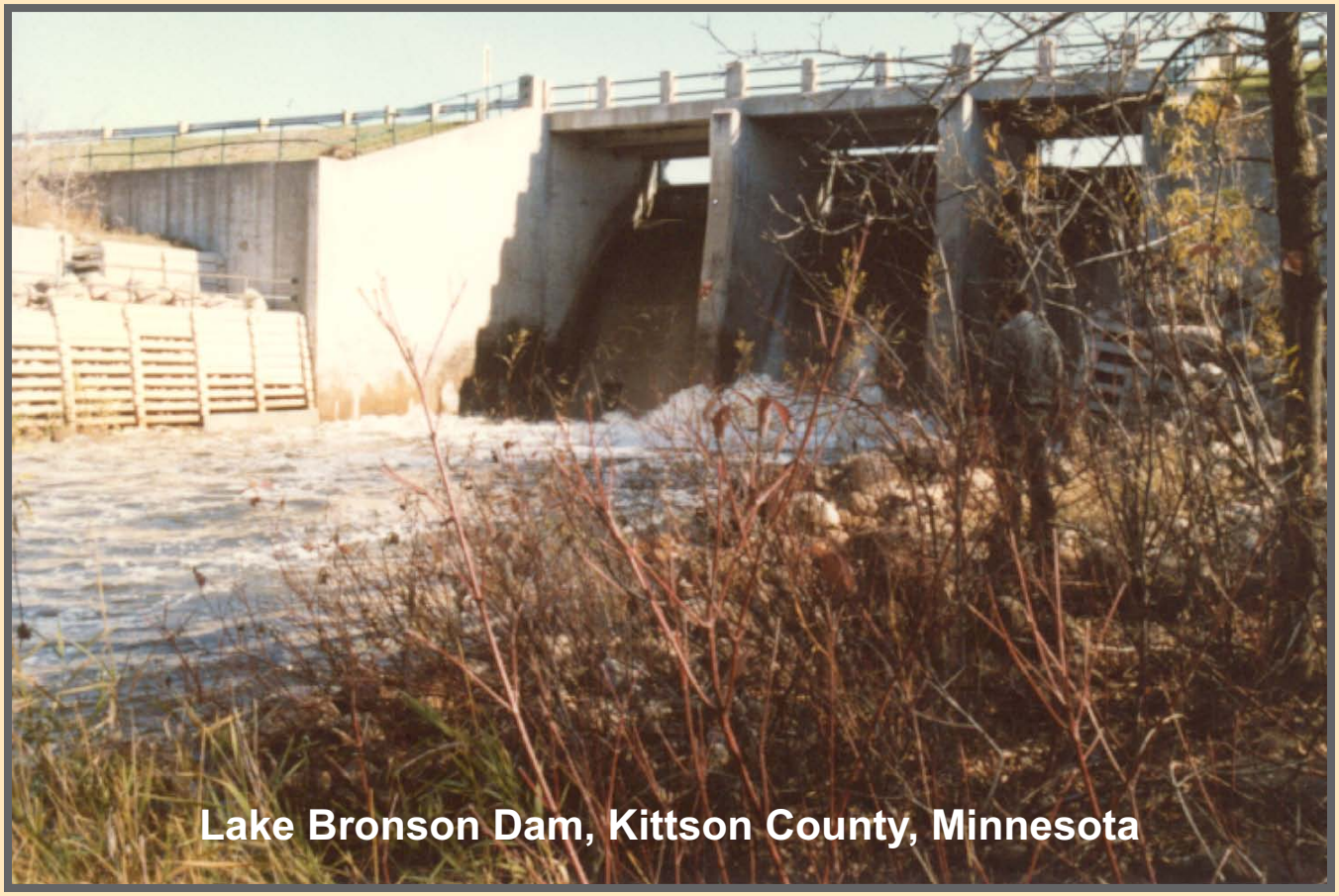
Impacts of a Lake Bronson Dam Break on the Cities of Lake Bronson and Hallock, Minnesota



Lake Bronson Dam, Kittson County, Minnesota

Minnesota
Department of Natural Resources
Waters

October 2004

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Dana Dostert, PG

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September 2004

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Minnesota
Department of Natural Resources
Waters

"Helping people ensure the future of our resources"

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Appendix

Introduction

The Lake Bronson Dam is a high-hazard[1] dam located in Lake Bronson State Park, near the city of Lake Bronson in Kittson County, Minnesota. Issues associated with the Lake Bronson Dam include the potential for major flooding, including personal injury and loss of life in the cities of Lake Bronson and Hallock, if the Lake Bronson Dam should fail. Specific concerns are areas adjacent to the river between the dam and the city of Lake Bronson, Kittson County State Aid Highway 28 over the Lake Bronson Dam, and several houses in the city of Lake Bronson. In the city of Hallock, specific areas of concern include the city park and campground at the Hallock Dam, and several residences along the river. There is also concern about the possible overtopping of levees between Minnesota Highway 175 and US Highway 75.

Using the U.S. Army Corps of Engineers computer program HEC-RAS (Hydrologic Engineering Center-River Analysis System), a computer model was created for a 38-mile length of the South Fork Two River between US Highway 75 in Hallock, Minnesota, and a cross-section located approximately three miles northeast of the Lake Bronson Dam. The computer model was used to calculate potential water surface elevations in the cities, and to delineate areas subject to flooding as a result of a dam break.

[1]A high hazard dam is defined by Minnesota Rules as a dam that will likely result in the loss of life if it should fail.

Project Location

The city of Lake Bronson is located west of, and approximately three river miles downstream of, the Lake Bronson Dam. The city of Hallock is located approximately 15 miles northwest of, and 31 river miles downstream of the Lake Bronson Dam, at the junction of the South Branch and Middle Branch Two River (see Figure 1). The South Branch Two River, like the other branches of the Two River and most of the ditches in Kittson County, flows from east to west. The South Branch Two River merges with, and becomes, the Middle Branch Two River in Hallock, just upstream of MN Highway 175, downstream of station 2.40. Further downstream, the Middle Branch Two River combines with the North Branch Two River and flows to the Red River of the North. For purposes of this report, the river in the project area will be referred to as the South Branch Two River.

Most of the South Branch Two River Watershed is contained within Kittson and Roseau Counties. Upstream of the Lake Bronson Dam, large wetland complexes store water from precipitation (rain and snow), reducing the inflows to the South Branch Two River. Downstream of the dam, the Two River Watershed is actively ditched.

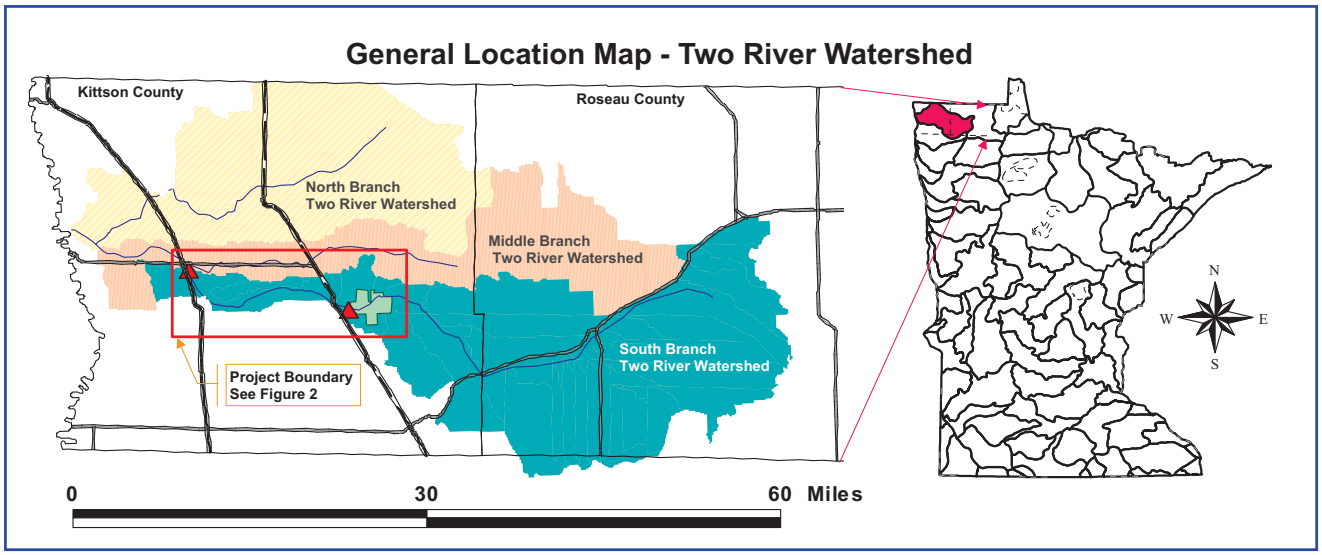


Figure 1 - General location map showing Two River Watershed and approximate project location.

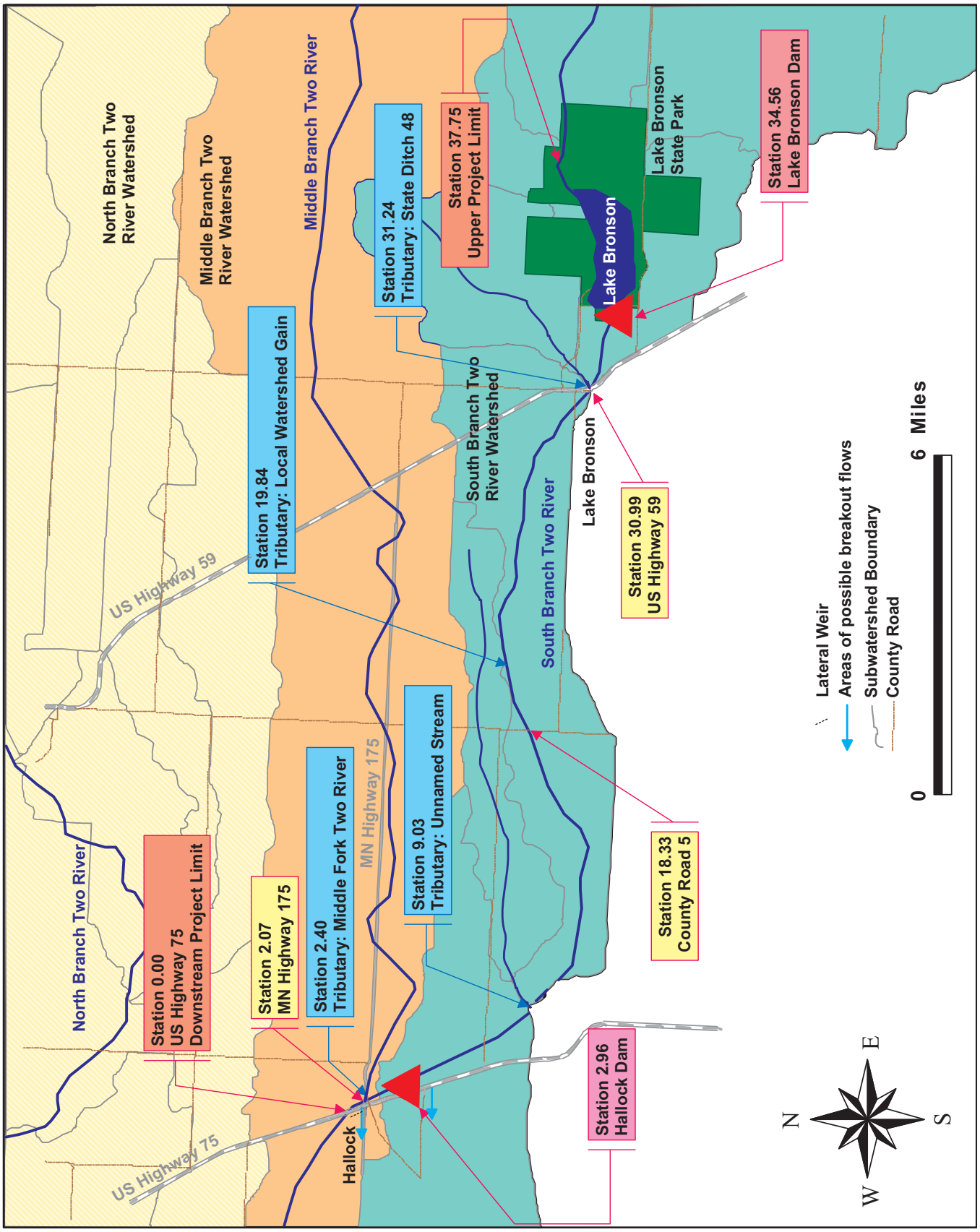


Figure 2 - Project Location Map-South Branch Two River

The drainage area of the South Branch Two River at the Lake Bronson Dam is approximately 457 square miles. The drainage area of the Middle Branch Two River is 205 square miles. At the downstream project limit (US Highway 75 in Hallock) the drainage area of the combined South and Middle Branch Two River is approximately 701 square miles.

Figure 2 is a location map for the Lake Bronson dam break project. This map shows the South Branch Two River Watershed for the area included in the dam break model, including the South Branch Two River, the cities of Lake Bronson and Hallock, the Lake Bronson and Hallock dams, tributaries, and major bridge locations. Station numbers are also given for key features in the watershed. In this report, the station number is the distance in miles along the South Branch Two River from the downstream project limit (US Highway 75 in Hallock = station 0.00) to the upper project limit northeast of Lake Bronson (station 37.75). The water surface elevation of the project area varies from approximately 985 feet above sea level[2] on the South Branch Two River at station 37.75 to approximately 792 feet on the Middle Branch Two River at station 0.00.

Background

Lake Bronson was created by construction of a dam in 1937, for the purpose of providing a backup source of municipal water for the cities of Hallock, Lake Bronson and other locations in Kittson County. Lake Bronson has a surface area of approximately 313 acres. At its deepest location, near the dam, the lake is approximately 32 feet deep, with an average depth of approximately 10 feet. At the present time, Lake Bronson is used for recreational purposes only, with no municipal water supplied by the lake.

The Lake Bronson Dam is a concrete structure consisting of three ogee spillways[3] in three 20-foot bays (see Figure 3). In each bay is an operable, four-foot gate on top of the spillway that is used to maintain lake levels and control outflows from the lake. The runout elevation of the dam with gates fully open is 968.0 feet. However, the gates are normally kept in the closed position, maintaining a runout elevation of 972 feet and a normal pool elevation slightly higher than 972 feet. The Inflow Design Flood[4] elevation is 978 feet, while the minimum tailwater elevation immediately downstream of the dam is approximately 944 feet. A 750-foot long embankment exists on the north side of the dam while a second (shorter) embankment extends to the south. The lowest elevation on top of the embankments is approximately 977 feet. Kittson County State Aid Highway 28 is built on top of the embankments and the dam and, in addition to being a roadway, forms the westerly shore of Lake Bronson. The maximum flood elevation is not expected to greatly exceeded 978 feet due to the flat terrain adjacent to the lake and the overtopping of the embankments.

Figure 3 is a photograph of the downstream side of the Lake Bronson Dam taken in August, 1983 showing the approximate geometry of the dam. The three gates were in the closed position and no water was flowing over the top of the dam at that time (the water observed in the center bay is due to leakage at the base of the center gate).

[2]For this report, all elevations will be in National Geodetic Vertical Datum, 1929 adjustment.

[3]An ogee spillway consists of an S-shaped spillway where water flows over the spillway into the tailwater. The purpose of an ogee spillway is to efficiently move water over the dam.

[4]The Inflow Design Flood is defined as "The Maximum Probable Flood, which is the largest flood that can reasonably be expected to occur on a given stream at a selected point."

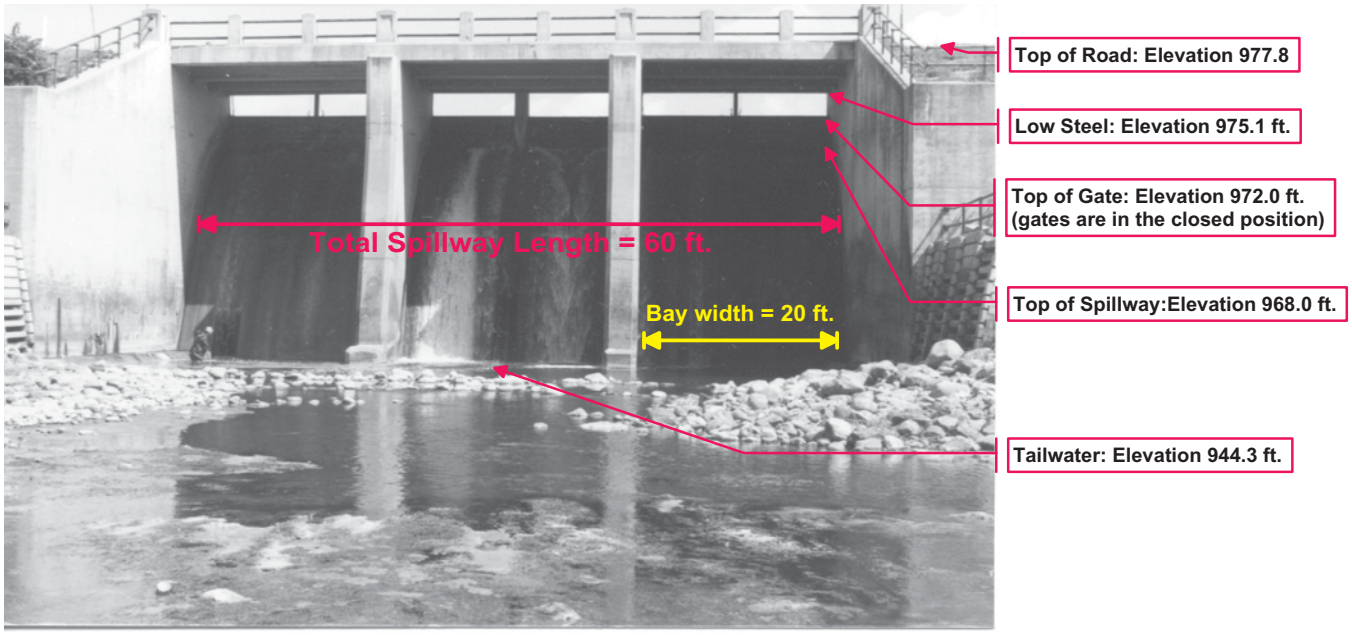


Figure 3 - Lake Bronson Dam

PROJECT DESCRIPTION

The primary purpose of this study is to quantify the impact(s) of a failure of the Lake Bronson Dam on the cities of Lake Bronson and Hallock. Specific questions to be addressed are the travel time of the floodwave from the dam to the cities of Lake Bronson and Hallock, and the maximum water surface elevation of the floodwave at those locations. Three different scenarios were modeled:

SCENARIO 1 - Sunny day dam failure with a fast break. This is a failure during normal summer flow conditions with a steady inflow of 15 cfs[5] to Lake Bronson. In this scenario, it is assumed that piping will cause a complete failure of the dam down to elevation 950 feet, and that the failure will occur within a 15-minute time span. All gates are modeled in the fully closed position, maintaining a runout elevation of 972.0 feet (Figure 4 shows the model parameters used for each of the three dam break scenarios).

[5]15 cfs is the Annual Q50 value at the USGS gage in the city of Lake Bronson for the period from 1988 to 2004, as well as the August and September Q50 for the same period.

SCENARIO 2 - 100-year flood with a slow break. This is a failure of the dam during a 100-year flood event with failure occurring when the lake elevation exceeds the minimum elevation of the dam embankment (roadway) by approximately one foot. In this scenario, the concrete dam will remain intact, with the failure occurring in the earthen dikes adjacent to the dam. The failure will represent the erosion of earthen materials to elevation 946.0 feet due to overtopping and down cutting. The failure will be trapezoidal in shape with a bottom width of 20 feet, a top width of 76 feet, a side slope ratio of 1:1, and will occur in 12 hours. In this scenario, the three gates will be kept in the fully closed position as the flood elevation increases, simulating inoperable gates due to ice or debris jamming. The runout elevation is 972 feet and the initial pool elevation is 972.49 feet.

SCENARIO 3 - 100-year flood with a fast break. This is a failure of the dam during a 100-year flood with the dam break occurring near the peak of the flood event. In this scenario, a breach will form in 15 minutes, representing the rapid and complete failure of the concrete structure and parts of the earthen embankments. The size of the failure will be large, with the breach area being 2574 square feet. The breach will be trapezoidal in shape with a bottom width of 60 feet and a top width of 138 feet. In this scenario, the gates of the dam will be adjusted in accordance with the operating plan for this dam (see Appendix D).

For flood frequencies greater than the 100-year flood, including the Inflow Design Flood, breakout flows occur at the dam and other locations upstream and downstream of the dam. Therefore, in Scenarios 2 and 3, the 100-year flood was modeled rather than the Inflow Design Flood.

Figure 4 - Breach Parameters and Results

	Scenario 1	Scenario 2	Scenario 3
Breach Parameters	Sunny Day Failure Full concrete dam failure	100-Year Flood Event Earthen dam erosion due to overtopping	100-Year Flood Event Full failure of one concrete bay
- Failure Time	15 minutes	12 hours	15 minutes
- Bottom Elevation	950 ft.	946 ft.	946 ft.
- Top Width	70 ft.	76 ft.	138 ft.
- Base Width	70 ft.	20 ft.	60 ft.
- Side Slopes	Vertical	1:1	1:1.5
- Breach Area	1540 ft^2	1248 ft^2	2574 ft^2

HEC-RAS Model Description

A HEC-RAS model was created for the project area between US Highway 75 in Hallock to approximately three miles northeast of the Lake Bronson Dam (see Figure 2). The basic model consists of 105 cross-sections, nine bridges and three dams. Four tributaries are also incorporated into the model to add flows, simulating the natural gain observed in the stream. Two lateral weirs are incorporated into the model to duplicate the observed removal of water from the stream during periods of major flooding. A profile of the model, showing water surface elevations observed in the Scenario 3 configuration, is shown in Figure 5. This profile also shows the location of the cross sections, bridges, dams, tributaries and lateral weirs.

Cross sectional information was gathered from topographic quadrangle maps by drawing a line at the desired location. Points, including UTM coordinates and approximate elevations, were interpolated from the maps and entered into the model. The contour interval of the quadrangle maps is five feet and elevations were interpolated between contour lines. As there is no information on the shape of the stream below the water surface, the shape and depth were estimated and then adjusted to match the known shapes and depths at bridges and dams.

In addition to cross sections obtained from topographic maps, other cross-sections were interpolated by the HEC-RAS program and represent an average section between known cross sections. The number of interpolated cross sections created for the Scenarios 2 and 3 models was small, and were used primarily to calculate flow upstream and downstream of bridges and dams. However, in Scenario 1, the large distance between cross sections, the small flows observed prior to dam break, and the relatively large size of the floodwave after dam break, required the addition of hundreds of interpolated cross sections.

Details for nine of the bridges was obtained from the Kittson County Highway Department and the Minnesota Department of Transportation. Information obtained included deck elevations, low steel elevations, lengths, pier sizes and locations, and thalwag (point of low flow) in the river channel beneath each bridge.

A tenth crossing, at US Highway 59 in the city of Lake Bronson, is actually three 12' by 16' culverts, each approximately 70 feet in length. HEC-RAS had difficulty with these culverts and all attempts to model the Highway 59 crossing as culverts failed. Therefore, this crossing was modeled as a dam with three 12' by 16' gates. Each gate simulated the characteristics of a culvert while the crest of the dam simulated the elevations of the roadway.

The three dams used in the model include the Lake Bronson Dam, the city of Hallock Dam and the dam used to model the US Highway 59 crossing. The dams at Hallock and US Highway 59 were modeled as non-operable dams with their gates in the fully open position. The Lake Bronson Dam, which has operable gates, was modeled with the gates in the closed positions in Scenarios 1 and 2. In Scenario 3, the gates were moved in accordance with the operating plan established for this dam. Design, elevations, gate sizes and other parameters of the dams were obtained from the DNR Dam Safety files.

A significant issue during flooding in Hallock is “breakout”. Breakout occurs when water surface elevations are sufficiently high that waters are able to flow overland into adjacent watersheds, rather than remain in the river channel of the original watershed. Breakout is a significant issue in the South Branch Two River (and other parts of the Red River of the North Watershed), due to the flatness of the terrain. Several locations of possible breakout for the South Branch Two River have been identified near and in the city of Hallock and are shown in Figure 2. However, determining when breakout occurs, and how much water is involved, requires very accurate topographic information which was not available for this study.

