# SILVER RANCH WATERSHED

FOR

Bismarck

CITY OF BISMARCK, ND

---

# *STORMWATER MASTER PLAN REPORT*

## Volume I of III –Stormwater Master Plan

**December 2018**

*AE2S Project #: P00501-2015-013*

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# SILVER RANCH WATERSHED STORMWATER MASTER PLAN REPORT

## CERTIFICATION

December 2018

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of North Dakota.

This document was originally
issued and sealed by
Jeffrey M. Hruby,
Registration Number
PE-5403
on December 04, 2018
and the original documents
are stored at the offices of
Advanced Engineering &
Environmental Services, Inc.

Prepared by:
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1815 Schafer St., Suite 301
Bismarck, ND 58501

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# I-1.0 BACKGROUND & SUMMARY

The City of Bismarck continues to experience growth along its fringes. The focus of this stormwater master plan is the Silver Ranch Watershed located generally east of Bismarck Expressway/Centennial Road and north of East Main Avenue (Highway 10) (***Figure I - 1***). This watershed encompasses an area of approximately 6.4 square miles (4,095 acres). Analysis was generally limited to the three significant drainages located in the Silver Ranch Watershed. These significant drainages, for the purpose of this Master Plan, are identified as follows; Silver Ranch Coulee, Sunrise Tributary, and Eastern Tributary (***Figure I - 2***).

## I-1.1 MASTER PLAN PURPOSE

The overarching purpose of this Master Plan is to develop a comprehensive approach that manages stormwater on a watershed scale and provides adequate drainage consistent with the City's ordinances.

As the watershed urbanizes, increased stormwater runoff can lead to local flooding and degradation of water quality. In order to mitigate for the increased stormwater runoff and water quality degradation, the City's general policy is to proactively develop regional stormwater master plans prior to areas developing. The overall goal of a stormwater master plan is to outline the key stormwater and drainage infrastructure and/or policies that will be needed to address watershed specific challenges, provide the appropriate level of service for roadways, and meet the City's stormwater management ordinance and design criteria. This Master Plan was developed to act as a stormwater management and drainage guide for the City, landowners, developers, and associated stakeholders as the Silver Ranch Watershed develops.

The Silver Ranch Watershed is a tributary of Hay Creek, which is a tributary of Apple Creek and ultimately the Missouri River. During periods of flooding, the Hay Creek and Silver Ranch Watersheds interact, with flow going in both directions. Therefore, the City elected to include a large portion of the Hay Creek Watershed in this analysis to account for the effects of the connection. The portion of the Hay Creek Watershed reviewed as part of this Master Plan, generally north of East Main Avenue, is approximately 41.8 square miles, including the Silver Ranch Watershed (***Figure I - 1***). Therefore, the scope of this study also includes an evaluation of various improvement scenarios for the Silver Ranch/Hay Creek connection to the north of the East Main Avenue crossing.

## I-1.2 ORGANIZATION OF THE MASTER PLAN REPORT

The Silver Ranch Master Plan Report consists of three volumes each with a district function. Combined, these three volumes constitute the "Master Plan Report." In general, the three volumes are described as follows:

**Volume I – Master Plan Report** consists of the purpose and need for the study, key recommendations, stormwater management concepts for development activities, and a summary of identified improvements. Volume I is intended to function as a guide for the implementation of the Silver Ranch Watershed Master Plan.

**Volume II - Silver Ranch Watershed Methodology & Analysis** details the hydrologic and hydraulic modeling completed for the development of the Silver Ranch Watershed Master Plan. Volume II is intended to document the analysis scenarios utilized in the development of the Master Plan recommendations and stormwater management concepts.

**Volume III – Silver Ranch and Hay Creek Watershed Connection Methodology & Analysis** details the hydrologic and hydraulic modeling completed for the analysis of the connection between the Silver Ranch and Hay Creek watersheds. Volume III is intended to document the study of the interconnection of the two watersheds and any resulting recommendations.

### I-1.3 MASTER PLAN MODELING SUMMARY

Conclusions and recommendations of this Master Plan were developed based on the results from project specific hydrologic and hydraulic modeling. Detailed descriptions of the model inputs and results are in included in ***Volume II*** and ***Volume III***.

Stormwater management and Master Plan recommendations for the Silver Ranch Watershed (***Volume II***) are based on the following modeling scenarios that are generally referenced in this ***Volume I***:

1. **Existing Conditions:** Utilized the existing land use, soils, road system, and drainage conveyance systems that were in-place at the start of the Master Plan process.
2. **Future Conditions, No Controls:** Utilized the future land-use plan, future road system, and drainage system improvements to demonstrate the need for watershed stormwater management. This scenario estimates the watershed response to future conditions without the implementation of stormwater management practices for peak flow compliance.
3. **Future Conditions, Local Pre-Post:** Utilized the future land-use plan, future road system, and recommended drainage system improvements estimating the watershed response to the planned future conditions with the implementation of local or onsite stormwater detention basins for peak discharge compliance.
4. **Master Planned Conditions, Unit Rate:** Utilized the future land-use plan, future road system, and recommended drainage system improvements to show the performance of the watershed when implementing a Unit Rate stormwater detention methodology throughout the watershed. This scenario assumed on-site or local detention basins for peak discharge compliance.
5. **Hydraulic Design for Future Crossings:** Utilized the existing land use, existing soils, future road system, and recommended drainage improvements. This scenario was

utilized for sizing road crossing and conveyance infrastructure for existing and future road crossings. Existing conditions hydrology was used because complete implementation of the Unit Rate requirement may result in lower discharge at some crossings, but the crossings may be constructed prior to complete implementation of the Unit Rate requirements. As such, the existing land use condition acts as the "worst case scenario" for peak flows at road crossings (existing and future) in the major drainage-ways for many areas in the watershed. This scenario will occur within the watershed when an improvement is implemented prior to full build-out upstream.

## I-1.4 DATA SOURCES

The following data sources were utilized in this study:

- 2016 LIDAR data (contours and DEM) obtained from the Metropolitan Planning Organization;
- Bismarck 2016 aerial photograph, obtained from the City of Bismarck;
- 2014 Fringe Area Road Master Plan (FARMP) prepared by SRF and HDR, obtained from the City;
- 2014 Bismarck Growth Management Plan (GMP) prepared by URS Corporation, obtained from the City;
- NRCS soils database, Version 36 for Burleigh County, obtained from the NRCS Geospatial Data Gateway January 2017;
- Rainfall depths from the City of Bismarck 2017 Stormwater Design Standards Manual;
- Site visits (various dates);
- Survey data collected as part of this project on various dates throughout the fall of 2016 through the spring of 2017;
- Various Stormwater Management Plans and Record Drawings provided by the City of Bismarck; and
- 43rd Avenue Reconstruction draft design documents and hydraulics/hydrology documents provided by Burleigh County Engineering on February 9, 2017.

## I-1.5 VERTICAL DATUM

Elevations presented throughout the Master Plan are in the North American Vertical Datum of 1988 (NAVD88), unless otherwise noted.

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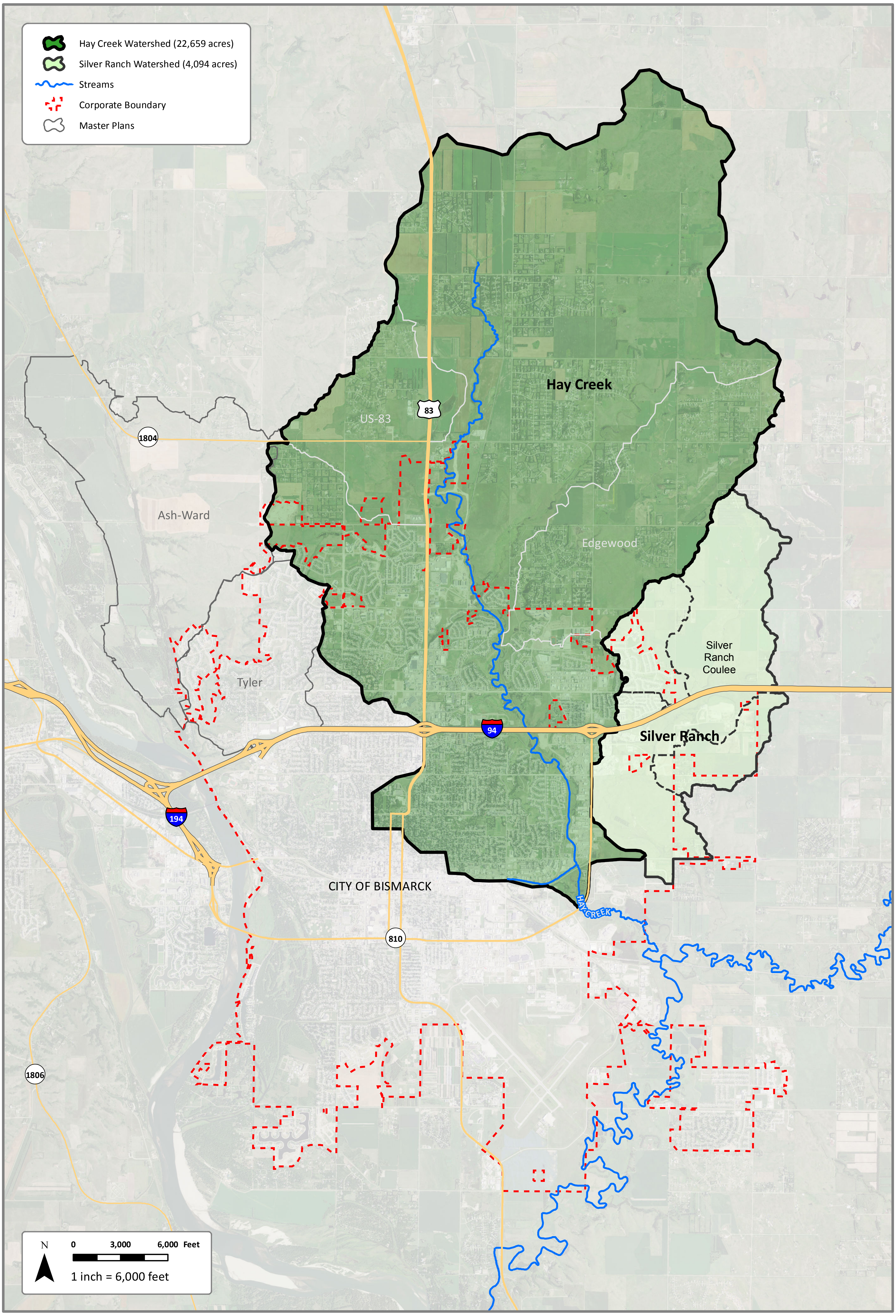
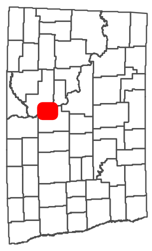


*Information depicted may include data unverified by AE2S. Any reliance upon such data is at the user's own risk. AE2S does not warrant this map or its features are either spatially or temporally accurate.*

Coordinate System: NAD 1983 StatePlane North Dakota South FIPS 3302 Feet Intl | Edited by: dlee | C:\Data\Projects\WAFS\Bismarck\00501-2015-013\GIS\Report Figure I-1 Project Location Map.mxd


Locator Map Not to Scale

City of Bismarck
Burleigh County, ND

Figure I-1

**PROJECT LOCATION MAP**

SILVER RANCH
WATERSHED STORMWATER
MASTER PLAN

Date: 10/26/2017

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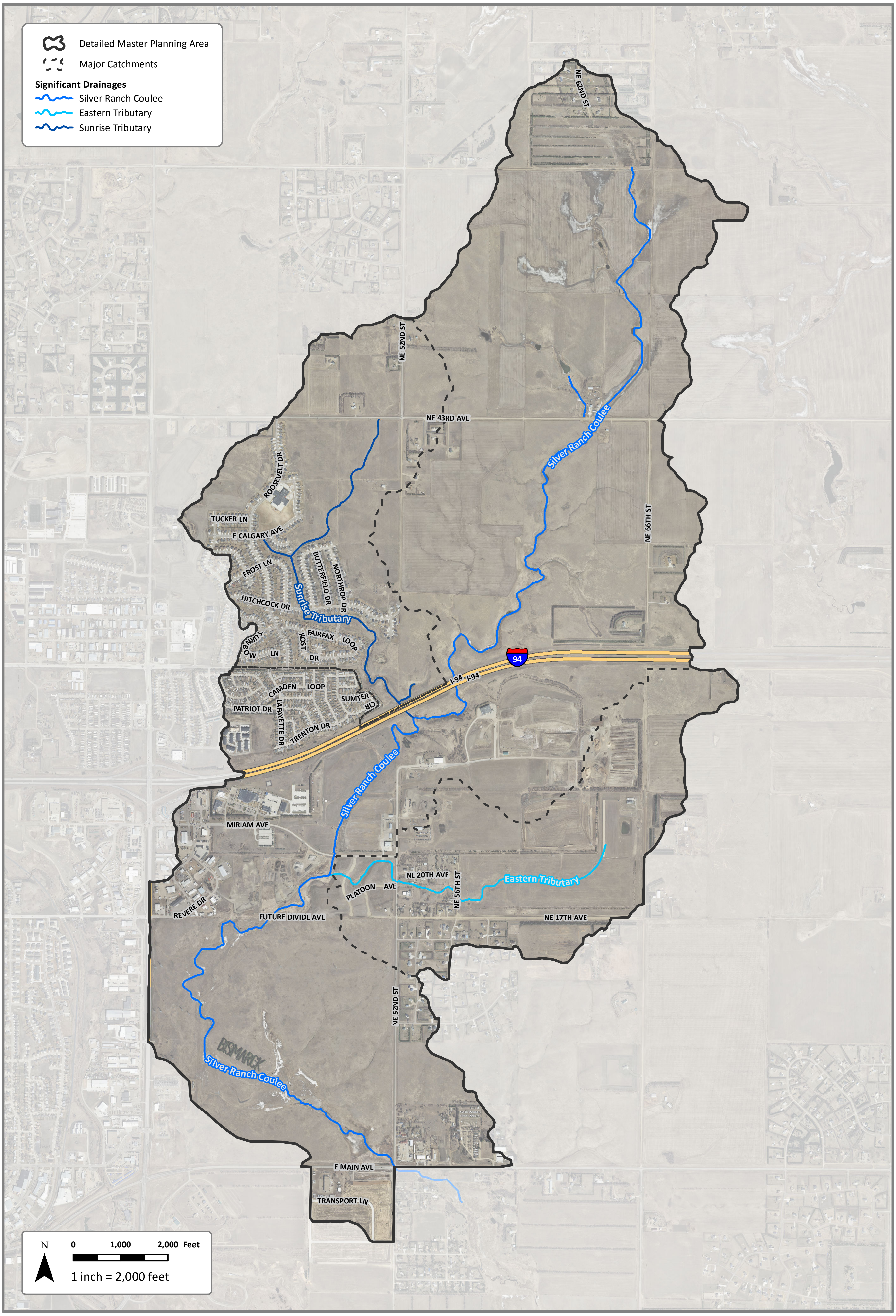

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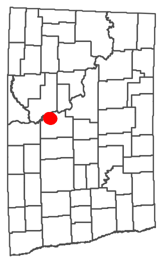
Coordinate System: NAD 1983 StatePlane North Dakota South FIPS 3302 Feet Intl | Edited by: dlee | C:\Data\Projects\WAFS\Bismarck\0501-2015-013\GIS\Report Figure I-2- Silver Ranch Watershed.mxd


Locator Map Not to Scale

City of Bismarck
Burleigh County, ND

Figure I-2

## SILVER RANCH WATERSHED

SILVER RANCH
WATERSHED STORMWATER
MASTER PLAN

Date: 10/26/2017

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# I-2.0 STORMWATER MASTER PLAN GOALS

The overarching purpose of this Master Plan is to develop a comprehensive approach that manages stormwater on a watershed scale and provides adequate drainage consistent with the City's ordinances. Achieving this purpose requires compliance with specific goals developed in conjunction with a City designated Working Group. The intent of the group is to bring the major City departments tasked with implementing this plan into the Master Plan development process. The City Working Group consisted of the following representatives:

- Michelle Klose, P.E. – Director of Utility Operations, Bismarck Public Works
- Gabe Schell, P.E. – City Engineer, Bismarck Engineering Department
- Waylon Erdmann, P.E. – Project Manager, Bismarck Engineering Department
- Terry Halstengard – Stormwater Program Coordinator, Bismarck Public Works
- Daniel Nairn, AICP – Planner/Land Use Planning, Bismarck Community Development Department, Planning Division
- Linda Oster, P.E. – Design & Construction Engineer, Bismarck Engineering Department
- Mike Greer, P.E. – Design & Construction Engineer, Bismarck Engineering Department
- Brad Wright, P.E. – Project Engineer, Bismarck Engineering Department
- Greg Larson – Burleigh County Water Resource District

The goals developed with the City Working Group were divided into primary and secondary goals.

## I-2.1 PRIMARY GOALS

Primary goals were developed to steer the overall Master Plan direction. The primary goals of the Silver Ranch Stormwater Master Plan are to:

1. Develop policies that minimize impacts from urbanization of the watershed for existing infrastructure and downstream areas;
2. Identify and require best management practices that can be implemented to match the pace and location of development;
3. Provide project timing and funding flexibility to the development community while minimizing long-term financial impacts to the City of Bismarck; and
4. Integrate the proposed stormwater recommendations and infrastructure with other applicable planning documents within the City and County, such as the 2014 City of Bismarck Growth Management Plan (Future Land Use Plan) and the 2014 MPO Bismarck Burleigh Fringe Area Road Master Plan.

### I-2.2 SECONDARY GOALS

Secondary goals were developed with the intent of identifying specific requirements necessary for the performance of the implemented Master Plan. The Secondary Goals for the Silver Ranch Stormwater Master Plan are to:

1. Determine minimum roadway elevations for future road crossings based on anticipated flood elevations;
2. Prepare conceptual designs for future road crossings.
3. Prepare conceptual designs for existing road crossings that are not in compliance with the applicable stormwater compliance requirements (City ordinances, State Stream Crossing Standards, etc.);
4. Identify potential improvements for existing stormwater and drainage facilities within the Silver Ranch Watershed; and
5. Develop recommendations for the Hay Creek and Silver Ranch connection such that the Silver Ranch Watershed Master Plan recommendations are independent of whether or not improvements or modifications are made to the connection in the future.

# I-3.0 STORMWATER MASTER PLAN RECOMMENDATIONS

The Stormwater Master Plan recommendations were developed in a collaborative process with the City Working Group. The following summarizes the key recommendations for this Master Plan, provides a brief justification, and where applicable, references the section where additional information can be found.

## RECOMMENDATION #1 - Peak runoff within Silver Ranch watershed shall not exceed the designated unit rate.

Description:

The maximum post-construction flow rate from a development or redevelopment site shall meet Unit Rate peak runoff criteria for the 2- and 100-year events. The peak runoff requirements are based on total site area (pervious and impervious) and shall be determined using the values shown in ***Table I - 4***.

The Unit Rate recommendation accounts for an amount of pervious ground, not to exceed 10% of the site's total area, discharging directly offsite without mitigation through a peak flow compliance post-construction Best Management Practice (BMP). The area discharging offsite must be 100% pervious and in no cases should the area allowed to discharge directly offsite be allowed to exceed 10% of the total site.

The Unit Rate Method and justification is more fully described in ***Section I-4.2***. Stormwater Design Standards for development activities is included in ***Section I-4.5***

Justification:

The Unit Rate release requirement meets all of the Primary Goals developed for this Master Plan. One of the main reasons this requirement was selected is that it allows for stormwater practices to be designed and constructed when and where development occurs and provides flexibility in the location of the stormwater facilities. Sizing of the Unit Rate BMPs was determined to have a minor impact on the area of sites to be developed. A comparison of a traditional versus Unit Rate BMP impact to the development area of residential and commercial development projects are shown in ***Figure I - 11*** and ***Figure I - 12*** respectively.

An allowance of up to 10% of the a pervious portion of the site not being routed to the peak flow compliance BMP was accounted for in the development of the allowable Unit Rate as recognition that there will be topographic and other constraints that may make capturing 100% of the site not practical.

## RECOMMENDATION #2 - Developer is responsible for construction costs of required stormwater BMPs.

Description:

For the Silver Ranch Watershed, post-construction peak flow compliance will be achieved using onsite and/or local stormwater facilities. The developer of a site is responsible for funding, designing, and constructing post-construction stormwater infrastructure in accordance with this Master Plan, the City of Bismarck Stormwater Design Standards Manual (SWDSM), and the City of Bismarck Code of Ordinances, including facilities required to meet the Unit Rate peak runoff criteria.

Specifically, the Silver Ranch Stormwater Master Plan does not included any recommended regional stormwater basins constructed by the City to provide post-construction peak flow compliance. Historically the practice of utilizing City funded regional facilities has been problematic from the timing of construction and the resulting amount of special assessments required to be held in abeyance.

Stormwater Design Standards for development activities, including a description of construction cost responsibility, is included in ***Section I-4.5***.

Justification:

This Master Plan recommends that all stormwater basins be constructed at the time of development to match the pace of urbanization of the watershed. This recommendation is much like other infrastructure that the development community designs and constructs; this practice puts all stormwater infrastructure in line with other infrastructure design and construction required of developers by the City.
Additionally, installation of peak flow compliance stormwater basins at the time of development has the added benefit of potentially reducing the size of downstream conveyance structures and reducing the erosion in natural channels.

## RECOMMENDATION #3 - Adopt a standard policy for long-term maintenance and operation of required stormwater BMPs

Description

Maintenance and operations of detention facilities is essential for the entire stormwater system to perform as intended. A policy should be established such that the maintenance and operations of these post-construction facilities complies with the following:

1. Single- and Two- Family Residential Developments will have a defined level of maintenance and all operational requirements provided by the City of Bismarck;

2. Maintenance and operational responsibilities for other types of land use will be determined on a case-by-case basis depending on the size and character of the development or ability of the Owner to provide the necessary maintenance; and
3. Flexibility should be provided to allow for unique solutions for commercial and industrial developments.

Maintenance and operations considerations are discussed in ***Section I-4.5.3***.

Justification

Residential developments do not have an organized or effective means for providing the necessary maintenance and operational requirements. City staff possess the knowledge, training, and experience to most efficiently facilitate the necessary inspections, reporting, and coordination of actions to keep post-construction facilities functioning as intended.

Commercial and industrial developments can have unique solutions that may be more appropriately operated by the individual site owners. For this Master Plan, an Industrial Use is defined as a site with an operation or use that requires a site specific NDPDES permit issued by the State of North Dakota.

All owner-operated facilities should be identified in the mandatory stormwater permitting process and roles and responsibilities outlined in a recorded maintenance agreement prior to approval of the permit.

### RECOMMENDATION #4 - Implement a Development Setback Line to maintain drainage and runoff storage corridors.

Description

A development setback line was developed along major drainages and is presented on ***Figure I - 3*** and ***Figure I - 4*** along with cross sections showing the elevation of the setback. At the discretion of City staff, areas within the development setback may be filled if mitigation is provided to offset the changes in volume and/or flow area. Anyone proposing to encroach on a development setback line shall do the following:

1. Document that the proposed encroachment does not reduce the ability of the conveyance to carry the 2- and 100-year design flows without increasing elevations upstream or downstream of the property;
2. Document that the proposed encroachment does not reduce the runoff storage capacity of the area or provide for additional, equivalent storage adjacent to the encroachment; and
3. Document that any structures placed in the proposed encroachment area are sufficiently elevated to protect against flooding.

Note that some areas have been shown on ***Figure I - 3*** and ***Figure I - 4*** as “Possible Fill Areas” and equivalent storage capacity is not required in those areas.

Documentation of the analysis to determine the limits of the Development Setback Line are include in ***Volume II***.

Justification

Preservation of large drainage areas and associated stormwater storage is key to protecting the public safety and minimizing the change for damage or destruction of property.

### RECOMMENDATION #5 - Arterial roads should only meet post-construction water quality requirements.

Description

Runoff from arterial roads has been accounted for by the designated Unit Rate. The following considerations shall be made regarding runoff from future arterial roads.

1. Runoff from arterial roads is to be routed directly to the nearest drainage way and discharged without peak flow mitigation, unless mitigation is determined necessary by City staff or is required to not impact existing structures;
2. In situations where drainage from arterial roadways must be routed through an adjacent property or development, mitigation shall be provided to meet the Unit Rate recommendations; and
3. Water quality must be provided for arterial roadway drainage.

Arterial roads included in this Master Plan were identified in the 2014 Fringe Area Road Master Plan (FARMP) and are shown on ***Figure I - 8***.

Justification

Since implementing detention facilities for arterial roads on public right-of-way can be challenging or impossible, runoff from arterial roads is accounted for in the allowable Unit Rate recommendations such that downstream infrastructure and property is protected from negative impacts.

In practice, the construction of arterial and major collector roads can lag behind the pace of development. Requiring adjacent development to account for the post-construction flows from future arterial road projects adds an unnecessary economic burden on development. The allowable Unit Rate was developed with consideration that the post-construction runoff from the FARMP roads may not be able to meet peak flow compliance requirements.

Water quality requirements compliance must be achieved to meet the requirements of the City’s MS4 permitted issued by the State of North Dakota.

## RECOMMENDATION #6 - Hay Creek and Silver Ranch connection should remain open and active.

### Description

The effective FEMA maps and Flood Insurance Study for Bismarck indicate that the Silver Ranch Watershed (referenced by FEMA as the Landfill Watershed) can break out and flow into the Hay Creek Watershed. As determined by this Master Plan, and not accounted for in the Flood Insurance Study, Hay Creek can also break out and flow into the Silver Ranch Watershed during flood events.

The Hay Creek and Silver Ranch Connection is recommended to remain as-is with flows from each watershed connecting in the 100-year event, preserving existing, large scale flow paths.

However, if the connection is blocked, an additional 5′ x 10′ box culvert is recommended at the Main Avenue crossing of Hay Creek offset about 3 feet above the creek invert so as to only function in larger events.  This culvert mitigates for increased elevations on Hay Creek caused by blocking the ability for the flow to discharge through the Silver Ranch Watershed.

***Volume III*** of the Master Plan Report contains additional information and discussion of the analysis of the Hay Creek and Silver Ranch connection.

### Justification

The Silver Ranch Stormwater Master Plan functions as intended whether the connection remains active or is blocked.  However, preserving the connection provides benefits to the Hay Creek Watershed without having to add significant additional infrastructure to mitigate for the flood flows that are not allowed to break out.

