August 31, 2021

TONGUE RIVER WATERSHED PLAN

Appendix D-3: Screening of Alternatives for Detailed Review

USDA United States Department of Agriculture
Natural Resources Conservation Service

HoustonEngineering Inc.

TONGUE RIVER WATERSHED PLAN

APPENDIX D-3: SCREENING OF ALTERNATIVES FOR DETAILED REVIEW

August 31, 2021

Pembina County Water Resource District
Cavalier, ND

USDA United States Department of Agriculture
Natural Resources Conservation Service

HoustonEngineering Inc.

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1 INTRODUCTION

1.1 BACKGROUND

This report will focus on the screening of channel stabilization and flood reduction strategies and alternatives based on technical data, practicality to implement, and their ability to satisfy the Purpose and Need for the Tongue River Watershed Plan. The Purpose and Need for the project are detailed in the *Tongue River Watershed Plan – Environmental Assessment* document. Alternatives that are deemed worthy to carry forward will be analyzed in more detail after the preliminary screening is completed by conducting preliminary hydrologic and hydraulic analyses, by implementing a concept level design, and by developing a preliminary cost estimate.

1.2 APPROACH

Preliminary development of alternatives focused on narrowing the range of alternatives by reviewing technical and practical considerations to evaluate potential to meet project objectives from the Purpose and Need. Strategies were first reviewed based on known causes of flooding and known issues related to loss of floodplain due to channel degradation along the mainstem of the Tongue River.

All reasonable alternatives that were identified were considered regardless of eligibility under Public Law 83-566 or other NRCS administered funding sources. Alternatives that remain after all technical and practical considerations have been vetted, and that have the potential to meet the goals presented in the Purpose and Need, are to be carried forward for a detailed review. After the preliminary screening, the benefits provided by the alternative(s) to be carried forward and analyzed in more detail will be determined to establish the benefit/cost ratio.

2 INITIAL STRATEGY SCREENING

The initial phase of the development of alternatives was a review of a comprehensive list of strategies that represent categories of types of alternatives. The initial list of strategies was developed based on guidance from *Red River Basin Flood Damage Reduction Work Group Technical and Scientific Advisory Committee Technical Paper No. 11* (Anderson & Kean, 2004). The goal of the strategy evaluation was to narrow the scope of the 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 in the 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 would provide 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 flood damage reduction strategies that were identified and considered in the planning process, within each category, is provided in **Table 1**.

***Table 1**: Flood Damage Reduction 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 Best 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 and soil health measures such as cover crops that increase organic matter in soils. These 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.
	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.

Category	Strategy	Description
	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. Existing dams in the watershed could be evaluated for additional flood storage.
	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.
	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, channel conveyance, and 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 by utilizing 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.

Category	Strategy	Description
	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 degraded channel would allow for more frequent access to a vegetated floodplain thereby providing retention that serves to reduce downstream flow rates. Incised channels can be modified to reduce channel conveyance for increased floodplain connectivity.
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.)

Given the planning purpose of addressing river channel erosion, additional alternatives were considered that would address that concern, which are listed in Table 2.

Table 2: Incised Channel Stabilization Strategy Description

Category	Strategy	Description
Natural Channel Design	Stage 0 Restoration	Construction of a braided channel system, composed of many small channels with vegetated islands between, spread out across a wide floodplain. Commonly would be constructed with significant quantities of large woody debris spread out across the floodplain; high densities of beaver dams to create wetland complexes would be expected to form.

Category	Strategy	Description
	Priority 1 Restoration – Relocated	Reconstruct geomorphically stable channel that establishes bankfull stage at the historical floodplain elevation. The majority of the channel is constructed at a new location on the floodplain, with fill from excavation utilized to place in existing incised channel. Wetlands typically left at locations in old channel.
	Priority 1 Restoration – In Place	Reconstruct geomorphically stable channel that establishes bankfull stage at the historical floodplain elevation. The majority of the channel is constructed within the existing channel extents.
	Priority 2 Restoration	Construct a new channel, much of it at a different location, to generate a geomorphically stable channel at the current channel elevation. Typically this would include the addition of inset floodplain benches, therefore widening the channel bottom as well as adding channel length to increase sinuosity.
	Priority 3 Restoration	Maintain the channel at its current location and elevation, but widen the bottom as necessary to create a stable channel.
Passive Restoration Measures	Beaver Dam Analogues	Posts and other small materials are installed by hand in the channel at strategic locations, to encourage beavers to construct dams. If beaver populations are thought to be low, trapping and relocating animals to augment the population may be as well.
Structural Measures	Constructed Check Dams	Concrete, steel, timber, and/or rock materials are utilized to construct dams within the channel to create or maintain the elevation of the river channel bottom.
	Riverbank Stabilization (Priority 4)	Riprap, concrete, steel, timber structures are installed to reduce erosion on banks.
	Armored Channel (Priority 4)	Concrete or rock materials are utilized to fully armor the bed and banks of a channel to resist erosion.

