FEBRUARY 2017

OLSSON PROJECT NO. 016-1500

PLATTE REPUBLICAN DIVERSION PROJECT FEASIBILITY REVIEW

PREPARED FOR:

PLATTE REPUBLICAN DIVERSION
LOWER REPUBLICAN
NATURAL RESOURCES DISTRICT
AND TRI-BASIN
NATURAL RESOURCES DISTRICT

OLSSON® ASSOCIATES

EXECUTIVE SUMMARY

FINDINGS:

Based on the results of this feasibility study, the Platte Republican Diversion Project would be cost-effective. With minimal improvements to the channel, and the existing bridge and culverts along Turkey Creek, diverting unallocated flows of up to 100 cfs from the Platte River basin could provide substantial benefits to the Republican River basin without negatively impacting Turkey Creek.

The water resources of the Platte and Republican Rivers have been extensively developed in part through the construction of many large reservoirs and canal delivery systems. This development has drastically altered the occurrence of surface water in both timing and location within each basin. The proximity of canals on the south side of the Platte River relative to tributaries to the Republican River now presents a golden opportunity.

While the Platte River basin has had incredible flows the past few years, the water supplies remain relatively low in the Republican River basin. This feasibility study looks at diverting excess flows from the Platte River basin into the Republican River via Turkey Creek.

Olsson used a three-step analysis strategy to develop a benefit cost ratio that would indicate the relative feasibility of this project.

1. The first step involved conducting a geomorphologic field analysis, an environmental assessment, and obtaining survey data to use during the analysis.
2. The second step involved creating a surface water hydraulic model for Turkey Creek. This model was used along with the information developed as part of step one to develop a list of improvements that are needed in order to protect or replace existing structures and mitigate against potential erosion that might occur along Turkey Creek under prolonged periods of higher flows resulting from the diversion project.
3. From the list of improvements, a cost of the project was developed for several different alternatives. A benefit cost ratio for the project was developed using information from the previous costs of providing equivalent benefits to streamflow in the Republican River basin by alternative means.

Given the favorable Benefit Cost Ratios, the Platte Republican Diversion project has great potential to provide needed additional flow into the Republican River basin when excess water is available in the Platte River.

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1.0 INTRODUCTION

This report documents the preliminary results of the feasibility review of the Platte Republican Diversion project in Gosper and Furnas counties, Nebraska. The feasibility review was conducted on behalf of the Lower Republican Natural Resources District (LRNRD) and the Tri-Basin Natural Resources District (TBNRD). The purpose of the proposed Platte Republican Diversion project is to divert unallocated flows from the Platte River to the Republican River via Turkey Creek. The purpose of the feasibility review is to determine impacts of diverting these unallocated flows into Turkey Creek, to develop a benefit-cost analysis for the project, and to provide additional guidance on the feasibility of the project.

Turkey Creek is a tributary to the Republican River and generally runs north to south starting approximately 4 miles east of Elwood, Nebraska. It empties into the Republican River between Edison and Oxford, Nebraska. The upper 4 to 5 miles of Turkey Creek runs through canyon areas and many stretches do not have a fully defined bed and bank. This upper section does have a fairly defined stream centerline, but the overall capacity of the creek in this section is less than the capacity of the creek in the middle and lower sections. The upper section of Turkey Creek also includes several farm ponds that currently retain a portion of the flow along Turkey Creek. The middle and lower portions of Turkey Creek have fully defined beds and banks that carry base flow. The primary land use for the adjacent properties to Turkey Creek are either pastures or farmland.

There are times during the year when the Platte River has potential excess flows that are not allocated or appropriated for downstream uses. Currently, these flows continue on down the Platte River past the proposed diversion point.

Excess flows in the Platte River will be used to help augment flows in the Republican River through Turkey Creek with a direct beneficial use to the state of Nebraska's interstate compact obligations, using publicly owned existing infrastructure. Other beneficial uses include groundwater recharge, and potential recreational benefits at Harlan County Lake.

2.0 REVIEW AND ANALYSIS OF EXISTING CONDITIONS OF TURKEY CREEK

2.1 Existing Characteristics

Topographic Summary of the Project Area

Turkey Creek can be divided into three distinct flow reaches based on channel capacity and characteristics.

The uppermost portions of the Turkey Creek watershed lack a defined channel, with runoff occurring through canyons as sheet flow. At approximately 5 miles downstream near Drive 432A, the creek and its tributaries have a fully defined bed and bank with a visible flowline. The eastern branch of Turkey Creek and the main channel of Turkey Creek, the portions of the watershed that will need to transmit the diverted water, can be divided into three distinct flow reaches based on channel capacity. Exhibit A in Appendix A is an overall map of the project reaches.

Upper Section of Project Area.

The upper section consists of the first 3,000 feet of eastern branch of Turkey Creek. It has a fairly steep slope for the entire length, which will generate higher velocities during flow events, significantly increasing the potential for erosion. It has a fairly defined centerline however lacks a channel bed, banks, and cross-sectional area to contain flows. Any runoff generated by rainfall events flows overland as sheet flow through this area. With no defined channel the flow is not contained and the upper section has an existing capacity of zero (0) cubic feet per second (cfs).

Middle Section of Project Area.

The middle section consists of approximately the next 5 miles of eastern branch of Turkey Creek. It has a defined channel, but has a more limited capacity and is generally steeper relative to the lower section. This middle section has a general top of bank capacity of ranging from 100 cfs at the beginning of the section to 650 cfs just north of Drive 432A. The capacity slowly increases as you progress downstream.

Several farms ponds along Turkey Creek in the upper/middle section affect flow downstream.

The remainder of Turkey Creek is referred to as the lower section. This section has a well-defined channel with higher channel capacities. There is a steady base flow during the majority of the year, and this section can handle the majority of larger storm events. The general top-of-bank capacity is 885 cfs for this portion of Turkey Creek.

Lower Section of Project Area.

2.2 Hydrology

A hydrologic analysis was completed along the entire project length to determine the typical flows that have historically occurred in Turkey Creek. It is important to establish the baseline conditions so that these baseline conditions can be considered relative to the conditions that will occur when diverted flows are added to the creek. This will help separate existing erosional conditions from potential new erosion concerns when designing channel improvements.

The project length was separated into different drainage areas to correctly determine typical flows from upstream to downstream along the creek. Exhibit B in the Appendix A shows the drainage areas as they were delineated. Drainage areas 1 and 2 are in the previously defined upper section, drainage areas 3 through 6 are in the middle section, and drainage areas 7 through 25 are in the lower section. The upper section was divided into two areas to more accurately reflect flows in that section. Downstream of the upper section, drainage areas were separated and delineated according to drainage structures or roadway crossings. A separate drainage area was developed for each structure and peak flows were calculated. Below the uppermost drainage area, the peak flows are combined to reflect a total flow in Turkey Creek at that location.