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## Table I - 1 Master Plan Recommendations Summary

| | Description | Justification |
|---|---|---|
| RECOMMENDATION #1<br>Peak runoff within Silver Ranch Watershed shall not exceed designated Unit Rate. | The maximum post-construction flow rate from a development or redevelopment site shall meet Unit Rate peak runoff criteria for the 2- and 100-year events as shown in ***Table I - 4***.<br>The Unit Rate Method is more fully described in ***Section I-4.2.***<br>The Unit Rate recommendation allows for an amount of pervious ground, not to exceed 10% of site's total area, discharging directly offsite without mitigation through a peak flow compliance post-construction facility.<br>Stormwater Design Standards for development activities is included in ***Section I-4.5*** | The Unit Rate release requirement meets all of the Primary Goals developed for this Master Plan.<br>The Unit Rate method allows for stormwater practices to be designed and constructed when and where development occurs and provides flexibility in the location of the stormwater facilities.<br>An allowance of up to 10% of the a pervious portion of the site not being routed to the peak flow compliance facility was accounted for in the development of the allowable Unit Rate as a recognition that there will be topographic and other constraints that make capturing 100% of the site may not be practical.<br>Sizing of the Unit Rate BMPs was determined to have a minimal impact on the area of sites to be developed. A comparison of a traditional versus Unit Rate BMP impact to development area of residential and commercial development projects are shown in ***Figure I - 11*** and ***Figure I - 12*** respectively. |
| RECOMMENDATION #2<br>Developer is responsible for construction costs of required stormwater BMPs. | Peak flow compliance will be met using onsite or local facilities.<br>Costs for the design and construction of stormwater management basins are to be paid by the developer.<br>The Master Plan does not included any regional stormwater basins constructed by the City. | Utilizing local facilities allow the impact from urbanization to match the pace of development potentially reducing the size of downstream conveyance structures and reducing the erosion in natural channels.<br>Stormwater Design Standards for development activities, including a description of construction cost responsibility, is included in ***Section I-4.5***. |
| RECOMMENDATION #3<br>Develop a standard policy for long-term maintenance and operation of required BMPs. | Maintenance and operations of detention facilities is essential for the entire stormwater system to perform as intended. A policy should be established such that the maintenance and operations responsibilities of the developer, owner and City. | All owner-operated facilities should be identified in the mandatory stormwater permitting process and roles and responsibilities outlined in a recorded maintenance agreement prior to approval of the permit.<br>Maintenance and operations considerations are discussed in ***Section I-4.5.3***. |
| RECOMMENDATION #4<br>Implement a Development Setback Line to maintain drainage and runoff storage corridors. | A development setback line was developed along major drainages and is presented on ***Figure I - 3*** and ***Figure I - 4*** along with cross sections showing the elevation of the setback. | Preservation of large drainage areas and associated stormwater storage is key to protecting the public safety and minimizing the change for damage or destruction of property. |
| RECOMMENDATION #5<br>Arterial roads should meet water quality requirements only. | Arterial roads included in this Master Plan were identified in the 2014 Fringe Area Road Master Plan (FARMP) do not need to provide peak flow compliance BMPs.<br>FARMP roads considered by this Master Plan are shown on ***Figure I - 8***. | Detention facilities for arterial roads on public right-of-way can be challenging or impossible, runoff from arterial roads is accounted in the allowable Unit Rate. |
| RECOMMENDATION #6<br>Hay Creek and Silver Ranch connection should remain open and active. | A connection exists between the Hay Creek and Silver Ranch watersheds that allows flood flows to break out in each direction.<br>This connection is recommended to remain active to preserve existing, large scale flow paths.<br>See ***Volume III*** for additional discussion if this analysis. | The Silver Ranch Stormwater Master Plan functions as intended whether the connection remains active or is blocked. However, preserving the connection provides benefits to the Hay Creek Watershed without having to add significant additional infrastructure to mitigate for the flood flows that are not allowed to break out. |

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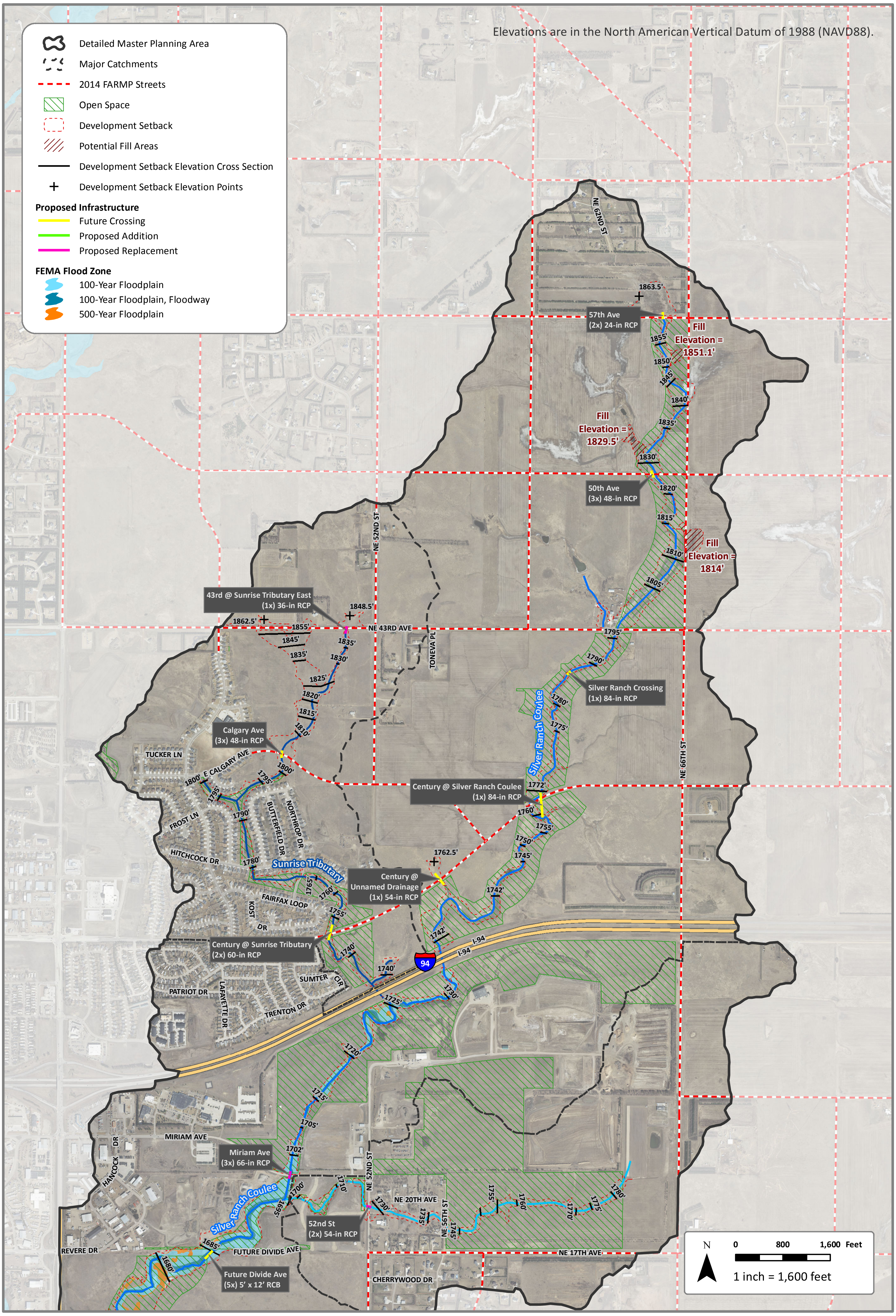
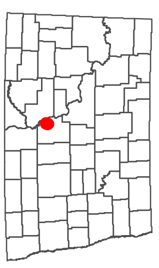


Coordinate System: NAD 1983 StatePlane North Dakota South FIPS 3302 Feet Intl | Edited by: dlee | C:\Data\Projects\WAFS\Bismarck\00501-2015-013\GIS\Report Figure I-3 - Master Plan Improvements North.mxd



City of Bismarck
Burleigh County, ND

Figure I-3

# MASTER PLAN IMPROVEMENTS & DEVELOPMENT SETBACK LINE (NORTH)

SILVER RANCH
WATERSHED STORMWATER
MASTER PLAN

Date: 1/17/2018

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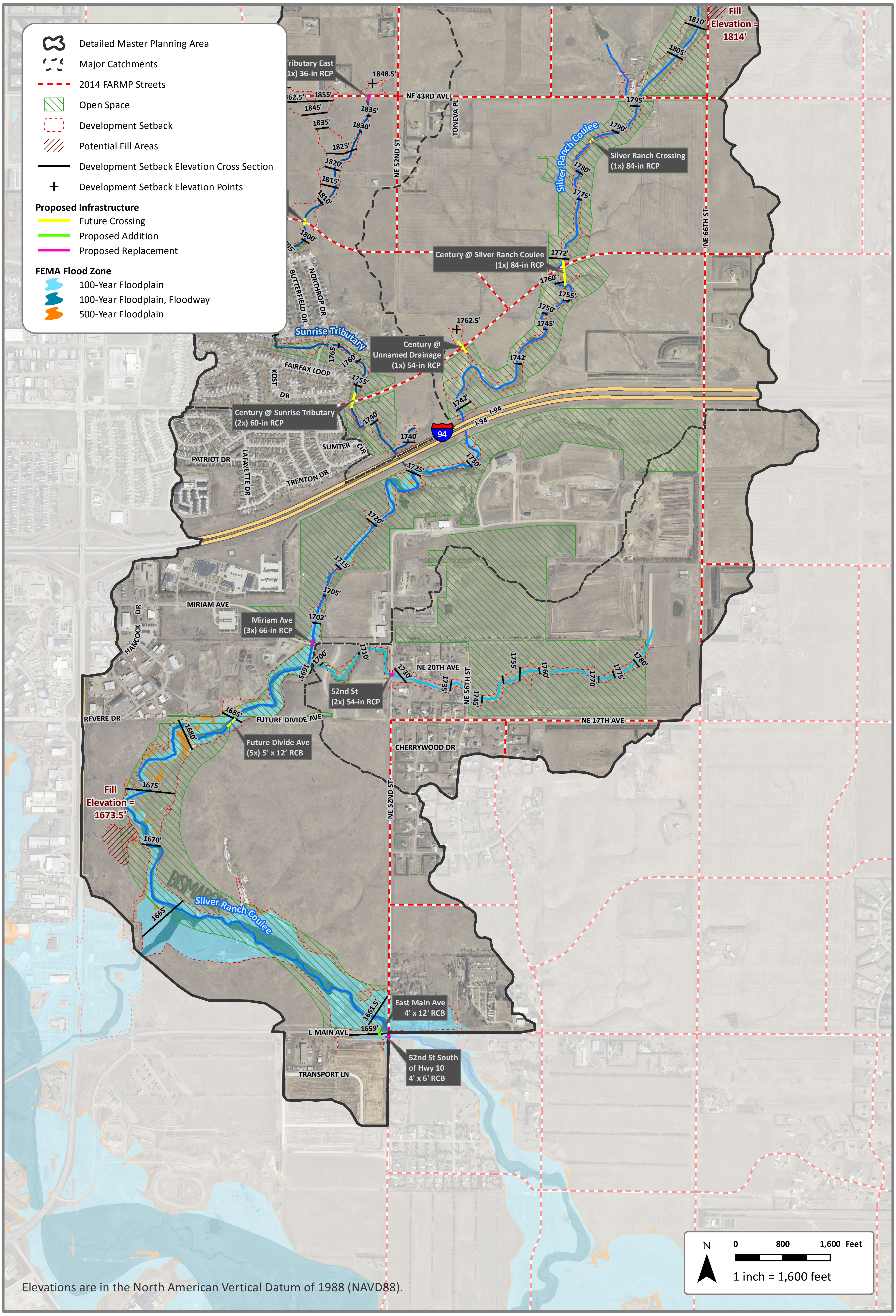

Elevations are in the North American Vertical Datum of 1988 (NAVD88).

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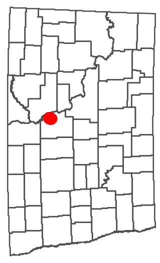
Coordinate System: NAD 1983 StatePlane North Dakota South FIPS 3302 Feet Intl | Edited by: dlee | C:\Data\Projects\WAFS\Bismarck\0501-2015-013\GIS\Report Figure I-4- Master Plan Improvements South.mxd


Locator Map Not to Scale

City of Bismarck
Burleigh County, ND

Figure I-4

# MASTER PLAN IMPROVEMENTS & DEVELOPMENT SETBACK LINE (SOUTH)

SILVER RANCH WATERSHED STORMWATER MASTER PLAN

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# I-4.0 STORMWATER MASTER PLAN

The purpose of the Silver Ranch Master Plan is to develop a comprehensive approach that manages stormwater on a watershed scale and provides adequate drainage consistent with the City's ordinances. This ***Section I-4.0*** was developed to function as a stormwater management and drainage guide for the City, landowners, developers, and associated stakeholders as the Silver Ranch Watershed continues to urbanize.

Included in the following sections are:

1. Recommended stormwater management strategies;
2. A summary of the justification for the Unit Rate Method;
3. Locations for the monitoring and reporting locations for the Master Plan;
4. Compliance requirements used to develop the Master Plan; and
5. Stormwater Design Standards applicable for Post-Construction Stormwater Management Permits (PCSMP) issued in the Silver Ranch Watershed.

## I-4.1 STORMWATER MANAGEMENT

The Stormwater Master Plan for Silver Ranch Watershed consists of stormwater management recommendations for:

1. Post-Construction Peak Discharge Compliance;
2. Post-Construction Water Quality Compliance; and
3. Drainage & Conveyance Implementation.

Developments within the Silver Ranch Watershed shall meet the requirements for peak discharge compliance, water quality compliance and drainage & conveyance implementation as discussed in the following sections of this Master Plan.

### I-4.1.1 Peak Discharge Compliance

The proposed Stormwater Master Plan utilizes a Unit Rate approach for managing post construction peak flow rates. A Unit Rate approach refers to the development of recommended peak runoff rates that are dependent on the size of a development or project site. This is a deviation from the approaches taken on past City of Bismarck Master Plans, which typically utilized either local or regional post-construction stormwater management facilities. These approaches, along with justification for the Unit Rate approach, are discussed further in ***Section I-4.2***.

Post-construction peak discharge requirements are accomplished for the Silver Ranch Watershed by utilizing the Unit Rate Method such that the post-construction runoff rate does not exceed 0.06 cfs/acre for the 2-year storm and 0.50 cfs/acre for the 100-year storm shown in ***Table I - 4*** on page 51.

Utilizing these Unit Rate recommendations for the Silver Ranch Watershed results in flow decreases of 8 cubic feet per second (cfs) for the 2-year event and 12 cfs for the 100-year event downstream of the East Main Ave crossing of Silver Ranch Coulee at the downstream end of the watershed. Based on analysis of watershed performance, compliance with the Unit Rate recommendations for the 2- and 100-year events achieves compliance for the 10-year storm event.

The Unit Rate recommendation accounts for an amount of pervious ground, not to exceed 10% of site's total area, discharging directly offsite without mitigation in a Post-Construction BMP. The area discharging offsite must be 100% pervious and in no case should the area allowed to discharge offsite be allowed to exceed 10% of the total site.

Peak runoff compliance using the Unit Rate methodology is presented in ***Figure I - 5*** and ***Figure I - 6***.

### I-4.1.2 Water Quality Compliance

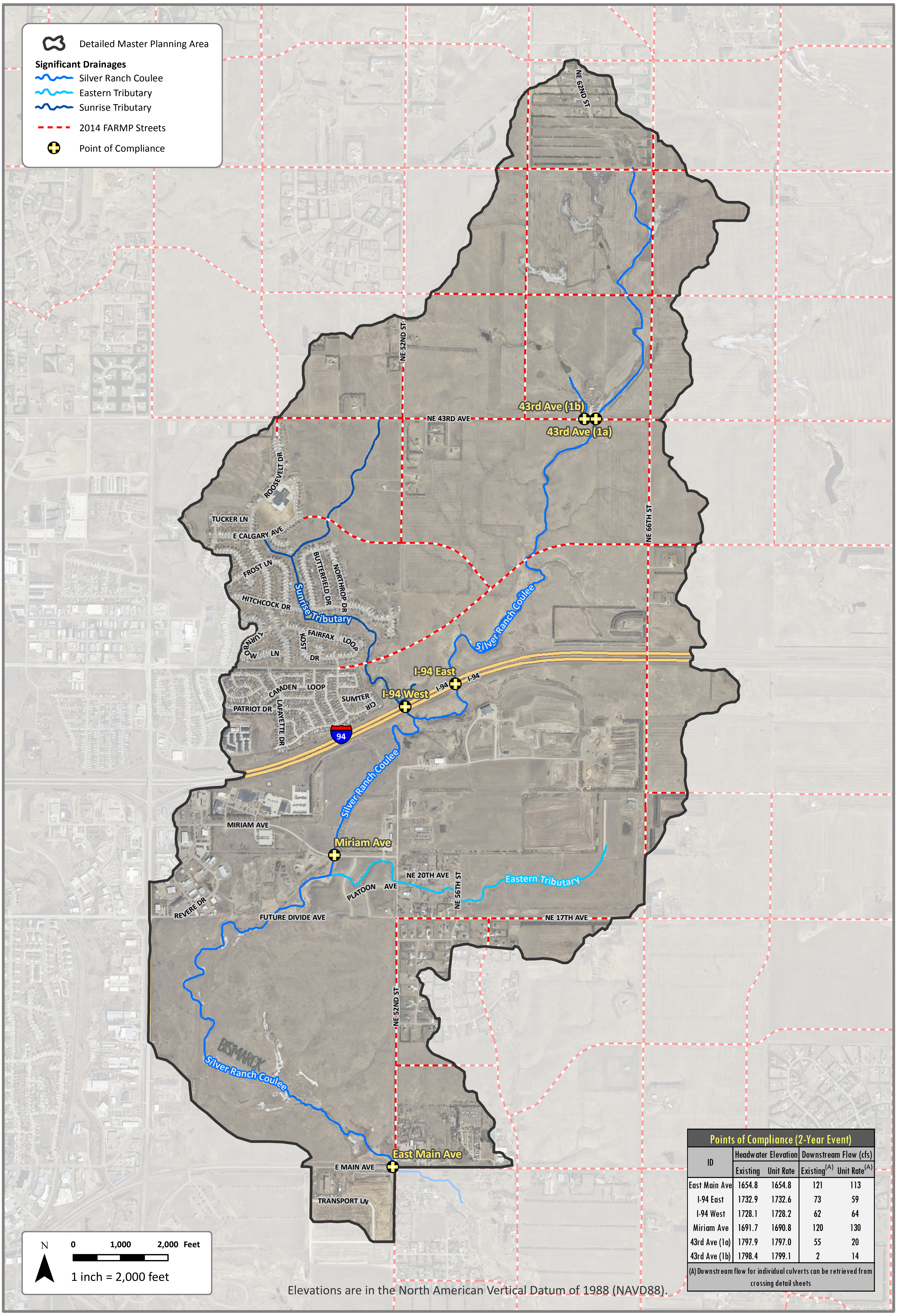
Post-construction water quality compliance is to be accomplished for the Silver Ranch Watershed by utilizing development specific BMPs to meet the requirements of the City's MS4 permit that is effective at the time of the development.

### I-4.1.3 Drainage & Conveyance Implementation

The performance of existing roadway crossings is presented on ***Figure I - 7***. Performance is presented on the figure as either being acceptable, meaning the road crossing requirements of the SWDSM is met, or unacceptable, meaning one or more requirements of the SWDSM is not met.

Hydraulic structure recommendations (proposed or upgraded culverts) were developed for existing road crossings not currently meeting the applicable stormwater standards as well as for known future roadways that cross the main drainages within the Silver Ranch Watershed. The recommended improvements are presented in ***Section I-5.0.***

The performance of existing and future roadways under Master Planned conditions, meaning full build-out has occurred and all recommended improvements have been implemented, is presented on ***Figure I - 8***. Performance is presented on the figure as either being acceptable, meaning the road crossing requirements of the SWDSM is met, or unacceptable, meaning one or more requirements of the SWDSM is not met.



Elevations are in the North American Vertical Datum of 1988 (NAVD88).

**Points of Compliance (2-Year Event)**

| ID | Headwater Elevation | | Downstream Flow (cfs) | |
|---|---|---|---|---|
| | Existing | Unit Rate | Existing$^{(A)}$ | Unit Rate$^{(A)}$ |
| East Main Ave | 1654.8 | 1654.8 | 121 | 113 |
| I-94 East | 1732.9 | 1732.6 | 73 | 59 |
| I-94 West | 1728.1 | 1728.2 | 62 | 64 |
| Miriam Ave | 1691.7 | 1690.8 | 120 | 130 |
| 43rd Ave (1a) | 1797.9 | 1797.0 | 55 | 20 |
| 43rd Ave (1b) | 1798.4 | 1799.1 | 2 | 14 |

(A) Downstream flow for individual culverts can be retrieved from crossing detail sheets

Coordinate System: NAD 1983 StatePlane North Dakota South FIPS 3302 Feet Intl | Edited by: dlee | C:\Data\Projects\WAFS\Bismarck\00501-2015-013\GIS\Report Figure I-5- 2-Year Flow Compliance.mxd

SILVER RANCH
WATERSHED STORMWATER
MASTER PLAN

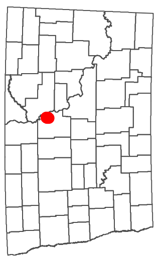
Date: 1/17/2018

Figure I-5

## 2-YEAR
## FLOW COMPLIANCE

City of Bismarck
Burleigh County, ND

Locator Map Not to Scale



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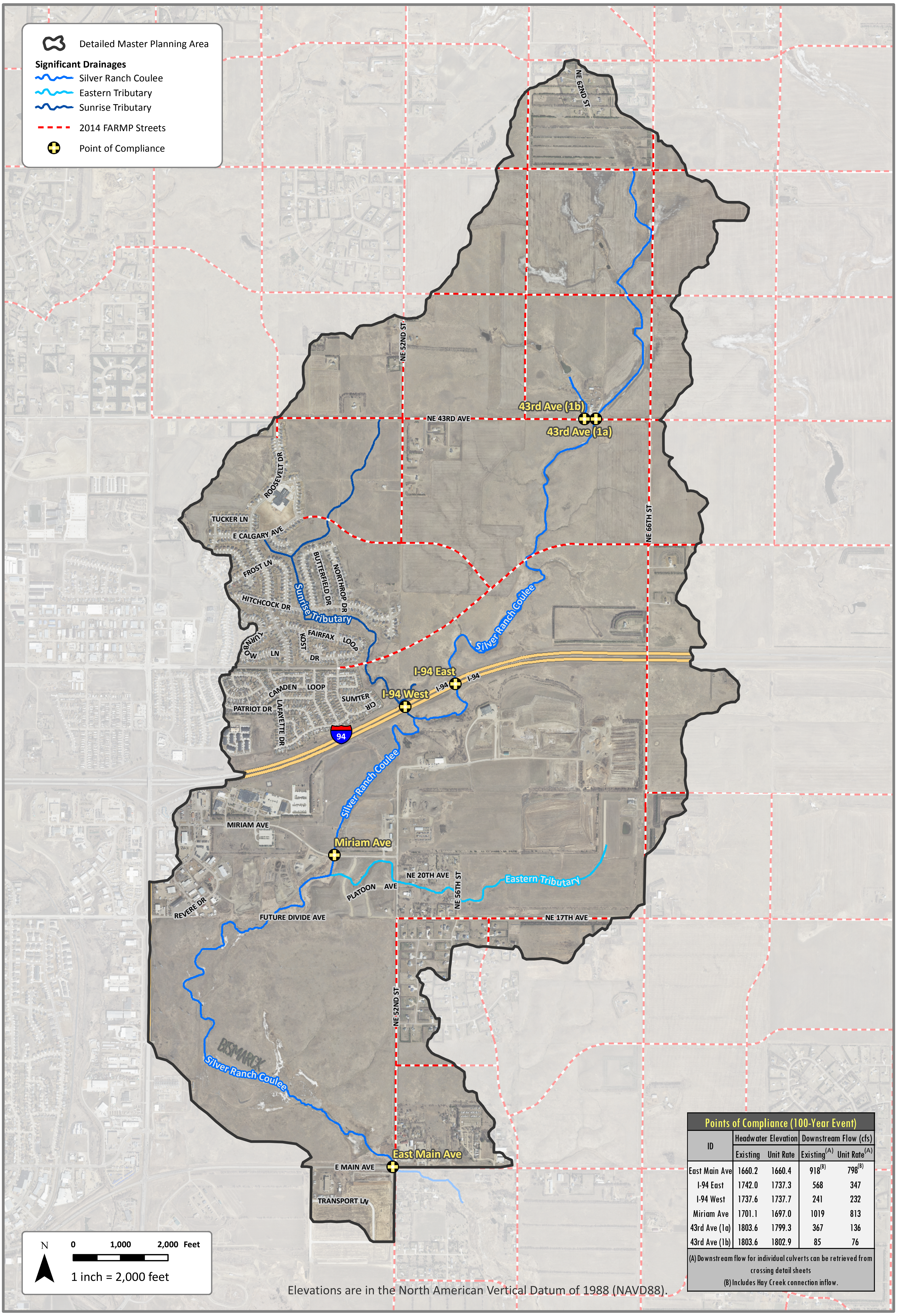


Points of Compliance (100-Year Event)

| ID | Headwater Elevation | | Downstream Flow (cfs) | |
|---|---|---|---|---|
| | Existing | Unit Rate | Existing(A) | Unit Rate(A) |
| East Main Ave | 1660.2 | 1660.4 | 918(B) | 798(B) |
| I-94 East | 1742.0 | 1737.3 | 568 | 347 |
| I-94 West | 1737.6 | 1737.7 | 241 | 232 |
| Miriam Ave | 1701.1 | 1697.0 | 1019 | 813 |
| 43rd Ave (1a) | 1803.6 | 1799.3 | 367 | 136 |
| 43rd Ave (1b) | 1803.6 | 1802.9 | 85 | 76 |

(A) Downstream flow for individual culverts can be retrieved from crossing detail sheets
(B) Includes Hay Creek connection inflow.

Elevations are in the North American Vertical Datum of 1988 (NAVD88).

