Appendix A-4 Historic Index Event Simulation

Event Selection & Initial Pool Conditions

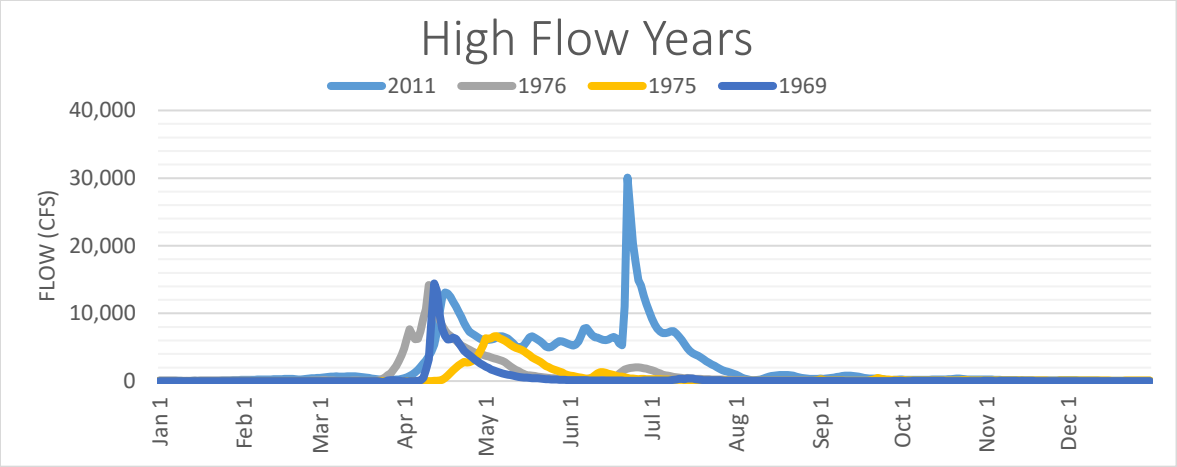
Event Selection

These events were selected by analyzing an unregulated flow series for the USGS's long term streamflow gaging station located along the Souris River at Sherwood for the period 1930-2017. This unregulated series provided a homogeneous dataset without the influence of Rafferty, Grant Devine and Boundary Dams. The unregulated dataset from the Reconstructed Hydrology (HH1) work was used for the period 1946-2017. Since the reconstructed hydrology work for the period 1930-1945 was not yet completed at the time, the observed records were used to select pre-1946 index events, since there was very little regulation within the basin during this period. This period pre-dates Rafferty, Boundary and Grand Devine Dams and a check of the 1946-1958 data confirmed a near 1:1 relationship between the observed and reconstructed flow. The Souris River at Sherwood was used for this analysis rather than the Souris River at Minot, since it represents the portion of the basin that can be managed by the major dams.

Peak mean daily flows and annual runoff volumes were evaluated to select the index years. For the high flow/flood events, the years with the largest peak mean daily flows and/or largest annual volumes are being suggested. These years were 1969, 1975, 1976, and 2011. The normal runoff years were selected by comparing annual runoff volumes and peak mean daily flows to historical medians. Medians were used rather than averages, since the extreme high flow years skew the distributions. Years with the bulk of the annual runoff volume occurring in the spring are being suggested, since the bulk of the annual runoff typically occurs from snowmelt and/or spring rainfall runoff. Normal years which occurred within drought periods were excluded, since the reservoir pool elevations would be lower than normal. This resulted in 1946, 1952, and 1987 being suggested for the normal years. For the low flow index years, continuous sequences of years are being suggested, as the reservoir storages will be impacted more by extended drought periods as opposed to any single extreme low flow year. Examining the departure from average over the period of record, three drought periods are evident, 1930-1942, 1957-1968, and 1984-1993. The droughts of the 1930's and 1980's were the most extreme and are therefore being recommended for the index periods.

High flow Events

The 2011, 1976, 1975 and 1969 events were selected as high flow events. The unregulated record at Sherwood, ND was used to select flood events. The 2011 event is the event of record in the basin. The 2011 event was caused by a severe rainfall event immediately preceded by a significant spring melt. In 1976 the basin experienced both a significant snowmelt and rainfall event. The 1975 snowmelt event was significant in terms of volume. The 1969 event was a significant snowmelt driven event in the basin. The 1969 event occurred immediately following a drought sequence. Based on the HEC-ResSIM period of record simulation, the 1969 event would have been preceded by abnormally low pool conditions had the Souris River Project been in place. Selected High Flow Events are displayed in Figure 1.



