

ASH-WARD
COULEE
WATERSHED



CITY OF BISMARCK,
ND

*STORMWATER
MASTER PLAN
UPDATE*

Allowable Unit Rate
Discharge

DRAFT

December 2024

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**ASH-WARD COULEE WATERSHED
STORMWATER MASTER PLAN UPDATE
ALLOWABLE UNIT RATE DISCHARGE
CERTIFICATION**



December 2024

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.

Jesse G. Kist, PE

Date: _____

Reg. No. PE-27402

Prepared by:
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- Appendix A: Cross Section Flow Rates (Existing and Full Buildout, Unit Rate)
- Appendix B: NRCS Hydrologic Soil Groups (HSG)
- Appendix C: Geotechnical Evaluation Report (2014)

1.0 BACKGROUND & SUMMARY

The City of Bismarck is experiencing growth, with development pressure generally expanding to the north. The focus of this stormwater master plan is the largely undeveloped region of the Ash-Ward Coulee Watershed generally located east of River Road, west of Tyler Parkway/57th Ave N, south of ND 1804/71st Ave NW, and north of Sandy River Drive & Frisco Way. The watershed is generally north of the Tyler Coulee Watershed, west of the North Washington Street Watershed, and east of the Missouri River bluff line along River Road. The total watershed consists of six main coulees and encompasses an area of approximately 3.9 square miles. For the purposes of this study, the coulees are numbered one to six from north to south.

The Ash-Ward Coulee Watershed is a tributary to Lower Burnt Creek, which is the reach of Burnt Creek that remained after the Burnt Creek Bypass Channel was constructed in the late 1990's. The Lower Burnt Creek has a local contributing watershed of approximately 6.7 square miles that includes the Ash-Ward Coulee Master Plan area, but also receives a small fraction of Burnt Creek flow that discharges into Lower Burnt Creek at the upstream end of the bypass channel at ND 1804. The Ash-Ward Coulee Watershed discharges into Lower Burnt Creek through culvert crossings installed under River Road at each of the six coulees previously mentioned.

1.1 MASTER PLAN PURPOSE

The overarching purpose of this Master Plan is to develop a comprehensive approach that manages the peak flow and water quality of 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. To mitigate the increased stormwater runoff and water quality degradation, the City's general policy is to proactively develop stormwater master plans for the larger watershed region 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 Ash-Ward Coulee Watershed develops.

1.2 UPDATED MASTER PLAN MODELING SUMMARY

Conclusions and recommendations of this Master Plan were developed based on the results from project specific hydrologic and hydraulic modeling. Stormwater management and updated Master Plan recommendations for the Ash-Ward Coulee Watershed are based on the following modeling scenarios that are generally referenced in this report:

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. Developments existing at the time this master plan update was performed are included in the existing conditions scenario. **Figure 7** shows the existing land use and existing developments. Detention present within the watershed, including upstream of existing road crossings, is accounted for in the existing conditions analysis.
2. **Master Planned Conditions, Unit Rate:** Generally utilized the Together 2045 Comprehensive Plan for future land use. This scenario demonstrates the performance of the watershed when implementing a Unit Rate approach to post-construction stormwater runoff throughout the watershed. This scenario assumes on-site, or local detention basins will be used to meet the Unit Rate criteria.
3. **Hydraulic Design for Future Crossings:** Existing conditions hydrology was used to develop road crossing design flows throughout each of the major coulees in the Ash-Ward Watershed. Existing conditions hydrology was used because although complete implementation of the Unit Rate requirement may result in lower flow rates, crossings are more likely to be constructed prior to full upstream buildout and implementation of the Unit Rate requirements. As such, the existing condition likely acts as the “worst case scenario” for peak flows at road crossings (existing and future) in the major drainageways.

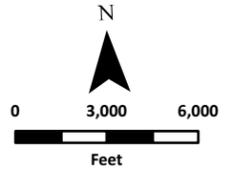
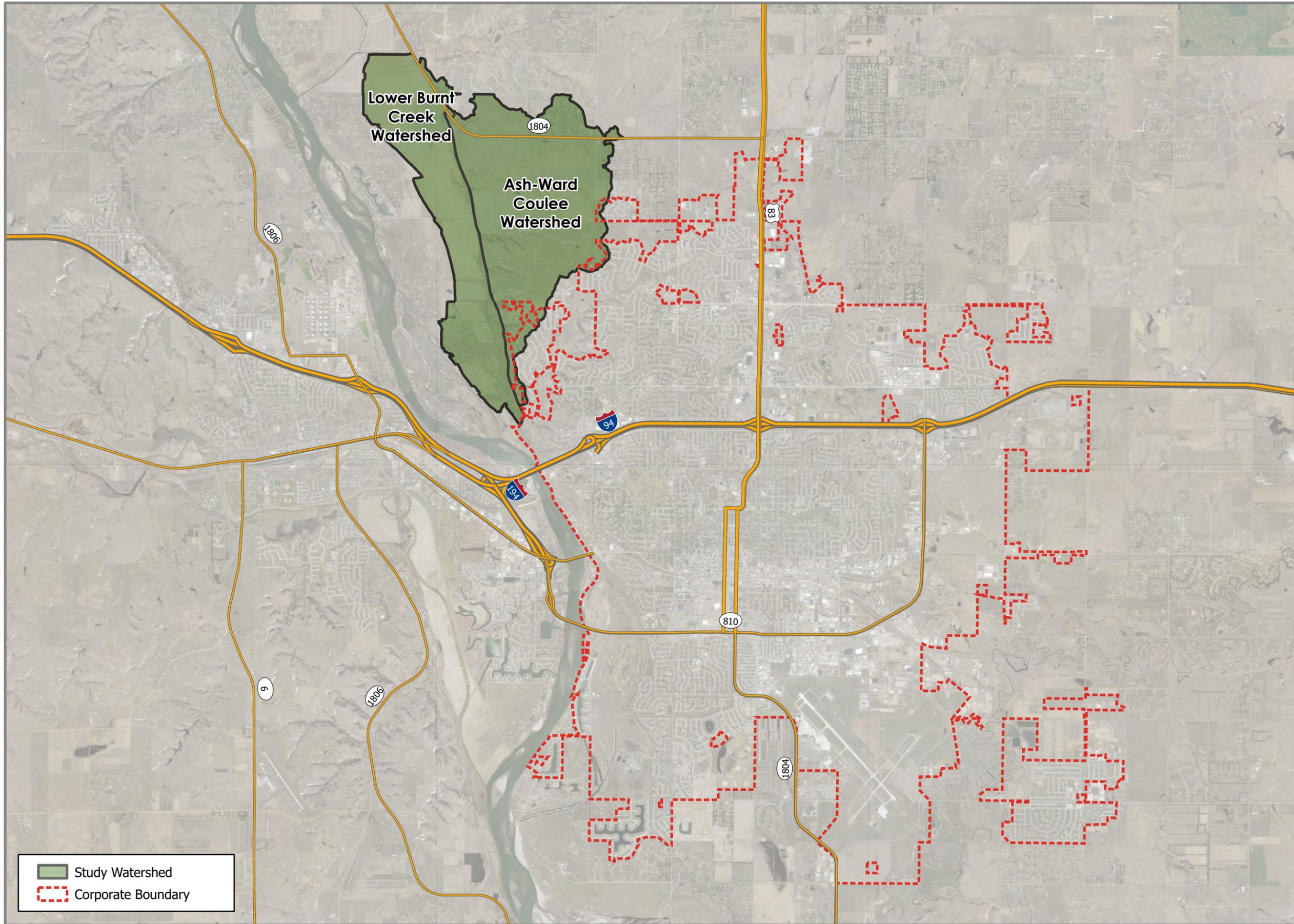
1.3 DATA SOURCES

The following data sources were utilized in this study:

- 2016 and 2023 LiDAR data (contours and DEM) obtained from the Metropolitan Planning Organization;
- North Dakota NAIP aerial photographs, obtained from the Department of Water Resources Map Service;
- Together 2045 Bismarck Comprehensive Plan, obtained from the City;
- 2015 Ash & Ward Coulee Master Plan and Appendices;
- NRCS soils data, obtained from the NRCS Web Soil Survey (**Appendix B**); and
- Atlas 14 rainfall depths from the City of Bismarck 2017 Stormwater Design Standards Manual.

1.4 VERTICAL DATUM

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



1 inch equals 6,000 feet



Locator Map Not to Scale

Bismarck
Burleigh County, ND

Figure 1

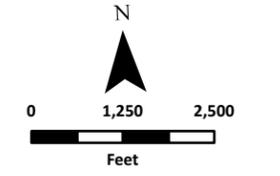
PROJECT LOCATION

ASH-WARD WATERSHED
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Figure 2

MAJOR WATERSHEDS

ASH-WARD WATERSHED
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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 working group. The intent of the working group is to bring the major City departments tasked with implementing this plan into the Master Plan development process. Specific City staff involved in the identification and selection of goals are the following representatives referred to as the City Working Group:

- Mike Greer, P.E. – Project Manager, Bismarck Engineering Department
- Terry Halstengard – Stormwater Program Coordinator, Bismarck Public Works

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

Goals were developed to steer the development of this Unit Rate Master Plan. The goals are divided into "primary" and "secondary" goals to reflect the overall intent of this Ash-Ward Coulee Watershed Master Plan update. To the extent reasonably possible, the recommendations of this master plan update meet all of these goals.

2.1 PRIMARY GOAL

The primary goal of the Master Plan is to develop a comprehensive approach that manages stormwater and provides adequate drainage consistent with the City's ordinances.

2.2 SECONDARY GOALS

Seven secondary goals were developed for this Stormwater Master Plan, which are to:

- Maintain flooding depths on Lower Burnt Creek under full buildout conditions of the Ash-Ward Coulee Watershed so as to not result in more than 0.1 feet of increase over existing conditions during the 2- and 100-year events;
- Consider and maintain the geotechnical setback line that was developed as part of the 2015 Ash-Ward Coulee Watershed Stormwater Master Plan and identify other development setbacks, as appropriate;
- Evaluate the potential for erosion along the coulee valleys and side slopes and develop a Unit Rate that reduces the magnitude of shear stress and velocity throughout the coulees;
- Develop an allowable Unit Rate discharge for the 2- and 100-year events as the method for stormwater peak flow mitigation to replace the regional detention approach proposed in the 2015 Ash & Ward Coulee Watershed Stormwater Master Plan;

- Integrate the proposed stormwater recommendations and infrastructure with other applicable planning documents within the City and County, such as the Together 2045 Comprehensive Plan;
- Develop flow criteria to guide the design of future coulee road crossings within the watershed; and
- Reduce overtopping of the River Road crossings through development of a Unit Rate discharge to achieve general compliance with State and Local requirements.

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 Stormwater Master Plan, provides a brief justification, and where applicable, references the section where additional information can be found.

RECOMMENDATION #1 - Peak runoff within Ash-Ward Coulee 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. Based on total site area (pervious and impervious), the peak post-construction runoff for the 2-year event shall not exceed 0.05 cfs/acre and for the 100-year event shall not exceed 0.50 cfs/acre for the area south of ND 1804 or 0.90 cfs/acre for the area north of ND 1804, as summarized in **Table 5** and shown on **Figure 5** and **Figure 6**

The Unit Rate recommendation accounts for up to 10% of the total site discharging directly offsite and not routed through a peak flow compliance post-construction Best Management Practice (BMP), however, that area must be entirely pervious. The area allowed to discharge directly offsite may be allowed to exceed 10% of the total site if pervious and justified based on topographical challenges associated with routing flows to the BMP. However, this deviation must be approved by the City Engineer and in no case should runoff from impervious areas be allowed to discharge directly offsite.

The Unit Rate Method is more fully described in **Section 4.2**. Stormwater Design Standards for development activities is included in **Section 4.6**

Justification:

The Unit Rate requirement meets all the Primary Goals developed for this Stormwater 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, it provides flexibility in the location of the stormwater facilities, and it will reduce shear stress in the coulees as well as reducing overtopping of road crossings on River Road. The performance of the Unit Rate Method is described in **Section 4.3**.

An allowance of 10% of the pervious portion of the site not being routed to the peak flow compliance BMP was accounted for in the development of the 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 Ash-Ward Coulee 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 Stormwater 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.

This updated Ash-Ward Watershed Stormwater Master Plan does not include any recommended regional stormwater basins to be constructed by the City for post-construction peak flow compliance. The past practice of City constructed regional facilities has been problematic regarding the timing of the construction and the resulting special assessments paid for by utility rate payers and held in abeyance.

Stormwater design standards specific to development activities in the Ash-Ward Watershed are included in **Section 4.6**.

Justification:

This Stormwater 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.

Installation of peak flow compliance stormwater basins at the time of development has the added benefit of potentially reducing the flows in the receiving coulees and reducing the erosion in those channels.

RECOMMENDATION #3 – Implement setbacks around the major drainage areas and bluff lines, including the existing geotechnical setback line.

Description

A geotechnical setback line was developed as part of the 2015 master planning effort. That setback line is located along the major drainages and is presented on **Figure 3**. Details regarding the geotechnical setback line are included in the original 2014 report by Braun Intertec which is attached as **Appendix C** to this Stormwater Master Plan.

Additional setbacks are included on **Figure 3** based on Parks & Open Space land use. The Parks & Open Space setback area is based on the land use of the same name from the City's Together 2045 Comprehensive Plan, however, the boundaries of the Parks & Open Space used in this Stormwater Master Plan have been minorly revised from the comprehensive plan to better fit the terrain and to generally match the geotechnical setback, where they overlap.

Anyone proposing to encroach on a setback line shall do the following:

1. Document that the proposed encroachment does not reduce the coulee's ability to convey the 2- or 100-year design flows. This documentation shall confirm that there is no rise in headwater elevations upstream or downstream of the proposed encroachment;
2. Document that any structure placed in the proposed encroachment area is sufficiently elevated to protect against flooding;
3. Provide a site-specific geotechnical analysis to verify that any encroachment does not present geotechnical risks to proposed or existing structures, infrastructure, or the surrounding area. The analysis should be performed and sealed by a qualified geotechnical engineer and must be approved by the City Engineer prior to any encroachment being allowed. In general, encroachments shall be discouraged and avoided;
4. Attenuate the peak flow rates discharging from the developed area in compliance with the Unit Rates presented in this Stormwater Master Plan; and
5. Demonstrate compliance with the City's MS4 permit, the City's Stormwater Design Standards, and all other applicable standards.

Justification

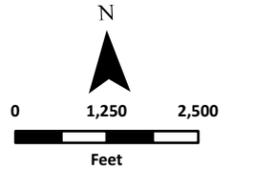
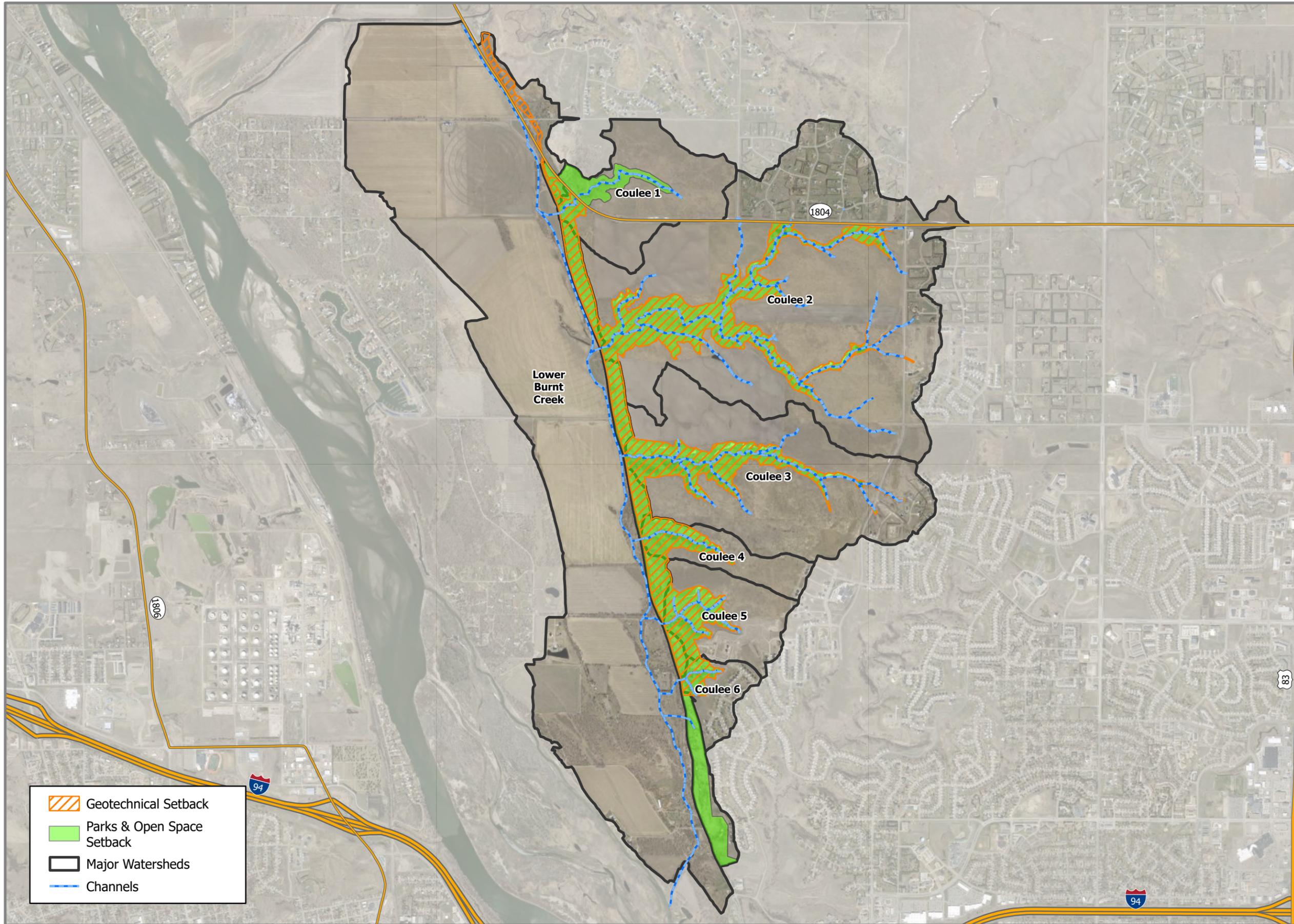
Preservation of large drainage areas and associated drainage paths, as well as protection of bluff lines and slopes with potential for geotechnical instability is key to protecting the public safety and minimizing the potential for damage or destruction of property and infrastructure.

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Table 1: Stormwater Master Plan Recommendations Summary

	Description	Justification
<p>RECOMMENDATION #1 Peak runoff within Ash-Ward Coulee Watershed shall not exceed designated Unit Rate.</p>	<p>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 such that the peak post-construction runoff for the 2-year event does not exceed 0.05 cfs/acre and for the 100-year event does not exceed 0.50 cfs/acre for the area south of ND 1804 or 0.90 cfs/acre for the area north of ND 1804, as summarized in Table 5 and shown on Figure 5 and Figure 6.</p> <p>The Unit Rate Method is more fully described in Section 4.2.</p> <p>The Unit Rate recommendation allows for an amount of pervious ground, equal to 10% of the site's total area, to discharge directly offsite without mitigation through a post-construction compliance post-construction facility. This area may exceed 10% of the site due to topographical constraints, however, this must be approved by the City Engineer and the area must be pervious.</p> <p>Stormwater Design Standards for development activities are included in Section 4.6.</p>	<p>The Unit Rate release requirement meets all of the primary and secondary goals developed for this Stormwater Master Plan.</p> <p>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.</p> <p>An allowance of up to 10% of the 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 impractical.</p>
<p>RECOMMENDATION #2 Developer is responsible for construction costs of required stormwater BMPs.</p>	<p>Peak flow compliance will be met using onsite or local facilities.</p> <p>Costs for the design and construction of stormwater management basins are to be paid by the developer.</p> <p>The Stormwater Master Plan does not include any regional stormwater basins or conveyance improvements constructed by the City.</p>	<p>Utilizing local facilities allows the impact from urbanization to be mitigated as development occurs, potentially reducing erosion in channels and impacts to road crossings, such as increased overtopping.</p> <p>Stormwater Design Standards for development activities, including a description of construction cost responsibility, is included in Section 4.6.</p>
<p>RECOMMENDATION #3 Implement setbacks around the major drainage areas and bluff lines, including the existing geotechnical setback line.</p>	<p>Setbacks are recommended along all the major drainage areas and bluff lines based on the existing geotechnical setback line from the 2015 master plan with additional setback areas added based on the Parks & Open Space land use used for this master plan around the major drainageways (Figure 8) and based on the land use presented in the Together 2045 Comprehensive Plan.</p> <p>Setbacks are presented on Figure 3.</p>	<p>In addition to mitigating the risks presented by steep slopes throughout the watershed, preservation of large drainage areas and associated stormwater storage is key to protecting the public safety and minimizing the potential for damage to property.</p>

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Figure 3

SETBACKS

ASH-WARD WATERSHED
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4.0 STORMWATER MASTER PLAN

Included in the following sections are:

1. Recommended stormwater management strategies;
2. Compliance requirements used to develop this Stormwater Master Plan;
3. Stormwater Design Standards applicable for Post-Construction Stormwater Management Permits (PCSMP) issued in the Ash-Ward Coulee Watershed; and
4. Reporting and compliance criteria for implementing this Stormwater Master Plan.

4.1 KEY MODIFICATIONS FROM THE ADOPTED 2015 WATERSHED MASTER PLAN

This updated Stormwater Master Plan does not include any regional detention facilities and eliminates most of the conveyance improvements recommended by the 2015 Master Plan. The 2015 Master Plan used regional stormwater facilities to control peak discharge rates whereas this Master Plan uses the Unit Rate Method. Specific road crossing designs were provided in the 2015 Stormwater Master Plan, whereas this plan does not provide specific designs but instead provides design flows to guide future crossing designs. Finally, with the implementation of this Stormwater Master Plan, hydraulic improvements to River Road crossings and along Lower Burnt Creek are no longer necessary, except for at the Wilderness Cove Road crossing.

4.2 STORMWATER MANAGEMENT

The Stormwater Master Plan for the Ash-Ward Coulee Watershed consists of stormwater management recommendations for post-construction peak discharge, post-construction water quality compliance, and drainage & conveyance design flows.

Developments within the Ash-Ward Coulee Watershed shall meet the requirements for peak discharge compliance, water quality compliance, and drainage & conveyance implementation as discussed in the following sections of this Stormwater Master Plan. In developing the master plan recommendations, consideration was given to shear stress within the major coulee drainages and to inundation along Lower Burnt Creek to ensure that neither was made worse by this Stormwater Master Plan under future full built-out conditions.

4.2.1 Crossings & Conveyance

Future crossings were not sized as part of this Master Plan due to uncertainty in crossing locations and to provide flexibility for future crossing placement within the master planned area. Instead of crossing specific design guidance, this Stormwater Master Plan provides design flow rates at incremental locations throughout all major drainage corridors within the master planned area for use in designing crossings to meet the requirements of the SWDSM. The design flow rates are based on existing conditions flow rates, to provide conservative crossing design with the understanding that crossing construction will often precede full upstream buildout. Design flow rates are presented on **Figure 4**, which includes an overview figure and four coulee specific

maps. Design flows may be interpolated to identify design flows for any location along the reported drainage corridors. In the case of a crossing proposed after full buildout of the upstream watershed, the City Engineer may consider a different design flow rate, if justified.

4.2.2 Peak Discharge Compliance

This Stormwater Master Plan utilizes a Unit Rate approach for managing post-construction peak flow rates. A Unit Rate approach refers to the development of peak runoff rates that are dependent on the size of a development or project site. For the Ash-Ward Coulee Watershed, the peak post-construction runoff for the 2-year event shall not exceed 0.05 cfs/acre and for the 100-year event shall not exceed 0.50 cfs/acre for the area south of ND 1804 or 0.90 cfs/acre for the area north of ND 1804, as summarized in **Table 5** and shown on **Figure 5** and **Figure 6**.

Utilizing the Unit Rate recommendations for the Ash-Ward Coulee Watershed results in post-construction flows that are less than pre-development flows in Coulees 1-5. The lower peak flows are necessary due to future increased runoff volumes (**Table 2**) and the need to maintain headwater at Lower Burnt Creek crossings to within 0.1 feet of existing conditions. Based on analysis of watershed performance, compliance with the Unit Rate for the 2- and 100-year events results in 10-year storm event flows that are reduced from the existing flow rates.

Table 2: Runoff Volume Comparison

Measurement Location	Runoff Volume (acre-ft)			
	Existing		Ash-Ward Full-Buildout	
	2-year	100-year	2-year	100-year
Coulee 1	6.8	51.4	23.6	77.3
Coulee 2	40.8	277.5	111.6	379.0
Coulee 3	13.6	108.7	56.1	179.5
Coulee 4	2.5	21.9	8.9	30.8
Coulee 5	3.3	32.1	13.6	45.9
LBC* Outlet	292.7	1091.4	432.5	1322.1

*LBC = Lower Burnt Creek

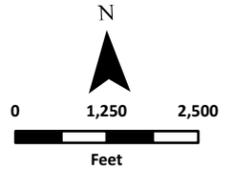
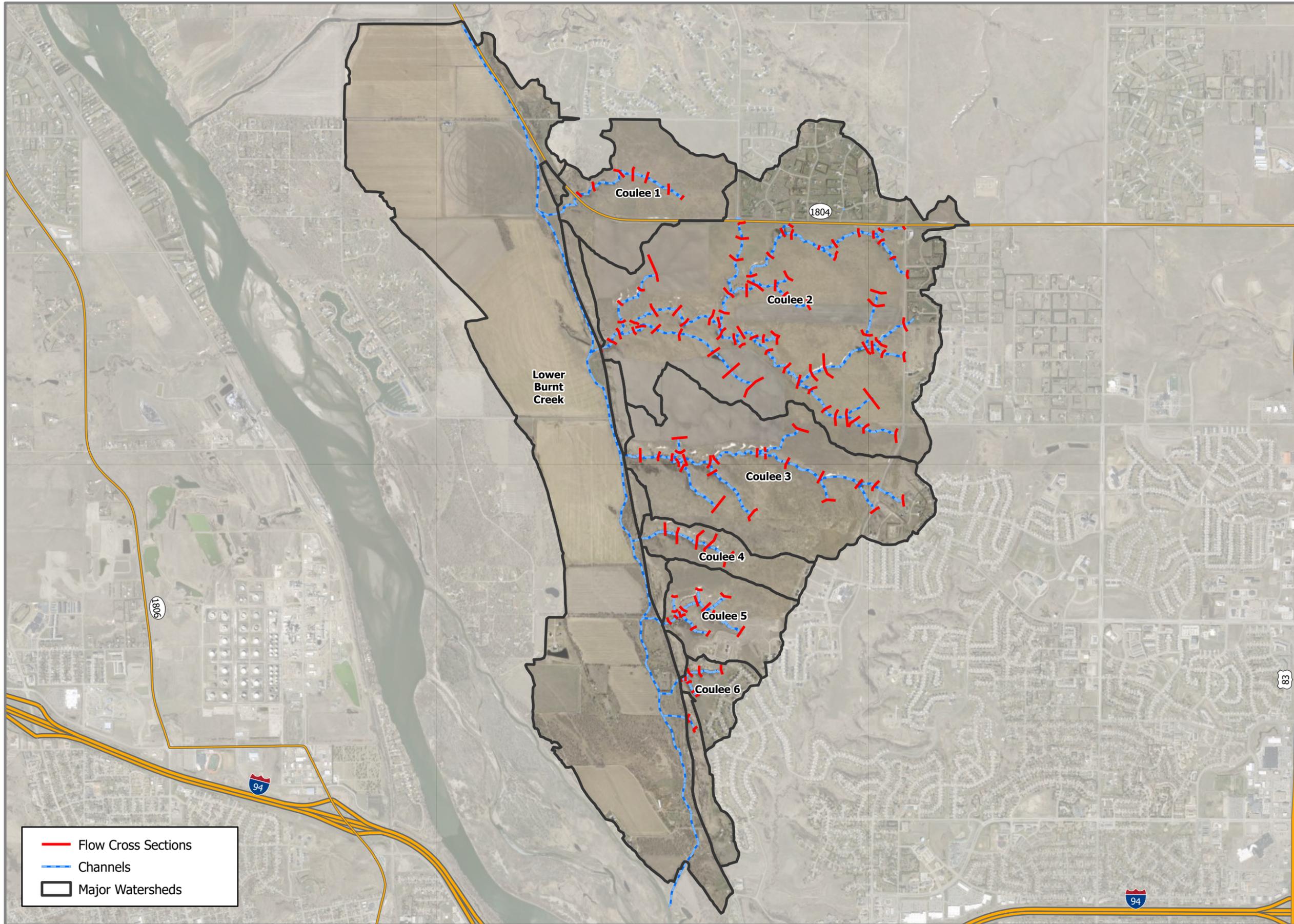
The Unit Rate allows for up to 10% of the total developable area to discharge directly offsite without attenuation in a post-construction BMP. The area discharging offsite must be entirely pervious. If topographical constraints exist, the amount of a site discharging directly offsite may exceed 10% of the total site area, if adequately justified and approved by the City Engineer.