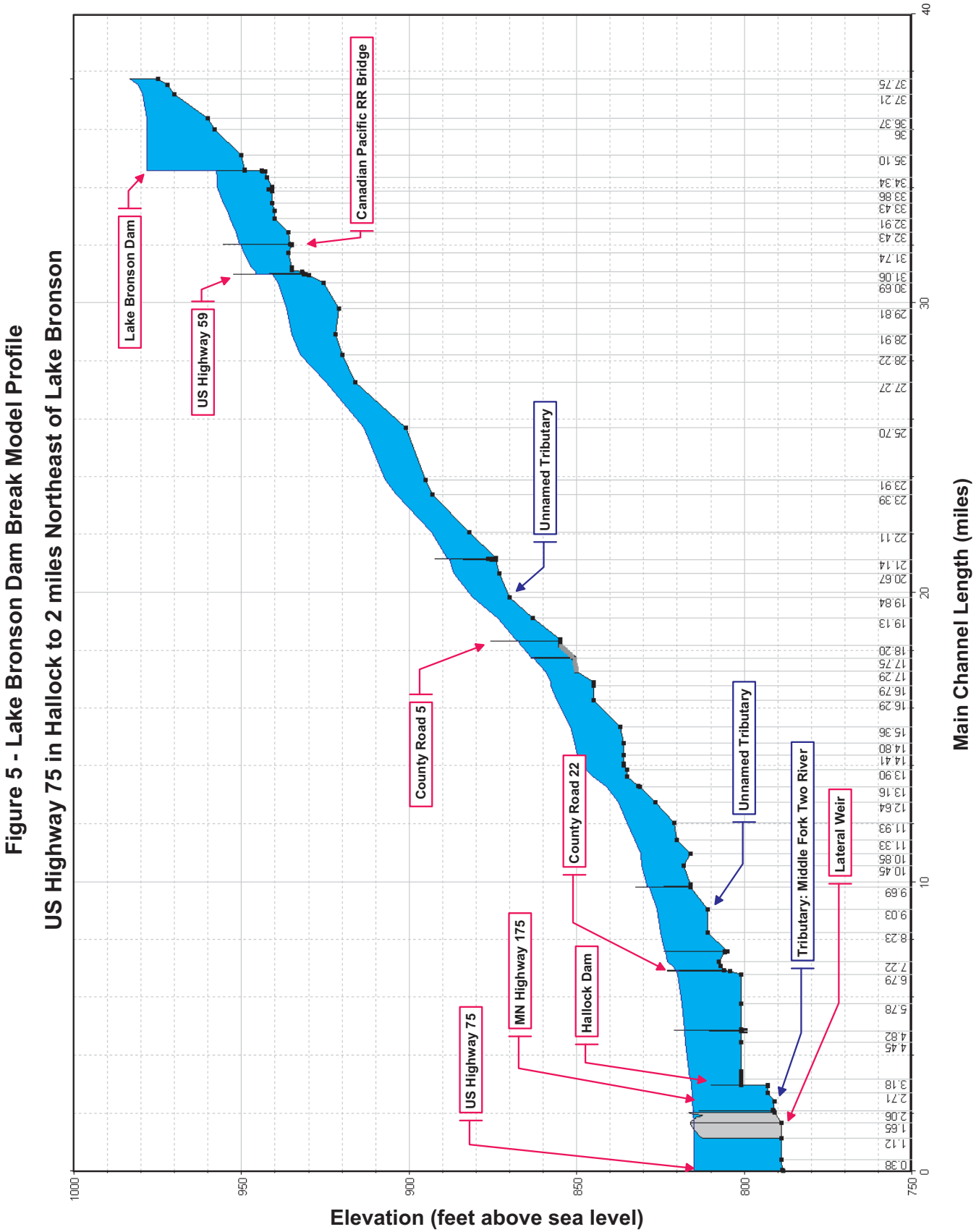


Figure 5 - Profile plot of project stream.

The South Branch Two River can receive or lose waters due to breakout. During the spring flood of April 1996, ice jams in the adjacent Roseau River watershed caused waters to breakout of that watershed and flow overland into the Two River watershed. Failure to account for break out will result in modeled water surface elevations that are different than observed water surface elevations.

In this study, the only area of breakout incorporated into the model is located at an unnamed coulee within Tourist Park in the city of Hallock. However, two lateral weirs were required by HEC-RAS due to the length of the lateral area and the number of cross sections in the breakout area. The weirs are located downstream of MN Highway 175, on the left (west) bank of the river. These lateral weirs allow water to overflow the Middle Branch Two River and flow into the Red River of the North, or back into the Two River downstream of station 0.00, when water surface elevations exceed 812.79, slightly higher than the 100-year flood elevation. The elevations of the weirs were obtained from the Minnesota Department of Transportation and represent the top of US Highway 75 in Hallock. The lateral weirs were only incorporated into Scenarios 2 and 3 as the water surface elevations observed in Scenario 1 were not high enough to cause breakout.

In order to model the behavior of a stream, an input hydrograph is needed to show the variations in discharge over a given time period. A hydrograph from the April, 1996 snowmelt event, based on USGS gage data from the South Branch Two River at Lake Bronson (USGS ID 05094000), was imported into the model and multiplied by a numerical value (1.50) so that the discharge at US Highway 59 matched that of a 100-year flood event. As the input hydrograph is based on an actual flood event, the dam break model used the times from that event, which started on April 15, 1996, with both peak water surface elevation and discharge occurring on April 22, 1996.

Using a hydrograph of the outflow of a lake as an inflow hydrograph is not a normally accepted procedure. However, in this case, there is limited storage in Lake Bronson during a 100-year flood event and the inflow hydrograph is nearly identical to the outflow hydrograph. The Scenario 2 model was run for the 100-year flood, without dam break, to compare the inflow and outflow hydrographs of Lake Bronson. The model confirmed that the reservoir had minimal effects on the 100-year flood hydrograph and that the inflow and outflow hydrographs are very similar.

Model Calibration

Upon completion of the computer model, it was calibrated to known water surface elevations and discharges at two locations. The first calibration was at the USGS gage located immediately upstream of US Highway 59 in the city of Lake Bronson. At this location, the flood insurance study[6] estimates a peak discharge of 7000 cfs as the 100-year flood event in the city of Lake Bronson. The second calibration was at the Minnesota Department of Natural Resources flood warning gage at MN Highway 175 in the city of Hallock. A rating curve had been developed for this location and model parameters were adjusted so that discharges and elevations from the dam break model were consistent with the curve. However, the highest measured discharge at this site, 4400 cfs, is well below the peak discharge associated with the dam break floodwave during the 100-year flood event. The flood insurance study estimates the 100-year discharge at this location to be 10,350 cfs at an elevation of 812.4.

To produce the desired flow of 10,350 cfs at the Highway 175 bridge, four tributaries were added to the model to simulate the naturally increasing flows. The tributaries were added to the model as lateral hydrographs, using the April, 1996 hydrograph from the USGS stream gage at Lake Bronson. They were also multiplied by a correction factor to produce discharges representative of the area of the tributaries' subwatersheds. The first tributary, State Ditch No. 48, which joins the South Fork Two River in the city of Lake Bronson (station 31.23), has an estimated peak flow of 590 cfs and a drainage area of 8.75 square miles. The second tributary represents additional flows added to the river from the local watershed. This tributary joins the river near County Road 5 (station 19.84), has an estimated peak flow of 765 cfs and a drainage area of 11.46 square miles. The third tributary, which joins the South Fork Two River near Township Road T-231 (station 9.03) approximately five miles upstream of the Hallock Dam, has an estimated peak discharge of 955 cfs and a drainage area of 14.30 square miles. The final tributary, representing the Middle Branch Two River, joins just upstream of the Highway 175 bridge and approximately one-half mile downstream of the Hallock Dam (station 2.40). USGS calculations indicate that the 100-year flood discharge on the Middle Branch Two River near Minnesota Highway 175 are 1000 cfs, therefore, the fourth tributary was adjusted to match[7].

As it was necessary to increase flows by approximately 3300 cfs at the MN Highway 175 bridge, they were added at the first three tributaries based on the size of their respective subwatersheds. The locations of the four tributaries are shown in Figure 2 and on the profile in Figure 5. The input hydrographs for the tributaries are based on the April, 1996 event, but with a reduced amplitude. The timing of the peak stage and discharge is the same as the original hydrograph.

After calibration of the Lake Bronson dam break model, individual models were created for each of the three scenarios described previously. Output hydrographs were calculated using a time interval of five minutes. In Scenario 1, the sunny day failure, the model simulated elevations and flows for the time period April 21, 0000 hours to April 24, 2400 hours. For Scenarios 2 and 3, the model simulated flows and stages from April 15, 0000 hours to May 4, 2400 hours. The longer time period was needed in Scenarios 2 and 3 to allow the South Branch Two River to build to the 100-year flood event prior to dam break. In Scenarios 1 and 3, the dam break begins at 0000 hours on April 22. In Scenario 2, the dam break occurs when the elevation of Lake Bronson reaches an elevation of 978.0 feet, which is approximately one foot above the minimum embankment (roadway) elevation.

[6]The "Flood Insurance Study for the City of Hallock, Minnesota", was completed in July, 1979, under funding by the U.S. Department of Housing and Urban Development, Federal Insurance Administration.

[7]In the 1979 Flood Insurance Study, a constant flow of 7000 cfs was used for the 100-year flood in the South Branch Two River from Lake Bronson to Hallock, and 3350 cfs was used for the 100-year flood in the Middle Branch Two River at Hallock.

An additional check was performed on the model to verify that the volume of water in the river and in Lake Bronson was consistent. First, the total volume of water in the South Branch Two River and Lake Bronson was calculated during the 100-year flood event (without dam break). This value was then compared to the volume of water in the river after the Scenario 3 dam break. It was observed that the river contained an additional amount of water, equal to 89% of the volume of Lake Bronson, with 10% of the original lake water remaining in the lake. Therefore, the volume of water found in Lake Bronson was consistent with the volume of water found in the river after the dam break.

After calibrating to the flood warning gage rating curve, it was found that the water surface elevations predicted by the dam break model substantially agreed with the flood insurance calculations up to a 10-year flood event, or approximately 4900 cfs, for the city of Hallock. Additional high-flow measurements are needed to extend the rating curve into the range of lower frequency floods.

Assumptions

The following assumptions were made during the dam break model development and calculation phases:

- No backwater effects in the Red River of the North that would impact the Lake Bronson dam break model, such as those seen in 1996 and 1997, when backwater conditions were observed on the Middle Branch Two River near US Highway 75 in Hallock. If backwater conditions exist during the Scenarios 2 and 3 dam breaks, which is likely during the 100-year flood event, water surface elevations in Hallock would most likely be higher than predicted by the model.

- The input hydrograph was derived from the April, 1996 spring snowmelt event, which occurred prior to the emergence of spring vegetation. It was assumed that the Two River channel is relatively free of vegetation and other obstructions, such as ice. In fact, the South Branch Two River is an entrenched stream consisting of a highly vegetated valley. Numerous stands of cottonwoods, elms, and other vegetation can be found along the channel and in the many segments of abandoned channels and oxbow lakes. During periods of major flooding, and especially after a breach in the Lake Bronson Dam, it is likely that vegetation and other debris would become trapped in bridges and other locations in the channel, creating natural dams, and causing even higher water levels at some locations. A specific concern would be at the Hallock Dam, where debris could easily become trapped behind the dam, reducing capacity, and causing water levels in the park and city to be higher than predicted by the model.

- No culverts under US Highway 75 in Hallock that would drain water from the east side of the road to the west side of the road. Culverts below the roadway may result in water surface elevations being slightly lower than expected.

- All input hydrographs are based on the observed hydrograph at the USGS gage in the city of Lake Bronson. The amplitude was reduced based on drainage areas, but the timing was unaltered. In reality, it is unlikely that all input hydrographs would peak simultaneously, as they do in this model.

- During periods of major flooding, such as those in Scenarios 2 and 3, emergency personnel will be on site monitoring the condition of the Lake Bronson Dam.

- Great effort has been put forth to make the Lake Bronson Dam Break model as accurate as possible. However, heavy reliance on the quadrangle maps for cross section elevations reduced the accuracy of the model.

Model Results

After completing calibration, the model computed water surface elevations and discharge hydrographs, using a time increment of five minutes, which produces a very accurate hydrograph. A shorter time interval would produce a slightly more accurate hydrograph, but also a very large amount of data, while a longer time interval would produce a slightly less accurate hydrograph.

The characteristics of the floodwave, including maximum stage, discharge, change in water surface elevation prior to dam break, and travel time were computed at six selected sites. The location of those six sites, shown on Figure 2, from upstream to downstream, are 1) Lake Bronson Dam tailwater; 2) US Highway 59 in the city of Lake Bronson and location of the USGS gage; 3) County Road 5, an intermediate site between the two cities; 4) City of Hallock Dam; 5) MN Highway 175 in Hallock, and the location of the MDNR flood warning gage site, and 6) US Highway 75 in Hallock. Peak stage and discharge information for all cross sections are shown in Appendix A through C, for Scenarios 1 through 3, respectively.

SCENARIO 1 - *Sunny Day Dam Break*

A sunny day dam break would produce the largest change in both peak discharge and height of floodwave when compared to the conditions prior to the dam break. However, the maximum water elevations observed during the sunny day dam break were significantly lower than those in the other two scenarios, due to lower water elevations prior to dam break.

Figure 6a shows water surface elevation hydrographs, for Lake Bronson and the six selected sites, from six hours prior to dam break to 48 hours after dam break. Prior to dam break, the approximate water surface reflects a flow of 15 cfs. At dam break, the level of Lake Bronson drops rapidly while the tailwater increases rapidly. Comparing the hydrographs in Figure 6a, it is possible to follow the dam break floodwave as it moves downstream. The time lag of the floodwave at each of the sites is clearly visible in the figure.

Figure 6b shows the discharge hydrograph as a result of the sunny day dam break. The maximum discharge, approximately 26,000 cfs, occurred immediately downstream of the Lake Bronson Dam, approximately two hours after dam break. As the wave moves downstream, the amplitude rapidly attenuates. By the time the wave arrives in the city of Lake Bronson, it has diminished to approximately 10,000 cfs. When the peak arrives at the Hallock Dam, approximately 14 hours after dam break, the discharge has diminished to less than 3000 cfs.

Figure 6c shows the height of the dam break floodwave[8] at the six selected sites along the river. The height rapidly diminishes as the wave moves downstream. At Lake Bronson tailwater, the height is approximately 17 feet. When the wave arrives in the city of Lake Bronson, three miles downstream, it has diminished to approximately 12 feet. At the Hallock dam, approximately 14 hours later, the floodwave has diminished to approximately five feet in height. After the floodwave passes the Hallock Dam, it increases in height, due to a change in the hydraulic properties of the river channel. At this location, the slope of the river channel becomes almost flat. As the velocity decreases, the water surface elevation increases, to maintain the channel discharge near the current rate of flow. The calculated water surface elevation downstream of the Hallock Dam was compared to the rating curve for the MDNR flood warning gage and found to be consistent with the curve.

In a sunny day dam break, nearly all of the water from Lake Bronson is contained within the river channel. Downstream of Lake Bronson and upstream of the city of Lake Bronson, the model indicates that some water overtops the river banks and flows onto lands adjacent to the river. The areas experiencing out-of-bank flows are not large and the waters flow back into the river channel as the floodwave passes. No water was observed overtopping bridges.

At the Canadian Pacific Railroad bridge (station 32.00), approximately 2.5 miles downstream of Lake Bronson, the peak water surface was higher than the low steel components of the bridge, causing a backwater to briefly form upstream of the bridge. The backwater quickly disappears as the floodwave moves downstream. That the floodwave exceeded the capacity of this bridge, and that the bridge becomes an impediment to flow, should be noted. At US Highway 59, the wave exceeded the capacity of the three gates, also causing a brief backwater to form upstream of the bridge, but the peak water surface did not exceed the elevation of the roadway.

[8]For purposes of this report, the dam break floodwave is defined as the change in stage or discharge due to the breaking of the dam, and is obtained by subtracting the hydrograph without dam break from the hydrograph with dam break.

Figure 6a: Scenario 1 - Sunny Day Dam Break

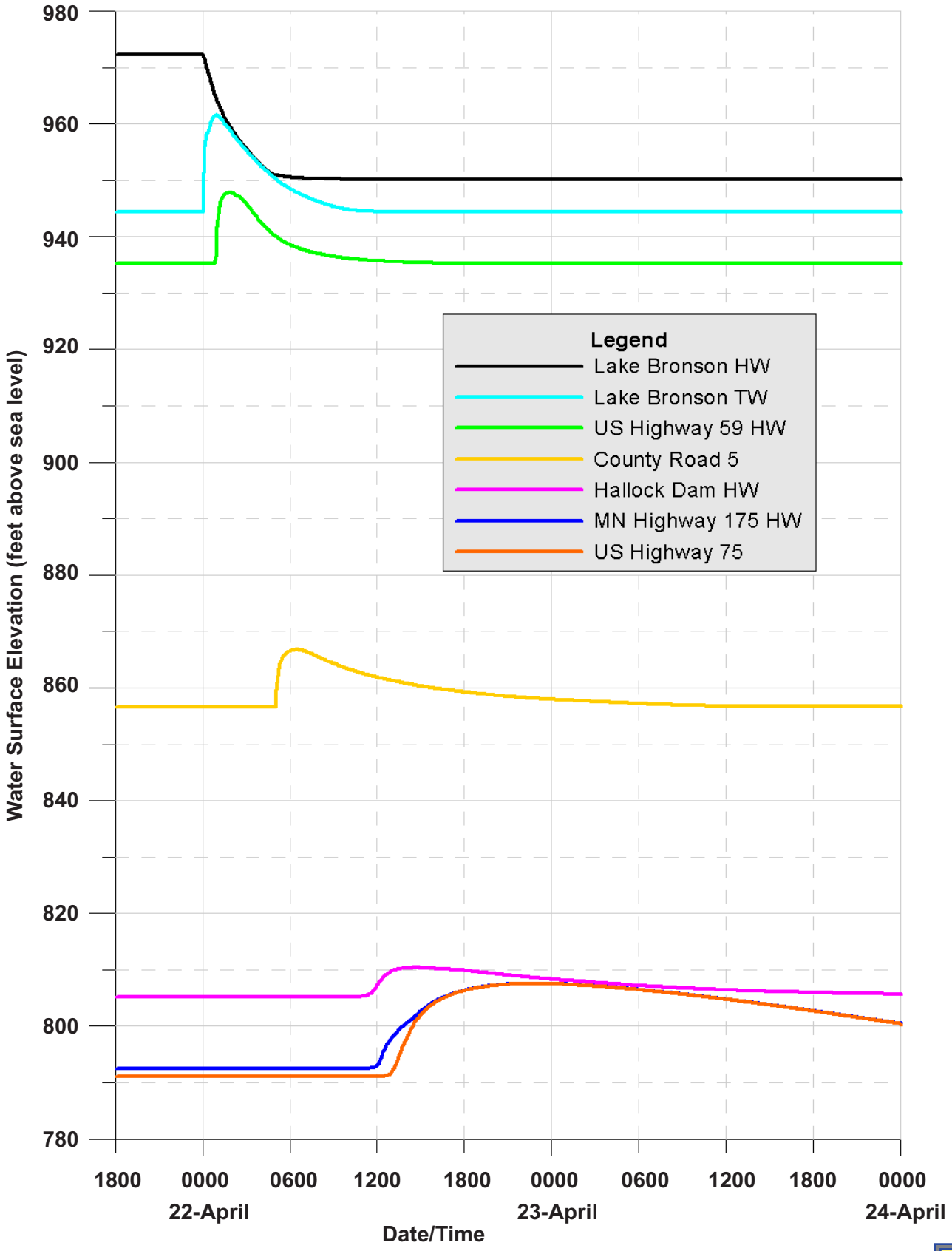
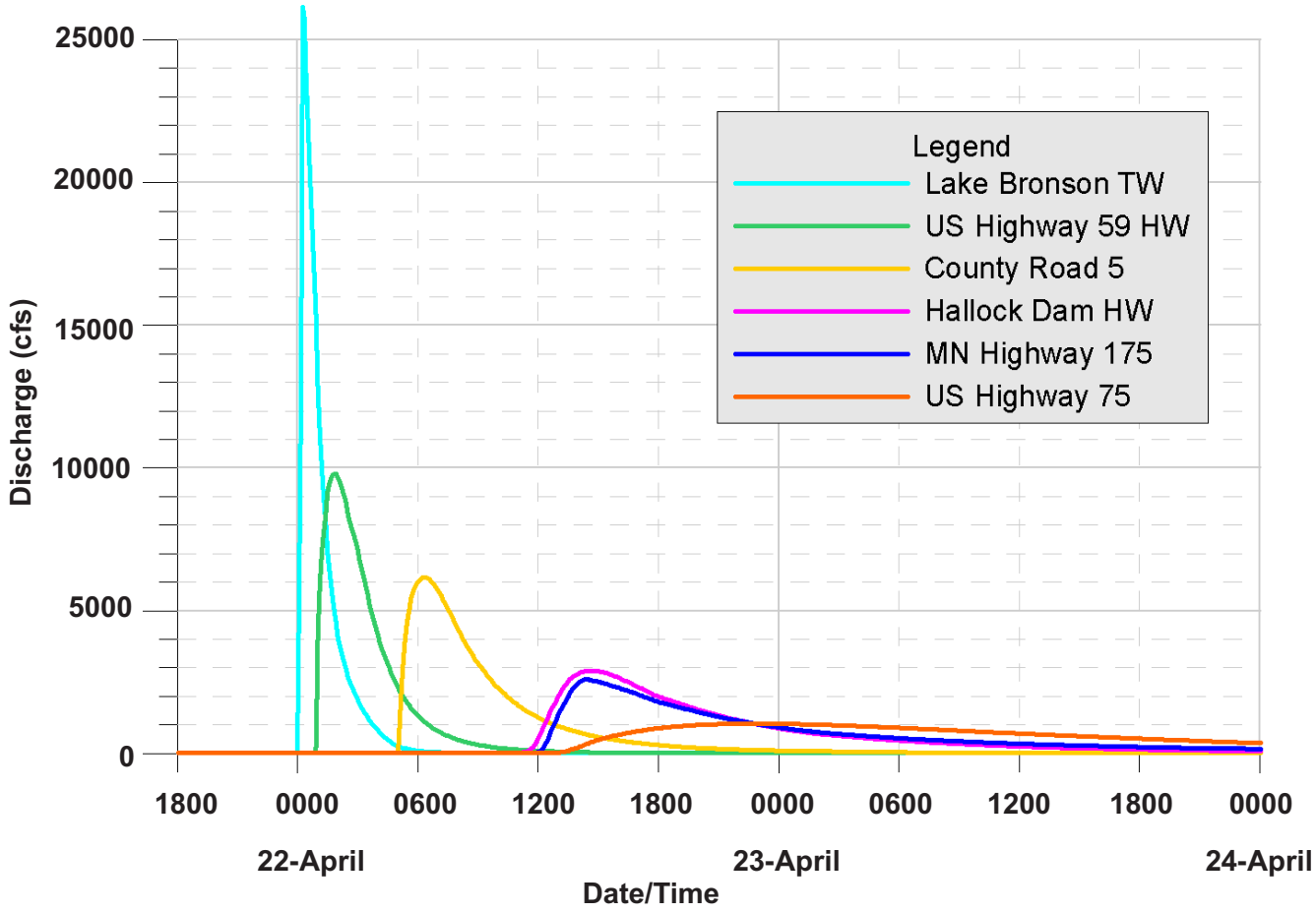


Figure 6b: Scenario 1 - Sunny Day Dam Break
Floodwave Discharge



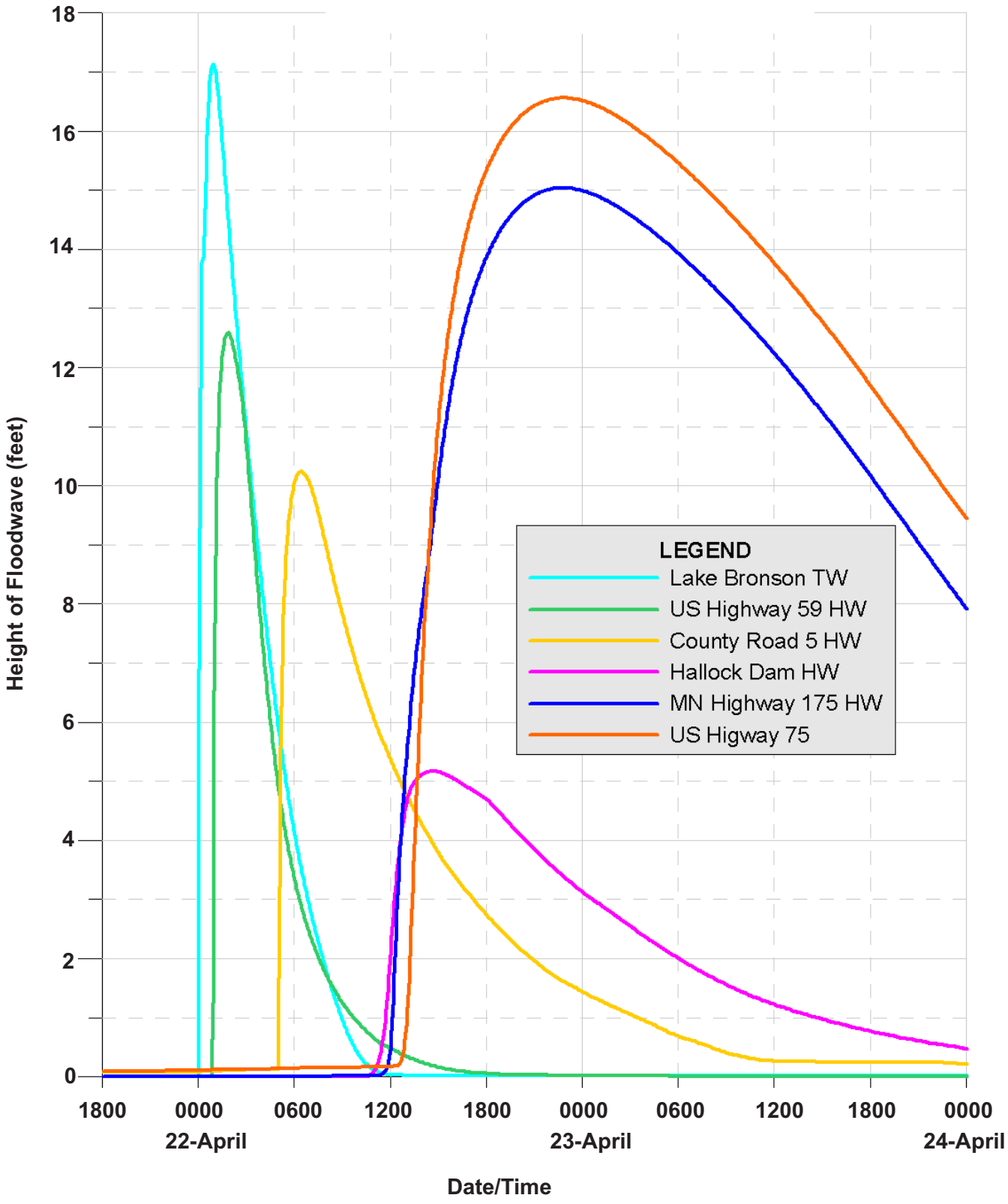
In a sunny day dam break, only one house in the city of Lake Bronson was determined to be at risk. A field survey in July, 2004 indicated that the maximum water elevation of a sunny day dam break would be approximately the same elevation as the first floor of the house. As the floodwave from this scenario is of relatively short duration in the city of Lake Bronson, any flooding at this residence would likely be minor, and pose a minimal risk to public safety. Within minutes of the peak, the water surface would begin to fall and no other residences would be at risk. By the time the floodwave reaches Hallock, it would diminish to the point where all waters are contained in the river channel.