2.1 TECHNICAL CONSIDERATIONS

A technical review was completed to aid in the preliminary screening of alternatives. The technical review included consideration for impacts to peak discharge within the planning extents, peak discharge downstream of Renwick Dam, inundation of cropland, and inundation of structures and roadways that would result from each of the alternatives considered. Any alternatives that would cause adverse impacts relative to the goals outlined in the Purpose and Need were eliminated from further review. Determination of peak flow and inundation impacts for some of the flood control alternatives were based on engineering judgement and prior experience with more detailed evaluations that were completed in the nearby Forest River Watershed (Houston Engineering Inc, 2020) and the Park River Watershed (Houston Engineering Inc, 2020).

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 project.

2.2.1 LOCAL FINANCING AND ACCEPTANCE

The PCWRD 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 received from the proposed project. To ensure successful financing of alternatives, or to obtain any required match for state and/or federal funding, proposed projects 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 impacts, if certain strategies were likely to lead to significant environmental issues, they were eliminated from further consideration. Selection of a strategy that would fit under the U.S. Army Corps of Engineers Nationwide Permit 27- Aquatic Habitat Restoration was a desire of the planning team, to ensure streamlined permitting.

2.2.3 ABILITY TO IMPLEMENT

The ability to implement strategies in a reasonable timeframe 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 issues with current local, state and federal laws and zoning ordinances. Selection of a strategy acceptable to landowners involved in the project was an important consideration.

2.2.4 ABILITY TO MAINTAIN

The PCWRD is currently responsible for evaluating and addressing any maintenance issues related to existing retention structures within the Tongue River Watershed. There are currently 10 existing retention structures in the Tongue River Watershed (including Senator Young Dam at the upstream limit of the RCPP planning extents and Renwick Dam at the downstream limit of the planning extents). All retention structures in the watershed except Renwick Dam have exceeded their design life, and many are in need of rehabilitation. Renwick Dam has already undergone the rehabilitation process and Senator Young, Bourbanis, and Olson Dams currently have rehabilitation plans underway. If these and other structures within the watershed continue to be rehabilitated, maintenance associated with the structures will also need to continue. The SLO has raised concern over proposed alternatives that would require significant maintenance in addition to the maintenance required for the existing structures. The concern is due to the lack of time and resources available to the SLO if they are to continue their current responsibility of maintaining the existing retention structures in the Tongue River Watershed. For this reason, alternatives that would require significant maintenance in the future were not carried forward for this study.

2.3 FLOOD DAMAGE REDUCTION STRATEGY OUTCOMES

Table 3 provides a list of strategies within each category, and rationale for strategies included/excluded from further review.

***Table 3**: Flood Damage Reduction 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 recreation and flood damages, this alternative is not locally preferred. • The No-Action Alternative would not address channel erosion and sediment/phosphorus delivery to Renwick Dam and shows similar inundation and damages when compared to the existing conditions flooding in the Tongue River Watershed, meaning that none of the goals presented in the Purpose and Need would be achieved.
Reduce Runoff Volume	Cropland Better Management Practices	Eliminate	• Alternative considered undesirable for local landowners. • Would not be effective in mitigating ongoing channel incision. • 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. • Would not be effective in mitigating ongoing channel incision.
	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. • Would not be effective in mitigating ongoing channel incision.
	Aquifer Storage	Eliminate	• Lack of monitoring associated with the Icelandic Aquifer and Pembina Delta Aquifer, both of which are located within the Tongue River Watershed upstream of Renwick Dam, causes uncertainty in storage available within the aquifer. • The ability for the SLO to maintain a passive infiltration system and surface storage site is limited. • Would not be effective in mitigating ongoing channel incision.

Category	Strategy	Determination	Rationale
	Other Beneficial Uses of Stored Water	Eliminate	• Would provide minimal impact to the goals outlined by the Purpose and Need. • While not likely practical as an individual alternative, this concept can be a component of other alternative enhancements. • Would not be effective in mitigating ongoing channel incision.
Increase Conveyance Capacity	Channelization	Eliminate	• Channelization throughout the watershed would cause adverse effects on the goals outlined in the Purpose and Need because shorter flow paths produce larger peak flow rates downstream of the planning watershed. • Historical channelization upstream of Hwy 89, through straightening and construction of levees, was a major contributor to the current incised channel condition.
	Drainage	Eliminate	• Increased drainage off farm fields would cause increased peak flow and inundation in downstream areas. • Would not be effective in mitigating ongoing channel incision, and upstream of Hwy 89 could serve to speed up channel incision process.
	Flood Water Diversion	Eliminate	• Flood water diversions often cause increased peak flow rates downstream because flows are routed through a straight path where they tend to meander in a natural water course. Shortening the flow path would likely cause increased peak flows downstream. • The flood water diversion would likely need to be implemented along with additional measures to prevent peak flow rate increases downstream. Many of the additional measures that would be needed to supplement the diversion are included in this table and were eliminated for various reasons. • No obvious location for a flood water diversion exists in, or upstream of the area of flood damage concern between ND State Highway 32 and Renwick Dam.
	Increase Roadway Capacity	Eliminate	• Increasing conveyance capacity could be used in localized areas to reduce agricultural damages by removal of cropland floodplain; however, increased conveyance through roadway crossings would cause an increase in peak flow rates downstream.

