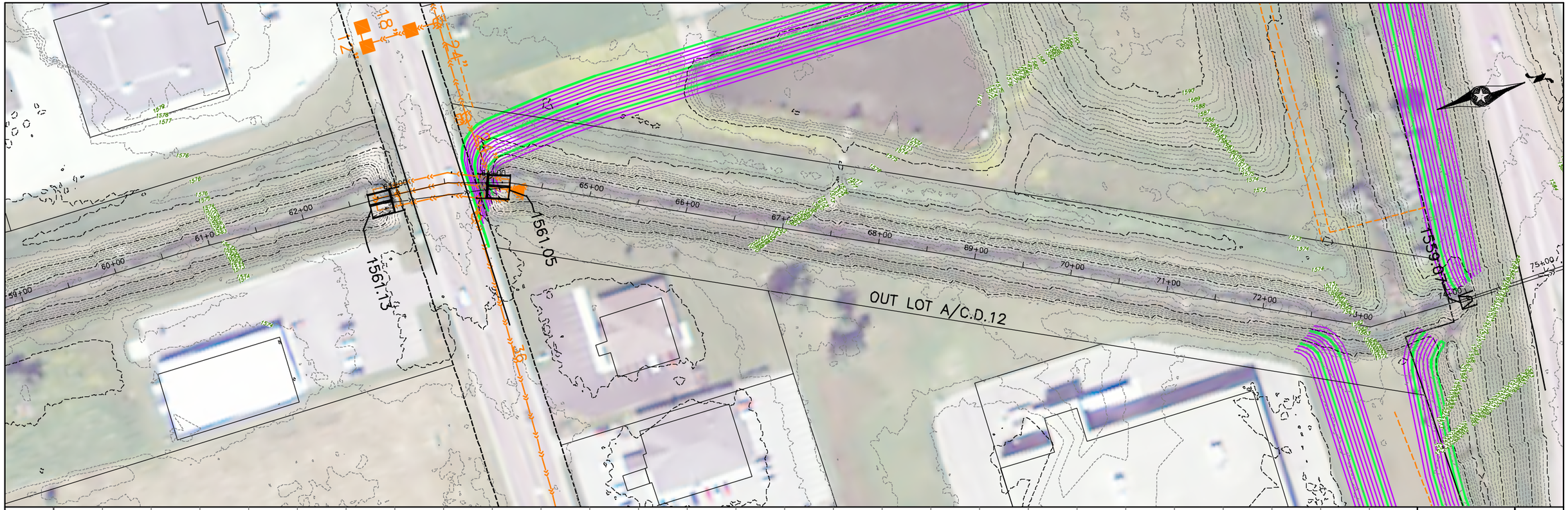
BOLTON & MENK, INC.
Consulting Engineers & Surveyors
MANKATO, MN FAIRMONT, MN SLEEPY EYE, MN BURNSVILLE, MN
WILLMAR, MN CHASKA, MN RAMSEY, MN MAPLEWOOD, MN
BAXTER, MN ROCHESTER, MN AMES, IA SPENCER, IA