4.2.3 Water Quality Compliance

Post-construction water quality compliance shall meet the City's MS4 permit and SWDSM.

4.2.4 Land Use

Existing and master planned land use assumptions are shown on **Figure 7** and **Figure 8**.



1 inch equals 2,500 feet



Locator Map Not to Scale

Bismarck
Burleigh County, ND

Figure 4.0

DESIGN FLOWS OVERVIEW

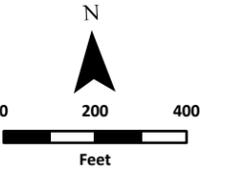
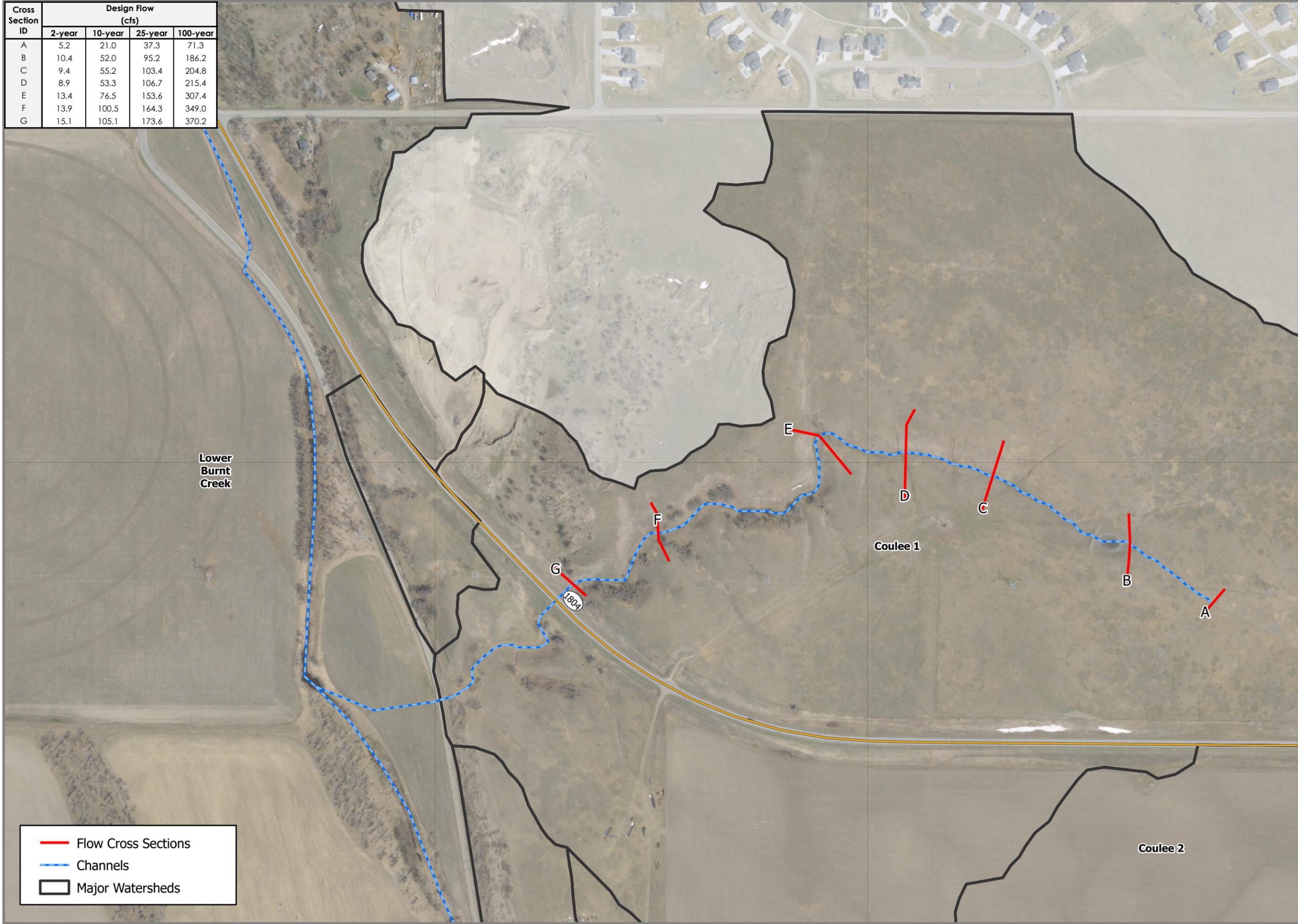
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Cross Section ID	Design Flow (cfs)			
	2-year	10-year	25-year	100-year
A	5.2	21.0	37.3	71.3
B	10.4	52.0	95.2	186.2
C	9.4	55.2	103.4	204.8
D	8.9	53.3	106.7	215.4
E	13.4	76.5	153.6	307.4
F	13.9	100.5	164.3	349.0
G	15.1	105.1	173.6	370.2



1 inch equals 400 feet



Locator Map Not to Scale

Bismarck
Burleigh County, ND

Figure 4.1

**DESIGN FLOWS
COULEE 1**

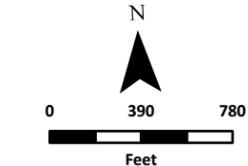
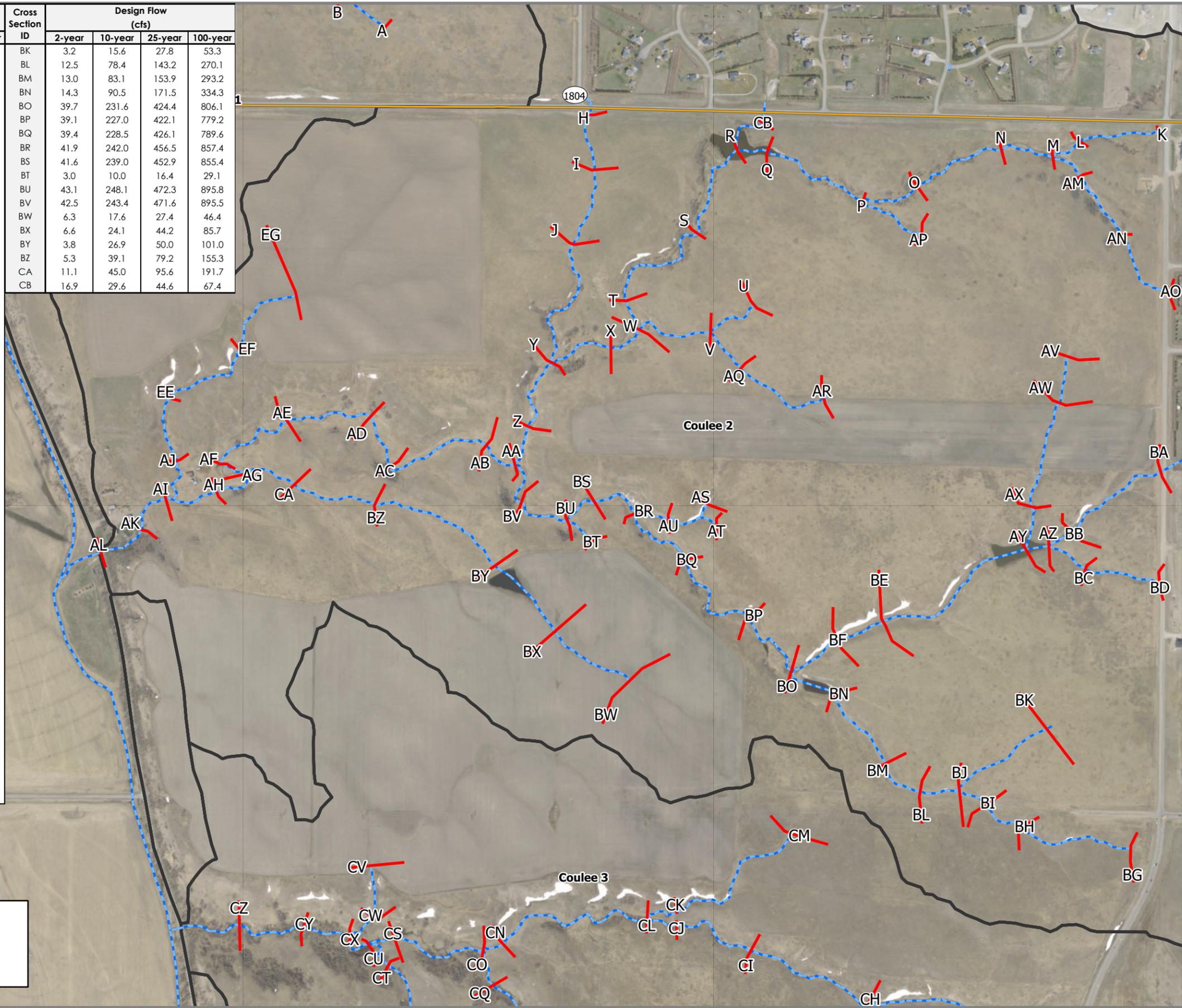
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Cross Section ID	Design Flow (cfs)				Cross Section ID	Design Flow (cfs)			
	2-year	10-year	25-year	100-year		2-year	10-year	25-year	100-year
H	14.3	31.7	41.4	57.2	BK	3.2	15.6	27.8	53.3
I	14.2	31.5	41.1	56.9	BL	12.5	78.4	143.2	270.1
J	14.0	34.7	50.4	87.3	BM	13.0	83.1	153.9	293.2
K	10.2	23.5	36.6	63.4	BN	14.3	90.5	171.5	334.3
L	16.8	38.6	58.9	99.6	BO	39.7	231.6	424.4	806.1
M	35.1	89.5	140.0	242.0	BP	39.1	227.0	422.1	779.2
N	36.3	95.2	150.1	260.4	BQ	39.4	228.5	426.1	789.6
O	39.0	106.1	169.1	296.8	BR	41.9	242.0	456.5	857.4
P	43.9	125.0	201.0	354.4	BS	41.6	239.0	452.9	855.4
Q	46.1	135.3	221.2	392.5	BT	3.0	10.0	16.4	29.1
R	59.7	163.7	259.0	447.4	BU	43.1	248.1	472.3	895.8
S	60.0	171.9	279.4	495.7	BV	42.5	243.4	471.6	895.5
T	60.1	171.1	280.4	501.9	BW	6.3	17.6	27.4	46.4
U	7.8	24.3	39.1	68.2	BX	6.6	24.1	44.2	85.7
V	21.5	62.8	99.3	170.7	BY	3.8	26.9	50.0	101.0
W	71.6	218.1	366.1	674.5	BZ	5.3	39.1	79.2	155.3
X	71.1	217.2	364.5	671.4	CA	11.1	45.0	95.6	191.7
Y	84.5	261.6	434.4	801.7	CB	16.9	29.6	44.6	67.4
Z	84.1	265.3	442.1	819.2					
AA	110.3	503.2	917.1	1724.8					
AB	109.8	499.0	910.6	1720.1					
AC	111.0	499.7	916.4	1719.0					
AD	110.1	490.7	901.2	1717.9					
AE	110.9	489.4	910.3	1742.8					
AF	111.0	537.5	1066.7	2214.6					
AG	115.5	557.4	1098.5	2226.5					
AH	115.1	525.7	975.7	1844.4					
AI	121.4	543.7	997.3	1873.3					
AJ	23.9	94.6	159.3	289.5					
AK	122.6	547.7	996.4	1877.7					
AL	123.0	548.7	996.6	2391.9					
AM	15.0	41.6	66.3	116.6					
AN	12.8	33.9	54.2	95.8					
AO	11.5	29.8	47.6	83.9					
AP	7.0	21.6	34.6	60.3					
AQ	14.0	38.9	60.7	103.1					
AR	11.1	29.8	45.8	76.5					
AS	4.0	16.8	29.2	54.2					
AT	1.4	9.9	18.7	37.4					
AU	5.2	25.6	46.0	88.3					
AV	1.0	7.9	15.8	32.7					
AW	1.0	7.9	15.7	32.6					
AX	7.2	26.1	44.7	81.9					
AY	33.8	119.8	198.8	355.5					
AZ	24.5	78.3	127.8	225.6					
BA	11.5	33.5	53.2	92.2					
BB	16.5	50.0	80.8	141.1					
BC	5.9	19.6	32.0	56.6					
BD	4.1	13.7	22.4	39.6					
BE	36.3	140.7	238.5	432.9					
BF	34.7	147.8	257.5	477.9					
BG	4.1	15.8	26.7	48.8					
BH	10.0	35.5	58.2	104.2					
BI	9.4	53.6	94.9	176.3					
BJ	14.3	82.0	147.5	275.6					



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Bismarck
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Figure 4.2

**DESIGN FLOWS
COULEE 2**

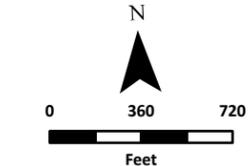
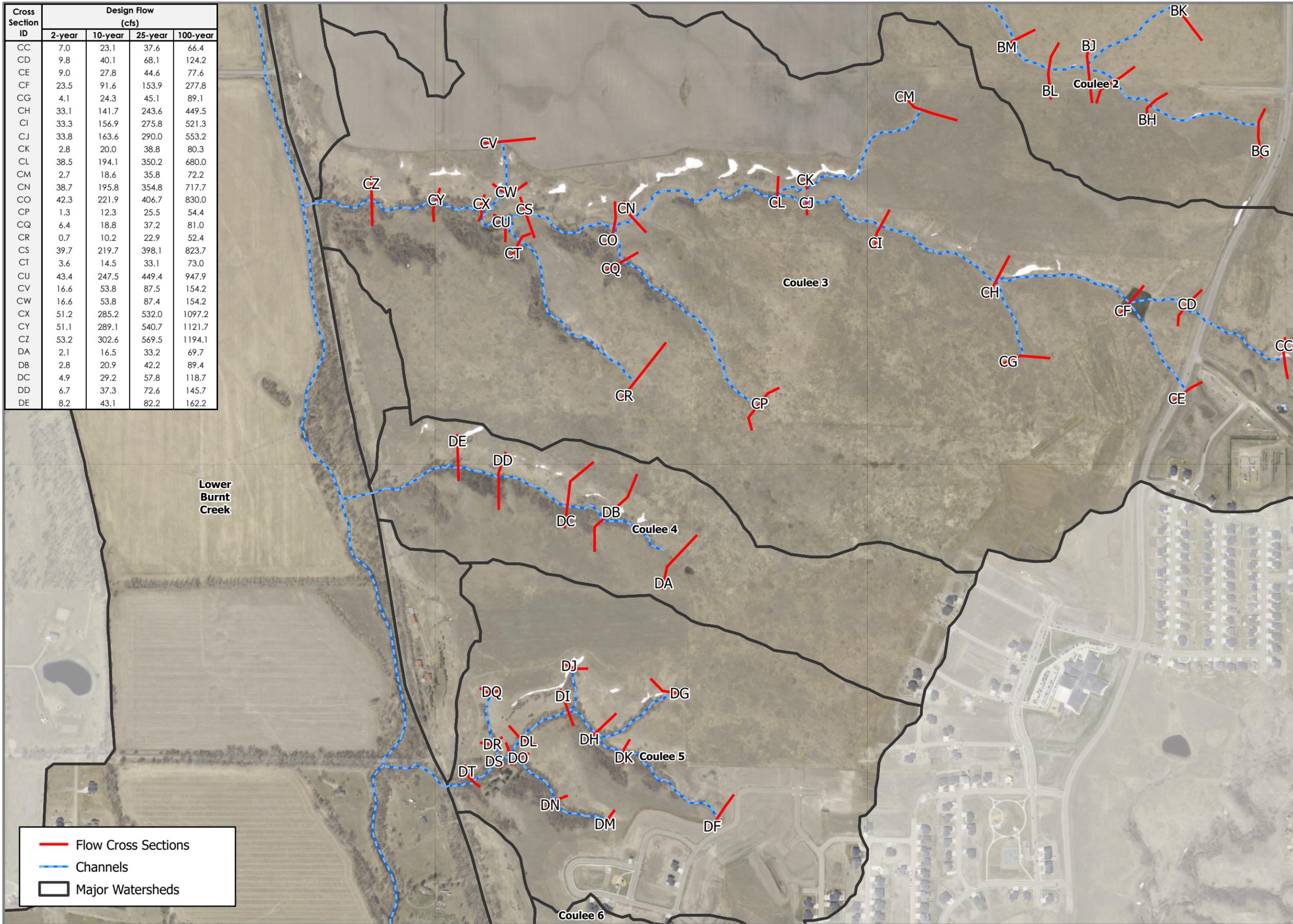
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 Coordinate System: NAD 1983 StatePlane North Dakota South FIPS 3302 Feet | Edited by: JKist | C:\Users\JKist\AE2S\00501-2023-002 Bismarck Ash-Ward Coulee Unit Rate Master Plan Update - Documents\11.0 AE2S GIS\ArcGIS Pro - AshWard2023\GIS\AshWard_2023.aprx | Figure 4.2 - Road Crossing Design Flows - Coulee 2

Cross Section ID	Design Flow (cfs)			
	2-year	10-year	25-year	100-year
CC	7.0	23.1	37.6	66.4
CD	9.8	40.1	68.1	124.2
CE	9.0	27.8	44.6	77.6
CF	23.5	91.6	153.9	277.8
CG	4.1	24.3	45.1	89.1
CH	33.1	141.7	243.6	449.5
CI	33.3	156.9	275.8	521.3
CJ	33.8	163.6	290.0	553.2
CK	2.8	20.0	38.8	80.3
CL	38.5	194.1	350.2	680.0
CM	2.7	18.6	35.8	72.2
CN	38.7	195.8	354.8	717.7
CO	42.3	221.9	406.7	830.0
CP	1.3	12.3	25.5	54.4
CQ	6.4	18.8	37.2	81.0
CR	0.7	10.2	22.9	52.4
CS	39.7	219.7	398.1	823.7
CT	3.6	14.5	33.1	73.0
CU	43.4	247.5	449.4	947.9
CV	16.6	53.8	87.5	154.2
CW	16.6	53.8	87.4	154.2
CX	51.2	285.2	532.0	1097.2
CY	51.1	289.1	540.7	1121.7
CZ	53.2	302.6	569.5	1194.1
DA	2.1	16.5	33.2	69.7
DB	2.8	20.9	42.2	89.4
DC	4.9	29.2	57.8	118.7
DD	6.7	37.3	72.6	145.7
DE	8.2	43.1	82.2	162.2



1 inch equals 720 feet



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Bismarck
Burleigh County, ND

Figure 4.3

**DESIGN FLOWS
COULEES 3 & 4**

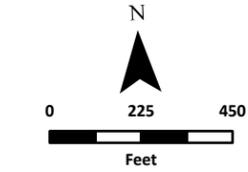
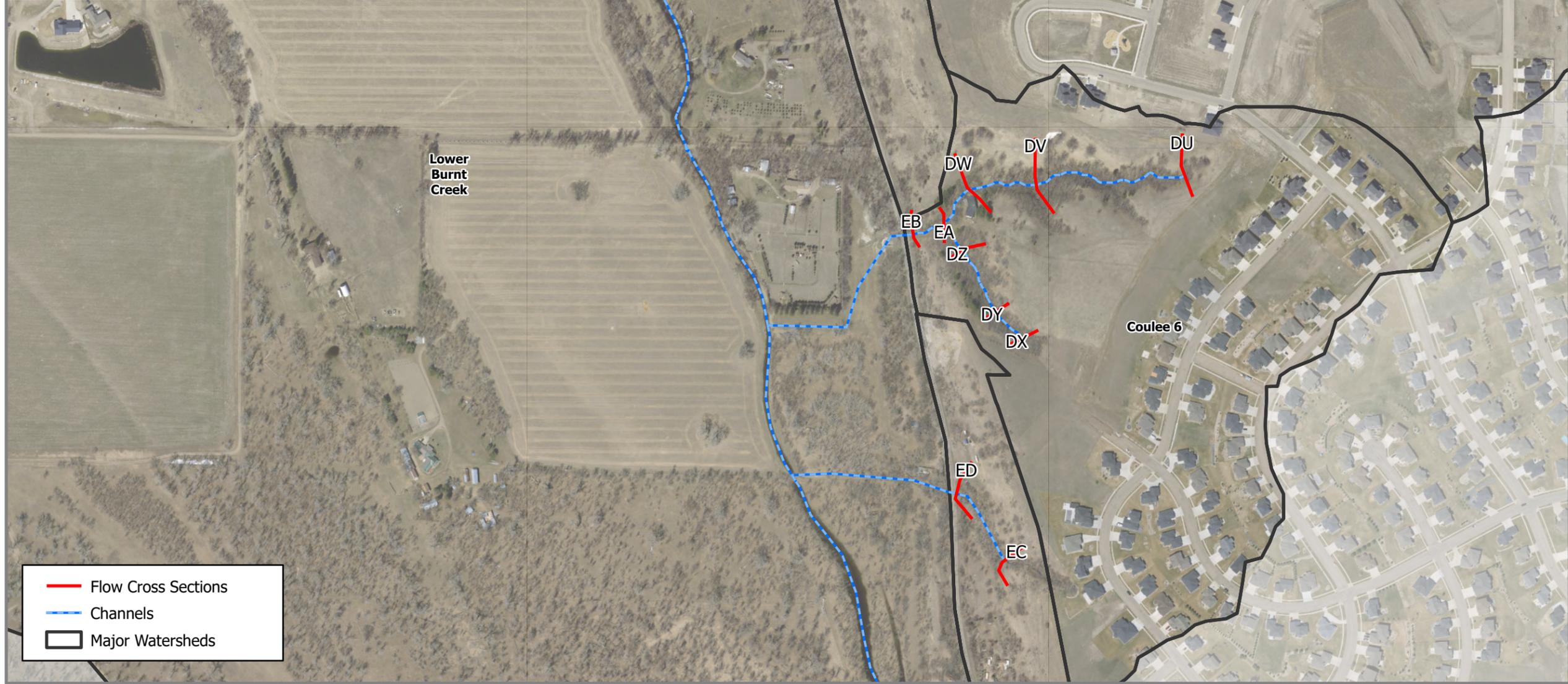
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Cross Section ID	Design Flow (cfs)			
	2-year	10-year	25-year	100-year
DF	9.9	24.7	41.8	78.2
DG	0.4	6.1	13.7	31.4
DH	17.4	53.6	95.8	184.7
DI	19.7	65.2	116.8	225.5
DJ	0.1	2.3	5.3	12.4
DK	12.9	38.2	66.0	124.9
DL	19.2	64.8	116.4	224.9
DM	1.8	6.7	13.2	28.2
DN	2.6	12.3	24.3	50.9
DO	5.4	15.2	29.5	60.8
DP	23.7	85.1	156.2	304.7
DQ	0.2	3.3	7.4	16.8
DR	1.0	8.4	16.7	35.0
DS	23.7	92.6	178.8	338.7
DT	21.6	69.8	164.3	335.0
DU	7.9	13.8	19.8	32.1
DV	15.3	29.5	43.4	71.3
DW	17.3	35.8	53.6	89.8
DX	9.6	16.9	24.1	38.6
DY	9.6	16.9	24.1	38.6
DZ	9.5	16.8	24.0	38.5
EA	22.9	44.7	77.9	140.2
EB	24.7	51.1	85.9	162.7
EC	11.2	22.1	31.6	50.3
ED	23.8	48.8	70.1	110.5



1 inch equals 450 feet



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Bismarck
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Figure 4.4