Two different hydrologic methods were utilized to calculate peak flows along Turkey Creek. The method chosen was based on the size of each drainage area being analyzed. The first method, Technical Release 55 (TR-55), is a simplified procedure to calculate storm runoff volume, peak rate of discharge, and hydrographs for small watersheds and was used for drainage areas under 5 square miles. The second method, which involved using selected Regional Regression Equations, was used for the drainage areas greater than 5 square miles.

Because of a flatter slope and larger flow area, the peak flows actually decrease somewhat toward the downstream areas of Turkey Creek. Peak flows for the 2-year, 10-year, 25-year, 50-year, and 100-year events were calculated. Exhibit C in Appendix A shows the peak flows that were calculated for each drainage area and the cumulative flows along Turkey Creek.

2.3 Hydraulics

Next, the hydraulic characteristics of Turkey Creek were modeled using HEC-RAS 4.0. The HEC-RAS program was developed by the Hydrologic Engineering Center and is designed to model one-dimensional steady flow, one and two-dimensional unsteady flow, sediment transport/mobile bed conditions, and water temperature / water quality conditions. Input data for the HEC-RAS model included the hydrologic information discussed above, LiDAR and survey data to represent the channel shape and the topography, and channel and overbank roughness coefficients. The one-dimensional steady flow model was utilized for this project. The current conditions of Turkey Creek were analyzed to establish the existing water surface elevations along the project length. Each existing drainage structure was also analyzed as part of this modeling effort.

2.4 Geomorphology

A geomorphologic analysis was performed along the entire project length. Soil samples, stream measurements, erosion areas, and other pertinent information were collected during the site visit and used during the analysis. The full geomorphology report is included in Appendix B for reference. The general purpose of the geomorphology study was to determine what would be the potential impact of adding the diverted flows into Turkey Creek for an extended length of time. Flow rates of 40 cfs and 100 cfs were both analyzed for their impacts and length of time that the diverted flows could realistically be diverted into Turkey Creek without causing erosion issues. General findings from this analysis conclude that the upper section would require extensive grading to create a defined channel area or installation of a pipe to handle the new flows. Without a newly created channel, either flow amount would have a highly erosive effect on the existing ground creating large areas of erosion.

The middle and lower sections of Turkey Creek have enough existing capacity to handle 40 cfs of flow during certain times of the year. If the diverted flow of 40 cfs is allowed down Turkey Creek during the months of September through April, the existing creek conditions appear to be sufficient to handle the additional flows. If diverted flows of 100 cfs are introduced into Turkey Creek during the same months, the number of continuous days in a row will need to be monitored. Based off existing conditions and capacity it is recommended that a flow of 100 cfs only be diverted into Turkey Creek for a maximum of 5 continuous days before reducing the diversion of excess flows. Longer periods of the diverted flow of 100 cfs would begin to affect the stability of Turkey Creek and could begin to cause sloughing along the banks and headcutting to the existing flowline. Therefore, it is recommended that the diverted flows be stopped for at least 7 days after the 5 days of continuous 100 cfs of flow. The final recommendation for this will be determined during final design.

2.5 Environmental Evaluation

A full wetland delineation was completed along the project reach to determine the extent of existing wetlands. A memo, site map, and wetland map of each drainage structure are included in Appendix C for reference. The location of the existing wetlands will be taken into account during final design. Erosion control measures and proposed grading will be designed to avoid affecting existing wetlands and the creek. If the U.S. Army Corps of Engineers (USACE) requires a Clean Water Act (CWA) Section 404 permit, it is anticipated that a nationwide permit will be obtainable. The Section 404 permit program regulates the construction activities that take place in waters of the U.S. including wetlands.

Existing Condition Information

Generally, the current condition of Turkey Creek is stable and it can handle typical flows that occur each year. However, if a consistent 40 to 100 cfs is going to be introduced into the system, some improvements must be made to allow Turkey Creek to maintain its current integrity.

2.6 Existing Conditions Conclusion

During large storm events in the upper section, the terrain of the large canyon areas allows the water to spread out and continue to flow downstream without causing issues to the surrounding properties. The middle and lower sections of Turkey Creek have enough capacity to handle the 100-year flood event without overtopping the banks. The existing bridges can also handle up to a 100-year storm event without overtopping. In the vicinity of some of the existing drainage structures there is bank erosion. Left unchecked, this erosion could potentially undermine the structures. Table 1, below, lists each of the existing structure and indicates if it is already in need of repairs due to erosion. The recommended actions are listed with the anticipated size of the erosion repair needed. A large erosion repair size is approximately 150 tons of riprap, medium repair is 75 tons of riprap, and small repair is 25 tons of riprap. The cost associated with these repairs are listed in Table 1 and Table 2 below and are not included as part of the project costs because the erosion at these structures will need to be addressed regardless of whether or not the excess flows are diverted into Turkey Creek. All existing structures require some erosion repair be completed. Generally, the current condition of Turkey Creek is stable and it can handle typical flows that occur each year. However, if a consistent 40 to 100 cfs is going to be introduced into the system, some improvements must be made to allow Turkey Creek to maintain its current integrity.

Table 1. Turkey Creek Structures – Current Conditions

Drainage Area Number	Structure	Existing Size	Recommended Actions	Cost
7	County Road 738	36" Culvert	Small Erosion Repair	$2,000
8	Private Drive 432a	1 span - 20' wide Bridge	Small Erosion Repair	$2,000
9	County Road 737	Triple 9' x 10' Box Culverts	Small Erosion Repair	$2,000
10	County Road 735	120" Culvert	Small Erosion Repair	$2,000
11	Field Access	96" Culvert	Small Erosion Repair	$2,000
12	Private Drive 432	72" Culvert	Medium Erosion Repair	$6,000
13	County Road 731	1 span - 85' wide Bridge	Large Erosion Repair	$12,000
14	County Road 730	1 span - 55' wide Bridge	Small Erosion Repair	$2,000

15	County Road 728	3 span – 90' wide Bridge	Medium Erosion Repair	$6,000
16	County Road 727	1 span – 60' wide Bridge	Small Erosion Repair	$2,000
17	County Road 726	3 span – 100' wide Bridge	Large Erosion Repair	$12,000
18	County Road 431/725	3 span – 100' wide Bridge	Medium Erosion Repair	$6,000
None	County Road 431	1 span – 40' wide Bridge	Large Erosion Repair	$12,000
19	Highway 6	4 span – 190' wide Bridge	Large Erosion Repair	$12,000
20	County Road 722	1 span – 45' wide Bridge	Small Erosion Repair	$2,000
21	County Road 721	3 span – 125' wide Bridge	Large Erosion Repair	$12,000
22	BNSF Bridge	1 span – 55' wide Bridge	Large Erosion Repair	$12,000
22	Highway 136	3 span – 105' wide Bridge	Large Erosion Repair	$12,000
23	County Road 720	3 span – 85' wide Bridge	Medium Erosion Repair	$6,000
24	Field Access	Twin 60" Culverts	Small Erosion Repair	$2,000
25	Field Crossing	36" Culvert	Medium Erosion Repair	$6,000

Table 2 – Turkey Creek Structures - Estimated Costs for Erosion Repair

Construction Item	Quantity	Unit Price	Total Price
Small Erosion Protection	9 Each	$2,000/Each	$18,000
Medium Erosion Protection	5 Each	$6,000/Each	$30,000
Large Erosion Protection	7 Each	$12,000/Each	$84,000
Estimated Total Erosion Repair Costs			**$132,000**

3.0 PROPOSED IMPROVEMENTS

3.1 Overview of Improvements

The geomorphologic analysis was used to help determine whether the existing creek would be able to handle the diverted flows or whether improvements will be needed. The potential areas of concerns observed during the geomorphologic field investigation and analysis were reviewed and focused on during the conceptual design.