The large size of breach in Scenario 1 and the fast failure time result in a large dam break floodwave. A failure with a smaller breach size or a longer breach time would greatly reduce the amplitude of the floodwave and eliminate any impacts on residential properties in the project area.

Appendix A is a profile output table showing the initial and maximum discharge and water surface elevations for all cross sections and structures in Scenario 1. Data is also shown in tabular form in Figure 9, along with the data from the other two dam break scenarios.

Figure 6c: Scenario 1 - Sunny Day Dam Break

Height of Dam Break Floodwave



SCENARIO 2 - *Erosion of embankment during 100-year flood event*

In Scenario 2, the Lake Bronson dam was set to fail when the water surface exceeded the elevation of the embankment (977.0 feet) by one foot. The failure represents erosion of earthen materials along the embankment or emergency spillway. It is the smallest of the three scenarios examined, yet represents a fairly large failure over the course of 12 hours. All gates on the dam are held in the fully closed position, simulating the conditions where the gates have been jammed with ice or other debris.

Using the data from the April, 1996 spring flood and adjusting that data for an approximate 100-year flood event, the Lake Bronson Dam failed on April 19 at approximately 1900 hours. This failure is approximately three days prior to the snowmelt event reaching peak water surface elevation and discharge. The results of the model are shown in Figures 7a-d and in Figure 9.

Figure 7a shows the combined dam break and 100-year flood event hydrographs for Lake Bronson and the six selected sites. In Figure 7a, the elevation of Lake Bronson can be seen rising as the discharge increases to the 100-year flood event. At elevation 978 feet, approximately one foot above the road embankment and with water flowing over the embankment, the embankment fails. With failure, the elevation of Lake Bronson drops rapidly and the floodwave is clearly visible on the hydrographs for all of the selected sites. However, at the lower three sites, the wave is less visible as it is nearly incorporated into the leading edge of the spring snowmelt event.

Without dam break, the elevation of Lake Bronson would have risen to approximately 978.6 feet. The dam break floodwave was responsible for the maximum water elevations at all sites, however, as it moved downstream, attenuation of the wave and incorporation into the 100-year flood event reduced its size. Spreading the dam break floodwave on the 100-year flood event also helps to reduce the elevation of the wave. Failure of the Lake Bronson Dam prior to the peak of the 100-year flood event would reduce the magnitude of the combined floodwave for the upper three sites and for the city of Lake Bronson.

Figure 7b shows the calculated discharge for the combined 100-year flood event and the dam break due to overtopping and erosion of the embankment. The peak discharge, approximately 27,000 cfs, is slightly greater than the peak discharge observed in Scenario 1, and is a result of greater discharge in the channel due to the snowmelt event. Like the hydrograph in Scenario 1, the discharge rapidly attenuates as the wave moves downstream. Note than in Scenario 2, the size of the breach is approximately 20% smaller than the breach in Scenario 1, while the time to the maximum opening of the breach is eight times longer. A faster breach or larger opening in Scenario 2 would cause both the maximum water elevation and discharge to be higher.

The peak discharges of dam break Scenario 2 are numerically closer at each of the six selected sites than those of Scenario 1. At the Lake Bronson Dam, the smaller breach area and the longer time period reduced the peak discharge of the floodwave to less than 15,000 cfs, while at the Hallock Dam, the floodwave had a peak discharge of approximately 12,000 cfs. Further enhancing the peak discharge of the floodwave is the time lag between the dam break and the rising time of the 100-year flood event. At Lake Bronson, the dam break occurred before the peak of the 100-year flood event. At sites further downstream, the dam break peak arrives closer to the peak of the 100-year flood event. The added discharges from the 100-year flood event helped maintain higher peak water surface elevations and discharges for the dam break flood event.

Figure 7a: Scenario 2 - 100-Year Flood Event with Embankment Failure

Water Surface Elevation vs. Time

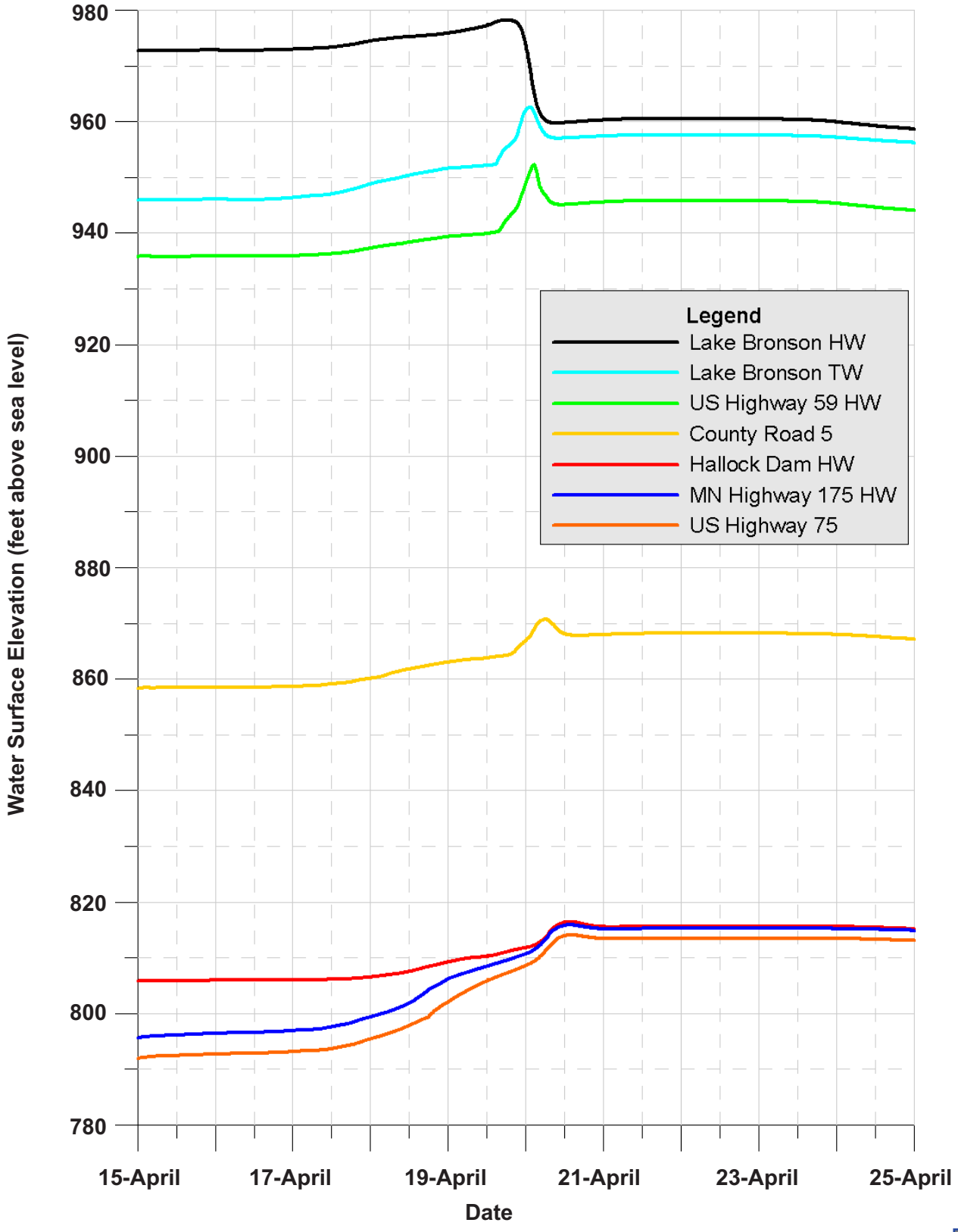
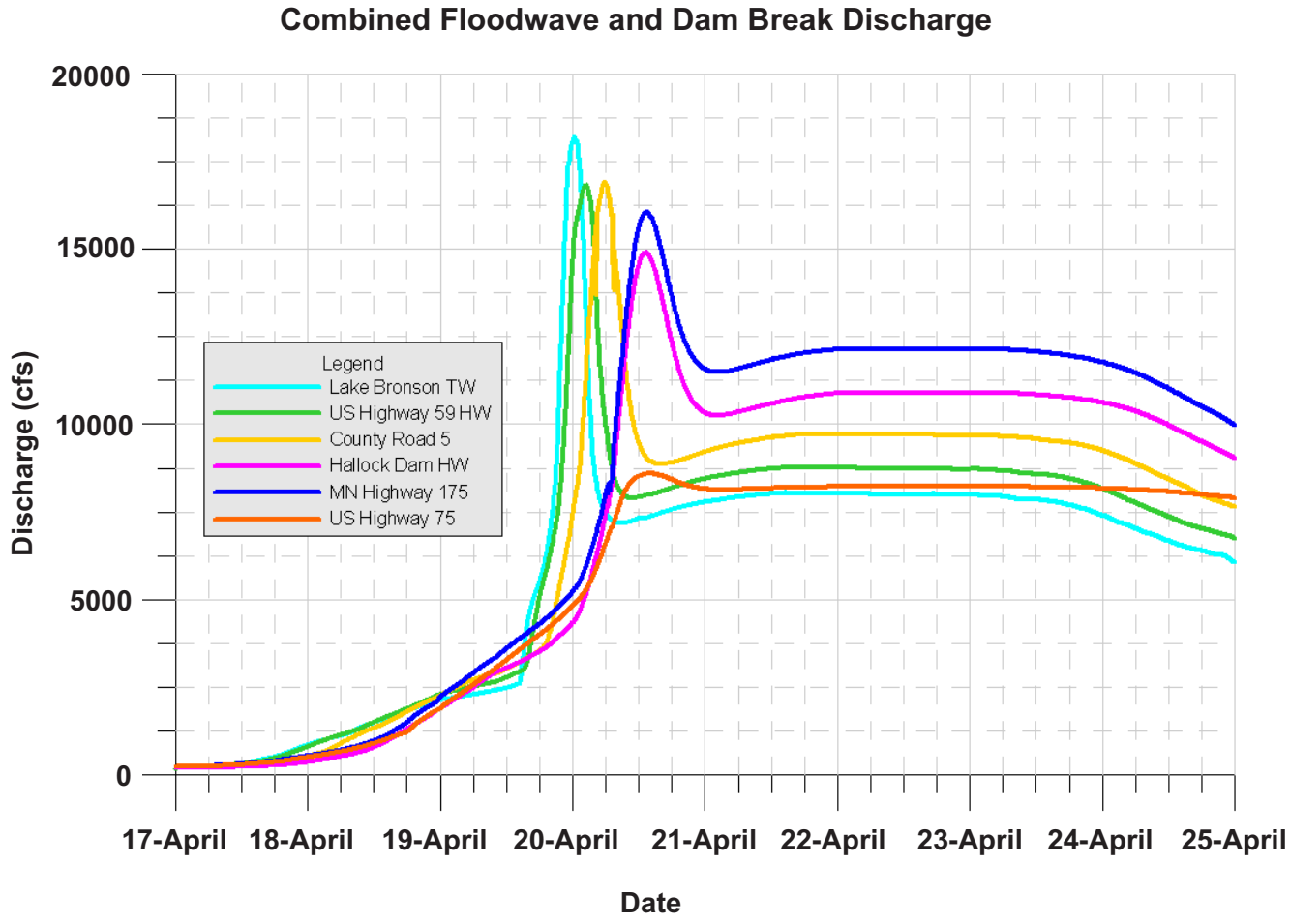


Figure 7b: Scenario 2 - 100-Year Flood with Embankment Failure



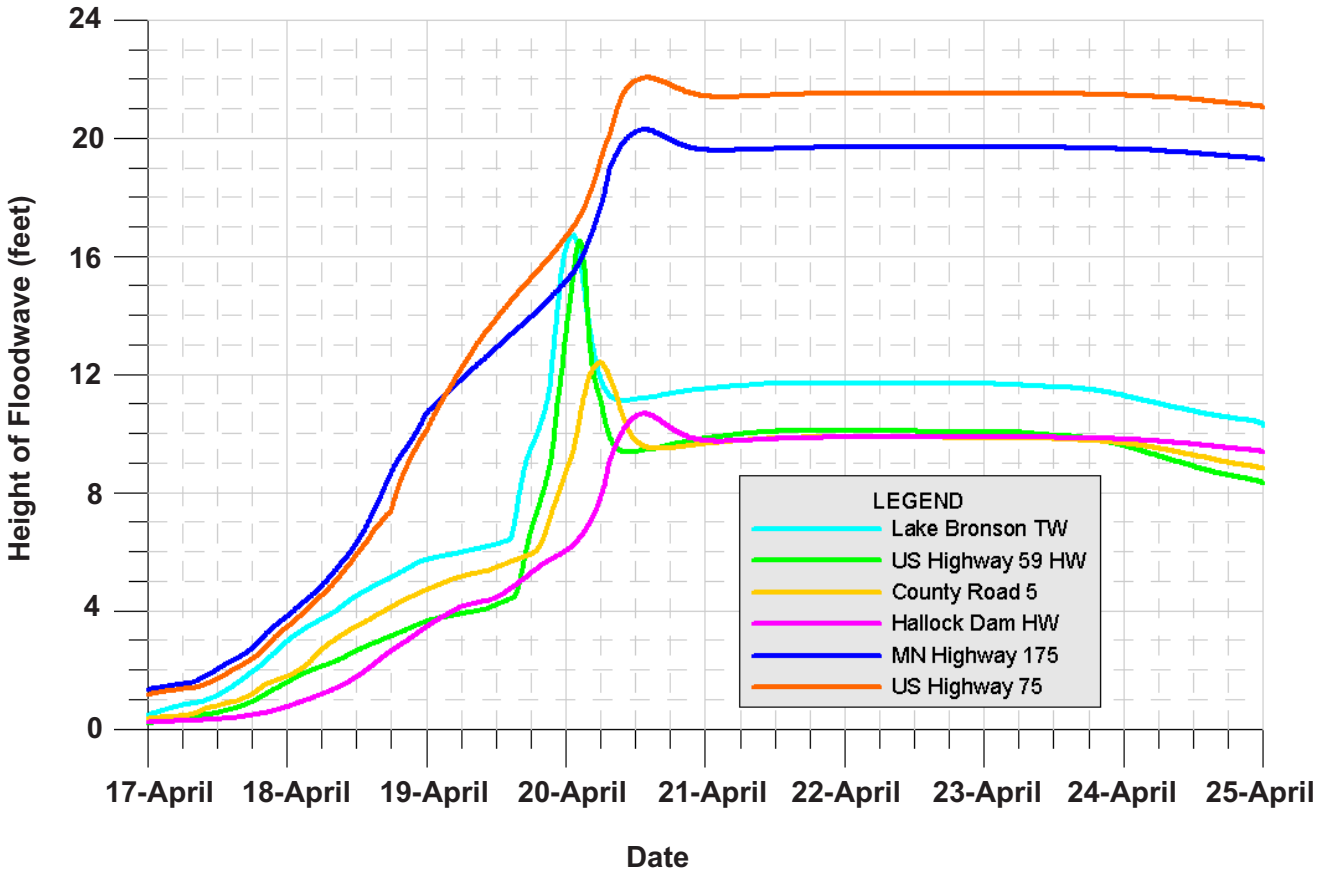
As the peak of the floodwave moved past MN Highway 175, rising water overtopped US Highway 75 and breakout flows occurred in the vicinity of station 1.80. After losing water to the breakout, the peak dam break discharge reduced to approximately 7,000 cfs at US Highway 75.

Figure 7c was obtained by taking the water surface elevation prior to the start of the flood event, on April 15 at 0000, and subtracting that elevation from the water surface elevations of the Scenario 2 dam break floodwave. As seen in Scenario 1, the height of the dam break floodwave decreases as it moves down-stream until the wave passes the Hallock Dam, where the height increases due to changes in the hydraulic properties of the channel.

Figure 7d was obtained by taking the calculated water surface elevation with dam break and subtracting that elevation from the water surface elevation without dam break. The net result is the height of the dam break floodwave. Figure 7d also shows that the height of the floodwave has been reduced to less than 1.5 feet by the time it reaches the city of Hallock. However, a rise of 1.5 feet during a 100-year flood event can significantly increase property damages and threats to public safety.

Figure 7c: Scenario 2 - 100-Year Flood with Embankment Failure

Height of Combined Floodwaves



Approximately six residential properties were identified to be at risk during a Scenario 2 dambreak in the city of Lake Bronson. These residences can be seen in the inundation map in Appendix E. The level of risk for each residence varies, from water up to the first floor, to approximately eight feet over the first floor level of the residence identified in Scenario 1. As in all of the scenarios, the warning time for these residences is approximately one hour to the leading edge of the dam break floodwave to two hours until the peak of the floodwave.

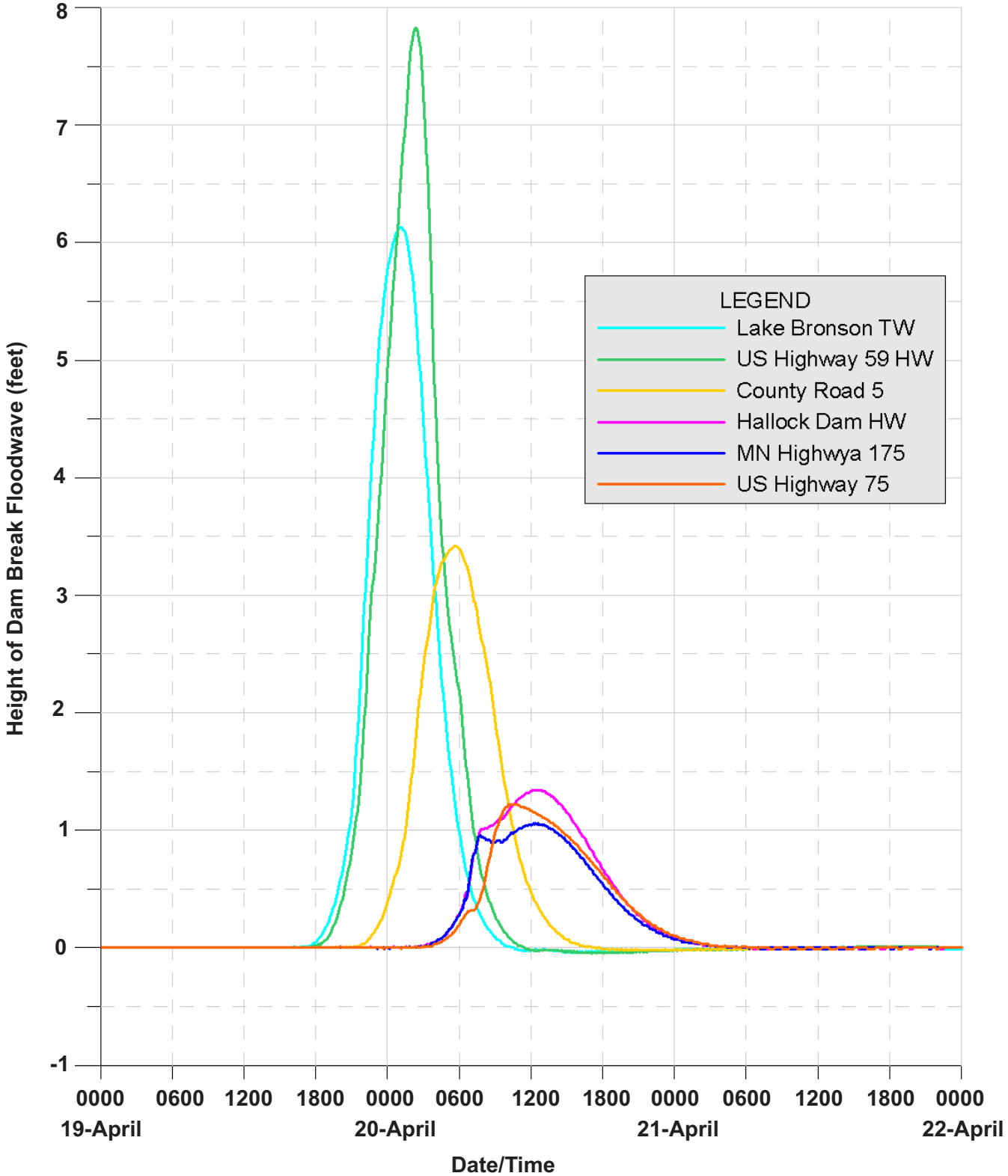
In the city of Hallock, a Scenario 2 dam break during a 100-year flood event will increase property damage. However, with sufficient warning time, approximately eight hours to the leading edge of the floodwave and 14 hours to the floodwave peak, individuals can be evacuated from areas of expected flooding.

In Scenario 2, the fact that the dam break occurred three days prior to the peak of the flood resulted in lower water surface elevations than if the break had occurred during the peak of a 100-year flood event.

Appendix B is a profile output table showing the initial and maximum discharge and water surface elevations for all cross sections and structures in Scenario 2. Data is also shown in tabular form in Figure 9, along with the data from the other two dam break scenarios.

Figure 7d: Scenario 2 - 100-Year Flood with Embankment Failure

Height of Dam Break Floodwave



SCENARIO 3 - *100-year flood event with a fast break*

Scenario 3 is a fast forming, massive dam break occurring at the peak of a 100-year flood event. The area of the break is 67% greater than the Scenario 1 break, and represents a complete washout of the dam and significant amounts of the earthen embankments adjacent to the dam. It is an extremely unlikely event and represents the worst possible dam break.

In Scenario 3, the gates of the Lake Bronson Dam are adjusted as required by the operating plan (see Appendix D) which requires that the gates be opened in specific sequences when the water surface elevation exceeds 972.5 feet. Initially, the gates are operated individually, with a maximum change of 0.5 feet and a minimum time between adjustments of two hours. If water levels continue to rise after all three gates are open two feet, the operator is required to move all three an additional 0.5 feet in a minimum of two-hour time increment until water stops rising, or all gates are fully open. Closure is not considered in this report as the dam will fail when the water elevation of Lake Bronson is near its peak.

Incorporating the operating plan for the Lake Bronson Dam into the model was a complicated task as these types of gates have not previously been incorporated into a HEC-RAS model. Essentially, three 4' by 20' operable gates and three 3' by 20' non-operable gates were created for the model to duplicate the operation of the three existing 7' by 20' gates. In this scenario, using six gates provided an extremely close simulation to the three gates in the dam.

The initial conditions for the Scenarios 2 and 3 models were based on flow from April 15, 1996 at 0000, which was approximately 100 cfs. At 100 cfs, the elevation of Lake Bronson would be 972.67 with the gates fully closed. However, the operating plan requires the gate(s) to be opened when lake elevation exceeds 972.50 feet. Therefore, in Scenario 3, the simulation began with gate number two opened 0.5 feet, as required by the operating plan.

Figure 8a shows the water surface elevations at the six selected sites. As in Scenario 1, failure of the Lake Bronson Dam occurrs at 0000 on April 22. The waviness of the rising hydrograph, as seen in the Lake Bronson tailwater and at the US Highway 59 site on April 17 through 19, is due to manipulation of the gates in the dam. At the last three downstream sites, the water surface elevations converge to nearly equal the headwater elevation at the Hallock Dam. This convergence is due to backwater and flooding between US Highway 75 and MN Highway 175.

Figure 8b shows the five minute discharge for the combined dam break and 100-year flood event at the six selected sites. The peak discharge, exceeding 60,000 cfs in the Lake Bronson tailwater, is a direct result of the large breach, the very fast failure time of 15 minutes, and failure of the dam during a 100-year flood event. A change in any of these parameters toward more average conditions would greatly reduce the water surface elevation and discharge of a Scenario 3 floodwave. Note that the discharge at US Highway 75 is impacted by the removal of large volumes of water upstream at the lateral weirs. Additionally, the flatness of the channel geometry between this site and the Hallock Dam result in slower velocities and higher elevations, as seen in Figure 8c.

Figure 8c shows the change in water surface from the initial elevation throughout the time period of the model. The elevation due to the 100-year flood event as well as the dam break flood event is readily visible in the hydrograph. Manipulation of the gates in the Lake Bronson Dam, as prescribed by the operating plan, can also be seen in the stepped appearance of the rising limb of the hydrograph at the Lake Bronson tailwater, and at the US Highway 59 and County Road 5 bridges.