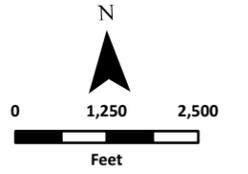
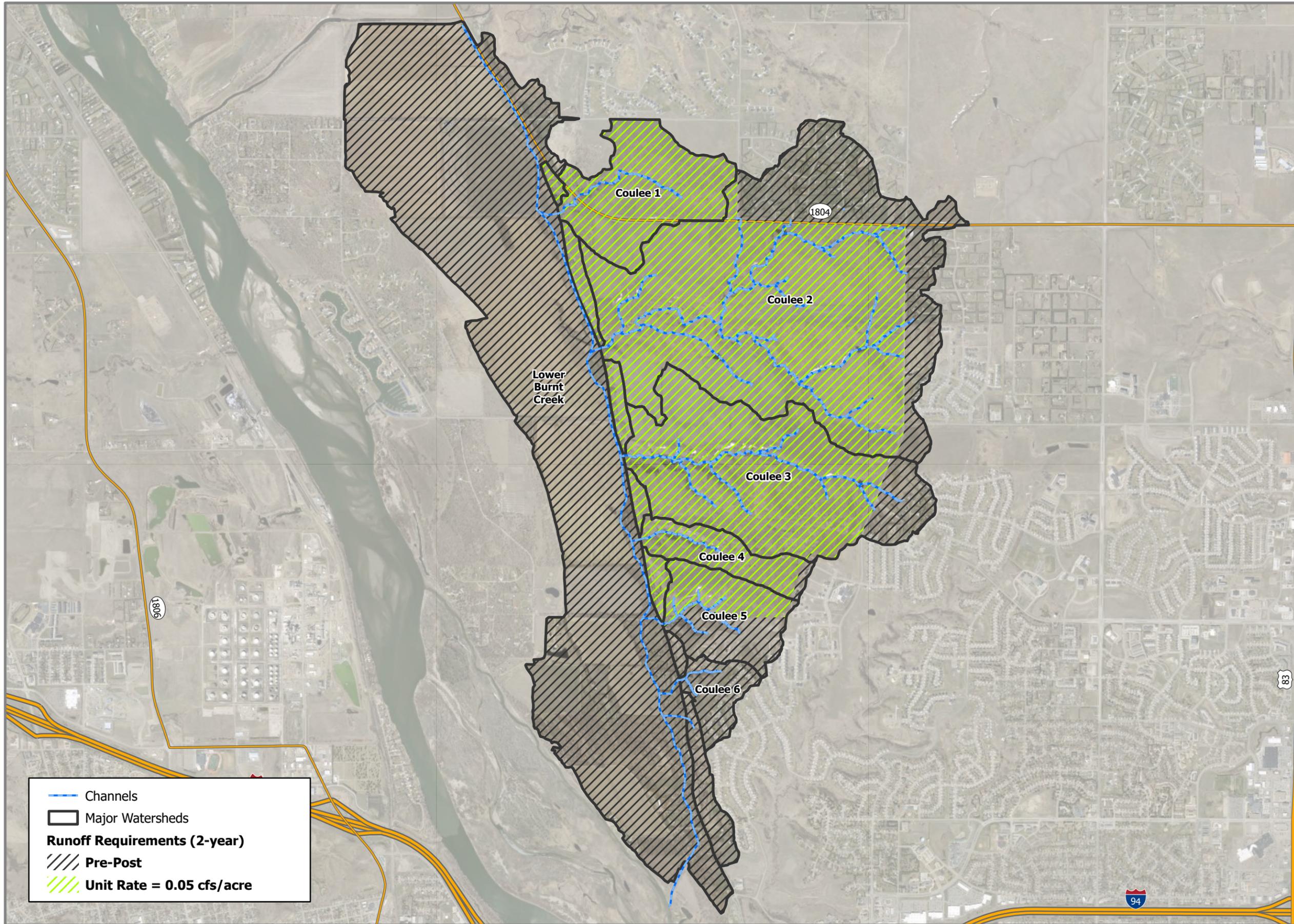
**DESIGN FLOWS
COULEES 5 & 6**

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Figure 5

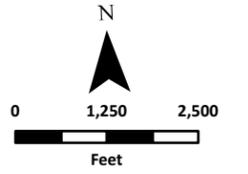
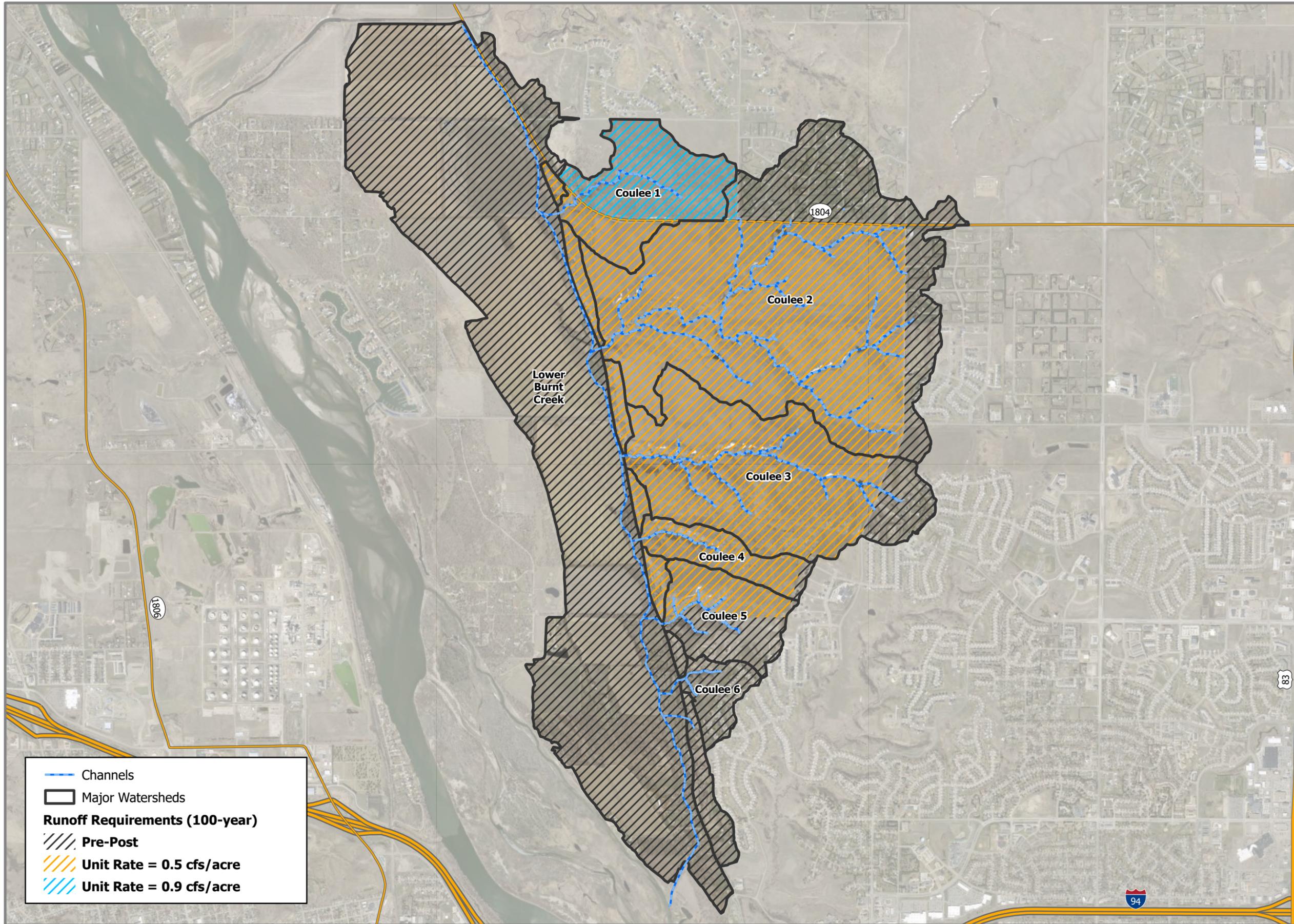
2-YEAR RUNOFF REQUIREMENTS

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Figure 6

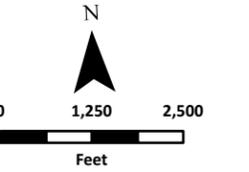
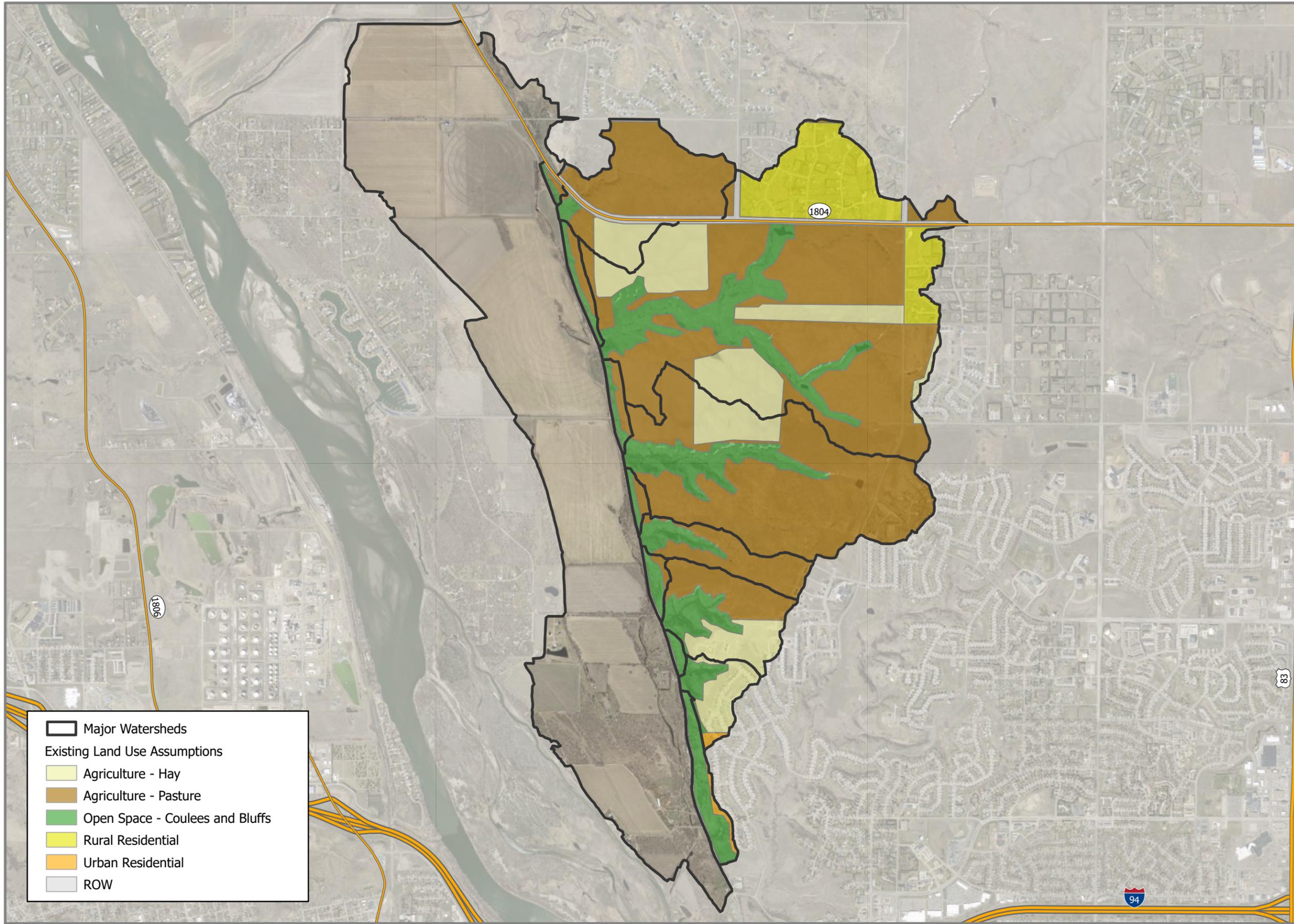
100-YEAR RUNOFF REQUIREMENTS

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Figure 7

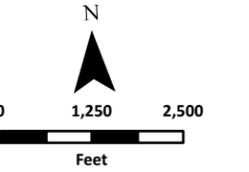
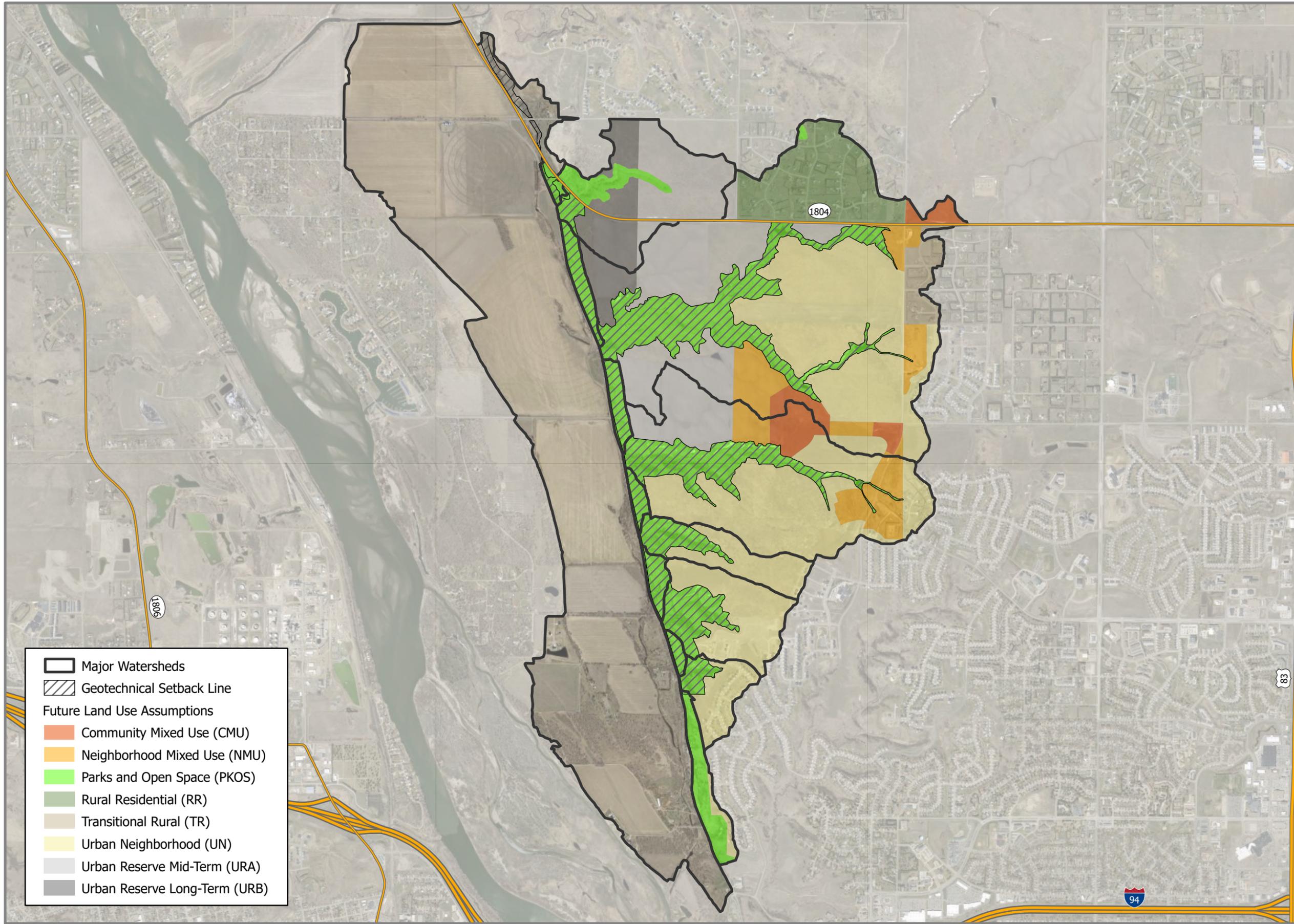
**EXISTING
LAND USE
ASSUMPTIONS**

ASH-WARD WATERSHED
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Bismarck
Burleigh County, ND

Figure 8

**MASTER PLAN
LAND USE
ASSUMPTIONS**

ASH-WARD WATERSHED
MASTER PLAN UPDATE

Date: 11/25/2024



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4.3 UNIT RATE METHOD PERFORMANCE

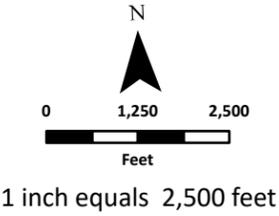
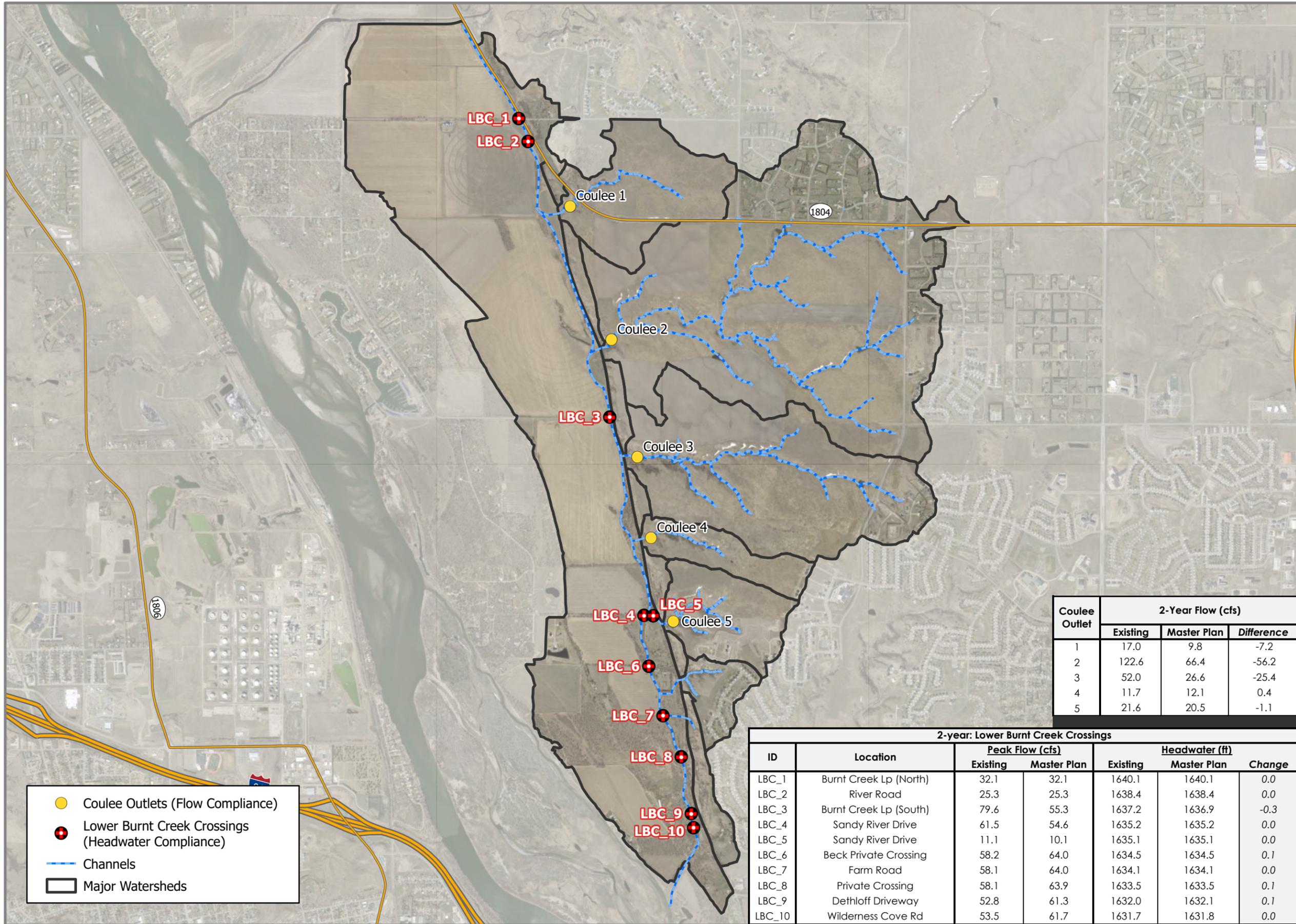
The performance of the Unit Rate Method compared to existing conditions is discussed in this section. **Figure 9** and **Figure 10** demonstrate compliance with this Master Plan’s goals and include tables presenting existing and master planned flow conditions at the outlets of Coulees 1-5 near River Road as well as flow and headwater conditions at crossings along Lower Burnt Creek. Peak flows in Coulees 1-5 are significantly reduced relative to existing conditions, resulting in the notable coulee flow reduction presented on the tables in **Figure 9** and **Figure 10** and the road overtopping reduction presented in **Table 3**.

Over detaining runoff using a Unit Rate approach for the Ash-Ward Coulee Watershed is beneficial for reducing shear stress in the coulees, reducing existing road overtopping, and addressing runoff volume driven issues, such as along Lower Burnt Creek. The increased volumes of runoff from urbanization of the Ash-Ward Coulee Watershed (**Table 2**) have the potential to increase negative impacts along Lower Burnt Creek, however, the selected Unit Rates were developed to comply with the Stormwater Master Plan goals (**Section 2.0**) which limit headwater increases along Lower Burnt Creek to 0.1 ft of existing conditions. Shear stress in the major coulees for existing and master planned conditions is presented in **Figure 11** and **Figure 12** for the 2-year event and in **Figure 13** and **Figure 14** for the 100-year event.

Table 3: River Road Overtopping

Location	River Road Overtopping Flows (cfs)					
	Existing				Full Buildout, Unit Rate	
	2-year	10-year	25-year	100-year	2-year	100-year
Coulee 1	0.0	9.5	63.5	141.0	0.0	57.2
Coulee 2	0.0	25.2	402.4	1374.3	0.0	98.2
Coulee 3	0.0	67.8	241.6	684.6	0.0	110.7
Coulee 4	0.0	0.0	0.0	90.8	0.0	3.6
Coulee 5	0.0	0.0	54.8	220.2	0.0	106.5

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Burleigh County, ND

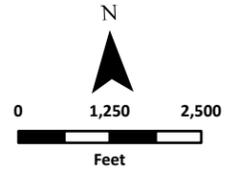
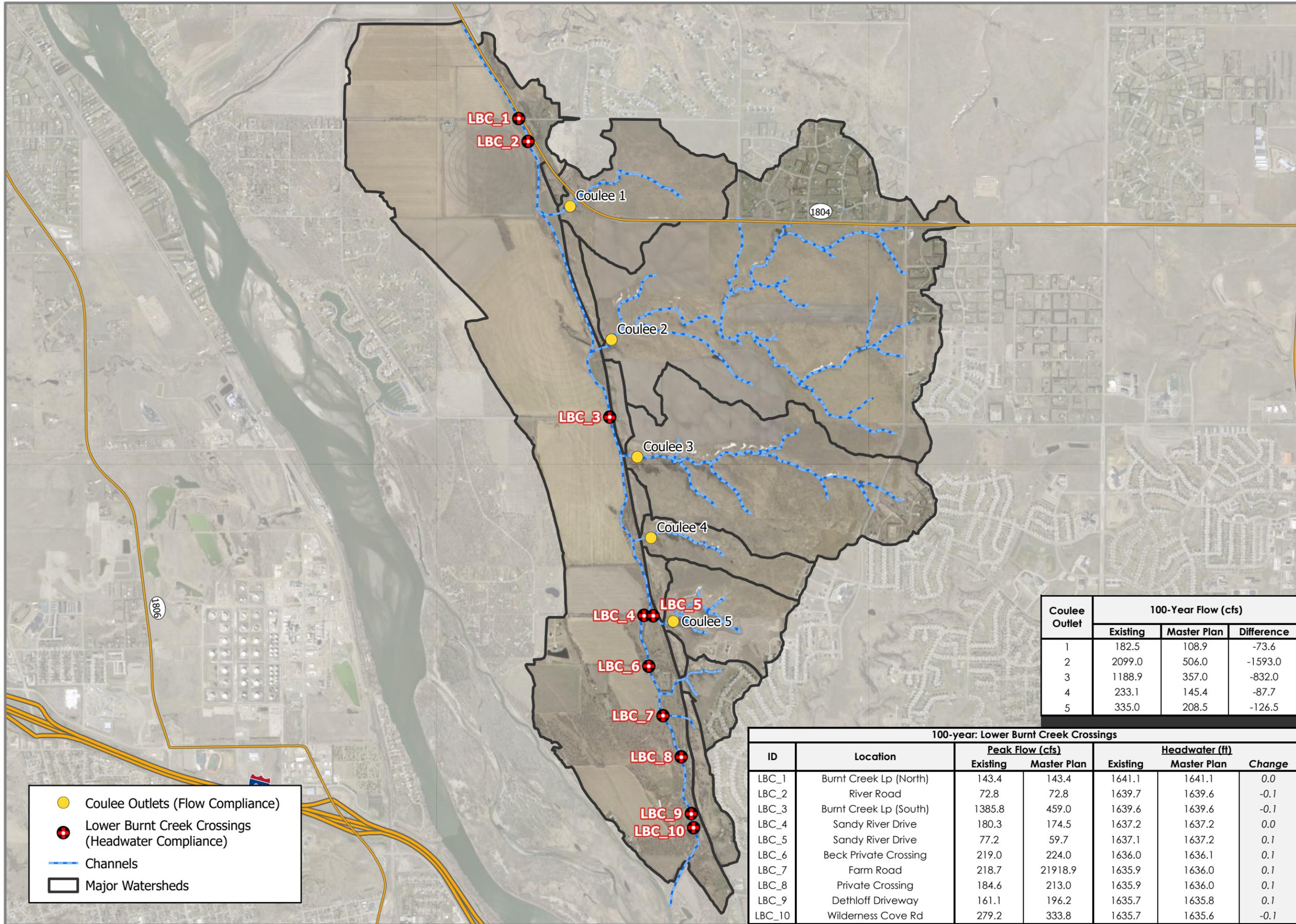
Figure 9
**2-YEAR
UNIT RATE
PERFORMANCE**

ASH-WARD WATERSHED
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Date: 11/25/2024



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Bismarck
Burleigh County, ND

Figure 10

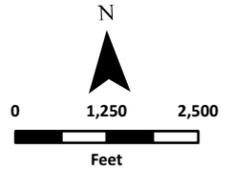
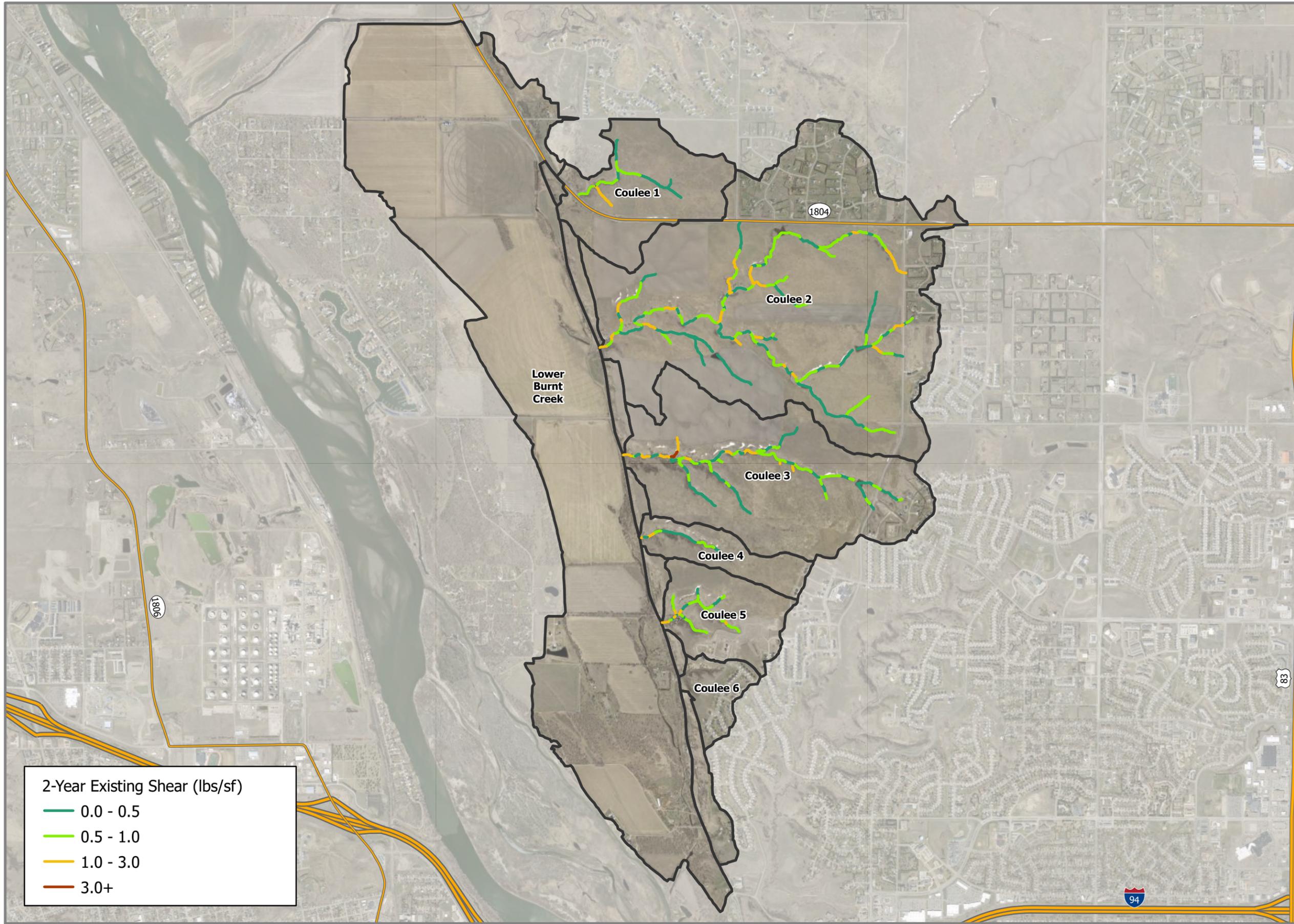
**100-YEAR
UNIT RATE
PERFORMANCE**