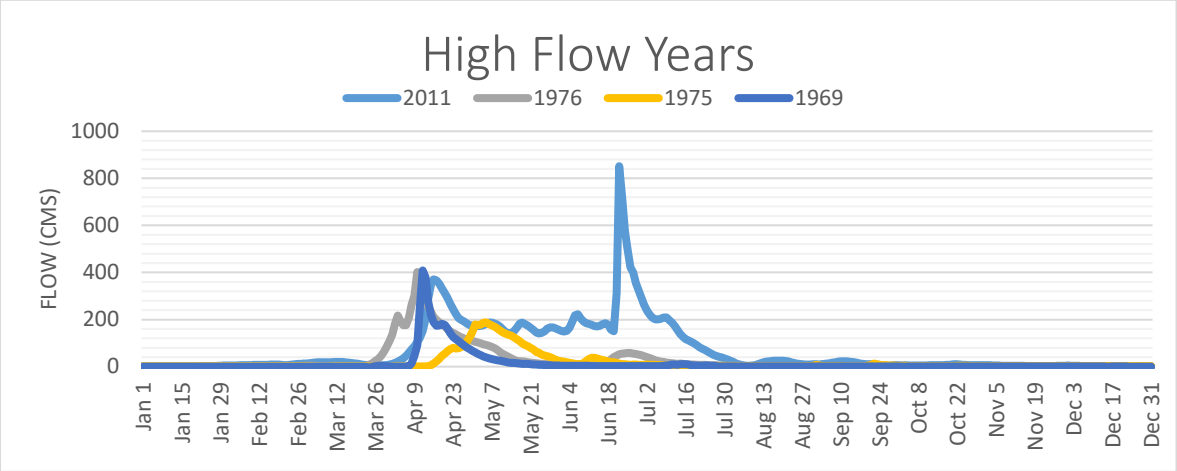
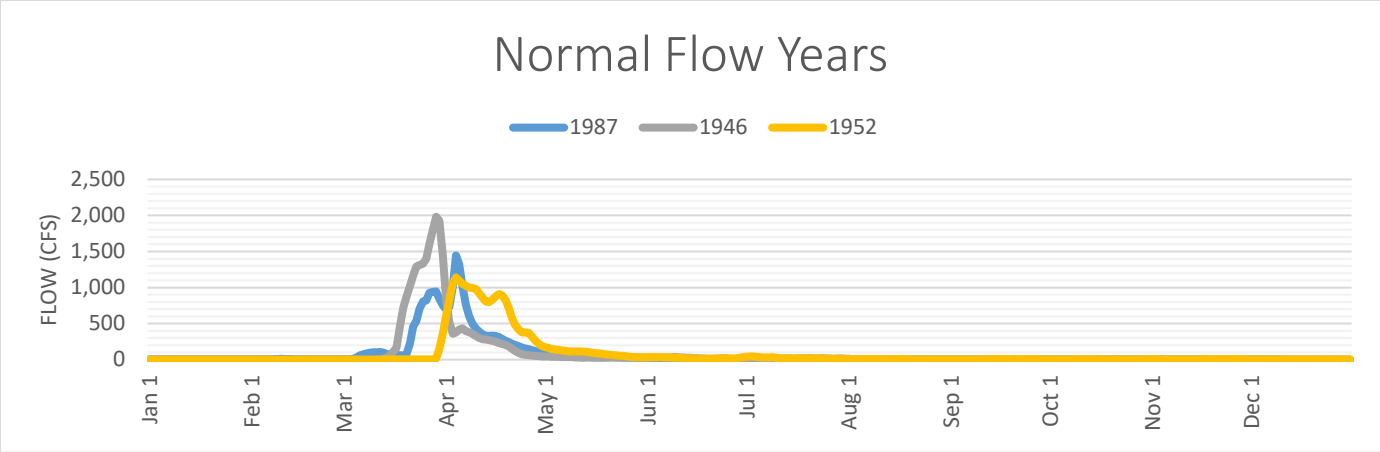


Figure 1. Unregulated Streamflow response at Sherwood Crossing – High Flow Years

Normal Flow Years

The 1946, 1952 and 1987 events were selected to be representative of normal flow years. Selected Normal Flow Events are displayed in Figure 2.



