SILVER RANCH WATERSHED

FOR

CITY OF BISMARCK, ND

STORMWATER MASTER PLAN REPORT

Volume III – Hay Creek Watershed and Hay Creek/Silver Ranch Connection Methodology & Analysis

December 2018

AE2S Project #: P00501-2015-013

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SILVER RANCH WATERSHED
STORMWATER MASTER PLAN REPORT
VOLUME III

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
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Registration Number
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on December 04, 2018
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III-1.0 HAY CREEK STUDY PURPOSE & BACKGROUND

III-1.1 HAYCREEK STUDY PURPOSE

Hay Creek is located immediately to the west of the Silver Ranch watershed, as shown in ***Figure III - 1.*** The effective FEMA maps and Flood Insurance Study for Bismarck, ND indicate that the Silver Ranch Watershed (referenced by FEMA as the Landfill Watershed) can break out and flow towards Hay Creek near the intersection of the Bismarck Expressway and Main Avenue (***Figure III - 2***).

While not accounted for in the Flood Insurance Study, the flood profile elevations and LiDAR data for Hay Creek also indicate that Hay Creek could flow towards the Silver Ranch Watershed (***Figure III - 3***).

In order to better understand the hydraulic connection between these two watersheds, an updated analysis of the Hay Creek watershed was requested by the City of Bismarck.

III-1.2 ORGANIZATION OF THE MASTER PLAN REPORT

The Silver Ranch Master Plan Report consists of three volumes each with a distinct function. Combined, these three volume 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.

III-1.3 MODEL SCOPE AND LEVEL OF DETAIL

The Hay Creek model encompasses the entire Hay Creek watershed that drains to the Bismarck Expressway, as shown previously in ***Figure III - 3***. The scope of the study was performed at a higher level, so there is less hydrologic and hydraulic (H&H) detail for the Hay Creek watershed than there is for the Silver Ranch Watershed H&H model. However, similar to the approach for the Silver Ranch H&H model, the general level of detail of the study is such that existing infrastructure such as road crossings, culverts, and other stormwater infrastructure was modeled when located on main drainage-ways or when it was determined appropriate due to upstream land use changes or sensitive nearby infrastructure.

III-1.4 DATA SOURCES

The following data sources were utilized for the Hay Creek Watershed study:

- 2016 LIDAR data (contours and DEM) obtained from the Metropolitan Planning Organization;
- Bismarck 2016 aerial photograph, obtained from the City of Bismarck;
- US83 / ND1804 Stormwater Master Plan Report (May 2014) and InfoSWMM model, prepared by AE2S;
- Edgewood Regional Stormwater Facilities Final Design Memorandum, prepared by AE2S, dated January 7, 2014 (and associated InfoSWMM model);
- North Washington Watershed InfoSWMM model, prepared by and obtained from Apex Engineering Group;
- NRCS soils database, Version 36 for Burleigh County, obtained from the NRCS Geospatial Data Gateway January 2017;
- Rainfall depths from the City of Bismarck 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; and
- Various Stormwater Management Plans and Record Drawings provided by the City.

III-1.5 VERTICAL DATUM

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

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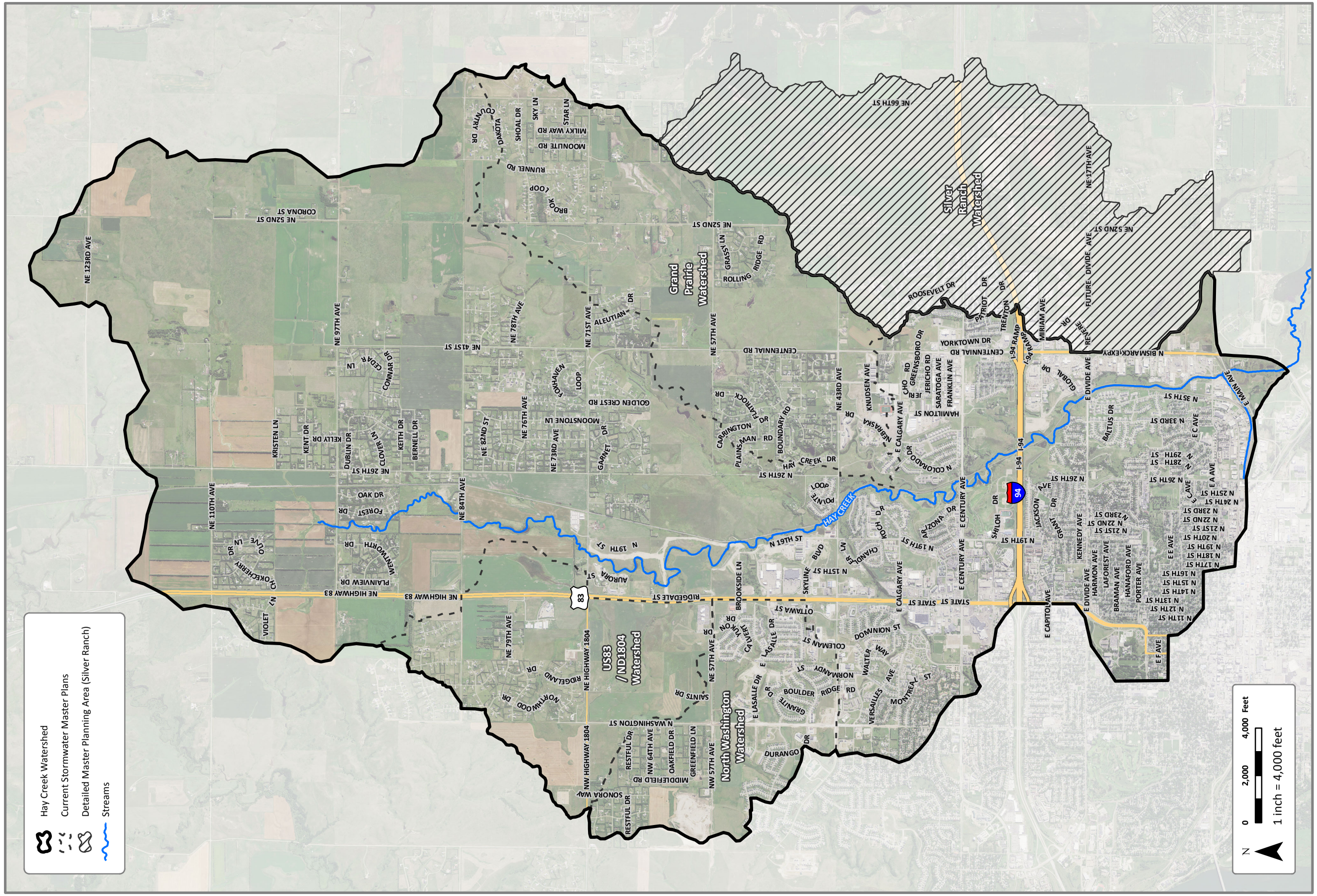

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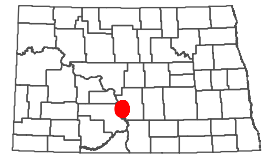
Coordinate System: NAD 1983 StatePlane North Dakota South FIPS 3302 Feet Intl | Edited by: dlee | C:\Data\Projects\WAFS\Bismarck\00501-2015-013\GIS\Report Figure III-1- Hay Creek Watershed.mxd



Locator Map Not to Scale

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Burleigh County, ND

Figure III-1

HAY CREEK WATERSHED

SILVER RANCH WATERSHED STORMWATER MASTER PLAN

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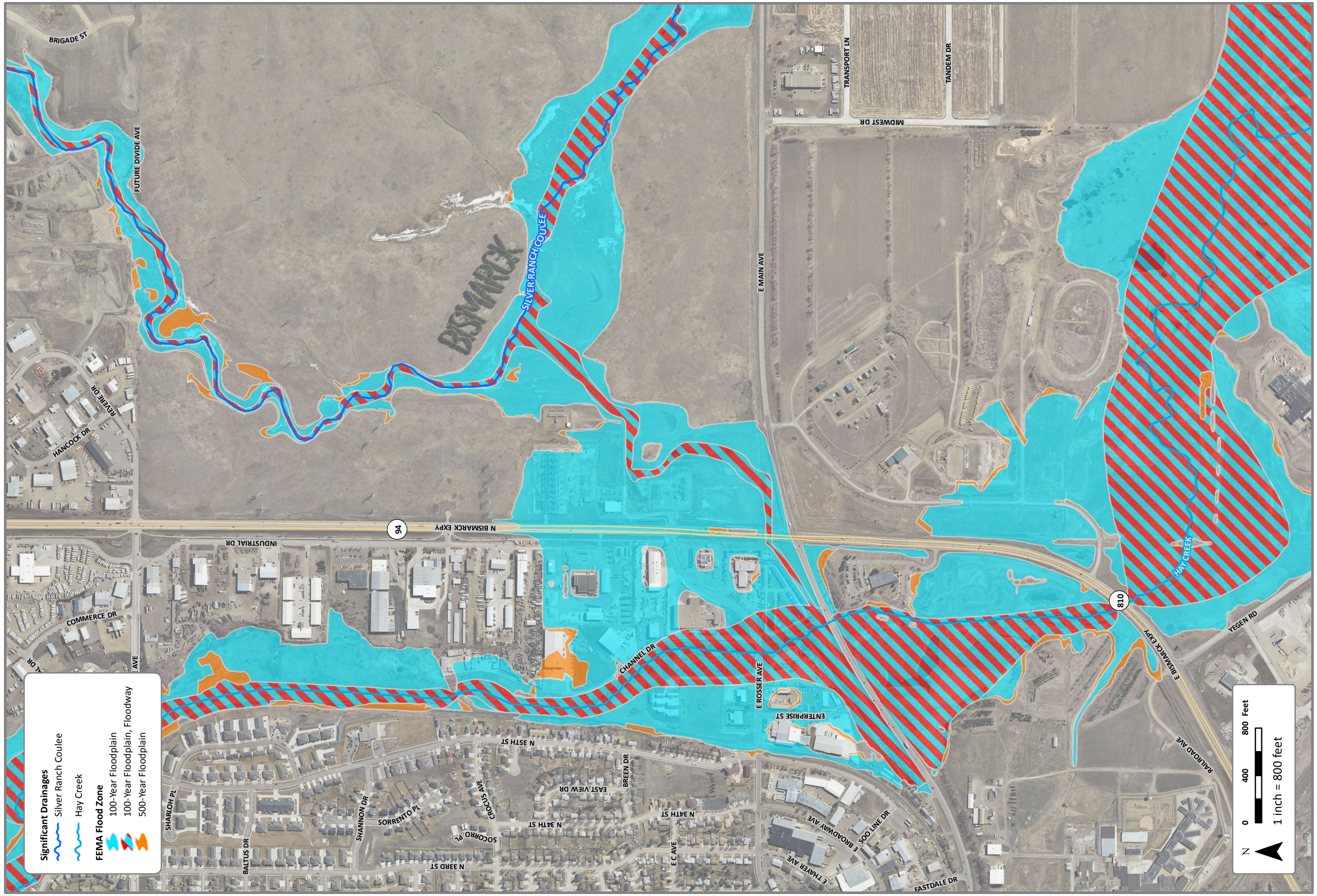

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Figure III-2

FEMA FLOODPLAINS NEAR HAY CREEK / SILVER RANCH CONNECTION

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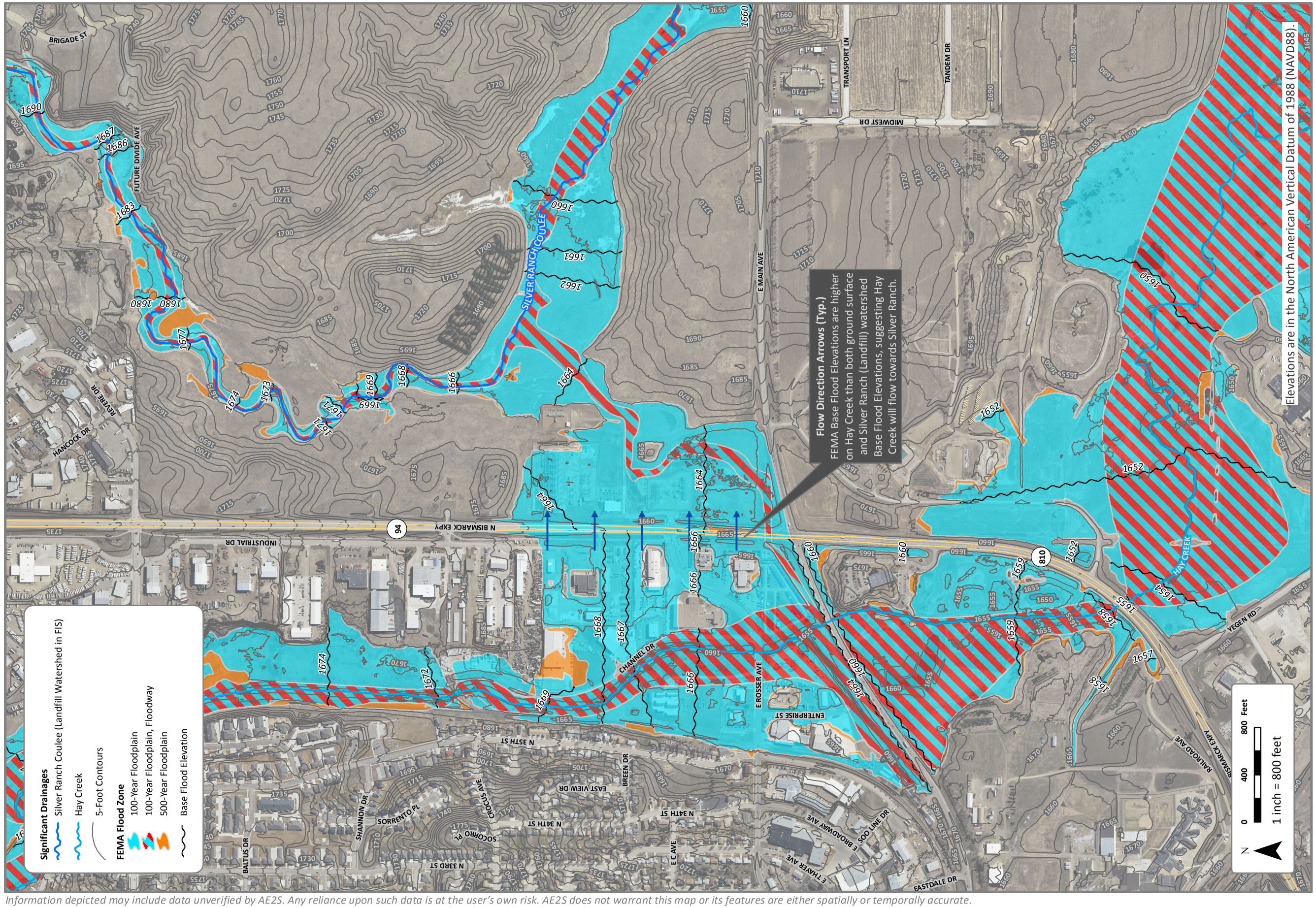

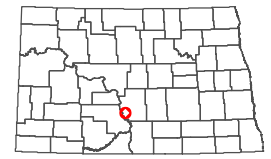

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Figure III-3

HAY CREEK FLOODPLAIN ELEVATIONS

SILVER RANCH WATERSHED STORMWATER MASTER PLAN

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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 III-3- Hay Creek Floodplain Elevations.mxd

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III-2.0 KEY FINDINGS AND RECOMMENDATIONS

III-2.1 KEY FINDINGS

The key findings documented by Volume III of the Silver Ranch Master Plan are:

1. **The Silver Ranch and Hay Creek connection allows floodwaters to flow between each watershed.** Previous analysis of the Silver Ranch watershed had determined that floodwaters flowed from Silver Ranch to the Hay Creek Watershed. However, with updated LiDAR topography and more advanced hydraulic modeling, this Master Plan has determined that floodwaters cross between the watersheds in each direction.
    a. The "Landfill Watershed Flood Insurance Study Report" prepared by Houston Engineering (HEI) and dated December 27th, 2002 concluded that flood flows from the Silver Ranch Watershed (referred to by FEMA as the Landfill Watershed) broke out into the Hay Creek watershed and recommended that the connection be closed.
    b. This current Master Plan utilized both an HEC-RAS 2D and InfoSWMM Analysis to demonstrate that connection between the Silver Ranch and Hay Creek watersheds allow floodwaters to move between both drainages.
    c. ***Figure III - 9*** and ***Figure III - 10*** show the predicted water surface elevations and watershed response to the 100-year flood for the Silver Ranch and Hay Creek watersheds at the connection point.
2. **Blocking the connection results in additional infrastructure requirements for each watershed**. Analysis completed for this Master plan determined that if the connection is blocked the result would be:
    a. Limited benefit to the Silver Ranch watershed because the Main Avenue crossing is predicted to overtop in both the Existing and Future land use conditions requiring infrastructure improvements.
    b. Increased flood elevations and inundation area within the Hay Creek watershed require upgrades to the Hay Creek crossing at Main Avenue.
3. **Keeping the connection active results in no adverse impacts to the watersheds**. Keeping the connection active results in Hay Creek floodwater breaking out into the Silver Ranch Watershed resulting in lower flood elevations and reduced inundation area for Hay Creek. Analysis completed for this Master Plan determined that if the connection is left active the result would be:
    a. No adverse impact to the Silver Ranch watershed because the Main Avenue crossing is still predicted to overtop requiring infrastructure improvements.
    b. Decreased flood elevations and inundation area within the Hay Creek watershed with no improvements identified as being required.
4. **Master Plan functions for either a block or active connection**. The Silver Ranch Watershed Master Plan was developed in a manner that allows the City the flexibility

to choose if the connection between the two watersheds is left active or closed. Recommendations included in ***Volume I*** and ***Volume II*** are valid for either connection condition.

5. **Master Plan H&H modeling for Silver Ranch Watershed utilized an active connection with breakout flows from Hay Creek.** Modeling analysis and results included in ***Volume I*** and ***Volume II*** for the Silver Ranch Watershed were developed with an active connection between the watersheds. Thus, the improvement plan and preliminary designs included in ***Volume I*** and ***Volume II*** account for the additional flows from the Hay Creek watershed during the 100-year event.