ASH-WARD WATERSHED
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Figure 11

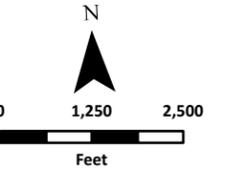
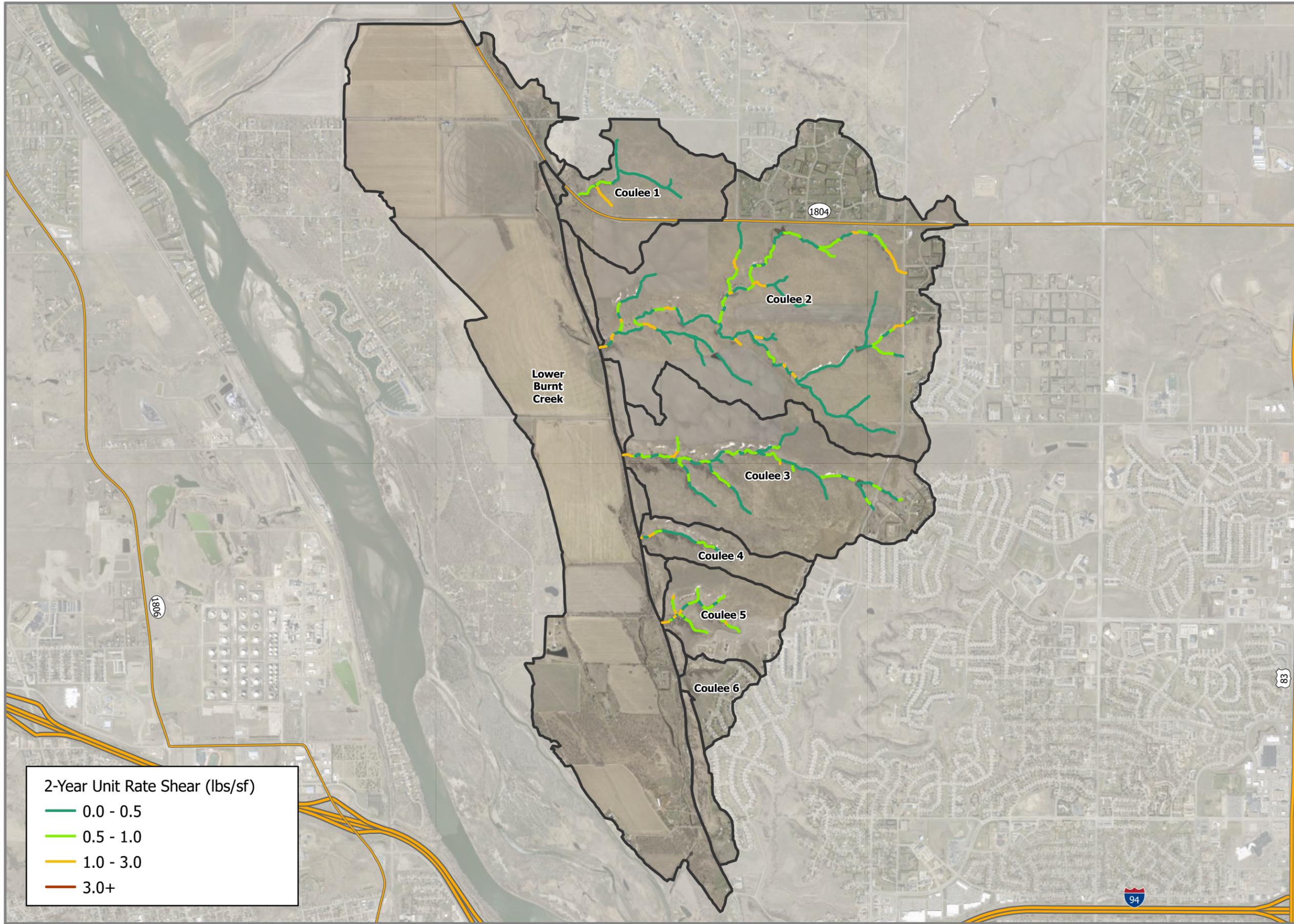
**2-YEAR
EXISTING
SHEAR STRESS**

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Figure 12

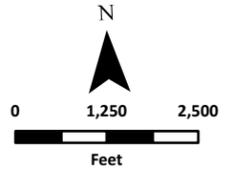
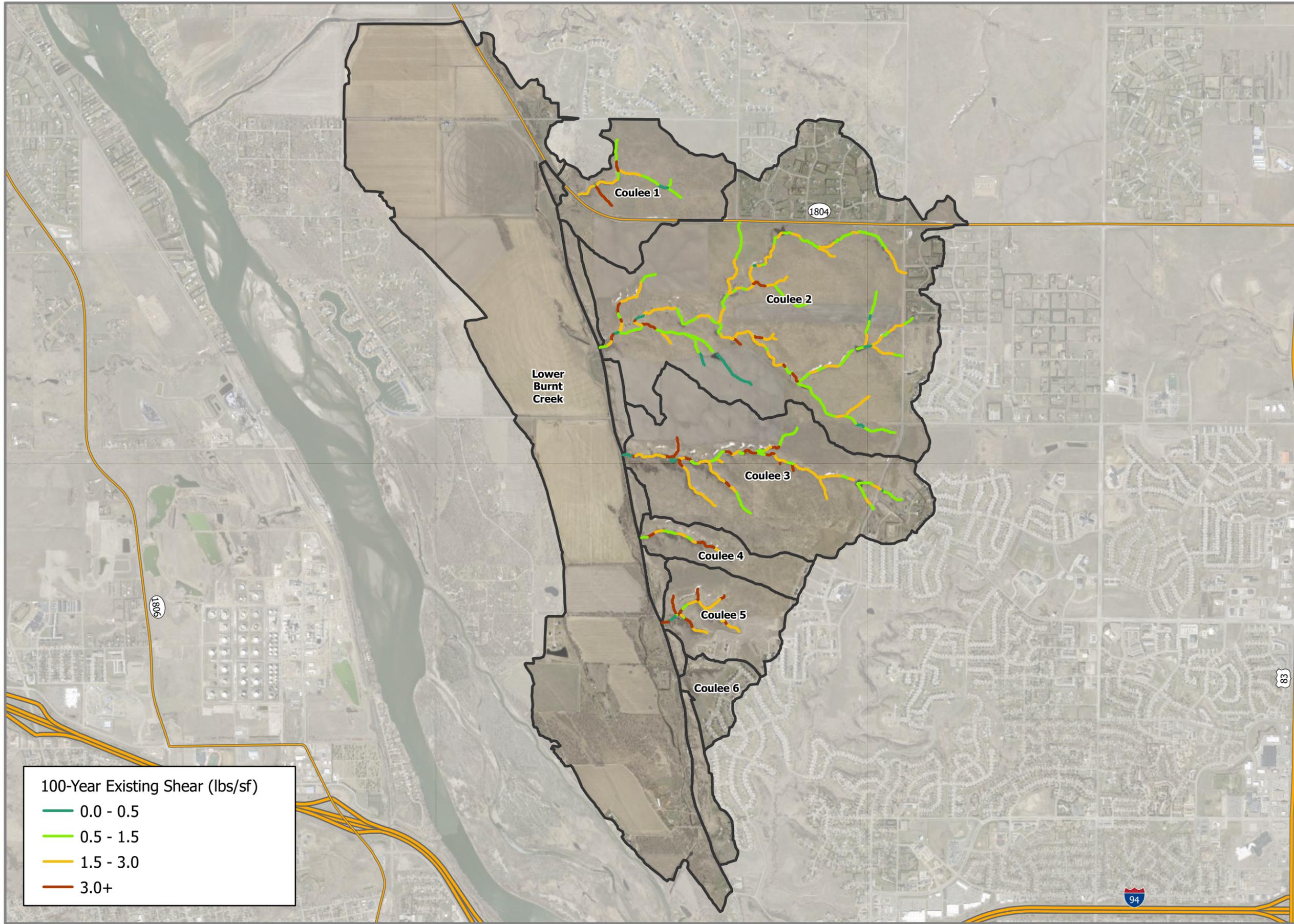
**2-YEAR
UNIT RATE
SHEAR STRESS**

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Figure 13

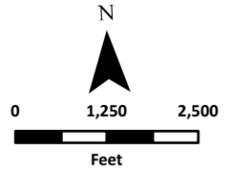
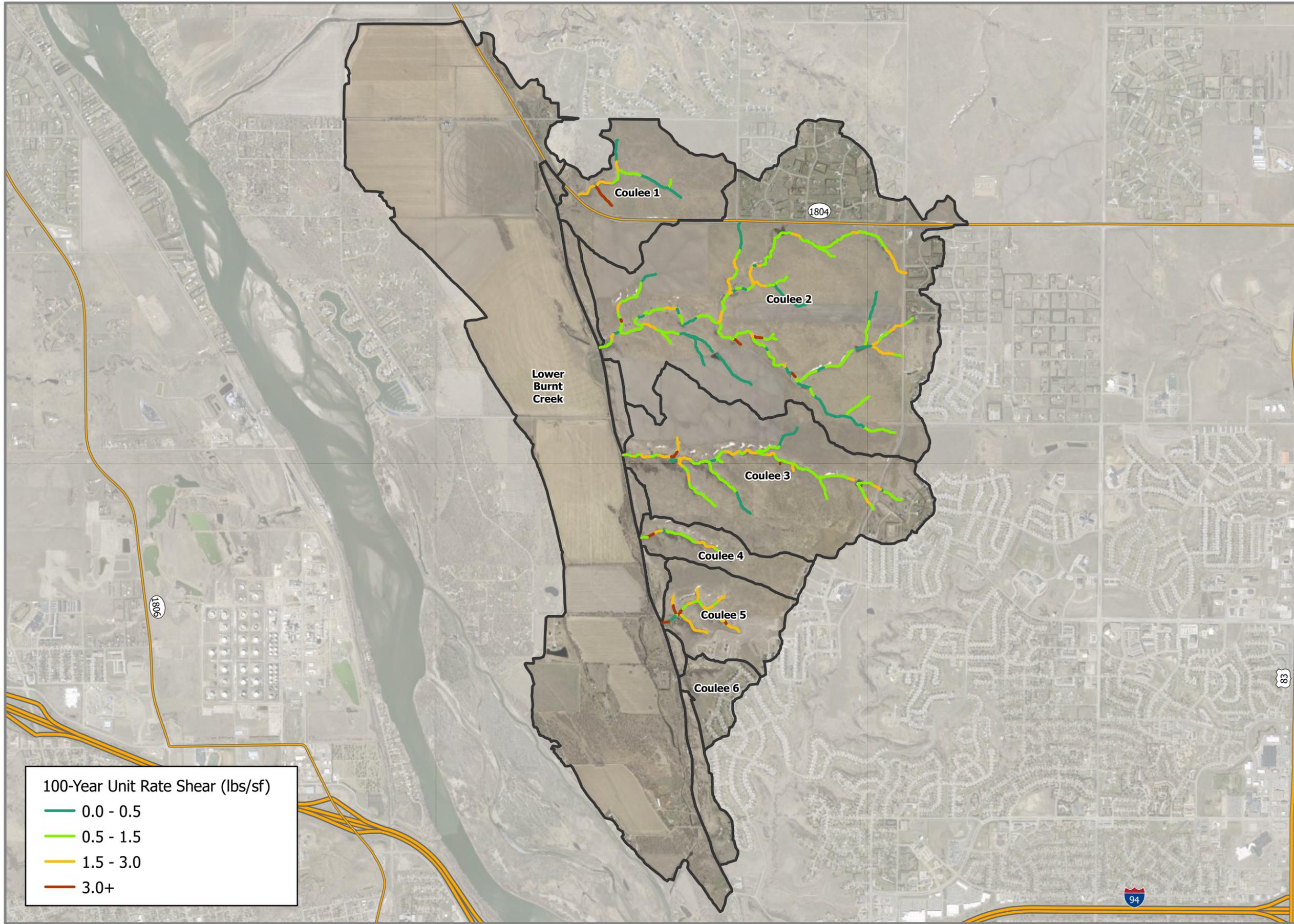
**100-YEAR
EXISTING
SHEAR STRESS**

ASH-WARD WATERSHED
MASTER PLAN UPDATE

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Bismarck
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Figure 14

**100-YEAR
UNIT RATE
SHEAR STRESS**

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4.4 MASTER PLAN REPORTING LOCATIONS

Master Plan performance is presented at designated reporting points throughout the watershed, primarily at Coulee Outlets and crossings along Lower Burnt Creek (LBC), as presented on **Figure 9** and **Figure 10**, which serve as the points of analysis for this master plan, with the Coulee Outlets serving as flow rate points of compliance and the LBC crossings serving as headwater depth points of compliance, per the Master Plan goals from **Section 2.0**. Design flows presented on **Figure 4** act as additional flow reporting points within each coulee, and **Appendix A** presents both existing and full built-out, unit rate flow rates at each cross section. The following sections provide a summary of the specific Points of Compliance and Flow Reporting Points identified or utilized by this Stormwater Master Plan.

4.4.1 Road Crossing Design Flow Cross Sections

Flow reporting cross sections were placed incrementally along each of the major coulees in the Ash-Ward Coulee Watershed to provide design flow information for future crossings of the drainageways. In general, the cross sections are intended to provide design flow data that can be interpolated to determine the applicable flow for any location. The design flow rates match existing conditions runoff rates due to the likelihood of road crossing construction preceding full buildout of the watershed upstream of the crossing and because the existing conditions runoff is almost always higher than future conditions due to the recommended Unit Rate approach. In the case of a crossing being proposed after full buildout of the upstream watershed, the City Engineer may consider accepting a different design flow rate, if sufficiently justified.

The flow reporting cross sections are presented on **Figure 4** which includes an overview figure and four additional coulee specific maps that present the design flow rates.

4.4.2 Points of Compliance

Points of compliance are key locations where changes in flow rate or flow depth could have adverse impacts to infrastructure or downstream users. Points of compliance were assessed throughout this Master Planning process to ensure the Stormwater Master Plan goals are achieved. The following Points of Compliance were identified and are presented on **Figure 9** and **Figure 10** along with tables presenting existing and master plan (full buildout, unit rate) flows and headwater elevations for the 2- and 100-year storm events.

1. Bottom of Coulees 1-5 (See **Figure 9** and **Figure 10**)
2. LBC Crossings (See **Figure 9** and **Figure 10**)

4.5 STORMWATER COMPLIANCE REQUIREMENTS

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

4.5.1 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 (SWDSM). Specific applicable criteria are as follows:

1. Unit Rate recommendations and proposed infrastructure is 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 Stormwater 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 Stormwater Master Plan, "pre-development" is defined as current conditions and existing land use including previously approved temporary stormwater ponds.
 - c. This Stormwater Master Plan utilizes a 24-hour storm consistent with the City's SWDSM.
 - d. The Unit Rate Method may require utilizing smaller than the 4-inch diameter minimum orifice allowed by the SWDSM, if approved by the City Engineer. **Figure 15** demonstrates a schematic design of an engineered outlet for low flow protection.
- 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.
- Future road crossing structures are to be 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.

4.5.2 County Requirements

For the purposes of this Stormwater Master Plan, all areas within the Ash-Ward Coulee Watershed are considered to be within the jurisdiction of the City of Bismarck.

4.5.3 State Requirements

Public highways, streets, or roads in the Ash-Ward Coulee Watershed shall be designed to meet the requirements of NDAC Article 89-14 Public Highway Stream Crossings. In general, the requirements of NDAC 89-14 are summarized as follows:

1. Design flood frequency is determined by NDAC Section 89-14-01-03 and summarized below.
 - a. For regional and urban state highway roads in the urban system, bridges, box culverts, and roadway culverts shall be designed to not overtop in the 25-year event.
 - b. For non-interstate state highway roads in the rural system, roadway culverts shall be designed to not overtop in the 25-year event.
 - c. For major collectors in the county rural system, roadway culverts shall be designed to not overtop in the 25-year event.
 - d. The table presented in NDAC Section 89-14-01-03 should be used to confirm all design flood frequencies and for all situations not referenced above.
2. Allowable headwater over culvert crossings is determined by NDAC Section 89-14-01-05 and summarized below.
 - a. The allowable headwater when passing the design flood frequency varies from pipe diameter plus 2 feet, to 1.5 or 2 times the pipe diameter, depending on the streambed slope and pipe size. The table in NDAC Section 89-14-01-05 shall be referenced for allowable headwater.

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 the future onsite post-construction BMPs 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.

4.5.4 Street Crossing Criteria Hierarchy

To balance the potential impact of headwater elevations at existing and future roadway crossings, the hierarchy presented in **Table 4** shall be utilized to size the minimum culvert pipe size at each significant crossing. These standards are generally consistent with Table 6-8 of the SWDSM.

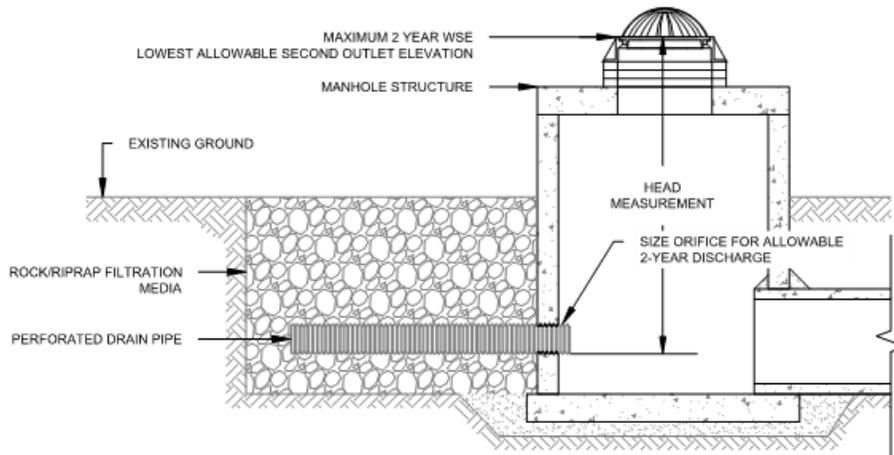
Table 4: Stream Crossing Design Hierarchy

Situation	Road Crossing Criteria
All Street Crossings	<ul style="list-style-type: none"> ➤ 25-year HW < Allowable HW per table in NDAC 89-14-01-05 ➤ 25-year HW < Overtopping Elevation
Local Road Crossings	<ul style="list-style-type: none"> ➤ 25-year HW < 1.5 x Culvert Diameter ➤ 100-year HW < 6" above highest point on street section (typically the centerline) ➤ If feasible, maintain freeboard from overtopping in the 100-year event.
Collector & Arterial	<ul style="list-style-type: none"> ➤ 100-year HW < Overtopping Elevation ➤ If feasible, maintain 1-foot of freeboard from overtopping in the 100-year event.

Notes:

"HW" = Headwater measured from the channel invert.

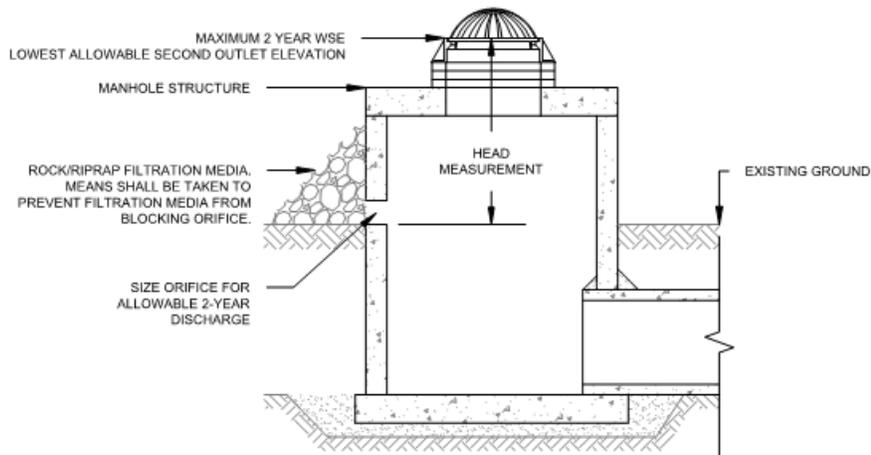
Figure 15: Engineered Outlet for Low Flow Protection



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

4.6 ASH-WARD COULEE 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 Ash-Ward Coulee Watershed, watershed specific revisions to the requirements of the SWDSM are recommended for development and redevelopment activities in the Stormwater Master Plan area.

The following sections and tables summarize the recommended modifications to the performance requirements, analysis and reporting requirements, and design standards and analysis methodologies for the Ash-Ward Coulee Watershed Stormwater Master Plan area.

Not every development or redevelopment scenario has been identified during the development of the Ash-Ward Coulee Watershed Stormwater 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.

4.6.1 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 5** of the Ash-Ward Coulee Watershed Stormwater Master Plan and *Section 4.1.1* of the SWDSM.

Table 5: Point of Discharge Peak Flow Compliance Unit Rate Method

Point of Discharge Location	Peak Discharge Control Requirement
Public Storm Sewer System, New Outfalls to Surface Waters, or Other Location Designated by the City Engineer	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: <ul style="list-style-type: none"> 2-year event = 0.05 cfs/acre 100-year event = 0.50 cfs/acre (South of ND 1804) 100-year event = 0.90 cfs/acre (North of ND 1804) The Unit Rate recommendation accounts for an amount of pervious ground, equaling up to exceed 10% of site's total area, discharging directly offsite without attenuation in a Post-Construction BMP.

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

1. Projects located inside of the Ash-Ward Coulee Watershed Stormwater Master Plan area that require a PCSMP will need to provide on-site or local post-construction BMPs to address the peak discharge compliance performance requirements of **Table 5**.
2. The allowable post-construction discharge is determined by the total site area times the Unit Rate values presented in **Table 5**. A maximum of 10% of the site area, if entirely pervious, may be routed directly offsite if justified by topographic or other constraints.
3. Area designated as "Parks and Open Space" in the master planned land use assumptions (**Figure 8**) that remain pervious or undeveloped 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. Areas inside of the identified setbacks shall not be developed and are not required to meet the requirements of the Unit Rate allowable discharge, but instead shall maintain existing runoff rates. Minor improvements within the setback areas, such as road crossings, shall only provide attenuation if deemed necessary by the City Engineer.
5. Projects located inside of the Ash-Ward Coulee Watershed Stormwater Master Plan that require a PCSMP and are 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 post-construction 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 Ash-Ward Coulee Watershed Stormwater Master Plan area, the existing conditions hydrologic summary and analysis is to be replaced with:

Summary table for Points of Analysis that includes:

1. Tributary Area of Onsite Project;
2. Tributary Area of Offsite Run-on Areas;

3. Report the Post-Construction Allowable Unit Rate Runoff consistent with **Table 6**; and
4. Reporting of total storm volumes is not required.

The following is a recommended summary table to be included in SWMP submittals for the Ash-Ward Coulee Watershed as required by the PCSMP Checklist (SM-05).

Table 6: PCSMP SWMP Recommended Unit Rate Report Table

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

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

Documentation showing how the entire site, 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. Offsite Flows
 - a. BMPs shall be designed to meet Unit Rate requirements in the absence of offsite flow considerations. BMPs shall then account for offsite flows by:
 - i. Routing the offsite flows around the proposed detention basin; or
 - ii. Routing undeveloped flows through the onsite detention basin and including an outlet structure or stabilized overflow structure that can accommodate the offsite flows without impacting the Unit Rate compliance of onsite runoff.

2. Engineered outlets for Unit Rate detention basins smaller than 4-inches in diameter are to provide clog protection consistent with **Figure 15** or another 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, if approved by the City Engineer.

Analysis Methodologies

Per the requirements of the SWDSM, there are no revisions specific to the Ash-Ward Coulee Watershed Stormwater Master Plan.

4.6.2 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, there are no revisions specific to the Ash-Ward Coulee Watershed Stormwater Master Plan.

Analysis and Reporting Requirements

Per the requirements of the SWDSM, there are no revisions specific to the Ash-Ward Coulee Watershed Stormwater 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 15** or other approved method.

Analysis Methodologies

Per the requirements of the SWDSM, there are no revisions specific to the Ash-Ward Coulee Watershed Stormwater Master Plan.