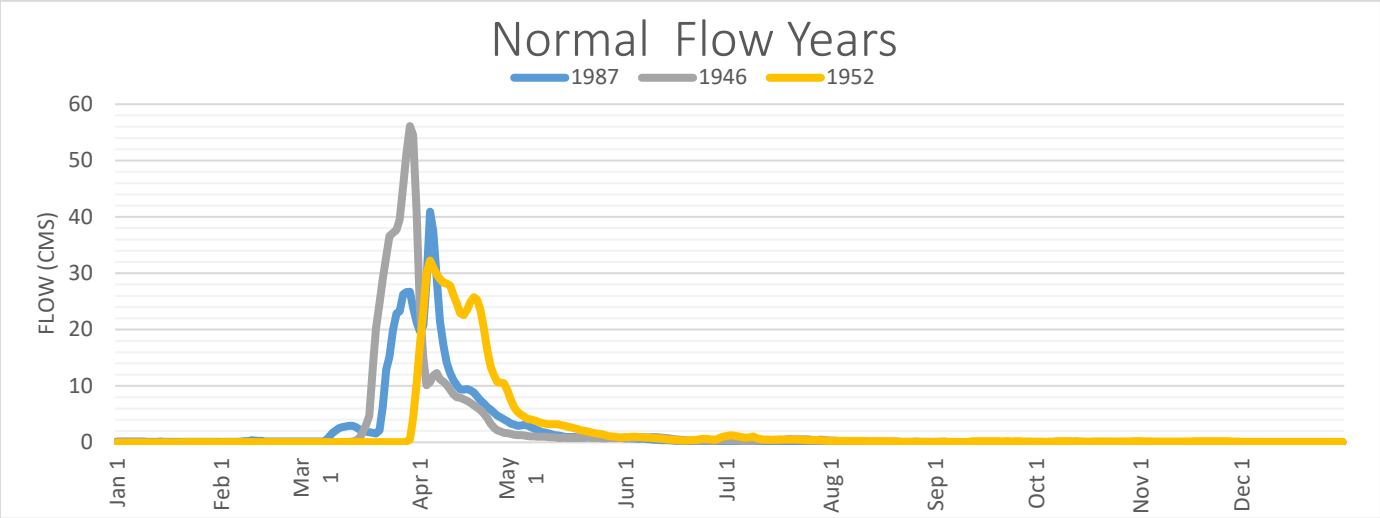


Figure 2. Unregulated Streamflow response at Sherwood Crossing – High Flow Years

Drought Sequences

Two drought sequences will be analyzed: 1988-1993 and 1931-1937. Figure 3 displays unregulated flows at Sherwood, North Dakota for the two, selected, drought sequences.