Figure 8d shows the height of the dam break floodwave which continually attenuates as it moves downstream. The floodwave is impacted less by the hydraulics and geometry of the channel, and more by

Figure 8a: Scenario 3 - 100-Year Flood with Fast Dam Break

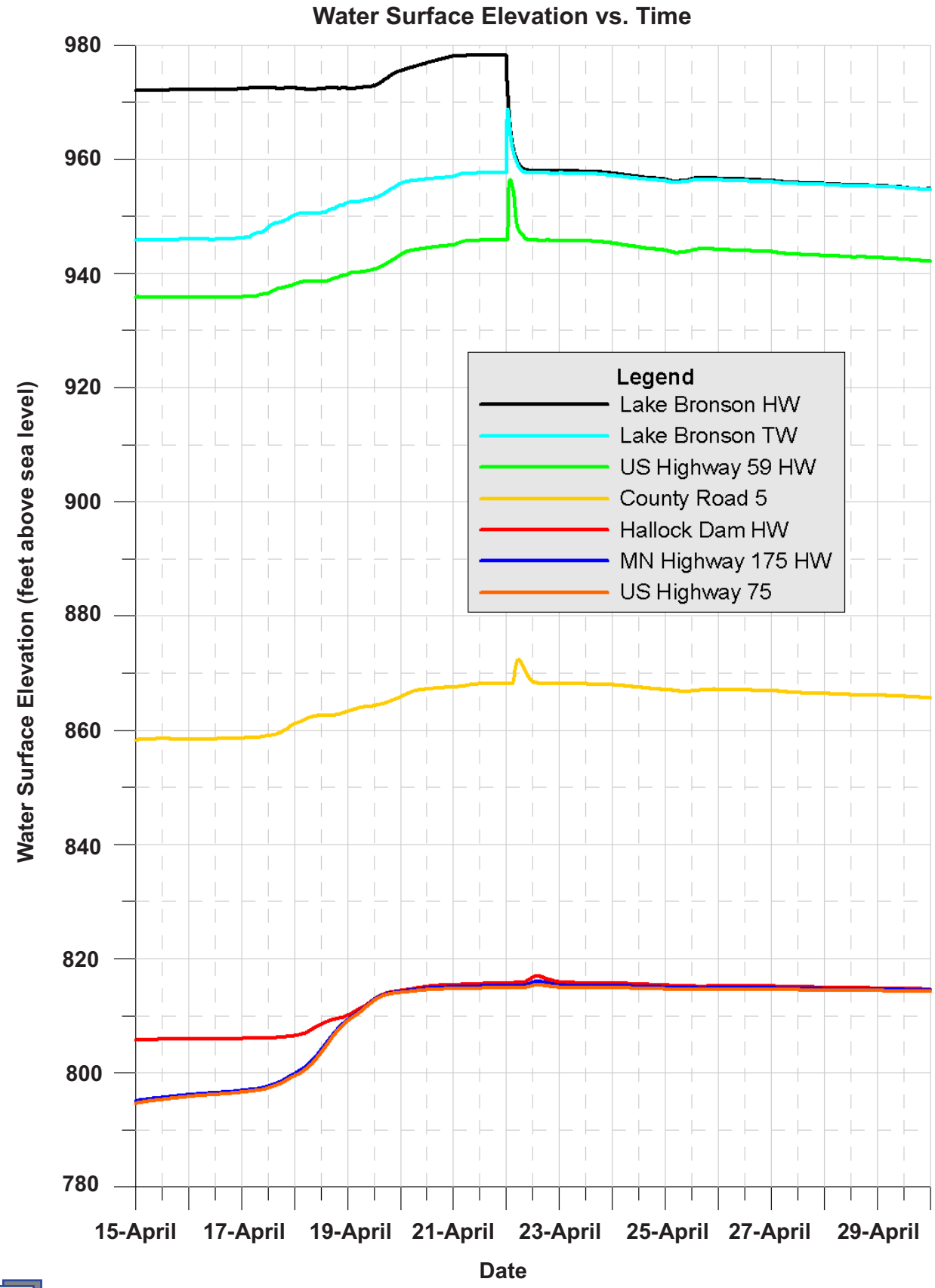
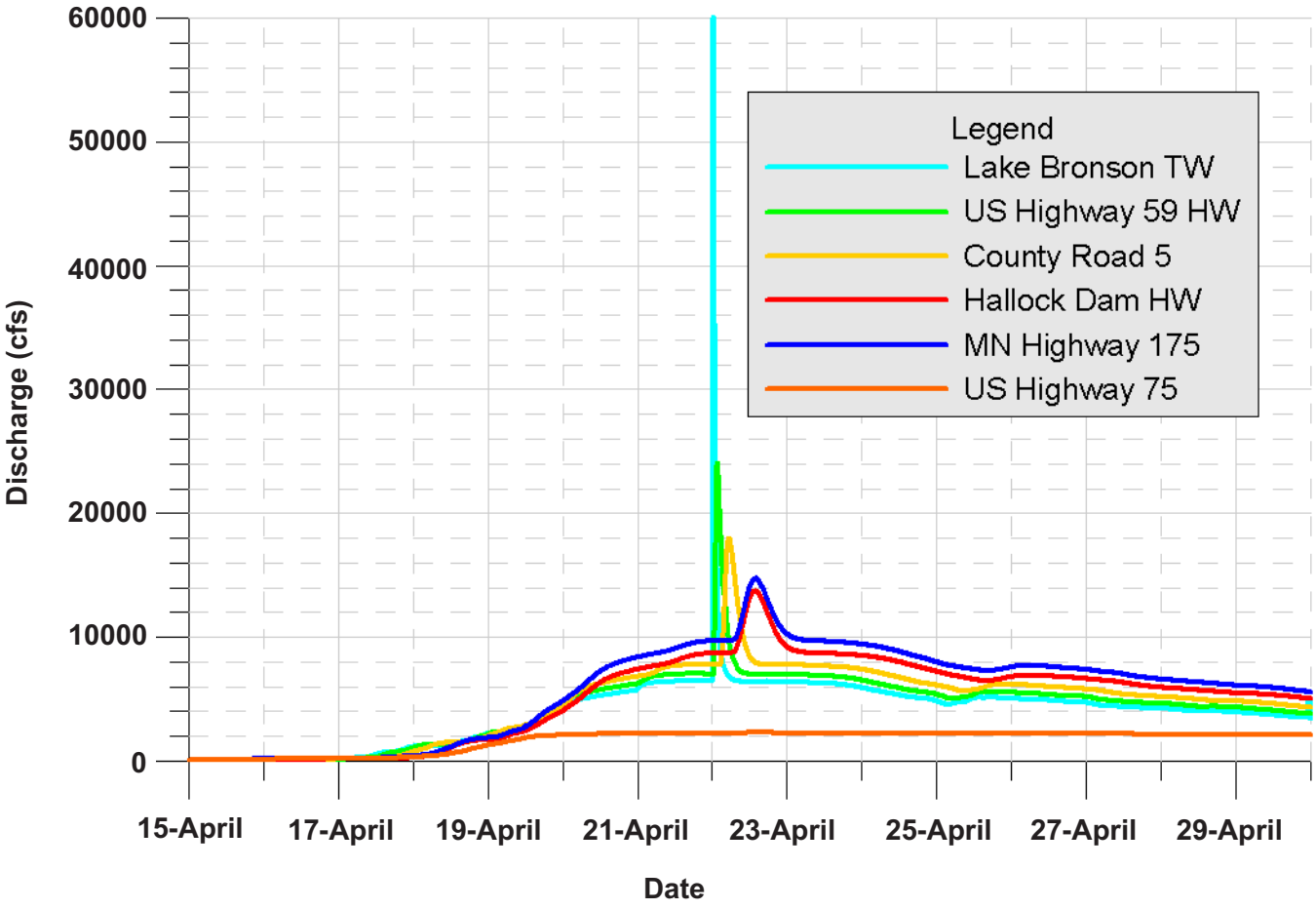


Figure 8b: Scenario 3 - 100-Year Flood with Fast Dam Break

Combined Dam Break and 100-Year Flood Event

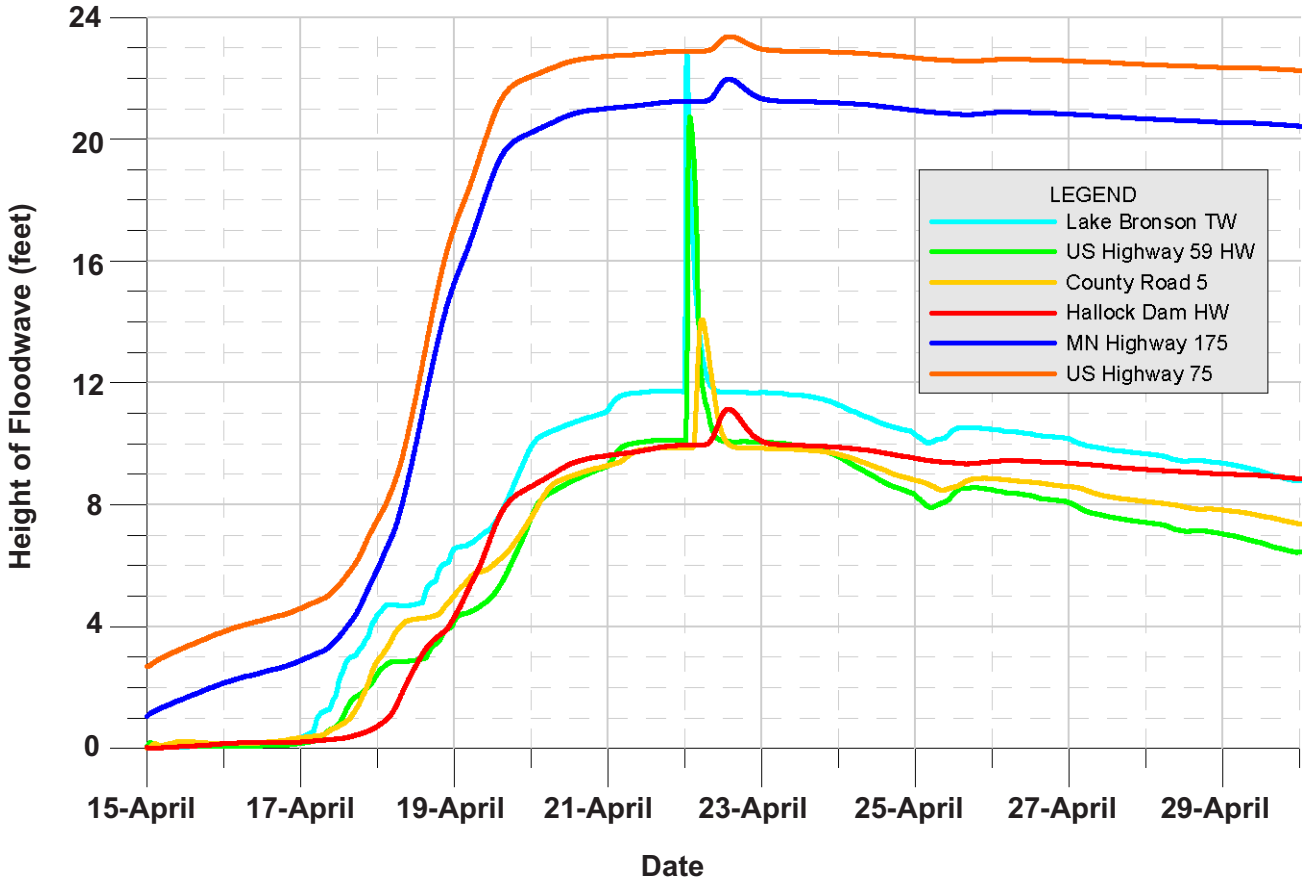


the 100-year flood event and structures that could impede peak flow. These factors combine to make the overall height of the floodwave lower than in Scenario 1, even though the Scenario 3 breach is much larger and the breach time is the same.

Placing the dam break floodwave at the peak of the 100-year flood event allows it to spread out on the flood event as well as flow onto additional floodplain areas, which helps attenuate the wave. Also, due to high water surface elevations at most of the bridges in

Figure 8c: Scenario 3 - 100-Year Flood with Fast Dam Break

Combined Dam Break and 100-Year Flood Event

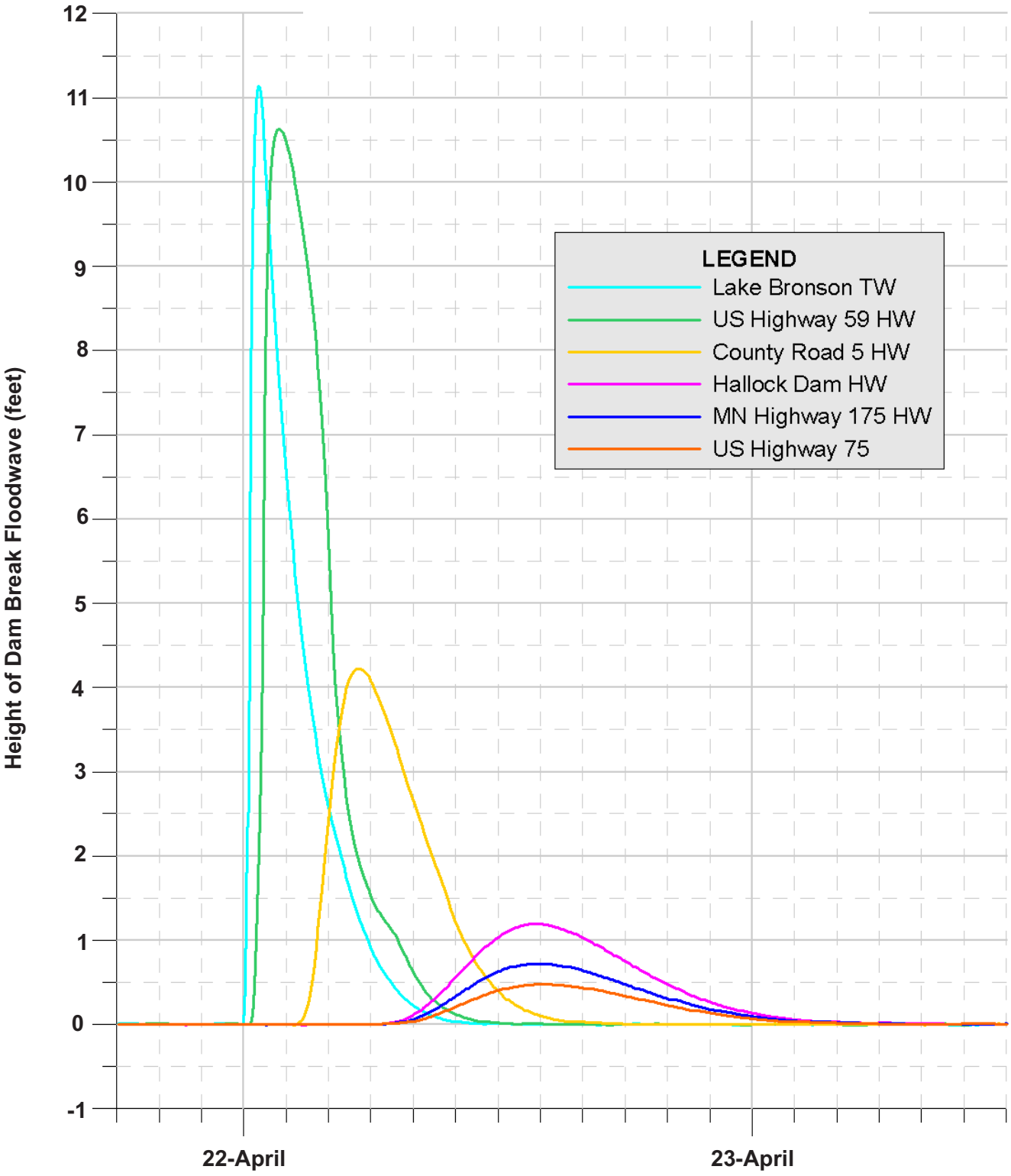


the area of flooding, the floodwave spreads out of the river channel. The dam break peak is further reduced by the action of the bridges on the floodwave. Finally, near the downstream limits of the project area, the remaining combined floodwave results in a significant volume of water leaving the South Branch Two River via the lateral weirs. Water leaving the project area via the lateral weirs will either flow to the Red River of the North through other waterways, or will re-enter the South Branch Two River downstream of the project area.

Appendix C is a profile output table showing the initial and maximum discharge and water surface elevations for all cross sections and structures in Scenario 3. Data is also shown in tabular form in Figure 9, along with the data from the other two dam break scenarios.

Figure 8d: Scenario 3 - 100-Year Flood with Fast Dam Break

Height of Floodwave



Summary Table of the Three Dam Break Scenarios

Figure 9 is a table showing the results for various parameters at the six selected sites during each of the three dam break scenarios. Parameters in the table include water surface elevations, discharge, amplitude of the dam floodwave and travel time of the dam break floodwave to the six selected sites.

Figure 9a lists headwater and tailwater elevations obtained prior to arrival of the dam break floodwave. The elevations in Scenarios 2 and 3 differ significantly, even though they both would occur during a 100-year flood event. The reason for this difference is that Scenario 2 would occur while the 100-year flood event is still building, while Scenario 3 would occur near the peak of the 100-year flood event. For all sites in Scenarios 2 and 3, the elevations are a best estimate as it was often difficult to differentiate rising waters of the 100-year flood event from the first arrivals of the dam break floodwave.

Figure 9b shows the peak headwater and tailwater elevation at each of the six selected sites for each of the three scenarios. In Scenario 1, the peak elevation is due to the dam break. In Scenarios 2 and 3, the peak elevation is a result of the combined 100-year flood event and the dam break floodwave.

Figure 9c shows the amplitude (height) of the dam break floodwave (in feet) for the headwater at each of the six selected sites. The height of the floodwave was determined by running the model without dam break and subtracting that value from the water surface elevation obtained with dam break. Only headwater elevations were calculated using this method. Note that these numbers are very similar to the numbers obtained by subtracting the value in Figure 9b from the respective value in Figure 9a. The slight differences were due to interpolation when determining the value from the hydrographs for Figures 9a and 9b.

Figure 9d shows discharge prior to the arrival of the dam break floodwave, and the peak discharge as a result of the floodwave. Determining the pre-floodwave discharge is very subjective as the value is interpolated from a hydrograph at the same time as the pre-breach headwater elevation shown in Figure 9a. The peak discharge represents the instantaneous value reported by HEC-RAS for the scenario modeled.

Figure 9e shows the approximate travel time of the dam break floodwave. The first time listed is the approximate time to the leading edge of the floodwave, as interpolated from a hydrograph. The second is the time to peak water surface elevation. In several scenarios, the peak discharge occurred up to 30 minutes after peak water surface elevation due to the hydraulic properties of floodwaves.

Figure 9 - Model Comparison			
	SCENARIO 1	**SCENARIO 2**	**SCENARIO 3**
Figure 9a - Pre-breach Headwater / Tailwater Elevations			
Lake Bronson Dam	972.22 / 944.41 ft.	978.16 / 952.00 ft.	978.23 / 957.56 ft.
US Highway 59	935.22 / 931.17 ft.	940.20 / 936.80 ft.	945.82 / 941.02 ft.
County Road 5	856.58 / 856.45 ft.	863.70 / 862.37 ft.	868.65 / 863.65 ft.
Hallock Dam	805.20 / 794.36 ft.	810.20 / 808.59 ft	815.80 / 815.70 ft.
MN Highway 175	792.55 / 792.46 ft.	808.20 / 808.14 ft.	815.30 / 815.21 ft.
US Highway 75	791.09 ft.	807.00 ft.	814.90 ft.
Figure 9b - Peak Floodwave Headwater / Tailwater Elevations			
Lake Bronson Dam	NA / 961.54 ft.	NA / 962.59 ft.	NA / 968.74 ft.
US Highway 59	947.80 / 942.47 ft.	952.24 / 944.68 ft.	956.48 / 949.24 ft.
County Road 5	866.74 / 866.37 ft.	870.72 / 868.90 ft.	872.32 / 870.17 ft.
Hallock Dam	810.36 / 803.45 ft.	816.45 / 816.31 ft	816.94 / 816.78 ft.
MN Highway 175	807.57 / 801.08 ft.	815.88 / 815.46 ft.	815.98 / 815.82 ft.
US Highway 75	804.24 ft.	814.04 ft.	815.37 ft.
Figure 9c - Amplitude of Dam Break Floodwave			
Lake Bronson Dam	17.14 ft.	6.13 ft.	11.16 ft.
US Highway 59	12.59 ft.	7.83 ft.	10.67 ft.
County Road 5	10.24 ft.	3.42 ft.	4.16 ft.
Hallock Dam	5.17 ft.	1.34 ft.	1.20 ft.
MN Highway 175	15.04 ft.	1.06 ft.	0.75 ft.
US Highway 75	16.56 ft.	1.22 ft.	0.48 ft.
Figure 9d - Pre-Floodwave Discharge / Peak Dam Break Floodwave Discharge			
Lake Bronson Dam	15 / 26,130 cfs	1,920 / 14,568 cfs.	6,421 / 60,384 cfs
US Highway 59	16 / 9,802 cfs	2,110 / 13,461 cfs.	7,016 / 24,375 cfs
County Road 5	18 / 6,166 cfs	2,340 / 13,531 cfs.	7,770 / 18,377 cfs
Hallock Dam	18 / 2,900 cfs	2,500 / 11,923 cfs.	8,740 / 13,803 cfs
MN Highway 175	18 / 2,600 cfs	2,700 / 12,843 cfs	9,730 / 14,500 cfs
US Highway 75	18 / 1,047 cfs	3,080 / 9,405 cfs	10,270 / 14,787 cfs
Figure 9e - Floodwave Travel Time: Time to Leading Edge and Peak Floodwave			
Lake Bronson Dam	0:00 / 00:55	00:00 / 02:40	00:00 / 01:30
US Highway 59	00:50 / 01:50	00:30 / 03:55	00:20 / 03:05
County Road 5	05:10 / 06:25	04:00 / 08:00	02:20 / 06:55
Hallock Dam	10:50 / 14:25	07:00 / 13:05	07:20 / 17:50
MN Highway 175	11:30 / 15:45	07:55 / 14:45	08:20 / 18:20
US Highway 75	13:10 / 16:25	09:00 / 15:35	08:20 / 18:45

Inundation Maps

Maps showing the expected areas of inundation, in the cities of Lake Bronson and Hallock, are shown in Appendix E and F. These maps show the approximate areal extremity of inundation that can be expected by the combined 100-year flood event and massive dam break in Scenario 3. Each map is based on a 2003 air photo.

Overlaying each photo are lines representing the approximate FEMA (Federal Emergency Management Agency) 100-Year and 500-Year floodplain limits. The heavy dark blue lines, perpendicular to the river channel, represent the approximate location and length of interpolated cross sections. At one end of the cross section line is a number indicating the station number, which is also the river distance in miles from the downstream most cross section (US Highway 75 in Hallock). The yellow hatching represents the areas that can expect to be flooded during a Scenario 3 dam break.

Conclusions

1. A sunny day dam break, as modeled in Scenario 1 is unlikely to cause any fatalities. The size of the breach modeled in Scenario 1 was large, however, a smaller breach, or a longer breach time, would greatly diminish the discharge and height of the dam break floodwave.

2. The greatest potential for injury in a Scenario 1 dam break would be to individuals in motor vehicles driving on the road over the dam shortly after or during the dam break.

3. A failure of the Lake Bronson Dam has the potential to cause injury and property damage in the city of Lake Bronson. The leading edge of a floodwave would arrive at US Highway 59 in Lake Bronson within 30 to 60 minutes of the breach, while the peak floodwave would arrive in two to four hours, depending on the configuration of the breach and the flows in the river prior to the breach.

4. For the City of Hallock, the leading edge of the floodwave would arrive approximately eight to 13 hours after dam break, and the peak water surface elevation would occur from 13 to 18 hours after dam break. With proper notification, planning, and training, the impacts of a Lake Bronson dam break could be limited to property damage in Hallock. Sufficient times exists to warn and remove potential victims from the expected innundation areas, including the campground near the Hallock Dam.

5. For the three scenarios modeled, the results indicate that the dam break floodwave with the highest amplitude occurs in Scenario 1 but the maximum water surface elevation of this floodwave is lower than those observed in Scenarios 2 and 3. The floodwaves in Scenarios 2 and 3 have smaller amplitudes because they are attenuated by floodplain storage and they would incorporate into the 100-year flood event.

6. Each of the scenarios would pose a significant risk for personal injury and loss of life for any individuals caught in the various floodwaves. The greatest risk observed would be to persons in motor vehicles driving over the dam in Scenario 1 and to persons on the dam in Scenarios 2 and 3. Further downstream, the risk is reduced as the water would rise at a slower rate and adults should be able to avoid the slower rising water.

7. A dam failure at night or on weekends, when the dam is not observed, should be a source of serious concern for the city of Lake Bronson.

8. Several dwellings within the city of Lake Bronson are potentially at risk if the Lake Bronson Dam should fail during a major flood event.

9. It may be desirable to further evaluate the forces on the Canadian National Railroad bridge from a dam break flood wave to determine the likelihood of failure. All three scenarios exceeded the capacity of the bridge, and water surface elevations in Scenarios 2 and 3 exceeded the elevation of the top of the bridge. A copy of this report will be forwarded to the Canadian National Railroad for their review.

10. The threat to public safety could be greatly diminished by using a stream gage with an automatic notification system that would notify concerned individuals of rapidly changing water conditions or very high water elevations. A copy of the *Emergency Notification Contacts* and *Notification Flow Chart* are included in Appendix G and H.

References

Prediction of Embankment Dam Breach Parameters, Dam Safety Office-Water Research Laboratory, July 1998.

"Hydrologic Design for Reservoirs", US Army Corps of Engineers, EM-1110-2-1420

Design of Small Dams, US Department of Interior, Bureau of Reclamation, Washington DC, 1977

Flood Insurance Study for the City of Hallock, Minnesota, U.S. Department of Housing and Urban Development, Federal Insurance Administration, 1979.

