EXPANDED RECAPTURE RECONNAISSANCE STUDY

Prepared for:

Platte River Recovery Implementation Program (PRRIP)

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Project No. 6011PRR01

The following members of the LRE Water staff contributed to this report.

Project Manager & Environmental Scientist – Jonathan Mohr
Technical Lead – Mark Mitisek, PH
Model Leads – Hanna Anderson, PE; Ryan Gilliom, PH;
Hydrogeologists – Jacob Bauer, PG; Dave Hume, PG; Jon Libra, GIT

With support provided by:

Inter-Fluve
Geomorphologist – Josh Epstein, Joel Peterson, Jackie Van Der Hout

RJH Consultants
Engineers - Tom MacDougall, PE and Christopher Leclair

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EXECUTIVE SUMMARY

The Expanded Recapture Reconnaissance Study's (Study) main goal is to help the Platte River Recovery Implementation Program (Program) and State of Nebraska Department of Natural Resources (NeDNR) determine how to more effectively control the timing and rate of surface and groundwater return flows to the Platte River to reduce deficits to target flows. The primary Study objectives were:

1) To determine the capability, capacity, and potential impacts for Plum Creek to convey augmented surface water flows;

2) To evaluate the potential to install a gravity outlet from Elwood Reservoir to convey surface water to the Platte River through Plum Creek;

3) To evaluate the net benefit of additional recapture wells, or a combination of the two proposed actions, and;

4) To identify the most cost-effective strategy for reducing deficits to target flows.

Existing agreements between the Central Nebraska Public Power and Irrigation District (CNPPID) and the Program, NeDNR, and Tri-Basin Natural Resources District (TBNRD) provide for the diversion of excess flows for groundwater recharge in Elwood Reservoir, Phelps County Canal, Cottonwood Ranch, and other facilities. The Study aims to create strategies for the Program and NeDNR to optimize excess flow diversions and recharge from Elwood Reservoir to maximize the Program's capacity to reduce deficits to U.S. Fish and Wildlife Service (USFWS) target flows for the Platte River near Grand Island (United States Geological Survey (USGS) stream gage (06770500) and NeDNR's ability to reduce shortages on the Platte River below Overton.

The Project Area in general covers areas in which proposed new infrastructure projects would be located and can be described generally as Elwood Reservoir to the west, the Platte River to the north, Cottonwood Ranch on the east, and Highway 23 to the south. The Project Area is located entirely within the boundaries of the TBNRD.

The Study answers the following key questions for the Program and NeDNR as presented below:

Program Questions:

1) **What is the capability of Plum Creek to effectively convey flows to the Platte River?**

   Plum Creek appears to be capable of conveying augmented flows from Elwood Reservoir to the Platte River with minimal losses. Augmentation flows of up to 50 cfs released through an Elwood Reservoir gravity outlet are consistent with the estimated ordinary high water line (OHWL) in Plum Creek and would pose minimal geomorphic risk when added to existing baseflow (12 cfs). Flow releases up to 100 cfs plus baseflow would likely require minor to major bank repairs. Shorter duration, lower flow events present the lowest risk to geomorphic impacts.

2) If Plum Creek is used to convey flows, what impacts the stream and existing infrastructure can be expected and what will it cost to mitigate those impacts?

If Plum Creek is used to convey flow, it will likely result in an increase in both minor and/or major geomorphic impacts depending on the magnitude and duration of augmented flow events. Minor erosion impacts can be expected at exposed unvegetated areas/banks located at or below OHWL. Major bank erosion impacts can be expected at exposed unvegetated areas where existing bank undercutting or bank sloughing is actively occurring adjacent to the channel above the OHWL. These areas are primarily located in the upper portion of the Project Area where exposed sand/gravel banks were observed.

Infrastructure improvements including replacement of existing culverts that are damaged or have insufficient capacity would be required for at least 11 agricultural crossings and two public road crossings at CR430 and CR437 at an estimated cost of $450,000.

Erosion mitigation techniques such as shaping, revegetation, erosion control, bank grading, fabric encapsulated lifts, or armor would be likely options to mitigate damages. The geomorphic impacts vary based on flow magnitude and duration with estimated capital costs for mitigation ranging from $1.2M to $10M (including infrastructure improvements). An adaptive management approach should be used to mitigate geomorphic risk and impacts to Plum Creek from augmented flow.

3) What type of infrastructure would be associated with a gravity outlet from Elwood Reservoir, conceptually how would it be configured, what is a reasonable design capacity of the outlet, and how much does it cost?

Existing infrastructure owned by CNPPID could be utilized to release water from Elwood Reservoir using gravity flow. The lowest cost option is the use of CNPPID's evacuation pipeline located near the pump station into a new constructed open channel to convey water to Plum Creek. The second option would be the installation of a headgate and intake structure on the existing E65 canal directly east of Elwood Reservoir and south of existing Siphon 3 to convey releases from Elwood Reservoir through a buried pipeline. The conceptual capacity options for the outlet and conveyance infrastructure were assumed to be 50 and 100 cfs, based upon the results of the Plum Creek stream assessment.

Using the evacuation pipeline and open channel to pass water to the Highway 283 culvert has an estimated to capital cost between $2.82M (50 cfs) and $3.30M (100 cfs). The installation of a headgate south of Siphon 3 and a spillway on the east side of E65 would lead to a buried pipeline to the culvert under Highway 283. The range of capital costs for a 50 cfs pipeline is $6.34M (PVC) to $7.50M (steel) and the range of capital cost for a 100 cfs pipeline is $7.14M (PVC) to $9.47M (steel).

4) **Can additional recapture wells operated by the Program improve the net benefit (score) to the river, and if so by how much, what is a practical size and location for an additional recapture wellfield, and how much does it cost?**

For the Program, the 8 existing recapture wells in combination with an Elwood Reservoir gravity outlet appear to maximize the potential deficit reduction benefit to the river without the addition of new recapture wells.

If new recapture wells are added to the Program's existing recapture wells without an Elwood Reservoir gravity outlet, the net benefit (score) to the river can be improved by approximately 900 AF (150 AF/well) for areas close to the river (Recapture Zone 1) or by as much as 3,600 AF (600 AF/well) for areas located further from the river (Recapture Zone 3). The practical size of each well field would be based on available sites with adequate well spacing to accommodate between 3 to 6 wells, which can either be located together or separately as two well fields.

In general, wells located farther from the river can pump more and provide greater net benefit due to the smaller impact on recharge accretions to the stream. Therefore, to maximize their net benefit, recapture wells located in Recapture Zones 2-4 would require higher capacity wells and pipelines that result in higher costs. The total cost (50-yr project life cycle) for adding additional recapture wells ranges from \$17.11M (PVC) to \$18.02M (steel) for well fields/pipelines located close to the river (Recapture Zone 1) to \$25.57M (PVC) to \$30.28M (steel) for well fields/pipelines located further from the river (Recapture Zone 3).

5) **How would a potential combination of a gravity outlet and recapture wells work in offsetting target flows?**

The ability of recapture wells to pump intentionally recharged groundwater from the aquifer is largely dependent on the volume of excess flows stored and managed in Elwood Reservoir because of the reservoir's capacity relative to other, smaller recharge projects. With a gravity outlet of 50 or 100 cfs, significantly less recharge would occur for the Program and it would be necessary to carefully manage operations of the Program's 8 existing recapture wells. The combination of a gravity outlet and existing recapture wells results in the highest scores of all alternatives evaluated, adding between 4,465 AF (50 cfs) to 5,009 AF (100 cfs) to the Program's established score of 6,800 AF.

6) **What is the most cost-effective method for the Program to leverage excess flows through groundwater recharge and recapture and/or surface water releases from Elwood Reservoir to offset deficits to USFWS target flows at Grand Island, Nebraska?**

   The Cost Analysis shows that the most cost-effective scenario for the Program is the 50 cfs open channel alternative with existing recapture well at $7.41M ($33/AF) over the assumed 50-yr project life cycle. If the Program is considering additional recapture wells and no outlet from Elwood Reservoir, the most cost-effective scenario is new recapture wells in Recapture Zone 3 using a PVC pipeline at $25.57M ($141/AF) over the assumed 50-year project life cycle.

NeDNR Questions:

7) **If the NeDNR were to develop a recapture well program to aid in the retiming of available recharge from Elwood Reservoir, how much could recapture wells offset shortages to the river?**

   If NeDNR were to develop a recapture well program, new recapture wells can offset shortages to the river by approximately 1,100 AF (183 AF/well) for areas close to the river (Recapture Zone 1) or by as much as 3,800 AF (633 AF/well) for areas located further from the river (Recapture Zone 3).

8) **What is the most cost-effective method for NeDNR to maximize groundwater recharge and offset shortages in the Platte River below Overton, Nebraska?**

   The Cost Analysis shows that the most cost effective scenario for NeDNR is to develop new recapture wells, specifically with well placement in Recapture Zone 3 using a PVC pipeline at $24.65M ($129/AF) over the assumed 50-yr project life cycle.

SECTION 1: INTRODUCTION

1.1 Purpose

The Platte River Recovery Implementation Program (the Program) is tasked with implementing a Water Action Plan to reduce flow deficits that negatively impact targeted threatened and endangered species along the mainstem of the Platte River near Grand Island, Nebraska. As a part of that plan, the Program is responsible for developing and managing water supply projects used to enhance Platte River streamflow. Within the State of Nebraska, the Program manages multiple projects in coordination with stakeholder entities to maximize available flows to reduce target flow deficits.

Key to the Program's efforts is three existing groundwater recharge projects located within the CNPPID system in Gosper and Phelps counties, south of the Platte River between Lexington and Elm Creek, Nebraska. These include management of excess Platte River flows stored in Elwood Reservoir, flows through the Phelps County Canal to enhance recharge, and the Cottonwood Ranch recharge project. Although these projects provided significant benefits to the Platte River, the timing of return flows (accretions) from these projects is not controllable, resulting in continuous return flows to the Platte River regardless of whether there are deficits to target flows at Grand Island. The Expanded Recapture Reconnaissance Study (Project) aims to create a strategy to optimize the Program's deficit reduction benefits from these existing recharge projects by incorporating new project elements such as a gravity outlet from Elwood Reservoir or additional recapture wells to make controlled returns to the river during periods of shortage.

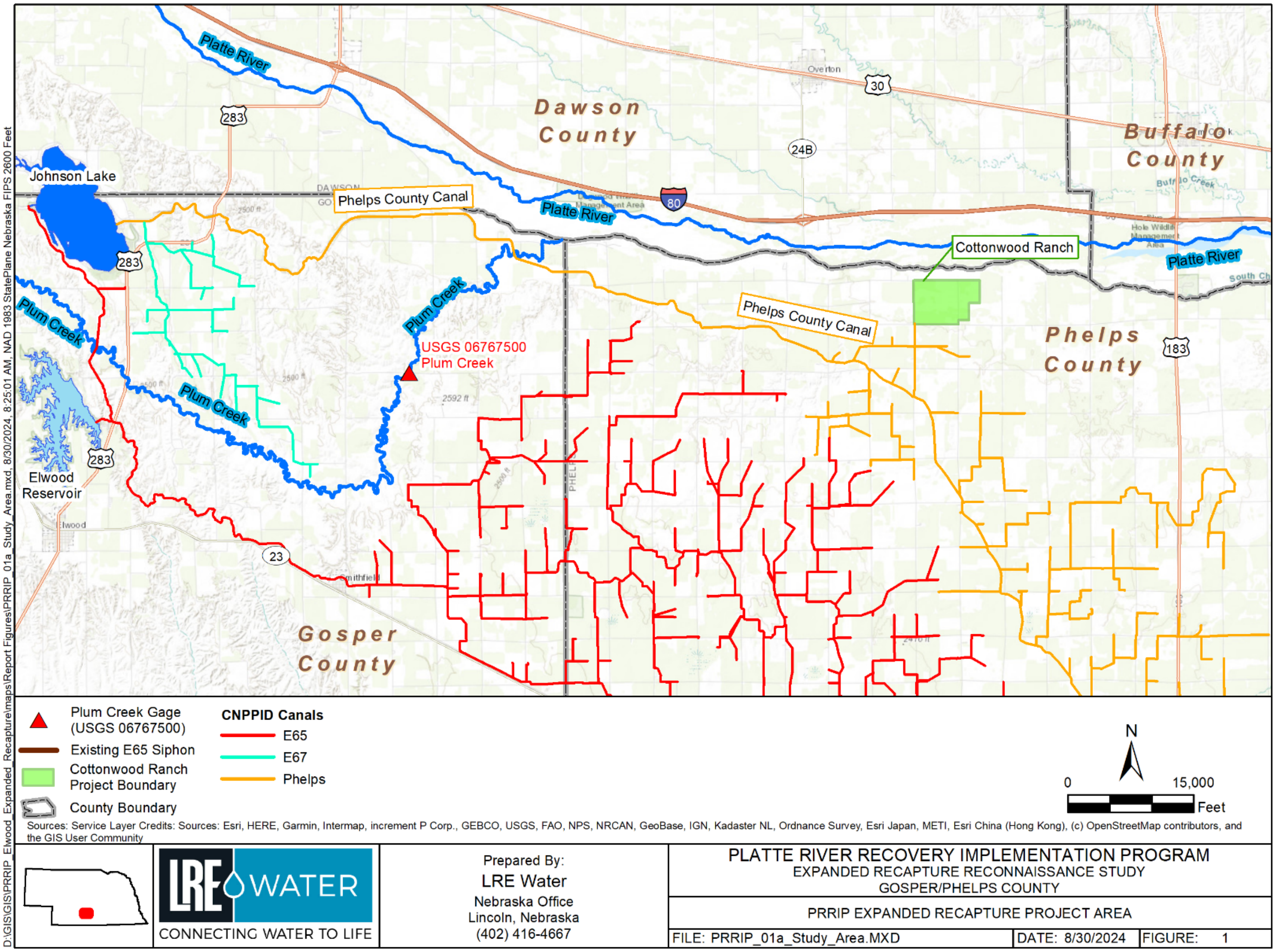
The Expanded Recapture Reconnaissance Study (Study) being conducted by LRE is designed to provide clear insight into the feasibility, costs, and benefits of a range of infrastructure scenarios (portfolios) that may be used to optimize the timing of Program excess flows to meet target flow deficits. Prior to the project portfolios being established and the trade-off analysis being completed, four technical evaluations need to be completed:

1) Plum Creek Stream Assessment
2) Plum Creek Hydrologic Assessment
3) Elwood Reservoir Outlet Assessment
4) Recapture Well Assessment
5) Permitting and Land Right Assessment

1.2 Project Area

The Project Area in general covers areas known to physically receive recharge from the existing recharge projects and can be described generally as Elwood Reservoir to the west, the Platte River to the north, Cottonwood Ranch on the east, and Highway 23 to the south (see **Figure 1**). The focus area of Plum Creek is also shown in **Figure 1** and includes the lower reaches of the stream below Elwood Reservoir, generally west of Highway 283 to the confluence with the Platte River.

Figure 1 – PRRIP Expanded Recapture Project Area



SECTION 2: STREAM ASSESSMENT

2.1 Background

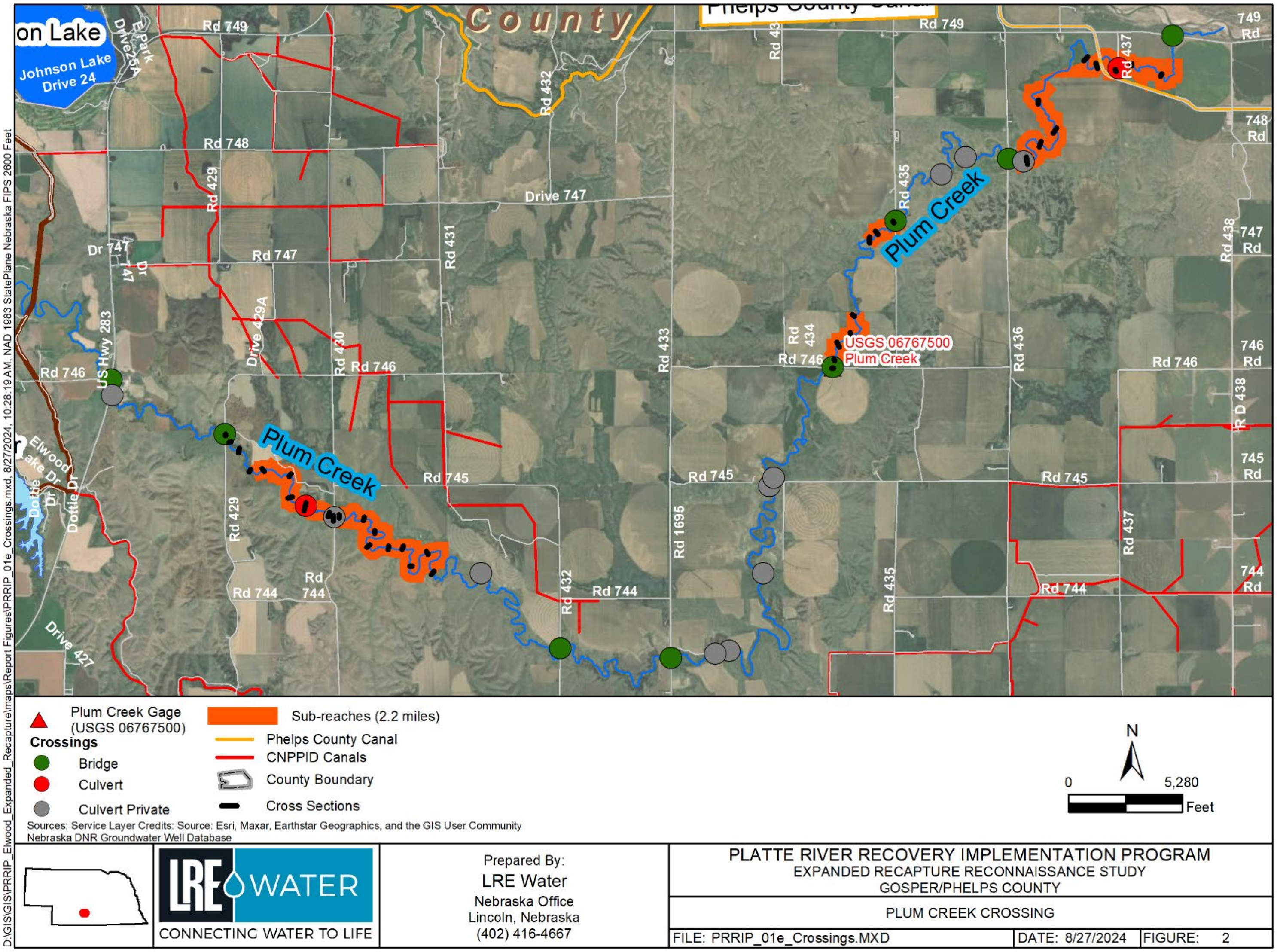
To evaluate the ability of Plum Creek to convey Program water from Elwood Reservoir to the Platte River, a complementary study was completed by Inter-Fluve, Inc. to inform the Program on the geomorphology, hydrology, hydraulics, and land use history of Plum Creek. The result was the Plum Creek Geomorphic Reconnaissance and Hydrologic Assessment (Assessment) which is included as Attachment A. A summary of the major Assessment efforts include:

- An existing review of stream gage data and reports,
- A field geomorphic and infrastructure assessment,
- Creation of a 1-D HEC-RAS hydraulic model,
- Completion of a geomorphic risk assessment for flows ranging from 25 to 1,400 cubic feet per second (cfs), and
- A planning level cost estimate.

The focus reach began at Highway 283 below Elwood Reservoir downstream to the confluence with the Platte River and included a total of four sub-reaches totaling 2.2 miles, or 7.7% of the total 28.4 miles, as shown in **Figure 2**. The team collected 43 topographic cross sections, visited ten public and two private crossings, obtained photographic documentation of channel conditions, measured stream velocity, documented agricultural crossings through desktop assessment, and recorded data on current stream conditions.

The flow of Plum Creek was dramatically altered after the construction of Elwood Reservoir in the late 1970s. Interflow and seepage from Elwood Reservoir to Plum Creek has been observed and was an inadvertent result of the project. The dam and reservoir have increased baseflow volume and duration altering the overall hydrograph as compared to pre-Elwood Reservoir conditions. Furthermore, the upper end of Plum Creek, which is mostly dry or ephemeral in nature, is representative of what the creek may have been like pre-Elwood Reservoir.

Figure 2 - Plum Creek Sub-reaches and Crossings



2.2 Site Investigation

The geomorphic reconnaissance field assessment and topographic survey of Plum Creek were completed in November 2023 by two members of Inter-Fluve with support by LRE Water staff. Flows were measured at two locations where LRE had placed pressure transducers with loggers within the stream near the crossings with CR 430 and CR 436. A custom web-map[1] was created for the project to document key locations, infrastructure, and photos visited during the site investigation.

2.3 Channel and Infrastructure Assessment

Geomorphology

The reaches investigated all had similar geomorphologic character, typical of stream systems in agricultural regions. Due to increased runoff rates from agricultural landscapes, Plum Creek experiences increased magnitude, frequency, and flashiness of flows. The channel is deeply incised with an incipient floodplain formed within much of the incised channel. Channel bed and banks were dominated by silt. Deeper incision is likely to continue due to the silt-dominated geology, even without changes to hydrology such as augmented flows delivered to Plum Creek from Elwood Reservoir.

Crossing Assessment

A total of 43 topographic cross-sections were surveyed within the four priority reaches. This data was used to support a hydraulic assessment, which included a HEC-RAS 1D, steady state model that was developed by Inter-Fluve also using available LiDAR. In total, 21 road crossings were visually assessed between the field and desktop assessment starting from U.S. Highway 283 to the confluence with the Platte River, as shown in **Figure 2**. Photographic documentation of conditions at each crossing were obtained and is available in the Report (Attachment A).

In summary, two public road crossings will need improvement, including the potential replacement of a culvert with a bridge at CR430 and potential removal of the culvert on CR437, potentially without replacement as it appears to be on an abandoned roadway. At least two private crossings were verified to be undersized. Further investigation would be needed to fully understand the scale of improvements needed on private crossings.

Hydraulic Assessment

The field reconnaissance included a survey of the Ordinary High Water Level (OHWL) indicators, which were used within the HEC-RAS 1D hydraulic model to help determine risk thresholds for flow rates ranging from 25 to 1,400 cfs. The field staff also used data to estimate channel erosion risk, supported by a literature review. A key flow threshold, the OHWL elevation, was estimated to be 50 cfs.

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[1] PRRIP – Expanded Recapture Reconnaissance Study Web Map, https://lre-inc.maps.arcgis.com/apps/instant/sidebar/index.html?appid=eec15d338ebe417192c65c2310861417

Channel Capacity

The channel capacity was evaluated at all 43 surveyed locations using HEC-RAS. This analysis concluded that flow rates of 100 cfs or less will likely be contained within the channel. Flow rates from 100 cfs to 350 cfs will occur in the main channel with inundation occurring in abandoned channels. Flows greater than 445 cfs would likely trigger significant overbank flooding.

Channel Erosion Risk

The estimated baseflow of 12 cfs defined by the hydrologic assessment below indicates the creek is in stable condition with an approximate critical velocity of 2 ft/s, which can vary greatly depending on site specific stream conditions. Using the HEC-RAS model, it was estimated that a 1.8-year return period would result in an event of 100 cfs with critical velocities in the range of 4-5 ft/s. Flow velocities greater than 200 cfs would likely result in flow velocities in excess of 6 ft/s, which would not only mobilize sediment could result in erosion of poorly vegetated banks.

The hydraulic model was also used to anticipate the risk of infrastructure impacts, geomorphic impacts, and potential mitigation costs for a range of flow augmentation scenarios from 25 to 1,400 cfs. To visualize the risk, Inter-Fluve created a table (Table 7 within the Report in Attachment A, shown as **Table 1** below) displaying risk based upon total flow. Based upon this review, 25 cfs would be a low risk for all categories. The first increase in risk (low/medium threshold) begins at 50 cfs total flow when considering the potential for geomorphic impacts. From 50 to 200 cfs, the risk for geomorphic impacts increases.

High-Flow Event Site Visit

After a significant rain event in the Plum Creek watershed on July 1, 2024, with local reports of 3 to 5 inches of rain reported in the area, the Plum Creek near Smithfield stream gage (06767500) (Plum Creek Near Smithfield) gage peaked at 437 cfs at 0600 with a 11.88 ft stage height. On July 4, 2024, a staff member from RJH was able to travel the focus reach and visibly record water levels when the flow was down to 100 cfs and a stage height of 6.9. Documentation of this flow event can be found in Attachment B.

Table 1 - Infrastructure, geomorphic, and cost risk

Outlet Capacity (cfs)	Total Flow (cfs)	Return interval	Infrastructure Impacts	Geomorphic Impacts	Potential Mitigation Cost	Description of Potential Impacts
13	25	1.0-yr	L	L	L	Sustained releases could result in a small increase in erosion but minimal geomorphic risk and negligible infrastructure risk.
38	50	1.5-yr	L	L/M	L	Water surface elevations at approximate OHW elevation. Increased erosion risk at erosion prone areas (e.g., no vegetation or existing bank failures). Minimal repairs expected.
50*	62	-	L	L/M	L	
63	75	-	L	M	L	Flows greater than 50 cfs result in water surface elevations that increasingly inundate and subject erosion-prone areas to flow. Greater flow rates in this range increase both shear stress and velocity, creating an increasing continuum of risk. Erosion is expected to be largely confined to the channel. Avulsion risk is low.
88	100	-	L	M	L	
100*	112	-	L	M	L	
188	200	-	L	M	L	
283	295	5-yr	M	M	M	Water surface elevations consistently at or near channel capacity. Overbank flooding in isolated locations increases both geomorphic and infrastructure risk, including risk of channel avulsion.
338	350	-	H	H	M	Water surface elevations consistently greater than bank elevations leading to probable geomorphic adjustments, creating conditions that might result in channel avulsion. Erosion and geomorphic changes are likely to occur at erosion prone areas and locations where flooding accesses previous channel bed or potential channel cut-off areas.
433	445	-	H	H	M	
708	720	10-yr	H	H	H	Consistent overbank flooding has high risk of erosion and channel avulsion that would impact property and could impact infrastructure, requiring costly repair.
1,388	1,400	25-yr	H	H	H	

Risks are presented in categories ranging from low, low-moderate, moderate, and high. It is assumed that baseflow in Plum Creek is 12 cfs. *50 cfs and 100 cfs outlet capacity were not modeled and results presented here are based on the other discharges modelled.

2.4 Summary of Findings

- Augmented flows should attempt to mimic the periodicity of the existing flow regime.
- A total augmented flow rate of 50 cfs, or a total flow of 62 cfs within Plum Creek with average baseflow, is considered to pose low to moderate geomorphic risk. This risk can be managed by tracking real-time flows within Plum Creek, considering seasonal hydrograph trends, and predicted precipitation events when planning releases.
- Flow rates between 75 and 275 cfs will be contained in the channel, with an assigned moderate risk. Flows in this range could cause downed trees and branches to clog culverts, could cause erosion around tree roots and expedite additional trees to fall, especially at the upper end of the focus reach. Major bank restoration efforts may be needed, especially for sustained flows exceeding 100 cfs.
- Flows greater than 350 cfs are considered high risk, resulting in culvert overtopping and failure and significant erosion creating risk to existing roads, bridges, and utilities.

2.5 Cost Estimates

The Report provided planning level cost estimates for the Program to consider for infrastructure improvements such as culvert upgrades, bank restoration, and an adaptive management program. As a next step, site specific cost estimates will be needed for individual culverts and bank repair actions. The following assumptions were considered:

- Existing corrugated metal culverts would be replaced with arched corrugated metal pipe.
- State or county highway design requirements were not considered and would need to be integrated into future plans.
- Unit cost approximations were derived from the State of Nebraska summary of bid tabulations and familiarity with similar construction activity.
- An estimate of vulnerable streambanks was quantified using Google Earth.
- Cost estimates include mobilization, demolition and disposal, excavation, erosion control, and riprap protection.

Mitigation cost information for the assessed sub-reaches were extrapolated to the full stream segment to develop total estimated planning level mitigation cost ranges for the 50 cfs and 100 cfs scenarios as shown in **Table 2**. For the purposes of this study, the estimated mitigation costs are treated as capital improvements that likely would be completed during project development and construction.

Table 2 - Estimated Plum Creek Mitigation Cost for 50 and 100 cfs Augmentation Scenarios

	50 cfs Scenario		100cfs Scenario	
Item	**Lower**	**Upper**	**Lower**	**Upper**
Plum Creek Mitigation* Costs	$0	$1,230,662	$971,575	$7,513,516
Culverts & Stream Crossings	$449,000	$449,000	$449,000	$449,000
Total	$449,000	$1,679,662	$1,420,575	$7,962,516
30% Contingency	$134,700	$503,899	$426,173	$2,388,755
Total w/ contingency	***$583,700***	***$2,183,561***	***$1,846,748***	***$10,351,271***

**Cost estimates for assessment reaches (1-4) were utilized to estimate potential mitigation costs for the entire 28.4 miles. Mitigation costs include erosion mitigation techniques such as shaping, revegetation, erosion control, bank grading, fabric encapsulated lifts, and/or channel armoring.*

SECTION 3: HYDROLOGIC ASSESSMENT

3.1 Background

A hydrologic assessment, based upon the historical and recent hydrology of Plum Creek was completed by LRE, to supplement the findings of the stream assessment to evaluate the physical ability and availability of a channel capacity of Plum Creek to convey releases from Elwood Reservoir. The Plum Creek Near Smithfield gage located north of County Road (CR) 746 was used as the principal data source for the evaluation, along with historical field measurements of streamflow data available from 2004 for multiple locations on Plum Creek. Historical hydrologic data was supplemented by LRE using two temporary streamflow stations to confirm recent hydrology and gains/losses on Plum Creek. For a detailed summary of the available historical hydrology, data collection efforts, methods, analysis, and results from the Plum Creek Hydrologic Assessment refer to Attachment C.

3.2 Hydrologic Assessment

The Plum Creek hydrologic assessment was designed to utilize historical hydrologic data from Plum Creek to determine key monthly and annual flow statistics needed to characterize average baseflow, potential gains or losses, and the available capacity of Plum Creek to convey releases from Elwood Reservoir. A summary of these tasks is described below.

Plum Creek Historical Streamflow

To characterize the hydrology of Plum Creek, monthly and annual statistics were compiled based on the Plum Creek Near Smithfield gage. The gage has been intermittently recording streamflow on Plum Creek since June 1946, with several multi-year to decade-long gaps in the historical record. Originally managed by the United States Geological Survey (USGS) the gage was transitioned to NeDNR in October 2002. **Figure 2** shows the location of the Plum Creek gage**. Figure 3** below summarizes the available period of record recorded by each managing agency and the available combine full record from both agencies.

Table 3 below is a summary of monthly and annual flow statistics for the Plum Creek Near Smithfield gage for the representative period from October 1980 to December 2023. Monthly flow statistics shows a range of average flows from approximately 11 to 13 cfs in the winter months (November to February); May as the highest flow month averaging 20 cfs; and the low flow season (July to October) averages approximately 10 to 12 cfs with an increase in average flows in the month of July (13 cfs) due to monsoonal rain events. Monthly minimums and maximums also show that the hydrologic record is extremely variable ranging between 0 and 1400 cfs. Annually, flows average approximately 12 cfs and have ranged between 0 and 1400 cfs.

Figure 3 - Period of Record of Gage 06767500, Plum Creek Near Smithfield, NE

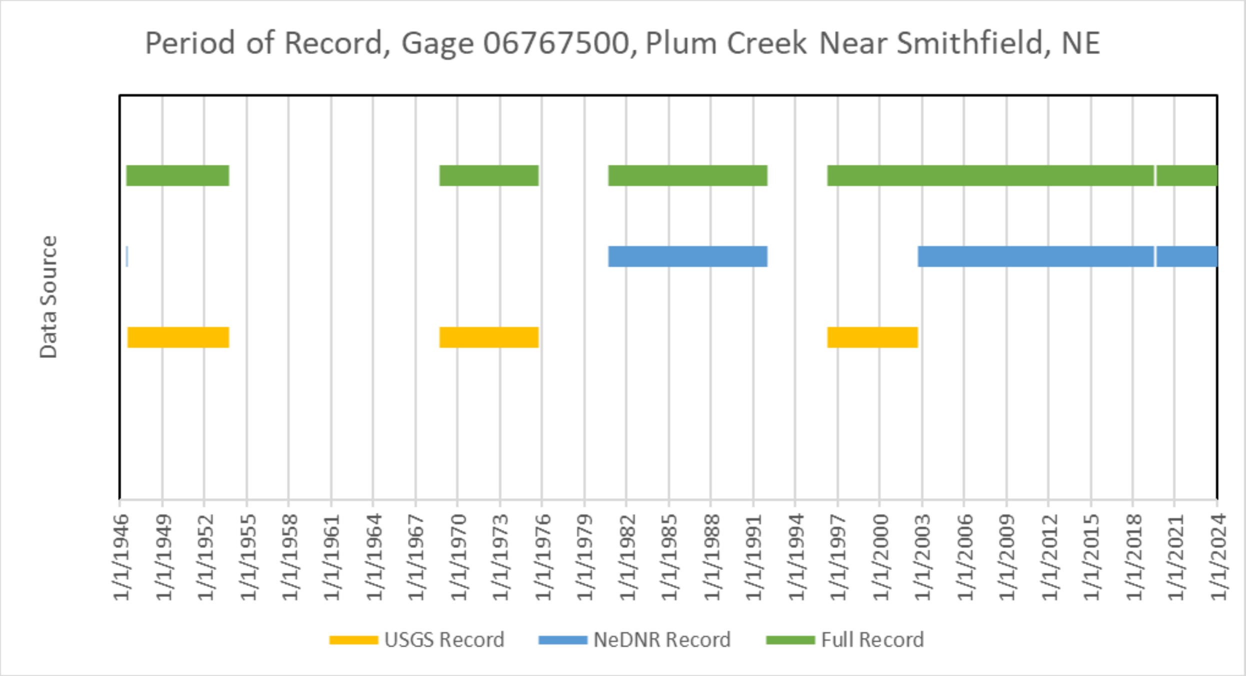


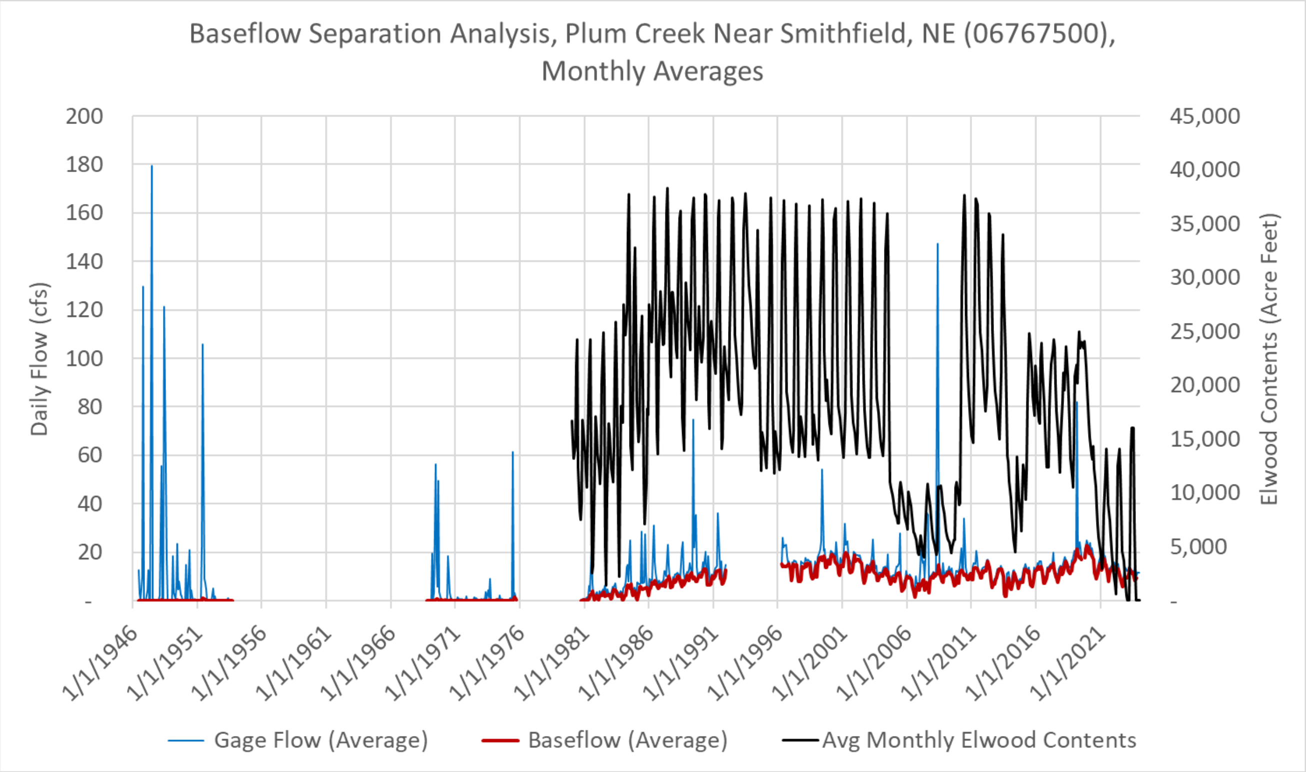
Table 3 - Plum Creek near Smithfield, Ne (06767500)
Monthly and Annual Flow Statistics

Monthly and Annual Flow Statistics (cfs) (10/1980 to 12/2023)				
Month	**Min**	**Mean**	**Median**	**Max**
Jan	0.0	11.8	12.0	68.0
Feb	0.1	13.2	13.0	65.0
Mar	0.2	16.2	14.0	531.0
Apr	0.3	14.0	14.0	100.0
May	0.7	19.6	14.0	1,400.0
Jun	2.4	18.7	13.0	716.0
Jul	0.8	13.2	10.8	280.0
Aug	1.0	12.4	9.3	307.0
Sep	0.5	9.6	8.3	384.0
Oct	0.4	10.9	10.0	113.0
Nov	0.2	11.9	11.4	35.4
Dec	0.2	11.9	12.0	41.2
Annual	**0.0**	**13.6**	**12.0**	**1,400.0**

Baseflow Separation Analysis

Downstream of Elwood Reservoir, Plum Creek is heavily impacted by groundwater seepage and infiltration from the reservoir that results in the consistent baseflow seen in Plum Creek. This is evident in **Figure 4** below showing the historically observed monthly flows at the Plum Creek Near Smithfield, NE (06767500) gage compared to Elwood Reservoir storage content, showing the presence of year-round baseflow following the construction of Elwood Reservoir in the late 1970s that was not present in earlier years. It is also important to note that below Elwood Reservoir there are no major tributaries. Additional sources that contribute to baseflow gains in Plum Creek include nearby Johnson Lake, E65 Canal, Phelps County Canal, and local recharge from irrigated agriculture and natural precipitation.

Figure 4 - Plum Creek Near Smithfield, NE vs Elwood Contents



To assess the available capacity in Plum Creek for additional releases from Elwood Reservoir, flow at the Smithfield gage (06767500) was separated into baseflow (gains from subsurface flow) and “storm flow” driven by storm runoff. Baseflow was calculated as the 30-day Q10, or lowest 3 days in the last 30, on a running basis. This approach is defended in Brodie 2008[2]. This running statistical calculation allows for a straightforward approach to separating seasonal variation in baseflow. The results of the baseflow separation

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[2] Brodie, Ross S., Stephen Hostetler, and Emily Slatter. "Comparison of daily percentiles of streamflow and rainfall to investigate stream–aquifer connectivity." Journal of hydrology 349.1-2 (2008): 56-67.

analysis show that the monthly average baseflow (10/1980 to 12/2023) ranges between 7 and 12 cfs, with an annual average of approximately 10 cfs. For the more recent period (01/1995 to 12/2023) the annual average has increased to approximately 12 cfs.

Gains Calculation

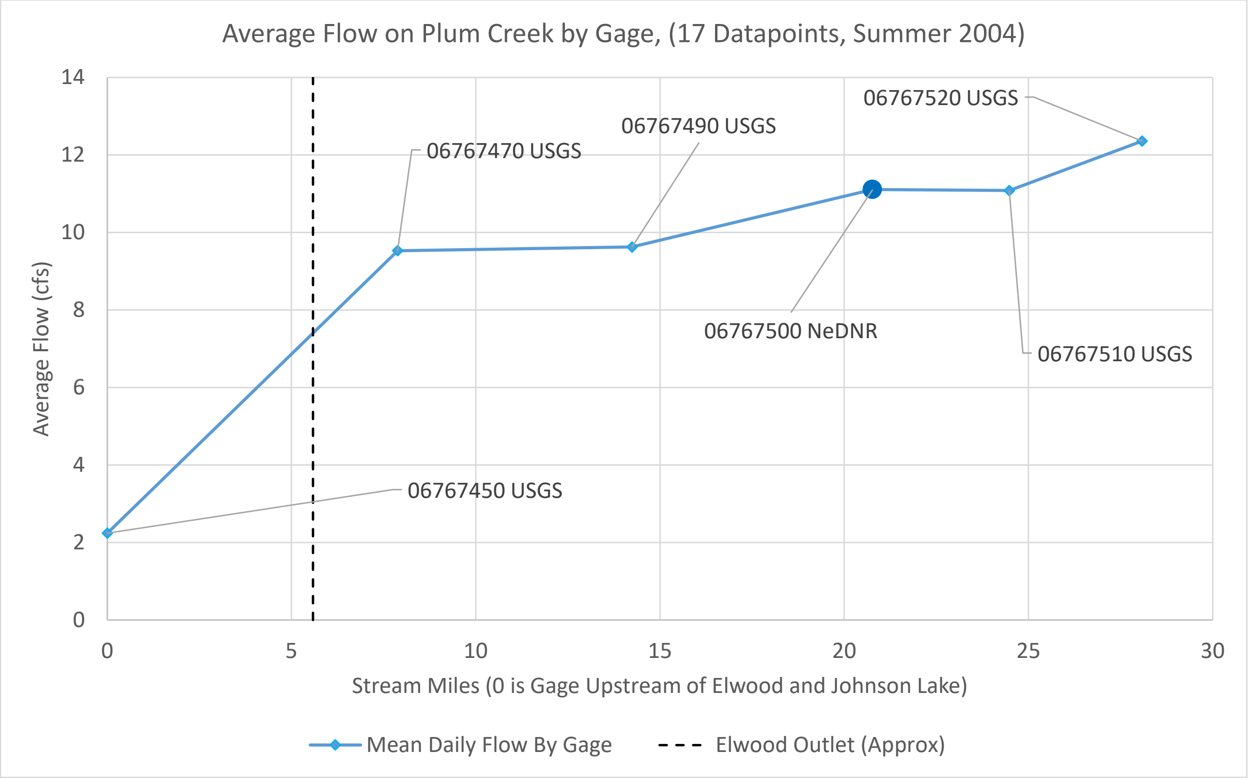
In 2004, the USGS completed paired field measurements at five locations on Plum Creek (Table 1) recording between 16 to 17 measurements at each gage (field site) throughout 2004. These paired measurements and the corresponding observed measurements at the Plum Creek Near Smithfield gage were used to evaluate the gains and losses along Plum Creek from Elwood to the confluence with the Platte River. The average flow across all paired measurements was used to determine the upstream-to-downstream gains. Stream mile was then used to proportionally distribute the gains along each reach based on distance (i.e. cfs/mile). Average gains for each reach ranged from 0.10%/mile to 0.93%/mile.

A review of these paired measurements shows that Plum Creek sees significant gains, averaging ~0.31 cfs/mile (10.1 cfs total gains from Elwood Reservoir to the Confluence with the Platte River) for all reaches with the majority of the gains occurring directly below Elwood Reservoir. Plum Creek mainstem gains an average of ~0.15 cfs per mile with only small variations seasonally.

Figure 5 below shows the average flow from the paired measurements at 5 different sites as well as the approximate location of Elwood Reservoir. Starting at site 06707450 upstream of the Elwood outlet shows very little (~2 cfs) baseflow before increasing sharply to approximately 10 cfs at site 06767470 directly below Elwood, then steadily increasing to just over 20.2 miles to 12 cfs at site 06767520 (0.5 mi W of Gosper County Line) near the confluence with the Platte River.

To confirm the gains observed on Plum Creek in 2004, LRE installed two temporary streamflow stations on Plum Creek (described above). These stations confirmed Plum Creek is a gaining stream averaging a gain of 1.96 cfs over 16.6 miles resulting in mainstem gains of ~0.12 cfs per mile.

Figure 5 - Average Flow Measurements along Plum Creek (WY2004)

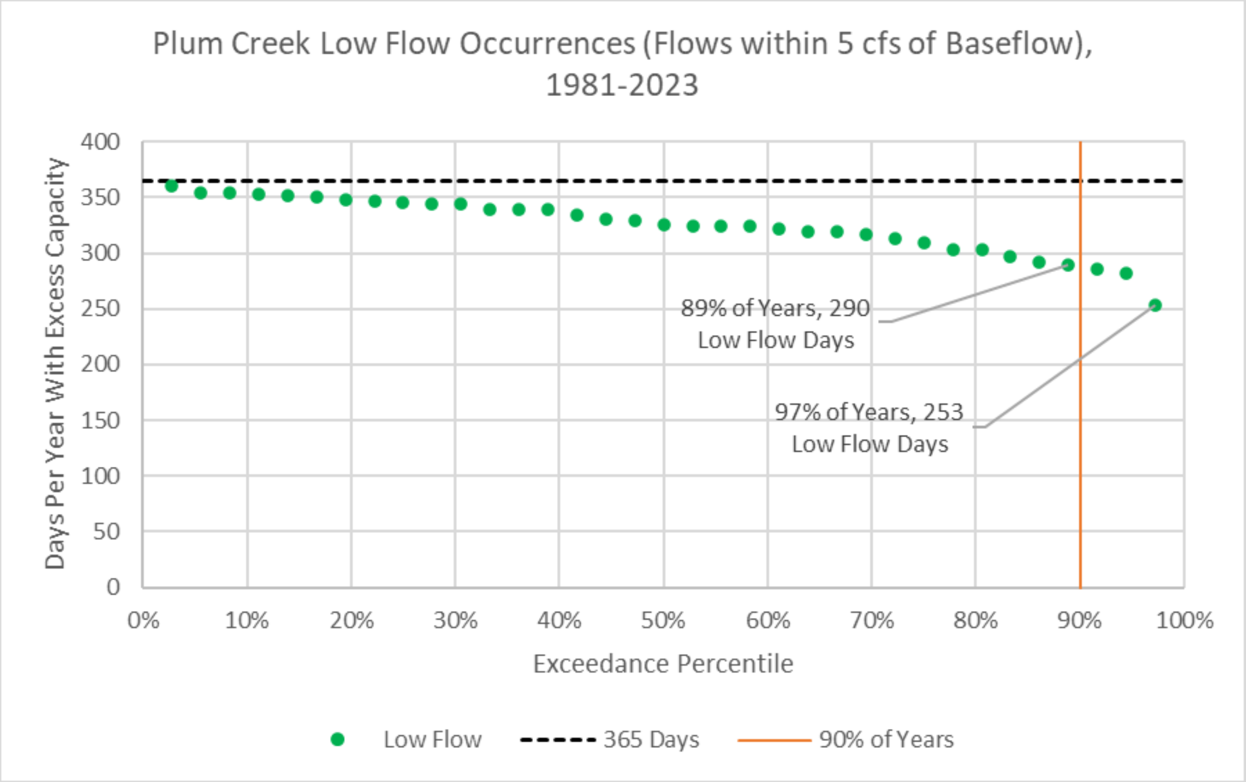


Plum Creek Available Capacity

To understand and quantify the available capacity for Plum Creek to convey releases from Elwood Reservoir, LRE investigated the occurrence of low flow days, defined as days where the historical streamflow was within 5 cfs of baseflow (12 cfs). Low flow days are days when the channel capacity is not fully utilized by naturally occurring flows. Therefore, it is available to accommodate gravity releases from Elwood Reservoir. The occurrence of low flow days shows the % of time (days) each year when there is available capacity not taking into account design or geomorphic risk thresholds. **Figure 6** below is an exceedance plot (occurrence) of the number of low flow days by water year.

The plot shows that approximately 90% of years have at least 290 days where flows are at or near baseflow, and there is additional available capacity in Plum Creek. All water years in the observed period (WY1981 to WY2023) have at least 253 days with available capacity. The infrequency of flow events exceeding baseflow indicates that Plum Creek is well suited to the needs of the Program to make releases at all times of the year to meet downstream flow targets.

Figure 6 - Recurrence of Low Flow Days on Plum Creek

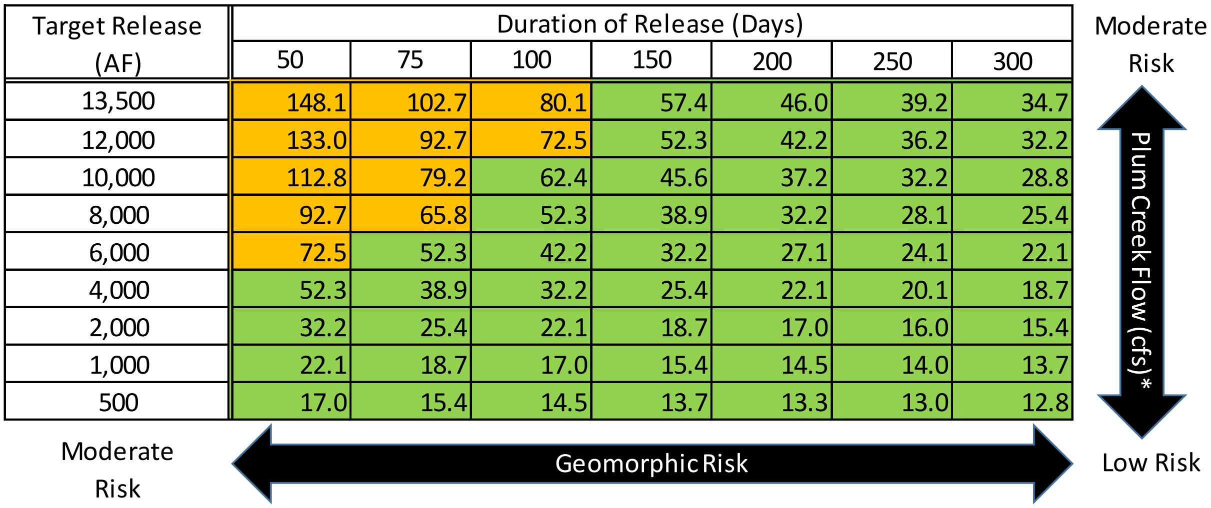


Plum Creek Required Capacity for Additional Releases

Inter-Fluve's assessment of geomorphic risk indicates that flows up to 62 cfs (50 cfs release + 12 cfs baseflow) will result in low to moderate geomorphic impacts on Plum Creek, while flows exceeding 62 cfs will lead to moderate impacts. To contextualize these potential risks and determine the capacity range needed for Plum Creek based on excess flows and target releases, **Table 4** was created. This table illustrates the range of flows assuming constant release rates over short (50 days) and long (300 days) durations, with up to 13,500 acre-feet (AF) of available volume to release annually. It is important to note that actual release rates and volumes will vary annually, monthly, and daily, depending on storage availability in Elwood Reservoir and target flow deficits. The table provides a reasonable estimate of Plum Creek's capacity requirements to accommodate additional releases while considering geomorphic risk

Table 4 shows that higher flow rates over shorter durations pose a greater geomorphic risk than lower flows over longer durations. It also demonstrates that lower flow rates (≤50 cfs) can still achieve significant release volumes over an extended period. Furthermore, the table indicates that sustained releases of over 57.4 cfs (45.4 cfs release + 12 cfs baseflow) for 150 days result in 13,500 AF of releases annually. Shorter duration releases (less than 150 days) will require release rates greater than 62 cfs, leading to moderate impacts on Plum Creek.

Table 4 - Plum Creek Capacity Requirement Considering Geomorphic Risk



Target Release (AF)	Duration of Release (Days)						
	50	75	100	150	200	250	300
13,500	148.1	102.7	80.1	57.4	46.0	39.2	34.7
12,000	133.0	92.7	72.5	52.3	42.2	36.2	32.2
10,000	112.8	79.2	62.4	45.6	37.2	32.2	28.8
8,000	92.7	65.8	52.3	38.9	32.2	28.1	25.4
6,000	72.5	52.3	42.2	32.2	27.1	24.1	22.1
4,000	52.3	38.9	32.2	25.4	22.1	20.1	18.7
2,000	32.2	25.4	22.1	18.7	17.0	16.0	15.4
1,000	22.1	18.7	17.0	15.4	14.5	14.0	13.7
500	17.0	15.4	14.5	13.7	13.3	13.0	12.8

*Plum Creek Flow includes an assumed 12 cfs of baseflow.

3.3 Summary of Findings

Below is a summary the key questions and findings from the Plum Creek Hydrologic Assessment:

- Can Plum Creek be used to convey flows to meet target flow deficits and, if so, are there stream gains or losses that need to be accounted for?

Year-round baseflow became evident in the Plum Creek Near Smithfield gage record after the completion of Elwood Reservoir, Johnson Lake, E65 Canal, and Phelps County Canal in the late 1970s. Using a statistical method the sustained baseflow was determined to average approximately 10 cfs (10/1980 to 12/2023). The more recent period (1/1995 to 12/2023) shows an increase in the sustained baseflow of approximately 12 cfs.

- Are there stream gains or losses on Plum Creek that need to be accounted for?

Using USGS field measurements from multiple months in 2004 and stream distances, the observed record shows Plum Creek downstream of Elwood Reservoir is a gaining stream averaging ~0.15 cfs/mile. Recent hydrology collected by LRE (November 2023 to April 2024) confirms the 2004 observations showing Plum Creek with average gains of ~0.12 cfs/mile. Note these conclusions are based on a limited data set that does not include extreme wet or dry years. Gains or losses may still need to be accounted for in some years. Additional monitoring and analysis is warranted.

- Historically, how many days each year does Plum Creek have available capacity to convey releases from Elwood Reservoir?

Plum Creek is well-suited to handle additional releases from Elwood Reservoir to deficits to target flows at Grand Island with all years in the observed record having over 250 days at or near baseflow conditions with available capacity.

- Considering the potential geomorphic impacts to Plum Creek, what is the required capacity of the stream to convey additional releases and for what duration?

Inter-Fluve's assessment of geomorphic risk concludes that flows up to 62 cfs (50 cfs release + 12 cfs baseflow) will result in low to moderate geomorphic impacts to Plum Creek. A sustained releases of over 57.4 cfs (45.4 cfs release + 12 cfs baseflow) for 150 days results in 13,500 AF of releases annually. Shorter duration releases (less than 150 days) will require release rates of greater than 62 cfs resulting in moderate impacts to Plum Creek.

SECTION 4: ELWOOD RESERVOIR OUTLET ASSESSMENT

4.1 Background

The gravity outlet assessment included a feasibility-level concept and cost analysis by RJH Consultants, Inc. (RJH) as documented within the Concept and Cost Opinions for Conveyance Facilities to Plum Creek memo (Attachment D). The goal was to develop feasibility-level concepts and cost estimates for infrastructure that would control releases and convey Program water from Elwood Reservoir to Plum Creek. After a site visit and consultation with CNPPID staff, the focus of the gravity outlet assessment was primarily on the east side of Elwood Reservoir and the existing E65 Canal south of Siphon 3.

4.2 Alternatives

After consideration of four initial gravity outlet concepts, the Program elected to evaluate two primary alignments, each assumed to convey 50 and 100 cfs and referred to as Alternative A: Open Channel and Alternative B: Buried Pipeline. The alignment of the two alternatives carried forward can be found in **Figure 7** and are described below.

<u>Alternative A1 – Evacuation Outlet and Open Channel (100 CFS)</u>

- Similar to the original Alternative 2 described above utilizing Central's Elwood Reservoir Evacuation Pipeline.
- A 5,900-feet long lined open channel, 5-feet wide, with a normal flow depth of 3-feet.
- Trapezoidal channel with side slopes of 2H:1V.
- Assumes that siphon three is buried adequately to allow excavation of the open channel.

<u>Alternative A2 - Evacuation Outlet and Open Channel (50 CFS)</u>

- As described for A1, with the exception of a 5,900-feet long lined open channel, 3-feet wide, with a normal flow depth of 2.5 -feet.

<u>Alternative B1 – New E65 Outlet and Pipeline (100 CFS)</u>

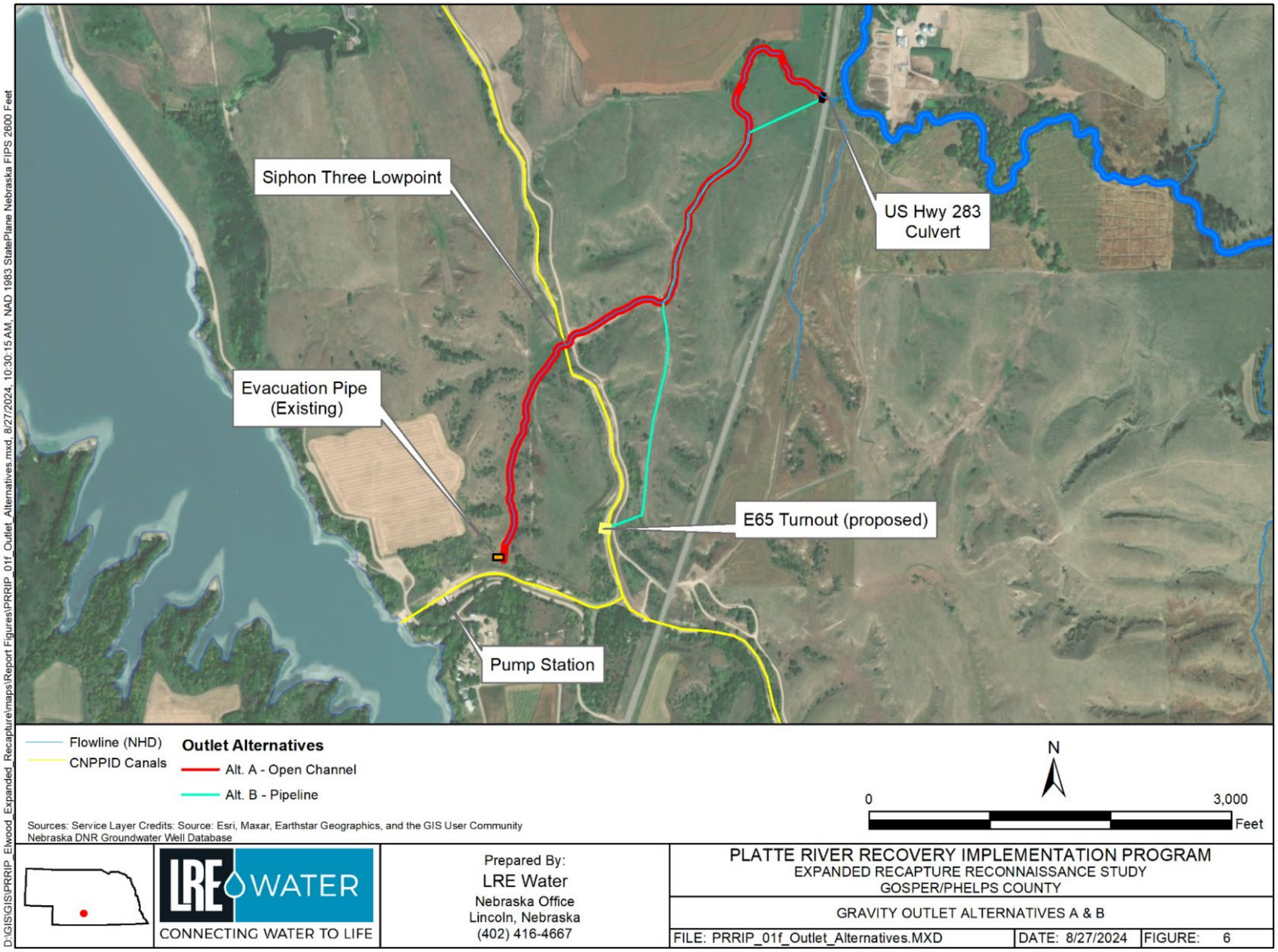
- Similar to the Alternative 1 described above, with the exception of having the new canal headgate downstream of the turnout structure at the south end of the siphon three discharge point to avoid constructing a headgate the topography is flat on either side of the canal.
- Buried gravity 4,500-feet steel pipeline with 90-feet of head from the intake to the discharge under Highway 283.
- A 36-inch diameter steel welded pipe within a trench 6-feet wide, 3.5-feet deep.

- A total of four property owners, including two private property owners, Central, and Gosper County right-of-way.

Alternative B2 – New E65 Outlet and Pipeline (50 CFS)

- As described for B1 but using a 30-inch diameter steel welded pipe within a trench 5.5-feet wide, 3.5-feet deep.

Figure 7 - Gravity Outlet Alternatives A & B



4.4 Preferred Alternative Concept and Cost

The Opinion of Probable Project cost is shown in **Table 5** for the preferred alternatives.

Table 5 - Elwood Reservoir Outlet Capital Cost (OPPC) Summary

Concept	OPPC[3] ($)
Alt A1: Open Channel, 100 cfs	3,300,000
Alt A2: Open Channel, 50 cfs	2,820,000
Alt B1: Steel Pipeline, 100 cfs	9,470,000
Alt B2: Steel Pipeline, 50 cfs	7,500,000
Alt B1: PVC Pipeline, 100 cfs	7,144,000
Alt B2: PVC, Pipeline, 50 cfs	6,340,000

Prior to pursuing the conceptual design of a 50 cfs and 100 cfs Elwood Reservoir outlets, LRE completed modeling assessments to determine the incremental benefits (i.e., score increases) from the gravity outlet alone and in combination with additional recapture wells. This is addressed in the Trade Off analysis described below.

<u>Cost Considerations</u>

- The pipeline concept is more expensive per linear foot than the open channel and includes construction of two gated concrete structures to control and diver flow in the canal and a third structure to dissipate high-energy flow at the pipeline discharge.
- The open channel concept utilizes existing infrastructure owned and operated by Central to divert flow from Elwood Reservoir.
- The cost for permitting easements or land acquisition should be added to the cost opinions.
- The annual maintenance cost for the channel alternatives is $12,500 annually and pipeline maintenance cost is $3,000 annually.
- The pipeline option includes only three property owners, including Central.
- The open channel option includes four property owners including Central.
- A bridge, culvert, or other crossing would be needed along E65 to maintain access along the canal.

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[3] OPPC does not include the cost to replace or enlarge the culvert under U.S. Route 283 or land acquisition.

SECTION 5: RECAPTURE WELL ASSESSMENT

5.1 Background

Recapture wells add a controllable element to recharge projects that otherwise generate return flows to the Platte River over which the Program has no control of timing, magnitude, or location. Recapture wells currently play an important role in maximizing the benefit of the Program's existing recharge projects by discharging groundwater directly to the Platte River specifically during periods with deficits to target flows at Grand Island. Similarly, the use of recapture wells by NeDNR could help to maximize the net benefit to the Platte River during times of shortage.

5.2 Approach

The purpose of the recapture well assessment is to determine the feasibility of adding new recapture wells to enhance Platte River flows for the benefit of both the Program and NeDNR. Evaluating a range of conceptual wellfields to understand infrastructure requirements, costs, and net benefits (score) to support a comparative Trade Off analysis. A detailed summary of the recapture well analysis, completed by LRE, can be found in Attachment E.

As a part of the recapture well assessment the following key tasks were completed by LRE:

<u>Hydrogeologic Cross Sections</u>

- The analysis started with the completion of two hydrogeologic cross-sections stretching from Elwood Reservoir following Plum Creek, and south of the Platte River from west to east. Registered well logs from the NeDNR Groundwater Well Database were used to characterize both the alluvial and Ogallala aquifer. The cross sections are shown as Figures 2 and 3 in Attachment E.
- Areas of greater saturated thickness were identified, and the similar groundwater elevations of both aquifers indicated that they are in hydrogeologic connection with each other. Almost all the wells evaluated, all of which were within 2 to 3 miles of the Platte River or Plum Creek, were completed in either the alluvial aquifer, the Ogallala aquifer, or both. Well depths, pumping yields, screening intervals, and hydraulic heads (static water levels) were used to inform the selection of new recapture areas.

<u>Natural Conveyance</u>

- A review of natural conveyances and drains in the Project Area flowing to the Platte River determined the most effective method to deliver recapture water was through an underground pipeline.
- Most natural drainages were dry, thus adding new water would create challenges with erosion, phragmites, beavers, seepage, erosion, and losses from evapotranspiration.

Recapture Well Zones and Areas

- Utilizing Stream Depletion Factors (SDF) from the Platte River Cooperative Hydrology Study (COHYST), three primary groundwater areas, or Recapture Zones, for analyzing recharge well options were established. Each Zone represents a range of SDFs at varying distances from the Platte River, both north and south of the Phelps County Canal (see **Figure 7**).