III-2.2 RECOMMENDATIONS

Recommendations for the Silver Ranch and Hay Creek watershed connection are as follows:

1. **The Silver Ranch and Hay Creek connection is recommended to remain active with flows from each watershed linking in the 100-year event, preserving existing, large scale flow paths**.
    a. The Master Plan functions whether the connection remains active or is blocked.
    b. Preserving the connection provides benefits to the Hay Creek Watershed without having to add significant additional infrastructure to the Silver Ranch Watershed.
    c. Blocking the connection would likely worsen flooding conditions in the Hay Creek Watershed and still require additional infrastructure in the Silver Ranch Watershed.
2. **If the connection is blocked, the City should implement the following measures:**
    a. Hay Creek improvements consisting of an additional 5'x10' box culvert under Main Avenue to provide the additional conveyance to avoid exacerbating flooding risk on already-developed properties;
    b. Perform additional review of flow increases and headwater elevations downstream of Main Avenue and work with the landowner(s) downstream to obtain approvals for the increased flows and perform proper mitigation as necessary; and
    c. Obtain necessary FEMA approvals, which would likely include a Conditional Letter of Map Revision (CLOMR) prior to construction and a Letter of Map Revision (LOMR) after construction. As part of that approval, it may be appropriate to update the FEMA hydrology for Hay Creek.

III-3.0 HYDROLOGIC AND HYDRAULIC MODEL DEVELOPMENT

The hydrologic and hydraulic modeling methods used for the development of this Master Plan are discussed in the following sections.

III-3.1 HYDROLOGIC & HYDRAULIC MODEL SUMMARY

The hydrologic and hydraulic analyses were carried out using InfoSWMM, a proprietary GIS-integrated version of EPA SWMM, which is widely accepted for stormwater modeling. The hydraulic features modeled include natural channels, urban and rural storage areas, and culverts. InfoSWMM provides an effective and comprehensive method for modeling complex drainage systems.

In order to evaluate the hydraulics of the Hay Creek / Silver Ranch connection and what effect it has on 100-year peak flows / inundation in both Silver Ranch and Hay Creek, a series of hydrologic and hydraulic (H&H) model scenarios were developed. Only the 100-year event was modeled for the Hay Creek study.

For the Hay Creek and Hay Creek / Silver Ranch Connection evaluation, the following H&H scenarios were developed:

1. **Baseline Runoff Conditions and Connection Active:** This scenario includes the following:
    a. Silver Ranch existing conditions (Existing land use, soils, road system, and drainage conveyance systems that were in-place prior to the start of the Master Plan process).
    b. Hay Creek baseline conditions, which uses the master planned conditions for previously approved Stormwater Master Plans and the existing condition for areas that have not been master planned. Approved Master Plans were US83 / ND1804, North Washington, and Grand Prairie.
    c. Connection between the two watersheds in its current form.

    This scenario is named "EXISTING_100YR_HAY_CR" in the InfoSWMM model named "SILVERRANCH_MASTERMODEL FINAL."
2. **Master-Planned Conditions, Unit Rate and Connection Active:** This scenario is the same as Scenario 1, except that the Silver Ranch watershed is in its Stormwater Master Plan condition.

    This scenario is named "FUTURE_ONSITE_100YR_HAY_CR" in the InfoSWMM model named "SILVERRANCH_MASTERMODEL FINAL."
3. **Baseline Runoff Conditions and Connection Blocked:** This scenario is the same as Scenario 1, except that the connection between the two watersheds is blocked. Blocking the connection in the model was simulated by turning off the InfoSWMM hydraulic network between the Silver Ranch drainage and east of Bismarck Expressway.

This scenario is named "EXISTING_100YR_NO_CONNECT" in the InfoSWMM model named "SILVERRANCH_MASTERMODEL FINAL."

4. **Master-Planned Conditions, Unit Rate and Connection Blocked:** This scenario is the same as Scenario 2, except that the connection between the two watersheds is blocked and an additional box culvert is added under Main Avenue to provide additional capacity for Hay Creek to offset the loss in conveyance from blocking the connection. Blocking the connection in the model was done in the same way as Scenario 3.

   This scenario is named "FUTURE_ONSITE_100YR_NO_CONN" in the InfoSWMM model named "SILVERRANCH_MASTERMODEL FINAL."

III-3.2 HYDROLOGIC MODEL INPUT

Hydrologic model input consists of rainfall, land use (impervious area), soils, watershed boundaries, Curve Number (CN) values, and Time of Concentration (Tc) estimates. These inputs are summarized in the following sections.

As described previously, the only two hydrologic scenarios evaluated for the Hay Creek study were the baseline condition and future land use (with unit rate release) conditions in Silver Ranch. In other words, Hay Creek was assumed to stay in its baseline condition as creating a master plan for Hay Creek was outside the scope of this project.

III-3.2.1 Rainfall

The same rainfall data was used for Hay Creek and Silver Ranch. Only the 100-year event was analyzed for the Hay Creek / Silver Ranch connection (***Table III - 1***).

Table III - 1: Atlas 14, 24-hour Design Storm Depths for Bismarck, ND

Event	Rainfall Depth (in)
100-Year	5.3

III-3.2.2 Land Use

For the Hay Creek Watershed study, a combination of existing land use and master planned land use was utilized. Percent impervious was determined based on values provided in the City's SWDSM when applicable. For land uses not specifically referenced in the SWDSM, percent impervious was determined by reviewing sample areas within the watershed.

Land Use within Master-Planned Areas

Master planned land use was utilized for up-to-date stormwater master plans, which are: US83/ND1804, North Washington, and Grand Prairie watersheds. For additional detail on land use within these watersheds, refer to the respective master plan reports.

Land Use outside Master-Planned Areas

Existing land use was input to the model in all other areas. The land uses within the remaining parts of Hay Creek not covered by the three master plans are shown in ***Figure III - 4*** and summarized in ***Table III - 2***. For agricultural areas, the cover was assumed to be a 50-50 mix of cropland and pasture/rangeland.

Table III - 2: Hay Creek Watershed Land Use

Land Use	Area (ac)	Fraction of Watershed	Percent Impervious
Ag – Cropland/ Pasture/Rangeland	7,293.3	32%	0%
Civic	303.5	1%	50%
Commercial	874.9	4%	85%
Industrial	515.0	2%	90%
Open Space	1,051.8	5%	0%
Low Density Residential	2,481.1	5%	38%
Rural Residential, 2-5 acre Lots	2,939.2	13%	10%
Rural ROW	511.8	2%	40%
US83 / ND1804 Master Plan	1,877.6	8%	*
North Washington Master Plan	1,474.2	7%	*
Grand Prairie Master Plan	3,330.9	15%	*
Totals	**22,653.3**		

*Percent Impervious not available due to the Land Use being a Master Plan consisting of numerous different land uses.

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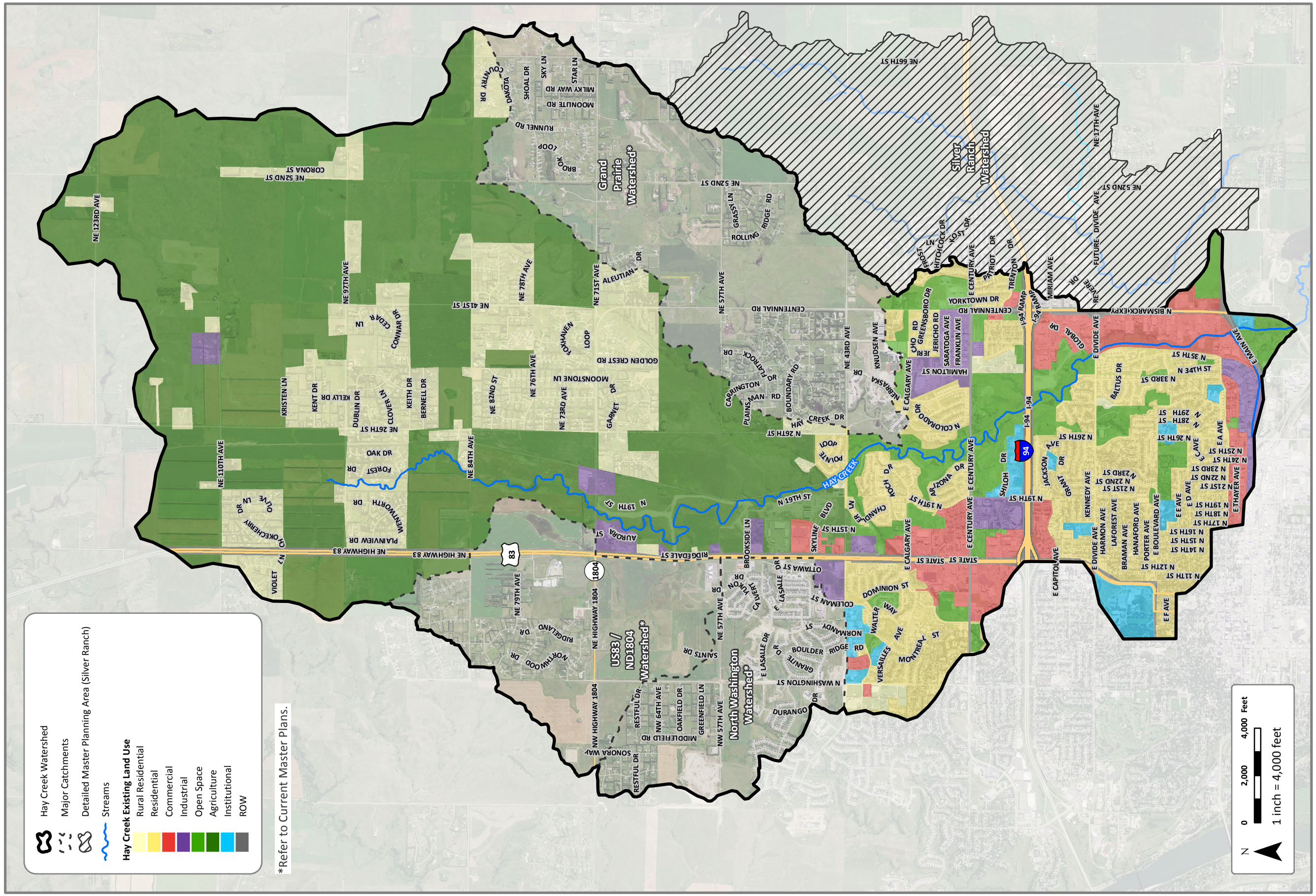

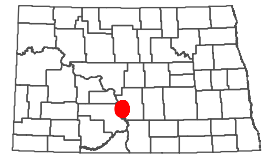

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Figure III-4

HAY CREEK WATERSHED EXISTING LAND USE

SILVER RANCH WATERSHED STORMWATER MASTER PLAN

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III-3.2.3 Soils

For areas outside the three up-to-date stormwater master plans, soils were obtained from the NRCS Web Soil Survey. Hydrologic Soil Group (HSG) classifications are presented on ***Figure III - 5***. The watershed is primarily HSG B soils with small portions of HSG A, C, and D soils, not accounting for the soil types that exist within the three up-to-date stormwater master plans.

III-3.2.4 Sub-Watershed Boundaries and Runoff Parameters

Within previously master-planned areas, sub-watershed boundaries were taken directly from the master plan. For areas outside those three master plans, sub-watersheds were generally delineated to be consistent with the original 1995 Hay Creek stormwater master plan, with adjustments made as necessary to reflect better topographic information and infrastructure constructed since the time of that master plan. ***Figure III - 6*** (two pages) illustrates the Hay Creek sub-watershed boundaries and summarizes the runoff parameters for each sub-watershed.

III-3.2.5 Curve Numbers

To provide consistency with the Silver Ranch analysis, the NRCS Curve Number (CN) and Time of Concentration (Tc) methodology were used for the Hay Creek Watershed.

CN Approach for Master-Planned Areas
For the three previously master-planned watersheds (US83/ND1804, North Washington, and Grand Prairie), CN values based on the Master Plan conditions were input to the Hay Creek model.

CN Approach for Non-Master-Planned Areas
One difference between the Hay Creek runoff analysis approach and the Silver Ranch analysis approach is that aggregate (combined pervious and impervious) CN values were used, except for the US83/ND1804 and Grand Prairie watersheds that had already split pervious and impervious runoff calculations. Using an aggregate CN approach for Hay Creek is appropriate since the main concern for Silver Ranch is a large rainfall event in Hay Creek where aggregate CN values produce similar runoff estimates as split pervious/impervious CN values.

The aggregate CN values were computed using the same pervious and impervious CN values that were used for the Silver Ranch watershed (***Table III - 3***).

Table III - 3: Hay Creek Watershed Curve Number Summary

HSG	Open Space Curve Number	Cropland Curve Number	Pasture/Rangeland Curve Number	Impervious Curve Number
A	39	62	39	98
B	61	73	61	98
C	74	80	74	98
D	80	84	80	98

III-3.2.6 Time of Concentration

Tc Approach for Non-Master-Planned Areas

Time of concentration (Tc) was determined using the methodology described in USDA Technical Report 55 – Urban Hydrology for Small Watersheds. Tc calculations for this master plan assumed a maximum sheet flow length of 100 feet and a minimum Tc length of 5 minutes.

Tc values were determined using existing land use coverage, LiDAR data, and aerial imagery to determine flow path, slope, and surface conditions.

Tc Approach for Master-Planned Areas

Similar to the CN value approach, Tc's for sub-watersheds within previously master-planned areas that are based on current methodology were taken directly from those master plans and based on the "master plan condition".

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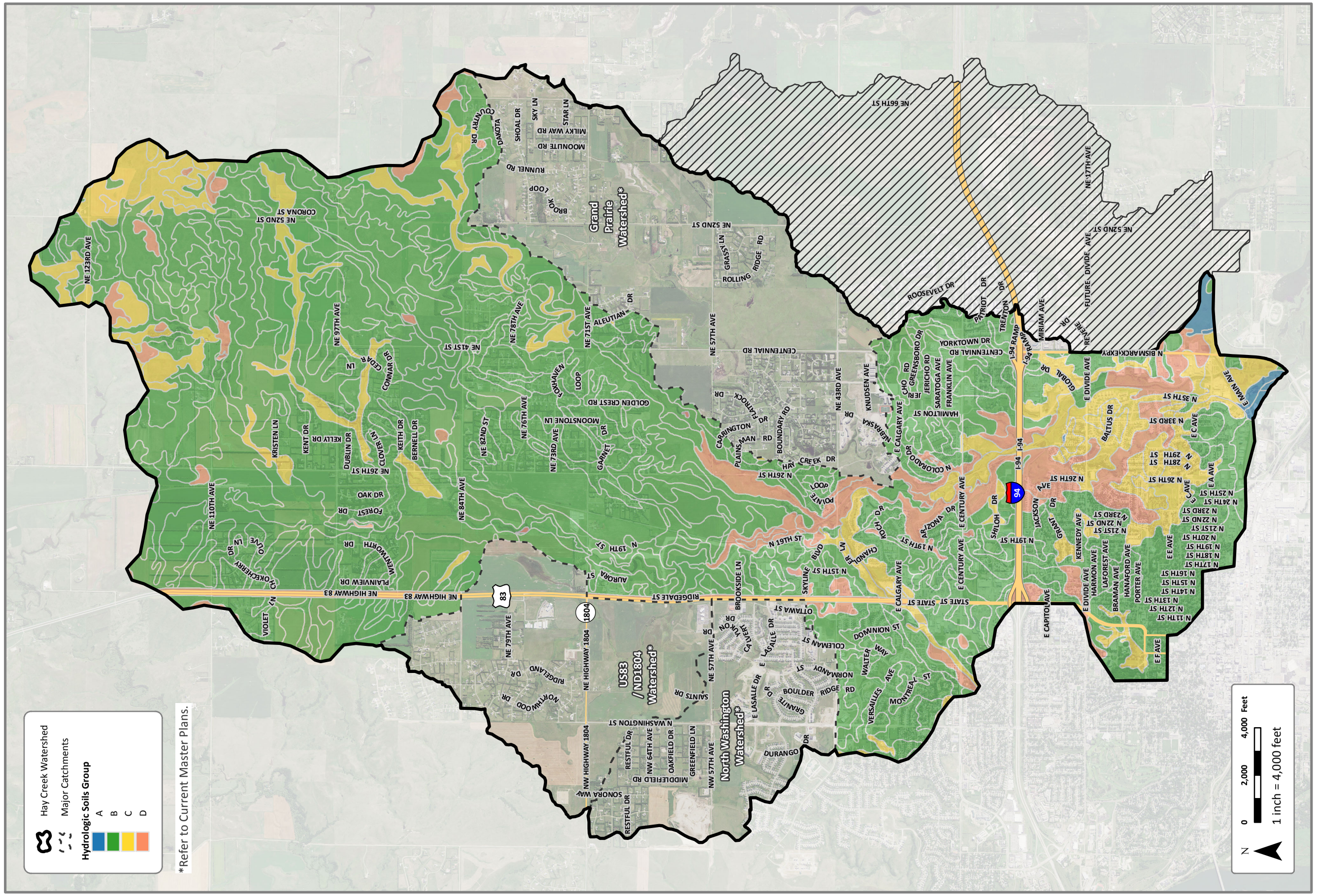