Appendix A

HEC-RAS Plan: Plan 05 River: South Fork Two R Reach: Main Channel

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main Channel	37.75	Max WS	15.60	979.00	979.50		979.53	0.007923	1.31	11.90	47.66	0.46
Main Channel	37.75	20APR1996 2400	15.60	979.00	979.50		979.53	0.007923	1.31	11.90	47.66	0.46
Main Channel	37.52	Max WS	34.69	972.00	973.09		973.11	0.001823	1.06	32.74	59.93	0.25
Main Channel	37.52	20APR1996 2400	15.81	972.00	972.86		972.87	0.001365	0.78	20.24	47.12	0.21
Main Channel	37.21	Max WS	30.67	970.00	972.23		972.23	0.000016	0.17	185.74	198.10	0.03
Main Channel	37.21	20APR1996 2400	15.03	970.00	972.22		972.22	0.000004	0.08	184.04	196.15	0.01
Main Channel	36.37	Max WS	12.20	960.00	972.22		972.22	0.000000	0.00	3368.51	590.96	0.00
Main Channel	36.37	20APR1996 2400	15.00	960.00	972.22		972.22	0.000000	0.00	3364.51	590.60	0.00
Main Channel	36	Max WS	11.57	958.00	972.22		972.22	0.000000	0.00	7119.39	1253.70	0.00
Main Channel	36	20APR1996 2400	15.00	958.00	972.22		972.22	0.000000	0.00	7111.13	1252.62	0.00
Main Channel	35.10	Max WS	18.17	950.00	972.22		972.22	0.000000	0.00	16759.58	1104.85	0.00
Main Channel	35.10	20APR1996 2400	15.00	950.00	972.22		972.22	0.000000	0.00	16752.17	1104.65	0.00
Main Channel	34.59	Max WS	700.64	949.00	972.38		972.38	0.000000	0.09	8176.55	685.05	0.00
Main Channel	34.59	20APR1996 2400	15.00	949.00	972.22		972.22	0.000000	0.00	8064.25	680.44	0.00
Main Channel	34.57	Max WS	210.35	949.00	972.43		972.43	0.000000	0.03	8208.99	686.37	0.00
Main Channel	34.57	20APR1996 2400	15.00	949.00	972.22		972.22	0.000000	0.00	8064.25	680.44	0.00
Main Channel	34.565	Max WS	89.65	949.00	972.44		972.44	0.000000	0.01	8216.91	686.69	0.00
Main Channel	34.565	20APR1996 2400	15.00	949.00	972.22		972.22	0.000000	0.00	8064.25	680.44	0.00
Main Channel	34.562	Max WS	15.41	949.00	972.45		972.45	0.000000	0.00	8221.69	686.89	0.00
Main Channel	34.562	20APR1996 2400	15.01	949.00	972.22		972.22	0.000000	0.00	8064.25	680.44	0.00
Main Channel	34.561	Max WS	-12.44	949.00	972.45	949.40	972.45	0.000000	0.00	8223.58	686.97	0.00
Main Channel	34.561	20APR1996 2400	15.01	949.00	972.22	949.43	972.22	0.000000	0.00	8064.25	680.44	0.00
Main Channel	34.56		Inl Struct									
Main Channel	34.559	Max WS	14472.20	944.00	961.55		961.59	0.000080	1.58	9146.29	879.86	0.09
Main Channel	34.559	20APR1996 2400	15.01	944.00	944.62		944.66	0.007455	1.47	10.19	32.70	0.47
Main Channel	34.558	Max WS	14499.54	944.00	961.55		961.59	0.000081	1.59	9145.97	879.85	0.09
Main Channel	34.558	20APR1996 2400	17.17	944.00	944.60		944.65	0.011529	1.79	9.57	31.69	0.58
Main Channel	34.55	Max WS	14560.20	943.65	961.55		961.58	0.000073	1.54	9454.60	883.30	0.08
Main Channel	34.55	20APR1996 2400	17.36	943.65	944.40		944.42	0.003674	1.17	14.82	39.44	0.34
Main Channel	34.54	Max WS	14499.86	943.40	961.55		961.58	0.000067	1.50	9674.82	885.75	0.08
Main Channel	34.54	20APR1996 2400	15.41	943.40	944.31		944.32	0.001052	0.71	21.65	47.67	0.19
Main Channel	34.53	Max WS	14382.96	943.00	961.50		961.57	0.000235	2.20	6562.26	879.39	0.14
Main Channel	34.53	20APR1996 2400	15.43	943.00	944.26		944.27	0.000737	0.74	20.85	33.08	0.16
Main Channel	34.34	Max WS	14376.83	942.50	961.48		961.50	0.000028	1.12	12867.46	960.20	0.05
Main Channel	34.34	20APR1996 2400	15.14	942.50	943.55		943.56	0.000268	0.40	38.16	72.40	0.10
Main Channel	34.01	Max WS	14337.63	941.00	961.29		961.38	0.000198	2.44	5874.96	588.15	0.14
Main Channel	34.01	20APR1996 2400	15.03	941.00	943.38		943.38	0.000038	0.26	58.90	49.50	0.04
Main Channel	33.92	Max WS	13912.61	942.00	960.96		961.24	0.000522	4.27	3265.77	303.63	0.22
Main Channel	33.92	20APR1996 2400	15.48	942.00	943.26		943.27	0.001082	0.89	17.32	27.56	0.20
Main Channel	33.86	Max WS	13825.98	941.00	960.82		961.08	0.000489	4.21	4637.31	846.23	0.22
Main Channel	33.86	20APR1996 2400	15.03	941.00	943.09		943.09	0.000240	0.59	25.68	24.62	0.10
Main Channel	33.43	Max WS	13276.79	941.00	959.39		959.66	0.000844	4.18	3175.99	414.49	0.27
Main Channel	33.43	20APR1996 2400	15.57	941.00	942.23		942.25	0.001734	1.11	14.00	22.81	0.25
Main Channel	33.18	Max WS	12852.56	940.00	958.08		958.43	0.001140	4.74	2710.75	366.01	0.31
Main Channel	33.18	20APR1996 2400	15.04	940.00	941.26		941.26	0.000074	0.33	45.56	42.88	0.06
Main Channel	32.91	Max WS	12098.82	940.00	956.59		956.96	0.000869	4.90	2468.53	257.53	0.28
Main Channel	32.91	20APR1996 2400	17.54	940.00	940.70		940.71	0.001760	0.84	20.79	52.19	0.24

HEC-RAS Plan: Plan 05 River: South Fork Two R Reach: Main Channel (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Main Channel	32.43	Max WS	10335.73	936.00	954.62		954.83	0.000703	3.75	2753.03	367.20	0.24
Main Channel	32.43	20APR1996 2400	15.95	936.00	937.73		937.74	0.000594	0.81	19.62	22.74	0.15
Main Channel	32.02	Max WS	10019.00	935.50	953.66		953.76	0.000318	2.51	3998.62	541.64	0.16
Main Channel	32.02	20APR1996 2400	15.05	935.50	937.03		937.03	0.000040	0.22	68.86	76.84	0.04
Main Channel	32.005	Max WS	10021.78	935.35	953.64	942.57	953.74	0.000319	2.51	3990.13	539.99	0.16
Main Channel	32.005	20APR1996 2400	15.03	935.35	937.02	935.80	937.02	0.000032	0.20	73.43	76.77	0.04
Main Channel	32.00		Bridge									
Main Channel	31.995	Max WS	9955.82	935.15	953.20		953.33	0.000428	2.81	3545.37	503.76	0.19
Main Channel	31.995	20APR1996 2400	15.00	935.15	937.02		937.02	0.000007	0.12	126.25	93.69	0.02
Main Channel	31.98	Max WS	9949.75	935.00	953.17		953.29	0.000430	2.81	3535.35	501.53	0.19
Main Channel	31.98	20APR1996 2400	14.99	935.00	937.02		937.02	0.000006	0.11	132.48	93.68	0.02
Main Channel	31.74	Max WS	9684.88	936.00	952.20		952.53	0.001228	4.60	2147.94	318.10	0.31
Main Channel	31.74	20APR1996 2400	15.56	936.00	936.86		936.87	0.001107	0.71	22.05	51.00	0.19
Main Channel	31.06	Max WS	9802.98	932.00	947.74		948.14	0.001282	5.11	1919.07	251.65	0.33
Main Channel	31.06	20APR1996 2400	15.01	932.00	935.21		935.21	0.000004	0.10	147.92	87.61	0.01
Main Channel	31.00	Max WS	9803.10	931.50	947.80		947.94	0.000322	3.00	3269.73	340.45	0.17
Main Channel	31.00	20APR1996 2400	14.99	931.50	935.21		935.21	0.000001	0.05	297.21	144.34	0.01
Main Channel	30.995	Max WS	9803.07	931.25	947.80	938.14	947.94	0.000301	2.92	3355.04	345.54	0.17
Main Channel	30.995	20APR1996 2400	15.00	931.25	935.21	931.73	935.21	0.000000	0.04	333.74	147.96	0.01
Main Channel	30.99		Inl Struct									
Main Channel	30.985	Max WS	9787.24	930.90	942.50		944.22	0.006691	10.51	931.09	141.23	0.72
Main Channel	30.985	20APR1996 2400	15.00	930.90	931.38		931.40	0.002428	1.02	14.78	35.55	0.28
Main Channel	30.98	Max WS	9779.96	930.85	942.12		944.04	0.007771	11.10	880.87	137.66	0.77
Main Channel	30.98	20APR1996 2400	16.73	930.85	931.33		931.35	0.003109	1.14	14.64	35.50	0.31
Main Channel	30.94	Max WS	9752.70	930.00	941.82		942.88	0.003353	8.26	1180.51	154.38	0.53
Main Channel	30.94	20APR1996 2400	25.77	930.00	930.48	930.57	930.76	0.087467	4.24	6.07	25.24	1.53
Main Channel	30.69	Max WS	9504.36	925.50	939.71		940.01	0.001280	4.40	2158.72	356.18	0.32
Main Channel	30.69	20APR1996 2400	15.54	925.50	926.71		926.72	0.001480	1.02	15.26	25.25	0.23
Main Channel	29.81	Max WS	7832.30	921.00	936.54		936.61	0.000232	2.24	3491.66	438.95	0.14
Main Channel	29.81	20APR1996 2400	15.00	921.00	923.49		923.49	0.000003	0.10	155.39	83.35	0.01
Main Channel	28.91	Max WS	7707.71	922.00	935.03		935.23	0.000541	3.58	2155.61	253.52	0.22
Main Channel	28.91	20APR1996 2400	15.31	922.00	923.21		923.22	0.000570	0.65	23.52	37.34	0.14
Main Channel	28.22	Max WS	7659.35	920.00	932.06		932.42	0.001163	4.84	1584.06	210.57	0.31
Main Channel	28.22	20APR1996 2400	15.83	920.00	921.04		921.05	0.000853	0.71	22.14	41.30	0.17
Main Channel	27.27	Max WS	7614.84	916.00	925.62		926.02	0.001749	5.10	1493.25	250.03	0.37
Main Channel	27.27	20APR1996 2400	15.84	916.00	916.85		916.86	0.002013	0.94	16.83	39.61	0.25
Main Channel	25.70	Max WS	7236.74	901.00	913.16		913.44	0.000776	4.26	1699.57	201.09	0.26
Main Channel	25.70	20APR1996 2400	15.13	901.00	901.96		901.96	0.000580	0.55	27.61	57.53	0.14
Main Channel	23.91	Max WS	6855.64	895.00	906.18		906.46	0.001022	4.29	1598.08	230.03	0.29
Main Channel	23.91	20APR1996 2400	14.98	895.00	896.00		896.01	0.000680	0.61	24.58	49.18	0.15
Main Channel	23.39	Max WS	6815.90	893.00	903.37		903.75	0.001736	4.97	1371.30	236.94	0.36
Main Channel	23.39	20APR1996 2400	16.07	893.00	893.80		893.81	0.001765	0.85	18.98	47.47	0.24
Main Channel	22.11	Max WS	6686.60	882.00	893.70		894.01	0.001219	4.47	1496.74	231.81	0.31
Main Channel	22.11	20APR1996 2400	15.23	882.00	882.94		882.95	0.001102	0.75	20.40	43.29	0.19
Main Channel	21.20	Max WS	6510.67	876.25	887.36		887.65	0.001675	4.27	1523.70	321.31	0.35
Main Channel	21.20	20APR1996 2400	15.43	876.25	877.22		877.24	0.001537	0.95	16.16	30.39	0.23

HEC-RAS Plan: Plan 05 River: South Fork Two R Reach: Main Channel (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Main Channel	21.18	Max WS	6416.20	876.15	886.43		887.53	0.003812	8.38	765.47	106.31	0.55
Main Channel	21.18	20APR1996 2400	17.48	876.15	877.03		877.05	0.003503	1.32	13.27	28.57	0.34
Main Channel	21.175	Max WS	6420.16	876.05	886.41	883.66	887.48	0.003700	8.30	773.29	106.50	0.54
Main Channel	21.175	20APR1996 2400	18.57	876.05	876.86	876.64	876.90	0.006278	1.64	11.34	27.28	0.45
Main Channel	21.17		Bridge									
Main Channel	21.165	Max WS	6378.47	875.55	886.19		887.22	0.003548	8.14	783.23	107.68	0.53
Main Channel	21.165	20APR1996 2400	17.85	875.55	876.35		876.42	0.011382	2.14	8.33	20.91	0.60
Main Channel	21.16	Max WS	6386.51	875.30	886.21		887.17	0.003200	7.87	811.19	108.45	0.51
Main Channel	21.16	20APR1996 2400	16.55	875.30	876.16		876.21	0.006476	1.70	9.73	22.59	0.46
Main Channel	21.14	Max WS	6454.92	875.00	886.79		887.00	0.001105	3.70	1746.34	335.11	0.29
Main Channel	21.14	20APR1996 2400	15.48	875.00	876.07		876.08	0.000921	0.80	19.34	32.28	0.18
Main Channel	20.67	Max WS	6356.11	873.00	884.97		885.18	0.000700	3.65	1741.77	242.02	0.24
Main Channel	20.67	20APR1996 2400	15.40	873.00	873.89		873.90	0.000696	0.57	26.93	60.35	0.15
Main Channel	19.84	Max WS	6312.00	870.00	879.71		880.15	0.002090	5.34	1183.04	211.30	0.40
Main Channel	19.84	20APR1996 2400	15.67	870.00	870.86		870.88	0.001968	0.94	16.65	38.54	0.25
Main Channel	19.13	Max WS	6280.66	863.00	872.81		873.10	0.002192	4.32	1455.44	371.72	0.38
Main Channel	19.13	20APR1996 2400	15.49	863.00	863.91		863.93	0.002169	1.02	15.16	33.34	0.27
Main Channel	18.40	Max WS	6158.85	855.25	866.99		867.13	0.000915	2.98	2063.33	475.68	0.25
Main Channel	18.40	20APR1996 2400	15.19	855.25	856.70		856.71	0.000558	0.71	21.50	29.64	0.15
Main Channel	18.35	Max WS	6152.58	855.10	866.74	862.22	866.88	0.000962	3.05	2016.08	466.76	0.26
Main Channel	18.35	20APR1996 2400	15.28	855.10	856.56	855.77	856.57	0.000545	0.70	21.79	29.83	0.14
Main Channel	18.33		Bridge									
Main Channel	18.30	Max WS	6143.74	854.95	866.42		866.57	0.001049	3.17	1936.45	451.31	0.27
Main Channel	18.30	20APR1996 2400	15.23	854.95	856.43		856.44	0.000508	0.68	22.33	30.20	0.14
Main Channel	18.20	Max WS	6135.10	854.75	865.77		865.96	0.001310	3.52	1744.78	411.77	0.30
Main Channel	18.20	20APR1996 2400	15.25	854.75	856.12		856.13	0.000771	0.80	19.11	27.94	0.17
Main Channel	17.77	Max WS	6106.19	851.00	862.79	858.03	862.98	0.001272	3.49	1749.02	407.34	0.30
Main Channel	17.77	20APR1996 2400	15.23	851.00	852.29	851.61	852.30	0.000567	0.72	21.15	28.64	0.15
Main Channel	17.76		Bridge									
Main Channel	17.29	Max WS	6033.95	850.00	858.26		858.49	0.001796	3.83	1574.61	413.93	0.35
Main Channel	17.29	20APR1996 2400	17.64	850.00	850.53		850.54	0.001872	0.69	25.53	90.58	0.23
Main Channel	16.91	Max WS	5871.45	845.00	856.35		856.40	0.000330	1.84	3218.56	758.25	0.15
Main Channel	16.91	20APR1996 2400	15.01	845.00	846.88		846.89	0.000082	0.37	40.19	34.22	0.06
Main Channel	16.87	Max WS	5865.50	845.00	856.27		856.33	0.000348	1.87	3163.68	755.31	0.16
Main Channel	16.87	20APR1996 2400	15.00	845.00	846.87		846.87	0.000086	0.38	39.59	34.07	0.06
Main Channel	16.79	Max WS	5854.30	845.00	856.12		856.17	0.000391	1.94	3044.51	748.91	0.16
Main Channel	16.79	20APR1996 2400	15.00	845.00	846.83		846.83	0.000095	0.39	38.29	33.74	0.06
Main Channel	16.29	Max WS	5815.47	845.00	854.24		854.46	0.002124	3.76	1547.94	475.41	0.37
Main Channel	16.29	20APR1996 2400	15.06	845.00	846.01		846.03	0.001669	0.97	15.56	30.50	0.24
Main Channel	15.36	Max WS	5256.06	837.00	849.37		849.73	0.000849	4.83	1473.62	452.08	0.27
Main Channel	15.36	20APR1996 2400	15.18	837.00	838.16		838.16	0.000311	0.49	31.19	48.64	0.11
Main Channel	14.80	Max WS	5151.55	836.00	848.39		848.46	0.000210	2.20	2809.69	576.02	0.13
Main Channel	14.80	20APR1996 2400	15.01	836.00	837.72		837.72	0.000022	0.19	78.77	69.58	0.03
Main Channel	14.41	Max WS	5137.42	836.00	847.69		847.83	0.000470	3.05	1778.06	300.24	0.20
Main Channel	14.41	20APR1996 2400	15.02	836.00	837.62		837.63	0.000076	0.32	47.10	47.82	0.06

HEC-RAS Plan: Plan 05 River: South Fork Two R Reach: Main Channel (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main Channel	14.10	Max WS	5125.65	836.00	846.14		846.52	0.001553	4.91	1090.33	253.92	0.35
Main Channel	14.10	20APR1996 2400	15.10	836.00	837.43		837.43	0.000169	0.44	34.55	39.91	0.08
Main Channel	14.06	Max WS	5115.12	836.00	845.56		846.09	0.002733	5.83	893.82	225.78	0.45
Main Channel	14.06	20APR1996 2400	15.35	836.00	837.25		837.27	0.001845	1.21	12.64	18.88	0.26
Main Channel	14.03	Max WS	5115.80	836.00	845.47		845.77	0.001329	4.39	1173.91	237.88	0.32
Main Channel	14.03	20APR1996 2400	15.19	836.00	837.02		837.03	0.000629	0.60	25.22	48.28	0.15
Main Channel	13.90	Max WS	5112.03	835.00	845.23		845.30	0.000235	2.17	2785.22	510.34	0.14
Main Channel	13.90	20APR1996 2400	15.09	835.00	836.35		836.36	0.000095	0.30	51.02	68.85	0.06
Main Channel	13.67	Max WS	5109.42	835.00	843.99		844.36	0.002284	4.83	1057.95	234.98	0.40
Main Channel	13.67	20APR1996 2400	15.76	835.00	835.86		835.87	0.002059	0.96	16.44	38.30	0.26
Main Channel	13.32	Max WS	5103.17	831.75	839.92		840.24	0.002096	4.59	1111.50	249.87	0.38
Main Channel	13.32	20APR1996 2400	17.03	831.75	832.33		832.35	0.003882	1.26	13.55	33.85	0.35
Main Channel	13.16	Max WS	5102.03	831.00	839.66		839.97	0.001979	4.47	1140.80	255.32	0.37
Main Channel	13.16	20APR1996 2400	15.88	831.00	831.89		831.90	0.001798	0.92	17.33	38.92	0.24
Main Channel	12.64	Max WS	5032.48	826.50	835.18		835.44	0.001085	4.08	1235.24	216.51	0.29
Main Channel	12.64	20APR1996 2400	15.54	826.50	827.40		827.42	0.001573	0.87	17.93	39.70	0.23
Main Channel	11.93	Max WS	4917.54	821.00	832.41		832.60	0.000477	3.59	2065.46	433.08	0.21
Main Channel	11.93	20APR1996 2400	15.05	821.00	822.33		822.33	0.000119	0.34	44.02	56.60	0.07
Main Channel	11.33	Max WS	4844.52	820.00	829.95		830.25	0.001990	4.40	1099.84	251.98	0.37
Main Channel	11.33	20APR1996 2400	15.47	820.00	821.21		821.23	0.001736	1.10	14.03	23.18	0.25
Main Channel	10.85	Max WS	4506.13	816.00	827.77		827.93	0.000396	3.19	1569.87	273.17	0.19
Main Channel	10.85	20APR1996 2400	15.01	816.00	819.10		819.10	0.000004	0.10	152.07	101.21	0.01
Main Channel	10.45	Max WS	4459.04	818.00	827.45		827.49	0.000276	1.63	2785.01	687.99	0.14
Main Channel	10.45	20APR1996 2400	15.05	818.00	818.98		818.99	0.000524	0.53	28.45	58.03	0.13
Main Channel	9.80	Max WS	4418.50	816.00	826.09		826.28	0.000809	3.43	1340.02	320.19	0.25
Main Channel	9.80	20APR1996 2400	15.08	816.00	817.44		817.44	0.000312	0.53	28.70	39.91	0.11
Main Channel	9.73	Max WS	4416.12	816.00	825.74	821.74	825.95	0.000996	3.66	1232.57	287.25	0.27
Main Channel	9.73	20APR1996 2400	15.19	816.00	817.28	816.59	817.29	0.000578	0.66	22.90	35.65	0.15
Main Channel	9.71		Bridge									
Main Channel	9.69	Max WS	4413.60	816.00	825.47		825.70	0.001177	3.84	1158.45	262.12	0.30
Main Channel	9.69	20APR1996 2400	15.24	816.00	817.11		817.12	0.001294	0.90	16.96	30.69	0.21
Main Channel	9.03	Max WS	4284.31	811.00	821.70		821.91	0.000655	3.66	1268.58	271.64	0.23
Main Channel	9.03	20APR1996 2400	14.90	811.00	812.86		812.86	0.000035	0.24	62.11	53.83	0.04
Main Channel	8.23	Max WS	4097.08	811.00	819.90		819.99	0.000929	2.45	1670.92	522.52	0.24
Main Channel	8.23	20APR1996 2400	15.03	811.00	812.01		812.02	0.001825	1.01	14.91	29.37	0.25
Main Channel	7.59	Max WS	4030.53	805.00	818.43	811.20	818.60	0.000434	3.29	1226.84	135.71	0.19
Main Channel	7.59	20APR1996 2400	15.01	805.00	808.87	805.58	808.87	0.000002	0.10	156.61	73.35	0.01
Main Channel	7.58		Bridge									
Main Channel	7.57	Max WS	4027.42	805.76	818.38		818.55	0.000455	3.33	1208.45	135.46	0.20
Main Channel	7.57	20APR1996 2400	15.01	805.76	808.87		808.87	0.000003	0.10	145.35	73.33	0.01
Main Channel	7.22	Max WS	4022.00	807.50	817.79		817.90	0.000951	2.73	1471.31	397.91	0.25
Main Channel	7.22	20APR1996 2400	15.33	807.50	808.74		808.75	0.000570	0.64	23.81	38.42	0.14
Main Channel	7.09	Max WS	3998.15	807.00	815.87		817.06	0.005802	8.73	457.94	81.68	0.65
Main Channel	7.09	20APR1996 2400	15.45	807.00	808.24		808.26	0.002098	1.23	12.58	20.36	0.28
Main Channel	6.94	Max WS	3814.26	806.00	814.49		814.66	0.000594	3.37	1295.48	235.04	0.22
Main Channel	6.94	20APR1996 2400	16.41	806.00	806.69		806.70	0.001611	0.73	22.35	64.64	0.22

