Appendix B-4: Alternative 2

Full Supply Level

HEC-ResSim Initial Alternative Assessment

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1. Alternative Description & Objective

This alternative prioritizes maintaining Rafferty Reservoir, Grant Devine Reservoir, and Lake Darling at Full Supply Level (FSL). FSL is maintained without regard to flood status or apportionment. Results of this alternative were compared to baseline model results, which reflect present day operations of Boundary, Rafferty, Grant Devine, and Lake Darling reservoirs (Annex A & Annex B). This analysis was conducted using the full period of record available at the time of the simulation (1946-2017). FSL levels for each reservoir can be seen in **Error! Reference source not found.**.

Table 1. Full Supply Level (FSL) for each reservoir

Reservoir	FSL Standard (ft)	FSL Metric (m)
Rafferty	1806.1	550.5
Boundary	1840	560.83
Grant Devine	1843.8	562
Lake Darling	1597	486.8

1.1 Alternative Development

This alternative was proposed as an extreme bookend case by the Public Advisory Group during the 2019 March workshops held in Minot, ND and is meant to identify the maximum amount of water supply Rafferty, Grant Devine, and Lake Darling could provide. The alternative details were discussed at the workshop and provided to the ResSim alternatives modeling team in April 2019. This case is considered to be the opposite of Alternative 1, which models the reservoirs as dry dams.

1.2 Alternative Fine Tuning

This alternative was not carried forward into Phase 3, as it is a representative extreme bookend case and will not be considered as a realistic alternative for this study.

1.3 HEC-ResSim Nomenclature

Within HEC-ResSim, a new network, alternative and simulation run was generated to reflect each proposed alternative. To generate the alternative network, a copy of the base network was made and modified to reflect the proposed alternative. A table indicating the nomenclature associated with the ResSim network, alternative and simulation used to model the alternative is listed in Table 2. Model nomenclature.

Table 2. Model nomenclature

Scenario	Time Window	ResSim Model Name	Network Name	Alternative Name	Simulation Name
Baseline	1946-2017	SourisRiverPos	cal2Fsl	Base	00_BL_AnxA_46_17
FSL	1946-2017	SourisRiverPoS	02_FSL_BL	02_FSL_BL	02_FSL_1946_2017

2. Operational Rules

Table 3 presents the operational rules that were included in the base HEC-ResSim model alternative to specifically reflect the changes required in support of the 02_FSL_BL alternative.

Table 3. Operation Rules Added Specific to Alternative

Name of Dam	Name of Rule, Outlet or IF Statement or State Variable Element	Rule Description
Rafferty Reservoir	Normal drawdown	Annual 1 Feb Drawdown
	Conditional drawdown	Flood status dependent drawdown
Boundary Reservoir		
Grant Devine Reservoir	Normal drawdown	Annual 1 Feb Drawdown
	Conditional drawdown	Flood status dependent drawdown
Lake Darling Reservoir	Normal drawdown	Annual 1 Feb Drawdown
	Conditional drawdown	Flood status dependent drawdown

Two changes were made in the operations for Rafferty Reservoir, Grant Devine Reservoir, and Lake Darling Dam through edits implemented by editing the “a_fld_MASTER_gc_gd” state variable.

First, the normal drawdown for each reservoir was changed to the same elevation as FSL at each respective site to eliminate the annual drawdown.

Second, the conditional drawdown defined in the script was removed by entering a direct override of the logic considering if the model were in a flood year or not. Removing this allowed the state variable to calculate a guide curve at FSL with no drawdown.

Figure 1 displays where the normal drawdown statement was implemented into the state variable script for each reservoir. The relevant model feature is indicated by the red box. Figure 2 provides a screenshot of where the conditional drawdown was manually overridden. The max drawdown was also overridden so the guide curves consistently remain at FSL for each reservoir. Figure 3 shows an “else” statement that was added to resolve the model’s need for a volume to be added to Rafferty reservoir. Prior to this addition, the act of removing drawdowns triggered an error, as there was no value here.

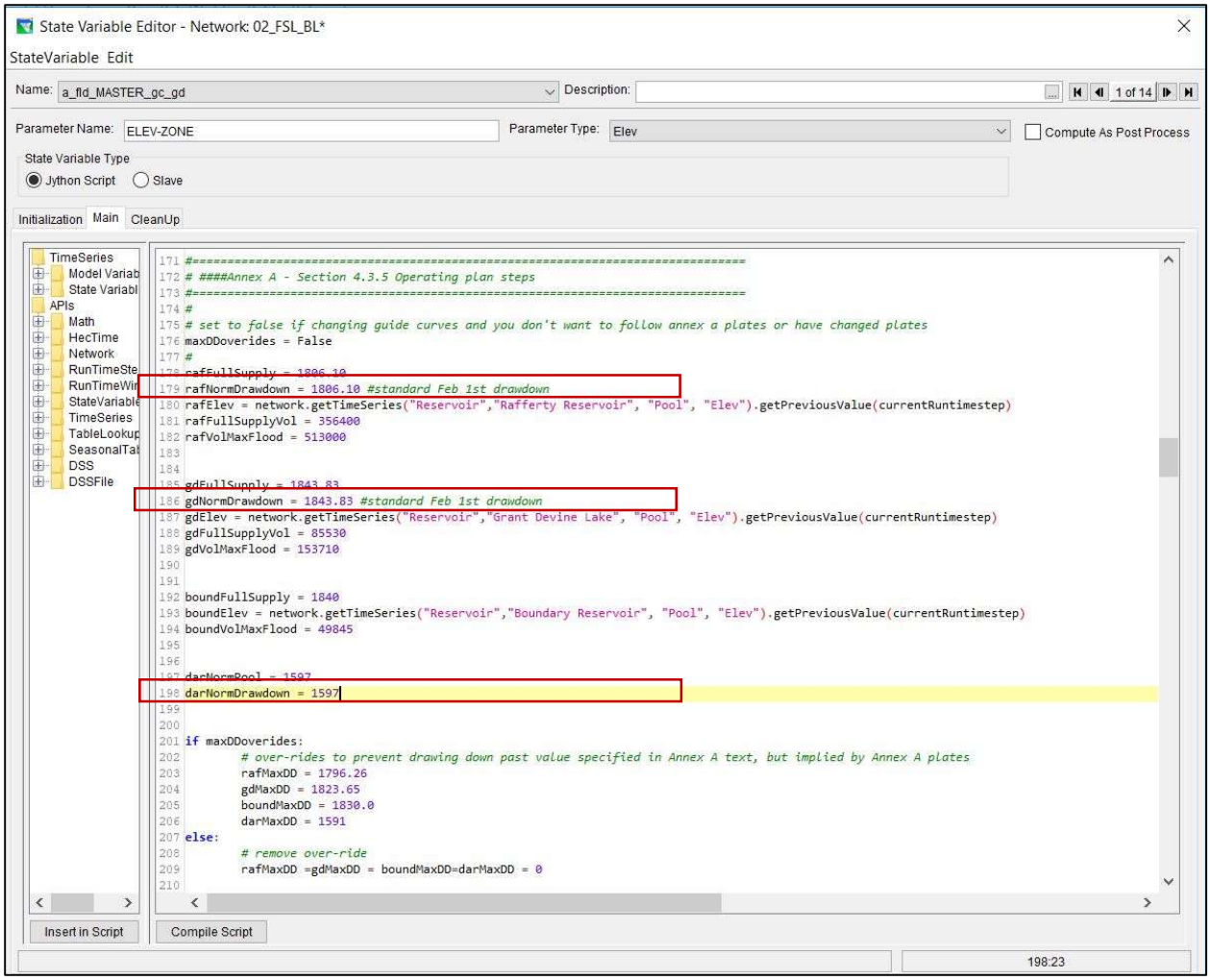


Figure 1. New script for normal drawdown limits at each reservoir

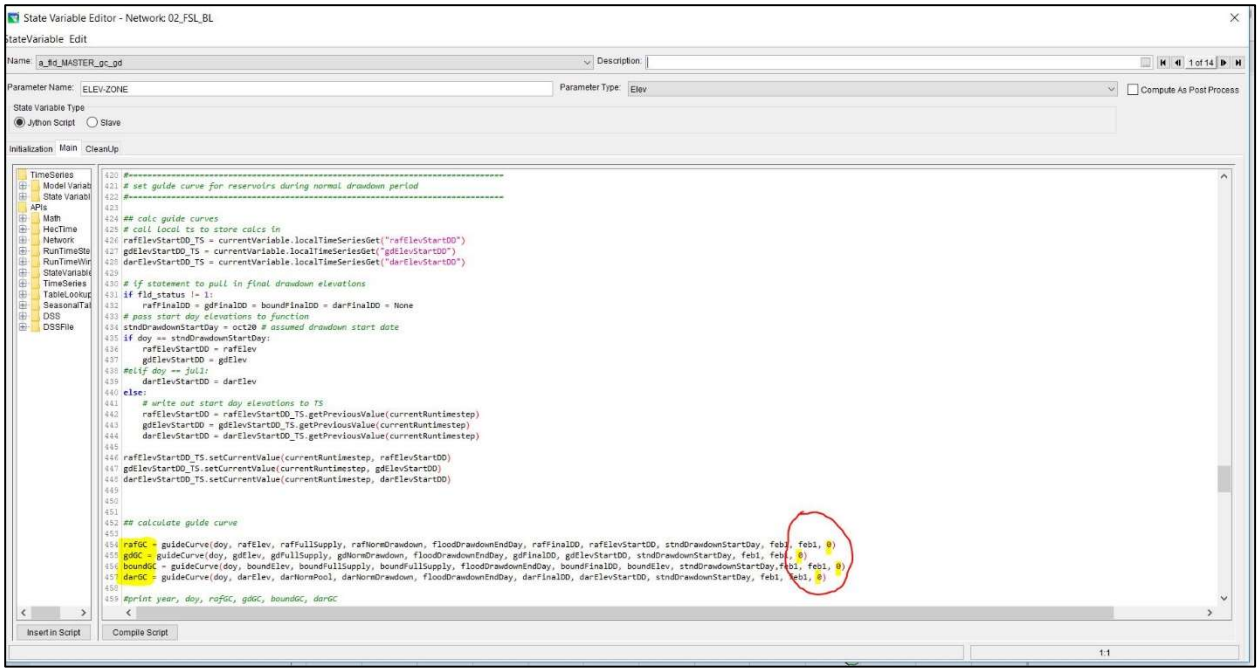


Figure 2. New script forcing the guide curve to stay at FSL for each reservoir regardless of flood condition

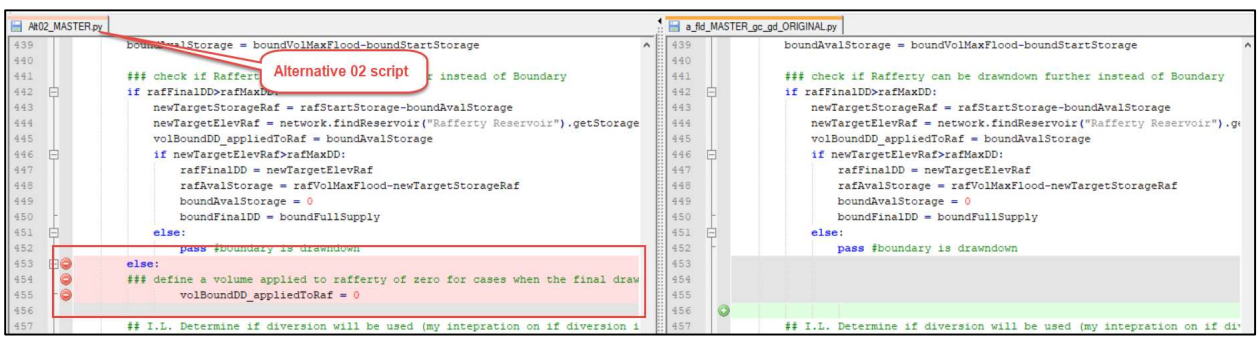


Figure 3. New Rafferty "else" statement

3. Alternative vs Baseline Scenario Results

Plates 01-18 show hydrographs detailing the results of Alternative 2 relative to the baseline scenario at Rafferty, Boundary, Grant Devine, and Lake Darling reservoirs, as well as seven critical mainstem flow locations, for select "index" years. Index years were selected to be representative of high, medium, and low flow years in the basin. High flow years include 2011, 1976, 1975, and 1969, medium flow years include 1987, 1952, and 1946, and low flow years include 1937, 1988, and two extended drought sequences: 1931-1937 and 1988-1991. For Alternative 2, all index years within the simulation time window are plotted.

Plate 19 displays performance indicator results for all study reaches over the entire simulation (1946-2017). More information regarding performance indicator (PI) results and PI development can be found in the Data Collection for the Analysis of Alternatives Report (DW4) and Appendix A-5.

4. Summary of Results

Pool elevations and flow volumes remain higher during normal and high flow events compared to baseline conditions. Index events focusing on drought years do not show substantial benefit to water supply during drought years. Downstream flow peaks are generally higher than baseline conditions. Downstream locations reach flood levels more quickly and remain in flood conditions longer than in baseline conditions.

4.1 Performance Indicators

4.1.1 Reservoirs

Since this scenario solely attempts to hold the reservoirs at or above full supply level (FSL), there is more water in the reservoirs year-round. Subsequently, Boundary, Rafferty, and Grant Devine show improvements to water supply, and the higher pool elevations at Rafferty and Grant Devine provide improved fish habitat. Rafferty and Boundary show improvements to recreation PIs. At Lake Darling, higher lake levels mean flood operations are activated at Mouse River Park more often, and historic sites and boating accesses are flooded more often.

4.1.2 Riverine Reaches

Since there is more water in the reservoirs during this simulation, there is typically less water flowing through the river at most times of the year. However, since there is no storage in the reservoirs, floods are exacerbated. These effects are shown in Figure 4 and Figure 5, which show more occurrences of flows less than 20 cfs (0.6 cms) and flows greater than 1,000 cfs (28 cms). This change in the flow regime corresponds to more structural and agricultural damages throughout the basin, more bank erosion, and more fish kills. Also, since the river generally spends less time at moderate flows, there is less opportunity for recreation and reductions in water supply, fish and wildlife habitat, and water quality.

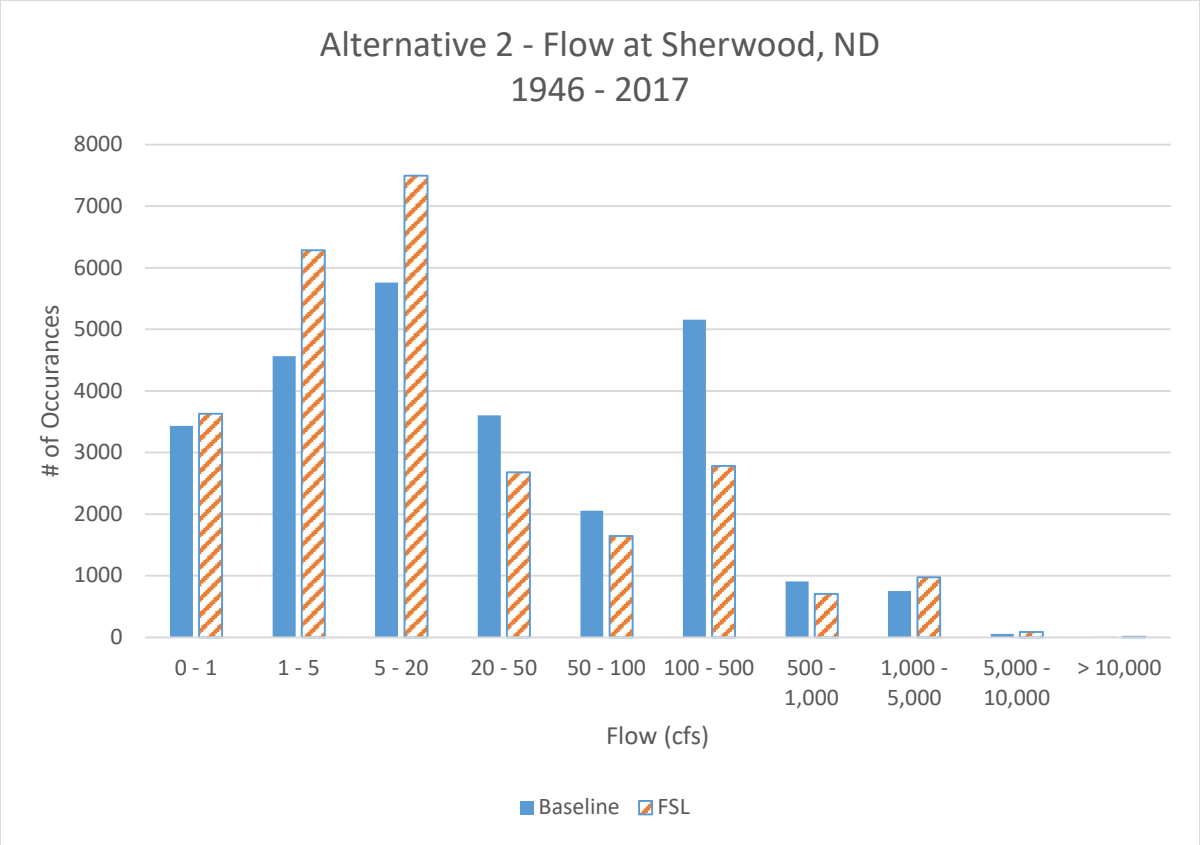


Figure 4. Flow distribution at Sherwood, ND

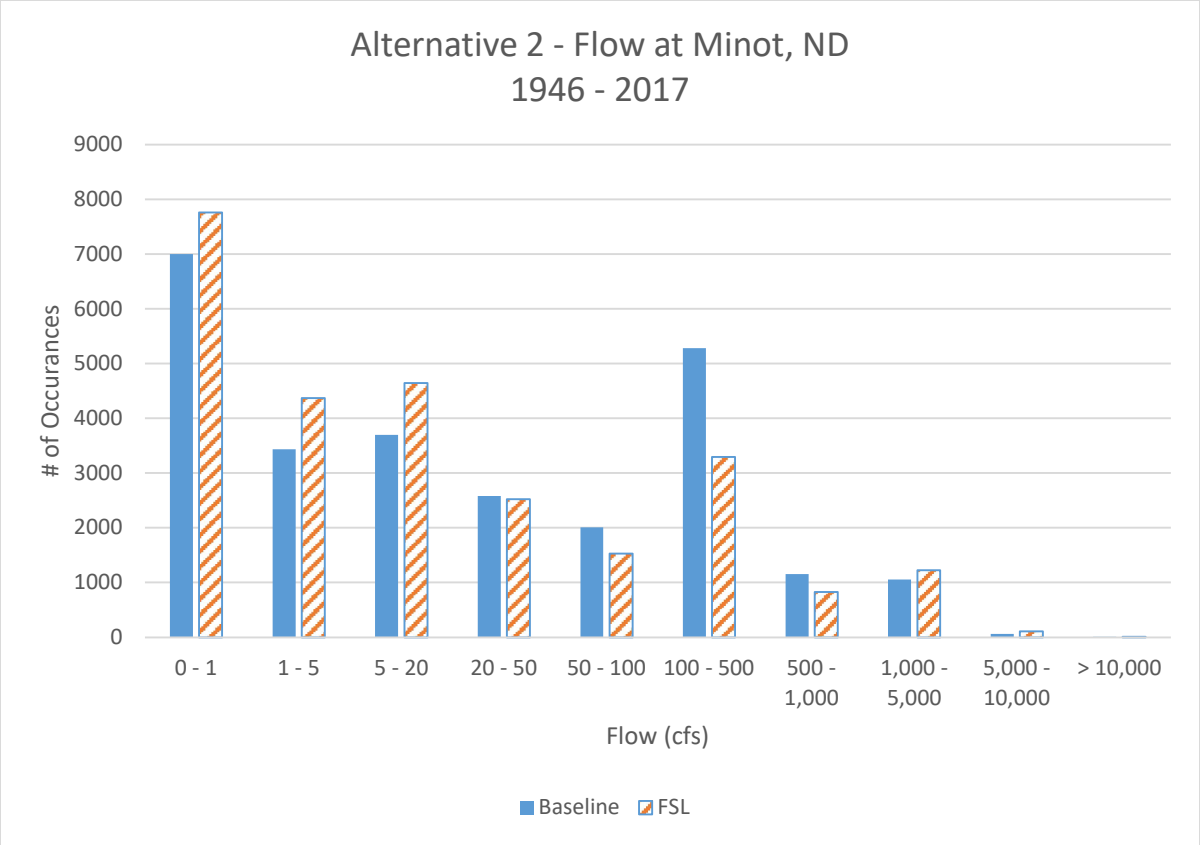
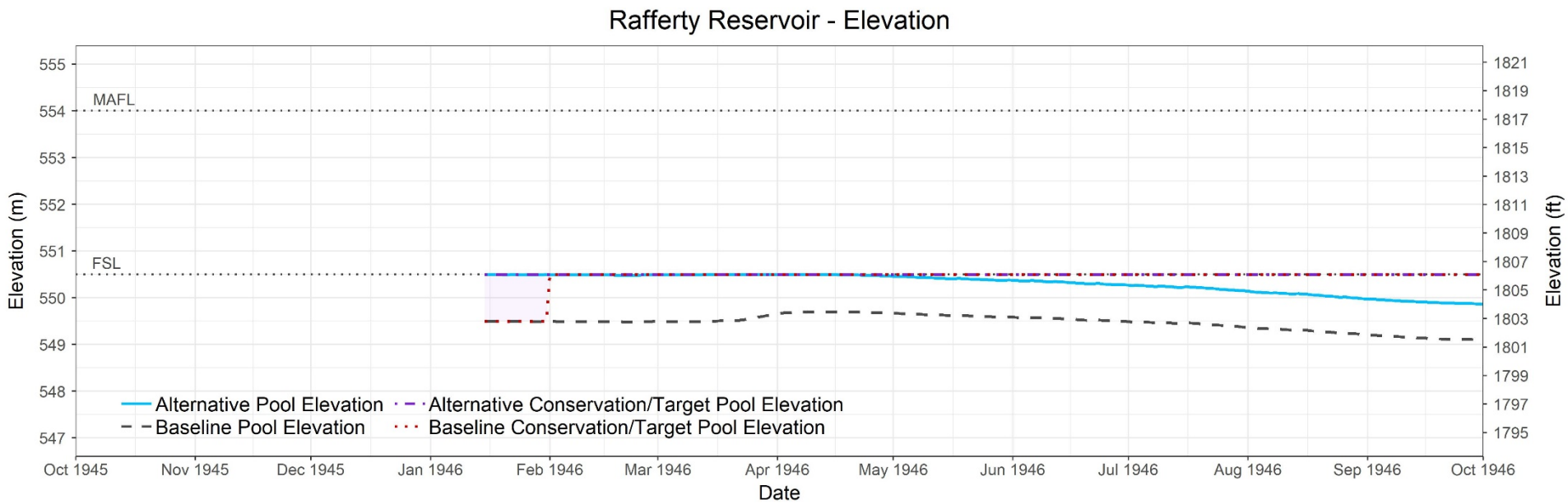


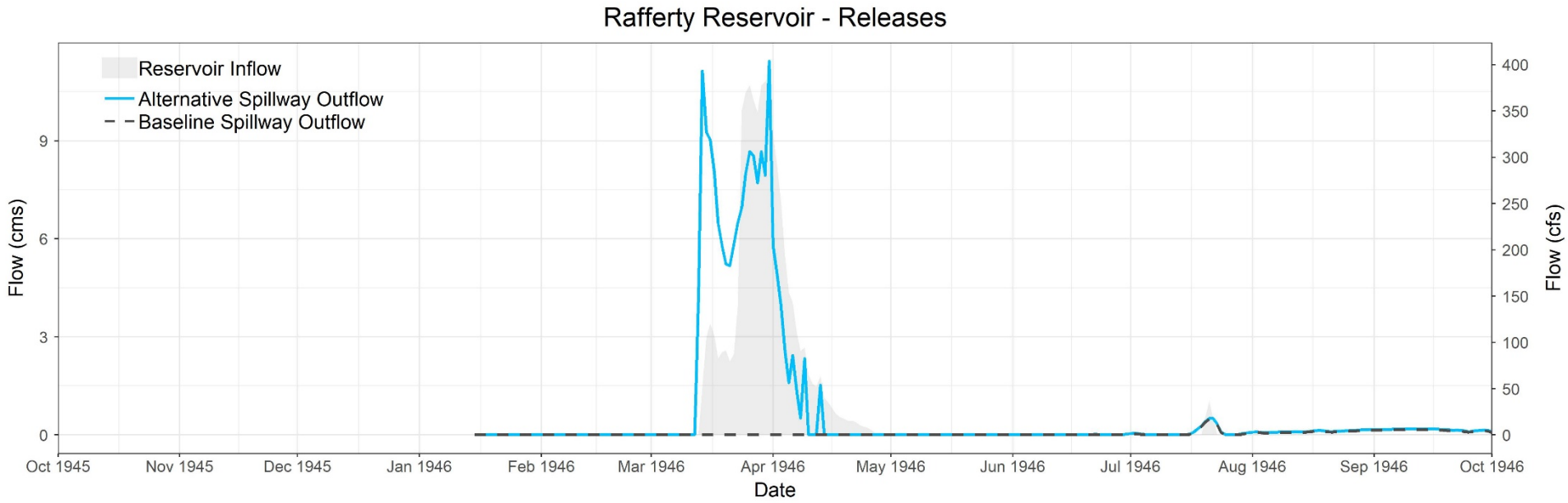
Figure 5. Flow distribution at Minot, ND

5. References

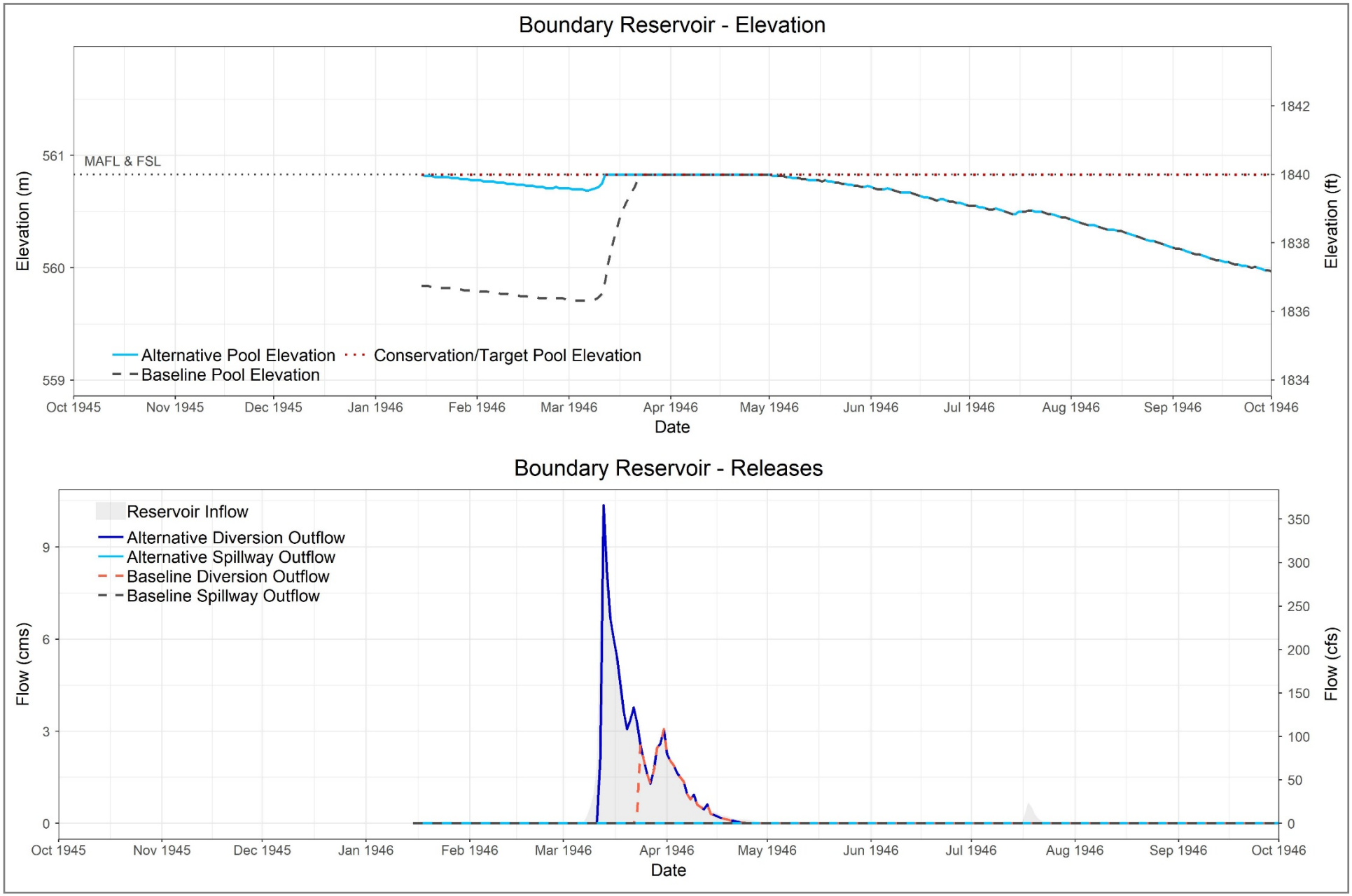
1. "HEC-DSSVue," U.S Army Corps of Engineers, Hyraulic Engineering Center, Febuary 2010.
2. "HEC-ResSim, Reservoir System Simulation, Version 3.3", U.S Army Corps of Engineers, Hydraulic Engineering Center, December 2018.
3. Canada and USA, 1989. Agreement between the Government of Canada and the United States for Water Supply and Flood Control in the Souris River Basin.
4. Canada and USA, 2000. Interim Measures As Modified For Apportionment of the Souris River.

Plate 01	Reservoirs – 1946	Alternative 2 (Phase 2) Souris River Plan of Study

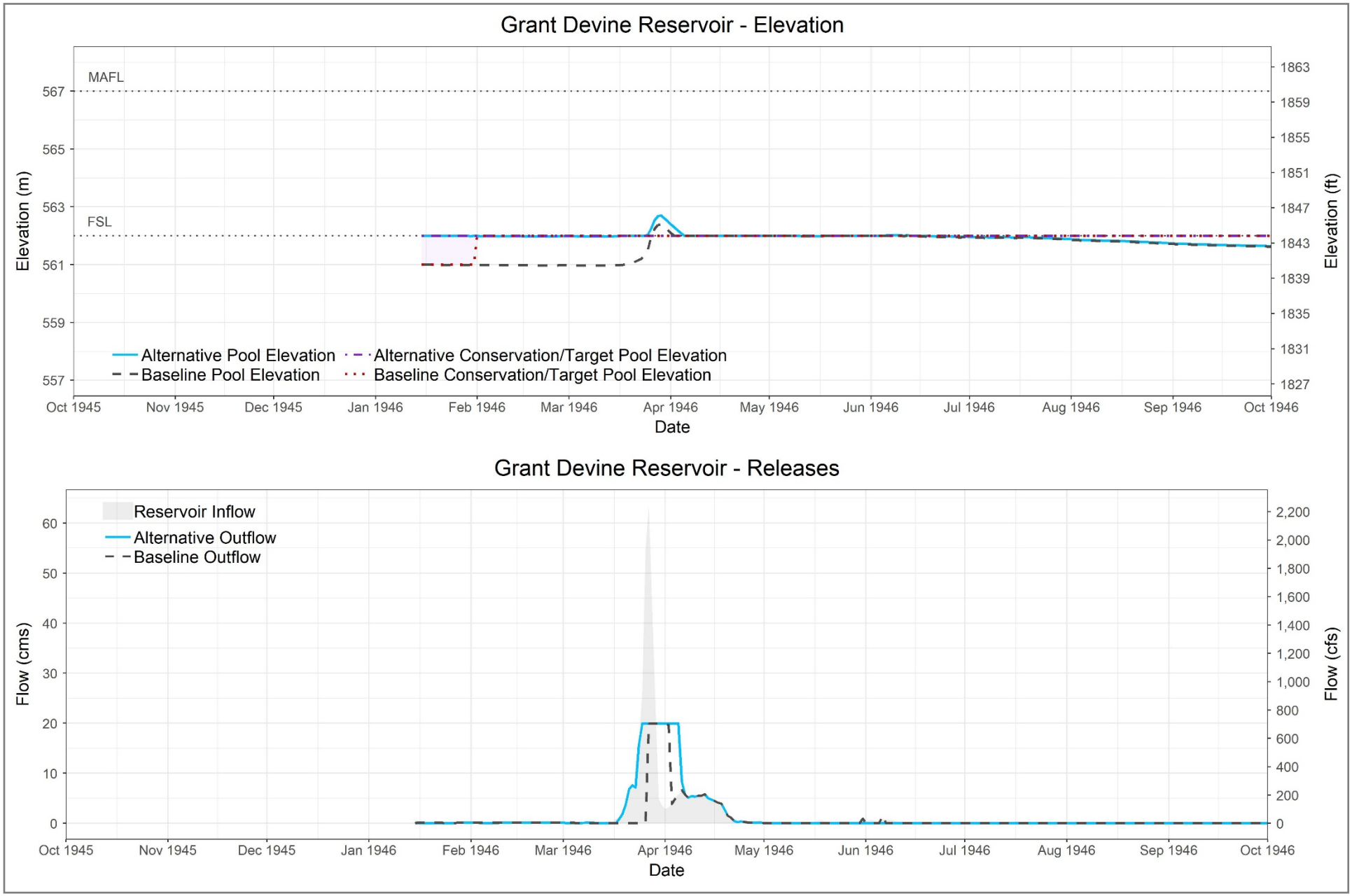




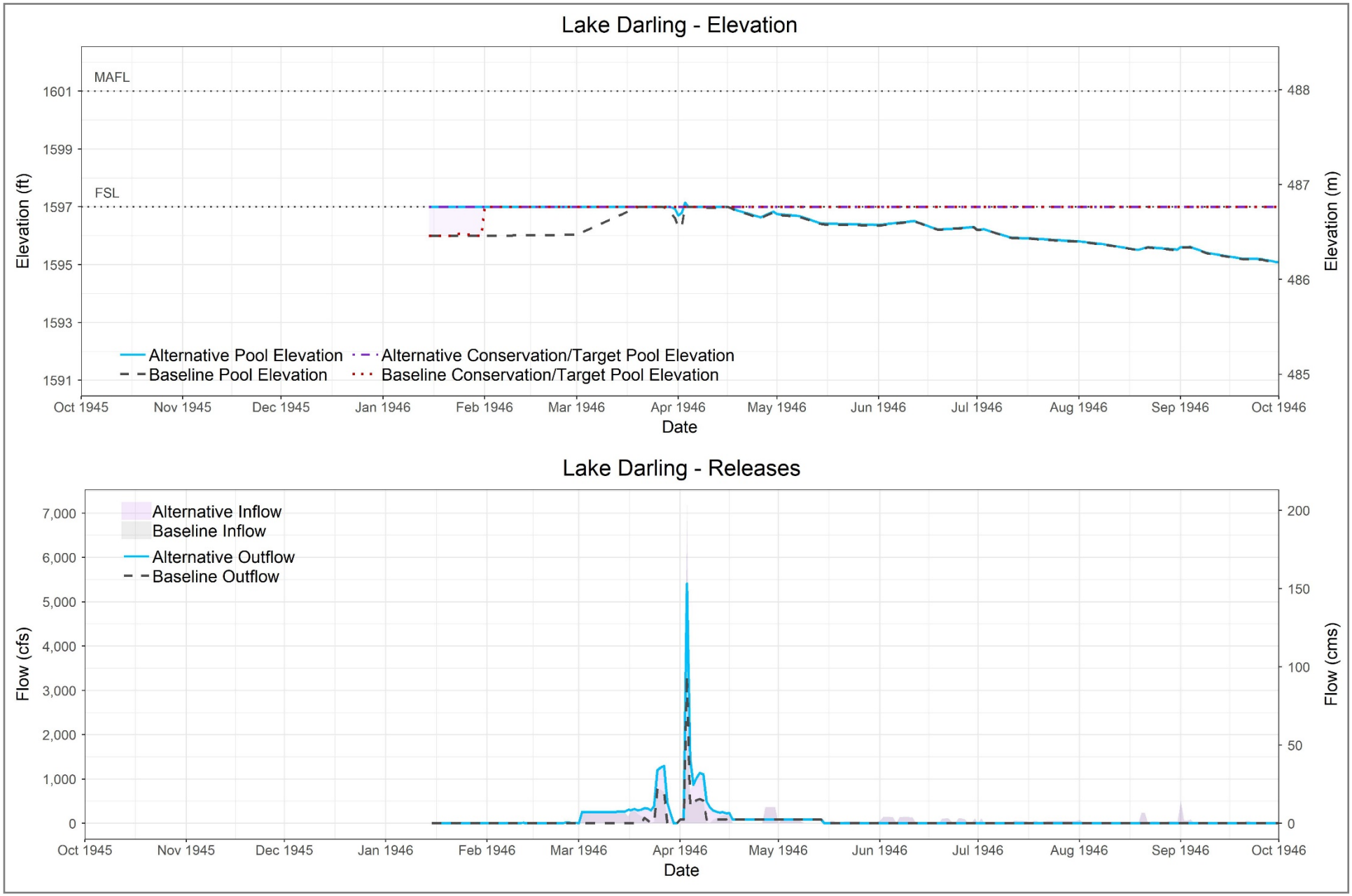
**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



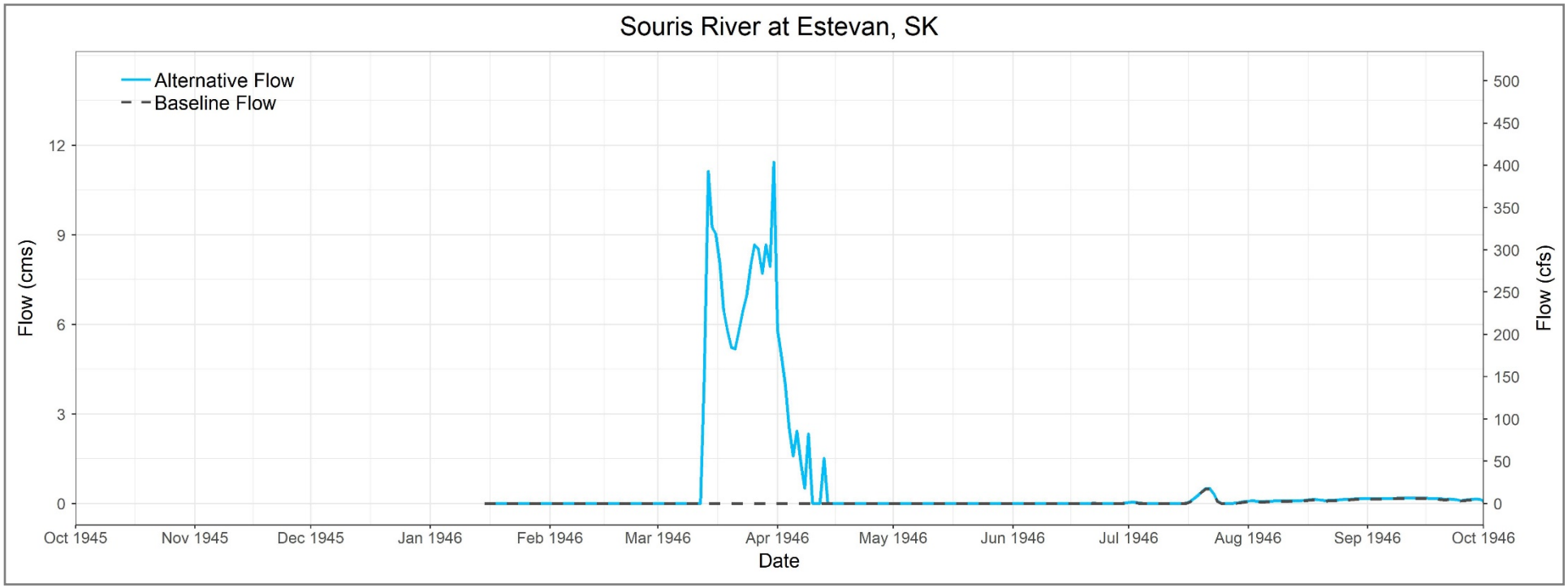
**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*

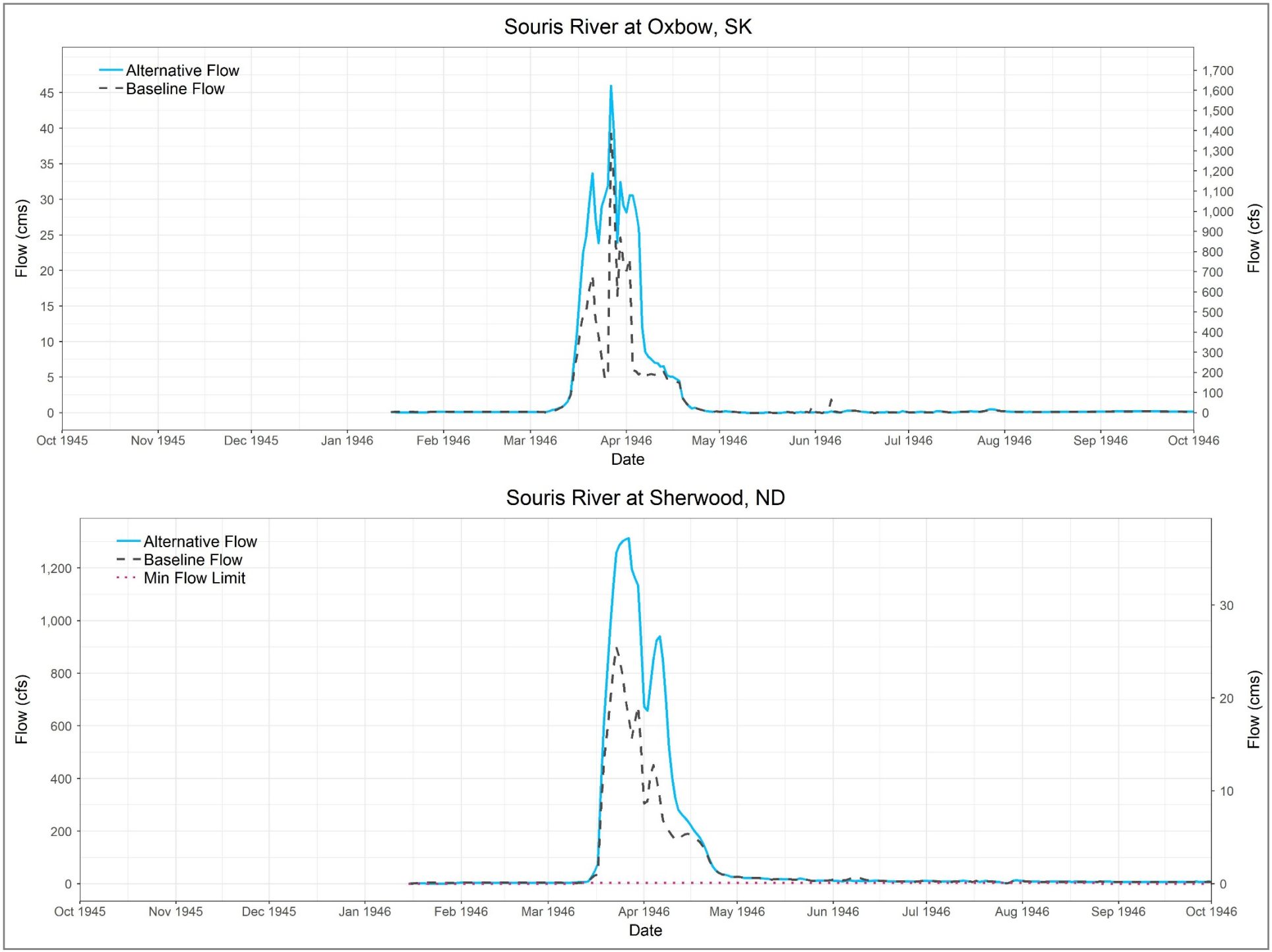
Plate 02

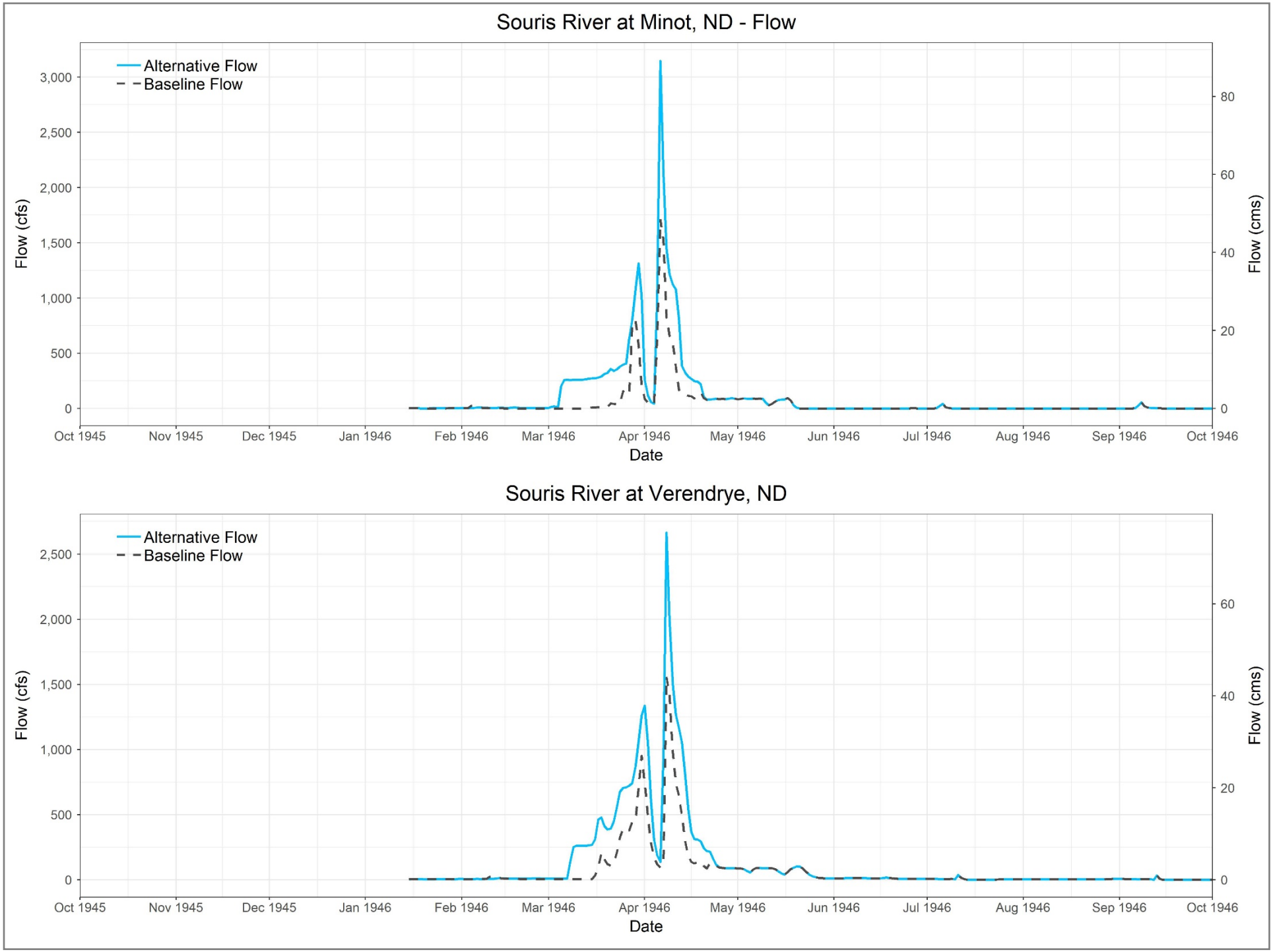
Critical Flow Locations – 1946

Alternative 2 (Phase 2)

Souris River Plan of Study




Souris River at Oxbow, SK
Alternative Flow
Baseline Flow
Flow (cms)
Flow (cfs)
Date
Oct 1945
Nov 1945
Dec 1945
Jan 1946
Feb 1946
Mar 1946
Apr 1946
May 1946
Jun 1946
Jul 1946
Aug 1946
Sep 1946
Oct 1946
Souris River at Sherwood, ND
Alternative Flow
Baseline Flow
Min Flow Limit
Flow (cfs)
Flow (cms)
Date


Souris River at Minot, ND - Flow
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
Date
Souris River at Verendrye, ND
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
Date