Coordinate System: NAD 1983 StatePlane North Dakota South FIPS 3302 Feet Intl | Edited by: dlee | C:\Data\Projects\WAFS\Bismarck\00501-2015-013\GIS\Report Figure I-6- 100-Year Flow Compliance.mxd

SILVER RANCH
WATERSHED STORMWATER
MASTER PLAN

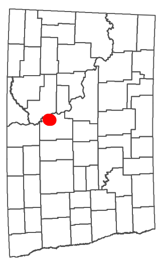
Date: 1/17/2018

# FLOW COMPLIANCE
# 100-YEAR

Figure I-6

City of Bismarck
Burleigh County, ND

Locator Map Not to Scale



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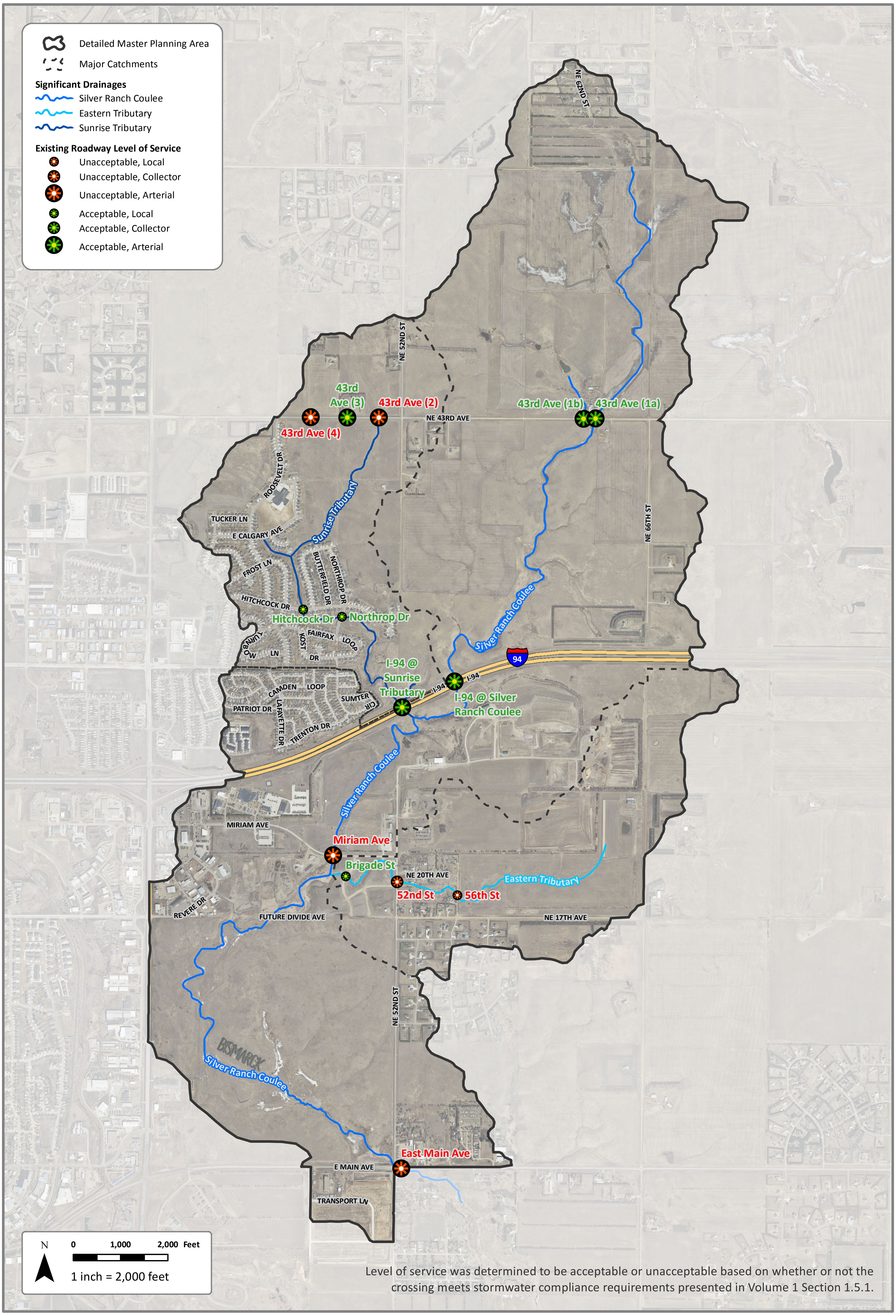
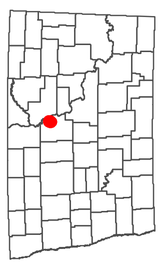


Level of service was determined to be acceptable or unacceptable based on whether or not the crossing meets stormwater compliance requirements presented in Volume 1 Section 1.5.1.

*Information depicted may include data unverified by AE2S. Any reliance upon such data is at the user's own risk. AE2S does not warrant this map or its features are either spatially or temporally accurate.*

Coordinate System: NAD 1983 StatePlane North Dakota South FIPS 3302 Feet Intl | Edited by: dlee | C:\Data\Projects\WAFS\Bismarck\0501-2015-013\GIS\Report Figure I-7 - Existing Roadway Level of Service.mxd



City of Bismarck
Burleigh County, ND

Figure I-7

## EXISTING ROADWAY LEVEL OF SERVICE

SILVER RANCH
WATERSHED STORMWATER
MASTER PLAN

Date: 10/27/2017

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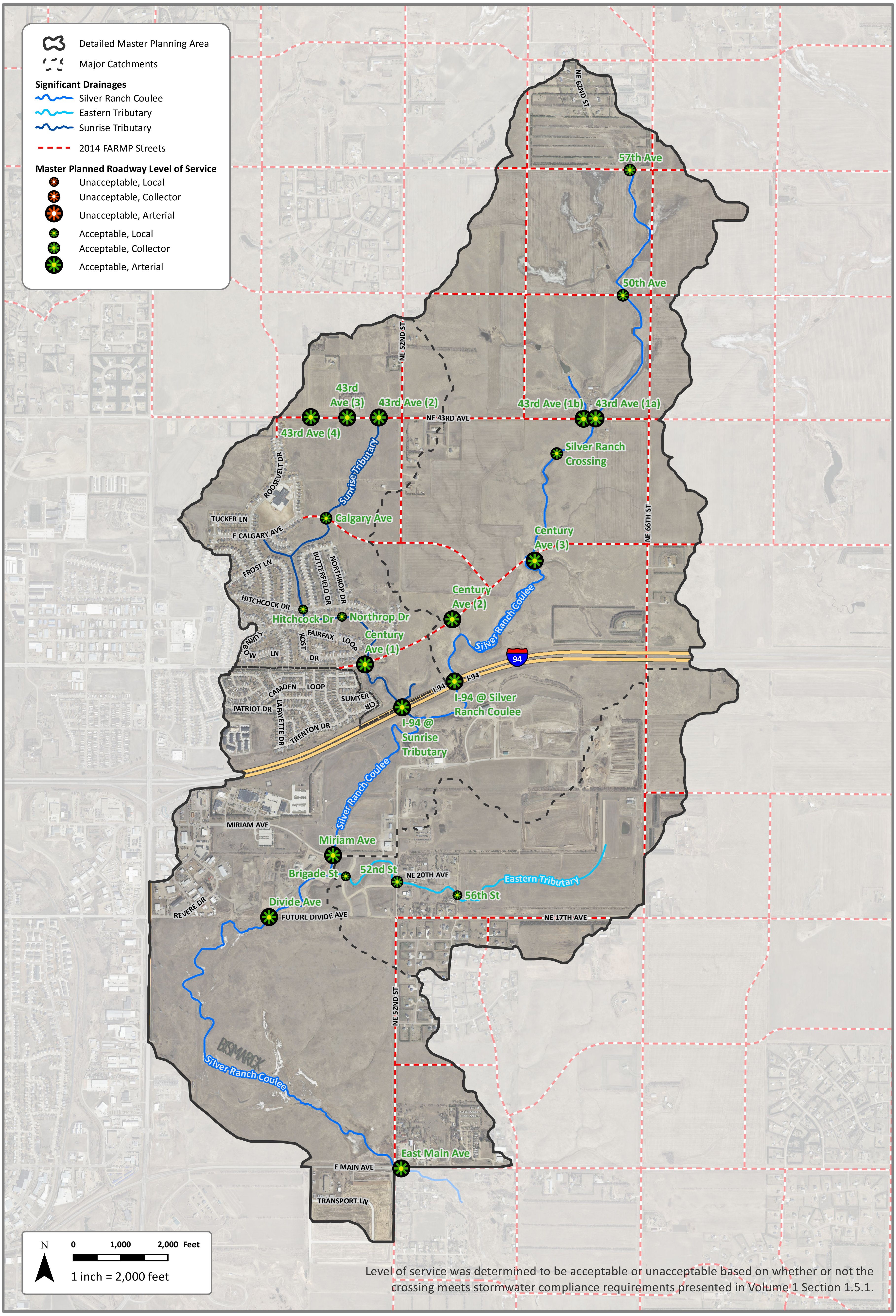


Level of service was determined to be acceptable or unacceptable based on whether or not the crossing meets stormwater compliance requirements presented in Volume 1 Section 1.5.1.

*Information depicted may include data unverified by AE2S. Any reliance upon such data is at the user's own risk. AE2S does not warrant this map or its features are either spatially or temporally accurate.*

Coordinate System: NAD 1983 StatePlane North Dakota South FIPS 3302 Feet Intl | Edited by: dlee | C:\Data\Projects\WAFS\Bismarck\00501-2015-013\GIS\Report Figure I-8- Master Planned Roadway Level of Service.mxd

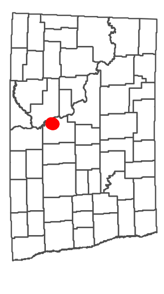
SILVER RANCH
WATERSHED STORMWATER
MASTER PLAN

Date: 10/27/2017

Figure I-8

## MASTER PLANNED LEVEL OF SERVICE

City of Bismarck
Burleigh County, ND


Locator Map Not to Scale

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## I-4.2 UNIT RATE METHOD JUSTIFICATION

A major recommendation of the Silver Ranch Watershed Master Plan is for stormwater peak flow compliance to be managed utilizing Unit Rate Method of sizing. Recommending the use of local and onsite facilities for stormwater management is a departure from past City policy of favoring regional facilities. This recommendation was based on meeting the Mater Plan goals established by the Working Group. The following sections provide a brief discussion on the analysis completed to justify the recommendation to utilize the local facilities sized using a Unit Rate Method.

### I-4.2.1 Comparison of Stormwater Management Concepts

In the development of this Master Plan, the following unique stormwater management concepts were analyzed and reviewed to determine suitability for this watershed:

1. **Local Facilities, Pre-Post Method** where individual property owners/developers design, construct, and maintain post-construction stormwater Best Management Practices (BMPs) sized such that post-construction runoff did not exceed existing runoff from a site (meeting the City's Code of Ordinances).

   For large watersheds, utilizing only Local Facilities for peak flow compliance can result in adverse impacts to downstream facilities despite providing peak flow compliance that meets existing conditions leaving the site. This watershed scale impact is the result of increased runoff volumes from developments within the watershed building up at downstream facilities and road crossings. This increased volume creates increased headwater conditions and subsequently causes peak flows to increase as demonstrated in ***Figure I - 9*** and ***Figure I - 10*** on page 36.

2. **Regional Facilities, Pre-Post Method** consisting of large post-construction stormwater BMPs constructed to provide peak flow mitigation and water quality compliance for multiple properties and/or projects. Regional facilities have typically been designed, constructed, and maintained by the City of Bismarck. Construction is funded by special assessing the benefiting properties with the City holding costs in abeyance for areas that have not yet been annexed into the City. These costs are transferred to a property if/when it is annexed into the City. Maintenance and operation is funded by stormwater utility monthly fees.

   Watershed master planning with Regional Facilities has the advantage of being able to mitigate peak flow increases resulting from increased runoff rates and increased total volume of runoff by essentially over-detaining stormwater runoff in large facilities. When utilizing a Regional Facilities approach, it may be difficult to match the pace of development, resulting in difficulties for the development community and larger financial requirements for the City of Bismarck.

3. **Local Facilities, Unit Rate Method** consists of determining an acceptable peak rate of runoff from the areas currently undeveloped within the watershed and designating a

specific rate of runoff per acre for various storm events. This approach is similar to a traditional pre–post approach to managing post-construction runoff, but eliminates the need for determining existing runoff conditions.

Watershed master planning with Local Facilities utilizing the Unit Rate Method has the advantage of being able to mitigate peak flow increases resulting from increased runoff rates and increased total volume of runoff by essentially over-detaining stormwater runoff. The results provided are similar to those obtained by Regional Facilities, except employing a larger number of smaller, distributed basins that are constructed at the pace of urbanization and in a location that is determined by the development. When utilizing this approach, there will be an increased total number of facilities to be maintained and operated. The developer constructs the facility at the time of development rather than the City constructing a larger regional facility and assessing the benefited properties. This method also has the potential advantage of reducing other infrastructure costs such as storm sewer and natural channel erosion and maintenance.

These concepts were analyzed and reviewed for compliance with the primary master plan goals, the results of which are presented in ***Table I - 2.***

### I-4.2.2 Comparison to Master Plan Goals

As presented in ***Table I - 2,*** the Local Facilities, Unit Rate Method is the only stormwater management concept to satisfy all four of the primary master plan goals. Using the Unit Rate Method to size local stormwater facilities allows for the watershed wide benefit realized with regional facilities while installing the mitigation BMP at the time of development.

Table I - 2: Master Plan Concept Comparison

| Primary Goal | Local Pre-Post | Regional Pre-Post | Local Unit Rate |
|---|---|---|---|
| **Goal 1:**<br>Minimize downstream impacts from urbanization. |  | ✓ | ✓ |
| **Goals 2:**<br>Match pace of development. | ✓ |  | ✓ |
| **Goal 3:**<br>Flexible funding and minimized financial impacts to City. | ✓ |  | ✓ |
| **Goal 4:**<br>Integrate with applicable planning documents. | ✓ | ✓ | ✓ |

### I-4.2.3 Comparison of Performance

The Local Facilities, Pre-Post Method was not selected since this method does not meet Master Plan Goal 1 because:

1. **Future condition flows throughout the watershed and at the downstream end of the watershed are significantly increased. *Figure I - 9*** and ***Figure I - 10*** presents the

hydrographs downstream of East Main Ave for existing conditions, the Local Facilities, Pre-Post Method and the Local Facilities, Unit Rate Method. As demonstrated**,** the Local Facilities, Pre-Post Method results in an increase of about 34 cfs in the 2-year storm and 200 cfs in the 100-year storm downstream of the East Main Ave crossing when compared to existing conditions.

2. **Local facilities sized using the Unit Rate Method result in Future Condition flows being equal or less than the Existing Condition**. As demonstrated with ***Figure I - 9*** and ***Figure I - 10,*** The Unit Rate concept results in essentially matching existing peak runoff for both the 2- and 100-year storms.

The Regional Facilities, Pre-Post Method was does not meet the Master Plan Goal 2 & 3 because:

1. **Initial analysis indicated that a large number of regional facilities are necessary to meet peak flow compliance upstream of I-94**. Regional facilities are best justified when the number of total facilities in a watershed can be reduced. Watershed physical characteristics including topography and exiting development limited the locations and feasibility for large regional facilities that utilized natural valley storage;
2. **Regional facilities are not conducive to matching the pace of development.** Implementation of regional facilities either significantly precede development of the watershed or lag behind the impacts of development due to the difficulty in predicting the order in which the watershed will develop. In other watersheds, using regional facilities has resulted in either lack of stormwater management or large balances of special assessments held in abeyance ; and
3. **Regional facilities are not practical for placement in the coulee in the region downstream of I-94**. Regional valley storage facilities are not practical south of I-94 due to the relatively flat topography and presence of regulatory floodplain and the significant permitting requirements that would be necessary for the construction of each facility.

### I-4.2.4 Comparison of Implementation

Implementation of local facilities sized using the Unit Rate Method will result in larger detention ponds than those sized using the traditional Pre-Post Method. To quantify the increase associated with using the Unit Rate Method, two post-construction BMP scenarios were analyzed:

1. **Residential Development: *Figure I - 11*** presents a theoretical 40-acre residential development with the approximate post-construction BMP sizing for a traditional Pre-Post Method compared to the Unit Rate Method. Also included is a table presenting the necessary pond footprints (presented in square footage and percent of site area) for 1-acre, 10-acre, and 40-acre residential developments**.**
2. **Commercial Development: *Figure I - 12*** presents a conceptual 40-acre commercial development with the approximate post-construction BMP sizing for a traditional Pre-Post Method compared to the Unit Rate Method. Also included is a table presenting the

necessary pond footprints (presented in square footage and percent of site area) for 1-acre, 10-acre, and 40-acre commercial developments.

Figure I - 9: 2-Year Storm Concept Comparison at East Main Ave

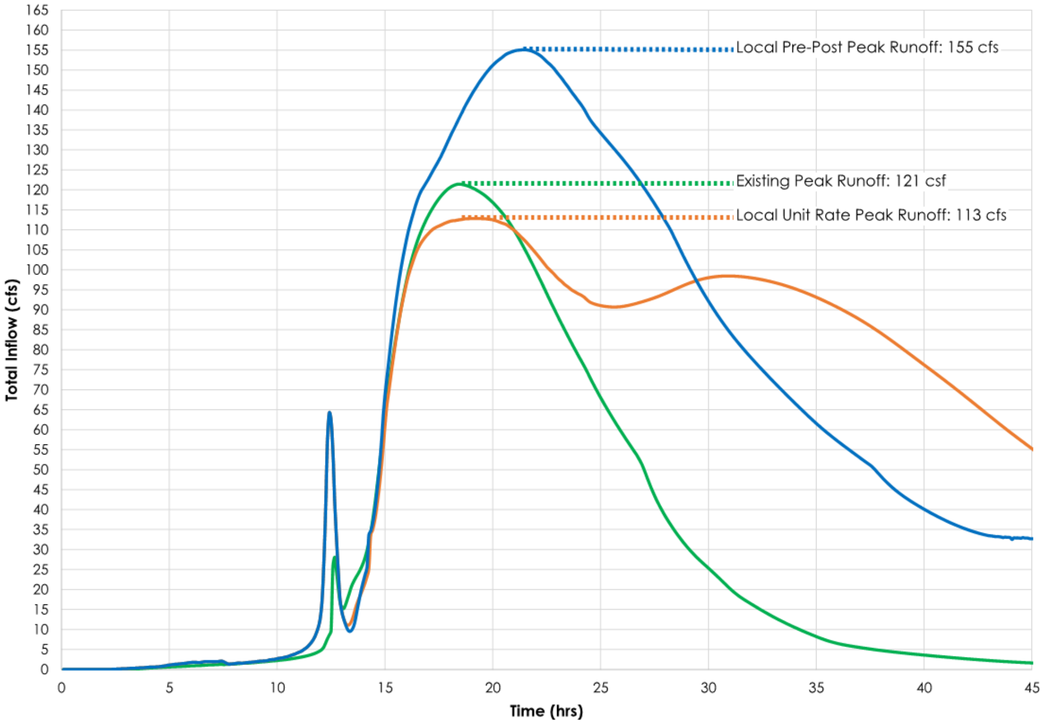
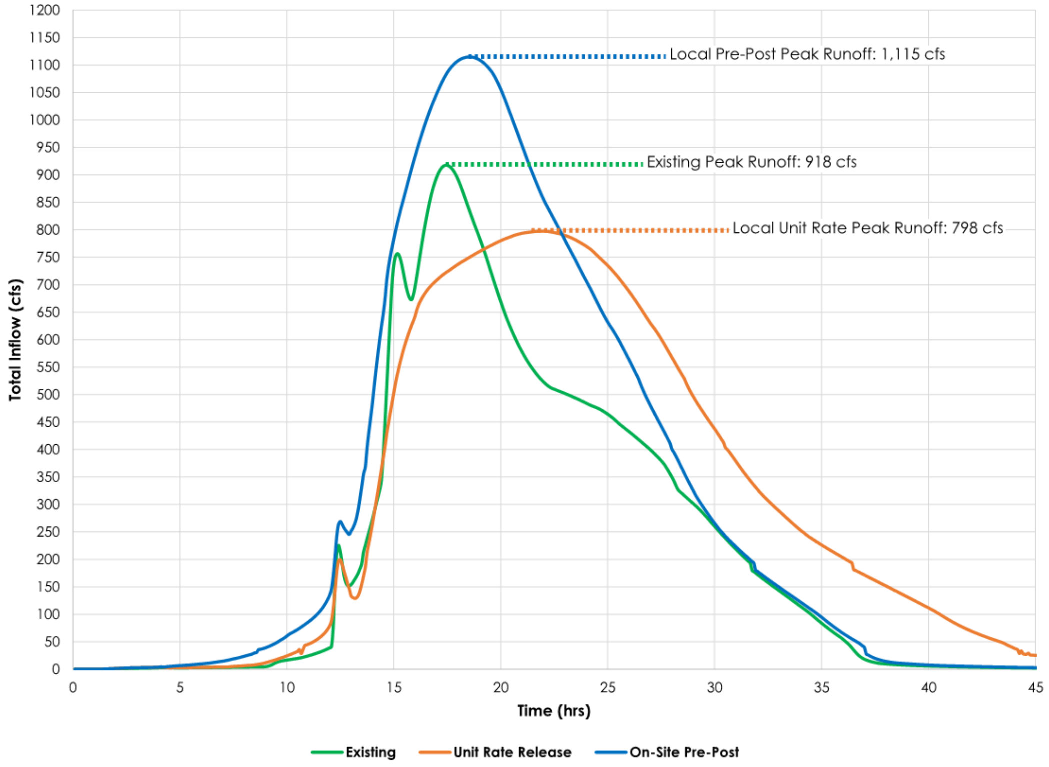


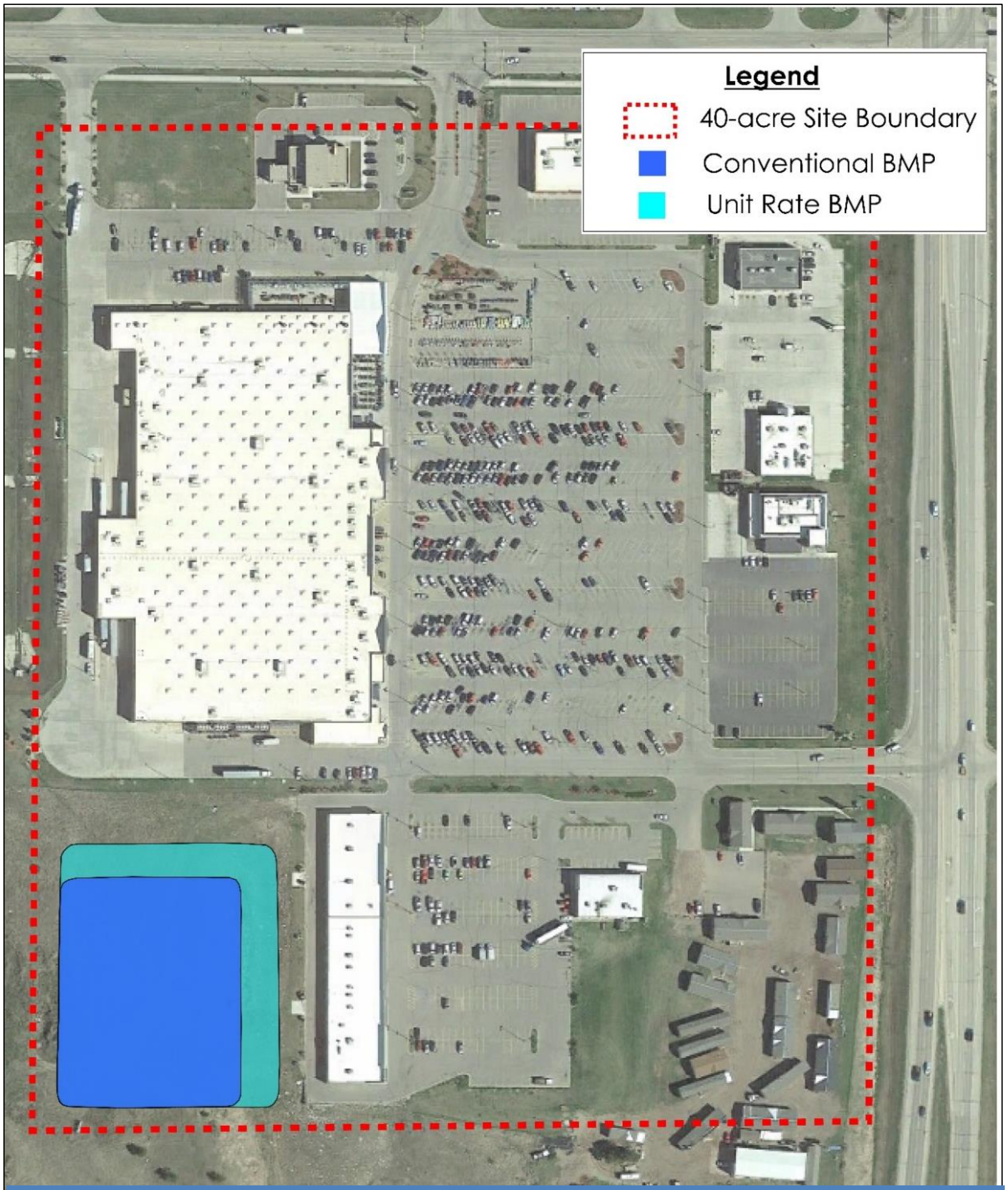
Figure I - 10: 100-Year Storm Concept Comparison at East Main Ave



## Figure I - 11: 40-Acre Residential Site BMP Comparison

| Residential Sites | | | | | | |
|---|---|---|---|---|---|---|
| | Conventional BMP | | Unit Rate BMP | | Increase | |
| Area (Acre) | Size of BMP (sq ft) | % of Site | Size of BMP (sq ft) | % of Site | Size of BMP (sq ft) | % of Site |
| **40** | 53,300 | 3% | 69,700 | 4% | 17,400 | 1% |
| **10** | 13,100 | 3% | 19,600 | 4.5% | 6,500 | 1.5% |
| **1** | 1,700 | 4% | 2,600 | 6% | 900 | 2% |

## Figure I - 12: 40-Acre Commercial Site BMP Comparison



| Commercial Sites | | | | | | |
|---|---|---|---|---|---|---|
| | Conventional BMP | | Unit Rate BMP | | Increase | |
| Area (Acre) | Size of BMP (sq ft) | % of Site | Size of BMP (sq ft) | % of Site | Size of BMP (sq ft) | % of Site |
| **40** | 87,100 | 5% | 122,000 | 7% | 34,900 | 2% |
| **10** | 21,800 | 5% | 31,400 | 7.2% | 9,600 | 2.2% |
| **1** | 3,000 | 7% | 3,900 | 9 | 900 | 2% |

## I-4.3 MASTER PLAN REPORTING LOCATIONS

Master Plan performance is presented at designated Points of Compliance, Points of Analysis, and Flow Reporting Points. Watershed performance and goal achievement was reviewed at select points throughout the watershed, located mainly on the significant drainages (***Figure I - 2***). These points are referred to as Points of Compliance, Points of Analysis, and Flow Reporting Points.  The following sections provide a brief summary of the specific Points of Compliance, Points of Analysis, and Flow Reporting Points identified or utilized by this Master Plan.

### I-4.3.1 Points of Compliance

Points of Compliance are key locations where changes in flow rate or flow depth would have adverse impacts to significant existing infrastructure or downstream users. To achieve the Master Plan goals at Points of Compliance, master planned flows and water surface elevations need to be equal to or less than the existing condition.   The following five Points of Compliance were identified and are presented on ***Figure I - 5*** and ***Figure I - 6*** along with tables presenting Existing and Unit Rate flows and headwater elevations:

1. 43rd Avenue at Silver Ranch Coulee
2. I-94 at Sunrise Tributary
3. I-94 at Silver Ranch Coulee
4. Miriam Ave at Silver Ranch Coulee
5. East Main Ave at Silver Ranch Coulee

### I-4.3.2 Points of Analysis & Flow Reporting Points

In general, Points of Analysis are existing roadway crossings requiring upgrades, select future roadway crossings, or intermediate locations on significant drainages that are designated as Flow Reporting Points.  Points of Analysis and Flow Reporting Points are intended to act as reference points for reviewing existing and design flows as well as to aid in the design of possible future crossings not identified by this Master Plan.