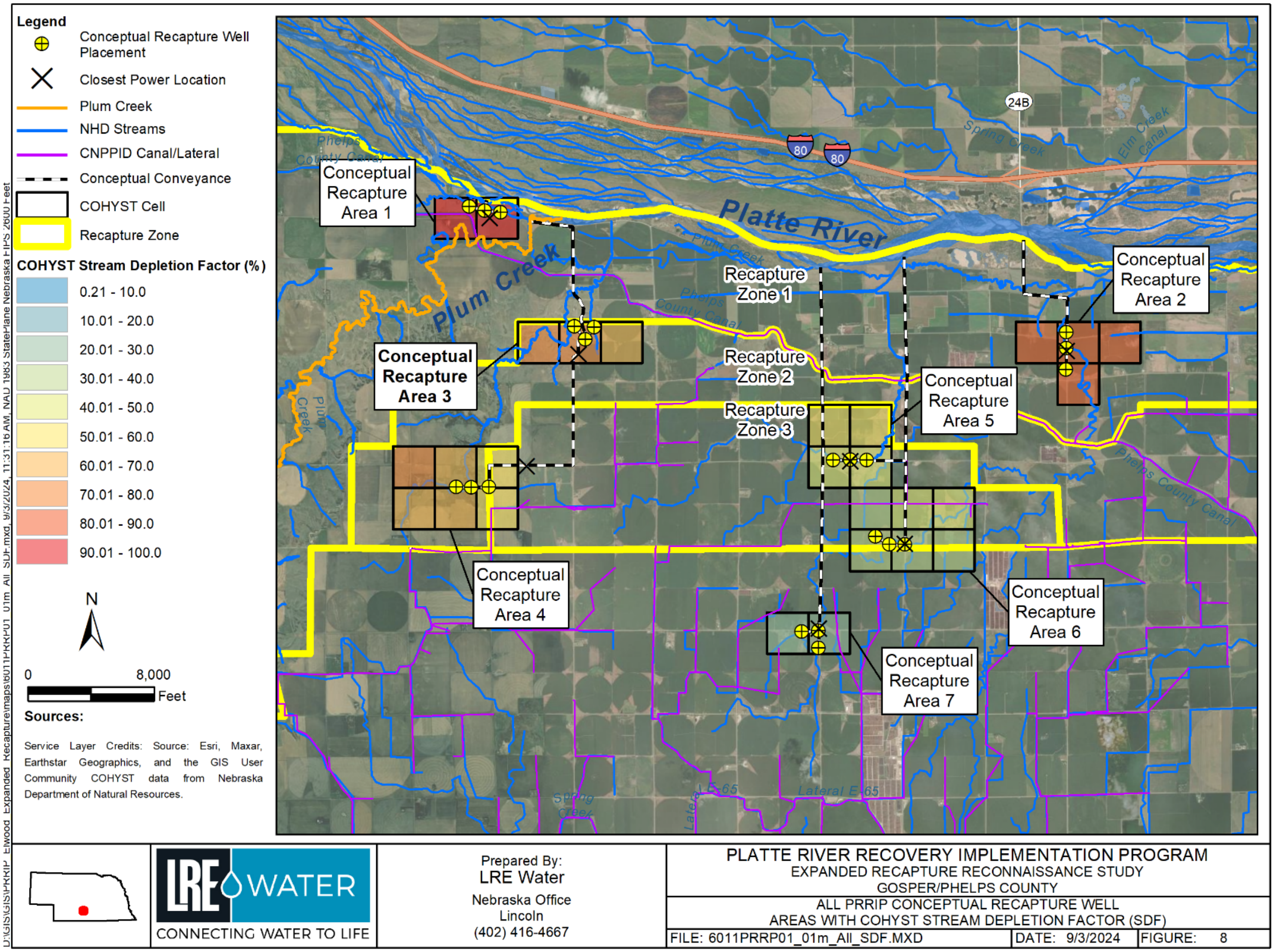
- Recapture Zone 1 - A proposed land area relatively close (0 to 2 miles) to the Platte River or Plum Creek and generally within an SDF Zone > 80 and with existing conveyance (stream or drain) that is able to convey flows naturally to the Platte River. In general, the area can be described as north of Phelps County Canal to the Platte River and is similar to the Program's existing recapture well network.

- Recapture Zone 2 - Proposed recapture sites are located between 2 to 5 miles south of the Platte River and south of Phelps County Canal, in a range of SDF Recapture Zone between 60 and 80. Conveyance of recapture water from a wellfield located in Zone 2 would require a pipeline, including a crossing of Phelps County Canal, to reach the Platte River. The Zone 2 area is irregularly shaped and bound in general to the north by the Phelps County Canal, south by County Rd 745 and 747, and to the east at K Rd.

- Recapture Zone 3 - Zone 3 area covers a SDF zone ranging from 30 to 60. Proposed recapture sites are located more than 3 to 5 miles from the Platte River and south of Phelps County Canal and require constructed conveyance infrastructure.

- Recapture Zone 4 – Beyond 5 miles from the Platte River, requiring extensive conveyance infrastructure.

Figure 8 – Conceptual Recapture Well Sites



Sources:

Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community COHYST data from Nebraska Department of Natural Resources.

5.3 Recapture Wellfield Analysis

Seven conceptual well sites (Recapture Areas) within the established Recapture Zones were then identified with the assistance of Program staff, based on proximity to natural conveyance/drains and power, land use, well spacing, and competing water sources (co-mingled, surface water, groundwater only). Each conceptual well site includes the siting of three wells with connecting pipelines. Conceptual well designs and estimated costs were established for each Recapture Area based on well logs information from nearby alluvial wells including estimated well yield, well depth, screen interval, and static water level necessary for estimated well costs. Total pipeline lengths were also calculated to support conveyance pipeline costs estimates.

Recapture Well Performance

Key to the recapture well assessment and to the management and use of recapture wells is the performance and accounting of each recapture well's net benefit in terms of reducing target flow deficits. Analyses show that recapture wells located closer to the river provide less net benefit to the river because pumping has a larger near-term depletive effect on recharge accretions to the stream.

Essentially, recapture wells located in close proximity to the river provide the benefit of pumping during periods of shortage but much of the pumped water would have reached the river in a similar time frame anyway. Conversely, recapture wells further from the river provide greater net benefits because pumping has a lesser near-term effect on recharge accretions to the stream. This dynamic is important as recapture wells close to the stream can outpace recharge accretions if not carefully managed, ultimately increasing target flow deficits, while recapture wells farther from the stream can pump substantially more with comparatively smaller impacts to recharge accretions.

To represent this dynamic an aquifer balance model was developed using GoldSim (described below) to optimize the well capacity and number of wells required in each recapture scenario based upon available recharge and whether existing recapture wells are operating. **Table 6** below summarizes the well requirements for each recapture area for the Program and NeDNR. Program well requirements are based on available recharge from Elwood Reservoir and Phelps County Canal, assuming 8 existing recapture wells are operating. NeDNR well requirements are only based on available recharge from Elwood Reservoir.

Table 6 - Program and NeDNR Recapture Well Requirements

Recapture Zone	Recapture Area	COHYST SDF	Average Well Yields* (gpm)	Average Well Depth* (ft)	Average Screen Length* (ft)	Program Well			NeDNR Well		
						Well Field Capacity (gpm)	Well Count	Well Capacity (gpm)	Well Field Capacity (gpm)	Well Count	Well Capacity (gpm)
1	1	94.2	913	48	28	1,800	3	600	2,700	3	900
	2	87.2	814	51	26	1,800	3	600	2,700	3	900
2	3	71.7	767	360	22	1,500	3	500	2,100	3	700
	4	64.8	665	242	45	1,500	3	500	2,100	3	700
3	5	45.7	1085	287	60	3,000	3	1,000	2,700	3	900
	6	33.7	1058	215	80	3,000	3	1,000	2,700	3	900

*Averge well yields, well depths, and screen intervals based on averages from nearby wells from the NeDNR well database.

To estimate the cost of developing Recapture Zones 1-3 a comprehensive cost tool was created. Unit cost for wells and conveyance were developed based on Program costs associated with the recent development of Cottonwood Ranch wells from 2019 and updated with 2024 pipe costs. Well counts and conveyance infrastructure cost estimates for each zone are limited based on remaining recharge (after existing recapture wells) with a maximum of 36 wells per Recapture Zone. Costs represent well capacities ranging from 500 gpm to 1,000 gpm, well depths from 48 to 360 feet, and conveyance pipelines from 2.53 to 4.68 miles depending on the performance requirements for each Recapture Zone. **Table 7** summarizes well, conveyance pipeline (PVC & steel), and total capital cost estimates for each Recapture Zone.

Table 7 - Well Conveyance Pipeline Capital Cost Summary

Program Well and Pipeline Requirements and Capital Cost for Additional Recapture Wells

Requirement	Recapture Zone 1 (Recapture Area 1 & 2)		Recapture Zone 2 (Recapture Area 3 & 4)		Recapture Zone 3 (Recapture Area 5 & 6)	
Well Count	6		6		6	
Well Capacity (gpm/well)	600		500		1000	
Well Cost ($)*	$475,474		$653,862		$709,038	
Conveyance Pipeline (Miles)	2.53 miles[1]		5.61 miles[2]		4.68 miles[3]	
Pipeline Cost ($)*	PVC	Steel	PVC	Steel	PVC	Steel
	$1,727,220	$2,630,343	$4,180,477	$6,555,857	$7,401,977	$12,108,169
OPPC ($)*	**$2,202,694**	**$3,105,817**	**$4,834,340**	**$7,209,720**	**$8,111,015**	**$12,817,207**

*Costs include a 30% design and construction contingency

1. Recapture Zone 1 includes the following estimated pipe capacities: 10" = 0.63 mi, 12" = 0.19 mi, 14" = 1.72 mi
2. Recapture Zone 2 includes the following estimated pipe capacities: 8" = 0.57 mi, 12" = 3.11 mi, 18" = 1.93 mi
3. Recapture Zone 3 includes the following estimated pipe capacities: 12" = 0.38 mi, 16" = 0.38 mi, 18" = 1.46 mi, 24" = 2.46 mi

NeDNR Well and Pipeline Requirements and Capital Cost for New Recapture Wells

Requirement	Recapture Zone 1 (Recapture Area 1 & 2)		Recapture Zone 2 (Recapture Area 3 & 4)		Recapture Zone 3 (Recapture Area 5 & 6)	
Well Count	6		6		6	
Well Capacity (gpm/well)	900		700		900	
Well Cost ($)*	$521,365		$684,457		$693,741	
Conveyance Pipeline (Miles)	2.53 miles[1]		5.60 miles[2]		4.68 miles[3]	
Pipeline Cost ($)*	PVC	Steel	PVC	Steel	PVC	Steel
	$2,642,526	$4,155,853	$5,756,970	$9,287,854	$7,301,429	$11,940,589
OPPC ($)*	**$3,163,891**	**$4,677,218**	**$6,441,427**	**$9,972,311**	**$7,995,170**	**$12,634,330**

*Costs include a 30% design and construction contingency

1. Recapture Zone 1 includes the following estimated pipe capacities: 10" = 0.63 mi, 14" = 0.19 mi, 18" = 1.72 mi
2. Recapture Zone 2 includes the following estimated pipe capacities: 10" = 0.57 mi, 12" = 0.19 mi, 16" = 2.92 mi, 20" = 1.93 mi
3. Recapture Zone 3 includes the following estimated pipe capacities: 10" = 0.38 mi, 14" = 0.38 mi, 18" = 1.46 mi, 24" = 2.46 mi

SECTION 6: TRADE-OFF ANALYSIS

6.1 Model Development

The Trade Off analysis was completed by LRE to evaluate the range of possible project configurations, costs, and the scores of project portfolios to meet target flows deficits. This was done using a custom GoldSim model developed for this project and designed to replicate the existing Elwood Reservoir Score Model (originally developed in 2018) as modified by the Program's Executive Director's Office in 2024 to incorporate the reservoir outlet concept and both existing and new recapture wells. The GoldSim model ("the Model") incorporates three primary components, which include:

1) The Elwood Reservoir storage balance, which includes separate accounting of excess flow diversions (inflows) and reservoir seepage (recharge outflows) for both the Program and NeDNR, as wells as a gravity outlet option for the Program;

2) The Aquifer Storage Balance, which includes groundwater recharge from Elwood Reservoir and Phelps County Canal, accretions to the Platte River from recharge, and recapture well pumping and associated depletive effects and;

3) The Scoring Model, which routes net river returns from accretions, recapture pumping, and releases to Grand Island to determine beneficial reductions to target flow deficits.

Some of the key assumptions used in the alternatives modeling were as follows:

- All diversions of excess flows into Elwood Reservoir were assumed to be constrained by the requirements for the existing pump station.
- CNPPID irrigation operations at Elwood Reservoir were represented in a manner consistent with the original Elwood Reservoir recharge score analysis.
- Elwood Reservoir storage could not exceed the 37,800 AF maximum pool volume.
- Excess flow diversions into Elwood Reservoir were capped at 30,000 AF annually, consistent with the original Elwood recharge score analysis.
- Excess flow diversions into Elwood Reservoir were assumed to be split 50/50 between the Program and NeDNR.
- Program excess flow water could exit the reservoir as seepage (i.e., groundwater recharge) or through a gravity outlet (50 cfs or 100 cfs capacity). NeDNR excess flow water could only recharge.
- Program gravity outlet releases were constrained to only occur if the reservoir storage level was above dead pool (12,100 AF).

- Program gravity outlet releases were constrained to only occur during months with shortages at Grand Island, limited by the available supply of Program excess flow storage above dead pool, the outlet capacity, and the deficit volume.

Detailed documentation of the GoldSim Model, data sources used, and more information regarding modeling assumptions will be bundled with source data spreadsheets in the final project deliverable packet.

6.2 Project Portfolio Evaluation

With the three components combined in the Model, it provides the Program a systematic and robust solution needed to evaluate the range of possible project portfolios and represented inflows available from:

- Excess flows;
- Management and accounting of flows in and through Elwood Reservoir;
- Outflows in the form of seepage into the aquifer as recharge or releases directly to the Platte River (via Plum Creek) from Elwood Reservoir;
- Aquifer accounting of recharge to limit available pumping (based on lagged accretions and depletions); and
- The net benefit (score) of each project to reduce target flow deficits at Grand Island.

Prior to completing the Trade Off analysis, the model was calibrated and validated to the established scores of each existing project (1947-1994). Once validated the model was run in a baseline condition representing actual excess flow diversions, Elwood Reservoir accounting, recharge, pumping, and net benefits to the Platte River. The Program's operations accounting records through 2023 were used to establish antecedent or starting conditions of Elwood Reservoir and the alluvial aquifer including the current timing of lagged accretions and depletions. With the starting conditions established, the model was then executed in the forward mode from 1947 to 2023 for a total of ten scenarios representing the range of possible project configurations and scores of project portfolios. Note that the forward mode of the model was run continuously reflecting lagged accretions and depletive effects of pumping from the earlier historical period (1947-1994) that carry forward into the latter recent period (1995-2023).

6.3 Analysis and Reporting

Scores were compiled based on averages for the Programs official scoring period (1947-1994) and the recent period (1995-2023) and compared to and the Program's established score for existing projects of 6,800 AF (including 2,800 AF for Elwood Reservoir recharge, 2,700 AF for Phelps recharge, and 1,300 AF for the 8 existing recapture wells) or the NeDNR estimated score of 3,400 AF (based on recharge-only operations) to determine the incremental score value of each project.

Table 8 below summarizes the ten scenarios evaluated and the incremental scores of each. The following scenarios are included based on the identified project objectives: For the Program, Scenario 1 represents the Program baseline with the existing recharge and recapture projects within the CNPPID system. Scenarios 1.1 to 1.3 evaluate the use of additional recapture wells in zones 1-3, and Scenarios 2 and 3 evaluate the use of a 50 cfs or 100 cfs gravity outlet from Elwood Reservoir with no additional recapture wells. For NeDNR, Scenario 4 represents the NeDNR baseline of recharge accretions to the Platte River at or above Overton, with no routing to Grand Island, and Scenarios 4.1 to 4.3 evaluate the use of new recapture wells in Zones 1-3.

The results of the Trade Off analysis (1947-1994) show the following:

1) The Program's use of a 100 cfs outlet structure with no additional recapture wells results in the highest net benefit (score) to the Platte River, adding 5,009 AF to the Program's established score of 6,800 AF.
2) Without an outlet structure, the addition of new recapture wells in Recapture Zone 1 (north of Phelps County Canal) results in the lowest score adding 887 AF (148 AF/well), while Recapture Zone 3 results in the highest score of adding 3,635 AF (606 AF/well).
3) If NeDNR develops new recapture wells based on only available recharge from Elwood Reservoir, Recapture Zone 3 results in the highest score adding 3,809 AF (635 AF/well) to the NeDNR's estimated score of 3,400 AF.

Cost considerations associated with each of the ten scenarios are presented in the section below.

1995-2023 Scoring Period: It is important to note that the results of the Trade Off analysis focus on the official scoring period (1947-1994). However, the model was developed to include the 1995-2023 period to attempt to get a sense of project performance during the more recent hydrologic period. Although this period was represented there is much uncertainty due to differences in data sources, assigned hydrologic conditions (annual vs real-time), averages calculated over 48 years vs 29 years, and real EA releases not starting until 2007. These are just a few of the challenges with correctly representing the 1995-2023 period. The results of the model reflect reduced excess flows availability during the recent hydrologic period and therefore uniformly lower scores.

Table 8 – Scenario and Score Summary

Scenario	Scenario Description	Elwood Outlet Capacity (cfs)	Existing Recapture Well Count	New Recapture Well Count	New Well Yield (gpm)	New Well Yield Per Well for 6 wells (gpm)	Established Score (1947-1994)	Score (1947-1994)	Incremental Gain from Established Score (1947-1994)	Score (1995-2023)	Incremental Gain from Established Score (1995-2023)
1.0	No Elwood Outlet, 8 Existing Recapture Wells, No New Recapture Wells (Program Baseline)	0	8	0	-	-	6,800[1]	7,089	289	6,842	42
1.1	No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 1)	0	8	6	3600	600		7,687	887	7,317	517
1.2	No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 2)	0	8	6	3000	500		8,055	1,255	7,541	741
1.3	No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 3)	0	8	6	6000	1000		10,435	3,635	9,316	2,516
2.0	50 cfs Elwood Outlet, 7 Existing Recapture Wells, No New Recapture Wells	50	7	0	-	-		11,265	4,465	10,837	4,037
3.0	100 cfs Elwood Outlet, 6 Existing Recapture Wells, No New Recapture Wells	100	6	0	-	-		11,809	5,009	11,578	4,778
4.0	Elwood Reservoir Recharge Only (NeDNR Baseline)	0	0	0	-	-	3,400[2]	3,422	22	3,545	145
4.1	Elwood Reservoir Recharge and New Recapture Wells (Zone 1)	0	0	6	5400	900		4,526	1,126	4,424	1,024
4.2	Elwood Reservoir Recharge and New Recapture Wells (Zone 2)	0	0	6	4200	700		5,111	1,711	4,820	1,420
4.3	Elwood Reservoir Recharge and New Recapture Wells (Zone 3)	0	0	6	5400	900		7,209	3,809	6,487	3,087

1. Established Score: Program established score based on the aggregate score for Elwood Reservoir (2,800 AF), Phelps County Canal (2,700 AF), and an estimated 1,300 AF for the 8 existing recapture wells (based on an approved score of 160 AF for the Cook well). Does not include Cottonwood BSR.
2. NeDNR established score above Overton based on the approximate modeled results of Elwood Reservoir Recharge Only (Scenario 4.0). Does not include WMC Losses to Grand Island.

SECTION 7: COST ANALYSIS

Total capital costs were compiled for each project scenario described above in Table 8 based on the capital costs compiled from the assessments of Plum Creek (Table 2), the Elwood Reservoir gravity outlet (Table 5), and recapture wells (Table 7). Total capital costs were then combined with the estimated O&M over an assumed 50-yr project life cycle to calculate total project costs. O&M over an assumed 50-yr project life cycle include O&M for recapture wells (including pump replacements), O&M for the gravity outlet, Plum Creek O&M (inclusive of wood debris removal and beaver/phragmites mitigation), easements, SCADA, HP/electric, and Tri-Basin NRD staff time assuming a 3% annual rate of escalation. For detailed cost information for each project portfolio was compiled using a comprehensive cost template. For summary of the template, data sources, unit costs, and assumptions used in the Cost Analysis refer to Attachment D.

Table 9 below summarizes the total capital costs ($), O&M ($), total costs ($), and unit costs ($/AF) for each scenario based on the scores summarized in Table 8 above. Note that unit costs presented are based on total costs divided by total score over the assumed 50-yr project life cycle.

The results of the Cost Analysis shows that although the use of a 100 cfs outlet structure with six existing recapture wells results in the highest (score) it is a more expensive gravity outlet alternative with a total cost ranging between $20.58M ($82/AF) for the open channel outlet alternative to $26.75M ($107/AF) for a steel pipeline outlet. The Cost Analysis shows that the most cost-effective scenario for the Program (highest score (AF)/lowest cost) is the 50 cfs open channel alternative at $7.41M ($33/AF). If the Program is considering additional recapture wells the most cost-effective scenario is the new recapture wells in Recapture Zone 3 using a PVC pipeline at $25.57M ($141/AF). Similarly, if NeDNR were to develop new recapture wells, Recapture Zone 3 is the most cost-effective alternative using a PVC pipeline at $24.65M ($129/AF).

Excess Flow Costs: Note that the capital and O&M costs discussed herein do not include the initial purchase and diversion of excess flows into Program recharge projects located within the CNPPID system (Elwood Reservoir, Phelps County Canal, and Cottonwood Ranch). In a Water Service Agreement (WSA) between the Program and CNPPID dated December 7, 2022, the Program prepaid $9,154,956.24 for excess flow diversions totaling 50,000 AF into Phelps County Canal at $35.92/AF and 134,927.7 AF into Elwood Reservoir at $54.54/AF. The initial term of the agreement is through December 31, 2032, but can be extended through successive one-year agreements for up to another 10 years or until the full volume of water is delivered (whichever is sooner). Total excess flow deliveries during the first two years of this WSA (through August 2024) include about 3,173 AF into Elwood Reservoir and about 1,125 AF into Phelps County Canal, far below the annual averages that would be required to deliver all pre-paid water by 2032. There is a separate WSA from August 2018 concerning the Cottonwood Ranch recharge project, in which CNPPID is to repay the Program for the capital costs of the delivery pipeline construction through deliveries of excess flows. As of August 2024, an estimated 28,000 AF is still to be delivered based on the remaining pipeline cost balance and a term through December 31, 2032.

Table 9 – Scenario Cost Summary

Scenario	Cost Scenario	Scenario Name	Elwood Reservoir Outlet Costs[1]	Plum Creek Mitigation & Infrastructure Costs[2]	Recapture Well Costs[3]	Conveyance Pipeline Costs[4]	Total Capital Cost[5]	O&M (50-Yr Project Life)[6]	Total Costs (50-Yr Project Life)[7]	Score (AF/Yr) (1947-1994)[8]	Total Score (AF) (50-yr Project Life)[9]	Unit Cost ($/AF) (1947-1994)[10]	Score (AF/Yr) (1995-2023)[11]	Total Score (AF) (50-yr Project Life)[12]	Unit Cost ($/AF) (1995-2023)[13]
1	1.0	No Elwood Outlet, 8 Existing Recapture Wells, No New Recapture Wells (Program Baseline)	$0	$0	$0	$0	$0	$0	$0	289	14,448	$0	42	2,120	$0
1.1	1.1A	No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 1) (PVC)	$0	$0	$475,474	$1,727,220	$2,202,694	$14,885,546	$17,113,239	887	44,351	$386	517	25,870	$662
	1.1B	No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 1) (Steel)	$0	$0	$475,474	$2,630,343	$3,105,817	$14,885,546	$18,016,362	887	44,351	$406	517	25,870	$696
1.2	1.2A	No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 2) (PVC)	$0	$0	$653,862	$4,180,477	$4,834,340	$13,724,629	$18,583,968	1,255	62,741	$296	741	37,031	$502
	1.2B	No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 2) (Steel)	$0	$0	$653,862	$6,555,857	$7,209,720	$13,724,629	$20,959,348	1,255	62,741	$334	741	37,031	$566
1.3	1.3A	No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 3) (PVC)	$0	$0	$709,038	$7,401,977	$8,111,015	$17,437,959	$25,573,974	3,635	181,762	$141	2,516	125,816	$203
	1.3B	No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 3) (Steel)	$0	$0	$709,038	$12,108,169	$12,817,207	$17,437,959	$30,280,166	3,635	181,762	$167	2,516	125,816	$241
2	2.0	50 cfs Elwood Outlet (Open Channel), 7 Existing Recapture Wells	$2,816,104	$1,383,630	$0	$0	$4,199,734	$3,107,831	$7,407,565	4,465	223,257	$33	4,037	201,838	$37
	2A	50 cfs Elwood Outlet (PVC), 7 Existing Recapture Wells	$6,339,920	$1,383,630	$0	$0	$7,723,550	$3,107,831	$10,931,381	4,465	223,257	$49	4,037	201,838	$54
	2B	50 cfs Elwood Outlet (Steel), 7 Existing Recapture Wells	$7,502,720	$1,383,630	$0	$0	$8,886,350	$3,107,831	$12,094,181	4,465	223,257	$54	4,037	201,838	$60
3	3	100 cfs Elwood Outlet (Open Channel), 6 Existing Recapture Wells	$3,290,192	$6,099,009	$0	$0	$9,389,201	$11,086,030	$20,575,231	5,009	250,446	$82	4,778	238,916	$86
	3A	100 cfs Elwood Outlet (PVC), 6 Existing Recapture Wells	$7,144,000	$6,099,009	$0	$0	$13,243,009	$11,086,030	$24,429,039	5,009	250,446	$98	4,778	238,916	$102
	3B	100 cfs Elwood Outlet (Steel), 6 Existing Recapture Wells	$9,469,600	$6,099,009	$0	$0	$15,568,609	$11,086,030	$26,754,639	5,009	250,446	$107	4,778	238,916	$112
4	4.0	Elwood Recharge Only (No New Infrastructure) - NeDNR Baseline	$0	$0	$0	$0	$0	$0	$0	0	0	$0	123	6,142	$0
4.1	4.1A	New Recapture Wells Only (Zone 1) (PVC)	$0	$0	$521,365	$2,642,526	$3,163,891	$17,322,669	$20,511,560	1,105	55,228	$371	1,002	50,118	$409
	4.1B	New Recapture Wells Only (Zone 1) (Steel)	$0	$0	$521,365	$4,155,853	$4,677,218	$17,322,669	$22,024,887	1,105	55,228	$399	1,002	50,118	$439
4.2	4.2A	New Recapture Wells Only (Zone 2) (PVC)	$0	$0	$684,457	$5,756,970	$6,441,427	$15,349,378	$21,815,805	1,689	84,444	$258	1,399	69,930	$312
	4.2B	New Recapture Wells Only (Zone 2) (Steel)	$0	$0	$684,457	$9,287,854	$9,972,311	$15,349,378	$25,346,689	1,689	84,444	$300	1,399	69,930	$362
4.3	4.3A	New Recapture Wells Only (Zone 3) (PVC)	$0	$0	$693,741	$7,301,429	$7,995,170	$16,625,584	$24,645,754	3,787	189,349	$130	3,065	153,249	$161
	4.3B	New Recapture Wells Only (Zone 3) (Steel)	$0	$0	$693,741	$11,940,589	$12,634,330	$16,625,584	$29,284,914	3,787	189,349	$155	3,065	153,249	$191

1. Elwood Reservoir Outlet Costs ($) from Tabel ES-3.
2. Plum Creek Mitigation and Infrastructure Costs ($) assume an average of the cost range provided in Table ES-2 for 50 cfs and 100 cfs flow augmentation scenarios.
3. Recapture Well Costs ($) from Table ES-5.
4. Conveyance Pipeline Costs ($) from Table ES-5.
5. Total Capital Costs ($) = Sum of Elwood Reservoir Outlet Costs, Plum Crk Mitigation & Infrastructure Costs, Recapture Well Costs, and Conveyance Pipeline Costs.
6. O&M (50-Yr Project Life) ($) includes costs for O&M for recapture wells (including pump replacements), O&M for the gravity outlet, Plum Creek O&M (inclusive of wood debris removal and beaver/phragmites mitigation), easements, SCADA, HP/electric, and Tri-Basin NRD staff time. The total
7. Total Costs ($) (50-Yr Project Life) plus $25,000 for permitting of recapture wells scenarios or $100,000 for permitting of Elwood Reservoir outlet scenarios.
8. Scores (AF) (1947-1994) from Table ES-6.
9. Total Score (AF) (50-yr Project Life)= Scores (1947-1994) X 50
10. Unit Cost ($/AF) (1947-1994) = Total Costs ($) (50-Yr Project Life)/Total Score (AF) (50-yr Project Life), for the 1947-1994 period.
11. Scores (AF) (1995-2023) from Table ES-6.
12. Total Score (AF) (50-yr Project Life)= Scores (1995-2023) X 50
13. Unit Cost ($/AF) (1995-2023) = Total Costs ($) (50-Yr Project Life)/Total Score (AF) (50-yr Project Life), for the 1995-2023 period.

SECTION 8: PERMITTING AND LAND RIGHTS

The following summary is provided to describe potential permitting impacts for recapture wells, streambank stabilization, or other improvements to Plum Creek, and the Elwood Reservoir gravity outlet and flow path. It is important to note that continuous changes to the definition of ‘waters of the United States’ (WOTUS), most recently in May 2023, creates a high-level of uncertainty in the definition of a jurisdictional waterway within the Clear Water Act and how each state perceives the definition. The U.S. Army Corps of Engineers (USACE), Nebraska Regulatory Office, may request that the Program complete a wetland delineation and request an Approved Jurisdictional Determination (AJD) before proceeding with any project that may potentially impact WOTUS.

Given the uncertainty with jurisdictional status at the time of this report, it may be advantageous to proceed with the 404 NWP permit process for any project that does not require mitigation, rather than pursuing the AJD process and potentially causing project delays.

Recapture Wells

A well permit will need to be obtained from TBNRD for any new recapture well. The TBNRD will ensure there adequate spacing to avoid impacts to existing water users. Specifically, within Section 8.3 C(i) of the Rules and Regulations which state the following requirements:

- All wells or physically connected wells with a total pumping capacity in excess of 1,000 gpm must be 1,320 feet (1/4 mile) from all existing registered wells with a capacity in excess of 50 gpm, even if registered under the same ownership.
- All wells or physically connected wells with a total pumping capacity in excess of 1,500 gpm must be 2,640 feet (1/2 mile) from all existing registered wells with a capacity in excess of 50 gpm, even if registered under the same ownership.

Given the high density of high-capacity wells within the Study Area, well spacing will likely be a challenge. Based upon correspondence with TBNRD, a variance for recapture well spacing could be considered, but may require hydrogeologic assessment, aquifer pumping test, and/or a groundwater model to provide evidence that recapture wells would not interfere with existing wells. Any new well will also require registration with the NeDNR.

Plum Creek Stream and Riparian Corridor

Mitigation actions, such as streambank stabilization, within the Plum Creek channel or any adjacent wetlands, or within the Ordinary High Water Level (OHWL), will require a wetland delineation, Section 404 permit, and an environmental review to ensure there are no impacts to cultural resources or Threatened and Endangered species. The level of effort, and any stream or wetland mitigation actions, will be directly based upon the length of stream or wetland area. For wetland impacts below 0.10-acres or less than 500 Liner Feet (LF) of stream bank impact, should be authorized under a NWP. Impacts of a single project above those thresholds could require wetland or stream mitigation and/or an Individual Permit.

The agricultural crossings over Plum Creek could potentially be exempt from Section 404 permitting based upon Section 404(f) of the CWA, which mentions construction or maintenance of farm roads, which is assumed to include crossings, is exempt, assuming the flow and/or circulation of waters is not impaired and the reach of the waters are not reduced. Based upon 404(f), improvements to existing agricultural crossings should not require 404 permit, however, correspondence with the U.S. Army Corps of Engineers (USACE) is advised.

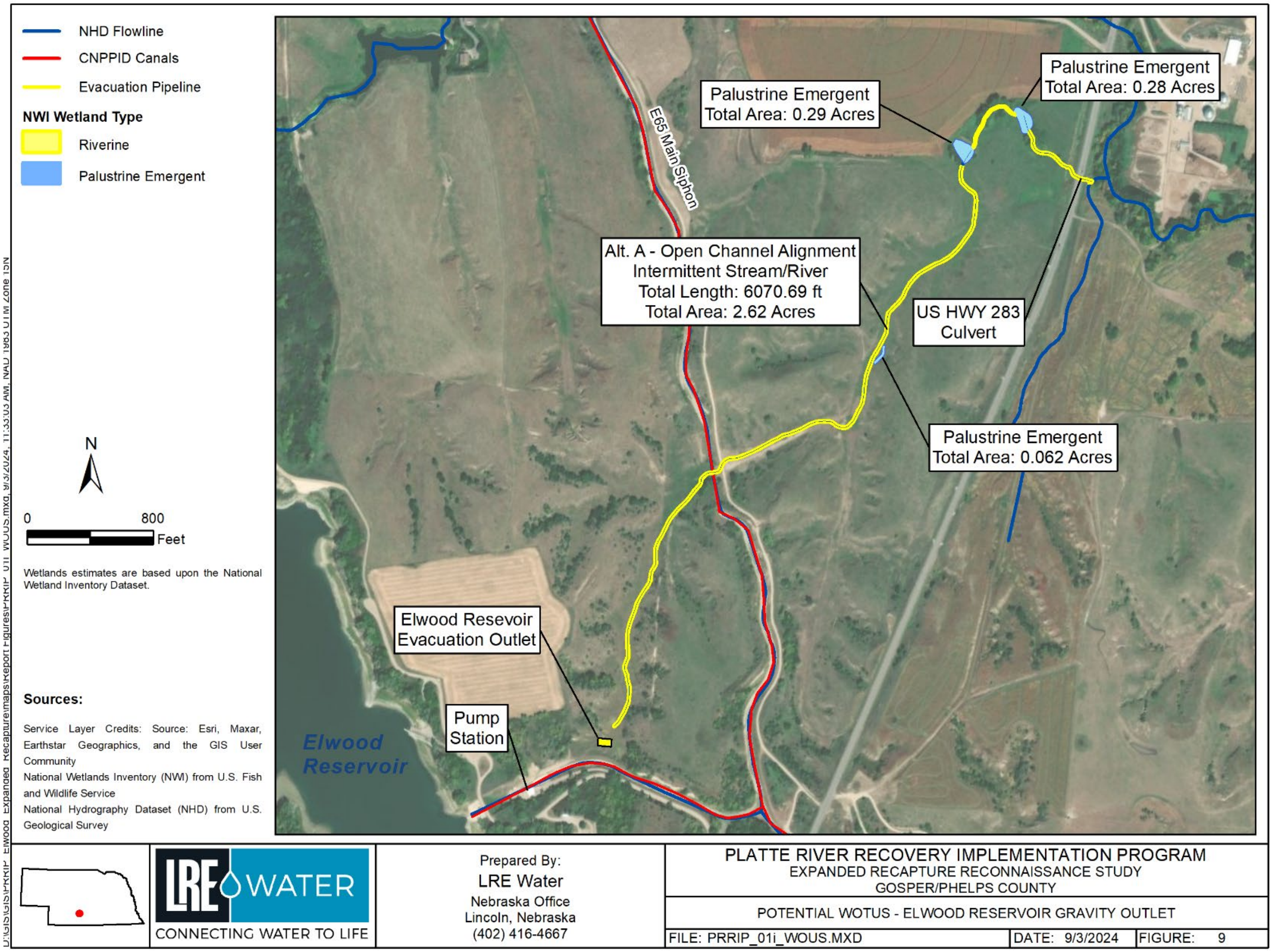
Gravity Outlet Alternative A: Open Channel

A desktop review of the wetland resources from the evacuation pipeline to the Highway 283 culvert was completed using aerial photo interpretation, the USGS National Hydrography Dataset (NHD), and U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) with results shown in **Figure 9**. This review shows that the flowline from the Elwood Reservoir evacuation pipeline to the culvert is classified as an intermittent stream (FCODE 46003) and totals nearly 6,000-feet. Additionally, the flow line is identified as having nearly 3-acres of riparian wetlands along the entire length, in addition to nearly 1-acre of palustrine emergent wetlands towards the downstream end. A review of aerial photography shows a small earthen berm 675-feet west of the culvert and a small pool just downstream of the berm. A review of Google Earth Street View also appears to confirm the presence of willow trees in the area.

Based upon the desktop review, a wetland delineation would be required along with correspondence with the USACE on the jurisdiction status of the flowline. Given that the flowline is classified as an intermittent stream, has wetlands present, and flows directly to Plum Creek, it appears likely that the channel and wetlands could be considered jurisdiction, as they would have a directly flow path to an active waterway.

It is likely an Individual Permit (IP) and mitigation of stream and wetland impacts would be required, due to impacts exceeding mitigation thresholds, as the linear distance of impact could be over one mile. Should the Program move ahead with the open channel concept, it is recommended to complete the wetland delineation at the early stages.

Figure 9 – Potential WOTUS – Elwood Reservoir Gravity Outlet



Wetlands estimates are based upon the National Wetland Inventory Dataset.

Sources:

Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
National Wetlands Inventory (NWI) from U.S. Fish and Wildlife Service
National Hydrography Dataset (NHD) from U.S. Geological Survey

Prepared By:
LRE Water
Nebraska Office
Lincoln, Nebraska
(402) 416-4667

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
EXPANDED RECAPTURE RECONNAISSANCE STUDY
GOSPER/PHELPS COUNTY

POTENTIAL WOTUS - ELWOOD RESERVOIR GRAVITY OUTLET

FILE: PRRIP_01i_WOUS.MXD | DATE: 9/3/2024 | FIGURE: 9

Gravity Outlet Alternative B: Buried Pipeline

Construction of the gravity outlet within the existing E65 canal would require correspondence with the USACE to help determine if a new diversion/intake to a pipeline inlet conveying water to Plum Creek would be exempt under the CWA, Section 404(f)(1), which provides exemptions for the maintenance and construction of irrigation ditches is the proposed activity does not impair the flow or circulation of WOTUS or reduce the reach of such waters.

Permitting the pipeline would depend upon the jurisdictional status of the ephemeral channel leading to Plum Creek. If the ephemeral channel is determined to be jurisdictional, it is likely that an NWP would be suitable, assuming impacts are temporary (side cast of material during construction) and the outlet to the Highway 283 culvert is likely small enough to also be permitted under a NWP.

The buried pipeline or open channel options would require correspondence with the Nebraska Department of Transportation and potentially a Gosper County floodplain or Right-of-Way permit.

LAND RIGHTS/EASEMENTS

Construction of the gravity outlet would require easements and/or acquisition of property from private landowners and coordination with Central, who would own and operate any new infrastructure located on their property at Elwood Reservoir. The following is a brief summary of land right considerations.

Private Landowners

- There are three property owners with land where the open channel concept would be located and two where the pipeline would be located.
- At least 11 agricultural crossings are present along Plum Creek and would require access agreements for construction improvements. A more detailed review should be completed to document the exact number of crossings.
- The number of locations needing streambank mitigation actions is unknown. Streambank improvements should not require acquisition or easements.
- It remains likely that new recapture wells would be located on private property and multiple property owners along the conceptual wellfield pipeline alignments.

CNPPID

- The open channel concept crosses a road along the existing E65 canal and would require a bridge, culvert, or low water crossing to allow continued access.
- The new diversion/intake, pipeline, and open channel would require an operation and service agreement with CNPPID.

Gosper County

- Coordination and permits from Gosper County would be required to replace the 8-foot diameter CMP at CR430 and potential removal of the culverts at CR437.
- Both projects are located on county property and should not require easements or acquisition.

NDOT

- The Highway 283 culvert would need to be inspected and construction of a drop structure from either the open channel or pipeline would require a permit and approval from NDOT.

SECTION 9: SUMMARY AND CONCLUSIONS

9.1 Findings

Below is a summary of the key findings and conclusions from the Expanded Recapture and Reconnaissance Study.

1) Plum Creek appears to be capable of conveying augmented flows from Elwood Reservoir to the Platte River with minimal losses. Augmentation flows of up to 50 cfs released through an Elwood Reservoir gravity outlet are consistent with the estimated ordinary high water line (OHWL) in Plum Creek and would pose minimal geomorphic risk when added to existing baseflow (12 cfs). Flow up to 100 cfs plus baseflow (112 cfs) above the OHWL may require minor to major bank repairs. Shorter-term duration, lower flow events present the lowest risk of geomorphic impacts.

2) If Plum Creek is used to convey flow, it will result in an increase in both minor and/or major geomorphic impacts depending on the magnitude and duration of augmented flow events. Minor erosion impacts can be expected at exposed unvegetated areas/banks located at or below OHWL. Major bank erosion impacts can be expected at exposed unvegetated areas where existing bank undercutting or bank sloughing is actively occurring adjacent to the channel above the OHWL. These areas are primarily located in the upper portion of the Project Area where exposed sand/gravel banks were observed.

   Infrastructure improvements including replacement of existing culverts that are damaged or have insufficient capacity would be required for at least 11 agricultural crossings and two public road crossings at CR430 and CR437 at an estimated cost of $450,000.

   Erosion mitigation techniques such as shaping, revegetation, erosion control, bank grading, fabric encapsulated lifts, or armor would be likely options to mitigate damages. The geomorphic impacts vary based on flow magnitude and duration with estimated capital costs for mitigation ranging from $1.2M to $10M (including infrastructure improvements). An adaptive management approach should be used to mitigate geomorphic risk and impacts to Plum Creek from augmented flow.

3) Existing infrastructure owned by CNPPID could be utilized to release water from Elwood Reservoir using gravity flow. The lowest cost option is the use of CNPPID's evacuation pipeline located near the pump station into a new constructed open channel to convey water to Plum Creek. The second option would be the installation of a headgate and intake structure on the existing E65 canal directly east of Elwood Reservoir and south of Siphon 3 to convey releases from Elwood Reservoir through a buried pipeline. The conceptual capacity options for the outlet and conveyance infrastructure were assumed to be 50 and 100 cfs, based upon the results of the Plum Creek stream assessment.

   Using the evacuation pipeline and open channel to pass water to the Highway 283 culvert has an estimated to capital cost between $2.82M (50 cfs) and $3.30M (100 cfs). The installation of a headgate south of Siphon 3 and a spillway on the east side of E65 would lead to a buried pipeline to the culvert under Highway 283. The range of capital costs for a 50 cfs pipeline is $6.34M (PVC) to $7.50M (steel) and the range of capital cost for a 100 cfs pipeline is $7.14M (PVC) to $9.47M (steel).

4) For the Program, the 8 existing recapture wells in combination with an Elwood Reservoir gravity outlet appear to maximize the potential deficit reduction benefit to the river without the addition of new recapture wells.

   If new recapture wells are added to the Program's existing recapture wells without an Elwood Reservoir gravity outlet, the net benefit (score) to the river can be improved by approximately 900 AF (150 AF/well) for areas close to the river (Recapture Zone 1) or by as much as 3,600 AF (600 AF/well) for areas located further from the river (Recapture Zone 3). The practical size of each well field would be based on available sites with adequate well spacing to accommodate between 3 to 6 wells, which can either be located together or separately as two well fields.

   In general, wells located farther from the river can pump more and provide greater net benefit due to the smaller impact on recharge accretions to the stream. Therefore, to maximize their net benefit, recapture wells located in Recapture Zones 2-4 would require higher capacity wells and pipelines that result in higher costs. The total cost (over the assumed 50-yr project life cycle) for adding additional recapture wells ranges from $17.11M (PVC) to $18.02M (steel) for well fields/pipelines located close to the river (Recapture Zone 1) to $25.57M (PVC) to $30.28M (steel) for well fields/pipelines located further from the river (Recapture Zone 3).

5) The ability of recapture wells to pump intentionally recharged groundwater from the aquifer is largely dependent on the volume of excess flows stored and managed in Elwood Reservoir because of the reservoir's capacity relative to other, smaller recharge projects. With a gravity outlet of 50 or 100 cfs, significantly less recharge would occur for the Program and it would be necessary to carefully manage operations of the Program's 8 existing recapture wells. The combination of a gravity outlet and existing recapture wells results in the highest scores of all alternatives evaluated, adding between 4,465 AF (50 cfs) to 5,009 AF (100 cfs) to the Program's established score of 6,800 AF.

6) The Cost Analysis shows that the most cost-effective scenario for the Program is the 50 cfs open channel alternative with existing recapture well at $7.41M ($33/AF) over the assumed 50-yr project life cycle. If the Program is considering additional recapture wells and no outlet from Elwood Reservoir the most cost-effective scenario is new recapture wells in Recapture Zone 3 using a PVC pipeline at $25.57M ($141/AF) over the assumed 50-yr project life cycle.

7) If NeDNR were to develop a recapture well program, new recapture wells can offset shortages to the river by approximately 1,100 AF (183 AF/well) for areas close to the river (Recapture Zone 1) or by as much as 3,800 AF (633 AF/well) for areas located further from the river (Recapture Zone 3).

8) The Cost Analysis shows that the most cost effective scenario for NeDNR is to develop new recapture wells, specifically with well placement in Recapture Zone 3 (SDF 60-70%, or 3-4 miles south of the Platte River) using a PVC pipeline at $24.65M ($129/AF) over the assumed 50-yr project life cycle.

9.2 Next Steps

Below is a summary of considerations for the next steps beyond the Expanded Recapture Reconnaissance Study:

- **Well Yields** – Sustainable alluvial well yields in the area vary significantly (between 300 to 1,000 gpm). Site specific evaluation of hydrogeology and aquifer conditions are necessary to accurately determine prospective well yields.

- **Elwood Reservoir Operations** – The modeling of Elwood Reservoir assumes the required pumping into and release from Elwood Reservoir are coordinated around CNPPID's current operation of the reservoir for irrigation. This will likely change if CNPPID proceeds to construct a new E65 Canal and siphons and a gravity inlet to Elwood Reservoir. Model refinements will be necessary to better represent CNPPID's planned future operations once they become known.

- **Recapture Well Operations** – Modeled recapture well pumping operations were limited to a monthly volumetric rate based on the estimated capacity of each well and seasonally with pumping only allowed from March through November. For all gravity outlet scenarios, recapture wells were pumped to reduce deficits remaining after outlet releases. Additional investigation supporting the use and optimization of recapture wells in combination with a gravity outlet is warranted.

- **Alluvial Saturated Sand** – The primary conduit for conveying aquifer recharge from existing recharge projects back to the Platte River is alluvial saturated sand not the Ogallala aquifer. Wells logs indicate wells located further from the Platte River in Recapture Zones 2 and 3 are primarily screened in the Ogallala aquifer. If pumping is only allowed from alluvial saturated sand, well yields farther from the river may not be sustainable or result in well interference concerns. Preliminary feedback from NeDNR suggests this may not be a significant issue for the state. However, the Program may have issues of policy and/or perception related to water recharged vs water recaptured that warrant further consideration.

- **Real-time vs Annual Hydrologic Conditions** – Annual hydrologic conditions from the 1947 to 1994 period are used as the basis for assigning target flows to determine excesses/shortages and transit losses (WMC transit loss factors). In the more recent period (1995 to 2023) real-time hydrologic conditions are used as the basis for assigning target flows and transit losses. A preliminary comparative analysis completed by EDO staff indicates the use of real-time hydrologic conditions for the more recent period 1995-2023 results in a slightly lower overall estimate of shortages and slightly higher excess flow compared to the annual hydrologic condition. However, a closer look at the analysis on a monthly timestep suggests little meaningful difference when considering the magnitude of augmentation flows that the Program could contribute to the Platte River compared to the typical magnitude of shortages. Scores can be further impacted by the assignment of transit losses based on annual or real-time monthly hydrologic conditions. Additional investigation, sensitivity testing, and/or model refinements are warranted.

- **Aquifer Accounting** – The Program would benefit from the establishment of an operations and management plan for existing recapture wells to ensure that pumping practices are sustainable. Under several scenarios aggressive pumping or overuse of recapture wells can result in negative accretions to the Platte River that actually increase target flow deficits. Aquifer accounting and management should include both short-term and long-term impacts to the river, ensuring pumping today will not detrimentally impact the river long-term.
- **Plum Creek Streamflow Monitoring –** In support of planning, permitting, and operation of a gravity outlet from Elwood Reservoir, and the implementation of an adaptive management of Plum Creek. It is recommended that a streamflow monitoring program be implemented on Plum Creek.
- **Aquifer Timing** - The timing of aquifer accretions and depletions in this analysis utilize multiple sources for Unit Response Functions (URFs). Program URFs associated with Phelps County Canal, Elwood Reservoir, and the Cook Well are site specific project URFs generated from the Program's groundwater model(s) or Integrated Decision Support Alluvial Water Accounting System (IDS AWAS). URFs utilized for recapture wells are based on SDFs from COHYST. This difference is important to the timing of the aquifer accretions and pumping impacts to the stream. It is recommended that the GoldSim model be refined to use a consistent set of URF's based upon a single representative groundwater model.
- **Scoring** - Historically, all Program projects have been individually scored. This exercise highlights the benefits of collectively scoring inter-dependent Water Action Plan projects to better understand the aggregate net benefit to the river.
- **Geomorphic Impacts and Costs –** To evaluate the geomorphic impacts for the full length of Plum Creek additional surveying and H&H modeling would need to be completed to support refined costs.
- **Cost** – Costs included in the Study were established at a reconnaissance level resulting in conservative estimates to support the Model and to provide resources for decision makers. These costs are intended to serve as a foundation for future planning efforts for comparative purposes and include a 30% contingency. A detailed cost analysis should be refined in subsequent Phases of this project supporting actual costs of the selected alternatives.

ATTACHMENT A

Plum Creek Geomorphic Reconnaissance and Hydrologic Assessment

(Inter-Fluve - July 15, 2024)

TECHNICAL MEMORANDUM

To:	Jonathan Mohr, PM; Mark Mitisek, Technical Lead; Page Weil, Water Resources Engineer: LRE Water
From:	Jackie Van Der Hout, Joel Peterson, Josh Epstein: Inter-Fluve
Date:	July 15, 2024
Project:	Elwood Expanded Recapture Reconnaissance Study
Re:	Plum Creek Geomorphic Reconnaissance and Hydrologic Assessment

EXECUTIVE SUMMARY

The Platte River Recovery Implementation Program (PRRIP) has initiated an investigation of flow recharges into the Platte River to meet Platte River target flow objectives for threatened and endangered species. As a part of this effort, Plum Creek has been identified as a potential channel to convey surface flows from the Elwood Reservoir into the Platte River.

This memo summarizes the results of a study to inform the PRRIP on the geomorphology, hydrology, hydraulics, and land use history of Plum Creek. Study efforts include an existing data review, field geomorphic assessment, hydraulic model development, a risk assessment, and planning level cost estimates.

The Plum Creek geomorphic field assessment evaluated the condition of the channel at four representative stream reaches and twelve stream crossings on Plum Creek downstream of Elwood Reservoir. Results and estimates presented in this document apply to Reaches 1, 2, 3 and 4 (see Figure 6). The field investigation concluded that the geomorphic condition of the channel is generally in fair to good condition for most of the cross-sections surveyed and is suitable to convey flow. The assessment also showed that Plum Creek has some areas with deeply incised channels, and more significant erosion and bank stability issues due to grazing and/or agricultural practices or lack of woody debris requiring mitigation. The condition of infrastructure located on Plum Creek at each major or minor stream crossing ranges from fair to good for existing bridges to poor for several existing culverts which are in need of replacement or are undersized. In addition, there are a total of twelve private crossings that would need to be improved or replaced. The estimated cost of replacing the four culverts and improving twelve private crossings $449,000.

To determine the available capacity of the Plum Creek and risks for conveying flows a hydraulic model was developed based on observations from the field assessment. The ordinary high water (OHW) elevation was used as the baseline for determining risk. The OHW elevation is used as the primary indicator for channel forming flow that typically occurs multiple times each year and has an important influence on geomorphology and vegetation in the system. Based on field observations and hydraulic modeling a flow rate of 50 cubic feet per second (cfs) was found to be correlated with the OHW elevation and was assigned a low-moderate risk because it is representative of the existing flow regime on Plum Creek. The hydraulic model was also used to anticipate the risk to infrastructure impacts,

geomorphic impacts, and potential for mitigation costs for a range of flow augmentation scenarios from 25 to 1,400 cfs. The results of the analysis shows the risk to infrastructure impacts are low for flows less than 200 cfs, moderate for flows between 200 cfs and 295 cfs and high for flows exceeding 350 cfs; the risk to geomorphic impacts are low for flows less than 50 cfs, moderate for flows between 50 cfs and 295 cfs, and high for flows exceeding 300 cfs, and; the risk to potential cost mitigation are low for flows less than 200 cfs, moderate for flows between 283 cfs and 445 cfs, and high for flows exceeding 720 cfs.

Flow augmentation between 50 cfs and 100 cfs is of particular interest given the goals of the PRRIP. Flow augmentation of 50 cfs is estimated to result in minor bank repair, estimated at 0 to 400 linear feet over a five-year period, with a cost of between 0 and $100k estimated for the 2.2 miles assessed in Reaches 1, 2, 3 and 4. Because this flow rate is near the OHWL, increased erosion will occur if augmentation were to take place when flow rates are above base flow conditions, or when sustained periods of release subject erosion-prone areas to flow. Most repairs are likely to be concentrated in the upper reaches of Plum Creek. Flow augmentation of 100 cfs is expected to result in water surface elevations greater than the OHWL, which is anticipated to result in both minor and major bank erosion, with a cost between $50k and $500k over a five-year period. Increased minor erosion will occur at exposed, unvegetated areas. Major bank erosion is likely to occur at exposed areas and areas where there is existing bank undercutting or bank sloughing and in the downstream portion of the project, where exposed sand/gravel is subject to flow.

Risk factors for geomorphic channel adjustment (erosion) include magnitude of flow as well as frequency and duration. Increasing frequency and/or duration of flows will increase the risk of lateral or vertical channel adjustment, such as bank erosion. To mitigate these adjustments the study recommends adaptive management actions and planning level infrastructure improvement cost estimates are summarized herein.

Mitigation cost information for the 2.2 miles assessed were extrapolated to the full 28.4-mile reach of Plum Creek to develop estimated mitigation cost ranges for the 50 cfs and 100 cfs scenarios (see Table 1). Additional detail can be found in Table 13 - 15.

	50 cfs Scenario		**100cfs Scenario**	
Item	**Lower**	**Upper**	**Lower**	**Upper**
Plum Creek Mitigation Costs	$0	$1,230,662	$971,575	$7,513,516
Culverts & Stream Crossings	$449,000	$449,000	$449,000	$449,000
Total	$449,000	$1,679,662	$1,420,575	$7,962,516
30% Contingency	$134,700	$503,899	$426,173	$2,388,755
Total w/ contingency	***$583,700***	***$2,183,561***	***$1,846,748***	***$10,351,271***

Table 1. Summary mitigation cost summary information for the entire 28.4-mile Plum Creek project area. Cost estimates for assessment reaches (1-4) were utilized to estimate potential mitigation costs for the entire 28 miles.

FLUVIAL GEOMORPHOLOGY OVERVIEW

Like all fluvial systems, Plum Creek's biophysical characteristics are governed by geomorphic processes. A brief summary of pertinent geomorphic processes is presented below.

Dynamic Equilibrium

Healthy alluvial stream systems move sediment frequently, in a loose balance between erosion and deposition. As materials erode from stream beds and banks in high velocity areas (such as the outside of meander bends or constrictions) they are carried to depositional areas where slow-moving water allows them to settle (such as the inside of meander bends and wider portions). This process of erosion and deposition results in the sinuous lateral migration patterns of rivers that create and renew floodplains.

The term "dynamic equilibrium" is used to refer to the natural meandering of rivers while in a general state of balance of sediment inputs and transport. While streams in a state of equilibrium may display dynamic behaviors such as movement across the floodplain, erosion, and deposition; the planform geometry, cross-sectional shape, and slope of streams in equilibrium remain relatively consistent over decadal time scales, even as their sub-reaches could at any time be characterized along a continuum of degradation (downcutting or incising) to aggradation (depositing).

Various sizes and volumes of sediments can be mobilized by a range of flow rates. For instance, fine-grained sediment may be transported by flows throughout the year, while larger sediments move only during floods, and perhaps massive volumes of sediment move during large, but rare, floods. Accounting for the frequency and sediment transport capacity of high-water events, the majority of sediment transported by a stream system over the long-term typically occurs from flooding with 1.5- to 2-year recurrence interval. These flows are referred to as the “channel forming flow” or “bankfull flow” due to the frequency of these flow being sufficient to cause regular maintenance of channel shape and riparian vegetation.

One indicator that a stream is incised and disconnected from its floodplain is when the elevation of the bankfull flow is well below adjacent upland areas. By this indicator, Plum Creek is an incised stream system. An incised stream might remain in an unstable state for many decades due to steep slopes, and lack of vegetation to provide flow resistance to slow velocity along the bank and dense roots systems to bind soils.

Stream Evolution

The evolution of channel planform patterns is broadly influenced by biology, geology, and hydrology (Figure 1). Biological influences may include riparian vegetation, animals, macroinvertebrates, and large woody debris. Geologic influence on channel patterns includes physical characteristics of bed and bank sediments, bedrock exposures, and watershed topography. Lastly, hydrologic influences on channel patterns include overall climate, precipitation patterns, stream slope, and discharge. The combined influence of biology, hydrology, and geology set up the dynamic equilibrium of a stream system. A change in one of these influences can result in instability and a shift in channel forms.

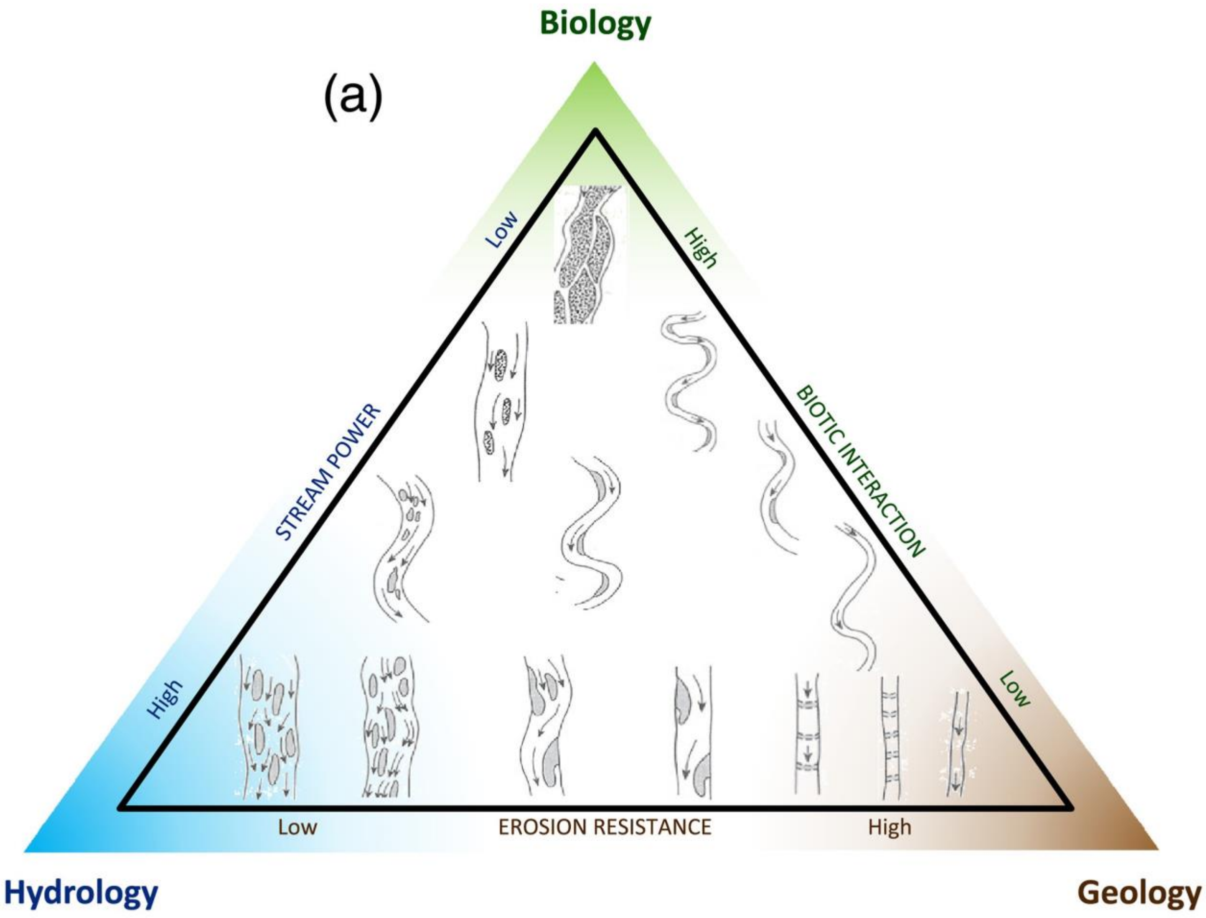


Figure 1: Stream evolution triangle showing typical planform channel patterns as defined by Schumm (1985). Axis shows relative influence of biology, hydrology, and geology on channel form (figure from Castro and Thorne 2019).

Building off the stream evolution triangle, the stream evolution model offers a conceptual framework to understand why and how creek systems adapt and evolve to change (Figure 2, Cluer and Thorne, 2014).

In this conceptual model, the pre-disturbance channel (Stage 0 or Stage 1) is a channel with a high level of connectivity to the floodplain. Alterations in the biology, geology or hydrology of the system propel the stream into a state of channelization (Stage 2), or channel degradation (Stage 3). These Stages can be followed by floodplain widening through the process of lateral migration (Stage 4), or arrested degradation (Stage 3s). Following Stage 4, the channel may begin to aggrade if excess sediment is supplied to the system (Stage 5) followed by the stabilization of the system and vegetation growth on the floodplain (Stage 6). As the channel stabilizes it will continue to laterally migrate across its floodplain (Stage 7) and may eventually evolve into a floodplain-channel system with numerous backwaters, abandoned oxbows, and riparian wetlands (Stage 8).

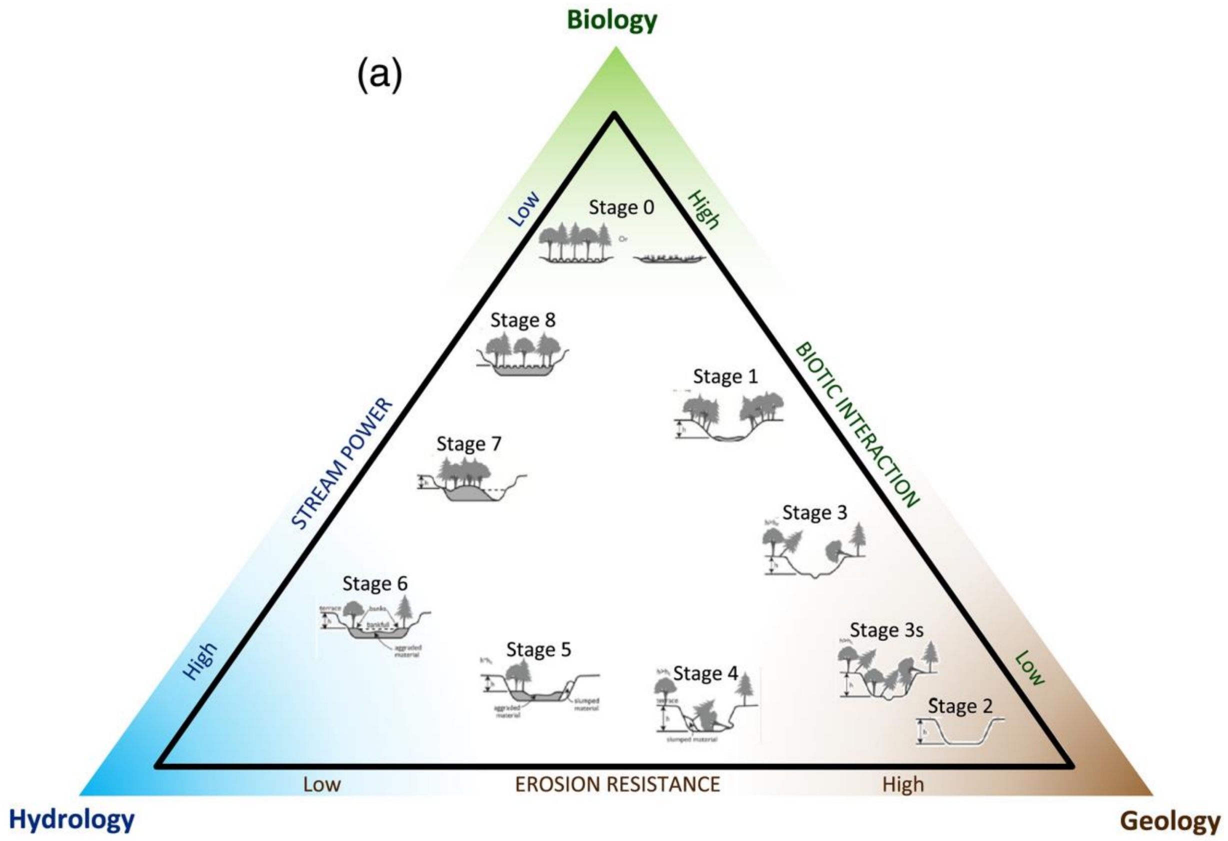


Figure 2***: (a) Stream evolution triangle showing stages of stream evolution (Cluer and Thorne 2014).***

WATERSHED CONTEXT

The Plum Creek watershed is located in south-central Nebraska. Starting at the Elwood Reservoir, the lower reach of the Plum Creek watershed of approximately 111 square miles (Figure 3). Plum Creek flows generally eastward from its headwaters to its confluence with the Platte River.

The watershed is located in a semi-arid climate which tends to experience a late spring to early summer hydroperiod (Vogel, 2007). Additional significant sources of precipitation in the region include spring and summer thunderstorms, which are typically short-duration and high intensity, producing peak stream flows (Voge, 2007).