Category	Strategy	Determination	Rationale
Increase Temporary Flood Storage	On-Channel Dam	Eliminate	• On-channel impoundments have 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. • Existing dams in the watershed could be evaluated for additional flood storage. • Ability of the SLO to maintain an on-channel dam is limited.
	Reduced Bridge/Culvert Capacity	Eliminate	• ND Century Code provide Stream Crossing Standards that do not allow culvert sizes to be reduced.
	Wetland Restoration/ Creation	Eliminate	• 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. • A preliminary evaluation of NWI wetlands that have been drained in the watershed between Senator Young and Renwick Dams indicates that the total area of drained wetlands is less than 1% of the total watershed area. Therefore, minimal impacts to peak flow reduction and inundation are expected. • Preliminary hydric soil data and Table 5-2 from the ND Hydrology Manual (USDA, SCS) indicate that there is flow reduction potential for damage areas and at the outlet at Renwick Dam; 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 such as a Stage Zero Restoration Approach.
	Setback Levees	Eliminate	• The ability of the SLO to successfully implement in a reasonable timeframe and maintain sufficient locations is limited. • Would not be effective in mitigating ongoing channel incision.
	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 Tongue River Watershed.

Category	Strategy	Determination	Rationale
	Off-Channel Impoundment	Carry Forward	• Storage in the Tongue River Watershed could be used to address flood damage impacts upstream of Renwick Dam. • A preliminary site was identified as having potential to reduce cropland inundation and peak flows in the watershed upstream of Renwick Dam. • Ability of the SLO to maintain an off-channel impoundment is limited.
	River Restoration/ Stabilization	Carry Forward	• Increased access to floodplain where the channel is currently degraded has the potential to reduce flood inundation and peak discharge downstream. • The SLO has expressed the desire to address channel degradation issues and loss of floodplain along this stretch of the Tongue River. • Low maintenance retention ponds adjacent to the restoration could be built to provide fill material for the degraded channel and to provide additional flood reduction benefits. • Natural channel design methods are intended to ensure that river restoration projects remain stable for a natural range of hydrologic and sediment transport conditions in the watershed, and therefore do not require maintenance. Grade control structure would be the only expected potential O&M need.
Protection/ Avoidance	Levees	Eliminate	• Levees that would help to contain breakout flows that currently exist along the Tongue River corridor would cause an increase in peak discharge and inundation downstream. Would need to mitigate downstream impacts by combining levees with another alternative. Other alternatives that would be needed to supplement the levees are included in this table and were eliminated for various reasons. • Ring levees around farmsteads were not considered for an individual alternative because they would not adequately address the objectives in the Purpose and Need. • Would not be effective for mitigating channel incision; levees were a major driver of the existing incision problem.

Category	Strategy	Determination	Rationale
	Flood Warning System	Eliminate	• Not practical for the Tongue River. During the 25-year event, there is an approximate 2-day lag between the peak rainfall intensity and the peak outflow from Renwick Dam. This is not sufficient time to implement temporary measures to meet objectives defined in the Purpose and Need. • Would not be effective for mitigating channel incision.
	Floodplain Easements	Eliminate	• Floodplain easements would be required on the areas with inundation longer than 24-hours for the 25-year, 4-day event to meet the objectives defined in the Purpose and Need. • Local acceptance and financing would likely be an issue. • Alternative does not address concerns for the loss of floodplain cropland, forest, and riparian wetlands adjacent to the Tongue River. • Would not be effective for mitigating channel incision.

2.4 RIVER RESTORATION AND CHANNEL STABILIZATION STRATEGY OUTCOMES

The river restoration and channel stabilization strategy was selected to be carried forward for a more detailed review in the plan based on the rationale provided in **Table 3** . There are several techniques and strategies that can be used to achieve channel stabilization. **Table 4** provides a list of strategies for channel stabilization, and rationale for strategies included/excluded from further review within the river restoration alternative. Note that all strategies would incorporate removal of existing levees along the Tongue River in the vicinity of Highway 89, would reduce sediment/phosphorus delivery to Renwick Dam to at least some degree.

Table 4: Incised Channel Stabilization Strategy Description

Category	Strategy	Determination	Rationale
Natural Channel Design	Stage 0 Restoration	Eliminate	• Not compatible with existing Highway 89 bridge and associated fill across the floodplain. • Not compatible with CRP hayfields downstream of Highway 89. • Local acceptance and financing would be an issue.

Category	Strategy	Determination	Rationale
	Priority 1 Restoration – Relocated	Eliminate	• The Highway 89 bridge is located on the far south side of the valley, therefore severely limiting options for locating a new channel. To maintain desired sinuosity, a new channel constructed on the floodplain would be nearly adjacent to the existing channel. Downstream of Highway 89 landowner not willing to lose his CRP hayfield. • Reduces erosion from the current channel and upland slopes, as well as halting the progression of incision upstream. • Geologic investigation indicates that floodplain soil materials are highly erodible, loose, remnants of Pierre Shale. Density of floodplain soils is lower than the compacted channel fill would be. Geologic investigation identified no gravel particles, likely due to historic land leveling and tillage. If a new channel was constructed on the floodplain it would need to be over-excavated and lined with gravel to avoid immediate incision. River would capture the old channel quickly in this scenario, creating an over-widened channel, unless the old channel was also armored with grade control structures, which would generate both high risk of failure and high construction costs. • Relocating the channel would require removal of mature riparian forests, which provide critical shade to the channel for state fish species of concern are habitat for ESA listed bat species. Mature riparian trees also lessen the speed of lateral channel migration. • For this alternative to be realistic, relocation of the Highway 89 bridge (or addition of a 2nd bridge) near the center of the floodplain would be necessary. Ideally the road fill would be dropped as well. These actions are both cost prohibitive and undesirable due to access limitations, during construction and future flood events, to the Cavalier Air Force Station.

Category	Strategy	Determination	Rationale
	Priority 1 Restoration – In Place	Carry Forward	• The SLO has expressed the desire to address channel degradation issues and loss of floodplain along this stretch of the Tongue River. • Low maintenance retention ponds adjacent to the restoration could be built to provide fill material for the degraded channel and to provide additional flood reduction benefits. • Reduces erosion from the current channel and upland slopes, as well as halting the progression of incision upstream. • Maintains mature riparian trees adjacent to the river channel, with the exception of those that will have to be cut in association with levee removal. • Historic meanders will be able to be reactivated in conjunction with levee removal and hydrology to the floodplain and floodplain wetlands restored. • The channel can be designed to remain centered below the existing Highway 89 bridge and will reduce risk of future erosion on the road fill during floods. • Fish passable grade control structures will provide incision-counter measures and reconnect the channel with it's natural floodplain. • Natural channel design methods are intended to ensure that river restoration projects remain relatively stable for a natural range of hydrologic and sediment transport conditions in the watershed and therefore do not require maintenance. Natural levels of erosion and channel migration can be tolerated. The rock arch rapids grade control structure would be the only expected potential O&M need.

Category	Strategy	Determination	Rationale
Passive Restoration Measures	Priority 2 Restoration	Eliminate	• Maintaining the channel at its current bed elevation will not address instabilities on adjacent upland slopes that have been undercut by incision. • Grade control structures would need to be installed to halt the upstream progress of incision. • Adjacent riparian forest would need to be cut to allow adequate room for an even wider channel than what has eroded, in which to construct a stable inset floodplain. • Bank stabilization measures would be expensive, particularly on the south side of the channel. • Additional loss of land and trees would be unacceptable to landowners or the SLO.
	Priority 3 Restoration	Eliminate	• Maintaining the channel at its current bed elevation will not address instabilities on adjacent upland slopes that have been undercut by incision. • Grade control structures would need to be installed to halt the upstream progress of incision. • Stabilizing high banks in a narrow channel would be very expensive, particularly on the high terrace on the south side.
	Beaver Dam Analogues	Eliminate	• Beavers are active in the Tongue River and establish dams in the project reach nearly every summer. In every case, high velocities in the incised channel resulted in dam failure during spring runoff, even in low snowpack years. Beaver dams do span multiple years upstream of the incised reach and on small tributaries. While BDAs cannot be a stand-alone strategy, they could be incorporated in portions of the channel that are not significantly incised.

Category	Strategy	Determination	Rationale
Structural Measures	Constructed Check Dams	Eliminate	• On intermittent channels in farm fields gullies are occasionally treated by installation of rock, timber, concrete, or earthen check dams spaced at intervals; after which surface sediment runoff can fill between the dams naturally. This is not an effective approach on alluvial rivers and can result in major instability; potentially a braided channel due to uncontrolled depositional patterns behind 8 ft high dams. • Although dams could be constructed to be stable, they would have an unacceptable negative result on aquatic species habitat; this type of project could not be permitted on the Tongue River. Would not meet NWP27.
	Riverbank Stabilization (Priority 4)	Eliminate	• Stabilizing high banks would be very expensive, particularly on the high terrace locations on the south side. • Nothing would prevent incision from continuing to progress upstream. • Heavy handed structural approaches to riverbank stabilization may not be permitted and could have a negative impact on aquatic species habitat. Would not meet NWP27.
	Armored Channel (Priority 4)	Eliminate	• Stabilizing high banks would be very expensive, particularly on the high terrace locations on the south side. • Heavy armor in the channel, of a size that would not mobilize during flood flows, would have a negative impact on aquatic species habitat and would be unlikely to be permitted. Would not meet NWP27.