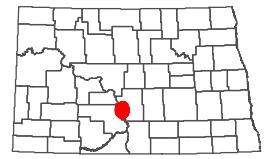

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Burleigh County, ND

Figure III-5

HAY CREEK WATERSHED HYDROLOGIC SOIL GROUP CLASSIFICATION

SILVER RANCH WATERSHED STORMWATER MASTER PLAN

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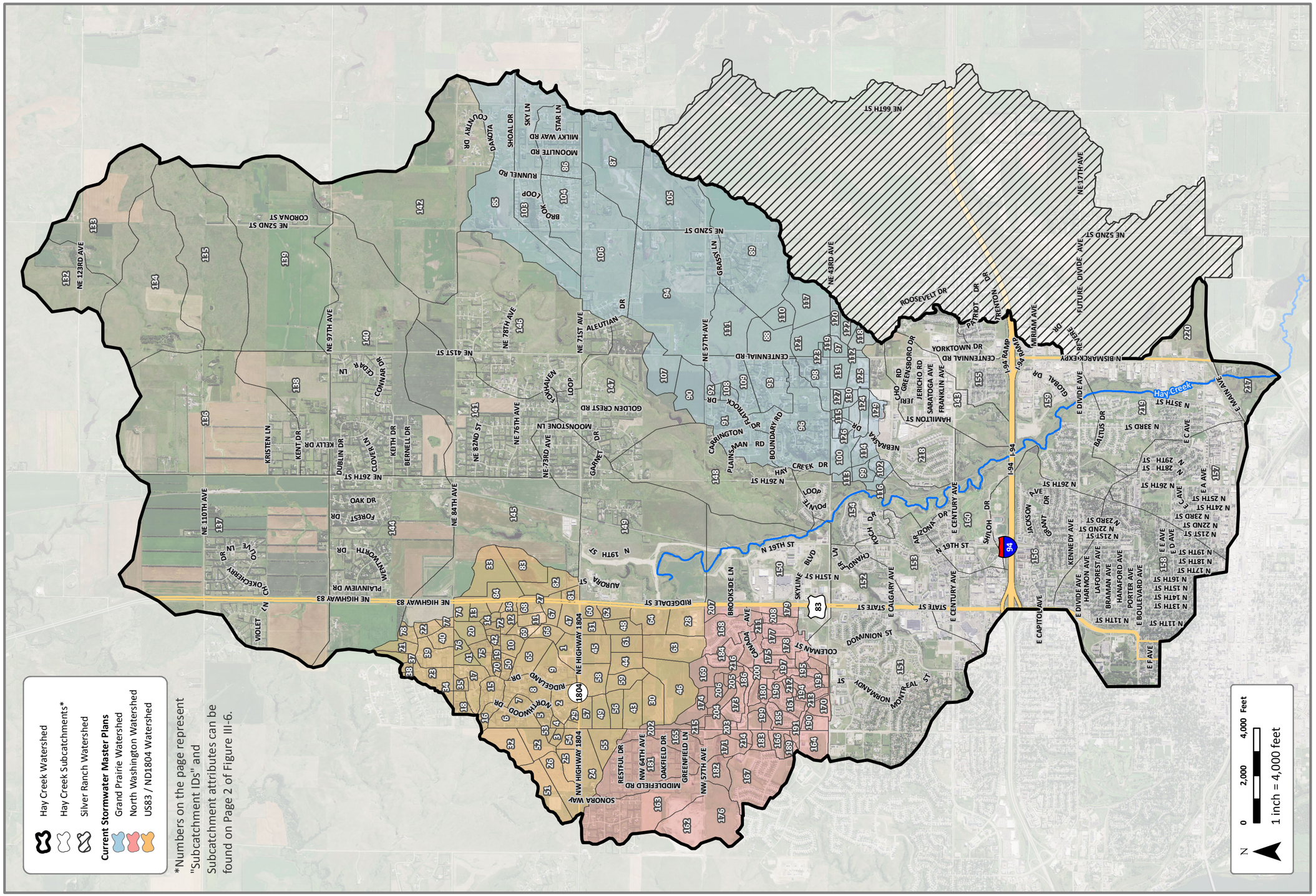

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Figure III-6

HAY CREEK SUBCATCHMENTS

SILVER RANCH
WATERSHED STORMWATER
MASTER PLAN

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ID	Subwatershed	Acreage	CN	Tc (min)
1	US83_3_5_A_FUTURE	16.0	72	14.5
2	US83_3_5_B_FUTURE	33.8	79	24.3
3	US83_3_5_J_FUTURE	7.2	77	30.0
4	US83_3_5_K_FUTURE	4.7	81	15.3
5	US83_3_5_C_FUTURE	16.0	77	22.4
6	US83_3_5_D_FUTURE	32.3	79	21.3
7	US83_3_5_E_FUTURE	15.0	77	17.8
8	US83_3_5_F_FUTURE	41.7	77	34.9
9	US83_3_5_G_FUTURE	57.0	76	12.9
10	US83_3_4_A_FUTURE	20.4	73	45.0
11	US83_3_4_B_FUTURE	9.2	75	8.2
12	US83_3_4_Q_FUTURE	8.6	72	14.0
13	US83_3_4_J_FUTURE	9.2	75	50.0
14	US83_3_4_C_FUTURE	3.9	74	55.0
15	US83_3_4_D_FUTURE	26.6	75	33.2
16	US83_3_4_E_FUTURE	13.0	79	42.1
17	US83_3_4_F_FUTURE	35.8	77	36.7
18	US83_3_4_G_FUTURE	15.0	78	31.7
19	US83_3_4_H_FUTURE	8.5	74	40.0
20	US83_3_4_I_FUTURE	27.0	69	50.0
21	US83_3_4_K_FUTURE	23.9	76	65.0
22	US83_3_4_L_FUTURE	14.1	77	55.0
23	US83_3_4_M_FUTURE	34.3	74	30.1
24	US83_3_6_A_FUTURE	63.5	73	17.2
25	US83_3_6_B_FUTURE	22.8	72	12.0
26	US83_3_5_H_FUTURE	54.9	72	20.3
27	US83_3_4_P_FUTURE	7.4	76	6.0
28	US83_3_6_D_FUTURE	22.9	74	15.2
29	US83_3_6_E_FUTURE	3.0	74	6.0
30	US83_3_6_L_FUTURE	44.9	74	22.7
31	US83_3_6_H_FUTURE	10.9	60	7.1
32	US83_3_5_I_FUTURE	51.6	74	15.7
33	US83_3_4_Z_FUTURE	36.2	70	15.7
34	US83_3_4_S_FUTURE	5.0	79	27.5
35	US83_3_4_T_FUTURE	7.9	75	27.6
36	US83_3_4_R_FUTURE	4.3	76	10.2
37	US83_3_4_N_FUTURE	13.3	76	70.0
38	US83_3_4_W_FUTURE	3.1	79	23.1
39	US83_3_4_U_FUTURE	34.8	77	36.3
40	US83_3_4_V_FUTURE	17.6	77	24.5
41	US83_3_4_X_FUTURE	14.1	68	28.0
42	US83_3_4_Y_FUTURE	4.4	71	50.0
43	US83_3_6_G_FUTURE	39.1	74	17.9
44	US83_3_6_I_FUTURE	22.5	74	16.7
45	US83_3_6_K_FUTURE	32.8	75	11.1
46	US83_3_6_J_FUTURE	74.5	72	12.0
47	US83_3_5_M_FUTURE	10.0	71	10.7
48	US83_3_6_C_FUTURE	9.3	75	14.5
49	US83_3_6_F_FUTURE	24.1	73	11.1
50	US83_3_4_A_IMP_FUTURE	8.8	98	45.0
51	US83_3_5_H_IMP_FUTURE	35.2	98	20.3
52	US83_3_5_I_IMP_FUTURE	23.6	98	15.7
53	US83_3_5_J_IMP_FUTURE	3.9	98	30.0
54	US83_3_6_B_IMP_FUTURE	16.1	98	12.0
55	US83_3_6_A_IMP_FUTURE	28.6	98	17.2
56	US83_3_6_G_IMP_FUTURE	17.6	98	17.9
57	US83_3_6_F_IMP_FUTURE	18.5	98	11.1
58	US83_3_6_K_IMP_FUTURE	42.1	98	11.1
59	US83_3_6_L_IMP_FUTURE	22.6	98	22.7
60	US83_3_6_H_IMP_FUTURE	17.5	98	7.1
61	US83_3_6_I_IMP_FUTURE	25.0	98	16.7
62	US83_3_6_C_IMP_FUTURE	29.4	98	14.5
63	US83_3_6_J_IMP_FUTURE	69.2	98	12.0
64	US83_3_6_D_IMP_FUTURE	56.7	98	15.2
65	US83_3_5_G_IMP_FUTURE	28.4	98	12.9
66	US83_3_5_A_IMP_FUTURE	28.3	98	14.5
67	US83_3_5_M_IMP_FUTURE	30.2	98	10.7
68	US83_3_4_B_IMP_FUTURE	17.1	98	8.2
69	US83_3_4_Q_IMP_FUTURE	15.9	98	14.0
70	US83_3_4_H_IMP_FUTURE	2.9	98	40.0
71	US83_3_4_Y_IMP_FUTURE	3.4	98	50.0
72	US83_3_4_C_IMP_FUTURE	7.3	98	55.0
73	US83_3_4_R_IMP_FUTURE	7.9	98	10.2
74	US83_3_4_J_IMP_FUTURE	17.1	98	50.0
75	US83_3_4_I_IMP_FUTURE	18.3	98	50.0
76	US83_3_4_X_IMP_FUTURE	6.9	98	28.0
77	US83_3_4_L_IMP_FUTURE	4.8	98	55.0
78	US83_3_4_K_IMP_FUTURE	5.8	98	65.0
79	US83_3_4_N_IMP_FUTURE	2.5	98	70.0
80	US83_3_6_E_IMP_FUTURE	5.7	98	6.0
81	US83_3_4_P_IMP_FUTURE	15.5	98	6.0
82	US83_3_4_O_FUTURE	22.7	72	15.7
83	US83_3_4_Z_IMP_FUTURE	67.3	98	15.7
84	US83_3_4_O_IMP_FUTURE	50.0	98	15.7
85	GP_FUT_HC_4-1_PER	385.4	73	266.0
86	GP_FUT_HC_4-2_PER	208.9	77	60.0
87	GP_FUT_HC_4-3_PER	228.9	74	200.0
88	GP_FUT_HC_4-6_1_PER	58.3	73	15.9
89	GP_FUT_HC_4-5_PER	240.4	74	290.0
90	GP_FUT_HC_4-6_2_PER	42.6	71	26.5
91	GP_FUT_HC_4-6_6	112.2	71	47.9
92	GP_FUT_HC_4-6_3_PER	20.5	74	33.8
93	GP_FUT_HC_4-6_4_PER	124.8	75	43.8
94	GP_FUT_HC_4-4_PER	429.0	72	360.0
95	GP_FUT_HC_4-6_5	22.8	65	23.2
96	GP_FUT_HC_4-6_7	183.7	57	53.4
97	GP_FUT_HC_5-3_4_PER	5.8	74	9.8
98	GP_FUT_HC_5-3_2	44.7	76	14.3
99	GP_FUT_HC_5-3_7_E_PER	12.8	78	15.7
100	GP_FUT_HC_5-3_6_PER	36.0	67	19.9
101	GP_FUT_HC_5-3_5B_E_PER	4.8	72	14.3
102	GP_FUT_HC_5-3_7_W_PER	18.8	78	15.7
103	GP_FUT_HC_4-1_IMP	129.5	98	266.0
104	GP_FUT_HC_4-2_IMP	13.3	98	60.0
105	GP_FUT_HC_4-3_IMP	134.0	98	200.0
106	GP_FUT_HC_4-4_IMP	228.9	98	360.0
107	GP_FUT_HC_4-6_2_IMP	79.4	98	26.5
108	GP_FUT_HC_4-6_3_IMP	4.8	98	33.8
109	GP_FUT_HC_4-6_4_IMP	28.1	98	43.8
110	GP_FUT_HC_4-6_1_IMP	26.8	98	15.9
111	GP_FUT_HC_4-5_IMP	146.1	98	290.0
112	GP_FUT_HC_5-3_4_IMP	11.8	98	9.8
113	GP_FUT_HC_5-3_7_E_IMP	8.9	98	15.7
114	GP_FUT_HC_5-3_6_IMP	23.0	98	19.9
115	GP_FUT_HC_5-3_5B_E_IMP	9.8	98	14.3
116	GP_FUT_HC_5-3_7_W_IMP	7.1	98	15.7
117	GP_FUT_HC_5-3_1B_PER	51.6	72	20.0
118	GP_FUT_HC_5-3_3A_PER	6.5	70	20.0
119	GP_FUT_HC_5-3_1A_PER	2.1	68	10.0
120	GP_FUT_HC_5-3_3B	15.1	78	20.0
121	GP_FUT_HC_5-3_1B_IMP	63.0	98	20.0
122	GP_FUT_HC_5-3_3A_IMP	25.7	98	20.0
123	GP_FUT_HC_5-3_1A_IMP	6.4	98	10.0
124	GP_FUT_HC_5-3_5B_S_PER	29.0	64	35.0
125	GP_FUT_HC_5-3_5A_E_PER	11.8	72	35.0
126	GP_FUT_HC_5-3_5B_W_PER	5.9	71	14.3
127	GP_FUT_HC_5-3_5A_W_PER	8.0	78	16.7
128	GP_FUT_HC_5-3_5B_W_IMP	6.9	98	14.3
129	GP_FUT_HC_5-3_5B_S_IMP	17.5	98	35.0
130	GP_FUT_HC_5-3_5A_W_IMP	12.3	98	16.7
131	GP_FUT_HC_5-3_5A_E_IMP	39.0	98	35.0
132	HC_1-1	177.5	70	67.0
133	HC_1-2	291.6	72	87.0
134	HC_1-3	424.4	71	62.0
135	HC_1-4	437.8	70	78.0
136	HC_1-5	755.3	69	36.0
137	HC_1-6	1228.2	68	126.0
138	HC_2-1B	261.7	68	33.0
139	HC_2-1A	689.7	69	147.0
140	HC_2-2	875.2	67	93.0
141	HC_2-4	525.6	66	99.0
142	HC_3-1	754.6	69	70.0
143	HC_6-3	273.1	77	40.0
144	HC_2-3	744.1	67	112.0
145	HC_2-5	514.3	69	55.0
146	HC_3-2	767.5	67	42.0
147	HC_3-3A	388.8	65	39.0
148	HC_3-3B	450.5	69	52.0
149	HC_3-7	774.8	69	97.0
150	HC_3-11	465.3	76	35.0
151	HC_5-1	768.3	77	47.0
152	HC_5-2	145.5	82	14.0
153	HC_5-4	381.8	84	20.0
154	HC_5-5	279.7	76	39.0
155	HC_6-5	212.3	73	39.0
156	HC_6-1	449.0	81	44.0
157	HC_6-4C	442.8	82	35.0
158	HC_6-3C	761.8	76	28.0
159	HC_6-6	530.8	84	42.0
160	HC_6-2	284.2	77	28.0
161	NWASH_HC_3-9E1	26.3	76	31.0
162	NWASH_HC_3-8C	63.1	76	35.0
163	NWASH_HC_3-8A	196.7	68	140.0
164	NWASH_HC_3-9D1	32.3	91	23.0
165	NWASH_HC_3-8E	51.1	64	80.0
166	NWASH_HC_3-9C2	16.0	88	10.0
167	NWASH_HC_3-8F	119.6	77	33.0
168	NWASH_HC_3-10AC	51.8	83	13.0
169	NWASH_HC_3-9BA	30.1	86	12.0
170	NWASH_HC_3-9D3	16.9	90	24.0
171	NWASH_HC_3-8G2	33.4	80	16.0
172	NWASH_HC_3-9C1	5.0	92	10.0
173	NWASH_HC_3-9B2	24.1	76	10.0
174	NWASH_HC_3-9AB	24.0	92	10.0
175	NWASH_HC_3-10CA	19.4	78	41.0
176	NWASH_HC_3-8D	77.2	75	41.0
177	NWASH_HC_3-10CC	16.3	85	10.0
178	NWASH_HC_3-10CB	44.4	83	26.0
179	NWASH_HC_3-10BB	18.6	86	25.0
180	NWASH_HC_3-9C7	12.3	75	45.0
181	NWASH_HC_3-8B	159.8	64	83.0
182	NWASH_HC_3-8G1	28.2	68	21.0
183	NWASH_HC_3-9C3	15.6	90	15.0
184	NWASH_HC_3-10AB	23.0	81	17.0
185	NWASH_HC_3-9C5	22.5	75	12.0
186	NWASH_HC_3-9C8	19.3	75	18.0
187	NWASH_HC_3-9DB	8.4	92	10.0
188	NWASH_HC_3-9DA	8.7	89	10.0
189	NWASH_HC_3-9C2A	8.8	92	10.0
190	NWASH_HC_3-9D2	16.8	92	11.0
191	NWASH_HC_3-9C4A	2.3	75	12.0
192	NWASH_HC_3-9D4	6.9	77	10.0
193	NWASH_HC_3-9D6	14.1	75	15.0
194	NWASH_HC_3-9D8	6.9	72	14.0
195	NWASH_HC_3-9D7	16.1	81	29.0
196	NWASH_HC_3-9E3	5.3	77	62.0
197	NWASH_HC_3-9E4	4.0	77	29.0
198	NWASH_HC_3-9C6	9.4	70	22.0
199	NWASH_HC_3-9C4	12.2	76	11.0
200	NWASH_HC_3-9E2	9.0	69	31.0
201	NWASH_HC_3-9C6A	10.5	84	10.0
202	NWASH_HC_3-9AA	11.2	92	15.0
203	NWASH_HC_3-9A1	15.8	78	10.0
204	NWASH_HC_3-9AC	12.5	72	18.0
205	NWASH_HC_3-9BC	8.7	70	17.0
206	NWASH_HC_3-9AD	19.1	79	10.0
207	NWASH_HC_3-10BA	18.9	92	17.0
208	NWASH_HC_3-10CD	13.8	92	16.0
209	NWASH_HC_3-9BB	1.6	75	10.0
210	NWASH_HC_3-10AA	9.6	79	14.0
211	NWASH_HC_3-10CE	19.0	80	26.0
212	NWASH_HC_3-9D9	4.2	75	10.0
213	NWASH_HC_3-9D5	7.8	78	10.0
214	NWASH_HC_3-8G3	25.1	82	11.0
215	NWASH_HC_3-9AE	5.8	91	10.0
216	NWASH_HC_3-9BD	14.8	86	10.0
217	HC_7-2	86.9	65	25.0
218	HC_5-6	246.2	76	39.0
219	HC_7-1	487.0	87	16.0
220	HC_7-3	94.6	70	35.0

Figure III-6 (Page 2)

HAY CREEK SUBCATCHMENTS TABLE

Date: 09/27/2017

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III-3.3 HYDRAULIC MODEL INPUT

Similar to the hydrologic model development, constructing the hydraulic portion of the InfoSWMM model involved combining both up-to-date stormwater master plan models and new hydraulic model input.