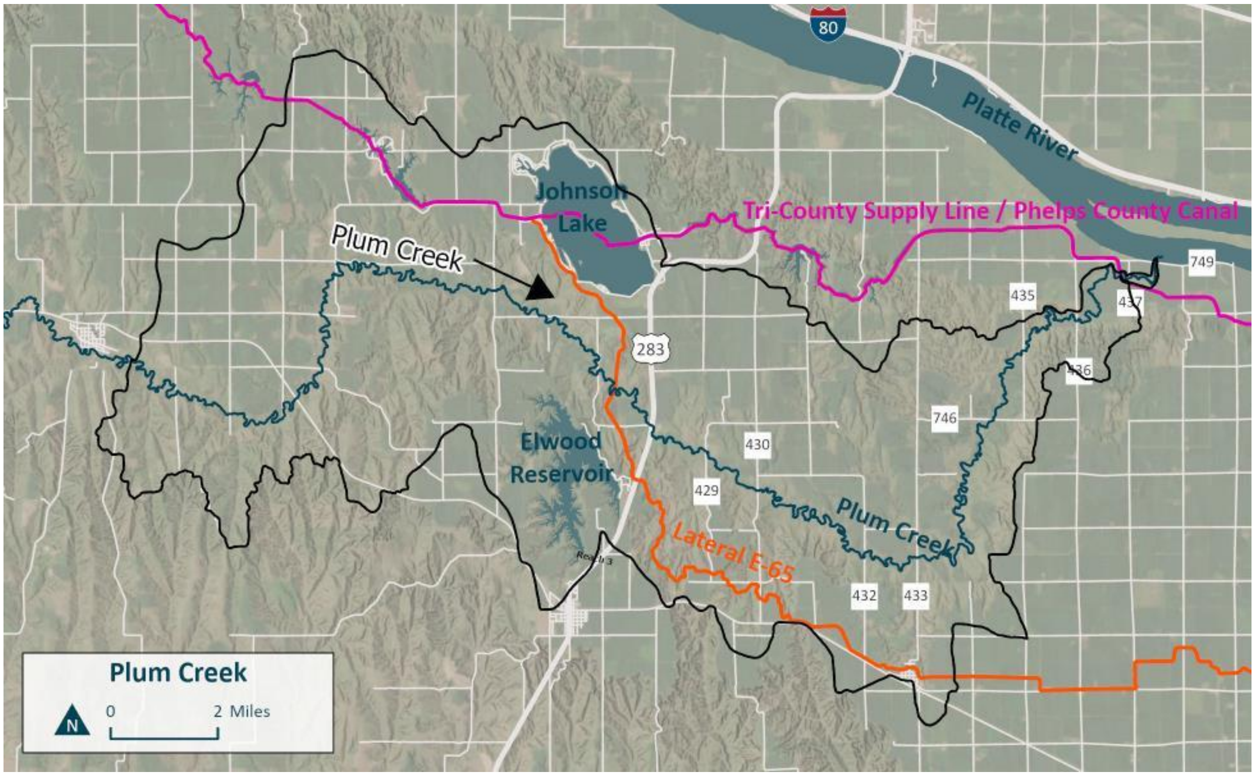


Figure 3: Plum Creek Watershed Area

The hydrology of the Plum Creek watershed was dramatically altered by the construction of the Elwood Reservoir in the late 1970s. Built by the Central Nebraska Public Power and Irrigation District as part of an effort to modernize the E-65 irrigation canal system, the Elwood Reservoir supplies water for agricultural uses in the area. Water is pumped from the E-65 irrigation canal into the reservoir during the early spring, and then released back to the E-65 irrigation canal to meet irrigation demands in the mid to late summer. Interflow and seepage from Elwood Reservoir into Plum Creek has been observed and is considered an inadvertent result of the construction of the dam. The dam and reservoir therefore increase baseflow volume and duration altering the overall hydrograph on Plum Creek relative to historical, pre-Elwood conditions. The geomorphology and vegetation of Plum Creek have begun adjusting to these relatively recent changes.

Watershed Geology

The dominant surficial geology in the Plum Creek watershed is unconsolidated deposits of loess (wind-blown silt sediments) (Figure 4). The loess was deposited during and immediately following the last ice age. Winds blowing from the north and west entrained fined grained material eroded by glacial ice, natural weathering processes, and meltwater channels. Larger sand-sized material was deposited in a large dune field north of the modern Plum Creek watershed commonly referred to as the Nebraska Sand Hills. Finer silt-size sediments were carried over and through the Sand Hills and deposited in a vast plain including most of the modern Plum Creek valley. A small portion of the lower watershed is not solely composed of loess as a result of having been reworked by the fluvial processes of the Platte River.

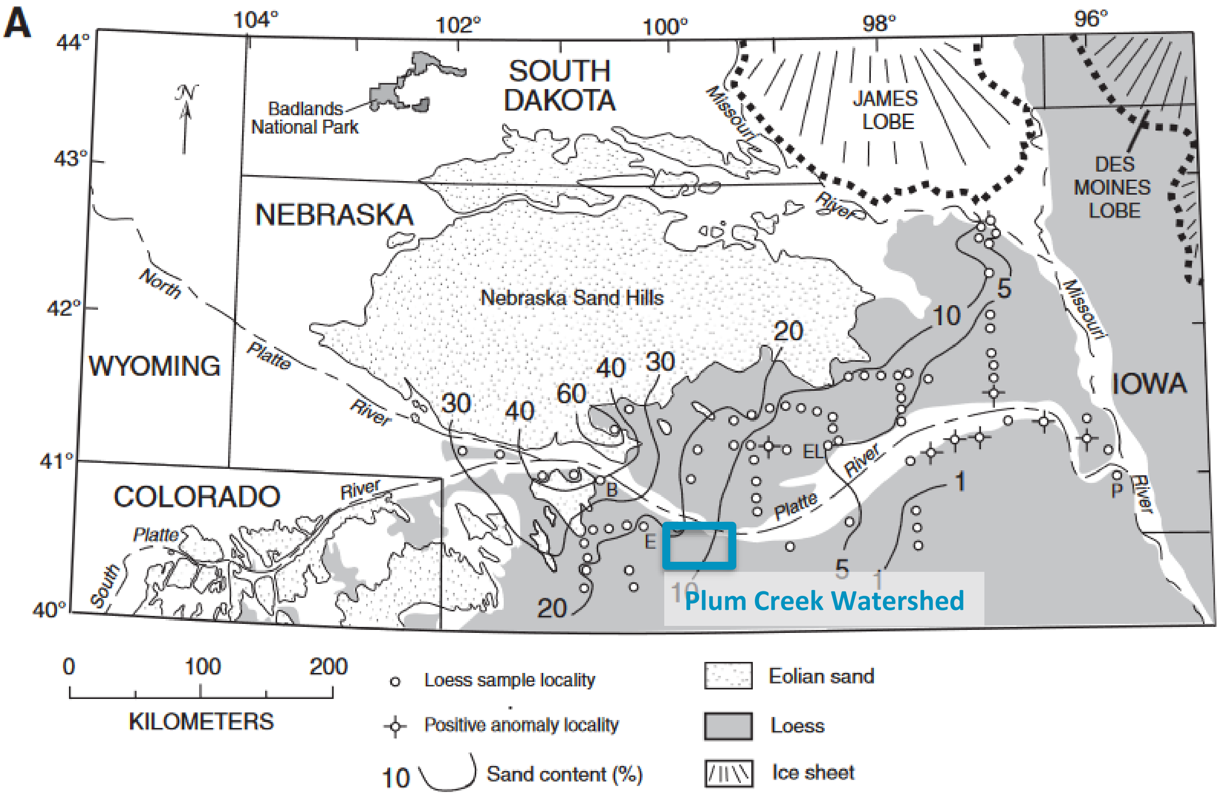


Figure 4: Loess deposits in Nebraska. Modified from Muhs et al. 2008.

Watershed Land Use

The Plum Creek watershed is nearly 100% agricultural, with the exception of the open water areas (reservoirs). The primary agricultural land use types are range (pasture and grasslands) and corn/soybean rotation (Figure 5).

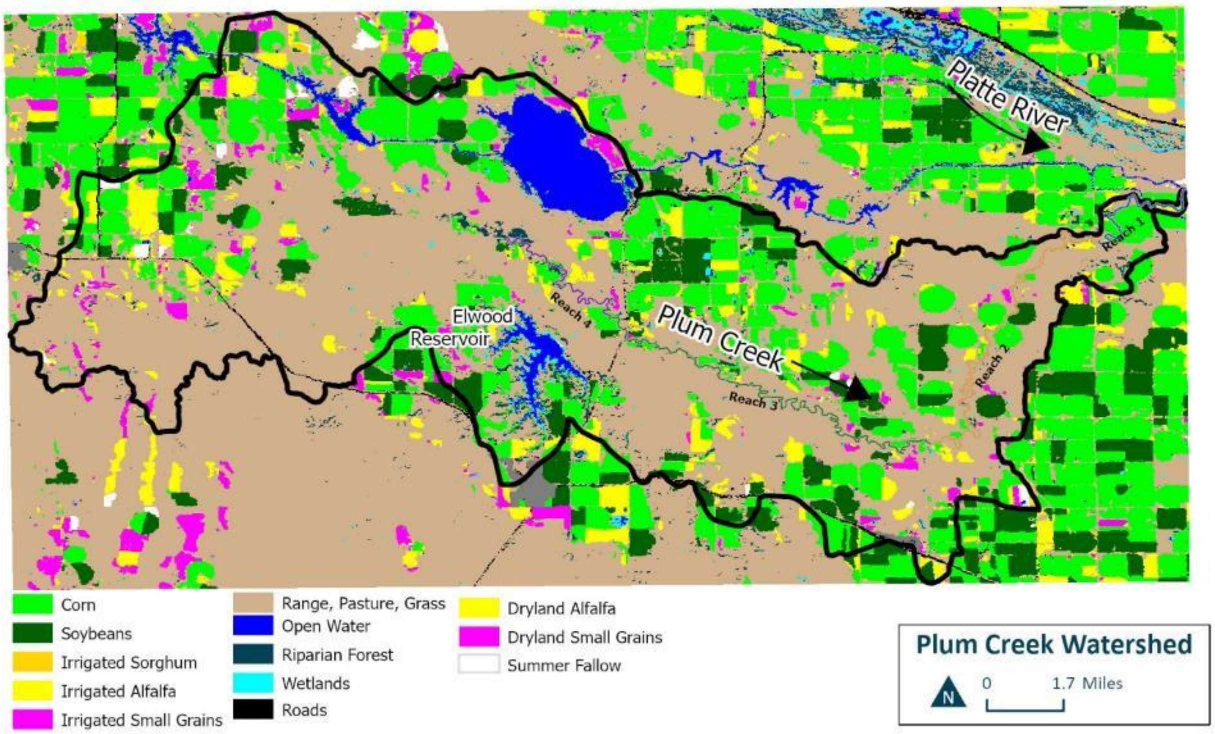


Figure 5: Map of land use within and surrounding the Plum Creek watershed.

GEOMORPHIC RECONNAISSANCE

Assessment reaches along the study area were identified for the geomorphic reconnaissance, primarily based on representative geomorphic characteristics and indicators and land access permissions. During the field assessment, topographic survey data were collected, and geomorphic features were assessed and documented. In addition, photographs of bridge crossings in the study area were collected. Assessed reaches are shown in (Figure 6). Forty-three topographic cross-sections were collected across these reaches, and ten public and two private crossings were documented.

The field geomorphic reconnaissance was undertaken from November 7th to 9th, 2023. Weather was sunny to partly cloudy, with temperatures varying between the low 40s to the high 60, and flows within Plum Creek were relatively constant, recorded as 10.8 to 10.9 cfs) at Gage 06767500 Plum Creek near Smithfield, NE, which is located at the intersection of Plum Creek and County Road 746. Field reconnaissance we performed over four representative reaches spread along the length stretching from Elwood Reservoir near River Mile 28 to the confluence of Plum Creek with the Platte River. The reaches assessed in the field cover 2.2 miles, or about 7.7% of the 28.4 miles of Plum Creek below Elwood Reservoir (see Table 2).

Area	Length (ft)	Length (miles)	% of Plum Creek
1	4,439	0.8	3.0%
2	1,545	0.3	1.0%
3	3,992	0.8	2.7%
4	1,603	0.3	1.1%
Other Reaches (not studied)	138,238	26.2	92.3%
Total Length of Plum Creek – Elwood to Platte River Confluence	149,817	28.4	100%

Table 2. Length of Plum Reaches, including Reaches 1, 2, 3 and 4.

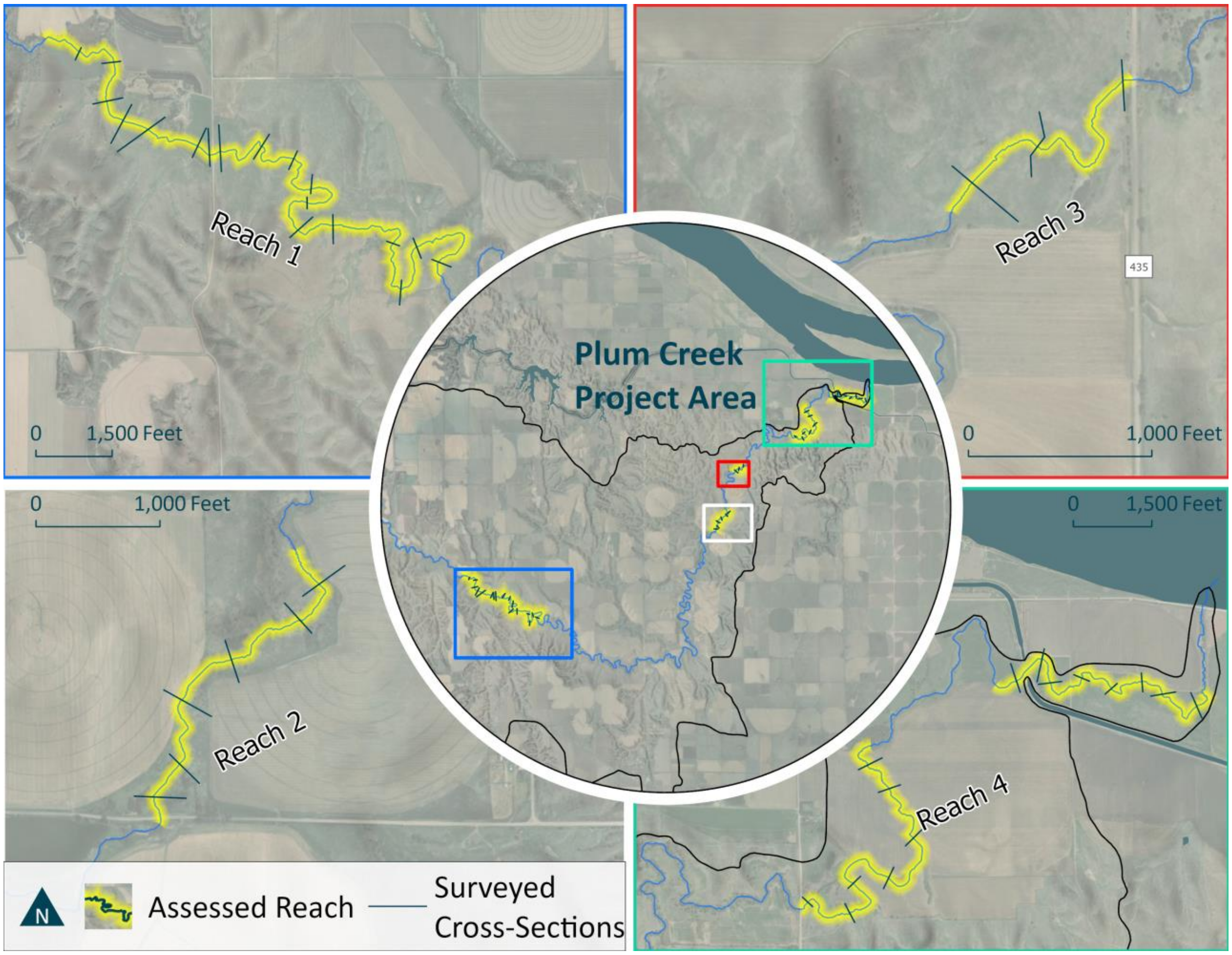


Figure 6: Overview map of the study area and inset maps showing cross sections surveyed. The reaches assessed are highlighted in yellow.

Geomorphology

Each of the assessed reaches can be characterized as having similar geomorphic characteristics. Plum Creek displays characteristics typical of stream systems in agricultural regions and their stream evolution trajectories. Agricultural watersheds typically experience increased magnitude, frequency, and flashiness of flows due to increased water runoff rates in agricultural landscapes. This altered hydrology impacts channel morphology by increasing channel incision, channel widening, and sediment transport capacity.

The removal of vegetation across agricultural landscapes can result in stream response including lateral adjustment (channel widening) and decreased sediment storage. This is due in part to the decreased recruitment of roughness elements such as woody debris, and the proliferation of invasive species with shallower root systems that provide less bank stability compared to native grasses and vegetation. On the other hand, well established populations of invasive species, such as reed canary grass, can stabilize banks and limit channel movement when compared to bare banks.

The channel morphology of today's Plum Creek is representative of the agricultural land use impacts described above. The channel is deeply incised with an incipient floodplain formed within much of the incised channel. Channel bed and banks were dominated by silt.

The morphology of the creek channel suggests incision in this system occurred in two-phases. In the first phase, the channel incised 10 to 15 feet before stabilizing. Tree establishment soon occurred near the waterline of the incised channel. During the second phase, the creek lowered by another 3- to- 5 feet. This second incision resulted in the present elevation of the channel (Figure 7). Since the second phase of incision, the creek has been undergoing a continuing lateral migration to form a new floodplain at the lower elevation, similar to the representation of Stage 5 of the channel evolution model (Cluer and Thorne, 2014; see Figure 2).

Due to the silt-dominated geology of the area, there is minimal material present competent to serve as a hydraulic grade control, capable of holding the creek at its present grade. Deeper incision is likely to continue and is a concern for future management, even without any changes to hydrology such as augmented flows delivered to Plum Creek from Elwood Reservoir.

Figure 7: Typical incised conditions observed along Plum Creek banks.

Vegetation

Vegetation within and adjacent to the channel was typically dominated by grasses. Large trees were present in wetter areas near the channel; however, these sections showed limited signs of natural rejuvenation (Figure 8). The effects of browsing in pastured areas likely contribute to the lack of natural riparian tree recruitment. Large trees were also commonly located above the incipient floodplain in a characteristic "pistol grip" shape, suggesting the trees began growing prior to incision, and then slumping ground shifted the tree, which later bent its growth to regain a more vertical form. Frequently observed tree species include cottonwood, elm, or walnut.

Figure 8: Typical cross-section observed on Plum Creek including minor erosion on left bank, floodplain bar formation at bottom of channel, and "pistol grip" tree. Picture taken downstream from County Road 430 crossing.

Crossing Assessment

A visual assessment of all publicly accessible stream crossings within the study area was completed (Figure 9) during the field investigation. Other crossings were documented through a desktop assessment. Photographic documentation of the conditions of each crossing is provided in Appendix A. In total, 12 were documented, 10 of which are public roads and two are private crossings. In addition, a desktop survey shows an additional eight private crossings that were not accessible. Seven of the eight inaccessible crossings appear to be culverts while the eighth is either a washed-out culvert or is a ford crossing located approximately 2,400 feet downstream of County Road 433. An irrigation canal siphon passes underneath Plum Creek approximately 1,500 feet upstream of the County Road 437 crossing but there is no crossing over Plum Creek at the siphon location.

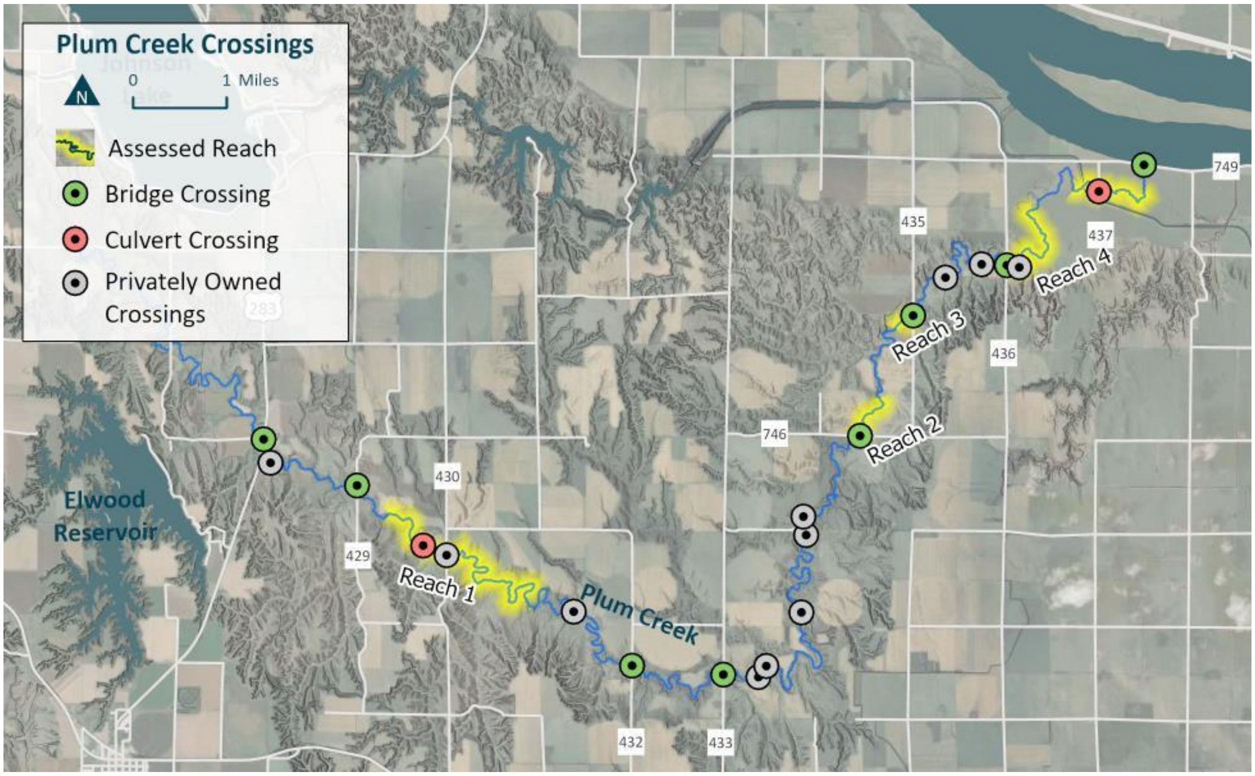


Figure 9: Crossing Overview map of Plum Creek.

Of those 12 crossings, eight were bridges with low-chords (bottom side of bridge) located 15 to 20 feet above the water level at the time of survey (Figure 10). The remaining four observed crossings were undersized culverted crossings (Figure 11), two of which are private crossings.

The culvert at County Road 430 was an 8-foot diameter corrugated metal pipe (CMP). There are two culverts at County Road 437; a 5-foot diameter CMP with a large pool at the downstream end set at the stream elevation and another 5-foot diameter CMP to provide additional capacity during flood flows. Two private culvert crossings were also observed and appeared to be undersized. The first is located upstream of County Road 430 and consists of an 8-foot diameter CMP without soil cover, which indicates that the crossing had been overtopped and is actively eroding. The second was a 5-foot arch culvert with a deep pool and evidence of scour downstream, near the Burks property crossing County Road 436.

Figure 10: Typical bridge crossing of Plum Creek. Picture from Country Road 435 Crossing.

Figure 11: Typical culvert crossing on Plum Creek.

Hydraulic Assessment

A HEC-RAS 1D, steady state model was developed using available LiDAR and the cross-section information collected by IFI in November 2023. No structures (bridges, culverts, etc.) were included in the model so results are only valid at sections where hydraulics are not impacted by proximity to bridges or culverts. These results should be considered as estimates appropriate for a reconnaissance level study to be used for screening purposes of channel capacity and areas of high velocity/hydraulic shear stress.

Flow rates and their associated return periods modeled in HEC-RAS are presented in Table 3. Flow magnitudes vary from somewhat greater than baseflow to large flood events. A frequency analysis performed by LRE Water identified the 5-, 10-, and 25-yr "excess" peak annual flow, which was defined as the peak flow minus baseflow. A year-round average baseflow of 12 cfs (also determined by LRE Water) was added to the excess peak flows. The return period for other flows was determined from the LRE Water flow frequency analysis.

Table 3. Flow rates and associated return periods modeled in HEC-RAS.

Return Period [1]	Flow (cfs)	Return Period [1]	Flow (cfs)
1.1-yr	25	2.6-yr	200
1.1-yr	30	3.9-yr	275
1.2-yr	35	5.3-yr	350
1.3-yr	40	6.1-yr	445
1.3-yr	45	10-yr	720
1.5-yr	50	25-yr	1,400
1.8-yr	100		

[1] Return periods are estimated based on hydrologic analysis performed by LRE Water.

During the field reconnaissance, IFI identified and surveyed Ordinary High Water (OHW) indicators. The HEC-RAS hydraulic model was used to determine the flow rate that resulted in water surface elevations that coincided with the OHW to help determine risk thresholds. Based on field and hydraulic modeling results, the OHW elevation corresponds to 50 cfs. It should be noted, however, that the OHW field indicators are variable, varying in elevation at a cross section and in relative elevation along the stream profile, so OHW-elevation-producing flow of 50 cfs was determined based on a qualitative best fit along the length of the stream profile.

Channel Capacity

Channel capacity was evaluated at all forty-two surveyed cross sections using the HEC-RAS hydraulic model. For each of the modeled flow rates a determination was made whether: (1) the flow was completely contained within the channel; (2) there was minor overbank flooding; or (3) there was significant overbank flooding and flow over the floodplain that could result in erosion or channel avulsion (channel cutoff). The top of the channel was defined as the location on the bank where there is a clear transition to the valley floor, as shown in Figure 13. Minor flooding was defined as inundation in areas whether there was off-channel storage or incoming drainageways that would provide storage but would not effectively convey flow down-valley. An example of this is depicted on the right side of Figure 12, which shows two drainageways entering the creek from the east. During low flows these areas will not be inundated, but at some threshold value they will become flooded by backwater and not likely to result in erosion. At greater flow rates, the water surface elevation will exceed bank height and will flow over the floodplain and convey the flood waters down-valley. These flows pose the greatest risk of channel avulsion or other excessive erosion that would likely require repair.

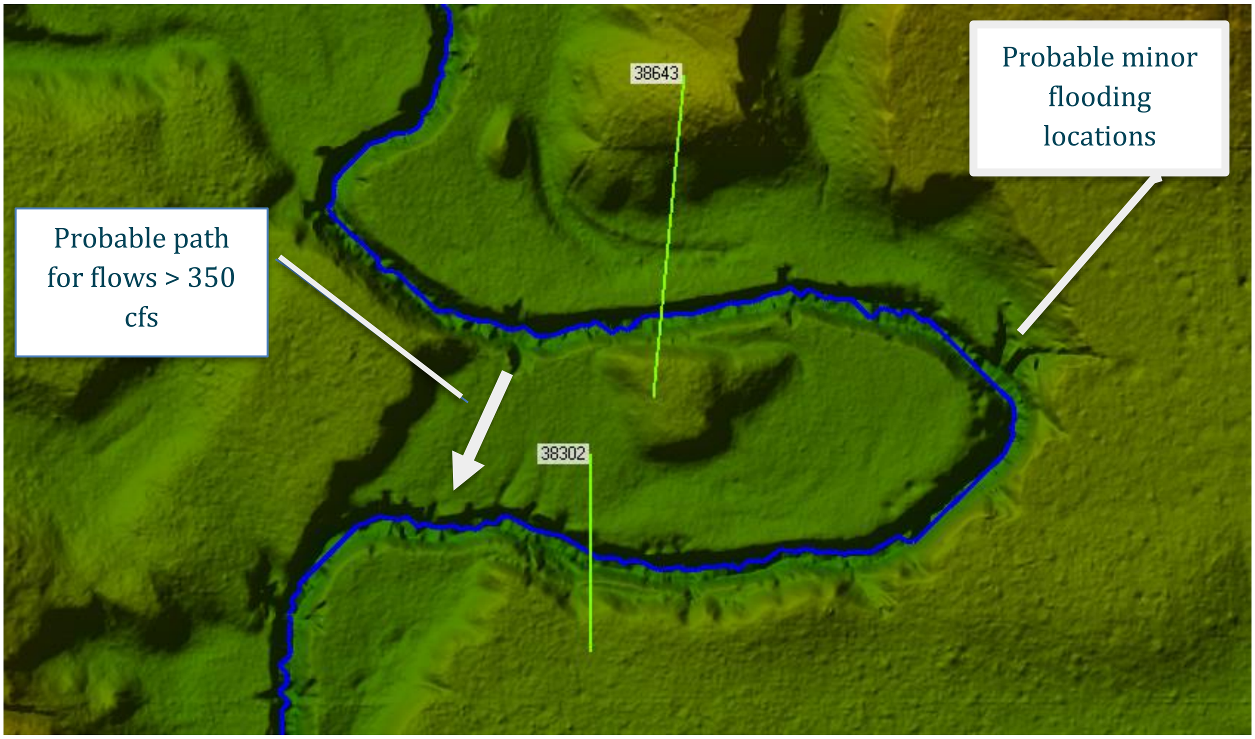


Figure 12. Plan view of Plum Creek and successive surveyed cross sections. Flow is from top to bottom of figure.

Table 4 provides an indication of channel capacity at different flow rates. For flow rates ranging from baseflow up to approximately 100 cfs the flow will be contained in the channel. For flow rates between about 100 cfs and 350 cfs the main channel will convey flow, but some off-channel areas, including abandoned channels that are connected to the creek, will become inundated. The risk of erosion and channel avulsion due to these flow rates will be discussed in subsequent sections.

Table 4. Channel capacity in Plum Creek for different flow rates.

Flow Rate (cfs)	Flow Contained in Main Channel	Minor Off-Channel or Backwater Flooding	Significant Overbank Flooding
25	X		
50	X		
100	X		
200		X	
275		X	
350		X	
445		X	X
720			X
1400			X

Locations like that depicted in Figure 12 represent areas where flood flows could cause excessive erosion or avulsion, significantly altering the planform of the channel. An example of this is shown for the uppermost reach surveyed. Model results for this reach show that the main channel will convey approximately 350 cfs; however, at greater flows the floodplain will be engaged by surface water and there is the possibility that floodplain erosion or potentially a channel avulsion could occur.

Channel Erosion Risk

Our understanding of the main channel condition is that channel bottom material comprises primarily silt material of loess origin with approximate critical velocity of 2 ft/s and critical shear of approximately 0.0475 lb/sf (Fischenich, 2001). Hanson and Simon (1991) showed in a study that included Nebraska, however, that there can be six orders of magnitude change in critical shear depending on cohesion, roots, exact material specification, moisture content, bulk density, etc. Those authors found that critical shear ranged from near zero (0.002 lb/sf) to as much as 1.4 lb/sf, with an average of about 0.06 lb/sf (for moderately resistant material). Their results are from field tests in Eastern Nebraska performed on loess soils.

Banks are vegetated with areas of trees and shrubs above the bankfull water elevation (Figure 13). This part of the stream bank is more resistant to erosion, with critical velocities of 4-6 ft/s as reported for areas with long native grasses, which hydraulically behave similarly to the reed canary grass present in Plum Creek. Channel depths exceeding the bankfull elevation, especially for prolonged periods, dramatically increase the risk of erosion and channel adjustment. Figure 13 also shows a typical example of the ordinary high-water elevation (OHW). The OHW is analogous to the channel-forming or bankfull elevation with an elevation produced by the 1 to 1.5 year return period flow rate, which in this case is between 25 and 50 cfs.

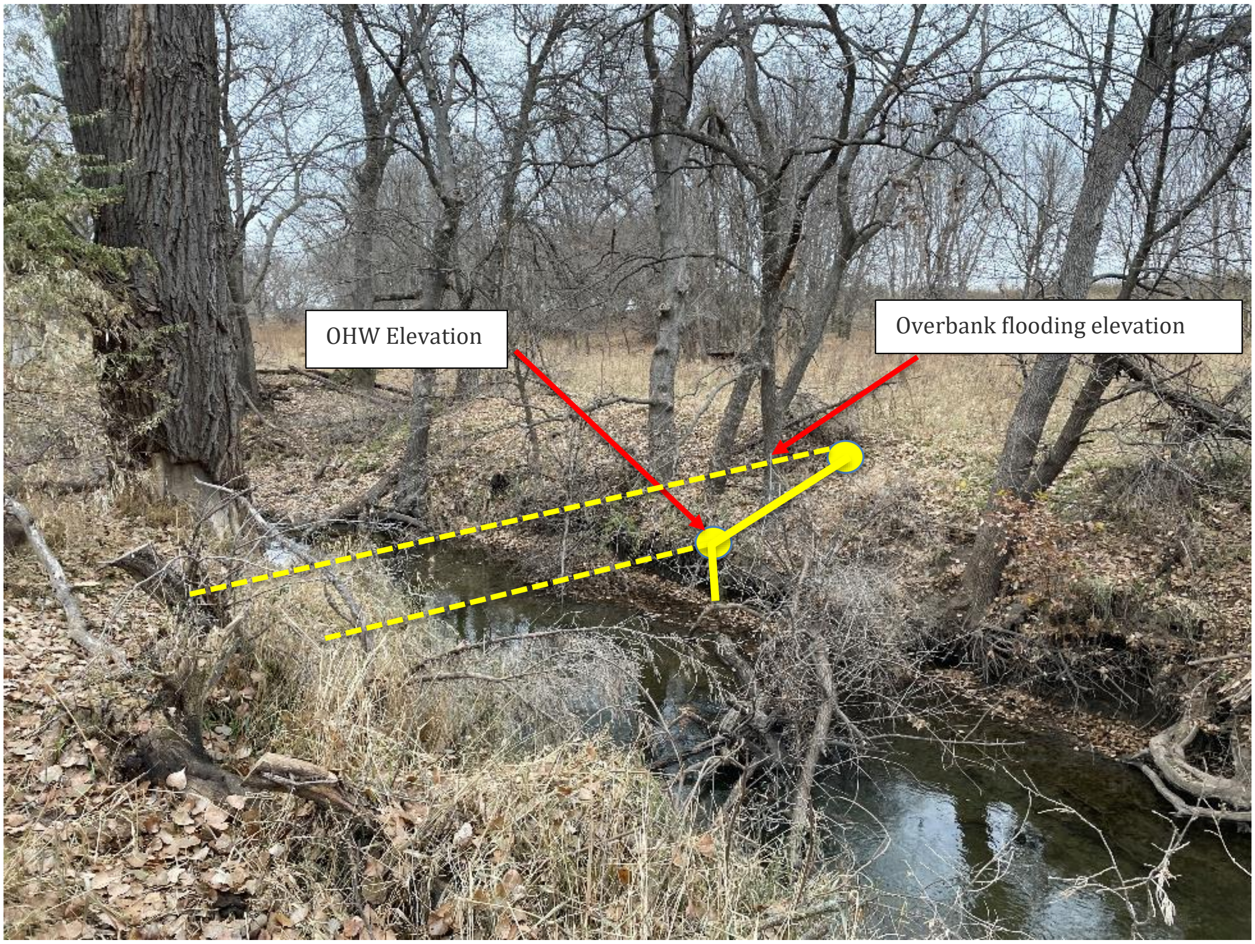


Figure 13. Depiction of channel locations showing points typical elevations of overbank flooding (channel capacity) and elevation above which there is an increased risk of erosion.

Simulated velocity and shear stress averages are presented in Table 5. The hydraulic model developed to help inform the reconnaissance level study is based on coarse underlying topographic data and consequently has some limitations that can be improved in future phases if appropriate. There were several cross sections where model geometry needs to be further evaluated because results at those sections did not appear to be consistent with other cross sections (e.g., excessively high velocity). Averaging the results over all 42 cross sections will help reduce the impact of specific cross sections.

Modeled velocities at 25 cfs, which includes 12 cfs baseflow, range from about 1.9-5.7 ft/s, which are greater than the published critical velocity of 2 ft/s. Channel velocities vary markedly at a cross section for a given flow rate and throughout the stream, so there are areas of the channel exhibiting greater or lesser velocity than the critical velocity. Moreover, the critical velocity itself varies due to changes in bed sediment particle size distribution and cohesion. Field observations conducted by IFI in fall 2023 during low flows of approximately 10 cfs indicated that the creek was stable under those flow conditions. Model results for the 50 cfs flow show that modeled depths corresponding with this flow rate correlate with the approximate ordinary high water (OHW) elevation observed in the field (see Figure 13 and Figure 14). The OHW elevation is typically associated with a transition in vegetation and soil conditions. In Plum Creek, the flow associated with the OHW elevation likely occurs multiple times each year and has an important influence on geomorphology and vegetation in the system. It is assumed that the OHW is correlated with the effective discharge, which is defined as the discharge or range of discharges that transports the largest proportion of annual suspended sediment over the long term and has been found to have a return period of about 1.5 years for many U.S. streams (Simon et al., 2004).

The 1.8-yr return period event of 100 cfs results in modeled velocities of in the range of 4 – 5 cfs, which likely mobilizes fine and coarse sediment in the creek. It's worth noting that in this system the size of coarse sediment is in the sand fraction. Flow greater than 200 cfs will likely result in flow velocities in excess of 6 ft/s, which will not only mobilize sediment but could result in erosion of banks that are not well vegetated, have bare soil near the base of trees, where there is incipient bank failure due to sloughing or even potentially vegetated banks. Flows greater than approximately 350 cfs will result in channel and floodplain velocities that could result in significant bed and bank erosion as well as erosion in floodplain areas.

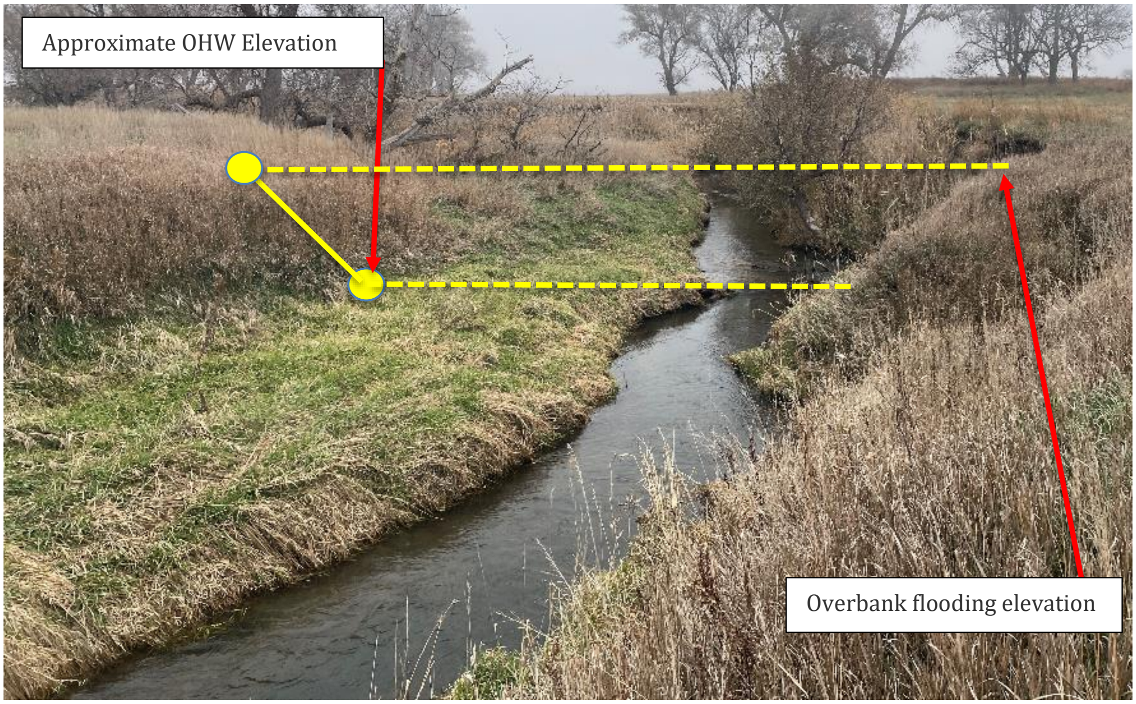


Figure 14. Representative cross section showing channel configuration where the bed is inset deeper into the surrounding floodplain, and a bar has formed and been colonized by reed canary grass. The OHW line corresponds to the transition from the bar to the bank.

Table 5. Averaged model results for velocity, and shear stress from all modeled cross sections over a range of flows, from 25 cfs up to 1,400 cfs.

Flow (cfs)	Return Interval	Average Velocity (ft/s)	Average Shear (lb/sf)
25	1.0-yr	3.1	0.26
30		3.3	0.28
35		3.4	0.3
40		3.6	0.32
45		3.7	0.33
50	1.5-yr	3.8	0.35
75		4.3	0.41
100		4.7	0.47
200		6	0.65
275		6.7	0.77
350		7.1	0.84
445		7.6	0.92
720	10-yr	8.6	1.15
1,400	25-yr	9.7	1.35

The preceding analysis indicates that total flow rates (baseflow + stormflow + release) less than 50 cfs are least likely to significantly impact channel geomorphology. To better define the risk of channel erosion and channel alteration, flow rates from 25 to 50 cfs, in 5 cfs increments, were simulated in the hydraulic model. Each of the 42 cross sections was categorized by whether the water surface elevation for a given flow rate exceeded one, both, or neither OHW elevations. For each of these categories, and for each flow rate, the percentage of sections in each category was then determined for all cross sections and then by assessed reach (Table 6). If the percentage of cross sections that exhibited water surface elevations exceeding the OHW elevation was greater than 50%, a high frequency was assigned, between 33 and 50% was assigned moderate frequency, and less than 33% was assigned low frequency. These categories are somewhat arbitrary but are linked to the risk of channel erosion. More frequent exposure to flow will result in greater erosion risk. The results for reaches 2 and 3 were combined because there were six and three cross sections in each reach, respectively. As Table 6 indicates, OHW elevations are wetted less frequently for a given flow rate in the most downstream reach. Overall, total flows of 30 cfs or less result in infrequent water surface elevation exceeding the estimated 50 cfs OHW so therefore are likely to present little risk of erosion or alteration of channel morphology. There is a moderate frequency of water surface elevations exceeding OHWs for the upper portion of the channel

(Reach 1 and Reaches 2 and 3) between 35 and 45 cfs. Flow rates of 50 cfs or greater were classified as high frequency in two of the reaches and frequency in the most downstream reach, though the overall frequency for the entire channel is moderate. Modeled water surface elevations change approximately 0.25 ft for every 5 cfs change in flow rate and OHW elevations surveyed in the field correspond with flow rates in the 25-50 cfs range. Because of the relatively narrow range of flows, the small changes in water surface elevations produced by the change in flows, the identification in the field of OHW elevations, and model uncertainty, these results should not be viewed as definitive, but rather should be viewed as reasonable estimates requiring refinement and validation.

Table 6. Percent of cross sections by reach where water surface elevation is greater than both OHW elevations.

	Flow Rate (cfs)						
	25	30	35	40	45	50	
Reach	Percent of Sections in reach where water surface exceeds OHW elevation on both sides of channel						Number of Sections
Reach 1	22%	22%	33%	39%	44%	56%	18
Reaches 2 and 3	11%	33%	67%	67%	67%	67%	9
Reach 4	0%	0%	13%	13%	13%	13%	15
All Reaches WSE > Both OHW Elevations	12%	17%	33%	36%	38%	43%	42

KEY	LOW FREQUENCY	MODERATE FREQUENCY	HIGH FREQUENCY

Infrastructure and Geomorphic Risk

An evaluation of infrastructure and geomorphic risk is summarized in Table 7. Bridges were found to be appropriately sized for potential flow augmentations, as they are sized to the 100-year event. The reconnaissance effort identified infrastructure at risk under both current and augmented flow conditions at all culverts evaluated through the field reconnaissance. Cost estimates for the replacement of observed, undersized culverts, are provided in the Recommendations section. In addition to culvert replacement, the culvert located on County Road 437 should be evaluated for use and whether removal without replacement may be the more appropriate option. It is recommended that the County Road 430 culvert crossing be replaced with a bridge. Crossings on private properties may be replaced by larger culverts, bridges, or ford crossings, depending on project financing.

Estimated baseflow in Plum Creek is approximately 12 cfs. During the field assessment performed by IFI (11/7/23 – 11/9/23) the flow rate averaged 10.9 cfs. Based on field observations and hydraulic modeling, the channel forming flow is approximately 50 cfs. If 50 cfs is met or exceeded consistently over time, there is a risk that the channel may respond to this new managed hydrology, such as through lateral or vertical adjustment of the banks and/or bed boundaries. Total flow rates of 25 cfs or less are not likely to cause significant geomorphic changes in Plum Creek and would result in minimal costs associated with channel repairs – considered low risk within the risk analysis framework presented for infrastructure, geomorphic and mitigation costs. A total flow rate of 50 cfs or less (augmented flow of 38 cfs) carries an increased risk of erosion (low-moderate) and is likely to result in relatively low-cost repairs. Flow rates of 50 cfs (augmented flows of 63 cfs) to 300 cfs carry a moderate risk of causing geomorphic changes and more frequent repairs, with more significant and costly repairs increasing with increasing flow rate.

The risk categories are illustrated in Table 7. Additional cross sections are depicted in Appendix A. In Figure 15 the approximate OHW level is shown, along with HEC-RAS-simulated water surface elevations. Flow rates greater than about 50 cfs will produce water surface elevations that access erosion-prone areas. At 50 cfs, the flow will just access the erosion prone area so some erosion could occur and, if it does, is likely to be localized, which falls under the low/moderate ‘L/M’ risk category. Flows between 75 cfs and 275 cfs will stay within the channel but will pose a greater erosion risk with increasing flow. There is will almost certainly be channel widening at the location shown in Figure 15 and there is a risk that bank erosion increases longitudinally along the length of the creek during sustained duration flows. However, as long as the flow is contained withing the channel, there is lower risk for channel avulsion or planform change, which has been assigned a moderate ‘M’ geomorphic risk. However, for greater flow rates (i.e., 350 cfs shown in Figure 15), water elevations will exceed bank height in many locations and could produce channel avulsions, as shown in Figure 12, which leads to the high ‘H’ geomorphic risk.

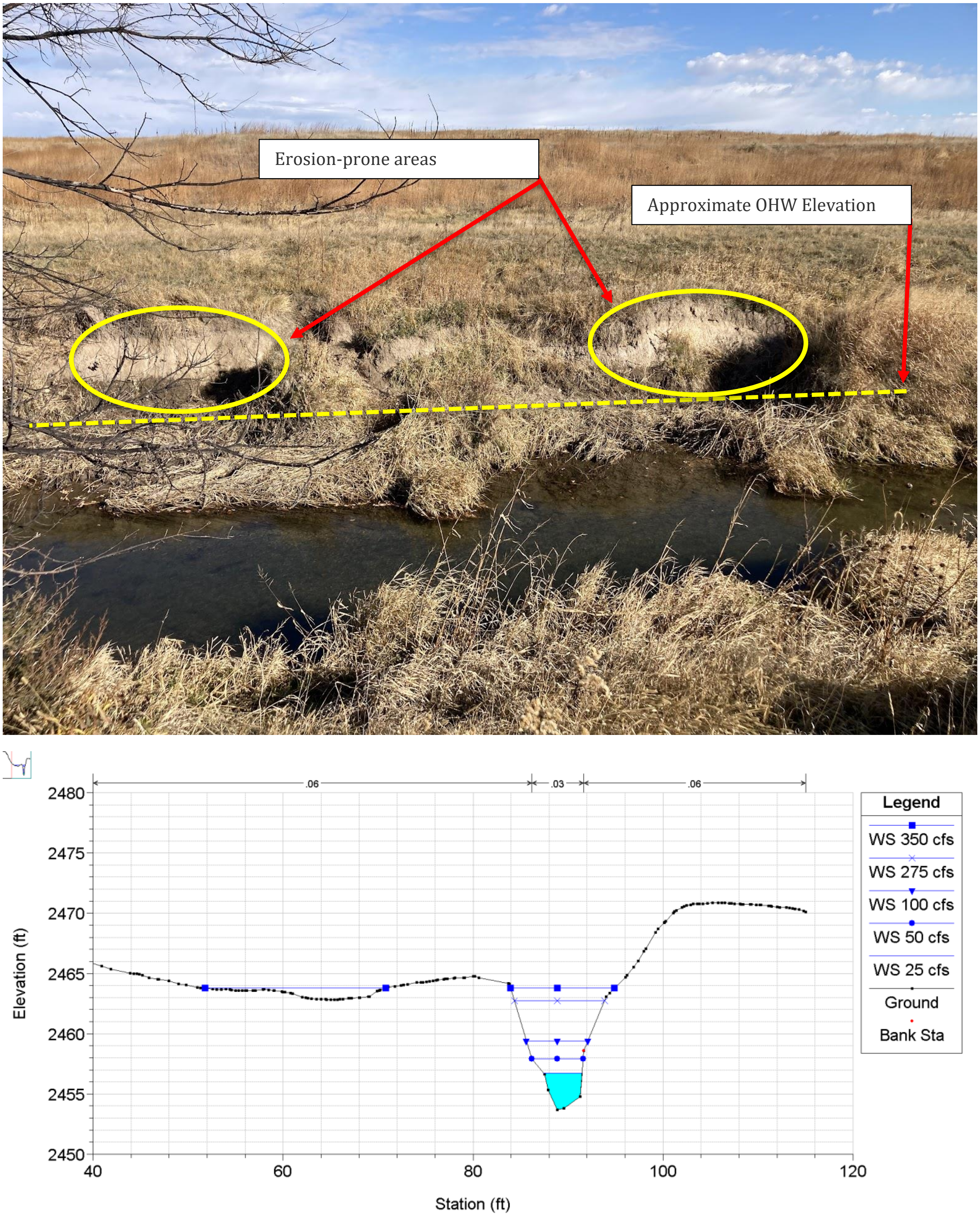


Figure 15. Picture of Plum Creek and corresponding HEC-RAS Section 383643. Additional cross sections from HEC-RAS are presented in Appendix A.

Table 7. Infrastructure, geomorphic, and cost risk. Risks are presented in categories ranging from low, low-moderate, moderate, and high. It is assumed that baseflow in Plum Creek is 12 cfs. *50 cfs and 100 cfs outlet capacity were not modeled and results presented here are based on the other discharges modelled.

Outlet Capacity (cfs)	Total Flow (cfs)	Return interval	Infrastructure Impacts	Geomorphic Impacts	Potential Mitigation Cost	Description of Potential Impacts
13	25	1.0-yr	L	L	L	Sustained releases could result in a small increase in erosion but minimal geomorphic risk and negligible infrastructure risk.
38	50	1.5-yr	L	L/M	L	Water surface elevations at approximate OHW elevation. Increased erosion risk at erosion prone areas (e.g., no vegetation or existing bank failures). Minimal repairs expected.
50*	62	-	L	L/M	L	
63	75	-	L	M	L	Flows greater than 50 cfs result in water surface elevations that increasingly inundate and subject erosion-prone areas to flow. Greater flow rates in this range increase both shear stress and velocity creating an increasing continuum of risk. Erosion is expected to be largely confined to the channel. Avulsion risk is low.
88	100	-	L	M	L	
100*	112	-	L	M	L	
188	200	-	L	M	L	
283	295	5-yr	M	M	M	Water surface elevations consistently at or near channel capacity. Overbank flooding in isolated locations increases both geomorphic and infrastructure risk, including risk of channel avulsion.
338	350	-	H	H	M	Water surface elevations consistently greater than bank elevations leading to probable geomorphic adjustments, producing conditions that could lead to channel avulsion. Erosion/geomorphic likely to occur at erosion prone areas and locations where flooding access previous channel bed or potential channel cut-off areas.
433	445	-	H	H	M	
708	720	10-yr	H	H	H	Consistent overbank flooding has high risk of erosion and channel avulsion that would impact property and could impact infrastructure, requiring costly repair.
1,388	1,400	25-yr	H	H	H	

To better understand the feasibility of releasing available water from Elwood into Plum Creek it is important to place future flow scenarios into context of magnitude, frequency, and duration of historical flow events based on the available record. For example, if the record shows that Plum Creek flows regularly exceed 35 cfs for a sustained period (weeks) then supplementing flow during low-flow periods (i.e., baseflow < 12 cfs for an extended period of time) for sustained length of time is not likely to result in substantial geomorphic changes. Flow data were analyzed for the 1981 – 2023 period to determine the number of days that flow exceeded a given value, the average length of time the flow remained at or above that value, the number, and the average number of days per year that flow rates exceed that value (Table 8). The average time of exceedance for these events is 2.1 to 2.6 days, indicating a relatively flashy system, hydrographs rise and fall over a relatively short time. The average number of days per year that flow exceeds the threshold values is also presented in Table 8, ranging from 1.8 days per year for 100 cfs to 11.0 days per year for 25 cfs. These data indicate that Plum Creek generally experiences few, short duration flows exceeding baseflow. Augmented flows should attempt to mimic the periodicity of the existing flow regime to whatever extent possible. Increasing the duration of releases or the frequency of sustained flows increases geomorphic risk.

Table 8. Frequency and persistence of flow rates ranging from 25 to 100 cfs for the 1981 – 2023 period[1].

Flow Rate (cfs)	Number of Days Exceeding	Number of Events Exceeding	Average Duration of Exceedance (days)	Average Time per Year Exceeding (days)	Average Number Events per year
25	464	180.0	2.6	11.0	4.3
30	320	132.0	2.4	7.6	3.1
35	258	98.0	2.6	6.1	2.3
40	225	90.0	2.5	5.4	2.1
45	195	82.0	2.4	4.6	2.0
50	177	76.0	2.3	4.2	1.8
75	100	46.0	2.2	2.4	1.1
100	75	35.0	2.1	1.8	0.8

The streamflow on a given day was also compared to the moving 10-day average (+/- 5 days), and if the streamflow was less than the moving average of 30 cfs, a release was assumed to be permitted. If these two conditions were met, a theoretical release of 30 cfs – total streamflow was calculated. This method was used to analyze potential direct release using daily streamflow data from 1981-2023. Using this

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[1] Note: there are 4 years with missing/incomplete data (1992-1995) which have been excluded from the data analysis period used (WY1981-WY2023). The flood frequency analysis performed only utilizes years with full observed records in calculating flood statistics.

method, a daily average of 17.5 cfs could be released. Results of this analysis for 2000 and 2001 are shown below in **Error! Reference source not found.**. In general, during periods of excess moisture (spring), both baseflow (indirect release) and flow rates are elevated. Opportunities for direct diversion are most prevalent in late summer and fall when flow augmentation in the Platte River would presumably be most beneficial. **Error! Reference source not found.** also shows several 'spikes' indicating r elatively large direct releases followed by very short period of no direct release, which are artifacts of the computational method. Further refinement of this method, for example, using a longer moving average, would smooth the calculated flow additions. This approach would permit the desired direct release total volume, would time releases during low-flow periods, and would likely maintain existing Plum Creek geomorphology, which could allow for greater, sustained releases during low-flow periods.

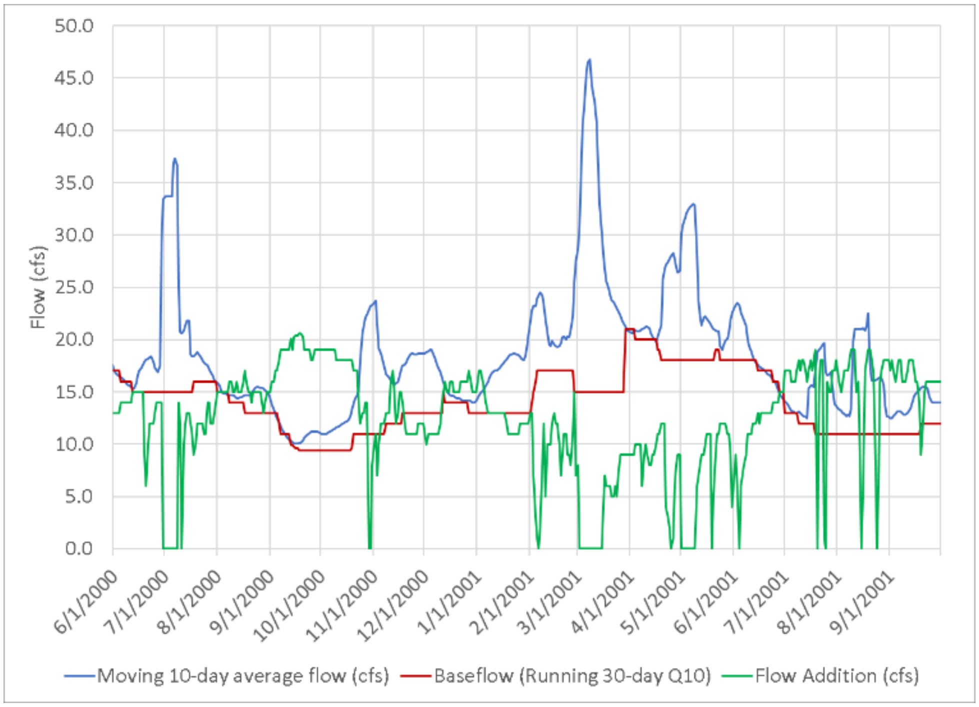

Figure 16. Hydrographs showing 10-day moving average flow rate, baseflow estimated by LRE Water, and potential direct flow diversion.

RECOMMENDATIONS

Flow Enhancements

The objective of the recapture program is to evaluate the feasibility of using a portion of excess flow diversions to provide direct deficit reduction to the Platte River via a new gravity outlet to Plum Creek from Elwood Reservoir during periods of shortage. Release rates and volumes will vary year to year based on target flow deficits. Table 9 below shows the range of flows assuming a constant release rate for up to 13,500 AF showing the anticipated range of flows in Plum Creek will result in low to moderate geomorphic risk. Table 9 also shows that higher flows for shorter durations have a higher geomorphic risk than lower flows for longer durations.

Table 9: Risk relative to target release volumes over time.

Target Release (AF)	cfs	Days With Constant Release						
		50	75	100	150	200	250	300
13,500	Release	136.1	90.7	68.1	45.4	34.0	27.2	22.7
	Total	148.1	102.7	80.1	57.4	46.0	39.2	34.7
12,000	Release	121.0	80.7	60.5	40.3	30.2	24.2	20.2
	Total	133.0	92.7	72.5	52.3	42.2	36.2	32.2
10,000	Release	100.8	67.2	50.4	33.6	25.2	20.2	16.8
	Total	112.8	79.2	62.4	45.6	37.2	32.2	28.8
8,000	Release	80.7	53.8	40.3	26.9	20.2	16.1	13.4
	Total	92.7	65.8	52.3	38.9	32.2	28.1	25.4
6,000	Release	60.5	40.3	30.2	20.2	15.1	12.1	10.1
	Total	72.5	52.3	42.2	32.2	27.1	24.1	22.1
4,000	Release	40.3	26.9	20.2	13.4	10.1	8.1	6.7
	Total	52.3	38.9	32.2	25.4	22.1	20.1	18.7
2,000	Release	20.2	13.4	10.1	6.7	5.0	4.0	3.4
	Total	32.2	25.4	22.1	18.7	17.0	16.0	15.4
1,000	Release	10.1	6.7	5.0	3.4	2.5	2.0	1.7
	Total	22.1	18.7	17.0	15.4	14.5	14.0	13.7
500	Release	5.0	3.4	2.5	1.7	1.3	1.0	0.8
	Total	17.0	15.4	14.5	13.7	13.3	13.0	12.8

Moderate Risk ↕ Low Risk

Moderate Risk ↔ Low Risk

* Totals include an assumed 12 cfs of baseflow.

Under a scenario of increased supplemental flows, the risk of geomorphic change and infrastructure risk increases. Flow augmentation of 50 cfs is unlikely to pose significant geomorphic risk. In order to mitigate this risk, direct flow diversions should be managed in accordance with real-time flow data within Plum Creek. Real-time flow or stage data will allow release managers to ensure that the amount of flow enhancements together with existing flow in Plum Creek do not exceed a combined 50 cfs. Considerations of seasonal hydrograph trends and predicted precipitation events will be necessary for appropriate release planning.

Flows of 75 cfs or greater, which includes one of the Program's proposed Elwood releases of 100 cfs, will pose a heightened geomorphic risk due to increased shear stress along the outside of banks and will likely result in flow velocities in excess of 6 ft/s, which will not only mobilize sediment but could result in erosion of vegetated banks. Flow rates greater than 75 cfs will result in water surface elevations greater than the ordinary high water level (OHW), which will cause increasing erosion within the channel (both lateral bank migration as well as longitudinal extent of erosion). Overbank flooding due to flows greater than about 350 cfs dramatically increases the risk of channel avulsion and potential change of stream planform.

Adaptive Management

Developing a strategic monitoring and adaptive management framework will be required with any flow augmentation efforts. As a baseline for adaptive management actions, an ongoing monitoring and assessment program is recommended. Annual geomorphic and vegetation assessments are recommended, as well as additional assessments after major storm events on an as-needed basis to track the geomorphic response of the system and identify potential maintenance needs. Ongoing assessments should monitor for geomorphic change indicators, such as eroding banks and channel avulsions. Baseline data from ongoing assessments will be important to evaluate the impacts of flow augmentation on the stability and overall geomorphology of the channel. It is recommended that the PRRIP plan for approximately $25k per year for annual for geomorphic and vegetation monitoring. Post-storm event monitoring may be desired by the program in addition to the annual monitoring for infrequent, large magnitude events.

Additional bank restoration efforts may be required to address excessive erosion or high-risk areas. Bank restoration may include native revegetation efforts, bioengineered bank solutions, and hard armoring techniques. Selective cattle exclusion may be worth considering at especially high-risk areas to reduce pressure on banks and increase re-vegetation success. The intention of selective cattle fencing would be to exclude cattle only from select high-risk banks, while still providing them access to creek water in the surrounding areas.

PLANNING LEVEL COST ESTIMATES

Planning level cost estimates for culvert infrastructure upgrades and bank restoration actions were developed to assist the PRRIP plan for strategic investments and maintenance activity. Individual estimates for crossings identified through desktop analysis were not included; however, the private crossing estimates provided in Table 10 can be used for concept-level budgeting purposes. Cost estimates were developed using 2023 data and escalated by 5% to 2024 dollars. Cost estimates developed in this reconnaissance level study are intended to help with project planning. However, it is anticipated that site specific cost estimates will be needed for individual culvert or bank repair actions to increase accuracy. Culvert replacement cost estimates were developed using the assumption that flow capacity at public road crossings would need to be approximately double their current capacity. Existing round corrugated metal culverts were assumed to be replaced with arched corrugated metal pipe to provide additional conveyance capacity while minimizing vertical requirements. State or local highway design requirements were not considered and would need to be integrated into future phases of the project. Unit cost approximations were derived from the State of Nebraska summary of bid tabulations, other sources available that were viewed as having reasonable unit costs, and experience with cost estimation of similar construction activity. Quantity takeoffs were performed using Google Earth for linear and aerial extents and assumed thicknesses where necessary. Cost estimates include mobilization, demolition and disposal, roadway excavation and repair, erosion control, and upstream and downstream riprap protection.

Table 10. Planning level culvert replacement cost for existing culverts presented in 2024 dollars.

Item	Replacement Cost
Replace 60" Culvert under gravel road 437 with 112x75 CMP Pipe Arch	$96,000
Replace existing private crossing with 60" CMP	$31,000
Replace 96" Culvert under gravel road 430 with 117x79 CMP Pipe Arch	$87,000
Replace existing private crossing with 60" CMP	$31,000
TOTAL	$245,000

Instead of replacing the culverts on private property with culverts, a hardened riprap crossing could be constructed. The probable cost for a single riprap crossing is approximately $17,000.

After direct releases are implemented, a period of adaptive management will be required to determine if there are changes to Plum Creek that require bank restoration or repair. Opinions of costs per linear foot are presented in Table 11 for minor and major bank repairs. Minor repairs are considered those that are limited to banks or near banks, are limited to a maximum depth of erosion of 1.5 feet, and require minor earthwork, erosion control blanket, and seeding. Major repairs are assumed to occur on the bank and into the adjacent floodplain, requiring more extensive earthwork, and include a bioengineered bank restoration treatment like Fabric Encapsulated Lifts (FES) or possibly bank armoring using rock.

Table 11. Planning level cost estimates for minor and major bank restoration activity presented in cost / linear foot in 2024 dollars.

Item	Cost per linear foot ($/LF)
Minor bank restoration	$190
Major bank restoration	$540

Cost Estimates Organized by Risk Level

Planning-level costs were estimated for each infrastructure and geomorphic risk category, presented in Table 12 for Reaches 1-4 only. For each risk category a description of the likely level of mitigation effort over a five-year period is presented along with anticipated mitigation cost over a five-year period. Risk category-specific estimates were developed for the assessed reaches (1-4) and utilized to develop costs per mile in an effort to estimate costs over the 28 miles of Plum Creek.

Low infrastructure and geomorphic risk, consistent with current or slightly increased erosion, is likely to result in little or relatively minor bank restoration efforts and mitigation costs. Mitigation associated with low/moderate geomorphic risk category is estimated between $50k and $250k in Reaches 1-4 over a 5-year period resulting from fairly localized bank erosion events that occur at locations along the creek that are already prone to erosion requiring both minor and major bank restoration efforts.

Flow rates between 75 cfs and 275 cfs will largely be contained within the channel but will be greater than the OHW elevation, with an assigned moderate ‘M’ risk. Flows in this range could cause already downed trees and branches to clog culverts, could cause erosion around some tree roots, causing them to fall into the channel, and, particularly at the upper end of this range, cause erosion around culvert headwalls. Increasing the duration of the release time will increase the risk of erosion. From a geomorphic perspective, flows in this range will access areas on the channel bank that are prone to erosion, causing increased erosion, with erosion increasing with increasing flow rates requiring major bank restoration efforts (requiring bioengineering bank restoration treatment or armored protection). Sustained flows over time in this range could drown vegetation, further exacerbating erosion. Localized erosion areas would likely become greater both in terms of width and longitudinal extent with increasing flows and duration of flow. Mitigation costs in Reaches 1-4 over the first 5-year period are estimated to range from $250k to $1 million. Cost estimates for anticipated mitigation beyond the initial 5-years were not estimated.