Post Construction Drainage and Conveyance

Per the requirements of the SWDSM, there are no revisions specific to the Ash-Ward Coulee Watershed Stormwater Master Plan

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Table 7: Ash-Ward Coulee Watershed 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	<ol style="list-style-type: none"> 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." Post-Construction Unit Rate values are: <ul style="list-style-type: none"> ➤ 2-year event = 0.05 cfs/acre ➤ 100-year event = 0.50 cfs/acre (South of ND 1804) ➤ 100-year event = 0.90 cfs/acre (North of ND 1804) The Unit Rate shall be applied to the entire development area (pervious and impervious) including any areas diverted from the peak flow compliance BMP. 10% of the site area may be diverted from the post-construction BMP due to identified constraints. If topographical challenges or other constraints necessitate it, pervious areas exceeding the allocated 10% may be allowed to runoff without being routed through the post-construction BMP, however, the additional runoff shall be minimized and must be approved by the City Engineer. Areas designated as "Parks and Open Space" in the master plan land use assumptions (Figure 8) that remain open space or pervious area are exempt from meeting the Unit Rate allowable discharge. Demonstration of compliance with design storms other than the 2- and 100-year storm events is not required if the allowable Unit Rate is achieved for the 2- and 100-year storms. Undeveloped offsite flows are to be determined per the requirements of the SWDSM, rather than the Unit Rate. 	<ol style="list-style-type: none"> Report the allowable "Unit Rate" discharge from the entire site. <ol style="list-style-type: none"> Existing Condition hydrologic analysis, or reporting, is not required for projects utilizing the Unit Rate Method. 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 6) 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. The total rate discharge from the site, including any pervious areas not routed through the BMP, must be less than the allowable Unit Rate, unless otherwise approved by the City Engineer. 	<ol style="list-style-type: none"> Offsite Flows <ol style="list-style-type: none"> BMPs shall be designed to meet Unit Rate requirements in the absence of offsite flow considerations. BMPs shall then account for offsite flows by: <ol style="list-style-type: none"> Routing the offsite flows around the proposed detention basin; or Routing undeveloped flows through the onsite detention basin and including an outlet structure or stabilized overflow structure that can accommodate the offsite flows without impacting the Unit Rate compliance of onsite runoff. Unit Rate flows may necessitate engineered peak flow outlets smaller than 4-inches in diameter. In such situations, low flow structures with appropriate clog protection shall be utilized consistent with Figure 15 or another approved method. Pervious area 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. This area may exceed 10% due to topographical constraints if the area remains pervious and is approved by the City Engineer. 	<p>Per the SWDSM.</p>
SWDSM Section 5.0 - Post-Construction Stormwater Quality Compliance	<p>Per the SWDSM.</p>	<p>Per the SWDSM.</p>	<ol style="list-style-type: none"> All impervious areas must be routed through the post-construction water quality BMP. Post-construction water quality requirements may necessitate engineered water quality outlets smaller than 2-inches in diameter. In such situations, low flow structures with clog protection shall be utilized consistent with Figure 15 or another approved method. 	<p>Per the SWDSM.</p>
SWDSM Section 6.0 - Post Construction Drainage and Conveyance	<ol style="list-style-type: none"> Street Drainage per the SWDSM. Storm Sewer System per the SWDSM. Culverts per the SWDSM except: <ol style="list-style-type: none"> Design flow rates, provided on Figure 4 were developed by reporting existing flow rates to ensure crossing design compliance and allow crossings to precede full upstream buildout. Local, Collector, and Arterial Streets: per the SWDSM. Design with flows from Figure 4. Open Channels per the SWDSM. Outlet Protection per the SWDSM. 	<p>Per the SWDSM.</p>	<p>Per the SWDSM.</p>	<p>Per the SWDSM.</p>

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5.0 IMPROVEMENT PLAN

Included in the development of the Stormwater Master Plan are specific improvement recommendations necessary to achieve the Stormwater Master Plan goals. In general, because the stormwater management concept for this Stormwater Master Plan is to utilize local BMPs with a Unit Rate approach there are no specific regional improvements to be implemented other than at future road crossings.

5.1 ROAD CROSSINGS

Conceptual design for future roadway crossings were not developed as part of this Master Plan due to the unknown location of future road alignments and crossing locations.

Under full buildout conditions of the watershed, it was determined that an additional 36-inch culvert is likely required at the Wilderness Cove Road crossing of Lower Burnt Creek, consistent with the improvement recommendation for this crossing in the 2015 Ash & Ward Coulee Master Plan. The new culvert will be approximately 50 feet long and may be CMP, HDPE, or RCP, as directed by the City Engineer. Construction of this additional culvert may be undertaken at any time, as desired by the City or County, or as dictated by actual site conditions and flood impacts.

5.2 STORM SEWER TRUNK MAINS

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

5.3 REGIONAL PEAK DISCHARGE BMPS

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

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Appendix A: Cross Section Flow Rates (Existing and Full Buildout, Unit Rate)

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Appendix A: Cross Section Flow Rates (Existing and Full Buildout, Unit Rate)

Cross Section ID	Existing (Design) Flow (cfs)				Unit Rate Flow (cfs)		Cross Section ID	Existing (Design) Flow (cfs)				Unit Rate Flow (cfs)	
	2-year	10-year	25-year	100-year	2-year	100-year		2-year	10-year	25-year	100-year	2-year	100-year
A	5.2	21.0	37.3	71.3	1.2	19.0	BR	41.9	242.0	456.5	857.4	13.1	177.4
B	10.4	52.0	95.2	186.2	3.0	51.5	BS	41.6	239.0	452.9	855.4	12.8	176.5
C	9.4	55.2	103.4	204.8	3.0	53.8	BT	3.0	10.0	16.4	29.1	0.9	6.3
D	8.9	53.3	106.7	215.4	3.0	57.6	BU	43.1	248.1	472.3	895.8	13.4	183.6
E	13.4	76.5	153.6	307.4	3.3	75.5	BV	42.5	243.4	471.6	895.5	13.3	182.1
F	13.9	100.5	164.3	349.0	6.0	92.4	BW	6.3	17.6	27.4	46.4	0.5	4.4
G	15.1	105.1	173.6	370.2	9.7	122.7	BX	6.6	24.1	44.2	85.7	1.3	7.1
H	14.3	31.7	41.4	57.2	10.4	30.0	BY	3.8	26.9	50.0	101.0	1.7	10.0
I	14.2	31.5	41.1	56.9	10.3	30.0	BZ	5.3	39.1	79.2	155.3	2.4	14.3
J	14.0	34.7	50.4	87.3	10.0	32.2	CA	11.1	45.0	95.6	191.7	7.5	54.1
K	10.2	23.5	36.6	63.4	9.9	40.4	CB	16.9	29.6	44.6	67.4	20.3	34.6
L	16.8	38.6	58.9	99.6	10.1	42.2	CC	7.0	23.1	37.6	66.4	6.5	65.6
M	35.1	89.5	140.0	242.0	26.8	144.4	CD	9.8	40.1	68.1	124.2	6.6	66.6
N	36.3	95.2	150.1	260.4	27.5	157.6	CE	9.0	27.8	44.6	77.6	7.5	68.4
O	39.0	106.1	169.1	296.8	27.7	165.7	CF	23.5	91.6	153.9	277.8	14.2	136.5
P	43.9	125.0	201.0	354.4	27.8	169.9	CG	4.1	24.3	45.1	89.1	1.5	13.6
Q	46.1	135.3	221.2	392.5	27.1	179.5	CH	33.1	141.7	243.6	449.5	14.6	143.3
R	59.7	163.7	259.0	447.4	44.2	207.3	CI	33.3	156.9	275.8	521.3	14.9	148.0
S	60.0	171.9	279.4	495.7	42.9	213.0	CJ	33.8	163.6	290.0	553.2	15.1	150.5
T	60.1	171.1	280.4	501.9	42.8	211.7	CK	2.8	20.0	38.8	80.3	1.8	10.7
U	7.8	24.3	39.1	68.2	1.5	11.3	CL	38.5	194.1	350.2	680.0	15.6	159.2
V	21.5	62.8	99.3	170.7	1.7	23.5	CM	2.7	18.6	35.8	72.2	1.5	10.8
W	71.6	218.1	366.1	674.5	44.6	229.3	CN	38.7	195.8	354.8	717.7	16.1	176.6
X	71.1	217.2	364.5	671.4	44.3	228.2	CO	42.3	221.9	406.7	830.0	21.4	227.9
Y	84.5	261.6	434.4	801.7	52.0	272.7	CP	1.3	12.3	25.5	54.4	1.3	8.4
Z	84.1	265.3	442.1	819.2	52.0	279.0	CQ	6.4	18.8	37.2	81.0	5.2	33.0
AA	110.3	503.2	917.1	1724.8	59.2	459.3	CR	0.7	10.2	22.9	52.4	1.9	12.7
AB	109.8	499.0	910.6	1720.1	58.9	457.3	CS	39.7	219.7	398.1	823.7	19.4	226.3
AC	111.0	499.7	916.4	1719.0	60.0	462.9	CT	3.6	14.5	33.1	73.0	2.5	26.8
AD	110.1	490.7	901.2	1717.9	60.0	458.1	CU	43.4	247.5	449.4	947.9	25.6	297.4
AE	110.9	489.4	910.3	1742.8	60.9	464.3	CV	16.6	53.8	87.5	154.2	3.8	25.6
AF	111.0	537.5	1066.7	2214.6	61.0	518.3	CW	16.6	53.8	87.4	154.2	3.8	25.6
AG	115.5	557.4	1098.5	2226.5	63.0	518.5	CX	51.2	285.2	532.0	1097.2	24.8	308.0
AH	115.1	525.7	975.7	1844.4	62.8	487.5	CY	51.1	289.1	540.7	1121.7	25.2	329.5
AI	121.4	543.7	997.3	1873.3	64.3	497.3	CZ	53.2	302.6	569.5	1194.1	26.7	360.5
AJ	23.9	94.6	159.3	289.5	4.5	50.1	DA	2.1	16.5	33.2	69.7	1.8	12.0
AK	122.6	547.7	996.4	1877.7	65.1	506.0	DB	2.8	20.9	42.2	89.4	2.4	21.7
AL	123.0	548.7	996.6	2391.9	65.4	508.5	DC	4.9	29.2	57.8	118.7	3.7	36.9
AM	15.0	41.6	66.3	116.6	15.3	90.0	DD	6.7	37.3	72.6	145.7	6.3	61.6
AN	12.8	33.9	54.2	95.8	15.1	85.4	DE	8.2	43.1	82.2	162.2	8.1	76.7
AO	11.5	29.8	47.6	83.9	15.2	84.9	DF	9.9	24.7	41.8	78.2	10.4	76.7
AP	7.0	21.6	34.6	60.3	1.0	8.3	DG	0.4	6.1	13.7	31.4	1.1	6.9
AQ	14.0	38.9	60.7	103.1	0.8	12.7	DH	17.4	53.6	95.8	184.7	13.3	107.6
AR	11.1	29.8	45.8	76.5	1.1	9.0	DI	19.7	65.2	116.8	225.5	16.2	132.7
AS	4.0	16.8	29.2	54.2	0.8	7.6	DJ	0.1	2.3	5.3	12.4	0.4	2.6
AT	1.4	9.9	18.7	37.4	0.6	6.1	DK	12.9	38.2	66.0	124.9	10.9	88.0
AU	5.2	25.6	46.0	88.3	1.4	13.4	DL	19.2	64.8	116.4	224.9	15.8	132.4
AV	1.0	7.9	15.8	32.7	0.7	5.2	DM	1.8	6.7	13.2	28.2	2.0	27.9
AW	1.0	7.9	15.7	32.6	0.7	5.2	DN	2.6	12.3	24.3	50.9	2.8	43.2
AX	7.2	26.1	44.7	81.9	0.7	11.5	DO	5.4	15.2	29.5	60.8	5.6	46.8
AY	33.8	119.8	198.8	355.5	16.2	132.9	DP	23.7	85.1	156.2	304.7	20.7	190.2
AZ	24.5	78.3	127.8	225.6	15.6	110.9	DQ	0.2	3.3	7.4	16.8	0.7	4.0
BA	11.5	33.5	53.2	92.2	14.3	87.8	DR	1.0	8.4	16.7	35.0	1.3	18.5
BB	16.5	50.0	80.8	141.1	14.5	91.5	DS	23.7	92.6	178.8	338.7	21.3	207.5
BC	5.9	19.6	32.0	56.6	3.1	31.2	DT	21.6	69.8	164.3	335.0	20.3	208.5
BD	4.1	13.7	22.4	39.6	3.1	30.9	DU	7.9	13.8	19.8	32.1	8.0	31.7
BE	36.3	140.7	238.5	432.9	14.6	133.8	DV	15.3	29.5	43.4	71.3	17.0	72.8
BF	34.7	147.8	257.5	477.9	13.3	138.3	DW	17.3	35.8	53.6	89.8	18.6	87.5
BG	4.1	15.8	26.7	48.8	0.5	6.0	DX	9.6	16.9	24.1	38.6	9.8	38.3
BH	10.0	35.5	58.2	104.2	0.5	12.1	DY	9.6	16.9	24.1	38.6	9.8	38.3
BI	9.4	53.6	94.9	176.3	1.0	13.4	DZ	9.5	16.8	24.0	38.5	9.8	38.3
BJ	14.3	82.0	147.5	275.6	1.4	23.2	EA	22.9	44.7	77.9	140.2	28.6	135.1
BK	3.2	15.6	27.8	53.3	0.7	6.6	EB	24.7	51.1	85.9	162.7	30.0	153.6
BL	12.5	78.4	143.2	270.1	1.4	21.0	EC	11.2	22.1	31.6	50.3	11.6	49.6
BM	13.0	83.1	153.9	293.2	1.7	23.4	ED	23.8	48.8	70.1	110.5	17.6	98.1
BN	14.3	90.5	171.5	334.3	2.2	30.6	EE	22.5	83.0	138.7	250.6	4.5	28.2
BO	39.7	231.6	424.4	806.1	13.7	166.2	EF	21.0	76.4	127.4	230.0	4.0	26.5
BP	39.1	227.0	422.1	779.2	12.8	167.7	EG	19.5	69.9	116.4	209.7	3.6	23.0
BQ	39.4	228.5	426.1	789.6	12.9	170.7							

*Reference Figure 4 for cross section locations.

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Appendix B: NRCS Hydrologic Soil Groups (HSG)

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MAP LEGEND

Area of Interest (AOI)

 Area of Interest (AOI)

Soils

Soil Rating Polygons

 A
 A/D
 B
 B/D
 C
 C/D
 D
 Not rated or not available

Soil Rating Lines

 A
 A/D
 B
 B/D
 C
 C/D
 D
 Not rated or not available

Soil Rating Points

 A
 A/D
 B
 B/D

 C
 C/D
 D
 Not rated or not available

Water Features

 Streams and Canals

Transportation

 Rails
 Interstate Highways
 US Routes
 Major Roads
 Local Roads

Background

 Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
 Web Soil Survey URL:
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Burleigh County, North Dakota
 Survey Area Data: Version 24, Sep 7, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: May 17, 2021—May 30, 2021

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
C132C	Williams-Zahl-Zahill complex, 6 to 9 percent slopes	B	2.2	0.1%
C740A	Temvik silt loam, 0 to 3 percent slopes	B	13.0	0.5%
C740B	Temvik silt loam, 3 to 6 percent slopes	B	33.8	1.3%
C740C	Temvik silt loam, 6 to 9 percent slopes	B	0.5	0.0%
E2651F	Werner-Amor-Arnegard loams, 9 to 50 percent slopes	D	514.3	20.3%
E2747D	Werner-Chama-Sen silt loams, 9 to 15 percent slopes	C	401.7	15.9%
E2969D	Sen silt loam, 9 to 15 percent slopes	C	12.2	0.5%
E2987B	Sen-Chama silt loams, 3 to 6 percent slopes	C	23.3	0.9%
E2987C	Sen-Chama silt loams, 6 to 9 percent slopes	C	179.9	7.1%
E3107F	Cabba-Badland complex, 6 to 70 percent slopes	D	56.8	2.2%
E3753C	Omio-Amor silt loams, 6 to 9 percent slopes	C	242.1	9.6%
E3755A	Temvik-Wilton silt loams, 0 to 3 percent slopes	B	11.1	0.4%
E3763B	Temvik-Wilton-Williams silt loams, 3 to 6 percent slopes	B	151.8	6.0%
E3801A	Mandan-Linton silt loams, 0 to 2 percent slopes	B	106.3	4.2%
E3802B	Linton-Mandan silt loams, 2 to 6 percent slopes	B	438.9	17.3%
E3802C	Linton-Mandan silt loams, 6 to 9 percent slopes	B	197.5	7.8%
E3802E	Linton-Sutley-Mandan silt loams, 9 to 25 percent slopes	B	38.4	1.5%
E3813A	Grassna silt loam, loess, 0 to 2 percent slopes	B	60.9	2.4%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
E3813B	Grassna silt loam, loess, 2 to 6 percent slopes	B	27.9	1.1%
E4033A	Lallie silty clay, 0 to 1 percent slopes, occasionally flooded	C/D	4.5	0.2%
E4105A	Lohler complex, 0 to 2 percent slopes, occasionally flooded	C	11.7	0.5%
E4112A	Lohler silt loam, 0 to 2 percent slopes, occasionally flooded	C	1.2	0.0%
EW	Water		1.6	0.1%
Totals for Area of Interest			2,531.7	100.0%

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

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Appendix C: Geotechnical Evaluation Report (2014)

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Geotechnical Evaluation Report

Ash/Ward Coulee Watershed Storm Water Master Plan
Bismarck, North Dakota

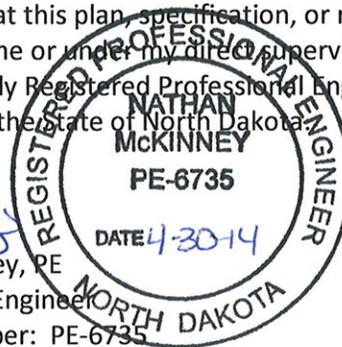
Prepared for

Advanced Engineering and Environmental Services, Inc.

Professional Certification:

I hereby certify that this plan, specification, or 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.


Nathan L. McKinney, PE
Principal / Senior Engineer
Registration Number: PE-6735
April 30, 2014



Project BM-13-04106

Braun Intertec Corporation

April 30, 2014

Project BM-13-04106

Jeff Hruby, PE
Advanced Engineering and Environmental Services, Inc.
1815 Schafer Drive, Suite 301
Bismarck, ND 58501

Re: Ash/Ward Coulee Watershed Storm Water Master Plan
Bismarck, North Dakota

Dear Mr. Hruby:

We are pleased to present this Geotechnical Evaluation Report for the analyses we performed along the river and coulee bluffs in the Ash and Ward Coulee Watersheds in Bismarck, North Dakota. We understand our geotechnical evaluation will be used to determine an appropriate setback for development along the bluffs within these watersheds and will be used to evaluate how storm water storage and conveyance systems may impact slope stability. A detailed summary of our results and recommendations are included in the attached report.

Thank you for making Braun Intertec your geotechnical consultant for this project. If you have questions about this report, or if there are other services that we can provide in support of our work to date, please call Nate McKinney at 701.232.8701.

Sincerely,

BRAUN INTERTEC CORPORATION



Nathan L. McKinney, PE
Principal – Senior Engineer



Steven P. Nagle, PE
Vice President – Principal Engineer

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 - 1. Geotechnical Cross Section Locations
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- C. Surface Soil Testing
 - 1. Grab Sample Location Sketch
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A. Introduction

A.1. Project Description

Advanced Engineering and Environmental Services (AE2S) is developing a Storm Water Master Plan for the City of Bismarck for six watersheds in north Bismarck. Two of the major watersheds in the project area include the Ash and Ward Coulee watersheds. These watersheds are located above the Missouri River flood plain and drain down steep slopes to the Burnt Creek Watershed. These steep slopes have several areas of instability and historically the bluffs along the Missouri River have experienced instability. The Burnt Creek Watershed is within the Missouri River Flood Plain and has a very low gradient.

As part of the Storm Water Master Plan development, we were requested to visit the watersheds and perform a desktop analysis of the stability of the slopes in order to develop a preliminary geotechnical setback line for development along the top of the slopes. We also collected samples to assist AE2S in the analysis of potential erosion in the surficial soils at the base of the coulees during rain events.

A.2. Purpose

Our geotechnical evaluation will be used to determine an appropriate setback for development along the bluffs within these watersheds and will be used to evaluate how storm water storage and conveyance systems may impact slope stability.

A.3. Organization of This Report

This report contains a number of appendices whose contents are intended to help illustrate the project limits, existing surface conditions, and geologic conditions. The Appendix is organized as follows:

- A. Geotechnical Cross Sections
 1. Geotechnical Cross Section Locations – illustrates the location of each analytical cross section
 2. Typical Steep Slope Cross Section – illustrates the subsurface conditions and topographic features of a typical slope with a relatively steep gradient
 3. Typical Slope with a Bench Cross Section - illustrates the subsurface conditions and topographic features of a typical slope with a bench mid slope
 4. Typical Gradual Slope Cross Section - illustrates the subsurface conditions and topographic features of a typical slope with a relatively gradual gradient
- B. Geotechnical Setback
 1. Geotechnical Setback Aerial Overview

2. Geotechnical Setback Maps – aerial maps that illustrate the geotechnical setback zone
- C. Surface Soil Testing
1. Grab Sample Location Sketch – locations within coulees where surface samples were collected for testing
 2. Sieve-Hydrometer Test Results – laboratory test results from surface samples

A.4. Scope of Services

A.4.a. Site History Review

Our evaluation was based in part on the gathering and review of available geologic maps, boring logs, laboratory tests and stability analyses performed by our firm and other firms for historic projects within and near the watersheds. The available soil boring data was primarily from the southern portion of the watersheds or to the south of the watersheds, as that is where most of the development in the area has taken place to date. The information obtained from this review was used to fit geologic profiles to the cross sections for our analyses, and develop parameters for the analyses.

A.4.b. Field Reconnaissance

As part of our evaluation, we performed a reconnaissance of many of the slopes within the watersheds, focusing primarily on the larger slopes along River Drive as well as some of the coulee slopes. The reconnaissance was used to characterize the slopes and to take note of visible, apparent or suspected, slope movements as well as local topography.

A.4.c. Stability Analyses

Cross sections considered typical for geographically similar properties throughout the project limits were analyzed to determine their in-situ stability and help evaluate a setback distance, as needed, to obtain a factor of safety of at least 1.5 for slope stability. A factor of safety of 1.5 was chosen as a baseline as it is a minimum value cited by several geotechnical references for structures on or near slopes. Our analyses were completed in general accordance with Engineering Manual 1110-2-1902, *Slope Stability*, published by the US Army Corps of Engineers October 31, 2003. We performed steady-state analyses using the computer program Slope/W, from GeoStudio 2012 version 8.12.3.7901. Slope/W was used to evaluate the slope stability of the in-situ slope condition, and where needed, to measure the horizontal setback distance that would be required to obtain the minimum factor of safety requirement.

Physical properties and shear strength parameters assigned to the materials in our analytical cross sections were estimated mainly from shear tests performed on samples obtained from borings taken within or near the south end of the site. These properties and parameters were assigned on a regional (not cross section-specific) basis, as most cross sections were not located in close proximity to available borings. The assigned properties and parameters are summarized in Section B.2.

A.4.d. Geotechnical Report

Data obtained from the site history review and site reconnaissance were used to evaluate the subsurface profile and groundwater conditions, perform engineering analyses related to slope stability and prepare a report with recommendations for a geotechnical setback line.

B. Results

B.1. Characteristics and Selection of Analytical Cross Sections

Based on our site reconnaissance and our review of the LIDAR information available in the watersheds, we characterized the various slope types along River Road and in the coulees into 3 main categories. The first category was slopes with a relatively steep gradient, usually steeper than 2H:1V. The second category was slopes that have a relatively flat bench part way down the length of the slope. The third category was slopes that have a relatively gradual gradient, usually shallower than 3H:1V. All three of these slope types are illustrated in Appendix A.

Once we characterized the 3 slope types, we then selected cross sections representative of each slope type with varying slope heights, or vertical relief between the toe of the slope and the top of the slope. AE2S provided us with topographic information at each cross section, and the locations of each section are noted at the beginning of Appendix A.

B.2. Material Properties

B.2.a. Geology

The generalized subsurface conditions assumed for our cross sections were based on a review of the "Geology of the Bismarck-Mandan Area" map as well as soil borings we have taken in the area. The map indicates that the project area is generally covered by wind-blown deposits (Loess) overlying the Cannonball Formation. The Cannonball Formation generally consists of alternating beds of sandstone and mudstone. It has been our experience that the upper portions of this formation are highly weathered and have the consistency of a hard soil, as opposed to "rock". The base of the slopes often contain several feet of slopewash as well.

In our borings, the loess was typically about 10 to 15 feet thick with a relative density of very loose to loose. Below the loess, the Cannonball Formation was highly weathered and texturally classified as silty sand or fat clay (shale) that was typically medium dense nearer to the surface and transitioned to very

dense/hard at depth. Ultimately, the properties assumed for our analysis are summarized in the following table.

Table 1. Material Properties

Material	Unit Weight (pcf)	Friction Angle (deg)	Cohesion (psf)
Loess	105	28	0
Weathered Shale	120	24	700

B.2.b. Groundwater

Long term groundwater measurements were not available in this area. Given the lack of information and the uncertainty of how future land use could affect groundwater conditions, we conservatively assumed for our models that the groundwater would be perched on top of the weathered shale bedrock.

B.3. Analytical Results

The results of our analytical models suggested that a geotechnical setback could be generalized by extending a line through a cross section from the toe of the slope up to its projection at the surface beyond the top of the slope. An example of this line projection is illustrated on the “Typical Steep Slope” figure attached in Appendix A. The models also revealed that the slope of this line projection was dependent on the height of the slope, and not the slope gradient (i.e. steep vs. gradual). Based on all of the models that we analyzed, we then developed the criteria for assigning a geotechnical setback line as summarized in the following table.

Table 2. Criteria for Determining Geotechnical Setback

Slope Height	Setback Distance Projected from Toe of Slope at a Gradient of
< 50 feet	3H:1V
$50 \leq X < 80$ feet	3.5H:1V
$80 \leq X < 120$ feet	4H:1V
≥ 120 feet	4.5H:1V

Since this criteria was based on knowing the toe of the slope, we then defined the toe of all slopes within the watersheds and provided this information in CAD format to AE2S. Using the criteria in Table 2 and

our toe of slope line, AE₂S then used a combination of GIS and CAD software functions to generate a geotechnical setback line that we ultimately reviewed and provided feedback on. A top of slope line was also generated, primarily for those cases where the slope gradient was shallower than the geotechnical setback line projection. The figures attached in Appendix B titled *Geotechnical Setback* were then generated by AE₂S. The area shaded in red is bounded by a line that was either formed by the geotechnical setback line or the top of slope line, whichever was furthest from the toe of the slope.

C. Conclusions and Recommendations

The area shaded in red on the attached figures in Appendix B is considered the geotechnical setback from the slopes along River Road and within the Ash and Ward Coulees. The lack of site-specific boring and laboratory test information available for many of the specific cross sections analyzed, however, is one of the limitations tempering our analyses that helped develop the setback. The specific types of development ultimately considered for any given property is another limitation and something that could impact local slope stability and the recommended geotechnical setback.

Therefore, we recommend the geotechnical setback be considered an area where future development should not be planned. If it is desired for development to encroach into this area, we recommend the developer perform a site specific slope stability analysis, including, but not limited to, geotechnical borings, laboratory testing of material strength properties, and slope stability analyses.

D. Qualifications

D.1. Continuity of Professional Responsibility

This report is based on a limited amount of information, and a number of assumptions were necessary to help us develop our recommendations. It is recommended that our firm continue to assist in the evaluation of slope stability as development plans are put together, and in the evaluation of structure stability and performance through further exploration, testing and analysis of prospective sites.

D.2. Use of Report

This report is for the exclusive use of the parties to which it has been addressed. Without written approval, we assume no responsibility to other parties regarding this report. Our evaluation, analyses and recommendations may not be appropriate for other parties or projects.

D.3. Standard of Care

In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession currently practicing in the same locality. No warranty, express or implied, is made.