3 PRELIMINARY ALTERNATIVES

Strategies identified in the initial strategy evaluation are used to preliminarily identify a range of alternatives. Only two flood damage reduction alternatives remained after the initial strategy evaluation. These alternatives were then evaluated to determine their potential to attain the objectives from the Purpose and Need. The following provides a brief description of each alternative considered.

3.1 NO-ACTION ALTERNATIVE (FUTURE WITHOUT PROJECT)

The No-Action Alternative is required to be considered based on the NRCS *National Watershed Program Manual* (2015). From a flood control perspective, there are nine existing dams within the Tongue River watershed in the planning area upstream of Renwick Dam. The location of the dams, and the drainage area they control, are shown in **Figure 3.1**. The existing dams were all constructed between 1955 and 1961. As of 2021, all of these dams have exceeded their original design life of 50-years, and the three high hazard dams in the watershed are currently engaged in NRCS PL-566 Watershed Rehabilitation Plans. Renwick Dam, specifically, was rehabilitated for a 100-yr lifespan starting in 2014. Currently, most of the remaining high hazard dams in the watershed (Senator Young, Olson, and Bourbanis) are undergoing rehabilitation planning efforts. The potential for adding flood storage to those dams does not exist, due to topographic limitations and performance criteria needed to meet dam safety requirements. At this stage in the rehabilitation planning process, it is clear that structural rehabilitation of Senator Young and Olson is likely to be pursued, therefore the No Action Alternative assumes those structures will remain in place for another 50-years. With the recent determination that Herzog Dam also falls into a high hazard designation, by NRCS criteria, the Sponsor will be seeking to initiate planning on that dam as well. The No-Action Alternative assumes that existing dams will remain in place but no further flood damage reduction measures would be installed in the watershed. The resultant effect on discharge and inundation within the watershed is the same as the existing condition in the watershed which was reported on in the *Tongue River Watershed Plan – Existing Conditions Hydrology and Hydraulics Report* (Houston Engineering Inc., 2021). If in the future some of the dams are decommissioned, or if nothing is done to rehabilitate the structures in a way that eliminates any federal investment, the resultant peak discharge and inundation downstream of the structures would increase.

The No-Action Alternative does not successfully address any of the objectives outlined in the Purpose and Need. At best, the No-Action Alternative would produce flood damage results upstream of Renwick Dam that are the same as the existing condition of the watershed. Regardless of the results of rehabilitation planning efforts, or status of existing dams, channel incision would continue upstream, destroying high quality stream habitat, riparian areas, forest resources, and requiring infrastructure projects as outlined in Appendix D-8. Sediment generated from channel incision would fill the permanent pool of Renwick Dam, as outlined in Appendix D-8, effectively turning it into a dry dam unless an expensive dredging project were to be done. Recreation use of the reservoir would be eliminated, without dredging, and downstream flood reduction benefits from Renwick Dam would decrease in the future as sediment began to fill the flood pool.

3.2 RIVER CORRIDOR RESTORATION (ALTERNATIVES 2 & 3)

Channel instability, incision, and degradation have been observed in the Tongue River between Senator Young and Renwick Dams in recent years resulting in the loss of floodplain cropland, forestland, and

riparian wetlands. These issues have been of particular concern in the Tongue River near North Dakota State Highway 89 in Sections 28 and 29 of Beaulieu Township, Pembina County, ND. NRCS engineering staff have been monitoring the channel incision in this area since 2015 and have utilized this data to develop the detailed information and preliminary design for a river corridor restoration project described in other Appendix D reports. The resulting flows and inundation with the river corridor restoration alternative in-place are also provided in that report. **Figure 3.2** shows the approximate location of the proposed restoration extents.

Appendix D-4 Channel Stabilization Conceptual Design Report provides a detailed description of the two proposed restoration alternatives developed for final consideration in the Watershed Plan/EA. Comparative costs and benefits are outlined in Appendix D-5 Economics Evaluation Technical Memorandum and Appendix D-8 Project Benefits Reports. The alternatives are identical in all aspects, with the exception of the size of the floodplain excavations.

3.3 PRELIMINARY ALTERNATIVE ELIMINATED FROM FINAL CONSIDERATION

One other preliminary alternative was evaluated to determine the potential for an off-channel impoundment to reduce flood damages in the Tongue River Watershed upstream of Renwick Dam. The site would have included an on-channel crossing a few hundred feet downstream of the Tongue River crossing with 131st Avenue NE (just upstream of the Tongue River crossing with North Dakota State Highway 5) to divert flood flows to the storage site. The storage site would contain an embankment located in portions of Section 24 in Beaulieu Township and Section 19 in Akra Township, Pembina County, ND. The site would be dry during non-flood conditions. A principal spillway would route flows through an existing ditch south of North Dakota State Highway 5 until it eventually outlets into an existing swale in Section 20 of Akra Township, Pembina County, ND. The swale would cross State Highway 5 and travel through portions of Section 17 and Section 8 of Akra Township before intersecting the Tongue River upstream of the reservoir at Renwick Dam. The flows that travel through the principal spillway, existing ditch, and swale would also be routed through Morrison Dam which is located in Section 8 of Akra Township. **Figure 3.3** shows the proposed location of the off-channel storage site that was preliminarily evaluated.