Flows of 350 cfs and greater that results in water surface elevation exceeding bank elevations are considered high risk flows, resulting in potential culverts being overtopped and culvert failure and potential significant erosion that threatens infrastructure along the creek (e.g., roads, bridges, other utilities). From a geomorphic perspective, channel avulsion and bank erosion on the order of several feet at various locations is anticipated. Mitigation costs for this category are likely to exceed $1 million over a five-year period for Reaches 1-4. Mitigation costs do not include any work on existing bridges, which are expected to be analyzed in a future phase. It’s assumed that some culverts would need to be upgraded before any releases are done. Mitigation cost estimates were developed in more detail for 50 cfs and 100 cfs flow augmentation scenarios, and presented in Tables Table 13-Table 16.

Table 12. Planning-level Plum Creek mitigation costs for infrastructure and geomorphic risk categories, not including culverts, crossings and bridge replacement or retrofit.

Risk Level	**Infrastructure**	**Geomorphic**	**Reaches 1-4 Plum Creek Mitigation Cost (over 5 years)**	**28 Mile Plum Creek Mitigation Cost (over 5 years)**
Low (L)	Baseline risk to crossings, roads, other infrastructure	Baseline vertical/lateral adjustment / processes	$0-$100K	$0-$1.3M
L/M	N/A	Increased erosion – lateral/vertical adjustment	$50-$K	$646K-$3.25M
M	Culverts plugged, erosion around headwalls – changes that require eventual maintenance/repair	Ongoing lateral adjustment requiring eventual maintenance / restoration effort, drowning out vegetation	$250K – $1M	$3.25M – $12.9
H	Culverts/crossings overtopped, piping, failure – requiring more immediate maintenance/repair, lateral adjustments threatening infrastructure such as roads, utilities, irrigation (pumps, water conveyance ditches/siphons), private structures	Channel response including avulsion(s), several feet of bank lost	**>$1M**	>$12.9

ESTIMATION OF IMPACTS AND MITIGATION COSTS: 50 CFS AND 100 CFS FLOW AUGMENTATION SCENARIOS

The following section explores the likely impacts (extent and location/reach), mitigation actions, and costs associated with 50 cfs and 100 cfs flow augmentation scenarios. Estimates developed for Reaches 1-4 were used to extrapolate costs to the whole 28-mile section of Plum Creek that flows from the area adjacent to Elwood Reservoir to the Platte River confluence. Tables Table 13-Table 16 present "lower range" and "upper range" costs for the 50 cfs and 100 cfs scenarios. Additionally, a 30% contingency was applied to the cost estimates. Locations of impacts were estimated based on Inter-Fluve's field evaluation of Plum Creek where bank erosion, bank undercutting, channel bank condition, and channel substrate were observed. Reconnaissance level estimates of locations and extent of erosion presented below are intended to help with decision making by the PRRIP in advancing the project through critical decision points and evaluations. Estimates should be considered as preliminary, supported by information gathered during this reconnaissance study phase, and field observations collected in Reaches 1-4, which represents less than 10% of the 28 miles. Estimates presented have not been informed by detailed characterization of bank and bed surface / subsurface materials, or bank erosion analytical framework that could be pursued in future phases of this project.

Based on field observations, Reach 1 exhibited the most bank erosion and undercutting. Reach 4 exhibited erosion-prone areas on the inside (bank side) of phragmites stands of vegetation. Reach 2/3 exhibited the fewest examples of bank erosion and undercutting. It is assumed that the stream crossing and culvert upgrades would be need to constructed before operations begin for 50 cfs or 100 cfs scenarios. The estimated cost for the culvert upgrades could change in the future following the detailed analysis that would be needed to develop site specific designs and associated construction cost estimates. Furthermore, it is possible that in the future, additional culverts or private crossings could be identified in the reaches not assessed as a part of this reconnaissance level effort. Furthermore, it is assumed that existing bridges do not require retrofit or upgrades to accommodate future flow augmentation.

50 cfs Flow Augmentation Scenario

As described previously, flow augmentation of 50 cfs is not likely to pose a significant geomorphic risk. Impacts of the 50 cfs scenario likely include only minor bank erosion in Reach 1 with more limited erosion extents anticipated in downstream reaches. The previous section defines minor and major bank repairs. Cost estimates for the lower and upper range of mitigation efforts associated with the 50 cfs scenario are presented in Table 133Table 144.

100 cfs Flow Augmentation Scenario

Flow augmentation of 100 cfs is likely to result in minor and major bank repairs. Major bank repairs are likely to occur when the OHWL is exceeded and areas of existing erosion, unvegetated areas, or already existing undercut areas are subject to elevated flow rates and shear stress. In the downstream-most reach (Reach 4), there are areas of sandier bed and bank material. During the November 2023 field visit it was observed that bed and banks contained more sand and gravel than upstream reaches and there were several areas exhibiting evidence of ongoing erosional processes which were located on the inside (bank side) of phragmites stands. During longer, sustained high-flow events (greater than the OHWL), exposed non-cohesive material in this lower reach are likely to be eroded. Cost estimates for the lower and upper range of mitigation efforts associated with the 100 cfs scenario are presented in Table 15Table 14.

Table 13. Estimated lower range mitigation costs for the 28 miles of Plum Creek associated with the 50 cfs release scenario.

Impact	**Extent/Location**	**Estimated Impact** (in Reaches 1-4 over 5 yrs)	**Mitigation**	**Reach 1-4 Cost**	**Estimated Cost /Mile**	**Total Cost** (28.4 Miles)
Minor Bank Erosion	Reach 1 Reach 2/3 Reach 4	0 linear feet 0 linear feet 0 linear feet	Minor bank shaping, revegetation, erosion control	$0	$0	$0
Major Bank Erosion	All reaches	No estimated impacts	Bank Grading, fabric encapsulated lifts, or armor	$0	$0	$0
Excessive Channel Scour	All reaches	Minimal	Unlikely to require mitigation	$0	$0	$0
			Total Plum Creek Mitigation Costs	**$0**	**$0**	**$0**
Infrastructure	All reaches	4 existing culverts need to be replaced to accommodate flows	New Culverts			$245,000
Stream Crossings	12 private steam crossings	Inundation to private stream crossings	New Riprap Crossings			$204,000
			Total Infrastructure Costs			**$449,000**
			Total			**$449,000**
			Contingency (30%)			**$134,700**
			Total (w/ contingency)			**$583,700**

Table 14. Estimated Upper Range Mitigation costs for the 28 miles of Plum Creek associated with the 50 cfs release scenario.

Impact	**Extent/Location**	**Estimated Impact** (in Reaches 1-4 over 5 yrs)	**Mitigation**	**Reach 1-4 Cost**	**Estimated Cost /Mile**	**Total Cost** (28.4 Miles)
Minor Bank Erosion	Reach 1 Reach 2/3 Reach 4	200 linear feet 100 linear feet 100 linear feet	Minor bank shaping, revegetation, erosion control	$95,000	$43,379	$1,230,662
Major Bank Erosion	All reaches	No estimated impacts	Bank Grading, fabric encapsulated lifts, or armor	$0	$0	$0
Excessive Channel Scour	All reaches	Minimal	Unlikely to require mitigation	$0	$0	$0
			Total Plum Creek Mitigation Costs	**$95,000**	**$43,379**	**$1,230,662**
Infrastructure	All reaches	4 existing culverts need to be replaced to accommodate flows	New Culverts			$245,000
Stream Crossings	12 private steam crossings	Inundation to private stream crossings	New Riprap Crossings			$204,000
			Total Infrastructure Costs			**$449,000**
			Total			**$1,679,662**
			Contingency (30%)			**$503,899**
			Total (w/ contingency)			**$2,183,561**

Table 15. Estimated lower range mitigation costs for the 28 miles of Plum Creek associated with the 100 cfs release scenario.

Impact	**Extent/Location**	**Estimated Impact** (in Reaches 1-4 over 5 yrs)	**Mitigation**	**Reach 1-4 Cost**	**Estimated Cost /Mile**	**Total Cost** (28.4 Miles)
Minor Bank Erosion	Reach 1 Reach 2/3 Reach 4	200 linear feet 100 linear feet 100 linear feet	Minor bank shaping, revegetation, erosion control	$75,000	$34,247	$971,575
Major Bank Erosion	All reaches	No estimated impacts	Bank Grading, fabric encapsulated lifts, or armor	$0	$0	$0
Excessive Channel Scour	All reaches	Minor localized scour addressed in major bank erosion repair	Addressed by major bank erosion repair	$0	$0	$0
Total Plum Creek Mitigation Costs				**$75,000**	**$34,247**	**$971,575**
Infrastructure	All reaches	4 existing culverts need to be replaced to accommodate flows	New Culverts			$245,000
Stream Crossings	12 private steam crossings	Inundation to private stream crossings	New Riprap Crossings			$204,000
Total Infrastructure Costs						**$449,000**
Total						**$1,420,575**
Contingency (30%)						**$426,173**
Total (w/ contingency)						**$1,846,748**

Table 16. Estimated upper range mitigation costs for the 28 miles of Plum Creek associated with the 100 cfs release scenario.

Impact	**Extent/Location**	**Estimated Impact** (in Reaches 1-4 over 5 yrs)	**Mitigation**	**Reach 1-4 Cost**	**Estimated Cost /Mile**	**Total Cost** (28.4 Miles)
Minor Bank Erosion	Reach 1 Reach 2/3 Reach 4	1200 linear feet 200 linear feet 500 linear feet	Minor bank shaping, revegetation, erosion control	$360,000	$164,384	$4,663,562
Major Bank Erosion	Reach 1 Reach 2/3 Reach 4	200 linear feet 100 linear feet 100 linear feet	Bank Grading, fabric encapsulated lifts, or armor	$220,000	$100,457	$2,849,954
Excessive Channel Scour	All reaches	Minor localized scour addressed in major bank erosion repair	Addressed by major bank erosion repair	$0	$0	$0
			Total Plum Creek Mitigation Costs	**$580,000**	**$264,840**	**$7,513,516**
Infrastructure	All reaches	4 existing culverts need to be replaced to accommodate flows	New Culverts			$245,000
Stream Crossings	12 private steam crossings	Inundation to private stream crossings	New Riprap Crossings			$204,000
			Total Infrastructure Costs			**$449,000**
			Total			**$7,962,516**
			Contingency (30%)			**$2,388,755**
			Total (w/ contingency)			**$10,351,271**

NEXT STEPS

If the PRRIP advances this project into a more detailed planning phase, some additional field data collection and analysis are recommended to better understand channel capacity, vertical and lateral channel stability before implementation of a flow release plan. Additional efforts including, but not limited to the following should be considered:

1. **Topographic Data:** Acquire additional topographic data from ground survey or mobilizing a LiDAR flight. A LiDAR flight conducted before leaf-out with minimum flow and snow or ice presence on the landscape would be very useful for future phases. For the ground-based survey, it is advised that additional topographic surveys along Plum Creek be collected to characterize cross sectional and longitudinal elevations in areas that were not surveyed during the reconnaissance level study.
2. **As-Builts:** Obtain as-built information on bridges and culverts to determine their capability to convey flow. If as-built information is not available, then these structures will need to be surveyed.
3. **Sediment & Erosion:** Bed and bank sediment and erosion study. Field characterization of bed and bank sediment to fit into analysis framework developed to better predict vertical and lateral channel adjustments to flow supplementation program scenarios. Better correlate OHW observations and hydraulic modeling results to improve understanding of cross section and reach-based variations of effective discharge throughout the system.
4. **Detailed Hydraulic Modeling:** The hydraulic model built for the reconnaissance level study can be improved upon to inform the more detailed future phases of the project. Using the additional survey and as-built information, refine the HEC-RAS model to include all crossings and additional cross-sections to better understand hydraulics and flow conveyance along the entire length of Plum Creek below Elwood Reservoir. Refining the HEC-RAS model to include additional cross sections, culvert and bridge information, accurately noting channel roughness along the length of the stream, calibrating the model to know water surface elevation/flow rate data, and surveying locations of bankfull elevation to provide more accurate model results with less uncertainty. Opportunistic collection of water surface elevations over different points in the annual hydrograph would assist in calibrating the hydraulic model.
5. **Cost Refinement:** The cost estimates provided should be modified after completion of a more detailed evaluation of the entire focus reach starting at the culvert under Highway 283 to the Platte River confluence. The additional assessment would provide the PRRIP higher confidence in the capabilities and constraints of Plum Creek to convey target flows and potential risk. Prior to advancing to a design phase, the linear distance of vulnerable streambanks and specific locations of agricultural crossing should be field verified prior to proceeding with mitigation actions.

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ATTACHMENT B

Stream Flow Observations

(RJH - July 4, 2024)

MEMORANDUM

Project 23138

TO: **Tom MacDougall, P.E. – RJH Consultants, Inc.**

FROM: **Matt Kull – RJH Consultants, Inc.**

DATE: **July 04, 2024**

RE: **Elwood Recapture Reconnaissance Study**
Plum Creek Streambed Field Visit Summary

This memorandum presents a summary of observations made during a July 04, 2024 visit to Plum Creek near Elwood, Nebraska for the Elwood Recapture Reconnaissance Study performed by RJH Consultants, Inc. (RJH). This memorandum is a summary of the observations made during the inspection and is not intended to be a verbatim account of what transpired.

Background

The field visit was performed by Matt Kull (RJH) on July 4th from approximately 09:30 to 11:30. Observations were made from bridges and culverts along Plum Creek near Elwood Reservoir. A summary of observations made during the inspection is provided below.

Observations

Observations were made and photographs were taken at the following bridges and culverts along Plum Creek:

- State Highway 283 Bridge.
- County Road 429 Bridge.
- County Road 430 Culvert.
- County Road 432 Bridge.
- County Road 433 Bridge.
- County Road 746 Bridge.

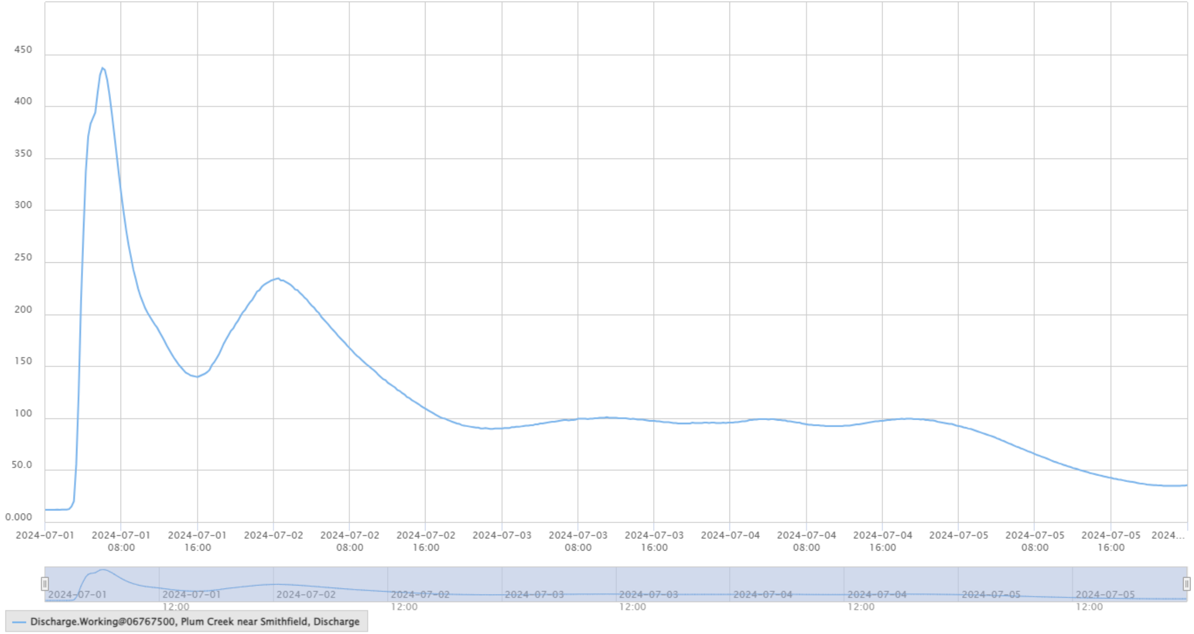
Flow through Plum Creek at the time of inspection was much higher than normal due to recent storm events in the area. The normal flow in Plum Creek is approximately 10 to 15 cubic feet per second (cfs). According to the Plum Creek near Smithfield (06767500) gage, the July 1st intial peak flow in Plum Creek was 431 cfs at the time of inspection (7/4/2024) was approximately 100 cfs. Figure 1 shows a hydrograph of the July 1st event.

A summary of observations made at each location is provided below:

- State Highway 283 Bridge
    - Some vegetation submerged due to high flows.
    - No visible signs of scour/erosion
    - See photographs 1 through 4.
- County Road 429 Bridge
    - Some vegetation (including the base of some trees adjacent to streambed) submerged due to high flows.

  - Scour/erosion noted in one location upstream of the bridge (see photograph 7).
  - See photographs 5 through 9.
- County Road 430 Culvert
  - Some vegetation (including the base of some trees adjacent to streambed) submerged due to high flow.
  - Potential scour/erosion noted in one location upstream of the culvert and one location downstream of the culvert (see photographs 12 and 15).
  - See photographs 10 through 15.
- County Road 432 Bridge
  - Some vegetation and small trees submerged due to high flow.
  - Potential scour/erosion noted in one location downstream of the bridge (see photograph 19).
  - See photographs 16 through 19.
- County Road 433 Bridge
  - Some vegetation (including the base of some trees adjacent to streambed) submerged due to high flow.
  - Multiple instances of potential scour/erosion noted upstream and downstream of the bridge (see photographs 22 and 24).
  - See photographs 20 through 24.
- County Road 746 Bridge
  - Some vegetation (including the base of some trees adjacent to streambed) submerged due to high flow.
  - Concrete blocks installed along stream bank upstream of bridge (see photograph 26).
  - Stream gage located downstream of bridge. Potential scour/erosion was noted in this area (see photograph 28).
  - See photographs 25 through 28

Figure 1: Plum Creek near Smithfield (06767500) discharge (cfs) – July 1 to July 5, 2024



https://nednr.nebraska.gov/RealTime/Stations/InstantaneousGraph/06767500

Photographs:

Photograph 1. Looking upstream from State Highway 283 bridge.

Photograph 2. Looking upstream from State Highway 283 bridge.

Photograph 3. Looking downstream from State Highway 283 bridge.

Photograph 4. Looking downstream from State Highway 283 bridge.

Photograph 5. Looking upstream from County Road 429 bridge.

Photograph 6. Looking upstream from County Road 429 bridge.

Photograph 7. Potential scour/erosion upstream of County Road 429 bridge.

Photograph 8. Looking downstream from County Road 429 bridge.

Photograph 9. Looking downstream from County Road 429 bridge.

Photograph 10. Looking upstream from County Road 430 culvert.

Photograph 11. Looking upstream from County Road 430 culvert.

Photograph 12. Potential erosion/scour upstream of County Road 430 culvert.

Photograph 13. Looking downstream from County Road 430 culvert.

Photograph 14. Looking downstream from County Road 430 culvert.


07.04.2024

Photograph 15. Potential erosion/scour upstream of County Road 430 culvert.


07.04.2024

Photograph 16. Looking upstream from County Road 432 bridge.

Photograph 17. Looking upstream from County Road 432 bridge.

Photograph 18. Looking downstream from County Road 432 bridge.

Photograph 19. Potential erosion/scour downstream of County Road 432 bridge.

Photograph 20. Looking upstream from County Road 433 bridge.

Photograph 21. Looking upstream from County Road 433 bridge.

Photograph 22. Potential erosion/scour upstream of County Road 433 bridge.

Photograph 23. Looking downstream from County Road 433 bridge.

Photograph 24. Potential erosion/scour downstream of County Road 433 bridge.


07.04.2024

Photograph 25. Looking upstream from County Road 746 bridge.


07.04.2024

Photograph 26. Concrete blocks along streambank upstream of County Road 746 bridge.

Photograph 27. Looking downstream from County Road 746 bridge.

Photograph 28. Potential erosion/scour near stream gage downstream of County Road 746 bridge.

ATTACHMENT C

Plum Creek Hydrologic Assessment

(LRE – August 25, 2024)

LRE WATER
CONNECTING WATER TO LIFE

Memorandum

To: Seth Turner, Platte River Recovery Implementation Program

From: Mark Mitisek, LRE Water, Inc.

Date: August 25, 2024

Project: Expanded Recapture Reconnaissance Study

Subject: Plum Creek Hydrologic Assessment

Introduction/Purpose

The purpose of this memo is to detail data collection efforts, methods, analysis, and results of the Plum Creek hydrologic assessment completed by LRE Water (LRE) supplementing the Stream Assessment completed by Inter-Fluve[1]. This memorandum focuses on historically observed hydrology on Plum Creek and watershed statistics used to evaluate the feasibility and availability of channel capacity of Plum Creek to convey releases from Elwood Reservoir. LRE's efforts were focused on addressing the following questions:

- Can Plum Creek be used to convey flows to meet target flow deficits and, if so, are there stream gains or losses that need to be accounted for?
- Are there stream gains or losses on Plum Creek that need to be accounted for?
- Historically, how many days each year does Plum Creek have available capacity to convey releases from Elwood Reservoir?
- Considering the potential geomorphic impacts to Plum Creek, what is the required capacity of the stream to convey additional releases and for what duration?

Plum Creek Streamflow Data and Watershed Statistics

The basis of LRE's watershed assessment is supported by publicly available historic streamflow information, recent observed streamflow data collected by LRE, and calculated watershed statistics necessary for the assessment. **Figure 1** below shows the project area, stream gage, and field site locations on Plum Creek downstream of Elwood Reservoir used in this investigation. The sections below describe these data sources.

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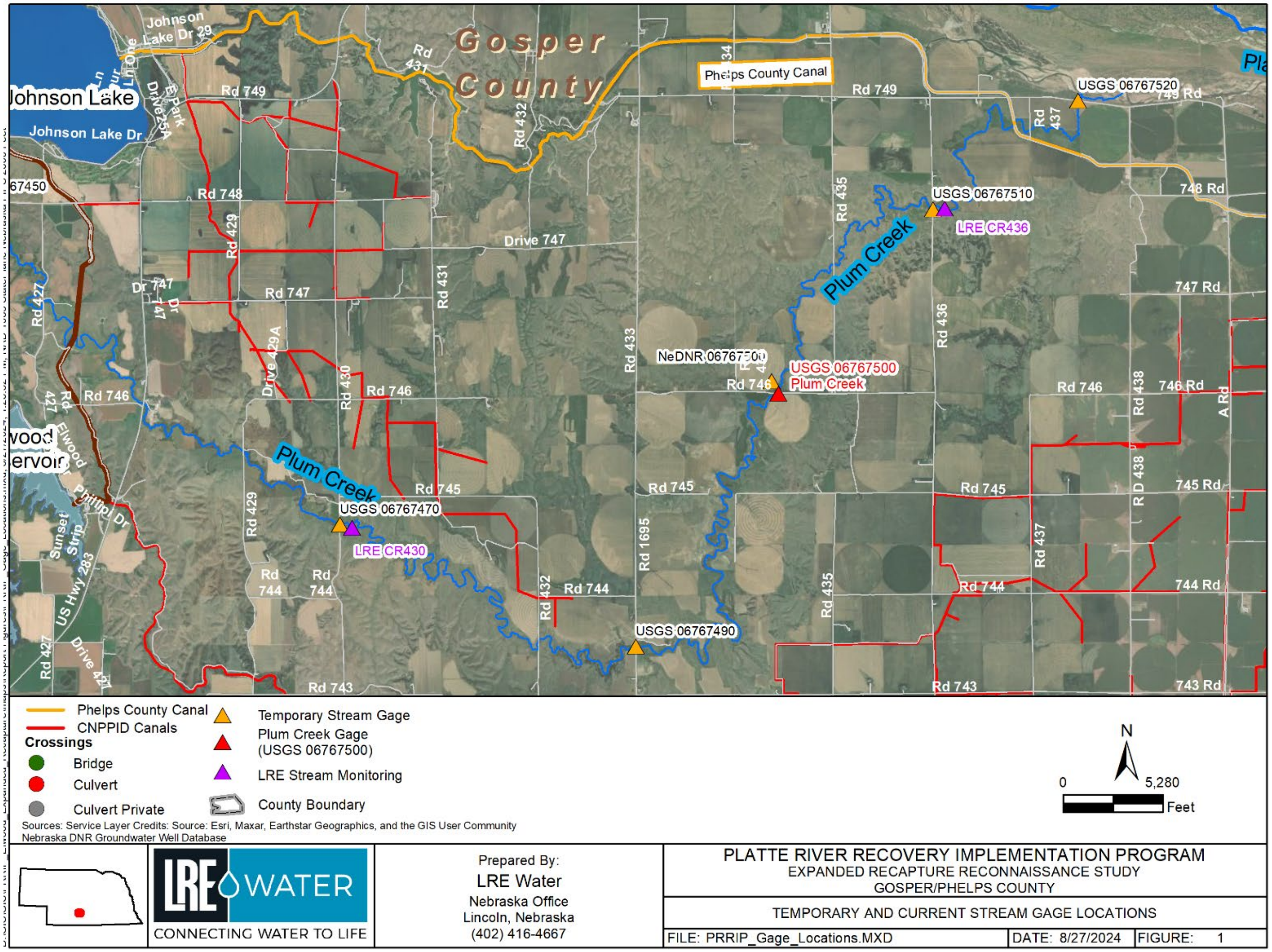
[1] Plum Creek Geomorphic Reconnaissance and Hydrologic Assessment, Inter-Fluve, July 19, 2024

Figure 1: Plum Creek Focus Area and Stream Monitoring Locations



Plum Creek Historical Streamflow

The Plum Creek Near Smithfield gage (06767500) shown in **Figure 1** has been recording streamflow on Plum Creek since June 22, 1946. Originally managed by the United States Geological Survey (USGS) the gage was transitioned to NeDNR in October 2002. **Figure 2** below summarizes the available period of record recorded by each managing agency and the available combine full record from both agencies. **Table 1** summarizes the percentage of missing data for the full available record (06/1946 to 12/2023) and for the period of record after October 1980 when Elwood Reservoir came online. As shown by Figure 2 the period of record prior to October 1980 is intermittent with missing data in the late 1950's, early 1960's, and late 1970's.The recent period from October 1980 to December 2023 is more representative of the existing hydrologic conditions on Plum Creek. Therefore was the focus of this assessment. The combine record shows this more recent period is fairly complete with the exception of a data gap in the early 1990's.

Figure 2: Period of Record of Gage 06767500, Plum Creek Near Smithfield, NE

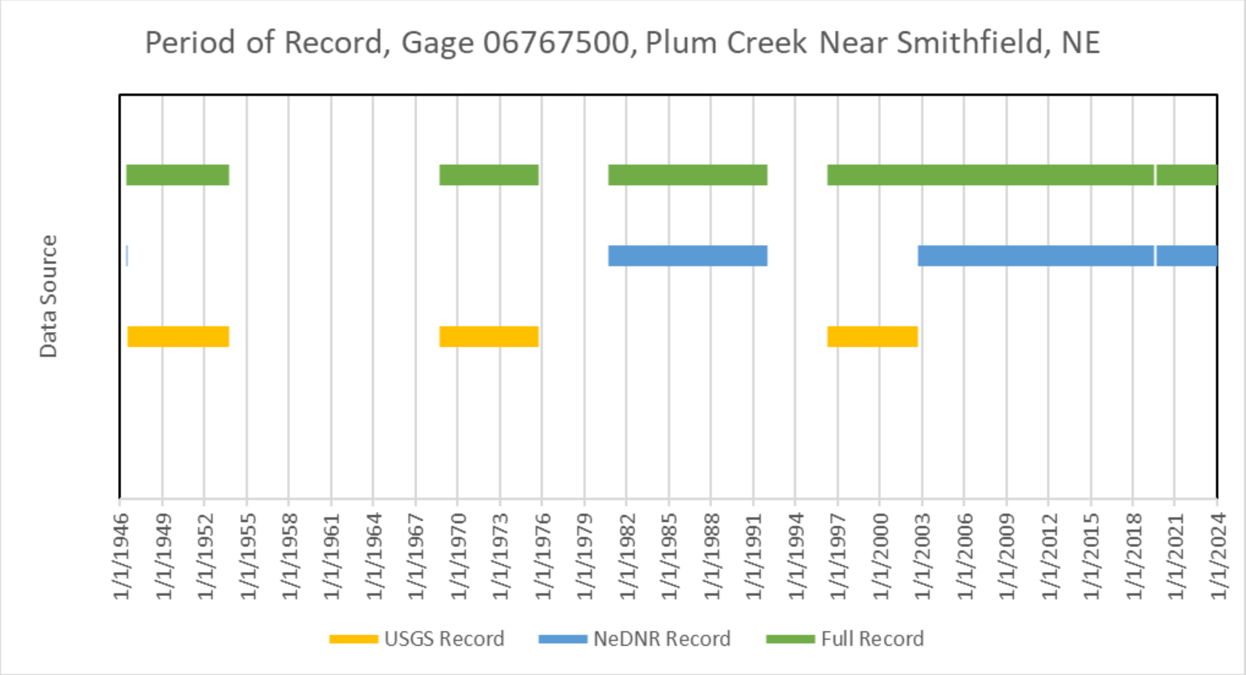


Table 1: Plum Creek Near Smithfield, NE (06767500) – (06/22/1946 to 12/31/2023)

Gage	ID #	Managing Agency	% Missing (06/1946 -12/2023)	% Missing (10/1980-12/2023)
Plum Creek Near Smithfield, NE	06767500	USGS	73.2%	85.0%
		NeDNR	58.3%	25.2%
		Combine	31.5%	10.2%

Table 2 below is a summary of monthly and annual flow statistics for the Plum Creek Near Smithfield gage for the representative period from October 1980 to December 2023. Monthly flow statistics shows a range of average flows from approximately 11 to 13 cfs in the winter months (November to February); May as the highest flow month averaging 20 cfs; and the low flow season (July to October) averages approximately 10 to 12 cfs with an increase in average flows in the month of July (13 cfs) due to monsoonal rain events. Monthly minimums and maximums also show that the hydrologic record is extremely variable ranging between 0 and 1400 cfs. Annually, flows average approximately 12 cfs and ranging between 0 and 1400 cfs.

Table 2: Plum Creek Near Smithfield, Ne (06767500) - Monthly and Annual Flow Statistics

Monthly and Annual Flow Statistics (cfs)
(10/1980 to 12/2023)

Month	Min	Mean	Median	Max
Jan	0.0	11.8	12.0	68.0
Feb	0.1	13.2	13.0	65.0
Mar	0.2	16.2	14.0	531.0
Apr	0.3	14.0	14.0	100.0
May	0.7	19.6	14.0	1,400.0
Jun	2.4	18.7	13.0	716.0
Jul	0.8	13.2	10.8	280.0
Aug	1.0	12.4	9.3	307.0
Sep	0.5	9.6	8.3	384.0
Oct	0.4	10.9	10.0	113.0
Nov	0.2	11.9	11.4	35.4
Dec	0.2	11.9	12.0	41.2
Annual	**0.0**	**13.6**	**12.0**	**1,400.0**

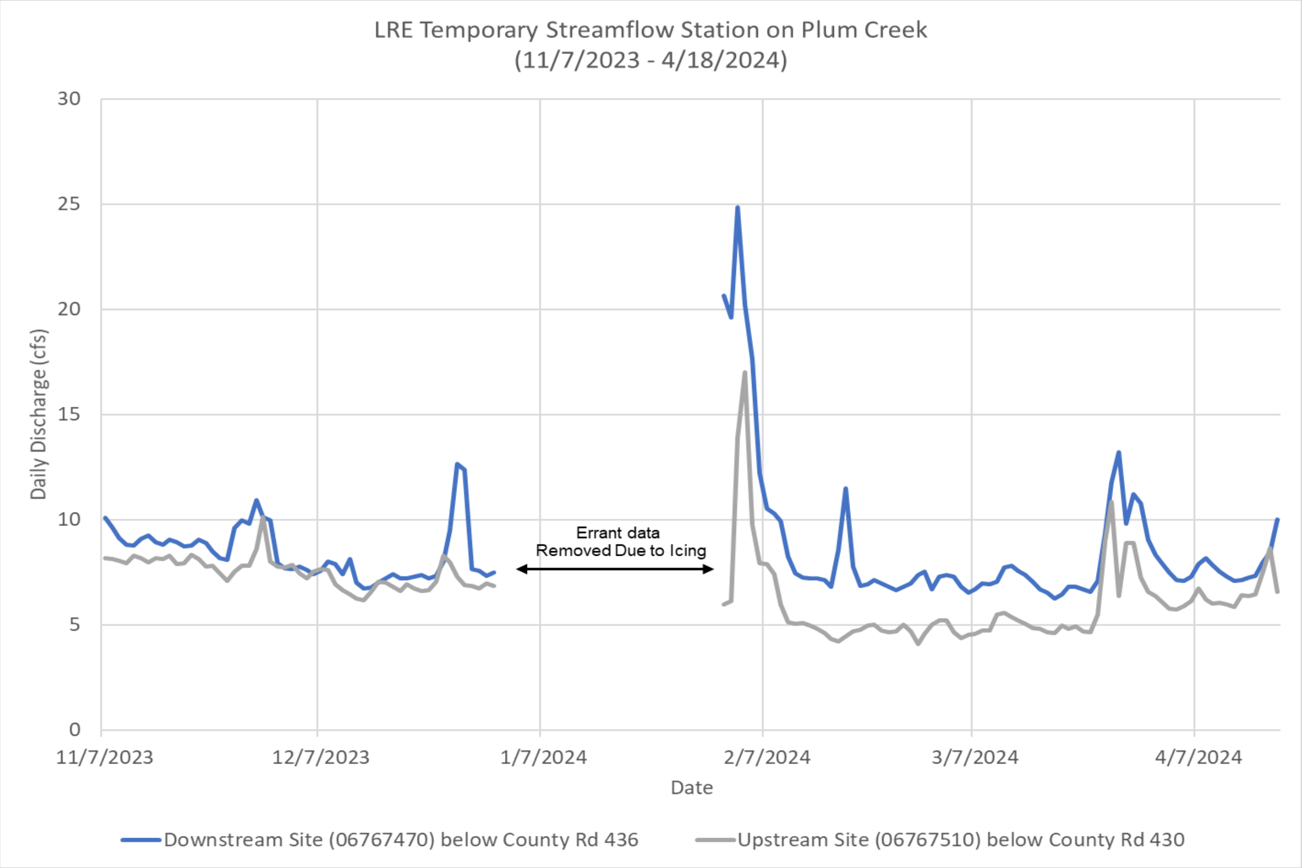
Recent Observed Stage and Estimated Discharge

To supplement the available USGS/NeDNR streamflow record on Plum Creek and confirm gains/losses based on recent hydrology, LRE installed two temporary streamflow stations using continuous recording pressure transducers. The location of the temporary stations were chosen based on field sites previous established by the USGS in 2004. The location of the temporary stations *LRE CR430* below County Rd 430 (corresponds to USGS 06767510) and *LRE CR436* below County Rd 436 (corresponds to USGS 06767470) are shown in Figure 1.

Photos of each location are shown in **Figure 3** below. LRE installed the pressure transducers on November 6, 2023, and removed the stations on June 20, 2024, prior to the conclusion of this study. The stage and discharge data collected or estimated from these sensors were used to confirm recent trends in gains or losses and any periods with zero flow observed. Data collected were only used to validate relative trends between the two stations. A plot of the average daily discharge for these sites is shown below in **Figure 4**. Note stage-discharge relationships are based on field observations, surveys of each cross-section, and Mannings based flow estimates. Stage-discharge relationships for each site with supporting survey/cross-section information is included in **Attachment 1**.

Figure 3: LRE Temporary Streamflow Stations

Figure 4: LRE Temporary Streamflow Stations (November 7, 2024, to April 18, 2024)



Baseflow Separation Analysis

Downstream of Elwood Reservoir, Plum Creek is heavily impacted by groundwater seepage and infiltration from the reservoir that results in the consistent baseflow seen in Plum Creek. This is evident in **Figure 6** below showing the historically observed monthly flows at the Plum Creek Near Smithfield, NE (06767500) gage compared to Elwood Reservoir storage content, showing the presence of year-round baseflow following the construction of Elwood Reservoir in the late 1970s that was not present in earlier years. It is also important to note that below Elwood Reservoir there are no major tributaries. Additional sources that contribute to baseflow gains in Plum Creek include nearby Johnson Lake, E65 Canal, Phelps County Canal, and local recharge from irrigated agriculture and natural precipitation.

To assess the available capacity in Plum Creek for additional releases from Elwood Reservoir, flow at the Plum Creek Near Smithfield gage was separated into baseflow (gains from subsurface flow) and "storm flow" driven by storm runoff. Baseflow was calculated as the 30-day Q10, or lowest 3 days in the last 30, on a running basis. This approach is defended in Brodie 2008[2]. This running statistical calculation allows for a straightforward approach to separating seasonal variation in baseflow.

Figure 6: Plum Creek Near Smithfield Streamflow Compared to Elwood Reservoir Storage Content

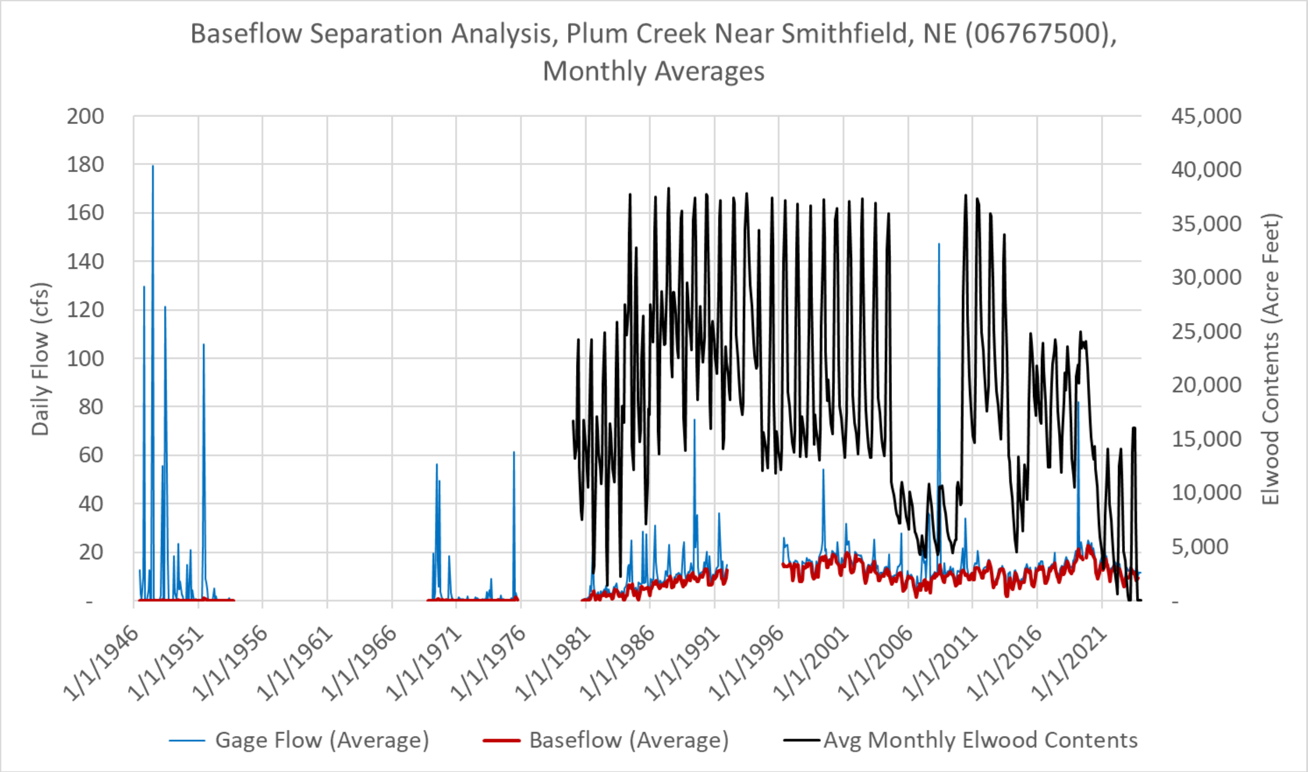


Figure 7 below shows an example period (06/1/2000 to 10/1/2001) of this separation, showing how gage flow is split into baseflow and storm flow, showing short-duration storm flow events, likely linked to large rainfall events. Dividing the observed historical streamflow record into baseflow and storm flows allows for monthly and annual statistics to be evaluated separately providing insights on the historical occurrence of peak flows and available channel capacity. **Figures 8** shows the average monthly baseflow and storm flow for the available intermittent period of record between 1946 and 2023.

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[2] Brodie, Ross S., Stephen Hostetler, and Emily Slatter. "Comparison of daily percentiles of streamflow and rainfall to investigate stream–aquifer connectivity." Journal of hydrology 349.1-2 (2008): 56-67.

Figure 7: Baseflow separation example, 6/1/2000 - 10/1/2001

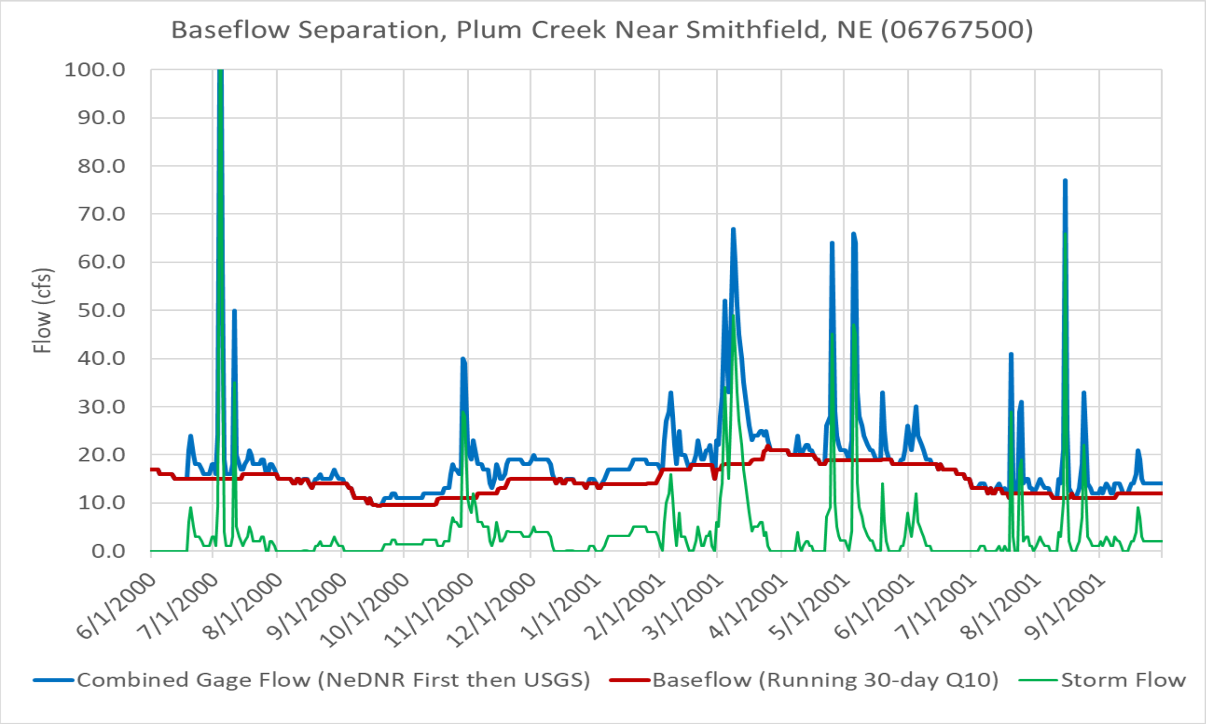


Figure 8: Plum Creek Near Smithfield Monthly Average Baseflow and Storm Flow

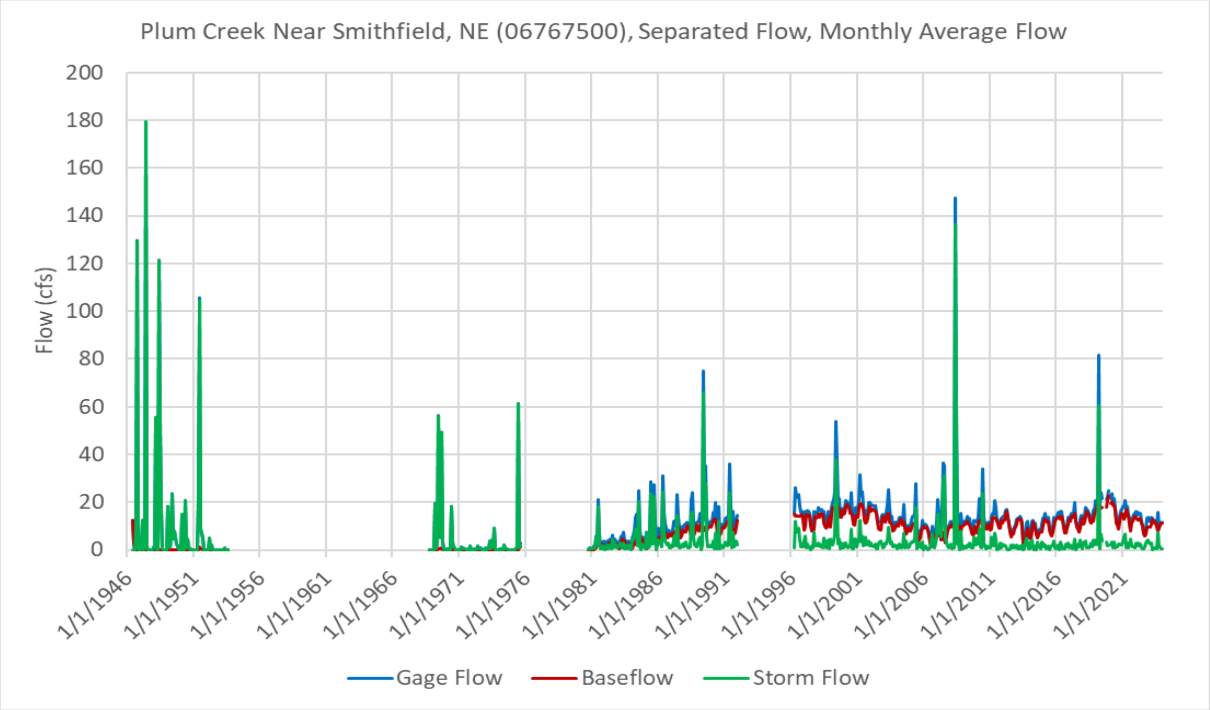


Table 3 summarizes monthly and annual flow statistics for the Plum Creek Near Smithfield gage, calculated baseflow, and storm flow for the representative historical period (10/1980 to 12/2023). Statistics are shown on a monthly and annual basis as well as the summary of the more recent hydrologic period (01/1995 to 12/2023).

Table 3 shows:

- **Gage Flow** – Monthly average ranges between 10 and 20 cfs, annual average is approximately 14 cfs. For the more recent period (1995 to 2023) the annual average has increased to approximately 15 cfs.
- **Baseflow** – Monthly average ranges between 7 and 12 cfs, annual average is approximately 10 cfs. For the more recent period (1995-2023) the annual average has increased to approximately 12 cfs.
- **Storm Flow** – Monthly average ranges between 2 and 8 cfs, annual average is approximately 4 cfs. For the more recent period (1995-2023) the annual average has decreased to approximately 4 cfs.

Table 3: Monthly and Annual Gage, Baseflow, and Stormflow Flow Statistics
Plum Creek Near Smithfield, NE (06767500) (10/1980 to 12/2023)

Month	**Gage Flow**				**Baseflow**				**Storm Flow**			
	Min	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**
Jan	0.0	11.8	12.0	68.0	0.0	9.4	9.8	24.0	0.0	2.4	1.8	66.4
Feb	0.1	13.2	13.0	65.0	0.1	10.2	11.0	20.5	0.0	3.0	2.0	59.4
Mar	0.2	16.2	14.0	531.0	0.1	11.6	12.0	21.9	0.0	4.6	2.0	509.6
Apr	0.3	14.0	14.0	100.0	0.3	12.2	12.8	21.5	0.0	1.9	0.7	94.1
May	0.7	19.6	14.0	1400.0	0.4	11.8	12.4	20.0	0.0	7.8	1.0	1388.1
Jun	2.4	18.7	13.0	716.0	0.8	11.0	11.2	20.0	0.0	7.7	0.5	707.3
Jul	0.8	13.2	10.8	280.0	0.8	9.0	9.5	18.9	0.0	4.2	0.4	275.2
Aug	1.0	12.4	9.3	307.0	1.0	7.8	7.9	18.0	0.0	4.6	1.0	300.0
Sep	0.5	9.6	8.3	384.0	0.5	7.2	6.7	18.4	0.0	2.5	0.9	379.2
Oct	0.4	10.9	10.0	113.0	0.4	8.0	7.8	19.5	0.0	2.8	2.1	107.5
Nov	0.2	11.9	11.4	35.4	0.2	10.0	9.7	20.9	0.0	1.8	1.2	24.2
Dec	0.2	11.9	12.0	41.2	0.2	10.3	10.0	24.3	0.0	1.5	1.0	24.7
Annual	**0.0**	**13.6**	**12.0**	**1400.0**	**0.0**	**9.9**	**10.0**	**24.3**	**0.0**	**3.7**	**1.1**	**1388.1**
1995-2023	**0.8**	**15.0**	**11.7**	**1400.0**	**0.8**	**11.5**	**9.8**	**24.3**	**0.0**	**3.5**	**0.8**	**1388.1**

Gains Calculation

In 2004, the USGS completed paired field measurements at five locations on Plum Creek recording between 16 to 17 measurements at each field site throughout 2004 (**Table 4)**. These paired measurements and the corresponding observed measurements at the Plum Creek Near Smithfield gage were used to evaluate the gains and losses along Plum Creek from Elwood to the confluence with the Platte River (**Figure 1**). The average flow across all paired measurements was used to determine the upstream-to-downstream gains. Additionally, river locations were used to assess gains per mile across all stations based on the stream miles summarized in **Table 4**.

Gages listed below in **Table 4** were only in operation during WY 2004 during which time between 14 measurements were collected on the same days at all gages. Data from the 5 gages were only compared on the days when all gages had recorded observations.

Table 4: USGS Field Measurements – Plum Creek (2004)

Gage ID	USGS Field Measurements (Count)	Stream Mileage (upstream of Platte River confluence)
Plum Creek 0.5 mi W of Gosper County Line, NE (06767520) - LRE CR436	17	0
Plum Creek 2 MI W of Gosper County Line, NE (06767510)	16	3.6
Plum Creek Near Smithfield, NE (06767500)	14*	7.31
Plum Creek 2.5 mi N of Smithfield, NE (06767490)	16	13.84
Plum Creek 2.5 mi E of Elwood Res Near Elwood, NE (06767470) - LRE CR430	17	20.2
Plum Creek 1 mi S of Johnson Lake Near Elwood, NE (06767450)	17	28.08

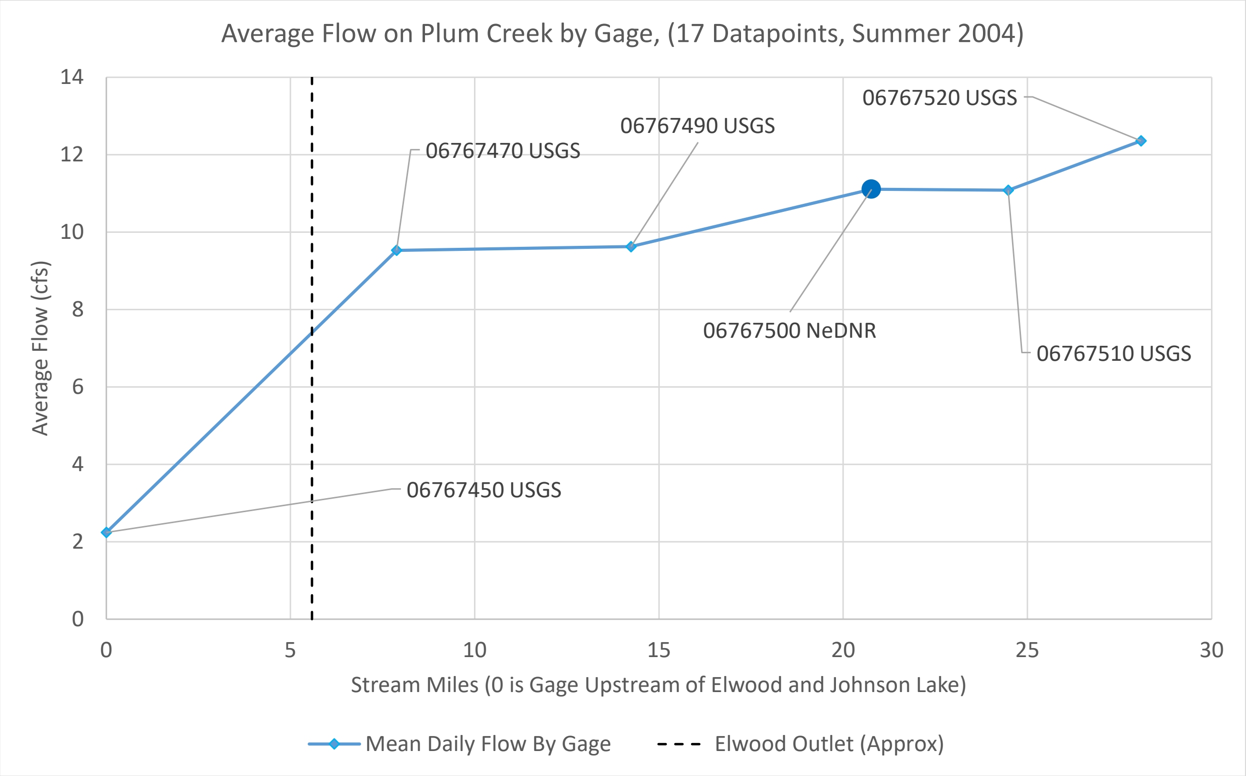
* Average daily streamflow from the Plum Creek Near Smithfield gage were paired to 14 paired field measurements that were collected on the same days at all gages

A review of these paired measurements shows that Plum Creek sees significant gains, a ~0.31 cfs per mile (10.1 cfs total gains from Elwood Reservoir to the Confluence with the Platte River) for all months with the majority of the gains occurring directly below Elwood Reservoir. Mainstem gains downstream from Elwood average ~0.15 cfs per mile with only small variations seasonally.

Figure 9 below shows the average flow from the paired measurements at 5 different sites as well as the approximate location of Elwood Reservoir. Starting at site 06707450 upstream of the Elwood Reservoir shows very little (~2 cfs) baseflow before increasing sharply to approximately 10 cfs at site 06767470 directly below Elwood, then steadily increasing to just over 20.2 miles to 12 cfs at site 06767520 (0.5 mi W of Gosper County Line) near the confluence with the Platte River.

To confirm the gains observed on Plum Creek in 2004, LRE installed two temporary streamflow stations on Plum Creek (described above). These stations confirmed Plum Creek is a gaining stream averaging a gain of 1.96 cfs over 16.6 miles resulting in mainstem gains of ~0.12 cfs per mile.

Figure 9: Average Paired Flow Measurements on Plum Creek (WY2004)

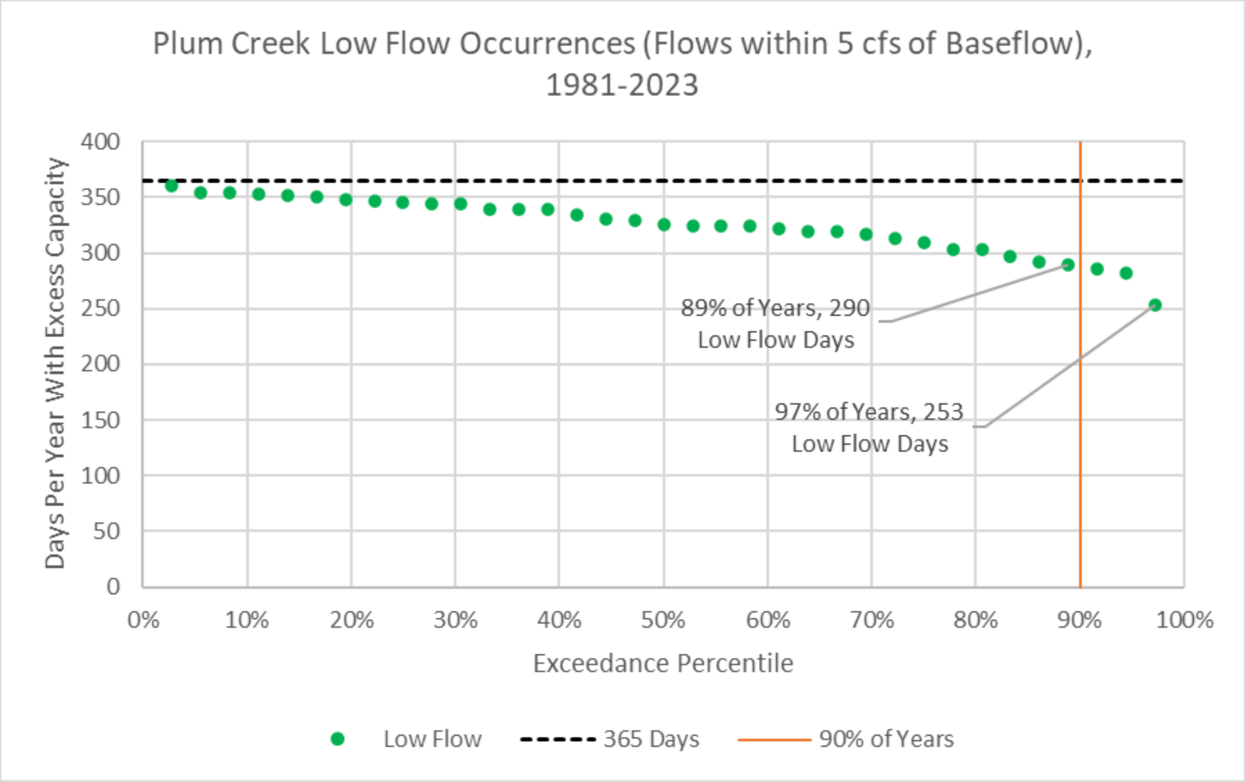


Plum Creek Available Capacity

To understand and quantify the available capacity for Plum Creek to convey releases from Elwood Reservoir, LRE investigated the occurrence of low flow days, defined as days where the historical streamflow was within 5 cfs of baseflow (12 cfs). Low flow days are days when the channel capacity is not fully utilized by naturally occurring flows. Therefore is available to accommodate gravity releases from Elwood Reservoir. The occurrence of low flow days show the % of time (days) each year when there is available capacity not taking in to account design or geomorphic risk thresholds. **Figure 10** below is an exceedance plot (occurrence) of the number of low flow days by water year.

The plot shows that approximately 90% of years have at least 290 days where flows are at or near baseflow, and there is additional available capacity in Plum Creek. All water years in the observed period (WY1981 to WY2023) have at least 253 days with available capacity. The infrequency of flow events exceeding baseflow indicates that Plum Creek is well suited to the needs of the Program to make releases at all times of the year to meet downstream flow targets.

Figure 10: Recurrence of Low Flow Days on Plum Creek



Plum Creek Required Capacity for Additional Releases

Inter-Fluve's assessment of geomorphic risk indicates that flows up to 62 cfs (50 cfs release + 12 cfs baseflow) will result in low to moderate geomorphic impacts on Plum Creek, while flows exceeding 62 cfs will lead to moderate impacts. To contextualize these potential risks and determine the capacity range needed for Plum Creek based on excess flows and target releases, **Table 5** was created. This table illustrates the range of flows assuming constant release rates over short (50 days) and long (300 days) durations, with up to 13,500 acre-feet (AF) of available volume to release annually. It is important to note that actual release rates and volumes will vary annually, monthly, and daily, depending on storage availability in Elwood Reservoir and target flow deficits. The table provides a reasonable estimate of Plum Creek's capacity requirements to accommodate additional releases while considering geomorphic risk.

The target release volume of up to 13,500 AF is an annual average based on the Water Service Agreement between the Program and CNPPID, in which the Program prepaid for nearly 135,000 AF of excess flow deliveries over an initial 10-year period from 2023 to 2032. Values in the shaded area represent potential Elwood Reservoir outlet flow rates ("release") in cubic-feet-per-second (cfs), including an assumed 12 cfs baseflow.

Table 5 shows that higher flow rates over shorter durations pose a greater geomorphic risk than lower flows over longer durations. It also demonstrates that lower flow rates (≤50 cfs) can still achieve significant release volumes over an extended period. Furthermore, the table indicates that sustained releases of over 57.4 cfs (45.4 cfs release + 12 cfs baseflow) for 150 days result in 13,500 AF of releases annually. Shorter duration releases (less than 150 days) will require release rates greater than 62 cfs, leading to moderate impacts on Plum Creek.

Table 5: Plum Creek Capacity Requirement Considering Geomorphic Risk

Target Release (AF)	Duration of Release (Days)						
	50	75	100	150	200	250	300
13,500	148.1	102.7	80.1	57.4	46.0	39.2	34.7
12,000	133.0	92.7	72.5	52.3	42.2	36.2	32.2
10,000	112.8	79.2	62.4	45.6	37.2	32.2	28.8
8,000	92.7	65.8	52.3	38.9	32.2	28.1	25.4
6,000	72.5	52.3	42.2	32.2	27.1	24.1	22.1
4,000	52.3	38.9	32.2	25.4	22.1	20.1	18.7
2,000	32.2	25.4	22.1	18.7	17.0	16.0	15.4
1,000	22.1	18.7	17.0	15.4	14.5	14.0	13.7
500	17.0	15.4	14.5	13.7	13.3	13.0	12.8

Moderate Risk

Plum Creek Flow (cfs)*

Low Risk

Moderate Risk

Geomorphic Risk

*Plum Creek Flow includes an assumed 12 cfs of baseflow.

Conclusions

Below is a summary the answers the questions:

- Can Plum Creek be used to convey flows to meet target flow deficits and, if so, are there stream gains or losses that need to be accounted for?

  Year-round baseflow became evident in the Plum Creek Near Smithfield gage record after the completion of Elwood Reservoir, Johnson Lake, E65 Canal, and Phelps County Canal in the late 1970s. Using a statistical method the sustained baseflow was determined to average approximately 10 cfs (10/1980 to 12/2023). The more recent period (1/1995 to 12/2023) shows an increase in the sustained baseflow of approximately 12 cfs.

- Are there stream gains or losses on Plum Creek that need to be accounted for?

  Using USGS field measurements from multiple months in 2004 and stream distances the observed record shows Plum Creek downstream of Elwood Reservoir is a gaining stream averaging ~0.15 cfs/mile. Recent hydrology collected by LRE (November 2023 to April 2024) confirms the 2004 observations showing Plum Creek with average gains of ~0.12 cfs/mile. Note these conclusions are based on a limited data set that does not include extreme wet or dry years. Gains or losses may still need to be accounted for in some years. Additional monitoring and analysis is warranted.

- Historically, how many days each year does Plum Creek have available capacity to convey releases from Elwood Reservoir?

  Plum Creek is well-suited to handle additional releases from Elwood Reservoir to deficits to target flows at Grand Island with all years in the observed record having over 250 days at or near baseflow conditions with available capacity.

- Considering the potential geomorphic impacts to Plum Creek, what is the required capacity of the stream to convey additional releases and for what duration?

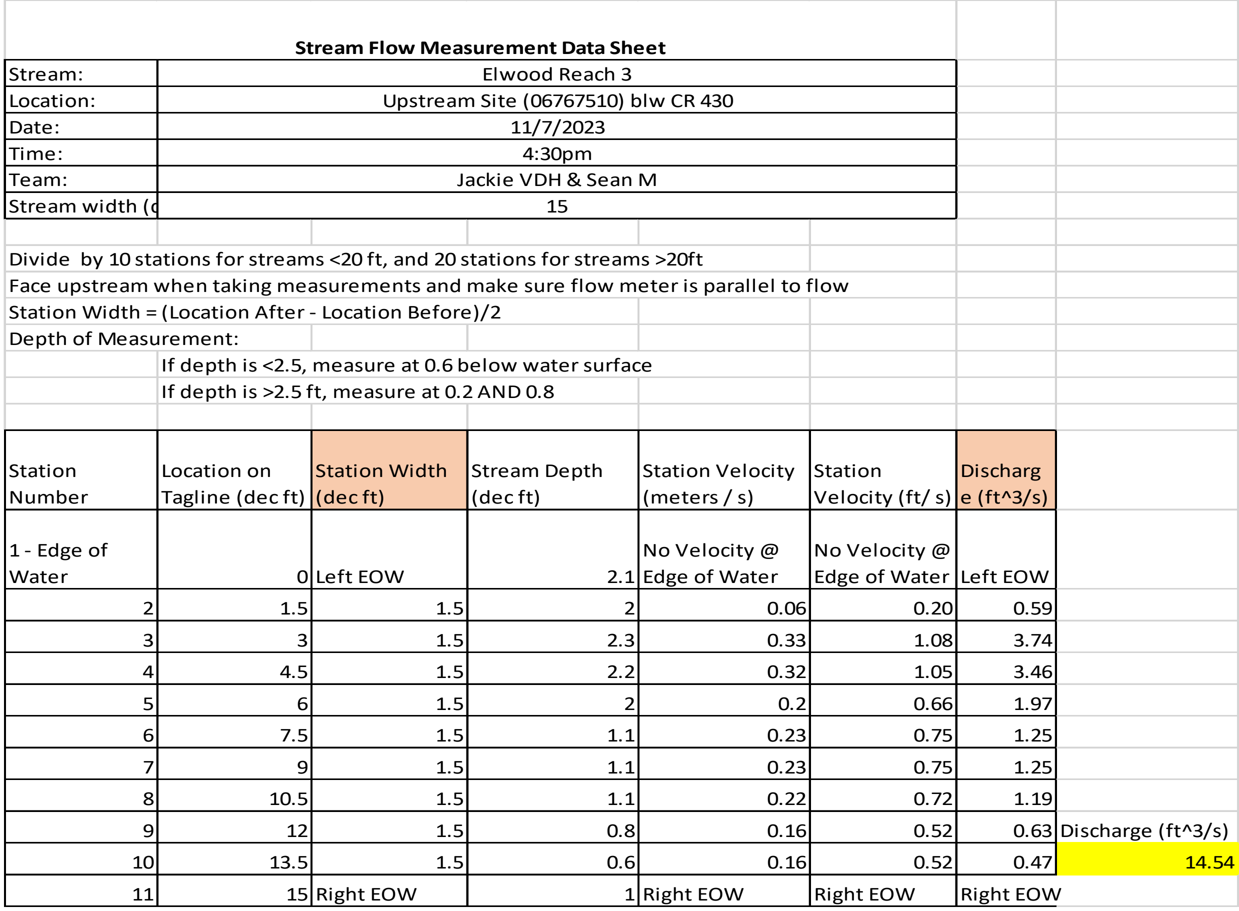
  Inter-Fluve's assessment of geomorphic risk concludes flows up to 62 cfs (50 cfs release + 12 cfs baseflow) will result in low to moderate geomorphic impacts to Plum Creek. A sustained releases of over 57.4 cfs (45.4 cfs release + 12 cfs baseflow) for 150 days results in 13,500 AF of releases annually. Shorter duration releases (less than 150 days) will require release rates of greater than 62 cfs resulting in moderate impacts to Plum Creek.