As described previously, three hydraulic scenarios were evaluated as part of this study:

1. Existing hydraulic conditions, including connection between Hay Creek and Silver Ranch
2. Blocking the connection between Hay Creek and Silver Ranch but providing no additional conveyance capacity on Hay Creek to offset the lost capacity from the blocked connection.
3. Blocking the connection between Hay Creek and Silver Ranch and providing additional conveyance capacity on Hay Creek to offset the lost capacity from the blocked connection.

III-3.3.1 Watersheds within Current Stormwater Master Plans

For the three current stormwater master plan areas, the hydraulics from the respective master plan scenarios were input to the Hay Creek model with each master plan watershed was assumed to be fully built-out and with all the master plan improvements constructed.

III-3.3.2 Watersheds without Current Stormwater Master Plans

For the remaining portion of the watershed, including the main stem of Hay Creek, the hydraulic network was assembled based on a combination of LiDAR and survey data. Channel flow was modeled in InfoSWMM using natural cross sections assembled from in-field survey and LiDAR data. Culvert sizes, inverts, and material type were determined based on AE2S field survey data (***Figure III - 17*** included at the end of ***Volume III***), NDDOT data, City of Bismarck survey data, and stormwater management plans provided by the City of Bismarck.

Roughness coefficients were determined based on site visits, site photos, aerial imagery, and Google street view. All vegetated channels, reinforced concrete pipe (RCP), and corrugated metal pipe (CMP) were assigned a roughness of 0.05, 0.013, and 0.024, respectively, except for the downstream end of Hay Creek near the Silver Ranch connection, where channel and overbank roughness values were fine-tuned to accurately reflect field conditions.

III-3.3.3 Overall Model Network

The hydraulic model network is shown in ***Figure III - 7*** (four pages), including the connection between Silver Ranch and Hay Creek that is discussed in more detail in ***Section III-4.0***.

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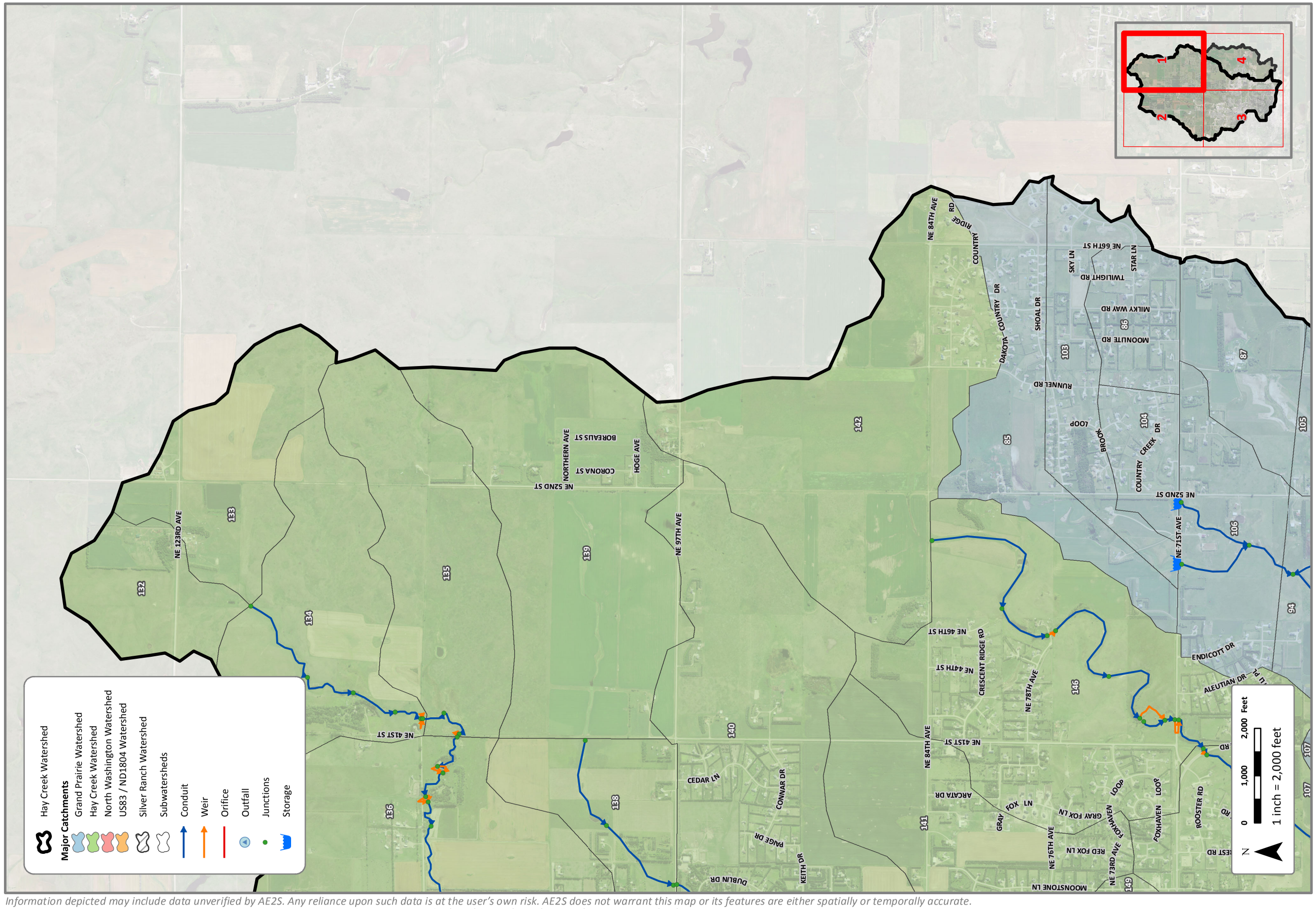

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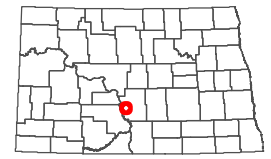
Coordinate System: NAD 1983 StatePlane North Dakota South FIPS 3302 Feet Intl | Edited by: dlee | C:\Data\Projects\WAFS\Bismarck\00501-2015-013\GIS\Report Figure III-7- Combined Hay Creek and Silver Ranch InfoSWMM Model Network.mxd



Locator Map Not to Scale

City of Bismarck
Burleigh County, ND

Figure III-7 (Page 1)

COMBINED HAY CREEK AND SILVER RANCH INFOSWMM MODEL NETWORK (NW)

SILVER RANCH WATERSHED STORMWATER MASTER PLAN

Date: 10/26/2017

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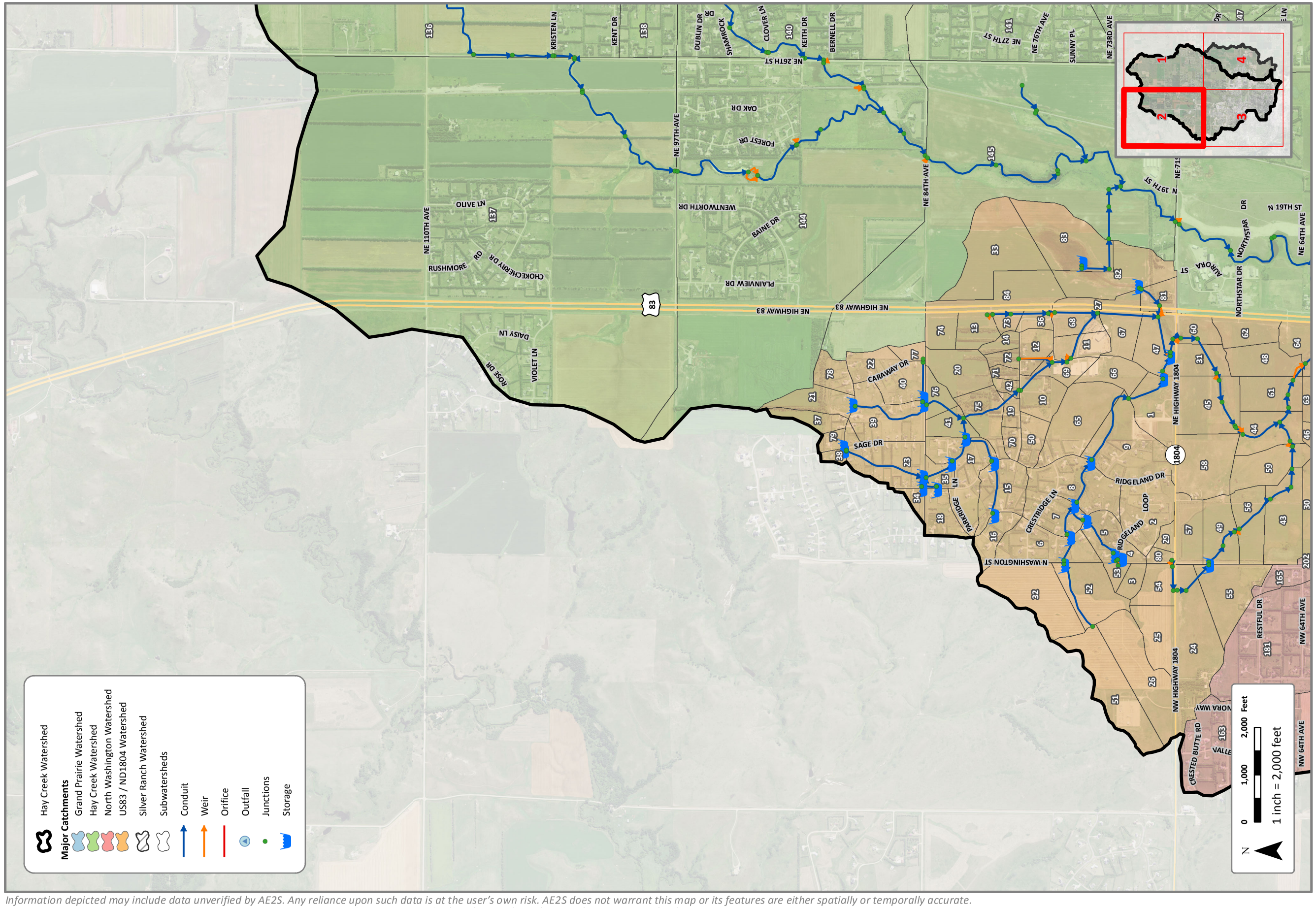

Locator Map Not to Scale

City of Bismarck
Burleigh County, ND

Figure III-7 (Page 2)

COMBINED HAY CREEK AND SILVER RANCH INFOSWMM MODEL NETWORK (SW)

SILVER RANCH WATERSHED STORMWATER MASTER PLAN

Date: 10/26/2017

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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 III-7- Combined Hay Creek and Silver Ranch InfoSWMM Model Network.mxd

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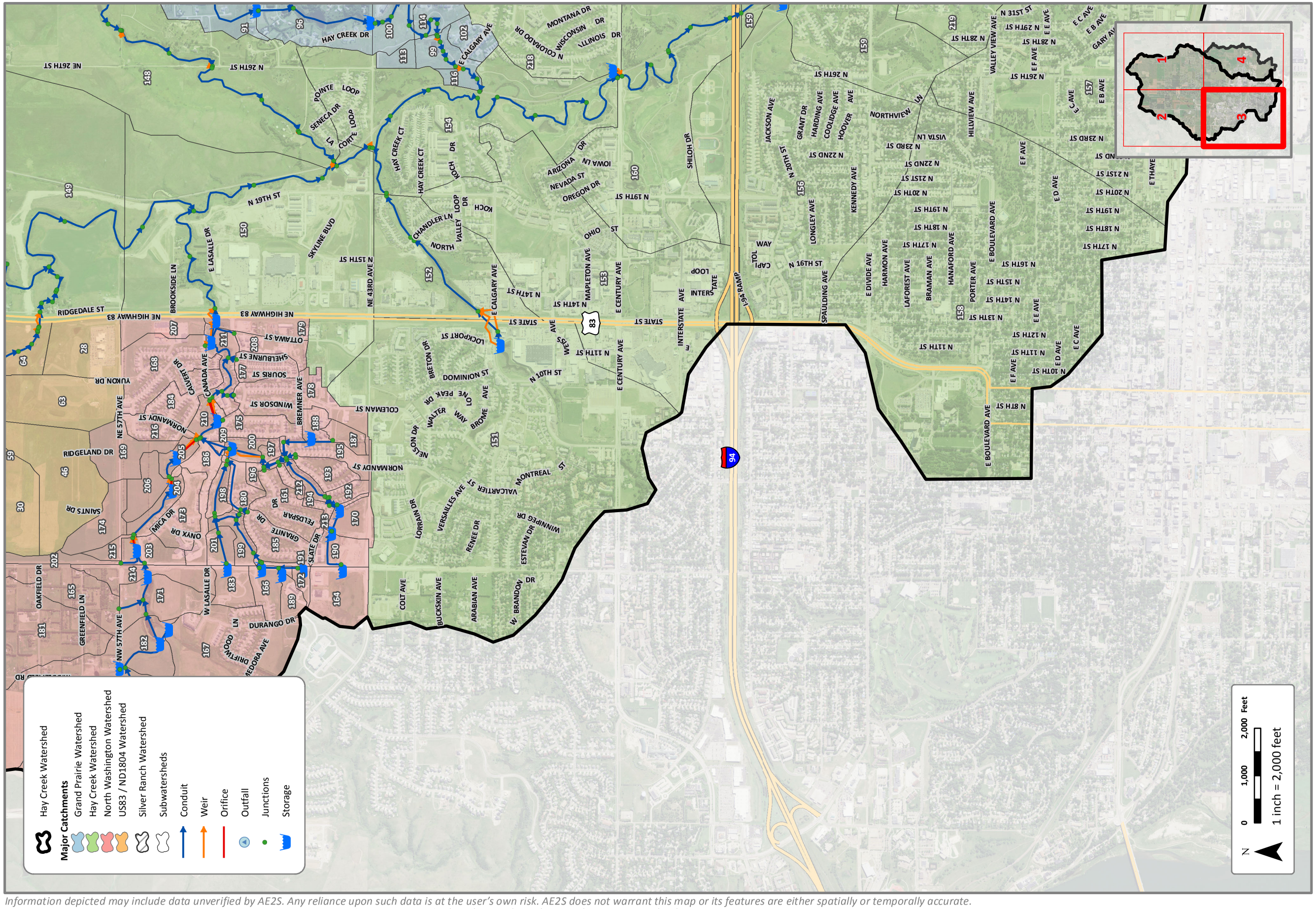

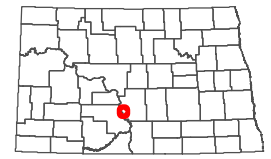

Locator Map Not to Scale

City of Bismarck
Burleigh County, ND

Figure III-7 (Page 3)

COMBINED HAY CREEK AND SILVER RANCH INFOSWMM MODEL NETWORK (SE)

SILVER RANCH
WATERSHED STORMWATER
MASTER PLAN

Date: 10/26/2017

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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 III-7- Combined Hay Creek and Silver Ranch InfoSWMM Model Network.mxd

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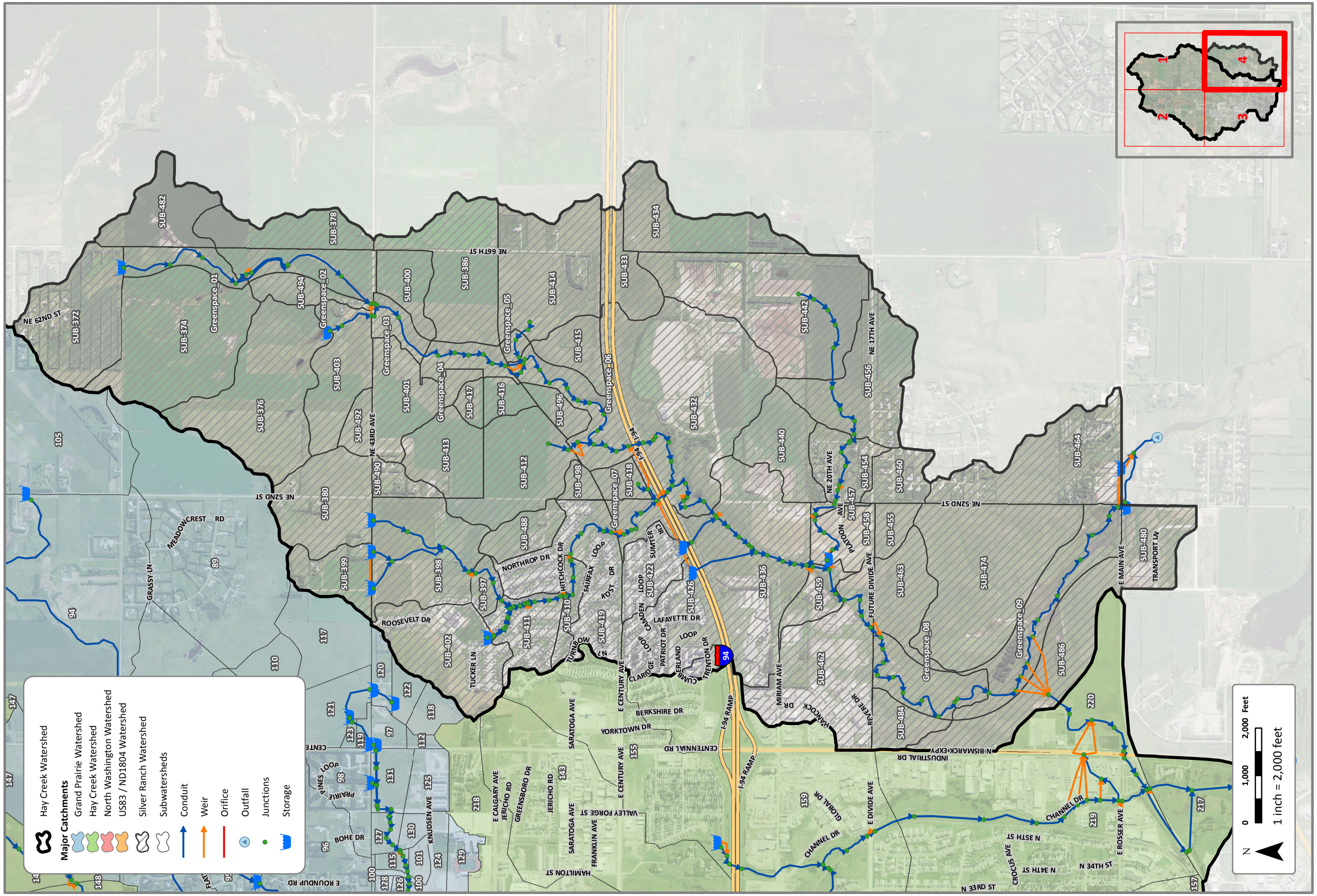

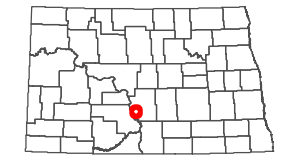

Locator Map Not to Scale

City of Bismarck
Burleigh County, ND

Figure III-7 (Page 4)

COMBINED HAY CREEK AND SILVER RANCH INFOSWMM MODEL NETWORK (NE)

SILVER RANCH WATERSHED STORMWATER MASTER PLAN

Date: 10/26/2017

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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 III-7- Combined Hay Creek and Silver Ranch InfoSWMM Model Network.mxd

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III-4.0 HAY CREEK / SILVER RANCH EXISTING CONNECTION

The reason for including the Hay Creek watershed in the Silver Ranch Master Plan was to review the potential for high flows to either go from Hay Creek to Silver Ranch or from Silver Ranch to Hay Creek. Additional detailed analysis was completed for the connection, as described in the following sections.