Appendix A

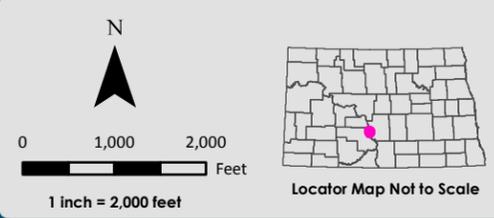
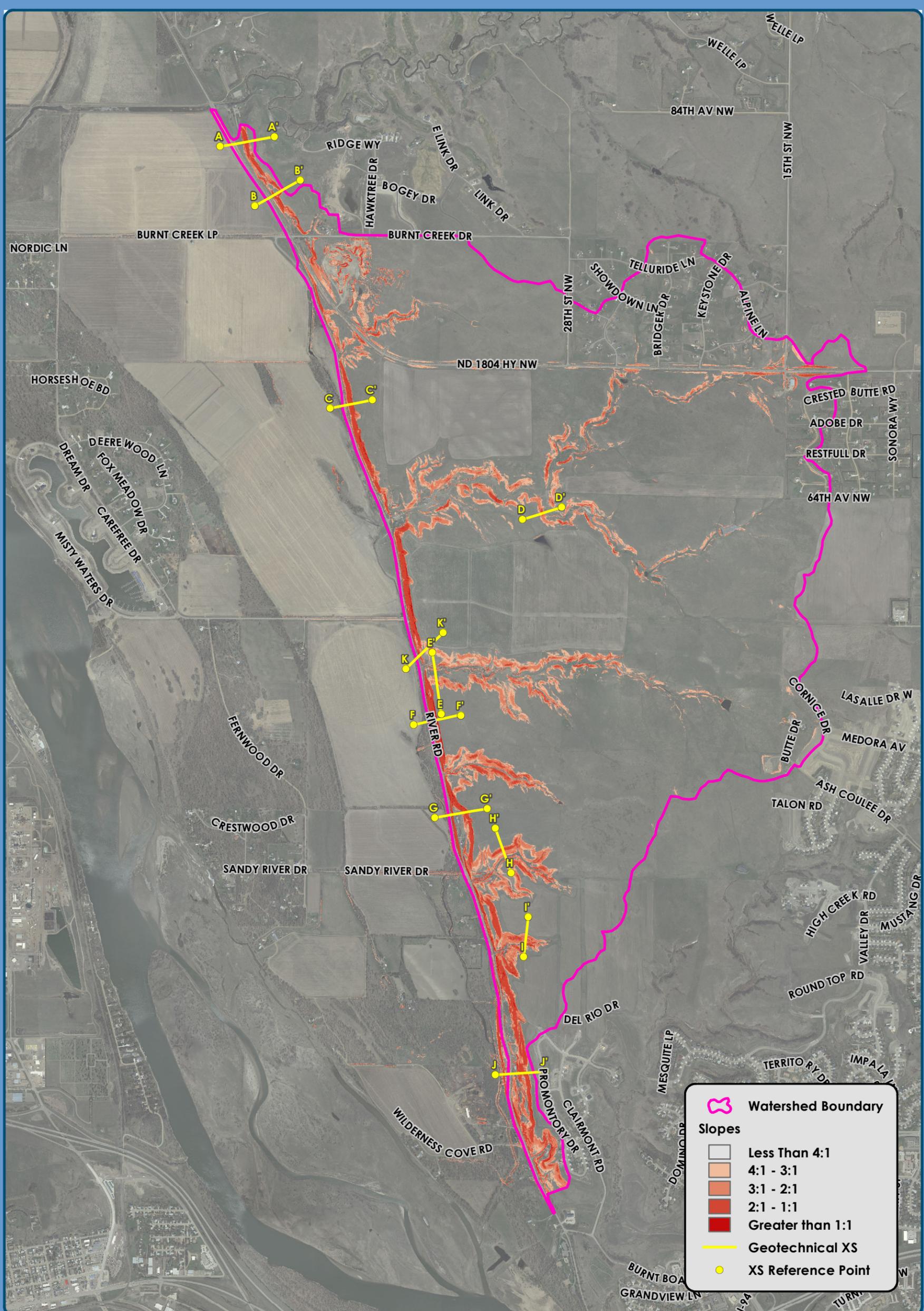
Geotechnical Cross Sections

Geotechnical Cross Section Locations

Typical Steep Slope Cross Section

Typical Slope with a Bench Cross Section

Typical Gradual Slope Cross Section



Geotechnical Cross Sections

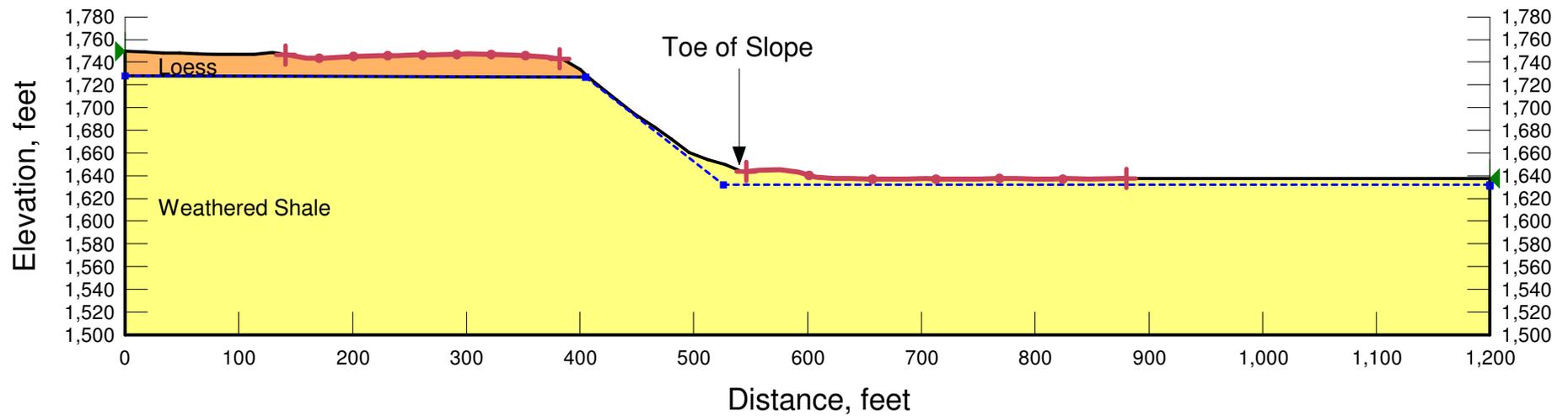
City of Bismarck

Ash and Ward Coulee Stormwater Master Plan



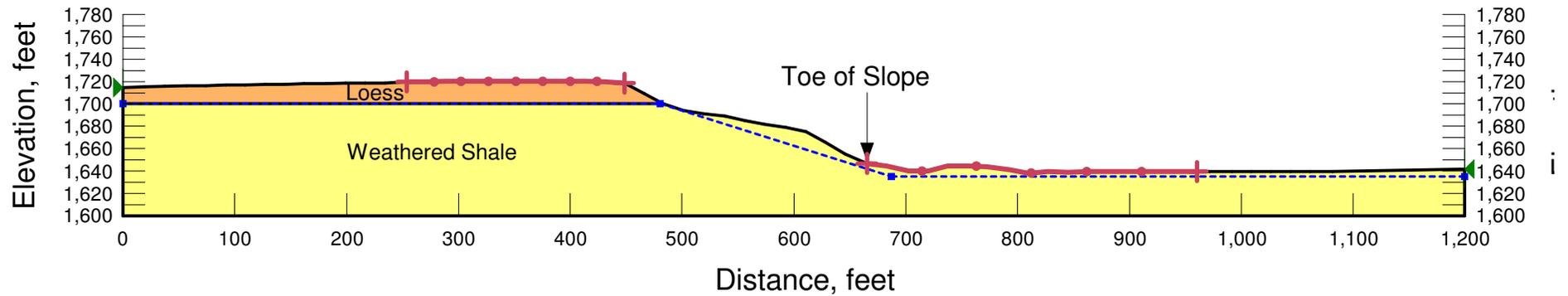
BM-13-04106: Geotechnical Setback Analysis Ash and Ward Coulee Stormwater Master Plan Bismarck, ND

Typical Steep Slope



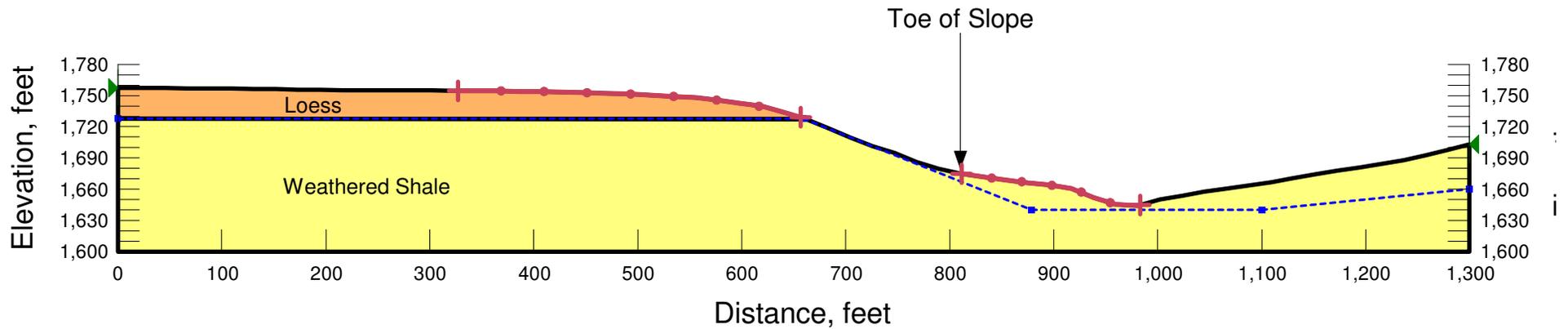
BM-13-04106: Geotechnical Setback Analysis Ash and Ward Coulee Stormwater Master Plan Bismarck, ND

Typical Slope with a Bench



BM-13-04106: Geotechnical Setback Analysis Ash and Ward Coulee Stormwater Master Plan Bismarck, ND

Typical Gradual Slope

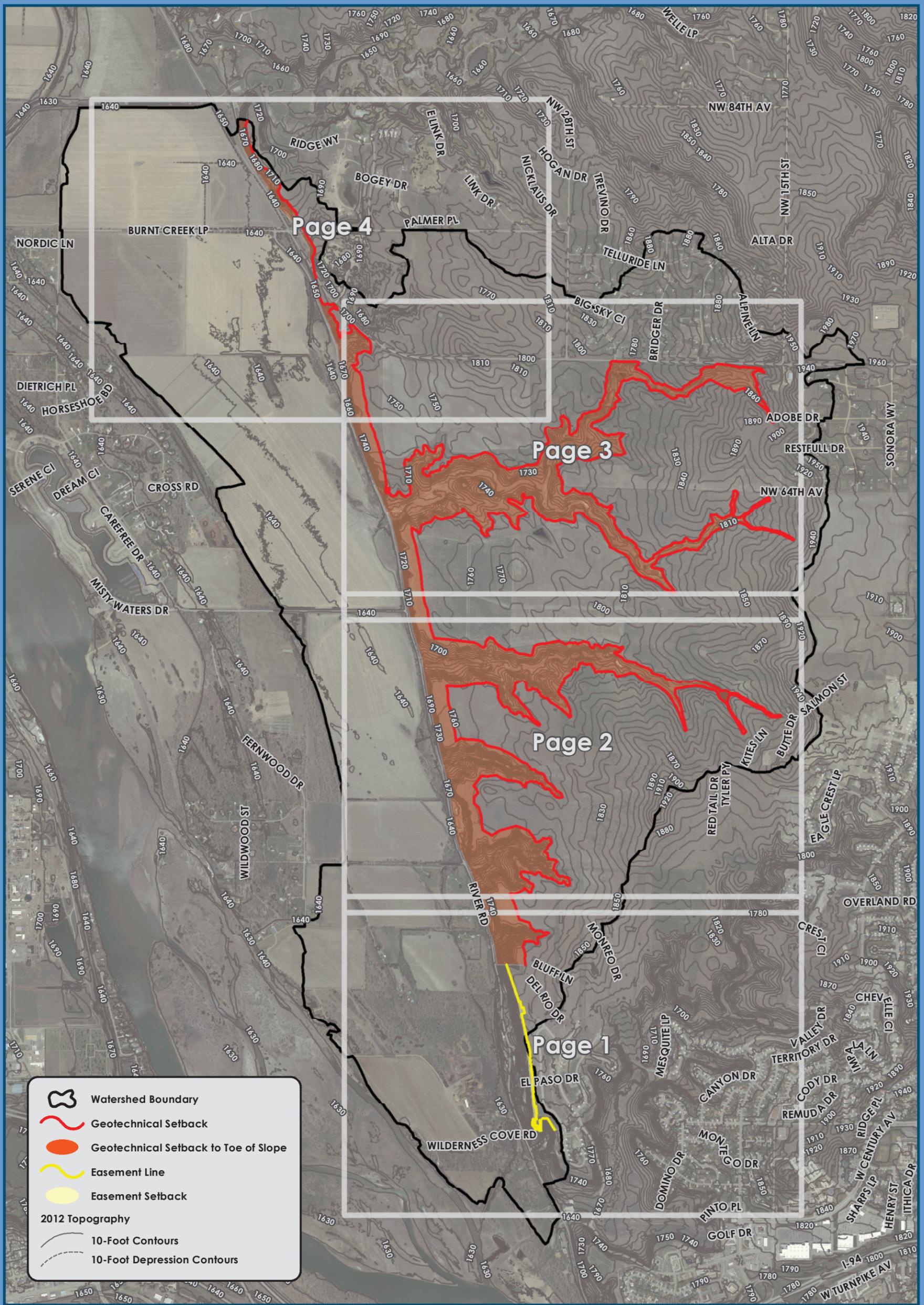


Appendix B

Geotechnical Setback

Geotechnical Setback Aerial Overview

Geotechnical Setback Maps



	Watershed Boundary
	Geotechnical Setback
	Geotechnical Setback to Toe of Slope
	Easement Line
	Easement Setback
2012 Topography	
	10-Foot Contours
	10-Foot Depression Contours

Any reliance upon this map is at user's own risk. AE2S does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.

0 1,000 2,000 Feet

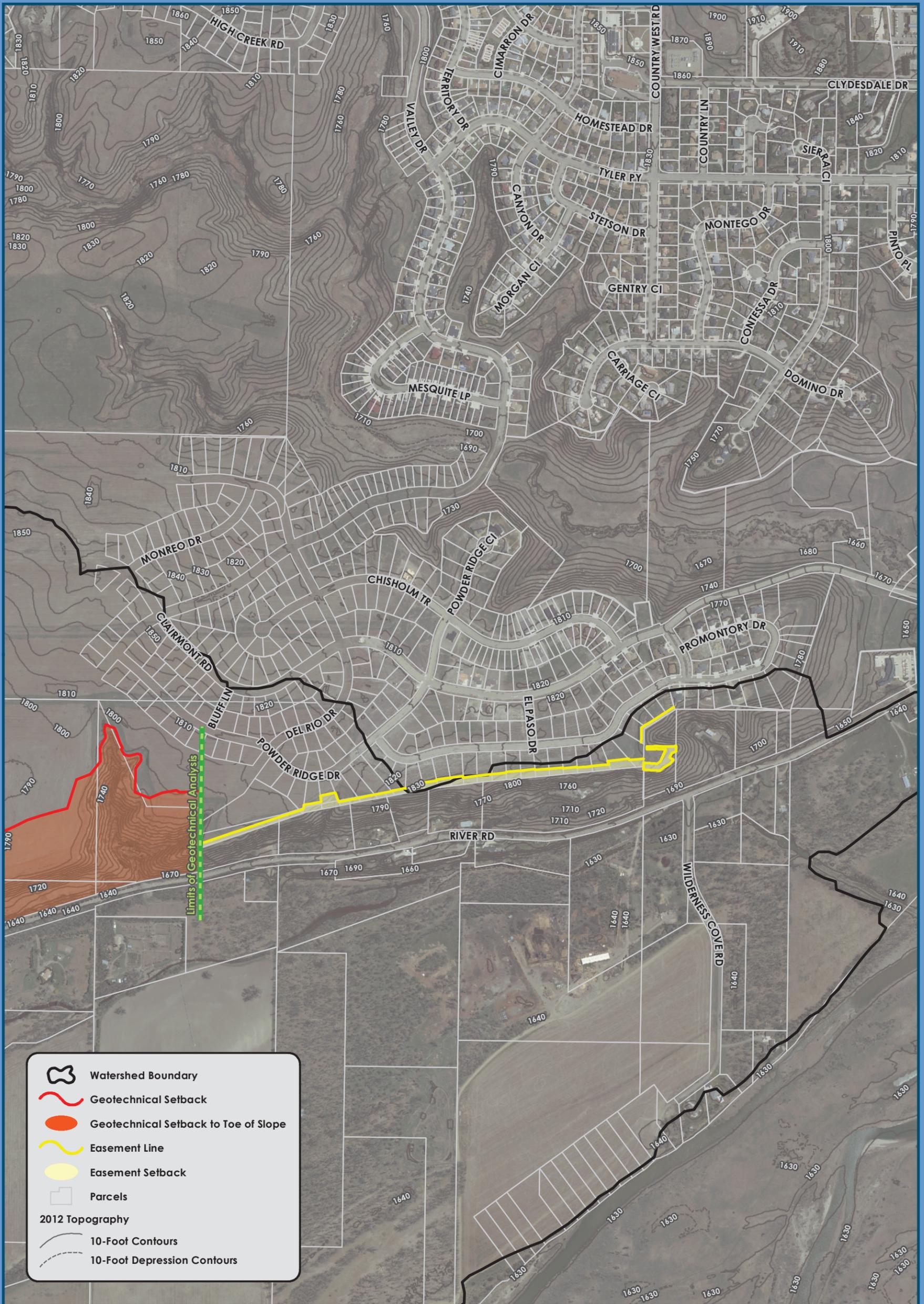
1 inch = 2,000 feet

Locator Map Not to Scale

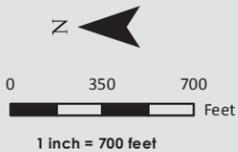
Geotechnical Setback- Overview

City of Bismarck Ash and Ward Coulee Stormwater Master Plan

Advanced Engineering and Environmental Services, Inc.



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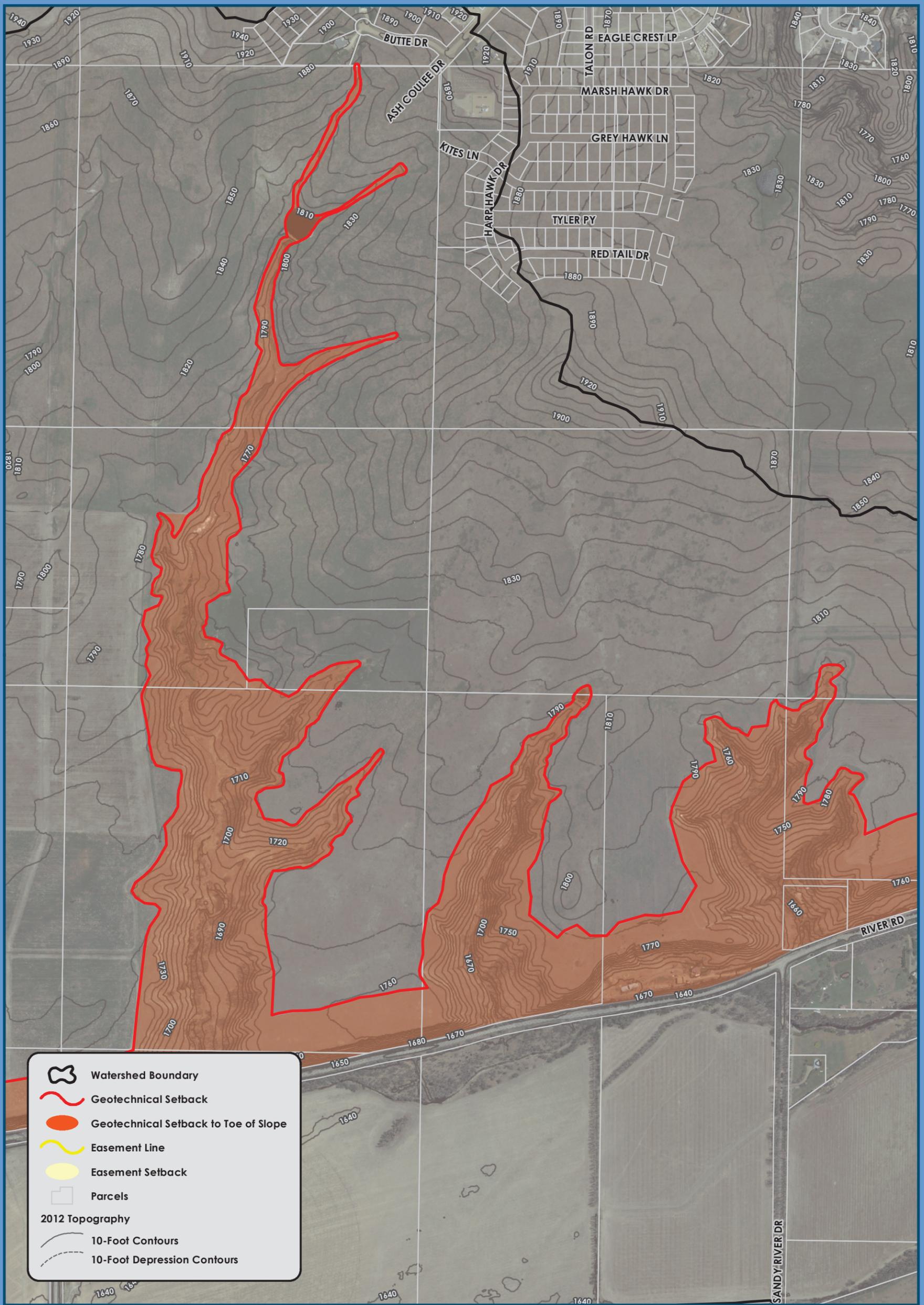


Geotechnical Setback

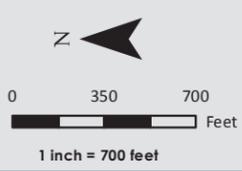
City of Bismarck

Ash and Ward Coulee Stormwater Master Plan



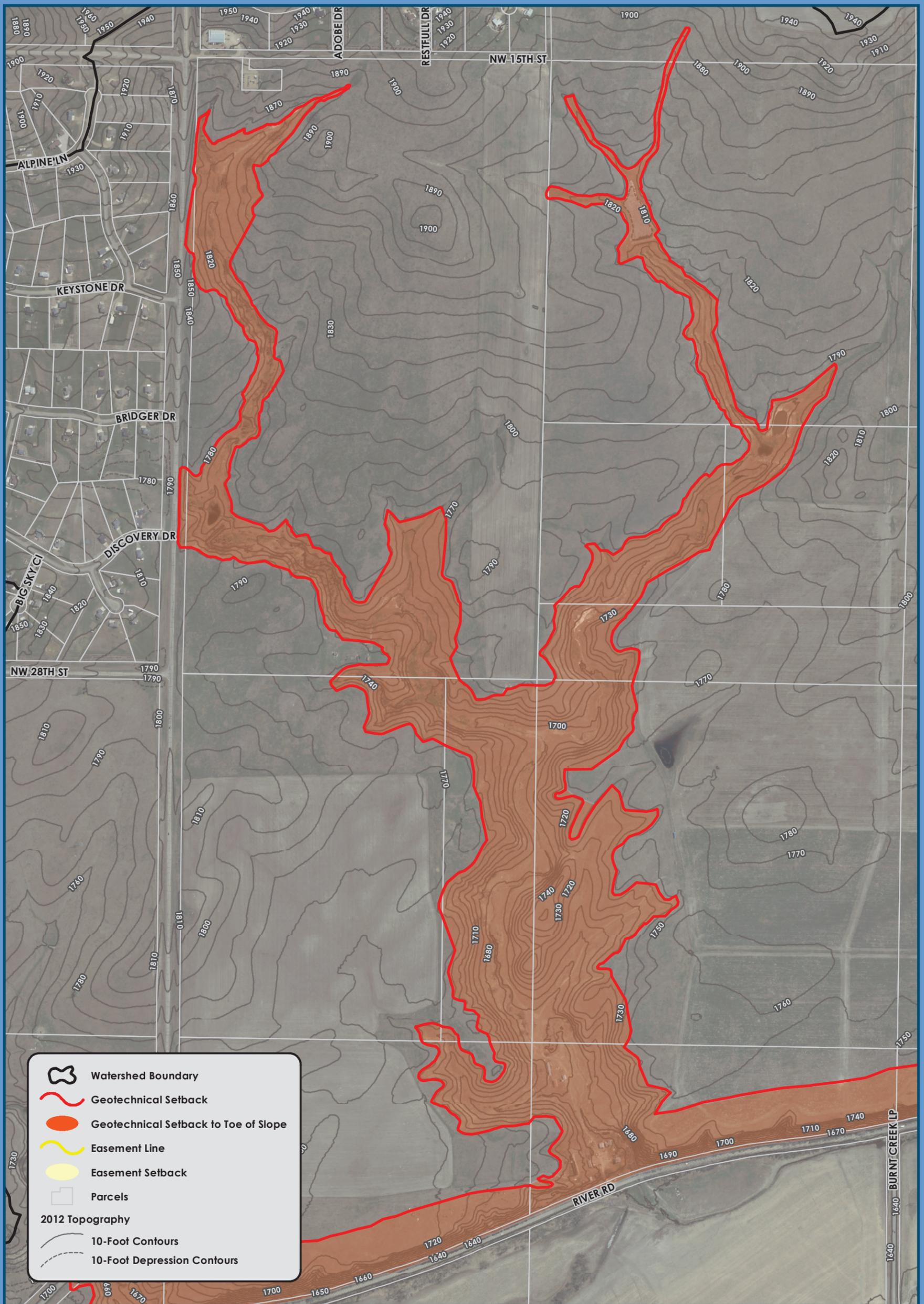


Any reliance upon this map is at user's own risk. AE2S does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.

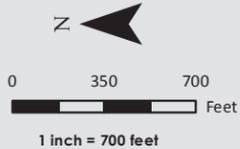


Geotechnical Setback
City of Bismarck
Ash and Ward Coulee Stormwater Master Plan





Any reliance upon this map is at user's own risk. AE2S does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.