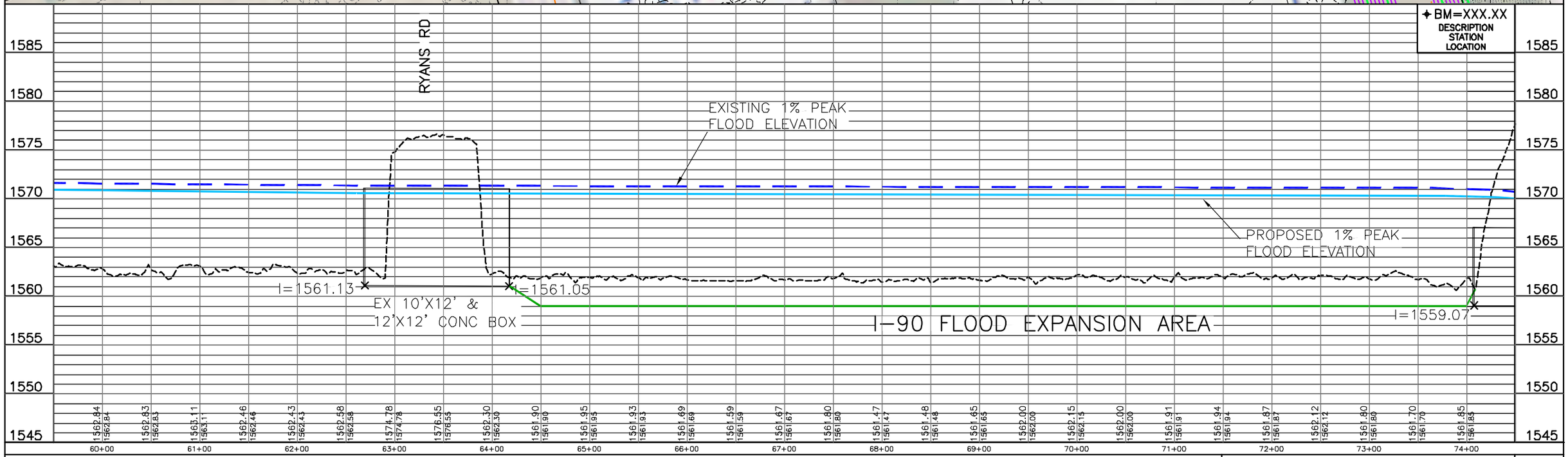
CITY OF WORTHINGTON, MN

CD 12 FLOOD MITIGATION

VFG – 1 – CD 12 – DITCH PROFILE
45+00–60+00

FIGURE 13





HORZ. SCALE 0 50 100 FEET

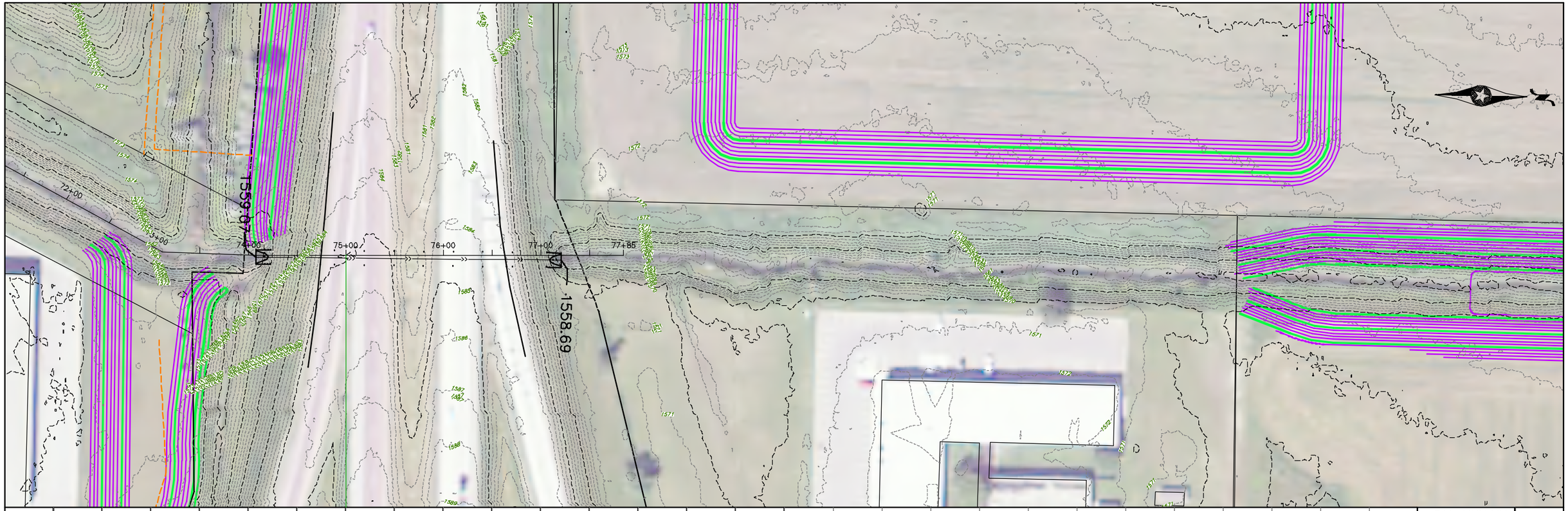
VERT. SCALE 0 5 10 FEET

I:\Projects\F13102940\C3D\102940_profile.dwg 3/22/13 11:25 am

BOLTON & MENK, INC.
Consulting Engineers & Surveyors
MANKATO, MN FAIRMONT, MN SLEEPY EYE, MN BURNSVILLE, MN
WILLMAR, MN CHASKA, MN RAMSEY, MN MAPLEWOOD, MN
BAXTER, MN ROCHESTER, MN AMES, IA SPENCER, IA