III-4.1 HEC-RAS 2D ANALYSIS

Based on the LiDAR data, there are potentially multiple overflow paths between Hay Creek and Silver Ranch located north of East Main Avenue. Therefore, in order to ensure that the InfoSWMM analysis (***Section III-4.2***) accurately reflected the necessary overflow paths, a separate HEC-RAS 2D analysis was developed for both Silver Ranch and Hay Creek in the area where they can connect.

The HEC-RAS 2D terrain was assembled based on LiDAR and survey data, which included breaklines, and 2D connections (with culverts) for the necessary road crossings within the model area including the culverts under the Bismarck Expressway just north East Main Avenue. Land use cover (and associated roughness) was based on aerial photographs and HEC-RAS guidance for 2D roughness values.

100-year flow hydrographs from the Silver Ranch and Hay Creek watersheds were input as an upstream boundary condition for their respective channels. Downstream boundary conditions were based on normal depth.

Figure III - 8 illustrates the resulting 100-year inundation, which shows that the Bismarck Expressway would overtop just north of Rosser Avenue. Based on the flow hydrograph at that location, the flow is coming from Hay Creek and going towards Silver Ranch.

In addition to the road overtopping, the culverts under the Bismarck Expressway just north of County Highway 10 also discharge from Hay Creek to Silver Ranch.

These results indicate that the FEMA effective analysis did not consider the main flow direction, flood waters moving from the Hay Creek watershed to Silver Ranch watershed, for this connection.

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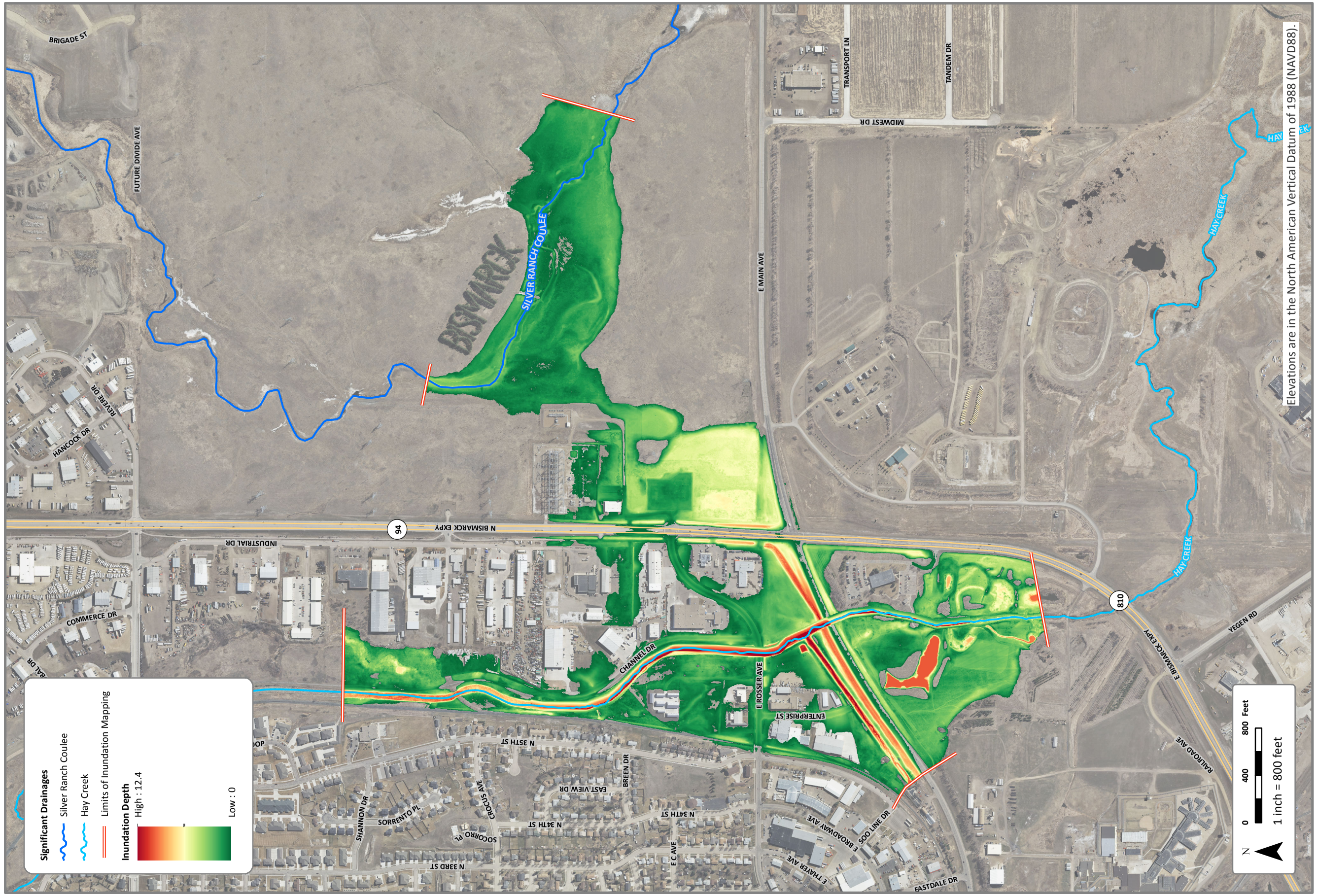
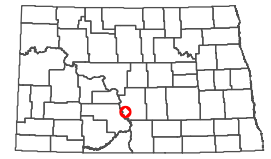


Elevations are in the North American Vertical Datum of 1988 (NAVD88).



Locator Map Not to Scale

City of Bismarck
Burleigh County, ND

Figure III-8

100-YEAR INUNDATION AT THE SILVER RANCH AND HAY CREEK CONNECTION

SILVER RANCH WATERSHED STORMWATER MASTER PLAN

Date: 10/27/2017

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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 III-8- 100-Year Inundation at the Silver Ranch and Hay Creek Connection.mxd

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III-4.2 INFOSWMM ANALYSIS

Following the HEC-RAS 2D analysis, an InfoSWMM network was assembled to connect the Hay Creek and Silver Ranch InfoSWMM models. The InfoSWMM network was based on flow paths observed from the HEC-RAS 2D analysis, and InfoSWMM parameters were adjusted such that the flow traveling from Hay Creek to Silver Ranch approximately matched the HEC-RAS 2D analysis.

Figure III - 9 shows the 100-year culvert flow, flow overtopping the road, and total flow (culvert and road overtopping) through and over the Bismarck Expressway north of the intersection with East Main Avenue for the Baseline Conditions with Connection Active scenario. The hydrographs illustrate that at the beginning of the flood, both the culvert and road are flowing to the east, but that later in the storm, some of the flow that overtops the roadway enters Hay Creek again through the culverts.

Figure III - 9: Hay Creek 100-Year Flow through Bismarck Expressway (Baseline Runoff Conditions with Connection Active)

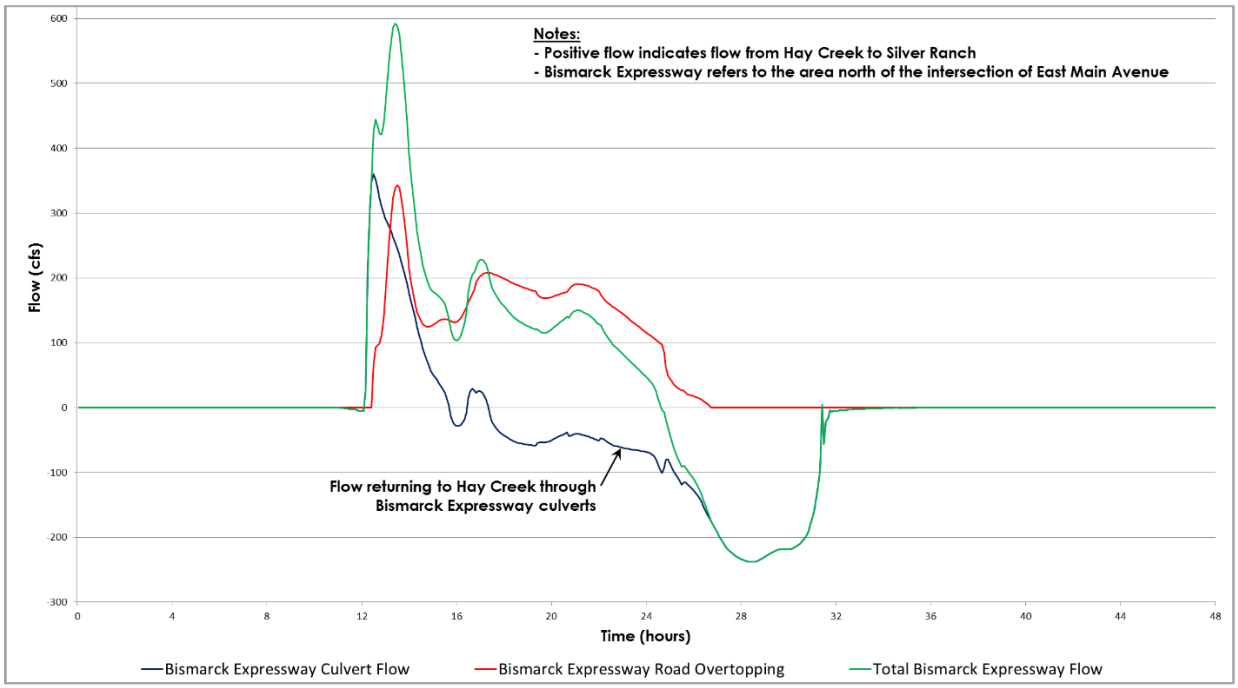


Figure III - 10 compares the total flow through the Bismarck Expressway north of the intersection of East Main Avenue to the flow that ultimately reaches Silver Ranch after accounting for the routing that occurs in the low-lying area east of Bismarck Expressway. The figure indicates that the peak flow entering Silver Ranch is much less than the peak flow through the Bismarck Expressway because of the storage routing effect of the low-lying area east of the Bismarck Expressway. Further, the "Flow Entering Silver Ranch" hydrograph shows that at the very beginning of when the connection starts to flow, flow is leaving Silver Ranch (about 30 cfs).

Figure III - 10: Hay Creek 100-Year Flow to Silver Ranch Expressway (Baseline Runoff Conditions with Connection Active)

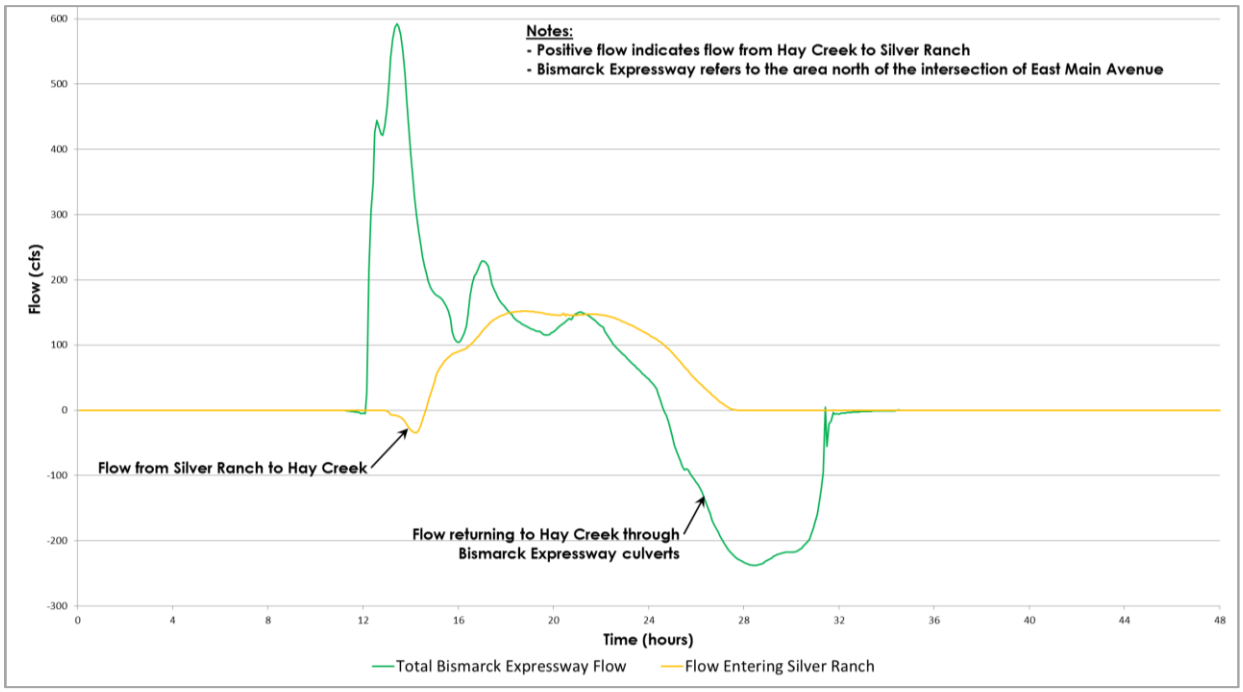


Table III - 4 compares the existing conditions 100-year peak flows at various locations along Silver Ranch including and not including overflow from Hay Creek. ***Figure III - 11*** through ***Figure III - 14*** show the full hydrographs for the same locations.

The results indicate that with the Hay Creek / Silver Ranch connection, Silver Ranch peak flows are slightly lower immediately downstream of the connection because of the minor amount of flow leaving Silver Ranch at the very beginning when the connection begins to convey flow between the two watersheds (See ***Figure III - 10***). However, downstream of the connection, flow increases within Silver Ranch because of the total Hay Creek overflow volume.

Table III - 4: 100-Year Peak Flow for Baseline Runoff Conditions with Active and Blocked Connection

Location	Active Connection (cfs)	Blocked Connection (cfs)	Change** (cfs)	Change**
Silver Ranch at Connection	1,325	1,365	40	3.0%
Silver Ranch – E Main Avenue & 52nd Street Intersection	915	835	-80	-8.7%
Silver Ranch Downstream Study Limits	915	840	-75	-8.2%
Hay Creek Downstream of Main Avenue	3,780	4,510*	730	16.2%

*Includes eliminating Bismarck Expressway overtopping and storage east of Bismarck Expressway.
**Positive values mean flow increases at the location when the connection is blocked (without connection).

While comparing flows is useful to evaluate the changes associated with the connection active or blocked, impacts to landowners are more appropriately defined by elevation changes. ***Table III - 5*** compares the 100-year flood elevations upstream of Main Avenue on the Silver Ranch, and ***Table III - 6*** and ***Table III - 7*** show the 100-year flood elevations upstream of Main Avenue and the Bismarck Expressway on Hay Creek, respectively. The results indicate the following conclusions:

- For the Silver Ranch Watershed, blocking the connection would lower flood elevations only 0.2 feet at the existing East Main Avenue & 52nd Street intersection.
- If the Silver Ranch crossing at East Main Avenue & 52nd Street intersection is improved as outlined in ***Volume II*** of this Master Plan and the connection is blocked, the headwater elevation difference at East Main Ave on Silver Ranch would be more noticeable (reduces by about 0.6 feet) since roadway overtopping at East Main Avenue & 52nd Street would be eliminated with the proposed crossing improvement. In general, road (weir) overflow is more efficient and less sensitive to flow changes than culvert flow.
- While the 100-year flood elevation upstream of Hay Creek crossing of Main Avenue would only increase 0.2 feet if the connection was blocked and no additional improvements were made, this minor increase causes Main Avenue to overtop east of the Bismarck Expressway and create flooding south of Main Avenue and east of the Bismarck Expressway, where there currently is not predicted to experience flooding from a Hay Creek overflow.
- Regardless of whether the blocked connection flow is forced to overtop Main Avenue or directed through the proposed 5'x10' box culvert, the headwater upstream of the Bismarck Expressway on Hay Creek is about 0.6 – 0.7 feet higher. This increase is similar along Hay Creek for the reach between Main Avenue and the Bismarck Expressway. While this land is the ND Game and Fish Department (State) land, and no additional structures would be impacted, FEMA and landowner approval of these impacts would be necessary prior to blocking the connection and/or installing the additional culvert under Main Avenue.

Table III - 5: 100-Year WSE at East Main Avenue Crossing of Silver Ranch Coulee

Silver Ranch Runoff Condition	Connection Status	100-Year Event Elevation	Overtopping Elevation
Existing	Active	1660.2	1659.4
Existing	Blocked	1660.1	1659.4
Master-Planned	Active	1660.4	1660.65*
Master-Planned	Blocked	1659.7	1660.65*

*Once master-planned improvements have been implemented.
Note: All results are for baseline runoff conditions in Hay Creek watershed.