The proposed site showed that an off-channel impoundment does have the potential to reduce cropland inundation and peak discharges in the Tongue River Watershed upstream of Renwick Dam. The site would be designed to mitigate any potential increase to peak flows downstream of Renwick Dam as well. However, the site does not address the issues related to channel stability in the Tongue River near North Dakota State Highway 89. Furthermore, the implementation of an additional storage site in the Tongue River Watershed was not looked upon favorably by the SLO due to concerns over the ability to maintain the structure over its design life. Several other retention structures exist within the watershed and the SLO has raised concern over adding additional structures that will need maintenance in the future. Therefore, due to the alternative not addressing channel stability concerns and the limited ability for the SLO to maintain the site, this alternative was eliminated from detailed review.

4 REFERENCES

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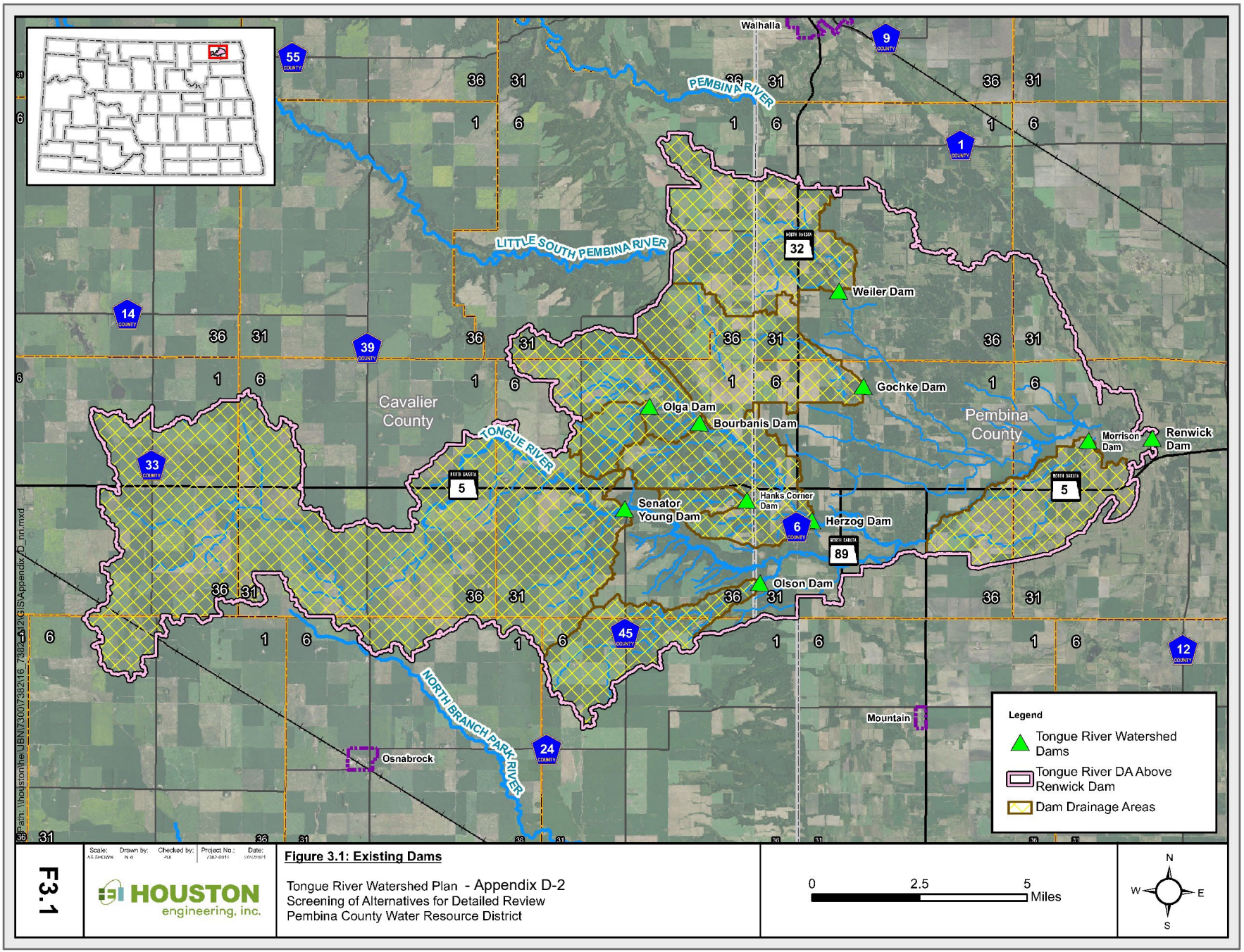
FIGURES