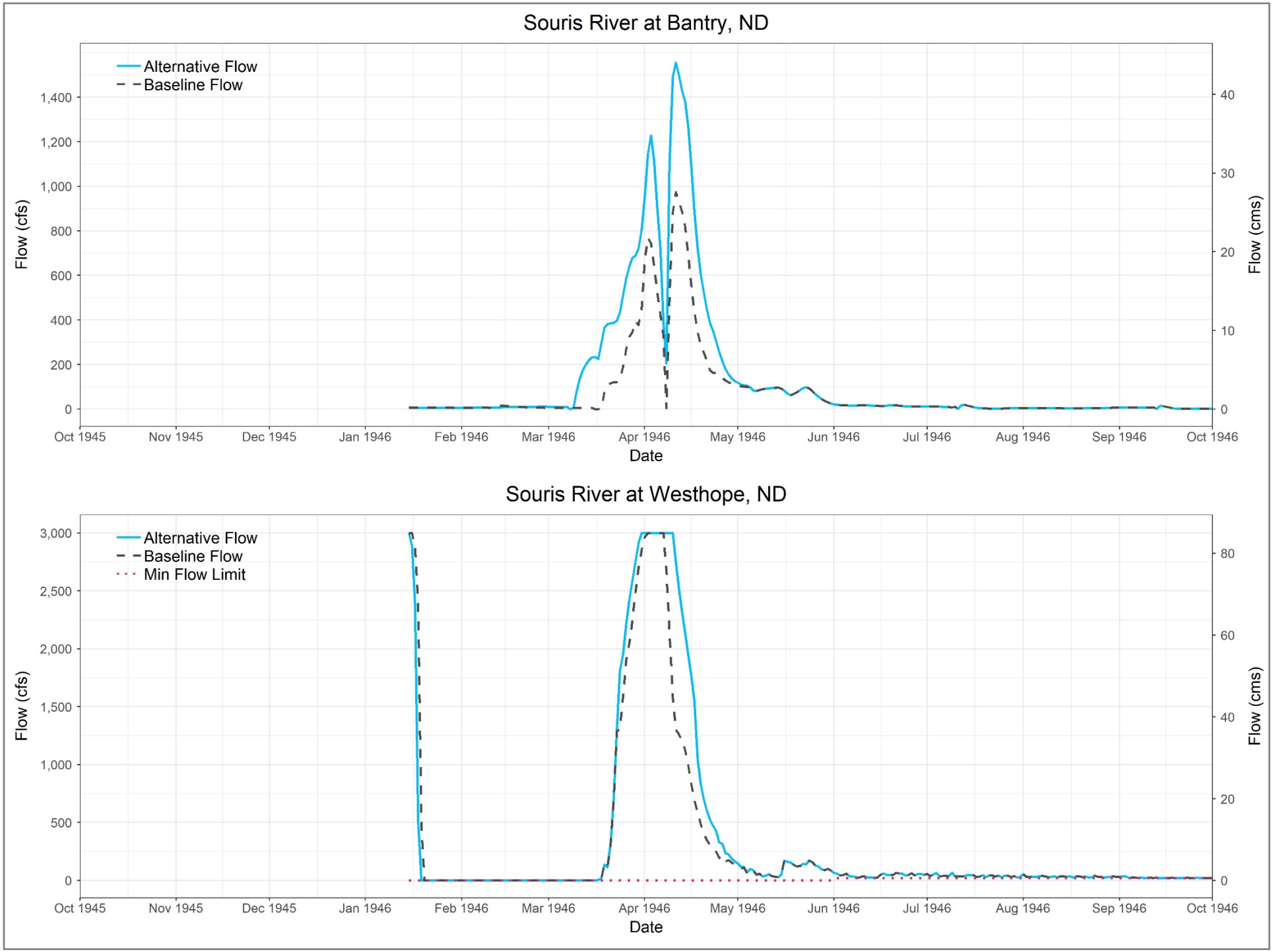
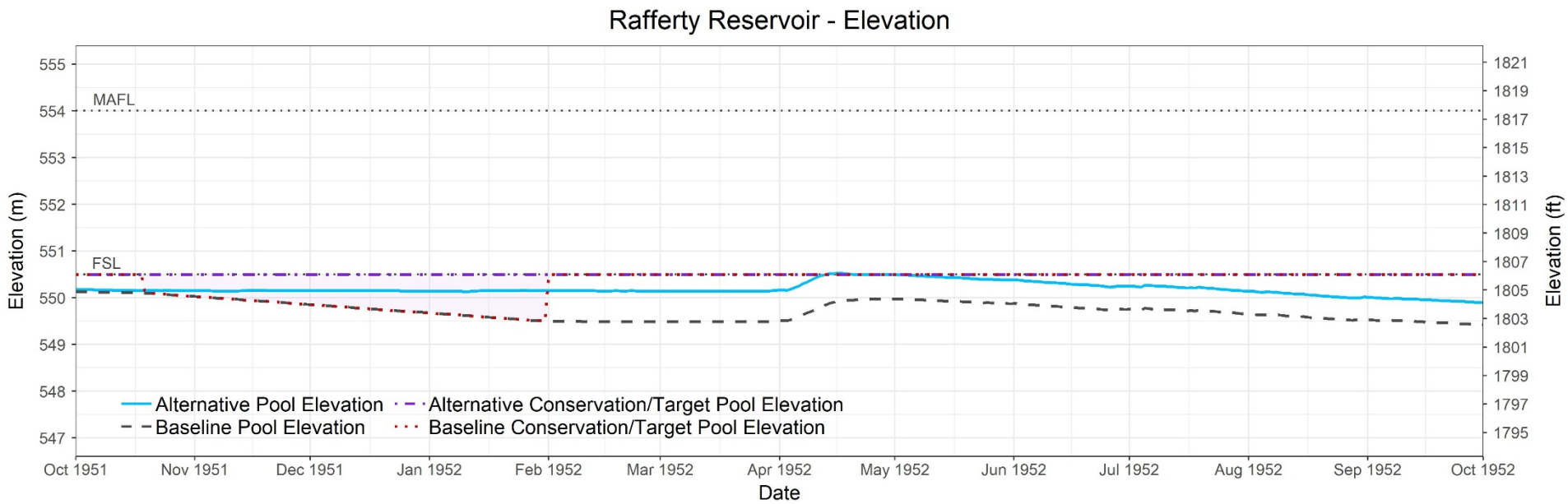
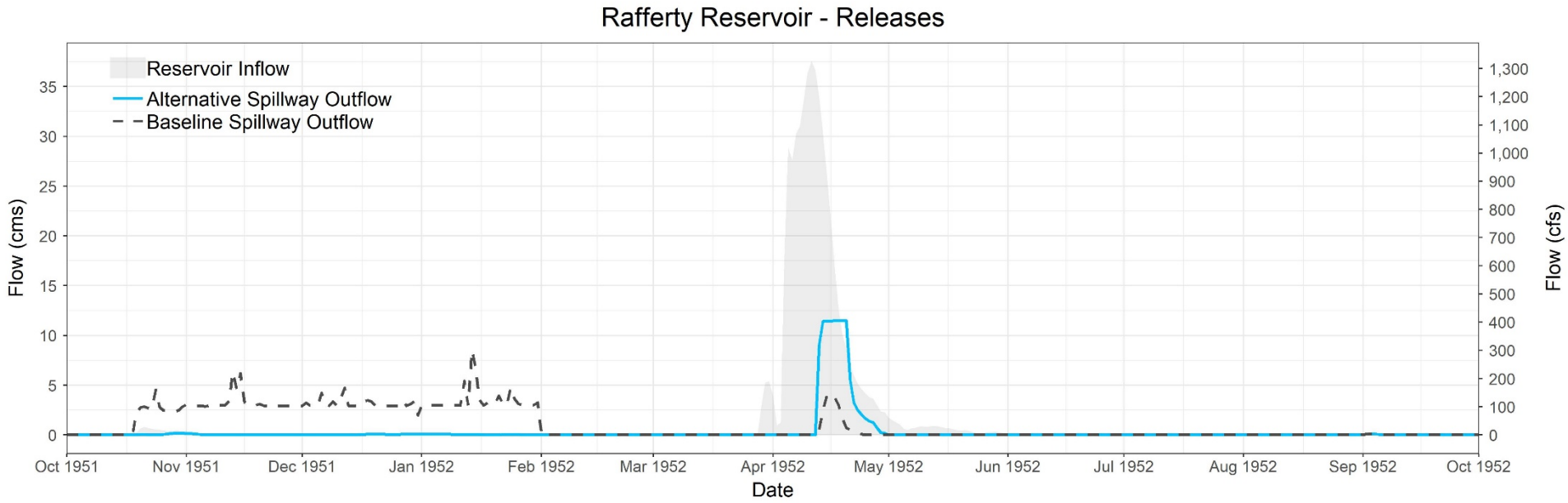
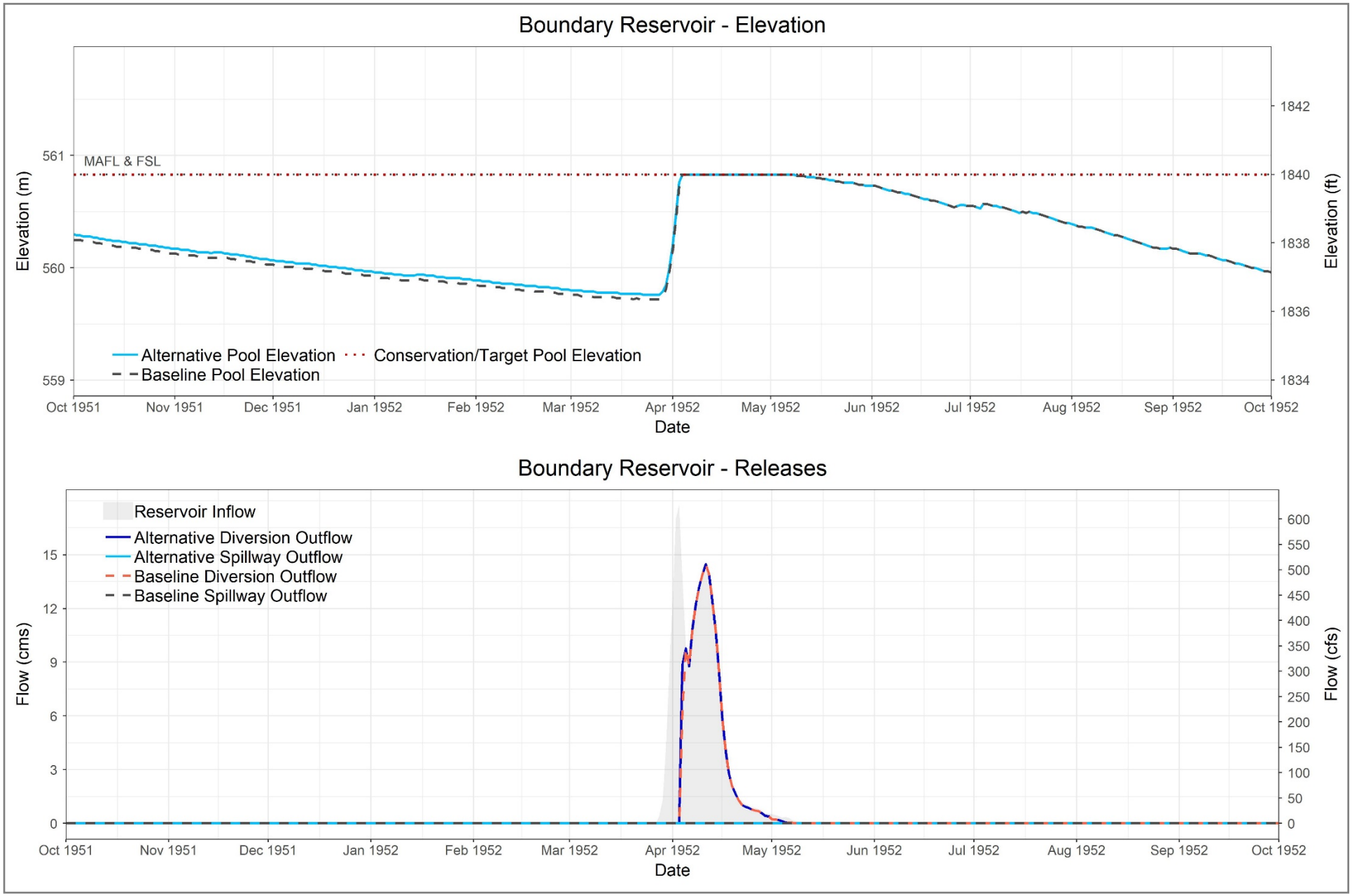

Souris River at Bantry, ND
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
Date
Souris River at Westhope, ND
Alternative Flow
Baseline Flow
Min Flow Limit
Flow (cfs)
Flow (cms)
Date

Plate 03	Reservoirs – 1952	Alternative 2 (Phase 2) Souris River Plan of Study

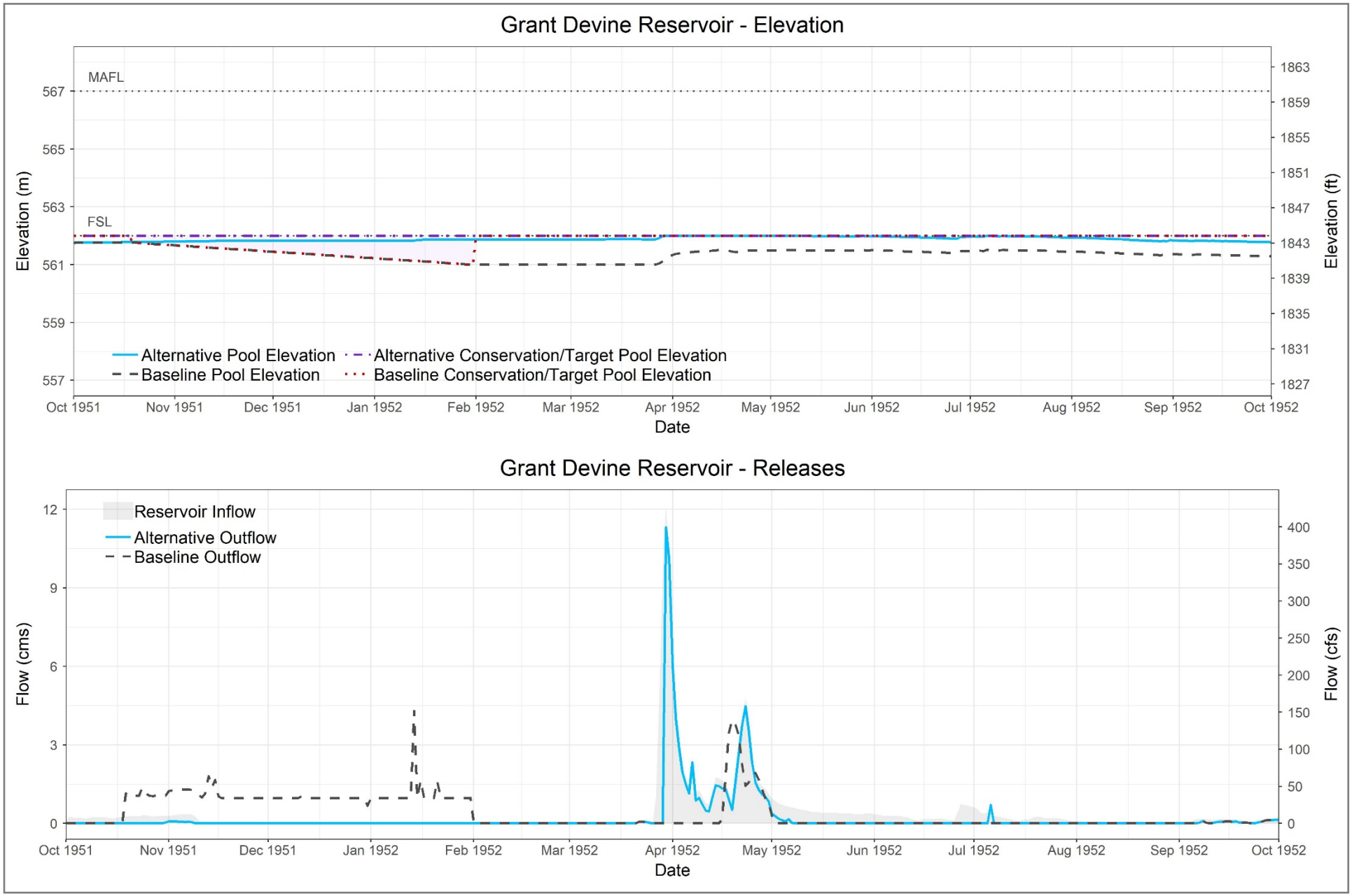




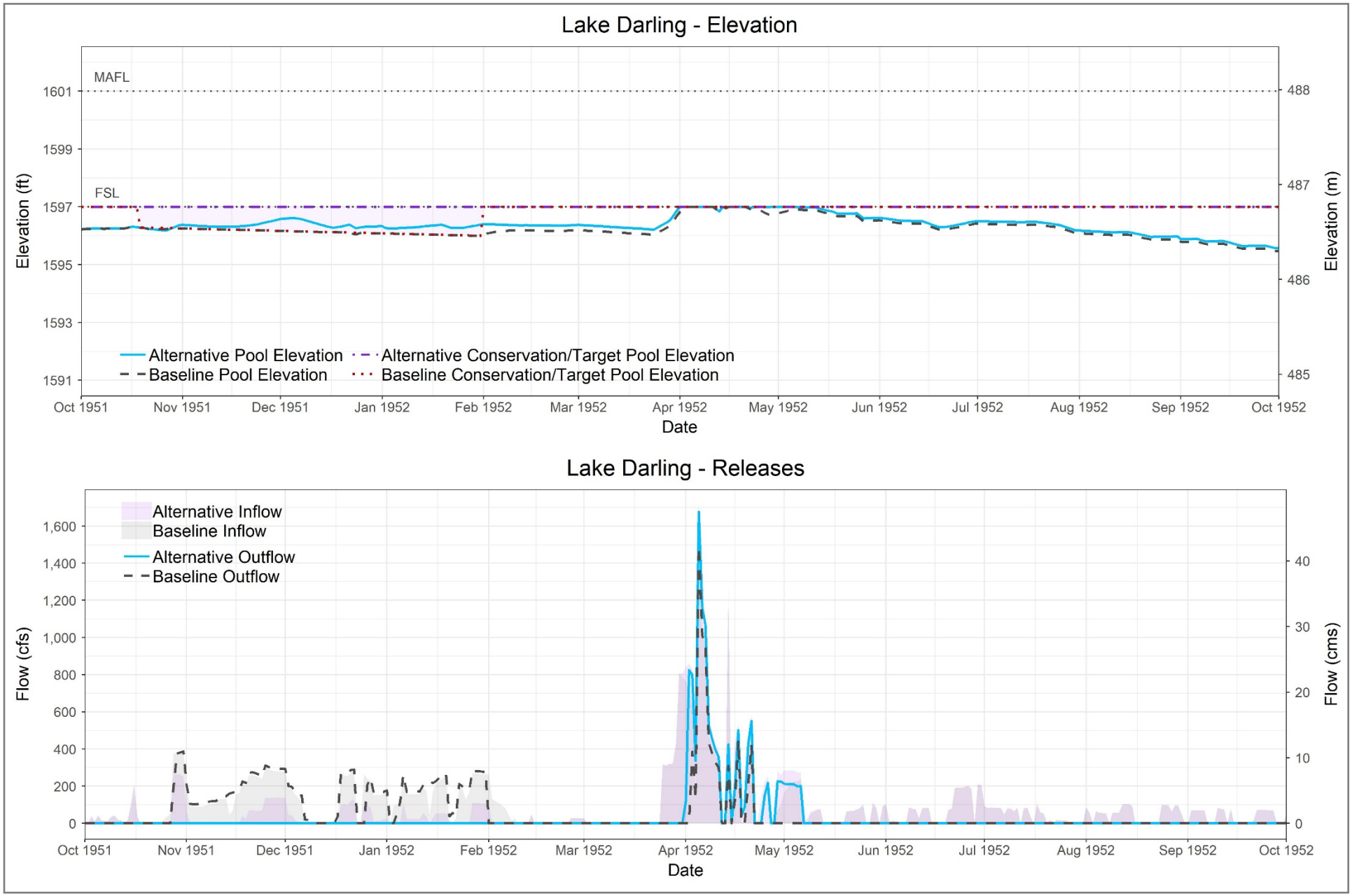
**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



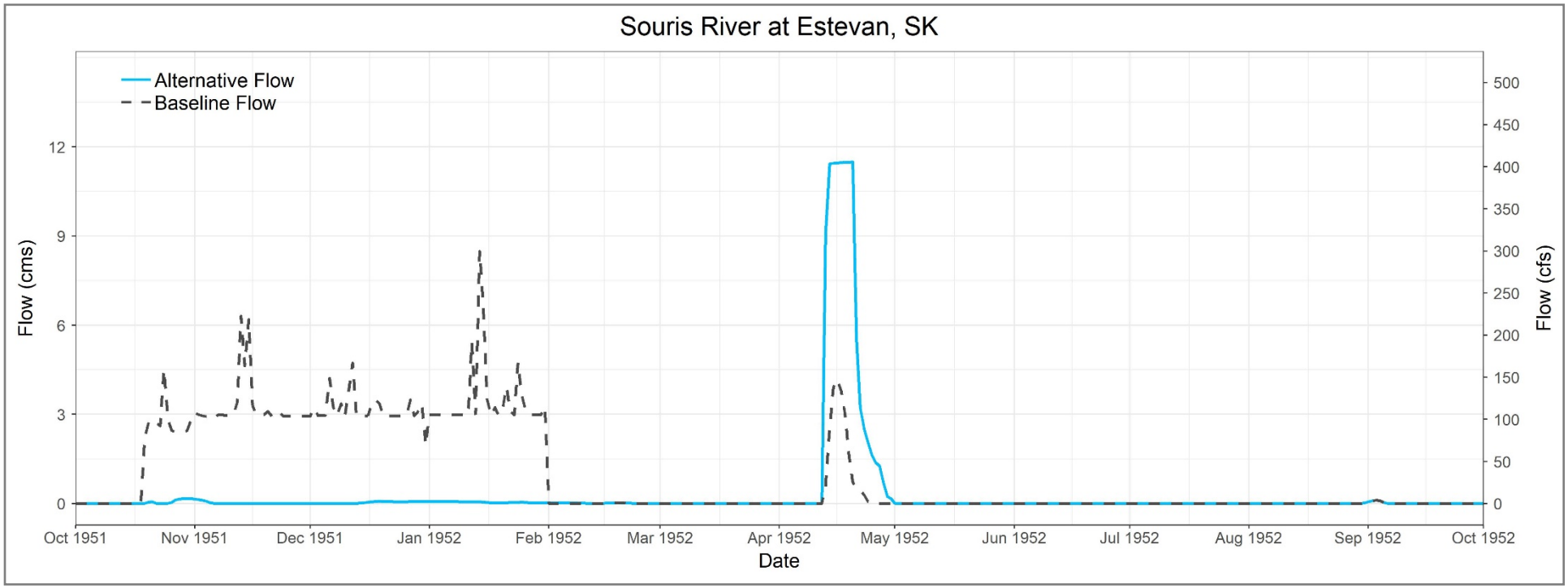
**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*

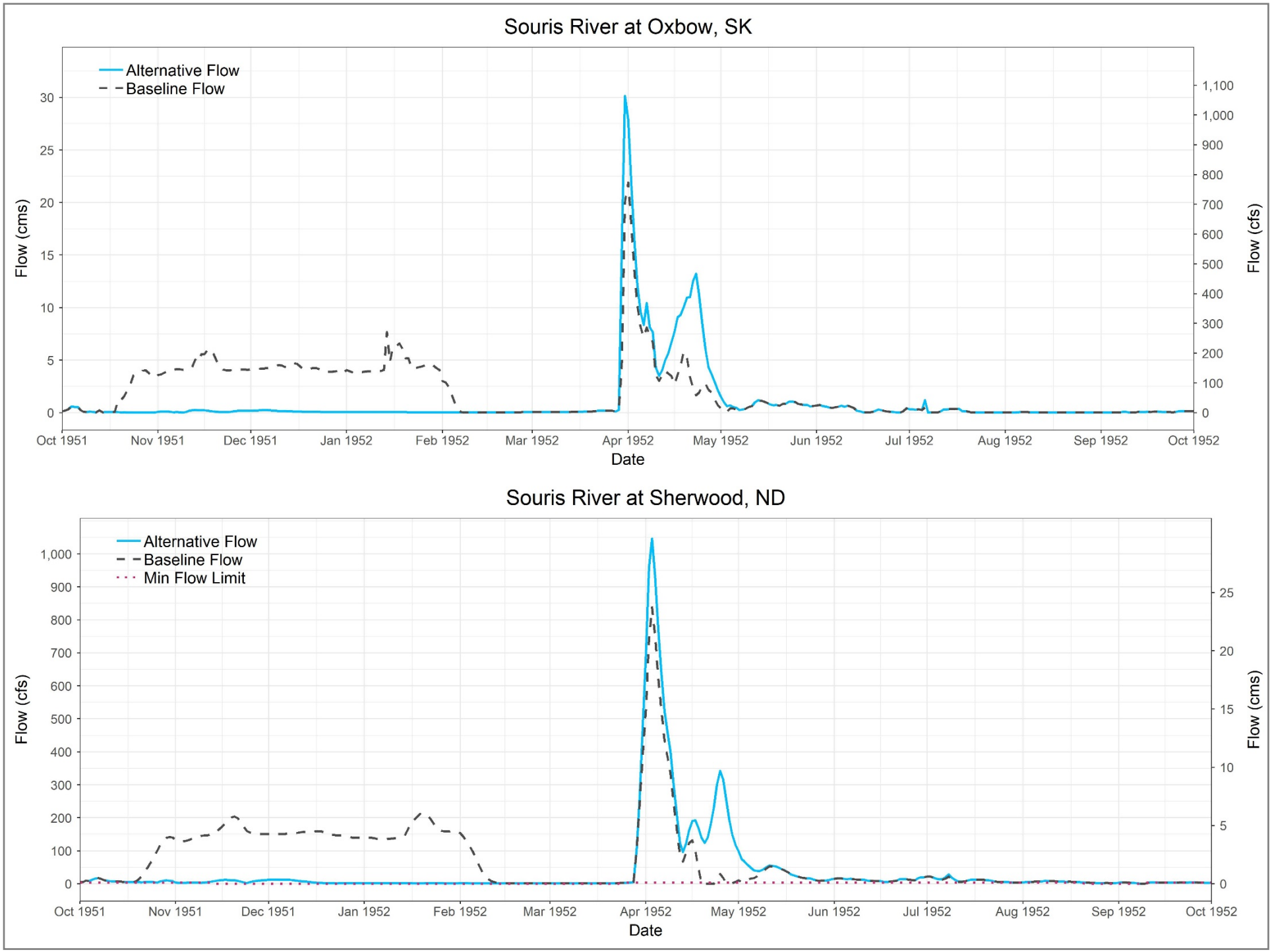
Plate 04

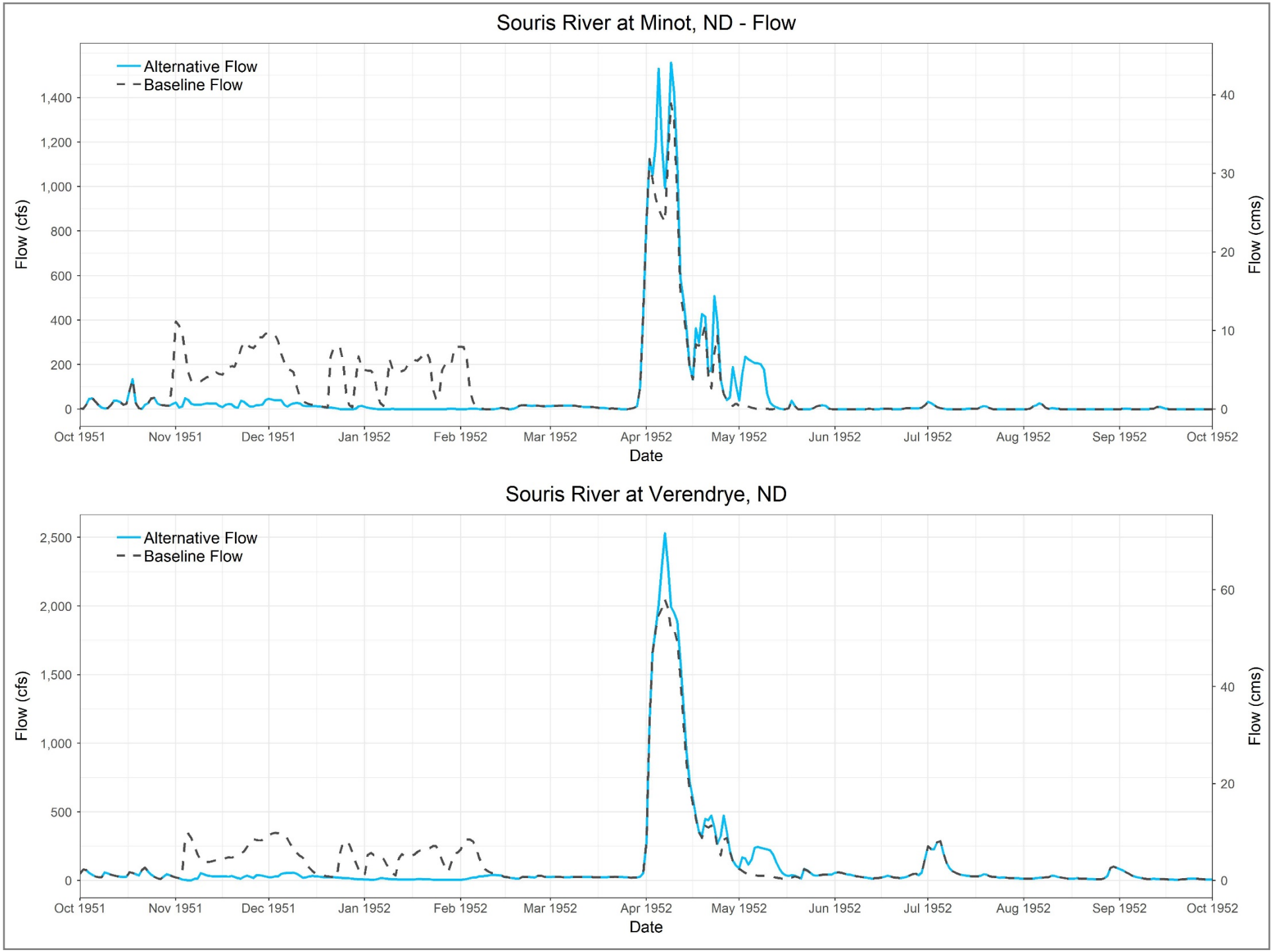
Critical Flow Locations – 1952

Alternative 2 (Phase 2)

Souris River Plan of Study




Souris River at Oxbow, SK
Alternative Flow
Baseline Flow
Flow (cms)
Flow (cfs)
Date
Oct 1951
Nov 1951
Dec 1951
Jan 1952
Feb 1952
Mar 1952
Apr 1952
May 1952
Jun 1952
Jul 1952
Aug 1952
Sep 1952
Oct 1952
Souris River at Sherwood, ND
Alternative Flow
Baseline Flow
Min Flow Limit
Flow (cfs)
Flow (cms)
Date


Souris River at Minot, ND - Flow
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
Date
Souris River at Verendrye, ND
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
Date

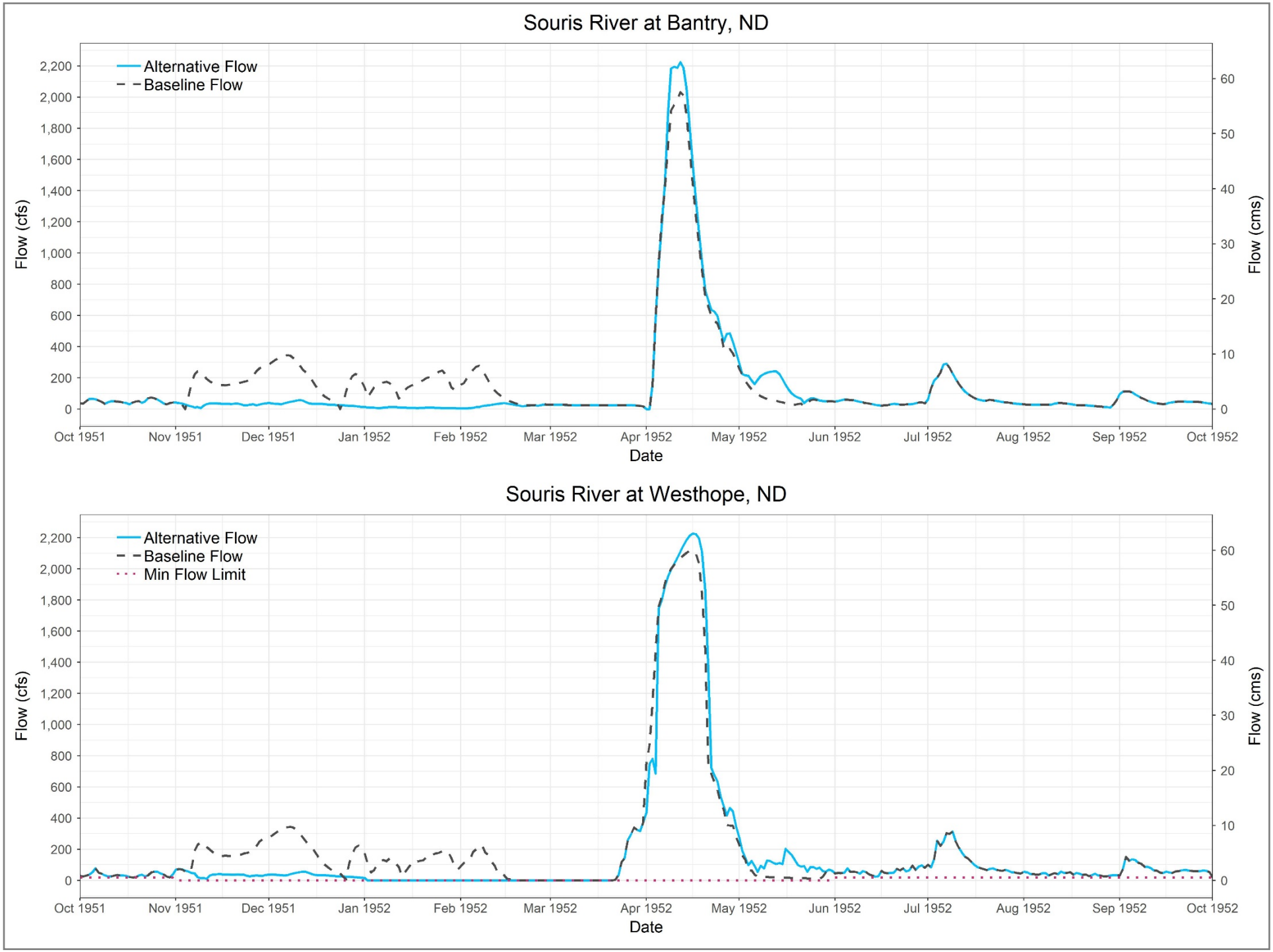
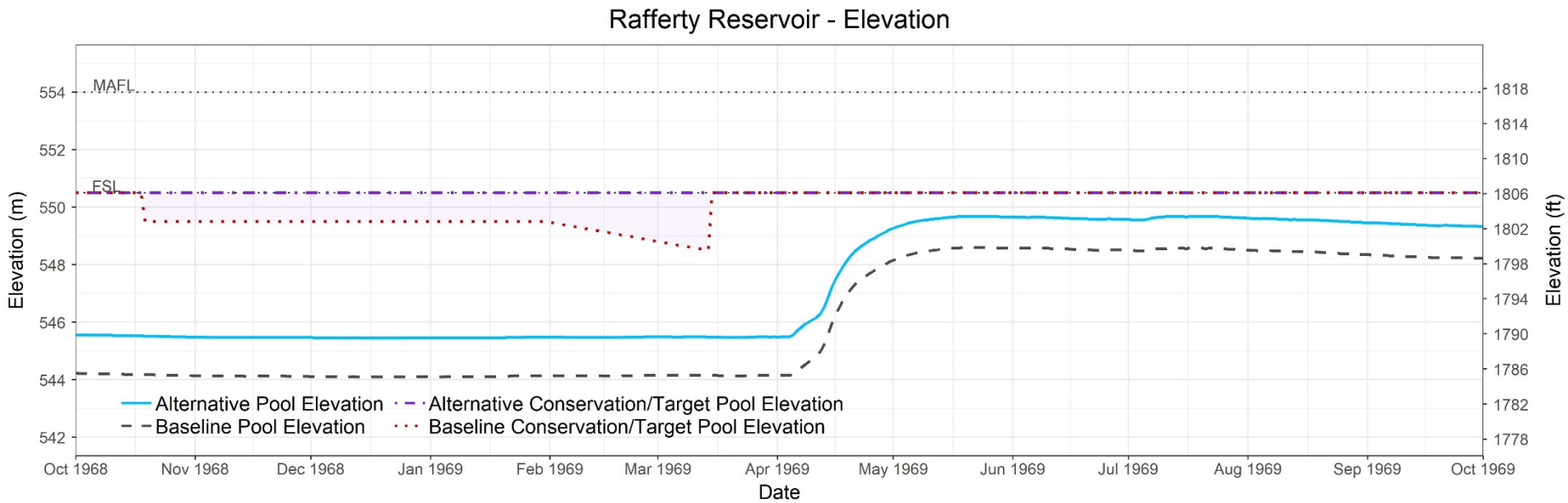
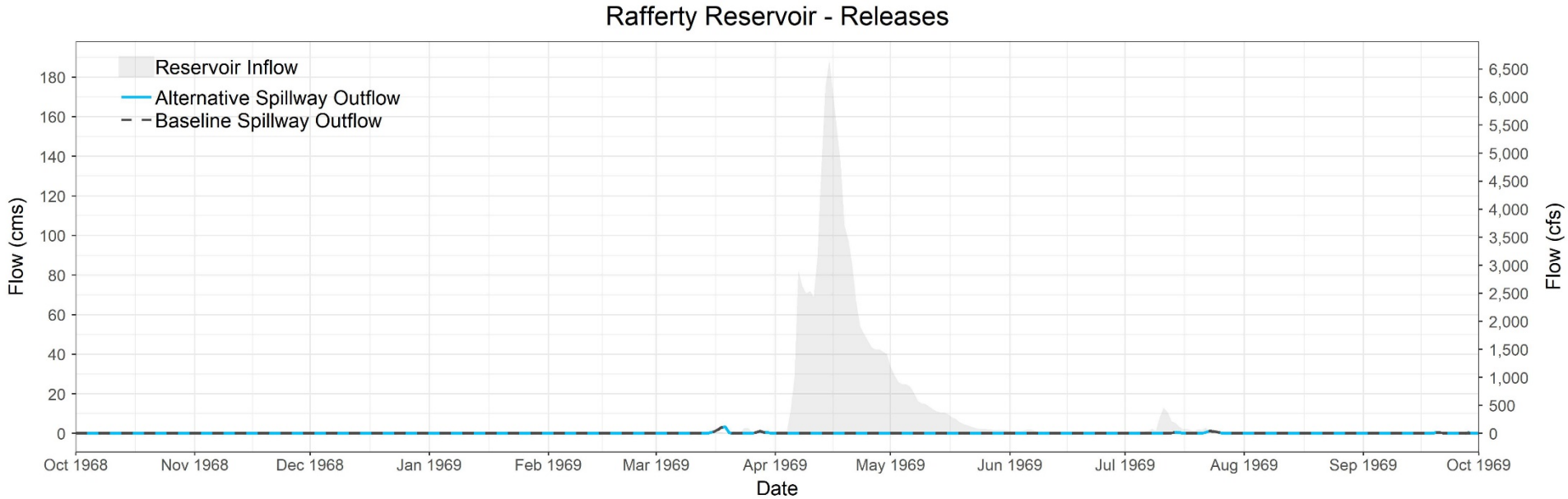
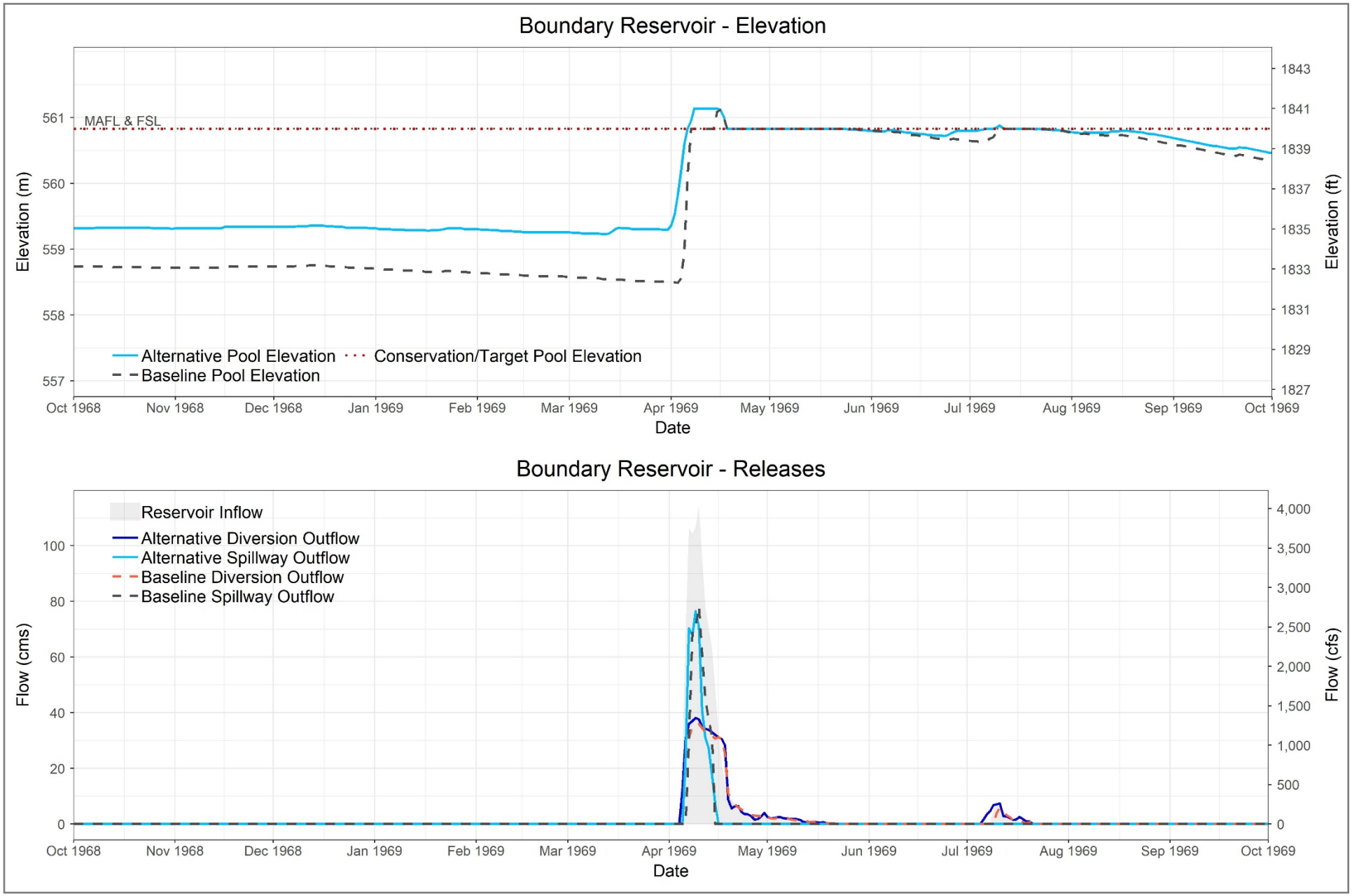

Souris River at Bantry, ND
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
Date
Oct 1951
Nov 1951
Dec 1951
Jan 1952
Feb 1952
Mar 1952
Apr 1952
May 1952
Jun 1952
Jul 1952
Aug 1952
Sep 1952
Oct 1952
Souris River at Westhope, ND
Alternative Flow
Baseline Flow
Min Flow Limit
Flow (cfs)
Flow (cms)
Date

Plate 05	Reservoirs – 1969	Alternative 2 (Phase 2) Souris River Plan of Study

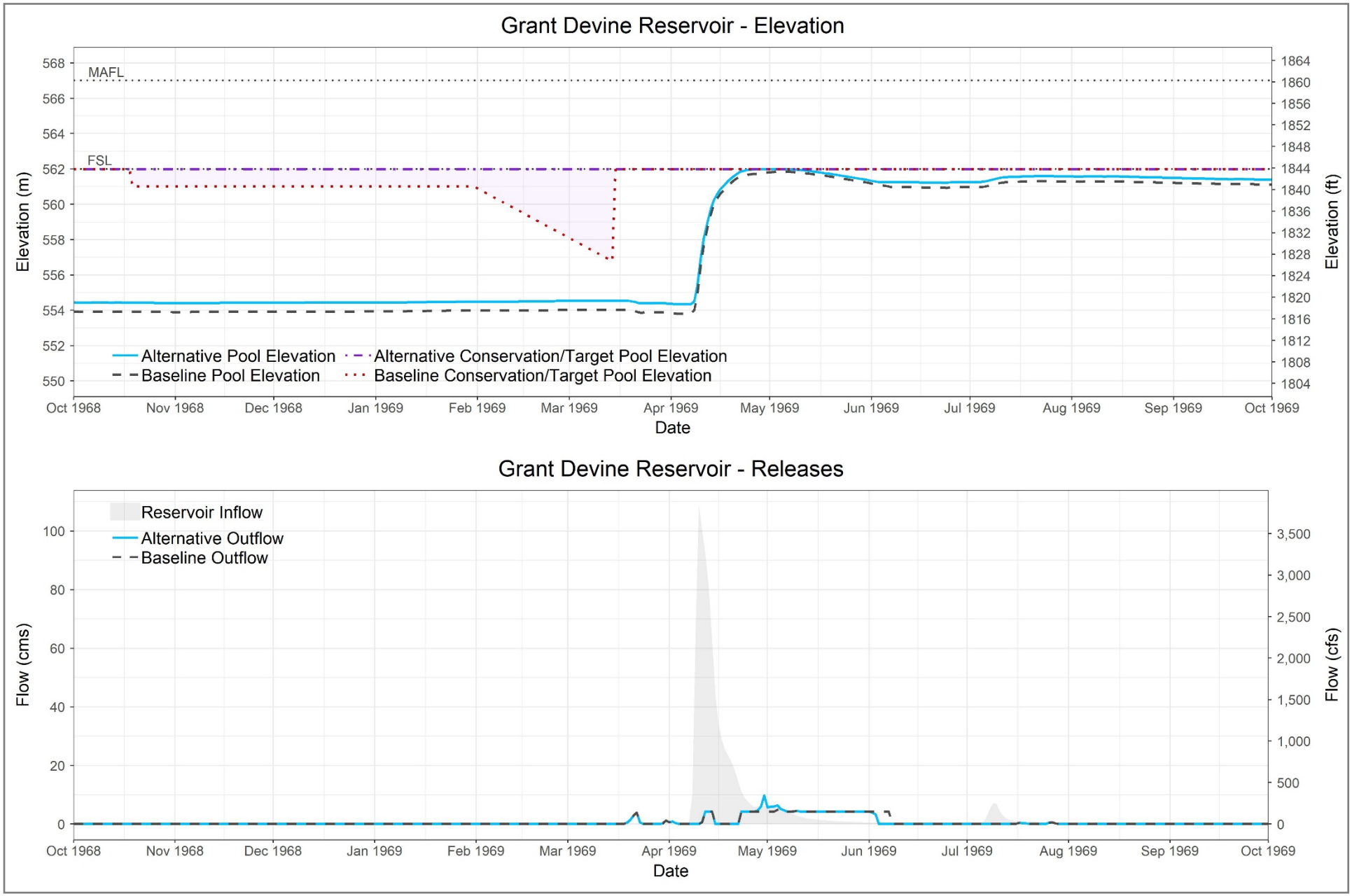




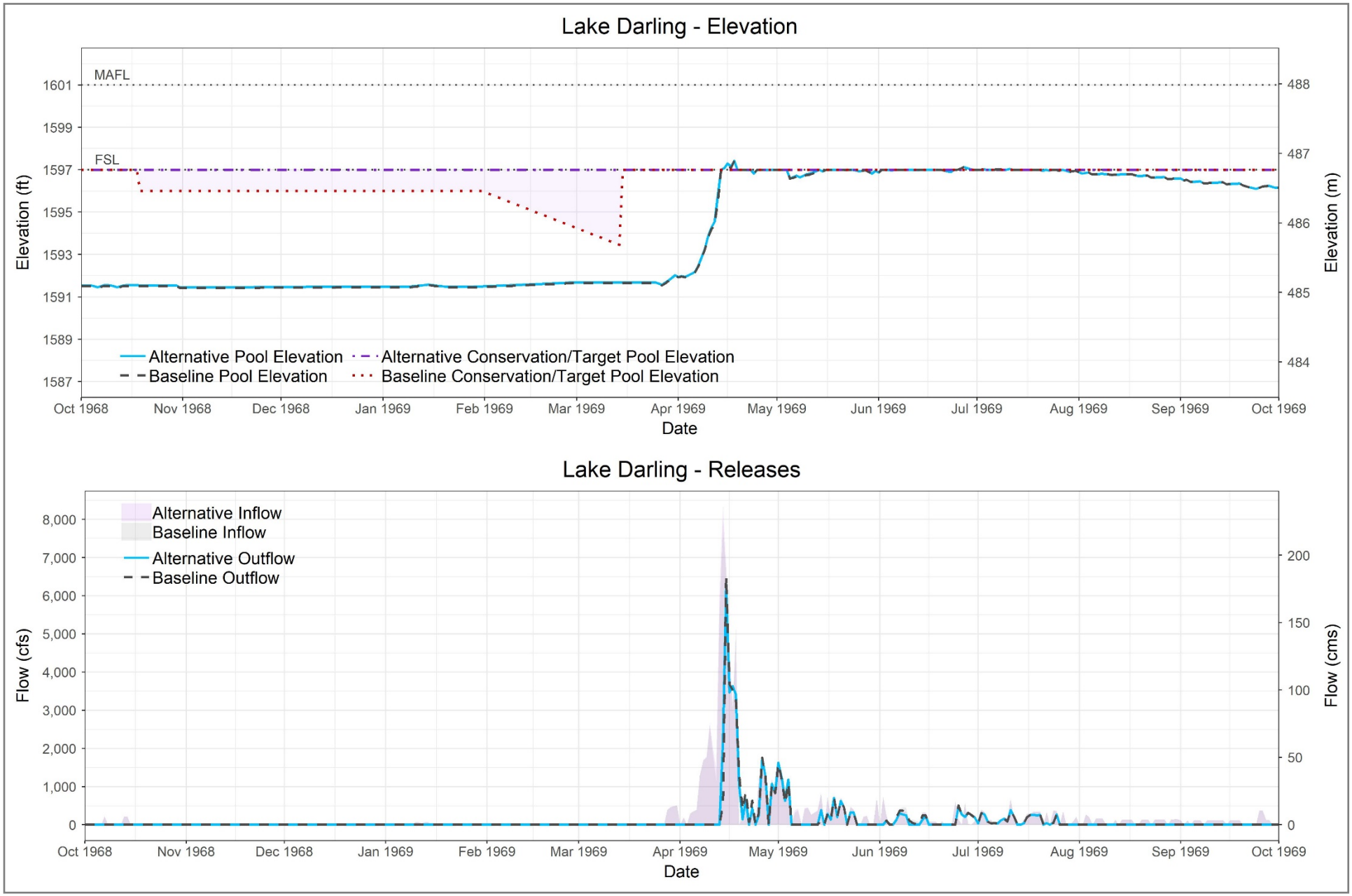
**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