Table III - 6: 100-Year WSE at Main Avenue Crossing of Hay Creek

Silver Ranch Runoff Condition	Connection Status	100-Year Event Elevation	Overtopping Elevation
Existing	Active	1664.3	1663.65
Existing	Blocked	1664.5*	1663.65
Master-Planned	Active	1664.3**	1663.65
Master-Planned	Blocked	1664.2***	1663.65

*Causes Main Avenue to overtop east of Bismarck Expressway where it does not with the connection active.
**Master Plan with connection active does not include any modifications to Hay Creek.
***Master plan with connection blocked includes an additional 5'x10' RCB under Main Avenue.
Note: All results are for baseline runoff conditions in Hay Creek watershed.

Table III - 7: 100-Year WSE at Bismarck Expressway Crossing of Hay Creek

Silver Ranch Runoff Condition	Connection Status	100-Year Event Elevation	Overtopping Elevation
Existing	Active	1657.7	1662.0
Existing	Blocked	1658.4	1662.0
Master-Planned	Active	1657.7*	1662.0
Master-Planned	Blocked	1658.3**	1662.0

*Master Plan with connection active does not include any modifications to Hay Creek.
**Master plan with connection blocked includes an additional 5'x10' RCB under Main Avenue.
Note: All results are for baseline runoff conditions in Hay Creek watershed.

Figure III - 11: 100-Year Silver Ranch Hydrographs, Immediately Downstream of Hay Creek / Silver Ranch Connection (Baseline Runoff Conditions with Connection Active)

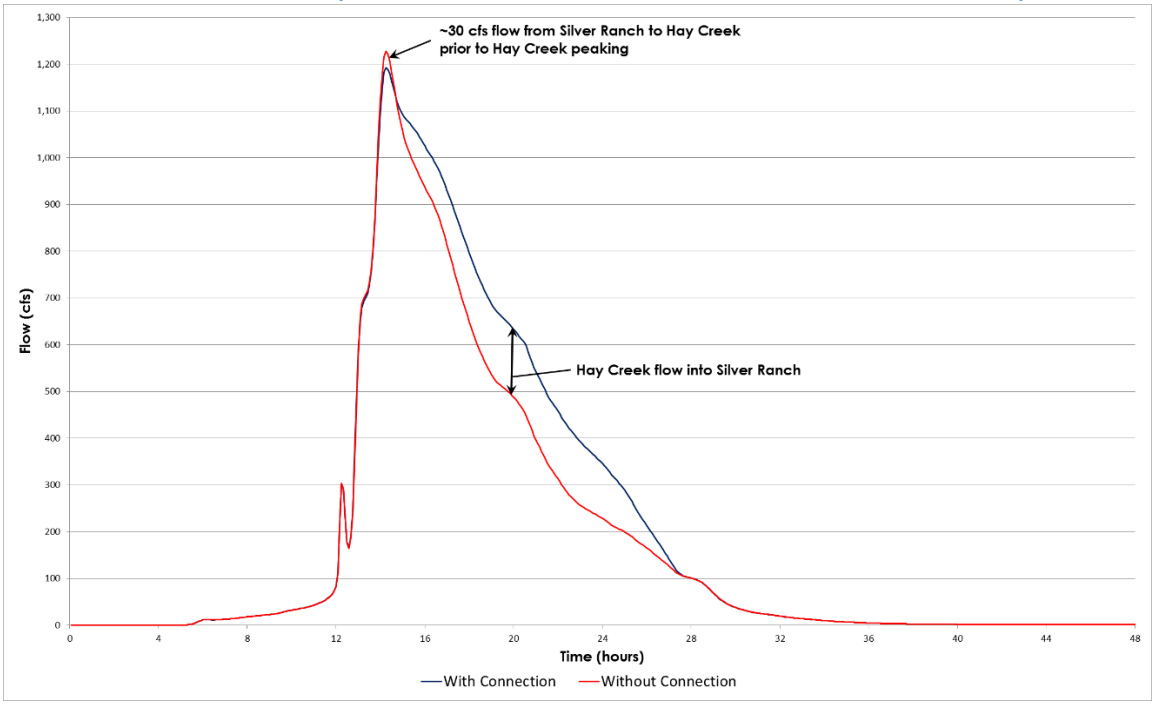


Figure III - 12: 100-Year Silver Ranch Hydrographs, East Main Avenue / 52nd Street (Baseline Runoff Conditions with Connection Active)

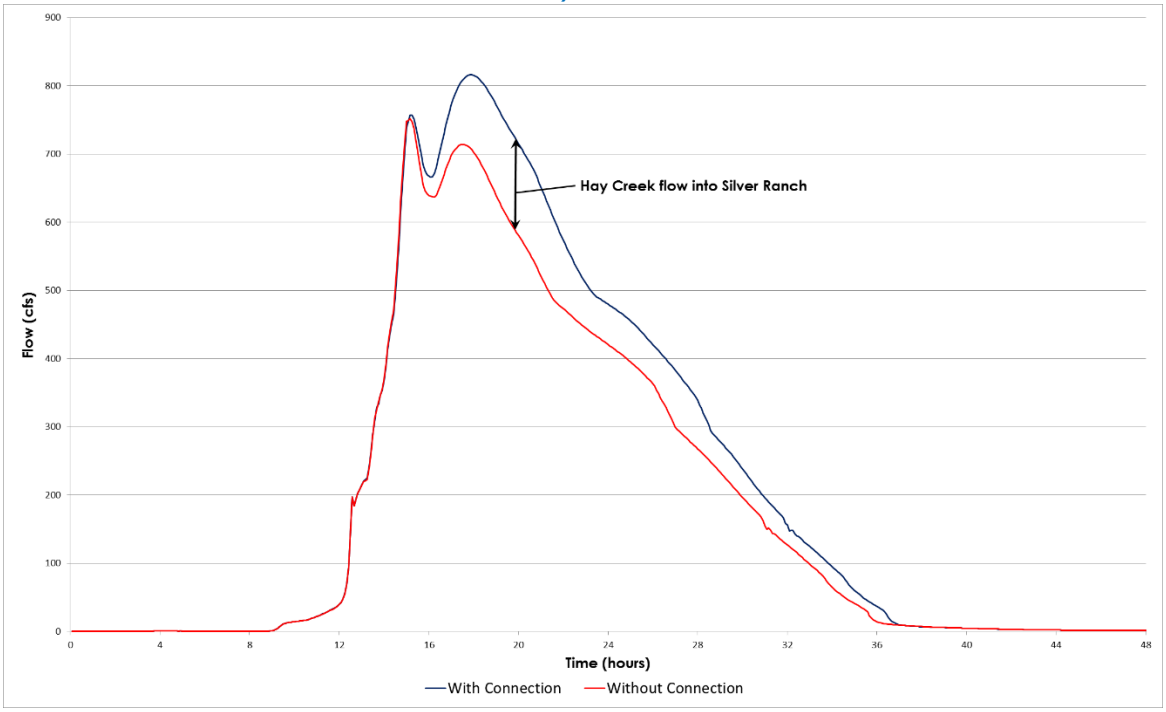


Figure III - 13: 100-Year Silver Ranch Hydrographs, Downstream End of Silver Ranch Study Limits (Baseline Runoff Conditions with Connection Active)

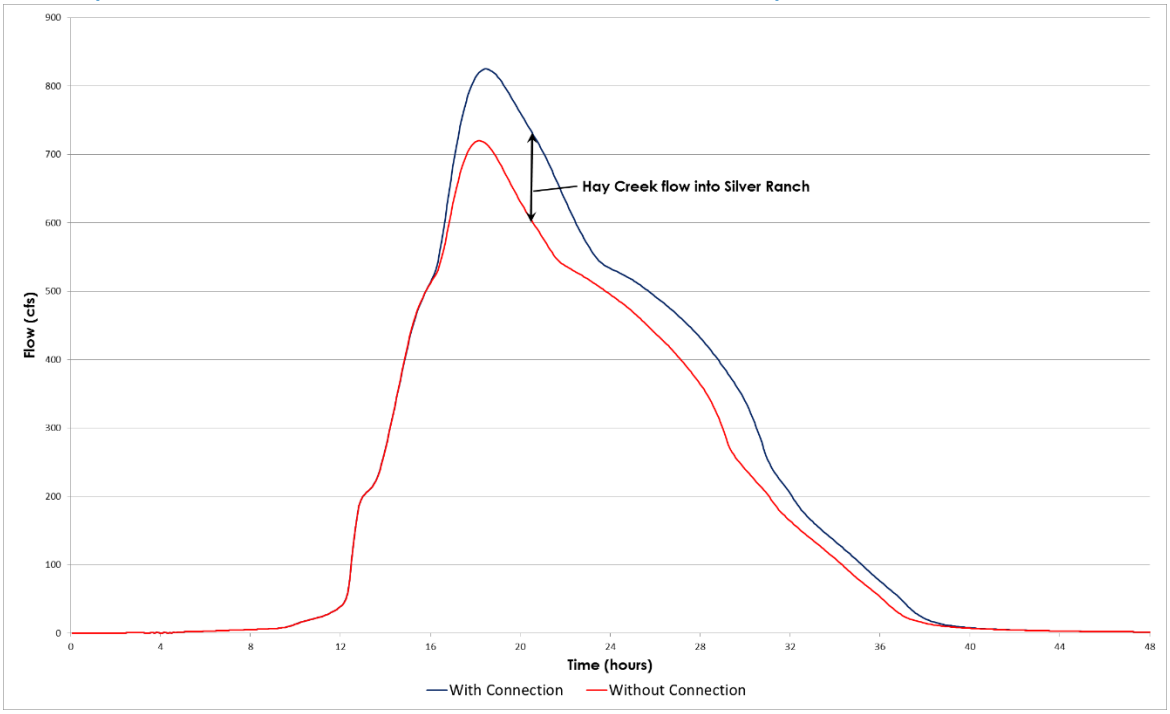


Figure III - 14: 100-Year Silver Ranch Hydrographs, Hay Creek Downstream of Main Avenue (Baseline Runoff Conditions with Connection Active)

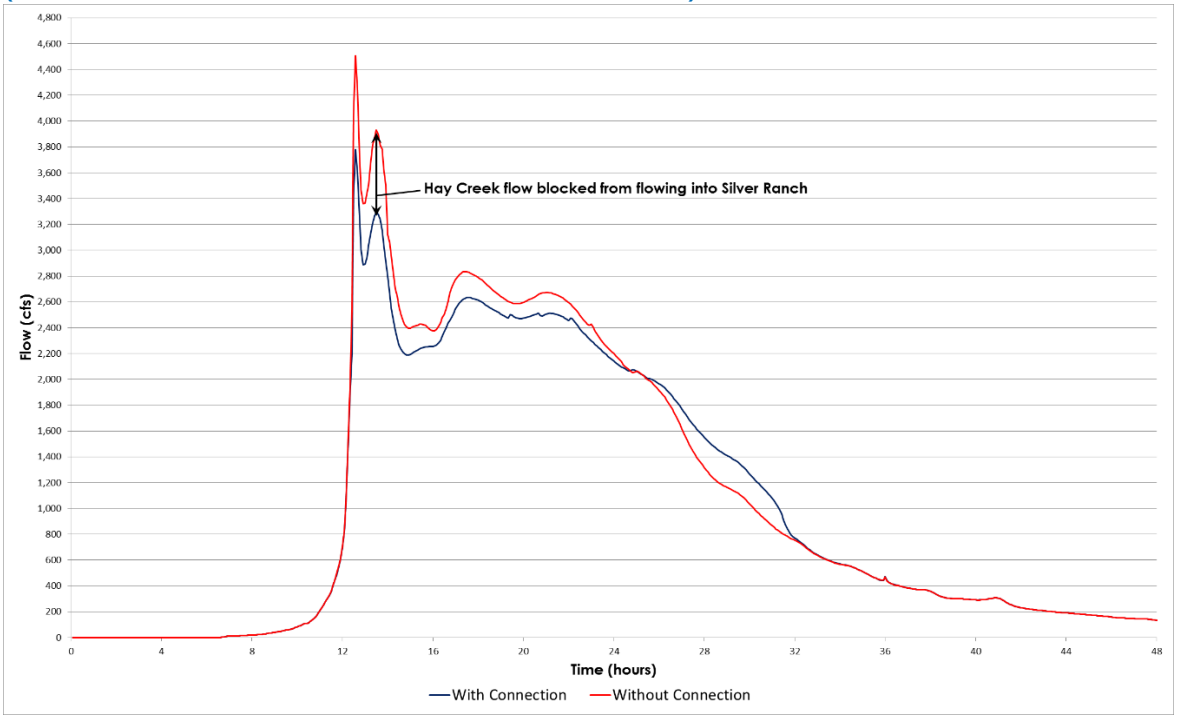


Table III - 8 shows the same information as ***Table III - 4*** except with the Master Plan conditions for Silver Ranch. While there are minor differences from existing conditions, the same general results apply when the Master Plan for Silver Ranch is implemented.

Two 100-year Silver Ranch hydrographs are shown in ***Figure III - 15*** and ***Figure III - 16***, where the differences between the existing conditions hydrographs are most noticeable. ***Figure III - 16*** shows the 100-year flow immediately downstream of the connection. While the peaks are very similar to existing conditions (***Figure III - 12),*** the tail of the hydrograph is much flatter for the Master Plan conditions, which creates a more noticeable difference between the connection being active versus inactive. Because of the flatter tail of the Silver Ranch hydrograph, the effects are also more noticeable at the downstream limits of the Silver Ranch study area (comparing ***Figure III - 13*** with ***Figure III - 16***.

Table III - 8: Silver Ranch Master Plan 100-Year Peaks – (Master-Planned Conditions, Unite Rate with Connection Active and Blocked)

Location	Active Connection (cfs)	Blocked Connection (cfs)	Change** (cfs)	Change**
Silver Ranch at Connection	1,130	1,160	30	2.6%
Silver Ranch – E Main Avenue & 52nd Street Intersection	820	670	-150	-22.4%
Silver Ranch Downstream Study Limits	820	690	-130	-18.8%
Hay Creek Downstream of Main Avenue	3,790	4,335*	545	12.6%

*Includes eliminating Bismarck Expressway overtopping and storage east of Bismarck Expressway. Accounts for additional 5'x10' box culvert under Main Avenue to fully mitigate floodplain elevation increases upstream of Main Avenue due to blocking the connection.
**Positive values mean flow increases at the location when the connection is blocked (without connection).

Figure III - 15: 100-Year Silver Ranch Hydrographs, Immediately Downstream of Hay Creek / Silver Ranch Connection (Master-Planned Conditions, Unit Rate and Connection Active)

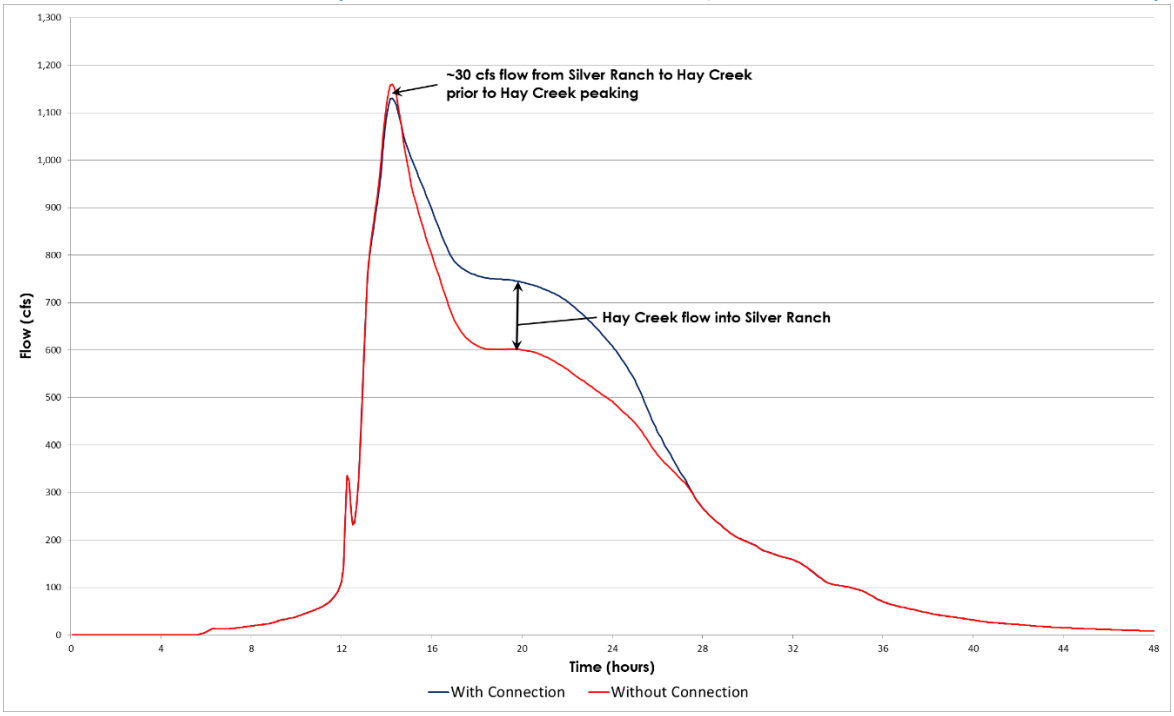
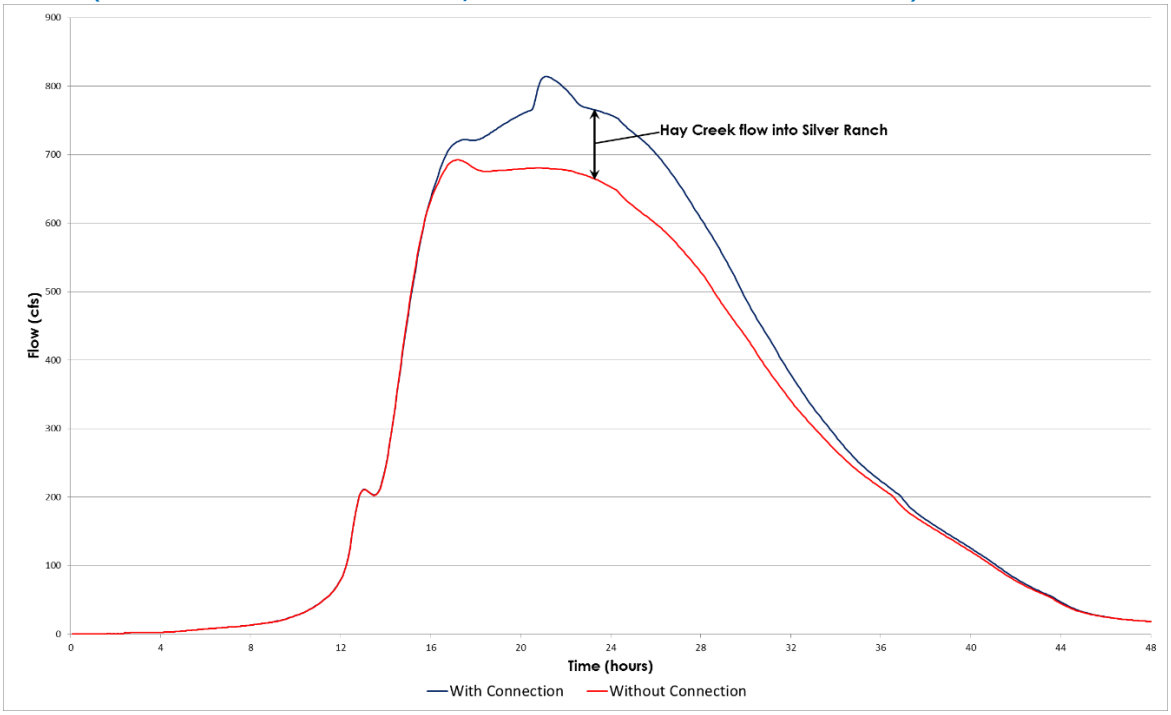


Figure III - 16: 100-Year Silver Ranch Hydrographs, Downstream End of Silver Ranch Study Limits (Master-Planned Conditions, Unit Rate and Connection Active)



III-5.0 HAY CREEK / SILVER RANCH CONNECTION ALTERNATIVES

In general, there are three options for the Hay Creek / Silver Ranch connection:

1. Keep connection active (no change);
2. Improve the existing connection; and
3. Block the existing connection.

Each of the options have benefits and drawbacks, which are discussed in the following sections.