At Points of Analysis, flows and headwater elevations are presented as either existing or design. Design values represent the maximum flow/headwater at each point when comparing the Unit Rate values against flows rates from existing conditions with future crossings constructed. Design values represent the worst-case scenario at each point.

Upstream headwater at Points of Analysis is desired to not exceed the existing condition, though this is not a requirement with exceptions being made based on surrounding land use and infrastructure as well as whether or not the increase occurs within a designated "Open Space."  The Points of Analysis and Flow Reporting Points identified in this Master Plan are presented on ***Figure I - 13***, ***Figure I - 14***, and ***Figure I - 15*** along with tables presenting existing and design flows as well as headwater elevations for Points of Analysis.

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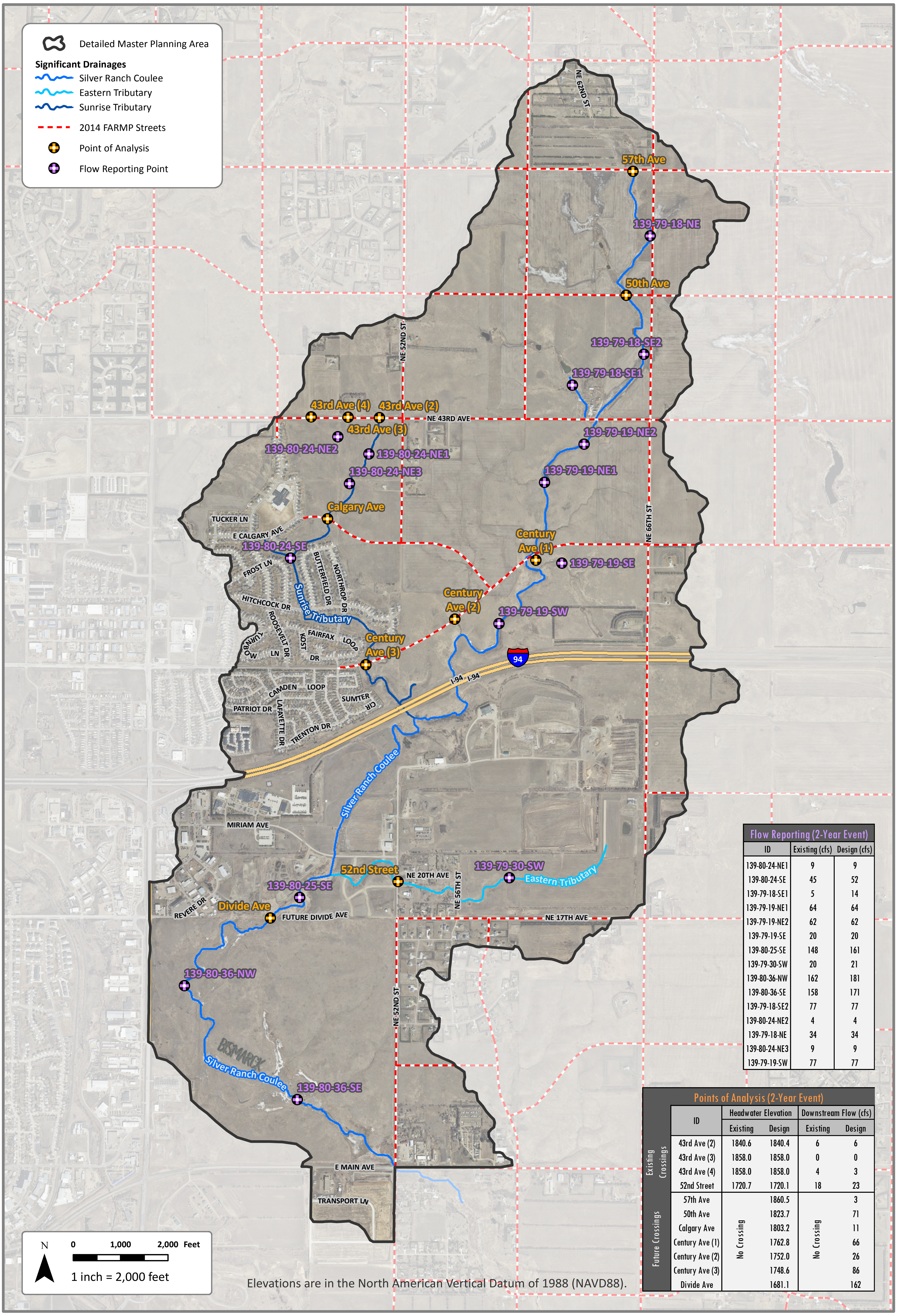

Elevations are in the North American Vertical Datum of 1988 (NAVD88).

**Flow Reporting (2-Year Event)**

| ID | Existing (cfs) | Design (cfs) |
|---|---|---|
| 139-80-24-NE1 | 9 | 9 |
| 139-80-24-SE | 45 | 52 |
| 139-79-18-SE1 | 5 | 14 |
| 139-79-19-NE1 | 64 | 64 |
| 139-79-19-NE2 | 62 | 62 |
| 139-79-19-SE | 20 | 20 |
| 139-80-25-SE | 148 | 161 |
| 139-79-30-SW | 20 | 21 |
| 139-80-36-NW | 162 | 181 |
| 139-80-36-SE | 158 | 171 |
| 139-79-18-SE2 | 77 | 77 |
| 139-80-24-NE2 | 4 | 4 |
| 139-79-18-NE | 34 | 34 |
| 139-80-24-NE3 | 9 | 9 |
| 139-79-19-SW | 77 | 77 |

**Points of Analysis (2-Year Event)**

|  | ID | Headwater Elevation |  | Downstream Flow (cfs) |  |
|---|---|---|---|---|---|
|  |  | Existing | Design | Existing | Design |
| Existing Crossings | 43rd Ave (2) | 1840.6 | 1840.4 | 6 | 6 |
|  | 43rd Ave (3) | 1858.0 | 1858.0 | 0 | 0 |
|  | 43rd Ave (4) | 1858.0 | 1858.0 | 4 | 3 |
|  | 52nd Street | 1720.7 | 1720.1 | 18 | 23 |
| Future Crossings | 57th Ave | No Crossing | 1860.5 | No Crossing | 3 |
|  | 50th Ave |  | 1823.7 |  | 71 |
|  | Calgary Ave |  | 1803.2 |  | 11 |
|  | Century Ave (1) |  | 1762.8 |  | 66 |
|  | Century Ave (2) |  | 1752.0 |  | 26 |
|  | Century Ave (3) |  | 1748.6 |  | 86 |
|  | Divide Ave |  | 1681.1 |  | 162 |

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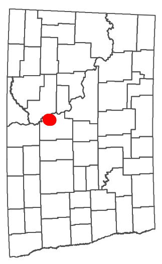
Locator Map Not to Scale

City of Bismarck
Burleigh County, ND

Figure I-13

**2-YEAR**
**DESIGN FLOWS**

SILVER RANCH
WATERSHED STORMWATER
MASTER PLAN

Date: 1/17/2018

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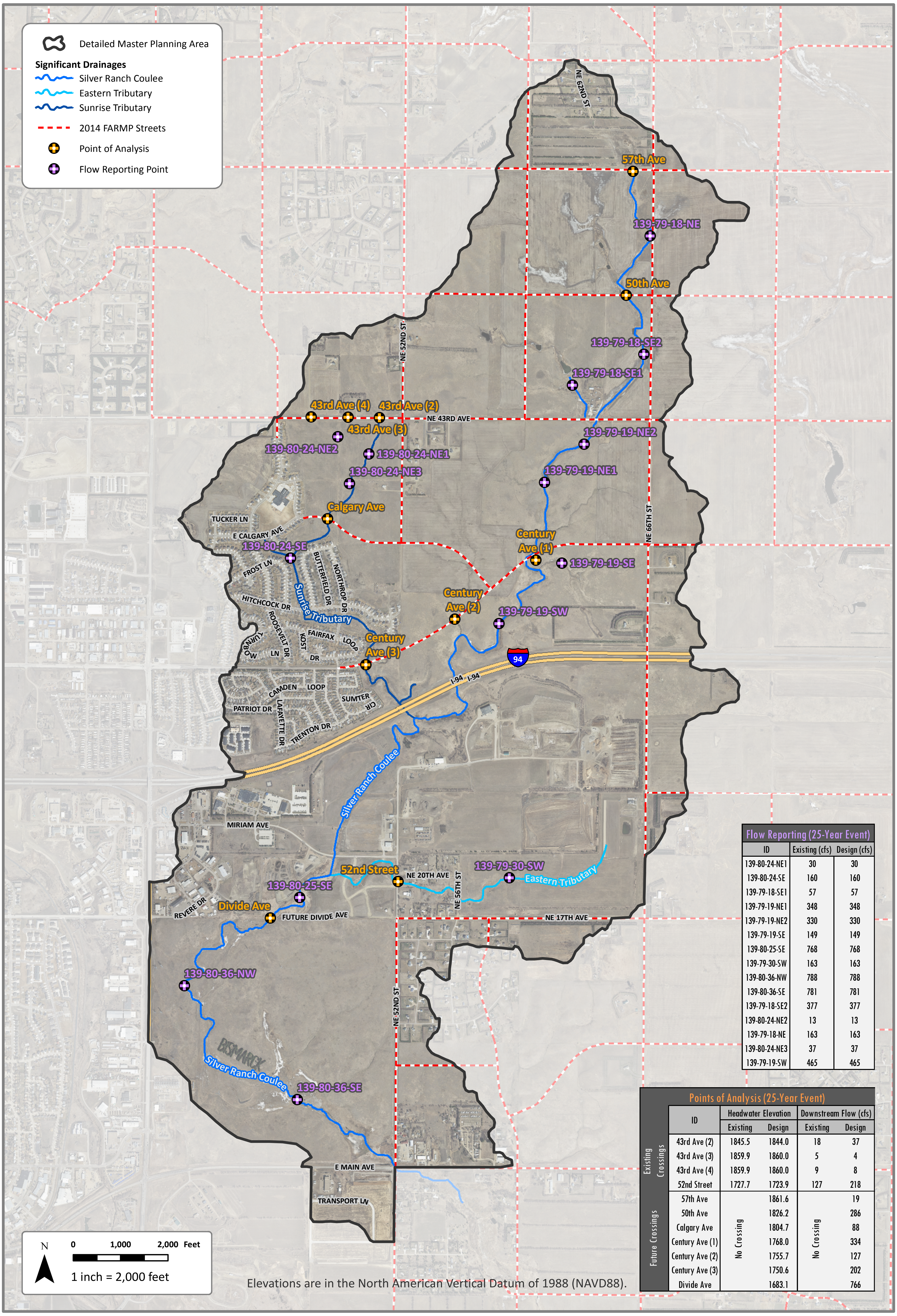

Elevations are in the North American Vertical Datum of 1988 (NAVD88).

**Flow Reporting (25-Year Event)**

| ID | Existing (cfs) | Design (cfs) |
|---|---|---|
| 139-80-24-NE1 | 30 | 30 |
| 139-80-24-SE | 160 | 160 |
| 139-79-18-SE1 | 57 | 57 |
| 139-79-19-NE1 | 348 | 348 |
| 139-79-19-NE2 | 330 | 330 |
| 139-79-19-SE | 149 | 149 |
| 139-80-25-SE | 768 | 768 |
| 139-79-30-SW | 163 | 163 |
| 139-80-36-NW | 788 | 788 |
| 139-80-36-SE | 781 | 781 |
| 139-79-18-SE2 | 377 | 377 |
| 139-80-24-NE2 | 13 | 13 |
| 139-79-18-NE | 163 | 163 |
| 139-80-24-NE3 | 37 | 37 |
| 139-79-19-SW | 465 | 465 |

**Points of Analysis (25-Year Event)**

|  | ID | Headwater Elevation |  | Downstream Flow (cfs) |  |
|---|---|---|---|---|---|
|  |  | Existing | Design | Existing | Design |
| Existing Crossings | 43rd Ave (2) | 1845.5 | 1844.0 | 18 | 37 |
|  | 43rd Ave (3) | 1859.9 | 1860.0 | 5 | 4 |
|  | 43rd Ave (4) | 1859.9 | 1860.0 | 9 | 8 |
|  | 52nd Street | 1727.7 | 1723.9 | 127 | 218 |
| Future Crossings | 57th Ave | No Crossing | 1861.6 | No Crossing | 19 |
|  | 50th Ave |  | 1826.2 |  | 286 |
|  | Calgary Ave |  | 1804.7 |  | 88 |
|  | Century Ave (1) |  | 1768.0 |  | 334 |
|  | Century Ave (2) |  | 1755.7 |  | 127 |
|  | Century Ave (3) |  | 1750.6 |  | 202 |
|  | Divide Ave |  | 1683.1 |  | 766 |

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SILVER RANCH
WATERSHED STORMWATER
MASTER PLAN

Date: 1/17/2018

Figure I-14
**25-YEAR**
**DESIGN FLOWS**

City of Bismarck
Burleigh County, ND

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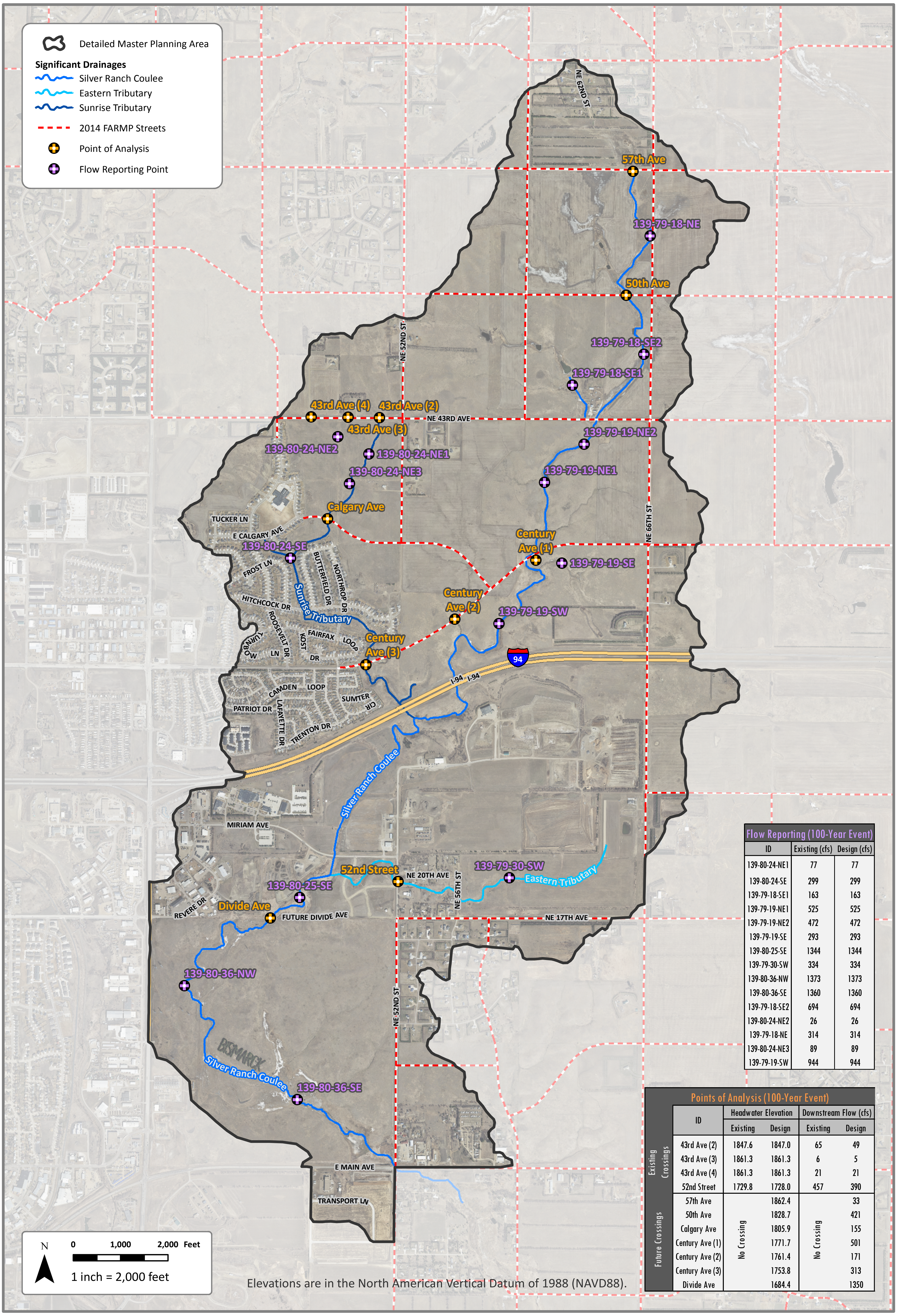

**Flow Reporting (100-Year Event)**

| ID | Existing (cfs) | Design (cfs) |
|---|---|---|
| 139-80-24-NE1 | 77 | 77 |
| 139-80-24-SE | 299 | 299 |
| 139-79-18-SE1 | 163 | 163 |
| 139-79-19-NE1 | 525 | 525 |
| 139-79-19-NE2 | 472 | 472 |
| 139-79-19-SE | 293 | 293 |
| 139-80-25-SE | 1344 | 1344 |
| 139-79-30-SW | 334 | 334 |
| 139-80-36-NW | 1373 | 1373 |
| 139-80-36-SE | 1360 | 1360 |
| 139-79-18-SE2 | 694 | 694 |
| 139-80-24-NE2 | 26 | 26 |
| 139-79-18-NE | 314 | 314 |
| 139-80-24-NE3 | 89 | 89 |
| 139-79-19-SW | 944 | 944 |

**Points of Analysis (100-Year Event)**

|  | ID | Headwater Elevation |  | Downstream Flow (cfs) |  |
|---|---|---|---|---|---|
|  |  | Existing | Design | Existing | Design |
| Existing Crossings | 43rd Ave (2) | 1847.6 | 1847.0 | 65 | 49 |
|  | 43rd Ave (3) | 1861.3 | 1861.3 | 6 | 5 |
|  | 43rd Ave (4) | 1861.3 | 1861.3 | 21 | 21 |
|  | 52nd Street | 1729.8 | 1728.0 | 457 | 390 |
| Future Crossings | 57th Ave | No Crossing | 1862.4 | No Crossing | 33 |
|  | 50th Ave |  | 1828.7 |  | 421 |
|  | Calgary Ave |  | 1805.9 |  | 155 |
|  | Century Ave (1) |  | 1771.7 |  | 501 |
|  | Century Ave (2) |  | 1761.4 |  | 171 |
|  | Century Ave (3) |  | 1753.8 |  | 313 |
|  | Divide Ave |  | 1684.4 |  | 1350 |

Elevations are in the North American Vertical Datum of 1988 (NAVD88).

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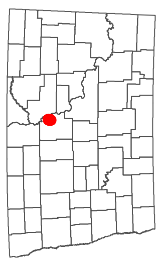
SILVER RANCH
WATERSHED STORMWATER
MASTER PLAN

Date: 1/17/2018

Figure I-15

**100-YEAR**
**DESIGN FLOWS**

City of Bismarck
Burleigh County, ND


Locator Map Not to Scale

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## I-4.4 STORMWATER COMPLIANCE REQUIREMENTS

Development of this Master Plan included meeting requirements for local, county, and State drainage regulations. The following sections summarize the general requirements for each jurisdiction.

### I-4.4.1 City Requirements

The City of Bismarck includes performance criteria within Title 14.1 of the City's Code of Ordinances. Additional City design criteria are included within the City's Stormwater Design Standards Manual. Specific applicable criteria are as follows:

1. Unit Rate recommendations and proposed infrastructure were designed such that flows meet the City's requirements at Points of Compliance located throughout the Master Planning area. These requirements are summarized as follows:
    a. No increase in post-development flows compared to pre-development flows for the 2-, 10-, and 100-year storm events (14.1-02-03 6.a.).
        i. Based on analysis of watershed performance, compliance with the Unit Rate recommendations for the 2- and 100-year events achieves compliance for the 10-year storm event.
        ii. Because of this, the recommended Master Plan approach of utilizing a Unit Rate method does not require the 10-year event to be analyzed.
    b. For the purposes of this Master Plan, "pre-development" is defined as current conditions and existing land use (see ***Section II-2.2*** in ***Volume II*** for additional information).
    c. This Master Plan utilizes a 24-hour storm consistent with the City's SWDSM.
    d. The Unit Rate Method will require utilizing smaller than the 4-inch diameter minimum orifice allowed by the SWDSM. ***Figure I - 16*** (see page 50) demonstrates a schematic design of an engineered outlet for low flow protection.
2. Meet the City's MS4 permit requirements as outlined in Appendix 1 of the Authorization to Discharge under the North Dakota Pollutant Discharge Elimination System Permit No. NDR04-0000, or the current effective MS4 permit requirements.
3. Future and existing road crossing structures were sized to meet Section 6 of the SWDSM.
    a. Allowable headwater over culvert crossing per Table 6-7 of the SWDSM which states that the 25-year, 24-hour event shall be less than 1.5 times the culvert diameter or rise.
    b. Allowable Street overtopping per Table 6-8 of the SWDSM.

   i. Local Streets: No overtopping in the 25-year storm and no more than 6” of depth over the highest point on the street section in the 100-year storm; and
   ii. Collector & Arterial Streets: No overtopping in the 100-year storm.

### I-4.4.2 County Requirements

For the purposes of this Master Plan, all areas within the Silver Ranch Watershed are considered to be within the limits of the City of Bismarck when implementation of this Master Plan occurs.

### I-4.4.3 State Requirements

The Silver Ranch watershed includes drainages that cross Interstate 94 therefore, both North Dakota Department of Transportation (NDDOT) and State Water Commission (SWC) criteria for stream crossings, level of service, and backwater are applicable. Meeting the requirements of NDAC Article 89-14 Public Highway Stream Crossings is required at these locations. In general, the requirements of NDAC 89-14 are summarized as follows:

1. Design flood frequency is determined by section 89-14-01-03.
   a. For regional and urban State Highway roads in the urban system, no roadway overtopping shall occur up to the 25-year event.
   b. For non-interstate State Highway roads in the rural system, no roadway overtopping shall occur up to the 25-year event.
2. Allowable headwater over culvert crossings is determined by section 89-14-01-05.
   a. For the Master Plan area, streambed slopes are greater than 10 feet/mile (entire study area).
   b. The allowable headwater when passing the design flood frequency shall be no greater than two pipe diameters.

The State Engineer/State Water Commission regulates construction of dams. Per NDCC Article 61-16.1-38, permits are required for structures retaining more than 25 acre-feet of water for medium- or high-hazard dams. Since these facilities will be constructed in an urban area, it is likely that any detention facility exceeding 25 acre-feet of storage, even if temporary, would be classified as a dam and would require formal approval through the State permitting process.

### I-4.4.4 Water Quality Compliance

Water quality shall be provided by each development per the City of Bismarck SWDSM in order to meet MS4 requirements.

### I-4.4.5 Street Crossing Criteria Hierarchy

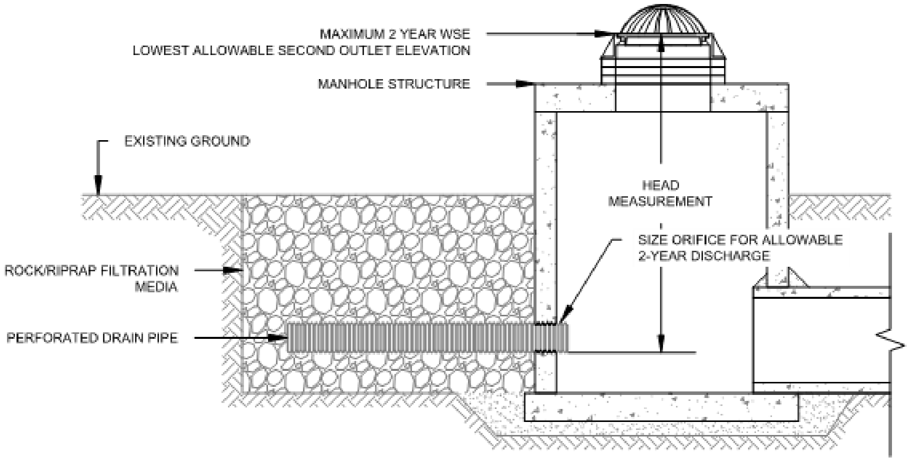
To balance the potential impact of headwater elevations at existing and future roadway crossings, the hierarchy presented in ***Table I - 3*** shall be utilized to size the minimum culvert pipe size at each significant crossing.

Table I - 3: Stream Crossing Design Hierarchy

| Situation | Road Crossing Criteria |
|---|---|
| **Crossing is within a FEMA Floodplain** | ➢ 25-year HW < 1.5 x Culvert Diameter<br>➢ 100-year HW < Overtopping Elevation<br>➢ 100-year WSE < 1-foot rise over FEMA BFE |
| **Crossing is within a "Open Space" as designated by the Bismarck Future Land Use Plan** | ➢ 25-year HW < 1.5 x Culvert Diameter<br>➢ 100-year HW < Overtopping Elevation<br>➢ 100-year WSE inundation area to remain inside of land use designated "Open Space" |
| **Crossing is not within a FEMA Floodplain or designated "Open Space"** | ➢ 25-year HW < 1.5 x Culvert Diameter<br>➢ 100-year HW < Overtopping Elevation<br>➢ Engineer's judgement used to determine the appropriate balance between infrastructure recommendations and 100-year WSE inundation area. |
| **All Crossings** | If feasible, provide 1-foot of freeboard in the 100-year event. |

Notes:
"HW" = Headwater measured from the channel invert.
"BFE" = Base Flood Elevation
"WSE" = Water Surface Elevation

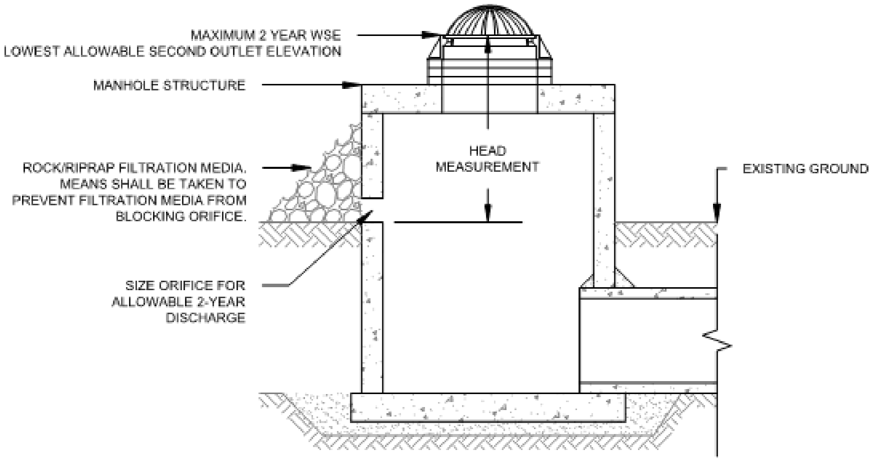
## Figure I - 16: Engineered Outlet for Low Flow Protection



**GENERAL NOTES**

1. ACTUAL DEPTH OF DRAIN PIPE, SIZE OF MEDIA, AND QUANTITY OF MEDIA WILL VARY. THESE DETERMINATIONS SHALL BE MADE PER ENGINEERS JUDGEMENT.