Walhalla
PEMBINA RIVER
LITTLE SOUTH PEMBINA RIVER
TONGUE RIVER
NORTH BRANCH PARK RIVER
Cavalier County
Pembina County
Weiler Dam
Gochke Dam
Olga Dam
Bourbanis Dam
Morrison Dam
Renwick Dam
Senator Young Dam
Hanks Corner Dam
Herzog Dam
Olson Dam
Osnabrock
Mountain
Legend
Tongue River Watershed Dams
Tongue River DA Above Renwick Dam
Dam Drainage Areas
F3.1
Figure 3.1: Existing Dams
Tongue River Watershed Plan - Appendix D-2
Screening of Alternatives for Detailed Review
Pembina County Water Resource District
HOUSTON engineering, inc.
0 2.5 5 Miles
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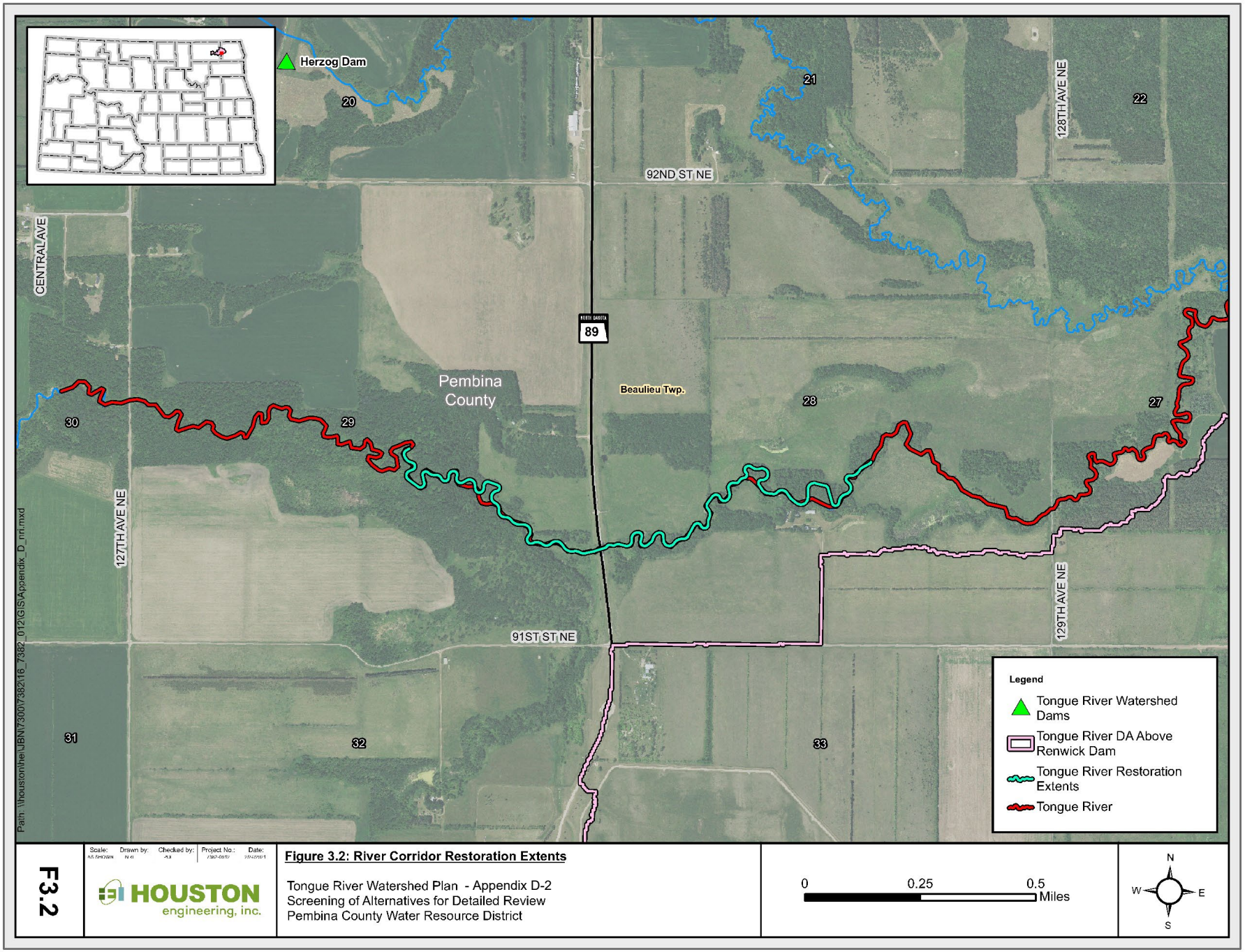
W
E
S