III-5.1 KEEP CONNECTION ACTIVE

Maintaining the connection would involve continuing to allow Hay Creek to flow east along Rosser Avenue and the ditch just north of Main Avenue, overtop Bismarck Expressway, and "backflow" through the culverts under Bismarck Expressway just north of Main Avenue. Water that has overtopped Bismarck Expressway or flowed through the culverts would pond in the low-lying area to the northeast of the Bismarck Expressway / Main Avenue intersection, and ultimately flow northeast to Silver Ranch or back to Hay Creek.

III-5.1.1 Benefits

The primary benefit to maintaining the connection is that the connection reduces peak flows on Hay Creek by over 700 cfs under existing conditions and almost 550 cfs under the Silver Ranch Master Plan conditions. These flow reductions on Hay Creek are important for not exacerbating existing flooding risk along Hay Creek.

III-5.1.2 Drawbacks

There are two main drawbacks to maintaining the connection:

1. No comprehensive plan currently exists that outlines the measures needed to avoid increasing flows on Hay Creek as development continues to expand in the Hay Creek watershed. While individual sub-watershed master plans exist (such as the US83 / ND1804 Stormwater Master Plan), those master plans focused on maintaining existing peak discharges for an individual watershed, not Hay Creek. The Silver Ranch Master Plan suggests that for a large watershed such as Hay Creek, a detention standard that is more restrictive than "pre-post" and/or adding conveyance capacity to the Hay Creek floodway may be required to mitigate for increased flows.

   Since no plan for Hay Creek currently exists, flooding of the Bismarck Expressway and the amount of water that flows from Hay Creek into Silver Ranch could worsen over time.

2. As ***Table III - 5*** and ***Table III - 8*** indicate, Silver Ranch flows are slightly higher at the East Main Avenue & 52nd Street intersection because of the connection. However, the Silver Ranch Master Plan, documented in ***Volume II***, accounted for these flows and the Master-Planned approach ensures headwater elevations are not increased from existing

conditions. So while blocking the connection may provide an additional benefit in the Silver Ranch Watershed, maintaining the connection does not result in adverse impacts under Master-Planned Conditions.

III-5.2 IMPROVE CONNECTION

Due to the flood peak timing for both the Hay Creek and Silver Ranch watersheds being similar and the peak flood level at Hay Creek upstream of Main Avenue, it is not feasible to use Hay Creek as additional conveyance capacity for Silver Ranch to alleviate Silver Ranch flooding at the intersection of County Highway 10 and 52nd Street. Therefore, any improvement to the connection could cause more water from Hay Creek (larger watershed) to enter Silver Ranch (smaller watershed), increasing the downstream flooding risk in the Silver Ranch watershed.

III-5.3 BLOCK CONNECTION

Because blocking the connection would eliminate conveyance capacity for Hay Creek and Hay Creek is a FEMA defined floodway, any elevation increase would either have to be approved by each affected landowner or the increases mitigated for. Since the structures north of Main Avenue are already at risk for flooding, FEMA would likely require that any increases be mitigated.

In order to mitigate for the lost capacity, an additional 5'x10' box culvert would need to be placed under Main Avenue with its invert offset 3 feet higher than the invert for the existing twin 8'x10' box culverts. Additionally, it is likely that the east end of Rosser Avenue and/or Bismarck Expressway would need to be raised immediately north of the intersection with Rosser Avenue and the low-lying area northeast of the Bismarck Expressway / Main Avenue intersection would need to be filled.

III-5.3.1 Benefits

If the connection was blocked, there would be three main benefits:

1. As ***Table III - 5*** and ***Table III - 8*** indicate, blocking the connection would somewhat reduce the amount of water that flows through the Silver Ranch watershed since Hay Creek currently overflows into Silver Ranch.
2. It would be easier to develop the area to the northeast of the Bismarck Expressway / Main Avenue intersection.
3. 100-Year overflow for the Bismarck Expressway would be eliminated.

III-5.3.2 Drawbacks

There are two main drawbacks to blocking the connection:

1. An additional 5'x10' box culvert would be needed under Main Avenue to provide the additional conveyance on Hay Creek that was eliminated by the blocked connection to avoid exacerbating flooding risk on already-developed properties.
2. As ***Table III - 5*** and ***Table III - 8*** show, flows downstream of Main Avenue would be noticeably increased. Increased flows can cause floodplain elevations to increase if additional conveyance improvements are not constructed or approvals from affected landowners obtained. Additional review would be necessary prior to proceeding with blocking the connection to ensure no impacts occur further downstream without proper mitigation.

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III-6.0 SURVEY MAP BOOK

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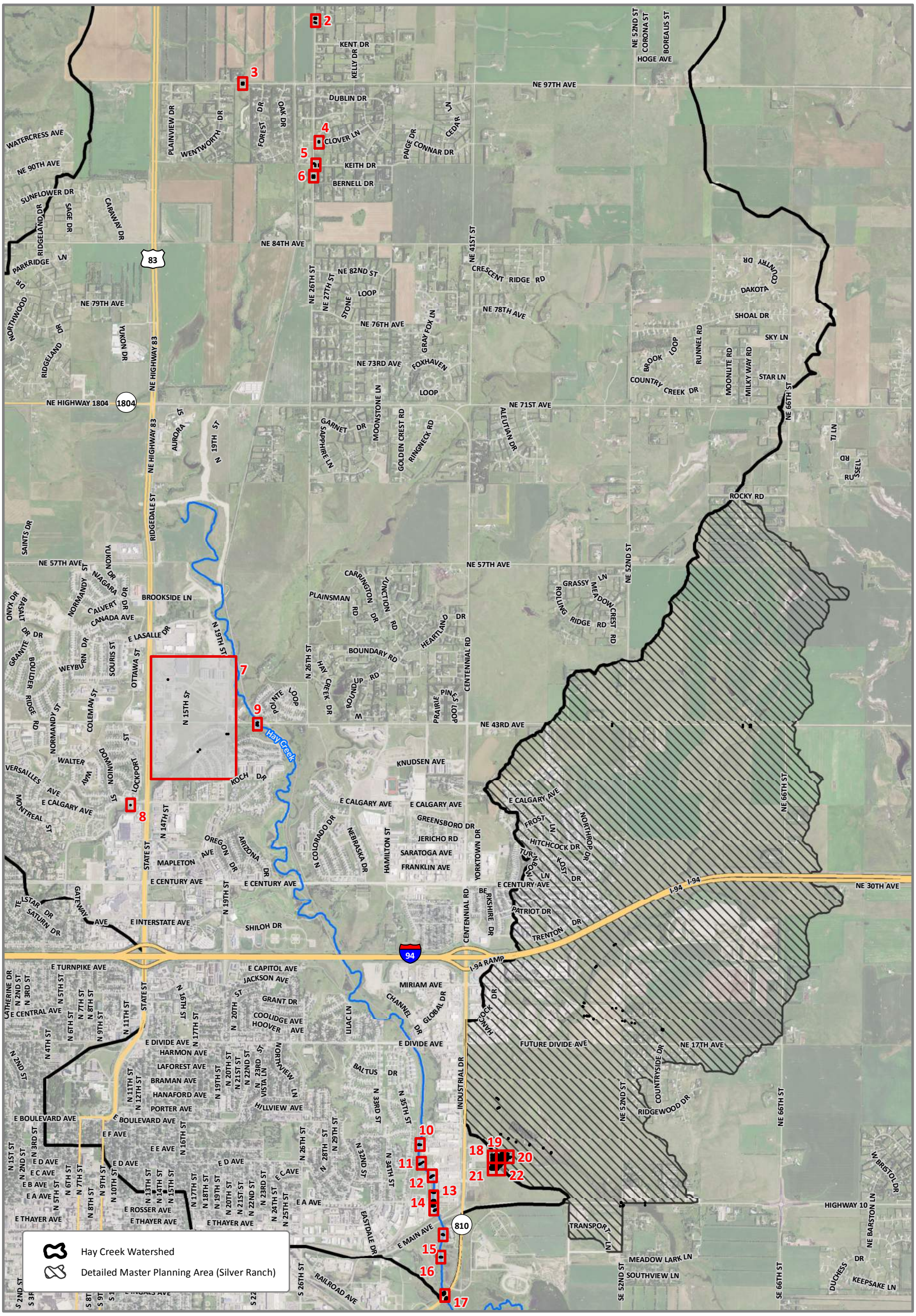

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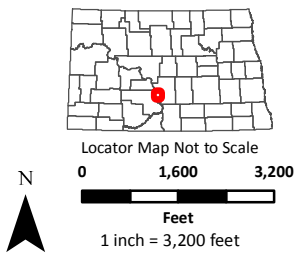

Figure III-17

HAY CREEK SURVEY MAPBOOK- PAGE 1 (INDEX)

SILVER RANCH WATERSHED STORMWATER MASTER PLAN
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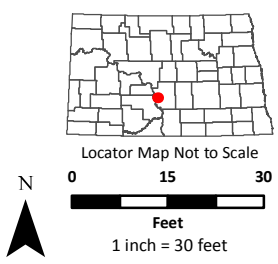

Figure III-17

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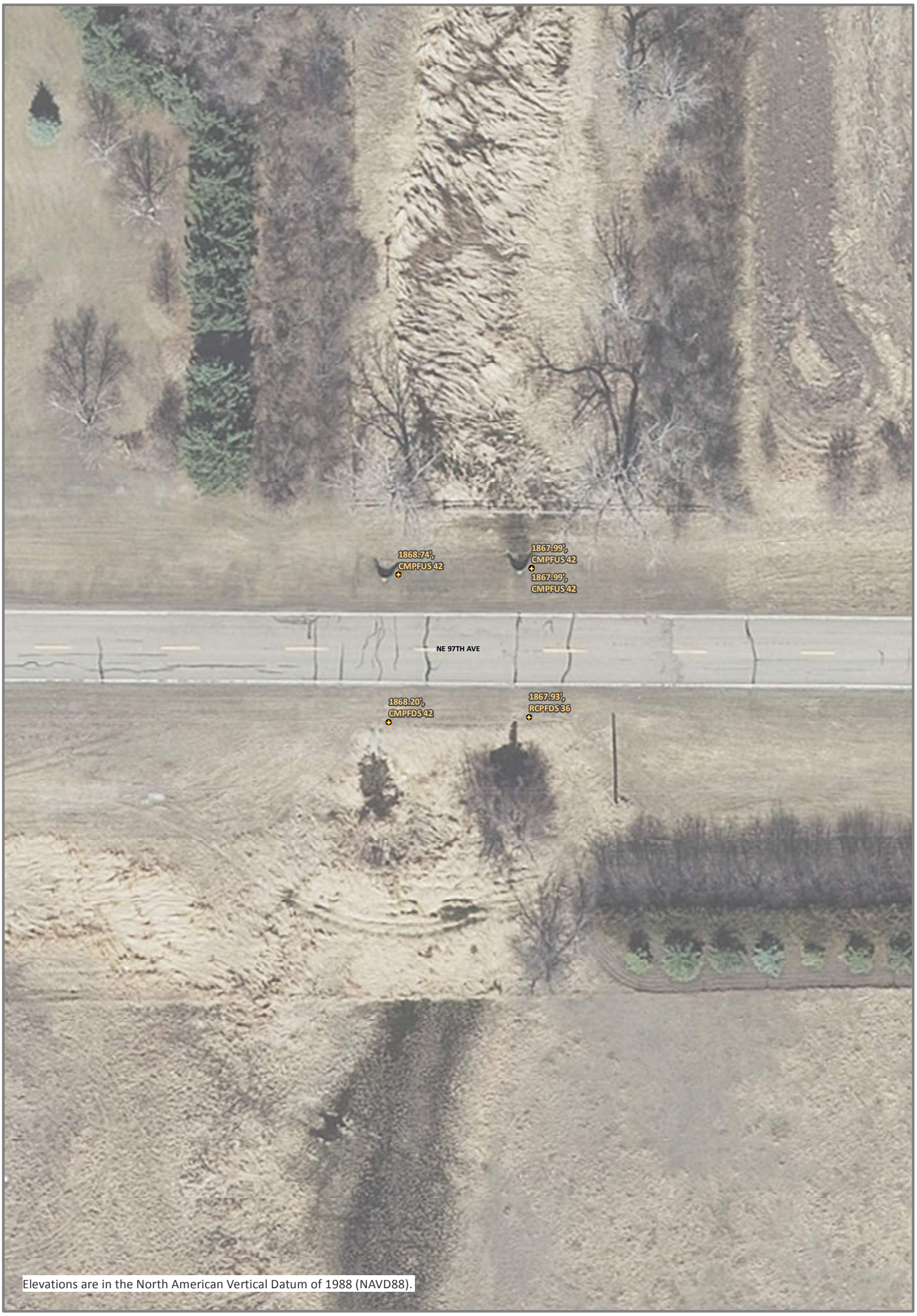

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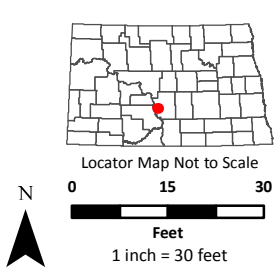

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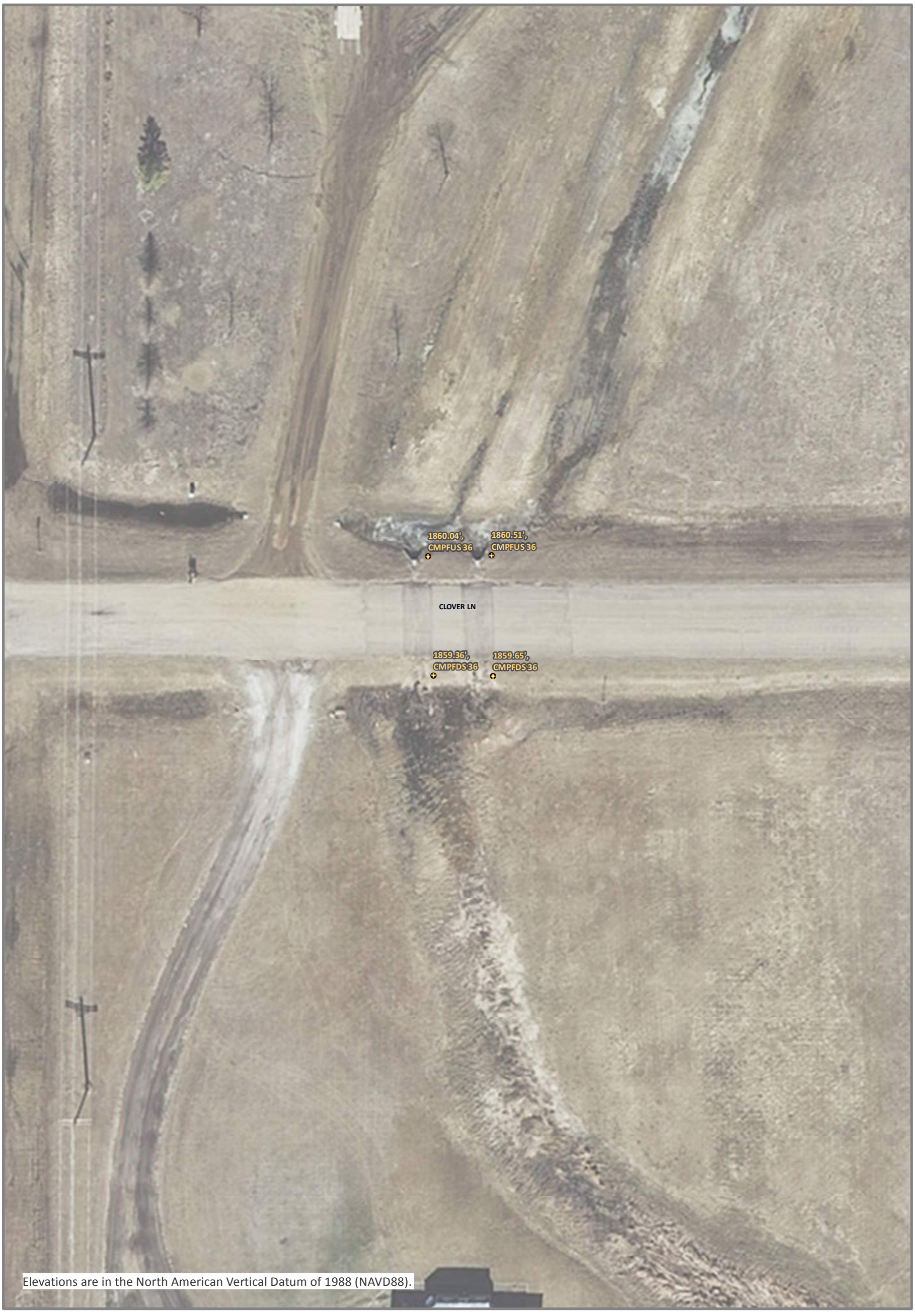