**1 LOW FLOW STRUCTURE - UNDERDRAIN**
NOT TO SCALE



**GENERAL NOTES**

1. ACTUAL DEPTH SIZE OF MEDIA, AND QUANTITY OF MEDIA WILL VARY. THESE DETERMINATIONS SHALL BE MADE PER ENGINEERS JUDGEMENT.

**2 LOW FLOW STRUCTURE - ORIFICE W/ FILTRATION MEDIA**
NOT TO SCALE

## I-4.5 SILVER RANCH WATERSHED STORMWATER DESIGN STANDARDS

Stormwater design standards in the City of Bismarck are defined by Title 14.1 of the City Code of Ordinances and the Stormwater Design Standards Manual (SWDSM). To meet the specific stormwater management goals of the Silver Ranch Master Plan area, watershed specific revisions to the requirements of the SWDSM are recommend for development and redevelopment activities in the Master Plan area.

The following sections and ***Table I - 6*** summarize the recommended modifications to the performance requirements, analysis and reporting requirements, design standards and analysis methodologies for the Silver Ranch Master Plan area.

Not every development or redevelopment scenario has been identified during the development of the Silver Ranch Master Plan. Additional requirements or modifications to the SWDSM may be identified by the City Engineer during the mandatory stormwater scoping sheet submittal described in the SWDSM.

### I-4.5.1 Post-Construction Peak Flow Compliance

Post-construction peak flow compliance for development and redevelopment projects shall meet the requirements of the SWDSM with the following modifications:

**Performance Requirements**

The requirements of Section 4.1 of the SWDSM are to be replaced with the following:

Projects that require a Post-Construction Stormwater Management Permit (PCSMP) are subject to Peak Discharge Control requirements and shall include peak discharge post-construction structural or non-structural BMPs to conform to the requirements of ***Table I - 4*** of the Silver Ranch Master Plan and *Section 4.1.1* of the SWDSM.

Table I - 4: Point of Discharge Peak Flow Compliance Unit Rate Method

| Point of Discharge Location | Peak Discharge Control Requirement |
|---|---|
| Public Storm Sewer System and New Outfalls to Surface Waters | Post-Construction runoff resulting from the 2- and 100-year 24-hour rainfall events shall not exceed the runoff rate of the Post-Construction Unit Rate values of:<br>• **2-year Storm = 0.06 cfs/acre**<br>• **100-year Storm = 0.50 cfs/acre**<br>The Unit Rate recommendation accounts for an amount of pervious ground, not to exceed 10% of site's total area, discharging directly offsite without mitigation in a Post-Construction BMP. |

Clarifications to *Section 4.1.1* of the SWDSM are as follows:

1. Projects located inside of the Silver Ranch Master Plan that require a PCSMP will need to provide an on-site or local post-construction BMPs to address peak discharge compliance performance requirements of ***Table I - 4***.
2. The allowable post-construction discharge is determined by the total site area times the Unit Rate values of ***Table I - 4***. A maximum of 10% of the site area may not be routed to a peak flow compliance BMP due to topographic or other constraints.
3. Area designated as “Green Space” in the Future Land Use Plan that remain open space or pervious area after development activities are exempt from meeting the requirements of the Unit Rate allowable discharge and do not need to be routed to the peak discharge compliance BMP.
4. Area inside of the Development Setback Line and outside of designated “Green Space” shall meet the requirements of the Unit Rate allowable discharge.
5. Projects located inside of the Silver Ranch Master Plan that require a PCSMP and are located in an area with a previously approved PCSMP\SWMP shall provide documentation that the project meets the requirements for Peak Discharge Compliance by utilizing one of the scenarios described in Section 4.1.1 of the SWDSM.
6. Post-construction peak flow compliance with other design storms is not required. Note that post-construction design storm requirements for other stormwater BMPs (i.e. storm sewers, street conveyance, and other structures necessary to convey post-construction flows to the peak flow BMP) need to meet applicable requirements of the SWDSM.
7. Flows entering a site from undeveloped offsite areas are to be determined per the requirements of the SWDSM. PCSMP applications are not to consider these undeveloped offsite areas when calculating the allowable Unit Rate value for the PCSMP application.

### Analysis and Reporting Requirements

PCSMP applications utilizing the Unit Rate method are not required to provide the Existing Conditions hydrologic analysis included in *Section 4.2.1* of the SWDSM or *Item 4.2* of the PCSMP Checklist (SM-05).

For projects requiring a PCSMP in the Silver Ranch Master Plan area, the Existing Conditions hydrologic summary and analysis is to be replaced with:

Summary Table for of the Project Site Catchments by Point of Analysis that Includes:

1. Tributary Area of Onsite Project,
2. Tributary Area of Offsite Run-on Areas, and
3. Report the Post-Construction Allowable Unit Rate Runoff consistent with ***Table I - 4.***
4. Reporting of total storm volumes is not required.

Following is a recommend summary table to be included in the SWMP as required by the PCSMP Checklist (SM-05).

Table I - 5: PCSMP SWMP Recommended Unit Rate Report Table

| Project Hydrologic Modeling Summary – Allowable Unit Rate Discharge | | | | | |
|---|---|---|---|---|---|
| | | Allowable Post-Construction Peak Flow (cfs) | | | |
| ***Point of Analysis*** | **Site Area (Ac)** | **2-Year** | **100-Year** | **Area to BMP (Ac)** | **% to BMP** |
| *Point of Analysis 1* | | | | | |
| *Point of Analysis 2* | | | | | |
| *Point of Analysis 3* | | | | | |
| *Point of Analysis 4* | | | | | |
| | | | ***Total Site*** | | |

Required Exhibit 3.0 noted by PCSMP Checklist (SM-05) must include the following:

Documentation showing how the entire site area, both pervious and impervious, is conveyed to the post-construction peak flow compliance BMP and note any areas that cannot be routed to the BMP.

### Design Standards

In addition to the minimum design standards presented in Section 4.3 of the SWDSM, the following considerations will be applied to Unit Rate sized post-construction peak flow compliance BMPs:

1. Design of BMPs are to account for undeveloped offsite flows by:
    a. Routing undeveloped flows around proposed detention basin; or
    b. Route undeveloped flows to the detention basin and design a stabilized overflow accounting for offsite flowrates. Note that the BMP should be designed to meet the Unit Rate requirements not including the off-site flows.
2. Engineered Outlets for Unit Rate detention basins smaller than 4-inches in diameter are to provide clog protection consistent with ***Figure I - 16*** or other approved method.
3. Due to topographic constraints, a maximum of 10% of pervious area of the site may be allowed to drain without being routed to a post-construction BMP.

### Analysis Methodologies

Per the requirements of the SWDSM, no revisions for the Silver Ranch Master Plan.

## I-4.5.2 Post-Construction Water Quality Compliance

Post construction peak flow compliance for development and redevelopment projects should meet the requirements of the SWDSM with the following modifications:

### Performance Requirements

Per the requirements of the SWDSM, no revisions for the Silver Ranch Master Plan.

### Analysis and Reporting Requirements

Per the requirements of the SWDSM, no revisions for the Silver Ranch Master Plan.

### Design Standards

In addition to the minimum design standards presented in Section 5.3 of the SWDSM, the following considerations will be applied to Unit Rate sized post-construction water quality compliance BMPs:

1. Engineered Outlets for Unit Rate detention basins smaller than 2-inches in diameter are to provide clog protection consistent with ***Figure I - 16*** or other approved method.

### Analysis Methodologies

Per the requirements of the SWDSM, no revisions for the Silver Ranch Master Plan.

### Post Construction Drainage and Conveyance

Per the requirements of the SWDSM, no revisions for the Silver Ranch Master Plan.

## I-4.5.3 Construction, Maintenance, and Operation Responsibilities

It is recommended that the City develop a standard policy for the construction, maintenance and operation of post-construction stormwater facilities. In general, the City has developed practices for the construction and operation of public storm sewers, street drainage, culverts, and other conveyance hydraulic structures located within public right-of-ways or easements.

The City does not have a consistent practice for the construction, maintenance, and operation of stormwater basins installed for peak flow and water quality compliance. Policies for stormwater basins (ponds) is recommended to identify the responsible party and funding for the following components:

1. Design and Construction;
2. Vegetation Maintenance;
3. Functional Maintenance; and
4. Operation/Inspection

When formulating a policy, consideration for flexibility should be included as responsibilities will likely be dependent on the type and size of the development or final use of the site being served by the stormwater facility. For example, single family residential subdivisions typically do not have the knowledge or resources to maintain stormwater infrastructure. Conversely, industrial uses are highly regulated by individual site-specific permits and would be better suited for high levels of owner responsibility.

The following sections provide key considerations for future policy development. ***Table I - 7*** recommend framework of responsibility by land use.

### Design and Construction Considerations

Title 14.1 of the Code of City Ordinances and the SWDSM provide sufficient guidance for the analysis and design of stormwater basins. It is recommended that the City develop policies for when the Developer is responsible for funding the construction and when special assessments or other method of public financing could be utilized.

### Vegetation Maintenance Considerations

<u>Vegetation Maintenance is a minimum level of vegetation maintenance provided for the stormwater basin.</u>

In general, vegetation maintenance consists of mowing of the vegetation, replacement or upkeep of the vegetation, and other any other necessary improvements for the upkeep of the stormwater basin. Vegetation maintenance is not a function of aesthetics.

For stormwater basins where the City has the primary responsibility to provide maintenance, it is recommended that a policy be developed to define the minimum amount of upkeep that will be provided by the City staff and paid for via the stormwater utility fees. Vegetation maintenance to provide for aesthetic considerations would be the responsibility of the developer, owner, or other association.

### Functional Maintenance Considerations

Functional maintenance is defined as the level of maintenance necessary for the stormwater basin to function as intended within the City's stormwater program.

Examples of functional maintenance include the periodic removal of woody growth, invasive plant removal, repair of energy dissipation features, dredging of accumulated sediments, and repair of engineered outlet structures.

Typically functional maintenance will require specialized equipment and labor provided by the City or a contractor. Developments consisting of predominantly residential land use or small mixed use areas will likely not possess the knowledge or ability to provide functional maintenance.

### Operational Considerations

Operations is defined as the necessary inspections, reporting, and documentation of corrective actions to keep the stormwater basin functioning as intended.

The City's stormwater program and compliance with the MS4 permit requirements will result in numerous post-construction BMPs distributed throughout the City. Compliance with the MS4 permit requirements is the responsibility of the City.

Operational policies should be developed that provide the tools for the City stormwater staff to facilitate the compliance of the MS4 requirements by being the primary source of knowledge and information for the operation of the stormwater system.

Table I - 6: Silver Ranch Master Plan Stormwater Design Standards Summary

| Stormwater Design Standard Requirements | Performance Requirement | Analysis & Reporting Requirements | Design Standards | Analysis Methodologies |
|---|---|---|---|---|
| **SWDSM Section 4.0 - Post Construction Peak Discharge Compliance** | 1. Post-Construction runoff rates are required to meet a maximum rate as determined by the total site area times the applicable post-construction "Unit Rate."<br>2. Post-Construction Unit Rate values are:<br>➢ **2-year Storm = 0.06 cfs/acre**<br>➢ **100-year Storm = 0.50 cfs/acre**<br>3. The Unit Rate shall be applied to the overall development area (pervious and impervious) including any areas diverted from the peak flow compliance BMP.<br>4. A maximum of 10% of the site area may be diverted from the peak flow compliance BMP due to topographic or other constraints.<br>5. Areas designated as "Green Space" in the Future Land Use Plan that remain open space or pervious area after development activities are exempt from meeting the requirements of the Unit Rate allowable discharge.<br>6. Compliance with design storms other than the 2- and 100-year storm events is not required.<br>7. Undeveloped offsite flows are to be determined per the requirements of the SWDSM, rather than the Unit Rate. | 1. Report the allowable "Unit Rate" discharge from the entire site.<br>a. Existing Condition hydrologic analysis, or reporting, is not required for projects utilizing the Unit Rate method.<br>b. References in the SWDSM to "Existing Conditions" hydrologic analysis are to be replaced with documentation of the allowable Unit Rate discharge from the subject site. (***Table I - 5***)<br>2. Provide a figure that documents how Post-Construction BMPs capture runoff from the entire project site (pervious and impervious) and notes any areas that cannot be routed to the BMP.<br>3. The total rate discharge from the site, including any pervious areas not routed through the BMP, must be less than the allowable Unit Rate. | 1. Offsite flows shall be accounted for in the design of post-construction BMPs by one of the following methods:<br>a. Route undeveloped flows around proposed detention basin; or<br>b. Route undeveloped flows to the detention basin and design a stabilized overflow for offsite flows. Said overflow shall be set above the 100-year WSE produced by onsite developed flows.<br>2. Unit Rate flows may necessitate engineered outlets smaller than 4-inches in diameter. In such situations, low flow structures with appropriate clog protection shall be utilized consistent with ***Figure I - 16***, or other approved method.<br>3. Pervious area of up to 10% of the total site area may be allowed to drain to the downstream drainageway without being routed to a post-construction BMP, at the discretion of City staff. | Per the SWDSM |
| **SWDSM Section 5.0 - Post-Construction Stormwater Quality Compliance** | Per the SWDSM. | Per the SWDSM | 1. All impervious areas must be routed through the post-construction water quality BMP.<br>2. Post-construction water quality requirements may necessitate engineered outlets smaller than 2-inches in diameter. In such situations, low flow structures with appropriate clog protection shall be utilized consistent with ***Figure I - 16***, or other approved method. | Per the SWDSM |
| **SWDSM Section 6.0 - Post Construction Drainage and Conveyance** | 1. **Street Drainage** per the SWDSM<br>2. **Storm Sewer System** per the SWDSM<br>3. **Culverts** per the SWDSM except:<br>a. Design flow rates, provided by ***Figure I - 13***, ***Figure I - 14***, and ***Figure I - 15*** were developed by reporting the higher of "Existing Runoff with Future Crossings" or "Full Build-out with Unit Rate and Future Crossings."<br>b. **Local Streets** 100-Year Allowable WSE < the Upstream Development Setback Line elevation provided by ***Figure I - 1*** and ***Figure I - 4***<br>c. **Collector and Arterial Street** design WSE that meet the preliminary design presented in ***Section I-5.0*** and/or ***Table I - 3***<br>4. **Open Channels** per the SWDSM<br>5. **Outlet Protection** per the SWDSM | Per the SWDSM | Per the SWDSM | Per the SWDSM |

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Table I - 7: Construction, Maintenance & Operational Responsibility of Stormwater BMP Summary by Land Use

| Development Type | Construction | Vegetation Maintenance | Functional Maintenance | Operations |
|---|---|---|---|---|
| **One and Two Family Residential** | **Preferred:** Developer funds the design and construction of the required post-construction BMPs.<br>**Alternative**: Developer funds the design of the BMP and the City funds the construction via special assessment to the project properties. | **Preferred**: City provides a minimum level of maintenance as determined via to be established policy. City costs are funded by Stormwater Utility Fees.<br>**Alternate:** HOA contracts with third party or the City to provide higher than minimum level of maintenance. Costs are paid by HOA by direct payment to contractor or assessment to benefiting properties via development agreement with the City. | **Preferred**: City provides all functional maintenance for the post-construction BMPs where the development includes public streets. City costs are funded by the Stormwater Utility Fees.<br>**Alternate:** Developments with private streets will enter into a development agreement with the City for Functional Maintenance to be provided by a contractor or the City. Costs are paid by HOA by direct payment to contractor or assessment to benefiting properties via development agreement with the City. | **Preferred:** Operations provided by the City and funded by the Stormwater Utility Fees.<br>**Alternative:** None |
| **Multi-Family Residential** | **Preferred:** Developer/Owner funds the design and construction of the required post-construction BMPs.<br>**Alternative**: None, all post-construction BMPs are to be installed by the Developer/Owner. | **Option 1**: Owner contracts with third party or the City to provide a minimum level of maintenance. Costs are paid by Owner by direct payment to contractor or assessment to benefiting properties via development agreement with the City.<br>**Option 2:** City provides a minimum level of maintenance as determined by policy. City costs are funded by Stormwater Utility Fees. | **Option 1**: Owner contracts with third party or the City to provide functional maintenance. Costs are paid by Owner by direct payment to contractor or assessment to benefiting properties via development agreement with the City.<br>**Option 2:** City provides a functional maintenance as determined by policy. City costs are funded by Stormwater Utility Fees. | **Preferred:** Operations provided by the City and funded by the Stormwater Utility Fees.<br>**Alternative:** None |
| **Commercial** | **Preferred:** Developer/Owner funds the design and construction of the required post-construction BMPs.<br>**Alternative**: None, all post-construction BMPs are to be installed by the Developer/Owner | **Option 1**: Owner contracts with third party or the City to provide a minimum level of maintenance. Costs are paid by Owner by direct payment to contractor or assessment to benefiting properties via development agreement with the City.<br>**Option 2:** City provides a minimum level of maintenance as determined by policy. City costs are funded by Stormwater Utility Fees. | **Option 1**: Owner contracts with third party or the City to provide functional maintenance. Costs are paid by Owner by direct payment to contractor or assessment to benefiting properties via development agreement with the City.<br>**Option 2:** City provides a functional maintenance as determined by policy. City costs are funded by Stormwater Utility Fees. | **Preferred:** Operations provided by the Owner with all costs directly paid by the owner. City uses Stormwater Utility Fees as a method to cover costs of non-compliance and enforcement.<br>**Alternative:** Operations provided by the City and funded by the Stormwater Utility Fees. |
| **Industrial (Sites that have an NDPES Permit)** | **Preferred:** Developer/Owner funds the design and construction of the required post-construction BMPs.<br>**Alternative**: None | **Preferred**: Owner provides a minimum level of maintenance as determined via to be established policy. Costs are paid directly by the Owner.<br>**Alternate:** Owner enters into development agreement with the City to provide aesthetic maintenance. Costs are assessed directly to the Owner | **Preferred**: Owner provides a functional maintenance as determined via to be established policy. Costs are paid directly by the Owner.<br>**Alternate:** Owner enters into development agreement with the City to provide functional maintenance. Costs are assessed directly to the Owner | **Preferred:** Operations provided by the Owner with all costs directly paid by the owner.<br>**Alternative:** None, Industrial uses are unique and the individual Owners are responsible for the operation of stormwater BMPs to support the land use and industry. |

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# I-5.0 IMPROVEMENT PLAN

Included in the development of the Master Plan are specific improvement recommendations necessary to achieve the master plan goals. In general, because the stormwater management concept for this Master Plan is to utilize local BMPs with unit rate methodology there are no specific regional improvements to be implemented other than at existing and future road crossings.

## I-5.1 ROAD CROSSINGS

Conceptual designs for existing and future roadway crossings were developed for all arterial and collector streets identified in the master planning area as well as for local street crossings as identified or requested by the City Working Group. As summary of these crossing and opinion of total costs is provided in the table below.

Table I - 8: Road Crossing Summary

| Crossing ID | Type | Opinion of Total Costs |
|---|---|---|
| **#1 57th Ave** | Future | $385,000 |
| **#2 50th Ave** | Future | $450,000 |
| **#3 43rd Ave 1A & 1B** | Existing | $665,000 |
| **#4 43rd Ave 2, 3 & 4** | Existing | $155,000 |
| **#5 Calgary Ave** | Future | $280,000 |
| **#6 Century Ave 1** | Future | $770,000 |
| **#7 Century Ave 2** | Future | $325,000 |
| **#8 Century Ave 3** | Future | $445,000 |
| **#9 Miriam Ave** | Existing | $425,000 |
| **#10 52nd St** | Existing | $240,000 |
| **#11 Future Divide Ave** | Future | $6,092,000 |
| **#12 East Main Ave** | Existing | $1,301,000 |
| **#13 Silver Ranch Rd** | Future | $445,000 |
| **#14 Main Ave at Hay Creek** | Existing | $485,000 |
| | **Total** | **$12,463,000** |

The locations of these crossings are shown on ***Figure I - 3*** and ***Figure I - 4.***

Crossing summary “cut sheets” are provided for each of the improvements listed in ***Table I - 8***. These “cut sheets” document the key analysis results, design considerations, major construction items, and opinion of costs for each location.

Preliminary grading and hydraulic designs are provided for the proposed crossings and key existing crossing locations and are included as ***Exhibits*** in ***Volume II*** and ***Volume III*** of this Master Plan.

## I-5.2 STORM SEWER TRUNK MAINS

Trunk mains were not developed as part of this Master Plan due to the unknown location of peak flow compliance facilities. Trunk mains should be designed in conformance with the SWDSM requirements.

## I-5.3 REGIONAL PEAK DISCHARGE BMPS

No specific regional peak discharge compliance BMPs are recommend for the implementation of the Master Plan. Peak discharge compliance in the Master Plan condition will be completed using facilities designed and constructed in conformance with the Unit Rate requirements to match the pace of development.

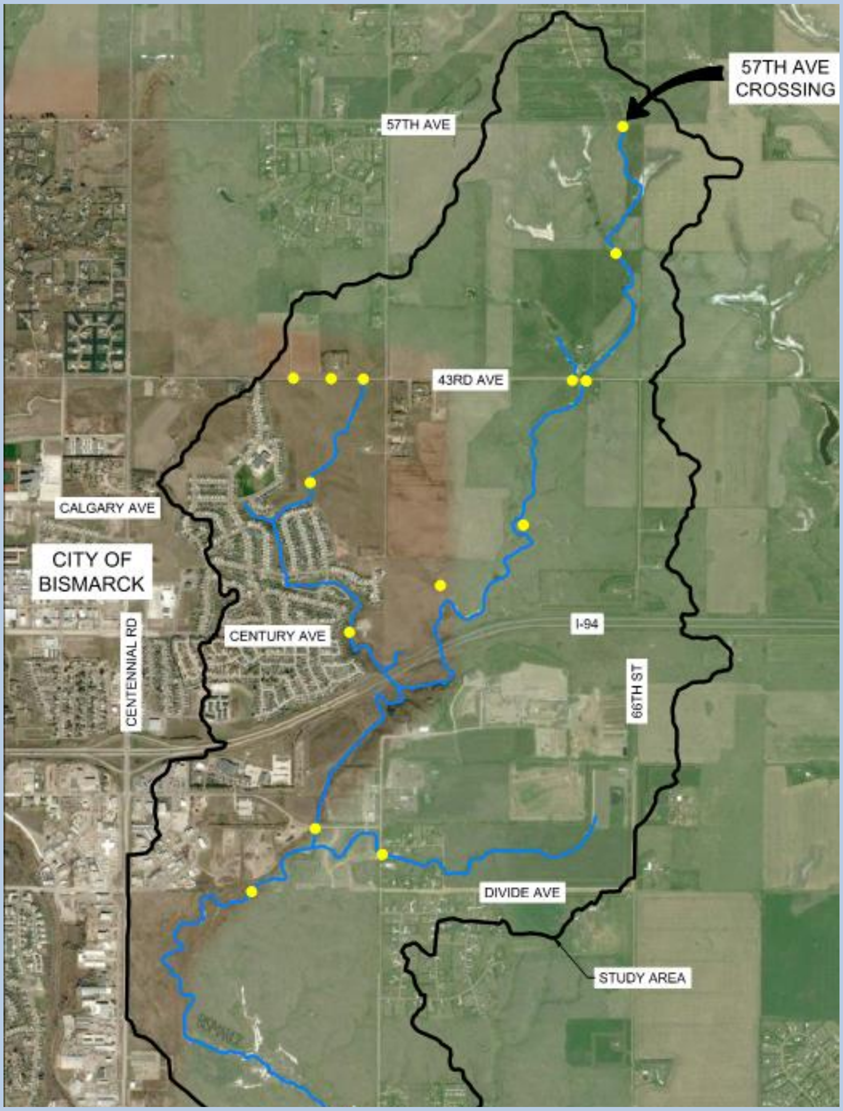
## I-5.4 IMPROVEMENT PRELIMINARY DESIGN SUMMARY

The following sections provide a summary for the crossings identified in ***Table I - 8***.

Included on the Improvement Summary is a possible equivalent hydraulic structure that could be evaluated during the final design of the crossing location. Equivalent hydraulic alternatives need to:

1. Pass the design downstream flow without exceeding the design allowable headwater; and
2. Produce a 100-year WSE equal to or less than the preliminary design headwater elevation consistent with the Development Setback Line.

Preliminary design Exhibits and detailed opinion of costs are included in ***Volume II*** and ***Volume III*** of this Master Plan.

| **Improvement ID & Name: Crossing #1 57th Ave** | |
|---|---|
| **Location** | Future 57th Ave crossing of Silver Ranch Coulee |
|  | |
| **Contributing Drainage Area** | 108.2 Acres |
| **Development Condition** | Future |
| **Implementation Trigger** | Construction of 57th Ave road in Section 18 of Township 139N Range 79W. This portion of 57th Ave is currently not installed. |
| **Improvement Description** | Two (2) 24-inch diameter RCP culverts.<br>57th Ave is listed in the 2014 Fringe Road Master Plan as a future arterial roadway. The Silver Ranch Master Plan assumed that the future roadway section would consist of a 120-foot wide right of way with 25% slopes.<br>The 57th Ave future roadway and crossing is shown on Exhibit 1A & 1B. |

## Improvement ID & Name: Crossing #1 57th Ave

**Opinion of Capital Costs**

$385,000 including engineering and construction.
Opinion of costs do not include the purchase of right-of-way or easements.

**Implementation Inputs & Results**

**Hydraulic Data**

| Storm Event | WSE Up (FT) | Area Up (SF) | Q Out (CFS) |
|---|---|---|---|
| Invert | 1860 | 31,000 | 0 |
| Q2 | 1860.7 | 66,260 | 6 |
| Q25 | 1861.6 | 137,000 | 19 |
| Q100 | 1862.4 | 211,000 | 33 |

"WSE Up" = calculated water surface elevation on upstream end of culvert.
"Area Up" = calculated water surface area on upstream end of culvert.
"Q Out" = calculated outflow from the downstream end of crossing.