HEC-RAS Plan: Plan 05 River: South Fork Two R Reach: Main Channel (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main Channel	6.93	Max WS	3806.38	806.00	814.46		814.63	0.000600	3.38	1287.93	234.47	0.22
Main Channel	6.93	20APR1996 2400	12.40	806.00	806.62		806.63	0.001647	0.69	17.96	57.95	0.22
Main Channel	6.925	Max WS	3805.74	805.75	814.45	809.68	814.61	0.000535	3.26	1346.07	238.84	0.21
Main Channel	6.925	20APR1996 2400	24.02	805.75	806.49	806.19	806.50	0.002412	0.94	25.56	69.12	0.27
Main Channel	6.92		Bridge									
Main Channel	6.915	Max WS	3786.71	804.45	814.37		814.53	0.000487	3.17	1334.06	228.57	0.20
Main Channel	6.915	20APR1996 2400	15.70	804.45	805.31		805.33	0.002406	1.04	15.11	35.04	0.28
Main Channel	6.91	Max WS	3787.42	804.20	814.37		814.52	0.000437	3.07	1391.06	232.96	0.19
Main Channel	6.91	20APR1996 2400	14.55	804.20	805.28		805.29	0.000616	0.61	23.80	43.98	0.15
Main Channel	6.90	Max WS	3785.42	804.20	814.35		814.49	0.000441	3.07	1385.62	232.54	0.19
Main Channel	6.90	20APR1996 2400	15.32	804.20	805.25		805.25	0.000815	0.69	22.27	42.54	0.17
Main Channel	6.79	Max WS	3746.90	801.00	814.20		814.30	0.000239	2.55	1616.77	229.87	0.15
Main Channel	6.79	20APR1996 2400	15.01	801.00	805.21		805.21	0.000001	0.07	206.68	96.04	0.01
Main Channel	5.78	Max WS	3179.65	801.00	812.83		812.91	0.000308	2.17	1463.44	238.99	0.15
Main Channel	5.78	20APR1996 2400	15.00	801.00	805.20		805.20	0.000001	0.06	234.14	97.31	0.01
Main Channel	4.88	Max WS	2937.14	801.00	812.01		812.03	0.000083	1.20	2548.41	466.09	0.08
Main Channel	4.88	20APR1996 2400	15.00	801.00	805.20		805.20	0.000000	0.04	409.63	175.24	0.00
Main Channel	4.86	Max WS	2939.68	800.25	812.00	804.68	812.02	0.000081	1.19	2567.94	465.69	0.08
Main Channel	4.86	20APR1996 2400	14.99	800.25	805.20	800.78	805.20	0.000000	0.03	433.00	175.24	0.00
Main Channel	4.85		Bridge									
Main Channel	4.84	Max WS	2936.01	799.75	811.97		811.99	0.000080	1.18	2571.17	464.38	0.08
Main Channel	4.84	20APR1996 2400	15.00	799.75	805.20		805.20	0.000000	0.03	448.58	175.24	0.00
Main Channel	4.82	Max WS	2935.44	801.00	811.96		811.99	0.000085	1.20	2527.95	463.93	0.08
Main Channel	4.82	20APR1996 2400	15.00	801.00	805.20		805.20	0.000000	0.04	409.63	175.24	0.00
Main Channel	4.45	Max WS	2914.12	801.00	811.83		811.85	0.000057	1.06	2882.37	523.58	0.07
Main Channel	4.45	20APR1996 2400	15.00	801.00	805.20		805.20	0.000001	0.03	432.41	304.91	0.01
Main Channel	3.45	Max WS	2902.04	801.00	811.12		811.19	0.000278	2.06	1425.18	263.57	0.15
Main Channel	3.45	20APR1996 2400	15.02	801.00	805.19		805.19	0.000002	0.07	224.62	153.95	0.01
Main Channel	3.34	Max WS	2902.26	801.00	811.10		811.11	0.000058	1.01	2894.59	462.64	0.07
Main Channel	3.34	20APR1996 2400	14.99	801.00	805.19		805.19	0.000000	0.03	565.58	344.65	0.00
Main Channel	3.27	Max WS	2901.92	801.00	810.87		811.01	0.000615	2.95	984.00	169.21	0.22
Main Channel	3.27	20APR1996 2400	15.00	801.00	805.19		805.19	0.000001	0.06	253.85	103.31	0.01
Main Channel	3.18	Max WS	2901.32	801.00	810.61		810.71	0.000551	2.60	1125.94	251.33	0.20
Main Channel	3.18	20APR1996 2400	15.01	801.00	805.19		805.19	0.000004	0.09	166.54	125.05	0.01
Main Channel	3.05	Max WS	2900.77	801.00	810.44		810.49	0.000182	1.88	2194.78	470.72	0.12
Main Channel	3.05	20APR1996 2400	14.98	801.00	805.19		805.19	0.000000	0.04	409.74	211.35	0.00
Main Channel	2.99	Max WS	2900.51	801.00	810.36	805.06	810.43	0.000227	2.11	1851.11	376.24	0.14
Main Channel	2.99	20APR1996 2400	15.00	801.00	805.19	801.43	805.19	0.000000	0.04	385.58	188.31	0.00
Main Channel	2.96		Inl Struct									
Main Channel	2.92	Max WS	1062.02	793.00	807.60		807.61	0.000012	0.58	1903.49	230.40	0.03
Main Channel	2.92	20APR1996 2400	15.00	793.00	794.37		794.38	0.000288	0.47	32.03	49.88	0.10
Main Channel	2.71	Max WS	1056.32	793.00	807.60		807.60	0.000006	0.38	2811.34	341.38	0.02
Main Channel	2.71	20APR1996 2400	15.32	793.00	793.92		793.93	0.001090	0.73	20.95	45.43	0.19
Main Channel	2.40	Max WS	1053.22	791.00	807.59		807.59	0.000006	0.45	2398.29	252.71	0.02
Main Channel	2.40	20APR1996 2400	14.92	791.00	793.09		793.09	0.000066	0.31	48.66	47.12	0.05
Main Channel	2.11	Max WS	1052.13	791.58	807.57		807.58	0.000015	0.67	1887.33	332.03	0.04

HEC-RAS Plan: Plan 05 River: South Fork Two R Reach: Main Channel (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main Channel	2.11	20APR1996 2400	15.20	791.58	792.69		792.70	0.000883	0.83	18.40	28.23	0.18
Main Channel	2.08	Max WS	1046.84	791.48	807.57	794.90	807.58	0.000014	0.66	1911.80	343.41	0.04
Main Channel	2.08	20APR1996 2400	15.14	791.48	792.54	791.99	792.56	0.001083	0.89	17.04	27.35	0.20
Main Channel	2.07		Bridge									
Main Channel	2.06	Max WS	1047.16	791.23	807.57		807.57	0.000013	0.65	1974.02	372.34	0.03
Main Channel	2.06	20APR1996 2400	15.23	791.23	792.47		792.48	0.000532	0.69	22.18	30.72	0.14
Main Channel	2.01	Max WS	1050.05	791.00	807.57		807.57	0.000006	0.35	3071.63	449.05	0.02
Main Channel	2.01	20APR1996 2400	15.43	791.00	792.28		792.29	0.001020	0.88	17.56	27.43	0.19
Main Channel	1.12	Max WS	1048.48	786.50	807.55		807.56	0.000003	0.42	4304.04	641.27	0.02
Main Channel	1.12	20APR1996 2400	15.01	786.50	790.99		790.99	0.000001	0.07	205.36	72.33	0.01
Main Channel	0.02	Max WS	1047.89	788.75	807.54		807.54	0.000003	0.32	3527.77	482.53	0.02
Main Channel	0.02	20APR1996 2400	14.99	788.75	790.98		790.98	0.000004	0.09	160.28	103.04	0.01
Main Channel	0.00	Max WS	1047.60	788.50	807.54	790.71	807.54	0.000003	0.32	3545.15	482.51	0.02
Main Channel	0.00	20APR1996 2400	15.49	788.50	790.98	788.87	790.98	0.000003	0.09	177.70	103.03	0.01

Appendix B

HEC-RAS Plan: Plan 06 River: South Fork Two R Reach: Main Channel

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main Channel	37.75	Max WS	6442.31	975.00	983.08		983.64	0.002969	7.10	1921.89	613.94	0.49
Main Channel	37.75	14APR1996 2400	115.50	975.00	976.76		976.85	0.004686	2.34	49.46	56.10	0.44
Main Channel	37.52	Max WS	6441.94	972.00	980.50		980.88	0.001422	5.13	1656.18	358.38	0.34
Main Channel	37.52	14APR1996 2400	87.28	972.00	973.76		973.78	0.000901	1.02	85.20	96.67	0.19
Main Channel	37.21	Max WS	6441.47	970.00	979.22		979.30	0.000366	2.90	5010.93	992.92	0.18
Main Channel	37.21	14APR1996 2400	118.34	970.00	972.83		972.84	0.000057	0.42	347.90	335.79	0.05
Main Channel	36.37	Max WS	6439.93	960.00	978.40		978.41	0.000021	0.84	8757.63	1211.12	0.04
Main Channel	36.37	14APR1996 2400	80.47	960.00	972.74		972.74	0.000000	0.02	3679.12	618.28	0.00
Main Channel	36	Max WS	6438.96	958.00	978.38		978.39	0.000005	0.43	16092.99	1573.35	0.02
Main Channel	36	14APR1996 2400	118.67	958.00	972.74		972.74	0.000000	0.02	7788.44	1338.36	0.00
Main Channel	35.10	Max WS	6434.18	950.00	978.37		978.37	0.000001	0.27	25758.55	1940.87	0.01
Main Channel	35.10	14APR1996 2400	81.82	950.00	972.74		972.74	0.000000	0.00	17332.08	1120.21	0.00
Main Channel	34.59	Max WS	6428.91	949.00	978.36		978.37	0.000004	0.49	17335.83	2992.79	0.02
Main Channel	34.59	14APR1996 2400	116.93	949.00	972.74		972.74	0.000000	0.01	8424.21	695.10	0.00
Main Channel	34.57	Max WS	6429.37	949.00	978.36		978.37	0.000004	0.49	17334.73	2992.79	0.02
Main Channel	34.57	14APR1996 2400	99.04	949.00	972.74		972.74	0.000000	0.01	8423.28	695.06	0.00
Main Channel	34.565	Max WS	6429.34	949.00	978.36		978.37	0.000004	0.49	17334.37	2992.79	0.02
Main Channel	34.565	14APR1996 2400	96.83	949.00	972.74		972.74	0.000000	0.01	8423.11	695.05	0.00
Main Channel	34.562	Max WS	6428.67	949.00	978.36		978.37	0.000004	0.49	17334.00	2992.79	0.02
Main Channel	34.562	14APR1996 2400	99.07	949.00	972.74		972.74	0.000000	0.01	8423.11	695.05	0.00
Main Channel	34.561	Max WS	6429.29	949.00	978.36	954.67	978.37	0.000004	0.49	17334.00	2992.79	0.02
Main Channel	34.561	14APR1996 2400	99.94	949.00	972.74	949.92	972.74	0.000000	0.01	8423.11	695.05	0.00
Main Channel	34.56		Inl Struct									
Main Channel	34.5599	Max WS	6429.05	944.00	957.58		957.60	0.000071	1.12	5729.83	841.83	0.08
Main Channel	34.5599	14APR1996 2400	99.94	944.00	945.90		945.91	0.000875	1.06	93.94	98.50	0.19
Main Channel	34.559	Max WS	6429.04	944.00	957.58		957.60	0.000071	1.12	5729.47	841.82	0.08
Main Channel	34.559	14APR1996 2400	100.19	944.00	945.89		945.91	0.000890	1.07	93.51	98.28	0.19
Main Channel	34.558	Max WS	6429.04	944.00	957.58		957.60	0.000071	1.12	5729.21	841.82	0.08
Main Channel	34.558	14APR1996 2400	100.43	944.00	945.89		945.91	0.000906	1.08	93.06	98.05	0.20
Main Channel	34.55	Max WS	6428.90	943.65	957.58		957.59	0.000060	1.07	6023.68	845.11	0.07
Main Channel	34.55	14APR1996 2400	100.72	943.65	945.87		945.88	0.000368	0.79	127.68	109.61	0.13
Main Channel	34.54	Max WS	6429.03	943.40	957.57		957.59	0.000054	1.03	6233.70	847.44	0.07
Main Channel	34.54	14APR1996 2400	100.14	943.40	945.86		945.86	0.000208	0.65	154.39	115.90	0.10
Main Channel	34.53	Max WS	6429.03	943.00	957.52		957.58	0.000374	1.99	3231.92	700.60	0.16
Main Channel	34.53	14APR1996 2400	100.67	943.00	945.83		945.84	0.000409	0.98	102.83	68.85	0.14
Main Channel	34.34	Max WS	6428.49	942.50	957.37		957.38	0.000016	0.71	9102.81	876.73	0.04
Main Channel	34.34	14APR1996 2400	99.74	942.50	945.61		945.62	0.000045	0.27	363.84	314.15	0.04
Main Channel	34.01	Max WS	6427.84	941.00	957.20		957.25	0.000144	1.76	3657.89	467.08	0.11
Main Channel	34.01	14APR1996 2400	100.45	941.00	945.52		945.52	0.000060	0.47	215.06	103.76	0.06
Main Channel	33.92	Max WS	6427.66	942.00	957.00		957.13	0.000362	2.96	2175.12	252.48	0.18
Main Channel	33.92	14APR1996 2400	99.82	942.00	945.45		945.46	0.000204	0.76	130.59	75.30	0.10
Main Channel	33.86	Max WS	6427.68	941.00	956.86		957.01	0.000444	3.04	2223.31	404.96	0.19
Main Channel	33.86	14APR1996 2400	100.49	941.00	945.38		945.39	0.000215	0.88	113.71	54.26	0.11
Main Channel	33.43	Max WS	6427.14	941.00	955.38		955.58	0.000822	3.62	1777.59	282.27	0.25
Main Channel	33.43	14APR1996 2400	100.66	941.00	943.59		943.63	0.001358	1.62	62.19	48.09	0.25
Main Channel	33.18	Max WS	6426.90	940.00	954.28		954.52	0.000796	3.95	1626.37	219.64	0.26
Main Channel	33.18	14APR1996 2400	100.47	940.00	942.56		942.57	0.000250	0.91	110.31	56.55	0.11

HEC-RAS Plan: Plan 06 River: South Fork Two R Reach: Main Channel

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main Channel	37.75	Max WS	6442.31	975.00	983.08		983.64	0.002969	7.10	1921.89	613.94	0.49
Main Channel	37.75	14APR1996 2400	115.50	975.00	976.76		976.85	0.004686	2.34	49.46	56.10	0.44
Main Channel	37.52	Max WS	6441.94	972.00	980.50		980.88	0.001422	5.13	1656.18	358.38	0.34
Main Channel	37.52	14APR1996 2400	87.28	972.00	973.76		973.78	0.000901	1.02	85.20	96.67	0.19
Main Channel	37.21	Max WS	6441.47	970.00	979.22		979.30	0.000366	2.90	5010.93	992.92	0.18
Main Channel	37.21	14APR1996 2400	118.34	970.00	972.83		972.84	0.000057	0.42	347.90	335.79	0.05
Main Channel	36.37	Max WS	6439.93	960.00	978.40		978.41	0.000021	0.84	8757.63	1211.12	0.04
Main Channel	36.37	14APR1996 2400	80.47	960.00	972.74		972.74	0.000000	0.02	3679.12	618.28	0.00
Main Channel	36	Max WS	6438.96	958.00	978.38		978.39	0.000005	0.43	16092.99	1573.35	0.02
Main Channel	36	14APR1996 2400	118.67	958.00	972.74		972.74	0.000000	0.02	7788.44	1338.36	0.00
Main Channel	35.10	Max WS	6434.18	950.00	978.37		978.37	0.000001	0.27	25758.55	1940.87	0.01
Main Channel	35.10	14APR1996 2400	81.82	950.00	972.74		972.74	0.000000	0.00	17332.08	1120.21	0.00
Main Channel	34.59	Max WS	6428.91	949.00	978.36		978.37	0.000004	0.49	17335.83	2992.79	0.02
Main Channel	34.59	14APR1996 2400	116.93	949.00	972.74		972.74	0.000000	0.01	8424.21	695.10	0.00
Main Channel	34.57	Max WS	6429.37	949.00	978.36		978.37	0.000004	0.49	17334.73	2992.79	0.02
Main Channel	34.57	14APR1996 2400	99.04	949.00	972.74		972.74	0.000000	0.01	8423.28	695.06	0.00
Main Channel	34.565	Max WS	6429.34	949.00	978.36		978.37	0.000004	0.49	17334.37	2992.79	0.02
Main Channel	34.565	14APR1996 2400	96.83	949.00	972.74		972.74	0.000000	0.01	8423.11	695.05	0.00
Main Channel	34.562	Max WS	6428.67	949.00	978.36		978.37	0.000004	0.49	17334.00	2992.79	0.02
Main Channel	34.562	14APR1996 2400	99.07	949.00	972.74		972.74	0.000000	0.01	8423.11	695.05	0.00
Main Channel	34.561	Max WS	6429.29	949.00	978.36	954.67	978.37	0.000004	0.49	17334.00	2992.79	0.02
Main Channel	34.561	14APR1996 2400	99.94	949.00	972.74	949.92	972.74	0.000000	0.01	8423.11	695.05	0.00
Main Channel	34.56		Inl Struct									
Main Channel	34.5599	Max WS	6429.05	944.00	957.58		957.60	0.000071	1.12	5729.83	841.83	0.08
Main Channel	34.5599	14APR1996 2400	99.94	944.00	945.90		945.91	0.000875	1.06	93.94	98.50	0.19
Main Channel	34.559	Max WS	6429.04	944.00	957.58		957.60	0.000071	1.12	5729.47	841.82	0.08
Main Channel	34.559	14APR1996 2400	100.19	944.00	945.89		945.91	0.000890	1.07	93.51	98.28	0.19
Main Channel	34.558	Max WS	6429.04	944.00	957.58		957.60	0.000071	1.12	5729.21	841.82	0.08
Main Channel	34.558	14APR1996 2400	100.43	944.00	945.89		945.91	0.000906	1.08	93.06	98.05	0.20
Main Channel	34.55	Max WS	6428.90	943.65	957.58		957.59	0.000060	1.07	6023.68	845.11	0.07
Main Channel	34.55	14APR1996 2400	100.72	943.65	945.87		945.88	0.000368	0.79	127.68	109.61	0.13
Main Channel	34.54	Max WS	6429.03	943.40	957.57		957.59	0.000054	1.03	6233.70	847.44	0.07
Main Channel	34.54	14APR1996 2400	100.14	943.40	945.86		945.86	0.000208	0.65	154.39	115.90	0.10
Main Channel	34.53	Max WS	6429.03	943.00	957.52		957.58	0.000374	1.99	3231.92	700.60	0.16
Main Channel	34.53	14APR1996 2400	100.67	943.00	945.83		945.84	0.000409	0.98	102.83	68.85	0.14
Main Channel	34.34	Max WS	6428.49	942.50	957.37		957.38	0.000016	0.71	9102.81	876.73	0.04
Main Channel	34.34	14APR1996 2400	99.74	942.50	945.61		945.62	0.000045	0.27	363.84	314.15	0.04
Main Channel	34.01	Max WS	6427.84	941.00	957.20		957.25	0.000144	1.76	3657.89	467.08	0.11
Main Channel	34.01	14APR1996 2400	100.45	941.00	945.52		945.52	0.000060	0.47	215.06	103.76	0.06
Main Channel	33.92	Max WS	6427.66	942.00	957.00		957.13	0.000362	2.96	2175.12	252.48	0.18
Main Channel	33.92	14APR1996 2400	99.82	942.00	945.45		945.46	0.000204	0.76	130.59	75.30	0.10
Main Channel	33.86	Max WS	6427.68	941.00	956.86		957.01	0.000444	3.04	2223.31	404.96	0.19
Main Channel	33.86	14APR1996 2400	100.49	941.00	945.38		945.39	0.000215	0.88	113.71	54.26	0.11
Main Channel	33.43	Max WS	6427.14	941.00	955.38		955.58	0.000822	3.62	1777.59	282.27	0.25
Main Channel	33.43	14APR1996 2400	100.66	941.00	943.59		943.63	0.001358	1.62	62.19	48.09	0.25
Main Channel	33.18	Max WS	6426.90	940.00	954.28		954.52	0.000796	3.95	1626.37	219.64	0.26
Main Channel	33.18	14APR1996 2400	100.47	940.00	942.56		942.57	0.000250	0.91	110.31	56.55	0.11

HEC-RAS Plan: Plan 06 River: South Fork Two R Reach: Main Channel (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Main Channel	21.17		Bridge									
Main Channel	21.16	Max WS	7007.84	875.30	887.62		888.43	0.002328	7.23	969.17	115.67	0.44
Main Channel	21.16	14APR1996 2400	101.53	875.30	876.86		877.03	0.010075	3.31	30.71	36.64	0.64
Main Channel	21.14	Max WS	7008.75	874.00	888.03		888.14	0.000439	2.75	2546.53	380.61	0.19
Main Channel	21.14	14APR1996 2400	102.53	874.00	876.43		876.46	0.000758	1.28	80.40	57.54	0.19
Main Channel	20.67	Max WS	7007.56	873.00	886.60		886.75	0.000703	3.09	2266.56	405.99	0.23
Main Channel	20.67	14APR1996 2400	98.10	873.00	874.95		874.97	0.000452	0.94	104.78	81.01	0.15
Main Channel	19.84	Max WS	7005.25	870.00	880.96		881.30	0.001804	4.71	1486.65	286.68	0.36
Main Channel	19.84	14APR1996 2400	102.10	870.00	872.07		872.09	0.000878	1.30	78.35	60.61	0.20
Main Channel	19.13	Max WS	7775.48	863.00	873.49		873.81	0.002202	4.51	1724.21	413.71	0.39
Main Channel	19.13	14APR1996 2400	100.02	863.00	864.70		864.77	0.003114	2.09	47.89	47.21	0.37
Main Channel	18.40	Max WS	7774.76	855.00	868.20	862.75	868.31	0.000684	2.73	2850.78	605.39	0.22
Main Channel	18.40	14APR1996 2400	102.75	855.00	858.33	856.44	858.34	0.000303	0.87	117.50	74.43	0.12
Main Channel	18.33		Bridge									
Main Channel	18.20	Max WS	7774.44	855.00	866.73		866.95	0.001462	3.77	2060.72	475.20	0.32
Main Channel	18.20	14APR1996 2400	101.21	855.00	857.28		857.34	0.002261	1.89	53.50	48.04	0.32
Main Channel	17.77	Max WS	7773.84	851.00	863.59	858.72	863.81	0.001353	3.70	2100.50	469.57	0.31
Main Channel	17.77	14APR1996 2400	100.48	851.00	853.42	852.27	853.46	0.001219	1.72	58.53	37.86	0.24
Main Channel	17.76		Bridge									
Main Channel	17.75	Max WS	7773.86	850.75	863.06		863.30	0.001572	3.95	1969.32	447.36	0.33
Main Channel	17.75	14APR1996 2400	99.17	850.75	853.31		853.34	0.000924	1.55	63.89	39.00	0.21
Main Channel	17.29	Max WS	7773.57	850.00	859.37		859.59	0.001493	3.74	2079.59	493.96	0.32
Main Channel	17.29	14APR1996 2400	100.98	850.00	851.33		851.34	0.000711	0.99	102.26	102.59	0.17
Main Channel	16.91	Max WS	7772.92	845.00	857.79		857.84	0.000227	1.84	4356.27	816.69	0.13
Main Channel	16.91	14APR1996 2400	99.97	845.00	850.61		850.61	0.000035	0.32	309.97	173.11	0.04
Main Channel	16.87	Max WS	7772.93	845.00	857.74		857.80	0.000234	1.86	4315.99	814.69	0.13
Main Channel	16.87	14APR1996 2400	100.27	845.00	850.60		850.61	0.000035	0.32	308.54	172.11	0.04
Main Channel	16.79	Max WS	7773.09	845.00	857.64		857.69	0.000248	1.89	4232.22	810.52	0.14
Main Channel	16.79	14APR1996 2400	99.84	845.00	850.59		850.59	0.000035	0.33	306.12	170.40	0.04
Main Channel	16.29	Max WS	7772.12	845.00	855.90		856.06	0.001010	3.21	2430.61	561.71	0.27
Main Channel	16.29	14APR1996 2400	101.12	845.00	846.90		846.97	0.002780	2.10	48.07	42.99	0.35
Main Channel	15.36	Max WS	7769.90	837.00	851.67		852.01	0.000690	5.03	3016.05	889.03	0.26
Main Channel	15.36	14APR1996 2400	99.21	837.00	839.83		839.84	0.000187	0.79	126.19	65.08	0.10
Main Channel	14.80	Max WS	7768.51	836.00	850.50		850.59	0.000200	2.50	4219.34	761.58	0.14
Main Channel	14.80	14APR1996 2400	100.93	836.00	839.46		839.46	0.000063	0.46	221.12	114.34	0.06
Main Channel	14.41	Max WS	7767.91	836.00	849.74		849.93	0.000457	3.54	2451.30	355.69	0.20
Main Channel	14.41	14APR1996 2400	99.10	836.00	839.23		839.24	0.000158	0.70	141.56	76.79	0.09
Main Channel	14.10	Max WS	7767.50	836.00	848.00		848.46	0.001401	5.56	1692.94	394.33	0.34
Main Channel	14.10	14APR1996 2400	100.75	836.00	838.82		838.84	0.000330	1.03	97.97	51.31	0.13
Main Channel	14.06	Max WS	7767.40	836.00	847.55		848.13	0.002013	6.20	1548.01	431.84	0.41
Main Channel	14.06	14APR1996 2400	101.18	836.00	838.31		838.42	0.003692	2.66	37.98	29.24	0.41
Main Channel	14.03	Max WS	7767.38	836.00	847.48		847.84	0.001114	4.88	1825.01	411.70	0.31
Main Channel	14.03	14APR1996 2400	100.47	836.00	838.01		838.04	0.000830	1.32	76.27	55.28	0.20
Main Channel	13.90	Max WS	7767.22	835.00	847.22		847.31	0.000225	2.49	3989.03	699.15	0.14
Main Channel	13.90	14APR1996 2400	100.01	835.00	837.69		837.70	0.000155	0.55	181.75	139.64	0.09