Attachment 1

LRE Temporary Stage-Discharge Curves and Supporting Survey/Cross-section Information

Upstream Site (06767510) blw CR 430

Stream Survey (11/7/2024)



Stream Flow Measurement Data Sheet

Stream:	Elwood Reach 3
Location:	Upstream Site (06767510) blw CR 430
Date:	11/7/2023
Time:	4:30pm
Team:	Jackie VDH & Sean M
Stream width (	15

Divide by 10 stations for streams <20 ft, and 20 stations for streams >20ft

Face upstream when taking measurements and make sure flow meter is parallel to flow

Station Width = (Location After - Location Before)/2

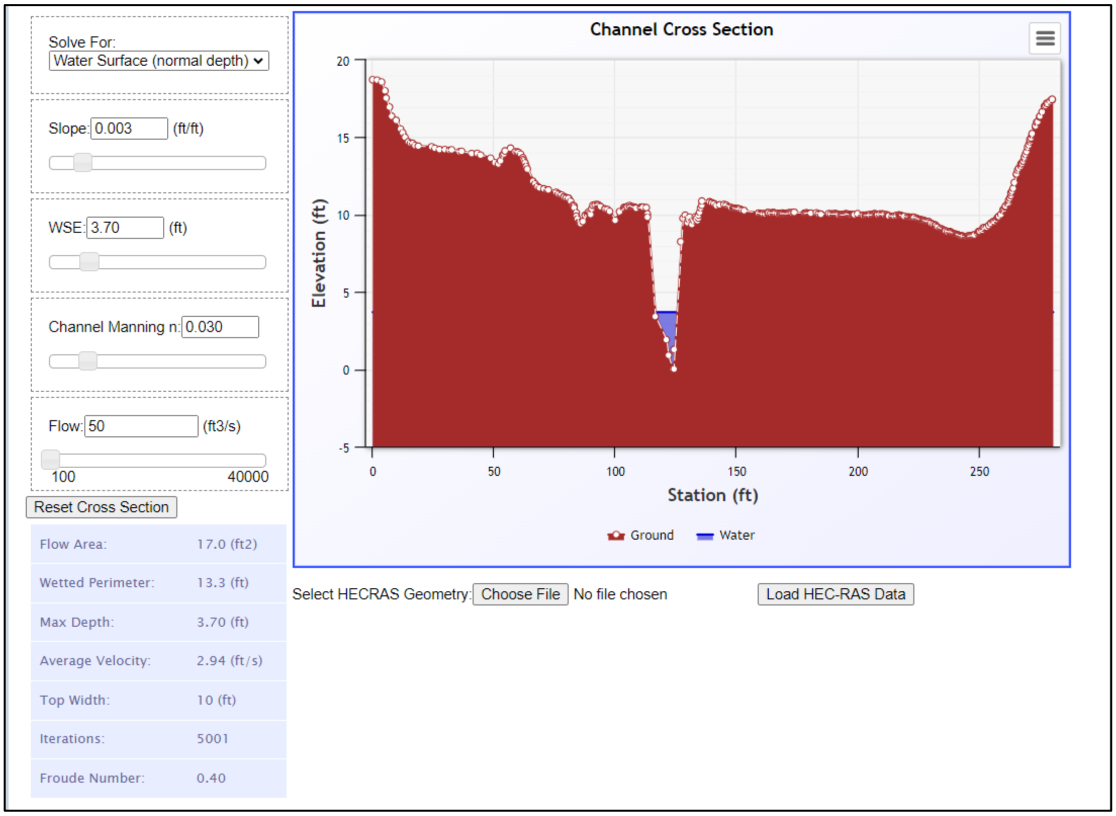
Depth of Measurement:

If depth is <2.5, measure at 0.6 below water surface

If depth is >2.5 ft, measure at 0.2 AND 0.8

Station Number	Location on Tagline (dec ft)	Station Width (dec ft)	Stream Depth (dec ft)	Station Velocity (meters / s)	Station Velocity (ft/ s)	Discharge (ft^3/s)	
1 - Edge of Water	0	Left EOW	2.1	No Velocity @ Edge of Water	No Velocity @ Edge of Water	Left EOW	
2	1.5	1.5	2	0.06	0.20	0.59	
3	3	1.5	2.3	0.33	1.08	3.74	
4	4.5	1.5	2.2	0.32	1.05	3.46	
5	6	1.5	2	0.2	0.66	1.97	
6	7.5	1.5	1.1	0.23	0.75	1.25	
7	9	1.5	1.1	0.23	0.75	1.25	
8	10.5	1.5	1.1	0.22	0.72	1.19	
9	12	1.5	0.8	0.16	0.52	0.63	Discharge (ft^3/s)
10	13.5	1.5	0.6	0.16	0.52	0.47	14.54
11	15	Right EOW	1	Right EOW	Right EOW	Right EOW	

Cross-Section and Mannings Parameters



Solve For: Water Surface (normal depth)

Slope: 0.003 (ft/ft)

WSE: 3.70 (ft)

Channel Manning n: 0.030

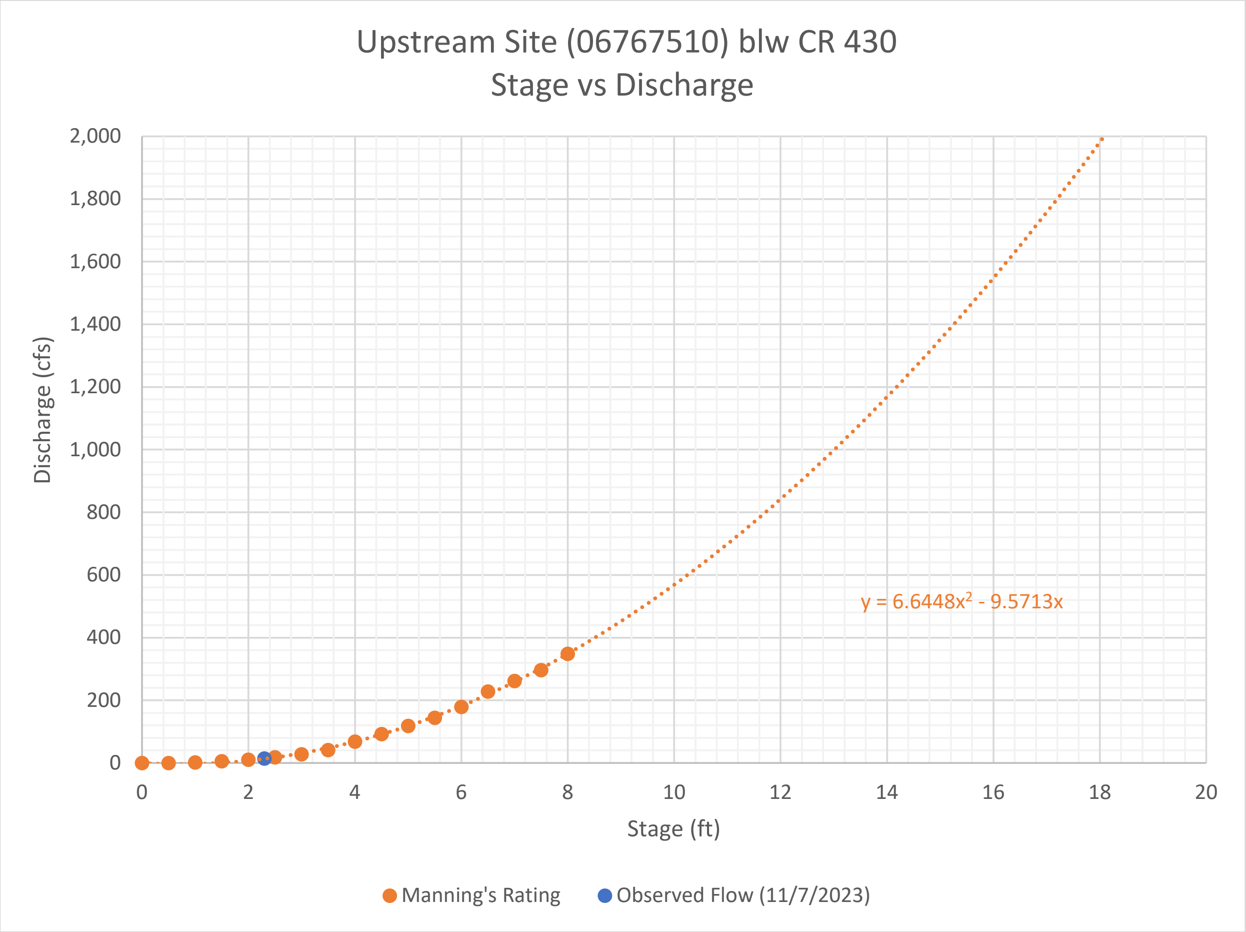
Flow: 50 (ft3/s)

Flow Area:	17.0 (ft2)
Wetted Perimeter:	13.3 (ft)
Max Depth:	3.70 (ft)
Average Velocity:	2.94 (ft/s)
Top Width:	10 (ft)
Iterations:	5001
Froude Number:	0.40

Select HECRAS Geometry: No file chosen

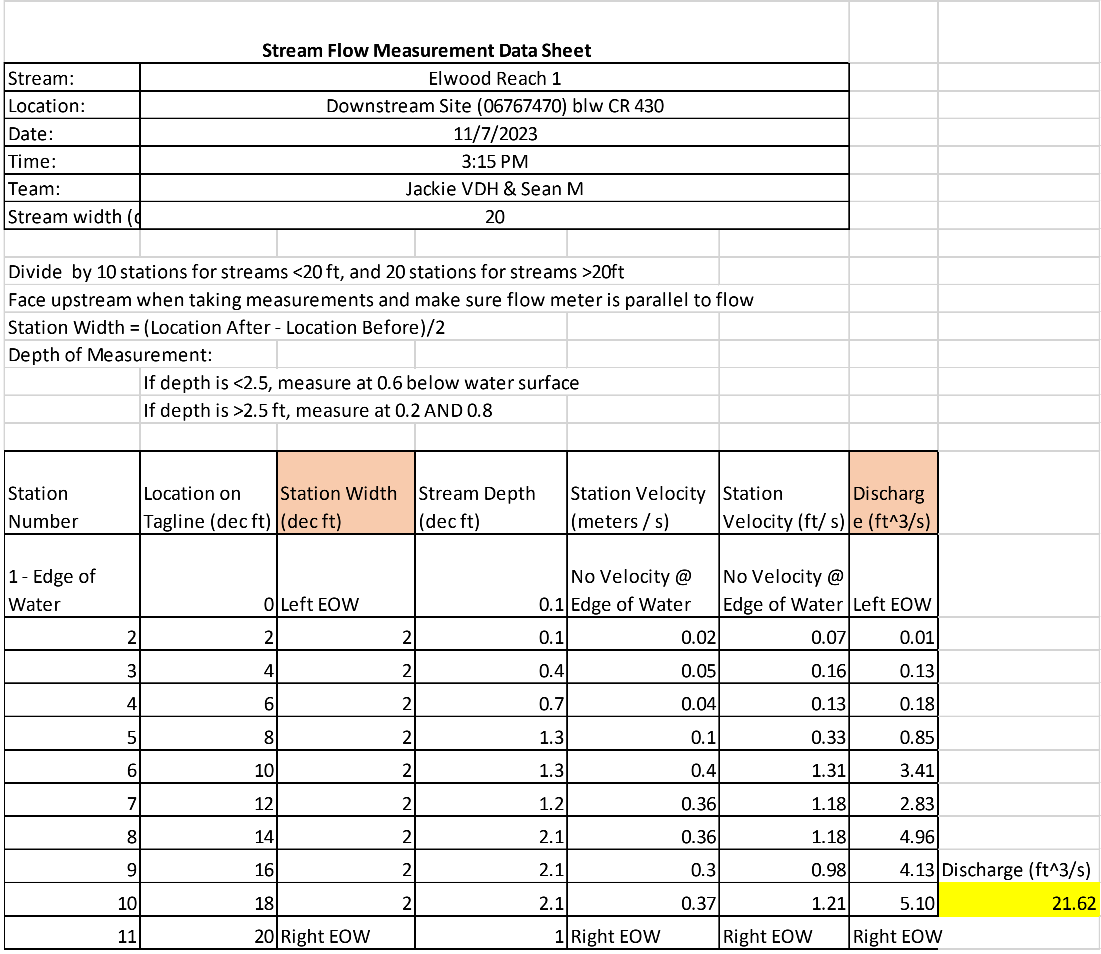
https://www.weather.gov/aprfc/NormalDepthCalc

Stage Discharge Relationship Based on Mannings Parameters



Downstream Site (06767470) blw CR 436

Stream Survey (11/7/2024)



Stream Flow Measurement Data Sheet

Stream:	Elwood Reach 1
Location:	Downstream Site (06767470) blw CR 430
Date:	11/7/2023
Time:	3:15 PM
Team:	Jackie VDH & Sean M
Stream width (	20

Divide by 10 stations for streams <20 ft, and 20 stations for streams >20ft

Face upstream when taking measurements and make sure flow meter is parallel to flow

Station Width = (Location After - Location Before)/2

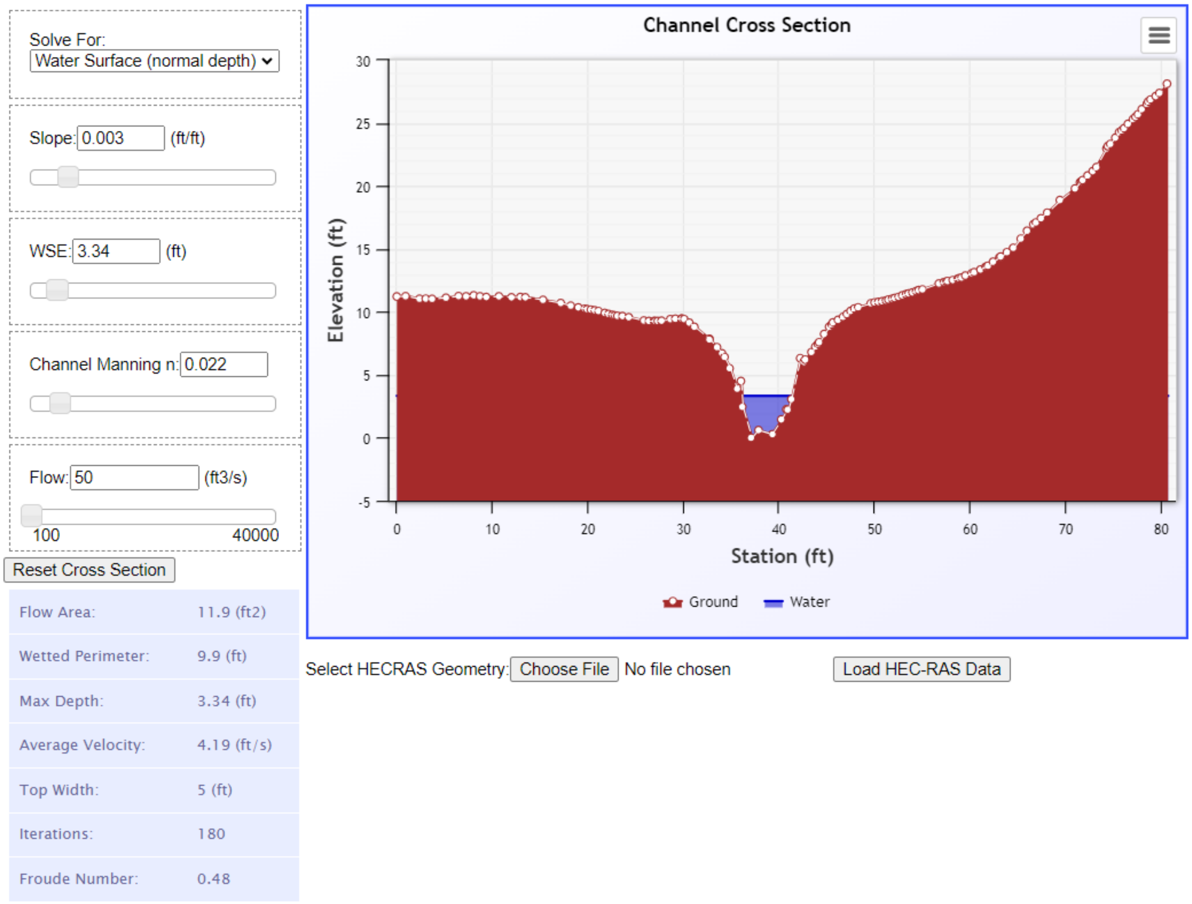
Depth of Measurement:

If depth is <2.5, measure at 0.6 below water surface

If depth is >2.5 ft, measure at 0.2 AND 0.8

Station Number	Location on Tagline (dec ft)	Station Width (dec ft)	Stream Depth (dec ft)	Station Velocity (meters / s)	Station Velocity (ft/ s)	Discharge (ft^3/s)	
1 - Edge of Water	0	Left EOW	0.1	No Velocity @ Edge of Water	No Velocity @ Edge of Water	Left EOW	
2	2	2	0.1	0.02	0.07	0.01	
3	4	2	0.4	0.05	0.16	0.13	
4	6	2	0.7	0.04	0.13	0.18	
5	8	2	1.3	0.1	0.33	0.85	
6	10	2	1.3	0.4	1.31	3.41	
7	12	2	1.2	0.36	1.18	2.83	
8	14	2	2.1	0.36	1.18	4.96	
9	16	2	2.1	0.3	0.98	4.13	Discharge (ft^3/s)
10	18	2	2.1	0.37	1.21	5.10	21.62
11	20	Right EOW	1	Right EOW	Right EOW	Right EOW	

Cross-Section and Mannings Parameters



Solve For: Water Surface (normal depth)

Slope: 0.003 (ft/ft)

WSE: 3.34 (ft)

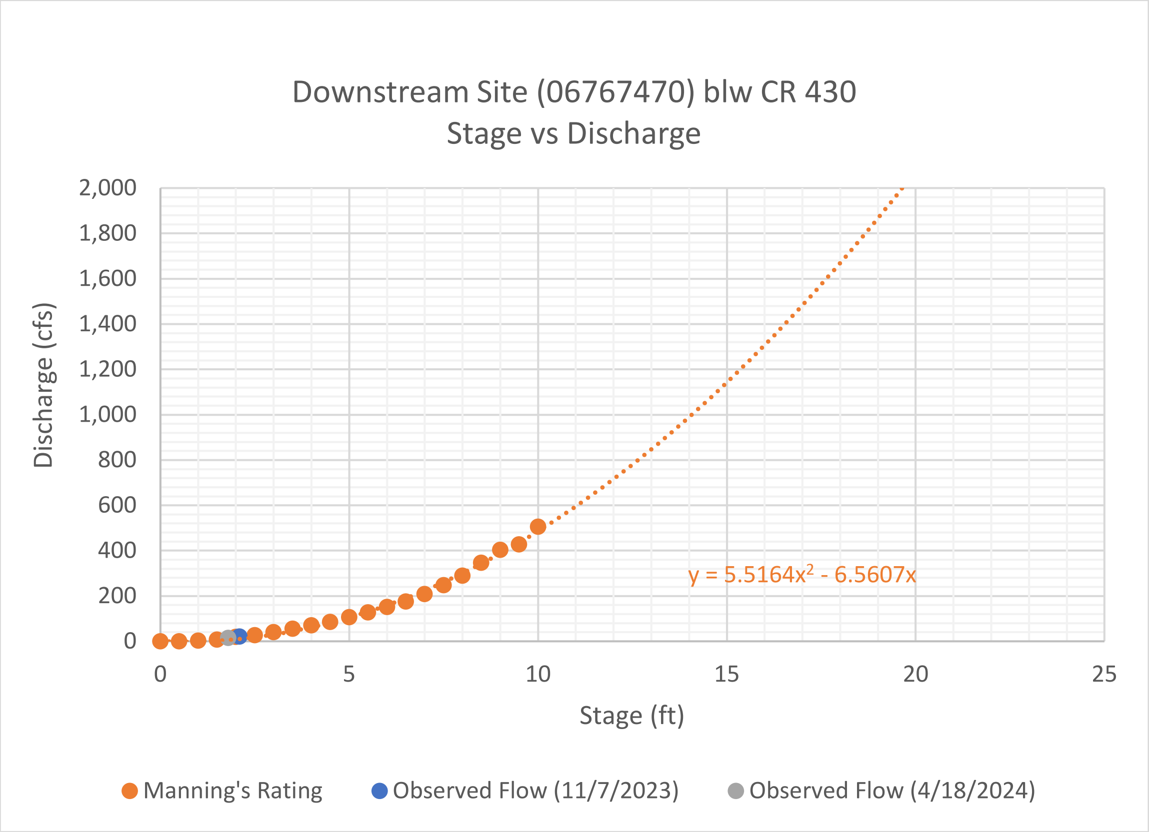
Channel Manning n: 0.022

Flow: 50 (ft3/s)

Flow Area:	11.9 (ft2)
Wetted Perimeter:	9.9 (ft)
Max Depth:	3.34 (ft)
Average Velocity:	4.19 (ft/s)
Top Width:	5 (ft)
Iterations:	180
Froude Number:	0.48

https://www.weather.gov/aprfc/NormalDepthCalc

Stage Discharge Relationship Based on Mannings Parameters



ATTACHMENT D

Concept and Cost Opinions for Conveyance Facilities to Plum Creek

(RJH – July 17, 2024)

RJH
CONSULTANTS, INC.

TECHNICAL MEMORANDUM

Project 23138

TO: **Jonathan Mohr – LRE Water, Inc.**

FROM: **Tom MacDougall, P.E. – RJH Consultants, Inc.**

DATE: **July 17, 2024**

RE: **Elwood Recapture Reconnaissance Study: Concept and Cost Opinions for Conveyance Facilities to Plum Creek**

ALLAN T. MACDOUGALL
E-15483

Allan T. MacDougall

Digitally signed by Allan T. MacDougall
DN: C=US,
E=tmacdougall@rjh-consultants.com,
O="RJH Consultants, Inc.", CN=Allan
T. MacDougall
Reason: I am the author of this
document
Date: 2024.07.17 17:40:06-06'00'

Introduction

The Platte River Recovery Implementation Program (Program) retained LRE Water (LRE) to evaluate the feasibility of conveying environmental flows from Elwood Reservoir to the Platte River within Plum Creek. This evaluation is called the Elwood Recapture Reconnaissance Study Project (Project). As part of this Project, LRE retained RJH Consultants, Inc. (RJH) to develop feasibility-level concepts and costs for infrastructure that could control releases and convey flows from Elwood Reservoir to Plum Creek. This memorandum presents two concepts for new infrastructure needed to control releases and convey flows from Elwood Reservoir (including through the E-65 Canal adjacent to the reservoir) to Plum Creek. The details of the concepts presented herein should be considered feasibility-level and were developed based on initial discussions with both the Program and the owner of Elwood Reservoir and the E-65 Canal, Central Nebraska Public Power and Irrigation District (CNPPID) . Other entities collaborating on this Project include the State of Nebraska, Nebraska Department of Natural Resources (NeDNR), and the Tri-Basin Natural Resources District (TBNRD).

Background

Elwood Reservoir is in Gosper County, Nebraska, about 3 miles north of the town of Elwood, Nebraska, and has an existing outlet located approximately 1 mile south of Plum Creek, a perennial stream that is tributary to the Platte River. The Program can store water for environmental releases in Elwood Reservoir. Typical base flows in Plum Creek are estimated to be between 5 and 15 cubic feet per second (cfs). A site vicinity map is shown on Figure 1. The Program is evaluating if sufficient environmental flows could feasibly be released from Elwood Reservoir, conveyed via Plum Creek, and discharged into the Platte River with the goal of timing releases to reduce flow shortages in the Platte River near Grand Island. There are times when supplemental flows provide significant environmental benefits to threatened and endangered species.

Proposed Concepts

General

Initially, RJH considered various potential concepts to convey up to 100 cfs from Elwood Reservoir to Plum Creek. Following some discussion with the Program and LRE, RJH presented three initial concepts to the Program in a draft memorandum dated January 2024.

One of the initial concepts was to convey water released from Elwood Dam through CNPPID's existing E-65 Canal and an existing siphon (Siphon 3), install a new turnout north of Siphon 3, convey flows through a new pipeline that would be immediately south of County Road 746 (and just south of Plum Creek), and discharge flow to Plum Creek near the intersection of Road 746 and U.S. Route 283. This concept was eliminated from further consideration because it would require the use of CNPPID's Siphon 3 and CNPPID will likely discontinue using and maintaining Siphon 3 in approximately the next two years.

RJH continued to develop two concepts to convey water from Elwood Reservoir to Plum Creek. These concepts are referred to herein as Alternative A (Alt A) and Alternative B (Alt B). Alt A is to divert water through an existing evacuation pipeline at the Elwood Pump Station and convey those releases to Plum Creek through a new lined channel. Alt B is to divert water from the E-65 Canal through a buried conveyance pipeline, and to Plum Creek. The two concepts are further discussed in the following sections.

As requested by LRE and the Program, RJH developed two options for each concept: one to convey a maximum flow of 50 cfs, and an enlarged option that could convey up to 100 cfs. The alignments for each concept are shown on Figure 2. The E-65 Canal, Siphon 3, the Elwood pump station, and the evacuation pipeline are existing conveyance infrastructure owned and operated by CNPPID and are shown on Figure 3.

Alternative A: Open Channel

The "Alternative A" concept would convey a maximum of either 100 cfs (Alt A1) or 50 cfs (Alt A2) from the Elwood evacuation pipeline to Plum Creek in a lined open channel. The existing Elwood evacuation pipeline consists of a 42-inch-diameter reinforced concrete pipe (RCP) that increases to a 48-inch-diameter RCP and extends from the pump station along the north of the E-65 Canal to a riprap-lined stilling basin. The stilling basin discharges to a natural ephemeral drainage that flows north, crosses over Siphon 3, is conveyed through a culvert below U.S. Route 283, and then discharges into Plum Creek. A new lined channel would be constructed from the outlet of the existing stilling basin, along the flowline of the natural drainage, through an existing culvert below U.S. Route 283, and connect to Plum Creek, a total distance of approximately 5,900 feet. The channel lining could be riprap or an erosion-resistant material that is more readily available in the area (i.e., soil cement, etc.). For this feasibility study, RJH included riprap as the channel lining because this is a proven and reliable lining material, and it provides a conservative cost for channel lining. In future phases of design, the location and type of channel lining needs to be evaluated. A plan of the lined channel alignment is shown on Figure 4, and a profile view is shown on Figure 5.

For both capacity options, the lined channel would be trapezoidal with side slopes of 2H:1V. For Alt A1 (100 cfs), the bottom width of the channel would be about 5 feet with a normal flow depth of 3 feet. For Alt A2 (50 cfs), the channel bottom width would be about 3 feet with a normal flow depth of 2.5 feet. Flow velocities in the channel are anticipated to be about 4 feet per second (fps), and flow conditions should be subcritical along most of the channel length. An energy dissipation structure at the downstream end of the riprap channel would likely not be required. Typical cross sections of Alt A1 and Alt A2 are shown on Figure 6.

The channel alignment would cross Siphon 3 of the E-65 Canal. The depth of soil cover over Siphon 3 is reportedly 6 to 8 feet. A soil cover of 8 feet would be sufficient to excavate the channel and maintain an appropriate soil cover. A soil cover of 6 feet is likely insufficient to allow for channel excavation and maintain sufficient clearance over Siphon 3. The exact depth of soil cover of Siphon 3 will need to be identified if this concept is advanced.

Additionally, the channel alignment crosses an access road along the E-65 Canal. Therefore, a bridge, culvert, or a low-water crossing would be needed to allow continued road access along the E-65 canal. The new lined channel would cross the following parcels (with property owners listed in parentheses): 370017773 (CNPPID), 370017811 (Dustin and Amber O'Hanlon), 370017781 (Jane Jack), 370017792 (Knoerzer Farms Inc.) and Gosper County right-of-way.

Alternative B: Buried Pipeline

The "Alternative B" concept would convey a maximum of either 100 cfs (Alt B1) or 50 cfs (Alt B2) from the E-65 Canal to Plum Creek through a buried gravity pipeline. Flows discharged from Elwood Reservoir would be conveyed through the Elwood outlet to the E-65 Canal (consistent with current operations) and to a new diversion/intake located approximately 2,250 feet (along the canal) from the Elwood pump station. The intake would consist of a new canal headgate located near the south side of Siphon 3, and a turnout structure on the east side of the E-65 Canal. Due to topography, RJH sited the new canal headgate north of the turnout structure to regulate canal flow and control headwater for the turnout structure. Siting the headgate north of the location where E-65 Siphon 3 currently releases back into the canal would be more cost effective than constructing one at the proposed location of the turnout structure where a relatively steep bank is present on the west side of the canal.

A new pipeline would extend from the new turnout/intake structure approximately 4,500 linear feet and would generally follow the valley bottom of an ephemeral drainage. The ephemeral drainage is west of U.S. Route 283 and south of County Road 746 as shown on Figure 6. The pipe diameter for Alt B1 (100 cfs) would be 36 inches. The pipe diameter for Alt B2 (50 cfs) would be 30 inches. For this feasibility study, RJH selected to use steel pipe because of experience with other water conveyance projects and because evaluations of external pipe loadings and internal pressures was beyond the scope of this study. Other, possibly more economical pipe materials, should be considered in future stages of evaluation. The pipe would discharge to a new energy dissipation structure west of U.S. Route 283, and then flow would cross U.S. Route 283 though an existing culvert (or possibly a new culvert) and be discharged to Plum Creek. The energy dissipation structure would likely consist of a discharge headwall, a concrete plunge pool, and a grouted riprap rundown to reduce the velocities of flow being conveyed through the culvert under U.S. Route 283. A plan of the pipeline alternative is shown on Figure 7, and a profile is shown on Figure 8.

The pipeline would flow by gravity with about 90 feet of head from the intake to the discharge. It is anticipated that the pipeline would be buried at least 42 inches below the existing ground based on the frost depth provided in the City of Omaha, Nebraska, Municipal Code[1]. Typical cross sections of the pipeline are shown on Figure 9. The pipeline alignment would cross the following parcels shown on Figure 10 (with property owners listed in parentheses): 370017773 (CNPPID), 370017781 (Jane Jack), 370017792 (Knoerzer Farms Inc.), and Gosper County right-of-way.

Opinion of Probable Project Costs

RJH developed a feasibility-level Opinion of Probable Project Costs (OPPC) based on the concepts presented in this memorandum. RJH based our opinion of costs on bid tabulations compiled from similar projects, estimates from RS Means cost data books, adjustments for location and inflation using ENR index of construction prices, and general experience with heavy civil construction projects. The intent of the cost opinion was to develop a Class 4 level estimate as defined by ASTM International (ASTM) standard E2516-

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[1] RJH did not identify a published local building code that provided a local typical frost depth.

11(19). This level is appropriate for a study or feasibility phase where the design engineering is between 1 and 15 percent complete. The reliability of this level of estimate according to the ASTM should be considered relatively low, with expectations that the cost opinion may overestimate actual costs by about 30 percent or underestimate actual costs by about 50 percent. It is our opinion that RJH has defined concepts for the key infrastructure needed to convey the anticipated flows from Elwood Dam to Plum Creek and has identified the primary cost items to construct each concept.

For the infrastructure's capital costs, RJH's OPPC ranges between about $2.8 million to $9.5 million (2024 dollars). This includes 30 percent for general design and construction contingencies, and a 10 percent allowance for design engineering. RJH did not include estimates for permitting, easements, or land acquisition in our opinion of costs. RJH also did not develop or include estimates for annual maintenance costs. The OPPC for each concept is presented in Table 1 below.

TABLE 1
OPPC SUMMARY(1)

Concept	OPPC(2) ($)
Alt A1: Open Channel, 100 cfs	3,300,000
Alt A2: Open Channel, 50 cfs	2,820,000
Alt B1: Steel Pipeline, 100 cfs	9,470,000
Alt B2: Steel Pipeline, 50 cfs	7,500,000

Notes:
(1) Additional detail for these costs is provided in Attachment 1.
(2) OPPC does not include the cost to replace or enlarge the culvert under U.S. Route 283.

The pipeline concepts (Alt B1 and B2) have higher capital costs than the open channel concepts (Alt A1 and A2). The welded steel pipe concept is more expensive per linear foot than the open channel concepts. Moreover, the pipeline concept includes the construction of two gated concrete structures to control and divert flow in the E-65 canal and a third concrete structure to dissipate high-energy flow at the pipeline discharge. The open channel concept uses existing infrastructure (the Elwood pump station) to divert flow from the reservoir and control flow in the channel. CNPPID has stated that they could allow either concept given their historic use of the emergency release (very rarely) and the existing capacity of the E-65 canal. CNPPID did not anticipate significant concerns for advancing either of these concepts. For either concept, costs for annual maintenance, permitting, easements (or land acquisition) should be added to RJH's cost opinions presented above.

Additionally, RJH assumed that it would be acceptable to use an existing culvert below U.S Route 283 because RJH considered that the Program would not release environmental flows to Plum Creek during periods of high runoff or flooding, when the culvert would be used for conveying runoff. In future studies, additional evaluation and stakeholder coordination should be performed to confirm this assumption. If this assumption is invalid, there would be additional cost to convey flows across US Route 283, or to cross Rd 746 and discharge releases upstream of the bridge (US. Route 283) over Plum Creek.

RJH developed opinions for approximate maintenance costs using generalized information from pipe manufacturers, pipe designers, and discussions with pipeline and channel engineers. Channel maintenance costs can vary significantly based on the size of the channel, anticipated life span before a major rehabilitation is needed, soil stability of the materials underlying the channel, surface drainages that are adjacent to or intersect the channel, the propensity for vegetation or soils to clog the channel, the need for herbicides to be applied routinely, and the quality of the channel armoring materials used. For planning and feasibility-evaluation purposes, RJH considers an annual maintenance cost for the channel alternatives (Alt A1 and Alt 2) of $12,500 to be reasonable.

Pipeline maintenance costs can vary widely to account for factors such as soil corrosion conditions, anticipated lifespan, pipe size, pipe material, changing soil moistures, quality of the water being conveyed (i.e., buildup of mineral deposits, etc.), public access to open ends (i.e., vandalism, etc.), and other factors. For planning and feasibility-evaluation purposes, RJH considers an annual maintenance cost for the pipeline alternatives (Alt B1 and Alt B2) of $3,000 to be reasonable.

Concept Comparison

RJH considered the likely advantages, disadvantages, and considerations for both concepts, shown in Table 2 below.

TABLE 2
ADVANTAGES, DISADVANTAGES, AND CONSIDERATIONS

	Advantages	Disadvantages	Other Considerations
Pipeline	• Possibly discharge to an existing culvert under U.S. Route 283. • Alignment follows an existing drainage, and deep excavation is unlikely. • Adds operational utility to the E-65 canal.	• Pipeline alignment would require easement through private property. • Construction cost likely higher than the open channel concept.	• Three property owners impacted: CNPPID, Knoerzer, and J. Jack.
Open Channel	• Possibly discharges to an existing culvert under U.S. Route 283. • Construction is likely easier, and the capital cost is likely lower than the pipeline.	• The alignment likely has the highest impact to property owners and may require purchase instead of easements. • Longest alignment. • Higher losses from infiltration and evaporation than a pipeline.	• Four property owners impacted: CNPPID, Knoerzer, J. Jack, and O'Hanlon. • Bridge, culvert, or other crossing needed to maintain vehicle access along E-65 canal. • Need to confirm sufficient cover on siphon to allow for a crossing channel.

These comparisons are based on feasibility-level evaluations. Additional study, data collection, and evaluation may be warranted to advance the advantages and disadvantages of each alternative.

Considerations for Advancing the Project

Advancement of the Project will require additional data collection, design, and coordination with stakeholders. RJH anticipates stakeholders would include local landowners, Nebraska Department of Transportation (NDOT), CNPPID, and permitting agencies. RJH anticipates that some of the actions needed to advance the Project include:

- Obtain a topographic survey of the Project site to facilitate civil design. The concepts presented in this report are based on publicly available topographic data.
- Explore the depth of soil cover over Siphon 3 to better understand the feasibility of excavating a channel in this location.
- Coordinate with local landowners and Gosper County regarding easements or land acquisition and develop estimated costs to develop easements or to purchase the land required for the Project.
- Collect data on the size and existing conditions of the existing culvert across U.S. Route 283. Use of the existing culvert to periodically convey flows across U.S. Route 283 will require coordination with, and approval from NDOT. It is possible that enlargement of the culvert to route the Project flows and meet NDOT criteria may be required and this would require NDOT permission and coordination.
- Evaluate and comply as needed with environmental permitting requirements. The Project may require obtaining environmental permits to construct and operate the Project.
- Perform engineering and analyses needed to support designs for a cost-effective and reliable conveyance system. The concepts presented herein are feasibility-level.

The above list is intended to provide key actions and considerations for advancement of the Project and is not intended to be a comprehensive outline of all needed future Project activities.

Closure

RJH has developed and initially considered two concepts to convey flows from Elwood Reservoir to Plum Creek. For each concept, options for two sizes were developed to convey maximum flows of either 100 cfs or 50 cfs. RJH recommends that for feasibility-evaluations and project planning purposes, costs for the 100 cfs pipeline be initially considered ($9.5 million). If needed for cost-benefit justification of the Project, RJH recommends that the minimum cost for infrastructure used in feasibility evaluations be $2.8 million.

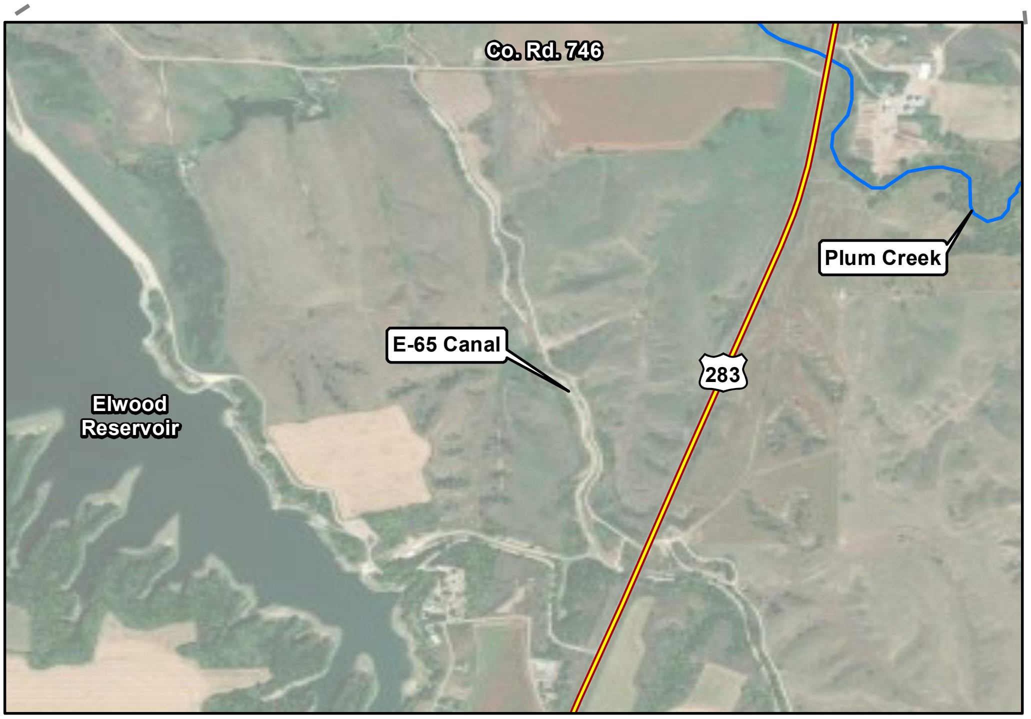
Figures

Attachments: Attachment 1 – Additional Detail for Cost Opinions

ATM/cbb

PROJECT VICINITY MAP
(NOT TO SCALE)

PROJECT LOCATION MAP
(NOT TO SCALE)



SITE LOCATION MAP
(NOT TO SCALE)

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RJH
CONSULTANTS, INC.

ELWOOD RECAPTURE RECONNAISSANCE STUDY

SITE LOCATION AND VICINITY MAP

PROJECT NO. 23138

July 2024

Figure 1

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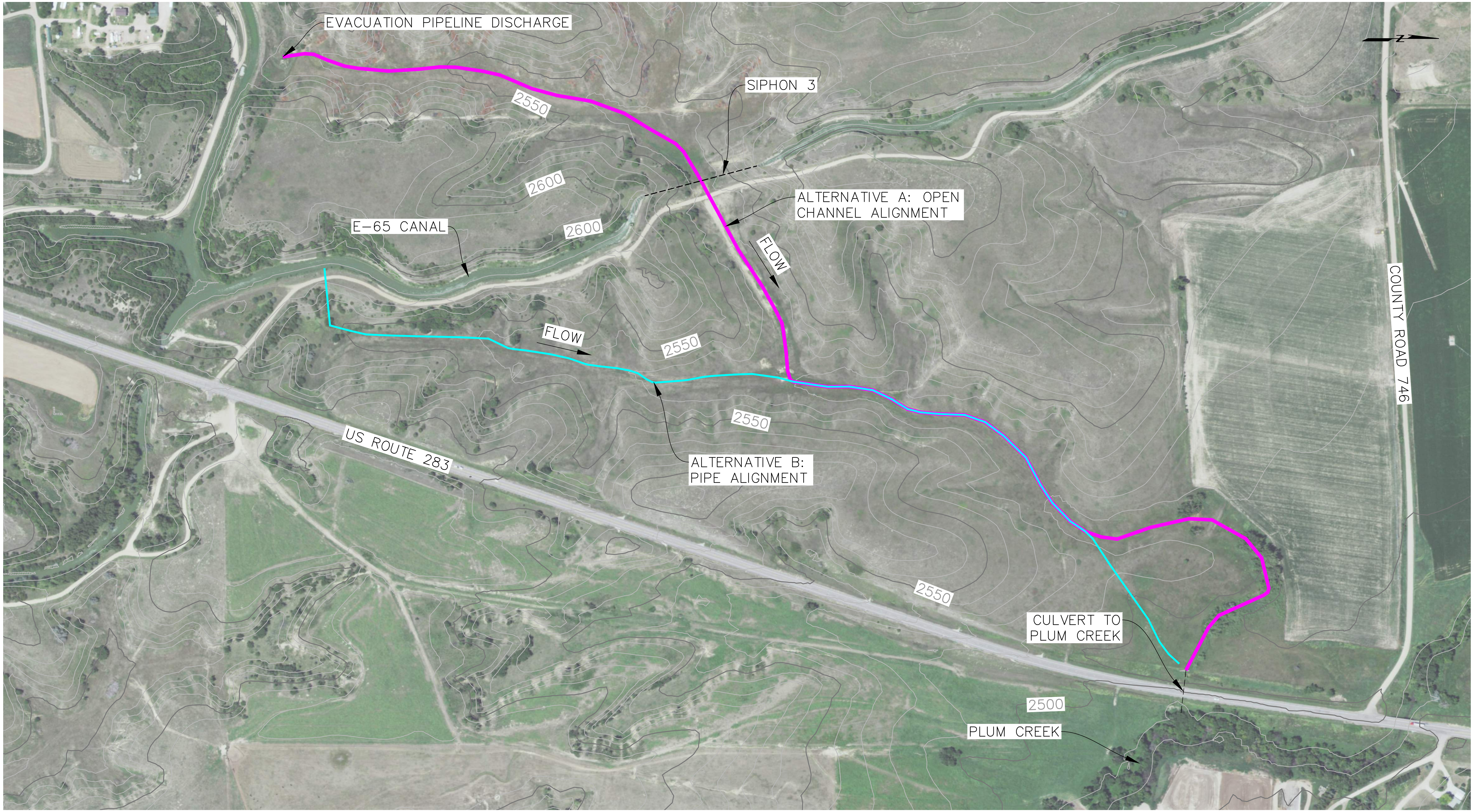

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PRELIMINARY
NOT FOR CONSTRUCTION

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ELWOOD RECAPTURE
RECONNAISSANCE STUDY

CONCEPT OVERVIEW

PROJECT NO. 23138

July 2024

Figure 2

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ELWOOD RECAPTURE
RECONNAISSANCE STUDY

EXISTING CNPPID
INFRASTRUCTURE

PROJECT NO. 23138

July 2024

Figure 3

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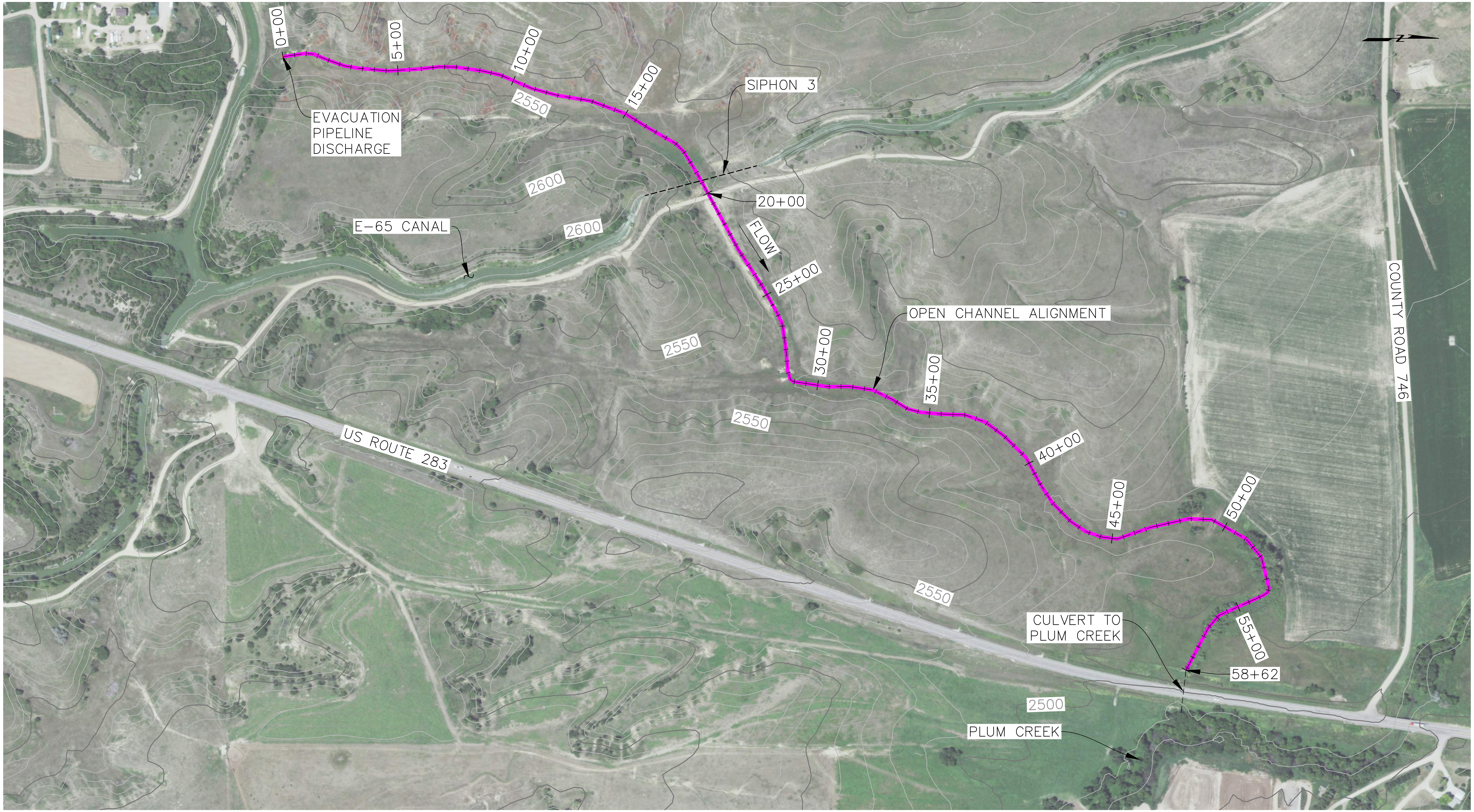

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ELWOOD RECAPTURE
RECONNAISSANCE STUDY

PROJECT NO. 23138

ALTERNATIVE A
OPEN CHANNEL
ALIGNMENT

July 2024

Figure 4

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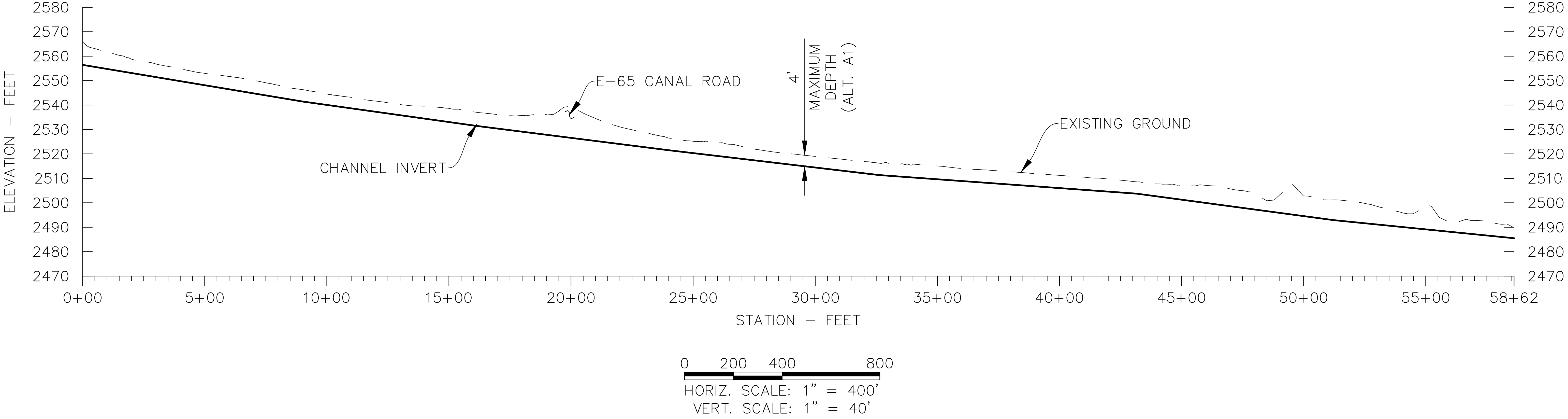

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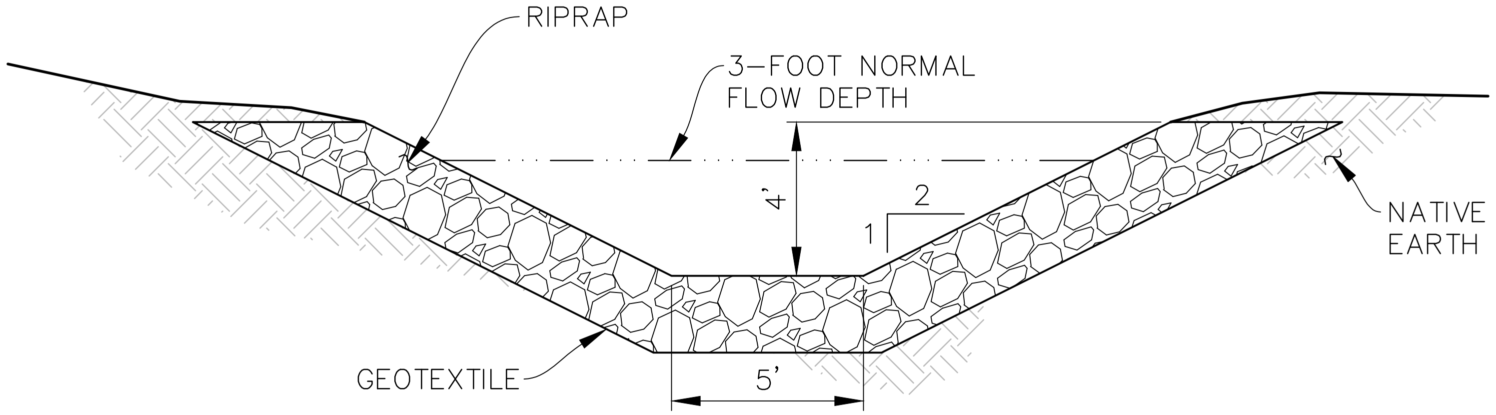
ELWOOD RECAPTURE
RECONNAISSANCE STUDY

PROJECT NO. 23138

ALTERNATIVE A
OPEN CHANNEL
PROFILE

July 2024

Figure 5



ALTERNATIVE A1
100 CFS CHANNEL SECTION

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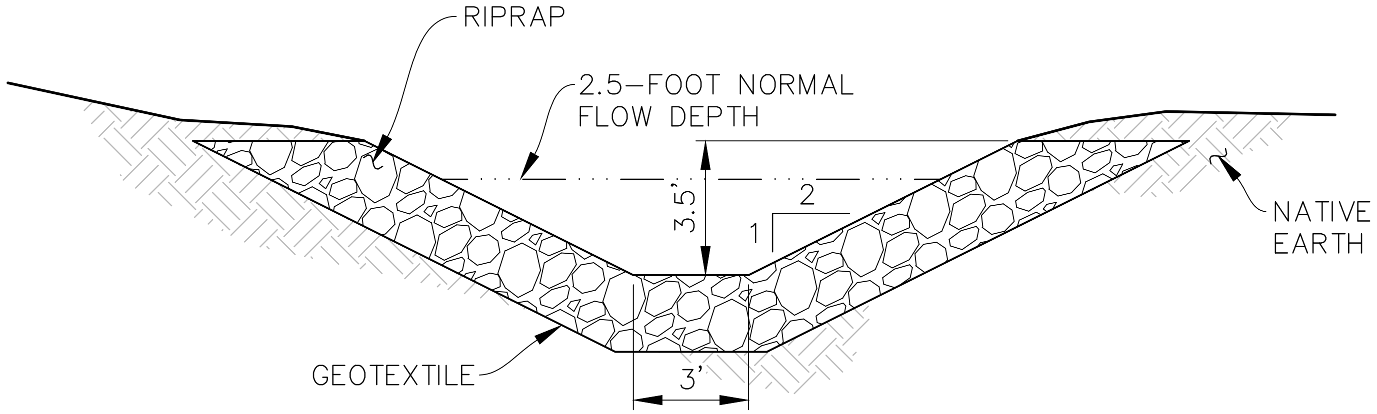

ALTERNATIVE A2
50 CFS CHANNEL SECTION

0 2.5 5 10
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ELWOOD RECAPTURE
RECONNAISSANCE STUDY

PROJECT NO. 23138

ALTERNATIVE A
CHANNEL SECTION

July 2024

Figure 6

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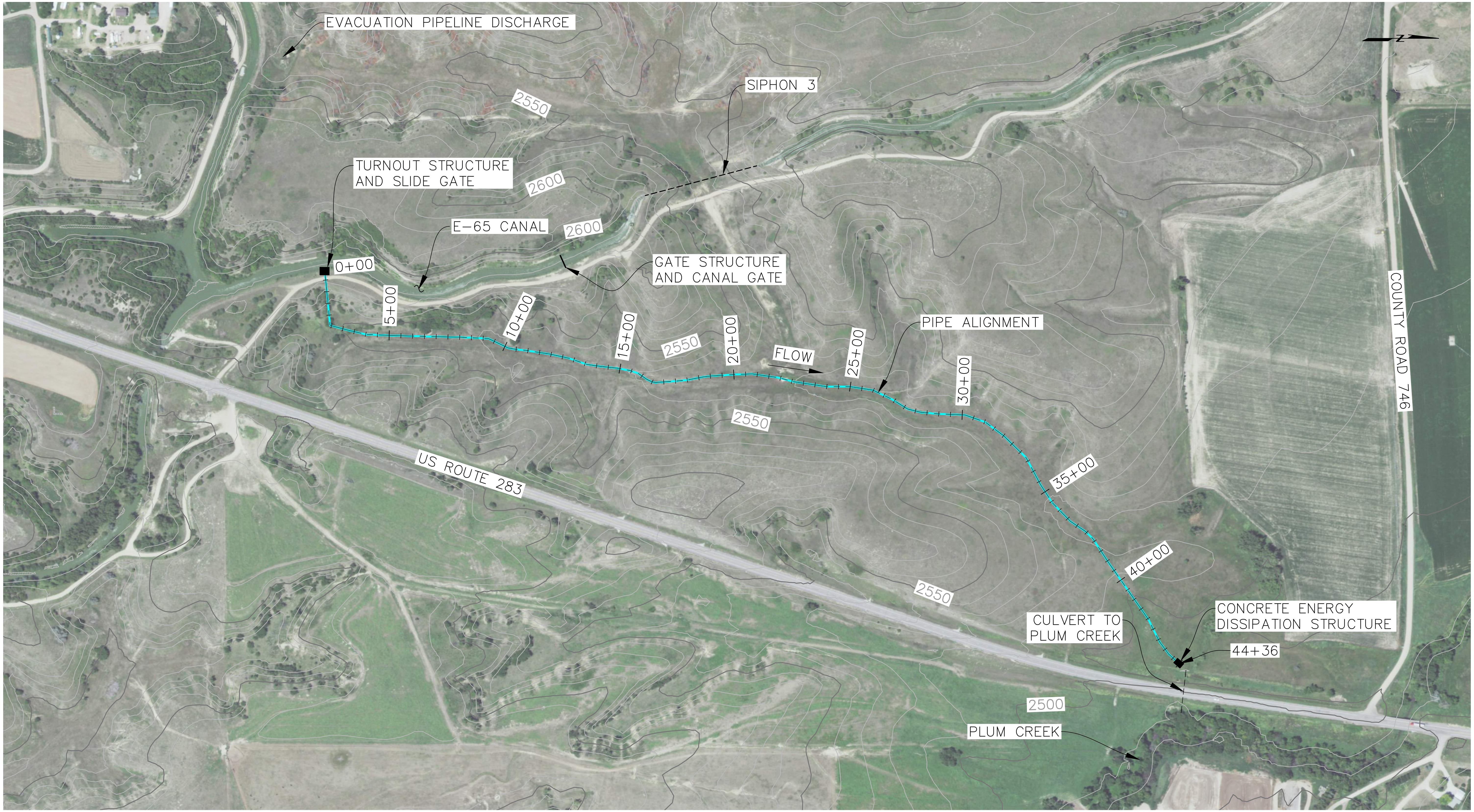

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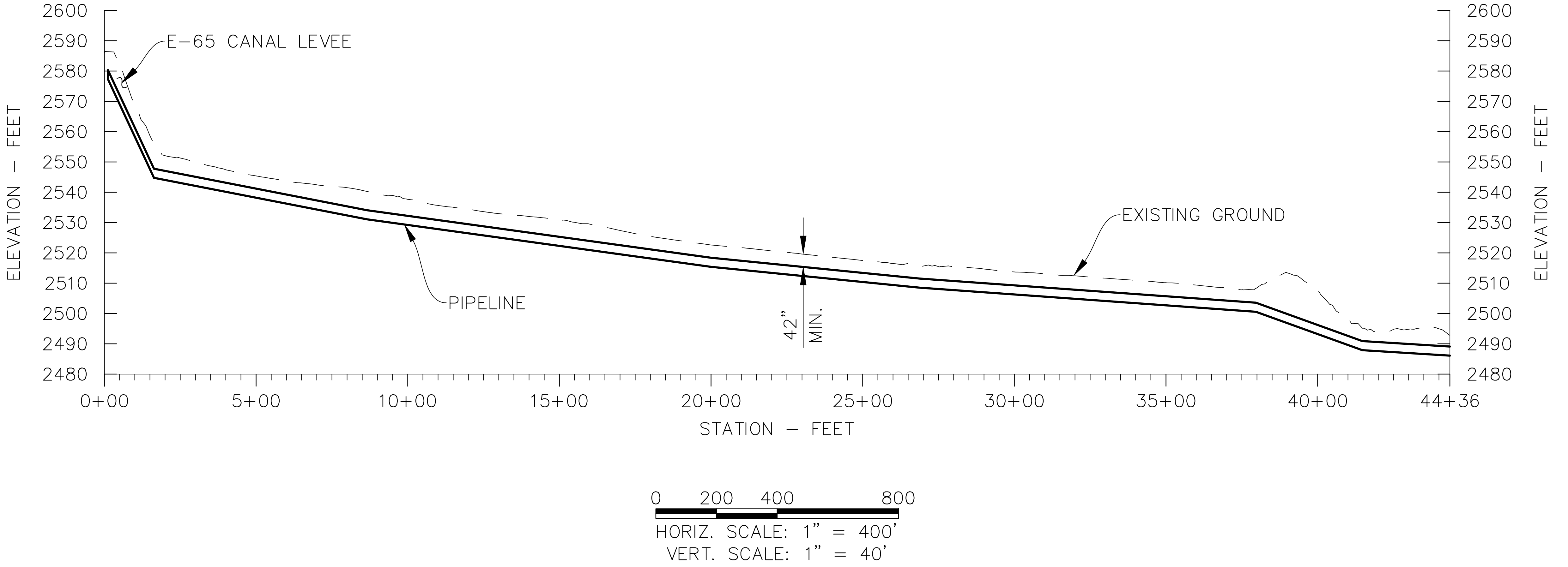
ELWOOD RECAPTURE
RECONNAISSANCE STUDY

PROJECT NO. 23138

ALTERNATIVE B
PIPE ALIGNMENT

July 2024

Figure 7



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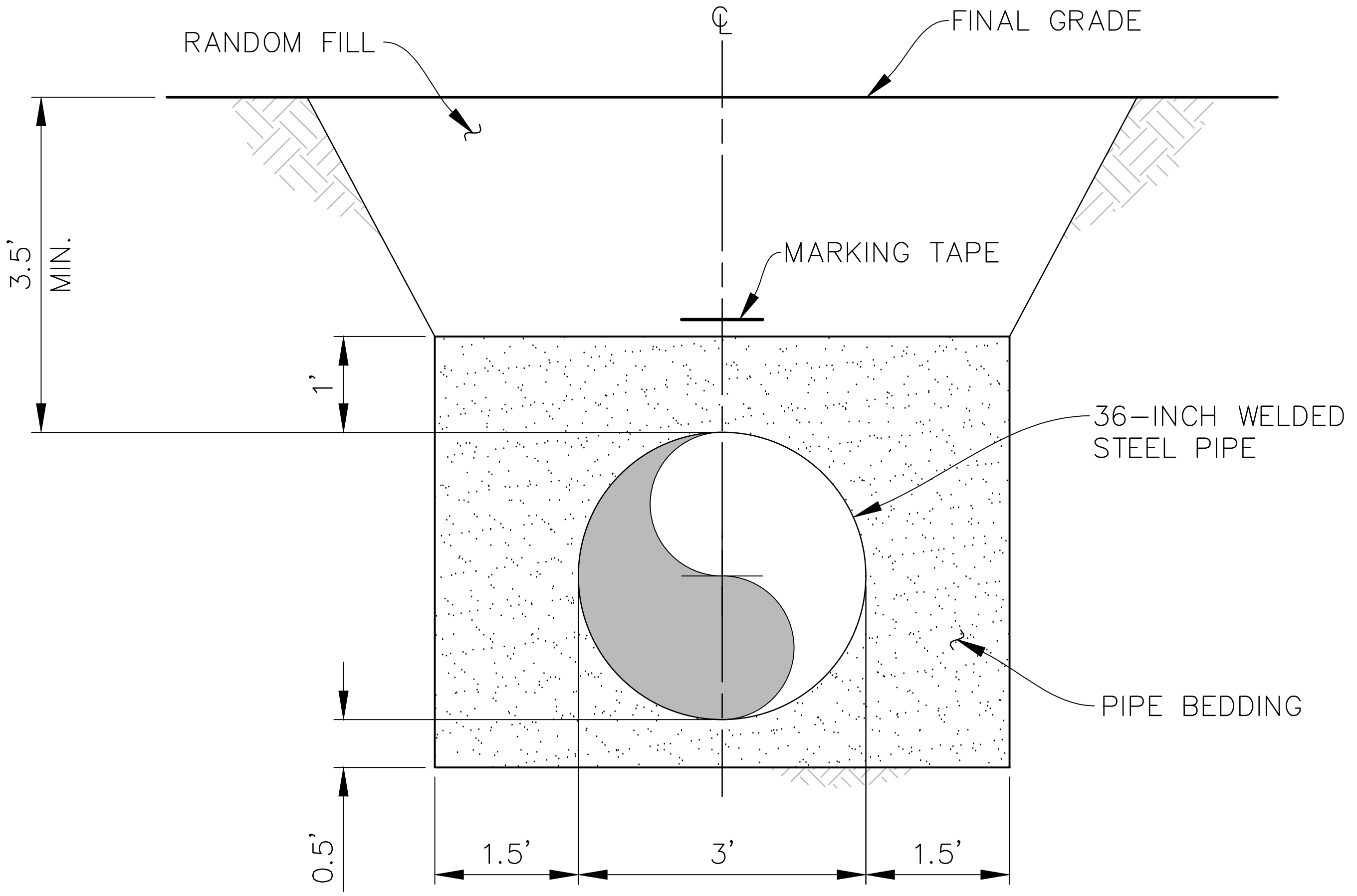
ELWOOD RECAPTURE
RECONNAISSANCE STUDY

PROJECT NO. 23138

ALTERNATIVE B
PIPE PROFILE

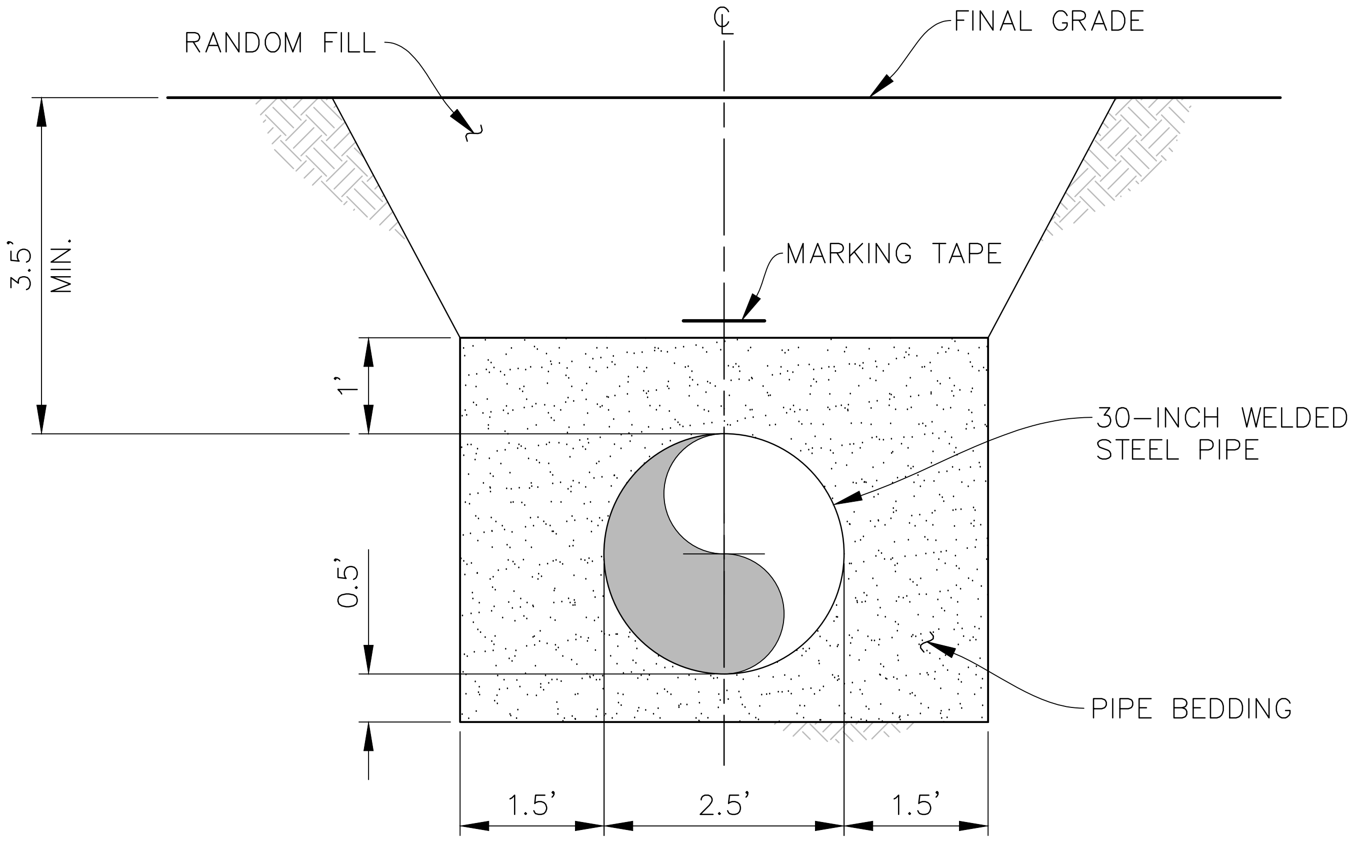
July 2024

Figure 8



ALTERNATIVE B1
100 CFS CHANNEL SECTION

0 1 2 4
SCALE IN FEET



ALERNATIVE B2
50 CFS CHANNEL SECTION

0 1 2 4
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PRELIMINARY
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CONSULTANTS, INC.