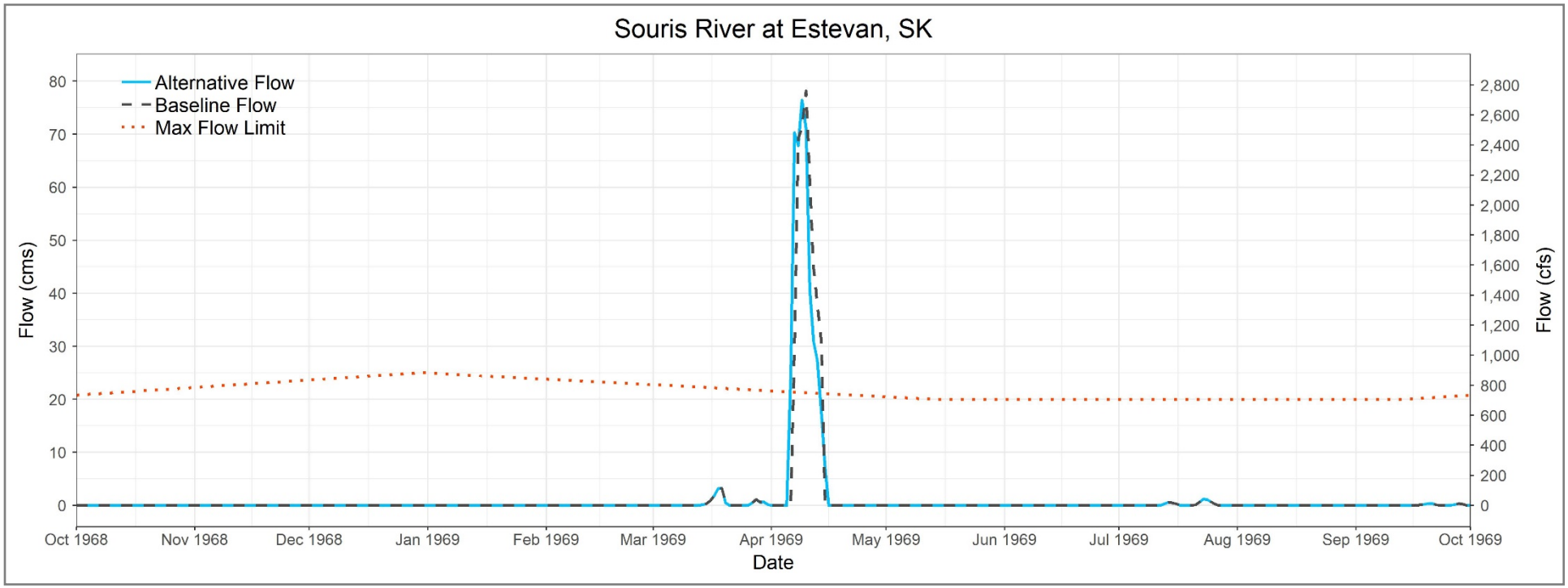
**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*

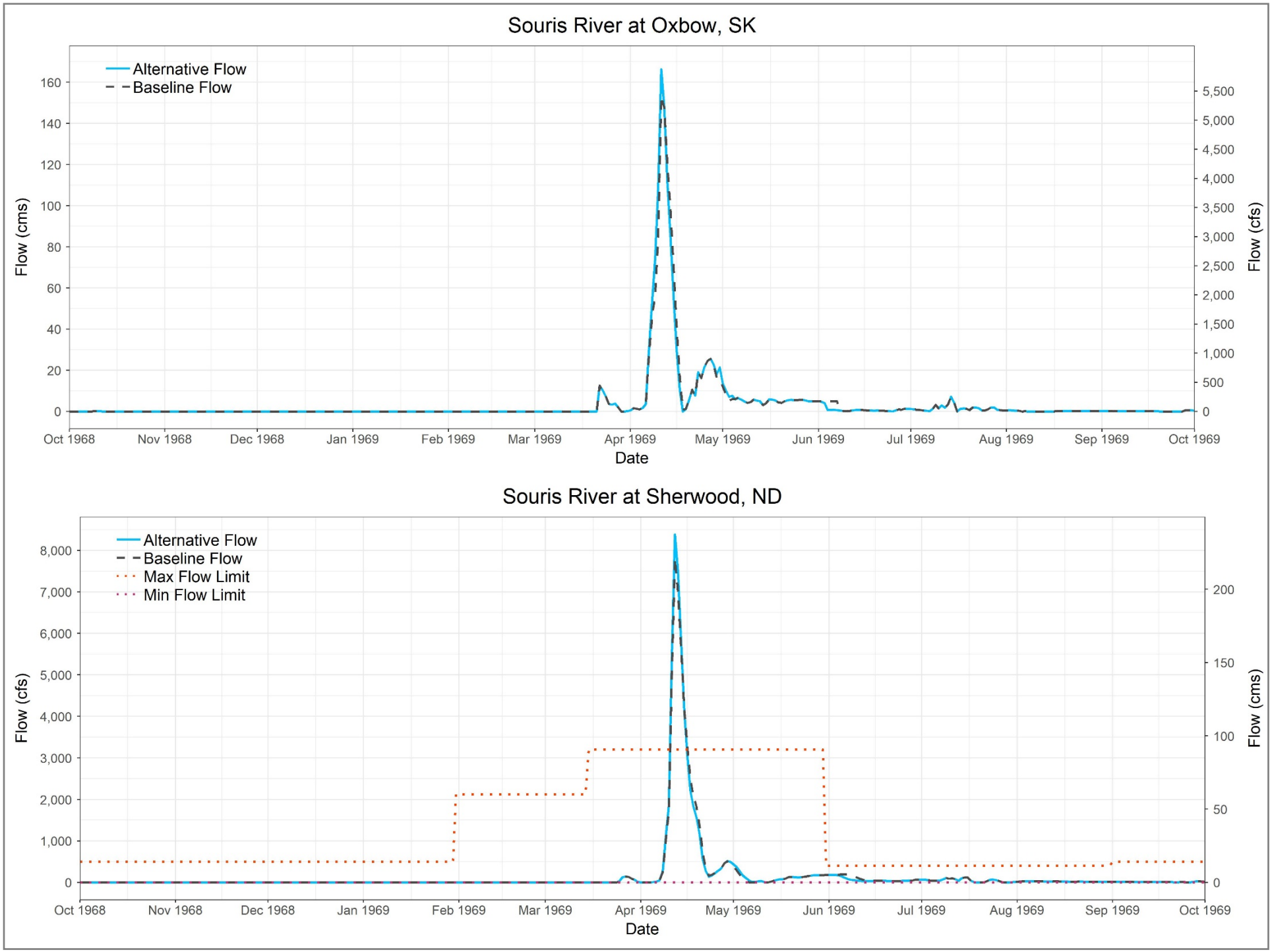
Plate 06

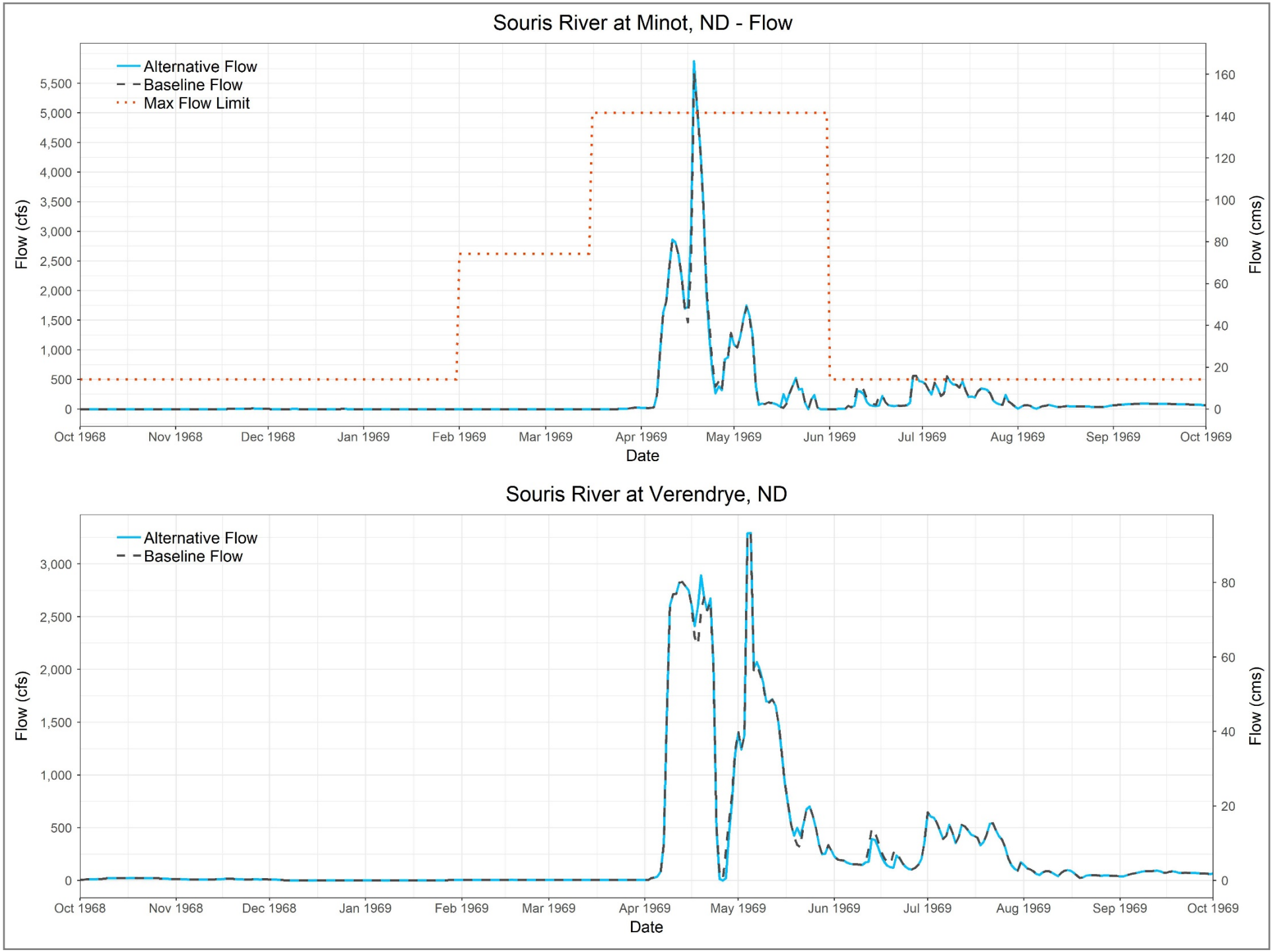
Critical Flow Locations – 1969

Alternative 2 (Phase 2)

Souris River Plan of Study




Souris River at Oxbow, SK
Alternative Flow
Baseline Flow
Flow (cms)
Flow (cfs)
Date
Oct 1968
Nov 1968
Dec 1968
Jan 1969
Feb 1969
Mar 1969
Apr 1969
May 1969
Jun 1969
Jul 1969
Aug 1969
Sep 1969
Oct 1969
Souris River at Sherwood, ND
Alternative Flow
Baseline Flow
Max Flow Limit
Min Flow Limit
Flow (cfs)
Flow (cms)
Date


Souris River at Minot, ND - Flow
Alternative Flow
Baseline Flow
Max Flow Limit
Flow (cfs)
Flow (cms)
Date
Souris River at Verendrye, ND
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
Date

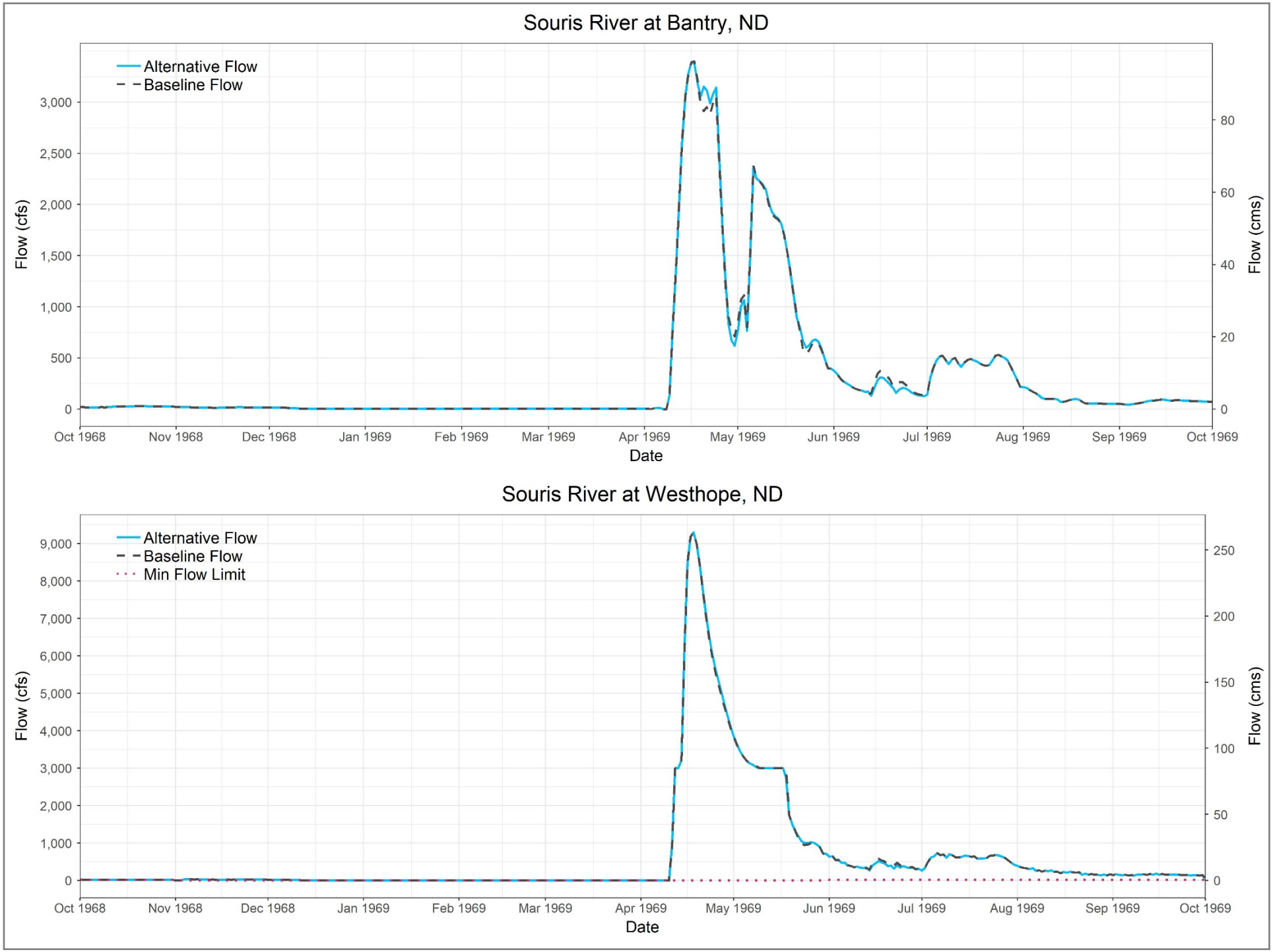
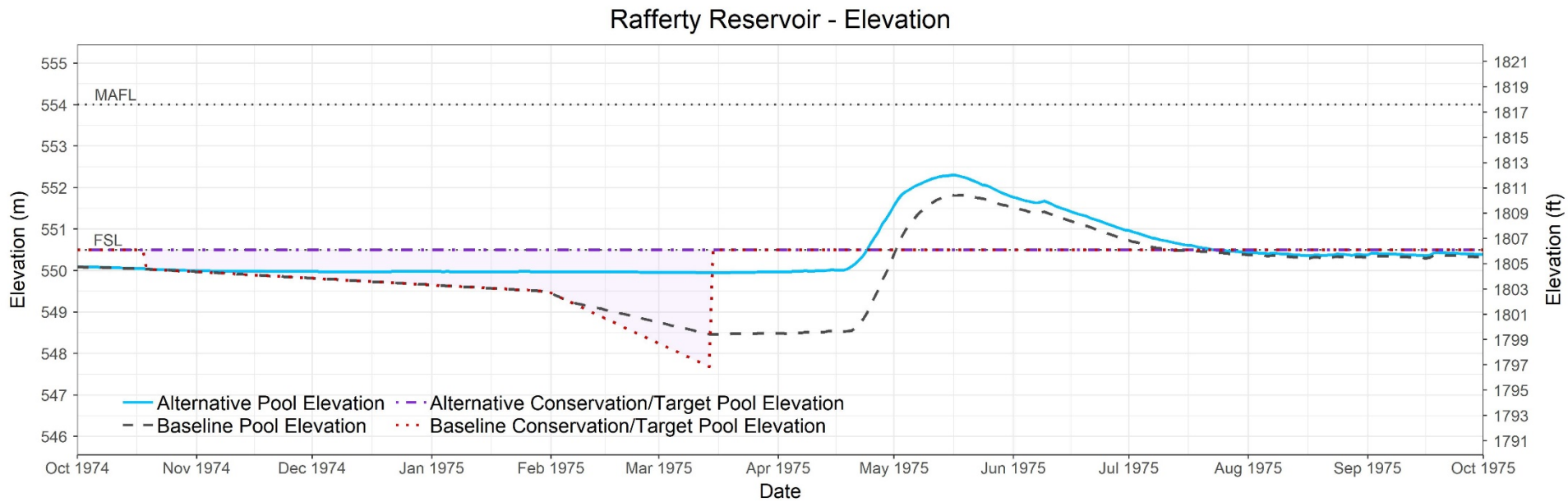
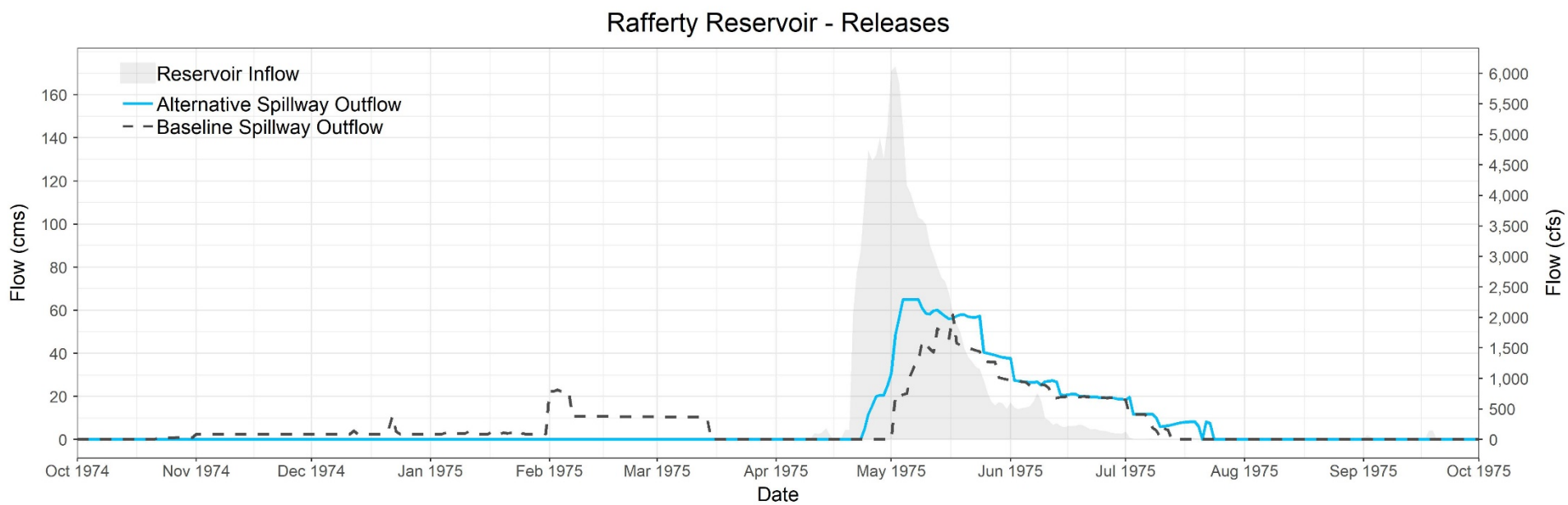
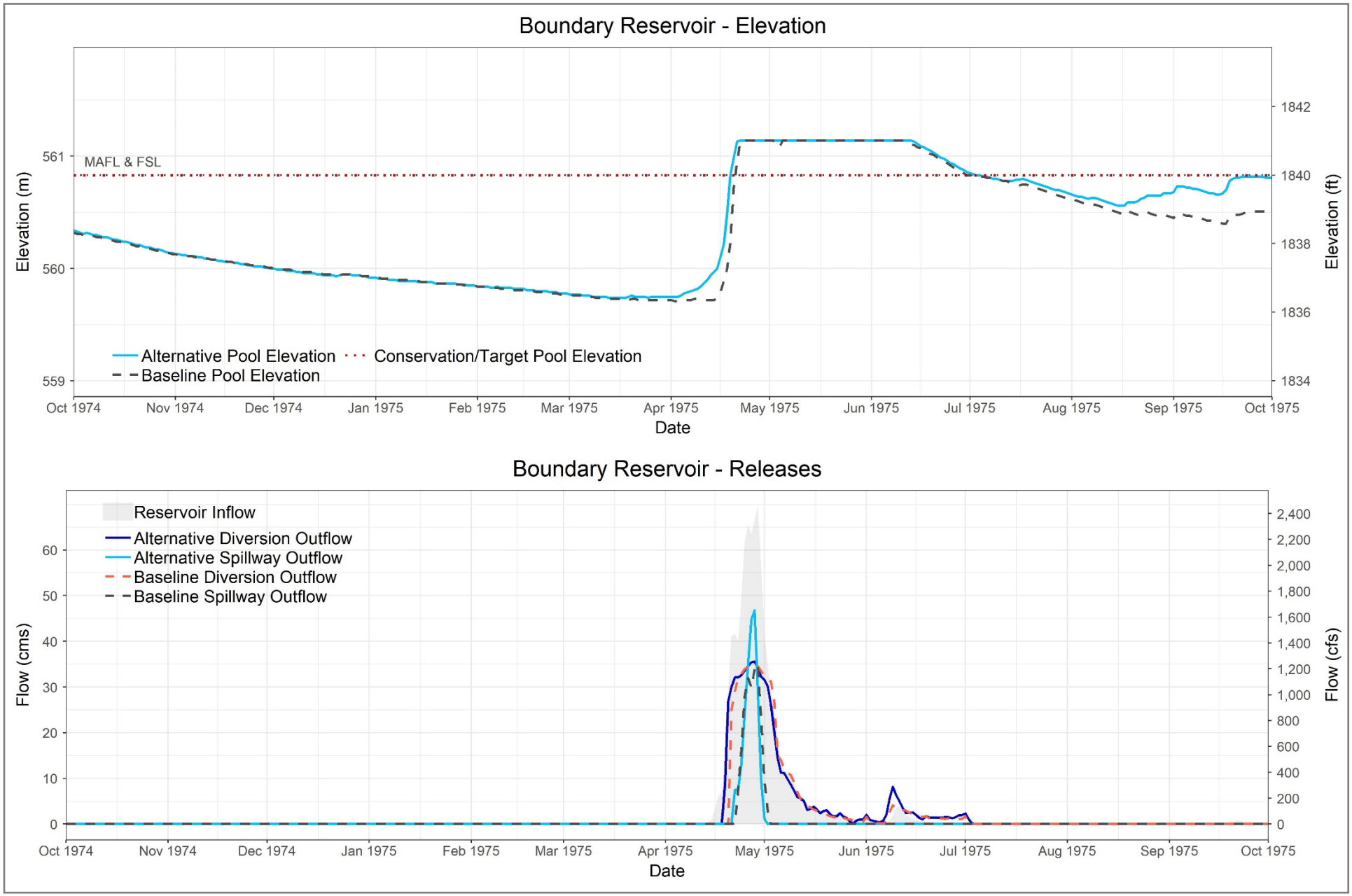

Souris River at Bantry, ND
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
Date
Souris River at Westhope, ND
Alternative Flow
Baseline Flow
Min Flow Limit
Flow (cfs)
Flow (cms)
Date

Plate 07	Reservoirs – 1975	Alternative 2 (Phase 2) Souris River Plan of Study

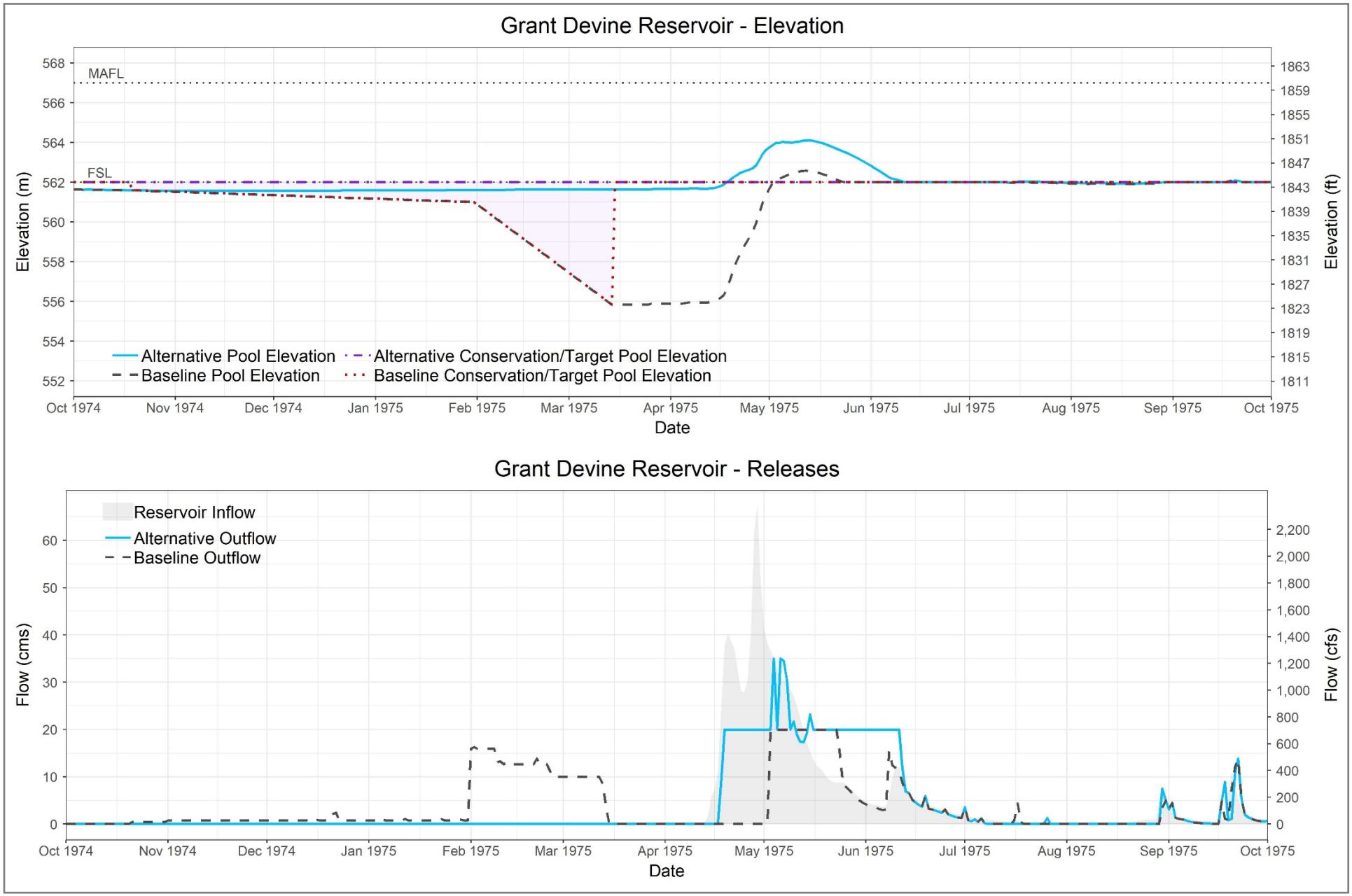




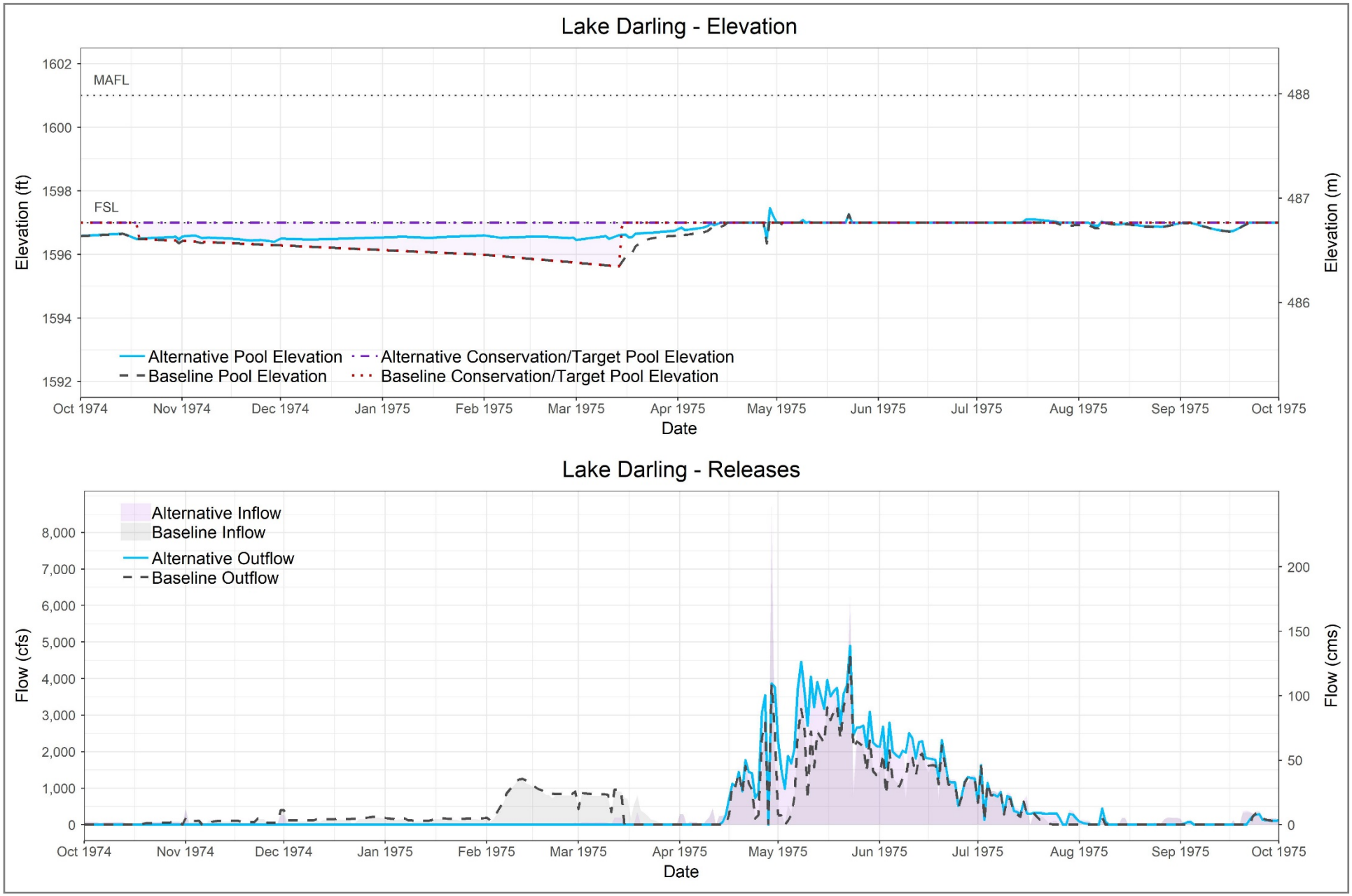
**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



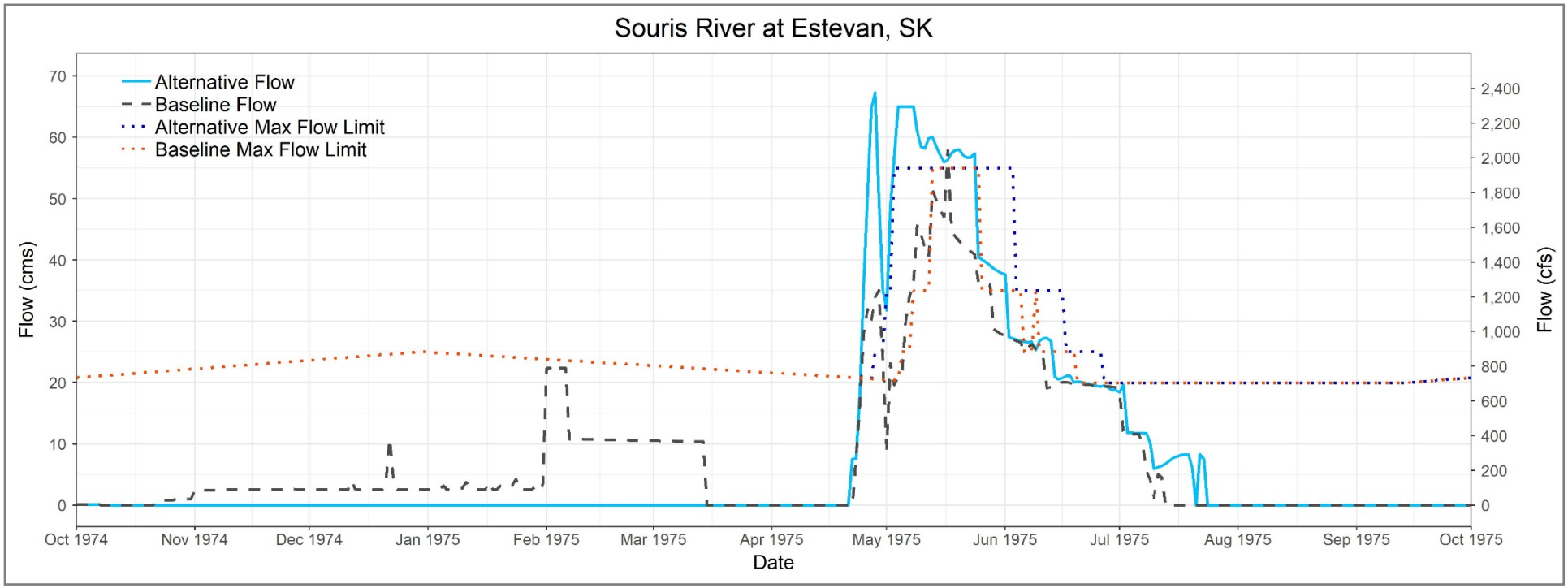
**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*

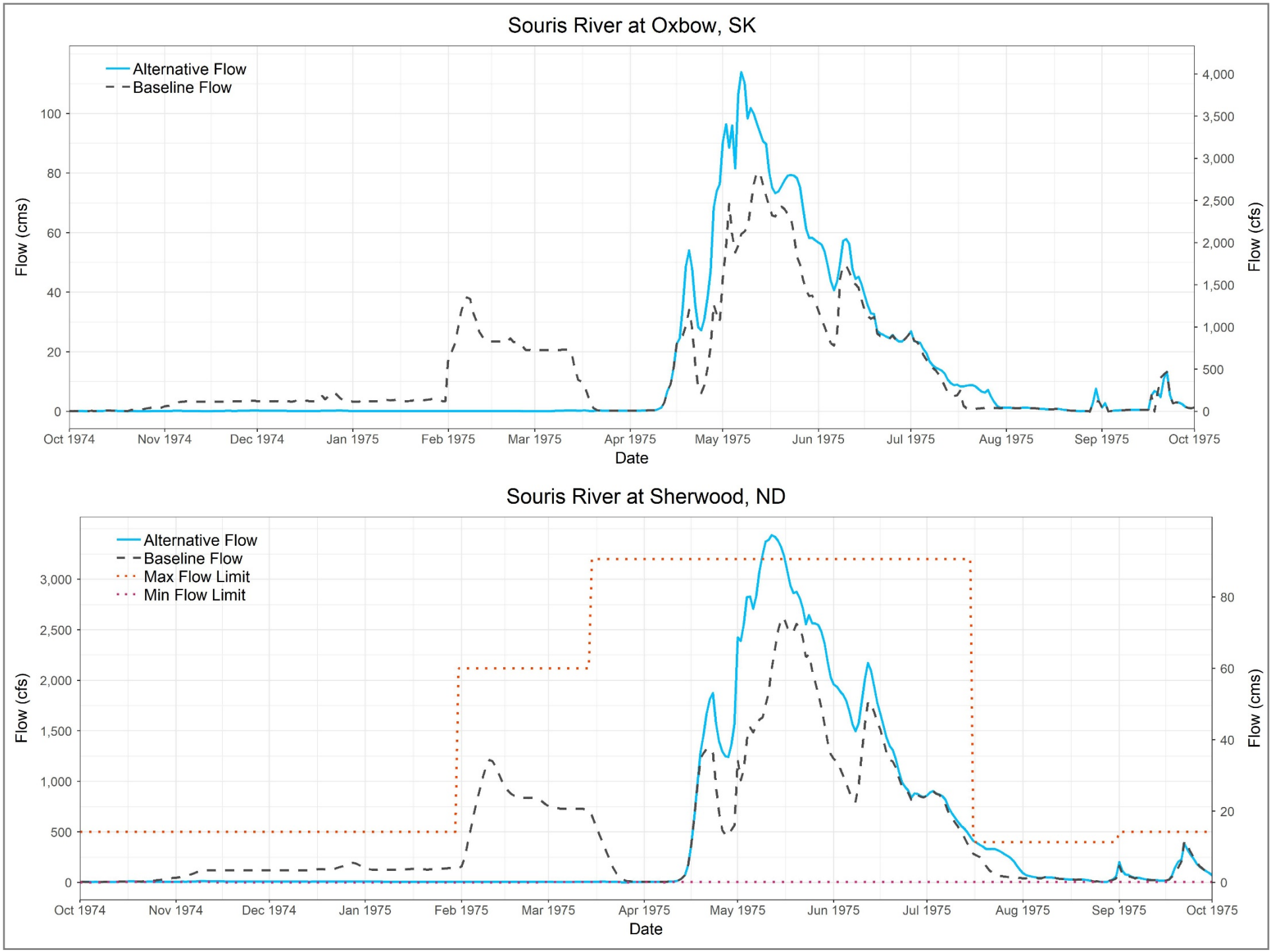
Plate 08

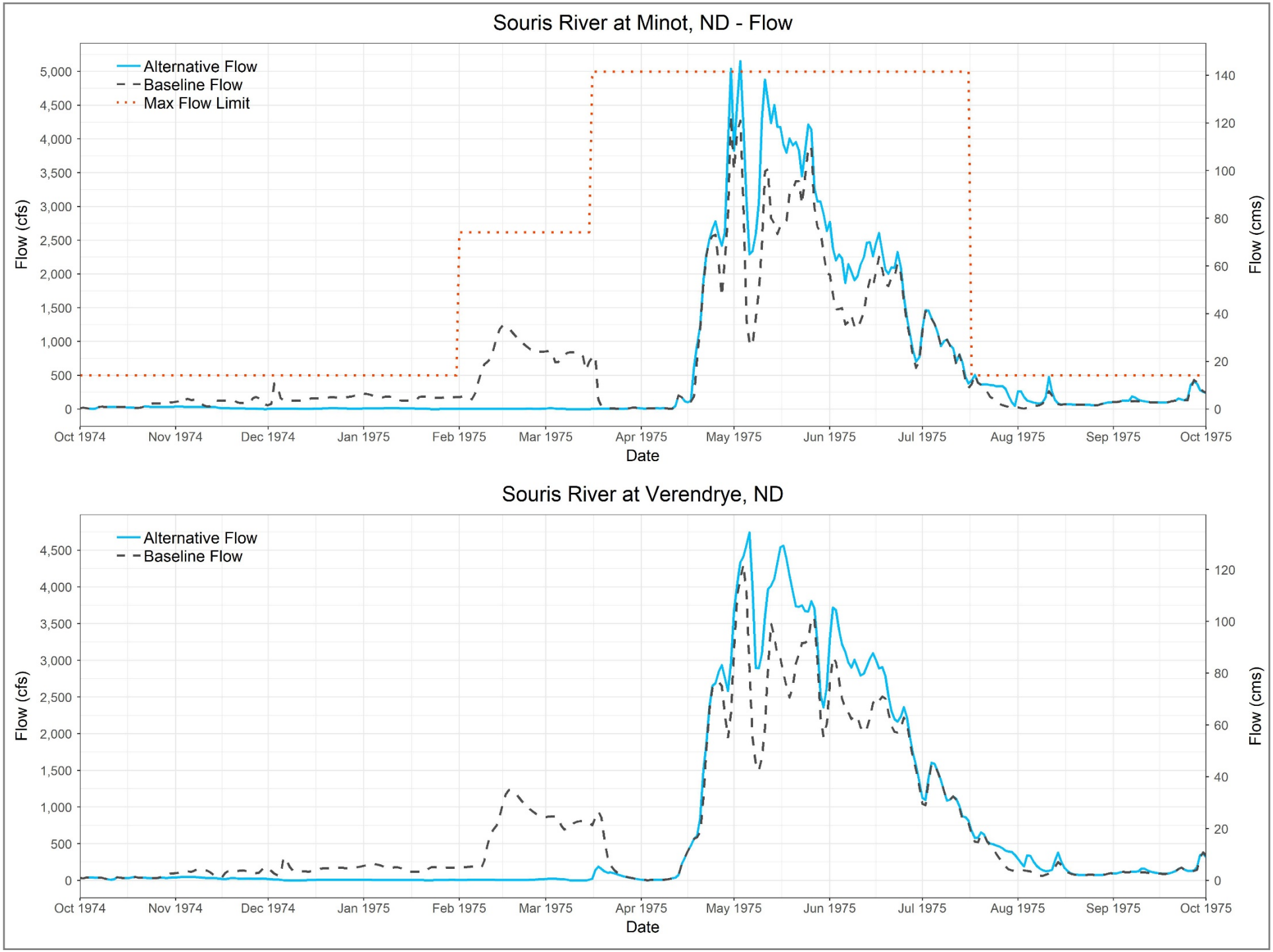
Critical Flow Locations – 1975

Alternative 2 (Phase 2)

Souris River Plan of Study




Souris River at Oxbow, SK
Alternative Flow
Baseline Flow
Flow (cms)
Flow (cfs)
Date
Souris River at Sherwood, ND
Alternative Flow
Baseline Flow
Max Flow Limit
Min Flow Limit
Flow (cfs)
Flow (cms)
Date


Souris River at Minot, ND - Flow
Alternative Flow
Baseline Flow
Max Flow Limit
Flow (cfs)
Flow (cms)
Date
Oct 1974
Nov 1974
Dec 1974
Jan 1975
Feb 1975
Mar 1975
Apr 1975
May 1975
Jun 1975
Jul 1975
Aug 1975
Sep 1975
Oct 1975
Souris River at Verendrye, ND
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
Date

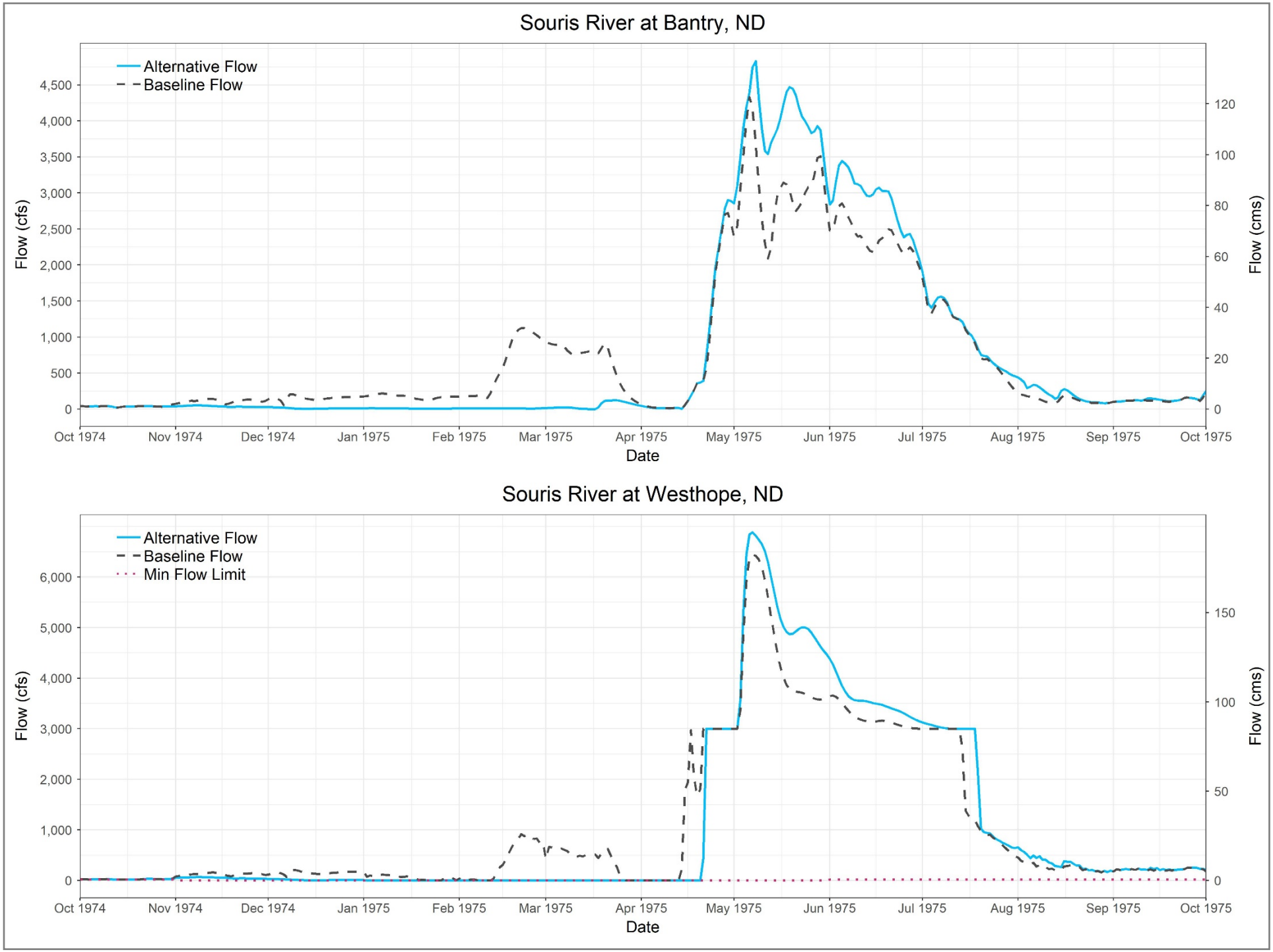
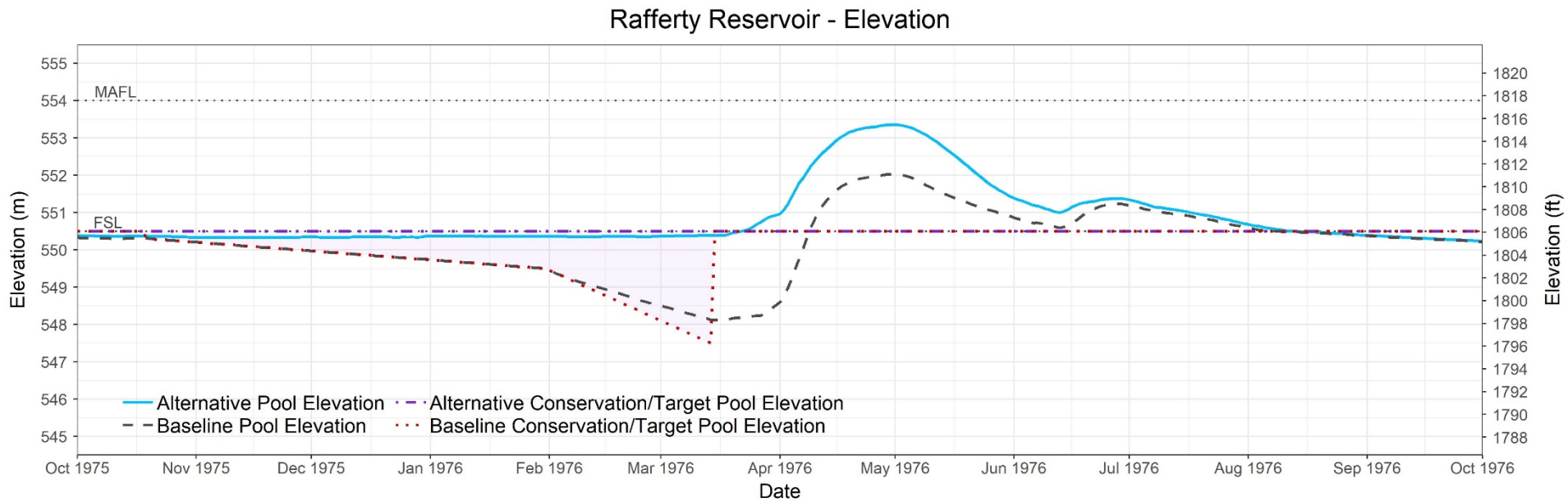
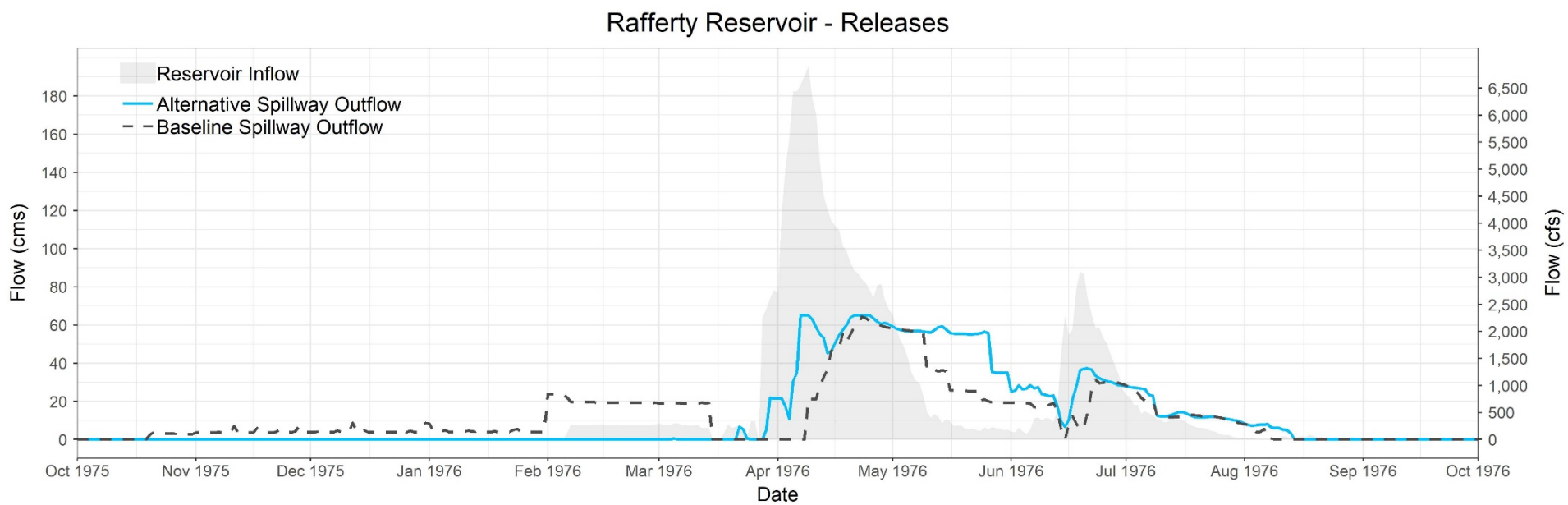
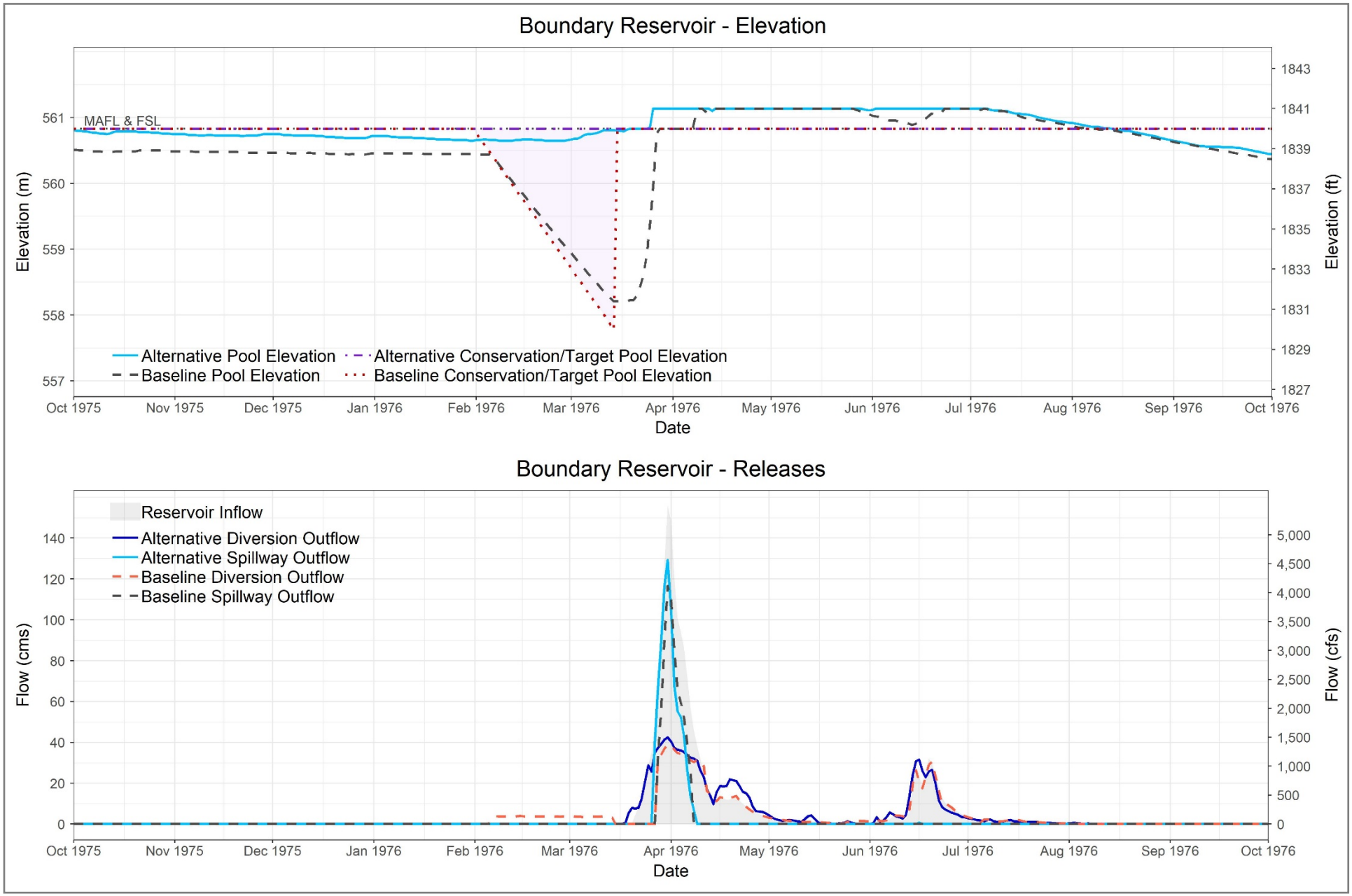

Souris River at Bantry, ND
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
Date
Souris River at Westhope, ND
Alternative Flow
Baseline Flow
Min Flow Limit
Flow (cfs)
Flow (cms)
Date

Plate 09	Reservoirs – 1976	Alternative 2 (Phase 2) Souris River Plan of Study

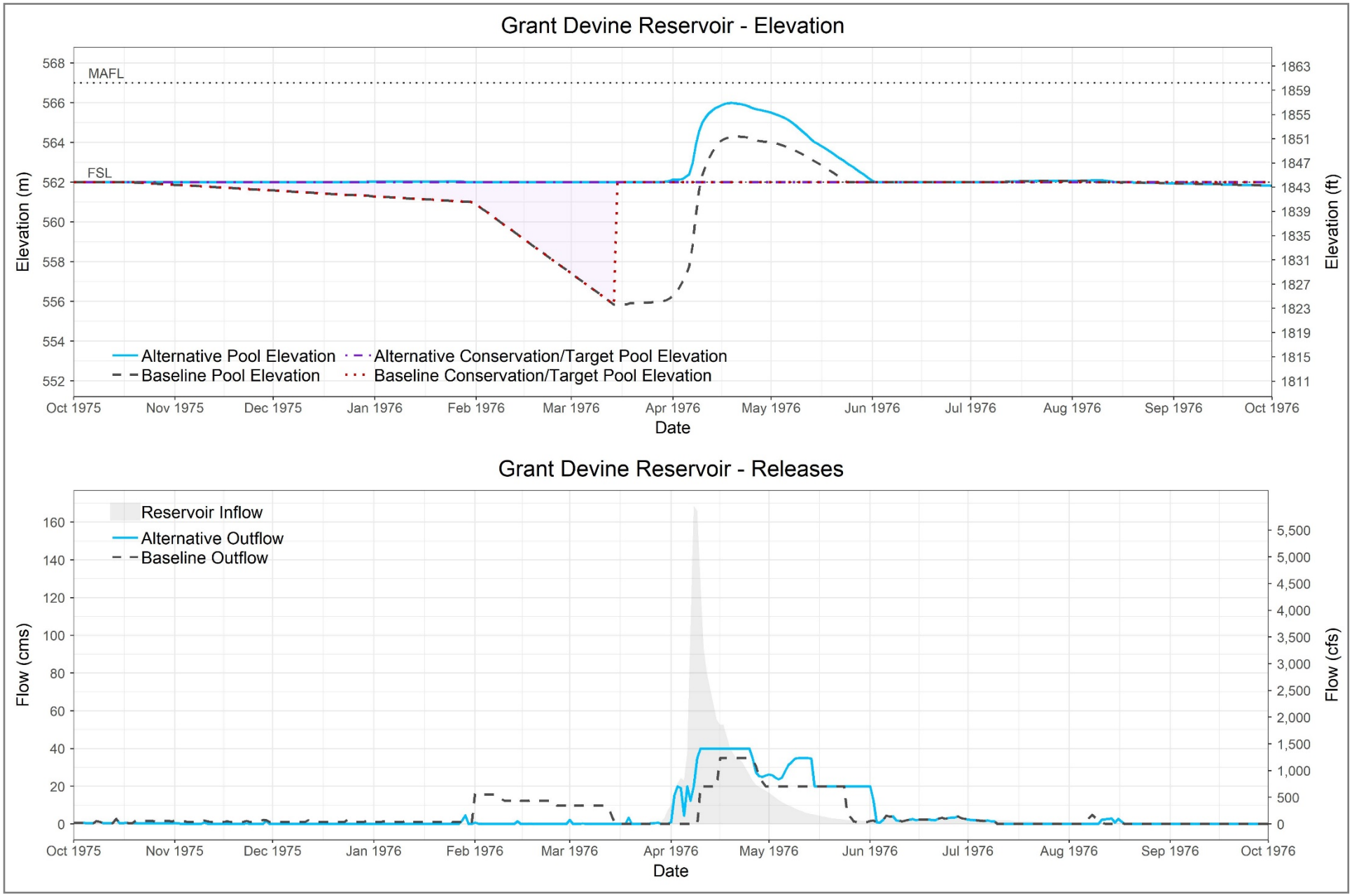




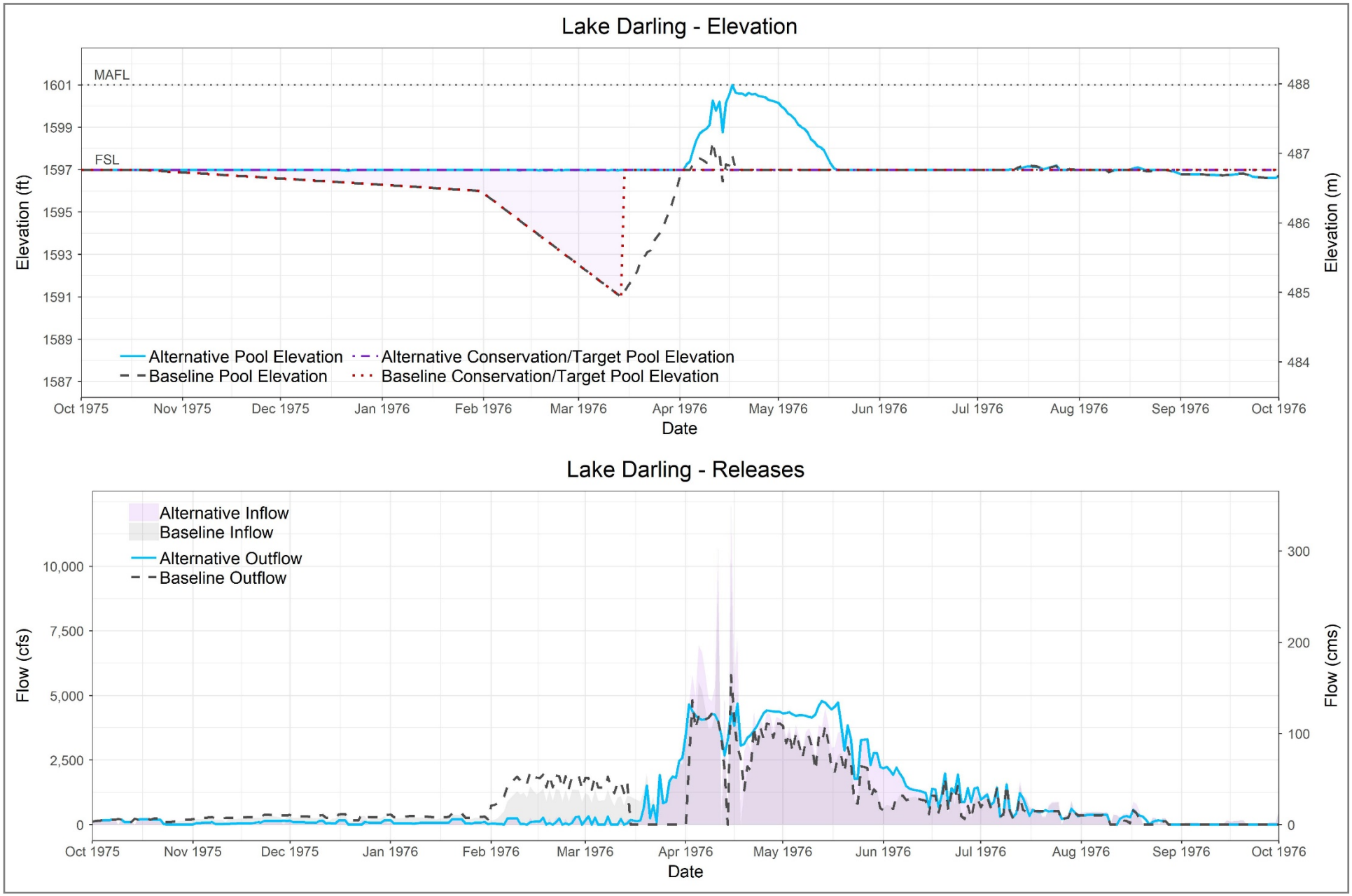
**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



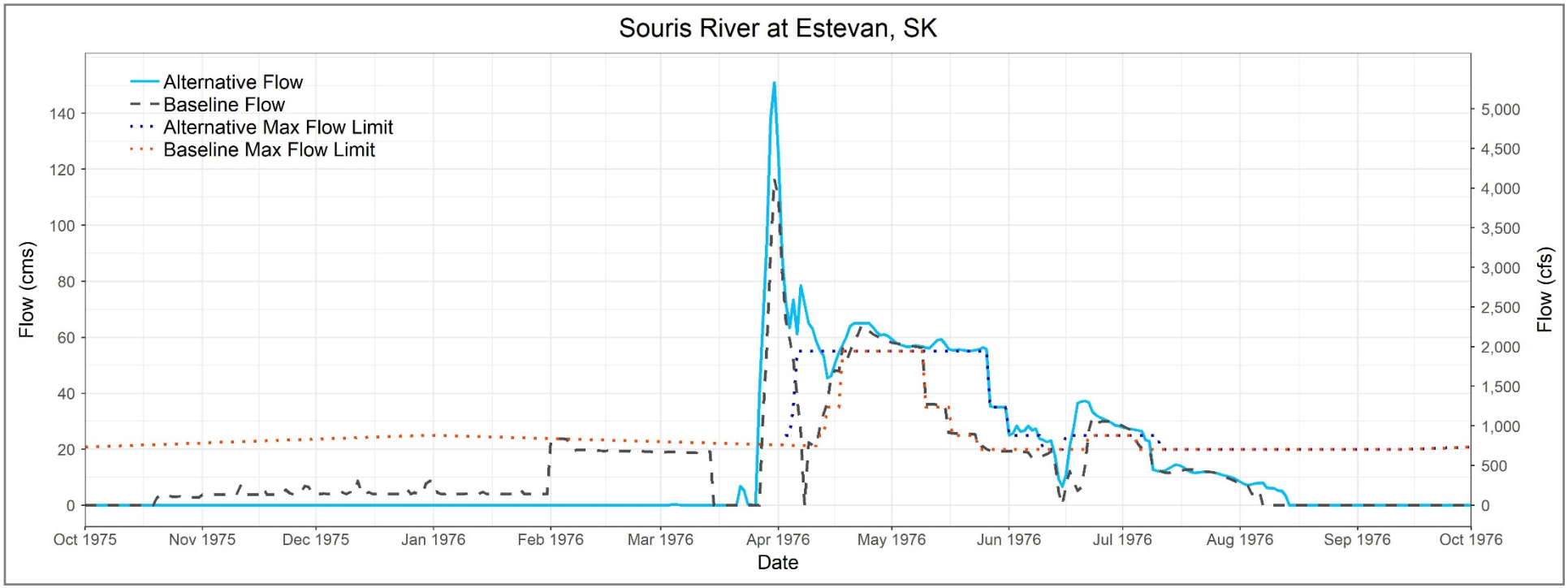
**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*

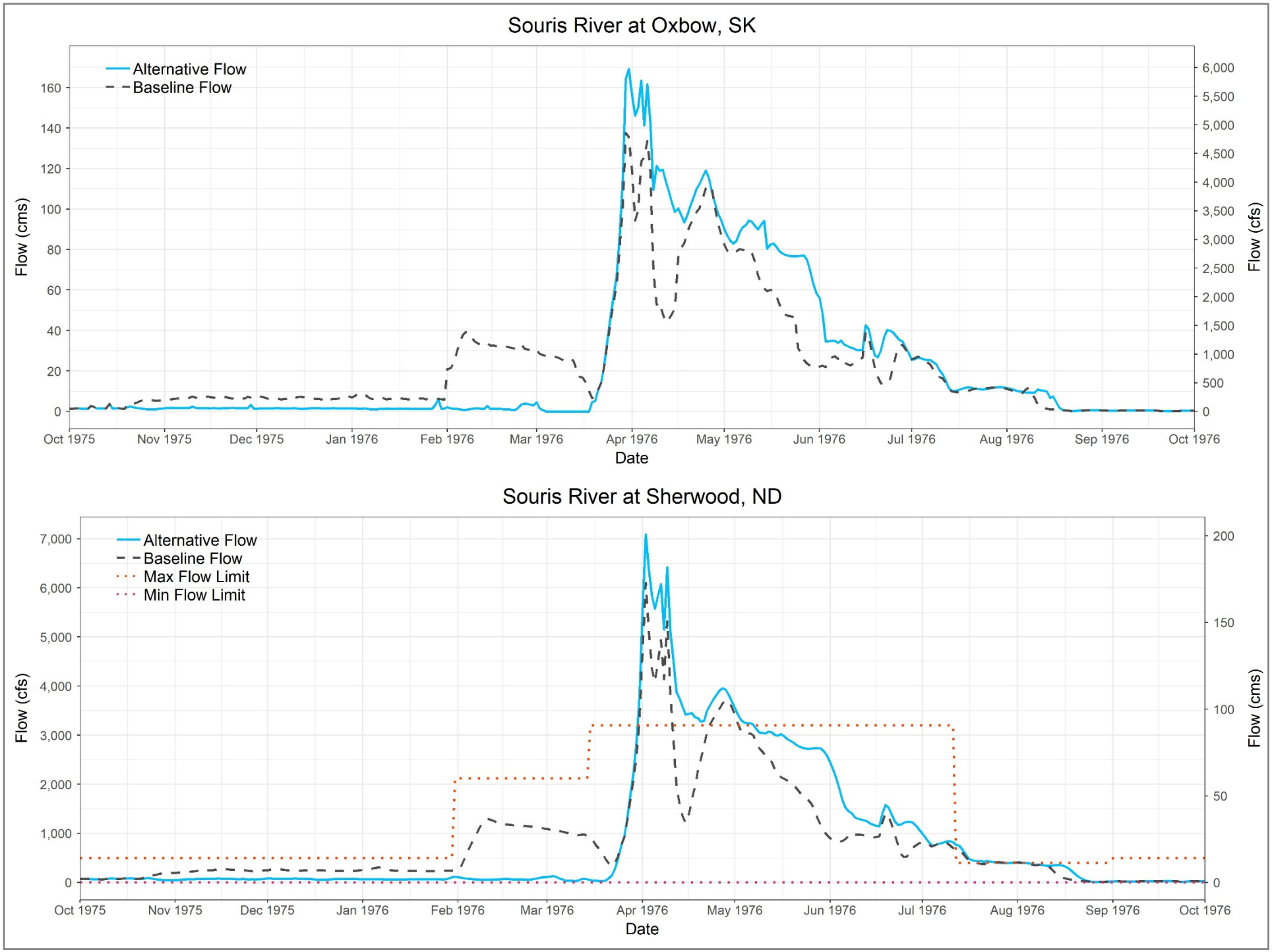
Plate 10

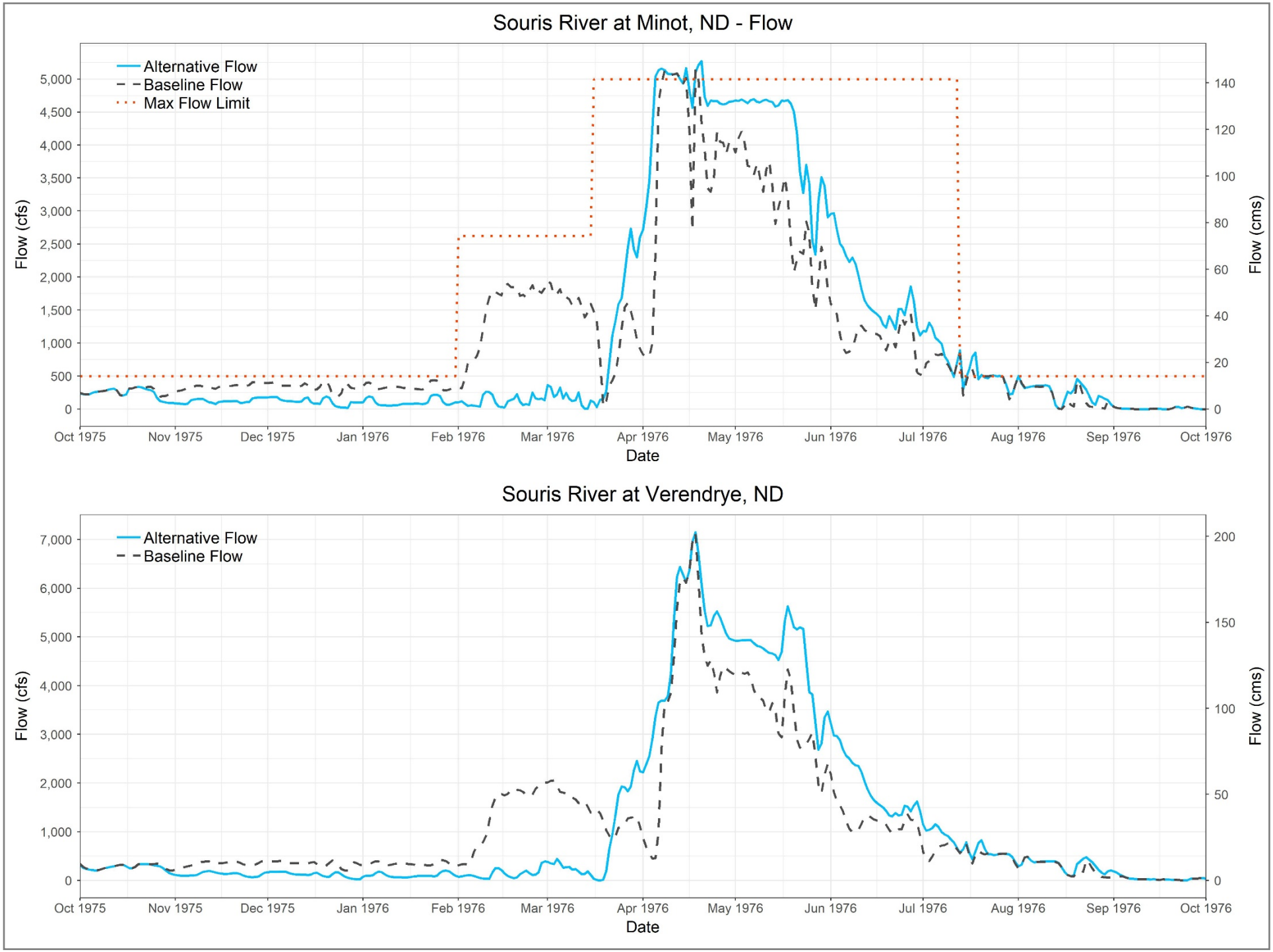
Critical Flow Locations – 1976

Alternative 2 (Phase 2)

Souris River Plan of Study




Souris River at Oxbow, SK
Alternative Flow
Baseline Flow
Flow (cms)
Flow (cfs)
Date
Souris River at Sherwood, ND
Alternative Flow
Baseline Flow
Max Flow Limit
Min Flow Limit
Flow (cfs)
Flow (cms)
Date


Souris River at Minot, ND - Flow
Alternative Flow
Baseline Flow
Max Flow Limit
Flow (cfs)
Flow (cms)
Date
Souris River at Verendrye, ND
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
Date

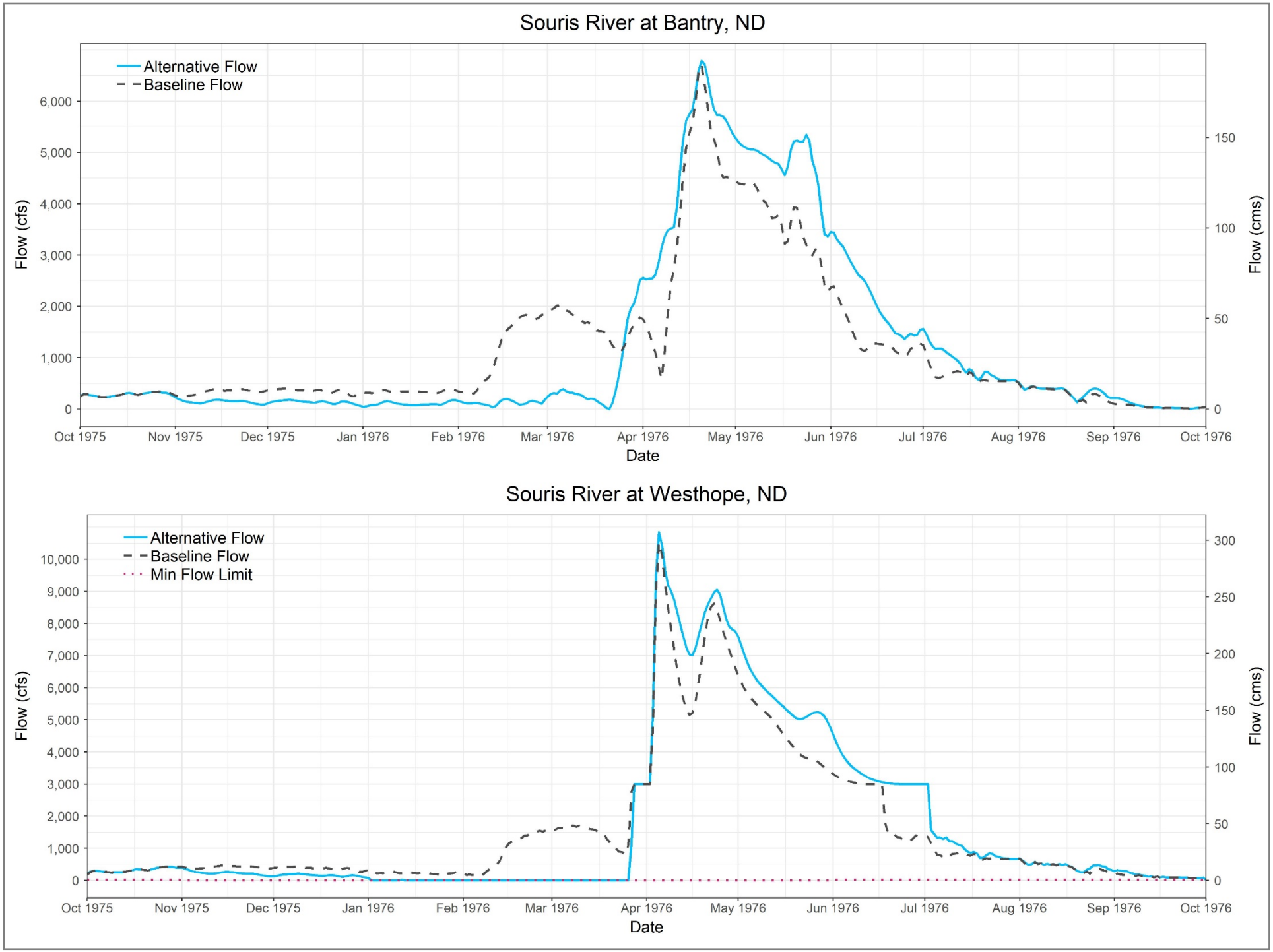
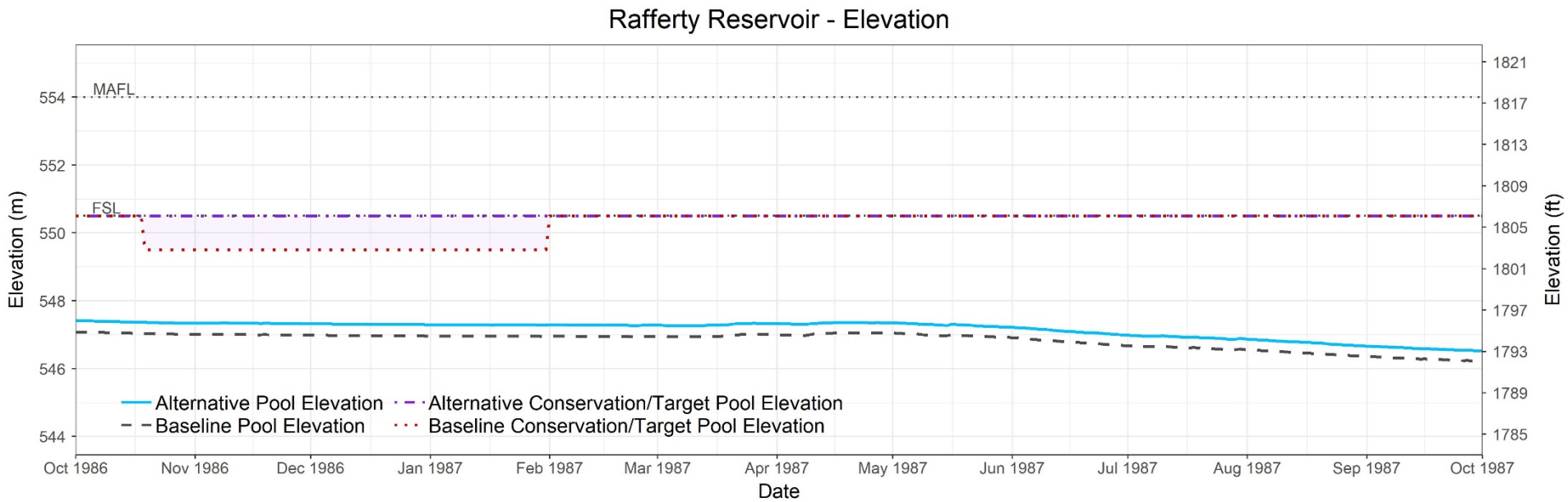
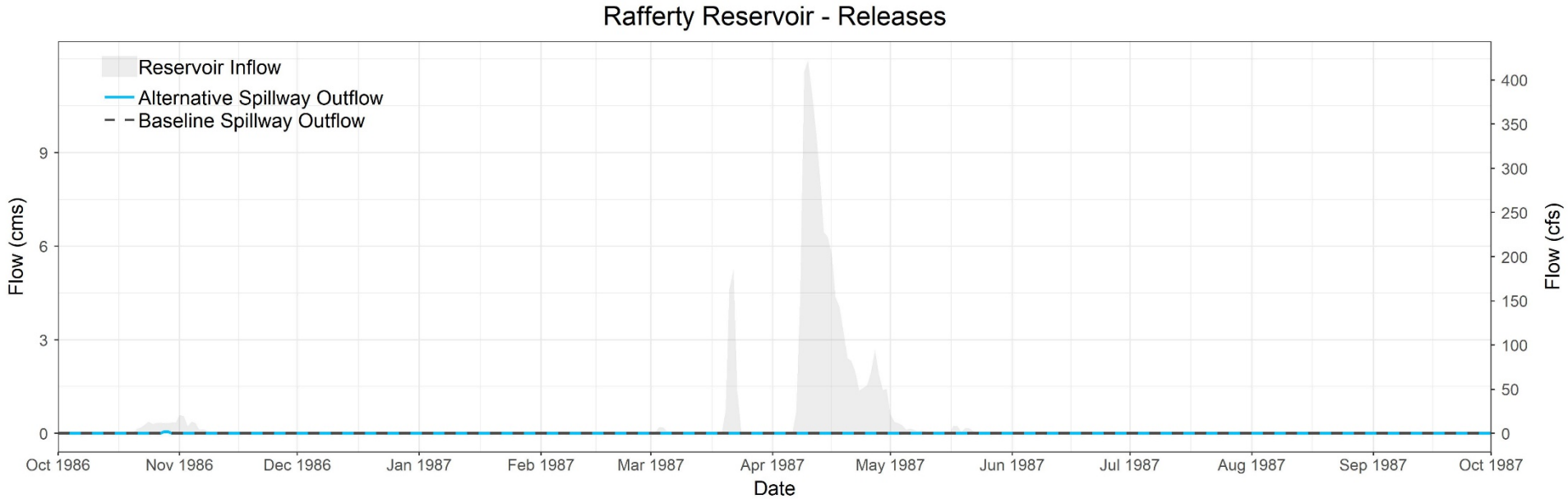
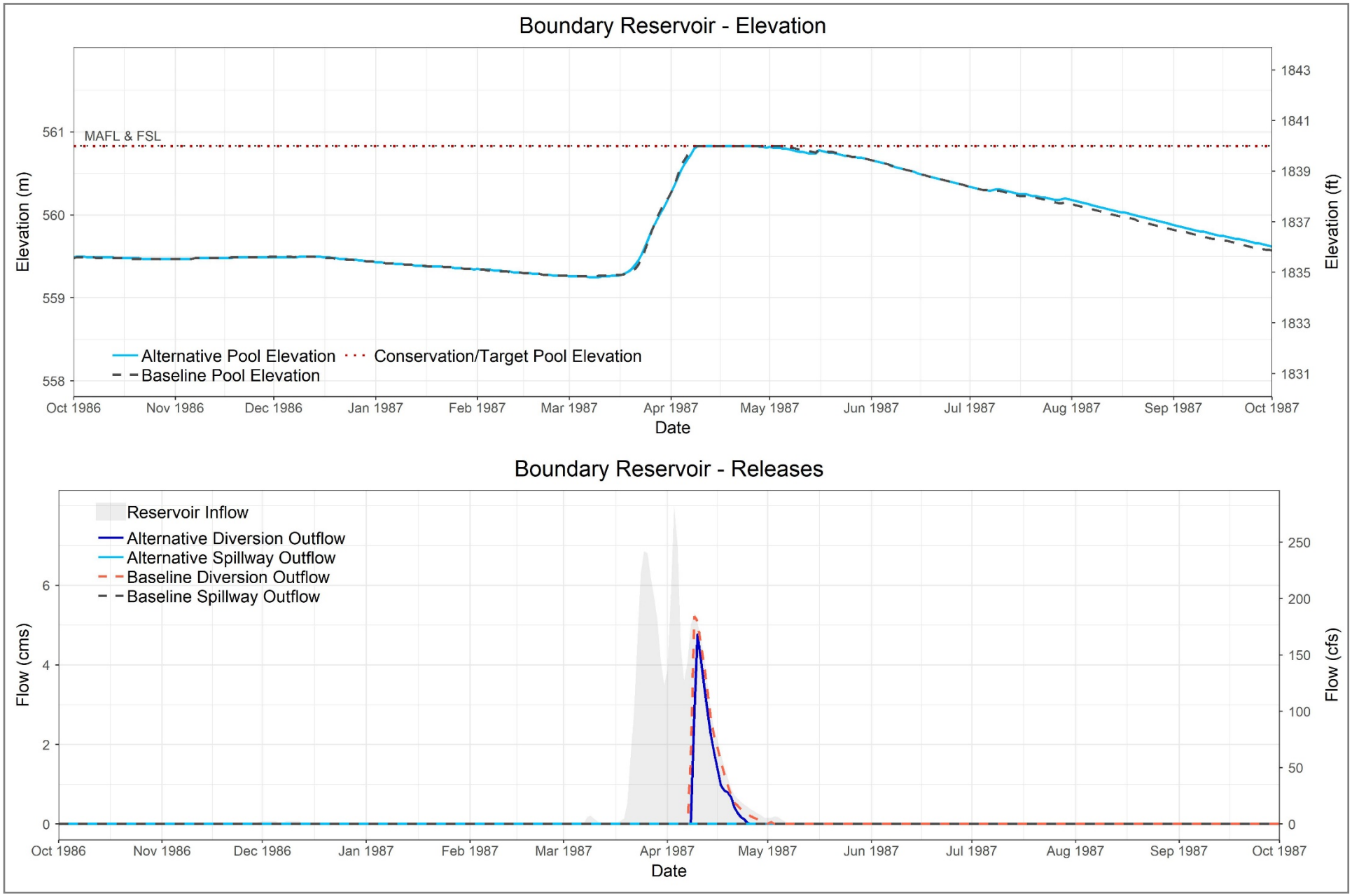

Souris River at Bantry, ND
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
Date
Souris River at Westhope, ND
Alternative Flow
Baseline Flow
Min Flow Limit
Flow (cfs)
Flow (cms)
Date

Plate 11	Reservoirs – 1987	Alternative 2 (Phase 2) Souris River Plan of Study

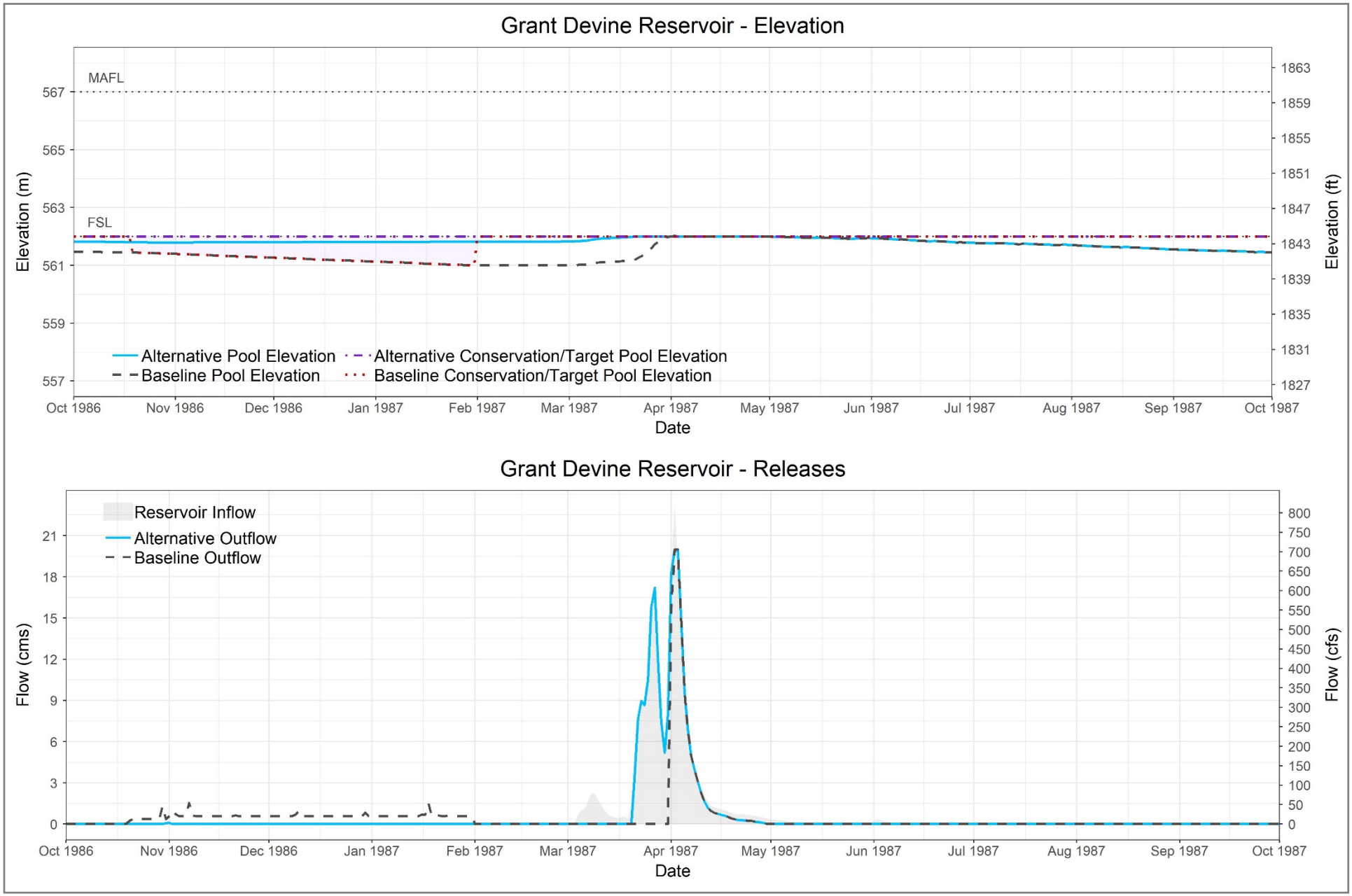




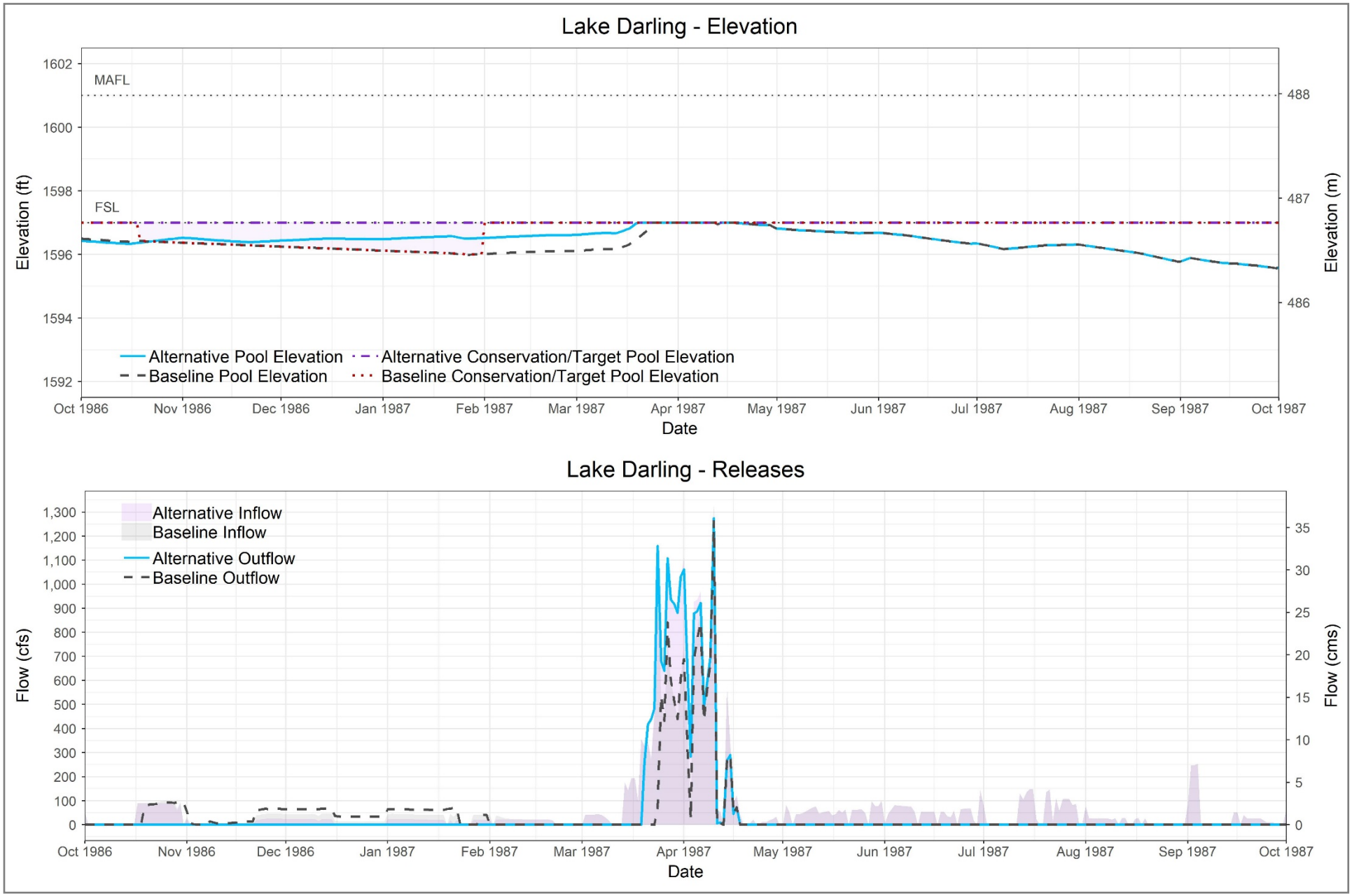
**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



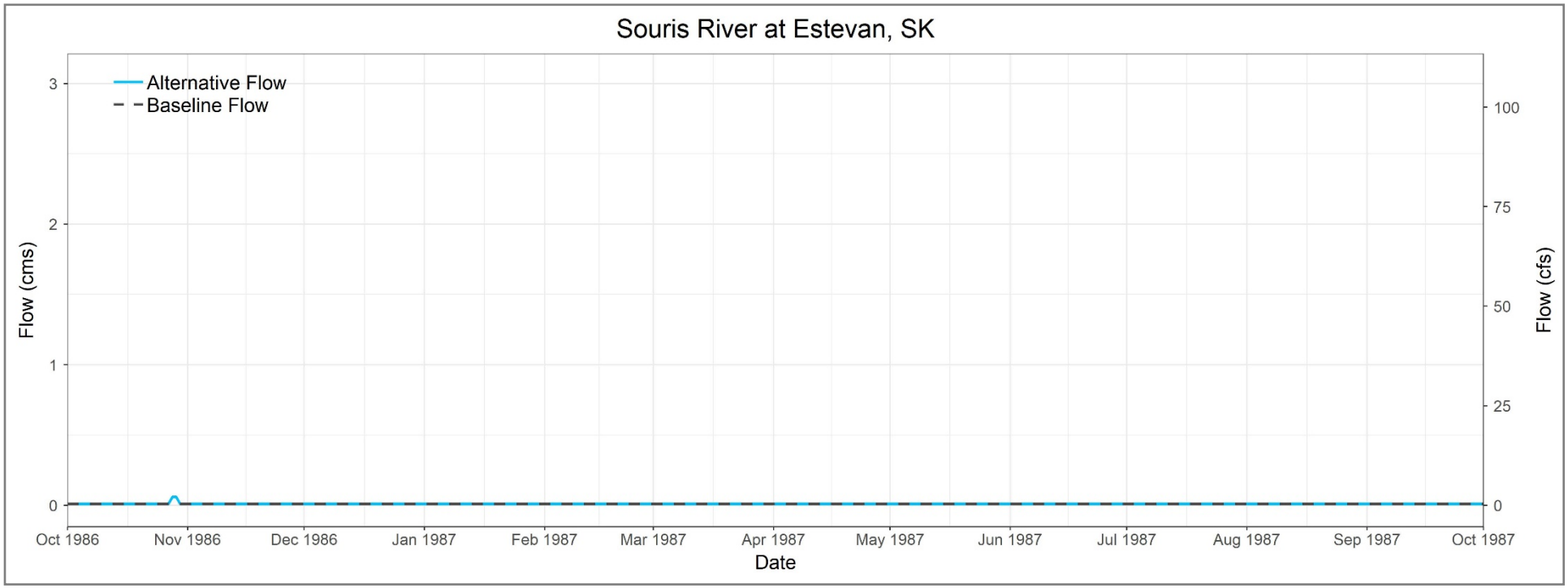
**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*

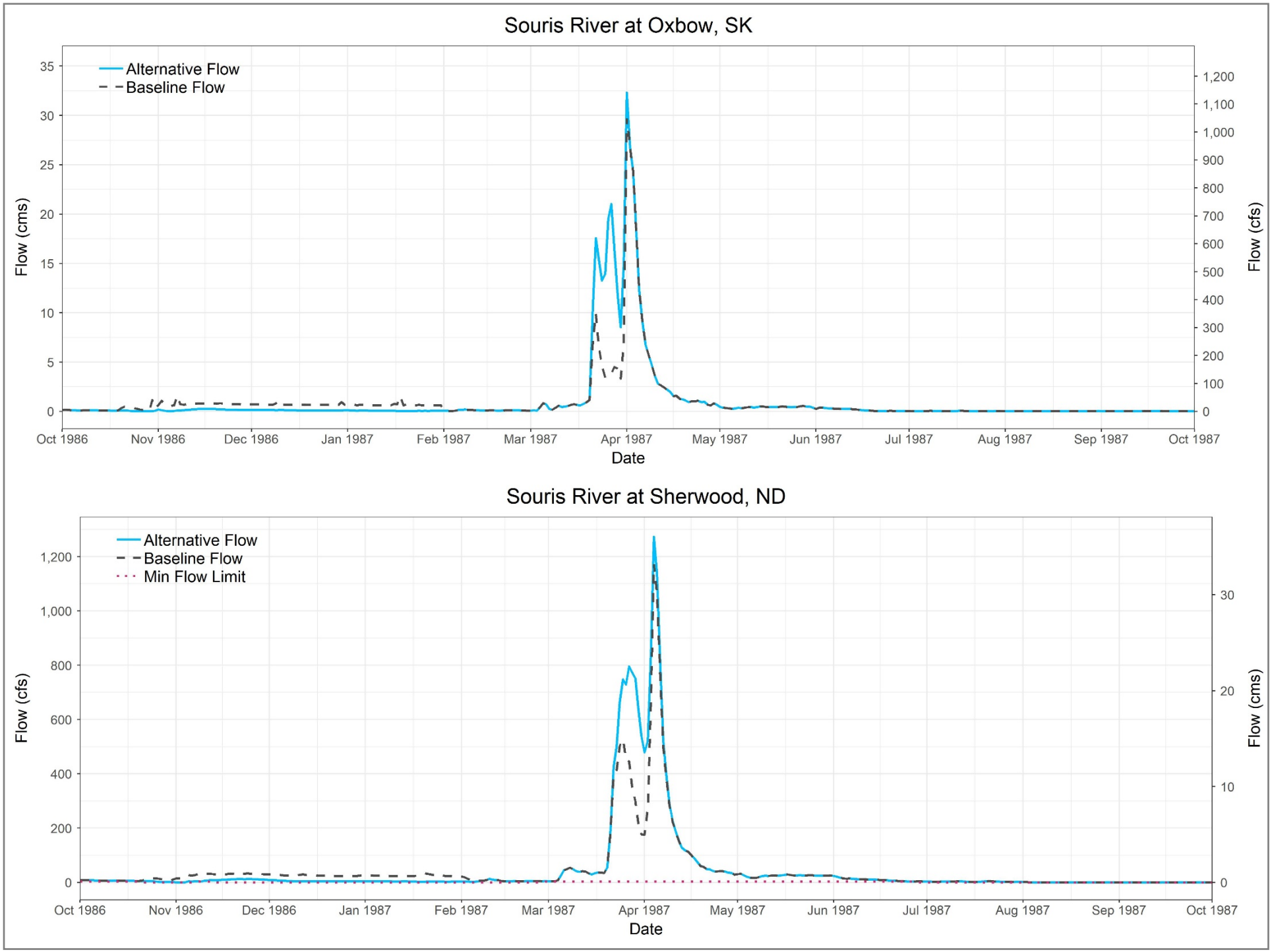
Plate 12

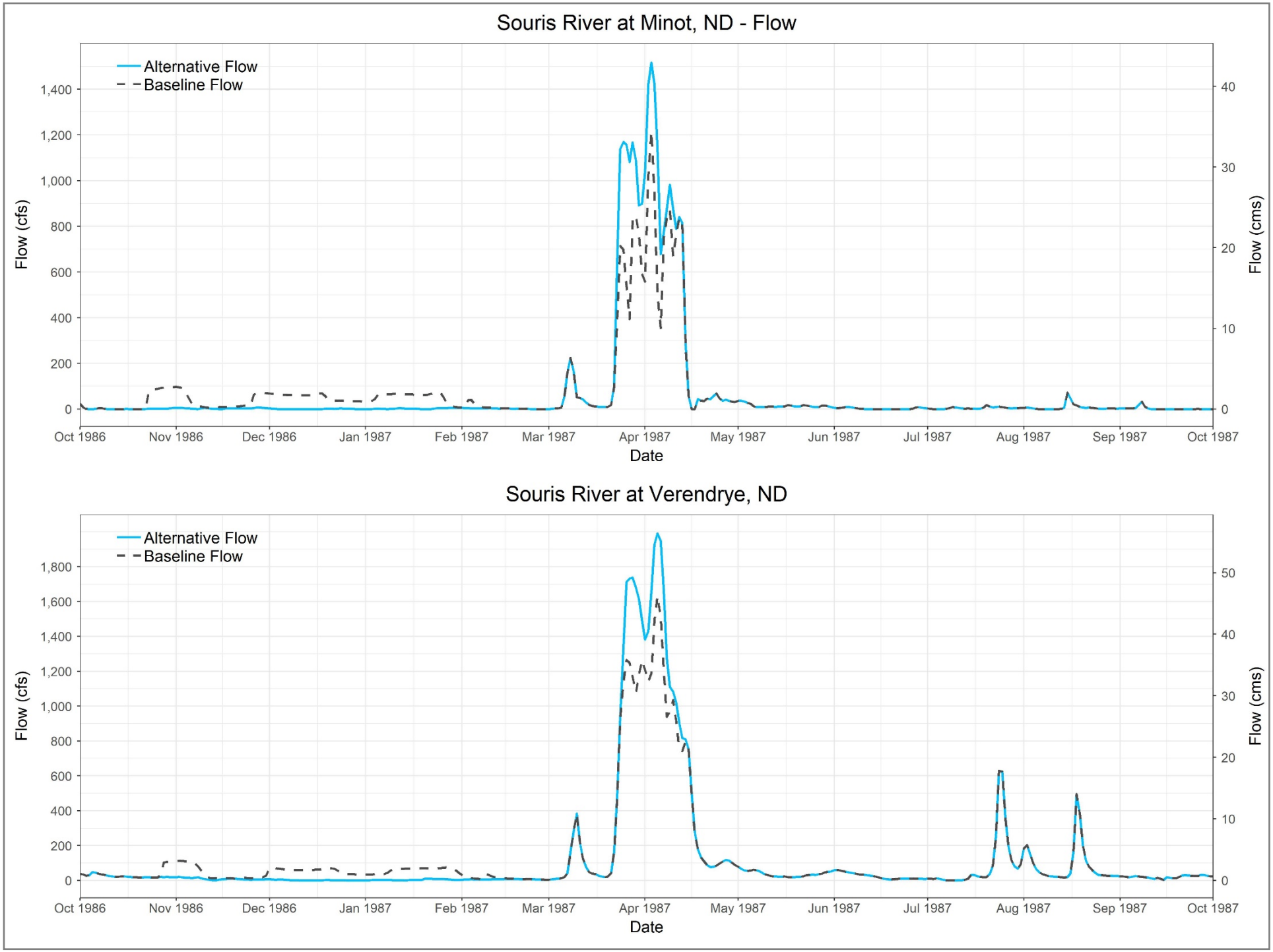
Critical Flow Locations – 1987

Alternative 2 (Phase 2)

Souris River Plan of Study




Souris River at Oxbow, SK
Alternative Flow
Baseline Flow
Flow (cms)
Flow (cfs)
Date
Oct 1986
Nov 1986
Dec 1986
Jan 1987
Feb 1987
Mar 1987
Apr 1987
May 1987
Jun 1987
Jul 1987
Aug 1987
Sep 1987
Oct 1987
Souris River at Sherwood, ND
Alternative Flow
Baseline Flow
Min Flow Limit
Flow (cfs)
Flow (cms)
Date


Souris River at Minot, ND - Flow
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
Date
Oct 1986
Nov 1986
Dec 1986
Jan 1987
Feb 1987
Mar 1987
Apr 1987
May 1987
Jun 1987
Jul 1987
Aug 1987
Sep 1987
Oct 1987
Souris River at Verendrye, ND
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
Date

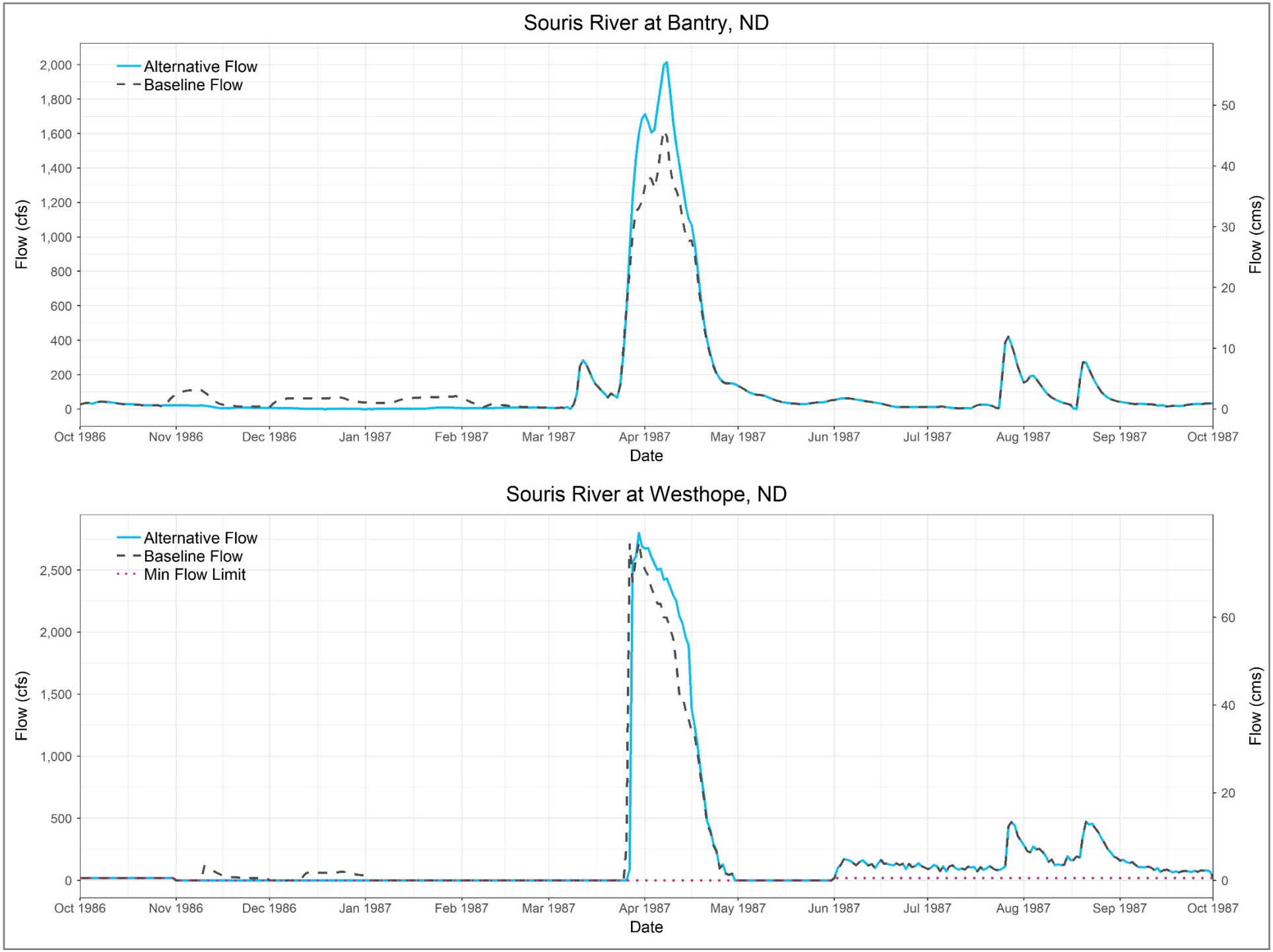
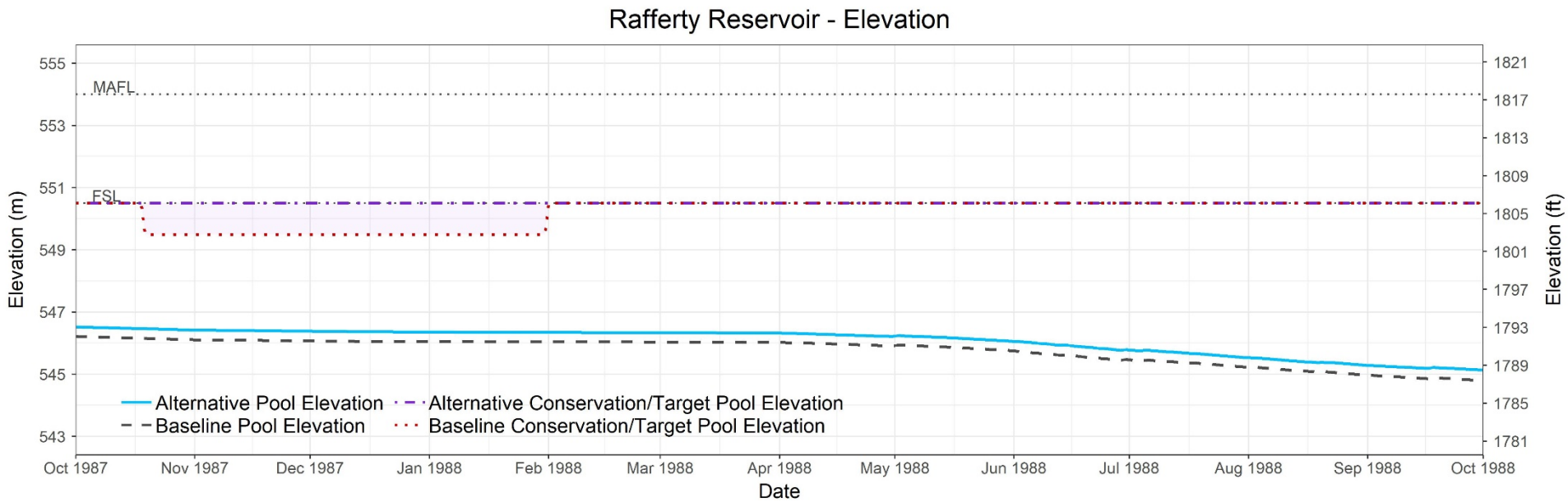
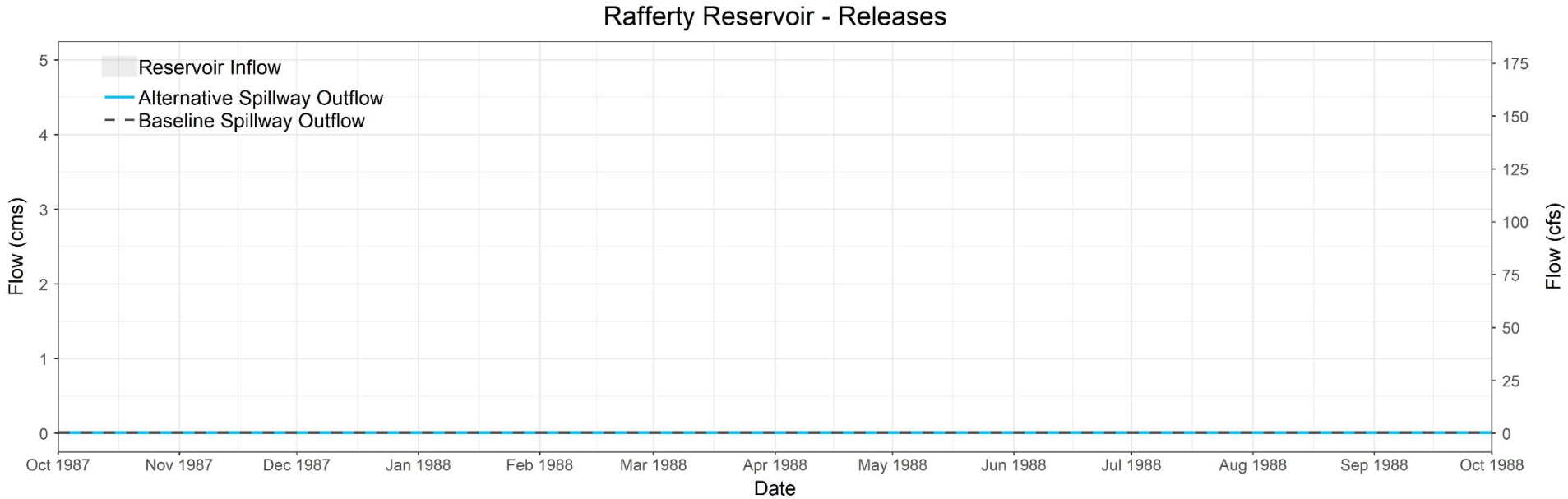
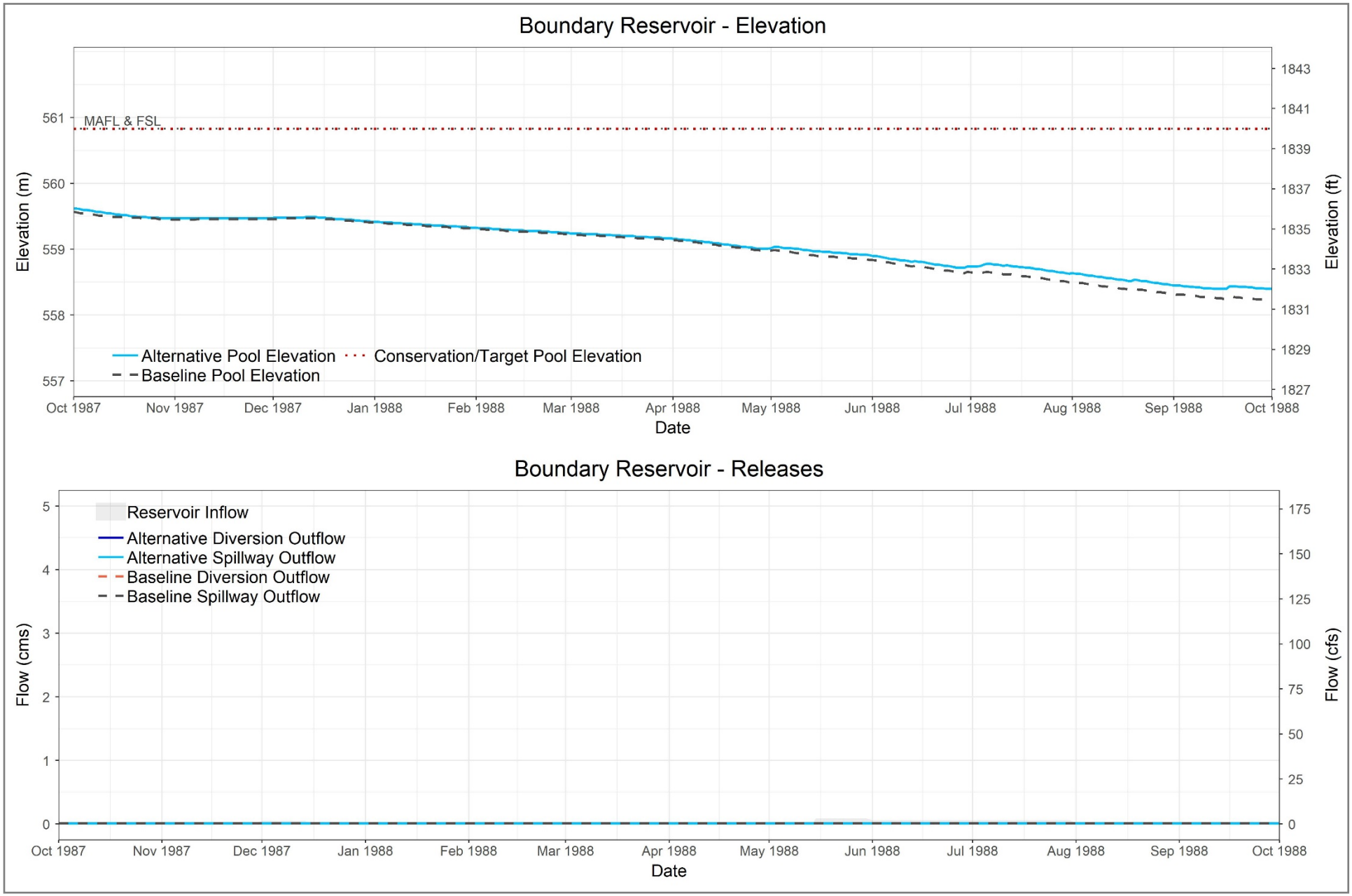

Souris River at Bantry, ND
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
Date
Souris River at Westhope, ND
Alternative Flow
Baseline Flow
Min Flow Limit
Flow (cfs)
Flow (cms)
Date

Plate 13	Reservoirs – 1988	Alternative 2 (Phase 2) Souris River Plan of Study

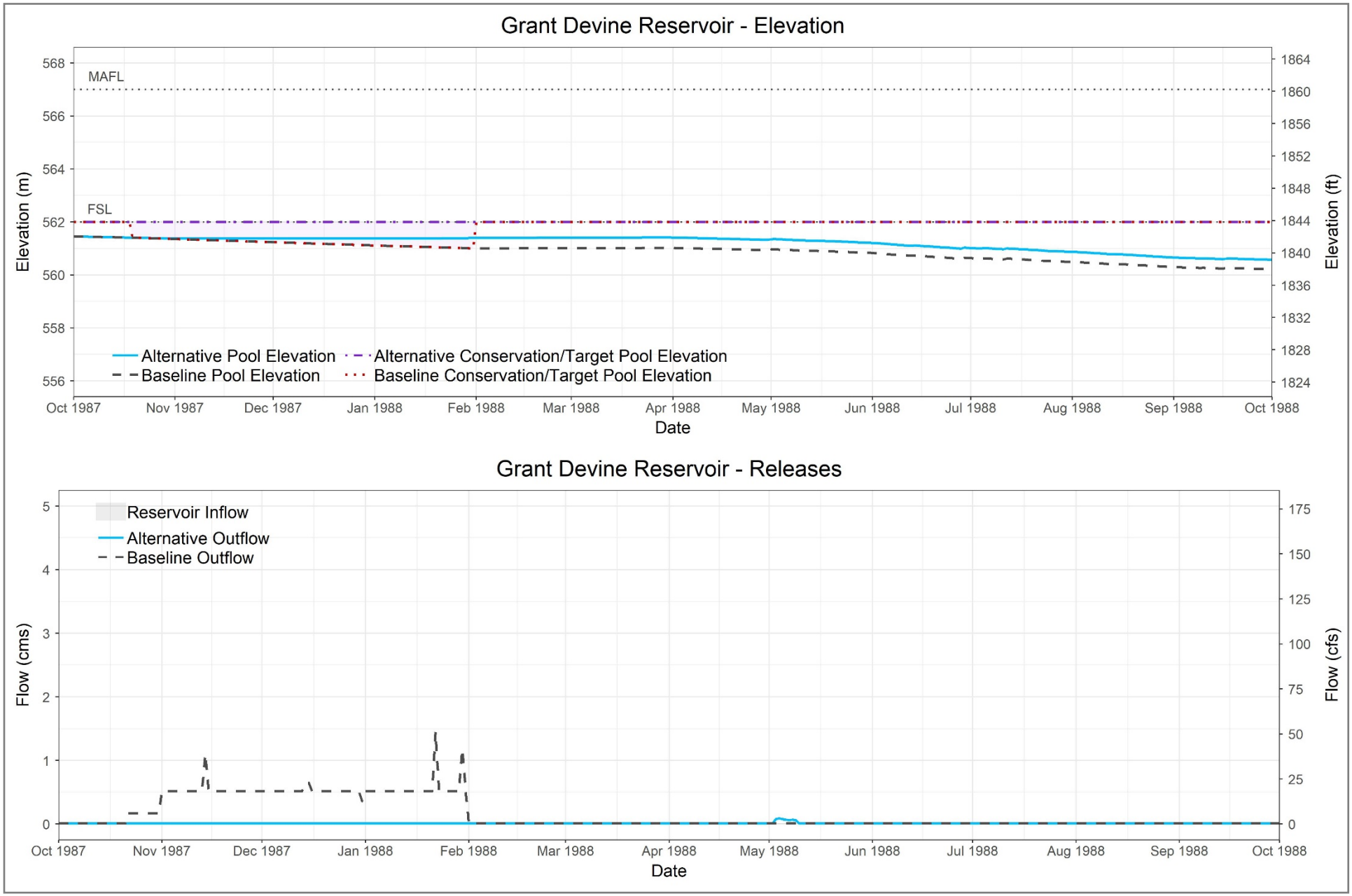




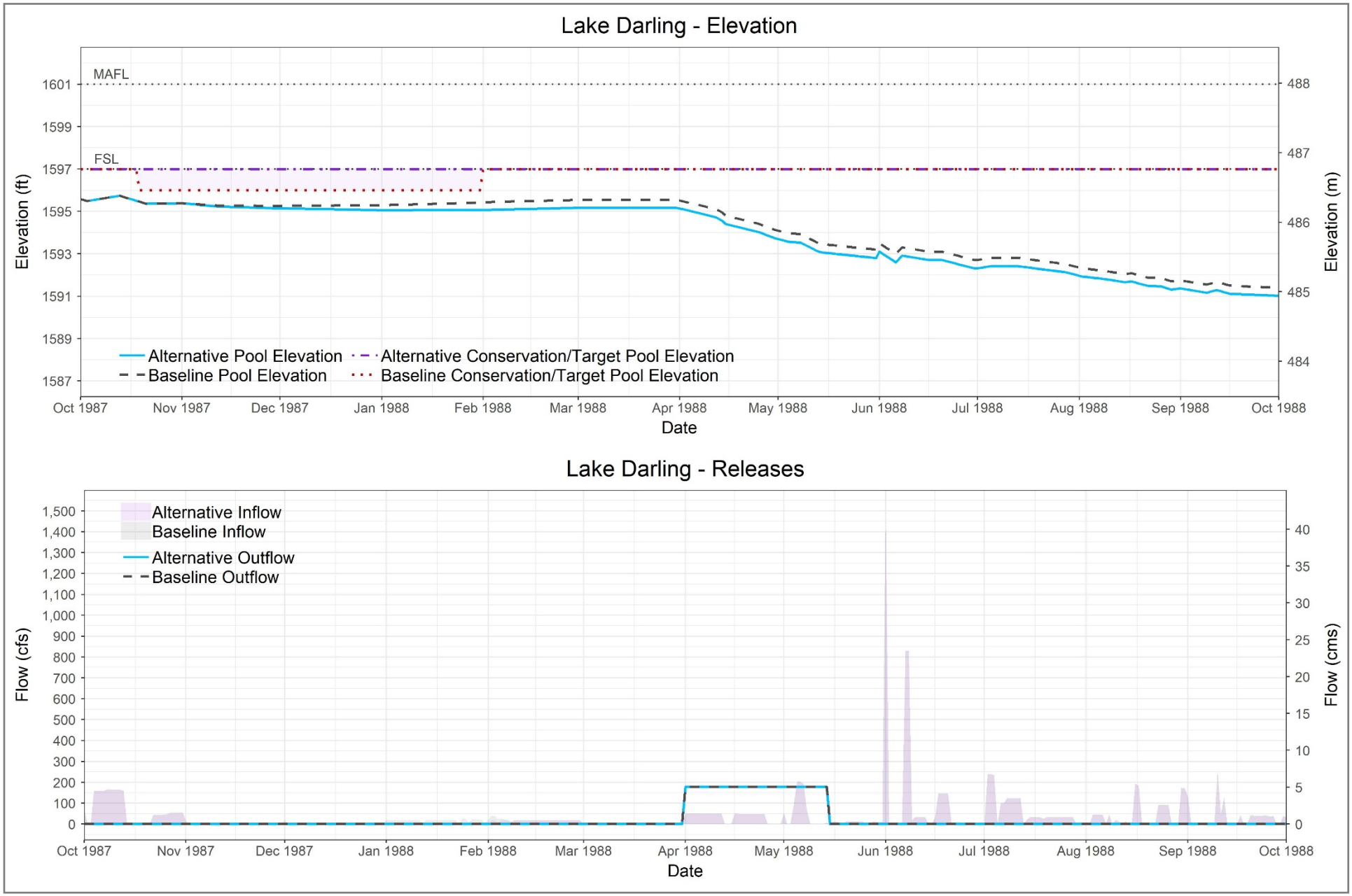
**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



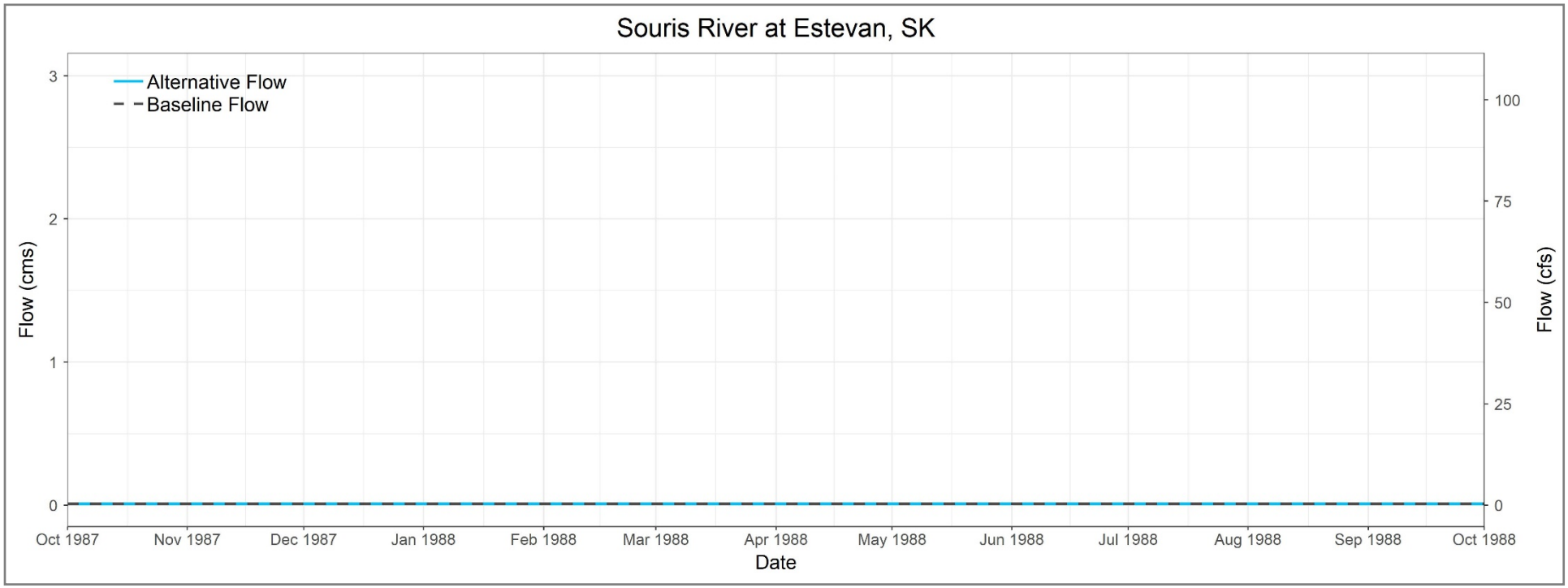
**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*

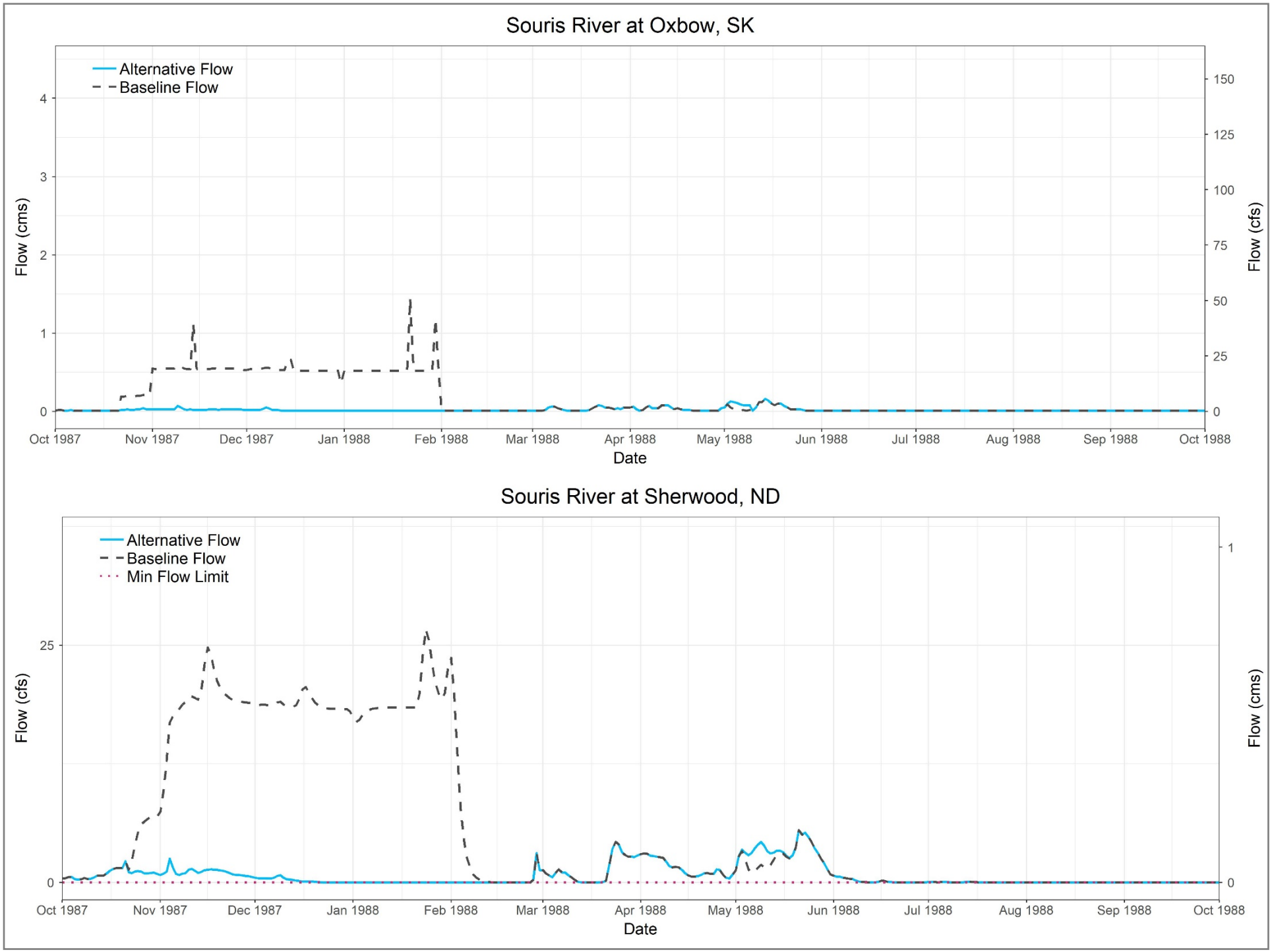
Plate 14

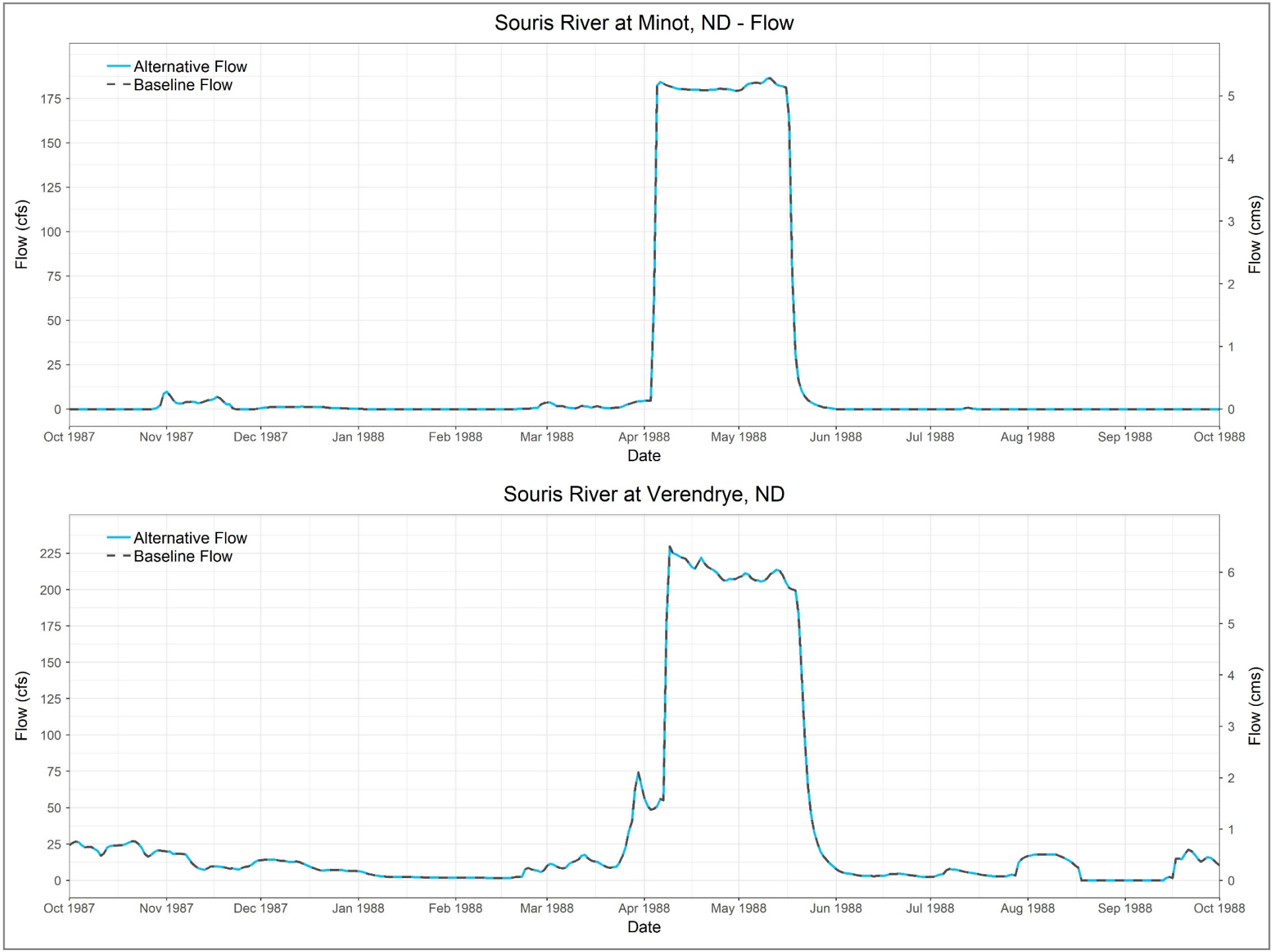
Critical Flow Locations – 1988

Alternative 2 (Phase 2)

Souris River Plan of Study




Souris River at Oxbow, SK
Alternative Flow
Baseline Flow
Flow (cms)
Flow (cfs)
0
1
2
3
4
0
25
50
75
100
125
150
Oct 1987
Nov 1987
Dec 1987
Jan 1988
Feb 1988
Mar 1988
Apr 1988
May 1988
Jun 1988
Jul 1988
Aug 1988
Sep 1988
Oct 1988
Date
Souris River at Sherwood, ND
Alternative Flow
Baseline Flow
Min Flow Limit
Flow (cfs)
Flow (cms)
0
25
0
1
Oct 1987
Nov 1987
Dec 1987
Jan 1988
Feb 1988
Mar 1988
Apr 1988
May 1988
Jun 1988
Jul 1988
Aug 1988
Sep 1988
Oct 1988
Date


Souris River at Minot, ND - Flow
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
0
25
50
75
100
125
150
175
0
1
2
3
4
5
Oct 1987
Nov 1987
Dec 1987
Jan 1988
Feb 1988
Mar 1988
Apr 1988
May 1988
Jun 1988
Jul 1988
Aug 1988
Sep 1988
Oct 1988
Date
Souris River at Verendrye, ND
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
0
25
50
75
100
125
150
175
200
225
0
1
2
3
4
5
6
Oct 1987
Nov 1987
Dec 1987
Jan 1988
Feb 1988
Mar 1988
Apr 1988
May 1988
Jun 1988
Jul 1988
Aug 1988
Sep 1988
Oct 1988
Date

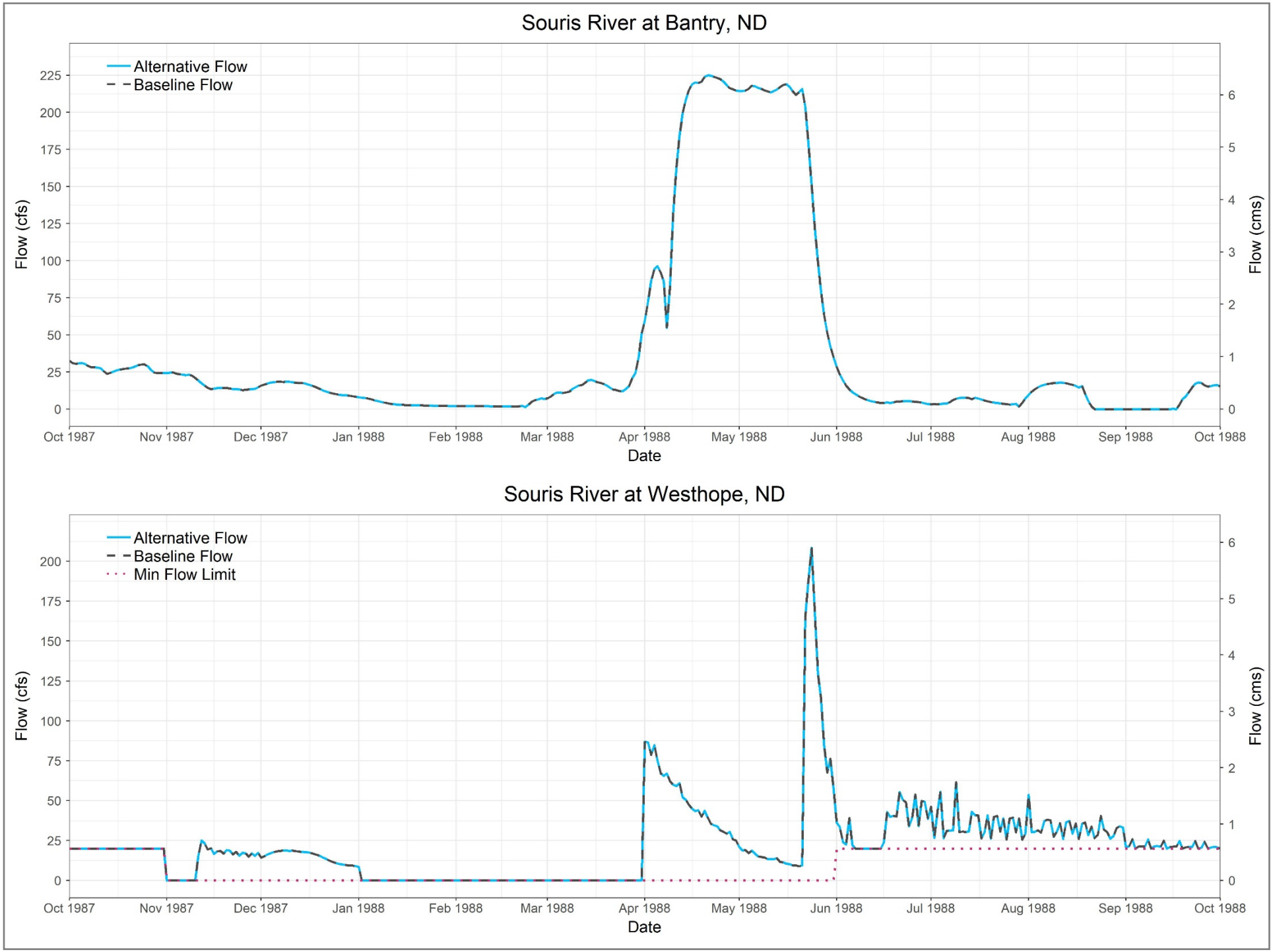
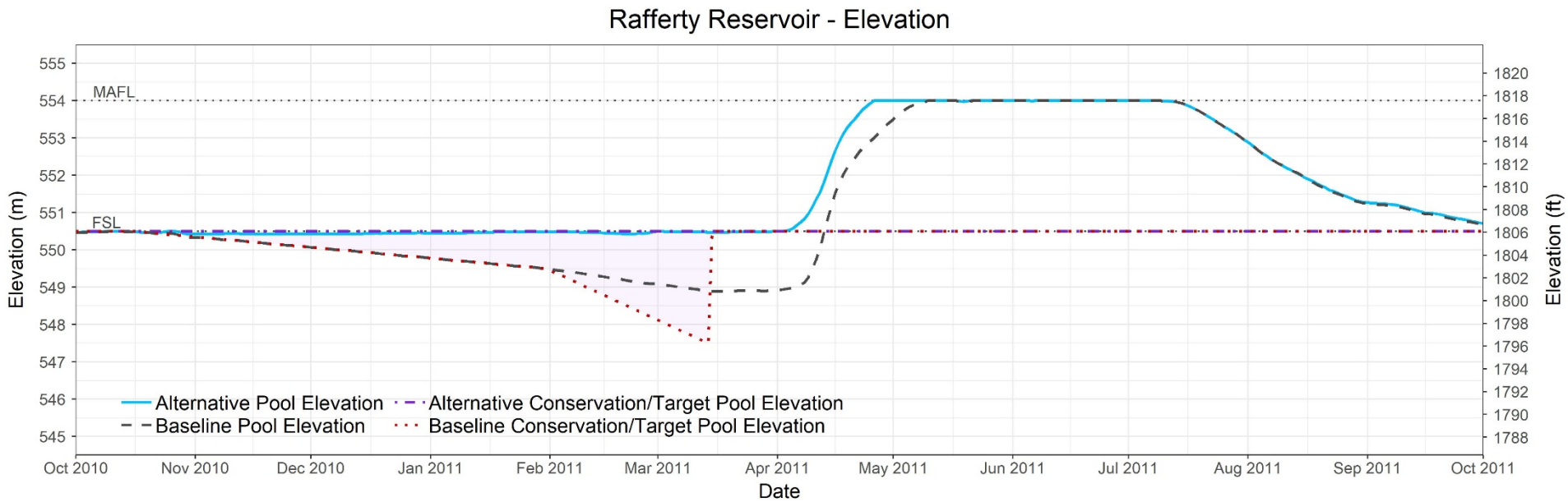
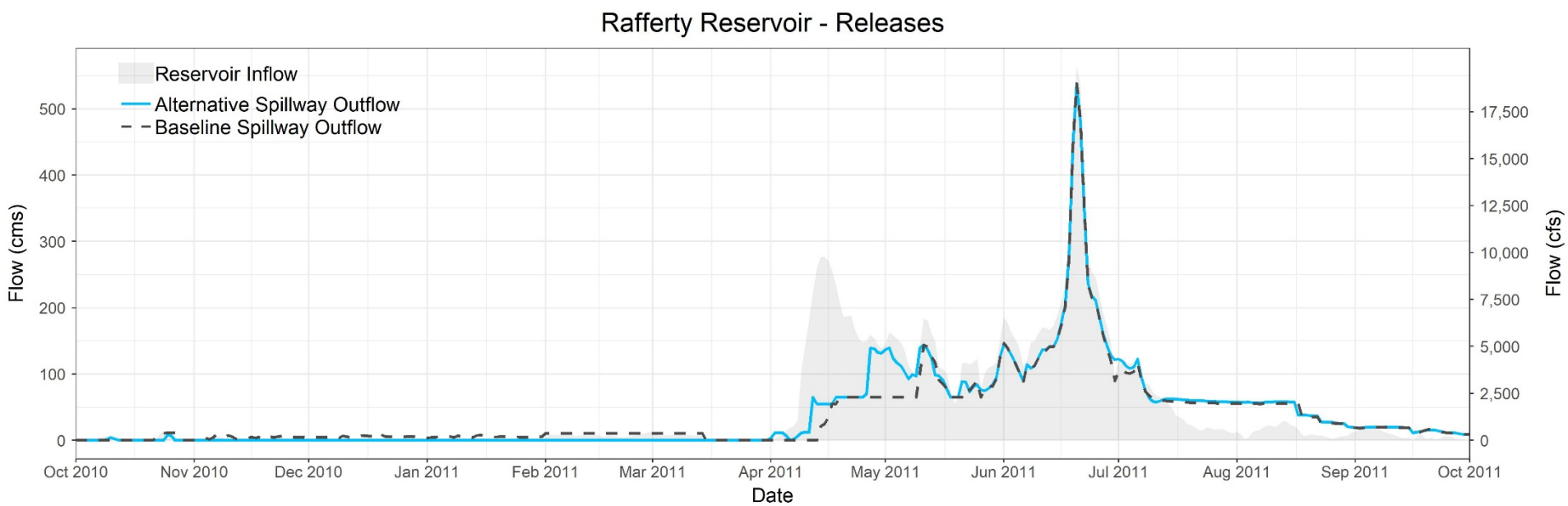
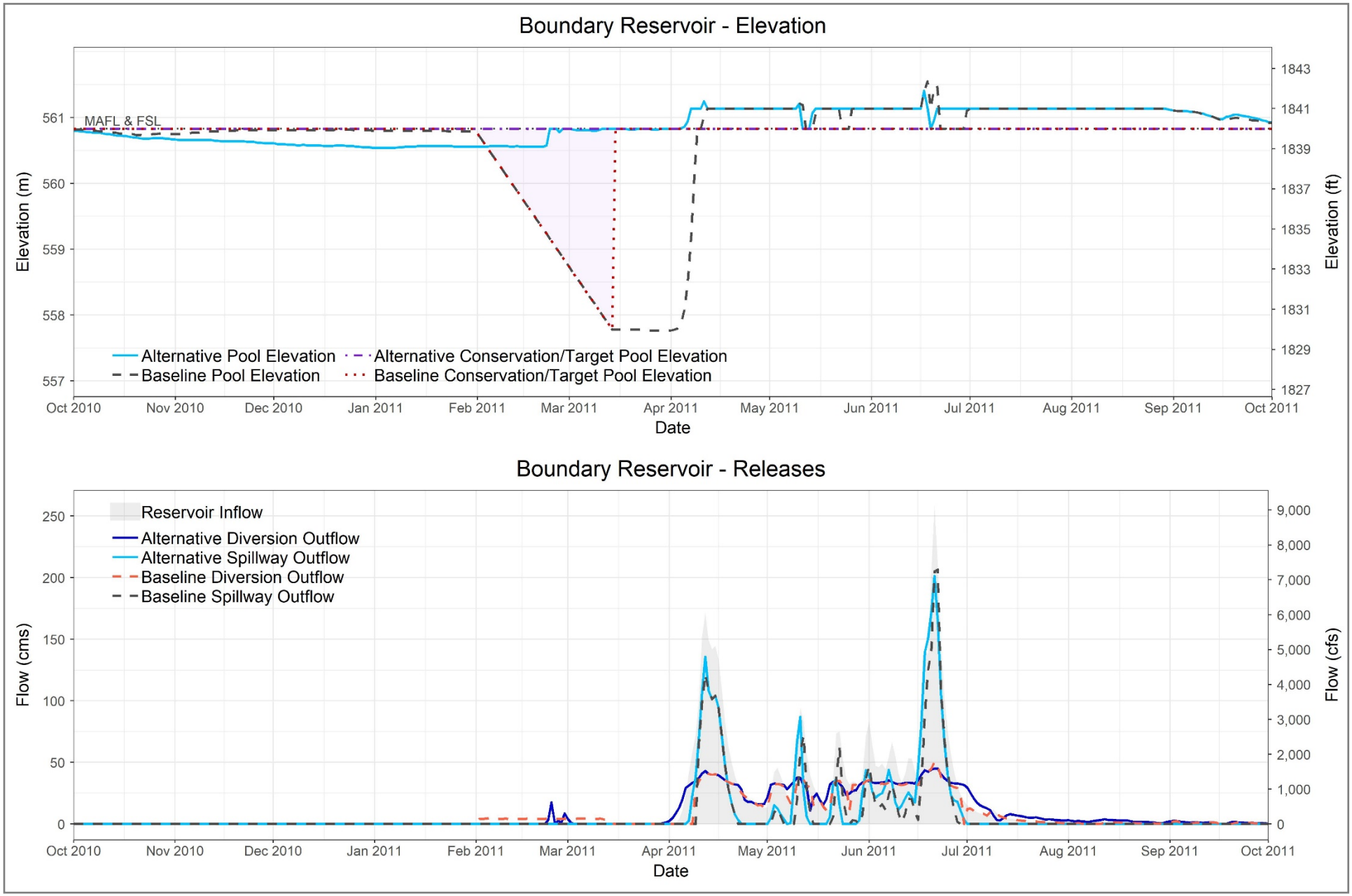