CITY OF WORTHINGTON, MN
CD 12 FLOOD MITIGATION
VFG – 1 – CD 12 – DITCH PROFILE
60+00–75+00

FIGURE 14



INTERSTATE 90

EXISTING 1% PEAK FLOOD ELEVATION

PROPOSED 1% PEAK FLOOD ELEVATION

I=1559.07 EX 100"X154" CONC ARCH I=1558.69

1585 1580 1575 1570 1565 1560 1555 1550 1545

1562.12 1562.12 | 1561.80 1561.80 | 1561.70 1561.70 | 1561.85 1561.85 | 1577.72 1577.72 | 1585.00 1585.00 | 1584.46 1584.46 | 1584.31 1584.31 | 1583.24 1583.24 | 1573.66 1573.66 | 1561.58 1561.58

73+00 74+00 75+00 76+00 77+00 78+00 79+00 80+00 81+00 82+00 83+00 84+00 85+00 86+00

✦ BM=XXX.XX
DESCRIPTION
STATION
LOCATION

HORZ. SCALE 0 50 100 FEET

VERT. SCALE 0 5 10 FEET

I:\Projects\F13102940\C3D\102940_profile.dwg 3/22/13 11:25 am

BOLTON & MENK, INC.
Consulting Engineers & Surveyors
MANKATO, MN FAIRMONT, MN SLEEPY EYE, MN BURNSVILLE, MN
WILLMAR, MN CHASKA, MN RAMSEY, MN MAPLEWOOD, MN
BAXTER, MN ROCHESTER, MN AMES, IA SPENCER, IA

CITY OF WORTHINGTON, MN
CD 12 FLOOD MITIGATION
VFG – 1 – CD 12 – DITCH PROFILE
72+00–80+00

FIGURE 15

APPENDIX B

Opinions of Probable Construction Cost

OPINION OF PROBABLE COST
FLOOD MITIGATION STUDY - NOBLES COUNTY DITCH 12
1. CONSTRUCT I-90 REGIONAL BASIN
CITY OF WORTHINGTON, MN

H:\WGTN\F13102940\Excel\[CostEstimate_5-23-13.xls]Channel Cleaning

ITEM NO.	ITEM	UNIT	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	1	$50,000.00	$50,000.00
2	COMMON EXCAVATION - I-90 BASIN	CY	145000	$7.00	$1,015,000.00
3	UTILITY RELOCATION (1)	LS	1	$50,000.00	$50,000.00
4	EASEMENT ACQUISITION	ACRE	10.5	$87,120.00	$914,760.00
5	TEMPORARY CONSTRUCTION EASEMENTS	LS	1	$8,712.00	$8,712.00
6	SEDIMENT AND EROSION CONTROL	LS	1	$2,000.00	$2,000.00
7	SEED, FERTILIZER, AND MULCH	ACRE	12.7	$2,500.00	$31,750.00
				SUBTOTAL	$2,072,222.00
				20% CONTINGENCY	$414,444.40
				TOTAL CONSTRUCTION COSTS	**$2,487,000**
				ENGINEERING AND ADMINISTRATION	$373,050.00
				TOTAL PROJECT COST	**$2,860,000**

NOTES:

(1) UTILITY RELOCATION COSTS ARE ESTIMATES ONLY. CITY VERIFICATION REQUIRED.

OPINION OF PROBABLE COST
FLOOD MITIGATION STUDY - NOBLES COUNTY DITCH 12
2. REPLACE EAST OXFORD CROSSING
CITY OF WORTHINGTON, MN

H:\WGTN\F13102940\Excel\[CostEstimate_5-23-13.xls]Channel Cleaning

ITEM NO.	ITEM	UNIT	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	1	$10,000.00	$10,000.00
2	REMOVE AND REPLACE BITUMINOUS PAVEMENT	SQ YDS	250	$60.00	$15,000.00
3	10'X10' CONCRETE BOX CULVERT (EAST OXFORD CROSSING)	LF	122	$900.00	$109,800.00
4	10'X10' CONCRETE BOX CULVERT END SECTION	EA	2	$12,000.00	$24,000.00
5	UTILITY RELOCAITON (1)	LS	1	$15,000.00	$15,000.00
6	TEMPORARY CONSTRUCTION EASEMENT	LS	1	$2,000.00	$2,000.00
7	SEDIMENT AND EROSION CONTROL	LS	1	$1,000.00	$1,000.00
				SUBTOTAL	$176,800.00
				20% CONTINGENCY	$35,360.00
				TOTAL CONSTRUCTION COSTS	**$212,000**
				ENGINEERING AND ADMINISTRATION	$31,800.00
				TOTAL PROJECT COST	**$244,000**

NOTES:

(1) UTILITY RELOCATION COSTS ARE ESTIMATES ONLY.