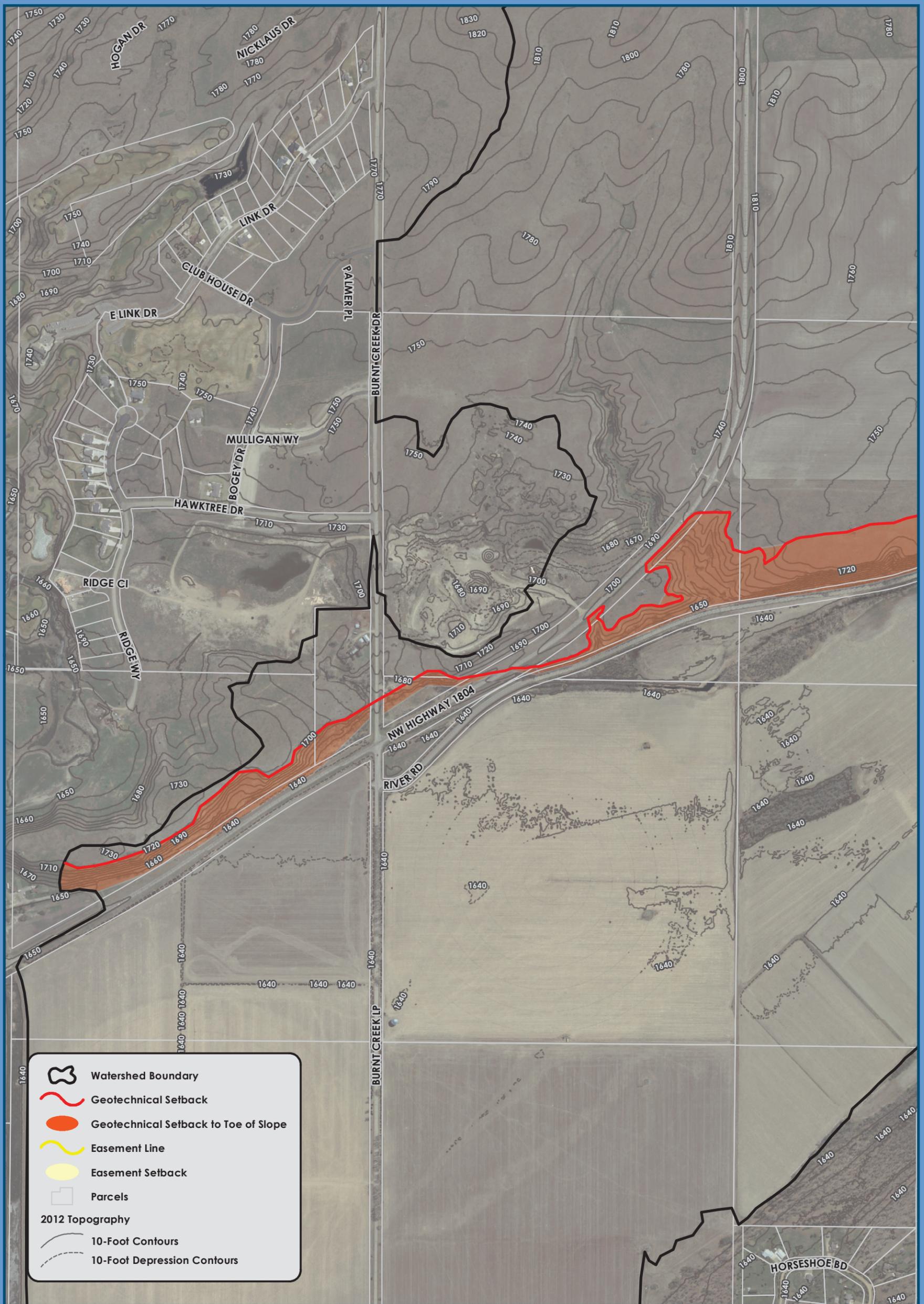


Locator Map Not to Scale

Geotechnical Setback

City of Bismarck Ash and Ward Coulee Stormwater Master Plan

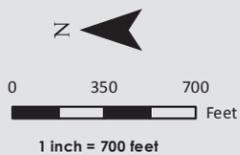




-  Watershed Boundary
-  Geotechnical Setback
-  Geotechnical Setback to Toe of Slope
-  Easement Line
-  Easement Setback
-  Parcels
- 2012 Topography**
-  10-Foot Contours
-  10-Foot Depression Contours

Any reliance upon this map is at user's own risk. AE2S does not warrant the map or its features are either spatially or temporally accurate or fit for a particular use.

Page 4 of 4



Geotechnical Setback
City of Bismarck
Ash and Ward Coulee Stormwater Master Plan



Appendix C

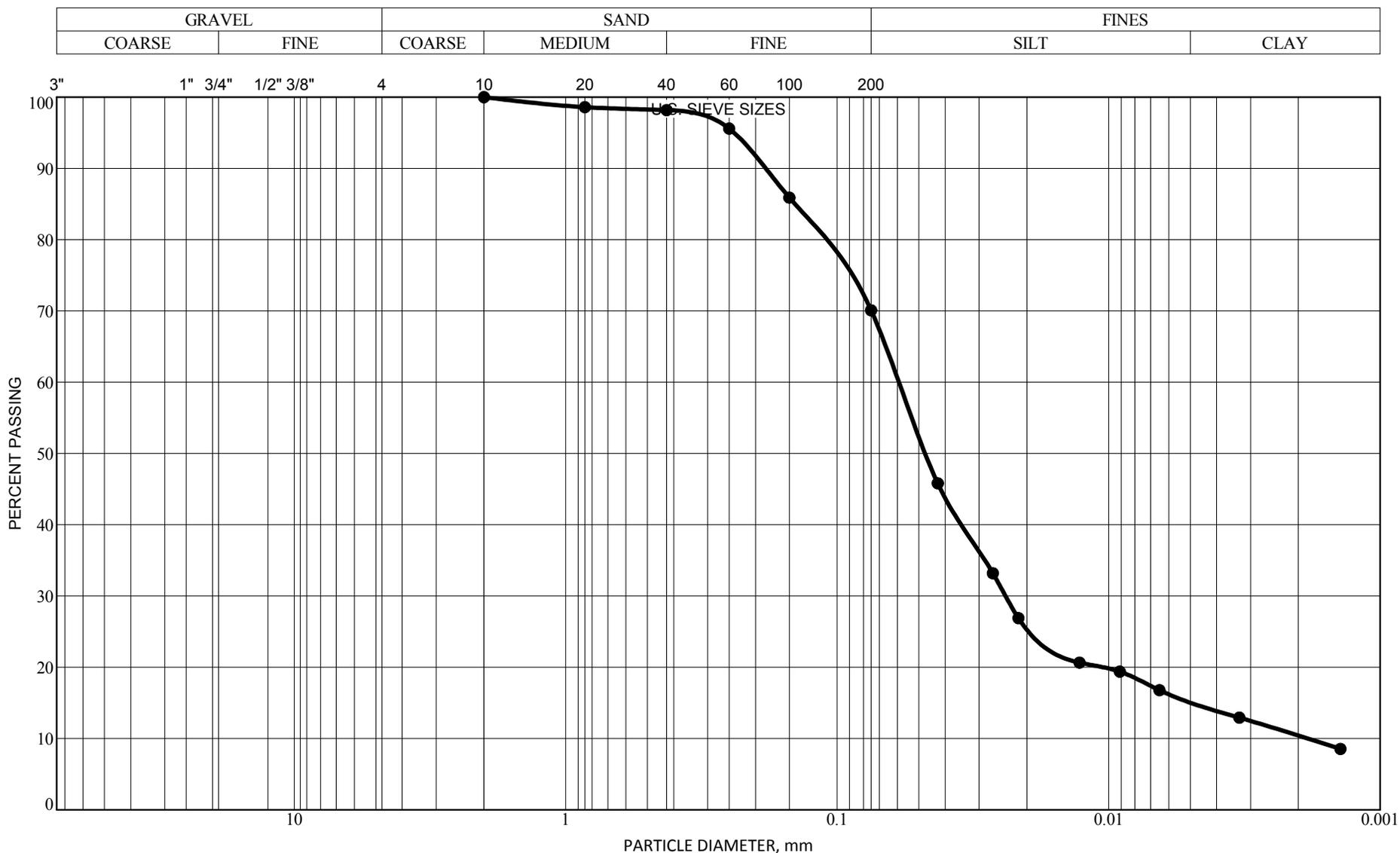
Surface Soil Testing

Grab Sample Location Sketch
Sieve-Hydrometer Test Results

Ash and Ward Coulee
Surface Sediment Grab Sample Locations



GRAIN SIZE ACCUMULATION CURVE (ASTM)



G:\ASTM N:\GINT\PROJECTS\BISMARCK\2013\04106.GPJ BRAUN_V8_CURRENT.GDT 11/19/13 12:14

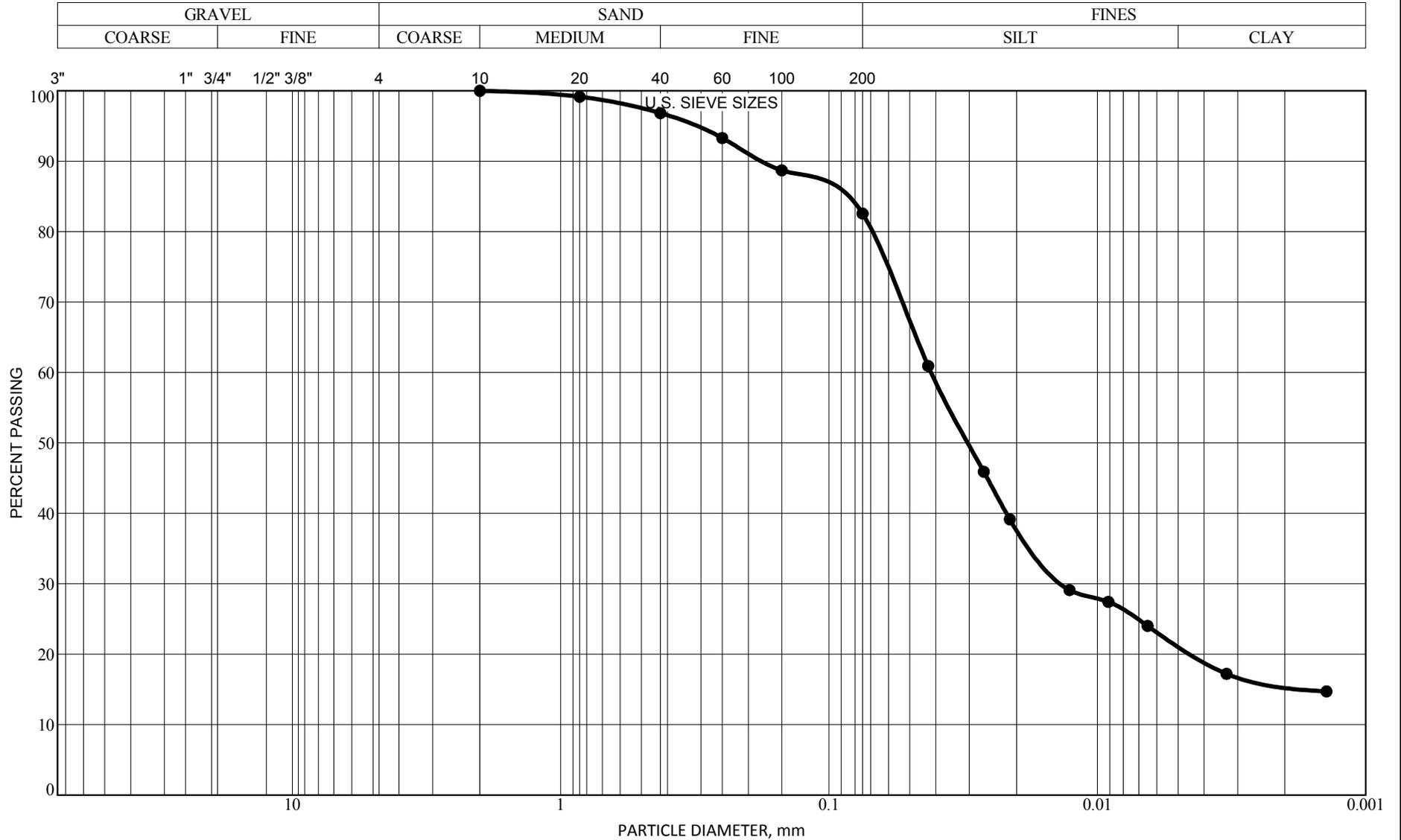


Braun Project BM-13-04106
Geotechnical Setback Analysis
Ash/Ward Coulee Stormwater Management Plan
Ash/Ward Districts
Bismarck, North Dakota
 BORING: 01 DEPTH: 0.5'

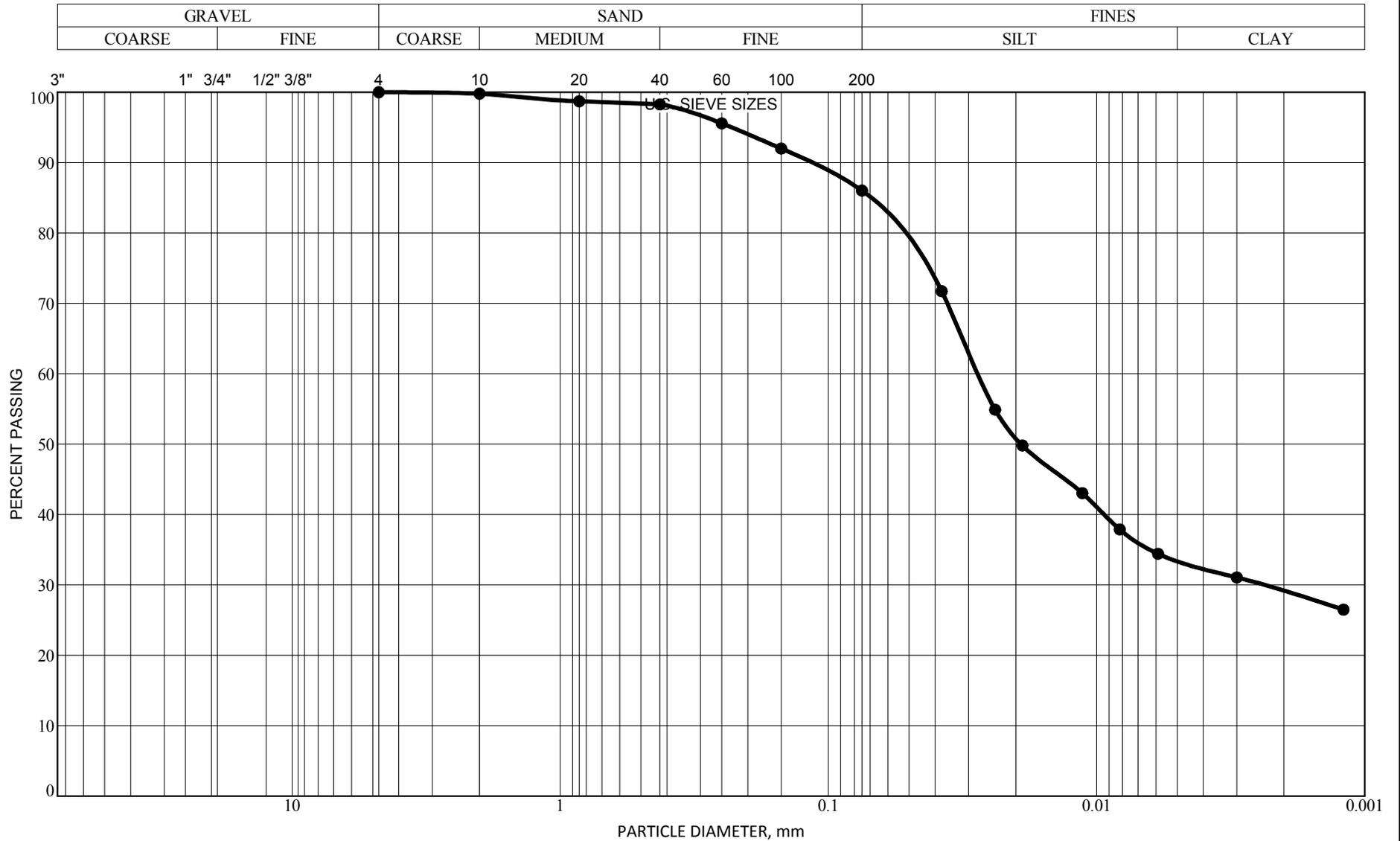
GRAVEL	0.0%
SAND	29.9%
SILT	54.8%
CLAY	15.3%
D60=0.059	Cu=31.8
D30=0.024	Cc=5.2
D10=0.002	

CLASSIFICATION:

GRAIN SIZE ACCUMULATION CURVE (ASTM)



GRAIN SIZE ACCUMULATION CURVE (ASTM)



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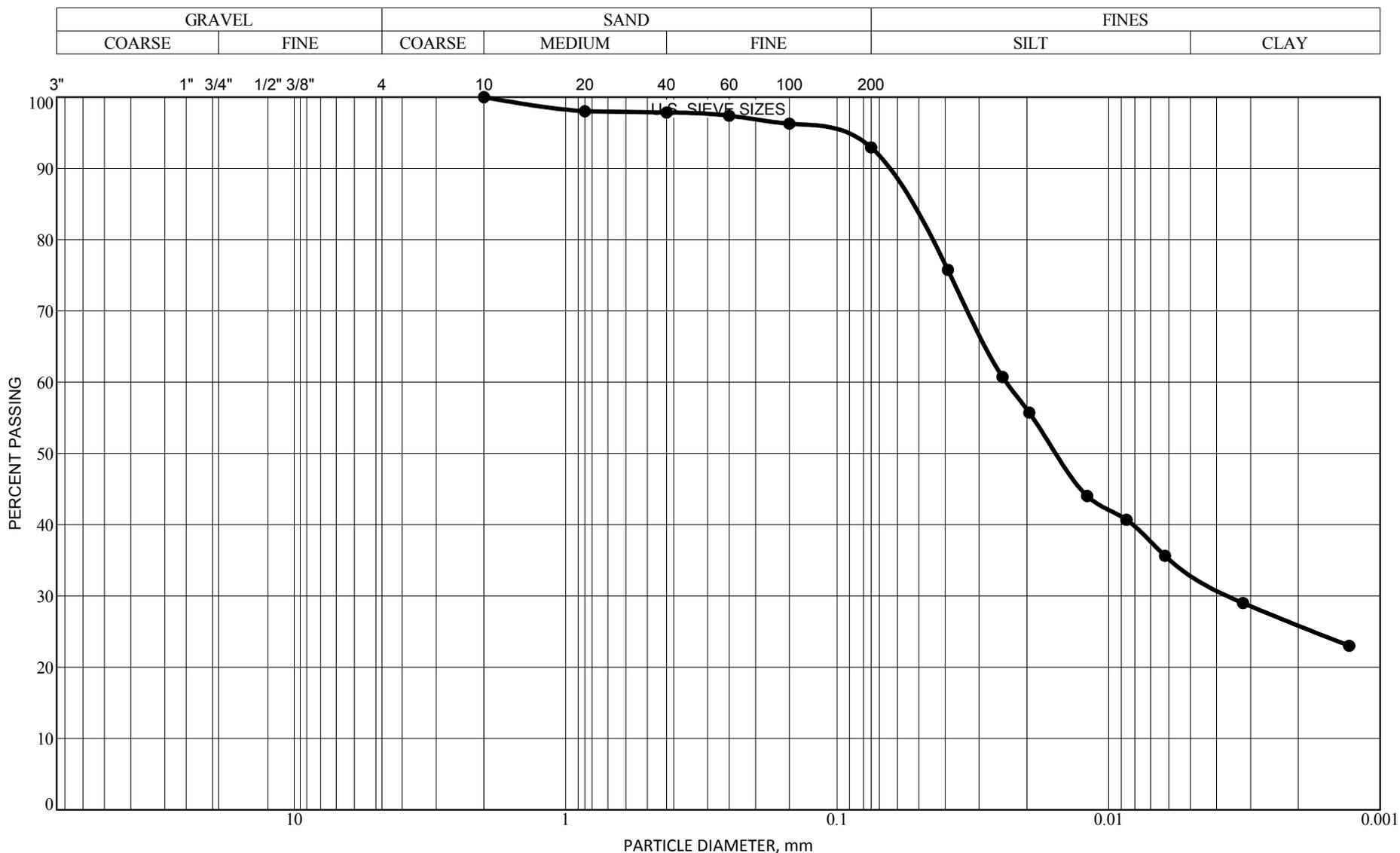


Braun Project BM-13-04106
Geotechnical Setback Analysis
Ash/Ward Coulee Stormwater Management Plan
Ash/Ward Districts
Bismarck, North Dakota
 BORING: 03 DEPTH: 0.5'

GRAVEL	0.0%
SAND	14.0%
SILT	52.4%
CLAY	33.6%
D60=0.027	Cu=
D30=0.002	Cc=
D10=	

CLASSIFICATION:

GRAIN SIZE ACCUMULATION CURVE (ASTM)



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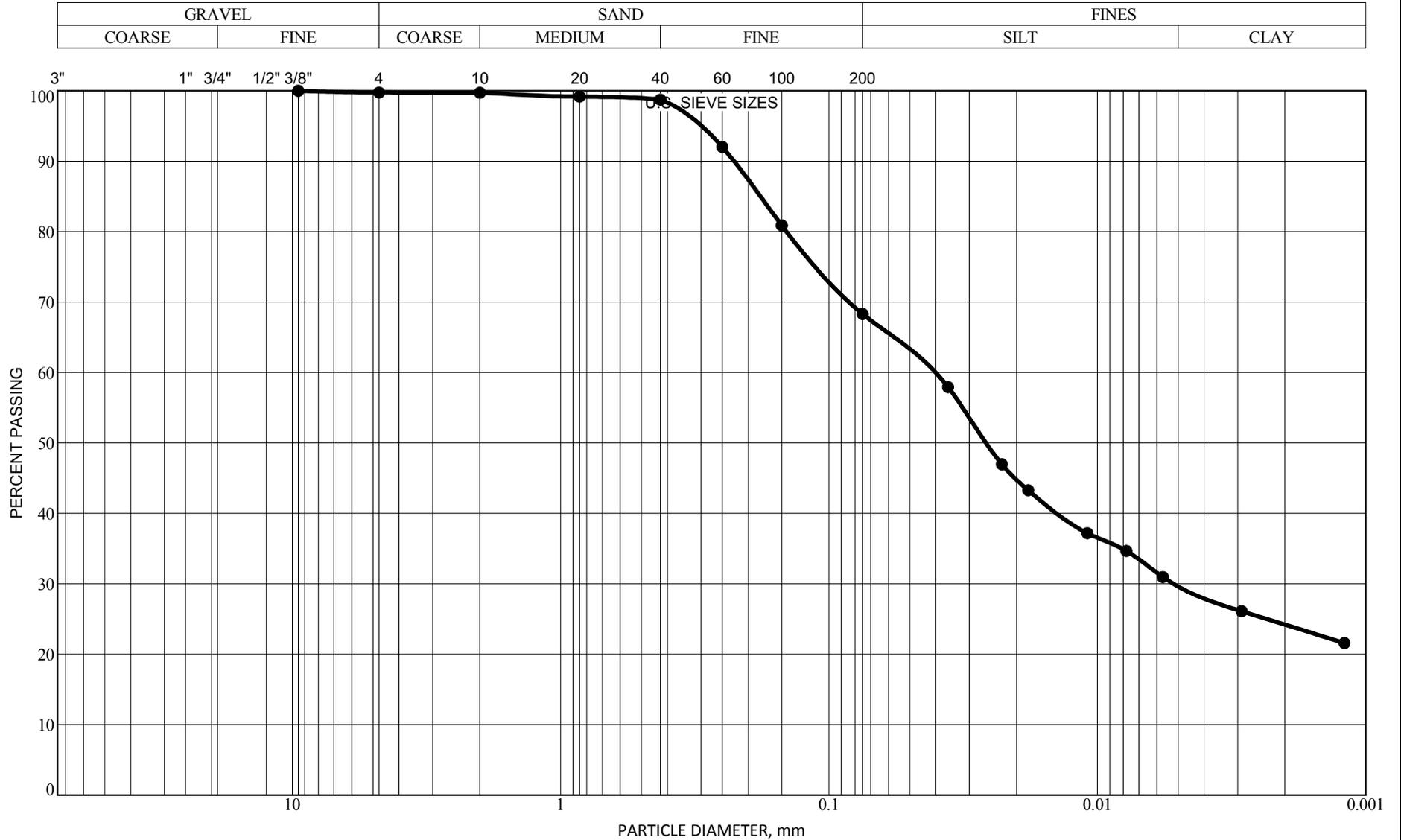


Braun Project BM-13-04106
Geotechnical Setback Analysis
Ash/Ward Coulee Stormwater Management Plan
Ash/Ward Districts
Bismarck, North Dakota
 BORING: 04 DEPTH: 0.5'

GRAVEL	0.0%
SAND	7.1%
SILT	59.5%
CLAY	33.5%
D60=0.024	Cu=
D30=0.004	Cc=
D10=	

CLASSIFICATION:

GRAIN SIZE ACCUMULATION CURVE (ASTM)

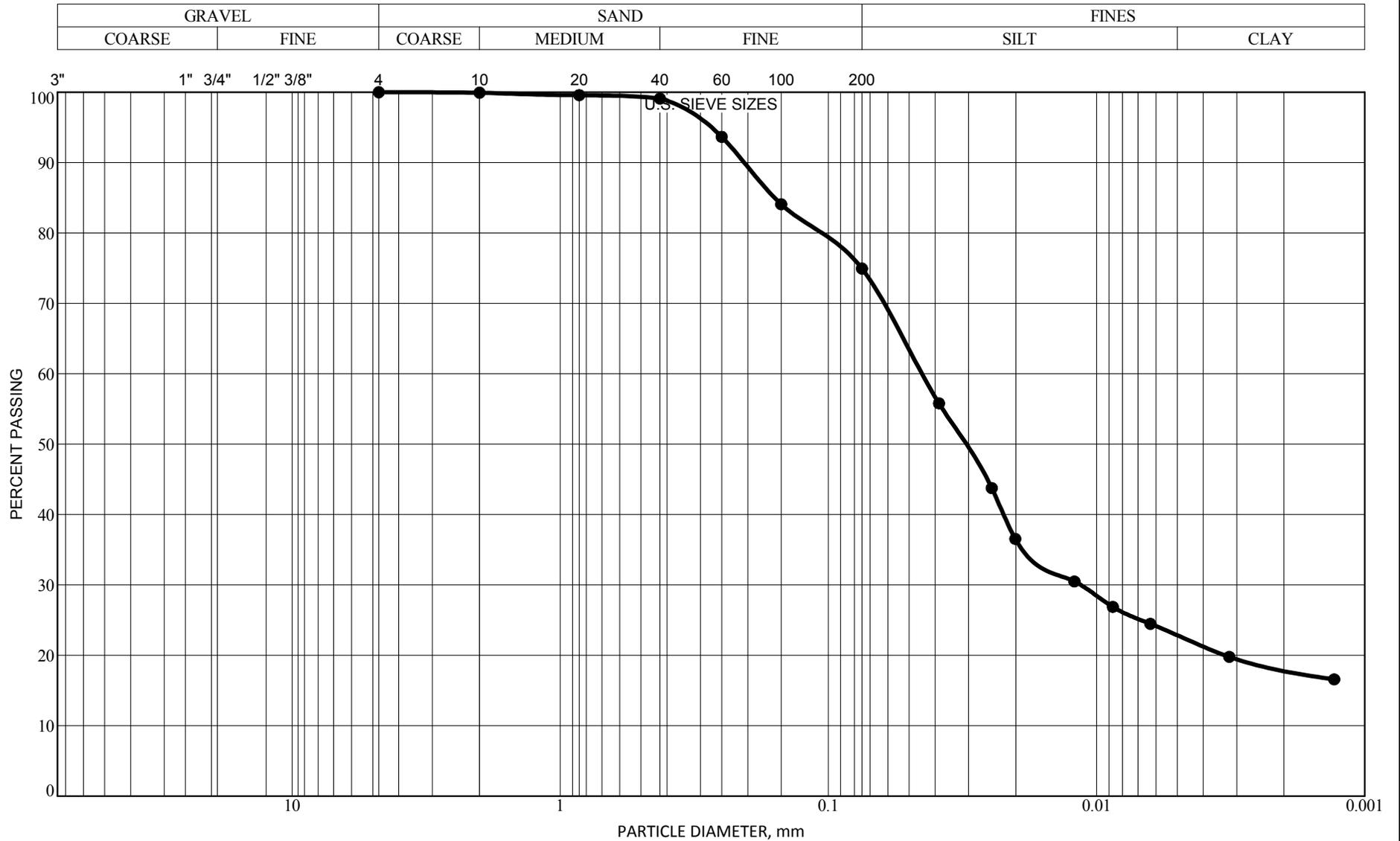


Braun Project BM-13-04106
Geotechnical Setback Analysis
Ash/Ward Coulee Stormwater Management Plan
Ash/Ward Districts
Bismarck, North Dakota
 BORING: 05 DEPTH: 0.5'