The proposed improvements that would be required as part of the Platte Republican Diversion project are separated into two main categories. The first type of improvement includes modifications to the existing creek channel so that it will handle the diverted flows without causing additional erosion. The second type of improvements includes modifications to existing structures including bridges, culverts, and farm ponds so that they will not be impacted by the diverted flows.

Two different diverted flow values (40 cfs and 100 cfs) were analyzed in the HEC-RAS model to determine how the existing channel and proposed improvements in the upper section would handle the diverted flows over an extended period of time.

3.2 Channel Improvements

Because of the significantly greater channel slopes, the initial focus with regard to channel improvements was in the upper section - the first 3,000 feet of the east branch of Turkey Creek. The existing creek cross-section and slope are not equipped to handle the diverted flows without causing erosion along the existing flow path. A new, larger and more defined typical section will need to be established for the upper section to increase capacity and minimize the potential for erosion from the diverted flows. It is also important that the channel slope in the upper section be reduced to decrease the velocity and in turn minimize potential erosion. A series of grade control structures will need to be installed in the upper 3000-foot section to create a more stable slope. Exhibit D in Appendix A shows the proposed profile along Turkey Creek for this section. The proposed grade control structures can be constructed out of riprap, sheet pile or lumber. The proposed grade structures would include a 4-foot drop on the downstream side of the structure to allow a 1 percent slope to be established for the first 3,000 feet of Turkey Creek. A 1 percent slope is stable and would minimize the erosion that otherwise might occur during the introduction of diverted flows.

Another improvement option for the upper section would be to install a new underground polyvinyl chloride (PVC) pipe for the entire 3,000-foot length instead of grading a defined creek channel. The new pipe would need to be in the range of 36-inches diameter to 48-inches diameter in size. The actual pipe size would be determined during final design. A smaller pipe could be utilized with a steeper slope while a larger pipe would be needed with a flatter slope.

The middle section of Turkey Creek (approximately the next 5 miles) has an intermittently defined channel with varying capacity. Some grading would need to be completed along this section to increase the capacity to handle up to a 100 cfs without causing headcutting or incising of the existing creek. Total regrading of Turkey Creek would not be necessary, but rather would consist of widening of the existing channel in some areas to allow the diverted flows to stay within the banks.

The rest of Turkey Creek's cross-section downstream of the first 5 miles currently has sufficient capacity to handle the diverted flows along with the current base flow that Turkey Creek carries, which is approximately 12 cfs. No substantial improvements are anticipated along this stretch. There may be some minor grading that occurs along this section to repair large areas of erosion that have occurred over time. Any minor grading will take place above the ordinary high water mark (OHWM) so as to minimize any impacts to the existing stream and allow a Nationwide Section 404 permit to be obtained if needed.

3.3 Improvements to Existing Structures

The second category of proposed improvements deals with the existing structures and erosion control measures that need to be installed at each drainage structure location. As indicated above, many of the existing drainage structures at the upstream face have erosion issues that need to be addressed regardless of whether the diverted flows are introduced into Turkey Creek. If measures are not taken to control erosion in these areas erosion will continue to expand and may eventually compromise bridge abutments or cause failure along roadway embankments. It is proposed that riprap will be installed at the upstream face to provide protection either at bridge abutments or the inlets of culverts. The cost of these improvements are separate from the estimated project costs.

There are additional improvements to these existing structures that would be recommended in order to accommodate the introduction of diverted flows into the creek. Table 3 and 4 below lists the additional improvements anticipated for each drainage structure for both 40 cfs and 100 cfs starting at the upstream end of the project and continuing downstream along Turkey Creek. The erosion protection improvements are listed as large, medium and small. This refers to the anticipated amounts of riprap that may have to be installed at each location. A large amount is approximately 150 tons of riprap, medium is 75 tons of riprap, and small is 25 tons of riprap. This erosion protection is in addition to the riprap that will need to be placed at the structures due to existing erosion issues. Tables 3 and 4 below list the total number of erosion protection improvements and their associated costs. The additional riprap reflects the protection needed due to the diverted flows into Turkey Creek. A few existing drainage structures will overtop during a flow of 40 cfs or 100 cfs. Currently, it is anticipated that four drainage structures will need to replaced, or upsized or that an additional culvert will need to be added to handle the diverted flows.

Table 3 – Turkey Creek Structures at 40 cfs - Estimated Costs for Erosion Repair

Construction Item	Quantity	Unit Price	Total Price
Small Erosion Protection	2 Each	$2,000/Each	$4,000
Medium Erosion Protection	14 Each	$6,000/Each	$84,000
Large Erosion Protection	5 Each	$12,000/Each	$60,000
Estimated Total Erosion Repair Costs			**$148,000**

Table 4 – Turkey Creek Structures at 100 cfs - Estimated Costs for Erosion Repair

Construction Item	Quantity	Unit Price	Total Price
Small Erosion Protection	2 Each	$2,000/Each	$4,000
Medium Erosion Protection	14 Each	$6,000/Each	$84,000
Large Erosion Protection	5 Each	$12,000/Each	$60,000
Estimated Total Erosion Repair Costs			**$148,000**

The existing farm ponds will also need some improvements to handle the diverted flows. Either new overflow structures or additional pipes will need to be constructed at each farm pond location to allow the diverted flow to travel downstream instead of creating additional ponding areas and erosion along the farm pond embankment. These improvements could also include some riprap or other method of erosion control to protect the existing embankment.

4.0 BENEFIT-COST ANALYSIS

4.1 Overview

A benefit-cost analysis (BCA) was completed for this project to determine the economic feasibility and potential benefit to the TBNRD, LRNRD and the residents of these two natural resources districts. In this analysis, the cost of designing, constructing, and maintaining the project is compared to the potential benefits or cost savings that it may provide by contrasting these costs with the costs of several previous efforts to reduce consumptive use and/or increase streamflows in the Republican River basin.