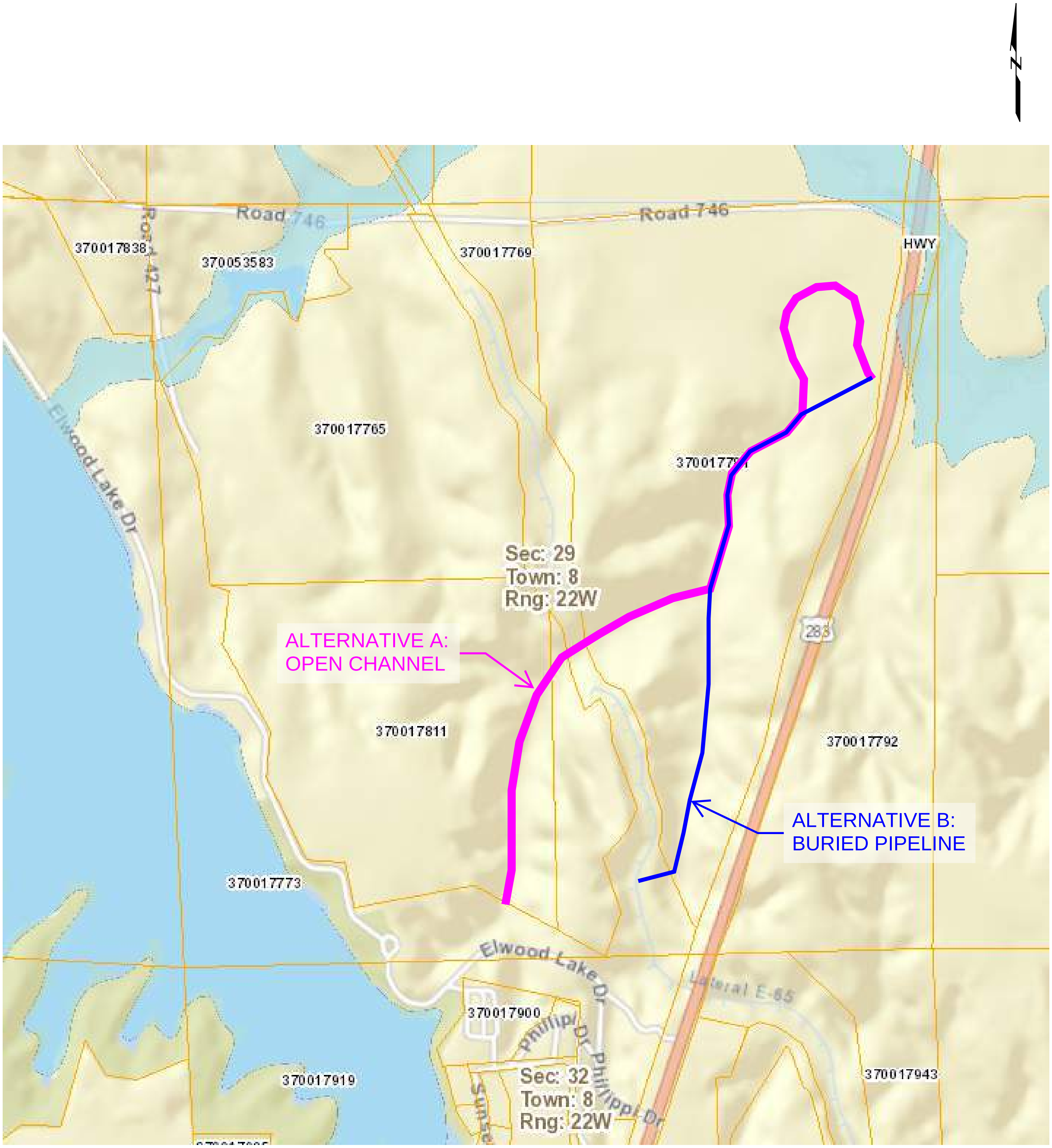
ELWOOD RECAPTURE
RECONNAISSANCE STUDY

ALTERNATIVE B
PIPE SECTION

PROJECT NO. 23138

July 2024

Figure 9



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PRELIMINARY
NOT FOR CONSTRUCTION

RJH CONSULTANTS, INC.

ELWOOD RECAPTURE
RECONNAISSANCE STUDY

PROPERTY MAP

PROJECT NO. 23138

July 2024

Figure 10

P:\23138 – ELWOOD RECAPTURE RECONNAISSANCE STUDY\CAD\MEMOFIGURES\23138_RECAPTURESTUDY.DWG 7/11/2024 2:28 PM

ATTACHMENT 1

ADDITIONAL DETAIL FOR COST OPINIONS

Cost Breakdown

Alternative A - Open Channel

Alternative A1 - *100 cfs*

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
1	Mobilization and Demobilization	LS	1	50,000	50,000
2	Clearing and Grubbing	LS	1	40,000	40,000
3	Excavation	CY	23,400	5	117,000
4	Type M Riprap	CY	12,100	130	1,573,000
5	Geotextile	SF	192,300	2	384,600
Base Construction Cost (BCC)					**2,164,600**
Design and Construction Contingency (30% of BCC)					649,380
Design Engineering (7% of BCC)					216,460
Construction Engineering and Management (10% of BCC)					259,752
Opinion of Probable Project Cost (OPPC)					**3,290,192**

Alternative A2 - *50 cfs*

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
1	Mobilization and Demobilization	LS	1	50,000	50,000
2	Clearing and Grubbing	LS	1	40,000	40,000
3	Excavation	CY	17,900	5	89,500
4	Type M Riprap	CY	10,300	130	1,339,000
5	Geotextile	SF	167,100	2	334,200
Base Construction Cost (BCC)					**1,852,700**
Design and Construction Contingency (30% of BCC)					555,810
Design Engineering (7% of BCC)					185,270
Construction Engineering and Management (10% of BCC)					222,324
Opinion of Probable Project Cost (OPPC)					**2,816,104**

Cost Breakdown

Alternative B - Buried ***Steel*** Pipeline

Alternative B1 - *100 cfs*

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
1	Mobilization and Demobilization	LS	1	50,000	50,000
2	Clearing and Grubbing	LS	1	32,000	32,000
3	36" Welded Steel Pipe, Bedding, and Excavation	LF	4,500	890	4,005,000
4	Energy Dissipation Structure and Riprap Rundown	LS	1	193,000	193,000
5	Canal Gate, Structure, and Instrumentation	LS	1	1,700,000	1,700,000
6	Slide Gate, Turnout Structure, and Instrumentation	LS	1	250,000	250,000
Base Construction Cost (BCC)					**6,230,000**
Design and Construction Contingency (30% of BCC)					1,869,000
Design Engineering (7% of BCC)					623,000
Construction Engineering and Management (10% of BCC)					747,600
Opinion of Probable Project Cost (OPPC)					**9,469,600**

Alternative B2 - *50 cfs*

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
1	Mobilization and Demobilization	LS	1	50,000	50,000
2	Clearing and Grubbing	LS	1	32,000	32,000
3	30" Welded Steel Pipe, Bedding, and Excavation	LF	4,500	620	2,790,000
4	Energy Dissipation Structure and Riprap Rundown	LS	1	134,000	134,000
5	Canal Gate, Structure, and Instrumentation	LS	1	1,700,000	1,700,000
6	Slide Gate, Turnout Structure, and Instrumentation	LS	1	230,000	230,000
Base Construction Cost (BCC)					**4,936,000**
Design and Construction Contingency (30% of BCC)					1,480,800
Design Engineering (7% of BCC)					493,600
Construction Engineering and Management (10% of BCC)					592,320
Opinion of Probable Project Cost (OPPC)					**7,502,720**

Cost Breakdown

Alternative B - Buried ***PVC*** Pipeline

Alternative B1 - 100 cfs

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
1	Mobilization and Demobilization	LS	1	50,000	50,000
2	Clearing and Grubbing	LS	1	32,000	32,000
3	36" PVC Pipe, Bedding, and Excavation	LF	4,500	550	2,475,000
4	Energy Dissipation Structure and Riprap Rundown	LS	1	193,000	193,000
5	Canal Gate, Structure, and Instrumentation	LS	1	1,700,000	1,700,000
6	Slide Gate, Turnout Structure, and Instrumentation	LS	1	250,000	250,000
Base Construction Cost (BCC)					**4,700,000**
Design and Construction Contingency (30% of BCC)					1,410,000
Design Engineering (7% of BCC)					470,000
Construction Engineering and Management (10% of BCC)					564,000
Opinion of Probable Project Cost (OPPC)					**7,144,000**

Alternative B2 - 50 cfs

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
1	Mobilization and Demobilization	LS	1	50,000	50,000
2	Clearing and Grubbing	LS	1	32,000	32,000
3	30" PVC Pipe, Bedding, and Excavation	LF	4,500	450	2,025,000
4	Energy Dissipation Structure and Riprap Rundown	LS	1	134,000	134,000
5	Canal Gate, Structure, and Instrumentation	LS	1	1,700,000	1,700,000
6	Slide Gate, Turnout Structure, and Instrumentation	LS	1	230,000	230,000
Base Construction Cost (BCC)					**4,171,000**
Design and Construction Contingency (30% of BCC)					1,251,300
Design Engineering (7% of BCC)					417,100
Construction Engineering and Management (10% of BCC)					500,520
Opinion of Probable Project Cost (OPPC)					**6,339,920**

ATTACHMENT E

Recapture Well Assessment

(LRE – August 26, 2024)

CONNECTING WATER TO LIFE

Memorandum

To:	Seth Turner, Platte River Recovery Program
From:	Mark Mitisek, LRE Water, Inc.
Date:	August 27, 2024
Project:	Expanded Recapture Reconnaissance
Subject:	Study Recapture Well Assessment

Background

Recapture wells add a controllable element to recharge projects that otherwise generate return flows to the Platte River over which the Program has no control of timing, magnitude, or location through accretions. Recapture wells currently play an important role in maximizing the benefit of the Program's existing recharge projects by discharging groundwater directly to the Platte River specifically during periods with deficits to target flows at Grand Island. Similarly, the use of recapture wells by NeDNR could help to maximize the net benefit to the Platte River during times of shortage.

Purpose

The purpose of the recapture well assessment is to determine the feasibility of adding new recapture wells and net benefit to the Platte River for both the Program and NeDNR. Evaluating a range of conceptual wellfields to understand infrastructure requirements, costs, and net benefits (score) to support a comparative Trade Off analysis. The assessment focused on the following questions:

- Would additional recapture wells improve the net benefit to the river?
- What is a practical number of new wells?
- What would the well sizes and yields be expected to meet project goals?
- How does well location impact net accretions to the Platte River?
- What is the range of costs for implementing additional/recapture wells?

Existing Recapture Wells

Beginning in October 2016, the Program began the operation of a single recapture well on the Program-owned Cook tract. Referred to as the Cook Well (G-178735), this recapture well discharges into to the North Phelps County Drain, which traverses Program land directly to the Platte River. In 2022, the Program partnered with TBNRD to install seven additional recapture wells near the Program's Cottonwood Ranch recharge project. **Figure 1** shows the location of the 8 existing recapture wells. On average, the existing recapture well network can provide up to 10-12 cfs to the Platte River, supporting a score of around 160 AF/well (Note the Cook Well is the only recapture well to be officially scored). Pumping yield, well specifications, and cost information for all the Program's existing recapture wells was provided by the EDO staff and used throughout this assessment for comparative purposes, modeling assumptions, and in support of estimated capital and O&M costs.

Hydrogeologic Cross Sections

LRE's recapture well assessment began with the completion of two hydrogeologic cross-sections that provided a visual description of the type, location, and depth of all wells south of the Platte River from west to east (A to A') and along Plum Creek downstream of Elwood Reservoir (B to B') as shown in **Figure 2**. Registered well logs from the NeDNR Groundwater Well Database were used to characterize both the alluvial and Ogallala aquifers. Areas of greater saturated thickness were identified, and the similar groundwater elevations of both aquifers indicated that they are in hydrogeologic connection with each other. All of the wells in the Project Area were completed in either the alluvial aquifer, the Ogallala aquifer, or both. Well depths, pumping yields, screening intervals, and hydraulic heads (static water levels) were used to inform the selection of new recapture areas. The cross sections can be found in **Figures 3 and 4**.

Natural Conveyance

One of the initial goals was to site a recapture wellfield near a natural drainageway to save cost for conveyance to the Platte River or Plum Creek. Although this was a factor in the selection of conceptual recapture areas described below, a desktop and windshield survey of natural conveyances and drains in the Project Area determined that most natural drainages were dry and that the most effective method to deliver recapture water was through an underground pipeline. Adding water to ephemeral or intermittent streams has created challenges for the TBNRD and PRRIP with erosion, phragmites, beavers, seepage, and transit losses. It was determined that conveyance via natural drainages was likely not a feasible option.

Figure 1 – Existing Recapture Well Network

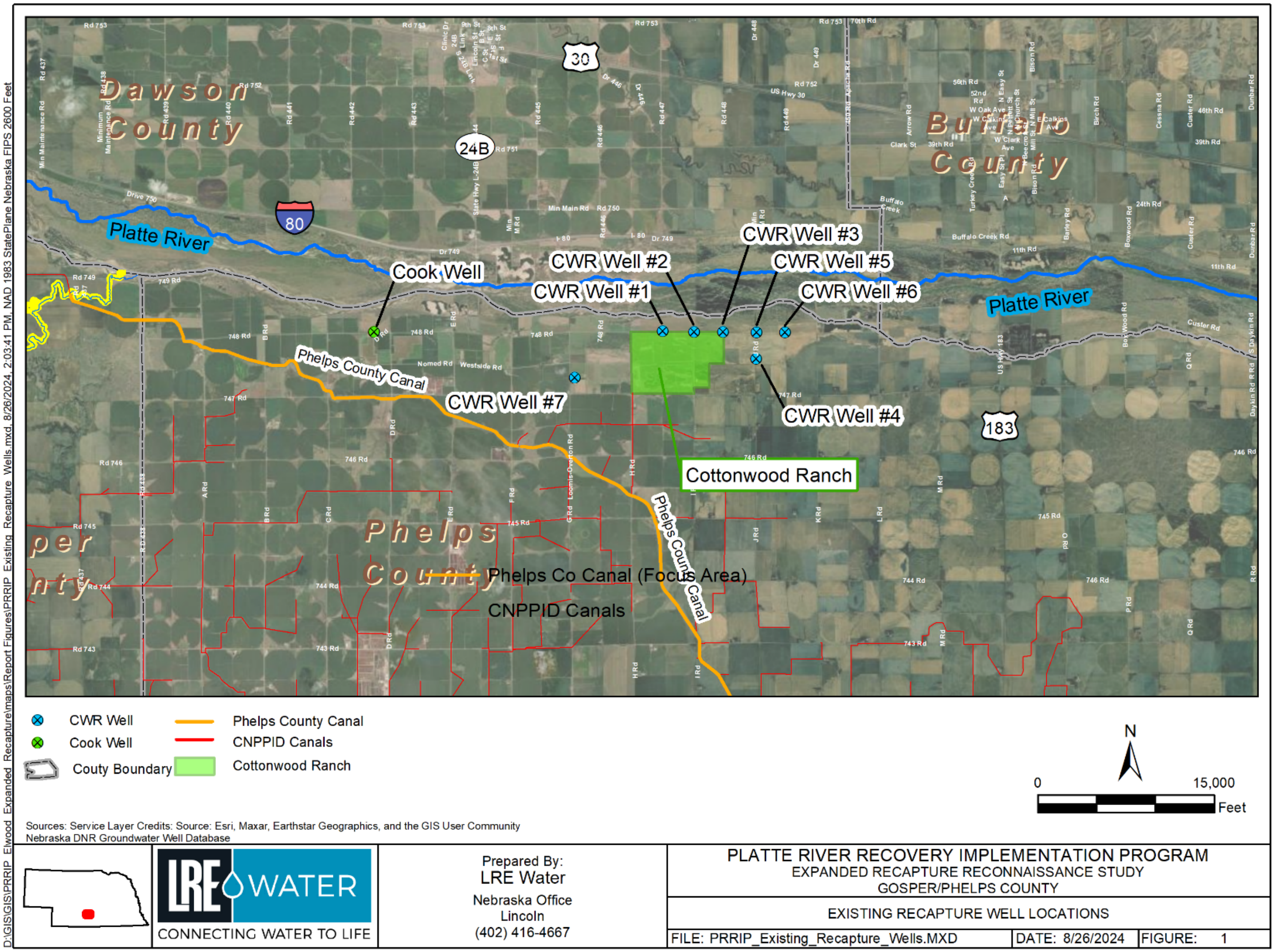


Figure 2 – Cross Section Locations

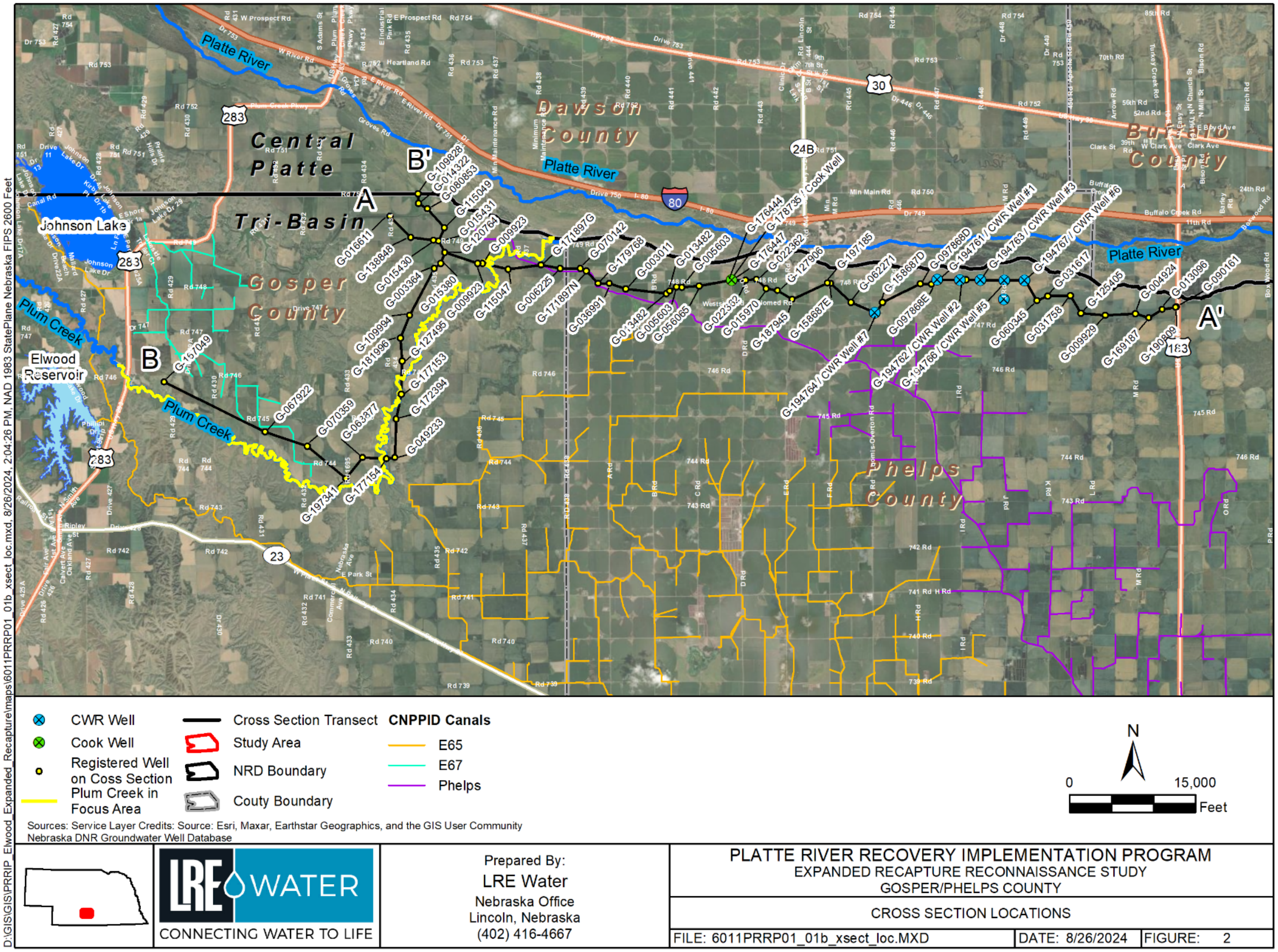
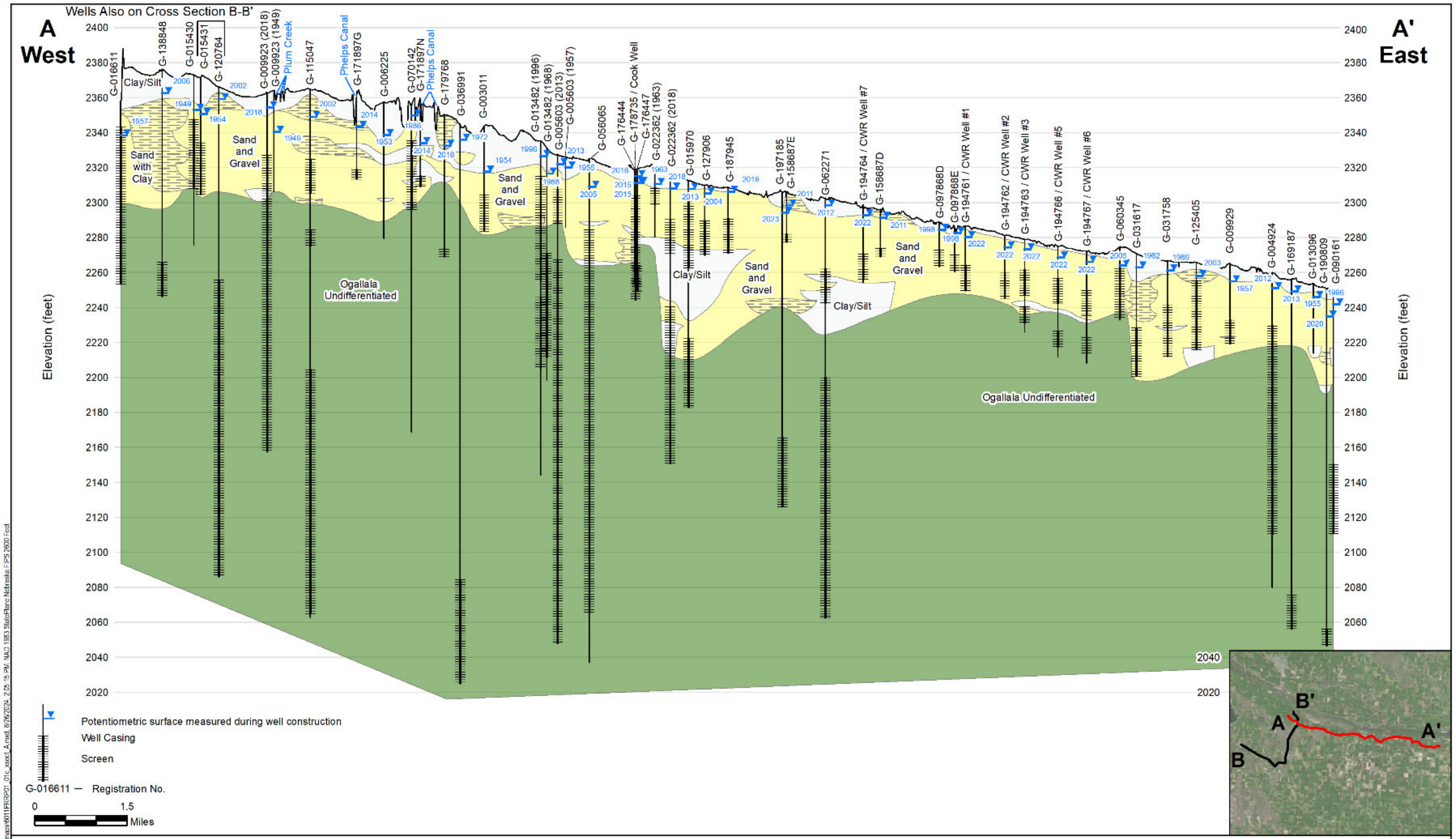


Figure 3 – Cross Section A – A’



Geologic Contact (all contacts are inferred)
Clay/Silt (clay, sandy clay, and silt undifferentiated - low-permeable confining geologic layer)
Clayey Sand (sand, gravel, with clay and silt)
Sand and Gravel (Undifferentiated with minore component of clay or silt)
Ogallala (unconsolidated to semi-consolidated silt, sand, gravel, sandstone, limestone)

Unconsolidated referes to Quaternary deposits (i.e., sand, gravel, glacial till, loess, etc.) including sand derived from weathered Ogallala Formation where it cannot be differentiated from overlying Quaternary sand.)

Note: Geologic contacts are interpreted from well logs from Nebraska DNR Groundwater Well Database.

Drawn: 8/26/2024
Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, IGN, and the GIS User Community Nebraska DNR Groundwater Well Database

LRE WATER
CONNECTING WATER TO LIFE

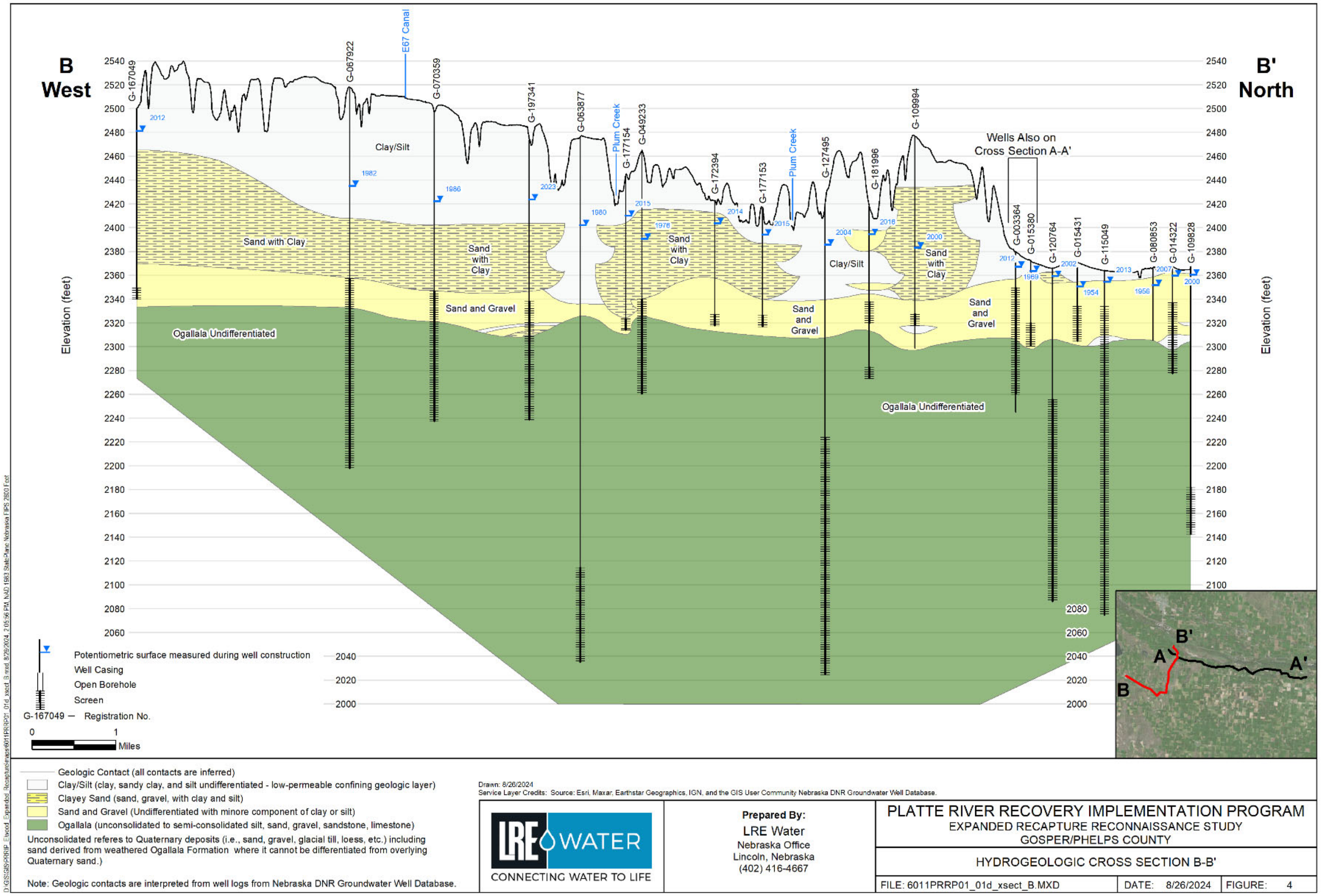
Prepared By:
LRE Water
Nebraska Office
Lincoln, Nebraska
(402) 416-4667

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
EXPANDED RECAPTURE RECONNAISSANCE STUDY
GOSPER/PHELPS COUNTY

HYDROGEOLOGIC CROSS SECTION A-A'

FILE: 6011PRRP01_01c_xsect_A.MXD	DATE: 8/26/2024	FIGURE: 3

Figure 4 – Cross Section B – B’

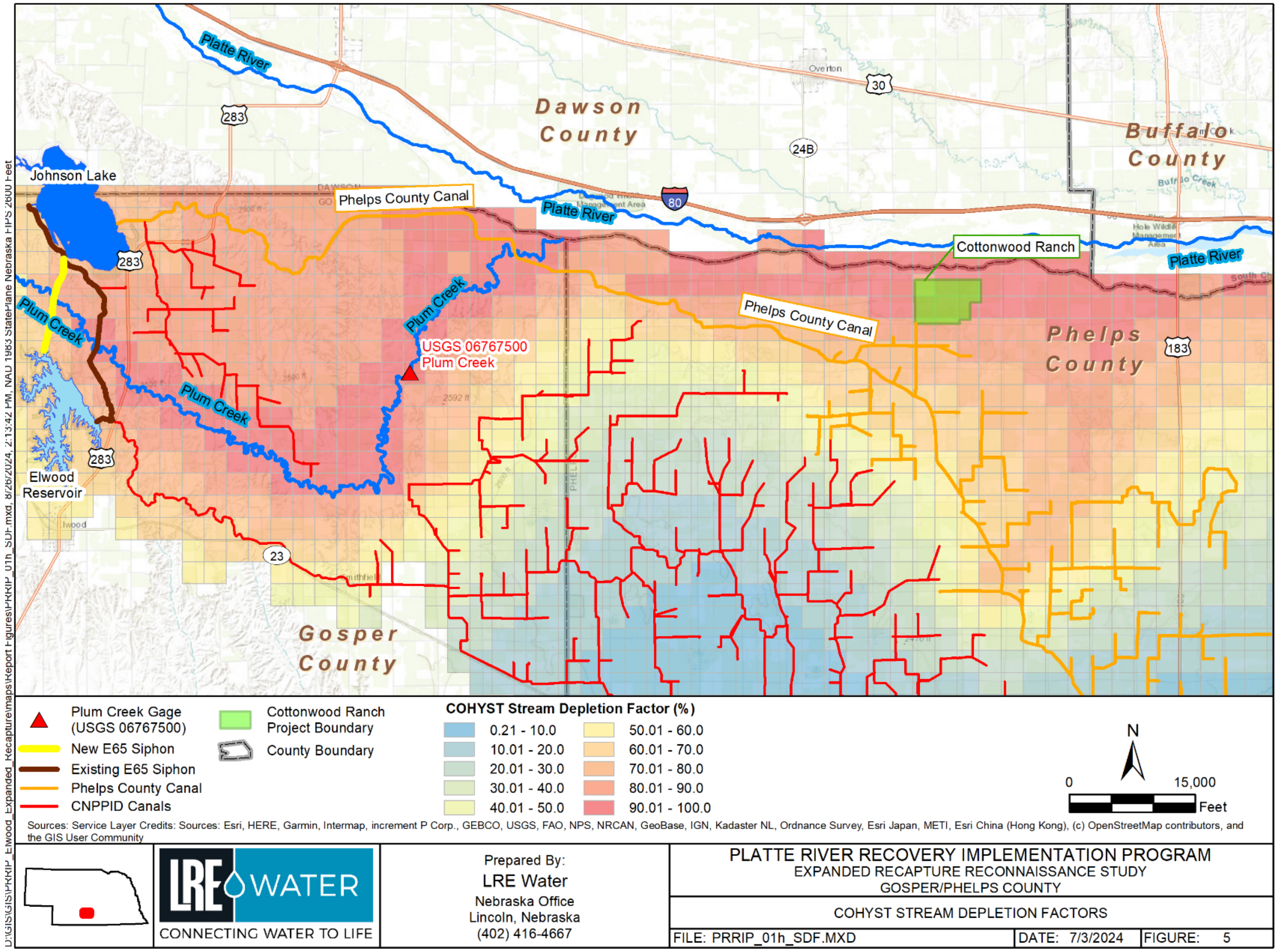


Stream Depletion Factors

The effects of groundwater pumping on surface water take time to occur. The flow and storage of water in a groundwater system strongly depend on the aquifer's hydraulic properties, such as the hydraulic conductivity. Initially, the effects of groundwater pumping are seen as changes in the nearby aquifer groundwater level. However, as time goes on, in areas where groundwater and surface water are hydrologically connected, the relative effect to streamflow increases. Generally, the farther a well is from a stream, the longer the lag time between pumping and observed depletions to streamflow. To compare depletions between locations, water managers in Nebraska use a Stream Depletions Factor (SDF), which is the proportion of streamflow depletions relative to total groundwater pumping in a given length of time.

A gridded SDF data set for the Project Area generated from the Platte River Cooperative Hydrology Study (COHYST) numerical groundwater model provided by NeDNR staff was used in this study to identify areas/zones of high/low hydrologic connectivity. **Figure 5** shows the range of SDF values in the Project Area with higher SDF values (>80) close to the river indicating high hydrologic connectivity and SDF values decreasing further from the river/stream indicating lower hydrologic connectivity.

Figure 5 – COHYST Stream Depletion Factors



Recapture Zones

As part of the assessment, LRE was tasked with evaluating the performance of conceptual wellfields considering a variety SDFs. The goal is to understand the trade-offs associated with recapture wells, explore the range of possible project configurations, assess the benefits and challenges of each site, and estimate the costs of developing new/additional recapture wells.

To facilitate this evaluation, recapture zones were created to group different ranges of SDFs representing varying distances from the river, with similar characteristics. Three recapture zones shown in **Figure 6** were delineated based on the proximity to existing drainageways, covering a wide range of SDFs, and potential locations where a conceptual wellfield could be placed with minimal or no disruption to active row crop agricultural operations. The boundaries were largely delineated based upon COHYST model grids. Actual well siting criteria, discussed later, were not taken into consideration for this conceptual evaluation. Prior to planning for new/additional recapture wells, site specific studies and evaluation would be required.

Recapture Zone 1

Recapture Zone 1 includes a proposed land area relatively close (0 to 2 miles) to the Platte River or Plum Creek and generally within an SDF zone > 80 and with existing conveyance (stream or drain) that is may possibly convey flows naturally to the Platte River or be routed by a relatively short pipeline. In general, the area can be described as starting on the west side, near Highway 283 just east of Elwood Reservoir, the Platte River to the north (also the TBNRD boundary), Road K to the east of CWR, and mostly north of the Phelps County Canal, except for an area west of A Road, where the area meets the Plum Creek watershed.

Recapture Zone 2

Proposed recapture sites are located between 2 to 5 miles south of the Platte River and south of Phelps County Canal, in a range of SDF zone between 60 and 80. Conveyance of recapture water from a wellfield located in Zone 2 would require a pipeline, including a crossing of Phelps County Canal, to reach the Platte River. The Zone 2 area is irregularly shaped and bound in general to the north by the Phelps County Canal, south by County Rd 745 and 747, and to the east at K Rd.

Recapture Zone 3

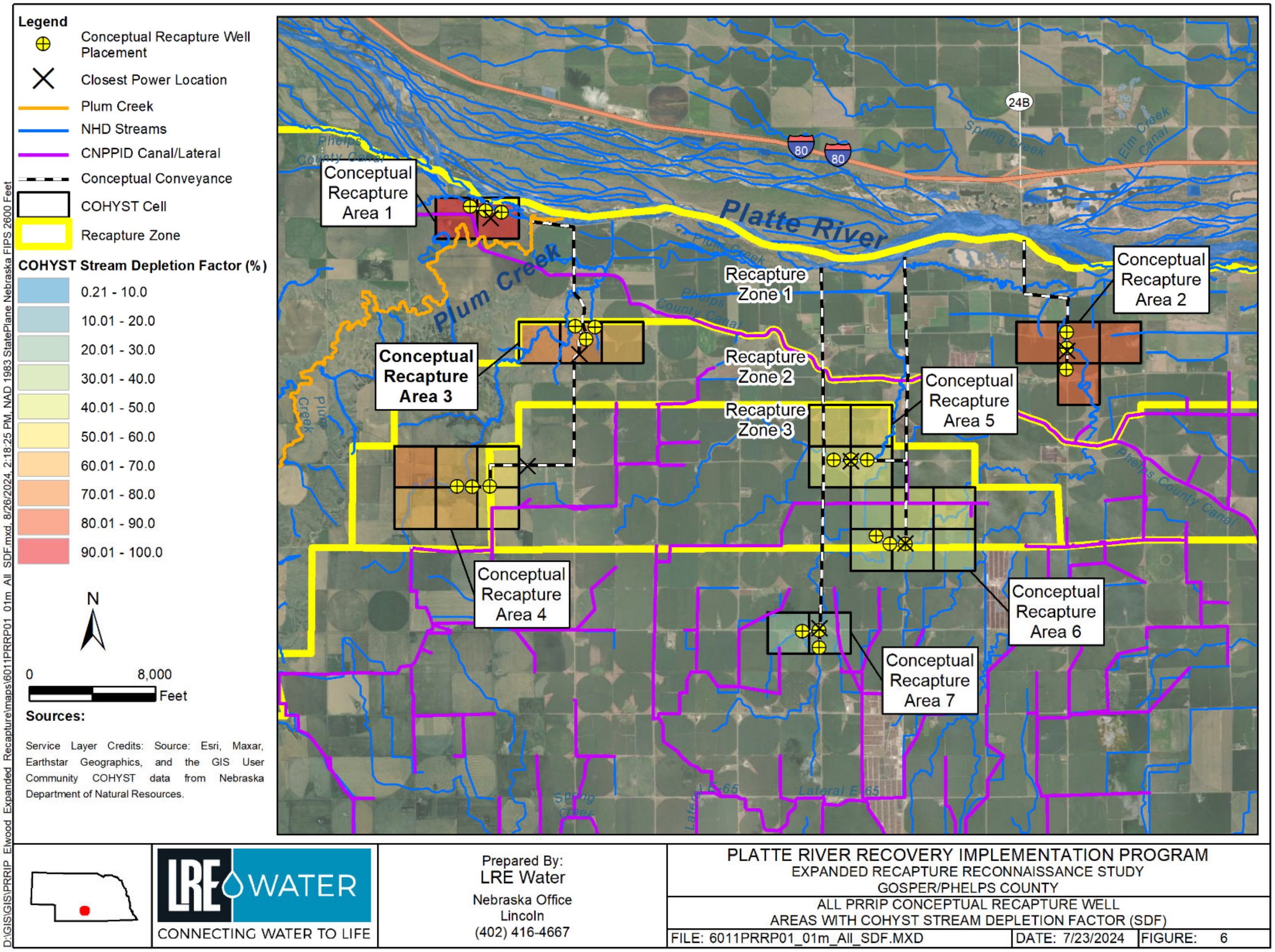
The Zone 3 area covers an SDF zone ranging from 30 to 60. Proposed recapture sites are located more than 3 to 5 miles from the Platte River and south of Phelps County Canal and require constructed conveyance infrastructure. The Zone 3 area is bound north between 747 Rd and 746 Rd, south by 745 Rd, east by F Rd, and west by Rd 437.

Conceptual Recapture Well Sites (Recapture Areas)

Seven conceptual well sites (recapture areas) within the established recapture zones were then identified with the assistance of Program staff, based on proximity to natural conveyance/drains and power, land use, well spacing, and avoidance of competing water sources. **Figure 6** shows the location of each conceptual well site within recapture zones 1-3 including the siting of three networked wells with one discharge pipeline and a conveyance pipeline to the river. Maps of conceptual well sites and pipelines for each recapture area are included in Attachment 1. Cost estimates costs for each recapture area were established based on well log information from nearby alluvial wells including well depths and screen intervals necessary to estimate well costs.

Conceptual pipeline alignments were also developed to connect conceptual well sites each recapture zone together utilizing County roads right of way. Pipeline segment lengths were also calculated to support conveyance pipeline costs estimates. Taking into account hydraulic requirements of connecting pipes and cumulative flow rates based on cumulative well yield requirements.

Figure 6 – Recapture Zones and Conceptual Well Fields



Recapture Well Site Requirements

Key to the recapture well assessment and to the management and use of recapture wells is the performance and accounting of each recapture well's net benefit in terms of reducing deficits to target flows at Grand Island. Analyses show that recapture wells located closer to the river provide less net benefit to the river because pumping has a larger near term depletive effect on recharge accretions to the stream. Essentially, recapture wells located in close proximity to the river provide the benefit of pumping during periods of shortage but much of the pumped water would have reached the river in a similar time frame anyway. Conversely, recapture wells farther from the river provide greater net benefits because pumping has a lesser near term effect on recharge accretions to the stream. This dynamic is important as recapture wells close to the stream can outpace recharge accretions if not carefully managed, ultimately increasing target flow deficits, while recapture wells farther from the stream can pump substantially more with smaller impacts to recharge accretions. This dynamic is important to quantify and understand both net benefits to the river and infrastructure capacity requirements (cost) of conceptual well sites.

To represent this dynamic an aquifer balance model was developed using GoldSim to optimize the well capacity and number of wells required in each recapture scenario based upon available recharge and existing recapture wells are operations (See GoldSim Model Documentation and Assumptions for additional information about the GoldSim model). The model was run in each recapture zone for the Program and NeDNR scenarios separately. Program well requirements are based on available recharge from Elwood Reservoir and Phelps County Canal assuming 8 existing recapture wells are operating. NeDNR well requirements are only based on available recharge from Elwood Reservoir.

Table 1 below summarizes the well requirements for each recapture area for the Program and NeDNR.

Table 1 - Program and NeDNR Recapture Well Requirements

Recapture Zone	Recapture Area	COHYST SDF	Average Well Yields* (gpm)	Average Well Depth* (ft)	Average Screen Length* (ft)	Program Well			NeDNR Well		
						Well Field Capacity (gpm)	Well Count	Well Capacity (gpm)	Well Field Capacity (gpm)	Well Count	Well Capacity (gpm)
1	1	94.2	913	48	28	1,800	3	600	2,700	3	900
	2	87.2	814	51	26	1,800	3	600	2,700	3	900
2	3	71.7	767	360	22	1,500	3	500	2,100	3	700
	4	64.8	665	242	45	1,500	3	500	2,100	3	700
3	5	45.7	1085	287	60	3,000	3	1,000	2,700	3	900
	6	33.7	1058	215	80	3,000	3	1,000	2,700	3	900

*Averge well yields, well depths, and screen intervals based on averages from nearby wells from the NeDNR well database.

Recapture Well Costs

To estimate the cost of developing recapture zones 1-3 a comprehensive cost tool was created (see Cost Analysis for detailed cost information for each recapture zone) incorporating unit capital costs for each conceptual well field and pipeline. Unit cost for wells and conveyance were developed based on Program costs associated with the recent development of Cottonwood Ranch wells from 2019 and updated with 2024 pipe costs.

Well counts and conveyance infrastructure cost estimates for each zone are based on well and pipeline capacities described in Table 1 with a max of 6 wells per recapture zone (3 in each recapture area). Costs represent well capacities ranging from 500 gpm to 1,000 gpm, well depths from 48 to 360 feet, and conveyance pipelines from 2.53 to 4.68 miles depending on the performance requirements for each recapture zone. **Table 2** summarizes well, conveyance pipeline (PVC & steel), and total capital cost estimates for each recapture zone.

Table 2 – Well and Conveyance Pipeline Capital Cost Summary

Program Well and Pipeline Requirements and Capital Cost for Additional Recapture Wells

Requirement	Recapture Zone 1 (Recapture Area 1 & 2)		Recapture Zone 2 (Recapture Area 3 & 4)		Recapture Zone 3 (Recapture Area 5 & 6)	
Well Count	6		6		6	
Well Capacity (gpm/well)	600		500		1000	
Well Cost ($)*	$475,474		$653,862		$709,038	
Conveyance Pipeline (Miles)	2.53 miles[1]		5.61 miles[2]		4.68 miles[3]	
Pipeline Cost ($)*	PVC	Steel	PVC	Steel	PVC	Steel
	$1,727,220	$2,630,343	$4,180,477	$6,555,857	$7,401,977	$12,108,169
OPPC ($)*	**$2,202,694**	**$3,105,817**	**$4,834,340**	**$7,209,720**	**$8,111,015**	**$12,817,207**

*Costs include a 30% design and construction contingency

1. Recapture Zone 1 includes the following estimated pipe capacities: 10" = 0.63 mi, 12" = 0.19 mi, 14" = 1.72 mi
2. Recapture Zone 2 includes the following estimated pipe capacities: 8" = 0.57 mi, 12" = 3.11 mi, 18" = 1.93 mi
3. Recapture Zone 3 includes the following estimated pipe capacities: 12" = 0.38 mi, 16" = 0.38 mi, 18" = 1.46 mi, 24" = 2.46 mi

NeDNR Well and Pipeline Requirements and Capital Cost for New Recapture Wells

Requirement	Recapture Zone 1 (Recapture Area 1 & 2)		Recapture Zone 2 (Recapture Area 3 & 4)		Recapture Zone 3 (Recapture Area 5 & 6)	
Well Count	6		6		6	
Well Capacity (gpm/well)	900		700		900	
Well Cost ($)*	$521,365		$684,457		$693,741	
Conveyance Pipeline (Miles)	2.53 miles[1]		5.60 miles[2]		4.68 miles[3]	
Pipeline Cost ($)*	PVC	Steel	PVC	Steel	PVC	Steel
	$2,642,526	$4,155,853	$5,756,970	$9,287,854	$7,301,429	$11,940,589
OPPC ($)*	**$3,163,891**	**$4,677,218**	**$6,441,427**	**$9,972,311**	**$7,995,170**	**$12,634,330**

*Costs include a 30% design and construction contingency

1. Recapture Zone 1 includes the following estimated pipe capacities: 10" = 0.63 mi, 14" = 0.19 mi, 18" = 1.72 mi
2. Recapture Zone 2 includes the following estimated pipe capacities: 10" = 0.57 mi, 12" = 0.19 mi, 16" = 2.92 mi, 20" = 1.93 mi
3. Recapture Zone 3 includes the following estimated pipe capacities: 10" = 0.38 mi, 14" = 0.38 mi, 18" = 1.46 mi, 24" = 2.46 mi

Recapture Well Siting Criteria

For the assessment, the wellfields were conceptual in nature, with a limited effort on siting wells in ideal locations. Below is a summary of the criteria to be considered when siting wells or wellfields as part of a more refined planning and design effort:

- Existing Land Cover - siting wells in locations outside of cropland and active pastures. Target open space, grass fence lines, and similar land areas without active agricultural operations.
- Hydrogeology – complete a hydrogeologic study to identify areas with sufficient saturated thickness to meet pumping demands. Hydrogeologic studies can be used to identify potential concerns with well interference and provide supporting information to groundwater models.
- Distance from the River - identify areas outside of the floodway. In the past, wells have been constructed in the 100-year floodplain (1% chance event) without being required to build above the floodplain elevation.
- Net Benefit to the Platte River – lower SDF will yield a higher net benefit.
- Max Wells Available/Well Spacing Requirements – due to the high density of irrigation, private domestic wells, and stock wells, well spacing could be a challenge, especially if wells are built in a network and pump a total capacity greater than 1,000 GPM. Early coordination with TBNRD will be important prior to siting recapture wells. A cumulative impact analysis may be needed to evaluate the cumulative impacts of multiple wells on the overall groundwater system and surrounding environment. The use of a groundwater model may provide evidence necessary to support a request of a variance from TBNRD on well spacing requirements.
- Natural Conveyance – a windshield and desktop survey of active waterways revealed that many appear to dry most of the time. Adding water to a dry waterway could create challenges with Phragmites, beavers, and create challenges for agricultural crossings.
- Conveyance Infrastructure Requirements – engineering design will be required to update cost, properly size any necessary pipeline, creek or canal crossing, etc.
- Aquifer Pumping Test – an aquifer pumping or capacity test will provide aquifer characteristics to support well design and help ensure each well provides the maximum yield.
- Site Requirements/Constraints – consideration should be given to site constraints such as the floodplain, access to power lines, avoiding disruption of agricultural operations, and ease of access for operation and maintenance.

- Estimated Yield – carefully designing the well casing based upon sieve analysis to determine an adequate screen location and size, well development, and completion methods can boost yield.

- Estimated Score - a proposed well or wellfield should be reanalyzed using GoldSim and similar methodologies completed by LRE and EDO staff to support this study.

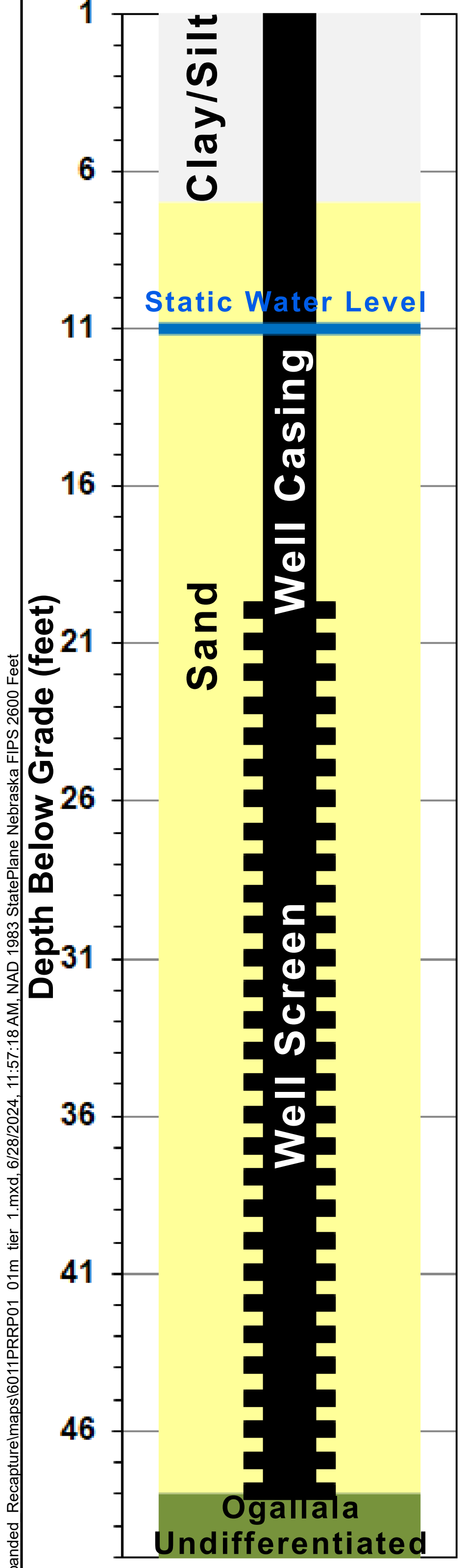
- Permitting Requirements – consideration should be given to limiting impacts to wetlands and WOUS and coordinating with TBNRD on well permits and adequate spacing.

- Land Ownership and Easements – early communication with property owners can expedite the process for acquiring easements or purchasing property for wells and associated infrastructure.

- Competing Water Sources – groundwater modeling and/or well inference assessments will help identify potential impacts to neighboring groundwater users.

Attachment 1
Conceptual Well Fields

CONCEPTUAL GEOLOGY AND WELL DESIGN



Legend

- ⊕ Conceptual Recapture Well Placement
- ● NeDNR Registered Well Used in Well Design
- ✕ Closest Power Location
- NHD Streams
- CNPPID Canal/Lateral
- Conceptual Conveyance
- ☐ COHYST Cell
- ☐ Parcel Boundary
- ☐ Recapture Zone

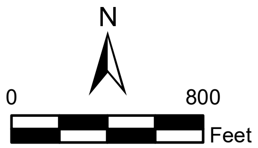
NeDNR Permitted Acres

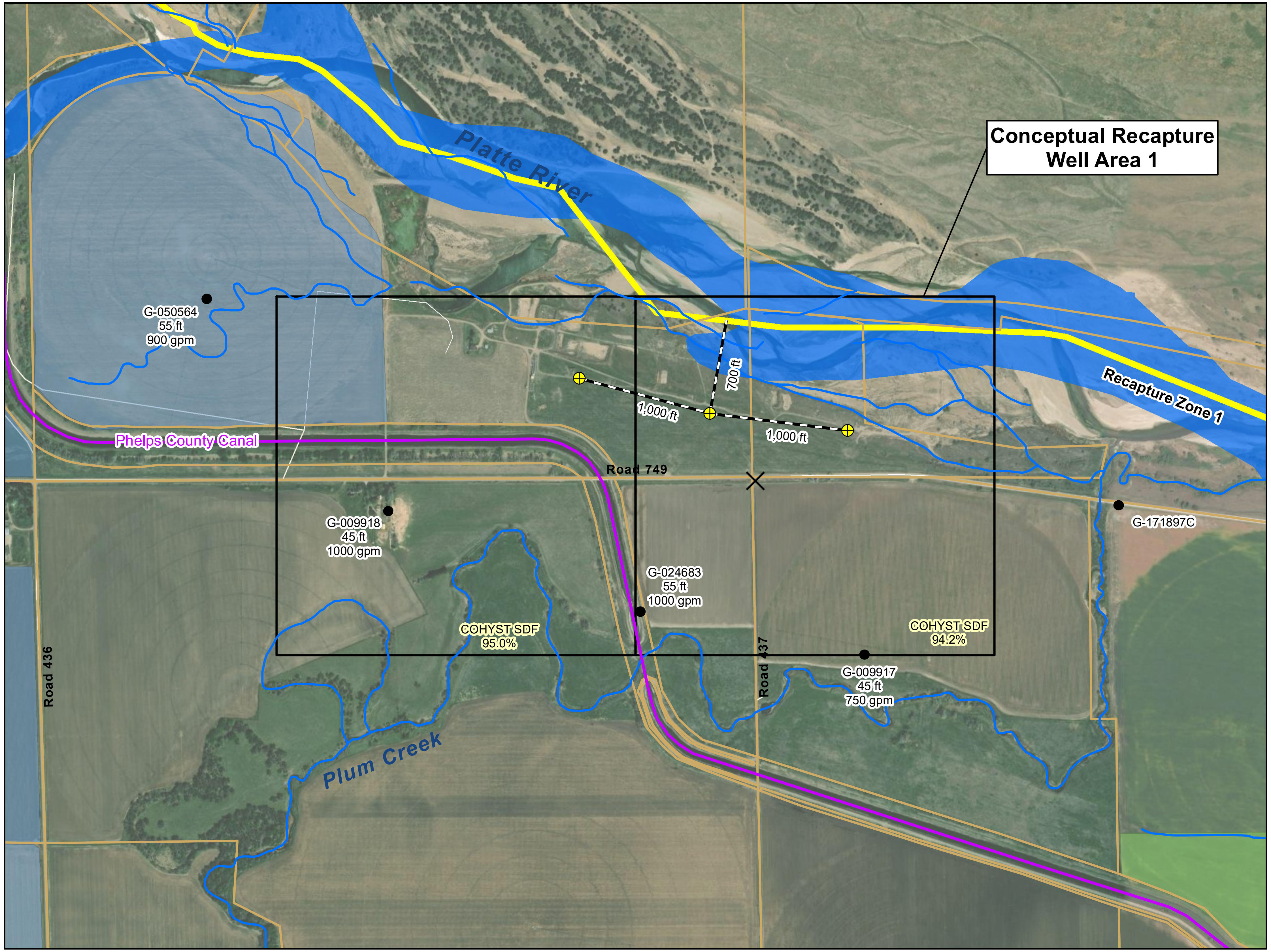
- ▨ DNR Commingled
- ▨ Surface Water (NeDNR)
- ▨ Commingled (NRD)
- ▨ Groundwater (NRD)

Conceptual Well Design Averaged From Nearby Alluvial Wells:

Static Water Level: 11 ft
Screen Interval: 20-48 ft
Well Depth: 48 ft
Yield: 913 gpm

ft: feet
gpm: gallons per minute





Sources:

Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
Nebraska DNR Groundwater Well Database. COHYST data from Nebraska Department of Natural Resources. Statewide Permitted Acres from Department of Natural Resource.

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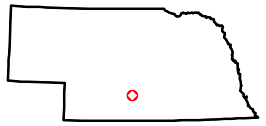

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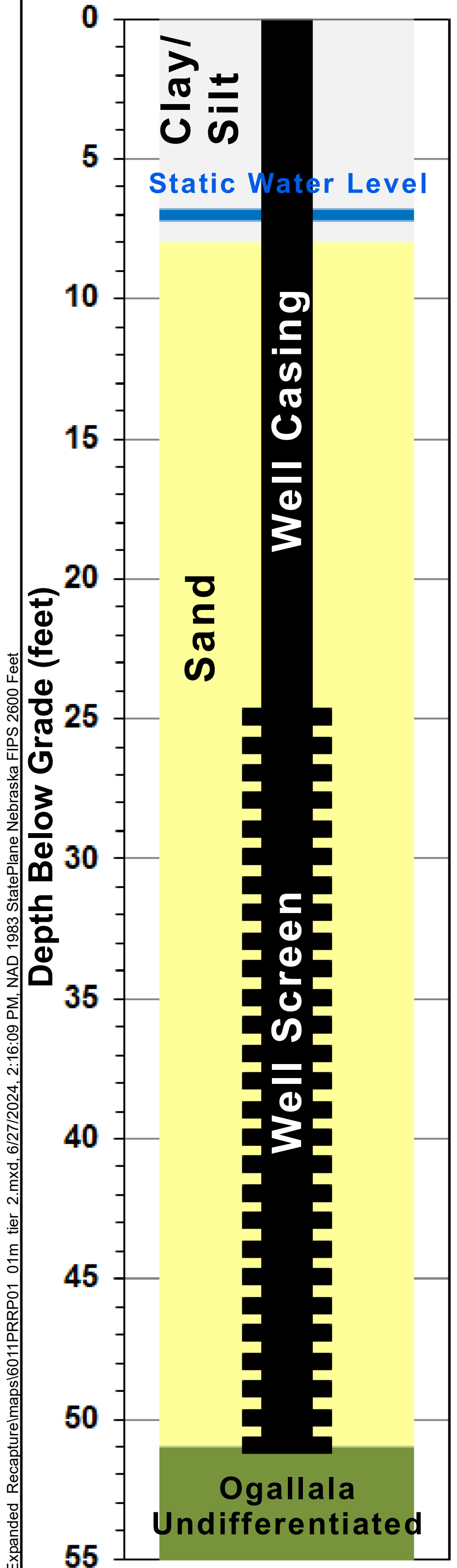
GOSPER/PHELPS COUNTY

PRRIP CONCEPTUAL RECAPTURE WELL AREA 1 WITH 1,000 FT SPACING

FILE:6011PRRP01_01m_tier_1.MXD | DATE: 6/28/2024 | FIGURE: 1

C:\GIS\GIS\PRRIP_Elwood_Expanded_Recapture\maps\6011PRRP01_01m_tier_2.mxd, 6/27/2024, 2:16:09 PM, NAD 1983 StatePlane Nebraska FIPS 2600 Feet

CONCEPTUAL GEOLOGY AND WELL DESIGN



Legend

- ⊕ Conceptual Recapture Well Placement
- ● NeDNR Registered Well Used in Well Design
- ✕ Closest Power Location
- NHD Streams
- CNPPID Canal/Lateral
- Conceptual Conveyance
- ☐ COHYST Cell
- ☐ Parcel Boundary
- ☐ Recapture Zone

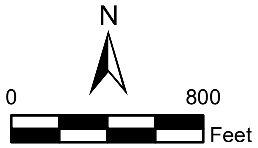
NeDNR Permitted Acres

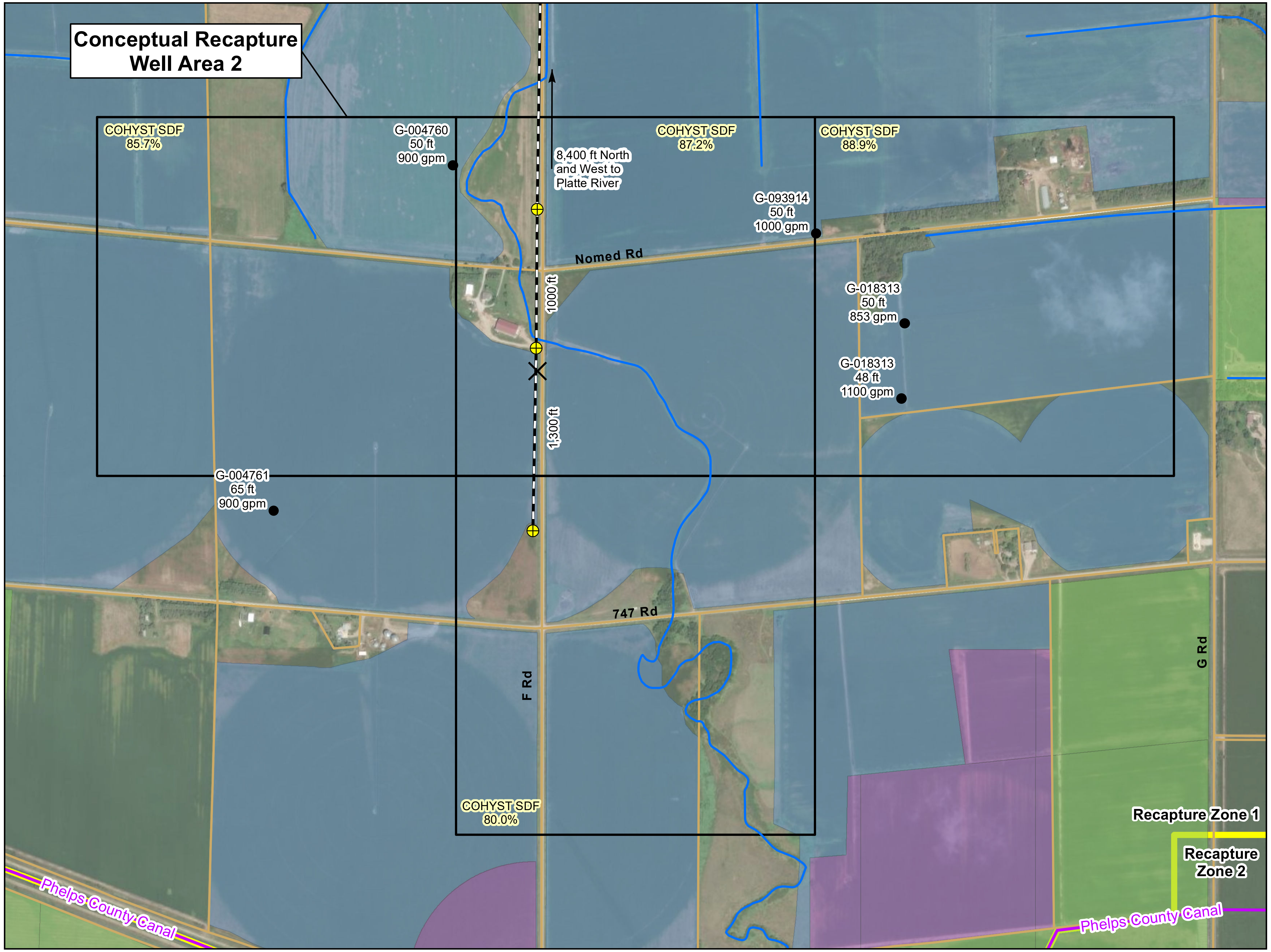
- 🟪 DNR Commingled
- 🟩 Surface Water (NeDNR)
- ▨ Commingled (NRD)
- 🟦 Groundwater (NRD)

Conceptual Well Design Averaged From Nearby Alluvial Wells:

Static Water Level: 7 ft
Screen Interval: 25-51 ft
Well Depth: 51 ft
Yield: 814 gpm

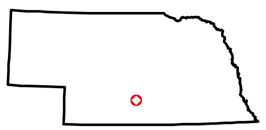
ft: feet
gpm: gallons per minute





Sources:

Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community Nebraska DNR Groundwater Well Database. COHYST data from Nebraska Department of Natural Resources. Statewide Permitted Acres from Department of Natural Resource.