HEC-RAS Plan: Plan 06 River: South Fork Two R Reach: Main Channel (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main Channel	13.67	Max WS	7766.69	835.00	845.30		845.79	0.002466	5.60	1392.89	297.95	0.43
Main Channel	13.67	14APR1996 2400	100.30	835.00	837.08		837.11	0.000820	1.30	77.02	56.62	0.20
Main Channel	13.32	Max WS	7766.44	831.75	841.30		841.73	0.001951	5.28	1564.80	412.86	0.39
Main Channel	13.32	14APR1996 2400	101.53	831.75	833.14		833.21	0.003490	2.15	47.22	48.56	0.38
Main Channel	13.16	Max WS	7766.44	831.00	841.07		841.47	0.001861	5.11	1603.93	438.38	0.38
Main Channel	13.16	14APR1996 2400	100.50	831.00	832.83		832.87	0.001562	1.63	61.59	52.31	0.27
Main Channel	12.64	Max WS	7765.99	826.50	837.35		837.67	0.000915	4.58	1908.32	404.43	0.28
Main Channel	12.64	14APR1996 2400	100.10	826.50	828.31		828.35	0.001750	1.48	67.78	73.01	0.27
Main Channel	11.93	Max WS	7764.48	821.00	834.97		835.17	0.000408	3.90	3423.65	627.43	0.20
Main Channel	11.93	14APR1996 2400	100.76	821.00	825.03		825.03	0.000041	0.37	271.21	140.37	0.05
Main Channel	11.33	Max WS	7763.70	820.00	832.60		832.89	0.001040	4.36	1849.58	313.48	0.29
Main Channel	11.33	14APR1996 2400	100.65	820.00	822.50		822.54	0.001549	1.69	59.63	47.80	0.27
Main Channel	10.85	Max WS	7762.84	816.00	830.85		831.07	0.000401	3.89	2663.33	523.32	0.20
Main Channel	10.85	14APR1996 2400	100.62	816.00	820.57		820.57	0.000020	0.30	334.46	135.62	0.03
Main Channel	10.45	Max WS	7762.20	818.00	830.41		830.45	0.000142	1.66	4936.05	760.00	0.11
Main Channel	10.45	14APR1996 2400	100.09	818.00	820.14		820.15	0.000377	0.79	127.14	111.23	0.13
Main Channel	9.80	Max WS	7760.36	816.00	829.07		829.28	0.000570	3.79	2703.37	597.00	0.22
Main Channel	9.80	14APR1996 2400	100.41	816.00	818.75		818.77	0.000434	0.96	105.11	76.39	0.14
Main Channel	9.73	Max WS	7760.26	816.00	828.83	823.24	829.06	0.000631	3.91	2565.93	575.17	0.23
Main Channel	9.73	14APR1996 2400	100.00	816.00	818.55	817.26	818.57	0.000650	1.11	90.05	70.70	0.17
Main Channel	9.71		Bridge									
Main Channel	9.69	Max WS	7759.79	816.00	828.13		828.41	0.000867	4.33	2184.57	509.70	0.27
Main Channel	9.69	14APR1996 2400	100.66	816.00	818.37		818.40	0.000958	1.29	78.24	65.91	0.21
Main Channel	9.03	Max WS	7757.70	811.00	826.03		826.24	0.000398	3.84	3155.13	686.41	0.20
Main Channel	9.03	14APR1996 2400	99.68	811.00	816.46		816.46	0.000009	0.24	408.24	128.90	0.02
Main Channel	8.23	Max WS	8718.80	811.00	824.90		824.96	0.000179	2.01	4441.46	578.54	0.12
Main Channel	8.23	14APR1996 2400	101.60	811.00	813.19		813.25	0.001565	1.94	52.49	34.06	0.27
Main Channel	7.59	Max WS	8717.65	805.00	823.66	813.73	823.95	0.000444	4.38	2154.12	244.13	0.21
Main Channel	7.59	14APR1996 2400	99.07	805.00	810.66	806.21	810.67	0.000015	0.31	317.12	98.89	0.03
Main Channel	7.58		Bridge									
Main Channel	7.57	Max WS	8717.69	805.76	823.42		823.73	0.000481	4.49	2085.13	237.53	0.22
Main Channel	7.57	14APR1996 2400	73.04	805.76	810.69		810.69	0.000009	0.24	308.45	99.00	0.02
Main Channel	7.22	Max WS	8717.28	807.50	822.99		823.05	0.000207	2.02	4372.90	627.69	0.13
Main Channel	7.22	14APR1996 2400	126.59	807.50	810.38		810.40	0.000407	0.99	127.76	83.86	0.14
Main Channel	7.09	Max WS	8716.76	807.00	821.13		822.37	0.003254	8.99	1031.24	223.05	0.53
Main Channel	7.09	14APR1996 2400	80.36	807.00	809.48		809.52	0.001371	1.58	50.82	40.92	0.25
Main Channel	6.94	Max WS	8716.58	806.00	820.26	811.94	820.42	0.000293	3.51	4364.58	658.49	0.17
Main Channel	6.94	14APR1996 2400	130.76	806.00	808.39	806.86	808.39	0.000172	0.67	196.06	122.00	0.09
Main Channel	6.92		Bridge									
Main Channel	6.90	Max WS	8716.59	804.20	819.88		820.04	0.000284	3.52	4234.38	658.49	0.17
Main Channel	6.90	14APR1996 2400	100.63	804.20	806.34		806.36	0.000772	1.08	93.25	87.06	0.18
Main Channel	6.79	Max WS	8716.40	801.00	819.71		819.85	0.000213	3.27	4390.52	658.49	0.15
Main Channel	6.79	14APR1996 2400	100.58	801.00	806.13		806.13	0.000021	0.34	299.92	107.37	0.04
Main Channel	5.78	Max WS	8714.67	801.00	818.41		818.52	0.000242	2.75	4254.19	1011.74	0.15
Main Channel	5.78	14APR1996 2400	99.38	801.00	806.02		806.03	0.000017	0.31	319.48	110.17	0.03
Main Channel	4.88	Max WS	8712.31	801.00	817.68		817.73	0.000083	1.81	6459.02	1097.08	0.09

HEC-RAS Plan: Plan 06 River: South Fork Two R Reach: Main Channel (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main Channel	4.88	14APR1996 2400	100.70	801.00	805.97		805.97	0.000006	0.18	556.40	206.05	0.02
Main Channel	4.86	Max WS	8712.34	800.25	817.68	807.10	817.72	0.000082	1.80	6473.09	1095.55	0.09
Main Channel	4.86	14APR1996 2400	97.16	800.25	805.97	801.37	805.97	0.000005	0.17	579.46	205.99	0.02
Main Channel	4.85		Bridge									
Main Channel	4.84	Max WS	8712.34	799.75	817.61		817.66	0.000083	1.81	6419.69	1084.14	0.09
Main Channel	4.84	14APR1996 2400	100.25	799.75	805.97		805.97	0.000005	0.17	595.14	206.01	0.02
Main Channel	4.82	Max WS	8712.31	801.00	817.60		817.65	0.000086	1.83	6370.62	1082.46	0.09
Main Channel	4.82	14APR1996 2400	99.85	801.00	805.97		805.97	0.000006	0.18	556.01	205.97	0.02
Main Channel	4.45	Max WS	8711.29	801.00	817.46		817.50	0.000066	1.66	7053.62	922.74	0.08
Main Channel	4.45	14APR1996 2400	100.15	801.00	805.96		805.96	0.000006	0.15	667.51	315.70	0.02
Main Channel	3.45	Max WS	8707.19	801.00	816.46		816.61	0.000286	3.17	3213.46	389.24	0.17
Main Channel	3.45	14APR1996 2400	99.88	801.00	805.87		805.87	0.000026	0.30	332.51	164.69	0.04
Main Channel	3.34	Max WS	8706.98	801.00	816.44		816.48	0.000071	1.66	5877.79	681.29	0.08
Main Channel	3.34	14APR1996 2400	100.16	801.00	805.86		805.86	0.000004	0.13	800.13	355.47	0.01
Main Channel	3.27	Max WS	8706.96	801.00	816.15		816.38	0.000702	3.84	2289.57	330.56	0.24
Main Channel	3.27	14APR1996 2400	99.94	801.00	805.86		805.86	0.000016	0.31	324.41	108.87	0.03
Main Channel	3.18	Max WS	8704.92	801.00	815.95		816.10	0.000360	3.37	3936.47	700.00	0.18
Main Channel	3.18	14APR1996 2400	100.08	801.00	805.84		805.84	0.000051	0.40	251.68	137.21	0.05
Main Channel	3.05	Max WS	8704.75	801.00	815.78		815.87	0.000176	2.67	5186.20	581.24	0.13
Main Channel	3.05	14APR1996 2400	99.97	801.00	805.82		805.82	0.000007	0.19	552.94	242.31	0.02
Main Channel	2.99	Max WS	8704.45	801.00	815.67	807.25	815.80	0.000243	3.13	4125.90	441.92	0.16
Main Channel	2.99	14APR1996 2400	100.01	801.00	805.82	801.91	805.82	0.000008	0.20	511.36	211.44	0.02
Main Channel	2.96		Inl Struct									
Main Channel	2.92	Max WS	8704.45	793.00	815.57		815.66	0.000099	2.49	4147.65	340.80	0.10
Main Channel	2.92	14APR1996 2400	100.01	793.00	795.97		795.98	0.000148	0.66	152.47	86.67	0.09
Main Channel	2.71	Max WS	8703.36	793.00	815.54		815.57	0.000043	1.50	6330.27	600.69	0.07
Main Channel	2.71	14APR1996 2400	100.10	793.00	795.83		795.83	0.000116	0.56	177.60	106.14	0.08
Main Channel	2.40	Max WS	8702.96	791.00	815.43		815.49	0.000062	2.03	5423.34	527.27	0.08
Main Channel	2.40	14APR1996 2400	99.99	791.00	795.71		795.71	0.000032	0.38	264.57	108.91	0.04
Main Channel	2.11	Max WS	9708.72	791.58	815.27		815.36	0.000120	2.75	6937.72	840.01	0.11
Main Channel	2.11	14APR1996 2400	100.06	791.58	795.62		795.63	0.000078	0.64	155.85	55.72	0.07
Main Channel	2.08	Max WS	9708.66	791.00	815.29	806.75	815.32	0.000068	1.33	9777.94	1845.26	0.08
Main Channel	2.08	14APR1996 2400	100.31	791.00	795.57	792.61	795.60	0.000288	1.28	78.46	24.55	0.13
Main Channel	2.07		Bridge									
Main Channel	2.06	Max WS	9708.67	791.00	814.81		814.84	0.000084	1.42	8909.44	1779.51	0.09
Main Channel	2.06	14APR1996 2400	100.49	791.00	795.54		795.57	0.000298	1.29	77.64	24.47	0.13
Main Channel	2.01	Max WS	9708.35	790.00	814.71		814.82	0.000250	2.65	4103.71	588.71	0.15
Main Channel	2.01	14APR1996 2400	99.49	790.00	795.50		795.51	0.000136	0.93	107.01	31.63	0.09
Main Channel	1.80		Lat Struct									
Main Channel	1.65	Max WS	7763.24	789.00	814.36		814.46	0.000175	2.60	3717.72	614.87	0.13
Main Channel	1.65	14APR1996 2400	100.63	789.00	795.33		795.34	0.000040	0.59	169.56	37.90	0.05
Main Channel	1.50		Lat Struct									
Main Channel	1.12	Max WS	6574.05	790.00	813.87		813.99	0.000183	2.81	2700.84	272.03	0.13
Main Channel	1.12	14APR1996 2400	99.65	790.00	794.19		794.23	0.000739	1.78	56.06	22.25	0.20
Main Channel	0.38	Max WS	6572.51	789.00	813.56		813.57	0.000011	0.66	10137.79	925.37	0.03

HEC-RAS Plan: Plan 06 River: South Fork Two R Reach: Main Channel (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main Channel	0.38	14APR1996 2400	100.55	789.00	792.26		792.27	0.000252	1.05	95.75	38.81	0.12
Main Channel	0.02	Max WS	6571.28	788.75	813.51		813.53	0.000021	1.21	9882.31	1686.80	0.05
Main Channel	0.02	14APR1996 2400	99.50	788.75	792.00		792.01	0.000030	0.37	270.76	112.20	0.04
Main Channel	0.00	Max WS	6571.18	788.50	813.51	794.22	813.53	0.000021	1.21	9701.69	1650.22	0.05
Main Channel	0.00	14APR1996 2400	101.26	788.50	792.00	789.29	792.00	0.000026	0.35	287.71	112.16	0.04

APPENDIX C

HEC-RAS Plan: Plan 4G River: South Fork Two R Reach: Main Channel

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main Channel	37.75	Max WS	6407.22	975.00	985.20		985.57	0.001310	5.68	3451.44	818.07	0.34
Main Channel	37.75	14APR1996 2400	115.50	975.00	976.78		976.86	0.004441	2.29	50.47	56.67	0.43
Main Channel	37.52	Max WS	-916.00	972.00	983.06		983.07	0.000010	-0.54	2758.92	503.16	0.03
Main Channel	37.52	14APR1996 2400	87.94	972.00	973.66		973.69	0.001240	1.16	76.02	91.32	0.22
Main Channel	37.21	Max WS	-4549.45	970.00	980.27		980.32	0.000189	-2.25	6051.33	1000.04	0.13
Main Channel	37.21	14APR1996 2400	117.98	970.00	972.34		972.35	0.000176	0.60	209.50	223.63	0.09
Main Channel	36.37	Max WS	-15545.90	960.00	979.26		979.32	0.000096	-1.89	9841.13	1304.59	0.10
Main Channel	36.37	14APR1996 2400	80.38	960.00	972.05		972.05	0.000000	0.02	3268.65	581.90	0.00
Main Channel	36	Max WS	1271.57	958.00	978.42		978.42	0.000000	0.09	16158.03	1574.83	0.00
Main Channel	36	14APR1996 2400	118.93	958.00	972.06		972.06	0.000000	0.02	6911.49	1226.20	0.00
Main Channel	35.10	Max WS	-26971.90	950.00	978.71		978.73	0.000015	-1.11	26421.31	1991.29	0.04
Main Channel	35.10	14APR1996 2400	81.51	950.00	972.06		972.06	0.000000	0.00	16572.81	1099.79	0.00
Main Channel	34.59	Max WS	6425.34	949.00	978.17		978.17	0.000004	0.51	16761.89	2992.79	0.02
Main Channel	34.59	14APR1996 2400	117.39	949.00	972.06		972.06	0.000000	0.01	7955.34	675.94	0.00
Main Channel	34.57	Max WS	6425.22	949.00	978.17		978.17	0.000004	0.51	16760.43	2992.79	0.02
Main Channel	34.57	14APR1996 2400	97.55	949.00	972.06		972.06	0.000000	0.01	7954.31	675.90	0.00
Main Channel	34.565	Max WS	6425.33	949.00	978.17		978.17	0.000004	0.51	16760.06	2992.79	0.02
Main Channel	34.565	14APR1996 2400	94.16	949.00	972.06		972.06	0.000000	0.01	7954.19	675.90	0.00
Main Channel	34.562	Max WS	6425.36	949.00	978.17		978.17	0.000004	0.51	16759.70	2992.79	0.02
Main Channel	34.562	14APR1996 2400	98.23	949.00	972.06		972.06	0.000000	0.01	7954.31	675.90	0.00
Main Channel	34.561	Max WS	6425.37	949.00	978.17	954.66	978.17	0.000004	0.51	16759.70	2992.79	0.02
Main Channel	34.561	14APR1996 2400	99.34	949.00	972.06	949.92	972.06	0.000000	0.01	7954.31	675.90	0.00
Main Channel	34.56		Inl Struct									
Main Channel	34.5599	Max WS	36903.53	944.00	968.74		968.82	0.000099	2.33	15806.00	992.28	0.10
Main Channel	34.5599	14APR1996 2400	99.34	944.00	945.90		945.91	0.000867	1.06	93.83	98.45	0.19
Main Channel	34.559	Max WS	36902.74	944.00	968.74		968.82	0.000099	2.33	15805.69	992.27	0.10
Main Channel	34.559	14APR1996 2400	99.53	944.00	945.89		945.91	0.000881	1.07	93.39	98.22	0.19
Main Channel	34.558	Max WS	36901.92	944.00	968.74		968.82	0.000099	2.33	15805.33	992.26	0.10
Main Channel	34.558	14APR1996 2400	100.07	944.00	945.89		945.91	0.000901	1.08	92.98	98.00	0.19
Main Channel	34.55	Max WS	36895.36	943.65	968.74		968.82	0.000093	2.28	16154.67	999.62	0.10
Main Channel	34.55	14APR1996 2400	100.92	943.65	945.87		945.88	0.000370	0.79	127.72	109.62	0.13
Main Channel	34.54	Max WS	36889.05	943.40	968.74		968.82	0.000089	2.25	16404.25	1004.85	0.10
Main Channel	34.54	14APR1996 2400	99.99	943.40	945.86		945.86	0.000208	0.65	154.37	115.90	0.10
Main Channel	34.53	Max WS	36885.97	943.00	968.68		968.81	0.000167	2.88	13209.82	991.13	0.13
Main Channel	34.53	14APR1996 2400	100.76	943.00	945.83		945.84	0.000409	0.98	102.83	68.85	0.14
Main Channel	34.34	Max WS	36210.52	942.50	968.67		968.72	0.000045	1.79	20409.15	1144.86	0.07
Main Channel	34.34	14APR1996 2400	99.65	942.50	945.61		945.62	0.000045	0.27	363.81	314.12	0.04
Main Channel	34.01	Max WS	36426.11	941.00	968.34		968.55	0.000223	3.65	10194.13	634.94	0.16
Main Channel	34.01	14APR1996 2400	100.54	941.00	945.52		945.52	0.000060	0.47	215.06	103.76	0.06
Main Channel	33.92	Max WS	35106.08	942.00	967.68		968.38	0.000701	6.74	5524.19	350.74	0.28
Main Channel	33.92	14APR1996 2400	99.74	942.00	945.45		945.46	0.000204	0.76	130.57	75.29	0.10
Main Channel	33.86	Max WS	35025.84	941.00	967.64		968.12	0.000533	5.97	12396.94	1265.10	0.24
Main Channel	33.86	14APR1996 2400	100.56	941.00	945.38		945.39	0.000215	0.88	113.71	54.26	0.11
Main Channel	33.43	Max WS	34134.58	941.00	966.11		966.54	0.000782	5.28	6463.36	560.98	0.27
Main Channel	33.43	14APR1996 2400	100.60	941.00	943.59		943.63	0.001357	1.62	62.18	48.08	0.25
Main Channel	33.18	Max WS	32732.58	940.00	964.94		965.37	0.000998	5.28	6275.18	708.14	0.30
Main Channel	33.18	14APR1996 2400	100.53	940.00	942.56		942.57	0.000251	0.91	110.32	56.55	0.11

HEC-RAS Plan: Plan 4G River: South Fork Two R Reach: Main Channel

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Main Channel	37.75	Max WS	6407.22	975.00	985.20		985.57	0.001310	5.68	3451.44	818.07	0.34
Main Channel	37.75	14APR1996 2400	115.50	975.00	976.78		976.86	0.004441	2.29	50.47	56.67	0.43
Main Channel	37.52	Max WS	-916.00	972.00	983.06		983.07	0.000010	-0.54	2758.92	503.16	0.03
Main Channel	37.52	14APR1996 2400	87.94	972.00	973.66		973.69	0.001240	1.16	76.02	91.32	0.22
Main Channel	37.21	Max WS	-4549.45	970.00	980.27		980.32	0.000189	-2.25	6051.33	1000.04	0.13
Main Channel	37.21	14APR1996 2400	117.98	970.00	972.34		972.35	0.000176	0.60	209.50	223.63	0.09
Main Channel	36.37	Max WS	-15545.90	960.00	979.26		979.32	0.000096	-1.89	9841.13	1304.59	0.10
Main Channel	36.37	14APR1996 2400	80.38	960.00	972.05		972.05	0.000000	0.02	3268.65	581.90	0.00
Main Channel	36	Max WS	1271.57	958.00	978.42		978.42	0.000000	0.09	16158.03	1574.83	0.00
Main Channel	36	14APR1996 2400	118.93	958.00	972.06		972.06	0.000000	0.02	6911.49	1226.20	0.00
Main Channel	35.10	Max WS	-26971.90	950.00	978.71		978.73	0.000015	-1.11	26421.31	1991.29	0.04
Main Channel	35.10	14APR1996 2400	81.51	950.00	972.06		972.06	0.000000	0.00	16572.81	1099.79	0.00
Main Channel	34.59	Max WS	6425.34	949.00	978.17		978.17	0.000004	0.51	16761.89	2992.79	0.02
Main Channel	34.59	14APR1996 2400	117.39	949.00	972.06		972.06	0.000000	0.01	7955.34	875.94	0.00
Main Channel	34.57	Max WS	6425.22	949.00	978.17		978.17	0.000004	0.51	16760.43	2992.79	0.02
Main Channel	34.57	14APR1996 2400	97.55	949.00	972.06		972.06	0.000000	0.01	7954.31	675.90	0.00
Main Channel	34.565	Max WS	6425.33	949.00	978.17		978.17	0.000004	0.51	16760.06	2992.79	0.02
Main Channel	34.565	14APR1996 2400	94.16	949.00	972.06		972.06	0.000000	0.01	7954.19	675.90	0.00
Main Channel	34.562	Max WS	6425.36	949.00	978.17		978.17	0.000004	0.51	16759.70	2992.79	0.02
Main Channel	34.562	14APR1996 2400	98.23	949.00	972.06		972.06	0.000000	0.01	7954.31	675.90	0.00
Main Channel	34.561	Max WS	6425.37	949.00	978.17	954.66	978.17	0.000004	0.51	16759.70	2992.79	0.02
Main Channel	34.561	14APR1996 2400	99.34	949.00	972.06	949.92	972.06	0.000000	0.01	7954.31	675.90	0.00
Main Channel	34.56		Inl Struct									
Main Channel	34.5599	Max WS	36903.53	944.00	968.74		968.82	0.000099	2.33	15806.00	992.28	0.10
Main Channel	34.5599	14APR1996 2400	99.34	944.00	945.90		945.91	0.000867	1.06	93.83	98.45	0.19
Main Channel	34.559	Max WS	36902.74	944.00	968.74		968.82	0.000099	2.33	15805.69	992.27	0.10
Main Channel	34.559	14APR1996 2400	99.53	944.00	945.89		945.91	0.000881	1.07	93.39	98.22	0.19
Main Channel	34.558	Max WS	36901.92	944.00	968.74		968.82	0.000099	2.33	15805.33	992.26	0.10
Main Channel	34.558	14APR1996 2400	100.07	944.00	945.89		945.91	0.000901	1.08	92.98	98.00	0.19
Main Channel	34.55	Max WS	36895.36	943.65	968.74		968.82	0.000093	2.28	16154.67	999.62	0.10
Main Channel	34.55	14APR1996 2400	100.92	943.65	945.87		945.88	0.000370	0.79	127.72	109.62	0.13
Main Channel	34.54	Max WS	36889.05	943.40	968.74		968.82	0.000089	2.25	16404.25	1004.85	0.10
Main Channel	34.54	14APR1996 2400	99.99	943.40	945.86		945.86	0.000208	0.65	154.37	115.90	0.10
Main Channel	34.53	Max WS	36885.97	943.00	968.68		968.81	0.000167	2.88	13209.82	991.13	0.13
Main Channel	34.53	14APR1996 2400	100.76	943.00	945.83		945.84	0.000409	0.98	102.83	68.85	0.14
Main Channel	34.34	Max WS	36210.52	942.50	968.67		968.72	0.000045	1.79	20409.15	1144.86	0.07
Main Channel	34.34	14APR1996 2400	99.65	942.50	945.61		945.62	0.000045	0.27	363.81	314.12	0.04
Main Channel	34.01	Max WS	36426.11	941.00	968.34		968.55	0.000223	3.65	10194.13	634.94	0.16
Main Channel	34.01	14APR1996 2400	100.54	941.00	945.52		945.52	0.000060	0.47	215.06	103.76	0.06
Main Channel	33.92	Max WS	35106.08	942.00	967.68		968.38	0.000701	6.74	5524.19	350.74	0.28
Main Channel	33.92	14APR1996 2400	99.74	942.00	945.45		945.46	0.000204	0.76	130.57	75.29	0.10
Main Channel	33.86	Max WS	35025.84	941.00	967.64		968.12	0.000533	5.97	12396.94	1265.10	0.24
Main Channel	33.86	14APR1996 2400	100.56	941.00	945.38		945.39	0.000215	0.88	113.71	54.26	0.11
Main Channel	33.43	Max WS	34134.58	941.00	966.11		966.54	0.000782	5.28	6463.36	560.98	0.27
Main Channel	33.43	14APR1996 2400	100.60	941.00	943.59		943.63	0.001357	1.62	62.18	48.08	0.25
Main Channel	33.18	Max WS	32732.58	940.00	964.94		965.37	0.000998	5.28	6275.18	708.14	0.30
Main Channel	33.18	14APR1996 2400	100.53	940.00	942.56		942.57	0.000251	0.91	110.32	56.55	0.11