4.2 Costs of Diversion Project

Based on the recommended described above and the improvements listed in Tables 3-4, estimated construction costs have been generated for the following improvements to Turkey Creek:

1) Additional improvements needed to handle 40 cfs of diverted flows under two options:

   a. Pipe installation in upper section (Table 5)
   b. Grading improvements in upper section (Table 6)
2) Additional improvements need to handle 100 cfs of diverted flows under two options:
   a. Pipe installation in upper section (Table 7)
   b. Grading improvements in upper section (Table 8)

The three major costs for this project are the grading along the creek, pipe installation and erosion control measures. The majority of the grading will be completed in the upper section to create a larger and defined, stable channel. An estimated unit price of $10 per cubic yard (CY) of earthwork was used to develop the cost for grading. If it is determined that the excavated material can be spoiled onsite, then a lower unit price may be realized for this project. Installing a new pipe in the upper section (instead of grading a larger creek section) is also analyzed as part of an estimated project cost. An average cost of $65 per linear foot was used for the pipe for the 40 cfs option and an average cost of $90 per linear foot was used for the pipe for the 100 cfs option. Installing erosion control measures at the upstream face of the existing structures will be the other major project cost. It has been estimated that each structure will have a cost in the range of $2,000 - $12,000, depending on the magnitude of measures required to accommodate the diverted flows. These erosion control measures are in addition to the erosion repair improvements listed in tables 1-2. The grade control structures needed to create a more stable slope in the upper reach of the project have been estimated at $10,000 for each structure. The four existing drainage structures that cross the stream cannot handle the diverted flows without overtopping; the cost of dealing with this issue are estimated at $10,000 per structure for 40 cfs and $15,000 per structure for 100 cfs. Three well-defined field drives in the upper section will each need a culvert crossing installed along with the proposed channel improvements. Those culvert crossings are estimated to be $5,000 each for 40 cfs and $7,500 each for 100 cfs. The last construction cost is associated with the existing farm ponds. The farm pond improvements are estimated to be $7,500 per pond for 40cfs and $10,000 per pond for 100 cfs. The anticipated construction cost of the diversion structure from Canal E-65 into Turkey Creek is also included at a cost of $315,000. All unit prices are based on past construction costs on prior projects and the Nebraska Department of Road's Average Unit Price Summaries.

Table 5 – Estimated Project Costs – Diverting 40 cfs with Pipe Installation in Upper Section

Construction Item	Quantity	Unit Price	Total Price
Mobilization	1 Each	$50,000/Each	$50,000
Pipe Installation	3,000 LF	$65/LF	$195,000
Small Erosion Protection	2 Each	$2,000/Each	$4,000
Medium Erosion Protection	14 Each	$6,000/Each	$84,000
Large Erosion Protection	5 Each	$12,000/Each	$60,000
Grade Control Structures	9 Each	$10,000/Each	$90,000
New Drainage Structures	4 Each	$10,000/Each	$40,000
New Culvert Crossings	3 Each	$5,000/Each	$15,000
Farm Pond Improvements	7 Each	$7,500/Each	$52,500
Contingency (30%)			$175,000
Estimated Total Construction Cost			**$765,500**
Engineering Fees			$235,000
Construction Observation (10% of Construction Cost)			$76,550
Diversion Structure	1 Each	$315,000/Each	$315,000
Estimated Total Project Cost			**$1,392,050**

Table 6 – Estimated Project Costs – Diverting 40 cfs with Grading in Upper Section

Construction Item	Quantity	Unit Price	Total Price
Mobilization	1 Each	$80,000/Each	$80,000
Earthwork	45,000 CY	$10/CY	$450,000
Small Erosion Protection	2 Each	$2,000/Each	$4,000
Medium Erosion Protection	14 Each	$6,000/Each	$84,000
Large Erosion Protection	5 Each	$12,000/Each	$60,000
Grade Control Structures	9 Each	$10,000/Each	$90,000
New Drainage Structures	4 Each	$10,000/Each	$40,000
New Culvert Crossings	3 Each	$5,000/Each	$15,000
Farm Pond Improvements	7 Each	$7,500/Each	$52,500
Contingency (30%)			$260,000
Estimated Total Construction Cost			**$1,135,500**
Engineering Fees			$235,000
Construction Observation (10% of Construction Cost)			$115,000
Diversion Structure	1 Each	$315,000/Each	$315,000
Estimated Total Project Cost			**$1,800,500**

Table 7 – Estimated Project Costs – Diverting 100 cfs with Pipe Installation in Upper Section

Construction Item	Quantity	Unit Price	Total Price
Mobilization	1 Each	$65,000/Each	$65,000
Pipe Installation	3,000 LF	$90/LF	$270,000
Small Erosion Protection	2 Each	$2,000/Each	$4,000
Medium Erosion Protection	14 Each	$6,000/Each	$84,000
Large Erosion Protection	5 Each	$12,000/Each	$60,000
Grade Control Structures	9 Each	$10,000/Each	$90,000
New Drainage Structures	4 Each	$15,000/Each	$60,000
New Culvert Crossings	3 Each	$7,500/Each	$22,500
Farm Pond Improvements	7 Each	$10,000/Each	$70,000
Contingency (30%)			$220,000
Estimated Total Construction Cost			**$945,500**
Engineering Fees			$235,000
Construction Observation (10% of Construction Cost)			$95,000
Diversion Structure	1 Each	$315,000/Each	$315,000
Estimated Total Project Cost			**$1,590,500**

Table 8 – Estimated Project Costs – Diverting 100 cfs with Grading in Upper Section

Construction Item	Quantity	Unit Price	Total Price
Mobilization	1 Each	$85,000/Each	$85,000
Earthwork	45,000 CY	$10/CY	$450,000
Small Erosion Protection	2 Each	$2,000/Each	$4,000
Medium Erosion Protection	14 Each	$6,000/Each	$84,000
Large Erosion Protection	5 Each	$12,000/Each	$60,000
Grade Control Structures	9 Each	$10,000/Each	$90,000
New Drainage Structures	4 Each	$15,000/Each	$60,000
New Culvert Crossings	3 Each	$7,500/Each	$22,500
Farm Pond Improvements	7 Each	$10,000/Each	$70,000
Contingency (30%)			$275,000
Estimated Total Construction Cost			**$1,200,500**
Engineering Fees			$235,000
Construction Observation (10% of Construction Cost)			$120,000
Diversion Structure	1 Each	$315,000/Each	$315,000
Estimated Total Project Cost			**$1,870,500**

The estimated total construction costs are listed below in Table 9 and are based on the preliminary analysis and design. Two costs are given for the 40 cfs option, and two costs are given for the 100 cfs option. All the construction costs currently have a 30 percent contingency fee included in the total and the estimated costs would be refined during final design. Table 9 also lists estimated total project costs when incorporating the estimated cost for final design and construction observation. Project land rights acquisition costs have not been estimated as part of project development costs. The sponsors anticipate acquiring easements from landowners without compensation.