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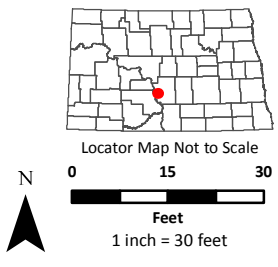

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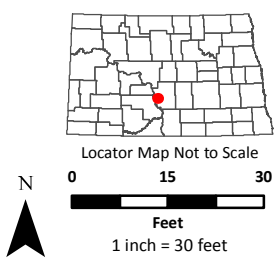

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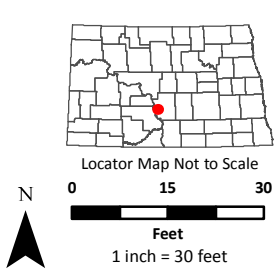

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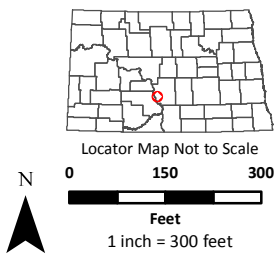

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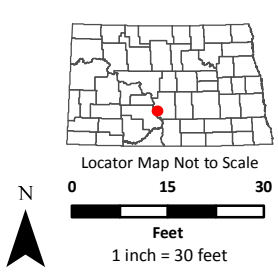

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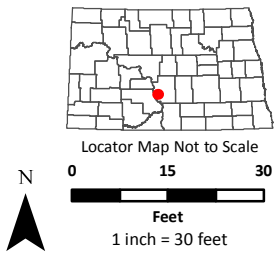

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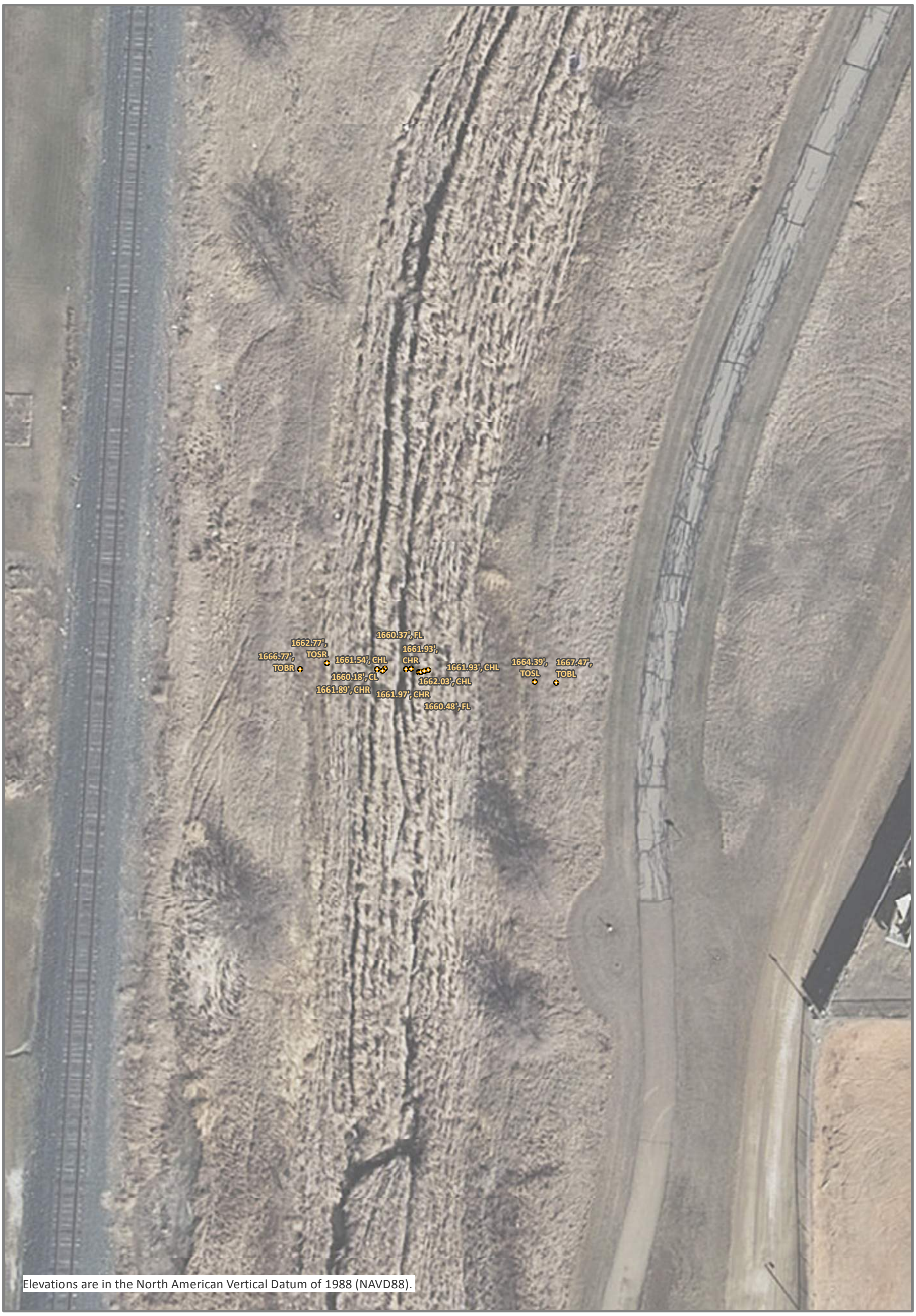

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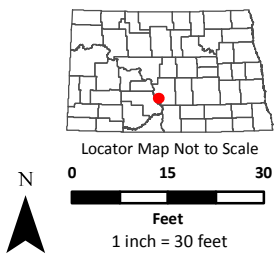

Figure III-17

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SILVER RANCH WATERSHED STORMWATER MASTER PLAN
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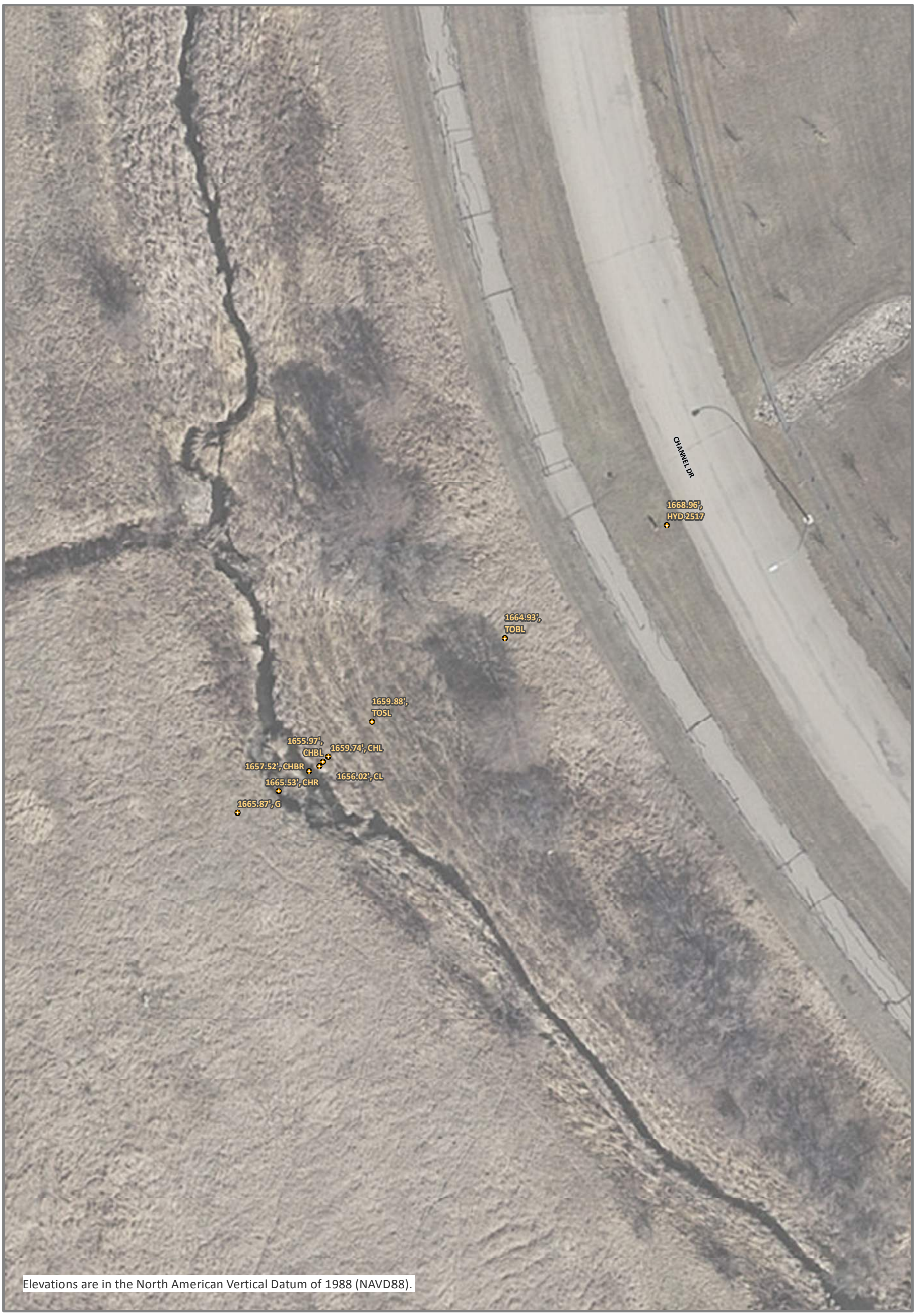

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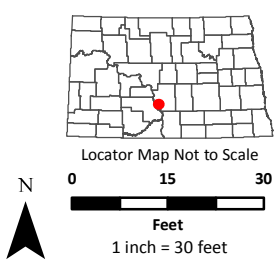
Coordinate System: NAD 1983 StatePlane North Dakota South FIPS 3302 Feet Intl | Edited by: dlee | C:\Data\Projects\WAFS\Bismarck\00501-2015-013\GIS\Report Figure III-17- Hay Creek Survey Mapbook.mxd



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SILVER RANCH WATERSHED STORMWATER MASTER PLAN
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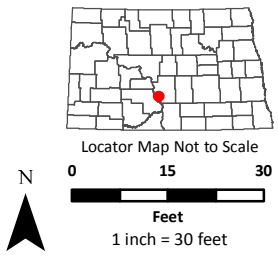

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SILVER RANCH WATERSHED STORMWATER MASTER PLAN
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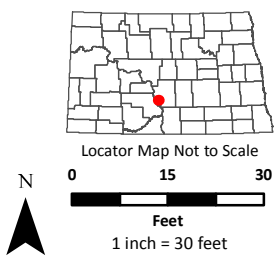

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SILVER RANCH WATERSHED STORMWATER MASTER PLAN
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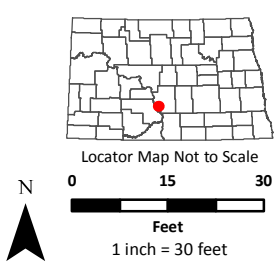

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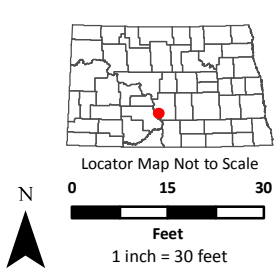

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SILVER RANCH WATERSHED STORMWATER MASTER PLAN
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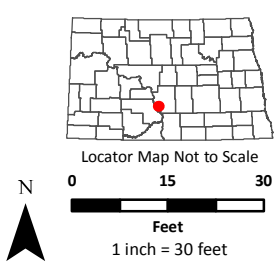

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SILVER RANCH WATERSHED STORMWATER MASTER PLAN
City of Bismarck | Burleigh County, ND

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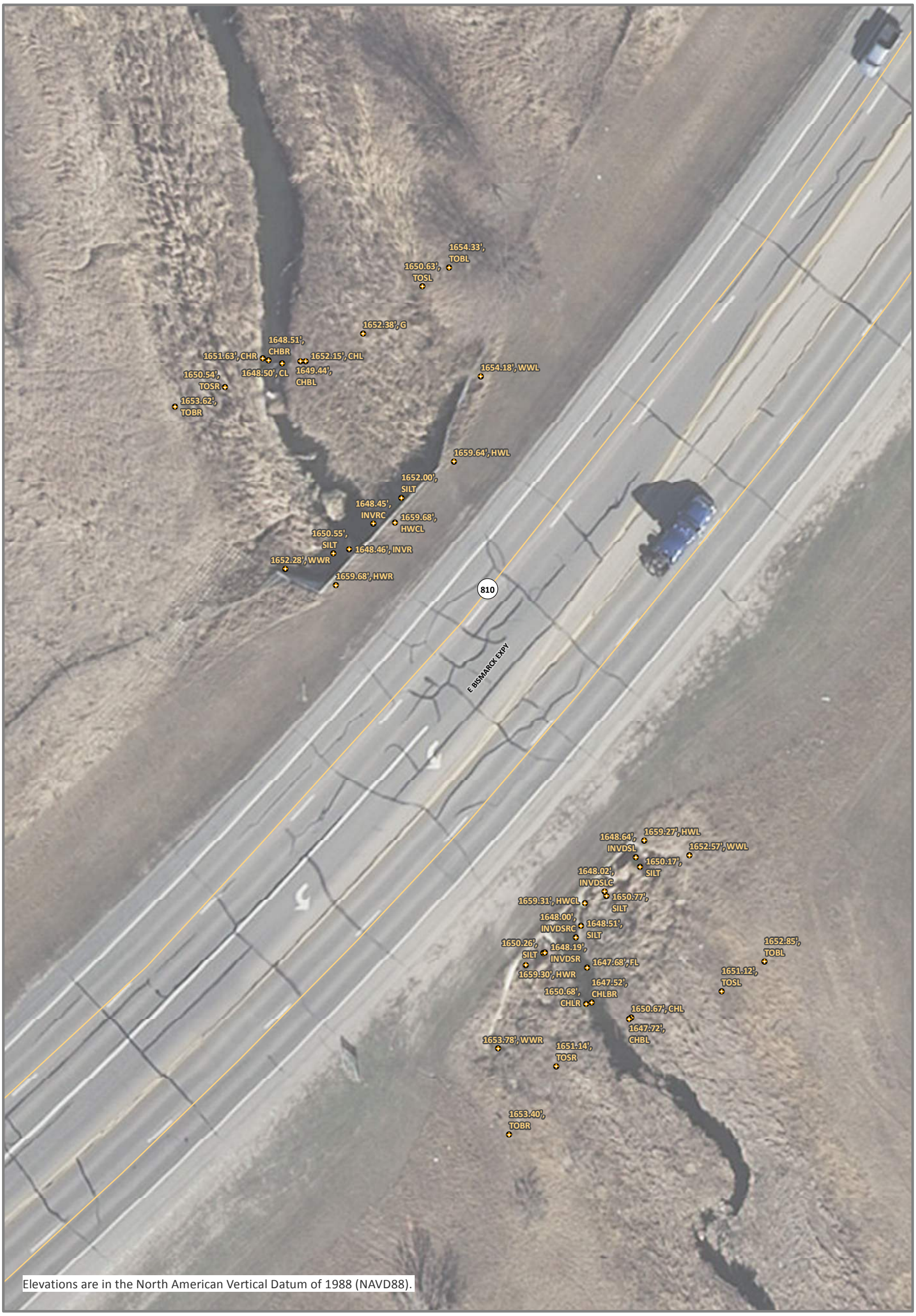

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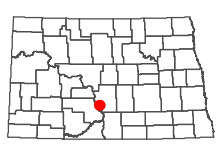

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SILVER RANCH WATERSHED STORMWATER MASTER PLAN
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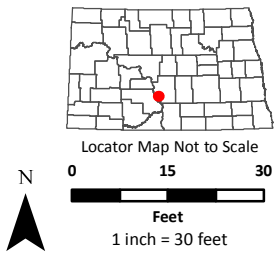

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SILVER RANCH WATERSHED STORMWATER MASTER PLAN
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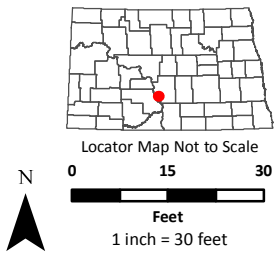

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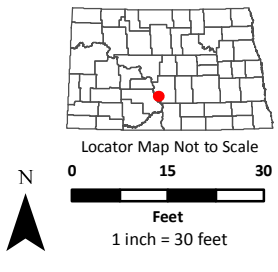

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Elevations are in the North American Vertical Datum of 1988 (NAVD88).

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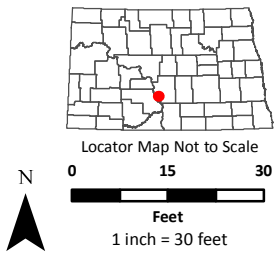

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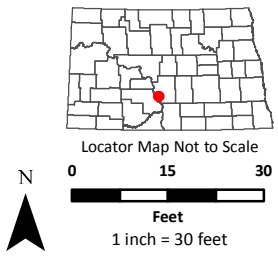

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