GRAVEL	0.3%
SAND	31.4%
SILT	38.3%
CLAY	30.0%
D60=0.042	Cu=
D30=0.005	Cc=
D10=	

CLASSIFICATION:

GRAIN SIZE ACCUMULATION CURVE (ASTM)



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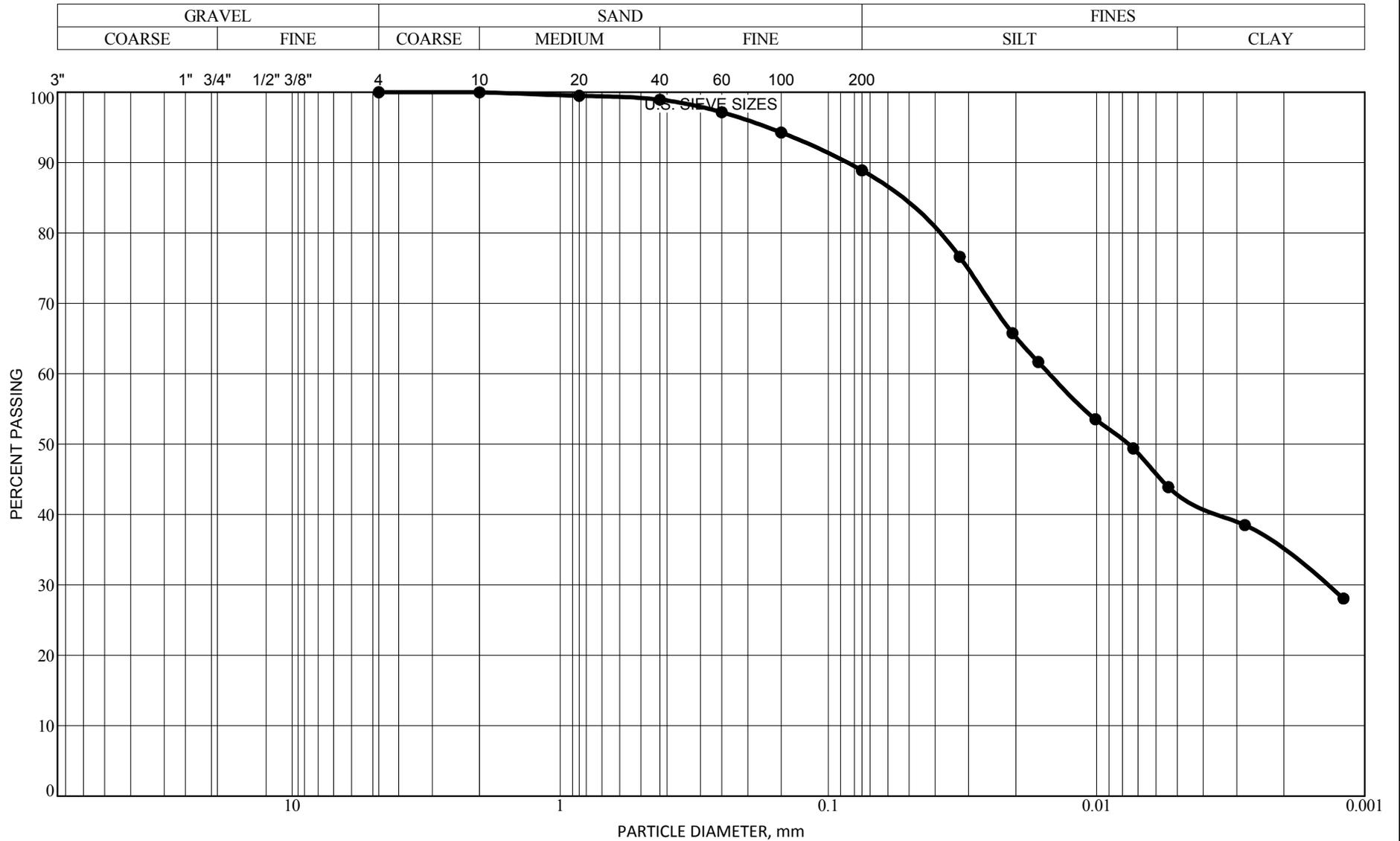


Braun Project BM-13-04106
Geotechnical Setback Analysis
Ash/Ward Coulee Stormwater Management Plan
Ash/Ward Districts
Bismarck, North Dakota
 BORING: 06 DEPTH: 0.5'

GRAVEL	0.0%
SAND	25.1%
SILT	52.1%
CLAY	22.9%
D60=0.045	Cu=
D30=0.012	Cc=
D10=	

CLASSIFICATION:

GRAIN SIZE ACCUMULATION CURVE (ASTM)

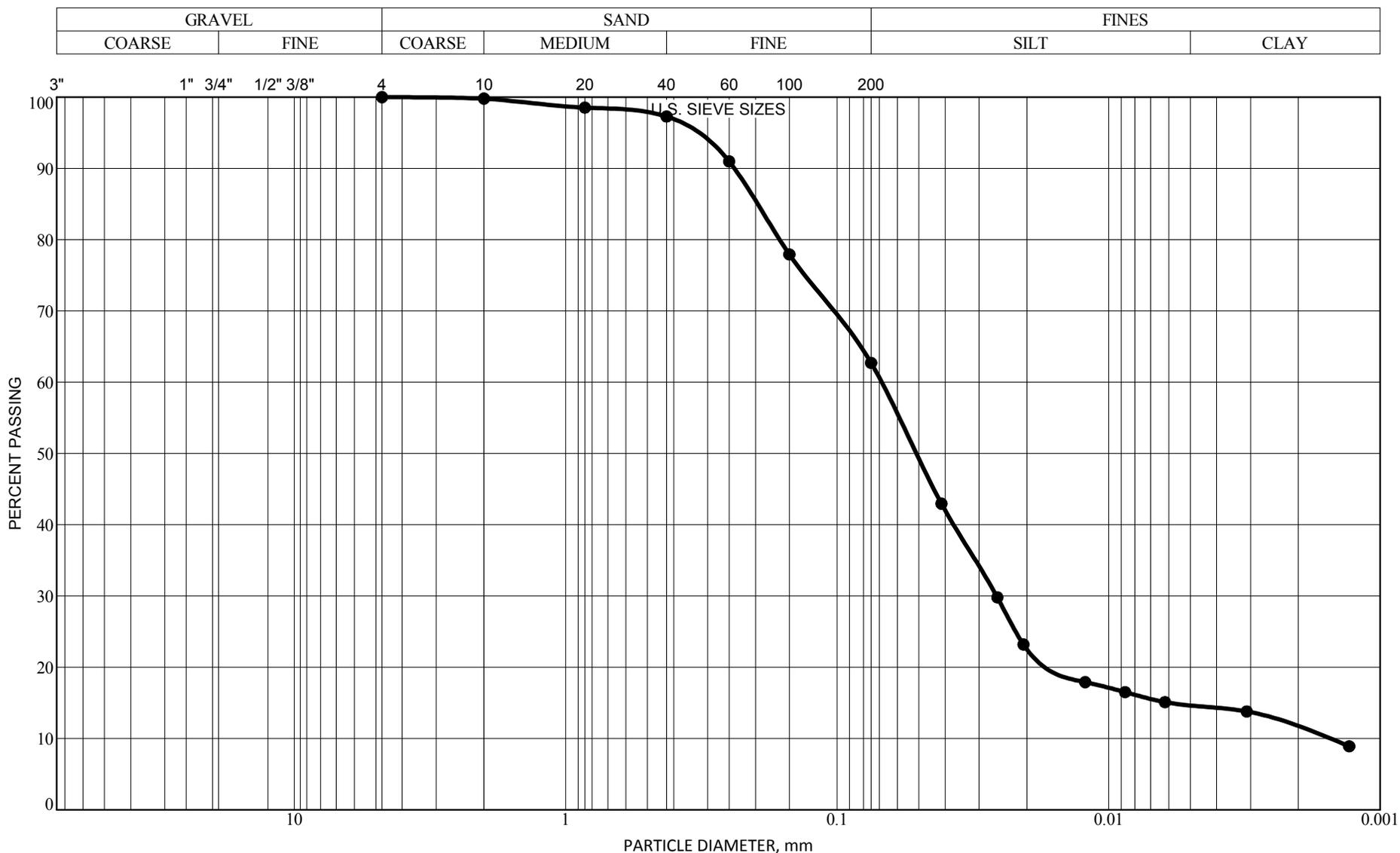


Braun Project BM-13-04106
Geotechnical Setback Analysis
Ash/Ward Coulee Stormwater Management Plan
Ash/Ward Districts
Bismarck, North Dakota
 BORING: 07 DEPTH: 0.5'

GRAVEL	0.0%
SAND	11.1%
SILT	45.6%
CLAY	43.3%
D60=0.015	Cu=
D30=0.001	Cc=
D10=	

CLASSIFICATION:

GRAIN SIZE ACCUMULATION CURVE (ASTM)



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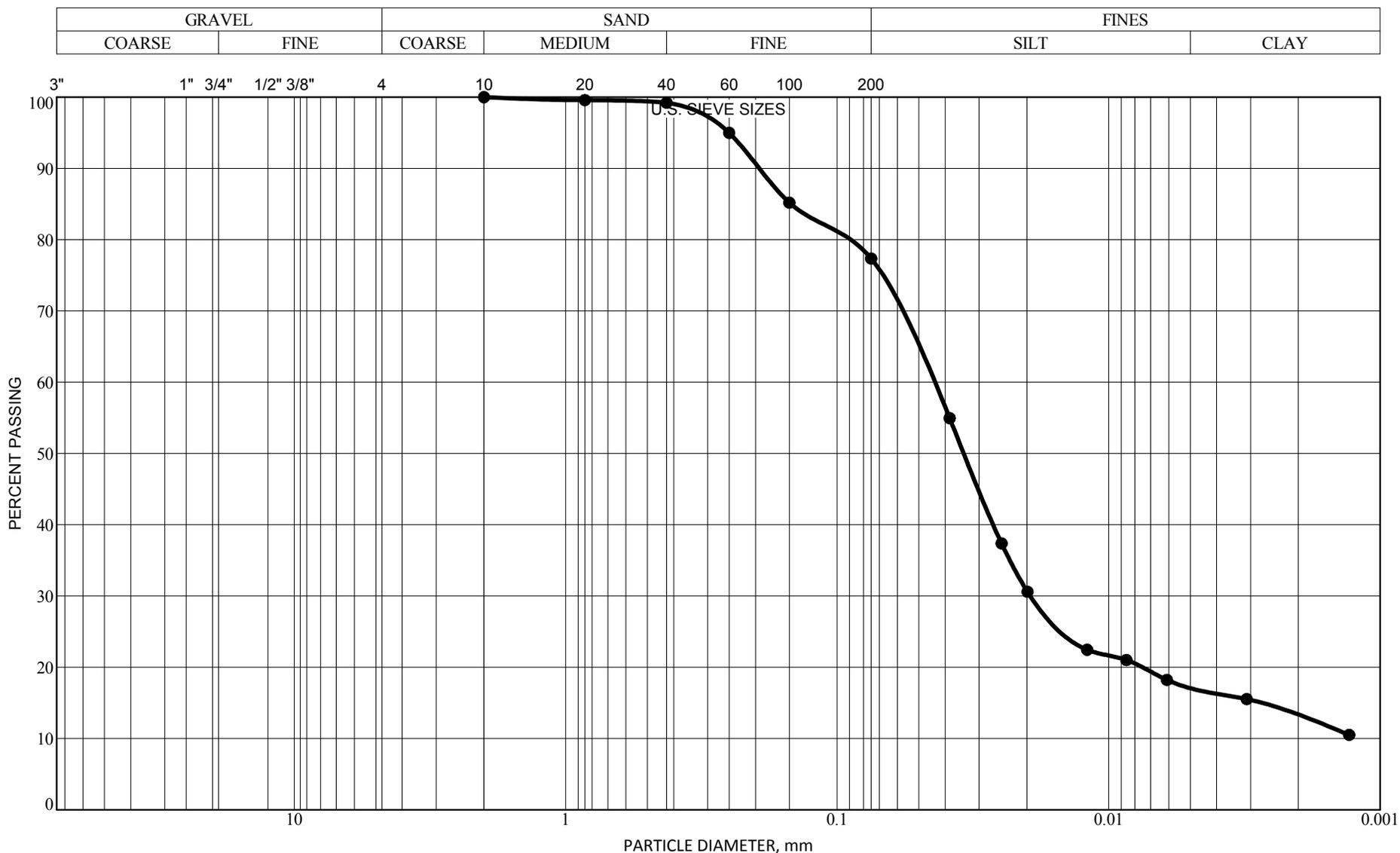


Braun Project BM-13-04106
Geotechnical Setback Analysis
Ash/Ward Coulee Stormwater Management Plan
Ash/Ward Districts
Bismarck, North Dakota
 BORING: 08 DEPTH: 0.5'

GRAVEL	0.0%
SAND	37.3%
SILT	48.0%
CLAY	14.7%
D60=0.069	Cu=43.8
D30=0.026	Cc=6.1
D10=0.002	

CLASSIFICATION:

GRAIN SIZE ACCUMULATION CURVE (ASTM)



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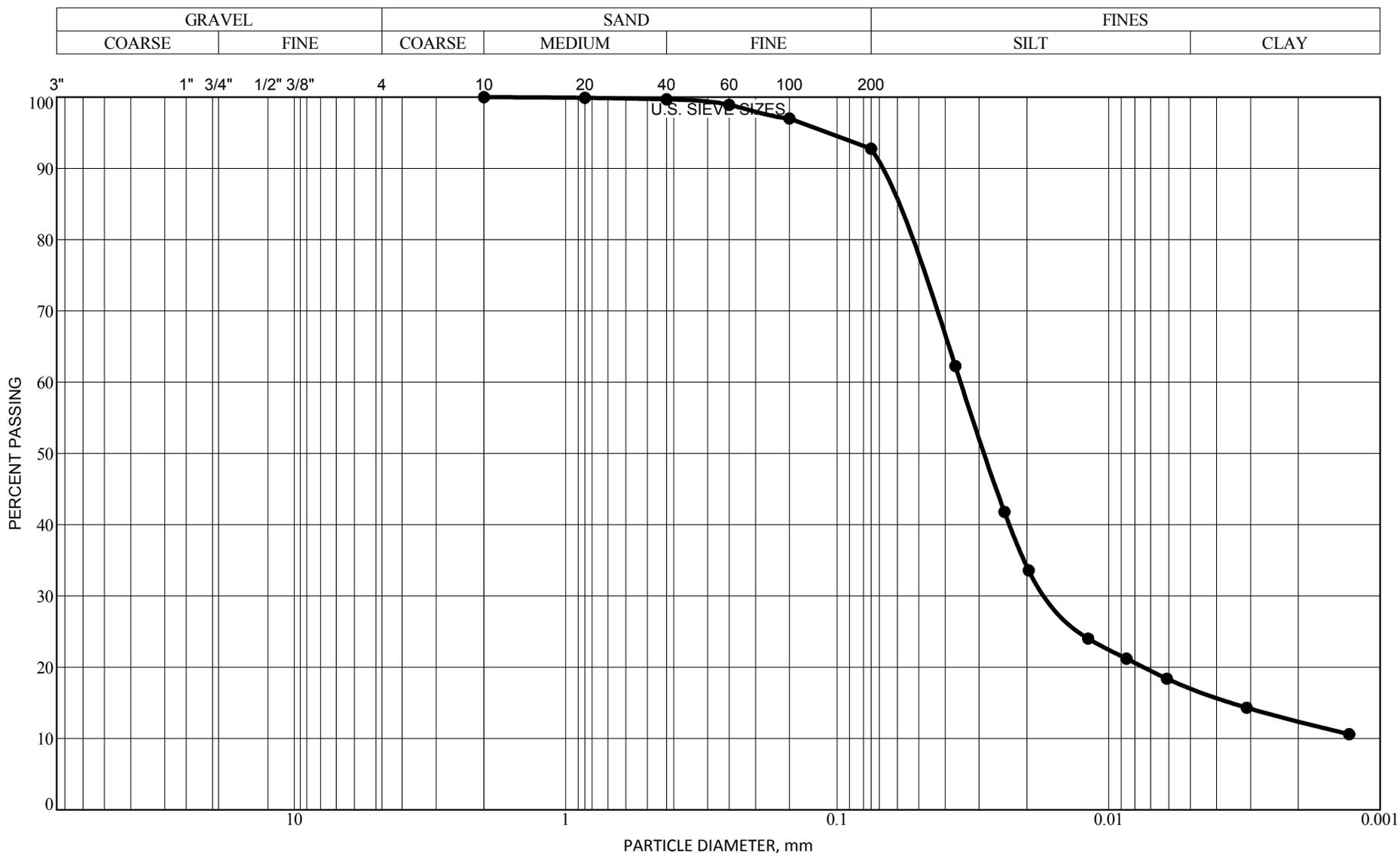


Braun Project BM-13-04106
Geotechnical Setback Analysis
Ash/Ward Coulee Stormwater Management Plan
Ash/Ward Districts
Bismarck, North Dakota
 BORING: 09 DEPTH: 0.5'

GRAVEL	0.0%
SAND	22.6%
SILT	59.9%
CLAY	17.4%
D60=0.045	Cu=
D30=0.019	Cc=
D10=	

CLASSIFICATION:

GRAIN SIZE ACCUMULATION CURVE (ASTM)



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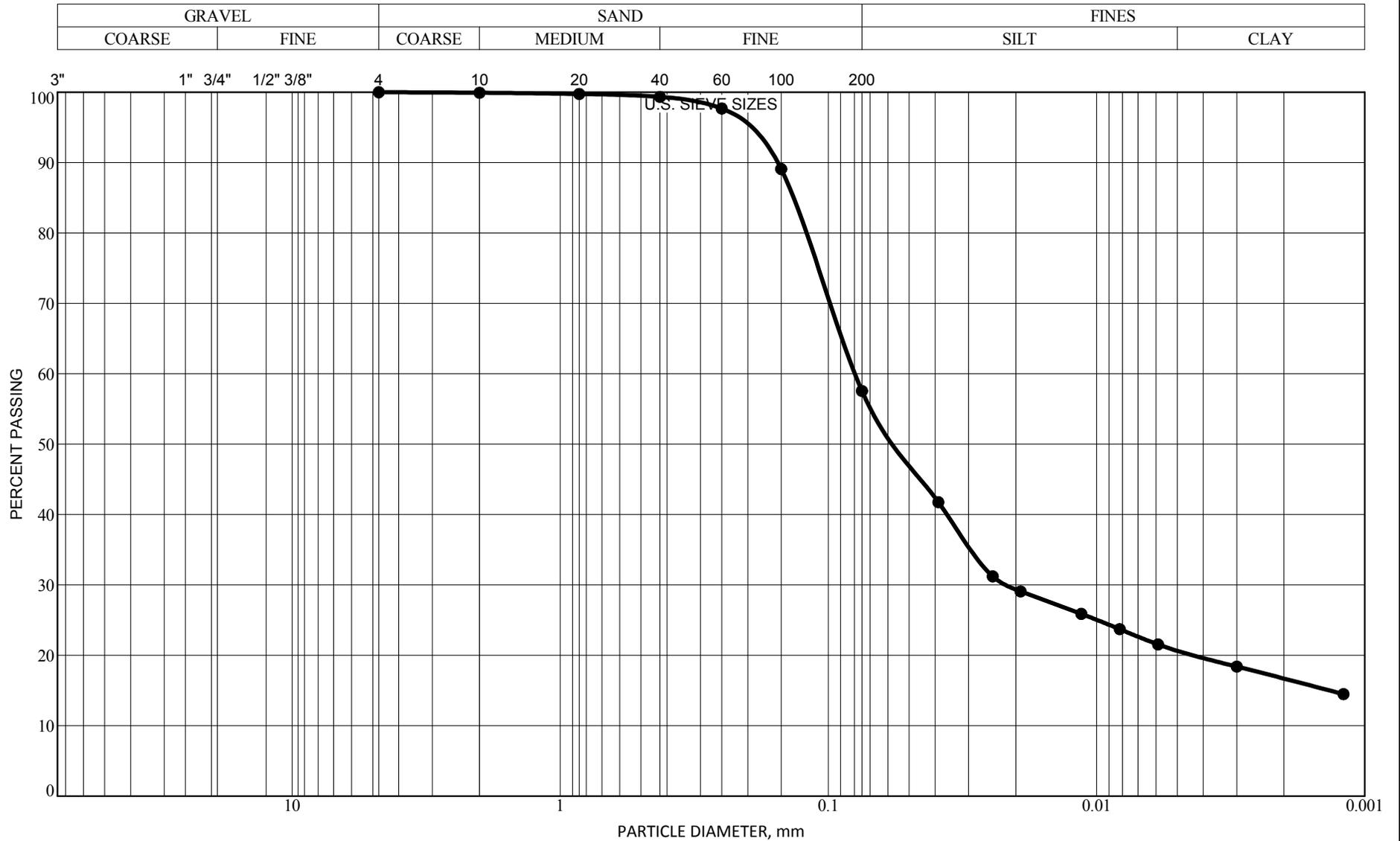


Braun Project BM-13-04106
Geotechnical Setback Analysis
Ash/Ward Coulee Stormwater Management Plan
Ash/Ward Districts
Bismarck, North Dakota
 BORING: 10 DEPTH: 0.5'

GRAVEL	0.0%
SAND	7.2%
SILT	75.6%
CLAY	17.2%
D60=0.035	Cu=
D30=0.016	Cc=
D10=	

CLASSIFICATION:

GRAIN SIZE ACCUMULATION CURVE (ASTM)



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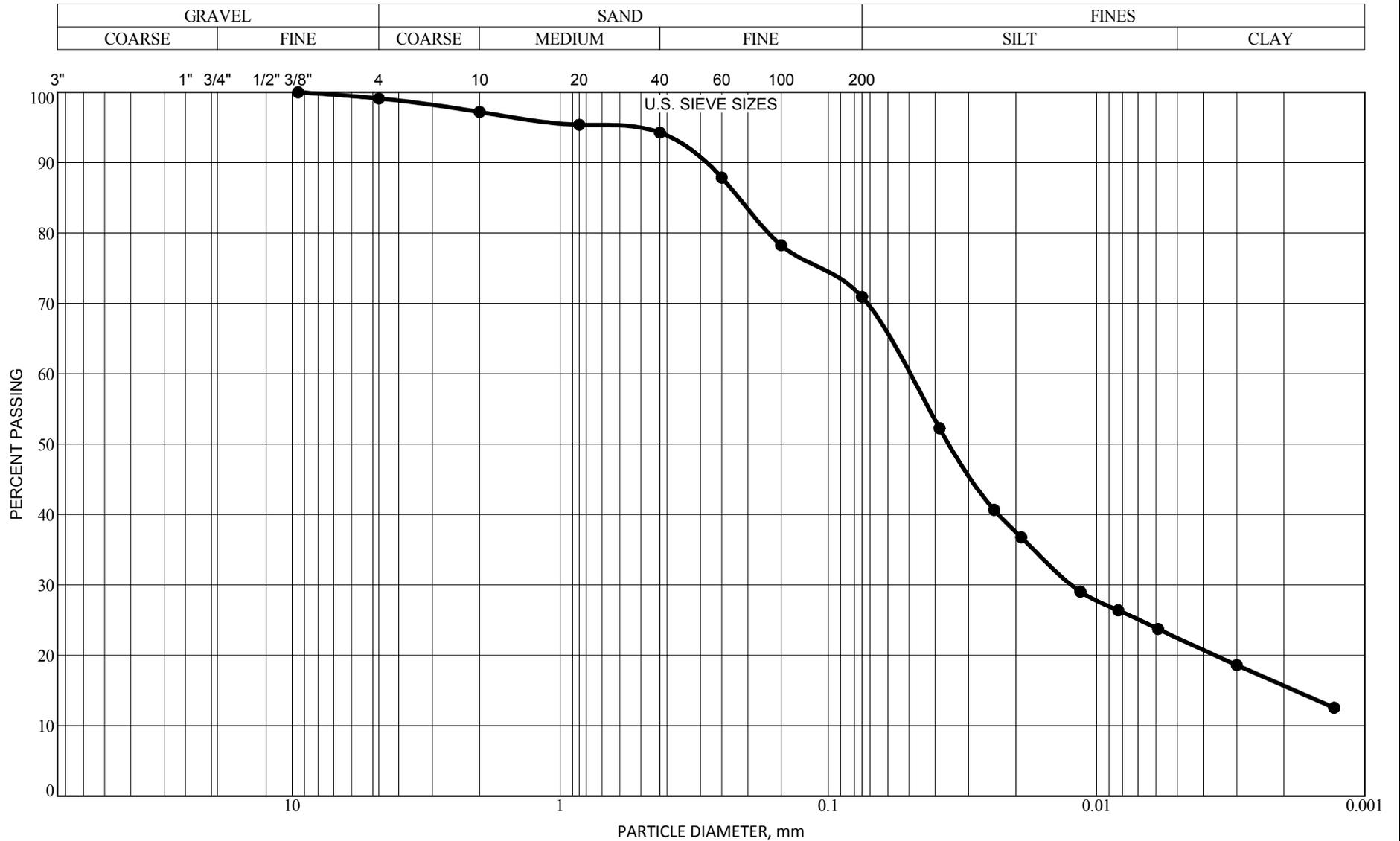


Braun Project BM-13-04106
Geotechnical Setback Analysis
Ash/Ward Coulee Stormwater Management Plan
Ash/Ward Districts
Bismarck, North Dakota
 BORING: 11 DEPTH: 0.5'

GRAVEL	0.0%
SAND	42.4%
SILT	36.8%
CLAY	20.8%
D60=0.079	Cu=
D30=0.021	Cc=
D10=	

CLASSIFICATION:

GRAIN SIZE ACCUMULATION CURVE (ASTM)



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Braun Project BM-13-04106
Geotechnical Setback Analysis
Ash/Ward Coulee Stormwater Management Plan
Ash/Ward Districts
Bismarck, North Dakota
 BORING: 12 DEPTH: 0.5'

GRAVEL	0.9%
SAND	28.2%
SILT	48.4%
CLAY	22.5%
D60=0.051	Cu=
D30=0.012	Cc=
D10=	

CLASSIFICATION: