Fargo, ND | HEI No. 8150-0002
June 26, 2020

May 22, 2013 – Cart Creek at Crystal, ND Looking Southeast

NORTH BRANCH PARK RIVER WATERSHED PLAN: APPENDIX D-2

Screening of Alternatives for Detailed Review

NORTH BRANCH PARK RIVER WATERSHED PLAN

SCREENING OF ALTERNATIVES FOR DETAILED REVIEW

June 26, 2020

Park River Joint Water Resource District

Houston Engineering, Inc.
1401 21st Ave. N
Fargo, ND 58102
Phone # 701.237.5065

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision, and that I am a duly Licensed Engineer under the laws of the State of North Dakota.

Bret T. Zimmerman, PE PE-10646	Paul D. LeClaire, PE PE-28012
Date	Date

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APPENDICES

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1 APPROACH

Preliminary development of alternatives focused on narrowing the range of alternatives by reviewing and analyzing technical and practical considerations to evaluate potential to meet project objectives from the Purpose and Need. Strategies were first evaluated based on known causes of flooding. In some cases, a preliminary hydrologic analysis was completed to reasonably evaluate a strategies' potential to meet flood damage reduction objectives. Alternative concepts that were based on strategies that would meet the project objectives were then developed and preliminarily analyzed to further narrow the range of alternatives based on the ability to address the Purpose and Need.

To assist with a comparative analysis of the alternatives, the following indicators were established as pass-fail criteria for the preliminary development of alternatives. The objectives and associated indicators are summarized below:

- **INDICATOR NO. 1:** Reduce cropland inundation for flood durations equal to or less than four days by 5% within the Cart Creek subwatershed during the 10-year flood event. Flood durations greater than four days generally represent the maximum anticipated damages for crop types present in the study watershed. These crop types include wheat, soybeans, corn, dry beans, potatoes, and sugar beets. The percent reduction goal was set based on reductions in inundation that resulted from a sensitivity analysis where the runoff originating from the 50 square mile subwatershed west of ND Highway 32 was removed from the hydrologic and hydraulic models. This resulted an approximate 30% reduction in inundated cropland acres during the 10-year flood event. Refer to Section 2.1.3 of this report for more information on this sensitivity analysis. A 5% reduction in cropland inundation was deemed to be a realistic expectation of the preliminary screening for alternatives.
- **INDICATOR NO. 2:** Increased flood resiliency for public and private infrastructure along the Cart Creek would be gained by a reduced frequency of high flow rates. The following reduction in peak flow rates were assumed to be realistic targets based on reasonable expected acre-feet reduction for alternatives from the peak of the flood hydrograph. Acre-feet reductions presented below should be considered "ideal", meaning these reductions can only be achieved if alternatives were placed in locations that exactly match the source and timing of flood flows. In practice, placement of hydrologically ideal volume reduction measures is generally limited due to the feasibility of other technical, practical, and environmental concerns.
    - **(a)** 20% on the Cart Creek at Crystal, ND. A 20% reduction of the 10-year peak flow rate would require approximately 1,300 acre-feet of volume reduction from the peak of the flood hydrograph.
    - **(b)** 10% on the North Branch at the confluence of the Cart Creek. A 10% reduction of the 10-year peak flow rate would require approximately 1,300 acre-feet of volume reduction from the peak of the flood hydrograph.
- **INDICATOR NO. 3**: Reduce the 100-year event peak flow rate by 30% on the Cart Creek at the community of Crystal, ND. Reducing the 100-year peak flow rate by 30% on the Cart Creek would result in a with-project conditions 100-year peak flow rate approximately equivalent to the existing conditions 50-year peak flow rate. Based on preliminary economic review, this would represent an approximate 40% reduction in damages to the community of Crystal, ND during the 100-year flood event.
- **INDICATOR NO. 4**: No increase in peak flow rate at the outlet of the North Branch Watershed. Included in this are flow rates along the channel and breakout flows to the east.

The alternatives that successfully achieve the objectives defined in the Purpose and Need statement based on the presented indicators are proposed to be carried forward for a detailed review. It should be noted that these indicators are used as a preliminary screening tool, and an incremental analysis of benefits as required in the National Watershed Planning Manual will be completed to establish highest benefit/cost ratio for each alternative studied in detail. All reasonable alternatives that were identified were considered, regardless of eligibility under Public Law 83-566, or other NRCS administered funding sources.

2 INITIAL STRATEGY SCREENING

The initial phase of the development of alternatives was a review of a comprehensive list of strategies that represent categorized types of alternatives. The goal of the strategy evaluation was to narrow the scope of preliminary alternative review through the acceptance or elimination of strategies based on limited technical evaluation and practical considerations. To aid in this review, strategies were categorized into five generalized groups.

1. No-Action involves forecasting the watershed condition if no alternative plan is selected.
2. Reduce runoff volume involves structural and non-structural practices that result in reductions to the excess runoff volume from the water budget during a rain event.
3. Increase conveyance capacity provides additional hydraulic capacity within the watershed at known damage locations.
4. Increase temporary flood storage provides additional flood storage within the watershed, typically through structural measures that would maximize available flood storage.
5. Protection/Avoidance are structural and non-structural practices that would reduce damage frequency for land, structures, and infrastructure.

A description of strategies that have been identified and considered within each category is provided in **Table 1**.

Table 1: Strategy Description

Category	Strategy	Description
No-Action	No-Action	The future-without-project, or No-Action, alternative is required under Public Law 83-566 Watershed Planning. Involves forecasting the watershed conditions that are expected to exist if an alternative plan is not selected.
Reduce Runoff Volume	Cropland Better Management Practices	Cropland management practices have been developed to conserve soil and water resources. These are collectively referred to as best management practices (BMPs). The most commonly used agricultural BMPs are forms of conservation tillage that leave the soil better protected by crop residues than other tillage methods. This may also increase infiltration, thereby reducing runoff. The reduction in runoff varies with the topography, amount of rain, and type of soil.
	Conversion to Grassland	Perennial grassland including CRP, hay meadow, and well-managed pasture can produce less rainstorm runoff than cultivated cropland.
	Conversion to Forest	Forestland can produce less rainstorm runoff than cultivated cropland. The effects on snow accumulation and spring snowmelt runoff from forestland have not been well documented.

Category	Strategy	Description
	Aquifer Storage	The recharging of underground aquifers can potentially provide storage capacity when combined with a passive infiltration system and a surface storage site. Using underground aquifers to store runoff is dependent on the location and availability of the aquifer within the watershed.
	Other beneficial uses of stored water	Stored water can be used for domestic or industrial purposes, or for stream flow augmentation during drier periods of the year to improve fish habitat and provide other instream flow benefits. Use of this water results in drawdown of a storage reservoir, providing annual removal of water from the spring flood volume.
Increase Conveyance Capacity	Channelization	Channelization projects may include enlarging or realigning natural channels or creating channels in areas of natural overland flow. Channelization projects are usually constructed to decrease localized flooding; however, the potential increase to flooding downstream of the channelization extents must be considered and mitigated for.
	Drainage	The primary purpose of agricultural drainage in the Red River Basin is to remove excess surface water and soil moisture. Depending on the type of drainage, this can allow the ground to warm up faster in the spring, provide an aerated rooting zone for crop development, and minimize drowning of crops by excess precipitation. The need for outlets for field drainage led to the development of larger collector ditch systems in many areas of the Red River Basin.
	Flood Water Diversion	Diversion projects typically remove water from a flood-prone stream, convey it safely around a known damage site, and return it to a downstream watercourse. A diversion is an alternative to channelization or protection measures, such as levees and floodwalls, when environmental impacts, cost, or other land use issues are better addressed by this measure.
	Increase Roadway Capacity	During high flows in flat topography, road crossings typically restrict conveyance more than the available channel capacity. Roadway capacities can be increased in these instances to reduce flooding caused by high headwater elevations on roadway bridges and/or culverts. While this strategy can reduce localized flooding upstream of roadways, downstream flooding must be considered and mitigated for.
Increase Temporary Flood Storage	On-Channel Dam	On-channel dams are constructed to temporarily store and attenuate peak flows downstream. The most important consideration from an overall flood control standpoint is the timing of the storage and release of attenuated peak flows. An embankment is typically constructed across a natural water course with a regulated outflow structure.
	Reduced Bridge/Culvert Capacity	Culvert sizing is a technique that can be used to control runoff rates. By appropriately sizing road and drainage system culverts throughout a subwatershed or watershed, the flow rates can be regulated to better suit downstream channel capacities. Excess water is temporarily detained upstream of culverts.

Category	Strategy	Description
	Wetland Restoration/Creation	Created or restored wetlands are basins that are implemented primarily to attain a natural resource and/or habitat objective. Wetlands developed for natural resource and/or habitat objectives can provide temporary flood storage. Temporary flood storage is considered beneficial if the topography allows for levels to be managed to provide a reasonable assurance that flood storage is available when needed without adversely impacting other objectives.
	Setback Levees	Levee systems set back from the river channel can be used to increase channel retardance, increase the channel conveyance, and increase floodplain connectivity allowing for increased storage within the river corridor. Setback levees require balancing the increased channel retardance with the increased conveyance volume from containing breakout flows. Setback levees are generally located where geotechnical stability is ensured. Setback levees require careful consideration to drainage of lands directly adjacent to the levees to ensure additional damages are not caused by a lack of an adequate outlet when high water conditions are present within the levee corridor.
	Meter Runoff	Drain tile and culvert sizing can be used to store runoff within the existing landscape. Utilizes existing depressions within the watershed that consist of agricultural fields bounded by existing roads. Culverts at the outlet of the depressions are sized so that runoff is stored for a short time so that agricultural lands are not adversely impacted.
	Off-Channel Impoundment	Off-channel impoundments are constructed to temporarily store and release flood waters when downstream flooding recedes. The most important consideration from an overall flood control standpoint is the timing of the storage and release of floodwaters. Off-channel impoundments typically consist of an embankment constructed around an area adjacent to a channel with topography conducive to storing runoff. From a locally acceptable perspective, the best suited locations are typically in already flood prone areas, where higher value crop land or pasture land is not required to be removed from production. A control structure is typically required to divert flows from the channel into the impoundment location.
	River Corridor Protection/ Restoration	Existing riparian corridors would be restored and protected to ensure proper geomorphic conditions are present. From a flood damage reduction standpoint, restoration of a degrading channel would allow for more frequent access to a vegetated floodplain to reduce downstream flow rates. Incised channels can be modified to reduce channel conveyance for increased floodplain connectivity. Setback levees are often required to contain the floodplain and to keep break out flows contained within the riparian corridor.

Category	Strategy	Description
Protection/ Avoidance	Levees	Levee systems are meant to contain the natural floodwaters and the natural floodplain and can be used to protect communities, rural farmsteads, and cropland. If a levee system encroaches on the natural floodplain, the system can result in increased flows and downstream flooding must be considered and mitigated for. As with setback levees, consideration for drainage of land directly adjacent to the levee is critical. In many urban settings, this results in large lift stations being installed with high capacity electrical pumps to lift water over the levee during floods.
	Flood Warning System	Flood warnings and emergency response begins with long- and short-term forecasts of flood potential and can lead to sandbagging, earthen levee construction, or other emergency protection methods, and ultimately evacuation, if necessary. Available timing between flood warning issuance and actual flood conditions is critical to ensure emergency response can be coordinated.
	Floodplain Easements	Landowners would be compensated through establishment of a set-aside easement to no longer operate on flood prone areas. (Emergency Watershed Protection Program, etc…)

2.1 TECHNICAL CONSIDERATIONS

A technical evaluation was completed to provide sufficient information of various strategy types for initial review to meet objectives from the Purpose and Need. The technical evaluation utilized the hydrologic and hydraulic models developed for the North Branch Park River Watershed. The development of the HEC-HMS and HEC-RAS models is documented in the *North Branch Park River Watershed Plan Existing Conditions Hydrology and Hydraulic Report* (HEI, 2018). Multiple reporting locations were selected to evaluate model results. The reporting locations are shown on **Figure D-2-A.1** in **Attachment D-2-A** and are further summarized below.

- Cart Creek at 86th Street NE – Downstream of the confluence of Cart Creek and an Pembina County Drain 28.
- Cart Creek at Pembina County Road 12 – Downstream of the confluence of Cart Creek and an unnamed tributary.
- Cart Creek at 138th Avenue NE near Crystal, ND – Downstream of a railroad crossing and at the downstream end of where the Cart Creek flows through the community of Crystal.
- Cart Creek at North Dakota Highway No. 18. – Downstream of Crystal, between Crystal and the confluence with the North Branch Park River.
- North Branch Park River at 77th Street NE – Downstream of the confluence of the North Branch Park River and Cart Creek.
- North Branch Park River Outlet (Channel Only) – This reporting location only accounts for the flow within the North Branch Park River channel near the confluence with the Middle Branch Park River. The reporting location is located at the Burlington Northern Santa Fe (BNSF) Railroad crossing.
- North Branch Park River Outlet (Including Breakouts) – This reporting location accounts for both the channel flows measured at the BNSF Railroad crossing and all breakout/overland flows near the outlet of

the North Branch Park River. Flows measured at this reporting location span an approximate 9 mile long transect.

To accurately evaluate the technical consideration alternatives, both the changes in peak flow and inundated acres need to be compared to existing conditions. **Table 3** and **Table 4** provides information on peak flow and inundated acres for the different technical considerations alternatives as discussed in the following sections.

2.1.1 REDUCE RUNOFF VOLUME

A sensitivity analysis was completed using the watershed hydrologic and hydraulic models to assess the maximum flood volume reduction benefits that could be attained by converting cropland to perennial vegetation. While not all strategies that categorically fit under the *Reduce Runoff Volume* category are focused on cropland conversion to perennial vegetation, this review assumed that other strategies within the category would hydrologically perform equivalent to perennial vegetation at their optimum design. For this analysis, cropland refers to lands with NLCD Land Use Codes of pasture/hay (81) and cultivated crops (82) (Homer, et al., 2015). While conversion of all the cropland within the watershed may not be practical to implement, it provides a baseline of the highest potential flood volume reduction in the watershed through the use of these practices. In total, there are 214 square miles (83% of the total area) of cropland within the North Branch Watershed. Three scenarios were evaluated for the purposes of this analysis. The three scenarios consisted of converting cropland (pasture/hay and cultivated crops) to perennial vegetation in three regions of the North Branch Watershed. The three regions are shown on **Figure D-2-2.1.1** and the regions that were selected include;

- All cropland within the North Branch Watershed would be converted to perennial vegetation.
- Cropland west of ND State Highway No. 32 in the North Branch Subwatershed (area draining to the North Branch of the Park River) would be converted to perennial vegetation, with the remaining watershed left as the existing condition.
- Cropland west of ND State Highway No. 32 in the Cart Creek Subwatershed (area draining to Cart Creek) would be converted to perennial vegetation, with the remaining watershed left as the existing condition.

While conversion from cropland to perennial vegetation would represent the maximum achievable hydrologic reduction to runoff volume, a more practical ability to implement would be somewhere between the results of the sensitivity analysis and the existing conditions.

NRCS Curve Number values were adjusted in the hydrologic model to assume that all cropland within the three regions discussed would be converted to perennial vegetation based on guidance from *TR-55 Urban Hydrology for Small Watersheds* (NRCS, 1986). **Table 2** below summarizes the existing and modified NRCS Curve Numbers that were used for this analysis.

Table 2: NRCS 24 Hour Curve Number Modifications for Perennial Vegetation Analysis

NLCD Land Use Code	Condition	Hydrologic Soil Type						
		A	B	C	D	A/D	B/D	C/D
Pasture/Hay (81)	*Existing*	49	69	79	84	84	84	84
	Perennial Vegetation	30	58	71	78	78	78	78
Cultivated Crops (82)	*Existing*	61	71	78	81	61	71	78

NLCD Land Use Code	Condition	Hydrologic Soil Type A	B	C	D	A/D	B/D	C/D
	Perennial Vegetation	30	58	71	78	30	58	78

The hydrologic and hydraulic models for the North Branch Watershed were used to compute reduced volume flood hydrographs that would result from cropland conversion. The analysis was only completed on the 10-year rainfall event because reductions during large flood events is expected to be reduced. Using NRCS Curve Number methods to calculate the rainfall/runoff volume relationship results in a higher percentage of rainfall converted to runoff as the rainfall depth increases. **Table 3** shows peak flow reductions and changes to inundated acres for the three scenarios. Hydrographs showing preliminary modeling results for the 10-year event are available in **Attachment D-2-A.2**.

2.1.2 INCREASE CONVEYANCE CAPACITY

Increased hydraulic capacity within the watershed would result in a reduced travel time and reduced access to natural flood plain areas. To estimate the effects of increased conveyance capacity within the North Branch Park River Watershed, existing bridge and culvert crossings on Cart Creek were approximately doubled in available flow area and analyzed using the hydraulic model. Culverts within the floodplain were also increased in size to reduce inundation. The crossings that were modified for this analysis are shown on **Figure D-2-2.1.2**. This analysis was completed mainly for the Cart Creek Subwatershed due to the location of the identified damage centers. This analysis indicated that peak flood flow rates at the North Branch Park River outlet (including overland flow) increase by 4% during the 10-year event, and 9% during the 100-year event. Refer to **Table 3** for changes in peak flow at the reporting locations and changes to inundated acres for this scenario. Hydrographs showing preliminary modeling results are available in **Attachment D-2-A.3**.

2.1.3 INCREASE TEMPORARY FLOOD STORAGE

As indicated by hydraulic modeling and supported by public comment, much of the flooding that occurs within the North Branch Watershed is east of North Dakota State Highway No. 32 (ND Highway 32). West of ND Highway 32, runoff quickly accumulates in steeper topography, and flows to the east where the topography flattens to create expansive floodplain areas. The area west of ND Highway 32 accounts for approximately 50% of the drainage area to Crystal, ND and 42% of the drainage area to the North Branch Park River outlet. The hydrologic model was used to estimate the effects of removing flood volume from west of Highway 32 for two scenarios. The scenarios include; removing all runoff volume from west of ND Highway 32 in the Cart Creek Subwatershed and removing all runoff volume west of ND Highway 32 in both the North Branch Subwatershed and the Cart Creek Subwatershed as shown on **Figure D-2-2.1.3**. **Table 3** shows peak flow reductions and changes to inundated acres for the two scenarios described. Hydrographs showing preliminary modeling results are available in **Attachment D-2-A.4**. Hydrographs at locations along the Cart Creek are identical for both scenarios.

2.1.4 TEMPORARY PROTECTION

Flood timing was reviewed from the existing conditions hydrologic and hydraulic models to assess the potential for advanced warning systems and installation of temporary protection measures. Measures could be established by local emergency management officials to better inform residents of impending flood risk.

When comparing the peak intensity of rainfall with the peak outflow from the North Branch Park River Watershed, an approximate 2.5-day lag is observed for a 10-year event.

2.1.5 WETLAND RESTORATION

The National Wetlands Inventory (NWI) dataset was used to apply the methods described in USGS Open File Report 2007-1159 (Gleason, Tangen, Laubhan, Kermes, & Euliss Jr., 2007). This report provides a method to estimate potential surficial flood storage volumes for drained wetland basins in the Prairie Pothole Region, which includes the North Branch Park River Watershed. Drained wetland basins are described as NWI wetlands indicated as drained or partially drained. Within the North Branch Watershed, there are approximately 375 acres of NWI wetlands attributed as being drained or partially drained. Using methods from the USGS Open File Report 2007-1159, the potentially available flood storage within each individual NWI drained based was calculated. In total, this resulted in approximately 561 acre-feet of available surficial flood storage. The locations of the NWI drained basins within the watershed are presented in **Figure D-2-2.1.5**. Each of the NWI drained basins was overlaid with the subbasins from the hydrologic model, and an adjustment was made to curve numbers to reflect the change in volume based on the calculated available surficial flood storage. The hydrologic and hydraulic models were then re-ran using these adjusted factors that accounted for the potentially available surficial flood storage to estimate flow reductions as compared to the existing conditions. It should be noted, that, while the NWI dataset may not be considered a comprehensive source for all landscape areas representing potential restorable wetlands, it was assumed to be appropriate for depressional basins that facilitate flood storage through changes in water depth within the wetland basin.

Vegetative restoration of other wetlands that may not lend themselves to providing significant surficial storage were also analyzed. Reestablishment of perennial vegetation in areas that contain hydric soils was reviewed and analyzed with the hydrologic and hydraulic models. The two scenarios considered in this analysis are as follows:

- Conversion of lands containing hydric soils with a hydric rating greater than or equal to 50. As indicated by the SSURGO soil database, areas with a hydric rating greater than or equal to 50 in the North Branch Park River Watershed make up approximately 40 square miles of the total 257 square mile drainage area, or 15.7%.
- Conversion of lands containing hydric soils with a hydric rating of 100. Areas with a 100% hydric rating in the North Branch Park River Watershed make up approximately 15 square miles of the total 258 square mile drainage area, or 5.8%.

NRCS Curve Number values for areas indicated as hydric soils under each scenario were adjusted to reflect runoff volume reductions as indicated in Table 5-2 in the North Dakota Hydrology Manual (USDA, SCS). These adjusted NRCS Curve Numbers were then input into the hydrologic and hydraulic model and used to estimate changes in peak flow and inundation acres. Refer to **Table 3** for changes in peak flow and inundated acres for the scenarios described. A map showing partially drained or ditched wetlands based on the NWI dataset, and areas with hydric soils in the North Branch Park River Watershed is presented in **Figure D-2-2.1.5**. Hydrographs showing preliminary modeling results with wetland conversion based on hydric soil data are available in **Attachment D-2-A.5**.

2.1.6 RIPARIAN CORRIDOR RESTORATION

Riparian corridor restoration was evaluated using the hydraulic model for the North Branch Park River Watershed. Channel capacity was reduced to the 1.5-year event to simulate increased access to the floodplain storage for larger events. Riparian corridor restoration focused on the Cart Creek Subwatershed because existing damages indicated by modeling results and public input were located within the Cart Creek Subwatershed. Much of Cart Creek floodplain along this reach is considered perched, meaning the floodplain slopes away from the channel. Under this condition, an increased access to the floodplain would result in an increased frequency of breakout flows, which contribute to flood damages within the watershed. To account for this, two different setback levee scenarios were evaluated along with the riparian corridor restoration; a 500-foot corridor and a 1,000-foot corridor. An approximate estimate of area required within each setback levee option is 1,690 acres for the 500-foot corridor and 2,350 acres for the 1,000-foot corridor. In addition to increased access the floodplain storage and utilization of setback levees, channel sinuosity was evaluated in areas were straighten channels have potential to be remaindered. Reach lengths between cross sections were modified to reflect a sinuosity of 1.7.

For this analysis, riparian corridor restoration along the entirety of Cart Creek was considered with a 500-foot corridor and a 1,000-foot corridor, as well as with and without restoration of sinuous channel design. To review how different regions of restoration for Cart Creek affect changes in peak flow and inundated acreage, three areas along Cart Creek were isolated (lower, middle, and upper). Because changes to peak flow and inundated acres were quantified for Cart Creek with and without restored oxbows/sinuous channel design for the entire Cart Creek, individual regions were only analyzed assuming that the restored sinuous channel design in each region are included. Maps showing the locations of potential sinuous channel restorations (designed sinuosity of Cart Creek east of Mountain, ND is not displayed in figures and was only accounted for with elongated reach lengths in the hydraulic model). The two setback levee options, and potentially impacted structures within the setback levee corridor are presented in **Figure D-2-2.1.6a**. Figures showing the three regions, Lower Cart Creek, Middle Cart Creek, and Upper Cart Creek, are presented in **Figure D-2-2.1.6b**, **Figure D-2-2.1.6c**, and **Figure D-2-2.1.6d** respectively.

The hydraulic model was used to evaluate the 10-year and 100-year events with modified channel capacity, increased sinuosity, the two setback levee scenarios for the entire Cart Creek, and the isolated regions of Cart Creek. Setback levee elevations were set at an elevation equal to the 10-year water surface profile elevation, with allowed overtopping during the 100-year event. During the 10-year event, flow rates at the two identified reporting locations along Cart Creek decrease by 24-29% for the 500-foot setback levee corridor option and 29-35% for the 1,000-foot corridor option. Further downstream at the outlet of the North Branch Park River Watershed (including overland flow), flow reductions for the 10-year event are 6-8% for the 500-foot corridor and 21-24% for the 1,000-foot corridor. Peak flow and inundated acreage changes are presented in **Table 4** for all scenarios described. Additional information on how each region of Cart Creek affects the peak flow and inundation at the reporting locations can be found in **Table 4**. The water surface profile increases in various locations along the Cart Creek for riparian corridor restoration. Additional consideration was given to structures located within the setback levees. Increasing the water surface profile for larger events poses additional risk for these structures. **Figure D-2-2.1.6e**, **Figure D-2-2.1.6f**, and **Figure D-2-2.1.6g** show profile data for Lower Cart Creek, Middle Cart Creek, and Upper Cart Creek respectively. The profile data includes water surface profiles for the 100-year event, proposed channel fill elevations, and structures located within the 1,000-foot corridor. Hydrographs showing preliminary modeling results for all scenarios described in this section are available in **Attachment D-2-A.6**.

Table 3: Peak Flow and Inundation Changes for Technical Consideration Alternatives 2.1.1-2.1.5

Scenario	Existing Conditions	Reduce Runoff Volume: Reduced Runoff Volume (All)	Reduce Runoff Volume: Reduced Runoff Volume West of Hwy 32	Reduce Runoff Volume: Reduced Runoff Volume West of Hwy 32 in Cart Creek	Increase Conveyance Capacity	Increase Temporary Flood Storage: Temporary Flood Storage (North Branch)	Increase Temporary Flood Storage: Temporary Flood Storage (Cart Creek)	Wetland Restoration: Wetland Restoration (NWI)	Wetland Restoration: Wetland Restoration (Hydric Soils Rating ≥ 50)	Wetland Restoration: Wetland Restoration (Hydric Soils Rating = 100)
Recurrence Interval and Location	*Peak Flow - 10 Year, cfs (% Change)*									
10-yr at 86th St NE - Cart Creek	1,200	851 (-29.1%)	1,013 (-15.6%)	1,013 (-15.6%)	1,270 (5.8%)	676 (-43.7%)	676 (-43.7%)	1,191 (-0.7%)	801 (-33.3%)	956 (-20.3%)
10-yr at County Road 12 - Cart Creek	2,475	1,604 (-35.2%)	2,100 (-15.2%)	2,100 (-15.2%)	2,615 (5.7%)	1,471 (-40.6%)	1,471 (-40.6%)	2,447 (-1.1%)	1,469 (-40.6%)	1,748 (-29.4%)
10-yr at Crystal, ND - Cart Creek	2,466	1,565 (-36.5%)	2,067 (-16.2%)	2,067 (-16.2%)	2,605 (5.6%)	1,495 (-39.4%)	1,495 (-39.4%)	2,442 (-1.0%)	1,496 (-39.3%)	1,805 (-26.8%)
10-yr at Highway 18 - Cart Creek	2,367	1,455 (-38.5%)	1,965 (-17.0%)	1,965 (-17.0%)	2,497 (5.5%)	1,393 (-41.1%)	1,393 (-41.1%)	2,336 (-1.3%)	1,412 (-40.3%)	1,713 (-27.6%)
10-yr at 77th St NE - North Branch Downstream of Cart Creek	3,377	2,257 (-33.2%)	2,882 (-14.7%)	3,129 (-7.3%)	3,518 (4.2%)	2,022 (-40.1%)	2,698 (-20.1%)	3,350 (-0.8%)	2,207 (-34.6%)	2,792 (-17.3%)
10-yr at North Branch Outlet (Channel Only)	809	717 (-11.4%)	779 (-3.7%)	795 (-1.7%)	818 (1.1%)	701 (-13.3%)	770 (-4.8%)	808 (-0.1%)	725 (-10.4%)	775 (-4.2%)
10-yr at North Branch Outlet (Including Breakouts)	2,833	1,800 (-36.5%)	2,472 (-12.7%)	2,674 (-5.6%)	2,936 (3.6%)	1,772 (-37.5%)	2,370 (-16.3%)	2,812 (-0.7%)	1,905 (-32.8%)	2,426 (-14.4%)

Duration (Hours)	Existing Conditions: Cropland	Existing Conditions: Total	Reduced Runoff Volume (All): Cropland	Reduced Runoff Volume (All): Total	Reduced Runoff Volume West of Hwy 32: Cropland	Reduced Runoff Volume West of Hwy 32: Total	Reduced Runoff Volume West of Hwy 32 in Cart Creek: Cropland	Reduced Runoff Volume West of Hwy 32 in Cart Creek: Total	Increase Conveyance Capacity: Cropland	Increase Conveyance Capacity: Total	Temporary Flood Storage (North Branch): Cropland	Temporary Flood Storage (North Branch): Total	Temporary Flood Storage (Cart Creek): Cropland	Temporary Flood Storage (Cart Creek): Total	Wetland Restoration (NWI): Cropland	Wetland Restoration (NWI): Total	Wetland Restoration (Hydric Soils Rating ≥ 50): Cropland	Wetland Restoration (Hydric Soils Rating ≥ 50): Total	Wetland Restoration (Hydric Soils Rating = 100): Cropland	Wetland Restoration (Hydric Soils Rating = 100): Total
	Inundated Acres - 10 Year (% Change)																			
0-24	2,223	2,793	1,501 (-32.5%)	2,093 (-25.1%)	2,078 (-6.5%)	2,650 (-5.1%)	2,111 (-5.0%)	2,670 (-4.4%)	2,378 (6.9%)	2,977 (6.6%)	1,934 (-13.0%)	2,684 (-3.9%)	1,875 (-15.7%)	2,477 (-11.3%)	2,210 (-0.6%)	2,773 (-0.7%)	1,617 (-27.3%)	2,196 (-21.4%)	1,893 (-14.9%)	2,445 (-12.5%)
24-48	1,636	2,206	1,064 (-35.0%)	1,561 (-29.2%)	1,460 (-10.8%)	2,015 (-8.6%)	1,536 (-6.2%)	2,097 (-4.9%)	1,513 (-7.6%)	2,088 (-5.3%)	1,255 (-23.3%)	1,711 (-22.4%)	1,287 (-21.4%)	1,767 (-19.9%)	1,633 (-0.2%)	2,205 (0.0%)	1,086 (-33.6%)	1,558 (-29.4%)	1,362 (-16.7%)	1,902 (-13.8%)
48-72	1,145	1,617	812 (-29.1%)	1,146 (-29.1%)	1,015 (-11.4%)	1,446 (-10.5%)	1,031 (-9.9%)	1,481 (-8.4%)	1,036 (-9.5%)	1,490 (-7.8%)	697 (-39.1%)	929 (-42.5%)	895 (-21.9%)	1,287 (-20.4%)	1,144 (-0.1%)	1,620 (0.2%)	816 (-28.8%)	1,161 (-28.2%)	991 (-13.5%)	1,412 (-12.6%)
72-96	859	1,144	403 (-53.1%)	582 (-49.1%)	713 (-17.0%)	927 (-18.9%)	787 (-8.4%)	1,048 (-8.3%)	720 (-16.2%)	972 (-15.0%)	512 (-40.4%)	629 (-45.0%)	692 (-19.4%)	910 (-20.4%)	844 (-1.8%)	1,122 (-1.9%)	472 (-45.1%)	641 (-44.0%)	698 (-18.8%)	941 (-17.7%)
96-120	471	628	209 (-55.5%)	300 (-52.2%)	426 (-9.6%)	573 (-8.8%)	469 (-0.4%)	627 (-0.1%)	442 (-6.2%)	612 (-2.4%)	319 (-32.1%)	393 (-37.4%)	381 (-19.0%)	526 (-16.2%)	465 (-1.2%)	621 (-1.0%)	317 (-32.7%)	433 (-30.9%)	454 (-3.5%)	606 (-3.5%)
>120	1,724	2,480	1,361 (-21.1%)	2,054 (-17.2%)	1,634 (-5.2%)	2,359 (-4.9%)	1,684 (-2.3%)	2,428 (-2.1%)	1,451 (-15.8%)	2,196 (-11.5%)	1,366 (-20.8%)	2,010 (-19.0%)	1,633 (-5.3%)	2,363 (-4.7%)	1,713 (-0.7%)	2,466 (-0.6%)	1,408 (-18.3%)	2,102 (-15.3%)	1,621 (-6.0%)	2,352 (-5.2%)
TOTAL	8,059	10,867	5,351 (-33.6%)	7,737 (-28.8%)	7,326 (-9.1%)	9,970 (-8.3%)	7,619 (-5.5%)	10,351 (-4.8%)	7,540 (-6.4%)	10,335 (-4.9%)	6,084 (-24.5%)	8,356 (-23.1%)	6,762 (-16.1%)	9,330 (-14.1%)	8,009 (-0.6%)	10,807 (-0.6%)	5,716 (-29.1%)	8,091 (-25.5%)	7,019 (-12.9%)	9,658 (-11.1%)

Recurrence Interval and Location	Existing Conditions	Reduced Runoff Volume (All)	Reduced Runoff Volume West of Hwy 32	Reduced Runoff Volume West of Hwy 32 in Cart Creek	Increase Conveyance Capacity	Temporary Flood Storage (North Branch)	Temporary Flood Storage (Cart Creek)	Wetland Restoration (NWI)	Wetland Restoration (Hydric Soils Rating ≥ 50)	Wetland Restoration (Hydric Soils Rating = 100)
	Peak Flow - 100 Year, cfs (% Change)									
100-yr at 86th St NE - Cart Creek	2,840	- -	- -	- -	3,025 (6.5%)	1,709 (-39.8%)	1,709 (-39.8%)	2,826 (-0.5%)	2,046 (-28.0%)	2,420 (-14.8%)
100-yr at County Road 12 - Cart Creek	5,978	- -	- -	- -	6,591 (10.3%)	3,651 (-38.9%)	3,651 (-38.9%)	5,914 (-1.1%)	4,361 (-27.0%)	4,876 (-18.4%)
100-yr at Crystal, ND - Cart Creek	6,277	- -	- -	- -	6,897 (9.9%)	3,699 (-41.1%)	3,699 (-41.1%)	6,212 (-1.0%)	4,155 (-33.8%)	4,720 (-24.8%)
100-yr at Highway 18 - Cart Creek	4,961	- -	- -	- -	5,570 (12.3%)	3,688 (-25.7%)	3,689 (-25.6%)	4,946 (-0.3%)	4,164 (-16.1%)	4,483 (-9.6%)
100-yr at 77th St NE - North Branch Downstream of Cart Creek	5,797	- -	- -	- -	6,251 (7.8%)	4,814 (-17.0%)	5,378 (-7.2%)	5,785 (-0.2%)	5,092 (-12.2%)	5,428 (-6.4%)
100-yr at North Branch Outlet (Channel Only)	967	- -	- -	- -	1,000 (3.4%)	909 (-6.0%)	948 (-2.0%)	966 (-0.1%)	928 (-4.0%)	951 (-1.7%)
100-yr at North Branch Outlet (Including Breakouts)	6,593	- -	- -	- -	7,191 (9.1%)	4,558 (-30.9%)	5,466 (-17.1%)	6,552 (-0.6%)	5,035 (-23.6%)	5,825 (-11.6%)

Table 4: Peak Flow and Inundation Changes for Technical Consideration Alternative 2.1.6

Scenario	Existing Conditions	Riparian Corridor Restoration									
		Channel Fill, 1000' Corridor	Channel Fill, Restored Oxbows, 1000' Corridor	Channel Fill, 500' Corridor	Channel Fill, Restored Oxbows, 500' Corridor	Channel Fill, Restored Oxbows, 1000' Corridor - Lower	Channel Fill, Restored Oxbows, 500' Corridor - Lower	Channel Fill, Restored Oxbows, 1000' Corridor - Middle	Channel Fill, Restored Oxbows, 500' Corridor - Middle	Channel Fill, Restored Oxbows, 1000' Corridor - Upper	Channel Fill, Restored Oxbows, 500' Corridor - Upper
Recurrence Interval and Location	*Peak Flow - 10 Year, cfs (% Change)*										
10-yr at 86th St NE - Cart Creek	1,200	777	777	871	860	1,200	1,200	1,204	1,203	767	841
		(-35.3%)	(-35.3%)	(-27.4%)	(-28.3%)	(0.0%)	(0.0%)	(0.3%)	(0.2%)	(-36.1%)	(-29.9%)
10-yr at County Road 12 - Cart Creek	2,475	1,752	1,714	1,824	1,798	2,475	2,475	2,087	2,121	2,065	2,098
		(-29.2%)	(-30.7%)	(-26.3%)	(-27.4%)	(0.0%)	(0.0%)	(-15.7%)	(-14.3%)	(-16.6%)	(-15.2%)
10-yr at Crystal, ND - Cart Creek	2,466	1,748	1,714	1,883	1,832	2,487	2,491	1,988	1,987	2,021	2,107
		(-29.1%)	(-30.5%)	(-23.6%)	(-25.7%)	(0.9%)	(1.0%)	(-19.4%)	(-19.4%)	(-18.0%)	(-14.6%)
10-yr at Highway 18 - Cart Creek	2,367	1,692	1,671	1,840	1,769	2,390	2,199	1,958	1,982	1,914	2,040
		(-28.5%)	(-29.4%)	(-22.3%)	(-25.3%)	(1.0%)	(-7.1%)	(-17.3%)	(-16.3%)	(-19.1%)	(-13.8%)
10-yr at 77th St NE - North Branch Downstream of Cart Creek	3,377	2,584	2,443	2,987	2,904	2,923	3,182	3,133	3,189	3,101	3,204
		(-23.5%)	(-27.7%)	(-11.5%)	(-14.0%)	(-13.4%)	(-5.8%)	(-7.2%)	(-5.6%)	(-8.2%)	(-5.1%)
10-yr at North Branch Outlet (Channel Only)	809	760	752	796	790	770	805	803	810	797	803
		(-6.1%)	(-7.0%)	(-1.6%)	(-2.3%)	(-4.8%)	(-0.5%)	(-0.7%)	(0.1%)	(-1.5%)	(-0.7%)
10-yr at North Branch Outlet (Including Breakouts)	2,833	2,232	2,150	2,673	2,599	2,358	2,775	2,764	2,833	2,693	2,764
		(-21.2%)	(-24.1%)	(-5.6%)	(-8.3%)	(-16.8%)	(-2.0%)	(-2.4%)	(0.0%)	(-4.9%)	(-2.4%)

Duration (Hours	Existing Conditions		Channel Fill, 1000' Corridor		Channel Fill, Restored Oxbows, 1000' Corridor		Channel Fill, 500' Corridor		Channel Fill, Restored Oxbows, 500' Corridor		Channel Fill, Restored Oxbows, 1000' Corridor - Lower		Channel Fill, Restored Oxbows, 500' Corridor - Lower		Channel Fill, Restored Oxbows, 1000' Corridor - Middle		Channel Fill, Restored Oxbows, 500' Corridor - Middle		Channel Fill, Restored Oxbows, 1000' Corridor - Upper		Channel Fill, Restored Oxbows, 500' Corridor - Upper	
	Peak Flow - 10 Year, cfs (% Change)																					
	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total
0-24	2,223	2,793	1,699	2,129	1,623	2,034	1,823	2,302	1,737	2,141	2,043	2,553	2,163	2,683	1,976	2,482	1,969	2,481	1,907	2,426	1,991	2,514
			(-23.6%)	(-23.8%)	(-27.0%)	(-27.2%)	(-18.0%)	(-17.6%)	(-21.9%)	(-23.4%)	(-8.1%)	(-8.6%)	(-2.7%)	(-4.0%)	(-11.1%)	(-11.2%)	(-11.4%)	(-11.2%)	(-14.2%)	(-13.1%)	(-10.4%)	(-10.0%)
24-48	1,636	2,206	1,408	1,940	1,338	1,816	1,482	2,012	1,479	1,997	1,367	1,895	1,440	1,959	1,638	2,213	1,676	2,250	1,674	2,224	1,704	2,278
			(-14.0%)	(-12.1%)	(-18.2%)	(-17.7%)	(-9.4%)	(-8.8%)	(-9.6%)	(-9.5%)	(-16.5%)	(-14.1%)	(-12.0%)	(-11.2%)	(0.1%)	(0.3%)	(2.4%)	(2.0%)	(2.3%)	(0.8%)	(4.1%)	(3.3%)
48-72	1,145	1,617	1,003	1,451	967	1,409	944	1,393	899	1,344	899	1,325	921	1,352	1,158	1,630	1,112	1,585	1,163	1,657	1,124	1,606
			(-12.4%)	(-10.3%)	(-15.6%)	(-12.9%)	(-17.6%)	(-13.8%)	(-21.5%)	(-16.9%)	(-21.5%)	(-18.1%)	(-19.6%)	(-16.4%)	(1.1%)	(0.8%)	(-2.9%)	(-1.9%)	(1.5%)	(2.5%)	(-1.9%)	(-0.7%)
72-96	859	1,144	642	934	619	909	763	1,049	732	1,022	679	954	766	1,049	856	1,164	862	1,150	852	1,156	856	1,148
			(-25.3%)	(-18.3%)	(-28.0%)	(-20.5%)	(-11.2%)	(-8.2%)	(-14.8%)	(-10.7%)	(-21.0%)	(-16.6%)	(-10.9%)	(-8.3%)	(-0.4%)	(1.8%)	(0.3%)	(0.6%)	(-0.8%)	(1.1%)	(-0.4%)	(0.4%)
96-120	471	628	501	681	532	716	425	574	449	603	442	607	409	550	464	618	469	626	520	678	498	663
			(6.5%)	(8.5%)	(12.9%)	(14.0%)	(-9.7%)	(-8.6%)	(-4.6%)	(-4.0%)	(-6.1%)	(-3.3%)	(-13.0%)	(-12.4%)	(-1.5%)	(-1.5%)	(-0.4%)	(-0.2%)	(10.5%)	(8.1%)	(5.7%)	(5.6%)
>120	1,724	2,480	2,102	2,992	2,178	3,139	1,828	2,627	1,919	2,797	2,004	2,852	1,855	2,690	1,759	2,542	1,728	2,485	1,857	2,647	1,772	2,540
			(21.9%)	(20.6%)	(26.3%)	(26.6%)	(6.0%)	(5.9%)	(11.3%)	(12.8%)	(16.2%)	(15.0%)	(7.6%)	(8.5%)	(2.0%)	(2.5%)	(0.2%)	(0.2%)	(7.7%)	(6.7%)	(2.8%)	(2.4%)
TOTAL	8,059	10,867	7,354	10,127	7,257	10,023	7,266	9,957	7,215	9,903	7,434	10,185	7,554	10,283	7,852	10,648	7,816	10,578	7,973	10,789	7,945	10,748
			(-8.8%)	(-6.8%)	(-10.0%)	(-7.8%)	(-9.8%)	(-8.4%)	(-10.5%)	(-8.9%)	(-7.8%)	(-6.3%)	(-6.3%)	(-5.4%)	(-2.6%)	(-2.0%)	(-3.0%)	(-2.7%)	(-1.1%)	(-0.7%)	(-1.4%)	(-1.1%)

Recurrence Interval and Location	Existing Conditions	Channel Fill, 1000' Corridor	Channel Fill, Restored Oxbows, 1000' Corridor	Channel Fill, 500' Corridor	Channel Fill, Restored Oxbows, 500' Corridor	Channel Fill, Restored Oxbows, 1000' Corridor - Lower	Channel Fill, Restored Oxbows, 500' Corridor - Lower	Channel Fill, Restored Oxbows, 1000' Corridor - Middle	Channel Fill, Restored Oxbows, 500' Corridor - Middle	Channel Fill, Restored Oxbows, 1000' Corridor - Upper	Channel Fill, Restored Oxbows, 500' Corridor - Upper
	Peak Flow - 100 Year, cfs (% Change)										
100-yr at 86th St NE - Cart Creek	2,840	2,519	2,518	2,128	2,148	2,841	2,841	2,881	2,881	2,521	2,115
		(-11.3%)	(-11.3%)	(-25.1%)	(-24.4%)	(0.0%)	(0.0%)	(1.4%)	(1.4%)	(-11.2%)	(-25.5%)
100-yr at County Road 12 - Cart Creek	5,978	4,550	4,438	4,643	4,477	5,978	5,978	5,159	5,133	5,226	5,318
		(-23.9%)	(-25.8%)	(-22.3%)	(-25.1%)	(0.0%)	(0.0%)	(-13.7%)	(-14.1%)	(-12.6%)	(-11.0%)
100-yr at Crystal, ND - Cart Creek	6,277	4,761	4,598	4,783	4,560	6,264	6,264	5,227	5,185	5,355	5,500
		(-24.2%)	(-26.7%)	(-23.8%)	(-27.4%)	(-0.2%)	(-0.2%)	(-16.7%)	(-17.4%)	(-14.7%)	(-12.4%)
100-yr at Highway 18 - Cart Creek	4,961	4,767	4,627	4,623	4,474	4,937	4,831	5,236	5,185	4,661	4,702
		(-3.9%)	(-6.7%)	(-6.8%)	(-9.8%)	(-0.5%)	(-2.6%)	(5.5%)	(4.5%)	(-6.0%)	(-5.2%)
100-yr at 77th St NE - North Branch Downstream of Cart Creek	5,797	6,186	6,105	6,115	6,015	6,051	6,121	5,833	5,821	5,725	5,725
		(6.7%)	(5.3%)	(5.5%)	(3.8%)	(4.4%)	(5.6%)	(0.6%)	(0.4%)	(-1.2%)	(-1.2%)
100-yr at North Branch Outlet (Channel Only)	967	967	964	963	956	965	968	967	967	966	965
		(0.0%)	(-0.3%)	(-0.4%)	(-1.1%)	(-0.2%)	(0.1%)	(0.0%)	(0.0%)	(-0.1%)	(-0.2%)
100-yr at North Branch Outlet (Including Breakouts)	6,593	5,949	5,870	5,845	5,673	5,932	6,016	6,629	6,606	6,490	6,489
		(-9.8%)	(-11.0%)	(-11.3%)	(-14.0%)	(-10.0%)	(-8.8%)	(0.5%)	(0.2%)	(-1.6%)	(-1.6%)

2.2 PRACTICAL CONSIDERATIONS

The practicality of each strategy was also assessed to determine if there is a reasonable ability for the local sponsor to successfully finance, implement, and maintain the alternative.

2.2.1 LOCAL FINANCING AND ACCEPTANCE

The sponsoring local organization (SLO) has the authority to operate under certain provisions of North Dakota Century Code (NDCC) Chapter 61, which allows for project specific taxing authority through the formulation of an Assessment District to finance project installation, operation and maintenance, and rehabilitation. Under NDCC Chapter 61, establishment of an Assessment District requires that a vote be conducted, with votes cast based on the monetary value of benefits/damages received from the proposed project. In order to ensure successful financing of all (or any required match for potential future state and/or federal funding), alternatives need to have local support and acceptance to establish the required local taxing authority.

2.2.2 ENVIRONMENTAL CONCERNS

The ability to successfully address regulatory concerns was considered during the strategy evaluation. While the planning effort will be used to identify potential impacts and work to minimize any such impacts, if certain strategies were likely to lead to significant environmental issues they were eliminated from further consideration.

2.2.3 ABILITY TO IMPLEMENT

The ability of strategies to be implemented in a reasonable timeframe and maintain sufficient locations was considered to ensure that outcomes from the planning effort can efficiently be implemented after permitting is completed and financing is in place. The primary considerations were the SLO’s ability to secure land rights, assurances of participation for any required voluntary programs, and potential for violation of current local/state laws and zoning ordinances.

2.3 OUTCOMES

From the initial strategy evaluation, the following strategies were selected to move forward with preliminary alternative identification:

- No-Action
- Flood Water Diversion (Increase Conveyance Capacity)
- On-Channel Impoundment (Increase Temporary Flood Storage)
- Set-back Levees (Increase Temporary Flood Storage)
- Off-Channel Impoundment (Increase Temporary Flood Storage)

Table 5 provides a list of strategies within each category, and rationale for strategies’ determination of either carry forward or eliminate from further review.

Table 5: Strategy Review

Category	Strategy	Determination	Rationale
No-Action	No-Action	Carry Forward	• Required; based on public comment and the SLO's desire to pursue solutions for flood damages, this alternative is not locally preferred. • No dams or existing flood water storage structures presently exist in the North Branch Watershed and changes to land use are not planned. • For the North Branch Watershed Plan, existing conditions is the No-Action alternative.
Reduce Runoff Volume	Cropland Better Management Practices	Eliminate	• Alternative considered undesirable for local landowners. • While not practical as an individual alternative, this concept can be a component of other alternative enhancements.
	Conversion to Grassland	Eliminate	• Converting prime farmland to grassland is considered undesirable for local landowners.
	Conversion to Forest	Eliminate	• Converting prime farmland to forest is considered undesirable for local landowners. • Implementation of conversion to Forest would take considerable amount of time, and the alternative would not be effective for several years.
	Aquifer Storage	Eliminate	• Limited availability to the Icelandic Aquifer in the north eastern part of the watershed would cause implementation to be challenging and costly. The Icelandic Aquifer extents are shown on **Figure D-2-2.3a**
	Other Beneficial Uses of Stored Water	Eliminate	• Limited availability of stored water in the North Branch Watershed. • While not likely practical as an individual alternative, this concept can be a component of other alternative enhancements.

Category	Strategy	Determination	Rationale
Increase Conveyance Capacity	Channelization	Eliminate	• Channelization throughout the watershed would not be practical because shorter flow paths produce larger flow rates downstream of the planning watershed.
	Drainage	Eliminate	• Increased drainage off farm fields would causes increased peak flow and inundation in downstream areas.
	Flood Water Diversion	Carry Forward	• There is potential for significant flood damages at the community of Crystal, ND. A flood water diversion around the south and west side of the community will be investigated. • Additional measures may be needed to mitigate any increased downstream flow rates.
	Increase Roadway Capacity	Eliminate	• Increasing conveyance capacity could be used in localized areas to reduce ag damages by removal of cropland floodplain, however model results (Section 2.1.2) showed that increasing conveyance capacity would increase flow rates downstream of the planning watershed.
Increase Temporary Storage	On-Channel Dam	Carry Forward	• A site near Milton, ND was identified early in scoping, and will be preliminarily investigated. • No other on-channel impoundments were investigated due to a high likelihood of significant impacts to existing riparian areas. Impacts include likely loss of habitat, water quality concerns, and creation of aquatic life barriers. Other sites were considered in prior studies but eliminated due to these concerns.
	Reduced Bridge/Culvert Capacity	Eliminate	• ND Century Code provide Stream Crossing Standards that do not allow culvert sizes to be reduced.

Category	Strategy	Determination	Rationale
	Wetland Restoration/ Creation	Eliminate	• Wetland restoration in the upper watershed has been identified as a potential alternative from comments from the interagency planning team. • The ability of the SLO to successfully implement in a reasonable timeframe and maintain sufficient locations is limited, given land rights are typically secured through a voluntary easement program. • Preliminary analysis using NWI wetlands and USGS Open File Report 2007-1159 indicated minimal reductions to peak flood flows and inundation in problem areas (see **Table 3**). • Preliminary hydric soil data and Table 5-2 from the ND Hydrology Manual indicated flow reduction potential for damage areas and at the outlet of the North Branch Park River, however it is not considered practical for the SLO to successfully implement sufficient acres to attain the objectives in the Purpose and Need. • While not practical as an individual alternative, wetland restoration/creation can be a component of other alternative enhancements.
	Setback Levees	Carry Forward	• Levees would be used to contain breakout flows and provide floodplain storage along the Cart Creek. • Measures may be needed to mitigate flow rate increases because of elimination of breakout flows.
	Meter Runoff	Eliminate	• The ability of the SLO to successfully implement in a reasonable timeframe is limited. • Concept was adopted to reduce flooding along the Red River but would cause an increase to agricultural damages within the North Branch Watershed.

Category	Strategy	Determination	Rationale
	Off-Channel Impoundment	Carry Forward	• Storage would be used to attenuate peak flow rates associated with flood damages. • Model results show that attenuated flood volume would reduce peak outflows downstream of the planning watershed. • Correctly managed releases of stored water may help to address geomorphic concerns due to altered hydrology.
	River Corridor Restoration/ Protection	Eliminate	• Reduced channel incision in the Cart Creek east of Mountain, ND may also reduce sedimentation in the lower planning watershed. • Increased access to floodplain may also reduce peak flows within the lower planning watershed, where agricultural flood damages are primarily occurring. • SLO has indicated that the ability to implement in a timely manner on the scale analyzed through the sensitivity analysis discussed in Section 2.1.6 is not practical. • Lack of local acceptance would have a high probability of an inability to general a local funding requirement as discussed in Section 2.2.1.
Protection/ Avoidance	Levees	Eliminate	• Levees for the community of Crystal are not practical due to proximity of structures and building sites to Cart Creek. • Ring levees around farmsteads were not considered for an individual alternative because they would not adequately address the objectives in the Purpose and Need.
	Flood Warning System	Eliminate	• Not practical for the North Branch Park River. During the 10-year event, there is an approximate 2.5-day lag between the peak rainfall intensity and the peak inflow to the Park River mainstem. This is not sufficient time to implement temporary measures to meet objectives defined in the Purpose and Need.

Category	Strategy	Determination	Rationale
	Floodplain Easements	Eliminate	• Floodplain easements would be required on the areas with inundation longer than 24-hours for the 10-year, 4-day event to meet the objectives defined in the Purpose and Need. This would require approximately 10,500 acres. • Ability of the SLO to implement in a timely manner is limited.

3 PRELIMINARY ALTERNATIVES

The strategies identified in the Initial Strategy Evaluation were used to preliminarily identify a range of alternatives. These alternatives were then analyzed to determine their potential to attain the objectives from the Purpose and Need statement. The following sections provide a brief description of each alternative considered.

3.1 ALTERNATIVE IDENTIFICATION AND ANALYSIS

Alternatives identified for this phase of alternative investigation consisted of review of the existing conditions hydrologic and hydraulic model, available topographic field survey data, LiDAR topographic data and other readily available geospatial information. A watershed map illustrating the location(s) of alternative components is shown on **Figure D-2-3.1a**. In order to evaluate the model results, the same reporting locations presented in Section 2.1 were used, and the reporting locations are shown on **Figure D-2-B.1**. Peak flow reductions at reporting locations and inundated acres for the alternatives discussed are shown in **Table 6**. The 10-year inundation was broken down into different regions to quantify Indicator 1 from the Purpose and Need. The different regions are presented in **Figure D-2-3.1b**. The 10-year inundated acres in the different regions presented in **Figure D-2-3.1b** are shown in **Table 7**.

3.1.1 ALTERNATIVE 1 – AGRICULTURAL LEVEES (STAND-ALONE)

The hydraulic model for the North Branch Park River Watershed was used to estimate areas where agricultural damages are occurring during the 10-year rainfall event. Available data, including LiDAR and historic aerial imagery, were used to estimate locations where agricultural levees could be installed to contain flows within a defined floodplain and reduce breakout flows. This preliminary review indicated that agricultural levees, also referred to as setback levees, are most applicable along the Cart Creek between ND Highway 32, and the Pembina/Walsh County line. In this area, much of the Cart Creek is perched, meaning the channel banks are higher than the adjacent floodplain. These sections of perched channel result in flows beyond bank full breaking out and traveling away from the channel.

Setback levees were placed between 200 and 300 feet from the channel to minimize land use changes and allow for a fringe floodplain. Setback levees placed west of ND Highway 18 along the Cart Creek were primarily placed to contain breakout flows. Hydraulic modeling has indicated that flooding in this area of the watershed is primarily caused by inundation of cropland as breakout flows move overland. When the breakout flows on Cart Creek are contained, an increase in stage ensues downstream of the confluence of

Cart Creek with the North Branch Park River. This results in increased frequency of breakout flows. Two scenarios were considered for this analysis including; setback levees on only Cart Creek, and setback levees on Cart Creek and North Branch Park River downstream of the confluence with Cart Creek. A map showing the two setback levee scenarios is presented in **Figure D-2-3.1.1**.

The two identified setback levee alternatives were analyzed with the hydraulic model to evaluate their ability to meet objectives from the Purpose and Need. For the Cart Creek only scenario, at the North Branch outlet (including breakout flows) peak flows were reduced by 5% and 12% for the 10 and 100-year events, respectively. For the setback levees on Cart Creek and North Branch Park River scenario, at the North Branch outlet (including breakout flows) peak flows were reduced by 5% and 19% for the 10 and 100-year events, respectively. At the North Branch outlet (channel only) peak flows were increased by 205% for the 10-year event and 243% for the 100-year events. The increase in peak flows in the channel would result in increased damages along the channel between the North Branch outlet and where naturally occurring breakout flows reenter the channel. Peak flow and inundated acreage changes are presented in **Table 6** for both setback levee scenarios. The 10-year inundated acreage in different regions are presented in **Table 7**. Hydrographs showing preliminary modeling results are available in **Attachment D-2-B.2**.

3.1.2 ALTERNATIVE 2 – MILTON DAM

Milton Dam is a proposed on-channel dam located on the North Branch Park River near the community of Milton, ND. The embankment is located near the headwaters of the North Branch Park River approximately 1.6 river miles upstream of the ND Highway 66 crossing and has a contributing watershed of 45 square miles. The dam would be constructed as an earthen embankment with an outlet structure that would attenuate flood flows. The attenuated flows would inundate riparian and vegetated floodplain habitat upstream of the embankment. The results indicated approximately 114 acres of inundation for the 10-year event and 148 acres for the 100-year event. At maximum inundation for the 10-year and 100-year events, 1,559 acre-feet (0.7 inches) and 2,249 acre-feet (0.9 inches) of flood storage would be provided. A location map of Milton Dam is provided in **Figure D-2-3.1.2**.

Milton Dam was incorporated into the hydrologic and hydraulic model to analyze the 10-year and 100-year rainfall events. This analysis indicated flow reductions immediately downstream of the dam along the North Branch Park River. For example, at ND Highway 32 on the North Branch Park River, 55% and 25% reductions in peak flow were observed for the 10-year and 100-year events, respectively. However due to the location of the impoundment site within the watershed, no changes to peak flow were observed for indicated damage locations in the Cart Creek Subwatershed. At the North Branch outlet (including breakout flows) peak flows were reduced by 10% and 9% for the 10 and 100-year events, respectively. **Table 6** shows the resulting peak flow changes at all identified reporting locations, and inundated acreage changes in the North Branch Watershed. The 10-year inundated acreage in different regions are presented in **Table 7**. Hydrographs at the identified reporting locations are available in **Attachment D-2-B.3**.

3.1.3 ALTERNATIVE 3 – CART CREEK IMPOUNDMENT SITE 1

Cart Creek Impoundment Site 1 would consist of two proposed flood pools located adjacent to each other. The primary flood pool (Flood Pool 1) is an off-channel impoundment constructed of earthen embankments in Section 24 of Thingvalla Township. In order to get flows from the Cart Creek into Flood Pool 1, an inlet channel would be constructed to divert high flows to the south from Cart Creek on the west side of 131st Avenue NE into Flood Pool 1. The secondary flood pool (Flood Pool 2) is primarily located in the SW ¼ of

Section 19 in Park Township. Flood Pool 2 is an on-channel site and consists of a system of earthen embankments with a reduced hydraulic capacity outlet. The reduced capacity outlet would convey the 2-year event within the channel. Larger events would result in attenuated flows to provide increased access to floodplain storage contained within the setback levees. In total, Cart Creek Impoundment Site 1 would have a drainage area of 36.3 square miles and would provide 4,600 acre-feet (2.4 inches) of flood storage. The drainage area is primarily located west of ND Highway 32. Flood Pools 1 and 2 would require a total estimated area of 785 acres. The amount of inundated area would vary depending on the flood event. Both flood pools are proposed as dry dams, meaning no normal or conservation pool would be permanently held. A site map for Cart Creek Impoundment Site 1 is available in **Figure D-2-3.1.3**.

Both Farm Service Agency (FSA) Conservation Reserve Program (CRP) and NRCS Wetland Reserve Program (WRP) are present throughout much of Flood Pool 1. Coordinating with NRCS and CRP will be required to facilitate the flood storage that would be provided by Flood Pool 1.

The hydrologic and hydraulic model was modified to include Cart Creek Impoundment Site 1 and used to analyze the 10-year and 100-year events. Approximately 365 acres and 595 acres would be inundated within Flood Pools 1 and 2 for the 10-year and 100-year events, respectively. Immediately downstream of the impoundment, at the Cart Creek crossing with 86th Street NE, peak flow rates are reduced by 80% for the 10-year event and 85% for the 100-year event. Further downstream at Crystal, ND, peak flow rates are reduced by 25% for the 10-year event and 30% for the 100-year event. At the outlet of the North Branch Park River Watershed (including overland flow), peak flow rates are reduced by 10% for the 10-year event and 12% for the 100-year event. **Table 6** shows the resulting peak flow changes at the identified reporting locations, and inundated acreage changes in the North Branch Watershed. The 10-year inundated acreage in different regions are presented in **Table 7**. Hydrographs at the identified reporting locations are available in **Attachment D-2-B.3**.

3.1.4 ALTERNATIVE 4 – CART CREEK IMPOUNDMENT SITE 2

Cart Creek Impoundment Site 2 would consist of three proposed flood pools located in Thingvalla and Gardar Townships, Pembina County. This area has flatter topography adjacent to floodplain escarpment. This flatter topography allows for flood storage to be provided with reasonable embankment heights. Flood Pool 1 is located in the east half of Section 32, Thingvalla Township, and consists of an earthen embankment along the north, east, and south sides of the east half of Section 32. Flood Pool 2 is located primarily in Section 5 of Gardar Township, and a small portion in Section 8 of Gardar Township. Flood Pool 2 consists of an earthen embankment that would be constructed around the north, east, and south sides of the impoundment. Flood Pool 3 is located in the west half of Section 9 of Gardar Township and consists of earthen embankment that would be constructed around the north, east, and south sides of the west half of Section 9. A site map for Cart Creek Impoundment Site 2 is provided in **Figure D-2-3.1.4**.

Inflows would be split between Flood Pools 1 and 2 from the upstream watershed. Excess inflows not stored within Flood Pool 2 would be allowed to overflow into Flood Pool 3. Flow splits and overflows would be regulated through a series of hydraulic control structures. In total, Cart Creek Impoundment Site 2 would have a drainage area of 17.8 square miles and would provide 3,800 acre-feet (4 inches) of flood storage. The drainage area is primarily located west of ND Highway 32. All three flood pools would require a total estimated area of 852 acres.

Both Farm Service Agency (FSA) Conservation Reserve Program (CRP) and NRCS Wetland Reserve Program (WRP) are present in Flood Pools 1 and 2. Coordinating with NRCS and CRP will be required to facilitate the flood storage that would be provided by Flood Pools 1 and 2.

The hydrologic and hydraulic models were modified to include Cart Creek Impoundment Site 2 and used to analyze the 10-year and 100-year events. Approximately 436 acres and 648 acres would be inundated within Flood Pools 1, 2, and 3 for the 10-year and 100-year events, respectively. The drainage area regulated by Cart Creek Impoundment Site 2 contributes primarily through an unnamed intermittent tributary that outlets into the Cart Creek in Section 4 of Crystal Township, Pembina County. As such, no flow reduction benefit is realized further upstream on the Cart Creek where damages were indicated east of Mountain, ND. The site does provide an opportunity to reduce flooding further downstream, and at Crystal, ND. At Crystal, ND, peak flow rates are reduced by 20% for the 10-year event and 31% for the 100-year event. At the outlet of the North Branch Park River Watershed (including overland flow), peak flow rates are reduced by 7% for the 10-year event and 8% for the 100-year event. **Table 6** shows the resulting peak flow changes at the identified reporting locations, and inundated acreage changes in the North Branch Watershed. The 10-year inundated acreage in different regions are presented in **Table 7**. Hydrographs at the identified reporting locations are available in **Attachment D-2-B.3**.

3.1.5 ALTERNATIVE 5 – DIVERSION CHANNEL

The proposed diversion channel would divert flows from Cart Creek west of 137th Ave NE around the community of Crystal, ND back into Cart Creek east of 138th Ave NE. From Cart Creek west of 137th Ave NE, the proposed diversion channel routes flood flows south to an existing swale. The diversion channel generally follows the swale alignment south and east until the quarter section line. The diversion channel is then routed east through the railroad and 138th Ave NE into Cart Creek. In addition to the diversion channel, the structure near the diversion inlet on 137th Ave NE would be downsized to divert more flow into the channel, and a road raise along 137th Ave NE north of ND Highway 66 would be included. The channel would be designed to divert flows so that during a 100-year event there would be no structural impacts in and around the community of Crystal, ND. The channel would remain dry during periods of low flows. A location map is provided in **Figure D-2-3.1.5**.

The hydrologic and hydraulic model was modified to include the diversion channel and was used to analyze potential downstream impacts to the 10-year and 100-year events. At the identified reporting location in Crystal, ND the peak flow reduced by 51% for the 10-year event and 64% for the 100-year event. Further downstream, at the ND Highway 18 crossing with Cart Creek (secondary reporting location), peak flow rates increased by 3% for the 10-year event and 26% for the 100-year event. At the outlet of the North Branch Park River Watershed (including overland flow), the peak flow rate for the 10-year event reduced by 1% and the peak flow rate for the 100-year event increased 9%. **Table 6** shows the resulting peak flow changes at the identified reporting locations, and inundated acreage changes in the North Branch Watershed. The 10-year inundated acreage in different regions are presented in **Table 7**. Hydrographs at various reporting locations are available in **Attachment D-2-B.4**.

3.1.6 ALTERNATIVE 6 – DIVERSION CHANNEL WITH TEMPORARY FLOOD STORAGE

The diversion channel described in Section 3.1.5 would be used in combination with temporary flood storage in the Cart Creek subwatershed to meet community protection objectives for the community of

Crystal, ND, as well as agricultural flood damage reduction objectives. The hydrologic and hydraulic model was modified to remove runoff outflow from west of ND State Highway 32 to simulate the effects of upstream storage. This could be accomplished by combining Alternative 6 with Cart Creek Impoundment Sites 1 and/or 2. At the identified reporting location in Crystal, ND the peak flow reduced by 59% for the 10-year event and 73% for the 100-year event. Further downstream, at the ND Highway 18 crossing with Cart Creek (secondary reporting location), peak flow rates decreased by 44% for the 10-year event and 21% for the 100-year event. At the outlet of the North Branch Park River Watershed (including overland flow), peak flow rates reduced by 14% for the 10-year event and 6% for the 100-year event. **Table 6** shows the resulting peak flow changes at the identified reporting locations, and inundated acreage changes in the North Branch Watershed. The 10-year inundated acreage in different regions are presented in **Table 7**. Hydrographs at various reporting locations are available in **Attachment D-2-B.4**.

Table 6: Peak Flow and Inundation Changes for Identified Alternatives

Scenario	Existing Conditions	Alternative 1: Agricultural Levees – Setback Levees (Cart Creek and North Branch)	Alternative 1: Agricultural Levees – Setback Levees (Cart Creek Only)	Alternative 2: Milton Dam	Alternative 3: Cart Creek Impoundment Site 1	Alternative 4: Cart Creek Impoundment Site 2	Alternative 5: Diversion Channel	Alternative 6: Diversion Channel with Temporary Flood Storage
Recurrence Interval and Location	*Peak Flow - 10 Year, cfs (% Change)*							
10-yr at 86th St NE - Cart Creek	1,200	1,057 (-11.9%)	1,057 (-11.9%)	1,200 (0.0%)	241 (-79.9%)	1,200 (0.0%)	1,200 (0.0%)	613 (-48.9%)
10-yr at County Road 12 - Cart Creek	2,475	2,125 (-14.1%)	2,125 (-14.1%)	2,475 (0.0%)	1,894 (-23.5%)	1,950 (-21.2%)	2,472 (-0.1%)	1,349 (-45.5%)
10-yr at Crystal, ND - Cart Creek	2,466	2,206 (-10.5%)	2,206 (-10.5%)	2,466 (0.0%)	1,840 (-25.4%)	1,976 (-19.9%)	1,221 (-50.5%)	1,000 (-59.4%)
10-yr at Highway 18 - Cart Creek	2,367	2,047 (-13.5%)	2,047 (-13.5%)	2,367 (0.0%)	1,706 (-27.9%)	1,877 (-20.7%)	2,432 (2.7%)	1,329 (-43.9%)
10-yr at 77th St NE - North Branch Downstream of Cart Creek	3,377	3,129 (-7.3%)	2,836 (-16.0%)	3,141 (-7.0%)	2,943 (-12.9%)	3,071 (-9.1%)	3,402 (0.7%)	2,687 (-20.4%)
10-yr at North Branch Outlet (Channel Only)	809	2,471 (205.4%)	797 (-1.5%)	786 (-2.8%)	791 (-2.2%)	792 (-2.1%)	806 (-0.4%)	770 (-4.8%)
10-yr at North Branch Outlet (Including Breakouts)	2,833	2,688 (-5.1%)	2,682 (-5.3%)	2,558 (-9.7%)	2,539 (-10.4%)	2,635 (-7.0%)	2,806 (-1.0%)	2,441 (-13.8%)

Duration (Hours	Existing Conditions Cropland	Existing Conditions Total	Alt. 1 Setback Levees (Cart Creek and North Branch) Cropland	Total	Alt. 1 Setback Levees (Cart Creek Only) Cropland	Total	Alt. 2 Cropland	Total	Alt. 3 Cropland	Total	Alt. 4 Cropland	Total	Alt. 5 Cropland	Total	Alt. 6 Cropland	Total
	Inundated Acres - 10 Year (% Change)															
0-24	2,223	2,793	1,770 (-20.4%)	2,300 (-17.7%)	1,980 (-11.0%)	2,522 (-9.7%)	2,270 (2.1%)	2,926 (4.8%)	1,963 (-11.7%)	2,535 (-9.2%)	2,091 (-5.9%)	2,650 (-5.1%)	2,114 (-4.9%)	2,586 (-7.4%)	1,468 (-34.0%)	1,895 (-32.2%)
24-48	1,636	2,206	1,245 (-23.9%)	1,720 (-22.0%)	1,511 (-7.7%)	2,057 (-6.7%)	1,564 (-4.4%)	2,093 (-5.1%)	1,446 (-11.6%)	1,955 (-11.4%)	1,568 (-4.2%)	2,127 (-3.6%)	1,611 (-1.6%)	2,162 (-2.0%)	1,237 (-24.4%)	1,663 (-24.6%)
48-72	1,145	1,617	762 (-33.5%)	1,171 (-27.6%)	991 (-13.4%)	1,420 (-12.2%)	967 (-15.5%)	1,317 (-18.6%)	940 (-17.9%)	1,355 (-16.2%)	1,028 (-10.3%)	1,481 (-8.4%)	1,109 (-3.2%)	1,573 (-2.7%)	945 (-17.5%)	1,360 (-15.9%)
72-96	859	1,144	580 (-32.5%)	906 (-20.8%)	901 (4.9%)	1,232 (7.7%)	677 (-21.2%)	840 (-26.5%)	735 (-14.5%)	980 (-14.3%)	785 (-8.6%)	1,048 (-8.4%)	876 (2.0%)	1,168 (2.1%)	751 (-12.6%)	1,029 (-10.1%)
96-120	471	628	363 (-23.0%)	510 (-18.8%)	477 (1.3%)	625 (-0.4%)	356 (-24.4%)	447 (-28.8%)	475 (1.0%)	641 (2.1%)	464 (-1.4%)	622 (-0.9%)	471 (0.1%)	627 (0.0%)	461 (-2.1%)	614 (-2.1%)
>120	1,724	2,480	1,679 (-2.6%)	2,480 (0.0%)	1,972 (14.4%)	2,784 (12.2%)	1,849 (7.3%)	2,758 (11.2%)	1,661 (-3.7%)	2,398 (-3.3%)	1,685 (-2.3%)	2,426 (-2.2%)	1,773 (2.8%)	2,598 (4.7%)	1,767 (2.5%)	2,591 (4.5%)
TOTAL	8,059	10,867	6,399 (-20.6%)	9,087 (-16.4%)	7,832 (-2.8%)	10,640 (-2.1%)	7,684 (-4.7%)	10,381 (-4.5%)	7,220 (-10.4%)	9,864 (-9.2%)	7,621 (-5.4%)	10,354 (-4.7%)	7,954 (-1.3%)	10,714 (-1.4%)	6,630 (-17.7%)	9,152 (-15.8%)

Recurrence Interval and Location	Existing Conditions	Alt. 1 Setback Levees (Cart Creek and North Branch)	Alt. 1 Setback Levees (Cart Creek Only)	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6
	Peak Flow - 100 Year, cfs (% Change)							
100-yr at 86th St NE - Cart Creek	2,840	2,758 (-2.9%)	2,758 (-2.9%)	2,840 (0.0%)	430 (-84.9%)	2,840 (0.0%)	2,840 (0.0%)	1,635 (-42.4%)
100-yr at County Road 12 - Cart Creek	5,978	5,555 (-7.1%)	5,555 (-7.1%)	5,978 (0.0%)	4,943 (-17.3%)	4,688 (-21.6%)	5,972 (-0.1%)	3,607 (-39.7%)
100-yr at Crystal, ND - Cart Creek	6,277	5,890 (-6.2%)	5,890 (-6.2%)	6,277 (0.0%)	4,416 (-29.6%)	4,342 (-30.8%)	2,240 (-64.3%)	1,670 (-73.4%)
100-yr at Highway 18 - Cart Creek	4,961	4,814 (-3.0%)	4,814 (-3.0%)	4,961 (0.0%)	4,394 (-11.4%)	4,372 (-11.9%)	6,242 (25.8%)	3,937 (-20.6%)
100-yr at 77th St NE - North Branch Downstream of Cart Creek	5,797	5,271 (-9.1%)	5,749 (-0.8%)	5,740 (-1.0%)	5,605 (-3.3%)	5,630 (-2.9%)	6,163 (6.3%)	5,681 (-2.0%)
100-yr at North Branch Outlet (Channel Only)	967	3,315 (242.8%)	950 (-1.8%)	958 (-0.9%)	957 (-1.0%)	960 (-0.7%)	977 (1.0%)	952 (-1.6%)
100-yr at North Branch Outlet (Including Breakouts)	6,593	5,314 (-19.4%)	5,757 (-12.7%)	5,990 (-9.1%)	5,801 (-12.0%)	6,071 (-7.9%)	7,206 (9.3%)	6,180 (-6.3%)

Table 7: 10-Year Inundation Changes in Identified Regions of the North Branch Park River Watershed

Region	Duration (Hours)	Existing Conditions		Alternative 1: Agricultural Levees — Setback Levees (Cart Creek and North Branch)		Alternative 1: Agricultural Levees — Setback Levees (Cart Creek Only)		Alternative 2: Milton Dam		Alternative 3: Cart Creek Impoundment Site 1		Alternative 4: Cart Creek Impoundment Site 2		Alternative 5: Diversion Channel		Alternative 6: Diversion Channel with Storage	
Upper Cart Creek	*Inundated Acres in Upper Cart Creek - 10 Year (% Change)*																
	-	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total
	0-24	942 -	1,127 -	788 (-16.3%)	967 (-14.2%)	789 (-16.2%)	967 (-14.2%)	942 (0.0%)	1,127 (0.0%)	717 (-23.9%)	873 (-22.5%)	851 (-9.7%)	1,022 (-9.3%)	901 (-4.4%)	1,081 (-4.1%)	521 (-44.7%)	664 (-41.1%)
	24-48	444 -	557 -	483 (8.8%)	614 (10.2%)	483 (8.8%)	615 (10.4%)	444 (0.0%)	557 (0.0%)	338 (-23.9%)	406 (-27.1%)	410 (-7.7%)	512 (-8.1%)	443 (-0.2%)	554 (-0.5%)	249 (-43.9%)	292 (-47.6%)
	48-72	176 -	217 -	168 (-4.5%)	202 (-6.9%)	168 (-4.5%)	202 (-6.9%)	176 (0.0%)	217 (0.0%)	141 (-19.9%)	167 (-23.0%)	168 (-4.5%)	205 (-5.5%)	176 (0.0%)	216 (-0.5%)	156 (-11.4%)	186 (-14.3%)
	72-96	90 -	98 -	112 (24.4%)	133 (35.7%)	112 (24.4%)	133 (35.7%)	90 (0.0%)	98 (0.0%)	83 (-7.8%)	90 (-8.2%)	89 (-1.1%)	97 (-1.0%)	90 (0.0%)	98 (0.0%)	81 (-10.0%)	89 (-9.2%)
	96-120	66 -	79 -	68 (3.0%)	81 (2.5%)	68 (3.0%)	81 (2.5%)	66 (0.0%)	79 (0.0%)	77 (16.7%)	94 (19.0%)	67 (1.5%)	80 (1.3%)	67 (1.5%)	80 (1.3%)	76 (15.2%)	90 (13.9%)
	>120	263 -	360 -	322 (22.4%)	416 (15.6%)	321 (22.1%)	415 (15.3%)	263 (0.0%)	360 (0.0%)	252 (-4.2%)	337 (-6.4%)	260 (-1.1%)	355 (-1.4%)	261 (-0.8%)	358 (-0.6%)	295 (12.2%)	389 (8.1%)
	Total	1,981 -	2,437 -	1,941 (-2.0%)	2,414 (-0.9%)	1,941 (-2.0%)	2,414 (-0.9%)	1,981 (0.0%)	2,437 (0.0%)	1,609 (-18.8%)	1,967 (-19.3%)	1,846 (-6.8%)	2,271 (-6.8%)	1,938 (-2.2%)	2,387 (-2.1%)	1,378 (-30.4%)	1,710 (-29.8%)
Lower Cart Creek	*Inundated Acres in Lower Cart Creek - 10 Year (% Change)*																
	-	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total
	0-24	480 -	597 -	443 (-7.7%)	540 (-9.5%)	443 (-7.7%)	540 (-9.5%)	480 (0.0%)	597 (0.0%)	482 (0.4%)	619 (3.7%)	468 (-2.5%)	588 (-1.5%)	456 (-5.0%)	534 (-10.6%)	371 (-22.7%)	477 (-20.1%)
	24-48	423 -	568 -	405 (-4.3%)	577 (1.6%)	370 (-12.5%)	506 (-10.9%)	423 (0.0%)	568 (0.0%)	373 (-11.8%)	492 (-13.4%)	387 (-8.5%)	523 (-7.9%)	388 (-8.3%)	523 (-7.9%)	335 (-20.8%)	431 (-24.1%)
	48-72	262 -	357 -	369 (40.8%)	505 (41.5%)	284 (8.4%)	384 (7.6%)	262 (0.0%)	357 (0.0%)	213 (-18.7%)	281 (-21.3%)	249 (-5.0%)	337 (-5.6%)	270 (3.1%)	367 (2.8%)	220 (-16.0%)	288 (-19.3%)
	72-96	163 -	201 -	284 (74.2%)	384 (91.0%)	166 (1.8%)	222 (10.4%)	163 (0.0%)	201 (0.0%)	128 (-21.5%)	152 (-24.4%)	138 (-15.3%)	165 (-17.9%)	164 (0.6%)	205 (2.0%)	110 (-32.5%)	130 (-35.3%)
	96-120	56 -	66 -	167 (198.2%)	223 (237.9%)	73 (30.4%)	83 (25.8%)	56 (0.0%)	66 (0.0%)	366 (553.6%)	524 (693.9%)	52 (-7.1%)	60 (-9.1%)	59 (5.4%)	69 (4.5%)	56 (0.0%)	63 (-4.5%)
	>120	364 -	513 -	72 (-80.2%)	82 (-84.0%)	405 (11.3%)	577 (12.5%)	364 (0.0%)	513 (0.0%)	55 (-84.9%)	66 (-87.1%)	365 (0.3%)	515 (0.4%)	371 (1.9%)	523 (1.9%)	371 (1.9%)	521 (1.6%)
	Total	1,748 -	2,302 -	1,740 (-0.5%)	2,312 (0.4%)	1,740 (-0.5%)	2,312 (0.4%)	1,748 (0.0%)	2,302 (0.0%)	1,617 (-7.5%)	2,132 (-7.4%)	1,659 (-5.1%)	2,188 (-5.0%)	1,708 (-2.3%)	2,222 (-3.5%)	1,463 (-16.3%)	1,910 (-17.0%)
Upper North Branch	*Inundated Acres in Upper North Branch - 10 Year (% Change)*																
	-	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total
	0-24	289 -	361 -	321 (11.1%)	425 (17.7%)	289 (0.0%)	361 (0.0%)	334 (15.6%)	501 (38.8%)	289 (0.0%)	361 (0.0%)	289 (0.0%)	361 (0.0%)	289 (0.0%)	361 (0.0%)	227 (-21.5%)	282 (-21.9%)
	24-48	188 -	308 -	172 (-8.5%)	270 (-12.3%)	188 (0.0%)	308 (0.0%)	146 (-22.3%)	215 (-30.2%)	188 (0.0%)	308 (0.0%)	188 (0.0%)	308 (0.0%)	188 (0.0%)	308 (0.0%)	171 (-9.0%)	273 (-11.4%)
	48-72	67 -	155 -	59 (-11.9%)	139 (-10.3%)	67 (0.0%)	155 (0.0%)	13 (-80.6%)	33 (-78.7%)	67 (0.0%)	155 (0.0%)	67 (0.0%)	155 (0.0%)	67 (0.0%)	155 (0.0%)	98 (46.3%)	196 (26.5%)
	72-96	39 -	92 -	37 (-5.1%)	86 (-6.5%)	39 (0.0%)	92 (0.0%)	1 (-97.4%)	4 (-95.7%)	39 (0.0%)	92 (0.0%)	39 (0.0%)	92 (0.0%)	39 (0.0%)	92 (0.0%)	49 (25.6%)	114 (23.9%)
	96-120	21 -	45 -	21 (0.0%)	44 (-2.2%)	21 (0.0%)	45 (0.0%)	3 (-85.7%)	8 (-82.2%)	21 (0.0%)	45 (0.0%)	21 (0.0%)	45 (0.0%)	21 (0.0%)	45 (0.0%)	22 (4.8%)	51 (13.3%)
	>120	54 -	177 -	57 (5.6%)	179 (1.1%)	54 (0.0%)	177 (0.0%)	106 (96.3%)	295 (66.7%)	54 (0.0%)	177 (0.0%)	54 (0.0%)	177 (0.0%)	54 (0.0%)	176 (-0.6%)	59 (9.3%)	185 (4.5%)
	Total	658 -	1,137 -	667 (1.4%)	1,144 (0.6%)	658 (0.0%)	1,137 (0.0%)	604 (-8.2%)	1,055 (-7.2%)	658 (0.0%)	1,137 (0.0%)	658 (0.0%)	1,137 (0.0%)	658 (0.0%)	1,137 (0.0%)	625 (-5.0%)	1,101 (-3.2%)
Lower North Branch	*Inundated Acres in Lower North Branch - 10 Year (% Change)*																
	-	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total	Cropland	Total
	0-24	512 -	671 -	217 (-57.6%)	329 (-51.0%)	458 (-10.5%)	617 (-8.0%)	510 (-0.4%)	684 (1.9%)	475 (-7.2%)	645 (-3.9%)	483 (-5.7%)	642 (-4.3%)	468 (-8.6%)	573 (-14.6%)	349 (-31.8%)	451 (-32.8%)
	24-48	580 -	744 -	220 (-62.1%)	301 (-59.5%)	469 (-19.1%)	599 (-19.5%)	552 (-4.8%)	753 (1.2%)	546 (-5.9%)	721 (-3.1%)	582 (0.3%)	755 (1.5%)	590 (1.7%)	748 (0.5%)	482 (-16.9%)	636 (-14.5%)
	48-72	640 -	870 -	251 (-60.8%)	428 (-50.8%)	472 (-26.3%)	662 (-23.9%)	517 (-19.2%)	710 (-18.4%)	519 (-18.9%)	735 (-15.5%)	543 (-15.2%)	766 (-12.0%)	596 (-6.9%)	816 (-6.2%)	471 (-26.4%)	673 (-22.6%)
	72-96	568 -	734 -	265 (-53.3%)	444 (-39.5%)	585 (3.0%)	766 (4.4%)	424 (-25.4%)	537 (-26.8%)	484 (-14.8%)	628 (-14.4%)	519 (-8.6%)	675 (-8.0%)	583 (2.6%)	754 (2.7%)	510 (-10.2%)	675 (-8.0%)
	96-120	327 -	424 -	202 (-38.2%)	291 (-31.4%)	315 (-3.7%)	403 (-5.0%)	230 (-29.7%)	291 (-31.4%)	322 (-1.5%)	423 (-0.2%)	324 (-0.9%)	423 (-0.2%)	324 (-0.9%)	421 (-0.7%)	307 (-6.1%)	397 (-6.4%)
	>120	1,043 -	1,387 -	894 (-14.3%)	1,263 (-8.9%)	1,191 (14.2%)	1,571 (13.3%)	1,118 (7.2%)	1,512 (9.0%)	988 (-5.3%)	1,316 (-5.1%)	1,005 (-3.6%)	1,337 (-3.6%)	1,085 (4.0%)	1,497 (7.9%)	1,043 (0.0%)	1,449 (4.5%)
	Total	3,670 -	4,831 -	2,048 (-44.2%)	3,057 (-36.7%)	3,490 (-4.9%)	4,617 (-4.4%)	3,351 (-8.7%)	4,487 (-7.1%)	3,334 (-9.2%)	4,468 (-7.5%)	3,456 (-5.8%)	4,598 (-4.8%)	3,647 (-0.6%)	4,808 (-0.5%)	3,162 (-13.8%)	4,281 (-11.4%)

**Inundation west of North Dakota Highway 32 was not included because it is upstream of the identified damage centers.*

3.2 PRELIMINARY EVALUATION

The identified preliminary alternatives were evaluated using the hydrologic and hydraulic model in order to assess their potential to meet objectives from the Purpose and Need. The indicators described in Section 1 were used to determine if the alternatives meet the objectives from the Purpose and Need. Available GIS data was also reviewed to estimate potential resource impacts. Based on this review, the alternatives that will be carried forward are listed as follows:

- Alternative 3 – Cart Creek Impoundment Site 1
- Alternative 4 – Cart Creek Impoundment Site 2
- Alternative 6 – Diversion Channel with Temporary Flood Storage

Table 8 provides information on the ability of each Alternative to meet objectives defined in the Purpose and Need statement based on performance for the indicators discussed in Section 1 and provides the rationale to either carry forward or eliminate alternatives from further consideration. Due to the preliminary nature of this review, if the alternative peak flow was within 1% of the required peak flow reduction for an indicator, it was considered passing for that indicator. Alternatives evaluated in this report should be considered conceptual and are subject to revision as each of the selected alternatives are evaluated in detail.

Table 8: Preliminary Alternative Evaluation Summary

Alternative	INDICATOR 1: ***Reduce the 10-year cropland inundation for durations less than four days by 5% in Cart Creek Subwatershed.*** *Acre Reduction (Percent Change)*	INDICATOR 2(a): ***Reduce the 10-year event peak flow rate by 20% on the Cart Creek at Crystal, ND.*** *(Percent Change in Q-peak 10-year)*	INDICATOR 2(b): ***Reduce the 10-year event peak flow rate by 10% on the North Branch at the confluence of the Cart Creek.*** *(Percent Change in Q-peak 10-year)*	INDICATOR 3: ***Reduce the 100-year event peak flow rate by 30% on the Cart Creek at Crystal, ND.*** *(Percent Change in Q-peak 100-year)*	INDICATOR 4: ***No increase in peak flow rate at the outlet of the North Branch Watershed.*** *(Rationale discussion)*	Determination	Additional Comments
1. Agricultural Levees	**YES** *165 Acres (5.5% Reduction)*	**NO** *(10.5% Reduction)*	**YES** *(16.0% Reduction)*	**NO** *(6.2% Reduction)*	**YES** *Negligible changes observed for Cart Creek Only option.*	Eliminate	• Alternative does not meet Indicators 2(a) and 3. • Ag levees along the North Branch significantly alter the portion of flow in the channel as compared to the breakouts to the east. This would result in increased damages as a result of increased flow rates along the North Branch channel. • SLO has indicated that the ability to implement on the scale analyzed through the preliminary alternative analysis based on considerations discussed in Section 2.1.6 is not practical.
2. Milton Dam	**NO** *0 Acres (0.0% Reduction)*	**NO** *(0.0% Reduction)*	**NO** *(7.0% Reduction)*	**NO** *(0.0% Reduction)*	**YES** *Slight reduction at North Branch outlet.*	Eliminate	• Alternative does not meet Indicators 1, 2(a), 2(b), or 3. • The alternative has potential for significant adverse resource impacts through inundation of existing riparian habitat and geomorphic concerns downstream of the dam.
3. Cart Creek Impoundment Site 1	**YES** *505 Acres (16.9% Reduction)*	**YES** *(25.4% Reduction)*	**YES** *(12.9% Reduction)*	**YES** *(29.6% Reduction)*	**YES** *Slight reduction at North Branch outlet.*	**Carry Forward**	• Alternative meets all indicators. • Opportunity for positive resource impacts through conversion of cropland to perennial vegetation.
4. Cart Creek Impoundment Site 2	**YES** *220 Acres (7.4% Reduction)*	**YES** *(19.9% Reduction)*	**YES** *(9.1% Reduction)*	**YES** *(30.8% Reduction)*	**YES** *Slight reduction at North Branch outlet.*	**Carry Forward**	• Alternative meets all indicators. • Opportunity for positive resource impacts through conversion of cropland to perennial vegetation.
5. Diversion Channel	**NO** *92 Acres (3.1% Reduction)*	**YES** *(50.5% Reduction)*	**NO** *(0.7% Increase)*	**YES** *(64.3% Reduction)*	**NO** *Slight increase in discharge for the 100-year event.*	Eliminate	• Alternative does not meet Indicators 1, 2(b) or 4.
6. Diversion Channel with Temporary Flood Storage	**YES** *937 Acres (31.4% Reduction)*	**YES** *(59.4% Reduction)*	**YES** *(20.4% Reduction)*	**YES** *(73.4% Reduction)*	**YES** *Slight reduction at North Branch outlet.*	**Carry Forward**	• Alternative meets all indicators

4 REFERENCES

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Homer, C., Dewitz, J., Yang, L., Jin, S., Danielson, P., Xian, G., . . . and Megown, K. (2015). Completion of the 2011 National Land Cover Database for the Conterminous United States-Representing a Decade of Land Cover Change Information. *Photogrammetric Engineering and Remote Sensing*, 345-354.

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FIGURES

Figure D-2-2.1.1:	Reduced Runoff Volume
Figure D-2-2.1.2:	Increased Conveyance Capacity
Figure D-2-2.1.3:	Increased Temporary Flood Storage
Figure D-2-2.1.5:	Wetland Restoration
Figure D-2-2.1.6a:	Riparian Corridor Restoration
Figure D-2-2.1.6b:	Riparian Corridor Restoration (Lower Cart Creek)
Figure D-2-2.1.6c:	Riparian Corridor Restoration (Middle Cart Creek)
Figure D-2-2.1.6d:	Riparian Corridor Restoration (Upper Cart Creek)
Figure D-2-2.1.6e:	Riparian Corridor Restoration Profile (Lower Cart Creek)
Figure D-2-2.1.6f:	Riparian Corridor Restoration Profile (Middle Cart Creek)
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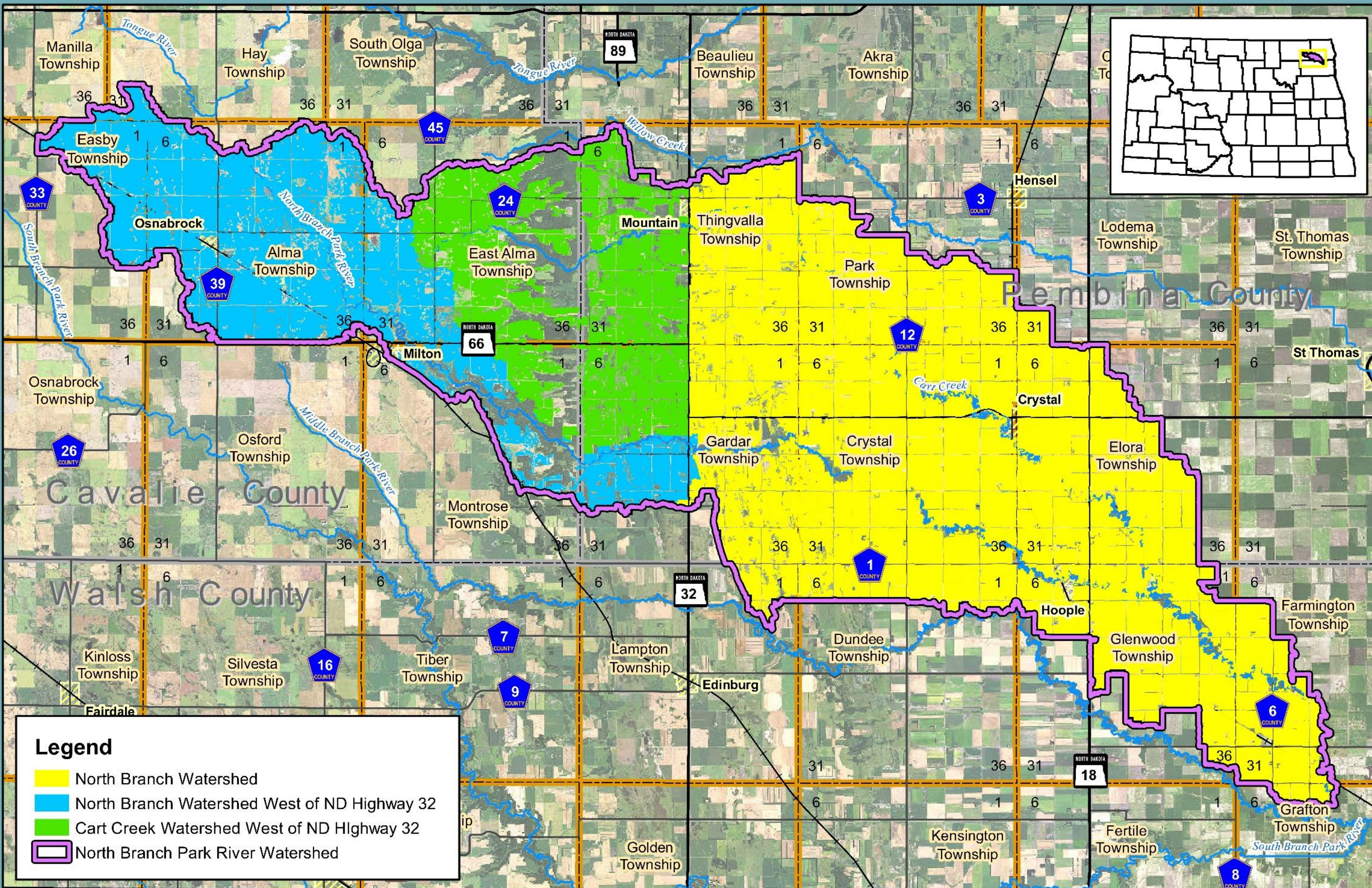
Figure D-2-2.3a:	Aquifer Storage
Figure D-2-3.1a:	Identified Alternatives
Figure D-2-3.1b:	Inundation Regions
Figure D-2-3.1.1:	Alternative 1 – Agricultural Levees
Figure D-2-3.1.2:	Alternative 2 – Milton Dam
Figure D-2-3.1.3:	Alternative 3 – Cart Creek Impoundment Site 1
Figure D-2-3.1.4:	Alternative 4 – Cart Creek Impoundment Site 2
Figure D-2-3.1.5:	Alternative 5 – Diversion Channel



F-2.1.1

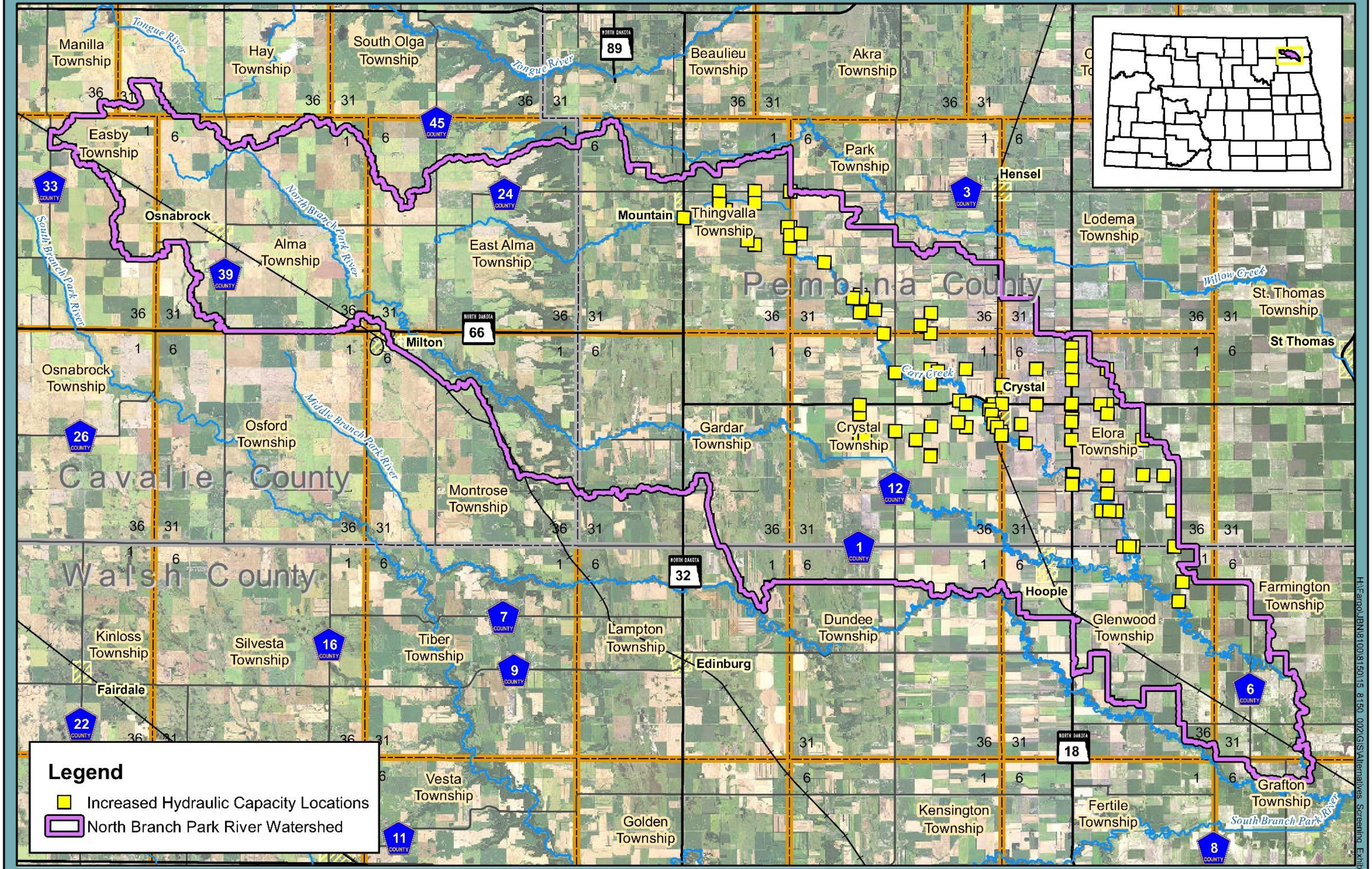
Figure 2.1.1: Reduce Runoff Volume

North Branch Park River Watershed
Screening of Alternatives for Detailed Review
Park River Joint Water Resource District

N W E S

0 1.75 3.5 7 Miles

Houston Engineering Inc.



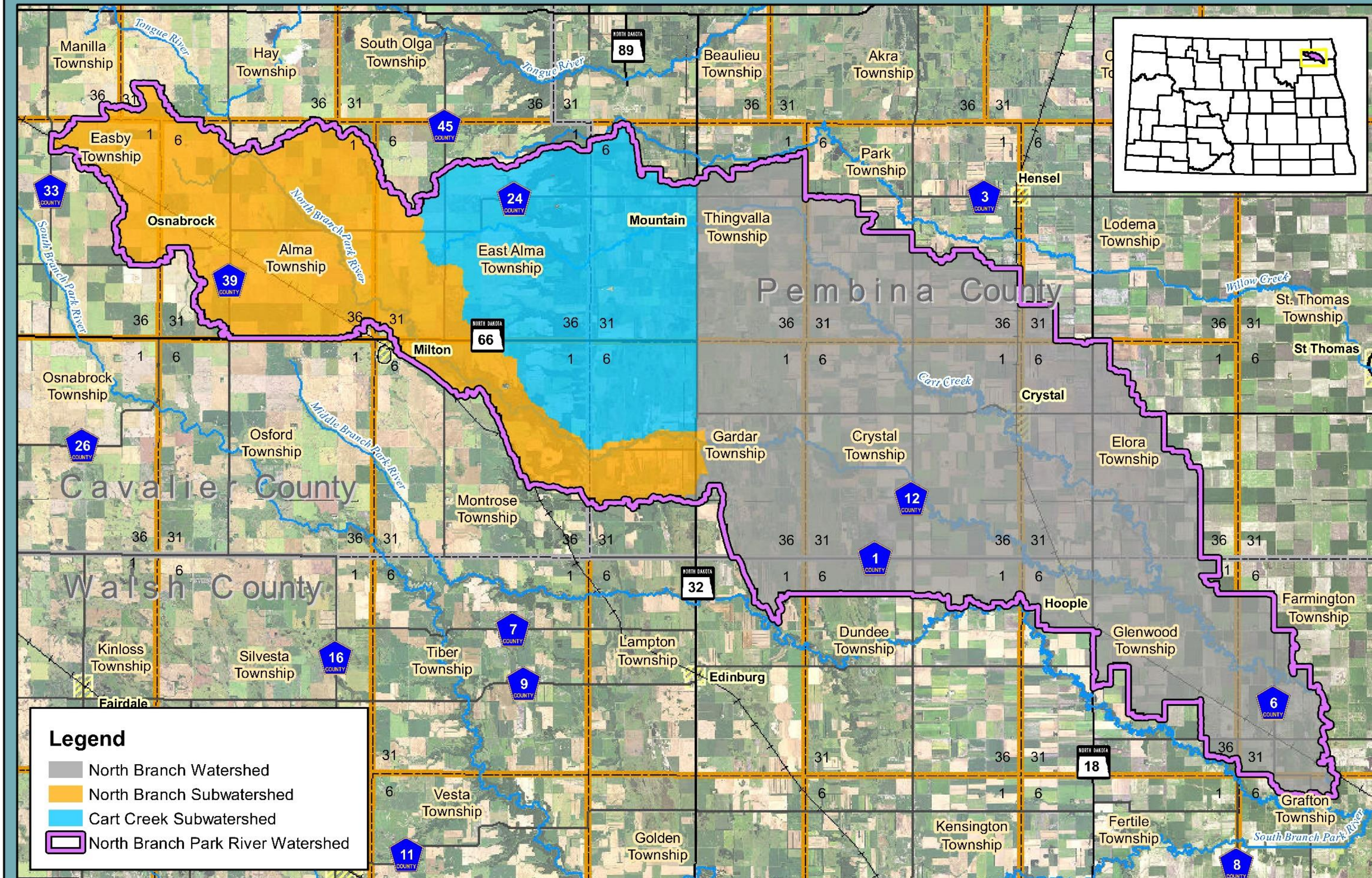
F-2.1.2

Figure 2.1.2: Increase Conveyance Capacity

North Branch Park River Watershed
Screening of Alternatives for Detailed Review
Park River Joint Water Resource District

0 1.75 3.5 7 Miles

Houston Engineering Inc.

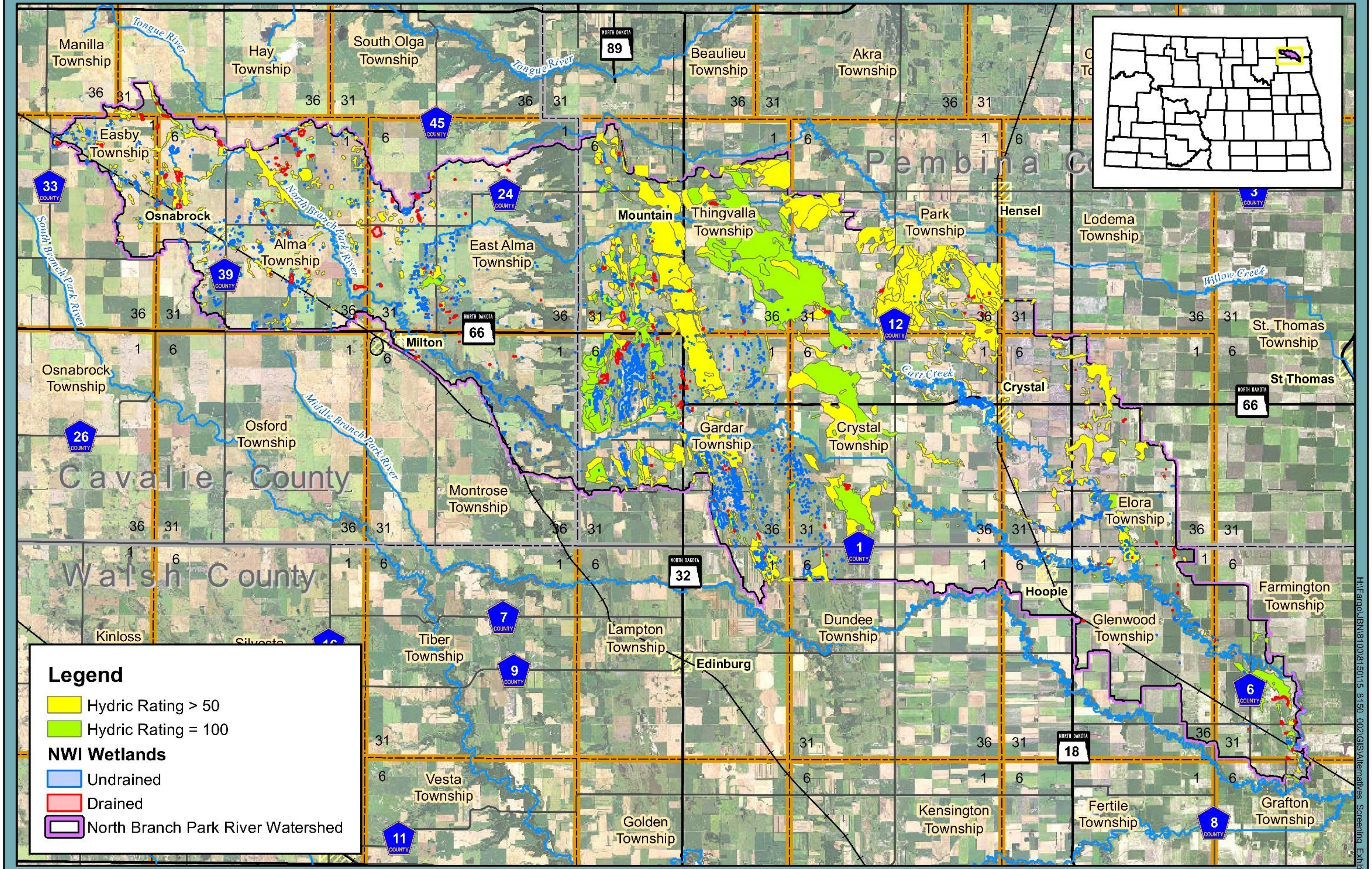


F-2.1.3

Figure 2.1.3: Increase Temporary Flood Storage

North Branch Park River Watershed
Screening of Alternatives for Detailed Review
Park River Joint Water Resource District

Houston Engineering Inc.



F-2.1.5

Figure 2.1.5: Wetland Restoration

North Branch Park River Watershed
Screening of Alternatives for Detailed Review
Park River Joint Water Resource District

0 1.75 3.5 7 Miles

Houston Engineering Inc.

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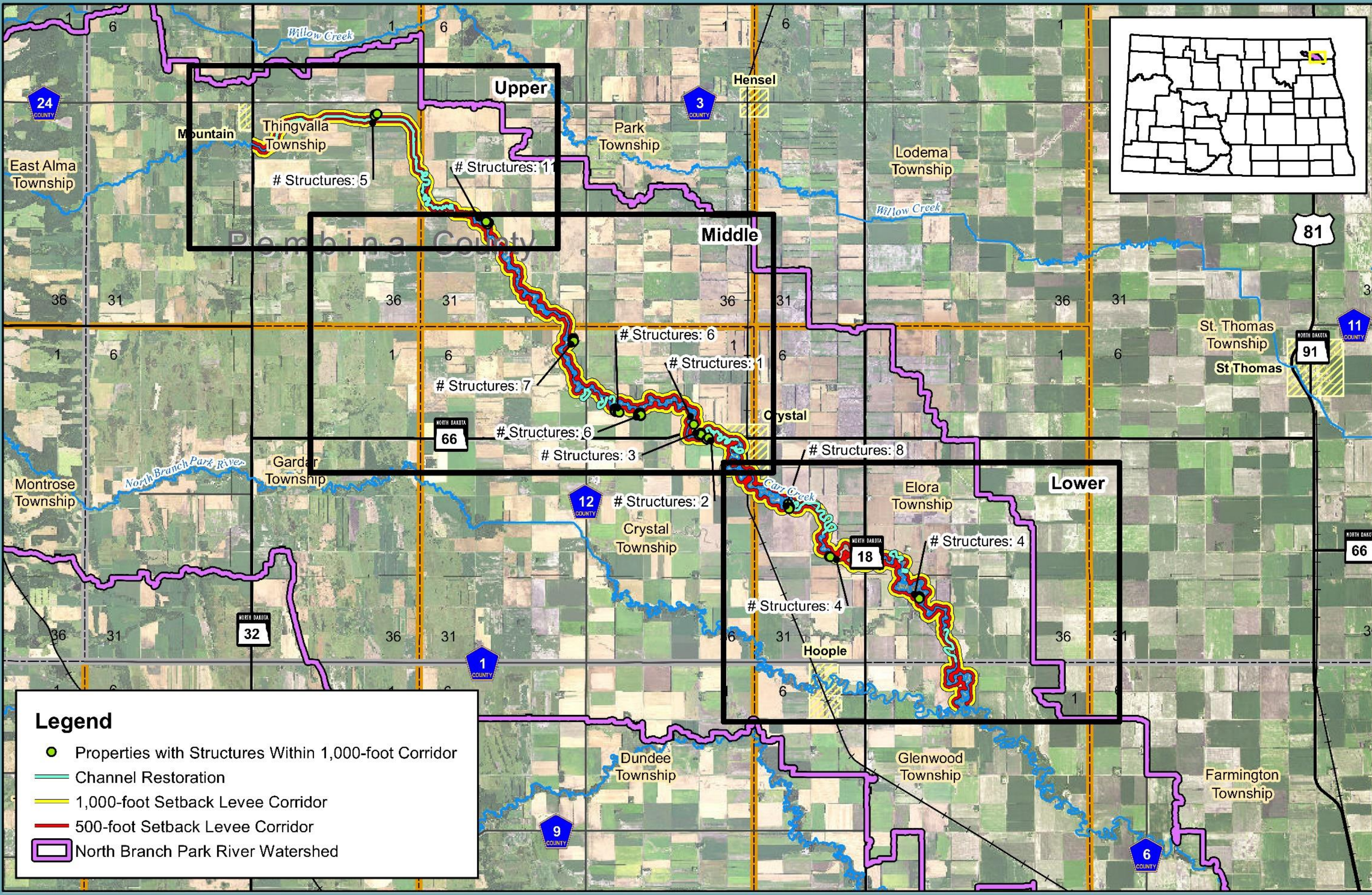


F-2.1.6a

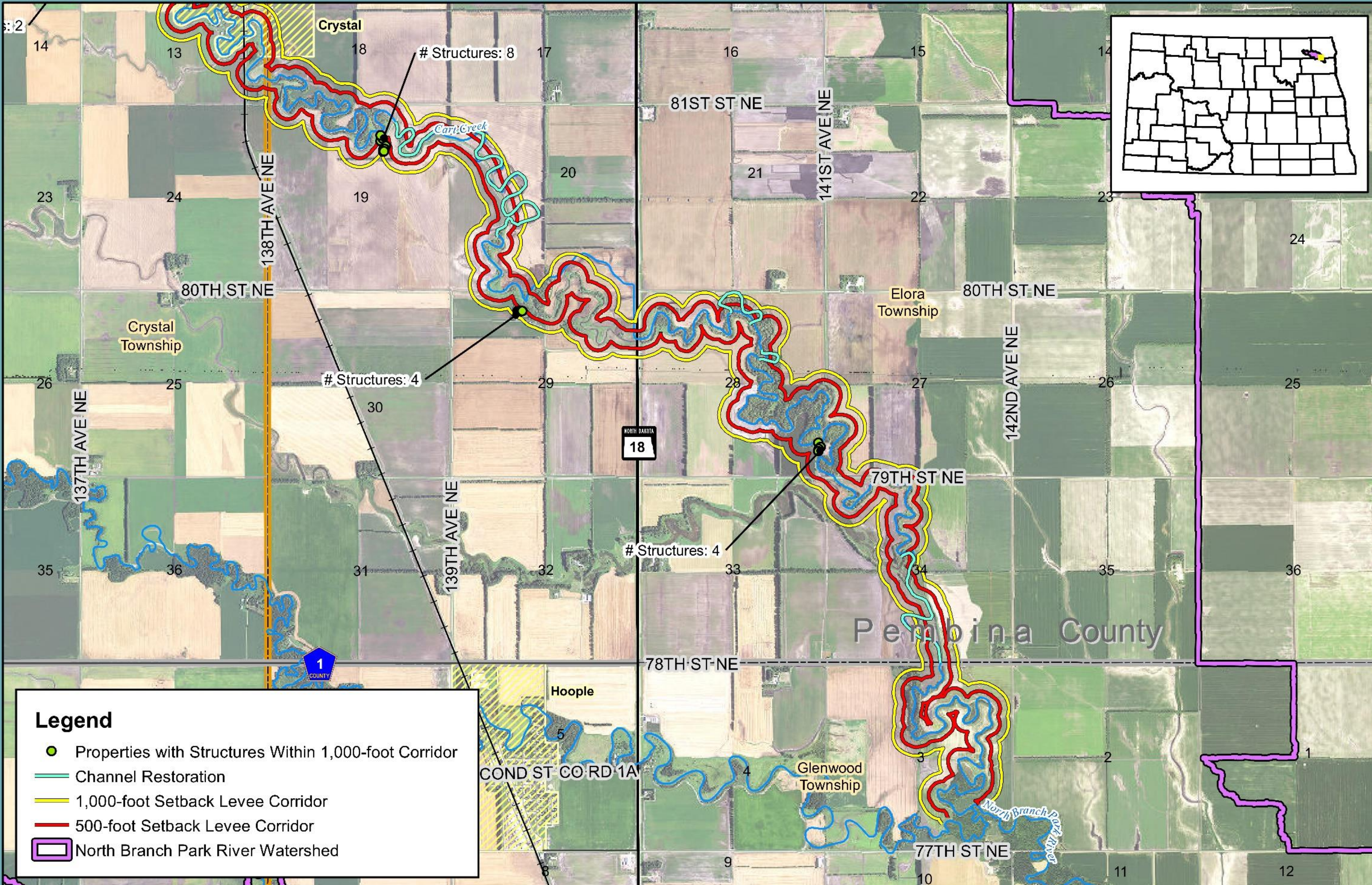
Figure 2.1.6a: Riparian Corridor Restoration

North Branch Park River Watershed
Screening of Alternatives for Detailed Review
Park River Joint Water Resource District

N W E S

0 1 2 4 Miles

Houston Engineering Inc.



F-2.1.6b

Figure 2.1.6b: Riparian Corridor Restoration (Lower Cart Creek)

North Branch Park River Watershed
Screening of Alternatives for Detailed Review
Park River Joint Water Resource District

0 0.325 0.65 1.3 Miles

Houston Engineering Inc.

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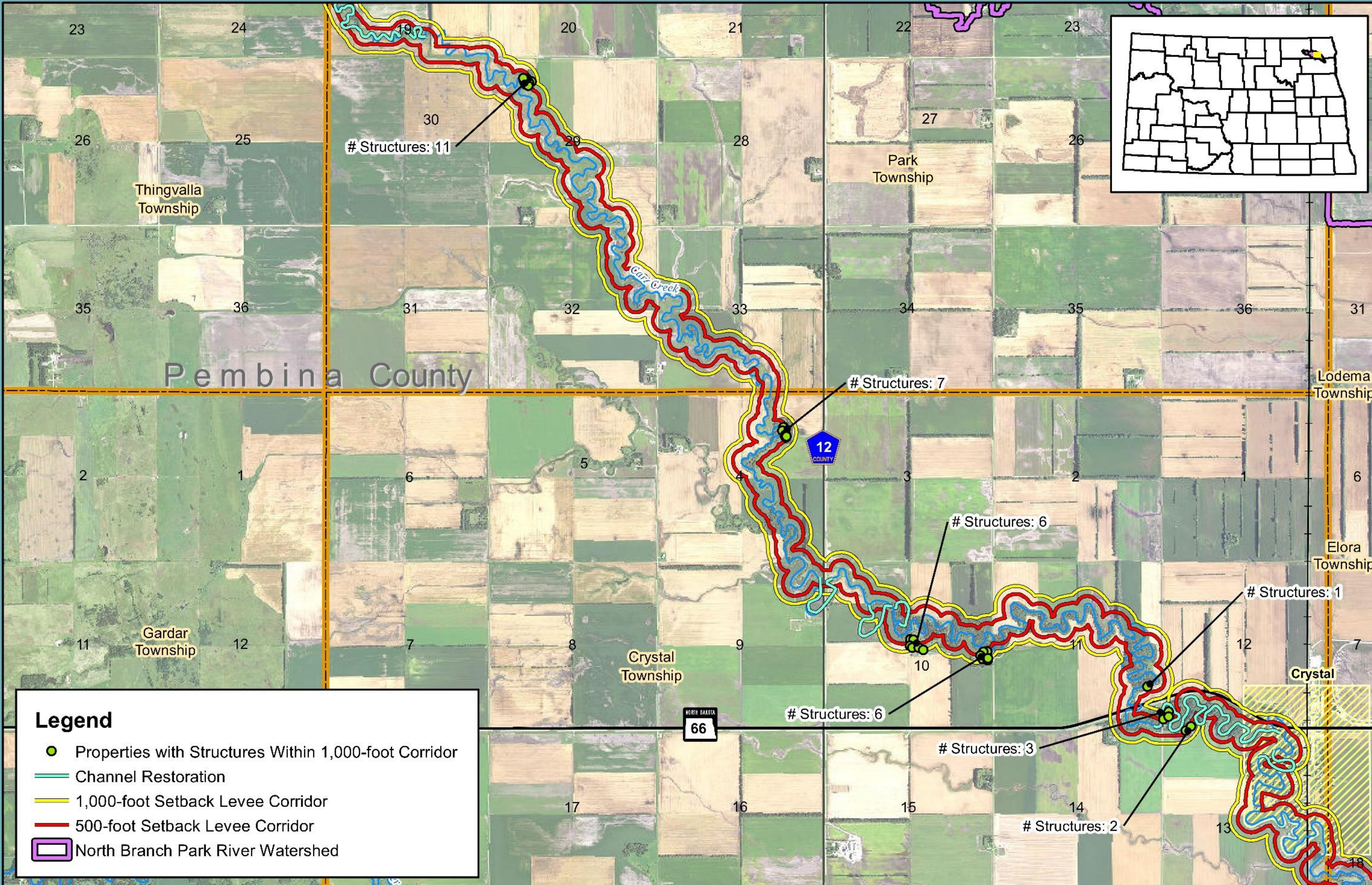

F-2.1.6c

Figure 2.1.6c: Riparian Corridor Restoration (Middle Cart Creek)

North Branch Park River Watershed
Screening of Alternatives for Detailed Review
Park River Joint Water Resource District

N W E S

0 0.375 0.75 1.5 Miles

Houston Engineering Inc.

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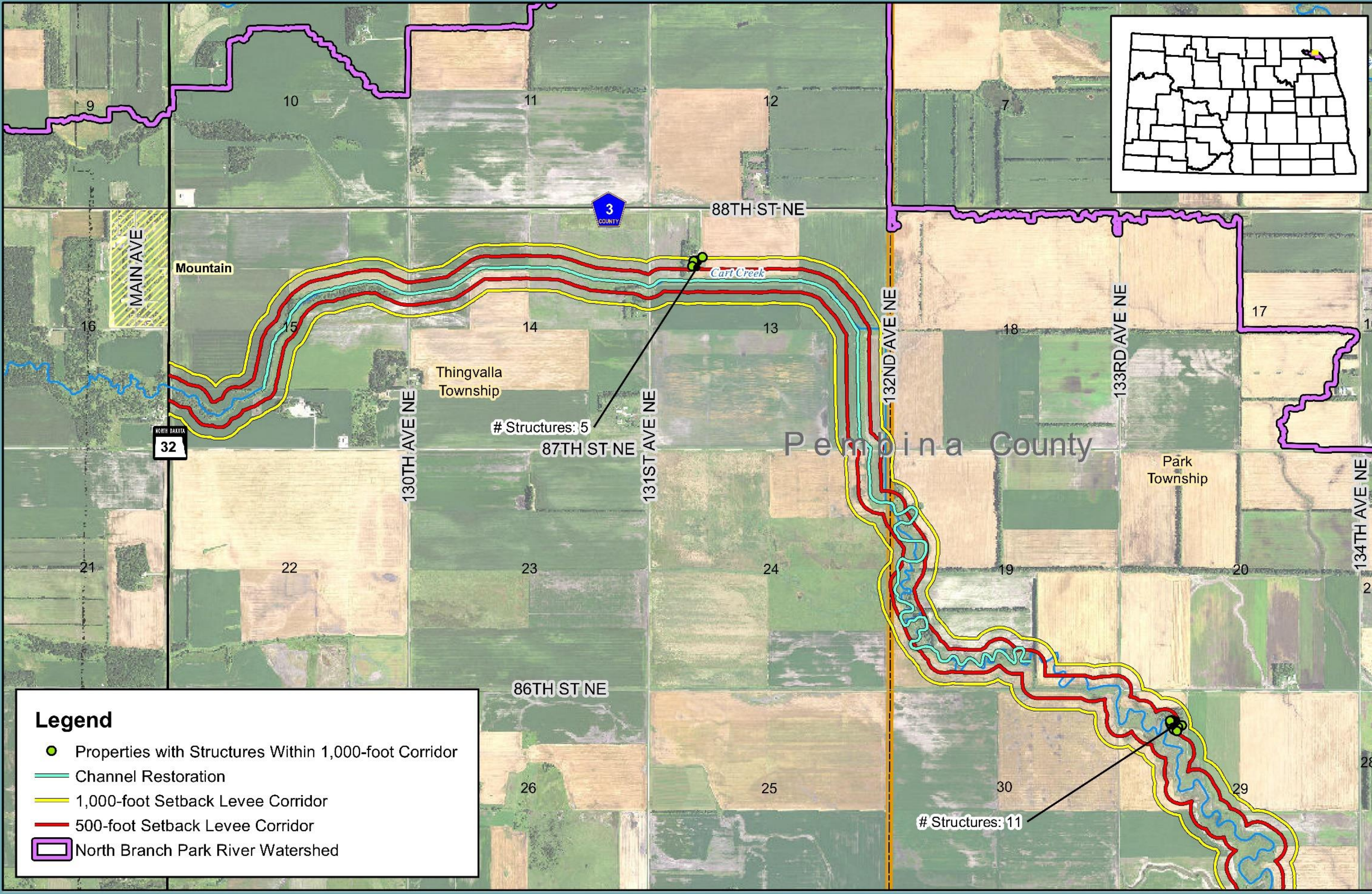

F-2.1.6d

Figure 2.1.6d: Riparian Corridor Restoration (Upper Cart Creek)

North Branch Park River Watershed
Screening of Alternatives for Detailed Review
Park River Joint Water Resource District

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Figure D-2-2.1.6e: Riparian Corridor Restoration Profile (Lower Cart Creek)

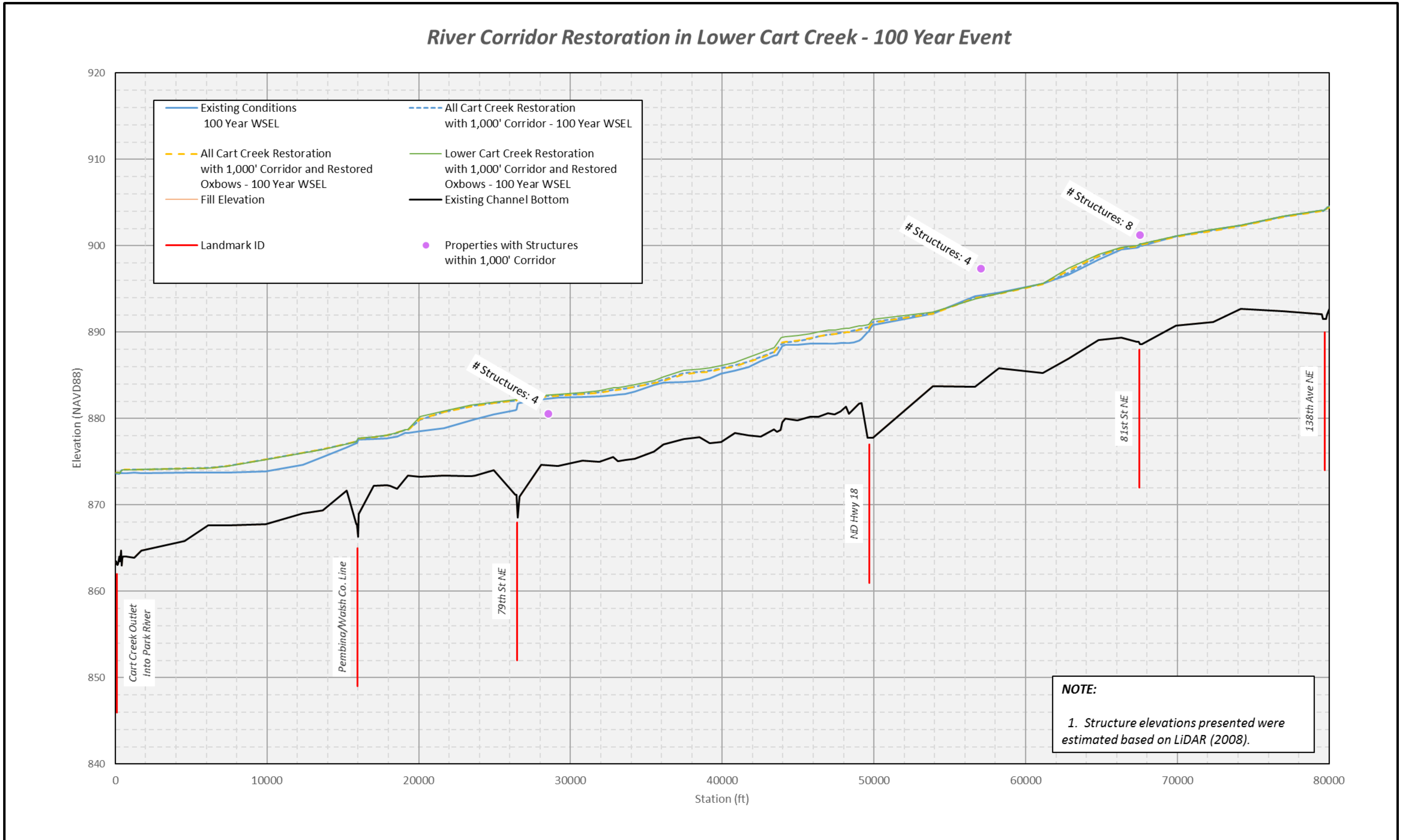


Figure D-2-2.1.6f: Riparian Corridor Restoration Profile (Middle Cart Creek)

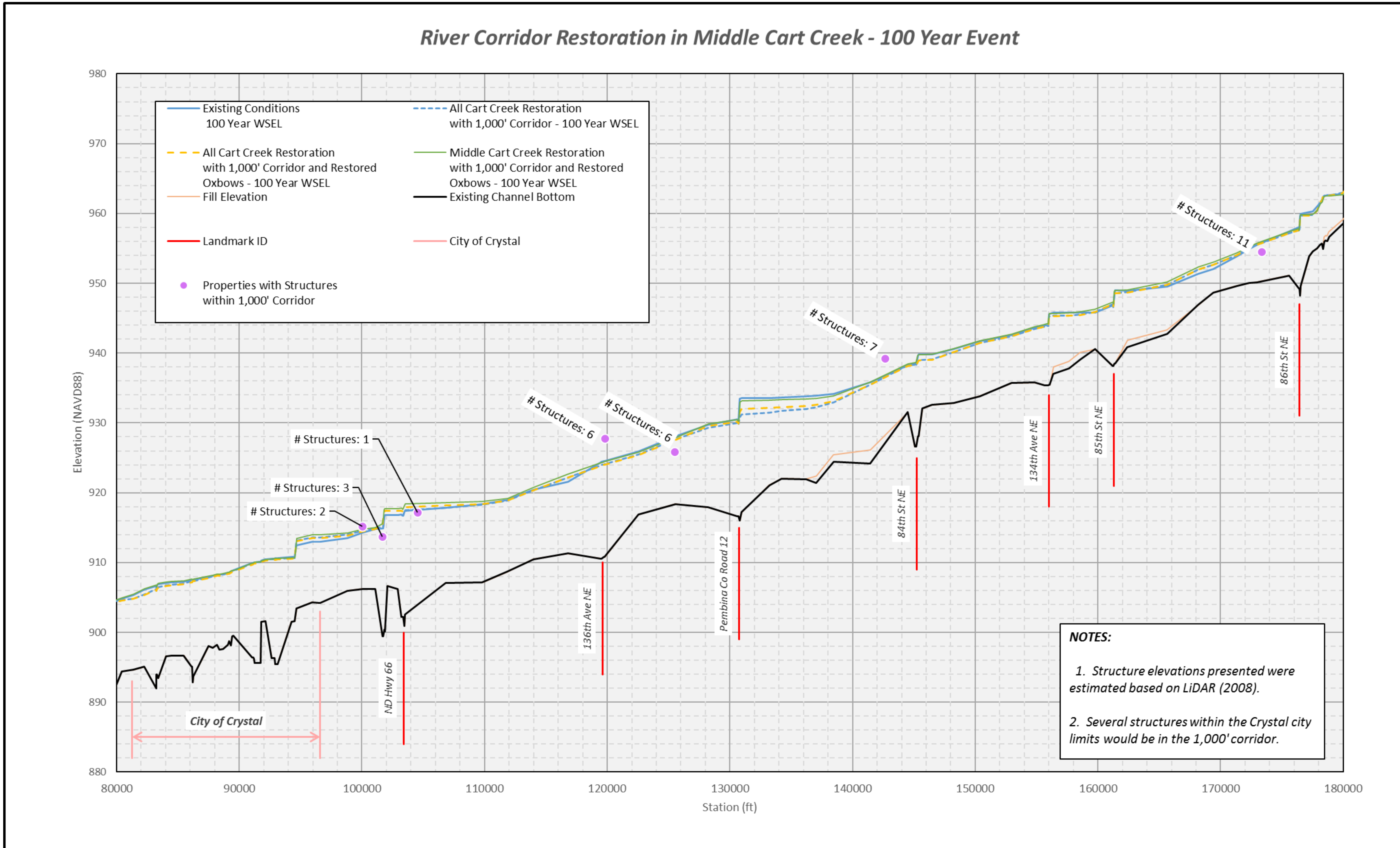
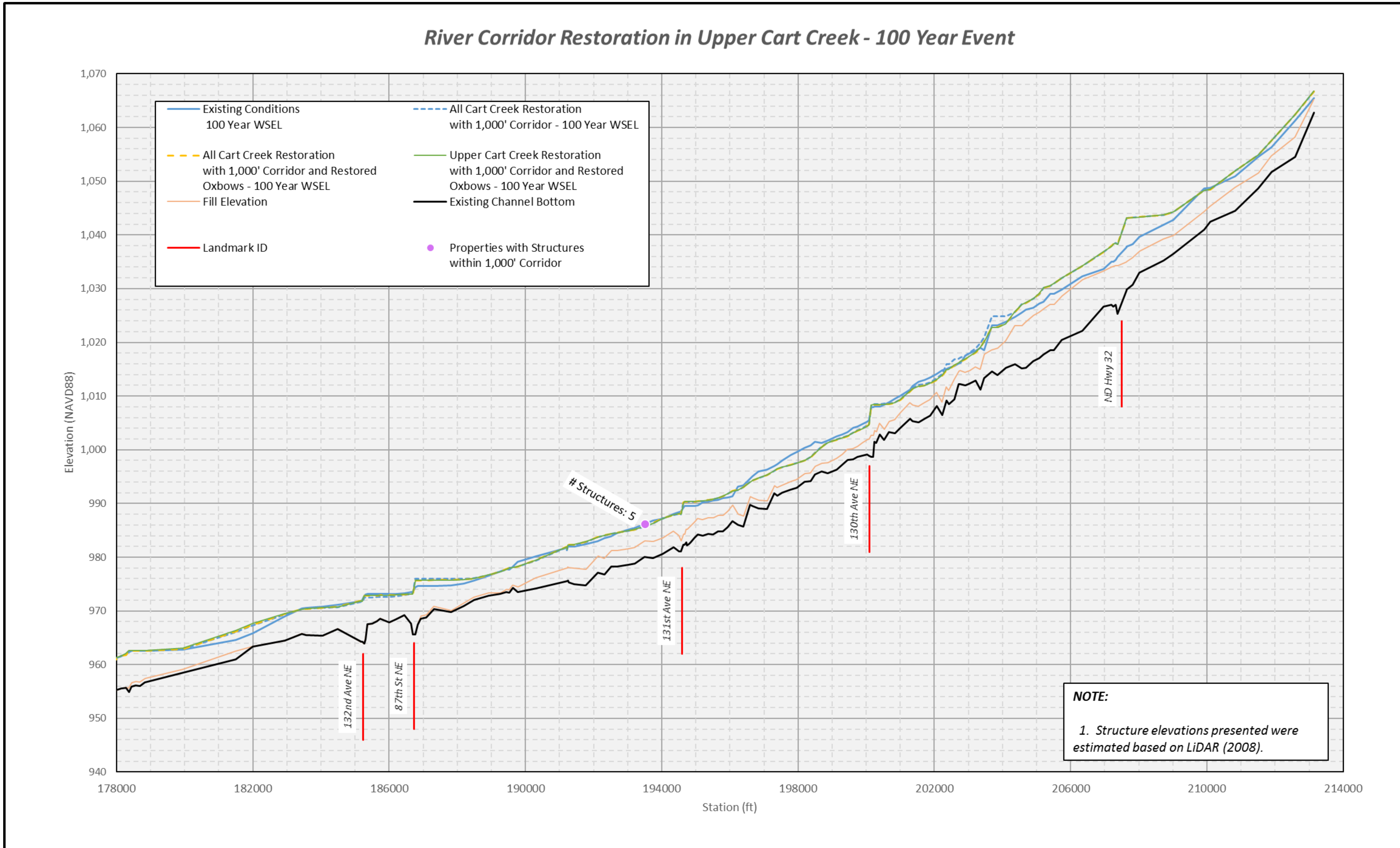
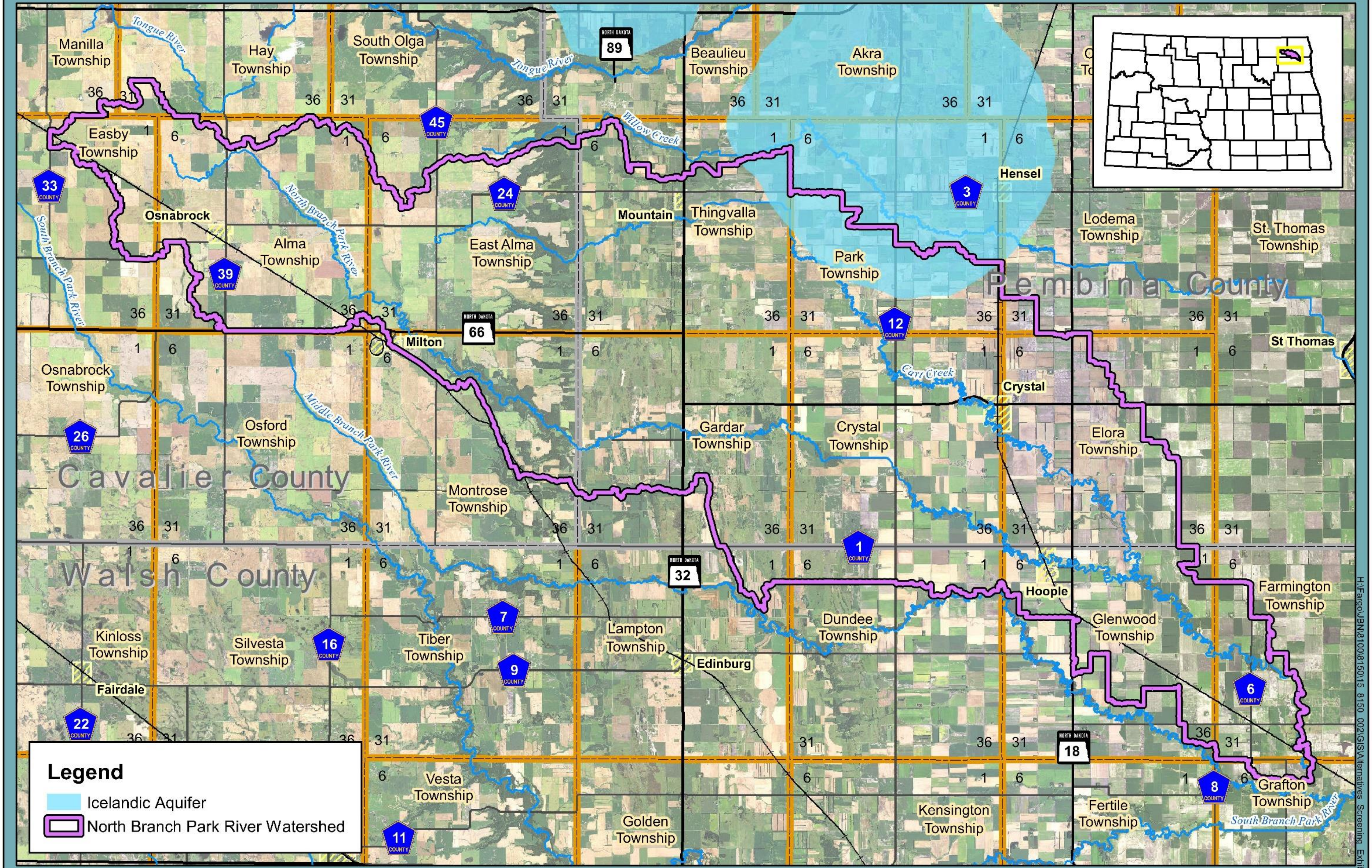


Figure D-2-2.1.6g: Riparian Corridor Restoration Profile (Upper Cart Creek)





F-2.3a

Figure 2.3a: Aquifer Storage

North Branch Park River Watershed
Screening of Alternatives for Detailed Review
Park River Joint Water Resource District

0 1.75 3.5 7 Miles

Houston Engineering Inc.

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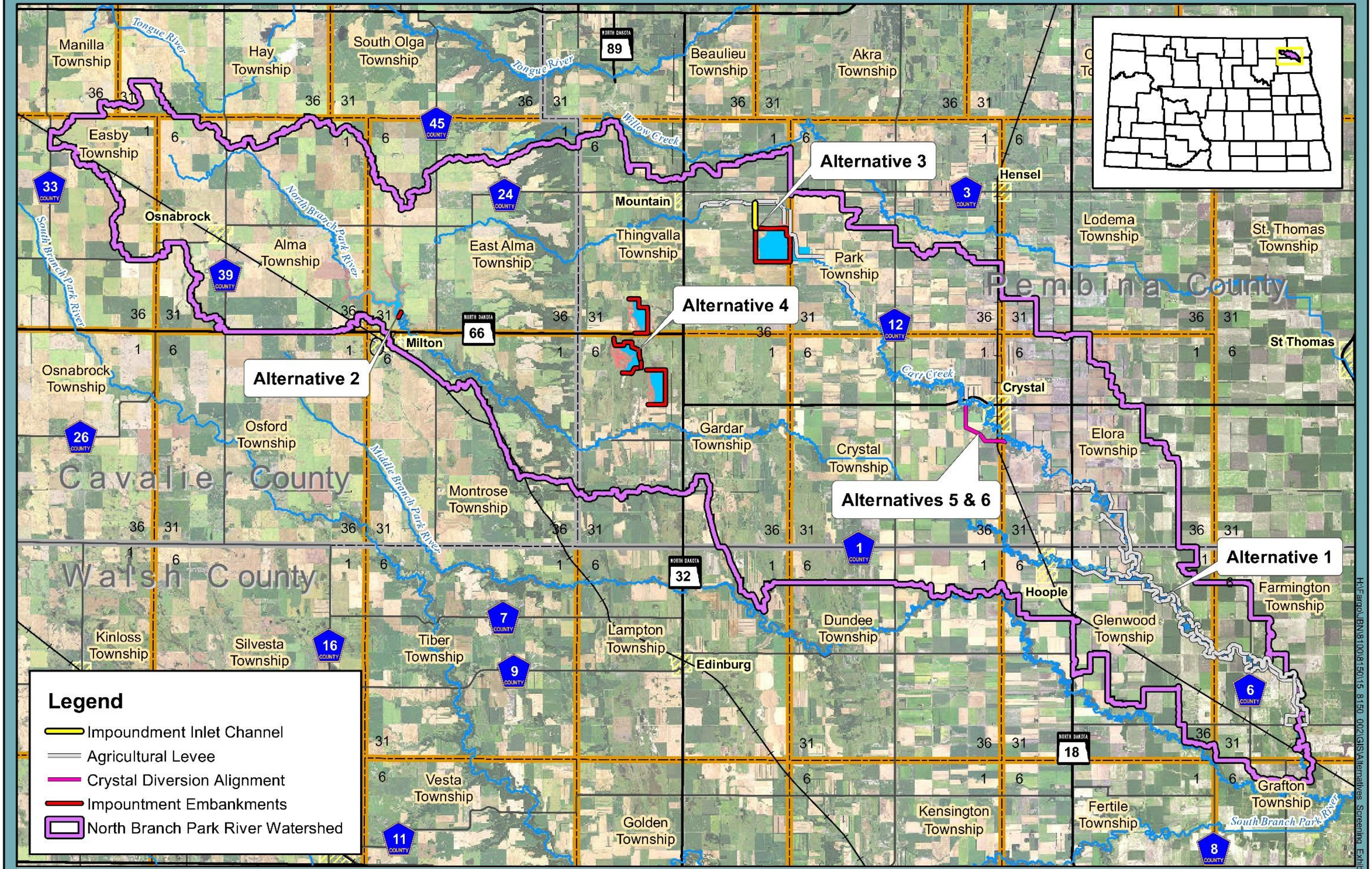

F-3.1a

Figure 3.1a: Identified Alternatives

North Branch Park River Watershed
Screening of Alternatives for Detailed Review
Park River Joint Water Resource District

Houston Engineering Inc.

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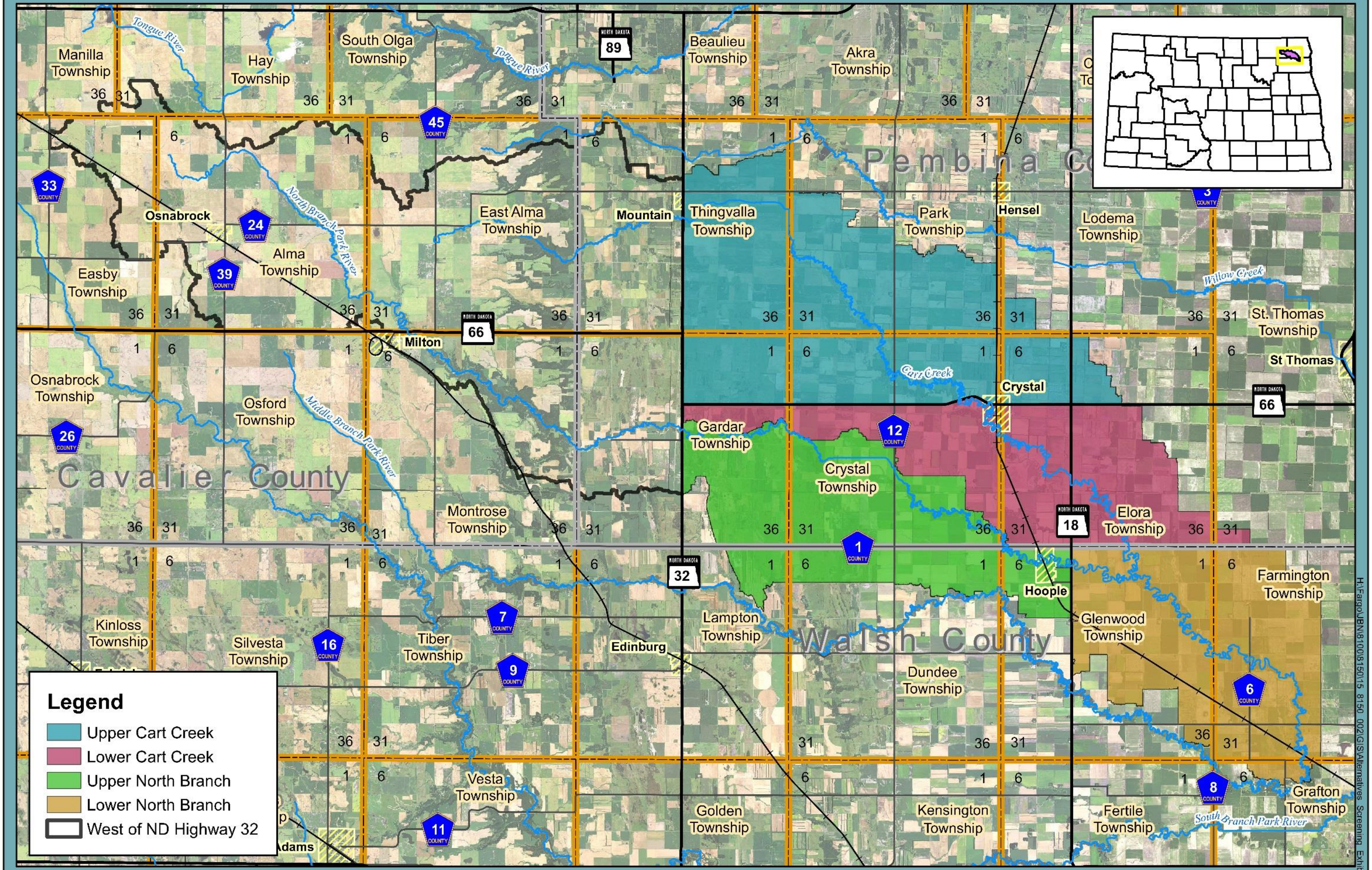

F-3.1b

Figure 3.1b: Inundation Regions

North Branch Park River Watershed
Screening of Alternatives for Detailed Review
Park River Joint Water Resource District

0 1.75 3.5 7 Miles

Houston Engineering Inc.

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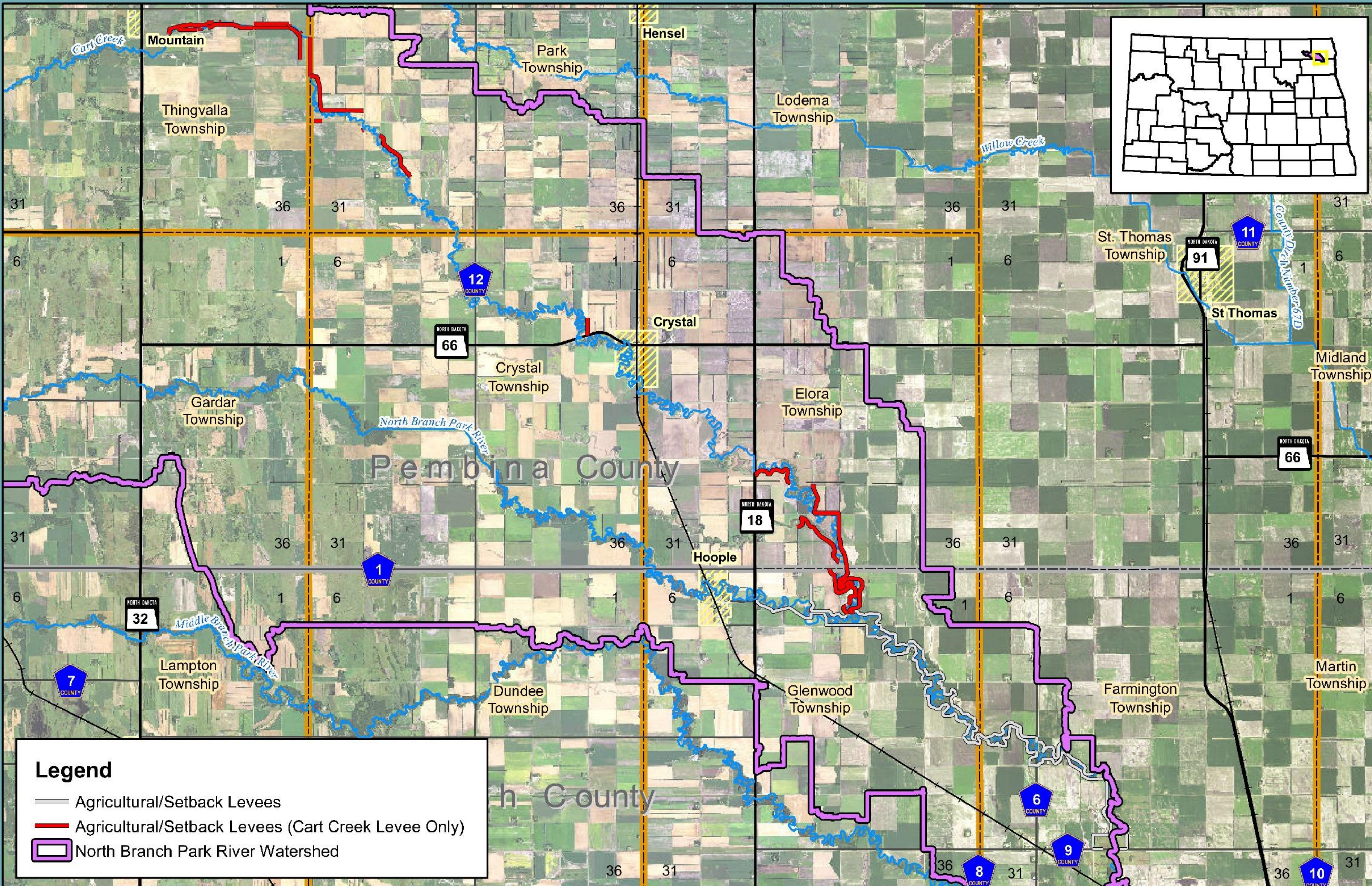


F-3.1.1

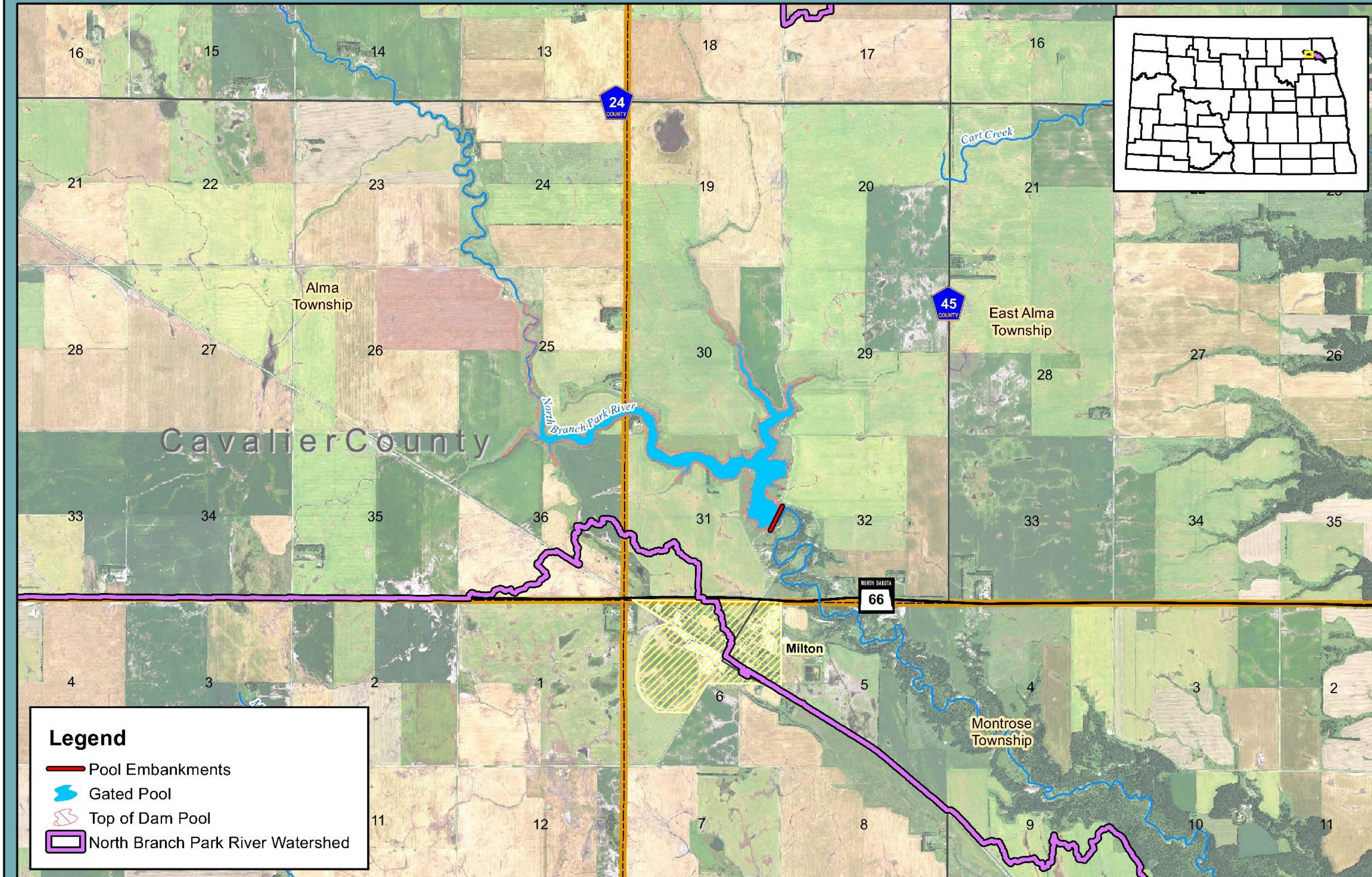
Figure 3.1.1: Alternative 1 - Agricultural Levees

North Branch Park River Watershed
Screening of Alternatives for Detailed Review
Park River Joint Water Resource District

N W E S

0 1 2 4 Miles

Houston Engineering Inc.



F-3.1.2

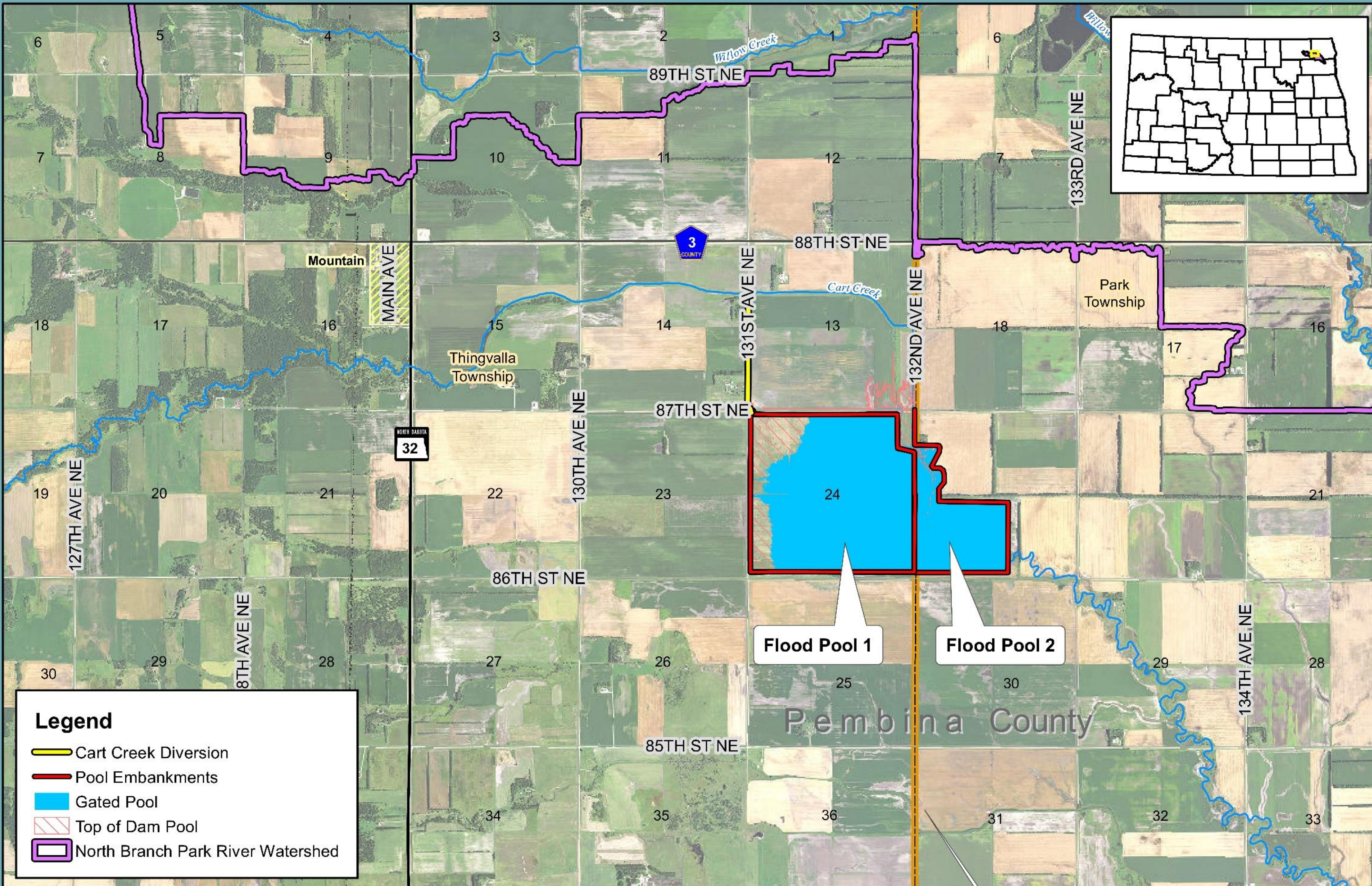
Figure 3.1.2: Alternative 2 - Milton Dam

North Branch Park River Watershed
Screening of Alternatives for Detailed Review
Park River Joint Water Resource District

N
W E
S

0 0.375 0.75 1.5
Miles

Houston Engineering Inc.

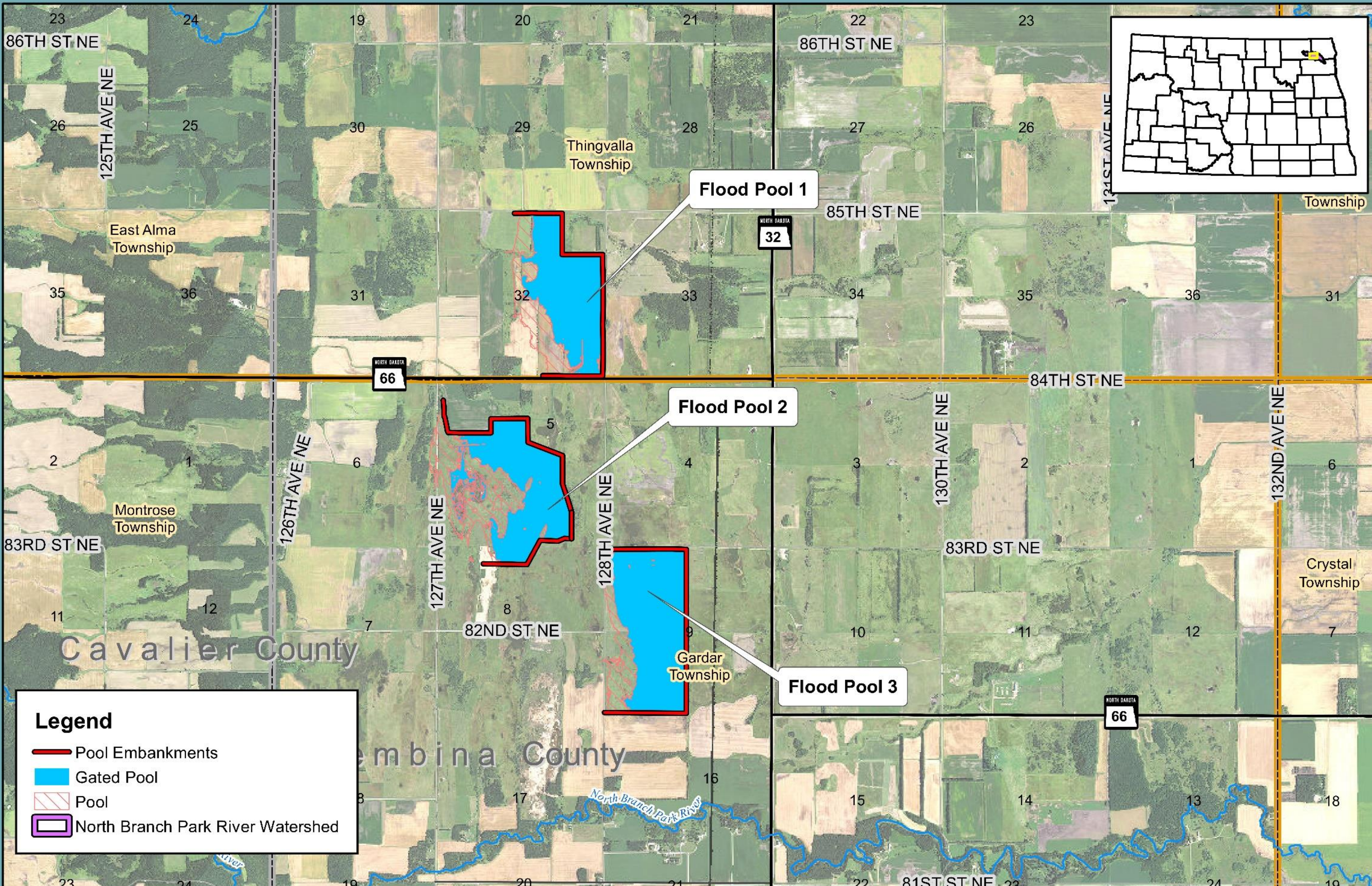


F-3.1.3

Figure 3.1.3: Alternative 3 - Cart Creek Impoundment Site 1

North Branch Park River Watershed
Screening of Alternatives for Detailed Review
Park River Joint Water Resource District

Houston Engineering Inc.



F-3.1.4

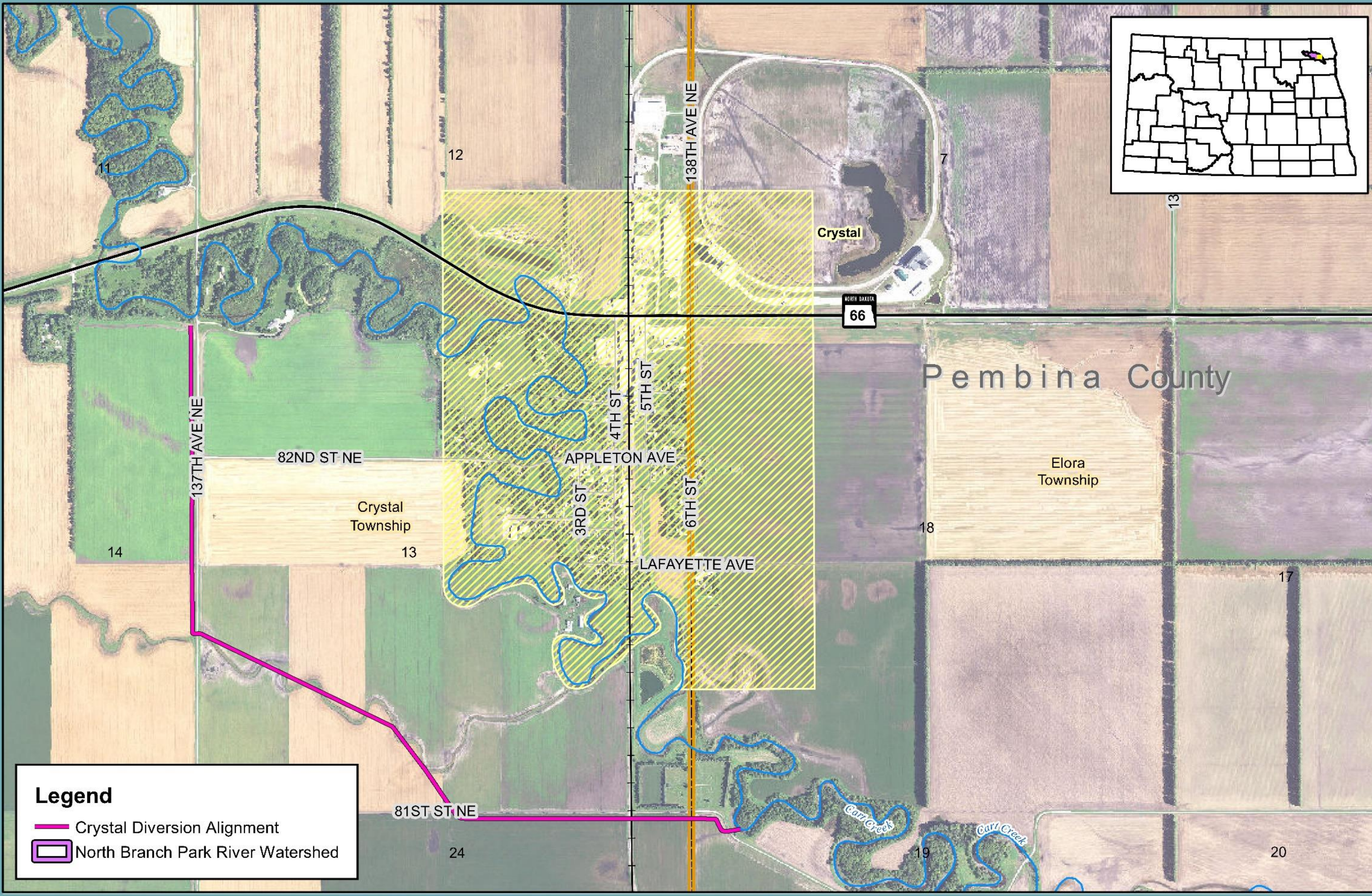
Figure 3.1.4: Alternative 4 - Cart Creek Impoundment Site 2

North Branch Park River Watershed
Screening of Alternatives for Detailed Review
Park River Joint Water Resource District

N W E S

0 0.375 0.75 1.5 Miles

Houston Engineering Inc.



F-3.1.5

Figure 3.1.5: Alternative 5 - Diversion Channel

North Branch Park River Watershed
Screening of Alternatives for Detailed Review
Park River Joint Water Resource District

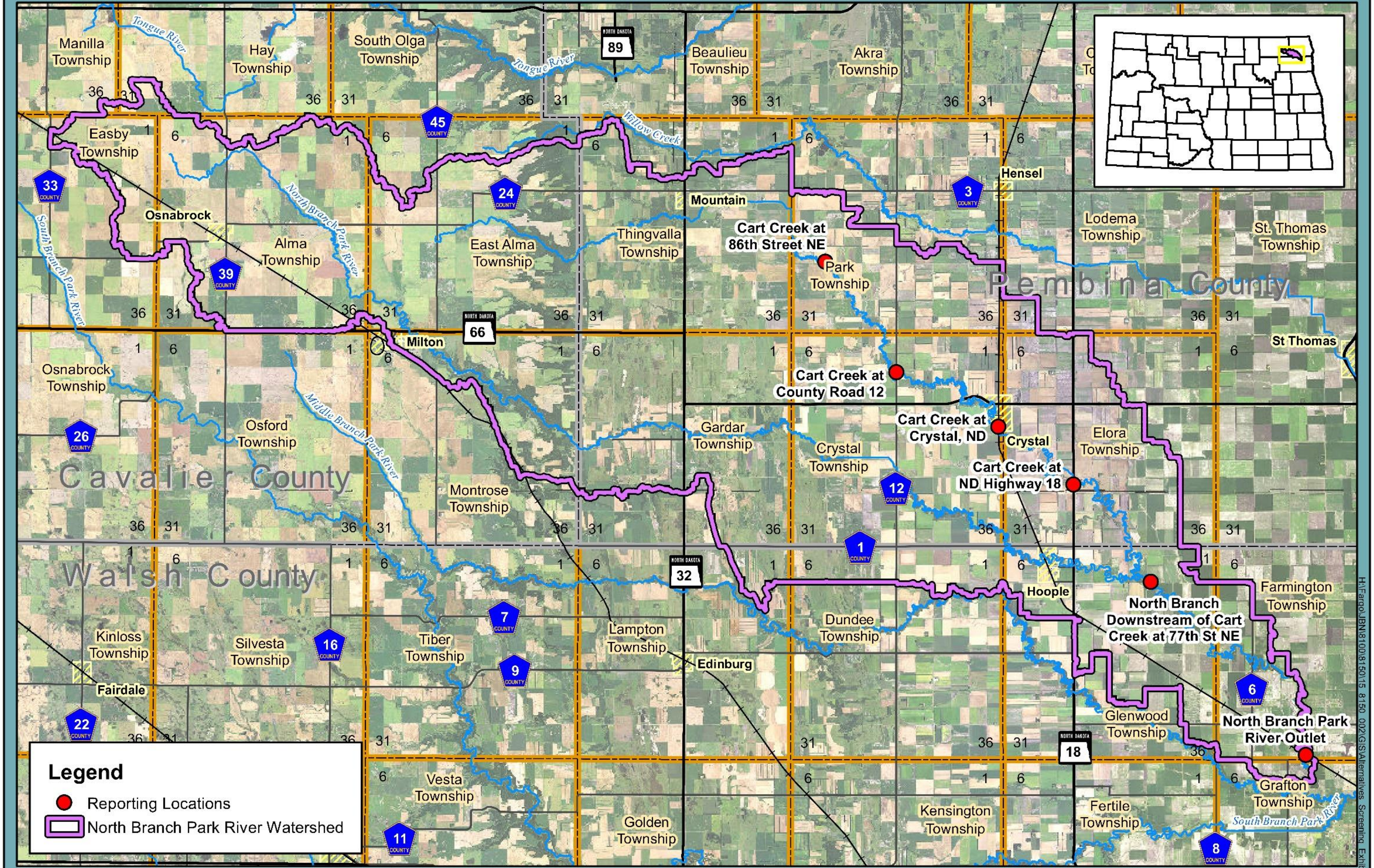
N W E S

0 0.125 0.25 0.5 Miles

Houston Engineering Inc.

ATTACHMENT D-2-A

Figure D-2-A.1: Technical Considerations – Reporting Locations
D-2-A.2 Reduce Runoff Volume – Hydrographs
D-2-A.3 Increase Conveyance Capacity – Hydrographs
D-2-A.4 Increase Temporary Flood Storage – Hydrographs
D-2-A.5 Wetland Restoration – Hydrographs
D-2-A.6 Riparian Corridor Restoration – Hydrographs



F-A.1

Figure A.1: Technical Considerations - Reporting Locations

North Branch Park River Watershed
Screening of Alternatives for Detailed Review
Park River Joint Water Resource District

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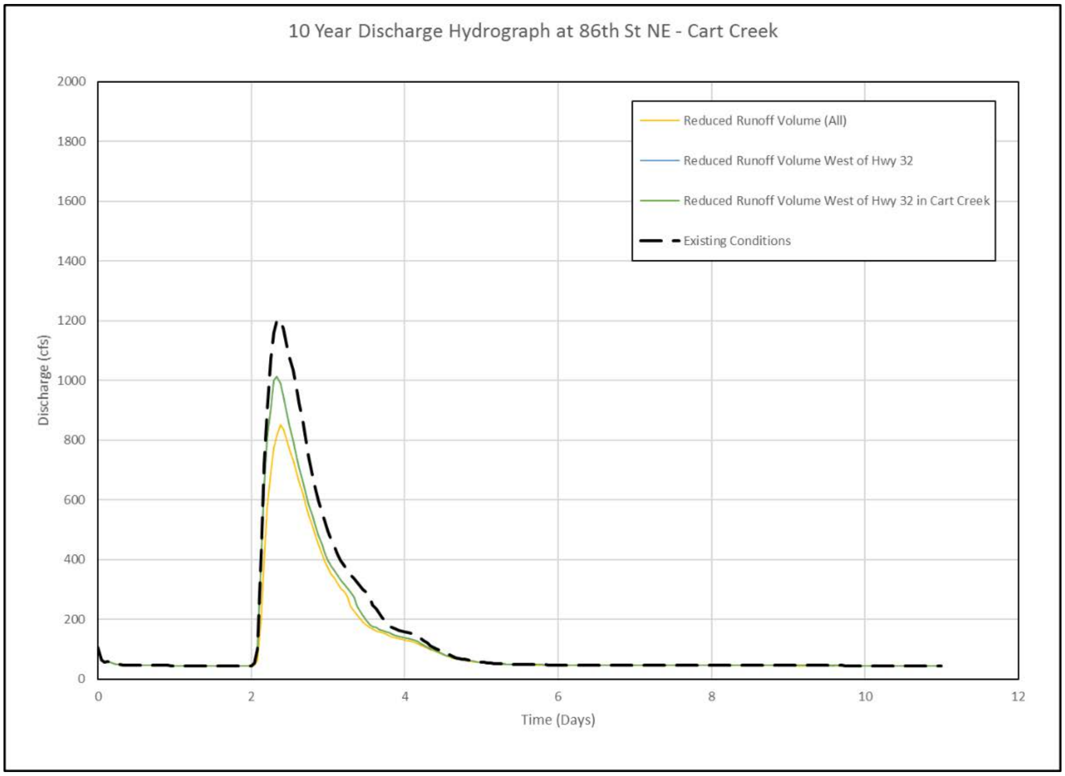
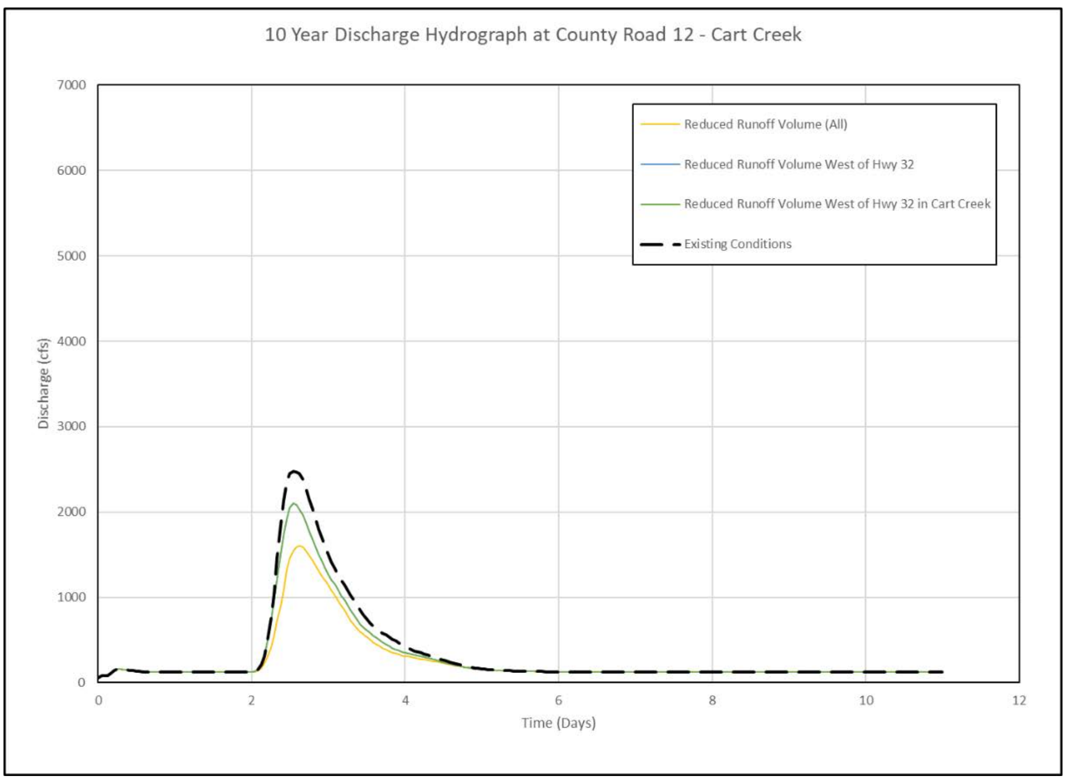
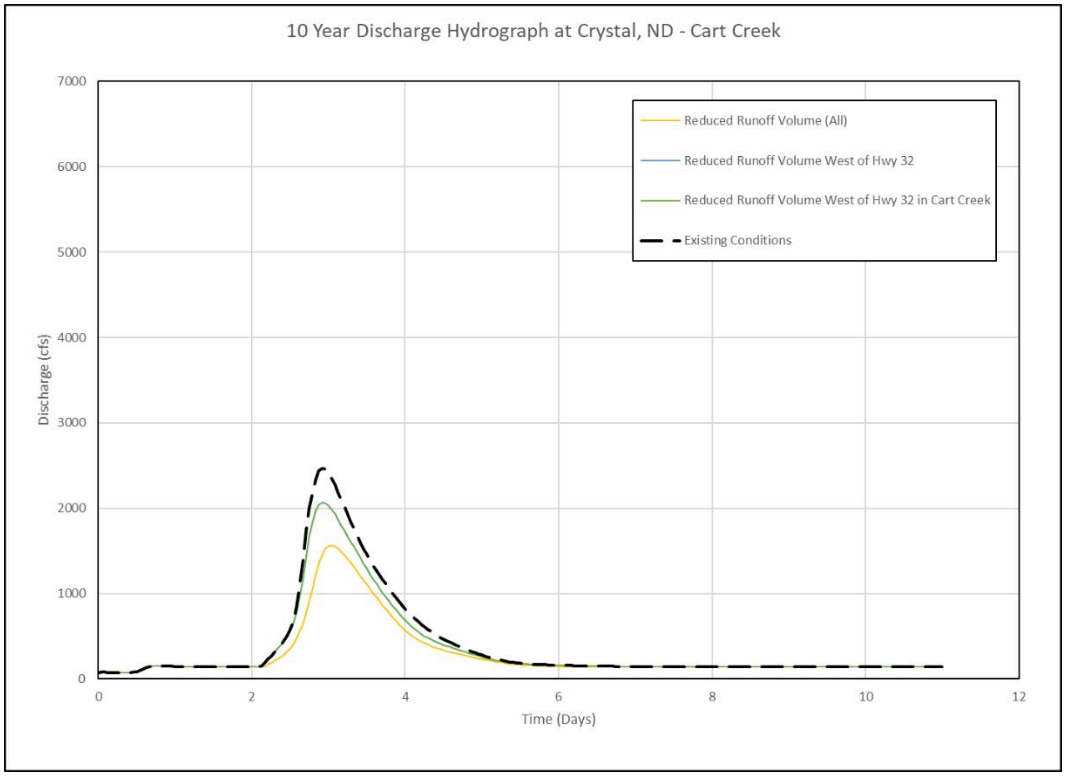
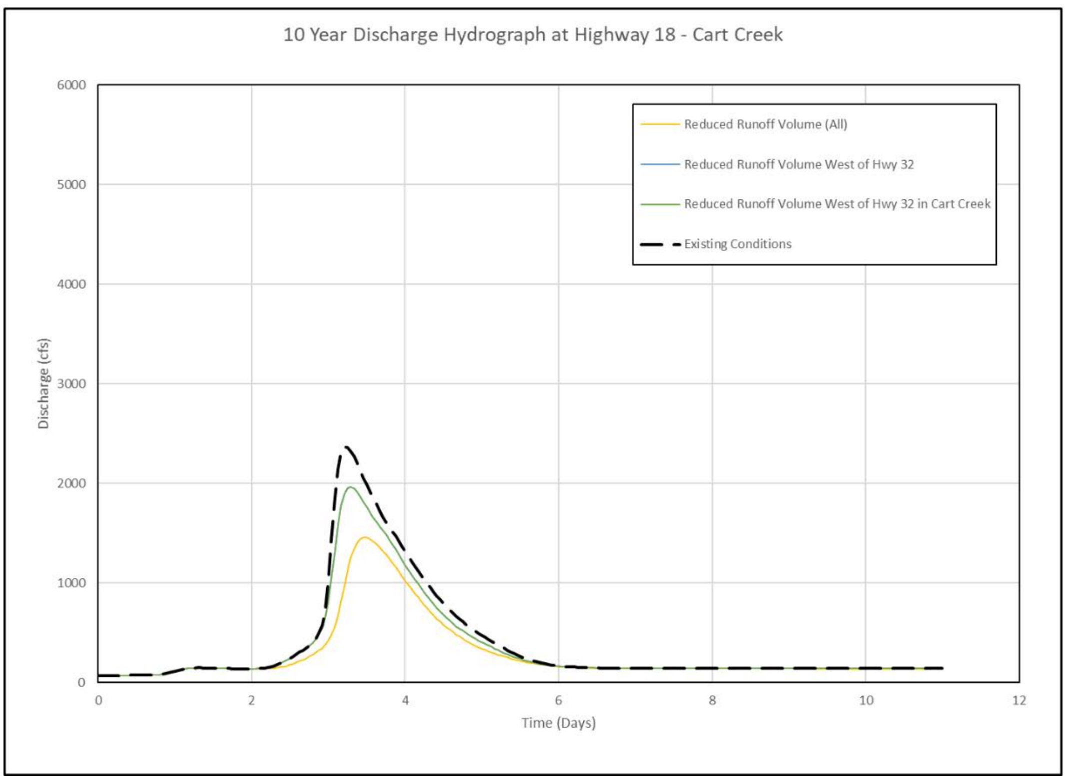
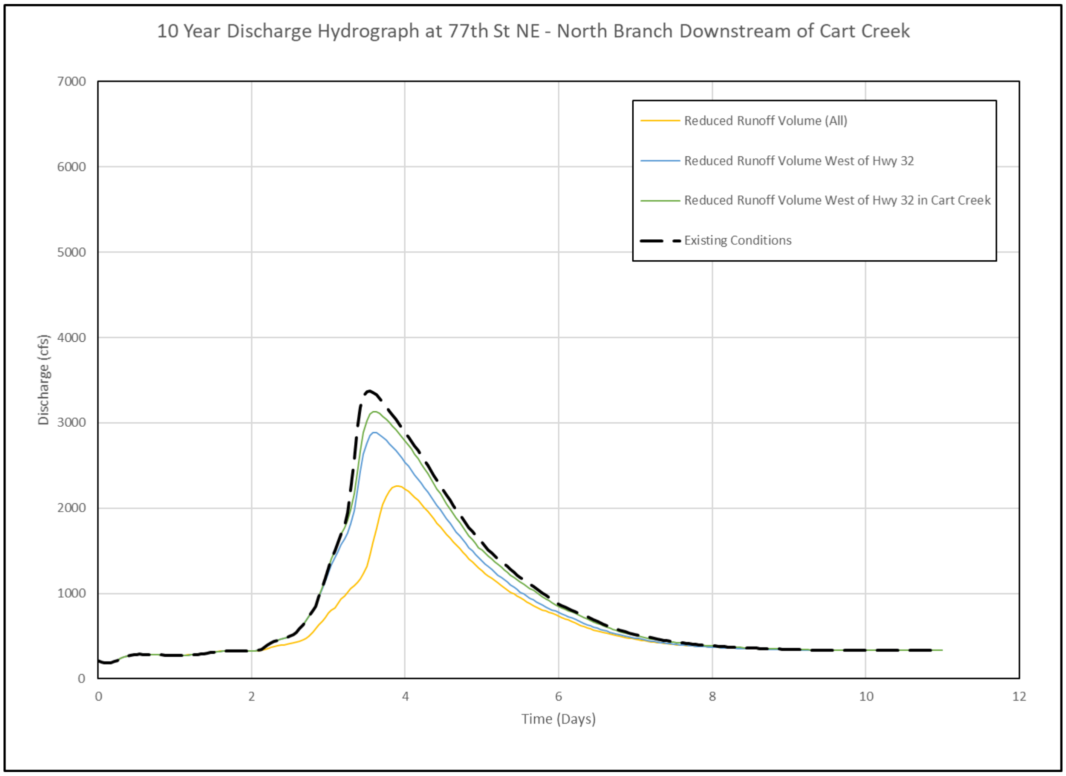
D-2-A.2 REDUCE RUNOFF VOLUME - HYDROGRAPHS

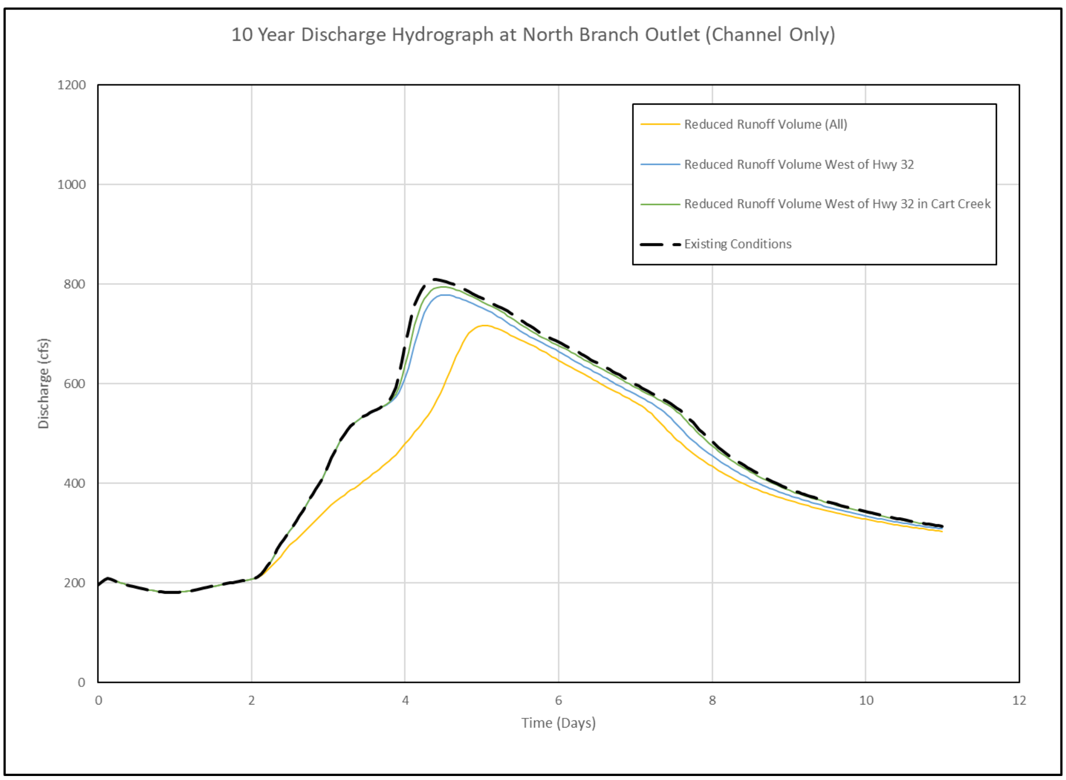


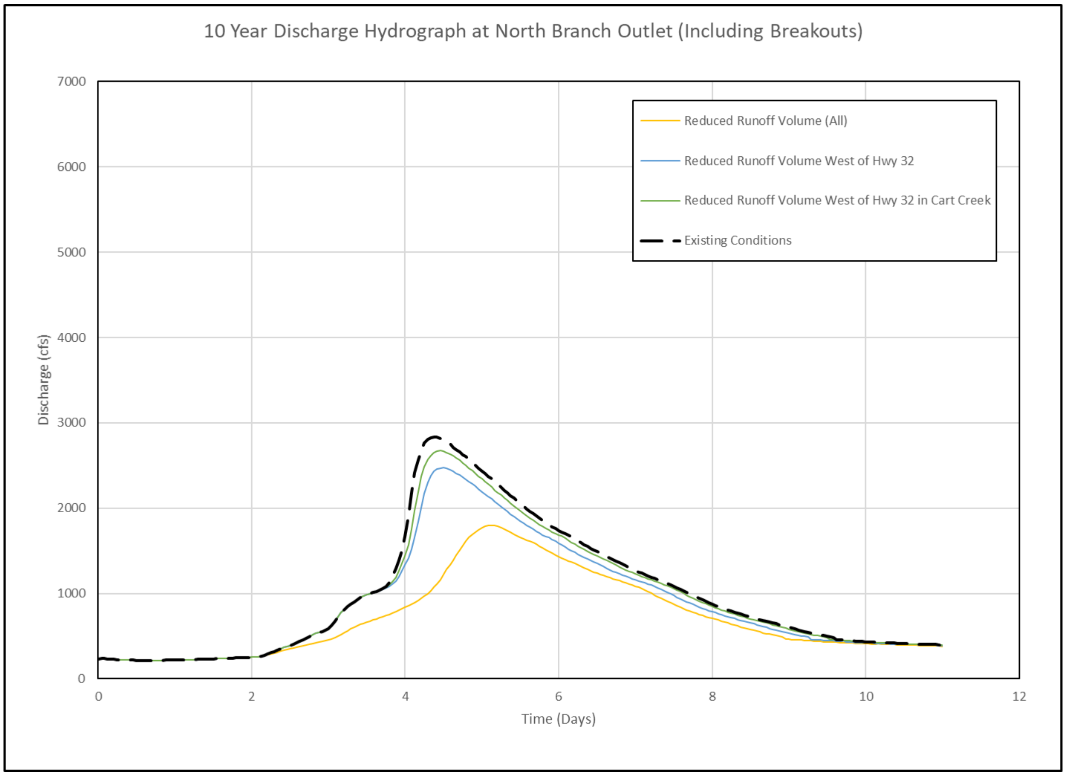



10 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Reduced Runoff Volume (All)
Reduced Runoff Volume West of Hwy 32
Reduced Runoff Volume West of Hwy 32 in Cart Creek
Existing Conditions
Discharge (cfs)
Time (Days)

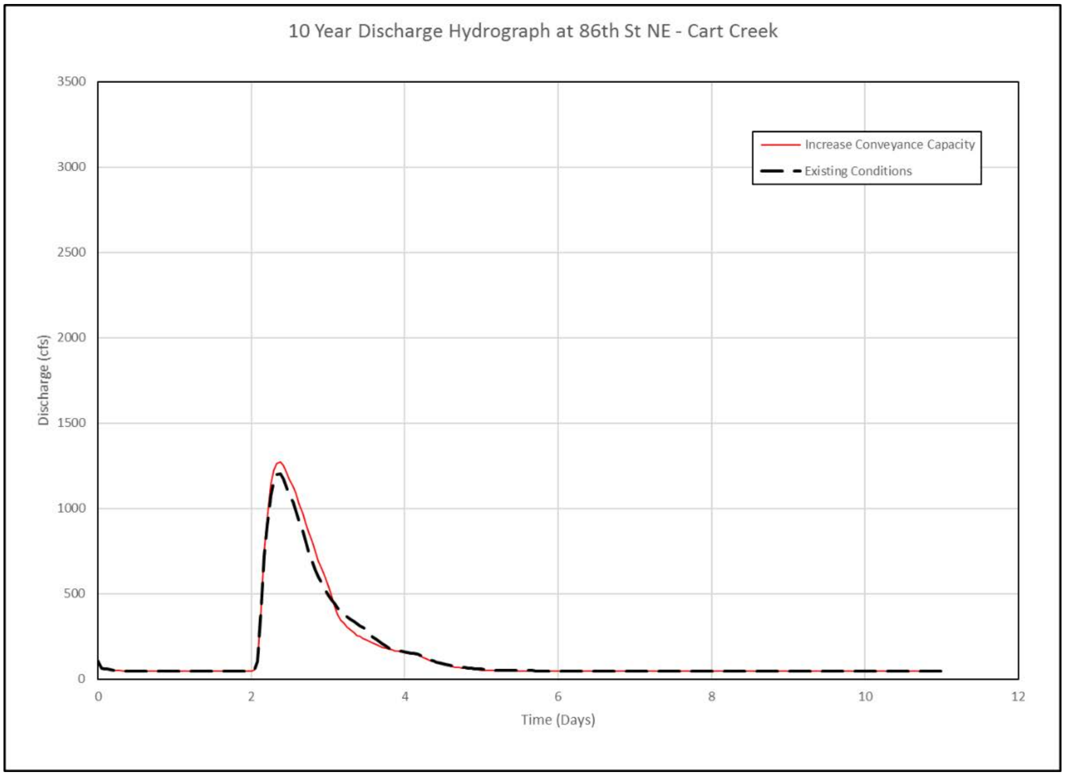

10 Year Discharge Hydrograph at Highway 18 - Cart Creek
Reduced Runoff Volume (All)
Reduced Runoff Volume West of Hwy 32
Reduced Runoff Volume West of Hwy 32 in Cart Creek
Existing Conditions
Discharge (cfs)
Time (Days)

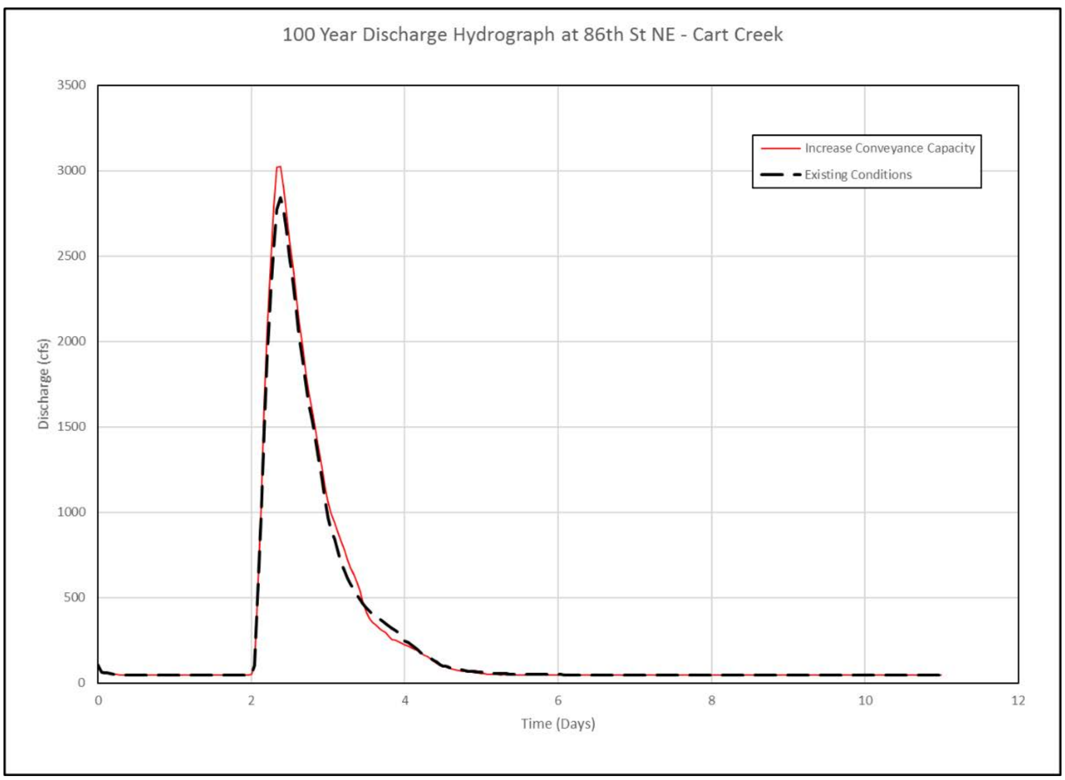

10 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Reduced Runoff Volume (All)
Reduced Runoff Volume West of Hwy 32
Reduced Runoff Volume West of Hwy 32 in Cart Creek
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

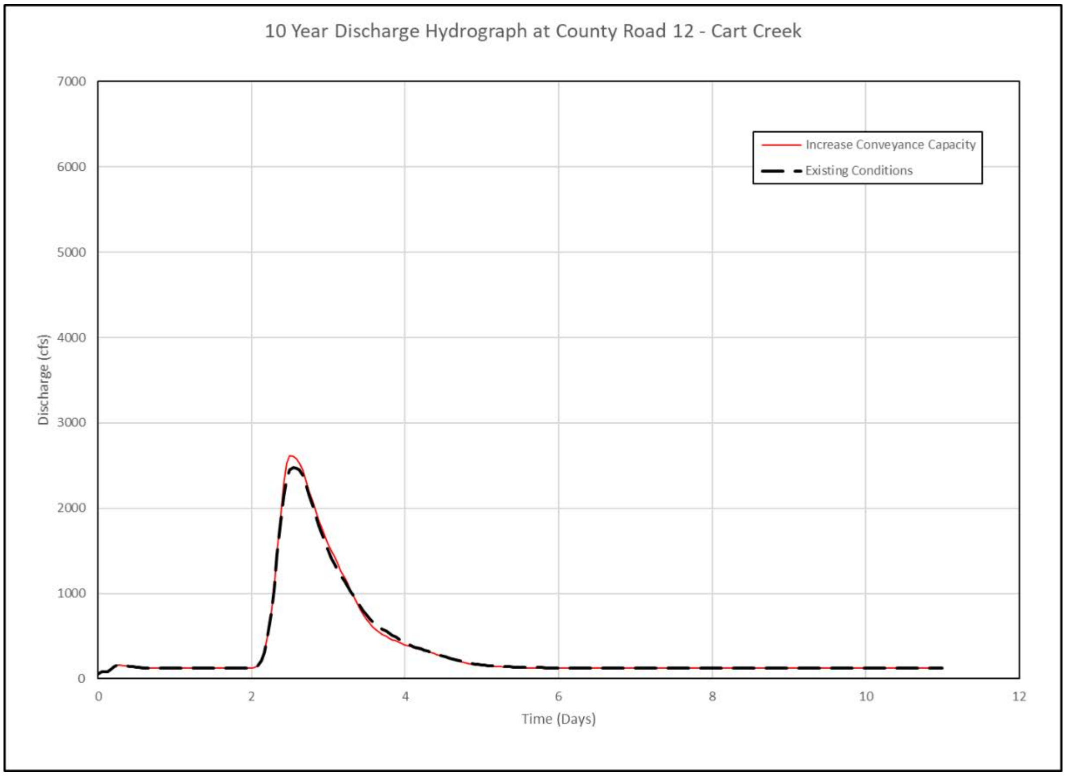

10 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Reduced Runoff Volume (All)
Reduced Runoff Volume West of Hwy 32
Reduced Runoff Volume West of Hwy 32 in Cart Creek
Existing Conditions
Discharge (cfs)
Time (Days)
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12

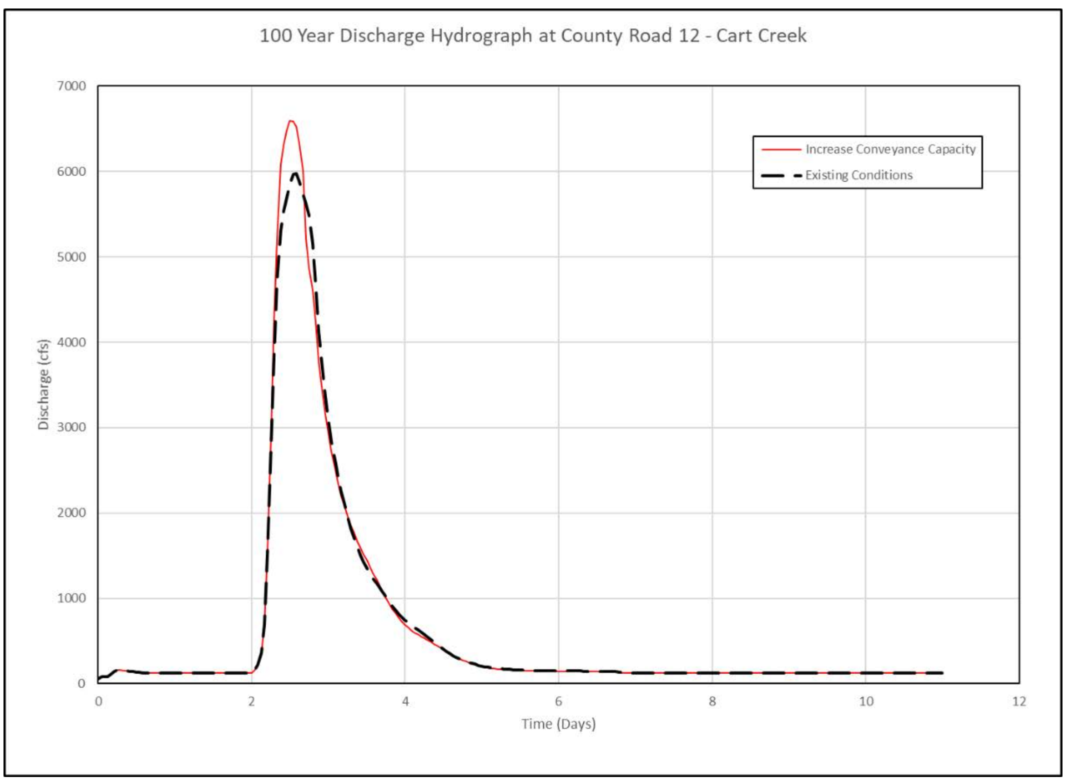

10 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
Time (Days)
Reduced Runoff Volume (All)
Reduced Runoff Volume West of Hwy 32
Reduced Runoff Volume West of Hwy 32 in Cart Creek
Existing Conditions

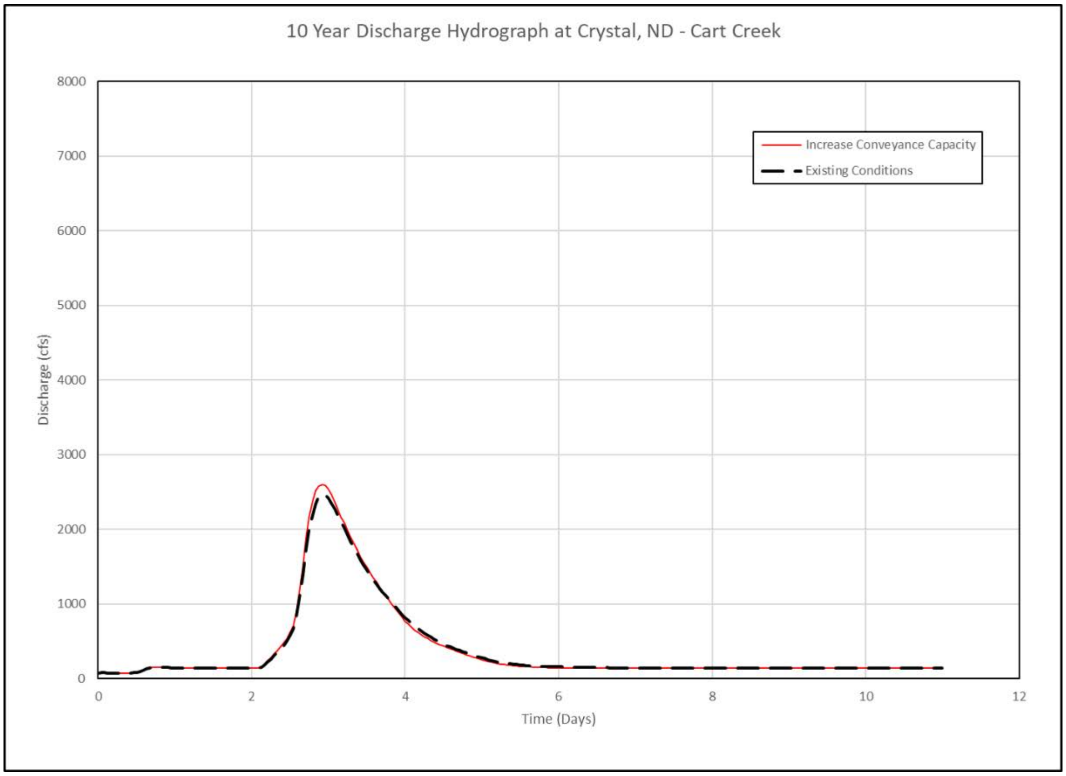
D-2-A.3 INCREASE CONVEYANCE CAPACITY - HYDROGRAPHS

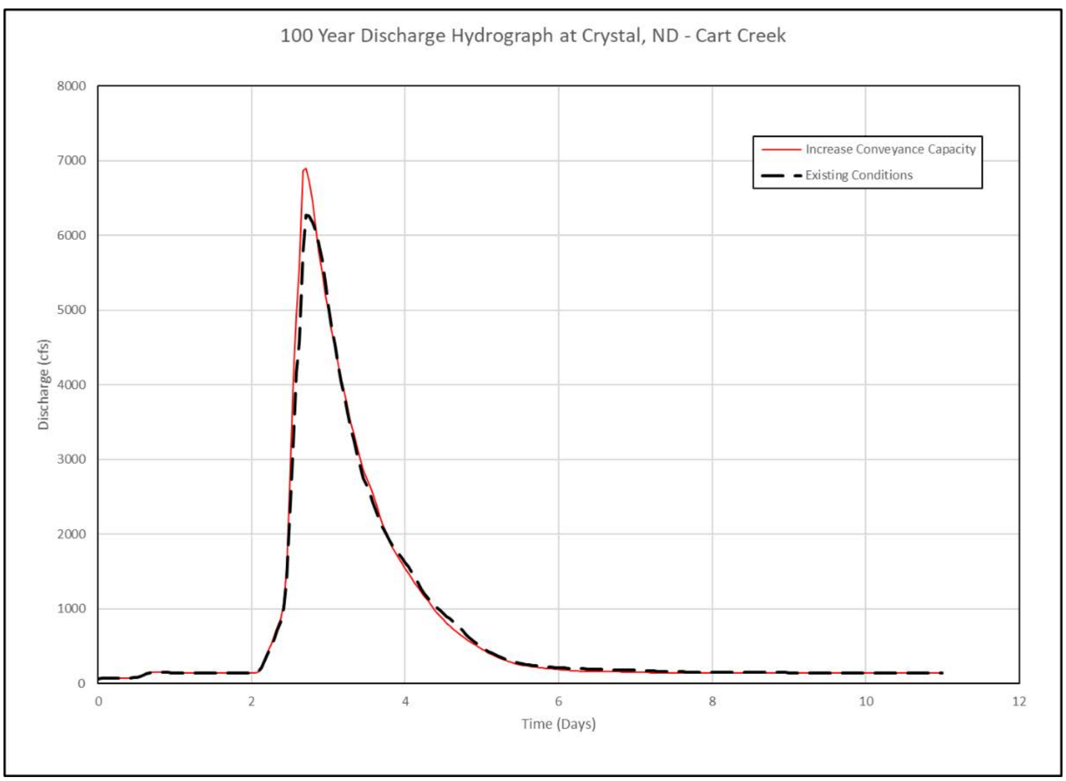


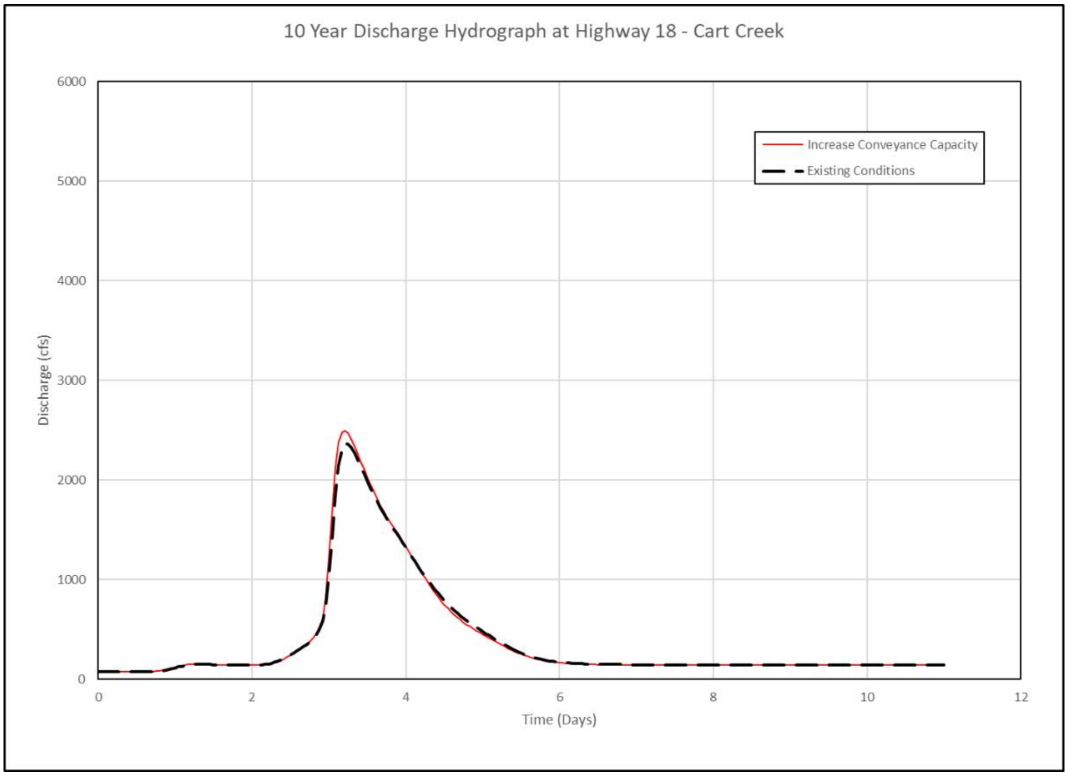


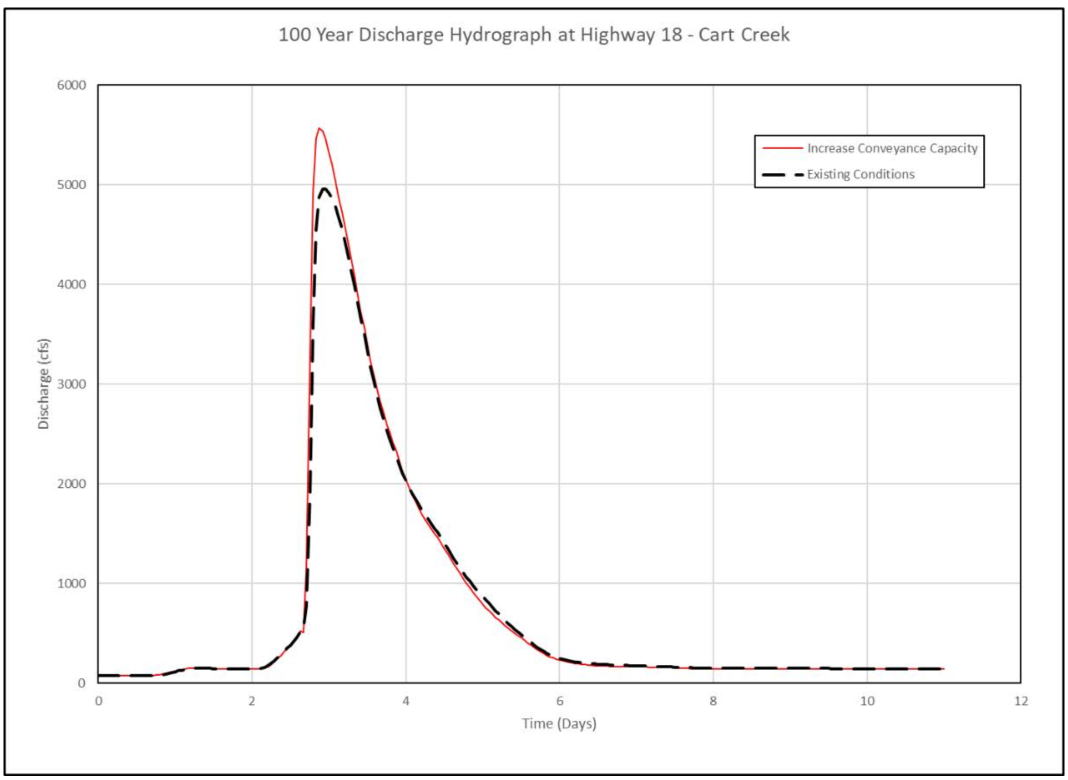

10 Year Discharge Hydrograph at County Road 12 - Cart Creek
Increase Conveyance Capacity
Existing Conditions
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
Time (Days)

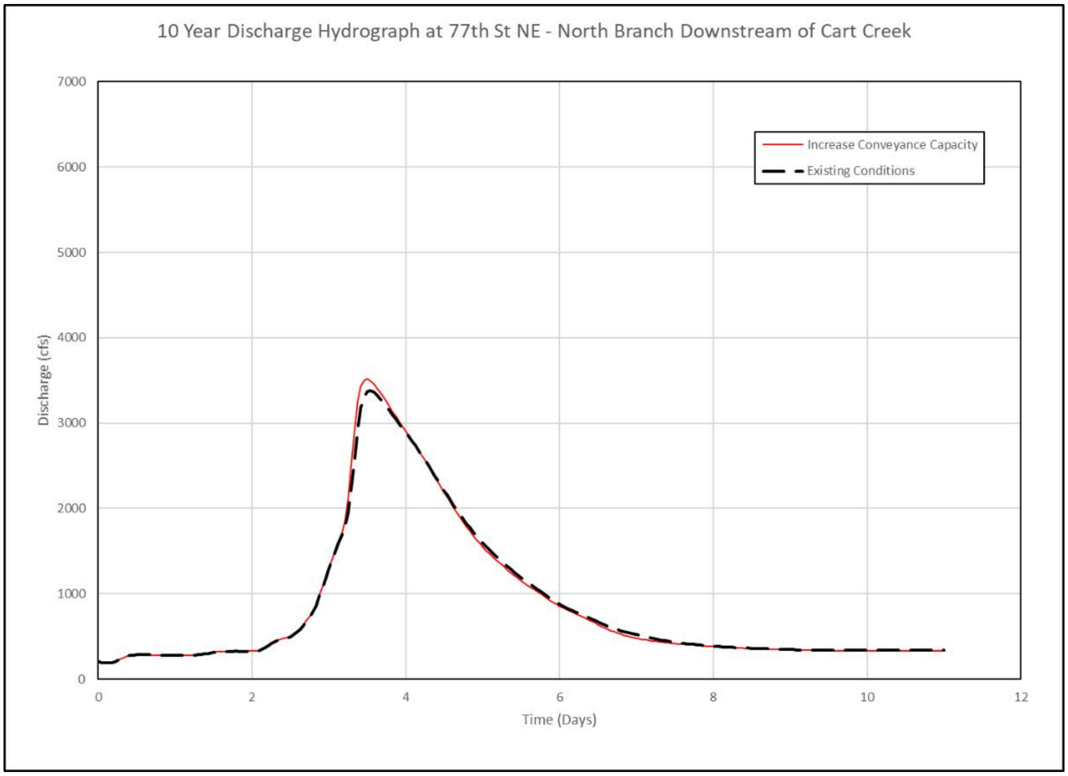

100 Year Discharge Hydrograph at County Road 12 - Cart Creek
Increase Conveyance Capacity
Existing Conditions
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
Time (Days)

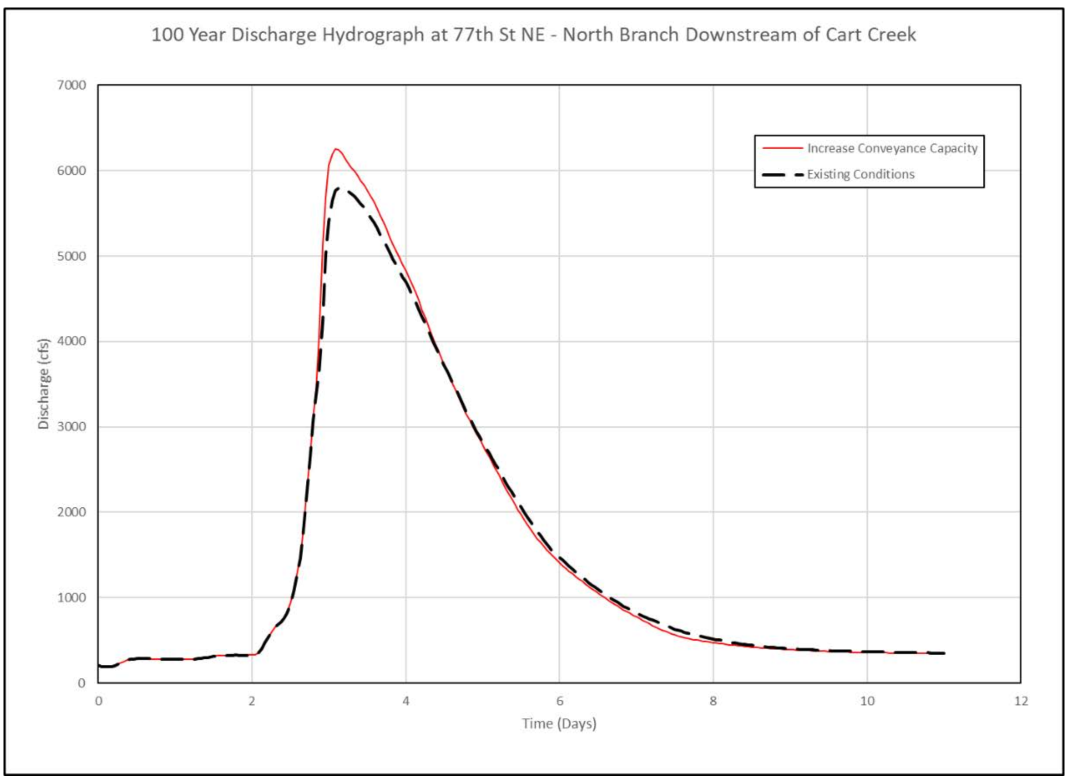

10 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Increase Conveyance Capacity
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
8000
0
2
4
6
8
10
12

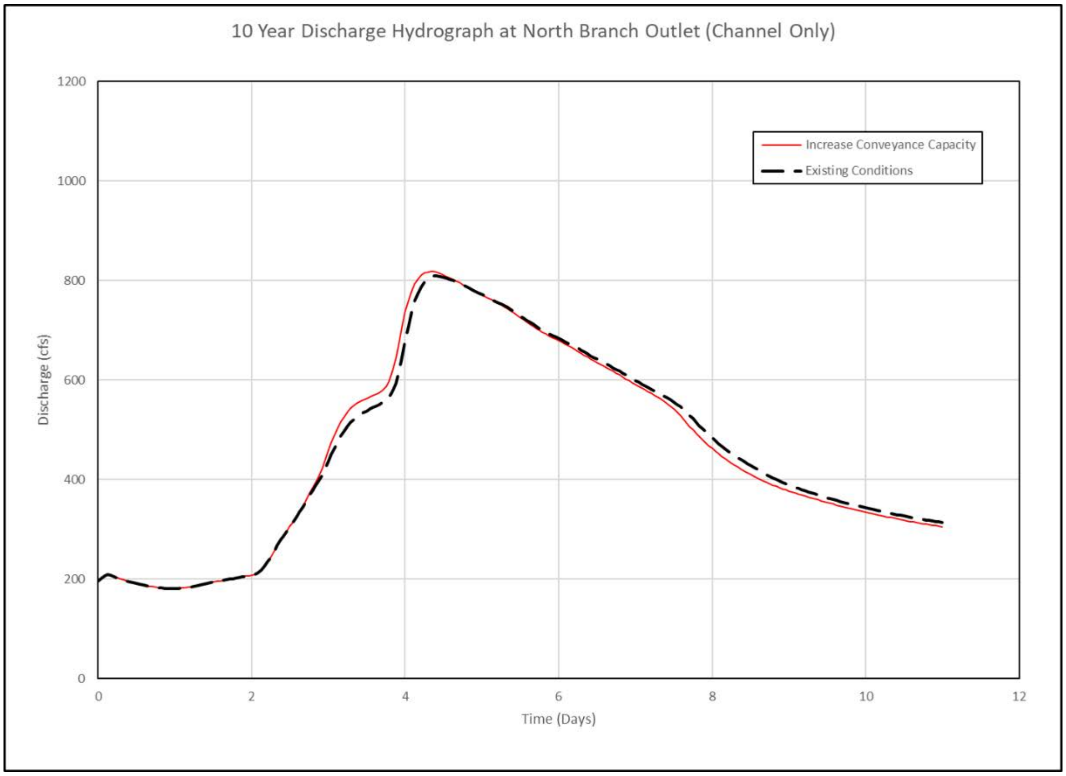

100 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Increase Conveyance Capacity
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
8000
0
2
4
6
8
10
12

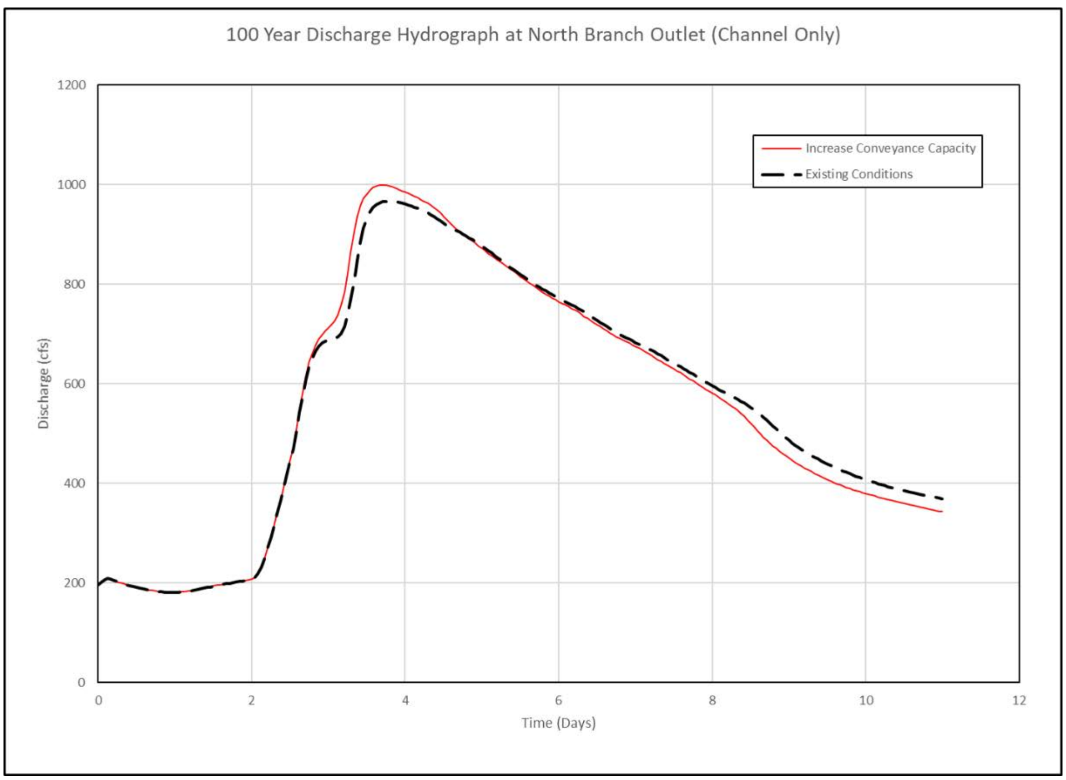

10 Year Discharge Hydrograph at Highway 18 - Cart Creek
Increase Conveyance Capacity
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
0
2
4
6
8
10
12

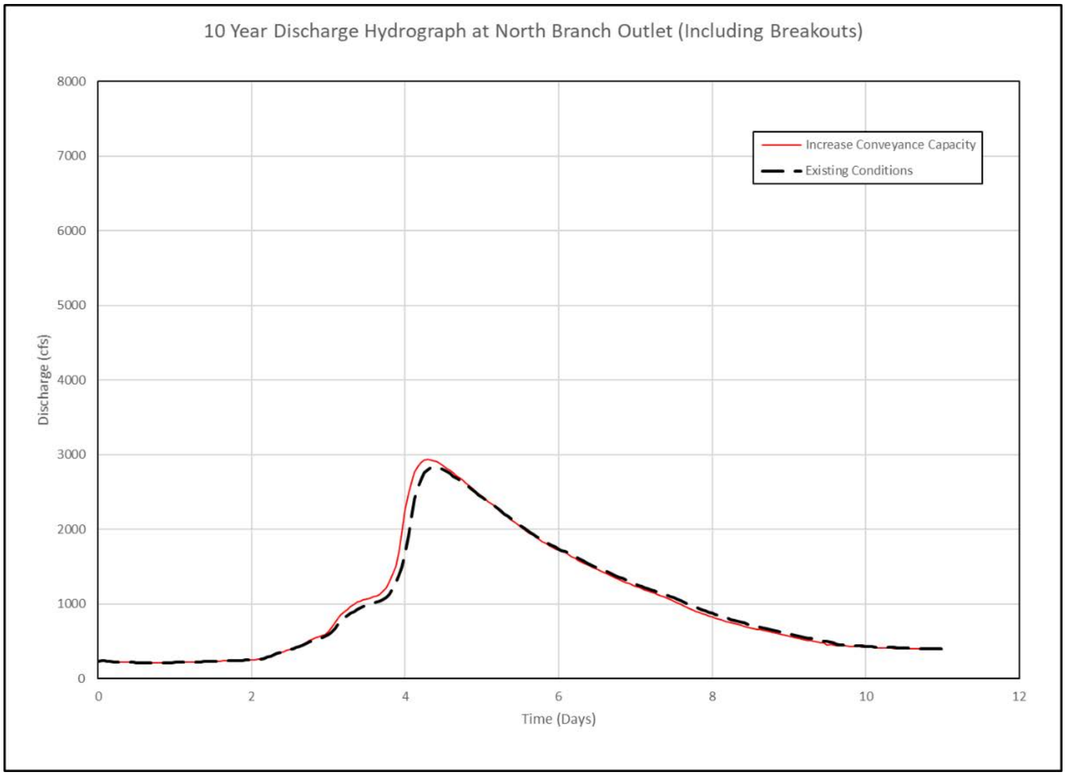

100 Year Discharge Hydrograph at Highway 18 - Cart Creek
Increase Conveyance Capacity
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
0
2
4
6
8
10
12

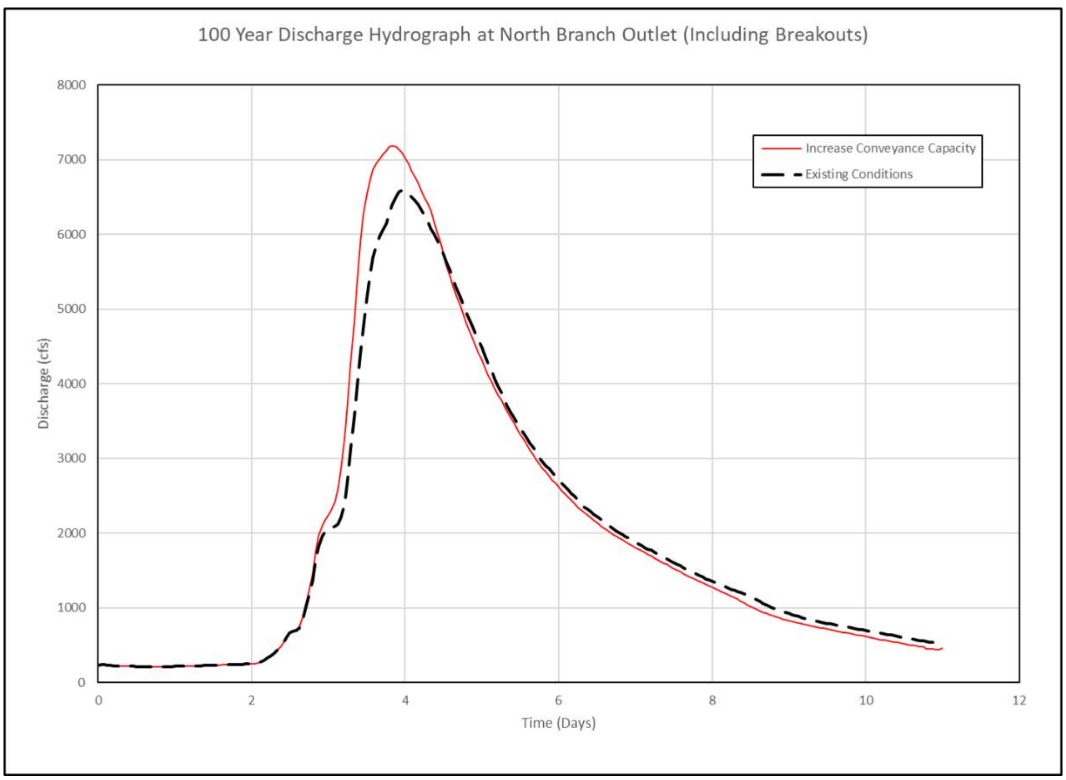

10 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Increase Conveyance Capacity
Existing Conditions
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
Time (Days)


100 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Increase Conveyance Capacity
Existing Conditions
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
Time (Days)

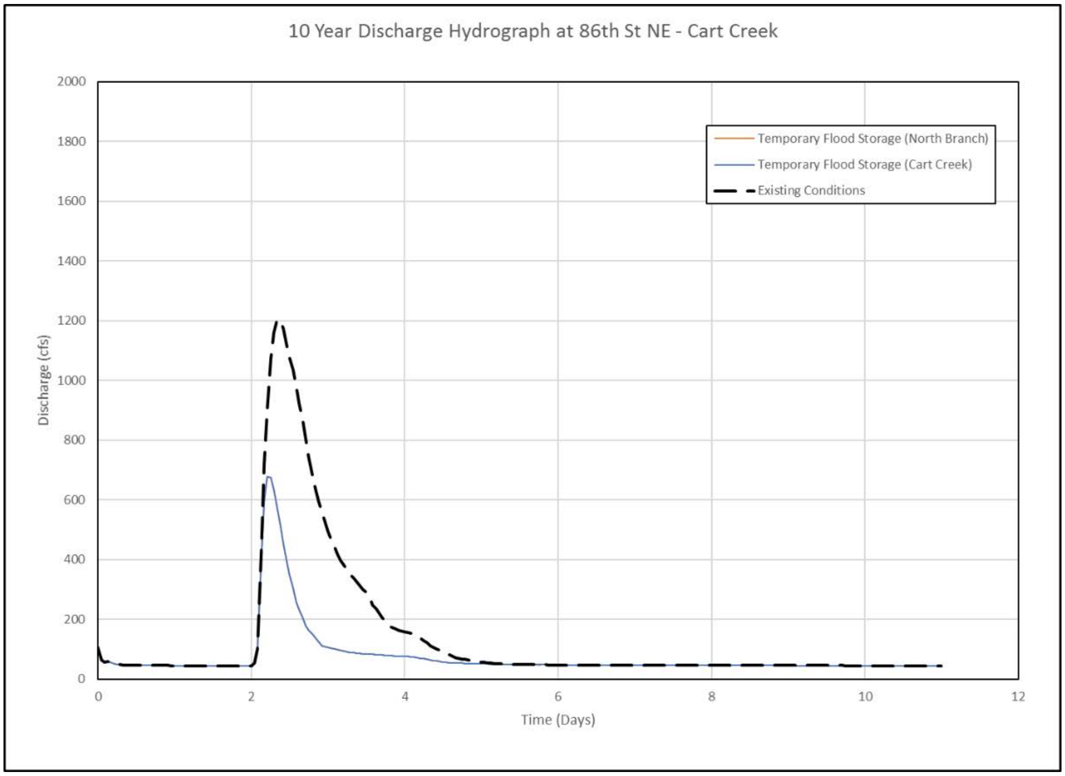

10 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Increase Conveyance Capacity
Existing Conditions
Discharge (cfs)
Time (Days)
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12

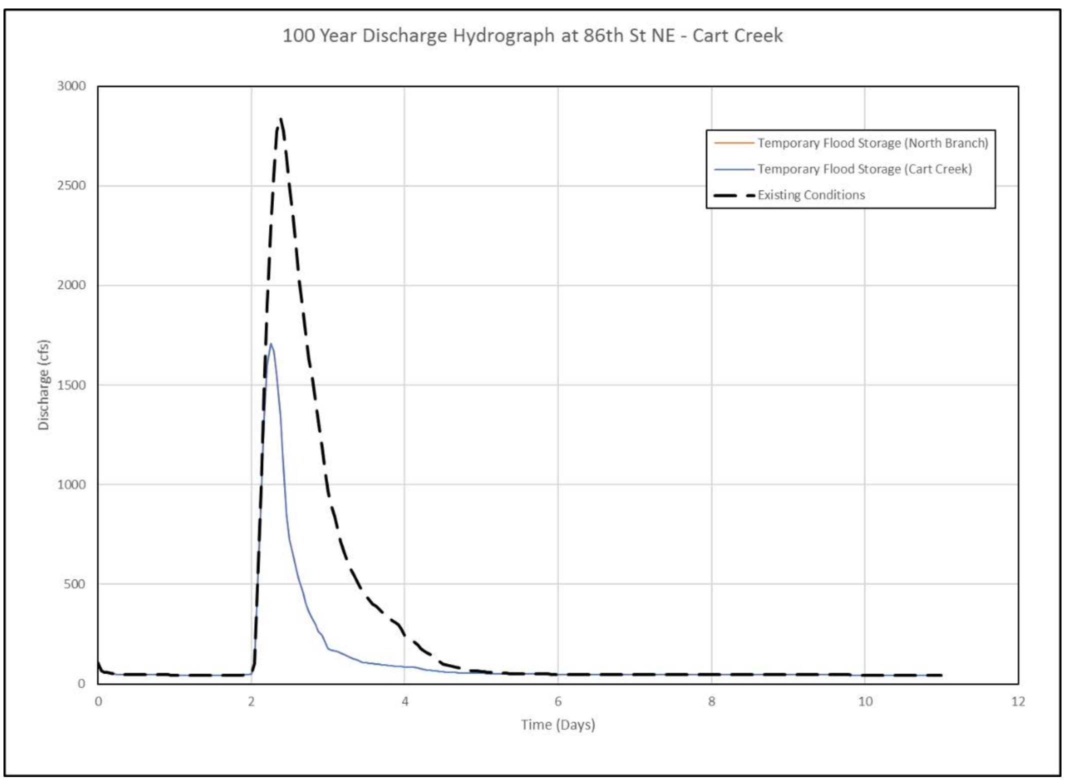

100 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Increase Conveyance Capacity
Existing Conditions
Discharge (cfs)
Time (Days)
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12

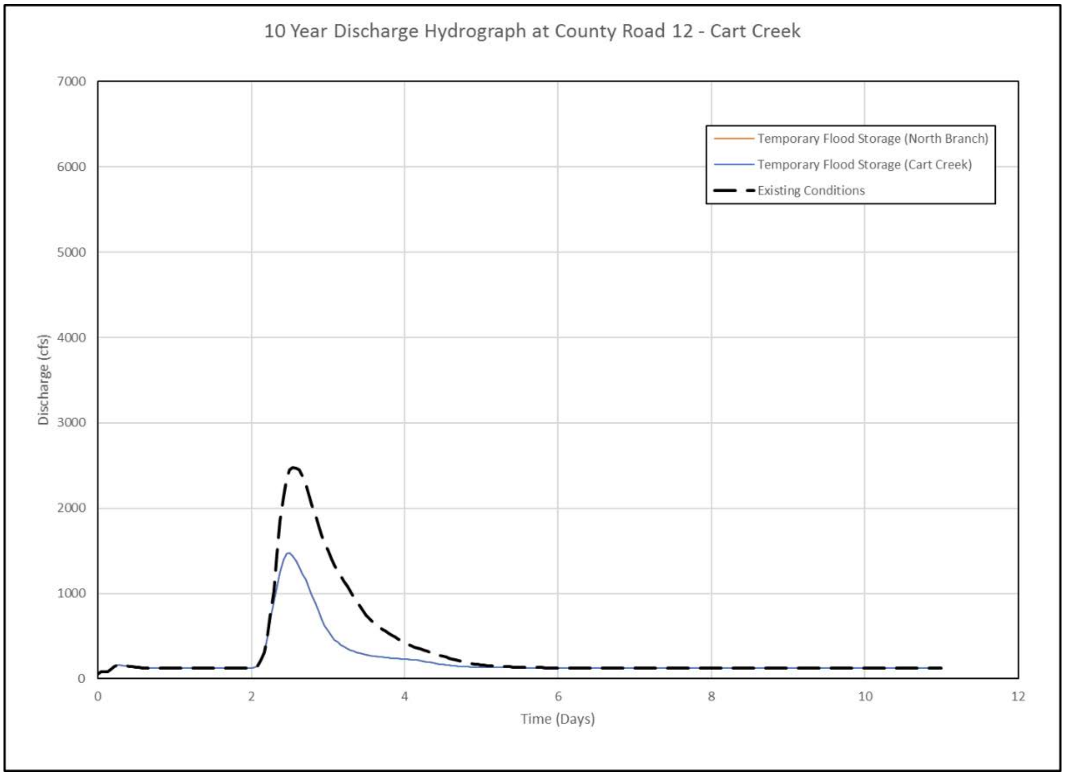

10 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Discharge (cfs)
Time (Days)
Increase Conveyance Capacity
Existing Conditions
0
1000
2000
3000
4000
5000
6000
7000
8000
0
2
4
6
8
10
12

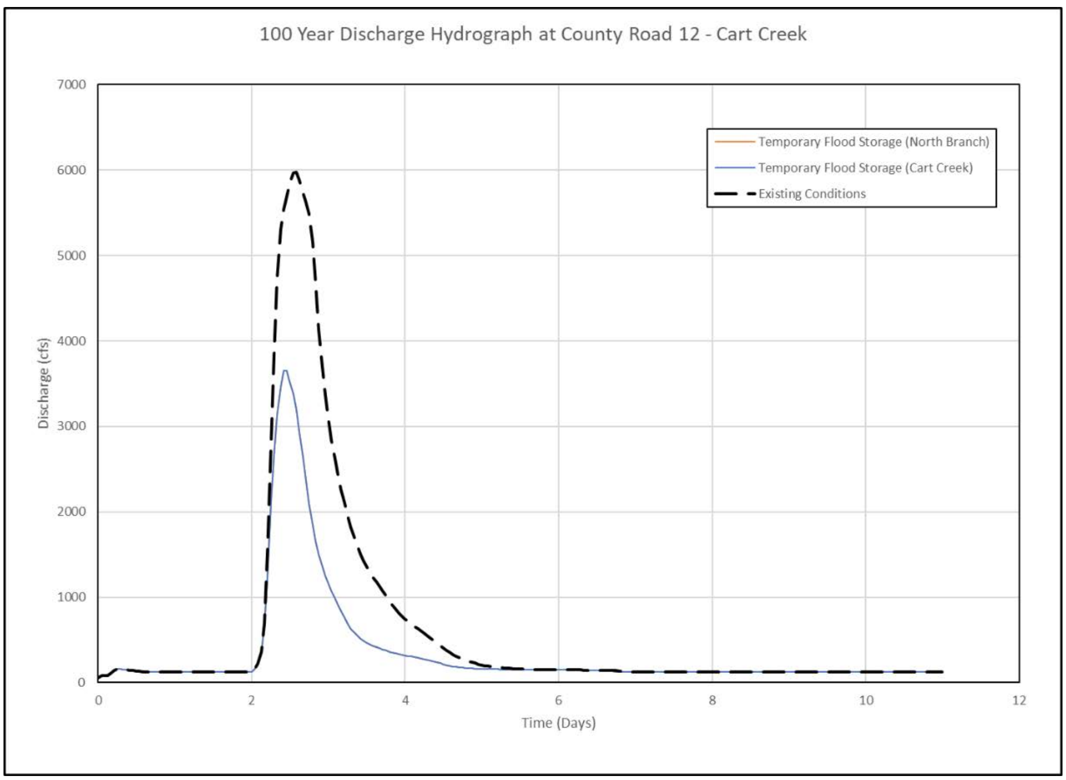

100 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Discharge (cfs)
Time (Days)
Increase Conveyance Capacity
Existing Conditions
0
1000
2000
3000
4000
5000
6000
7000
8000
0
2
4
6
8
10
12

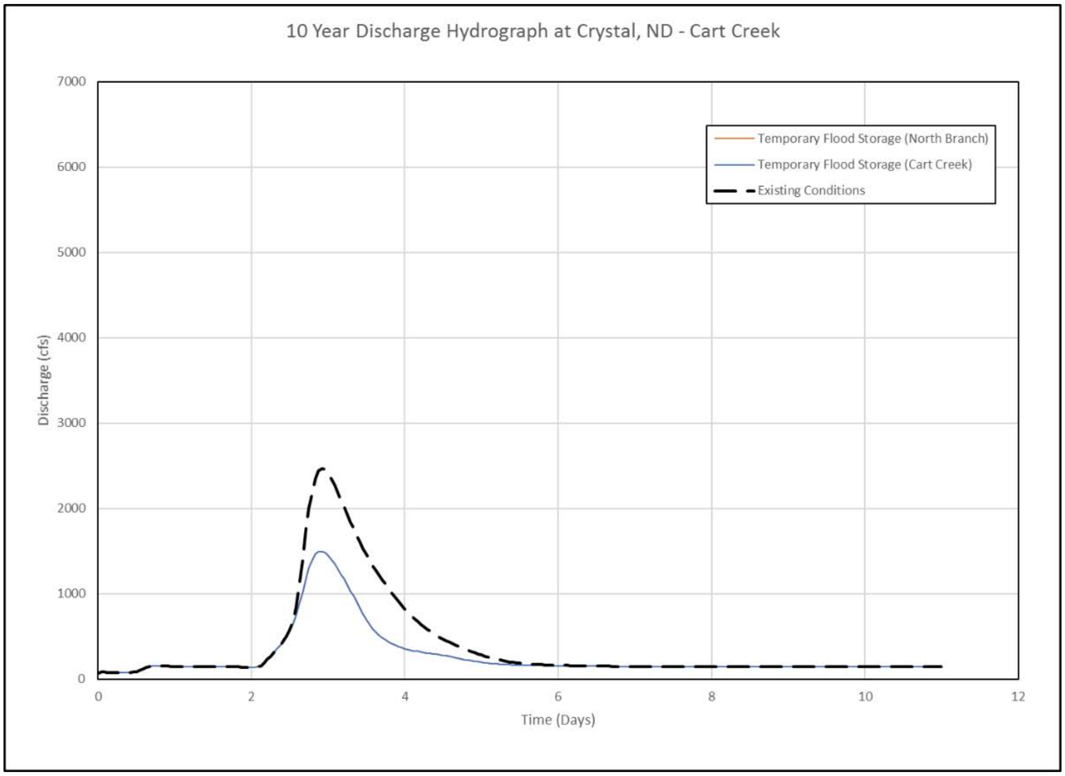
D-2-A.4 INCREASE TEMPORARY FLOOD STORAGE – HYDROGRAPHS



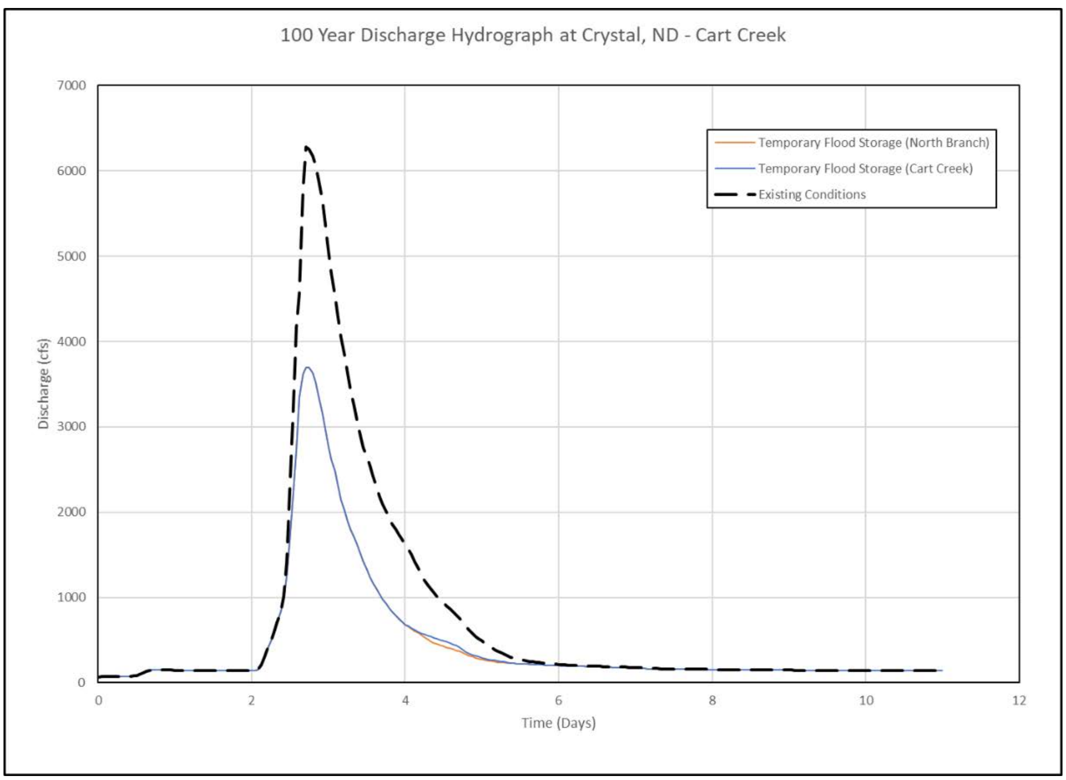



10 Year Discharge Hydrograph at County Road 12 - Cart Creek
Temporary Flood Storage (North Branch)
Temporary Flood Storage (Cart Creek)
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

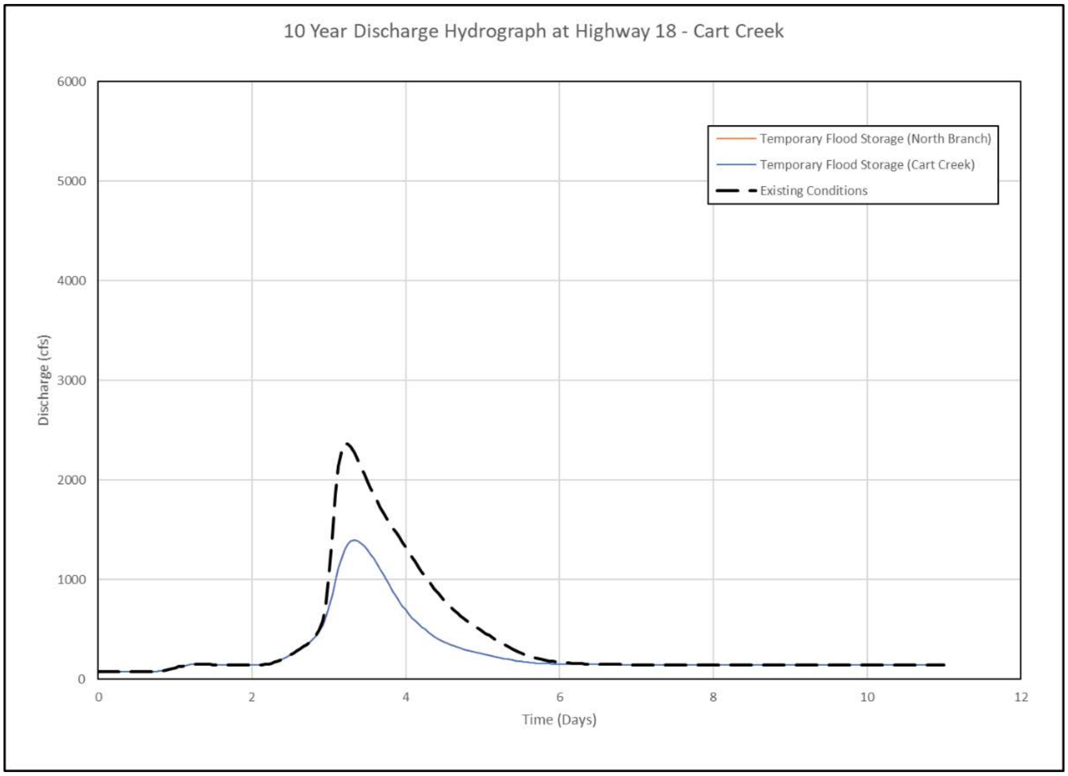

100 Year Discharge Hydrograph at County Road 12 - Cart Creek
Temporary Flood Storage (North Branch)
Temporary Flood Storage (Cart Creek)
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

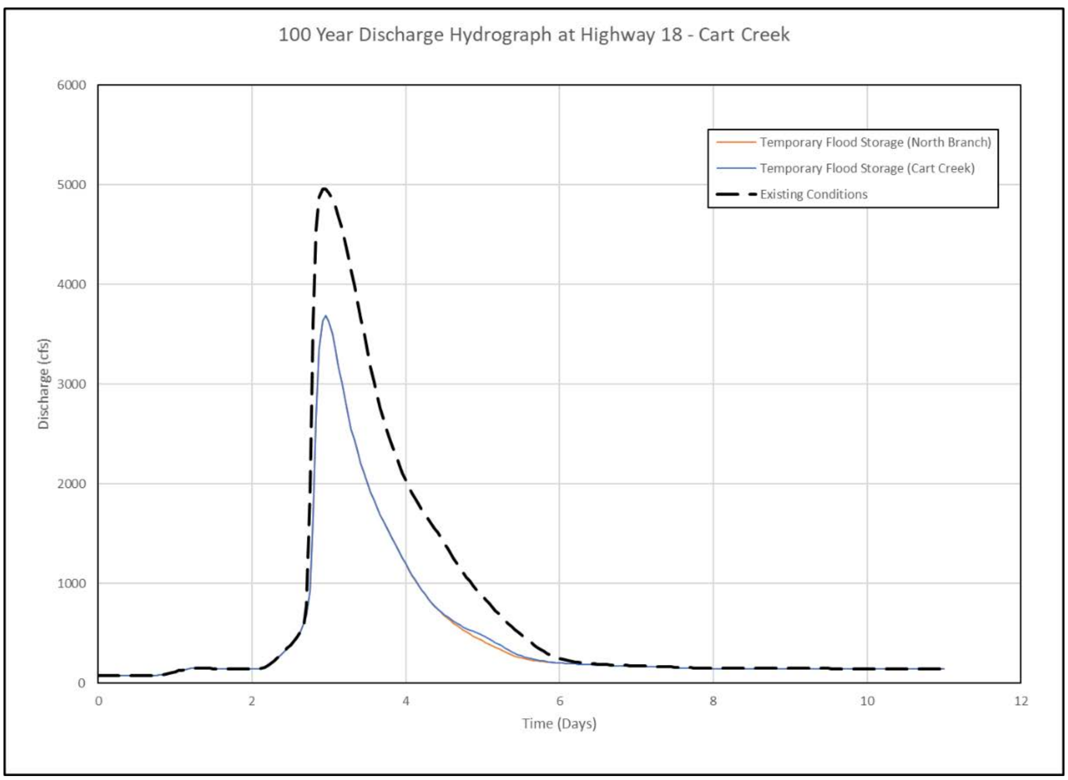


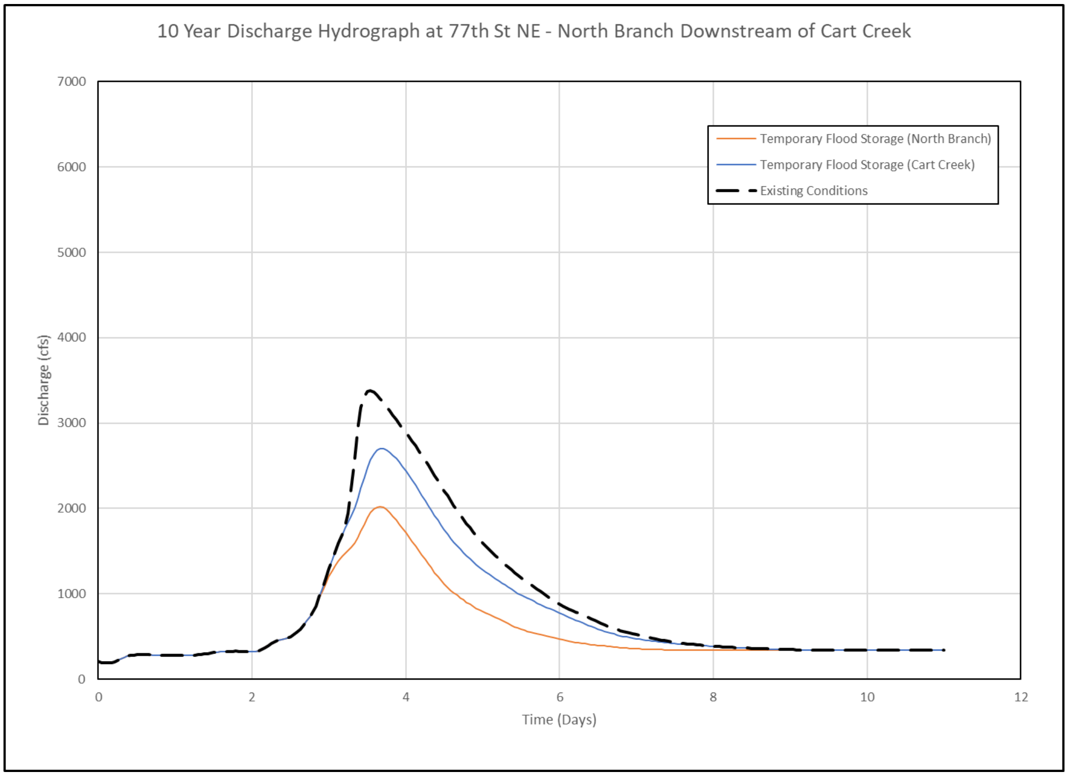
10 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Temporary Flood Storage (North Branch)
Temporary Flood Storage (Cart Creek)
Existing Conditions
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
Time (Days)



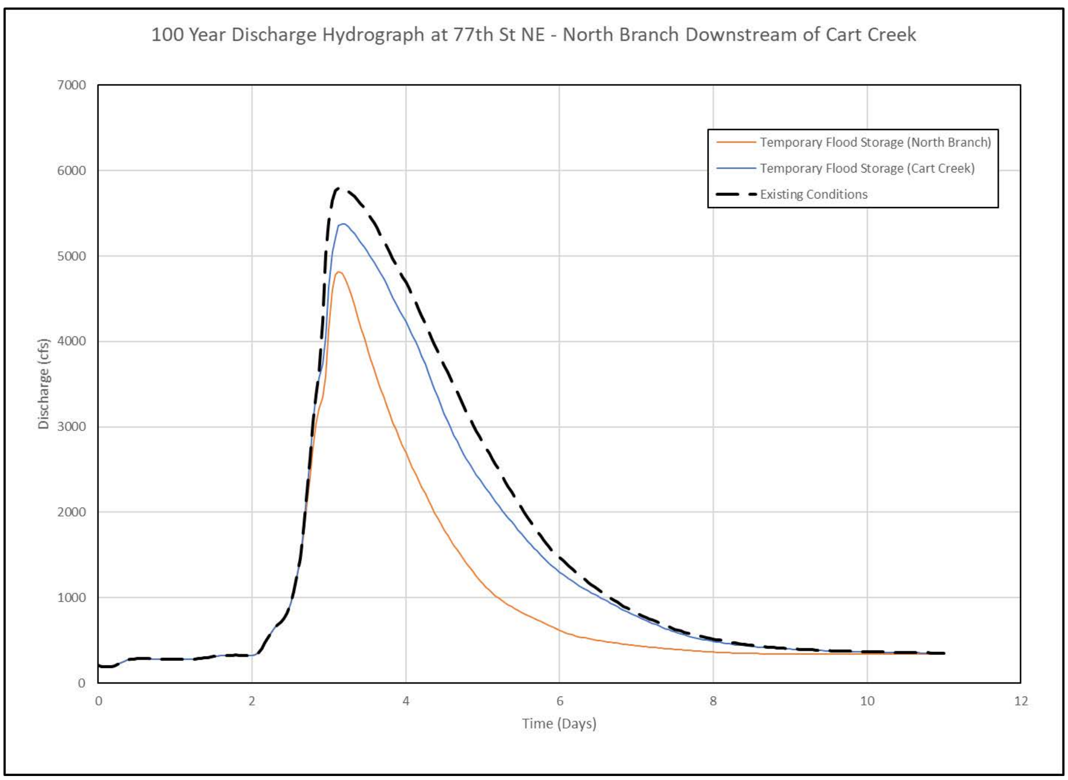
100 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Temporary Flood Storage (North Branch)
Temporary Flood Storage (Cart Creek)
Existing Conditions
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
Time (Days)


10 Year Discharge Hydrograph at Highway 18 - Cart Creek
Temporary Flood Storage (North Branch)
Temporary Flood Storage (Cart Creek)
Existing Conditions
Discharge (cfs)
0
1000
2000
3000
4000
5000
6000
0
2
4
6
8
10
12
Time (Days)

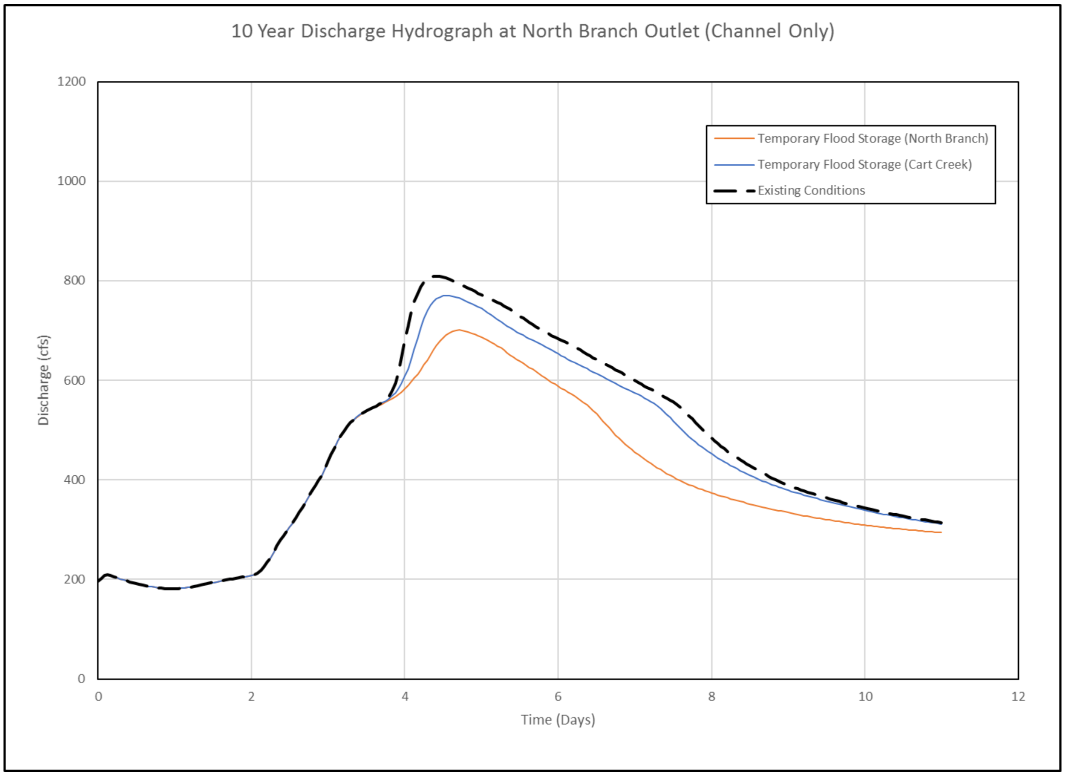

100 Year Discharge Hydrograph at Highway 18 - Cart Creek
Temporary Flood Storage (North Branch)
Temporary Flood Storage (Cart Creek)
Existing Conditions
Discharge (cfs)
0
1000
2000
3000
4000
5000
6000
0
2
4
6
8
10
12
Time (Days)

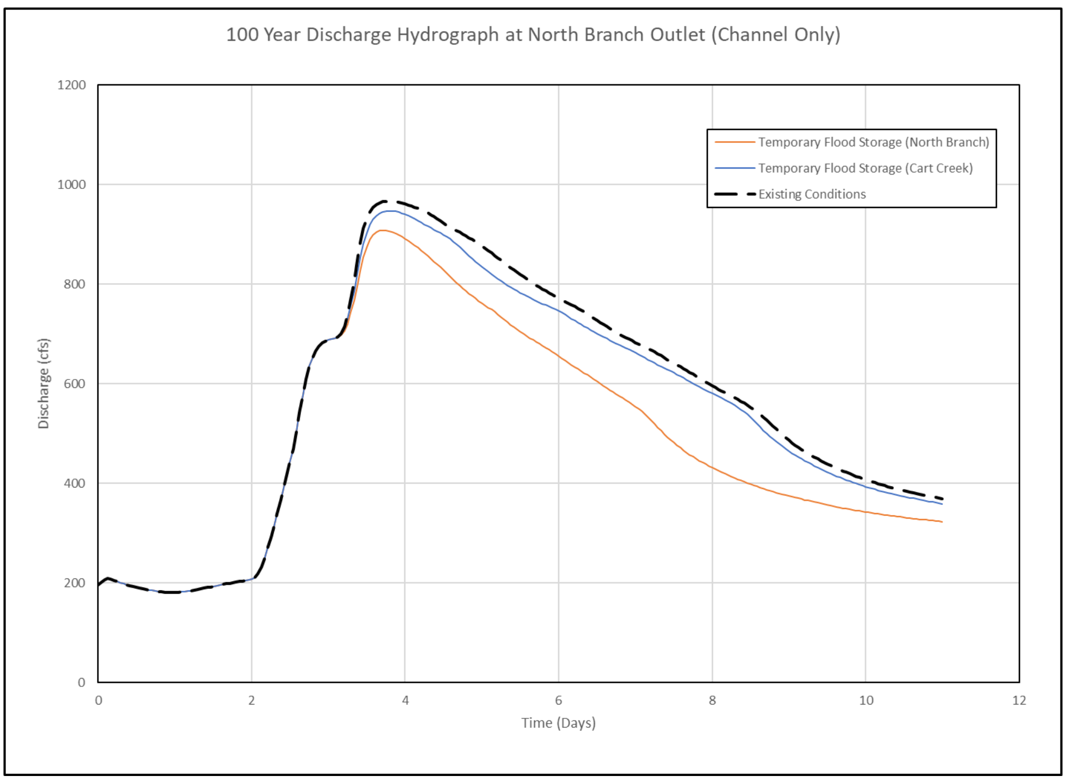


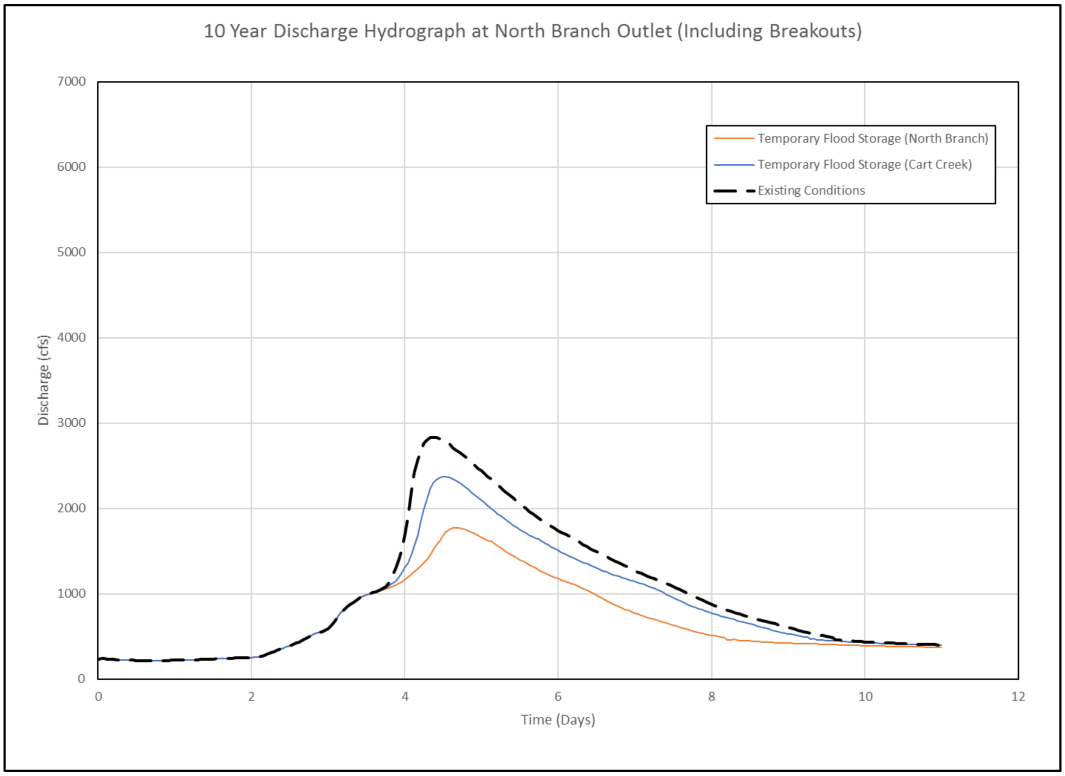
10 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Temporary Flood Storage (North Branch)
Temporary Flood Storage (Cart Creek)
Existing Conditions
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
Time (Days)

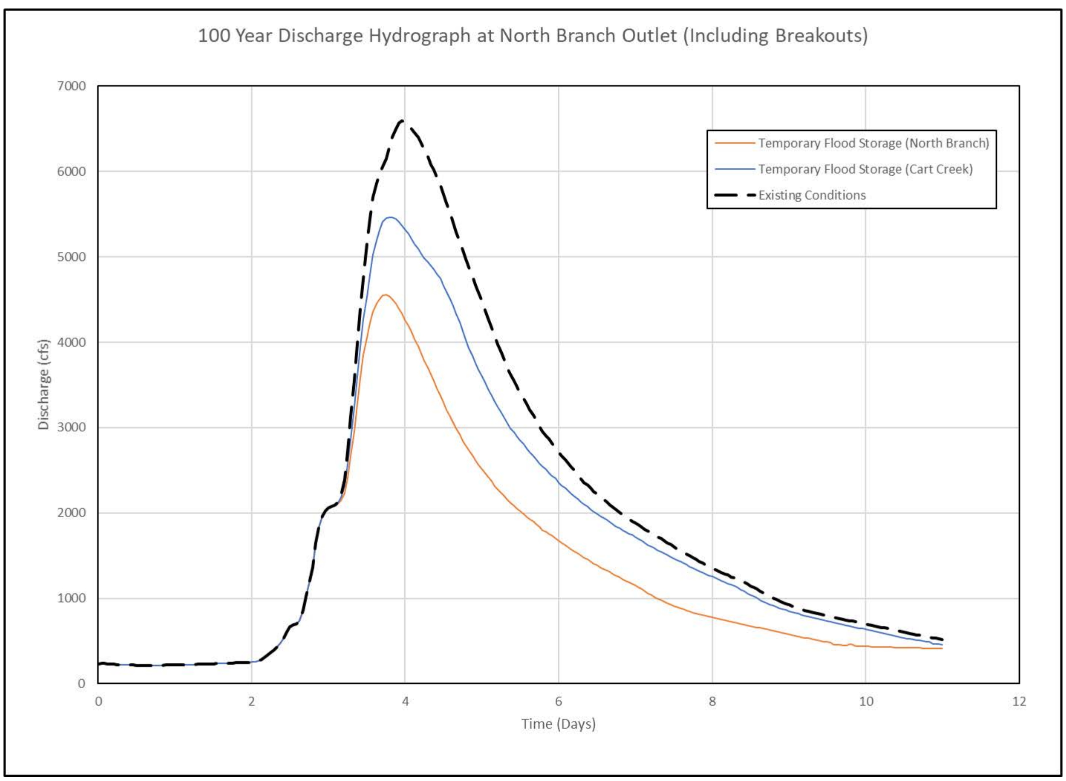


100 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Temporary Flood Storage (North Branch)
Temporary Flood Storage (Cart Creek)
Existing Conditions
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
Time (Days)

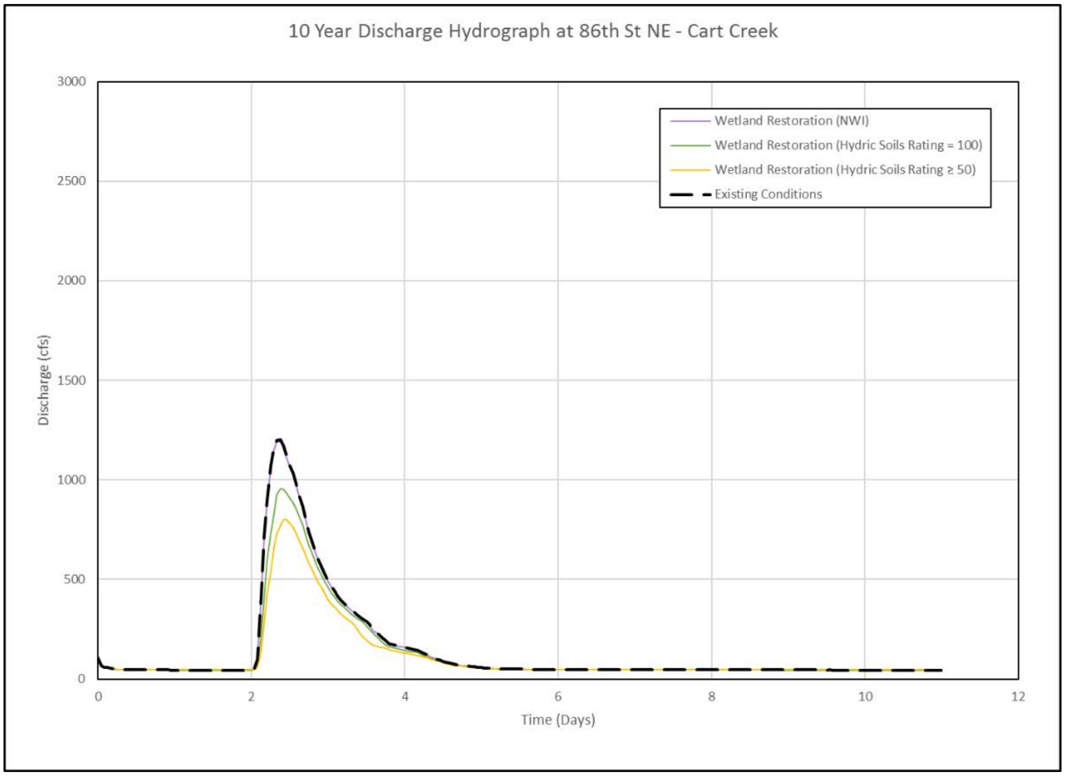

10 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Temporary Flood Storage (North Branch)
Temporary Flood Storage (Cart Creek)
Existing Conditions
Discharge (cfs)
Time (Days)
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12

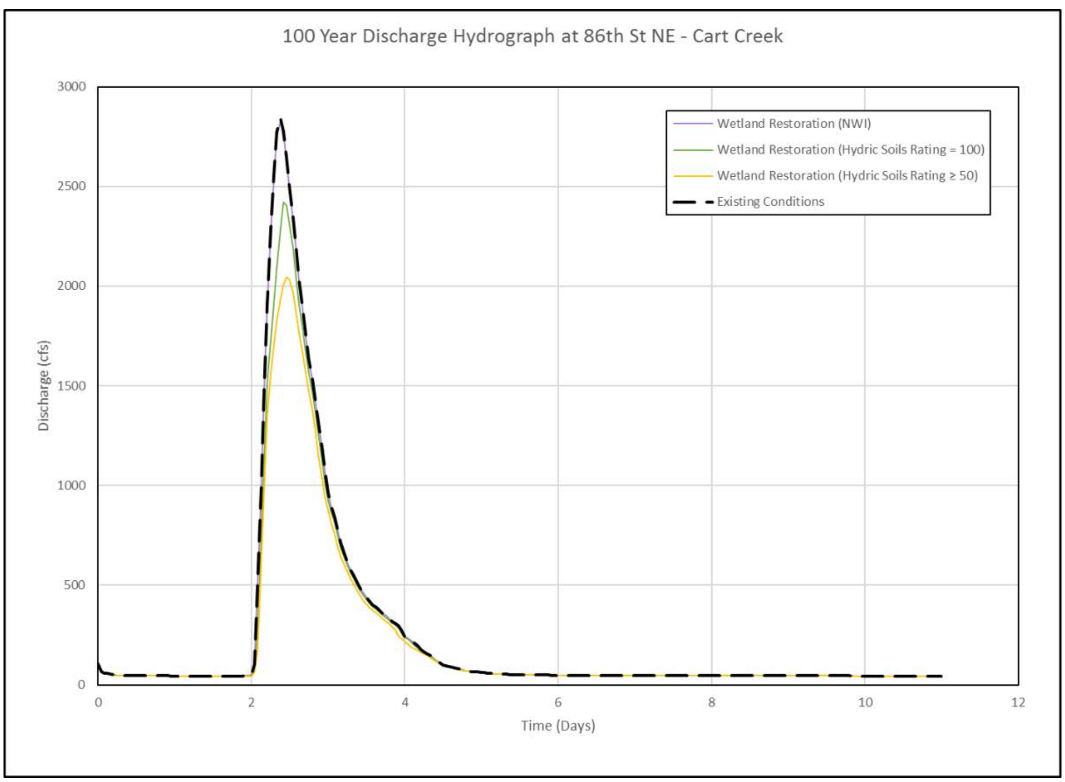

100 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Temporary Flood Storage (North Branch)
Temporary Flood Storage (Cart Creek)
Existing Conditions
Discharge (cfs)
Time (Days)
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12

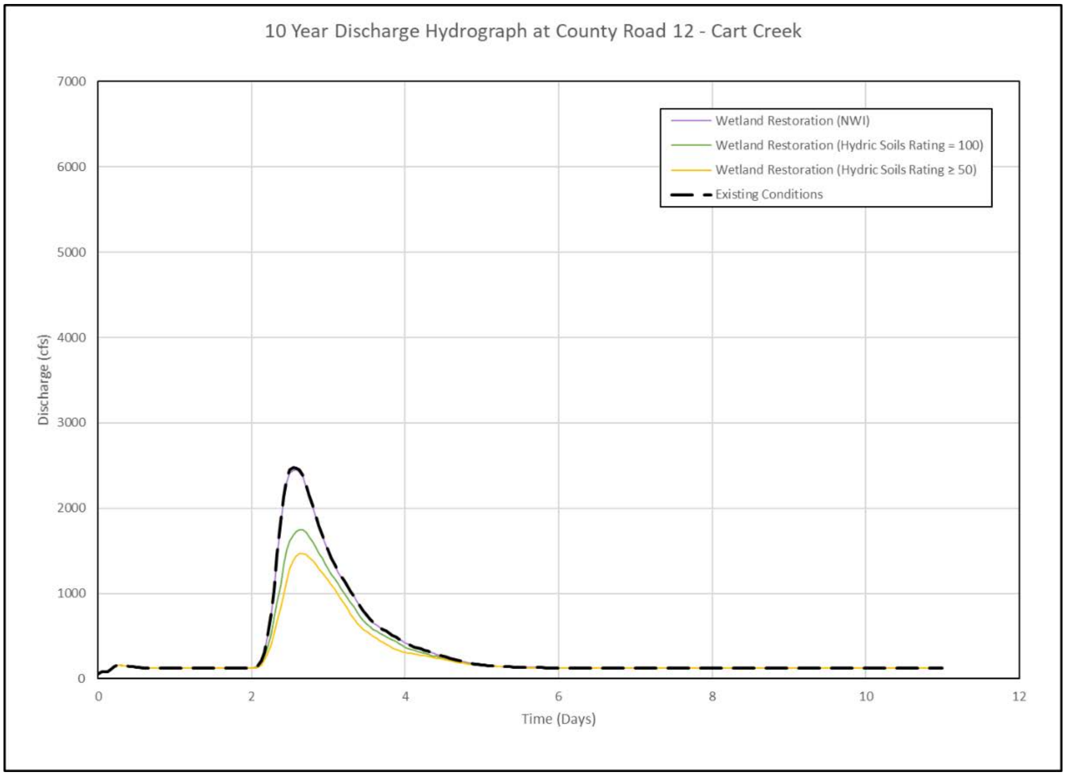

10 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Temporary Flood Storage (North Branch)
Temporary Flood Storage (Cart Creek)
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

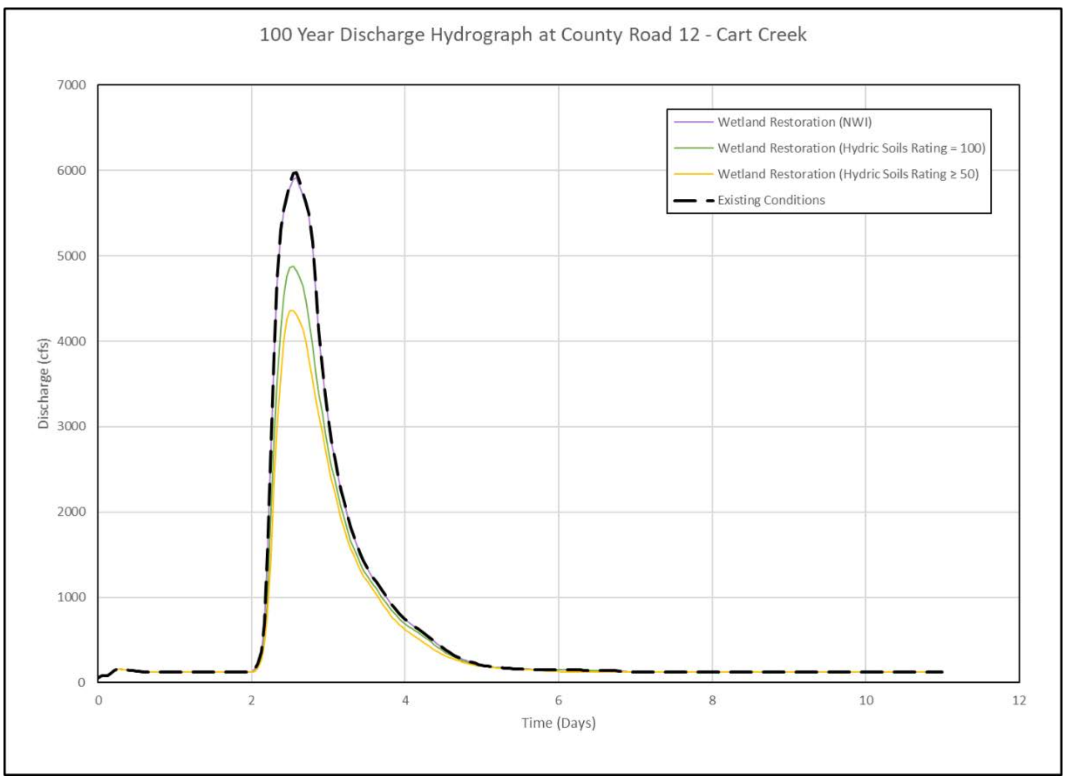

100 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Temporary Flood Storage (North Branch)
Temporary Flood Storage (Cart Creek)
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

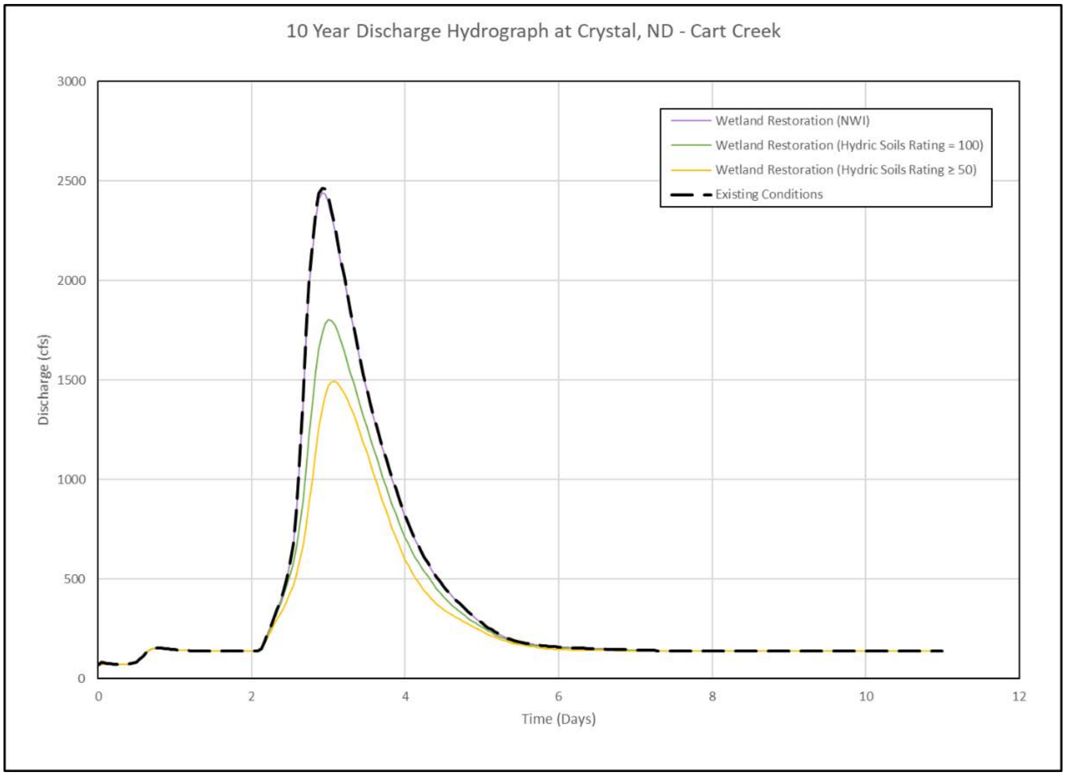
D-2-A.5 WETLAND RESTORATION – HYDROGRAPHS

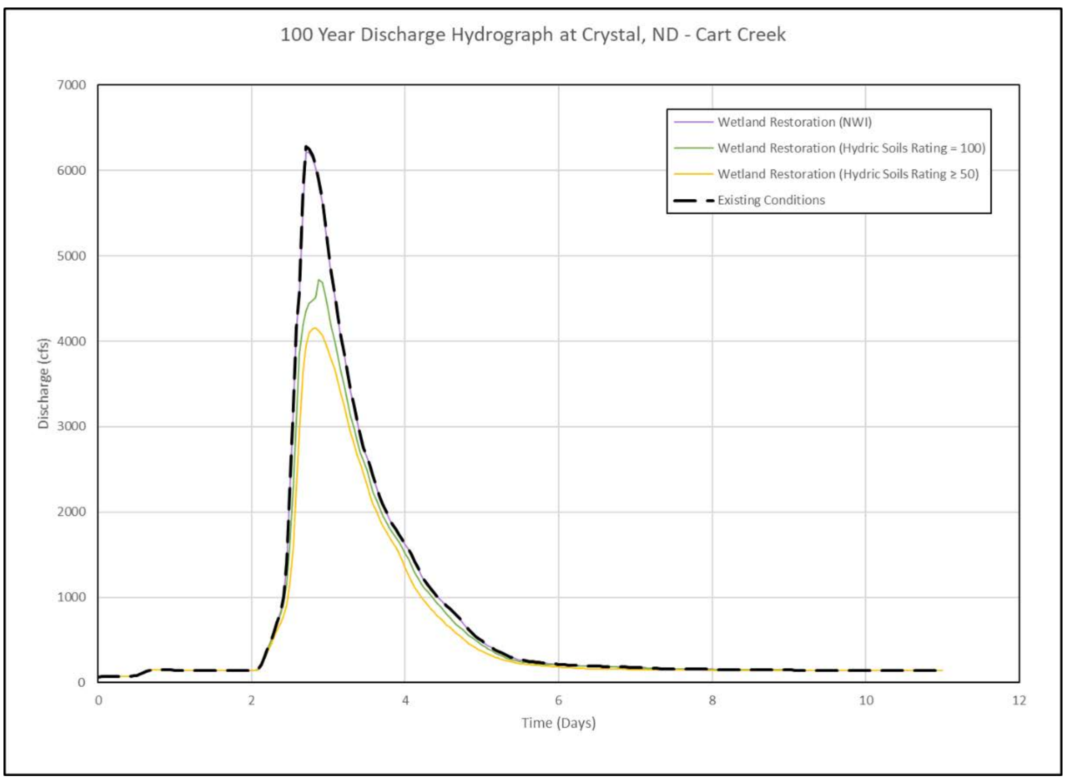


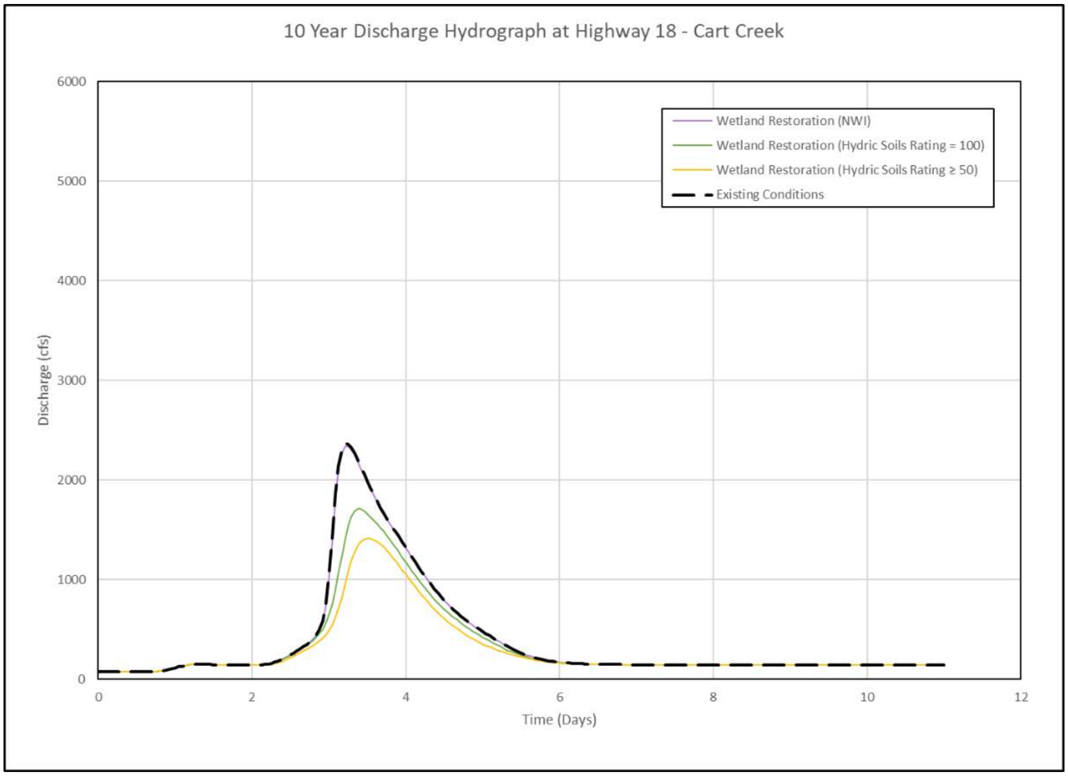


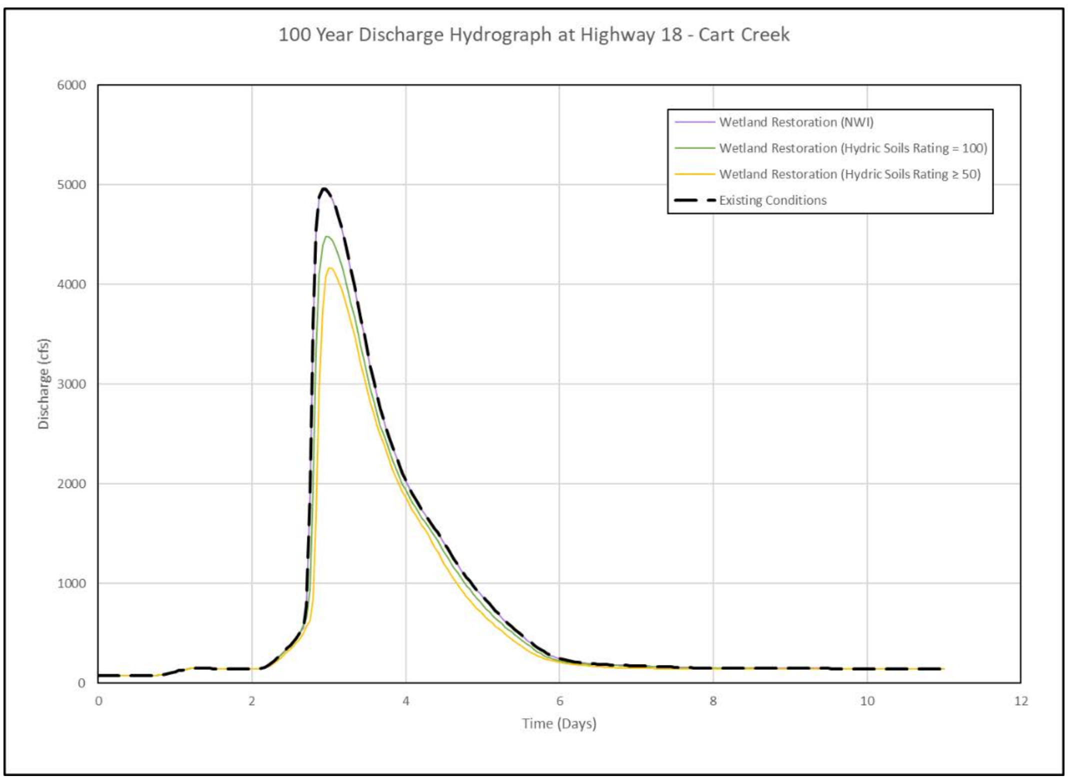

10 Year Discharge Hydrograph at County Road 12 - Cart Creek
Wetland Restoration (NWI)
Wetland Restoration (Hydric Soils Rating = 100)
Wetland Restoration (Hydric Soils Rating ≥ 50)
Existing Conditions
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
Time (Days)

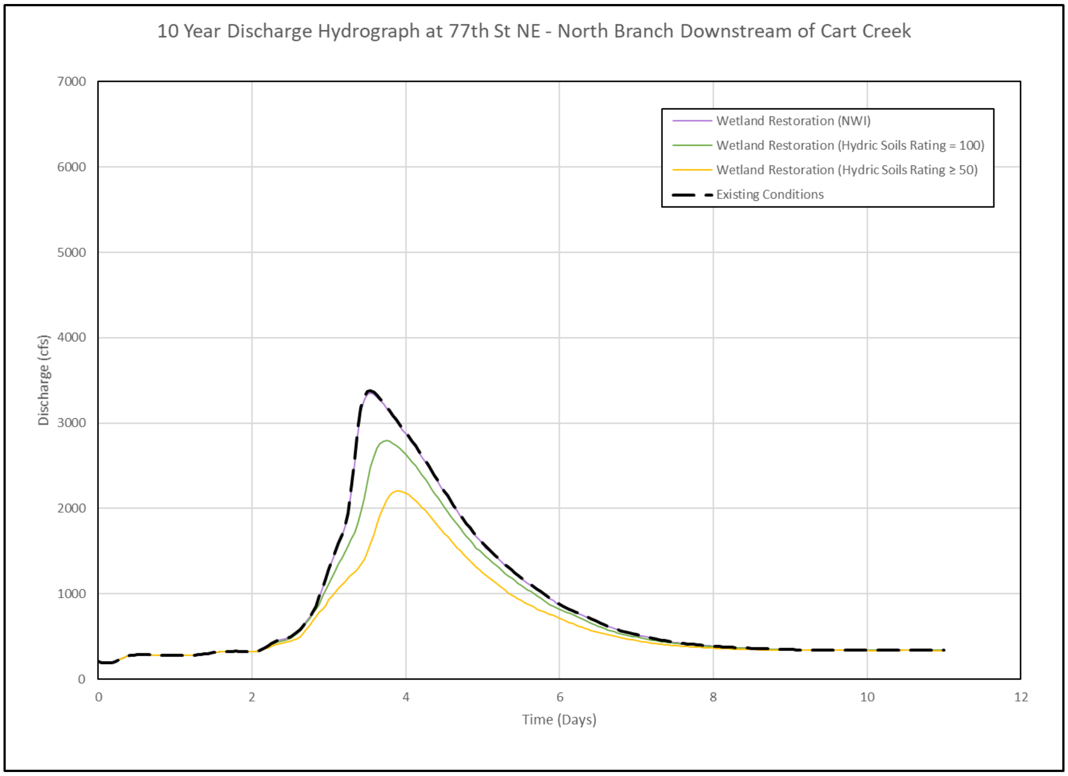

100 Year Discharge Hydrograph at County Road 12 - Cart Creek
Wetland Restoration (NWI)
Wetland Restoration (Hydric Soils Rating = 100)
Wetland Restoration (Hydric Soils Rating ≥ 50)
Existing Conditions
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
Time (Days)

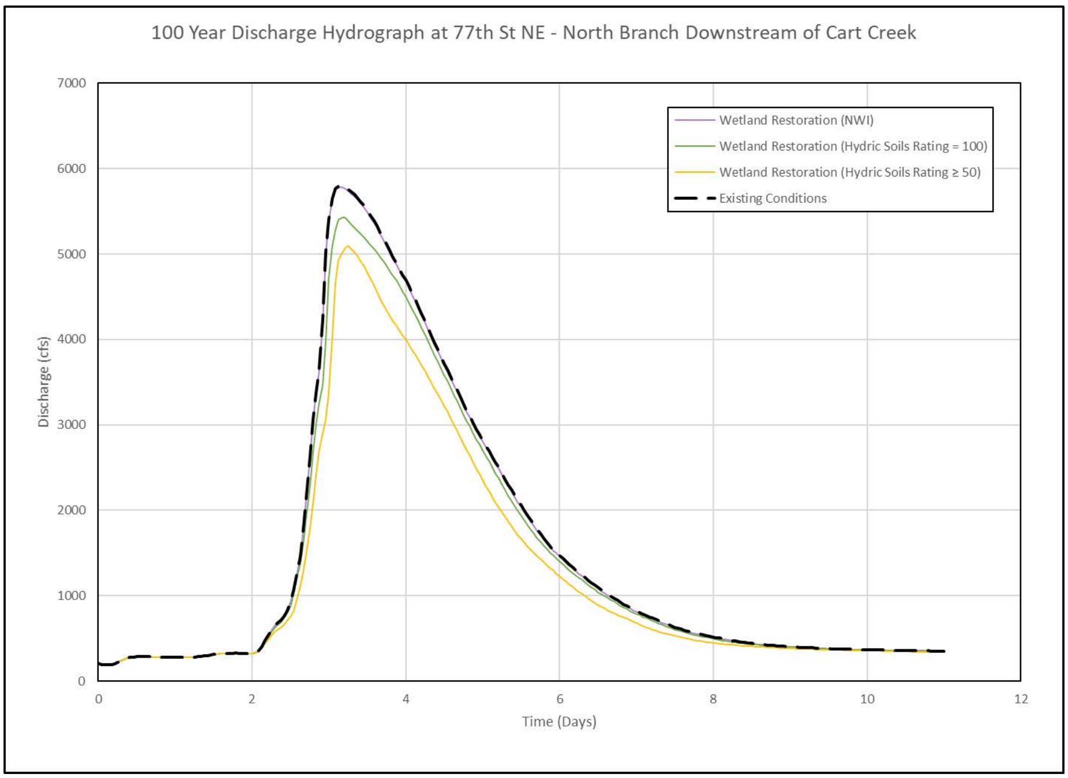

10 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Wetland Restoration (NWI)
Wetland Restoration (Hydric Soils Rating = 100)
Wetland Restoration (Hydric Soils Rating ≥ 50)
Existing Conditions
Discharge (cfs)
Time (Days)
0
500
1000
1500
2000
2500
3000
0
2
4
6
8
10
12

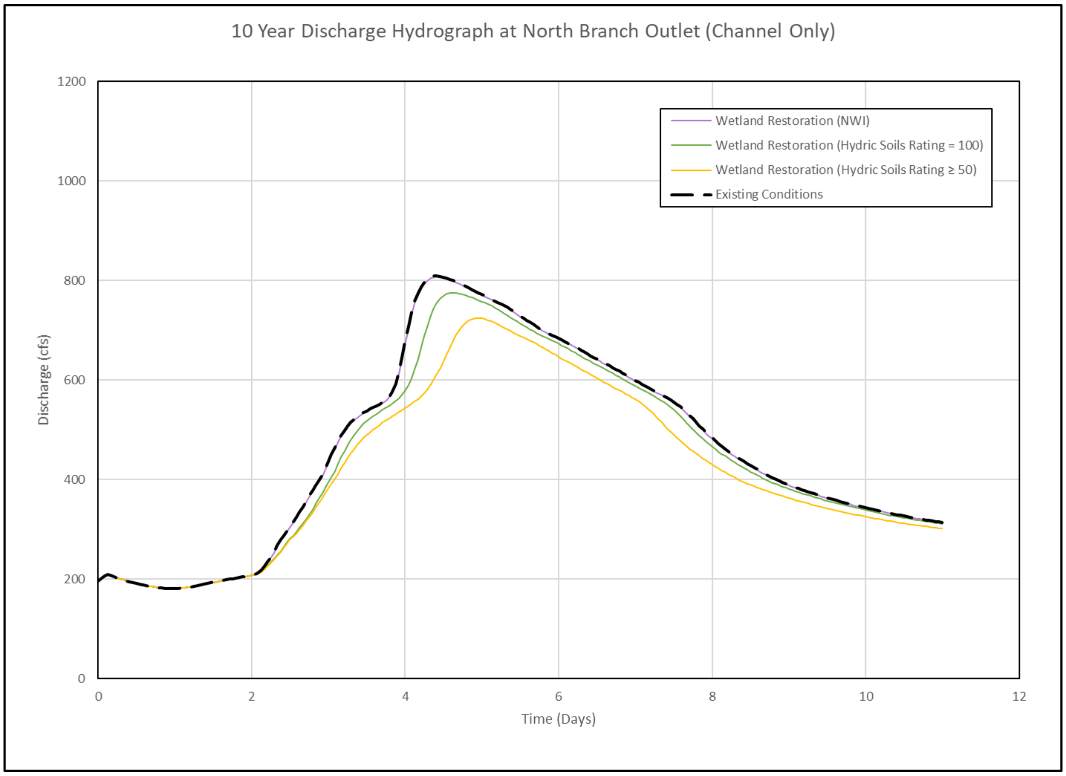

100 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Wetland Restoration (NWI)
Wetland Restoration (Hydric Soils Rating = 100)
Wetland Restoration (Hydric Soils Rating ≥ 50)
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

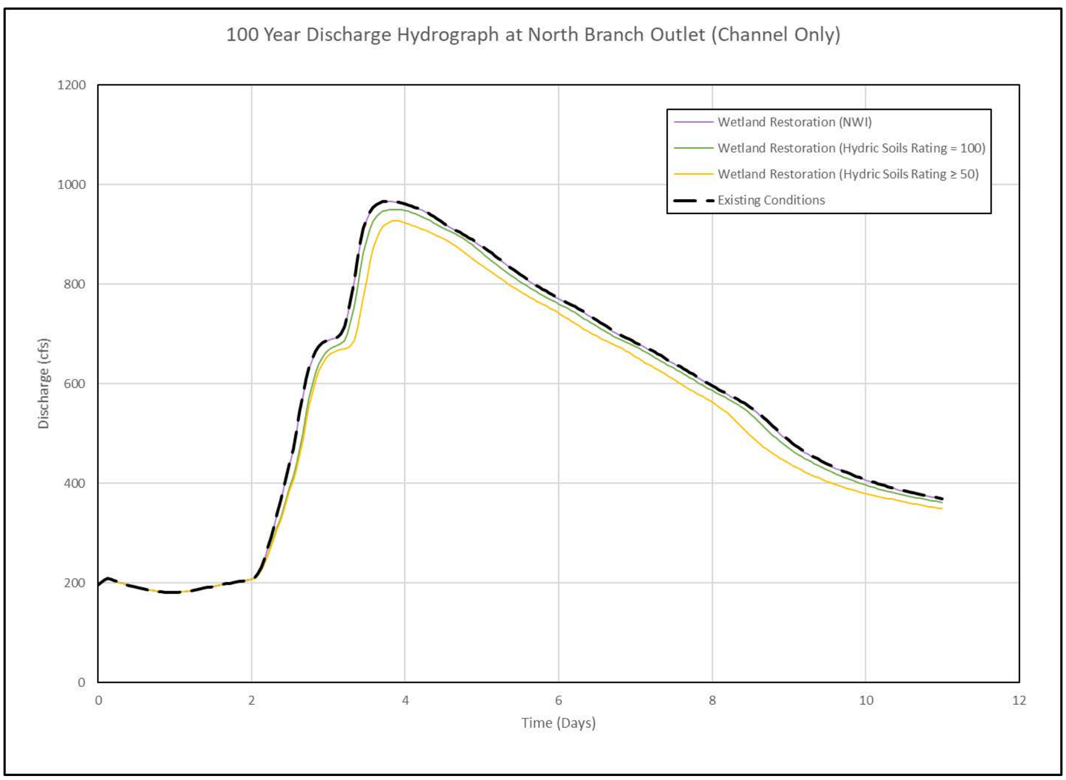

10 Year Discharge Hydrograph at Highway 18 - Cart Creek
Wetland Restoration (NWI)
Wetland Restoration (Hydric Soils Rating = 100)
Wetland Restoration (Hydric Soils Rating ≥ 50)
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
0
2
4
6
8
10
12

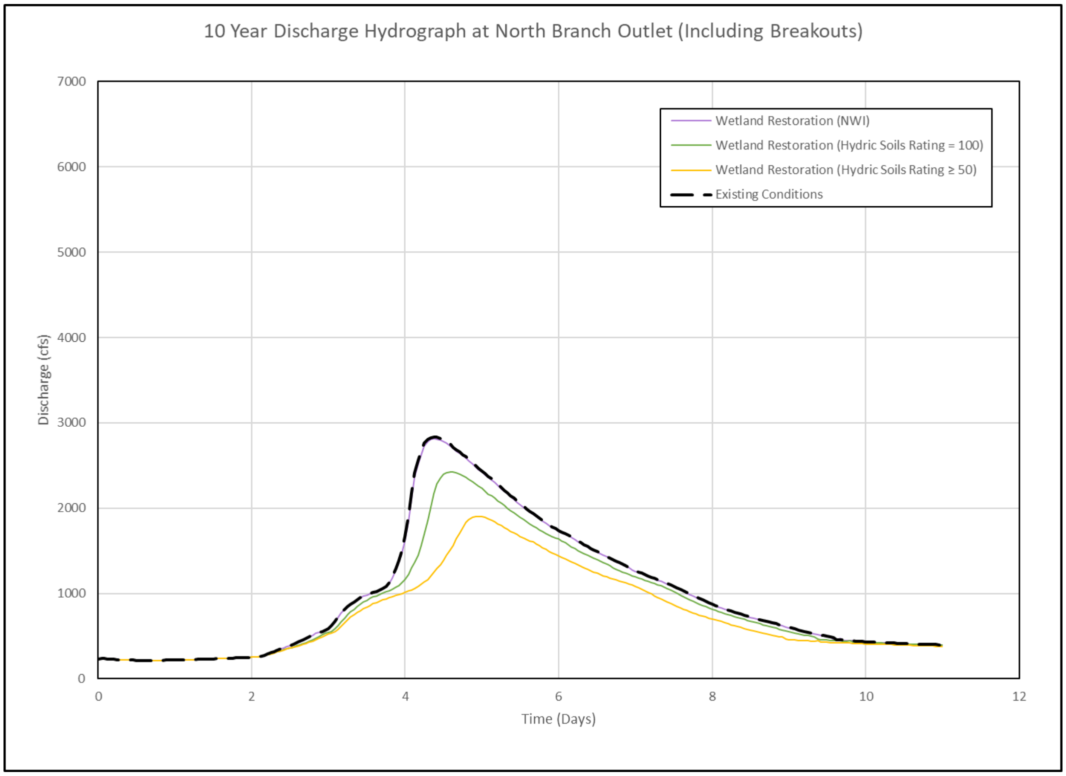

100 Year Discharge Hydrograph at Highway 18 - Cart Creek
Wetland Restoration (NWI)
Wetland Restoration (Hydric Soils Rating = 100)
Wetland Restoration (Hydric Soils Rating ≥ 50)
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
0
2
4
6
8
10
12

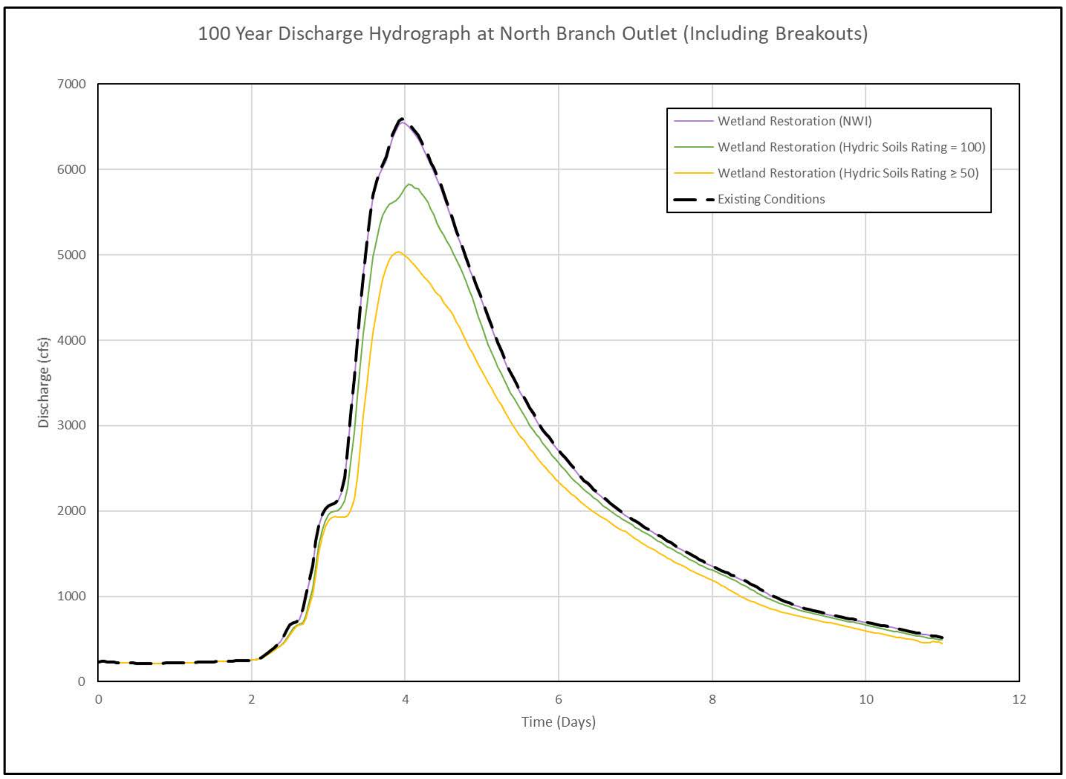

10 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Wetland Restoration (NWI)
Wetland Restoration (Hydric Soils Rating = 100)
Wetland Restoration (Hydric Soils Rating ≥ 50)
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12


100 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Wetland Restoration (NWI)
Wetland Restoration (Hydric Soils Rating = 100)
Wetland Restoration (Hydric Soils Rating ≥ 50)
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

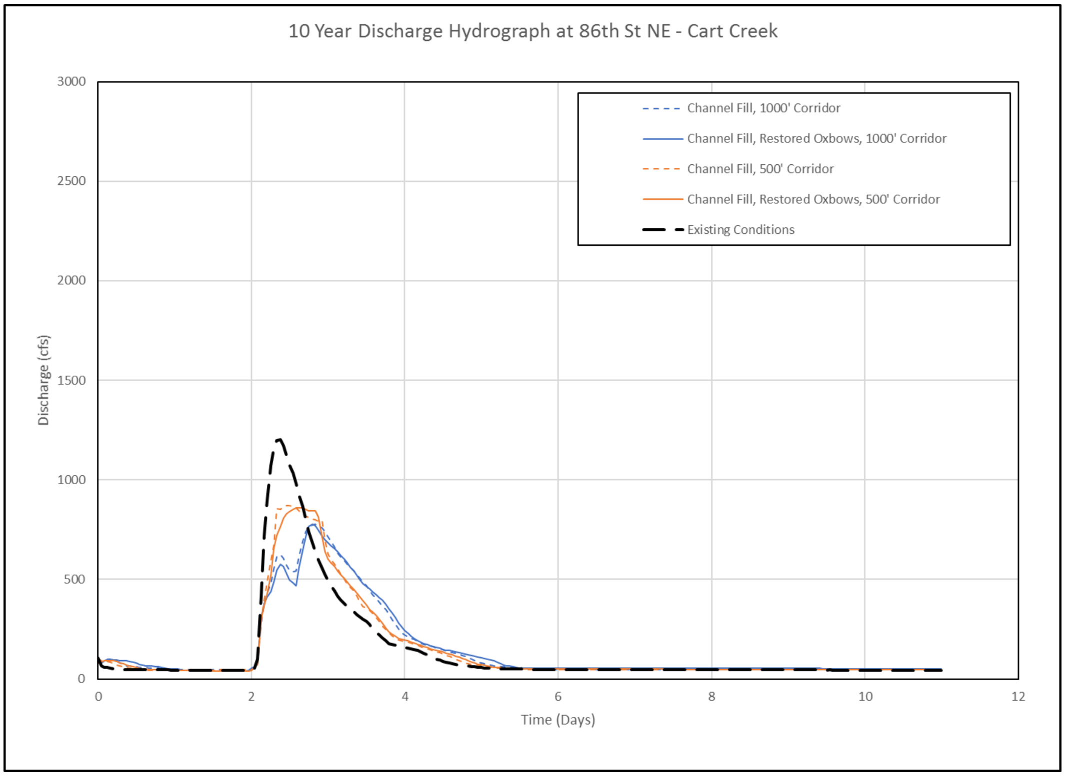

10 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Discharge (cfs)
Time (Days)
Wetland Restoration (NWI)
Wetland Restoration (Hydric Soils Rating = 100)
Wetland Restoration (Hydric Soils Rating ≥ 50)
Existing Conditions
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12

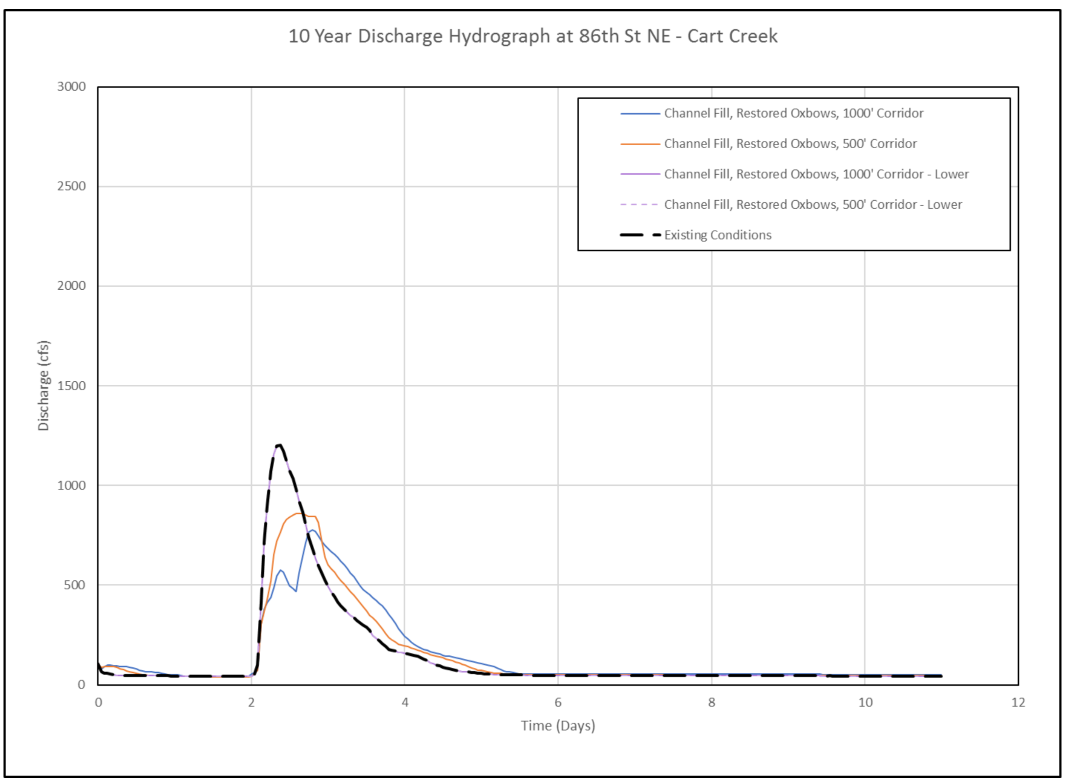

100 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Discharge (cfs)
Time (Days)
Wetland Restoration (NWI)
Wetland Restoration (Hydric Soils Rating = 100)
Wetland Restoration (Hydric Soils Rating ≥ 50)
Existing Conditions
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12

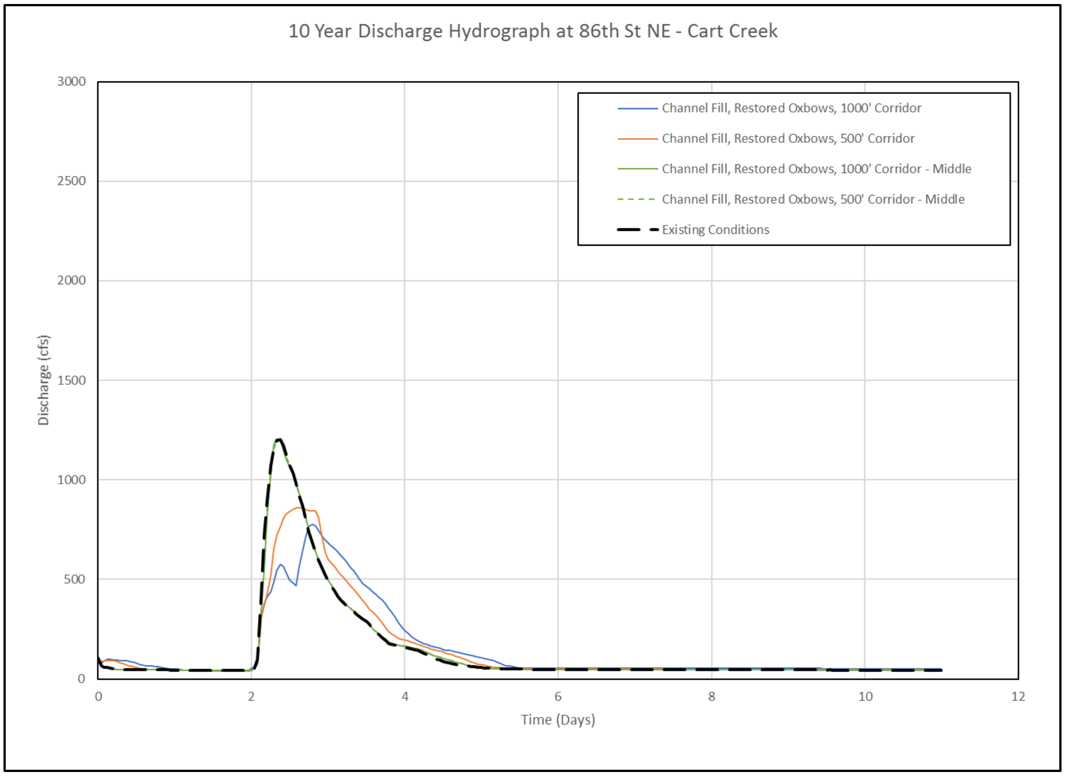

10 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Wetland Restoration (NWI)
Wetland Restoration (Hydric Soils Rating = 100)
Wetland Restoration (Hydric Soils Rating ≥ 50)
Existing Conditions
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
Time (Days)

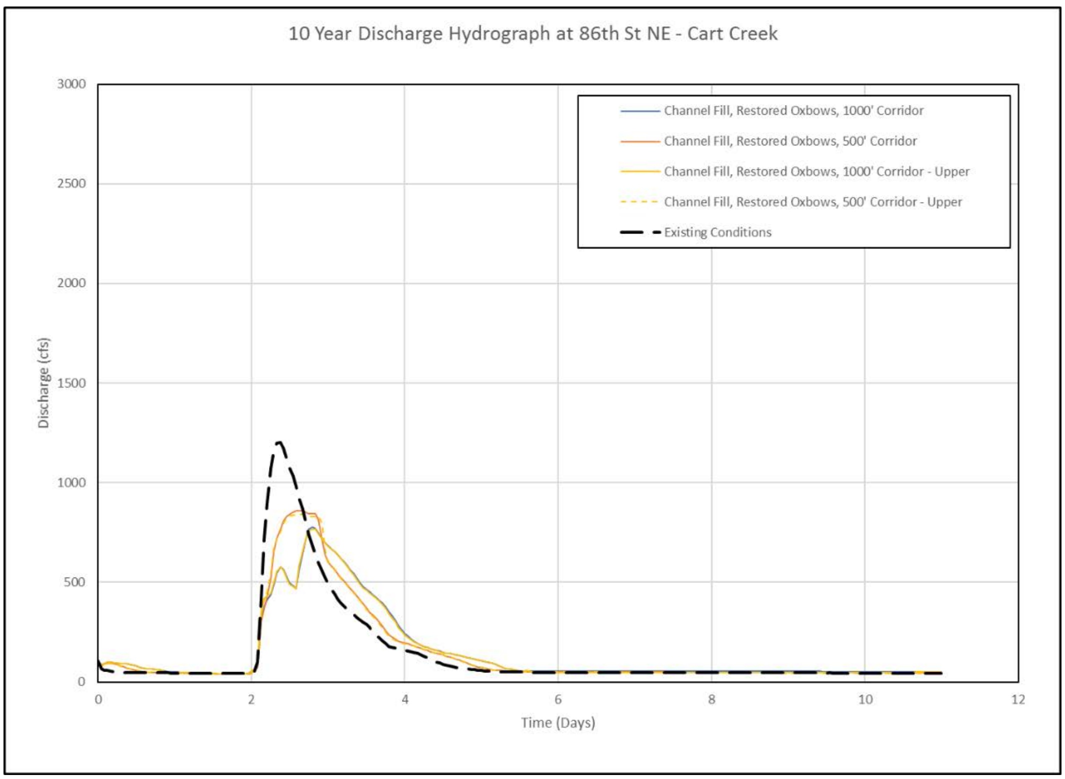

100 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Wetland Restoration (NWI)
Wetland Restoration (Hydric Soils Rating = 100)
Wetland Restoration (Hydric Soils Rating ≥ 50)
Existing Conditions
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
Time (Days)

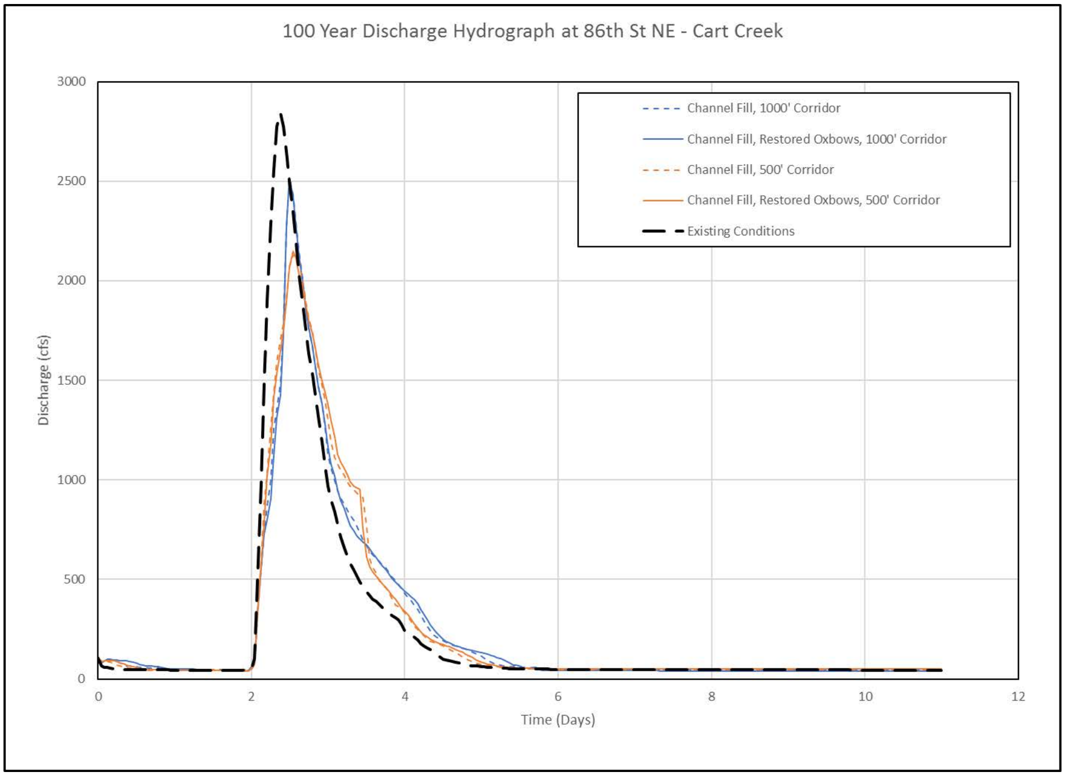
D-2-A.6 RIPARIAN CORRIDOR RESTORATION – HYDROGRAPHS



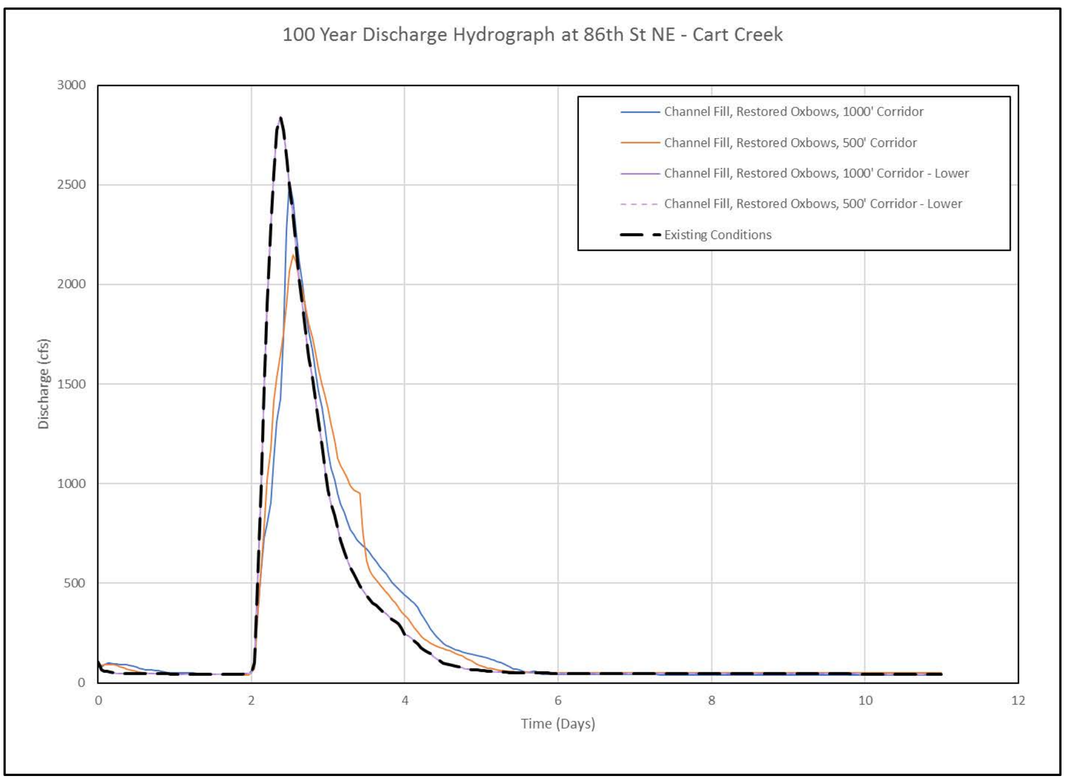



10 Year Discharge Hydrograph at 86th St NE - Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Middle
Channel Fill, Restored Oxbows, 500' Corridor - Middle
Existing Conditions
Discharge (cfs)
Time (Days)
3000
2500
2000
1500
1000
500
0
0
2
4
6
8
10
12

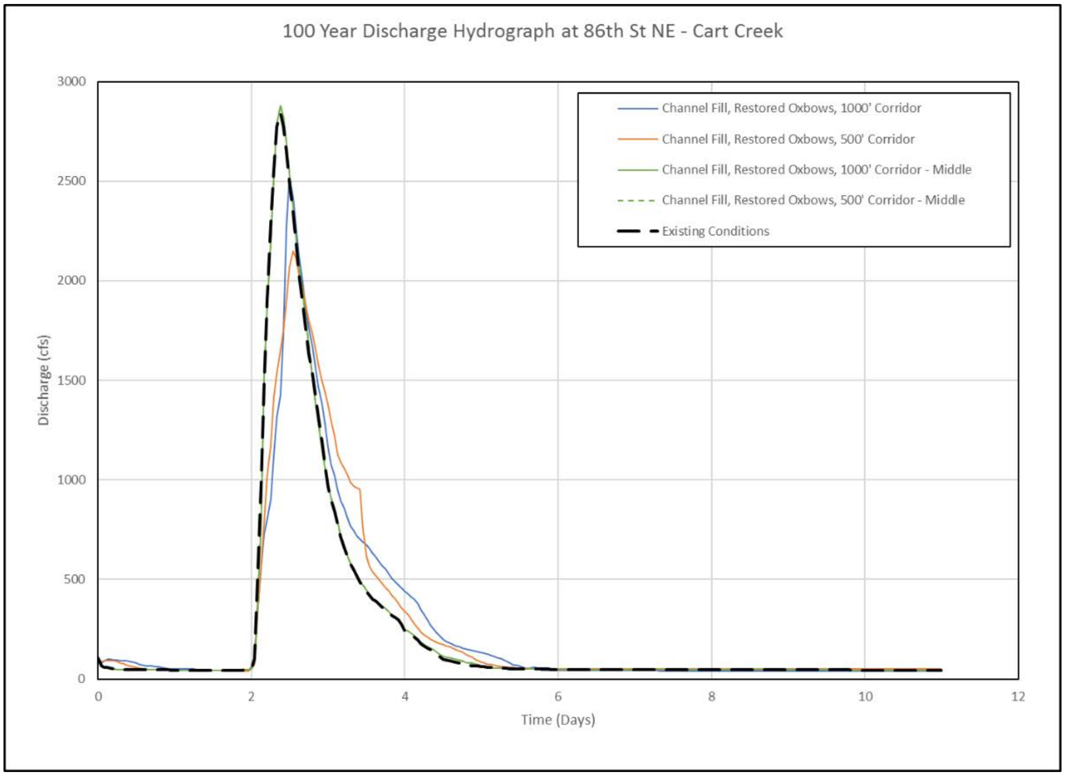

10 Year Discharge Hydrograph at 86th St NE - Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Upper
Channel Fill, Restored Oxbows, 500' Corridor - Upper
Existing Conditions
Discharge (cfs)
Time (Days)
3000
2500
2000
1500
1000
500
0
0
2
4
6
8
10
12

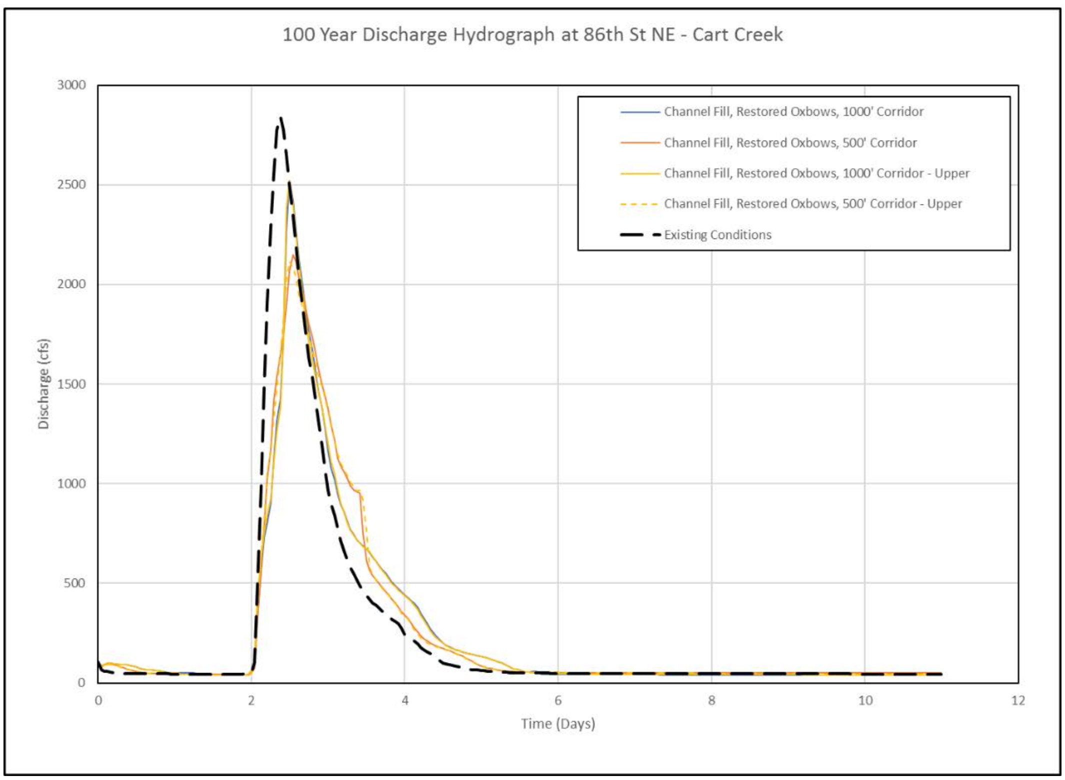


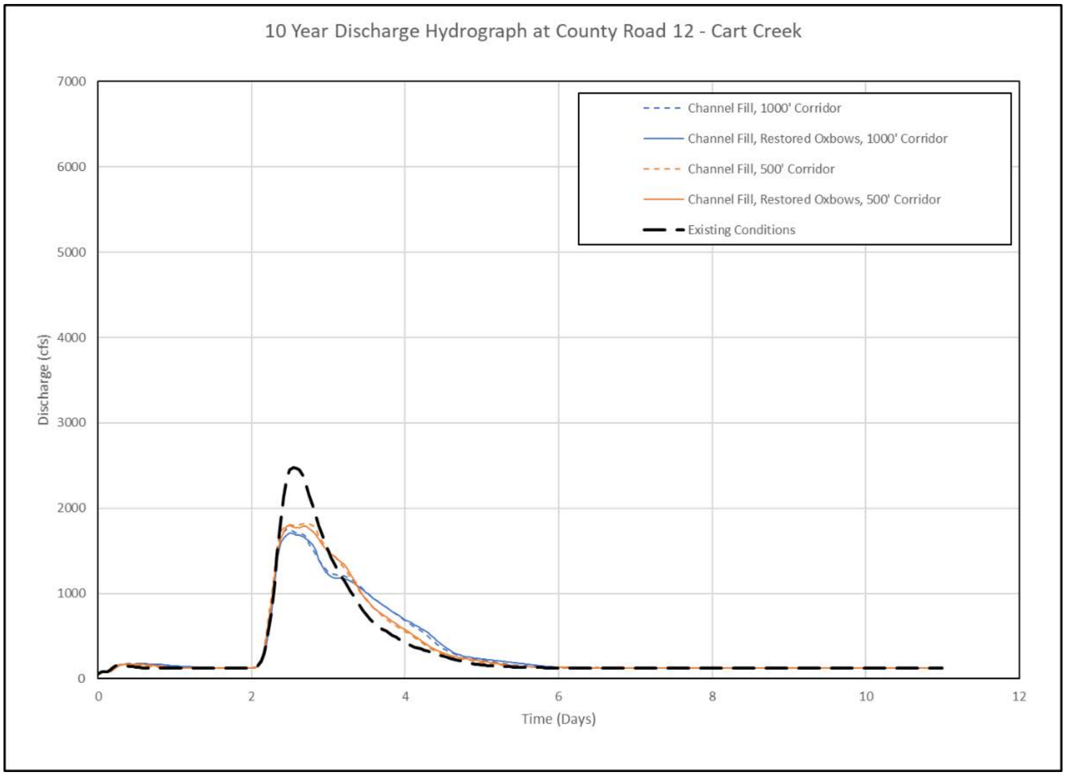
100 Year Discharge Hydrograph at 86th St NE - Cart Creek
Channel Fill, 1000' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, 500' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Existing Conditions
Discharge (cfs)
Time (Days)
0
500
1000
1500
2000
2500
3000
0
2
4
6
8
10
12

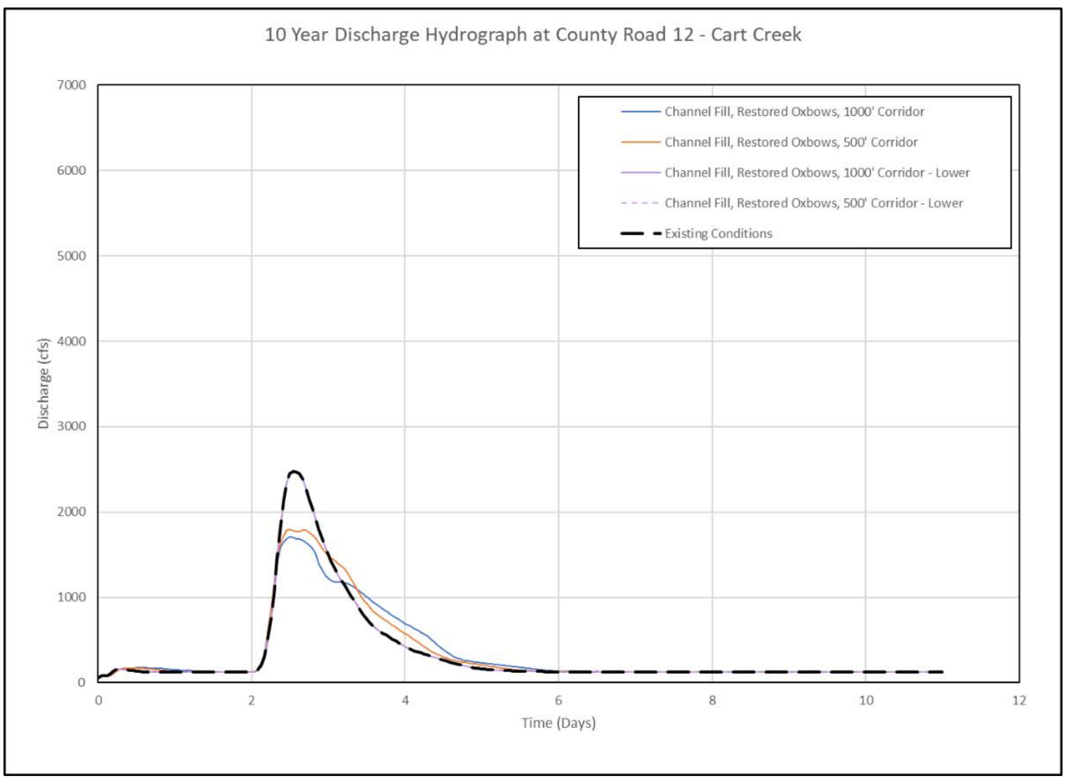


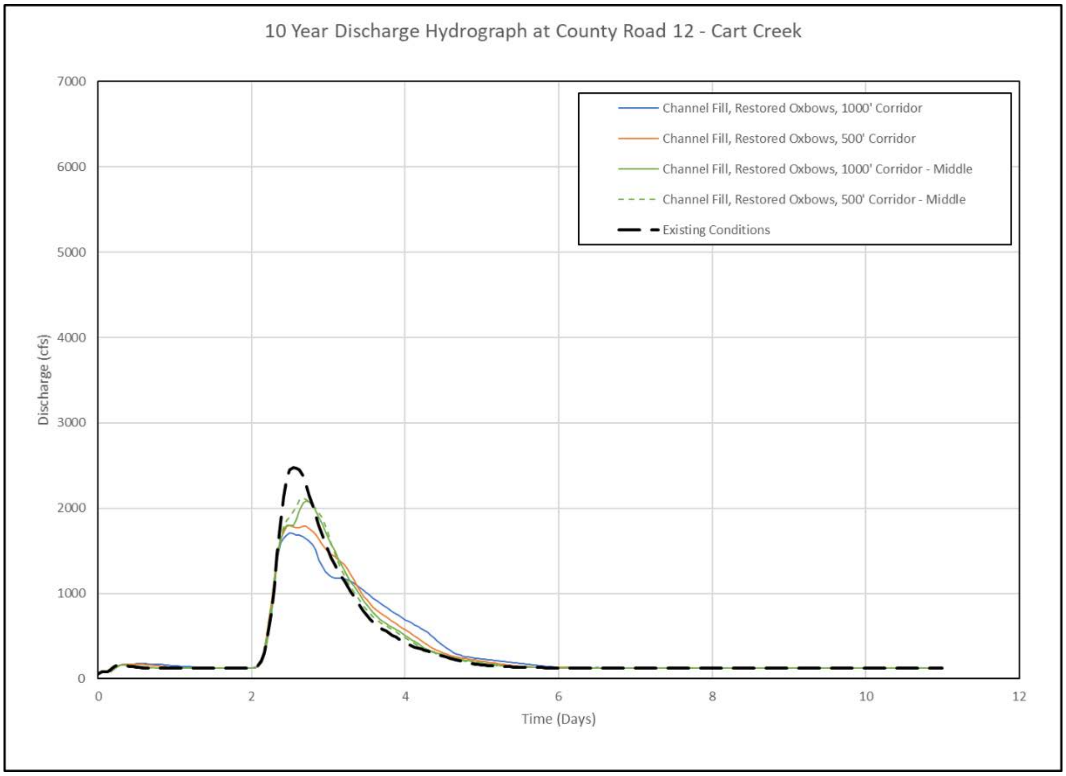
100 Year Discharge Hydrograph at 86th St NE - Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Lower
Channel Fill, Restored Oxbows, 500' Corridor - Lower
Existing Conditions
Discharge (cfs)
Time (Days)
0
500
1000
1500
2000
2500
3000
0
2
4
6
8
10
12

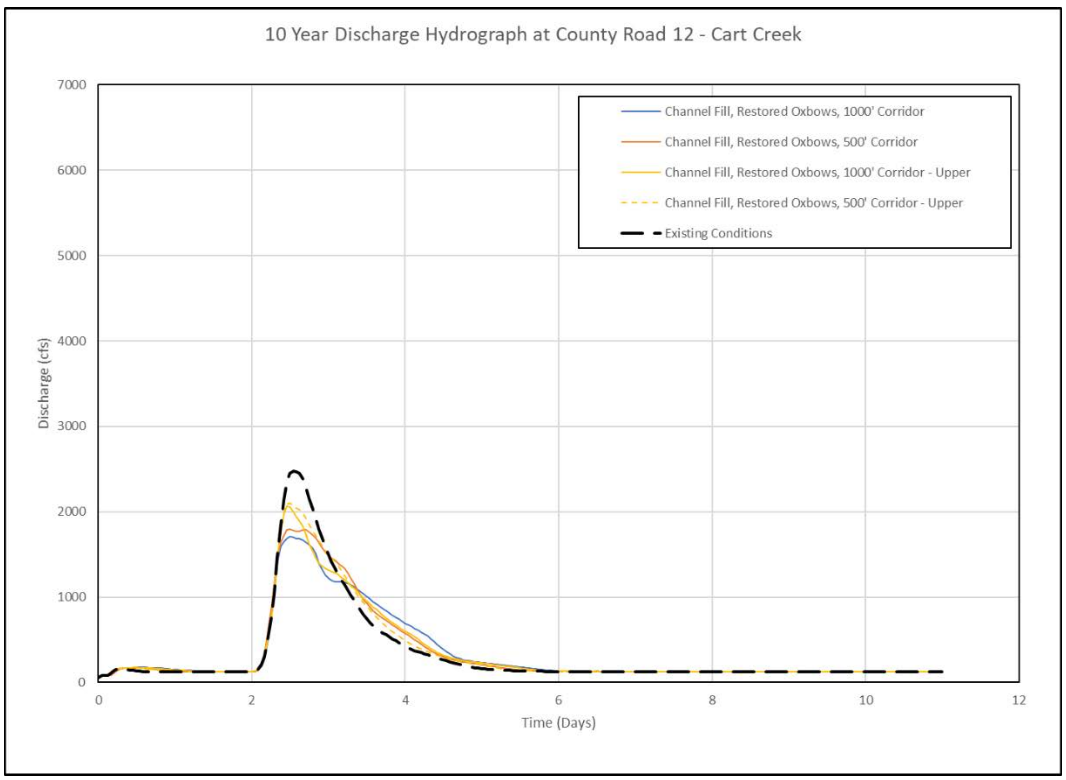

100 Year Discharge Hydrograph at 86th St NE - Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Middle
Channel Fill, Restored Oxbows, 500' Corridor - Middle
Existing Conditions
Discharge (cfs)
Time (Days)

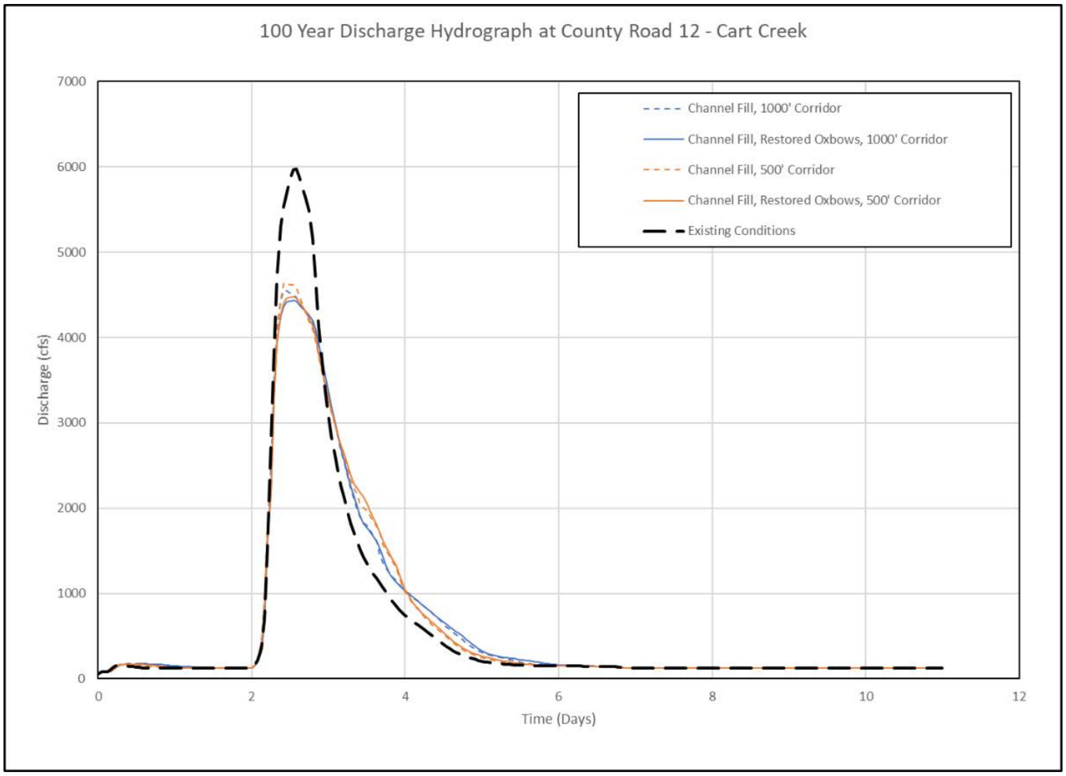

100 Year Discharge Hydrograph at 86th St NE - Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Upper
Channel Fill, Restored Oxbows, 500' Corridor - Upper
Existing Conditions
Discharge (cfs)
Time (Days)

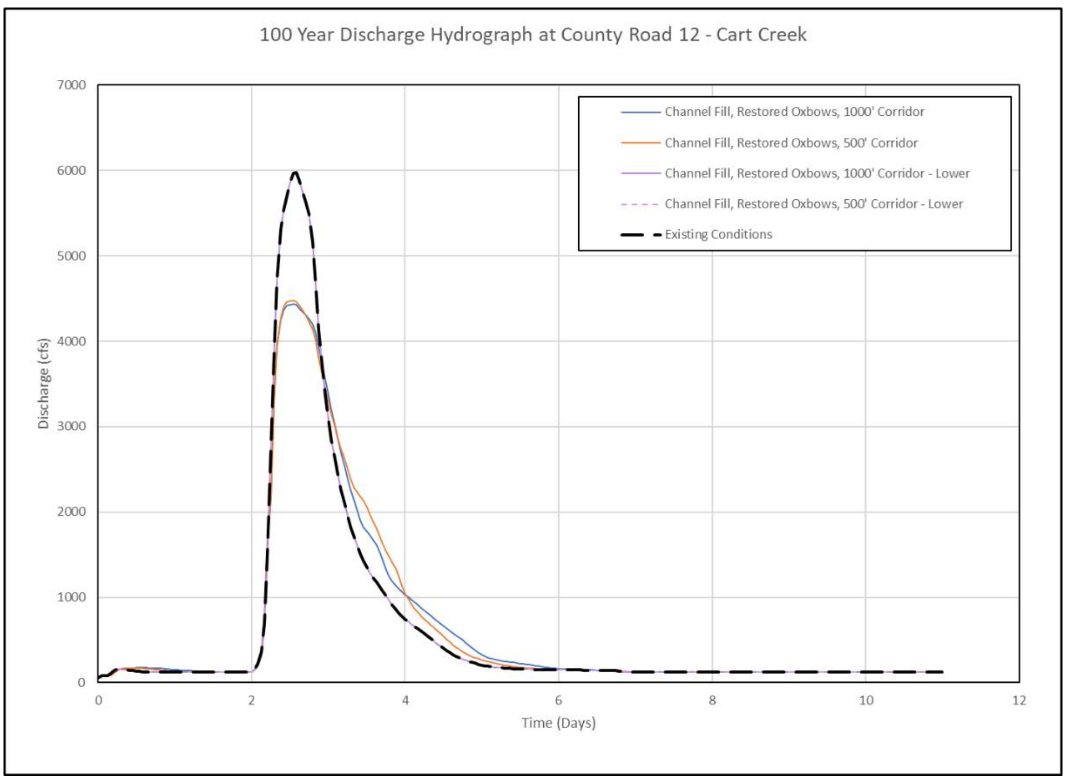

10 Year Discharge Hydrograph at County Road 12 - Cart Creek
Channel Fill, 1000' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, 500' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

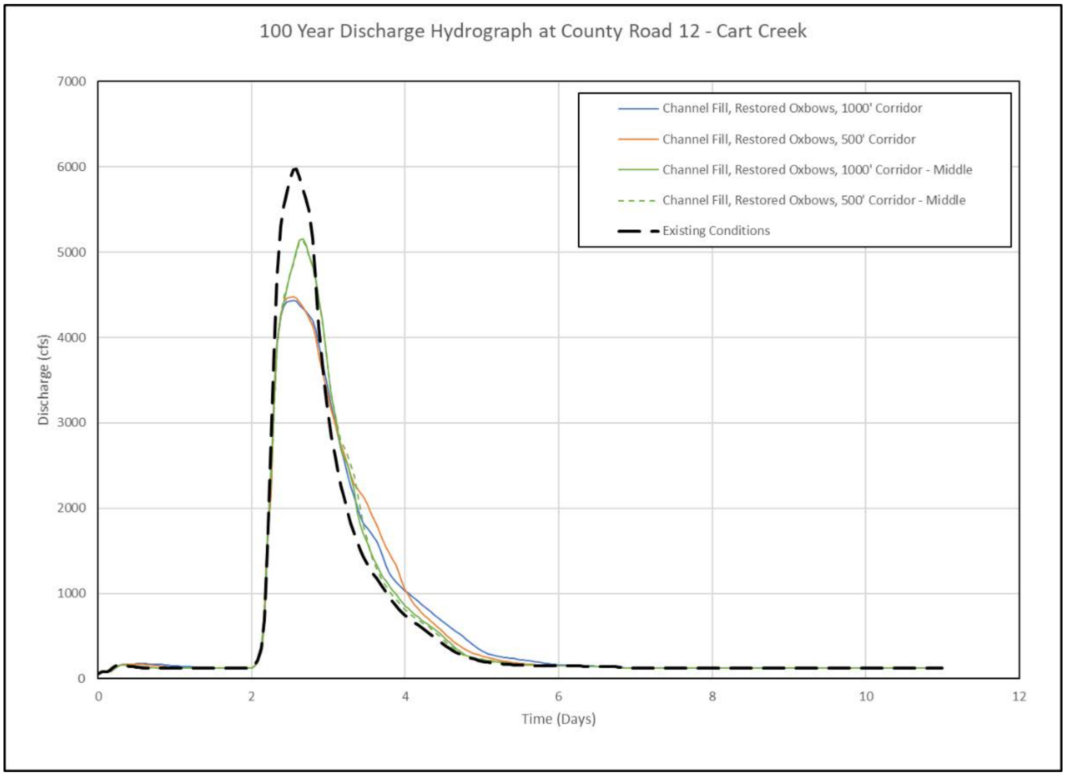

10 Year Discharge Hydrograph at County Road 12 - Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Lower
Channel Fill, Restored Oxbows, 500' Corridor - Lower
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12


10 Year Discharge Hydrograph at County Road 12 - Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Middle
Channel Fill, Restored Oxbows, 500' Corridor - Middle
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
2
4
6
8
10
12

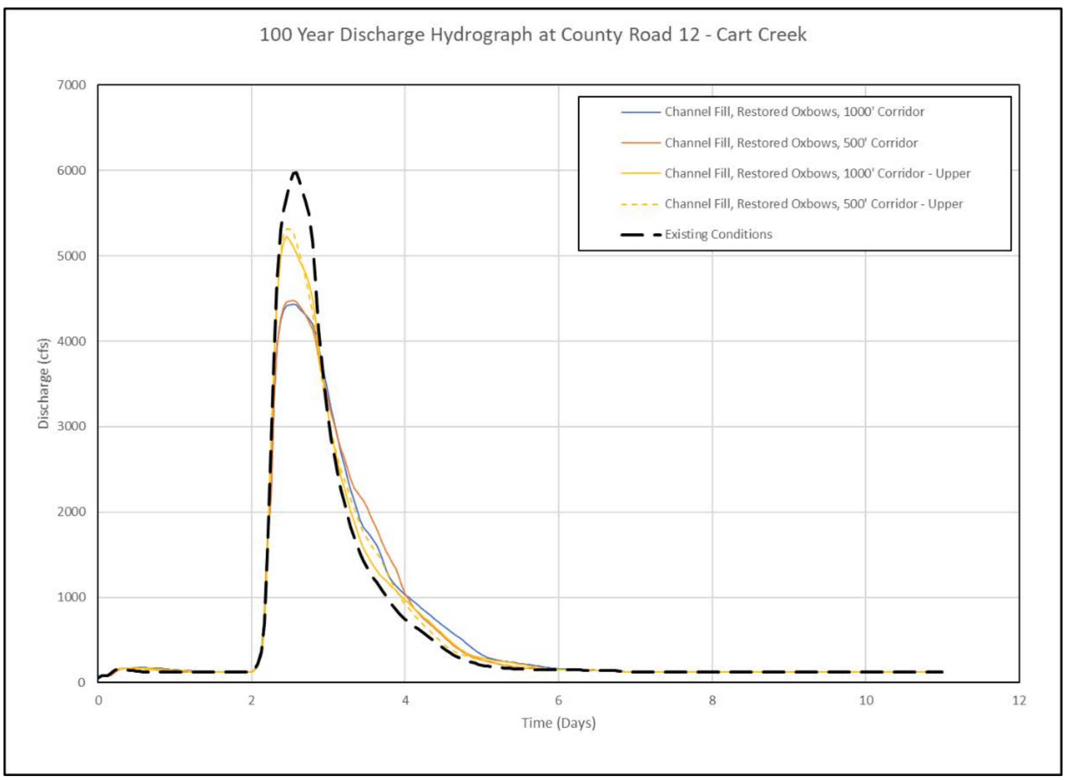

10 Year Discharge Hydrograph at County Road 12 - Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Upper
Channel Fill, Restored Oxbows, 500' Corridor - Upper
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
2
4
6
8
10
12


100 Year Discharge Hydrograph at County Road 12 - Cart Creek
Discharge (cfs)
Time (Days)
Channel Fill, 1000' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, 500' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Existing Conditions

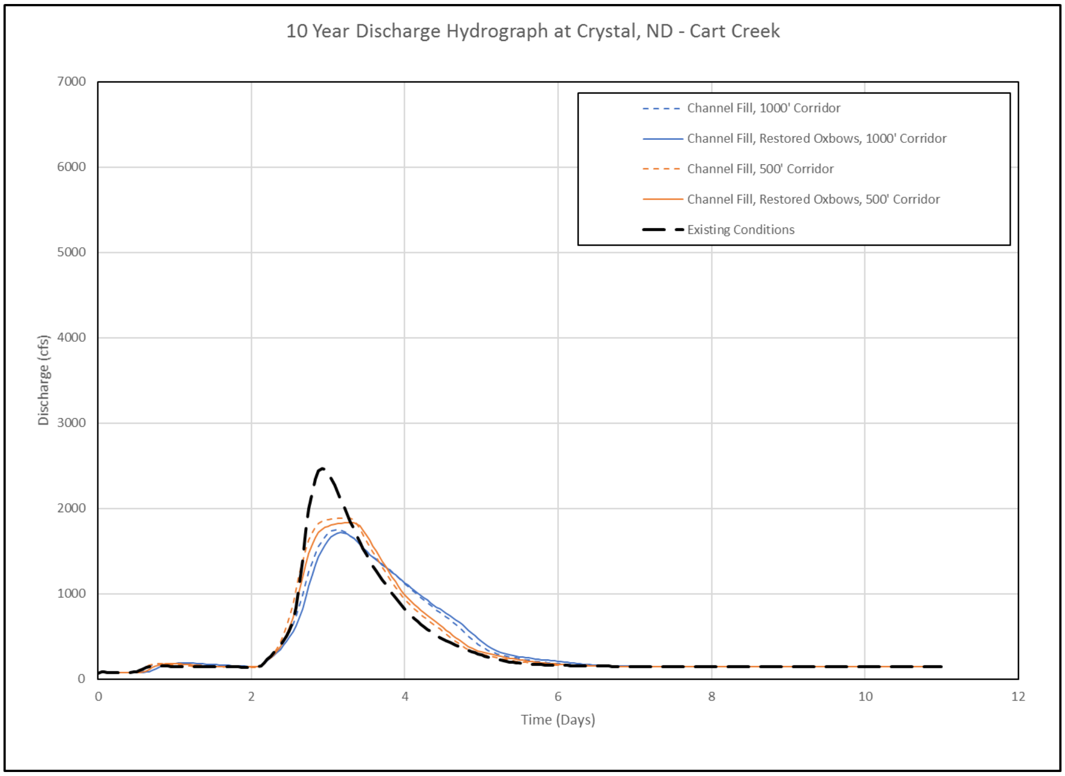

100 Year Discharge Hydrograph at County Road 12 - Cart Creek
Discharge (cfs)
Time (Days)
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Lower
Channel Fill, Restored Oxbows, 500' Corridor - Lower
Existing Conditions

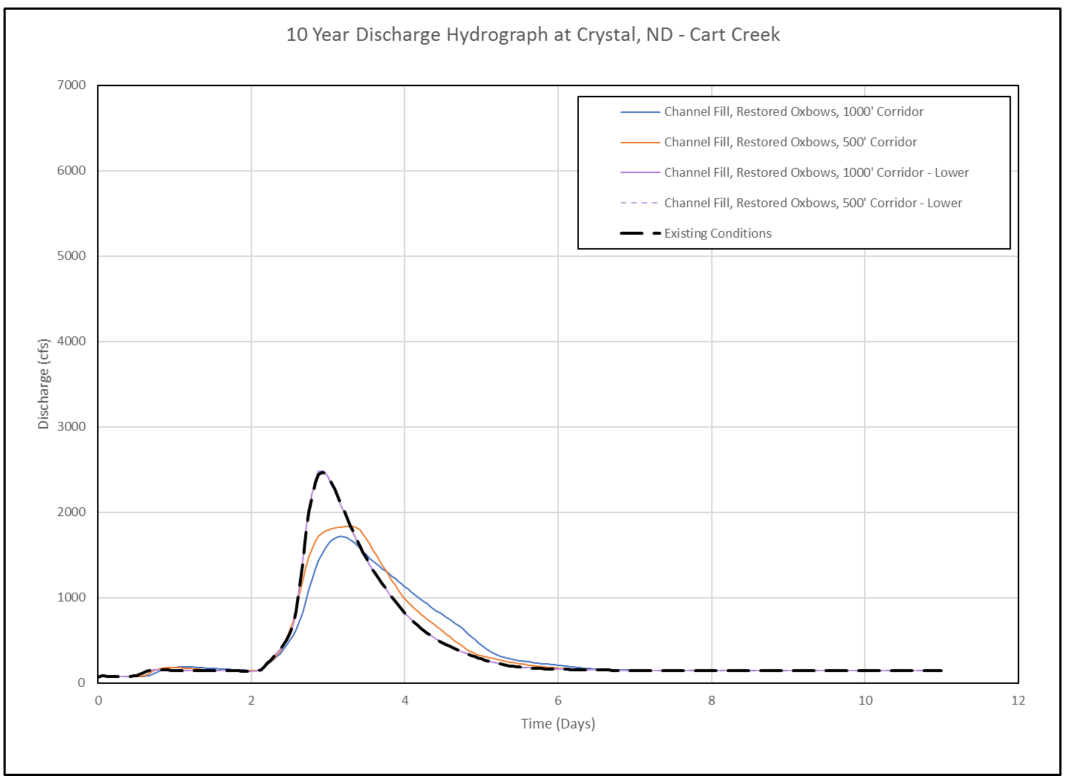


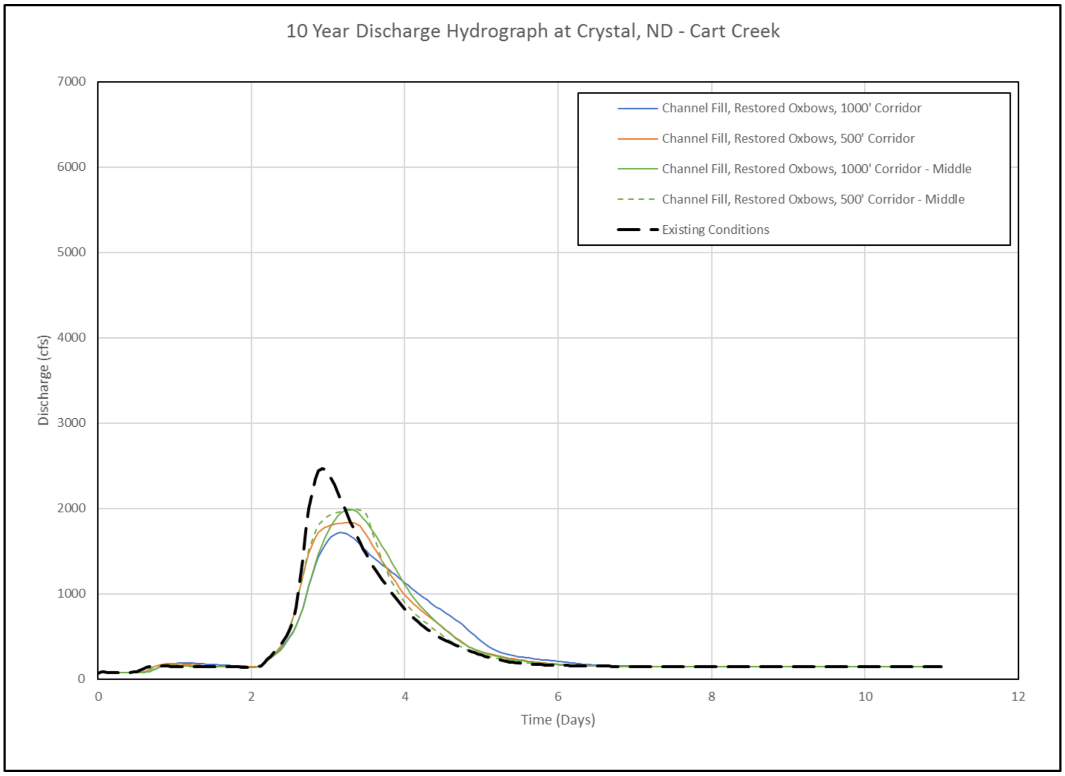
100 Year Discharge Hydrograph at County Road 12 - Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Middle
Channel Fill, Restored Oxbows, 500' Corridor - Middle
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

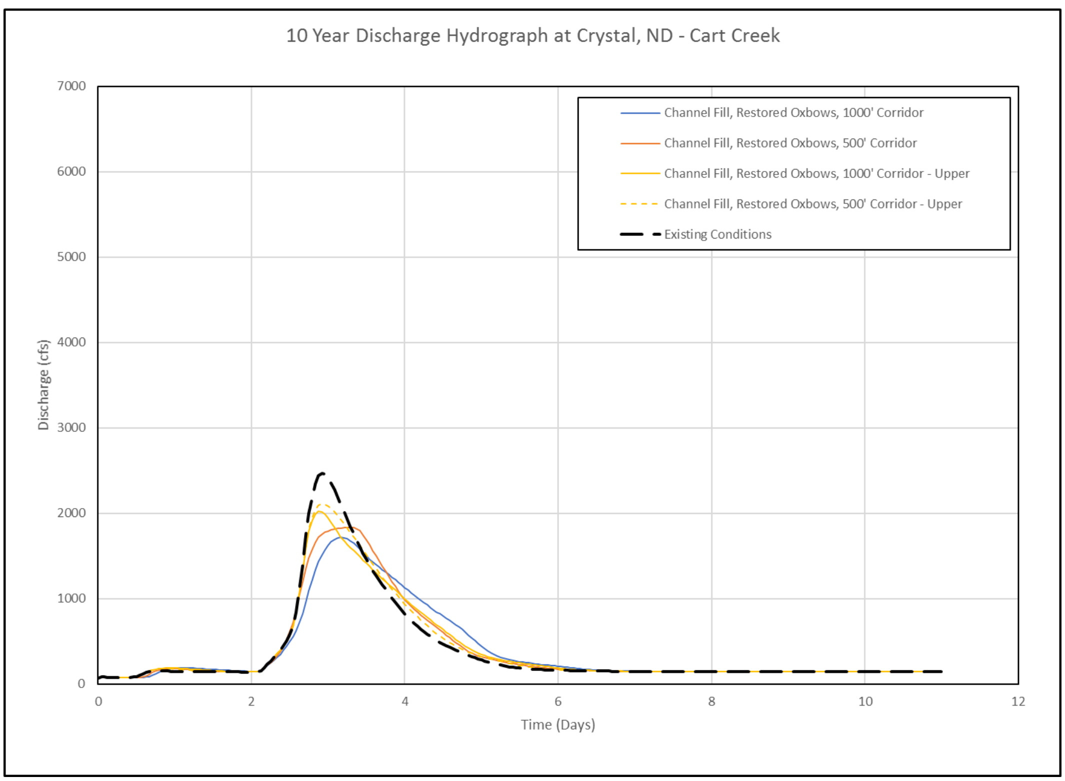


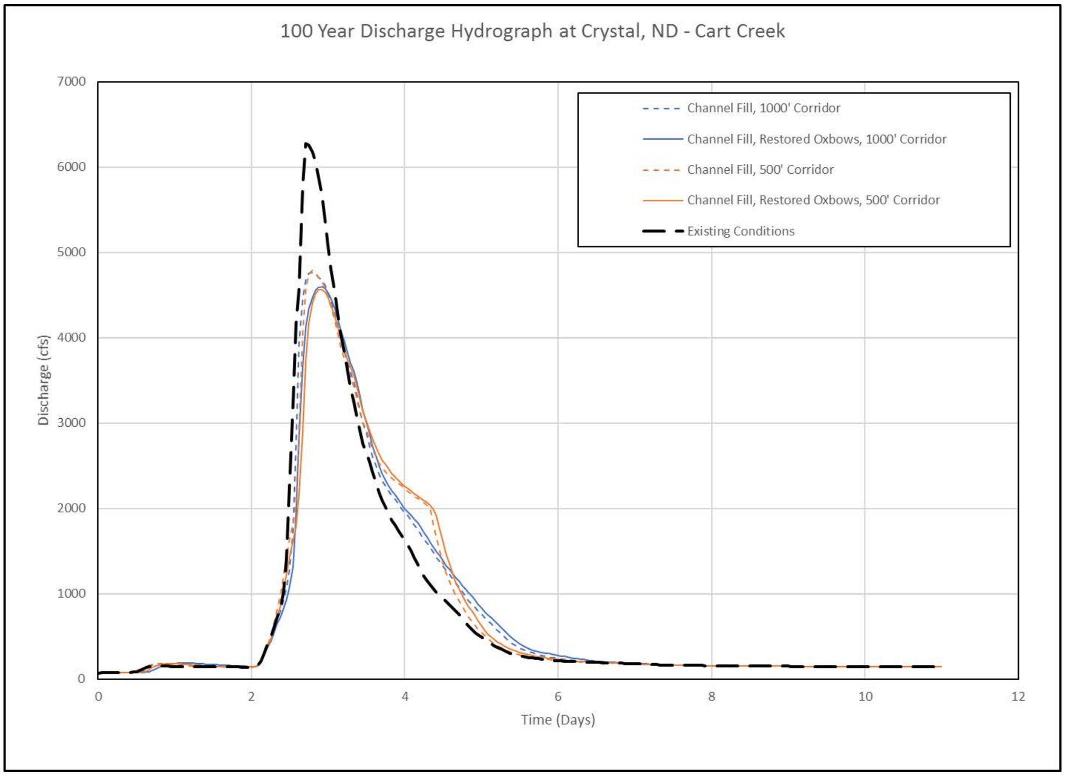
100 Year Discharge Hydrograph at County Road 12 - Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Upper
Channel Fill, Restored Oxbows, 500' Corridor - Upper
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

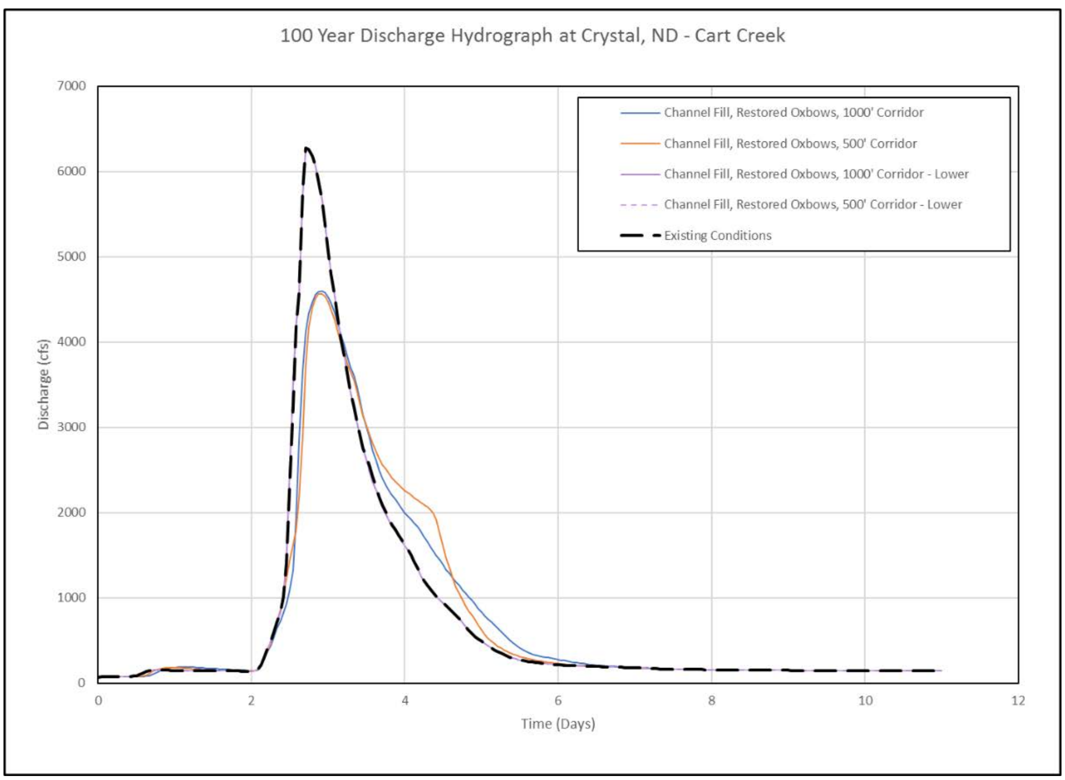

10 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Channel Fill, 1000' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, 500' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

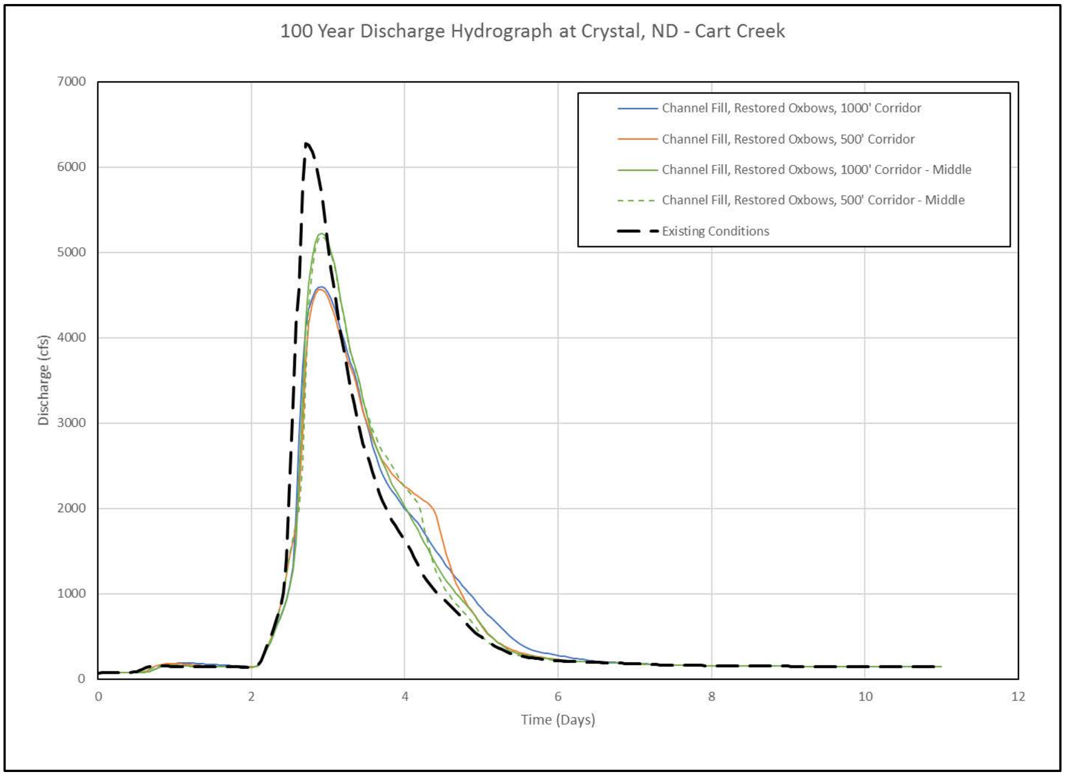

10 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Lower
Channel Fill, Restored Oxbows, 500' Corridor - Lower
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

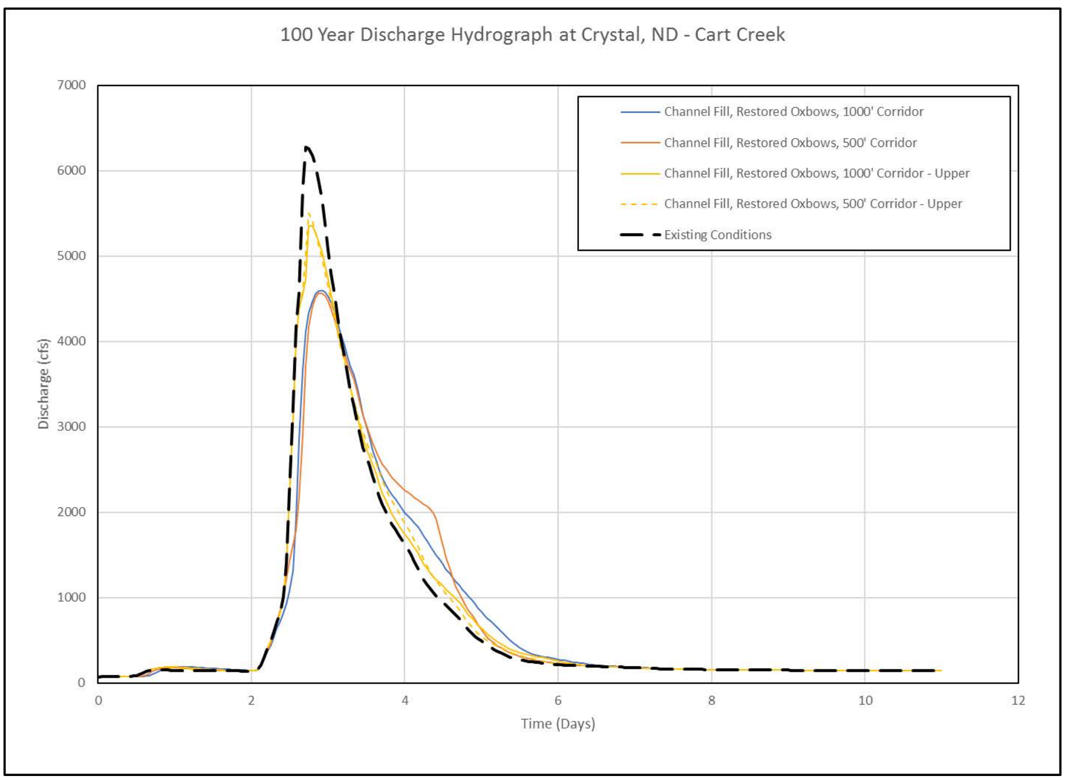

10 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Middle
Channel Fill, Restored Oxbows, 500' Corridor - Middle
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
2
4
6
8
10
12

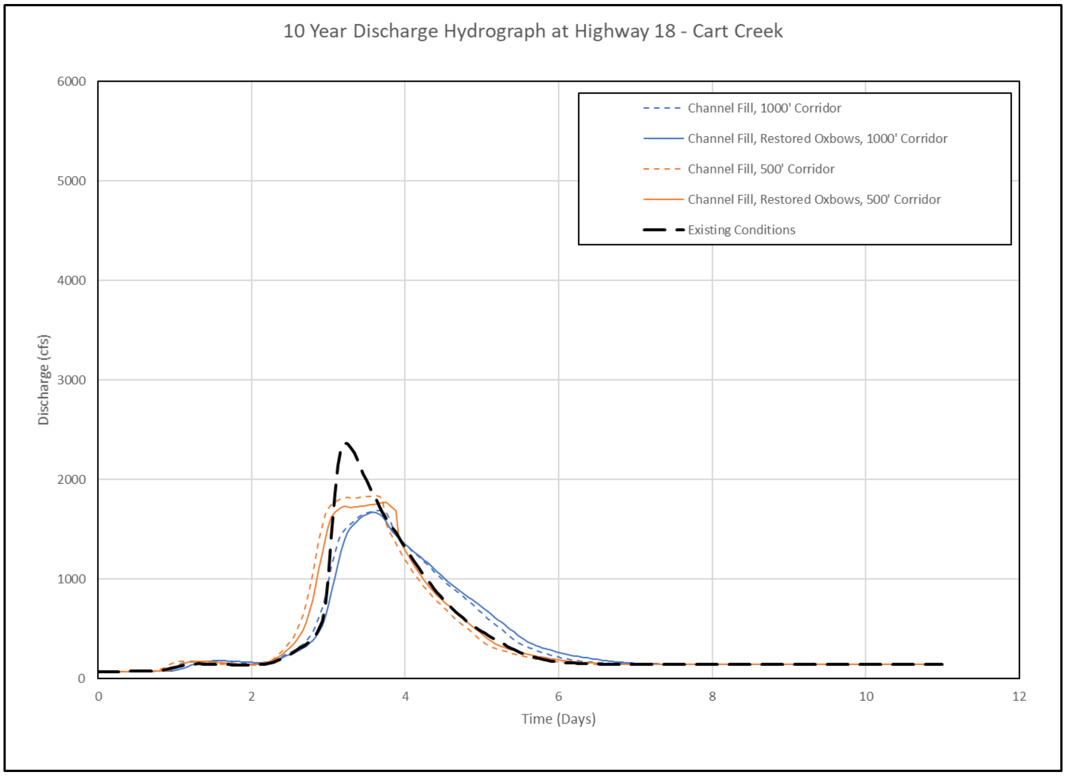

10 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Upper
Channel Fill, Restored Oxbows, 500' Corridor - Upper
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
2
4
6
8
10
12

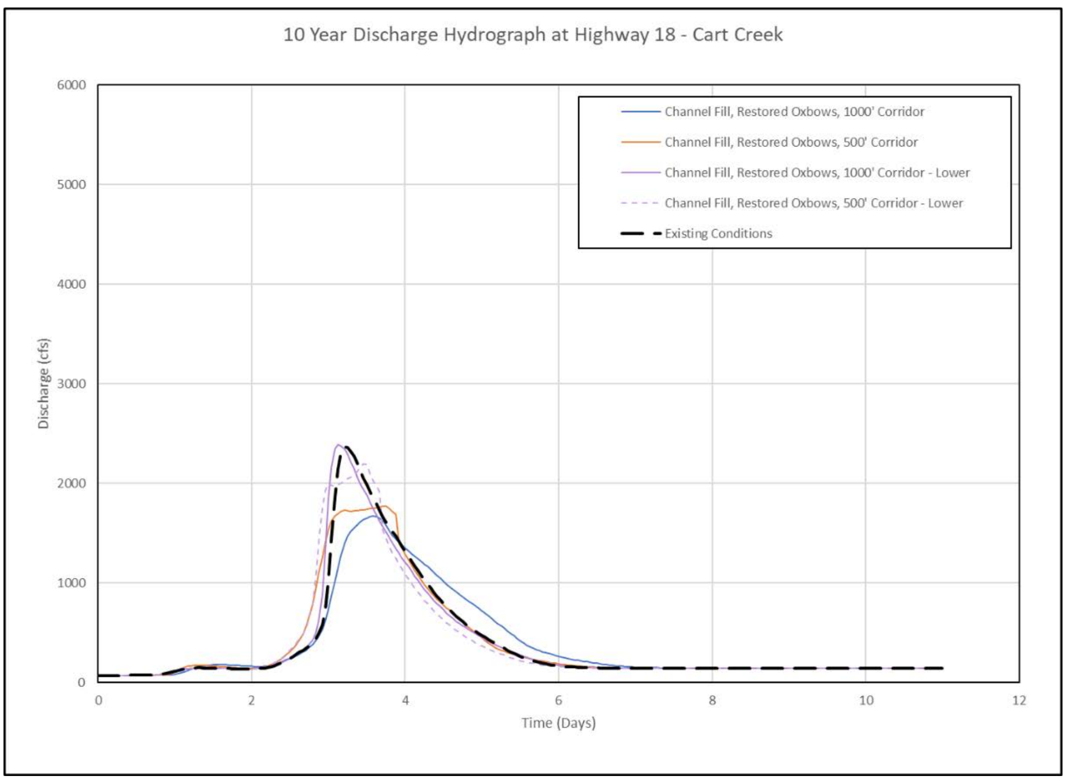

100 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Channel Fill, 1000' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, 500' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

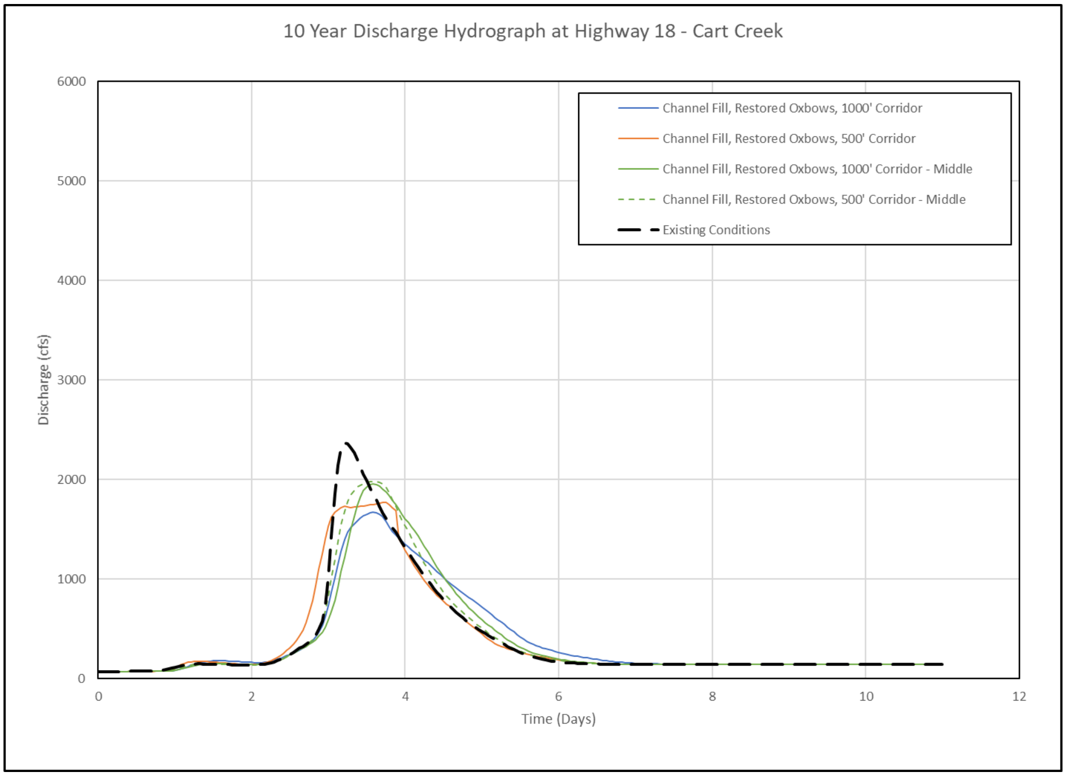

100 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Lower
Channel Fill, Restored Oxbows, 500' Corridor - Lower
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

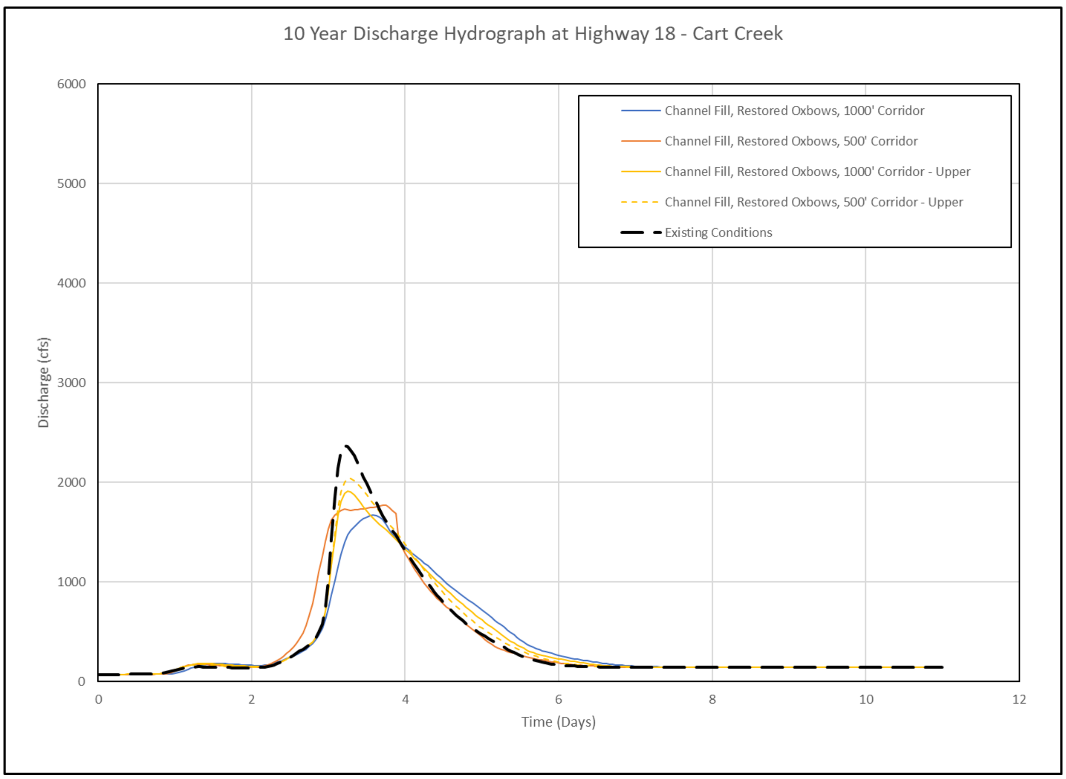

100 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Discharge (cfs)
Time (Days)
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Middle
Channel Fill, Restored Oxbows, 500' Corridor - Middle
Existing Conditions
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

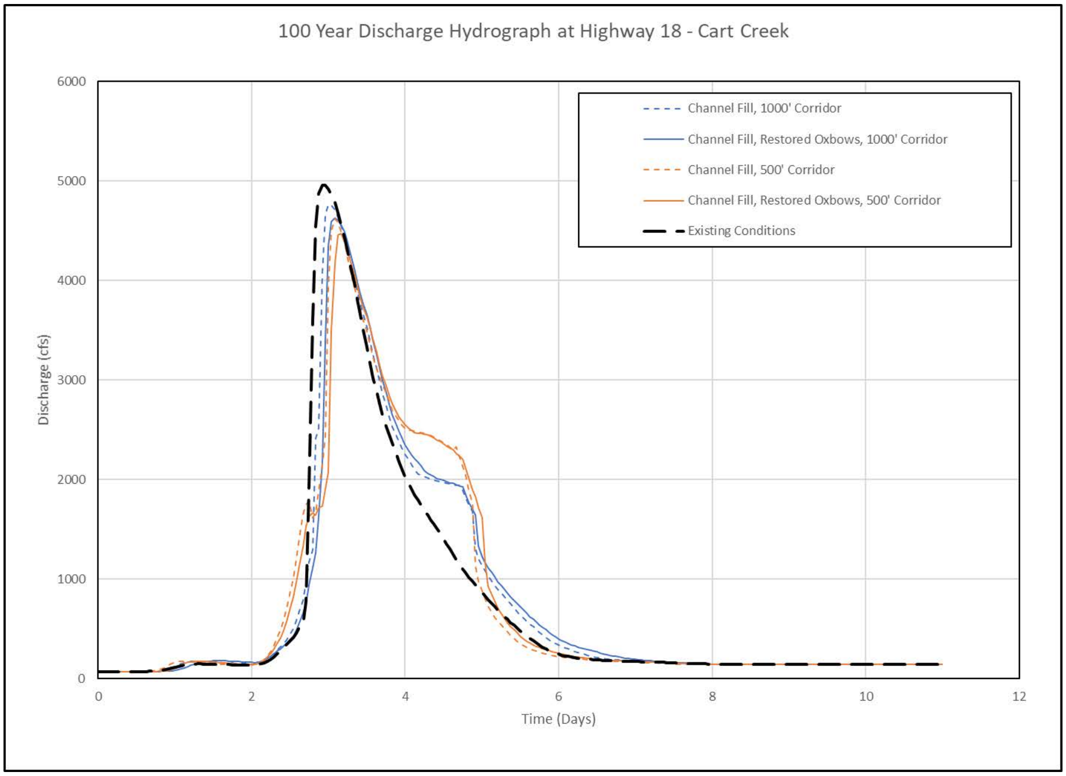

100 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Discharge (cfs)
Time (Days)
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Upper
Channel Fill, Restored Oxbows, 500' Corridor - Upper
Existing Conditions
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

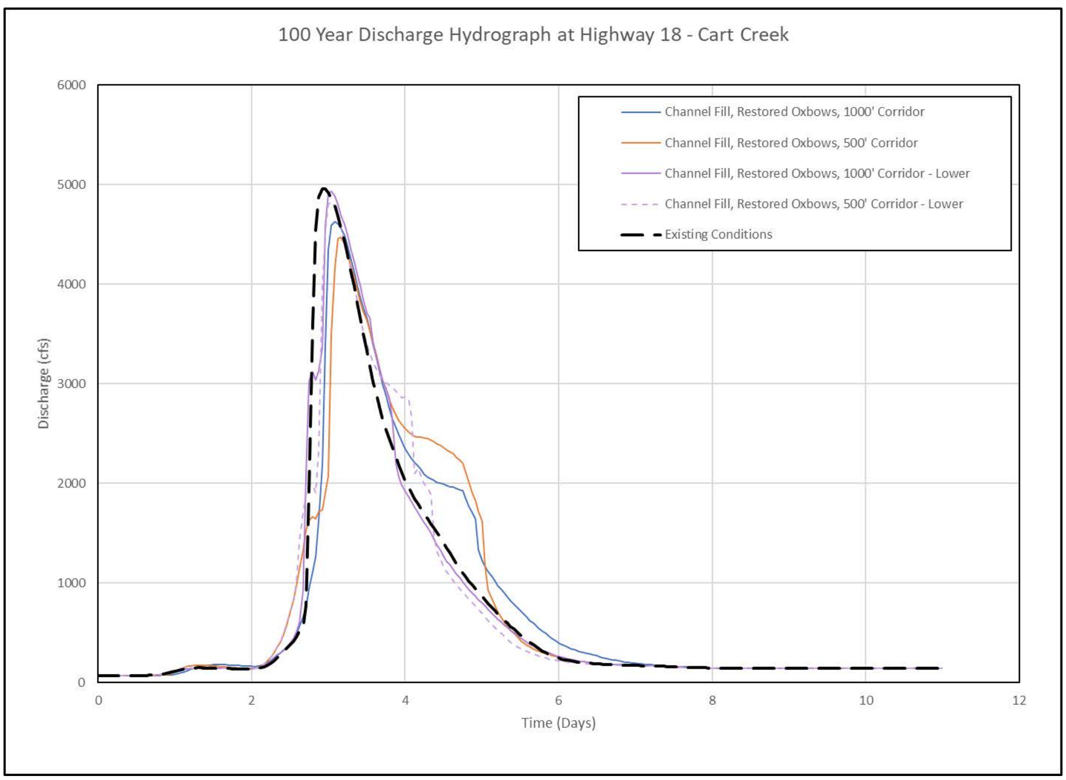

10 Year Discharge Hydrograph at Highway 18 - Cart Creek
Channel Fill, 1000' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, 500' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
0
2
4
6
8
10
12

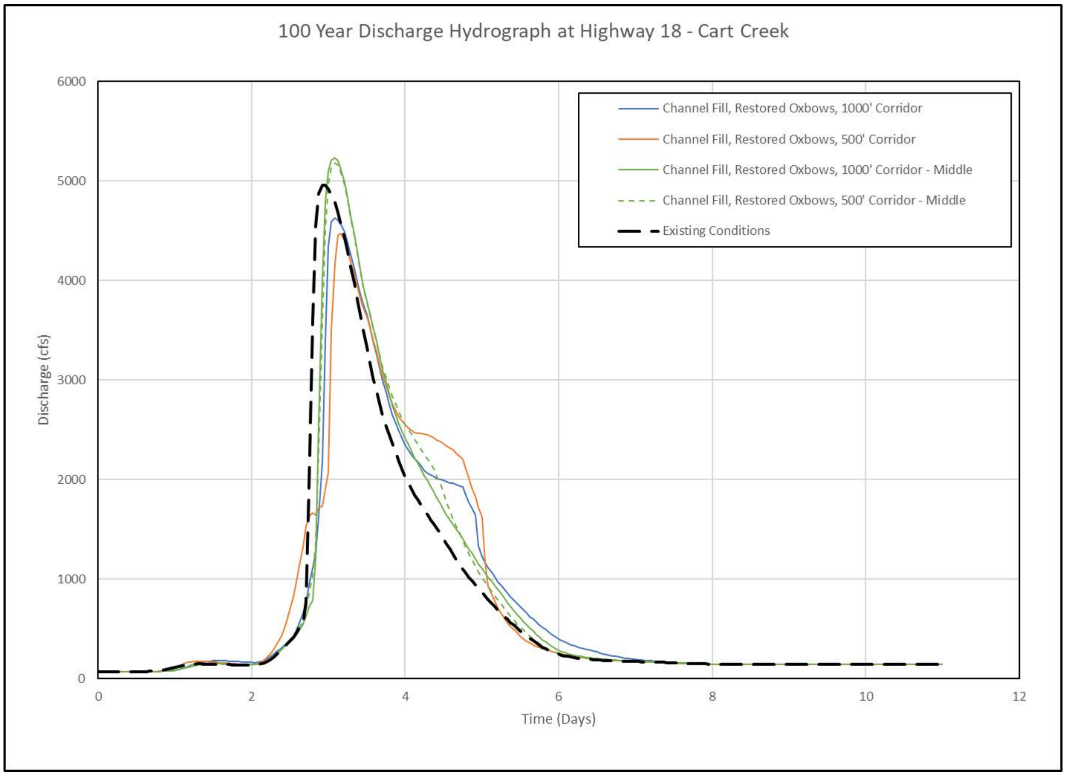

10 Year Discharge Hydrograph at Highway 18 - Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Lower
Channel Fill, Restored Oxbows, 500' Corridor - Lower
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
0
2
4
6
8
10
12


10 Year Discharge Hydrograph at Highway 18 - Cart Creek
Discharge (cfs)
Time (Days)
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Middle
Channel Fill, Restored Oxbows, 500' Corridor - Middle
Existing Conditions
0
1000
2000
3000
4000
5000
6000
0
2
4
6
8
10
12

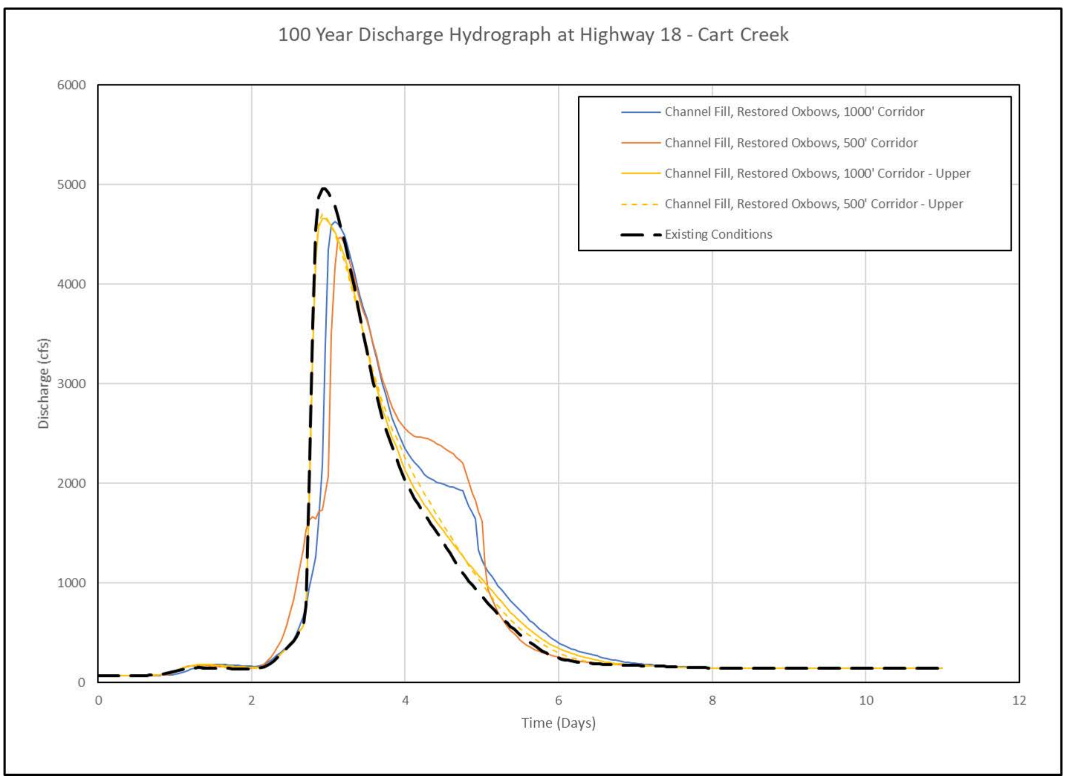

10 Year Discharge Hydrograph at Highway 18 - Cart Creek
Discharge (cfs)
Time (Days)
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Upper
Channel Fill, Restored Oxbows, 500' Corridor - Upper
Existing Conditions
0
1000
2000
3000
4000
5000
6000
0
2
4
6
8
10
12


100 Year Discharge Hydrograph at Highway 18 - Cart Creek
Discharge (cfs)
Time (Days)
Channel Fill, 1000' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, 500' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Existing Conditions
0
1000
2000
3000
4000
5000
6000
0
2
4
6
8
10
12

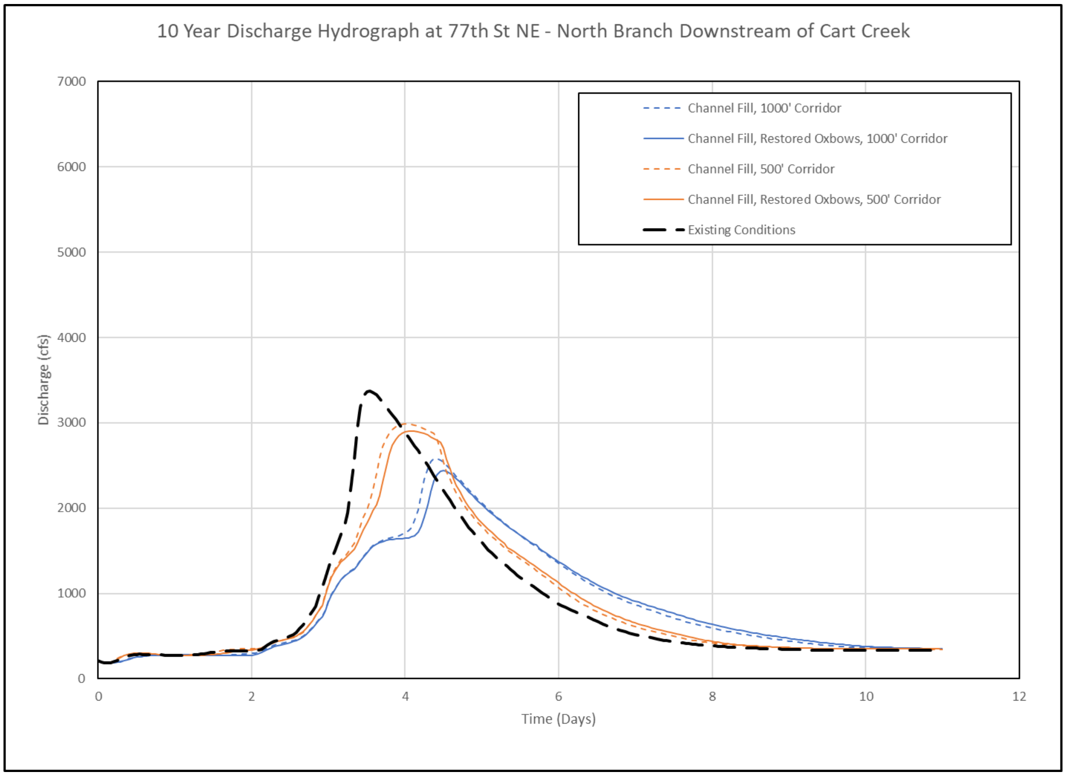

100 Year Discharge Hydrograph at Highway 18 - Cart Creek
Discharge (cfs)
Time (Days)
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Lower
Channel Fill, Restored Oxbows, 500' Corridor - Lower
Existing Conditions
0
1000
2000
3000
4000
5000
6000
0
2
4
6
8
10
12



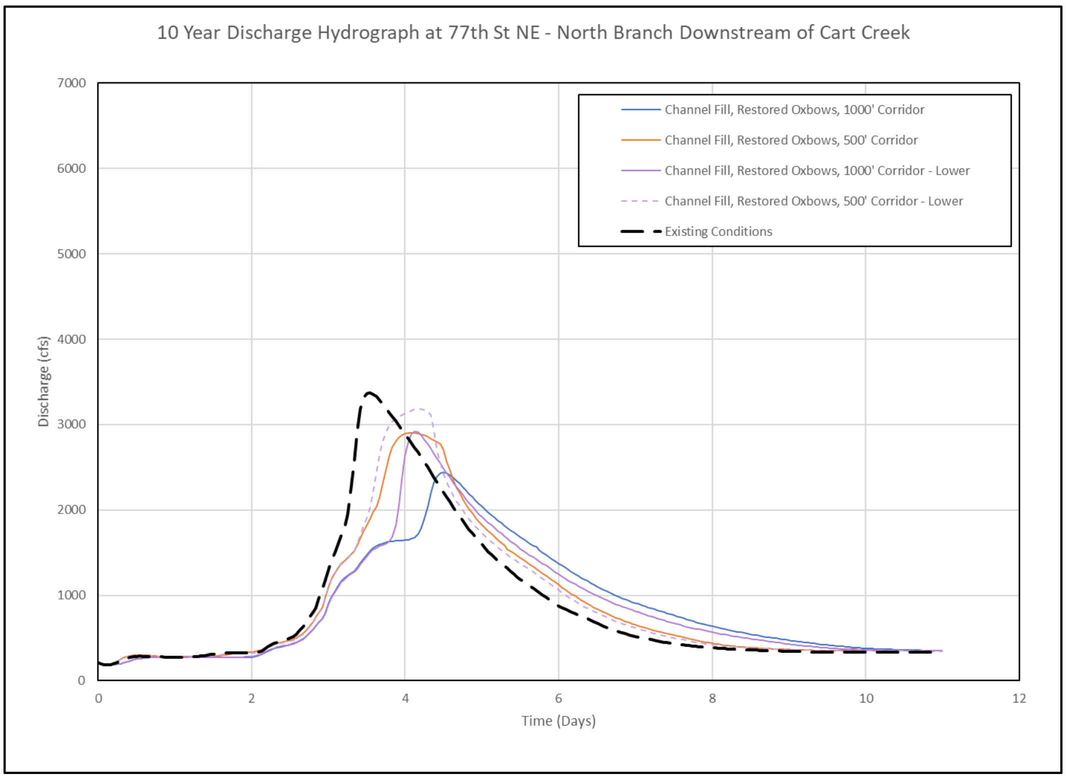
100 Year Discharge Hydrograph at Highway 18 - Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Middle
Channel Fill, Restored Oxbows, 500' Corridor - Middle
Existing Conditions
Discharge (cfs)
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
Time (Days)



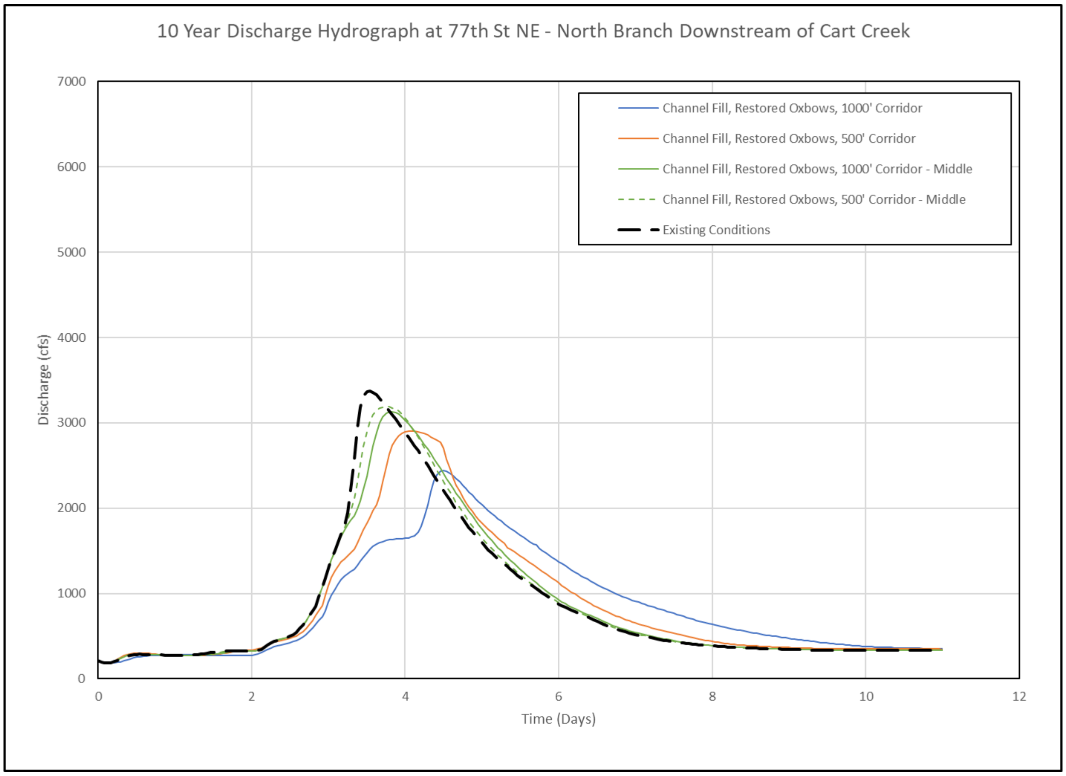
100 Year Discharge Hydrograph at Highway 18 - Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Upper
Channel Fill, Restored Oxbows, 500' Corridor - Upper
Existing Conditions
Discharge (cfs)
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
Time (Days)



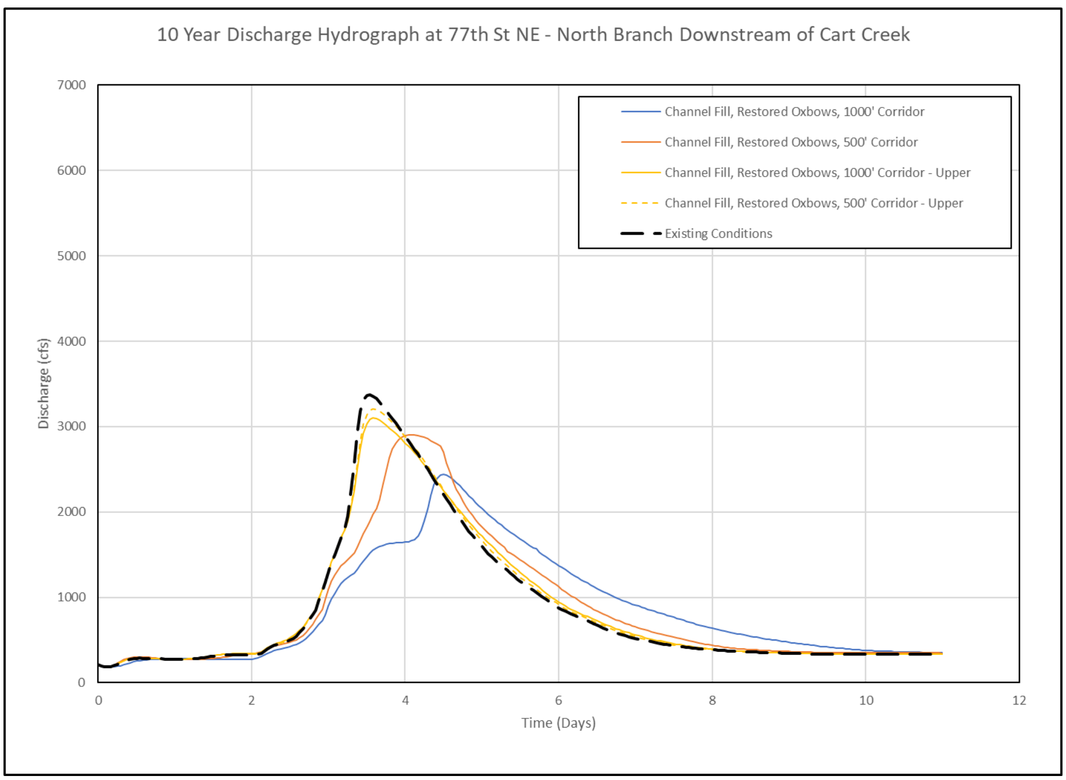
10 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Channel Fill, 1000' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, 500' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12



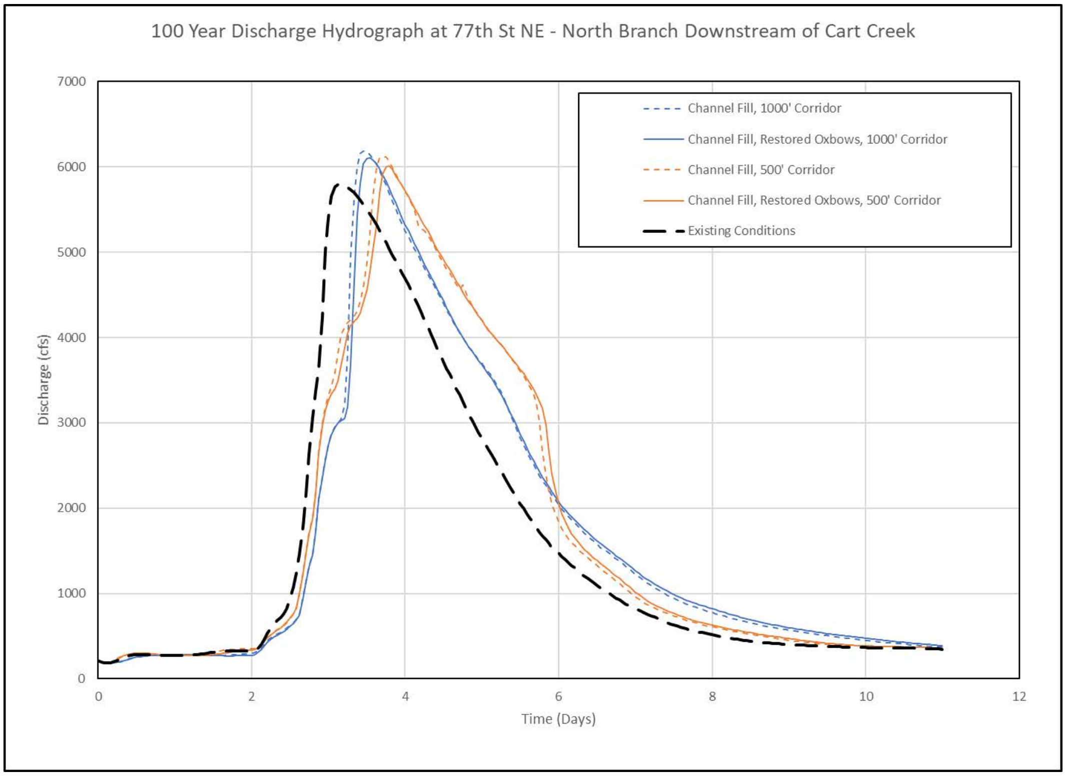
10 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Lower
Channel Fill, Restored Oxbows, 500' Corridor - Lower
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

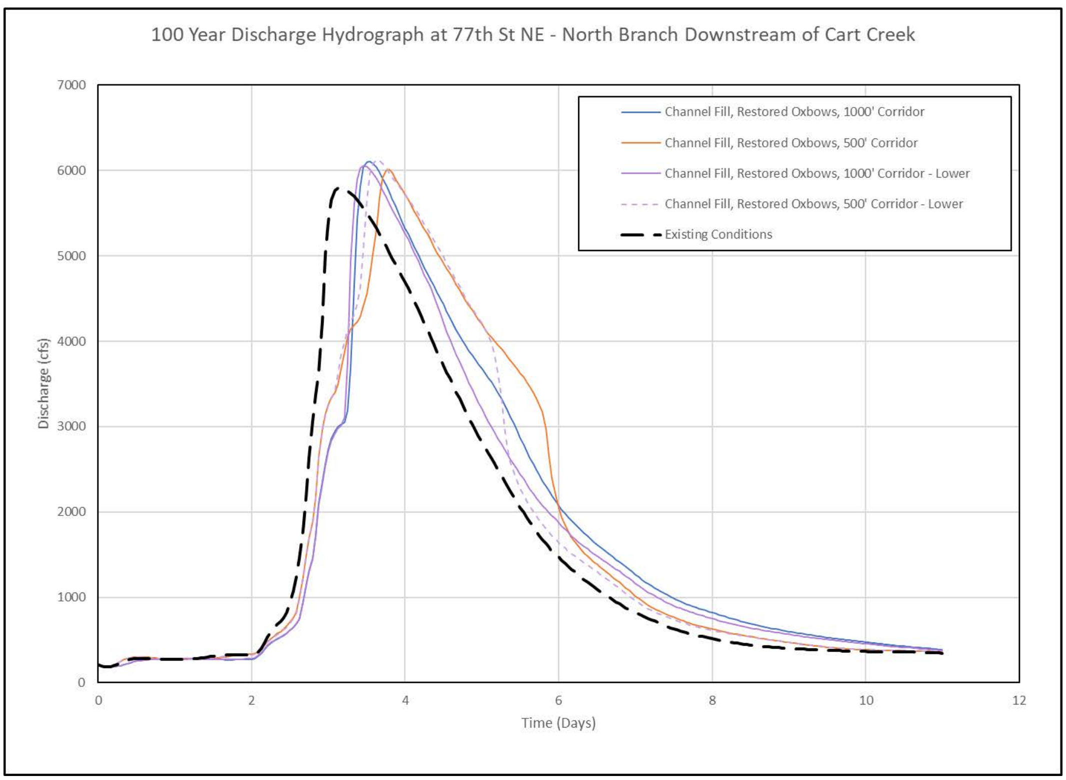


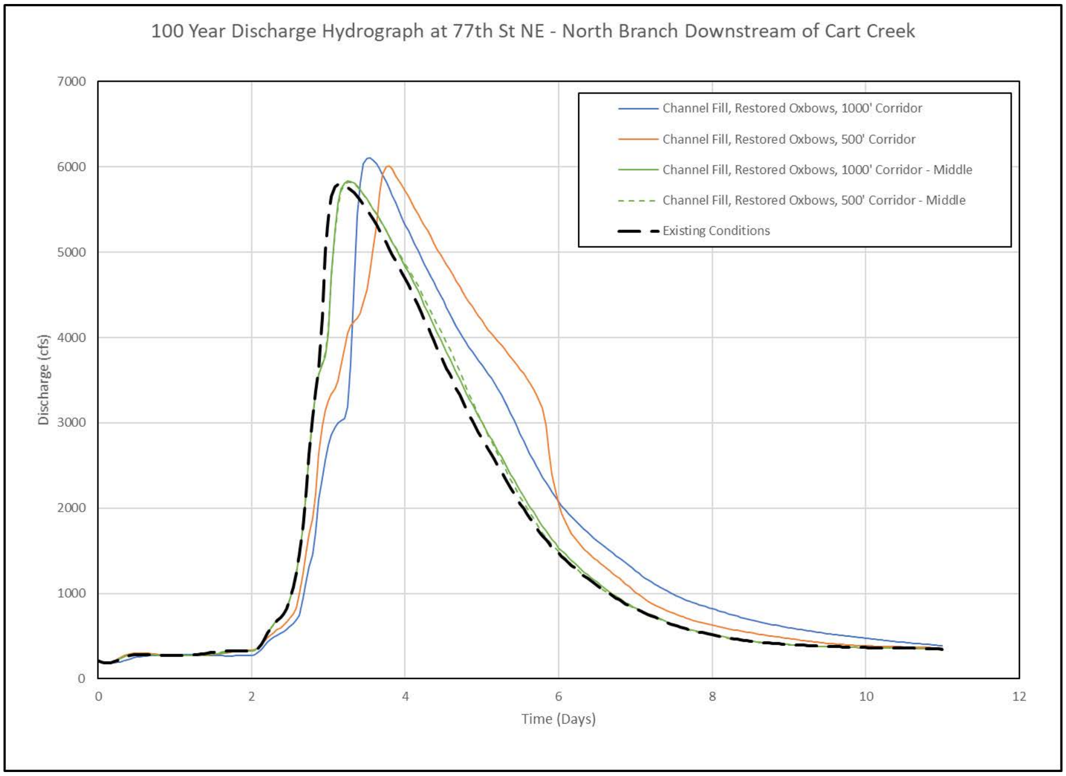
10 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Middle
Channel Fill, Restored Oxbows, 500' Corridor - Middle
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

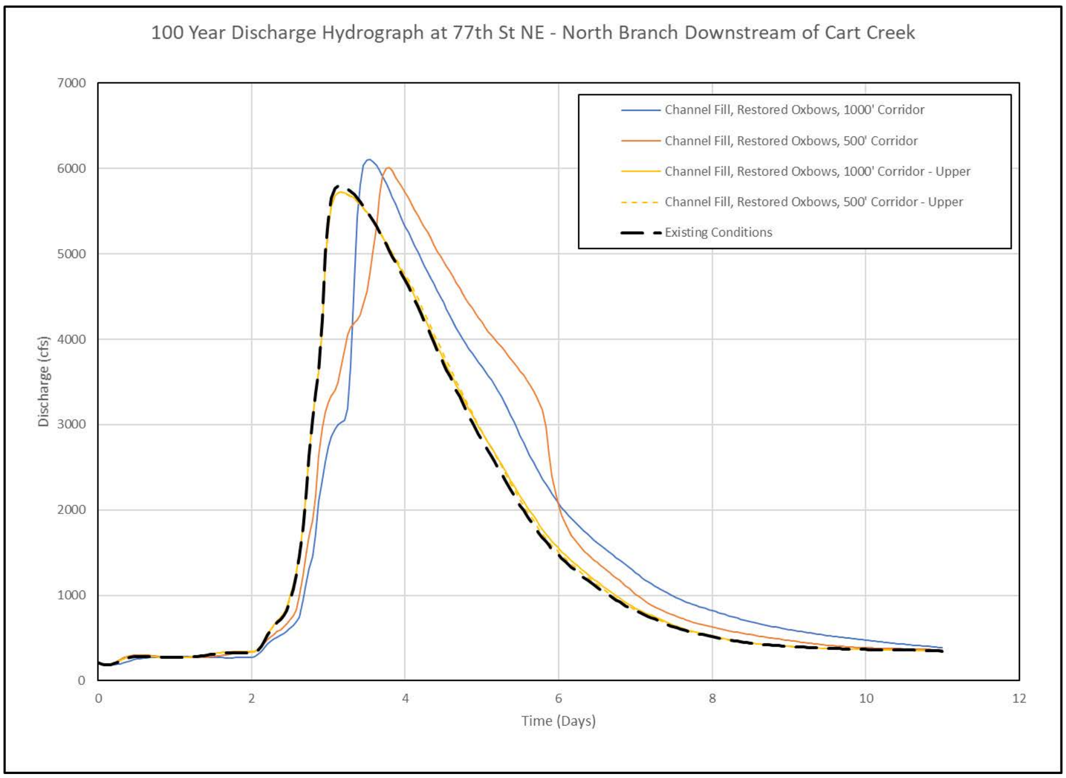


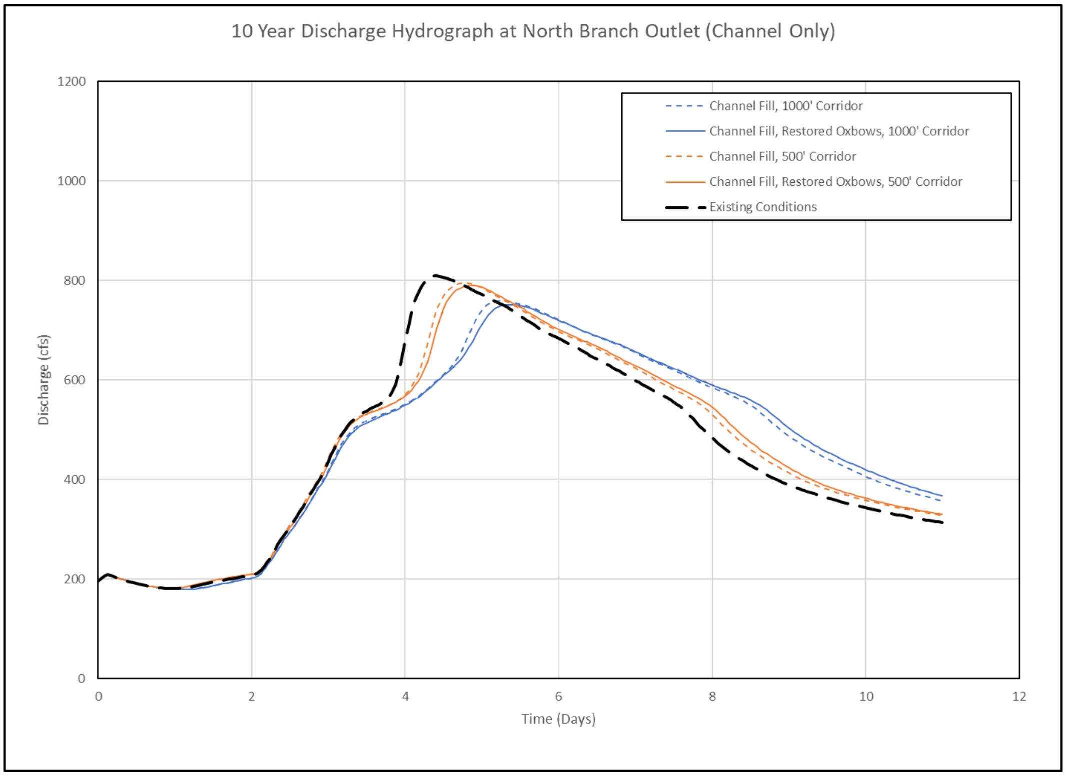
10 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Upper
Channel Fill, Restored Oxbows, 500' Corridor - Upper
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12


100 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Channel Fill, 1000' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, 500' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

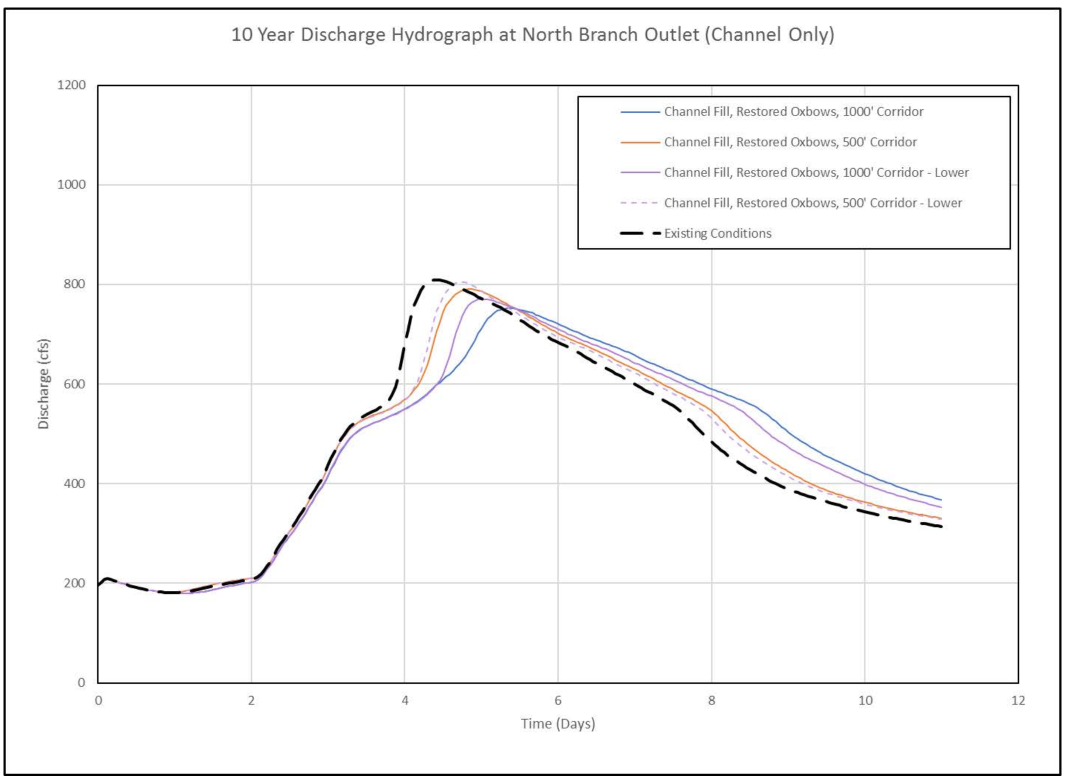

100 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Lower
Channel Fill, Restored Oxbows, 500' Corridor - Lower
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12


100 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Middle
Channel Fill, Restored Oxbows, 500' Corridor - Middle
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

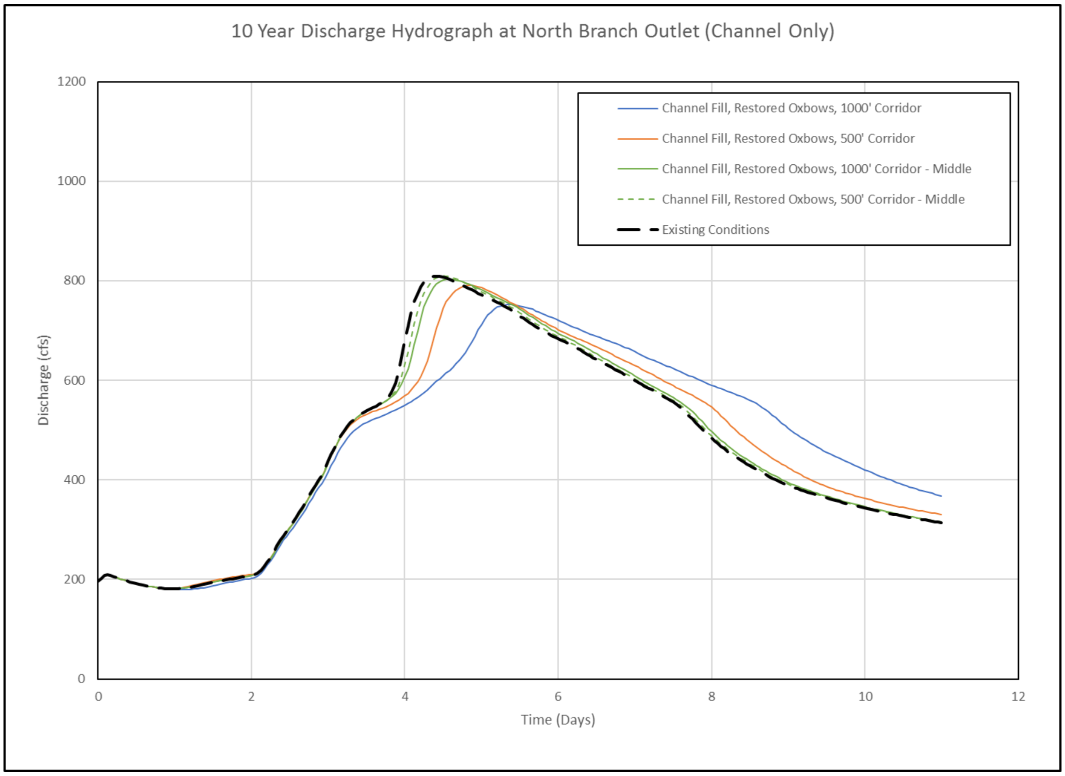

100 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Upper
Channel Fill, Restored Oxbows, 500' Corridor - Upper
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

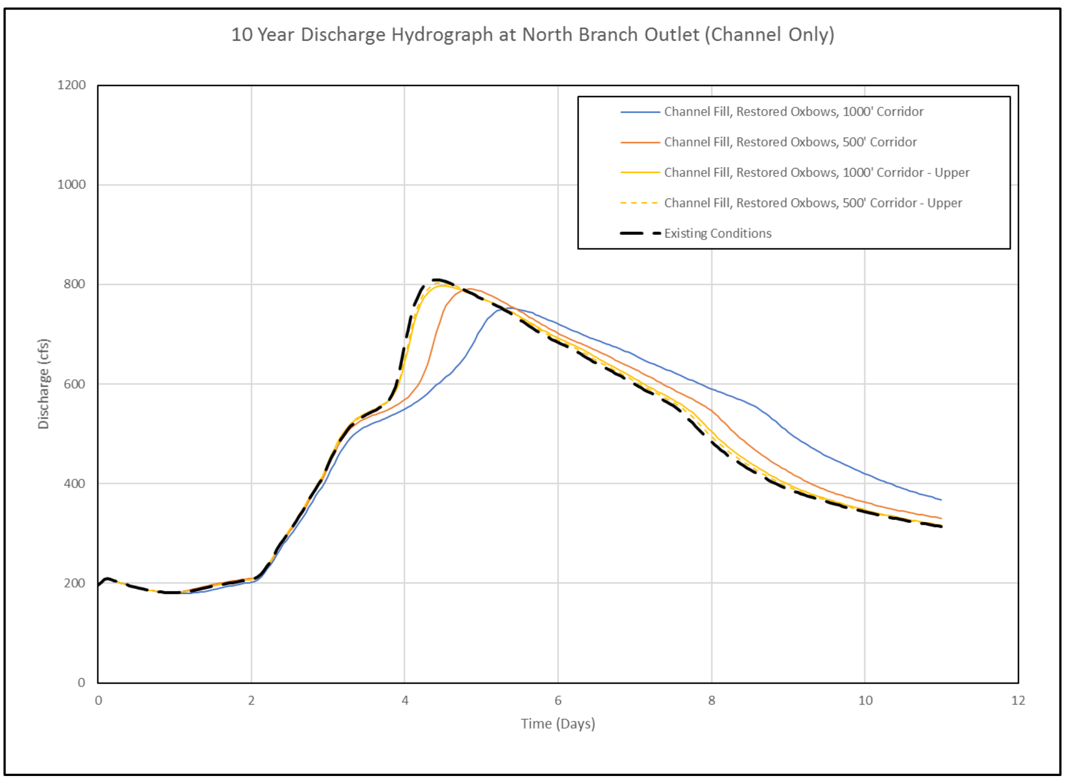


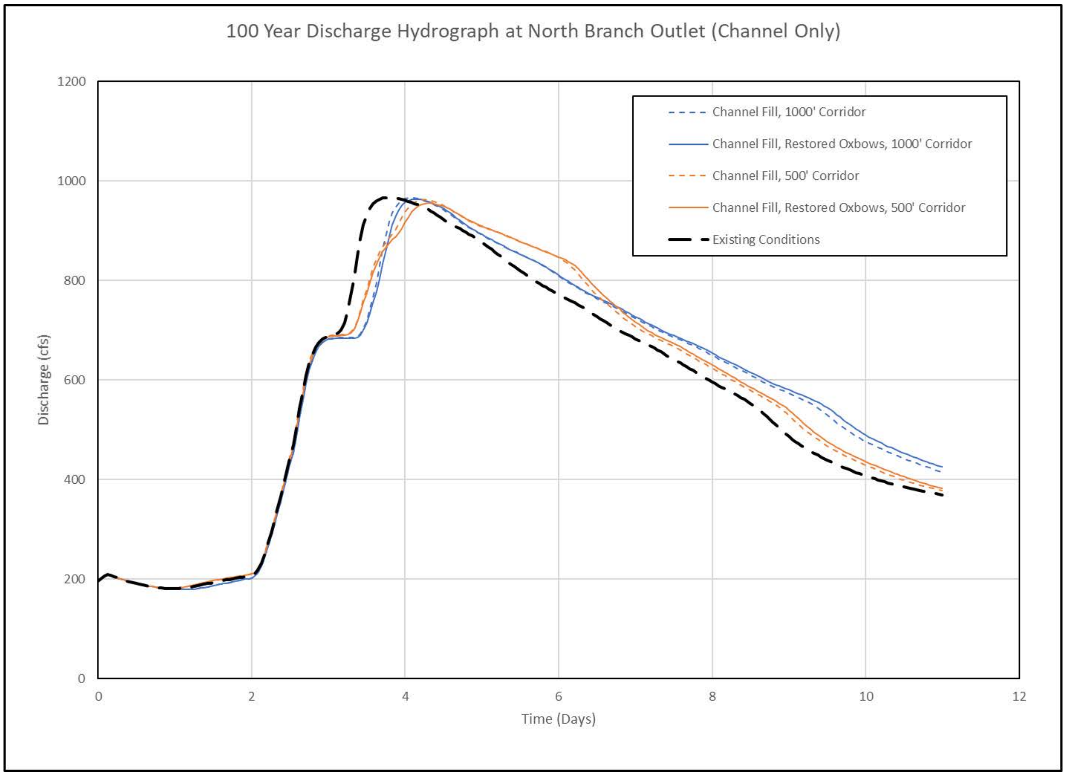
10 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Channel Fill, 1000' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, 500' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Existing Conditions
Discharge (cfs)
Time (Days)
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12

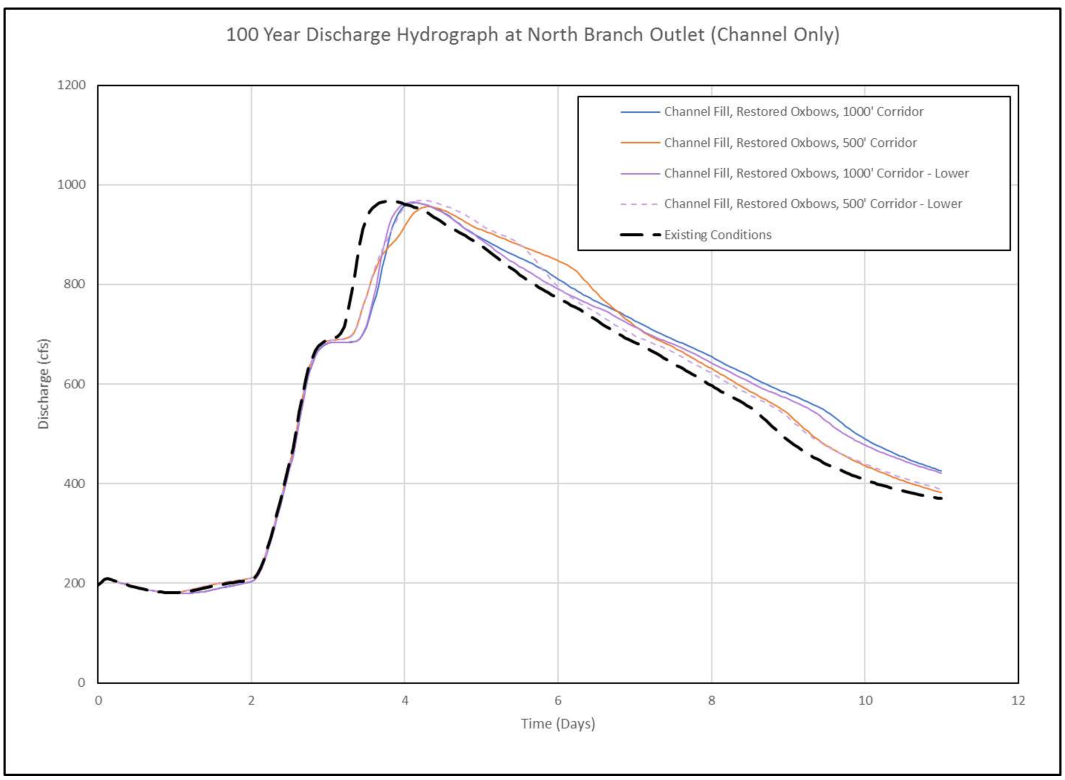


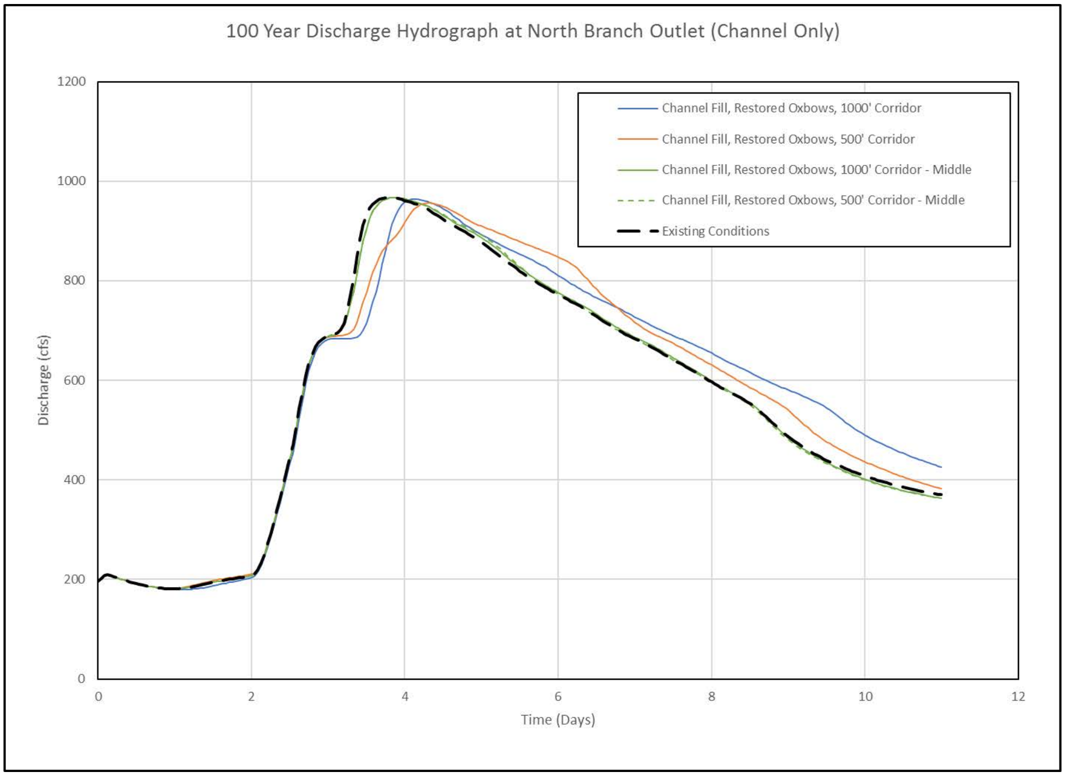
10 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Lower
Channel Fill, Restored Oxbows, 500' Corridor - Lower
Existing Conditions
Discharge (cfs)
Time (Days)
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12

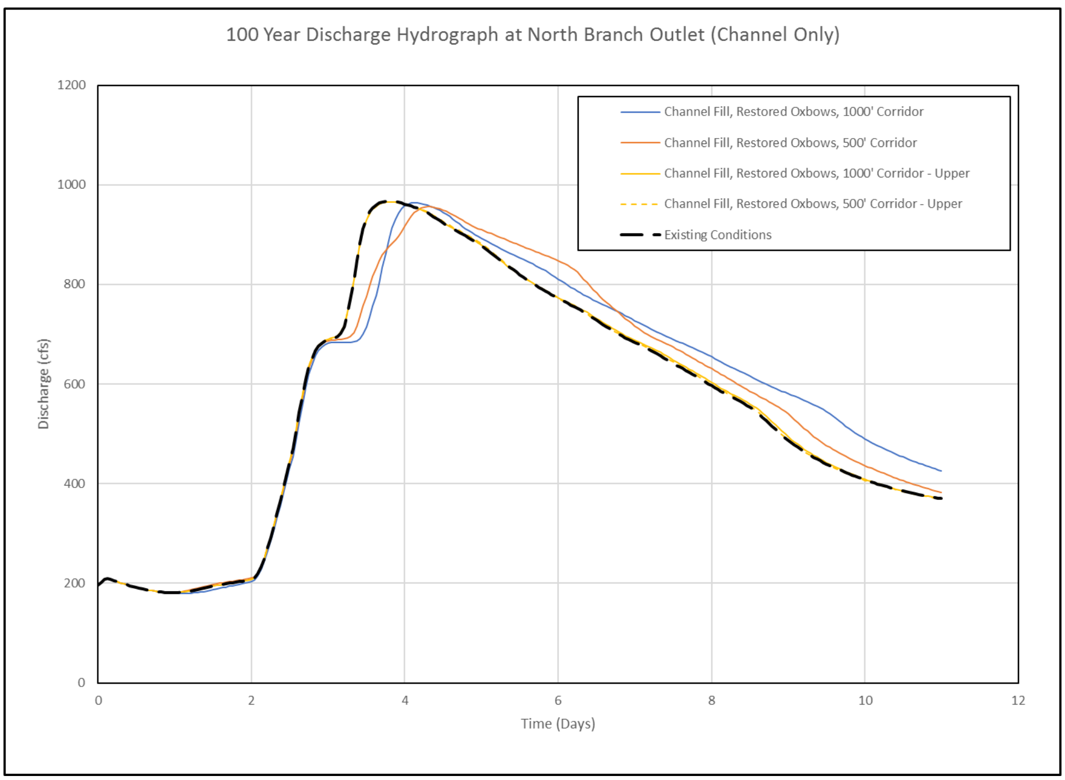

10 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Discharge (cfs)
Time (Days)
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Middle
Channel Fill, Restored Oxbows, 500' Corridor - Middle
Existing Conditions

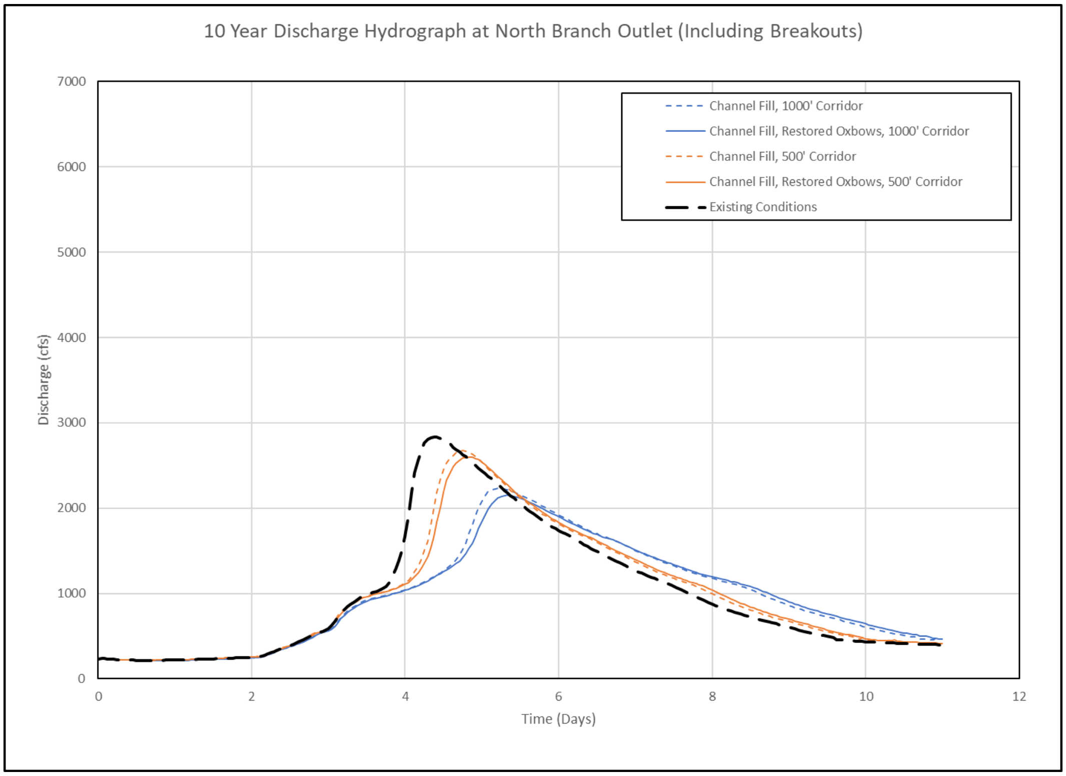

10 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Discharge (cfs)
Time (Days)
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Upper
Channel Fill, Restored Oxbows, 500' Corridor - Upper
Existing Conditions

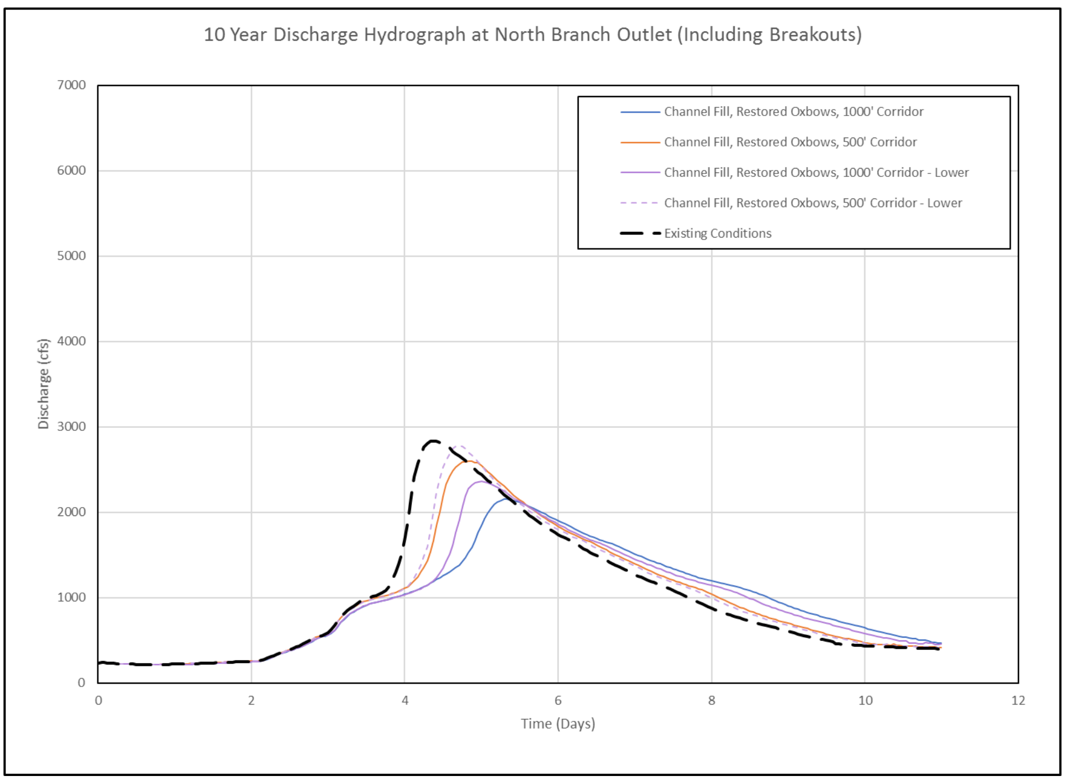

100 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Channel Fill, 1000' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, 500' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Existing Conditions
Discharge (cfs)
Time (Days)
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12

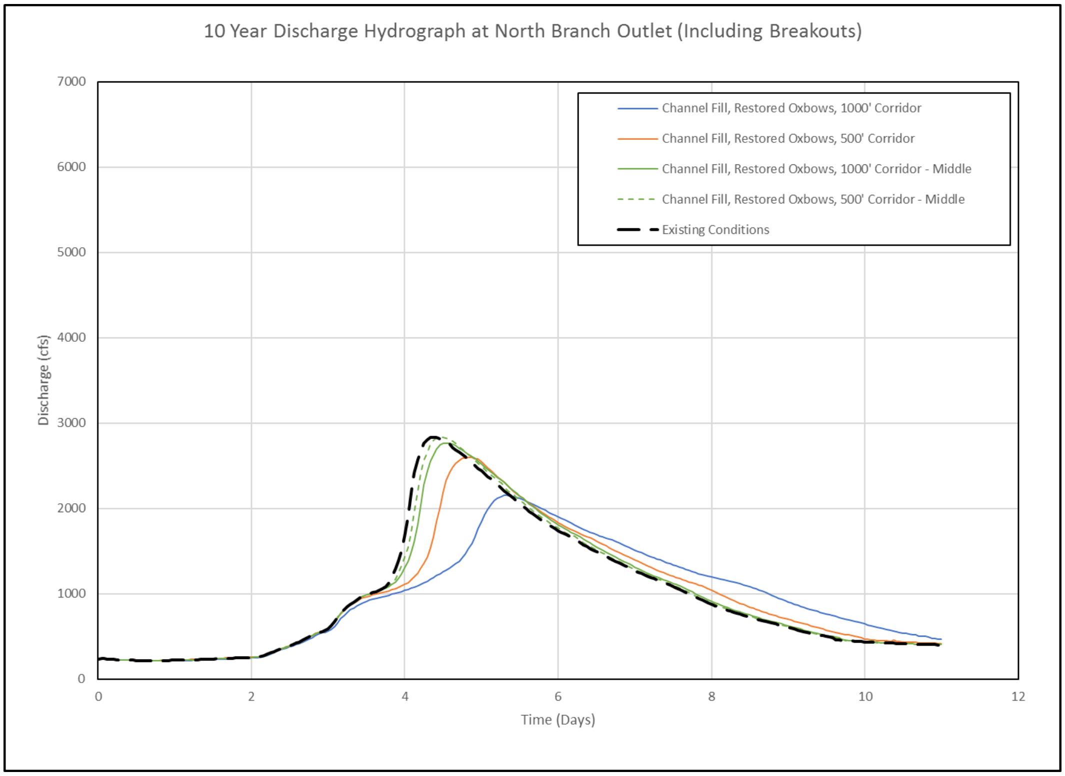

100 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Lower
Channel Fill, Restored Oxbows, 500' Corridor - Lower
Existing Conditions
Discharge (cfs)
Time (Days)
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12

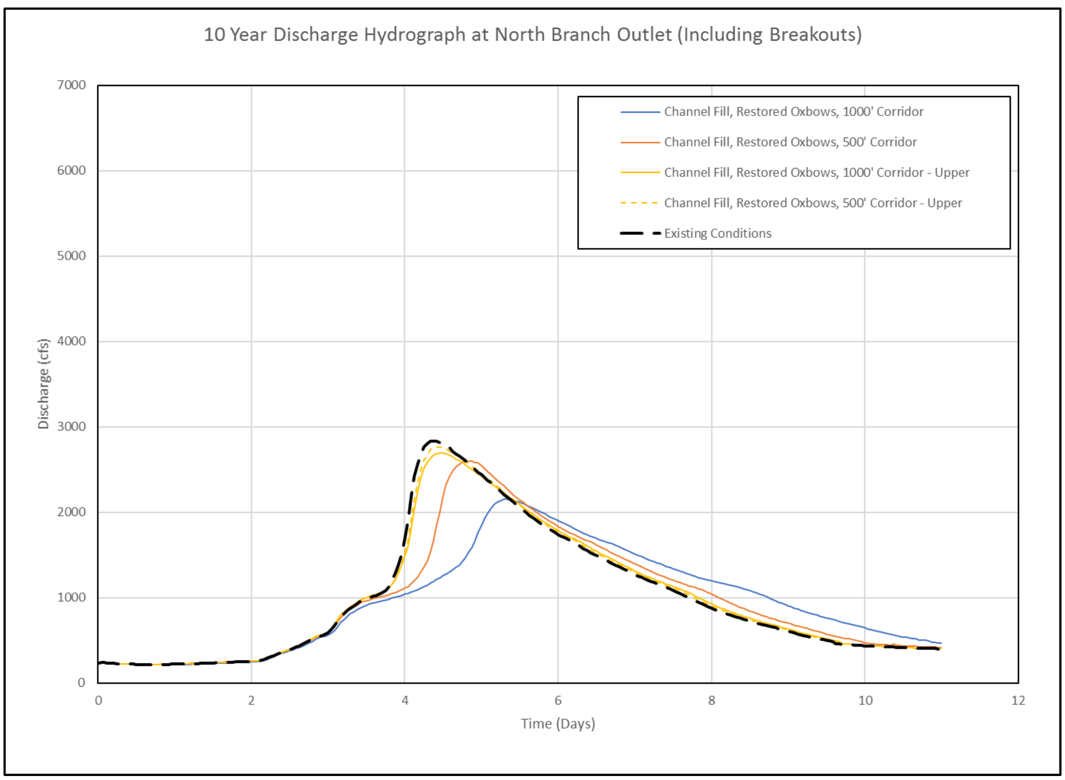

100 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Discharge (cfs)
Time (Days)
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Middle
Channel Fill, Restored Oxbows, 500' Corridor - Middle
Existing Conditions

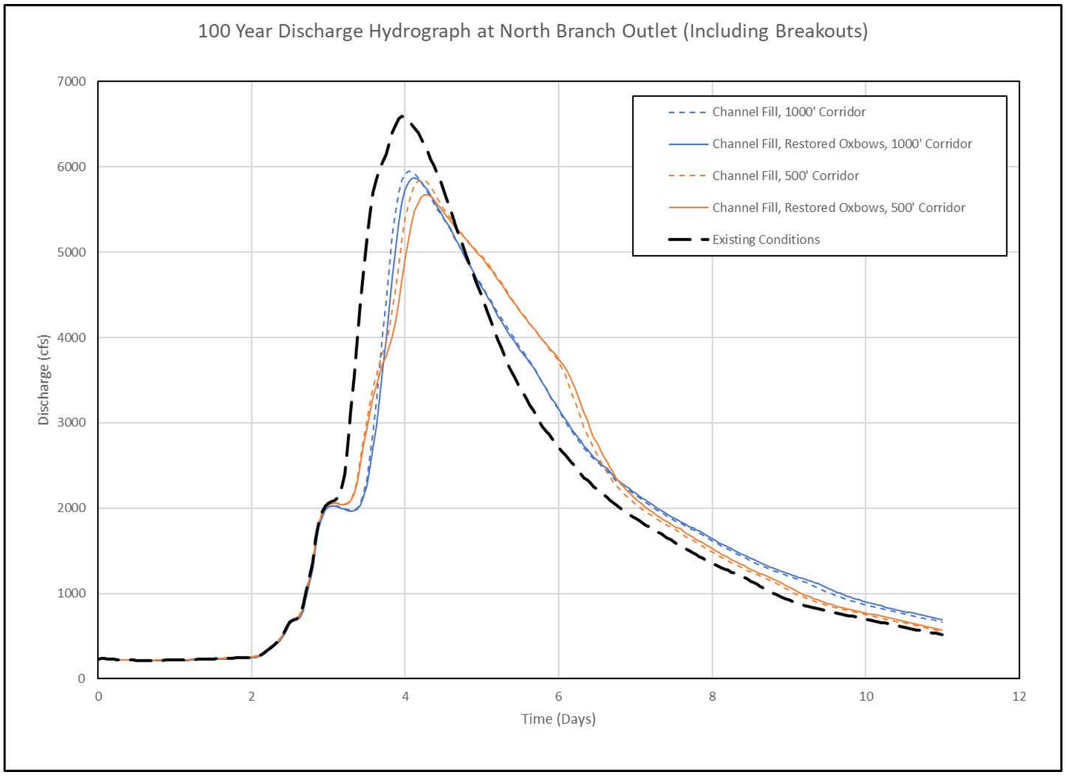

100 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Discharge (cfs)
Time (Days)
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Upper
Channel Fill, Restored Oxbows, 500' Corridor - Upper
Existing Conditions


10 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Channel Fill, 1000' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, 500' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

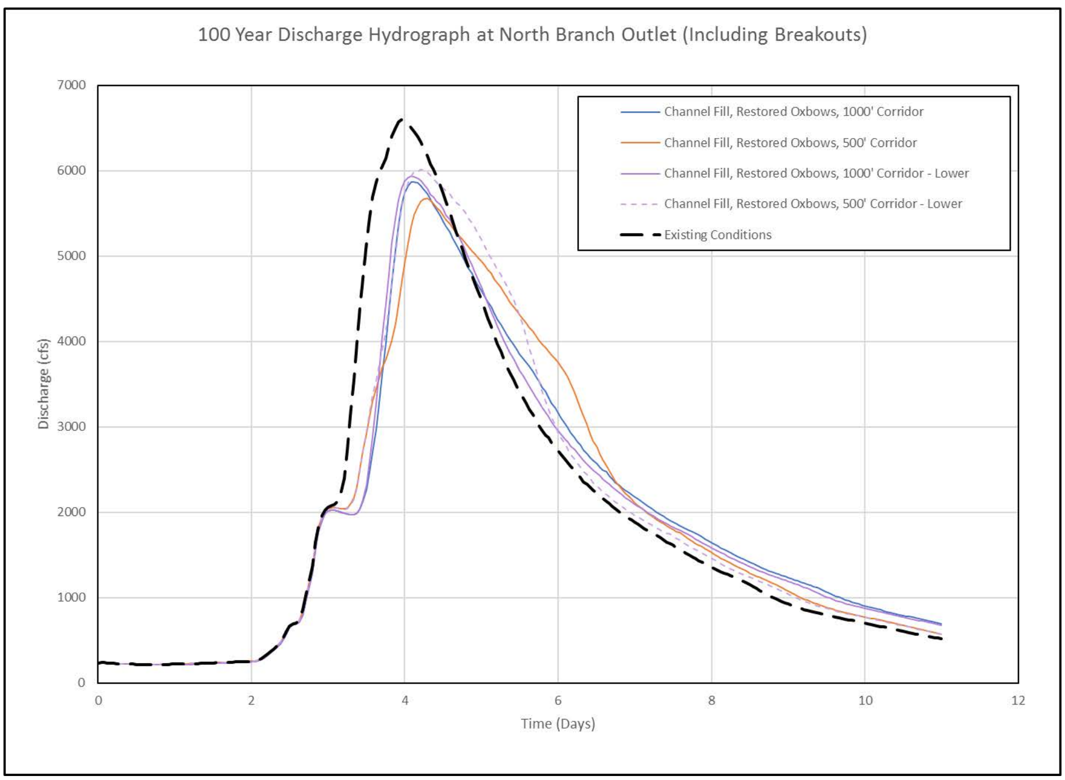

10 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Lower
Channel Fill, Restored Oxbows, 500' Corridor - Lower
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12


10 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Middle
Channel Fill, Restored Oxbows, 500' Corridor - Middle
Existing Conditions

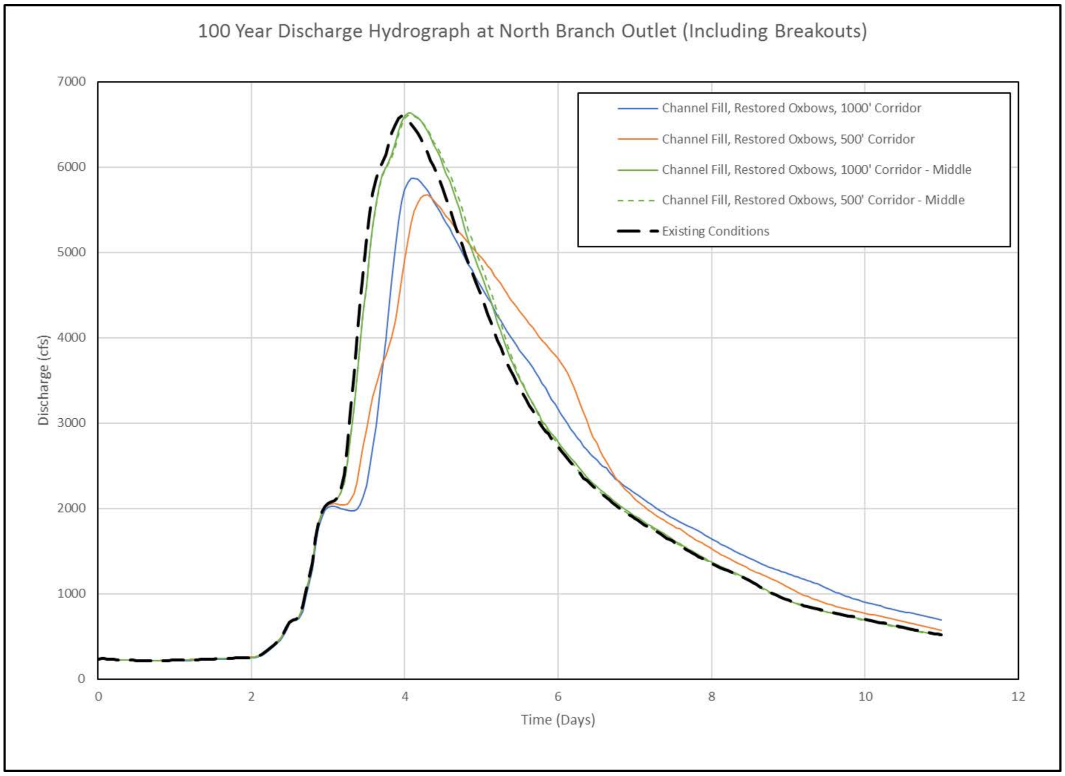

10 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Upper
Channel Fill, Restored Oxbows, 500' Corridor - Upper
Existing Conditions

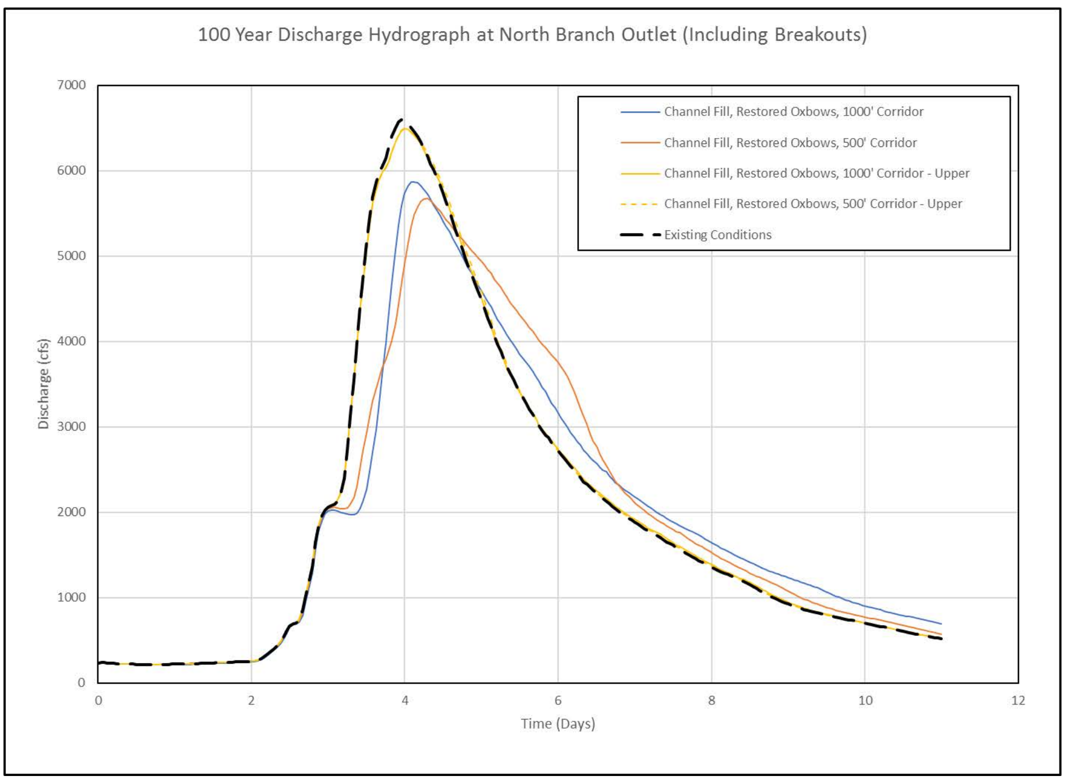


100 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Channel Fill, 1000' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, 500' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12



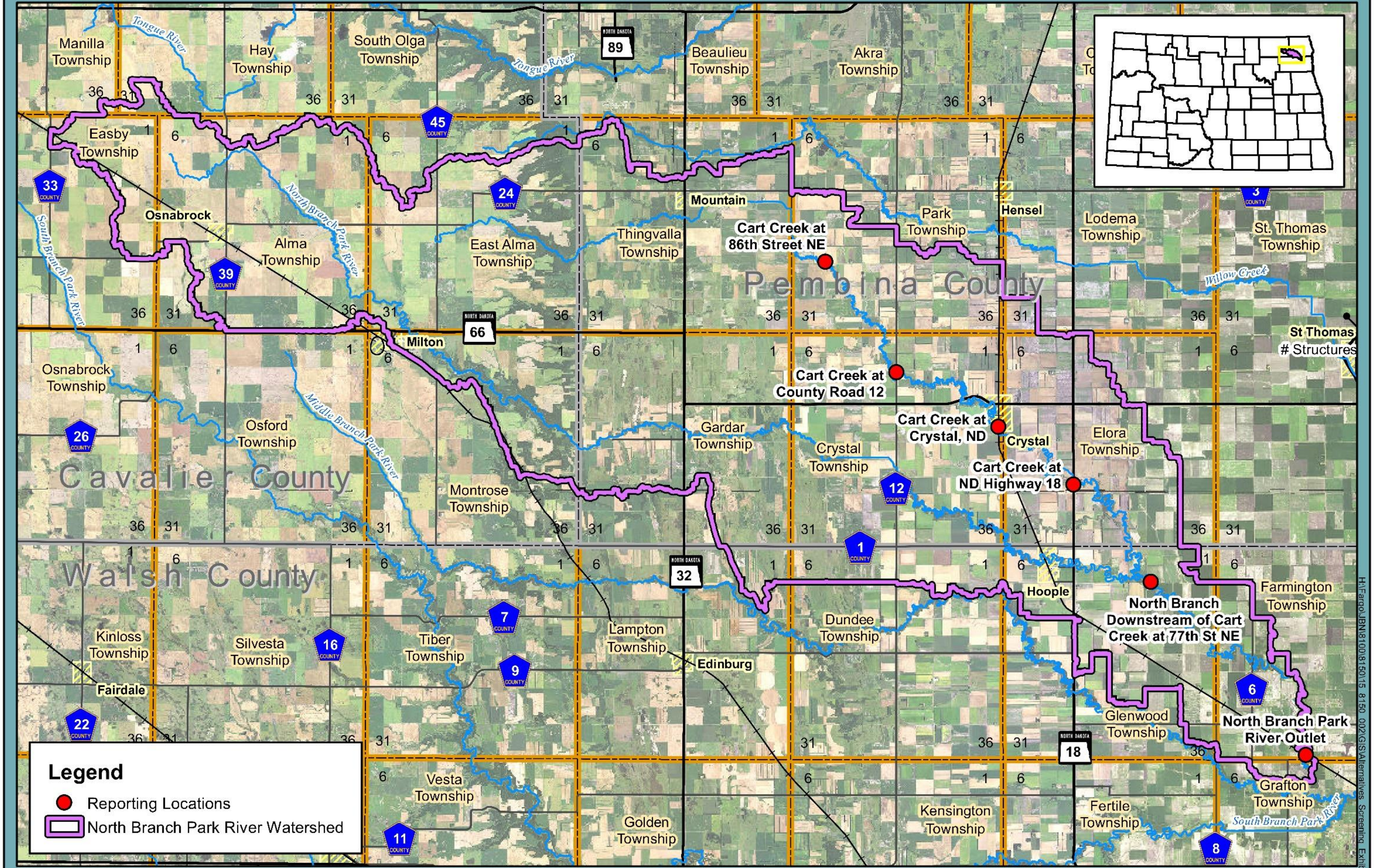
100 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Lower
Channel Fill, Restored Oxbows, 500' Corridor - Lower
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12


100 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Middle
Channel Fill, Restored Oxbows, 500' Corridor - Middle
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12


100 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Channel Fill, Restored Oxbows, 1000' Corridor
Channel Fill, Restored Oxbows, 500' Corridor
Channel Fill, Restored Oxbows, 1000' Corridor - Upper
Channel Fill, Restored Oxbows, 500' Corridor - Upper
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

ATTACHMENT D-2-B

Figure D-2-B.1: Identified Alternatives – Reporting Locations
D-2-B.2 Alternative 1 – Agricultural Levees (Stand-Alone) – Hydrographs
D-2-B.3 Alternatives 2-4 – Milton Dam, Cart Creek Impoundment Site 1, and 2 – Hydrographs
D-2-B.4 Alternatives 5-6 – Diversion Channel, and Diversion Channel with Storage – Hydrographs



F-B.1

Figure B.1: Identified Alternatives - Reporting Locations

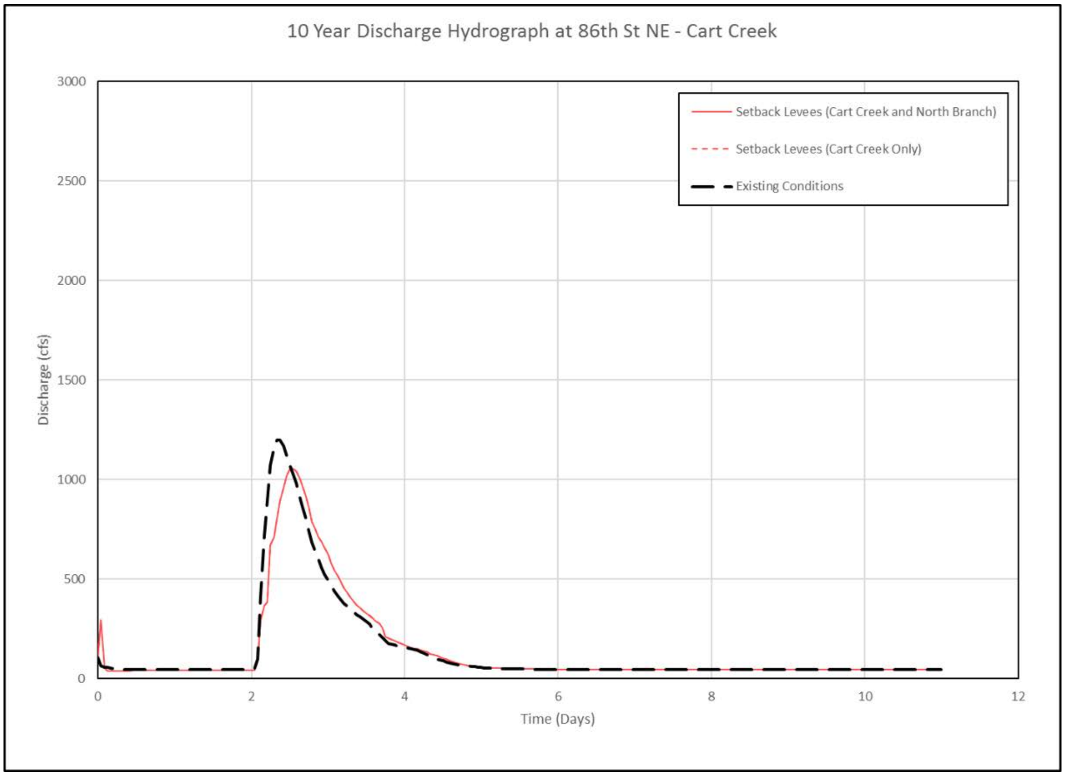
North Branch Park River Watershed
Screening of Alternatives for Detailed Review
Park River Joint Water Resource District

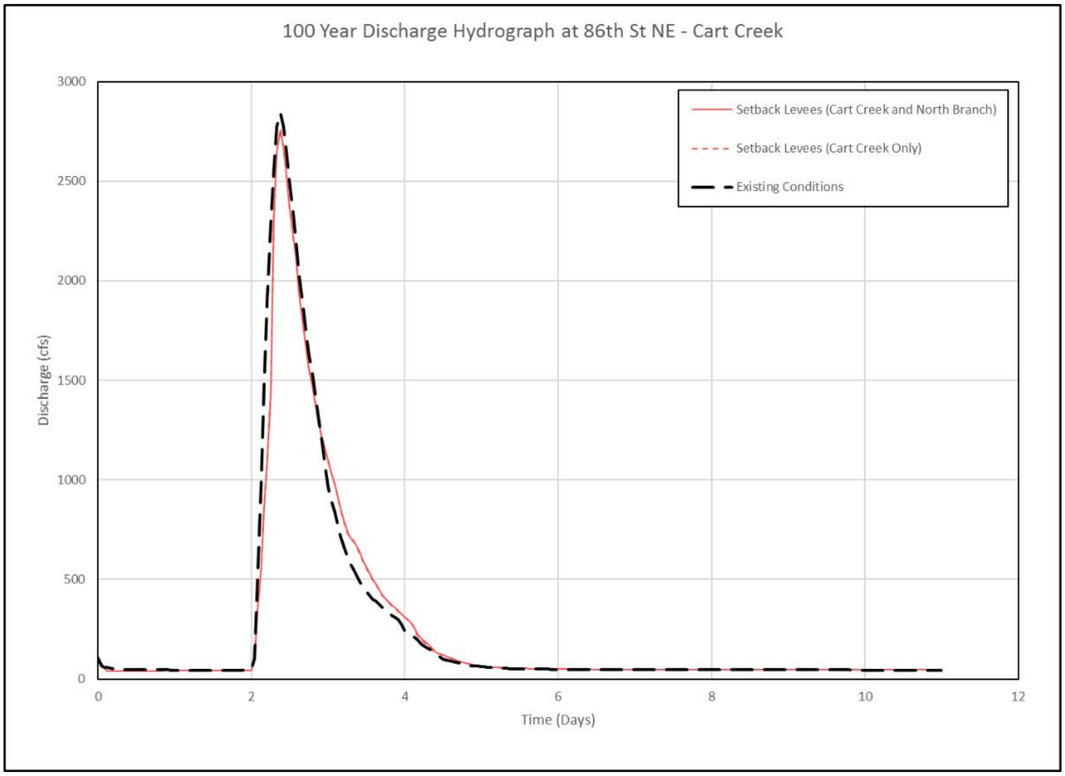
0 1.75 3.5 7 Miles

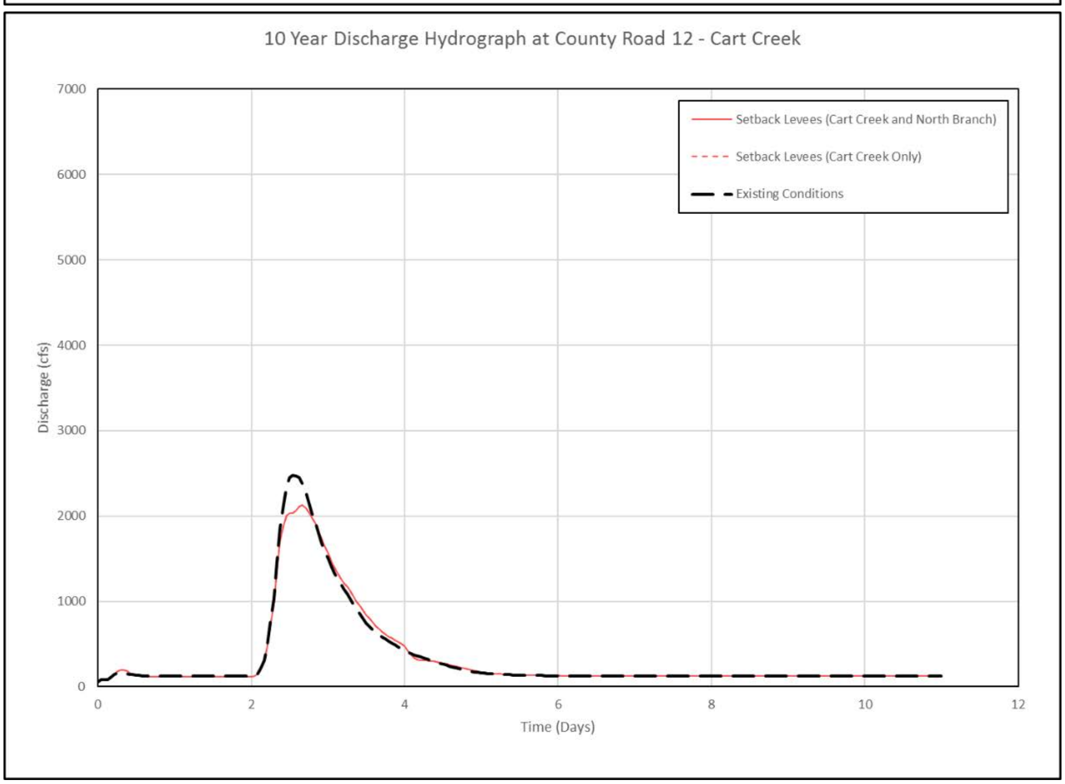
Houston Engineering Inc.

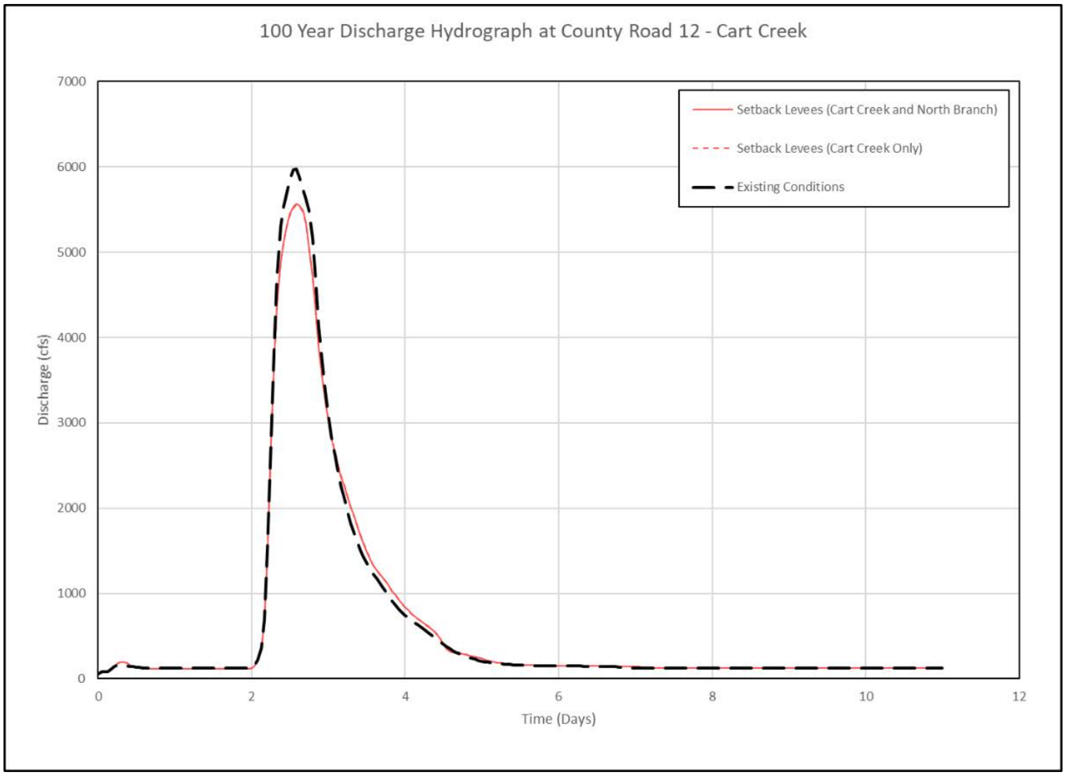
H:\Fargo\JBN\8100\8150\15_8150_002\GIS\Alternatives_Screening_Exhibit_A_RCPP.mxd

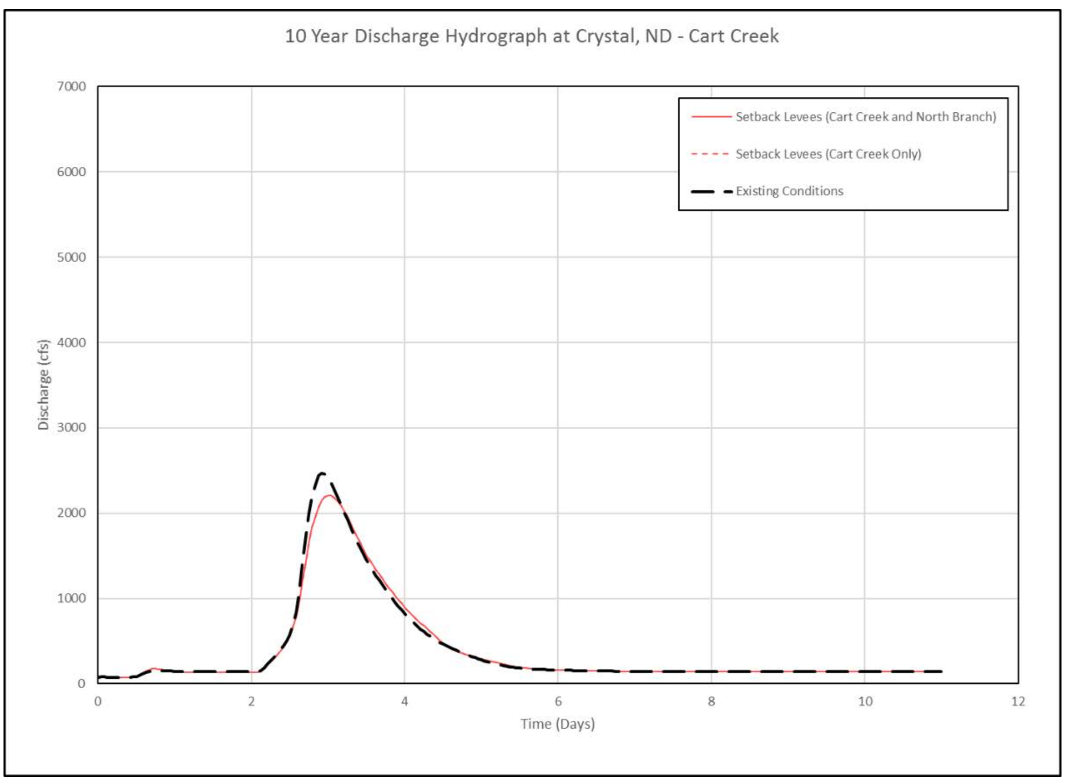
D-2-B.2 ALTERNATIVE 1 – AGRICULTURAL LEVEES (STAND-ALONE) - HYDROGRAPHS

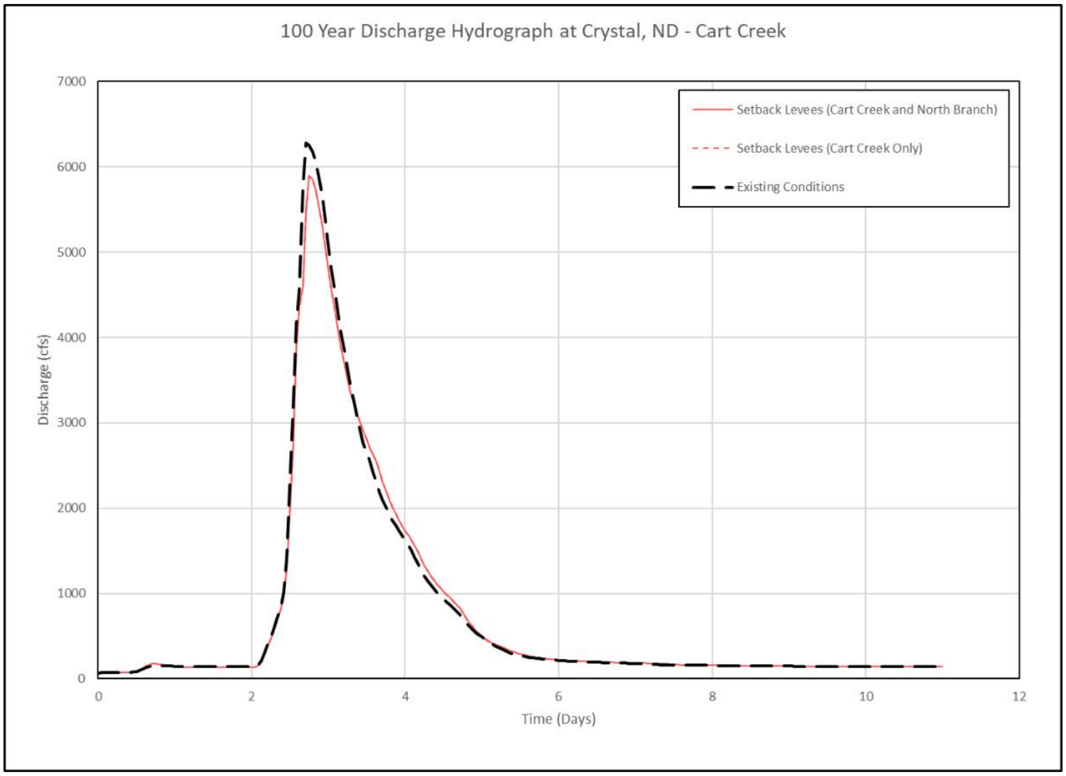


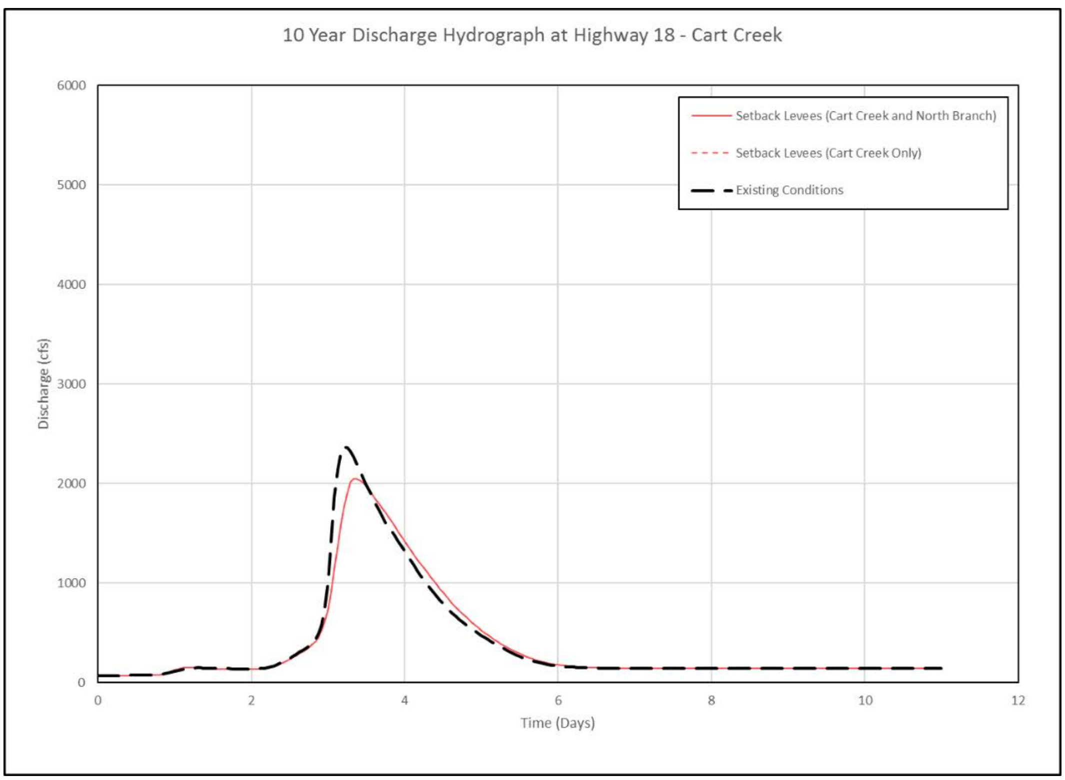

100 Year Discharge Hydrograph at 86th St NE - Cart Creek
Setback Levees (Cart Creek and North Branch)
Setback Levees (Cart Creek Only)
Existing Conditions
Discharge (cfs)
Time (Days)
0
500
1000
1500
2000
2500
3000
0
2
4
6
8
10
12

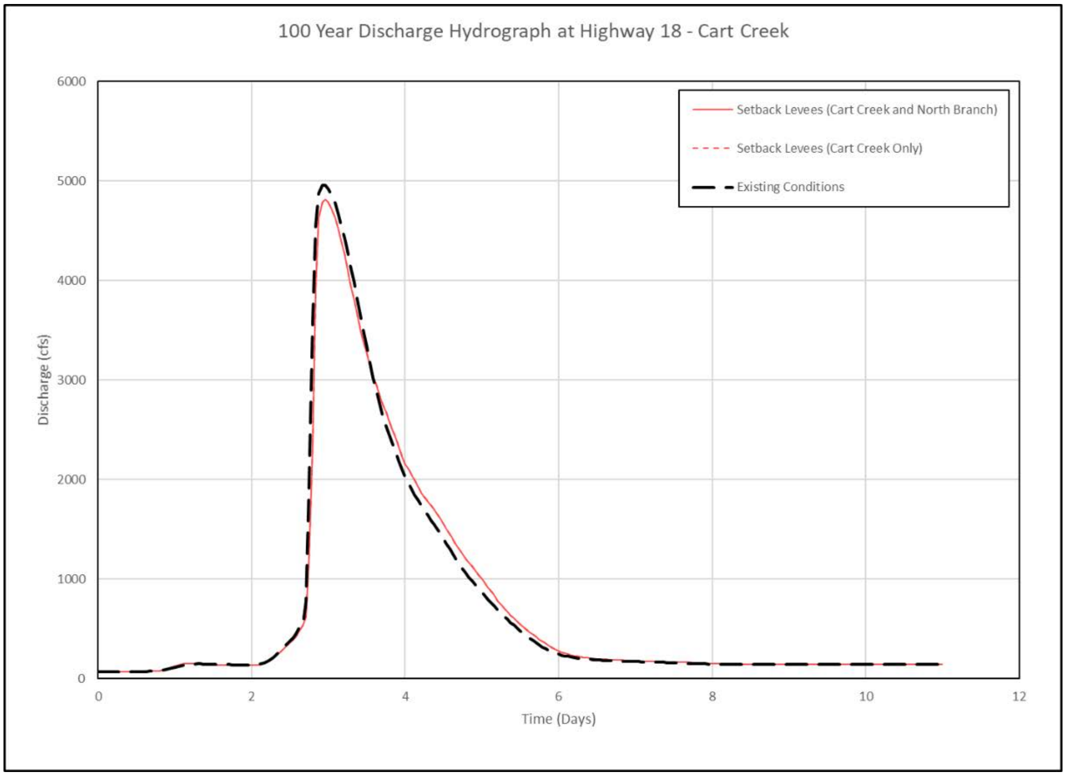

10 Year Discharge Hydrograph at County Road 12 - Cart Creek
Setback Levees (Cart Creek and North Branch)
Setback Levees (Cart Creek Only)
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

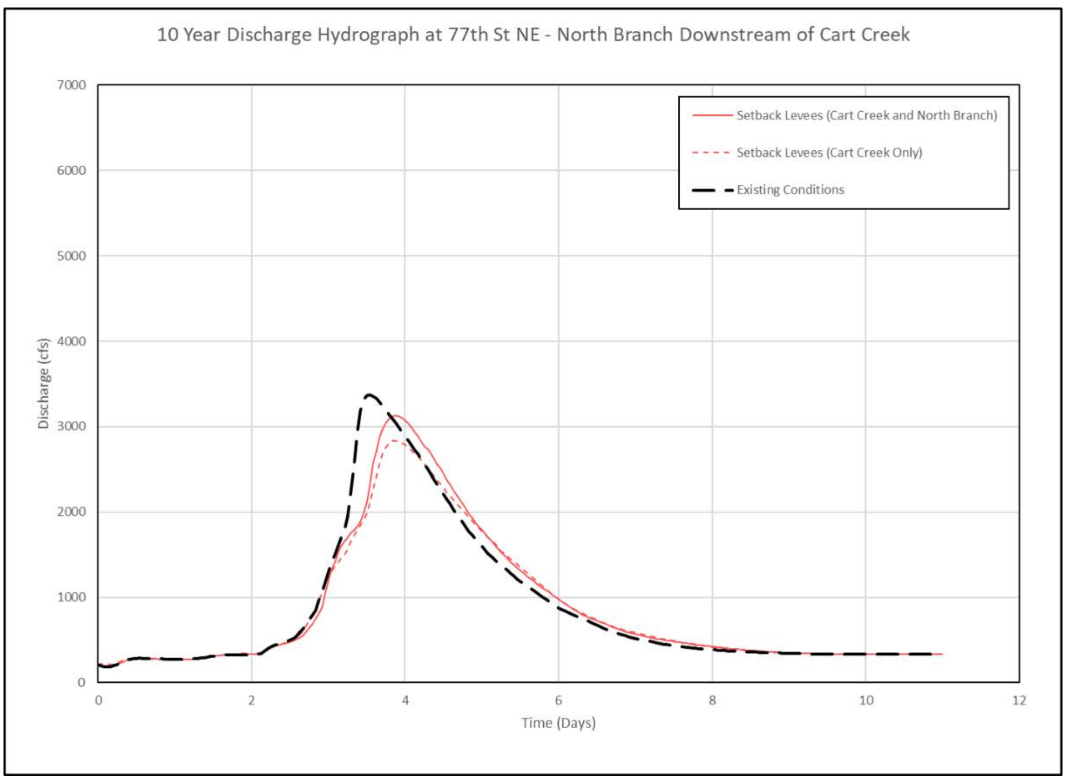

100 Year Discharge Hydrograph at County Road 12 - Cart Creek
Setback Levees (Cart Creek and North Branch)
Setback Levees (Cart Creek Only)
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12


10 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Setback Levees (Cart Creek and North Branch)
Setback Levees (Cart Creek Only)
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12


100 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Setback Levees (Cart Creek and North Branch)
Setback Levees (Cart Creek Only)
Existing Conditions
Discharge (cfs)
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
Time (Days)


10 Year Discharge Hydrograph at Highway 18 - Cart Creek
Setback Levees (Cart Creek and North Branch)
Setback Levees (Cart Creek Only)
Existing Conditions
Discharge (cfs)
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
Time (Days)


100 Year Discharge Hydrograph at Highway 18 - Cart Creek
Setback Levees (Cart Creek and North Branch)
Setback Levees (Cart Creek Only)
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
0
2
4
6
8
10
12


10 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Setback Levees (Cart Creek and North Branch)
Setback Levees (Cart Creek Only)
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
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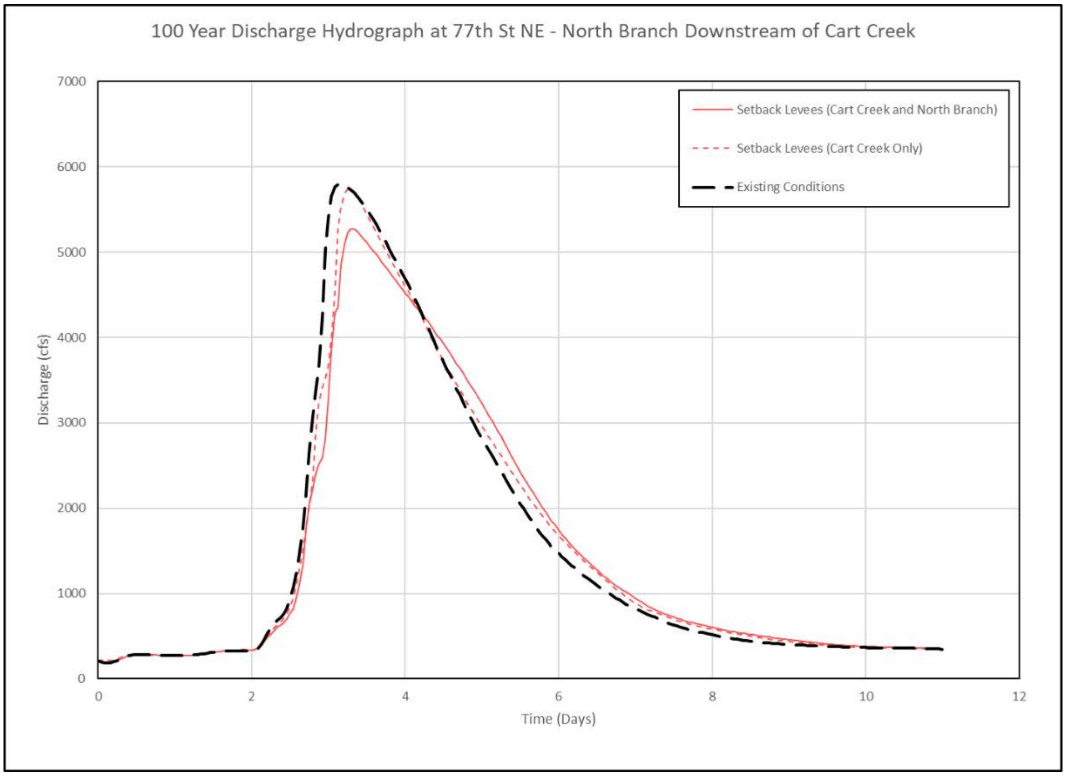
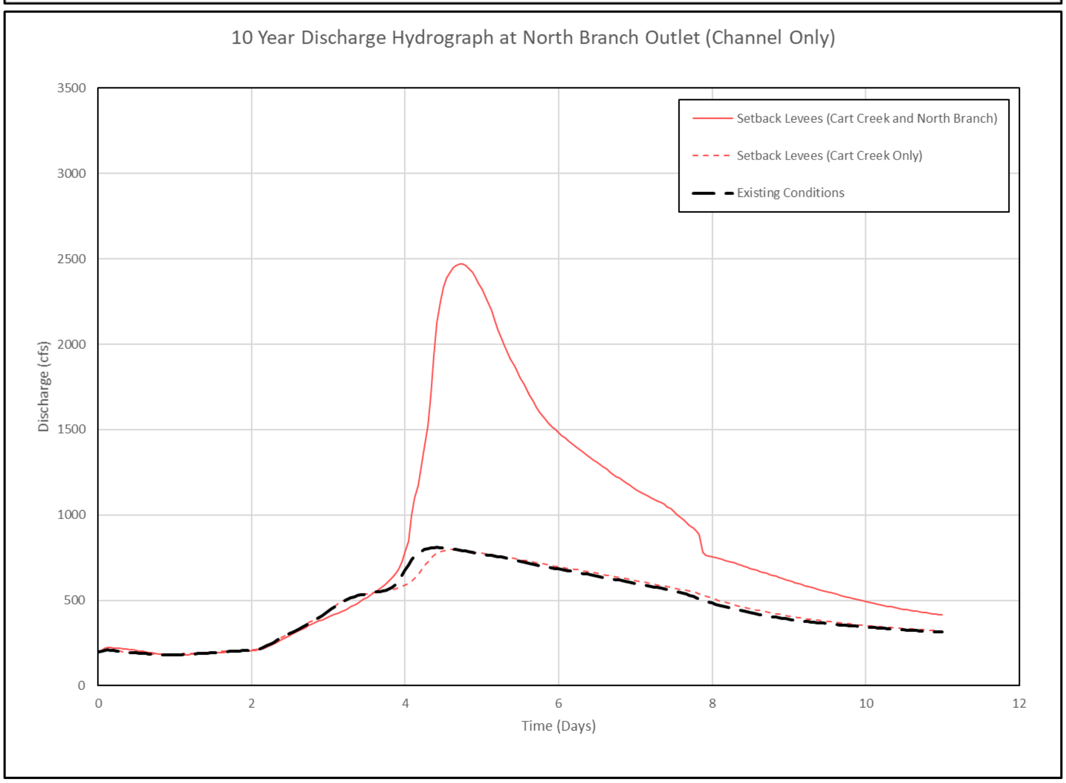
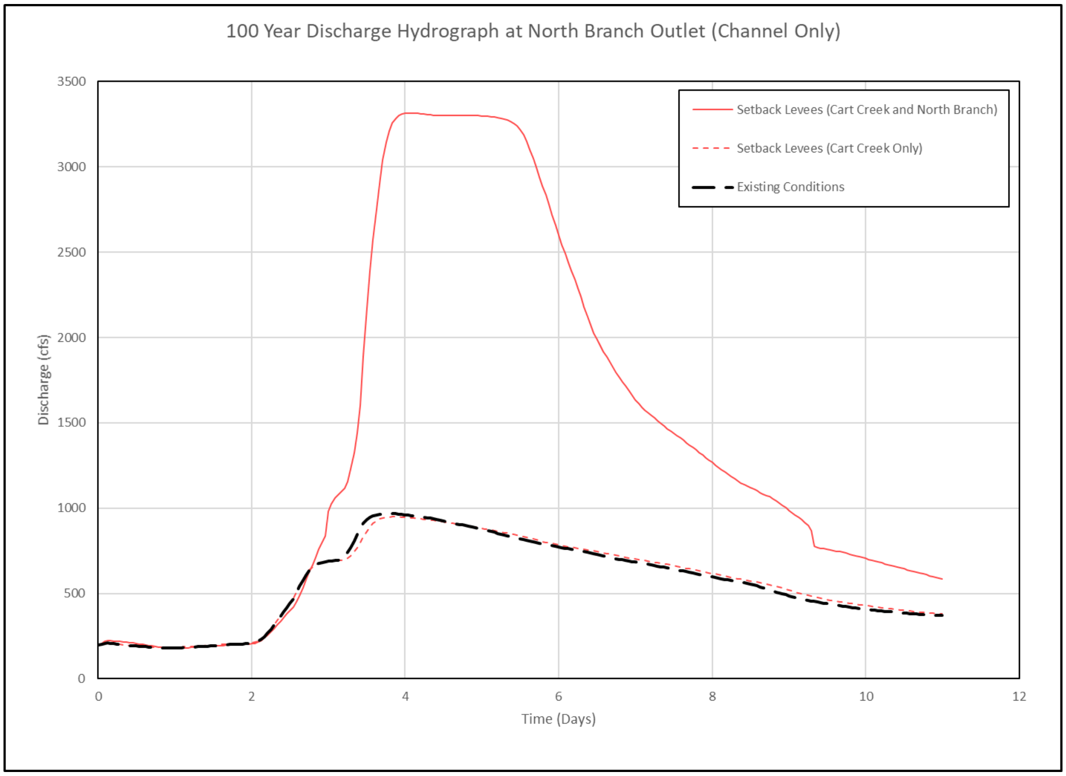
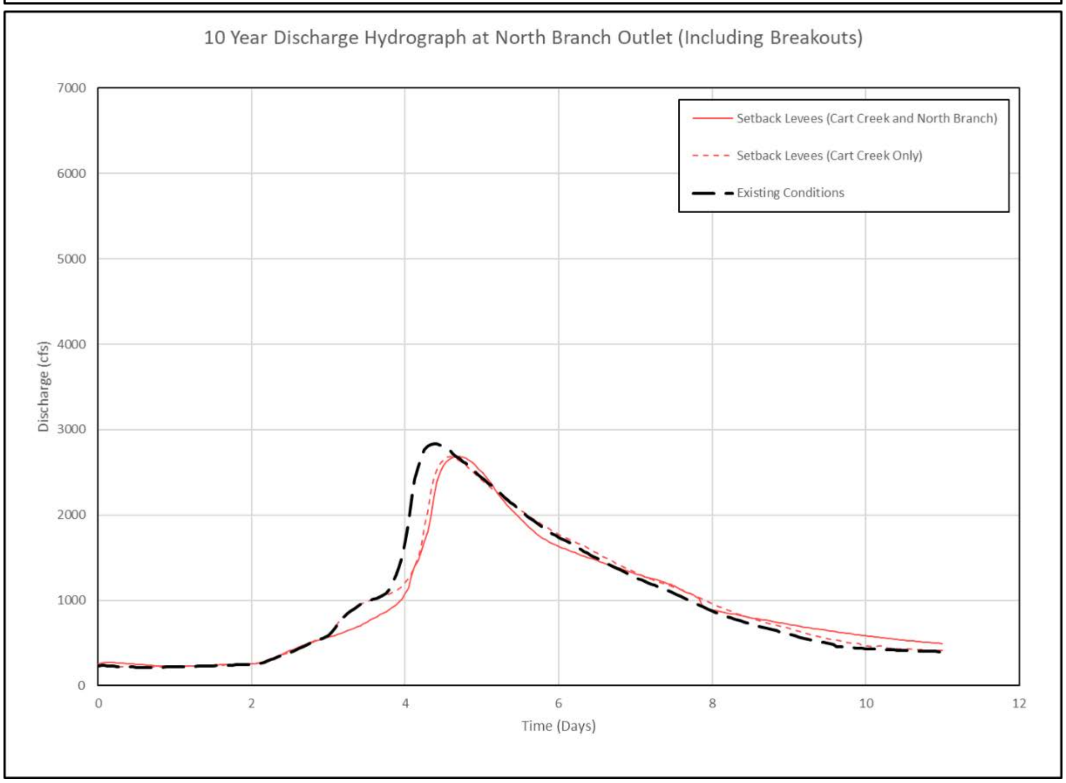

100 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Setback Levees (Cart Creek and North Branch)
Setback Levees (Cart Creek Only)
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

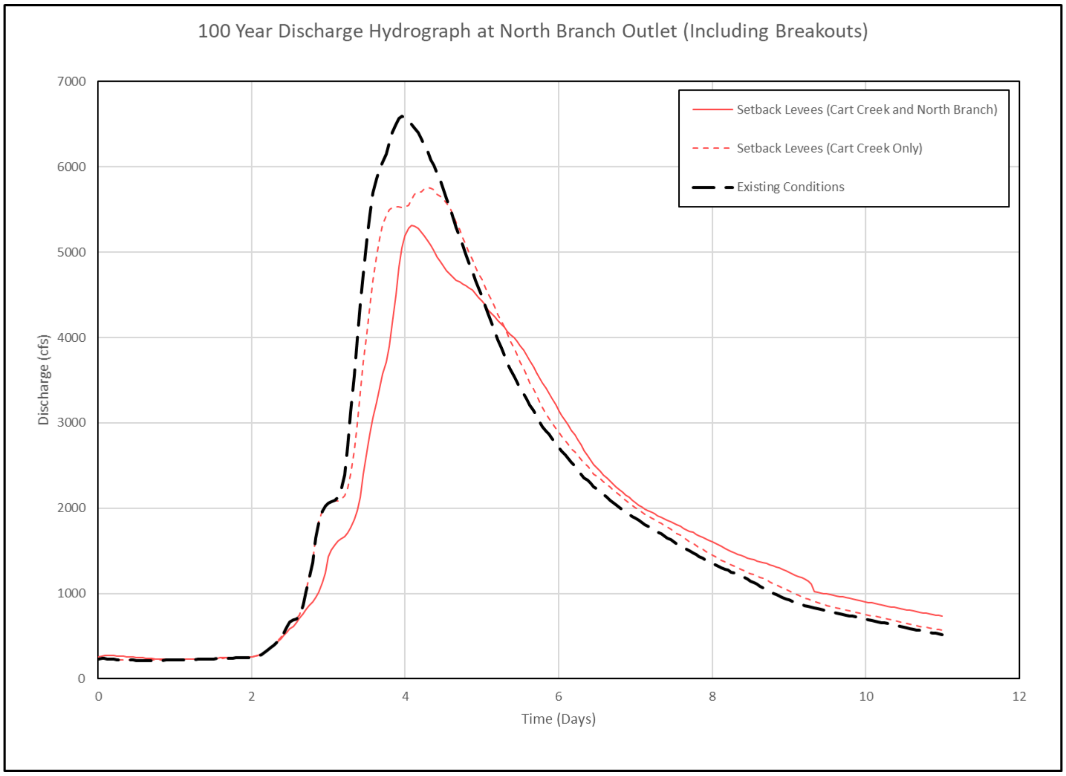

10 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Setback Levees (Cart Creek and North Branch)
Setback Levees (Cart Creek Only)
Existing Conditions
Discharge (cfs)
Time (Days)
0
500
1000
1500
2000
2500
3000
3500
0
2
4
6
8
10
12



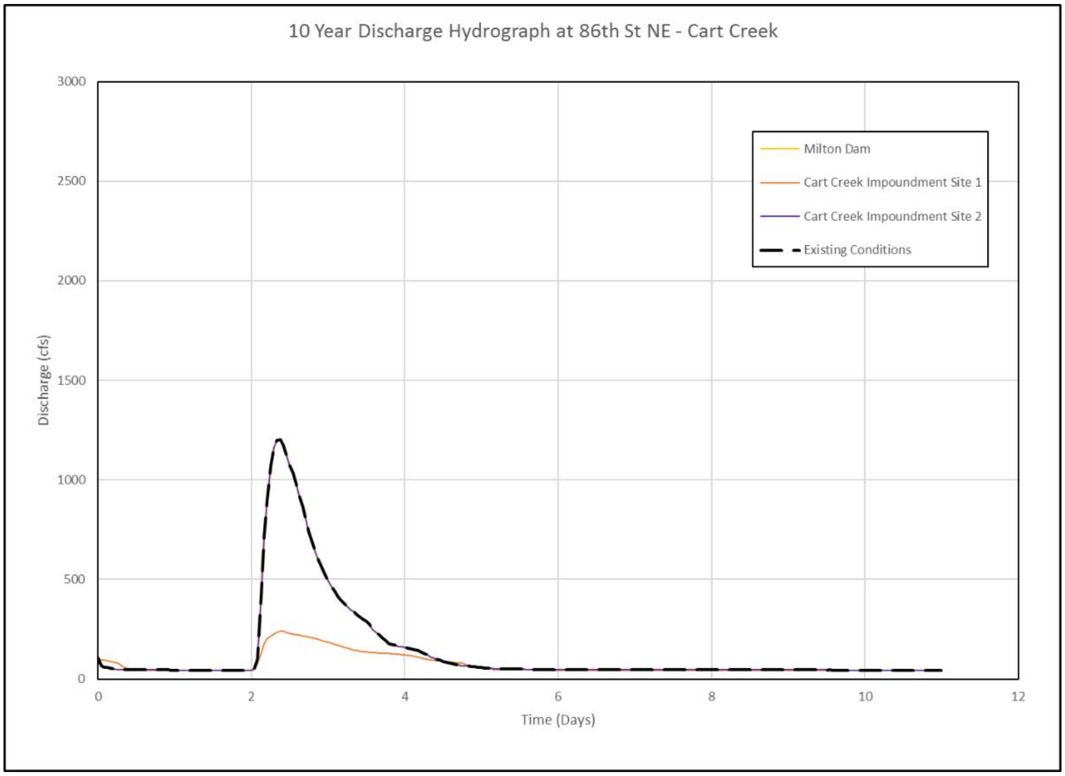
100 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Setback Levees (Cart Creek and North Branch)
Setback Levees (Cart Creek Only)
Existing Conditions
Discharge (cfs)
Time (Days)
0
500
1000
1500
2000
2500
3000
3500
0
2
4
6
8
10
12

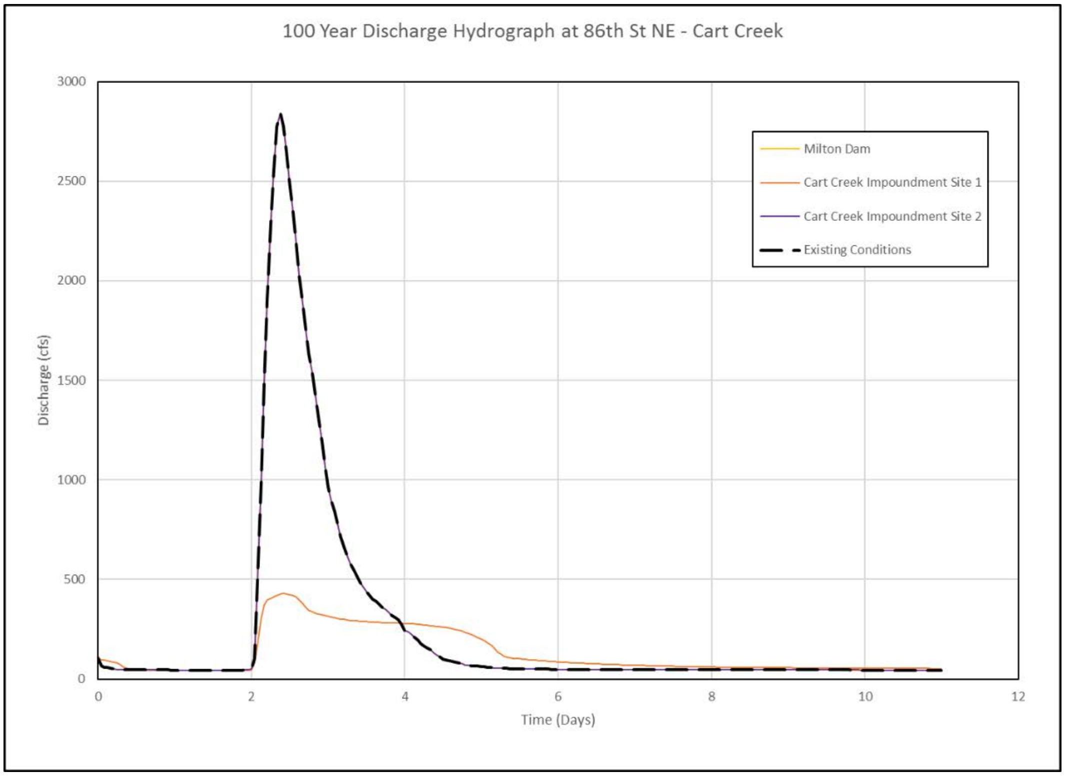


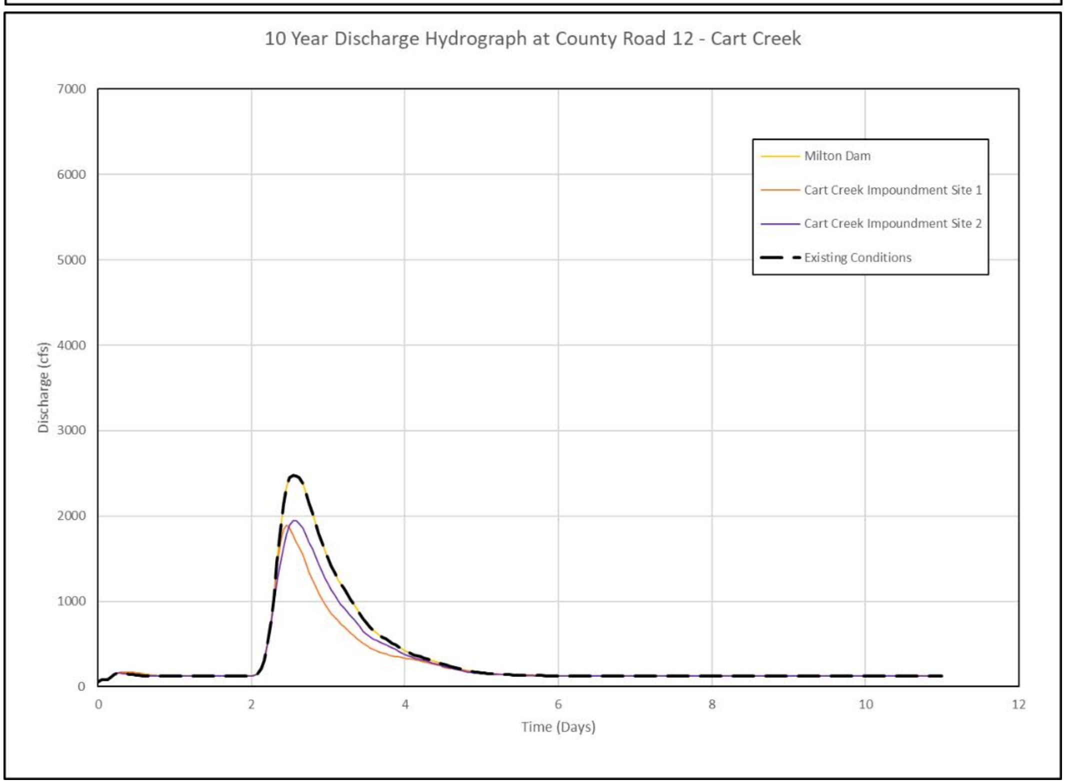
10 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Setback Levees (Cart Creek and North Branch)
Setback Levees (Cart Creek Only)
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