Table 9 – Estimated Project Costs

Project Option	Estimated Construction Cost	Estimated Total Project Cost
40 cfs with Pipe Option	$756,500	$1,392,050
40 cfs with Grading Option	$1,135,500	$1,800,500
100 cfs with Pipe Option	$945,500	$1,590,500
100 cfs with Grading Option	$1,200,500	$1,870,500

4.3 Benefits

The benefits of the project are generally related to improving water supply conditions in the Republican River. Water use is limited in the Republican River basin (Basin) due to the Republican River Compact (Compact). Nebraska is allocated a certain percentage of the Basins water supply, which varies from year to year based on climatic conditions. During many previous dry years, Nebraska has used more than its allocation of water. Excess flows from the Platte River would be used to offset any potential overuse in the future, reducing or eliminating the cost of other management actions that might be needed.

The Nebraska Department of Natural Resources (NeDNR) has studied the potential amounts of water that may be available from the Platte River for this project. This evaluation involved a comparison of the historic Platte River streamflows against all currently existing demands to this water to compute flows in excess of current demands. Other agencies, including the Platte River Recovery Program are evaluating projects that could affect the future occurrence and availability of excess flows in the Platte River. The water that may be available for this project would be water diverted into the Tri-County Supply Canal for use in generating hydropower and which would otherwise be returned to the Platte River at the J2 return. When there are excess flows downstream of the J2 return (as measured at the Overton gage), some of this water can be retained in the canals and delivered for other purposes, such as to supply water to this diversion project. Data from the NeDNR study from the Overton gage for the years 2000 to 2008 were used to estimate the excess flows that may be available to divert into Turkey Creek during a given year and to calculate the actual water the project could provide based on several assumed capacity limitations. These years were chosen because it was a dry period in which Nebraska could have potentially benefited from the diversion of water into the basin by assisting the state with Compact compliance.

Exhibit E in Appendix A is a spreadsheet that shows the total monthly excess flows available in the Platte River basin during 2000 to 2007. It also contains the amount of water that would be able to be diverted into Turkey Creek based on a project capacity of either 40 cfs or 100 cfs. Table 10 below shows the average annual amount of water that would be available to divert from the Platte River basin during these years.

Table 10 – Potential Acre-Feet Available to Divert

Diversion Capacity Amount	Average Potential Amount
No Limit	56,938 acre-feet
40 cfs	5,806 acre-feet
100 cfs	11,431 acre-feet

The total available excess flows during this period average 56,938 acre-feet per year. The second row lists the amount that could be diverted with a 40 cfs limit on the flow rate. The third row lists the amount that could be diverted with a 100 cfs limit on the flow rate. It is anticipated that when excess flows from the Platte River are available, there would be an opportunity to divert them into Turkey Creek throughout the entire length of the year if desired.

Table 11 below contains the same information as in Table 10, but it limits the available excess flows to the non-irrigation season (September through April).

Table 11 – Potential Acre-Feet Available to Divert during September through April

Diversion Capacity Amount	Average Potential Amount
No Limit	53,850 acre-feet
40 cfs	4,885 acre-feet
100 cfs	9,846 acre-feet

The expected lifetime of the project would be 50 years. While it is difficult to know how often the project will be able to provide these average annual benefits, under the conditions from 2000-2007, the project could have provided substantial benefits during four out of eight years. Based on past experience with potential shortfalls in the Republican River basin, water from the project would be beneficial during about four out of every 10 years. Combining these two probabilities yields an estimated average benefit of two out of every 10 years. These values for flow availability will be used in computing a range of benefit-cost ratios below.

4.4 Alternative Costs

There are several metrics available to assess the cost to Nebraska to offset any water use in excess of its allocation that may occur in the future. While Nebraska was ordered by the U.S. Supreme Court to pay Kansas $5.5 million for its over use of approximately 70,000 acre-feet of water during 2005-2006, the Court made it clear that the cost of a future violation would likely be significantly greater, so using this value as a metric would likely undervalue the benefits of a transfer of water into the Basin from the Platte River.

Another available metric would be the costs of previous actions taken by the state and the natural resources districts (NRDs) to reduce consumptive uses of water in an effort to maintain compliance with the Compact. From 2006 to 2008, surface water was leased from irrigation districts in the basin to assist with compliance with the Republican River Compact (Compact). The state and the local NRDs paid $18,722,500, which resulted in a reduction of consumptive use of 51,614 acre-feet, which equates to $362 per acre-feet of water. This value will be used to assign a benefit to the potential volumes of water that could be delivered from this project during future dry years.

Another available metric would be to utilize the cost associated with the Nebraska Cooperative Republican Platte Enhancement (N-CORPE) project for the LRNRD. The N-CORPE project provides construction costs and delivery costs for water which can be related to this project to develop potential benefit. These costs are summarized in Table 12. Based on these costs, and an assumed average annual delivery of 3,750 acre-feet, the annual delivery cost for water from N-CORPE is $272.59 per acre-foot, or $195,000 per year. The annual delivery cost for the surface water option and the N-CORPE option will be used to calculate a range of benefit-cost ratios below.

Table 12 – Computation of Average Annual Delivery Cost for LRNRD for water from N-CORPE

Cost Items	Cost to LRNRD
Capitol Cost (including interest)	$41,360,511.00
Cost per year - 50 years	$827,210.22
Average Annual Capacity	3,750
Annual Cost per AF – capacity	$220.59
Water Delivery Cost	$52.00
Cost per AF	$272.59

4.5 Benefit-Cost Ratio

The average cost per acre-foot for the alternative sources of water evaluated above are next used to calculate a range of benefit-cost ratios for the Platte Republican Diversion project. Table 13 and Table 14 compute the total delivery costs for the project based on the construction costs presented above and an assumed value of $44.35 acre-foot for the water delivery.

Table 13 – Potential Annual Cost – 40 cfs

Cost Items	PRD Project – Pipe Option	PRD Project – Grading Option
Capitol Cost	$1,392,050.00	$1,800,500.00
Cost per year - 50 years	$27,841.00	$36,010.00
Average Annual Supply*	977 acre-feet	977 acre-feet
Annual Capital Cost per AF	$28.50	$36.86
Water Delivery Cost	$44.35	$44.35
Total Cost per AF	$72.85	$81.21

*20% of 4,885 acre-feet from Table 11 to adjust for benefits in 2 out of 10 years

Table 14 – Potential Annual Cost – 100 cfs

Cost Items	PRD Project – Pipe Option	PRD Project – Grading Option
Capitol Cost	$1,590,500.00	$1,870,500.00
Cost per year - 50 years	$31,810.00	$37,410.00
Average Annual Supply*	1,969 acre-feet	1,969 acre-feet
Annual Cost per AF – capacity	$16.16	$19.00
Water Delivery Cost	$44.35	$44.35
Total Cost per AF	$60.51	$63.35

*20% of 9,846 acre-feet from Table 11 to adjust for benefits in 2 out of 10 years

So the annual cost per acre-foot of water delivered by the Platte Diversion Project would range from $60 to $82, depending on the construction option and the ultimate capacity of the project. Table 15 compares this range of values to the range of costs for alternative sources of water.