Souris River at Bantry, ND
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
Date
Oct 1987
Nov 1987
Dec 1987
Jan 1988
Feb 1988
Mar 1988
Apr 1988
May 1988
Jun 1988
Jul 1988
Aug 1988
Sep 1988
Oct 1988
Souris River at Westhope, ND
Alternative Flow
Baseline Flow
Min Flow Limit
Flow (cfs)
Flow (cms)
Date

Plate 15	Reservoirs – 2011	Alternative 2 (Phase 2) Souris River Plan of Study

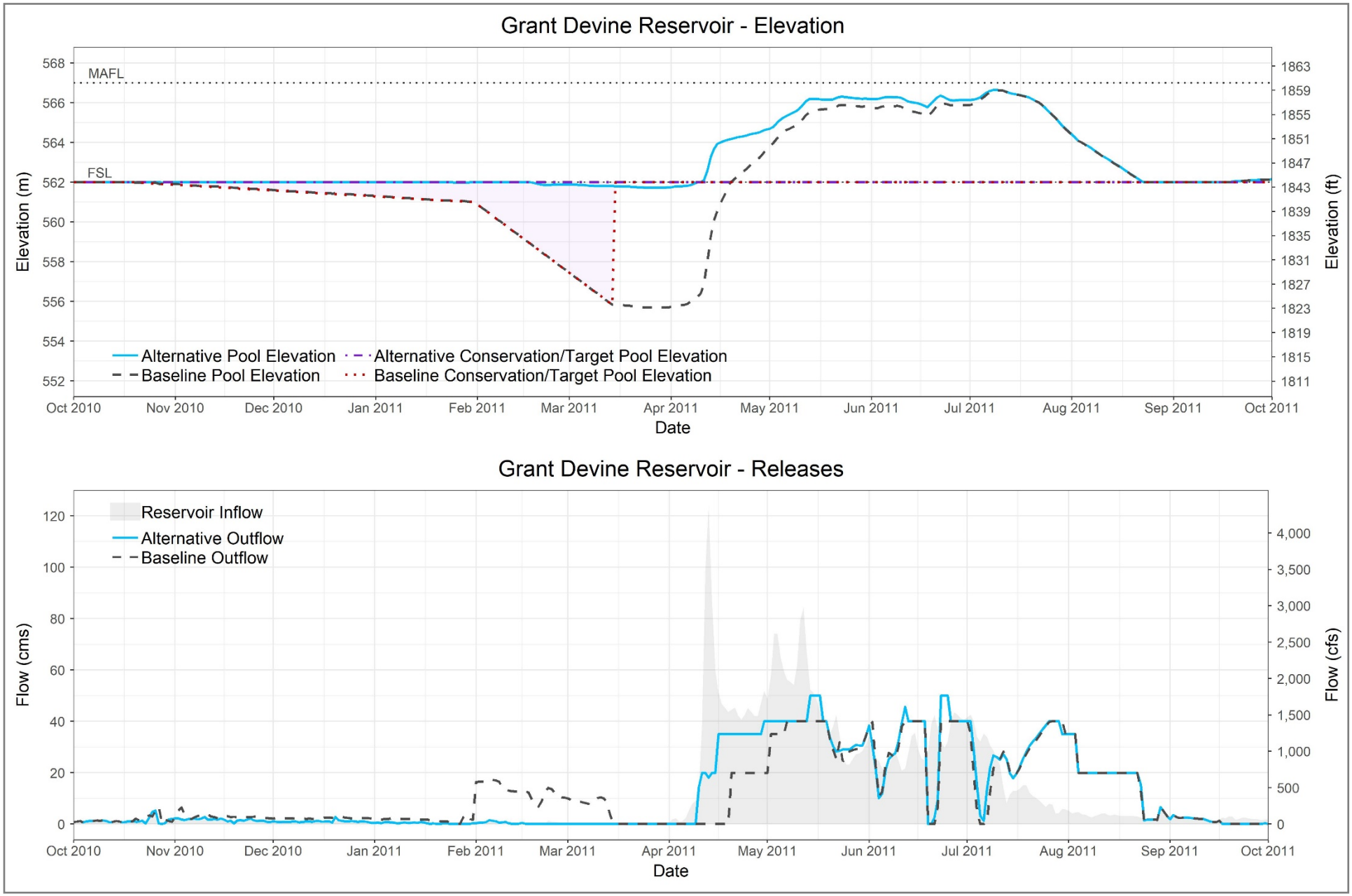




**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*

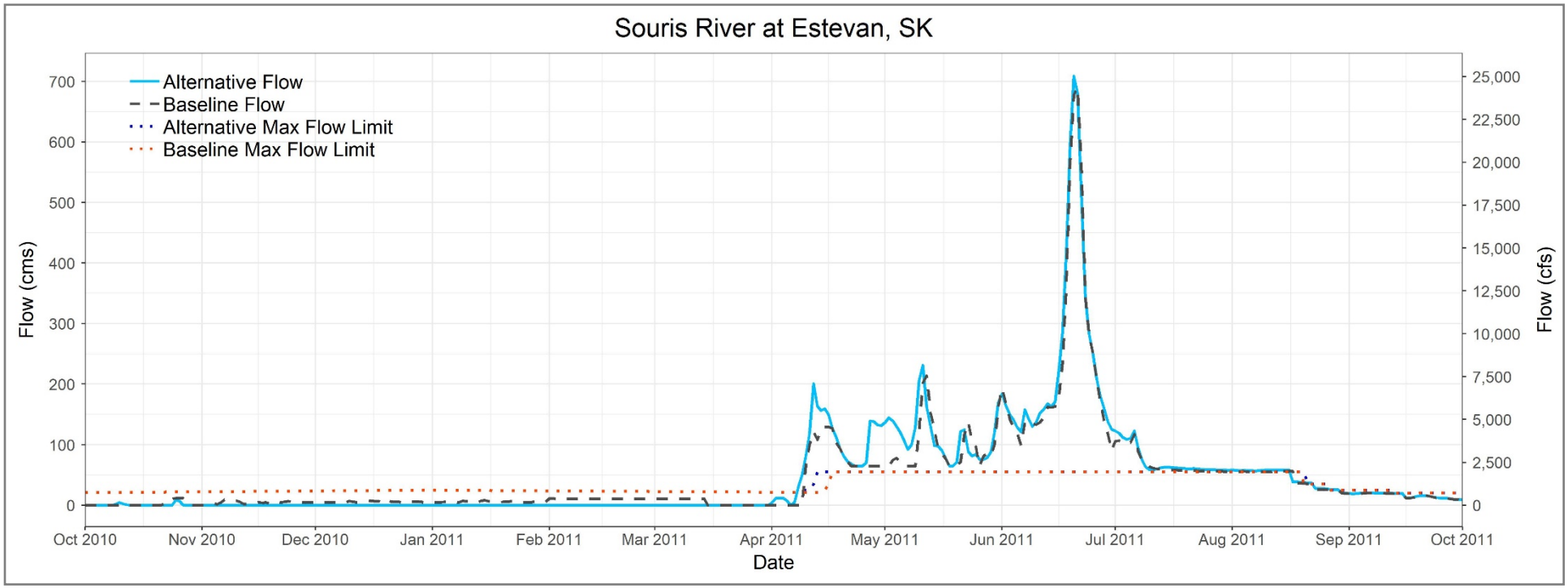
**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*

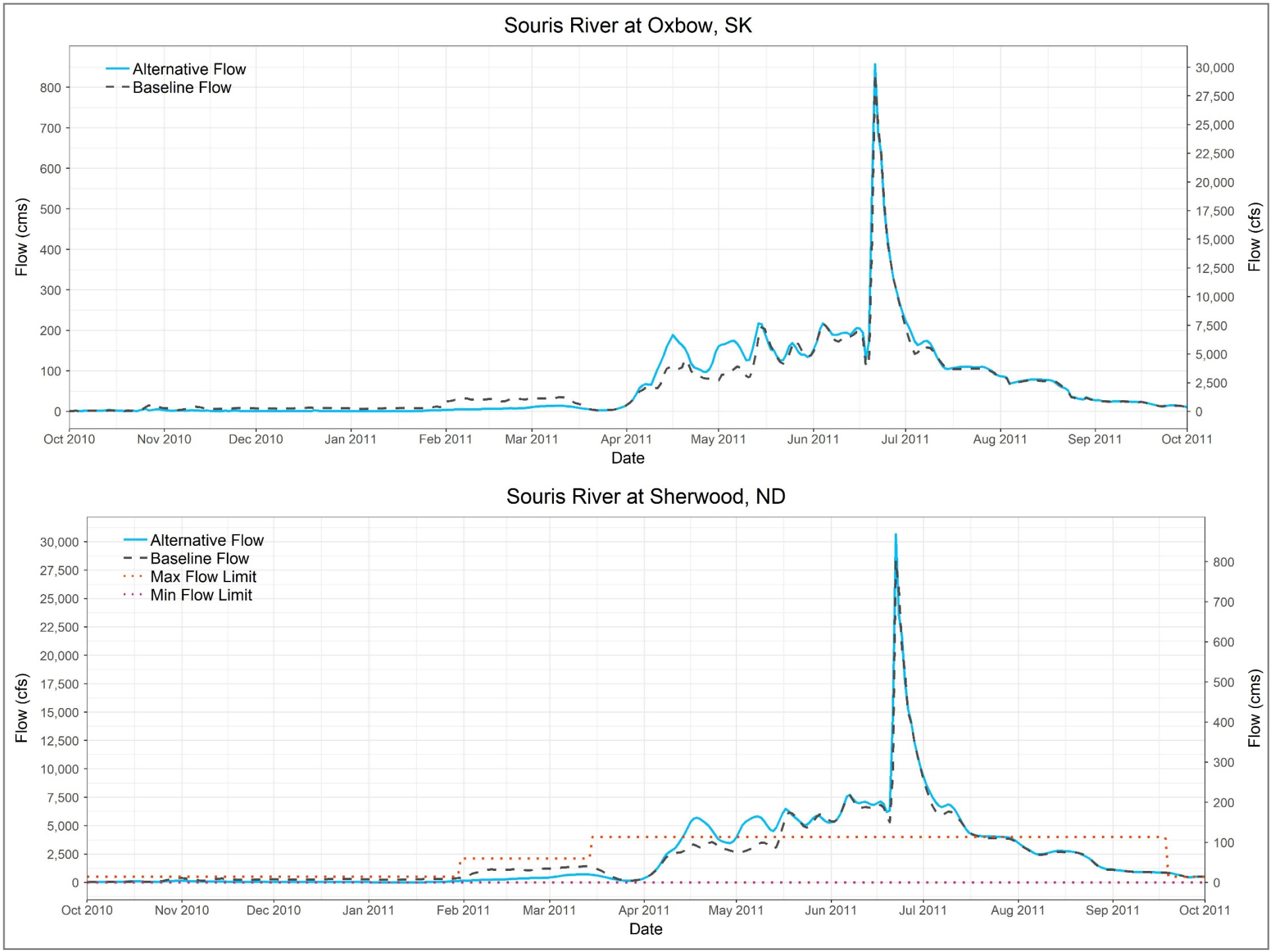
Plate 16

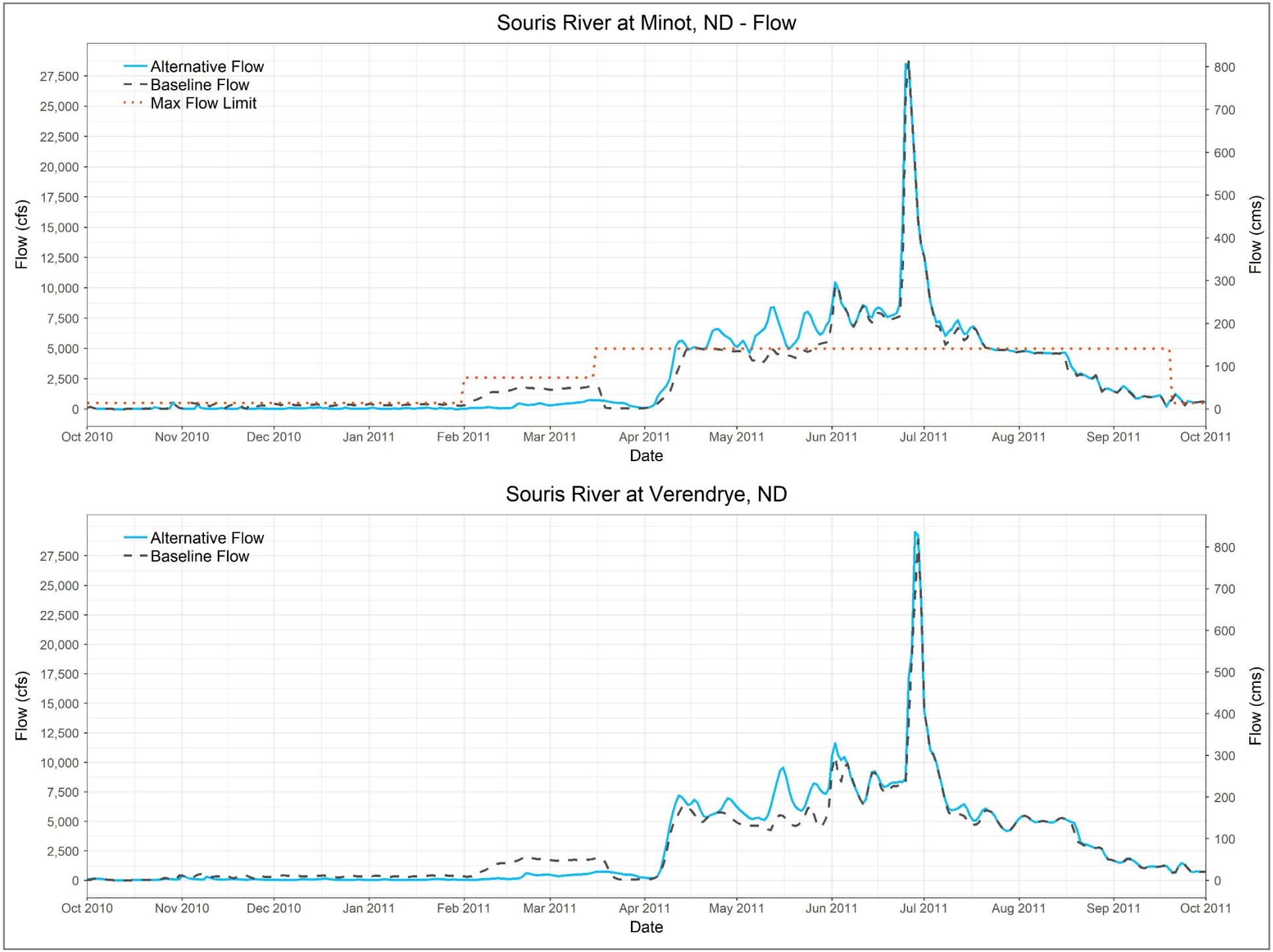
Critical Flow Locations – 2011

Alternative 2 (Phase 2)

Souris River Plan of Study




Souris River at Oxbow, SK
Alternative Flow
Baseline Flow
Flow (cms)
Flow (cfs)
Date
Souris River at Sherwood, ND
Alternative Flow
Baseline Flow
Max Flow Limit
Min Flow Limit
Flow (cfs)
Flow (cms)
Date


Souris River at Minot, ND - Flow
Alternative Flow
Baseline Flow
Max Flow Limit
Flow (cfs)
Flow (cms)
Date
Oct 2010
Nov 2010
Dec 2010
Jan 2011
Feb 2011
Mar 2011
Apr 2011
May 2011
Jun 2011
Jul 2011
Aug 2011
Sep 2011
Oct 2011
Souris River at Verendrye, ND
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
Date

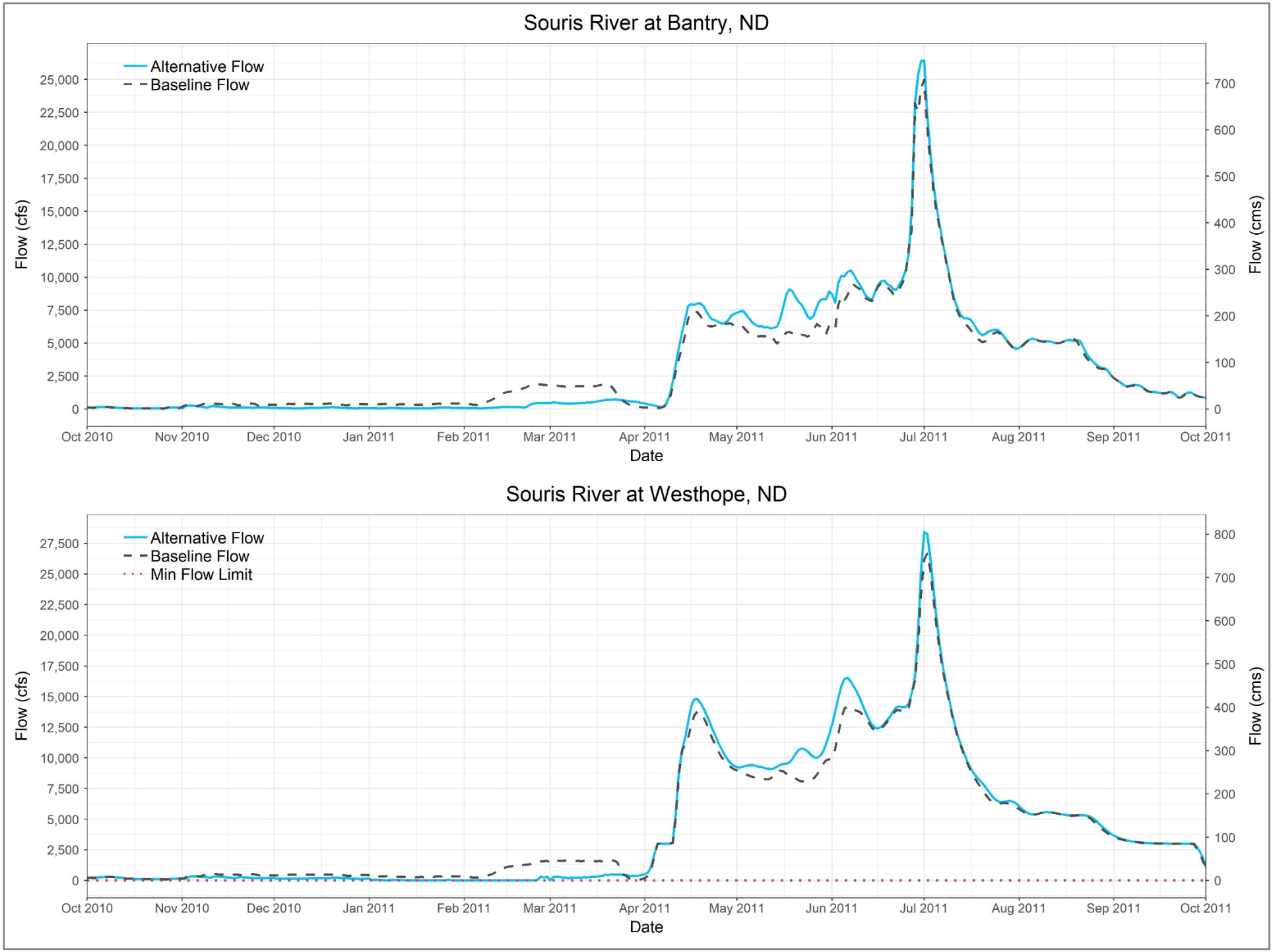
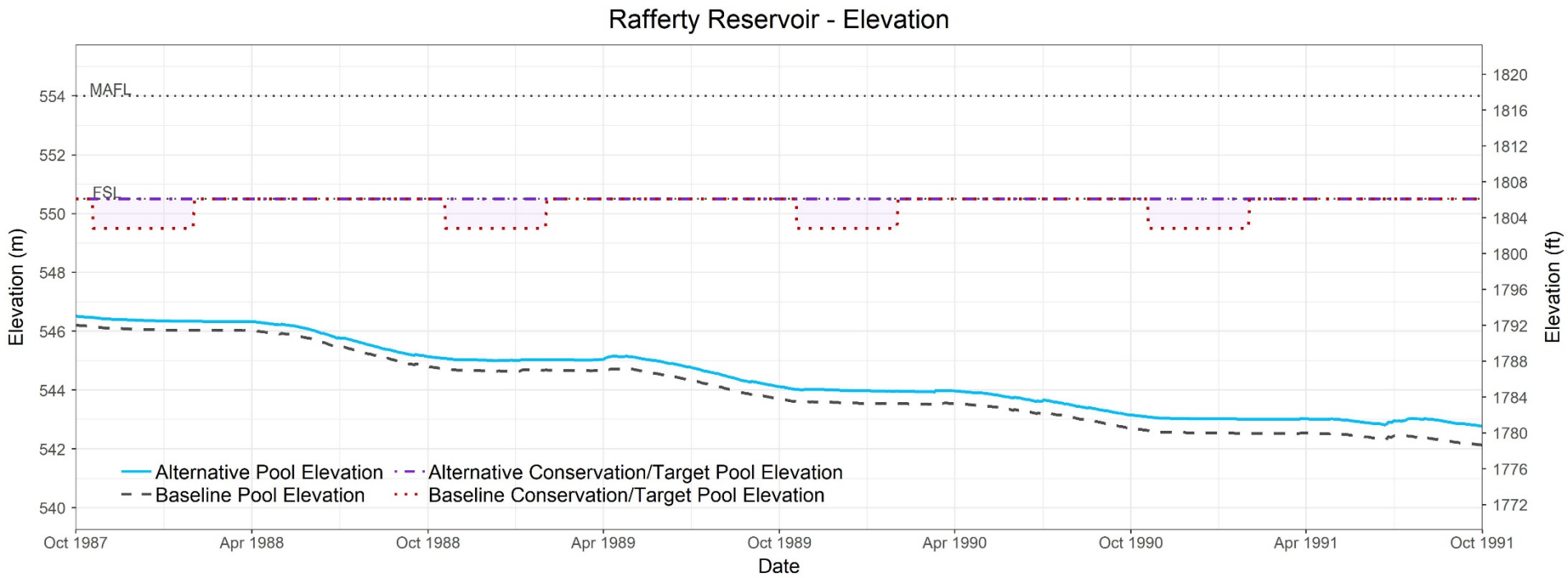
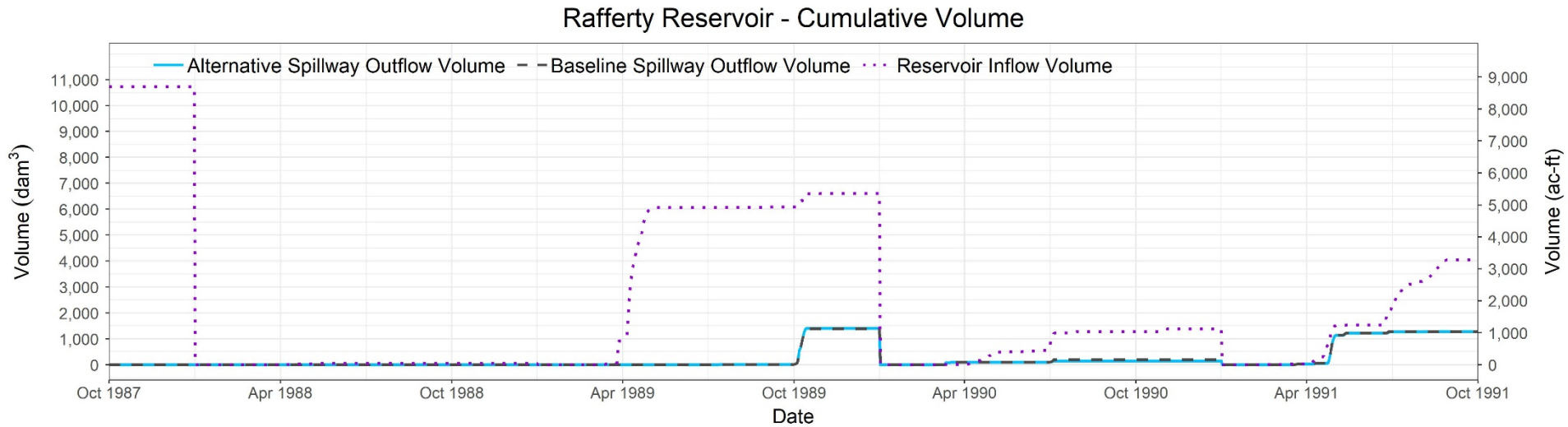
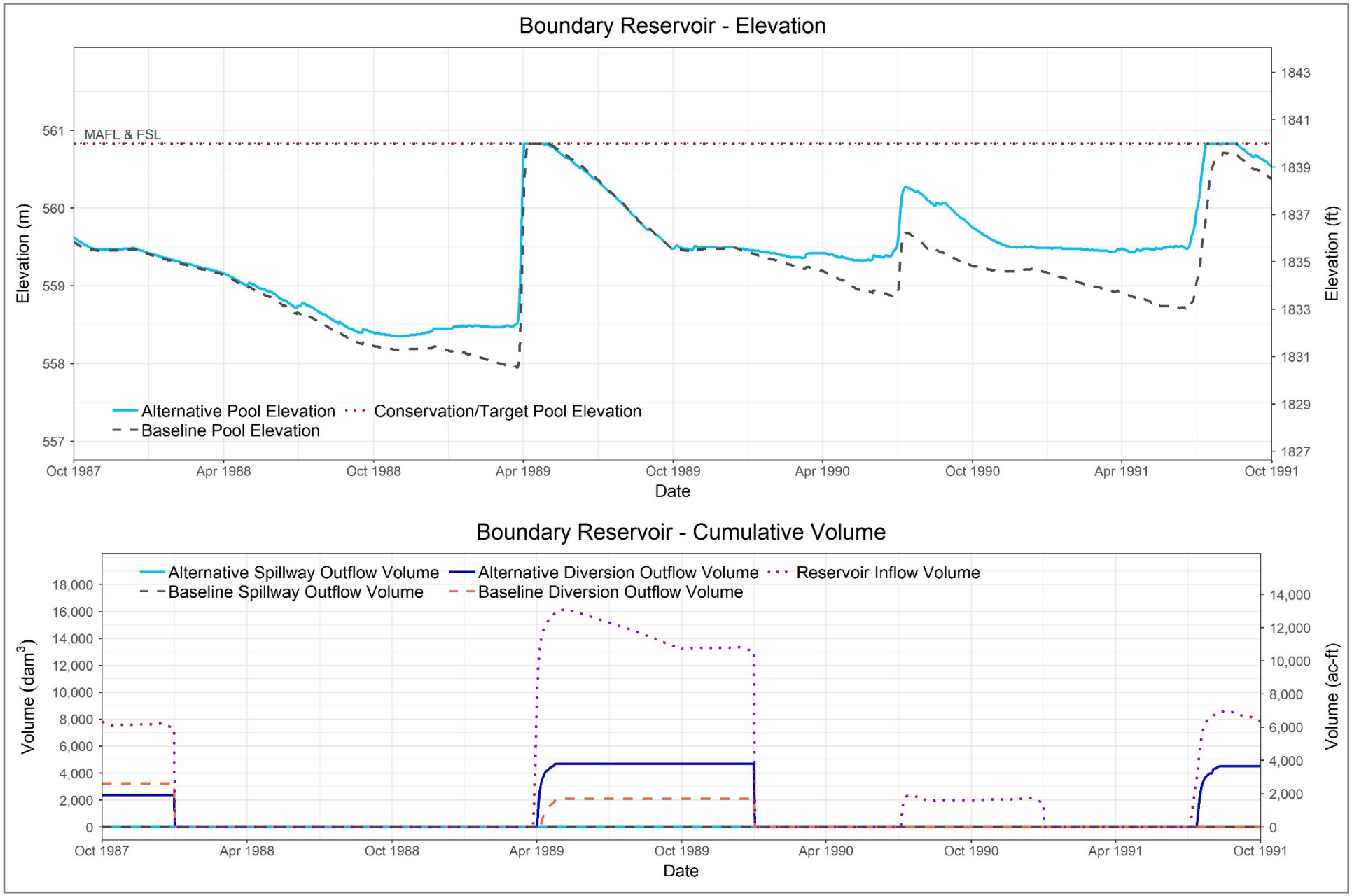

Souris River at Bantry, ND
Alternative Flow
Baseline Flow
Flow (cfs)
Flow (cms)
Date
Souris River at Westhope, ND
Alternative Flow
Baseline Flow
Min Flow Limit
Flow (cfs)
Flow (cms)
Date

Plate 17	Reservoirs – 1988-1991	Alternative 2 (Phase 2) Souris River Plan of Study

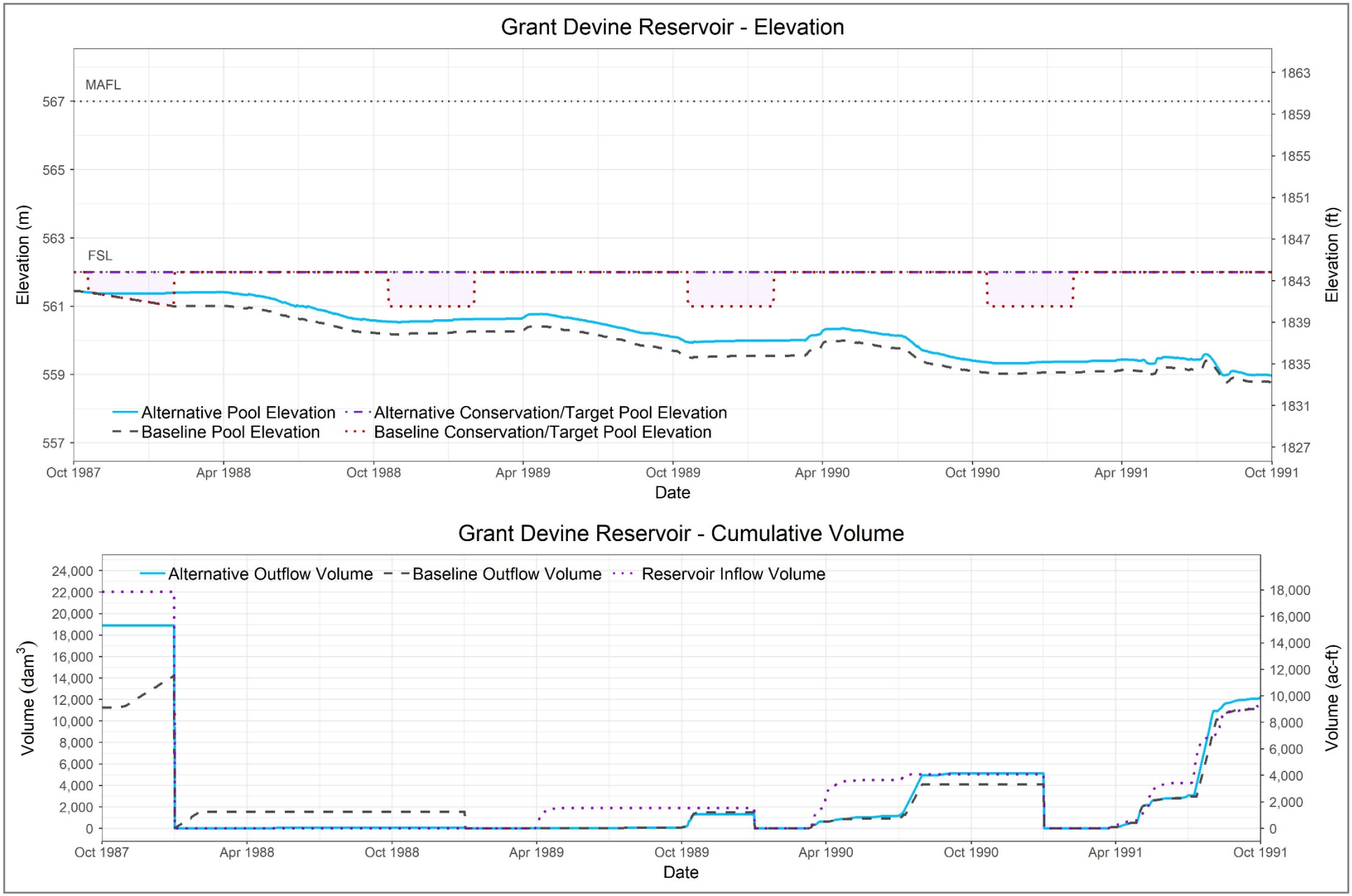




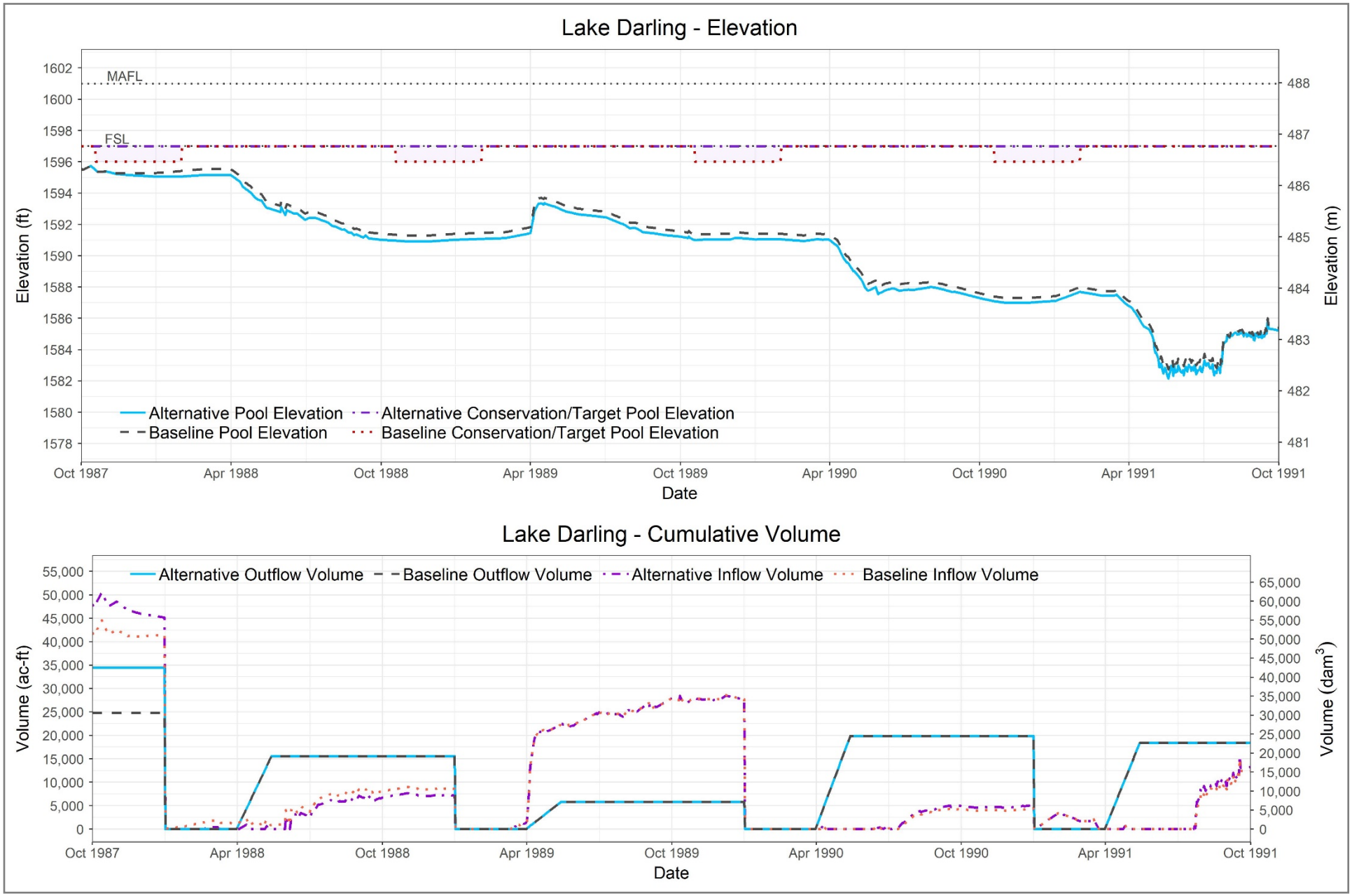
**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*



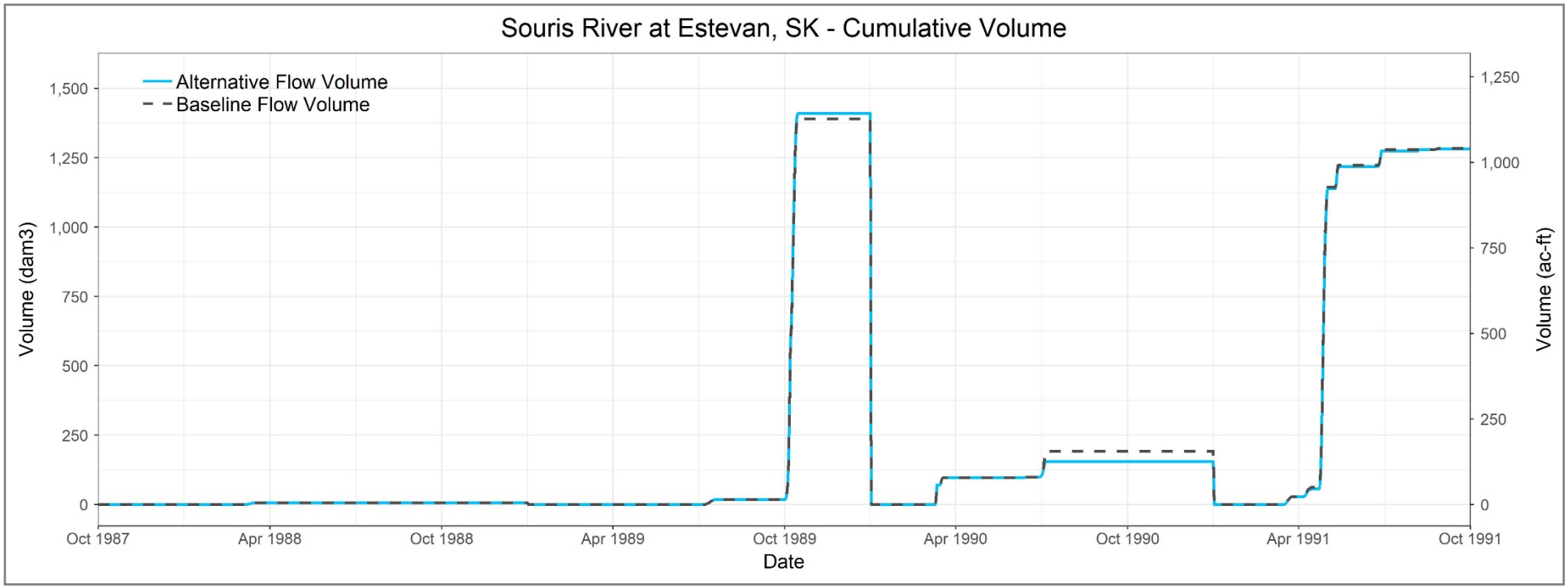
**MAFL = Maximum Allowable Flood Level, FSL = Full Supply Level*

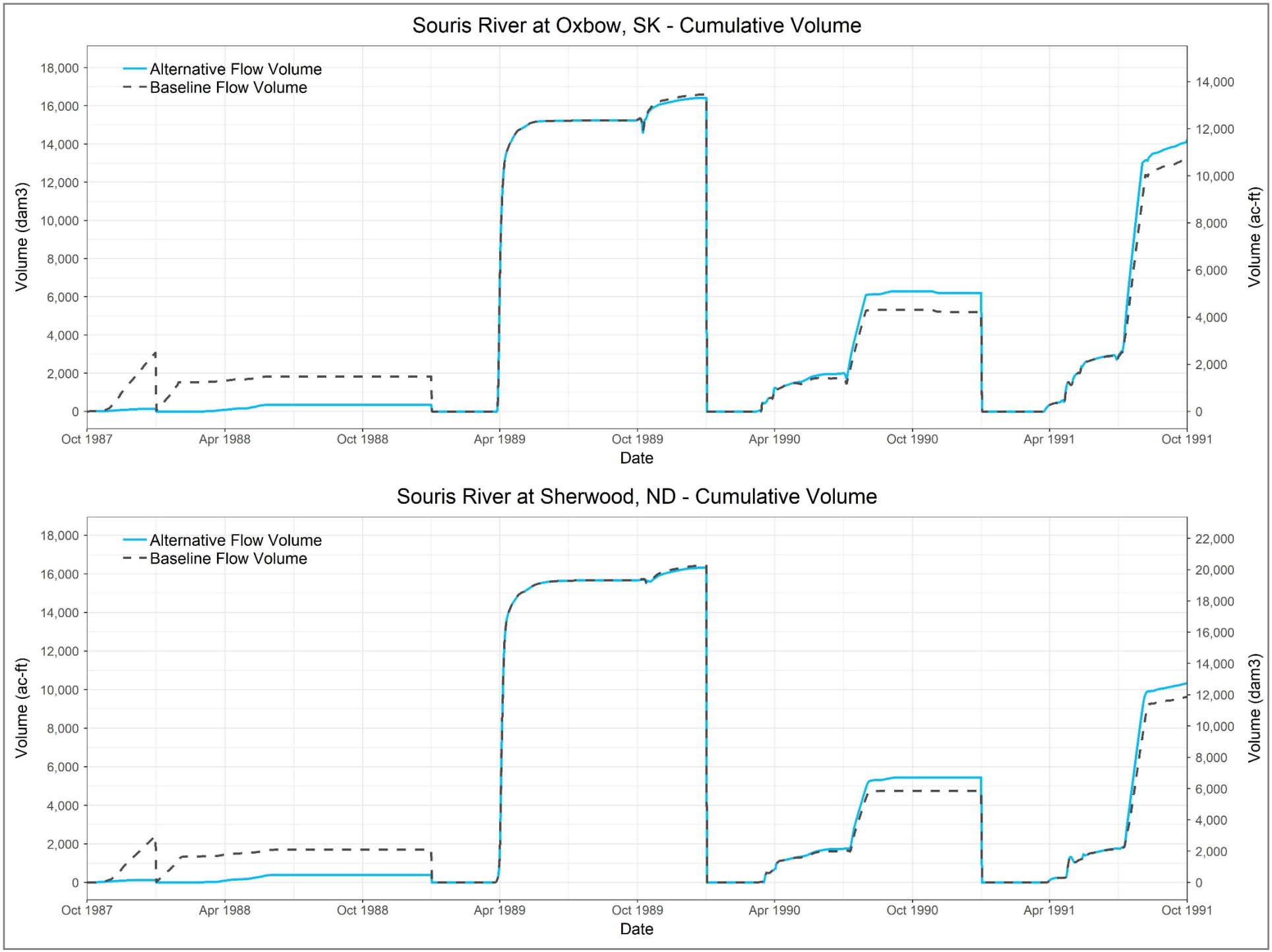
Plate 18

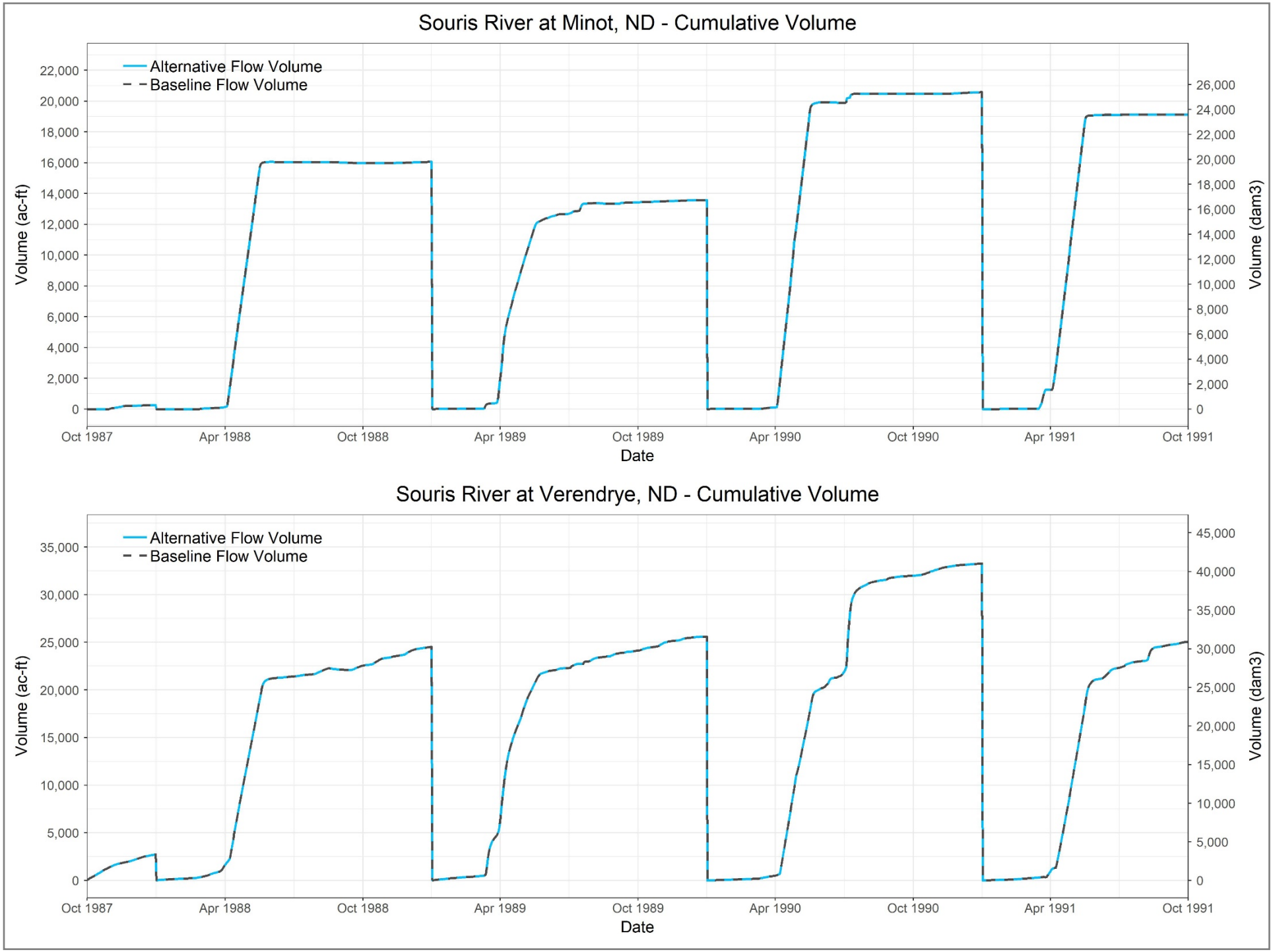
Critical Flow Locations – 1988-1991

Alternative 2 (Phase 2)

Souris River Plan of Study




Souris River at Oxbow, SK - Cumulative Volume
Alternative Flow Volume
Baseline Flow Volume
Volume (dam3)
Volume (ac-ft)
Date
Souris River at Sherwood, ND - Cumulative Volume
Alternative Flow Volume
Baseline Flow Volume
Volume (ac-ft)
Volume (dam3)
Date


Souris River at Minot, ND - Cumulative Volume
Alternative Flow Volume
Baseline Flow Volume
Volume (ac-ft)
Volume (dam3)
Date
Souris River at Verendrye, ND - Cumulative Volume
Alternative Flow Volume
Baseline Flow Volume
Volume (ac-ft)
Volume (dam3)
Date

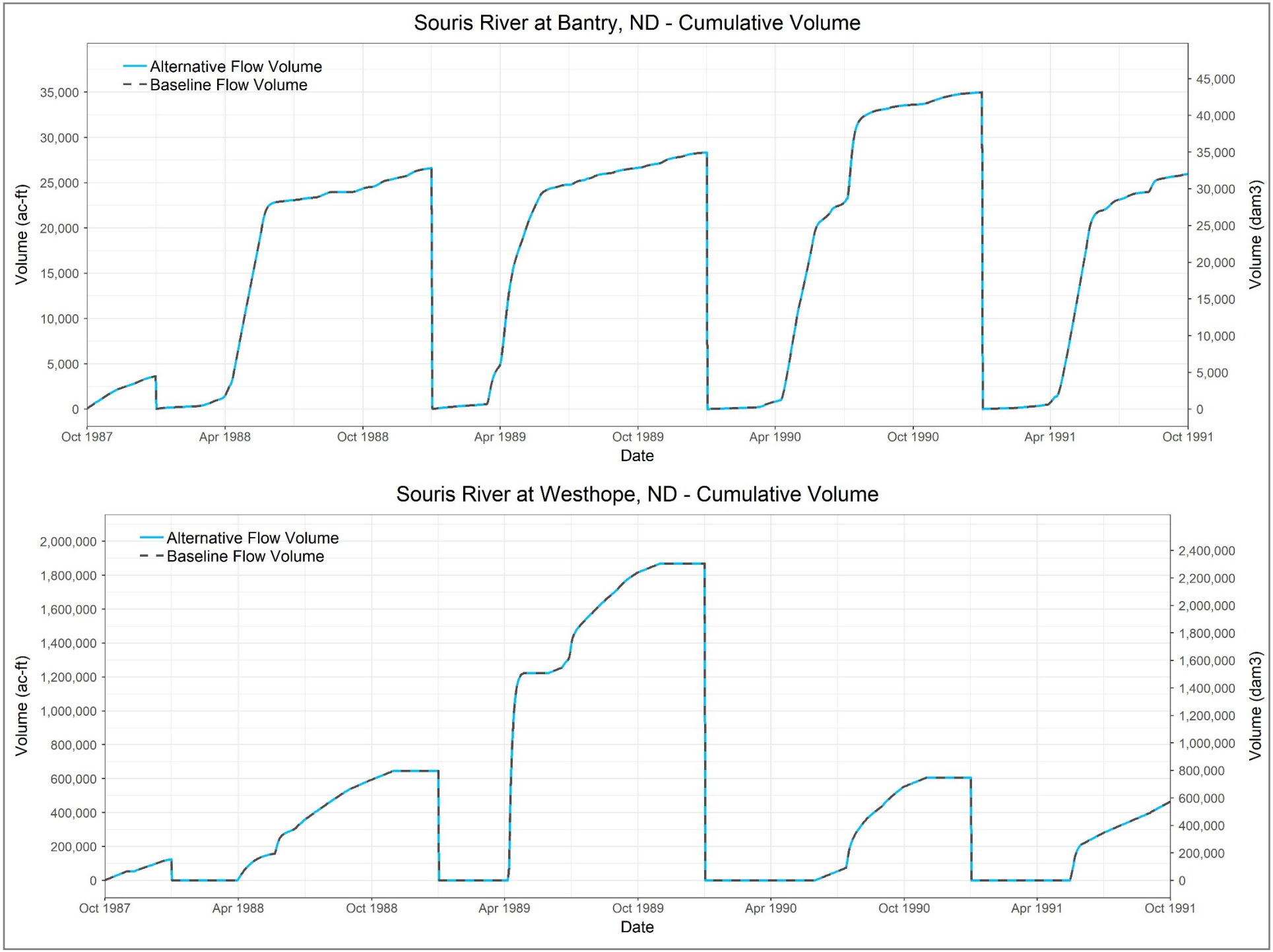
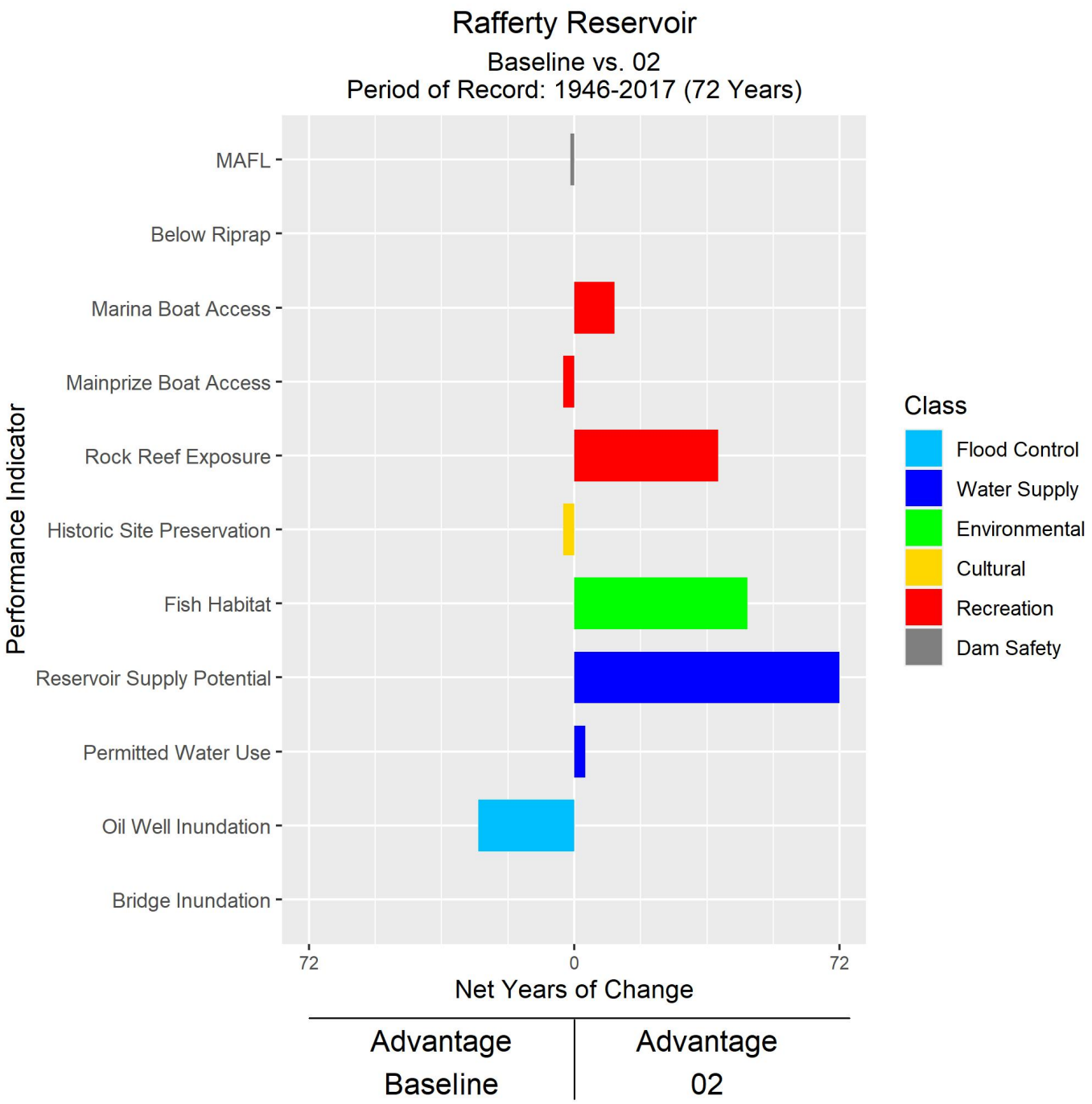
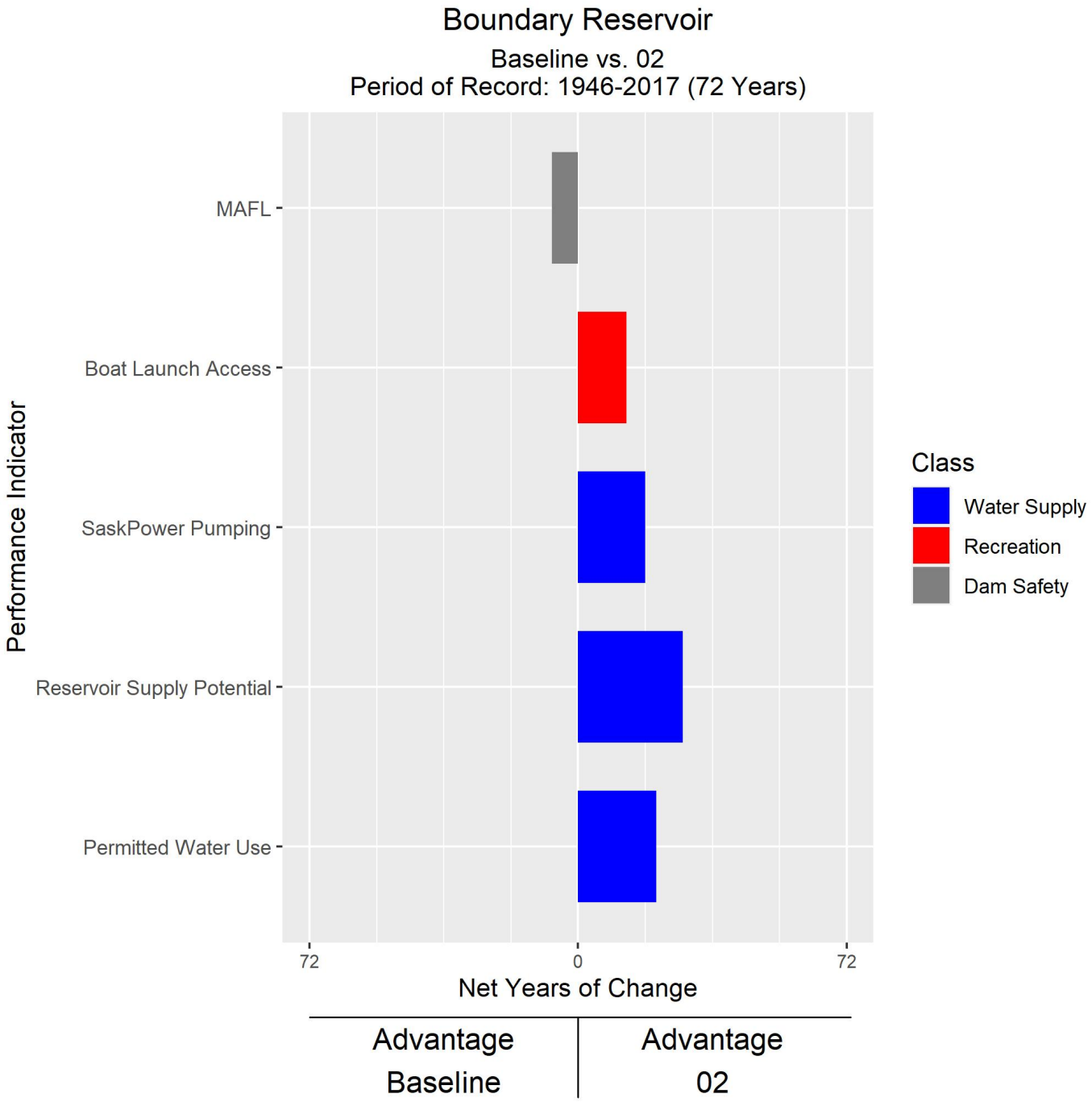
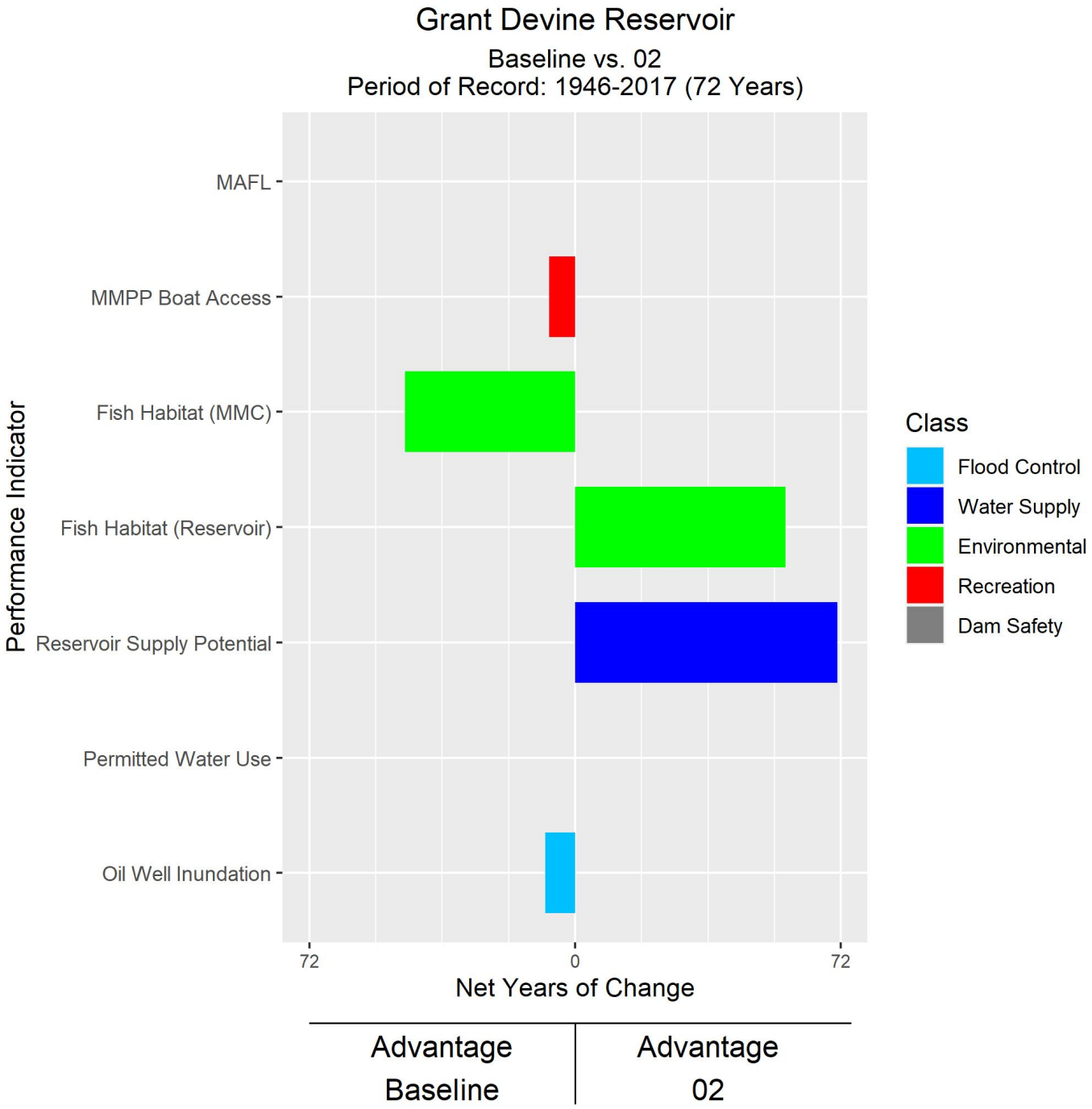
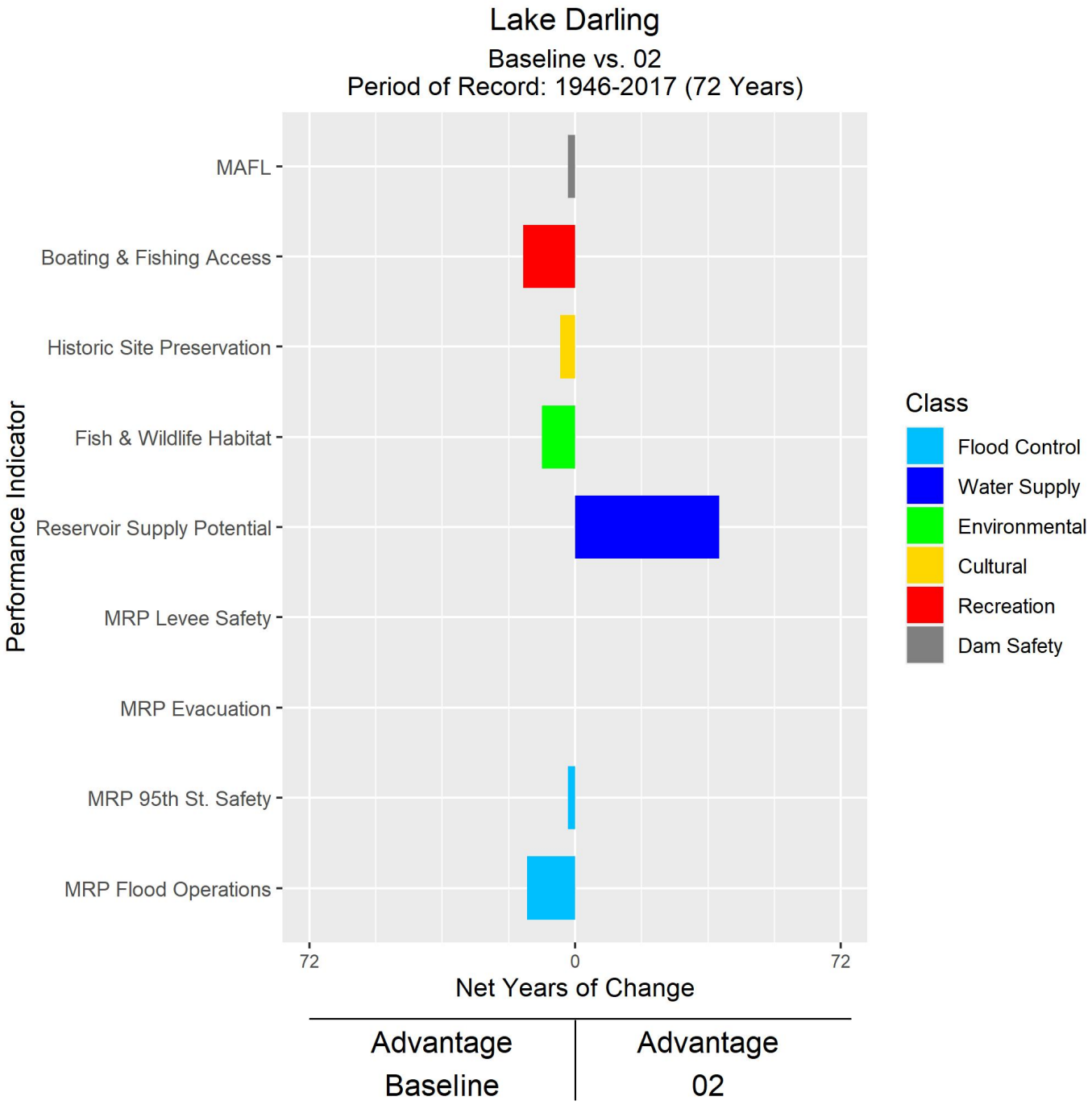

Souris River at Bantry, ND - Cumulative Volume
Alternative Flow Volume
Baseline Flow Volume
Volume (ac-ft)
Volume (dam3)
Date
Oct 1987
Apr 1988
Oct 1988
Apr 1989
Oct 1989
Apr 1990
Oct 1990
Apr 1991
Oct 1991
Souris River at Westhope, ND - Cumulative Volume
Alternative Flow Volume
Baseline Flow Volume
Volume (ac-ft)
Volume (dam3)
Date

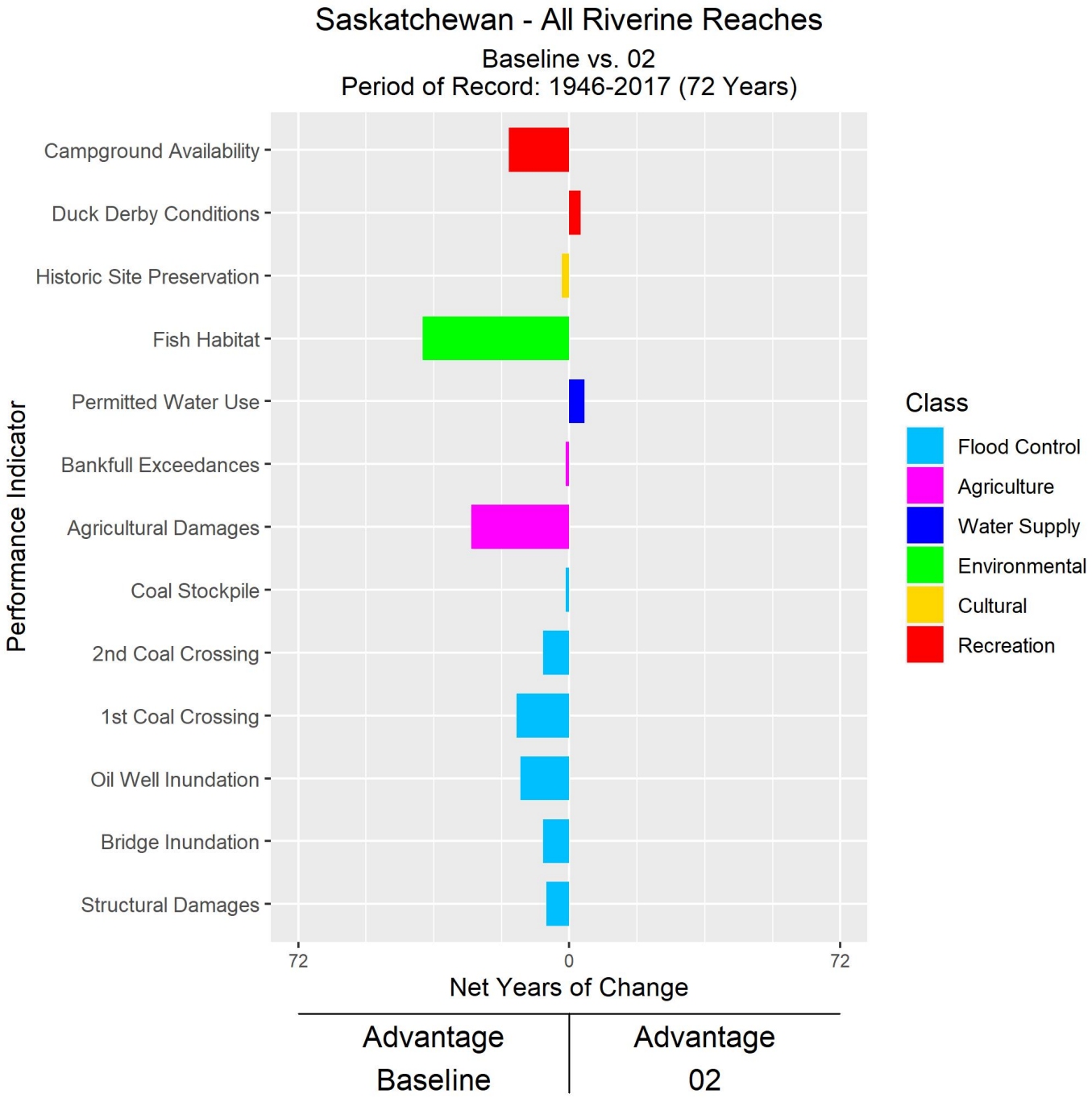
Plate 19	Performance Indicators 1946-2017 (72 years)	Alternative 02 vs. Baseline (Phase 2)

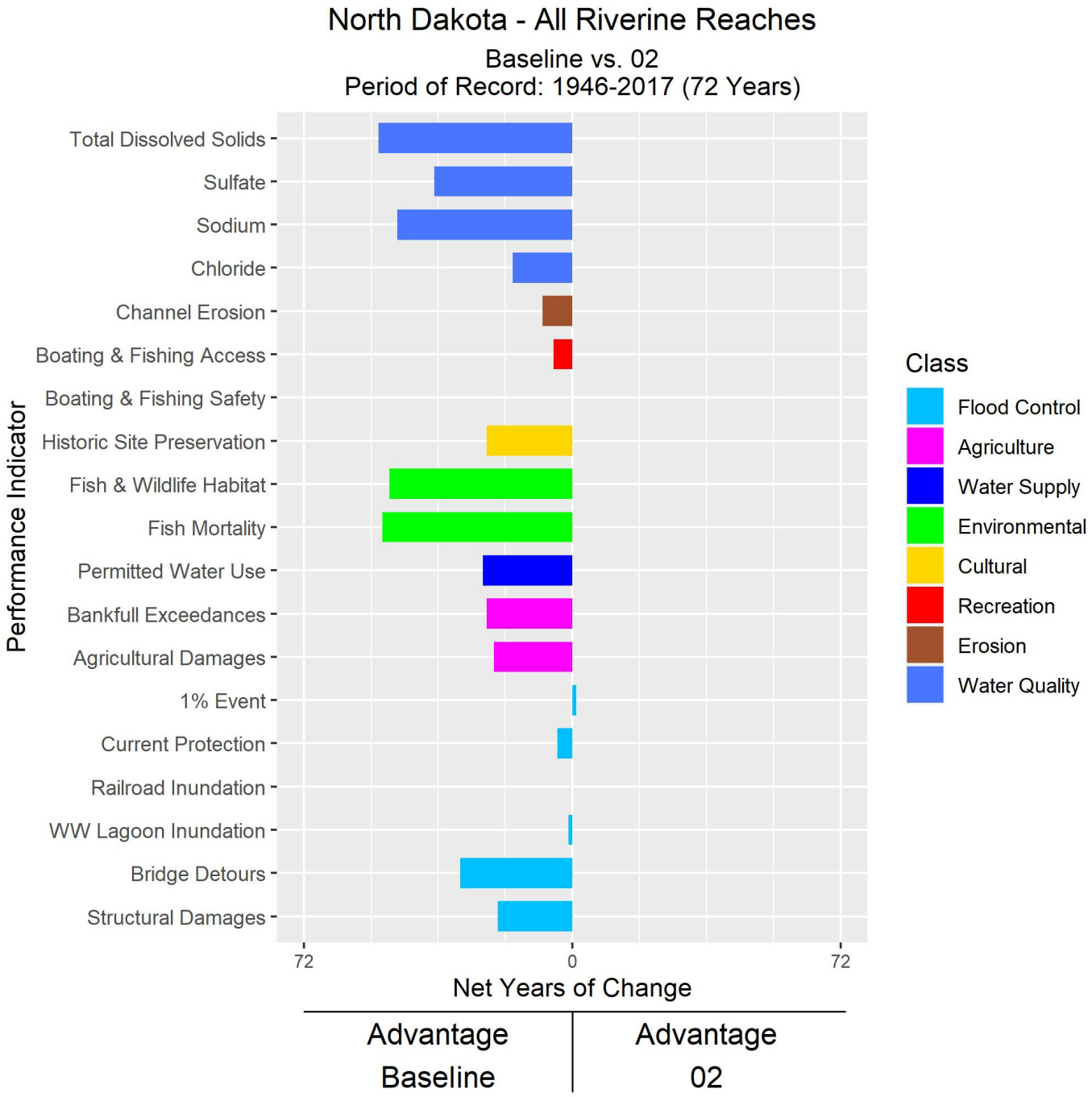


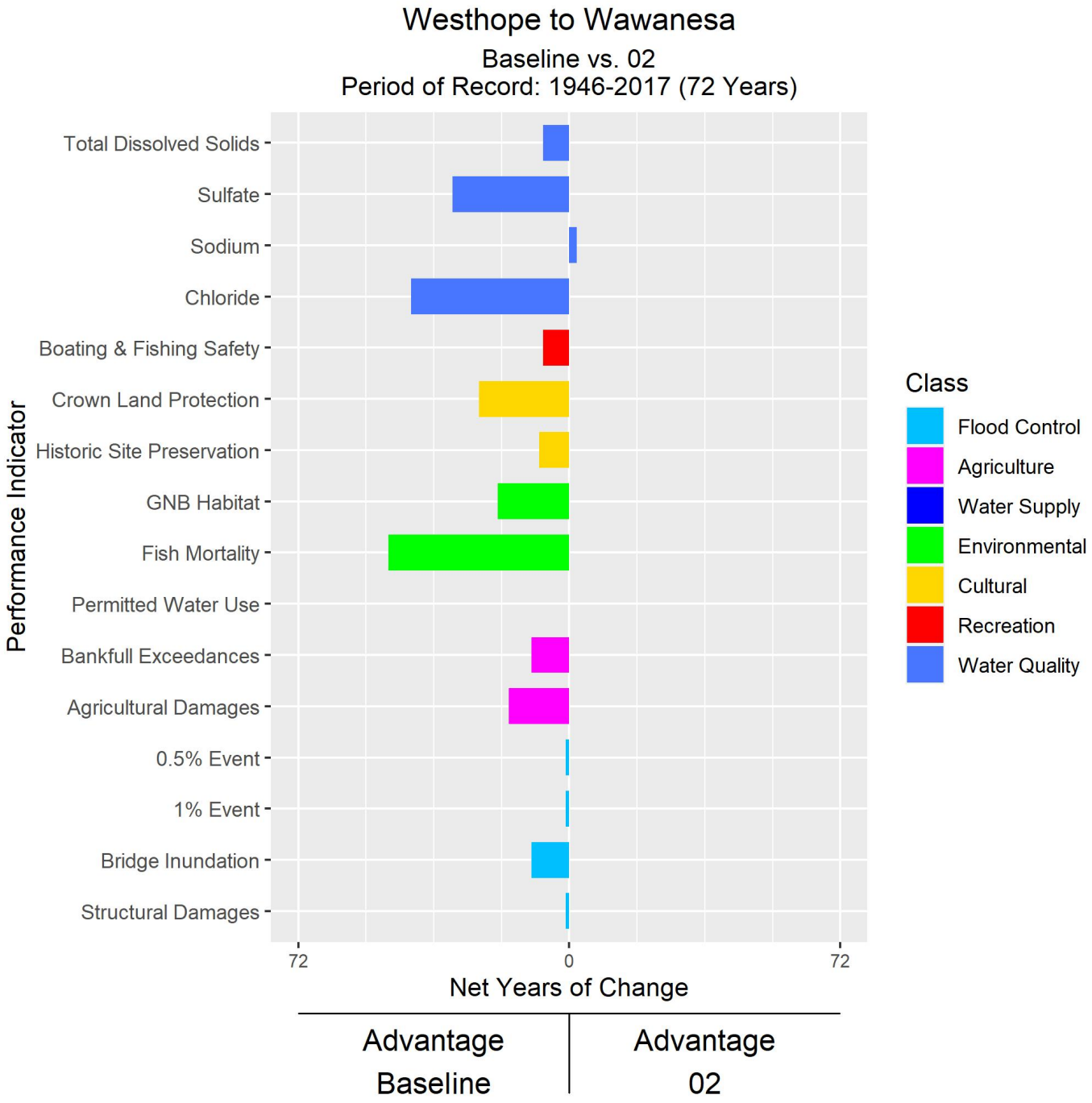

Boundary Reservoir
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
MAFL
Boat Launch Access
SaskPower Pumping
Reservoir Supply Potential
Permitted Water Use
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Water Supply
Recreation
Dam Safety

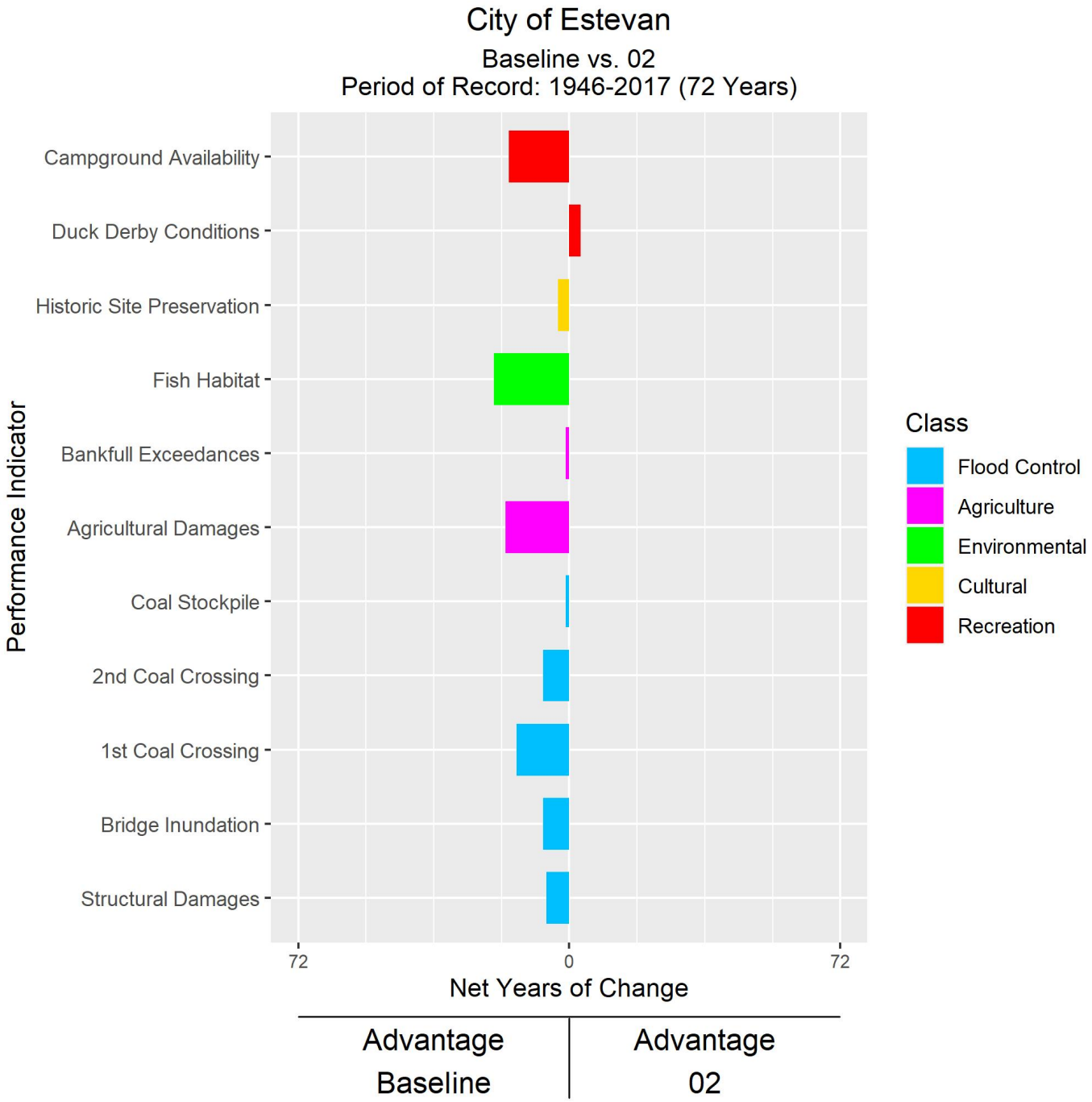

Grant Devine Reservoir
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
MAFL
MMPP Boat Access
Fish Habitat (MMC)
Fish Habitat (Reservoir)
Reservoir Supply Potential
Permitted Water Use
Oil Well Inundation
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Water Supply
Environmental
Recreation
Dam Safety

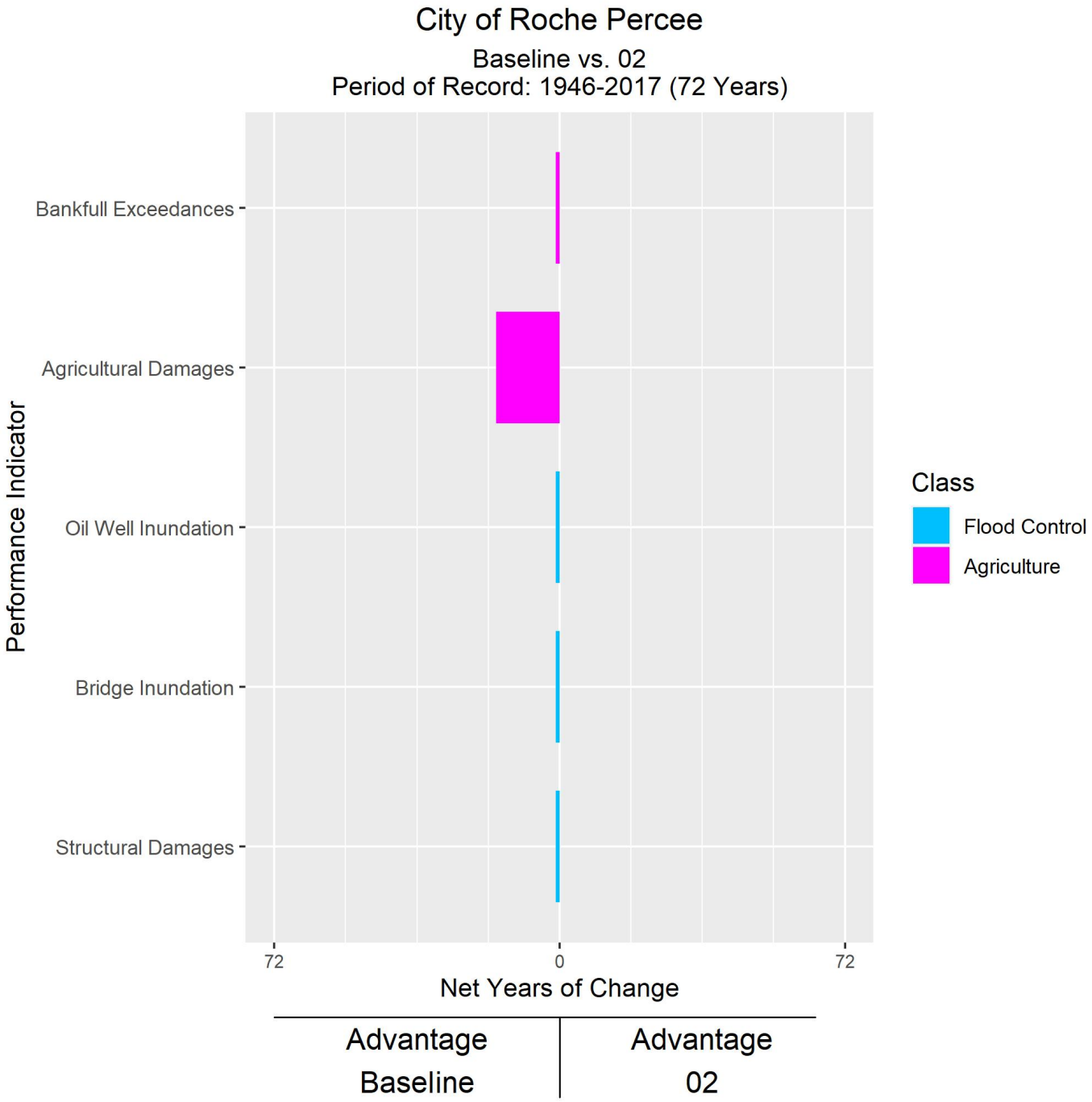

Lake Darling
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
MAFL
Boating & Fishing Access
Historic Site Preservation
Fish & Wildlife Habitat
Reservoir Supply Potential
MRP Levee Safety
MRP Evacuation
MRP 95th St. Safety
MRP Flood Operations
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Water Supply
Environmental
Cultural
Recreation
Dam Safety

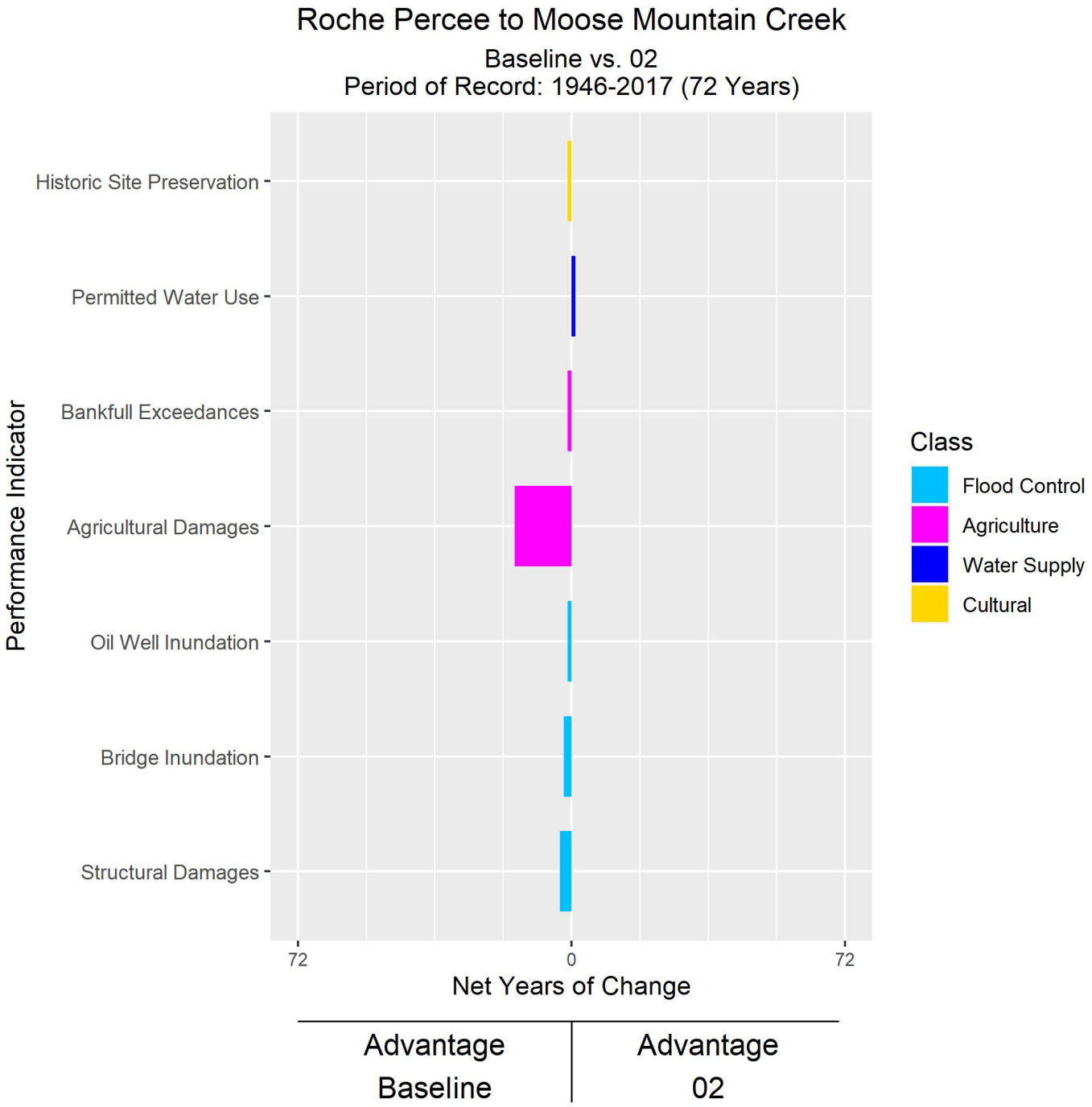

Saskatchewan - All Riverine Reaches
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Campground Availability
Duck Derby Conditions
Historic Site Preservation
Fish Habitat
Permitted Water Use
Bankfull Exceedances
Agricultural Damages
Coal Stockpile
2nd Coal Crossing
1st Coal Crossing
Oil Well Inundation
Bridge Inundation
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture
Water Supply
Environmental
Cultural
Recreation

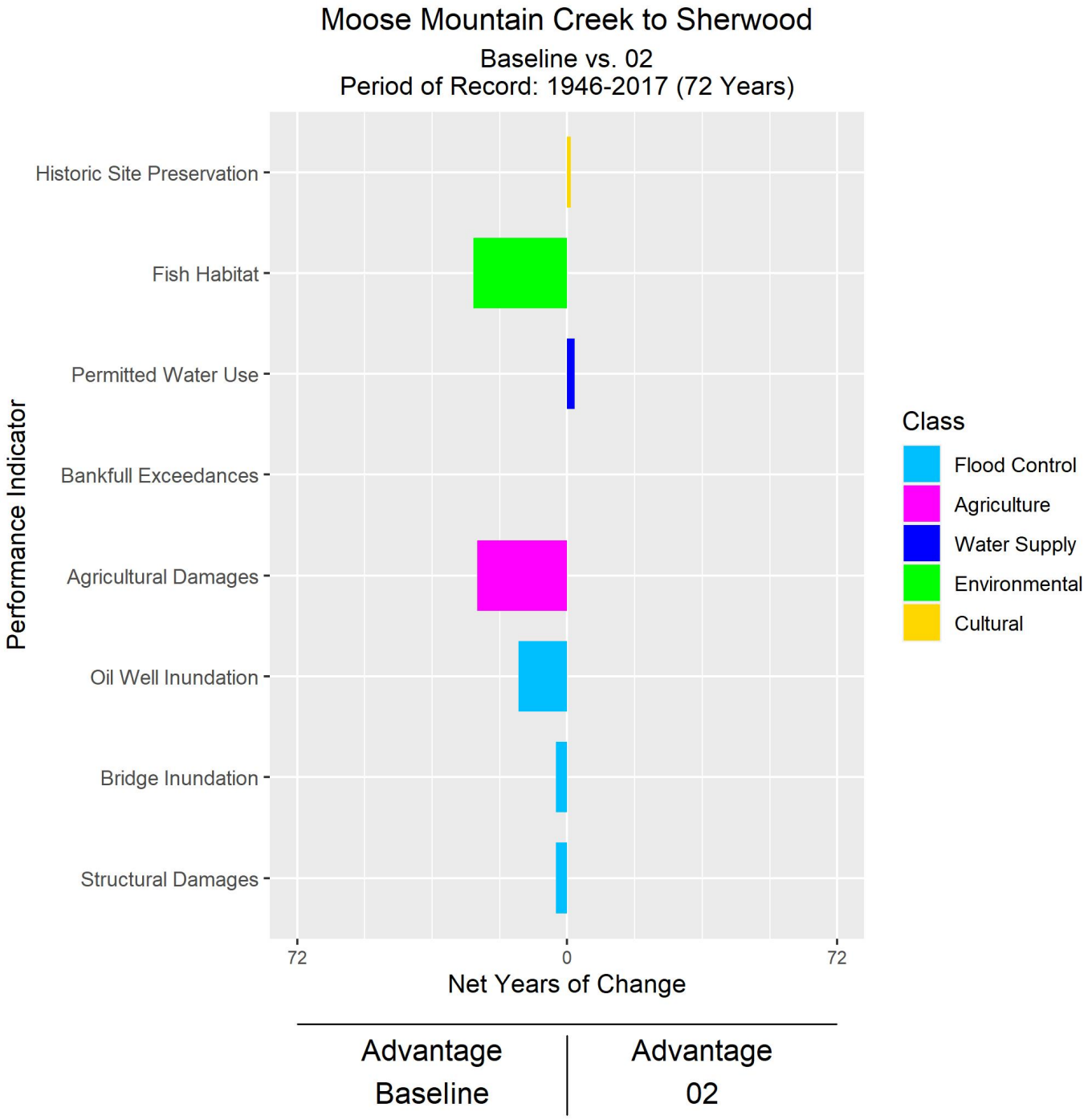

North Dakota - All Riverine Reaches
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Total Dissolved Solids
Sulfate
Sodium
Chloride
Channel Erosion
Boating & Fishing Access
Boating & Fishing Safety
Historic Site Preservation
Fish & Wildlife Habitat
Fish Mortality
Permitted Water Use
Bankfull Exceedances
Agricultural Damages
1% Event
Current Protection
Railroad Inundation
WW Lagoon Inundation
Bridge Detours
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture
Water Supply
Environmental
Cultural
Recreation
Erosion
Water Quality

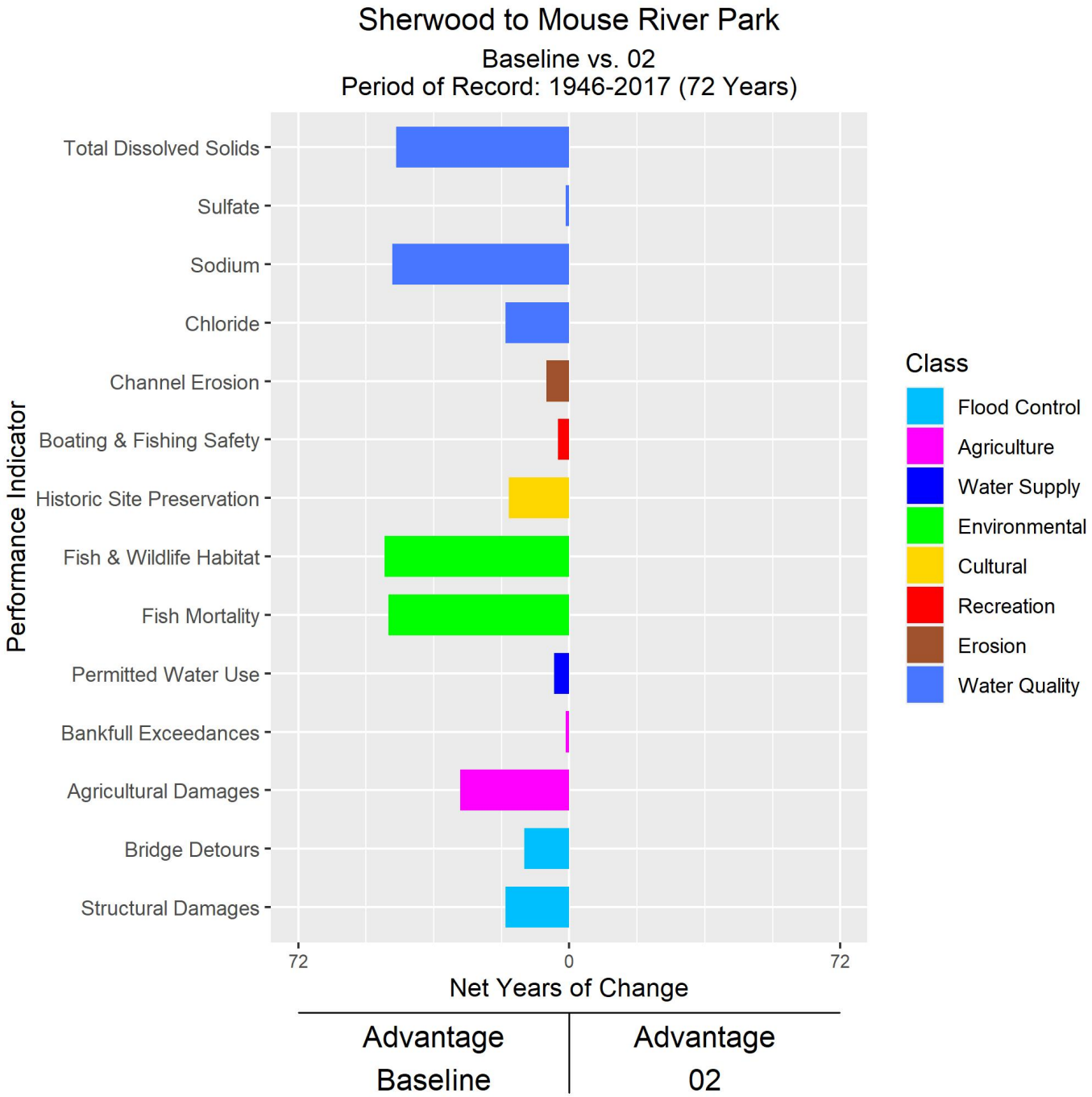

Westhope to Wawanesa
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Total Dissolved Solids
Sulfate
Sodium
Chloride
Boating & Fishing Safety
Crown Land Protection
Historic Site Preservation
GNB Habitat
Fish Mortality
Permitted Water Use
Bankfull Exceedances
Agricultural Damages
0.5% Event
1% Event
Bridge Inundation
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture
Water Supply
Environmental
Cultural
Recreation
Water Quality