**Culvert Data**

| Culvert Size (IN) | IE Up (FT) | IE Dn (FT) | Length (FT) |
|---|---|---|---|
| 24 | 1860 | 1858 | 162 |
| 24 | 1860 | 1858 | 162 |

Street Overflow Elev = 1863.6 ft

**Proposed Improvements**

**Remove**: None
**Install:**

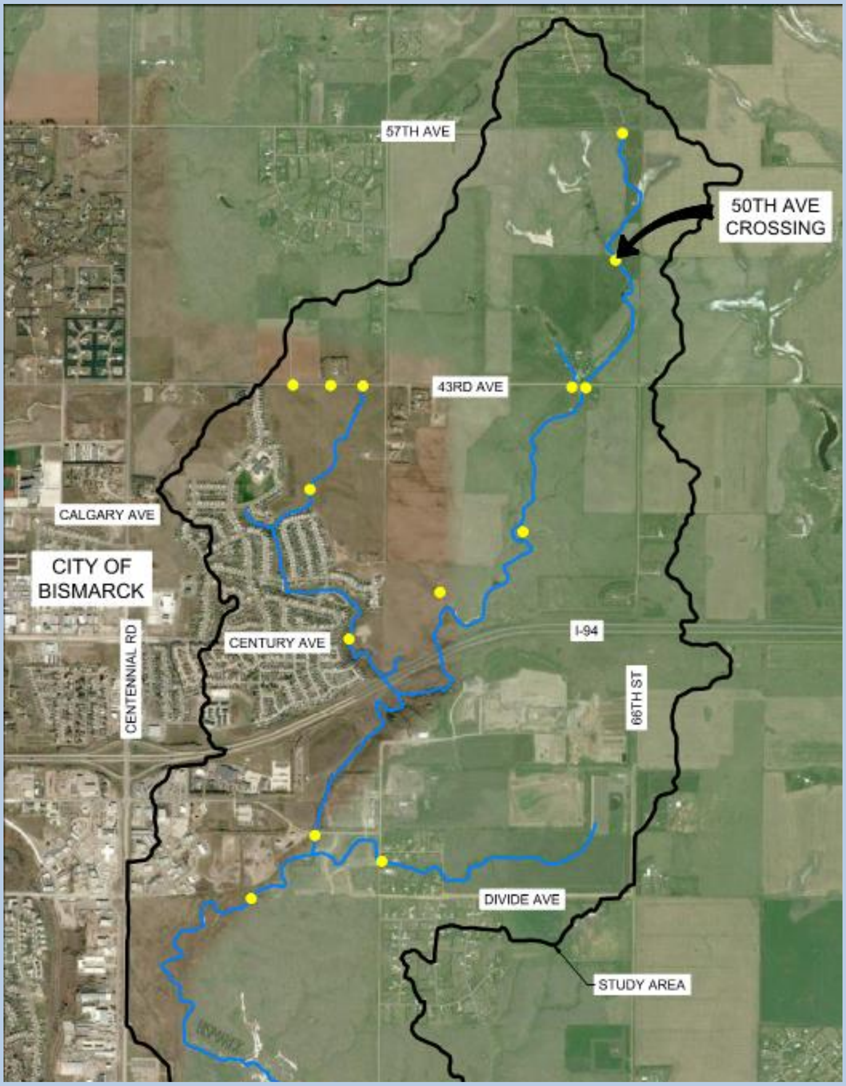
| Spec | Description | Unit | Quantity |
|---|---|---|---|
| 202-4.1 | Unclassified Excavation | CY | 20,000 |
| 802-4.5 | 24" Storm Sewer Pipe | LF | 324 |
| 802-4.55 | 24" FES | EA | 4 |
| SP | Final Stabilization | SF | 205,000 |

**Equivalent Hydraulic Section**

1. Install a single 36-inch diameter RCP culvert. This alternative may require that the vertical alignment of 57th Ave be raised to allow for sufficient cover over the 36-inch culvert.
2. Preliminary hydraulic analysis predicts that this alternative would result in a 25-year WSE of 1861.5, which meets the allowable headwater requirements of the SWDSM and ND Stream Crossing Standards.
3. Preliminary hydraulic analysis predicts that this alternative would result in a 100-year WSE of 1862.4.

**Additional Comments**

1. Hydraulic sizing of the proposed improvements is recommend to utilize the Existing Condition flowrates.
2. Final design to confirm that the design headwater elevations meet the requirements of the SWDSM and the ND Stream Crossing Standards.
3. Final design to confirm that the assumed upstream stage areas have been maintained.
4. Elevations are in the North American Vertical Datum of 1988 (NAVD88)

| **Improvement ID & Name: Crossing #2 50th Ave** | |
|---|---|
| **Location** | Future 50th Ave crossing of Silver Ranch Coulee |
|  | |
| **Contributing Drainage Area** | 366.8 Acres |
| **Development Condition** | Future |
| **Implementation Trigger** | Construction of 50th Ave road in Section 18 of Township 139N Range 79W. This portion of 50th Ave is currently not installed. |
| **Improvement Description** | Three (3) 48-inch RCP culverts.<br>50th Ave is listed in the 2014 Fringe Road Master Plan as a future collector roadway. The Silver Ranch Master Plan assumed that the future roadway section would consist of an 80-foot wide right of way with 25% slopes.<br>The 50th Ave future roadway and crossing is shown on Exhibit 2A & 2B. |

## Improvement ID & Name: Crossing #2 50th Ave

**Opinion of Capital Cost**

$450,000 including engineering and construction.
Opinion of costs do not include the purchase of right-of-way or easements.

**Implementation Inputs & Results**

**Hydraulic Data**

| Storm Event | WSE Up (FT) | Area Up (SF) | Q Out (CFS) |
|---|---|---|---|
| Invert | 1822 | 13,900 | 0 |
| $Q_2$ | 1823.7 | 32,100 | 64 |
| $Q_{25}$ | 1826.2 | 145,000 | 236 |
| $Q_{100}$ | 1828.7 | 225,000 | 312 |

"WSE Up" = calculated water surface elevation on upstream end of culvert.
"Area Up" = calculated water surface area on upstream end of culvert.
"Q Out" = calculated outflow from the downstream end of crossing.

**Culvert Data**

| Culvert Size (IN) | IE Up (FT) | IE Dn (FT) | Length (FT) |
|---|---|---|---|
| 48 | 1822 | 1820 | 200 |
| 48 | 1822 | 1820 | 200 |
| 48 | 1822 | 1820 | 200 |

Street Overflow Elev = 1830

**Proposed Improvements**

**Remove**: None

**Install:**

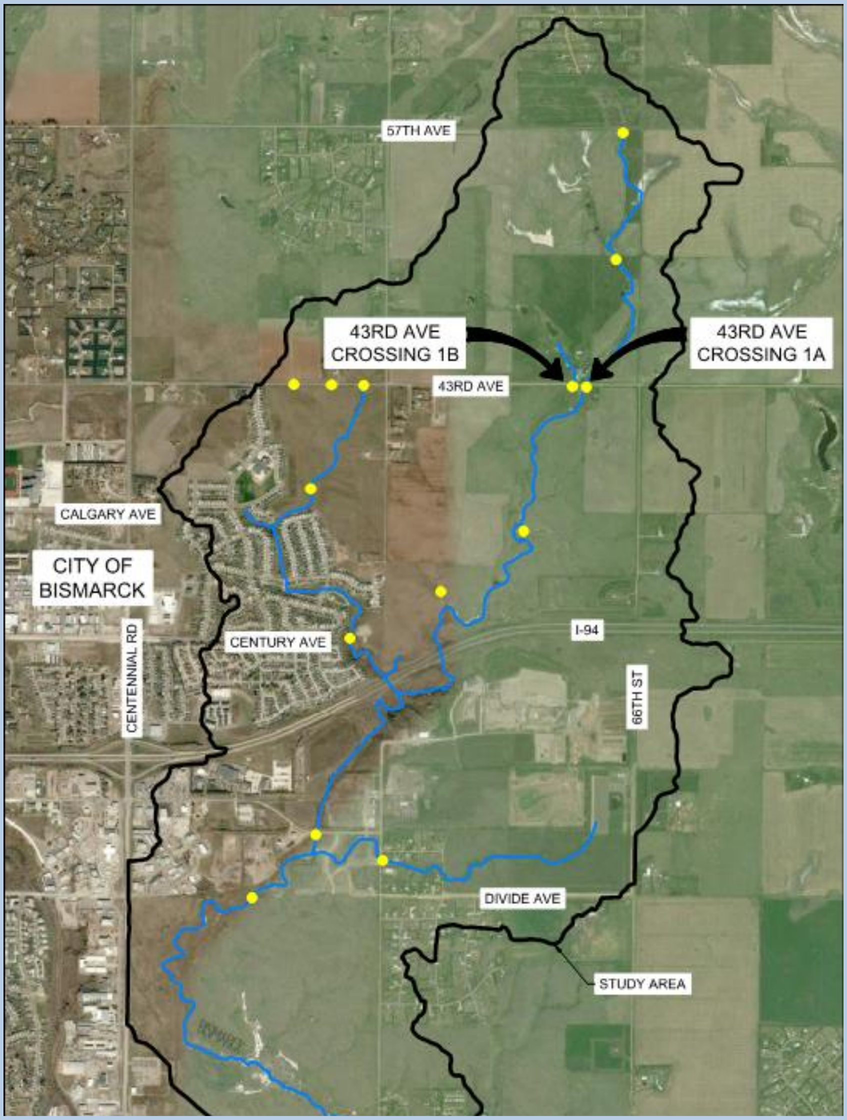
| Spec | Description | Unit | Quantity |
|---|---|---|---|
| 202-4.1 | Unclassified Excavation | CY | 10,200 |
| 802-4.11 | 48" Storm Sewer Pipe | LF | 600 |
| 802-4.61 | 48" FES | EA | 6 |
| SP | Final Stabilization | SF | 46,000 |

**Equivalent Hydraulic Section**

1. Install two (2) 60-inch diameter culverts at the same invert elevations and lengths listed above. Selection of the final culvert sizing will be based on the actual road crossing geometry.
2. Preliminary hydraulic analysis predicts that this alternative would result in a 25-year WSE of 1826.5, which meets the allowable headwater requirements of the SWDSM and ND Stream Crossing Standards.
3. Preliminary hydraulic analysis predicts that this alternative would result in a 100-year WSE of 1828.6.

**Additional Comments**

1. Hydraulic sizing of the proposed improvements is recommend to utilize the Existing Condition flowrates.
2. Final design to confirm that the design headwater elevations meet the requirements of the SWDSM and the ND Stream Crossing Standards.
3. Final design to confirm that the assumed upstream stage areas have been maintained.
4. Elevations are in the North American Vertical Datum of 1988 (NAVD88)

| **Improvement ID & Name: Crossing #3 43rd Ave (1A & 1B)** | |
|---|---|
| **Location** | 43rd Ave crossing of Silver Ranch Coulee |
|  | |
| **Contributing Drainage Area** | 728 Acres |
| **Development Condition** | Existing |
| **Implementation Trigger** | Conversion of 43rd Ave from a rural road to urban arterial street section in Section 18 of Township 139N Range 79W. This crossing is located approximately 1,200 feet west of the 66th St NE intersection with 43rd Ave. |

## Improvement ID & Name: Crossing #3 43rd Ave (1A & 1B)

**Improvement Description**

Crossing 1A 124 foot extension of an existing 4’x9’ reinforced box culvert
Crossing 1B 132 foot extension of existing 42-inch RCP culvert
43th Ave is listed in the 2014 Fringe Road Master Plan as a future collector roadway. The Silver Ranch Master Plan assumed that the future roadway section would consist of a 120-foot wide right of way with 25% slopes.
The 43th Ave future roadway and Crossing 1A is shown on Exhibit 3A & 3B.
The 43th Ave future roadway and Crossing 1B is shown on Exhibit 4A & 4B.

**Opinion of Capital Cost**

$665,000 including engineering and construction.
Opinion of costs do not include the purchase of right-of-way or easements.

**Implementation Inputs & Results**

**Hydraulic Data Crossing 1A**

| Storm Event | WSE Up (FT) | Area Up (SF) | Q Out (CFS) |
|---|---|---|---|
| Invert | 1796.1 | 0 | 0 |
| $Q_2$ | 1797.8 | 200 | 50 |
| $Q_{25}$ | 1801.0 | 125,000 | 248 |
| $Q_{100}$ | 1802.5 | 195,000 | 326 |

“WSE Up” = calculated water surface elevation on upstream end of culvert.
“Area Up” = calculated water surface area on upstream end of culvert.
“Q Out” = calculated outflow from the downstream end of crossing.

**Hydraulic Data Crossing 1B**

| Storm Event | WSE Up (FT) | Area Up (SF) | Q Out (CFS) |
|---|---|---|---|
| Invert | 1797.7 | 0 | 0 |
| $Q_2$ | 1799.1 | 200 | 14 |
| $Q_{25}$ | 1800.2 | 8,700 | 31 |
| $Q_{100}$ | 1803.7 | 40,000 | 79 |

“WSE Up” = calculated water surface elevation on upstream end of culvert.
“Area Up” = calculated water surface area on upstream end of culvert.
“Q Out” = calculated outflow from the downstream end of crossing.

**Culvert Data Crossing 1A**

| Culvert Size (FT) | IE Up (FT) | IE Dn (FT) | Length (FT) |
|---|---|---|---|
| 4 x 9 | 1796.1 | 1792.4 | 248 |

Street Overflow Elev = 1808.6’

**Culvert Data Crossing 1B**

| Culvert Size (IN) | IE Up (FT) | IE Dn (FT) | Length (FT) |
|---|---|---|---|
| 42 | 1797.7 | 1794.6 | 256 |

Street Overflow Elev = 1808.6’

## Improvement ID & Name: Crossing #3 43rd Ave (1A & 1B)

**Proposed Improvements**

**Remove**: None

**Install:**

| Spec | Description | Unit | Quantity |
|---|---|---|---|
| 202-4.1 | Unclassified Excavation | CY | 20,000 |
| 802-4.10 | 42” Storm Sewer Pipe | LF | 132 |
| 802-4.60 | 42” FES | EA | 2 |
| SP | 4 x 9 Precast RCB Culvert | LF | 124 |
| SP | 4 x 9 Box Culvert Ends | EA | 2 |
| SP | Final Stabilization | SF | 70,000 |

**Equivalent Hydraulic Section**

No alternatives were considered because the project is an extension of existing structures.

**Additional Comments**

1. Hydraulic sizing of the proposed improvements is recommend to utilize the Existing Condition flowrates.
2. Final design to confirm that the design headwater elevations meet the requirements of the SWDSM and the ND Stream Crossing Standards.
3. Final design to confirm that the assumed upstream stage areas have been maintained.
4. Elevations are in the North American Vertical Datum of 1988 (NAVD88)

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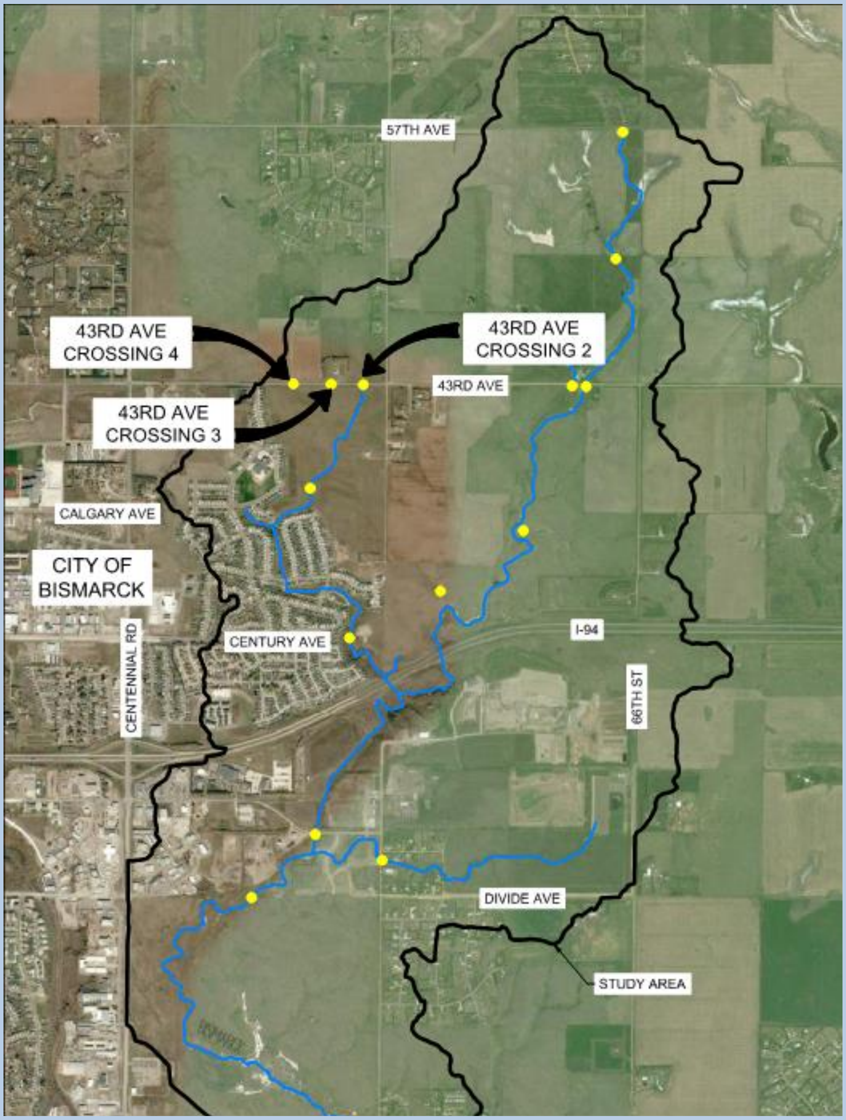
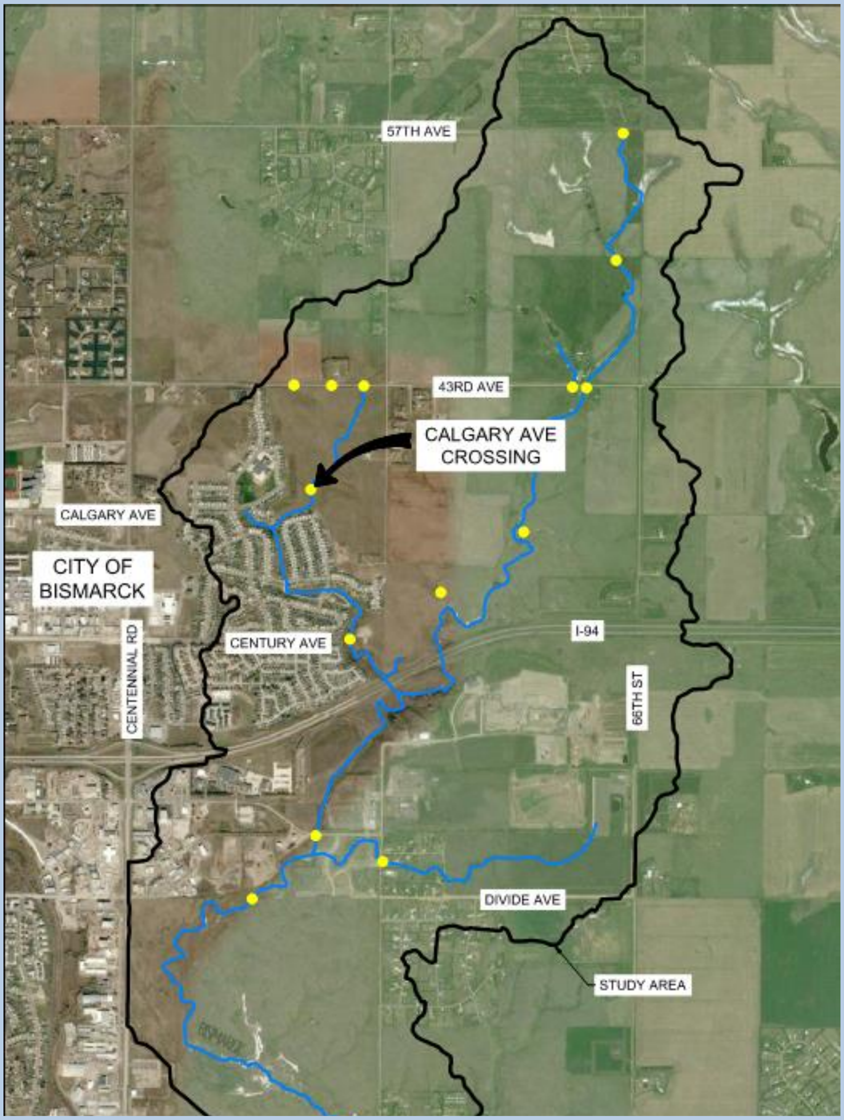
| **Improvement ID & Name: Crossing #4 43rd Ave (2) and Crossing #5 43rd Ave (3) & (4)** | |
|---|---|
| **Location** | Existing Culverts on 43rd Ave between Roosevelt St and 52nd Street |
|  | |
| **Contributing Drainage Area** | 43rd Ave(2) = 87.7 Acres & 43rd Ave(3 & 4) = 41.8 Acres |
| **Development Condition** | Existing |
| **Implementation Trigger** | Conversion of 43rd Ave from a rural road to urban arterial street section in Section 18 of Township 139N Range 79W. This crossing is located approximately 1,200 feet west of the 66th St NE intersection with 43rd Ave. |
| **Improvement Description** | 43rd Ave Crossing 2 upgrade existing to 36-inch culvert<br>43rd Ave Crossing 3 extend existing 15-inch culvert<br>43rd Ave Crossing 4 extend existing 18-inch culvert |

| **Improvement ID & Name: Crossing #4 43rd Ave (2) and Crossing #5 43rd Ave (3) & (4)** | |
|---|---|
| **Opinion of Capital Cost** | $155,000 |
| **Implementation Inputs & Results** | Not applicable, extension of existing culverts |
| **Proposed Improvements** | **Remove**: None<br>**Install:** |
| **Equivalent Hydraulic Section** | None were considered as these locations are minor existing crossing that will need to be extended via a future 43rd Ave reconstruction project. |
| **Additional Comments** | 1. Hydraulic sizing of the proposed improvements is recommend to utilize the Existing Condition flowrates.<br>2. Final design to confirm that the design headwater elevations meet the requirements of the SWDSM and the ND Stream Crossing Standards.<br>3. Final design to confirm that the assumed upstream stage areas have been maintained.<br>4. Elevations are in the North American Vertical Datum of 1988 (NAVD88) |

| Spec | Description | Unit | Quantity |
|---|---|---|---|
| 802-4.2 | 15” Storm Sewer Pipe | LF | 100 |
| 802-4.3 | 18” Storm Sewer Pipe | LF | 100 |
| 802-4.9 | 36” Storm Sewer Pipe | LF | 220 |
| 802-4.54 | 15” Flared End | EA | 2 |
| 802-4.55 | 18” Flared End | EA | 2 |
| 802.4.59 | 36” Flared End | EA | 2 |

<table>
<tr><th colspan="2">Improvement ID & Name: Crossing #5 Calgary Ave</th></tr>
<tr><td><strong>Location</strong></td><td>Future Calgary Ave crossing of the Sunrise Tributary.</td></tr>
<tr><td colspan="2">


</td></tr>
<tr><td><strong>Contributing Drainage Area</strong></td><td>256.7 Acres</td></tr>
<tr><td><strong>Development Condition</strong></td><td>Future</td></tr>
<tr><td><strong>Implementation Trigger</strong></td><td>Construction of Calgary Ave road in Section 24 of Township 139N Range 79W. This portion of Calgary Ave is currently not installed.</td></tr>
<tr><td><strong>Improvement Description</strong></td><td>Three (3) 48-inch diameter RCP culverts.<br>Calgary Ave is listed in the 2014 Fringe Road Master Plan as a future collector roadway. The Silver Ranch Master Plan assumed that the future roadway section would consist of an 80-foot wide right of way with 25% slopes.<br>The Calgary Ave future roadway and crossing is shown on Exhibit 5A & 5B.</td></tr>
</table>

**Improvement ID & Name: Crossing #5 Calgary Ave**

**Opinion of Capital Cost**

$280,000 including engineering and construction.
Opinion of costs do not include the purchase of right-of-way or easements.

**Implementation Inputs & Results**

**Hydraulic Data**

| Storm Event | WSE Up (FT) | Area Up (SF) | Q Out (CFS) |
|---|---|---|---|
| Invert | 1802.25 | 50 | 0 |
| $Q_2$ | 1803.2 | 4,100 | 11 |
| $Q_{25}$ | 1804.7 | 23,000 | 88 |
| $Q_{100}$ | 1805.9 | 50,000 | 155 |

"WSE Up" = calculated water surface elevation on upstream end of culvert.
"Area Up" = calculated water surface area on upstream end of culvert.
"Q Out" = calculated outflow from the downstream end of crossing.

**Culvert Data**

| Culvert Size (IN) | IE Up (FT) | IE Dn (FT) | Length (FT) |
|---|---|---|---|
| 48 | 1802.25 | 1801.75 | 140 |
| 48 | 1802.25 | 1801.75 | 140 |
| 48 | 1802.25 | 1801.75 | 140 |

Street Overflow Elev = 1809.3′

**Proposed Improvements**

**Remove**: None
**Install:**

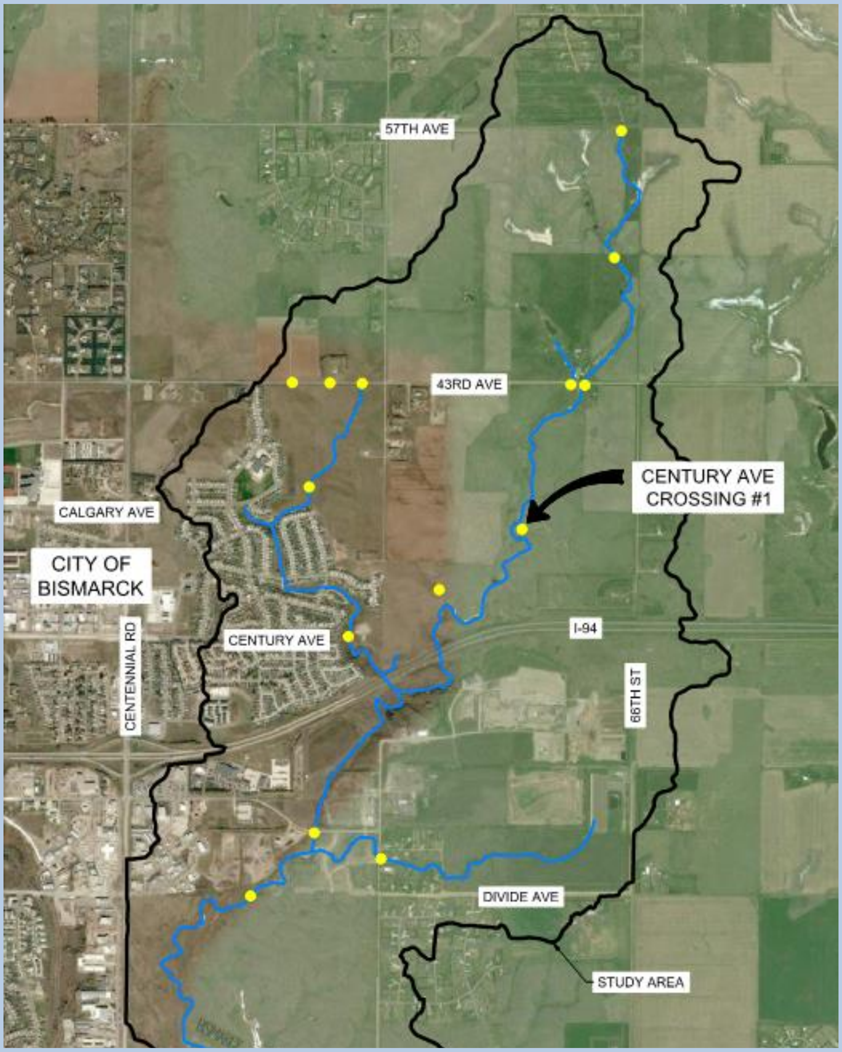
| Spec | Description | Unit | Quantity |
|---|---|---|---|
| 202-4.1 | Unclassified Excavation | CY | 5,000 |
| 802-4.11 | 48″ Storm Sewer Pipe | LF | 420 |
| 802-4.61 | 48″ FES | EA | 6 |
| SP | Final Stabilization | SF | 45,000 |

**Equivalent Hydraulic Section**

1. Install a 9′ x 4′ concrete box culvert at the same invert elevations and lengths listed above. Selection of the final culvert sizing will be based on the actual road crossing geometry.
2. Preliminary hydraulic analysis predicts that this alternative would result in a 25-year WSE of 1804.7, which appears, meets the allowable headwater requirements of the SWDSM and ND Stream Crossing Standards.
3. Preliminary hydraulic analysis predicts that this alternative would result in a 100-year WSE of 1805.8.