Table 15 – Benefit Cost Ratios in Comparison to Project Alternative

Design Alternative	Surface water leasing	N-CORPE
40 cfs – pipe	5.0:1	3.7:1
40 cfs – grading	4.5:1	3.4:1
100 cfs – pipe*	6.0:1	4.5:1
100 cfs – grading*	5.7:1	4.3:1

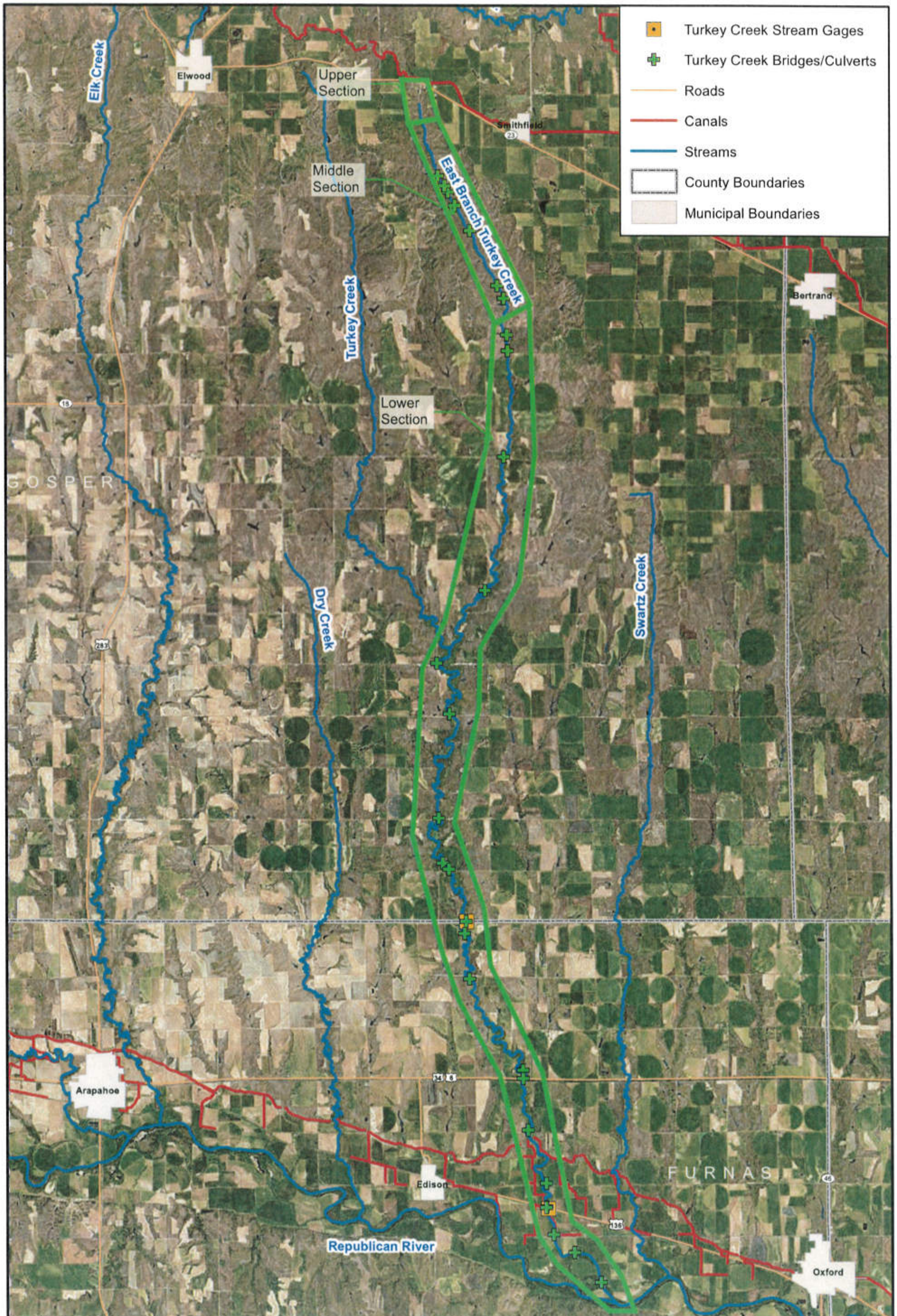
*Benefit-Cost Analysis for 100 cfs option is slightly inflated. In reality the 100 cfs flows can only be diverted into Turkey Creek for 5 days at a time and not for the entire length of time it is available.

In general, the Benefit-cost ratio for the project would appear to fall within the range of 3.4 to 6:1, indicating the diversion project would provide water for streamflow in the Republican River at costs that are significantly lower than other alternative sources. Therefore, the project would be highly feasible.

5.0 SUMMARY AND CONCLUSIONS

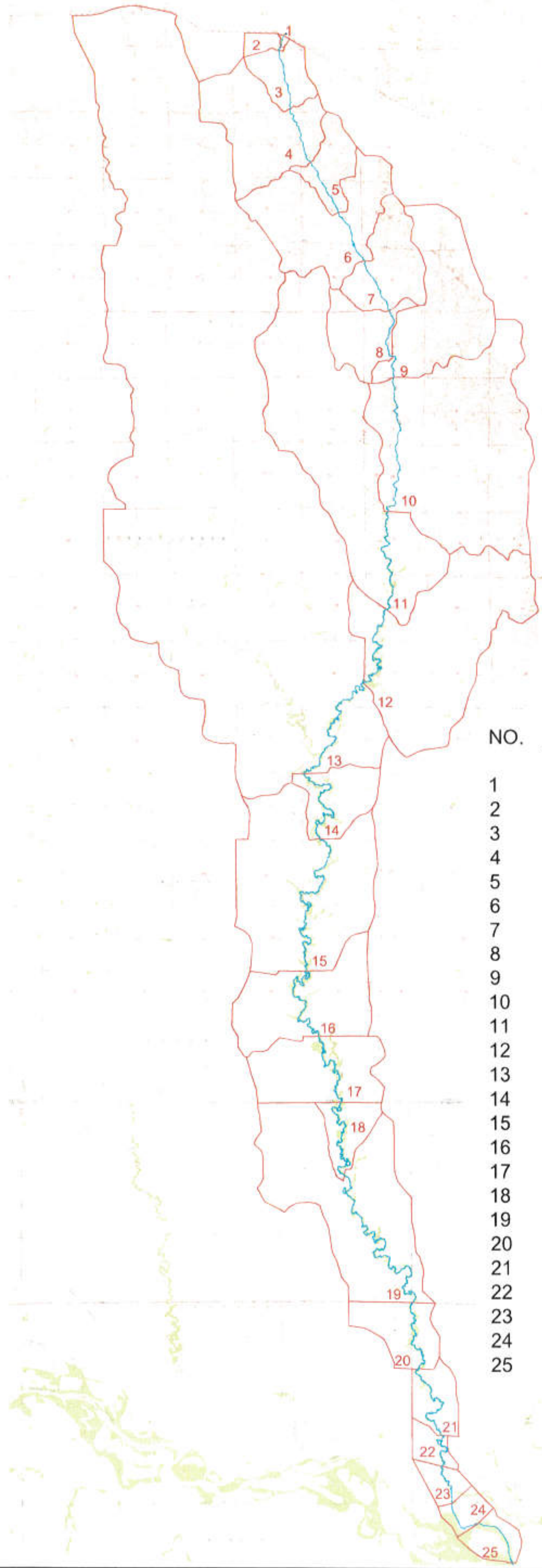
Based on the preliminary feasibility analysis completed for the Platte Republican Diversion project, the benefit-cost analysis clearly shows the project would provide a significant benefit over the lifetime of the project given the assumptions made for availability of excess flows from the Platte River. With creek improvements in the upper section and erosion control measures at each drainage structure and farm ponds, Turkey Creek will be able to handle diverted flows up to 100 cfs for the designated periods of time without negatively affecting the surrounding land or causing any significant erosion to the existing creek system.