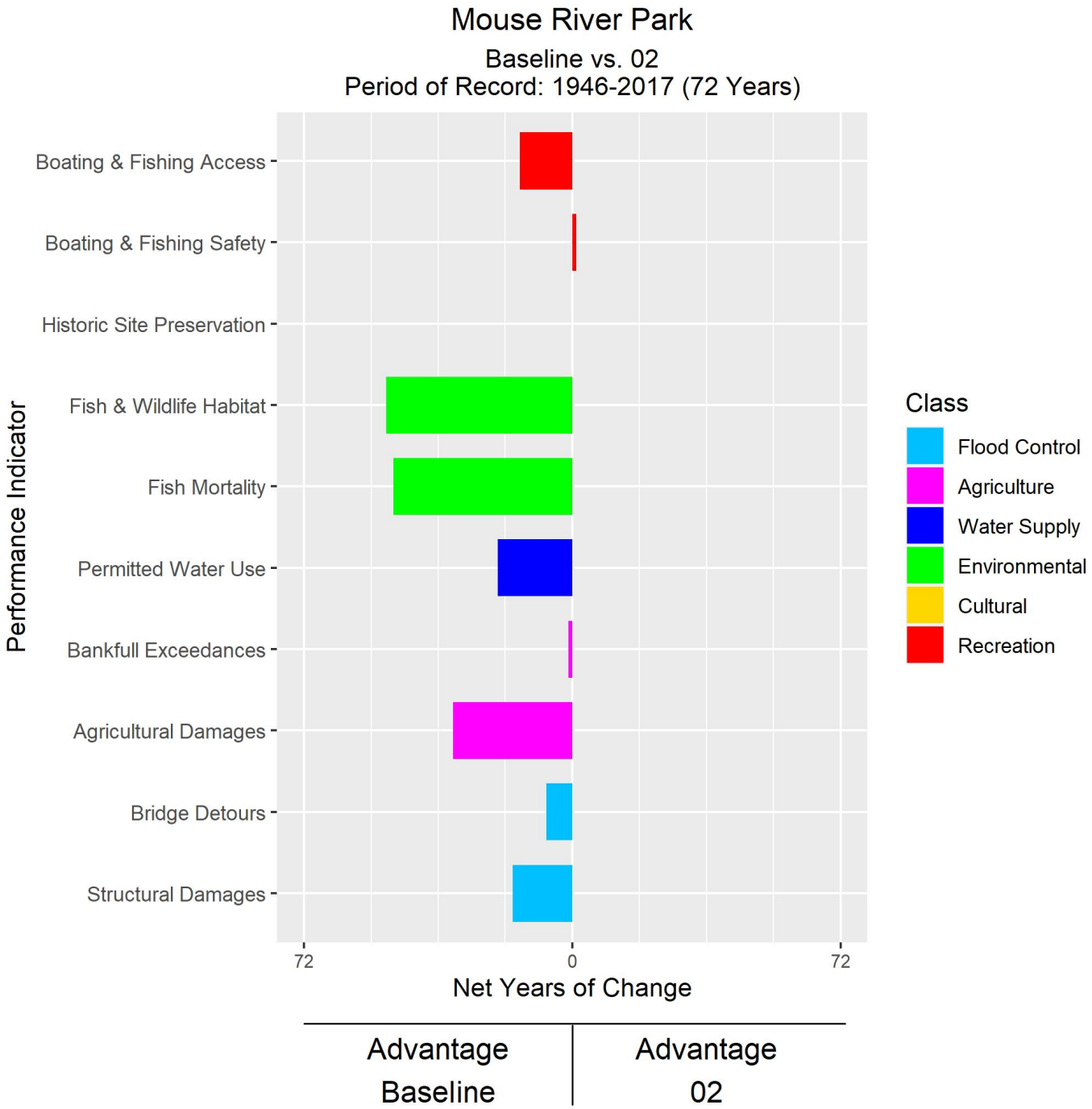

City of Estevan
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Campground Availability
Duck Derby Conditions
Historic Site Preservation
Fish Habitat
Bankfull Exceedances
Agricultural Damages
Coal Stockpile
2nd Coal Crossing
1st Coal Crossing
Bridge Inundation
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture
Environmental
Cultural
Recreation

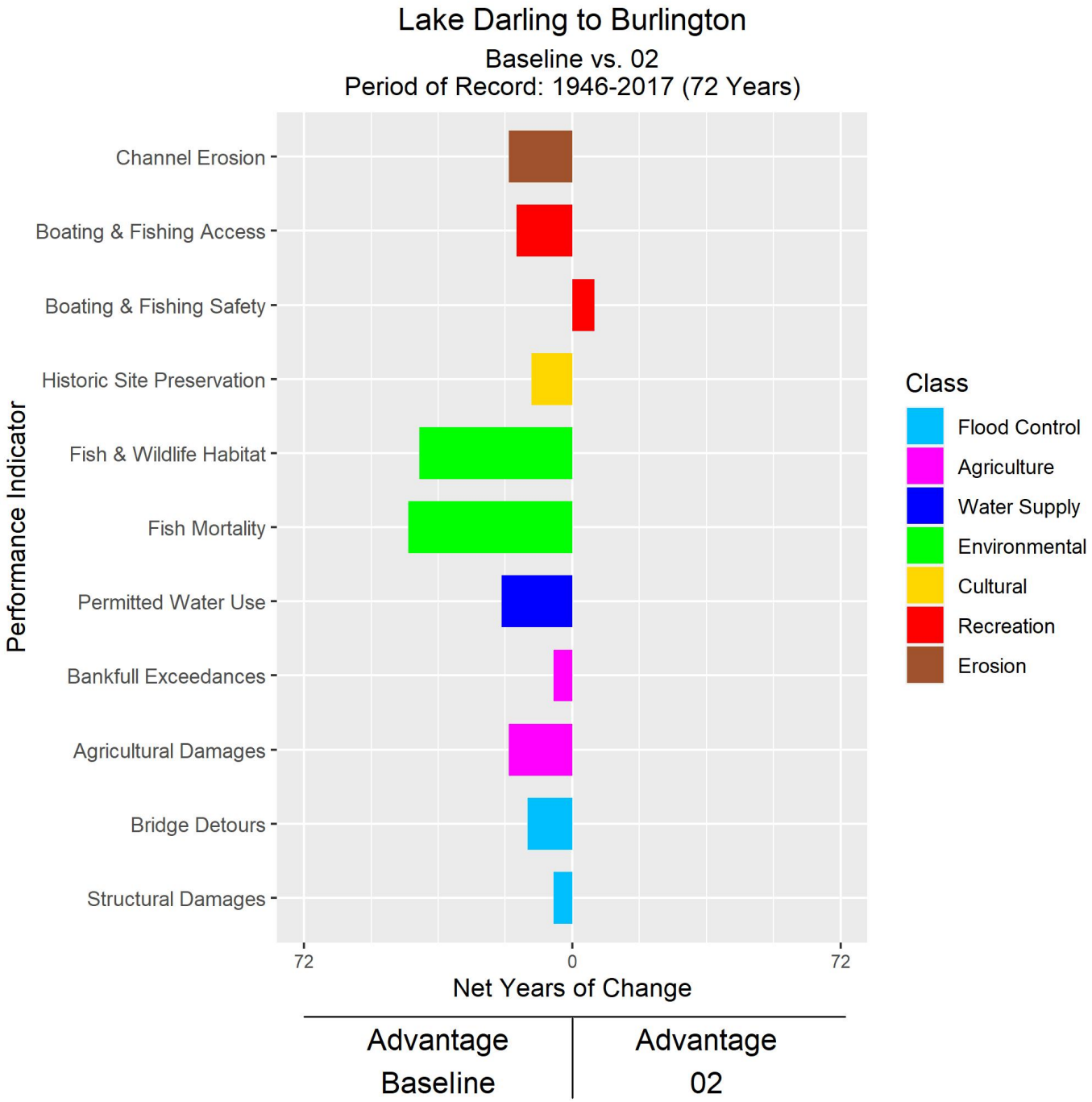

City of Roche Percee
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Bankfull Exceedances
Agricultural Damages
Oil Well Inundation
Bridge Inundation
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture

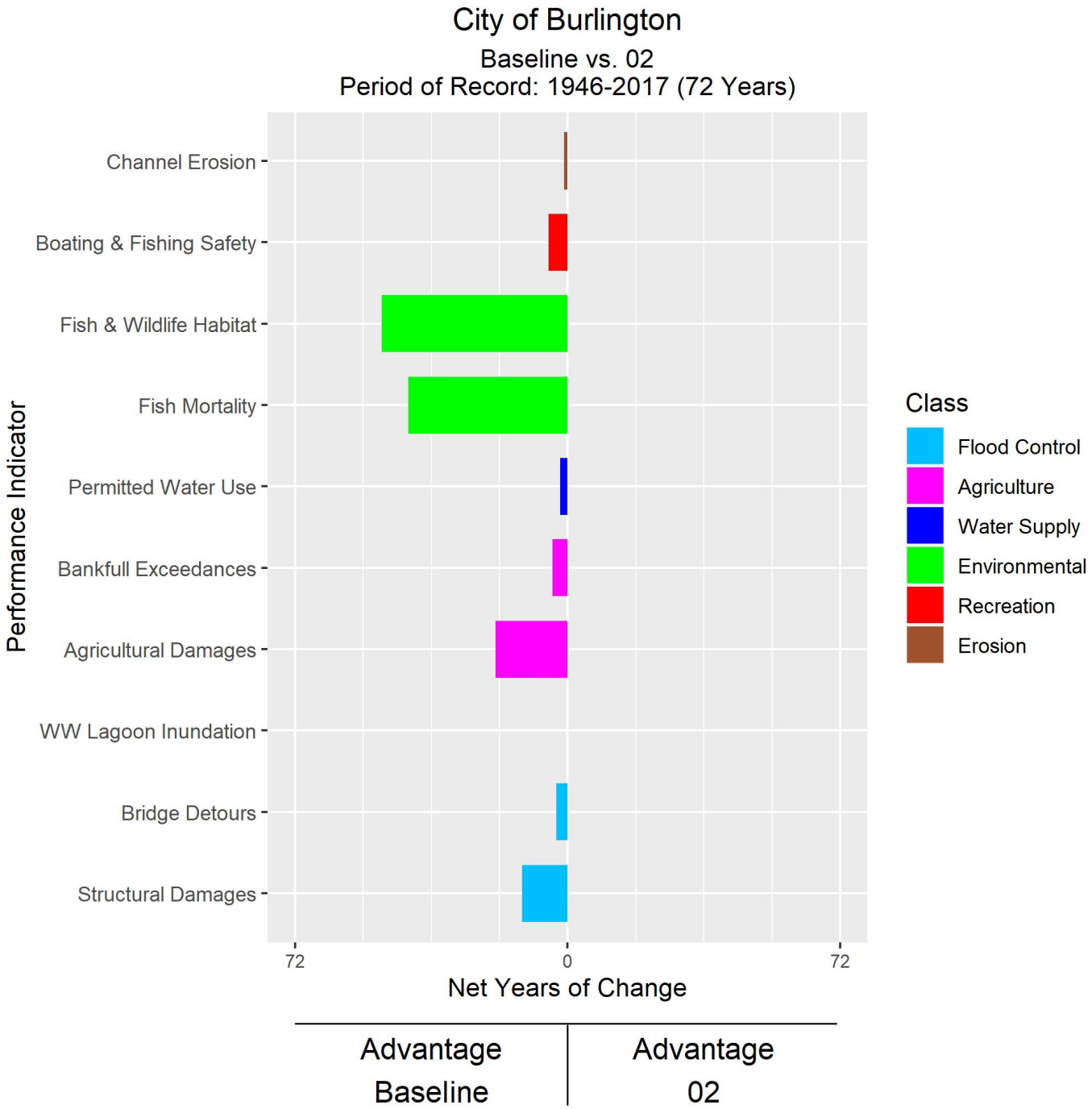

Roche Percee to Moose Mountain Creek
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Historic Site Preservation
Permitted Water Use
Bankfull Exceedances
Agricultural Damages
Oil Well Inundation
Bridge Inundation
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture
Water Supply
Cultural

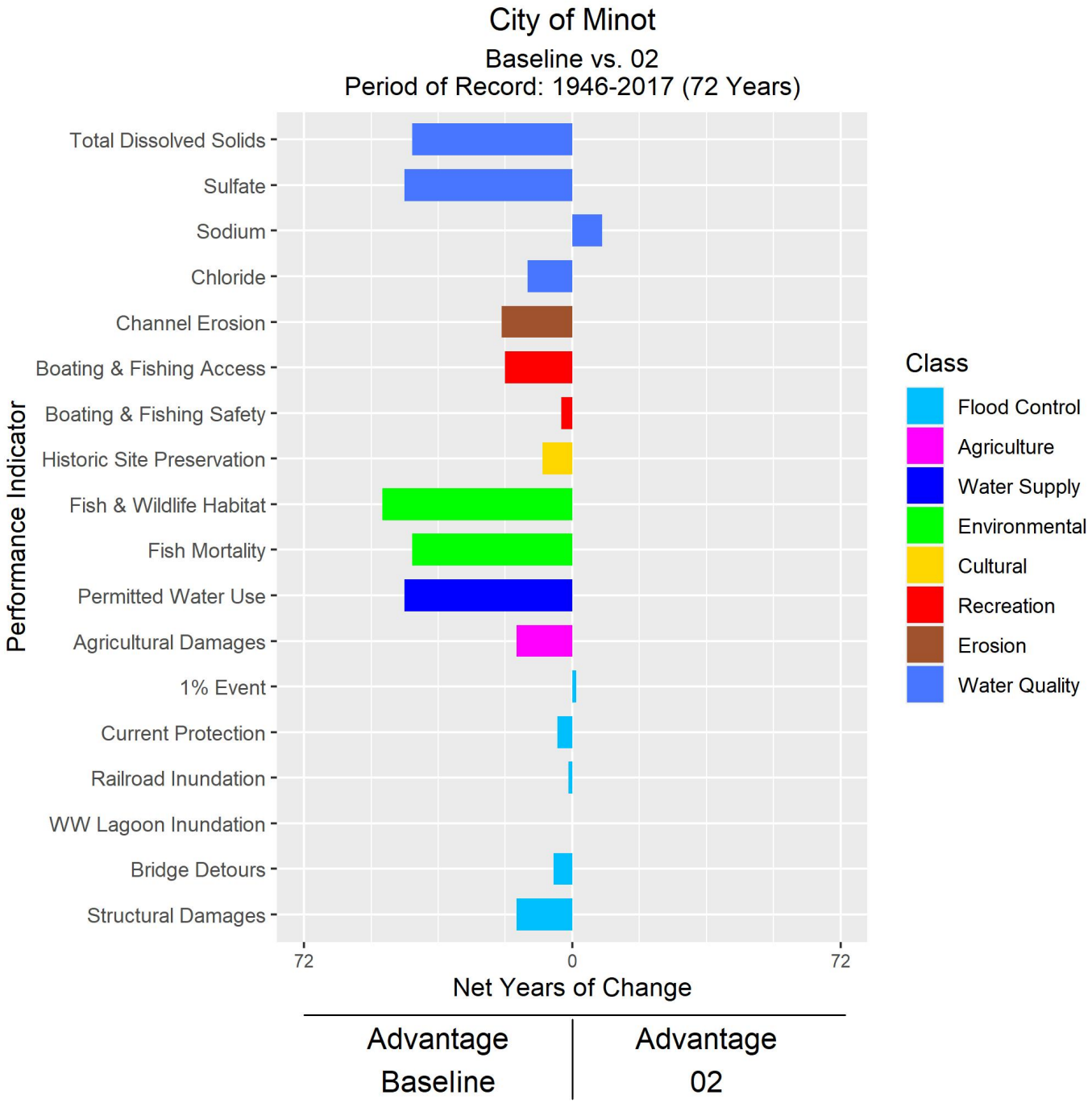

Moose Mountain Creek to Sherwood
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Historic Site Preservation
Fish Habitat
Permitted Water Use
Bankfull Exceedances
Agricultural Damages
Oil Well Inundation
Bridge Inundation
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture
Water Supply
Environmental
Cultural

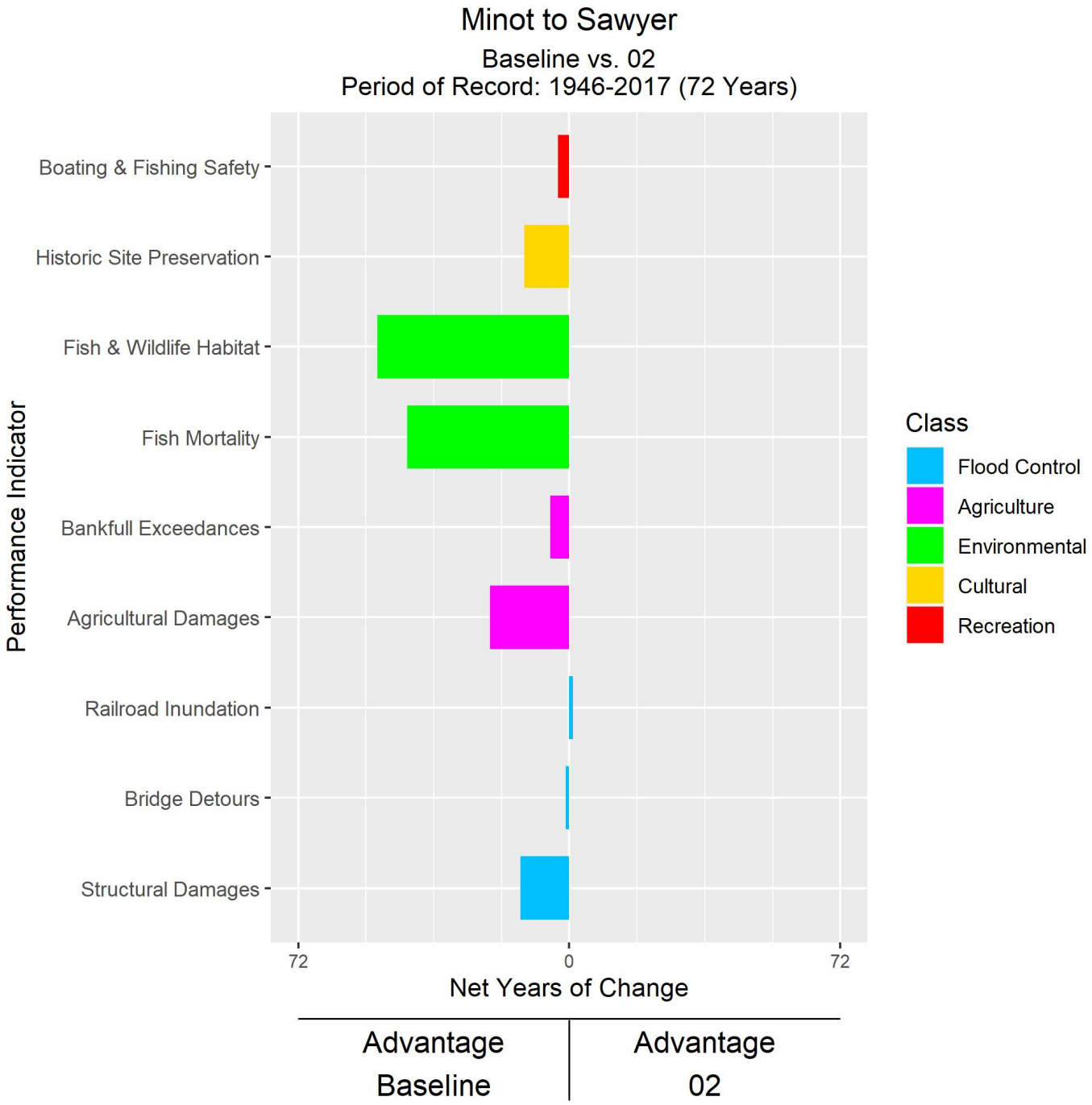

Sherwood to Mouse River Park
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Total Dissolved Solids
Sulfate
Sodium
Chloride
Channel Erosion
Boating & Fishing Safety
Historic Site Preservation
Fish & Wildlife Habitat
Fish Mortality
Permitted Water Use
Bankfull Exceedances
Agricultural Damages
Bridge Detours
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture
Water Supply
Environmental
Cultural
Recreation
Erosion
Water Quality

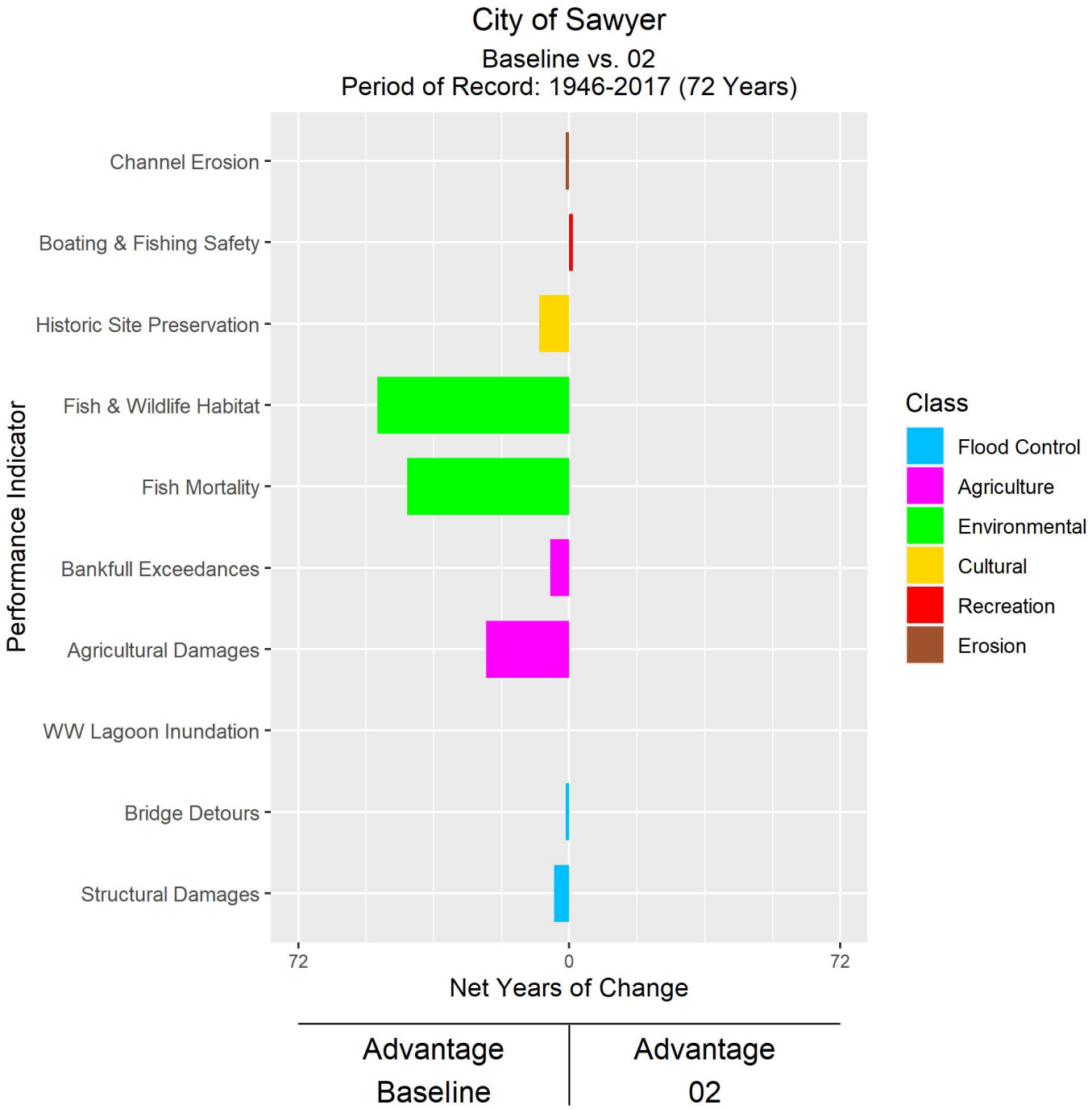

Mouse River Park
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Boating & Fishing Access
Boating & Fishing Safety
Historic Site Preservation
Fish & Wildlife Habitat
Fish Mortality
Permitted Water Use
Bankfull Exceedances
Agricultural Damages
Bridge Detours
Structural Damages
72
0
72
Net Years of Change
Advantage
Baseline
Advantage
02
Class
Flood Control
Agriculture
Water Supply
Environmental
Cultural
Recreation

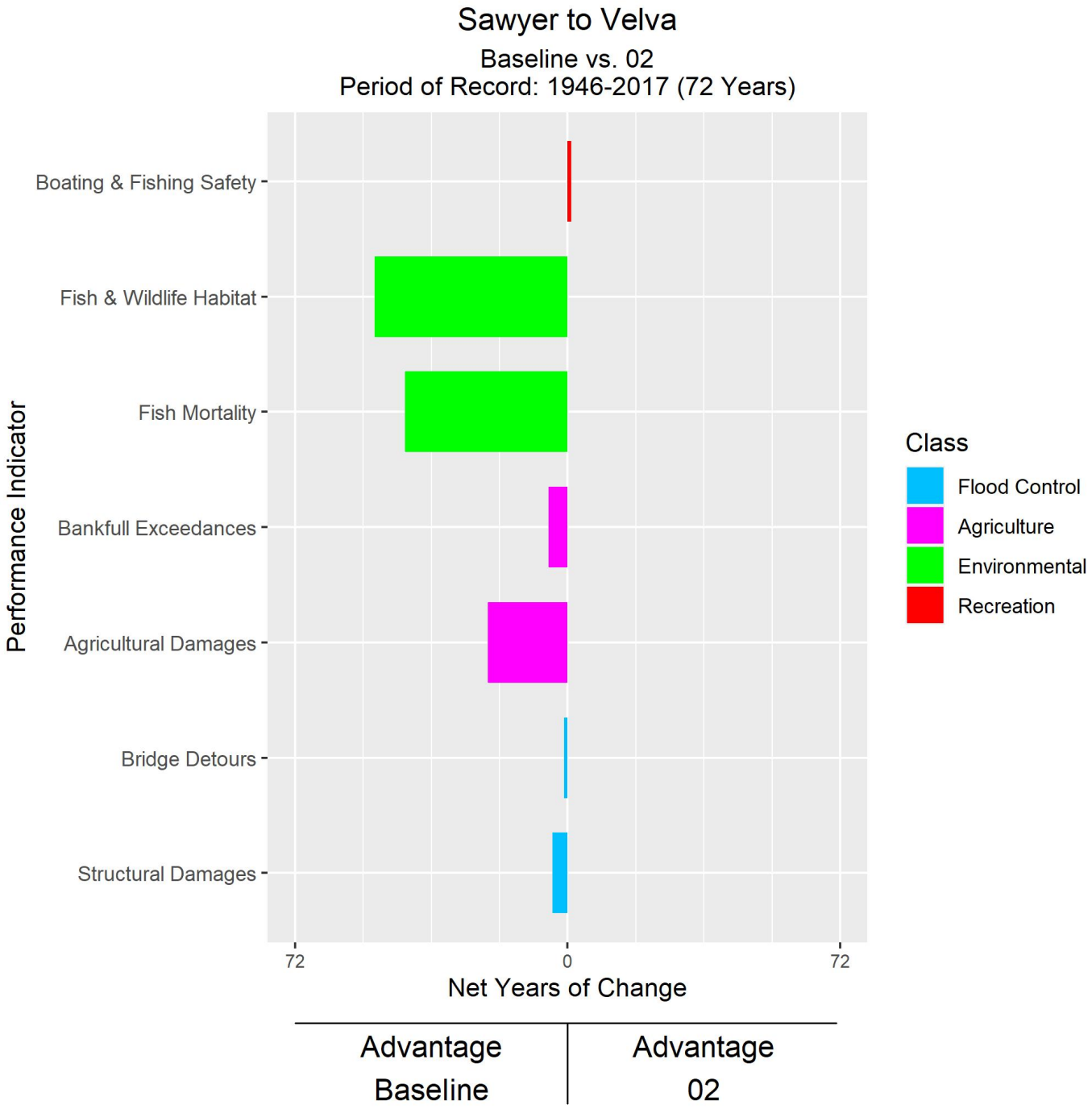

Lake Darling to Burlington
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Channel Erosion
Boating & Fishing Access
Boating & Fishing Safety
Historic Site Preservation
Fish & Wildlife Habitat
Fish Mortality
Permitted Water Use
Bankfull Exceedances
Agricultural Damages
Bridge Detours
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture
Water Supply
Environmental
Cultural
Recreation
Erosion

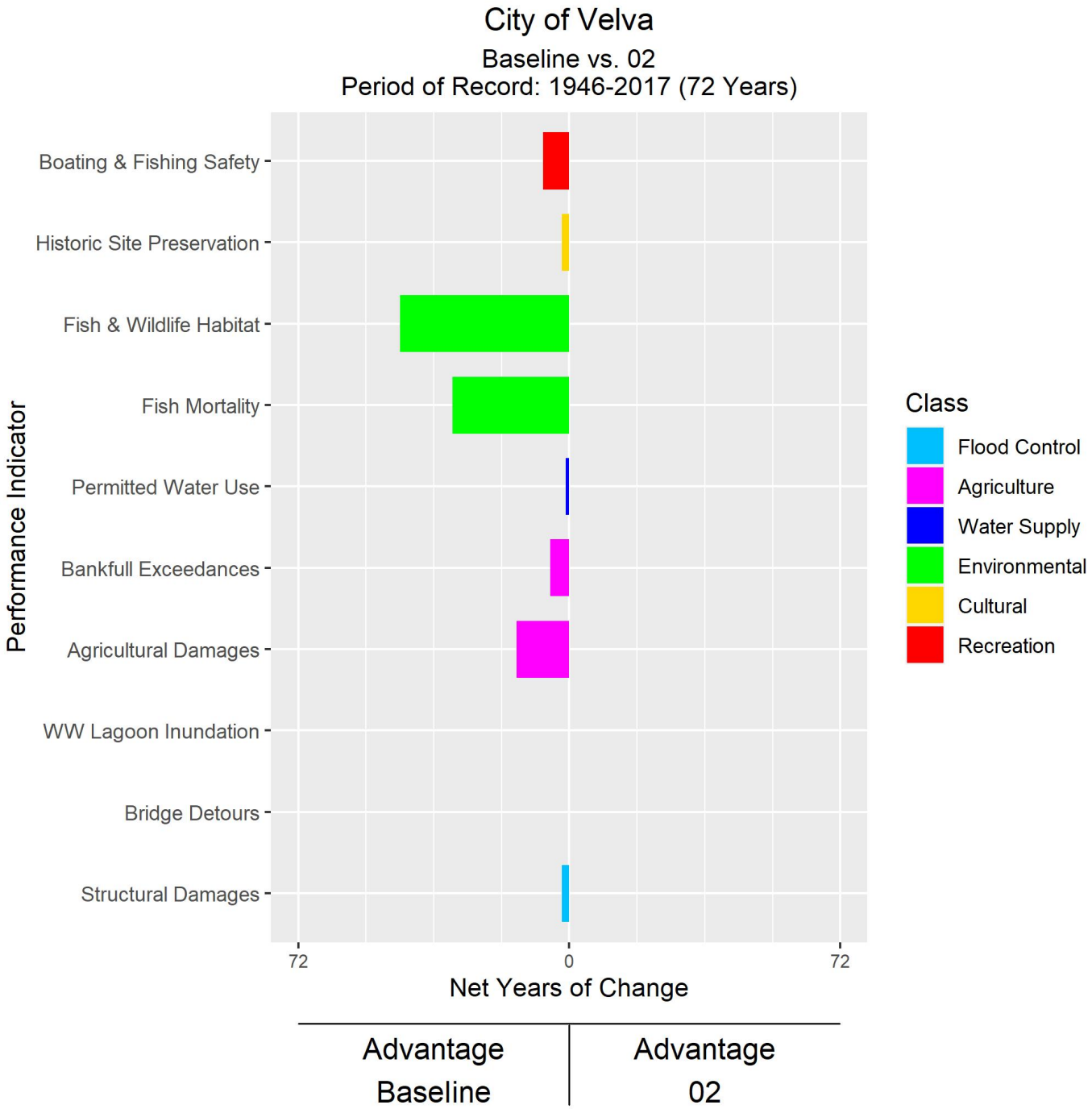

City of Burlington
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Channel Erosion
Boating & Fishing Safety
Fish & Wildlife Habitat
Fish Mortality
Permitted Water Use
Bankfull Exceedances
Agricultural Damages
WW Lagoon Inundation
Bridge Detours
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture
Water Supply
Environmental
Recreation
Erosion

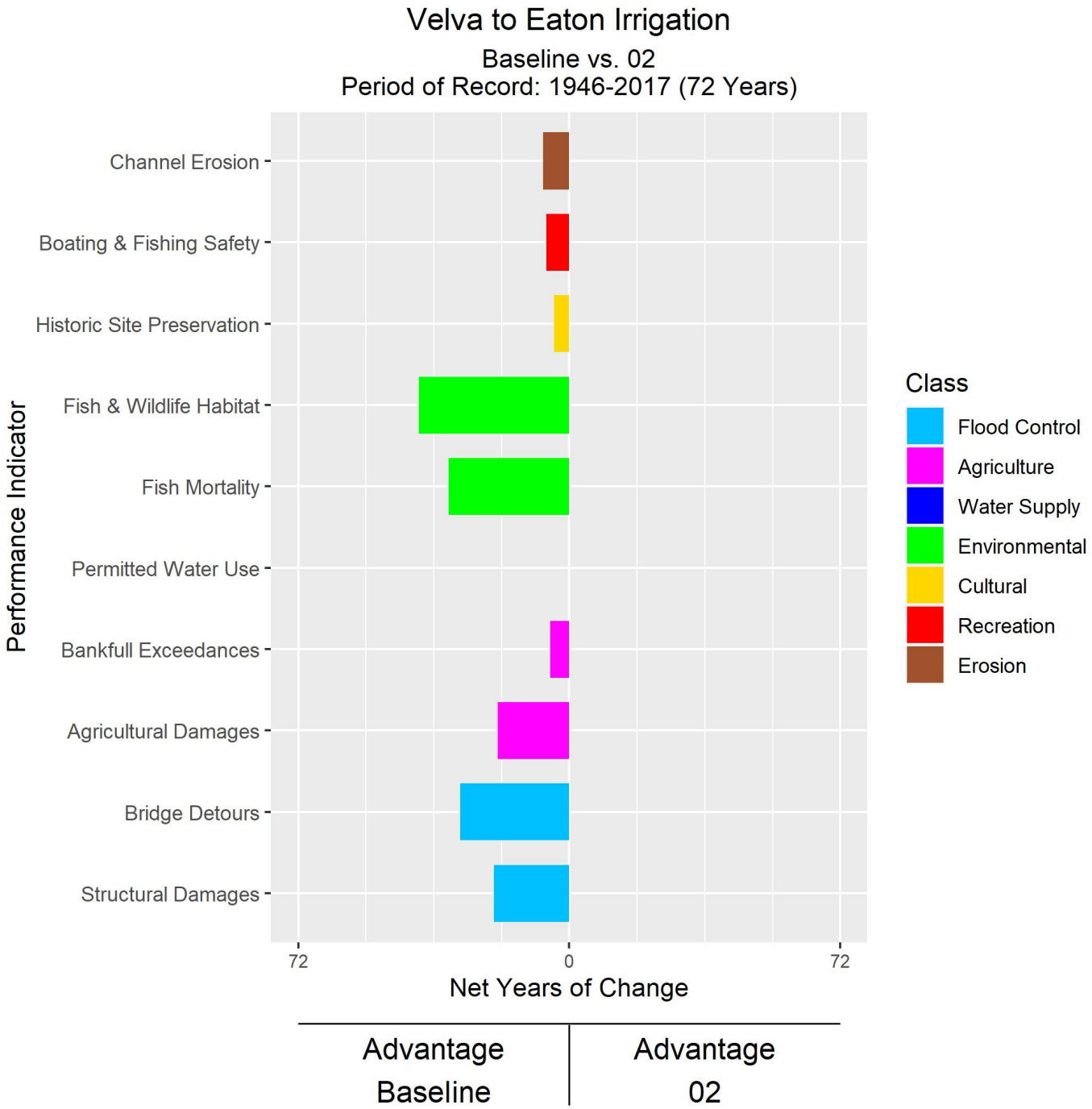

City of Minot
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Total Dissolved Solids
Sulfate
Sodium
Chloride
Channel Erosion
Boating & Fishing Access
Boating & Fishing Safety
Historic Site Preservation
Fish & Wildlife Habitat
Fish Mortality
Permitted Water Use
Agricultural Damages
1% Event
Current Protection
Railroad Inundation
WW Lagoon Inundation
Bridge Detours
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture
Water Supply
Environmental
Cultural
Recreation
Erosion
Water Quality

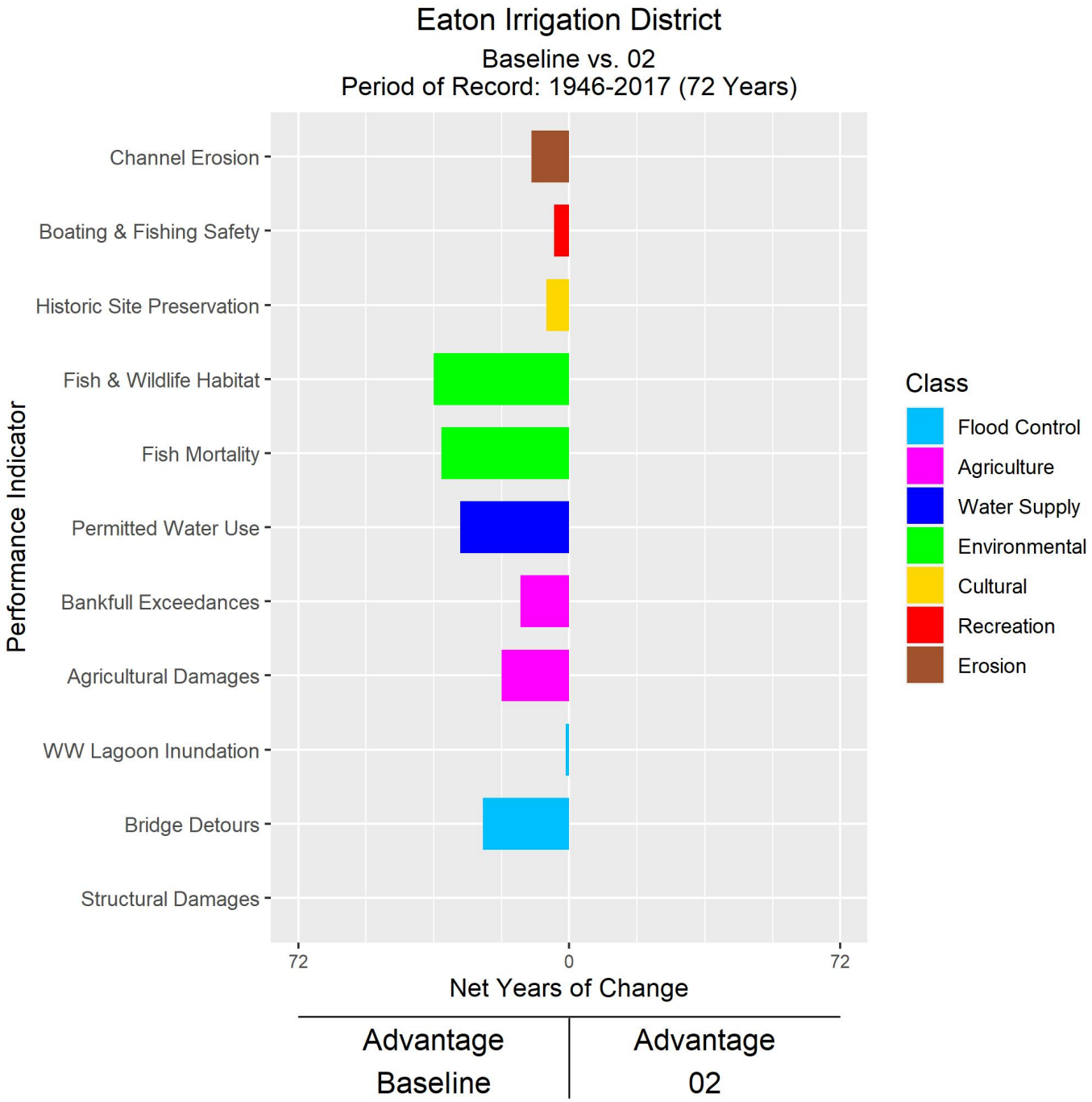

Minot to Sawyer
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Boating & Fishing Safety
Historic Site Preservation
Fish & Wildlife Habitat
Fish Mortality
Bankfull Exceedances
Agricultural Damages
Railroad Inundation
Bridge Detours
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture
Environmental
Cultural
Recreation

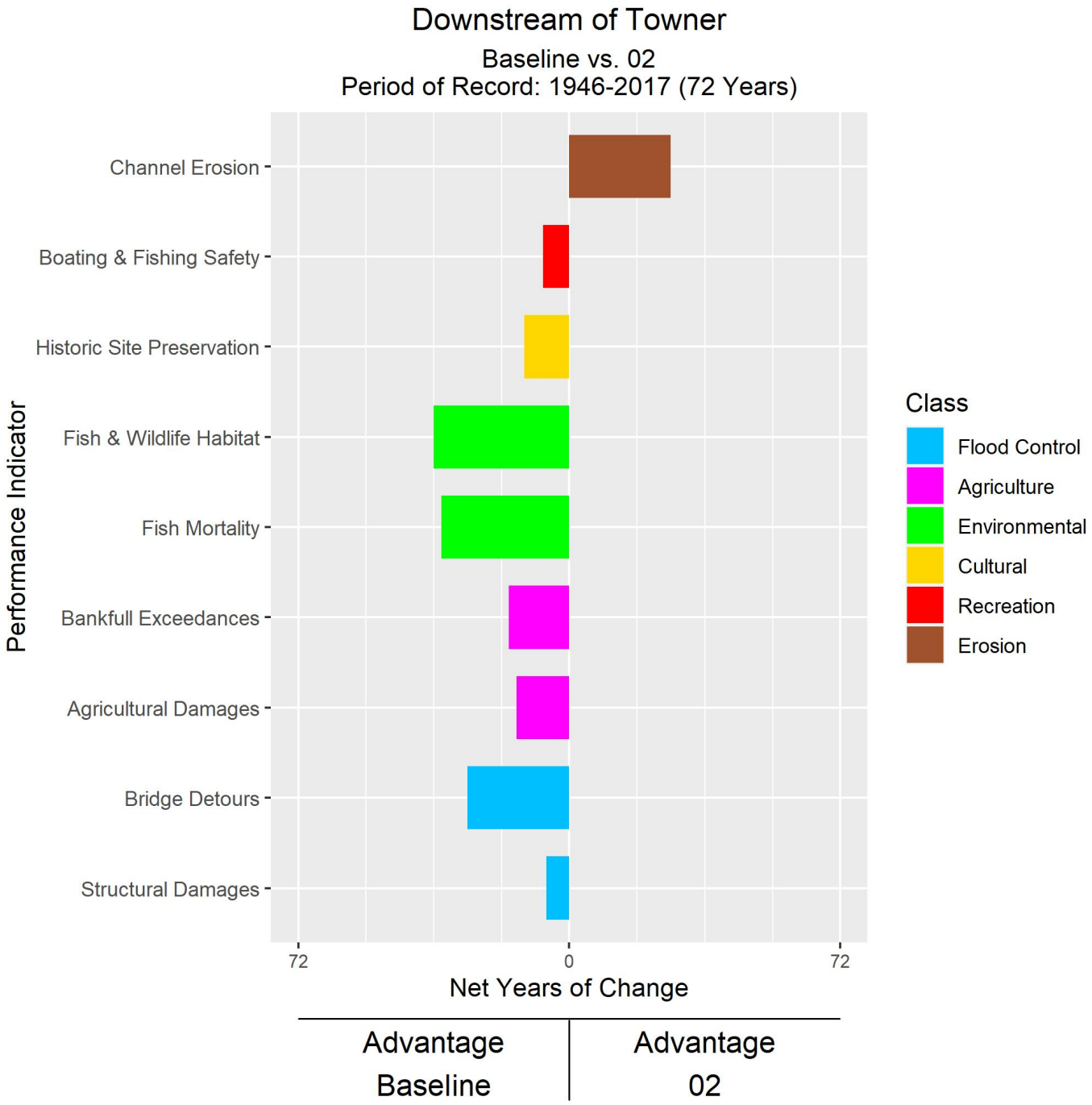

City of Sawyer
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Channel Erosion
Boating & Fishing Safety
Historic Site Preservation
Fish & Wildlife Habitat
Fish Mortality
Bankfull Exceedances
Agricultural Damages
WW Lagoon Inundation
Bridge Detours
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture
Environmental
Cultural
Recreation
Erosion

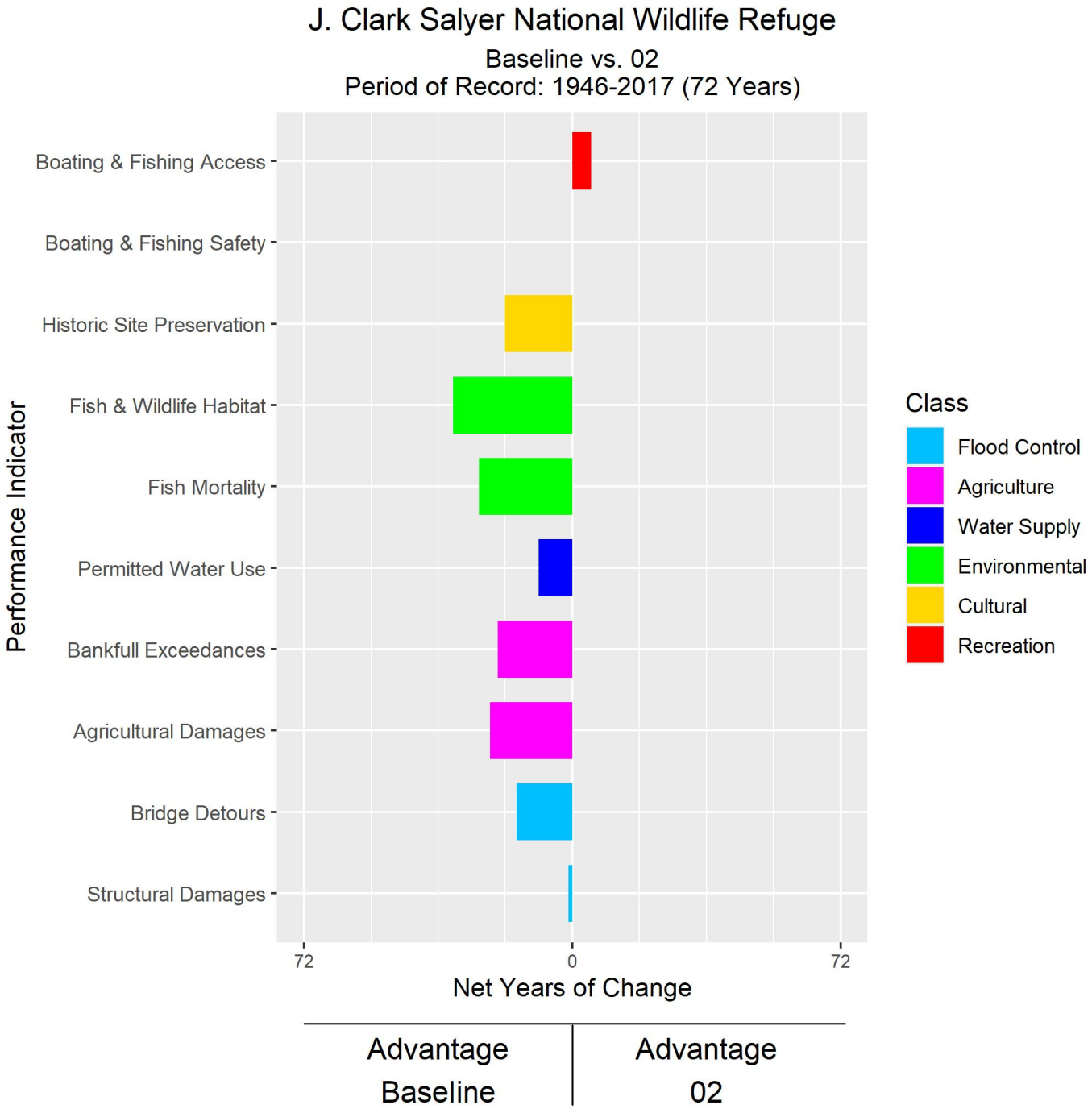

Sawyer to Velva
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Boating & Fishing Safety
Fish & Wildlife Habitat
Fish Mortality
Bankfull Exceedances
Agricultural Damages
Bridge Detours
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture
Environmental
Recreation


City of Velva
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Boating & Fishing Safety
Historic Site Preservation
Fish & Wildlife Habitat
Fish Mortality
Permitted Water Use
Bankfull Exceedances
Agricultural Damages
WW Lagoon Inundation
Bridge Detours
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture
Water Supply
Environmental
Cultural
Recreation


Velva to Eaton Irrigation
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Channel Erosion
Boating & Fishing Safety
Historic Site Preservation
Fish & Wildlife Habitat
Fish Mortality
Permitted Water Use
Bankfull Exceedances
Agricultural Damages
Bridge Detours
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture
Water Supply
Environmental
Cultural
Recreation
Erosion


Eaton Irrigation District
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Channel Erosion
Boating & Fishing Safety
Historic Site Preservation
Fish & Wildlife Habitat
Fish Mortality
Permitted Water Use
Bankfull Exceedances
Agricultural Damages
WW Lagoon Inundation
Bridge Detours
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture
Water Supply
Environmental
Cultural
Recreation
Erosion


Downstream of Towner
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Channel Erosion
Boating & Fishing Safety
Historic Site Preservation
Fish & Wildlife Habitat
Fish Mortality
Bankfull Exceedances
Agricultural Damages
Bridge Detours
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture
Environmental
Cultural
Recreation
Erosion


J. Clark Salyer National Wildlife Refuge
Baseline vs. 02
Period of Record: 1946-2017 (72 Years)
Performance Indicator
Boating & Fishing Access
Boating & Fishing Safety
Historic Site Preservation
Fish & Wildlife Habitat
Fish Mortality
Permitted Water Use
Bankfull Exceedances
Agricultural Damages
Bridge Detours
Structural Damages
72
0
72
Net Years of Change
Advantage Baseline
Advantage 02
Class
Flood Control
Agriculture
Water Supply
Environmental
Cultural
Recreation