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PRRIP CONCEPTUAL RECAPTURE WELL AREA 2 WITH 1,000 FT SPACING

FILE:6011PRRP01_01m_tier_2.MXD
DATE: 6/27/2024
FIGURE: 2

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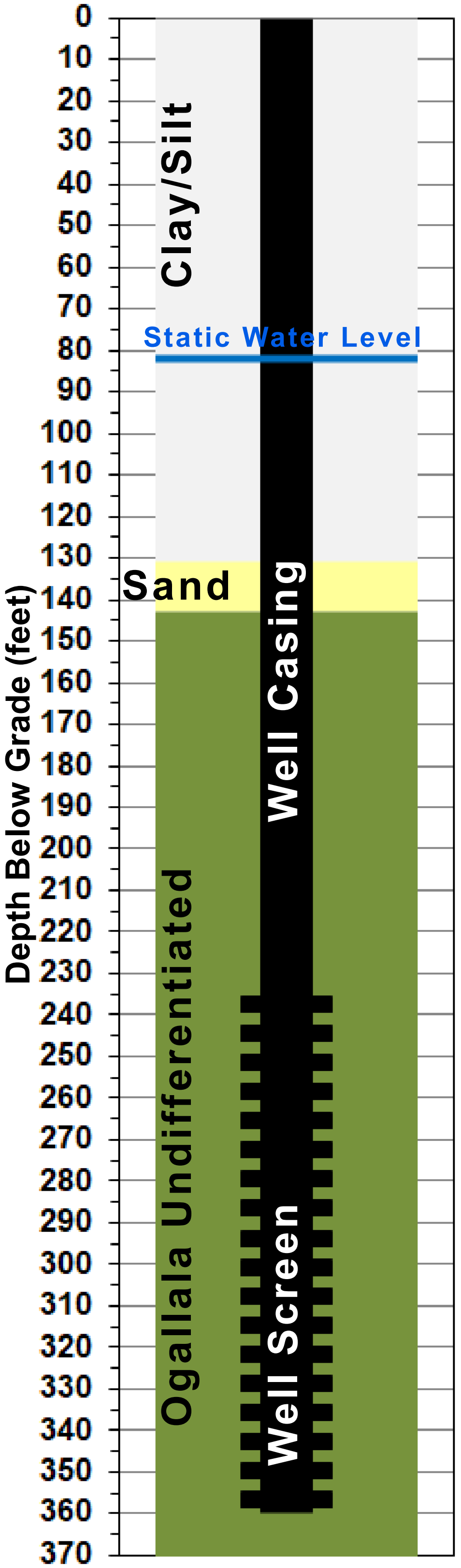
CONCEPTUAL GEOLOGY AND WELL DESIGN



Legend

⊕	Conceptual Recapture Well Placement
●	NeDNR Registered Well Used in Well Design
✕	Closest Power Location
—	NHD Streams
—	CNPPID Canal/Lateral
- - -	Conceptual Conveyance
☐	COHYST Cell
☐	Parcel Boundary
☐	Recapture Zone

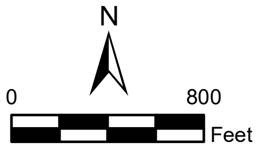
NeDNR Permitted Acres

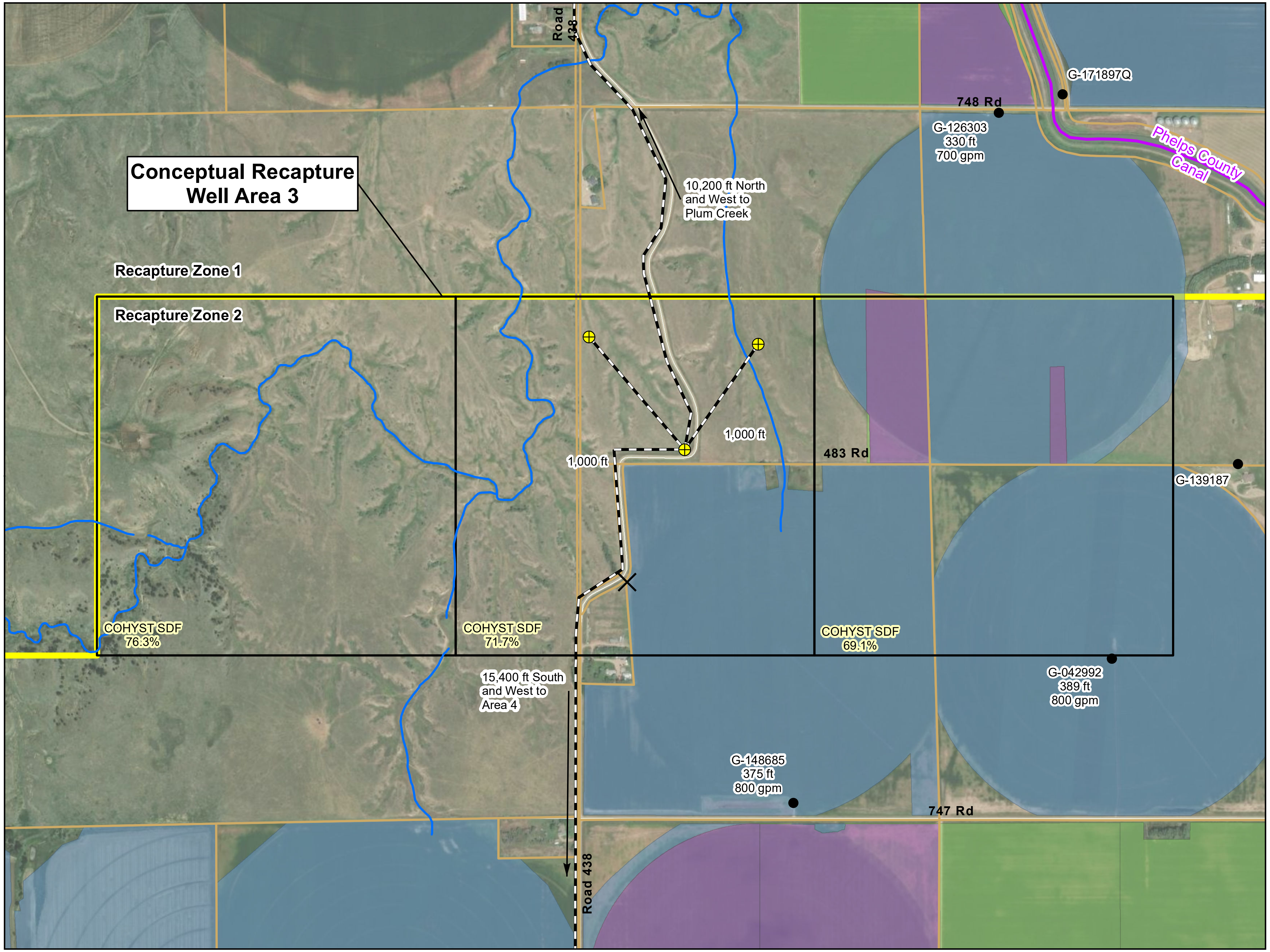
🟪	DNR Commingled
🟩	Surface Water (NeDNR)
🟨	Commingled (NRD)
🟦	Groundwater (NRD)

Conceptual Well Design Averaged From Nearby Alluvial Wells:

Static Water Level: 82 ft
Screen Interval: 238-360 ft
Well Depth: 360 ft
Yield: 767 gpm

ft: feet
gpm: gallons per minute





Sources:

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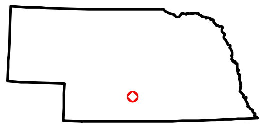
Nebraska DNR Groundwater Well Database. COHYST data from Nebraska Department of Natural Resources. Statewide Permitted Acres from Department of Natural Resource.



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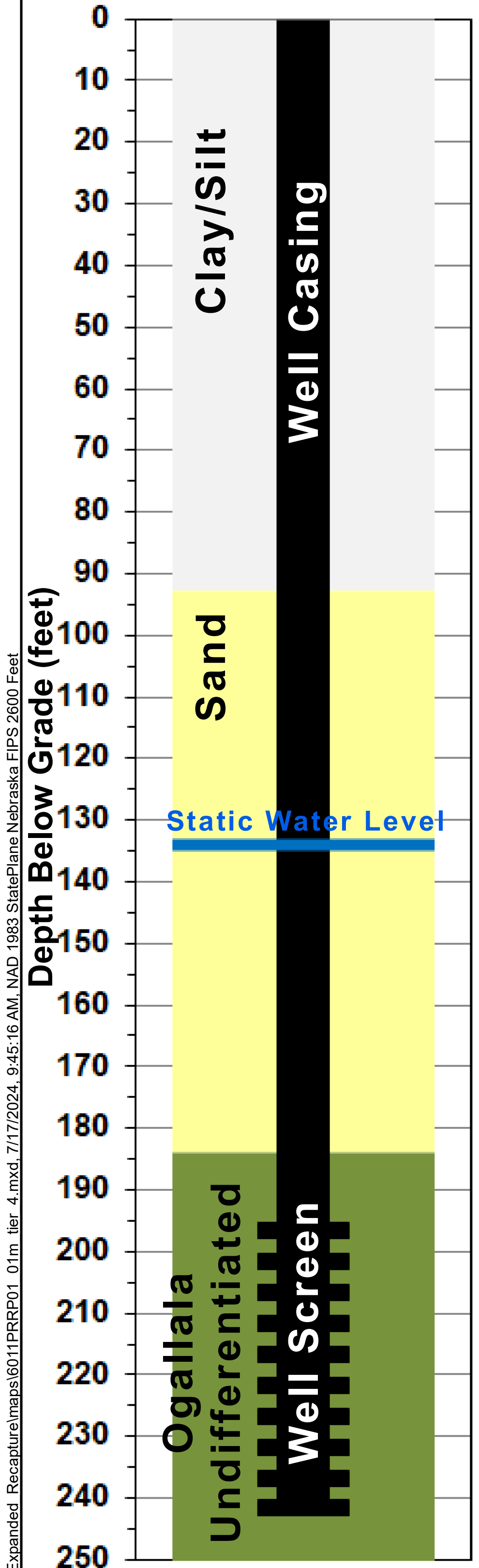
PRRIP CONCEPTUAL RECAPTURE WELL AREA 3 WITH 1,000 FT SPACING

FILE:6011PRRP01_01m_tier_3.MXD	DATE: 7/17/2024	FIGURE: 3

CONCEPTUAL GEOLOGY AND WELL DESIGN



Legend

- ⊕ Conceptual Recapture Well Placement
- ● NeDNR Registered Well Used in Well Design
- ✕ Closest Power Location
- NHD Streams
- CNPPID Canal/Lateral
- Conceptual Conveyance
- ☐ COHYST Cell
- ☐ Parcel Boundary
- ☐ Recapture Zone

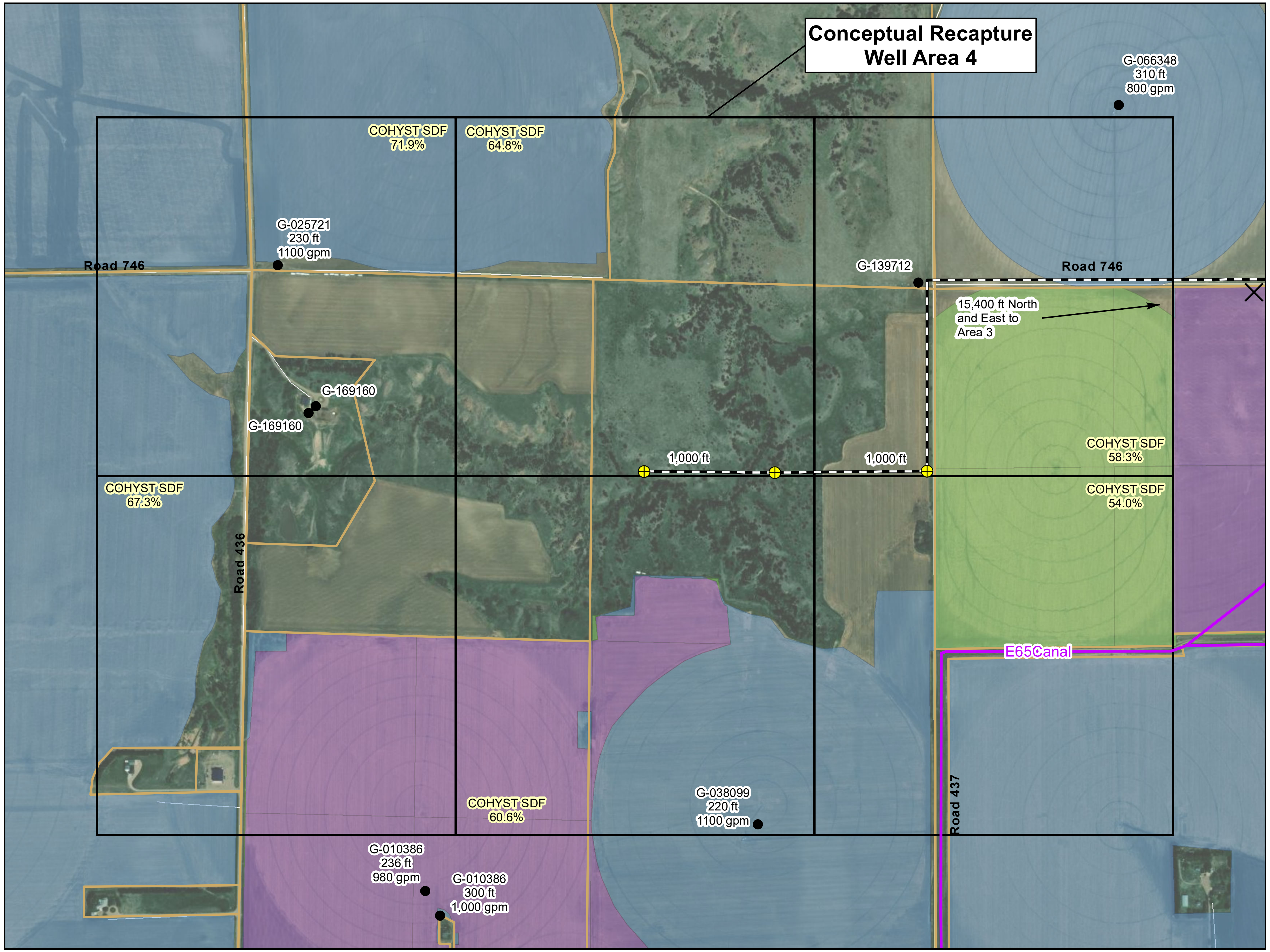
NeDNR Permitted Acres

- 🟪 DNR Commingled
- 🟩 Surface Water (NeDNR)
- 🟨 Commingled (NRD)
- 🟦 Groundwater (NRD)

Conceptual Well Design Averaged From Nearby Alluvial Wells:

Static Water Level: 134 ft
Screen Interval: 197-242 ft
Well Depth: 242 ft
Yield: 665 gpm

ft: feet
gpm: gallons per minute



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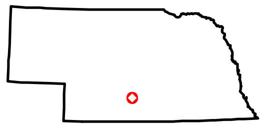
Feet

Sources:

Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
Nebraska DNR Groundwater Well Database. COHYST data from Nebraska Department of Natural Resources. Statewide Permitted Acres from Department of Natural Resource.



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PRRIP CONCEPTUAL RECAPTURE WELL AREA 4 WITH 1,000 FT SPACING

FILE:6011PRRP01_01m_tier_4.MXD
DATE: 7/17/2024
FIGURE: 4

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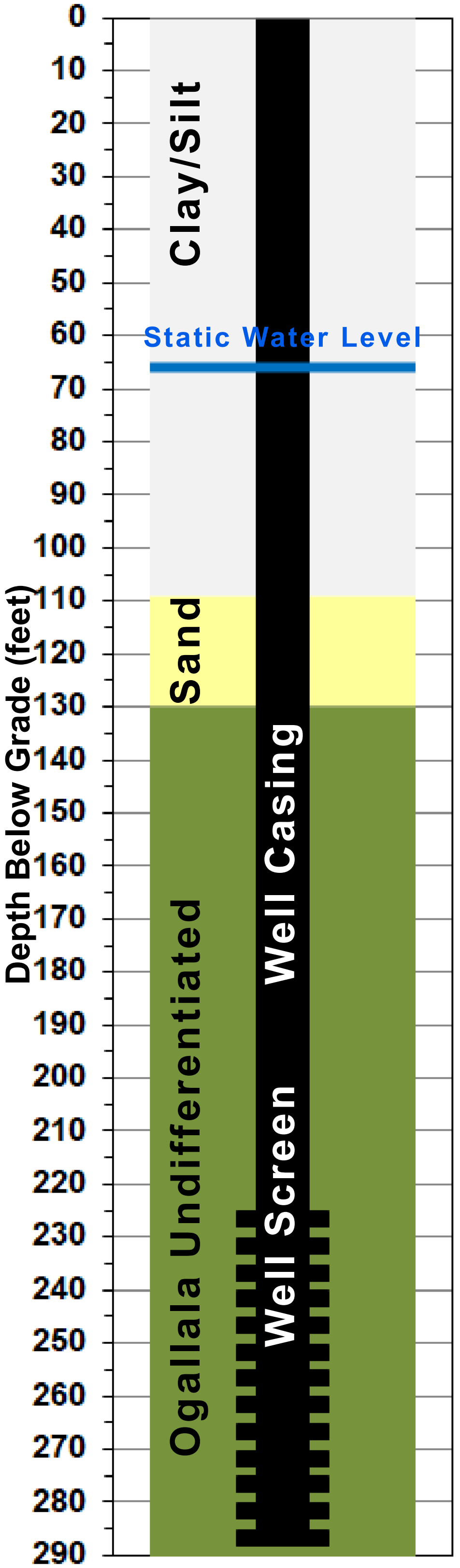
CONCEPTUAL GEOLOGY AND WELL DESIGN



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Legend

- ⊕ Conceptual Recapture Well Placement
- ● NeDNR Registered Well Used in Well Design
- ✕ Closest Power Location
- NHD Streams
- CNPPID Canal/Lateral
- Conceptual Conveyance
- ☐ COHYST Cell
- ☐ Parcel Boundary
- ☐ Recapture Zone

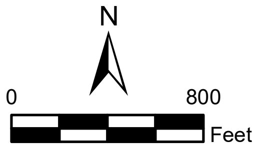
NeDNR Permitted Acres

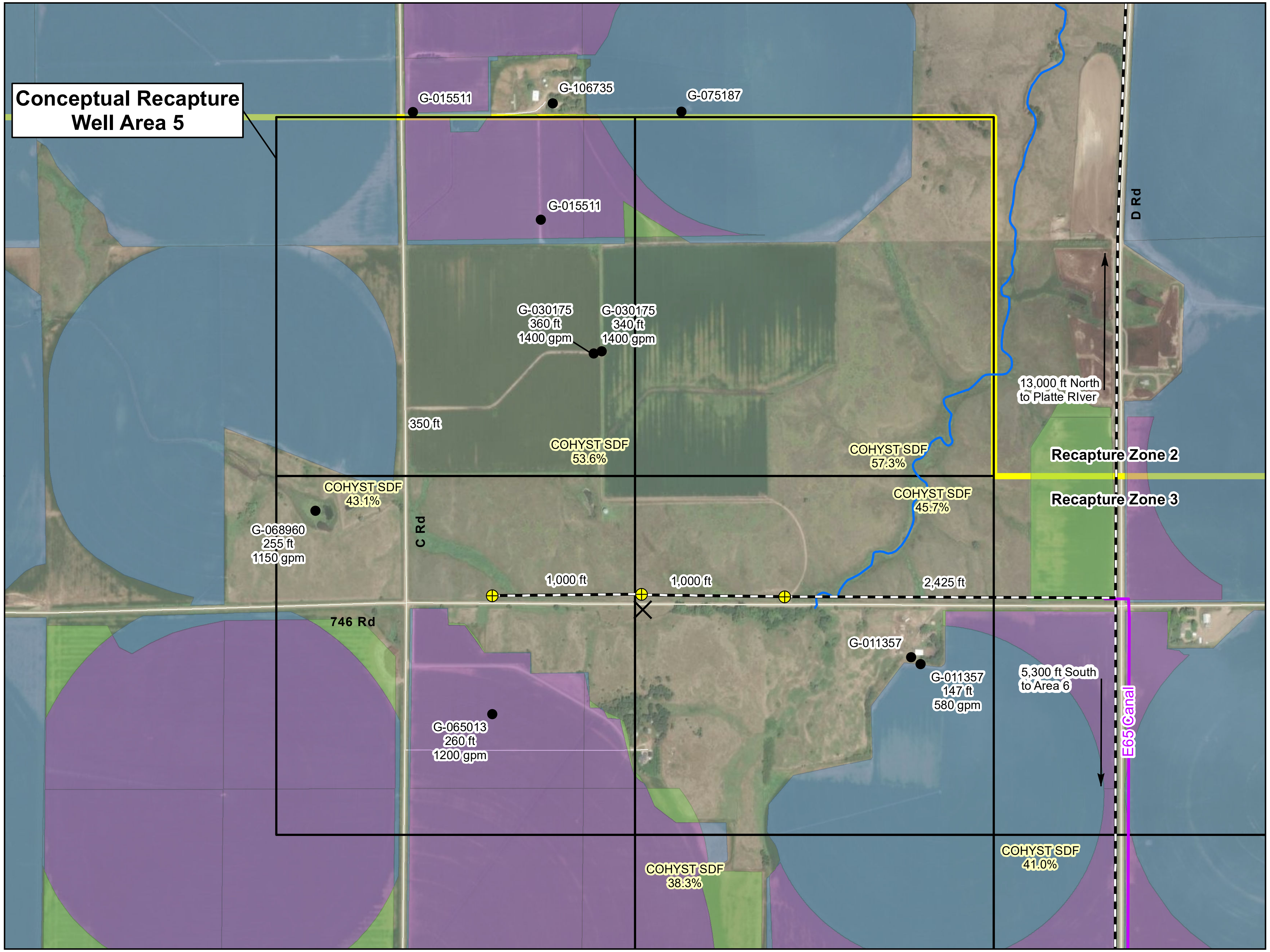
- ▨ DNR Commingled
- ▨ Surface Water (NeDNR)
- ▨ Commingled (NRD)
- ▨ Groundwater (NRD)

Conceptual Well Design Averaged From Nearby Alluvial Wells:

Static Water Level: 66 ft
Screen Interval: 227-287 ft
Well Depth: 287 ft
Yield: 1,085 gpm

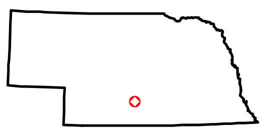
ft: feet
gpm: gallons per minute





Sources:

Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
Nebraska DNR Groundwater Well Database. COHYST data from Nebraska Department of Natural Resources. Statewide Permitted Acres from Department of Natural Resource.



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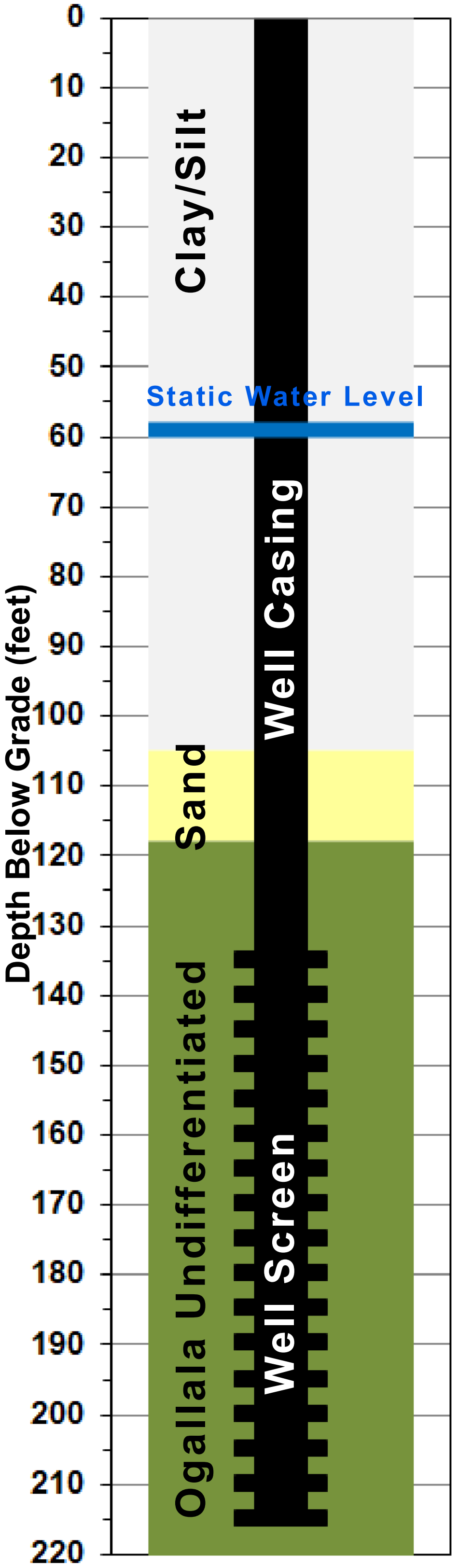
PRRIP CONCEPTUAL RECAPTURE WELL AREA 5 WITH 1,000 FT SPACING

FILE:6011PRRP01_01m_tier_5.MXD | DATE: 7/17/2024 | FIGURE: 5

CONCEPTUAL GEOLOGY AND WELL DESIGN



Legend

⊕	Conceptual Recapture Well Placement
●	NeDNR Registered Well Used in Well Design
✕	Closest Power Location
▬	NHD Streams
▬	CNPPID Canal/Lateral
- - -	Conceptual Conveyance
☐	COHYST Cell
☐	Parcel Boundary
☐	Recapture Zone

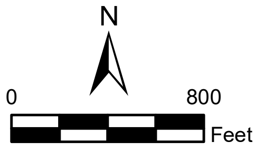
NeDNR Permitted Acres

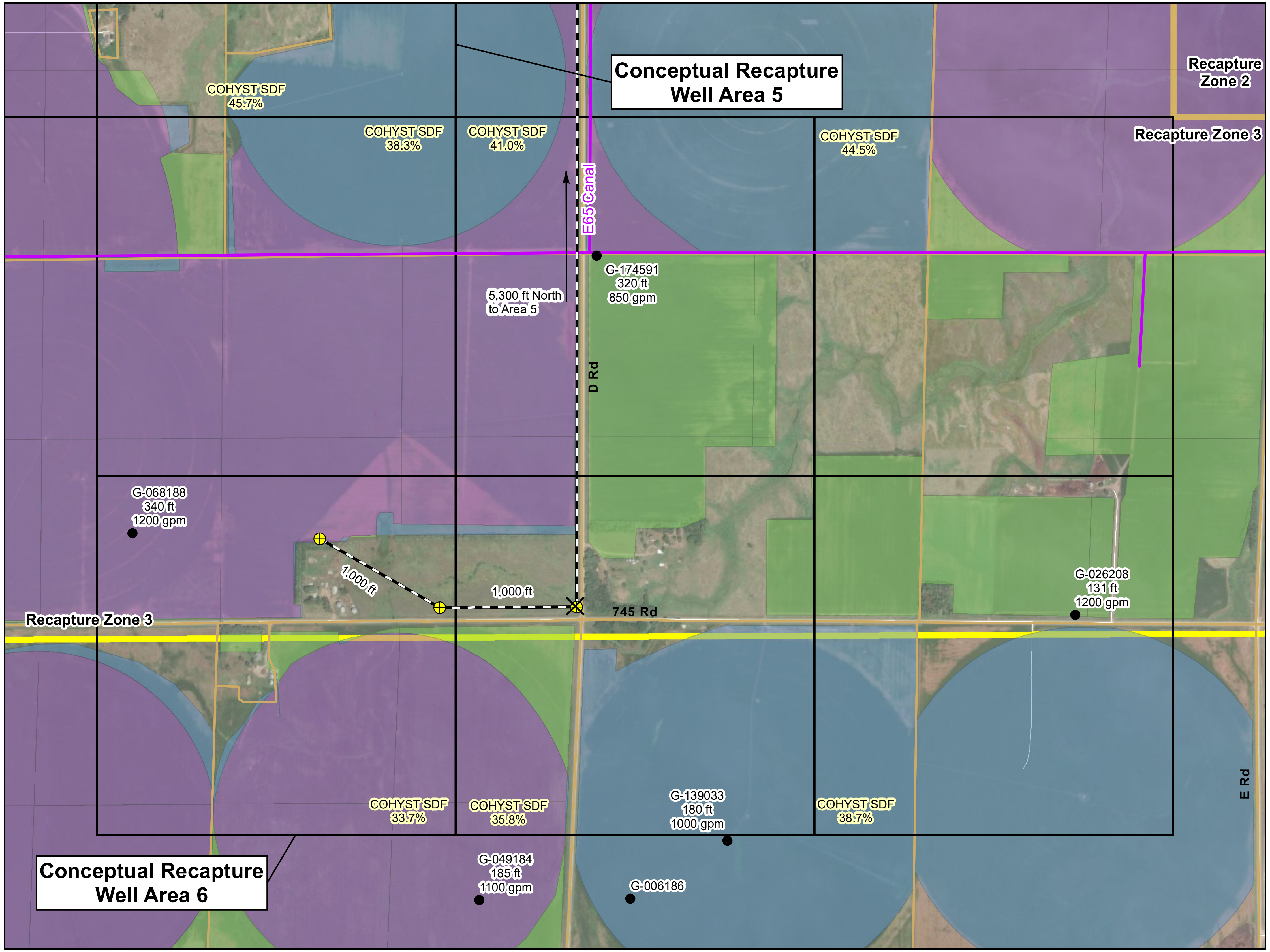
🟪	DNR Commingled
🟩	Surface Water (NeDNR)
🟨	Commingled (NRD)
🟦	Groundwater (NRD)

Conceptual Well Design Averaged From Nearby Alluvial Wells:

Static Water Level: 59 ft
Screen Interval: 135-215 ft
Well Depth: 215 ft
Yield: 1,058 gpm

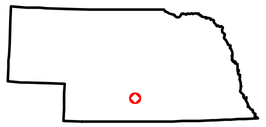
ft: feet
gpm: gallons per minute





Sources:

Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community Nebraska DNR Groundwater Well Database. COHYST data from Nebraska Department of Natural Resources. Statewide Permitted Acres from Department of Natural Resource.



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PRRIP CONCEPTUAL RECAPTURE WELL AREA 6 WITH 1,000 FT SPACING

FILE:6011PRRP01_01m_tier_6.MXD
DATE: 7/17/2024
FIGURE: 6

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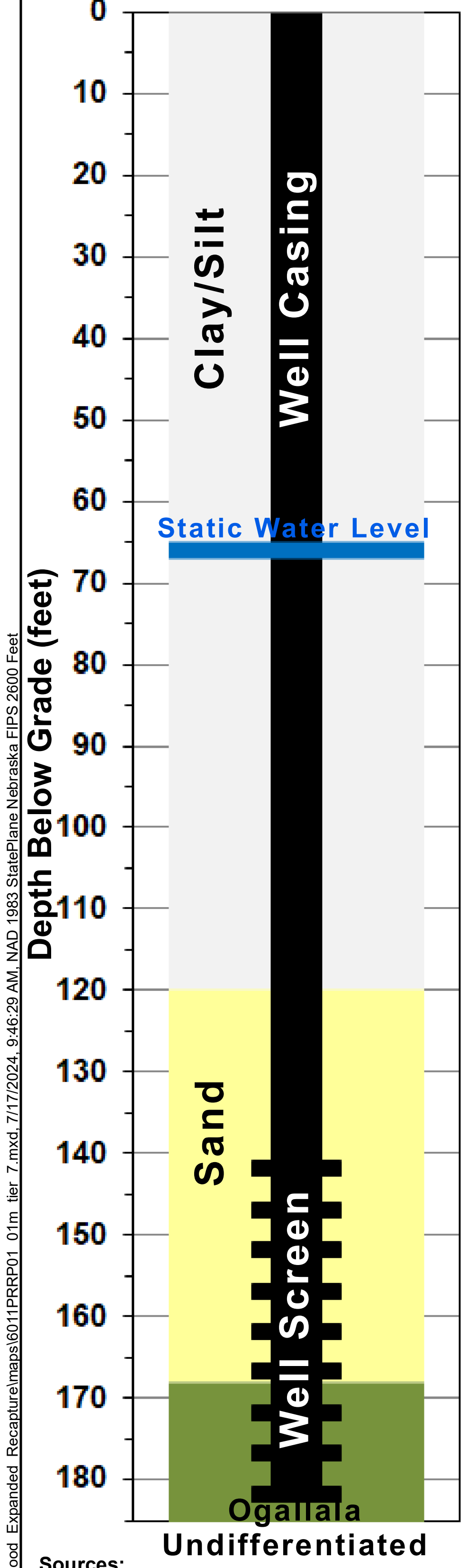
CONCEPTUAL GEOLOGY AND WELL DESIGN



Legend

⊕	Conceptual Recapture Well Placement
●	NeDNR Registered Well Used in Well Design
✕	Closest Power Location
—	NHD Streams
—	CNPPID Canal/Lateral
- - -	Conceptual Conveyance
☐	COHYST Cell
☐	Parcel Boundary
☐	Recapture Zone

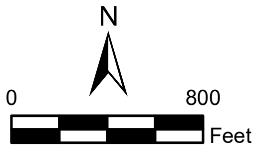
NeDNR Permitted Acres

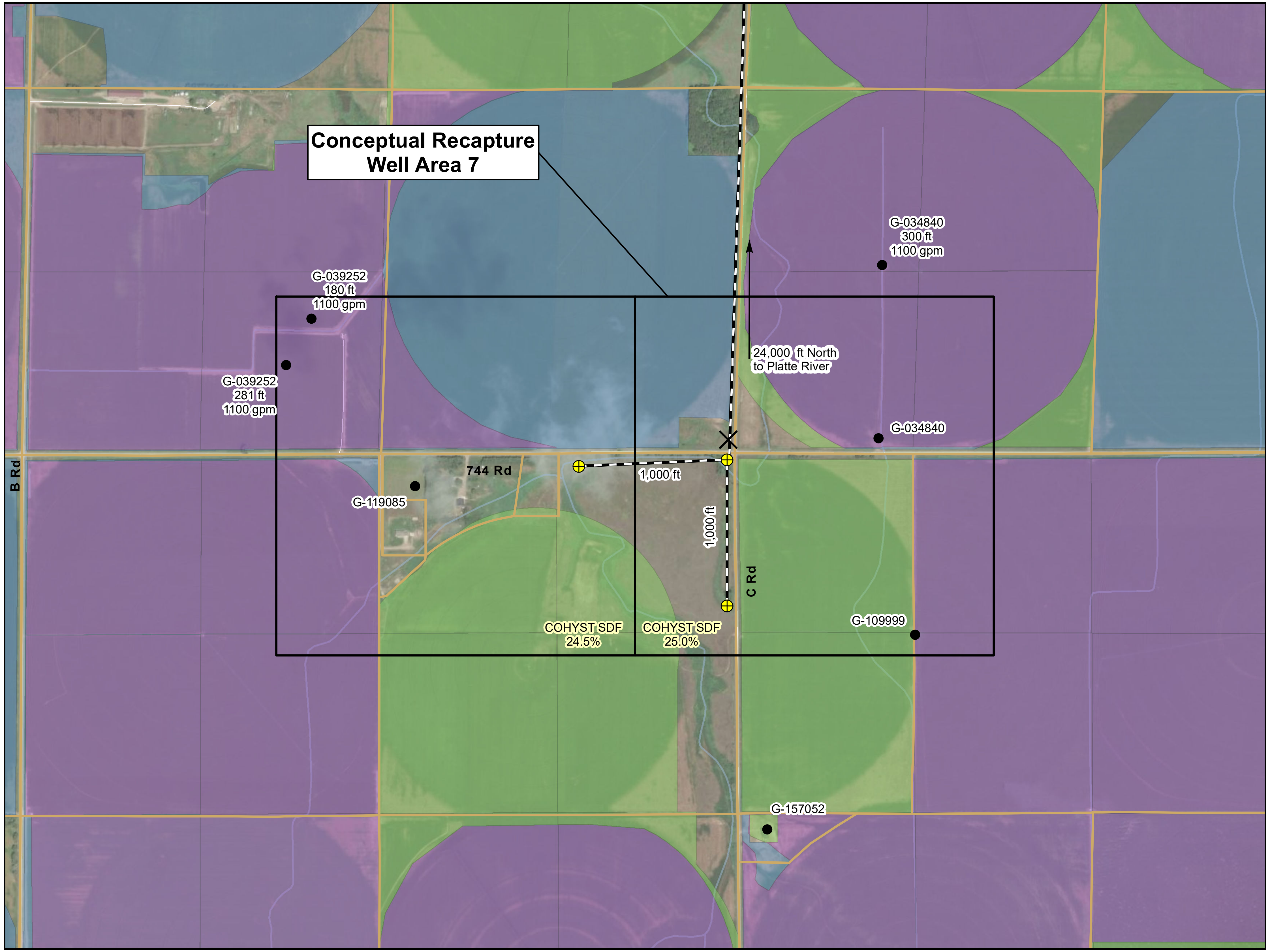
■	DNR Commingled
■	Surface Water (NeDNR)
■	Commingled (NRD)
■	Groundwater (NRD)

Conceptual Well Design Averaged From Nearby Alluvial Wells:

Static Water Level: 66 ft
Screen Interval: 142-182 ft
Well Depth: 182 ft
Yield: 1,040 gpm

ft: feet
gpm: gallons per minute





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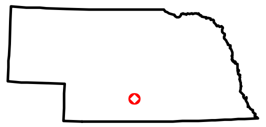
Sources:

Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
Nebraska DNR Groundwater Well Database. COHYST data from Nebraska Department of Natural Resources. Statewide Permitted Acres from Department of Natural Resource.



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PRRIP CONCEPTUAL RECAPTURE WELL AREA 7 WITH 1,000 FT SPACING

FILE:6011PRRP01_01m_tier_7.MXD | DATE: 7/17/2024 | FIGURE: 7

ATTACHMENT F

Cost Analysis

(LRE – August 25, 2024)

LRE WATER
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Memorandum

To: Seth Turner, Platte River Recovery Program

From: Mark Mitisek, LRE Water, Inc.

Date: August 26, 2024

Project: Expanded Recapture Reconnaissance

Subject: Study Cost Analysis – Capital Costs and O&M

Introduction and Purpose

The purpose of this memo is to provide a comprehensive overview of the total estimated cost associated for each scenario defined in the Expanded Recapture Reconnaissance Study. This includes a breakdown of the capital costs for mitigation and infrastructure, the gravity outlet, and the recapture well and pipeline. As well as a summary of the O&M cost requirements for each project component over a 50-yr project life cycle. All analyses in this reconnaissance study were at a high, conceptual level and all design elements were preliminary and conceptual (~15%). Therefore, all capital costs include 30% contingencies to account for the high degree of uncertainty. The sections below detail the costs for each of these project components used in each scenario.

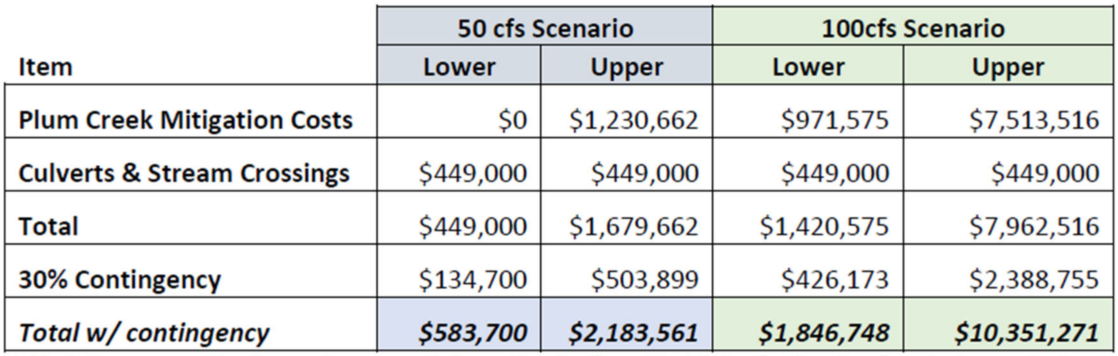
Note that the capital and O&M costs discussed herein do not include the initial purchase and diversion of excess flows into Program recharge projects located within the CNPPID system (Elwood Reservoir, Phelps County Canal, and Cottonwood Ranch). In a Water Service Agreement (WSA) between the Program and CNPPID dated December 7, 2022, the Program prepaid $9,154,956.24 for excess flow diversions totaling 50,000 AF into Phelps County Canal at $35.92/AF and 134,927.7 AF into Elwood Reservoir at $54.54/AF. The initial term of the agreement is through December 31, 2032 but can be extended through successive one-year agreements for up to another 10 years or until the full volume of water is delivered (whichever is sooner). Total excess flow deliveries during the first two years of this WSA (through August 2024) include about 3,173 AF into Elwood Reservoir and about 1,125 AF into Phelps County Canal, far below the annual averages that would be required to deliver all pre-paid water by 2032. There is a separate WSA from August 2018 concerning the Cottonwood Ranch recharge project, in which CNPPID is to repay the Program for the capital costs of the delivery pipeline construction through deliveries of excess flows. As of August 2024, an estimated 28,000 AF is still to be delivered based on the remaining pipeline cost balance and a term through December 31, 2032.

Capital Costs

Plum Creek Mitigation and Infrastructure Capital Costs

Utilization of Plum Creek to convey gravity releases from Elwood Reservoir will result in an increase in both minor and/or major geomorphic impacts requiring mitigation and infrastructure improvements depending on the magnitude and duration of augmented flow events. The Plum Creek Geomorphic Reconnaissance and Hydrologic Assessment[1] prepared by Inter-Fluve summarizes theses impacts and estimates the up-front capital costs for first five years using an adaptive management approach. **Table 1** below from Inter-Fluve's report summarizes the range of estimated capital costs for a 50 cfs and 100 cfs scenarios including a 30% contingency. Cost details for each scenario from the report are included in **Attachment 1**.

Table 1 - Plum Creek Mitigation and Infrastructure Capital Costs



	50 cfs Scenario		100cfs Scenario	
Item	**Lower**	**Upper**	**Lower**	**Upper**
Plum Creek Mitigation Costs	$0	$1,230,662	$971,575	$7,513,516
Culverts & Stream Crossings	$449,000	$449,000	$449,000	$449,000
Total	$449,000	$1,679,662	$1,420,575	$7,962,516
30% Contingency	$134,700	$503,899	$426,173	$2,388,755
Total w/ contingency	***$583,700***	***$2,183,561***	***$1,846,748***	***$10,351,271***

Table 1. Summary mitigation cost summary information for the entire 28.4-mile Plum Creek project area. Cost estimates for assessment reaches (1-4) were utilized to estimate potential mitigation costs for the entire 28 miles.

Gravity Outlet Capital Costs

Estimated capital costs for a gravity outlet concepts from Elwood Reservoir were prepared by RJH Consultants for two selected alternatives for assumed capacities of 50 or 100 cfs. These concepts are referred to herein as Alternative A (Alt A) and Alternative B (Alt B). Alt A is to divert water through an existing evacuation pipeline at the Elwood Pump Station and convey those releases to Plum Creek through a new lined channel. Alt B is to divert water from the E-65 Canal through a buried conveyance pipeline (steel or PVC), and to Plum Creek. Estimated capital costs for each alternative from RJH's report[2] are summarized in

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[1] Plum Creek Geomorphic Reconnaissance and Hydrologic Assessment, Inter-Fluve, July 19, 2024

[2] Elwood Recapture Reconnaissance Study: Concept and Cost Opinions for Conveyance Facilities to Plum Creek, RJH Consultants, Inc., July 17, 2024

Table 2 below include a 30% contingency. Cost details for each scenario from the report are included in **Attachment 2**.

Table 2 – Elwood Gravity Outlet Capital Costs (OPPC)

Concept	OPPC[3] ($)
Alt A1: Open Channel, 100 cfs	3,300,000
Alt A2: Open Channel, 50 cfs	2,820,000
Alt B1: Steel Pipeline, 100 cfs	9,470,000
Alt B2: Steel Pipeline, 50 cfs	7,500,000
Alt B1: PVC Pipeline, 100 cfs	7,144,000
Alt B2: PVC, Pipeline, 50 cfs	6,340,000

Recapture Well and Pipeline Capital Costs

The recapture well and associated pipeline alternatives identified in the Recapture Well Assessment[4] were used to estimate capital costs for each for conceptual well field located in recapture zones 1-3. Infrastructure requirements for each well field/pipeline are dependent on the capacity requirements, well depths, and pipeline lengths. Required well and pipeline capacities were optimized for each scenario based on available/remaining recharge, pumping impacts on net accretions, and existing recapture well pumping.

Program capacity requirements assume recharge available from Elwood Reservoir and Phelps County Canal with eight existing recapture wells. NeDNR capacity requirements assume recharge available from Elwood Reservoir with no existing recapture wells.

Well and pipeline requirements defined in Table 1 from the Recapture Well Assessment were used as the basis to estimate capital costs for recapture zones 1-3. Unit cost for wells and conveyance were developed based on Program costs associated with the development of Cottonwood Ranch wells in 2021 and updated with 2024 pipe costs. Unit costs for wells include drilling the recapture well, well infrastructure (casing/screen/pump), gravel pack and grout seal, well development, surface facilities, and power. Unit costs

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[3] OPPC does not include the cost to replace or enlarge the culvert under U.S. Route 283 or land acquisition.

[4] Recapture Well Assessment, LRE Water, Inc., August 25, 2024

for pipelines include clearing/grubbing, pipe and pipe installation (8” to 24”), surface facilities, pipeline bridge/mount (Phelps crossing), drain-back/discharge structures, dewatering, and erosion control/seeding. All well and pipeline unit cost are summarized in **Attachment 3**.

Well counts and conveyance infrastructure cost estimates for each zone are limited based on remaining aquifer supply from intentional groundwater recharge (after existing recapture wells) with a max of 6 wells per Recapture Zone. Costs represent well capacities ranging from 500 gpm to 1,000 gpm, well depths from 48 to 360 feet, and conveyance pipelines from 2.53 to 4.68 miles depending on the performance requirements for each Recapture Zone. **Table 3** below summarizes well, conveyance pipeline (PVC & steel), and total capital cost (OPPC) estimates for each Recapture Zone including a 30% contingency for design and construction.

Table 3 – Recapture Well and Pipeline Capital Costs

Program Well and Pipeline Requirements and Capital Cost for Additional Recapture Wells

Requirement	Recapture Zone 1 (Recapture Area 1 & 2)		Recapture Zone 2 (Recapture Area 3 & 4)		Recapture Zone 3 (Recapture Area 5 & 6)	
Well Count	6		6		6	
Well Capacity (gpm/well)	600		500		1000	
Well Cost ($)*	$475,474		$653,862		$709,038	
Conveyance Pipeline (Miles)	2.53 miles[1]		5.61 miles[2]		4.68 miles[3]	
Pipeline Cost ($)*	PVC	Steel	PVC	Steel	PVC	Steel
	$1,727,220	$2,630,343	$4,180,477	$6,555,857	$7,401,977	$12,108,169
OPPC ($)*	**$2,202,694**	**$3,105,817**	**$4,834,340**	**$7,209,720**	**$8,111,015**	**$12,817,207**

*Costs include a 30% design and construction contingency

1. Recapture Zone 1 includes the following estimated pipe capacities: 10" = 0.63 mi, 12" = 0.19 mi, 14" = 1.72 mi
2. Recapture Zone 2 includes the following estimated pipe capacities: 8" = 0.57 mi, 12" = 3.11 mi, 18" = 1.93 mi
3. Recapture Zone 3 includes the following estimated pipe capacities: 12" = 0.38 mi, 16" = 0.38 mi, 18" = 1.46 mi, 24" = 2.46 mi

NeDNR Well and Pipeline Requirements and Capital Cost for New Recapture Wells

Requirement	Recapture Zone 1 (Recapture Area 1 & 2)		Recapture Zone 2 (Recapture Area 3 & 4)		Recapture Zone 3 (Recapture Area 5 & 6)	
Well Count	6		6		6	
Well Capacity (gpm/well)	900		700		900	
Well Cost ($)*	$521,365		$684,457		$693,741	
Conveyance Pipeline (Miles)	2.53 miles[1]		5.60 miles[2]		4.68 miles[3]	
Pipeline Cost ($)*	PVC	Steel	PVC	Steel	PVC	Steel
	$2,642,526	$4,155,853	$5,756,970	$9,287,854	$7,301,429	$11,940,589
OPPC ($)*	**$3,163,891**	**$4,677,218**	**$6,441,427**	**$9,972,311**	**$7,995,170**	**$12,634,330**

*Costs include a 30% design and construction contingency

1. Recapture Zone 1 includes the following estimated pipe capacities: 10" = 0.63 mi, 14" = 0.19 mi, 18" = 1.72 mi
2. Recapture Zone 2 includes the following estimated pipe capacities: 10" = 0.57 mi, 12" = 0.19 mi, 16" = 2.92 mi, 20" = 1.93 mi
3. Recapture Zone 3 includes the following estimated pipe capacities: 10" = 0.38 mi, 14" = 0.38 mi, 18" = 1.46 mi, 24" = 2.46 mi

O&M/Annual Costs

Important to the total cost of each project is the associated O&M and annual costs over an estimated 50-yr project life cycle. Below is a summary of the estimated O&M/annual costs for each project component:

- **Plum Creek** - Plum Creek annual O&M is inclusive of wood debris removal and beaver/phragmites mitigation is estimated as 1.5% of capital costs/year or $20,755/yr (2024) for 50 cfs and $91,485 (2024) for the 100 cfs.
- **Gravity Outlet** - Gravity Outlet annual O&M for Alternatives A and B:
    - RJH's opinion of an annual maintenance cost for the channel alternatives (Alt A1 and Alt 2) is $12,500/yr5 in 2024.
    - RJH's opinion of an annual maintenance cost for the pipeline alternatives (Alt B1and Alt B2) is $3,000/yr6 in 2024.
- **Recapture Wells** - Recapture Well annual/O&M inclusive of easements (for wells or conveyance pipeline on private property), HP/electric, SCADA, O&M, Tri-Basin staff time was estimated based on actual 2024 costs for the operation of the Cook well and Cottonwood Ranch wells 1-7 from Program staff as presented in Table 4 below. Unit costs per well were used to estimate annual O&M for new recapture wells. Note that the total Recapture Well annual/O&M costs also include new pumps in year 25 (unit pump costs escalated by 3% annually for 25-yrs), which is not reflected below.

Table 4 – Recapture Well Annual/O&M Costs - Cook and CWR Wells 1-7 (2024)

Item	Unit	Quantity	Unit Cost	Total
Easements	$/Easement	4	$ 3,000	$ 12,000
HP/Electric	$/Well	8	$ 4,000	$ 32,000
SCADA	$/Well	8	$ 200	$ 1,600
O&M	$/Well	8	$ 1,250	$ 10,000
Tri-Basin NRD Staff time	$/Well	8	$ 3,125	$ 25,000
			Total	$ 80,600

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[5] RJH developed opinions for approximate maintenance costs using generalized information from pipe manufacturers, pipe designers, and discussions with pipeline and channel engineers. Channel maintenance costs can vary significantly based on the size of the channel, anticipated life span before a major rehabilitation is needed, soil stability of the materials underlying the channel, surface drainages that are adjacent to or intersect the channel, the propensity for vegetation or soils to clog the channel, the need for herbicides to be applied routinely, and the quality of the channel armoring materials used. For planning and feasibility-evaluation purposes, RJH's opinion of an annual maintenance cost for the channel alternatives (Alt A1 and Alt 2) is $12,500.

[6] Pipeline maintenance costs can vary widely to account for factors such as soil corrosion conditions, anticipated lifespan, pipe size, pipe material, changing soil moistures, quality of the water being conveyed (i.e., buildup of mineral deposits, etc.), public access to open ends (i.e., vandalism, etc.), and other factors. For planning and feasibility-evaluation purposes, RJH's opinion of an annual maintenance cost for the pipeline alternatives (Alt B1 and Alt B2) is $3,000.

- **Easements** - Easement annual costs are estimated to be $3,000/yr (2024) for each private property parcel intersected are based on actual 2024 easement costs for the operation of the Cook well and Cottonwood Ranch wells 1-7. **Table 5** below summarizes the easement counts and costs for each infrastructure scenario. Note that easements are not required for public rights-of-way or Program-owned property.

Table 5 – Easement Counts and Costs

Infrastructure Scenario	Easement Count	Easement Costs/yr (2024)
Elwood Reservoir Outlet - Open Channel (Alt A)	2	$6,000
Elwood Reservoir Outlet - Pipeline (Alt B)	3	$9,000
New Recapture Wells (Zone 1)	4	$12,000
New Recapture Wells (Zone 2)	3	$9,000
New Recapture Wells (Zone 3)	2	$6,000

- **Contingency** - Annual/O&M costs include a 10% contingency to account for miscellaneous unanticipated costs.
- **50-yr Project Life** - To estimate the annual/O&M costs over the 50-yr project life cycle costs were escalated annually by an estimated 3%.

Permitting Costs

Permitting costs were estimated for recapture wells, stream improvements, and gravity outlet scenarios. For recapture well scenarios permitting costs are inclusive of hydrogeologic and well siting studies, groundwater modeling, and small-scale 404 permitting for pipeline alignments, waterway crossings, and outfall structure resulting in an estimated costs of $25,000.

For improvements to Plum Creek to mitigate potential stream erosion and similar impacts, permitting cost would be inclusive of wetland delineations and 404 permitting, estimated up-front cost over a 5-year period is $100,000.

For Elwood Reservoir gravity outlet scenarios permitting costs are inclusive of wetland delineations, 404 permitting, stream assessment, wetland mitigation planning, and mitigation design and construction, resulting in an estimated costs of $100,000 with the assumption the open channel is considered a jurisdictional waterway by the USACE due to it flowing directly to a perennial stream. Cost would be significantly lower should the waterway be considered non-jurisdictional, or only a part of it is considered jurisdictional, and only minor wetland impacts warranted evaluation.

Total Costs

To complete the cost analysis and determine the total cost of each project portfolio (scenario) being evaluated in the Trade Off Analysis an Excel template (PRRIP_Recon_Costs_2024_V4.xlsx) was created. The template incorporates all applicable capital costs estimates for each project portfolio (scenario) from associated with mitigation and infrastructure, the gravity outlet, and the recapture well and pipeline define above; all applicable O&M/annual costs over the 50-yr project life cycle defined above; and applicable permitting costs defined above. A comprehensive detailed cost for each project portfolio (scenarios 1-4.3) for PVC and steel alternatives being evaluated is included in **Attachment 4**. A summary of the total capital and O&M costs used in the Trade Off analysis is presented below in **Table 6**.

Table 6 – Total Capital and O&M Costs

Scenario	Cost Scenario	Scenario Name	Elwood Reservoir Outlet Costs[1]	Plum Creek Mitigation & Infrastructure Costs[2]	Recapture Well Costs[3]	Conveyance Pipeline Costs[4]	Total Capital Cost[5]	O&M (50-Yr Project Life)[6]	Total Costs (50-Yr Project Life)[7]
1	1.0	No Elwood Outlet, 8 Existing Recapture Wells, No New Recapture Wells (Program Baseline)	$0	$0	$0	$0	$0	$0	$0
1.1	1.1A	No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 1) (PVC)	$0	$0	$475,474	$1,727,220	$2,202,694	$14,885,546	$17,113,239
	1.1B	No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 1) (Steel)	$0	$0	$475,474	$2,630,343	$3,105,817	$14,885,546	$18,016,362
1.2	1.2A	No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 2) (PVC)	$0	$0	$653,862	$4,180,477	$4,834,340	$13,724,629	$18,583,968
	1.2B	No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 2) (Steel)	$0	$0	$653,862	$6,555,857	$7,209,720	$13,724,629	$20,959,348
1.3	1.3A	No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 3) (PVC)	$0	$0	$709,038	$7,401,977	$8,111,015	$17,437,959	$25,573,974
	1.3B	No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 3) (Steel)	$0	$0	$709,038	$12,108,169	$12,817,207	$17,437,959	$30,280,166
2	2.0	50 cfs Elwood Outlet (Open Channel), 7 Existing Recapture Wells	$2,816,104	$1,383,630	$0	$0	$4,199,734	$3,107,831	$7,407,565
	2A	50 cfs Elwood Outlet (PVC), 7 Existing Recapture Wells	$6,339,920	$1,383,630	$0	$0	$7,723,550	$3,107,831	$10,931,381
	2B	50 cfs Elwood Outlet (Steel), 7 Existing Recapture Wells	$7,502,720	$1,383,630	$0	$0	$8,886,350	$3,107,831	$12,094,181
3	3	100 cfs Elwood Outlet (Open Channel), 6 Existing Recapture Wells	$3,290,192	$6,099,009	$0	$0	$9,389,201	$11,086,030	$20,575,231
	3A	100 cfs Elwood Outlet (PVC), 6 Existing Recapture Wells	$7,144,000	$6,099,009	$0	$0	$13,243,009	$11,086,030	$24,429,039
	3B	100 cfs Elwood Outlet (Steel), 6 Existing Recapture Wells	$9,469,600	$6,099,009	$0	$0	$15,568,609	$11,086,030	$26,754,639
4	4.0	Elwood Recharge Only (No New Infrastructure) - NeDNR Baseline	$0	$0	$0	$0	$0	$0	$0
4.1	4.1A	New Recapture Wells Only (Zone 1) (PVC)	$0	$0	$521,365	$2,642,526	$3,163,891	$17,322,669	$20,511,560
	4.1B	New Recapture Wells Only (Zone 1) (Steel)	$0	$0	$521,365	$4,155,853	$4,677,218	$17,322,669	$22,024,887
4.2	4.2A	New Recapture Wells Only (Zone 2) (PVC)	$0	$0	$684,457	$5,756,970	$6,441,427	$15,349,378	$21,815,805
	4.2B	New Recapture Wells Only (Zone 2) (Steel)	$0	$0	$684,457	$9,287,854	$9,972,311	$15,349,378	$25,346,689
4.3	4.3A	New Recapture Wells Only (Zone 3) (PVC)	$0	$0	$693,741	$7,301,429	$7,995,170	$16,625,584	$24,645,754
	4.3B	New Recapture Wells Only (Zone 3) (Steel)	$0	$0	$693,741	$11,940,589	$12,634,330	$16,625,584	$29,284,914

1. Elwood Reservoir Outlet Costs ($) from Tabel 2.
2. Plum Creek Mitigation and Infrastructure Costs ($) assume an average of the cost range provided in Table 1 for 50 cfs and 100 cfs flow augmentation scenarios.
3. Recapture Well Costs ($) from Table 3.
4. Conveyance Pipeline Costs ($) from Table 3.
5. Total Capital Costs ($) = Sum of Elwood Reservoir Outlet Costs, Plum Crk Mitigation & Infrastructure Costs, Recapture Well Costs, and Conveyance Pipeline Costs.
6. O&M (50-Yr Project Life) ($) includes costs for O&M for recapture wells (including pump replacements), O&M for the gravity outlet, Plum Creek O&M (inclusive of wood debris removal and beaver/phragmites mitigation), easements, SCADA, HP/electric, and Tri-Basin NRD staff time. The total cumulative estimated O&M includes a 10% contingency and was escalated 3%/yr for 50-yr representing the O&M cost over the project life.
7. Total Costs ($) (50-Yr Project Life) plus $25,000 for permitting of recapture wells scenarios or $100,000 for permitting of Elwood Reservoir outlet scenarios.

Attachment 1
Plum Creek Mitigation and Infrastructure Detailed Costs

Table 133. Estimated lower range mitigation costs for the 28 miles of Plum Creek associated with the 50 cfs release scenario.

Impact	**Extent/Location**	**Estimated Impact** (in Reaches 1-4 over 5 yrs)	**Mitigation**	**Reach 1-4 Cost**	**Estimated Cost /Mile**	**Total Cost** (28.4 Miles)
Minor Bank Erosion	Reach 1 Reach 2/3 Reach 4	0 linear feet 0 linear feet 0 linear feet	Minor bank shaping, revegetation, erosion control	$0	$0	$0
Major Bank Erosion	All reaches	No estimated impacts	Bank Grading, fabric encapsulated lifts, or armor	$0	$0	$0
Excessive Channel Scour	All reaches	Minimal	Unlikely to require mitigation	$0	$0	$0
Total Plum Creek Mitigation Costs				**$0**	**$0**	**$0**
Infrastructure	All reaches	4 existing culverts need to be replaced to accommodate flows	New Culverts			$245,000
Stream Crossings	12 private steam crossings	Inundation to private stream crossings	New Riprap Crossings			$204,000
Total Infrastructure Costs						**$449,000**
Total						**$449,000**
Contingency (30%)						**$134,700**
Total (w/ contingency)						**$583,700**

Table 144. Estimated Upper Range Mitigation costs for the 28 miles of Plum Creek associated with the 50 cfs release scenario.

Impact	**Extent/Location**	**Estimated Impact** (in Reaches 1-4 over 5 yrs)	**Mitigation**	**Reach 1-4 Cost**	**Estimated Cost /Mile**	**Total Cost** (28.4 Miles)
Minor Bank Erosion	Reach 1 Reach 2/3 Reach 4	200 linear feet 100 linear feet 100 linear feet	Minor bank shaping, revegetation, erosion control	$95,000	$43,379	$1,230,662
Major Bank Erosion	All reaches	No estimated impacts	Bank Grading, fabric encapsulated lifts, or armor	$0	$0	$0
Excessive Channel Scour	All reaches	Minimal	Unlikely to require mitigation	$0	$0	$0
Total Plum Creek Mitigation Costs				**$95,000**	**$43,379**	**$1,230,662**
Infrastructure	All reaches	4 existing culverts need to be replaced to accommodate flows	New Culverts			$245,000
Stream Crossings	12 private steam crossings	Inundation to private stream crossings	New Riprap Crossings			$204,000
Total Infrastructure Costs						**$449,000**
Total						**$1,679,662**
Contingency (30%)						**$503,899**
Total (w/ contingency)						**$2,183,561**

Table 155. Estimated lower range mitigation costs for the 28 miles of Plum Creek associated with the 100 cfs release scenario.

Impact	**Extent/Location**	**Estimated Impact** (in Reaches 1-4 over 5 yrs)	**Mitigation**	**Reach 1-4 Cost**	**Estimated Cost /Mile**	**Total Cost** (28.4 Miles)
Minor Bank Erosion	Reach 1 Reach 2/3 Reach 4	200 linear feet 100 linear feet 100 linear feet	Minor bank shaping, revegetation, erosion control	$75,000	$34,247	$971,575
Major Bank Erosion	All reaches	No estimated impacts	Bank Grading, fabric encapsulated lifts, or armor	$0	$0	$0
Excessive Channel Scour	All reaches	Minor localized scour addressed in major bank erosion repair	Addressed by major bank erosion repair	$0	$0	$0
			Total Plum Creek Mitigation Costs	**$75,000**	**$34,247**	**$971,575**
Infrastructure	All reaches	4 existing culverts need to be replaced to accommodate flows	New Culverts			$245,000
Stream Crossings	12 private steam crossings	Inundation to private stream crossings	New Riprap Crossings			$204,000
			Total Infrastructure Costs			**$449,000**
			Total			**$1,420,575**
			Contingency (30%)			**$426,173**
			Total (w/ contingency)			**$1,846,748**

Table 166. Estimated upper range mitigation costs for the 28 miles of Plum Creek associated with the 100 cfs release scenario.