Herzog Dam
20
21
22
92ND ST NE
128TH AVE NE
CENTRAL AVE
89
Pembina County
Beaulieu Twp.
28
27
30
29
127TH AVE NE
129TH AVE NE
91ST ST NE
31
32
33
Legend
Tongue River Watershed Dams
Tongue River DA Above Renwick Dam
Tongue River Restoration Extents
Tongue River
Path: \\houstonhei\JBN\7300\7382116_7382_012\GIS\Appendix_D_rri.mxd
F3.2
HOUSTON engineering, inc.
Figure 3.2: River Corridor Restoration Extents
Tongue River Watershed Plan - Appendix D-2
Screening of Alternatives for Detailed Review
Pembina County Water Resource District
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0.25
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Miles
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W
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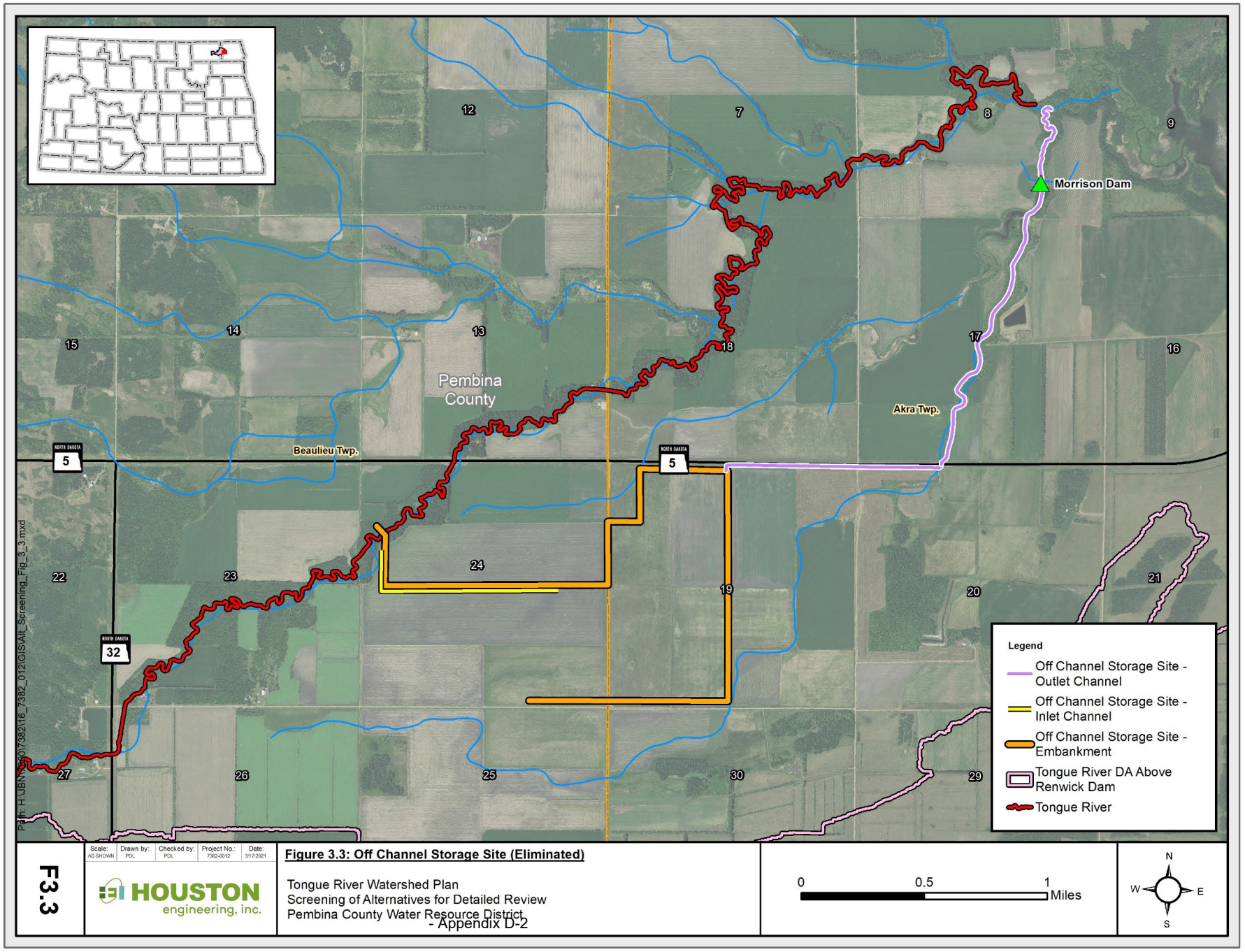
Morrison Dam
Pembina County
Akra Twp.
Beaulieu Twp.
NORTH DAKOTA 5
NORTH DAKOTA 32
12
7
8
9
15
14
13
18
17
16
22
23
24
19
20
21
27
26
25
30
29
Legend
Off Channel Storage Site - Outlet Channel
Off Channel Storage Site - Inlet Channel
Off Channel Storage Site - Embankment
Tongue River DA Above Renwick Dam
Tongue River
0
0.5
1
Miles
N
W
E
S
F3.3
HOUSTON engineering, inc.
Figure 3.3: Off Channel Storage Site (Eliminated)
Tongue River Watershed Plan
Screening of Alternatives for Detailed Review
Pembina County Water Resource District

- Appendix D-2