APPENDIX A – EXHIBITS



PROJECT: 016-1500		Turkey Creek	OLSSON ASSOCIATES
DRAWN BY: MKM			
DATE: August 17, 2016			Exhibit A

Sources: NDNR, USGS, US Census Bureau, ESRI



NO.	DESCRIPTION	DA (MI²)
1	UPPER REACH	0.02
2	UPPER REACH	0.18
3	UPPER REACH	0.87
4	UPPER REACH	3.06
5	UPPER REACH	3.81
6	UPPER REACH	6.35
7	ROAD 738	7.70
8	DRIVE 432A	8.71
9	DRIVE 737	11.40
10	ROAD 735	17.68
11	FIELD ACCESS	23.83
12	ROAD 432	28.71
13	ROAD 731	57.69
14	ROAD 730	58.71
15	ROAD 728	63.34
16	ROAD 727	65.70
17	ROAD 726	67.57
18	ROAD 431	68.22
19	HWY 6	72.66
20	ROAD 722	73.64
21	ROAD 721	74.29
22	BNSF / HWY 136	74.60
23	ROAD 720	74.93
24	FIELD ACCESS	75.26
25	FIELD ACCESS	75.72

DWG: C:\Temp\AcPublish_5628\Drainage areas.dwg USER: dlightbody
DATE: Dec 23, 2016 10:04am XREFS:

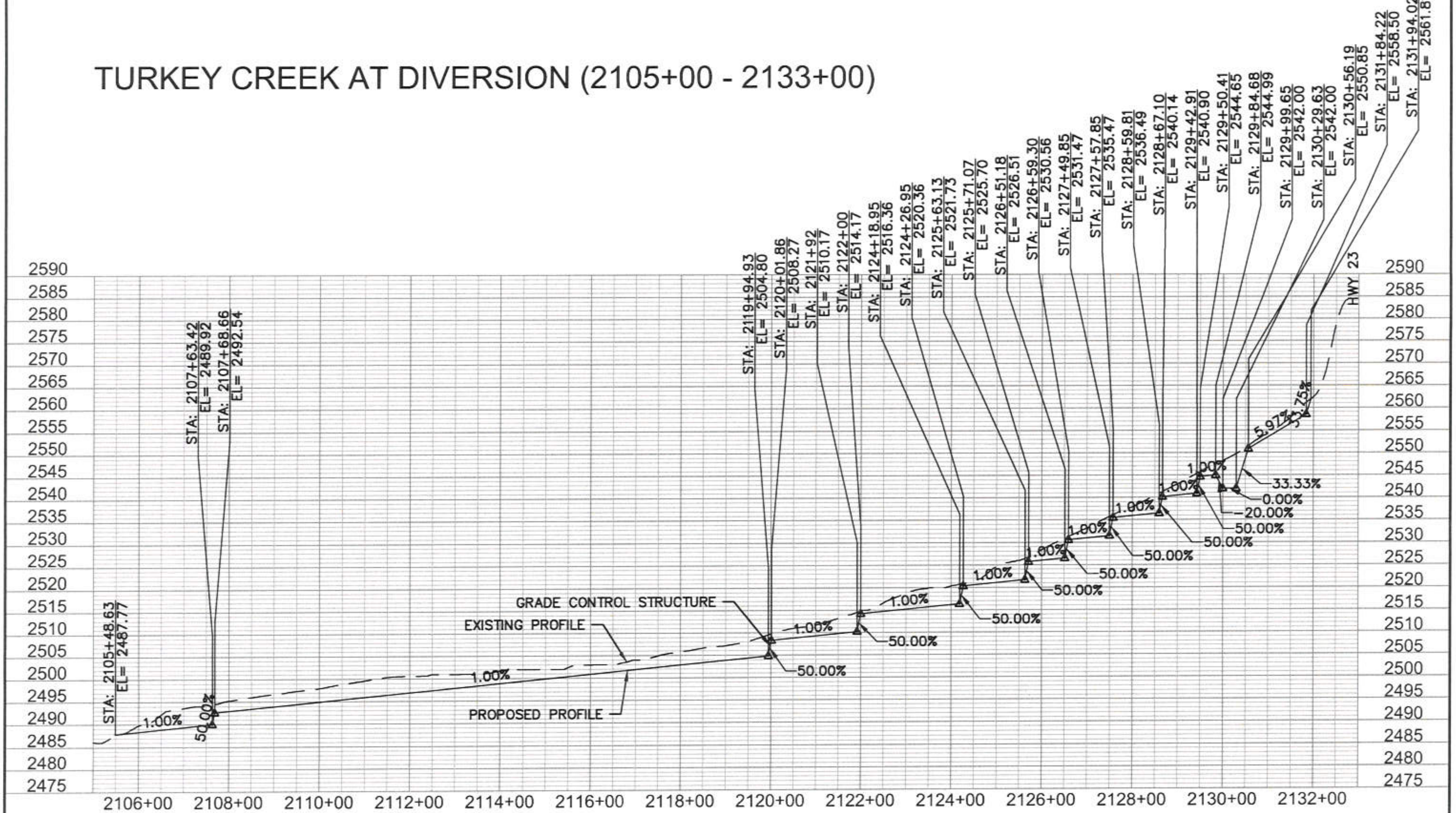
PROJECT NO: 016-1500 DRAWN BY: DSL DATE: 12/23/16	EAST BRANCH TURKEY CREEK DRAINAGE AREA MAP	OLSSON ASSOCIATES 601 P Street, Suite 200 P.O. Box 84608 Lincoln, NE 68508 TEL 402.474.6311 FAX 402.474.5160	EXHIBIT B