**Additional Comments**

1. Hydraulic sizing of the proposed improvements is recommend to utilize the Existing Condition flowrates.
2. Final design to confirm that the design headwater elevations meet the requirements of the SWDSM and the ND Stream Crossing Standards.
3. Final design to confirm that the assumed upstream stage areas have been maintained.
4. Elevations are in the North American Vertical Datum of 1988 (NAVD88)

| **Improvement ID & Name: Crossing #6 Century Ave (1)** | |
|---|---|
| **Location** | Future Century Ave Crossing of Silver Ranch Coulee |
|  | |
| **Contributing Drainage Area** | 1016.2 Acres |
| **Development Condition** | Future |
| **Implementation Trigger** | Construction of Century Ave road in Section 19 of Township 139N Range 79W. This portion of Century Ave is currently not installed. |
| **Improvement Description** | One (1) 84-inch diameter RCP culvert.<br>Century Ave is listed in the 2014 Fringe Road Master Plan as a future collector roadway. The Silver Ranch Master Plan assumed that the future roadway section would consist of a 120-foot wide right of way with 25% slopes.<br>The Century Ave (1) Ave future roadway and crossing is shown on Exhibit 6A & 6B. |

## Improvement ID & Name: Crossing #5 Calgary Ave

**Opinion of Capital Cost**

$770,000 including engineering and construction.
Opinion of costs do not include the purchase of right-of-way or easements.

**Implementation Inputs & Results**

**Hydraulic Data**

| Storm Event | WSE Up (FT) | Area Up (SF) | Q Out (CFS) |
|---|---|---|---|
| Invert | 1760.3 | 700 | 0 |
| $Q_2$ | 1762.8 | 9,700 | 66 |
| $Q_{25}$ | 1767.9 | 105,000 | 329 |
| $Q_{100}$ | 1771.1 | 183,000 | 478 |

“WSE Up” = calculated water surface elevation on upstream end of culvert.
“Area Up” = calculated water surface area on upstream end of culvert.
“Q Out” = calculated outflow from the downstream end of crossing.

**Culvert Data**

| Culvert Size (IN) | IE Up (FT) | IE Dn (FT) | Length (FT) |
|---|---|---|---|
| 84 | 1760.3 | 1752.3 | 390 |

Street Overflow Elev = 1787.3’

**Proposed Improvements**

**Remove**: None

**Install:**

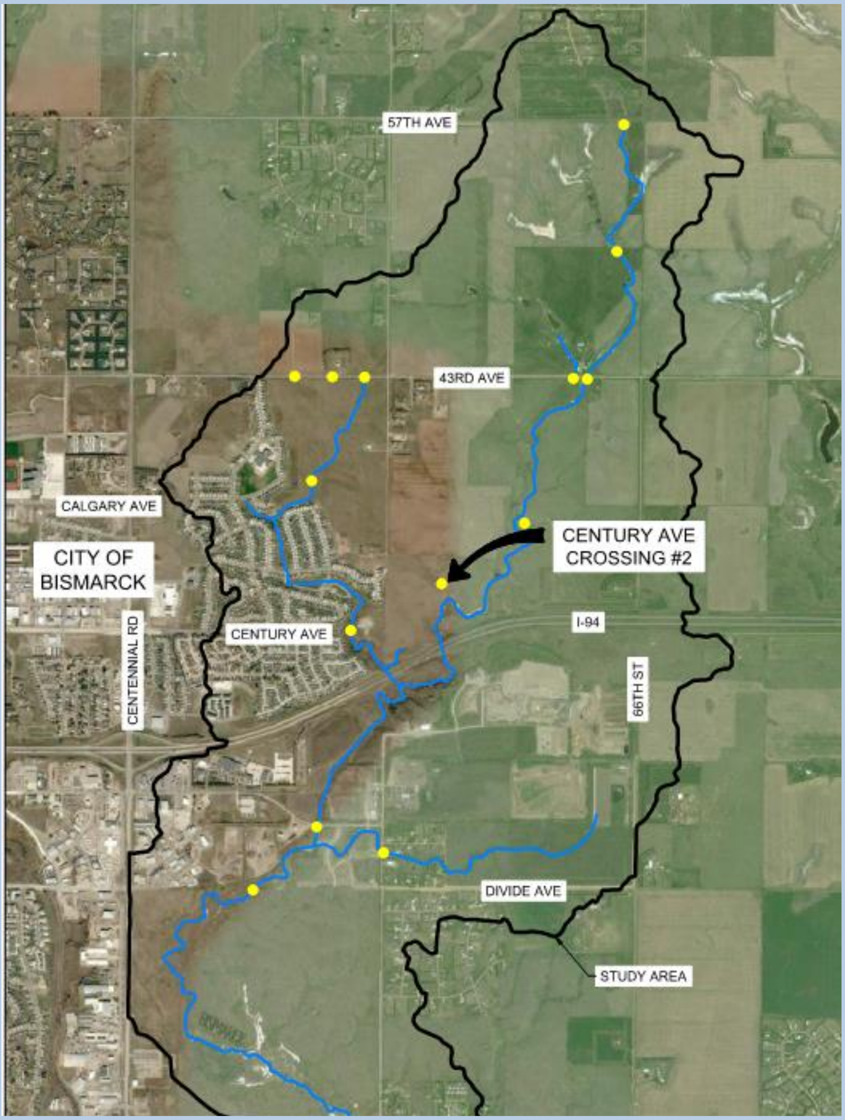
| Spec | Description | Unit | Quantity |
|---|---|---|---|
| 202-4.1 | Unclassified Excavation | CY | 25,000 |
| 802-4.17 | 84” Storm Sewer Pipe | LF | 390 |
| 802-4.67 | 84” FES | EA | 2 |
| SP | Final Stabilization | SF | 150,000 |

**Equivalent Hydraulic Section**

1. Install three (3) 48-inch diameter culvert at the same invert elevations and lengths listed above. Selection of the final culvert sizing will be based on the actual road crossing geometry.
2. Preliminary hydraulic analysis predicts that this alternative would result in a 25-year WSE of 1,762.2, which appears to meet the allowable headwater requirements of the SWDSM and ND Stream Crossing Standards.
3. Preliminary hydraulic analysis predicts that this alternative would result in a 100-year WSE of 1769.3.

**Additional Comments**

1. Hydraulic sizing of the proposed improvements is recommend to utilize the Existing Condition flowrates.
2. Final design to confirm that the design headwater elevations meet the requirements of the SWDSM and the ND Stream Crossing Standards and confirm that the assumed upstream stage areas have been maintained.
3. Elevations this page are in NAVD88. Exhibit 7A and 7B elevations are listed in NGVD29 to match City designs.

| **Improvement ID & Name: Crossing #7 Century Ave (2)** | |
|---|---|
| **Location** | Future Century Ave Crossing of Minor Tributary North of Silver Ranch Coulee |
|  | |
| **Contributing Drainage Area** | 148.6 Acres |
| **Development Condition** | Future |
| **Implementation Trigger** | Construction of Century Ave road in Section 24 of Township 139N Range 79W. This portion of Century Ave is currently not installed. |
| **Improvement Description** | One 54-inch diameter RCP culvert.<br>Century Ave is listed in the 2014 Fringe Road Master Plan as a future collector roadway. The Silver Ranch Master Plan assumed that the future roadway section would consist of a 120-foot wide right of way with 25% slopes.<br>The Century Ave (2) future roadway and crossing is shown on Exhibit 7A & 7B. |

| Improvement ID & Name: Crossing #7 Century Ave (2) | |
|---|---|
| **Opinion of Capital Cost** | $325,000 including engineering and construction. Opinion of costs do not include the purchase of right-of-way or easements. |
| **Implementation Inputs & Results** | **Hydraulic Data** |

| Storm Event | WSE Up (FT) | Area Up (SF) | Q Out (CFS) |
|---|---|---|---|
| Invert | 1750.2 | 175 | 0 |
| $Q_2$ | 1752 | 2,500 | 26 |
| $Q_{25}$ | 1755.7 | 15,000 | 127 |
| $Q_{100}$ | 1761.4 | 42,000 | 171 |

"WSE Up" = calculated water surface elevation on upstream end of culvert.
"Area Up" = calculated water surface area on upstream end of culvert.
"Q Out" = calculated outflow from the downstream end of crossing.

**Culvert Data**

| Culvert Size (IN) | IE Up (FT) | IE Dn (FT) | Length (FT) |
|---|---|---|---|
| 54 | 1750.2 | 1742.3 | 245 |

Street Overflow Elev = 1765.1'

**Proposed Improvements**

**Remove**: None

**Install:**

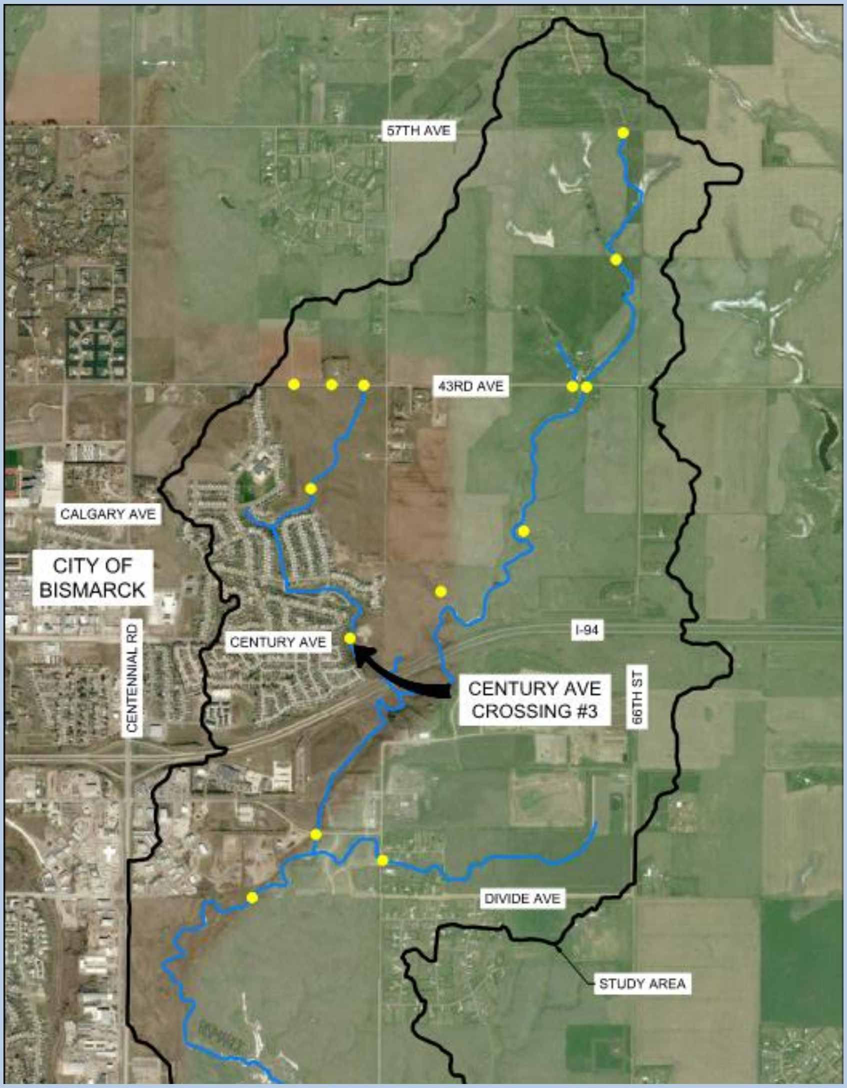
| Spec | Description | Unit | Quantity |
|---|---|---|---|
| 202-4.1 | Unclassified Excavation | CY | 14,000 |
| 802-4.12 | 54" Storm Sewer Pipe | LF | 245 |
| 802-4.45 | 54" FES | EA | 2 |
| SP | Final Stabilization | SF | 45,000 |

**Improvement Alternatives**

1. Install three (3) 36-inch diameter culvert at the same invert elevations and lengths listed above. Selection of the final culvert sizing will be based on the actual road crossing geometry.
2. Preliminary hydraulic analysis predicts that this alternative would result in a 25-year WSE of 1752.7, which appears to meet the allowable headwater requirements of the SWDSM and ND Stream Crossing Standards.
3. Preliminary hydraulic analysis predicts that this alternative would result in a 100-year WSE of 1758.7.

**Additional Comments**

1. Hydraulic sizing of the proposed improvements is recommend to utilize the Existing Condition flowrates.
2. Final design to confirm that the design headwater elevations meet the requirements of the SWDSM and the ND Stream Crossing Standards.
3. Final design to confirm that the assumed upstream stage areas have been maintained.
4. Elevations this page are in NAVD88. Exhibit 8A and 8B elevations are listed in NGVD29 to match City designs.

| **Improvement ID & Name: Crossing #8 Century Ave (3)** | |
|---|---|
| **Location** | Future Century Ave crossing of Sunrise Tributary |
|  | |
| **Contributing Drainage Area** | 584.6 Acres |
| **Development Condition** | Future |
| **Implementation Trigger** | Construction of Century Ave road on the north line of Section 24 of Township 139N Range 79W. This portion of Century Ave is currently not installed. |
| **Improvement Description** | Two (2) 60-inch diameter RCP culvert.<br>Century Ave is listed in the 2014 Fringe Road Master Plan as a future collector roadway. The Silver Ranch Master Plan assumed that the future roadway section would consist of a 120-foot wide right of way with 25% slopes.<br>The Century Ave (3) future roadway and crossing is shown on Exhibit 8A & 8B. |

## Improvement ID & Name: Crossing #8 Century Ave (3)

**Opinion of Capital Cost**

$445,000 including engineering and construction.
Opinion of costs do not include the purchase of right-of-way or easements.

**Implementation Inputs & Results**

**Hydraulic Data**

| Storm Event | WSE Up (FT) | Area Up (SF) | Q Out (CFS) |
|---|---|---|---|
| Invert | 1746.3 | 90 | 0 |
| $Q_2$ | 1748.6 | 8,200 | 87 |
| $Q_{25}$ | 1750.6 | 25,000 | 202 |
| $Q_{100}$ | 1754.2 | 56,000 | 324 |

“WSE Up” = calculated water surface elevation on upstream end of culvert.
“Area Up” = calculated water surface area on upstream end of culvert.
“Q Out” = calculated outflow from the downstream end of crossing.

**Culvert Data**

| Culvert Size (IN) | IE Up (FT) | IE Dn (FT) | Length (FT) |
|---|---|---|---|
| 60 | 1746.3 | 1744.3 | 275 |
| 60 | 1746.3 | 1744.3 | 275 |

Street Overflow Elev = 1,762.8’

**Proposed Improvements**

**Remove**: None

**Install:**

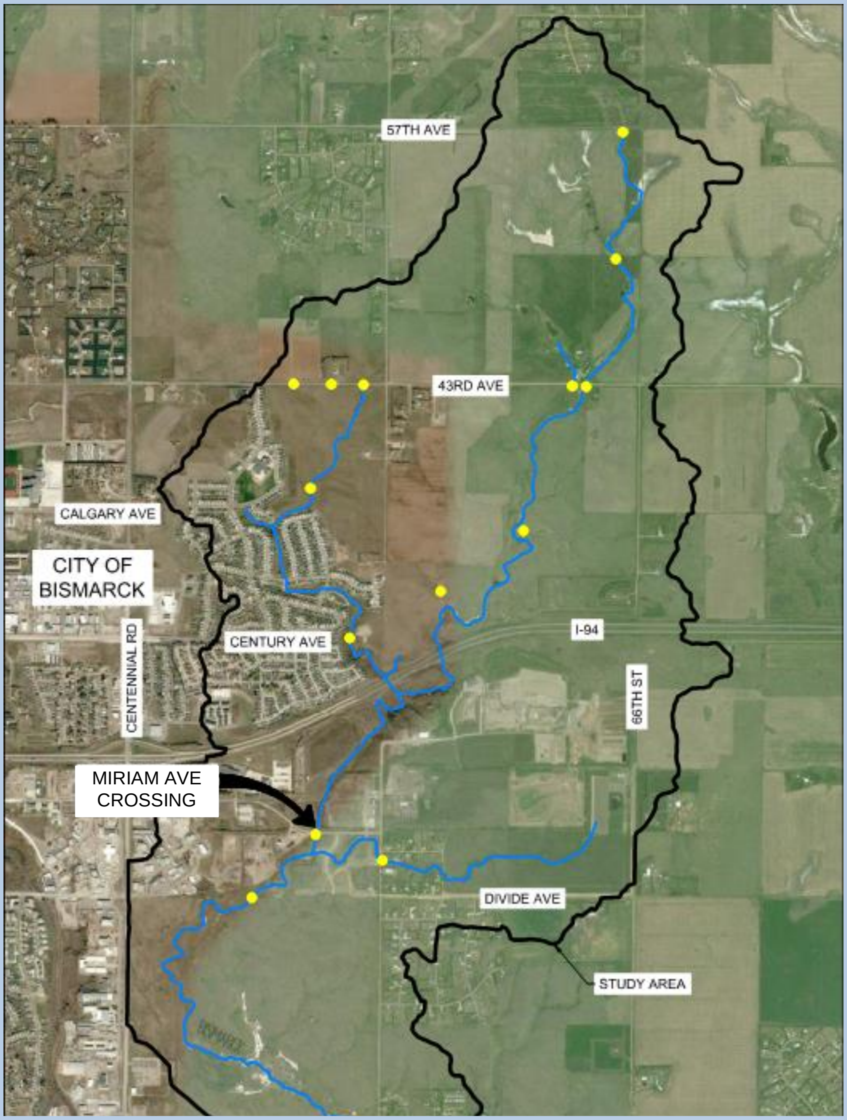
| Spec | Description | Unit | Quantity |
|---|---|---|---|
| 202-4.1 | Unclassified Excavation | CY | 8,000 |
| 802-4.13 | 60” Storm Sewer Pipe | LF | 550 |
| 802-4.46 | 60” FES | EA | 4 |
| SP | Final Stabilization | SF | 60,000 |

**Equivalent Hydraulic Section**

1. Install 9’ x 5’ concrete box culvert at the same invert elevations and lengths listed above. Selection of the final culvert sizing will be based on the actual road crossing geometry.
2. Preliminary hydraulic analysis predicts that this alternative would result in a 25-year WSE of 1748.5, which appears to meet the allowable headwater requirements of the SWDSM and ND Stream Crossing Standards.
3. Preliminary hydraulic analysis predicts that this alternative would result in a 100-year WSE of 1752’.

**Additional Comments**

1. Hydraulic sizing of the proposed improvements is recommend to utilize the Existing Condition flowrates.
2. Final design to confirm that the design headwater elevations meet the requirements of the SWDSM and the ND Stream Crossing Standards.
3. Final design to confirm that the assumed upstream stage areas have been maintained.
4. Elevations are in the North American Vertical Datum of 1988 (NAVD88)

| **Improvement ID & Name: Crossing #9 Miriam Ave** | |
|---|---|
| **Location** | Existing Miriam Ave crossing of Silver Ranch Coulee |
|  | |
| **Contributing Drainage Area** | 2655.5 Acres |
| **Development Condition** | Existing |
| **Implementation Trigger** | In the existing condition the crossing does not meet the SWDSM for a collector street crossing. During the 100-year even this location overtops by 0.7 feet. |
| **Improvement Description** | Removal of the two (2) 42-inch and one (1) 36-inch RCP culvert<br>Installation of three (3) 66-inch diameter RCP culverts.<br>Miriam Ave is classified as a collector street in the future land use plan. |

## Improvement ID & Name: Crossing #9 Miriam Ave

**Opinion of Capital Cost**

$425,000 including engineering and construction.
Opinion of costs do not include the purchase of right-of-way or easements.

**Implementation Inputs & Results**

**Hydraulic Data**

| Storm Event | WSE Up (FT) | Area Up (SF) | Q Out (CFS) |
|---|---|---|---|
| Invert | 1688.1 | 0 | 0 |
| $Q_2$ | 1690.8 | 900 | 122 |
| $Q_{25}$ | 1694.7 | 8,000 | 602 |
| $Q_{100}$ | 1698.9 | 78,000 | 954 |

"WSE Up" = calculated water surface elevation on upstream end of culvert.
"Area Up" = calculated water surface area on upstream end of culvert.
"Q Out" = calculated outflow from the downstream end of crossing.

**Culvert Data**

| Culvert Size (IN) | IE Up (FT) | IE Dn (FT) | Length (FT) |
|---|---|---|---|
| 66 | 1688.1 | 1687.5 | 125 |
| 66 | 1688.1 | 1687.5 | 125 |
| 66 | 1688.1 | 1687.5 | 125 |

**Proposed Improvements**

**Remove:**

| Spec | Description | Unit | Quantity |
|---|---|---|---|
| SP | 36" Pipe | LF | 125 |
| SP | 42" Pipe | LF | 250 |

**Install:**

| Spec | Description | Unit | Quantity |
|---|---|---|---|
| 802-4.14 | 66" Storm Sewer Pipe | LF | 375 |
| 802-4.47 | 66" FES | EA | 4 |
| SP | Replace Street Base and AC | SF | 3,200 |
| SP | Final Stabilization | SF | 15,000 |

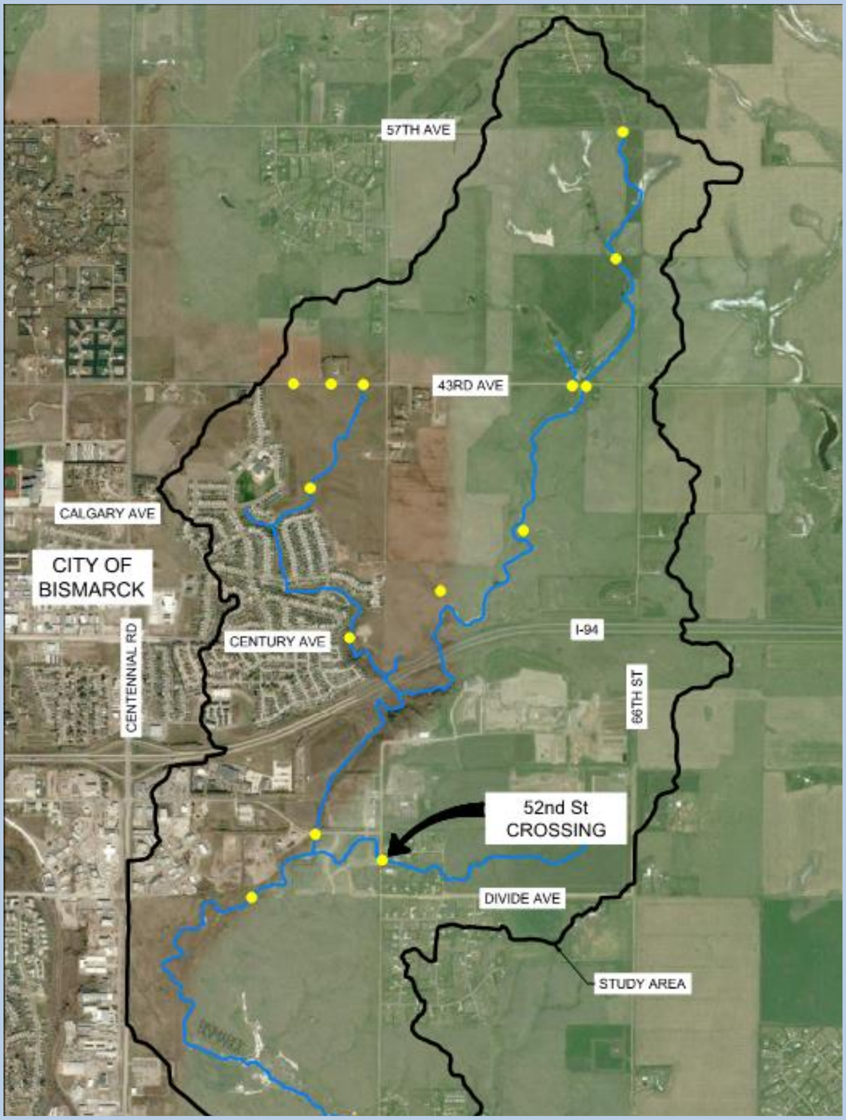
**Improvement Alternatives**

Do nothing, leave the existing facility with the understanding that the road will overtop in the 100-year event.

**Additional Comments**

1. The existing crossing is sufficient to meet ND stream crossing standards.
2. Upgrading the crossing is only recommended in the future if there is a significant change in the road vertical profile or typical section.
3. If in the future, the functional classification is reduced to a local street it is recommended that the existing crossing remain.
4. Elevations are in the North American Vertical Datum of 1988 (NAVD88)

| **Improvement ID & Name: Crossing #10 52nd St** | |
|---|---|
| **Location** | 52nd St crossing of the Eastern Tributary |



| | |
|---|---|
| **Contributing Drainage Area** | 452.1 Acres |
| **Development Condition** | Existing and Future |
| **Implementation Trigger** | Existing condition crossing does not meet the SWDSM for a local street crossing. During the 100-year even this location overtops by greater than 1-foot. Future condition 52nd Ave is listed as an arterial in the road master plan. The SWDSM recommends that urban arterials be designed to not overtop in the 100-year event. |
| **Improvement Description** | Remove one (1) 48-inch culvert<br>Install two (2) 54-inch RCP culverts |

## Improvement ID & Name: Crossing #10 52nd St

**Opinion of Capital Cost**

$240,000 including engineering and construction.
Opinion of costs do not include the purchase of right-of-way or easements.

**Implementation Inputs & Results**

**Hydraulic Data**

| Storm Event | WSE Up (FT) | Area Up (SF) | Q Out (CFS) |
|---|---|---|---|
| Invert | 1718.9 | 0 | 0 |
| $Q_2$ | 1720.2 | 1,000 | 30 |
| $Q_{25}$ | 1723.9 | 25,000 | 218 |
| $Q_{100}$ | 1728 | 93,000 | 391 |

"WSE Up" = calculated water surface elevation on upstream end of culvert.
"Area Up" = calculated water surface area on upstream end of culvert.
"Q Out" = calculated outflow from the downstream end of crossing.