Impact	**Extent/Location**	**Estimated Impact** (in Reaches 1-4 over 5 yrs)	**Mitigation**	**Reach 1-4 Cost**	**Estimated Cost /Mile**	**Total Cost** (28.4 Miles)
Minor Bank Erosion	Reach 1 Reach 2/3 Reach 4	1200 linear feet 200 linear feet 500 linear feet	Minor bank shaping, revegetation, erosion control	$360,000	$164,384	$4,663,562
Major Bank Erosion	Reach 1 Reach 2/3 Reach 4	200 linear feet 100 linear feet 100 linear feet	Bank Grading, fabric encapsulated lifts, or armor	$220,000	$100,457	$2,849,954
Excessive Channel Scour	All reaches	Minor localized scour addressed in major bank erosion repair	Addressed by major bank erosion repair	$0	$0	$0
Total Plum Creek Mitigation Costs				**$580,000**	**$264,840**	**$7,513,516**
Infrastructure	All reaches	4 existing culverts need to be replaced to accommodate flows	New Culverts			$245,000
Stream Crossings	12 private steam crossings	Inundation to private stream crossings	New Riprap Crossings			$204,000
Total Infrastructure Costs						**$449,000**
Total						**$7,962,516**
Contingency (30%)						**$2,388,755**
Total (w/ contingency)						**$10,351,271**

Attachment 2
Elwood Gravity Outlet Detailed Costs

Cost Breakdown

Alternative A - Open Channel

Alternative A1 - *100 cfs*

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
1	Mobilization and Demobilization	LS	1	50,000	50,000
2	Clearing and Grubbing	LS	1	40,000	40,000
3	Excavation	CY	23,400	5	117,000
4	Type M Riprap	CY	12,100	130	1,573,000
5	Geotextile	SF	192,300	2	384,600
Base Construction Cost (BCC)					**2,164,600**
Design and Construction Contingency (30% of BCC)					649,380
Design Engineering (7% of BCC)					216,460
Construction Engineering and Management (10% of BCC)					259,752
Opinion of Probable Project Cost (OPPC)					**3,290,192**

Alternative A2 - *50 cfs*

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
1	Mobilization and Demobilization	LS	1	50,000	50,000
2	Clearing and Grubbing	LS	1	40,000	40,000
3	Excavation	CY	17,900	5	89,500
4	Type M Riprap	CY	10,300	130	1,339,000
5	Geotextile	SF	167,100	2	334,200
Base Construction Cost (BCC)					**1,852,700**
Design and Construction Contingency (30% of BCC)					555,810
Design Engineering (7% of BCC)					185,270
Construction Engineering and Management (10% of BCC)					222,324
Opinion of Probable Project Cost (OPPC)					**2,816,104**

Cost Breakdown

Alternative B - Buried ***Steel*** Pipeline

Alternative B1 - *100 cfs*

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
1	Mobilization and Demobilization	LS	1	50,000	50,000
2	Clearing and Grubbing	LS	1	32,000	32,000
3	36" Welded Steel Pipe, Bedding, and Excavation	LF	4,500	890	4,005,000
4	Energy Dissipation Structure and Riprap Rundown	LS	1	193,000	193,000
5	Canal Gate, Structure, and Instrumentation	LS	1	1,700,000	1,700,000
6	Slide Gate, Turnout Structure, and Instrumentation	LS	1	250,000	250,000
Base Construction Cost (BCC)					**6,230,000**
Design and Construction Contingency (30% of BCC)					1,869,000
Design Engineering (7% of BCC)					623,000
Construction Engineering and Management (10% of BCC)					747,600
Opinion of Probable Project Cost (OPPC)					**9,469,600**

Alternative B2 - *50 cfs*

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
1	Mobilization and Demobilization	LS	1	50,000	50,000
2	Clearing and Grubbing	LS	1	32,000	32,000
3	30" Welded Steel Pipe, Bedding, and Excavation	LF	4,500	620	2,790,000
4	Energy Dissipation Structure and Riprap Rundown	LS	1	134,000	134,000
5	Canal Gate, Structure, and Instrumentation	LS	1	1,700,000	1,700,000
6	Slide Gate, Turnout Structure, and Instrumentation	LS	1	230,000	230,000
Base Construction Cost (BCC)					**4,936,000**
Design and Construction Contingency (30% of BCC)					1,480,800
Design Engineering (7% of BCC)					493,600
Construction Engineering and Management (10% of BCC)					592,320
Opinion of Probable Project Cost (OPPC)					**7,502,720**

Cost Breakdown

Alternative B - Buried ***PVC*** Pipeline

Alternative B1 - *100 cfs*

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
1	Mobilization and Demobilization	LS	1	50,000	50,000
2	Clearing and Grubbing	LS	1	32,000	32,000
3	36" PVC Pipe, Bedding, and Excavation	LF	4,500	550	2,475,000
4	Energy Dissipation Structure and Riprap Rundown	LS	1	193,000	193,000
5	Canal Gate, Structure, and Instrumentation	LS	1	1,700,000	1,700,000
6	Slide Gate, Turnout Structure, and Instrumentation	LS	1	250,000	250,000
Base Construction Cost (BCC)					**4,700,000**
Design and Construction Contingency (30% of BCC)					1,410,000
Design Engineering (7% of BCC)					470,000
Construction Engineering and Management (10% of BCC)					564,000
Opinion of Probable Project Cost (OPPC)					**7,144,000**

Alternative B2 - *50 cfs*

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
1	Mobilization and Demobilization	LS	1	50,000	50,000
2	Clearing and Grubbing	LS	1	32,000	32,000
3	30" PVC Pipe, Bedding, and Excavation	LF	4,500	450	2,025,000
4	Energy Dissipation Structure and Riprap Rundown	LS	1	134,000	134,000
5	Canal Gate, Structure, and Instrumentation	LS	1	1,700,000	1,700,000
6	Slide Gate, Turnout Structure, and Instrumentation	LS	1	230,000	230,000
Base Construction Cost (BCC)					**4,171,000**
Design and Construction Contingency (30% of BCC)					1,251,300
Design Engineering (7% of BCC)					417,100
Construction Engineering and Management (10% of BCC)					500,520
Opinion of Probable Project Cost (OPPC)					**6,339,920**

Attachment 3
Recapture Well and Pipeline Unit Costs

Recapture Well Unit Costs (2024)

Item No.	Item	Unit	Unit Price($)
1	Mobilization/Demobilization	LS	$2,772
2	Drilling 24-inch Hole	LF	$50
3	Furnish/Install 16-inch PVC Casing	LF	$33
4	Furnish/Install 16-inch PVC Screen	LF	$39
5	Grout Seal	LF	$55
6	Furnish/Install Gravel Pack	LF	$22
7	Well Development	HR	$139
8	Short-Term Well Testing	LS	$1,109
9	Submersible Turbine Pump/Motor (500 gpm)	LS	$12,387
	Submersible Turbine Pump/Motor (600 gpm)	LS	$14,064
	Submersible Turbine Pump/Motor (700 gpm)	LS	$15,741
	Submersible Turbine Pump/Motor (800 gpm)	LS	$17,419
	Submersible Turbine Pump/Motor (900 gpm)	LS	$19,096
	Submersible Turbine Pump/Motor (1,000 gpm)	LS	$20,773
10	Surface Facilities	LS	$8,038
11	Power	LS	$21,429

Pipeline Unit Costs (2024)

Item No.	Item	Unit	Unit Price (PVC) ($)	Unit Price (Steel) ($)
1	Mobilization/Demobilization	LS	$50,000	$50,000
2	Surface Facilities	LS/Well	$5,700	$5,700
3	Clearing and Grubbing	LF	$7	$7
4	Discharge Pipeline 8"	LF	$26	$43
5	Discharge Pipeline 10"	LF	$36	$60
6	Discharge Pipeline 12"	LF	$48	$79
7	Discharge Pipeline 14"	LF	$75	$125
8	Discharge Pipeline 16"	LF	$95	$158
9	Discharge Pipeline 18"	LF	$135	$225
10	Discharge Pipeline 20"	LF	$175	$292
11	Discharge Pipeline 24"	LF	$250	$417
12	Pipeline Bridge /Mounting	LS	$10,000	$10,000
13	Drain-Back Structure	LS	$6,700	$6,700
14	Discharge Structure	LS	$6,000	$6,000
15	Dewatering	LS	$111,625	$186,042
16	Erosion Control and Seeding	LF	$3	$3

LS = Lump Sum
LF = Linear Feet
HR = Hour

Attachment 4
Total Capital and O&M Detailed Costs for Trade Off Scenarios 1 - 4.3

Scenario 1.0: No Elwood Outlet, 8 Existing Recapture Wells, No New Recapture Wells (Program Baseline)

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
No Changes to Elwood Reservoir Outlet					
1					
2					
3					
4					
5					
6					
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
No Changes to Plum Creek					
1	Plum Creek Mitigation Costs				0
2	Culverts & Stream Crossings				0
Base Mitigation Cost (BMC)					0
Contingency (30% of BMC)					0
Opinion of Probable Project Cost (OPPC)					**0**
No New Recapture Wells					
1	Mobilization/Demobilization	LS	0	2,772	0
2	Drilling 24-inch Hole	LF	0	50	0
3	Furnish/Install 16-inch PVC Casing	LF	0	33	0
4	Furnish/Install 16-inch PVC Screen	LF	0	39	0
5	Grout Seal	LF	0	55	0
6	Furnish/Install Gravel Pack	LF	0	22	0
7	Well Development	HR	0	139	0
8	Short-Term Well Testing	LS	0	1,109	0
9	Submersible Turbine Pump/Motor	LS	0	12,387	0
10	Surface Facilities	LS	0	8,038	0
11	Power	LS	0	21,429	0
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Well Pipeline - PVC					
1	Mobilization/Demobilization	LS	0	50,000	0
2	Surface Facilities	LS/Well	0	5,700	0
3	Clearing and Grubbing	LF	0	7	0
4	Discharge Pipeline 8"	LF	0	26	0
5	Discharge Pipeline 10"	LF	0	36	0
6	Discharge Pipeline 12"	LF	0	48	0
7	Discharge Pipeline 14"	LF	0	75	0
8	Discharge Pipeline 16"	LF	0	95	0
9	Discharge Pipeline 18"	LF	0	135	0
10	Discharge Pipeline 20"	LF	0	175	0
11	Discharge Pipeline 24"	LF	0	250	0
12	Pipeline Bridge /Mounting	LS	0	10,000	0
13	Drain-Back Structure	LS	0	6,700	0
14	Discharge Structure	LS	0	6,000	0
15	Dewatering	LS	0	0	0
16	Erosion Control and Seeding	LF	0	3	0
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Subtotal					0
O&M (50-Yr Project Life)					0
Permitting					0
Total Opinion of Probable Project Cost (OPPC)					**0**

Scenario 1.1A: No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 1) (PVC)

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
No Changes to Elwood Reservoir Outlet					
1					
2					
3					
4					
5					
6					
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
No Changes to Plum Creek					
1	Plum Creek Mitigation Costs				0
2	Culverts & Stream Crossings				0
Base Mitigation Cost (BMC)					0
Contingency (30% of BMC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Wells (Recapture Zone 1/Recapture Area 1 & 2) - 6 Wells					
1	Mobilization/Demobilization	LS	2	2,772	5,544
2	Drilling 24-inch Hole	LF	297	50	14,818
3	Furnish/Install 16-inch PVC Casing	LF	135	33	4,490
4	Furnish/Install 16-inch PVC Screen	LF	162	39	6,286
5	Grout Seal	LF	60	55	3,326
6	Furnish/Install Gravel Pack	LF	324	22	7,184
7	Well Development	HR	24	139	3,326
8	Short-Term Well Testing	LS	6	1,109	6,652
9	Submersible Turbine Pump/Motor	LS	6	14,064	84,383
10	Surface Facilities	LS	6	8,038	48,229
11	Power	LS	6	21,429	128,571
Base Construction Cost (BCC)					312,812
Design and Construction Contingency (30% of BCC)					93,843
Design Engineering (10% of BCC)					31,281
Construction Engineering and Management (12% of BCC)					37,537
Opinion of Probable Project Cost (OPPC)					**475,474**
Recapture Well Pipeline - PVC					
1	Mobilization/Demobilization	LS	1	50,000	50,000
2	Surface Facilities	LS/Well	6	5,700	34,200
3	Clearing and Grubbing	LF	13400	7	95,289
4	Discharge Pipeline 8"	LF	0	26	0
5	Discharge Pipeline 10"	LF	3300	36	118,800
6	Discharge Pipeline 12"	LF	1000	48	47,500
7	Discharge Pipeline 14"	LF	9100	75	682,500
8	Discharge Pipeline 16"	LF	0	95	0
9	Discharge Pipeline 18"	LF	0	135	0
10	Discharge Pipeline 20"	LF	0	175	0
11	Discharge Pipeline 24"	LF	0	250	0
12	Pipeline Bridge /Mounting	LS	0	10,000	0
13	Drain-Back Structure	LS	2	6,700	13,400
14	Discharge Structure	LS	2	6,000	12,000
15	Dewatering	LS	1	42,440	42,440
16	Erosion Control and Seeding	LF	13400	3	40,200
Base Construction Cost (BCC)					1,136,329
Design and Construction Contingency (30% of BCC)					340,899
Design Engineering (10% of BCC)					113,633
Construction Engineering and Management (12% of BCC)					136,359
Opinion of Probable Project Cost (OPPC)					**1,727,220**
Subtotal					2,202,694
O&M (50-Yr Project Life)					14,885,546
Permitting					25,000
Total Opinion of Probable Project Cost (OPPC)					**17,113,239**

Scenario 1.1B: No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 1) (Steel)

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
No Changes to Elwood Reservoir Outlet					
1					
2					
3					
4					
5					
6					
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
No Changes to Plum Creek					
1	Plum Creek Mitigation Costs				0
2	Culverts & Stream Crossings				0
Base Mitigation Cost (BMC)					0
Contingency (30% of BMC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Wells (Recapture Zone 1/Recapture Area 1 & 2) - 6 Wells					
1	Mobilization/Demobilization	LS	2	2,772	5,544
2	Drilling 24-inch Hole	LF	297	50	14,818
3	Furnish/Install 16-inch PVC Casing	LF	135	33	4,490
4	Furnish/Install 16-inch PVC Screen	LF	162	39	6,286
5	Grout Seal	LF	60	55	3,326
6	Furnish/Install Gravel Pack	LF	324	22	7,184
7	Well Development	HR	24	139	3,326
8	Short-Term Well Testing	LS	6	1,109	6,652
9	Submersible Turbine Pump/Motor	LS	6	14,064	84,383
10	Surface Facilities	LS	6	8,038	48,229
11	Power	LS	6	21,429	128,571
Base Construction Cost (BCC)					312,812
Design and Construction Contingency (30% of BCC)					93,843
Design Engineering (10% of BCC)					31,281
Construction Engineering and Management (12% of BCC)					37,537
Opinion of Probable Project Cost (OPPC)					**475,474**
Recapture Well Pipeline - Steel					
1	Mobilization/Demobilization	LS	1	50,000	50,000
2	Surface Facilities	LS/Well	6	5,700	34,200
3	Clearing and Grubbing	LF	13400	7	95,289
4	Discharge Pipeline 8"	LF	0	43	0
5	Discharge Pipeline 10"	LF	3300	60	198,000
6	Discharge Pipeline 12"	LF	1000	79	79,167
7	Discharge Pipeline 14"	LF	9100	125	1,137,500
8	Discharge Pipeline 16"	LF	0	158	0
9	Discharge Pipeline 18"	LF	0	225	0
10	Discharge Pipeline 20"	LF	0	292	0
11	Discharge Pipeline 24"	LF	0	417	0
12	Pipeline Bridge /Mounting	LS	0	10,000	0
13	Drain-Back Structure	LS	2	6,700	13,400
14	Discharge Structure	LS	2	6,000	12,000
15	Dewatering	LS	1	70,733	70,733
16	Erosion Control and Seeding	LF	13400	3	40,200
Base Construction Cost (BCC)					1,730,489
Design and Construction Contingency (30% of BCC)					519,147
Design Engineering (10% of BCC)					173,049
Construction Engineering and Management (12% of BCC)					207,659
Opinion of Probable Project Cost (OPPC)					**2,630,343**
Subtotal					3,105,817
O&M (50-Yr Project Life)					14,885,546
Permitting					25,000
Total Opinion of Probable Project Cost (OPPC)					**18,016,362**

Scenario 1.2A: No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 2) (PVC)

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
No Changes to Elwood Reservoir Outlet					
1					
2					
3					
4					
5					
6					
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
No Changes to Plum Creek					
1	Plum Creek Mitigation Costs				0
2	Culverts & Stream Crossings				0
Base Mitigation Cost (BMC)					0
Contingency (30% of BMC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Wells (Recapture Zone 2/Recapture Area 3 & 4) - 6 Wells					
1	Mobilization/Demobilization	LS	2	2,772	5,544
2	Drilling 24-inch Hole	LF	1806	50	90,106
3	Furnish/Install 16-inch PVC Casing	LF	1605	33	53,385
4	Furnish/Install 16-inch PVC Screen	LF	201	39	7,800
5	Grout Seal	LF	60	55	3,326
6	Furnish/Install Gravel Pack	LF	402	22	8,914
7	Well Development	HR	24	139	3,326
8	Short-Term Well Testing	LS	6	1,109	6,652
9	Submersible Turbine Pump/Motor	LS	6	12,387	74,320
10	Surface Facilities	LS	6	8,038	48,229
11	Power	LS	6	21,429	128,571
Base Construction Cost (BCC)					430,173
Design and Construction Contingency (30% of BCC)					129,052
Design Engineering (10% of BCC)					43,017
Construction Engineering and Management (12% of BCC)					51,621
Opinion of Probable Project Cost (OPPC)					**653,862**
Recapture Well Pipeline - PVC					
1	Mobilization/Demobilization	LS	1	50,000	50,000
2	Surface Facilities	LS/Well	6	5,700	34,200
3	Clearing and Grubbing	LF	29600	7	210,489
4	Discharge Pipeline 8"	LF	3000	26	76,500
5	Discharge Pipeline 10"	LF	0	36	0
6	Discharge Pipeline 12"	LF	16400	48	779,000
7	Discharge Pipeline 14"	LF	0	75	0
8	Discharge Pipeline 16"	LF	0	95	0
9	Discharge Pipeline 18"	LF	10200	135	1,377,000
10	Discharge Pipeline 20"	LF	0	175	0
11	Discharge Pipeline 24"	LF	0	250	0
12	Pipeline Bridge /Mounting	LS	1	10,000	10,000
13	Drain-Back Structure	LS	1	6,700	6,700
14	Discharge Structure	LS	1	6,000	6,000
15	Dewatering	LS	1	111,625	111,625
16	Erosion Control and Seeding	LF	29600	3	88,800
Base Construction Cost (BCC)					2,750,314
Design and Construction Contingency (30% of BCC)					825,094
Design Engineering (10% of BCC)					275,031
Construction Engineering and Management (12% of BCC)					330,038
Opinion of Probable Project Cost (OPPC)					**4,180,477**
Subtotal					4,834,340
O&M (50-Yr Project Life)					13,724,629
Permitting					25,000
Total Opinion of Probable Project Cost (OPPC)					**18,583,968**

Scenario 1.2B: No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 2) (Steel)

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
No Changes to Elwood Reservoir Outlet					
1					
2					
3					
4					
5					
6					
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
No Changes to Plum Creek					
1	Plum Creek Mitigation Costs				0
2	Culverts & Stream Crossings				0
Base Mitigation Cost (BMC)					0
Contingency (30% of BMC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Wells (Recapture Zone 2/Recapture Area 3 & 4) - 6 Wells					
1	Mobilization/Demobilization	LS	2	2,772	5,544
2	Drilling 24-inch Hole	LF	1806	50	90,106
3	Furnish/Install 16-inch PVC Casing	LF	1605	33	53,385
4	Furnish/Install 16-inch PVC Screen	LF	201	39	7,800
5	Grout Seal	LF	60	55	3,326
6	Furnish/Install Gravel Pack	LF	402	22	8,914
7	Well Development	HR	24	139	3,326
8	Short-Term Well Testing	LS	6	1,109	6,652
9	Submersible Turbine Pump/Motor	LS	6	12,387	74,320
10	Surface Facilities	LS	6	8,038	48,229
11	Power	LS	6	21,429	128,571
Base Construction Cost (BCC)					430,173
Design and Construction Contingency (30% of BCC)					129,052
Design Engineering (10% of BCC)					43,017
Construction Engineering and Management (12% of BCC)					51,621
Opinion of Probable Project Cost (OPPC)					**653,862**
Recapture Well Pipeline - Steel					
1	Mobilization/Demobilization	LS	1	50,000	50,000
2	Surface Facilities	LS/Well	6	5,700	34,200
3	Clearing and Grubbing	LF	29600	7	210,489
4	Discharge Pipeline 8"	LF	3000	43	127,500
5	Discharge Pipeline 10"	LF	0	60	0
6	Discharge Pipeline 12"	LF	16400	79	1,298,333
7	Discharge Pipeline 14"	LF	0	125	0
8	Discharge Pipeline 16"	LF	0	158	0
9	Discharge Pipeline 18"	LF	10200	225	2,295,000
10	Discharge Pipeline 20"	LF	0	292	0
11	Discharge Pipeline 24"	LF	0	417	0
12	Pipeline Bridge /Mounting	LS	1	10,000	10,000
13	Drain-Back Structure	LS	1	6,700	6,700
14	Discharge Structure	LS	1	6,000	6,000
15	Dewatering	LS	1	186,042	186,042
16	Erosion Control and Seeding	LF	29600	3	88,800
Base Construction Cost (BCC)					4,313,064
Design and Construction Contingency (30% of BCC)					1,293,919
Design Engineering (10% of BCC)					431,306
Construction Engineering and Management (12% of BCC)					517,568
Opinion of Probable Project Cost (OPPC)					**6,555,857**
Subtotal					7,209,720
O&M (50-Yr Project Life)					13,724,629
Permitting					25,000
Total Opinion of Probable Project Cost (OPPC)					**20,959,348**

Scenario 1.3A: No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 3) (PVC)

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
No Changes to Elwood Reservoir Outlet					
1					
2					
3					
4					
5					
6					
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
No Changes to Plum Creek					
1	Plum Creek Mitigation Costs				0
2	Culverts & Stream Crossings				0
Base Mitigation Cost (BMC)					0
Contingency (30% of BMC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Wells (Recapture Zone 3/Recapture Area 5 & 6) - 6 Wells					
1	Mobilization/Demobilization	LS	2	2,772	5,544
2	Drilling 24-inch Hole	LF	1506	50	75,138
3	Furnish/Install 16-inch PVC Casing	LF	1086	33	36,122
4	Furnish/Install 16-inch PVC Screen	LF	420	39	16,298
5	Grout Seal	LF	60	55	3,326
6	Furnish/Install Gravel Pack	LF	840	22	18,626
7	Well Development	HR	24	139	3,326
8	Short-Term Well Testing	LS	6	1,109	6,652
9	Submersible Turbine Pump/Motor	LS	6	20,773	124,639
10	Surface Facilities	LS	6	8,038	48,229
11	Power	LS	6	21,429	128,571
Base Construction Cost (BCC)					466,472
Design and Construction Contingency (30% of BCC)					139,942
Design Engineering (10% of BCC)					46,647
Construction Engineering and Management (12% of BCC)					55,977
Opinion of Probable Project Cost (OPPC)					**709,038**
Recapture Well Pipeline - PVC					
1	Mobilization/Demobilization	LS	1	50,000	50,000
2	Surface Facilities	LS/Well	6	5,700	34,200
3	Clearing and Grubbing	LF	11725	7	83,378
4	Discharge Pipeline 8"	LF	0	26	0
5	Discharge Pipeline 10"	LF	0	36	0
6	Discharge Pipeline 12"	LF	2000	48	95,000
7	Discharge Pipeline 14"	LF	0	75	0
8	Discharge Pipeline 16"	LF	2000	95	190,000
9	Discharge Pipeline 18"	LF	7725	135	1,042,875
10	Discharge Pipeline 20"	LF	0	175	0
11	Discharge Pipeline 24"	LF	13000	250	3,250,000
12	Pipeline Bridge /Mounting	LS	1	10,000	10,000
13	Drain-Back Structure	LS	1	6,700	6,700
14	Discharge Structure	LS	1	6,000	6,000
15	Dewatering	LS	1	66,394	66,394
16	Erosion Control and Seeding	LF	11725	3	35,175
Base Construction Cost (BCC)					4,869,722
Design and Construction Contingency (30% of BCC)					1,460,916
Design Engineering (10% of BCC)					486,972
Construction Engineering and Management (12% of BCC)					584,367
Opinion of Probable Project Cost (OPPC)					**7,401,977**
Subtotal					8,111,015
O&M (50-Yr Project Life)					17,437,959
Permitting					25,000
Total Opinion of Probable Project Cost (OPPC)					**25,573,974**

Scenario 1.3B: No Elwood Outlet, 8 Existing Recapture Wells, New Recapture Wells (Zone 3) (Steel)

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
No Changes to Elwood Reservoir Outlet					
1					
2					
3					
4					
5					
6					
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
No Changes to Plum Creek					
1	Plum Creek Mitigation Costs				0
2	Culverts & Stream Crossings				0
Base Mitigation Cost (BMC)					0
Contingency (30% of BMC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Wells (Recapture Zone 3/Recapture Area 5 & 6) - 6 Wells					
1	Mobilization/Demobilization	LS	2	2,772	5,544
2	Drilling 24-inch Hole	LF	1506	50	75,138
3	Furnish/Install 16-inch PVC Casing	LF	1086	33	36,122
4	Furnish/Install 16-inch PVC Screen	LF	420	39	16,298
5	Grout Seal	LF	60	55	3,326
6	Furnish/Install Gravel Pack	LF	840	22	18,626
7	Well Development	HR	24	139	3,326
8	Short-Term Well Testing	LS	6	1,109	6,652
9	Submersible Turbine Pump/Motor	LS	6	20,773	124,639
10	Surface Facilities	LS	6	8,038	48,229
11	Power	LS	6	21,429	128,571
Base Construction Cost (BCC)					466,472
Design and Construction Contingency (30% of BCC)					139,942
Design Engineering (10% of BCC)					46,647
Construction Engineering and Management (12% of BCC)					55,977
Opinion of Probable Project Cost (OPPC)					**709,038**
Recapture Well Pipeline - Steel					
1	Mobilization/Demobilization	LS	1	50,000	50,000
2	Surface Facilities	LS/Well	6	5,700	34,200
3	Clearing and Grubbing	LF	11725	7	83,378
4	Discharge Pipeline 8"	LF	0	43	0
5	Discharge Pipeline 10"	LF	0	60	0
6	Discharge Pipeline 12"	LF	2000	79	158,333
7	Discharge Pipeline 14"	LF	0	125	0
8	Discharge Pipeline 16"	LF	2000	158	316,667
9	Discharge Pipeline 18"	LF	7725	225	1,738,125
10	Discharge Pipeline 20"	LF	0	292	0
11	Discharge Pipeline 24"	LF	13000	417	5,416,667
12	Pipeline Bridge /Mounting	LS	1	10,000	10,000
13	Drain-Back Structure	LS	1	6,700	6,700
14	Discharge Structure	LS	1	6,000	6,000
15	Dewatering	LS	1	110,656	110,656
16	Erosion Control and Seeding	LF	11725	3	35,175
Base Construction Cost (BCC)					7,965,901
Design and Construction Contingency (30% of BCC)					2,389,770
Design Engineering (10% of BCC)					796,590
Construction Engineering and Management (12% of BCC)					955,908
Opinion of Probable Project Cost (OPPC)					**12,108,169**
Subtotal					12,817,207
O&M (50-Yr Project Life)					17,437,959
Permitting					25,000
Total Opinion of Probable Project Cost (OPPC)					**30,280,166**

Scenario 2.0: 50 cfs Elwood Outlet (Open Channel), 7 Existing Recapture Wells

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
Elwood Reservoir Outlet - Open Channel (50 cfs)					
1	Mobilization and Demobilization	LS	1	50,000	50,000
2	Clearing and Grubbing	LS	1	40,000	40,000
3	Excavation	CY	17900	5	89,500
4	Type M Riprap	CY	10300	130	1,339,000
5	Geotextile	SF	167100	2	334,200
6					0
Base Construction Cost (BCC)					1,852,700
Design and Construction Contingency (30% of BCC)					555,810
Design Engineering (10% of BCC)					185,270
Construction Engineering and Management (12% of BCC)					222,324
Opinion of Probable Project Cost (OPPC)					**2,816,104**
Plum Creek Mitigation and Infrastructure Improvements (50 cfs) - Over 5-Years					
1	Plum Creek Mitigation Costs				615,331
2	Culverts & Stream Crossings				449,000
Base Mitigation Cost (BMC)					1,064,331
Contingency (30% of BMC)					319,299
Opinion of Probable Project Cost (OPPC)					**1,383,630**
No New Recapture Wells					
1	Mobilization/Demobilization	LS	0	2,772	0
2	Drilling 24-inch Hole	LF	0	50	0
3	Furnish/Install 16-inch PVC Casing	LF	0	33	0
4	Furnish/Install 16-inch PVC Screen	LF	0	39	0
5	Grout Seal	LF	0	55	0
6	Furnish/Install Gravel Pack	LF	0	22	0
7	Well Development	HR	0	139	0
8	Short-Term Well Testing	LS	0	1,109	0
9	Submersible Turbine Pump/Motor	LS	0	12,387	0
10	Surface Facilities	LS	0	8,038	0
11	Power	LS	0	21,429	0
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Well Pipeline - PVC					
1	Mobilization/Demobilization	LS	0	50,000	0
2	Surface Facilities	LS/Well	0	5,700	0
3	Clearing and Grubbing	LF	0	7	0
4	Discharge Pipeline 8"	LF	0	26	0
5	Discharge Pipeline 10"	LF	0	36	0
6	Discharge Pipeline 12"	LF	0	48	0
7	Discharge Pipeline 14"	LF	0	75	0
8	Discharge Pipeline 16"	LF	0	95	0
9	Discharge Pipeline 18"	LF	0	135	0
10	Discharge Pipeline 20"	LF	0	175	0
11	Discharge Pipeline 24"	LF	0	250	0
12	Pipeline Bridge /Mounting	LS	0	10,000	0
13	Drain-Back Structure	LS	0	6,700	0
14	Discharge Structure	LS	0	6,000	0
15	Dewatering	LS	0	0	0
16	Erosion Control and Seeding	LF	0	3	0
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Subtotal					4,199,734
O&M (50-Yr Project Life)					3,107,831
Permitting					100,000
Total Opinion of Probable Project Cost (OPPC)					**7,407,565**

Scenario 2.0A: 50 cfs Elwood Outlet (PVC), 7 Existing Recapture Wells

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
Elwood Reservoir Outlet - PVC Pipeline (50 cfs)					
1	Mobilization and Demobilization	LS	1	50,000	50,000
2	Clearing and Grubbing	LS	1	32,000	32,000
3	30" PVC Pipe, Bedding, and Excavation	LF	4500	450	2,025,000
4	Energy Dissipation Structure and Riprap Rundown	LS	1	134,000	134,000
5	Canal Gate, Structure, and Instrumentation	LS	1	1,700,000	1,700,000
6	Slide Gate, Turnout Structure, and Instrumentation	LS	1	230,000	230,000
Base Construction Cost (BCC)					4,171,000
Design and Construction Contingency (30% of BCC)					1,251,300
Design Engineering (10% of BCC)					417,100
Construction Engineering and Management (12% of BCC)					500,520
Opinion of Probable Project Cost (OPPC)					**6,339,920**
Plum Creek Mitigation and Infrastructure Improvements (50 cfs) - Over 5-Years					
1	Plum Creek Mitigation Costs				615,331
2	Culverts & Stream Crossings				449,000
Base Mitigation Cost (BMC)					1,064,331
Contingency (30% of BMC)					319,299
Opinion of Probable Project Cost (OPPC)					**1,383,630**
No New Recapture Wells					
1	Mobilization/Demobilization	LS	0	2,772	0
2	Drilling 24-inch Hole	LF	0	50	0
3	Furnish/Install 16-inch PVC Casing	LF	0	33	0
4	Furnish/Install 16-inch PVC Screen	LF	0	39	0
5	Grout Seal	LF	0	55	0
6	Furnish/Install Gravel Pack	LF	0	22	0
7	Well Development	HR	0	139	0
8	Short-Term Well Testing	LS	0	1,109	0
9	Submersible Turbine Pump/Motor	LS	0	12,387	0
10	Surface Facilities	LS	0	8,038	0
11	Power	LS	0	21,429	0
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Well Pipeline - PVC					
1	Mobilization/Demobilization	LS	0	50,000	0
2	Surface Facilities	LS/Well	0	5,700	0
3	Clearing and Grubbing	LF	0	7	0
4	Discharge Pipeline 8"	LF	0	26	0
5	Discharge Pipeline 10"	LF	0	36	0
6	Discharge Pipeline 12"	LF	0	48	0
7	Discharge Pipeline 14"	LF	0	75	0
8	Discharge Pipeline 16"	LF	0	95	0
9	Discharge Pipeline 18"	LF	0	135	0
10	Discharge Pipeline 20"	LF	0	175	0
11	Discharge Pipeline 24"	LF	0	250	0
12	Pipeline Bridge /Mounting	LS	0	10,000	0
13	Drain-Back Structure	LS	0	6,700	0
14	Discharge Structure	LS	0	6,000	0
15	Dewatering	LS	0	0	0
16	Erosion Control and Seeding	LF	0	3	0
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Subtotal					7,723,550
O&M (50-Yr Project Life)					3,107,831
Permitting					100,000
Total Opinion of Probable Project Cost (OPPC)					**10,931,381**

Scenario 2.0B: 50 cfs Elwood Outlet (Steel), 7 Existing Recapture Wells

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
Elwood Reservoir Outlet - Steel Pipeline (50 cfs)					
1	Mobilization and Demobilization	LS	1	50,000	50,000
2	Clearing and Grubbing	LS	1	32,000	32,000
3	30" Welded Steel Pipe, Bedding, and Excavation	LF	4500	620	2,790,000
4	Energy Dissipation Structure and Riprap Rundown	LS	1	134,000	134,000
5	Canal Gate, Structure, and Instrumentation	LS	1	1,700,000	1,700,000
6	Slide Gate, Turnout Structure, and Instrumentation	LS	1	230,000	230,000
Base Construction Cost (BCC)					4,936,000
Design and Construction Contingency (30% of BCC)					1,480,800
Design Engineering (10% of BCC)					493,600
Construction Engineering and Management (12% of BCC)					592,320
Opinion of Probable Project Cost (OPPC)					**7,502,720**
Plum Creek Mitigation and Infrastructure Improvements (50 cfs) - Over 5-Years					
1	Plum Creek Mitigation Costs				615,331
2	Culverts & Stream Crossings				449,000
Base Mitigation Cost (BMC)					1,064,331
Contingency (30% of BMC)					319,299
Opinion of Probable Project Cost (OPPC)					**1,383,630**
No New Recapture Wells					
1	Mobilization/Demobilization	LS	0	2,772	0
2	Drilling 24-inch Hole	LF	0	50	0
3	Furnish/Install 16-inch PVC Casing	LF	0	33	0
4	Furnish/Install 16-inch PVC Screen	LF	0	39	0
5	Grout Seal	LF	0	55	0
6	Furnish/Install Gravel Pack	LF	0	22	0
7	Well Development	HR	0	139	0
8	Short-Term Well Testing	LS	0	1,109	0
9	Submersible Turbine Pump/Motor	LS	0	12,387	0
10	Surface Facilities	LS	0	8,038	0
11	Power	LS	0	21,429	0
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Well Pipeline - Steel					
1	Mobilization/Demobilization	LS	0	50,000	0
2	Surface Facilities	LS/Well	0	5,700	0
3	Clearing and Grubbing	LF	0	7	0
4	Discharge Pipeline 8"	LF	0	43	0
5	Discharge Pipeline 10"	LF	0	60	0
6	Discharge Pipeline 12"	LF	0	79	0
7	Discharge Pipeline 14"	LF	0	125	0
8	Discharge Pipeline 16"	LF	0	158	0
9	Discharge Pipeline 18"	LF	0	225	0
10	Discharge Pipeline 20"	LF	0	292	0
11	Discharge Pipeline 24"	LF	0	417	0
12	Pipeline Bridge /Mounting	LS	0	10,000	0
13	Drain-Back Structure	LS	0	6,700	0
14	Discharge Structure	LS	0	6,000	0
15	Dewatering	LS	0	0	0
16	Erosion Control and Seeding	LF	0	3	0
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Subtotal					8,886,350
O&M (50-Yr Project Life)					3,107,831
Permitting					100,000
Total Opinion of Probable Project Cost (OPPC)					**12,094,181**

Scenario 3.0: 100 cfs Elwood Outlet (Open Channel), 6 Existing Recapture Wells

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
Elwood Reservoir Outlet - Open Channel (100 cfs)					
1	Mobilization and Demobilization	LS	1	50,000	50,000
2	Clearing and Grubbing	LS	1	40,000	40,000
3	Excavation	CY	23400	5	117,000
4	Type M Riprap	CY	12100	130	1,573,000
5	Geotextile	SF	192300	2	384,600
6					0
Base Construction Cost (BCC)					2,164,600
Design and Construction Contingency (30% of BCC)					649,380
Design Engineering (10% of BCC)					216,460
Construction Engineering and Management (12% of BCC)					259,752
Opinion of Probable Project Cost (OPPC)					**3,290,192**
Plum Creek Mitigation and Infrastructure Improvements (100 cfs) - Over 5-Years					
1	Plum Creek Mitigation Costs				4,242,546
2	Culverts & Stream Crossings				449,000
Base Mitigation Cost (BMC)					4,691,546
Contingency (30% of BMC)					1,407,464
Opinion of Probable Project Cost (OPPC)					**6,099,009**
No New Recapture Wells					
1	Mobilization/Demobilization	LS	0	2,772	0
2	Drilling 24-inch Hole	LF	0	50	0
3	Furnish/Install 16-inch PVC Casing	LF	0	33	0
4	Furnish/Install 16-inch PVC Screen	LF	0	39	0
5	Grout Seal	LF	0	55	0
6	Furnish/Install Gravel Pack	LF	0	22	0
7	Well Development	HR	0	139	0
8	Short-Term Well Testing	LS	0	1,109	0
9	Submersible Turbine Pump/Motor	LS	0	12,387	0
10	Surface Facilities	LS	0	8,038	0
11	Power	LS	0	21,429	0
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Well Pipeline - PVC					
1	Mobilization/Demobilization	LS	0	50,000	0
2	Surface Facilities	LS/Well	0	5,700	0
3	Clearing and Grubbing	LF	0	7	0
4	Discharge Pipeline 8"	LF	0	26	0
5	Discharge Pipeline 10"	LF	0	36	0
6	Discharge Pipeline 12"	LF	0	48	0
7	Discharge Pipeline 14"	LF	0	75	0
8	Discharge Pipeline 16"	LF	0	95	0
9	Discharge Pipeline 18"	LF	0	135	0
10	Discharge Pipeline 20"	LF	0	175	0
11	Discharge Pipeline 24"	LF	0	250	0
12	Pipeline Bridge /Mounting	LS	0	10,000	0
13	Drain-Back Structure	LS	0	6,700	0
14	Discharge Structure	LS	0	6,000	0
15	Dewatering	LS	0	0	0
16	Erosion Control and Seeding	LF	0	3	0
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Subtotal					9,389,201
O&M (50-Yr Project Life)					11,086,030
Permitting					100,000
Total Opinion of Probable Project Cost (OPPC)					**20,575,231**

Scenario 3.0A: 100 cfs Elwood Outlet (PVC), 6 Existing Recapture Wells

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
Elwood Reservoir Outlet - PVC Pipeline (100 cfs)					
1	Mobilization and Demobilization	LS	1	50,000	50,000
2	Clearing and Grubbing	LS	1	32,000	32,000
3	36" PVC Pipe, Bedding, and Excavation	LF	4500	550	2,475,000
4	Energy Dissipation Structure and Riprap Rundown	LS	1	193,000	193,000
5	Canal Gate, Structure, and Instrumentation	LS	1	1,700,000	1,700,000
6	Slide Gate, Turnout Structure, and Instrumentation	LS	1	250,000	250,000
Base Construction Cost (BCC)					4,700,000
Design and Construction Contingency (30% of BCC)					1,410,000
Design Engineering (10% of BCC)					470,000
Construction Engineering and Management (12% of BCC)					564,000
Opinion of Probable Project Cost (OPPC)					**7,144,000**
Plum Creek Mitigation and Infrastructure Improvements (100 cfs) - Over 5-Years					
1	Plum Creek Mitigation Costs				4,242,546
2	Culverts & Stream Crossings				449,000
Base Mitigation Cost (BMC)					4,691,546
Contingency (30% of BMC)					1,407,464
Opinion of Probable Project Cost (OPPC)					**6,099,009**
No New Recapture Wells					
1	Mobilization/Demobilization	LS	0	2,772	0
2	Drilling 24-inch Hole	LF	0	50	0
3	Furnish/Install 16-inch PVC Casing	LF	0	33	0
4	Furnish/Install 16-inch PVC Screen	LF	0	39	0
5	Grout Seal	LF	0	55	0
6	Furnish/Install Gravel Pack	LF	0	22	0
7	Well Development	HR	0	139	0
8	Short-Term Well Testing	LS	0	1,109	0
9	Submersible Turbine Pump/Motor	LS	0	12,387	0
10	Surface Facilities	LS	0	8,038	0
11	Power	LS	0	21,429	0
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Well Pipeline - PVC					
1	Mobilization/Demobilization	LS	0	50,000	0
2	Surface Facilities	LS/Well	0	5,700	0
3	Clearing and Grubbing	LF	0	7	0
4	Discharge Pipeline 8"	LF	0	26	0
5	Discharge Pipeline 10"	LF	0	36	0
6	Discharge Pipeline 12"	LF	0	48	0
7	Discharge Pipeline 14"	LF	0	75	0
8	Discharge Pipeline 16"	LF	0	95	0
9	Discharge Pipeline 18"	LF	0	135	0
10	Discharge Pipeline 20"	LF	0	175	0
11	Discharge Pipeline 24"	LF	0	250	0
12	Pipeline Bridge /Mounting	LS	0	10,000	0
13	Drain-Back Structure	LS	0	6,700	0
14	Discharge Structure	LS	0	6,000	0
15	Dewatering	LS	0	0	0
16	Erosion Control and Seeding	LF	0	3	0
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Subtotal					13,243,009
O&M (50-Yr Project Life)					11,086,030
Permitting					100,000
Total Opinion of Probable Project Cost (OPPC)					**24,429,039**

Scenario 3.0B: 100 cfs Elwood Outlet (Steel), 6 Existing Recapture Wells

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
Elwood Reservoir Outlet - Steel Pipeline (100 cfs)					
1	Mobilization and Demobilization	LS	1	50,000	50,000
2	Clearing and Grubbing	LS	1	32,000	32,000
3	36" Welded Steel Pipe, Bedding, and Excavation	LF	4500	890	4,005,000
4	Energy Dissipation Structure and Riprap Rundown	LS	1	193,000	193,000
5	Canal Gate, Structure, and Instrumentation	LS	1	1,700,000	1,700,000
6	Slide Gate, Turnout Structure, and Instrumentation	LS	1	250,000	250,000
Base Construction Cost (BCC)					6,230,000
Design and Construction Contingency (30% of BCC)					1,869,000
Design Engineering (10% of BCC)					623,000
Construction Engineering and Management (12% of BCC)					747,600
Opinion of Probable Project Cost (OPPC)					**9,469,600**
Plum Creek Mitigation and Infrastructure Improvements (100 cfs) - Over 5-Years					
1	Plum Creek Mitigation Costs				4,242,546
2	Culverts & Stream Crossings				449,000
Base Mitigation Cost (BMC)					4,691,546
Contingency (30% of BMC)					1,407,464
Opinion of Probable Project Cost (OPPC)					**6,099,009**
No New Recapture Wells					
1	Mobilization/Demobilization	LS	0	2,772	0
2	Drilling 24-inch Hole	LF	0	50	0
3	Furnish/Install 16-inch PVC Casing	LF	0	33	0
4	Furnish/Install 16-inch PVC Screen	LF	0	39	0
5	Grout Seal	LF	0	55	0
6	Furnish/Install Gravel Pack	LF	0	22	0
7	Well Development	HR	0	139	0
8	Short-Term Well Testing	LS	0	1,109	0
9	Submersible Turbine Pump/Motor	LS	0	12,387	0
10	Surface Facilities	LS	0	8,038	0
11	Power	LS	0	21,429	0
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Well Pipeline - Steel					
1	Mobilization/Demobilization	LS	0	50,000	0
2	Surface Facilities	LS/Well	0	5,700	0
3	Clearing and Grubbing	LF	0	7	0
4	Discharge Pipeline 8"	LF	0	43	0
5	Discharge Pipeline 10"	LF	0	60	0
6	Discharge Pipeline 12"	LF	0	79	0
7	Discharge Pipeline 14"	LF	0	125	0
8	Discharge Pipeline 16"	LF	0	158	0
9	Discharge Pipeline 18"	LF	0	225	0
10	Discharge Pipeline 20"	LF	0	292	0
11	Discharge Pipeline 24"	LF	0	417	0
12	Pipeline Bridge /Mounting	LS	0	10,000	0
13	Drain-Back Structure	LS	0	6,700	0
14	Discharge Structure	LS	0	6,000	0
15	Dewatering	LS	0	0	0
16	Erosion Control and Seeding	LF	0	3	0
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Subtotal					15,568,609
O&M (50-Yr Project Life)					11,086,030
Permitting					100,000
Total Opinion of Probable Project Cost (OPPC)					**26,754,639**

Scenario 4.0: Elwood Recharge Only (No New Infrastructure) - NeDNR Baseline

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
No Changes to Elwood Reservoir Outlet					
1					
2					
3					
4					
5					
6					
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
No Changes to Plum Creek					
1	Plum Creek Mitigation Costs				0
2	Culverts & Stream Crossings				0
Base Mitigation Cost (BMC)					0
Contingency (30% of BMC)					0
Opinion of Probable Project Cost (OPPC)					**0**
No New Recapture Wells					
1	Mobilization/Demobilization	LS	0	2,772	0
2	Drilling 24-inch Hole	LF	0	50	0
3	Furnish/Install 16-inch PVC Casing	LF	0	33	0
4	Furnish/Install 16-inch PVC Screen	LF	0	39	0
5	Grout Seal	LF	0	55	0
6	Furnish/Install Gravel Pack	LF	0	22	0
7	Well Development	HR	0	139	0
8	Short-Term Well Testing	LS	0	1,109	0
9	Submersible Turbine Pump/Motor	LS	0	12,387	0
10	Surface Facilities	LS	0	8,038	0
11	Power	LS	0	21,429	0
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Well Pipeline - PVC					
1	Mobilization/Demobilization	LS	0	50,000	0
2	Surface Facilities	LS/Well	0	5,700	0
3	Clearing and Grubbing	LF	0	7	0
4	Discharge Pipeline 8"	LF	0	26	0
5	Discharge Pipeline 10"	LF	0	36	0
6	Discharge Pipeline 12"	LF	0	48	0
7	Discharge Pipeline 14"	LF	0	75	0
8	Discharge Pipeline 16"	LF	0	95	0
9	Discharge Pipeline 18"	LF	0	135	0
10	Discharge Pipeline 20"	LF	0	175	0
11	Discharge Pipeline 24"	LF	0	250	0
12	Pipeline Bridge /Mounting	LS	0	10,000	0
13	Drain-Back Structure	LS	0	6,700	0
14	Discharge Structure	LS	0	6,000	0
15	Dewatering	LS	0	0	0
16	Erosion Control and Seeding	LF	0	3	0
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Subtotal					0
O&M (50-Yr Project Life)					0
Permitting					0
Total Opinion of Probable Project Cost (OPPC)					**0**

Scenario 4.1A: New Recapture Wells Only (Zone 1) (PVC)

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
No Changes to Elwood Reservoir Outlet					
1					
2					
3					
4					
5					
6					
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
No Changes to Plum Creek					
1	Plum Creek Mitigation Costs				0
2	Culverts & Stream Crossings				0
Base Mitigation Cost (BMC)					0
Contingency (30% of BMC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Wells (Recapture Zone 1/Recapture Area 1 & 2) - 6 Wells					
1	Mobilization/Demobilization	LS	2	2,772	5,544
2	Drilling 24-inch Hole	LF	297	50	14,818
3	Furnish/Install 16-inch PVC Casing	LF	135	33	4,490
4	Furnish/Install 16-inch PVC Screen	LF	162	39	6,286
5	Grout Seal	LF	60	55	3,326
6	Furnish/Install Gravel Pack	LF	324	22	7,184
7	Well Development	HR	24	139	3,326
8	Short-Term Well Testing	LS	6	1,109	6,652
9	Submersible Turbine Pump/Motor	LS	6	19,096	114,575
10	Surface Facilities	LS	6	8,038	48,229
11	Power	LS	6	21,429	128,571
Base Construction Cost (BCC)					343,003
Design and Construction Contingency (30% of BCC)					102,901
Design Engineering (10% of BCC)					34,300
Construction Engineering and Management (12% of BCC)					41,160
Opinion of Probable Project Cost (OPPC)					**521,365**
Recapture Well Pipeline - PVC					
1	Mobilization/Demobilization	LS	1	50,000	50,000
2	Surface Facilities	LS/Well	6	5,700	34,200
3	Clearing and Grubbing	LF	13400	7	95,289
4	Discharge Pipeline 8"	LF	0	26	0
5	Discharge Pipeline 10"	LF	3300	36	118,800
6	Discharge Pipeline 12"	LF	0	48	0
7	Discharge Pipeline 14"	LF	1000	75	75,000
8	Discharge Pipeline 16"	LF	0	95	0
9	Discharge Pipeline 18"	LF	9100	135	1,228,500
10	Discharge Pipeline 20"	LF	0	175	0
11	Discharge Pipeline 24"	LF	0	250	0
12	Pipeline Bridge /Mounting	LS	0	10,000	0
13	Drain-Back Structure	LS	2	6,700	13,400
14	Discharge Structure	LS	2	6,000	12,000
15	Dewatering	LS	1	71,115	71,115
16	Erosion Control and Seeding	LF	13400	3	40,200
Base Construction Cost (BCC)					1,738,504
Design and Construction Contingency (30% of BCC)					521,551
Design Engineering (10% of BCC)					173,850
Construction Engineering and Management (12% of BCC)					208,620
Opinion of Probable Project Cost (OPPC)					**2,642,526**
Subtotal					3,163,891
O&M (50-Yr Project Life)					17,322,669
Permitting					25,000
Total Opinion of Probable Project Cost (OPPC)					**20,511,560**

Scenario 4.1B: New Recapture Wells Only (Zone 1) (Steel)

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
No Changes to Elwood Reservoir Outlet					
1					
2					
3					
4					
5					
6					
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
No Changes to Plum Creek					
1	Plum Creek Mitigation Costs				0
2	Culverts & Stream Crossings				0
Base Mitigation Cost (BMC)					0
Contingency (30% of BMC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Wells (Recapture Zone 1/Recapture Area 1 & 2) - 6 Wells					
1	Mobilization/Demobilization	LS	2	2,772	5,544
2	Drilling 24-inch Hole	LF	297	50	14,818
3	Furnish/Install 16-inch PVC Casing	LF	135	33	4,490
4	Furnish/Install 16-inch PVC Screen	LF	162	39	6,286
5	Grout Seal	LF	60	55	3,326
6	Furnish/Install Gravel Pack	LF	324	22	7,184
7	Well Development	HR	24	139	3,326
8	Short-Term Well Testing	LS	6	1,109	6,652
9	Submersible Turbine Pump/Motor	LS	6	19,096	114,575
10	Surface Facilities	LS	6	8,038	48,229
11	Power	LS	6	21,429	128,571
Base Construction Cost (BCC)					343,003
Design and Construction Contingency (30% of BCC)					102,901
Design Engineering (10% of BCC)					34,300
Construction Engineering and Management (12% of BCC)					41,160
Opinion of Probable Project Cost (OPPC)					**521,365**
Recapture Well Pipeline - Steel					
1	Mobilization/Demobilization	LS	1	50,000	50,000
2	Surface Facilities	LS/Well	6	5,700	34,200
3	Clearing and Grubbing	LF	13400	7	95,289
4	Discharge Pipeline 8"	LF	0	43	0
5	Discharge Pipeline 10"	LF	3300	60	198,000
6	Discharge Pipeline 12"	LF	0	79	0
7	Discharge Pipeline 14"	LF	1000	125	125,000
8	Discharge Pipeline 16"	LF	0	158	0
9	Discharge Pipeline 18"	LF	9100	225	2,047,500
10	Discharge Pipeline 20"	LF	0	292	0
11	Discharge Pipeline 24"	LF	0	417	0
12	Pipeline Bridge /Mounting	LS	0	10,000	0
13	Drain-Back Structure	LS	2	6,700	13,400
14	Discharge Structure	LS	2	6,000	12,000
15	Dewatering	LS	1	118,525	118,525
16	Erosion Control and Seeding	LF	13400	3	40,200
Base Construction Cost (BCC)					2,734,114
Design and Construction Contingency (30% of BCC)					820,234
Design Engineering (10% of BCC)					273,411
Construction Engineering and Management (12% of BCC)					328,094
Opinion of Probable Project Cost (OPPC)					**4,155,853**
Subtotal					4,677,218
O&M (50-Yr Project Life)					17,322,669
Permitting					25,000
Total Opinion of Probable Project Cost (OPPC)					**22,024,887**

Scenario 4.2A: New Recapture Wells Only (Zone 2) (PVC)

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
No Changes to Elwood Reservoir Outlet					
1					
2					
3					
4					
5					
6					
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
No Changes to Plum Creek					
1	Plum Creek Mitigation Costs				0
2	Culverts & Stream Crossings				0
Base Mitigation Cost (BMC)					0
Contingency (30% of BMC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Wells (Recapture Zone 2/Recapture Area 3 & 4) - 6 Wells					
1	Mobilization/Demobilization	LS	2	2,772	5,544
2	Drilling 24-inch Hole	LF	1806	50	90,106
3	Furnish/Install 16-inch PVC Casing	LF	1605	33	53,385
4	Furnish/Install 16-inch PVC Screen	LF	201	39	7,800
5	Grout Seal	LF	60	55	3,326
6	Furnish/Install Gravel Pack	LF	402	22	8,914
7	Well Development	HR	24	139	3,326
8	Short-Term Well Testing	LS	6	1,109	6,652
9	Submersible Turbine Pump/Motor	LS	6	15,741	94,447
10	Surface Facilities	LS	6	8,038	48,229
11	Power	LS	6	21,429	128,571
Base Construction Cost (BCC)					450,300
Design and Construction Contingency (30% of BCC)					135,090
Design Engineering (10% of BCC)					45,030
Construction Engineering and Management (12% of BCC)					54,036
Opinion of Probable Project Cost (OPPC)					**684,457**
Recapture Well Pipeline - PVC					
1	Mobilization/Demobilization	LS	1	50,000	50,000
2	Surface Facilities	LS/Well	6	5,700	34,200
3	Clearing and Grubbing	LF	19400	7	137,956
4	Discharge Pipeline 8"	LF	0	26	0
5	Discharge Pipeline 10"	LF	3000	36	108,000
6	Discharge Pipeline 12"	LF	1000	48	47,500
7	Discharge Pipeline 14"	LF	0	75	0
8	Discharge Pipeline 16"	LF	15400	95	1,463,000
9	Discharge Pipeline 18"	LF	0	135	0
10	Discharge Pipeline 20"	LF	10200	175	1,785,000
11	Discharge Pipeline 24"	LF	0	250	0
12	Pipeline Bridge /Mounting	LS	1	10,000	10,000
13	Drain-Back Structure	LS	1	6,700	6,700
14	Discharge Structure	LS	1	6,000	6,000
15	Dewatering	LS	1	80,925	80,925
16	Erosion Control and Seeding	LF	19400	3	58,200
Base Construction Cost (BCC)					3,787,481
Design and Construction Contingency (30% of BCC)					1,136,244
Design Engineering (10% of BCC)					378,748
Construction Engineering and Management (12% of BCC)					454,498
Opinion of Probable Project Cost (OPPC)					**5,756,970**
Subtotal					6,441,427
O&M (50-Yr Project Life)					15,349,378
Permitting					25,000
Total Opinion of Probable Project Cost (OPPC)					**21,815,805**

Scenario 4.2B: New Recapture Wells Only (Zone 2) (Steel)

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
No Changes to Elwood Reservoir Outlet					
1					
2					
3					
4					
5					
6					
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
No Changes to Plum Creek					
1	Plum Creek Mitigation Costs				0
2	Culverts & Stream Crossings				0
Base Mitigation Cost (BMC)					0
Contingency (30% of BMC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Wells (Recapture Zone 2/Recapture Area 3 & 4) - 6 Wells					
1	Mobilization/Demobilization	LS	2	2,772	5,544
2	Drilling 24-inch Hole	LF	1806	50	90,106
3	Furnish/Install 16-inch PVC Casing	LF	1605	33	53,385
4	Furnish/Install 16-inch PVC Screen	LF	201	39	7,800
5	Grout Seal	LF	60	55	3,326
6	Furnish/Install Gravel Pack	LF	402	22	8,914
7	Well Development	HR	24	139	3,326
8	Short-Term Well Testing	LS	6	1,109	6,652
9	Submersible Turbine Pump/Motor	LS	6	15,741	94,447
10	Surface Facilities	LS	6	8,038	48,229
11	Power	LS	6	21,429	128,571
Base Construction Cost (BCC)					450,300
Design and Construction Contingency (30% of BCC)					135,090
Design Engineering (10% of BCC)					45,030
Construction Engineering and Management (12% of BCC)					54,036
Opinion of Probable Project Cost (OPPC)					**684,457**
Recapture Well Pipeline - Steel					
1	Mobilization/Demobilization	LS	1	50,000	50,000
2	Surface Facilities	LS/Well	6	5,700	34,200
3	Clearing and Grubbing	LF	19400	7	137,956
4	Discharge Pipeline 8"	LF	0	43	0
5	Discharge Pipeline 10"	LF	3000	60	180,000
6	Discharge Pipeline 12"	LF	1000	79	79,167
7	Discharge Pipeline 14"	LF	0	125	0
8	Discharge Pipeline 16"	LF	15400	158	2,438,333
9	Discharge Pipeline 18"	LF	0	225	0
10	Discharge Pipeline 20"	LF	10200	292	2,975,000
11	Discharge Pipeline 24"	LF	0	417	0
12	Pipeline Bridge /Mounting	LS	1	10,000	10,000
13	Drain-Back Structure	LS	1	6,700	6,700
14	Discharge Structure	LS	1	6,000	6,000
15	Dewatering	LS	1	134,875	134,875
16	Erosion Control and Seeding	LF	19400	3	58,200
Base Construction Cost (BCC)					6,110,431
Design and Construction Contingency (30% of BCC)					1,833,129
Design Engineering (10% of BCC)					611,043
Construction Engineering and Management (12% of BCC)					733,252
Opinion of Probable Project Cost (OPPC)					**9,287,854**
Subtotal					9,972,311
O&M (50-Yr Project Life)					15,349,378
Permitting					25,000
Total Opinion of Probable Project Cost (OPPC)					**25,346,689**

Scenario 4.3A: New Recapture Wells Only (Zone 3) (PVC)

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
No Changes to Elwood Reservoir Outlet					
1					
2					
3					
4					
5					
6					
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
No Changes to Plum Creek					
1	Plum Creek Mitigation Costs				0
2	Culverts & Stream Crossings				0
Base Mitigation Cost (BMC)					0
Contingency (30% of BMC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Wells (Recapture Zone 3/Recapture Area 5 & 6) - 6 Wells					
1	Mobilization/Demobilization	LS	2	2,772	5,544
2	Drilling 24-inch Hole	LF	1506	50	75,138
3	Furnish/Install 16-inch PVC Casing	LF	1086	33	36,122
4	Furnish/Install 16-inch PVC Screen	LF	420	39	16,298
5	Grout Seal	LF	60	55	3,326
6	Furnish/Install Gravel Pack	LF	840	22	18,626
7	Well Development	HR	24	139	3,326
8	Short-Term Well Testing	LS	6	1,109	6,652
9	Submersible Turbine Pump/Motor	LS	6	19,096	114,575
10	Surface Facilities	LS	6	8,038	48,229
11	Power	LS	6	21,429	128,571
Base Construction Cost (BCC)					456,409
Design and Construction Contingency (30% of BCC)					136,923
Design Engineering (10% of BCC)					45,641
Construction Engineering and Management (12% of BCC)					54,769
Opinion of Probable Project Cost (OPPC)					**693,741**
Recapture Well Pipeline - PVC					
1	Mobilization/Demobilization	LS	1	50,000	50,000
2	Surface Facilities	LS/Well	6	5,700	34,200
3	Clearing and Grubbing	LF	11725	7	83,378
4	Discharge Pipeline 8"	LF	0	26	0
5	Discharge Pipeline 10"	LF	2000	36	72,000
6	Discharge Pipeline 12"	LF	0	48	0
7	Discharge Pipeline 14"	LF	2000	75	150,000
8	Discharge Pipeline 16"	LF	0	95	0
9	Discharge Pipeline 18"	LF	7725	135	1,042,875
10	Discharge Pipeline 20"	LF	0	175	0
11	Discharge Pipeline 24"	LF	13000	250	3,250,000
12	Pipeline Bridge /Mounting	LS	1	10,000	10,000
13	Drain-Back Structure	LS	1	6,700	6,700
14	Discharge Structure	LS	1	6,000	6,000
15	Dewatering	LS	1	63,244	63,244
16	Erosion Control and Seeding	LF	11725	3	35,175
Base Construction Cost (BCC)					4,803,572
Design and Construction Contingency (30% of BCC)					1,441,071
Design Engineering (10% of BCC)					480,357
Construction Engineering and Management (12% of BCC)					576,429
Opinion of Probable Project Cost (OPPC)					**7,301,429**
Subtotal					7,995,170
O&M (50-Yr Project Life)					16,625,584
Permitting					25,000
Total Opinion of Probable Project Cost (OPPC)					**24,645,754**

Scenario 4.3B: New Recapture Wells Only (Zone 3) (Steel)

Item No.	Item	Unit	Estimated Quantity	Unit Price ($)	Total Price ($)
No Changes to Elwood Reservoir Outlet					
1					
2					
3					
4					
5					
6					
Base Construction Cost (BCC)					0
Design and Construction Contingency (30% of BCC)					0
Design Engineering (10% of BCC)					0
Construction Engineering and Management (12% of BCC)					0
Opinion of Probable Project Cost (OPPC)					**0**
No Changes to Plum Creek					
1	Plum Creek Mitigation Costs				0
2	Culverts & Stream Crossings				0
Base Mitigation Cost (BMC)					0
Contingency (30% of BMC)					0
Opinion of Probable Project Cost (OPPC)					**0**
Recapture Wells (Recapture Zone 3/Recapture Area 5 & 6) - 6 Wells					
1	Mobilization/Demobilization	LS	2	2,772	5,544
2	Drilling 24-inch Hole	LF	1506	50	75,138
3	Furnish/Install 16-inch PVC Casing	LF	1086	33	36,122
4	Furnish/Install 16-inch PVC Screen	LF	420	39	16,298
5	Grout Seal	LF	60	55	3,326
6	Furnish/Install Gravel Pack	LF	840	22	18,626
7	Well Development	HR	24	139	3,326
8	Short-Term Well Testing	LS	6	1,109	6,652
9	Submersible Turbine Pump/Motor	LS	6	19,096	114,575
10	Surface Facilities	LS	6	8,038	48,229
11	Power	LS	6	21,429	128,571
Base Construction Cost (BCC)					456,409
Design and Construction Contingency (30% of BCC)					136,923
Design Engineering (10% of BCC)					45,641
Construction Engineering and Management (12% of BCC)					54,769
Opinion of Probable Project Cost (OPPC)					**693,741**
Recapture Well Pipeline - Steel					
1	Mobilization/Demobilization	LS	1	50,000	50,000
2	Surface Facilities	LS/Well	6	5,700	34,200
3	Clearing and Grubbing	LF	11725	7	83,378
4	Discharge Pipeline 8"	LF	0	43	0
5	Discharge Pipeline 10"	LF	2000	60	120,000
6	Discharge Pipeline 12"	LF	0	79	0
7	Discharge Pipeline 14"	LF	2000	125	250,000
8	Discharge Pipeline 16"	LF	0	158	0
9	Discharge Pipeline 18"	LF	7725	225	1,738,125
10	Discharge Pipeline 20"	LF	0	292	0
11	Discharge Pipeline 24"	LF	13000	417	5,416,667
12	Pipeline Bridge /Mounting	LS	1	10,000	10,000
13	Drain-Back Structure	LS	1	6,700	6,700
14	Discharge Structure	LS	1	6,000	6,000
15	Dewatering	LS	1	105,406	105,406
16	Erosion Control and Seeding	LF	11725	3	35,175
Base Construction Cost (BCC)					7,855,651
Design and Construction Contingency (30% of BCC)					2,356,695
Design Engineering (10% of BCC)					785,565
Construction Engineering and Management (12% of BCC)					942,678
Opinion of Probable Project Cost (OPPC)					**11,940,589**
Subtotal					12,634,330
O&M (50-Yr Project Life)					16,625,584
Permitting					25,000
Total Opinion of Probable Project Cost (OPPC)					**29,284,914**