HEC-RAS Plan: Plan 4G River: South Fork Two R Reach: Main Channel (Continued)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Main Channel	21.17		Bridge									
Main Channel	21.16	Max WS	17894.83	875.30	892.55		894.02	0.009922	9.73	1838.27	425.31	0.83
Main Channel	21.16	14APR1996 2400	99.41	875.30	876.85		877.02	0.010020	3.28	30.30	36.43	0.63
Main Channel	21.14	Max WS	17935.64	874.00	892.99		893.19	0.000644	3.60	4983.95	665.51	0.23
Main Channel	21.14	14APR1996 2400	104.14	874.00	876.44		876.46	0.000777	1.29	80.62	57.61	0.19
Main Channel	20.67	Max WS	17804.22	873.00	891.51		891.68	0.000580	3.31	5394.23	774.20	0.22
Main Channel	20.67	14APR1996 2400	96.50	873.00	874.95		874.97	0.000440	0.92	104.54	80.96	0.14
Main Channel	19.84	Max WS	17782.47	870.00	884.90		885.38	0.002320	5.57	3190.13	578.25	0.42
Main Channel	19.84	14APR1996 2400	103.66	870.00	872.07		872.10	0.000898	1.32	78.55	60.66	0.20
Main Channel	19.13	Max WS	18422.78	863.00	876.73		877.20	0.002001	5.54	3326.37	545.83	0.40
Main Channel	19.13	14APR1996 2400	98.60	863.00	864.70		864.77	0.003069	2.07	47.66	47.14	0.36
Main Channel	18.40	Max WS	18077.96	855.00	872.39	865.52	872.53	0.000436	3.03	6810.34	1512.75	0.19
Main Channel	18.40	14APR1996 2400	104.32	855.00	858.29	856.45	858.30	0.000333	0.91	114.67	73.47	0.13
Main Channel	18.33		Bridge									
Main Channel	18.20	Max WS	17992.20	855.00	870.46		870.72	0.001144	4.05	4474.42	910.20	0.30
Main Channel	18.20	14APR1996 2400	100.98	855.00	857.39		857.43	0.001785	1.72	58.56	50.63	0.28
Main Channel	17.77	Max WS	17938.63	851.00	868.80	862.23	868.99	0.000505	3.53	5810.00	1123.42	0.21
Main Channel	17.77	14APR1996 2400	100.32	851.00	853.71	852.27	853.74	0.000732	1.44	69.88	40.24	0.19
Main Channel	17.76		Bridge									
Main Channel	17.75	Max WS	17920.07	850.75	865.86		866.27	0.001766	5.15	3536.86	686.42	0.37
Main Channel	17.75	14APR1996 2400	99.58	850.75	853.64		853.66	0.000541	1.29	77.32	41.73	0.17
Main Channel	17.29	Max WS	17555.82	850.00	862.44		862.78	0.001210	4.68	4267.26	988.48	0.31
Main Channel	17.29	14APR1996 2400	101.16	850.00	851.33		851.34	0.000714	0.99	102.23	102.59	0.17
Main Channel	16.91	Max WS	17212.19	845.00	861.19		861.29	0.000246	2.58	7449.31	1093.60	0.15
Main Channel	16.91	14APR1996 2400	99.79	845.00	850.61		850.61	0.000035	0.32	310.00	173.13	0.04
Main Channel	16.87	Max WS	17193.97	845.00	861.14		861.24	0.000250	2.60	7391.66	1085.27	0.15
Main Channel	16.87	14APR1996 2400	100.47	845.00	850.60		850.61	0.000035	0.33	308.51	172.09	0.04
Main Channel	16.79	Max WS	17182.37	845.00	861.03		861.14	0.000260	2.63	7274.42	1068.12	0.15
Main Channel	16.79	14APR1996 2400	99.63	845.00	850.59		850.59	0.000035	0.33	306.17	170.43	0.04
Main Channel	16.29	Max WS	16893.29	845.00	859.82		860.04	0.000583	3.70	4826.71	660.03	0.23
Main Channel	16.29	14APR1996 2400	101.35	845.00	846.90		846.97	0.002800	2.11	48.03	42.97	0.35
Main Channel	15.36	Max WS	16187.06	837.00	856.13		856.71	0.000854	6.91	7780.30	1445.44	0.30
Main Channel	15.36	14APR1996 2400	98.96	837.00	839.83		839.84	0.000186	0.78	126.23	65.09	0.10
Main Channel	14.80	Max WS	16070.45	836.00	854.62		854.81	0.000271	3.63	8099.23	1120.44	0.17
Main Channel	14.80	14APR1996 2400	101.17	836.00	839.46		839.46	0.000063	0.46	221.08	114.31	0.06
Main Channel	14.41	Max WS	16051.72	836.00	853.54		853.92	0.000605	5.10	4734.52	759.06	0.25
Main Channel	14.41	14APR1996 2400	98.86	836.00	839.23		839.24	0.000157	0.70	141.60	76.81	0.09
Main Channel	14.10	Max WS	16030.64	836.00	851.22		852.13	0.001813	7.91	3367.01	659.41	0.41
Main Channel	14.10	14APR1996 2400	100.99	836.00	838.82		838.83	0.000331	1.03	97.94	51.31	0.13
Main Channel	14.06	Max WS	16022.34	836.00	850.73		851.75	0.002304	8.45	3435.11	744.50	0.46
Main Channel	14.06	14APR1996 2400	100.99	836.00	838.31		838.42	0.003667	2.66	38.03	29.26	0.41
Main Channel	14.03	Max WS	16020.85	836.00	850.59		851.32	0.001471	7.01	3523.40	664.49	0.37
Main Channel	14.03	14APR1996 2400	100.70	836.00	838.01		838.04	0.000835	1.32	76.23	55.28	0.20
Main Channel	13.90	Max WS	16019.47	835.00	850.27		850.48	0.000374	3.87	6331.10	793.48	0.19
Main Channel	13.90	14APR1996 2400	99.77	835.00	837.69		837.70	0.000154	0.55	181.79	139.67	0.08

HEC-RAS Plan: Plan 4G River: South Fork Two R Reach: Main Channel (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main Channel	13.67	Max WS	15992.04	835.00	848.24		849.05	0.002312	7.27	2779.12	619.78	0.45
Main Channel	13.67	14APR1996 2400	100.54	835.00	837.08		837.11	0.000825	1.31	76.97	56.61	0.20
Main Channel	13.32	Max WS	15840.22	831.75	844.81		845.42	0.001539	6.44	3777.19	847.23	0.37
Main Channel	13.32	14APR1996 2400	101.34	831.75	833.14		833.21	0.003467	2.14	47.27	48.58	0.38
Main Channel	13.16	Max WS	15816.39	831.00	844.66		845.21	0.001374	6.08	4231.91	1024.54	0.35
Main Channel	13.16	14APR1996 2400	100.73	831.00	832.83		832.87	0.001574	1.64	61.54	52.30	0.27
Main Channel	12.64	Max WS	15533.11	826.50	841.68		842.16	0.000830	5.77	4556.34	883.36	0.29
Main Channel	12.64	14APR1996 2400	99.87	826.50	828.31		828.35	0.001739	1.47	67.82	73.04	0.27
Main Channel	11.93	Max WS	15127.48	821.00	839.05		839.46	0.000570	5.61	7118.61	1071.34	0.25
Main Channel	11.93	14APR1996 2400	101.03	821.00	825.03		825.03	0.000042	0.37	271.15	140.36	0.05
Main Channel	11.33	Max WS	14625.47	820.00	836.94		837.32	0.000721	5.01	3524.83	513.12	0.26
Main Channel	11.33	14APR1996 2400	100.43	820.00	822.50		822.54	0.001538	1.68	59.68	47.82	0.27
Main Channel	10.85	Max WS	14311.68	816.00	835.57		835.89	0.000396	4.81	8328.84	837.32	0.21
Main Channel	10.85	14APR1996 2400	100.90	816.00	820.57		820.57	0.000020	0.30	334.39	135.62	0.03
Main Channel	10.45	Max WS	14251.49	818.00	835.20		835.25	0.000088	1.83	8704.92	811.56	0.09
Main Channel	10.45	14APR1996 2400	99.81	818.00	820.14		820.15	0.000374	0.78	127.20	111.25	0.13
Main Channel	9.80	Max WS	14174.41	816.00	834.04		834.28	0.000385	4.19	6063.15	683.94	0.20
Main Channel	9.80	14APR1996 2400	100.69	816.00	818.75		818.77	0.000437	0.96	105.05	76.37	0.14
Main Channel	9.73	Max WS	14163.28	816.00	833.84	825.27	834.10	0.000405	4.26	5930.03	683.94	0.20
Main Channel	9.73	14APR1996 2400	99.71	816.00	818.55	817.26	818.57	0.000645	1.11	90.10	70.72	0.17
Main Channel	9.71		Bridge									
Main Channel	9.69	Max WS	14010.24	816.00	831.86		832.23	0.000714	5.09	4574.21	683.94	0.26
Main Channel	9.69	14APR1996 2400	101.17	816.00	818.37		818.40	0.000970	1.29	78.15	65.87	0.21
Main Channel	9.03	Max WS	13737.14	811.00	830.00		830.31	0.000424	4.80	6929.93	1039.26	0.21
Main Channel	9.03	14APR1996 2400	99.14	811.00	816.46		816.47	0.000009	0.24	408.31	128.91	0.02
Main Channel	8.23	Max WS	14544.56	811.00	828.87		828.94	0.000129	2.22	7958.33	1094.22	0.11
Main Channel	8.23	14APR1996 2400	102.12	811.00	813.19		813.25	0.001589	1.95	52.40	34.05	0.28
Main Channel	7.59	Max WS	14496.20	805.00	827.50	816.17	827.98	0.000527	5.63	3478.39	497.47	0.24
Main Channel	7.59	14APR1996 2400	98.53	805.00	810.67	806.21	810.67	0.000015	0.31	317.21	98.90	0.03
Main Channel	7.58		Bridge									
Main Channel	7.57	Max WS	14461.54	805.76	826.86		827.38	0.000608	5.88	3167.05	442.12	0.25
Main Channel	7.57	14APR1996 2400	93.28	805.76	810.67		810.67	0.000015	0.30	306.29	98.90	0.03
Main Channel	7.22	Max WS	14452.76	807.50	826.47		826.55	0.000156	2.27	6702.00	753.14	0.12
Main Channel	7.22	14APR1996 2400	106.48	807.50	810.41		810.42	0.000274	0.82	130.00	84.30	0.12
Main Channel	7.09	Max WS	14351.75	807.00	824.61		826.13	0.002711	10.19	2205.75	365.58	0.51
Main Channel	7.09	14APR1996 2400	95.74	807.00	809.43		809.49	0.002203	1.97	48.51	39.98	0.32
Main Channel	6.94	Max WS	14284.76	806.00	823.79	813.71	824.07	0.000374	4.65	6690.07	658.49	0.20
Main Channel	6.94	14APR1996 2400	107.77	806.00	808.41	806.80	808.41	0.000113	0.54	198.41	122.40	0.08
Main Channel	6.92		Bridge									
Main Channel	6.90	Max WS	14216.73	804.20	823.19		823.48	0.000375	4.68	6413.46	658.49	0.20
Main Channel	6.90	14APR1996 2400	81.44	804.20	806.31		806.33	0.000542	0.90	90.83	85.92	0.15
Main Channel	6.79	Max WS	14170.80	801.00	822.92		823.18	0.000299	4.41	6503.40	658.49	0.18
Main Channel	6.79	14APR1996 2400	119.99	801.00	806.14		806.15	0.000029	0.40	301.98	107.60	0.04
Main Channel	5.78	Max WS	13892.75	801.00	821.10		821.26	0.000267	3.36	7622.67	1349.28	0.16
Main Channel	5.78	14APR1996 2400	80.17	801.00	806.01		806.01	0.000011	0.25	317.42	109.88	0.03
Main Channel	4.88	Max WS	13766.56	801.00	820.20		820.28	0.000112	2.37	9782.39	1514.61	0.11

HEC-RAS Plan: Plan 4G River: South Fork Two R Reach: Main Channel (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main Channel	4.88	14APR1996 2400	119.71	801.00	805.98		805.98	0.000009	0.21	558.42	206.44	0.02
Main Channel	4.86	Max WS	13764.20	800.25	820.19	808.42	820.27	0.000111	2.36	9788.10	1514.61	0.11
Main Channel	4.86	14APR1996 2400	86.95	800.25	805.96	801.33	805.96	0.000004	0.15	578.36	205.77	0.02
Main Channel	4.85		Bridge									
Main Channel	4.84	Max WS	13751.79	799.75	820.08		820.16	0.000113	2.38	9642.92	1514.61	0.11
Main Channel	4.84	14APR1996 2400	99.71	799.75	805.97		805.97	0.000005	0.17	595.04	205.99	0.02
Main Channel	4.82	Max WS	13759.35	801.00	820.07		820.15	0.000116	2.40	9584.65	1514.61	0.11
Main Channel	4.82	14APR1996 2400	100.17	801.00	805.97		805.97	0.000006	0.18	556.09	205.99	0.02
Main Channel	4.45	Max WS	13747.55	801.00	819.87		819.94	0.000096	2.25	9433.97	1058.59	0.10
Main Channel	4.45	14APR1996 2400	99.84	801.00	805.95		805.96	0.000006	0.15	667.41	315.69	0.02
Main Channel	3.45	Max WS	13736.82	801.00	818.32		818.61	0.000439	4.35	3962.72	415.07	0.21
Main Channel	3.45	14APR1996 2400	100.18	801.00	805.87		805.87	0.000026	0.30	332.59	164.70	0.04
Main Channel	3.34	Max WS	13735.73	801.00	818.31		818.39	0.000111	2.28	7275.04	810.72	0.11
Main Channel	3.34	14APR1996 2400	99.90	801.00	805.86		805.86	0.000004	0.12	800.02	355.46	0.01
Main Channel	3.27	Max WS	13734.36	801.00	817.91		818.28	0.000884	4.93	2913.76	371.47	0.28
Main Channel	3.27	14APR1996 2400	100.13	801.00	805.86		805.86	0.000016	0.31	324.48	108.88	0.03
Main Channel	3.18	Max WS	13730.06	801.00	817.52		817.88	0.000649	4.97	4065.99	504.45	0.25
Main Channel	3.18	14APR1996 2400	99.92	801.00	805.84		805.84	0.000051	0.40	251.60	137.20	0.05
Main Channel	3.05	Max WS	13729.93	801.00	817.17		817.41	0.000378	4.19	5993.56	581.24	0.20
Main Channel	3.05	14APR1996 2400	100.10	801.00	805.82		805.82	0.000007	0.19	553.04	242.33	0.02
Main Channel	2.99	Max WS	13730.48	801.00	816.93	808.71	817.26	0.000519	4.88	4681.89	441.92	0.23
Main Channel	2.99	14APR1996 2400	99.94	801.00	805.82	801.90	805.82	0.000008	0.20	511.29	211.43	0.02
Main Channel	2.96		Inl Struct									
Main Channel	2.92	Max WS	13729.82	793.00	816.77		816.98	0.000205	3.74	4555.02	340.80	0.15
Main Channel	2.92	14APR1996 2400	99.94	793.00	795.73		795.74	0.000234	0.76	131.34	84.50	0.11
Main Channel	2.71	Max WS	13727.96	793.00	816.71		816.79	0.000084	2.20	7081.76	680.33	0.10
Main Channel	2.71	14APR1996 2400	100.48	793.00	795.47		795.48	0.000237	0.72	140.47	100.11	0.11
Main Channel	2.40	Max WS	13723.53	791.00	816.48		816.62	0.000132	3.08	5976.13	527.27	0.12
Main Channel	2.40	14APR1996 2400	99.86	791.00	795.23		795.23	0.000060	0.47	213.59	103.32	0.06
Main Channel	2.11	Max WS	14726.65	791.58	815.91		816.28	0.000378	5.00	3972.09	840.01	0.20
Main Channel	2.11	14APR1996 2400	100.25	791.58	795.06		795.07	0.000154	0.80	125.20	53.56	0.09
Main Channel	2.08	Max WS	14726.24	791.48	815.97	803.92	816.10	0.000184	3.51	15543.31	1840.01	0.14
Main Channel	2.08	14APR1996 2400	99.92	791.48	795.04	792.69	795.05	0.000138	0.77	129.31	53.86	0.09
Main Channel	2.07		Bridge									
Main Channel	2.06	Max WS	14725.80	791.23	815.81		815.93	0.000180	3.48	15702.78	1840.01	0.14
Main Channel	2.06	14APR1996 2400	100.00	791.23	795.03		795.03	0.000103	0.70	142.33	54.78	0.08
Main Channel	2.01	Max WS	14725.08	791.00	815.78		815.86	0.000101	2.40	7860.73	698.76	0.10
Main Channel	2.01	14APR1996 2400	100.04	791.00	795.00		795.01	0.000097	0.57	175.32	89.45	0.07
Main Channel	1.80		Lat Struct									
Main Channel	1.65	Max WS	9285.66	789.00	815.55		815.67	0.000188	2.86	4505.29	696.96	0.14
Main Channel	1.65	14APR1996 2400	99.98	789.00	794.86		794.87	0.000051	0.66	152.39	35.54	0.06
Main Channel	1.50		Lat Struct									
Main Channel	1.12	Max WS	2307.76	789.00	815.38		815.38	0.000004	0.55	10784.36	1046.29	0.02
Main Channel	1.12	14APR1996 2400	100.03	789.00	794.78		794.78	0.000006	0.24	416.43	96.77	0.02
Main Channel	0.38	Max WS	2306.18	789.00	815.37		815.37	0.000001	0.20	11869.30	981.07	0.01

HEC-RAS Plan: Plan 4G River: South Fork Two R Reach: Main Channel (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main Channel	0.38	14APR1996 2400	99.99	789.00	794.71		794.72	0.000028	0.50	200.32	46.32	0.04
Main Channel	0.02	Max WS	2304.72	788.75	815.37		815.37	0.000002	0.38	14671.69	1990.80	0.01
Main Channel	0.02	14APR1996 2400	100.00	788.75	794.69		794.69	0.000003	0.17	604.06	136.15	0.01
Main Channel	0.00	Max WS	2304.37	788.50	815.37	791.77	815.37	0.000002	0.40	13143.94	1990.80	0.02
Main Channel	0.00	14APR1996 2400	100.40	788.50	794.69	789.28	794.69	0.000003	0.16	621.49	136.14	0.01

APPENDIX D Additional Gate Operation Procedures, Lake Bronson Dam

1. For normal run-of-river operation, keep the three main gates closed. Maintain the pool elevation by using the low flow valve or by letting flow go over the top of the gates.

2. Start using the gates when the pool rises to a gage reading of 19.85 (0.5' above normal pool) and is still rising. Use only the center gate until it is 2' open; then use the south gate until it is 2' open; then use the north gate until 2' open. For openings more than 2', keep all gate openings about equal.

3. For a rising pool above gage 19.85, open the gates in 6" increments at 2 hour intervals. Monitor pool elevations and continue 6" incremental gate openings until the pool stops rising. As the pool recedes, use 6" closing increments. Begin closing gates when the pool has dropped 6" below the peak elevation. Continue checking pool and making incremental closings until pool is back to normal. The gate adjustment increment and frequency of checking the pool may be adjusted, based on runoff event experiences. The dam operator shall keep records of gate operations in a daily log, which can be used to fine tune the procedures. Consult with the Area Hydrologist and Dam Safety Supervisor to formally revise the procedures.

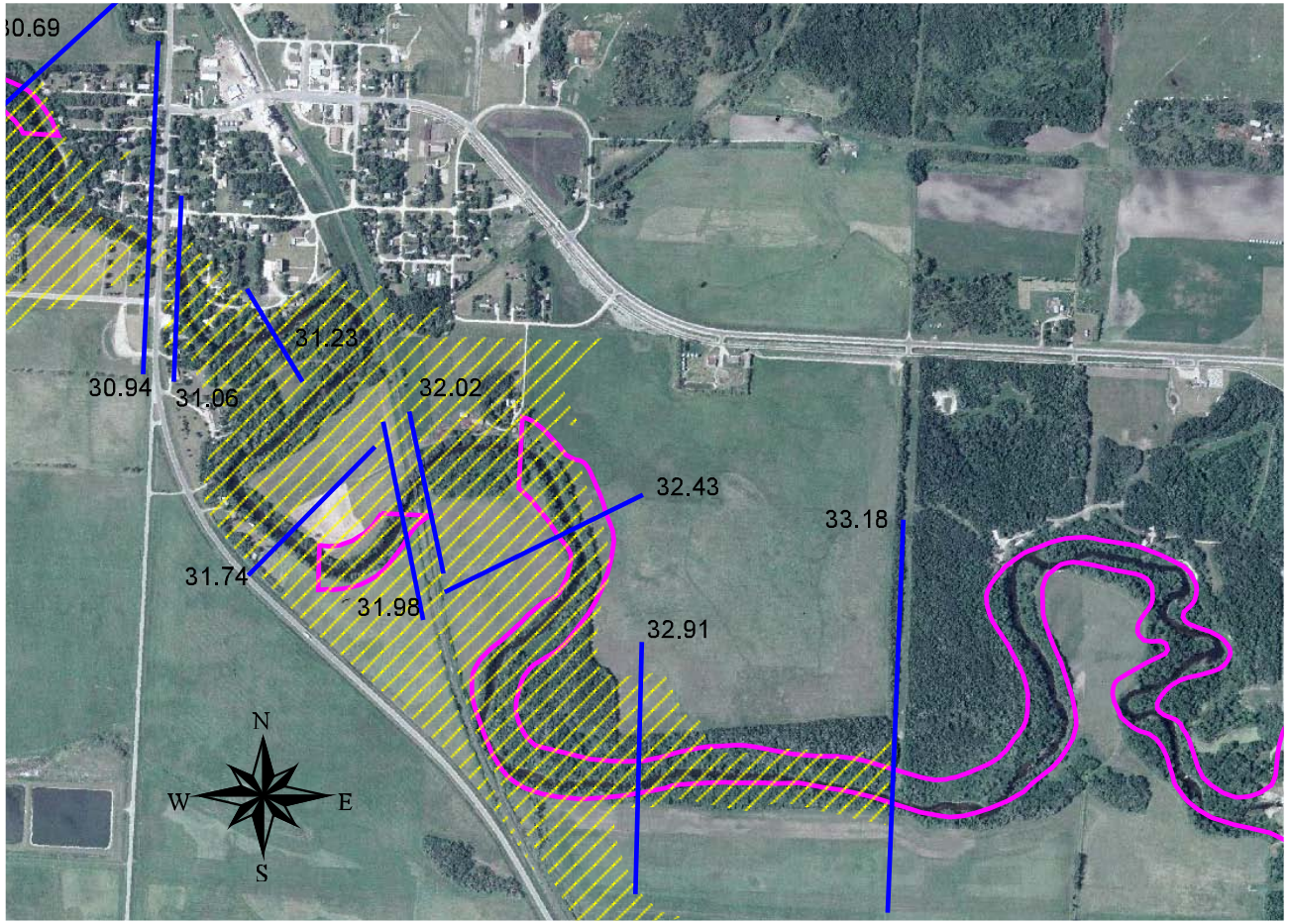
4. Implement a preflood drawdown of the lake when a rapid runoff of 3" of water (watershed average) is probable. Drawdown is to be to the top of the concrete spillway (gage reading 15.2). Three inches of runoff applies for snowmelt, rainfall or combinations therof.

5. Lower the pool when the dam is threatened by a breach of any kind. This lowering may result in spillway discharges which could flood downstream properties. The warning procedures described in the *Emergency Preparedness and Response Plan* should then be implemented.

6. Operate each of the gates at least once every three months to assure proper function. Open each of the gates to "full open" at least once a year. Keep records of these "tests" in the daily log. The DNR Dam Safety Supervisor may require gates to be opened fully when conducting annual inspections.

7. Maintain run-of-river flow for downstream needs. Consult with the Area Hydrologist for instream flow needs or when discharge ceases.

Appendix E: Inundation Map - City of Lake Bronson



LEGEND

- Cross Section Location and Number
- Inundation area - Scenario 3

FEMA Floodplains

- 100-Year Floodplain
- 500-Year Floodplain

Image : 2003-2004 FSA Color DOQs

Dam Break Floodwave Characteristics

Station	Leading Edge HH:MM	Time to Peak HH:MM	Max WSL feet
34.56	0:00	0:42	968.8
33.18	0:11	0:54	965.0
32.91	0:21	1:02	963.1
32.43	0:25	1:23	960.8
32.02	0:27	1:28	960.1
31.98	0:28	1:32	959.6
31.74	0:38	1:34	958.9
31.23	0:39	1:38	956.8
31.06	0:40	1:38	956.5
30.94	0:40	1:53	948.2
30.69	0:40	2:13	945.8

This map shows the approximate areas expected to be inundated by a combined 100-year flood event and a large dam break as defined by Scenario 3 of this report.

Scale: 4 inches is approximately 1 mile

Appendix F: Inundation Map - City of Hallock

LEGEND

- Cross Section Location and Number
- Inundation Area - Scenario 3

FEMA Floodplains

- 100-Year Floodplain
- 500-Year Floodplain
- Area of "Breakout" Flows

Image: 2003-2004 FSA color DOQs

Dam Break Floodwave Characteristics

Station	Leading Edge HH:MM	Time to Peak HH:MM	Max WSL feet
4.44	4:08	13:34	819.9
3.45	4:55	13:41	818.3
3.18	4:56	13:48	817.5
3.05	4:57	13:47	817.2
2.92	4:58	13:49	816.8
2.71	4:59	13:52	816.7
2.40	5:00	13:51	816.5
2.11	5:02	13:53	815.9
2.08	5:31	13:51	815.9
2.06	5:31	13:53	815.8
2.01	5:31	13:52	815.8
1.65	5:32	14:01	815.6
1.12	5:51	14:13	815.4
0.00	5:51	14:07	815.4

This map shows the approximate areas expected to be inundated by a combined 100-Year flood event and a large dam break as defined by Scenario 3 in this report.

Scale: 4 inches is approximately 1 mile

APPENDIX G Emergency Notification Contacts

October 13, 2004

ORIGINATING CALLER	TO BE NOTIFIED	PHONE NO.
OBSERVER	1. Lake Bronson State Park Manager/Asst. Manager	218-754-2200
Lake Bronson State Park	2. State Division of Homeland Security and Emergency Management Duty Officer	1-800-422-0798
	1. Kittson County Sheriff	Radio or 218-843-3535
	2. MNDNR Area Hydrologist Chad Konickson	218-681-0947 (w)
	Alt. MNDNR Regional Hydrologist Larry Kramka	218-755-3637 (w)
Kittson County Sheriff	1. Lake Bronson Fire Department	Radio
	2. Kittson Cty Highway Department Kelly Bengtson	218-843-2686 (w)
	3. Canadian Pacific Railroad Control Center	1-800-SOO-HELP
	4. MN State Patrol	Radio or 218-681-0942
	5. Hallock Fire Department	Radio
	6. Hallock Police Department	Radio
	7. Lancaster Fire Department	Radio
	8. Radio Stations	
	KROX- Crookston, MN	218-281-1140
	WDAY - Fargo, ND	701-237-6500
MNDNR Area or Regional Hydrologist	1. MNDNR Dam Safety Unit Dana Gauthier	651-296-0521 (w)
	ALT. Director-Division of Waters Kent Lokkesmoe	651-296-4810 (w)
	2. National Weather Service Grand Forks, ND	701-795-5119 701-795-5127
	St. Paul, MN	1-800-692-2110 952-361-6671
	3. U.S. Army Corps of Engineers Chief Emergency Operations Dave Christenson	651-290-5204 (w)
	ALT: (24 Hrs/Day Answering Service)	651-290-5220

APPENDIX H Emergency Notification Flow Chart

DESCRIPTION: A serious condition of distress which is progressively getting more severe but does not cause an imminent threat of failure. An example of this condition occurs when all gates are open and water levels are rising. Evacuation is not required.