OPINION OF PROBABLE COST
FLOOD MITIGATION STUDY - NOBLES COUNTY DITCH 12
3. REPLACE OSLO & McMILLAN CROSSING
CITY OF WORTHINGTON, MN

H:\WGTN\F13102940\Excel\[CostEstimate_5-23-13.xls]Channel Cleaning

ITEM NO.	ITEM	UNIT	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	1	$25,000.00	$25,000.00
2	REMOVE AND REPLACE BITUMINOUS PAVEMENT	SQ YDS	480	$60.00	$28,800.00
3	10'X10' CONCRETE BOX CULVERT (McMILLAN/OSLO CROSSINGS)	LF	378	$900.00	$340,200.00
4	10'X10' CONCRETE BOX CULVERT END SECTION	EA	2	$12,000.00	$24,000.00
5	PROPERTY ACQUISITION (1)	LS	1	$150,000.00	$150,000.00
6	TEMPORARY CONSTRUCTION EASEMENT	LS	1	$15,000.00	$15,000.00
7	UTILITY RELOCAITON (2)	LS	1	$25,000.00	$25,000.00
8	SEDIMENT AND EROSION CONTROL	LS	1	$1,000.00	$1,000.00
				SUBTOTAL	$609,000.00
				20% CONTINGENCY	$121,800.00
				TOTAL CONSTRUCTION COSTS	**$731,000**
				ENGINEERING AND ADMINISTRATION	$109,650.00
				TOTAL PROJECT COST	**$841,000**

NOTES:

(1) PROPERTY VALUATION PROVIDED BY CITY INCLUDING A 30% CONTINGENCY.

(2) UTILITY RELOCATION COSTS ARE ESTIMATES ONLY.

OPINION OF PROBABLE COST
FLOOD MITIGATION STUDY - NOBLES COUNTY DITCH 12
3. DITCH CLEANOUT AND WIDENING
CITY OF WORTHINGTON, MN

H:\WGTN\F13102940\Excel\[CostEstimate_5-23-13.xls]Channel Cleaning

ITEM NO.	ITEM	UNIT	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	1	$40,000.00	$40,000.00
2	COMMON EXCAVATION - CHANNEL WIDENING	CY	3400	$7.00	$23,800.00
3	CLEAR AND GRUB	AC	0.31	$8,000.00	$2,480.00
5	PROPERTY ACQUISITION (1)	LS	1	$600,000.00	$600,000.00
6	TEMPORARY CONSTRUCTION EASEMENT	LS	1	$60,000.00	$60,000.00
7	UTILITY RELOCAITON (2)	LS	1	$10,000.00	$10,000.00
8	SEDIMENT AND EROSION CONTROL	LS	1	$1,000.00	$1,000.00
				SUBTOTAL	$737,280.00
				20% CONTINGENCY	$147,456.00
				TOTAL CONSTRUCTION COSTS	**$885,000**
				ENGINEERING AND ADMINISTRATION	$132,750.00
				TOTAL PROJECT COST	**$1,018,000**

NOTES:

(1) PROPERTY VALUATION PROVIDED BY CITY INCLUDING A 30% CONTINGENCY.

(2) UTILITY RELOCATION COSTS ARE ESTIMATES ONLY.

OPINION OF PROBABLE COST
FLOOD MITIGATION STUDY - NOBLES COUNTY DITCH 12
4. ADDITIONAL FLOOD STORAGE
CITY OF WORTHINGTON, MN

H:\WGTN\F13102940\Excel\[CostEstimate_5-23-13.xls]Channel Cleaning

ITEM NO.	ITEM	UNIT	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
1	MOBILIZATION	LS	1	$10,000.00	$10,000.00
2	COMMON EXCAVATION - DIAGONAL ST BASIN	CY	14000	$7.00	$98,000.00
3	SEDIMENT AND EROSION CONTROL	LS	1	$2,000.00	$2,000.00
4	UTILITY RELOCAITON (1)	LS	1	$10,000.00	$10,000.00
5	PROPERTY ACQUISITION (2)	ACRE	14.8	$50,000.00	$740,000.00
6	TEMPORARY CONSTRUCTION EASEMENT	LS	1	$5,000.00	$5,000.00
7	SEED, FERTILIZER, AND MULCH	ACRE	2.4	$2,500.00	$6,000.00
				SUBTOTAL	$871,000.00
				20% CONTINGENCY	$174,200.00
				TOTAL CONSTRUCTION COSTS	**$1,045,000**
				ENGINEERING AND ADMINISTRATION	$156,750.00
				TOTAL PROJECT COST	**$1,202,000**

NOTES:

(1) UTILITY RELOCATION COSTS ARE ESTIMATES ONLY. CITY VERIFICATION REQUIRED.

(2) PROPERTY VALUATION PROVIDED BY CITY INCLUDING A 30% CONTINGENCY.