**Culvert Data**

| Culvert Size (IN) | IE Up (FT) | IE Dn (FT) | Length (FT) |
|---|---|---|---|
| 54 | 1718.9 | 1718.2 | 85 |
| 54 | 1718.9 | 1718.2 | 85 |
| | | | |

**Proposed Improvements**

**Remove:**

| Spec | Description | Unit | Quantity |
|---|---|---|---|
| SP | 48" Pipe | LF | 85 |

**Install:**

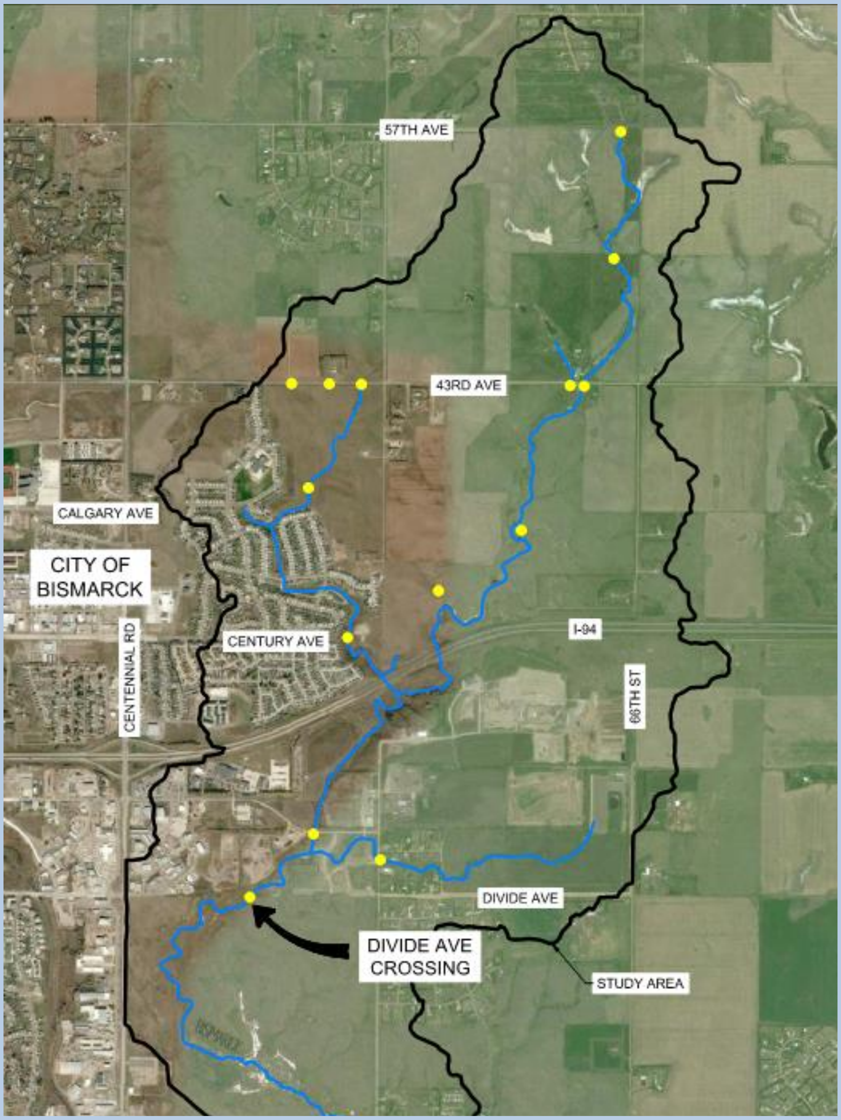
| Spec | Description | Unit | Quantity |
|---|---|---|---|
| 802-4.12 | 54" Storm Sewer Pipe | LF | 170 |
| 802-4.45 | 54" FES | EA | 4 |

**Improvement Alternatives**

Do nothing, leave the existing facility with the understanding that the road will overtop in the 100-year event.

**Additional Comments**

1. The existing crossing is sufficient to meet ND stream crossing standards.
2. Upgrading the crossing is only recommended in the future if there is a significant change in the road vertical profile or typical section.
3. If in the future, the functional classification is reduced to a local street it is recommended that the existing crossing remain.
4. Final design to confirm that the design headwater elevations meet the requirements of the SWDSM and the ND Stream Crossing Standards.
5. Final design to confirm that the assumed upstream stage areas have been maintained.
6. Elevations are in the North American Vertical Datum of 1988 (NAVD88)

| **Improvement ID & Name: Crossing #11 Future Divide Ave** | |
|---|---|
| **Location** | Future Divide Ave crossing of Silver Ranch Coulee |
|  | |
| **Contributing Drainage Area** | 3391.5 Acres |
| **Development Condition** | Future |
| **Implementation Trigger** | Construction of Divide Ave on the south line of Section 25 in Township 139N Range 79W. This section of Divide Ave has not been constructed. |
| **Improvement Description** | Five (5) 12′ x 5′ concrete box culverts.<br>Divide Ave is listed in the 2014 Fringe Road Master Plan as a future arterial roadway. The Silver Ranch Master Plan assumed that the future roadway section would consist of a 120-foot wide right of way with 25% slopes.<br>Future Divide Ave future roadway is shown on Exhibit 9A & 9B. |

## Improvement ID & Name: Crossing #11 Future Divide Ave

**Opinion of Capital Cost**

$6,092,000 including engineering and construction.
Opinion of costs do not include the purchase of right-of-way or easements.

**Implementation Inputs & Results**

**Hydraulic Data**

| Storm Event | WSE Up (FT) | Area Up (SF) | Q Out (CFS) |
|---|---|---|---|
| Invert | | N/A | 0 |
| $Q_2$ | 1681.1 | N/A | 162 |
| $Q_{25}$ | 1683.1 | N/A | 763 |
| $Q_{100}$ | 1684.3 | N/A | 1319 |

"WSE Up" = calculated water surface elevation on upstream end of culvert.
"Area Up" = calculated water surface area on upstream end of culvert.
"Q Out" = calculated outflow from the downstream end of crossing.

**Culvert Data**

| Culvert Size (IN) | IE Up (FT) | IE Dn (FT) | Length (FT) |
|---|---|---|---|
| 5′ x 12′ RCB | 1680 | 1678 | 375 |

Note: Preliminary Design is five (5) 12′ x 5′ concrete box culverts with the same elevation.
Street Overflow Elev = 1697.4

**Proposed Improvements**

**Remove**: None
**Install:**

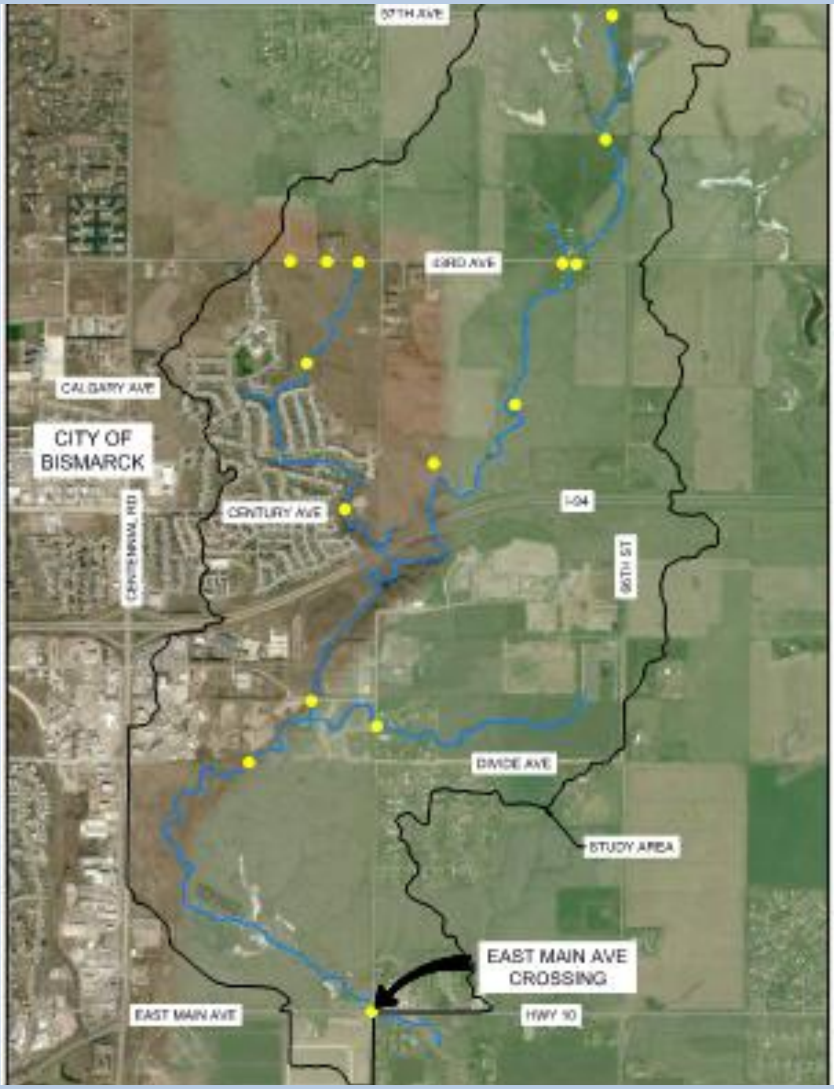
| Spec | Description | Unit | Quantity |
|---|---|---|---|
| 202-4.1 | Unclassified Excavation | CY | 180,000 |
| SP | 12′ x 5′ RCB Culvert | LF | 1,875 |
| SP | 12′ x 5′ Box Culvert Ends | EA | 10 |
| SP | Final Stabilization | SF | 450,000 |

**Equivalent Hydraulic Structure**

1. No Equivalent Hydraulic structures were analyzed.
2. As an alternative, replacing the culvert crossings with a bridge or other span should be evaluated during final design.
3. Final Designs need to consider the impact to the FEMA Floodplain and total rise during the 100-year event.
4. Final Design will need to include a LOMR for impacts to the regulatory FEMA Floodway.

**Additional Comments**

1. Hydraulic sizing of the proposed improvements is recommend to utilize the Existing Condition flowrates.
2. Final design to confirm that the design headwater elevations meet the requirements of the SWDSM and the ND Stream Crossing Standards.
3. Elevations are in the North American Vertical Datum of 1988 (NAVD88)

<table>
<tr><th colspan="2">Improvement ID & Name: Crossing #12 East Main Ave</th></tr>
<tr><td><b>Location</b></td><td>East Main Ave crossing of Silver Ranch Coulee</td></tr>
<tr><td colspan="2">
</td></tr>
<tr><td><b>Contributing Drainage Area</b></td><td>3,916 Acres</td></tr>
<tr><td><b>Development Condition</b></td><td>Existing Crossing</td></tr>
<tr><td><b>Implementation Trigger</b></td><td>Modification or reconstruction of East Main Ave at the intersection with 52nd Street. In the Existing Condition this area overtops by approximately 0.5-feet.</td></tr>
<tr><td><b>Improvement Description</b></td><td>32-foot extension of an existing 5′ x 11′ RCB culvert<br>One 4′ x 12′ RCB culvert under East Main Ave west of 52nd Street<br>One 4′ x 6′ RCB culvert under 52nd Street south of East Main Ave<br>Crossing 1B 90 foot extension of existing 42-inch RCP culvert<br>East Main Ave and 52nd St crossings are shown on Exhibit 10A&10B and 11A&11B.</td></tr>
</table>

**Improvement ID & Name: Crossing #12 East Main Ave**

| **Opinion of Capital Cost** | $1,301,000 including engineering and construction.<br>Opinion of costs do not include the purchase of right-of-way or easements. |
|---|---|

**Implementation Inputs & Results**

**Hydraulic Data (Existing 5′x11′ RCB & Proposed 4′x12′ RCB)**

**Hydraulic Data**

**5′ x 11′ RCB Culvert Extension**

| Storm Event | WSE Up (FT) | Area Up (SF) | Q Out (CFS) |
|---|---|---|---|
| Invert | 1652 | 0 | 0 |
| $Q_2$ | 1654.8 | 260,000 | 115 |
| $Q_{25}$ | 1658.1 | 1,140,000 | 378 |
| $Q_{100}$ | 1660.4 | 1,800,000 | 548 |

"WSE Up" = calculated water surface elevation on upstream end of culvert.
"Area Up" = calculated water surface area on upstream end of culvert.
"Q Out" = calculated outflow from the downstream end of crossing.

**4′ x 12′ RCB Culvert Installation**

| Storm Event | WSE Up (FT) | Area Up (SF) | Q Out (CFS) |
|---|---|---|---|
| Invert | 1656.4 | 0 | 0 |
| $Q_2$ | 1654.8 | 260,000 | 0 |
| $Q_{25}$ | 1658.1 | 1,140,000 | 66 |
| $Q_{100}$ | 1660.4 | 1,800,000 | 246 |

"WSE Up" = calculated water surface elevation on upstream end of culvert.
"Area Up" = calculated water surface area on upstream end of culvert.
"Q Out" = calculated outflow from the downstream end of crossing.

**4′ x 6′ RCB Culvert Installation**

| Storm Event | WSE Up (FT) | Area Up (SF) | Q Out (CFS) |
|---|---|---|---|
| Invert | 1652.8 | 0 | 0 |
| $Q_2$ | 1655.3* | 20,900 | 64* |
| $Q_{25}$ | 1565.5* | 33,000 | 111* |
| $Q_{100}$ | 1657.8* | 40,300 | 170* |

"WSE Up" = calculated water surface elevation on upstream end of culvert.
"Area Up" = calculated water surface area on upstream end of culvert.
"Q Out" = calculated outflow from the downstream end of crossing.
*From Local Watershed. Peak flows and water surface elevations not coincident with the Silver Ranch hydrograph.

**Implementation Inputs & Results**

**Culvert Data**

| Culvert Size (IN) | IE Up (FT) | IE Dn (FT) | Length (FT) |
|---|---|---|---|
| 5′ x 11 ′ | 1652.1 | 1651.9 | 152 |
| 4′ x 12′ | 1656.4 | 1654.6 | 80 |
| 4′ x 6′ | 1652.8 | 1652.0 | 94 |

## Improvement ID & Name: Crossing #12 East Main Ave

**Proposed Improvements**

**Remove**: None

**Install:**

| Spec | Description | Unit | Quantity |
|---|---|---|---|
| 202-4.1 | Unclassified Excavation | CY | 40,000 |
| SP | 6ft x 4ft Precast RCB Culvert | LF | 94 |
| SP | 11ft x 5ft Precast RCB Culvert | LF | 32 |
| SP | 12ft x 4ft Precast RCB Culvert | LF | 80 |
| SP | Box Culvert End Treatments | EA | 6 |
| SP | Final Stabilization | SF | 125,000 |

**Improvement Alternatives**

1. No Equivalent Hydraulic structures were analyzed.
2. As an alternative, waiving the City's allowable headwater requirement during the 100-year event may allow the existing crossing to function without the need for additional culverts.
3. Final Designs need to consider the impact to the FEMA Floodplain and total rise during the 100-year event.
4. Final Design will need to include a LOMR for impacts to the regulatory FEMA Floodway.

**Additional Comments**

1. Hydraulic sizing of the proposed improvements is recommend to utilize the Existing Condition flowrates.
2. Final design to confirm that the design headwater elevations meet the requirements of the SWDSM and the ND Stream Crossing Standards.
3. Final design to confirm that the assumed upstream stage areas have been maintained.
4. Elevations are in the North American Vertical Datum of 1988 (NAVD88)

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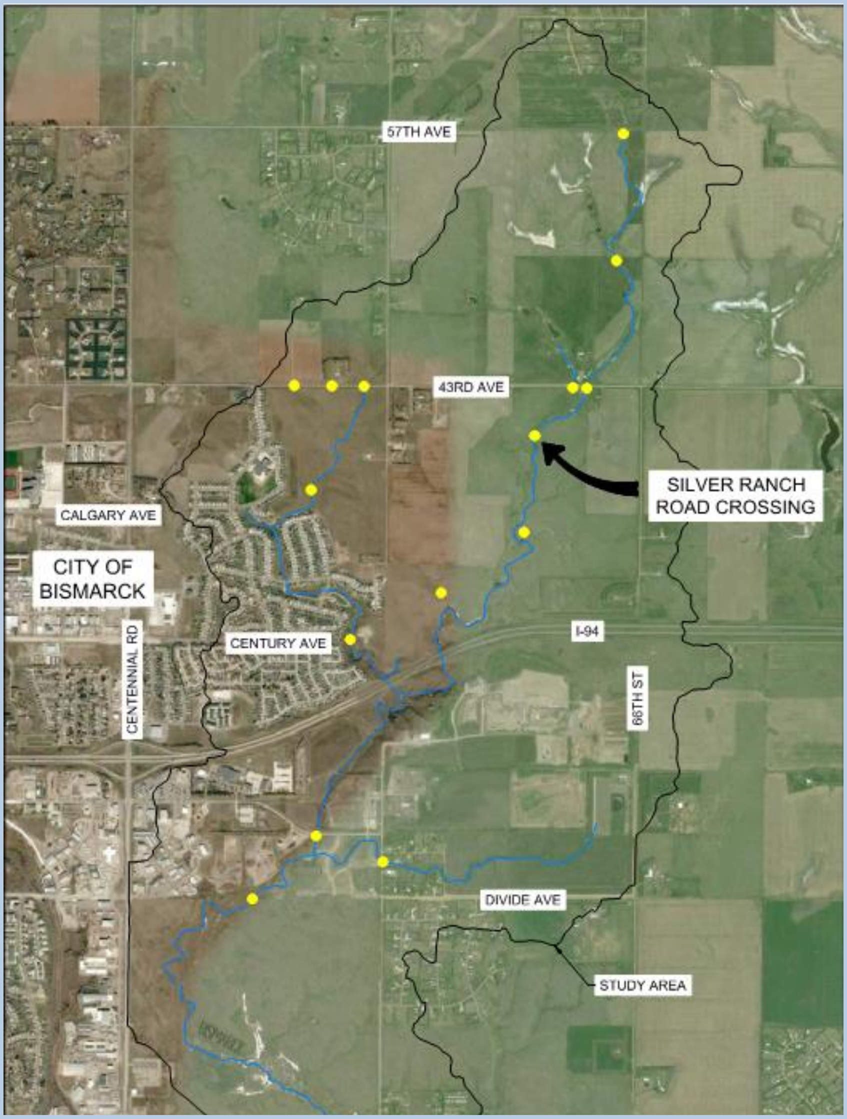
| **Improvement ID & Name: Crossing #13 Silver Ranch Crossing** | |
|---|---|
| **Location** | Future Silver Ranch Addition crossing of Silver Ranch Coulee. |
|  | |
| **Contributing Drainage Area** | 781 Acres |
| **Development Condition** | Future |
| **Implementation Trigger** | Silver Ranch Addition crossing of Silver Ranch Coulee |
| **Improvement Description** | Six (6) 48-inch diameter RCP culverts.<br>The Silver Ranch Road crossing of Silver Ranch Coulee will be a future local street. The Silver Ranch Master Plan assessed that the future roadway section will consist of an 80-foot wide right-of-way with 25% side slopes. |

## Improvement ID & Name: Crossing #13 Silver Ranch Crossing

**Opinion of Capital Cost**

$445,0000
Opinion of costs do not include the purchase of right-of-way or easements.

**Implementation Inputs & Results**

**Hydraulic Data**

| Storm Event | WSE Up (FT) | Area Up (SF) | Q Down (CFS) |
|---|---|---|---|
| Invert | 1784.75 | 150 | 0 |
| $Q_2$ | 1786.0 | 6,200 | 61 |
| $Q_{25}$ | 1787.9 | 33,000 | 204 |
| $Q_{100}$ | 1788.5 | 41,000 | 410 |

"WSE Up" = calculated water surface elevation on upstream end of culvert.
"Area Up" = calculated water surface area on upstream end of culvert.
"Q Out" = calculated outflow from the downstream end of crossing.

**Culvert Data**

| Culvert Size (IN) | IE Up (FT) | IE Dn (FT) | Length (FT) |
|---|---|---|---|
| 48 | 1784.75 | 1784 | 140 |

Note: Crossing Consists of a total of six (6) 48-inch culverts with the same invert and length considerations.

**Proposed Improvements**

**Remove**: None

**Install:**

| Spec | Description | Unit | Quantity |
|---|---|---|---|
| 202-4.1 | Unclassified Excavation | CY | 2,000 |
| 802-4.11 | 48" Storm Sewer Pipe | LF | 840 |
| 802-4.61 | 48" FES | EA | 12 |
| SP | Final Stabilization | SF | 15,000 |

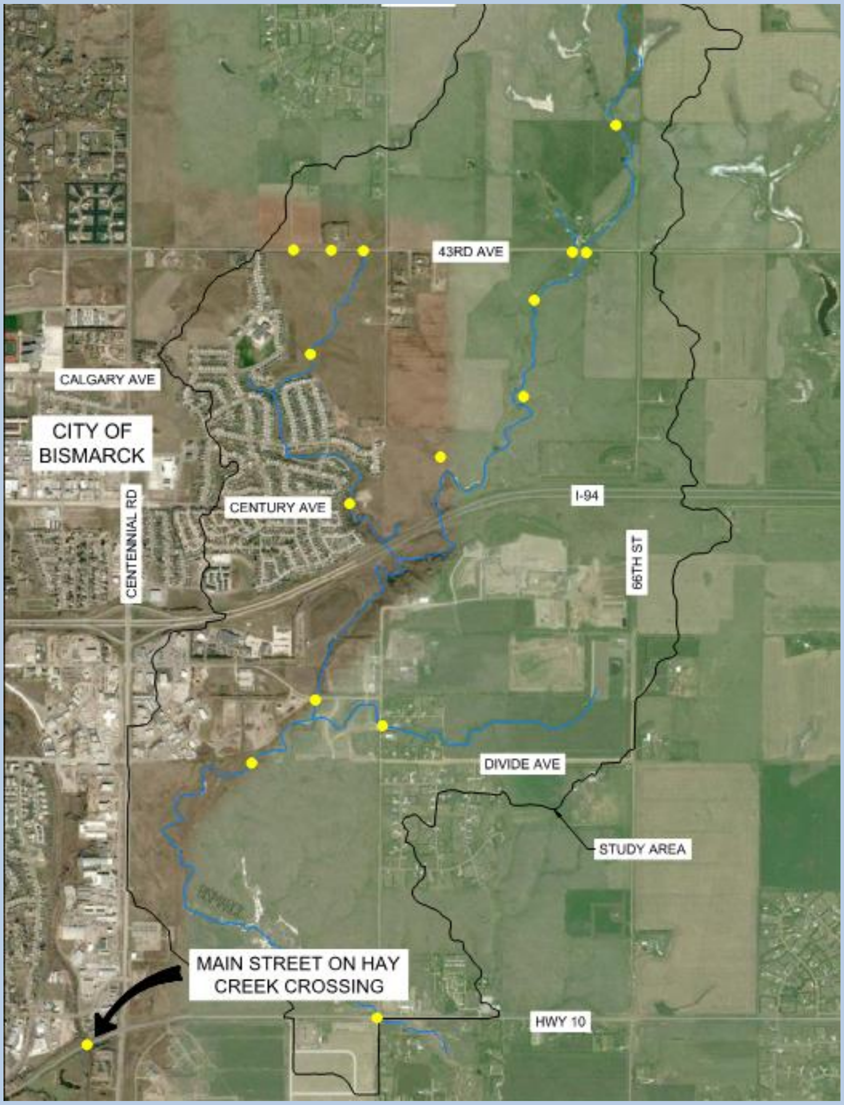
**Improvement Alternatives**

1. Install a 9' x 4' concrete box culvert at the same invert elevations and lengths listed above. Selection of the final culvert sizing will be based on the actual road crossing geometry.
2. Preliminary hydraulic analysis predicts that this alternative would result in a 25-year WSE of 1787.7, which appears to meet the allowable headwater requirements of the SWDSM and ND Stream Crossing Standards.
3. Preliminary hydraulic analysis predicts that this alternative would result in a 100-year WSE of 1788.3.

**Additional Comments**

1. Final design of the roadway crossing must result in a 100-year water surface elevation of 1788.5 or less to match the Development Setback Line.
2. Final design to confirm that the design headwater elevations meet the requirements of the SWDSM and the ND Stream Crossing Standards.
3. Final design does not need to confirm upstream stage areas.
4. Elevations are in the North American Vertical Datum of 1988 (NAVD88)

| **Improvement ID & Name: Crossing #14 Main Ave** | |
|---|---|
| **Location** | Main Ave at Hay Creek |



| | |
|---|---|
| **Contributing Drainage Area** | 22,571 Acres |
| **Development Condition** | Existing crossing of Hay Creek at Main Ave. |
| **Implementation Trigger** | Blocking of the Silver Ranch and Hay Creek watersheds connection. |
| **Improvement Description** | Installation of an additional 5′ x 10′ RCB culvert crossing. |

| **Improvement ID & Name: Crossing #14 Main Ave** | |
|---|---|
| **Opinion of Capital Cost** | $485,000<br>Opinion of costs do not include the purchase of right-of-way or easements. |
| **Implementation Inputs & Results** | See Hydraulic Data and Culvert Data below |

**Hydraulic Data**

| Storm Event | WSE Up (FT) | Area Up (SF) | Q Out (CFS) |
|---|---|---|---|
| Invert | | | |
| $Q_2$ | | | |
| $Q_{25}$ | | | |
| $Q_{100}$ | | | |

"WSE Up" = calculated water surface elevation on upstream end of culvert.
"Area Up" = calculated water surface area on upstream end of culvert.
"Q Out" = calculated outflow from the downstream end of crossing.

**Culvert Data**

| Culvert Size (IN) | IE Up (FT) | IE Dn (FT) | Length (FT) |
|---|---|---|---|
| 5′ x 10 ′ | | | 90 |

**Proposed Improvements**

**Remove**: None
**Install:**

| Spec | Description | Unit | Quantity |
|---|---|---|---|
| SP | Road Reconstruction | SY | 150 |
| SP | 10ft x 5ft Precast RCB Culvert | LF | 90 |
| SP | Box Culvert End Treatments | EA | 2 |
| SP | Final Stabilization | SF | 125,000 |

**Improvement Alternatives**

1. No Equivalent Hydraulic structures were analyzed.
2. As an alternative, waiving the City's allowable headwater requirement during the 100-year event may allow the existing crossing to function without the need for additional culverts.
3. Final Designs need to consider the impact to the FEMA Floodplain and total rise during the 100-year event.
4. Final Design will need to include a LOMR for impacts to the regulatory FEMA Floodway.

**Additional Comments**

1. Hydraulic sizing of the proposed improvements is recommend to utilize the Existing Condition flowrates.
2. Final design to confirm that the design headwater elevations meet the requirements of the SWDSM and the ND Stream Crossing Standards.
3. Final design to confirm that the assumed upstream stage areas have been maintained.
4. Elevations are in the North American Vertical Datum of 1988 (NAVD88)