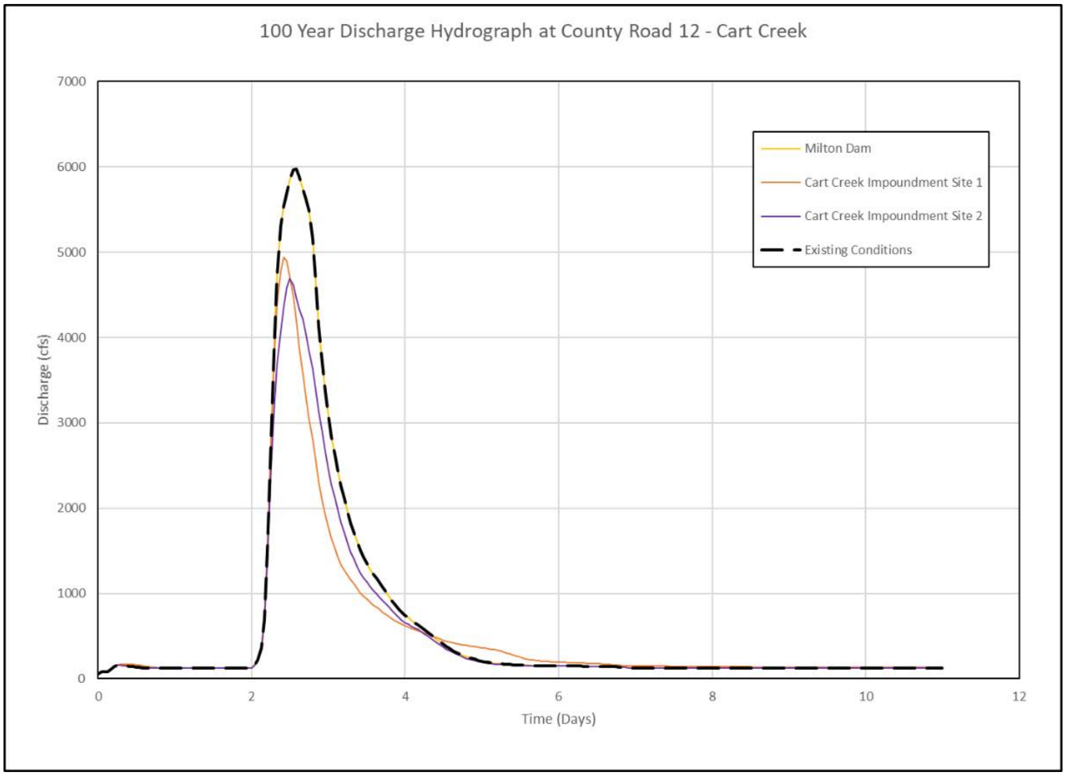

100 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Discharge (cfs)
Time (Days)
Setback Levees (Cart Creek and North Branch)
Setback Levees (Cart Creek Only)
Existing Conditions
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

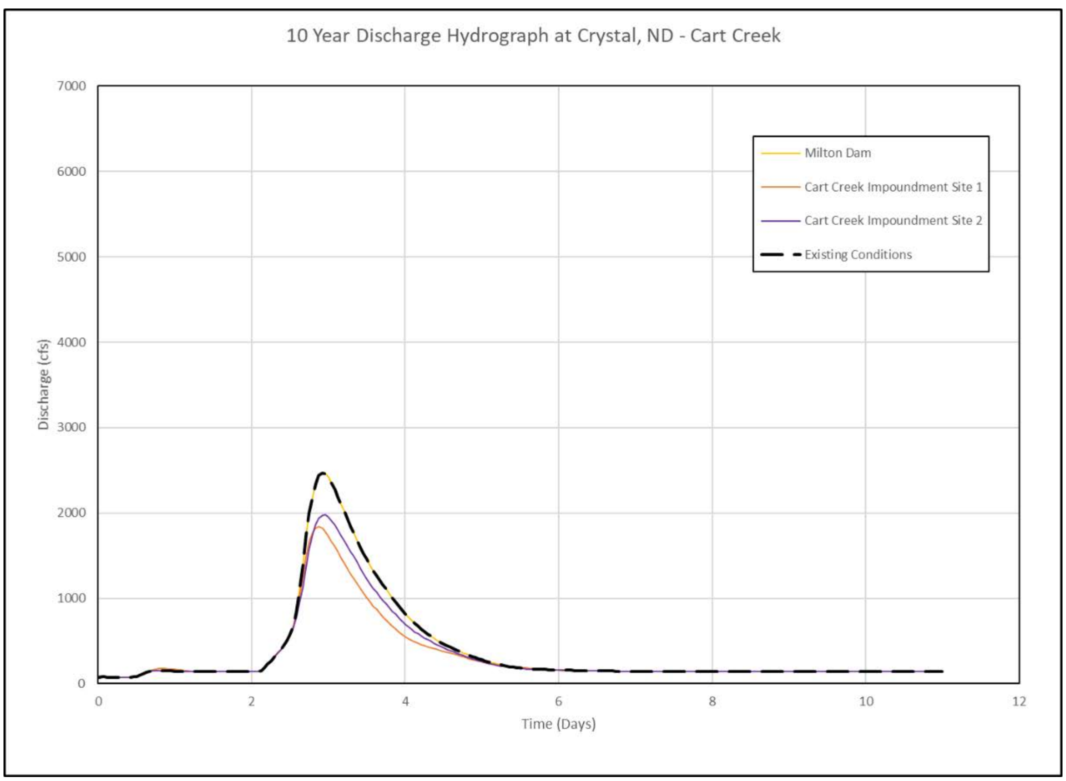
D-2-B.3 ALTERNATIVES 2-4 – MILTON DAM, CART CREEK IMPOUNDMENT SITE 1, AND 2 – HYDROGRAPHS

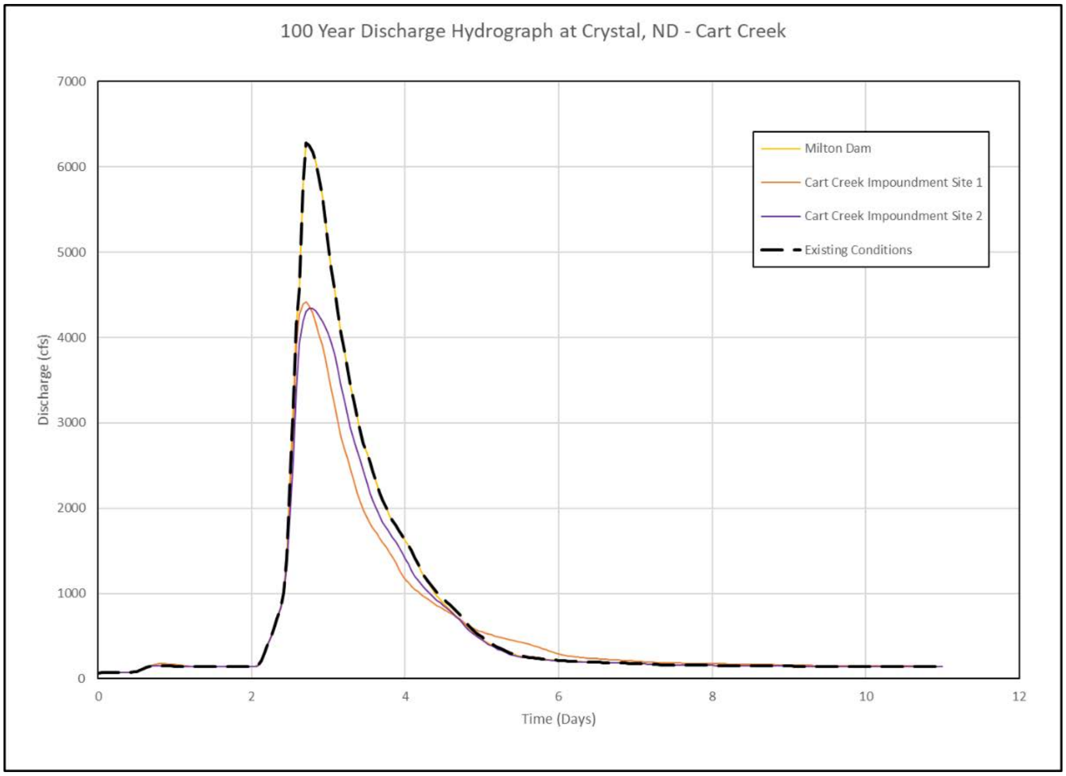


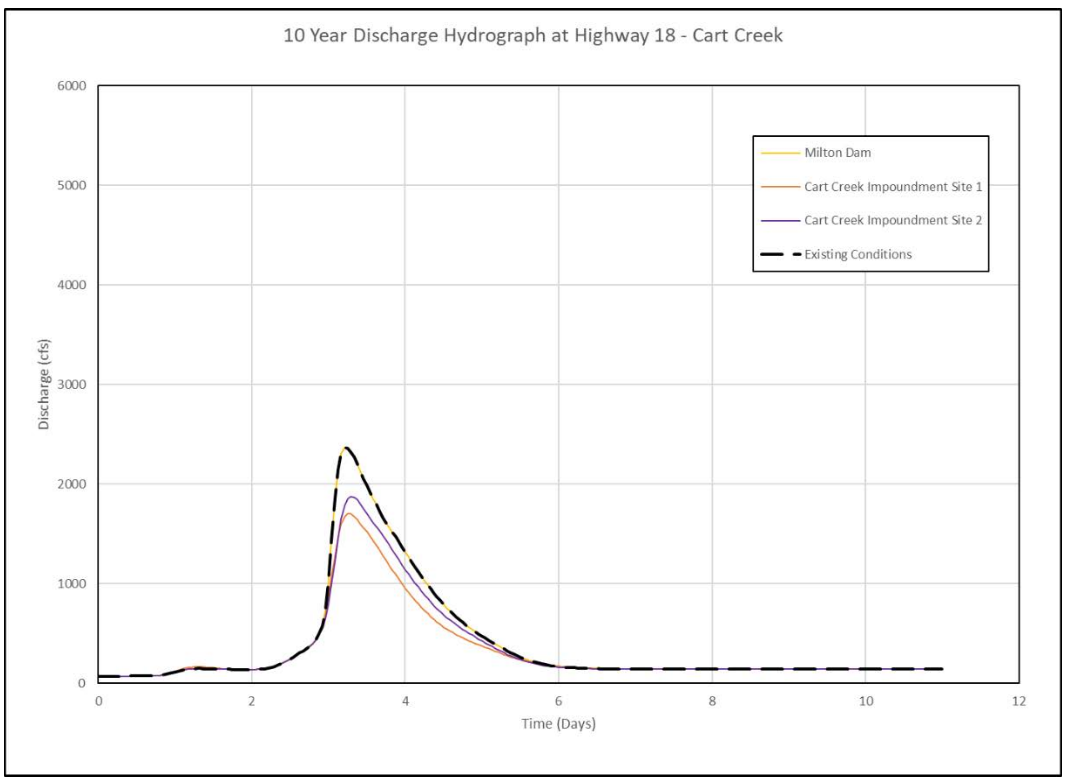

100 Year Discharge Hydrograph at 86th St NE - Cart Creek
Discharge (cfs)
Time (Days)
Milton Dam
Cart Creek Impoundment Site 1
Cart Creek Impoundment Site 2
Existing Conditions
0
500
1000
1500
2000
2500
3000
0
2
4
6
8
10
12


10 Year Discharge Hydrograph at County Road 12 - Cart Creek
Discharge (cfs)
Time (Days)
Milton Dam
Cart Creek Impoundment Site 1
Cart Creek Impoundment Site 2
Existing Conditions
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12


100 Year Discharge Hydrograph at County Road 12 - Cart Creek
Milton Dam
Cart Creek Impoundment Site 1
Cart Creek Impoundment Site 2
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12


10 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Milton Dam
Cart Creek Impoundment Site 1
Cart Creek Impoundment Site 2
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12


100 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Discharge (cfs)
Time (Days)
Milton Dam
Cart Creek Impoundment Site 1
Cart Creek Impoundment Site 2
Existing Conditions
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12


10 Year Discharge Hydrograph at Highway 18 - Cart Creek
Discharge (cfs)
Time (Days)
Milton Dam
Cart Creek Impoundment Site 1
Cart Creek Impoundment Site 2
Existing Conditions
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6000
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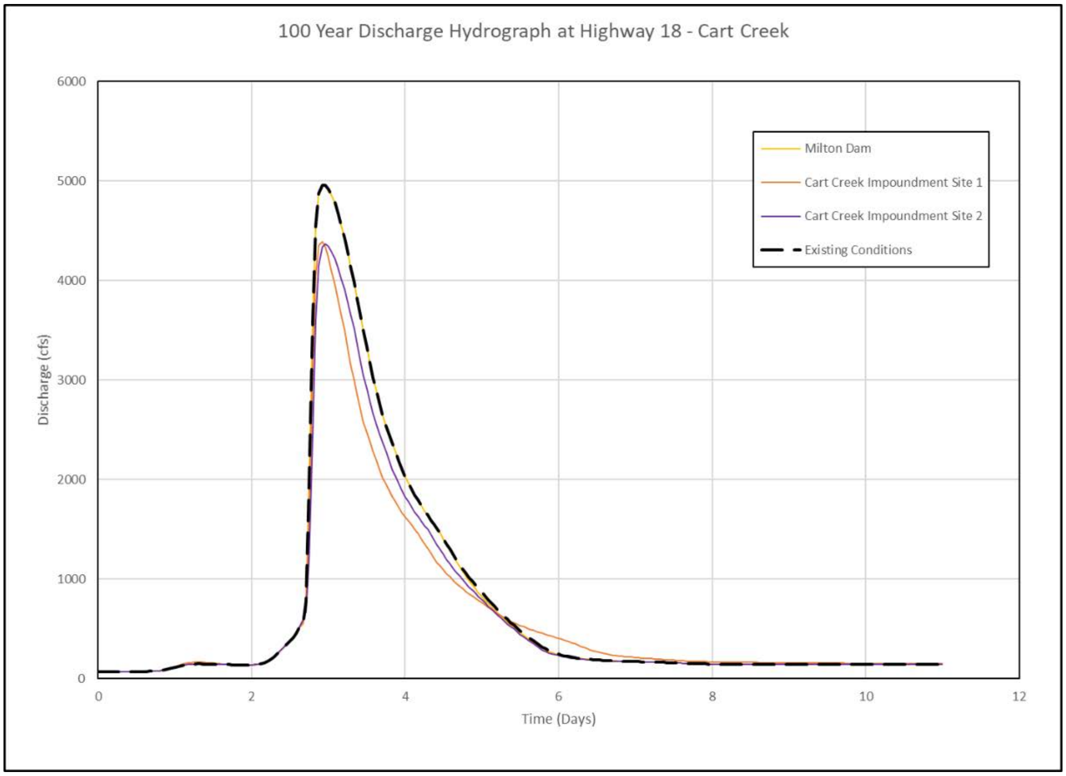
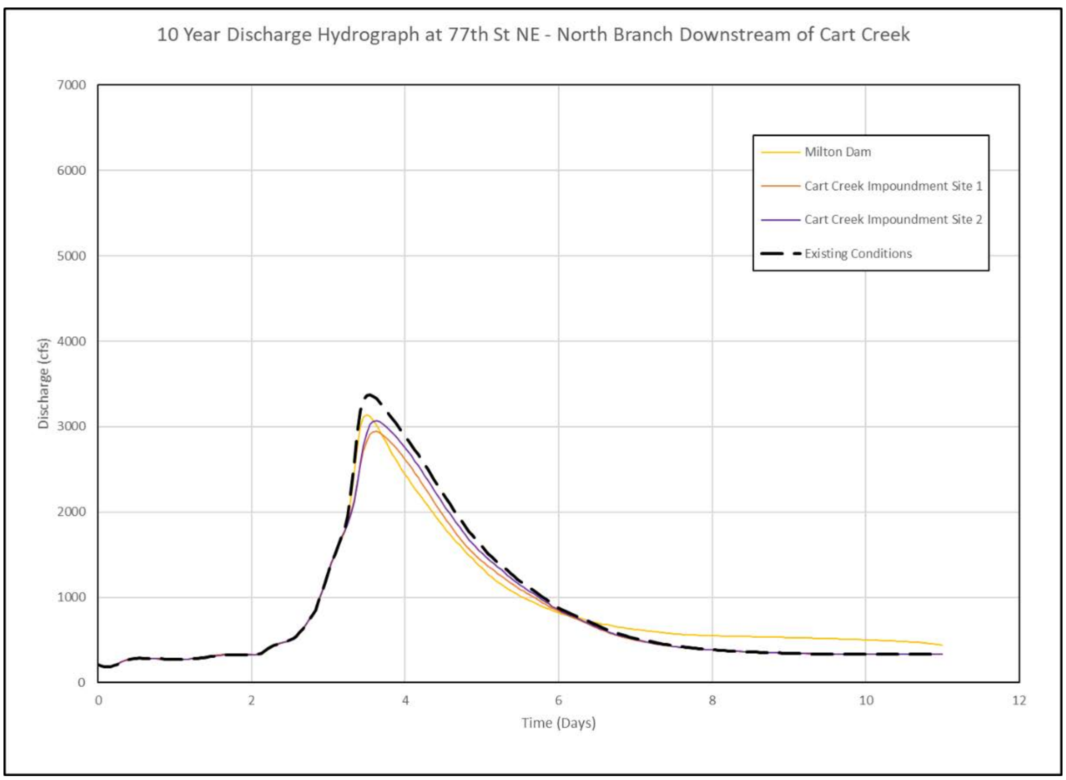
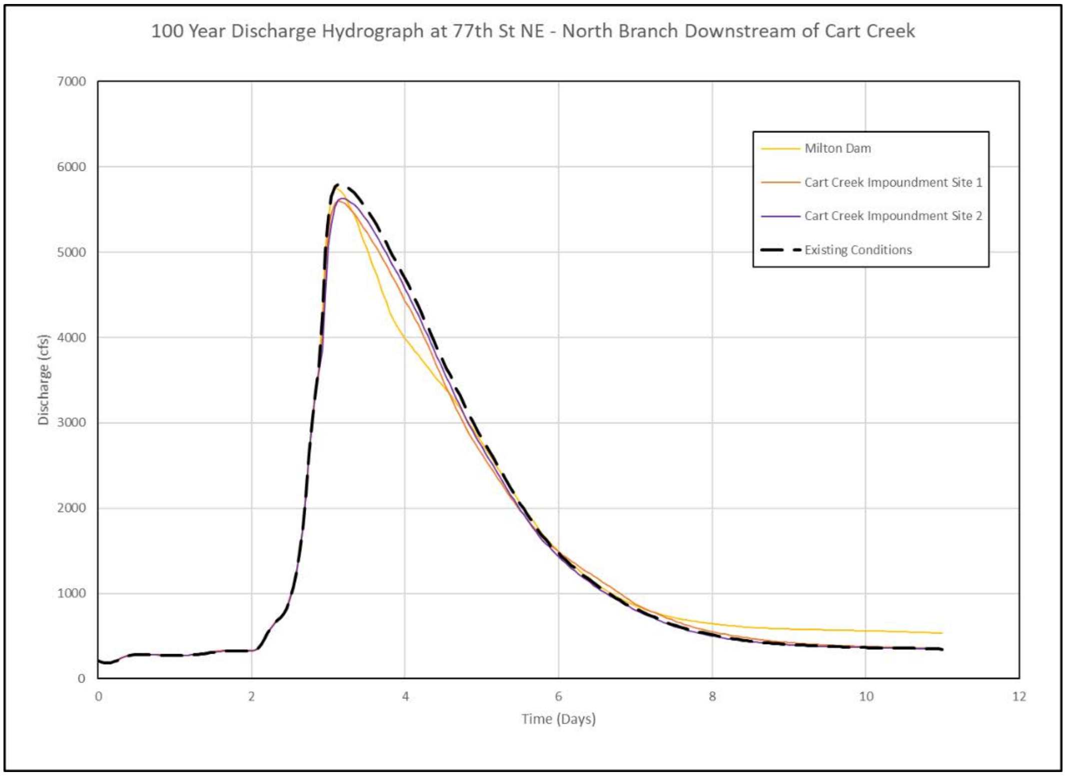
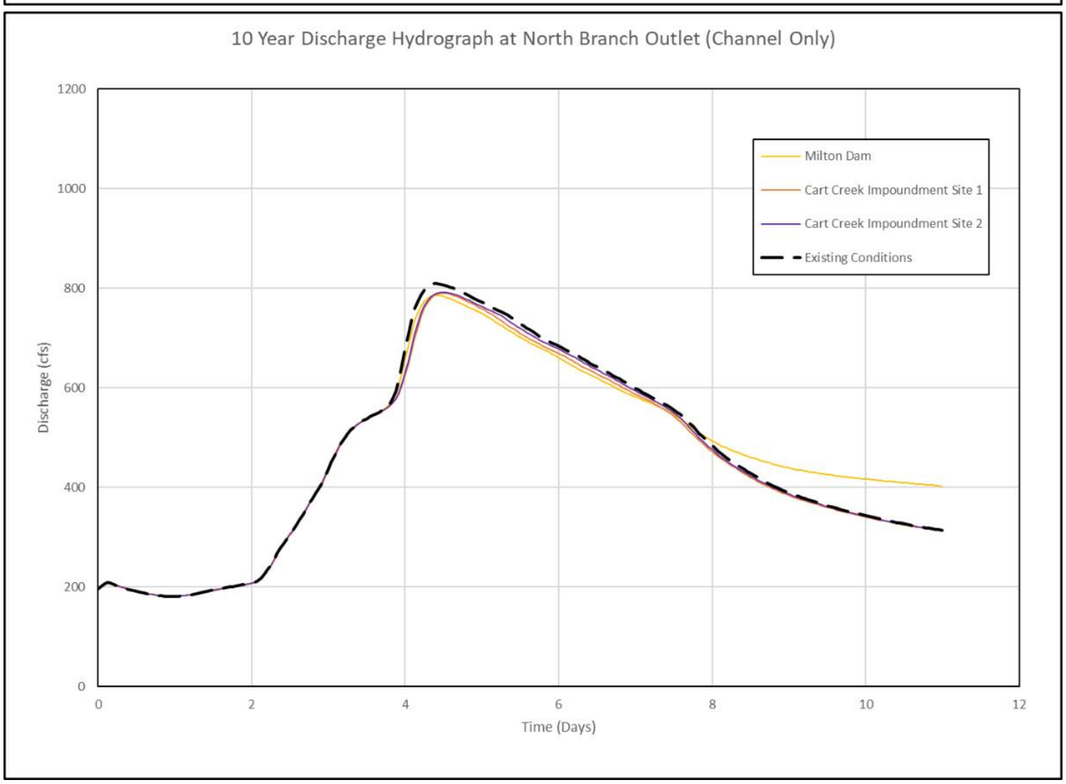
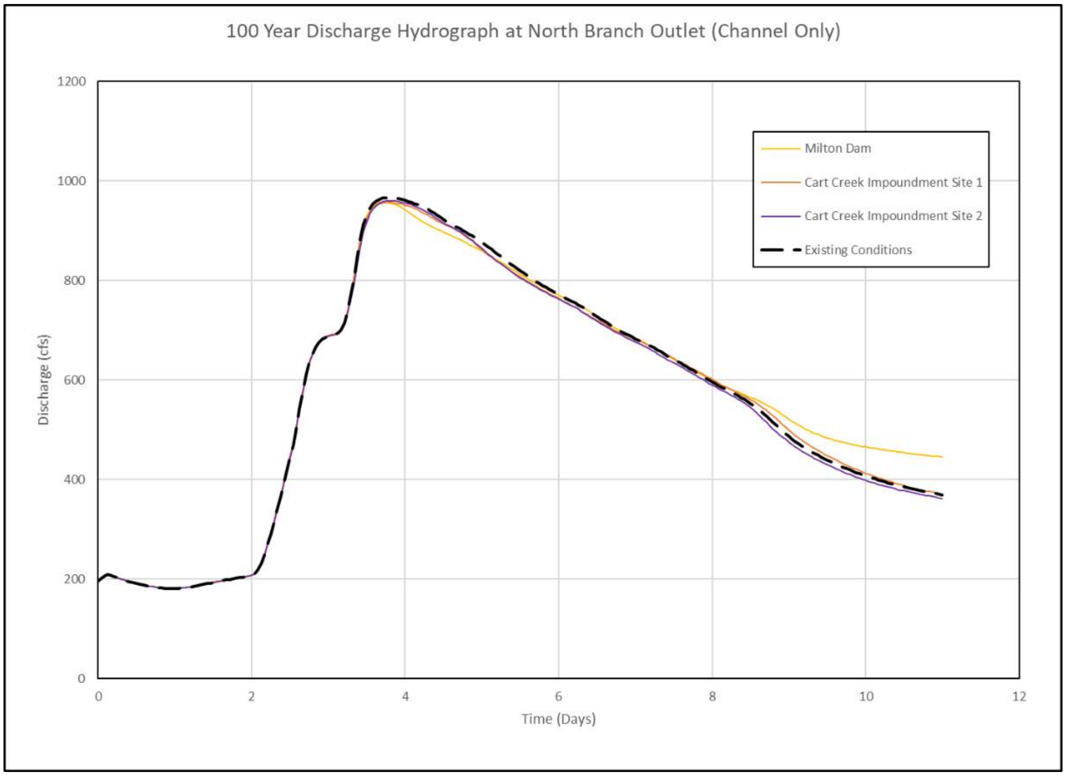
4
6
8
10
12

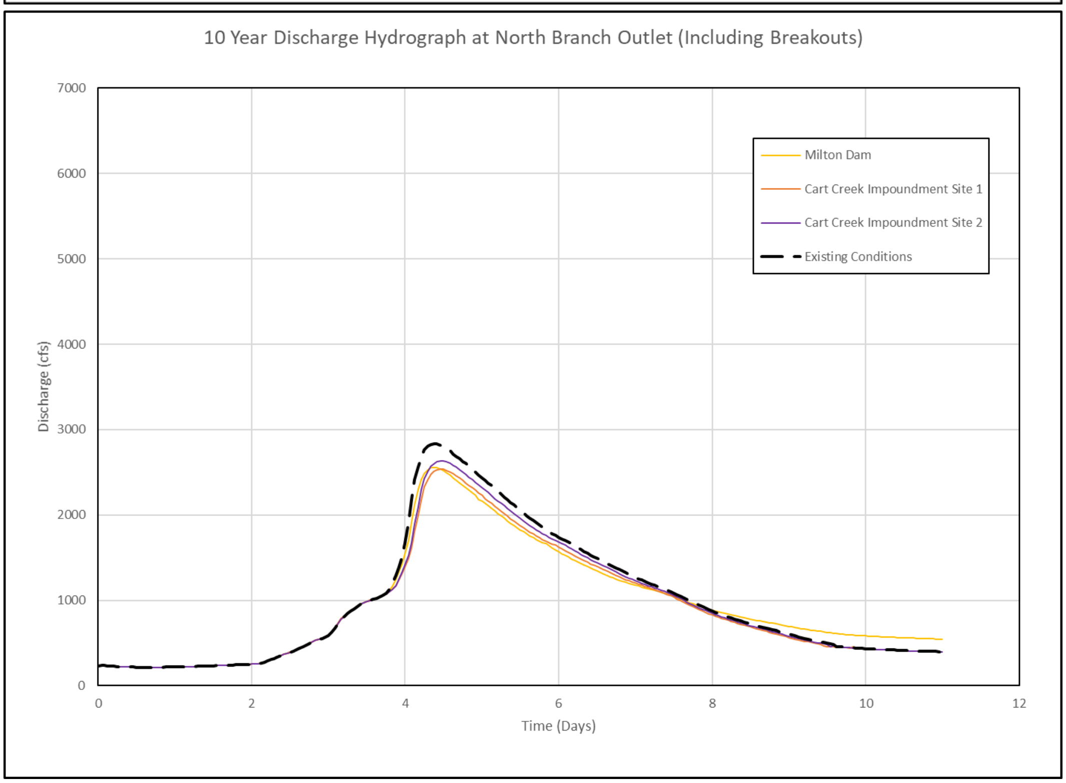

100 Year Discharge Hydrograph at Highway 18 - Cart Creek
Milton Dam
Cart Creek Impoundment Site 1
Cart Creek Impoundment Site 2
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
0
2
4
6
8
10
12

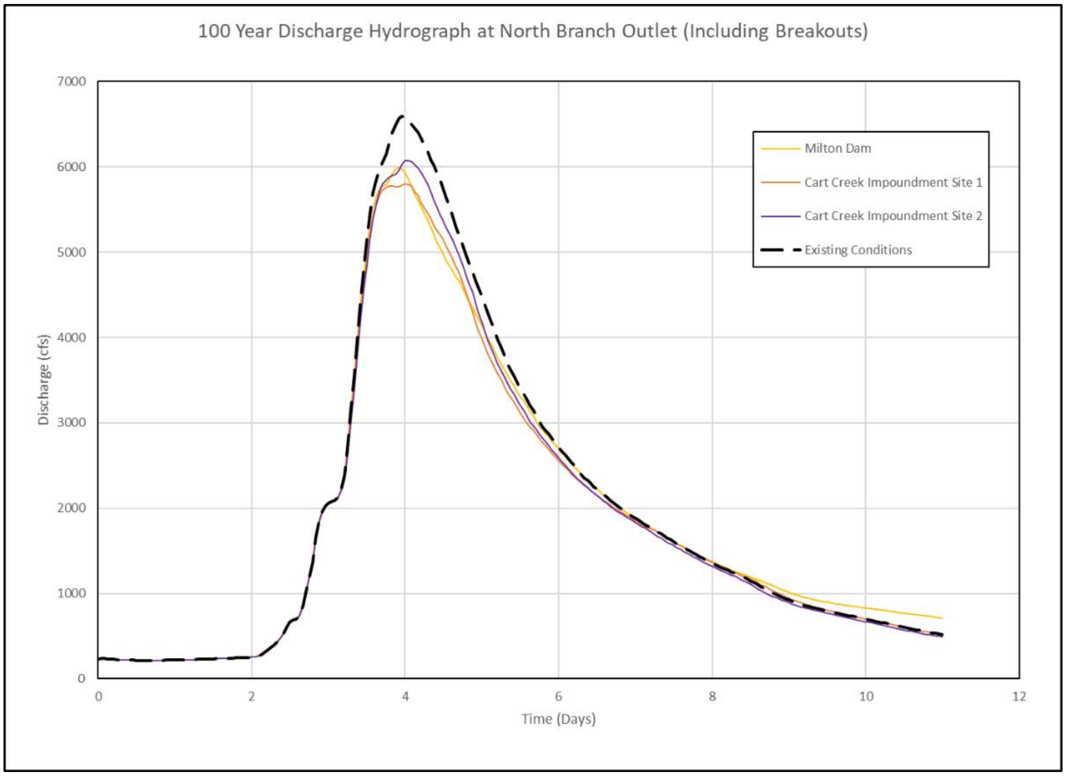

10 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Milton Dam
Cart Creek Impoundment Site 1
Cart Creek Impoundment Site 2
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12


100 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Discharge (cfs)
Time (Days)
Milton Dam
Cart Creek Impoundment Site 1
Cart Creek Impoundment Site 2
Existing Conditions

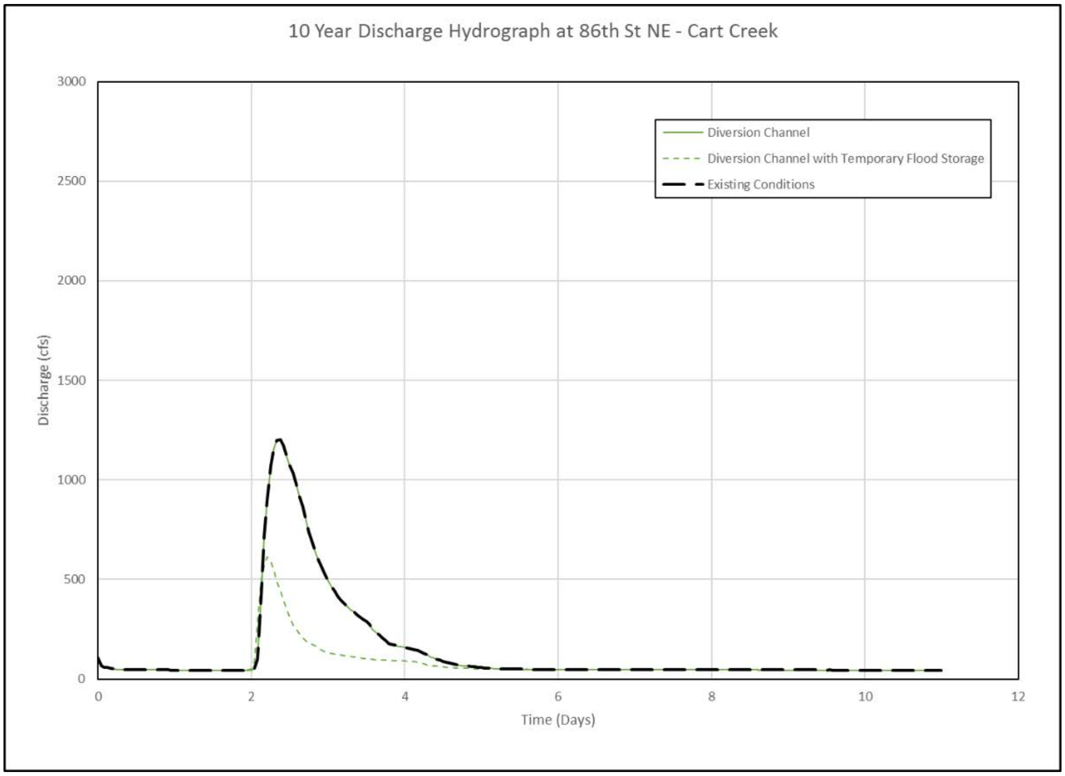

10 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Discharge (cfs)
Time (Days)
Milton Dam
Cart Creek Impoundment Site 1
Cart Creek Impoundment Site 2
Existing Conditions

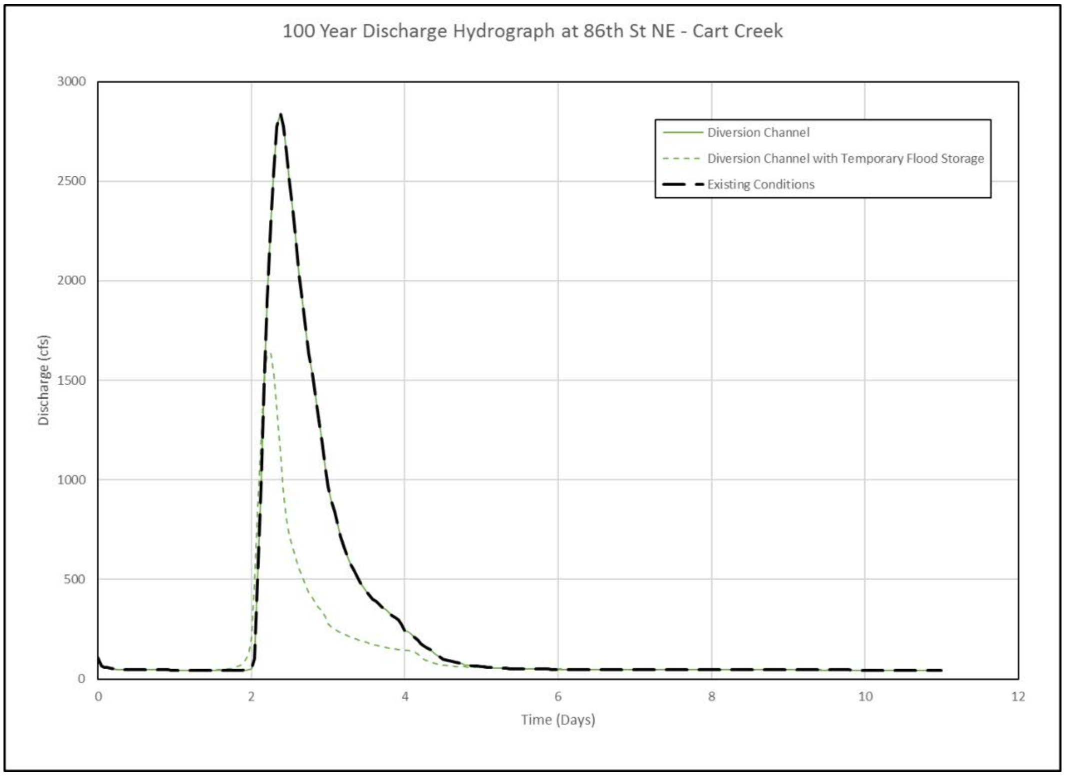

100 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Milton Dam
Cart Creek Impoundment Site 1
Cart Creek Impoundment Site 2
Existing Conditions
Discharge (cfs)
Time (Days)
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12


10 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Milton Dam
Cart Creek Impoundment Site 1
Cart Creek Impoundment Site 2
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

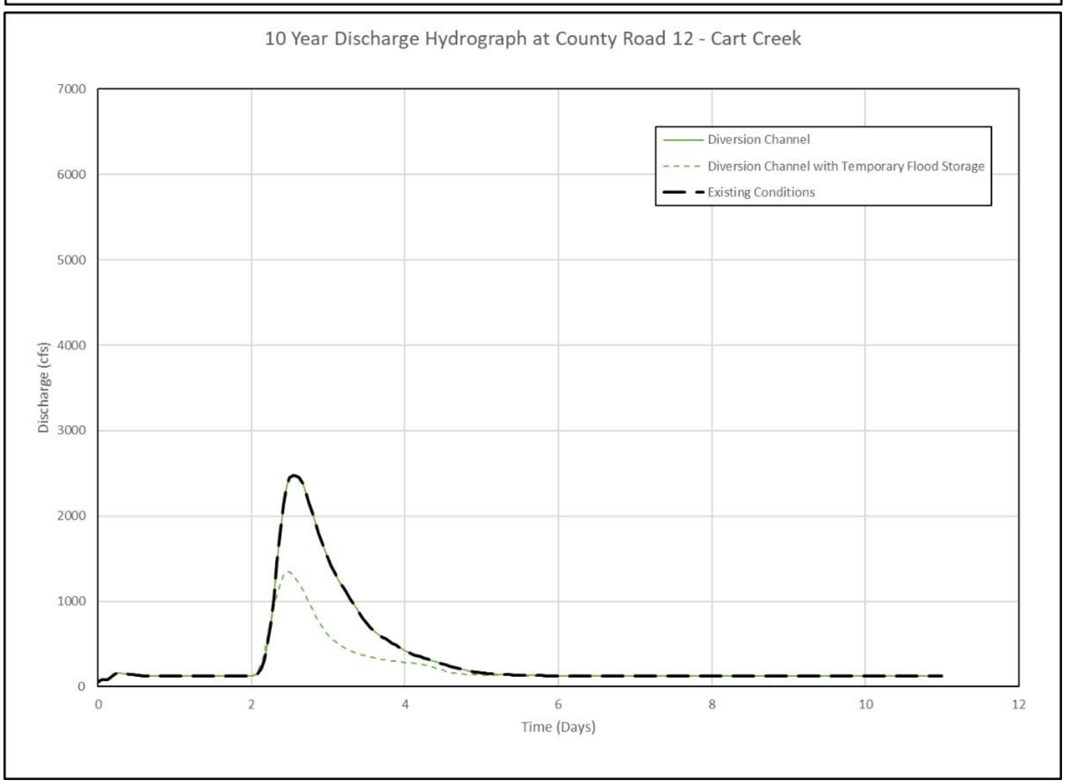

100 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Discharge (cfs)
Time (Days)
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
Milton Dam
Cart Creek Impoundment Site 1
Cart Creek Impoundment Site 2
Existing Conditions

D-2-B.4 ALTERNATIVES 5-6 – DIVERSION CHANNEL, AND DIVERSION CHANNEL WITH STORAGE – HYDROGRAPHS

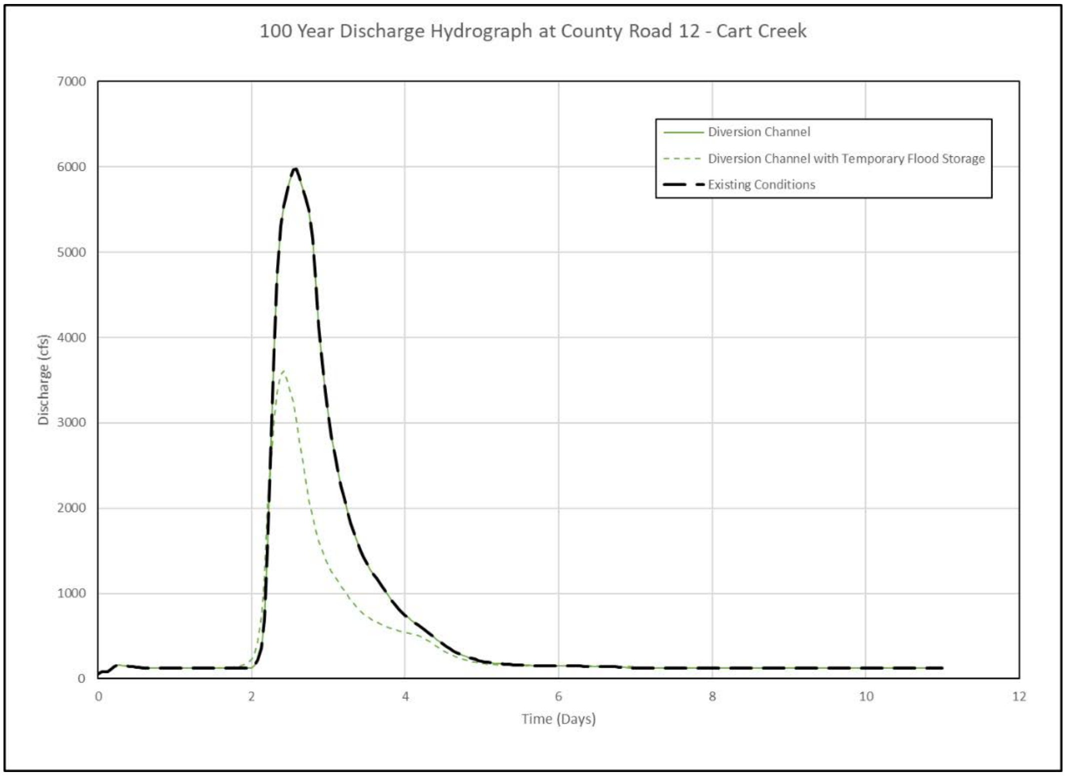




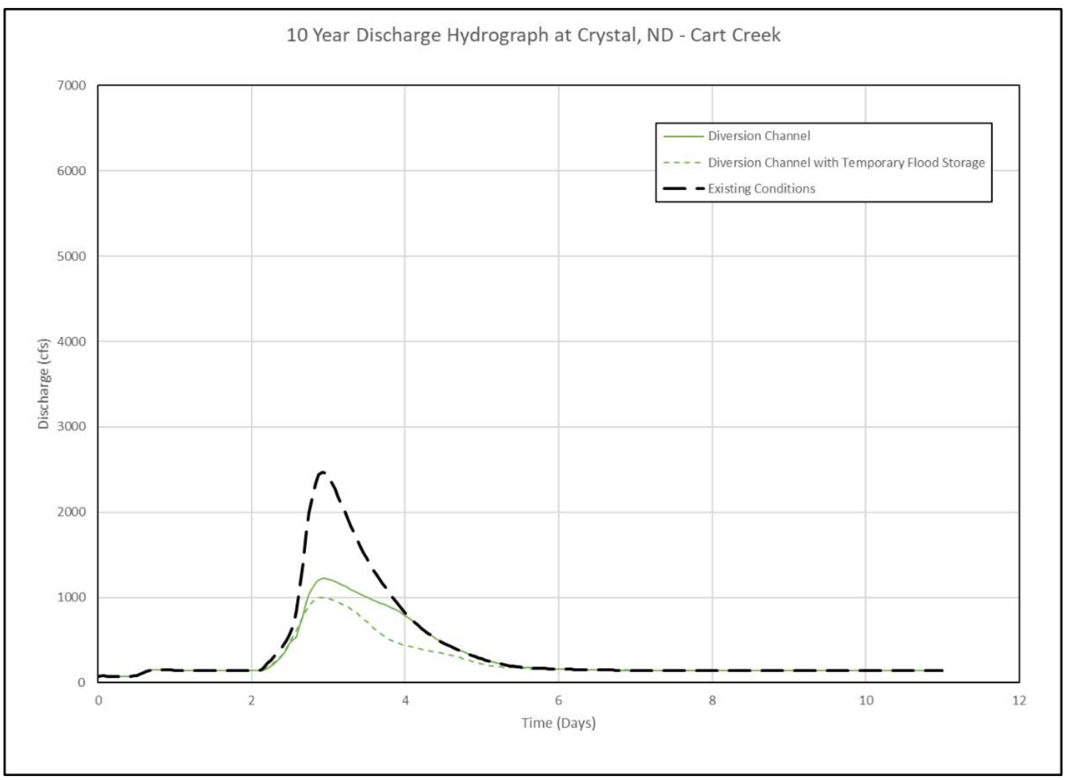
100 Year Discharge Hydrograph at 86th St NE - Cart Creek
Diversion Channel
Diversion Channel with Temporary Flood Storage
Existing Conditions
Discharge (cfs)
Time (Days)



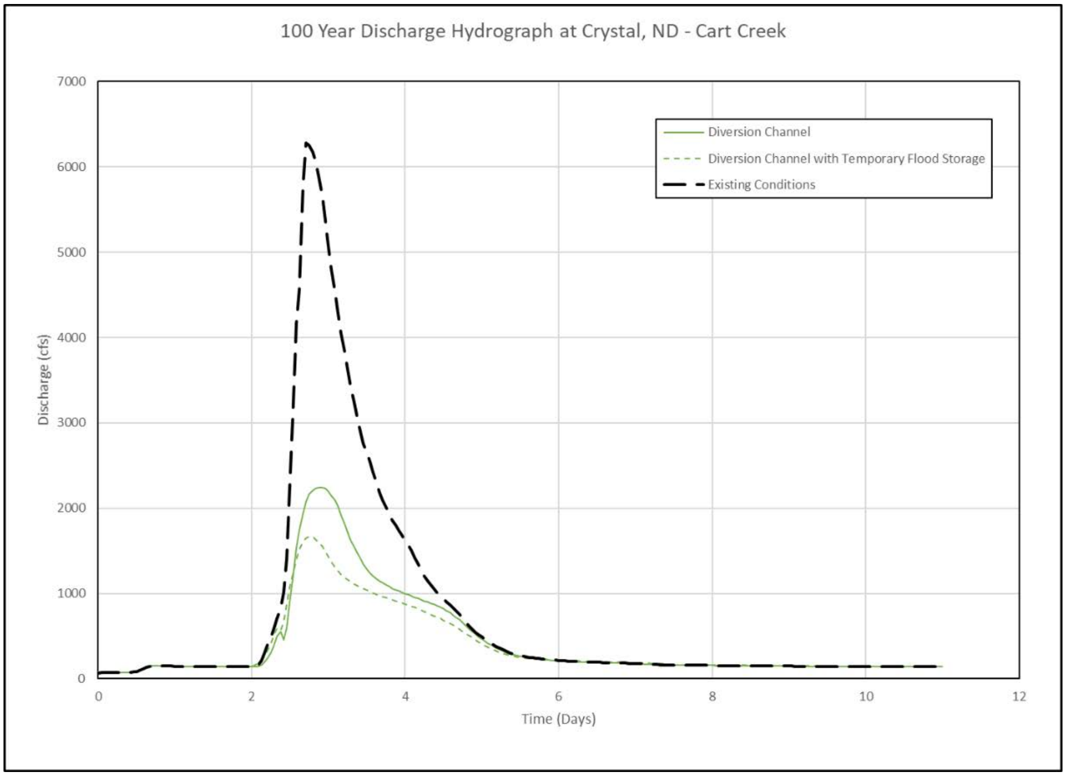
10 Year Discharge Hydrograph at County Road 12 - Cart Creek
Diversion Channel
Diversion Channel with Temporary Flood Storage
Existing Conditions
Discharge (cfs)
Time (Days)

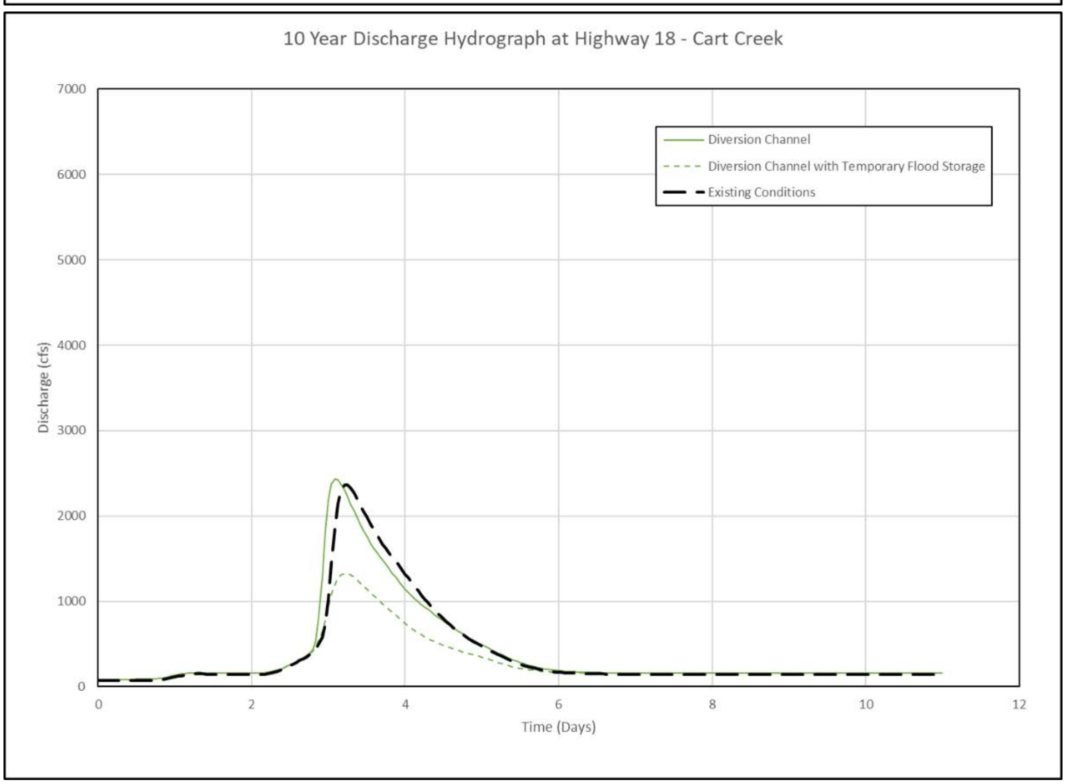


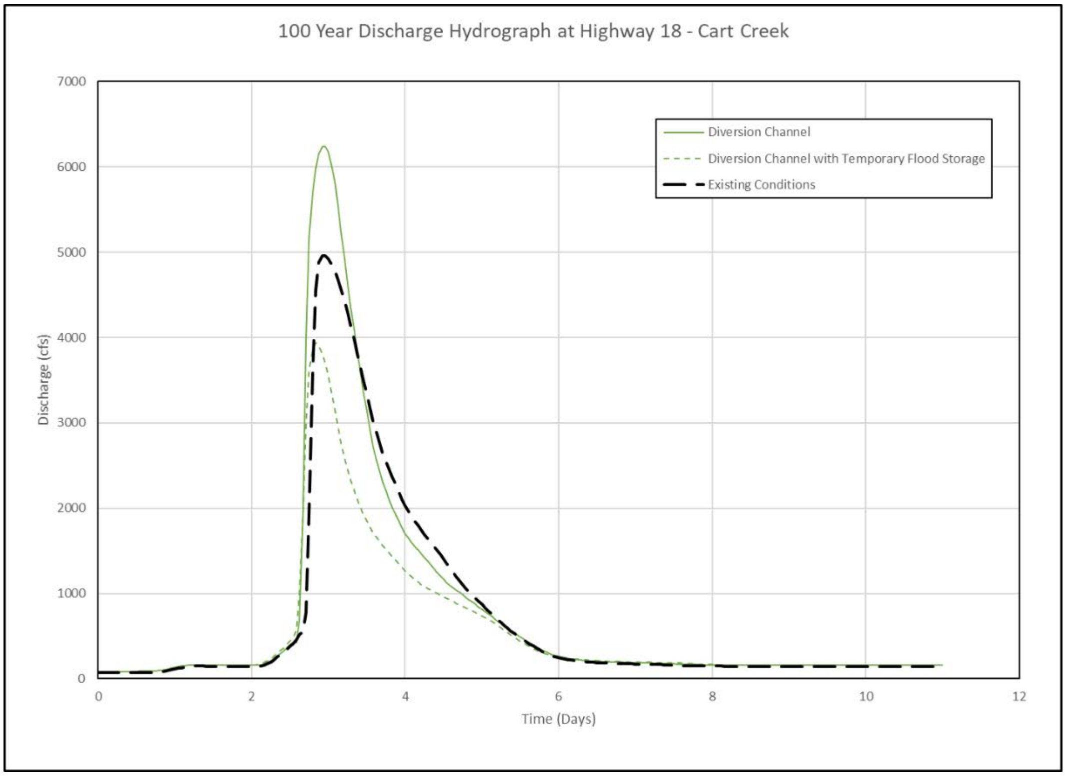
100 Year Discharge Hydrograph at County Road 12 - Cart Creek
Diversion Channel
Diversion Channel with Temporary Flood Storage
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12



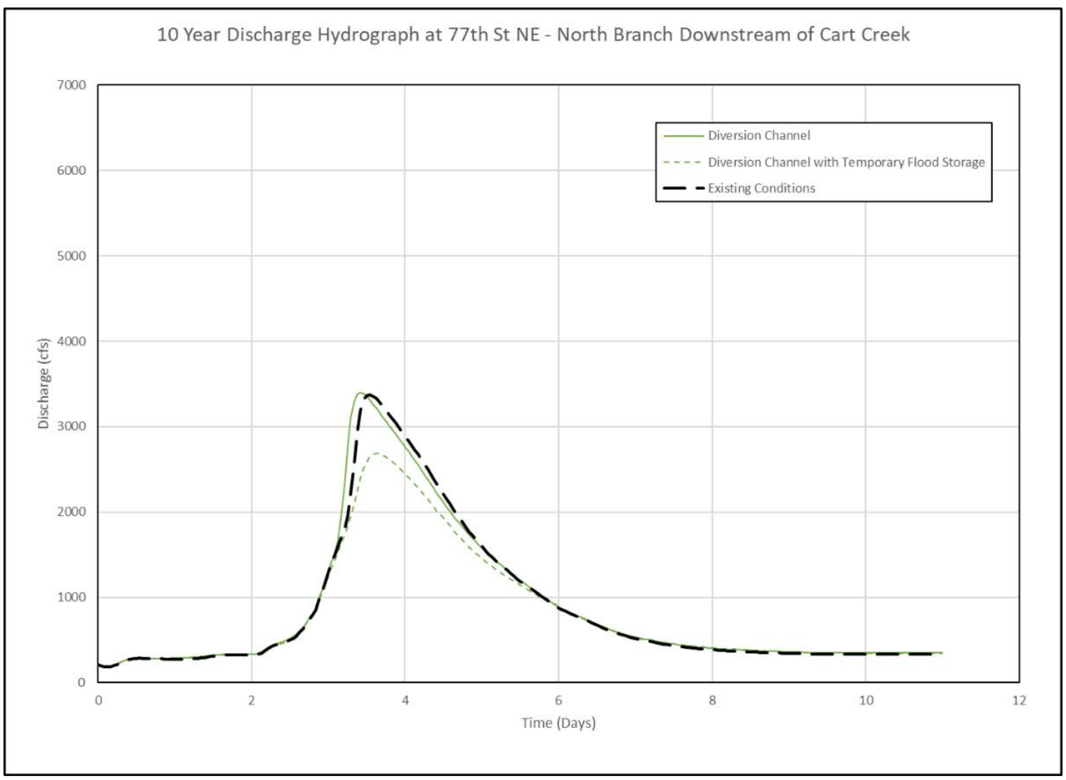
10 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Diversion Channel
Diversion Channel with Temporary Flood Storage
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12


100 Year Discharge Hydrograph at Crystal, ND - Cart Creek
Diversion Channel
Diversion Channel with Temporary Flood Storage
Existing Conditions
Discharge (cfs)
Time (Days)
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12

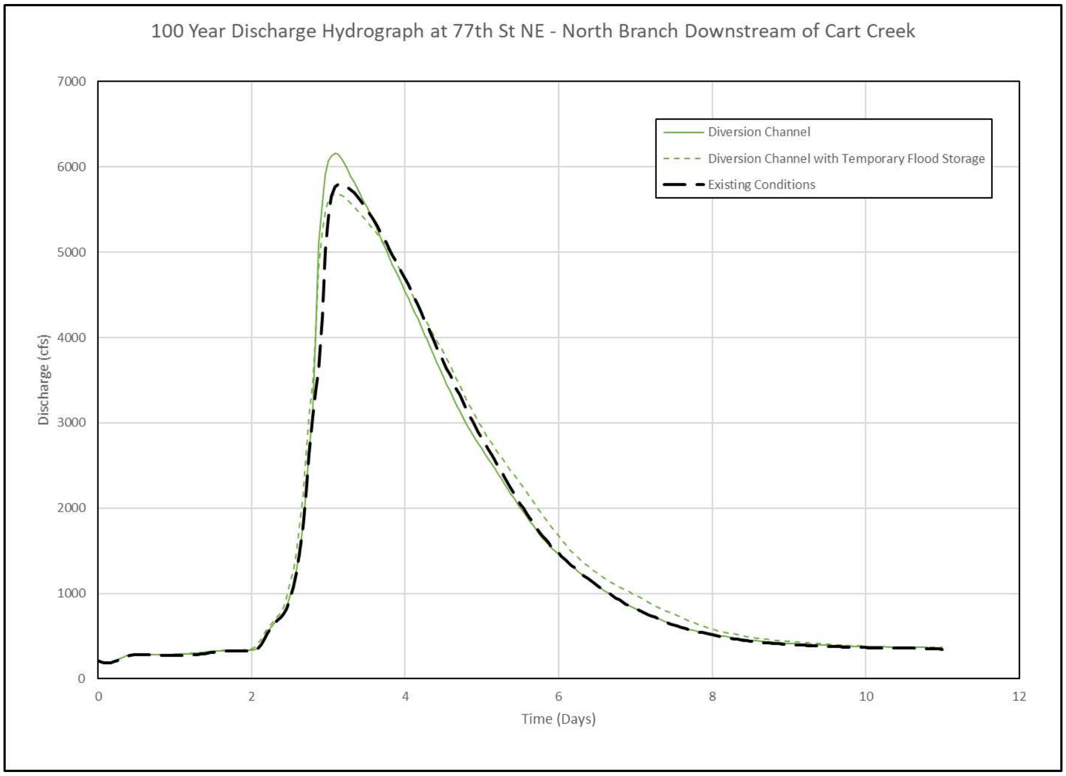

10 Year Discharge Hydrograph at Highway 18 - Cart Creek
Diversion Channel
Diversion Channel with Temporary Flood Storage
Existing Conditions
Discharge (cfs)
Time (Days)
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12

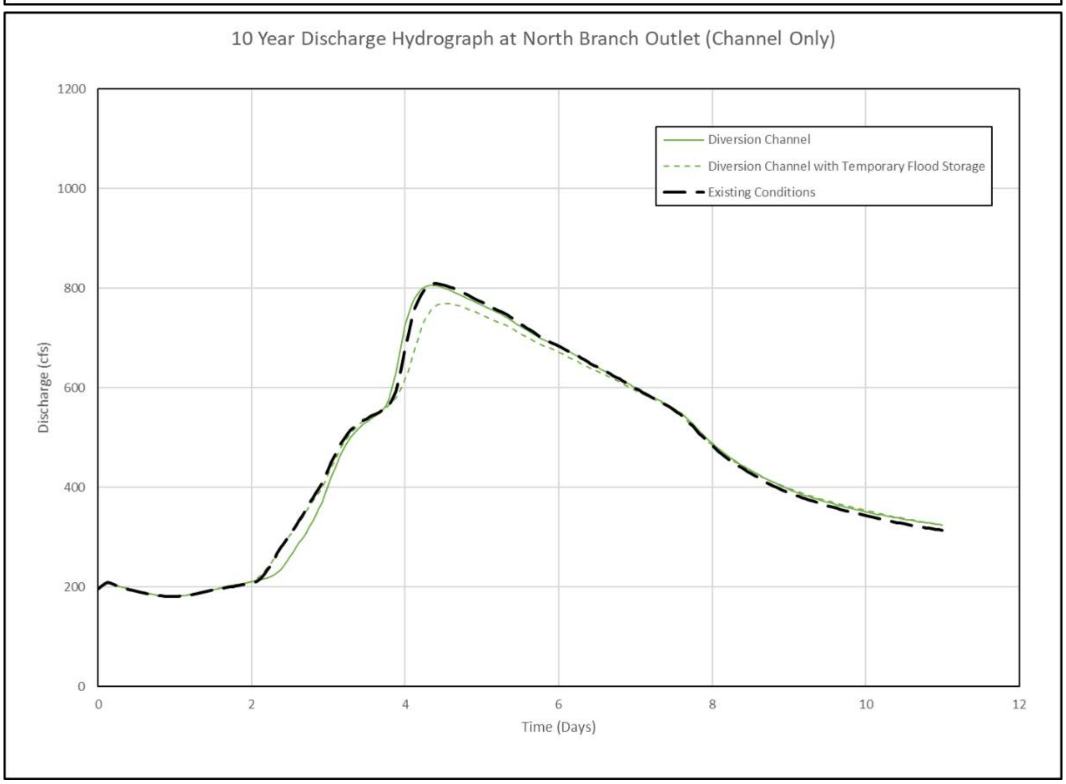


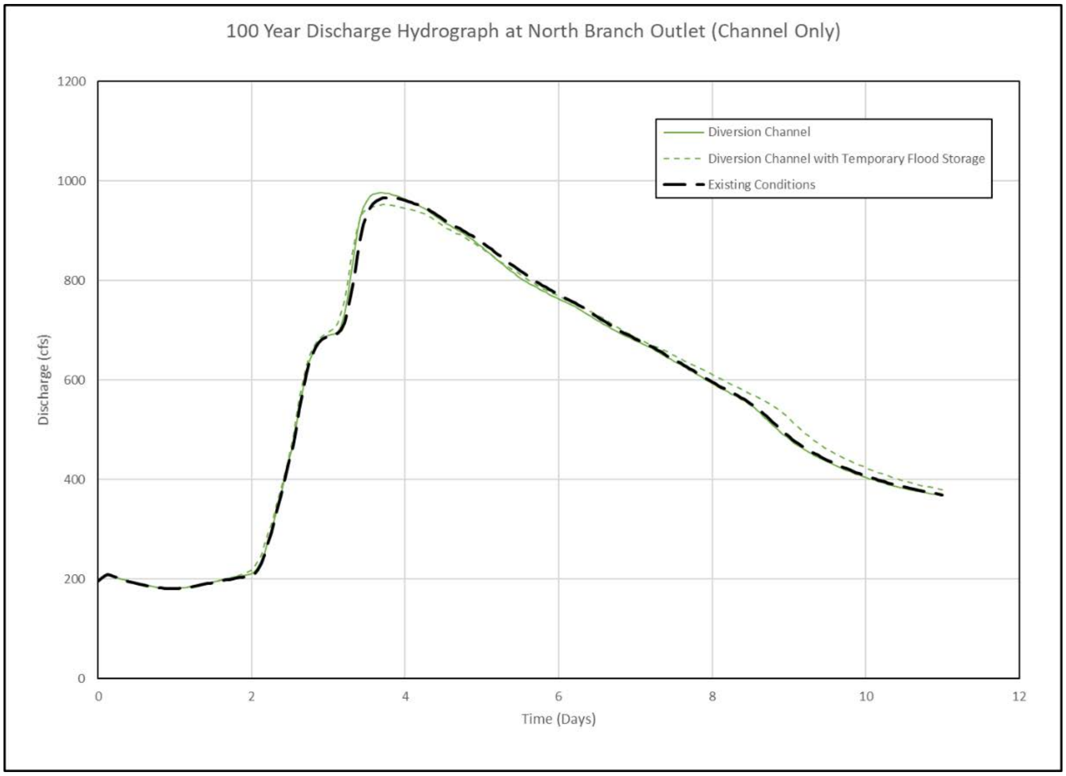
100 Year Discharge Hydrograph at Highway 18 - Cart Creek
Diversion Channel
Diversion Channel with Temporary Flood Storage
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12

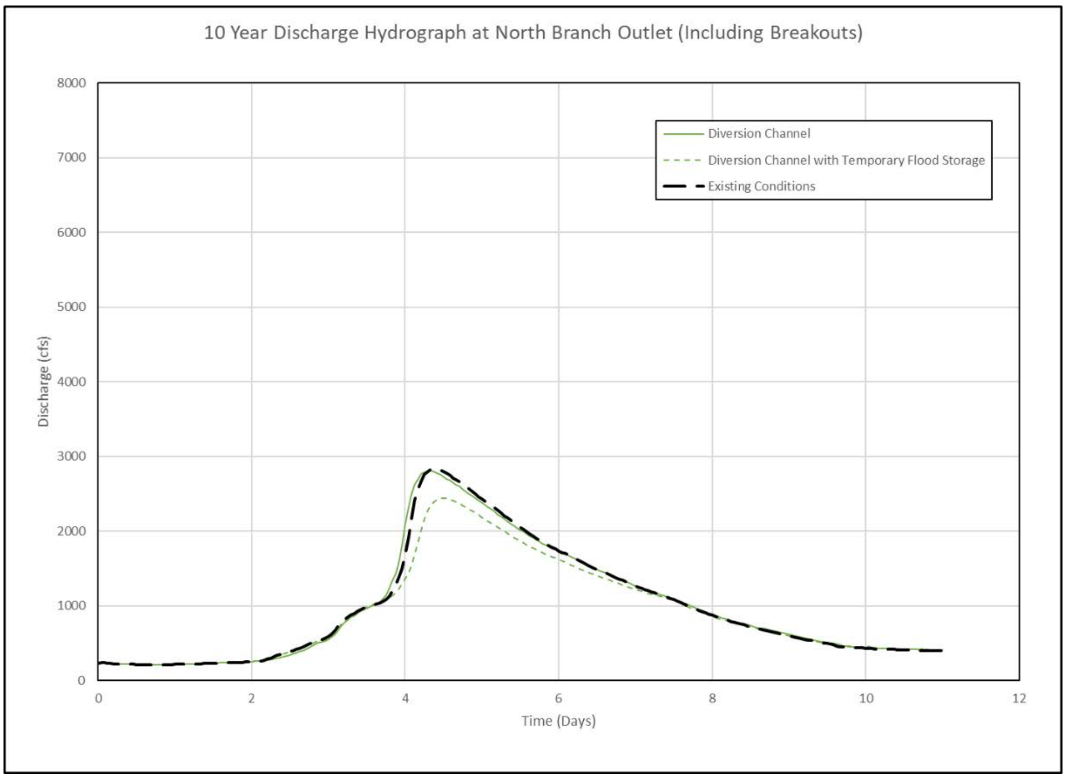


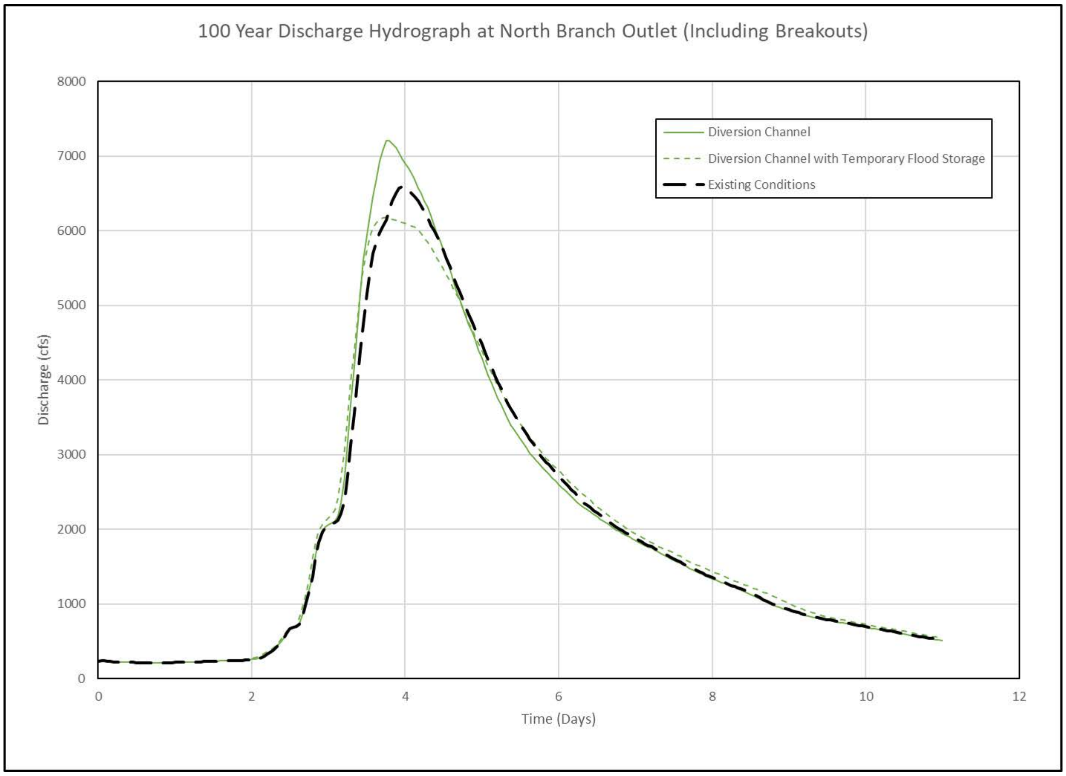
10 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Diversion Channel
Diversion Channel with Temporary Flood Storage
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12


100 Year Discharge Hydrograph at 77th St NE - North Branch Downstream of Cart Creek
Discharge (cfs)
Time (Days)
Diversion Channel
Diversion Channel with Temporary Flood Storage
Existing Conditions
0
1000
2000
3000
4000
5000
6000
7000
0
2
4
6
8
10
12


10 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Discharge (cfs)
Time (Days)
Diversion Channel
Diversion Channel with Temporary Flood Storage
Existing Conditions
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12


100 Year Discharge Hydrograph at North Branch Outlet (Channel Only)
Diversion Channel
Diversion Channel with Temporary Flood Storage
Existing Conditions
Discharge (cfs)
Time (Days)
0
200
400
600
800
1000
1200
0
2
4
6
8
10
12


10 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Diversion Channel
Diversion Channel with Temporary Flood Storage
Existing Conditions
Discharge (cfs)
Time (Days)
0
1000
2000
3000
4000
5000
6000
7000
8000
0
2
4
6
8
10
12



100 Year Discharge Hydrograph at North Branch Outlet (Including Breakouts)
Diversion Channel
Diversion Channel with Temporary Flood Storage
Existing Conditions
Discharge (cfs)
Time (Days)
8000
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12