EXHIBIT C

WRIR 99-4032A Peak-flow equations for the Upper Republican River Region

Drainage Area No.	Desc.	Sta	FL to US XS (ft)	DA Perimiter (mi)	DA (ac)	DA (mi²)	cumulative DA (mi²)	MCS	CR	Q2	Q10	Q25	Q50	Q100	
	point of diversion	213300	0	0	0	0.00	0.00	n/a	n/a	0	0	0	0	0	
1		212400	900	0.59	11.7	0.02	0.02	n/a	n/a	2	9	16	21	28	TR-55
2		211800	600	1.92	105.1	0.16	0.18	n/a	n/a	10	54	96	131	170	
3		207000	4800	3.81	442.8	0.69	0.87	n/a	n/a	30	152	275	373	485	
4		202000	5000	7.7	1399.7	2.19	3.06	n/a	n/a	75	345	617	839	1091	
5		197000	5000	9.63	481.3	0.75	3.81	n/a	n/a	77	332	587	798	1038	
6		192000	5000	11.95	1622.2	2.53	6.35	24.60	1.34	145	486	756	993	1282	Regression
7	US face Rd 738	187339.8	4660.2	13.4	864.3	1.35	7.70	21.43	1.36	134	441	682	892	1148	
8	US face Dr 432a	183058	4281.8	15.7	648.7	1.01	8.71	21.14	1.50	132	425	657	861	1111	
9	US face Dr 737	181052.5	2005.5	17.74	1719.9	2.69	11.40	21.97	1.48	161	531	825	1086	1406	
10	US face Rd 735	168284.8	12767.7	24.58	4022.1	6.28	17.68	19.38	1.65	163	521	807	1063	1377	
11	US face field access	157572	10712.8	26.26	3932.6	6.14	23.83	18.20	1.52	189	614	952	1252	1618	
12	US face Rd 432	146486.9	11085.1	30.15	3123.07	4.88	28.71	17.80	1.59	197	637	988	1301	1683	
13	US face Rd 731	131497	14989.9	39.13	18547.9	28.98	57.69	17.80	1.45	308	1039	1628	2156	2797	
14	US face Rd 730	119744	11753	40.69	653.1	1.02	58.71	17.80	1.50	304	1020	1599	2118	2750	
15	US face Rd 728	99396	20348	44.98	2965.8	4.63	63.34	17.80	1.59	303	1006	1578	2093	2724	
16	US face Rd 727	86092	13304	48.15	1510.4	2.36	65.70	17.80	1.68	298	981	1538	2043	2663	
17	US face Rd 726	75761	10331	50.35	1196.2	1.87	67.57	17.80	1.73	296	969	1519	2019	2635	
18	US face Rd 431	62500	13261	52.3	416.5	0.65	68.22	17.80	1.79	290	944	1481	1969	2572	
19	US face Hwy 6	38182	24318	57.68	2837.8	4.43	72.66	17.80	1.91	286	920	1444	1923	2517	
20	US face Rd 722	30154	8028	59.71	625.7	0.98	73.64	17.80	1.96	282	904	1418	1889	2474	
21	US face Rd 721	20101	10053	62.23	416.8	0.65	74.29	17.80	2.04	276	877	1376	1835	2406	
22	US face BNSF Br	15143	4958	63.72	201.3	0.31	74.60	17.80	2.08	272	862	1352	1803	2366	
23	US face Rd 720	11525	3618	65.01	211.9	0.33	74.93	17.80	2.12	269	850	1333	1778	2334	
24	US face field access	7700	3825	66.37	206.4	0.32	75.26	17.80	2.16	266	837	1313	1752	2301	
25	US face low flow	2977	4723	67.92	300.4	0.47	75.72	17.80	2.20	263	825	1293	1727	2269	

TURKEY CREEK AT DIVERSION (2105+00 - 2133+00)



PROJECT NO: 016-1500
DRAWN BY: DSL
DATE: 12/23/2016

UPPER REACH CHANNEL PROFILE OF TURKEY CREEK

OLSSON ASSOCIATES
601 P Street, Suite 200
P.O. Box 84608
Lincoln, NE 68508
TEL 402.474.6311
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EXHIBIT D

Exhibit E

No capacity limit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Total Sept.-Apr.
2000	113,458	118,240	68,988	2,620	-	-	-	-	-	-	11,498	1,394	316,200	316,200
2001	19,034	18,986	15,422	-	879	-	-	-	-	-	889	6,123	61,332	60,453
2002	10,108	14,706	3,570	-	-	-	-	-	-	-	-	69	28,453	28,453
2003	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2004	-	411	-	-	-	-	-	-	-	-	-	-	411	411
2005	1,545	-	-	-	48	4,308	-	-	-	-	-	-	5,901	1,545
2006	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2007	-	21,446	1,888	383	1,384	18,042	58	-	-	-	-	-	43,201	23,717
Average	18,018	21,724	11,234	375	289	2,794	7	-	-	-	1,548	948	56,937	53,847

40 cfs capacity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Total Sept.-Apr.
2000	2,500	2,500	2,500	2,500	-	-	-	-	-	-	2,500	1,394	13,894	13,894
2001	2,500	2,500	2,500	-	879	-	-	-	-	-	889	2,500	11,767	10,889
2002	2,500	2,500	2,500	-	-	-	-	-	-	-	-	69	7,569	7,569
2003	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2004	-	411	-	-	-	-	-	-	-	-	-	-	411	411
2005	1,545	-	-	-	48	2,500	-	-	-	-	-	-	4,093	1,545
2006	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2007	-	2,500	1,888	383	1,384	2,500	58	-	-	-	-	-	8,713	4,771
Average	1,131	1,301	1,174	360	289	625	7	-	-	-	424	495	5,806	4,885

100 cfs capacity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Total Sept.-Apr.
2000	6,000	6,000	6,000	2,620	-	-	-	-	-	-	6,000	1,394	28,015	28,015
2001	6,000	6,000	6,000	-	879	-	-	-	-	-	889	6,000	25,767	24,889
2002	6,000	6,000	3,570	-	-	-	-	-	-	-	-	69	15,640	15,640
2003	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2004	-	411	-	-	-	-	-	-	-	-	-	-	411	411
2005	1,545	-	-	-	48	4,308	-	-	-	-	-	-	5,901	1,545
2006	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2007	-	6,000	1,888	383	1,384	6,000	58	-	-	-	-	-	15,713	8,271
Average	2,443	3,051	2,182	375	289	1,289	7	-	-	-	861	933	11,431	9,846