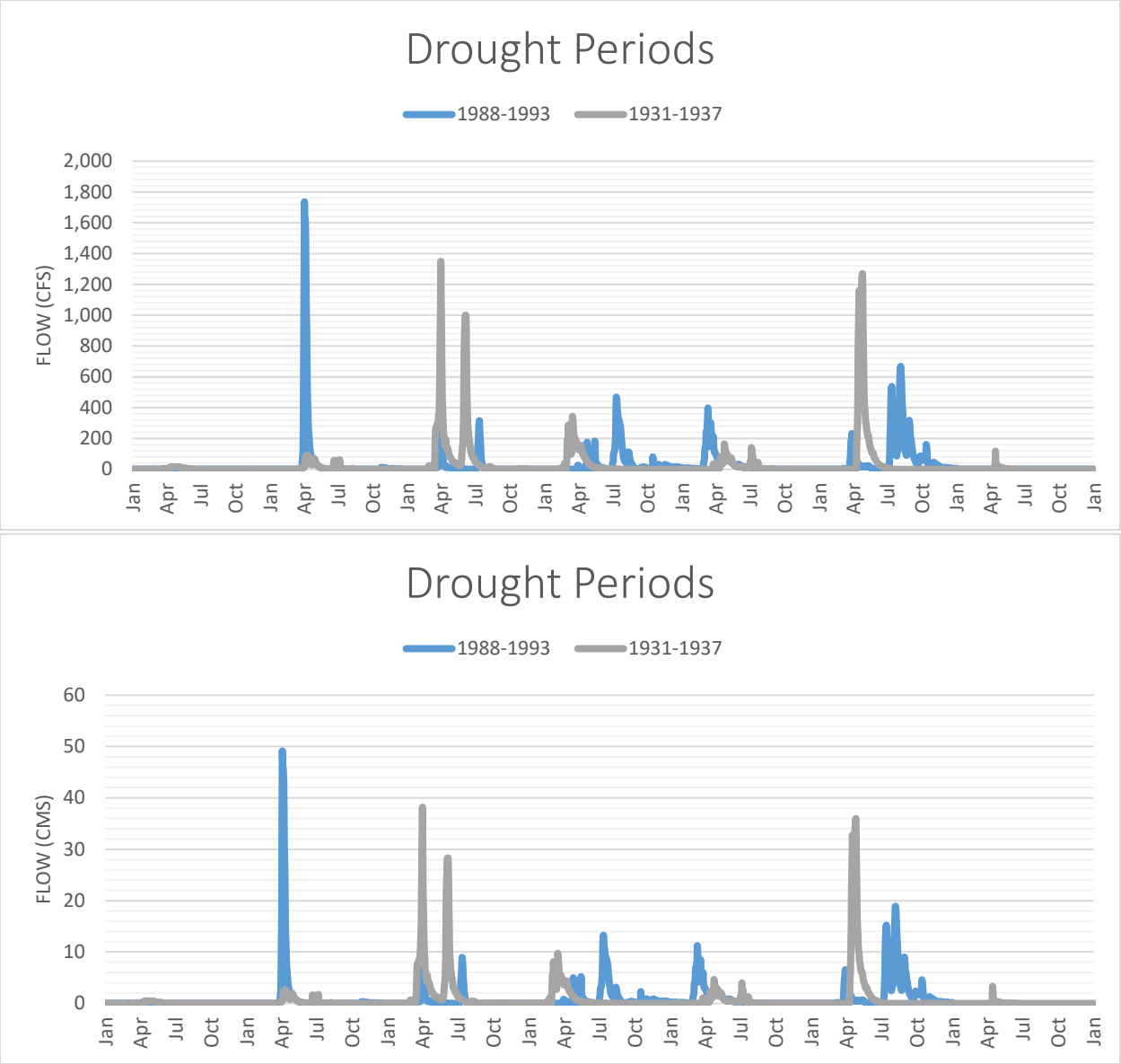


Figure 3. Selected Drought Sequences – Unregulated Flows at Sherwood

HEC-ResSIM Initial Conditions

To evaluate high and moderate flow sequences, as well as the 1980s/1990s drought sequence, a period of record simulation will be used, and results specific to each selected index event will be plotted and analyzed. Initial conditions will be specifically defined for each drought sequence analyzed.

The time window for the period of record simulation starts on January 14, 1946. The model initialization (warm-up) period starts on January 1, 1946. The model is run to December 31, 2017. Initial conditions are specified for January 1, 1946. J. Clark Refuge Structures are assumed to be at their guide curve (conservation pool) elevations on 1 January 1946. No releases are being made from the refuge structures. The starting, January 1, 1946 pool conditions for the Souris River Project reservoirs are summarized in Table 1. All pools are assumed to be at or below their guide curve/conservation pool elevations so no releases are being made from the reservoirs on 1 January 1946.

Table 1. Starting Pool Elevations – Moderate/High Flow Events and Late 1980s/Early 1990s Drought

Reservoir	Starting Pool Elevation (feet)	Starting Pool Elevation (meters)	Significance
Rafferty	1802.82	549.50	Normal 1 Feb Drawdown
Boundary	1836.77	559.85	Normal 1 Jan Pool[1]
Grant Devine	1840.55	561.00	Normal 1 Feb Drawdown
Lake Darling	1596.00	486.46	Normal 1 Feb Drawdown

[1] *Normal pool conditions represent the average of the 1 Jan pools during non-drought years. A period of record simulation run from 1946-2017 was analyzed to generate a reasonable representation of normal pool.*

Two different sets of initial pool conditions will be analyzed to assess the 1930s drought sequence. A period of record simulation run from 1946-2017 was analyzed to generate a series of reasonable initial pool conditions representative of normal pool and low pool conditions. Normal pool conditions represent the average of the 01 January pools during non-drought years. These values are displayed in Table 3. Low pool conditions represent the average of the 01 January pools during drought sequences. These values are displayed in Tables 4. Drought sequences were identified from 1957-1969 and 1984-1996. The time window for the 1930s drought simulation starts on January 15, 1930. The model initialization (warm-up) period starts on Jan 1, 1930. J. Clark Refuge Structures are assumed to be at their guide curve (conservation pool) elevations on Jan 1, 1930. No releases are being made from the refuge structures. All Souris River project pools are assumed to be at or below their guide curve/conservation pool elevations, so no releases are being made from the reservoirs on 01 Jan 1930 for either the normal initial pool or low initial pool scenarios.

Table 2. Starting Pool Elevations- Normal Pool Initial Conditions – 1930s drought

Reservoir	Starting Pool Elevation (feet)	Starting Pool Elevation (meters)	Normal 1 Feb Target Elevation (feet)	Normal 1 Feb Target Elevation (meters)
Rafferty	1802.08	549.27	1802.82	549.50
Boundary	1936.77	559.85	1840.00	560.80
Grant Devine	1840.76	561.06	1840.55	561.00
Lake Darling	1595.71	486.37	1596.00	486.46

Table 3. Starting Pool Elevations- Low Pool Initial Conditions – 1930s drought

Reservoir	Starting Pool Elevation (feet)	Starting Pool Elevation (meters)	Normal 1 Feb Target Elevation (feet)	Normal 1 Feb Target Elevation (meters)
Rafferty	1789.49	545.44	1802.82	549.50
Boundary	1834.59	559.18	1840.00	560.80
Grant Devine	1834.79	559.24	1840.55	561.00
Lake Darling	1592.07	485.26	1596.00	486.46

For certain alternatives, initial conditions may have to change slightly to reflect shifts in the timing of the apportionment year and changes in guide curve operation.